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APPENDIX 7-2

SCEIRDE ROCKS OFFSHORE WINDDFARM METOCEAN STUDY

Deltares

Skerd Rocks offshore wind farm metocean study

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Skerd Rocks offshore wind farm metocean study

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Summary

Fuinneamh Sceirde Teoranta is carrying out the design of the Skerd Rocks offshore wind farm envisioned to be built at the Atlantic coast of Ireland, approximately 10 km offshore southwest of Ard, County Galway. Deltares was requested to provide a metocean study as input for the design. The metocean study is aimed at providing the client with the following:

- Hindcast timeseries for a period of 43 years (01-01-1979 00:00 – 31-12-2021 23:00) with an hourly interval of parameters describing the wind, wave, water level and current conditions;
- Normal and extreme conditions for wind, wave, wave, water level and current conditions;
- Miscellaneous assessments including sea level rise projections, persistency tables (weather windows/downtime periods) and wave breaking and slamming.

Given that there are no high-resolution long term timeseries of wave and hydrodynamic conditions at the specific location of interest, these were generated using dedicated hydrodynamic and wave models driven using available wind data. The resulting timeseries were validated and calibrated using available local observations. These validated wind, wave, water level and current timeseries and other reanalysis and climate projection datasets were then used as basis for the determination of the requested metocean conditions.

For the determination of the wave and hydrodynamic conditions three turbine locations within the wind farm were considered.

This report presents the results of the metocean study and describes the methodology behind the obtained data. Summaries of the metocean conditions for the three turbine locations WTG15 (most-exposed), WTG08 (intermediate) and WTG11 (relatively sheltered), are given in the tables below, respectively. Of the considered locations, the stronger currents and the most extreme wave conditions are found at location WTG15, which is the most exposed location of the three. Note that here only the omni-directional RP 1-, 50-, 100- and 1,000-yr conditions are summarized; directional conditions and conditions for other return periods can be found in the main text.

A wave breaking and slamming assessment considering the full array of turbine locations was performed and the results show that wave slamming is only expected at the seven most exposed turbine locations (WTG12, WTG13, WTG15, WTG17, WTG18, WTG19 and WTG20) for the longer return periods. This is typically only the case for waves coming from westerly directions (North Atlantic). The most likely breaker type is spilling.

WTG15

Return Period (yrs)	1	50	100	1,000
Winds				
$U_{10,1hr}$ (m/s)	23.3 (23.2 - 23.3)	28.7 (26.3 - 31.9)	29.7 (26.5 - 34.4)	32.9 (27.0 - 47.4)
$U_{10,10min}$ (m/s)	25.3 (25.2 - 25.4)	31.6 (28.8 - 35.2)	32.7 (29.0 - 38.1)	36.4 (29.5 - 53.7)
$U_{170,1hr}$ (m/s)	29.7 (29.2 - 30.3)	38.1 (34.4 - 43.2)	39.6 (34.8 - 46.8)	44.5 (35.7 - 63.9)
$U_{170,10min}$ (m/s)	32.7 (32.1 - 33.4)	42.6 (38.1 - 48.6)	44.3 (38.6 - 53.0)	50.3 (39.7 - 74.4)
Water level				
High EWL (mLAT)	5.39 (5.38 - 5.41)	5.74 (5.62 - 5.90)	5.80 (5.64 - 6.04)	6.00 (5.69 - 6.75)
Low EWL (mLAT)	0.03 (0.05 - 0.00)	-0.33 (-0.22 - -0.47)	-0.39 (-0.24 - -0.57)	-0.54 (-0.29 - -0.98)
Tidal range HAT-LAT	5.33			
Tidal range MSL-LAT	2.71			
Local bed level (mLAT)	-42.14			
Currents (total)				
Surface (m/s)	0.78 (0.77 - 0.79)	0.95 (0.88 - 1.04)	0.98 (0.89 - 1.11)	1.07 (0.92 - 1.37)
Depth averaged (m/s)	0.68 (0.67 - 0.69)	0.83 (0.77 - 0.92)	0.85 (0.77 - 0.98)	0.94 (0.79 - 1.28)
Near-bottom (m/s)	0.42 (0.41 - 0.42)	0.51 (0.47 - 0.55)	0.52 (0.48 - 0.58)	0.57 (0.50 - 0.69)
Currents (residual)				
Surface (m/s)	0.54 (0.54 - 0.55)	0.68 (0.63 - 0.74)	0.70 (0.64 - 0.80)	0.78 (0.65 - 1.06)
Depth averaged (m/s)	0.48 (0.47 - 0.48)	0.59 (0.54 - 0.64)	0.61 (0.55 - 0.69)	0.68 (0.56 - 0.92)
Near-bottom (m/s)	0.29 (0.29 - 0.29)	0.36 (0.33 - 0.39)	0.37 (0.34 - 0.42)	0.42 (0.35 - 0.57)
Waves				
H_s (m)	8.11 (7.97 - 8.30)	12.56 (10.81 - 14.76)	13.35 (11.09 - 16.37)	15.97 (11.72 - 24.22)
T_p (s)	15.07 (15.00 - 15.15)	16.78 (16.18 - 17.47)	17.04 (16.28 - 17.92)	17.81 (16.50 - 19.74)
$H_{max,EHWL}$ (m)	15.08 (14.81 - 15.42)	23.34 (20.09 - 27.42)	24.80 (20.60 - 29.25)	28.80 (21.79 - 38.33)
$C_{max,EHWL}$ (mLAT)	14.53 (14.32 - 14.80)	21.66 (18.71 - 25.69)	23.07 (19.16 - 27.70)	27.19 (20.23 - 34.95)
$H_{max,MSL}$ (m)	15.08 (14.81 - 15.42)	23.34 (20.09 - 26.70)	24.80 (20.60 - 28.48)	28.04 (21.79 - 37.64)
$C_{max,MSL}$ (mLAT)	11.99 (11.79 - 12.25)	19.05 (16.10 - 22.38)	20.46 (16.55 - 24.28)	23.81 (17.61 - 31.03)
$H_{max,ELWL}$ (m)	15.08 (14.81 - 15.42)	23.34 (20.09 - 25.97)	24.41 (20.60 - 27.72)	27.29 (21.79 - 37.17)
$C_{max,ELWL}$ (mLAT)	9.48 (9.29 - 9.73)	16.48 (13.51 - 19.10)	17.53 (13.96 - 19.77)	20.50 (15.02 - 27.68)

WTG08

Return Period (yrs)	1	50	100	1,000
Winds				
$U_{10,1hr}$ (m/s)	23.3 (23.2 - 23.3)	28.7 (26.3 - 31.9)	29.7 (26.5 - 34.4)	32.9 (27.0 - 47.4)
$U_{10,10min}$ (m/s)	25.3 (25.2 - 25.4)	31.6 (28.8 - 35.2)	32.7 (29.0 - 38.1)	36.4 (29.5 - 53.7)
$U_{170,1hr}$ (m/s)	29.7 (29.2 - 30.3)	38.1 (34.4 - 43.2)	39.6 (34.8 - 46.8)	44.5 (35.7 - 63.9)
$U_{170,10min}$ (m/s)	32.7 (32.1 - 33.4)	42.6 (38.1 - 48.6)	44.3 (38.6 - 53.0)	50.3 (39.7 - 74.4)
Water level				
High EWL (mLAT)	5.43 (5.41 - 5.44)	5.77 (5.65 - 5.93)	5.83 (5.68 - 6.06)	6.04 (5.74 - 6.68)
Low EWL (mLAT)	0.03 (0.05 - 0.00)	-0.35 (-0.24 - -0.49)	-0.41 (-0.26 - -0.61)	-0.58 (-0.32 - -1.09)
Tidal range HAT-LAT	5.37			
Tidal range MSL-LAT	2.72			
Local bed level (mLAT)	-40.46			
Currents (total)				
Surface (m/s)	0.50 (0.49 - 0.51)	0.65 (0.60 - 0.70)	0.67 (0.62 - 0.75)	0.76 (0.64 - 0.97)
Depth averaged (m/s)	0.44 (0.43 - 0.44)	0.56 (0.53 - 0.61)	0.59 (0.54 - 0.65)	0.66 (0.56 - 0.84)
Near-bottom (m/s)	0.27 (0.26 - 0.27)	0.34 (0.32 - 0.37)	0.36 (0.33 - 0.39)	0.40 (0.35 - 0.49)
Currents (residual)				
Surface (m/s)	0.35 (0.34 - 0.35)	0.50 (0.44 - 0.58)	0.52 (0.45 - 0.64)	0.61 (0.48 - 0.89)
Depth averaged (m/s)	0.30 (0.29 - 0.31)	0.43 (0.38 - 0.51)	0.46 (0.39 - 0.55)	0.53 (0.42 - 0.76)
Near-bottom (m/s)	0.18 (0.18 - 0.19)	0.26 (0.23 - 0.31)	0.28 (0.24 - 0.34)	0.33 (0.25 - 0.47)
Waves				
H_s (m)	6.54 (6.38 - 6.72)	9.54 (8.63 - 10.64)	10.06 (8.89 - 11.63)	11.76 (9.50 - 16.13)
T_p (s)	14.60 (14.47 - 14.72)	16.50 (15.97 - 17.10)	16.78 (16.12 - 17.60)	17.66 (16.48 - 19.58)
$H_{max,EHWL}$ (m)	12.16 (11.86 - 12.48)	17.72 (16.04 - 19.78)	18.69 (16.52 - 21.62)	21.86 (17.65 - 28.75)
$C_{max,EHWL}$ (mLAT)	12.56 (12.33 - 12.80)	17.16 (15.68 - 19.05)	18.03 (16.08 - 20.81)	21.02 (17.06 - 28.40)
$H_{max,MSL}$ (m)	12.16 (11.86 - 12.48)	17.72 (16.04 - 19.78)	18.69 (16.52 - 21.62)	21.86 (17.65 - 27.83)
$C_{max,MSL}$ (mLAT)	9.96 (9.74 - 10.19)	14.37 (12.95 - 16.20)	15.22 (13.35 - 17.91)	18.14 (14.31 - 24.33)
$H_{max,ELWL}$ (m)	12.16 (11.86 - 12.48)	17.72 (16.04 - 19.78)	18.69 (16.52 - 21.62)	21.86 (17.65 - 26.96)
$C_{max,ELWL}$ (mLAT)	7.38 (7.18 - 7.60)	11.61 (10.24 - 13.39)	12.44 (10.63 - 15.07)	15.31 (11.58 - 18.53)

WTG11

Return Period (yrs)	1	50	100	1,000
Winds				
$U_{10,1hr}$ (m/s)	23.3 (23.2 - 23.3)	28.7 (26.3 - 31.9)	29.7 (26.5 - 34.4)	32.9 (27.0 - 47.4)
$U_{10,10min}$ (m/s)	25.3 (25.2 - 25.4)	31.6 (28.8 - 35.2)	32.7 (29.0 - 38.1)	36.4 (29.5 - 53.7)
$U_{170,1hr}$ (m/s)	29.7 (29.2 - 30.3)	38.1 (34.4 - 43.2)	39.6 (34.8 - 46.8)	44.5 (35.7 - 63.9)
$U_{170,10min}$ (m/s)	32.7 (32.1 - 33.4)	42.6 (38.1 - 48.6)	44.3 (38.6 - 53.0)	50.3 (39.7 - 74.4)
Water level				
High EWL (mLAT)	5.42 (5.41 - 5.44)	5.77 (5.64 - 5.92)	5.83 (5.66 - 6.07)	6.03 (5.71 - 6.80)
Low EWL (mLAT)	0.03 (0.05 - 0.00)	-0.34 (-0.23 - -0.48)	-0.40 (-0.25 - -0.58)	-0.57 (-0.32 - -1.01)
Tidal range HAT-LAT	5.36			
Tidal range MSL-LAT	2.72			
Local bed level (mLAT)	-25.89			
Currents (total)				
Surface (m/s)	0.61 (0.60 - 0.61)	0.74 (0.69 - 0.80)	0.76 (0.70 - 0.85)	0.84 (0.72 - 1.05)
Depth averaged (m/s)	0.53 (0.52 - 0.53)	0.64 (0.60 - 0.69)	0.66 (0.61 - 0.73)	0.73 (0.63 - 0.89)
Near-bottom (m/s)	0.35 (0.34 - 0.35)	0.42 (0.39 - 0.45)	0.43 (0.40 - 0.48)	0.48 (0.41 - 0.59)
Currents (residual)				
Surface (m/s)	0.46 (0.45 - 0.47)	0.66 (0.59 - 0.74)	0.70 (0.61 - 0.81)	0.81 (0.65 - 1.06)
Depth averaged (m/s)	0.40 (0.39 - 0.41)	0.58 (0.52 - 0.65)	0.61 (0.53 - 0.71)	0.71 (0.57 - 0.94)
Near-bottom (m/s)	0.26 (0.26 - 0.27)	0.38 (0.34 - 0.41)	0.40 (0.35 - 0.45)	0.46 (0.37 - 0.62)
Waves				
H_s (m)	4.63 (4.59 - 4.67)	6.08 (5.58 - 6.65)	6.33 (5.68 - 7.19)	7.17 (5.85 - 9.65)
T_p (s)	15.24 (15.21 - 15.28)	16.44 (16.06 - 16.86)	16.63 (16.13 - 17.23)	17.22 (16.27 - 18.71)
$H_{max,EHWL}$ (m)	8.60 (8.54 - 8.69)	11.30 (10.38 - 12.36)	11.77 (10.55 - 13.36)	13.33 (10.88 - 17.93)
$C_{max,EHWL}$ (mLAT)	10.72 (10.66 - 10.80)	13.24 (12.35 - 14.31)	13.70 (12.51 - 15.34)	15.27 (12.83 - 20.37)
$H_{max,MSL}$ (m)	8.60 (8.54 - 8.69)	11.30 (10.38 - 12.36)	11.77 (10.55 - 13.36)	13.33 (10.88 - 17.29)
$C_{max,MSL}$ (mLAT)	8.17 (8.12 - 8.24)	10.47 (9.66 - 11.45)	10.90 (9.81 - 12.39)	12.36 (10.10 - 16.34)
$H_{max,ELWL}$ (m)	8.60 (8.54 - 8.69)	11.30 (10.38 - 12.36)	11.77 (10.55 - 13.36)	13.33 (10.88 - 16.43)
$C_{max,ELWL}$ (mLAT)	5.67 (5.63 - 5.71)	7.75 (7.00 - 8.65)	8.15 (7.14 - 9.54)	9.52 (7.38 - 12.43)

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Symbol / Acronym	Unit	Description
C_{max}	m	Crest height associated with H_{max}
DA		Depth-averaged
DCSM-FM		Dutch Continental Shelf Model – Flexible Mesh
DSpr	°	Wave directional spreading
ECMWF		European Centre for Medium-range Weather Forecasts
EMODnet		European Marine Observation and Data Network
ERA5		ECMWF fifth reanalysis of the global weather and climate
EVA		Extreme Value Analysis
F_s	-	Directional spreading/Wave kinematic factor
GPD	-	Generalized Pareto Distribution
JONSWAP		Joint North Sea Wave Project
γ	-	Peak enhancement factor of the JONSWAP spectrum
Γ	-	The gamma function
HAT	m	Highest astronomical tide
H_s	m	Significant wave height
H_{max}	m	Maximum individual wave height
LAT	m	Lowest Astronomical Tide
mLAT	m	meter above Lowest Astronomical Tide
m_0	m^2	Variance (or zero moment) of the wave energy spectrum
m_1	m^2/s	First moment of the wave energy spectrum
m_2	m^2/s^2	Second moment of the wave energy spectrum
MSL	m	Mean sea level
mMSL	m	meter above Mean Sea Level
MWD	°N	Mean wave direction (‘coming from’ and clockwise from North)
OWF	-	Offshore Wind Farm
POT	-	Peak-over-threshold
ρ	-	Correlation coefficient

Symbol / Acronym	Unit	Description
rmse		Root-mean-square error
σ		Standard deviation
s	-	Directional spreading parameter or exponent
SWAN		Simulating WAves Nearshore
$T_{m0,1}$	s	Mean wave period based on the first moment of the wave energy spectrum, $T_{m01}=m_0/m1$
$T_{m0,2}$ or T_z	s	Mean wave period based on the second moment of the wave energy spectrum, $T_{m02}=\sqrt{(m_0/m_2)}$, also known as the zero-crossing wave period T_z
T_{hmax}	s	Period of H_{max}
T_p	s	Peak wave period
$U_{c,tid,mag}$	m/s	Tidal current speed
$U_{c,tid,dir}$	°N	Tidal current direction (‘going to’ and clockwise from North)
$U_{c,tot,mag}$	m/s	Total current speed
$U_{c,tot,dir}$	°N	Total current direction (‘going to’ and clockwise from North)
$U_{c,res,mag}$	m/s	Residual current speed
$U_{c,res,dir}$	°N	Residual current direction (‘going to’ and clockwise from North)
U_{xx} or $U_{xx, mag}$	m/s	1-hour averaged wind speed at *xx* m height
U_{dir}	°N	Wind direction (‘coming from’ and clockwise from North)
ξ_0 or ξ_b		Iribarren number (also known as surf-similarity parameter)

1 Introduction

1.1 Background

Fuinneamh Sceirde Teoranta is planning the construction and operation of the Skerd Rocks offshore wind farm (Skerd Rocks OWF), hereafter referred to as SROWF. Figure 1.1 shows an overview of SROWF site includiing the foreseen locations of the 20 wind turbines that will be installed within the OWF. SROWF is located approximately approximately 10 km offshore southwest of Ard, County Galway. Water depths at the turbines range from 24.5 to 57.5 m below LAT (cf. Table 3.26). The considered hub-height is 170 mMSL (172.7 mLAT).

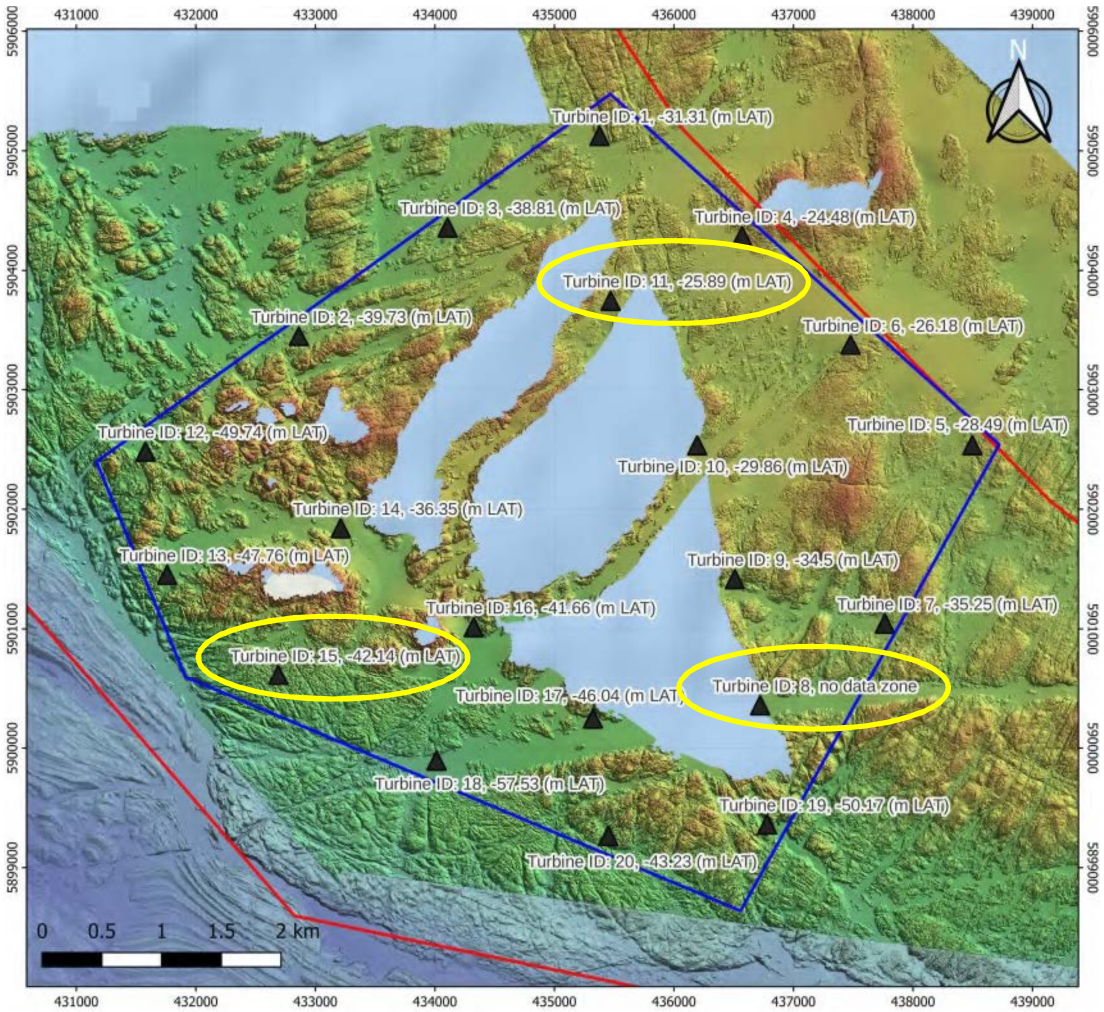


Figure 1.1 Overview Skerd Rocks offshore wind farm project location (source: Client). The metocean conditions at the encircled in yellow turbine locations are considered in detail in this study.

The metocean study aims to provide the inputs requested by the Client for the design of the wind farm. This report presents the methodology behind the metocean study as well as summarises the requested parameters. Next to this report, the results are also delivered in spreadsheet tables containing the derived statistics and csv-datafiles containing the hindcast timeseries at the chosen reference locations.

1.2 Objectives

The objective of the study is to provide the Client with metocean conditions to support the design of the various structures within the area of SROWF. As requested by the Client, the main goal is to provide the following metocean data:

I. Hindcast timeseries at the three locations given in Table 1.1 for a period of at least 25 years with an hourly interval for the following parameters:

- Winds: wind speeds and directions at 10 m above MSL ($U_{10,mag}$) and at the hub-height ($U_{170,mag}$)[1]. Wind direction ($U_{xx,dir}$) is defined as coming from;
- Waves (total signal): significant wave height H_s, peak wave period T_p, spectral mean wave period $T_{m0,1}$, spectral zero-crossing wave period $T_{m0,2}$, spectral mean wave period $T_{m-1,0}$, mean wave direction MWD, Directional spreading DSpr;
- Waves (wind-sea and swell signals): significant wave height H_s, peak wave period T_p, peak wave direction PWD, Directional spreading DSpr;
- Water levels (total, tidal and residual);
- Current speed and direction at surface, near-bottom and depth-averaged (total, tidal and residual).

II. Metocean conditions at the three locations given in Table 1.1:

1. Extreme conditions (return periods 1-, 10-, 50-, 100-, 500- and 1,000-year, omni and 30° directional sectors: 345-15°N, 15-45°N, …, 315-345°N):
    - Extreme Sea States: Significant wave height (H_s) and associated peak wave periods, peak enhancement factors, directional spreading values, wave kinematic factors, total depth-averaged current speeds, maximum wave heights (H_{max}), periods (T_{Hmax}) and crest heights (C_{max});
    - Severe Sea States;
    - Breaking wave assessment;
    - Extreme total and residual (surge) positive and negative water levels;
    - Extreme total and residual current speed depth-averaged, at surface and near-bottom.

2. Normal conditions
    - Tidal levels (from Lowest Astronomical Tide, LAT, through to Highest Astronomical Tide, HAT);
    - All-year and monthly roses and joint occurrence tables of H_s versus MWD;
    - All-year and monthly joint occurrence tables of H_s versus T_z and H_s versus T_p;
    - All-year and monthly joint occurrence tables of $U_{170,mag}$ versus $U_{170,dir}$;
    - All-year and monthly joint occurrence tables of $U_{170,mag}$ versus MWD;
    - All-year and monthly joint occurrence tables of H_s versus $U_{hub,mag}$;
    - All-year misalignment tables (joint occurrence tables of $U_{170,dir}$ versus MWD) conditioned on wind speed; and
    - All-year and monthly roses and all-year joint occurrence tables of total current speed versus direction at surface, near-bottom and depth-averaged;
    - Persistency Analyses (Weather windows and downtime) for wind speed at 10 mMSL height ($U_{10,mag}$), wind speed at hub-height ($U_{170,mag}$) and significant wave height (H_s).

The considered three reference locations (cf. Figure 1.1 and Table 1.1) have been determined in consultation with the Client by considering the spatial variation in the numerically computed maximum values of (depth-averaged) current velocity and significant wave height (H_s) and clustering the turbines in three groups: exposed, intermediate and (relatively) sheltered (refer

[1] The wind data at hub-height are derived by Wind Pioneers and are not part of this report.

to Section 3.1 for more details). The three selected location are considered as representative locations for the three clusters.

Table 1.1 Considered turbine assessment locations.

Location-ID	Longitude (°E)	Latitude (°N)	Depth (mLAT)	Cluster
WTG15	-10.0088562	53.2505132	-42.14	Fully Exposed
WTG08	-9.9483876	53.2487103	-40.46	Intermediate
WTG11	-9.9678154	53.2790192	-25.89	Relatively sheltered

1.3 Approach

The determination of the metocean timeseries and conditions is based on available hindcast, reanalysis, climate projection and observation datasets, detailed numerical modelling and data analyses.

Numerical modelling
Dedicated high resolution numerical modelling was carried out to derive the hindcast timeseries of wave and hydrodynamic parameters. The hydrodynamics (water levels and currents) were modelled using a refined version of Deltares' calibrated 2DH Flexible Mesh Dutch Continental Shelf Model (DCSM-FM). The DCSM-FM is the sixth-generation hydrodynamic model, developed by Deltares for the Dutch Government for the use in operational forecasting, water quality and ecology studies and covers the whole North Sea and part of the North Atlantic Ocean. Detailed background of the model setup, calibration and extensive validation is given in Deltares (2019).

The third-generation shallow water wave model SWAN (Simulating WAves Nearshore; http://swanmodel.sourceforge.net/) has been used for the numerical modelling of waves in combination with forcing by ERA5 wind data.

Data sources
The atmospheric data and boundary wave conditions needed to force the wave and hydrodynamic models, as well as the conditions for the wind and snow analyses were retrieved from the dataset of the most recent and accurate reanalysis of the European Centre for Medium-range Weather Forecast (ECMWF), ERA5. The ERA5 dataset currently covers the period from 1950 until now on a global model grid of about 0.25° x 0.25° (~30 km) at an hourly interval and has unprecedented accuracy in terms global atmospheric and wave data. The data from 1950 until 1978 are considered to be of lower quality than the data after that period given that more observations are available from 1979 for the applied data assimilation. In this study therefore the higher quality data from 01-01-1979 00:00 – 31-12-2021 23:00 are used.

Observations available in the Marine Institute database, from stations M1 (wave/meteorological buoy), Galway (tide gauge) and Inishmore (tide gauge), were used to validate and calibrate the model data. Furthermore, wind observations of the Doolickreef Rock metmast were used to further validate and calibrate the wind data.

The bathymetry data that were used as basis for the depth schematization of the hydrodynamic and wave models are from high-resolution (5x5 m) bathymetrical survey datasets (provided by the Client and publicly available from EMODnet[2]: European Marine Observation and Data Network) supplemented by the publicly available lower resolution (approximately 115x115 m) EMODnet dataset from 2020.

[2] https://portal.emodnet-bathymetry.eu/

Statistical analysis

The Deltares data analysis and transformation tool ORCA, see https://www.deltares.nl/en/software/orca/ and van Os and Caires (2011), was used in all statistical analyses to derive the normal, severe and extreme conditions as explained below:

- Normal conditions (wind, water levels, currents, waves) such as joint occurrence tables and roses of waves, wind and currents were computed empirically and directly from the multi-year timeseries. The water level timeseries were analysed using a tidal analysis tool to determine the tidal levels.
- The extreme conditions (including so-called normal and severe sea states) of the main (unconditioned) variables (wind, water levels, currents and waves) were computed by means of univariate extreme value analyses using the Peaks-Over-Threshold (POT) method (Caires, 2016 and Appendix B). The associated (conditioned) values of the other variables were determined by means of empirical relations and reliable mathematical models. Given that the locations of interest are at intermediate depths (-24.48 to -57.53 mLAT) which may cause non-linear behaviour and breaking of the higher wave heights in the spectrum, the crest wave heights were determined by first applying the Battjes and Groenendijk distribution (Battjes and Groenendijk, 2000), to determine the maximum wave height and then the Rienecker and Fenton (1981) theory to determine the crest height.

Whenever stratifying data into directional sectors, this was done using twelve 30° sectors with the first sector centred around the North (0/360°N). In terms of magnitudes, the following binning was applied per parameter type:

- wind speed: 40 wind speed bins with boundaries [0 1.5:1:40.5] m/s,
- current speed: 15 bins, with boundaries [0.00:0.05:0.60 0.70:0.10:0.90] m/s,
- wave height: 15 bins, with boundaries [0.0:1.0:15.0] m, and
- wave periods: 1 s wide bins, starting from 4.0 s.

In all situations of grouping data, the following logic was applied:

$$\text{Lower limit} \leq \text{Value} < \text{Upper limit}$$

Extreme conditions were determined for return periods of 1-, 10-, 50-, 100-, 500- and 1,000-year. The extreme conditions given in this report consist of the point estimates and the 95% confidence intervals. The design engineer should consider the point estimates as our best estimates and the lower and upper bound of the confidence intervals as possible but to a certain extent conservative or unconservative outcomes.

Directional conventions

In this report all wind and wave directions follow the nautical convention: wind and wave directional values are defined as coming from in degrees clockwise from the geographical North and referred to as °N (0°/360°N is coming from the North, 90°N is coming from the East, 180°N is coming from the South and 270°N is coming from the West). All current directions follow the oceanographic convention: current directional values are defined as going towards in degrees clockwise from the geographical North and referred to as °N (0°/360°N is going towards the North, 90°N is going towards the East, 180°N is going towards the South and 270°N is going towards the West).

Vertical reference level

All vertical levels in this report are referenced to the Lowest Astronomical Tide (LAT) level.

1.4 Outline of the report

The description, modelling and validation of the applied data are described first in the next chapter. The chapter can be skipped for those not wanting to look into the details of the data that have been used for the determination of the metocean conditions. Chapter 3 describes the statistical analyses of the parameters and presents metocean conditions in separate sections per variable group (wind, water level, currents and waves). Certain methods and models referred to in chapters 2 and 3 are described in more detail in Appendices A, B and C. Appendix D presents the spatial variation plots used for selecting the representative turbine locations.

The determined metocean conditions per assessment location are available digitally in the MS Excel spreadsheet (*.xlsx) files accompanying this report's pdf file with the same name (*11208193-002-HYE-0001-Skerd Rocks offshore wind farm metocean study_Metocean_WTG15/08/11.xlsx*). Furthermore, persistence tables are provided in other MS Excel files with "Persistency" added to the file name (*11208193-002-HYE-0001-Skerd Rocks offshore wind farm metocean study_Persistency_WTG15/08/11.xlsx*). The lists of contents of these files are given in Appendix E. Last, Appendix F presents the results of the breaking wave assessment performed at all 20 turbine locations (listed in Table 3.26) in the OWF area.

2 Data and numerical modelling

2.1 Winds

2.1.1 Introduction

In this section the data sources for wind speed and wind direction are described. Where relevant, these data are validated and calibrated against measurements to arrive at the wind dataset for the SROWF area, which formed the input for the analyses described in Section 3.2.

The wind data at 10 mMSL height used as basis for this study are from the ERA5 dataset. The hourly, 1-hour averaged wind velocity data from 1979 until 2021 (43 years, 01-01-1979 00:00 – 31-12-2021 23:00) were downloaded from the ERA5 repository in NetCDF format. For input to the hydrodynamic model discussed in Section 2.2.2, ERA5 wind data at 10 m height and air pressure data were downloaded for the region going from 15°W to 31°E and from 41.5°N to 67°N with a resolution of 0.25° x 0.25°. For the wave model discussed in Section 2.3.2, ERA5 wind data at 10 mMSL height were downloaded for the region going from -10.5°E to -9.6°E and from 53.0°N to 53.5°N with a resolution of 0.1° x 0.1°. For the ERA5 wind data validation and calibration discussed in this section, the ERA5 wind data at the coordinate (i.e. 53.3°N, -10°E) closest to the Doolickreef Rock metmast has been considered and additionally ERA5 data have been downloaded at the coordinate (i.e. 53.1°N, -11.2°E) closest to the location of the M1 buoy of the Marine institute (cf. Table 2.1). Pressure and temperature data for 10 m height were also obtained from the ERA5 dataset. The retrieved ERA5 wind velocity components have been converted to wind speed and direction[3].

The wind data at hub-height (170 mMSL / 172.7 mLAT) were provided by the Client through Wind-Pioneers and cover a period of 32 years (01-01-1990 00:00 – 31-12-2021 23:00). This dataset is based on ERA5 winds, which were enhanced through calibration using the Doolickreef Rock metmast data at 30 mMSL height and translating the data to hub-height (170 mMSL). The wind data at hub-height have an hourly timestep and represent 1 hour averaged wind speeds.

The validation and calibration of the 10 mMSL ERA5 wind data are presented next in Section 2.1.2. Validation and calibration of the wind at hub-height was already done by Wind Pioneers and is therefore not repeated here. The section ends with the definition of the SROWF wind timeseries used as basis for the determination of the normal and extreme wind conditions at SROWF in Section 2.1.3.

2.1.2 Data validation and calibration

The ERA5 10m wind speed and direction data were validated against available wind speed and direction observations in the region of SROWF. Figure 2.1 shows the considered two observation stations and Table 2.1 shows the time periods covered by the data, the heights at which the data are measured (above MSL) and their provenience.

Hourly 1-hour averaged wind speed and direction data at the M1 buoy location are available at approximately (assumed) 4 m height. At the Doolickreef Rock metmast location 10-minute interval, 10-min averaged wind speeds are available at multiple heights and wind directions at a single height. All wind observation data at the Doolickreef Rock metmast were converted to

[3] Using the nautical convention, i.e. the direction the wind is coming from in degrees clockwise from the North and referred to as °N. The direction of wind blowing from the North is 0°N, from the East is 90°N, from the South is 180°N and from the West is 270°N.

hourly-averaged data by averaging the 10-min averages from 30 minutes before to 30 minutes after the hour.

The observations are considered separately per instrument in the data validation.

Table 2.1 Available wind observation datasets.

Station	Period	Origin	Heights above MSL (m)
M1 (buoy)	06-02-2001 – 09-07-2007	Marine Institute[4]	4 (assumed)
Doolickreef Rock (metmast)	18-12-2002 – 16-10-2004	Client	Cup anemometer: 20.1, 29.4, 30.4 Wind vane: 30.0

Figure 2.1 Aerial overview of the wind observation stations. The SROWF area is outlined in red.

To be able to compare the observed wind speed data with the ERA5 data at 10 m height, the observed wind speeds at both locations were converted to the 10 m height assuming a vertical logarithmic wind profile (Komen et al., 1994), namely:

$$U(z) = \frac{u_*}{\kappa}\ln\left(\frac{z}{z_0}\right), \text{ with } z_0 = \alpha\frac{u_*^2}{g} \;\; z_0 = \alpha\frac{u_*^2}{g}$$

where z is the height, u_x is the friction velocity in m/s, z_0 is the surface roughness in m, κ is the von Karman constant, g = 9.81 m/s^2 is the acceleration due to gravity and α is the Charnock 'constant'. An iterative algorithm or the approximation of Wu (1982) can be used to determine the friction velocity from the measurements. Hereafter, the corresponding wind velocity at 10 mMSL (U_{10}) can be computed. There are different estimates for α available in the literature varying from 0.004 to 0.032 (see e.g. Komen et al., 1994). In line with other projects and as is also done in the wave modelling, α is set equal to 0.018. Assuming again that the wind directions vary little over the lower levels of the vertical profile, the wind directions at 10 m have been assumed to be equal to the wind directions at the measurement levels.

For the comparison of the Doolickreef Rock observation data with the ERA5 data the measurements at the lowest level of the metmast were used: 20.1 m above the metmast base. Although the metmast was situated at a rock with an elevation of 3.9 m above mean sea level, on advice of Wind Pioneers, it is assumed that the wind streamlines followed the rock profile and that the reference height is not influenced by this. This means that the 20.1 m above the metmast base was considered as 20.1 m above MSL.

[4] https://erddap.marine.ie/erddap/index.html

Figure 2.2 to Figure 2.5 show the density scatter and percentile comparisons and the main statistics of the data comparisons such as the correlation coefficient, root-mean-square errors, bias and standard deviation, see Appendix A for a description of how these statistics have been computed. For each station there is a figure with the omni-directional and directional wind speed comparisons (Figure 2.2 and Figure 2.4) and with the wind direction comparisons (Figure 2.3 and Figure 2.5).

The figures show a very high correlation between the observed wind speeds and directions and the ERA5 wind speeds and directions. The ERA5 wind fields are, therefore and in line with our experience in other locations, considered to be very reliable, due to the very high correlations with the observations and are considered to form a solid basis for the hydrodynamic and wave modelling.

As expected given the relatively coarse resolution of the ERA5 atmospheric model, having considered all comparisons in detail (and some timeseries plots, not shown here) it has been concluded that in the considered area the ERA5 data shows some underestimation of the high wind speed percentiles. For the determination of the normal and extreme conditions at the SROWF turbines the ERA5 wind speeds need, therefore, to be corrected/calibrated. On the other hand, there is no need to correct/calibrate the ERA5 wind directions.

The expressions to calibrate the wind speeds were defined based on the omnidirectional percentile fits at 10 mMSL height for the Doolickreef Rock metmast location (within the SROWF area), see Figure 2.4. Using these fits, the following correction is applied (only to the wind speeds that based on the fit are underestimated):

$$U_{10,corr} = 1.148U_{10} - 0.487 \qquad \text{(if } U_{10,corr} > U_{10}\text{, else } U_{10,corr} = U_{10}\text{)} \qquad (2.1)$$

Note that this wind speed correction is only applied to the wind data at 10 mMSL height used for determining of the normal and extreme wind conditions at the SROWF location, not to the data used to force the wave and hydrodynamic models. The models are forced with the raw ERA5 data, given the high correlation between the raw ERA5 data and the observation and that the quality of the model results does not depend only on the accuracy of the forcing winds. The effects of mismatches in the wind data and other model inaccuracies are considered jointly in the validation and calibration of the wave and hydrodynamic model results.

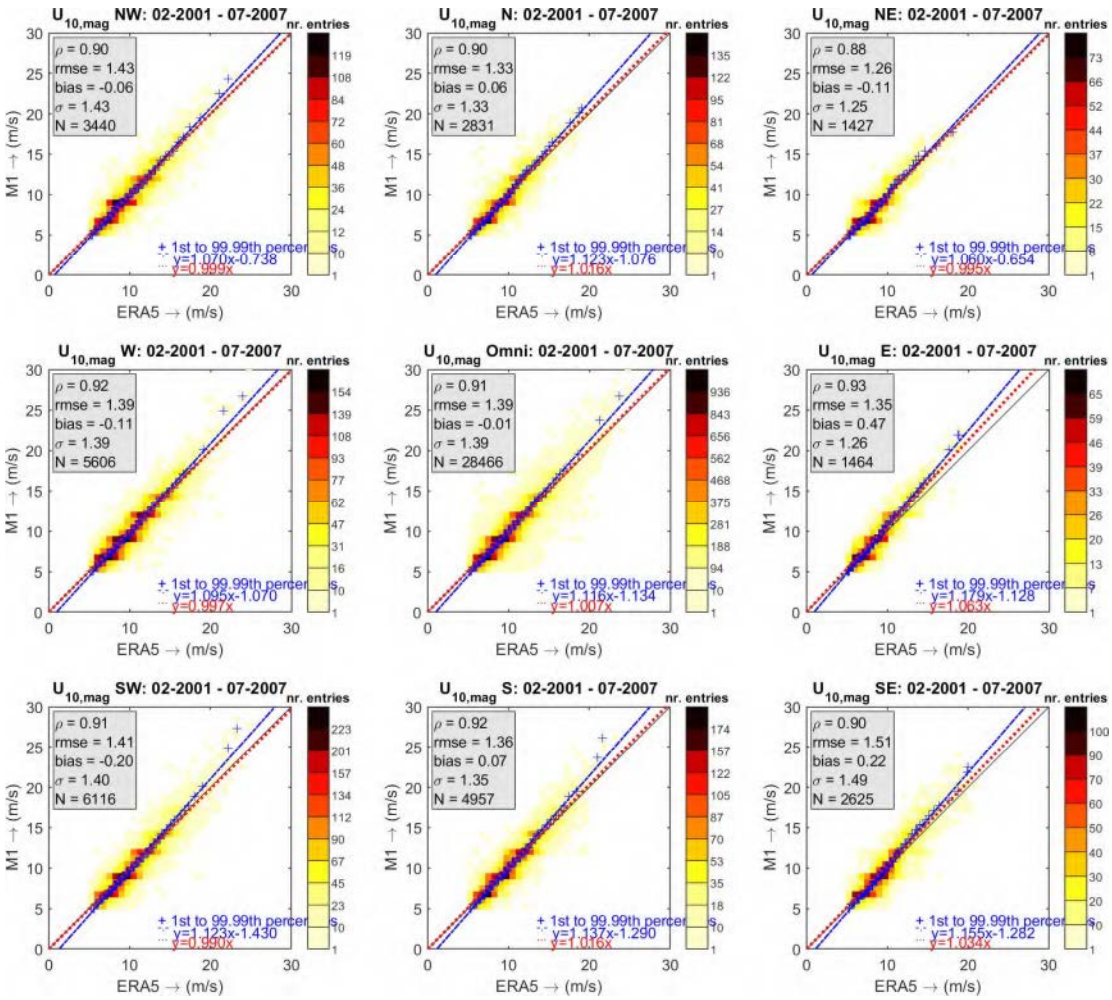


Figure 2.2 Wind speed density scatter comparisons between the M1 buoy observations and the ERA5 data at 10 mMSL height. The panel in the centre shows the omni-directional comparisons and the panels surrounding it show the comparisons for the corresponding directional sectors (from top left, clockwise: NW, N, NE, E, SE, S, SW and W). The symmetric fit to the data is given by the red dotted line and the linear fits through the data percentiles (blue pluses) is given by the dashed blue line. The statistics of the comparisons are printed in the panels.

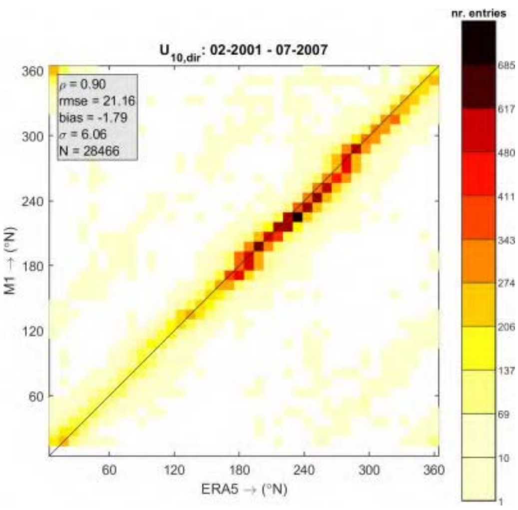


Figure 2.3 Wind direction density scatter comparisons between the M1 buoy observations and the ERA5 data at 10 mMSL height. The statistics of the comparisons are printed in the top left box.

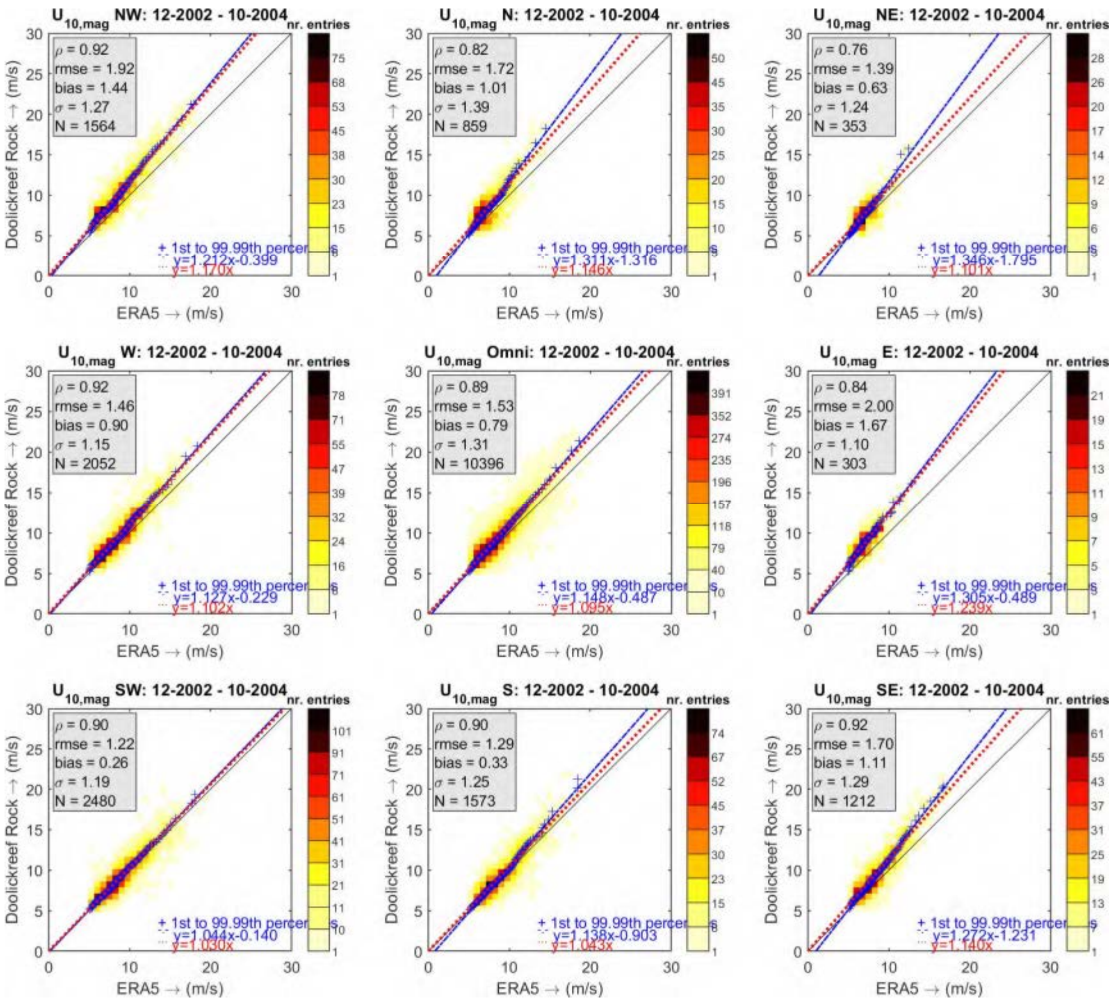


Figure 2.4 Wind speed density scatter comparisons between the Doolickreef Rock metmast observations and the ERA5 data at 10 mMSL height. The panel in the centre shows the omni-directional comparisons and the panels surrounding it show the comparisons for the corresponding directional sectors (from top left, clockwise: NW, N, NE, E, SE, S, SW and W).

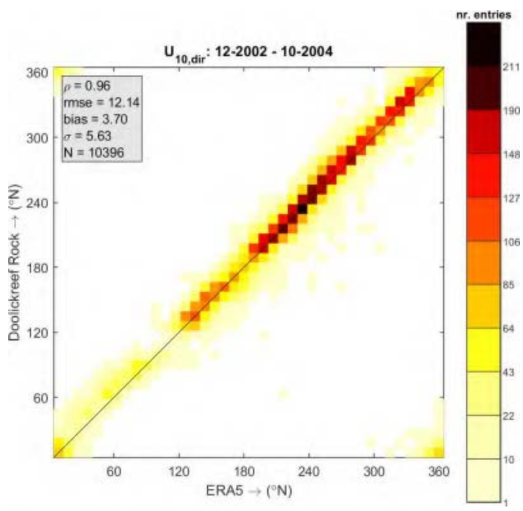


Figure 2.5 Wind direction density scatter comparisons between the Doolickreef Rock metmast observations and the ERA5 data at 10 mMSL height. The statistics of the comparisons are printed in the top left box.

2.1.3 The SROWF wind dataset

Based of the above presented validation and proposed calibration for the ERA5 data in the region of the SROWF, the wind speed and direction timeseries of SROWF were derived.

The 10 mMSL data are determined from the hourly 10 mMSL ERA5 wind data from the grid point nearest to the Doolickreef Rock metmast with coordinates -10.0°E and 53.3°N and cover 43 years (1979-2021). The wind speeds are calibrated using Equation (2.1) . The ERA5 wind directions need no calibration and remain therefore unchanged.

The wind data at hub-height (170 mMSL) were provided by the Client through Wind Pioneers and are considered calibrated. These data are also hourly and cover a shorter period of 32 years (1990-2021).

The resulting timeseries of wind speed and directions are considered to accurately describe the 1-hour averaged winds in the area of SROWF at 10 mMSL height and at hub-height. These timeseries are given in the csv-files accompanying this report and are used to determine the SROWF normal and extreme wind conditions described in Section 3.2.

2.2 Water levels and currents

2.2.1 Introduction

The hydrodynamic modelling performed in this study had the following objectives:

- give insight into the hydrodynamic conditions (tides, water levels and currents) that are representative for the Skerd Rocks region;
- provide water level and depth-averaged current timeseries required as input for the wave model.

The hydrodynamic conditions are derived from a simulation for the period of 1979–2021 (i.e. 43 years, 01-01-1979 00:00 – 31-12-2021 23:00) based on a horizontally two-dimensional, and vertically depth-averaged modelling approach (2DH). The DCSM-FM 2DH model with additional gradual grid refinements towards SROWF is applied. The modelling is described in the following section (Section 2.2.2). The model results were validated using available observation data (only water levels), as described in Section 2.2.3.

2.2.2 Hydrodynamic modelling

In the hydrodynamic modelling, the gradual refinement of the 2DH (depth-averaged) Dutch Continental Shelf Model (DCSM-FM) is applied. The DCSM-FM is the sixth-generation hydrodynamic model, developed by Deltares for the Dutch government, and which has been extensively calibrated. For detailed background information on the model including model setup, calibration and validation reference is made to report on the development of the sixth generation DCSM-FM (Deltares, 2019). In this report, only the main characteristics of the model and the additional model refinements and validation carried out proposedly for this study are discussed. For all other details, reference is made to Deltares (2019).

2.2.2.1 Model domain and bathymetry

The model covers the northwest European continental shelf. The western boundary of the model is located at 15°W, and the northern and southern boundaries in the west of the model domain are located at 64°N to 43°N respectively. The original DCSM-FM grid was designed to have a resolution that increases with decreasing water depth. The starting point was a grid with a uniform cell size of 1/10° in east-west direction and 1/15° in north-south direction. This course gird was refined in three steps with a factor of 2 by 2. The areas of refinement were specified with smooth polygons that were approximately aligned with the 800 m, 200 m, 50 m and 12.5 m isobaths (i.e. lines with equal depth). Areas with different resolutions are connected with triangles. the choice of isobaths ensures that the cell size scales with the square root of the depth, resulting in relatively limited variations of wave Courant number within the model domain.

The original DCSM-FM grid had a resolution of 0.5 nautical mile (~900 m) in the region of interest. As this was too coarse for our goal, we have gradually refined it around the area of interest (AOI) till we reached a horizontal resolution of ~25 m. The refinement was implemented in five steps (from the ~900 m to the ~25 m) with a factor of 2 by 2. The ~25 m resolution was chosen after analysing and comparing the results of the ~25 m, ~50 m, and the ~100 m resolutions. The 25 m resolution was considered sufficient as it led to the modelling thrustworthy patterns of detailed flow patterns (vortices) around the rocks. The bathymetry and grid of the entire DCSM-FM model is shown in Figure 2.6. The final grid and bathymetry at the AOI are shown in Figure 2.7. Figure 2.8 shows a clear flow vortex pattern in the AOI resolved by the numerical model.

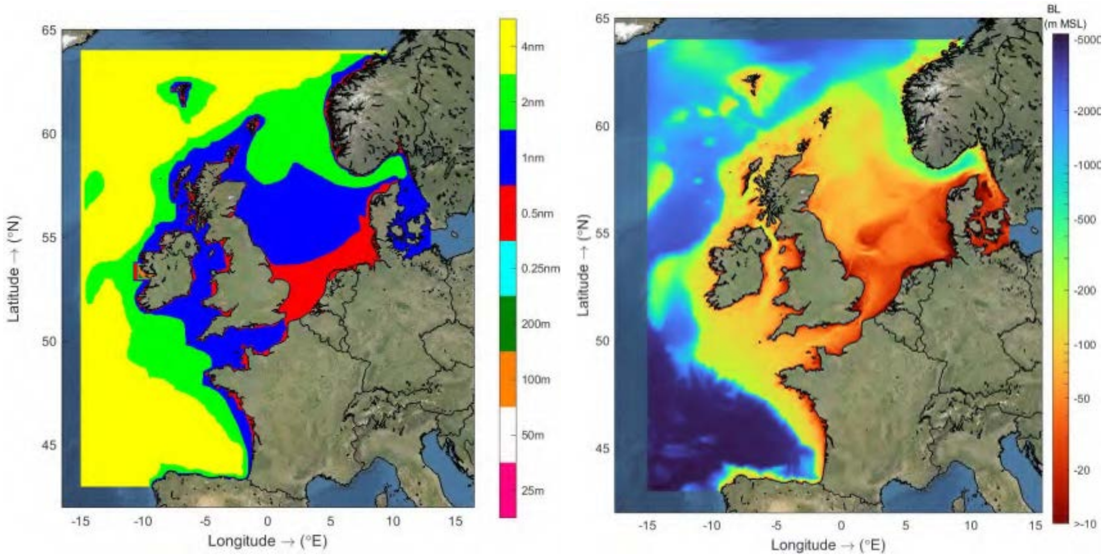


Figure 2.6 Grid (left panel, nm = nautical mile, m = meter) and bathymetry (right panel) of the entire DCSM-FM model.

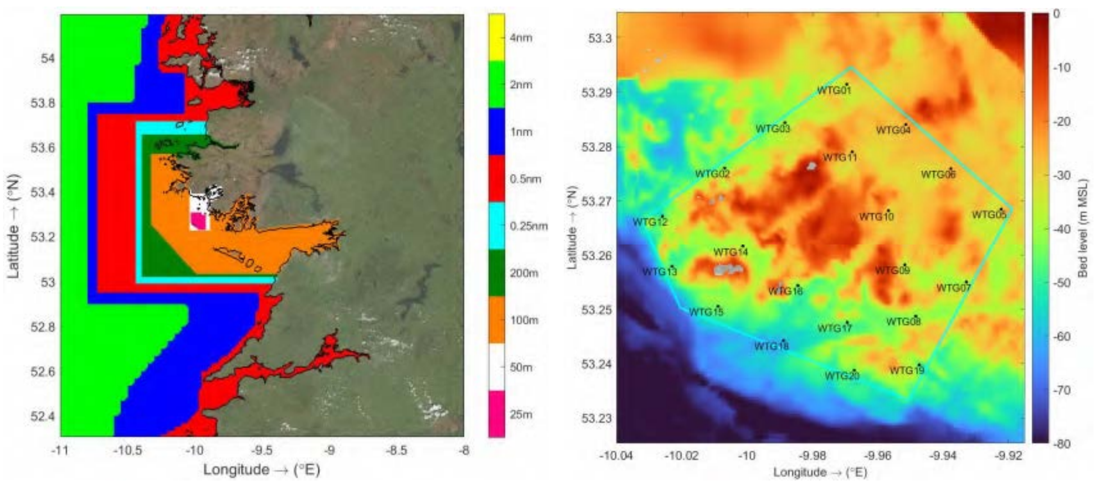


Figure 2.7 Local grid (left panel) and bathymetry (right panel) in the area surroundings of the Skerd Rocks OWF.

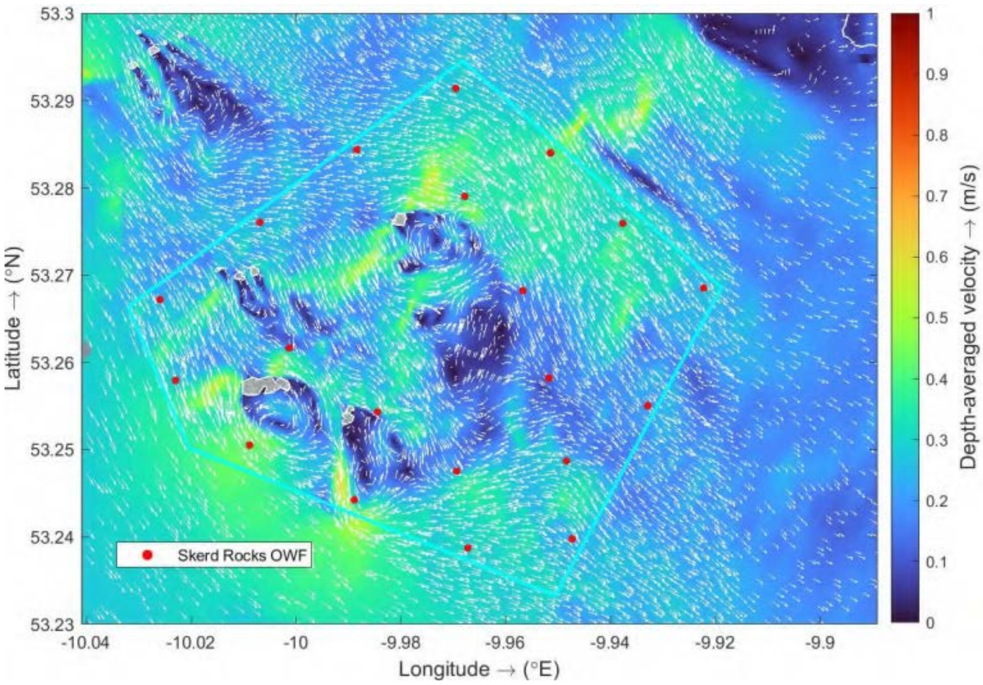


Figure 2.8 Detailed flow pattern within the Skerd Rocks OWF area.

The resulting grid has approximately 997,000 active cells with a variable resolution. The largest cells have a size of 1/10° in east-west direction and 1/15° in north-south direction, which corresponds to about 4 x 4 nautical miles (nm) or 4.9-8.1 km by 7.4 km, depending on the latitude. The smallest cells (shown in magenta) have a size of 25 m by 25 m in region of interest.

The DCSM-FM model bathymetry in the AOI has been derived from the bathymetrical survey datasets provided by the client, supplemented by high and low resolution datasets of EMODnet (cf. Section 1.3) and in-house digitized nautical charts data in the Skerd Rocks area. The EMODnet bathymetry data were converted to MSL using an in-house available conversion map for the North-West European coastal shelf.

2.2.2.2 Forcing conditions

The time- and space-varying hourly ERA5 10 mMSL wind and sea-level pressure data were used to force DCSM-FM. At the lateral open boundaries, water levels consisting of a tide and surge component were provided. For the tide, 33 harmonic constituents from the global tide model FES2012[5] were used, while for the surge an Inverse Barometer Correction was applied. The effect of sea-level rise has not been considered in the hydrodynamic modelling.

The model was run from 01-01-1979 00:00 until 31-12-2021 23:00 (43 years) to hindcast total water levels and depth-averaged currents. The computed total water level is the level that the sea surface (at a given point and time) would assume in the absence of waves and is also referred to as the still water level (SWL). It is comprised of the tide (astronomic) and surge (atmospheric or residual) water levels. Due to the large spatial extent of the model, the first 10 days of the model computations are always considered as a spin-up period; the results of that period are considered as not accurate enough for processing. These values are therefore excluded from the database. As these spin-up periods are chosen to fall in each previous years (i.e. modelling starts at 22 December 00:00 of the previous year), this has no effect on the resulting combined timeseries. Only for the first year (1979) this was not possible; for that specific year the modelling had to start at 01-01-1979 00:00. The first 10 days of the resulting

[5] https://www.aviso.altimetry.fr/en/data/products/auxiliary-products/global-tide-fes/description-fes2012.html

43 years of data were therefore discarded. Given the remaining length of the hydrodynamic timeseries, this has little to no effect on the statistics, also considering that no significant storms occurred during these first 10 days of 1979.

2.2.2.3 Output definitions

Spatial- and time-varying fields of still water level (SWL) and depth-averaged current (magnitudes and direction) were output by the model with a time step of 1 hour. These spatial and time-varying fields of SWL and depth-averaged current were used as input to the SWAN wave modelling (cf. Section 2.3.2.3 for details on the spin-up period). In addition, location-specific 10-minute timeseries of SWL and depth-averaged currents were output to allow for a detailed validation of the model outcomes. Likewise, location-specific 10-minute timeseries of SWL and depth-averaged currents were output at the SROWF area (for each grid cell of the 20 wind turbine locations).

2.2.3 Data validation and post-processing

After finishing the hindcast modelling, the resulting water level data were validated against available water level observations in the region of the study location. Unfortunately no local current observation datasets were available (yet) for the validation of the depth-averaged currents. Although the currents are a derivative of the time-varying water levels, it is strongly advised to perform a dedicated current validation assessment as soon as local current observations become available. This way one can ensure that any complex flow structure that may occur in the region is captured accurately.

After validation of the water level data (Section 2.2.3.1), the hydrodynamic timeseries have been further processed. First the depth-averaged current timeseries have been translated to corresponding surface and near-bottom current values (Section 2.2.3.2), after which the tidal and residual signals were derived from the water level and depth-averaged, surface and near-bottom current timeseries (Section 2.2.3.3).

2.2.3.1 Water level validation

Figure 2.9 shows the considered water level observation stations and Table 2.2 shows the time periods of the used data and their provenience. Water level data are available from Galway Port and Inishmore stations. These two stations are the nearest to the location of SROWF. All water level data were obtained from the Marine Institute[6], the State agency responsible for marine research, technology development and innovation in Ireland. Deltares contacted the Marine Institute and they replied by sharing the available data per station.

Statistical comparisons were made of the observed and modelled data for the full available data periods. The reference level of the water level observations was corrected to the model reference level (MSL), because mean differences may occur due to the different reference systems used by different observation locations. Next to the statistical comparisons, timeseries comparisons are also presented to demonstrate how well the model captures individual events in the observations.

[6] http://www.marine.ie/Home/site-area/data-services/real-time-observations/tidal-observations

Table 2.2 Periods of the available observation data per station.

Station	Period	Parameter	Origin
	Galway Port		
(a)	01-2008 – 01-2009	water level	Marine Institute
(b)	01-2010 – 01-2013	water level	Marine Institute
(c)	01-2014 – 01-2018	water level	Marine Institute
(d)	01-2019 – 01-2022	water level	Marine Institute
	Inishmore		
(a)	01-2014 – 01-2018	water level	Marine Institute
(b)	01-2019 – 01-2022	water level	Marine Institute

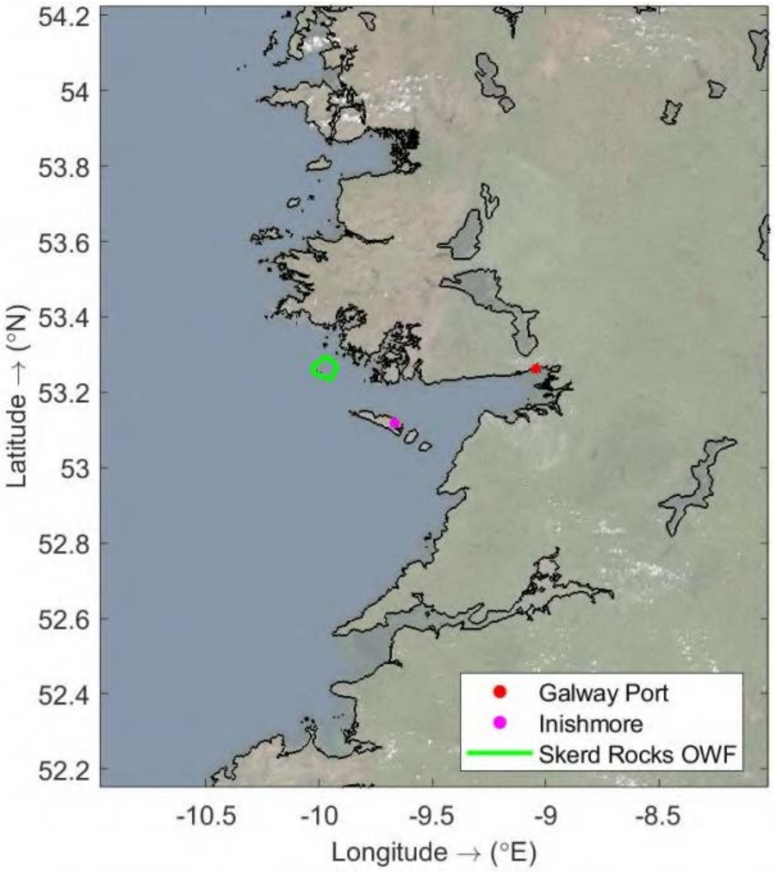


Figure 2.9 Aerial overview of the water level observation stations. The SROWF area is outlined in green..

Table 2.3 shows the main statistics of the water level data comparisons such as the correlation coefficient, bias and root-mean-square errors (RMSE) in the entire observation periods of available data for all stations considered (cf. Table 2.2). Additionally, Figure 2.10 and Figure 2.11 show the density scatter plots that present the correlations and the best fit formula per each station/period.

Table 2.3 Overview over all the statistics done by comparing the observed water level data with the modelled one over the periods mentioned in Table 2.2.

Station	Period	Correlation coefficient, ρ (-)	Bias correction value (m)	RMSE (m)
		Galway Port		
(a)	Jan/2008 – Jan/2009	0.995	-0.033	0.114
(b)	Jan/2010 - Jan/2013	0.996	-0.052	0.114
(c)	Jan/2014 - Jan/2018	0.994	-0.053	0.137
(d)	Jan/2019 - Jan/2022	0.995	-0.039	0.127
		Inishmore		
(a)	Jan/2008 – Jan/-2010	0.997	0.070	0.089
(b)	Jan/2019 - Jan/2022	0.997	-0.041	0.084

The statistical comparisons of the observed versus modelled water levels at all stations show a very high correlation of 0.994-0.997. The average root-mean square error (RMSE) between the observed and modelled water levels is 0.11 m. The bias is around 0 as the mean reference level of the observations have been corrected to the modelled reference level (MSL), the average bias-correction value is 0.050m.

In Figure 2.12 and Figure 2.13 the timeseries comparisons between the observed and modelled water levels at the Galway Port and Inishmore stations are presented. The figures also show the standard deviation (STD) values, which are approximately the same as the RMSE values because of the application of the bias correction. The figures show that after the bias correction of the reference level in the water level measurements the model accurately captures the water levels, also during peak storm conditions.

In conclusion of the overall data validation, the modelled water levels are considered to be very reliable, with high correlations with data observations and low root-mean-square-errors. Therefore, it is concluded that the model water level data form a solid basis for the determination of the normal and extreme water level conditions at the Skerd Rocks OWF.

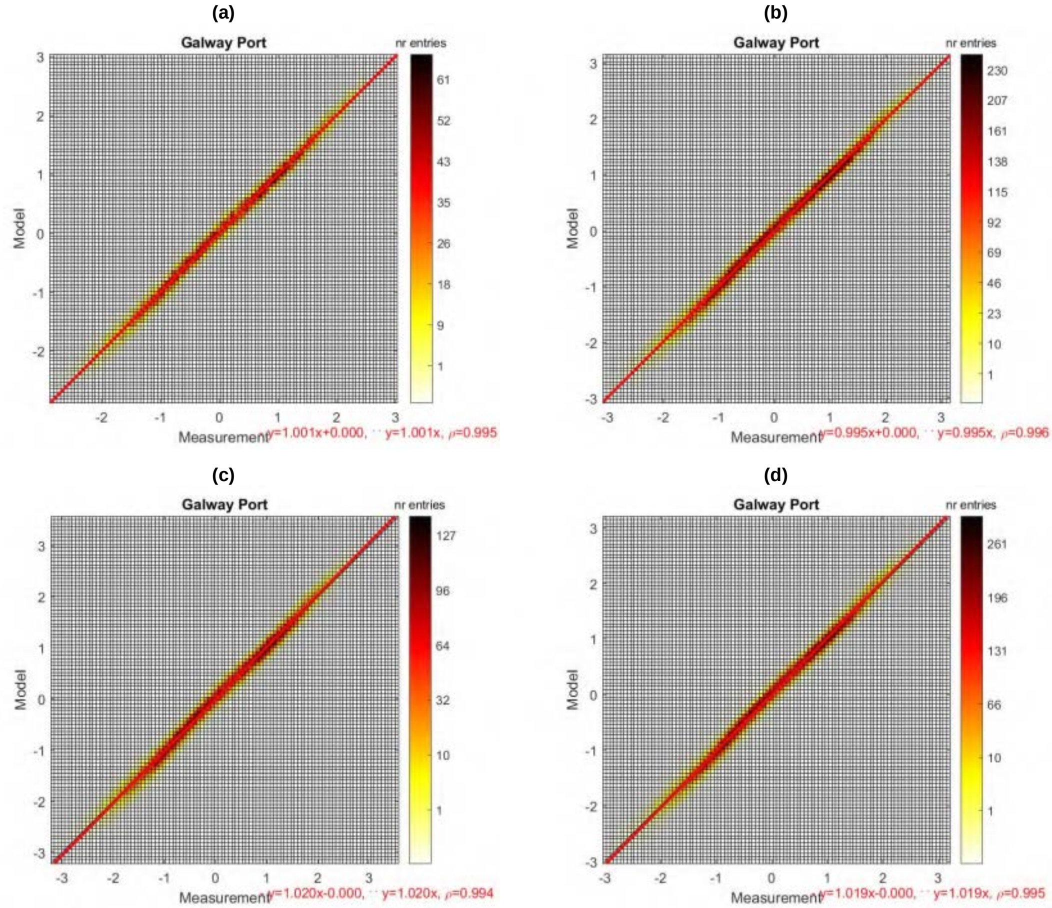


Figure 2.10 Water level density scatter comparisons for The Galway Port station observation and the model data. The symmetric fit to the data is given by the red dotted line. Only the correlation coefficient and the best fit formulas of the comparisons are printed. Letters a, b, c, and d corresponds to the letters in Table 2.3.

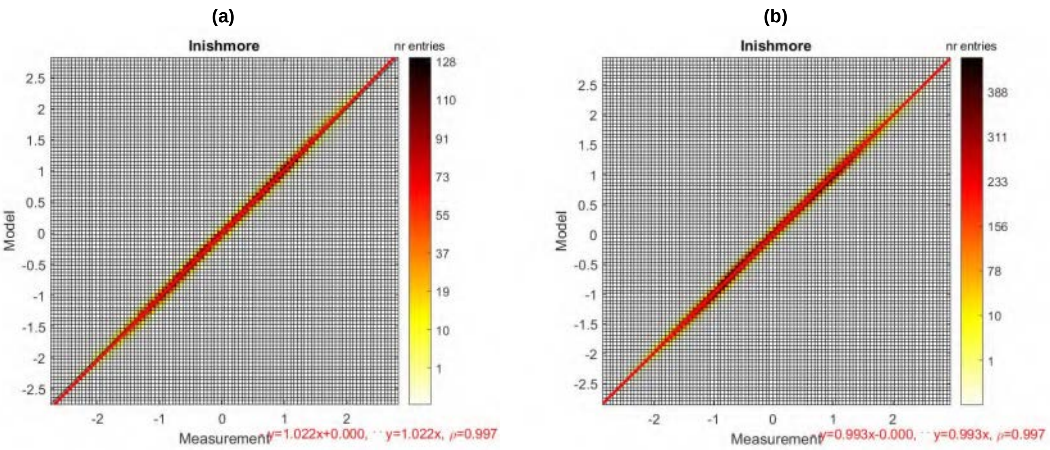
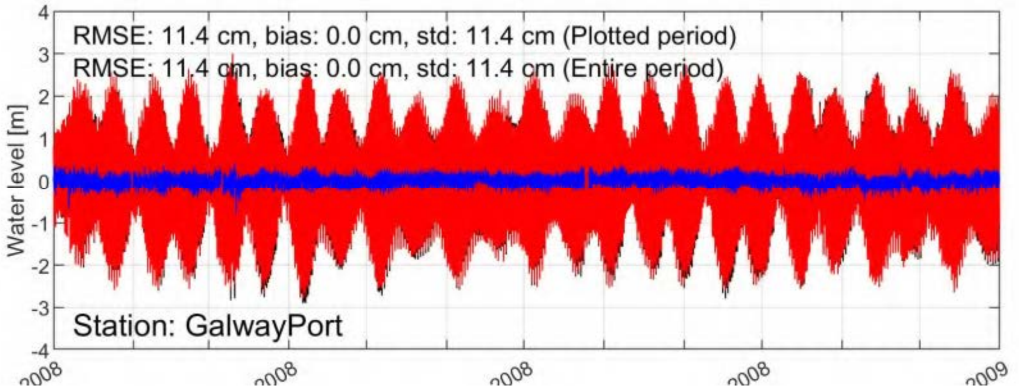
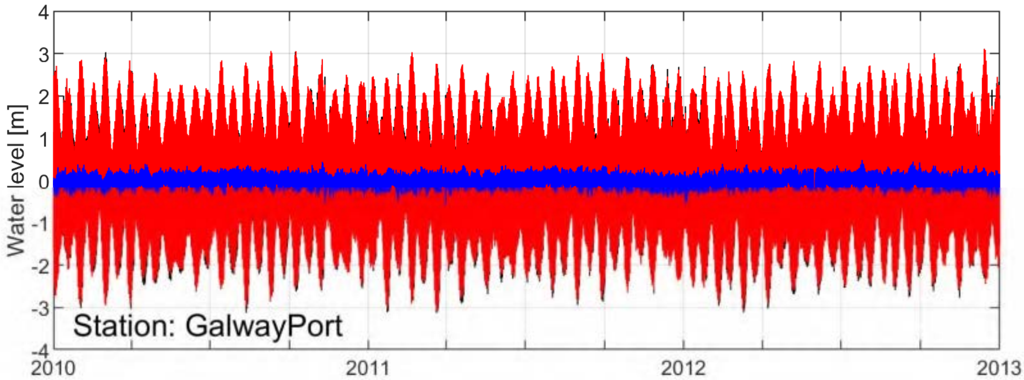


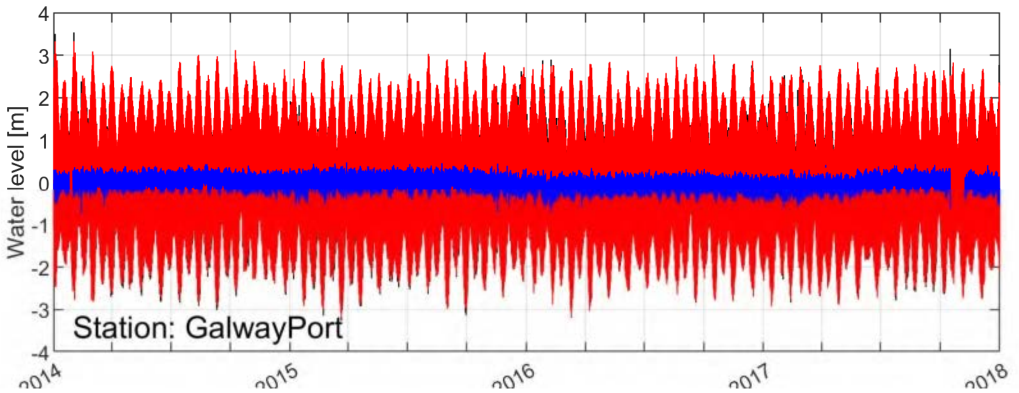
Figure 2.11 Water level density scatter comparisons for The Inishmore station observation and the model data. The symmetric fit to the data is given by the red dotted line. Only the correlation coefficient and the best fit formulas of the comparisons are printed. . Letters a and b corresponds to the letters in Table 2.3.



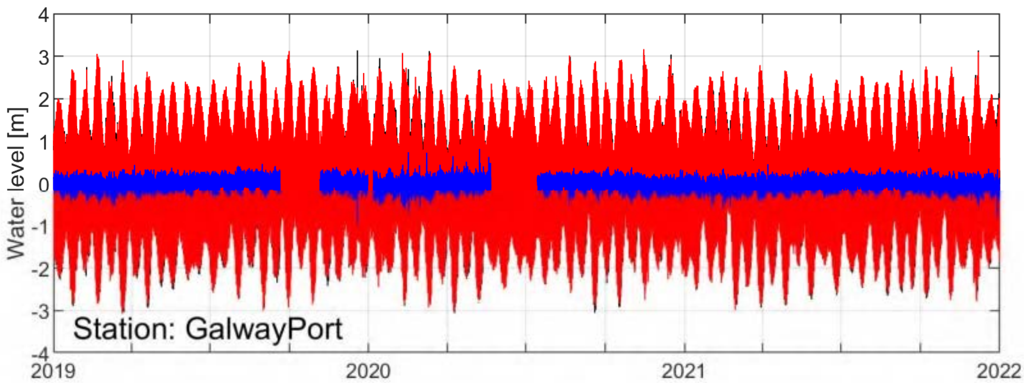
(a)



(b)



(c)



(d)

Figure 2.12 Timeseries comparison of the observed and modelled water levels data at Galway Port. Black lines indicate the observed data, red lines the modelled data and blue lines the difference between the two.

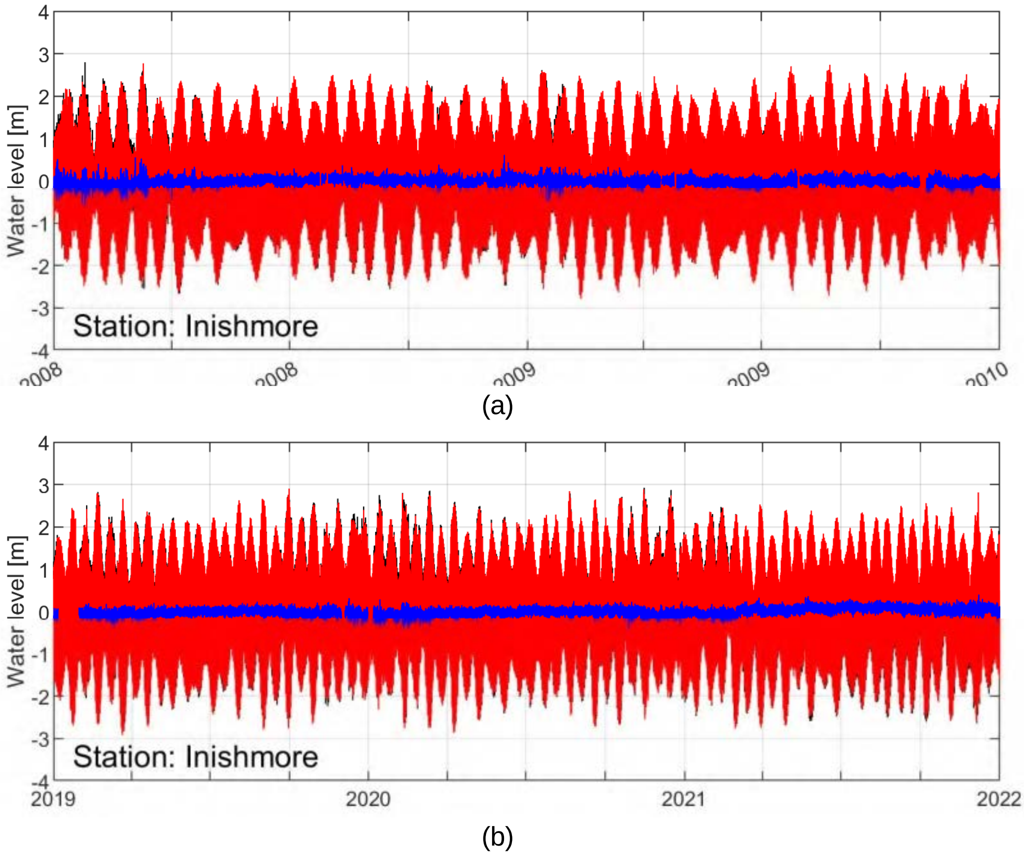


Figure 2.13 Timeseries comparison of the observed and modelled water levels data at Inishmore station. Black lines indicate the observed data, red lines the modelled data and blue lines the difference between the two.

2.2.3.2 Surface and near-bottom current velocities

To transform the depth-averaged current speed signals to the surface and near-bottom (0.5m above local bed level) a 1/7th-power current profile has been assumed. This profile is recommended by several standards (see e.g. DNVGL, 2020) and generally provides a good description of the distribution of the current speed over depth in open water. The validity of this assumption for SROWF needs, however, to be checked when local current observation become available in later project stages.

2.2.3.3 Tidal and residual current velocity components and water level

The total current velocity (depth-averaged, surface and near-bottom) was analysed to obtain the tidal current timeseries. This post-processing step was conducted using the T-Tide Harmonic Analysis Toolbox (Pawlowicz et al., 2002). This toolbox determines a tidal signal based on several tide constituents (e.g. M2. S2. O1, K1, etc.). Additionally, T-Tide applies a correction for the 18.6-year nodal cycle based on the start time of the supplied timeseries and the latitude of the measurement site. The analysis was carried out on the x- and y-components of the current separately, with the residual per component being computed by subtracting the tidal from the total signal per component.

The water level analysis was also carried out with T-Tide using the available 10-minute timeseries and subtracting the resulting tidal signal from the total water level, to obtain the non-tidal residual.

2.2.4 The SROWF water level and current dataset

The validation, calibration and post-processing of the 2DH DCSM-FM water level and current data led to the following hourly timeseries from 1979 until 2021 (11-01-1979 00:00 – 31-12-2021 23:00, 43 years):

- SWL (still water level, total water level)
- tidal level
- residual (surge) level
- total current speed and direction (depth-averaged, surface and near-bottom)
- tidal current speed and direction (depth-averaged, surface and near-bottom)
- residual current speed and direction (depth-averaged, surface and near-bottom)

The SWL corresponds to the raw model results as no calibration was deemed necessary based on the validation of the data at Galway Port and Inishmore stations. No local current observation data were available for performing further validation and/or calibration of the model results. The tidal and residual water levels and current data were obtained as described above by means of harmonic analysis. The resulting timeseries at the three turbine locations (WTG15, WTG08 and WTG11, see Table 1.1) are deemed to form a solid basis for the determination of the SROWF mean and extreme water level and current conditions described in respectively Sections 3.3 and 3.4.

2.3 Waves

2.3.1 Introduction

The wave data that were used to determine the SROWF wave normal and extreme conditions were derived by means of local wave modelling. The wave modelling is described in the next section and the validation of the model results in Section 2.3.3. The determined mean, extreme and severe SROWF wave conditions are given in Sections 3.5.2 to 3.5.6, respectively.

2.3.2 Wave modelling

Numerical wave modelling was performed using the wave model SWAN to produce long-term timeseries of accurate wave conditions in the Skerd Rocks offshore wind farm region. The dedicated local numerical wave model is forced with the ERA5 hourly 10 mMSL wind fields, hourly ERA5 wave conditions are given at the boundaries and the hourly depth-averaged current velocities and water levels from the 2DH DCSM-FM are input.

SWAN is widely used for nearshore wave modelling in the international coastal and offshore engineering communities and has been successfully validated under a large variety of field cases and conditions. The software is continually undergoing further development; see www.swan.tudelft.nl for more information. For this study we have used the latest operational version that includes the most recent insights and model developments (SWAN Version 41.31). The model has been run in the unstructured mode, which allows the generation of a boundary fitted grid and optimal resolution of the bathymetric features. Please refer to Appendix C for more general information on the SWAN model.

2.3.2.1 Model domain

SWAN requires the specification of three types of grids:

1. computational grid, which defines the 2D geographical locations of the nodes in the calculation grid;
2. directional grid, which defines the wave directional range (usually 360°) and resolution;
3. spectral grid, which defines the range and resolution of the computations in the wave frequency space.

A single unstructured computational grid (spatial domain) was developed for this study, with a spatial resolution varying between 50 m in the area of interest and 250 m further away. The model domain is shown in Figure 2.14. Relatively larger islands within the area of interest that are expected to remain mostly dry based on observations from available satellite images, are excluded from the computational grid. For these islands, all incoming wave energy will be absorbed at the land boundaries which are visible in Figure 2.16. Instead, relatively smaller islands that might become wet during high water conditions are included in the computational grid. The influence of these islands on the propagation of wave energy at the area of interest will be accounted for by the locally implemented (shallower) water depths. Finally, for reasons of computational efficiency, not all enclosed bays at the boundaries of the area were considered in the model, as the conditions in those areas do not influence the wave conditions reaching the SROWF region. Such excluded bays are visible at the east and north of the wave model outline in Figure 2.14.

The defined directional grid covers the full circle (360°). The number of directional bins was set to 36, resulting in a directional resolution of 10°. This is a typical and often used directional resolution in such wave studies.

The spectral grid of the numerical model covers a frequency range from 0.03 Hz to 2.5 Hz, allowing for representation of wave periods ranging from 0.40 s to 33.33 s. The distribution of the frequencies, f, is logarithmic with a constant relative resolution, Δf/f, close to 0.1. This results in a total number of frequency bins of 46. This way of distributing the modelled frequencies over the extent of the considered frequency range ensures that the resolution at lower frequencies is not as coarse as it would have been if an equidistant distribution of frequencies had been applied.

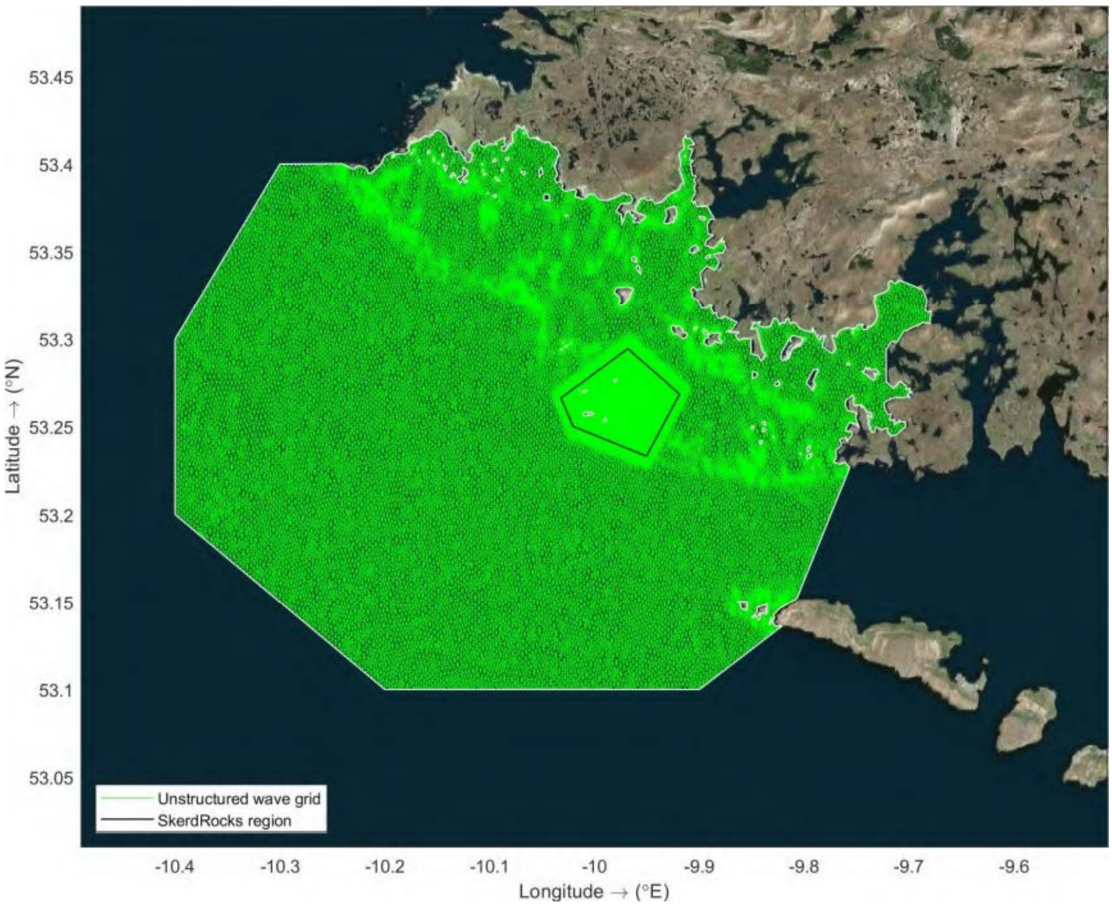


Figure 2.14 Computational SWAN wave model domain and grid.

2.3.2.2 Bathymetry

As for the hydrodynamic model, the bathymetry information for the wave model was based on a composite of various datasets with different resolutions. At the SROWF area, publicly available high resolution INFOMAR and EMODnet bathymetric data were combined with Deltares' in-house available data from historic navigational charts. The latter dataset was used to derive the complex topography at the very shallow areas of SROWF where information from high resolution INFOMAR and EMODnet was missing (e.g., see light blue areas in Figure 1.1). Further away from the area of interest, this composite bathymetry was supplemented by publicly available lower resolution bathymetry data from the EMODnet dataset from 2020.

Special care was taken during processing of the bathymetry to allow for smooth transitions between different datasets and at the same time to ensure that higher resolution data were leading over lower resolution data. Finally, the input bathymetry was referenced relative to MSL (mean sea level), based on a spatially varying conversion from LAT (lowest astronomical tide) which is available at the area from the large-scale 2DH DCSM-FM. The applied bathymetry of the wave model is shown in Figure 2.15 for the full domain and in more detail in the SROWF region in Figure 2.16.

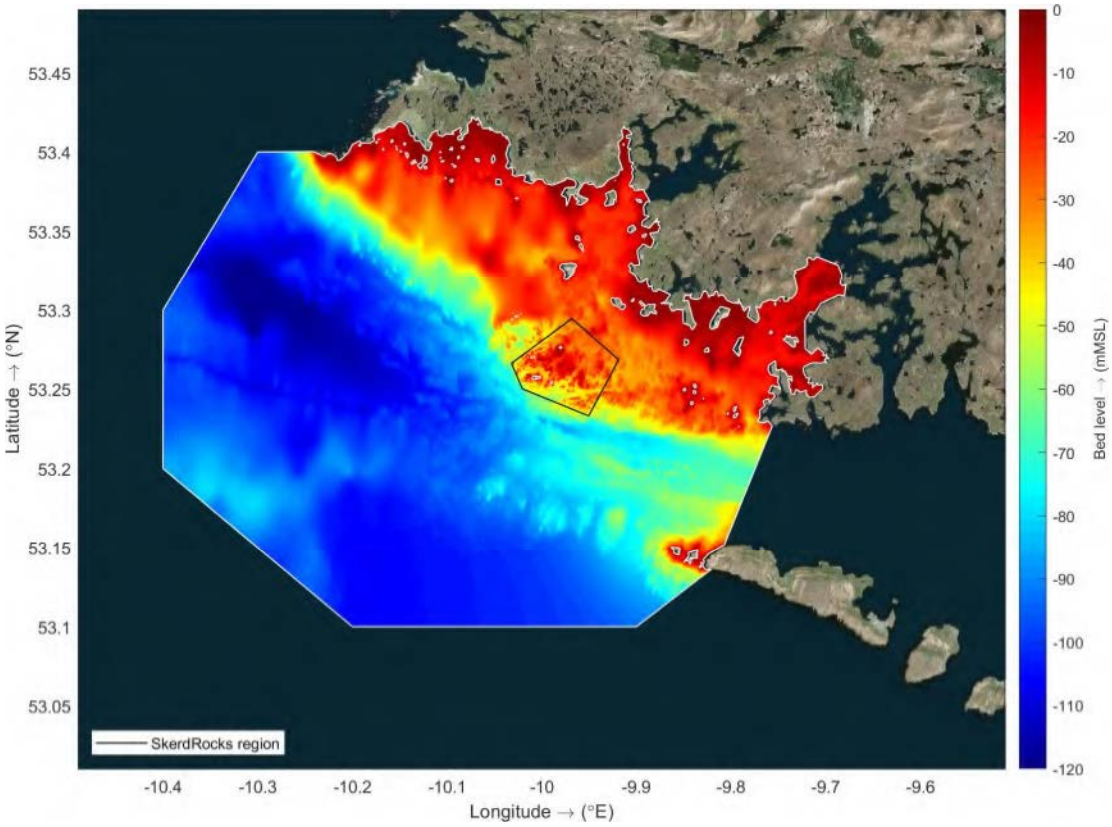


Figure 2.15 Bed levels relative to MSL as used in the computational grid of the wave model.

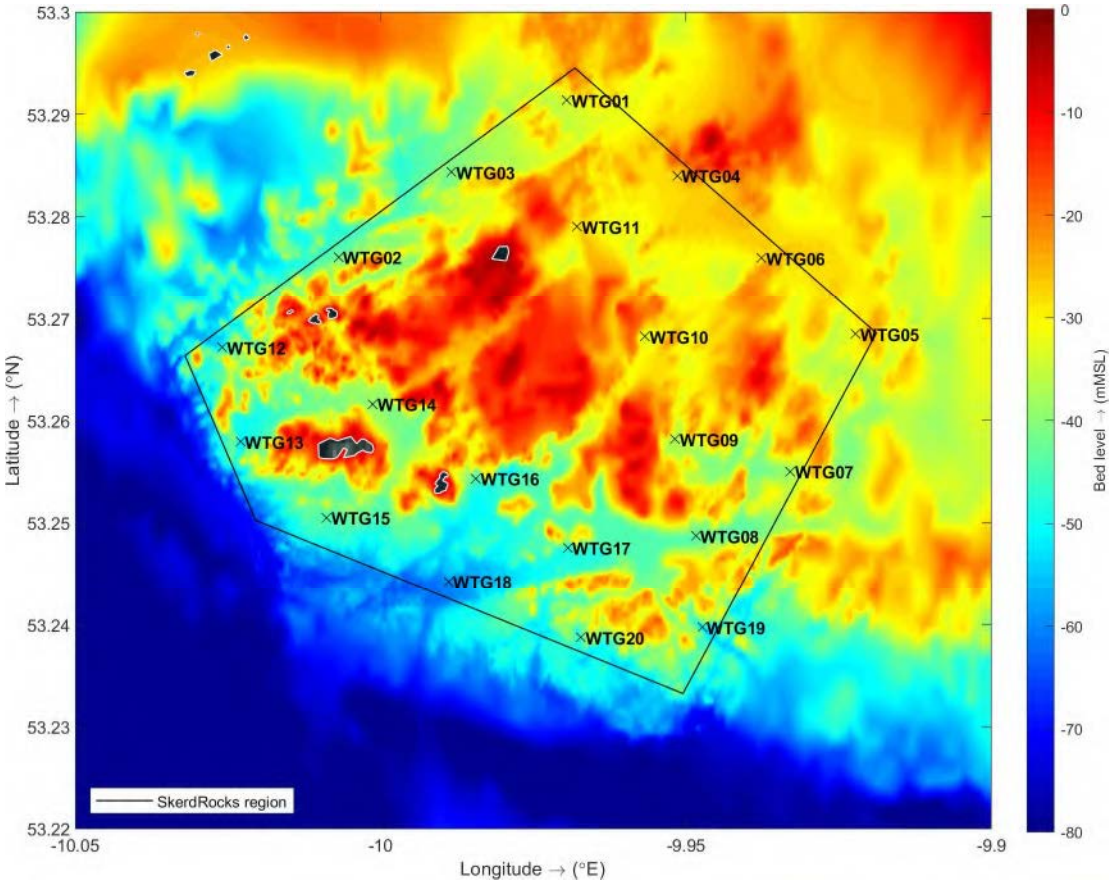


Figure 2.16 Bed levels relative to MSL as used in the surroundings of SROWF. Zoom of Figure 2.15.

2.3.2.3 Boundary and input conditions

The wave model was run in non-stationary mode (i.e. taking evolution of the wave conditions in time into account) for the period from 1979 to 2021 (43 years, 01-01-1979 00:00 – 31-12-2021 23:00). The model uses a timestep of one hour, which is equal to the time step of the (ERA5) input wind fields. The runs were divided in period of 6 months with the first 48 hours simulated time being considered as the spin-up period of the model[7]. In the case of 1979, the data of the first ten days should be considered as less accurate, due to the longer required spin-up period for the hydrodynamics model (10 days), for which no reliable data were available in 1978 (see Section 2.2.2.2). However, due to the relative large depths in the region and the relatively small influence of the hydrodynamics on the waves, the wave data for these first 10 days can still be used in the further processing, also considering that no significant storms occurred during that specific period.

Incoming boundary conditions

The SWAN model was forced at the outer boundaries of the overall domain with parameterized wave spectra described by ERA5 timeseries of five wave parameters (described in more detail below this list):

- Significant wave height, H_s
- Peak wave period, T_p
- Mean wave direction (coming from), MWD
- Directional spreading, DSpr

[7] The spin-up period is the modelling interval which is required for the model to start up and initialise. This includes allowing the wave energy from the boundary to distribute over the total modelling domain. A spin-up period of 48 hours (2 days) prior to to the actual modelling period (i.e. starting at 30 December or 29 June) is typically used. Results for the spin-up period may not be reliable and are discarded.

- Spectral shape, γ (an enhancement factor of the peak in the wave spectrum)

The spectral shape, γ, was at the boundary assumed constant and equal to the value of a standard JONSWAP (Hasselmann et al., 1973), γ = 3.3. The exact value of γ prescribed along the boundary is not critical, since the model will automatically properly redistribute the wave energy in the frequency domain and in balance with the wind forcing. The amount of directional spreading present at the incoming boundaries was derived from the ERA5 timeseries for "wave spectral directional width". For numerical reasons, this value was capped at a maximum of DSpr = 37.5° (one-sided directional spreading level from the mean direction), which corresponds to a cosine-m power of m = 1 in SWAN[8]. Furthermore, for this parameter the exact value prescribed at the boundary is again not critical, since the model will automatically properly redistribute the wave energy over the different directions in the computational domain.

Reflecting/transmitting boundaries
No reflecting or transmitting boundaries were defined in both modelling domains. All wave energy reaching an outer boundary or land boundary is assumed in the model to be fully absorbed at that location. For sloping shorelines and beaches that is a fitting and often applied approach. At the sections bordering enclosed waters waves propagate out of the computational domain uninfluenced (as if they move into these areas).

Wind input
The wave model was forced spatially using the raw ERA5 wind fields with no corrections on the wind speeds or directions. This is mainly because the quality of the wind data is very high, the data are highly correlated with the observations, although showing some (order 10-13%) underestimation of the high wind speed peaks (cf. Section 2.1.2). Given that the quality of the wave model results does not depend only on the accuracy of the forcing winds we apply the raw ERA5 and shall correct for mismatches in the wind data and other model inaccuracies in the calibration of the modelled wave data.

Hydrodynamics input
The spatially varying hourly water level and depth-averaged current fields, from the 2D DCSM-FM model have been used as input to the wave model. This means that the wave model accounts for the influence of the spatially distributed water levels and currents (speeds and directions) in the wave propagation and evolution.

2.3.2.4 Numerical and physics parameter settings

This section lists detailed settings for physics parameters and numerical aspects within the SWAN model. It is primarily included here for recording purposes, e.g. for possible future interpretation or reproduction of results. General readers may opt to skip this section.

The modelling was carried out using SWAN, version 41.31, in unstructured and non-stationary mode. The most relevant applied wave physics settings in the computations are:
- Dissipation of wave energy by bottom friction and wave breaking (wave steepness-induced and depth-induced) have both been applied in the SWAN computations.
  - For dissipation by bottom friction the JONSWAP formulation (Hasselmann et al., 1973) with a friction coefficient of 0.038 m^2s^{-3} (Zijlema et al., 2012) has been applied.
  - For dissipation by depth-induced wave breaking the Battjes-Janssen formulation (Battjes and Janssen, 1978) with a proportionality coefficient of 0.73 has been applied.
- For representing the effects of white-capping, the formulations by Rogers et al. (2003) have been applied, which is default setting since SWAN version 40.91 (see Appendix C for more details on the formulation).

[8] This power is used to describe directional distribution shape description according to $\cos^m(\theta)$, with θ representing the wave directions.

- For the wind drag the default Wu (1982) approximation of the Charnock relation has been applied (see Appendix C.2 for more details on the formulation).

The criteria for numerical accuracy thresholds were set as follows:
- the computation is finished in case of changes in the second derivative of the iteration curve of the significant wave height are less than 1% and the absolute (relative) change in significant wave height from one iteration to the next is less than 1.5 cm (1%) at 97.5% of the grid points, and
- a maximal number of 25 iterations is computed.

These settings mean that the computation will continue until a stable outcome has been reached for the modelled moment in time, with a maximum of 25 iterations to reach the result for that time step. Typically, 25 iteration steps will be sufficient, if not then often a setting in the model is incorrect or the computational grid is not optimal. In the computations performed for the present study, all timesteps after the two days spin-up period have been verified to have converged within 25 iterations (on average even within a much lower number), i.e. the computation has reached the proper numerical outcomes.

2.3.2.5 Output definitions

Spatial and time-varying fields of multiple wave (-related) parameters (H_s, T_p, other spectral wave periods and MWD) were produced by the model as output at a time step of 1 hour (i.e. the computational time step). In addition, location-specific timeseries of a larger set of parameters were generated in the numerical model to allow for detailed validation and assessments of the model outcomes.

Output timeseries as well as two-dimensional wave variance spectra (describing the wave-energy distribution over frequencies and directions) have been generated at the three assessment locations (cf. Table 1.1).

2.3.3 Data validation and calibration

There are no local wave observations available (yet) within the SWAN wave model area. It is therefore not possible to validate SWAN's modelling of the local bathymetric effect on the waves. SWAN has on the other hand been validated in several other regions with complex bathymetries and been shown to properly model waves in such regions, provided that the quality of the bathymetric data are high. Other variables affecting the accuracy of the wave results are the boundary waves and wind forcing fields. A correction for the combined effect of the accuracy of these variables on the results can be obtained by validating the ERA5 wave data against the M1 wave buoy (2001-2007) observations available from the Marine Institute. The buoy is located approximately 50 km to the west of the SROWF area (cf. Figure 2.17), outside the SWAN model domain, but close enough for the bias of the ERA5 waves to be representative to those due to inaccuracies in the wind forcing and boundary wave conditions in the SWAN results. The SWAN results are therefore calibrated using the same calibration that is deemed necessary to be applied to the ERA5 waves at the M1 buoy location. This validation/calibration needs to be updated when future local wave observation data become available.

Table 2.4 presents the time periods covered by the data, the available variables and the provenience. It should be noted further that the observed mean wave directions at M1 only cover a very short period of less than 2 months in 2007. The quality of that data is also considered as low, given the rather large observed variance in the data, which is not expected for that location (see further below).

Figure 2.17 Location of M1 wave buoy relative to SROWF. The red outlines indicate the model boundaries and SROWF area.

Table 2.4 Observed variables and periods covered by the wave observations.

Station	Coordinates	Available variables	Period	Resolution	Origin
M1 (buoy)	53.1266°N, -11.2°E	H_s, $T_{m0.2}$, MWD	02-2001 – 07-2007	hourly	Marine Institute[9]

Figure 2.18 and Figure 2.19 show the density scatter and percentile comparisons and the main statistics of respectively the significant wave height (H_s) and the zero-crossing wave period ($T_{m0,2}$) and mean wave direction comparisons. The plots present the relevant statistics such as the correlation coefficient, root-mean-square errors, bias and standard deviation.

The figures show good to excellent correlations between the ERA5 wave height (ρ=0.96, middle panel of Figure 2.18) and wave period (ρ=0.82, left panel of Figure 2.19) data and the observations and a slight underestimation of the significant wave height peaks.

As mentioned before, the quality of the observed mean wave directions is considered as low. It only covers a period of less than two months in 2007 and shows a relatively high variation in wave directions, whereas generally the main wave energy is coming from the West, from the North Atlantic (cf. right panel of Figure 2.19). The metadata also does not clearly describe over what frequency range the directions were observed, i.e. over the full frequency range or only covering shorter wind waves). The general trend in the mean wave direction is however captured correctly, giving confidence in the quality of the ERA5 data.

Having considered all comparisons in detail (and also some timeseries plots, not shown) it has been concluded that the ERA5 significant wave height data show some underestimation of the high significant wave height percentiles, which should be corrected. At M1, this underestimation is approximately 1.5% for an observed wave height of 15.0 m. It is assumed that this underestimation also applies at the incoming boundary of the local wave model and thus within the model domain, considering that the wave energy will not change much while travelling from the wave buoy location to the model domain edge due to the large offshore depths.

From the data comparisons and the corresponding data fittings it follows that the underestimation of the significant wave height is value dependent. The data are therefore calibrated using the percentile fit at M1 (blue line in the middle panel of Figure 2.18):

[9] https://erddap.marine.ie/erddap/index.html

$$H_{s,corrected} = 1.023H_s - 0.121 \quad (\text{if } H_{s,corrected} > H_s\text{, else } H_{s,corrected} = H_s) \tag{2.6}$$

This calibration is only applied when it holds that $H_{s,corrected}>H_s$ (i.e. no decrease of values). To maintain the deep-water wave steepness, the concurrent peak and mean wave periods are also corrected with a factor equal to $\sqrt{H_{s,corrected}/H_s}$, again only when it holds that $H_{s,corrected}>H_s$. The calibrated SWAN results within SROWF are considered to properly reflect the wave conditions in the considered calibration area (cf. Figure 2.16).

From the consideration of the mean wave direction comparison, we have concluded that the SWAN mean wave directions already properly reflect the corresponding values in the considered calibration area (including SROWF, cf. Figure 2.16): i.e. there is no need for a correction of theSWAN wave directions.

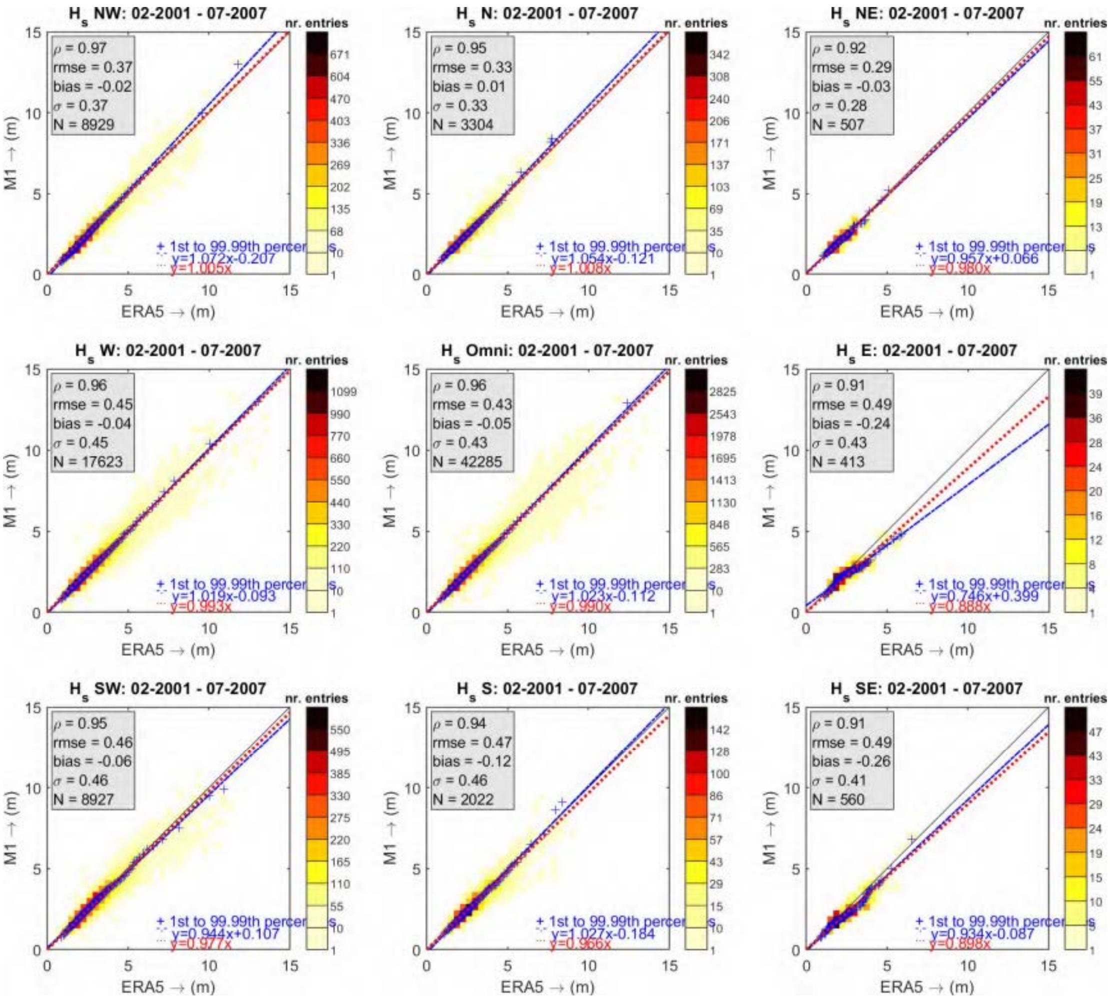


Figure 2.18 Significant wave height density scatter comparisons between the M1 observations and the uncalibrated ERA5 timeseries at M1. The panel in the middle shows the omni-directional comparisons and the panels surrounding it show the comparisons for the corresponding directional sectors (from top left, clockwise: NW, N, NE, E, SE, S, SW and W). The symmetric fit to the data is given by the red dotted line and the linear fit through the data percentiles (blue pluses) is given by the dashed blue line. The statistics of the comparisons are printed in the panels.

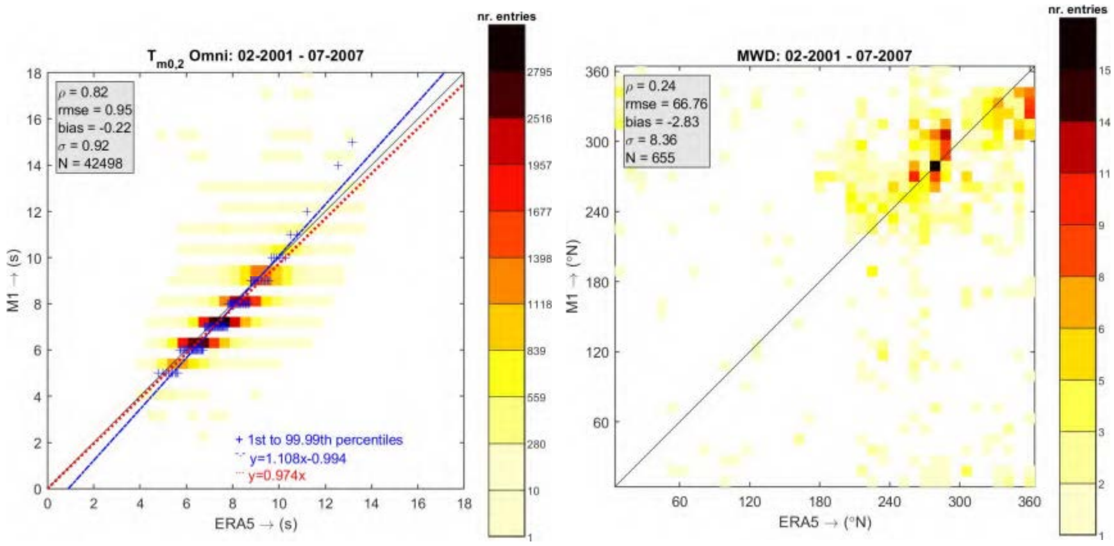


Figure 2.19 (Omni-directional) mean wave period $T_{m0,2}$ (left) and mean wave direction (right) density scatter comparisons between the M1 buoy observations and the ERA5 data.

In conclusion of the ERA5 data validation, adding to the fact that SWAN fully accounts for the effects of the complex bathymetry of the SROWF area, the wave conditions modelled using SWAN are considered to be very reliable, with very high correlations with the observations and considered to form a solid basis for the determination of the wave conditions in the SROWF area. The data needs however to be calibrated by applying value-dependent correction factors to the significant wave height data and the wave period data, there is no need to calibrate the wave directions.

Last, although the quality of the offshore data is high, it is advised to perform an additional dedicated validation of the local modelled wave data as soon as local wave observation data become available.This is needed to ensure that local bathymetrical features and their effect on the wave propagation are indeed captured correctly.

2.3.4 The SROWF wave dataset

Having validated the SWAN wave data and concluded that calibrated data forms a solid basis for the determination of the wave conditions at SROWF. The calibrated timeseries in the SROWF area were used to determine the normal and extreme wave conditions given in in Section Waves. The timeseries are hourly and cover the period from 1979 to 2021 (43 years, 01-01-1979 00:00 – 31-12-2021 23:00).

2.4 Other metocean data

2.4.1 Atmospheric pressure

Hourly timeseries of atmospheric data from 1979 to 2021 (43 years) were extracted from the ERA5 dataset and were used as input to the hydrodynamic modelling as described in Section 2.2.2. The validation of these data at the location of the M1 buoy of the Marine Institute (53.1266°N -11.2000°E, cf. Table 2.1) is presented below in Figure 2.20. The figure shows a perfect correlation (1.00) and almost no bias between the ERA5 values and the buoy observations. No calibration is deemed necessary. The ERA5 atmospheric pressure data are, therefore, considered to form a solid basis for the input to the hydrodynamic modelling.

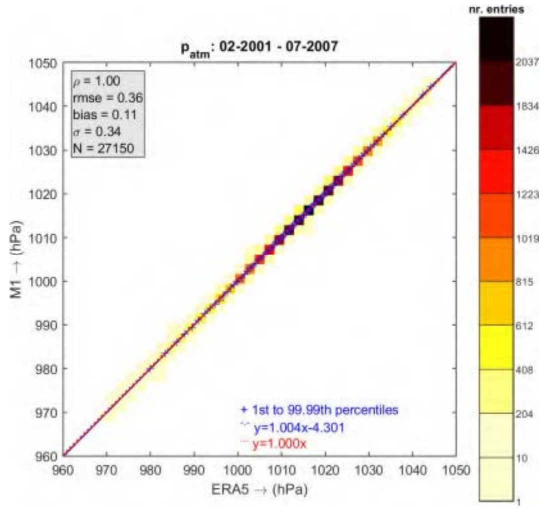


Figure 2.20 Density scatter of ERA5 atmospheric pressure values vs. observed values at the Marine Institute M1 buoy. The symmetric fit to the data is given by the red dotted line and the linear fit through the data percentiles (blue pluses) is given by the dashed blue line. The statistics of the comparisons are printed in the panel.

3 Metocean conditions

3.1 Introduction

Metocean parameters were derived for three locations in the wind farm area. These locations have been defined (in consultation with the Client) by considering the spatial variation of the modelled maximum values of (depth-averaged) current velocity and, significant wave height (H_s) and by clustering of the turbine locations into three groups: fully exposed, intermediate and relatively sheltered. For each of the three clusters the most conservative (in terms of wave conditions) and therewith representative locations were selected. The coordinates of and the local depths at the chosen locations are given in Table 1.1. Appendix D presents the spatial variation plots used in the selection of these locations.

The water depth at the SROWF output locations ranges between -42.14 and -25.89 mLAT (see fourth column of Table 1.1). The depths at turbines WTG15 and WTG11 were determined based on both the available bathymetrical survey datasets, which covered only part of the SROWF area. At turbine WTG08 no local bathymetrical survey data (cf. Figure 1.1) were available and the depth was therefore determined on the basis of an triangular interpolation between the survey dataset and digitized navigational charts.

In the sections below, metocean analyses are presented per metocean parameter. Wind (Section 3.2), water level (Section 3.3), current (Section 3.4) and wave (Section 3.5 and Section 3.6) data are presented for the three turbine locations in the wind farm.

Weather windows and downtime periods have been determined empirically from the hourly timeseries of wind speed at 10 mMSL height (U_{10}), wind speed at 170 mMSL height (i.e. hub-height) (U_{170}) and significant wave height (H_s) using the following settings:

- Thresholds wind speed at 10 and 170 mMSL: 6 m/s, 8 m/s, 10 m/s, 12 m/s, 14 m/s and 16 m/s
- Thresholds wave height: 0.75 m, 1.00 m, 1.25 m, 1.50 m, 1.75 m, 2.00 m, 2.50 m and 3.00 m
- Time windows: 3 h, 6 h, 12 h, 24 h and 48 h
- Probability of exceedance (percentiles): 50%, 75% and 90%

Further, the average number of non-overlapping weather window events per month over the full timeseries has also been determined empirically using the thresholds above. Given that the non-overlapping statistics are computed using the full timeseries, only the mean value is given (the probabilities of exceedance (percentiles) are not available).

These tables are given in the spreadsheet files accompanying this report (cf. Appendix E).

3.2 Winds

3.2.1 Introduction

In this section the mean wind conditions at the SROWF are given. The normal wind conditions were determined from the hourly hourly-averaged timeseries of wind speed and direction at hub-height: 170 m above MSL, cf. Section 2.1.3. The extreme wind conditions were determined for the wind speeds at both 10 m and 170 m (hub-height) above MSL. It is noted that for the main normal wind statistics no distinction has been made between the three assessment locations. Only for the Weibull distribution fits (normal wind conditions, hub-height), for which

12 wind x 12 (local) wave sectors are considered, distinction is made between the three assessment locations.

3.2.2 Normal conditions (only hub-height, 170 mMSL)

In order to characterise the normal wind conditions at SROWF, Figure 3.1 and Figure 3.3 show respectively the rose and joint occurrent table of the 1h-averaged wind speed and direction in the wind farm for hub-height (170 mMSL). The figures show that the most predominant and extreme wind speeds in SROWF are from the Southwest to West. The wind speeds at hub-height range from 0 to 40 m/s, but approximately 90% of the time the wind speed is lower than 17.0 m/s.

Next to the main wind statistics, Weibull distribution fits have been determined at each of the three turbine locations (cf. Table 1.1) for 12 x 12 directional wind/wave sectors. The Weibul fit parameters are provided for each of the three turbine locations and each of the combinations of wind/wave sectors in the spreadsheets accompanying this report (cf. Appendix E). An example result from these spreadsheets is presented in Table 3.1 for turbine WTG15 and the 240°N wind sector. This table shows for each of the 12 wave sectors the associated probabilities, Weibull fit parameters and the mean wind speed at hub-height within that subset of data. It is noted that for some combinations of wind and wave sectors no data are available. In those cases no values are presented.

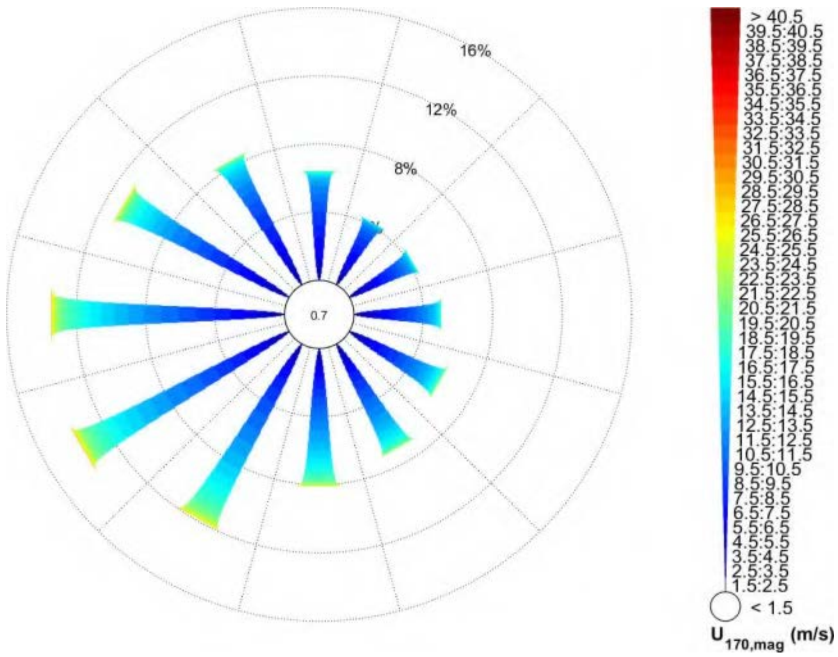


Figure 3.1 Rose of the SROWF 1h-average wind speed and direction (all-year) at 170 mMSL hub-height (U_{170}).

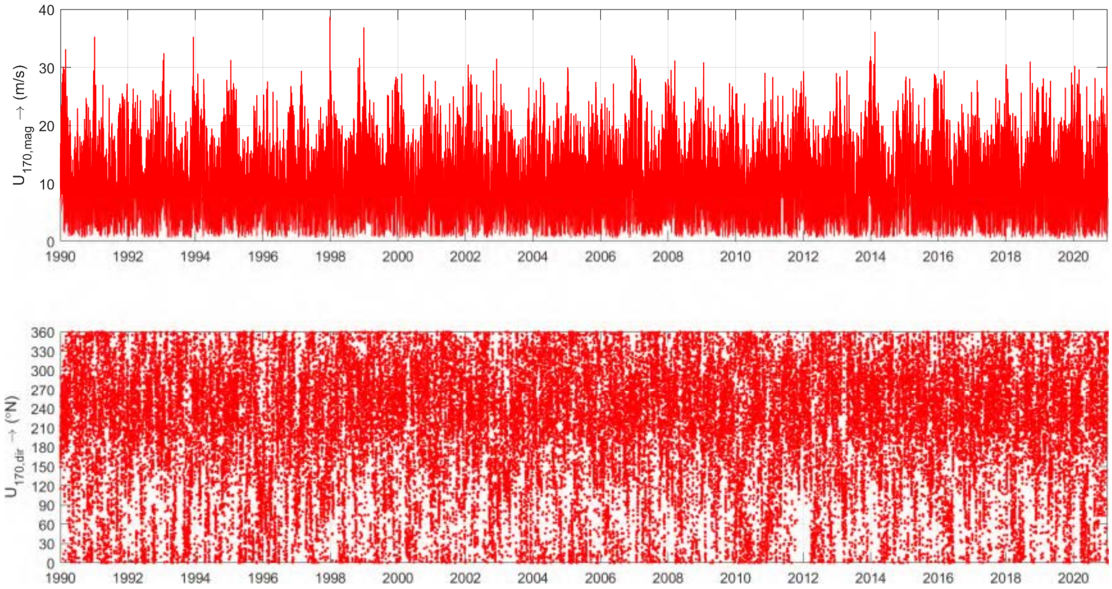


Figure 3.2 Timeseries of the SROWF 1h-average wind speed at 170 mMSL hub-height.

Joint Occurence Table, $U_{170,mag}$ vs. $U_{170,dir}$

$U_{170,mag}$ → (m/s) \ $U_{170,dir}$ →	345-15	15-45	45-75	75-105	105-135	135-165	165-195	195-225	225-255	255-285	285-315	315-345	
>40.5													
39.5-40.5													
38.5-39.5											0.00		0.00
37.5-38.5													
36.5-37.5									0.00				0.00
35.5-36.5									0.00		0.00		0.00
34.5-35.5								0.00	0.00	0.00			0.00
33.5-34.5										0.00			0.00
32.5-33.5									0.00	0.00			0.00
31.5-32.5								0.00	0.00	0.00			0.01
30.5-31.5							0.00	0.00	0.00	0.00	0.00		0.01
29.5-30.5							0.00	0.00	0.00	0.01	0.00		0.01
28.5-29.5							0.00	0.00	0.01	0.01	0.00	0.00	0.03
27.5-28.5							0.00	0.01	0.02	0.01	0.01		0.05
26.5-27.5	0.00				0.00	0.00	0.01	0.03	0.03	0.02	0.01	0.00	0.09
25.5-26.5					0.00	0.00	0.01	0.04	0.04	0.05	0.01	0.00	0.15
24.5-25.5	0.00		0.00		0.00	0.00	0.02	0.05	0.05	0.05	0.02	0.00	0.21
23.5-24.5	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.08	0.08	0.08	0.04	0.01	0.32
22.5-23.5	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.12	0.10	0.11	0.05	0.01	0.47
21.5-22.5	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.16	0.15	0.14	0.07	0.02	0.65
20.5-21.5	0.01	0.00	0.00	0.01	0.03	0.04	0.11	0.22	0.22	0.18	0.11	0.03	0.95
19.5-20.5	0.02	0.00	0.00	0.01	0.04	0.08	0.14	0.28	0.29	0.28	0.14	0.05	1.33
18.5-19.5	0.03	0.00	0.01	0.02	0.06	0.11	0.23	0.35	0.37	0.36	0.17	0.07	1.78
17.5-18.5	0.04	0.01	0.02	0.03	0.07	0.15	0.27	0.46	0.47	0.44	0.26	0.10	2.31
16.5-17.5	0.05	0.01	0.02	0.05	0.12	0.21	0.34	0.58	0.56	0.52	0.34	0.13	2.93
15.5-16.5	0.09	0.03	0.04	0.09	0.16	0.29	0.41	0.59	0.65	0.63	0.43	0.20	3.60
14.5-15.5	0.12	0.05	0.06	0.13	0.22	0.37	0.45	0.72	0.81	0.73	0.47	0.26	4.39
13.5-14.5	0.18	0.07	0.11	0.20	0.27	0.41	0.53	0.77	0.91	0.80	0.56	0.34	5.14
12.5-13.5	0.33	0.09	0.16	0.25	0.34	0.49	0.64	0.85	0.98	0.90	0.68	0.41	6.14
11.5-12.5	0.42	0.16	0.23	0.30	0.46	0.57	0.63	0.90	1.07	0.98	0.74	0.53	6.99
10.5-11.5	0.51	0.25	0.28	0.38	0.52	0.61	0.68	0.97	1.08	1.03	0.83	0.63	7.78
9.5-10.5	0.60	0.36	0.33	0.44	0.51	0.65	0.61	0.90	1.03	0.99	0.90	0.83	8.14
8.5-9.5	0.76	0.47	0.41	0.54	0.54	0.57	0.53	0.79	1.00	0.98	0.93	0.89	8.43
7.5-8.5	0.72	0.54	0.46	0.48	0.57	0.53	0.51	0.71	0.85	1.00	0.96	0.90	8.25
6.5-7.5	0.69	0.53	0.47	0.51	0.51	0.46	0.42	0.62	0.80	0.82	0.87	0.84	7.55
5.5-6.5	0.60	0.50	0.50	0.49	0.46	0.41	0.39	0.51	0.69	0.71	0.77	0.68	6.71
4.5-5.5	0.48	0.41	0.44	0.39	0.40	0.38	0.34	0.40	0.55	0.59	0.64	0.56	5.59
3.5-4.5	0.37	0.32	0.32	0.32	0.30	0.30	0.30	0.34	0.43	0.48	0.46	0.42	4.35
2.5-3.5	0.25	0.24	0.22	0.24	0.23	0.23	0.23	0.24	0.29	0.33	0.32	0.29	3.11
1.5-2.5	0.15	0.13	0.13	0.14	0.13	0.14	0.15	0.17	0.17	0.18	0.19	0.17	1.86
0.0-1.5	0.05	0.06	0.07	0.05	0.06	0.06	0.05	0.06	0.05	0.06	0.06	0.05	0.68
	6.47	4.25	4.27	5.08	6.03	7.10	8.13	11.94	13.77	13.50	11.04	8.42	100.00 Total

Figure 3.3 Joint occurrence table of the SROWF 1h-average wind speed and direction (all-year) at 170 mMSL hub-height.

Table 3.1 Example table of Weibull distribution scale (A) and shape (k) parameters for turbine location WTG15 and the 240°N wind-sector.

Wind sector range (°N) - 225-255				
Wave sector range (°N)	**Probability (%)**	**Weibull A (m/s)**	**Weibull k (-)**	**Mean wind speed (m/s)**
345 - 15				
15 - 45				
45 - 75				
75 - 105				
105 - 135	0.00	2.04	6.93	1.90
135 - 165	0.00	7.80	17.94	7.57
165 - 195	0.03	12.15	2.53	10.76
195 - 225	0.61	14.04	2.79	12.51
225 - 255	7.55	14.90	2.82	13.28
255 - 285	5.37	10.96	2.48	9.72
285 - 315	0.21	6.18	2.08	5.46
315 - 345	0.00	3.33	3.30	2.97

3.2.3 Extreme conditions

Extreme value analyses (EVA) of the 43-year long (1979-2020) timeseries of the 10 mMSL and the 32-year long (1990-2020) timeseries of the 170 mMSL wind speeds in SROWF were carried out using the Peaks-Over-Threshold (POT) method, see Appendix B. The EVA of the data included omni-directional analyses and directional analyses over 30º sectors for both heights. The sectors considered are: 345ºN-15ºN (0/360°), 15ºN-45ºN (30°), …, 285ºN-315ºN (300°) and 315ºN-345ºN (330°). In the omni-directional analysis all data are considered. In the directional analyses only the data falling in the sector of interest are taken into account. The data are stratified into sectors before the EVA are carried out, meaning that a given storm may be considered in more than one sector. The stratification into sectors before the analysis is necessary because we are interested in the return value for the above enumerated fixed sectors. If only storm peaks were to be stratified, the return values obtained for a given sector could have been underestimated.

The SROWF omni-directional 1-hour averaged wind speed return value plots at 10 mMSL and 170 mMSL height are given as example in Figure 3.4 and Figure 3.5 respectively. The directional return value estimates and corresponding 95% confidence intervals for the winds at 10 mMSL and 170 mMSL height are given in Table 3.2 and Table 3.3 respectively. The tables also present the corresponding 3-hr, 10-min, 1-min, 15-second and 3-second averaged wind speeds. These have been obtained by applying the Frøya-profile following the API guidelines (API, 2000) and the DNV recommended practice DNVGL-RP-C205 (DNVGL, 2020):

$$U(t) = U_{1h}\left[1 - 0.41 I_u \ln\left(\frac{t}{t_{1h}}\right)\right],$$

where $I_u = 0.06(1 + 0.043 U_{1h})$, $U(t)$ is the wind speed for a certain duration t (in seconds), U_{1h} is the input 1-hour averaged wind speed; the value of t_{1h} is fixed at 3600 s. Please note that the uncertainty bands of some directional sectors are relatively wide compared to the omnidirectional bands due to the smaller amount of data points available.

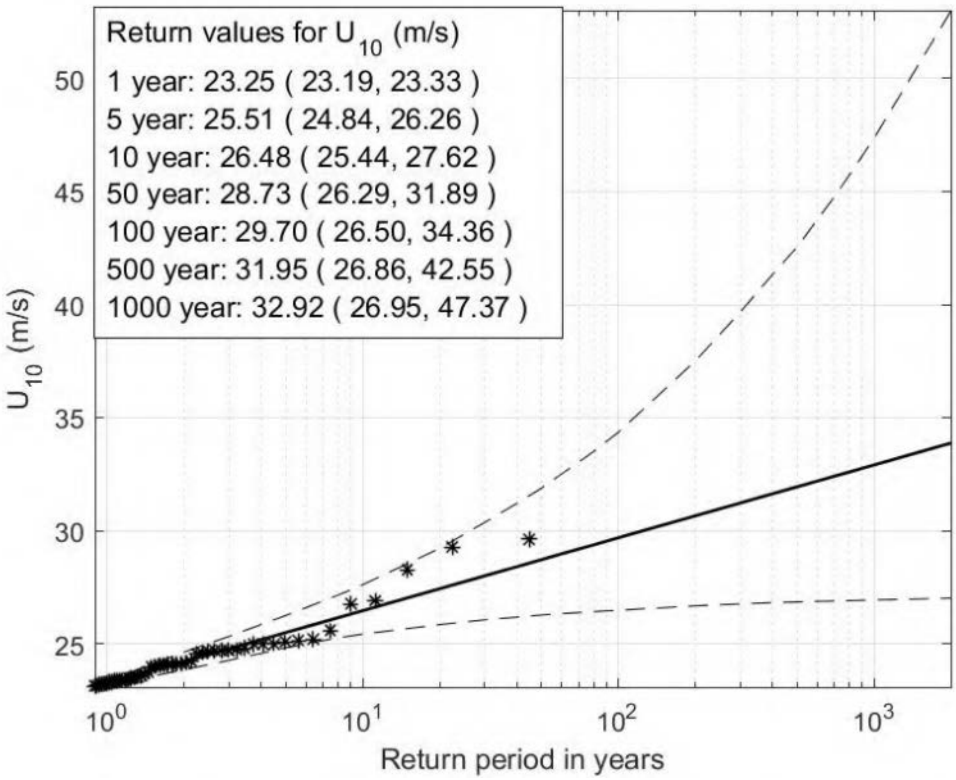


Figure 3.4 SROWF omni-directional 1-hour averaged 10 mMSL wind speed return value plot. The dashed lines are the associated 95% confidence intervals. The POT data are represented by the asterisks, with as plotting position (xi, (n+1)/(λ_u(n+1-i)), where n is the sample size, i the order and λ_u the Poisson rate.

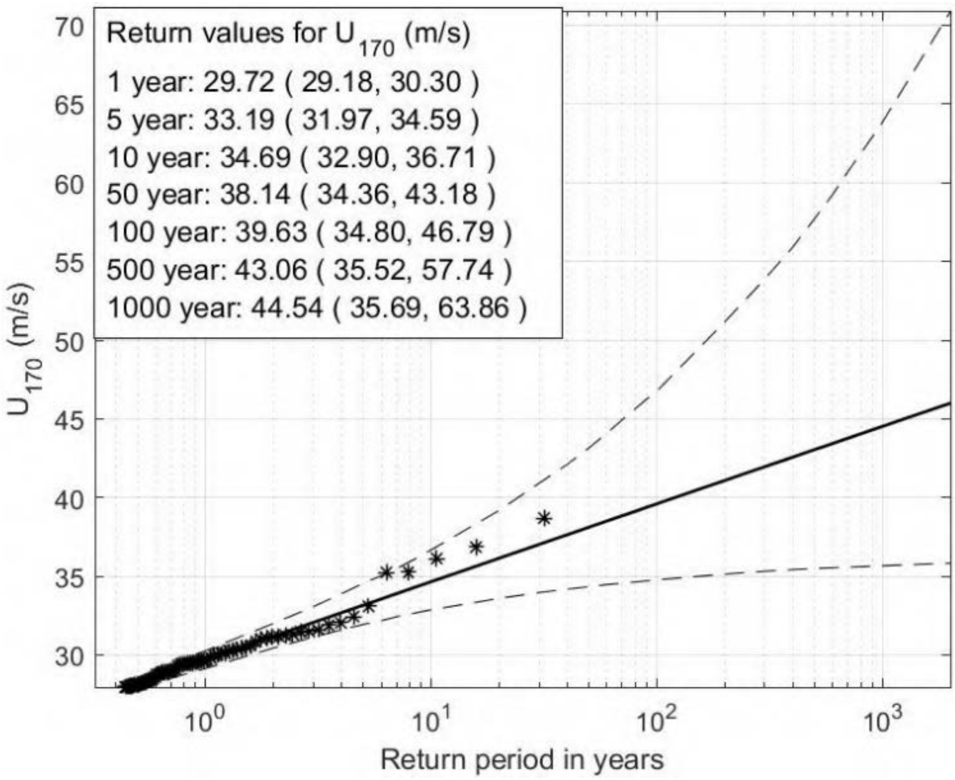


Figure 3.5 SROWF omni-directional 1-hour averaged 170 mMSL wind speed return value plot. The dashed lines are the associated 95% confidence intervals. The POT data are represented by the asterisks, with as plotting position (xi, (n+1)/(λ_u(n+1-i)), where n is the sample size, i the order and λ_u the Poisson rate.

Table 3.2 Directional wind speed return values (10 mMSL wind). Wind directions are defined as coming from clockwise from North.

Wind directions are coming FROM clockwise from the North	Sector 1 345-015deg	Sector 2 015-045deg	Sector 3 045-075deg	Sector 4 075-105deg	Sector 5 105-135deg	Sector 6 135-165deg	Sector 7 165-195deg	Sector 8 195-225deg	Sector 9 225-255deg	Sector 10 255-285deg	Sector 11 285-315deg	Sector 12 315-345deg	OMNI
1-yr													
Wind Speed 3 hr average (m/s)	14.0 (13.6 - 14.4)	11.8 (11.6 - 12.0)	11.9 (11.6 - 12.3)	13.4 (13.1 - 13.8)	15.1 (14.9 - 15.4)	16.5 (16.3 - 16.7)	18.8 (18.8 - 18.8)	20.1 (20.0 - 20.2)	20.8 (20.7 - 20.9)	20.8 (20.6 - 21.0)	19.4 (19.0 - 19.9)	16.4 (16.1 - 16.7)	22.0 (21.9 - 22.1)
Wind Speed 1 hr average (m/s)	14.7 (14.2 - 15.1)	12.3 (12.1 - 12.6)	12.5 (12.1 - 12.9)	14.1 (13.7 - 14.4)	15.8 (15.6 - 16.1)	17.3 (17.1 - 17.5)	19.8 (19.7 - 19.8)	21.2 (21.1 - 21.3)	22.0 (21.9 - 22.1)	22.0 (21.8 - 22.2)	20.5 (20.0 - 21.0)	17.2 (16.9 - 17.6)	23.3 (23.2 - 23.3)
Wind Speed 10 min average (m/s)	15.7 (15.3 - 16.2)	13.2 (13.0 - 13.4)	13.3 (12.9 - 13.8)	15.1 (14.7 - 15.5)	17.0 (16.7 - 17.3)	18.6 (18.4 - 18.9)	21.4 (21.4 - 21.4)	23.0 (22.8 - 23.1)	23.9 (23.8 - 24.0)	23.9 (23.6 - 24.1)	22.2 (21.6 - 22.8)	18.5 (18.2 - 18.9)	25.3 (25.2 - 25.4)
Wind Speed 1 min average (m/s)	17.1 (16.6 - 17.6)	14.2 (14.0 - 14.5)	14.4 (13.9 - 14.9)	16.3 (15.9 - 16.8)	18.5 (18.2 - 18.9)	20.3 (20.1 - 20.6)	23.4 (23.4 - 23.5)	25.3 (25.1 - 25.5)	26.3 (26.2 - 26.4)	26.3 (26.0 - 26.6)	24.4 (23.7 - 25.0)	20.2 (19.9 - 20.7)	27.9 (27.9 - 28.0)
Wind Speed 15 s gust (m/s)	17.9 (17.3 - 18.5)	14.9 (14.6 - 15.2)	15.0 (14.5 - 15.6)	17.1 (16.7 - 17.6)	19.4 (19.1 - 19.8)	21.4 (21.1 - 21.7)	24.7 (24.7 - 24.7)	26.6 (26.5 - 26.9)	27.7 (27.6 - 27.9)	27.7 (27.5 - 28.1)	25.7 (25.0 - 26.4)	21.3 (20.9 - 21.7)	29.5 (29.4 - 29.6)
Wind Speed 3 s gust (m/s)	18.9 (18.3 - 19.5)	15.6 (15.4 - 15.9)	15.8 (15.3 - 16.4)	18.0 (17.5 - 18.5)	20.5 (20.1 - 20.9)	22.5 (22.3 - 22.9)	26.1 (26.1 - 26.2)	28.2 (28.1 - 28.5)	29.4 (29.3 - 29.6)	29.4 (29.1 - 29.8)	27.2 (26.4 - 28.0)	22.5 (22.0 - 22.9)	31.4 (31.3 - 31.5)
5-yr													
Wind Speed 3 hr average (m/s)	16.5 (15.9 - 17.0)	14.0 (13.4 - 14.7)	14.8 (14.0 - 15.5)	15.8 (15.2 - 16.4)	17.4 (16.8 - 18.0)	18.3 (17.8 - 18.9)	20.6 (20.0 - 21.1)	22.1 (21.5 - 22.7)	23.1 (22.4 - 23.9)	23.4 (22.6 - 24.1)	22.4 (21.6 - 23.1)	18.9 (18.1 - 19.6)	24.1 (23.5 - 24.8)
Wind Speed 1 hr average (m/s)	17.3 (16.7 - 17.8)	14.6 (14.0 - 15.3)	15.4 (14.6 - 16.3)	16.6 (15.9 - 17.2)	18.3 (17.6 - 18.9)	19.3 (18.7 - 19.9)	21.7 (21.1 - 22.3)	23.4 (22.7 - 24.0)	24.5 (23.7 - 25.3)	24.8 (23.9 - 25.5)	23.7 (22.8 - 24.5)	19.9 (19.1 - 20.7)	25.5 (24.8 - 26.3)
Wind Speed 10 min average (m/s)	18.6 (17.9 - 19.2)	15.7 (14.9 - 16.5)	16.6 (15.7 - 17.5)	17.8 (17.1 - 18.5)	19.7 (19.0 - 20.4)	20.8 (20.2 - 21.5)	23.6 (22.9 - 24.3)	25.4 (24.7 - 26.2)	26.7 (25.8 - 27.7)	27.0 (26.1 - 27.9)	25.8 (24.8 - 26.7)	21.5 (20.6 - 22.4)	27.9 (27.1 - 28.7)
Wind Speed 1 min average (m/s)	20.3 (19.6 - 21.0)	17.0 (16.2 - 17.9)	18.0 (17.0 - 19.0)	19.4 (18.6 - 20.2)	21.6 (20.7 - 22.4)	22.8 (22.1 - 23.6)	25.9 (25.2 - 26.7)	28.1 (27.2 - 28.9)	29.6 (28.6 - 30.7)	29.9 (28.8 - 31.0)	28.5 (27.4 - 29.5)	23.6 (22.6 - 24.6)	30.9 (30.0 - 31.9)
Wind Speed 15 s gust (m/s)	21.3 (20.5 - 22.1)	17.8 (17.0 - 18.8)	18.9 (17.8 - 20.0)	20.4 (19.5 - 21.2)	22.7 (21.8 - 23.5)	24.0 (23.2 - 24.8)	27.4 (26.6 - 28.2)	29.7 (28.8 - 30.6)	31.3 (30.2 - 32.5)	31.7 (30.5 - 32.8)	30.1 (28.9 - 31.3)	24.9 (23.7 - 25.9)	32.7 (31.8 - 33.8)
Wind Speed 3 s gust (m/s)	22.5 (21.7 - 23.3)	18.8 (17.9 - 19.8)	19.9 (18.8 - 21.1)	21.5 (20.6 - 22.4)	24.0 (23.0 - 24.9)	25.4 (24.6 - 26.3)	29.0 (28.2 - 30.0)	31.5 (30.5 - 32.5)	33.3 (32.1 - 34.6)	33.7 (32.4 - 34.9)	32.0 (30.7 - 33.3)	26.3 (25.1 - 27.5)	34.8 (33.8 - 36.0)
10-yr													
Wind Speed 3 hr average (m/s)	17.3 (16.6 - 18.1)	14.9 (14.0 - 15.8)	16.0 (14.8 - 17.1)	16.7 (15.9 - 17.5)	18.4 (17.6 - 19.1)	19.1 (18.4 - 19.9)	21.3 (20.6 - 22.1)	22.9 (22.2 - 23.7)	24.1 (23.2 - 25.2)	24.4 (23.5 - 25.2)	23.5 (22.5 - 24.6)	20.0 (19.0 - 20.9)	24.9 (24.0 - 26.0)
Wind Speed 1 hr average (m/s)	18.2 (17.5 - 19.0)	15.6 (14.7 - 16.6)	16.7 (15.5 - 17.9)	17.5 (16.7 - 18.4)	19.3 (18.5 - 20.1)	20.1 (19.3 - 21.0)	22.5 (21.7 - 23.4)	24.3 (23.4 - 25.1)	25.6 (24.5 - 26.7)	25.9 (24.8 - 26.8)	24.9 (23.8 - 26.1)	21.0 (20.0 - 22.0)	26.5 (25.4 - 27.6)
Wind Speed 10 min average (m/s)	19.7 (18.8 - 20.6)	16.8 (15.7 - 17.9)	18.0 (16.6 - 19.3)	18.9 (17.9 - 19.8)	20.9 (19.9 - 21.7)	21.7 (20.9 - 22.7)	24.5 (23.6 - 25.5)	26.5 (25.5 - 27.4)	27.9 (26.8 - 29.2)	28.3 (27.1 - 29.3)	27.2 (25.9 - 28.6)	22.8 (21.6 - 23.9)	29.0 (27.8 - 30.3)
Wind Speed 1 min average (m/s)	21.5 (20.5 - 22.5)	18.2 (17.1 - 19.5)	19.6 (18.1 - 21.1)	20.6 (19.5 - 21.7)	22.9 (21.8 - 23.9)	23.9 (22.9 - 25.0)	27.0 (26.0 - 28.1)	29.3 (28.2 - 30.4)	31.0 (29.6 - 32.5)	31.4 (30.0 - 32.6)	30.1 (28.6 - 31.7)	25.1 (23.7 - 26.3)	32.2 (30.8 - 33.7)
Wind Speed 15 s gust (m/s)	22.6 (21.6 - 23.7)	19.1 (17.9 - 20.4)	20.6 (19.0 - 22.2)	21.7 (20.5 - 22.8)	24.1 (22.9 - 25.1)	25.1 (24.1 - 26.3)	28.5 (27.4 - 29.7)	31.0 (29.8 - 32.2)	32.8 (31.3 - 34.5)	33.2 (31.8 - 34.6)	31.8 (30.2 - 33.6)	26.4 (25.0 - 27.8)	34.1 (32.6 - 35.8)
Wind Speed 3 s gust (m/s)	23.9 (22.8 - 25.1)	20.2 (18.9 - 21.6)	21.8 (20.0 - 23.5)	22.9 (21.6 - 24.1)	25.5 (24.2 - 26.6)	26.6 (25.5 - 27.9)	30.3 (29.1 - 31.6)	32.9 (31.6 - 34.3)	34.9 (33.3 - 36.7)	35.4 (33.8 - 36.8)	33.9 (32.1 - 35.8)	28.0 (26.4 - 29.5)	36.4 (34.7 - 38.2)
50-yr													
Wind Speed 3 hr average (m/s)	19.1 (17.7 - 20.8)	17.0 (15.2 - 19.4)	18.8 (16.4 - 21.6)	18.5 (16.8 - 20.7)	20.6 (19.0 - 22.3)	20.8 (19.4 - 22.5)	23.1 (21.5 - 25.0)	24.9 (23.3 - 27.0)	26.3 (24.2 - 29.0)	26.5 (24.8 - 28.8)	25.8 (23.8 - 28.8)	22.4 (20.5 - 24.4)	27.0 (24.8 - 29.9)
Wind Speed 1 hr average (m/s)	20.1 (18.6 - 22.0)	17.9 (15.9 - 20.4)	19.7 (17.2 - 22.8)	19.5 (17.6 - 21.9)	21.8 (20.0 - 23.6)	21.9 (20.4 - 23.8)	24.5 (22.7 - 26.5)	26.4 (24.6 - 28.8)	28.0 (25.7 - 31.0)	28.2 (26.3 - 30.7)	27.4 (25.2 - 30.7)	23.7 (21.6 - 25.8)	28.7 (26.3 - 31.9)
Wind Speed 10 min average (m/s)	21.7 (20.1 - 23.9)	19.3 (17.1 - 22.1)	21.4 (18.5 - 24.8)	21.1 (19.0 - 23.8)	23.6 (21.6 - 25.7)	23.8 (22.1 - 25.9)	26.7 (24.7 - 29.0)	28.9 (26.9 - 31.6)	30.7 (28.1 - 34.2)	31.0 (28.8 - 33.8)	30.1 (27.5 - 33.9)	25.8 (23.4 - 28.2)	31.6 (28.8 - 35.2)
Wind Speed 1 min average (m/s)	23.8 (22.0 - 26.3)	21.0 (18.6 - 24.2)	23.4 (20.2 - 27.3)	23.1 (20.8 - 26.2)	26.0 (23.7 - 28.4)	26.2 (24.3 - 28.6)	29.5 (27.3 - 32.2)	32.1 (29.7 - 35.3)	34.2 (31.1 - 38.3)	34.5 (31.9 - 37.8)	33.4 (30.5 - 37.9)	28.5 (25.8 - 31.3)	35.2 (31.9 - 39.5)
Wind Speed 15 s gust (m/s)	25.1 (23.1 - 27.7)	22.1 (19.5 - 25.5)	24.7 (21.2 - 28.9)	24.3 (21.8 - 27.6)	27.5 (25.0 - 30.0)	27.7 (25.6 - 30.2)	31.2 (28.8 - 34.2)	34.1 (31.5 - 37.5)	36.3 (33.0 - 40.7)	36.7 (33.8 - 40.3)	35.5 (32.3 - 40.3)	30.2 (27.2 - 33.2)	37.4 (33.8 - 42.1)
Wind Speed 3 s gust (m/s)	26.6 (24.4 - 29.4)	23.4 (20.6 - 27.1)	26.1 (22.4 - 30.6)	25.8 (23.1 - 29.3)	29.1 (26.5 - 31.9)	29.4 (27.1 - 32.1)	33.2 (30.6 - 36.4)	36.3 (33.5 - 40.0)	38.8 (35.1 - 43.6)	39.1 (36.1 - 43.1)	37.8 (34.4 - 43.2)	32.1 (28.9 - 35.3)	39.9 (36.1 - 45.1)
100-yr													
Wind Speed 3 hr average (m/s)	19.7 (18.0 - 22.0)	17.9 (15.5 - 21.3)	20.0 (17.0 - 23.9)	19.2 (17.0 - 22.5)	21.6 (19.4 - 24.1)	21.5 (19.7 - 23.8)	23.8 (21.8 - 26.8)	25.7 (23.5 - 29.1)	27.3 (24.5 - 31.4)	27.4 (25.0 - 30.6)	26.7 (24.2 - 30.8)	23.5 (21.0 - 26.3)	27.9 (25.0 - 32.1)
Wind Speed 1 hr average (m/s)	20.7 (18.9 - 23.3)	18.8 (16.2 - 22.5)	21.1 (17.8 - 25.3)	20.3 (17.9 - 23.9)	22.8 (20.5 - 25.6)	22.7 (20.8 - 25.2)	25.3 (23.0 - 28.5)	27.4 (24.9 - 31.0)	29.0 (26.0 - 33.6)	29.2 (26.6 - 32.8)	28.4 (25.7 - 32.9)	24.9 (22.2 - 28.0)	29.7 (26.5 - 34.4)
Wind Speed 10 min average (m/s)	22.5 (20.4 - 25.3)	20.3 (17.4 - 24.4)	22.8 (19.2 - 27.6)	21.9 (19.3 - 26.0)	24.8 (22.2 - 27.9)	24.7 (22.5 - 27.6)	27.6 (25.0 - 31.3)	30.0 (27.2 - 34.2)	31.9 (28.4 - 37.2)	32.1 (29.1 - 36.2)	31.2 (28.0 - 36.4)	27.1 (24.1 - 30.7)	32.7 (29.0 - 38.1)
Wind Speed 1 min average (m/s)	24.7 (22.4 - 28.0)	22.2 (19.0 - 26.9)	25.1 (21.0 - 30.6)	24.1 (21.1 - 28.7)	27.4 (24.3 - 31.0)	27.2 (24.7 - 30.5)	30.6 (27.6 - 34.9)	33.4 (30.1 - 38.3)	35.6 (31.5 - 41.8)	35.8 (32.3 - 40.7)	34.8 (31.1 - 41.0)	30.0 (26.5 - 34.2)	36.5 (32.2 - 42.9)
Wind Speed 15 s gust (m/s)	26.0 (23.5 - 29.6)	23.4 (19.9 - 28.4)	26.5 (22.0 - 32.4)	25.4 (22.2 - 30.4)	28.9 (25.7 - 32.8)	28.8 (26.1 - 32.3)	32.4 (29.2 - 37.0)	35.4 (31.9 - 40.8)	37.8 (33.4 - 44.6)	38.0 (34.3 - 43.4)	36.9 (32.9 - 43.7)	31.8 (28.0 - 36.3)	38.8 (34.1 - 45.8)
Wind Speed 3 s gust (m/s)	27.6 (24.9 - 31.4)	24.8 (21.0 - 30.2)	28.0 (23.3 - 34.5)	26.9 (23.4 - 32.3)	30.7 (27.2 - 34.9)	30.5 (27.6 - 34.4)	34.5 (31.0 - 39.5)	37.7 (33.9 - 43.7)	40.4 (35.5 - 47.9)	40.6 (36.5 - 46.5)	39.4 (35.1 - 46.8)	33.8 (29.7 - 38.7)	41.5 (36.4 - 49.2)
500-yr													
Wind Speed 3 hr average (m/s)	20.9 (18.5 - 24.9)	19.9 (16.0 - 27.2)	22.8 (18.1 - 30.5)	20.7 (17.4 - 27.1)	23.8 (20.3 - 29.8)	23.1 (20.2 - 27.5)	25.6 (22.1 - 32.4)	27.7 (23.9 - 35.6)	29.4 (24.9 - 39.1)	29.2 (25.5 - 36.9)	28.5 (24.9 - 35.9)	25.9 (21.9 - 31.9)	29.9 (25.3 - 39.3)
Wind Speed 1 hr average (m/s)	22.1 (19.4 - 26.4)	21.0 (16.7 - 29.0)	24.1 (19.0 - 32.6)	21.8 (18.3 - 28.8)	25.3 (21.4 - 31.8)	24.4 (21.3 - 29.3)	27.2 (23.4 - 34.8)	29.5 (25.3 - 38.4)	31.4 (26.4 - 42.3)	31.2 (27.0 - 39.8)	30.4 (26.4 - 38.7)	27.5 (23.1 - 34.2)	32.0 (26.9 - 42.5)
Wind Speed 10 min average (m/s)	24.0 (21.0 - 28.9)	22.8 (18.0 - 31.8)	26.2 (20.6 - 36.1)	23.7 (19.7 - 31.7)	27.6 (23.2 - 35.1)	26.6 (23.1 - 32.3)	29.8 (25.5 - 38.6)	32.4 (27.7 - 42.9)	34.6 (28.9 - 47.6)	34.4 (29.6 - 44.6)	33.5 (28.9 - 43.2)	30.2 (25.1 - 37.9)	35.3 (29.4 - 47.9)
Wind Speed 1 min average (m/s)	26.4 (23.0 - 32.1)	25.1 (19.6 - 35.5)	29.0 (22.5 - 40.5)	26.1 (21.5 - 35.3)	30.6 (25.5 - 39.4)	29.5 (25.5 - 36.0)	33.1 (28.1 - 43.5)	36.2 (30.7 - 48.6)	38.8 (32.1 - 54.4)	38.5 (32.9 - 50.7)	37.5 (32.1 - 49.1)	33.6 (27.7 - 42.7)	39.6 (32.7 - 54.7)
Wind Speed 15 s gust (m/s)	27.9 (24.2 - 34.0)	26.4 (20.6 - 37.7)	30.7 (23.7 - 43.2)	27.6 (22.6 - 37.5)	32.4 (27.0 - 41.9)	31.2 (26.8 - 38.3)	35.1 (29.7 - 46.5)	38.5 (32.5 - 52.1)	41.3 (34.0 - 58.4)	41.0 (34.9 - 54.4)	39.9 (34.0 - 52.6)	35.6 (29.3 - 45.6)	42.2 (34.7 - 58.8)
Wind Speed 3 s gust (m/s)	29.6 (25.7 - 36.2)	28.0 (21.8 - 40.3)	32.6 (25.1 - 46.3)	29.2 (23.9 - 40.1)	34.4 (28.6 - 44.9)	33.2 (28.5 - 40.9)	37.4 (31.6 - 49.9)	41.1 (34.6 - 56.1)	44.3 (36.3 - 63.2)	43.9 (37.2 - 58.7)	42.7 (36.2 - 56.7)	38.0 (31.1 - 48.9)	45.2 (37.0 - 63.5)
1000-yr													
Wind Speed 3 hr average (m/s)	21.4 (18.6 - 26.0)	20.8 (16.1 - 30.4)	24.0 (18.5 - 33.9)	21.3 (17.5 - 29.2)	24.8 (20.5 - 32.6)	23.7 (20.5 - 29.4)	26.3 (22.2 - 35.8)	28.5 (24.0 - 39.6)	30.3 (25.0 - 43.6)	29.9 (25.6 - 40.3)	29.2 (25.1 - 38.5)	26.9 (22.2 - 34.6)	30.8 (25.4 - 43.5)
Wind Speed 1 hr average (m/s)	22.6 (19.6 - 27.7)	22.0 (16.9 - 32.5)	25.4 (19.4 - 36.5)	22.4 (18.3 - 31.2)	26.3 (21.7 - 34.9)	25.1 (21.6 - 31.4)	28.0 (23.5 - 38.6)	30.4 (25.5 - 42.9)	32.4 (26.5 - 47.5)	32.0 (27.1 - 43.7)	31.2 (26.6 - 41.6)	28.7 (23.4 - 37.3)	32.9 (27.0 - 47.4)
Wind Speed 10 min average (m/s)	24.5 (21.1 - 30.4)	23.9 (18.2 - 36.0)	27.7 (21.0 - 40.6)	24.4 (19.8 - 34.4)	28.8 (23.5 - 38.8)	27.5 (23.4 - 34.7)	30.7 (25.6 - 43.1)	33.5 (27.8 - 48.3)	35.8 (29.0 - 53.9)	35.3 (29.7 - 49.3)	34.4 (29.1 - 46.7)	31.5 (25.5 - 41.5)	36.4 (29.5 - 53.7)
Wind Speed 1 min average (m/s)	27.0 (23.2 - 33.8)	26.3 (19.9 - 40.4)	30.7 (23.0 - 45.9)	26.9 (21.6 - 38.5)	31.9 (25.9 - 43.7)	30.4 (25.8 - 38.9)	34.2 (28.2 - 48.9)	37.5 (30.8 - 55.2)	40.2 (32.3 - 62.1)	39.6 (33.1 - 56.4)	38.6 (32.4 - 53.3)	35.1 (28.2 - 47.0)	40.9 (32.8 - 61.9)
Wind Speed 15 s gust (m/s)	28.5 (24.4 - 35.9)	27.7 (20.9 - 43.0)	32.6 (24.3 - 49.1)	28.4 (22.8 - 41.0)	33.8 (27.3 - 46.7)	32.2 (27.2 - 41.4)	36.3 (29.9 - 52.4)	39.9 (32.7 - 59.3)	42.8 (34.2 - 67.1)	42.2 (35.1 - 60.7)	41.1 (34.3 - 57.3)	37.3 (29.8 - 50.3)	43.6 (34.8 - 66.8)
Wind Speed 3 s gust (m/s)	30.3 (25.8 - 38.3)	29.4 (22.0 - 46.1)	34.7 (25.7 - 52.8)	30.1 (24.1 - 43.9)	36.1 (29.0 - 50.2)	34.3 (28.8 - 44.3)	38.7 (31.7 - 56.4)	42.6 (34.8 - 64.1)	45.9 (36.5 - 72.8)	45.2 (37.4 - 65.7)	44.0 (36.6 - 61.8)	39.8 (31.6 - 54.2)	46.8 (37.1 - 72.5)

Table 3.3 Directional wind speed return values (170 mMSL wind). Wind directions are defined as coming from clockwise from North.

Wind directions are coming FROM clockwise from the North	Sector 1 345-015deg	Sector 2 015-045deg	Sector 3 045-075deg	Sector 4 075-105deg	Sector 5 105-135deg	Sector 6 135-165deg	Sector 7 165-195deg	Sector 8 195-225deg	Sector 9 225-255deg	Sector 10 255-285deg	Sector 11 285-315deg	Sector 12 315-345deg	OMNI
1-yr													
Wind Speed 3 hr average (m/s)	17.2 (16.6 - 17.9)	14.8 (14.5 - 15.1)	15.2 (14.8 - 15.7)	17.1 (16.5 - 17.7)	19.9 (19.4 - 20.6)	21.3 (21.0 - 21.6)	24.0 (23.8 - 24.3)	25.7 (25.5 - 26.0)	26.6 (26.5 - 26.8)	26.0 (25.6 - 26.5)	24.5 (24.2 - 25.0)	20.6 (20.0 - 21.2)	27.9 (27.4 - 28.4)
Wind Speed 1 hr average (m/s)	18.1 (17.5 - 18.8)	15.5 (15.2 - 15.8)	15.9 (15.5 - 16.4)	17.9 (17.3 - 18.6)	21.0 (20.4 - 21.7)	22.5 (22.2 - 22.8)	25.4 (25.2 - 25.8)	27.3 (27.1 - 27.7)	28.3 (28.2 - 28.6)	27.7 (27.2 - 28.2)	26.0 (25.7 - 26.5)	21.7 (21.1 - 22.4)	29.7 (29.2 - 30.3)
Wind Speed 10 min average (m/s)	19.5 (18.8 - 20.3)	16.6 (16.3 - 17.0)	17.1 (16.7 - 17.7)	19.3 (18.7 - 20.0)	22.8 (22.1 - 23.6)	24.4 (24.1 - 24.8)	27.8 (27.5 - 28.2)	29.9 (29.6 - 30.3)	31.1 (30.9 - 31.4)	30.3 (29.8 - 30.9)	28.5 (28.1 - 29.0)	23.6 (22.9 - 24.3)	32.7 (32.1 - 33.4)
Wind Speed 1 min average (m/s)	21.4 (20.6 - 22.2)	18.1 (17.7 - 18.5)	18.7 (18.2 - 19.3)	21.1 (20.4 - 21.9)	25.1 (24.3 - 25.9)	26.9 (26.5 - 27.4)	30.8 (30.5 - 31.3)	33.3 (33.0 - 33.8)	34.7 (34.4 - 35.0)	33.8 (33.2 - 34.5)	31.6 (31.1 - 32.2)	26.0 (25.1 - 26.8)	36.5 (35.8 - 37.3)
Wind Speed 15 s gust (m/s)	22.5 (21.6 - 23.4)	19.0 (18.6 - 19.4)	19.6 (19.0 - 20.2)	22.2 (21.4 - 23.1)	26.4 (25.6 - 27.4)	28.4 (28.0 - 28.9)	32.6 (32.3 - 33.1)	35.3 (35.0 - 35.8)	36.8 (36.6 - 37.1)	35.8 (35.2 - 36.6)	33.5 (33.0 - 34.2)	27.4 (26.5 - 28.3)	38.8 (38.0 - 39.7)
Wind Speed 3 s gust (m/s)	23.7 (22.8 - 24.7)	20.0 (19.6 - 20.5)	20.6 (20.1 - 21.3)	23.5 (22.6 - 24.4)	28.0 (27.1 - 29.0)	30.2 (29.7 - 30.7)	34.7 (34.4 - 35.3)	37.7 (37.3 - 38.2)	39.3 (39.0 - 39.7)	38.2 (37.5 - 39.1)	35.6 (35.1 - 36.4)	29.1 (28.1 - 30.1)	41.5 (40.7 - 42.5)
5-yr													
Wind Speed 3 hr average (m/s)	20.9 (19.9 - 22.0)	17.7 (16.7 - 18.8)	18.9 (17.7 - 20.3)	20.5 (19.6 - 21.4)	23.2 (22.2 - 24.0)	23.4 (22.7 - 24.1)	26.5 (25.6 - 27.4)	28.2 (27.3 - 29.1)	29.4 (28.4 - 30.4)	29.5 (28.3 - 30.5)	28.3 (26.9 - 29.9)	24.0 (22.9 - 25.0)	31.0 (29.9 - 32.3)
Wind Speed 1 hr average (m/s)	22.1 (20.9 - 23.3)	18.6 (17.6 - 19.8)	19.9 (18.6 - 21.4)	21.7 (20.6 - 22.6)	24.6 (23.5 - 25.5)	24.8 (24.1 - 25.5)	28.2 (27.2 - 29.2)	30.0 (29.1 - 31.1)	31.3 (30.3 - 32.5)	31.5 (30.2 - 32.6)	30.1 (28.6 - 31.9)	25.4 (24.2 - 26.5)	33.2 (32.0 - 34.6)
Wind Speed 10 min average (m/s)	24.0 (22.7 - 25.3)	20.1 (18.9 - 21.4)	21.6 (20.1 - 23.2)	23.5 (22.3 - 24.6)	26.8 (25.6 - 27.8)	27.1 (26.2 - 27.9)	30.9 (29.8 - 32.1)	33.1 (31.9 - 34.3)	34.6 (33.4 - 36.0)	34.7 (33.2 - 36.1)	33.2 (31.4 - 35.3)	27.8 (26.4 - 29.0)	36.7 (35.3 - 38.4)
Wind Speed 1 min average (m/s)	26.4 (25.0 - 28.0)	22.0 (20.7 - 23.5)	23.7 (22.0 - 25.5)	25.9 (24.5 - 27.1)	29.7 (28.3 - 30.9)	30.0 (29.0 - 30.9)	34.4 (33.1 - 35.8)	36.9 (35.6 - 38.4)	38.8 (37.4 - 40.4)	38.9 (37.2 - 40.5)	37.1 (35.1 - 39.6)	30.8 (29.2 - 32.3)	41.3 (39.6 - 43.3)
Wind Speed 15 s gust (m/s)	27.9 (26.3 - 29.5)	23.2 (21.7 - 24.7)	24.9 (23.1 - 26.9)	27.3 (25.8 - 28.6)	31.4 (29.9 - 32.7)	31.7 (30.7 - 32.8)	36.6 (35.1 - 38.1)	39.3 (37.9 - 40.9)	41.3 (39.8 - 43.1)	41.4 (39.5 - 43.2)	39.4 (37.2 - 42.1)	32.6 (30.9 - 34.2)	44.1 (42.2 - 46.2)
Wind Speed 3 s gust (m/s)	29.6 (27.9 - 31.4)	24.5 (23.0 - 26.2)	26.4 (24.5 - 28.5)	29.0 (27.4 - 30.4)	33.4 (31.8 - 34.8)	33.8 (32.6 - 34.9)	39.0 (37.5 - 40.7)	42.0 (40.5 - 43.8)	44.2 (42.5 - 46.2)	44.4 (42.3 - 46.3)	42.2 (39.8 - 45.1)	34.7 (32.8 - 36.4)	47.2 (45.2 - 49.6)
10-yr													
Wind Speed 3 hr average (m/s)	22.5 (21.0 - 24.0)	19.0 (17.5 - 20.5)	20.5 (18.8 - 22.3)	21.9 (20.7 - 23.2)	24.6 (23.3 - 25.6)	24.3 (23.4 - 25.2)	27.5 (26.3 - 28.7)	29.2 (27.9 - 30.6)	30.5 (29.2 - 32.1)	30.9 (29.5 - 32.2)	29.9 (27.8 - 32.4)	25.4 (24.0 - 26.8)	32.4 (30.8 - 34.1)
Wind Speed 1 hr average (m/s)	23.8 (22.2 - 25.4)	20.0 (18.4 - 21.7)	21.7 (19.8 - 23.6)	23.2 (21.8 - 24.6)	26.0 (24.7 - 27.1)	25.8 (24.8 - 26.7)	29.3 (28.0 - 30.6)	31.2 (29.8 - 32.7)	32.6 (31.2 - 34.4)	33.1 (31.5 - 34.6)	31.9 (29.6 - 34.7)	27.0 (25.4 - 28.5)	34.7 (32.9 - 36.7)
Wind Speed 10 min average (m/s)	25.9 (24.1 - 27.8)	21.6 (19.9 - 23.5)	23.5 (21.4 - 25.7)	25.2 (23.7 - 26.8)	28.5 (27.0 - 29.7)	28.2 (27.1 - 29.2)	32.2 (30.7 - 33.8)	34.4 (32.8 - 36.2)	36.1 (34.4 - 38.1)	36.6 (34.8 - 38.3)	35.2 (32.6 - 38.5)	29.5 (27.7 - 31.3)	38.5 (36.4 - 40.9)
Wind Speed 1 min average (m/s)	28.6 (26.5 - 30.8)	23.8 (21.8 - 25.9)	25.9 (23.5 - 28.4)	27.9 (26.1 - 29.7)	31.6 (29.9 - 33.1)	31.3 (30.0 - 32.5)	36.0 (34.2 - 37.8)	38.5 (36.6 - 40.7)	40.5 (38.5 - 43.0)	41.2 (39.0 - 43.2)	39.5 (36.4 - 43.4)	32.8 (30.8 - 34.9)	43.4 (40.9 - 46.2)
Wind Speed 15 s gust (m/s)	30.3 (28.0 - 32.6)	25.0 (22.9 - 27.3)	27.3 (24.8 - 30.0)	29.4 (27.5 - 31.4)	33.5 (31.6 - 35.1)	33.1 (31.8 - 34.4)	38.3 (36.3 - 40.2)	41.0 (38.9 - 43.4)	43.2 (41.0 - 45.9)	43.9 (41.5 - 46.1)	42.1 (38.7 - 46.4)	34.8 (32.6 - 37.1)	46.3 (43.6 - 49.5)
Wind Speed 3 s gust (m/s)	32.2 (29.7 - 34.7)	26.5 (24.2 - 29.0)	28.9 (26.2 - 31.9)	31.3 (29.2 - 33.4)	35.7 (33.6 - 37.4)	35.3 (33.8 - 36.7)	40.9 (38.8 - 43.0)	43.9 (41.6 - 46.5)	46.3 (43.9 - 49.2)	47.1 (44.4 - 49.5)	45.1 (41.4 - 49.8)	37.1 (34.7 - 39.6)	49.8 (46.8 - 53.2)
50-yr													
Wind Speed 3 hr average (m/s)	26.1 (23.0 - 30.2)	21.9 (18.9 - 25.8)	24.2 (20.7 - 28.5)	25.1 (22.4 - 28.4)	27.4 (25.0 - 30.3)	26.4 (24.6 - 28.6)	29.9 (27.4 - 33.0)	31.6 (29.1 - 35.1)	33.1 (30.4 - 37.2)	34.3 (31.3 - 37.7)	33.5 (29.0 - 40.9)	28.6 (25.7 - 32.2)	35.4 (32.1 - 39.8)
Wind Speed 1 hr average (m/s)	27.7 (24.4 - 32.2)	23.1 (19.9 - 27.4)	25.6 (21.9 - 30.4)	26.6 (23.7 - 30.3)	29.2 (26.6 - 32.3)	28.1 (26.0 - 30.5)	32.0 (29.2 - 35.4)	33.8 (31.1 - 37.8)	35.6 (32.5 - 40.2)	36.9 (33.5 - 40.8)	36.0 (30.9 - 44.3)	30.6 (27.3 - 34.5)	38.1 (34.4 - 43.2)
Wind Speed 10 min average (m/s)	30.4 (26.6 - 35.6)	25.2 (21.5 - 30.0)	28.0 (23.7 - 33.4)	29.1 (25.8 - 33.3)	32.1 (29.1 - 35.8)	30.8 (28.5 - 33.6)	35.4 (32.1 - 39.4)	37.5 (34.2 - 42.1)	39.5 (35.9 - 45.0)	41.1 (37.1 - 45.7)	40.1 (34.1 - 50.0)	33.7 (30.0 - 38.3)	42.6 (38.1 - 48.6)
Wind Speed 1 min average (m/s)	33.8 (29.4 - 40.0)	27.8 (23.6 - 33.4)	31.1 (26.1 - 37.4)	32.4 (28.5 - 37.3)	35.9 (32.3 - 40.1)	34.3 (31.6 - 37.6)	39.7 (35.8 - 44.4)	42.2 (38.4 - 47.7)	44.6 (40.4 - 51.2)	46.4 (41.7 - 52.1)	45.3 (38.2 - 57.3)	37.7 (33.3 - 43.2)	48.3 (42.9 - 55.6)
Wind Speed 15 s gust (m/s)	35.9 (31.1 - 42.6)	29.4 (24.8 - 35.4)	32.9 (27.6 - 39.8)	34.3 (30.2 - 39.7)	38.1 (34.3 - 42.8)	36.4 (33.5 - 40.0)	42.3 (38.1 - 47.5)	45.0 (40.8 - 51.1)	47.7 (43.0 - 55.0)	49.7 (44.5 - 55.9)	48.4 (40.6 - 61.7)	40.1 (35.4 - 46.1)	51.7 (45.8 - 59.8)
Wind Speed 3 s gust (m/s)	38.3 (33.1 - 45.7)	31.2 (26.3 - 37.7)	35.0 (29.3 - 42.6)	36.6 (32.1 - 42.4)	40.7 (36.5 - 45.8)	38.9 (35.7 - 42.8)	45.3 (40.7 - 51.0)	48.3 (43.7 - 55.0)	51.3 (46.1 - 59.3)	53.5 (47.8 - 60.4)	52.0 (43.5 - 66.8)	42.9 (37.7 - 49.5)	55.7 (49.2 - 64.7)
100-yr													
Wind Speed 3 hr average (m/s)	27.6 (23.6 - 33.4)	23.1 (19.3 - 28.8)	25.7 (21.3 - 32.3)	26.4 (23.0 - 31.1)	28.6 (25.5 - 32.8)	27.3 (24.9 - 30.6)	31.0 (27.7 - 35.9)	32.6 (29.3 - 37.8)	34.3 (30.7 - 40.3)	35.7 (31.7 - 41.0)	35.1 (29.2 - 46.1)	30.0 (26.3 - 35.2)	36.7 (32.5 - 43.0)
Wind Speed 1 hr average (m/s)	29.4 (25.0 - 35.9)	24.5 (20.3 - 30.7)	27.3 (22.5 - 34.6)	28.1 (24.3 - 33.3)	30.5 (27.1 - 35.2)	29.0 (26.4 - 32.8)	33.2 (29.5 - 38.7)	34.9 (31.3 - 40.9)	36.8 (32.8 - 43.7)	38.5 (34.0 - 44.4)	37.8 (31.2 - 50.4)	32.1 (27.9 - 37.9)	39.6 (34.8 - 46.8)
Wind Speed 10 min average (m/s)	32.4 (27.3 - 39.9)	26.7 (22.0 - 33.9)	30.0 (24.4 - 38.4)	30.8 (26.5 - 36.8)	33.6 (29.7 - 39.1)	31.9 (28.9 - 36.2)	36.7 (32.5 - 43.2)	38.8 (34.6 - 45.9)	41.0 (36.3 - 49.3)	43.0 (37.7 - 50.2)	42.2 (34.4 - 57.5)	35.4 (30.7 - 42.3)	44.3 (38.6 - 53.0)
Wind Speed 1 min average (m/s)	36.1 (30.3 - 45.1)	29.6 (24.2 - 37.9)	33.3 (26.9 - 43.3)	34.3 (29.3 - 41.4)	37.6 (33.1 - 44.2)	35.6 (32.1 - 40.7)	41.3 (36.3 - 49.1)	43.7 (38.7 - 52.2)	46.4 (40.8 - 56.4)	48.8 (42.4 - 57.5)	47.8 (38.5 - 66.5)	39.8 (34.1 - 47.9)	50.4 (43.5 - 61.0)
Wind Speed 15 s gust (m/s)	38.4 (32.1 - 48.2)	31.3 (25.5 - 40.3)	35.4 (28.4 - 46.3)	36.4 (31.0 - 44.2)	40.0 (35.1 - 47.2)	37.8 (34.1 - 43.4)	44.0 (38.5 - 52.6)	46.7 (41.2 - 56.1)	49.6 (43.5 - 60.7)	52.2 (45.3 - 61.9)	51.2 (41.0 - 72.0)	42.4 (36.2 - 51.3)	54.1 (46.5 - 65.8)
Wind Speed 3 s gust (m/s)	41.0 (34.1 - 51.8)	33.3 (27.0 - 43.2)	37.7 (30.1 - 49.7)	38.9 (33.0 - 47.4)	42.8 (37.4 - 50.7)	40.4 (36.3 - 46.5)	47.2 (41.2 - 56.7)	50.2 (44.1 - 60.6)	53.4 (46.7 - 65.7)	56.3 (48.6 - 67.0)	55.1 (43.9 - 78.3)	45.4 (38.7 - 55.2)	58.3 (49.9 - 71.4)
500-yr													
Wind Speed 3 hr average (m/s)	31.1 (24.9 - 42.7)	26.0 (20.0 - 37.9)	29.3 (22.3 - 43.3)	29.3 (23.7 - 38.5)	31.2 (26.4 - 40.3)	29.2 (25.3 - 37.1)	33.3 (28.1 - 44.7)	34.9 (29.7 - 46.1)	36.8 (31.0 - 50.4)	39.0 (32.4 - 51.2)	38.8 (29.6 - 64.1)	33.1 (27.2 - 44.2)	39.7 (33.1 - 52.3)
Wind Speed 1 hr average (m/s)	33.3 (26.4 - 46.5)	27.6 (21.0 - 41.0)	31.3 (23.6 - 47.2)	31.2 (25.2 - 41.6)	33.4 (28.1 - 43.7)	31.2 (26.9 - 40.1)	35.8 (30.0 - 48.8)	37.5 (31.8 - 50.4)	39.7 (33.2 - 55.5)	42.2 (34.7 - 56.4)	42.0 (31.6 - 72.0)	35.5 (28.9 - 48.2)	43.1 (35.5 - 57.7)
Wind Speed 10 min average (m/s)	36.9 (28.9 - 52.7)	30.3 (22.8 - 45.9)	34.5 (25.7 - 53.5)	34.5 (27.5 - 46.7)	37.0 (30.8 - 49.3)	34.4 (29.5 - 44.9)	39.8 (33.0 - 55.5)	41.8 (35.1 - 57.4)	44.4 (36.7 - 63.7)	47.4 (38.5 - 64.9)	47.2 (34.9 - 85.1)	39.5 (31.8 - 54.7)	48.5 (39.5 - 66.6)
Wind Speed 1 min average (m/s)	41.5 (32.1 - 60.6)	33.7 (25.1 - 52.3)	38.7 (28.3 - 61.6)	38.6 (30.4 - 53.3)	41.6 (34.4 - 56.4)	38.6 (32.8 - 51.1)	45.0 (36.9 - 64.1)	47.4 (39.3 - 66.5)	50.5 (41.3 - 74.4)	54.2 (43.4 - 75.9)	53.8 (39.2 - 101.8)	44.6 (35.4 - 63.1)	55.4 (44.6 - 78.0)
Wind Speed 15 s gust (m/s)	44.3 (34.0 - 65.3)	35.7 (26.4 - 56.2)	41.2 (30.0 - 66.5)	41.1 (32.2 - 57.2)	44.3 (36.5 - 60.7)	41.0 (34.7 - 54.8)	48.1 (39.2 - 69.3)	50.7 (41.9 - 71.9)	54.2 (44.1 - 80.8)	58.2 (46.3 - 82.5)	57.8 (41.7 - 111.9)	47.7 (37.7 - 68.2)	59.6 (47.6 - 84.9)
Wind Speed 3 s gust (m/s)	47.5 (36.2 - 70.9)	38.1 (28.0 - 60.7)	44.1 (31.8 - 72.1)	44.0 (34.3 - 61.8)	47.6 (38.9 - 65.7)	43.9 (37.0 - 59.1)	51.7 (41.9 - 75.2)	54.6 (44.9 - 78.2)	58.4 (47.2 - 88.2)	62.9 (49.8 - 90.1)	62.5 (44.7 - 123.5)	51.2 (40.2 - 74.0)	64.5 (51.2 - 92.8)
1000-yr													
Wind Speed 3 hr average (m/s)	32.6 (25.3 - 47.5)	27.2 (20.2 - 43.4)	30.9 (22.6 - 49.9)	30.4 (24.0 - 42.2)	32.2 (26.7 - 44.1)	30.1 (25.5 - 40.8)	34.3 (28.2 - 49.9)	35.8 (29.9 - 51.0)	37.9 (31.1 - 55.9)	40.4 (32.5 - 57.0)	40.4 (29.8 - 74.9)	34.4 (27.4 - 49.1)	41.0 (33.2 - 57.4)
Wind Speed 1 hr average (m/s)	35.0 (26.9 - 52.0)	28.9 (21.3 - 47.3)	33.0 (23.9 - 54.8)	32.6 (25.4 - 45.8)	34.5 (28.4 - 48.1)	32.1 (27.1 - 44.3)	36.9 (30.1 - 54.9)	38.6 (31.9 - 56.2)	40.9 (33.3 - 62.1)	43.8 (34.8 - 63.4)	43.8 (31.8 - 85.7)	37.0 (29.2 - 53.9)	44.5 (35.7 - 63.9)
Wind Speed 10 min average (m/s)	38.9 (29.4 - 59.5)	31.8 (23.1 - 53.6)	36.5 (26.1 - 63.0)	36.0 (27.8 - 51.8)	38.3 (31.2 - 54.6)	35.5 (29.6 - 50.0)	41.1 (33.1 - 63.0)	43.1 (35.2 - 64.6)	45.9 (36.8 - 72.1)	49.4 (38.7 - 73.8)	49.3 (35.1 - 103.4)	41.2 (32.1 - 61.8)	50.3 (39.7 - 74.4)
Wind Speed 1 min average (m/s)	43.9 (32.7 - 69.0)	35.5 (25.4 - 61.7)	41.1 (28.8 - 73.4)	40.4 (30.8 - 59.6)	43.2 (34.7 - 63.0)	39.8 (33.0 - 57.3)	46.6 (37.0 - 73.4)	49.0 (39.5 - 75.5)	52.3 (41.4 - 85.0)	56.5 (43.6 - 87.2)	56.5 (39.4 - 126.1)	46.7 (35.8 - 71.9)	57.6 (44.8 - 88.0)
Wind Speed 15 s gust (m/s)	46.8 (34.7 - 74.8)	37.7 (26.8 - 66.6)	43.8 (30.5 - 79.7)	43.1 (32.6 - 64.2)	46.1 (36.9 - 68.0)	42.4 (35.0 - 61.7)	49.8 (39.3 - 79.7)	52.5 (42.1 - 82.1)	56.1 (44.2 - 92.8)	60.8 (46.6 - 95.3)	60.8 (41.9 - 139.8)	50.0 (38.1 - 78.0)	62.0 (47.9 - 96.1)
Wind Speed 3 s gust (m/s)	50.3 (37.0 - 81.4)	40.3 (28.4 - 72.3)	46.9 (32.4 - 87.0)	46.2 (34.7 - 69.6)	49.5 (39.4 - 73.9)	45.5 (37.3 - 66.8)	53.6 (42.1 - 87.0)	56.5 (45.1 - 89.7)	60.6 (47.4 - 101.8)	65.8 (50.0 - 104.6)	65.8 (44.9 - 155.7)	53.8 (40.7 - 85.1)	67.2 (51.5 - 105.6)

3.3 Water levels

3.3.1 Introduction

The timeseries based on the 2D DCSM-FM results (cf. Section 2.2.4) are used as input for the statistical analysis, these timeseries cover the period of 11 January 1979 to 31 December 2021 (first 10 days are ignored as it covers the spin-up period of the model). Figure 3.6 to Figure 3.8 show the timeseries at the three turbine locations.

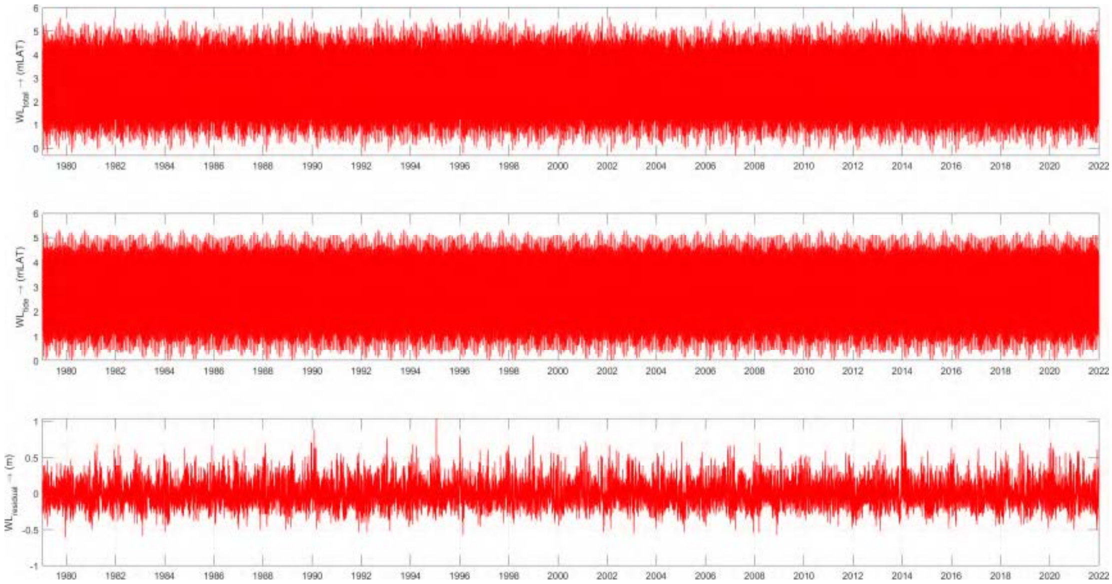


Figure 3.6 Timeseries of location WTG15 total (top panel), tidal (middle panel) and residual (bottom panel) water levels.

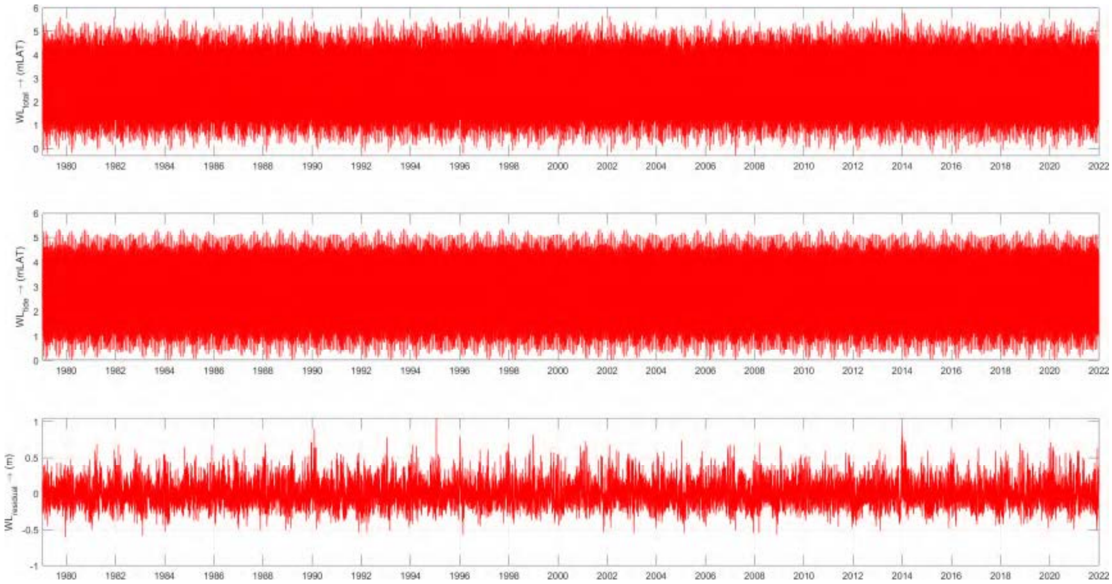


Figure 3.7 Timeseries of location WTG08 total (top panel), tidal (middle panel) and residual (bottom panel) water levels.

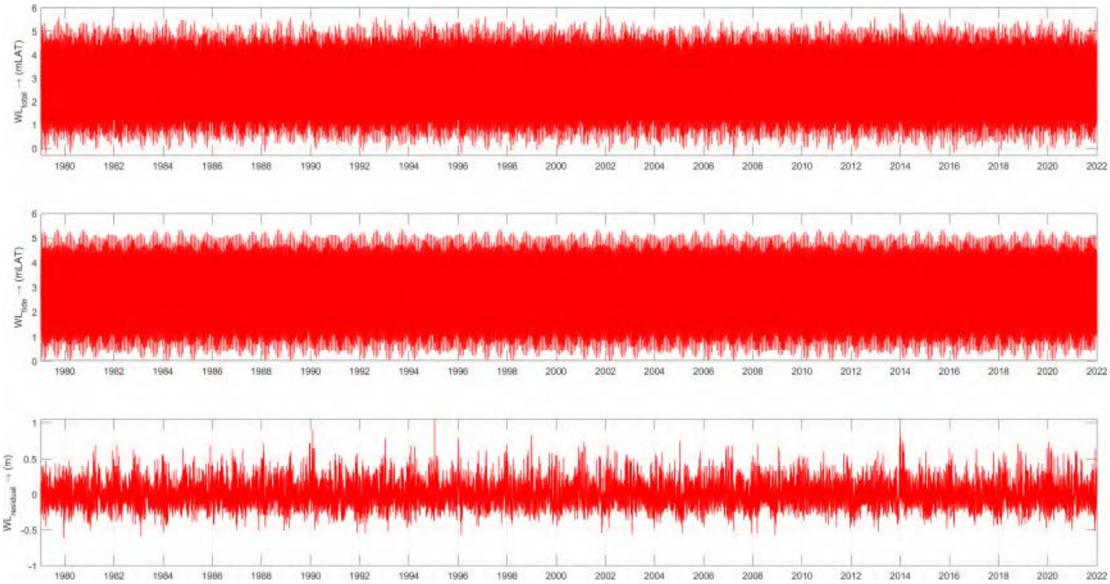


Figure 3.8 Timeseries of location WTG11 total (top panel), tidal (middle panel) and residual (bottom panel) water levels.

3.3.2 Tidal levels

The tidal levels computed at the three turbine locations are nearly identical due to relatively small distances between the locations. The levels are given in Table 3.4.

Table 3.4 Tidal levels.

Tidal levels	WTG15		WTG08		WTG11	
	mMSL	mLAT	mMSL	mLAT	mMSL	mLAT
Highest Astronomical tide, HAT	2.62	5.33	2.65	5.37	2.64	5.36
Mean High Water Spring, MHWS	2.18	4.89	2.20	4.93	2.19	4.91
Mean High Water, MHW	1.51	4.21	1.52	4.24	1.52	4.24
Mean High Water Neap, MHWN	0.93	3.64	0.94	3.66	0.94	3.66
Mean Sea Level, MSL	0.00	2.71	0.00	2.72	0.00	2.72
Mean Low Water Neap, MLWN	-0.91	1.80	-0.92	1.80	-0.92	1.80
Mean Low Water, MLW	-1.49	1.22	-1.50	1.22	-1.50	1.22
Mean Low Water Spring, MLWS	-2.18	0.53	-2.19	0.53	-2.19	0.53
Lowest Astronomical tide, LAT	-2.71	0.00	-2.72	0.00	-2.72	0.00

3.3.3 Extreme conditions

Extreme value analyses (EVA) of each 43-year long (11-01-1979 00:00 – 31-12-2021 23:50) timeseries of the total and residual water level at the three turbine locations were carried out using again the POT method, see Appendix B. The EVA were aimed at determining the extreme high and low extreme (still) water levels (EWL) at the turbine locations. The return value estimates are given in Table 3.5 and in the spreadsheets accompanying this report (cf. Appendix E). EVA fits to the data are shown in Figure 3.9 – Figure 3.11.

Table 3.5 Water level return value estimates.

Turbine	RP (yr)	High EWL (mLAT)	Low EWL (mLAT)
WTG15	1	5.39 (5.38 - 5.41)	0.03 (0.05 - 0.00)
	5	5.53 (5.49 - 5.58)	-0.13 (-0.09 - -0.17)
	10	5.59 (5.54 - 5.66)	-0.20 (-0.14 - -0.25)
	50	5.74 (5.62 - 5.90)	-0.33 (-0.22 - -0.47)
	100	5.80 (5.64 - 6.04)	-0.39 (-0.24 - -0.57)
	500	5.94 (5.67 - 6.47)	-0.50 (-0.28 - -0.84)
	1000	6.00 (5.69 - 6.75)	-0.54 (-0.29 - -0.98)
WTG08	1	5.43 (5.41 - 5.44)	0.03 (0.05 - 0.00)
	5	5.57 (5.53 - 5.61)	-0.14 (-0.10 - -0.18)
	10	5.63 (5.57 - 5.69)	-0.20 (-0.15 - -0.26)
	50	5.77 (5.65 - 5.93)	-0.35 (-0.24 - -0.49)
	100	5.83 (5.68 - 6.06)	-0.41 (-0.26 - -0.61)
	500	5.98 (5.72 - 6.46)	-0.53 (-0.31 - -0.93)
	1000	6.04 (5.74 - 6.68)	-0.58 (-0.32 - -1.09)
WTG11	1	5.42 (5.41 - 5.44)	0.03 (0.05 - 0.00)
	5	5.56 (5.52 - 5.60)	-0.14 (-0.10 - -0.18)
	10	5.62 (5.57 - 5.68)	-0.20 (-0.14 - -0.25)
	50	5.77 (5.64 - 5.92)	-0.34 (-0.23 - -0.48)
	100	5.83 (5.66 - 6.07)	-0.40 (-0.25 - -0.58)
	500	5.97 (5.70 - 6.54)	-0.52 (-0.30 - -0.87)
	1000	6.03 (5.71 - 6.80)	-0.57 (-0.32 - -1.01)

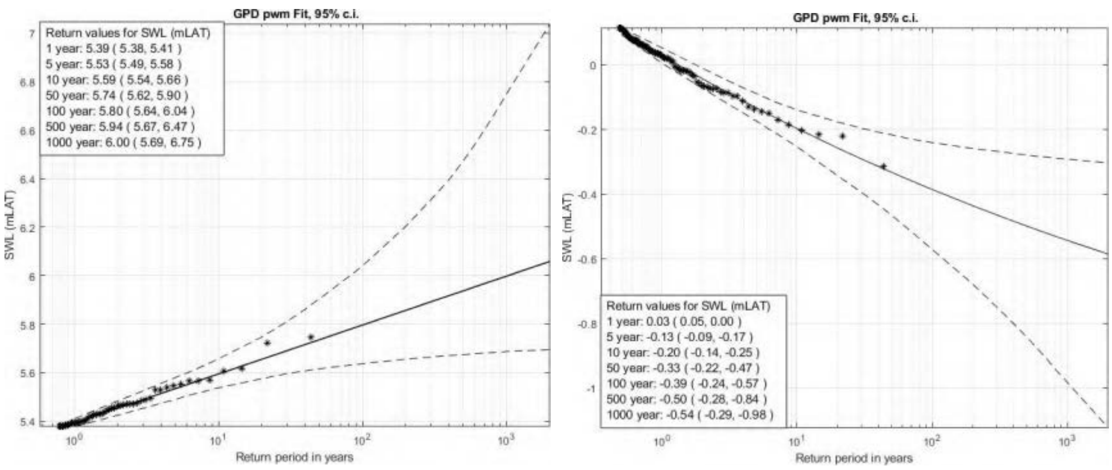


Figure 3.9 Water level return value plots for WTG15, left panel: high EWL and right panel: low EWL. The dashed lines are the associated 95% confidence intervals. The POT data are represented by the asterisks, with as plotting position (xi, (n+1)/(λ_u(n+1-i)), where n is the sample size, i the order and λ_u the Poisson rate.

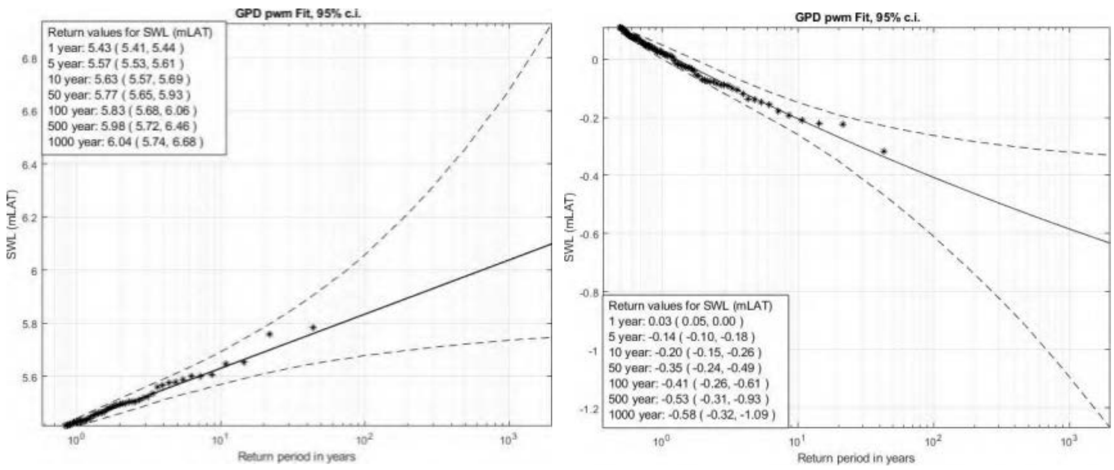


Figure 3.10 Water level return value plots for WTG08, left panel: high EWL and right panel: low EWL.

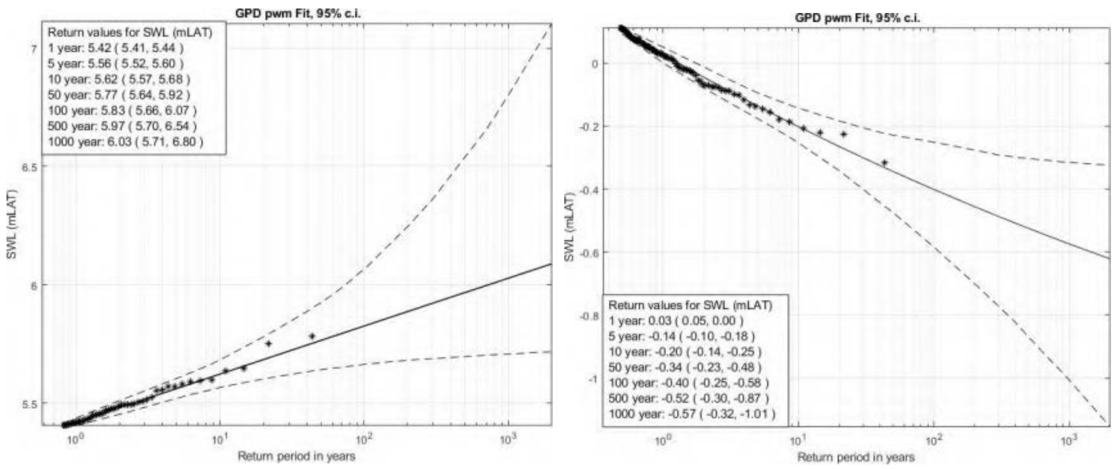


Figure 3.11 Water level return value plots for WTG11, left panel: high EWL and right panel: low EWL.

3.4 Currents

3.4.1 Introduction

In this section the statistics of normal and extreme conditions of the depth-averaged, near-bottom and surface, total, tidal and residual current velocities at the three considered turbine locations are presented. The timeseries derived from the 2DH DCSM-FM results are used as basis for the statistical analyses (see Section 2.2.4). In all situations the surface current is valid at the still water level, which varies over time due to tide and surge, and the near-bottom current at 0.5 m above the seabed (fixed level).

In the following the timeseries are presented. Given that per location there are three timeseries plots for depth-averaged, near-bottom and surface, respectively, these plots are given in separate subsections for each location to facilitate the consultation of the report. Note that the current direction timeseries are equal for all depth levels (surface, DA and near-bottom); those are thereford only shown in the depth-averaged plots.

3.4.1.1 WTG15

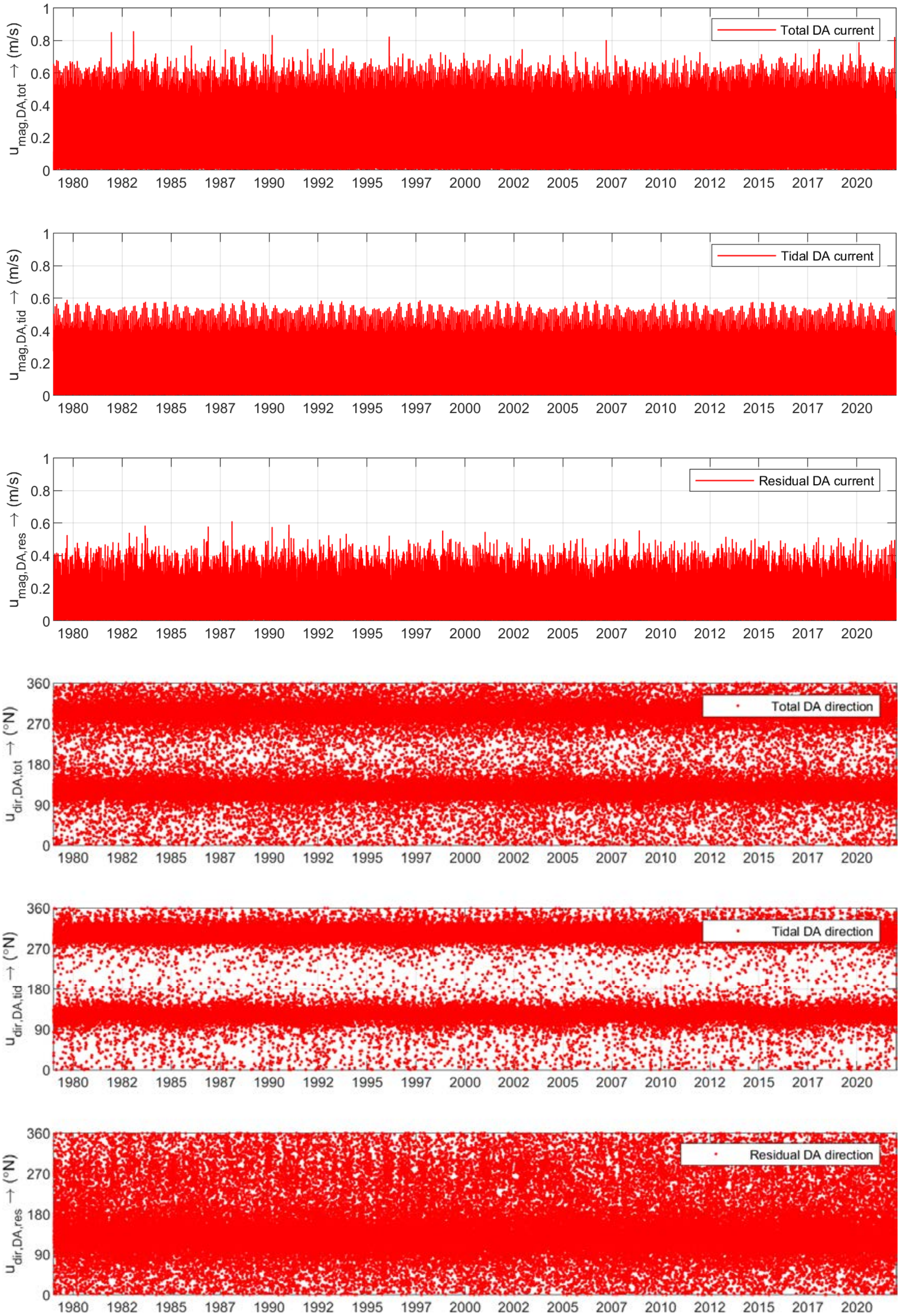


Figure 3.12 Timeseries of total, tidal and residual depth-averaged current velocities (top 3) and directions (bottom 3) at WTG15.

Figure 3.13 Timeseries of total, tidal and residual surface current velocities at WTG15.

Figure 3.14 Timeseries of total, tidal and residual near-bottom current velocities at WTG15.

3.4.1.2 WTG08

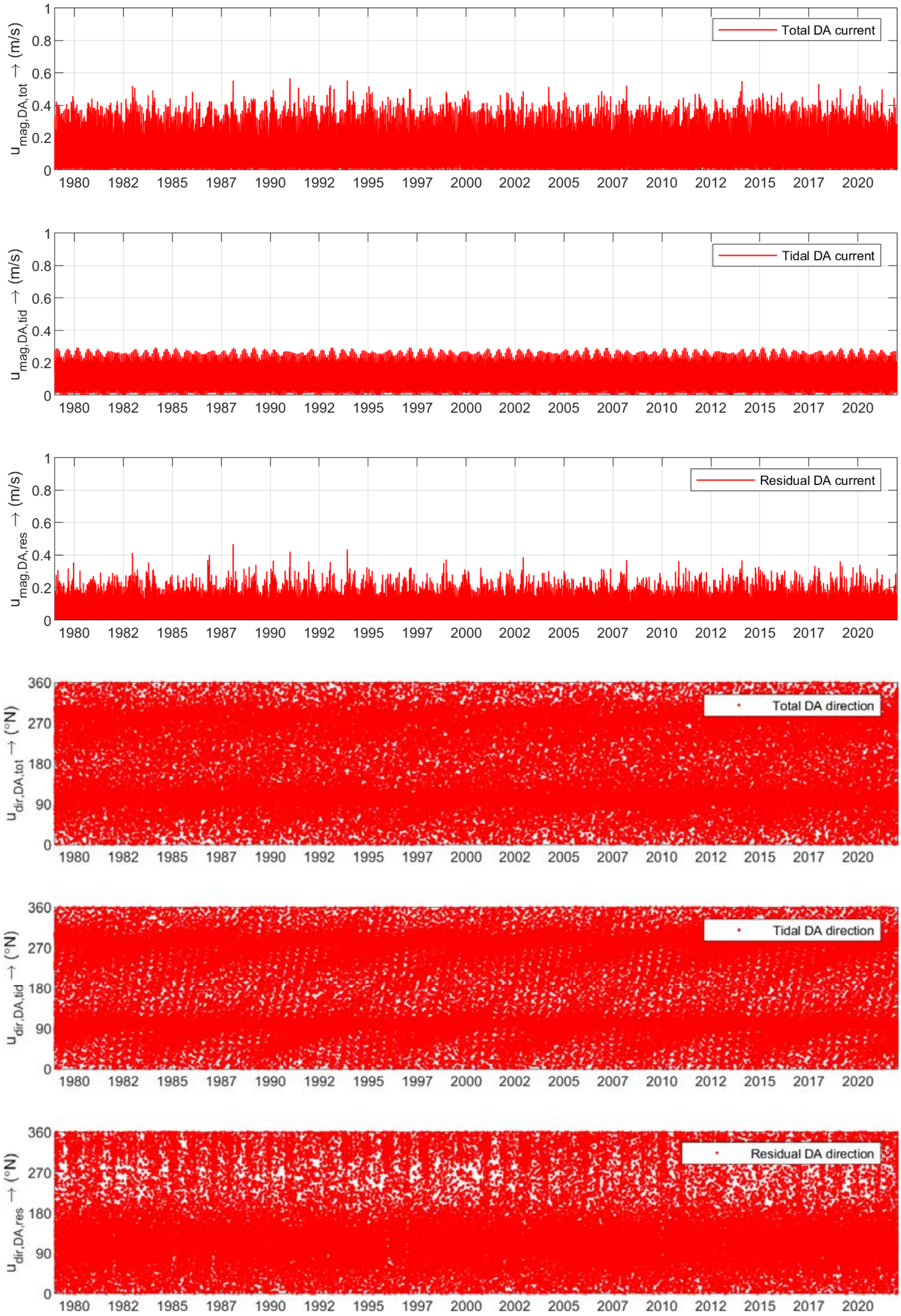


Figure 3.15 Timeseries of total, tidal and residual depth-averaged current velocities (top 3) and directions (bottom 3) at WTG08.

Figure 3.16 Timeseries of total, tidal and residual surface current velocities at WTG08.

Figure 3.17 Timeseries of total, tidal and residual near-bottom current velocities at WTG08.

3.4.1.3 WTG11

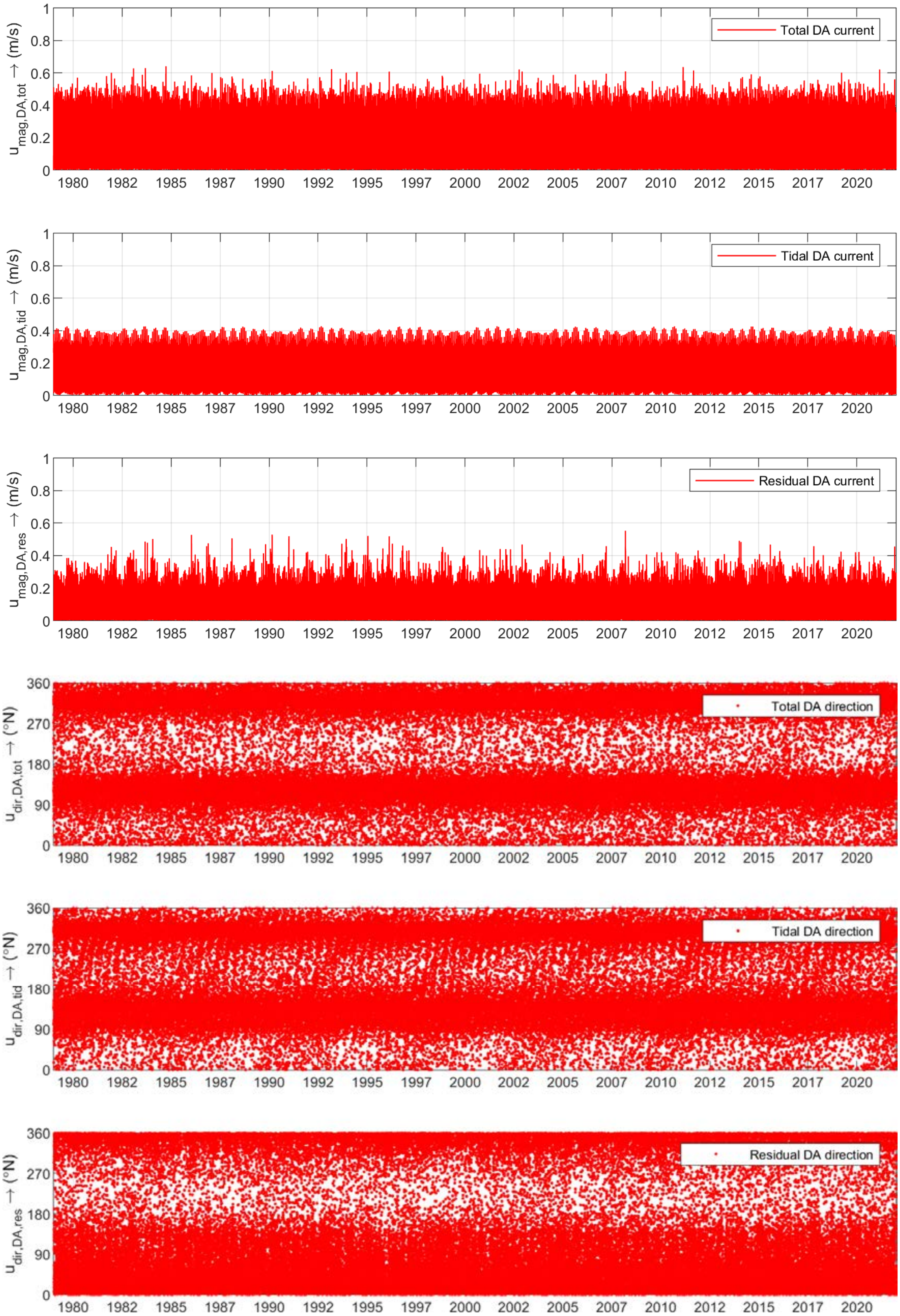


Figure 3.18 Timeseries of total, tidal and residual depth-averaged current velocities (top 3) and directions (bottom 3) at WTG11.

Figure 3.19 Timeseries of total, tidal and residual surface current velocities at WTG11.

Figure 3.20 Timeseries of total, tidal and residual near-bottom current velocities at WTG11.

3.4.2 Normal conditions

The normal current conditions are described by means of roses and joint occurrence tables. The figures are given in the following subsections per reference location. The roses and joint occurrence tables are also available in the spreadsheets per turbine location delivered together with this report.

The figures of current roses and joint occurrence tables show that:

- At WTG15 the depth-averaged (near-bottom and surface) currents are generally below 0.7 m/s (0.4 m/s and 0.8 m/s). The most predominant depth-averaged total currents are towards the East-southeast followed by the West-northwest. Tidal current velocities are generally below 0.6 m/s and are oriented from the East-southeast towards the West-northwest. The residual currents are generally smaller than the tidal current velocities and are mainly directed towards the East-southeast.
- At WTG08 the depth-averaged (near-bottom and surface) currents are generally below 0.4 m/s (0.3 m/s and 0.5 m/s). The most predominant depth-averaged total currents are towards the East followed by the West. Tidal current velocities are generally below 0.25 m/s and are oriented from the East towards the West (following the orientation of the gully in which WTG08 is located). The residual currents are generally smaller than the tidal current velocities and are mainly directed towards the East-southeast.
- At WTG11 the depth-averaged (near-bottom and surface) currents are generally below 0.5 m/s (0.35 m/s and 0.6 m/s). The most predominant depth-averaged total currents are towards North-northwest followed by East-southeast. Tidal current velocities are generally below 0.4 m/s and are oriented from the West-northwest towards the Southeast. The residual currents are generally smaller than the tidal current velocities and are mainly directed towards the North and North-northeast, while the highest residual currents are found towards the East-southeast.

3.4.2.1 WTG15

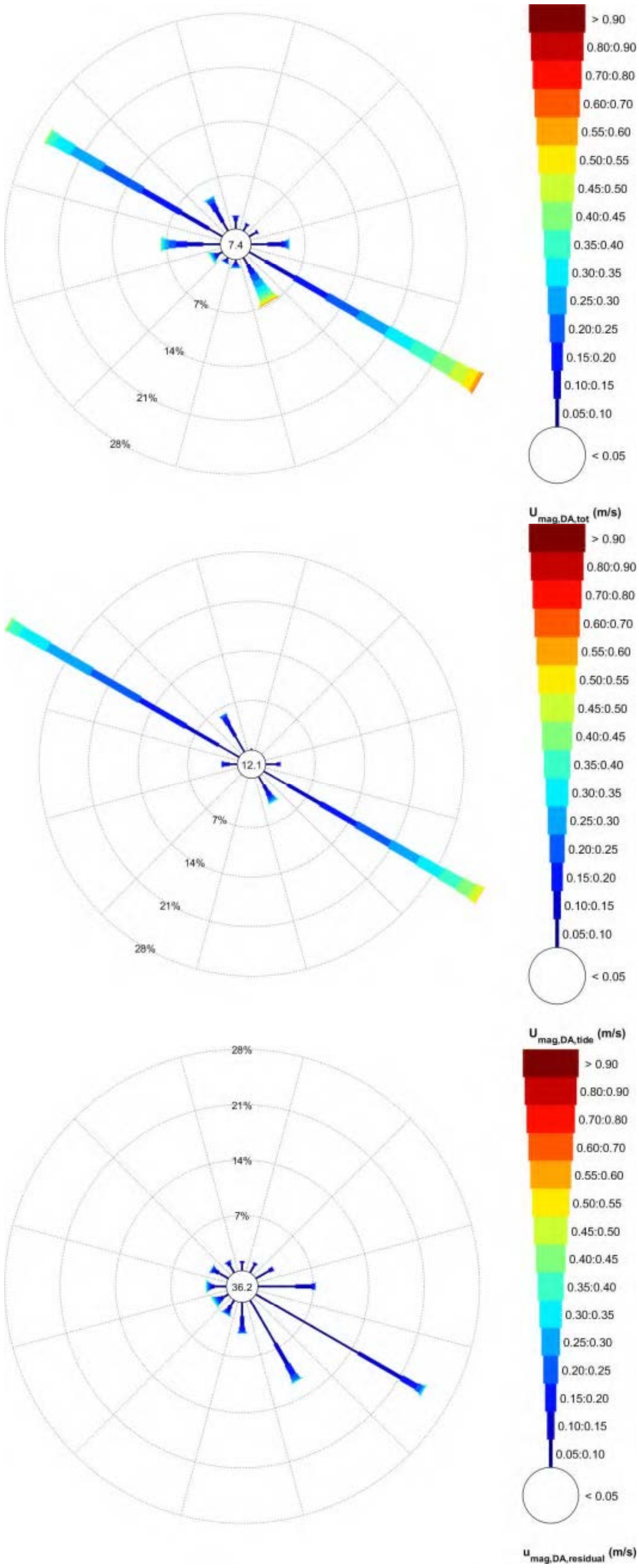


Figure 3.21 Roses of the depth-averaged total (top), tidal (middle) and residual (bottom) current speed and direction at WTG15.

$u_{mag,DA,tot}$ → (m/s) \ $u_{dir,DA,tot}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90					0.00	0.00							0.00
0.70-0.80					0.00	0.00							0.01
0.60-0.70					0.13	0.04					0.00		0.17
0.55-0.60					0.46	0.09				0.00	0.00		0.54
0.50-0.55					1.17	0.18	0.00		0.00	0.00	0.01	0.00	1.37
0.45-0.50				0.00	2.04	0.31	0.00		0.01	0.01	0.05	0.00	2.43
0.40-0.45				0.01	2.79	0.43	0.00	0.00	0.03	0.05	0.26	0.00	3.58
0.35-0.40				0.03	3.26	0.57	0.01	0.00	0.07	0.14	0.96	0.02	5.06
0.30-0.35	0.00			0.06	3.79	0.74	0.03	0.01	0.12	0.29	2.47	0.07	7.58
0.25-0.30	0.01		0.00	0.14	4.28	0.90	0.08	0.04	0.16	0.54	4.56	0.20	10.91
0.20-0.25	0.06	0.00	0.00	0.26	4.68	0.92	0.18	0.09	0.19	0.93	5.87	0.49	13.67
0.15-0.20	0.20	0.06	0.03	0.60	4.95	0.76	0.28	0.18	0.22	1.46	5.79	1.11	15.63
0.10-0.15	0.47	0.23	0.23	1.78	4.32	0.68	0.23	0.18	0.23	2.08	4.18	1.70	16.32
0.05-0.10	1.01	0.77	1.04	2.12	2.44	1.12	0.37	0.29	0.62	2.23	2.04	1.31	15.36
0.00-0.05	0.45	0.49	0.52	0.53	0.70	0.79	0.65	0.62	0.75	0.90	0.57	0.40	7.39
	2.20	1.56	1.83	5.53	35.03	7.54	1.82	1.40	2.42	8.63	26.75	5.30	100.00 Total

Joint Occurence Table, $u_{mag,DA,tot}$ vs. $u_{dir,DA,tot}$

$u_{mag,DA,tid}$ → (m/s) \ $u_{dir,DA,tid}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60					0.05								0.05
0.50-0.55					0.39								0.39
0.45-0.50					0.96	0.00					0.01		0.97
0.40-0.45					1.95	0.01					0.40		2.36
0.35-0.40					3.01	0.04					1.67		4.72
0.30-0.35					3.73	0.11					4.39	0.00	8.24
0.25-0.30					4.60	0.25				0.01	7.06	0.05	11.97
0.20-0.25				0.00	5.47	0.46				0.08	7.90	0.34	14.25
0.15-0.20				0.09	5.88	0.74				0.32	7.50	1.11	15.64
0.10-0.15				0.53	5.32	1.11				0.75	5.35	2.00	15.07
0.05-0.10	0.22	0.01	0.07	1.52	3.90	1.50	0.01	0.00	0.03	1.08	3.34	2.53	14.20
0.00-0.05	0.95	0.71	0.86	1.42	1.59	1.23	0.56	0.35	0.45	0.90	1.69	1.43	12.15
	1.17	0.72	0.93	3.56	36.84	5.45	0.57	0.35	0.49	3.15	39.33	7.46	100.00 Total

Joint Occurence Table, $u_{mag,DA,tid}$ vs. $u_{dir,DA,tid}$

$u_{mag,DA,res}$ → (m/s) \ $u_{dir,DA,res}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70					0.00								0.00
0.55-0.60					0.00	0.00							0.00
0.50-0.55				0.00	0.00	0.00			0.00	0.00			0.00
0.45-0.50				0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00		0.02
0.40-0.45				0.00	0.01	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.08
0.35-0.40				0.00	0.04	0.03	0.00	0.01	0.07	0.05	0.00	0.00	0.21
0.30-0.35				0.00	0.09	0.08	0.02	0.05	0.12	0.09	0.02	0.00	0.46
0.25-0.30	0.00	0.00	0.00	0.01	0.23	0.20	0.06	0.08	0.19	0.15	0.05	0.01	0.97
0.20-0.25	0.01	0.00	0.00	0.06	0.67	0.61	0.19	0.16	0.25	0.20	0.12	0.04	2.32
0.15-0.20	0.05	0.03	0.06	0.42	2.16	1.53	0.55	0.31	0.32	0.23	0.26	0.14	6.07
0.10-0.15	0.25	0.26	0.53	2.07	6.30	3.04	1.38	0.62	0.37	0.39	0.60	0.40	16.22
0.05-0.10	0.92	1.13	1.94	4.71	14.96	6.38	1.81	0.89	0.73	1.46	1.41	1.06	37.41
0.00-0.05	1.27	1.45	1.99	3.37	6.91	7.27	3.86	2.59	2.38	2.30	1.58	1.28	36.23
	2.50	2.88	4.52	10.65	31.39	19.16	7.87	4.71	4.47	4.88	4.04	2.94	100.00 Total

Joint Occurence Table, $u_{mag,DA,res}$ vs. $u_{dir,DA,res}$

Figure 3.22 Joint occurrence tables of depth-averaged total (top), tidal (middle) and residual (bottom) current speed and direction at WTG15.

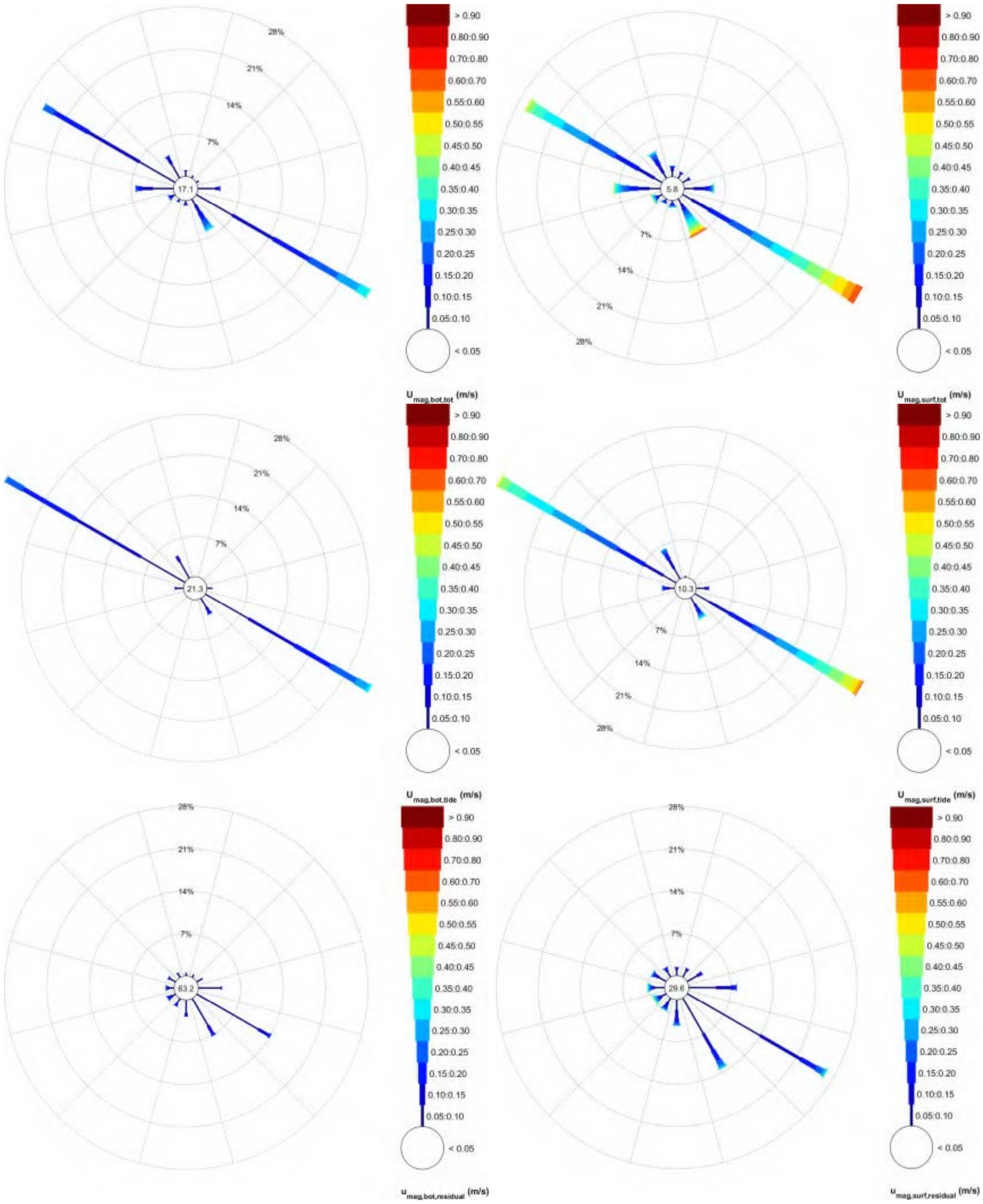


Figure 3.23 Roses of the near-bottom (left) and surface (right) total (top), tidal (middle) and residual (bottom) current speed and direction at WTG15.

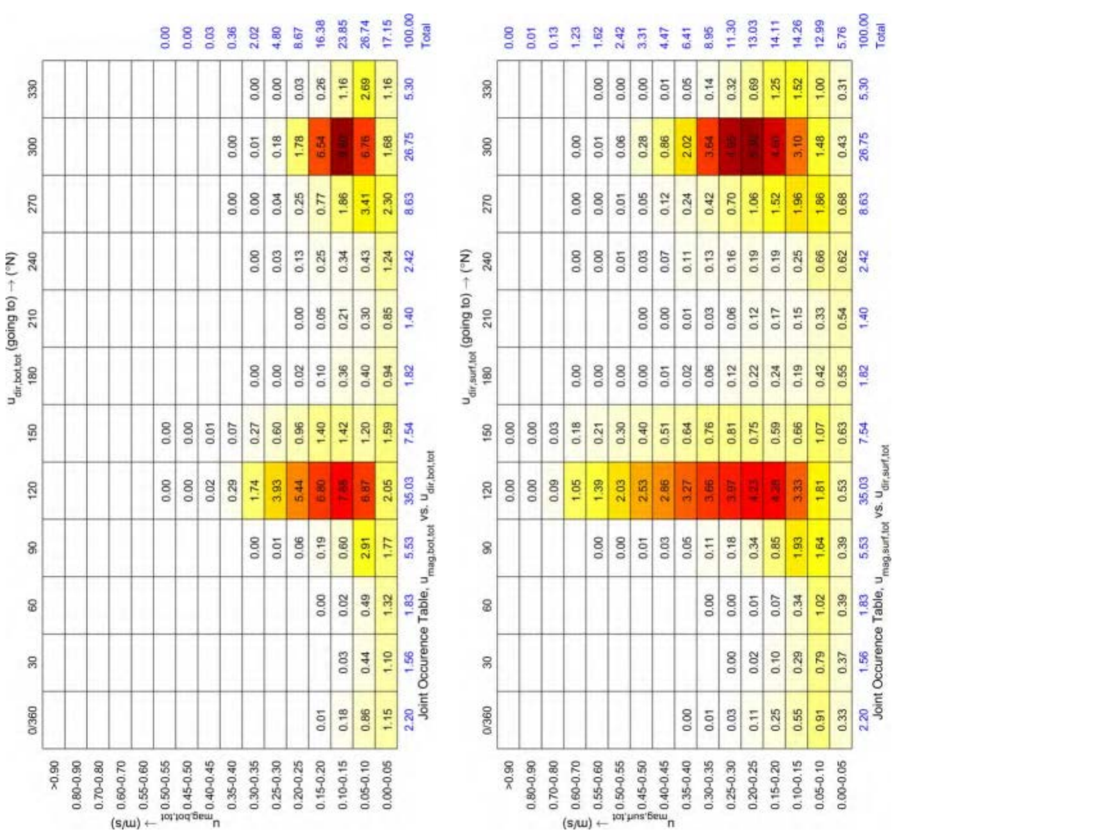


Figure 3.24 Joint occurrence tables of near-bottom (left) and surface (right) total current speed and direction at WTG15.

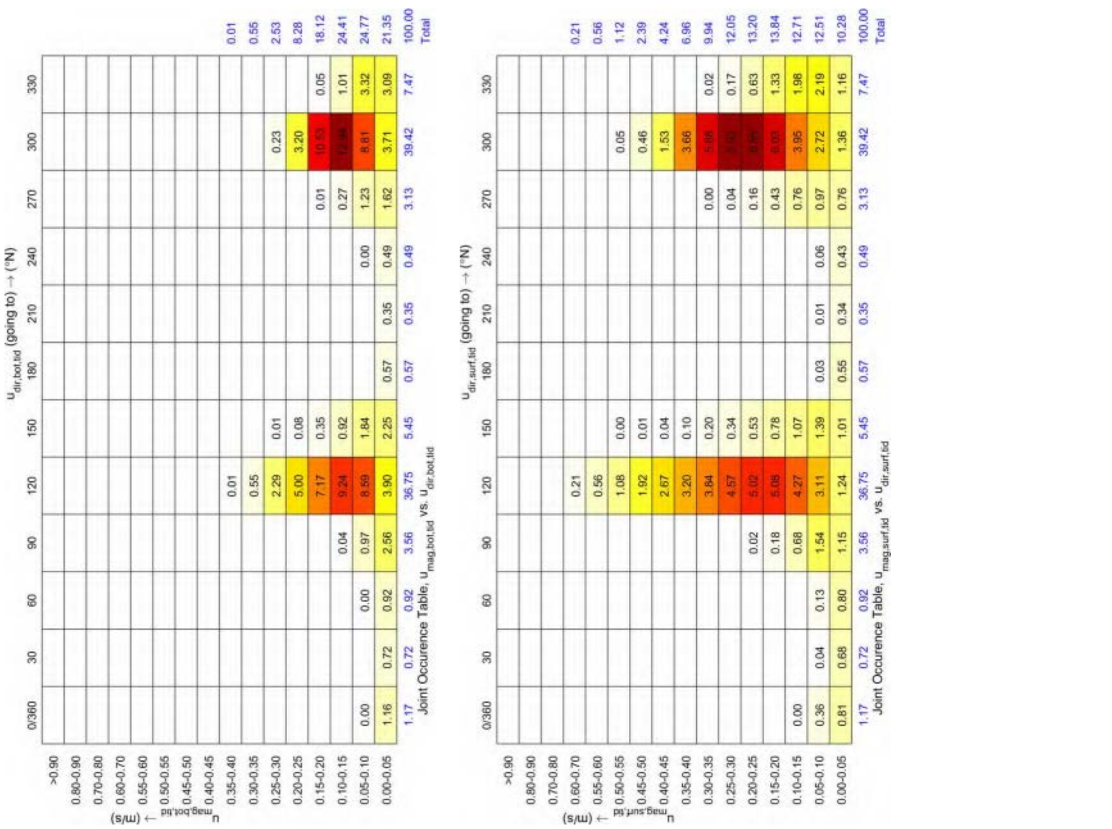


Figure 3.25 Joint occurrence tables of near-bottom (left) and surface (right) tidal and residual (bottom) current speed and direction at WTG15.

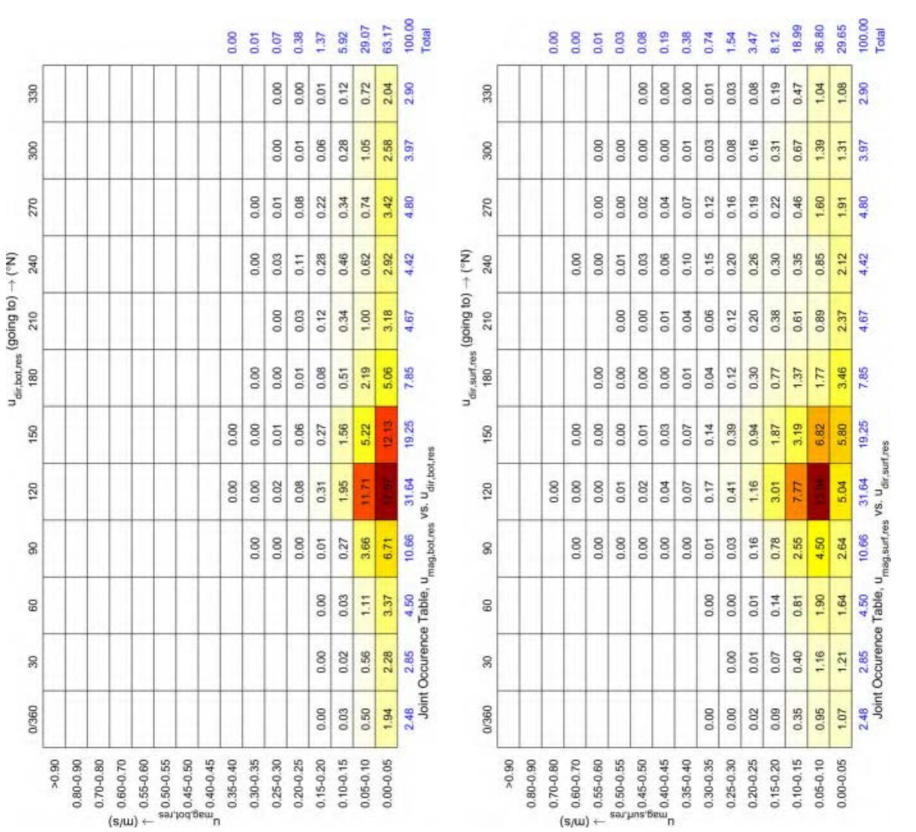


Figure 3.26 Joint occurrence tables of near-bottom (left) and surface (right) residual current speed and direction at WTG15.

3.4.2.2 WTG08

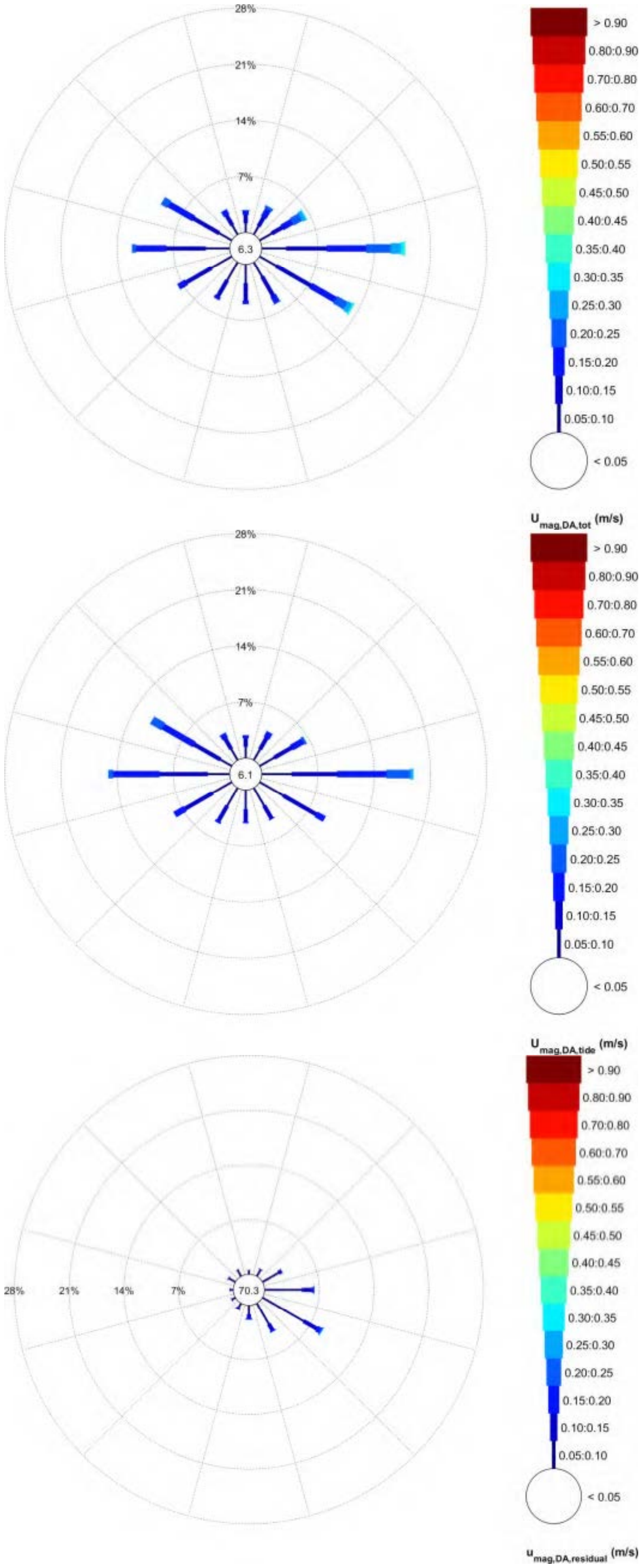


Figure 3.27 Roses of the depth-averaged total (top), tidal (middle) and residual (bottom) current speed and direction at WTG08.

$u_{mag,DA,tot}$ → (m/s) \ $u_{dir,DA,tot}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60				0.00	0.00								0.00
0.50-0.55				0.00	0.00								0.00
0.45-0.50				0.00	0.00								0.01
0.40-0.45			0.00	0.03	0.02								0.04
0.35-0.40		0.00	0.01	0.12	0.07								0.20
0.30-0.35		0.00	0.11	0.44	0.21	0.00					0.00		0.75
0.25-0.30	0.00	0.03	0.49	1.26	0.58	0.01	0.00			0.00	0.03	0.00	2.41
0.20-0.25	0.07	0.36	1.18	3.05	1.49	0.10	0.01	0.01	0.02	0.49	0.89	0.06	7.73
0.15-0.20	0.53	1.12	1.43	4.93	3.53	0.99	0.45	0.41	1.12	3.79	3.55	0.66	22.52
0.10-0.15	1.05	1.25	1.46	5.04	4.98	2.70	2.18	2.28	3.58	4.92	3.66	1.42	34.54
0.05-0.10	1.13	1.19	1.76	3.03	2.35	2.09	2.35	2.60	2.92	2.95	1.79	1.31	25.49
0.00-0.05	0.49	0.56	0.63	0.58	0.45	0.45	0.54	0.62	0.63	0.53	0.40	0.43	6.31
	3.29	4.51	7.07	18.47	13.69	6.34	5.53	5.92	8.28	12.69	10.32	3.89	100.00 Total

Joint Occurence Table, $u_{mag,DA,tot}$ vs. $u_{dir,DA,tot}$

$u_{mag,DA,tid}$ → (m/s) \ $u_{dir,DA,tid}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45													
0.35-0.40													
0.30-0.35													
0.25-0.30			0.00	0.42							0.00		0.42
0.20-0.25	0.01	0.07	0.34	2.95	0.01				0.00	0.64	1.59	0.07	5.67
0.15-0.20	0.37	0.80	1.60	6.15	1.17	0.15	0.17	0.30	1.47	5.74	4.47	0.63	23.03
0.10-0.15	1.08	1.57	2.48	5.64	4.72	1.82	1.59	2.14	3.96	6.02	3.75	1.48	36.25
0.05-0.10	1.40	1.56	2.10	3.73	3.42	2.57	2.42	2.61	2.75	2.71	1.64	1.59	28.50
0.00-0.05	0.72	0.81	0.94	0.64	0.23	0.33	0.47	0.47	0.28	0.17	0.45	0.62	6.13
	3.57	4.81	7.46	19.52	9.54	4.87	4.65	5.52	8.47	15.28	11.91	4.39	100.00 Total

Joint Occurence Table, $u_{mag,DA,tid}$ vs. $u_{dir,DA,tid}$

$u_{mag,DA,res}$ → (m/s) \ $u_{dir,DA,res}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50				0.00									0.00
0.40-0.45				0.00	0.00								0.00
0.35-0.40				0.00	0.00								0.01
0.30-0.35				0.00	0.01	0.00	0.00	0.00					0.02
0.25-0.30			0.00	0.02	0.05	0.01	0.01	0.00	0.00				0.09
0.20-0.25	0.00	0.00	0.00	0.06	0.16	0.04	0.05	0.01	0.00	0.00	0.00	0.00	0.33
0.15-0.20	0.00	0.01	0.04	0.26	0.55	0.16	0.18	0.06	0.01	0.01	0.01	0.01	1.30
0.10-0.15	0.05	0.13	0.46	1.30	1.93	0.90	0.49	0.19	0.07	0.06	0.11	0.07	5.77
0.05-0.10	0.48	0.92	2.34	4.76	6.06	3.09	1.15	0.64	0.48	0.42	0.92	0.90	22.16
0.00-0.05	4.41	5.03	7.52	11.55	12.74	8.22	4.38	2.84	2.44	2.66	3.78	4.76	70.33
	4.94	6.09	10.37	17.94	21.51	12.43	6.26	3.74	3.01	3.14	4.82	5.74	100.00 Total

Joint Occurence Table, $u_{mag,DA,res}$ vs. $u_{dir,DA,res}$

Figure 3.28 Joint occurrence tables of depth-averaged total (top), tidal (middle) and residual (bottom) current speed and direction at WTG08.

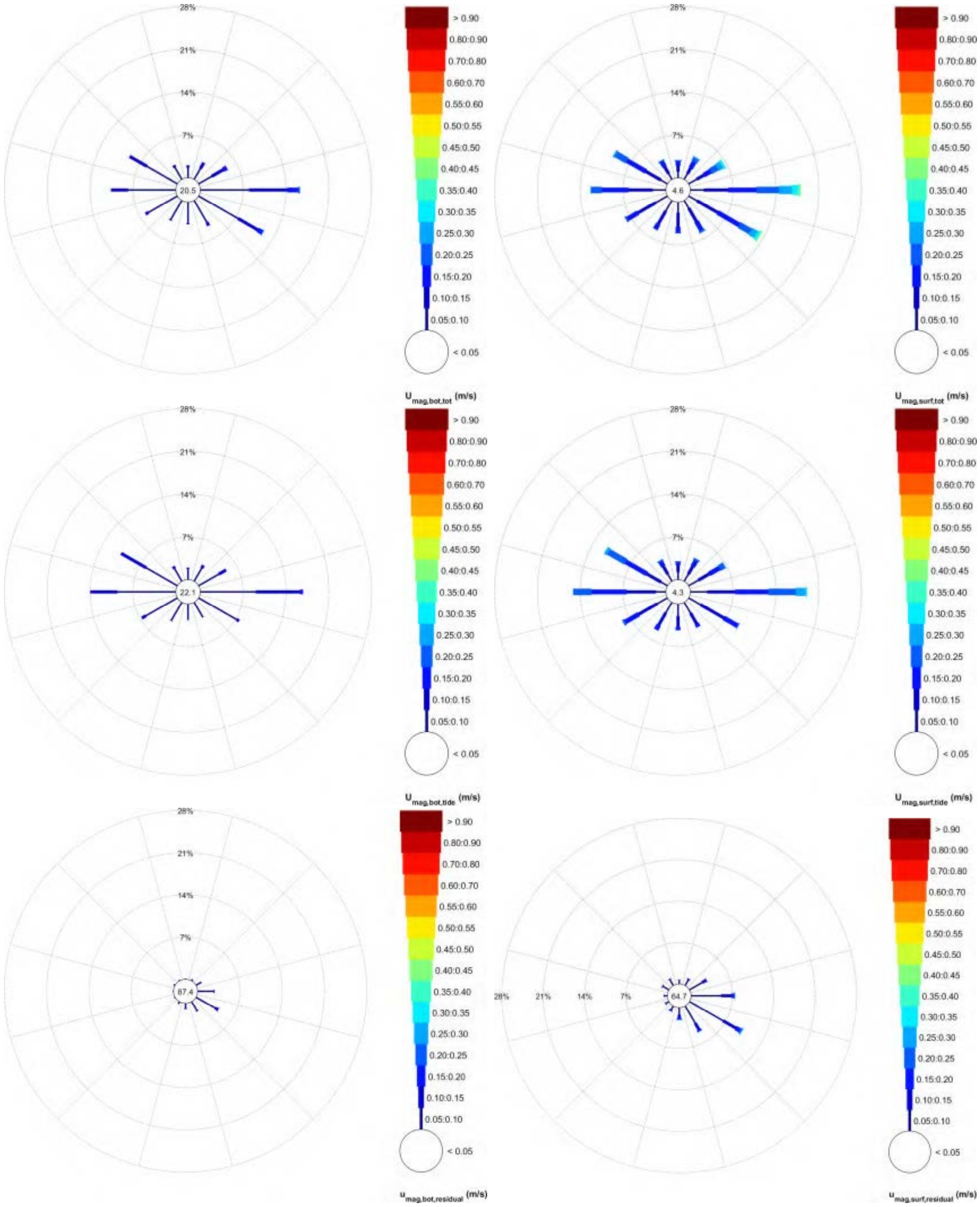


Figure 3.29 Roses of the near-bottom (left) and surface (right) total (top), tidal (middle) and residual (bottom) current speed and direction at WTG08.

$u_{dir,bot,tot}$ (going to) → (°N)

$u_{mag,bot,tot}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45													
0.35-0.40													
0.30-0.35				0.00	0.00								0.00
0.25-0.30			0.00	0.02	0.02								0.04
0.20-0.25		0.00	0.04	0.27	0.14	0.00							0.45
0.15-0.20	0.00	0.04	0.64	1.75	0.82	0.01	0.00			0.01	0.03	0.00	3.31
0.10-0.15	0.37	1.09	2.14	6.30	3.70	0.62	0.21	0.18	0.57	2.83	3.22	0.41	21.64
0.05-0.10	1.68	2.04	2.49	7.96	7.44	4.16	3.47	3.62	5.44	7.76	5.74	2.25	54.05
0.00-0.05	1.24	1.35	1.76	2.17	1.57	1.54	1.86	2.12	2.27	2.09	1.33	1.22	20.51
	3.29	4.51	7.07	18.47	13.69	6.34	5.53	5.92	8.28	12.69	10.32	3.89	100.00

Joint Occurence Table, $u_{mag,bot,tot}$ vs. $u_{dir,bot,tot}$

$u_{dir,surf,tot}$ (going to) → (°N)

$u_{mag,surf,tot}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70				0.00	0.00								0.00
0.55-0.60				0.00	0.00								0.00
0.50-0.55				0.01	0.01								0.01
0.45-0.50			0.00	0.03	0.02								0.05
0.40-0.45		0.00	0.01	0.11	0.06								0.19
0.35-0.40		0.00	0.08	0.36	0.17	0.00					0.00		0.61
0.30-0.35	0.00	0.01	0.33	0.92	0.43	0.01	0.00			0.00	0.01	0.00	1.71
0.25-0.30	0.02	0.15	0.83	2.10	1.02	0.04	0.00	0.00	0.00	0.10	0.28	0.01	4.56
0.20-0.25	0.21	0.69	1.25	3.66	2.10	0.33	0.09	0.08	0.27	1.77	2.09	0.24	12.79
0.15-0.20	0.73	1.13	1.23	4.66	4.06	1.66	0.99	0.94	2.01	4.36	3.59	0.94	26.31
0.10-0.15	0.96	1.05	1.37	4.04	3.92	2.49	2.29	2.45	3.36	3.95	2.77	1.32	29.97
0.05-0.10	0.99	1.06	1.51	2.17	1.56	1.49	1.78	2.01	2.19	2.13	1.27	1.06	19.22
0.00-0.05	0.38	0.42	0.45	0.41	0.33	0.32	0.38	0.44	0.45	0.37	0.30	0.32	4.58
	3.29	4.51	7.07	18.47	13.69	6.34	5.53	5.92	8.28	12.69	10.32	3.89	100.00

Joint Occurence Table, $u_{mag,surf,tot}$ vs. $u_{dir,surf,tot}$

Figure 3.30 Joint occurrence tables of near-bottom (left) and surface (right) total current speed and direction at WTG08.

$u_{dir,bot,tid}$ (going to) → (°N)

$u_{mag,bot,tid}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45													
0.35-0.40													
0.30-0.35													
0.25-0.30													
0.20-0.25													
0.15-0.20			0.00	0.55							0.00		0.56
0.10-0.15	0.20	0.55	1.35	7.22	0.48	0.03	0.05	0.10	0.78	4.43	4.77	0.43	20.38
0.05-0.10	1.78	2.49	3.83	9.06	7.17	2.86	2.60	3.44	5.94	9.53	5.86	2.38	56.93
0.00-0.05	1.61	1.78	2.28	2.69	1.85	1.96	1.99	1.96	1.74	1.33	1.33	1.60	22.13
	3.59	4.82	7.46	19.52	9.50	4.86	4.64	5.50	8.46	15.29	11.95	4.41	100.00

Joint Occurence Table, $u_{mag,bot,tid}$ vs. $u_{dir,bot,tid}$

$u_{dir,surf,tid}$ (going to) → (°N)

$u_{mag,surf,tid}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45													
0.35-0.40													
0.30-0.35				0.18									0.18
0.25-0.30		0.00	0.08	1.64						0.05	0.49	0.01	2.27
0.20-0.25	0.11	0.34	0.88	4.52	0.18	0.00	0.00	0.02	0.37	2.96	3.25	0.27	12.92
0.15-0.20	0.56	1.03	1.88	5.42	2.56	0.61	0.55	0.84	2.53	5.76	4.00	0.88	26.64
0.10-0.15	1.14	1.48	2.11	4.57	4.39	1.99	1.81	2.34	3.46	4.76	2.68	1.46	32.19
0.05-0.10	1.21	1.32	1.81	2.76	2.23	2.07	1.99	2.01	1.95	1.63	1.20	1.32	21.50
0.00-0.05	0.57	0.64	0.70	0.42	0.14	0.19	0.29	0.29	0.14	0.12	0.34	0.47	4.30
	3.59	4.82	7.46	19.51	9.50	4.86	4.64	5.50	8.46	15.29	11.95	4.41	100.00

Joint Occurence Table, $u_{mag,surf,tid}$ vs. $u_{dir,surf,tid}$

Figure 3.31 Joint occurrence tables of near-bottom (left) and surface (right) tidal current speed and direction at WTG08.

Joint Occurence Table, $u_{mag,bot,res}$ vs. $u_{dir,bot,res}$

$u_{mag,bot,res}$ → (m/s) \ $u_{dir,bot,res}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45													
0.35-0.40													
0.30-0.35													
0.25-0.30				0.00	0.00								0.00
0.20-0.25				0.00	0.01	0.00	0.00						0.01
0.15-0.20			0.00	0.02	0.07	0.01	0.01	0.00	0.00				0.12
0.10-0.15	0.00	0.00	0.02	0.20	0.48	0.13	0.14	0.04	0.01	0.01	0.01	0.00	1.06
0.05-0.10	0.12	0.32	1.00	2.59	3.69	1.74	0.86	0.36	0.16	0.12	0.26	0.19	11.40
0.00-0.05	4.74	5.70	9.29	15.20	17.48	10.67	5.25	3.33	2.82	2.98	4.49	5.46	87.41
Total	4.87	6.02	10.31	18.01	21.73	12.55	6.27	3.74	2.99	3.10	4.75	5.65	100.00

Joint Occurence Table, $u_{mag,surf,res}$ vs. $u_{dir,surf,res}$

$u_{mag,surf,res}$ → (m/s) \ $u_{dir,surf,res}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55				0.00	0.00								0.00
0.45-0.50				0.00	0.00								0.00
0.40-0.45				0.00	0.00								0.00
0.35-0.40				0.00	0.01	0.00	0.00	0.00					0.01
0.30-0.35			0.00	0.01	0.04	0.01	0.01	0.00					0.06
0.25-0.30		0.00	0.00	0.03	0.10	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.20
0.20-0.25	0.00	0.00	0.01	0.12	0.28	0.07	0.08	0.03	0.01	0.00	0.00	0.00	0.60
0.15-0.20	0.01	0.03	0.10	0.44	0.81	0.31	0.27	0.09	0.03	0.02	0.03	0.01	2.14
0.10-0.15	0.09	0.22	0.71	1.80	2.48	1.21	0.54	0.23	0.11	0.08	0.18	0.13	7.77
0.05-0.10	0.61	1.05	2.52	5.06	6.54	3.41	1.25	0.70	0.57	0.53	1.11	1.15	24.51
0.00-0.05	4.17	4.72	6.96	10.55	11.47	7.52	4.10	2.68	2.27	2.48	3.43	4.36	64.70
Total	4.87	6.02	10.31	18.01	21.73	12.55	6.27	3.74	2.99	3.10	4.75	5.65	100.00

Figure 3.32 Joint occurrence tables of near-bottom (left) and surface (right) residual current speed and direction at WTG08.

3.4.2.3 WTG11

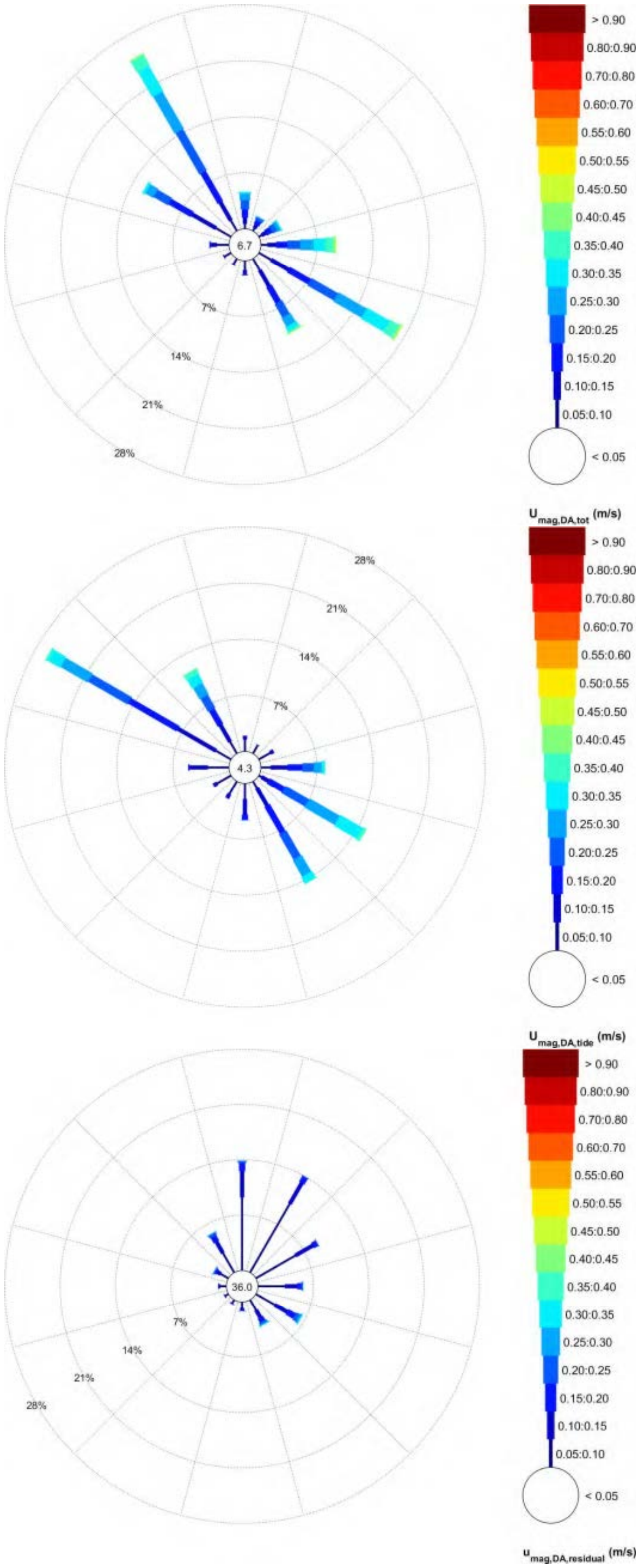


Figure 3.33 Roses of the depth-averaged total (top), tidal (middle) and residual (bottom) current speed and direction at WTG11.

$u_{dir,DA,tot}$ (going to) → (°N)

$u_{mag,DA,tot}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70				0.00	0.00	0.00							0.00
0.55-0.60				0.00	0.00	0.00							0.01
0.50-0.55				0.01	0.02	0.01						0.00	0.04
0.45-0.50			0.00	0.08	0.07	0.04						0.01	0.20
0.40-0.45	0.00	0.00	0.00	0.33	0.32	0.09					0.00	0.24	1.00
0.35-0.40	0.01	0.00	0.03	0.94	1.26	0.23				0.00	0.06	1.48	4.00
0.30-0.35	0.23	0.02	0.18	1.48	3.27	0.60	0.00			0.00	0.33	3.64	9.74
0.25-0.30	0.82	0.12	0.42	1.65	4.07	1.22	0.00		0.00	0.01	1.12	5.36	14.82
0.20-0.25	1.12	0.36	0.63	1.61	3.81	1.92	0.01		0.00	0.05	2.07	5.94	17.52
0.15-0.20	1.03	0.53	0.73	1.38	3.06	2.35	0.09	0.00	0.02	0.16	3.18	4.34	16.88
0.10-0.15	0.79	0.48	0.56	1.10	2.50	2.31	0.57	0.11	0.14	0.74	3.45	2.59	15.36
0.05-0.10	0.62	0.38	0.42	0.81	1.75	1.67	1.20	0.82	0.89	1.49	2.16	1.52	13.73
0.00-0.05	0.42	0.34	0.36	0.45	0.60	0.66	0.64	0.63	0.65	0.69	0.68	0.59	6.70
	5.04	2.23	3.33	9.86	20.73	11.11	2.51	1.57	1.70	3.14	13.05	25.71	100.00 Total

Joint Occurence Table, $u_{mag,DA,tot}$ vs. $u_{dir,DA,tot}$

$u_{dir,DA,tid}$ (going to) → (°N)

$u_{mag,DA,tid}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45											0.00	0.07	0.07
0.35-0.40				0.07	0.49	0.08					0.29	0.70	1.63
0.30-0.35				0.39	3.26	0.95					1.83	1.22	7.65
0.25-0.30				0.97	4.33	2.36					3.90	1.61	13.17
0.20-0.25				1.43	3.42	3.65	0.05				5.71	1.90	16.16
0.15-0.20	0.03		0.00	1.84	2.16	3.87	0.66	0.00		0.18	6.95	2.22	17.91
0.10-0.15	0.46	0.06	0.48	2.11	1.01	2.57	1.96	0.62	0.54	2.30	5.50	2.37	19.97
0.05-0.10	1.48	1.20	1.64	1.21	0.38	0.98	1.98	1.86	1.99	2.61	2.16	1.69	19.17
0.00-0.05	0.45	0.46	0.37	0.27	0.13	0.13	0.34	0.49	0.51	0.38	0.35	0.37	4.25
	2.42	1.72	2.49	8.30	15.18	14.57	4.99	2.98	3.03	5.47	26.69	12.16	100.00 Total

Joint Occurence Table, $u_{mag,DA,tid}$ vs. $u_{dir,DA,tid}$

$u_{dir,DA,res}$ (going to) → (°N)

$u_{mag,DA,res}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60					0.00								0.00
0.50-0.55				0.00	0.00	0.00						0.00	0.00
0.45-0.50				0.00	0.00	0.01					0.00	0.00	0.01
0.40-0.45				0.00	0.01	0.01				0.00	0.00	0.00	0.02
0.35-0.40	0.00	0.00	0.00	0.00	0.03	0.02	0.00		0.00	0.00	0.01	0.01	0.07
0.30-0.35	0.00	0.00	0.00	0.02	0.09	0.06	0.00			0.00	0.02	0.02	0.23
0.25-0.30	0.04	0.01	0.01	0.06	0.24	0.14	0.01	0.00	0.00	0.01	0.05	0.10	0.67
0.20-0.25	0.25	0.12	0.09	0.17	0.52	0.26	0.02	0.00	0.00	0.02	0.11	0.33	1.88
0.15-0.20	1.05	0.82	0.62	0.54	1.07	0.57	0.09	0.03	0.02	0.06	0.24	0.80	5.89
0.10-0.15	3.33	3.02	2.49	1.56	1.80	1.09	0.33	0.14	0.12	0.24	0.51	1.63	16.26
0.05-0.10	9.22	10.03	5.78	3.39	2.76	1.50	0.77	0.45	0.44	0.72	1.10	2.83	38.99
0.00-0.05	5.91	8.92	6.59	3.77	2.28	1.35	0.89	0.72	0.74	0.94	1.37	2.50	35.97
	19.79	22.92	15.58	9.51	8.79	5.01	2.11	1.34	1.31	1.99	3.42	8.23	100.00 Total

Joint Occurence Table, $u_{mag,DA,res}$ vs. $u_{dir,DA,res}$

Figure 3.34 Joint occurrence tables of depth-averaged total (top), tidal (middle) and residual (bottom) current speed and direction at WTG11.

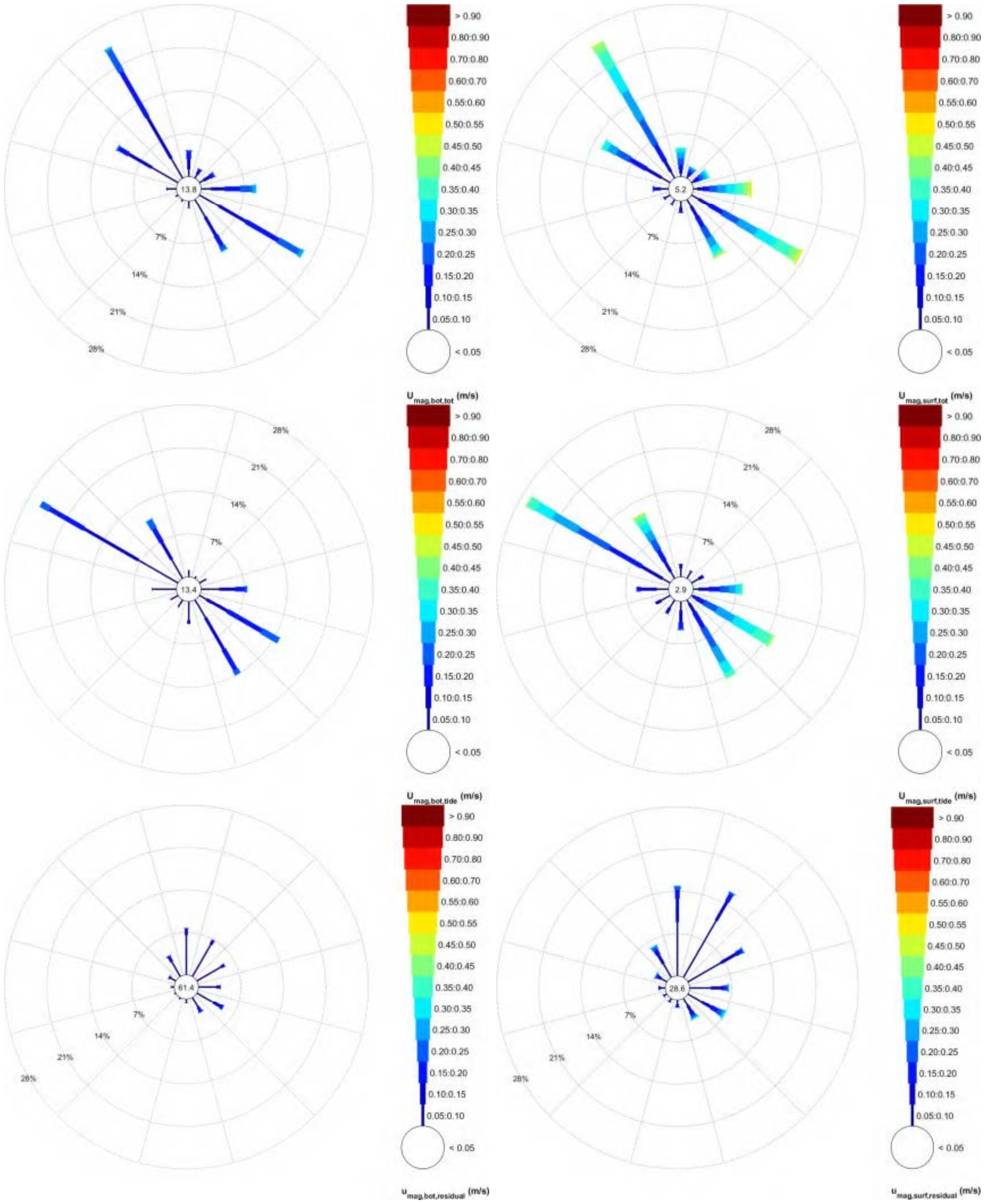


Figure 3.35 Roses of the near-bottom (left) and surface (right) total (top), tidal (middle) and residual (bottom) current speed and direction at WTG11.

$u_{dir,bot,tot}$ (going to) → (°N)

$u_{mag,bot,tot}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45				0.00	0.00	0.00							0.00
0.35-0.40				0.00	0.01	0.00							0.02
0.30-0.35			0.00	0.07	0.07	0.04						0.00	0.18
0.25-0.30	0.00	0.00	0.01	0.61	0.64	0.17					0.01	0.44	1.87
0.20-0.25	0.17	0.01	0.17	1.96	3.82	0.69	0.00			0.00	0.27	4.01	11.09
0.15-0.20	1.30	0.24	0.68	2.52	6.09	2.04	0.00		0.00	0.02	1.87	[illegible]	23.23
0.10-0.15	1.67	0.74	1.08	2.24	5.08	3.40	0.09	0.00	0.01	0.18	4.32	[illegible]	26.61
0.05-0.10	1.16	0.70	0.81	1.59	3.63	3.32	1.12	0.39	0.45	1.45	4.94	3.68	23.25
0.00-0.05	0.74	0.54	0.58	0.87	1.40	1.45	1.31	1.18	1.23	1.49	1.65	1.31	13.75
	5.04	2.23	3.33	9.86	20.73	11.11	2.51	1.57	1.70	3.14	13.05	25.71	100.00 Total

Joint Occurence Table, $u_{mag,bot,tot}$ vs. $u_{dir,bot,tot}$

$u_{dir,surf,tot}$ (going to) → (°N)

$u_{mag,surf,tot}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80				0.00	0.00	0.00							0.00
0.60-0.70				0.01	0.01	0.01							0.03
0.55-0.60			0.00	0.03	0.03	0.02						0.00	0.08
0.50-0.55			0.00	0.12	0.11	0.05						0.01	0.29
0.45-0.50	0.00	0.00	0.00	0.38	0.40	0.10					0.01	0.26	1.15
0.40-0.45	0.01	0.00	0.03	0.87	1.27	0.23				0.00	0.05	1.29	3.75
0.35-0.40	0.16	0.01	0.15	1.27	2.81	0.52	0.00			0.00	0.23	3.00	8.16
0.30-0.35	0.61	0.08	0.33	1.43	3.50	0.97	0.00		0.00	0.00	0.80	[illegible]	12.21
0.25-0.30	0.95	0.24	0.50	1.43	3.40	1.51	0.00		0.00	0.03	1.54	[illegible]	14.96
0.20-0.25	0.97	0.42	0.62	1.30	2.96	1.93	0.03	0.00	0.01	0.08	2.36	[illegible]	15.32
0.15-0.20	0.83	0.47	0.60	1.11	2.41	2.10	0.20	0.01	0.03	0.26	3.12	3.07	14.22
0.10-0.15	0.63	0.39	0.44	0.87	2.03	1.86	0.72	0.22	0.25	0.94	2.79	1.93	13.06
0.05-0.10	0.53	0.33	0.37	0.68	1.35	1.33	1.06	0.84	0.91	1.30	1.64	1.20	11.53
0.00-0.05	0.34	0.29	0.30	0.36	0.45	0.50	0.50	0.50	0.50	0.53	0.51	0.45	5.24
	5.04	2.23	3.33	9.86	20.73	11.11	2.51	1.57	1.70	3.14	13.05	25.71	100.00 Total

Joint Occurence Table, $u_{mag,surf,tot}$ vs. $u_{dir,surf,tot}$

Figure 3.36 Joint occurrence tables of near-bottom (left) and surface (right) total current speed and direction at WTG11.

$u_{dir,bot,tid}$ (going to) → (°N)

$u_{mag,bot,tid}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45													
0.35-0.40													
0.30-0.35													
0.25-0.30				0.00	0.02	0.00					0.01	0.18	0.21
0.20-0.25				0.38	3.15	0.85					1.62	1.52	7.52
0.15-0.20				1.59	6.36	3.83	0.00				6.38	2.51	20.67
0.10-0.15	0.02		0.00	2.61	4.00	5.92	0.63	0.00		0.13	[illegible]	3.26	26.84
0.05-0.10	1.08	0.42	1.30	2.95	1.35	3.40	3.10	1.47	1.43	3.86	7.45	3.54	31.36
0.00-0.05	1.32	1.31	1.20	0.77	0.28	0.48	1.23	1.49	1.60	1.49	1.13	1.10	13.39
	2.42	1.73	2.50	8.30	15.15	14.49	4.96	2.96	3.03	5.48	26.87	12.11	100.00 Total

Joint Occurence Table, $u_{mag,bot,tid}$ vs. $u_{dir,bot,tid}$

$u_{dir,surf,tid}$ (going to) → (°N)

$u_{mag,surf,tid}$ → (m/s)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50				0.00	0.00						0.00	0.09	0.10
0.40-0.45				0.08	0.58	0.11					0.26	0.62	1.64
0.35-0.40				0.32	2.71	0.78					1.45	1.02	6.28
0.30-0.35				0.76	3.86	1.84					3.13	1.35	10.94
0.25-0.30				1.15	3.17	2.82	0.01				4.58	1.58	13.31
0.20-0.25	0.00			1.44	2.45	3.50	0.25			0.01	[illegible]	1.84	15.25
0.15-0.20	0.11	0.00	0.04	1.80	1.34	2.94	1.04	0.07	0.03	0.73	[illegible]	2.04	16.19
0.10-0.15	0.67	0.18	0.86	1.68	0.68	1.78	1.95	0.99	0.96	2.59	3.98	2.03	18.36
0.05-0.10	1.34	1.23	1.34	0.87	0.27	0.64	1.48	1.59	1.72	1.90	1.41	1.26	15.03
0.00-0.05	0.31	0.31	0.26	0.20	0.10	0.08	0.22	0.32	0.32	0.26	0.24	0.27	2.90
	2.42	1.73	2.50	8.30	15.15	14.49	4.96	2.96	3.03	5.48	26.87	12.11	100.00 Total

Joint Occurence Table, $u_{mag,surf,tid}$ vs. $u_{dir,surf,tid}$

Figure 3.37 Joint occurrence tables of near-bottom (left) and surface (right) tidal current speed and direction at WTG11.

Joint Occurence Table, $u_{mag,bot,res}$ vs. $u_{dir,bot,res}$

$u_{mag,bot,res}$ → (m/s) \ $u_{dir,bot,res}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70													
0.55-0.60													
0.50-0.55													
0.45-0.50													
0.40-0.45													
0.35-0.40					0.00								0.00
0.30-0.35				0.00	0.00	0.01					0.00	0.00	0.01
0.25-0.30				0.00	0.01	0.01	0.00			0.00	0.00	0.00	0.04
0.20-0.25	0.00	0.00	0.00	0.01	0.09	0.07	0.00		0.00	0.00	0.02	0.02	0.23
0.15-0.20	0.09	0.03	0.03	0.10	0.42	0.24	0.01	0.00	0.00	0.01	0.09	0.19	1.22
0.10-0.15	1.08	0.79	0.61	0.61	1.36	0.69	0.09	0.02	0.02	0.06	0.29	0.93	6.55
0.05-0.10	6.56	6.09	4.63	2.95	3.10	1.83	0.65	0.30	0.27	0.50	0.92	2.77	30.57
0.00-0.05	11.51	[illegible]	10.69	6.09	4.01	2.24	1.37	1.01	1.02	1.40	2.02	4.07	61.38
Total	19.24	22.86	15.96	9.77	8.99	5.10	2.12	1.33	1.31	1.98	3.34	7.99	100.00

Joint Occurence Table, $u_{mag,surf,res}$ vs. $u_{dir,surf,res}$

$u_{mag,surf,res}$ → (m/s) \ $u_{dir,surf,res}$ (going to) → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	Total
>0.90													
0.80-0.90													
0.70-0.80													
0.60-0.70				0.00	0.00								0.00
0.55-0.60				0.00	0.00	0.00					0.00	0.00	0.00
0.50-0.55				0.00	0.00	0.01					0.00	0.00	0.01
0.45-0.50				0.00	0.01	0.01				0.00	0.00	0.00	0.02
0.40-0.45	0.00	0.00	0.00	0.00	0.02	0.02	0.00		0.00	0.00	0.01	0.01	0.07
0.35-0.40	0.00	0.00	0.00	0.01	0.07	0.05	0.00			0.00	0.02	0.02	0.18
0.30-0.35	0.02	0.01	0.01	0.04	0.18	0.11	0.00		0.00	0.00	0.04	0.07	0.48
0.25-0.30	0.12	0.05	0.04	0.10	0.36	0.19	0.01	0.00	0.00	0.01	0.08	0.20	1.16
0.20-0.25	0.48	0.31	0.23	0.28	0.72	0.35	0.04	0.01	0.01	0.03	0.15	0.47	3.08
0.15-0.20	1.52	1.37	1.10	0.80	1.21	0.69	0.14	0.05	0.04	0.09	0.29	0.94	8.24
0.10-0.15	3.94	3.61	2.88	1.81	1.85	1.11	0.40	0.18	0.16	0.31	0.55	1.68	18.46
0.05-0.10	8.86	[illegible]	6.32	3.54	2.65	1.40	0.75	0.47	0.46	0.73	1.07	2.60	39.72
0.00-0.05	4.30	6.64	5.37	3.19	1.93	1.15	0.77	0.63	0.65	0.81	1.14	2.00	28.58
Total	19.24	22.86	15.96	9.77	8.99	5.10	2.12	1.33	1.31	1.98	3.34	7.99	100.00

Figure 3.38 Joint occurrence tables of near-bottom (left) and surface (right) residual current speed and direction at WTG11.

3.4.3 Extreme conditions

Extreme value analyses of the 43-year long (11-01-1979 00:00 – 31-12-2020 23:00) timeseries of the depth-averaged, near-bottom and surface, total and residual current speeds were carried out using the POT method, see Appendix B. The EVA of the data included omni-directional analyses and directional analyses over 30º sectors. The sectors considered were: 345ºN-15ºN (0º/360º), 15ºN-45ºN (30º), …, 285ºN-315ºN (300º) and 315ºN-345ºN (330º). In the omni-directional analysis all data were considered. In the directional analysis only the data falling in the sector of interest were considered. The data were stratified into sectors before the EVA were carried out, meaning that a given storm may have been considered in more than one sector. The stratification into sectors before the analysis was necessary because we were interested in the return value for the above enumerated fixed sectors. If only storm peaks were to be stratified, the return values obtained for a given sector could have been underestimates.

Figure 3.39 shows the return value plots of the omni-directional, total depth-average current speed at the reference locations.

The resulting (omni-directional, directional, depth-averaged, near-bottom, surface, total and residual) return value estimates are given for WTG15 in Table 3.6 and Table 3.7, for WTG08 in Table 3.8 and Table 3.9 and last for WTG11 in Table 3.10 to Table 3.12. These tables also present the directional surface residual extremes including the effect of associated wind speeds (1.5% of $U_{10,associated}$) as suggested in Section 4.1.4 of DNVGL RP-C205 (DNVGL, 2020). It is noted that these values should be considered as conservative as the effect of the wind is already included in the depth-averaged current timeseries from which the surface currents are derived (cf. Section 2.2.3.2). The omni-directional values are not given as this value would not make sense.

As could already be seen in Figure 3.39, the most extreme currents are at WTG15, for which the 50-year total depth-averaged current speed estimate is 0.83 m/s. From Table 3.6 it follows that the corresponding 50-year total surface and near-bottom current speed estimates are respectively 0.95 m/s and 0.51 m/s.

The associated (conditional) wave (H_s and T_p) and wind conditions (U_{10}) were determined as described below:

H_s, T_p and U_{10}

The associated significant wave heights, H_s and wind speeds at 10 mMSL, U_{10} were computed by applying the relationships found between the depth-averaged total $u_{mag,total,DA}$ POT peak values and corresponding wave height/wind speed values (i.e. the values of the variables at the time of the peak current speeds that have been sampled to fit the extreme value distribution). For a given $u_{mag,total,DA}$ value the relations were used to compute the associated parameter values.

The associated peak wave periods, T_p were computed by first determining the relationships found between the significant wave height values and peak wave period values which corresponded to the depth-averaged total $u_{mag,total,DA}$ POT peak values. For the earlier determined associated significant wave height values the relations were used to compute the associated T_p values.

In the case a negative relation between $u_{mag,total,DA}$ and H_s was found (i.e. diminishing H_s values with increasing $u_{mag,total,DA}$), this negative relation was discarded and a constant relation was assumed. In those cases the point estimate was determined by the mean of the associated H_s values in the POT-subset and the lower- and upper-bounds by respectively the 2.5th and 97.5th percentile values.

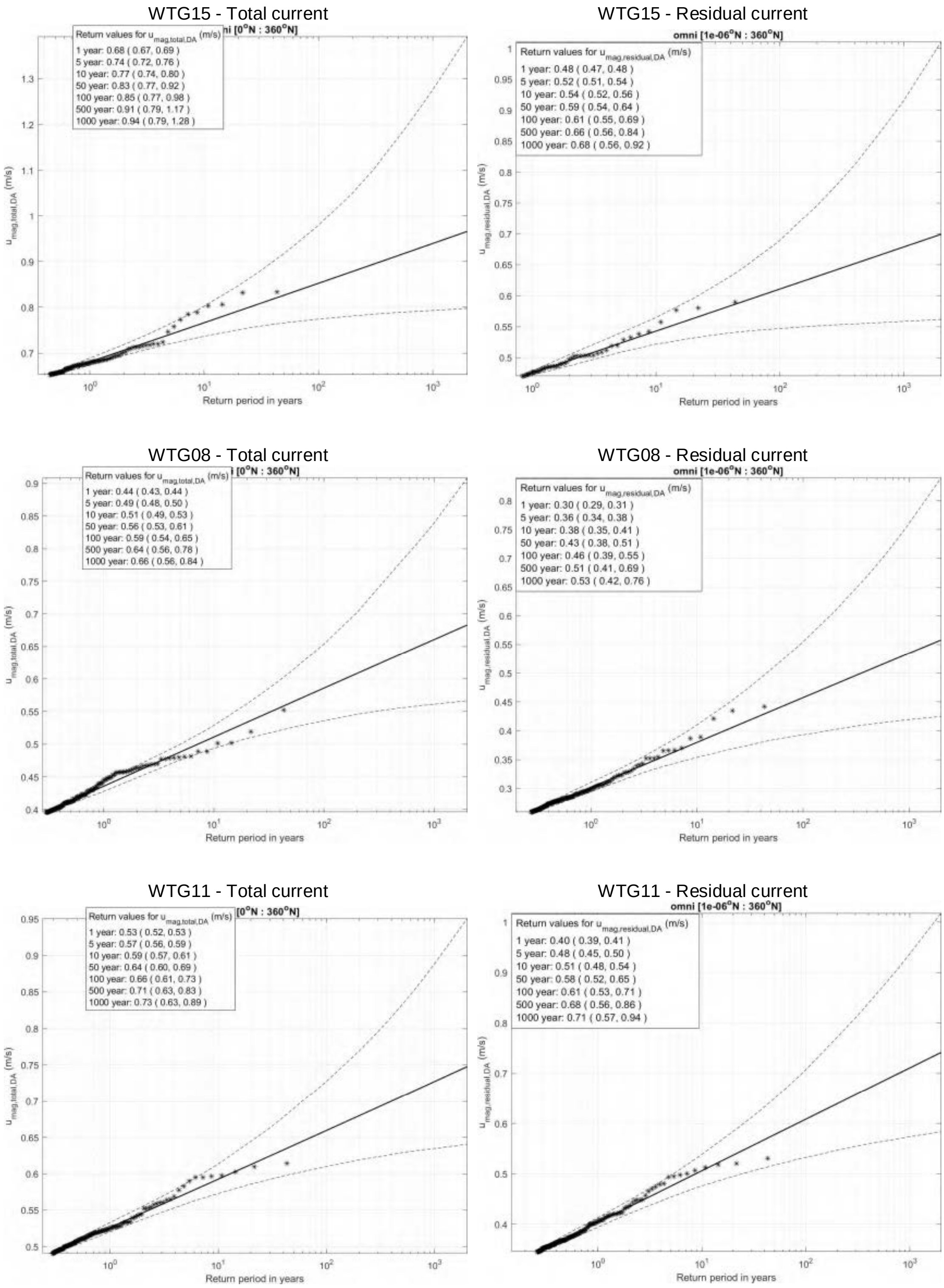


Figure 3.39 Omni-directional total depth-averaged current speed return value plot. The dashed lines are the associated 95% confidence intervals. The POT data are represented by the asterisks, with as plotting position (xi, (n+1)/(λ_u(n+1-i)), where n is the sample size, i the order and λ_u the Poisson rate.

Table 3.6 Directional current extremes at WTG15, return periods 1-, 5-, 10-, 50- and 100-yr.

Current directions are going TOWARDS clockwise from the North	**Sector 1** 345-015deg	**Sector 2** 015-045deg	**Sector 3** 045-075deg	**Sector 4** 075-105deg	**Sector 5** 105-135deg	**Sector 6** 135-165deg	**Sector 7** 165-195deg	**Sector 8** 195-225deg	**Sector 9** 225-255deg	**Sector 10** 255-285deg	**Sector 11** 285-315deg	**Sector 12** 315-345deg	**OMNI**
1-yr													
Current surface total (m/s)	0.28 (0.28 - 0.29)	0.20 (0.20 - 0.21)	0.19 (0.19 - 0.20)	0.45 (0.44 - 0.46)	0.76 (0.75 - 0.77)	0.76 (0.75 - 0.77)	0.39 (0.38 - 0.40)	0.33 (0.33 - 0.34)	0.52 (0.51 - 0.53)	0.51 (0.50 - 0.51)	0.56 (0.55 - 0.56)	0.41 (0.41 - 0.42)	0.78 (0.77 - 0.79)
Current surface residual (m/s)	0.22 (0.21 - 0.22)	0.20 (0.20 - 0.21)	0.20 (0.20 - 0.21)	0.30 (0.30 - 0.30)	0.47 (0.46 - 0.49)	0.45 (0.44 - 0.46)	0.37 (0.36 - 0.37)	0.41 (0.41 - 0.42)	0.51 (0.50 - 0.52)	0.47 (0.46 - 0.48)	0.37 (0.36 - 0.38)	0.29 (0.28 - 0.30)	0.54 (0.54 - 0.55)
Current surface residual + ass. wind component (m/s)	0.37 (0.24 - 0.53)	0.32 (0.22 - 0.44)	0.32 (0.22 - 0.43)	0.52 (0.40 - 0.60)	0.73 (0.63 - 0.83)	0.67 (0.49 - 0.77)	0.53 (0.40 - 0.66)	0.54 (0.43 - 0.70)	0.63 (0.53 - 0.74)	0.58 (0.49 - 0.70)	0.50 (0.37 - 0.70)	0.45 (0.31 - 0.64)	-
Current DA total (m/s)	0.25 (0.25 - 0.26)	0.18 (0.18 - 0.18)	0.17 (0.16 - 0.17)	0.39 (0.39 - 0.40)	0.66 (0.65 - 0.67)	0.66 (0.65 - 0.67)	0.34 (0.33 - 0.35)	0.29 (0.29 - 0.30)	0.46 (0.45 - 0.46)	0.45 (0.44 - 0.45)	0.49 (0.49 - 0.50)	0.36 (0.36 - 0.37)	0.68 (0.67 - 0.69)
Current DA residual (m/s)	0.19 (0.18 - 0.20)	0.18 (0.17 - 0.18)	0.18 (0.17 - 0.18)	0.26 (0.25 - 0.26)	0.41 (0.40 - 0.43)	0.39 (0.38 - 0.40)	0.32 (0.31 - 0.33)	0.36 (0.36 - 0.37)	0.45 (0.44 - 0.46)	0.42 (0.41 - 0.42)	0.32 (0.31 - 0.33)	0.25 (0.24 - 0.26)	0.48 (0.47 - 0.48)
Current near-bottom total (m/s)	0.15 (0.15 - 0.15)	0.11 (0.11 - 0.11)	0.10 (0.10 - 0.10)	0.24 (0.24 - 0.25)	0.40 (0.40 - 0.41)	0.40 (0.40 - 0.41)	0.21 (0.20 - 0.21)	0.18 (0.18 - 0.18)	0.27 (0.27 - 0.28)	0.27 (0.27 - 0.27)	0.30 (0.29 - 0.30)	0.22 (0.22 - 0.22)	0.42 (0.41 - 0.42)
Current near-bottom residual (m/s)	0.11 (0.11 - 0.12)	0.11 (0.10 - 0.11)	0.11 (0.10 - 0.11)	0.16 (0.16 - 0.16)	0.25 (0.24 - 0.26)	0.24 (0.23 - 0.25)	0.20 (0.19 - 0.20)	0.22 (0.22 - 0.22)	0.27 (0.27 - 0.28)	0.25 (0.25 - 0.26)	0.19 (0.19 - 0.20)	0.15 (0.15 - 0.16)	0.29 (0.29 - 0.29)
Associated H_s (m)	1.99 (0.61 - 4.45)	1.85 (1.84 - 1.86)	2.32 (0.75 - 6.21)	2.52 (2.50 - 2.55)	3.98 (3.83 - 4.12)	3.61 (3.48 - 3.76)	3.71 (3.58 - 3.84)	3.26 (3.25 - 3.28)	2.49 (2.48 - 2.50)	2.65 (2.57 - 2.74)	2.49 (2.45 - 2.53)	2.19 (2.16 - 2.23)	4.17 (4.06 - 4.28)
Associated T_p (s)	10.6 (8.6 - 14.0)	10.3 (10.2 - 10.3)	11.0 (9.4 - 15.0)	10.8 (10.8 - 10.9)	12.1 (12.0 - 12.2)	11.7 (11.6 - 11.8)	11.7 (11.6 - 11.9)	11.6 (11.6 - 11.6)	11.1 (11.0 - 11.1)	11.0 (10.9 - 11.1)	10.3 (10.3 - 10.4)	10.9 (10.9 - 10.9)	12.1 (12.0 - 12.2)
5-yr													
Current surface total (m/s)	0.32 (0.31 - 0.33)	0.23 (0.22 - 0.23)	0.23 (0.22 - 0.24)	0.51 (0.50 - 0.53)	0.82 (0.79 - 0.84)	0.84 (0.81 - 0.87)	0.45 (0.43 - 0.46)	0.38 (0.37 - 0.40)	0.57 (0.56 - 0.58)	0.56 (0.54 - 0.57)	0.61 (0.60 - 0.63)	0.45 (0.44 - 0.47)	0.85 (0.83 - 0.88)
Current surface residual (m/s)	0.27 (0.25 - 0.28)	0.24 (0.23 - 0.25)	0.23 (0.22 - 0.24)	0.39 (0.36 - 0.42)	0.57 (0.55 - 0.60)	0.55 (0.52 - 0.57)	0.43 (0.41 - 0.44)	0.46 (0.44 - 0.47)	0.57 (0.55 - 0.58)	0.53 (0.52 - 0.55)	0.44 (0.42 - 0.47)	0.35 (0.33 - 0.38)	0.60 (0.58 - 0.61)
Current surface residual + ass. wind component (m/s)	0.42 (0.29 - 0.59)	0.35 (0.25 - 0.48)	0.35 (0.25 - 0.46)	0.61 (0.46 - 0.72)	0.83 (0.72 - 0.95)	0.76 (0.57 - 0.88)	0.60 (0.45 - 0.73)	0.58 (0.46 - 0.75)	0.69 (0.58 - 0.80)	0.64 (0.55 - 0.76)	0.58 (0.44 - 0.78)	0.52 (0.36 - 0.72)	-
Current DA total (m/s)	0.28 (0.28 - 0.29)	0.20 (0.19 - 0.21)	0.20 (0.19 - 0.21)	0.45 (0.43 - 0.46)	0.71 (0.69 - 0.73)	0.73 (0.71 - 0.75)	0.39 (0.38 - 0.40)	0.34 (0.32 - 0.35)	0.50 (0.49 - 0.51)	0.49 (0.48 - 0.50)	0.54 (0.52 - 0.55)	0.40 (0.39 - 0.41)	0.74 (0.72 - 0.76)
Current DA residual (m/s)	0.23 (0.22 - 0.25)	0.21 (0.20 - 0.21)	0.20 (0.19 - 0.21)	0.34 (0.32 - 0.37)	0.50 (0.47 - 0.53)	0.48 (0.45 - 0.50)	0.37 (0.36 - 0.39)	0.40 (0.39 - 0.41)	0.49 (0.48 - 0.51)	0.47 (0.45 - 0.48)	0.39 (0.37 - 0.41)	0.31 (0.29 - 0.33)	0.52 (0.51 - 0.54)
Current near-bottom total (m/s)	0.17 (0.17 - 0.18)	0.12 (0.12 - 0.12)	0.12 (0.12 - 0.13)	0.27 (0.27 - 0.28)	0.43 (0.42 - 0.45)	0.45 (0.43 - 0.46)	0.24 (0.23 - 0.25)	0.20 (0.20 - 0.21)	0.30 (0.30 - 0.31)	0.29 (0.29 - 0.30)	0.32 (0.32 - 0.33)	0.24 (0.23 - 0.25)	0.45 (0.44 - 0.47)
Current near-bottom residual (m/s)	0.14 (0.13 - 0.15)	0.13 (0.12 - 0.13)	0.12 (0.12 - 0.13)	0.21 (0.19 - 0.22)	0.30 (0.29 - 0.32)	0.29 (0.28 - 0.30)	0.22 (0.21 - 0.23)	0.24 (0.24 - 0.25)	0.30 (0.29 - 0.31)	0.28 (0.27 - 0.29)	0.24 (0.23 - 0.25)	0.19 (0.18 - 0.20)	0.32 (0.31 - 0.33)
Associated H_s (m)	1.99 (0.61 - 4.45)	1.92 (1.90 - 1.94)	2.32 (0.75 - 6.21)	2.68 (2.64 - 2.72)	5.01 (4.65 - 5.41)	4.65 (4.34 - 4.99)	4.55 (4.32 - 4.78)	3.45 (3.39 - 3.50)	2.61 (2.58 - 2.63)	3.32 (3.14 - 3.49)	2.81 (2.72 - 2.90)	2.71 (2.55 - 2.88)	5.03 (4.73 - 5.36)
Associated T_p (s)	10.6 (8.6 - 14.0)	10.4 (10.3 - 10.4)	11.0 (9.4 - 15.0)	11.0 (11.0 - 11.0)	12.9 (12.6 - 13.3)	12.7 (12.4 - 13.1)	12.7 (12.4 - 12.9)	11.8 (11.7 - 11.9)	11.2 (11.2 - 11.2)	11.7 (11.5 - 11.9)	10.7 (10.6 - 10.8)	11.5 (11.3 - 11.7)	12.8 (12.6 - 13.1)
10-yr													
Current surface total (m/s)	0.34 (0.33 - 0.35)	0.24 (0.23 - 0.25)	0.24 (0.23 - 0.26)	0.54 (0.52 - 0.56)	0.84 (0.81 - 0.88)	0.87 (0.83 - 0.92)	0.47 (0.45 - 0.50)	0.40 (0.38 - 0.42)	0.59 (0.57 - 0.61)	0.58 (0.56 - 0.60)	0.64 (0.61 - 0.66)	0.47 (0.45 - 0.49)	0.88 (0.85 - 0.92)
Current surface residual (m/s)	0.29 (0.27 - 0.31)	0.25 (0.24 - 0.26)	0.24 (0.23 - 0.26)	0.43 (0.39 - 0.47)	0.61 (0.57 - 0.65)	0.58 (0.54 - 0.62)	0.45 (0.43 - 0.48)	0.48 (0.46 - 0.49)	0.59 (0.57 - 0.61)	0.56 (0.54 - 0.58)	0.48 (0.45 - 0.51)	0.38 (0.35 - 0.42)	0.62 (0.60 - 0.65)
Current surface residual + ass. wind component (m/s)	0.44 (0.30 - 0.62)	0.36 (0.26 - 0.50)	0.36 (0.26 - 0.48)	0.65 (0.49 - 0.77)	0.87 (0.74 - 0.99)	0.80 (0.60 - 0.93)	0.62 (0.47 - 0.76)	0.60 (0.48 - 0.77)	0.70 (0.59 - 0.83)	0.67 (0.57 - 0.80)	0.62 (0.47 - 0.83)	0.55 (0.38 - 0.76)	-
Current DA total (m/s)	0.30 (0.29 - 0.31)	0.21 (0.20 - 0.22)	0.21 (0.20 - 0.23)	0.47 (0.45 - 0.49)	0.73 (0.71 - 0.76)	0.76 (0.73 - 0.79)	0.41 (0.39 - 0.43)	0.35 (0.34 - 0.37)	0.51 (0.50 - 0.52)	0.51 (0.49 - 0.52)	0.56 (0.54 - 0.57)	0.42 (0.40 - 0.43)	0.77 (0.74 - 0.80)
Current DA residual (m/s)	0.25 (0.23 - 0.27)	0.22 (0.21 - 0.23)	0.21 (0.20 - 0.22)	0.38 (0.34 - 0.41)	0.53 (0.49 - 0.57)	0.51 (0.48 - 0.54)	0.39 (0.37 - 0.41)	0.42 (0.40 - 0.43)	0.50 (0.49 - 0.52)	0.49 (0.47 - 0.51)	0.42 (0.39 - 0.45)	0.33 (0.30 - 0.36)	0.54 (0.52 - 0.56)
Current near-bottom total (m/s)	0.18 (0.17 - 0.19)	0.13 (0.12 - 0.13)	0.13 (0.12 - 0.14)	0.29 (0.27 - 0.30)	0.45 (0.43 - 0.47)	0.46 (0.44 - 0.49)	0.25 (0.24 - 0.26)	0.21 (0.20 - 0.23)	0.31 (0.30 - 0.32)	0.31 (0.30 - 0.32)	0.34 (0.32 - 0.35)	0.25 (0.24 - 0.26)	0.47 (0.45 - 0.49)
Current near-bottom residual (m/s)	0.15 (0.14 - 0.16)	0.14 (0.13 - 0.15)	0.13 (0.12 - 0.14)	0.23 (0.21 - 0.25)	0.32 (0.30 - 0.34)	0.31 (0.29 - 0.33)	0.23 (0.22 - 0.24)	0.25 (0.24 - 0.26)	0.31 (0.30 - 0.32)	0.30 (0.29 - 0.31)	0.25 (0.24 - 0.27)	0.20 (0.19 - 0.22)	0.33 (0.32 - 0.34)
Associated H_s (m)	1.99 (0.61 - 4.45)	1.96 (1.93 - 1.98)	2.32 (0.75 - 6.21)	2.74 (2.69 - 2.80)	5.45 (4.94 - 6.05)	5.08 (4.59 - 5.56)	4.90 (4.61 - 5.21)	3.53 (3.45 - 3.60)	2.64 (2.61 - 2.67)	3.60 (3.35 - 3.86)	2.94 (2.82 - 3.07)	2.93 (2.71 - 3.15)	5.40 (4.97 - 5.92)
Associated T_p (s)	10.6 (8.6 - 14.0)	10.4 (10.4 - 10.5)	11.0 (9.4 - 15.0)	11.1 (11.0 - 11.1)	13.3 (12.9 - 13.8)	13.1 (12.7 - 13.6)	13.1 (12.7 - 13.4)	11.9 (11.8 - 12.0)	11.3 (11.2 - 11.3)	12.0 (11.8 - 12.3)	10.8 (10.7 - 11.0)	11.8 (11.5 - 12.0)	13.1 (12.8 - 13.5)
50-yr													
Current surface total (m/s)	0.38 (0.35 - 0.41)	0.26 (0.24 - 0.29)	0.28 (0.25 - 0.31)	0.59 (0.55 - 0.64)	0.89 (0.83 - 0.99)	0.95 (0.87 - 1.04)	0.53 (0.48 - 0.60)	0.45 (0.41 - 0.51)	0.62 (0.58 - 0.66)	0.62 (0.59 - 0.67)	0.69 (0.65 - 0.74)	0.52 (0.48 - 0.56)	0.95 (0.88 - 1.04)
Current surface residual (m/s)	0.34 (0.30 - 0.38)	0.28 (0.25 - 0.32)	0.27 (0.25 - 0.30)	0.53 (0.44 - 0.64)	0.68 (0.61 - 0.77)	0.66 (0.59 - 0.75)	0.50 (0.46 - 0.55)	0.52 (0.49 - 0.55)	0.62 (0.59 - 0.66)	0.62 (0.58 - 0.67)	0.56 (0.49 - 0.64)	0.45 (0.39 - 0.53)	0.68 (0.63 - 0.74)
Current surface residual + ass. wind component (m/s)	0.49 (0.33 - 0.69)	0.40 (0.27 - 0.56)	0.39 (0.28 - 0.53)	0.75 (0.54 - 0.94)	0.94 (0.78 - 1.12)	0.88 (0.64 - 1.05)	0.67 (0.50 - 0.84)	0.64 (0.50 - 0.83)	0.74 (0.61 - 0.88)	0.73 (0.60 - 0.89)	0.69 (0.51 - 0.96)	0.62 (0.42 - 0.87)	-
Current DA total (m/s)	0.33 (0.30 - 0.36)	0.23 (0.21 - 0.25)	0.24 (0.22 - 0.27)	0.52 (0.48 - 0.56)	0.78 (0.73 - 0.85)	0.82 (0.76 - 0.90)	0.46 (0.42 - 0.51)	0.40 (0.36 - 0.45)	0.53 (0.51 - 0.55)	0.55 (0.52 - 0.59)	0.60 (0.56 - 0.65)	0.45 (0.42 - 0.49)	0.83 (0.77 - 0.92)
Current DA residual (m/s)	0.29 (0.26 - 0.33)	0.25 (0.22 - 0.28)	0.23 (0.21 - 0.26)	0.46 (0.38 - 0.56)	0.59 (0.53 - 0.68)	0.58 (0.52 - 0.65)	0.43 (0.40 - 0.48)	0.46 (0.43 - 0.49)	0.52 (0.50 - 0.55)	0.54 (0.51 - 0.58)	0.49 (0.43 - 0.56)	0.39 (0.33 - 0.46)	0.59 (0.54 - 0.64)
Current near-bottom total (m/s)	0.20 (0.18 - 0.22)	0.14 (0.13 - 0.15)	0.15 (0.13 - 0.17)	0.31 (0.29 - 0.34)	0.48 (0.45 - 0.52)	0.50 (0.47 - 0.56)	0.28 (0.26 - 0.32)	0.24 (0.22 - 0.27)	0.33 (0.31 - 0.35)	0.33 (0.31 - 0.36)	0.37 (0.34 - 0.39)	0.27 (0.25 - 0.29)	0.51 (0.47 - 0.55)
Current near-bottom residual (m/s)	0.18 (0.16 - 0.20)	0.15 (0.14 - 0.17)	0.15 (0.13 - 0.16)	0.28 (0.23 - 0.34)	0.36 (0.32 - 0.41)	0.35 (0.31 - 0.40)	0.25 (0.23 - 0.28)	0.28 (0.26 - 0.29)	0.33 (0.31 - 0.35)	0.33 (0.31 - 0.36)	0.30 (0.26 - 0.34)	0.24 (0.21 - 0.28)	0.36 (0.33 - 0.39)
Associated H_s (m)	1.99 (0.61 - 4.45)	2.03 (1.97 - 2.11)	2.32 (0.75 - 6.21)	2.88 (2.77 - 3.02)	6.46 (5.49 - 7.84)	6.02 (5.08 - 7.11)	5.73 (5.08 - 6.54)	3.71 (3.55 - 3.92)	2.70 (2.64 - 2.76)	4.26 (3.74 - 4.92)	3.26 (2.98 - 3.58)	3.45 (2.97 - 3.94)	6.26 (5.39 - 7.57)
Associated T_p (s)	10.6 (8.6 - 14.0)	10.5 (10.4 - 10.6)	11.0 (9.4 - 15.0)	11.2 (11.1 - 11.4)	14.2 (13.3 - 15.3)	14.1 (13.1 - 15.1)	14.0 (13.3 - 14.9)	12.1 (11.9 - 12.3)	11.3 (11.2 - 11.4)	12.8 (12.2 - 13.5)	11.2 (10.9 - 11.5)	12.3 (11.8 - 12.9)	13.8 (13.1 - 14.9)
100-yr													
Current surface total (m/s)	0.39 (0.35 - 0.44)	0.27 (0.25 - 0.31)	0.29 (0.25 - 0.34)	0.61 (0.56 - 0.69)	0.92 (0.84 - 1.06)	0.98 (0.89 - 1.11)	0.56 (0.49 - 0.65)	0.47 (0.41 - 0.56)	0.63 (0.59 - 0.68)	0.64 (0.59 - 0.71)	0.71 (0.66 - 0.78)	0.53 (0.48 - 0.60)	0.98 (0.89 - 1.11)
Current surface residual (m/s)	0.36 (0.31 - 0.42)	0.30 (0.26 - 0.35)	0.29 (0.26 - 0.33)	0.57 (0.45 - 0.75)	0.71 (0.62 - 0.83)	0.69 (0.60 - 0.81)	0.52 (0.47 - 0.59)	0.54 (0.49 - 0.59)	0.63 (0.59 - 0.68)	0.64 (0.59 - 0.72)	0.59 (0.50 - 0.71)	0.48 (0.40 - 0.59)	0.70 (0.64 - 0.80)
Current surface residual + ass. wind component (m/s)	0.51 (0.35 - 0.73)	0.41 (0.28 - 0.59)	0.40 (0.28 - 0.55)	0.79 (0.55 - 1.05)	0.97 (0.79 - 1.17)	0.91 (0.66 - 1.11)	0.69 (0.51 - 0.88)	0.66 (0.51 - 0.87)	0.75 (0.62 - 0.90)	0.75 (0.62 - 0.94)	0.73 (0.52 - 1.03)	0.65 (0.43 - 0.93)	-
Current DA total (m/s)	0.34 (0.31 - 0.38)	0.24 (0.22 - 0.27)	0.25 (0.22 - 0.30)	0.53 (0.49 - 0.60)	0.80 (0.74 - 0.89)	0.85 (0.77 - 0.95)	0.48 (0.43 - 0.56)	0.42 (0.36 - 0.49)	0.53 (0.51 - 0.57)	0.57 (0.52 - 0.62)	0.62 (0.57 - 0.69)	0.47 (0.43 - 0.53)	0.85 (0.77 - 0.98)
Current DA residual (m/s)	0.31 (0.27 - 0.37)	0.26 (0.23 - 0.31)	0.24 (0.22 - 0.28)	0.49 (0.40 - 0.65)	0.62 (0.54 - 0.73)	0.60 (0.53 - 0.71)	0.45 (0.40 - 0.50)	0.48 (0.44 - 0.52)	0.53 (0.50 - 0.56)	0.57 (0.52 - 0.63)	0.52 (0.44 - 0.62)	0.42 (0.34 - 0.51)	0.61 (0.55 - 0.69)
Current near-bottom total (m/s)	0.21 (0.19 - 0.23)	0.14 (0.13 - 0.16)	0.15 (0.14 - 0.18)	0.32 (0.30 - 0.36)	0.49 (0.45 - 0.54)	0.52 (0.48 - 0.59)	0.29 (0.26 - 0.34)	0.25 (0.22 - 0.29)	0.33 (0.31 - 0.36)	0.34 (0.32 - 0.38)	0.38 (0.35 - 0.41)	0.28 (0.26 - 0.31)	0.52 (0.48 - 0.58)
Current near-bottom residual (m/s)	0.19 (0.16 - 0.22)	0.16 (0.14 - 0.19)	0.15 (0.14 - 0.18)	0.30 (0.24 - 0.40)	0.38 (0.33 - 0.44)	0.37 (0.32 - 0.43)	0.26 (0.24 - 0.29)	0.28 (0.26 - 0.31)	0.33 (0.31 - 0.36)	0.34 (0.31 - 0.38)	0.31 (0.27 - 0.38)	0.25 (0.21 - 0.32)	0.37 (0.34 - 0.42)
Associated H_s (m)	1.99 (0.61 - 4.45)	2.06 (1.98 - 2.18)	2.32 (0.75 - 6.21)	2.94 (2.80 - 3.13)	6.89 (5.70 - 8.73)	6.40 (5.24 - 7.86)	6.08 (5.23 - 7.26)	3.79 (3.57 - 4.11)	2.71 (2.64 - 2.81)	4.54 (3.89 - 5.47)	3.39 (3.03 - 3.87)	3.67 (3.06 - 4.43)	6.63 (5.51 - 8.46)
Associated T_p (s)	10.6 (8.6 - 14.0)	10.6 (10.5 - 10.7)	11.0 (9.4 - 15.0)	11.3 (11.1 - 11.5)	14.5 (13.5 - 16.1)	14.4 (13.3 - 15.9)	14.4 (13.5 - 15.8)	12.2 (11.9 - 12.6)	11.3 (11.3 - 11.5)	13.1 (12.4 - 14.1)	11.3 (10.9 - 11.9)	12.6 (11.9 - 13.5)	14.1 (13.2 - 15.6)

Table 3.7 Directional current extremes at WTG15, return periods 500- and 1000-yr.

Current directions are going TOWARDS clockwise from the North	Sector 1 345-015deg	Sector 2 015-045deg	Sector 3 045-075deg	Sector 4 075-105deg	Sector 5 105-135deg	Sector 6 135-165deg	Sector 7 165-195deg	Sector 8 195-225deg	Sector 9 225-255deg	Sector 10 255-285deg	Sector 11 285-315deg	Sector 12 315-345deg	OMNI
500-yr													
Current surface total (m/s)	0.42 (0.37 - 0.51)	0.29 (0.25 - 0.38)	0.32 (0.27 - 0.43)	0.66 (0.58 - 0.79)	0.97 (0.85 - 1.25)	1.05 (0.91 - 1.28)	0.61 (0.51 - 0.81)	0.52 (0.42 - 0.71)	0.65 (0.59 - 0.72)	0.69 (0.61 - 0.82)	0.77 (0.68 - 0.89)	0.58 (0.50 - 0.71)	1.04 (0.91 - 1.28)
Current surface residual (m/s)	0.40 (0.34 - 0.51)	0.33 (0.26 - 0.46)	0.32 (0.27 - 0.40)	0.66 (0.47 - 1.10)	0.76 (0.64 - 0.97)	0.76 (0.63 - 0.96)	0.56 (0.49 - 0.68)	0.58 (0.51 - 0.70)	0.65 (0.60 - 0.73)	0.71 (0.61 - 0.86)	0.67 (0.53 - 0.94)	0.55 (0.43 - 0.76)	0.76 (0.65 - 0.96)
Current surface residual + ass. wind component (m/s)	0.55 (0.37 - 0.82)	0.44 (0.29 - 0.69)	0.43 (0.29 - 0.62)	0.88 (0.57 - 1.40)	1.02 (0.81 - 1.32)	0.97 (0.68 - 1.26)	0.73 (0.53 - 0.96)	0.70 (0.52 - 0.98)	0.77 (0.63 - 0.95)	0.81 (0.64 - 1.07)	0.80 (0.55 - 1.25)	0.71 (0.46 - 1.10)	-
Current DA total (m/s)	0.36 (0.32 - 0.43)	0.26 (0.22 - 0.33)	0.28 (0.24 - 0.37)	0.58 (0.50 - 0.70)	0.85 (0.76 - 1.00)	0.91 (0.79 - 1.09)	0.53 (0.45 - 0.68)	0.46 (0.38 - 0.63)	0.54 (0.51 - 0.61)	0.61 (0.54 - 0.72)	0.67 (0.58 - 0.82)	0.51 (0.44 - 0.64)	0.91 (0.79 - 1.17)
Current DA residual (m/s)	0.35 (0.29 - 0.45)	0.29 (0.23 - 0.39)	0.27 (0.23 - 0.35)	0.57 (0.41 - 0.93)	0.66 (0.55 - 0.85)	0.66 (0.55 - 0.83)	0.48 (0.42 - 0.57)	0.52 (0.45 - 0.63)	0.54 (0.51 - 0.58)	0.62 (0.54 - 0.76)	0.59 (0.46 - 0.80)	0.47 (0.36 - 0.65)	0.66 (0.56 - 0.84)
Current near-bottom total (m/s)	0.22 (0.19 - 0.27)	0.15 (0.13 - 0.20)	0.17 (0.14 - 0.23)	0.35 (0.30 - 0.42)	0.51 (0.46 - 0.61)	0.56 (0.49 - 0.67)	0.33 (0.27 - 0.43)	0.28 (0.23 - 0.38)	0.34 (0.32 - 0.38)	0.37 (0.33 - 0.44)	0.41 (0.36 - 0.47)	0.30 (0.26 - 0.37)	0.56 (0.50 - 0.65)
Current near-bottom residual (m/s)	0.22 (0.18 - 0.27)	0.18 (0.15 - 0.22)	0.17 (0.14 - 0.21)	0.35 (0.25 - 0.58)	0.40 (0.34 - 0.52)	0.40 (0.33 - 0.51)	0.28 (0.24 - 0.34)	0.31 (0.27 - 0.37)	0.34 (0.32 - 0.38)	0.37 (0.32 - 0.45)	0.35 (0.28 - 0.50)	0.29 (0.23 - 0.41)	0.40 (0.34 - 0.51)
Associated H_s (m)	1.99 (0.61 - 4.45)	2.14 (2.01 - 2.40)	2.32 (0.75 - 6.21)	3.06 (2.85 - 3.43)	7.87 (6.08 - 11.06)	7.25 (5.51 - 9.83)	6.88 (5.47 - 9.33)	3.98 (3.62 - 4.71)	2.73 (2.65 - 2.92)	5.19 (4.14 - 7.04)	3.70 (3.11 - 4.76)	4.19 (3.20 - 5.93)	7.51 (5.72 - 11.22)
Associated T_p (s)	10.6 (8.6 - 14.0)	10.7 (10.5 - 11.1)	11.0 (9.4 - 15.0)	11.4 (11.2 - 11.8)	15.3 (13.8 - 18.0)	15.3 (13.6 - 17.8)	15.3 (13.7 - 18.1)	12.4 (12.0 - 13.2)	11.4 (11.3 - 11.6)	13.8 (12.6 - 15.9)	11.7 (11.0 - 12.8)	13.2 (12.1 - 15.2)	14.8 (13.4 - 17.9)
1000-yr													
Current surface total (m/s)	0.44 (0.37 - 0.54)	0.30 (0.25 - 0.43)	0.34 (0.27 - 0.48)	0.68 (0.58 - 0.85)	0.99 (0.85 - 1.35)	1.08 (0.92 - 1.37)	0.64 (0.51 - 0.89)	0.54 (0.43 - 0.81)	0.65 (0.60 - 0.74)	0.71 (0.62 - 0.88)	0.79 (0.69 - 0.94)	0.60 (0.50 - 0.78)	1.07 (0.92 - 1.37)
Current surface residual (m/s)	0.42 (0.35 - 0.55)	0.34 (0.27 - 0.51)	0.33 (0.27 - 0.43)	0.70 (0.47 - 1.34)	0.78 (0.64 - 1.04)	0.78 (0.63 - 1.02)	0.58 (0.50 - 0.72)	0.59 (0.51 - 0.77)	0.66 (0.60 - 0.74)	0.73 (0.62 - 0.93)	0.70 (0.54 - 1.05)	0.57 (0.44 - 0.85)	0.78 (0.65 - 1.06)
Current surface residual + ass. wind component (m/s)	0.57 (0.38 - 0.86)	0.46 (0.29 - 0.75)	0.44 (0.30 - 0.65)	0.92 (0.57 - 1.64)	1.04 (0.81 - 1.38)	1.00 (0.69 - 1.33)	0.74 (0.54 - 1.00)	0.72 (0.53 - 1.05)	0.77 (0.63 - 0.96)	0.84 (0.65 - 1.15)	0.84 (0.55 - 1.37)	0.74 (0.47 - 1.19)	-
Current DA total (m/s)	0.37 (0.32 - 0.46)	0.27 (0.22 - 0.37)	0.30 (0.24 - 0.41)	0.59 (0.51 - 0.74)	0.87 (0.77 - 1.06)	0.93 (0.79 - 1.16)	0.55 (0.45 - 0.75)	0.48 (0.38 - 0.71)	0.54 (0.51 - 0.62)	0.62 (0.54 - 0.77)	0.69 (0.58 - 0.88)	0.52 (0.44 - 0.70)	0.94 (0.79 - 1.28)
Current DA residual (m/s)	0.37 (0.30 - 0.49)	0.30 (0.23 - 0.43)	0.28 (0.23 - 0.38)	0.61 (0.42 - 1.12)	0.67 (0.56 - 0.91)	0.68 (0.56 - 0.90)	0.49 (0.42 - 0.60)	0.53 (0.45 - 0.69)	0.54 (0.51 - 0.59)	0.64 (0.54 - 0.82)	0.61 (0.47 - 0.90)	0.50 (0.37 - 0.72)	0.68 (0.56 - 0.92)
Current near-bottom total (m/s)	0.23 (0.20 - 0.29)	0.16 (0.13 - 0.22)	0.18 (0.14 - 0.25)	0.35 (0.31 - 0.44)	0.53 (0.47 - 0.64)	0.58 (0.50 - 0.71)	0.34 (0.27 - 0.47)	0.29 (0.23 - 0.43)	0.34 (0.32 - 0.39)	0.38 (0.33 - 0.48)	0.42 (0.37 - 0.50)	0.31 (0.27 - 0.41)	0.57 (0.50 - 0.69)
Current near-bottom residual (m/s)	0.23 (0.18 - 0.29)	0.18 (0.16 - 0.23)	0.18 (0.14 - 0.23)	0.37 (0.25 - 0.71)	0.41 (0.34 - 0.55)	0.41 (0.34 - 0.54)	0.28 (0.24 - 0.36)	0.32 (0.27 - 0.41)	0.34 (0.32 - 0.39)	0.39 (0.33 - 0.49)	0.37 (0.29 - 0.56)	0.31 (0.23 - 0.46)	0.42 (0.35 - 0.57)
Associated H_s (m)	1.99 (0.61 - 4.45)	2.17 (2.01 - 2.53)	2.32 (0.75 - 6.21)	3.11 (2.86 - 3.56)	8.29 (6.21 - 12.19)	7.60 (5.58 - 10.82)	7.22 (5.56 - 10.49)	4.06 (3.63 - 5.05)	2.74 (2.65 - 2.96)	5.47 (4.21 - 7.85)	3.84 (3.14 - 5.21)	4.42 (3.26 - 6.77)	7.88 (5.78 - 12.71)
Associated T_p (s)	10.6 (8.6 - 14.0)	10.7 (10.5 - 11.2)	11.0 (9.4 - 15.0)	11.4 (11.2 - 11.9)	15.7 (13.9 - 18.9)	15.6 (13.6 - 18.8)	15.7 (13.8 - 19.4)	12.5 (12.0 - 13.6)	11.4 (11.3 - 11.7)	14.1 (12.7 - 16.8)	11.8 (11.0 - 13.3)	13.5 (12.1 - 16.2)	15.2 (13.4 - 19.1)

Table 3.8 Directional current extremes at WTG08, return periods 1-, 5- and 10-yr.

Current directions are going TOWARDS clockwise from the North	Sector 1 345-015deg	Sector 2 015-045deg	Sector 3 045-075deg	Sector 4 075-105deg	Sector 5 105-135deg	Sector 6 135-165deg	Sector 7 165-195deg	Sector 8 195-225deg	Sector 9 225-255deg	Sector 10 255-285deg	Sector 11 285-315deg	Sector 12 315-345deg	OMNI
1-yr													
Current surface total (m/s)	0.26 (0.25 - 0.26)	0.30 (0.30 - 0.30)	0.40 (0.40 - 0.41)	0.48 (0.47 - 0.49)	0.48 (0.47 - 0.49)	0.28 (0.27 - 0.28)	0.23 (0.23 - 0.23)	0.22 (0.22 - 0.22)	0.23 (0.23 - 0.23)	0.27 (0.27 - 0.27)	0.29 (0.29 - 0.30)	0.25 (0.25 - 0.26)	0.50 (0.49 - 0.51)
Current surface residual (m/s)	0.15 (0.14 - 0.15)	0.17 (0.17 - 0.18)	0.20 (0.20 - 0.21)	0.29 (0.28 - 0.30)	0.33 (0.33 - 0.34)	0.27 (0.27 - 0.28)	0.29 (0.28 - 0.29)	0.23 (0.22 - 0.24)	0.18 (0.17 - 0.19)	0.16 (0.15 - 0.17)	0.16 (0.16 - 0.17)	0.15 (0.15 - 0.16)	0.35 (0.34 - 0.35)
Current surface residual + ass. wind component (m/s)	0.28 (0.17 - 0.45)	0.35 (0.22 - 0.47)	0.40 (0.26 - 0.55)	0.57 (0.47 - 0.68)	0.63 (0.55 - 0.73)	0.46 (0.31 - 0.59)	0.44 (0.31 - 0.56)	0.36 (0.24 - 0.50)	0.33 (0.20 - 0.46)	0.29 (0.18 - 0.43)	0.33 (0.19 - 0.51)	0.30 (0.17 - 0.46)	-
Current DA total (m/s)	0.23 (0.22 - 0.23)	0.27 (0.27 - 0.27)	0.35 (0.35 - 0.36)	0.42 (0.41 - 0.42)	0.42 (0.41 - 0.42)	0.24 (0.24 - 0.24)	0.20 (0.20 - 0.20)	0.19 (0.19 - 0.20)	0.20 (0.20 - 0.20)	0.24 (0.24 - 0.24)	0.26 (0.26 - 0.26)	0.22 (0.22 - 0.23)	0.44 (0.43 - 0.44)
Current DA residual (m/s)	0.13 (0.12 - 0.13)	0.15 (0.15 - 0.15)	0.18 (0.17 - 0.18)	0.25 (0.25 - 0.26)	0.29 (0.28 - 0.30)	0.24 (0.23 - 0.25)	0.25 (0.24 - 0.26)	0.20 (0.19 - 0.21)	0.16 (0.15 - 0.17)	0.14 (0.13 - 0.15)	0.14 (0.14 - 0.15)	0.13 (0.13 - 0.14)	0.30 (0.29 - 0.31)
Current near-bottom total (m/s)	0.14 (0.14 - 0.14)	0.16 (0.16 - 0.16)	0.21 (0.21 - 0.22)	0.26 (0.25 - 0.26)	0.26 (0.25 - 0.26)	0.15 (0.14 - 0.15)	0.12 (0.12 - 0.12)	0.12 (0.12 - 0.12)	0.12 (0.12 - 0.12)	0.15 (0.15 - 0.15)	0.16 (0.15 - 0.16)	0.13 (0.13 - 0.14)	0.27 (0.26 - 0.27)
Current near-bottom residual (m/s)	0.08 (0.07 - 0.08)	0.09 (0.09 - 0.09)	0.11 (0.11 - 0.11)	0.15 (0.15 - 0.16)	0.18 (0.18 - 0.18)	0.15 (0.14 - 0.15)	0.15 (0.15 - 0.15)	0.12 (0.12 - 0.13)	0.10 (0.09 - 0.10)	0.09 (0.08 - 0.09)	0.09 (0.09 - 0.09)	0.08 (0.08 - 0.08)	0.18 (0.18 - 0.19)
Associated H_s (m)	1.83 (0.59 - 3.87)	1.98 (1.96 - 2.01)	3.11 (3.02 - 3.21)	4.42 (4.29 - 4.56)	4.26 (4.12 - 4.42)	4.44 (4.32 - 4.58)	3.14 (3.09 - 3.20)	2.42 (2.37 - 2.47)	1.94 (1.91 - 1.97)	2.01 (2.00 - 2.01)	2.28 (2.19 - 2.38)	2.42 (2.36 - 2.47)	4.58 (4.39 - 4.76)
Associated T_p (s)	10.9 (8.4 - 14.9)	11.1 (11.1 - 11.2)	11.8 (11.8 - 11.9)	13.0 (12.8 - 13.1)	12.8 (12.6 - 13.0)	13.2 (13.0 - 13.3)	11.7 (11.6 - 11.7)	11.1 (11.1 - 11.2)	10.7 (10.6 - 10.7)	10.7 (10.6 - 10.7)	11.2 (11.1 - 11.3)	11.1 (11.1 - 11.2)	12.9 (12.7 - 13.1)
5-yr													
Current surface total (m/s)	0.27 (0.27 - 0.28)	0.33 (0.32 - 0.33)	0.44 (0.43 - 0.45)	0.53 (0.52 - 0.55)	0.54 (0.53 - 0.56)	0.31 (0.30 - 0.32)	0.26 (0.25 - 0.27)	0.24 (0.23 - 0.24)	0.25 (0.24 - 0.25)	0.28 (0.28 - 0.29)	0.32 (0.31 - 0.32)	0.28 (0.27 - 0.28)	0.56 (0.55 - 0.57)
Current surface residual (m/s)	0.18 (0.17 - 0.19)	0.20 (0.19 - 0.20)	0.24 (0.23 - 0.26)	0.35 (0.33 - 0.37)	0.41 (0.39 - 0.43)	0.34 (0.32 - 0.35)	0.34 (0.32 - 0.35)	0.28 (0.27 - 0.30)	0.23 (0.22 - 0.24)	0.21 (0.20 - 0.23)	0.20 (0.19 - 0.21)	0.19 (0.18 - 0.20)	0.41 (0.39 - 0.43)
Current surface residual + ass. wind component (m/s)	0.32 (0.20 - 0.50)	0.37 (0.24 - 0.49)	0.45 (0.30 - 0.60)	0.63 (0.52 - 0.75)	0.71 (0.61 - 0.81)	0.53 (0.37 - 0.67)	0.49 (0.36 - 0.62)	0.42 (0.29 - 0.56)	0.38 (0.25 - 0.52)	0.34 (0.22 - 0.49)	0.37 (0.22 - 0.55)	0.34 (0.20 - 0.50)	-
Current DA total (m/s)	0.24 (0.24 - 0.25)	0.29 (0.28 - 0.29)	0.38 (0.37 - 0.39)	0.46 (0.45 - 0.47)	0.47 (0.46 - 0.49)	0.27 (0.26 - 0.28)	0.22 (0.22 - 0.23)	0.21 (0.20 - 0.21)	0.22 (0.21 - 0.22)	0.25 (0.25 - 0.25)	0.28 (0.27 - 0.29)	0.24 (0.24 - 0.25)	0.49 (0.48 - 0.50)
Current DA residual (m/s)	0.16 (0.15 - 0.17)	0.18 (0.17 - 0.18)	0.21 (0.20 - 0.23)	0.30 (0.29 - 0.32)	0.36 (0.34 - 0.38)	0.29 (0.28 - 0.30)	0.30 (0.29 - 0.31)	0.25 (0.24 - 0.26)	0.20 (0.19 - 0.21)	0.19 (0.17 - 0.20)	0.18 (0.17 - 0.19)	0.16 (0.15 - 0.17)	0.36 (0.34 - 0.38)
Current near-bottom total (m/s)	0.15 (0.14 - 0.15)	0.17 (0.17 - 0.18)	0.23 (0.23 - 0.24)	0.28 (0.28 - 0.29)	0.29 (0.28 - 0.30)	0.17 (0.16 - 0.17)	0.14 (0.13 - 0.14)	0.13 (0.12 - 0.13)	0.13 (0.13 - 0.13)	0.15 (0.15 - 0.15)	0.17 (0.17 - 0.17)	0.15 (0.14 - 0.15)	0.30 (0.29 - 0.31)
Current near-bottom residual (m/s)	0.10 (0.09 - 0.10)	0.11 (0.10 - 0.11)	0.13 (0.12 - 0.14)	0.19 (0.18 - 0.20)	0.22 (0.21 - 0.23)	0.18 (0.17 - 0.18)	0.18 (0.18 - 0.19)	0.15 (0.14 - 0.16)	0.12 (0.12 - 0.13)	0.11 (0.10 - 0.12)	0.11 (0.10 - 0.11)	0.10 (0.09 - 0.10)	0.22 (0.21 - 0.23)
Associated H_s (m)	1.83 (0.59 - 3.87)	2.51 (2.37 - 2.69)	3.73 (3.56 - 3.90)	5.44 (5.17 - 5.72)	5.43 (5.09 - 5.79)	5.36 (5.08 - 5.66)	3.55 (3.41 - 3.72)	2.79 (2.69 - 2.89)	2.21 (2.12 - 2.32)	2.15 (2.11 - 2.19)	2.92 (2.74 - 3.11)	2.84 (2.72 - 2.97)	5.84 (5.54 - 6.12)
Associated T_p (s)	10.9 (8.4 - 14.9)	11.9 (11.7 - 12.1)	12.5 (12.3 - 12.6)	14.0 (13.7 - 14.3)	14.0 (13.7 - 14.4)	14.1 (13.8 - 14.4)	12.2 (12.0 - 12.4)	11.5 (11.4 - 11.6)	11.1 (11.0 - 11.3)	10.9 (10.8 - 11.0)	12.2 (11.9 - 12.4)	11.6 (11.5 - 11.8)	14.3 (14.0 - 14.6)
10-yr													
Current surface total (m/s)	0.28 (0.27 - 0.29)	0.34 (0.33 - 0.35)	0.45 (0.44 - 0.47)	0.55 (0.53 - 0.57)	0.57 (0.54 - 0.60)	0.33 (0.31 - 0.34)	0.27 (0.25 - 0.28)	0.25 (0.24 - 0.25)	0.25 (0.24 - 0.26)	0.29 (0.28 - 0.30)	0.33 (0.32 - 0.34)	0.29 (0.28 - 0.30)	0.59 (0.57 - 0.61)
Current surface residual (m/s)	0.20 (0.18 - 0.21)	0.21 (0.20 - 0.21)	0.26 (0.24 - 0.28)	0.37 (0.34 - 0.41)	0.44 (0.41 - 0.47)	0.37 (0.34 - 0.39)	0.35 (0.33 - 0.37)	0.31 (0.29 - 0.33)	0.25 (0.23 - 0.27)	0.23 (0.21 - 0.26)	0.22 (0.20 - 0.24)	0.20 (0.19 - 0.21)	0.43 (0.41 - 0.47)
Current surface residual + ass. wind component (m/s)	0.33 (0.21 - 0.52)	0.38 (0.25 - 0.50)	0.46 (0.31 - 0.62)	0.65 (0.53 - 0.79)	0.74 (0.63 - 0.85)	0.56 (0.39 - 0.70)	0.51 (0.37 - 0.64)	0.44 (0.31 - 0.59)	0.40 (0.26 - 0.54)	0.36 (0.24 - 0.52)	0.39 (0.24 - 0.57)	0.35 (0.21 - 0.52)	-
Current DA total (m/s)	0.25 (0.24 - 0.25)	0.30 (0.29 - 0.31)	0.40 (0.38 - 0.41)	0.48 (0.47 - 0.50)	0.50 (0.47 - 0.52)	0.29 (0.27 - 0.30)	0.23 (0.22 - 0.25)	0.21 (0.21 - 0.22)	0.22 (0.21 - 0.23)	0.25 (0.25 - 0.26)	0.29 (0.28 - 0.30)	0.25 (0.24 - 0.26)	0.51 (0.49 - 0.53)
Current DA residual (m/s)	0.17 (0.16 - 0.19)	0.18 (0.17 - 0.19)	0.23 (0.21 - 0.25)	0.33 (0.30 - 0.36)	0.38 (0.35 - 0.41)	0.30 (0.29 - 0.32)	0.32 (0.30 - 0.34)	0.27 (0.25 - 0.29)	0.22 (0.20 - 0.23)	0.21 (0.19 - 0.22)	0.19 (0.18 - 0.21)	0.18 (0.16 - 0.19)	0.38 (0.35 - 0.41)
Current near-bottom total (m/s)	0.15 (0.15 - 0.15)	0.18 (0.17 - 0.19)	0.24 (0.23 - 0.25)	0.30 (0.29 - 0.30)	0.31 (0.29 - 0.32)	0.18 (0.17 - 0.18)	0.14 (0.14 - 0.15)	0.13 (0.13 - 0.13)	0.13 (0.13 - 0.14)	0.15 (0.15 - 0.16)	0.17 (0.17 - 0.18)	0.15 (0.15 - 0.16)	0.31 (0.30 - 0.32)
Current near-bottom residual (m/s)	0.11 (0.10 - 0.11)	0.11 (0.11 - 0.12)	0.14 (0.13 - 0.15)	0.20 (0.18 - 0.22)	0.23 (0.22 - 0.25)	0.19 (0.18 - 0.20)	0.20 (0.19 - 0.21)	0.16 (0.15 - 0.18)	0.13 (0.12 - 0.14)	0.12 (0.11 - 0.14)	0.12 (0.11 - 0.13)	0.11 (0.10 - 0.11)	0.23 (0.22 - 0.25)
Associated H_s (m)	1.83 (0.59 - 3.87)	2.74 (2.52 - 2.99)	3.97 (3.73 - 4.21)	5.88 (5.52 - 6.25)	5.92 (5.43 - 6.43)	5.75 (5.35 - 6.18)	3.72 (3.51 - 3.98)	2.95 (2.81 - 3.09)	2.33 (2.18 - 2.50)	2.21 (2.15 - 2.28)	3.20 (2.94 - 3.46)	3.01 (2.84 - 3.19)	6.38 (5.96 - 6.81)
Associated T_p (s)	10.9 (8.4 - 14.9)	12.2 (11.9 - 12.5)	12.7 (12.5 - 12.9)	14.5 (14.1 - 14.8)	14.5 (14.0 - 15.1)	14.5 (14.1 - 15.0)	12.4 (12.1 - 12.7)	11.7 (11.5 - 11.8)	11.3 (11.1 - 11.6)	11.0 (10.9 - 11.2)	12.6 (12.2 - 12.9)	11.9 (11.6 - 12.1)	14.9 (14.5 - 15.4)

Table 3.9 Directional current extremes at WTG08, return periods 50-, 100-, 500- and 1000-yr.

Current directions are going TOWARDS clockwise from the North	**Sector 1** 345-015deg	**Sector 2** 015-045deg	**Sector 3** 045-075deg	**Sector 4** 075-105deg	**Sector 5** 105-135deg	**Sector 6** 135-165deg	**Sector 7** 165-195deg	**Sector 8** 195-225deg	**Sector 9** 225-255deg	**Sector 10** 255-285deg	**Sector 11** 285-315deg	**Sector 12** 315-345deg	**OMNI**
50-yr													
Current surface total (m/s)	0.29 (0.28 - 0.31)	0.36 (0.34 - 0.39)	0.48 (0.46 - 0.51)	0.60 (0.56 - 0.65)	0.64 (0.58 - 0.71)	0.36 (0.33 - 0.41)	0.29 (0.27 - 0.33)	0.26 (0.25 - 0.28)	0.27 (0.25 - 0.29)	0.30 (0.29 - 0.32)	0.35 (0.33 - 0.38)	0.31 (0.29 - 0.33)	0.65 (0.60 - 0.70)
Current surface residual (m/s)	0.23 (0.20 - 0.27)	0.22 (0.21 - 0.24)	0.30 (0.26 - 0.35)	0.43 (0.37 - 0.54)	0.50 (0.44 - 0.58)	0.43 (0.39 - 0.49)	0.39 (0.35 - 0.43)	0.36 (0.32 - 0.41)	0.30 (0.26 - 0.34)	0.29 (0.25 - 0.33)	0.26 (0.22 - 0.30)	0.24 (0.21 - 0.27)	0.50 (0.44 - 0.58)
Current surface residual + ass. wind component (m/s)	0.37 (0.23 - 0.57)	0.40 (0.26 - 0.53)	0.50 (0.33 - 0.69)	0.71 (0.55 - 0.92)	0.80 (0.67 - 0.96)	0.62 (0.43 - 0.80)	0.54 (0.39 - 0.70)	0.50 (0.35 - 0.67)	0.45 (0.29 - 0.62)	0.42 (0.27 - 0.59)	0.42 (0.26 - 0.64)	0.39 (0.23 - 0.57)	-
Current DA total (m/s)	0.26 (0.25 - 0.27)	0.32 (0.30 - 0.34)	0.42 (0.40 - 0.45)	0.53 (0.49 - 0.56)	0.56 (0.51 - 0.61)	0.32 (0.29 - 0.36)	0.25 (0.23 - 0.29)	0.23 (0.22 - 0.24)	0.23 (0.22 - 0.25)	0.26 (0.25 - 0.28)	0.31 (0.29 - 0.33)	0.27 (0.26 - 0.29)	0.56 (0.53 - 0.61)
Current DA residual (m/s)	0.20 (0.18 - 0.24)	0.20 (0.18 - 0.22)	0.26 (0.23 - 0.30)	0.38 (0.32 - 0.46)	0.44 (0.38 - 0.51)	0.34 (0.31 - 0.37)	0.36 (0.32 - 0.40)	0.32 (0.28 - 0.36)	0.26 (0.23 - 0.29)	0.25 (0.22 - 0.29)	0.23 (0.20 - 0.26)	0.21 (0.18 - 0.23)	0.43 (0.38 - 0.51)
Current near-bottom total (m/s)	0.16 (0.15 - 0.16)	0.19 (0.18 - 0.21)	0.26 (0.24 - 0.27)	0.32 (0.30 - 0.35)	0.34 (0.31 - 0.38)	0.20 (0.18 - 0.22)	0.16 (0.14 - 0.17)	0.14 (0.13 - 0.15)	0.14 (0.13 - 0.15)	0.16 (0.15 - 0.17)	0.19 (0.18 - 0.20)	0.17 (0.16 - 0.18)	0.34 (0.32 - 0.37)
Current near-bottom residual (m/s)	0.13 (0.11 - 0.14)	0.12 (0.11 - 0.13)	0.16 (0.14 - 0.19)	0.23 (0.20 - 0.29)	0.27 (0.24 - 0.31)	0.21 (0.19 - 0.23)	0.23 (0.21 - 0.26)	0.19 (0.17 - 0.22)	0.16 (0.14 - 0.18)	0.15 (0.13 - 0.18)	0.14 (0.12 - 0.16)	0.13 (0.11 - 0.14)	0.26 (0.23 - 0.31)
Associated H_s (m)	1.83 (0.59 - 3.87)	3.27 (2.76 - 3.88)	4.44 (4.00 - 4.96)	6.90 (6.19 - 7.72)	7.06 (6.12 - 8.19)	6.65 (5.89 - 7.63)	4.13 (3.71 - 4.72)	3.31 (3.02 - 3.70)	2.59 (2.28 - 3.02)	2.35 (2.20 - 2.59)	3.84 (3.30 - 4.53)	3.41 (3.08 - 3.82)	7.63 (6.72 - 8.78)
Associated T_p (s)	10.9 (8.4 - 14.9)	12.9 (12.2 - 13.7)	13.2 (12.7 - 13.7)	15.5 (14.8 - 16.4)	15.7 (14.7 - 16.9)	15.5 (14.7 - 16.5)	12.9 (12.4 - 13.6)	12.1 (11.8 - 12.5)	11.7 (11.2 - 12.4)	11.3 (11.0 - 11.8)	13.5 (12.7 - 14.5)	12.4 (11.9 - 12.8)	16.3 (15.3 - 17.6)
100-yr													
Current surface total (m/s)	0.30 (0.28 - 0.31)	0.37 (0.34 - 0.41)	0.49 (0.46 - 0.53)	0.62 (0.57 - 0.68)	0.67 (0.60 - 0.76)	0.38 (0.34 - 0.44)	0.30 (0.27 - 0.35)	0.27 (0.25 - 0.29)	0.27 (0.25 - 0.30)	0.31 (0.29 - 0.33)	0.36 (0.34 - 0.40)	0.32 (0.29 - 0.35)	0.67 (0.62 - 0.75)
Current surface residual (m/s)	0.25 (0.21 - 0.30)	0.23 (0.21 - 0.26)	0.32 (0.27 - 0.38)	0.46 (0.37 - 0.61)	0.53 (0.45 - 0.64)	0.46 (0.40 - 0.54)	0.40 (0.36 - 0.46)	0.39 (0.33 - 0.45)	0.32 (0.27 - 0.38)	0.31 (0.26 - 0.37)	0.27 (0.23 - 0.34)	0.25 (0.22 - 0.29)	0.52 (0.45 - 0.64)
Current surface residual + ass. wind component (m/s)	0.39 (0.24 - 0.60)	0.40 (0.26 - 0.55)	0.52 (0.34 - 0.72)	0.74 (0.56 - 0.99)	0.83 (0.68 - 1.02)	0.65 (0.45 - 0.85)	0.56 (0.39 - 0.73)	0.52 (0.36 - 0.72)	0.47 (0.30 - 0.66)	0.44 (0.28 - 0.63)	0.44 (0.26 - 0.67)	0.40 (0.24 - 0.60)	-
Current DA total (m/s)	0.26 (0.25 - 0.28)	0.33 (0.30 - 0.36)	0.43 (0.40 - 0.46)	0.54 (0.50 - 0.59)	0.58 (0.52 - 0.66)	0.33 (0.30 - 0.38)	0.26 (0.24 - 0.31)	0.23 (0.22 - 0.26)	0.24 (0.22 - 0.27)	0.27 (0.25 - 0.29)	0.32 (0.30 - 0.35)	0.28 (0.26 - 0.31)	0.59 (0.54 - 0.65)
Current DA residual (m/s)	0.22 (0.19 - 0.26)	0.20 (0.19 - 0.23)	0.28 (0.24 - 0.33)	0.40 (0.32 - 0.53)	0.46 (0.39 - 0.56)	0.35 (0.31 - 0.40)	0.38 (0.33 - 0.43)	0.34 (0.30 - 0.40)	0.27 (0.23 - 0.32)	0.27 (0.23 - 0.32)	0.24 (0.20 - 0.29)	0.22 (0.19 - 0.26)	0.46 (0.39 - 0.55)
Current near-bottom total (m/s)	0.16 (0.15 - 0.17)	0.20 (0.18 - 0.22)	0.26 (0.25 - 0.28)	0.33 (0.31 - 0.37)	0.35 (0.32 - 0.40)	0.20 (0.18 - 0.24)	0.16 (0.15 - 0.19)	0.14 (0.13 - 0.16)	0.14 (0.13 - 0.16)	0.16 (0.15 - 0.18)	0.19 (0.18 - 0.21)	0.17 (0.16 - 0.19)	0.36 (0.33 - 0.39)
Current near-bottom residual (m/s)	0.13 (0.11 - 0.16)	0.13 (0.12 - 0.14)	0.17 (0.15 - 0.21)	0.24 (0.20 - 0.33)	0.28 (0.24 - 0.34)	0.22 (0.19 - 0.24)	0.25 (0.22 - 0.29)	0.21 (0.18 - 0.24)	0.17 (0.14 - 0.20)	0.16 (0.14 - 0.20)	0.15 (0.12 - 0.18)	0.13 (0.12 - 0.16)	0.28 (0.24 - 0.34)
Associated H_s (m)	1.83 (0.59 - 3.87)	3.49 (2.84 - 4.41)	4.61 (4.07 - 5.31)	7.34 (6.43 - 8.48)	7.55 (6.36 - 9.08)	7.03 (6.07 - 8.39)	4.30 (3.78 - 5.11)	3.47 (3.09 - 4.03)	2.69 (2.31 - 3.32)	2.41 (2.21 - 2.77)	4.12 (3.43 - 5.11)	3.58 (3.16 - 4.12)	8.17 (6.98 - 9.80)
Associated T_p (s)	10.9 (8.4 - 14.9)	13.2 (12.3 - 14.4)	13.3 (12.8 - 14.0)	16.0 (15.0 - 17.1)	16.3 (15.0 - 17.9)	15.9 (14.9 - 17.3)	13.1 (12.4 - 14.1)	12.3 (11.8 - 12.9)	11.9 (11.3 - 12.9)	11.4 (11.0 - 12.1)	13.9 (12.9 - 15.4)	12.6 (12.0 - 13.2)	16.9 (15.6 - 18.7)
500-yr													
Current surface total (m/s)	0.30 (0.29 - 0.33)	0.39 (0.35 - 0.48)	0.51 (0.47 - 0.58)	0.67 (0.59 - 0.79)	0.73 (0.62 - 0.89)	0.41 (0.35 - 0.54)	0.33 (0.28 - 0.41)	0.29 (0.26 - 0.34)	0.28 (0.26 - 0.35)	0.32 (0.29 - 0.38)	0.38 (0.35 - 0.45)	0.34 (0.30 - 0.40)	0.73 (0.64 - 0.89)
Current surface residual (m/s)	0.29 (0.23 - 0.38)	0.24 (0.21 - 0.30)	0.36 (0.29 - 0.48)	0.52 (0.38 - 0.84)	0.59 (0.47 - 0.80)	0.52 (0.44 - 0.66)	0.42 (0.36 - 0.51)	0.44 (0.36 - 0.56)	0.37 (0.29 - 0.50)	0.36 (0.28 - 0.46)	0.31 (0.24 - 0.44)	0.29 (0.23 - 0.37)	0.59 (0.47 - 0.80)
Current surface residual + ass. wind component (m/s)	0.42 (0.25 - 0.68)	0.42 (0.26 - 0.59)	0.56 (0.36 - 0.82)	0.80 (0.57 - 1.22)	0.89 (0.69 - 1.18)	0.71 (0.48 - 0.97)	0.58 (0.40 - 0.78)	0.58 (0.38 - 0.82)	0.52 (0.32 - 0.78)	0.49 (0.31 - 0.73)	0.48 (0.27 - 0.78)	0.44 (0.26 - 0.67)	-
Current DA total (m/s)	0.27 (0.25 - 0.31)	0.35 (0.30 - 0.43)	0.45 (0.41 - 0.51)	0.59 (0.52 - 0.69)	0.63 (0.54 - 0.77)	0.37 (0.31 - 0.46)	0.29 (0.24 - 0.37)	0.25 (0.22 - 0.29)	0.25 (0.22 - 0.31)	0.28 (0.26 - 0.34)	0.34 (0.30 - 0.40)	0.30 (0.27 - 0.35)	0.64 (0.56 - 0.78)
Current DA residual (m/s)	0.25 (0.20 - 0.33)	0.21 (0.19 - 0.25)	0.31 (0.25 - 0.41)	0.45 (0.33 - 0.72)	0.51 (0.40 - 0.71)	0.37 (0.32 - 0.45)	0.41 (0.34 - 0.51)	0.39 (0.32 - 0.50)	0.31 (0.25 - 0.40)	0.32 (0.25 - 0.41)	0.27 (0.21 - 0.39)	0.25 (0.20 - 0.32)	0.51 (0.41 - 0.69)
Current near-bottom total (m/s)	0.16 (0.15 - 0.18)	0.21 (0.19 - 0.26)	0.27 (0.25 - 0.31)	0.36 (0.32 - 0.42)	0.39 (0.33 - 0.47)	0.22 (0.19 - 0.29)	0.18 (0.15 - 0.22)	0.15 (0.14 - 0.18)	0.15 (0.14 - 0.18)	0.17 (0.16 - 0.20)	0.21 (0.18 - 0.24)	0.19 (0.16 - 0.22)	0.39 (0.35 - 0.46)
Current near-bottom residual (m/s)	0.15 (0.12 - 0.20)	0.13 (0.12 - 0.15)	0.19 (0.15 - 0.26)	0.28 (0.20 - 0.45)	0.31 (0.25 - 0.42)	0.23 (0.20 - 0.28)	0.28 (0.23 - 0.35)	0.23 (0.19 - 0.30)	0.20 (0.15 - 0.27)	0.19 (0.15 - 0.25)	0.17 (0.13 - 0.24)	0.15 (0.12 - 0.20)	0.31 (0.25 - 0.42)
Associated H_s (m)	1.83 (0.59 - 3.87)	4.02 (2.95 - 6.25)	4.97 (4.20 - 6.10)	8.36 (6.88 - 10.65)	8.66 (6.82 - 11.47)	7.90 (6.43 - 10.43)	4.71 (3.92 - 6.15)	3.82 (3.20 - 4.97)	2.94 (2.38 - 4.24)	2.55 (2.23 - 3.36)	4.76 (3.68 - 6.70)	3.96 (3.30 - 4.92)	9.42 (7.45 - 12.82)
Associated T_p (s)	10.9 (8.4 - 14.9)	13.9 (12.4 - 16.9)	13.7 (12.9 - 14.8)	17.0 (15.5 - 19.4)	17.4 (15.5 - 20.4)	16.8 (15.2 - 19.4)	13.6 (12.6 - 15.3)	12.6 (12.0 - 13.9)	12.3 (11.4 - 14.4)	11.7 (11.1 - 13.2)	14.9 (13.3 - 17.8)	13.0 (12.2 - 14.2)	18.3 (16.1 - 22.1)
1000-yr													
Current surface total (m/s)	0.31 (0.29 - 0.34)	0.40 (0.35 - 0.52)	0.52 (0.47 - 0.60)	0.69 (0.60 - 0.84)	0.76 (0.63 - 0.95)	0.43 (0.35 - 0.60)	0.34 (0.28 - 0.44)	0.29 (0.26 - 0.37)	0.29 (0.26 - 0.37)	0.32 (0.29 - 0.41)	0.39 (0.35 - 0.48)	0.35 (0.31 - 0.43)	0.76 (0.64 - 0.97)
Current surface residual (m/s)	0.30 (0.23 - 0.41)	0.25 (0.21 - 0.32)	0.38 (0.29 - 0.52)	0.54 (0.39 - 0.96)	0.61 (0.47 - 0.88)	0.55 (0.45 - 0.72)	0.43 (0.37 - 0.54)	0.46 (0.37 - 0.61)	0.39 (0.29 - 0.56)	0.38 (0.29 - 0.51)	0.33 (0.24 - 0.50)	0.30 (0.24 - 0.41)	0.61 (0.48 - 0.89)
Current surface residual + ass. wind component (m/s)	0.44 (0.26 - 0.72)	0.42 (0.27 - 0.61)	0.58 (0.36 - 0.86)	0.83 (0.57 - 1.34)	0.91 (0.70 - 1.27)	0.74 (0.49 - 1.03)	0.59 (0.40 - 0.81)	0.60 (0.39 - 0.87)	0.54 (0.32 - 0.84)	0.51 (0.32 - 0.77)	0.49 (0.28 - 0.84)	0.45 (0.26 - 0.71)	-
Current DA total (m/s)	0.28 (0.25 - 0.32)	0.35 (0.31 - 0.48)	0.45 (0.41 - 0.52)	0.61 (0.53 - 0.73)	0.66 (0.55 - 0.83)	0.38 (0.32 - 0.50)	0.30 (0.25 - 0.40)	0.25 (0.23 - 0.31)	0.25 (0.22 - 0.33)	0.28 (0.26 - 0.36)	0.35 (0.31 - 0.43)	0.31 (0.27 - 0.37)	0.66 (0.56 - 0.84)
Current DA residual (m/s)	0.26 (0.21 - 0.36)	0.22 (0.19 - 0.26)	0.33 (0.25 - 0.45)	0.47 (0.33 - 0.83)	0.53 (0.41 - 0.79)	0.38 (0.32 - 0.48)	0.42 (0.35 - 0.54)	0.41 (0.33 - 0.55)	0.32 (0.25 - 0.44)	0.34 (0.26 - 0.45)	0.29 (0.22 - 0.43)	0.26 (0.20 - 0.36)	0.53 (0.42 - 0.76)
Current near-bottom total (m/s)	0.16 (0.15 - 0.18)	0.22 (0.19 - 0.28)	0.28 (0.25 - 0.32)	0.37 (0.32 - 0.45)	0.40 (0.34 - 0.51)	0.23 (0.19 - 0.32)	0.18 (0.15 - 0.23)	0.16 (0.14 - 0.19)	0.15 (0.14 - 0.20)	0.17 (0.16 - 0.21)	0.21 (0.18 - 0.26)	0.19 (0.16 - 0.24)	0.40 (0.35 - 0.49)
Current near-bottom residual (m/s)	0.16 (0.13 - 0.22)	0.13 (0.12 - 0.16)	0.20 (0.16 - 0.28)	0.29 (0.21 - 0.51)	0.32 (0.25 - 0.47)	0.24 (0.20 - 0.30)	0.30 (0.24 - 0.38)	0.25 (0.20 - 0.33)	0.21 (0.16 - 0.30)	0.20 (0.16 - 0.27)	0.17 (0.13 - 0.27)	0.16 (0.13 - 0.22)	0.33 (0.25 - 0.47)
Associated H_s (m)	1.83 (0.59 - 3.87)	4.25 (2.99 - 7.35)	5.10 (4.24 - 6.46)	8.80 (7.03 - 11.75)	9.13 (6.99 - 12.62)	8.28 (6.57 - 11.50)	4.88 (3.95 - 6.69)	3.97 (3.24 - 5.49)	3.05 (2.39 - 4.78)	2.60 (2.24 - 3.73)	5.03 (3.75 - 7.53)	4.12 (3.35 - 5.31)	9.96 (7.58 - 14.24)
Associated T_p (s)	10.9 (8.4 - 14.9)	14.2 (12.5 - 18.3)	13.8 (13.0 - 15.2)	17.5 (15.6 - 20.5)	17.9 (15.7 - 21.6)	17.2 (15.4 - 20.5)	13.8 (12.6 - 16.0)	12.8 (12.0 - 14.4)	12.5 (11.4 - 15.2)	11.8 (11.1 - 13.9)	15.3 (13.4 - 19.0)	13.2 (12.3 - 14.7)	18.9 (16.2 - 23.6)

Table 3.10 Directional current extremes at WTG11, return period 1-yr.

Current directions are going TOWARDS clockwise from the North	**Sector 1** 345-015deg	**Sector 2** 015-045deg	**Sector 3** 045-075deg	**Sector 4** 075-105deg	**Sector 5** 105-135deg	**Sector 6** 135-165deg	**Sector 7** 165-195deg	**Sector 8** 195-225deg	**Sector 9** 225-255deg	**Sector 10** 255-285deg	**Sector 11** 285-315deg	**Sector 12** 315-345deg	**OMNI**
1-yr													
Current surface total (m/s)	0.40 (0.40 - 0.40)	0.35 (0.35 - 0.35)	0.42 (0.42 - 0.43)	0.58 (0.58 - 0.59)	0.58 (0.57 - 0.59)	0.57 (0.56 - 0.58)	0.22 (0.21 - 0.23)	0.15 (0.15 - 0.15)	0.18 (0.18 - 0.19)	0.27 (0.27 - 0.28)	0.43 (0.43 - 0.43)	0.50 (0.50 - 0.50)	0.61 (0.60 - 0.61)
Current surface residual (m/s)	0.31 (0.31 - 0.32)	0.29 (0.28 - 0.30)	0.29 (0.28 - 0.30)	0.36 (0.35 - 0.38)	0.43 (0.41 - 0.44)	0.41 (0.41 - 0.42)	0.26 (0.25 - 0.27)	0.19 (0.19 - 0.19)	0.18 (0.18 - 0.19)	0.27 (0.25 - 0.28)	0.38 (0.38 - 0.39)	0.37 (0.36 - 0.38)	0.46 (0.45 - 0.47)
Current surface residual + ass. wind component (m/s)	0.47 (0.33 - 0.65)	0.45 (0.33 - 0.61)	0.44 (0.32 - 0.56)	0.58 (0.48 - 0.71)	0.68 (0.58 - 0.77)	0.70 (0.61 - 0.76)	0.47 (0.34 - 0.56)	0.36 (0.23 - 0.46)	0.34 (0.22 - 0.45)	0.43 (0.30 - 0.55)	0.60 (0.47 - 0.70)	0.56 (0.41 - 0.70)	-
Current DA total (m/s)	0.35 (0.35 - 0.35)	0.31 (0.30 - 0.31)	0.37 (0.36 - 0.37)	0.50 (0.50 - 0.51)	0.50 (0.49 - 0.51)	0.50 (0.50 - 0.50)	0.19 (0.19 - 0.19)	0.13 (0.13 - 0.14)	0.16 (0.16 - 0.17)	0.24 (0.24 - 0.25)	0.38 (0.38 - 0.38)	0.44 (0.44 - 0.44)	0.53 (0.52 - 0.53)
Current DA residual (m/s)	0.28 (0.27 - 0.28)	0.25 (0.25 - 0.26)	0.25 (0.25 - 0.26)	0.32 (0.31 - 0.33)	0.37 (0.36 - 0.38)	0.36 (0.35 - 0.37)	0.23 (0.22 - 0.24)	0.17 (0.16 - 0.17)	0.16 (0.16 - 0.17)	0.23 (0.22 - 0.24)	0.34 (0.33 - 0.34)	0.32 (0.32 - 0.33)	0.40 (0.39 - 0.41)
Current near-bottom total (m/s)	0.23 (0.23 - 0.23)	0.20 (0.20 - 0.20)	0.24 (0.24 - 0.24)	0.33 (0.33 - 0.33)	0.33 (0.33 - 0.34)	0.32 (0.32 - 0.33)	0.12 (0.12 - 0.13)	0.09 (0.08 - 0.09)	0.10 (0.10 - 0.11)	0.16 (0.15 - 0.16)	0.24 (0.24 - 0.25)	0.28 (0.28 - 0.29)	0.35 (0.34 - 0.35)
Current near-bottom residual (m/s)	0.18 (0.18 - 0.18)	0.16 (0.16 - 0.17)	0.16 (0.16 - 0.17)	0.21 (0.20 - 0.21)	0.24 (0.23 - 0.25)	0.24 (0.23 - 0.24)	0.15 (0.14 - 0.16)	0.11 (0.11 - 0.11)	0.10 (0.10 - 0.11)	0.15 (0.14 - 0.16)	0.22 (0.22 - 0.22)	0.21 (0.21 - 0.21)	0.26 (0.26 - 0.27)
Associated H_s (m)	1.58 (1.54 - 1.62)	1.59 (0.72 - 3.67)	1.48 (1.46 - 1.49)	1.62 (0.64 - 3.19)	3.32 (3.24 - 3.41)	3.51 (3.50 - 3.52)	2.31 (2.24 - 2.37)	2.09 (2.02 - 2.16)	2.44 (2.39 - 2.50)	2.77 (2.74 - 2.80)	1.49 (0.48 - 2.98)	1.72 (1.67 - 1.77)	2.63 (2.56 - 2.71)
Associated T_p (s)	10.4 (10.3 - 10.5)	10.4 (8.2 - 15.5)	10.5 (10.4 - 10.5)	11.0 (9.2 - 14.0)	12.9 (12.8 - 13.0)	12.9 (12.9 - 13.0)	11.1 (10.9 - 11.2)	11.0 (10.9 - 11.2)	11.5 (11.4 - 11.6)	12.1 (12.0 - 12.2)	10.4 (8.5 - 13.3)	10.4 (10.3 - 10.5)	12.1 (12.0 - 12.2)

Table 3.11 Directional current extremes at WTG11, return periods 5-, 10-, 50-, 100- and 500-yr.

Current directions are going TOWARDS clockwise from the North	Sector 1 345-015deg	Sector 2 015-045deg	Sector 3 045-075deg	Sector 4 075-105deg	Sector 5 105-135deg	Sector 6 135-165deg	Sector 7 165-195deg	Sector 8 195-225deg	Sector 9 225-255deg	Sector 10 255-285deg	Sector 11 285-315deg	Sector 12 315-345deg	OMNI
5-yr													
Current surface total (m/s)	0.42 (0.42 - 0.43)	0.38 (0.37 - 0.39)	0.46 (0.45 - 0.47)	0.62 (0.61 - 0.63)	0.64 (0.62 - 0.67)	0.64 (0.62 - 0.66)	0.26 (0.25 - 0.27)	0.17 (0.17 - 0.18)	0.23 (0.21 - 0.24)	0.31 (0.30 - 0.32)	0.46 (0.45 - 0.47)	0.53 (0.52 - 0.53)	0.66 (0.64 - 0.68)
Current surface residual (m/s)	0.35 (0.34 - 0.36)	0.33 (0.32 - 0.35)	0.33 (0.32 - 0.34)	0.44 (0.42 - 0.46)	0.51 (0.49 - 0.54)	0.50 (0.48 - 0.53)	0.34 (0.32 - 0.35)	0.22 (0.21 - 0.23)	0.22 (0.21 - 0.23)	0.35 (0.32 - 0.37)	0.45 (0.43 - 0.46)	0.43 (0.41 - 0.45)	0.54 (0.52 - 0.57)
Current surface residual + ass. wind component (m/s)	0.51 (0.36 - 0.69)	0.49 (0.36 - 0.65)	0.48 (0.35 - 0.61)	0.66 (0.54 - 0.79)	0.76 (0.65 - 0.87)	0.79 (0.68 - 0.87)	0.54 (0.40 - 0.64)	0.39 (0.26 - 0.50)	0.38 (0.25 - 0.48)	0.51 (0.37 - 0.65)	0.66 (0.52 - 0.77)	0.61 (0.46 - 0.78)	-
Current DA total (m/s)	0.37 (0.37 - 0.38)	0.33 (0.32 - 0.34)	0.40 (0.39 - 0.41)	0.54 (0.53 - 0.55)	0.56 (0.54 - 0.58)	0.55 (0.53 - 0.56)	0.22 (0.21 - 0.23)	0.15 (0.15 - 0.16)	0.20 (0.19 - 0.21)	0.27 (0.26 - 0.29)	0.41 (0.40 - 0.41)	0.47 (0.46 - 0.47)	0.57 (0.56 - 0.59)
Current DA residual (m/s)	0.31 (0.30 - 0.32)	0.29 (0.28 - 0.30)	0.29 (0.28 - 0.29)	0.39 (0.37 - 0.41)	0.45 (0.43 - 0.47)	0.44 (0.42 - 0.47)	0.29 (0.27 - 0.31)	0.19 (0.19 - 0.20)	0.19 (0.18 - 0.20)	0.30 (0.28 - 0.32)	0.39 (0.38 - 0.41)	0.37 (0.36 - 0.39)	0.48 (0.45 - 0.50)
Current near-bottom total (m/s)	0.24 (0.24 - 0.25)	0.21 (0.21 - 0.22)	0.26 (0.26 - 0.27)	0.35 (0.35 - 0.36)	0.37 (0.35 - 0.38)	0.36 (0.35 - 0.37)	0.15 (0.14 - 0.15)	0.10 (0.09 - 0.10)	0.13 (0.12 - 0.14)	0.18 (0.17 - 0.18)	0.26 (0.26 - 0.27)	0.30 (0.29 - 0.30)	0.38 (0.37 - 0.39)
Current near-bottom residual (m/s)	0.20 (0.19 - 0.21)	0.19 (0.18 - 0.20)	0.19 (0.18 - 0.19)	0.25 (0.24 - 0.27)	0.29 (0.28 - 0.31)	0.29 (0.27 - 0.30)	0.19 (0.18 - 0.20)	0.13 (0.12 - 0.13)	0.12 (0.12 - 0.13)	0.20 (0.18 - 0.21)	0.25 (0.24 - 0.26)	0.24 (0.23 - 0.26)	0.31 (0.30 - 0.32)
Associated H_s (m)	1.86 (1.78 - 1.94)	1.59 (0.72 - 3.67)	1.57 (1.54 - 1.59)	1.62 (0.64 - 3.19)	3.93 (3.76 - 4.13)	3.73 (3.66 - 3.80)	2.76 (2.63 - 2.90)	2.61 (2.46 - 2.76)	2.80 (2.69 - 2.90)	3.00 (2.93 - 3.07)	1.49 (0.48 - 2.98)	2.10 (1.98 - 2.23)	3.16 (3.00 - 3.32)
Associated T_p (s)	11.1 (10.8 - 11.3)	10.4 (8.2 - 15.5)	10.7 (10.6 - 10.7)	11.0 (9.2 - 14.0)	13.9 (13.6 - 14.2)	13.4 (13.2 - 13.5)	12.1 (11.8 - 12.4)	12.0 (11.7 - 12.3)	12.2 (12.0 - 12.3)	12.5 (12.4 - 12.6)	10.4 (8.5 - 13.3)	11.3 (11.0 - 11.6)	12.8 (12.6 - 13.0)
10-yr													
Current surface total (m/s)	0.43 (0.42 - 0.45)	0.39 (0.37 - 0.40)	0.47 (0.46 - 0.49)	0.63 (0.62 - 0.65)	0.67 (0.64 - 0.70)	0.67 (0.64 - 0.69)	0.27 (0.26 - 0.29)	0.18 (0.17 - 0.19)	0.24 (0.23 - 0.26)	0.33 (0.31 - 0.34)	0.47 (0.46 - 0.48)	0.54 (0.52 - 0.55)	0.68 (0.66 - 0.71)
Current surface residual (m/s)	0.37 (0.35 - 0.38)	0.35 (0.33 - 0.37)	0.34 (0.33 - 0.36)	0.47 (0.44 - 0.50)	0.55 (0.51 - 0.59)	0.54 (0.51 - 0.57)	0.37 (0.34 - 0.40)	0.23 (0.22 - 0.25)	0.23 (0.22 - 0.25)	0.38 (0.35 - 0.42)	0.47 (0.45 - 0.49)	0.45 (0.42 - 0.49)	0.58 (0.54 - 0.62)
Current surface residual + ass. wind component (m/s)	0.52 (0.37 - 0.72)	0.51 (0.38 - 0.68)	0.50 (0.36 - 0.63)	0.69 (0.57 - 0.83)	0.80 (0.67 - 0.93)	0.83 (0.71 - 0.92)	0.57 (0.43 - 0.68)	0.40 (0.27 - 0.52)	0.39 (0.26 - 0.50)	0.55 (0.39 - 0.70)	0.68 (0.54 - 0.80)	0.64 (0.48 - 0.82)	-
Current DA total (m/s)	0.38 (0.37 - 0.39)	0.34 (0.33 - 0.35)	0.41 (0.40 - 0.42)	0.55 (0.54 - 0.56)	0.58 (0.56 - 0.61)	0.57 (0.55 - 0.59)	0.24 (0.22 - 0.25)	0.16 (0.15 - 0.17)	0.22 (0.20 - 0.23)	0.29 (0.27 - 0.30)	0.42 (0.41 - 0.43)	0.48 (0.46 - 0.49)	0.59 (0.57 - 0.61)
Current DA residual (m/s)	0.32 (0.31 - 0.34)	0.31 (0.29 - 0.33)	0.30 (0.29 - 0.31)	0.42 (0.39 - 0.45)	0.48 (0.45 - 0.52)	0.48 (0.45 - 0.51)	0.32 (0.29 - 0.35)	0.21 (0.19 - 0.22)	0.20 (0.19 - 0.22)	0.33 (0.30 - 0.36)	0.41 (0.40 - 0.43)	0.40 (0.37 - 0.43)	0.51 (0.48 - 0.54)
Current near-bottom total (m/s)	0.25 (0.24 - 0.25)	0.22 (0.21 - 0.23)	0.27 (0.26 - 0.28)	0.36 (0.35 - 0.37)	0.38 (0.36 - 0.40)	0.38 (0.36 - 0.39)	0.16 (0.15 - 0.17)	0.10 (0.10 - 0.11)	0.14 (0.13 - 0.15)	0.19 (0.18 - 0.20)	0.27 (0.26 - 0.27)	0.31 (0.30 - 0.31)	0.39 (0.38 - 0.40)
Current near-bottom residual (m/s)	0.21 (0.20 - 0.22)	0.20 (0.19 - 0.21)	0.19 (0.19 - 0.20)	0.27 (0.25 - 0.29)	0.31 (0.29 - 0.34)	0.31 (0.29 - 0.33)	0.21 (0.19 - 0.23)	0.13 (0.12 - 0.14)	0.13 (0.13 - 0.14)	0.22 (0.20 - 0.24)	0.27 (0.26 - 0.28)	0.26 (0.24 - 0.28)	0.33 (0.31 - 0.34)
Associated H_s (m)	1.98 (1.86 - 2.10)	1.59 (0.72 - 3.67)	1.61 (1.57 - 1.64)	1.62 (0.64 - 3.19)	4.19 (3.94 - 4.47)	3.82 (3.73 - 3.91)	2.96 (2.77 - 3.18)	2.84 (2.63 - 3.04)	2.95 (2.81 - 3.08)	3.09 (2.99 - 3.21)	1.49 (0.48 - 2.98)	2.27 (2.09 - 2.46)	3.39 (3.16 - 3.63)
Associated T_p (s)	11.4 (11.1 - 11.7)	10.4 (8.2 - 15.5)	10.7 (10.7 - 10.8)	11.0 (9.2 - 14.0)	14.3 (13.9 - 14.7)	13.6 (13.4 - 13.7)	12.5 (12.1 - 13.0)	12.5 (12.1 - 12.9)	12.5 (12.2 - 12.7)	12.7 (12.5 - 12.8)	10.4 (8.5 - 13.3)	11.7 (11.3 - 12.1)	13.1 (12.8 - 13.4)
50-yr													
Current surface total (m/s)	0.46 (0.44 - 0.49)	0.41 (0.38 - 0.46)	0.51 (0.48 - 0.54)	0.67 (0.64 - 0.71)	0.73 (0.67 - 0.80)	0.73 (0.68 - 0.79)	0.31 (0.28 - 0.35)	0.20 (0.18 - 0.22)	0.29 (0.25 - 0.33)	0.36 (0.32 - 0.40)	0.50 (0.47 - 0.52)	0.56 (0.54 - 0.59)	0.74 (0.69 - 0.80)
Current surface residual (m/s)	0.40 (0.37 - 0.45)	0.39 (0.36 - 0.44)	0.38 (0.35 - 0.41)	0.55 (0.49 - 0.62)	0.64 (0.56 - 0.74)	0.63 (0.56 - 0.69)	0.44 (0.38 - 0.51)	0.27 (0.23 - 0.31)	0.27 (0.24 - 0.30)	0.46 (0.40 - 0.54)	0.53 (0.49 - 0.58)	0.51 (0.46 - 0.59)	0.66 (0.59 - 0.74)
Current surface residual + ass. wind component (m/s)	0.56 (0.39 - 0.78)	0.55 (0.40 - 0.75)	0.53 (0.38 - 0.68)	0.77 (0.61 - 0.95)	0.89 (0.72 - 1.07)	0.92 (0.77 - 1.03)	0.64 (0.47 - 0.79)	0.44 (0.28 - 0.58)	0.42 (0.28 - 0.56)	0.63 (0.44 - 0.82)	0.74 (0.58 - 0.88)	0.70 (0.51 - 0.92)	-
Current DA total (m/s)	0.40 (0.38 - 0.43)	0.36 (0.34 - 0.40)	0.44 (0.42 - 0.47)	0.58 (0.55 - 0.61)	0.63 (0.59 - 0.69)	0.62 (0.57 - 0.66)	0.27 (0.24 - 0.31)	0.18 (0.16 - 0.20)	0.26 (0.22 - 0.29)	0.32 (0.29 - 0.36)	0.44 (0.42 - 0.47)	0.50 (0.47 - 0.53)	0.64 (0.60 - 0.69)
Current DA residual (m/s)	0.35 (0.32 - 0.39)	0.34 (0.31 - 0.38)	0.33 (0.31 - 0.37)	0.49 (0.44 - 0.57)	0.56 (0.50 - 0.64)	0.56 (0.49 - 0.65)	0.38 (0.33 - 0.45)	0.23 (0.21 - 0.27)	0.23 (0.21 - 0.26)	0.40 (0.34 - 0.47)	0.47 (0.43 - 0.50)	0.45 (0.40 - 0.52)	0.58 (0.52 - 0.65)
Current near-bottom total (m/s)	0.26 (0.25 - 0.28)	0.24 (0.22 - 0.26)	0.29 (0.27 - 0.31)	0.38 (0.37 - 0.41)	0.42 (0.39 - 0.45)	0.42 (0.39 - 0.45)	0.18 (0.16 - 0.20)	0.11 (0.10 - 0.13)	0.16 (0.14 - 0.19)	0.21 (0.19 - 0.23)	0.28 (0.27 - 0.30)	0.32 (0.31 - 0.34)	0.42 (0.39 - 0.45)
Current near-bottom residual (m/s)	0.23 (0.21 - 0.25)	0.22 (0.20 - 0.25)	0.21 (0.20 - 0.23)	0.32 (0.28 - 0.36)	0.36 (0.32 - 0.42)	0.36 (0.32 - 0.39)	0.25 (0.22 - 0.29)	0.15 (0.13 - 0.18)	0.15 (0.14 - 0.17)	0.26 (0.22 - 0.31)	0.30 (0.28 - 0.33)	0.29 (0.26 - 0.34)	0.38 (0.34 - 0.41)
Associated H_s (m)	2.26 (2.01 - 2.55)	1.59 (0.72 - 3.67)	1.70 (1.63 - 1.78)	1.62 (0.64 - 3.19)	4.76 (4.25 - 5.41)	4.04 (3.85 - 4.24)	3.42 (2.99 - 3.99)	3.36 (2.91 - 3.92)	3.31 (3.02 - 3.65)	3.30 (3.09 - 3.60)	1.49 (0.48 - 2.98)	2.65 (2.25 - 3.15)	3.92 (3.48 - 4.50)
Associated T_p (s)	12.1 (11.4 - 12.8)	10.4 (8.2 - 15.5)	11.0 (10.8 - 11.1)	11.0 (9.2 - 14.0)	15.1 (14.4 - 16.2)	14.0 (13.6 - 14.4)	13.6 (12.6 - 14.8)	13.5 (12.6 - 14.5)	13.1 (12.6 - 13.8)	13.0 (12.6 - 13.5)	10.4 (8.5 - 13.3)	12.5 (11.6 - 13.7)	13.8 (13.2 - 14.6)
100-yr													
Current surface total (m/s)	0.47 (0.44 - 0.51)	0.42 (0.39 - 0.49)	0.52 (0.49 - 0.57)	0.68 (0.64 - 0.74)	0.75 (0.69 - 0.85)	0.75 (0.69 - 0.84)	0.33 (0.29 - 0.38)	0.21 (0.19 - 0.24)	0.31 (0.26 - 0.37)	0.37 (0.33 - 0.44)	0.51 (0.48 - 0.55)	0.58 (0.54 - 0.62)	0.76 (0.70 - 0.85)
Current surface residual (m/s)	0.42 (0.38 - 0.48)	0.41 (0.36 - 0.47)	0.39 (0.35 - 0.44)	0.58 (0.50 - 0.68)	0.68 (0.58 - 0.81)	0.67 (0.58 - 0.76)	0.47 (0.40 - 0.56)	0.28 (0.24 - 0.35)	0.28 (0.24 - 0.33)	0.50 (0.42 - 0.61)	0.56 (0.50 - 0.63)	0.54 (0.47 - 0.65)	0.70 (0.61 - 0.81)
Current surface residual + ass. wind component (m/s)	0.58 (0.40 - 0.81)	0.57 (0.41 - 0.78)	0.54 (0.39 - 0.71)	0.80 (0.63 - 1.01)	0.93 (0.74 - 1.14)	0.96 (0.79 - 1.10)	0.67 (0.49 - 0.85)	0.45 (0.28 - 0.62)	0.44 (0.28 - 0.59)	0.67 (0.46 - 0.88)	0.77 (0.60 - 0.93)	0.72 (0.52 - 0.97)	-
Current DA total (m/s)	0.41 (0.39 - 0.45)	0.37 (0.34 - 0.43)	0.46 (0.43 - 0.50)	0.59 (0.56 - 0.64)	0.65 (0.60 - 0.73)	0.64 (0.58 - 0.70)	0.29 (0.24 - 0.34)	0.18 (0.16 - 0.21)	0.27 (0.23 - 0.33)	0.33 (0.29 - 0.39)	0.45 (0.43 - 0.49)	0.51 (0.48 - 0.56)	0.66 (0.61 - 0.73)
Current DA residual (m/s)	0.37 (0.33 - 0.42)	0.36 (0.32 - 0.41)	0.35 (0.31 - 0.39)	0.52 (0.46 - 0.62)	0.59 (0.51 - 0.70)	0.60 (0.51 - 0.71)	0.41 (0.35 - 0.49)	0.25 (0.21 - 0.30)	0.25 (0.22 - 0.29)	0.43 (0.36 - 0.53)	0.49 (0.44 - 0.54)	0.47 (0.40 - 0.56)	0.61 (0.53 - 0.71)
Current near-bottom total (m/s)	0.27 (0.25 - 0.29)	0.24 (0.22 - 0.29)	0.30 (0.28 - 0.33)	0.39 (0.37 - 0.42)	0.43 (0.39 - 0.48)	0.43 (0.39 - 0.48)	0.19 (0.16 - 0.22)	0.12 (0.11 - 0.14)	0.17 (0.15 - 0.21)	0.21 (0.19 - 0.25)	0.29 (0.27 - 0.32)	0.33 (0.31 - 0.35)	0.43 (0.40 - 0.48)
Current near-bottom residual (m/s)	0.24 (0.22 - 0.27)	0.23 (0.21 - 0.27)	0.22 (0.20 - 0.25)	0.34 (0.29 - 0.39)	0.38 (0.33 - 0.46)	0.38 (0.33 - 0.43)	0.27 (0.23 - 0.32)	0.16 (0.14 - 0.19)	0.16 (0.14 - 0.19)	0.28 (0.23 - 0.34)	0.32 (0.29 - 0.36)	0.31 (0.27 - 0.37)	0.40 (0.35 - 0.45)
Associated H_s (m)	2.38 (2.06 - 2.78)	1.59 (0.72 - 3.67)	1.73 (1.65 - 1.86)	1.62 (0.64 - 3.19)	5.00 (4.36 - 5.88)	4.13 (3.88 - 4.43)	3.62 (3.05 - 4.42)	3.59 (2.99 - 4.44)	3.47 (3.09 - 3.95)	3.39 (3.12 - 3.82)	1.49 (0.48 - 2.98)	2.82 (2.31 - 3.55)	4.15 (3.59 - 4.93)
Associated T_p (s)	12.4 (11.6 - 13.4)	10.4 (8.2 - 15.5)	11.0 (10.8 - 11.3)	11.0 (9.2 - 14.0)	15.5 (14.5 - 16.9)	14.2 (13.7 - 14.8)	14.0 (12.7 - 15.8)	13.9 (12.8 - 15.5)	13.4 (12.7 - 14.4)	13.2 (12.7 - 13.9)	10.4 (8.5 - 13.3)	12.9 (11.8 - 14.6)	14.1 (13.4 - 15.2)
500-yr													
Current surface total (m/s)	0.49 (0.45 - 0.57)	0.45 (0.39 - 0.60)	0.56 (0.50 - 0.64)	0.71 (0.65 - 0.82)	0.81 (0.71 - 0.98)	0.81 (0.71 - 0.97)	0.36 (0.31 - 0.45)	0.23 (0.19 - 0.30)	0.35 (0.28 - 0.46)	0.40 (0.33 - 0.53)	0.54 (0.49 - 0.63)	0.60 (0.55 - 0.70)	0.82 (0.72 - 0.98)
Current surface residual (m/s)	0.46 (0.39 - 0.58)	0.45 (0.38 - 0.58)	0.42 (0.36 - 0.51)	0.65 (0.53 - 0.85)	0.76 (0.61 - 1.02)	0.76 (0.63 - 0.96)	0.54 (0.43 - 0.72)	0.31 (0.24 - 0.44)	0.31 (0.25 - 0.42)	0.58 (0.45 - 0.78)	0.62 (0.53 - 0.79)	0.59 (0.49 - 0.79)	0.78 (0.64 - 0.98)
Current surface residual + ass. wind component (m/s)	0.61 (0.41 - 0.91)	0.61 (0.42 - 0.89)	0.57 (0.40 - 0.78)	0.87 (0.66 - 1.19)	1.01 (0.77 - 1.35)	1.05 (0.83 - 1.30)	0.74 (0.51 - 1.01)	0.48 (0.29 - 0.71)	0.47 (0.29 - 0.68)	0.75 (0.50 - 1.05)	0.83 (0.62 - 1.09)	0.78 (0.54 - 1.12)	-
Current DA total (m/s)	0.44 (0.40 - 0.50)	0.39 (0.34 - 0.51)	0.49 (0.44 - 0.57)	0.62 (0.56 - 0.71)	0.70 (0.62 - 0.85)	0.69 (0.59 - 0.84)	0.32 (0.25 - 0.43)	0.20 (0.17 - 0.27)	0.31 (0.25 - 0.43)	0.36 (0.30 - 0.48)	0.48 (0.43 - 0.56)	0.53 (0.48 - 0.63)	0.71 (0.63 - 0.83)
Current DA residual (m/s)	0.40 (0.34 - 0.50)	0.40 (0.33 - 0.49)	0.38 (0.33 - 0.47)	0.59 (0.49 - 0.77)	0.67 (0.54 - 0.87)	0.67 (0.54 - 0.89)	0.47 (0.38 - 0.61)	0.28 (0.22 - 0.38)	0.27 (0.23 - 0.36)	0.50 (0.39 - 0.68)	0.54 (0.46 - 0.67)	0.52 (0.42 - 0.68)	0.68 (0.56 - 0.86)
Current near-bottom total (m/s)	0.28 (0.25 - 0.32)	0.26 (0.22 - 0.36)	0.32 (0.29 - 0.37)	0.41 (0.38 - 0.45)	0.46 (0.41 - 0.55)	0.46 (0.41 - 0.56)	0.21 (0.17 - 0.27)	0.13 (0.11 - 0.16)	0.20 (0.16 - 0.26)	0.23 (0.19 - 0.32)	0.31 (0.28 - 0.36)	0.34 (0.31 - 0.39)	0.46 (0.41 - 0.55)
Current near-bottom residual (m/s)	0.26 (0.22 - 0.32)	0.26 (0.22 - 0.31)	0.24 (0.21 - 0.29)	0.38 (0.32 - 0.48)	0.43 (0.35 - 0.56)	0.43 (0.36 - 0.54)	0.31 (0.24 - 0.40)	0.18 (0.14 - 0.24)	0.18 (0.15 - 0.24)	0.32 (0.26 - 0.43)	0.35 (0.30 - 0.44)	0.34 (0.28 - 0.45)	0.44 (0.37 - 0.56)
Associated H_s (m)	2.66 (2.17 - 3.46)	1.59 (0.72 - 3.67)	1.82 (1.68 - 2.07)	1.62 (0.64 - 3.19)	5.54 (4.56 - 7.14)	4.35 (3.93 - 5.06)	4.08 (3.18 - 5.64)	4.11 (3.10 - 6.06)	3.83 (3.23 - 4.85)	3.58 (3.17 - 4.44)	1.49 (0.48 - 2.98)	3.20 (2.39 - 4.74)	4.69 (3.80 - 6.13)
Associated T_p (s)	13.1 (11.8 - 15.1)	10.4 (8.2 - 15.5)	11.2 (10.9 - 11.8)	11.0 (9.2 - 14.0)	16.4 (14.8 - 18.9)	14.6 (13.8 - 16.0)	15.1 (13.0 - 18.5)	14.9 (13.0 - 18.6)	14.1 (13.0 - 16.1)	13.5 (12.8 - 15.0)	10.4 (8.5 - 13.3)	13.8 (11.9 - 17.3)	14.8 (13.7 - 16.8)

Table 3.12 Directional current extremes at WTG11, return period 1000-yr.

Current directions are going TOWARDS clockwise from the North	**Sector 1** 345-015deg	**Sector 2** 015-045deg	**Sector 3** 045-075deg	**Sector 4** 075-105deg	**Sector 5** 105-135deg	**Sector 6** 135-165deg	**Sector 7** 165-195deg	**Sector 8** 195-225deg	**Sector 9** 225-255deg	**Sector 10** 255-285deg	**Sector 11** 285-315deg	**Sector 12** 315-345deg	**OMNI**
1000-yr													
Current surface total (m/s)	0.50 (0.45 - 0.60)	0.46 (0.39 - 0.66)	0.57 (0.51 - 0.68)	0.72 (0.65 - 0.86)	0.83 (0.72 - 1.04)	0.83 (0.72 - 1.04)	0.38 (0.31 - 0.49)	0.23 (0.19 - 0.33)	0.37 (0.29 - 0.50)	0.41 (0.34 - 0.58)	0.55 (0.49 - 0.68)	0.61 (0.55 - 0.75)	0.84 (0.72 - 1.05)
Current surface residual (m/s)	0.47 (0.39 - 0.63)	0.47 (0.38 - 0.63)	0.43 (0.36 - 0.55)	0.68 (0.54 - 0.95)	0.80 (0.62 - 1.12)	0.80 (0.64 - 1.06)	0.57 (0.44 - 0.81)	0.32 (0.25 - 0.50)	0.33 (0.26 - 0.47)	0.61 (0.46 - 0.87)	0.65 (0.53 - 0.87)	0.62 (0.49 - 0.87)	0.81 (0.65 - 1.06)
Current surface residual + ass. wind component (m/s)	0.63 (0.42 - 0.96)	0.63 (0.43 - 0.94)	0.59 (0.40 - 0.82)	0.90 (0.67 - 1.28)	1.05 (0.79 - 1.45)	1.09 (0.85 - 1.40)	0.77 (0.53 - 1.10)	0.49 (0.29 - 0.77)	0.49 (0.30 - 0.73)	0.78 (0.51 - 1.14)	0.86 (0.62 - 1.17)	0.81 (0.55 - 1.20)	-
Current DA total (m/s)	0.45 (0.40 - 0.53)	0.40 (0.34 - 0.55)	0.50 (0.44 - 0.60)	0.63 (0.56 - 0.75)	0.72 (0.62 - 0.90)	0.71 (0.59 - 0.92)	0.33 (0.26 - 0.48)	0.21 (0.17 - 0.30)	0.33 (0.25 - 0.48)	0.37 (0.30 - 0.53)	0.49 (0.44 - 0.60)	0.54 (0.49 - 0.67)	0.73 (0.63 - 0.89)
Current DA residual (m/s)	0.41 (0.35 - 0.54)	0.41 (0.34 - 0.52)	0.39 (0.33 - 0.50)	0.63 (0.50 - 0.84)	0.70 (0.56 - 0.96)	0.71 (0.55 - 0.98)	0.49 (0.39 - 0.67)	0.29 (0.22 - 0.43)	0.28 (0.23 - 0.39)	0.53 (0.40 - 0.75)	0.56 (0.46 - 0.74)	0.54 (0.43 - 0.75)	0.71 (0.57 - 0.94)
Current near-bottom total (m/s)	0.28 (0.26 - 0.34)	0.26 (0.22 - 0.40)	0.33 (0.29 - 0.40)	0.41 (0.38 - 0.47)	0.48 (0.41 - 0.58)	0.48 (0.41 - 0.60)	0.22 (0.18 - 0.29)	0.13 (0.11 - 0.17)	0.21 (0.16 - 0.28)	0.24 (0.19 - 0.35)	0.31 (0.28 - 0.38)	0.35 (0.32 - 0.41)	0.48 (0.41 - 0.59)
Current near-bottom residual (m/s)	0.27 (0.23 - 0.35)	0.27 (0.22 - 0.34)	0.24 (0.21 - 0.31)	0.40 (0.33 - 0.53)	0.45 (0.36 - 0.62)	0.46 (0.37 - 0.60)	0.32 (0.25 - 0.45)	0.18 (0.14 - 0.27)	0.19 (0.15 - 0.27)	0.34 (0.26 - 0.47)	0.37 (0.30 - 0.50)	0.35 (0.28 - 0.50)	0.46 (0.37 - 0.62)
Associated H_s (m)	2.79 (2.20 - 3.82)	1.59 (0.72 - 3.67)	1.86 (1.70 - 2.17)	1.62 (0.64 - 3.19)	5.76 (4.64 - 7.74)	4.44 (3.94 - 5.42)	4.28 (3.22 - 6.29)	4.34 (3.14 - 6.92)	3.98 (3.27 - 5.34)	3.65 (3.18 - 4.75)	1.49 (0.48 - 2.98)	3.36 (2.42 - 5.38)	4.93 (3.87 - 6.77)
Associated T_p (s)	13.4 (11.9 - 16.0)	10.4 (8.2 - 15.5)	11.3 (11.0 - 12.0)	11.0 (9.2 - 14.0)	16.7 (15.0 - 19.8)	14.8 (13.8 - 16.8)	15.5 (13.1 - 20.0)	15.3 (13.0 - 20.3)	14.4 (13.1 - 17.0)	13.6 (12.8 - 15.5)	10.4 (8.5 - 13.3)	14.2 (12.0 - 18.8)	15.2 (13.7 - 17.6)

3.5 Waves

3.5.1 Introduction

The goal of this part of the study is to determine the normal and extreme wave conditions (and associated water level and current conditions) that apply at SROWF. These conditions were assessed by means of detailed analyses of the SROWF wave data (cf. Section 2.3.4). Using the SROWF wave data the normal conditions and Normal Sea State (NSS) tables were determined empirically (with no parametrical fits or assumptions), see respectively Sections 3.5.2 and 3.5.3, the Severe Sea State tables, see Section 3.5.5, and the Extreme Sea State tables, see Section 3.5.4, by means of extreme value analyses (cf. Appendix B).

Please note that in all cases only wave data for the period of 1990-2020 (32 years) has been used for the determination of the normal conditions. This was done to align with the period for which the hub-height wind data are available. This period is considered long enough for the derivation of the normal wave statistics.

The timeseries of the (total) wave data are shown in Figure 3.40 to Figure 3.42 for WTG15, 08 and 11 respectively.

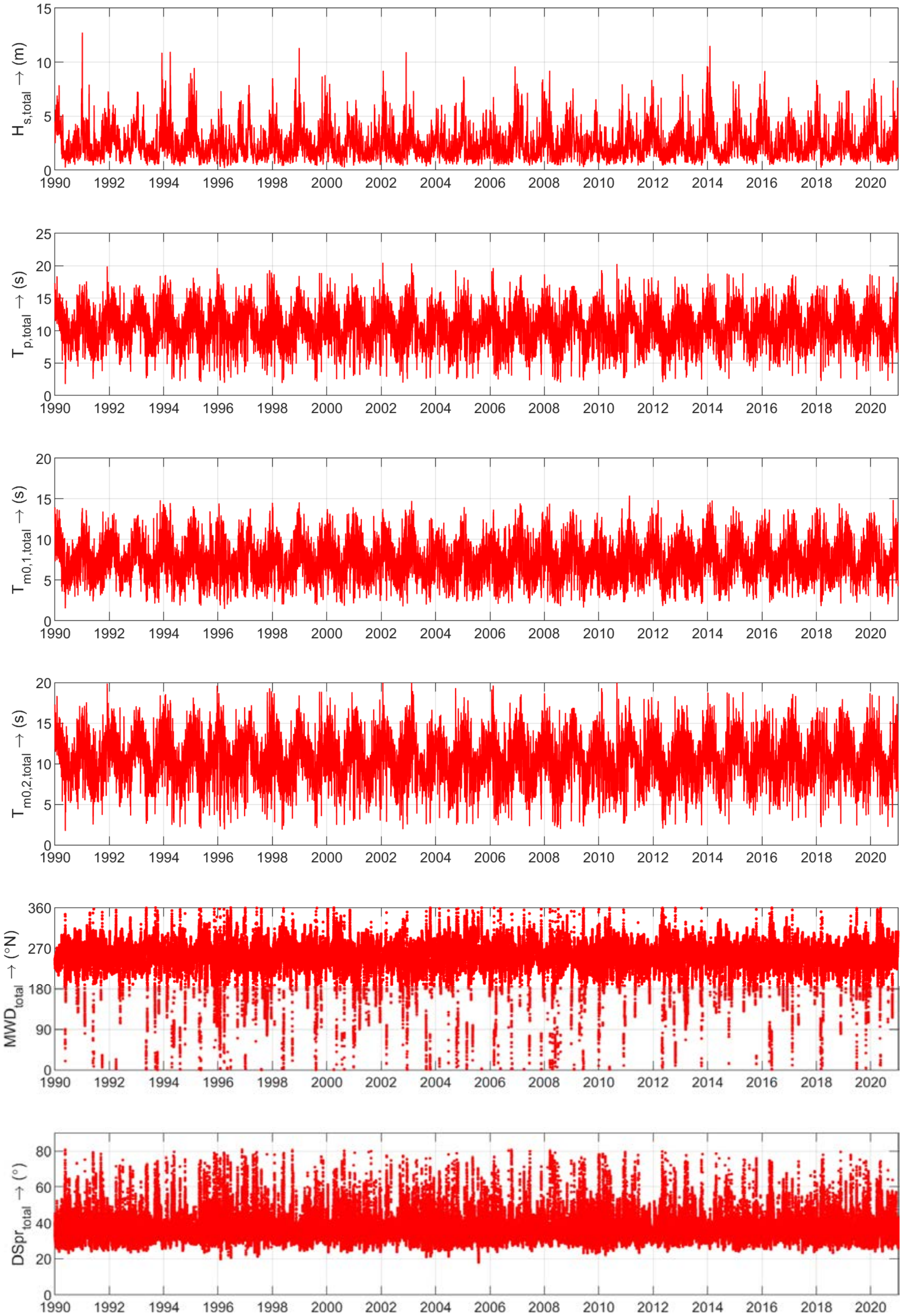


Figure 3.40 Timeseries of H_s (top), T_p (2nd from top), $T_{m0,1}$ (3rd from top), $T_{m0,2}$ (3rd from bottom), MWD (2nd from bottom) and DSpr (bottom) at WTG15.

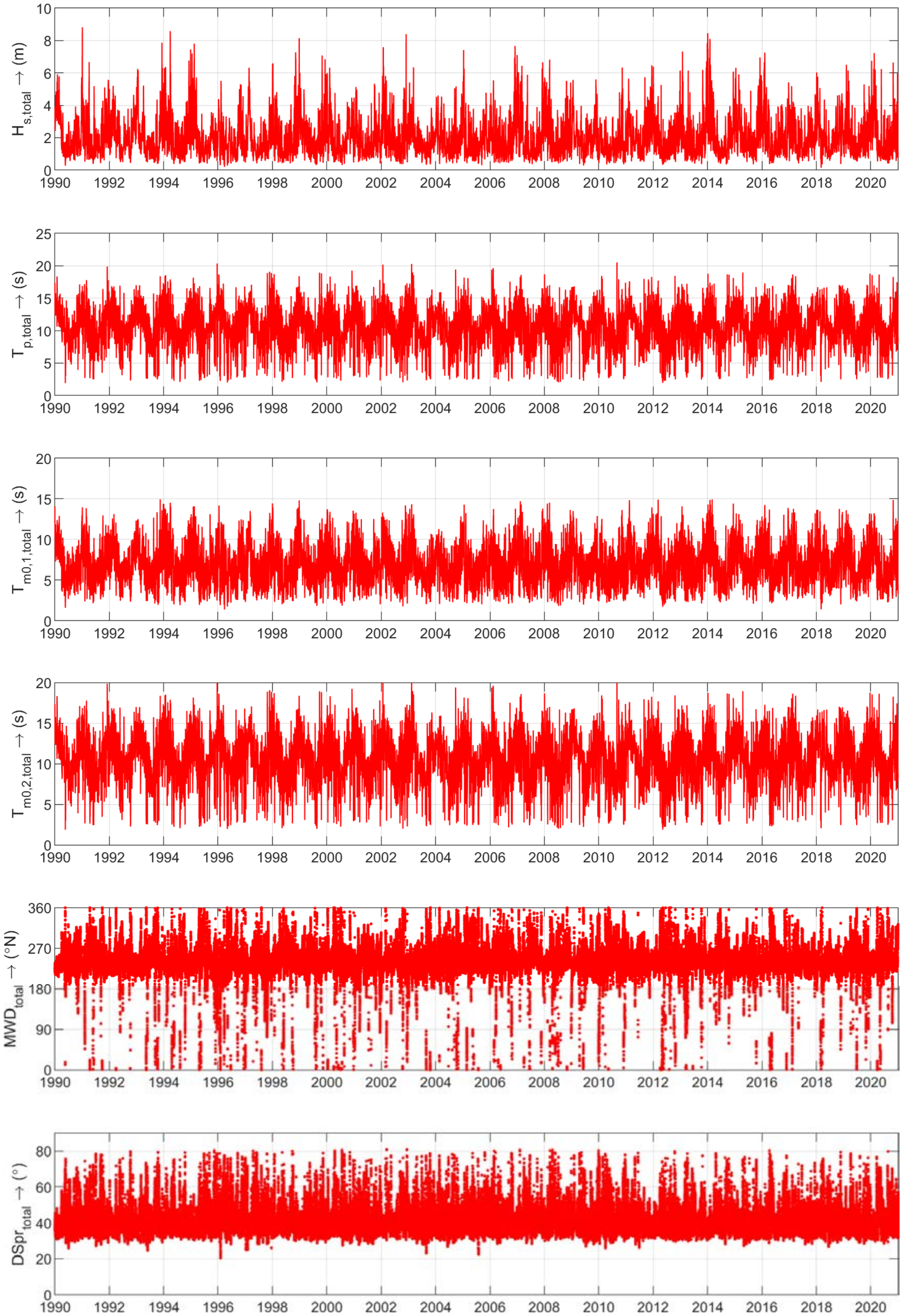


Figure 3.41 Timeseries of H_s (top), T_p (2nd from top), $T_{m0,1}$ (3rd from top), $T_{m0,2}$ (3rd from bottom), MWD (2nd from bottom) and DSpr (bottom) at WTG08.

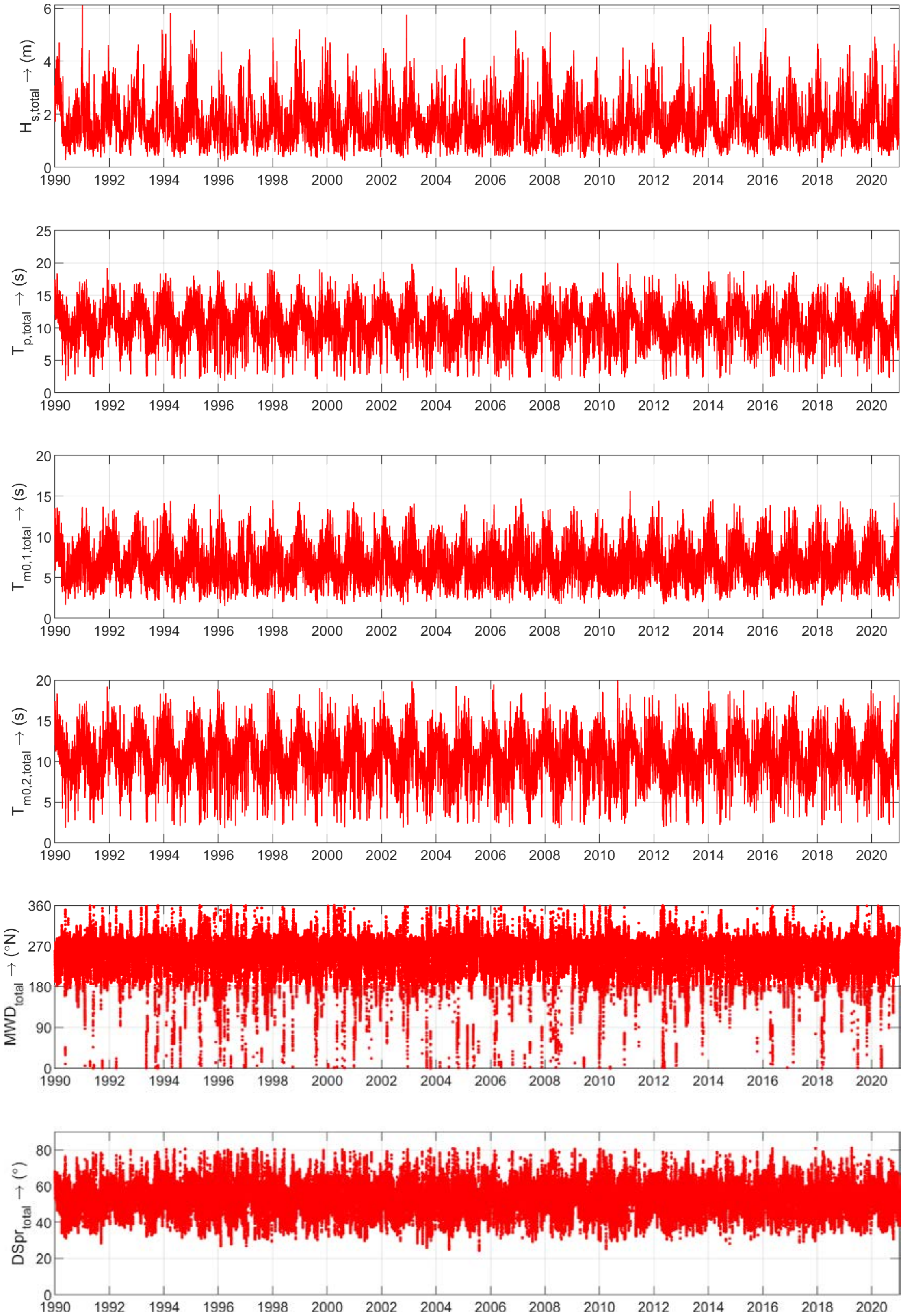


Figure 3.42 Timeseries of H_s (top), T_p (2nd from top), $T_{m0,1}$ (3rd from top), $T_{m0,2}$ (3rd from bottom), MWD (2nd from bottom) and DSpr (bottom) at WTG11.

3.5.2 Normal conditions

The normal wave conditions (total, wind-sea and swell) are given in terms of all-year roses of H_s versus MWD[10] and joint occurrence tables of H_s versus MWD[10] and H_s versus T_p[11]. At the three turbine locations (cf. Table 1.1) joint occurrence tables of H_s (only the total signal) versus the wind speeds at hub-height[11] are also given. Last misalignment tables of the wind direction at 170m above MSL versus MWD[12] (total, wind-sea and swell) are given. All roses and tables are provided in the spreadsheets accompanying this report (cf. Appendix E).

In the following subsections only the total all-year roses of H_s versus MWD and the total all-year joint occurrence tables of H_s versus MWD and H_s versus T_p are given per reference location. Further the all-year joint occurrence tables H_s versus U_{170} and the total all-data misalignment tables are also plotted.

The figures and tables show that:

- at the exposed turbine WTG15 the significant wave height is generally below 4.0 m (89% of the time) with associated peak wave periods below 14.0 s;
- at the intermediate turbine WTG08 the significant wave height is generally below 3.0 m (85% of the time) with associated peak wave periods below 14.0 s;
- at the relatively sheltered turbine WTG11 the significant wave height is mainly below 3.0 m (94% of the time) with associated peak wave periods below 15.0 s;
- the waves at SROWF are predominantly from the west-southwest and are typically generated far offshore on the North Atlantic (long waves); and
- as a result, for relatively low wind speeds (i.e. U_{170}<13 m/s) quite some misalignment between the wind and wave directions is observed for all three locations; the misalignment decreases with increasing wind speeds.

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[10] Available for all-data and for hub-height wind-speeds smaller than 10 m/s. The latter are only given in the spreadsheets accompanying this report (cf. Appendix E).

[11] Available for all -data and conditioned on 12x12 directional wind/wave sectors.

[12] Availabel for all -data and conditioned on wind speeds at hub-height.

3.5.2.1 WTG15

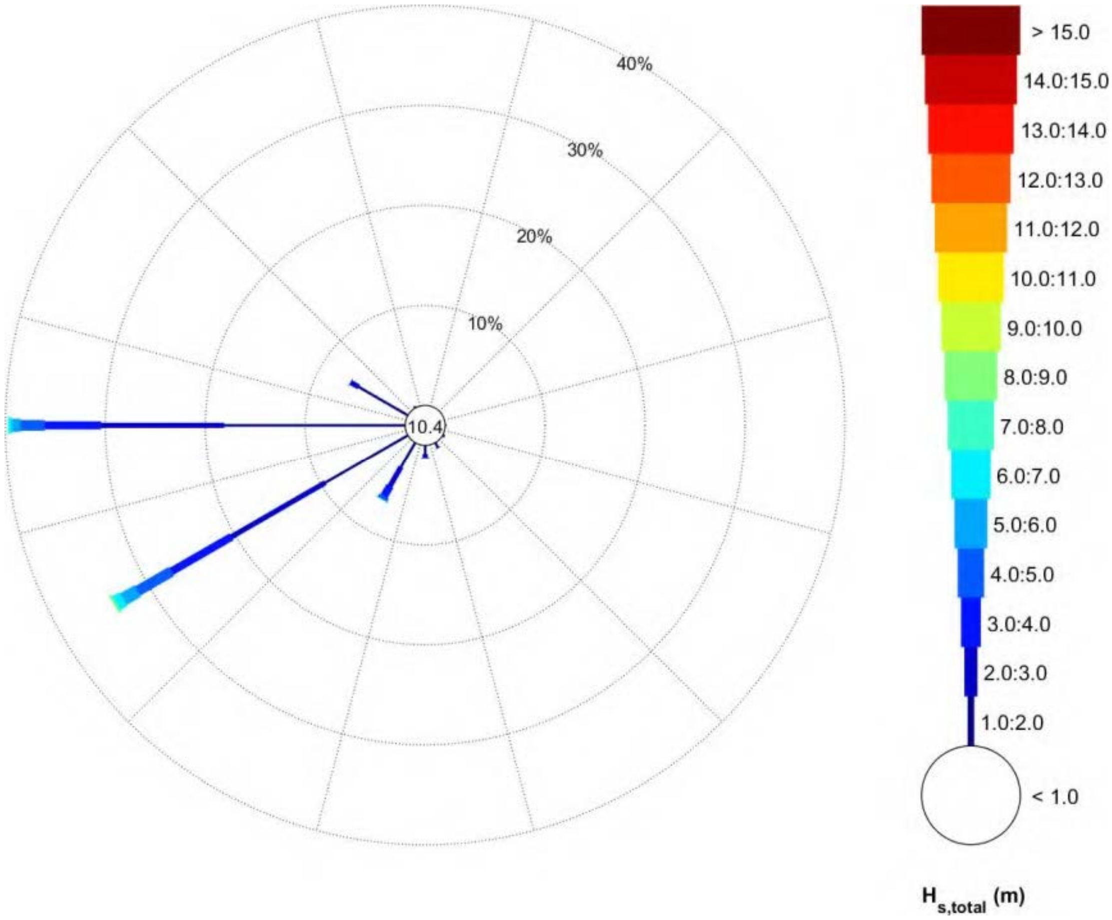

Figure 3.43 All-year significant wave height roses at WTG15 (total signal).

$MWD_{total} \rightarrow$ (°N)

$H_{s,total} \rightarrow$ (m)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>15.0													
14.0-15.0													
13.0-14.0													
12.0-13.0									0.00				0.00
11.0-12.0									0.00				0.00
10.0-11.0									0.01				0.01
9.0-10.0									0.02	0.00			0.02
8.0-9.0									0.08	0.02			0.10
7.0-8.0								0.00	0.27	0.11			0.38
6.0-7.0								0.02	0.73	0.28			1.04
5.0-6.0								0.07	1.62	0.85			2.54
4.0-5.0							0.01	0.34	3.89	2.43	0.00		6.68
3.0-4.0						0.00	0.06	1.16	6.95	5.65	0.07		13.90
2.0-3.0					0.00	0.07	0.36	2.22	10.82	12.32	0.89		26.68
1.0-2.0	0.04	0.02	0.02	0.13	0.24	0.55	0.87	2.83	9.55	18.12	5.68	0.20	38.27
0.0-1.0	0.23	0.18	0.26	0.48	0.41	0.28	0.22	0.33	0.95	3.03	3.23	0.79	10.39
	0.27	0.20	0.28	0.60	0.66	0.90	1.53	6.97	34.92	42.80	9.87	1.00	100.00 Total

Joint Occurence Table, $H_{s,total}$ vs. MWD_{total}

Figure 3.44 All-year joint occurrence table of H_s vs. MWD at WTG15 (total signal).

$H_{s,total}$ → (m) \ $T_{p,total}$ → (s)	0.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-11.0	11.0-12.0	12.0-13.0	13.0-14.0	14.0-15.0	15.0-16.0	16.0-17.0	17.0-18.0	>18.0	
>15.0																	
14.0-15.0																	
13.0-14.0																	
12.0-13.0														0.00			0.00
11.0-12.0													0.00	0.00	0.00		0.00
10.0-11.0												0.00	0.00	0.00	0.00		0.01
9.0-10.0											0.00	0.01	0.01	0.00	0.01	0.00	0.02
8.0-9.0										0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.10
7.0-8.0									0.00	0.02	0.05	0.09	0.10	0.07	0.03	0.01	0.38
6.0-7.0								0.00	0.04	0.13	0.21	0.24	0.26	0.11	0.03	0.02	1.04
5.0-6.0							0.00	0.05	0.23	0.58	0.65	0.42	0.41	0.14	0.04	0.02	2.54
4.0-5.0						0.01	0.11	0.44	1.06	1.73	1.37	0.89	0.69	0.27	0.08	0.03	6.68
3.0-4.0				0.00	0.05	0.30	0.86	2.00	3.08	3.13	2.15	1.27	0.75	0.19	0.05	0.05	13.90
2.0-3.0			0.01	0.21	0.94	2.33	3.50	5.26	6.02	4.56	2.17	0.94	0.46	0.17	0.05	0.05	26.68
1.0-2.0	0.04	0.24	0.65	1.44	3.39	6.89	8.00	7.59	5.30	2.78	1.00	0.47	0.30	0.11	0.05	0.03	38.27
0.0-1.0	0.75	0.27	0.45	0.83	1.57	2.50	1.78	1.10	0.67	0.26	0.09	0.03	0.04	0.01	0.01	0.00	10.39
	0.79	0.51	1.11	2.47	5.96	12.04	14.25	16.44	16.40	13.18	7.70	4.39	3.06	1.10	0.35	0.23	100.00 Total

Joint Occurence Table, $H_{s,total}$ vs. $T_{p,total}$

Figure 3.45 All-year joint occurrence table of H_s vs. T_p at WTG15 (total signal).

$U_{170,mag}$ → (m/s) \ $H_{s,total}$ → (m)	0.0-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-11.0	11.0-12.0	12.0-13.0	13.0-14.0	14.0-15.0	>15.0	
>40.5																	
39.5-40.5																	
38.5-39.5					0.00												0.00
37.5-38.5																	
36.5-37.5										0.00	0.00						0.00
35.5-36.5							0.00		0.00								0.00
34.5-35.5									0.00	0.00			0.00				0.00
33.5-34.5									0.00		0.00	0.00	0.00				0.00
32.5-33.5					0.00					0.00	0.00	0.00	0.00				0.00
31.5-32.5					0.00		0.00	0.00	0.00	0.00	0.00	0.00					0.01
30.5-31.5				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.01
29.5-30.5					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.01
28.5-29.5				0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00						0.03
27.5-28.5			0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00					0.05
26.5-27.5				0.00	0.01	0.02	0.03	0.02	0.01	0.00	0.00						0.09
25.5-26.5			0.00	0.00	0.02	0.04	0.05	0.02	0.01	0.01	0.00						0.15
24.5-25.5		0.00	0.01	0.01	0.04	0.06	0.05	0.03	0.01	0.00	0.00						0.21
23.5-24.5		0.00	0.01	0.03	0.06	0.09	0.07	0.04	0.02	0.00	0.00						0.32
22.5-23.5		0.00	0.02	0.06	0.12	0.15	0.07	0.03	0.01	0.00							0.47
21.5-22.5	0.00	0.01	0.04	0.12	0.20	0.17	0.09	0.03	0.01								0.65
20.5-21.5	0.00	0.02	0.07	0.22	0.30	0.21	0.09	0.03	0.01	0.00							0.95
19.5-20.5	0.00	0.03	0.14	0.40	0.40	0.22	0.09	0.03	0.00								1.33
18.5-19.5	0.01	0.05	0.27	0.57	0.53	0.23	0.10	0.03	0.00								1.78
17.5-18.5	0.01	0.12	0.46	0.82	0.58	0.21	0.09	0.02	0.00	0.00							2.31
16.5-17.5	0.01	0.22	0.77	1.01	0.63	0.21	0.07	0.02	0.00								2.93
15.5-16.5	0.02	0.43	1.11	1.20	0.59	0.19	0.05	0.01	0.00								3.60
14.5-15.5	0.07	0.67	1.54	1.32	0.58	0.15	0.04	0.01	0.00								4.39
13.5-14.5	0.12	1.08	2.01	1.29	0.50	0.12	0.03	0.00									5.14
12.5-13.5	0.19	1.67	2.48	1.23	0.43	0.11	0.03	0.00									6.14
11.5-12.5	0.33	2.36	2.71	1.14	0.34	0.08	0.02	0.00	0.00								6.99
10.5-11.5	0.52	3.15	2.78	0.94	0.32	0.06	0.01	0.00	0.00								7.78
9.5-10.5	0.67	3.79	2.60	0.77	0.25	0.05	0.01	0.00									8.14
8.5-9.5	0.99	4.22	2.32	0.66	0.18	0.05	0.01	0.00									8.42
7.5-8.5	1.09	4.39	1.96	0.60	0.16	0.03	0.01	0.00									8.25
6.5-7.5	1.19	4.10	1.61	0.50	0.12	0.02	0.00	0.00									7.55
5.5-6.5	1.32	3.65	1.26	0.36	0.10	0.02	0.01	0.00									6.71
4.5-5.5	1.28	2.99	0.96	0.27	0.07	0.01	0.00	0.00									5.59
3.5-4.5	1.03	2.35	0.71	0.18	0.06	0.01	0.00	0.00									4.35
2.5-3.5	0.83	1.65	0.46	0.12	0.04	0.01	0.00	0.00									3.11
1.5-2.5	0.52	0.96	0.28	0.07	0.03	0.00	0.00										1.86
0.0-1.5	0.20	0.36	0.09	0.03	0.01	0.00	0.00										0.68
	10.39	38.27	26.68	13.90	6.68	2.54	1.04	0.38	0.10	0.02	0.01	0.00	0.00				100.00 Total

Joint Occurence Table, $U_{170,mag}$ vs. $H_{s,total}$

Figure 3.46 All-year joint occurrence table of U_{170} vs. H_s at WTG15.

$U_{170,dir}$ → (°N) \ MWD_{total} → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
330	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.98	5.02	2.28	0.06	8.42
300	0.00	0.00			0.00	0.00	0.01	0.12	2.12	7.75	1.03	0.01	11.04
270					0.00		0.01	0.22	5.05	7.83	0.38	0.00	13.50
240					0.00	0.00	0.03	0.61	7.55	5.37	0.21	0.00	13.77
210	0.00	0.00			0.00	0.00	0.07	1.36	7.17	3.16	0.18	0.00	11.94
180	0.00		0.00	0.00	0.00	0.02	0.16	1.66	4.19	1.98	0.13	0.00	8.13
150	0.00		0.00	0.00	0.01	0.08	0.47	1.57	3.04	1.79	0.13	0.01	7.10
120	0.01	0.00	0.01	0.02	0.13	0.44	0.53	0.87	2.07	1.74	0.20	0.01	6.03
90	0.03	0.03	0.06	0.26	0.39	0.32	0.21	0.32	1.20	1.75	0.45	0.07	5.08
60	0.11	0.11	0.16	0.28	0.10	0.04	0.04	0.10	0.62	1.70	0.78	0.23	4.27
30	0.08	0.05	0.05	0.04	0.01	0.00	0.01	0.05	0.39	1.83	1.39	0.35	4.25
0/360	0.04	0.01	0.01	0.01	0.00	0.00	0.00	0.04	0.52	2.89	2.71	0.25	6.47
	0.27	0.20	0.28	0.60	0.66	0.90	1.53	6.97	34.91	42.80	9.88	1.00	100.00 Total

Joint Occurence Table, $U_{170,dir}$ vs. MWD_{total}

Figure 3.47 All-year misalignment joint occurrence table of $U_{170,dir}$ vs. MWD at WTG15 (total signal).

3.5.2.2 WTG08

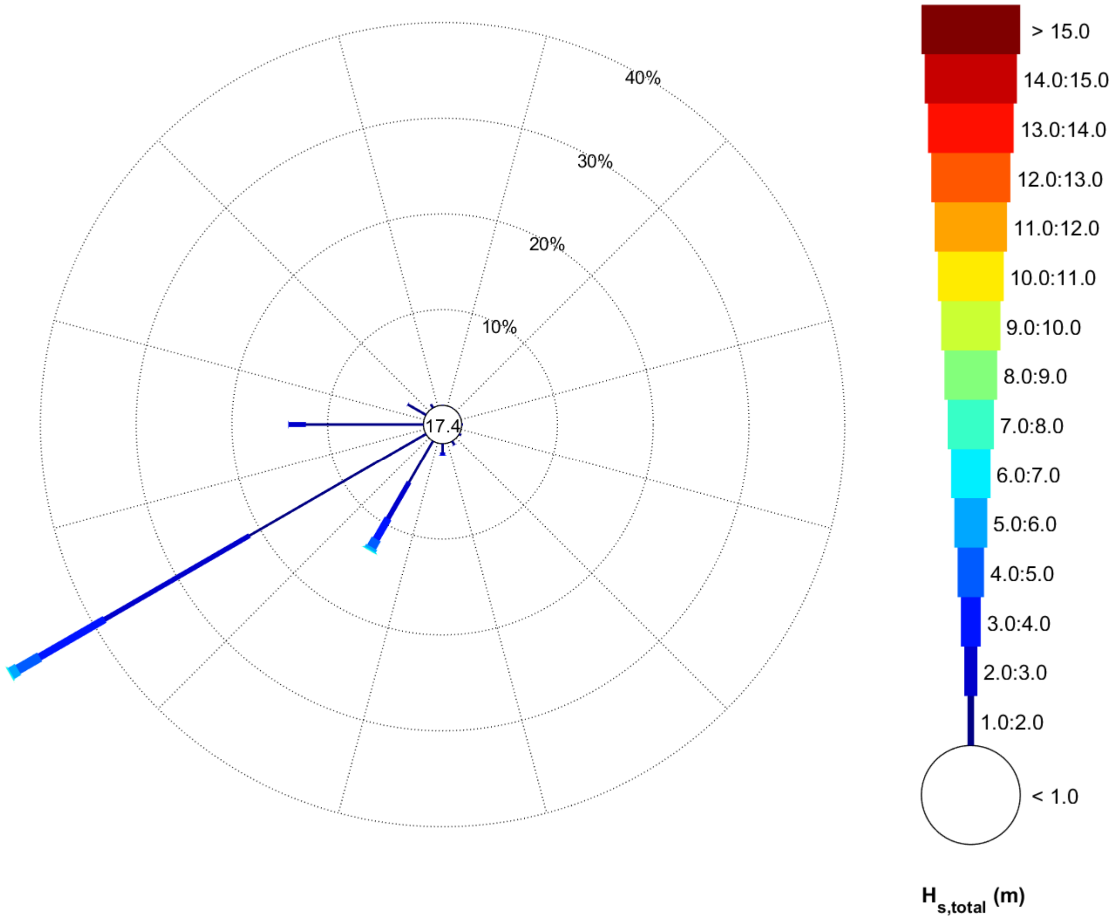

Figure 3.48 All-year significant wave height roses at WTG08 (total signal).

$H_{s,total}$ → (m) \ MWD_{total} → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>15.0													
14.0-15.0													
13.0-14.0													
12.0-13.0													
11.0-12.0													
10.0-11.0													
9.0-10.0													
8.0-9.0								0.00	0.01				0.01
7.0-8.0								0.03	0.02				0.05
6.0-7.0								0.11	0.14				0.26
5.0-6.0								0.30	0.83				1.13
4.0-5.0							0.00	0.97	2.61	0.00			3.58
3.0-4.0							0.04	2.47	7.84	0.05			10.39
2.0-3.0	0.00		0.00		0.00	0.04	0.31	4.39	17.48	1.80	0.04	0.00	24.06
1.0-2.0	0.07	0.03	0.05	0.14	0.23	0.45	0.91	5.00	21.28	12.28	2.18	0.46	43.07
0.0-1.0	0.61	0.38	0.49	0.53	0.38	0.30	0.33	0.66	3.03	5.65	3.41	1.67	17.44
	0.68	0.41	0.54	0.67	0.62	0.79	1.59	13.93	53.23	19.78	5.64	2.13	100.00 Total

Joint Occurence Table, $H_{s,total}$ vs. MWD_{total}

Figure 3.49 All-year joint occurrence table of H_s vs. MWD at WTG08 (total signal).

$H_{s,total}$ → (m) \ $T_{p,total}$ → (s)	0.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-11.0	11.0-12.0	12.0-13.0	13.0-14.0	14.0-15.0	15.0-16.0	16.0-17.0	17.0-18.0	>18.0	
>15.0																	
14.0-15.0																	
13.0-14.0																	
12.0-13.0																	
11.0-12.0																	
10.0-11.0																	
9.0-10.0																	
8.0-9.0												0.00	0.00	0.00	0.00		0.01
7.0-8.0										0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.05
6.0-7.0									0.00	0.02	0.04	0.07	0.06	0.03	0.02	0.01	0.26
5.0-6.0							0.00	0.01	0.07	0.16	0.17	0.26	0.25	0.15	0.04	0.01	1.13
4.0-5.0						0.00	0.03	0.13	0.38	0.76	0.85	0.58	0.57	0.19	0.07	0.03	3.58
3.0-4.0				0.00	0.02	0.15	0.38	0.93	1.85	2.39	2.00	1.16	0.99	0.36	0.10	0.06	10.39
2.0-3.0		0.00	0.01	0.14	0.62	1.24	2.39	3.90	4.96	4.73	3.03	1.77	0.92	0.23	0.06	0.06	24.06
1.0-2.0	0.19	0.25	0.53	1.10	2.91	6.18	7.56	8.33	7.54	4.77	2.09	0.91	0.45	0.15	0.07	0.05	43.07
0.0-1.0	1.75	0.23	0.41	0.92	2.30	3.70	3.23	2.41	1.40	0.64	0.23	0.09	0.10	0.02	0.01	0.01	17.44
	1.94	0.48	0.95	2.16	5.85	11.28	13.57	15.71	16.20	13.48	8.41	4.86	3.35	1.15	0.38	0.23	100.00 Total

Joint Occurence Table, $H_{s,total}$ vs. $T_{p,total}$

Figure 3.50 All-year joint occurrence table of H_s vs. T_p at WTG08 (total signal).

$U_{170,mag}$ → (m/s) \ $H_{s,total}$ → (m)	0.0-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-11.0	11.0-12.0	12.0-13.0	13.0-14.0	14.0-15.0	>15.0	
>40.5																	
39.5-40.5																	
38.5-39.5				0.00													0.00
37.5-38.5																	
36.5-37.5								0.00	0.00								0.00
35.5-36.5					0.00			0.00									0.00
34.5-35.5							0.00		0.00								0.00
33.5-34.5							0.00	0.00	0.00								0.00
32.5-33.5					0.00		0.00	0.00	0.00								0.00
31.5-32.5					0.00	0.00	0.00	0.00	0.00								0.01
30.5-31.5			0.00	0.00	0.00	0.00	0.00	0.00	0.00								0.01
29.5-30.5				0.00	0.00	0.01	0.00	0.00	0.00								0.01
28.5-29.5			0.00	0.00	0.00	0.01	0.01	0.00	0.00								0.03
27.5-28.5			0.00	0.01	0.01	0.02	0.01	0.00	0.00								0.05
26.5-27.5			0.00	0.01	0.02	0.04	0.01	0.00	0.00								0.09
25.5-26.5			0.00	0.01	0.04	0.06	0.02	0.01	0.00								0.15
24.5-25.5		0.00	0.01	0.03	0.06	0.07	0.02	0.00	0.00								0.21
23.5-24.5		0.00	0.02	0.06	0.11	0.09	0.03	0.01	0.00								0.32
22.5-23.5		0.01	0.04	0.12	0.18	0.09	0.02	0.00									0.47
21.5-22.5	0.00	0.02	0.08	0.20	0.23	0.09	0.02	0.00									0.65
20.5-21.5	0.00	0.04	0.14	0.37	0.30	0.09	0.02	0.00									0.95
19.5-20.5	0.00	0.06	0.29	0.55	0.31	0.10	0.02	0.00									1.33
18.5-19.5	0.01	0.11	0.48	0.75	0.34	0.08	0.02	0.00									1.78
17.5-18.5	0.01	0.22	0.78	0.89	0.31	0.08	0.01	0.00									2.31
16.5-17.5	0.01	0.39	1.17	0.97	0.31	0.06	0.01	0.00									2.93
15.5-16.5	0.03	0.70	1.58	0.99	0.26	0.04	0.00										3.60
14.5-15.5	0.10	1.07	1.99	0.96	0.23	0.04	0.01	0.00									4.39
13.5-14.5	0.18	1.69	2.23	0.83	0.18	0.03	0.00										5.14
12.5-13.5	0.31	2.48	2.46	0.70	0.15	0.03	0.00										6.14
11.5-12.5	0.55	3.30	2.39	0.61	0.12	0.02	0.00										6.99
10.5-11.5	0.89	4.04	2.20	0.55	0.09	0.01	0.00										7.78
9.5-10.5	1.20	4.54	1.90	0.43	0.07	0.01	0.00										8.14
8.5-9.5	1.66	4.79	1.57	0.33	0.07	0.01	0.00										8.42
7.5-8.5	1.96	4.64	1.29	0.31	0.05	0.01	0.00										8.25
6.5-7.5	2.08	4.14	1.06	0.22	0.04	0.01	0.00										7.55
5.5-6.5	2.23	3.44	0.83	0.17	0.03	0.01											6.71
4.5-5.5	2.10	2.73	0.61	0.12	0.02	0.00											5.59
3.5-4.5	1.68	2.10	0.44	0.10	0.02	0.01											4.35
2.5-3.5	1.34	1.40	0.29	0.07	0.01	0.00											3.11
1.5-2.5	0.81	0.84	0.16	0.04	0.00	0.00											1.86
0.0-1.5	0.31	0.30	0.05	0.01	0.00	0.00											0.68
	17.44	43.07	24.06	10.39	3.58	1.13	0.26	0.05	0.01								100.00 Total

Joint Occurence Table, $U_{170,mag}$ vs. $H_{s,total}$

Figure 3.51 All-year joint occurrence table of U_{170} vs. H_s at WTG08.

$U_{170,dir}$ → (°N) \ MWD_{total} → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
330	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.18	2.85	3.58	1.54	0.23	8.42
300	0.00	0.00	0.00		0.00	0.00	0.01	0.34	6.12	3.88	0.62	0.07	11.04
270	0.00	0.00					0.01	0.77	9.86	2.65	0.18	0.02	13.50
240	0.00	0.00			0.00	0.00	0.02	1.72	10.40	1.54	0.08	0.01	13.77
210	0.00	0.00			0.00	0.00	0.07	3.01	7.84	0.93	0.07	0.01	11.94
180	0.00	0.00	0.00	0.00	0.00	0.01	0.17	2.90	4.34	0.65	0.05	0.01	8.13
150	0.00	0.00	0.00	0.00	0.01	0.08	0.49	2.48	3.35	0.60	0.06	0.01	7.10
120	0.01	0.01	0.01	0.03	0.16	0.42	0.56	1.51	2.55	0.64	0.11	0.02	6.03
90	0.04	0.06	0.13	0.34	0.37	0.25	0.19	0.64	1.94	0.80	0.21	0.10	5.08
60	0.14	0.21	0.32	0.25	0.06	0.03	0.04	0.20	1.35	1.02	0.41	0.23	4.27
30	0.30	0.10	0.07	0.03	0.01	0.00	0.02	0.09	1.06	1.30	0.74	0.54	4.25
0/360	0.14	0.02	0.01	0.01	0.00	0.00	0.00	0.09	1.54	2.20	1.56	0.89	6.47
	0.68	0.41	0.54	0.67	0.62	0.79	1.59	13.93	53.22	19.78	5.64	2.13	100.00 Total

Joint Occurence Table, $U_{170,dir}$ vs. MWD_{total}

Figure 3.52 All-year misalignment joint occurrence table of $U_{170,dir}$ vs. MWD at WTG08 (total signal).

3.5.2.3 WTG11

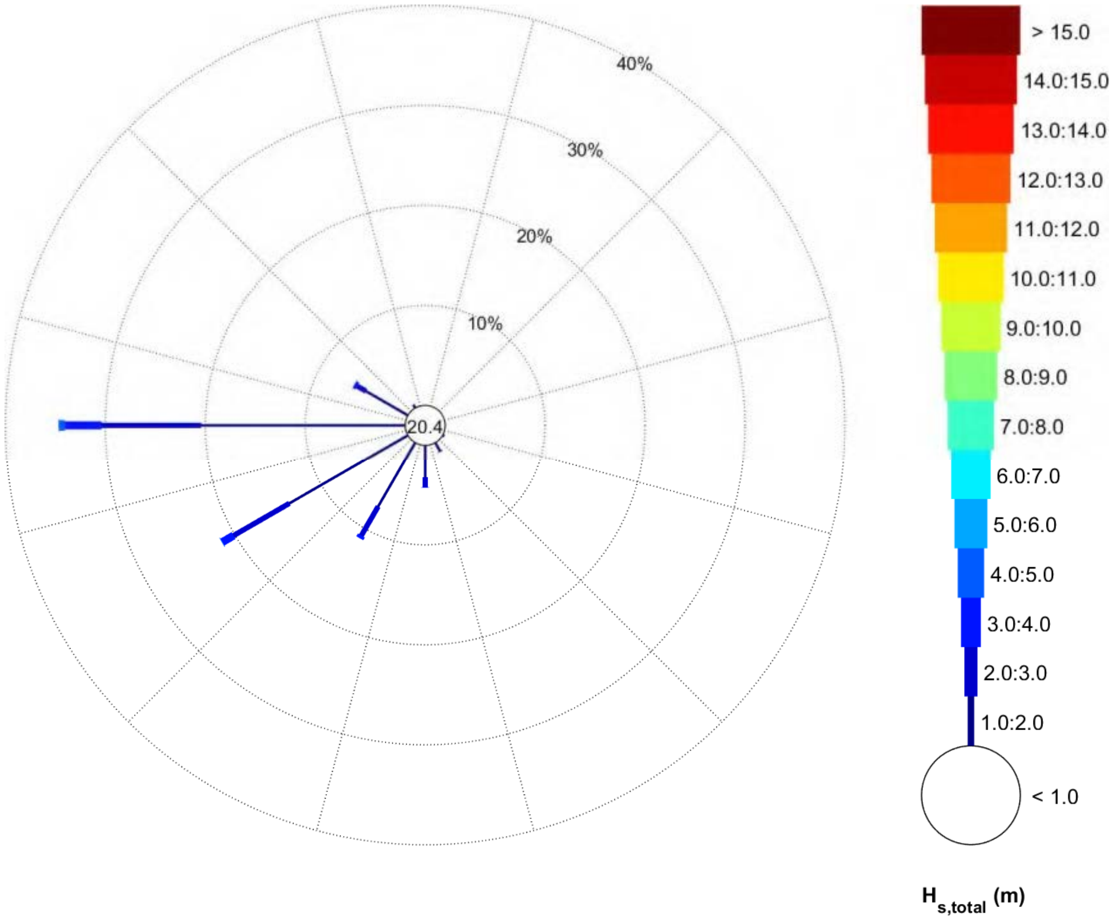

Figure 3.53 All-year significant wave height roses at WTG11 (total signal).

MWD_{total} → (°N)

$H_{s,total}$ → (m)	0/360	30	60	90	120	150	180	210	240	270	300	330	
>15.0													
14.0-15.0													
13.0-14.0													
12.0-13.0													
11.0-12.0													
10.0-11.0													
9.0-10.0													
8.0-9.0													
7.0-8.0													
6.0-7.0										0.00			0.00
5.0-6.0									0.00	0.03	0.00		0.03
4.0-5.0								0.00	0.06	0.63	0.04		0.74
3.0-4.0						0.00	0.04	0.32	1.28	3.66	0.29		5.60
2.0-3.0			0.00		0.00	0.09	1.01	3.35	6.45	9.95	1.02	0.00	21.87
1.0-2.0	0.05	0.02	0.03	0.07	0.20	0.96	3.23	7.42	13.69	20.43	4.84	0.38	51.33
0.0-1.0	0.37	0.23	0.35	0.51	0.56	0.61	0.86	1.43	3.05	7.52	3.91	1.03	20.44
	0.42	0.25	0.38	0.59	0.76	1.66	5.14	12.53	24.54	42.21	10.10	1.42	100.00 Total

Joint Occurence Table, $H_{s,total}$ vs. MWD_{total}

Figure 3.54 All-year joint occurrence table of H_s vs. MWD at WTG11 (total signal).

$H_{s,total}$ → (m) \ $T_{p,total}$ → (s)	0.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-11.0	11.0-12.0	12.0-13.0	13.0-14.0	14.0-15.0	15.0-16.0	16.0-17.0	17.0-18.0	>18.0	
>15.0																	
14.0-15.0																	
13.0-14.0																	
12.0-13.0																	
11.0-12.0																	
10.0-11.0																	
9.0-10.0																	
8.0-9.0																	
7.0-8.0																	
6.0-7.0														0.00			0.00
5.0-6.0											0.00	0.00	0.01	0.01	0.01	0.00	0.03
4.0-5.0									0.00	0.05	0.10	0.19	0.20	0.13	0.05	0.02	0.74
3.0-4.0					0.00	0.00	0.01	0.12	0.53	1.28	1.32	1.06	0.80	0.33	0.10	0.04	5.60
2.0-3.0			0.00	0.03	0.15	0.49	1.31	2.85	4.61	4.94	3.48	2.00	1.37	0.40	0.13	0.10	21.87
1.0-2.0	0.11	0.20	0.49	1.19	3.09	6.69	8.38	10.22	9.35	6.21	2.90	1.39	0.66	0.27	0.09	0.10	51.33
0.0-1.0	1.31	0.22	0.56	1.23	2.73	4.64	3.91	2.90	1.64	0.74	0.29	0.10	0.10	0.03	0.02	0.01	20.44
	1.43	0.41	1.05	2.45	5.98	11.82	13.62	16.09	16.14	13.21	8.09	4.75	3.14	1.17	0.40	0.26	100.00 Total

Joint Occurence Table, $H_{s,total}$ vs. $T_{p,total}$

Figure 3.55 All-year joint occurrence table of H_s vs. T_p at WTG11 (total signal).

$U_{170,mag}$ → (m/s) \ $H_{s,total}$ → (m)	0.0-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-11.0	11.0-12.0	12.0-13.0	13.0-14.0	14.0-15.0	>15.0	
>40.5																	
39.5-40.5																	
38.5-39.5			0.00														0.00
37.5-38.5																	
36.5-37.5					0.00	0.00											0.00
35.5-36.5				0.00	0.00												0.00
34.5-35.5					0.00	0.00											0.00
33.5-34.5					0.00	0.00											0.00
32.5-33.5			0.00		0.00	0.00											0.00
31.5-32.5			0.00	0.00	0.00	0.00	0.00										0.01
30.5-31.5			0.00	0.00	0.00	0.00											0.01
29.5-30.5			0.00	0.01	0.00	0.00	0.00										0.01
28.5-29.5			0.00	0.01	0.01	0.00											0.03
27.5-28.5		0.00	0.01	0.02	0.02	0.00											0.05
26.5-27.5		0.00	0.01	0.05	0.02	0.00											0.09
25.5-26.5		0.00	0.03	0.08	0.04	0.00											0.15
24.5-25.5		0.01	0.04	0.11	0.04	0.00											0.21
23.5-24.5		0.01	0.08	0.16	0.06	0.00											0.32
22.5-23.5	0.00	0.02	0.15	0.24	0.06	0.00											0.47
21.5-22.5	0.00	0.04	0.27	0.29	0.05	0.00											0.65
20.5-21.5	0.00	0.08	0.46	0.36	0.06	0.00											0.95
19.5-20.5	0.01	0.16	0.69	0.42	0.06												1.33
18.5-19.5	0.01	0.27	0.97	0.47	0.05												1.78
17.5-18.5	0.02	0.50	1.28	0.47	0.05	0.00											2.31
16.5-17.5	0.03	0.85	1.55	0.45	0.05												2.93
15.5-16.5	0.06	1.34	1.74	0.44	0.02												3.60
14.5-15.5	0.14	1.89	1.93	0.39	0.03												4.39
13.5-14.5	0.22	2.67	1.92	0.32	0.02												5.14
12.5-13.5	0.38	3.59	1.87	0.27	0.01												6.14
11.5-12.5	0.63	4.41	1.73	0.21	0.01												6.99
10.5-11.5	1.00	5.00	1.51	0.17	0.01												7.78
9.5-10.5	1.41	5.33	1.25	0.14	0.01												8.14
8.5-9.5	1.98	5.28	1.04	0.12	0.01												8.42
7.5-8.5	2.35	4.84	0.94	0.10	0.01												8.25
6.5-7.5	2.47	4.25	0.74	0.08	0.00												7.55
5.5-6.5	2.58	3.48	0.58	0.07	0.00												6.71
4.5-5.5	2.39	2.74	0.41	0.04	0.00												5.59
3.5-4.5	1.93	2.06	0.31	0.04	0.00												4.35
2.5-3.5	1.53	1.35	0.20	0.03	0.00												3.11
1.5-2.5	0.94	0.79	0.11	0.02													1.86
0.0-1.5	0.35	0.28	0.04	0.00													0.68
	20.44	51.33	21.87	5.60	0.74	0.03	0.00										100.00 Total

Joint Occurence Table, $U_{170,mag}$ vs. $H_{s,total}$

Figure 3.56 All-year joint occurrence table of U_{170} vs. H_s at WTG11.

MWD$_{total}$ → (°N)

$U_{170,dir}$ → (°N)	0/360	30	60	90	120	150	180	210	240	270	300	330	
330	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.21	0.89	4.34	2.77	0.12	8.42
300	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.38	1.78	7.47	1.28	0.03	11.04
270	0.00					0.00	0.11	0.85	3.48	8.63	0.41	0.01	13.50
240					0.00	0.01	0.32	1.84	5.13	6.31	0.16	0.00	13.77
210					0.00	0.02	0.61	3.01	4.85	3.35	0.11	0.00	11.94
180				0.00	0.00	0.05	0.92	2.51	2.55	2.01	0.09	0.00	8.13
150	0.00			0.00	0.01	0.29	1.38	1.72	1.89	1.73	0.06	0.00	7.10
120	0.00	0.00	0.01	0.02	0.16	0.74	1.01	1.01	1.42	1.52	0.12	0.01	6.03
90	0.02	0.04	0.07	0.28	0.44	0.43	0.40	0.52	0.99	1.51	0.31	0.06	5.08
60	0.13	0.13	0.24	0.25	0.11	0.08	0.13	0.22	0.59	1.43	0.74	0.21	4.27
30	0.18	0.06	0.05	0.03	0.02	0.03	0.05	0.12	0.40	1.55	1.28	0.48	4.25
0/360	0.07	0.01	0.01	0.01	0.01	0.01	0.04	0.12	0.57	2.36	2.77	0.50	6.47
	0.42	0.25	0.38	0.58	0.76	1.66	5.14	12.53	24.54	42.21	10.11	1.42	100.00
													Total

Joint Occurence Table, $U_{170,dir}$ vs. MWD$_{total}$

Figure 3.57 All-year misalignment joint occurrence table of $U_{170,dir}$ vs. MWD at WTG11 (total signal).

3.5.3 Normal Sea States (NSS)

A Normal Sea State (NSS) is characterised by a significant wave height and a peak wave period. Furthermore, it is associated with a concurrent mean wind speed or wind speed range. The significant wave height of the Normal Sea State is defined as the expected value of the significant wave height conditioned on the concurrent wind speed range. These values are presented in Table 3.13 to Table 3.15 for the omni-directional case (i.e. considering all directional sectors for wind and waves) of the total wave signal. The tables also provide the peak enhancement factors of the JONSWAP spectrum (Hasselman et al., 1973), computed from the NSS significant wave height and peak period using Torsethaugen et al. (1984), the associated directional spreading values and the percentages of the year characterized by such sea state.

It can be clearly noticed from the NSS tables that the amount of directional spreading increases with the amount of shelter the turbines have. The latter is caused by both dissipational effects and wave refraction.

The corresponding tables for the wind-sea and swell signals are provided in the spreadsheet tables accompanying this report (cf. Appendix E). Next to the omni-directional tables, a 12x12 wind/wave misalignment NSS tables were generated.

Table 3.13 Omni-directional Normal Sea States for WTG15 (total wave signal).

Wind dir. [deg]			OMNI				
Mean Wave dir. [deg]			OMNI				
Hourly mean wind Speed, 170 mMSL hub height (m/s)			Hs (m)	Tp (s)	g (-)	DSpr (°)	P(U,mis) (-)
Lower	Mean	Upper					
0	0.75	1.5	1.48	10.3	6.91	37.12	0.007
1.5	2	2.5	1.50	10.3	6.92	37.37	0.019
2.5	3	3.5	1.52	10.4	6.91	37.37	0.031
3.5	4	4.5	1.58	10.5	6.90	37.47	0.043
4.5	5	5.5	1.60	10.5	6.87	37.89	0.056
5.5	6	6.5	1.66	10.4	6.82	38.20	0.067
6.5	7	7.5	1.74	10.5	6.75	38.31	0.076
7.5	8	8.5	1.83	10.5	6.68	38.35	0.082
8.5	9	9.5	1.91	10.5	6.55	38.33	0.084
9.5	10	10.5	2.05	10.6	6.41	37.95	0.081
10.5	11	11.5	2.20	10.7	6.21	37.81	0.078
11.5	12	12.5	2.38	10.8	6.00	37.44	0.070
12.5	13	13.5	2.58	10.9	5.72	37.01	0.061
13.5	14	14.5	2.78	11.0	5.43	36.61	0.051
14.5	15	15.5	3.04	11.2	5.10	35.84	0.044
15.5	16	16.5	3.26	11.3	4.82	35.55	0.036
16.5	17	17.5	3.53	11.5	4.46	35.18	0.029
17.5	18	18.5	3.77	11.6	4.11	34.91	0.023
18.5	19	19.5	4.06	11.9	3.82	34.55	0.018
19.5	20	20.5	4.29	12.0	3.49	34.31	0.013
20.5	21	21.5	4.58	12.2	3.19	34.01	0.010
21.5	22	22.5	4.89	12.4	2.99	33.67	0.007
22.5	23	23.5	5.22	12.6	2.65	33.32	0.005
23.5	24	24.5	5.60	12.8	2.44	32.79	0.003
24.5	25	25.5	5.82	12.8	2.22	32.44	0.002
25.5	26	26.5	6.28	13.1	1.84	31.76	0.002
26.5	27	27.5	6.34	12.9	1.88	32.20	0.001
27.5	28	28.5	6.70	13.3	2.03	31.52	0.001
28.5	29	29.5	6.84	12.9	1.57	31.82	0.000
29.5	30	30.5	7.61	13.4	1.42	31.07	0.000
30.5	31	31.5	7.73	13.3	1.73	31.62	0.000
31.5	32	32.5	8.93	13.9	1.39	29.72	0.000
32.5	33	33.5	10.36	15.2	1.22	27.83	0.000
33.5	34	34.5	11.15	15.4	1.38	26.87	0.000
34.5	35	35.5	10.64	16.0	1.56	26.82	0.000
35.5	36	36.5	7.48	13.0	1.40	29.75	0.000
36.5	37	37.5	10.46	14.0	1.90	27.78	0.000
37.5	38	38.5					
38.5	39	39.5	4.21	11.2	1.19	39.15	0.000
39.5	40	40.5					
40.5		INF					
	SUM						1.000

Table 3.14 Omni-directional Normal Sea States for WTG08 (total wave signal).

Wind dir. [deg]			OMNI				
Mean Wave dir. [deg]			OMNI				
Hourly mean wind Speed, 170 mMSL hub height (m/s)			Hs (m)	Tp (s)	g (-)	DSpr (°)	P(U,mis) (-)
Lower	Mean	Upper					
0	0.75	1.5	1.23	10.3	6.95	42.05	0.007
1.5	2	2.5	1.25	10.4	6.94	42.37	0.019
2.5	3	3.5	1.26	10.5	6.95	42.48	0.031
3.5	4	4.5	1.31	10.5	6.96	42.65	0.043
4.5	5	5.5	1.32	10.5	6.94	43.07	0.056
5.5	6	6.5	1.38	10.5	6.90	43.37	0.067
6.5	7	7.5	1.45	10.5	6.87	43.39	0.076
7.5	8	8.5	1.53	10.6	6.85	43.27	0.082
8.5	9	9.5	1.60	10.5	6.77	42.99	0.084
9.5	10	10.5	1.72	10.6	6.70	42.26	0.081
10.5	11	11.5	1.86	10.6	6.61	41.73	0.078
11.5	12	12.5	2.01	10.8	6.49	41.21	0.070
12.5	13	13.5	2.18	10.9	6.31	40.50	0.061
13.5	14	14.5	2.36	11.0	6.16	39.80	0.051
14.5	15	15.5	2.57	11.2	5.99	38.91	0.044
15.5	16	16.5	2.75	11.4	5.83	38.58	0.036
16.5	17	17.5	2.98	11.5	5.67	37.86	0.029
17.5	18	18.5	3.18	11.7	5.50	37.50	0.023
18.5	19	19.5	3.42	11.9	5.32	37.03	0.018
19.5	20	20.5	3.60	12.0	5.07	36.65	0.013
20.5	21	21.5	3.84	12.2	4.90	36.31	0.010
21.5	22	22.5	4.10	12.5	4.61	35.78	0.007
22.5	23	23.5	4.37	12.6	4.26	35.43	0.005
23.5	24	24.5	4.67	12.8	4.12	35.02	0.003
24.5	25	25.5	4.87	12.8	3.78	34.41	0.002
25.5	26	26.5	5.22	13.0	3.42	33.71	0.002
26.5	27	27.5	5.31	12.9	2.99	33.65	0.001
27.5	28	28.5	5.45	13.1	3.27	33.99	0.001
28.5	29	29.5	5.68	12.9	2.91	33.52	0.000
29.5	30	30.5	6.27	13.3	2.09	32.92	0.000
30.5	31	31.5	6.36	13.2	1.78	33.34	0.000
31.5	32	32.5	7.12	13.7	1.27	32.12	0.000
32.5	33	33.5	7.58	14.9	1.27	32.44	0.000
33.5	34	34.5	7.87	15.1	1.30	31.98	0.000
34.5	35	35.5	7.73	15.8	2.80	31.79	0.000
35.5	36	36.5	6.16	14.8	4.34	32.52	0.000
36.5	37	37.5	7.94	13.8	1.10	30.70	0.000
37.5	38	38.5					
38.5	39	39.5	3.09	9.9	1.57	47.99	0.000
39.5	40	40.5					
40.5		INF					
	SUM						1.000

Table 3.15 Omni-directional Normal Sea States for WTG11 (swell wave signal).

Wind dir. [deg]							
Mean Wave dir. [deg]			OMNI				
Hourly mean wind Speed, 170 mMSL hub height (m/s)			Hs (m)	Tp (s)	g (-)	DSpr (°)	P(U,mis) (-)
Lower	Mean	Upper					
0	0.75	1.5	1.11	10.3	6.98	52.54	0.007
1.5	2	2.5	1.13	10.3	6.98	52.76	0.019
2.5	3	3.5	1.14	10.4	6.98	52.90	0.031
3.5	4	4.5	1.18	10.5	6.98	53.31	0.043
4.5	5	5.5	1.19	10.5	6.97	53.59	0.056
5.5	6	6.5	1.24	10.5	6.95	53.78	0.067
6.5	7	7.5	1.30	10.5	6.94	53.94	0.076
7.5	8	8.5	1.36	10.5	6.91	53.90	0.082
8.5	9	9.5	1.42	10.5	6.87	53.70	0.084
9.5	10	10.5	1.51	10.6	6.83	53.37	0.081
10.5	11	11.5	1.61	10.7	6.78	53.21	0.078
11.5	12	12.5	1.72	10.8	6.72	53.13	0.070
12.5	13	13.5	1.84	10.9	6.67	53.07	0.061
13.5	14	14.5	1.97	11.0	6.61	53.09	0.051
14.5	15	15.5	2.11	11.2	6.54	52.88	0.044
15.5	16	16.5	2.23	11.3	6.50	52.94	0.036
16.5	17	17.5	2.38	11.5	6.51	53.29	0.029
17.5	18	18.5	2.51	11.7	6.45	53.34	0.023
18.5	19	19.5	2.66	11.9	6.47	53.75	0.018
19.5	20	20.5	2.78	12.1	6.47	53.92	0.013
20.5	21	21.5	2.92	12.3	6.52	54.14	0.010
21.5	22	22.5	3.06	12.5	6.53	54.49	0.007
22.5	23	23.5	3.22	12.7	6.50	54.70	0.005
23.5	24	24.5	3.38	12.8	6.47	54.77	0.003
24.5	25	25.5	3.45	12.8	6.51	55.05	0.002
25.5	26	26.5	3.64	13.0	6.43	54.93	0.002
26.5	27	27.5	3.68	12.8	6.19	54.86	0.001
27.5	28	28.5	3.81	13.2	6.10	54.94	0.001
28.5	29	29.5	3.89	13.1	5.96	54.01	0.000
29.5	30	30.5	4.13	13.6	6.19	54.76	0.000
30.5	31	31.5	4.13	13.3	5.88	54.80	0.000
31.5	32	32.5	4.57	13.8	5.61	53.61	0.000
32.5	33	33.5	4.99	15.1	7.00	51.90	0.000
33.5	34	34.5	5.08	15.3	6.18	49.68	0.000
34.5	35	35.5	5.00	15.8	6.00	52.31	0.000
35.5	36	36.5	4.34	14.9	7.00	53.55	0.000
36.5	37	37.5	5.04	14.2	7.00	55.34	0.000
37.5	38	38.5					
38.5	39	39.5	2.87	10.1	3.56	51.21	0.000
39.5	40	40.5					
40.5		INF					
	SUM						1.000

3.5.4 Extreme Sea States (ESS)

The extreme sea state (ESS) tables consist of the significant wave height return values and the associated values of peak wave period (T_p), peak enhancement factor (γ), directional spreading (DSpr), wave kinematic factor (F_s), extreme high and low water level (EHWL/ELWL), maximum wave height (H_{max}), period (T_{hmax}) and crest height (C_{max}). These were determined by first carrying out the extreme value analyses of the 43-year long (01-01-1979 00:00 – 31-

12-2020 23:00) timeseries of the significant wave height and then determining the associated values.

The EVA of the H_s timeseries at each reference location were carried out using again the POT method in combination with the fitting of GPD (Generalized Pareto Distribution) fits (cf. Appendix B). In line with the wind and current analyses, omni-directional and directional (over 30º sectors) analyses were carried out. Again, the data were stratified into sectors before the EVA were carried out, meaning that a given storm may have been considered in more than one sector. The omni-directional H_s return value plots for each of the three considered turbine locations are given as example in Figure 3.58.

The associated (conditional) values of the other wave parameters and water levels were determined as described in the following.

<u>Peak wave periods and peak enhancement factors</u>
The associated peak periods T_p were computed by means of the power relation fit to the H_s and corresponding T_p values in the POT sample (i.e. the sample of H_s peak values to which the extreme value distribution was fitted to estimate the H_s return values). In case a negative relation was found (i.e. decreasing T_p with increasing H_s) a constant relation was assumed instead for all return periods. The point estimate was in that case described by the mean T_p value within the POT subset and the lower and upper bounds by the 2.5th and 97.5th percentile values of T_p within the POT subset. The associated peak enhancement factors of the JONSWAP spectrum (Hasselman et al., 1973) were computed from the ESS significant wave heights and associated peak wave periods using Torsethaugen et al. (1984).

<u>Depth-averaged current speed</u>
The associated depth-averaged current speed ($U_{c,DA,total}$) was computed by means of a linear fit to the H_s and corresponding current values in the POT sample. For a given H_s value the relation is used to compute the associated current value. In case a negative relation was found (i.e. decreasing $U_{c,DA,total}$ with increasing H_s) a constant relation was assumed instead for all return periods. The point estimate was in that case described by the mean $U_{c,DA,total}$ value within the POT subset and the lower and upper bounds by the 2.5th and 97.5th percentile values of $U_{c,DA,total}$ within the POT subset.

<u>Directional spreading and wave kinematic factor</u>
The associated directional spreading (DSpr) values were determined by computing the mean for the 10 highest storms with the POT subset. This means that the associated DSpr values are independent of the return period. The wave kinematic factor (F_s) is computed from the DSpr values using the relations described in Section 3.3.4 of DNVGL (2020) (see also Section 3.5.7):

$F_s = \left[\frac{s^2+s+1}{(s+1)(s+2)}\right]^{1/2}$, with $s = \frac{2}{DSpr^2} - 1$

<u>Maximum wave height, period and crest height</u>
Given that the local extreme waves may be depth-limited, for the determination of the maximum wave height (H_{max}) and corresponding crest height (C_{max}) the local depth at each reference location is taken into account. The maximum wave height (H_{max}) is defined as the largest wave height in 1,000 waves ($H_{0.1\%}$) during a given sea state. In deep waters the Rayleigh distribution is often assumed for the distribution of wave heights in a sea state. In regions where the highest waves in a sea state may be depth-limited another distribution needs to be considered. In this study (and as standard practice in other studies worldwide) we consider the Battjes and Groenendijk (2000) distribution for the wave height, since it accounts for eventual depth-induced wave breaking. Moreover, the Battjes and Groenendijk (2000) converges to the Rayleigh distribution when the waves are not depth-limited, in which case $H_{0.1\%} \approx 1.858*H_s$.

The Battjes and Groenendijk (2000) distribution needs as input H_s, the total water depth and the local bottom slope. For the water depths, three variations were considered:

- the total of the local bottom level plus the respective (directional) extreme high water level (EHWL) return values, assuming full correlation between significant wave height and the EHWL values;
- the total of the local bottom level plus mean sea level (MSL); and
- the total of the local bottom level plus the respective (directional) extreme low water level (ELWL) return values, assuming full correlation between significant wave height and the ELWL values

The (directional) extreme high and low water levels were computed similar as described in Section 3.3.3, while considering directional stratification based on the local concurrent mean wave directions. The local (directional) bottom slopes were determined as described in Section 3.7.2.2.

Based on an analysis of a large number of measurements, Goda (1978) has shown that the most likely wave period associated with the highest waves in a sea state is closely related to the peak wave period T_p. According to Goda this wave period is 0.9 to 1.0 times T_p. Our standard practice is to take the wave period associated with the maximum wave height (T_{Hmax}) equal to the peak wave period (T_p), which is also what is done in this study.

The crest height of the maximum wave height is determined using the Rienecker-Fenton wave theory (Rienecker and Fenton, 1981) on the basis of the total water depth considering the local water depth, H_{max} and T_{Hmax} values per return period.

The resulting directional extreme wave conditions are given in Table 3.16 and Table 3.17 for WTG15, Table 3.18 and Table 3.19 for WTG08 and Table 3.20 and Table 3.21 for WTG11 . As can be seen in the tables (and as expected) the turbine with the most extreme conditions is WTG15, with the most extreme waves coming from Sector 240 and with a 50-yr significant wave height return value slightly below 12.6 m with an associated peak period of 16.77 s.

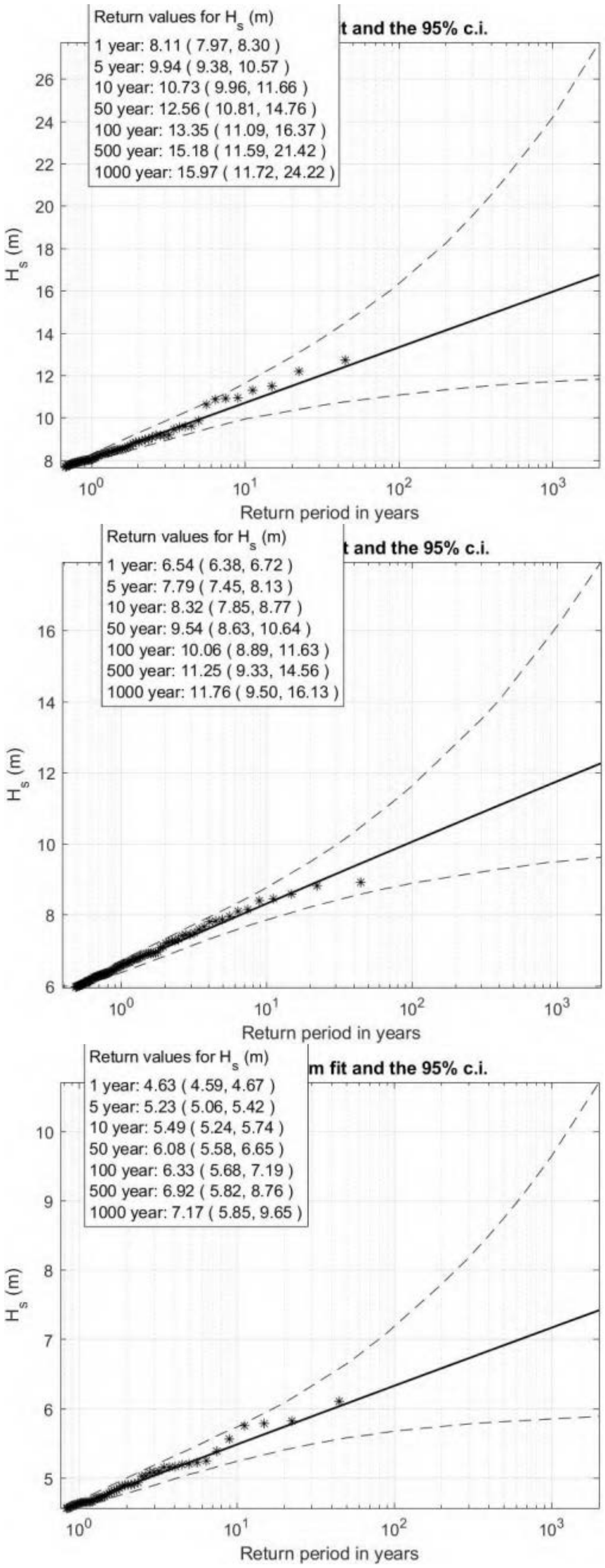

Figure 3.58 Omni-directional significant wave height return value plots of Location 028 (top), Location 101 (middle) and Location 140 (bottom). The dashed lines are the associated 95% confidence intervals. The POT data are represented by the asterisks, with as plotting position (xi, (n+1)/(λ_u(n+1-i)), where n is the sample size, i the order and λ_u the Poisson rate.

Table 3.16 Directional wave extremes at WTG15, return periods 1-, 5-, 10- and 50-yr.

Return period	Wave direction (coming from)	H_s	T_p	Peak enhancement factor, γ	Directional spreading, σ_θ	Wave kinematic factor, F_s	High EWL				Mean sea level			Low EWL				Ass. $U_{c,DA,total}$
							EHWL	H_{max}	T_{hmax}	C_{max}	H_{max}	T_{hmax}	C_{max}	ELWL	H_{max}	T_{hmax}	C_{max}	
(years)	(°N)	(m)	(s)	(-)	(°)	(-)	(mLAT)	(m)	(s)	(mLAT)	(m)	(s)	(mLAT)	(mLAT)	(m)	(s)	(mLAT)	(m/s)
	OMNI	8.11 (7.97 - 8.30)	15.07 (15.00 - 15.15)	1.05 (1.06 - 1.04)	26.64	0.90	5.39 (5.38 - 5.41)	15.08 (14.81 - 15.42)	15.07 (15.00 - 15.15)	14.53 (14.32 - 14.80)	15.08 (14.81 - 15.42)	15.07 (15.00 - 15.15)	11.99 (11.79 - 12.25)	0.03 (0.05 - 0.00)	15.08 (14.81 - 15.42)	15.07 (15.00 - 15.15)	9.48 (9.29 - 9.73)	0.25 (0.25 - 0.25)
	0	0.99 (0.93 - 1.04)	9.76 (9.62 - 9.91)	7.00 (7.00 - 7.00)	70.70	0.68	4.27 (4.26 - 4.29)	1.83 (1.73 - 1.94)	9.76 (9.62 - 9.91)	5.21 (5.14 - 5.29)	1.83 (1.73 - 1.94)	9.76 (9.62 - 9.91)	3.65 (3.59 - 3.70)	1.13 (1.14 - 1.11)	1.83 (1.73 - 1.94)	9.76 (9.62 - 9.91)	2.07 (2.03 - 2.11)	0.19 (0.19 - 0.19)
	30	0.87 (0.87 - 0.88)	9.12 (9.09 - 9.16)	7.00 (7.00 - 7.00)	74.87	0.69	4.09 (4.05 - 4.13)	1.62 (1.61 - 1.64)	9.12 (9.09 - 9.16)	4.92 (4.88 - 4.97)	1.62 (1.61 - 1.64)	9.12 (9.09 - 9.16)	3.54 (3.53 - 3.55)	1.27 (1.28 - 1.25)	1.62 (1.61 - 1.64)	9.12 (9.09 - 9.16)	2.10 (2.11 - 2.09)	0.19 (0.19 - 0.19)
	60	0.88 (0.88 - 0.89)	9.06 (9.05 - 9.08)	7.00 (7.00 - 7.00)	73.69	0.68	4.17 (4.11 - 4.24)	1.64 (1.64 - 1.65)	9.06 (9.05 - 9.08)	5.01 (4.94 - 5.09)	1.64 (1.64 - 1.65)	9.06 (9.05 - 9.08)	3.55 (3.55 - 3.55)	1.20 (1.20 - 1.20)	1.64 (1.64 - 1.65)	9.06 (9.05 - 9.08)	2.04 (2.04 - 2.04)	0.15 (0.15 - 0.15)
	90	0.99 (0.94 - 1.05)	8.37 (8.24 - 8.49)	7.00 (7.00 - 7.00)	61.77	0.69	4.43 (4.42 - 4.45)	1.85 (1.74 - 1.96)	8.37 (8.24 - 8.49)	5.38 (5.31 - 5.46)	1.85 (1.74 - 1.96)	8.37 (8.24 - 8.49)	3.66 (3.60 - 3.72)	1.04 (1.06 - 1.02)	1.85 (1.74 - 1.96)	8.37 (8.24 - 8.49)	1.99 (1.95 - 2.03)	0.17 (0.02 - 0.40)
	120	1.33 (1.32 - 1.35)	9.10 (9.07 - 9.13)	7.00 (7.00 - 7.00)	48.36	0.75	4.50 (4.47 - 4.54)	2.47 (2.45 - 2.51)	9.10 (9.07 - 9.13)	5.78 (5.74 - 5.83)	2.47 (2.45 - 2.51)	9.10 (9.07 - 9.13)	3.99 (3.98 - 4.01)	1.01 (1.06 - 0.95)	2.47 (2.45 - 2.51)	9.10 (9.07 - 9.13)	2.29 (2.32 - 2.25)	0.18 (0.03 - 0.40)
1	150	1.90 (1.88 - 1.92)	11.55 (11.55 - 11.56)	7.00 (7.00 - 7.00)	37.60	0.83	4.79 (4.79 - 4.79)	3.53 (3.49 - 3.57)	11.55 (11.55 - 11.56)	6.63 (6.61 - 6.65)	3.53 (3.49 - 3.57)	11.55 (11.55 - 11.56)	4.55 (4.53 - 4.58)	0.92 (0.94 - 0.89)	3.53 (3.49 - 3.57)	11.55 (11.55 - 11.56)	2.77 (2.77 - 2.76)	0.20 (0.20 - 0.20)
	180	2.97 (2.97 - 2.97)	10.97 (10.96 - 10.97)	7.00 (7.00 - 7.00)	40.21	0.81	4.97 (4.92 - 5.02)	5.52 (5.51 - 5.53)	10.97 (10.96 - 10.97)	7.91 (7.85 - 7.97)	5.52 (5.51 - 5.53)	10.97 (10.96 - 10.97)	5.66 (5.65 - 5.66)	0.65 (0.66 - 0.65)	5.52 (5.51 - 5.53)	10.97 (10.96 - 10.97)	3.61 (3.61 - 3.61)	0.17 (0.03 - 0.40)
	210	5.11 (4.92 - 5.33)	12.61 (12.48 - 12.75)	1.36 (1.47 - 1.27)	31.75	0.87	5.26 (5.26 - 5.26)	9.50 (9.14 - 9.90)	12.61 (12.48 - 12.75)	10.56 (10.34 - 10.81)	9.50 (9.14 - 9.90)	12.61 (12.48 - 12.75)	8.05 (7.82 - 8.31)	0.42 (0.44 - 0.39)	9.50 (9.14 - 9.90)	12.61 (12.48 - 12.75)	5.80 (5.59 - 6.03)	0.19 (0.18 - 0.19)
	240	8.02 (7.77 - 8.26)	14.90 (14.78 - 15.02)	1.04 (1.05 - 1.03)	26.64	0.90	5.34 (5.33 - 5.35)	14.90 (14.44 - 15.36)	14.90 (14.78 - 15.02)	14.34 (13.99 - 14.68)	14.90 (14.44 - 15.36)	14.90 (14.78 - 15.02)	11.84 (11.50 - 12.19)	0.15 (0.18 - 0.12)	14.90 (14.44 - 15.36)	14.90 (14.78 - 15.02)	9.44 (9.11 - 9.78)	0.24 (0.24 - 0.24)
	270	7.05 (6.86 - 7.25)	14.88 (14.75 - 15.02)	1.42 (1.49 - 1.36)	26.52	0.90	5.23 (5.22 - 5.24)	13.09 (12.75 - 13.48)	14.88 (14.75 - 15.02)	12.96 (12.71 - 13.26)	13.09 (12.75 - 13.48)	14.88 (14.75 - 15.02)	10.55 (10.29 - 10.83)	0.06 (0.09 - 0.03)	13.09 (12.75 - 13.48)	14.88 (14.75 - 15.02)	8.02 (7.79 - 8.29)	0.26 (0.26 - 0.26)
	300	3.06 (2.97 - 3.15)	11.25 (11.11 - 11.40)	7.00 (7.00 - 7.00)	28.61	0.89	4.99 (4.97 - 5.01)	5.68 (5.51 - 5.86)	11.25 (11.11 - 11.40)	8.02 (7.91 - 8.15)	5.68 (5.51 - 5.86)	11.25 (11.11 - 11.40)	5.75 (5.65 - 5.85)	0.22 (0.25 - 0.19)	5.68 (5.51 - 5.86)	11.25 (11.11 - 11.40)	3.28 (3.21 - 3.35)	0.24 (0.05 - 0.52)
	330	1.31 (1.31 - 1.31)	10.18 (10.17 - 10.18)	7.00 (7.00 - 7.00)	58.81	0.70	4.64 (4.63 - 4.66)	2.44 (2.44 - 2.44)	10.18 (10.17 - 10.18)	5.90 (5.88 - 5.91)	2.44 (2.44 - 2.44)	10.18 (10.17 - 10.18)	3.97 (3.97 - 3.97)	0.71 (0.74 - 0.66)	2.44 (2.44 - 2.44)	10.18 (10.17 - 10.18)	1.96 (2.00 - 1.92)	0.17 (0.17 - 0.17)
	OMNI	9.94 (9.38 - 10.57)	15.84 (15.62 - 16.08)	1.04 (1.02 - 1.07)	26.64	0.90	5.53 (5.49 - 5.58)	18.47 (17.44 - 19.64)	15.84 (15.62 - 16.08)	17.29 (16.43 - 18.30)	18.47 (17.44 - 19.64)	15.84 (15.62 - 16.08)	14.71 (13.85 - 15.70)	-0.13 (-0.09 - -0.17)	18.47 (17.44 - 19.64)	15.84 (15.62 - 16.08)	12.15 (11.30 - 13.14)	0.27 (0.26 - 0.27)
	0	1.39 (1.28 - 1.47)	10.65 (10.44 - 10.82)	7.00 (7.00 - 7.00)	70.70	0.68	4.75 (4.62 - 4.85)	2.58 (2.38 - 2.74)	10.65 (10.44 - 10.82)	6.08 (5.85 - 6.26)	2.58 (2.38 - 2.74)	10.65 (10.44 - 10.82)	4.04 (3.94 - 4.13)	0.54 (0.70 - 0.39)	2.58 (2.38 - 2.74)	10.65 (10.44 - 10.82)	1.87 (1.93 - 1.81)	0.19 (0.19 - 0.19)
	30	1.21 (1.11 - 1.30)	10.69 (10.27 - 11.09)	7.00 (7.00 - 7.00)	74.87	0.69	4.70 (4.53 - 4.84)	2.25 (2.07 - 2.42)	10.69 (10.27 - 11.09)	5.86 (5.59 - 6.08)	2.25 (2.07 - 2.42)	10.69 (10.27 - 11.09)	3.86 (3.77 - 3.96)	0.69 (0.85 - 0.57)	2.25 (2.07 - 2.42)	10.69 (10.27 - 11.09)	1.85 (1.91 - 1.82)	0.23 (0.22 - 0.24)
	60	1.21 (1.12 - 1.30)	10.75 (10.30 - 11.19)	7.00 (7.00 - 7.00)	73.69	0.68	4.83 (4.66 - 4.95)	2.25 (2.08 - 2.42)	10.75 (10.30 - 11.19)	5.98 (5.73 - 6.20)	2.25 (2.08 - 2.42)	10.75 (10.30 - 11.19)	3.87 (3.78 - 3.96)	0.56 (0.71 - 0.44)	2.25 (2.08 - 2.42)	10.75 (10.30 - 11.19)	1.72 (1.78 - 1.69)	0.20 (0.19 - 0.21)
	90	1.40 (1.30 - 1.50)	9.11 (8.93 - 9.26)	7.00 (7.00 - 7.00)	61.77	0.69	4.94 (4.79 - 5.07)	2.60 (2.41 - 2.78)	9.11 (8.93 - 9.26)	6.29 (6.03 - 6.51)	2.60 (2.41 - 2.78)	9.11 (8.93 - 9.26)	4.06 (3.95 - 4.15)	0.46 (0.60 - 0.36)	2.60 (2.41 - 2.78)	9.11 (8.93 - 9.26)	1.81 (1.85 - 1.81)	0.17 (0.02 - 0.40)
	120	1.81 (1.66 - 1.96)	9.89 (9.66 - 10.11)	7.00 (7.00 - 7.00)	48.36	0.75	5.00 (4.86 - 5.11)	3.36 (3.08 - 3.65)	9.89 (9.66 - 10.11)	6.75 (6.47 - 7.01)	3.36 (3.08 - 3.65)	9.89 (9.66 - 10.11)	4.46 (4.31 - 4.62)	0.47 (0.61 - 0.35)	3.36 (3.08 - 3.65)	9.89 (9.66 - 10.11)	2.23 (2.22 - 2.26)	0.18 (0.03 - 0.40)
5	150	2.43 (2.27 - 2.60)	11.62 (11.60 - 11.63)	7.00 (7.00 - 7.00)	37.60	0.83	5.08 (5.01 - 5.14)	4.51 (4.22 - 4.83)	11.62 (11.60 - 11.63)	7.45 (7.23 - 7.69)	4.51 (4.22 - 4.83)	11.62 (11.60 - 11.63)	5.09 (4.93 - 5.27)	0.48 (0.59 - 0.37)	4.51 (4.22 - 4.83)	11.62 (11.60 - 11.63)	2.87 (2.82 - 2.94)	0.26 (0.24 - 0.27)
	180	3.64 (3.44 - 3.86)	11.96 (11.67 - 12.27)	7.00 (7.00 - 7.00)	40.21	0.81	5.33 (5.24 - 5.40)	6.77 (6.39 - 7.18)	11.96 (11.67 - 12.27)	8.98 (8.67 - 9.30)	6.77 (6.39 - 7.18)	11.96 (11.67 - 12.27)	6.38 (6.16 - 6.63)	0.41 (0.48 - 0.35)	6.77 (6.39 - 7.18)	11.96 (11.67 - 12.27)	4.10 (3.94 - 4.29)	0.17 (0.03 - 0.40)
	210	6.46 (6.07 - 6.85)	13.42 (13.20 - 13.63)	1.05 (1.09 - 1.02)	31.75	0.87	5.43 (5.38 - 5.47)	12.01 (11.28 - 12.73)	13.42 (13.20 - 13.63)	12.35 (11.82 - 12.88)	12.01 (11.28 - 12.73)	13.42 (13.20 - 13.63)	9.71 (9.22 - 10.21)	0.21 (0.26 - 0.16)	12.01 (11.28 - 12.73)	13.42 (13.20 - 13.63)	7.29 (6.83 - 7.76)	0.22 (0.21 - 0.23)
	240	9.92 (9.33 - 10.50)	15.76 (15.51 - 16.00)	1.04 (1.02 - 1.07)	26.64	0.90	5.48 (5.44 - 5.53)	18.44 (17.35 - 19.52)	15.76 (15.51 - 16.00)	17.21 (16.30 - 18.14)	18.44 (17.35 - 19.52)	15.76 (15.51 - 16.00)	14.67 (13.77 - 15.59)	-0.01 (0.04 - -0.06)	18.44 (17.35 - 19.52)	15.76 (15.51 - 16.00)	12.22 (11.33 - 13.13)	0.27 (0.26 - 0.28)
	270	8.52 (8.13 - 8.88)	15.80 (15.57 - 16.01)	1.13 (1.18 - 1.10)	26.52	0.90	5.37 (5.33 - 5.40)	15.83 (15.11 - 16.51)	15.80 (15.57 - 16.01)	15.12 (14.54 - 15.69)	15.83 (15.11 - 16.51)	15.80 (15.57 - 16.01)	12.64 (12.07 - 13.18)	-0.12 (-0.06 - -0.16)	15.83 (15.11 - 16.51)	15.80 (15.57 - 16.01)	10.02 (9.48 - 10.54)	0.27 (0.26 - 0.27)
	300	3.67 (3.50 - 3.82)	12.17 (11.93 - 12.38)	7.00 (7.00 - 7.00)	28.61	0.89	5.18 (5.13 - 5.23)	6.83 (6.51 - 7.09)	12.17 (11.93 - 12.38)	8.87 (8.63 - 9.08)	6.83 (6.51 - 7.09)	12.17 (11.93 - 12.38)	6.42 (6.23 - 6.58)	0.00 (0.06 - -0.05)	6.83 (6.51 - 7.09)	12.17 (11.93 - 12.38)	3.74 (3.60 - 3.84)	0.24 (0.05 - 0.52)
	330	1.64 (1.55 - 1.73)	10.97 (10.75 - 11.16)	7.00 (7.00 - 7.00)	58.81	0.70	4.93 (4.84 - 4.99)	3.05 (2.88 - 3.21)	10.97 (10.75 - 11.16)	6.51 (6.33 - 6.66)	3.05 (2.88 - 3.21)	10.97 (10.75 - 11.16)	4.29 (4.20 - 4.38)	0.33 (0.42 - 0.25)	3.05 (2.88 - 3.21)	10.97 (10.75 - 11.16)	1.92 (1.91 - 1.93)	0.23 (0.21 - 0.24)
	OMNI	10.73 (9.96 - 11.66)	16.14 (15.85 - 16.48)	1.08 (1.04 - 1.14)	26.64	0.90	5.59 (5.54 - 5.66)	19.93 (18.50 - 21.67)	16.14 (15.85 - 16.48)	18.56 (17.32 - 20.10)	19.93 (18.50 - 21.67)	16.14 (15.85 - 16.48)	15.96 (14.74 - 17.50)	-0.20 (-0.14 - -0.25)	19.93 (18.50 - 21.67)	16.14 (15.85 - 16.48)	13.39 (12.17 - 14.94)	0.27 (0.27 - 0.28)
	0	1.52 (1.40 - 1.63)	10.91 (10.68 - 11.10)	7.00 (7.00 - 7.00)	70.70	0.68	4.90 (4.77 - 5.00)	2.83 (2.60 - 3.02)	10.91 (10.68 - 11.10)	6.36 (6.11 - 6.56)	2.83 (2.60 - 3.02)	10.91 (10.68 - 11.10)	4.18 (4.05 - 4.28)	0.35 (0.53 - 0.17)	2.83 (2.60 - 3.02)	10.91 (10.68 - 11.10)	1.82 (1.88 - 1.74)	0.19 (0.19 - 0.19)
	30	1.34 (1.23 - 1.46)	11.26 (10.76 - 11.73)	7.00 (7.00 - 7.00)	74.87	0.69	4.90 (4.73 - 5.03)	2.50 (2.28 - 2.72)	11.26 (10.76 - 11.73)	6.19 (5.90 - 6.43)	2.50 (2.28 - 2.72)	11.26 (10.76 - 11.73)	4.00 (3.88 - 4.11)	0.53 (0.69 - 0.42)	2.50 (2.28 - 2.72)	11.26 (10.76 - 11.73)	1.82 (1.86 - 1.82)	0.24 (0.23 - 0.26)
	60	1.34 (1.22 - 1.47)	11.35 (10.77 - 11.93)	7.00 (7.00 - 7.00)	73.69	0.68	5.00 (4.83 - 5.12)	2.48 (2.26 - 2.72)	11.35 (10.77 - 11.93)	6.28 (5.99 - 6.53)	2.48 (2.26 - 2.72)	11.35 (10.77 - 11.93)	3.99 (3.87 - 4.12)	0.40 (0.56 - 0.26)	2.48 (2.26 - 2.72)	11.35 (10.77 - 11.93)	1.68 (1.72 - 1.68)	0.22 (0.20 - 0.24)
	90	1.53 (1.40 - 1.65)	9.30 (9.10 - 9.48)	7.00 (7.00 - 7.00)	61.77	0.69	5.13 (4.95 - 5.25)	2.83 (2.60 - 3.06)	9.30 (9.10 - 9.48)	6.59 (6.30 - 6.84)	2.83 (2.60 - 3.06)	9.30 (9.10 - 9.48)	4.18 (4.05 - 4.30)	0.33 (0.45 - 0.24)	2.83 (2.60 - 3.06)	9.30 (9.10 - 9.48)	1.80 (1.80 - 1.83)	0.17 (0.02 - 0.40)
	120	2.01 (1.82 - 2.22)	10.18 (9.90 - 10.45)	7.00 (7.00 - 7.00)	48.36	0.75	5.17 (5.03 - 5.26)	3.74 (3.37 - 4.12)	10.18 (9.90 - 10.45)	7.12 (6.79 - 7.43)	3.74 (3.37 - 4.12)	10.18 (9.90 - 10.45)	4.67 (4.47 - 4.88)	0.30 (0.46 - 0.18)	3.74 (3.37 - 4.12)	10.18 (9.90 - 10.45)	2.26 (2.22 - 2.35)	0.18 (0.03 - 0.40)
10	150	2.64 (2.44 - 2.88)	11.64 (11.62 - 11.66)	7.00 (7.00 - 7.00)	37.60	0.83	5.15 (5.06 - 5.24)	4.91 (4.53 - 5.35)	11.64 (11.62 - 11.66)	7.75 (7.45 - 8.08)	4.91 (4.53 - 5.35)	11.64 (11.62 - 11.66)	5.32 (5.11 - 5.56)	0.33 (0.47 - 0.21)	4.91 (4.53 - 5.35)	11.64 (11.62 - 11.66)	2.95 (2.87 - 3.07)	0.28 (0.26 - 0.30)
	180	3.92 (3.64 - 4.25)	12.34 (11.96 - 12.77)	7.00 (7.00 - 7.00)	40.21	0.81	5.45 (5.33 - 5.55)	7.28 (6.76 - 7.89)	12.34 (11.96 - 12.77)	9.40 (8.98 - 9.87)	7.28 (6.76 - 7.89)	12.34 (11.96 - 12.77)	6.69 (6.38 - 7.06)	0.32 (0.40 - 0.25)	7.28 (6.76 - 7.89)	12.34 (11.96 - 12.77)	4.32 (4.09 - 4.64)	0.17 (0.03 - 0.40)
	210	7.04 (6.48 - 7.60)	13.73 (13.43 - 14.02)	1.02 (1.04 - 1.02)	31.75	0.87	5.49 (5.43 - 5.54)	13.08 (12.05 - 14.13)	13.73 (13.43 - 14.02)	13.13 (12.38 - 13.92)	13.08 (12.05 - 14.13)	13.73 (13.43 - 14.02)	10.46 (9.74 - 11.21)	0.15 (0.20 - 0.09)	13.08 (12.05 - 14.13)	13.73 (13.43 - 14.02)	8.00 (7.32 - 8.72)	0.23 (0.22 - 0.25)
	240	10.72 (9.85 - 11.57)	16.09 (15.73 - 16.41)	1.08 (1.04 - 1.14)	26.64	0.90	5.54 (5.47 - 5.61)	19.93 (18.31 - 21.51)	16.09 (15.73 - 16.41)	18.49 (17.09 - 19.92)	19.93 (18.31 - 21.51)	16.09 (15.73 - 16.41)	15.94 (14.56 - 17.35)	-0.05 (0.01 - -0.13)	19.93 (18.31 - 21.51)	16.09 (15.73 - 16.41)	13.50 (12.12 - 14.90)	0.28 (0.27 - 0.30)
	270	9.14 (8.61 - 9.64)	16.16 (15.86 - 16.44)	1.08 (1.12 - 1.05)	26.52	0.90	5.42 (5.37 - 5.47)	16.98 (16.00 - 17.92)	16.16 (15.86 - 16.44)	16.08 (15.26 - 16.88)	16.98 (16.00 - 17.92)	16.16 (15.86 - 16.44)	13.57 (12.77 - 14.35)	-0.18 (-0.11 - -0.25)	16.98 (16.00 - 17.92)	16.16 (15.86 - 16.44)	10.93 (10.16 - 11.68)	0.27 (0.27 - 0.27)
	300	3.90 (3.68 - 4.10)	12.49 (12.19 - 12.76)	7.00 (7.00 - 7.00)	28.61	0.89	5.26 (5.19 - 5.32)	7.25 (6.84 - 7.62)	12.49 (12.19 - 12.76)	9.20 (8.89 - 9.48)	7.25 (6.84 - 7.62)	12.49 (12.19 - 12.76)	6.67 (6.43 - 6.90)	-0.06 (0.01 - -0.14)	7.25 (6.84 - 7.62)	12.49 (12.19 - 12.76)	3.93 (3.75 - 4.08)	0.24 (0.05 - 0.52)
	330	1.75 (1.64 - 1.85)	11.21 (10.96 - 11.41)	7.00 (7.00 - 7.00)	58.81	0.70	5.03 (4.95 - 5.10)	3.25 (3.05 - 3.43)	11.21 (10.96 - 11.41)	6.72 (6.52 - 6.89)	3.25 (3.05 - 3.43)	11.21 (10.96 - 11.41)	4.40 (4.29 - 4.50)	0.23 (0.34 - 0.14)	3.25 (3.05 - 3.43)	11.21 (10.96 - 11.41)	1.93 (1.92 - 1.94)	0.24 (0.22 - 0.26)
	OMNI	12.56 (10.81 - 14.76)	16.78 (16.18 - 17.47)	1.22 (1.08 - 1.47)	26.64	0.90	5.74 (5.62 - 5.90)	23.34 (20.09 - 27.42)	16.78 (16.18 - 17.47)	21.66 (18.71 - 25.69)	23.34 (20.09 - 26.70)	16.78 (16.18 - 17.47)	19.05 (16.10 - 22.38)	-0.33 (-0.22 - -0.47)	23.34 (20.09 - 25.97)	16.78 (16.18 - 17.47)	16.48 (13.51 - 19.10)	0.29 (0.28 - 0.31)
	0	1.79 (1.54 - 2.06)	11.37 (10.94 - 11.79)	7.00 (7.00 - 7.00)	70.70	0.68	5.14 (4.91 - 5.39)	3.32 (2.86 - 3.84)	11.37 (10.94 - 11.79)	6.86 (6.39 - 7.40)	3.32 (2.86 - 3.84)	11.37 (10.94 - 11.79)	4.44 (4.19 - 4.72)	0.04 (0.37 - -0.39)	3.32 (2.86 - 3.84)	11.37 (10.94 - 11.79)	1.77 (1.85 - 1.62)	0.19 (0.19 - 0.19)
	30	1.64 (1.40 - 1.90)	12.41 (11.49 - 13.35)	7.00 (7.00 - 7.00)	74.87	0.69	5.25 (4.96 - 5.55)	3.05 (2.60 - 3.53)	12.41 (11.49 - 13.35)	6.82 (6.31 - 7.39)	3.05 (2.60 - 3.53)	12.41 (11.49 - 13.35)	4.29 (4.05 - 4.56)	0.28 (0.52 - 0.00)	3.05 (2.60 - 3.53)	12.41 (11.49 - 13.35)	1.87 (1.87 - 1.86)	0.28 (0.25 - 0.31)
	60	1.60 (1.36 - 1.89)	12.50 (11.47 - 13.69)	7.00 (7.00 - 7.00)	73.69	0.68	5.26 (4.99 - 5.61)	2.97 (2.54 - 3.51)	12.50 (11.47 - 13.69)	6.80 (6.30 - 7.44)	2.97 (2.54 - 3.51)	12.50 (11.47 - 13.69)	4.25 (4.02 - 4.55)	0.17 (0.41 - -0.11)	2.97 (2.54 - 3.51)	12.50 (11.47 - 13.69)	1.71 (1.72 - 1.73)	0.25 (0.22 - 0.30)
	90	1.73 (1.51 - 2.05)	9.60 (9.27 - 10.01)	7.00 (7.00 - 7.00)	61.77	0.69	5.49 (5.20 - 5.75)	3.22 (2.80 - 3.81)	9.60 (9.27 - 10.01)	7.16 (6.65 - 7.74)	3.22 (2.80 - 3.81)	9.60 (9.27 - 10.01)	4.38 (4.16 - 4.71)	0.15 (0.34 - -0.06)	3.22 (2.80 - 3.81)	9.60 (9.27 - 10.01)	1.83 (1.80 - 1.94)	0.17 (0.02 - 0.40)
	120	2.49 (2.08 - 3.00)	10.79 (10.28 - 11.36)	7.00 (7.00 - 7.00)	48.36	0.75	5.47 (5.25 - 5.69)	4.63 (3.87 - 5.58)	10.79 (10.28 - 11.36)	7.91 (7.27 - 8.67)	4.63 (3.87 - 5.58)	10.79 (10.28 - 11.36)	5.16 (4.74 - 5.70)	0.00 (0.25 - -0.24)	4.63 (3.87 - 5.58)	10.79 (10.28 - 11.36)	2.46 (2.28 - 2.76)	0.18 (0.03 - 0.40)
50	150	3.13 (2.70 - 3.66)	11.68 (11.65 - 11.73)	7.00 (7.00 - 6.43)	37.60	0.83	5.25 (5.11 - 5.43)	5.81 (5.02 - 6.80)	11.68 (11.65 - 11.73)	8.35 (7.76 - 9.11)	5.81 (5.02 - 6.80)	11.68 (11.65 - 11.73)	5.82 (5.38 - 6.40)	0.07 (0.34 - -0.25)	5.81 (5.02 - 6.80)	11.68 (11.65 - 11.73)	3.20 (3.02 - 3.47)	0.33 (0.28 - 0.38)
	180	4.52 (3.90 - 5.39)	13.12 (12.32 - 14.15)	7.00 (7.00 - 5.42)	40.21	0.81	5.66 (5.46 - 5.92)	8.40 (7.24 - 10.03)	13.12 (12.32 - 14.15)	10.30 (9.39 - 11.58)	8.40 (7.24 - 10.03)	13.12 (12.32 - 14.15)	7.38 (6.67 - 8.44)	0.14 (0.29 - -0.01)	8.40 (7.24 - 10.03)	13.12 (12.32 - 14.15)	4.85 (4.27 - 5.79)	0.17 (0.03 - 0.40)
	210	8.37 (7.25 - 9.71)	14.38 (13.84 - 14.97)	1.06 (1.02 - 1.16)	31.75	0.87	5.58 (5.49 - 5.70)	15.56 (13.47 - 18.05)	14.38 (13.84 - 14.97)	14.99 (13.41 - 17.01)	15.56 (13.47 - 18.05)	14.38 (13.84 - 14.97)	12.28 (10.73 - 14.25)	0.05 (0.15 - -0.08)	15.56 (13.47 - 18.05)	14.38 (13.84 - 14.97)	9.79 (8.29 - 11.71)	0.26 (0.24 - 0.30)
	240	12.54 (10.76 - 14.73)	16.77 (16.10 - 17.49)	1.23 (1.09 - 1.45)	26.64	0.90	5.65 (5.51 - 5.85)	23.30 (20.00 - 27.37)	16.77 (16.10 - 17.49)	21.56 (18.53 - 25.61)	23.30 (20.00 - 26.66)	16.77 (16.10 - 17.49)	19.02 (16.01 - 22.35)	-0.13 (-0.03 - -0.26)	23.30 (20.00 - 25.98)	16.77 (16.10 - 17.49)	16.62 (13.59 - 19.29)	0.31 (0.28 - 0.35)
	270	10.54 (9.38 - 11.82)	16.91 (16.30 - 17.54)	1.02 (1.06 - 1.02)	26.52	0.90	5.54 (5.44 - 5.65)	19.59 (17.43 - 21.97)	16.91 (16.30 - 17.54)	18.35 (16.46 - 20.54)	19.59 (17.43 - 21.97)	16.91 (16.30 - 17.54)	15.80 (13.95 - 17.97)	-0.32 (-0.19 - -0.46)	19.59 (17.43 - 21.97)	16.91 (16.30 - 17.54)	13.13 (11.31 - 15.26)	0.27 (0.27 - 0.28)
	300	4.35 (3.92 - 4.86)	13.09 (12.53 - 13.73)	7.00 (7.00 - 7.00)	28.61	0.89	5.42 (5.29 - 5.57)	8.09 (7.29 - 9.03)	13.09 (12.53 - 13.73)	9.87 (9.26 - 10.61)	8.09 (7.29 - 9.03)	13.09 (12.53 - 13.73)	7.19 (6.70 - 7.79)	-0.18 (-0.04 - -0.38)	8.09 (7.29 - 9.03)	13.09 (12.53 - 13.73)	4.34 (3.97 - 4.76)	0.24 (0.05 - 0.52)
	330	1.95 (1.75 - 2.17)	11.61 (11.20 - 12.05)	7.00 (7.00 - 7.00)	58.81	0.70	5.24 (5.08 - 5.41)	3.62 (3.25 - 4.04)	11.61 (11.20 - 12.05)	7.12 (6.77 - 7.53)	3.62 (3.25 - 4.04)	11.61 (11.20 - 12.05)	4.60 (4.40 - 4.83)	0.09 (0.27 - -0.11)	3.62 (3.25 - 4.04)	11.61 (11.20 - 12.05)	1.99 (1.96 - 2.02)	0.27 (0.24 - 0.31)

Table 3.17 Directional wave extremes at WTG15, return periods 100-, 500- and 1000-yr.

Return period	Wave direction (coming from)	H_s	T_p	Peak enhancement factor, γ	Directional spreading, σ_θ	Wave kinematic factor, F_s	High EWL				Mean sea level			Low EWL				Ass. $U_{c,DA,total}$
							EHWL	H_{max}	T_{hmax}	C_{max}	H_{max}	T_{hmax}	C_{max}	ELWL	H_{max}	T_{hmax}	C_{max}	
(years)	(°N)	(m)	(s)	(-)	(°)	(-)	(mLAT)	(m)	(s)	(mLAT)	(m)	(s)	(mLAT)	(mLAT)	(m)	(s)	(mLAT)	(m/s)
	OMNI	13.35 (11.09 - 16.37)	17.04 (16.28 - 17.92)	1.31 (1.10 - 1.68)	26.64	0.90	5.80 (5.64 - 6.04)	24.80 (20.60 - 29.25)	17.04 (16.28 - 17.92)	23.07 (19.16 - 27.70)	24.80 (20.60 - 28.48)	17.04 (16.28 - 17.92)	20.46 (16.55 - 24.28)	-0.39 (-0.24 - -0.57)	24.41 (20.60 - 27.72)	17.04 (16.28 - 17.92)	17.53 (13.96 - 19.77)	0.30 (0.28 - 0.33)
	0	1.88 (1.58 - 2.30)	11.51 (11.01 - 12.12)	7.00 (7.00 - 7.00)	70.70	0.68	5.22 (4.93 - 5.61)	3.49 (2.94 - 4.27)	11.51 (11.01 - 12.12)	7.03 (6.45 - 7.85)	3.49 (2.94 - 4.27)	11.51 (11.01 - 12.12)	4.53 (4.23 - 4.96)	-0.06 (0.35 - -0.69)	3.49 (2.94 - 4.27)	11.51 (11.01 - 12.12)	1.77 (1.87 - 1.57)	0.19 (0.19 - 0.19)
	30	1.76 (1.44 - 2.15)	12.85 (11.64 - 14.18)	7.00 (7.00 - 7.00)	74.87	0.69	5.36 (5.00 - 5.82)	3.27 (2.67 - 4.00)	12.85 (11.64 - 14.18)	7.06 (6.38 - 7.92)	3.27 (2.67 - 4.00)	12.85 (11.64 - 14.18)	4.41 (4.09 - 4.82)	0.22 (0.49 - -0.21)	3.27 (2.67 - 4.00)	12.85 (11.64 - 14.18)	1.93 (1.88 - 1.92)	0.30 (0.26 - 0.34)
	60	1.70 (1.41 - 2.12)	12.92 (11.67 - 14.57)	7.00 (7.00 - 7.00)	73.69	0.68	5.33 (5.01 - 5.84)	3.15 (2.62 - 3.93)	12.92 (11.67 - 14.57)	6.97 (6.36 - 7.91)	3.15 (2.62 - 3.93)	12.92 (11.67 - 14.57)	4.35 (4.06 - 4.79)	0.11 (0.39 - -0.28)	3.15 (2.62 - 3.93)	12.92 (11.67 - 14.57)	1.76 (1.74 - 1.81)	0.27 (0.23 - 0.33)
	90	1.79 (1.52 - 2.25)	9.68 (9.29 - 10.24)	7.00 (7.00 - 7.00)	61.77	0.69	5.62 (5.25 - 6.05)	3.33 (2.83 - 4.17)	9.68 (9.29 - 10.24)	7.35 (6.71 - 8.24)	3.33 (2.83 - 4.17)	9.68 (9.29 - 10.24)	4.45 (4.18 - 4.91)	0.11 (0.34 - -0.20)	3.33 (2.83 - 4.17)	9.68 (9.29 - 10.24)	1.85 (1.80 - 2.00)	0.17 (0.02 - 0.40)
	120	2.70 (2.16 - 3.46)	11.03 (10.37 - 11.80)	7.00 (7.00 - 7.00)	48.36	0.75	5.57 (5.29 - 5.93)	5.02 (4.01 - 6.43)	11.03 (10.37 - 11.80)	8.23 (7.39 - 9.38)	5.02 (4.01 - 6.43)	11.03 (10.37 - 11.80)	5.37 (4.81 - 6.18)	-0.09 (0.19 - -0.45)	5.02 (4.01 - 6.43)	11.03 (10.37 - 11.80)	2.58 (2.30 - 3.05)	0.18 (0.03 - 0.40)
100	150	3.32 (2.78 - 4.10)	11.70 (11.65 - 11.76)	7.00 (7.00 - 2.14)	37.60	0.83	5.27 (5.11 - 5.52)	6.18 (5.17 - 7.62)	11.70 (11.65 - 11.76)	8.58 (7.85 - 9.67)	6.18 (5.17 - 7.62)	11.70 (11.65 - 11.76)	6.04 (5.46 - 6.88)	-0.01 (0.31 - -0.46)	6.18 (5.17 - 7.62)	11.70 (11.65 - 11.76)	3.33 (3.08 - 3.75)	0.35 (0.29 - 0.43)
	180	4.77 (3.96 - 6.13)	13.42 (12.40 - 14.94)	6.89 (7.00 - 4.33)	40.21	0.81	5.74 (5.48 - 6.09)	8.86 (7.36 - 11.39)	13.42 (12.40 - 14.94)	10.65 (9.48 - 12.66)	8.86 (7.36 - 11.39)	13.42 (12.40 - 14.94)	7.67 (6.74 - 9.38)	0.07 (0.27 - -0.16)	8.86 (7.36 - 11.39)	13.42 (12.40 - 14.94)	5.09 (4.32 - 6.62)	0.17 (0.03 - 0.40)
	210	8.94 (7.50 - 10.79)	14.64 (13.97 - 15.40)	1.09 (1.02 - 1.28)	31.75	0.87	5.61 (5.50 - 5.78)	16.62 (13.93 - 20.06)	14.64 (13.97 - 15.40)	15.82 (13.74 - 18.71)	16.62 (13.93 - 20.06)	14.64 (13.97 - 15.40)	13.10 (11.06 - 15.94)	0.03 (0.14 - -0.15)	16.62 (13.93 - 20.06)	14.64 (13.97 - 15.40)	10.62 (8.62 - 13.40)	0.28 (0.24 - 0.32)
	240	13.31 (11.06 - 16.44)	17.03 (16.22 - 18.01)	1.30 (1.11 - 1.66)	26.64	0.90	5.70 (5.52 - 5.98)	24.73 (20.55 - 29.32)	17.03 (16.22 - 18.01)	22.92 (19.01 - 27.73)	24.73 (20.55 - 28.56)	17.03 (16.22 - 18.01)	20.39 (16.49 - 24.38)	-0.15 (-0.04 - -0.30)	24.42 (20.55 - 27.87)	17.03 (16.22 - 18.01)	17.72 (14.08 - 20.10)	0.33 (0.29 - 0.38)
	270	11.13 (9.62 - 13.05)	17.20 (16.43 - 18.10)	1.02 (1.05 - 1.04)	26.52	0.90	5.59 (5.46 - 5.74)	20.69 (17.89 - 24.26)	17.20 (16.43 - 18.10)	19.34 (16.85 - 22.76)	20.69 (17.89 - 24.26)	17.20 (16.43 - 18.10)	16.79 (14.33 - 20.17)	-0.36 (-0.22 - -0.56)	20.69 (17.89 - 24.05)	17.20 (16.43 - 18.10)	14.11 (11.68 - 17.25)	0.28 (0.27 - 0.28)
	300	4.52 (3.99 - 5.24)	13.31 (12.62 - 14.19)	7.00 (7.00 - 7.00)	28.61	0.89	5.48 (5.31 - 5.72)	8.40 (7.42 - 9.74)	13.31 (12.62 - 14.19)	10.12 (9.35 - 11.21)	8.40 (7.42 - 9.74)	13.31 (12.62 - 14.19)	7.38 (6.77 - 8.26)	-0.22 (-0.06 - -0.49)	8.40 (7.42 - 9.74)	13.31 (12.62 - 14.19)	4.50 (4.04 - 5.14)	0.24 (0.05 - 0.52)
	330	2.01 (1.77 - 2.34)	11.74 (11.24 - 12.35)	7.00 (7.00 - 7.00)	58.81	0.70	5.31 (5.10 - 5.60)	3.74 (3.28 - 4.35)	11.74 (11.24 - 12.35)	7.27 (6.81 - 7.89)	3.74 (3.28 - 4.35)	11.74 (11.24 - 12.35)	4.67 (4.42 - 5.01)	0.06 (0.25 - -0.21)	3.74 (3.28 - 4.35)	11.74 (11.24 - 12.35)	2.02 (1.97 - 2.10)	0.29 (0.25 - 0.34)
	OMNI	15.18 (11.59 - 21.42)	17.59 (16.45 - 19.15)	1.52 (1.14 - 2.45)	26.64	0.90	5.94 (5.67 - 6.47)	27.90 (21.53 - 34.98)	17.59 (16.45 - 19.15)	26.21 (20.00 - 31.89)	27.17 (21.53 - 34.20)	17.59 (16.45 - 19.15)	22.87 (17.38 - 28.09)	-0.50 (-0.28 - -0.84)	26.43 (21.53 - 33.55)	17.59 (16.45 - 19.15)	19.58 (14.80 - 24.64)	0.32 (0.28 - 0.37)
	0	2.05 (1.62 - 2.91)	11.77 (11.08 - 12.88)	7.00 (7.00 - 7.00)	70.70	0.68	5.34 (4.95 - 6.20)	3.80 (3.01 - 5.41)	11.77 (11.08 - 12.88)	7.33 (6.51 - 9.08)	3.80 (3.01 - 5.41)	11.77 (11.08 - 12.88)	4.70 (4.27 - 5.60)	-0.22 (0.32 - -1.43)	3.80 (3.01 - 5.41)	11.77 (11.08 - 12.88)	1.78 (1.89 - 1.49)	0.19 (0.19 - 0.19)
	30	2.02 (1.49 - 2.95)	13.75 (11.84 - 16.56)	7.00 (7.00 - 7.00)	74.87	0.69	5.55 (5.05 - 6.56)	3.76 (2.77 - 5.49)	13.75 (11.84 - 16.56)	7.52 (6.48 - 9.52)	3.76 (2.77 - 5.49)	13.75 (11.84 - 16.56)	4.69 (4.14 - 5.71)	0.11 (0.47 - -0.78)	3.76 (2.77 - 5.49)	13.75 (11.84 - 16.56)	2.09 (1.91 - 2.26)	0.33 (0.26 - 0.44)
	60	1.90 (1.46 - 2.79)	13.75 (11.92 - 16.93)	7.00 (7.00 - 7.00)	73.69	0.68	5.43 (5.02 - 6.36)	3.54 (2.72 - 5.18)	13.75 (11.92 - 16.93)	7.28 (6.43 - 9.15)	3.54 (2.72 - 5.18)	13.75 (11.92 - 16.93)	4.56 (4.12 - 5.53)	0.03 (0.37 - -0.63)	3.54 (2.72 - 5.18)	13.75 (11.92 - 16.93)	1.89 (1.78 - 2.22)	0.30 (0.24 - 0.42)
	90	1.90 (1.54 - 2.68)	9.81 (9.32 - 10.70)	7.00 (7.00 - 7.00)	61.77	0.69	5.87 (5.31 - 6.92)	3.52 (2.86 - 4.98)	9.81 (9.32 - 10.70)	7.71 (6.79 - 9.56)	3.52 (2.86 - 4.98)	9.81 (9.32 - 10.70)	4.55 (4.19 - 5.36)	0.05 (0.33 - -0.51)	3.52 (2.86 - 4.98)	9.81 (9.32 - 10.70)	1.90 (1.81 - 2.15)	0.17 (0.02 - 0.40)
	120	3.18 (2.28 - 5.01)	11.54 (10.54 - 13.05)	7.00 (7.00 - 2.28)	48.36	0.75	5.76 (5.33 - 6.52)	5.92 (4.24 - 9.30)	11.54 (10.54 - 13.05)	8.92 (7.56 - 11.69)	5.92 (4.24 - 9.30)	11.54 (10.54 - 13.05)	5.89 (4.94 - 7.94)	-0.26 (0.13 - -0.94)	5.92 (4.24 - 9.30)	11.54 (10.54 - 13.05)	2.94 (2.37 - 4.36)	0.18 (0.03 - 0.40)
500	150	3.76 (2.92 - 5.32)	11.73 (11.67 - 11.83)	4.60 (7.00 - 1.02)	37.60	0.83	5.31 (5.11 - 5.73)	6.99 (5.42 - 9.89)	11.73 (11.67 - 11.83)	9.09 (8.00 - 11.25)	6.99 (5.42 - 9.89)	11.73 (11.67 - 11.83)	6.51 (5.60 - 8.28)	-0.16 (0.27 - -1.02)	6.99 (5.42 - 9.89)	11.73 (11.67 - 11.83)	3.67 (3.18 - 4.62)	0.39 (0.31 - 0.56)
	180	5.31 (4.05 - 8.28)	14.05 (12.52 - 16.98)	5.58 (7.00 - 2.77)	40.21	0.81	5.87 (5.51 - 6.49)	9.88 (7.53 - 15.39)	14.05 (12.52 - 16.98)	11.43 (9.62 - 16.00)	9.88 (7.53 - 15.39)	14.05 (12.52 - 16.98)	8.34 (6.84 - 12.45)	-0.06 (0.23 - -0.60)	9.88 (7.53 - 15.39)	14.05 (12.52 - 16.98)	5.64 (4.39 - 9.40)	0.17 (0.03 - 0.40)
	210	10.26 (8.00 - 14.06)	15.19 (14.21 - 16.52)	1.22 (1.04 - 1.73)	31.75	0.87	5.66 (5.51 - 6.01)	19.07 (14.86 - 26.12)	15.19 (14.21 - 16.52)	17.79 (14.41 - 24.36)	19.07 (14.86 - 25.91)	15.19 (14.21 - 16.52)	15.09 (11.75 - 21.41)	-0.01 (0.13 - -0.32)	19.07 (14.86 - 25.22)	15.19 (14.21 - 16.52)	12.65 (9.32 - 18.27)	0.31 (0.26 - 0.40)
	240	15.04 (11.56 - 20.89)	17.59 (16.41 - 19.19)	1.49 (1.14 - 2.26)	26.64	0.90	5.79 (5.54 - 6.35)	27.71 (21.48 - 34.36)	17.59 (16.41 - 19.19)	25.91 (19.82 - 31.29)	27.01 (21.48 - 33.58)	17.59 (16.41 - 19.19)	22.72 (17.32 - 27.58)	-0.19 (-0.05 - -0.39)	26.34 (21.48 - 32.98)	17.59 (16.41 - 19.19)	19.73 (14.93 - 24.55)	0.35 (0.30 - 0.45)
	270	12.47 (10.02 - 16.65)	17.84 (16.64 - 19.55)	1.03 (1.04 - 1.17)	26.52	0.90	5.69 (5.48 - 6.03)	23.18 (18.63 - 29.56)	17.84 (16.64 - 19.55)	21.69 (17.49 - 28.36)	23.18 (18.63 - 28.79)	17.84 (16.64 - 19.55)	19.12 (14.96 - 24.95)	-0.47 (-0.25 - -0.81)	23.18 (18.63 - 27.98)	17.84 (16.64 - 19.55)	16.44 (12.31 - 19.60)	0.28 (0.27 - 0.30)
	300	4.85 (4.09 - 6.29)	13.72 (12.75 - 15.34)	7.00 (7.00 - 6.04)	28.61	0.89	5.62 (5.36 - 6.13)	9.02 (7.60 - 11.69)	13.72 (12.75 - 15.34)	10.65 (9.50 - 12.92)	9.02 (7.60 - 11.69)	13.72 (12.75 - 15.34)	7.78 (6.88 - 9.61)	-0.29 (-0.07 - -0.75)	9.02 (7.60 - 11.69)	13.72 (12.75 - 15.34)	4.84 (4.14 - 6.30)	0.24 (0.05 - 0.52)
	330	2.13 (1.78 - 2.82)	11.97 (11.28 - 13.15)	7.00 (7.00 - 7.00)	58.81	0.70	5.46 (5.14 - 6.17)	3.96 (3.32 - 5.24)	11.97 (11.28 - 13.15)	7.53 (6.86 - 8.95)	3.96 (3.32 - 5.24)	11.97 (11.28 - 13.15)	4.79 (4.44 - 5.51)	0.01 (0.24 - -0.42)	3.96 (3.32 - 5.24)	11.97 (11.28 - 13.15)	2.09 (1.97 - 2.39)	0.30 (0.25 - 0.42)
	OMNI	15.97 (11.72 - 24.22)	17.81 (16.50 - 19.74)	1.63 (1.15 - 2.92)	26.64	0.90	6.00 (5.69 - 6.75)	28.80 (21.79 - 38.33)	17.81 (16.50 - 19.74)	27.19 (20.23 - 34.95)	28.04 (21.79 - 37.64)	17.81 (16.50 - 19.74)	23.81 (17.61 - 31.03)	-0.54 (-0.29 - -0.98)	27.29 (21.79 - 37.17)	17.81 (16.50 - 19.74)	20.50 (15.02 - 27.68)	0.32 (0.28 - 0.40)
	0	2.11 (1.63 - 3.22)	11.86 (11.11 - 13.22)	7.00 (7.00 - 7.00)	70.70	0.68	5.38 (4.95 - 6.45)	3.91 (3.03 - 5.98)	11.86 (11.11 - 13.22)	7.42 (6.52 - 9.65)	3.91 (3.03 - 5.98)	11.86 (11.11 - 13.22)	4.76 (4.28 - 5.94)	-0.27 (0.32 - -1.81)	3.91 (3.03 - 5.98)	11.86 (11.11 - 13.22)	1.79 (1.90 - 1.46)	0.19 (0.19 - 0.19)
	30	2.13 (1.50 - 3.42)	14.10 (11.90 - 17.79)	7.00 (7.00 - 7.00)	74.87	0.69	5.62 (5.06 - 6.90)	3.96 (2.80 - 6.35)	14.10 (11.90 - 17.79)	7.69 (6.51 - 10.39)	3.96 (2.80 - 6.35)	14.10 (11.90 - 17.79)	4.80 (4.16 - 6.26)	0.08 (0.47 - -1.02)	3.96 (2.80 - 6.35)	14.10 (11.90 - 17.79)	2.18 (1.92 - 2.59)	0.34 (0.26 - 0.50)
	60	1.98 (1.48 - 3.16)	14.06 (12.00 - 18.12)	7.00 (7.00 - 7.00)	73.69	0.68	5.46 (5.02 - 6.58)	3.68 (2.75 - 5.87)	14.06 (12.00 - 18.12)	7.39 (6.45 - 9.79)	3.68 (2.75 - 5.87)	14.06 (12.00 - 18.12)	4.65 (4.13 - 5.97)	0.01 (0.37 - -0.77)	3.68 (2.75 - 5.87)	14.06 (12.00 - 18.12)	1.95 (1.80 - 2.54)	0.31 (0.24 - 0.47)
	90	1.93 (1.54 - 2.89)	9.85 (9.33 - 10.89)	7.00 (7.00 - 7.00)	61.77	0.69	5.96 (5.33 - 7.43)	3.58 (2.87 - 5.37)	9.85 (9.33 - 10.89)	7.83 (6.82 - 10.28)	3.58 (2.87 - 5.37)	9.85 (9.33 - 10.89)	4.58 (4.20 - 5.57)	0.04 (0.32 - -0.63)	3.58 (2.87 - 5.37)	9.85 (9.33 - 10.89)	1.92 (1.81 - 2.25)	0.17 (0.02 - 0.40)
	120	3.39 (2.31 - 5.93)	11.74 (10.57 - 13.67)	7.00 (7.00 - 1.44)	48.36	0.75	5.82 (5.34 - 6.80)	6.31 (4.29 - 11.02)	11.74 (10.57 - 13.67)	9.20 (7.60 - 13.06)	6.31 (4.29 - 11.02)	11.74 (10.57 - 13.67)	6.11 (4.97 - 9.06)	-0.31 (0.12 - -1.15)	6.31 (4.29 - 11.02)	11.74 (10.57 - 13.67)	3.12 (2.39 - 5.32)	0.18 (0.03 - 0.40)
1000	150	3.94 (2.95 - 5.98)	11.75 (11.67 - 11.86)	2.89 (7.00 - 1.13)	37.60	0.83	5.31 (5.12 - 5.81)	7.33 (5.47 - 11.11)	11.75 (11.67 - 11.86)	9.30 (8.03 - 12.10)	7.33 (5.47 - 11.11)	11.75 (11.67 - 11.86)	6.71 (5.63 - 9.06)	-0.21 (0.27 - -1.28)	7.33 (5.47 - 11.11)	11.75 (11.67 - 11.86)	3.82 (3.20 - 5.17)	0.41 (0.31 - 0.62)
	180	5.54 (4.08 - 9.57)	14.30 (12.55 - 18.06)	5.17 (7.00 - 2.32)	40.21	0.81	5.91 (5.52 - 6.68)	10.29 (7.58 - 17.79)	14.30 (12.55 - 18.06)	11.74 (9.65 - 18.13)	10.29 (7.58 - 17.79)	14.30 (12.55 - 18.06)	8.61 (6.87 - 14.51)	-0.11 (0.23 - -0.84)	10.29 (7.58 - 17.79)	14.30 (12.55 - 18.06)	5.88 (4.42 - 11.32)	0.17 (0.03 - 0.40)
	210	10.82 (8.18 - 15.65)	15.41 (14.29 - 17.00)	1.28 (1.04 - 1.98)	31.75	0.87	5.67 (5.51 - 6.12)	20.11 (15.19 - 28.46)	15.41 (14.29 - 17.00)	18.67 (14.66 - 26.79)	20.11 (15.19 - 27.68)	15.41 (14.29 - 17.00)	15.99 (12.00 - 23.27)	-0.02 (0.13 - -0.40)	20.11 (15.19 - 26.96)	15.41 (14.29 - 17.00)	13.57 (9.58 - 20.10)	0.32 (0.26 - 0.43)
	240	15.77 (11.69 - 23.11)	17.81 (16.46 - 19.70)	1.57 (1.15 - 2.59)	26.64	0.90	5.83 (5.54 - 6.55)	28.54 (21.73 - 36.97)	17.81 (16.46 - 19.70)	26.80 (20.04 - 33.71)	27.82 (21.73 - 36.25)	17.81 (16.46 - 19.70)	23.58 (17.55 - 29.90)	-0.20 (-0.06 - -0.42)	27.15 (21.73 - 35.77)	17.81 (16.46 - 19.70)	20.61 (15.16 - 26.99)	0.37 (0.30 - 0.49)
	270	13.03 (10.14 - 18.47)	18.09 (16.70 - 20.21)	1.04 (1.03 - 1.26)	26.52	0.90	5.73 (5.49 - 6.19)	24.22 (18.85 - 31.62)	18.09 (16.70 - 20.21)	22.71 (17.68 - 30.75)	24.22 (18.85 - 30.82)	18.09 (16.70 - 20.21)	20.14 (15.16 - 24.89)	-0.50 (-0.26 - -0.92)	24.04 (18.85 - 30.02)	18.09 (16.70 - 20.21)	17.29 (12.50 - 21.30)	0.28 (0.27 - 0.31)
	300	4.97 (4.11 - 6.80)	13.87 (12.77 - 15.86)	7.00 (7.00 - 5.26)	28.61	0.89	5.68 (5.37 - 6.35)	9.25 (7.63 - 12.63)	13.87 (12.77 - 15.86)	10.85 (9.53 - 13.79)	9.25 (7.63 - 12.63)	13.87 (12.77 - 15.86)	7.93 (6.90 - 10.30)	-0.31 (-0.07 - -0.86)	9.25 (7.63 - 12.63)	13.87 (12.77 - 15.86)	4.98 (4.16 - 6.91)	0.24 (0.05 - 0.52)
	330	2.17 (1.79 - 3.08)	12.04 (11.29 - 13.55)	7.00 (7.00 - 7.00)	58.81	0.70	5.52 (5.14 - 6.46)	4.03 (3.33 - 5.73)	12.04 (11.29 - 13.55)	7.63 (6.87 - 9.53)	4.03 (3.33 - 5.73)	12.04 (11.29 - 13.55)	4.83 (4.44 - 5.80)	-0.01 (0.24 - -0.50)	4.03 (3.33 - 5.73)	12.04 (11.29 - 13.55)	2.12 (1.98 - 2.61)	0.31 (0.25 - 0.46)

Table 3.18 Directional wave extremes at WTG08, return periods 1-, 5-, 10- and 50-yr.

Return period	Wave direction (coming from)	H_s	T_p	Peak enhancement factor, γ	Directional spreading, σ_θ	Wave kinematic factor, F_s	High EWL				Mean sea level			Low EWL				Ass. $U_{c,DA,total}$
							EHWL	H_{max}	T_{hmax}	C_{max}	H_{max}	T_{hmax}	C_{max}	ELWL	H_{max}	T_{hmax}	C_{max}	
(years)	(°N)	(m)	(s)	(-)	(°)	(-)	(mLAT)	(m)	(s)	(mLAT)	(m)	(s)	(mLAT)	(mLAT)	(m)	(s)	(mLAT)	(m/s)
1	OMNI	6.54 (6.38 - 6.72)	14.60 (14.47 - 14.72)	1.70 (1.79 - 1.62)	32.30	0.86	5.43 (5.41 - 5.44)	12.16 (11.86 - 12.48)	14.60 (14.47 - 14.72)	12.56 (12.33 - 12.80)	12.16 (11.86 - 12.48)	14.60 (14.47 - 14.72)	9.96 (9.74 - 10.19)	0.03 (0.05 - 0.00)	12.16 (11.86 - 12.48)	14.60 (14.47 - 14.72)	7.38 (7.18 - 7.60)	0.15 (0.15 - 0.15)
	0	1.07 (1.06 - 1.09)	8.91 (8.86 - 8.98)	7.00 (7.00 - 7.00)	68.13	0.68	4.50 (4.47 - 4.53)	1.99 (1.97 - 2.02)	8.91 (8.86 - 8.98)	5.52 (5.48 - 5.57)	1.99 (1.97 - 2.02)	8.91 (8.86 - 8.98)	3.74 (3.73 - 3.76)	0.72 (0.72 - 0.72)	1.99 (1.97 - 2.02)	8.91 (8.86 - 8.98)	1.74 (1.73 - 1.76)	0.11 (0.02 - 0.20)
	30	0.91 (0.87 - 0.95)	7.55 (7.31 - 7.82)	7.00 (7.00 - 7.00)	72.75	0.68	4.43 (4.43 - 4.43)	1.69 (1.62 - 1.77)	7.55 (7.31 - 7.82)	5.30 (5.27 - 5.34)	1.69 (1.62 - 1.77)	7.55 (7.31 - 7.82)	3.59 (3.56 - 3.63)	0.87 (0.87 - 0.87)	1.69 (1.62 - 1.77)	7.55 (7.31 - 7.82)	1.74 (1.71 - 1.78)	0.11 (0.03 - 0.20)
	60	0.91 (0.88 - 0.95)	5.99 (5.79 - 6.23)	7.00 (7.00 - 7.00)	72.80	0.68	4.51 (4.49 - 4.53)	1.69 (1.64 - 1.76)	5.99 (5.79 - 6.23)	5.39 (5.35 - 5.45)	1.69 (1.64 - 1.76)	5.99 (5.79 - 6.23)	3.61 (3.58 - 3.64)	0.92 (0.94 - 0.90)	1.69 (1.64 - 1.76)	5.99 (5.79 - 6.23)	1.81 (1.80 - 1.82)	0.12 (0.03 - 0.22)
	90	1.05 (1.02 - 1.09)	6.92 (6.81 - 7.07)	7.00 (7.00 - 7.00)	63.17	0.69	4.54 (4.53 - 4.55)	1.94 (1.89 - 2.02)	6.92 (6.81 - 7.07)	5.55 (5.52 - 5.60)	1.94 (1.89 - 2.02)	6.92 (6.81 - 7.07)	3.73 (3.70 - 3.77)	0.96 (0.97 - 0.95)	1.94 (1.89 - 2.02)	6.92 (6.81 - 7.07)	1.97 (1.95 - 1.99)	0.11 (0.11 - 0.11)
	120	1.34 (1.26 - 1.44)	9.16 (9.15 - 9.18)	7.00 (7.00 - 7.00)	56.02	0.71	4.58 (4.56 - 4.60)	2.49 (2.33 - 2.67)	9.16 (9.15 - 9.18)	5.86 (5.76 - 5.99)	2.49 (2.33 - 2.67)	9.16 (9.15 - 9.18)	4.01 (3.93 - 4.10)	0.99 (1.02 - 0.96)	2.49 (2.33 - 2.67)	9.16 (9.15 - 9.18)	2.28 (2.23 - 2.34)	0.12 (0.04 - 0.20)
	150	1.79 (1.69 - 1.88)	10.60 (10.34 - 10.87)	7.00 (7.00 - 7.00)	46.69	0.76	4.76 (4.70 - 4.83)	3.32 (3.14 - 3.50)	10.60 (10.34 - 10.87)	6.49 (6.34 - 6.65)	3.32 (3.14 - 3.50)	10.60 (10.34 - 10.87)	4.45 (4.36 - 4.55)	0.91 (0.98 - 0.84)	3.32 (3.14 - 3.50)	10.60 (10.34 - 10.87)	2.64 (2.61 - 2.68)	0.13 (0.13 - 0.14)
	180	2.73 (2.60 - 2.84)	11.57 (11.42 - 11.70)	7.00 (7.00 - 7.00)	41.13	0.80	5.01 (4.97 - 5.05)	5.07 (4.83 - 5.28)	11.57 (11.42 - 11.70)	7.70 (7.53 - 7.87)	5.07 (4.83 - 5.28)	11.57 (11.42 - 11.70)	5.42 (5.29 - 5.54)	0.67 (0.71 - 0.64)	5.07 (4.83 - 5.28)	11.57 (11.42 - 11.70)	3.39 (3.28 - 3.47)	0.13 (0.03 - 0.22)
	210	6.11 (5.92 - 6.32)	14.31 (14.17 - 14.45)	2.04 (2.25 - 1.86)	33.21	0.86	5.34 (5.34 - 5.35)	11.35 (10.99 - 11.74)	14.31 (14.17 - 14.45)	11.92 (11.68 - 12.19)	11.35 (10.99 - 11.74)	14.31 (14.17 - 14.45)	9.38 (9.13 - 9.65)	0.28 (0.31 - 0.25)	11.35 (10.99 - 11.74)	14.31 (14.17 - 14.45)	7.03 (6.81 - 7.28)	0.17 (0.16 - 0.17)
	240	6.32 (6.21 - 6.45)	14.56 (14.50 - 14.64)	2.06 (2.19 - 1.93)	32.38	0.86	5.38 (5.38 - 5.39)	11.75 (11.55 - 11.98)	14.56 (14.50 - 14.64)	12.24 (12.09 - 12.41)	11.75 (11.55 - 11.98)	14.56 (14.50 - 14.64)	9.67 (9.53 - 9.83)	0.06 (0.07 - 0.03)	11.75 (11.55 - 11.98)	14.56 (14.50 - 14.64)	7.11 (6.98 - 7.26)	0.15 (0.15 - 0.15)
	270	3.05 (3.05 - 3.05)	12.08 (9.31 - 14.94)	7.00 (1.07 - 7.00)	38.39	0.82	5.16 (5.13 - 5.19)	5.67 (5.66 - 5.67)	12.08 (9.31 - 14.94)	8.19 (8.17 - 8.26)	5.67 (5.66 - 5.67)	12.08 (9.31 - 14.94)	5.76 (5.77 - 5.81)	0.16 (0.16 - 0.15)	5.67 (5.66 - 5.67)	12.08 (9.31 - 14.94)	3.22 (3.22 - 3.26)	0.10 (0.10 - 0.11)
	300	1.89 (1.82 - 1.96)	10.32 (10.21 - 10.43)	7.00 (7.00 - 7.00)	42.95	0.79	4.99 (4.98 - 4.99)	3.52 (3.39 - 3.65)	10.32 (10.21 - 10.43)	6.82 (6.75 - 6.90)	3.52 (3.39 - 3.65)	10.32 (10.21 - 10.43)	4.56 (4.49 - 4.63)	0.31 (0.32 - 0.31)	3.52 (3.39 - 3.65)	10.32 (10.21 - 10.43)	2.15 (2.09 - 2.22)	0.12 (0.02 - 0.24)
	330	1.35 (1.33 - 1.37)	10.84 (5.05 - 13.17)	7.00 (1.78 - 7.00)	53.30	0.73	4.79 (4.79 - 4.80)	2.50 (2.46 - 2.55)	10.84 (5.05 - 13.17)	6.08 (6.15 - 6.11)	2.50 (2.46 - 2.55)	10.84 (5.05 - 13.17)	4.01 (4.07 - 4.04)	0.54 (0.59 - 0.48)	2.50 (2.46 - 2.55)	10.84 (5.05 - 13.17)	1.83 (1.94 - 1.81)	0.11 (0.11 - 0.11)
5	OMNI	7.79 (7.45 - 8.13)	15.45 (15.22 - 15.66)	1.29 (1.36 - 1.22)	32.30	0.86	5.57 (5.53 - 5.61)	14.47 (13.85 - 15.11)	15.45 (15.22 - 15.66)	14.38 (13.87 - 14.91)	14.47 (13.85 - 15.11)	15.45 (15.22 - 15.66)	11.69 (11.21 - 12.19)	-0.14 (-0.10 - -0.18)	14.47 (13.85 - 15.11)	15.45 (15.22 - 15.66)	9.03 (8.56 - 9.51)	0.16 (0.16 - 0.16)
	0	1.42 (1.32 - 1.52)	10.24 (9.86 - 10.59)	7.00 (7.00 - 7.00)	68.13	0.68	4.96 (4.86 - 5.04)	2.64 (2.44 - 2.83)	10.24 (9.86 - 10.59)	6.32 (6.12 - 6.50)	2.64 (2.44 - 2.83)	10.24 (9.86 - 10.59)	4.08 (3.98 - 4.19)	0.36 (0.44 - 0.29)	2.64 (2.44 - 2.83)	10.24 (9.86 - 10.59)	1.73 (1.71 - 1.76)	0.11 (0.02 - 0.20)
	30	1.27 (1.17 - 1.37)	9.87 (9.22 - 10.47)	7.00 (7.00 - 7.00)	72.75	0.68	4.86 (4.76 - 4.96)	2.36 (2.17 - 2.55)	9.87 (9.22 - 10.47)	6.08 (5.88 - 6.27)	2.36 (2.17 - 2.55)	9.87 (9.22 - 10.47)	3.94 (3.84 - 4.03)	0.37 (0.49 - 0.26)	2.36 (2.17 - 2.55)	9.87 (9.22 - 10.47)	1.59 (1.60 - 1.58)	0.11 (0.03 - 0.20)
	60	1.36 (1.22 - 1.51)	9.08 (8.13 - 10.09)	7.00 (7.00 - 7.00)	72.80	0.68	4.98 (4.86 - 5.07)	2.53 (2.27 - 2.80)	9.08 (8.13 - 10.09)	6.29 (6.04 - 6.52)	2.53 (2.27 - 2.80)	9.08 (8.13 - 10.09)	4.03 (3.90 - 4.17)	0.44 (0.54 - 0.34)	2.53 (2.27 - 2.80)	9.08 (8.13 - 10.09)	1.75 (1.72 - 1.79)	0.12 (0.03 - 0.22)
	90	1.49 (1.36 - 1.61)	8.48 (8.05 - 8.87)	7.00 (7.00 - 7.00)	63.17	0.69	5.03 (4.90 - 5.14)	2.77 (2.53 - 3.00)	8.48 (8.05 - 8.87)	6.47 (6.21 - 6.71)	2.77 (2.53 - 3.00)	8.48 (8.05 - 8.87)	4.16 (4.04 - 4.28)	0.43 (0.55 - 0.34)	2.77 (2.53 - 3.00)	8.48 (8.05 - 8.87)	1.87 (1.87 - 1.90)	0.12 (0.11 - 0.12)
	120	1.87 (1.73 - 1.98)	9.22 (9.21 - 9.23)	7.00 (7.00 - 7.00)	56.02	0.71	5.00 (4.89 - 5.10)	3.47 (3.21 - 3.68)	9.22 (9.21 - 9.23)	6.82 (6.56 - 7.03)	3.47 (3.21 - 3.68)	9.22 (9.21 - 9.23)	4.54 (4.40 - 4.65)	0.47 (0.59 - 0.37)	3.47 (3.21 - 3.68)	9.22 (9.21 - 9.23)	2.29 (2.27 - 2.31)	0.12 (0.04 - 0.20)
	150	2.36 (2.22 - 2.50)	12.09 (11.74 - 12.42)	7.00 (7.00 - 7.00)	46.69	0.76	5.15 (5.05 - 5.23)	4.39 (4.12 - 4.64)	12.09 (11.74 - 12.42)	7.46 (7.22 - 7.69)	4.39 (4.12 - 4.64)	12.09 (11.74 - 12.42)	5.04 (4.89 - 5.19)	0.50 (0.60 - 0.41)	4.39 (4.12 - 4.64)	12.09 (11.74 - 12.42)	2.83 (2.78 - 2.89)	0.16 (0.15 - 0.17)
	180	3.47 (3.27 - 3.67)	12.33 (12.14 - 12.52)	7.00 (7.00 - 7.00)	41.13	0.80	5.34 (5.25 - 5.42)	6.44 (6.08 - 6.81)	12.33 (12.14 - 12.52)	8.82 (8.51 - 9.12)	6.44 (6.08 - 6.81)	12.33 (12.14 - 12.52)	6.22 (6.00 - 6.44)	0.37 (0.45 - 0.30)	6.44 (6.08 - 6.81)	12.33 (12.14 - 12.52)	3.89 (3.75 - 4.05)	0.13 (0.03 - 0.22)
	210	7.51 (7.15 - 7.85)	15.19 (14.97 - 15.38)	1.30 (1.41 - 1.22)	33.21	0.86	5.48 (5.44 - 5.53)	13.96 (13.29 - 14.58)	15.19 (14.97 - 15.38)	13.90 (13.38 - 14.41)	13.96 (13.29 - 14.58)	15.19 (14.97 - 15.38)	11.28 (10.78 - 11.77)	0.09 (0.14 - 0.05)	13.96 (13.29 - 14.58)	15.19 (14.97 - 15.38)	8.81 (8.34 - 9.28)	0.20 (0.20 - 0.21)
	240	7.57 (7.19 - 7.93)	15.25 (15.05 - 15.44)	1.30 (1.44 - 1.21)	32.38	0.86	5.51 (5.47 - 5.55)	14.06 (13.35 - 14.73)	15.25 (15.05 - 15.44)	14.01 (13.46 - 14.55)	14.06 (13.35 - 14.73)	15.25 (15.05 - 15.44)	11.37 (10.83 - 11.89)	-0.11 (-0.07 - -0.15)	14.06 (13.35 - 14.73)	15.25 (15.05 - 15.44)	8.72 (8.20 - 9.22)	0.15 (0.15 - 0.15)
	270	3.35 (3.26 - 3.46)	12.08 (9.31 - 14.94)	7.00 (1.02 - 7.00)	38.39	0.82	5.36 (5.31 - 5.41)	6.23 (6.06 - 6.44)	12.08 (9.31 - 14.94)	8.71 (8.58 - 8.92)	6.23 (6.06 - 6.44)	12.08 (9.31 - 14.94)	6.09 (6.00 - 6.26)	-0.01 (0.04 - -0.06)	6.23 (6.06 - 6.44)	12.08 (9.31 - 14.94)	3.38 (3.33 - 3.52)	0.12 (0.12 - 0.13)
	300	2.35 (2.22 - 2.47)	10.98 (10.80 - 11.14)	7.00 (7.00 - 7.00)	42.95	0.79	5.16 (5.11 - 5.21)	4.37 (4.13 - 4.60)	10.98 (10.80 - 11.14)	7.46 (7.27 - 7.63)	4.37 (4.13 - 4.60)	10.98 (10.80 - 11.14)	5.03 (4.89 - 5.15)	0.07 (0.14 - -0.00)	4.37 (4.13 - 4.60)	10.98 (10.80 - 11.14)	2.38 (2.32 - 2.44)	0.12 (0.02 - 0.24)
	330	1.70 (1.59 - 1.82)	10.84 (5.05 - 13.17)	7.00 (2.98 - 7.00)	53.30	0.73	5.04 (4.97 - 5.10)	3.16 (2.96 - 3.37)	10.84 (5.05 - 13.17)	6.68 (6.63 - 6.86)	3.16 (2.96 - 3.37)	10.84 (5.05 - 13.17)	4.36 (4.38 - 4.49)	0.19 (0.27 - 0.11)	3.16 (2.96 - 3.37)	10.84 (5.05 - 13.17)	1.84 (1.93 - 1.89)	0.12 (0.12 - 0.13)
10	OMNI	8.32 (7.85 - 8.77)	15.78 (15.49 - 16.05)	1.20 (1.27 - 1.14)	32.30	0.86	5.63 (5.57 - 5.69)	15.46 (14.60 - 16.30)	15.78 (15.49 - 16.05)	15.20 (14.48 - 15.92)	15.46 (14.60 - 16.30)	15.78 (15.49 - 16.05)	12.48 (11.79 - 13.17)	-0.20 (-0.15 - -0.26)	15.46 (14.60 - 16.30)	15.78 (15.49 - 16.05)	9.78 (9.12 - 10.44)	0.16 (0.16 - 0.17)
	0	1.55 (1.41 - 1.69)	10.69 (10.21 - 11.16)	7.00 (7.00 - 7.00)	68.13	0.68	5.06 (4.96 - 5.14)	2.89 (2.63 - 3.15)	10.69 (10.21 - 11.16)	6.56 (6.32 - 6.77)	2.89 (2.63 - 3.15)	10.69 (10.21 - 11.16)	4.22 (4.08 - 4.36)	0.27 (0.38 - 0.16)	2.89 (2.63 - 3.15)	10.69 (10.21 - 11.16)	1.77 (1.74 - 1.80)	0.11 (0.02 - 0.20)
	30	1.43 (1.29 - 1.56)	10.82 (9.98 - 11.63)	7.00 (7.00 - 7.00)	72.75	0.68	4.99 (4.87 - 5.09)	2.65 (2.40 - 2.90)	10.82 (9.98 - 11.63)	6.36 (6.10 - 6.59)	2.65 (2.40 - 2.90)	10.82 (9.98 - 11.63)	4.09 (3.96 - 4.23)	0.24 (0.37 - 0.10)	2.65 (2.40 - 2.90)	10.82 (9.98 - 11.63)	1.61 (1.60 - 1.61)	0.11 (0.03 - 0.20)
	60	1.55 (1.38 - 1.75)	10.42 (9.23 - 11.76)	7.00 (7.00 - 7.00)	72.80	0.68	5.10 (4.98 - 5.20)	2.89 (2.57 - 3.25)	10.42 (9.23 - 11.76)	6.60 (6.31 - 6.89)	2.89 (2.57 - 3.25)	10.42 (9.23 - 11.76)	4.22 (4.05 - 4.41)	0.35 (0.47 - 0.22)	2.89 (2.57 - 3.25)	10.42 (9.23 - 11.76)	1.85 (1.80 - 1.92)	0.12 (0.03 - 0.22)
	90	1.68 (1.52 - 1.82)	9.07 (8.58 - 9.50)	7.00 (7.00 - 7.00)	63.17	0.69	5.19 (5.03 - 5.31)	3.12 (2.83 - 3.38)	9.07 (8.58 - 9.50)	6.81 (6.50 - 7.07)	3.12 (2.83 - 3.38)	9.07 (8.58 - 9.50)	4.35 (4.20 - 4.49)	0.30 (0.41 - 0.23)	3.12 (2.83 - 3.38)	9.07 (8.58 - 9.50)	1.93 (1.89 - 2.00)	0.12 (0.12 - 0.13)
	120	2.06 (1.88 - 2.22)	9.24 (9.22 - 9.25)	7.00 (7.00 - 7.00)	56.02	0.71	5.14 (5.01 - 5.26)	3.82 (3.50 - 4.12)	9.24 (9.22 - 9.25)	7.15 (6.84 - 7.43)	3.82 (3.50 - 4.12)	9.24 (9.22 - 9.25)	4.73 (4.55 - 4.90)	0.33 (0.46 - 0.23)	3.82 (3.50 - 4.12)	9.24 (9.22 - 9.25)	2.35 (2.30 - 2.40)	0.12 (0.04 - 0.20)
	150	2.57 (2.37 - 2.76)	12.58 (12.12 - 13.00)	7.00 (7.00 - 7.00)	46.69	0.76	5.26 (5.15 - 5.37)	4.77 (4.41 - 5.12)	12.58 (12.12 - 13.00)	7.79 (7.48 - 8.10)	4.77 (4.41 - 5.12)	12.58 (12.12 - 13.00)	5.26 (5.05 - 5.46)	0.37 (0.49 - 0.24)	4.77 (4.41 - 5.12)	12.58 (12.12 - 13.00)	2.92 (2.84 - 3.00)	0.17 (0.16 - 0.18)
	180	3.71 (3.44 - 4.00)	12.55 (12.31 - 12.81)	7.00 (7.00 - 7.00)	41.13	0.80	5.44 (5.33 - 5.55)	6.89 (6.39 - 7.44)	12.55 (12.31 - 12.81)	9.18 (8.78 - 9.62)	6.89 (6.39 - 7.44)	12.55 (12.31 - 12.81)	6.48 (6.19 - 6.82)	0.26 (0.36 - 0.17)	6.89 (6.39 - 7.44)	12.55 (12.31 - 12.81)	4.05 (3.85 - 4.31)	0.13 (0.03 - 0.22)
	210	8.09 (7.60 - 8.55)	15.52 (15.24 - 15.77)	1.18 (1.28 - 1.12)	33.21	0.86	5.54 (5.48 - 5.61)	15.04 (14.13 - 15.89)	15.52 (15.24 - 15.77)	14.78 (14.03 - 15.50)	15.04 (14.13 - 15.89)	15.52 (15.24 - 15.77)	12.13 (11.42 - 12.81)	0.03 (0.08 - -0.03)	15.04 (14.13 - 15.89)	15.52 (15.24 - 15.77)	9.63 (8.94 - 10.28)	0.22 (0.21 - 0.23)
	240	8.09 (7.62 - 8.57)	15.52 (15.28 - 15.75)	1.18 (1.29 - 1.10)	32.38	0.86	5.56 (5.51 - 5.62)	15.03 (14.15 - 15.93)	15.52 (15.28 - 15.75)	14.79 (14.08 - 15.54)	15.03 (14.15 - 15.93)	15.52 (15.28 - 15.75)	12.12 (11.44 - 12.84)	-0.17 (-0.12 - -0.22)	15.03 (14.15 - 15.93)	15.52 (15.28 - 15.75)	9.44 (8.78 - 10.13)	0.15 (0.15 - 0.15)
	270	3.48 (3.33 - 3.67)	12.08 (9.31 - 14.94)	7.00 (1.02 - 7.00)	38.39	0.82	5.42 (5.36 - 5.50)	6.47 (6.19 - 6.83)	12.08 (9.31 - 14.94)	8.92 (8.71 - 9.24)	6.47 (6.19 - 6.83)	12.08 (9.31 - 14.94)	6.23 (6.08 - 6.50)	-0.08 (-0.02 - -0.14)	6.47 (6.19 - 6.83)	12.08 (9.31 - 14.94)	3.46 (3.35 - 3.68)	0.13 (0.12 - 0.14)
	300	2.54 (2.37 - 2.71)	11.22 (11.00 - 11.43)	7.00 (7.00 - 7.00)	42.95	0.79	5.23 (5.17 - 5.28)	4.72 (4.40 - 5.04)	11.22 (11.00 - 11.43)	7.72 (7.48 - 7.95)	4.72 (4.40 - 5.04)	11.22 (11.00 - 11.43)	5.22 (5.04 - 5.41)	-0.02 (0.08 - -0.12)	4.72 (4.40 - 5.04)	11.22 (11.00 - 11.43)	2.49 (2.41 - 2.58)	0.12 (0.02 - 0.24)
	330	1.85 (1.71 - 2.00)	10.84 (5.05 - 13.17)	7.00 (3.63 - 7.00)	53.30	0.73	5.11 (5.03 - 5.20)	3.44 (3.18 - 3.72)	10.84 (5.05 - 13.17)	6.91 (6.83 - 7.15)	3.44 (3.18 - 3.72)	10.84 (5.05 - 13.17)	4.52 (4.51 - 4.68)	0.07 (0.18 - -0.05)	3.44 (3.18 - 3.72)	10.84 (5.05 - 13.17)	1.87 (1.98 - 1.92)	0.13 (0.13 - 0.13)
50	OMNI	9.54 (8.63 - 10.64)	16.50 (15.97 - 17.10)	1.08 (1.16 - 1.03)	32.30	0.86	5.77 (5.65 - 5.93)	17.72 (16.04 - 19.78)	16.50 (15.97 - 17.10)	17.16 (15.68 - 19.05)	17.72 (16.04 - 19.78)	16.50 (15.97 - 17.10)	14.37 (12.95 - 16.20)	-0.35 (-0.24 - -0.49)	17.72 (16.04 - 19.78)	16.50 (15.97 - 17.10)	11.61 (10.24 - 13.39)	0.17 (0.17 - 0.18)
	0	1.83 (1.55 - 2.19)	11.58 (10.67 - 12.66)	7.00 (7.00 - 7.00)	68.13	0.68	5.20 (5.04 - 5.41)	3.40 (2.87 - 4.07)	11.58 (10.67 - 12.66)	6.97 (6.53 - 7.55)	3.40 (2.87 - 4.07)	11.58 (10.67 - 12.66)	4.49 (4.21 - 4.87)	0.15 (0.32 - -0.08)	3.40 (2.87 - 4.07)	11.58 (10.67 - 12.66)	1.93 (1.81 - 2.08)	0.11 (0.02 - 0.20)
	30	1.79 (1.49 - 2.12)	12.95 (11.22 - 14.83)	7.00 (7.00 - 7.00)	72.75	0.68	5.19 (5.00 - 5.39)	3.32 (2.78 - 3.94)	12.95 (11.22 - 14.83)	6.92 (6.43 - 7.46)	3.32 (2.78 - 3.94)	12.95 (11.22 - 14.83)	4.46 (4.16 - 4.81)	0.05 (0.28 - -0.31)	3.32 (2.78 - 3.94)	12.95 (11.22 - 14.83)	1.79 (1.72 - 1.80)	0.11 (0.03 - 0.20)
	60	2.01 (1.66 - 2.48)	13.56 (11.15 - 16.92)	7.00 (7.00 - 7.00)	72.80	0.68	5.28 (5.11 - 5.51)	3.73 (3.08 - 4.62)	13.56 (11.15 - 16.92)	7.24 (6.71 - 7.99)	3.73 (3.08 - 4.62)	13.56 (11.15 - 16.92)	4.68 (4.32 - 5.22)	0.26 (0.44 - -0.02)	3.73 (3.08 - 4.62)	13.56 (11.15 - 16.92)	2.23 (2.04 - 2.51)	0.12 (0.03 - 0.22)
	90	2.10 (1.84 - 2.37)	10.30 (9.57 - 11.05)	7.00 (7.00 - 7.00)	63.17	0.69	5.48 (5.23 - 5.73)	3.90 (3.43 - 4.41)	10.30 (9.57 - 11.05)	7.52 (7.02 - 8.05)	3.90 (3.43 - 4.41)	10.30 (9.57 - 11.05)	4.77 (4.51 - 5.05)	0.14 (0.31 - -0.07)	3.90 (3.43 - 4.41)	10.30 (9.57 - 11.05)	2.19 (2.10 - 2.27)	0.13 (0.13 - 0.14)
	120	2.42 (2.08 - 2.89)	9.27 (9.24 - 9.30)	3.28 (7.00 - 1.19)	56.02	0.71	5.39 (5.15 - 5.65)	4.50 (3.87 - 5.37)	9.27 (9.24 - 9.30)	7.78 (7.19 - 8.53)	4.50 (3.87 - 5.37)	9.27 (9.24 - 9.30)	5.11 (4.76 - 5.61)	0.12 (0.36 - -0.14)	4.50 (3.87 - 5.37)	9.27 (9.24 - 9.30)	2.52 (2.40 - 2.75)	0.12 (0.04 - 0.20)
	150	2.97 (2.58 - 3.42)	13.47 (12.60 - 14.39)	7.00 (7.00 - 7.00)	46.69	0.76	5.42 (5.25 - 5.70)	5.52 (4.79 - 6.35)	13.47 (12.60 - 14.39)	8.38 (7.78 - 9.15)	5.52 (4.79 - 6.35)	13.47 (12.60 - 14.39)	5.69 (5.27 - 6.20)	0.15 (0.39 - -0.17)	5.52 (4.79 - 6.35)	13.47 (12.60 - 14.39)	3.14 (2.95 - 3.35)	0.19 (0.17 - 0.21)
	180	4.13 (3.67 - 4.75)	12.91 (12.52 - 13.41)	7.00 (7.00 - 6.98)	41.13	0.80	5.63 (5.44 - 5.85)	7.67 (6.83 - 8.84)	12.91 (12.52 - 13.41)	9.84 (9.14 - 10.78)	7.67 (6.83 - 8.84)	12.91 (12.52 - 13.41)	6.96 (6.45 - 7.70)	0.06 (0.24 - -0.17)	7.67 (6.83 - 8.84)	12.91 (12.52 - 13.41)	4.34 (4.00 - 4.86)	0.13 (0.03 - 0.22)
	210	9.41 (8.40 - 10.63)	16.22 (15.69 - 16.80)	1.05 (1.13 - 1.02)	33.21	0.86	5.68 (5.55 - 5.88)	17.49 (15.61 - 19.75)	16.22 (15.69 - 16.80)	16.85 (15.22 - 18.93)	17.49 (15.61 - 19.75)	16.22 (15.69 - 16.80)	14.14 (12.58 - 16.11)	-0.09 (0.02 - -0.21)	17.49 (15.61 - 19.75)	16.22 (15.69 - 16.80)	11.61 (10.10 - 13.55)	0.25 (0.23 - 0.29)
	240	9.26 (8.25 - 10.28)	16.07 (15.60 - 16.51)	1.05 (1.15 - 1.02)	32.38	0.86	5.68 (5.55 - 5.84)	17.20 (15.34 - 19.10)	16.07 (15.60 - 16.51)	16.60 (15.02 - 18.32)	17.20 (15.34 - 19.10)	16.07 (15.60 - 16.51)	13.88 (12.36 - 15.52)	-0.30 (-0.20 - -0.43)	17.20 (15.34 - 19.10)	16.07 (15.60 - 16.51)	11.15 (9.67 - 12.73)	0.15 (0.15 - 0.16)
	270	3.78 (3.41 - 4.31)	12.08 (9.31 - 14.94)	7.00 (1.03 - 7.00)	38.39	0.82	5.55 (5.43 - 5.72)	7.03 (6.33 - 8.01)	12.08 (9.31 - 14.94)	9.37 (8.86 - 10.18)	7.03 (6.33 - 8.01)	12.08 (9.31 - 14.94)	6.56 (6.16 - 7.23)	-0.22 (-0.08 - -0.37)	7.03 (6.33 - 8.01)	12.08 (9.31 - 14.94)	3.66 (3.37 - 4.21)	0.14 (0.12 - 0.17)
	300	2.96 (2.61 - 3.40)	11.72 (11.31 - 12.19)	7.00 (7.00 - 7.00)	42.95	0.79	5.37 (5.25 - 5.50)	5.49 (4.86 - 6.31)	11.72 (11.31 - 12.19)	8.30 (7.83 - 8.90)	5.49 (4.86 - 6.31)	11.72 (11.31 - 12.19)	5.66 (5.30 - 6.14)	-0.21 (-0.01 - -0.46)	5.49 (4.86 - 6.31)	11.72 (11.31 - 12.19)	2.75 (2.58 - 2.99)	0.12 (0.02 - 0.24)
	330	2.20 (1.90 - 2.57)	10.84 (5.05 - 13.17)	7.00 (4.77 - 7.00)	53.30	0.73	5.25 (5.10 - 5.46)	4.09 (3.52 - 4.77)	10.84 (5.05 - 13.17)	7.40 (7.12 - 7.99)	4.09 (3.52 - 4.77)	10.84 (5.05 - 13.17)	4.87 (4.73 - 5.27)	-0.14 (0.06 - -0.45)	4.09 (3.52 - 4.77)	10.84 (5.05 - 13.17)	2.02 (2.08 - 2.12)	0.14 (0.13 - 0.15)

Table 3.19 Directional wave extremes at WTG08, return periods 100-, 500- and 1000-yr.

Return period	Wave direction (coming from)	H_s	T_p	Peak enhancement factor, γ	Directional spreading, σ_θ	Wave kinematic factor, F_s	High EWL				Mean sea level			Low EWL				Ass. $U_{c,DA,total}$
							EHWL	H_{max}	T_{hmax}	C_{max}	H_{max}	T_{hmax}	C_{max}	ELWL	H_{max}	T_{hmax}	C_{max}	
(years)	(°N)	(m)	(s)	(-)	(°)	(-)	(mLAT)	(m)	(s)	(mLAT)	(m)	(s)	(mLAT)	(mLAT)	(m)	(s)	(mLAT)	(m/s)
	OMNI	10.06 (8.89 - 11.63)	16.78 (16.12 - 17.60)	1.05 (1.13 - 1.02)	32.30	0.86	5.83 (5.68 - 6.06)	18.69 (16.52 - 21.62)	16.78 (16.12 - 17.60)	18.03 (16.08 - 20.81)	18.69 (16.52 - 21.62)	16.78 (16.12 - 17.60)	15.22 (13.35 - 17.91)	-0.41 (-0.26 - -0.61)	18.69 (16.52 - 21.62)	16.78 (16.12 - 17.60)	12.44 (10.63 - 15.07)	0.17 (0.17 - 0.18)
	0	1.93 (1.57 - 2.49)	11.90 (10.76 - 13.46)	7.00 (7.00 - 7.00)	68.13	0.68	5.23 (5.05 - 5.51)	3.59 (2.92 - 4.62)	11.90 (10.76 - 13.46)	7.10 (6.56 - 7.96)	3.59 (2.92 - 4.62)	11.90 (10.76 - 13.46)	4.60 (4.24 - 5.18)	0.12 (0.31 - -0.19)	3.59 (2.92 - 4.62)	11.90 (10.76 - 13.46)	2.00 (1.83 - 2.29)	0.11 (0.02 - 0.20)
	30	1.94 (1.55 - 2.44)	13.84 (11.56 - 16.61)	7.00 (7.00 - 7.00)	72.75	0.68	5.24 (5.03 - 5.54)	3.61 (2.88 - 4.54)	13.84 (11.56 - 16.61)	7.13 (6.52 - 7.98)	3.61 (2.88 - 4.54)	13.84 (11.56 - 16.61)	4.62 (4.21 - 5.17)	-0.00 (0.27 - -0.49)	3.61 (2.88 - 4.54)	13.84 (11.56 - 16.61)	1.90 (1.77 - 1.99)	0.11 (0.03 - 0.20)
	60	2.20 (1.75 - 2.89)	14.92 (11.74 - 19.76)	7.00 (7.00 - 7.00)	72.80	0.68	5.33 (5.12 - 5.66)	4.09 (3.24 - 5.37)	14.92 (11.74 - 19.76)	7.49 (6.81 - 8.64)	4.09 (3.24 - 5.37)	14.92 (11.74 - 19.76)	4.90 (4.41 - 5.73)	0.24 (0.43 - -0.11)	4.09 (3.24 - 5.37)	14.92 (11.74 - 19.76)	2.43 (2.13 - 2.95)	0.12 (0.03 - 0.22)
	90	2.28 (1.93 - 2.68)	10.79 (9.81 - 11.85)	7.00 (7.00 - 7.00)	63.17	0.69	5.57 (5.27 - 5.94)	4.23 (3.58 - 4.99)	10.79 (9.81 - 11.85)	7.79 (7.14 - 8.59)	4.23 (3.58 - 4.99)	10.79 (9.81 - 11.85)	4.95 (4.59 - 5.38)	0.10 (0.30 - -0.21)	4.23 (3.58 - 4.99)	10.79 (9.81 - 11.85)	2.34 (2.18 - 2.46)	0.14 (0.13 - 0.15)
	120	2.55 (2.13 - 3.24)	9.28 (9.24 - 9.32)	2.13 (7.00 - 1.02)	56.02	0.71	5.48 (5.18 - 5.84)	4.74 (3.96 - 6.03)	9.28 (9.24 - 9.32)	8.00 (7.26 - 9.10)	4.74 (3.96 - 6.03)	9.28 (9.24 - 9.32)	5.25 (4.81 - 5.98)	0.07 (0.34 - -0.31)	4.74 (3.96 - 6.03)	9.28 (9.24 - 9.32)	2.60 (2.43 - 2.96)	0.12 (0.04 - 0.20)
100	150	3.11 (2.62 - 3.74)	13.77 (12.70 - 15.00)	7.00 (7.00 - 7.00)	46.69	0.76	5.46 (5.26 - 5.85)	5.78 (4.87 - 6.94)	13.77 (12.70 - 15.00)	8.58 (7.84 - 9.66)	5.78 (4.87 - 6.94)	13.77 (12.70 - 15.00)	5.85 (5.31 - 6.57)	0.08 (0.36 - -0.35)	5.78 (4.87 - 6.94)	13.77 (12.70 - 15.00)	3.24 (2.97 - 3.55)	0.20 (0.17 - 0.23)
	180	4.26 (3.73 - 5.06)	13.02 (12.57 - 13.63)	7.00 (7.00 - 4.82)	41.13	0.80	5.69 (5.46 - 6.00)	7.92 (6.94 - 9.39)	13.02 (12.57 - 13.63)	10.05 (9.23 - 11.27)	7.92 (6.94 - 9.39)	13.02 (12.57 - 13.63)	7.12 (6.51 - 8.06)	-0.01 (0.22 - -0.35)	7.92 (6.94 - 9.39)	13.02 (12.57 - 13.63)	4.42 (4.04 - 5.06)	0.13 (0.03 - 0.22)
	210	9.97 (8.63 - 11.71)	16.49 (15.81 - 17.28)	1.03 (1.11 - 1.03)	33.21	0.86	5.74 (5.56 - 6.03)	18.52 (16.03 - 21.76)	16.49 (15.81 - 17.28)	17.75 (15.57 - 20.85)	18.52 (16.03 - 21.76)	16.49 (15.81 - 17.28)	15.03 (12.92 - 17.98)	-0.13 (0.01 - -0.30)	18.52 (16.03 - 21.76)	16.49 (15.81 - 17.28)	12.49 (10.44 - 15.41)	0.27 (0.23 - 0.31)
	240	9.74 (8.46 - 11.22)	16.28 (15.70 - 16.89)	1.03 (1.12 - 1.03)	32.38	0.86	5.73 (5.57 - 5.96)	18.11 (15.72 - 20.86)	16.28 (15.70 - 16.89)	17.39 (15.33 - 19.94)	18.11 (15.72 - 20.86)	16.28 (15.70 - 16.89)	14.65 (12.67 - 17.09)	-0.36 (-0.21 - -0.54)	18.11 (15.72 - 20.86)	16.28 (15.70 - 16.89)	11.90 (9.97 - 14.28)	0.15 (0.15 - 0.16)
	270	3.91 (3.42 - 4.68)	12.08 (9.31 - 14.94)	5.78 (1.03 - 7.00)	38.39	0.82	5.60 (5.45 - 5.81)	7.27 (6.35 - 8.70)	12.08 (9.31 - 14.94)	9.56 (8.89 - 10.70)	7.27 (6.35 - 8.70)	12.08 (9.31 - 14.94)	6.71 (6.18 - 7.67)	-0.27 (-0.10 - -0.50)	7.27 (6.35 - 8.70)	12.08 (9.31 - 14.94)	3.75 (3.37 - 4.52)	0.15 (0.12 - 0.19)
	300	3.13 (2.68 - 3.74)	11.91 (11.39 - 12.53)	7.00 (7.00 - 7.00)	42.95	0.79	5.42 (5.27 - 5.63)	5.81 (4.98 - 6.96)	11.91 (11.39 - 12.53)	8.53 (7.91 - 9.41)	5.81 (4.98 - 6.96)	11.91 (11.39 - 12.53)	5.85 (5.37 - 6.52)	-0.27 (-0.03 - -0.68)	5.81 (4.98 - 6.96)	11.91 (11.39 - 12.53)	2.87 (2.64 - 3.17)	0.12 (0.02 - 0.24)
	330	2.35 (1.94 - 2.89)	10.84 (5.05 - 13.17)	7.00 (5.05 - 7.00)	53.30	0.73	5.30 (5.12 - 5.60)	4.36 (3.60 - 5.37)	10.84 (5.05 - 13.17)	7.59 (7.18 - 8.46)	4.36 (3.60 - 5.37)	10.84 (5.05 - 13.17)	5.02 (4.79 - 5.60)	-0.22 (0.04 - -0.63)	4.36 (3.60 - 5.37)	10.84 (5.05 - 13.17)	2.10 (2.10 - 2.28)	0.15 (0.13 - 0.16)
	OMNI	11.25 (9.33 - 14.56)	17.41 (16.38 - 18.93)	1.02 (1.09 - 1.06)	32.30	0.86	5.98 (5.72 - 6.46)	20.91 (17.35 - 26.95)	17.41 (16.38 - 18.93)	20.10 (16.80 - 26.31)	20.91 (17.35 - 26.10)	17.41 (16.38 - 18.93)	17.24 (14.05 - 22.43)	-0.53 (-0.31 - -0.93)	20.91 (17.35 - 25.25)	17.41 (16.38 - 18.93)	14.43 (11.32 - 18.63)	0.18 (0.17 - 0.20)
	0	2.15 (1.61 - 3.39)	12.54 (10.87 - 15.66)	7.00 (7.00 - 7.00)	68.13	0.68	5.26 (5.05 - 5.75)	4.00 (2.98 - 6.30)	12.54 (10.87 - 15.66)	7.36 (6.60 - 9.20)	4.00 (2.98 - 6.30)	12.54 (10.87 - 15.66)	4.83 (4.27 - 6.20)	0.07 (0.30 - -0.41)	4.00 (2.98 - 6.30)	12.54 (10.87 - 15.66)	2.19 (1.86 - 3.11)	0.11 (0.02 - 0.20)
	30	2.30 (1.64 - 3.38)	15.84 (12.10 - 21.54)	7.00 (7.00 - 7.00)	72.75	0.68	5.34 (5.05 - 5.92)	4.28 (3.05 - 6.28)	15.84 (12.10 - 21.54)	7.61 (6.63 - 9.51)	4.28 (3.05 - 6.28)	15.84 (12.10 - 21.54)	5.01 (4.31 - 6.37)	-0.08 (0.27 - -0.90)	4.28 (3.05 - 6.28)	15.84 (12.10 - 21.54)	2.23 (1.86 - 2.84)	0.11 (0.03 - 0.20)
	60	2.65 (1.89 - 4.17)	18.10 (12.73 - 28.89)	7.00 (7.00 - 7.00)	72.80	0.68	5.40 (5.13 - 6.00)	4.93 (3.51 - 7.75)	18.10 (12.73 - 28.89)	8.08 (6.96 - 10.94)	4.93 (3.51 - 7.75)	18.10 (12.73 - 28.89)	5.43 (4.56 - 7.79)	0.23 (0.43 - -0.27)	4.93 (3.51 - 7.75)	18.10 (12.73 - 28.89)	2.96 (2.27 - 4.93)	0.12 (0.03 - 0.22)
	90	2.67 (2.04 - 3.60)	11.82 (10.14 - 14.03)	7.00 (7.00 - 7.00)	63.17	0.69	5.74 (5.31 - 6.52)	4.96 (3.79 - 6.70)	11.82 (10.14 - 14.03)	8.37 (7.30 - 10.16)	4.96 (3.79 - 6.70)	11.82 (10.14 - 14.03)	5.36 (4.71 - 6.40)	0.05 (0.29 - -0.51)	4.96 (3.79 - 6.70)	11.82 (10.14 - 14.03)	2.71 (2.28 - 3.21)	0.15 (0.13 - 0.17)
	120	2.81 (2.19 - 4.15)	9.29 (9.25 - 9.36)	1.31 (7.00 - 1.40)	56.02	0.71	5.62 (5.20 - 6.36)	5.22 (4.07 - 7.72)	9.29 (9.25 - 9.36)	8.41 (7.35 - 10.61)	5.22 (4.07 - 7.72)	9.29 (9.25 - 9.36)	5.52 (4.87 - 6.99)	-0.01 (0.32 - -0.67)	5.22 (4.07 - 7.72)	9.29 (9.25 - 9.36)	2.79 (2.48 - 3.62)	0.12 (0.04 - 0.20)
500	150	3.39 (2.68 - 4.56)	14.34 (12.84 - 16.48)	7.00 (7.00 - 7.00)	46.69	0.76	5.53 (5.27 - 6.13)	6.30 (4.99 - 8.47)	14.34 (12.84 - 16.48)	8.96 (7.93 - 10.93)	6.30 (4.99 - 8.47)	14.34 (12.84 - 16.48)	6.17 (5.38 - 7.59)	-0.05 (0.34 - -0.82)	6.30 (4.99 - 8.47)	14.34 (12.84 - 16.48)	3.44 (3.02 - 4.15)	0.21 (0.17 - 0.27)
	180	4.50 (3.82 - 5.69)	13.21 (12.66 - 14.06)	7.00 (7.00 - 2.72)	41.13	0.80	5.80 (5.48 - 6.31)	8.37 (7.11 - 10.58)	13.21 (12.66 - 14.06)	10.43 (9.35 - 12.35)	8.37 (7.11 - 10.58)	13.21 (12.66 - 14.06)	7.40 (6.62 - 8.85)	-0.15 (0.19 - -0.79)	8.37 (7.11 - 10.58)	13.21 (12.66 - 14.06)	4.57 (4.11 - 5.45)	0.13 (0.03 - 0.22)
	210	11.21 (9.08 - 14.78)	17.06 (16.05 - 18.49)	1.02 (1.07 - 1.16)	33.21	0.86	5.87 (5.59 - 6.52)	20.83 (16.88 - 27.21)	17.06 (16.05 - 18.49)	19.88 (16.27 - 26.52)	20.83 (16.88 - 26.34)	17.06 (16.05 - 18.49)	17.11 (13.62 - 22.58)	-0.20 (-0.02 - -0.48)	20.83 (16.88 - 25.60)	17.06 (16.05 - 18.49)	14.59 (11.14 - 19.28)	0.30 (0.25 - 0.39)
	240	10.84 (8.72 - 14.20)	16.74 (15.82 - 17.94)	1.02 (1.09 - 1.20)	32.38	0.86	5.84 (5.58 - 6.31)	20.15 (16.21 - 26.39)	16.74 (15.82 - 17.94)	19.21 (15.72 - 25.44)	20.15 (16.21 - 25.70)	16.74 (15.82 - 17.94)	16.45 (13.06 - 21.82)	-0.46 (-0.24 - -0.89)	20.15 (16.21 - 24.86)	16.74 (15.82 - 17.94)	13.68 (10.35 - 18.09)	0.16 (0.15 - 0.16)
	270	4.21 (3.44 - 5.96)	12.08 (9.31 - 14.94)	2.65 (1.04 - 6.06)	38.39	0.82	5.68 (5.47 - 6.04)	7.82 (6.38 - 11.08)	12.08 (9.31 - 14.94)	9.97 (8.94 - 12.45)	7.82 (6.38 - 11.08)	12.08 (9.31 - 14.94)	7.04 (6.20 - 9.24)	-0.39 (-0.12 - -0.92)	7.82 (6.38 - 11.08)	12.08 (9.31 - 14.94)	3.97 (3.37 - 5.74)	0.16 (0.12 - 0.25)
	300	3.50 (2.81 - 4.65)	12.30 (11.55 - 13.34)	7.00 (7.00 - 7.00)	42.95	0.79	5.54 (5.29 - 6.06)	6.51 (5.22 - 8.65)	12.30 (11.55 - 13.34)	9.05 (8.06 - 10.86)	6.51 (5.22 - 8.65)	12.30 (11.55 - 13.34)	6.26 (5.50 - 7.58)	-0.41 (-0.04 - -1.30)	6.51 (5.22 - 8.65)	12.30 (11.55 - 13.34)	3.16 (2.75 - 3.64)	0.12 (0.02 - 0.24)
	330	2.69 (2.01 - 3.92)	10.84 (5.05 - 13.17)	7.00 (5.54 - 7.00)	53.30	0.73	5.37 (5.13 - 5.94)	5.00 (3.74 - 7.28)	10.84 (5.05 - 13.17)	8.02 (7.28 - 9.92)	5.00 (3.74 - 7.28)	10.84 (5.05 - 13.17)	5.38 (4.88 - 6.73)	-0.35 (0.00 - -1.07)	5.00 (3.74 - 7.28)	10.84 (5.05 - 13.17)	2.33 (2.16 - 2.99)	0.16 (0.13 - 0.19)
	OMNI	11.76 (9.50 - 16.13)	17.66 (16.48 - 19.58)	1.02 (1.08 - 1.11)	32.30	0.86	6.04 (5.74 - 6.68)	21.86 (17.65 - 28.75)	17.66 (16.48 - 19.58)	21.02 (17.06 - 28.40)	21.86 (17.65 - 27.83)	17.66 (16.48 - 19.58)	18.14 (14.31 - 24.33)	-0.58 (-0.32 - -1.09)	21.86 (17.65 - 26.96)	17.66 (16.48 - 19.58)	15.31 (11.58 - 18.53)	0.18 (0.17 - 0.21)
	0	2.23 (1.61 - 3.91)	12.77 (10.89 - 16.80)	7.00 (7.00 - 7.00)	68.13	0.68	5.27 (5.05 - 5.84)	4.15 (3.00 - 7.27)	12.77 (10.89 - 16.80)	7.46 (6.61 - 9.90)	4.15 (3.00 - 7.27)	12.77 (10.89 - 16.80)	4.91 (4.28 - 6.84)	0.06 (0.30 - -0.51)	4.15 (3.00 - 7.27)	12.77 (10.89 - 16.80)	2.26 (1.86 - 3.68)	0.11 (0.02 - 0.20)
	30	2.45 (1.67 - 3.88)	16.69 (12.26 - 24.05)	7.00 (7.00 - 7.00)	72.75	0.68	5.36 (5.06 - 6.10)	4.56 (3.10 - 7.21)	16.69 (12.26 - 24.05)	7.81 (6.67 - 10.40)	4.56 (3.10 - 7.21)	16.69 (12.26 - 24.05)	5.19 (4.33 - 7.12)	-0.10 (0.27 - -1.09)	4.56 (3.10 - 7.21)	16.69 (12.26 - 24.05)	2.39 (1.89 - 3.44)	0.11 (0.03 - 0.20)
	60	2.85 (1.93 - 4.92)	19.47 (13.06 - 34.23)	7.00 (7.00 - 7.00)	72.80	0.68	5.41 (5.13 - 6.12)	5.29 (3.60 - 9.14)	19.47 (13.06 - 34.23)	8.34 (7.01 - 12.47)	5.29 (3.60 - 9.14)	19.47 (13.06 - 34.23)	5.68 (4.61 - 9.24)	0.22 (0.43 - -0.33)	5.29 (3.60 - 9.14)	19.47 (13.06 - 34.23)	3.22 (2.32 - 6.36)	0.12 (0.03 - 0.22)
	90	2.84 (2.07 - 4.11)	12.24 (10.22 - 15.11)	7.00 (7.00 - 7.00)	63.17	0.69	5.80 (5.33 - 6.78)	5.27 (3.85 - 7.63)	12.24 (10.22 - 15.11)	8.61 (7.34 - 11.00)	5.27 (3.85 - 7.63)	12.24 (10.22 - 15.11)	5.54 (4.74 - 7.00)	0.04 (0.28 - -0.63)	5.27 (3.85 - 7.63)	12.24 (10.22 - 15.11)	2.88 (2.31 - 3.71)	0.15 (0.13 - 0.18)
	120	2.90 (2.21 - 4.58)	9.30 (9.25 - 9.38)	1.18 (7.00 - 1.78)	56.02	0.71	5.67 (5.21 - 6.61)	5.39 (4.11 - 8.51)	9.30 (9.25 - 9.38)	8.56 (7.37 - 11.35)	5.39 (4.11 - 8.51)	9.30 (9.25 - 9.38)	5.61 (4.89 - 7.48)	-0.03 (0.32 - -0.83)	5.39 (4.11 - 8.51)	9.30 (9.25 - 9.38)	2.87 (2.50 - 3.96)	0.12 (0.04 - 0.20)
1000	150	3.49 (2.70 - 4.95)	14.53 (12.88 - 17.12)	7.00 (7.00 - 7.00)	46.69	0.76	5.55 (5.28 - 6.24)	6.49 (5.02 - 9.19)	14.53 (12.88 - 17.12)	9.09 (7.95 - 11.53)	6.49 (5.02 - 9.19)	14.53 (12.88 - 17.12)	6.29 (5.40 - 8.10)	-0.08 (0.33 - -1.02)	6.49 (5.02 - 9.19)	14.53 (12.88 - 17.12)	3.52 (3.03 - 4.49)	0.21 (0.18 - 0.29)
	180	4.58 (3.85 - 5.94)	13.27 (12.68 - 14.22)	7.00 (7.00 - 2.30)	41.13	0.80	5.83 (5.49 - 6.47)	8.51 (7.15 - 11.04)	13.27 (12.68 - 14.22)	10.55 (9.38 - 12.80)	8.51 (7.15 - 11.04)	13.27 (12.68 - 14.22)	7.49 (6.64 - 9.16)	-0.20 (0.18 - -0.99)	8.51 (7.15 - 11.04)	13.27 (12.68 - 14.22)	4.62 (4.13 - 5.58)	0.13 (0.03 - 0.22)
	210	11.73 (9.20 - 16.27)	17.29 (16.11 - 19.01)	1.03 (1.06 - 1.25)	33.21	0.86	5.93 (5.60 - 6.81)	21.80 (17.10 - 28.93)	17.29 (16.11 - 19.01)	20.80 (16.46 - 28.57)	21.80 (17.10 - 27.99)	17.29 (16.11 - 19.01)	18.01 (13.81 - 24.37)	-0.22 (-0.02 - -0.57)	21.80 (17.10 - 27.23)	17.29 (16.11 - 19.01)	15.51 (11.33 - 19.08)	0.31 (0.25 - 0.43)
	240	11.30 (8.82 - 15.74)	16.92 (15.87 - 18.43)	1.03 (1.08 - 1.33)	32.38	0.86	5.88 (5.59 - 6.53)	21.00 (16.39 - 28.28)	16.92 (15.87 - 18.43)	20.00 (15.87 - 27.56)	21.00 (16.39 - 27.40)	16.92 (15.87 - 18.43)	17.23 (13.21 - 23.64)	-0.50 (-0.25 - -1.05)	21.00 (16.39 - 26.53)	16.92 (15.87 - 18.43)	14.45 (10.50 - 17.85)	0.16 (0.15 - 0.17)
	270	4.34 (3.44 - 6.73)	12.08 (9.31 - 14.94)	2.10 (1.04 - 1.91)	38.39	0.82	5.71 (5.48 - 6.13)	8.06 (6.39 - 12.50)	12.08 (9.31 - 14.94)	10.14 (8.95 - 13.49)	8.06 (6.39 - 12.50)	12.08 (9.31 - 14.94)	7.18 (6.20 - 10.22)	-0.43 (-0.12 - -1.16)	8.06 (6.39 - 12.50)	12.08 (9.31 - 14.94)	4.08 (3.37 - 6.53)	0.17 (0.12 - 0.29)
	300	3.66 (2.85 - 5.14)	12.45 (11.59 - 13.72)	7.00 (7.00 - 4.66)	42.95	0.79	5.58 (5.30 - 6.30)	6.80 (5.29 - 9.55)	12.45 (11.59 - 13.72)	9.27 (8.11 - 11.67)	6.80 (5.29 - 9.55)	12.45 (11.59 - 13.72)	6.43 (5.55 - 8.16)	-0.46 (-0.05 - -1.66)	6.80 (5.29 - 9.55)	12.45 (11.59 - 13.72)	3.28 (2.79 - 3.90)	0.12 (0.02 - 0.24)
	330	2.84 (2.03 - 4.50)	10.84 (5.05 - 13.17)	7.00 (5.69 - 7.00)	53.30	0.73	5.40 (5.13 - 6.10)	5.27 (3.78 - 8.37)	10.84 (5.05 - 13.17)	8.20 (7.31 - 10.73)	5.27 (3.78 - 8.37)	10.84 (5.05 - 13.17)	5.53 (4.90 - 7.39)	-0.39 (-0.01 - -1.26)	5.27 (3.78 - 8.37)	10.84 (5.05 - 13.17)	2.44 (2.18 - 3.49)	0.16 (0.14 - 0.21)

Table 3.20 Directional wave extremes at WTG11, return periods 1-, 5-, 10- and 50-yr.

Return period	Wave direction (coming from)	H_s	T_p	Peak enhancement factor, γ	Directional spreading, σ_θ	Wave kinematic factor, F_s	High EWL				Mean sea level			Low EWL				Ass. $U_{c,DA,total}$
							EHWL	H_{max}	T_{hmax}	C_{max}	H_{max}	T_{hmax}	C_{max}	ELWL	H_{max}	T_{hmax}	C_{max}	
(years)	(°N)	(m)	(s)	(-)	(°)	(-)	(mLAT)	(m)	(s)	(mLAT)	(m)	(s)	(mLAT)	(mLAT)	(m)	(s)	(mLAT)	(m/s)
1	OMNI	4.63 (4.59 - 4.67)	15.24 (15.21 - 15.28)	7.00 (7.00 - 7.00)	52.16	0.73	5.42 (5.41 - 5.44)	8.60 (8.54 - 8.69)	15.24 (15.21 - 15.28)	10.72 (10.66 - 10.80)	8.60 (8.54 - 8.69)	15.24 (15.21 - 15.28)	8.17 (8.12 - 8.24)	0.03 (0.05 - 0.00)	8.60 (8.54 - 8.69)	15.24 (15.21 - 15.28)	5.67 (5.63 - 5.71)	0.18 (0.02 - 0.33)
	0	1.03 (0.97 - 1.09)	9.22 (8.94 - 9.53)	7.00 (7.00 - 7.00)	71.85	0.68	4.35 (4.34 - 4.36)	1.91 (1.81 - 2.02)	9.22 (8.94 - 9.53)	5.34 (5.28 - 5.41)	1.91 (1.81 - 2.02)	9.22 (8.94 - 9.53)	3.71 (3.66 - 3.77)	0.90 (0.94 - 0.85)	1.91 (1.81 - 2.02)	9.22 (8.94 - 9.53)	1.89 (1.88 - 1.91)	0.17 (0.03 - 0.35)
	30	0.91 (0.90 - 0.93)	8.83 (8.79 - 8.87)	7.00 (7.00 - 7.00)	74.50	0.69	4.25 (4.25 - 4.25)	1.69 (1.67 - 1.72)	8.83 (8.79 - 8.87)	5.12 (5.11 - 5.14)	1.69 (1.67 - 1.72)	8.83 (8.79 - 8.87)	3.59 (3.58 - 3.61)	1.09 (1.11 - 1.08)	1.69 (1.67 - 1.72)	8.83 (8.79 - 8.87)	1.97 (1.97 - 1.97)	0.16 (0.03 - 0.37)
	60	0.87 (0.85 - 0.89)	7.70 (7.62 - 7.80)	7.00 (7.00 - 7.00)	75.30	0.69	4.43 (4.40 - 4.46)	1.62 (1.59 - 1.65)	7.70 (7.62 - 7.80)	5.26 (5.22 - 5.31)	1.62 (1.59 - 1.65)	7.70 (7.62 - 7.80)	3.55 (3.54 - 3.57)	1.00 (1.00 - 0.99)	1.62 (1.59 - 1.65)	7.70 (7.62 - 7.80)	1.83 (1.82 - 1.85)	0.17 (0.17 - 0.17)
	90	1.00 (0.98 - 1.02)	9.84 (9.83 - 9.84)	7.00 (7.00 - 7.00)	73.29	0.68	4.49 (4.47 - 4.50)	1.86 (1.83 - 1.90)	9.84 (9.83 - 9.84)	5.45 (5.42 - 5.49)	1.86 (1.83 - 1.90)	9.84 (9.83 - 9.84)	3.68 (3.67 - 3.71)	0.99 (1.00 - 0.98)	1.86 (1.83 - 1.90)	9.84 (9.83 - 9.84)	1.96 (1.95 - 1.97)	0.20 (0.03 - 0.35)
	120	1.28 (1.27 - 1.30)	10.03 (9.99 - 10.08)	7.00 (7.00 - 7.00)	49.32	0.75	4.60 (4.56 - 4.65)	2.38 (2.35 - 2.41)	10.03 (9.99 - 10.08)	5.84 (5.79 - 5.91)	2.38 (2.35 - 2.41)	10.03 (9.99 - 10.08)	3.96 (3.95 - 3.98)	0.93 (0.96 - 0.88)	2.38 (2.35 - 2.41)	10.03 (9.99 - 10.08)	2.17 (2.20 - 2.15)	0.17 (0.17 - 0.17)
	150	1.94 (1.92 - 1.95)	12.83 (6.17 - 19.22)	7.00 (1.64 - 7.00)	49.65	0.75	4.94 (4.94 - 4.94)	3.60 (3.58 - 3.63)	12.83 (6.17 - 19.22)	6.88 (6.90 - 7.02)	3.60 (3.58 - 3.63)	12.83 (6.17 - 19.22)	4.68 (4.68 - 4.84)	0.64 (0.64 - 0.63)	3.60 (3.58 - 3.63)	12.83 (6.17 - 19.22)	2.62 (2.60 - 2.79)	0.18 (0.18 - 0.18)
	180	2.80 (2.78 - 2.83)	11.84 (11.81 - 11.88)	7.00 (7.00 - 7.00)	49.46	0.75	5.19 (5.14 - 5.24)	5.21 (5.17 - 5.26)	11.84 (11.81 - 11.88)	8.07 (8.00 - 8.15)	5.21 (5.17 - 5.26)	11.84 (11.81 - 11.88)	5.64 (5.61 - 5.67)	0.43 (0.46 - 0.40)	5.21 (5.17 - 5.26)	11.84 (11.81 - 11.88)	3.40 (3.40 - 3.40)	0.21 (0.20 - 0.21)
	210	3.46 (3.42 - 3.52)	13.13 (13.09 - 13.18)	7.00 (7.00 - 7.00)	59.09	0.70	5.31 (5.28 - 5.33)	6.44 (6.35 - 6.53)	13.13 (13.09 - 13.18)	8.99 (8.91 - 9.09)	6.44 (6.35 - 6.53)	13.13 (13.09 - 13.18)	6.48 (6.42 - 6.55)	0.34 (0.38 - 0.30)	6.44 (6.35 - 6.53)	13.13 (13.09 - 13.18)	4.17 (4.15 - 4.21)	0.23 (0.23 - 0.24)
	240	3.93 (3.87 - 4.00)	13.90 (13.82 - 13.98)	7.00 (7.00 - 7.00)	58.65	0.70	5.34 (5.33 - 5.34)	7.31 (7.20 - 7.44)	13.90 (13.82 - 13.98)	9.64 (9.56 - 9.73)	7.31 (7.20 - 7.44)	13.90 (13.82 - 13.98)	7.12 (7.04 - 7.22)	0.22 (0.25 - 0.19)	7.31 (7.20 - 7.44)	13.90 (13.82 - 13.98)	4.74 (4.68 - 4.81)	0.19 (0.04 - 0.38)
	270	4.62 (4.56 - 4.68)	15.10 (15.03 - 15.17)	7.00 (7.00 - 7.00)	52.16	0.73	5.25 (5.23 - 5.27)	8.58 (8.48 - 8.70)	15.10 (15.03 - 15.17)	10.53 (10.43 - 10.64)	8.58 (8.48 - 8.70)	15.10 (15.03 - 15.17)	8.14 (8.06 - 8.24)	0.09 (0.11 - 0.07)	8.58 (8.48 - 8.70)	15.10 (15.03 - 15.17)	5.69 (5.62 - 5.78)	0.16 (0.16 - 0.16)
	300	3.86 (3.76 - 3.96)	14.53 (14.39 - 14.68)	7.00 (7.00 - 7.00)	46.73	0.76	5.00 (4.98 - 5.02)	7.17 (6.99 - 7.36)	14.53 (14.39 - 14.68)	9.25 (9.11 - 9.41)	7.17 (6.99 - 7.36)	14.53 (14.39 - 14.68)	7.06 (6.93 - 7.21)	0.11 (0.12 - 0.11)	7.17 (6.99 - 7.36)	14.53 (14.39 - 14.68)	4.58 (4.44 - 4.73)	0.25 (0.25 - 0.25)
	330	1.40 (1.34 - 1.47)	9.99 (9.86 - 10.12)	7.00 (7.00 - 7.00)	59.39	0.70	4.67 (4.65 - 4.70)	2.61 (2.50 - 2.72)	9.99 (9.86 - 10.12)	6.04 (5.96 - 6.13)	2.61 (2.50 - 2.72)	9.99 (9.86 - 10.12)	4.09 (4.03 - 4.16)	0.56 (0.62 - 0.50)	2.61 (2.50 - 2.72)	9.99 (9.86 - 10.12)	1.94 (1.93 - 1.94)	0.18 (0.18 - 0.18)
5	OMNI	5.23 (5.06 - 5.42)	15.77 (15.62 - 15.92)	7.00 (7.00 - 7.00)	52.16	0.73	5.56 (5.52 - 5.60)	9.72 (9.40 - 10.07)	15.77 (15.62 - 15.92)	11.73 (11.44 - 12.06)	9.72 (9.40 - 10.07)	15.77 (15.62 - 15.92)	9.09 (8.82 - 9.39)	-0.14 (-0.10 - -0.18)	9.72 (9.40 - 10.07)	15.77 (15.62 - 15.92)	6.48 (6.24 - 6.76)	0.18 (0.02 - 0.33)
	0	1.46 (1.33 - 1.56)	11.30 (10.71 - 11.75)	7.00 (7.00 - 7.00)	71.85	0.68	4.87 (4.75 - 4.95)	2.71 (2.48 - 2.90)	11.30 (10.71 - 11.75)	6.29 (6.04 - 6.49)	2.71 (2.48 - 2.90)	11.30 (10.71 - 11.75)	4.16 (4.02 - 4.27)	0.42 (0.54 - 0.32)	2.71 (2.48 - 2.90)	11.30 (10.71 - 11.75)	1.86 (1.85 - 1.88)	0.17 (0.03 - 0.35)
	30	1.32 (1.20 - 1.43)	9.79 (9.53 - 10.03)	7.00 (7.00 - 7.00)	74.50	0.69	4.78 (4.66 - 4.89)	2.45 (2.22 - 2.67)	9.79 (9.53 - 10.03)	6.06 (5.82 - 6.29)	2.45 (2.22 - 2.67)	9.79 (9.53 - 10.03)	4.00 (3.88 - 4.12)	0.57 (0.71 - 0.44)	2.45 (2.22 - 2.67)	9.79 (9.53 - 10.03)	1.86 (1.88 - 1.85)	0.16 (0.03 - 0.37)
	60	1.30 (1.17 - 1.43)	9.86 (9.24 - 10.46)	7.00 (7.00 - 7.00)	75.30	0.69	4.93 (4.80 - 5.02)	2.42 (2.18 - 2.66)	9.86 (9.24 - 10.46)	6.19 (5.93 - 6.42)	2.42 (2.18 - 2.66)	9.86 (9.24 - 10.46)	3.99 (3.85 - 4.12)	0.51 (0.61 - 0.41)	2.42 (2.18 - 2.66)	9.86 (9.24 - 10.46)	1.78 (1.75 - 1.82)	0.18 (0.18 - 0.18)
	90	1.44 (1.30 - 1.56)	9.92 (9.90 - 9.94)	7.00 (7.00 - 7.00)	73.29	0.68	4.93 (4.80 - 5.03)	2.68 (2.42 - 2.90)	9.92 (9.90 - 9.94)	6.33 (6.07 - 6.56)	2.68 (2.42 - 2.90)	9.92 (9.90 - 9.94)	4.13 (3.99 - 4.26)	0.45 (0.59 - 0.35)	2.68 (2.42 - 2.90)	9.92 (9.90 - 9.94)	1.87 (1.87 - 1.90)	0.20 (0.03 - 0.35)
	120	1.68 (1.56 - 1.80)	11.14 (10.83 - 11.43)	7.00 (7.00 - 7.00)	49.32	0.75	5.05 (4.95 - 5.14)	3.12 (2.90 - 3.34)	11.14 (10.83 - 11.43)	6.71 (6.48 - 6.92)	3.12 (2.90 - 3.34)	11.14 (10.83 - 11.43)	4.39 (4.26 - 4.51)	0.48 (0.61 - 0.38)	3.12 (2.90 - 3.34)	11.14 (10.83 - 11.43)	2.17 (2.16 - 2.19)	0.21 (0.20 - 0.22)
	150	2.53 (2.34 - 2.69)	12.83 (6.17 - 19.22)	7.00 (2.82 - 7.00)	49.65	0.75	5.20 (5.12 - 5.27)	4.70 (4.34 - 5.01)	12.83 (6.17 - 19.22)	7.79 (7.55 - 8.26)	4.70 (4.34 - 5.01)	12.83 (6.17 - 19.22)	5.35 (5.15 - 5.79)	0.34 (0.43 - 0.25)	4.70 (4.34 - 5.01)	12.83 (6.17 - 19.22)	3.01 (2.87 - 3.41)	0.25 (0.23 - 0.27)
	180	3.22 (3.09 - 3.34)	12.48 (12.28 - 12.65)	7.00 (7.00 - 7.00)	49.46	0.75	5.49 (5.40 - 5.56)	5.99 (5.74 - 6.21)	12.48 (12.28 - 12.65)	8.86 (8.62 - 9.08)	5.99 (5.74 - 6.21)	12.48 (12.28 - 12.65)	6.15 (5.99 - 6.30)	0.22 (0.27 - 0.18)	5.99 (5.74 - 6.21)	12.48 (12.28 - 12.65)	3.72 (3.60 - 3.84)	0.28 (0.26 - 0.31)
	210	3.88 (3.77 - 3.99)	13.50 (13.40 - 13.59)	7.00 (7.00 - 7.00)	59.09	0.70	5.46 (5.43 - 5.50)	7.21 (7.00 - 7.41)	13.50 (13.40 - 13.59)	9.68 (9.49 - 9.85)	7.21 (7.00 - 7.41)	13.50 (13.40 - 13.59)	7.03 (6.88 - 7.17)	0.11 (0.16 - 0.06)	7.21 (7.00 - 7.41)	13.50 (13.40 - 13.59)	4.53 (4.42 - 4.63)	0.26 (0.25 - 0.26)
	240	4.39 (4.27 - 4.52)	14.46 (14.31 - 14.61)	7.00 (7.00 - 7.00)	58.65	0.70	5.48 (5.44 - 5.53)	8.16 (7.93 - 8.40)	14.46 (14.31 - 14.61)	10.40 (10.19 - 10.62)	8.16 (7.93 - 8.40)	14.46 (14.31 - 14.61)	7.78 (7.59 - 7.96)	0.03 (0.08 - -0.01)	8.16 (7.93 - 8.40)	14.46 (14.31 - 14.61)	5.25 (5.10 - 5.40)	0.19 (0.04 - 0.38)
	270	5.22 (5.04 - 5.41)	15.79 (15.59 - 16.00)	7.00 (7.00 - 7.00)	52.16	0.73	5.42 (5.37 - 5.48)	9.70 (9.37 - 10.06)	15.79 (15.59 - 16.00)	11.59 (11.27 - 11.94)	9.70 (9.37 - 10.06)	15.79 (15.59 - 16.00)	9.08 (8.80 - 9.39)	-0.06 (-0.02 - -0.10)	9.70 (9.37 - 10.06)	15.79 (15.59 - 16.00)	6.54 (6.29 - 6.83)	0.17 (0.17 - 0.17)
	300	4.52 (4.35 - 4.68)	15.43 (15.21 - 15.64)	7.00 (7.00 - 7.00)	46.73	0.76	5.19 (5.13 - 5.23)	8.40 (8.08 - 8.71)	15.43 (15.21 - 15.64)	10.36 (10.07 - 10.65)	8.40 (8.08 - 8.71)	15.43 (15.21 - 15.64)	8.04 (7.78 - 8.29)	-0.07 (-0.01 - -0.12)	8.40 (8.08 - 8.71)	15.43 (15.21 - 15.64)	5.44 (5.22 - 5.65)	0.26 (0.25 - 0.26)
	330	1.80 (1.71 - 1.90)	10.78 (10.60 - 10.95)	7.00 (7.00 - 7.00)	59.39	0.70	5.02 (4.92 - 5.10)	3.35 (3.17 - 3.53)	10.78 (10.60 - 10.95)	6.80 (6.60 - 6.98)	3.35 (3.17 - 3.53)	10.78 (10.60 - 10.95)	4.52 (4.41 - 4.62)	0.20 (0.30 - 0.13)	3.35 (3.17 - 3.53)	10.78 (10.60 - 10.95)	2.02 (2.00 - 2.04)	0.18 (0.18 - 0.18)
10	OMNI	5.49 (5.24 - 5.74)	15.98 (15.78 - 16.18)	7.00 (7.00 - 7.00)	52.16	0.73	5.62 (5.57 - 5.68)	10.20 (9.74 - 10.66)	15.98 (15.78 - 16.18)	12.18 (11.76 - 12.62)	10.20 (9.74 - 10.66)	15.98 (15.78 - 16.18)	9.50 (9.11 - 9.91)	-0.20 (-0.14 - -0.25)	10.20 (9.74 - 10.66)	15.98 (15.78 - 16.18)	6.85 (6.50 - 7.23)	0.18 (0.02 - 0.33)
	0	1.63 (1.49 - 1.75)	12.04 (11.45 - 12.53)	7.00 (7.00 - 7.00)	71.85	0.68	4.99 (4.87 - 5.07)	3.03 (2.78 - 3.25)	12.04 (11.45 - 12.53)	6.60 (6.34 - 6.81)	3.03 (2.78 - 3.25)	12.04 (11.45 - 12.53)	4.34 (4.19 - 4.47)	0.28 (0.42 - 0.15)	3.03 (2.78 - 3.25)	12.04 (11.45 - 12.53)	1.92 (1.90 - 1.92)	0.17 (0.03 - 0.35)
	30	1.48 (1.32 - 1.63)	10.12 (9.80 - 10.39)	7.00 (7.00 - 7.00)	74.50	0.69	4.89 (4.75 - 5.02)	2.75 (2.45 - 3.02)	10.12 (9.80 - 10.39)	6.34 (6.03 - 6.62)	2.75 (2.45 - 3.02)	10.12 (9.80 - 10.39)	4.17 (4.01 - 4.33)	0.40 (0.58 - 0.21)	2.75 (2.45 - 3.02)	10.12 (9.80 - 10.39)	1.86 (1.87 - 1.83)	0.16 (0.03 - 0.37)
	60	1.49 (1.33 - 1.65)	10.71 (9.97 - 11.39)	7.00 (7.00 - 7.00)	75.30	0.69	5.06 (4.93 - 5.15)	2.77 (2.46 - 3.06)	10.71 (9.97 - 11.39)	6.51 (6.21 - 6.77)	2.77 (2.46 - 3.06)	10.71 (9.97 - 11.39)	4.18 (4.01 - 4.35)	0.43 (0.56 - 0.29)	2.77 (2.46 - 3.06)	10.71 (9.97 - 11.39)	1.90 (1.86 - 1.94)	0.19 (0.18 - 0.19)
	90	1.62 (1.47 - 1.76)	9.95 (9.93 - 9.97)	7.00 (7.00 - 7.00)	73.29	0.68	5.08 (4.95 - 5.19)	3.01 (2.73 - 3.27)	9.95 (9.93 - 9.97)	6.67 (6.38 - 6.92)	3.01 (2.73 - 3.27)	9.95 (9.93 - 9.97)	4.31 (4.16 - 4.46)	0.31 (0.44 - 0.23)	3.01 (2.73 - 3.27)	9.95 (9.93 - 9.97)	1.91 (1.89 - 1.99)	0.20 (0.03 - 0.35)
	120	1.83 (1.70 - 1.96)	11.52 (11.18 - 11.82)	7.00 (7.00 - 7.00)	49.32	0.75	5.17 (5.06 - 5.27)	3.41 (3.15 - 3.64)	11.52 (11.18 - 11.82)	6.99 (6.73 - 7.22)	3.41 (3.15 - 3.64)	11.52 (11.18 - 11.82)	4.55 (4.40 - 4.69)	0.33 (0.46 - 0.24)	3.41 (3.15 - 3.64)	11.52 (11.18 - 11.82)	2.18 (2.16 - 2.23)	0.23 (0.21 - 0.24)
	150	2.75 (2.54 - 2.94)	12.83 (6.17 - 19.22)	7.00 (3.55 - 7.00)	49.65	0.75	5.30 (5.20 - 5.38)	5.12 (4.72 - 5.47)	12.83 (6.17 - 19.22)	8.15 (7.86 - 8.69)	5.12 (4.72 - 5.47)	12.83 (6.17 - 19.22)	5.61 (5.39 - 6.12)	0.23 (0.34 - 0.13)	5.12 (4.72 - 5.47)	12.83 (6.17 - 19.22)	3.17 (3.01 - 3.63)	0.28 (0.25 - 0.30)
	180	3.40 (3.25 - 3.52)	12.73 (12.51 - 12.91)	7.00 (7.00 - 7.00)	49.46	0.75	5.58 (5.47 - 5.70)	6.32 (6.04 - 6.55)	12.73 (12.51 - 12.91)	9.17 (8.88 - 9.44)	6.32 (6.04 - 6.55)	12.73 (12.51 - 12.91)	6.38 (6.19 - 6.54)	0.16 (0.22 - 0.10)	6.32 (6.04 - 6.55)	12.73 (12.51 - 12.91)	3.90 (3.75 - 4.02)	0.32 (0.29 - 0.34)
	210	4.04 (3.91 - 4.15)	13.63 (13.52 - 13.72)	7.00 (7.00 - 7.00)	59.09	0.70	5.51 (5.46 - 5.56)	7.51 (7.26 - 7.71)	13.63 (13.52 - 13.72)	9.93 (9.71 - 10.12)	7.51 (7.26 - 7.71)	13.63 (13.52 - 13.72)	7.24 (7.07 - 7.39)	0.03 (0.10 - -0.04)	7.51 (7.26 - 7.71)	13.63 (13.52 - 13.72)	4.68 (4.56 - 4.78)	0.27 (0.26 - 0.27)
	240	4.59 (4.41 - 4.76)	14.69 (14.48 - 14.88)	7.00 (7.00 - 7.00)	58.65	0.70	5.54 (5.47 - 5.61)	8.53 (8.20 - 8.84)	14.69 (14.48 - 14.88)	10.73 (10.42 - 11.05)	8.53 (8.20 - 8.84)	14.69 (14.48 - 14.88)	8.06 (7.81 - 8.32)	-0.04 (0.03 - -0.10)	8.53 (8.20 - 8.84)	14.69 (14.48 - 14.88)	5.49 (5.28 - 5.70)	0.19 (0.04 - 0.38)
	270	5.48 (5.23 - 5.73)	16.07 (15.80 - 16.34)	7.00 (7.00 - 7.00)	52.16	0.73	5.50 (5.43 - 5.58)	10.18 (9.71 - 10.65)	16.07 (15.80 - 16.34)	12.06 (11.60 - 12.54)	10.18 (9.71 - 10.65)	16.07 (15.80 - 16.34)	9.50 (9.09 - 9.92)	-0.12 (-0.07 - -0.17)	10.18 (9.71 - 10.65)	16.07 (15.80 - 16.34)	6.92 (6.54 - 7.32)	0.17 (0.17 - 0.17)
	300	4.75 (4.54 - 4.97)	15.73 (15.45 - 16.00)	7.00 (7.00 - 7.00)	46.73	0.76	5.25 (5.19 - 5.30)	8.84 (8.44 - 9.24)	15.73 (15.45 - 16.00)	10.77 (10.40 - 11.15)	8.84 (8.44 - 9.24)	15.73 (15.45 - 16.00)	8.40 (8.06 - 8.74)	-0.14 (-0.06 - -0.21)	8.84 (8.44 - 9.24)	15.73 (15.45 - 16.00)	5.75 (5.47 - 6.05)	0.26 (0.26 - 0.26)
	330	1.95 (1.82 - 2.08)	11.04 (10.81 - 11.25)	7.00 (7.00 - 7.00)	59.39	0.70	5.13 (5.02 - 5.23)	3.62 (3.39 - 3.86)	11.04 (10.81 - 11.25)	7.06 (6.82 - 7.30)	3.62 (3.39 - 3.86)	11.04 (10.81 - 11.25)	4.67 (4.54 - 4.81)	0.08 (0.19 - -0.02)	3.62 (3.39 - 3.86)	11.04 (10.81 - 11.25)	2.06 (2.03 - 2.10)	0.18 (0.18 - 0.18)
50	OMNI	6.08 (5.58 - 6.65)	16.44 (16.06 - 16.86)	7.00 (7.00 - 7.00)	52.16	0.73	5.77 (5.64 - 5.92)	11.30 (10.38 - 12.36)	16.44 (16.06 - 16.86)	13.24 (12.35 - 14.31)	11.30 (10.38 - 12.36)	16.44 (16.06 - 16.86)	10.47 (9.66 - 11.45)	-0.34 (-0.23 - -0.48)	11.30 (10.38 - 12.36)	16.44 (16.06 - 16.86)	7.75 (7.00 - 8.65)	0.18 (0.02 - 0.33)
	0	1.99 (1.72 - 2.28)	13.50 (12.42 - 14.61)	7.00 (7.00 - 7.00)	71.85	0.68	5.16 (4.98 - 5.37)	3.69 (3.20 - 4.23)	13.50 (12.42 - 14.61)	7.16 (6.69 - 7.72)	3.69 (3.20 - 4.23)	13.50 (12.42 - 14.61)	4.75 (4.44 - 5.11)	0.08 (0.31 - -0.27)	3.69 (3.20 - 4.23)	13.50 (12.42 - 14.61)	2.14 (2.05 - 2.17)	0.17 (0.03 - 0.35)
	30	1.84 (1.50 - 2.22)	10.75 (10.16 - 11.33)	7.00 (7.00 - 7.00)	74.50	0.69	5.03 (4.81 - 5.29)	3.41 (2.79 - 4.12)	10.75 (10.16 - 11.33)	6.84 (6.28 - 7.52)	3.41 (2.79 - 4.12)	10.75 (10.16 - 11.33)	4.55 (4.20 - 4.97)	0.10 (0.43 - -0.43)	3.41 (2.79 - 4.12)	10.75 (10.16 - 11.33)	1.95 (1.91 - 1.86)	0.16 (0.03 - 0.37)
	60	1.92 (1.60 - 2.31)	12.53 (11.19 - 14.02)	7.00 (7.00 - 7.00)	75.30	0.69	5.24 (5.04 - 5.47)	3.57 (2.97 - 4.29)	12.53 (11.19 - 14.02)	7.16 (6.61 - 7.84)	3.57 (2.97 - 4.29)	12.53 (11.19 - 14.02)	4.66 (4.30 - 5.13)	0.35 (0.53 - 0.08)	3.57 (2.97 - 4.29)	12.53 (11.19 - 14.02)	2.32 (2.12 - 2.53)	0.20 (0.19 - 0.21)
	90	2.00 (1.73 - 2.30)	10.00 (9.97 - 10.04)	7.00 (7.00 - 7.00)	73.29	0.68	5.37 (5.12 - 5.63)	3.73 (3.21 - 4.27)	10.00 (9.97 - 10.04)	7.36 (6.82 - 7.92)	3.73 (3.21 - 4.27)	10.00 (9.97 - 10.04)	4.72 (4.43 - 5.04)	0.09 (0.26 - -0.09)	3.73 (3.21 - 4.27)	10.00 (9.97 - 10.04)	2.11 (1.98 - 2.25)	0.20 (0.03 - 0.35)
	120	2.15 (1.90 - 2.40)	12.24 (11.68 - 12.77)	7.00 (7.00 - 7.00)	49.32	0.75	5.35 (5.17 - 5.57)	3.99 (3.53 - 4.45)	12.24 (11.68 - 12.77)	7.52 (7.06 - 8.01)	3.99 (3.53 - 4.45)	12.24 (11.68 - 12.77)	4.91 (4.63 - 5.20)	0.04 (0.28 - -0.23)	3.99 (3.53 - 4.45)	12.24 (11.68 - 12.77)	2.26 (2.21 - 2.29)	0.26 (0.23 - 0.28)
	150	3.21 (2.84 - 3.63)	12.83 (6.17 - 19.22)	7.00 (4.78 - 7.00)	49.65	0.75	5.53 (5.34 - 5.70)	5.97 (5.27 - 6.75)	12.83 (6.17 - 19.22)	8.90 (8.37 - 9.92)	5.97 (5.27 - 6.75)	12.83 (6.17 - 19.22)	6.16 (5.75 - 7.08)	0.00 (0.21 - -0.19)	5.97 (5.27 - 6.75)	12.83 (6.17 - 19.22)	3.52 (3.24 - 4.34)	0.33 (0.29 - 0.38)
	180	3.81 (3.56 - 4.07)	13.30 (12.96 - 13.63)	7.00 (7.00 - 7.00)	49.46	0.75	5.75 (5.56 - 5.98)	7.09 (6.62 - 7.57)	13.30 (12.96 - 13.63)	9.86 (9.36 - 10.42)	7.09 (6.62 - 7.57)	13.30 (12.96 - 13.63)	6.93 (6.59 - 7.29)	0.05 (0.16 - -0.10)	7.09 (6.62 - 7.57)	13.30 (12.96 - 13.63)	4.37 (4.12 - 4.60)	0.39 (0.35 - 0.44)
	210	4.37 (4.12 - 4.64)	13.90 (13.70 - 14.10)	7.00 (7.00 - 7.00)	59.09	0.70	5.58 (5.50 - 5.69)	8.13 (7.66 - 8.63)	13.90 (13.70 - 14.10)	10.44 (10.02 - 10.91)	8.13 (7.66 - 8.63)	13.90 (13.70 - 14.10)	7.70 (7.35 - 8.09)	-0.12 (0.02 - -0.29)	8.13 (7.66 - 8.63)	13.90 (13.70 - 14.10)	5.03 (4.79 - 5.28)	0.29 (0.27 - 0.30)
	240	5.03 (4.68 - 5.48)	15.18 (14.79 - 15.65)	7.00 (7.00 - 7.00)	58.65	0.70	5.66 (5.51 - 5.88)	9.35 (8.69 - 10.18)	15.18 (14.79 - 15.65)	11.49 (10.83 - 12.37)	9.35 (8.69 - 10.18)	15.18 (14.79 - 15.65)	8.74 (8.20 - 9.45)	-0.17 (-0.04 - -0.33)	9.35 (8.69 - 10.18)	15.18 (14.79 - 15.65)	6.09 (5.63 - 6.69)	0.19 (0.04 - 0.38)
	270	6.07 (5.55 - 6.69)	16.68 (16.14 - 17.28)	7.00 (7.00 - 7.00)	52.16	0.73	5.66 (5.51 - 5.86)	11.27 (10.31 - 12.42)	16.68 (16.14 - 17.28)	13.15 (12.18 - 14.37)	11.27 (10.31 - 12.42)	16.68 (16.14 - 17.28)	10.49 (9.62 - 11.56)	-0.27 (-0.15 - -0.39)	11.27 (10.31 - 12.42)	16.68 (16.14 - 17.28)	7.83 (7.03 - 8.84)	0.17 (0.17 - 0.18)
	300	5.20 (4.80 - 5.74)	16.27 (15.78 - 16.89)	7.00 (7.00 - 7.00)	46.73	0.76	5.36 (5.25 - 5.50)	9.67 (8.92 - 10.67)	16.27 (15.78 - 16.89)	11.56 (10.84 - 12.55)	9.67 (8.92 - 10.67)	16.27 (15.78 - 16.89)	9.11 (8.47 - 10.01)	-0.28 (-0.13 - -0.44)	9.67 (8.92 - 10.67)	16.27 (15.78 - 16.89)	6.37 (5.83 - 7.17)	0.27 (0.26 - 0.27)
	330	2.23 (1.98 - 2.55)	11.50 (11.09 - 11.98)	7.00 (7.00 - 7.00)	59.39	0.70	5.32 (5.12 - 5.60)	4.15 (3.68 - 4.75)	11.50 (11.09 - 11.98)	7.57 (7.09 - 8.21)	4.15 (3.68 - 4.75)	11.50 (11.09 - 11.98)	4.99 (4.71 - 5.36)	-0.13 (0.07 - -0.40)	4.15 (3.68 - 4.75)	11.50 (11.09 - 11.98)	2.17 (2.08 - 2.29)	0.18 (0.18 - 0.18)

Table 3.21 Directional wave extremes at WTG11, return periods 100-, 500- and 1000-yr.

Return period	Wave direction (coming from)	H_s	T_p	Peak enhancement factor, γ	Directional spreading, σ_θ	Wave kinematic factor, F_s	High EWL				Mean sea level			Low EWL				Ass. $U_{c,DA,total}$
							EHWL	H_{max}	T_{hmax}	C_{max}	H_{max}	T_{hmax}	C_{max}	ELWL	H_{max}	T_{hmax}	C_{max}	
(years)	(°N)	(m)	(s)	(-)	(°)	(-)	(mLAT)	(m)	(s)	(mLAT)	(m)	(s)	(mLAT)	(mLAT)	(m)	(s)	(mLAT)	(m/s)
	OMNI	6.33 (5.68 - 7.19)	16.63 (16.13 - 17.23)	7.00 (7.00 - 7.00)	52.16	0.73	5.83 (5.66 - 6.07)	11.77 (10.55 - 13.36)	16.63 (16.13 - 17.23)	13.70 (12.51 - 15.34)	11.77 (10.55 - 13.36)	16.63 (16.13 - 17.23)	10.90 (9.81 - 12.39)	-0.40 (-0.25 - -0.58)	11.77 (10.55 - 13.36)	16.63 (16.13 - 17.23)	8.15 (7.14 - 9.54)	0.18 (0.02 - 0.33)
	0	2.13 (1.77 - 2.59)	14.04 (12.63 - 15.75)	7.00 (7.00 - 7.00)	71.85	0.68	5.20 (4.99 - 5.52)	3.95 (3.29 - 4.82)	14.04 (12.63 - 15.75)	7.36 (6.75 - 8.26)	3.95 (3.29 - 4.82)	14.04 (12.63 - 15.75)	4.92 (4.50 - 5.52)	0.02 (0.29 - -0.45)	3.95 (3.29 - 4.82)	14.04 (12.63 - 15.75)	2.26 (2.09 - 2.43)	0.17 (0.03 - 0.35)
	30	1.98 (1.55 - 2.60)	10.98 (10.25 - 11.85)	7.00 (7.00 - 7.00)	74.50	0.69	5.05 (4.82 - 5.38)	3.68 (2.88 - 4.84)	10.98 (10.25 - 11.85)	7.02 (6.33 - 8.03)	3.68 (2.88 - 4.84)	10.98 (10.25 - 11.85)	4.71 (4.24 - 5.41)	0.00 (0.41 - -0.77)	3.68 (2.88 - 4.84)	10.98 (10.25 - 11.85)	2.01 (1.94 - 1.98)	0.16 (0.03 - 0.37)
	60	2.11 (1.68 - 2.71)	13.26 (11.53 - 15.47)	7.00 (7.00 - 7.00)	75.30	0.69	5.29 (5.05 - 5.62)	3.92 (3.12 - 5.04)	13.26 (11.53 - 15.47)	7.42 (6.71 - 8.49)	3.92 (3.12 - 5.04)	13.26 (11.53 - 15.47)	4.88 (4.39 - 5.65)	0.34 (0.52 - 0.01)	3.92 (3.12 - 5.04)	13.26 (11.53 - 15.47)	2.54 (2.21 - 3.02)	0.20 (0.19 - 0.22)
	90	2.16 (1.78 - 2.66)	10.02 (9.98 - 10.07)	7.00 (7.00 - 7.00)	73.29	0.68	5.47 (5.16 - 5.88)	4.01 (3.32 - 4.93)	10.02 (9.98 - 10.07)	7.63 (6.92 - 8.57)	4.01 (3.32 - 4.93)	10.02 (9.98 - 10.07)	4.89 (4.49 - 5.43)	0.03 (0.25 - -0.25)	4.01 (3.32 - 4.93)	10.02 (9.98 - 10.07)	2.23 (2.03 - 2.50)	0.20 (0.03 - 0.35)
	120	2.27 (1.95 - 2.65)	12.50 (11.80 - 13.27)	7.00 (7.00 - 7.00)	49.32	0.75	5.40 (5.18 - 5.70)	4.22 (3.63 - 4.92)	12.50 (11.80 - 13.27)	7.70 (7.13 - 8.43)	4.22 (3.63 - 4.92)	12.50 (11.80 - 13.27)	5.05 (4.69 - 5.50)	-0.06 (0.25 - -0.48)	4.22 (3.63 - 4.92)	12.50 (11.80 - 13.27)	2.30 (2.24 - 2.37)	0.27 (0.24 - 0.30)
100	150	3.39 (2.89 - 4.03)	12.83 (6.17 - 19.22)	7.00 (5.01 - 7.00)	49.65	0.75	5.62 (5.39 - 5.87)	6.30 (5.37 - 7.48)	12.83 (6.17 - 19.22)	9.20 (8.47 - 10.62)	6.30 (5.37 - 7.48)	12.83 (6.17 - 19.22)	6.37 (5.81 - 7.65)	-0.09 (0.17 - -0.36)	6.30 (5.37 - 7.48)	12.83 (6.17 - 19.22)	3.66 (3.27 - 4.78)	0.35 (0.29 - 0.43)
	180	3.99 (3.65 - 4.41)	13.53 (13.08 - 14.05)	7.00 (7.00 - 7.00)	49.46	0.75	5.80 (5.58 - 6.09)	7.42 (6.79 - 8.20)	13.53 (13.08 - 14.05)	10.14 (9.49 - 10.99)	7.42 (6.79 - 8.20)	13.53 (13.08 - 14.05)	7.17 (6.71 - 7.77)	0.02 (0.15 - -0.18)	7.42 (6.79 - 8.20)	13.53 (13.08 - 14.05)	4.60 (4.24 - 5.05)	0.43 (0.36 - 0.50)
	210	4.50 (4.17 - 4.91)	13.99 (13.74 - 14.29)	7.00 (7.00 - 7.00)	59.09	0.70	5.60 (5.51 - 5.75)	8.36 (7.76 - 9.12)	13.99 (13.74 - 14.29)	10.63 (10.10 - 11.33)	8.36 (7.76 - 9.12)	13.99 (13.74 - 14.29)	7.88 (7.42 - 8.47)	-0.17 (-0.01 - -0.41)	8.36 (7.76 - 9.12)	13.99 (13.74 - 14.29)	5.17 (4.84 - 5.58)	0.29 (0.27 - 0.32)
	240	5.22 (4.76 - 5.88)	15.38 (14.88 - 16.05)	7.00 (7.00 - 7.00)	58.65	0.70	5.71 (5.52 - 6.03)	9.70 (8.84 - 10.93)	15.38 (14.88 - 16.05)	11.82 (10.95 - 13.14)	9.70 (8.84 - 10.93)	15.38 (14.88 - 16.05)	9.04 (8.32 - 10.12)	-0.21 (-0.06 - -0.43)	9.70 (8.84 - 10.93)	15.38 (14.88 - 16.05)	6.36 (5.73 - 7.29)	0.19 (0.04 - 0.38)
	270	6.32 (5.64 - 7.22)	16.92 (16.24 - 17.76)	7.00 (7.00 - 7.00)	52.16	0.73	5.73 (5.54 - 6.02)	11.74 (10.48 - 13.41)	16.92 (16.24 - 17.76)	13.63 (12.35 - 15.42)	11.74 (10.48 - 13.41)	16.92 (16.24 - 17.76)	10.92 (9.77 - 12.51)	-0.32 (-0.17 - -0.51)	11.74 (10.48 - 13.41)	16.92 (16.24 - 17.76)	8.23 (7.17 - 9.72)	0.18 (0.17 - 0.18)
	300	5.36 (4.86 - 6.13)	16.46 (15.85 - 17.32)	7.00 (7.00 - 7.00)	46.73	0.76	5.40 (5.26 - 5.61)	9.96 (9.02 - 11.40)	16.46 (15.85 - 17.32)	11.85 (10.93 - 13.29)	9.96 (9.02 - 11.40)	16.46 (15.85 - 17.32)	9.37 (8.55 - 10.68)	-0.34 (-0.15 - -0.58)	9.96 (9.02 - 11.40)	16.46 (15.85 - 17.32)	6.60 (5.91 - 7.76)	0.27 (0.26 - 0.28)
	330	2.33 (2.02 - 2.78)	11.66 (11.15 - 12.30)	7.00 (7.00 - 7.00)	59.39	0.70	5.39 (5.14 - 5.78)	4.34 (3.75 - 5.17)	11.66 (11.15 - 12.30)	7.74 (7.15 - 8.64)	4.34 (3.75 - 5.17)	11.66 (11.15 - 12.30)	5.10 (4.75 - 5.63)	-0.20 (0.04 - -0.58)	4.34 (3.75 - 5.17)	11.66 (11.15 - 12.30)	2.22 (2.09 - 2.40)	0.18 (0.18 - 0.18)
	OMNI	6.92 (5.82 - 8.76)	17.05 (16.24 - 18.21)	7.00 (7.00 - 7.00)	52.16	0.73	5.97 (5.70 - 6.54)	12.86 (10.81 - 16.28)	17.05 (16.24 - 18.21)	14.80 (12.76 - 18.51)	12.86 (10.81 - 16.28)	17.05 (16.24 - 18.21)	11.92 (10.04 - 15.27)	-0.52 (-0.30 - -0.87)	12.86 (10.81 - 15.48)	17.05 (16.24 - 18.21)	9.10 (7.33 - 11.50)	0.18 (0.02 - 0.33)
	0	2.42 (1.84 - 3.51)	15.13 (12.92 - 18.74)	7.00 (7.00 - 7.00)	71.85	0.68	5.25 (5.00 - 5.90)	4.50 (3.42 - 6.51)	15.13 (12.92 - 18.74)	7.78 (6.84 - 9.90)	4.50 (3.42 - 6.51)	15.13 (12.92 - 18.74)	5.29 (4.58 - 6.87)	-0.07 (0.28 - -0.89)	4.50 (3.42 - 6.51)	15.13 (12.92 - 18.74)	2.56 (2.16 - 3.46)	0.17 (0.03 - 0.35)
	30	2.30 (1.59 - 3.78)	11.44 (10.33 - 13.16)	7.00 (7.00 - 7.00)	74.50	0.69	5.09 (4.82 - 5.57)	4.27 (2.96 - 7.02)	11.44 (10.33 - 13.16)	7.40 (6.38 - 9.64)	4.27 (2.96 - 7.02)	11.44 (10.33 - 13.16)	5.06 (4.29 - 6.87)	-0.17 (0.37 - -1.63)	4.27 (2.96 - 7.02)	11.44 (10.33 - 13.16)	2.20 (1.95 - 2.71)	0.16 (0.03 - 0.37)
	60	2.55 (1.79 - 3.98)	14.88 (11.98 - 19.58)	7.00 (7.00 - 7.00)	75.30	0.69	5.35 (5.06 - 6.00)	4.73 (3.32 - 7.40)	14.88 (11.98 - 19.58)	8.02 (6.84 - 10.71)	4.73 (3.32 - 7.40)	14.88 (11.98 - 19.58)	5.43 (4.51 - 7.61)	0.33 (0.52 - -0.11)	4.73 (3.32 - 7.40)	14.88 (11.98 - 19.58)	3.09 (2.33 - 4.97)	0.22 (0.19 - 0.26)
	90	2.50 (1.85 - 3.73)	10.06 (9.98 - 10.16)	7.00 (7.00 - 1.04)	73.29	0.68	5.66 (5.19 - 6.57)	4.64 (3.44 - 6.93)	10.06 (9.98 - 10.16)	8.18 (7.02 - 10.46)	4.64 (3.44 - 6.93)	10.06 (9.98 - 10.16)	5.26 (4.56 - 6.68)	-0.05 (0.23 - -0.66)	4.64 (3.44 - 6.93)	10.06 (9.98 - 10.16)	2.52 (2.08 - 3.40)	0.20 (0.03 - 0.35)
	120	2.52 (2.02 - 3.41)	13.01 (11.95 - 14.62)	7.00 (7.00 - 7.00)	49.32	0.75	5.47 (5.19 - 6.00)	4.68 (3.75 - 6.33)	13.01 (11.95 - 14.62)	8.05 (7.21 - 9.67)	4.68 (3.75 - 6.33)	13.01 (11.95 - 14.62)	5.34 (4.76 - 6.49)	-0.26 (0.20 - -1.22)	4.68 (3.75 - 6.33)	13.01 (11.95 - 14.62)	2.42 (2.27 - 2.71)	0.29 (0.24 - 0.38)
500	150	3.75 (2.95 - 5.32)	12.83 (6.17 - 19.22)	7.00 (5.30 - 7.00)	49.65	0.75	5.82 (5.44 - 6.41)	6.96 (5.49 - 9.89)	12.83 (6.17 - 19.22)	9.83 (8.61 - 13.01)	6.96 (5.49 - 9.89)	12.83 (6.17 - 19.22)	6.82 (5.89 - 9.62)	-0.26 (0.12 - -0.85)	6.96 (5.49 - 9.89)	12.83 (6.17 - 19.22)	3.95 (3.30 - 6.39)	0.40 (0.30 - 0.59)
	180	4.40 (3.79 - 5.44)	14.04 (13.27 - 15.20)	7.00 (7.00 - 7.00)	49.46	0.75	5.89 (5.61 - 6.32)	8.18 (7.04 - 10.11)	14.04 (13.27 - 15.20)	10.79 (9.70 - 12.68)	8.18 (7.04 - 10.11)	14.04 (13.27 - 15.20)	7.76 (6.90 - 9.34)	-0.03 (0.14 - -0.37)	8.18 (7.04 - 10.11)	14.04 (13.27 - 15.20)	5.16 (4.42 - 6.53)	0.50 (0.39 - 0.69)
	210	4.76 (4.24 - 5.65)	14.19 (13.80 - 14.79)	7.00 (7.00 - 7.00)	59.09	0.70	5.64 (5.51 - 5.88)	8.85 (7.89 - 10.49)	14.19 (13.80 - 14.79)	11.02 (10.20 - 12.52)	8.85 (7.89 - 10.49)	14.19 (13.80 - 14.79)	8.26 (7.52 - 9.60)	-0.27 (-0.04 - -0.65)	8.85 (7.89 - 10.49)	14.19 (13.80 - 14.79)	5.48 (4.91 - 6.55)	0.31 (0.28 - 0.36)
	240	5.65 (4.88 - 7.15)	15.82 (15.02 - 17.21)	7.00 (7.00 - 7.00)	58.65	0.70	5.81 (5.53 - 6.49)	10.51 (9.08 - 13.30)	15.82 (15.02 - 17.21)	12.58 (11.15 - 15.65)	10.51 (9.08 - 13.30)	15.82 (15.02 - 17.21)	9.74 (8.51 - 12.33)	-0.30 (-0.09 - -0.67)	10.51 (9.08 - 13.30)	15.82 (15.02 - 17.21)	7.01 (5.91 - 9.40)	0.19 (0.04 - 0.38)
	270	6.89 (5.83 - 8.82)	17.47 (16.44 - 19.11)	7.00 (7.00 - 7.00)	52.16	0.73	5.89 (5.58 - 6.53)	12.80 (10.84 - 16.40)	17.47 (16.44 - 19.11)	14.74 (12.69 - 18.76)	12.80 (10.84 - 16.37)	17.47 (16.44 - 19.11)	11.93 (10.09 - 15.50)	-0.45 (-0.21 - -0.90)	12.80 (10.84 - 15.54)	17.47 (16.44 - 19.11)	9.17 (7.46 - 11.66)	0.18 (0.17 - 0.20)
	300	5.67 (4.94 - 7.08)	16.81 (15.96 - 18.28)	7.00 (7.00 - 7.00)	46.73	0.76	5.47 (5.27 - 5.92)	10.53 (9.19 - 13.16)	16.81 (15.96 - 18.28)	12.40 (11.08 - 15.19)	10.53 (9.19 - 13.16)	16.81 (15.96 - 18.28)	9.88 (8.70 - 12.36)	-0.46 (-0.18 - -0.99)	10.53 (9.19 - 13.16)	16.81 (15.96 - 18.28)	7.02 (6.03 - 9.15)	0.27 (0.26 - 0.29)
	330	2.53 (2.08 - 3.35)	11.95 (11.26 - 13.01)	7.00 (7.00 - 7.00)	59.39	0.70	5.50 (5.15 - 6.27)	4.71 (3.87 - 6.22)	11.95 (11.26 - 13.01)	8.08 (7.23 - 9.80)	4.71 (3.87 - 6.22)	11.95 (11.26 - 13.01)	5.33 (4.82 - 6.33)	-0.33 (0.01 - -0.97)	4.71 (3.87 - 6.22)	11.95 (11.26 - 13.01)	2.33 (2.14 - 2.76)	0.18 (0.18 - 0.19)
	OMNI	7.17 (5.85 - 9.65)	17.22 (16.27 - 18.71)	7.00 (7.00 - 4.15)	52.16	0.73	6.03 (5.71 - 6.80)	13.33 (10.88 - 17.93)	17.22 (16.27 - 18.71)	15.27 (12.83 - 20.37)	13.33 (10.88 - 17.29)	17.22 (16.27 - 18.71)	12.36 (10.10 - 16.34)	-0.57 (-0.32 - -1.01)	13.33 (10.88 - 16.43)	17.22 (16.27 - 18.71)	9.52 (7.38 - 12.43)	0.18 (0.02 - 0.33)
	0	2.54 (1.86 - 4.00)	15.55 (12.99 - 20.22)	7.00 (7.00 - 7.00)	71.85	0.68	5.26 (5.00 - 6.04)	4.71 (3.46 - 7.43)	15.55 (12.99 - 20.22)	7.93 (6.87 - 10.82)	4.71 (3.46 - 7.43)	15.55 (12.99 - 20.22)	5.44 (4.60 - 7.69)	-0.09 (0.27 - -1.07)	4.71 (3.46 - 7.43)	15.55 (12.99 - 20.22)	2.70 (2.18 - 4.16)	0.17 (0.03 - 0.35)
	30	2.42 (1.61 - 4.50)	11.62 (10.36 - 13.82)	7.00 (7.00 - 7.00)	74.50	0.69	5.09 (4.82 - 5.66)	4.50 (2.99 - 8.37)	11.62 (10.36 - 13.82)	7.55 (6.40 - 10.67)	4.50 (2.99 - 8.37)	11.62 (10.36 - 13.82)	5.20 (4.31 - 7.87)	-0.23 (0.37 - -2.06)	4.50 (2.99 - 8.37)	11.62 (10.36 - 13.82)	2.29 (1.97 - 3.40)	0.16 (0.03 - 0.37)
	60	2.73 (1.82 - 4.73)	15.55 (12.11 - 21.76)	7.00 (7.00 - 7.00)	75.30	0.69	5.37 (5.07 - 6.13)	5.08 (3.38 - 8.79)	15.55 (12.11 - 21.76)	8.28 (6.88 - 12.11)	5.08 (3.38 - 8.79)	15.55 (12.11 - 21.76)	5.68 (4.55 - 8.94)	0.33 (0.52 - -0.14)	5.08 (3.38 - 8.79)	15.55 (12.11 - 21.76)	3.36 (2.37 - 6.32)	0.22 (0.20 - 0.28)
	90	2.63 (1.87 - 4.33)	10.07 (9.99 - 10.19)	7.00 (7.00 - 1.09)	73.29	0.68	5.73 (5.20 - 6.90)	4.89 (3.48 - 8.04)	10.07 (9.99 - 10.19)	8.39 (7.04 - 11.49)	4.89 (3.48 - 8.04)	10.07 (9.99 - 10.19)	5.41 (4.58 - 7.42)	-0.08 (0.23 - -0.85)	4.89 (3.48 - 8.04)	10.07 (9.99 - 10.19)	2.65 (2.10 - 3.99)	0.20 (0.03 - 0.35)
	120	2.61 (2.04 - 3.82)	13.19 (11.99 - 15.28)	7.00 (7.00 - 7.00)	49.32	0.75	5.49 (5.19 - 6.11)	4.85 (3.78 - 7.10)	13.19 (11.99 - 15.28)	8.18 (7.23 - 10.33)	4.85 (3.78 - 7.10)	13.19 (11.99 - 15.28)	5.45 (4.78 - 7.07)	-0.33 (0.19 - -1.56)	4.85 (3.78 - 7.10)	13.19 (11.99 - 15.28)	2.47 (2.28 - 3.01)	0.30 (0.24 - 0.41)
1000	150	3.88 (2.97 - 6.09)	12.83 (6.17 - 19.22)	7.00 (5.35 - 7.00)	49.65	0.75	5.90 (5.45 - 6.72)	7.21 (5.51 - 11.32)	12.83 (6.17 - 19.22)	10.07 (8.63 - 14.47)	7.21 (5.51 - 11.32)	12.83 (6.17 - 19.22)	6.99 (5.91 - 10.85)	-0.33 (0.11 - -1.11)	7.21 (5.51 - 11.32)	12.83 (6.17 - 19.22)	4.07 (3.31 - 7.45)	0.41 (0.30 - 0.68)
	180	4.58 (3.83 - 6.04)	14.25 (13.32 - 15.81)	7.00 (7.00 - 7.00)	49.46	0.75	5.92 (5.62 - 6.41)	8.51 (7.12 - 11.22)	14.25 (13.32 - 15.81)	11.06 (9.76 - 13.69)	8.51 (7.12 - 11.22)	14.25 (13.32 - 15.81)	8.01 (6.95 - 10.32)	-0.05 (0.14 - -0.46)	8.51 (7.12 - 11.22)	14.25 (13.32 - 15.81)	5.42 (4.48 - 7.48)	0.53 (0.40 - 0.80)
	210	4.86 (4.26 - 6.01)	14.26 (13.81 - 15.02)	7.00 (7.00 - 6.23)	59.09	0.70	5.65 (5.52 - 5.93)	9.03 (7.92 - 11.18)	14.26 (13.81 - 15.02)	11.17 (10.22 - 13.12)	9.03 (7.92 - 11.18)	14.26 (13.81 - 15.02)	8.40 (7.55 - 10.18)	-0.30 (-0.05 - -0.76)	9.03 (7.92 - 11.18)	14.26 (13.81 - 15.02)	5.60 (4.93 - 7.07)	0.32 (0.28 - 0.39)
	240	5.84 (4.93 - 7.88)	16.01 (15.06 - 17.82)	7.00 (7.00 - 7.00)	58.65	0.70	5.85 (5.53 - 6.79)	10.85 (9.16 - 14.65)	16.01 (15.06 - 17.82)	12.91 (11.22 - 17.19)	10.85 (9.16 - 14.65)	16.01 (15.06 - 17.82)	10.04 (8.58 - 13.66)	-0.33 (-0.10 - -0.78)	10.85 (9.16 - 14.52)	16.01 (15.06 - 17.82)	7.30 (5.97 - 10.58)	0.19 (0.04 - 0.38)
	270	7.13 (5.88 - 9.70)	17.69 (16.49 - 19.78)	7.00 (7.00 - 7.00)	52.16	0.73	5.96 (5.59 - 6.81)	13.25 (10.94 - 18.02)	17.69 (16.49 - 19.78)	15.22 (12.79 - 20.65)	13.25 (10.94 - 17.34)	17.69 (16.49 - 19.78)	12.36 (10.18 - 16.56)	-0.51 (-0.22 - -1.11)	13.25 (10.94 - 16.46)	17.69 (16.49 - 19.78)	9.57 (7.54 - 12.51)	0.18 (0.17 - 0.20)
	300	5.77 (4.97 - 7.51)	16.93 (15.99 - 18.69)	7.00 (7.00 - 7.00)	46.73	0.76	5.50 (5.27 - 6.08)	10.73 (9.23 - 13.95)	16.93 (15.99 - 18.69)	12.59 (11.11 - 16.09)	10.73 (9.23 - 13.95)	16.93 (15.99 - 18.69)	10.06 (8.73 - 13.15)	-0.50 (-0.19 - -1.19)	10.73 (9.23 - 13.95)	16.93 (15.99 - 18.69)	7.17 (6.06 - 9.80)	0.27 (0.26 - 0.30)
	330	2.61 (2.10 - 3.63)	12.06 (11.29 - 13.33)	7.00 (7.00 - 7.00)	59.39	0.70	5.54 (5.15 - 6.51)	4.84 (3.90 - 6.74)	12.06 (11.29 - 13.33)	8.20 (7.25 - 10.38)	4.84 (3.90 - 6.74)	12.06 (11.29 - 13.33)	5.42 (4.84 - 6.69)	-0.38 (0.00 - -1.16)	4.84 (3.90 - 6.74)	12.06 (11.29 - 13.33)	2.38 (2.15 - 2.97)	0.18 (0.18 - 0.19)

3.5.5 Severe Sea States (SSS)

The Severe Sea States (DNVGL, 2021) are defined for 34 hub-height (170 mMSL) wind speed classes (0.0-1.5, 1.5-2.5, …, 32.5-33.5, 33.5-46.5 m/s)[13] and consist of the 50-year return values of the H_s data falling in that class and the associated peak wave periods. The considered wind speed classes have been specified by the Client with a hub-height wind speed cut-off of 33 m/s, with increments of 1 m/s centred around wind speeds from 2 m/s until 33 m/s, a higher class of all wind speeds above 33.5 and a lower class considering all speed below 1.5 m/s. The Severe Sea State tables for all three turbine locatinos are given in Table 3.22 to Table 3.24 (following the template provided by the client). These tables are also given in the spreadsheets accompanying this report (cf. Appendix E). The SSS results for all three turbine locations are also visualized in respectively Figure 3.59. This figures also present the 50-year ESS value (cf. Section 3.5.4) together with scatter plots of wind speed at hub-height versus significant wave height for all timesteps.

The $H_{s,SSS}$ return values are estimated using the POT method (cf. Appendix B). The associated peak wave periods were determined by computing the mean and the mean + one time the standard deviation of the concurrent peak wave periods in each POT sampleset. The maximum wave heights were computed in the same way as for the ESS values (cf. Section 3.5.4), while assuming the water level to be at MSL.

The tables also contain associated DNV/IEC period ranges, determined as given in the standards using:

$$T_{min,SSS} = 11.1\sqrt{H_{m0,SSS}/9.81} \leq T \leq 14.3\sqrt{H_{m0,SSS}/9.81} = T_{max,SSS}.$$

It is noted that the computed ranges, using the DNV/IEC formulae do not necessarily result in realistic values at the output locations as they have been derived for other locations and other type of environmental conditions.

When comparing the SSS values with the 50-year extreme sea states, these are in all cases more severe than the severe sea states estimate from the 33 m/s hub-height wind speed class. This is because the extreme sea states are associated with higher wind speeds, cf. Table 3.16 to Table 3.20.

[13] Note that these limits are based on the cut-in and cut-out wind speeds of the turbines and therefore different then described in Section 1.3.

Table 3.22 Severe Sea States for WTG15.

Bin	$U_{hub,lower}$ (m/s)	$U_{hub,upper}$ (m/s)	$H_{m0,SSS}$ (m)	$T_{p,SSS}$ (s)		$H_{max,SSS}$ (m)	$T_{min,SSS}$ (s)	$T_{max,SSS}$ (s)
				Mean	Mean+StDev			
1	0	1.5	6.72	11.93	13.73	12.48	12.52	16.13
2	1.5	2.5	6.87	13.22	14.80	12.77	12.66	16.31
3	2.5	3.5	7.04	12.97	14.70	13.08	12.82	16.51
4	3.5	4.5	7.20	13.36	15.09	13.38	12.96	16.70
5	4.5	5.5	7.36	14.46	15.83	13.69	13.11	16.89
6	5.5	6.5	7.53	13.84	15.49	13.99	13.26	17.08
7	6.5	7.5	7.69	14.12	15.73	14.29	13.40	17.26
8	7.5	8.5	7.85	14.84	16.23	14.60	13.54	17.44
9	8.5	9.5	8.02	14.55	15.93	14.90	13.68	17.62
10	9.5	10.5	8.18	14.60	15.99	15.20	13.82	17.80
11	10.5	11.5	8.34	14.59	16.03	15.51	13.96	17.98
12	11.5	12.5	8.51	15.25	16.55	15.81	14.09	18.15
13	12.5	13.5	8.67	14.82	16.25	16.11	14.23	18.33
14	13.5	14.5	8.83	14.79	16.27	16.42	14.36	18.50
15	14.5	15.5	9.00	14.45	15.93	16.72	14.49	18.67
16	15.5	16.5	9.16	14.71	16.05	16.97	14.60	18.81
17	16.5	17.5	9.32	14.30	15.80	17.14	14.67	18.90
18	17.5	18.5	9.48	15.39	16.61	17.32	14.75	19.00
19	18.5	19.5	9.65	14.55	15.96	17.50	14.82	19.10
20	19.5	20.5	9.81	15.89	17.08	17.67	14.90	19.19
21	20.5	21.5	9.97	14.26	15.77	17.84	14.97	19.29
22	21.5	22.5	10.13	14.25	15.84	18.02	15.04	19.38
23	22.5	23.5	10.30	14.14	15.65	18.19	15.12	19.47
24	23.5	24.5	10.46	14.28	15.81	18.36	15.19	19.57
25	24.5	25.5	10.62	14.92	16.16	18.53	15.26	19.65
26	25.5	26.5	10.79	14.26	15.67	18.71	15.33	19.75
27	26.5	27.5	10.95	14.32	15.45	18.88	15.40	19.84
28	27.5	28.5	11.11	14.59	15.96	19.05	15.47	19.93
29	28.5	29.5	11.27	14.59	15.96	19.22	15.54	20.02
30	29.5	30.5	11.43	14.59	15.95	19.38	15.60	20.10
31	30.5	31.5	11.59	14.59	15.95	19.55	15.67	20.19
32	31.5	32.5	11.77	14.59	15.94	19.74	15.74	20.28
33	32.5	33.5	11.92	14.59	15.94	19.89	15.81	20.36
34	33.5	46.5	11.99	14.59	15.94	19.97	15.84	20.40

Table 3.23 Severe Sea States for WTG08.

Bin	$U_{hub,lower}$ (m/s)	$U_{hub,upper}$ (m/s)	$H_{m0,SSS}$ (m)	$T_{p,SSS}$ (s)		$H_{max,SSS}$ (m)	$T_{min,SSS}$ (s)	$T_{max,SSS}$ (s)
				Mean	Mean+StDev			
1	0	1.5	5.62	12.11	13.97	10.45	11.46	14.76
2	1.5	2.5	5.73	12.68	14.39	10.65	11.57	14.90
3	2.5	3.5	5.85	13.29	14.99	10.87	11.68	15.05
4	3.5	4.5	5.96	13.61	15.34	11.08	11.80	15.20
5	4.5	5.5	6.08	13.65	15.36	11.30	11.91	15.35
6	5.5	6.5	6.19	13.86	15.59	11.51	12.02	15.49
7	6.5	7.5	6.31	14.22	15.83	11.72	12.13	15.63
8	7.5	8.5	6.42	14.01	15.73	11.93	12.24	15.77
9	8.5	9.5	6.54	14.41	15.90	12.15	12.35	15.91
10	9.5	10.5	6.65	15.22	16.30	12.36	12.46	16.05
11	10.5	11.5	6.76	14.56	16.10	12.57	12.57	16.19
12	11.5	12.5	6.88	15.12	16.52	12.78	12.67	16.32
13	12.5	13.5	6.99	14.46	16.03	13.00	12.78	16.46
14	13.5	14.5	7.11	14.53	16.10	13.21	12.88	16.59
15	14.5	15.5	7.22	15.52	16.62	13.42	12.98	16.72
16	15.5	16.5	7.33	14.48	16.02	13.63	13.08	16.86
17	16.5	17.5	7.45	15.39	16.71	13.84	13.19	16.99
18	17.5	18.5	7.56	15.52	16.74	14.06	13.29	17.12
19	18.5	19.5	7.68	15.17	16.57	14.27	13.39	17.24
20	19.5	20.5	7.79	15.51	16.88	14.48	13.49	17.37
21	20.5	21.5	7.90	15.16	16.48	14.69	13.58	17.50
22	21.5	22.5	8.02	15.34	16.79	14.90	13.68	17.63
23	22.5	23.5	8.13	14.29	15.83	15.12	13.78	17.75
24	23.5	24.5	8.25	15.08	16.61	15.33	13.87	17.87
25	24.5	25.5	8.36	14.27	15.78	15.53	13.97	17.99
26	25.5	26.5	8.48	14.28	15.82	15.76	14.07	18.12
27	26.5	27.5	8.59	13.97	15.33	15.97	14.16	18.24
28	27.5	28.5	8.71	14.77	16.17	16.18	14.25	18.36
29	28.5	29.5	8.82	14.78	16.17	16.35	14.33	18.46
30	29.5	30.5	8.93	14.79	16.18	16.47	14.38	18.53
31	30.5	31.5	9.04	14.80	16.18	16.59	14.44	18.60
32	31.5	32.5	9.16	14.81	16.18	16.73	14.49	18.67
33	32.5	33.5	9.27	14.82	16.19	16.84	14.54	18.74
34	33.5	46.5	9.32	14.82	16.19	16.89	14.57	18.77

Table 3.24 Severe Sea States for WTG11.

Bin	$U_{hub,lower}$ (m/s)	$U_{hub,upper}$ (m/s)	$H_{m0,SSS}$ (m)	$T_{p,SSS}$ (s)		$H_{max,SSS}$ (m)	$T_{min,SSS}$ (s)	$T_{max,SSS}$ (s)
				Mean	Mean+StDev			
1	0	1.5	4.40	13.15	14.77	8.17	10.13	13.05
2	1.5	2.5	4.44	13.29	14.98	8.25	10.18	13.11
3	2.5	3.5	4.49	13.58	15.28	8.34	10.23	13.18
4	3.5	4.5	4.53	13.25	14.98	8.43	10.29	13.25
5	4.5	5.5	4.58	13.95	15.60	8.51	10.34	13.32
6	5.5	6.5	4.63	14.65	16.03	8.60	10.39	13.39
7	6.5	7.5	4.68	14.81	16.18	8.69	10.45	13.46
8	7.5	8.5	4.72	15.05	16.30	8.78	10.50	13.52
9	8.5	9.5	4.77	14.43	15.89	8.86	10.55	13.59
10	9.5	10.5	4.82	14.50	16.01	8.95	10.60	13.66
11	10.5	11.5	4.86	15.11	16.40	9.04	10.65	13.72
12	11.5	12.5	4.91	15.01	16.32	9.12	10.70	13.79
13	12.5	13.5	4.96	14.89	16.24	9.21	10.76	13.86
14	13.5	14.5	5.00	15.32	16.50	9.30	10.81	13.92
15	14.5	15.5	5.05	14.71	16.03	9.38	10.86	13.99
16	15.5	16.5	5.10	14.78	16.13	9.47	10.91	14.05
17	16.5	17.5	5.14	14.64	16.00	9.56	10.96	14.11
18	17.5	18.5	5.19	15.53	16.68	9.65	11.01	14.18
19	18.5	19.5	5.24	15.20	16.42	9.73	11.06	14.24
20	19.5	20.5	5.28	14.69	16.12	9.82	11.11	14.31
21	20.5	21.5	5.33	15.12	16.47	9.91	11.15	14.37
22	21.5	22.5	5.38	14.72	16.21	9.99	11.20	14.43
23	22.5	23.5	5.42	14.40	15.81	10.08	11.25	14.50
24	23.5	24.5	5.47	14.20	15.88	10.17	11.30	14.56
25	24.5	25.5	5.52	14.36	15.88	10.25	11.35	14.62
26	25.5	26.5	5.57	14.88	16.22	10.34	11.40	14.68
27	26.5	27.5	5.61	14.09	15.47	10.43	11.44	14.74
28	27.5	28.5	5.66	14.58	15.99	10.52	11.49	14.81
29	28.5	29.5	5.70	14.57	15.98	10.60	11.54	14.86
30	29.5	30.5	5.75	14.56	15.97	10.68	11.58	14.92
31	30.5	31.5	5.79	14.55	15.96	10.77	11.63	14.98
32	31.5	32.5	5.85	14.54	15.95	10.86	11.68	15.04
33	32.5	33.5	5.89	14.53	15.94	10.90	11.70	15.08
34	33.5	46.5	5.91	14.52	15.93	10.93	11.71	15.09

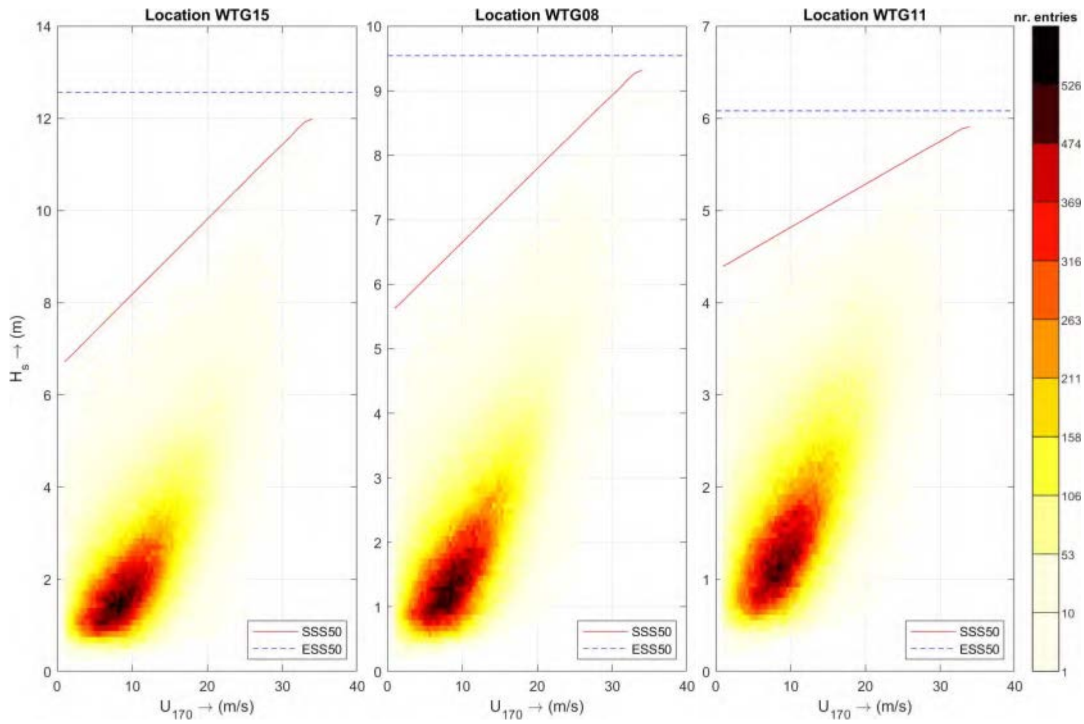

Figure 3.59 SSS results (red line) plotted over a density scatter plot of U_{170} vs. H_s for WTG15, WTG08 and WTG11 (left to right). The corresponding 50-year extreme H_s values (ESS) are represented by dashed blue lines.

3.5.6 Spectral form

From the analysis of several of the hindcast wave spectra we can conclude that the JONSWAP (Hasselmann et al., 1973) spectral form is suitable to describe the spectra at the turbine locations. The JONSWAP spectrum is therefore recommended for the parameterization of the wave spectral energy, S(f), given by

$$S(f) = \frac{ag^2}{(2\pi)^4} f^{-5} e^{\left(-\frac{5}{4}\left(\frac{f}{f_p}\right)^{-4}\right)} \gamma^{e^{(-0.5(f-fp/\sigma fp)^2)}}$$

where f is the wave frequency (1/T), T is the wave period, f_p is the spectral peak frequency ($1/T_p$), a is the generalised Phillips' constant,

$$a = 5 * \left(\frac{{H_s}^2 {f_p}^4}{g^2}\right) * (1 - 0.287 ln\gamma) * \pi^4$$

σ is the spectral width parameter (0.07 for $f \leq f_p$ and 0.09 for $f > f_p$) and γ is the peak enhancement factor.

The peak enhancement factor can be computed from the significant wave height and peak period values using Torsethaugen et al. (1984).

$$\gamma = e^{3.484\left(1-0.1975\mathrm{D}\frac{T_p^4}{H_s^2}\right)}$$

with D = 0.036 – 0.0056 $T_p/\sqrt{H_s}$ and capping γ between 1 and 7 (i.e. $1 \leq \gamma \leq 7$).

Figure 3.60 shows a few examples of JONSWAP fits to the computed spectra at the three turbine locations.

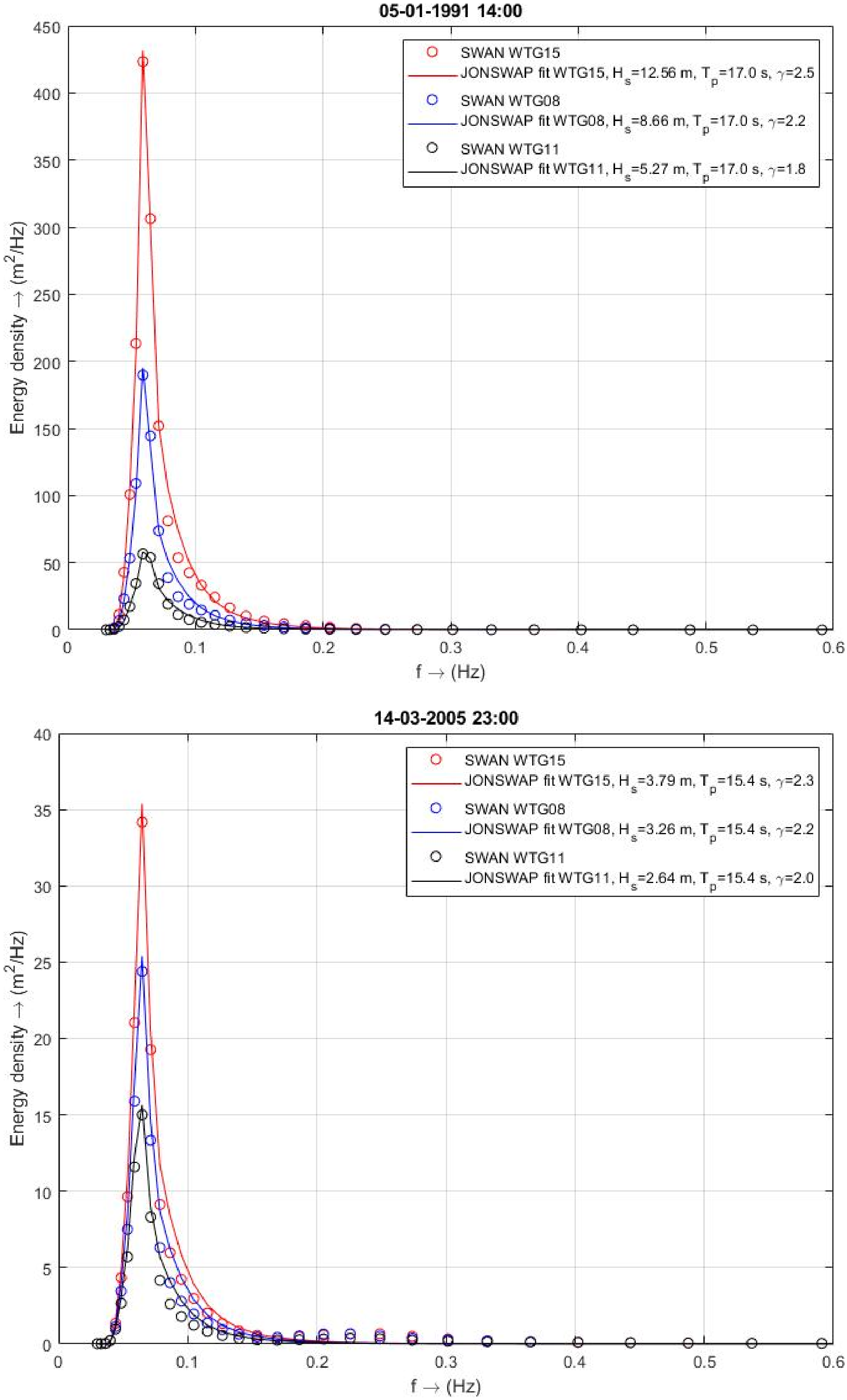

Figure 3.60 Examples of JONSWAP fits to extreme (top) and normal (bottom) wave conditions

3.5.7 Directional wave spreading

In this section we present the results of the analysis on the directional spreading distributions at the three considered turbine locations within SROWF (cf. Table 1.1) using the hindcast wave timeseries.

For the computations of forces on structural members the classification societies provide recommendations in terms of a directional spreading factor, Ø or F_s.

As given in DNVGL (2020), this factor can be taken as

$$F_s = \sqrt{(s^2 + s + 1)/((s+1)(s+2))}$$

with s being the directional spreading parameter or exponent of the wave directional spreading function

$$D(\theta) = \mathrm{A}\cos^{2s}(\theta/2)$$

where $\mathrm{A} = \Gamma(s+1)/\left[2\sqrt{\pi}\Gamma(s+1/2)\right]$ and Γ is the gamma function.

There is a direct relationship between the directional spreading parameter s and the SWAN model output DSpr in degrees (Holthuijsen, 2007), namely

$$DSpr = \frac{180}{\pi}\sqrt{\frac{2}{s+1}}$$

Using the expressions above, Figure 3.61 shows the variation of F_s with s and DSpr.

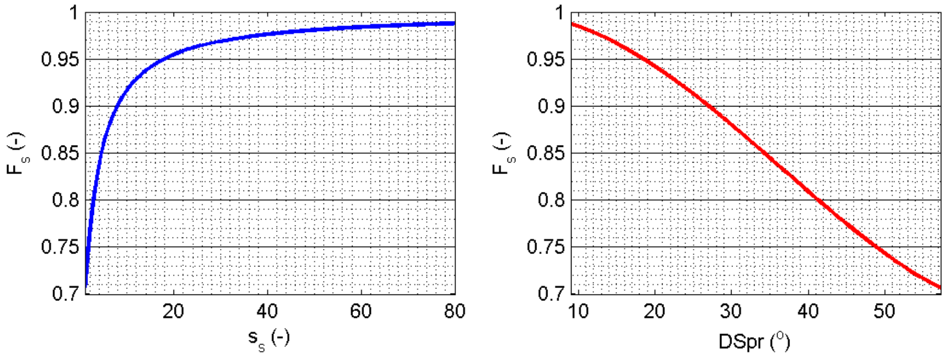

Figure 3.61 Relationship between F_s, s and DSpr.

Figure 3.62 shows the relations between DSpr and H_s at the three turbine locations. The panels show that at WTG15 the amount of directional spreading goes down with increasing wave heights to a value of about 26° (corresponding $F_s \approx 0.91$). This is also the case for WTG08, which goes down to about 32° (corresponding $F_s \approx 0.86$). For the relatively sheltered location WTG11, the amount of directional spreading goes up with increasing wave heights (due to wave dissipation effects and wave refraction) and reaches a more or less constant value of 55° (corresponding $F_s \approx 0.72$).

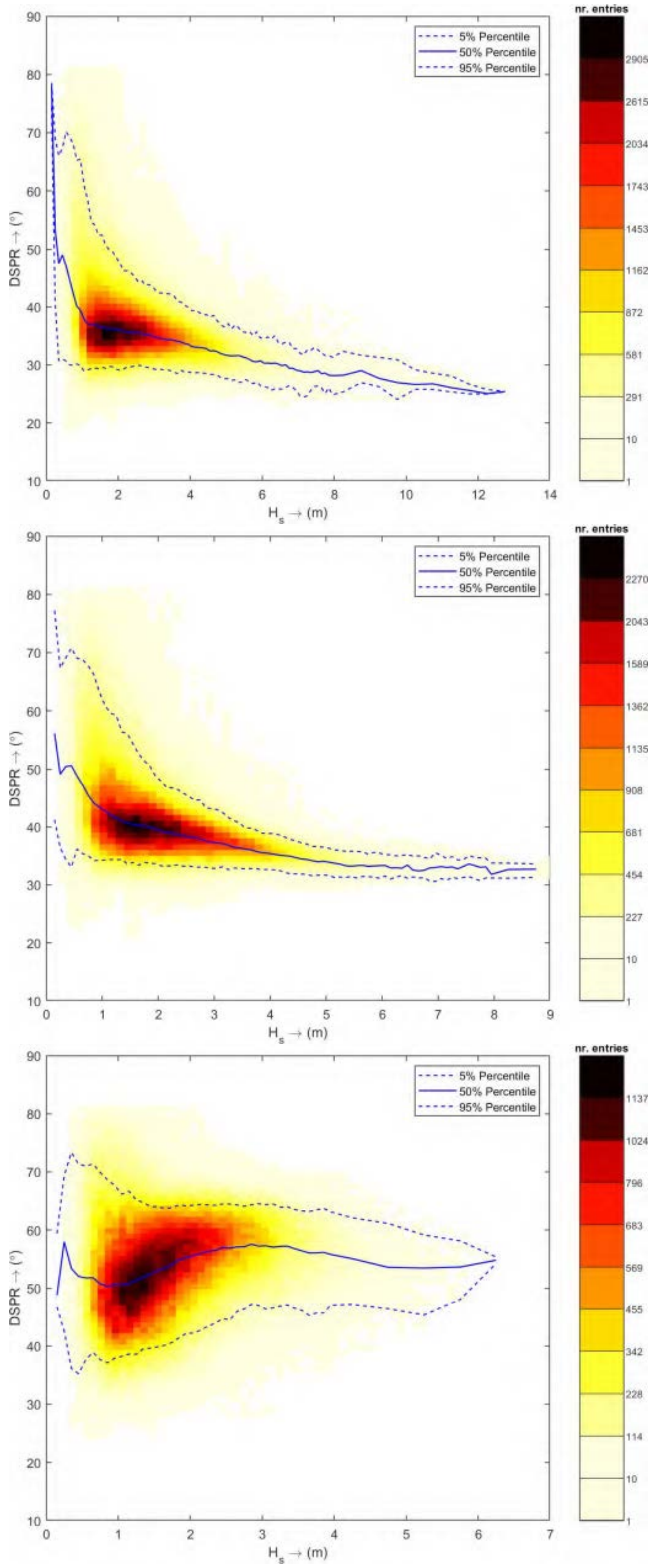

Figure 3.62 Directional wave spreading at WTG15 (top), WTG08 (middle) and WTG11 (bottom).

3.6 Climate change effects

3.6.1 Sea level rise

In order to obtain estimates of Sea Level Rise (SLR) in 50 and 100 years, we resort to the data from the *Intergovernmental Panel on Climate Change* (IPCC[14]). In IPCC's newest Assessment Report (AR6) different levels of greenhouse gas emissions (GHG) and other radiative forcings that might occur in the future and the impact of socioeconomic factors that may change over the next century, such as population, economic growth, education, urbanisation and the rate of technological development are considered in Shared Socioeconomic Pathways (SSPs[15]). The SSPs describe a total of nine different possible 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use. They comprise a stringent mitigation scenario (SSP1-2.6), two intermediate scenarios (SSP2-4.5 and SSP3-7.0) and one scenario with high GHG emissions (SSP5-8.5). Scenarios without additional efforts to constrain emissions ('baseline scenarios' or 'business-as-usual scenarios') lead to pathways ranging between SSP3-7.0 and SSP5-8.5. SSP1-2.6 is representative of a scenario that aims to keep global warming likely below 2°C above pre-industrial temperatures.

The AR6 projections of global mean sea level rise until 2150 (relative to 2000) for five SSP scenarios are presented in Figure 3.63 (IPCC, 2021). The figure shows a projected global mean sea level rise ranging between 0.3 m and 1.0 m by 2100.

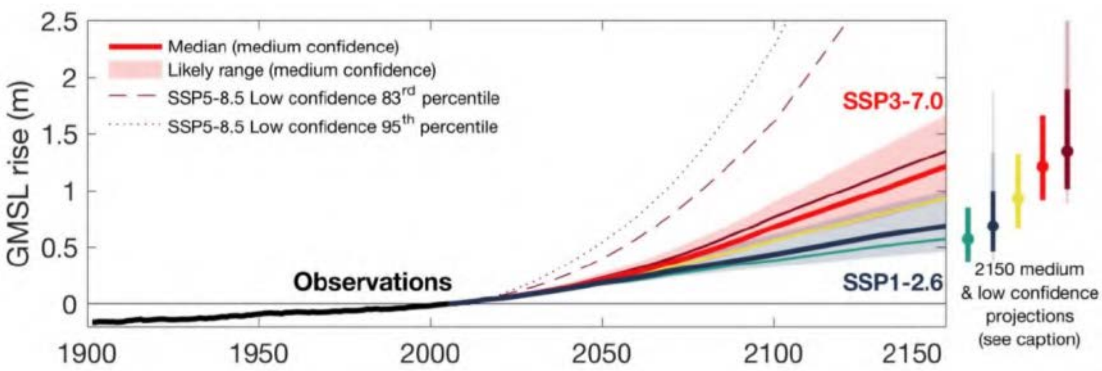

Figure 3.63 Global mean sea level change from 1900 to 2150, observed (1900–2018) and projected under the SSP scenarios (2000–2150), relative to a 1995–2014 baseline. Solid lines show median projections. Shaded regions show likely ranges for SSP1-2.6 and SSP3-7.0. Dotted and dashed lines show respectively the 83rd and 95th percentile low-confidence projections for SSP5-8.5. Bars at right show likely ranges for SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 in 2150. Lightly shaded thick/thin bars show 17th–83rd/5th–95th percentile low-confidence ranges in 2150 for SSP1-2.6 and SSP5-8.5. Low-confidence range for SSP5-8.5 in 2150 extends to 4.8/5.4 m at the 83rd/95th percentile. (from: IPCC, 2021, Box TS.4, Figure 1a)

Sea level rise is not globally uniform and varies regionally. The projections of sea level rise in the Skerd Rocks region were extracted from the *Sea Level projection Tool*[16] developed by NASA (Garner et al., 2021). These are given in Figure 3.64 for the intermediate scenario SSP2-4.5 and the high scenario SSP5-8.5. The corresponding sea level rise values for 2070 and 2120 relative to 2020 for SROWF are given in Table 3.25 Sea level rise values (in m) relative to 2020 for SROWF for 50- and 100-year time horizons (2070 and 2120) according to IPCC (2021).

[14] https://www.ipcc.ch/

[15] The illustrative scenarios are referred to as SSPx-y, where 'SSPx' refers to the Shared Socio-economic Pathway or 'SSP' describing the socio-economic trends underlying the scenario, and 'y' refers to the approximate level of radiative forcing (in W m^{-2}) in 2100.

[16] https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

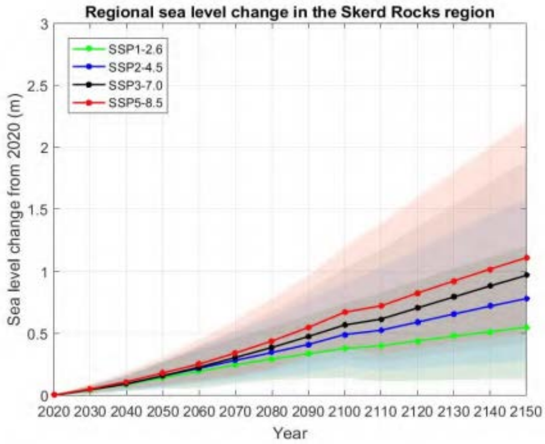

Figure 3.64 Sea level change (in m) relative to 2020 for the Skerd Rocks region for SSP1-2.6, SSP2- 4.5, SSP3-7.0 and SSP5- 8.5 according to IPCC (2021). The full lines indicate the 50th percentiles and the shadows the 5th to 95th percentile range.

It is noted that SLR has not been included in the numerical modelling performed for this study. With the median SLR value in 50 years ranging between 0.25 m and 0.34 m and the 100 years value ranging between 0.44 m and 0.82 m, the effect on the metocean parameters is expected to be rather limited. A larger available depth will likely result in slightly lower extreme current speeds and slightly higher extreme significant wave heights.

For a 50-year horizon (i.e. the approximate lifetime of the windfarm) the median of SSP2-4.5 (0.28m) is rather close to that of SSP5-8.5 (0.34m). Even though corresponding to the most pessimistic scenario, given that it does not lead to overly conservative values, the median of SSP5-8.5 is recommended to be considered as the input SLR value for the design.

Table 3.25 Sea level rise values (in m) relative to 2020 for SROWF for 50- and 100-year time horizons (2070 and 2120) according to IPCC (2021).

SSP1-2.6	**Lower (5th percentile)**	**Median (50th percentile)**	**Upper (95th percentile)**
2070	0.10	0.25	0.46
2120	0.12	0.44	0.93
SSP2-4.5	**Lower (5th percentile)**	**Median (50th percentile)**	**Upper (95th percentile)**
2070	0.12	0.28	0.51
2120	0.22	0.59	1.18
SSP3-7.0	**Lower (5th percentile)**	**Median (50th percentile)**	**Upper (95th percentile)**
2070	0.15	0.30	0.54
2120	0.31	0.70	1.36
SSP5-8.5	**Lower (5th percentile)**	**Median (50th percentile)**	**Upper (95th percentile)**
2070	0.16	0.34	0.60
2120	0.38	0.82	1.59

3.6.2 Wind, surge and wave climates

In this study the wind, surge and wave climates were assumed to be stationary. It must be said that this assumption is not always valid/justified, as the detection of both decadal variability and long-term trends in different climate indicators, reported by several authors, suggests. The presently established global warming phenomenon can affect the stationarity of the wind, surge and wave climate (i) by causing changes in atmospheric circulation regimes which affect the wind climate and subsequently the wave and surge climate, and additionally for the waves (ii) by causing the sea level rise and hence directly affecting the severity of shallow water waves (see Section 3.6.2).

The most recent IPCC studies show, however, no indication of climate change significantly affecting the storminess (wind, waves and surges) the region. In fact most studies indicate either non-significant changes or a slight decrease in the extreme wave heights (Meucci et al. 2020 and Lemos et al. 2021).

3.7 Wave breaking and slamming assessment

3.7.1 Introduction

The objectives of the wave breaking and slamming assessment are to determine the probability of wave breaking and to evaluate, if breaking occurs, what is the wave breaker type (spilling or plunging) and whether wave slamming needs to be considered in the design. This is assessed for conditions with return periods of 1-, 10-, 50-, and 100-year at all 20 turbine (WTG) locations within the Skerd Rocks OWF. The coordinates of all turbines and platforms are given in Table 3.26 (these are shown in Figure 1.1).

Table 3.26 Turbine coordinates

Location-ID	Longitude (°E)	Latitude (°N)	Depth (mLAT)
WTG01	-9.9694929	53.2913971	-31.31
WTG02	-10.0068831	53.2760281	-39.73
WTG03	-9.9884031	53.2843593	-38.81
WTG04	-9.9514275	53.2840130	-24.48
WTG05	-9.9222027	53.2684981	-28.49
WTG06	-9.9376456	53.2759355	-26.18
WTG07	-9.9328864	53.2550114	-35.25
WTG08	-9.9483876	53.2487103	-40.46
WTG09	-9.9517655	53.2582033	-34.50
WTG10	-9.9567177	53.2682180	-29.86
WTG11	-9.9678154	53.2790192	-25.89
WTG12	-10.0259192	53.2671703	-49.74
WTG13	-10.0229753	53.2579397	-47.76
WTG14	-10.0012875	53.2616191	-36.35
WTG15	-10.0088562	53.2505132	-42.14
WTG16	-9.9844290	53.2543269	-41.66
WTG17	-9.9693316	53.2475450	-46.04
WTG18	-9.9888599	53.2442227	-57.53
WTG19	-9.9473127	53.2397588	-50.17
WTG20	-9.9672086	53.2387354	-43.23

The assessment of the breaker type and the probability of wave breaking requires information on the maximum wave height and the seabed slope along the direction of wave propagation. In addition to the deterministic approach already applied to determine maximum wave height, a stochastic approach will also be applied, which enables the inclusion of an uncertainty range in the computations and a more direct evaluation of the associated wave period. For all turbines the wave data at their respective locations were used for analyses.

3.7.2 Approach

3.7.2.1 Stochastic approach (zero-crossing)

The stochastic approach for the determination of the maximum wave height is based on the wave spectrum, which is assumed to have a JONSWAP shape. Sea state surface elevation timeseries are derived from the spectrum based on a set of random phases and with a duration of 1,500 times the peak period. To reduce uncertainties 1,000 realisations are computed for each considered spectrum (each wave direction sector and each foundation location). The 0.1% exceedance wave height is defined from the individual wave height distribution for each realisation. The associated wave period, T_{ass} (= T_{Hmax}), is taken as the zero-crossing wave period of the $H_{0.1\%}$ wave.

An example of the distribution of $H_{0.1\%}$ and T_{ass} is depicted in Figure 3.65. This shows a spread in both wave heights and wave periods, which will affect the assessment of both probability of wave breaking and the breaking type classification.

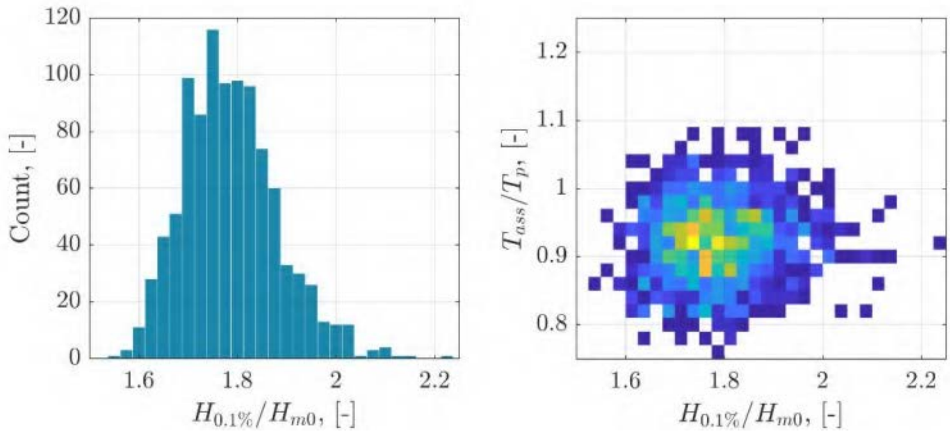

Figure 3.65 Example of the individual wave height distribution (left) and the scatter plot of $H_{0.1\%}/H_{m0}$ vs. T_{ass}/T_p (right). Warmer colours mean higher counts.

3.7.2.2 Determination of the seabed slope

The determination of the seabed slope is described in the following. At each location, all available bathymetry data within a radius of 500 m from the turbine location[17] are included. Next, the local gradient in the seabed (relative to its neighbouring points), $\nabla h = (\partial h/\partial x, \partial h/\partial y)$, is computed. Its 2-norm to calculate the gradient ($\|\nabla h\|_2$) is depicted in Figure 3.66, top-right. Each point is assigned a weight based on its proximity to all of the other points, i.e. a smaller weight, when close to other points and a larger weight when further away from other points in order to exclude the effect of data sparseness in the exceedance curves for seabed slopes (Figure 3.66, bottom-left).

The gradient expresses the magnitude and direction of the steepest slope in a given point, found through the approach within the random 70% of data points as explained in the paragraph above. The slope along the direction of wave propagation is achieved by a projection of these seabed gradient on the direction of wave propagation. A cumulative exceedance curve is constructed for each wave direction (Figure 3.66, bottom-right), where the individual weights for each point are applied in its constructive. The slope along a given direction is in general highly variable over the local area around the foundation location, to account for these variations, the quantiles of the seabed slope along the direction of propagation are considered in the analysis in Section 3.7.2.3. Since a negative slope is not applicable in the determination of the breaking probability (Section 3.7.2.3) nor the breaker type (Section 3.7.2.4), negative slopes are assigned a value of 0.

[17] A radius of 500 m is chosen to ensure that only bathymetrical features that might influence the waves locally are included. The value of 500 m is chosen pragmatically to include waves of various lengths.

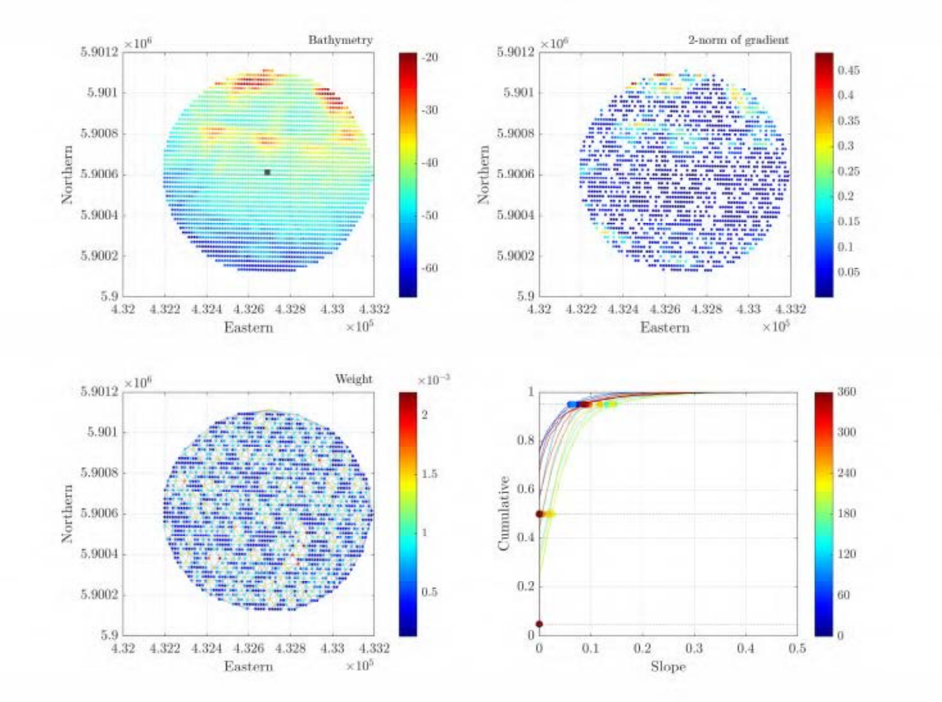

Figure 3.66 The local bathymetry and intermediate data sets for the slope definition around WTG08. Top-left: the local bathymetry. Top-right: the 2-norm of the seabed gradient. Bottom-left: the individual weight assigned to evaluation points. Bottom-right: cumulative exceedance curves for the seabed slope along the wave direction (identified with the colours).

3.7.2.3 Evaluation of breaking probability

The classification of the probability of breaking follows the expression of Goda (2010),

$$\frac{H_b}{h_b} = \frac{A}{h_b / L_0}\left\{1 - \exp\left[-1.5\pi \frac{h_b}{L_0}\left(1 + 15\tan^{4/3}\alpha\right)\right]\right\}$$

where A is the coefficient that needs to be determined. The probability of breaking, P_b, is assigned a value of 0% for $A \leq 0.12$ and the probability of breaking is assigned a value of 100% for $A = 0.18$ and is taken to vary linearly for $A \in [0.12{,}0.18]$ (Goda, 2010). The method by Goda (2010) is limited to the maximum wave height encountered in a sea state. Here $H_b = H_{0.1\%}$ is used and L_0 is the deep-water wave length .($L_0 = g/(2\pi)\,T_{ass}^2$) computed using the wave period associated with H_b, T_{ass}.

The local water depth, h_b, is determined from the seabed level plus the associated water level. $\tan\alpha$ is known from the definition of the seabed slope (the bathymetry on a transect taken along the wave direction) as explained in Section 3.7.2.2.

3.7.2.4 Definition of breaker type

The classification of the breaker type (spilling, plunging, surging) is done using the Iribarren number (also referred to as surf-similarity parameter) in accordance with the IEC-61400-3 standard (IEC, 2009), see Table 3.27.

Table 3.27 Classification of breaker type based on Iribarren number (IEC-61400-3).

Spilling	Plunging	Surging
$\boldsymbol{\xi_b < 0.40}$	$0.40 \leq \xi_b \leq 2.0$	$\xi_0 > 2.0$

The Iribarren number, ξ_b, is defined as

$$\xi_b = \frac{\tan\alpha}{\sqrt{H_b / L_0}} \quad ,$$

where L_0 is the deep-water wave length, α is the local slope of the seabed along the direction of wave propagation and H_b is the breaking wave height, assumed to be equal to $H_{0.1\%}$. Note that this assumption means that the $H_{0.1\%}$ might not be a breaking wave, so the interpertation of ξ_b must be combined with that of the probability of wave breaking (P_b). It is also noted that for the case of a negative slope along the direction of wave propagation, the Iribarren number is set to zero.

3.7.2.5 Wave slamming

The recommendation on whether or not to incorporate wave slamming in the design is based on the findings of Paulsen et al. (2019). Paulsen et al. (2019) investigated the influence of sand waves and current on the wave slamming on monopile-type foundation in irregular sea states. Paulsen et al. (2019) was the public deliverable from the Joint Industry Project JIP WiFi I&II and the work package was executed by Deltares.

Figure 3.67 describes according to Paulsen et al. (2019) the probability of slamming as a function of the sea state steepness parameter, $R = \bar{k}H_s \simeq \bar{k}H_{m0}$, where $\bar{k}$ is the linear wave number based on the $T_{m0,1}$ wave period. There is considerable scatter in the plot, however, the data does show increasing probability of slamming with increasing R. Accordingly, in this work the incorporation of slamming is recommend for R > 0.3. Note, however, that the probability of slamming on the foundation is generally smaller than the probability of wave breaking at or in the vicinity of the foundation.

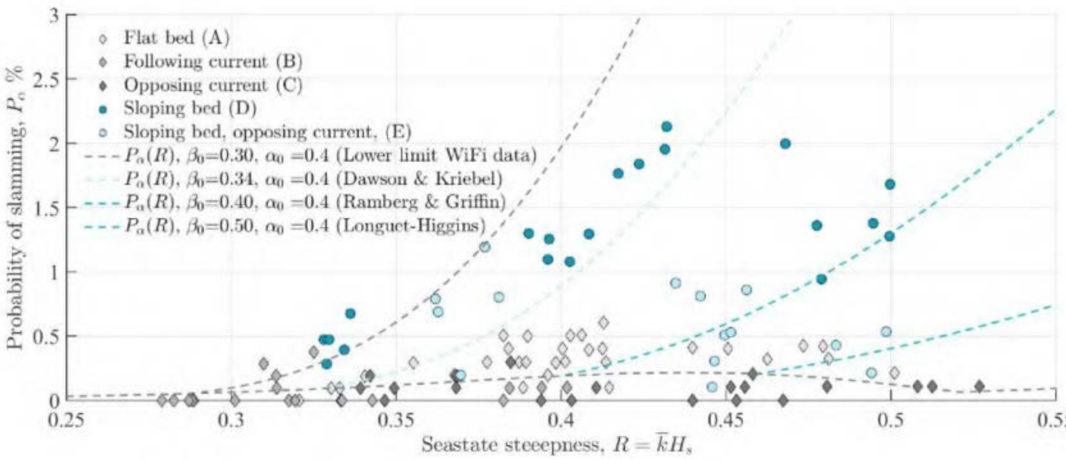

Figure 3.67 The probability of slamming as a function of the sea state steepness parameter, R. Taken from Paulsen et al. (2019).

3.7.3 Results

The analyses need as input the significant wave height return values and associated peak wave periods at each of the 20 WTG locations for the different return periods and directional sectors. Other than at the reference locations (Section 3.5.4), the significant wave height return value estimates were obtained for the purposes of this assesment using the Annual Maxima approach (Caires, 2016).

Figure 3.68 to Figure 3.70 show for the 50-year return period the directional output of the breaking wave and slamming assessment at WTG15, WTG08 and WTG11. The plots for all

WTG locations and 1-, 10-, 50- and 100-yr return periods are given in Appendix F.2. To help visualization, the omni-directional slamming results for all return periods are spatially summarized in Figure 3.72 to Figure 3.74. These figures show that wave slamming should be accounted for at all turbine locations for at least one of the directional sectors. Recall that the decision on whether or not to consider slamming should be made taking the breaking probability into account. The corresponding directional figures are presented separately in Appendix F.1.

The following conclusions are derived from the analysis of the figures:

- For all locations, the breaker type and breaking probability (middle and bottom panels) computed by the two different methods are compatible.
- For a return period of 1 year and for all turbine locations, there is no need to consider wave slamming.
- For turbines WTG12, WTG13, WTG15, WTG19 and WTG20 and a return period of 10 years there is at least one directional sector for which slamming should be considered. For a return period of 50 years, this is also the case for WTG18 and for a return period of 100 years also the case at WTG17.
- Based on the Iribarren number, the breaker type is most likely spilling breakers (median line generally well below 0.4), but there is a relatively large scatter in the values due to the large bed slope variations.
- Location WTG 15 is the only one of the reference locations for which the 50-yr breaking probability is higher than 0.2 and only for the 240° sector. This is also the only sector for which the steepness of the waves may lead to slamming.
- Note that in the whole region, given that the bed gradients can be high and the wave steepnessess are generally low, the Iribarren numbers can be high, the breaking probabilities are generally low and often with no need to account for slamming.

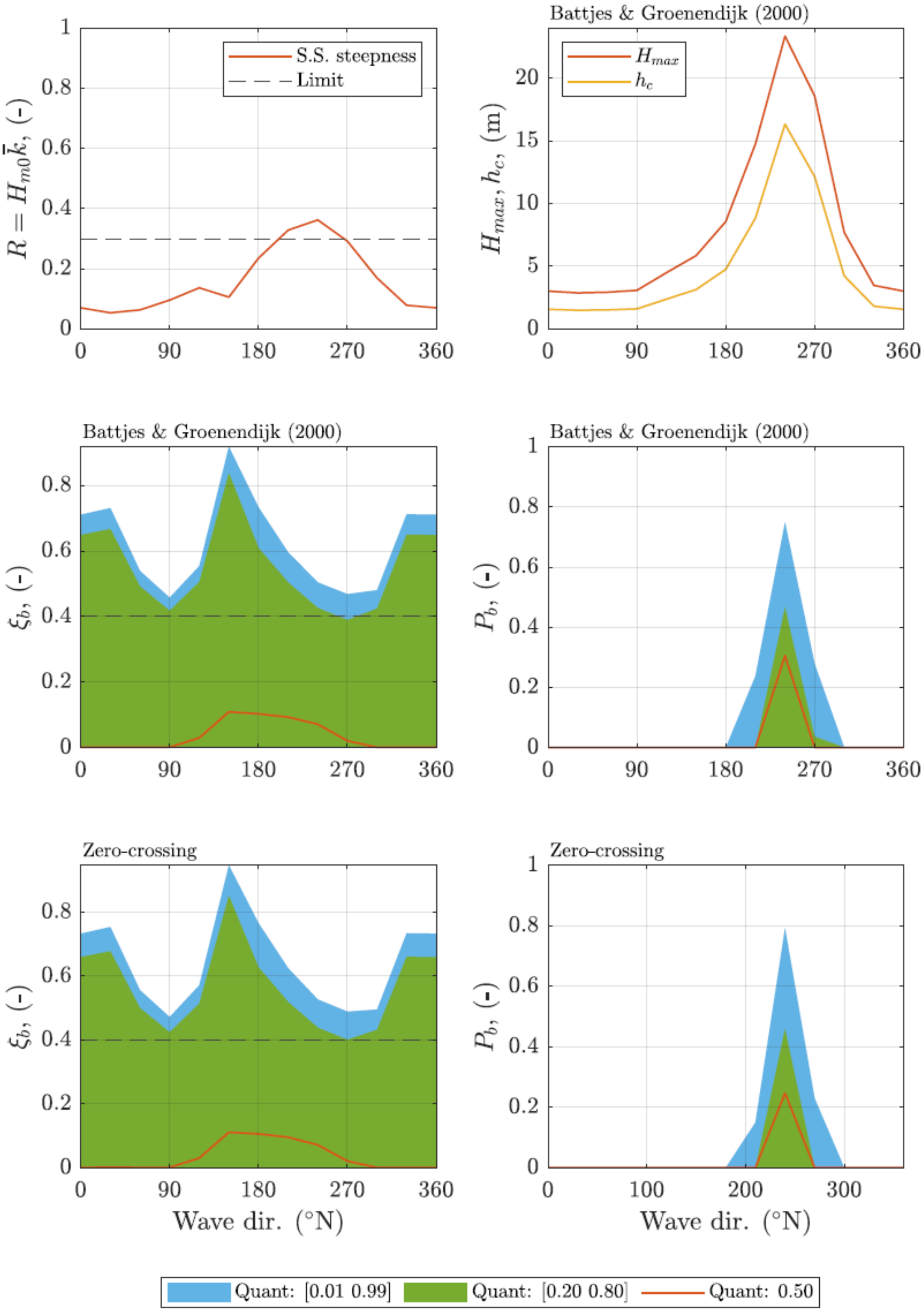

Figure 3.68 Directional output of the breaking wave and slamming assessment for turbine location WTG15 for 50-year return period environmental characteristics. Top left panel: The sea state steepness with a threshold of 0.3 (dashed line). Top right panel: The maximum wave and crest height. Middle and lower-left panels: The breaker type according to Iribarren for both the Battjes and Groenendijk (2000) and the zero-crossing approach. Middle and lower-right panels: The breaking probability for both aforementioned approaches.

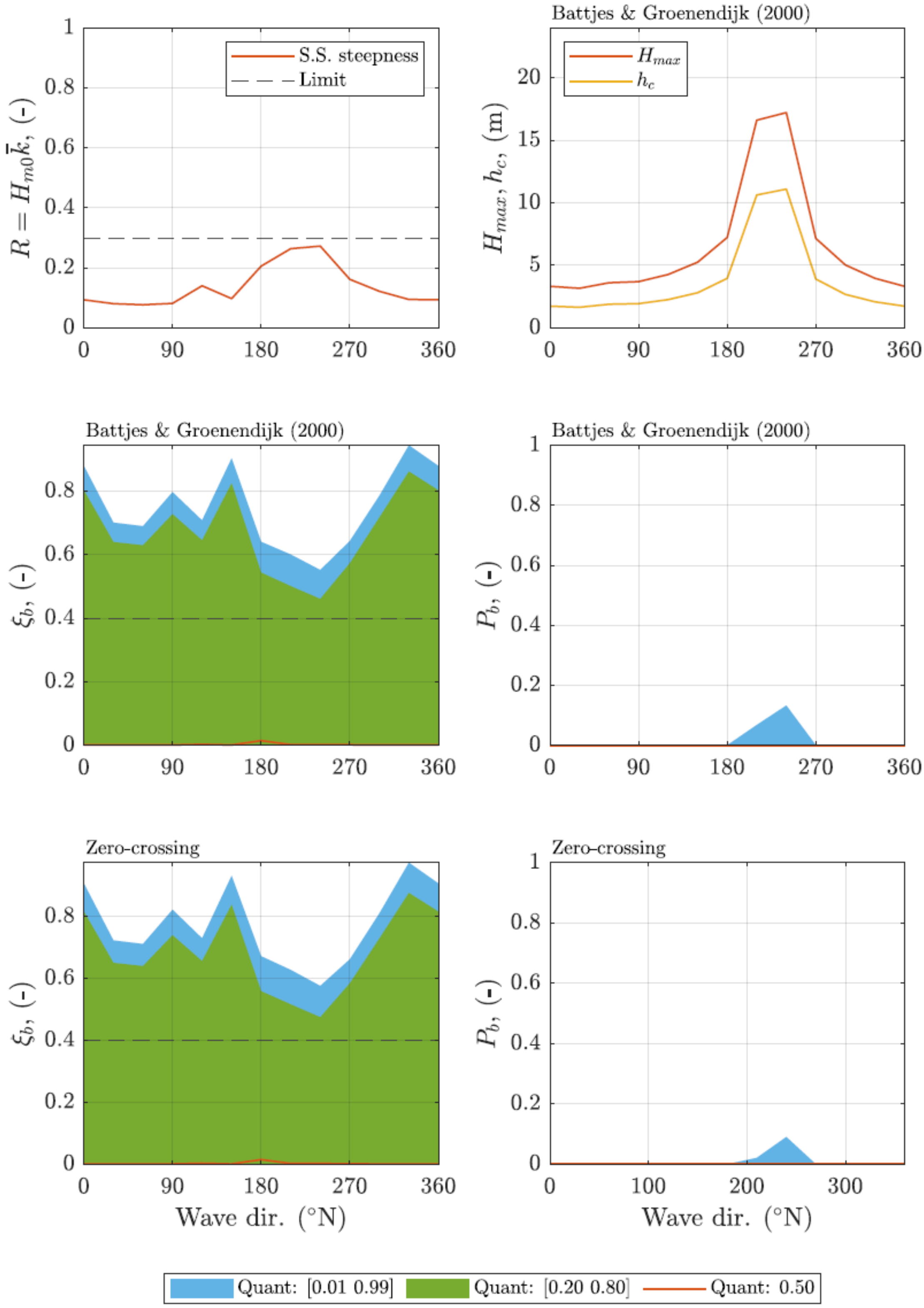

Figure 3.69 Directional output of the breaking wave and slamming assessment for turbine location WTG08 for 50-year return period environmental characteristics. Top left panel: The sea state steepness with a threshold of 0.3 (dashed line). Top right panel: The maximum wave and crest height. Middle and lower-left panels: The breaker type according to Iribarren for both the Battjes and Groenendijk (2000) and the zero-crossing approach. Middle and lower-right panels: The breaking probability for both aforementioned approaches.

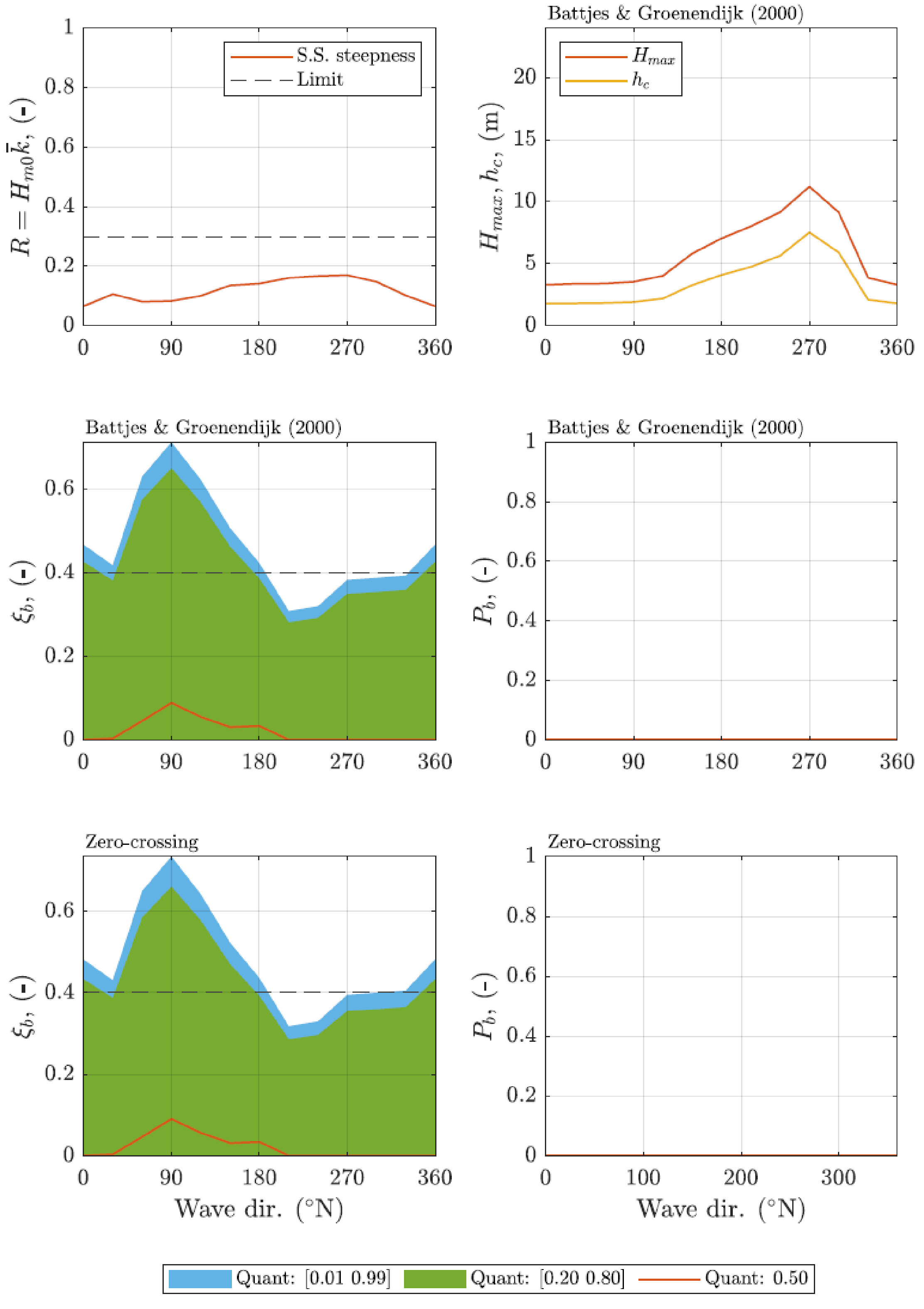

Figure 3.70 Directional output of the breaking wave and slamming assessment for turbine location WTG11 for 50-year return period environmental characteristics. Top left panel: The sea state steepness with a threshold of 0.3 (dashed line). Top right panel: The maximum wave and crest height. Middle and lower-left panels: The breaker type according to Iribarren for both the Battjes and Groenendijk (2000) and the zero-crossing approach. Middle and lower-right panels: The breaking probability for both aforementioned approaches.

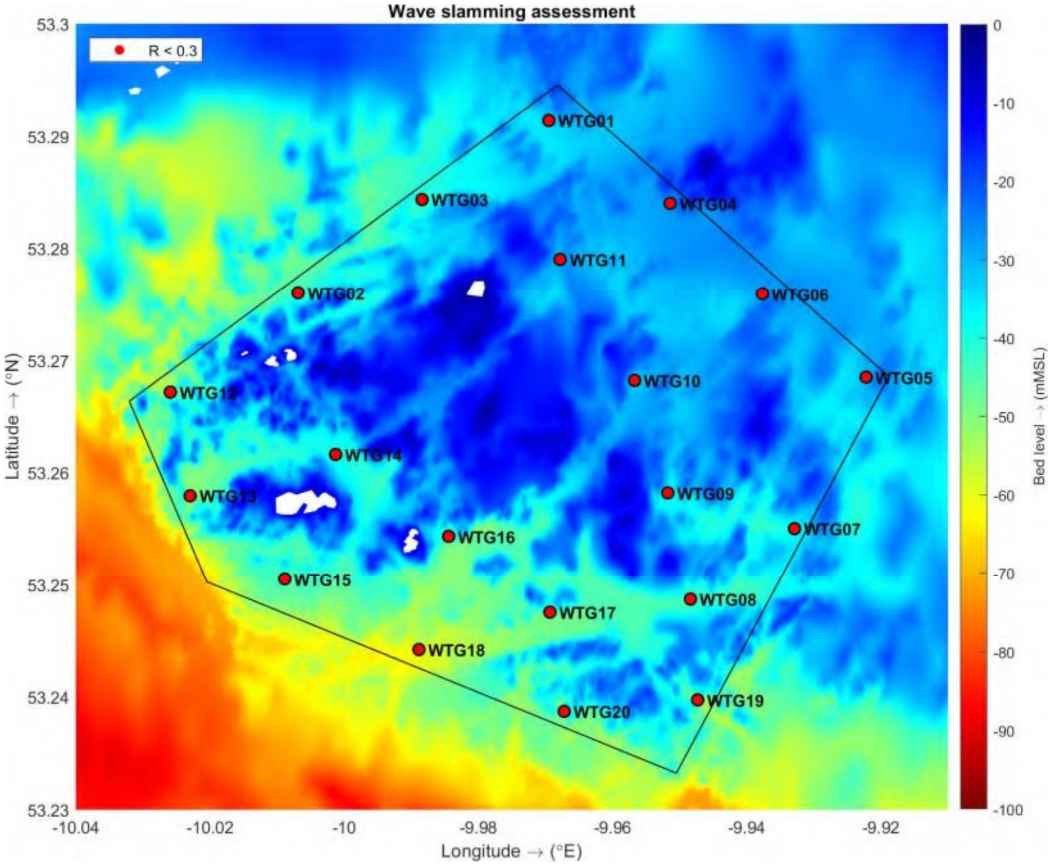

Figure 3.71 1-year omni-directional slamming analysis.

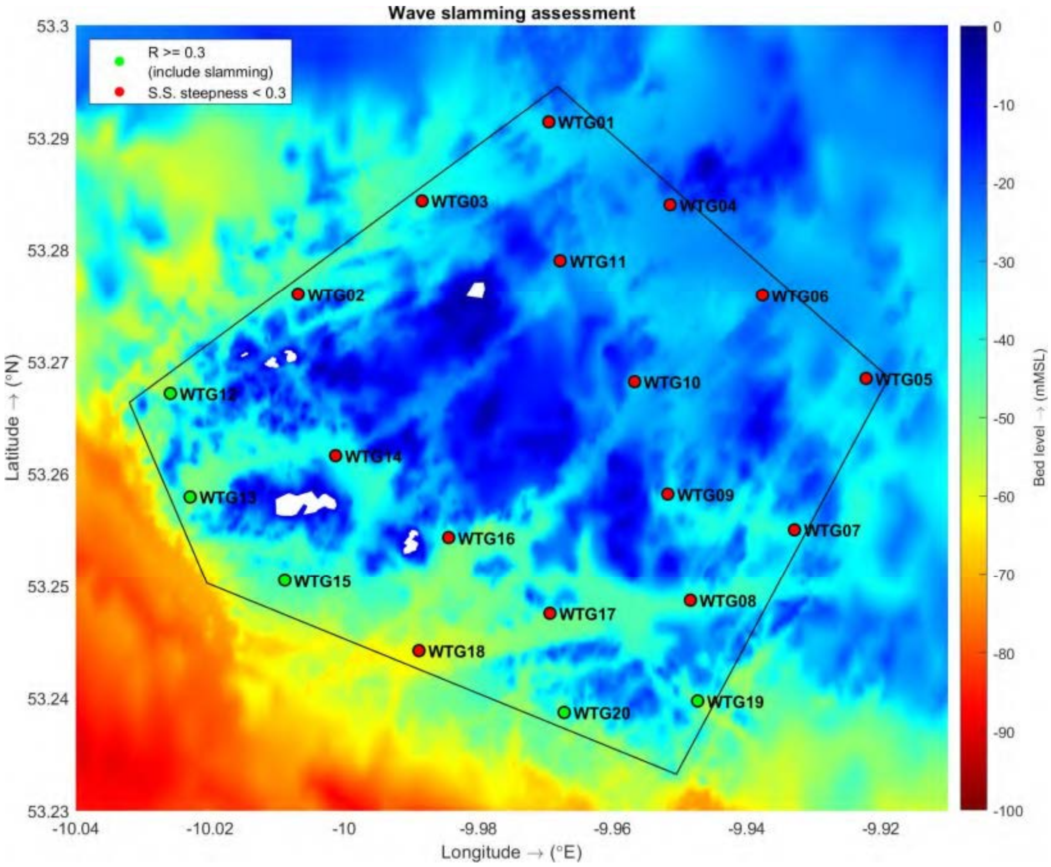

Figure 3.72 10-year omni-directional slamming analysis.

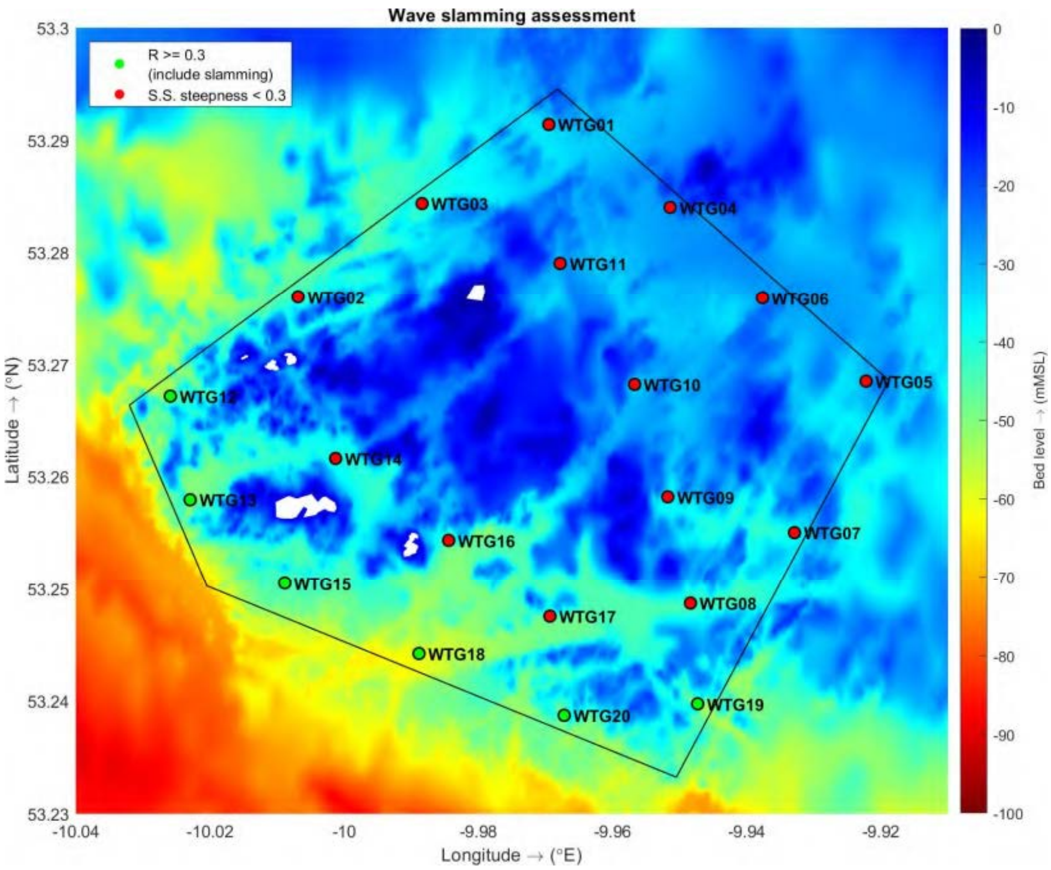

Figure 3.73 50-year omni-directional slamming analysis.

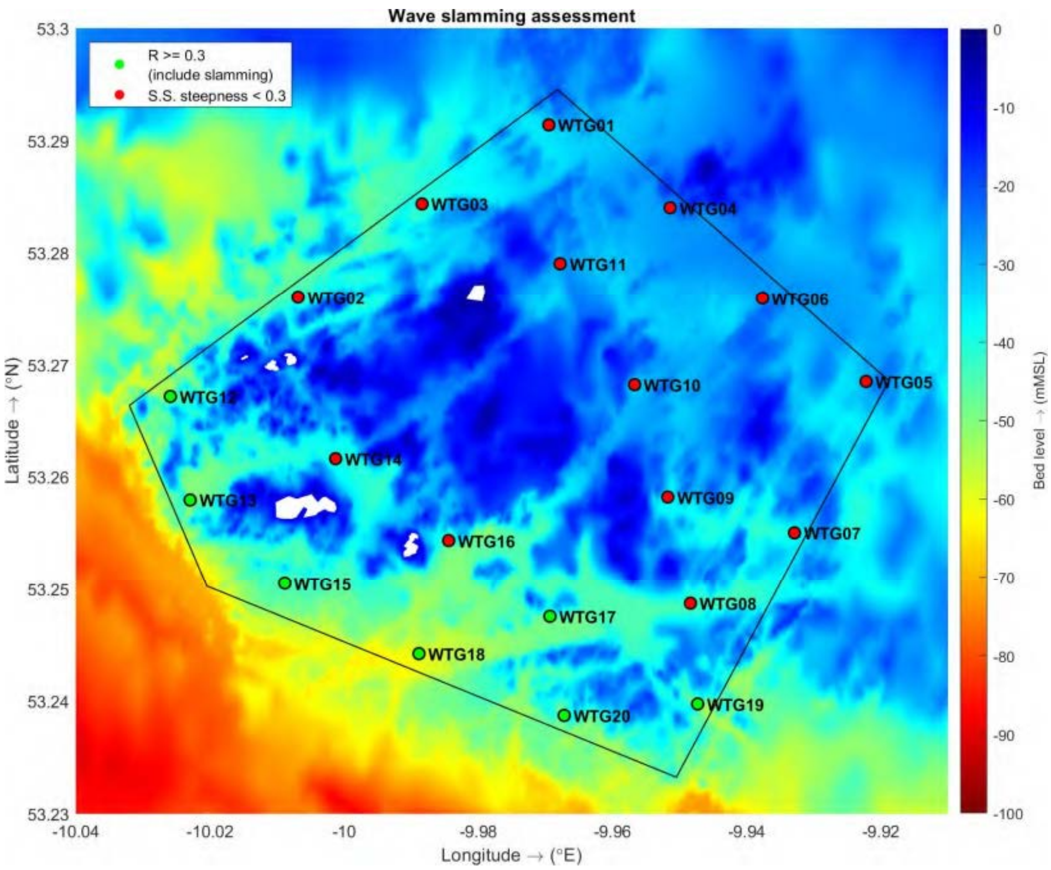

Figure 3.74 100-year omni-directional slamming analysis.

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Appendices

A Error statistics

A.1 Introduction

A particularity of certain environmental data (e.g. wave data) is that they can be classified into *linear data* (*e.g.* mean wave period and significant wave height) and *circular data* (*e.g.* mean wave direction and directional spread), and this distinction has to be taken into consideration when carrying out error analysis (Van Os and Caires, 2011). The statistical techniques for dealing with these two types of data are different – circular (or directional) data require a special approach. Basic concepts of statistical analysis of circular data are given in the books of Mardia (1972) and Fisher (1993).

A.2 Linear variables

Differences between linear variables are often quantified using the following standard statistics:

- the bias: $\bar{y} - \bar{x}$;
- the root-mean-square error: $RMSE = \sqrt{n^{-1} \sum (y_i - x_i)^2}$;
- the standard deviation: $\sigma = \sqrt{n^{-1} \sum \left[(y_i - \bar{y})(x_i - \bar{x}) \right]^2}$;
- the correlation coefficient: $\rho = \sum \left[(x_i - \bar{x})(y_i - \bar{y}) \right] \Big/ \sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}$;
- the symmetric slope: $r = \sqrt{\sum x_i^2 / \sum y_i^2}$.

In all these formulae x_i usually represents observations (or the dataset which is considered less uncertain or baseline), y_i represents the model results (or the dataset which is considered more uncertain or with a certain deviation from the baseline results) and n the number of observations.

A.3 Circular variables

If we compute an average of angles as their arithmetic mean, we may find that the result is of little use as a statistical location measure. Consider for instance the case of two angles of 359º and 1º; their arithmetic mean is 180º, when in reality 359º is only two degrees away from 1º and the mid direction between the two is 0º. This phenomenon is typical for circular data and illustrates the need for special definitions of statistical measures in general.

When dealing with circular data, each observation is considered as unit vector, and it requires vector addition rather than ordinary (or scalar) addition to compute the average of angles, the so-called mean direction.

Writing

$$C_n = \sum_{i=1}^{n} \cos x_i \quad \text{and} \quad S_n = \sum_{i=1}^{n} \sin x_i ,$$

the *sample resultant vector* R_n of a sample $\mathbf{x} = \{x_i, i = 1, \ldots, n\}$ is defined as

$$R_n = \sqrt{C_n^2 + S_n^2}\,,$$

and its *sample mean direction* $\bar{x} \equiv \bar{x}_n$ as the direction of R_n :

$$\bar{x} = TAN^{-1}(S_n / C_n) \tag{A.1}$$

where $TAN^{-1}(S_n/C_n)$ is the inverse of the tangent of (S_n/C_n) in the range [0, 2π [, *i.e.*,

$$TAN^{-1}(S_n/C_n) := \begin{cases} \tan^{-1}(S_n/C_n), & S_n > 0,\ C_n > 0 \\ \tan^{-1}(S_n/C_n) + \pi, & C_n < 0 \\ \tan^{-1}(S_n/C_n) + 2\pi, & S_n < 0,\ C > 0. \end{cases} .$$

The *sample mean resultant length* of $\mathbf{x} = \{x_i,\ i = 1,\ldots,n\}$ is defined by

$$\bar{R}_n = R_n / n,\ \ 0 \le \bar{R} \le 1.$$

If $\bar{R}_n = 1$, then all angles coincide.

Eq. (A.1) can be used to compute the bias between two circular variables by substituting x_i by $y_i - x_i$ in Eq. (A.1). In a similar way, the root-mean-square error and standard deviation between two circular variables can be computed.

Since circular data are concentrated on [0^{o}, 360^{o}], and in spite of the analogies with the linear case, it makes no sense to consider a symmetric slope for circular data other than one.

There are several circular analogues of the correlation coefficient, but the most widely used is the one proposed by Fisher and Lee (1983), the so-called *T*-linear correlation coefficient. Given two sets $\mathbf{x} = \{x_i, i = 1,\ldots,n\}$, $\mathbf{y} = \{y_i, i = 1,\ldots,n\}$ of circular data, the *T-linear correlation coefficient* between **x** and **y** is defined by

$$\rho_T = \frac{\sum_{1 \le i < j \le n} \sin(x_i - x_j)\sin(y_i - y_j)}{\sqrt{\sum_{1 \le i < j \le n} \sin^2(x_i - x_j) \sum_{1 \le i < j \le n} \sin^2(y_i - y_j)}}.$$

This statistic satisfies $-1 \le \rho_T \le 1$, and its population counterpart (which is not given here but can be seen in Fisher and Lee, 1983) satisfies properties analogous to those of the usual population correlation coefficient for linear data: that is, the population counterpart achieves the extreme values -1 and 1 if and only if the two population variables involved are exactly ‘*T*-linear associated’, with the sign indicating discordant or concordant rotation, respectively (see Fisher (1993), p. 146, for these concepts).

For computational ease, we use an equivalent formula for ρ_T , given by Fisher (1993):

$$\rho_T = \frac{4(AB - CD)}{\sqrt{(n^2 - E^2 - F^2)}\sqrt{(n^2 - G^2 - H^2)}} ,$$

where

$$A = \sum_{i=1}^{n} \cos x_i \cos y_i \ , \ B = \sum_{i=1}^{n} \sin x_i \sin y_i \ ,$$

$$C = \sum_{i=1}^{n} \cos x_i \sin y_i \ , \ D = \sum_{i=1}^{n} \sin x_i \cos y_i \ ,$$

$$E = \sum_{i=1}^{n} \cos(2x_i) , \quad F = \sum_{i=1}^{n} \sin(2x_i) ,$$

$$G = \sum_{i=1}^{n} \cos(2y_i) , \quad H = \sum_{i=1}^{n} \sin(2y_i) .$$

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B Extreme value analysis

B.1 Approach

The extreme value analysis approach applied in this study is based on the Peaks-Over-Threshold (POT) method, e.g. (Coles, 2001). It consists of fitting the Generalized Pareto Distribution (GPD) to the peaks of clustered excesses over a threshold, the excesses being the observations in a cluster minus the threshold, and calculating return values by taking into account the rate of occurrence of clusters. Under very general conditions this procedure ensures that the data can have only three possible, albeit asymptotic, distributions (the three forms of the GPD) and, moreover, that observations belonging to different peak clusters are (approximately) independent. More precisely, the peaks of clustered excesses over a high threshold *u*, $y = z - u$, are assumed to occur in time according to a Poisson process with rate λ_u and to be independently distributed with a GPD, whose distribution function is given by

$$F_u(y) = \begin{cases} 1 - \left(1 + \xi \dfrac{y}{\sigma_u}\right)^{-1/\xi}, & \text{for } \xi \neq 0 \\ 1 - \exp\left(-\dfrac{y}{\sigma_u}\right), & \text{for } \xi = 0, \end{cases},$$

where $0 < y < \infty$, $\sigma_u > 0$ and $-\infty < \xi < \infty$. The two parameters of the GPD are called scale (σ_u) and shape (ξ) parameters. When $\xi = 0$ the GPD is said to have a type I tail and amounts to the exponential distribution with mean σ_u; when $\xi > 0$ it has a type II tail and it is the Pareto distribution; and when $\xi < 0$ it has a type III tail and it is a special case of the beta distribution. If $\xi < 0$, the support of the GPD has an upper bound, $-\sigma_u/\xi$, which is called the *upper end-point* of the GPD and is to be thought of as the upper-limit of the excesses, the upper limit of the variable of interest being then $u - \sigma_u/\xi$.

One of the main applications of extreme value theory is the estimation of the *m year (m-year) return value*, the value which is exceeded on average once every *m* years. The *m*-year return value based on a POT/GPD analysis, z_m, is given by[18]

$$z_m = \begin{cases} u + \dfrac{\sigma_u}{\xi}\{(\lambda_u m)^{\xi} - 1\}, & \text{for } \xi \neq 0 \\ u + \sigma_u \ln(\lambda_u m), & \text{for } \xi = 0. \end{cases}$$

Note that this expression is obtained by solving $(1 - F_u(y)) = \dfrac{1}{\lambda_u m}$ for *y* and then adding the threshold *u* to the result.

18. In this report the natural logarithm of x is written as ln(x).

The choice of threshold represents a trade-off between bias and variance: choosing too low a threshold is likely to violate the asymptotic basis of the model, leading to bias; a threshold which is too high will generate fewer excesses with which to estimate the model, leading to high variance. An important property of the POT/GPD approach is the threshold stability property: if a GPD is a reasonable model for excesses of a threshold u_0, then for a higher threshold u a GPD should also apply; the two GPD's have identical shape parameter and their scale parameters bear a simple relation. This property of the GPD was used to find the optimal threshold to fit a GPD model to the data.

The sample to be used in the POT method has to be extracted from the original timeseries in such a way that the data can be modelled as independent observations. This is done by a process of declustering in which only the peak (highest) observations in clusters of successive exceedances of a specified threshold are retained and, of these, only those which in some sense are sufficiently apart (so that they belong to more or less 'independent storms') are considered as belonging to the collection of POT points. Specifically, in the present application we have treated cluster maxima at a distance of less than 48 h apart as belonging to the same cluster (storm).

There are several methods available for the estimation of the parameters of the GPD. For the type of data we are concerned with in this report the method of Probability-Weighted Moments (PWM) represents an adequate choice (for details, see Hosking and Wallis, 1987, Hosking et al., 1985 and Caires, 2016). In order to provide reliable asymmetric confidence bands, the method of PWM was combined with adjusted bootstrap estimates (see Coles and Simiu, 2003 and Caires, 2007) for computing confidence intervals.

To recap, the extreme value analysis procedure applied here consist of the following steps:

1. POT samples of storm maxima are collected from the original timeseries using different thresholds.
2. For each POT sample the GPD parameters and their uncertainties are estimated.
3. Based on the variation of the shape parameter estimates with the threshold, the optimal threshold is chosen.
4. Fixing this threshold, the definite return values estimates and confidence intervals are computed.

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C Description of SWAN

C.1 General

SWAN is the state-of-the-art third generation shallow water phase-averaging wave model.(Booij et al, 1999) SWAN has been developed at the Delft University of Technology (e.g., Van der Westhuysen, 2010 and Zijlema, 2010) with contributions by Deltares. It computes wave propagation and wave energy evolution efficiently and accurately and it describes several non-linear effects via parameterised formulations. More specifically, SWAN can account for several wave propagation phenomena, including (only the most relevant for the present project mentioned):

- Wave propagation in time and space, shoaling[19], refraction[20] due to current and depth, frequency shifting due to currents and non-uniform depth;
- Wave generation by wind;
- Three- and four-wave interactions[21];
- Energy dissipation by: white-capping, bottom friction and depth-induced breaking.

White-capping is the phenomenon that waves show foam effects at the wave crests due to dissipation of wave energy. It is sometimes called deep-water wave breaking, as opposite to shallow-water wave breaking that can be observed at the beach (depth-induced breaking). Bottom friction causes dissipation of wave energy when the waves are long enough to be influenced by the roughness of the sea bed while propagating. At shallow depths and for longer wave periods bed friction has the largest influence.

Furthermore, SWAN computations can be made on a regular, a curvi-linear grid and a triangular mesh in a Cartesian or spherical co-ordinate system. Nested runs, using input, namely two-dimensional wave spectra, from other (larger scale) models can be made with SWAN.

The SWAN model has been validated and verified successfully under a variety of field cases and is continually undergoing further development. It sets today's standard for nearshore wave modelling.

For more information on SWAN, reference is made to http://swanmodel.sourceforge.net/online_doc/online_doc.htm from where the SWAN scientific/technical documentation and used manual can be downloaded.

In short, the model solves the action balance equation, in Cartesian or spherical coordinates, without any ad hoc assumption on the shape of the wave spectrum. In Cartesian coordinates the equation is

$$\frac{\partial N}{\partial t}+\frac{\partial}{\partial x}\left(c_x N\right)+\frac{\partial}{\partial y}\left(c_y N\right)+\frac{\partial}{\partial \sigma}\left(c_\sigma N\right)+\frac{\partial}{\partial \theta}\left(c_\theta N\right)=\frac{S_{tot}}{\sigma}, \quad (0.1)$$

[19] Shoaling is the steepening of waves as they approach the coast and reach shallower water. This increases the energy density of the waves, leading to an increase in wave height.
[20] Refraction is the effect that (non-uniform) bed levels have on the propagation direction of waves.
[21] Multiple wave components at different frequencies can interact (in deeper water 4 components, in shallow water 3), leading to a redistribution of wave energy over different wave frequencies. Since it causes energy transfer between components/frequencies these are non-linear processes.

where N is the action density, t is the time, σ is the relative angular frequency, and θ the wave direction. The first term on the left-hand side of Eq. (0.1) represents the local rate of change of action density in time. The second and third terms represent propagation of action in geographical space. The fourth term represents shifting of the relative frequency due to variation in depth and currents. The fifth term represents depth-induced and current-induced refractions. The quantities C_x, C_y, C_θ and C_σ are the propagation speeds in the geographical x- and y-space, and in the θ- and the σ-space, respectively. The expressions of these propagation speeds are taken from linear wave theory. In Eq. (0.1) S_{tot} is the energy source term. This source term is the sum of separate source terms representing different types of processes: wave energy growth by wind input, wave energy transfer due to non-linear wave-wave interactions (both quadruplets and triads), and the decay of wave energy due to whitecapping, bottom friction, and depth induced wave breaking. For some source terms more than one formulation is implemented in SWAN, see http://swanmodel.sourceforge.net/online_doc/online_doc.htm.

C.2 Drag coefficient

In SWAN the input 10-m wind speeds are converted to surface stress using the drag coefficient. There are two options in SWAN for the drag coefficient parameterization,

1. the drag coefficient from Wu (1982), which corresponds to a roughness of a standard Charnock relation (1955) Charnock with a Charnock parameter of 0.0185 and which is given by the dashed red line in Figure C.1.
2. an approximation of Zijlema et al. (2012) which accounts for a decrease of the drag for wind speeds above 31.5 m/s and which is given by the full red line in Figure C.1.

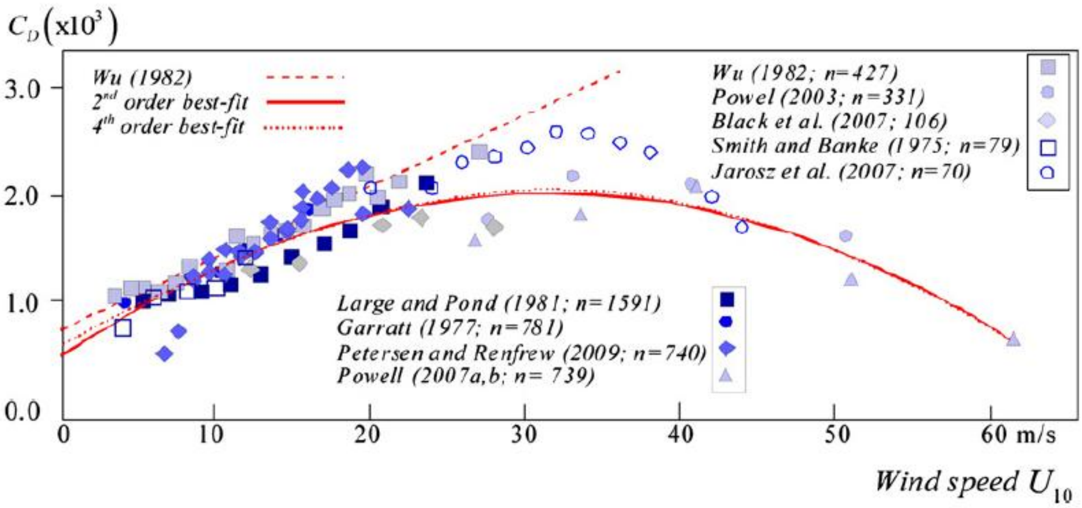

Figure C.1 Observed values of the wind drag coefficient (Cd) from various studies and the weighted best-fit 2nd and 4th-order polynomial (n is the number of independent data points per study). Figure taken from of Zijlema et al. (2012).

In this study the approximation of Wu (1982) is applied.

C.3 White-capping

Because it is relevant for the settings that have been chosen for the model, a more detail description of the available options for the modelling of wave growth and whitecapping is given.

SWAN's original formulation of dissipation by whitecapping is based on the pulse-based model of Hasselmann (1974), as adapted by the WAMDI group (1988):

$$S_{wcap}(\sigma,\theta) = -\Gamma\bar{\sigma}\frac{k}{\bar{k}}E(\sigma,\theta) \ ,$$

where

$$\Gamma = C_{ds}\left((1-\delta)+\delta\frac{k}{\bar{k}}\right)\left(\frac{\bar{s}}{\bar{s}_{PM}}\right)^4 ,$$

and which can also be written as

$$S_{wcap}(\sigma,\theta) = C_{ds}\left(\frac{\bar{s}}{\bar{s}_{PM}}\right)^4 \bar{\sigma}\left(\frac{k}{\bar{k}}\right)^n E(\sigma,\theta) \ , \quad (0.2)$$

a bar over a variable denotes its mean, *k* is the wavenumber, and *s* the wave steepness. The remaining parameters in Γ depend on the wind input formulation that is used and are determined by closing the energy balance of the waves in fully developed conditions.

In SWAN the following options are available:

- For situations in which the formulation recommended Komen et al. (1984) is used,
- δ=0, n=1 (default until SWAN version 40.85).
- For situations in which the formulation recommended by Rogers et al. (2003) is used:
- δ=1, n=2 (default since SWAN version 40.91).
- For situations in which the formulation recommended by Janssen (1991) is used
- δ=0.5, n≈1.5.

For *n*=1 the right hand side of Eq. (0.2) is proportional to $\frac{k}{\bar{k}}$. Increasing the parameter *n* above 1 has the effect of reducing dissipation at lower frequencies while increasing dissipation at higher frequencies, resulting in relatively more low frequency wave energy and larger wave periods. In this study the formulation recommended by Rogers et al. (2003), δ=1 and n=2, is applied.

In addition to these formulations based on Eq. (0.2), two extra formulations have been implemented in SWAN:

- the one suggested by Van der Westhuysen et al., 2007 and referred to as the Westhuysen formulation; and the
- the one suggested by Rogers et al. (2012) and referred to as the ST6 (as it is referred to in Source Term package of the WAVEWATCH III® model) formulation.

The Westhuysen formulation is not based as those described using Eq. B.4 on the average wave number $\bar{k}$ and does, therefore, not lead to an overestimation of dissipation of wind sea when just a little swell is present.

In the ST6 formulation models the wave breaking in two phases and with waves not breaking unless the spectral density, $E(f)$, exceeds a threshold spectral density, $E_T(f)$, calculated from the spectral saturation spectrum (Rogers et al., 2012, Eq. (5)), with

$$S_{wcap}(\sigma,\theta) = -\left[T_1(\sigma,\theta)+T_2(\sigma,\theta)\right]E(\sigma,\theta)$$

where

$T_1(k) = a_1 \gamma_1^{p_1}$ is the inherent term,

$T_2(k) = a_2 \int_{f'}^{f} \gamma_2^{p_2} df'$ accounts for the cumulative effect of (shorter) wave dissipation due to the breaking of longer waves,

$$\gamma_1 = \frac{\Delta(f)}{\tilde{E}(f)},\ \gamma_2 = \frac{\Delta(f')}{\tilde{E}(f')},\ \Delta(f) = E(f) - E_T(f),$$

$\tilde{E}$ is a normalizing generic spectral density and a_1, a_2, p_1 and p_2 are tuneable coefficients (Aijaz et al., 2016).

C.4 Numerics

As to SWAN's numerical approach, the integration of the propagation and of the source terms of Eq. (0.1) has been implemented with finite difference schemes in all four dimensions (geographical space and spectral space). A constant time increment is used for the time integration. The model propagates the wave action density of all components of the spectrum across the computational area using implicit schemes in geographical and spectral space, supplemented with a central approximation in spectral space. In geographical space the scheme is upwind and applied to each of the four directional quadrants of wave propagation in sequence. Three of such schemes are available in SWAN: a first-order backward space, backward time (BSBT) scheme, a second-order upwind scheme with second order diffusion (the SORDUP scheme) and a second order upwind scheme with third order diffusion (the S&L scheme). The numerical schemes used for the source term integration are essentially implicit. In order to match physical scales at relatively high frequencies and to ensure numerical stability at relatively large time steps, a limiter controlling the maximum total change of action density per iteration at each discrete wave component is imposed. The BSBT scheme is applied in this study.

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D Selection of output locations

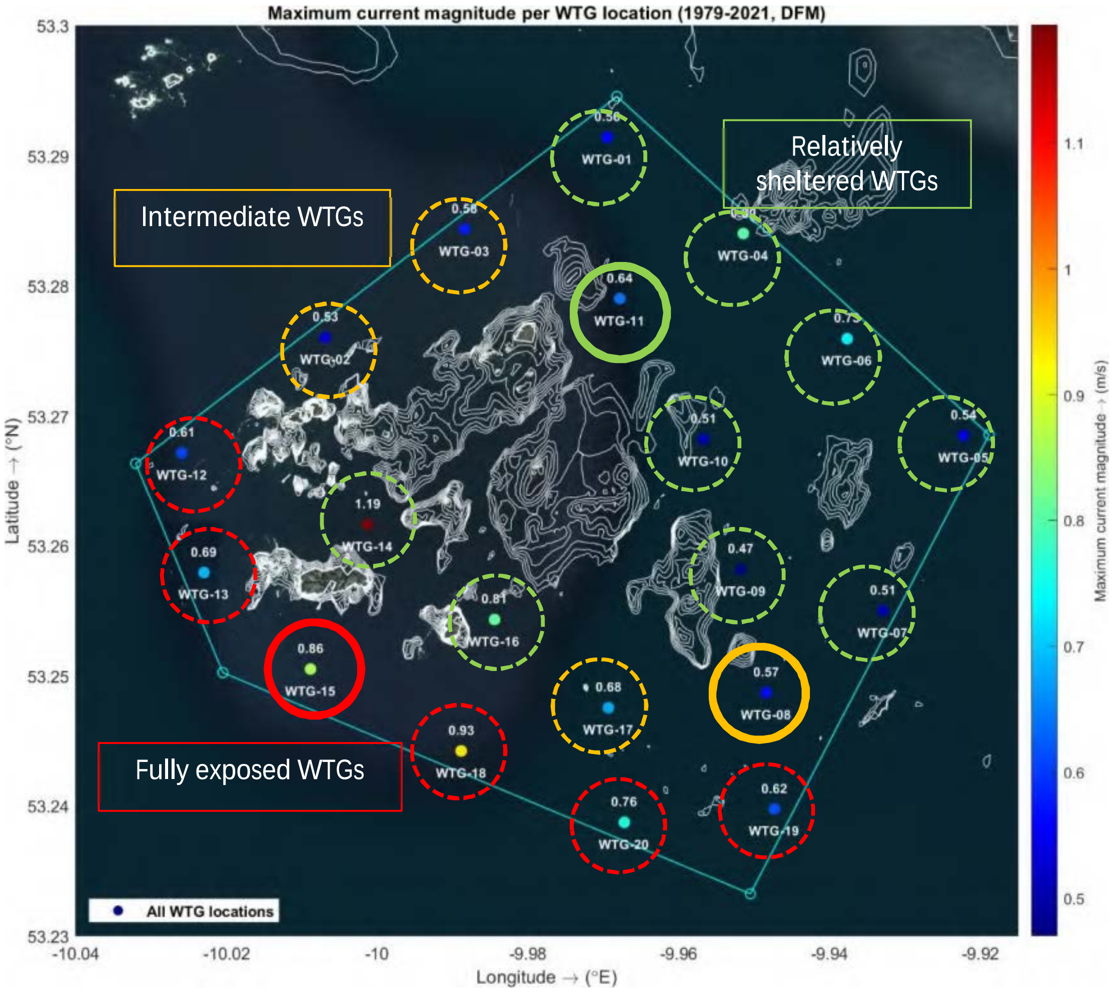


Figure D.1 Spatial variation of maximum modelled depth-averaged current speeds and clustering of turbine locations. Assessment locations WTG15, WTG08 and WTG11 are encircled with fat lines.

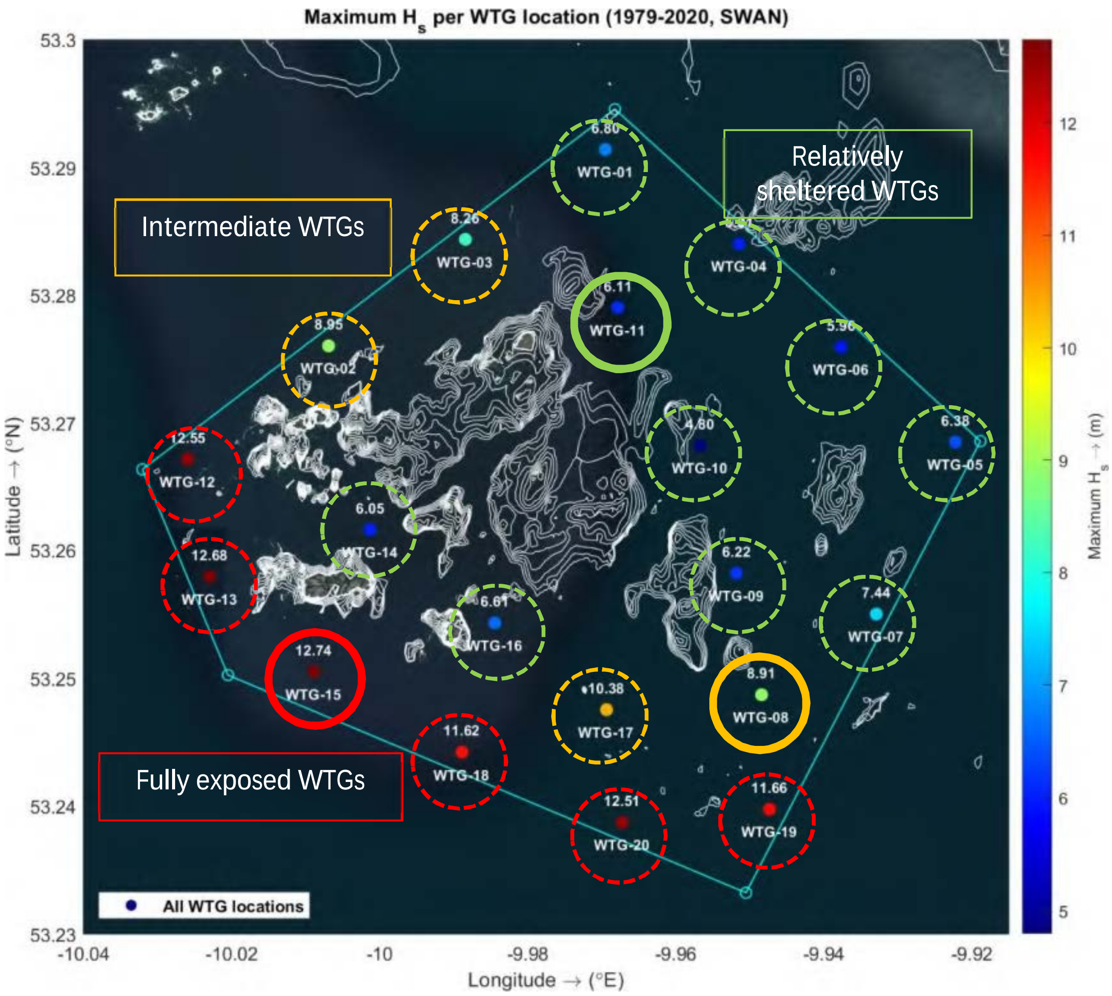


Figure D.2 Spatial variation of maximum modelled significant wave heights and clustering of turbine locations. Assessment locations WTG15, WTG08 and WTG11 are encircled with fat lines.

E Contents of the spreadsheets

The metocean spreadsheet files (one per output locations) accompanying this report (*11208193-002-HYE-0001_v3-Skerd Rocks offshore wind farm metocean study_Metocean_WTG15/08/11.xlsx*) contain the following sheets:

- Executive Summary – Summary of the determined metocean conditions.
- Extreme winds 10 mMSL – Directional return values of wind speeds at 10 mMSL height.
- Extreme winds 170 mMSL – Directional return values of wind speeds at 170 mMSL height (hub-height).
- Extreme water level – Return values of positive and negative SWL.
- Extreme currents – Directional return values of depth-averaged, surface and near-bottom total and residual current.
- Extreme waves (ESS) – Directional H_s return values and associated values of the other (wave) parameters.
- Extreme waves (SSS) – Omni-directional severe sea state wave conditons, conditioned on 170 mMSL wind speeds.
- Operational wind – All-year joint occurrence table and rose of wind at 170 mMSL height including Weibull-fit parameters for 12x12 wind/wave sectors.
- Tidal water levels
- JOT+Roses currents – All-year joint occurrence tables and roses of total, tidal and residual depth averaged, surface and near-bottom current speed and direction.
- JOT+Roses Hs-MWD – All-year joint occurrence tables and roses of H_s and MWD (total, wind-sea and swell signal). All-data and conditioned for U_{170}<10 m/s.
- JOT Hs-U170mag – All-year joint occurrence tables of U_{170} and H_s. All-data and conditioned on 12x12 wind/wave directional sectors.
- Misalignment U170dir-MWD – All-year joint occurrence tables of U170dir and MWD (total, wind-sea and swell signal). A single table for the full timeseries and 41 tables conditioned per wind-speed (U_{170}) bin.
- JOT Hs-Tp - total – All-year joint occurrence tables of H_s and T_p (total signal). All-data and conditioned on 12x12 wind/wave directional sectors.
- NSS - total – Normal Sea State tables (total signal). All-data and conditioned on 12x12 wind/wave directional sectors.
- JOT Hs-Tp - wind-sea – All-year joint occurrence tables of H_s and T_p (wind-sea signal). All-data and conditioned on 12x12 wind/wave directional sectors.
- NSS - wind-sea – Normal Sea State tables (wind-sea signal). All-data and conditioned on 12x12 wind/wave directional sectors.
- JOT Hs-Tp - swell – All-year joint occurrence tables of H_s and T_p (swell signal). All-data and conditioned on 12x12 wind/wave directional sectors.
- NSS - swell – Normal Sea State tables (swell signal). All-data and conditioned on 12x12 wind/wave directional sectors.

The persistency spreadsheet files (one per output locations) accompanying this report (*11208193-002-HYE-0001_v3-Skerd Rocks offshore wind farm metocean study_Persistency_WTG15/08/11.xlsx*) contain the following sheets:

- U10MAG Weather Window
- U10MAG Downtime
- U10MAG Non-overlapping Weather Window events
- U170MAG Weather Window

- U170MAG Downtime
- U170MAG Non-overlapping Weather Window events
- HSIG Weather Window
- HSIG Downtime
- HSIG Non-overlapping Weather Window events

F Breaking wave assessment results

F.1 Spatial results

F.1.1 RP1

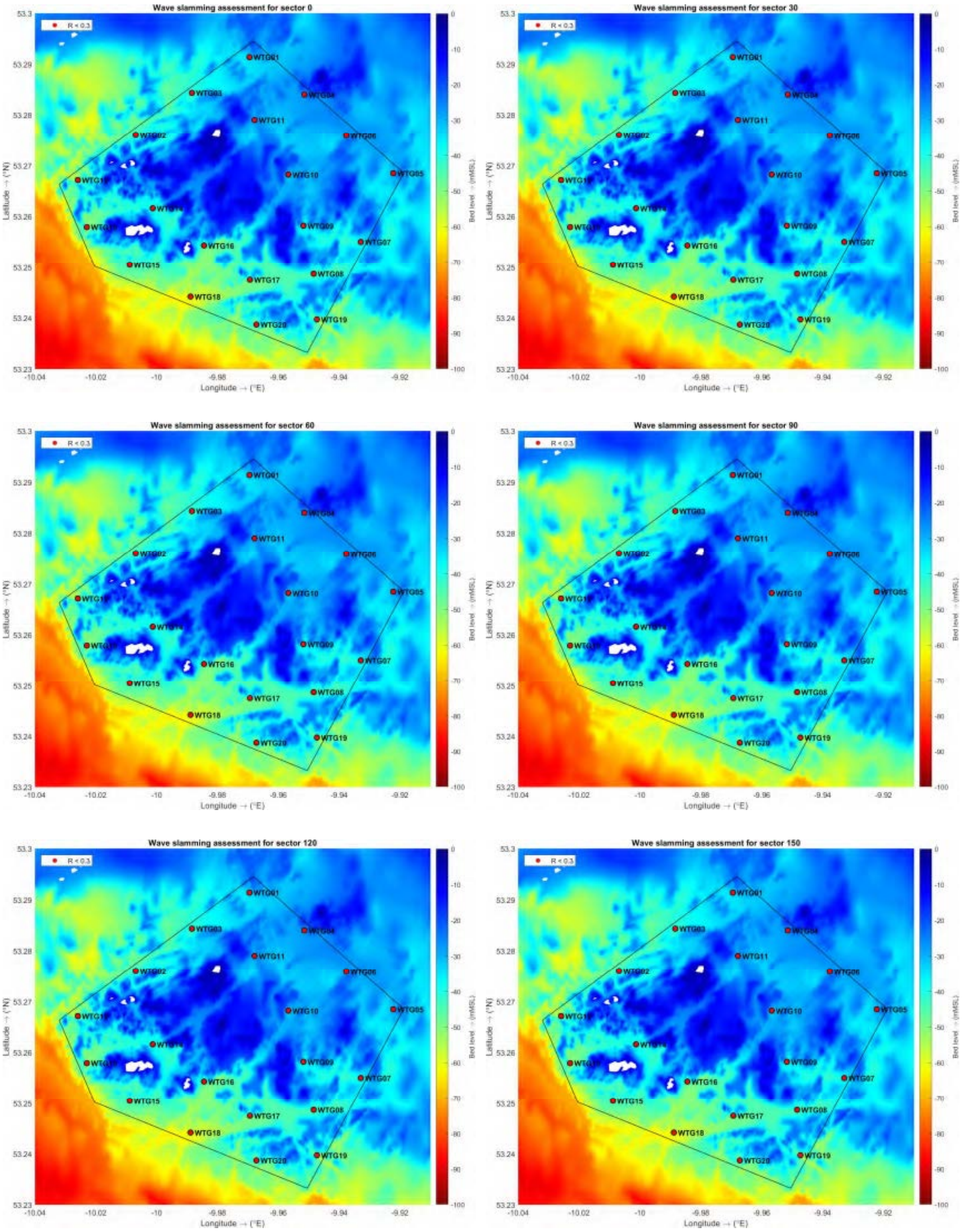


Figure F.1 1-year directional slamming analysis, sectors 0°, 30°, 60°, 90°, 120° and 150° (top left to bottom right).

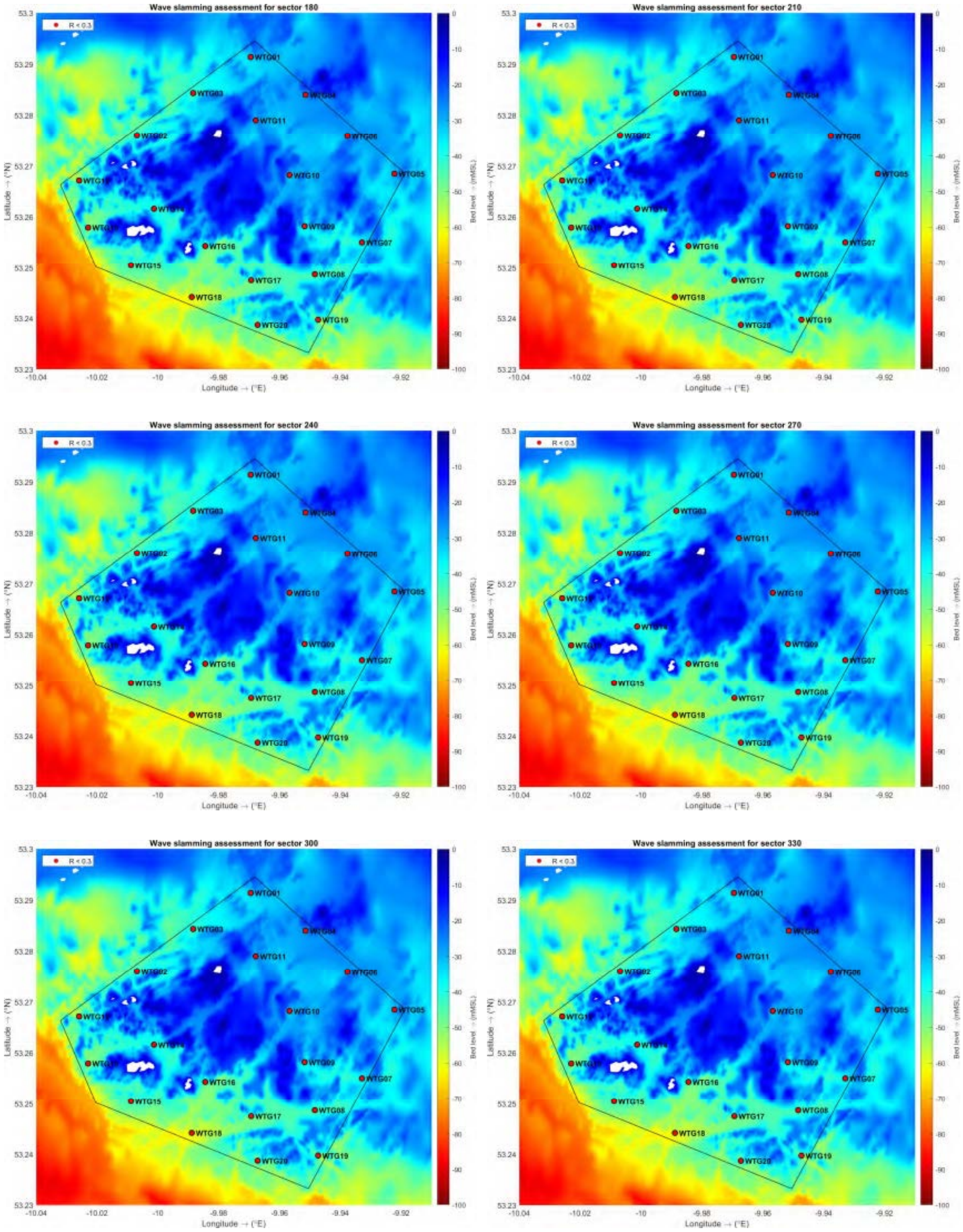


Figure F.2 1-year directional slamming analysis, sectors 180°, 210°, 240°, 270°, 300° and 330° (top left to bottom right).

F.1.2 RP10

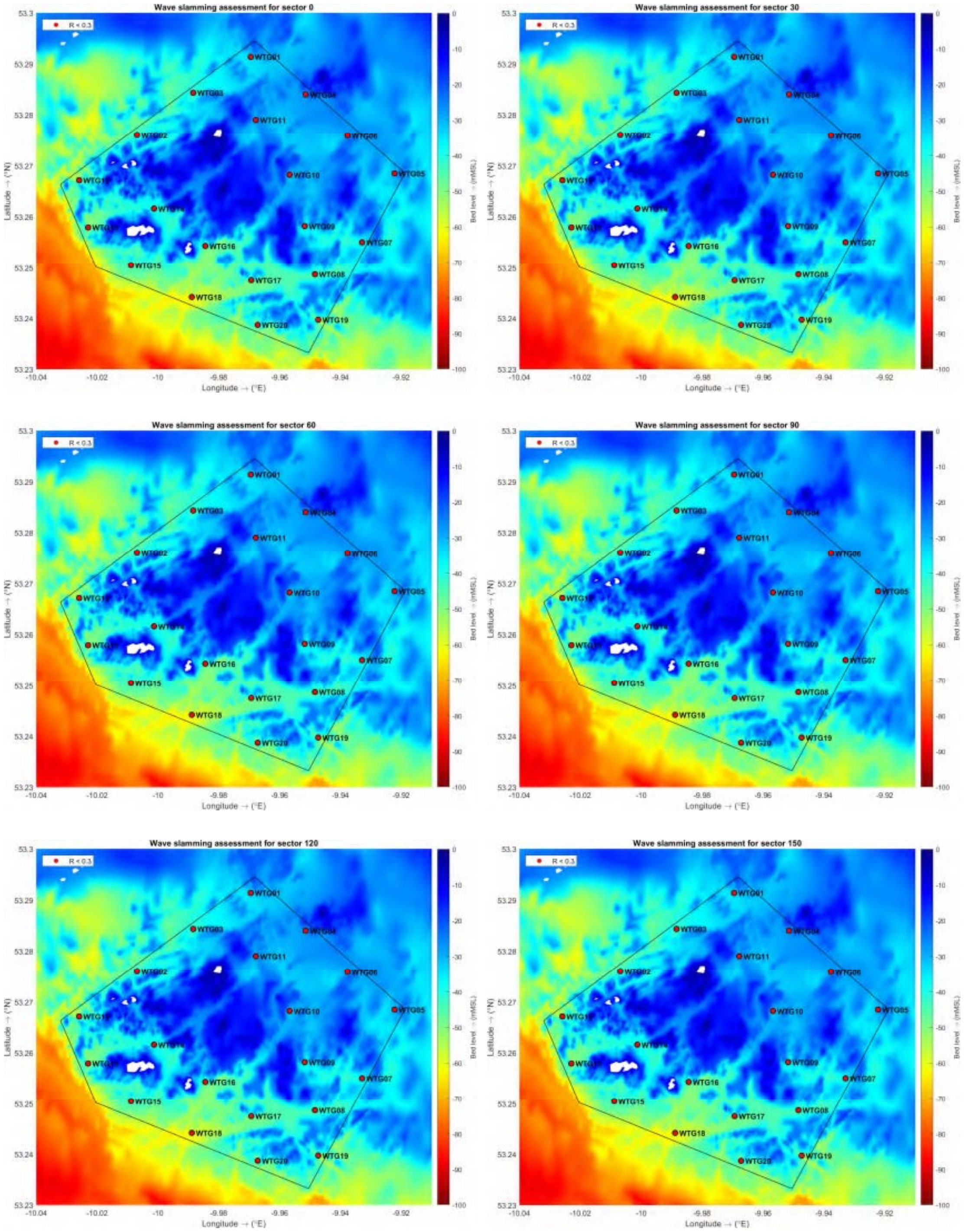


Figure F.3 10-year directional slamming analysis, sectors 0°, 30°, 60°, 90°, 120° and 150° (top left to bottom right).

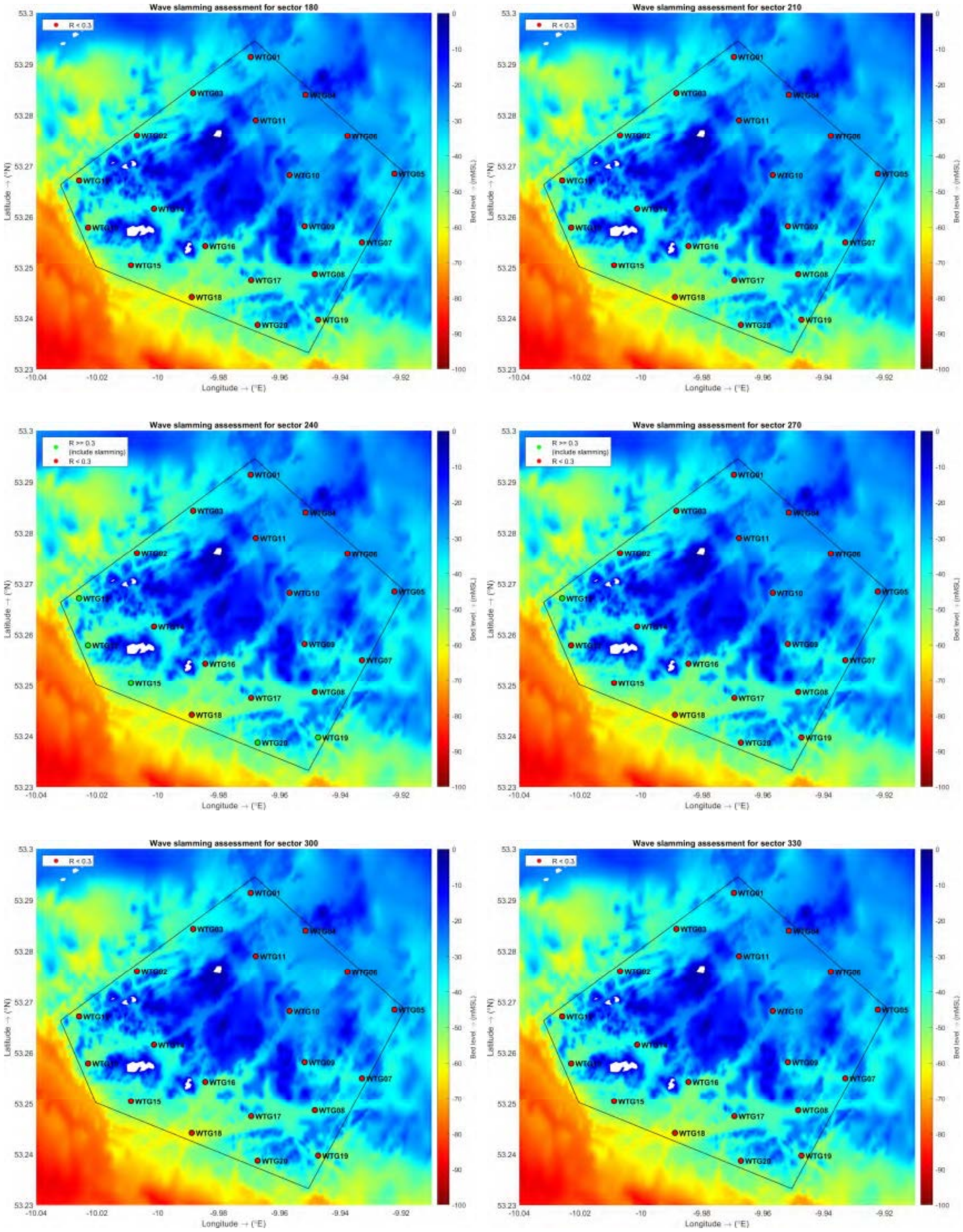


Figure F.4 10-year directional slamming analysis, sectors 180°, 210°, 240°, 270°, 300° and 330° (top left to bottom right).

F.1.3 RP50

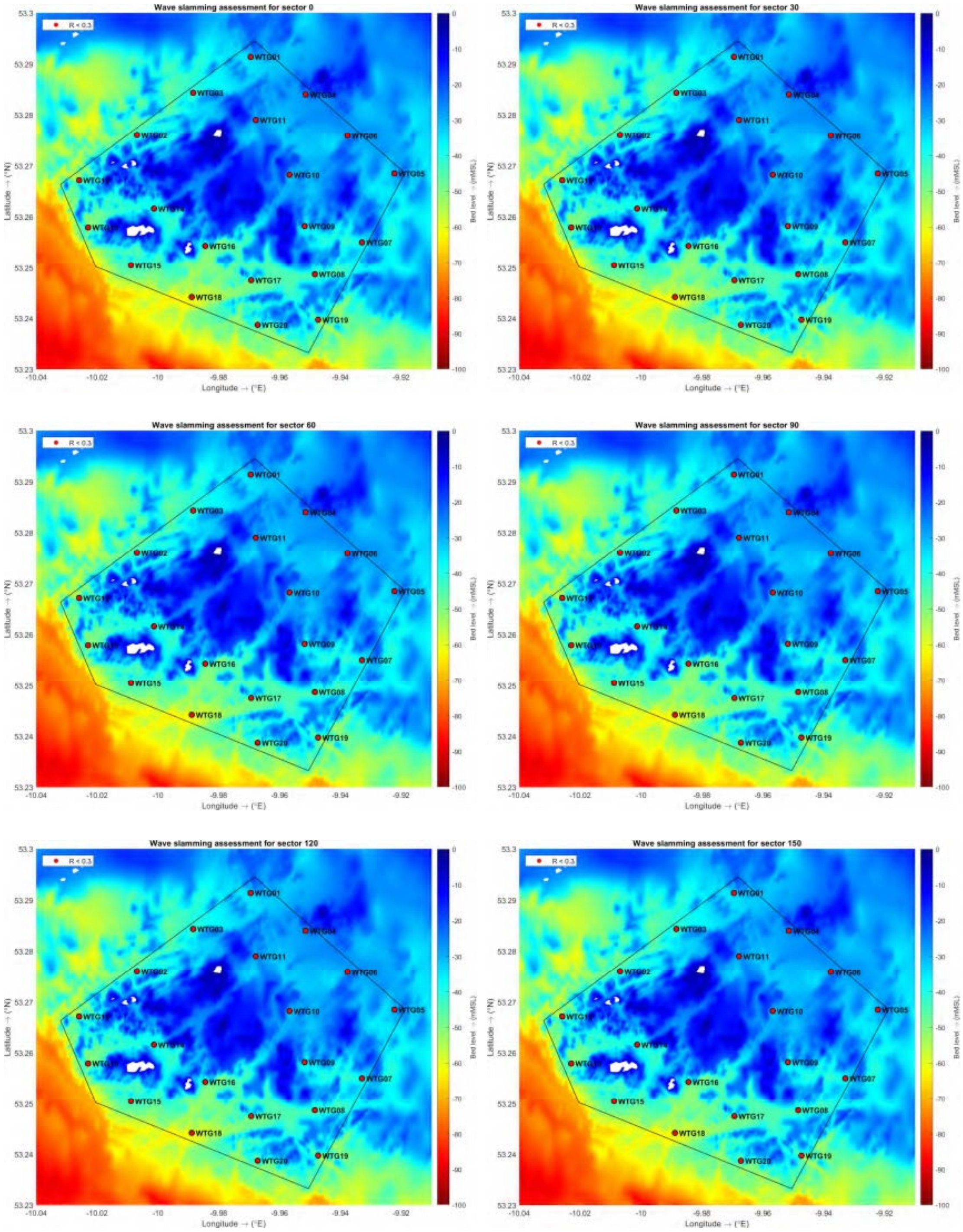


Figure F.5 50-year directional slamming analysis, sectors 0°, 30°, 60°, 90°, 120° and 150° (top left to bottom right).

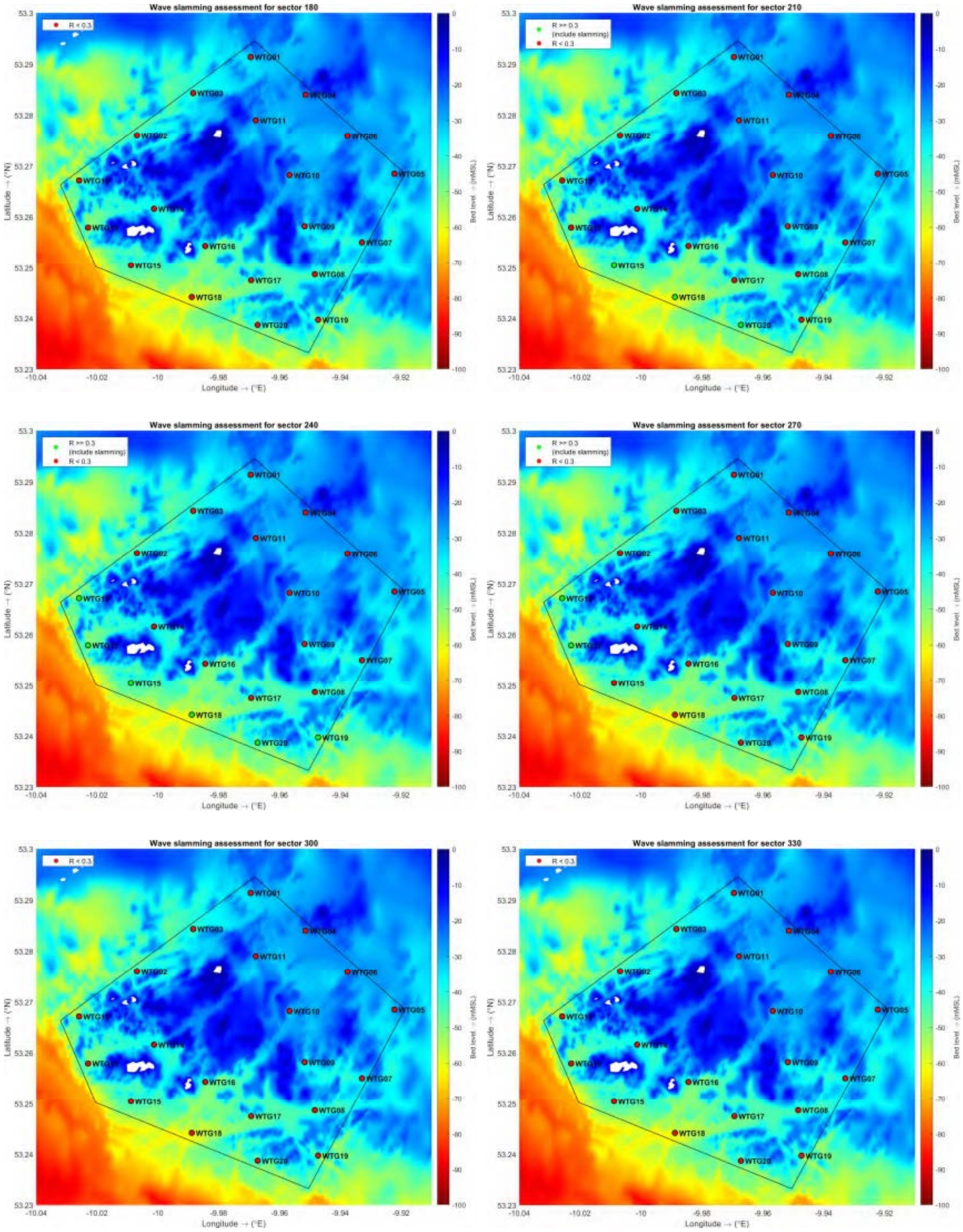


Figure F.6 50-year directional slamming analysis, sectors 180°, 210°, 240°, 270°, 300° and 330° (top left to bottom right).

F.1.4 RP100

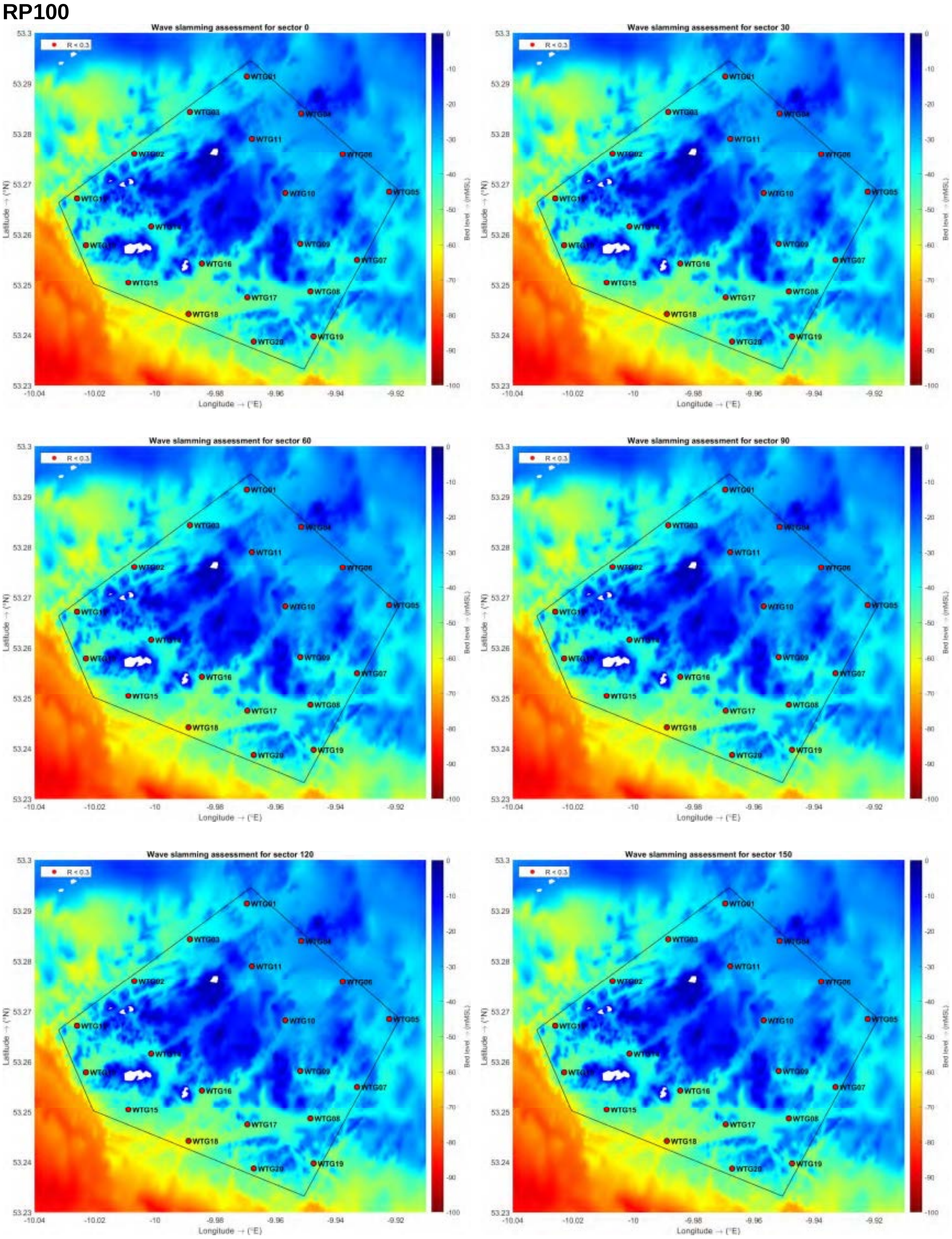


Figure F.7 100-year directional slamming analysis, sectors 0°, 30°, 60°, 90°, 120° and 150° (top left to bottom right).

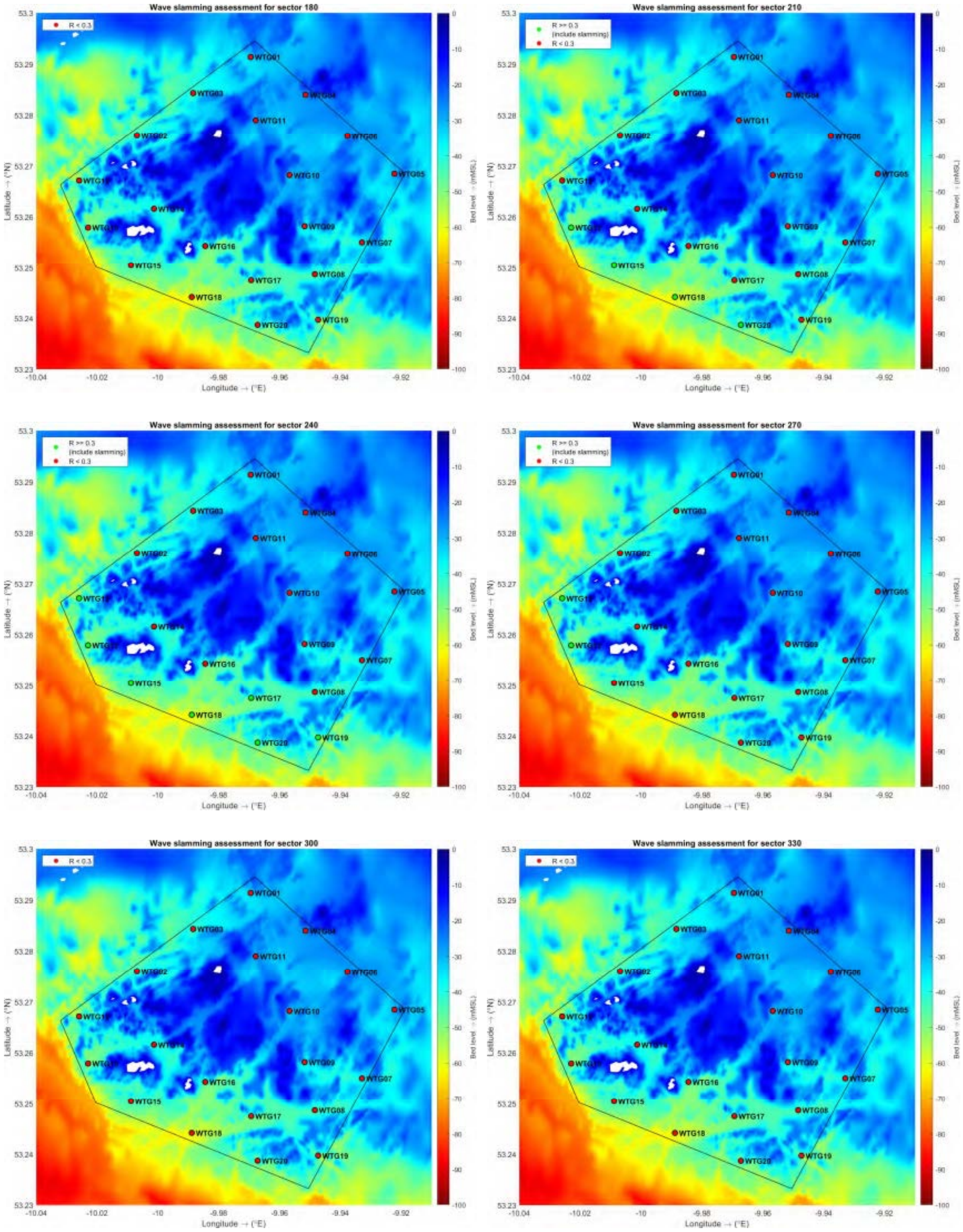
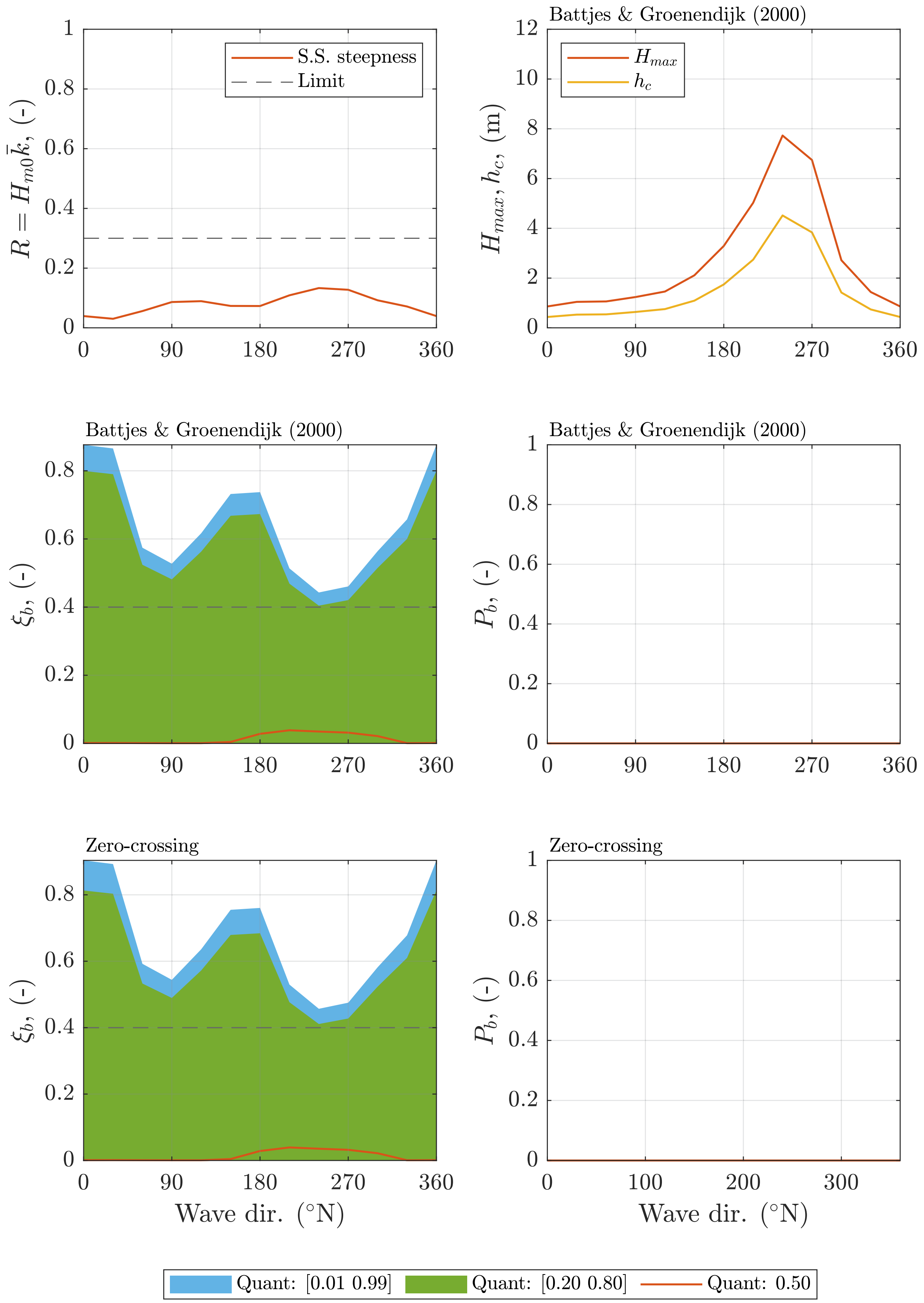
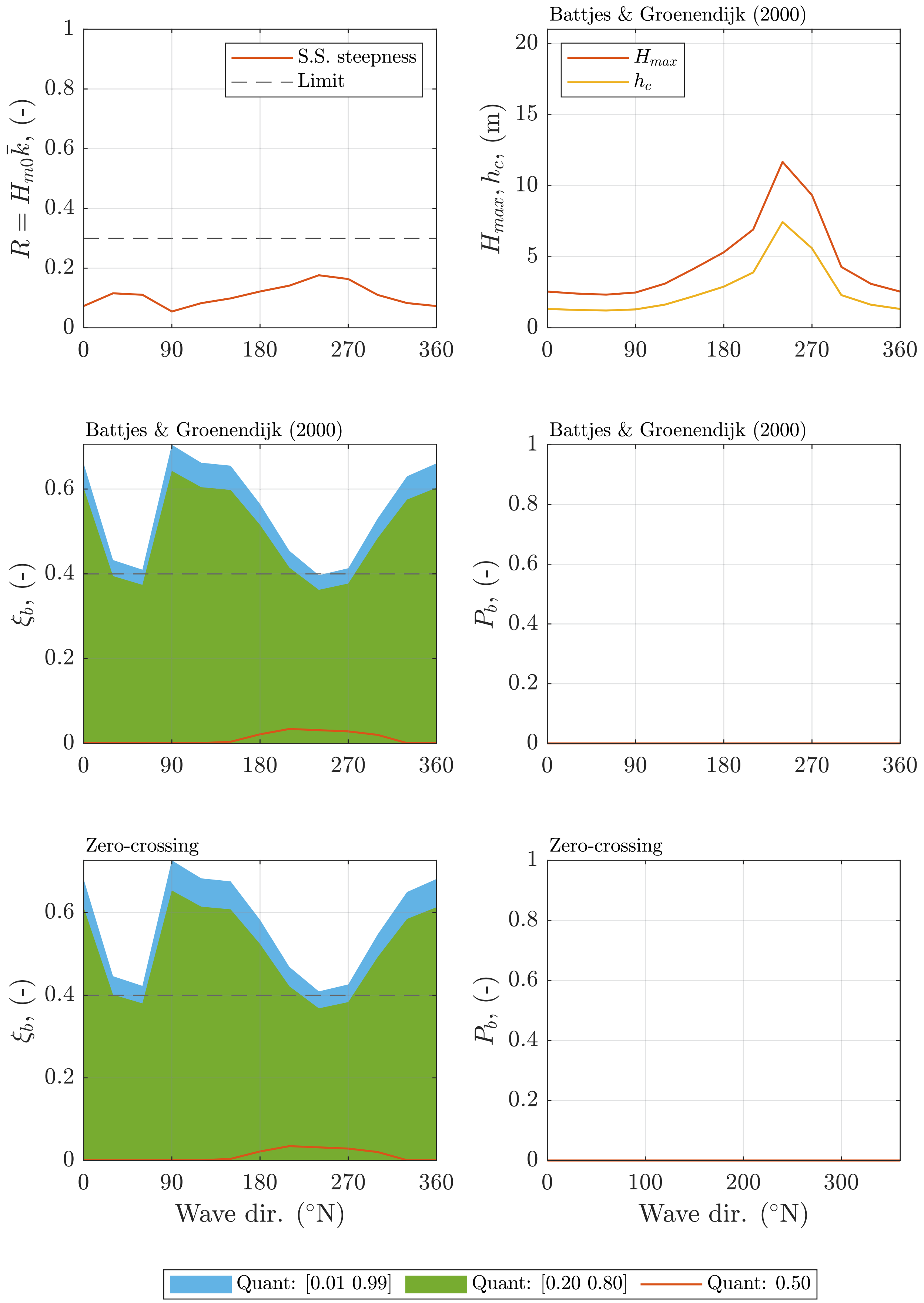


Figure F.8 100-year directional slamming analysis, sectors 180°, 210°, 240°, 270°, 300° and 330° (top left to bottom right).

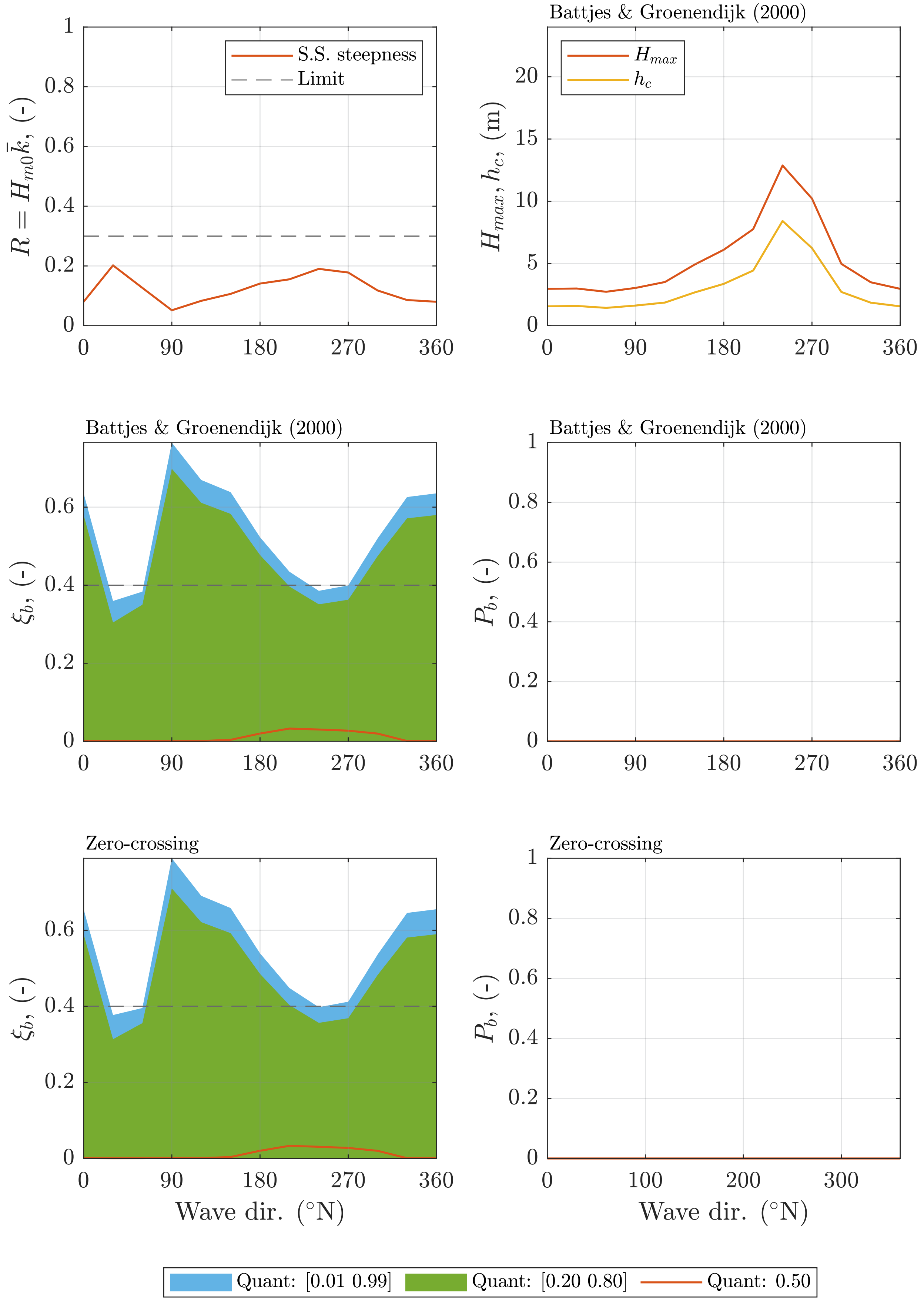
F.2 Results per location



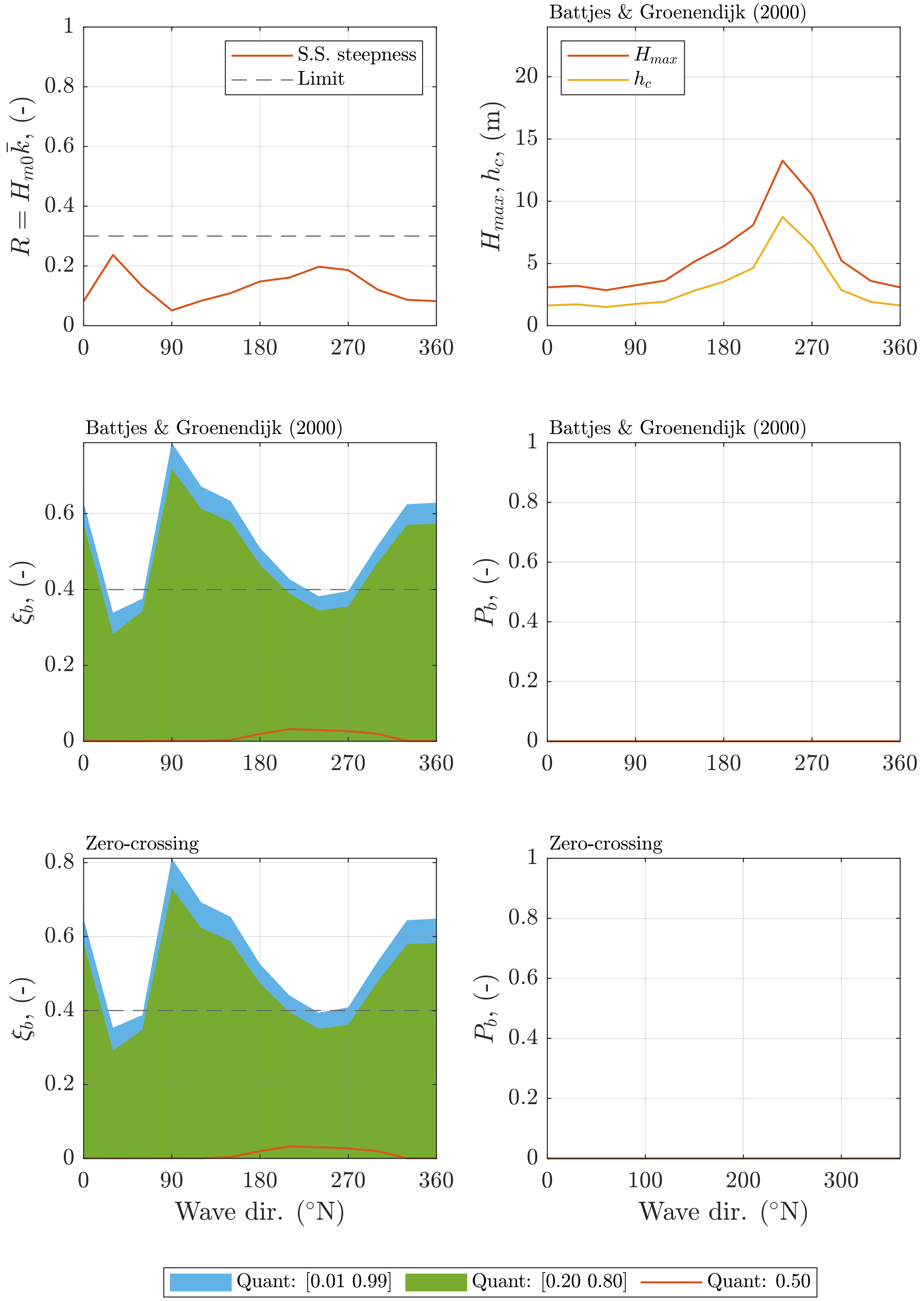
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG01
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.001a



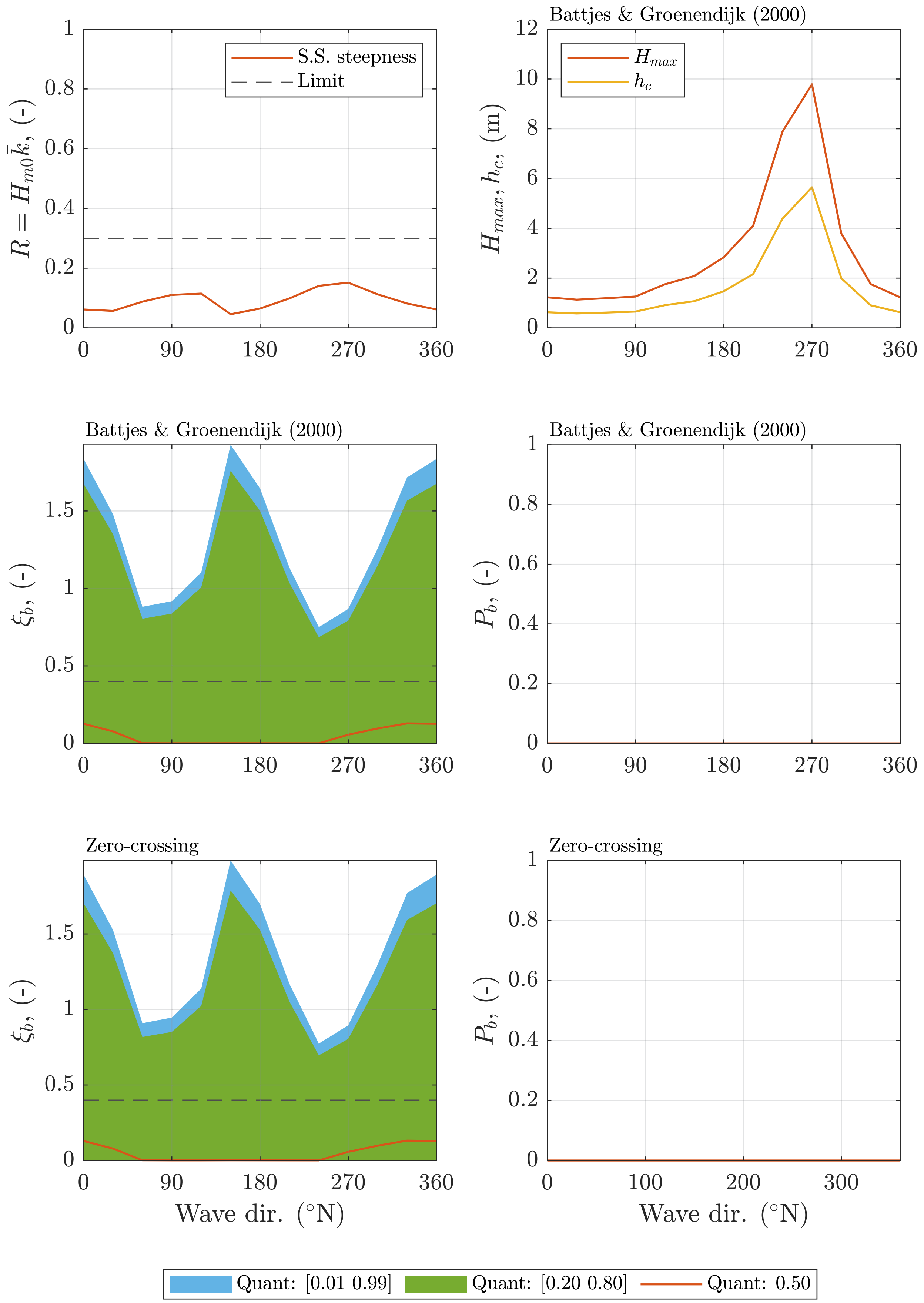
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG01
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.001b



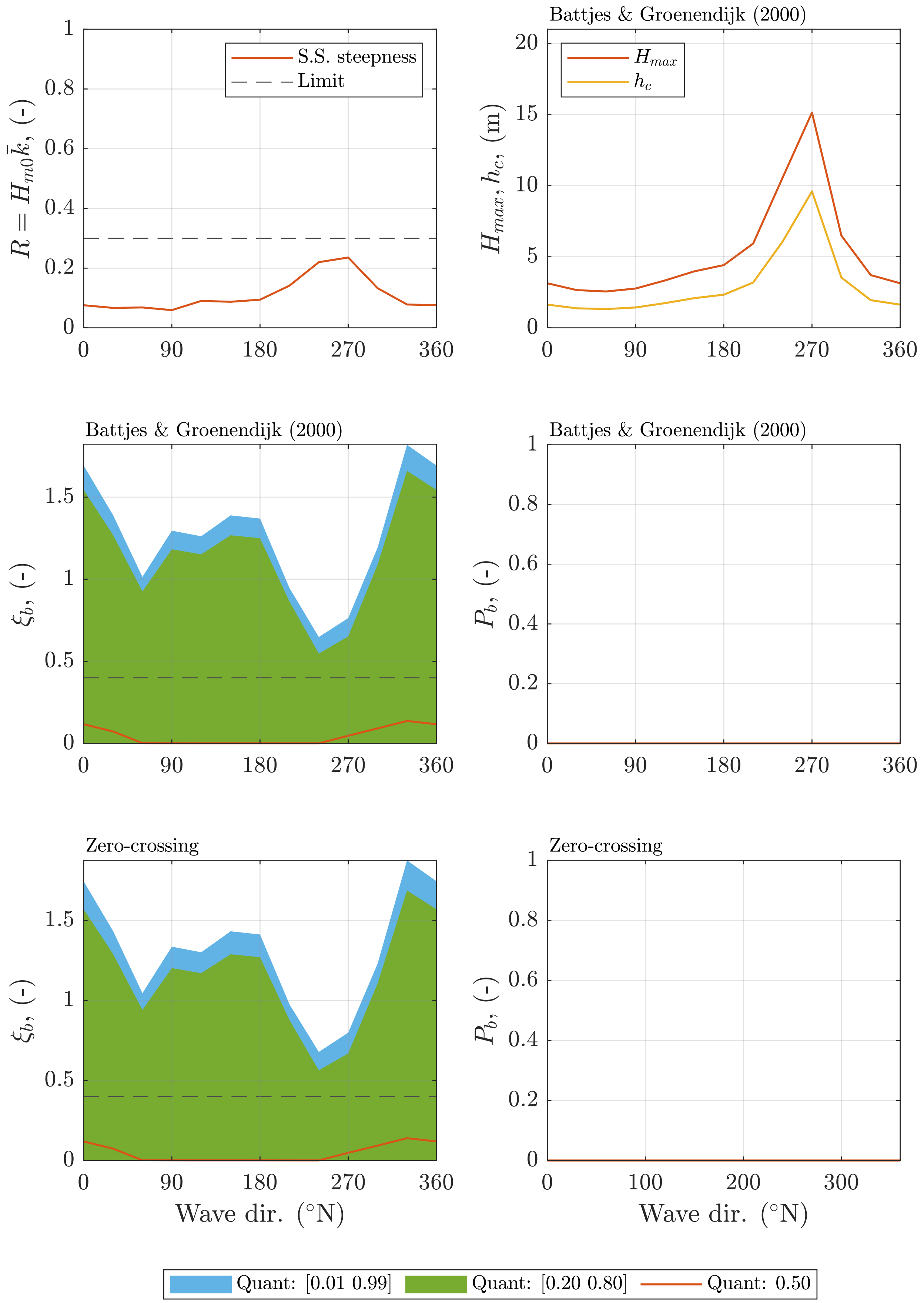
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG01
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.001c



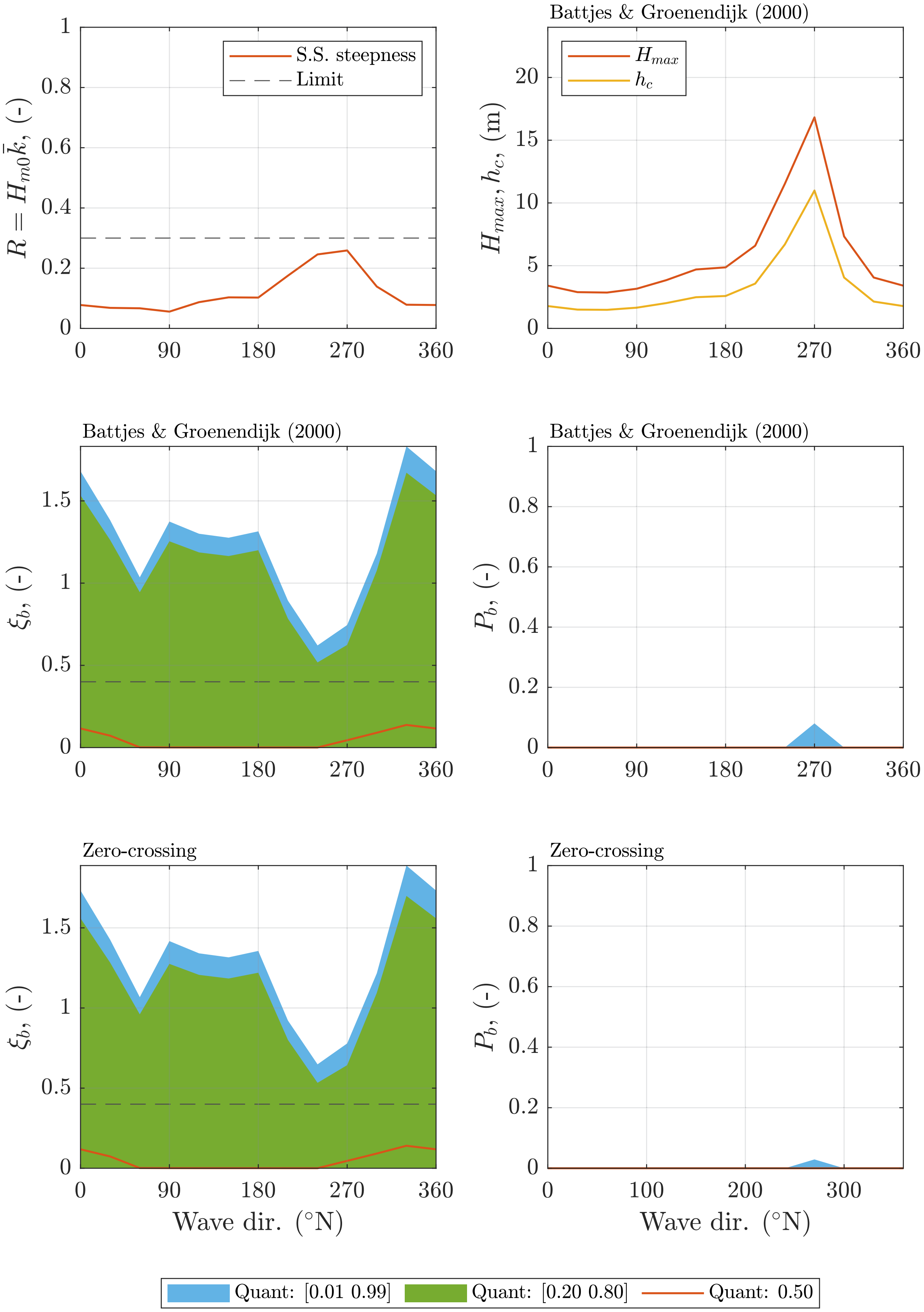
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG01
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.001d



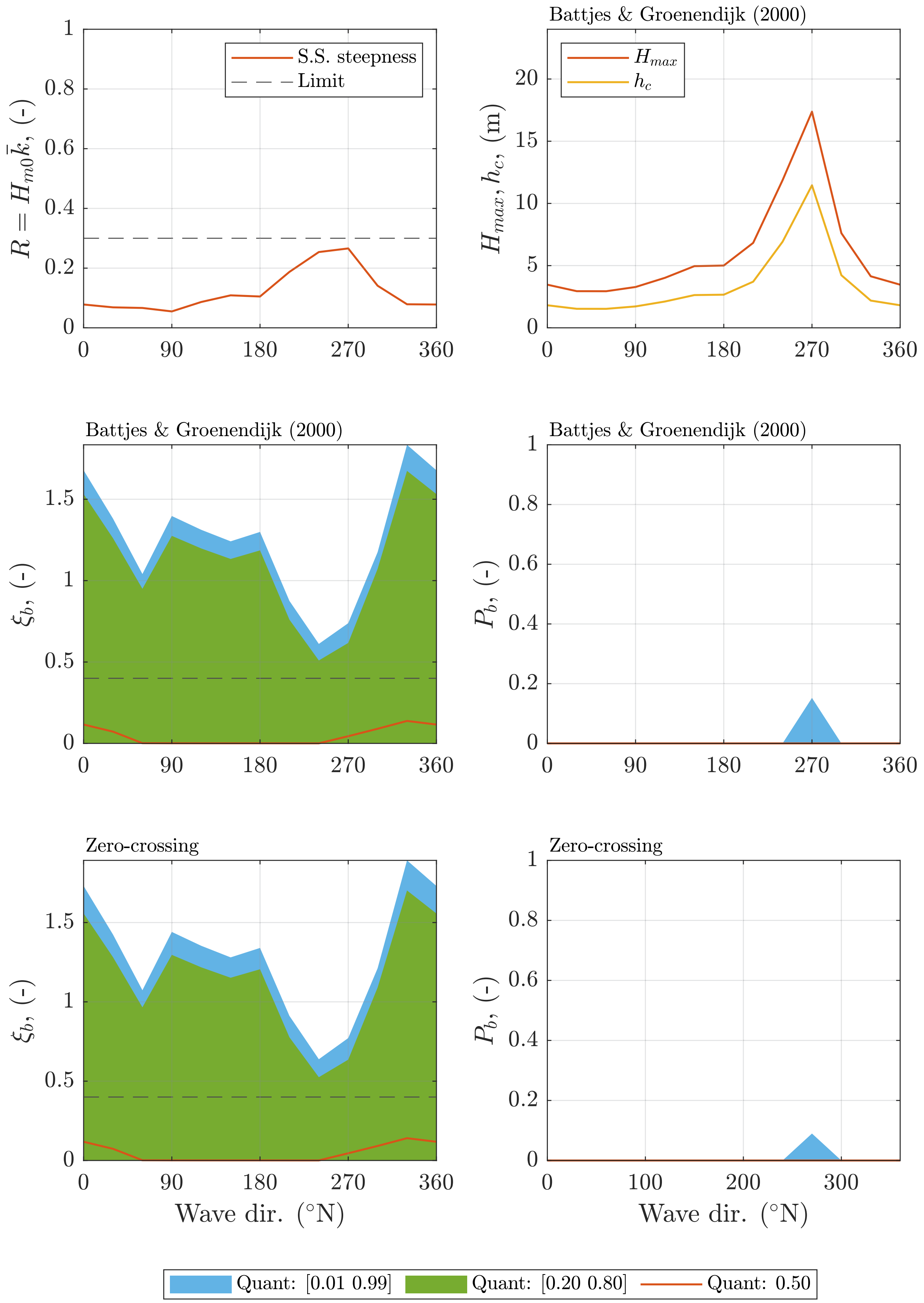
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG02
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.002a



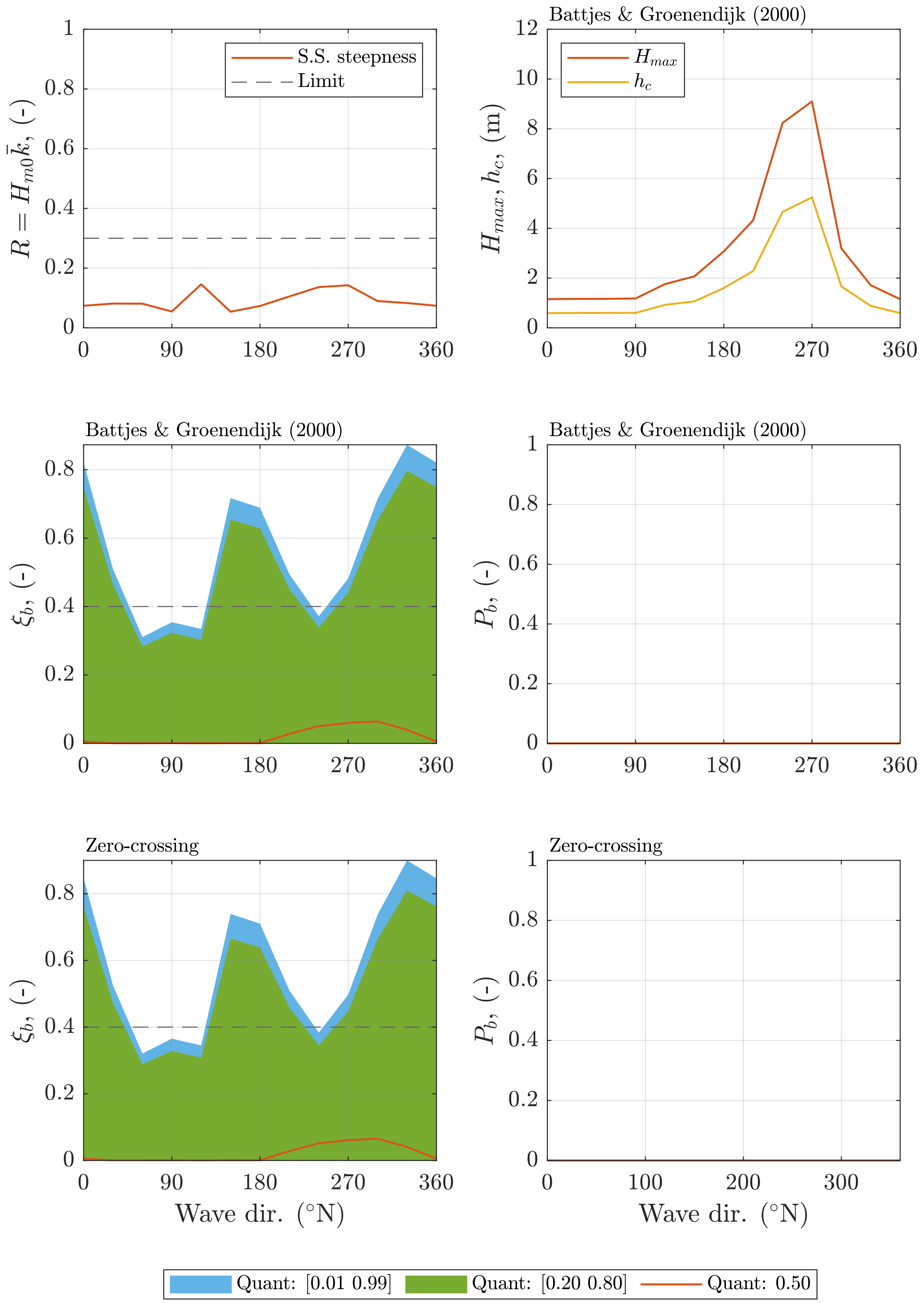
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG02
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.002b



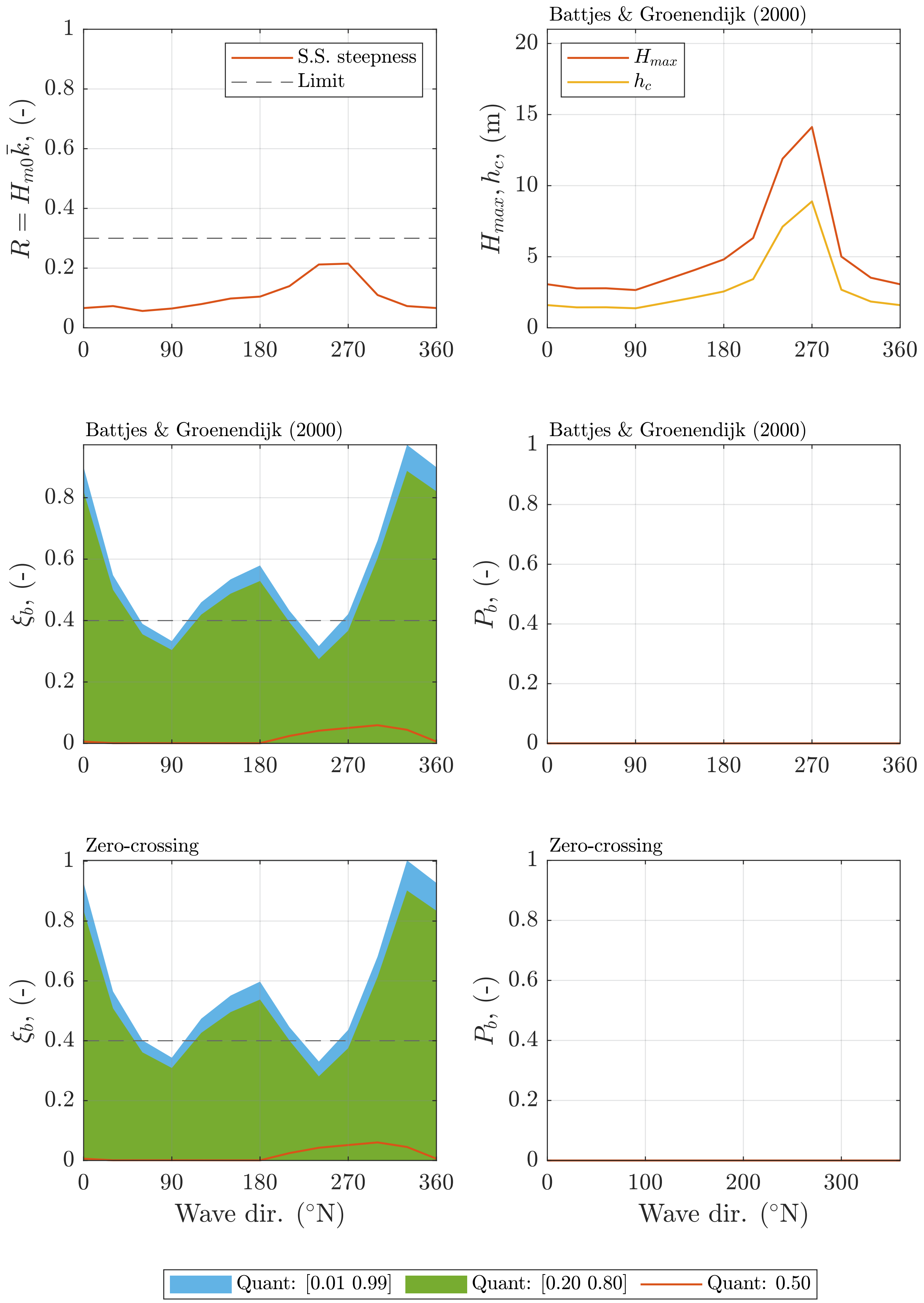
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG02
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.002c



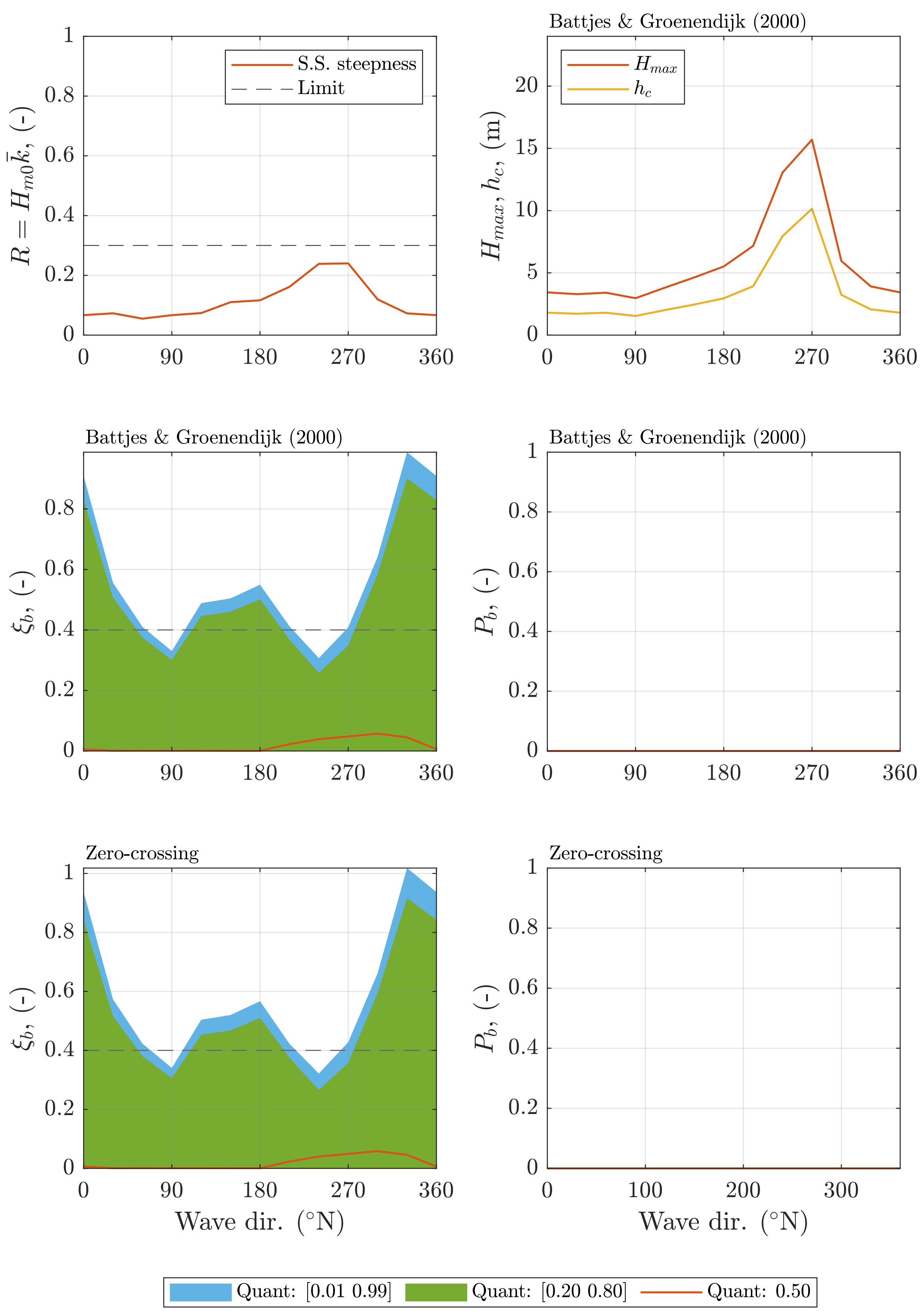
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG02
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.002d



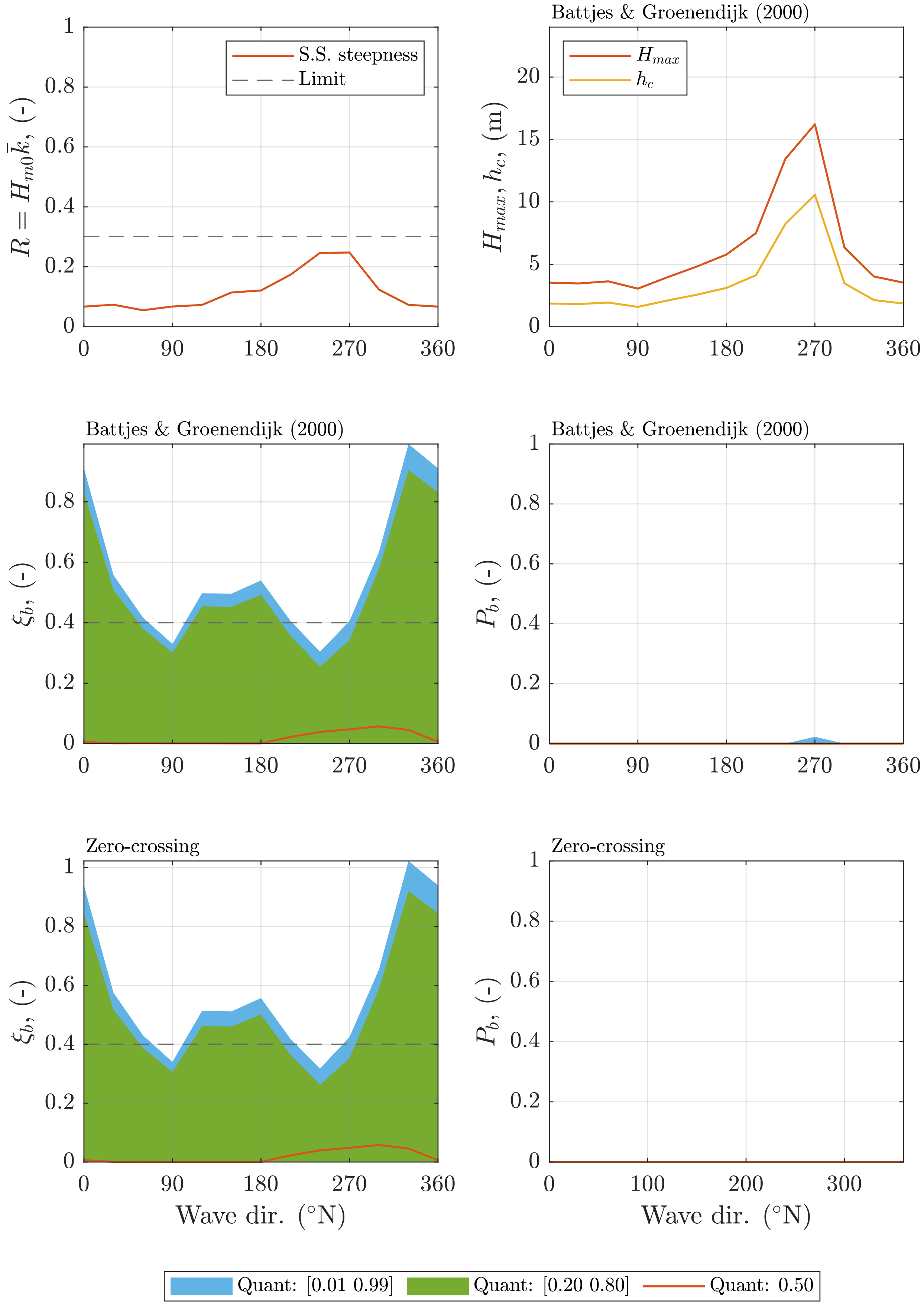
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG03
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.003a



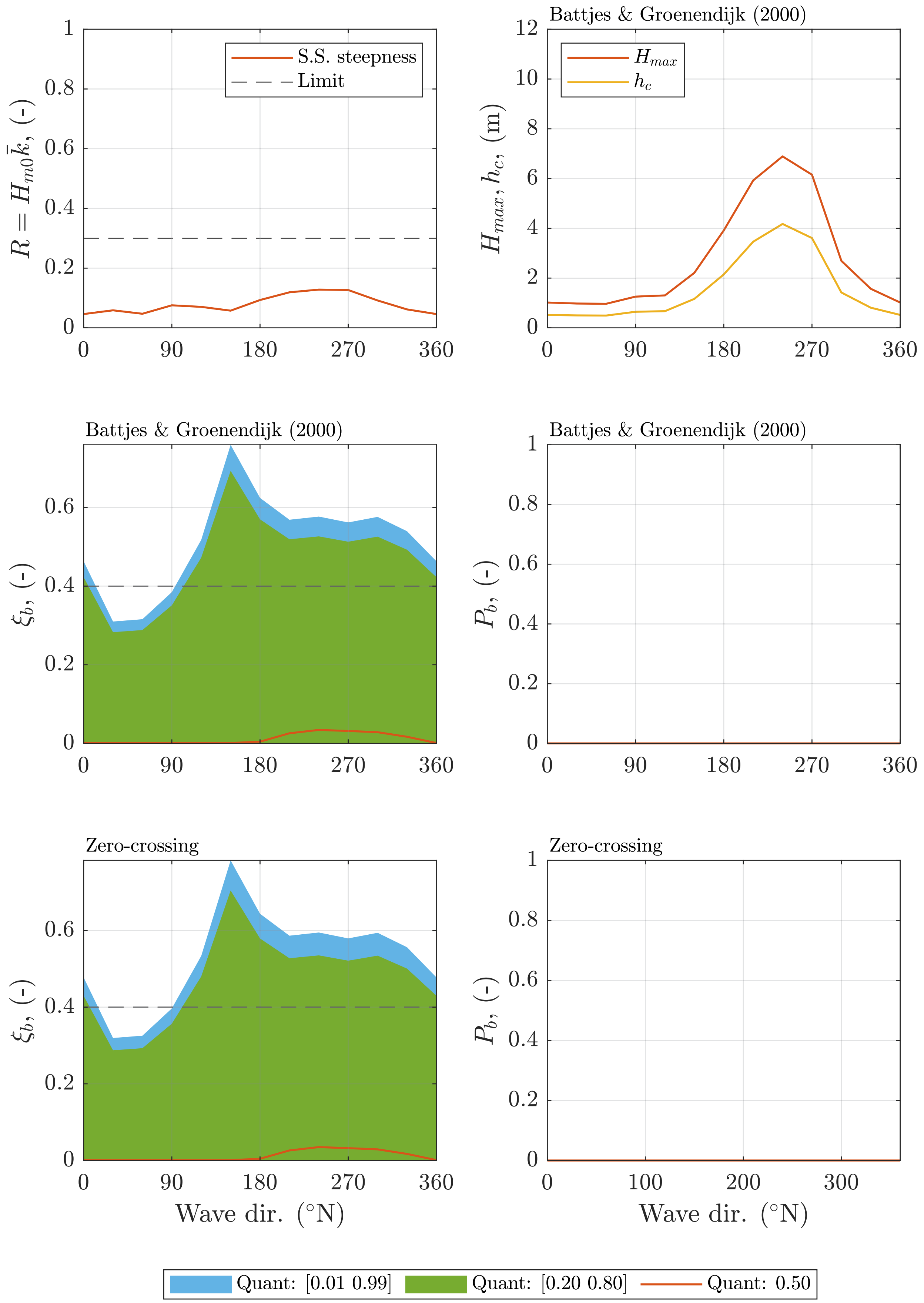
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG03
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.003b



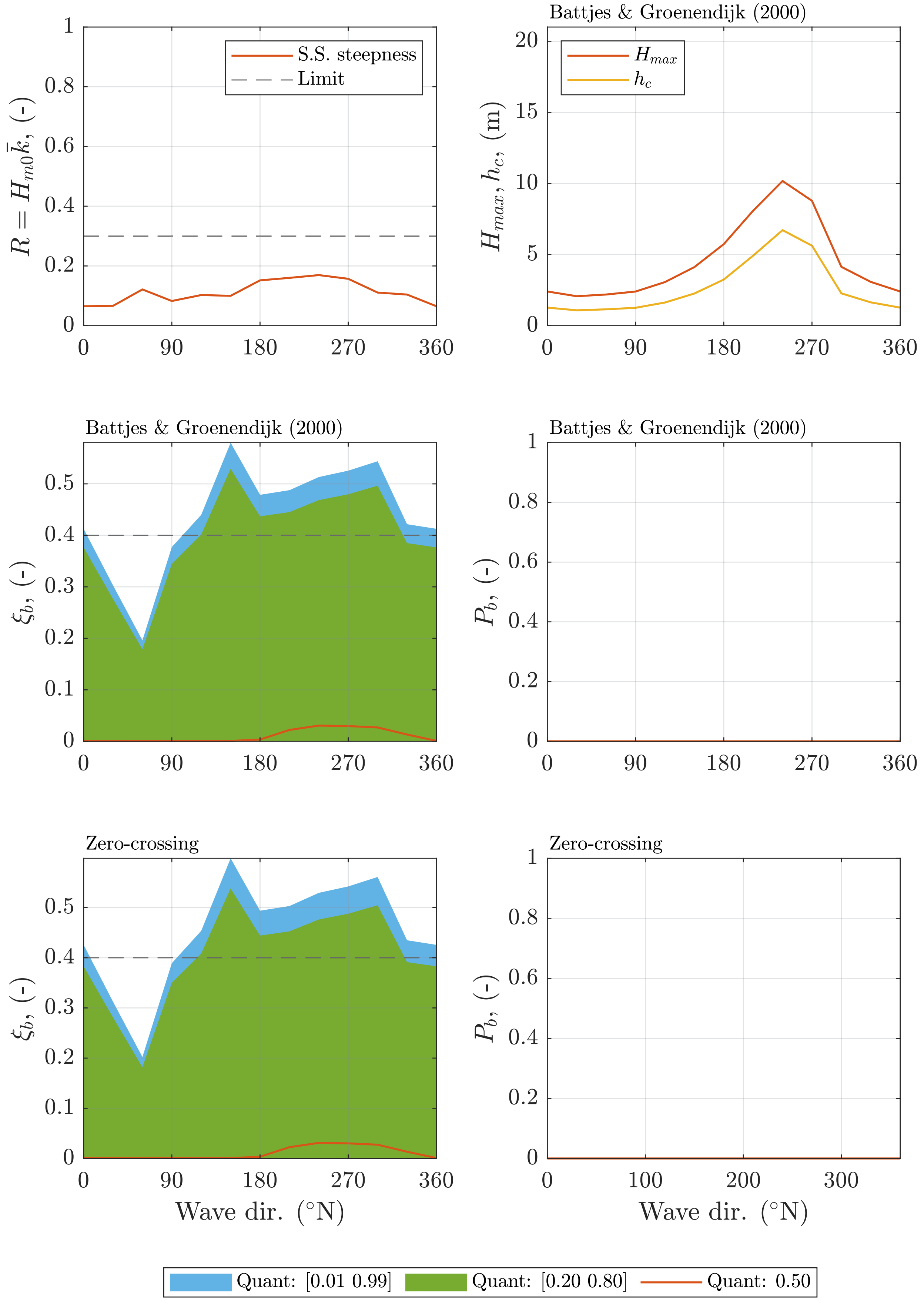
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG03
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.003c



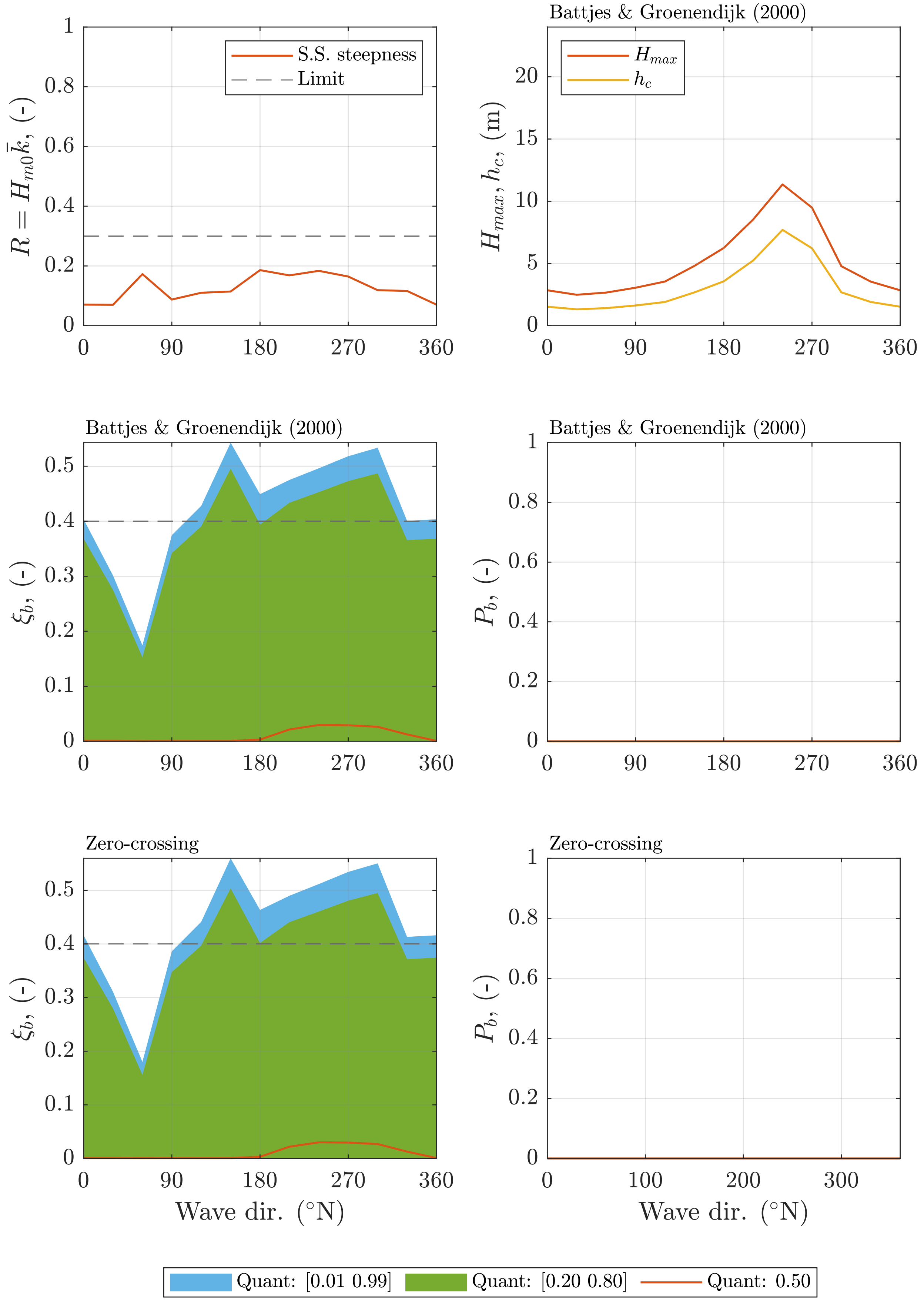
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG03
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.003d



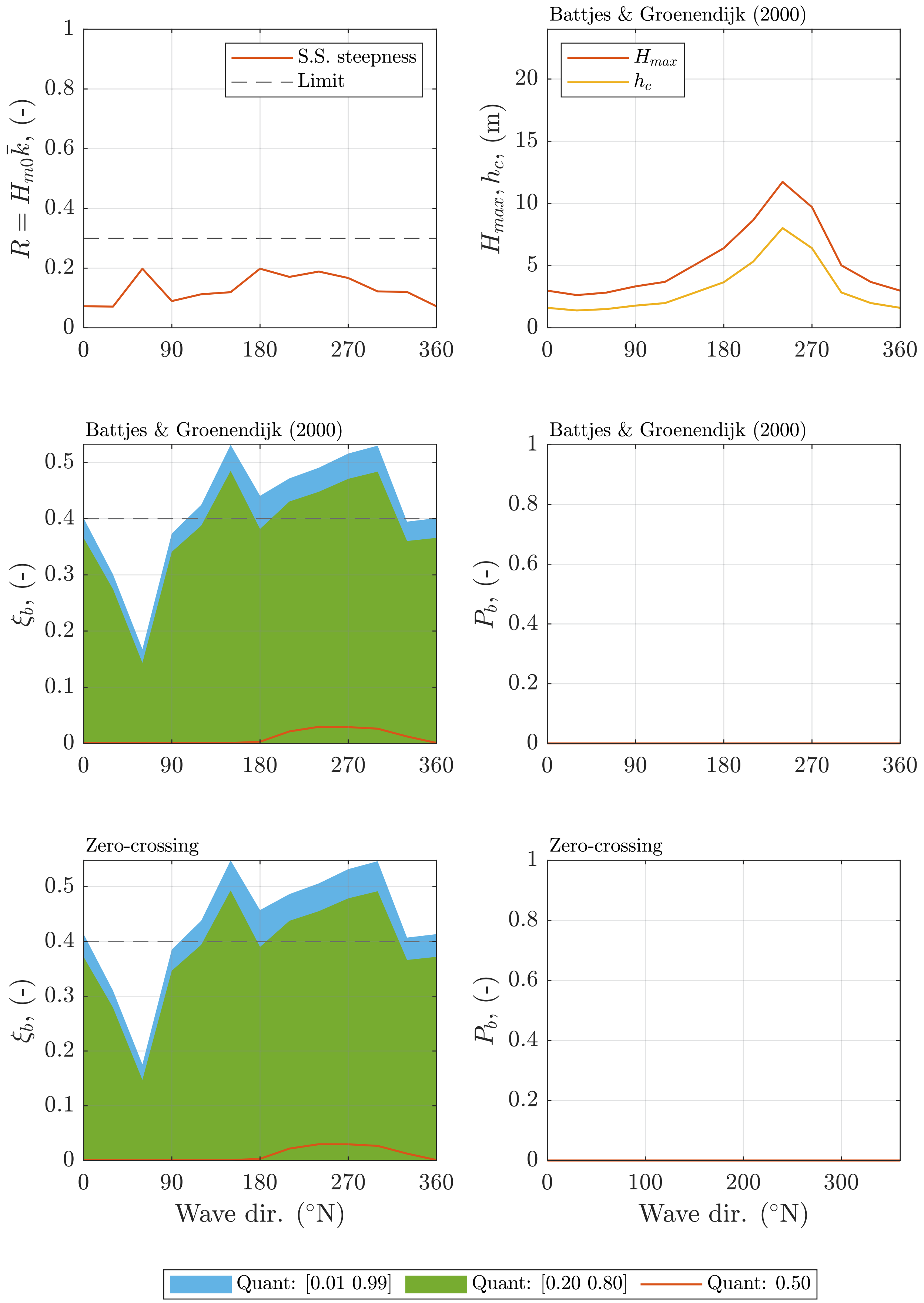
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG04
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.004a



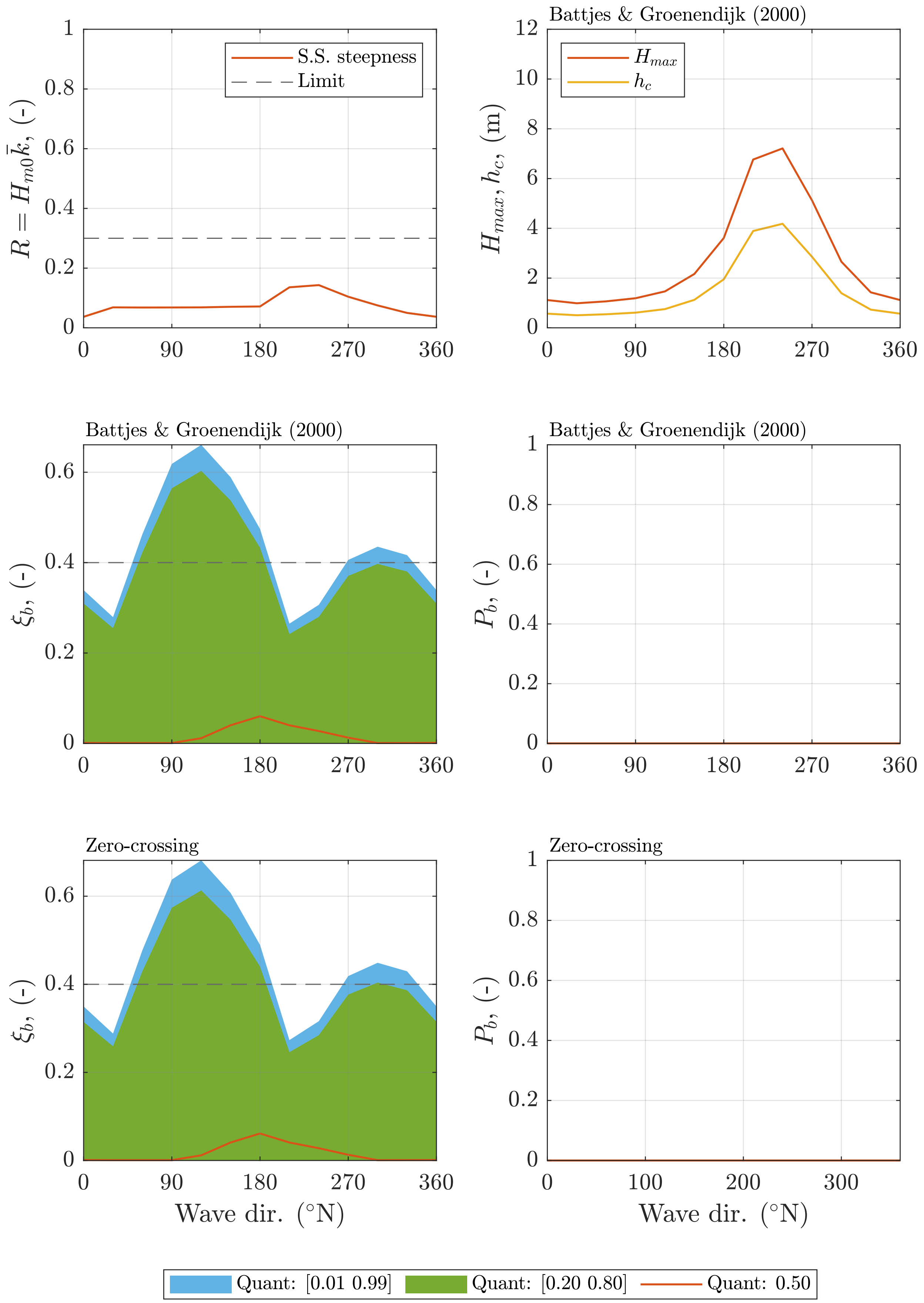
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG04
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.004b



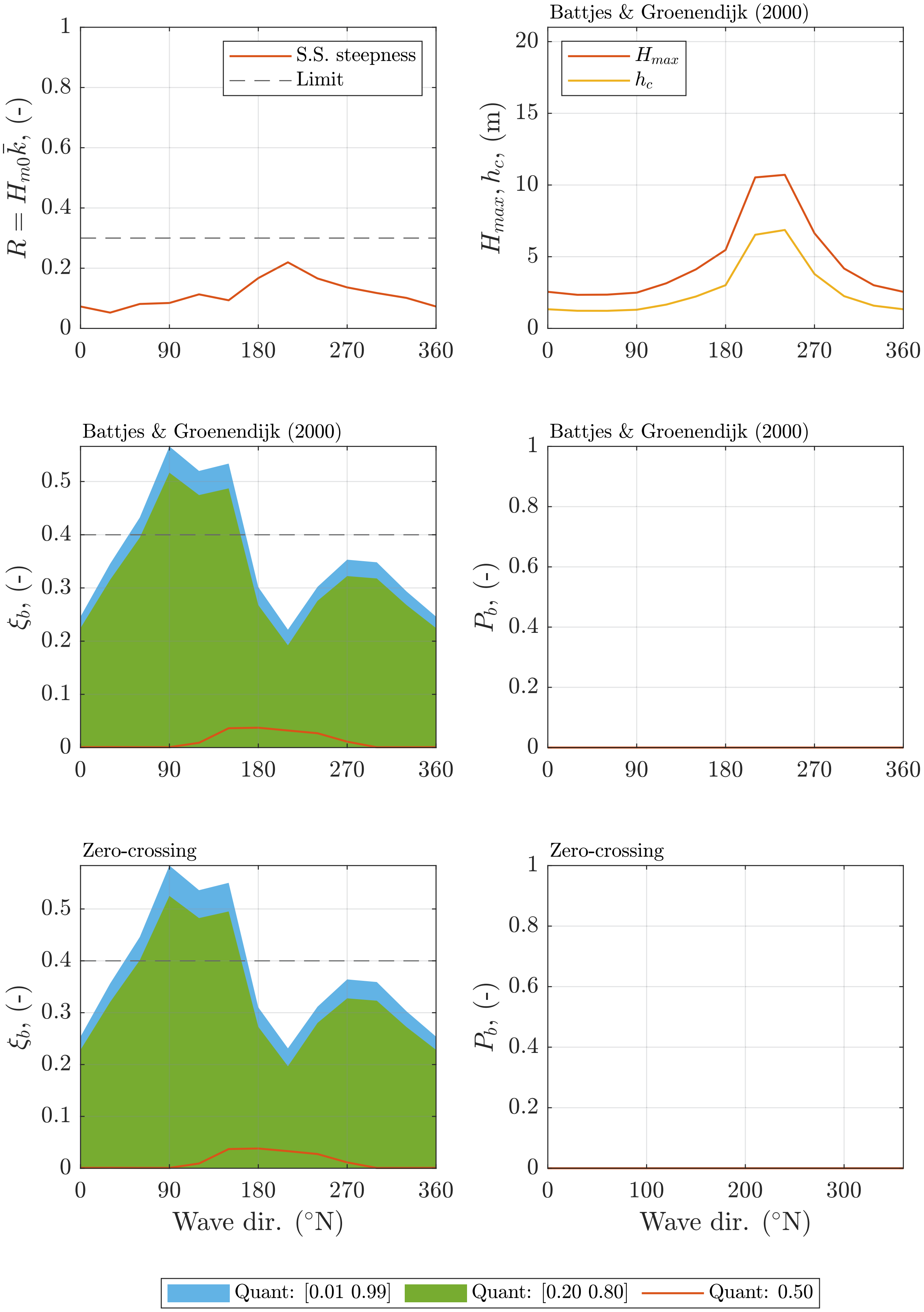
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG04
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.004c



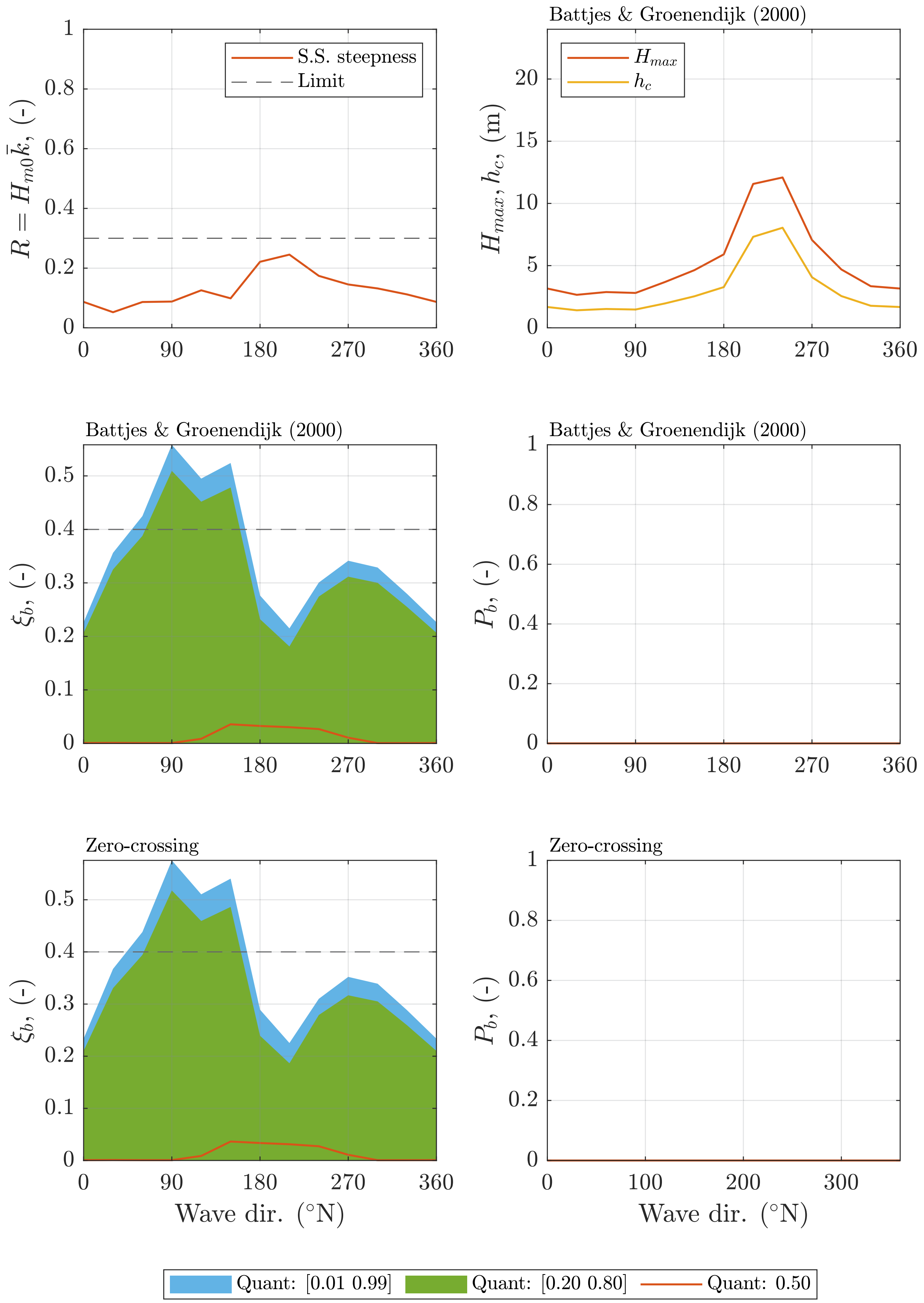
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG04
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.004d



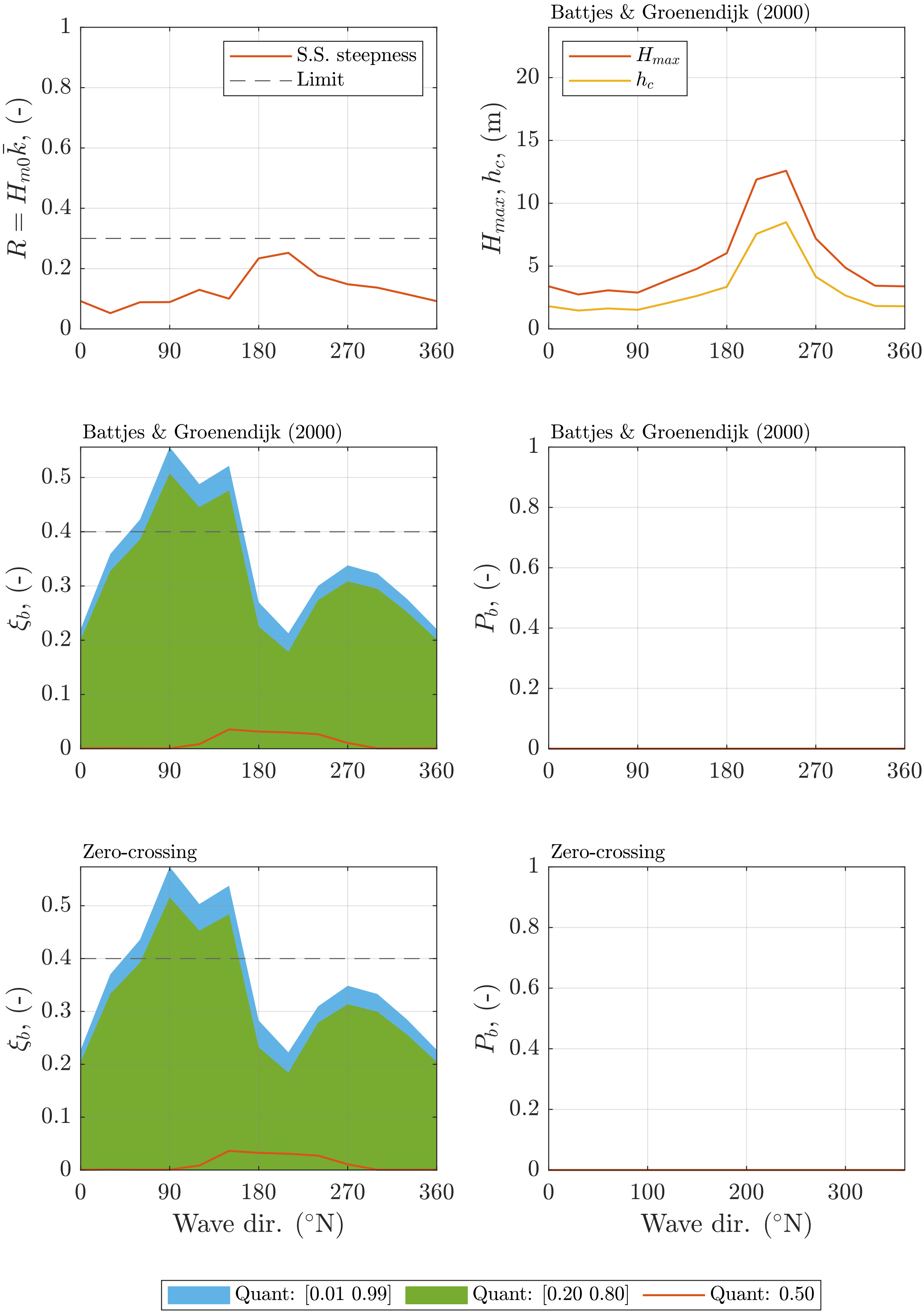
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG05
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.005a



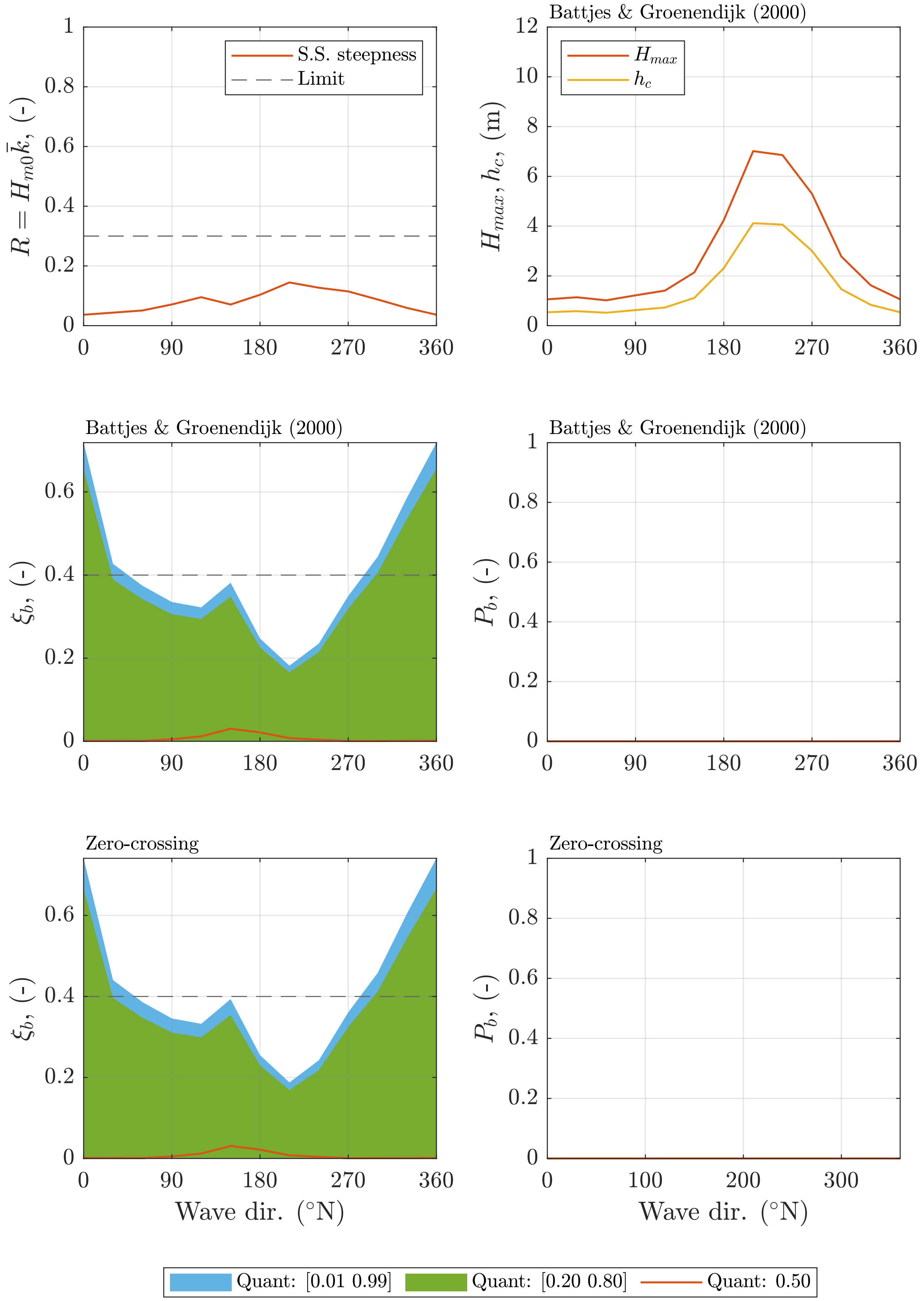
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG05
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.005b



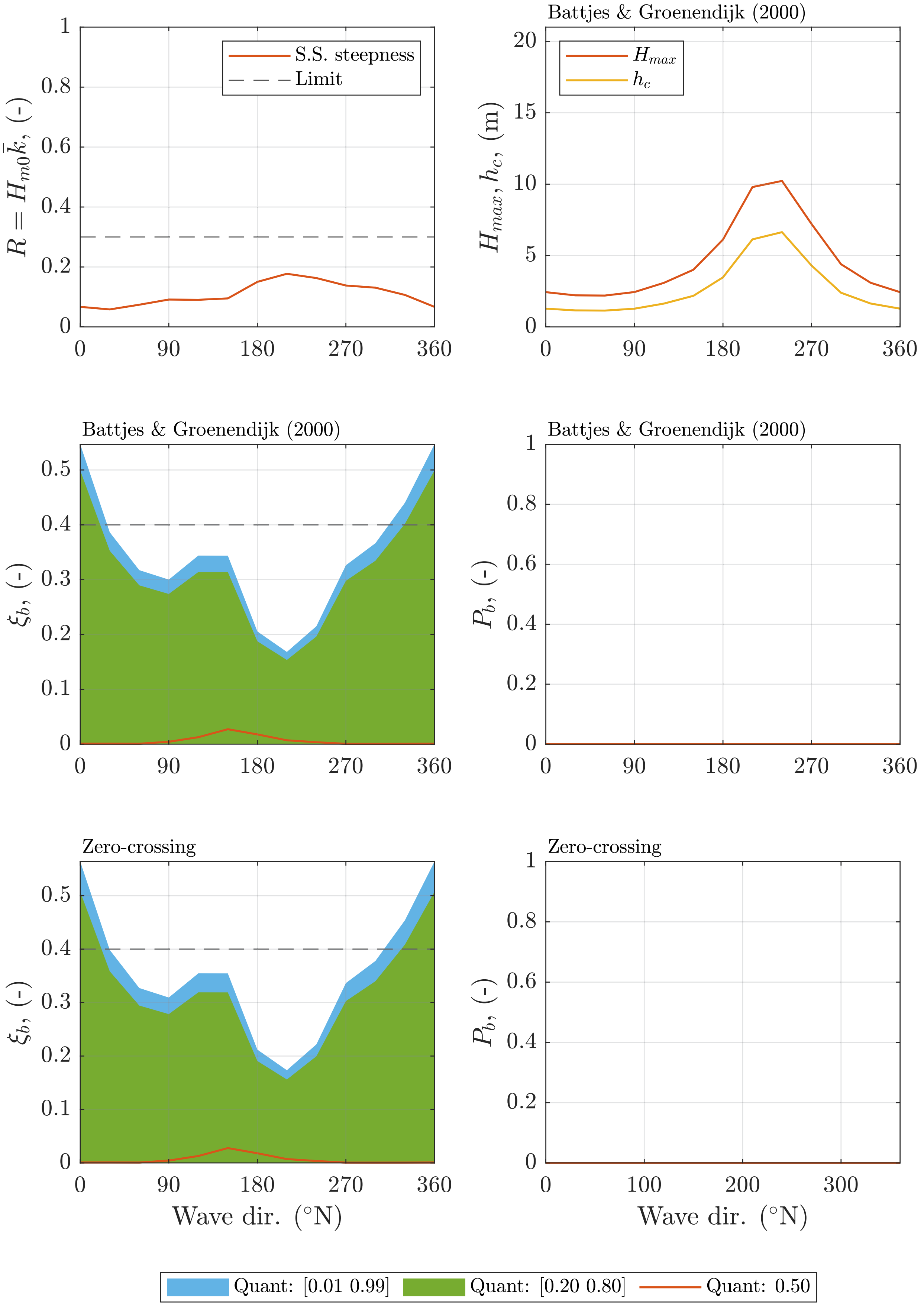
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG05
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.005c



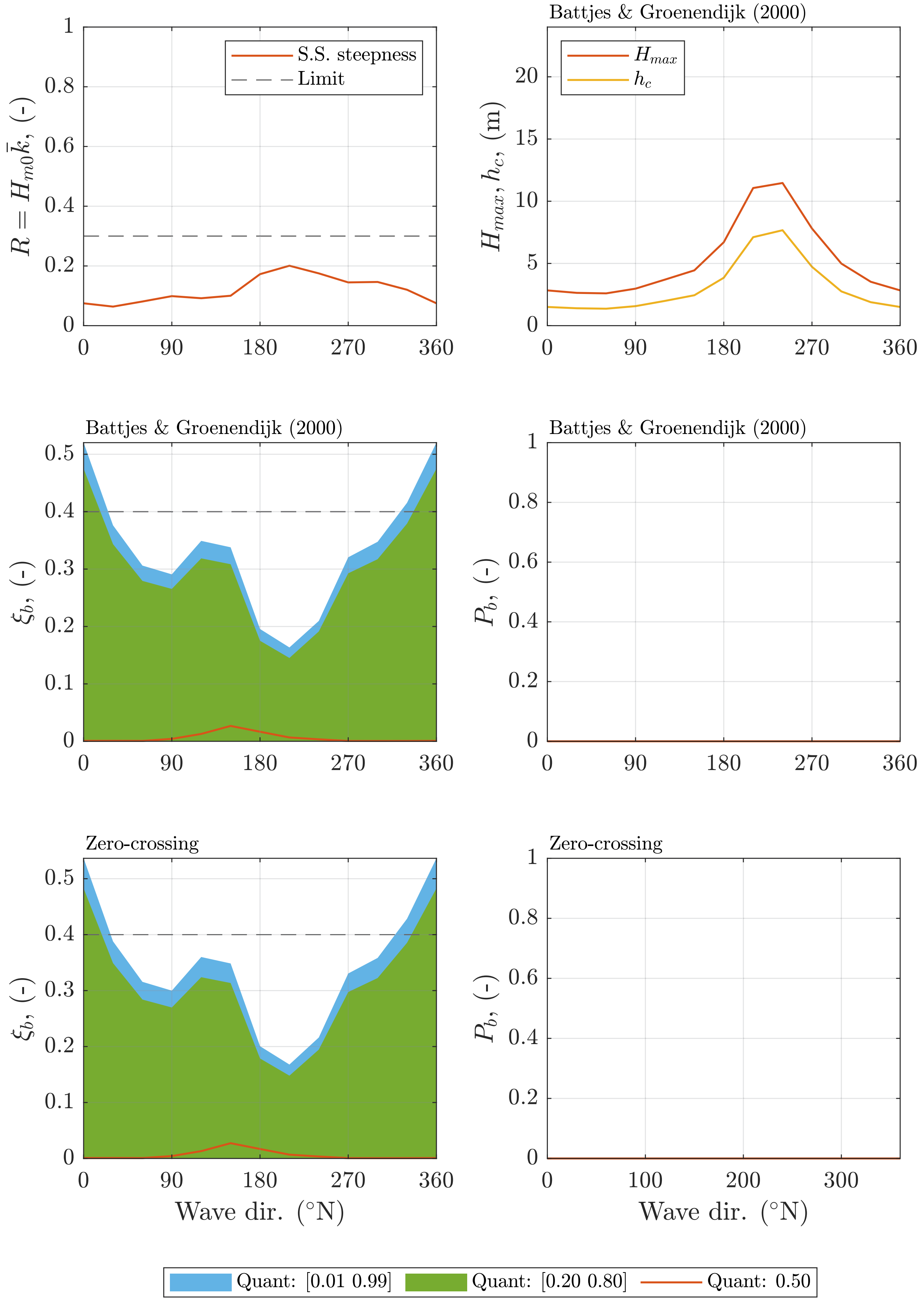
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG05
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.005d



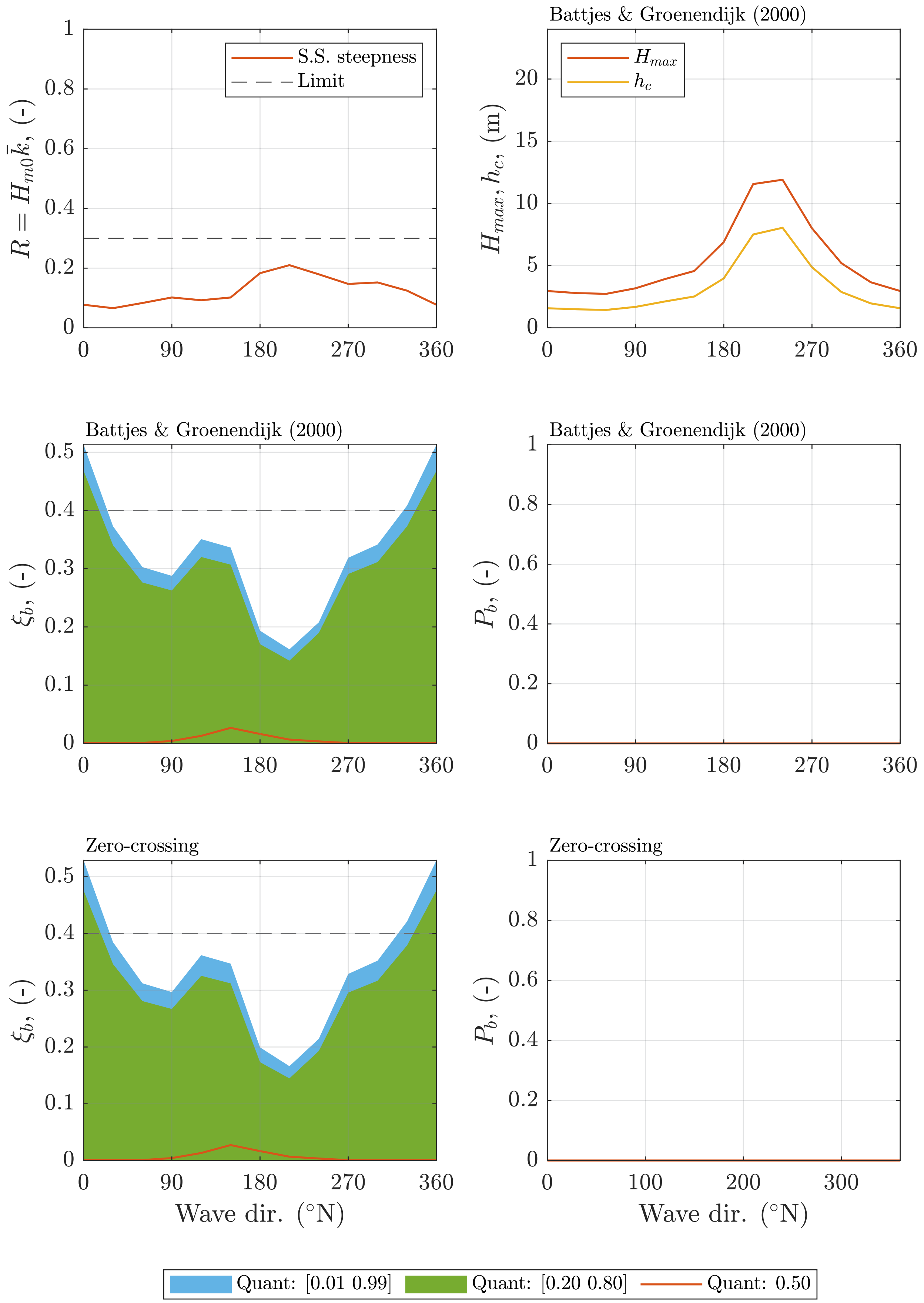
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG06
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.006a



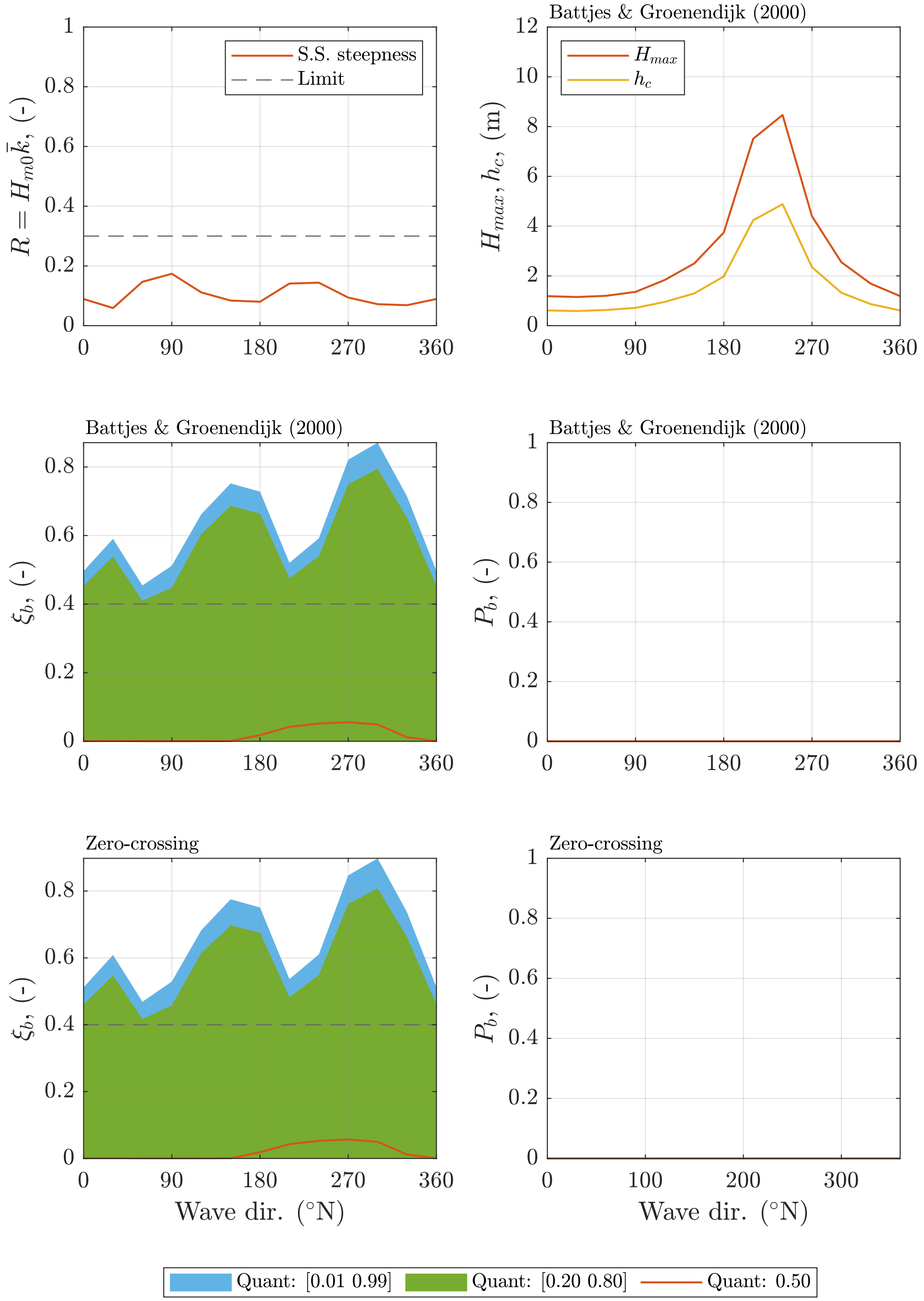
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG06
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.006b



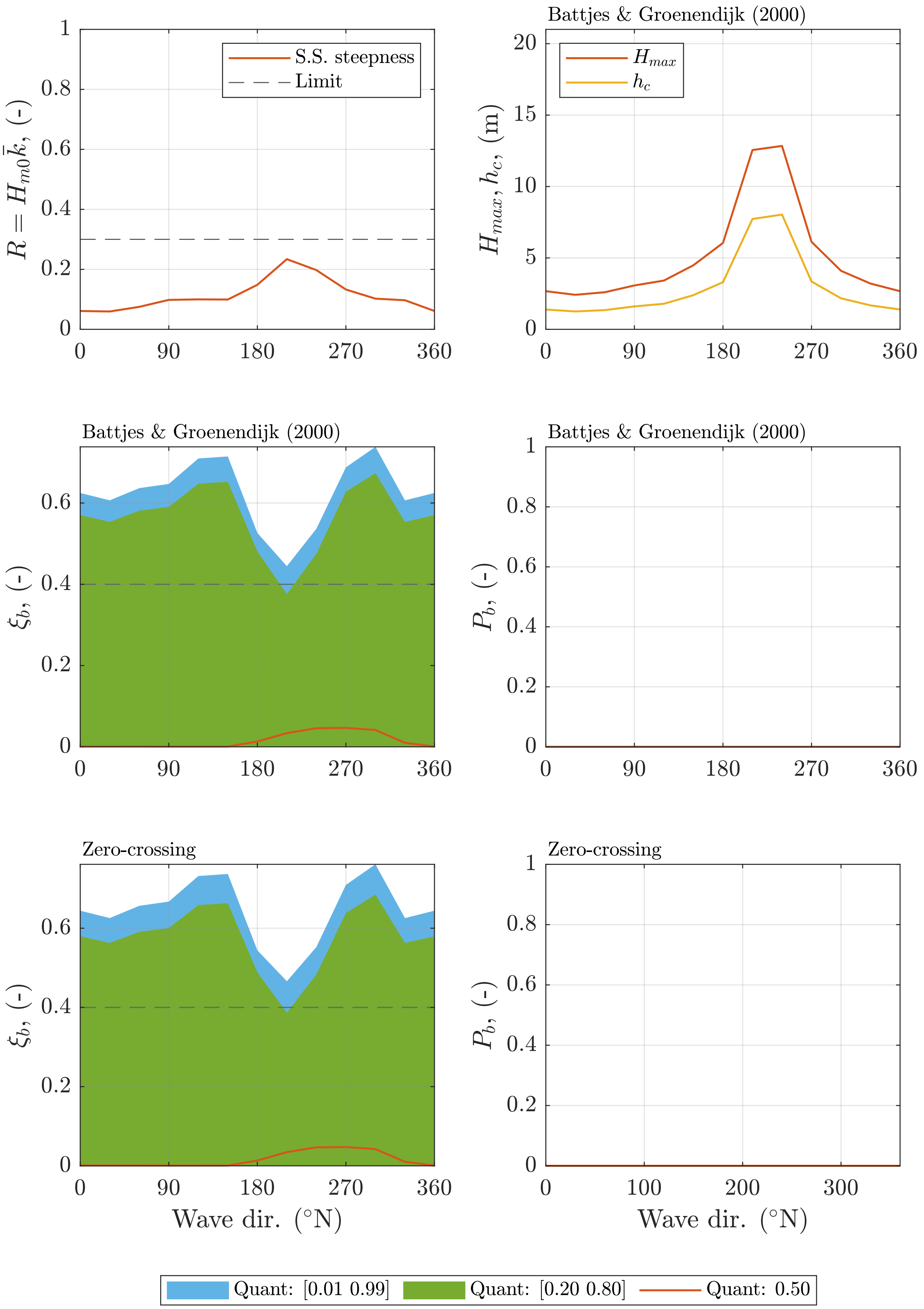
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG06
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.006c



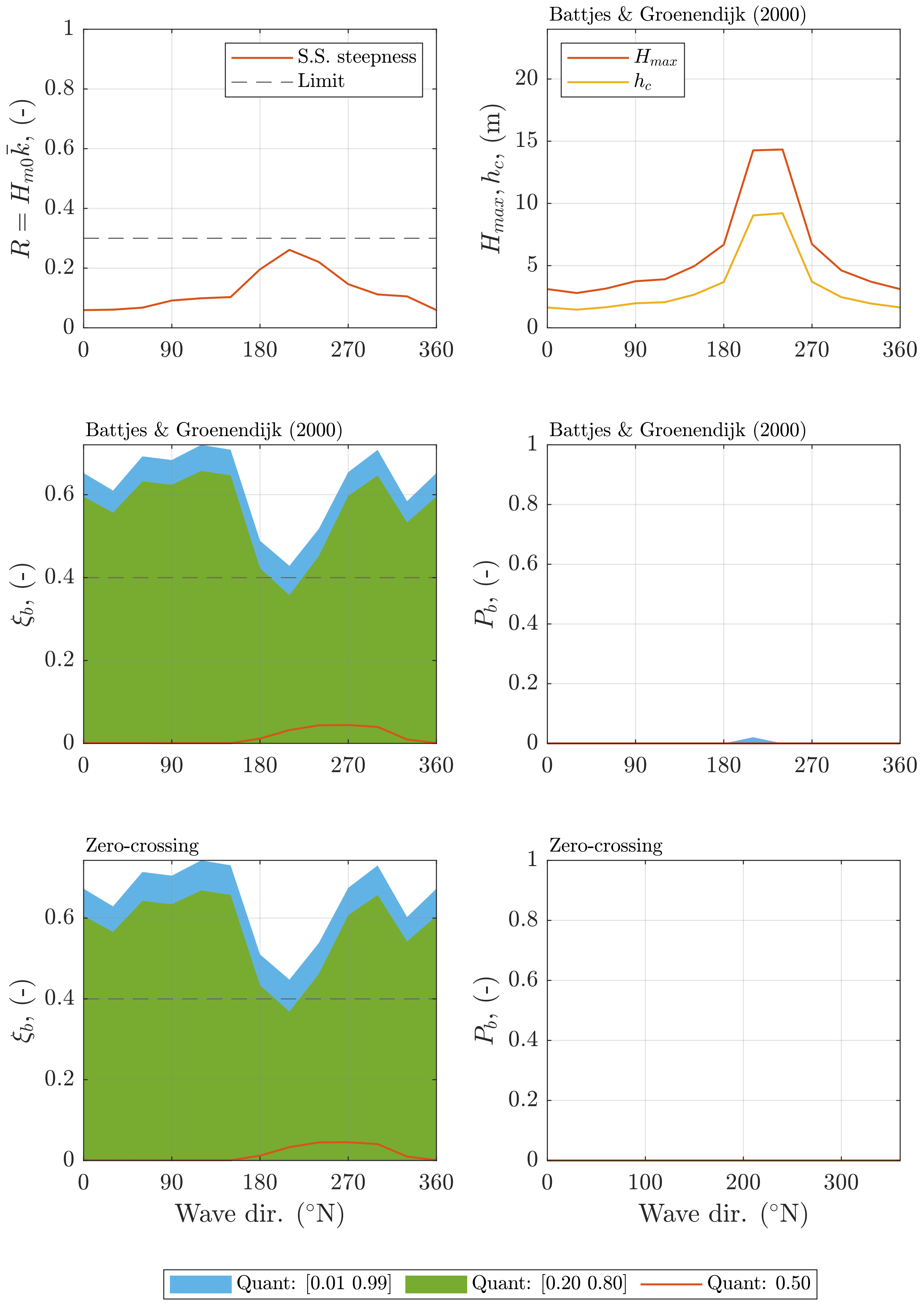
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG06
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.006d



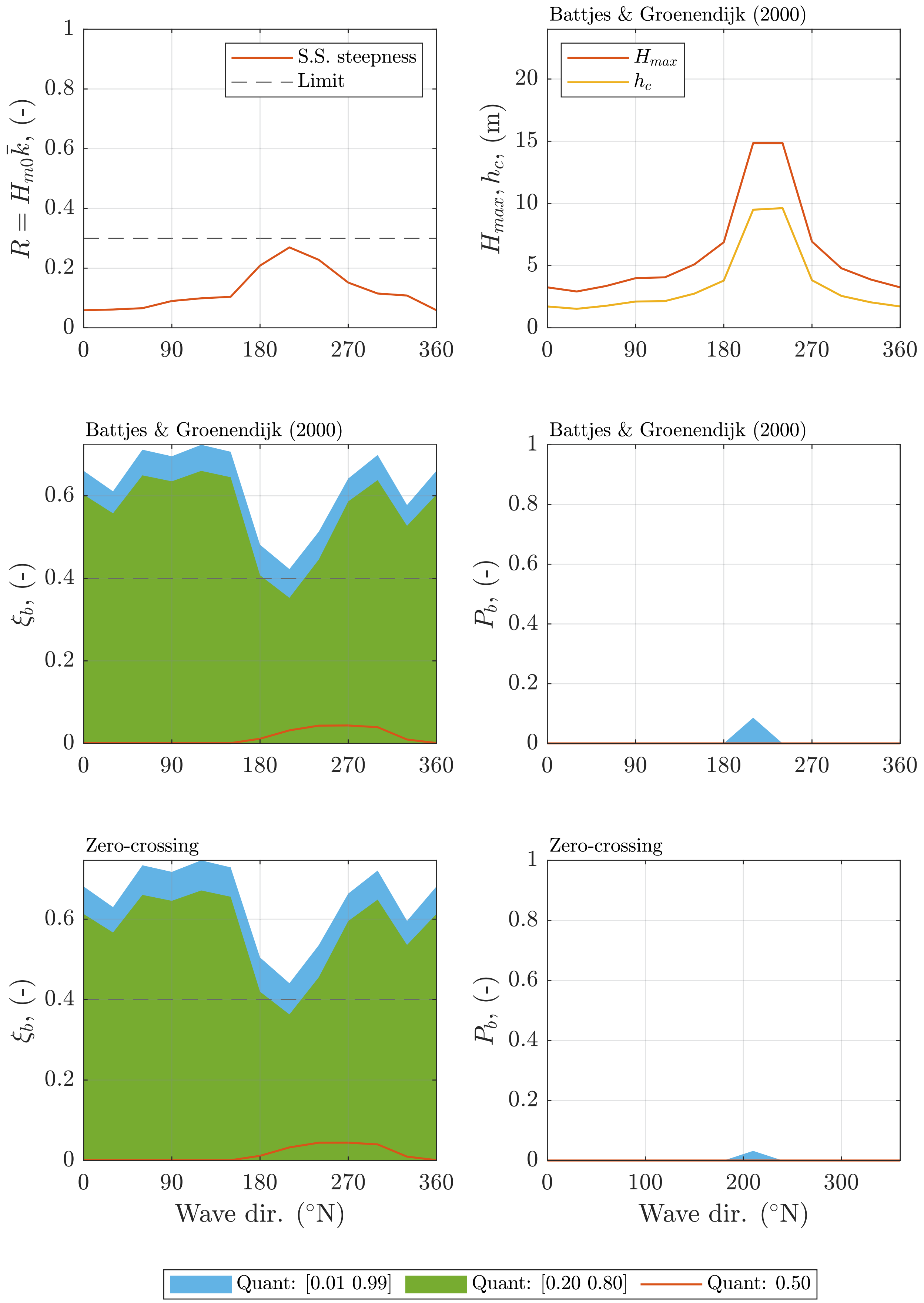
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG07
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.007a



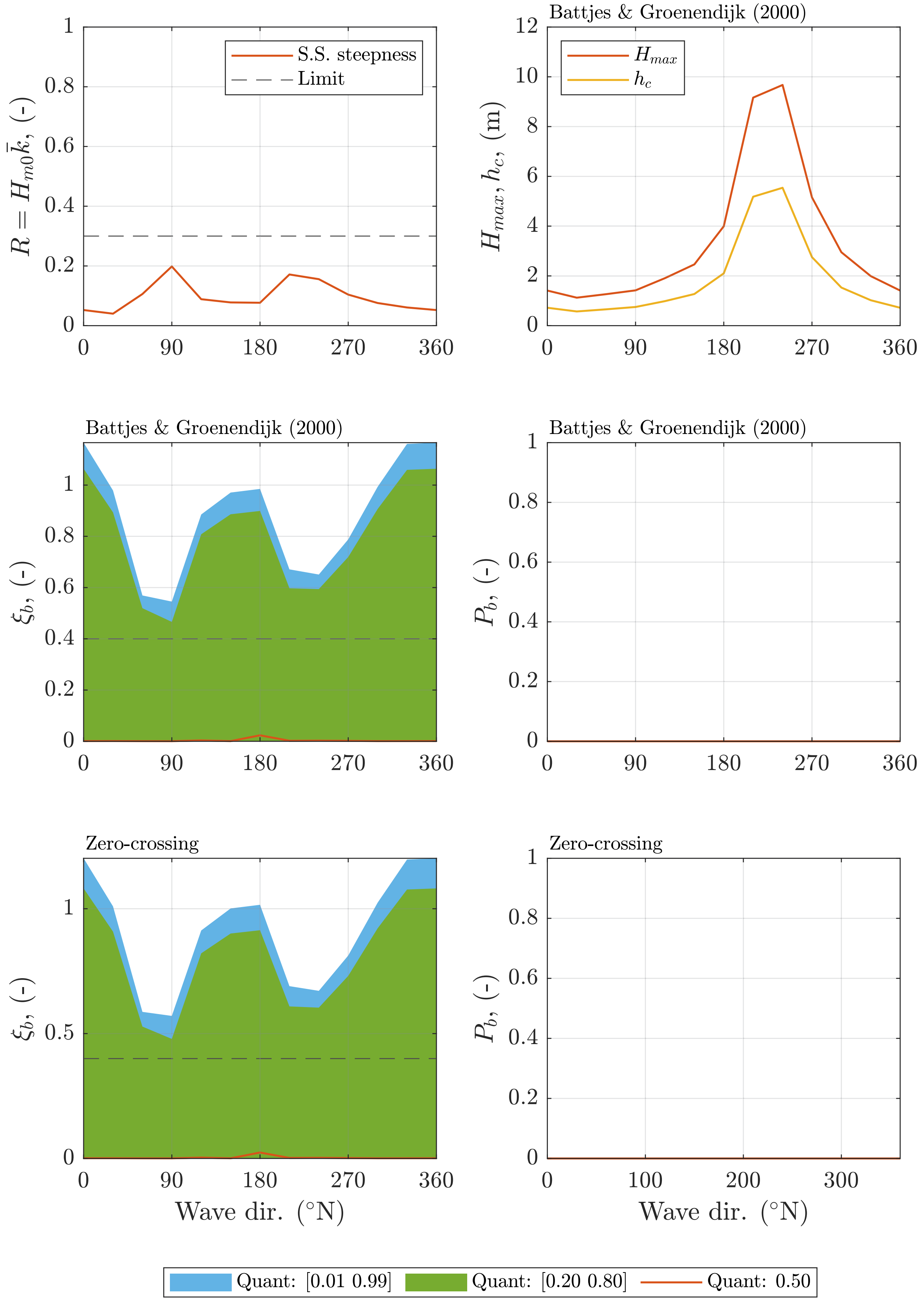
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG07
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.007b



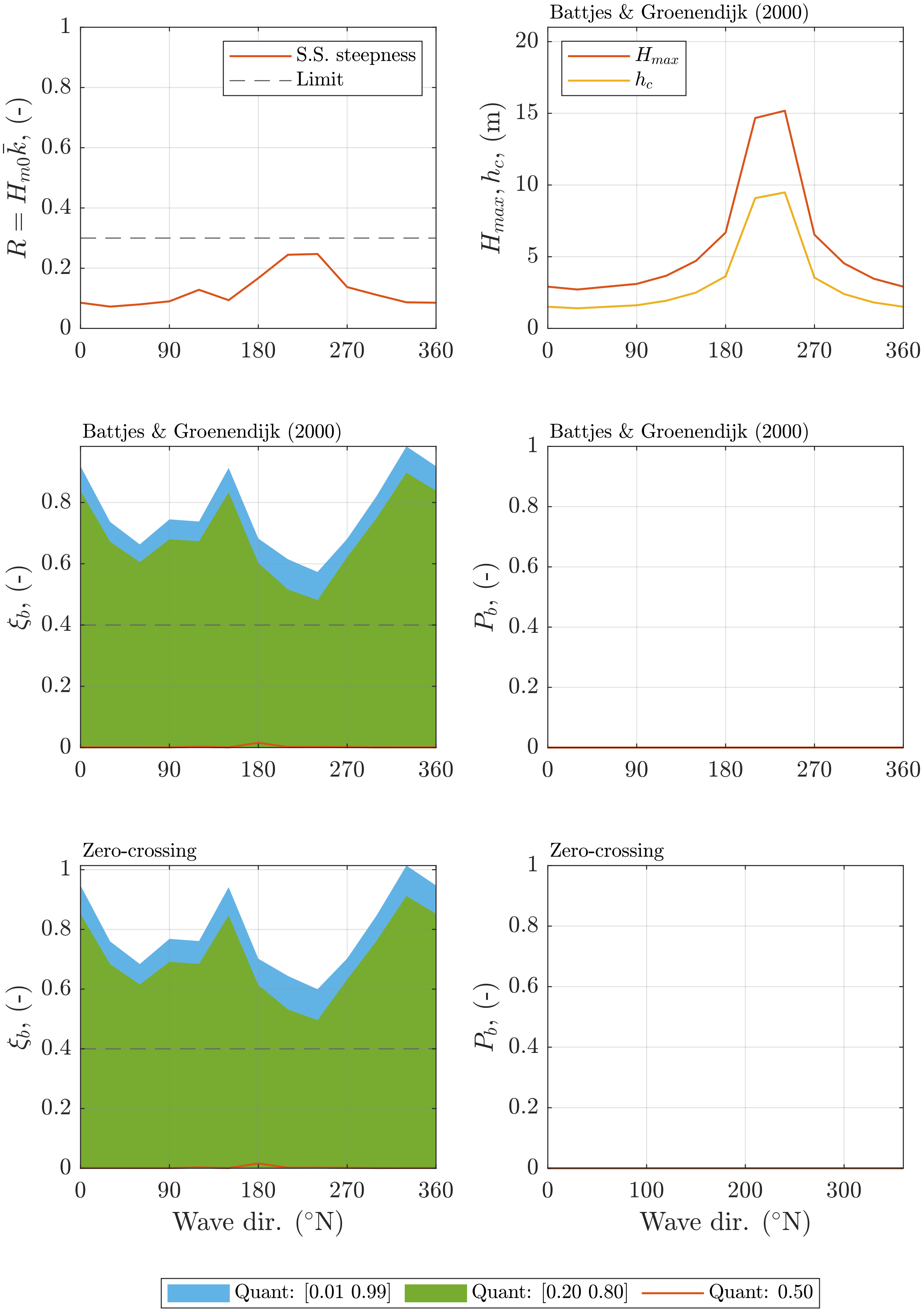
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG07
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.007c



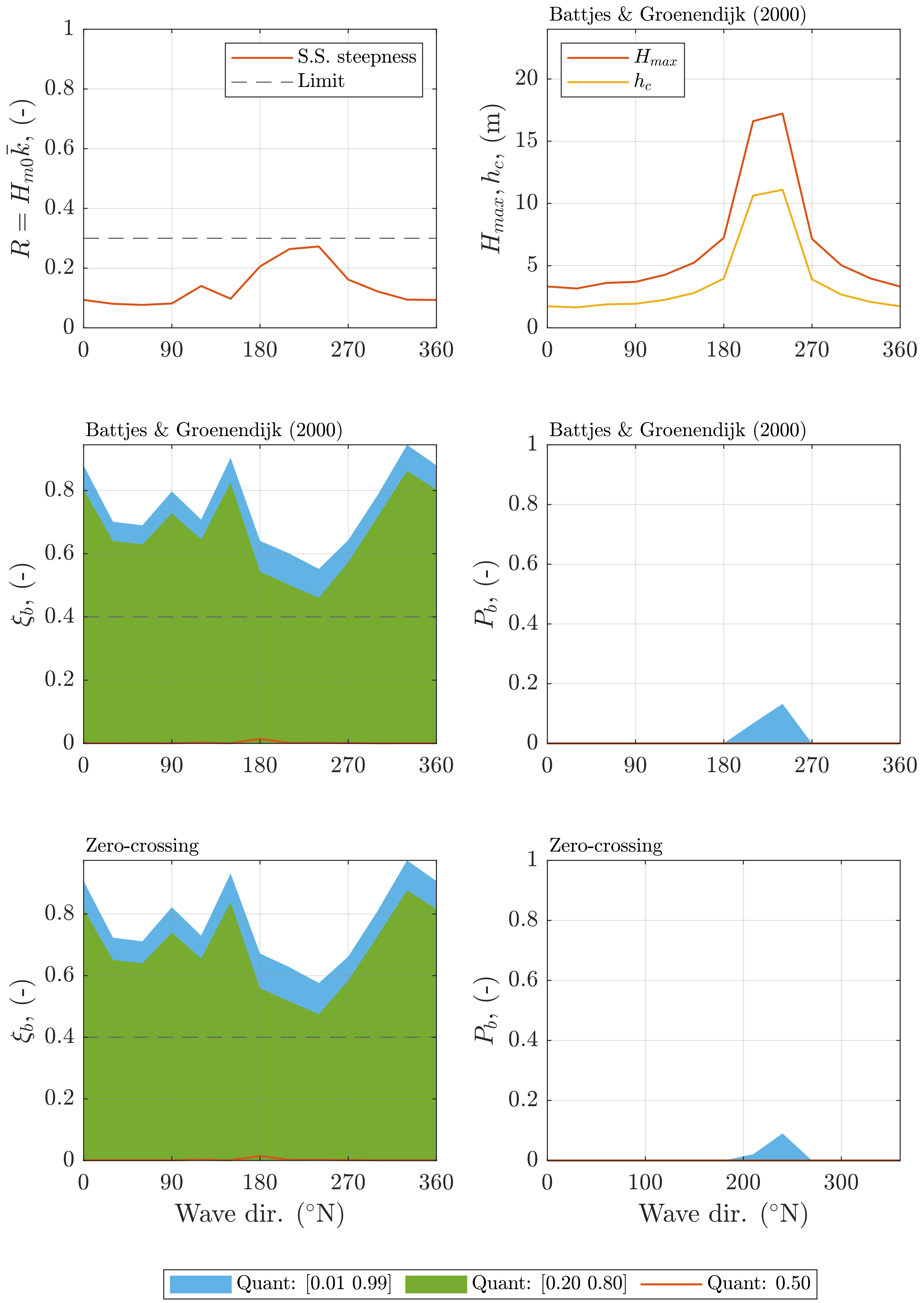
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG07
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.007d



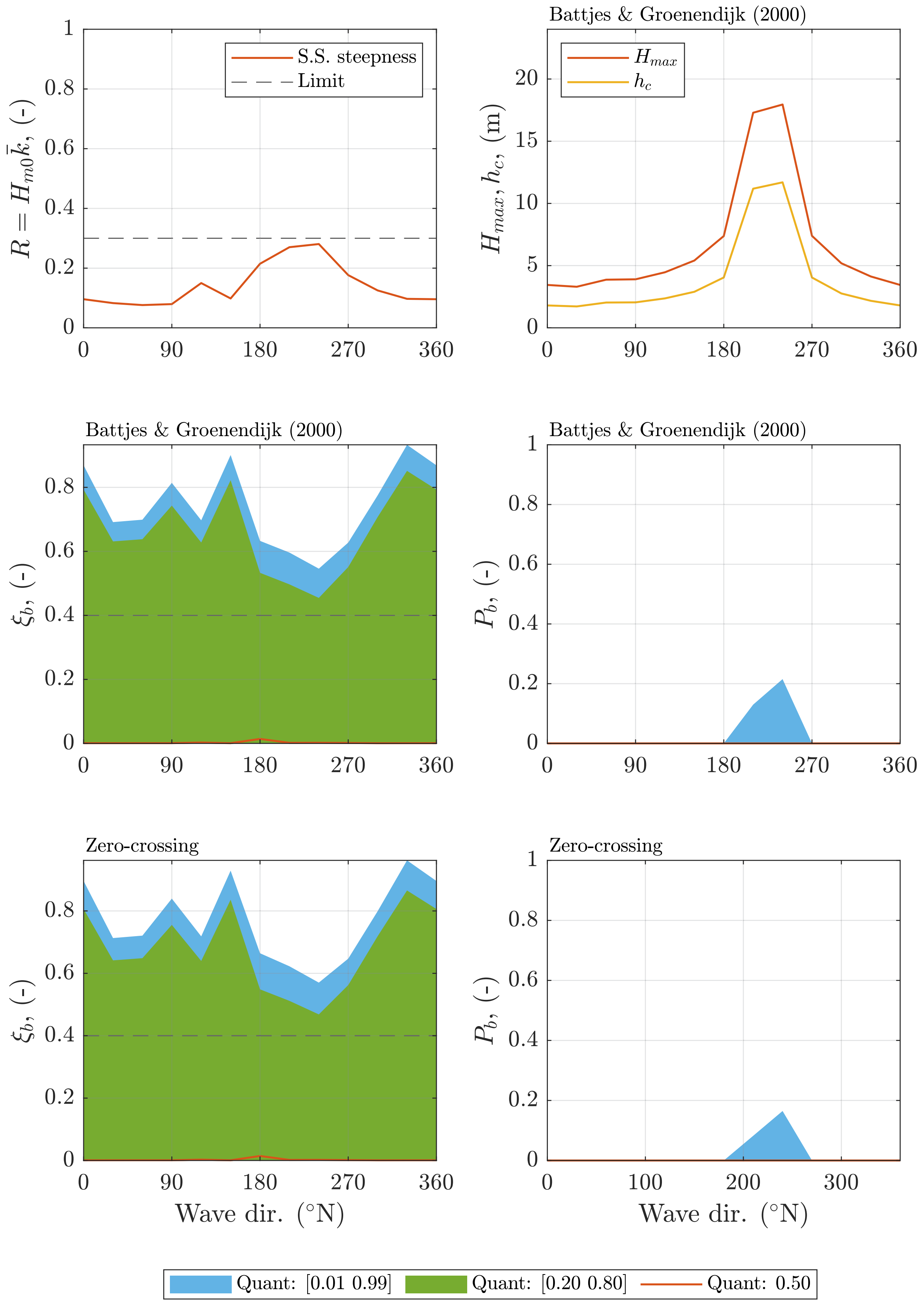
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG08
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.008a



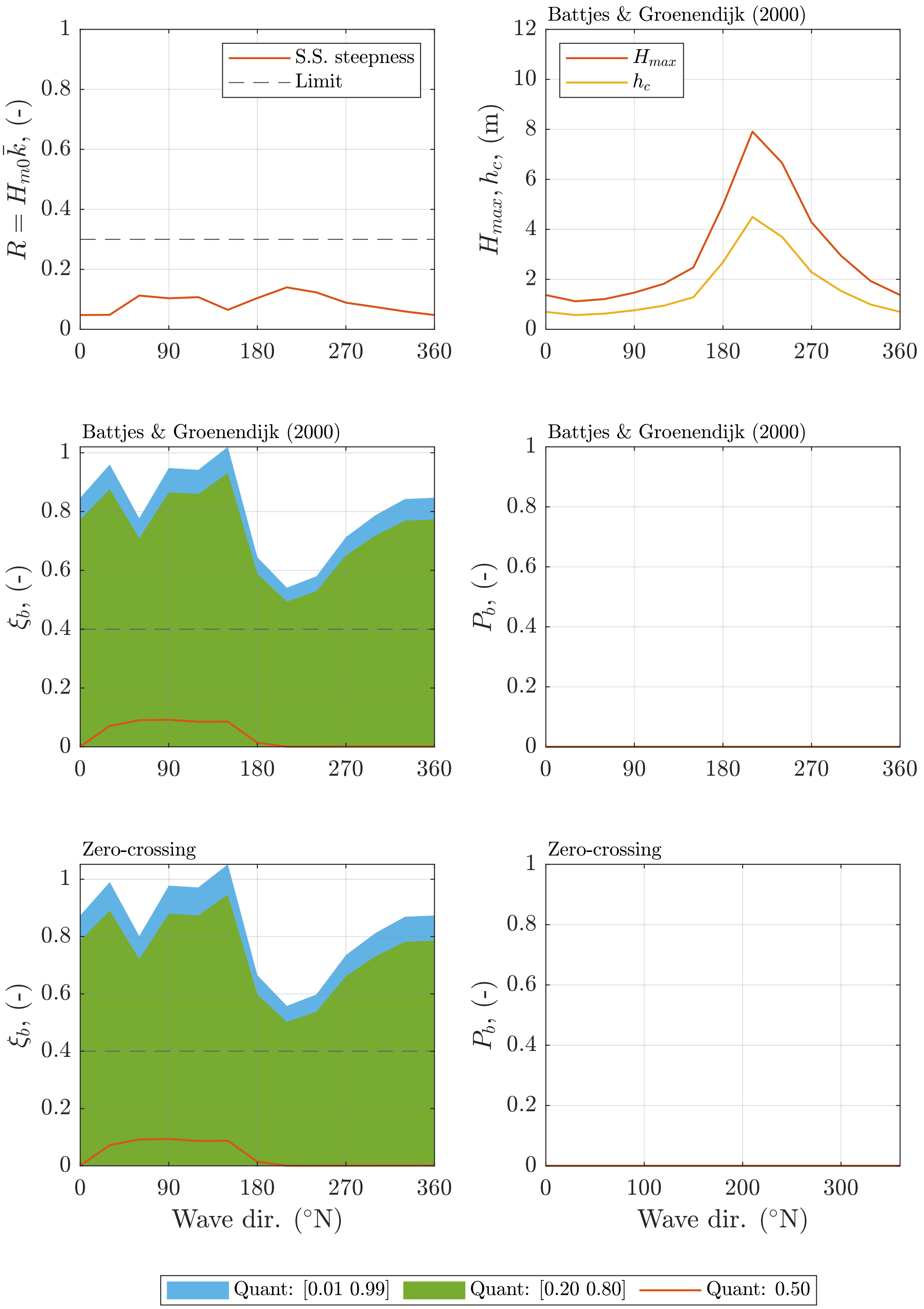
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG08
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.008b



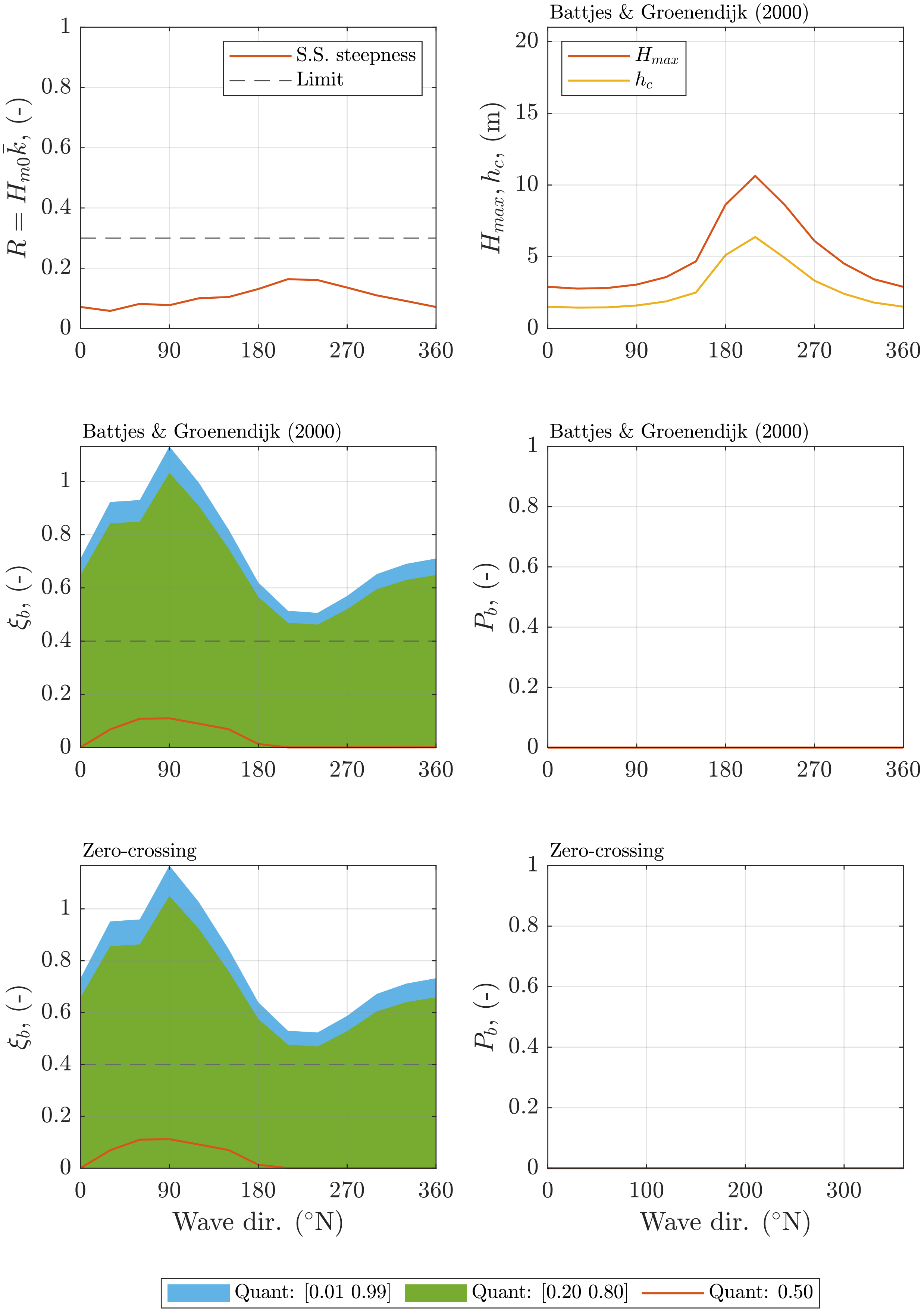
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG08
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.008c



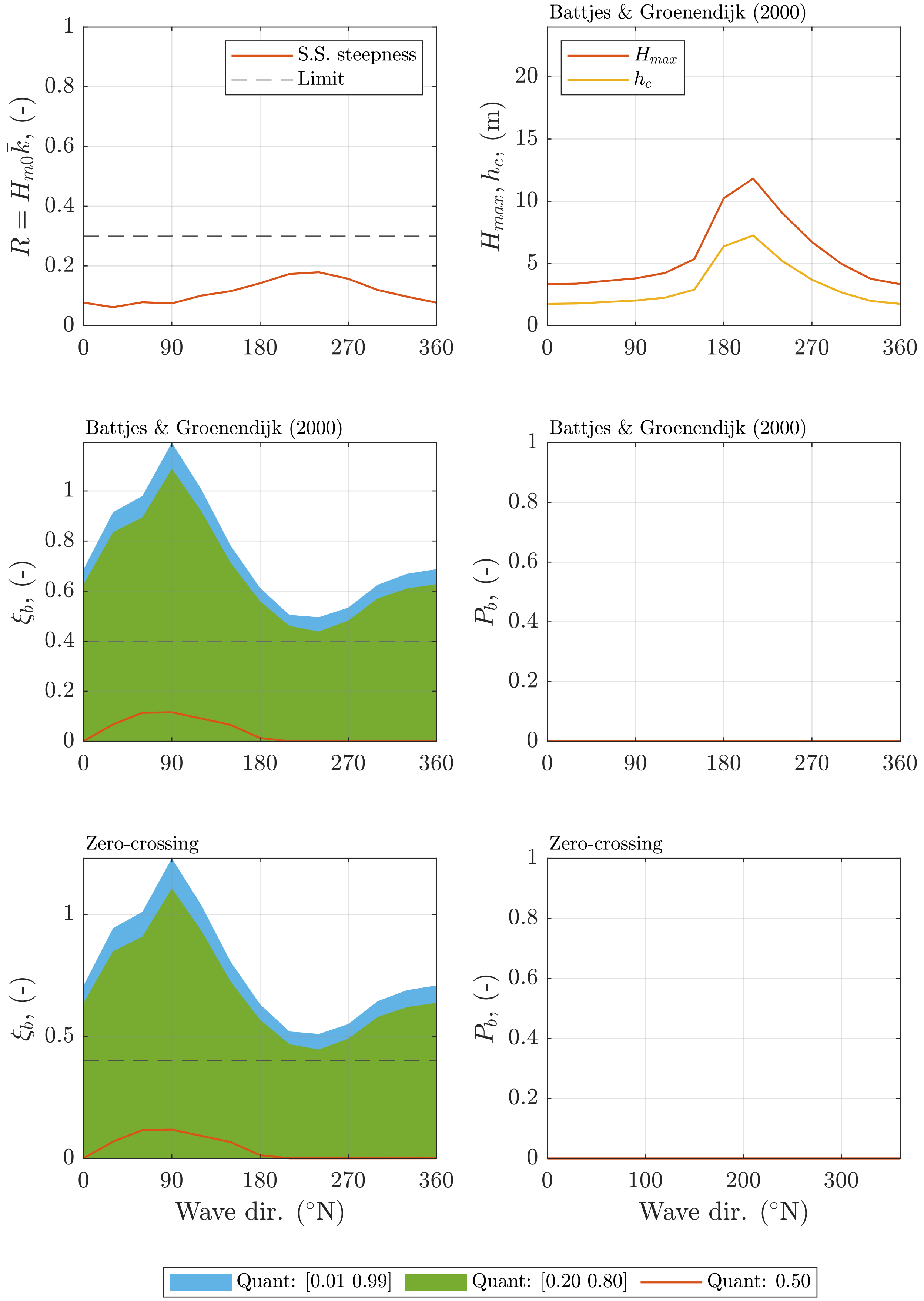
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG08
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.008d



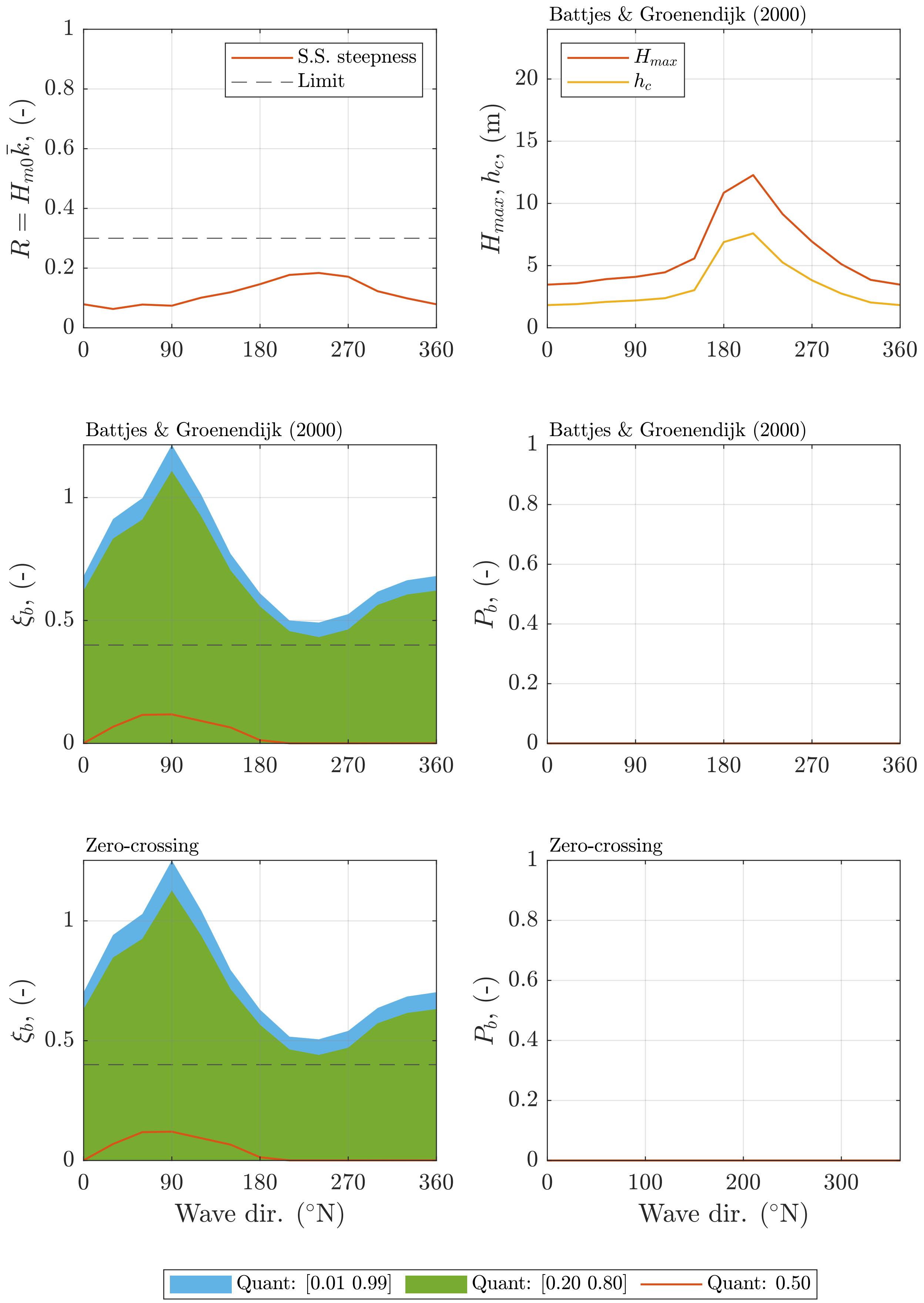
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG09
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.009a



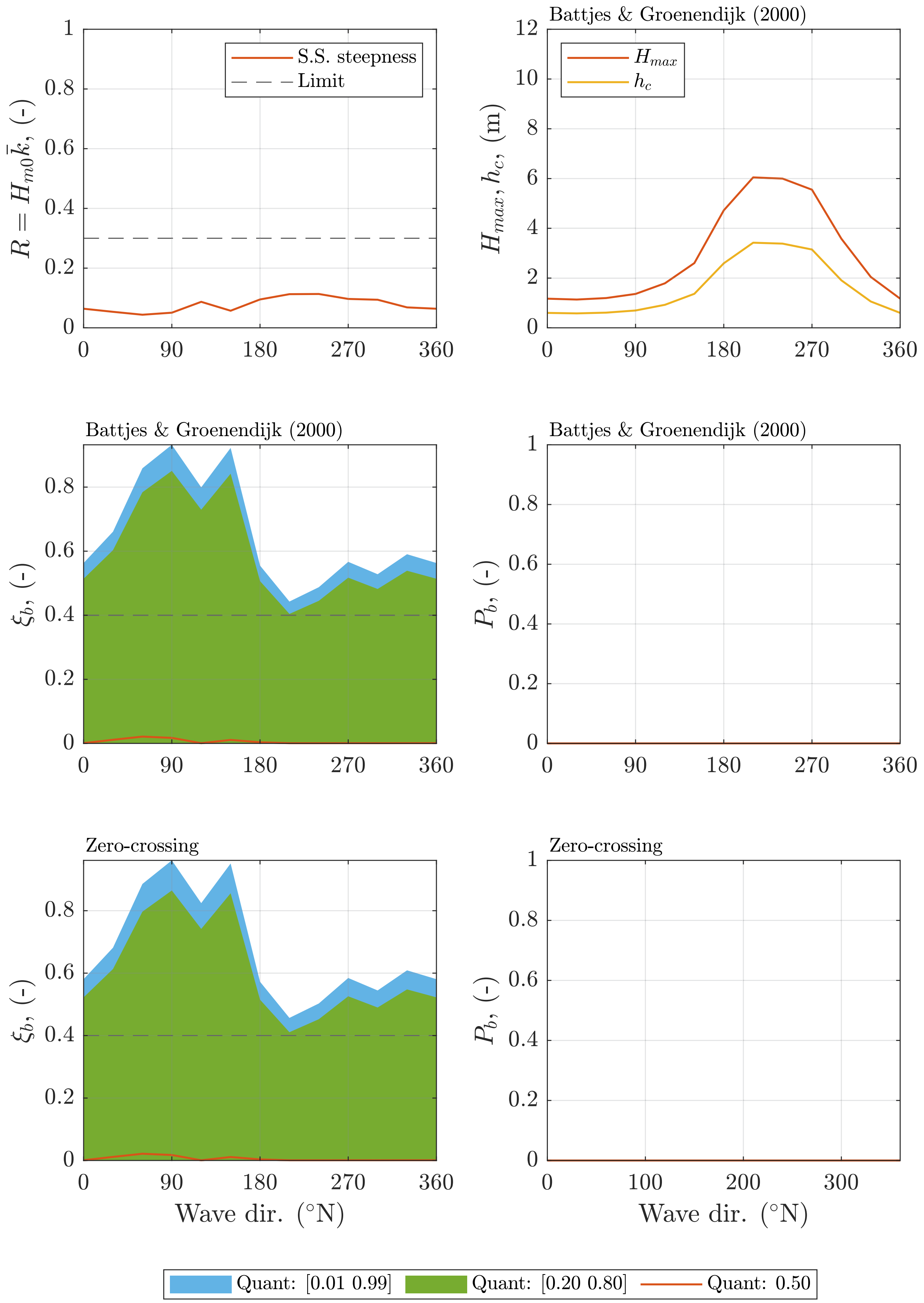
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG09
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.009b



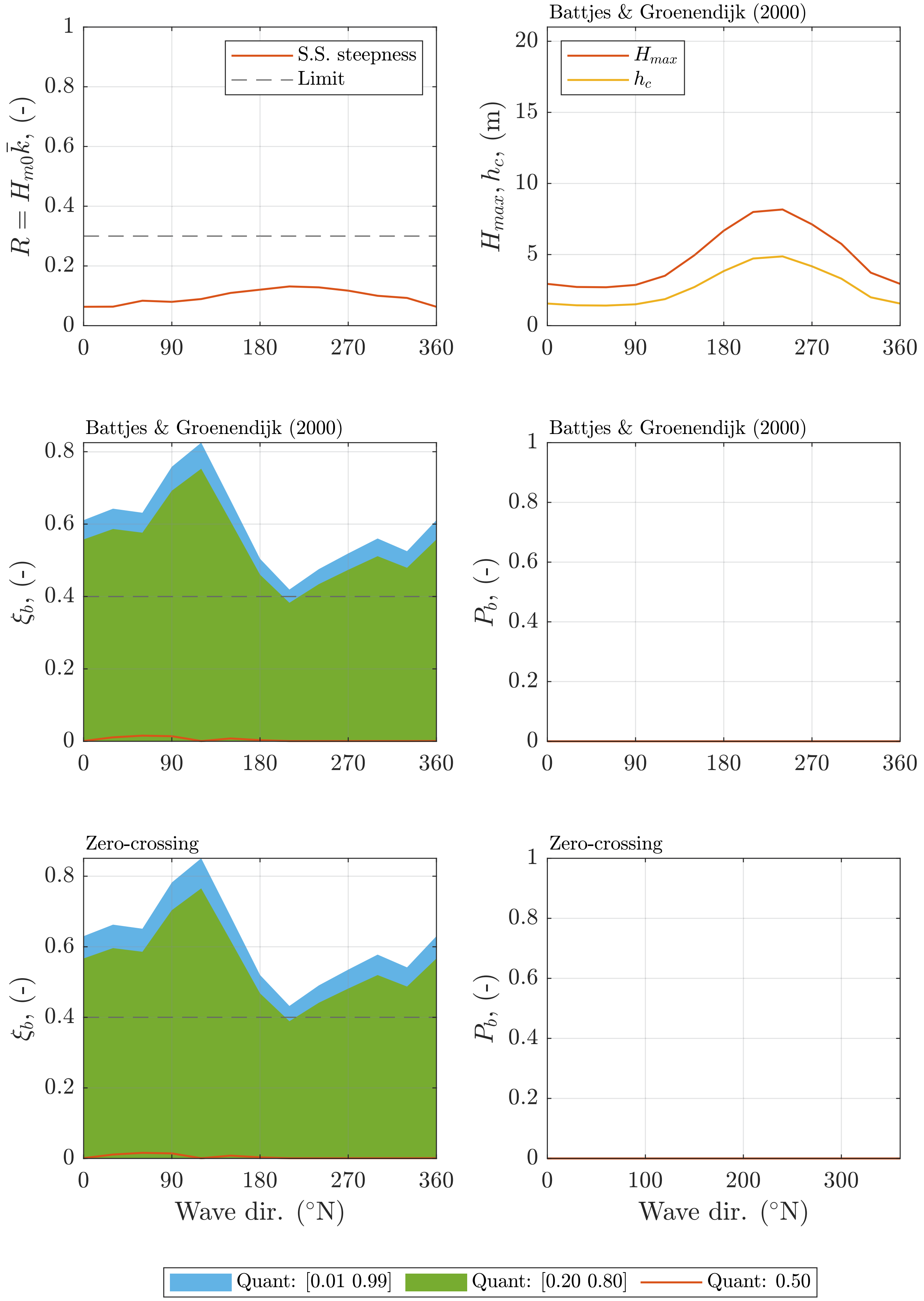
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG09
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.009c



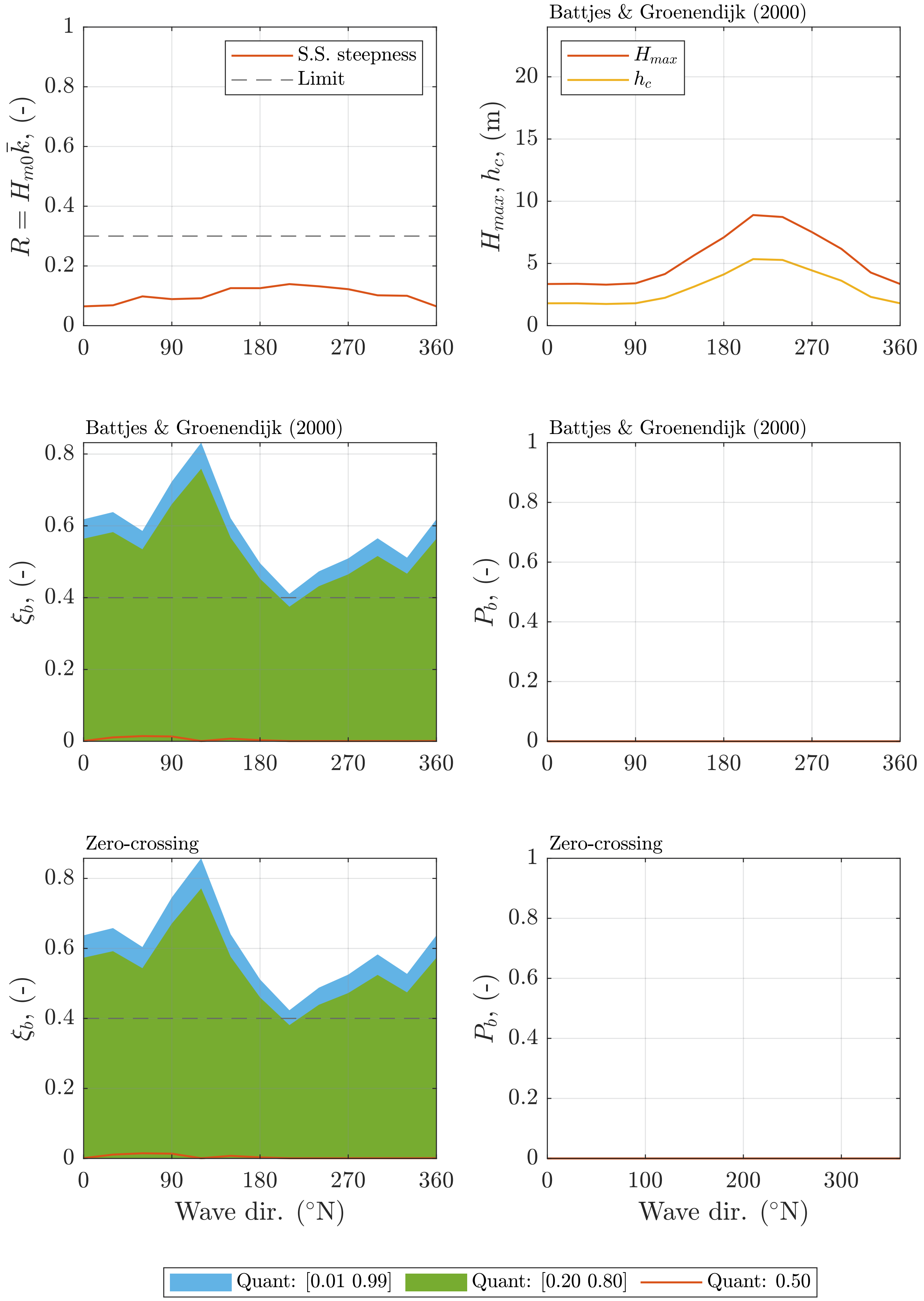
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG09
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.009d



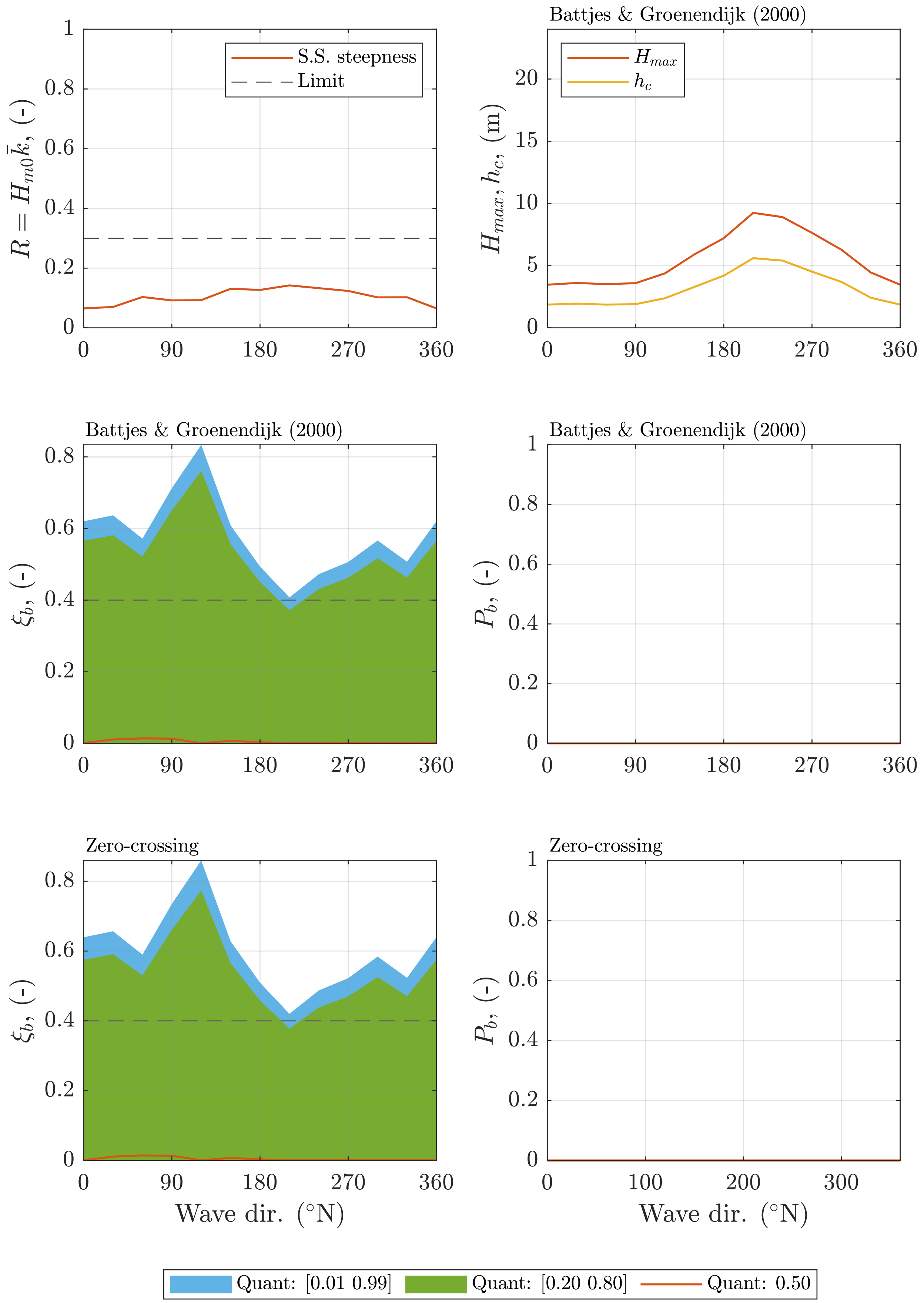
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG10
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.010a



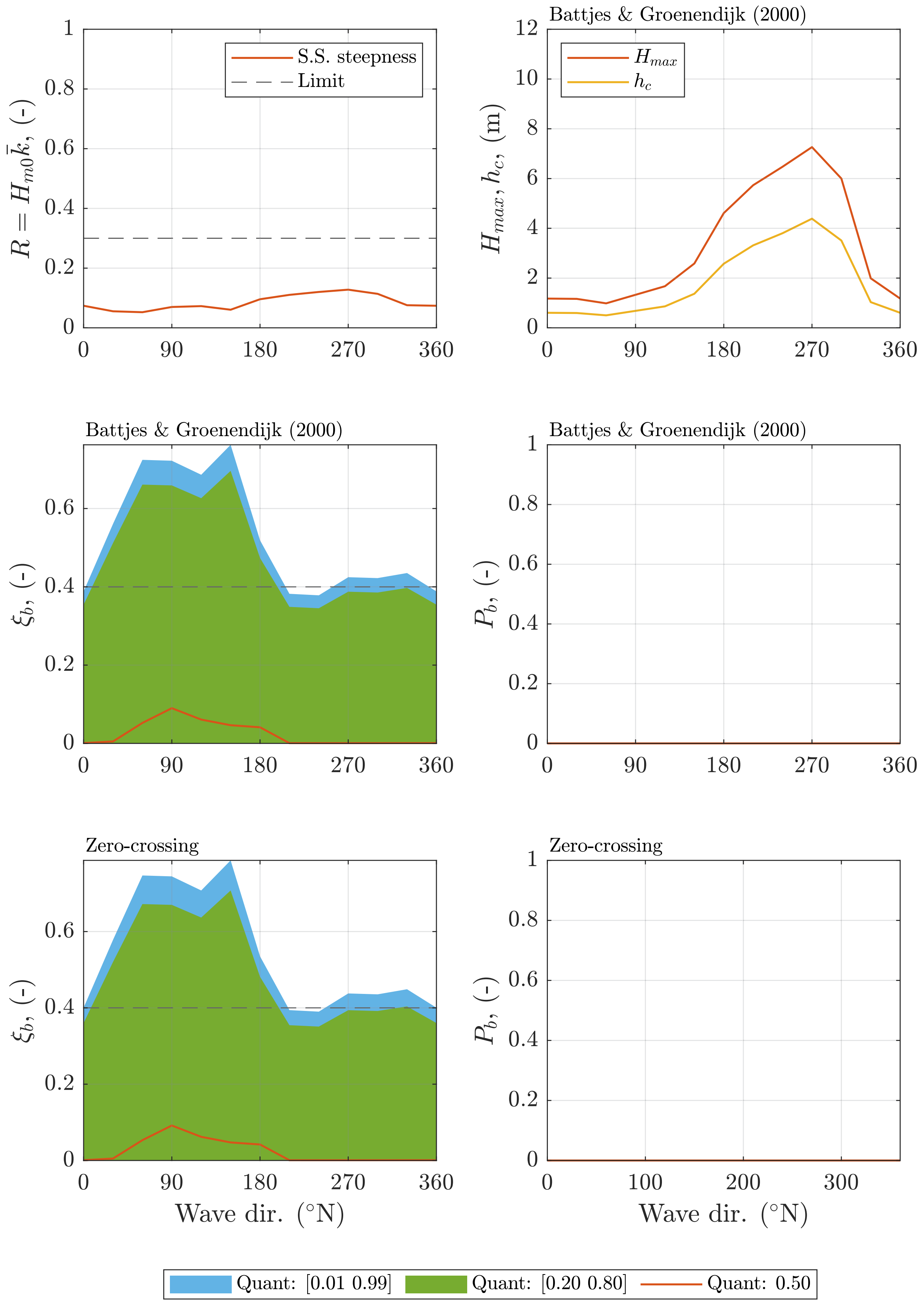
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG10
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.010b



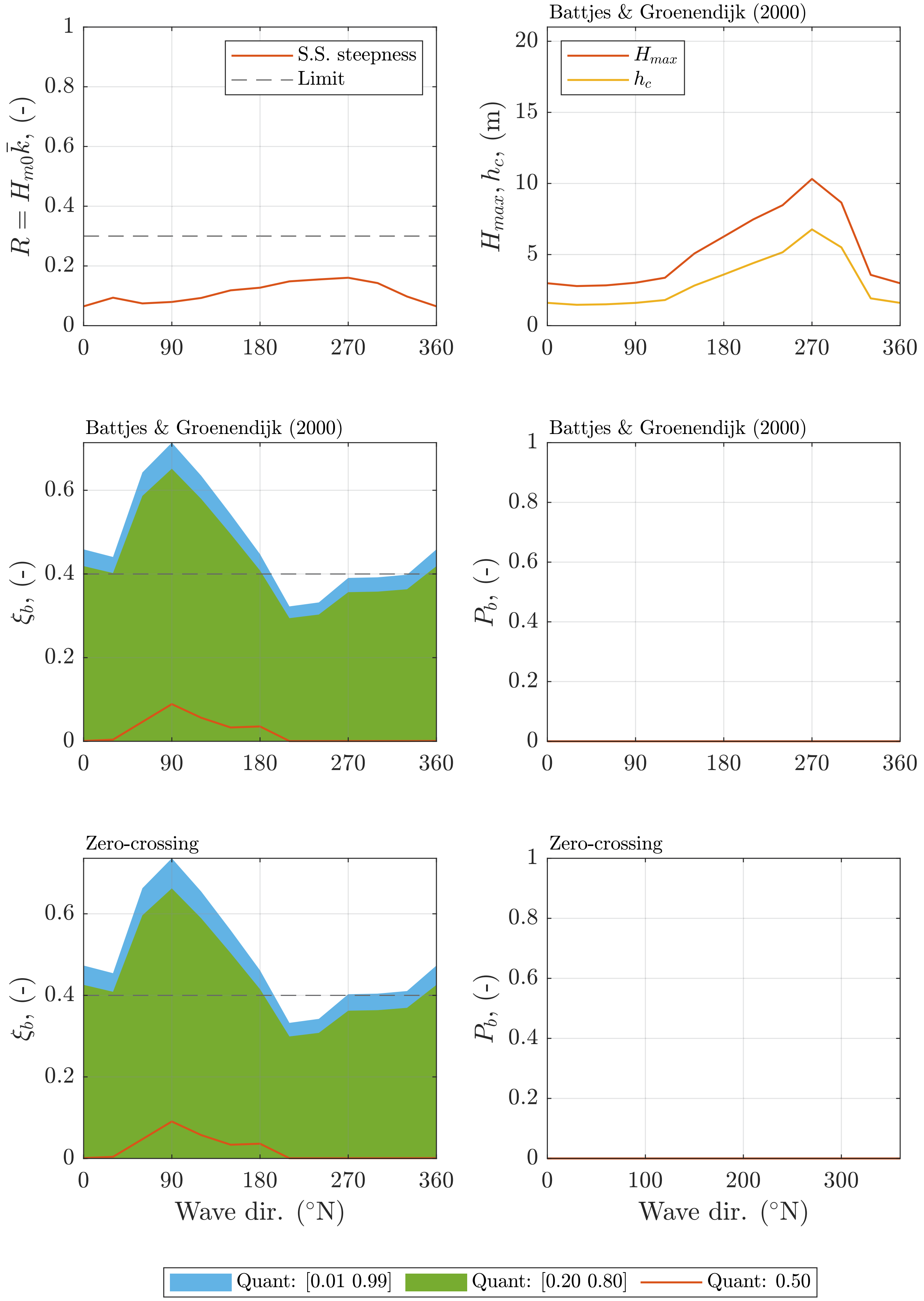
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG10
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.010c



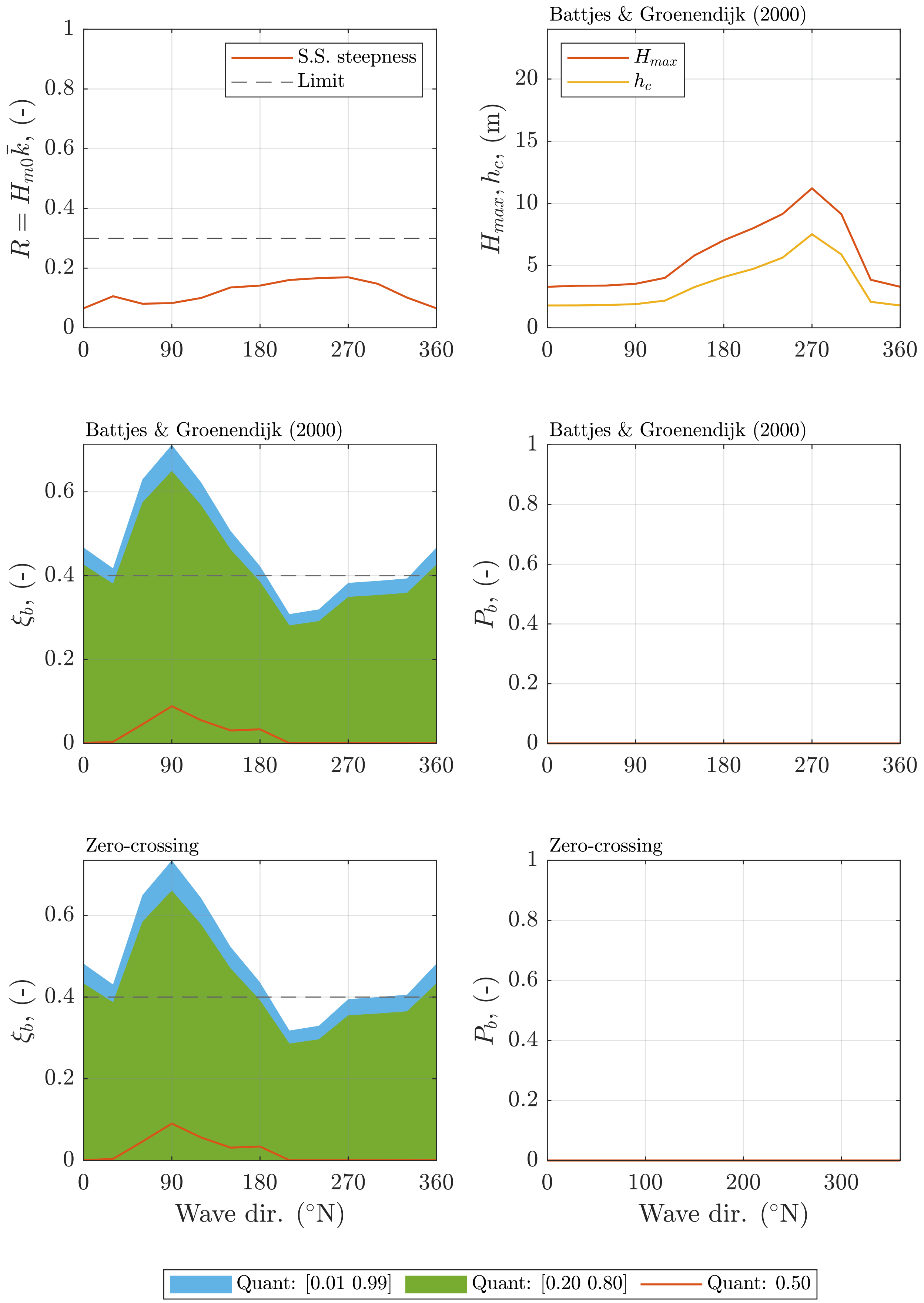
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG10
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.010d



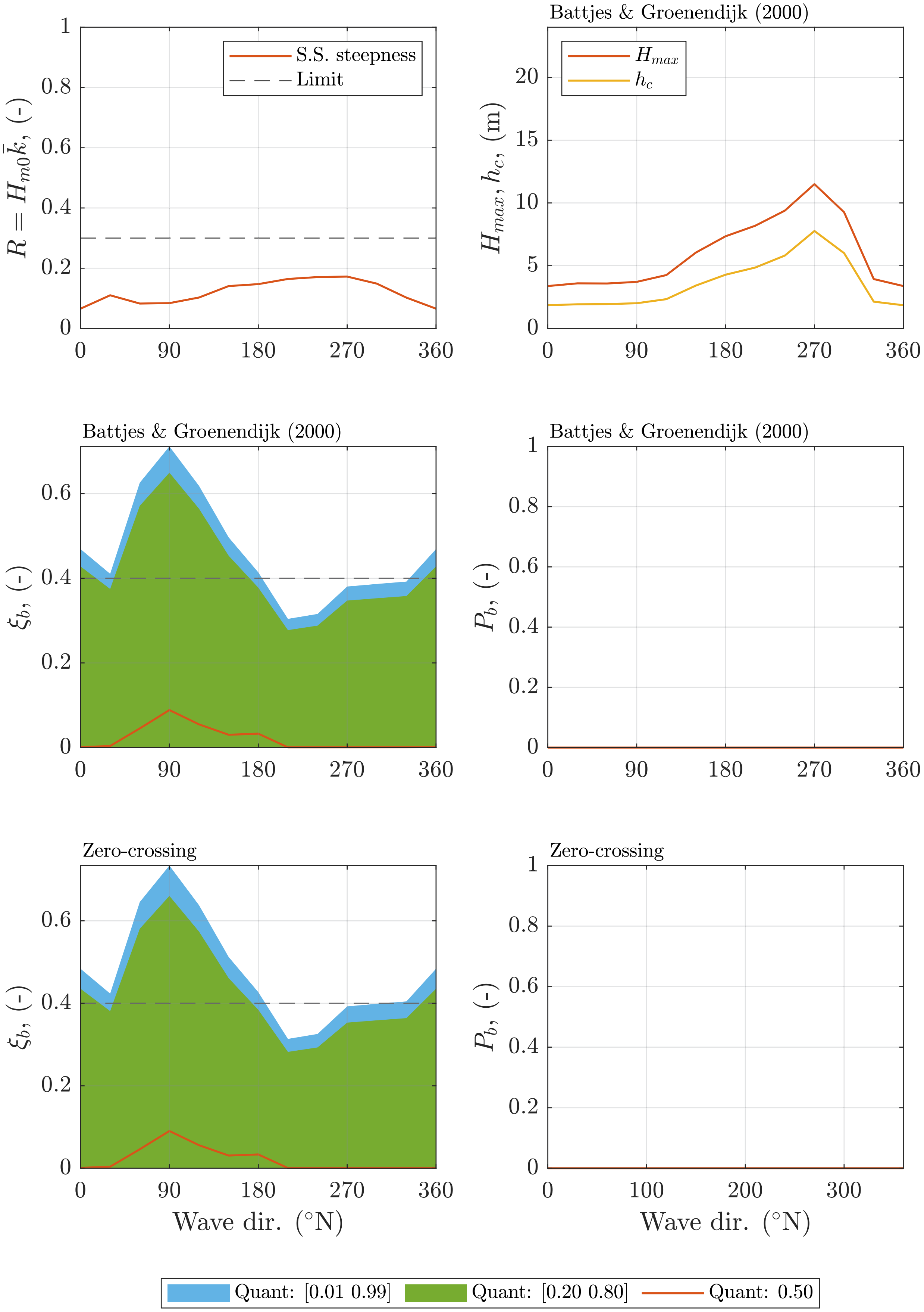
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG11
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.011a



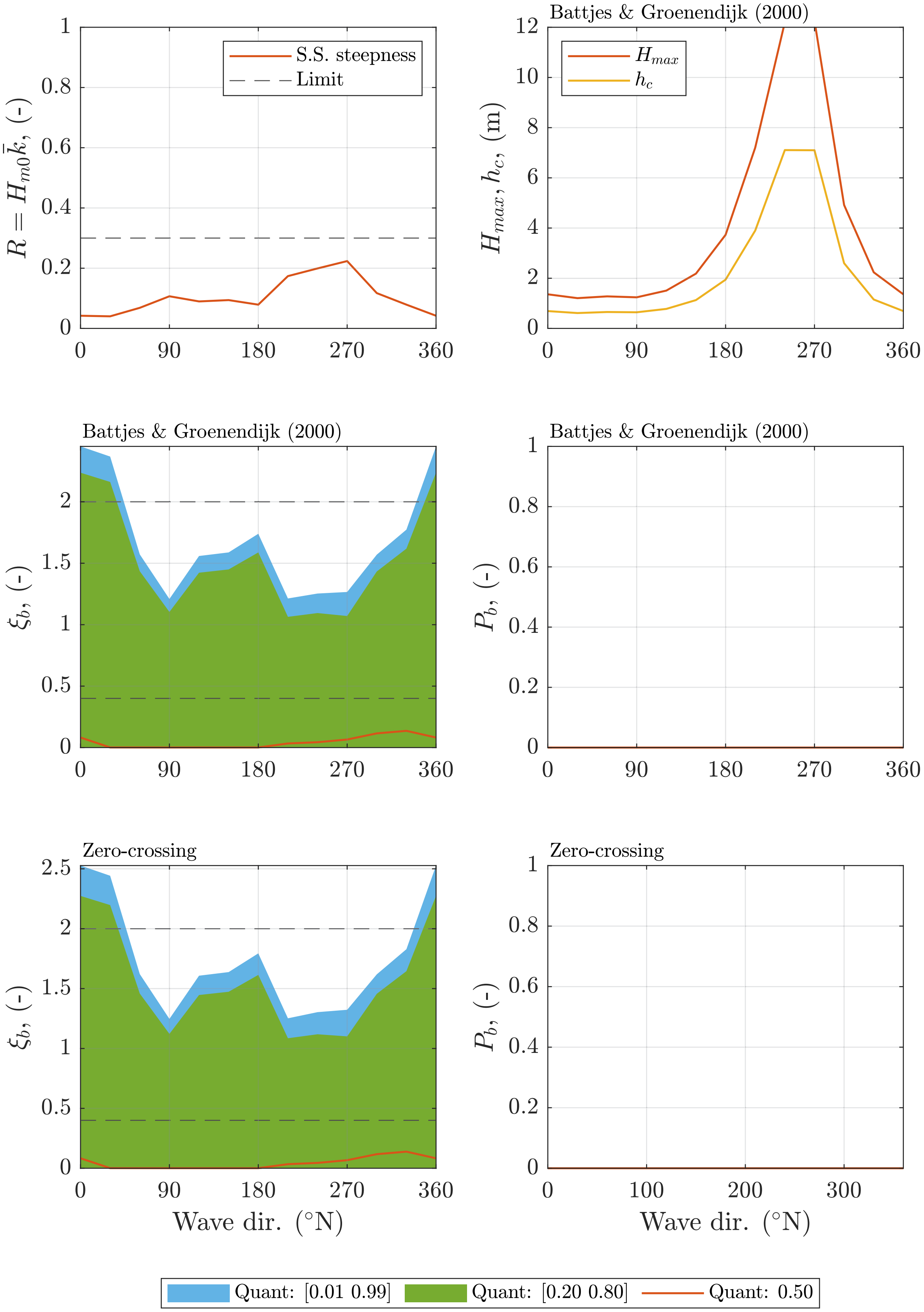
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG11
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.011b



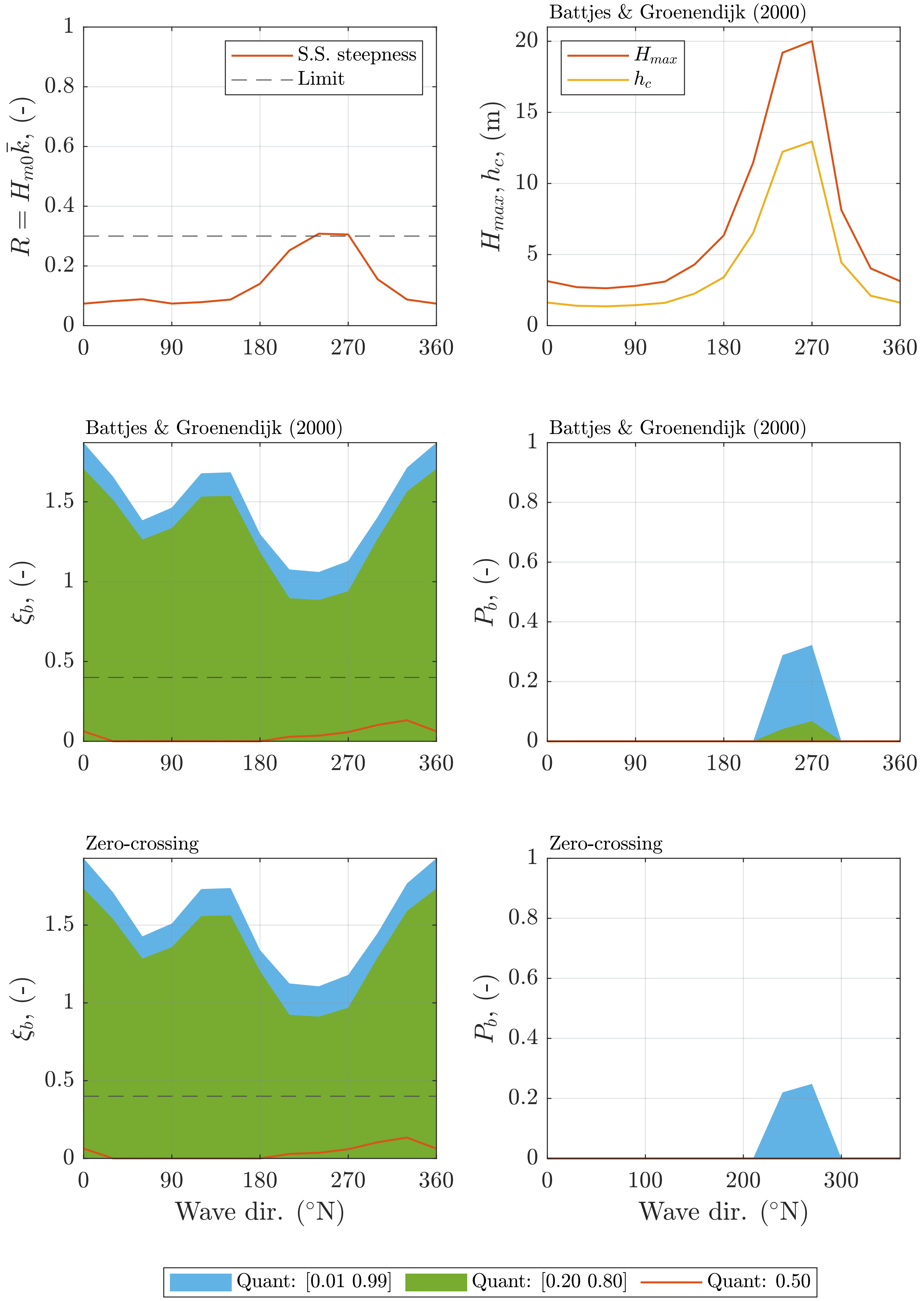
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG11
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.011c



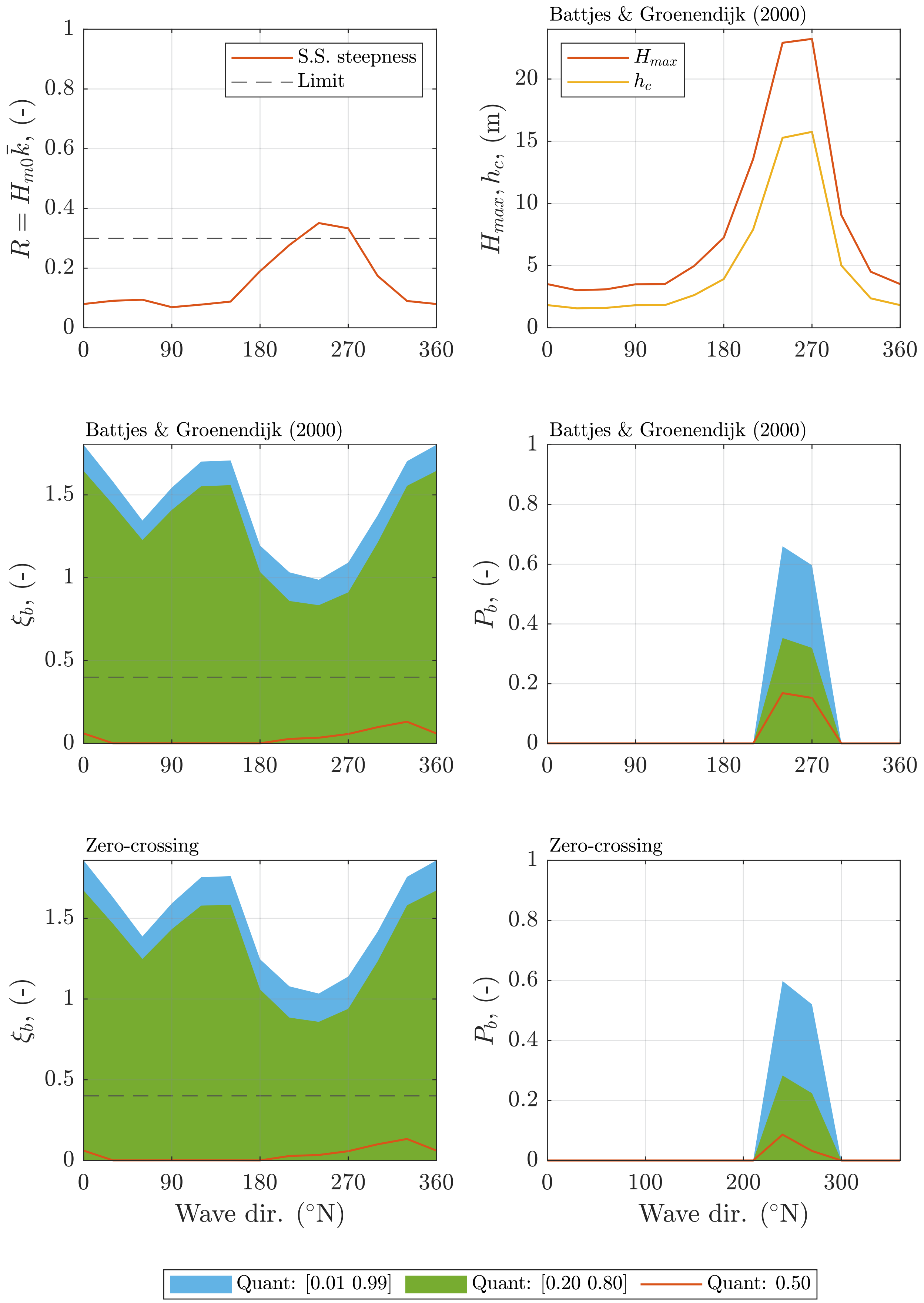
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG11
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.011d



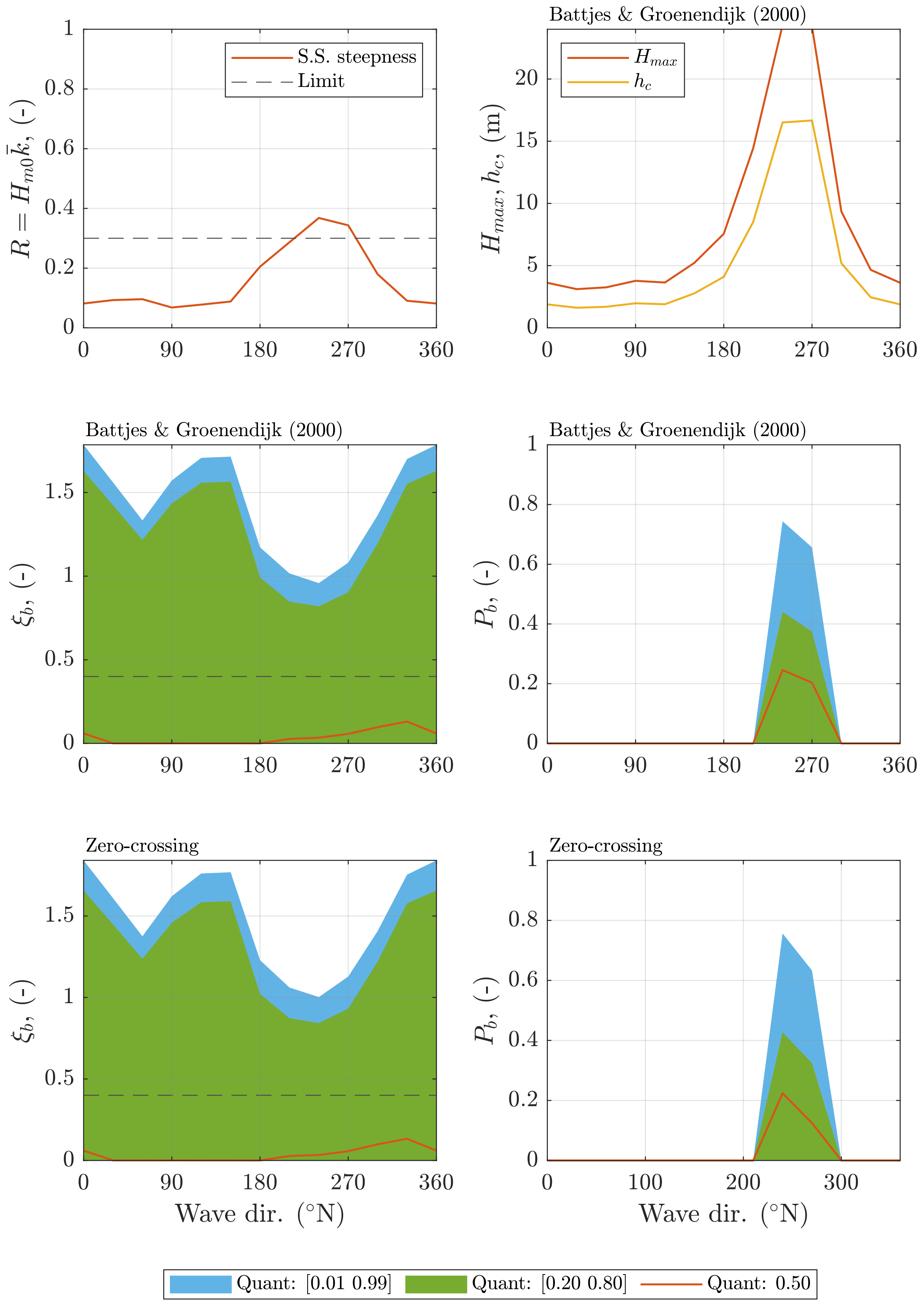
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG12
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.012a



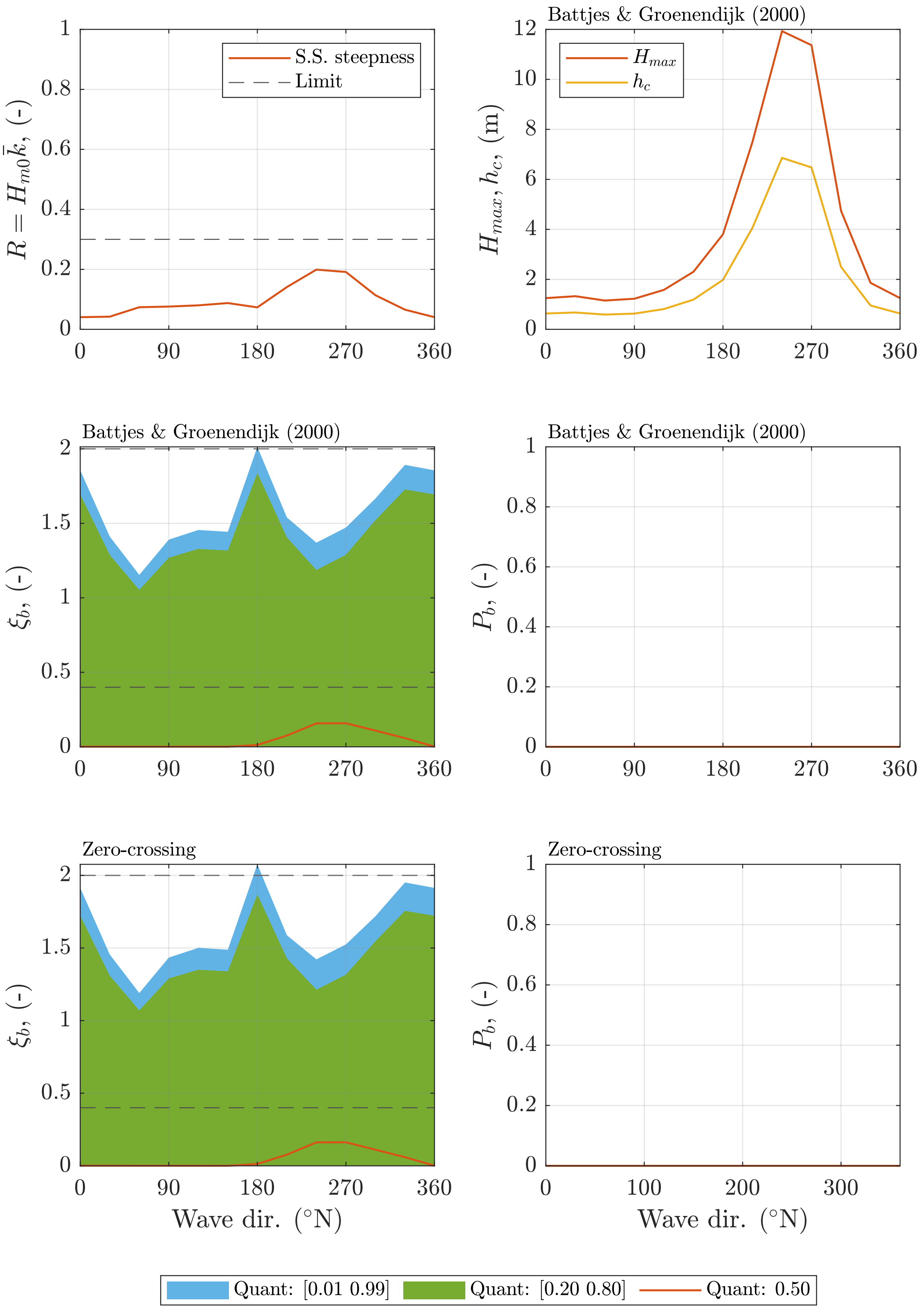
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG12
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.012b



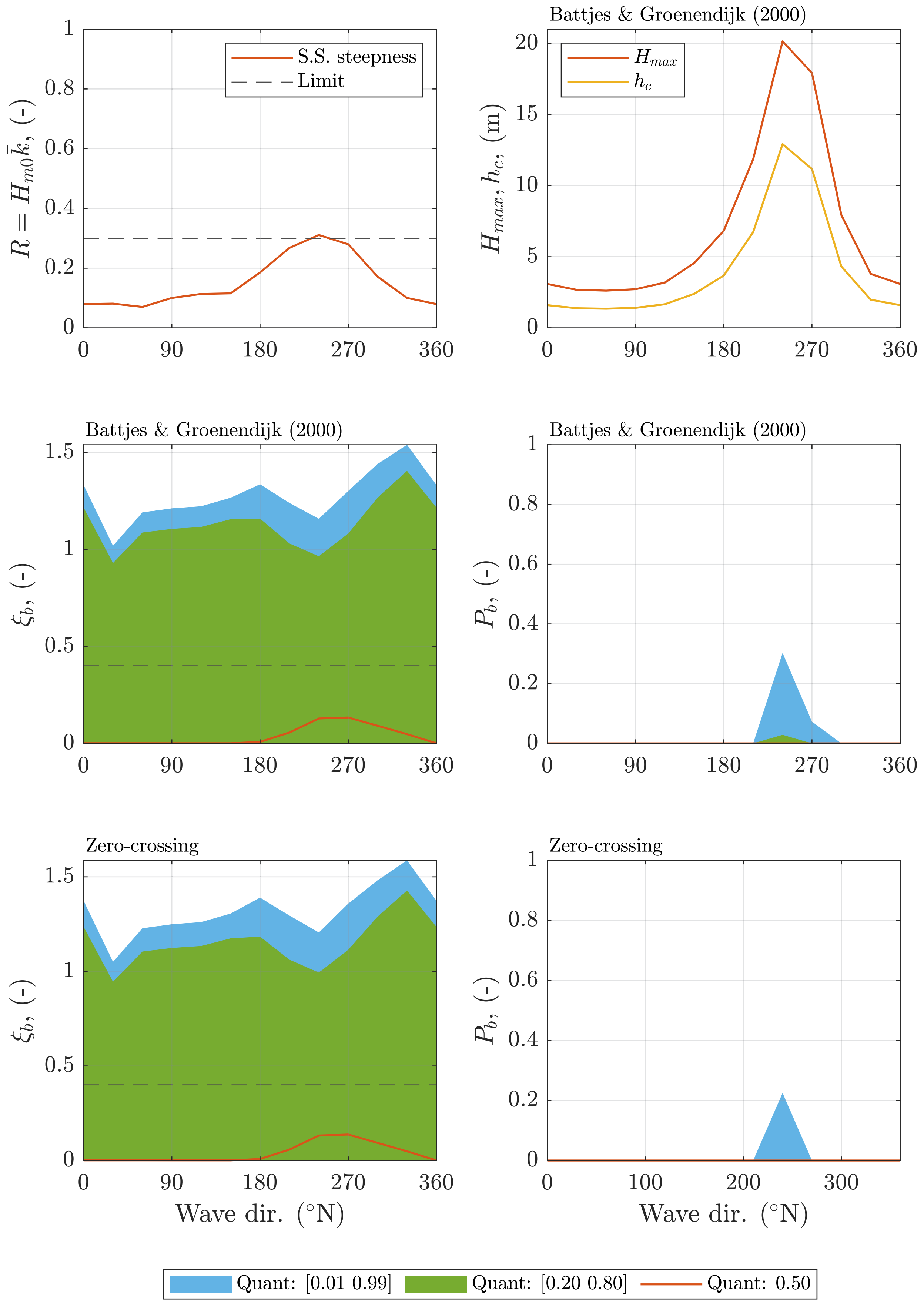
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG12
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.012c



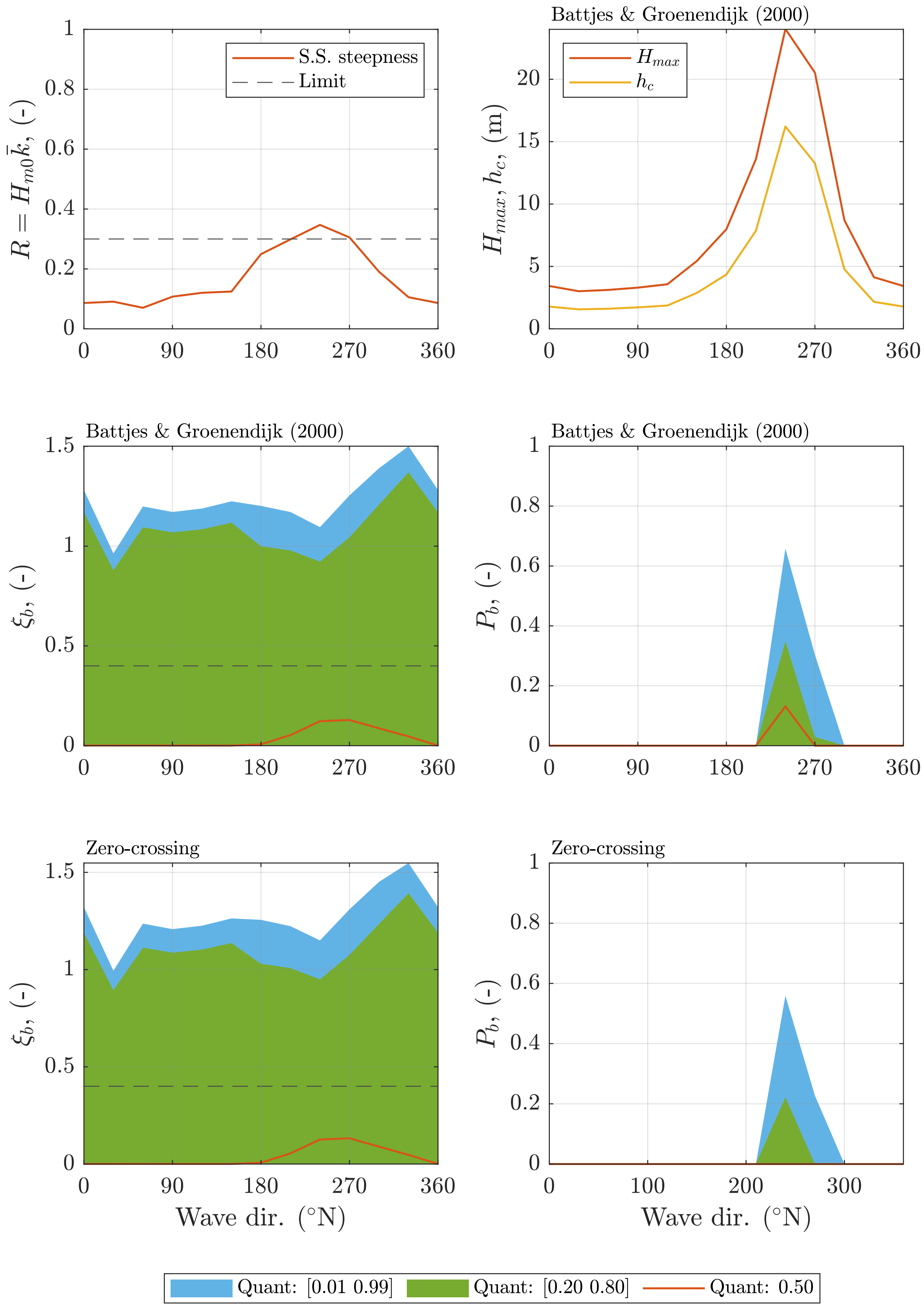
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG12
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.012d



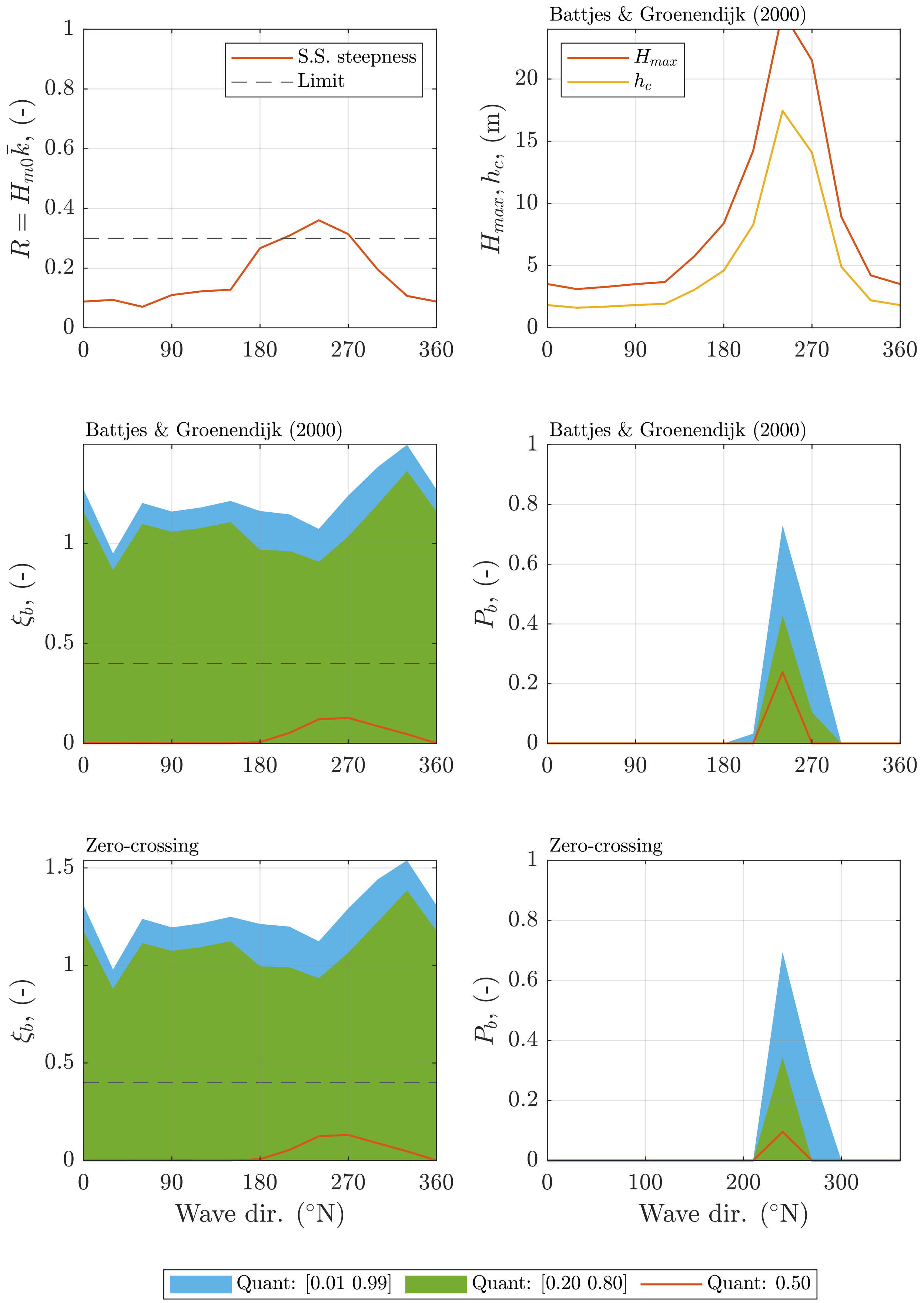
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG13
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.013a



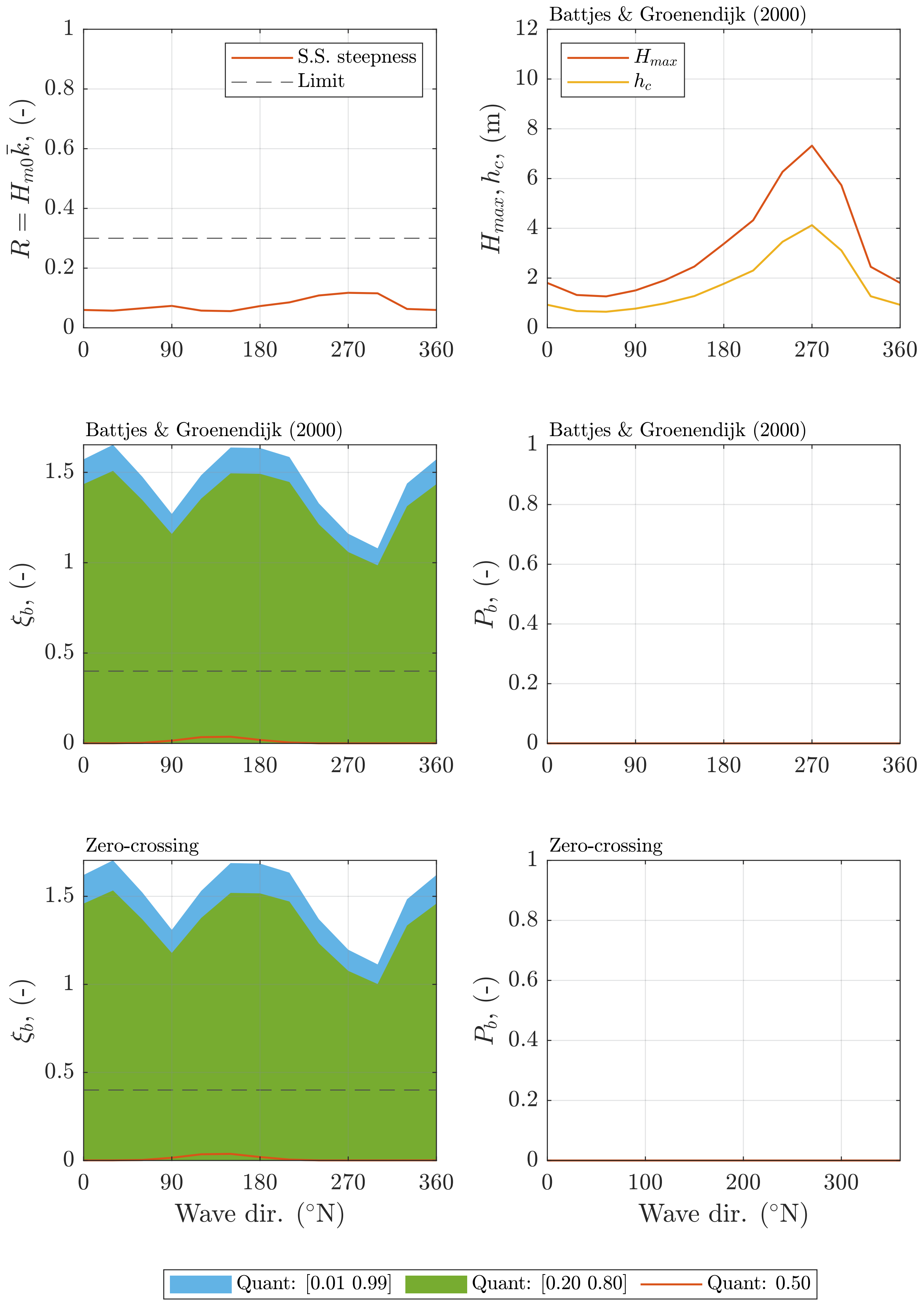
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG13
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.013b



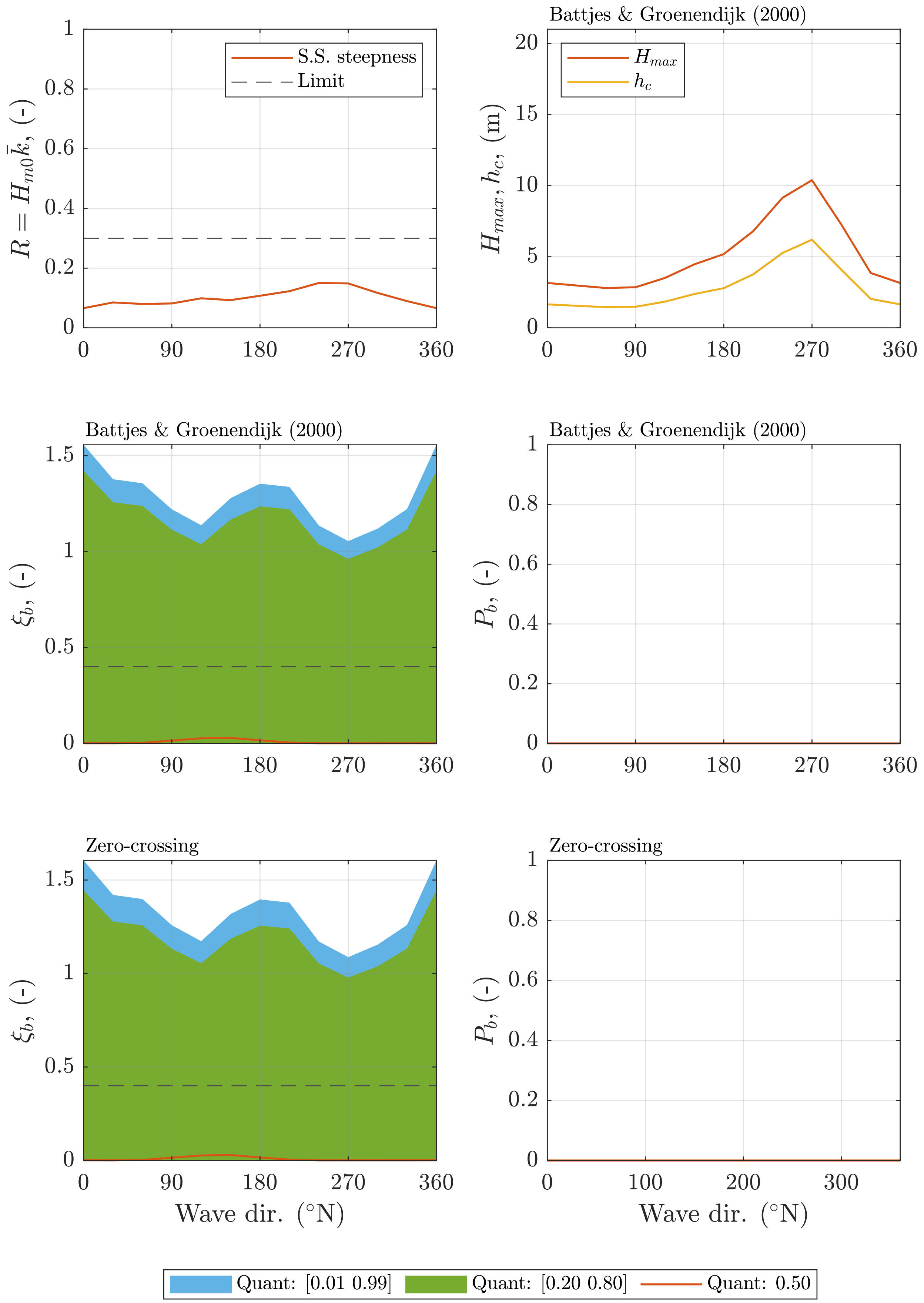
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG13
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.013c



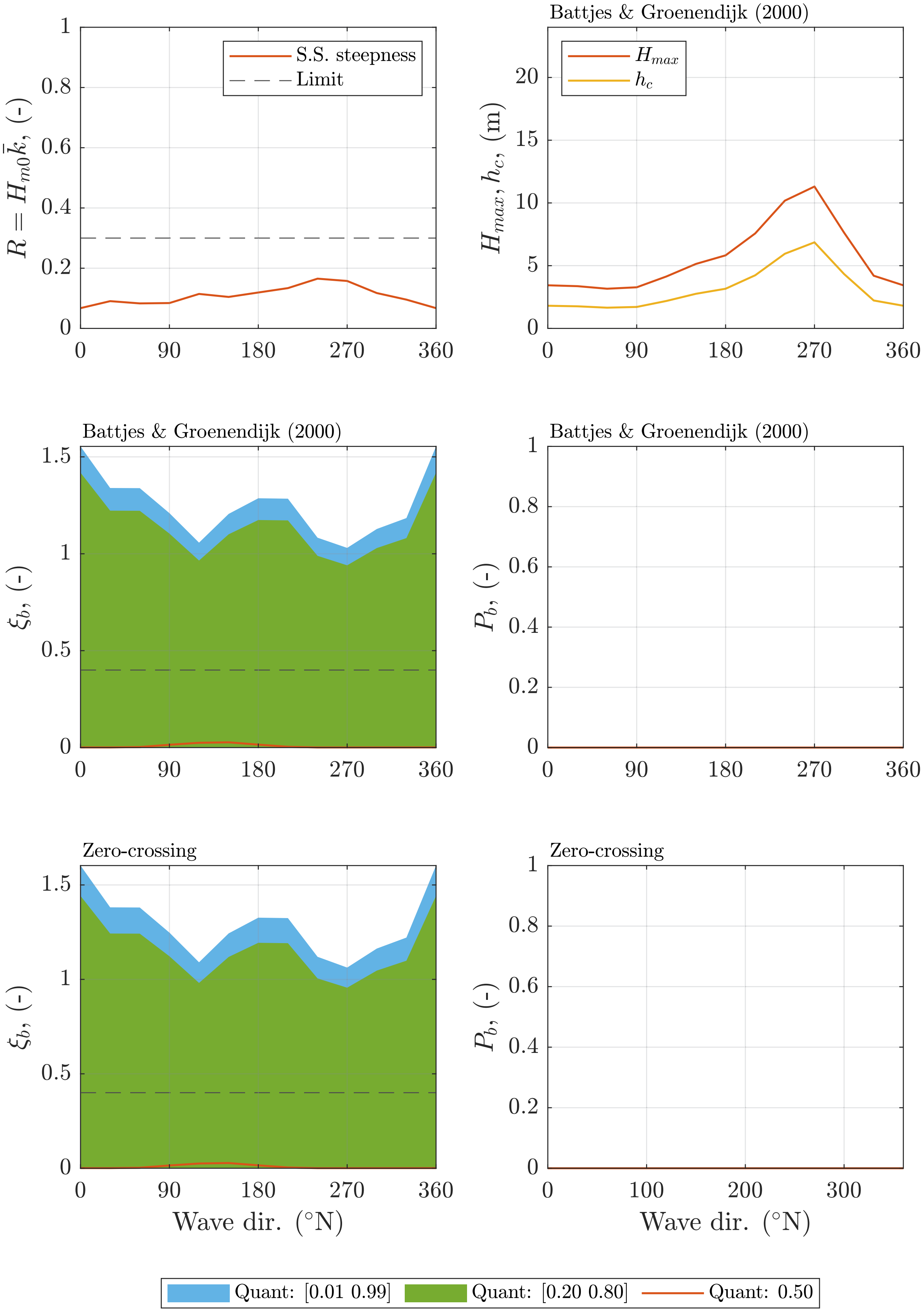
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG13
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.013d



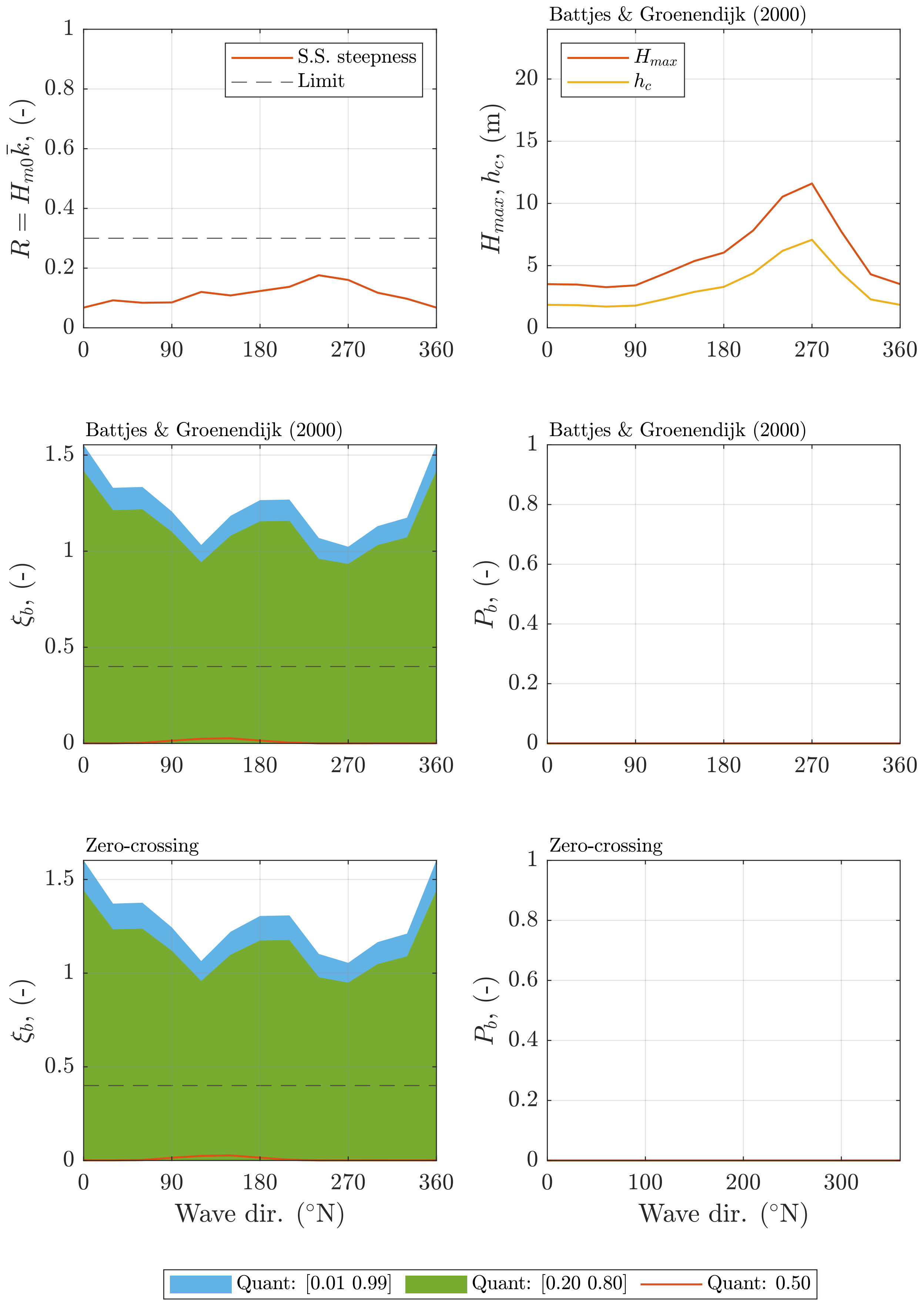
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG14
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.014a



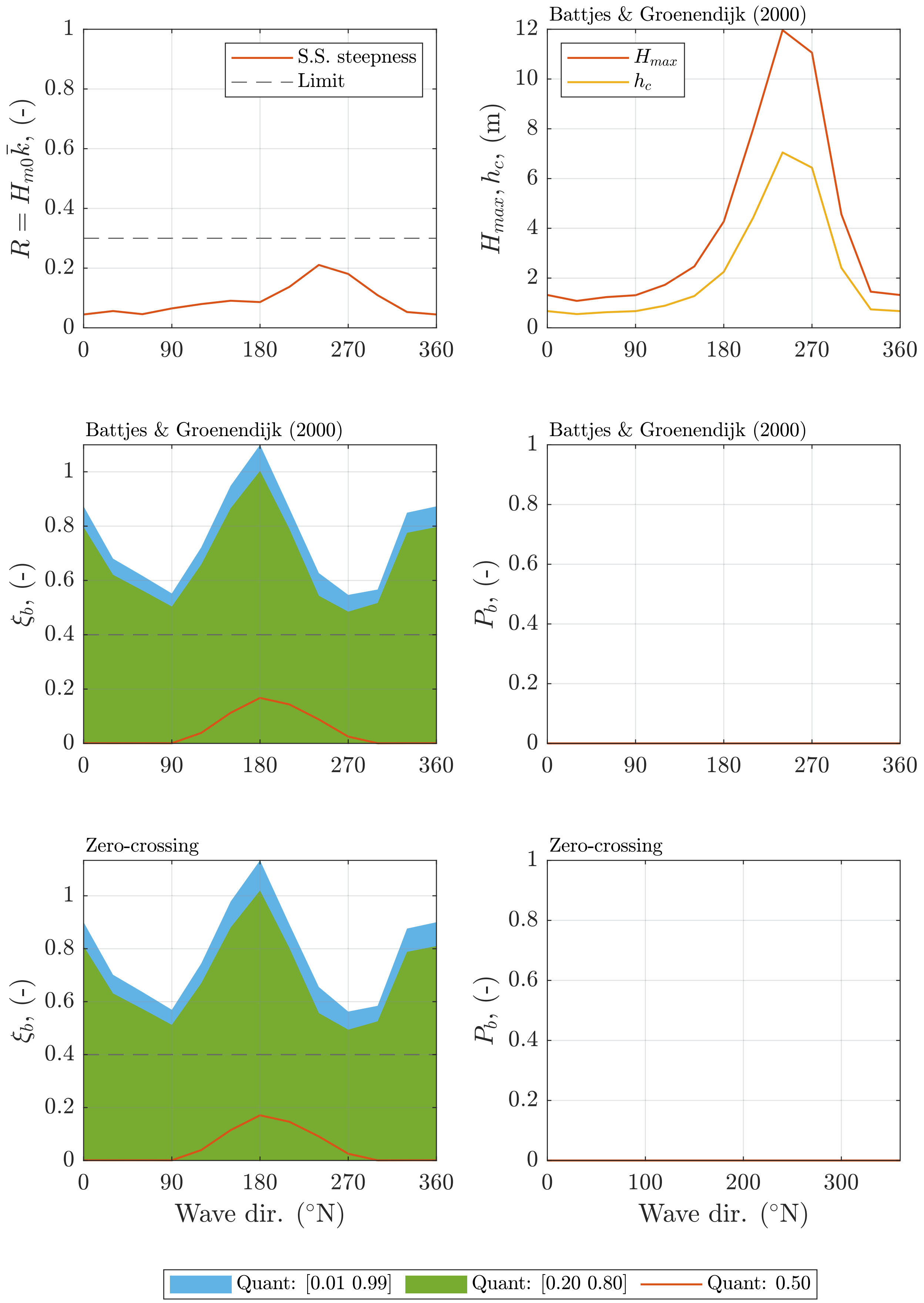
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG14
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.014b



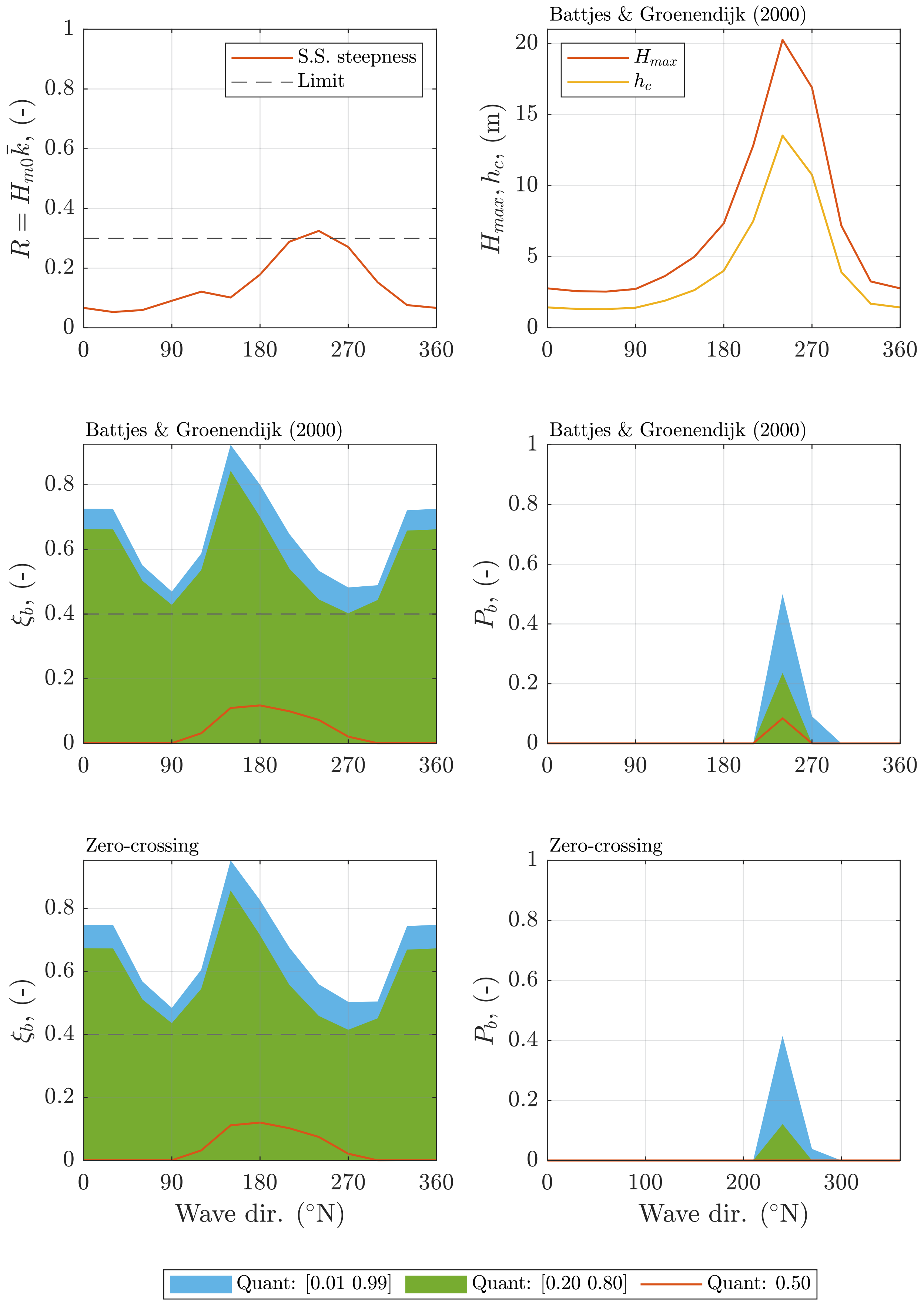
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG14
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.014c



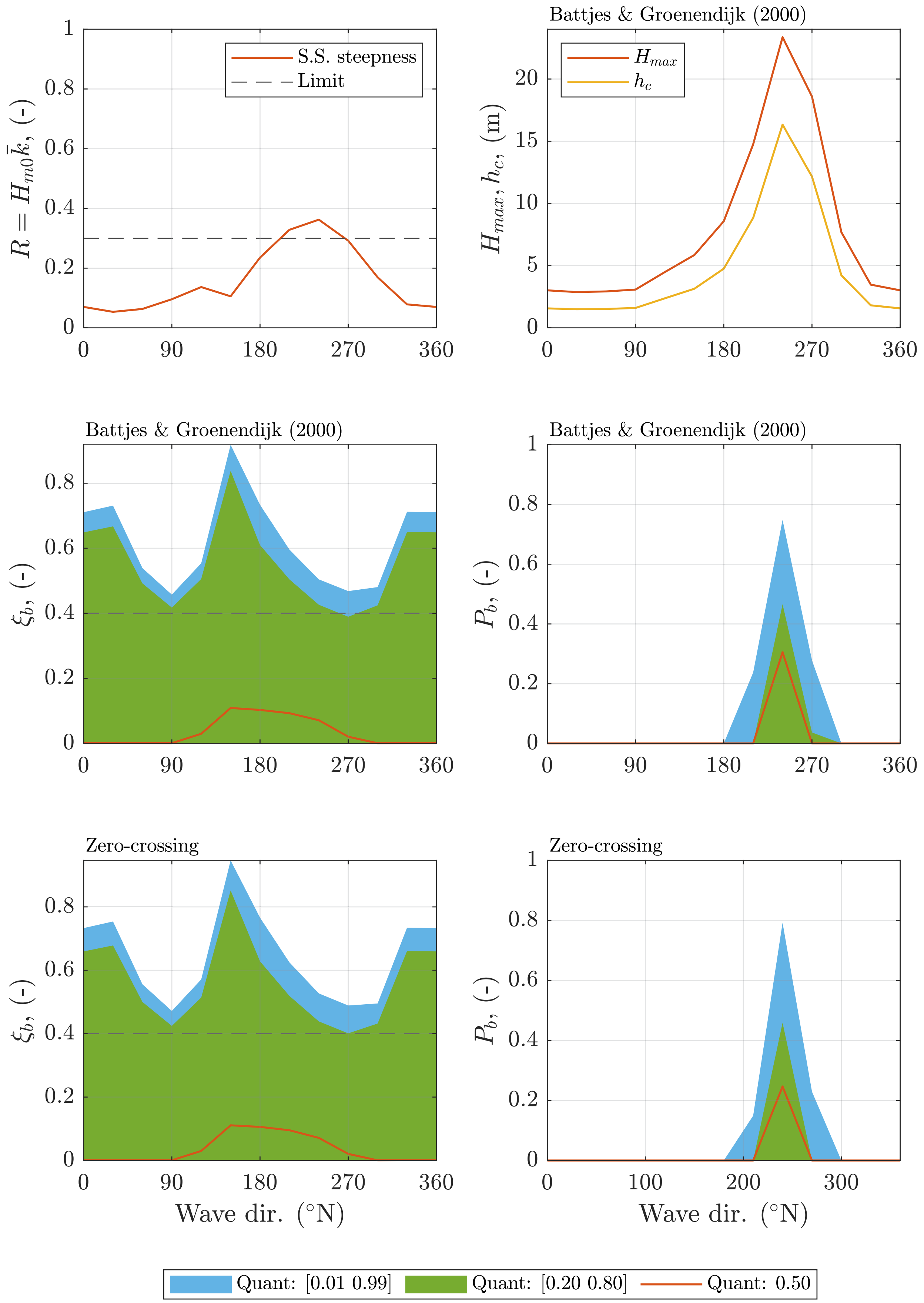
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG14
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.014d



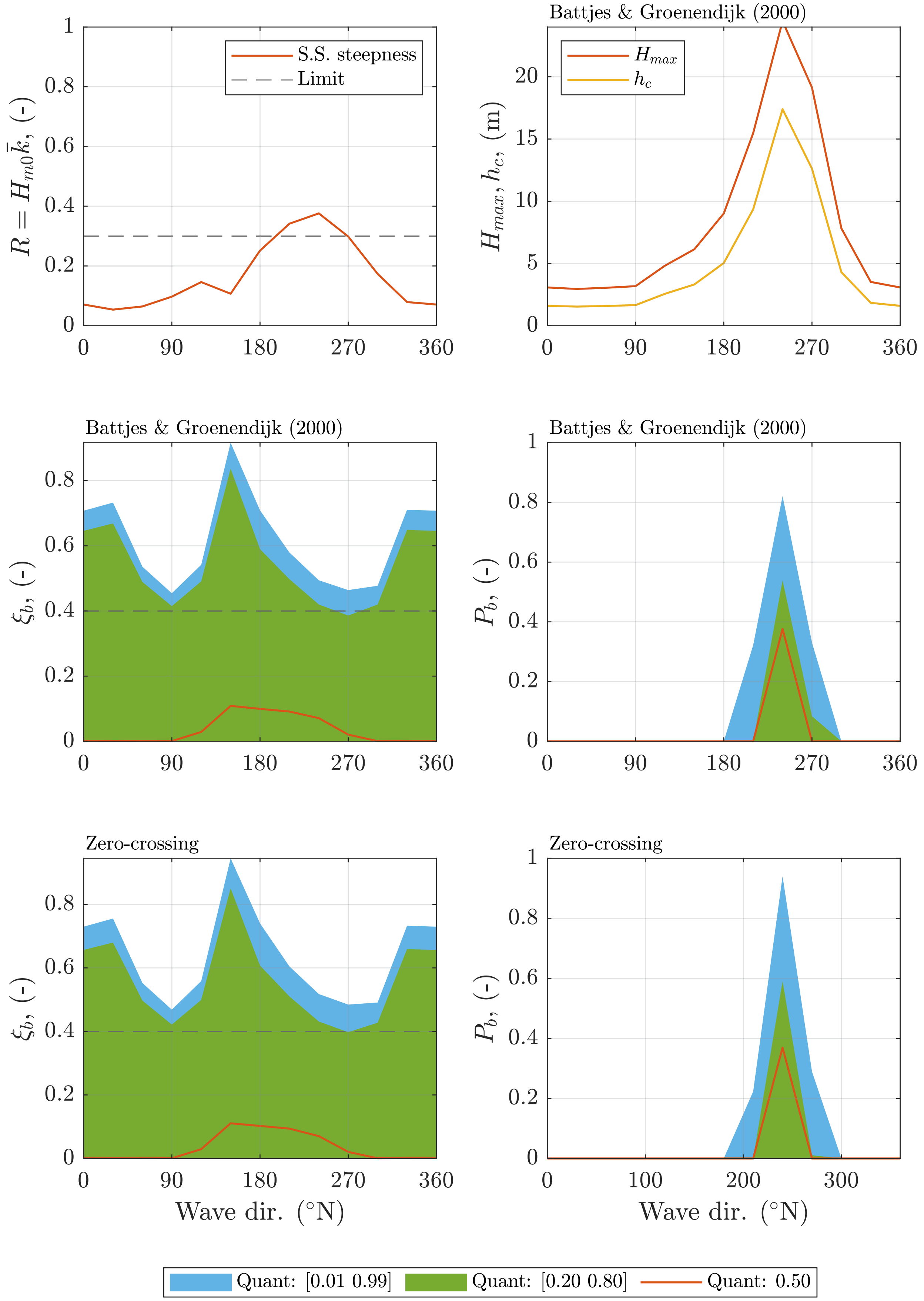
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG15
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.015a



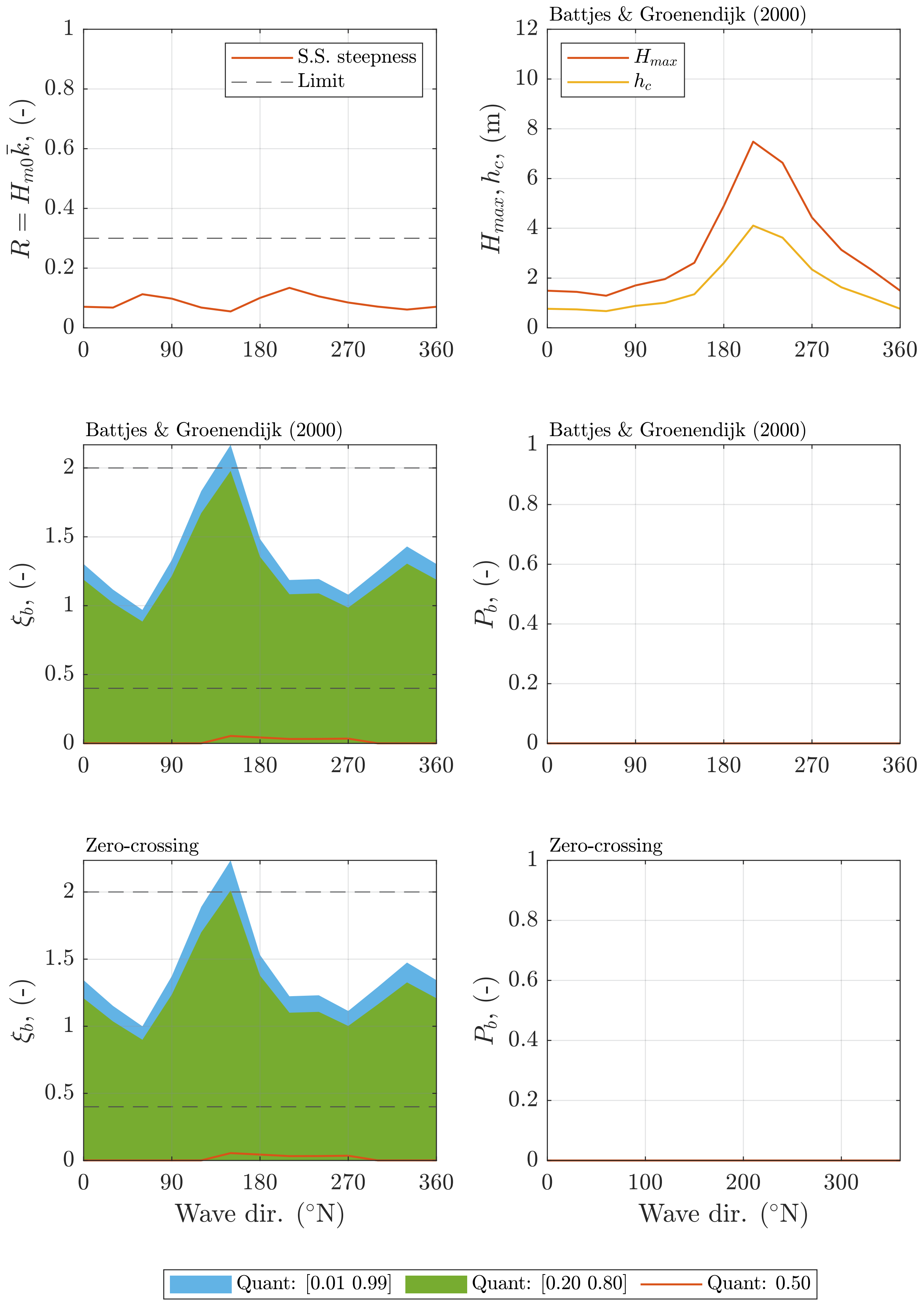
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG15
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.015b



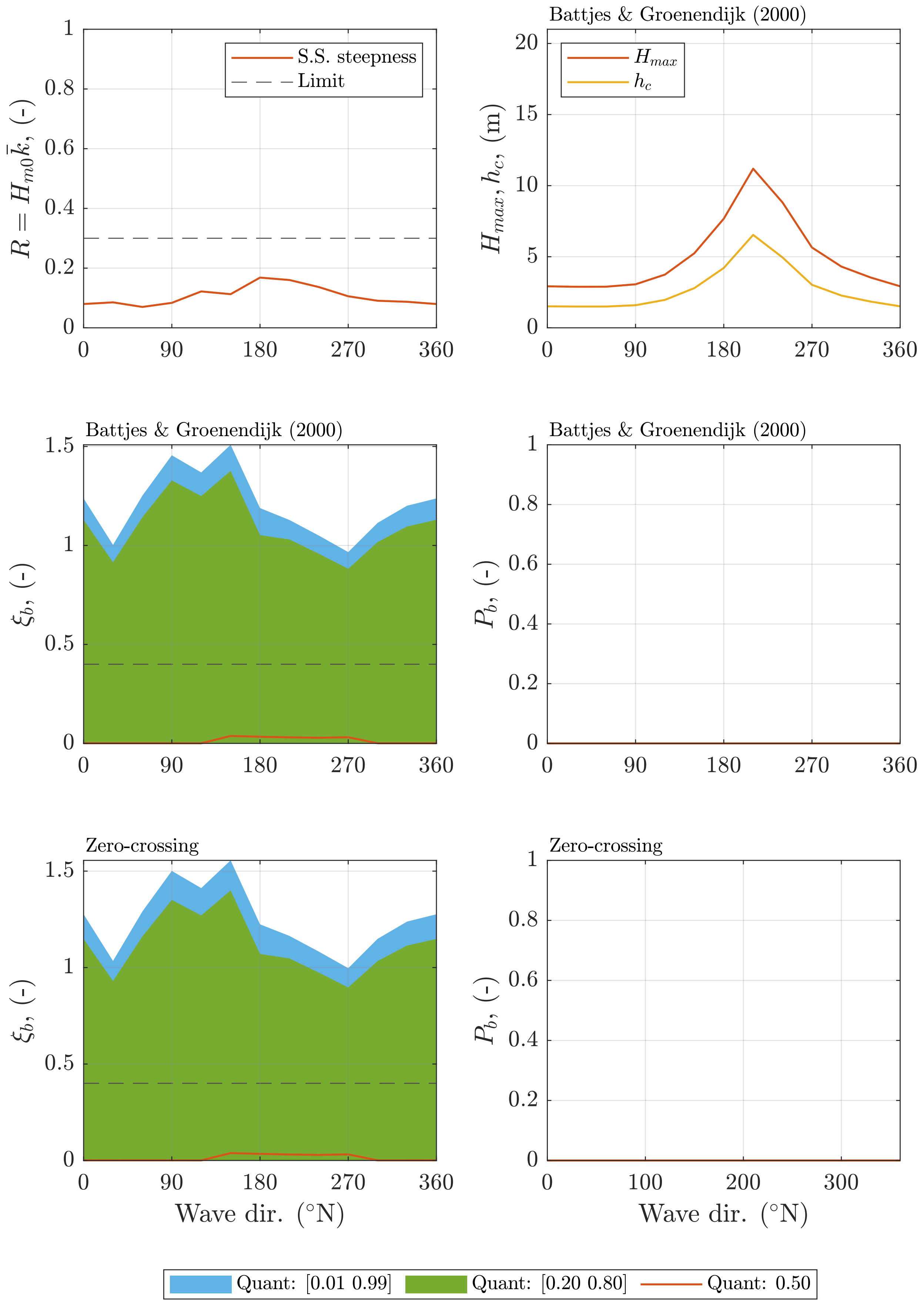
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG15
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.015c



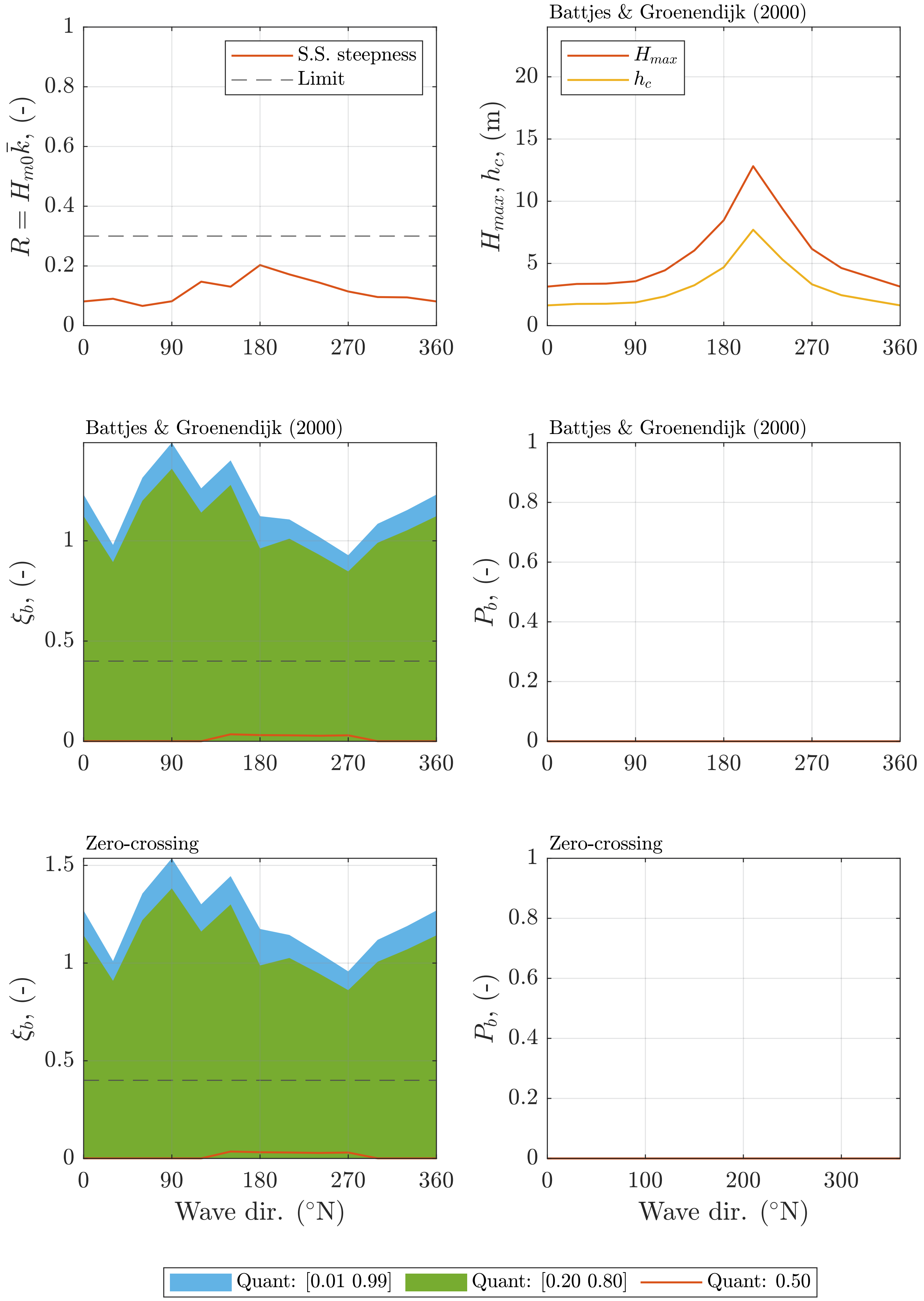
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG15
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.015d



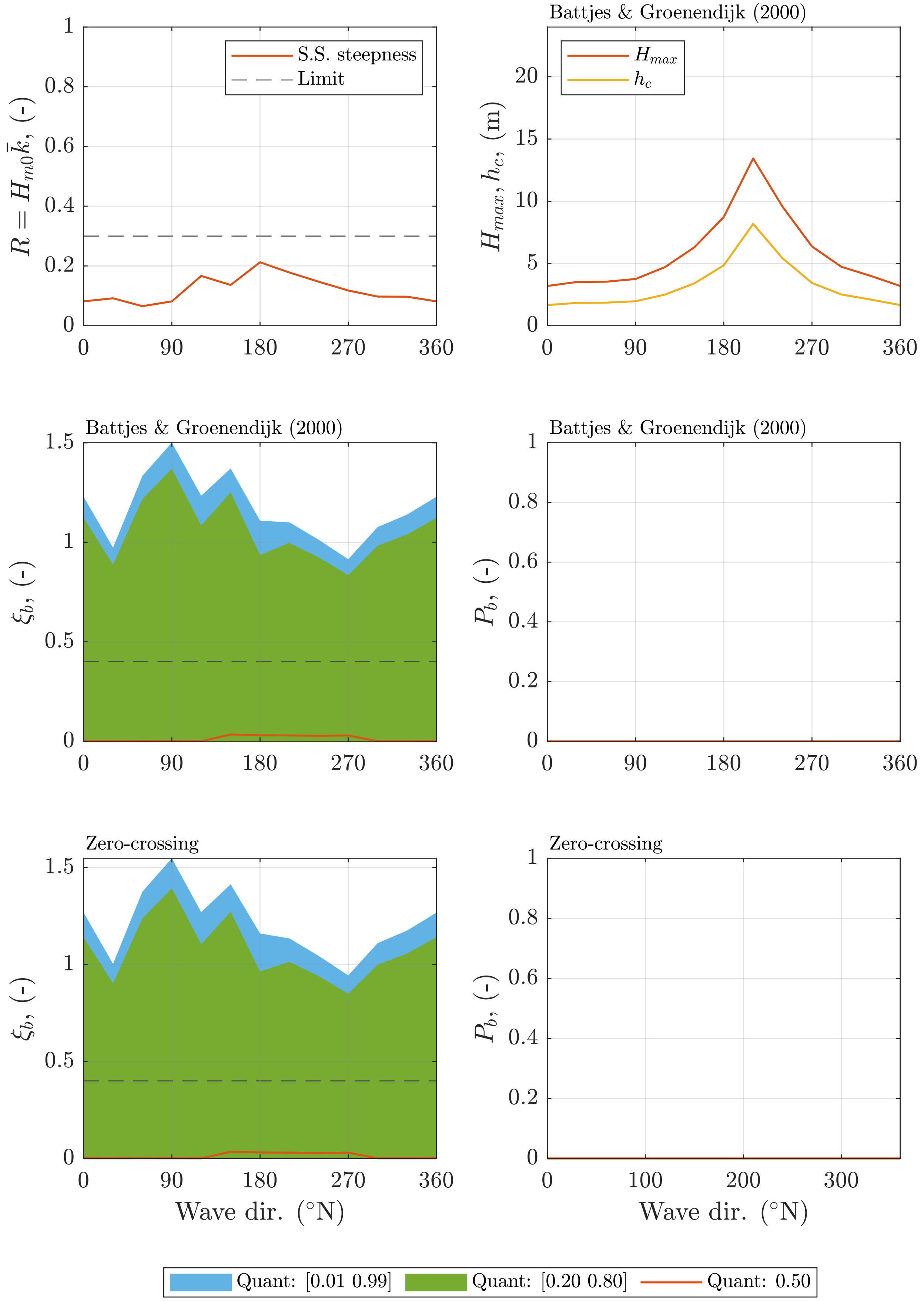
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG16
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.016a



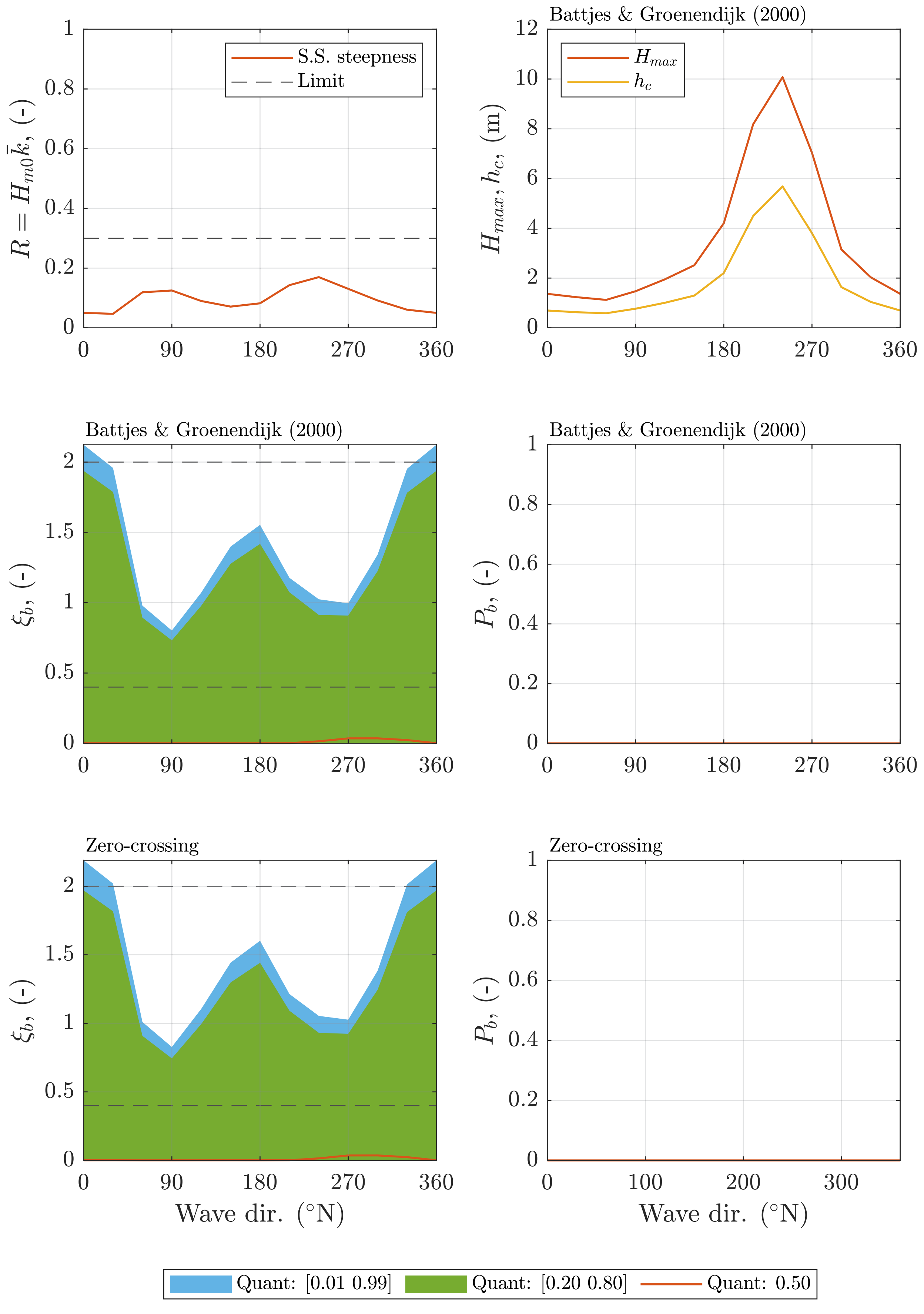
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG16
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.016b



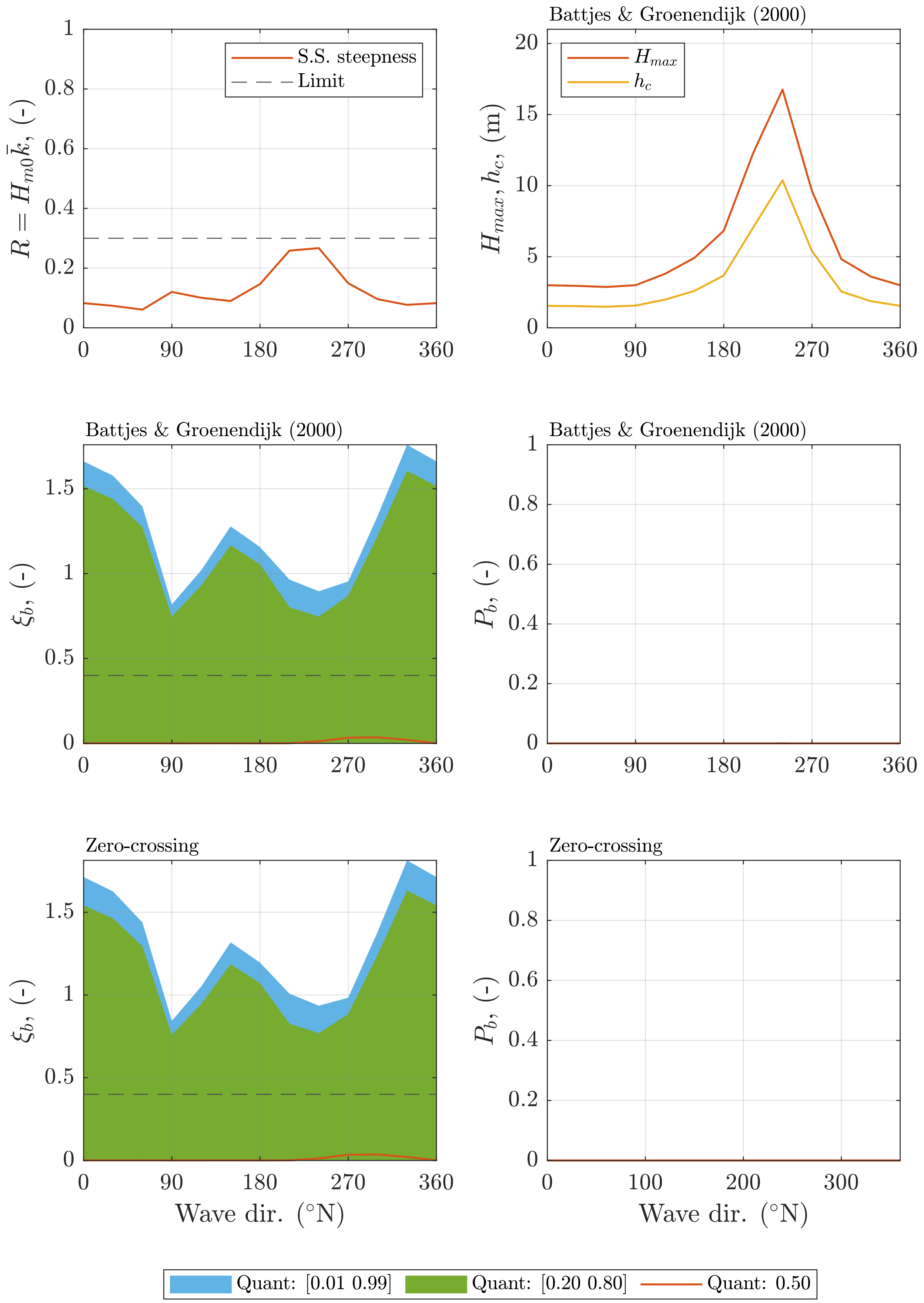
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG16
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.016c



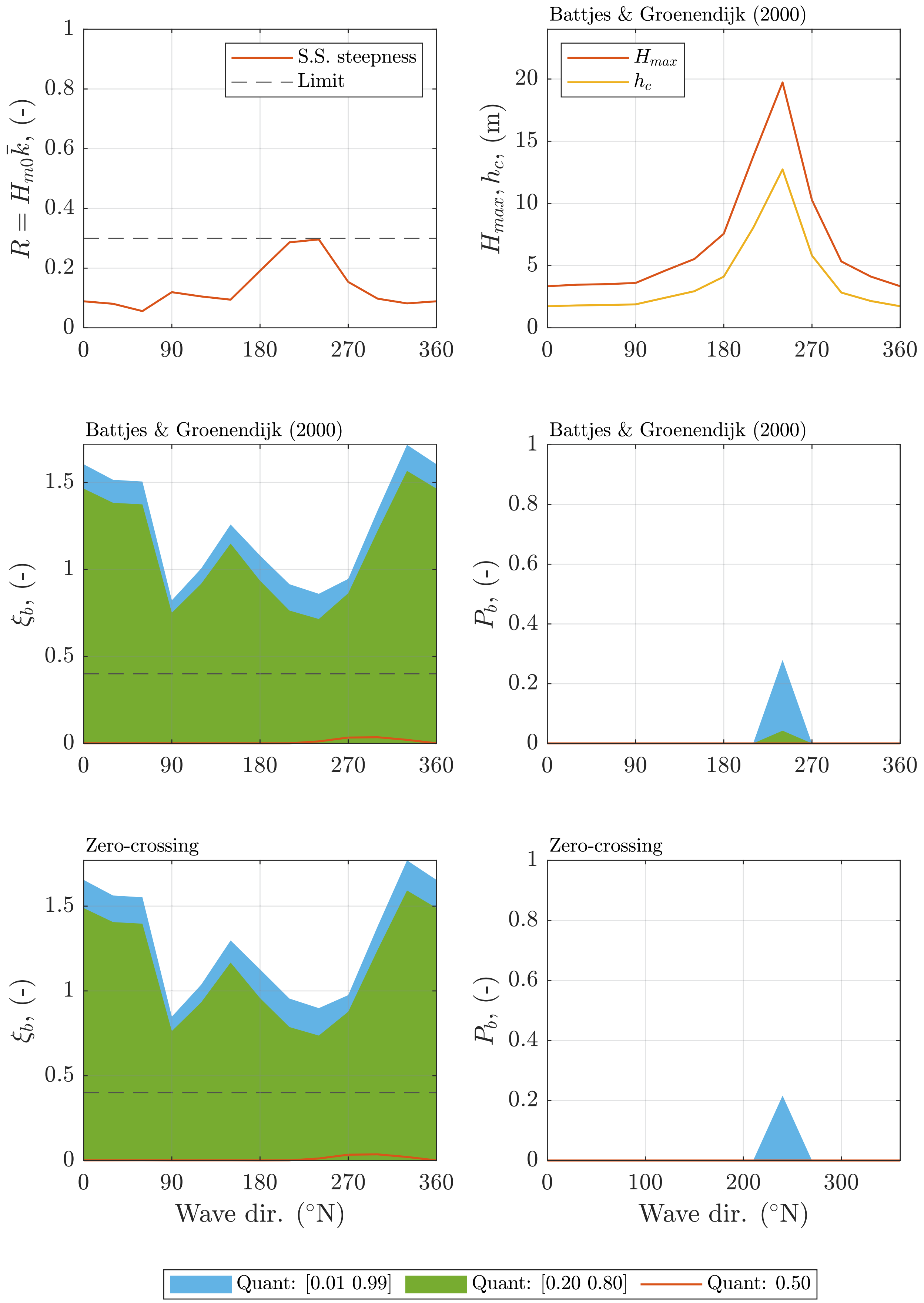
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG16
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.016d



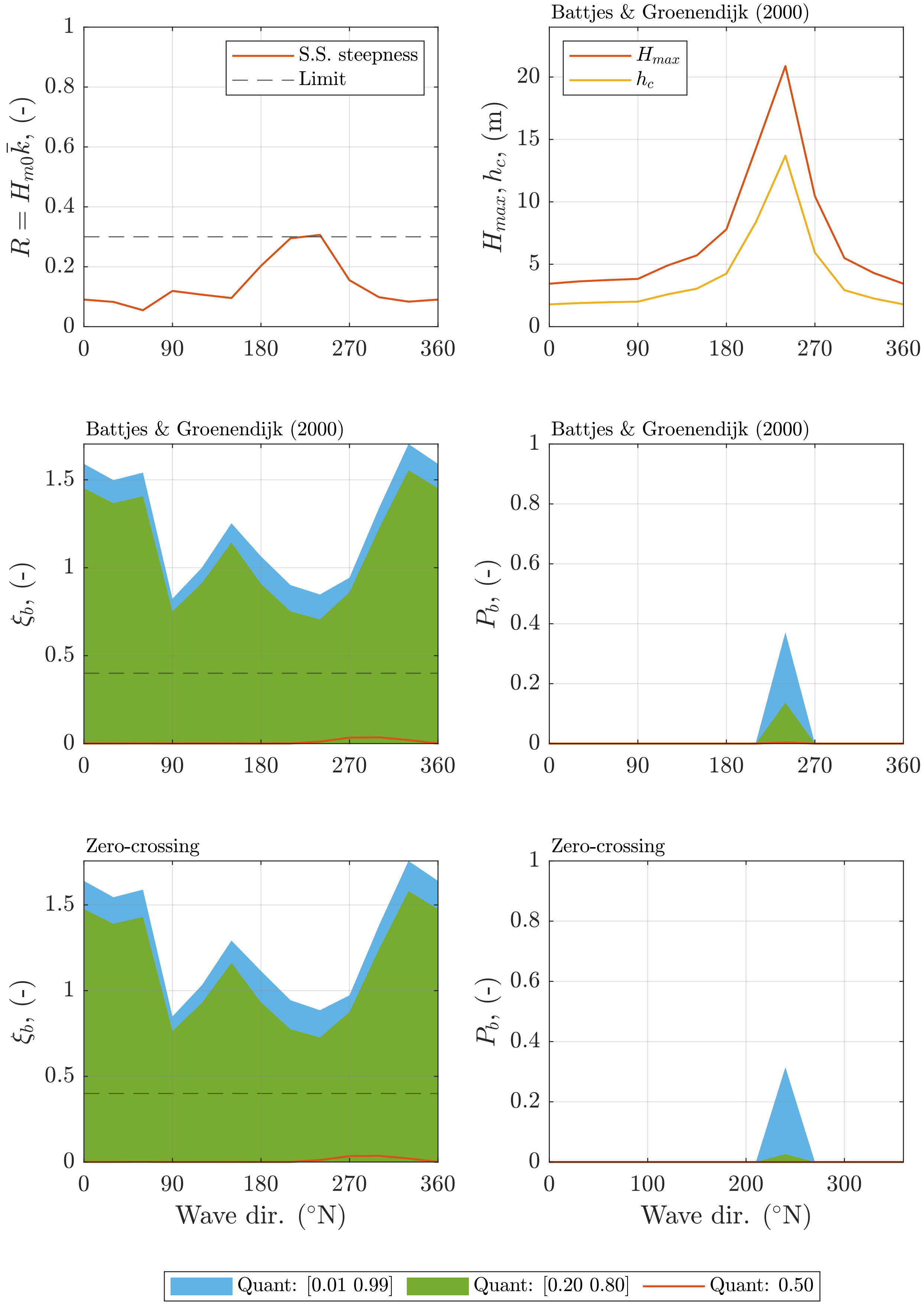
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG17
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.017a



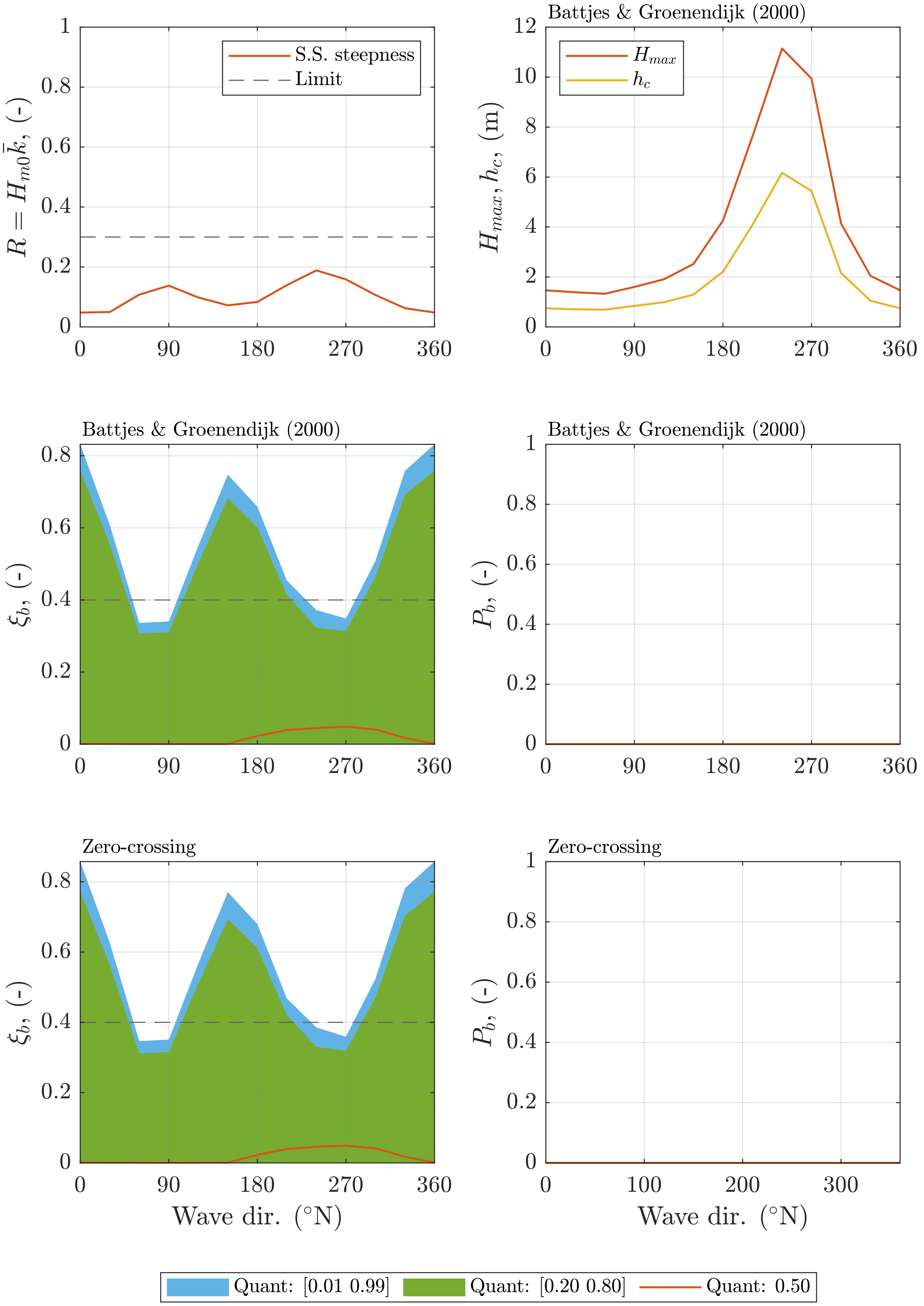
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG17
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.017b



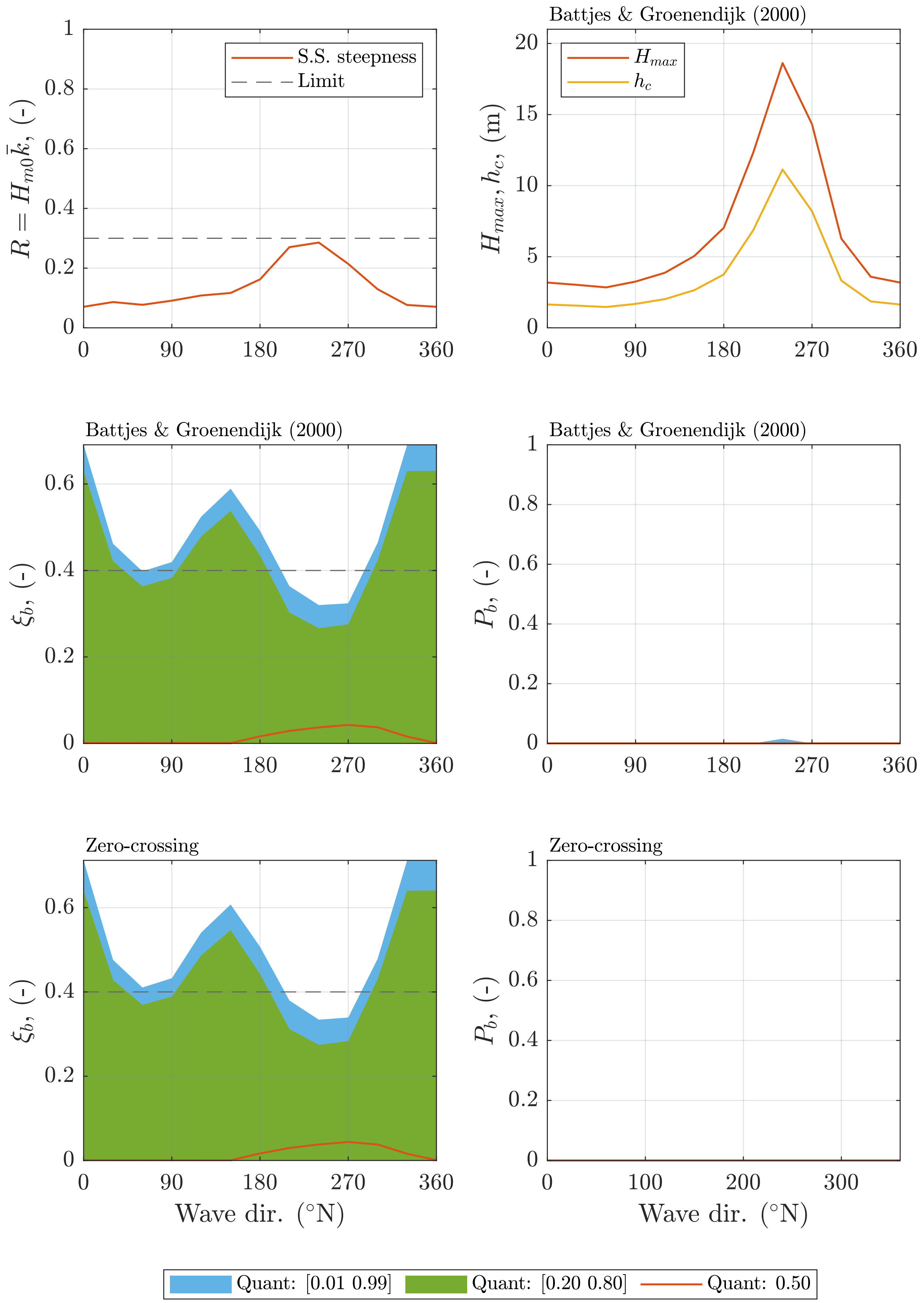
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG17
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.017c



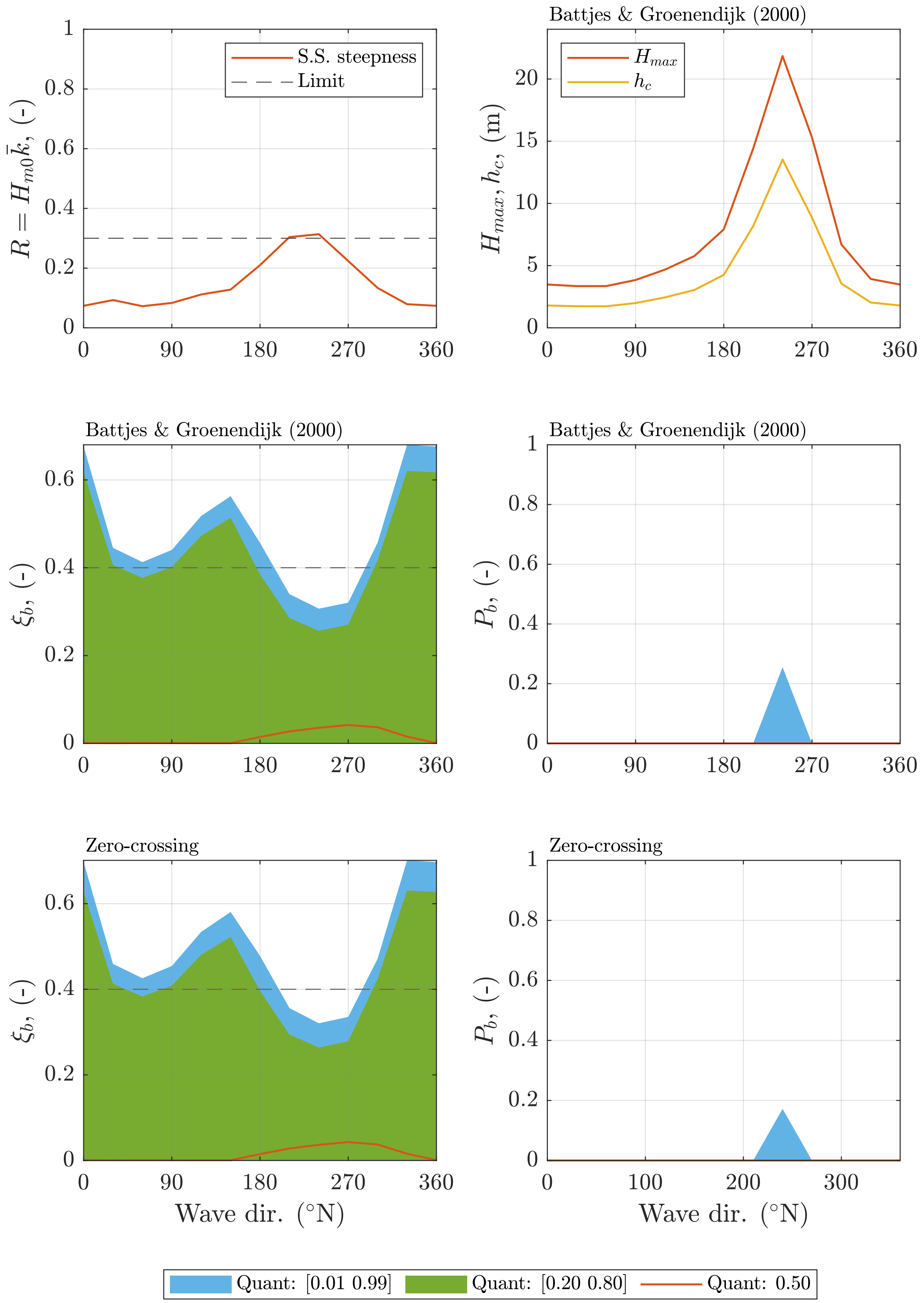
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG17
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.017d



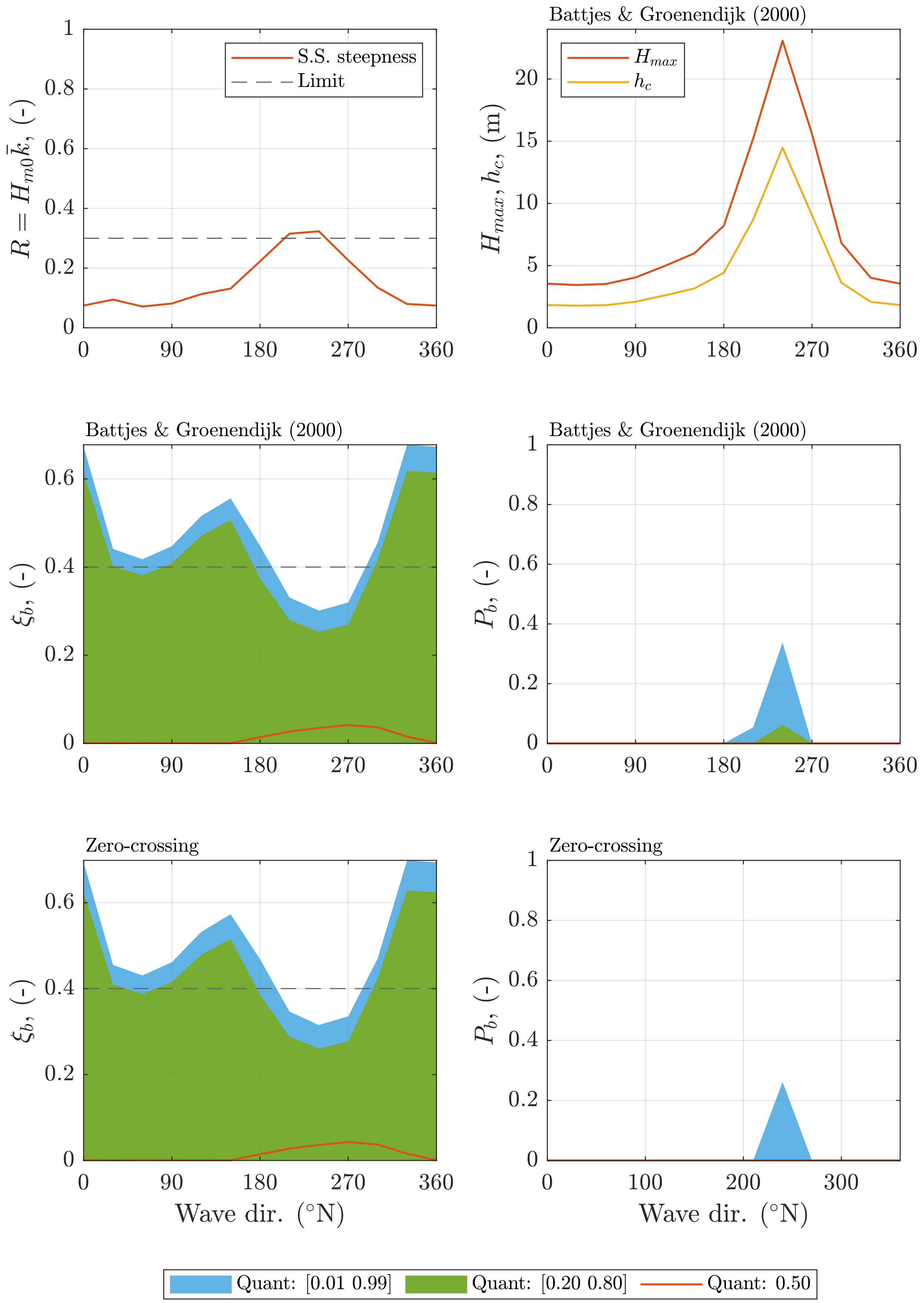
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG18
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.018a



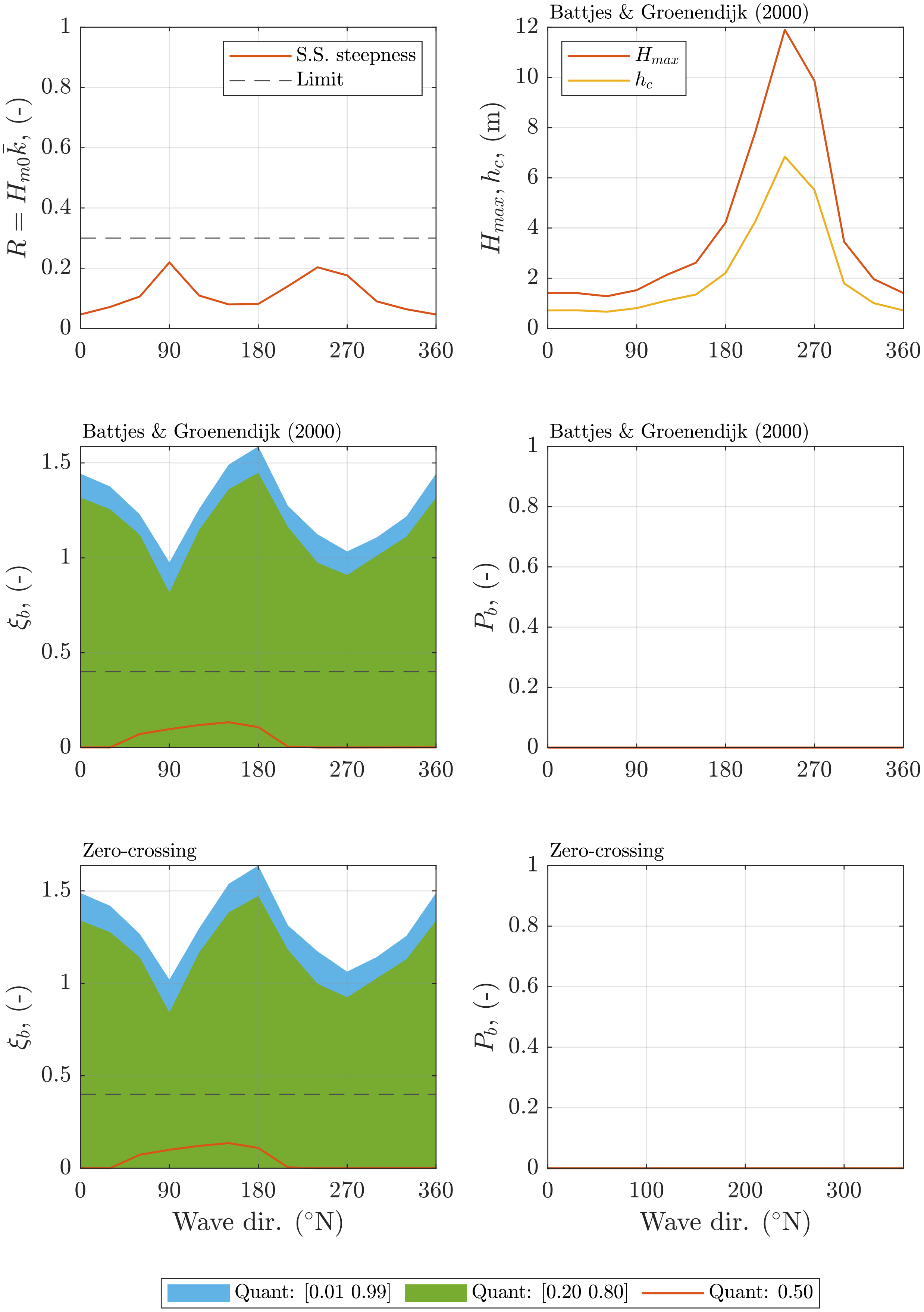
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG18
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.018b



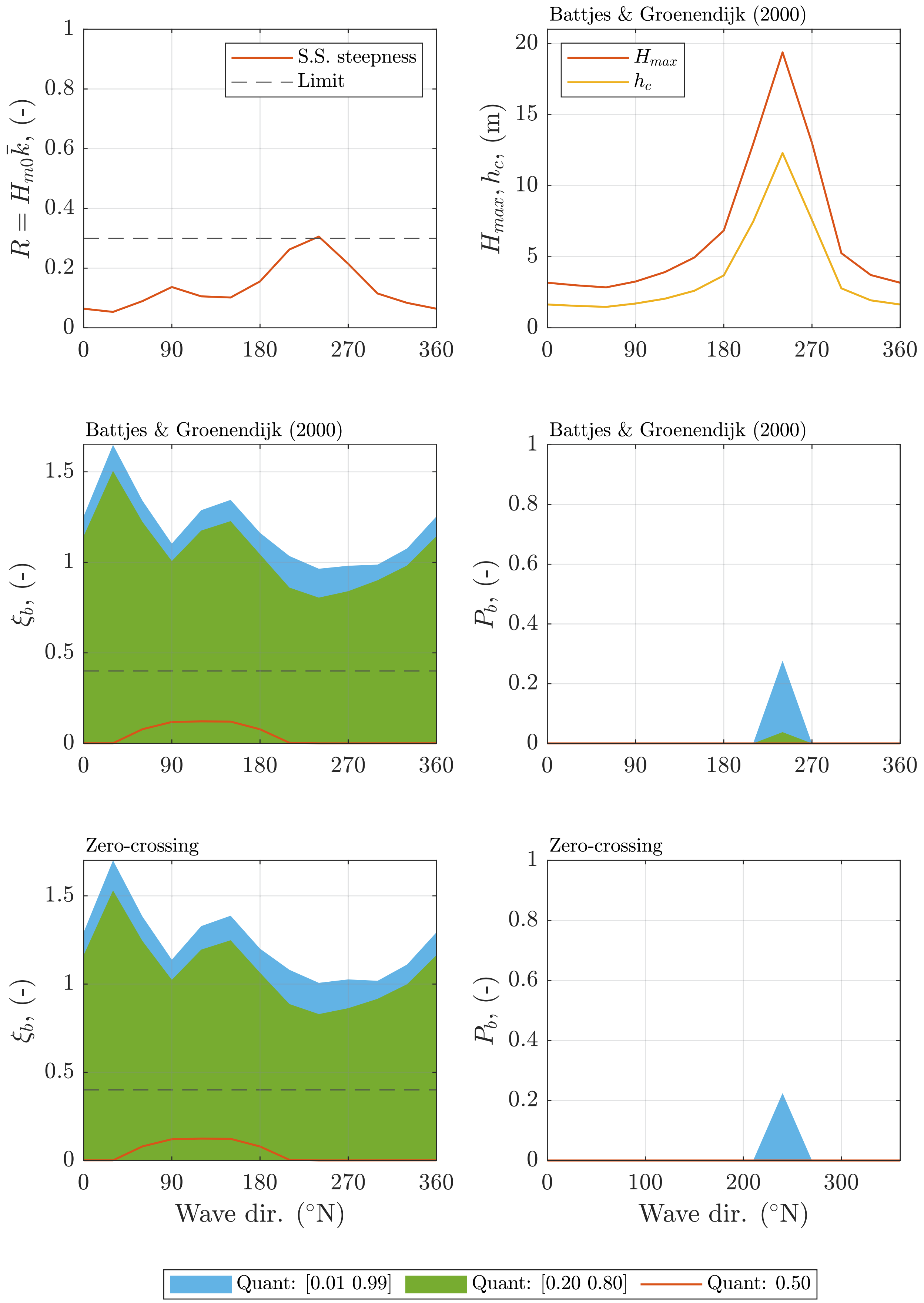
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG18
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.018c



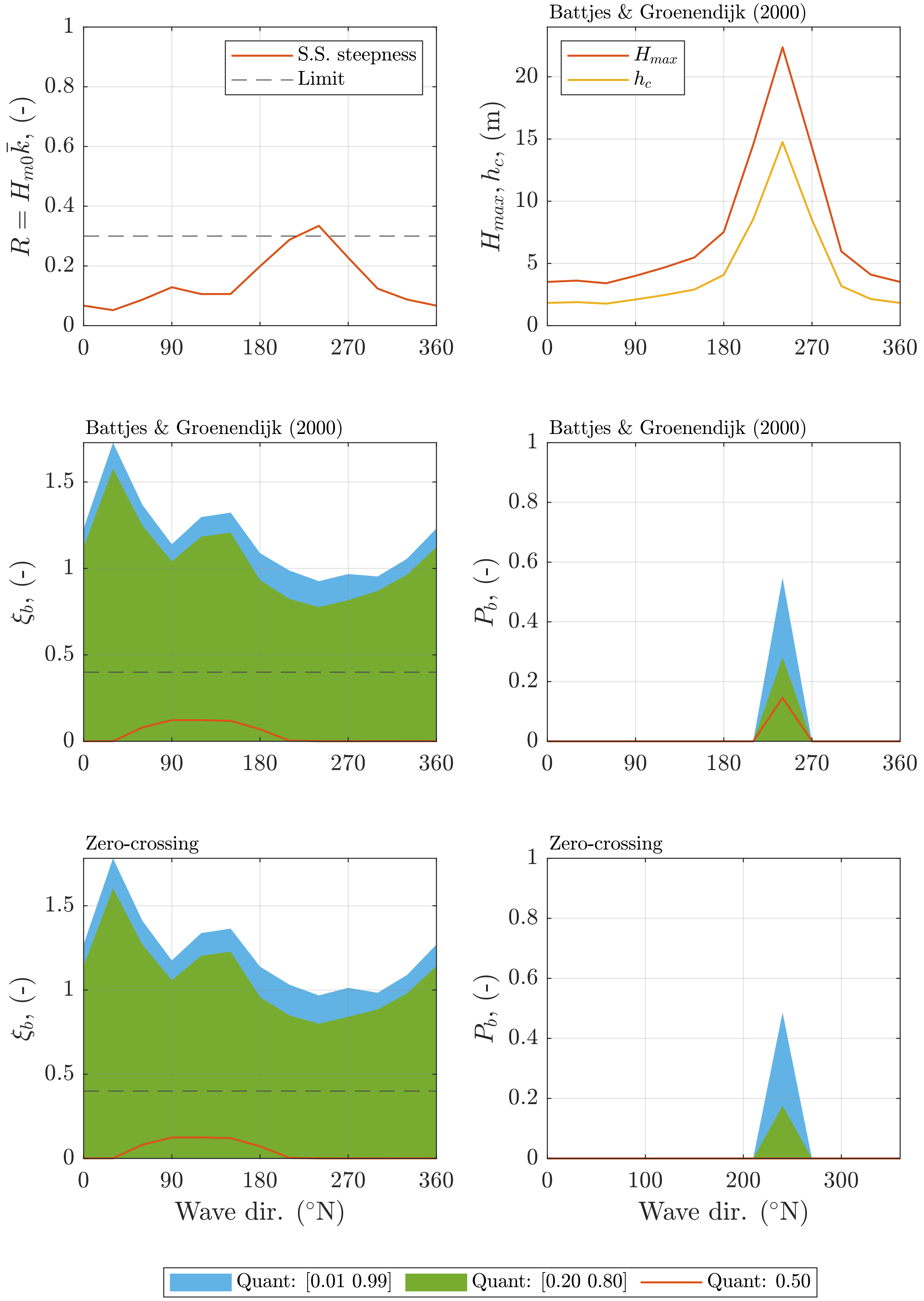
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG18
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.018d



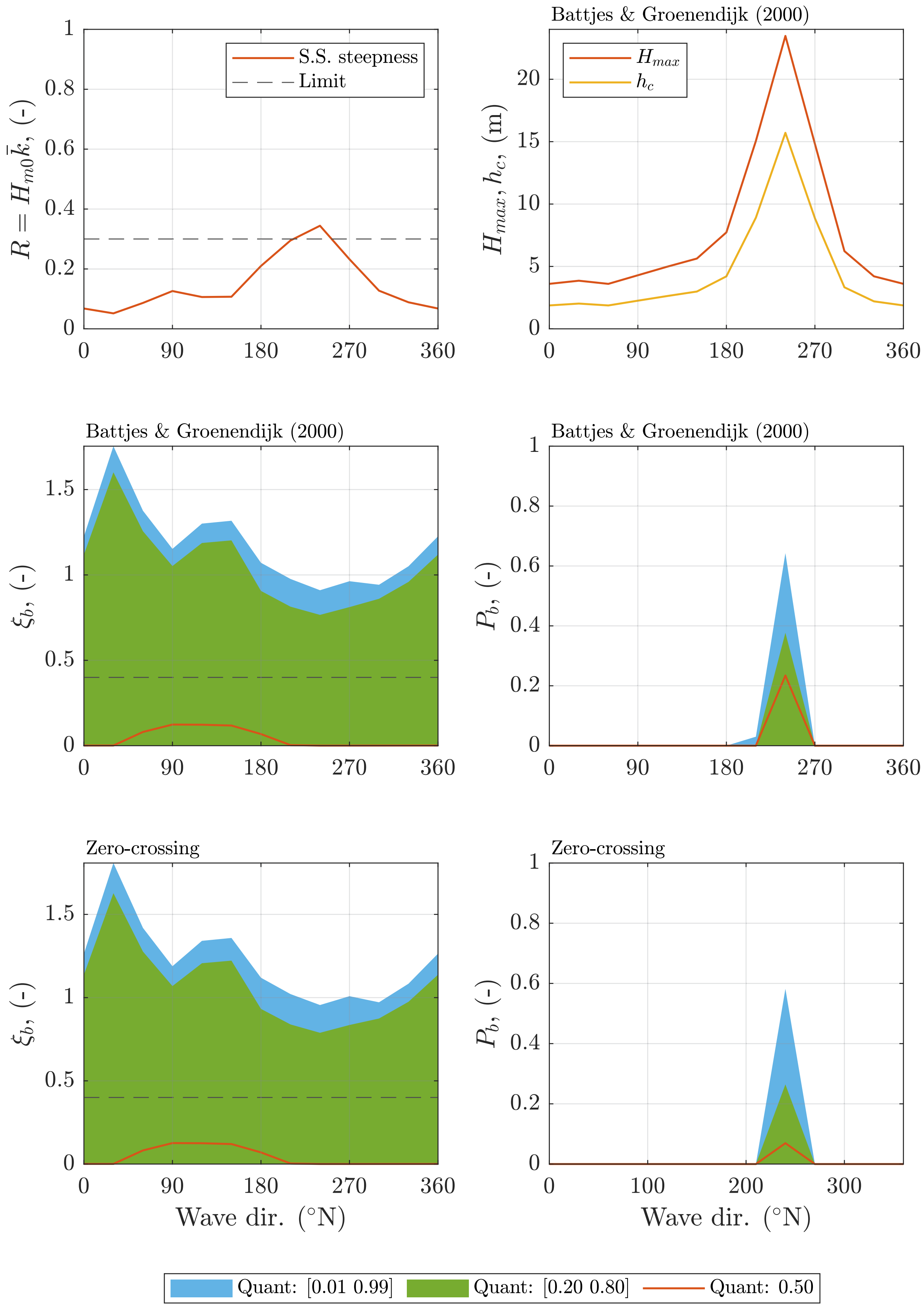
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG19
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.019a



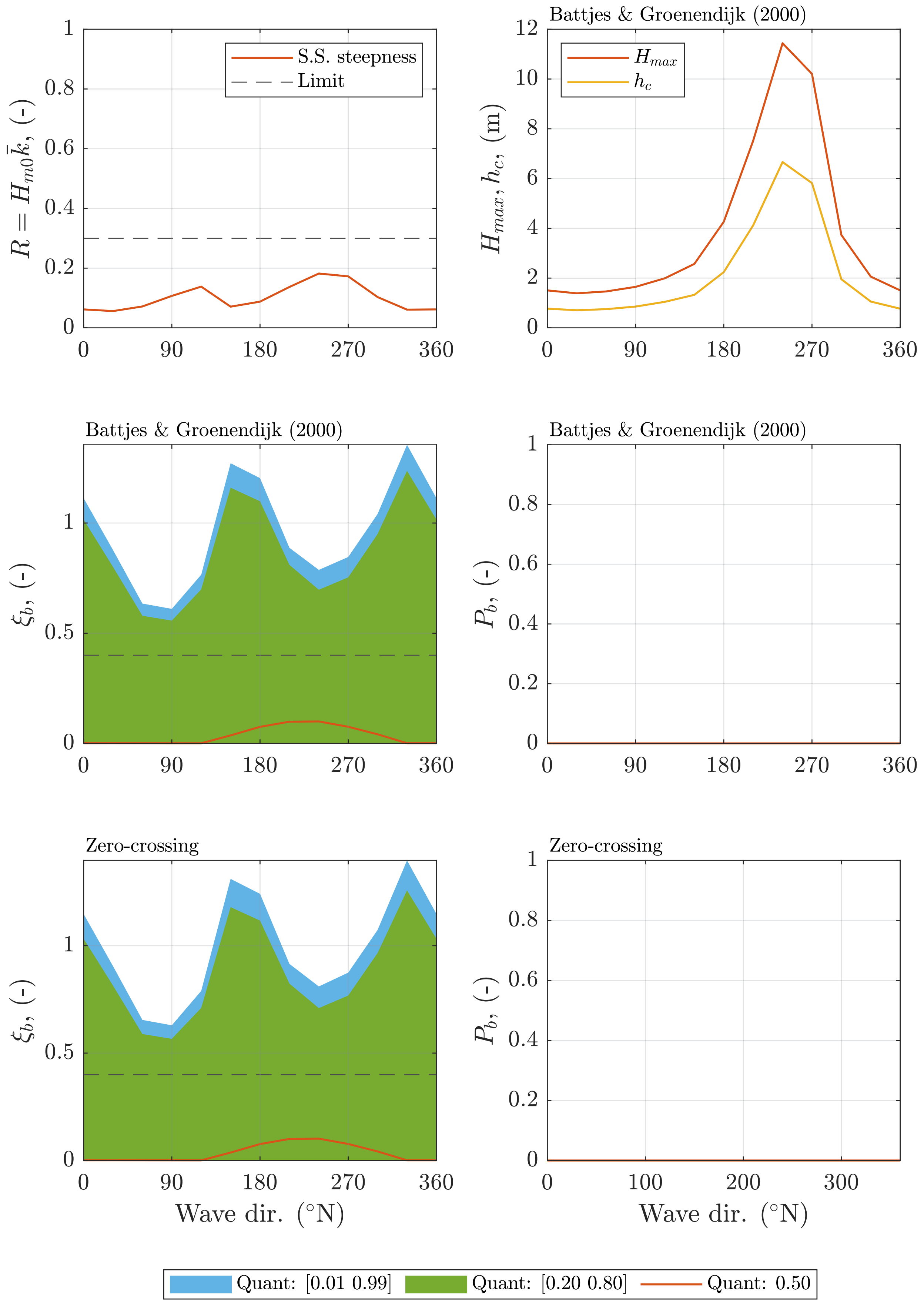
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG19
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.019b



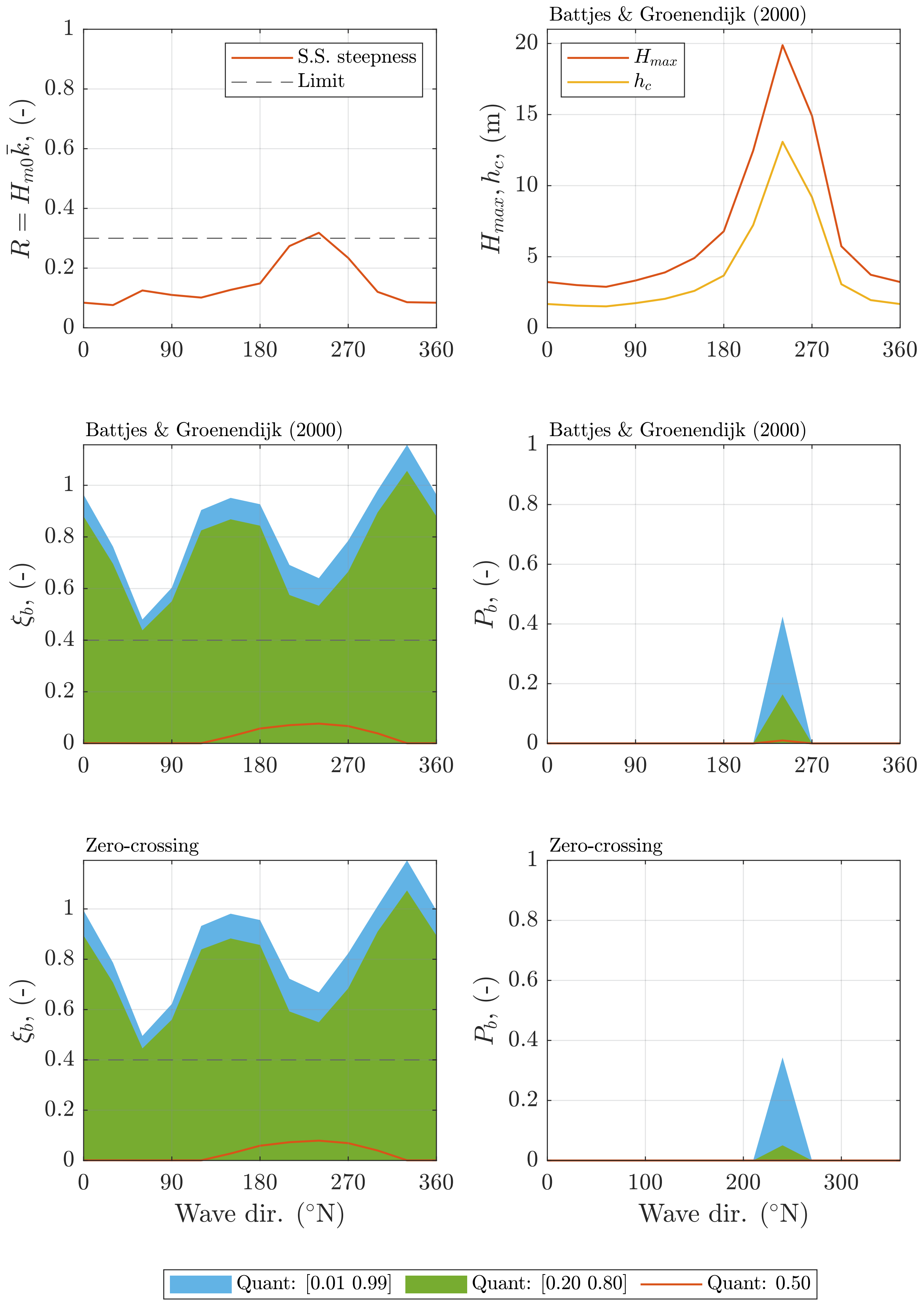
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG19
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.019c



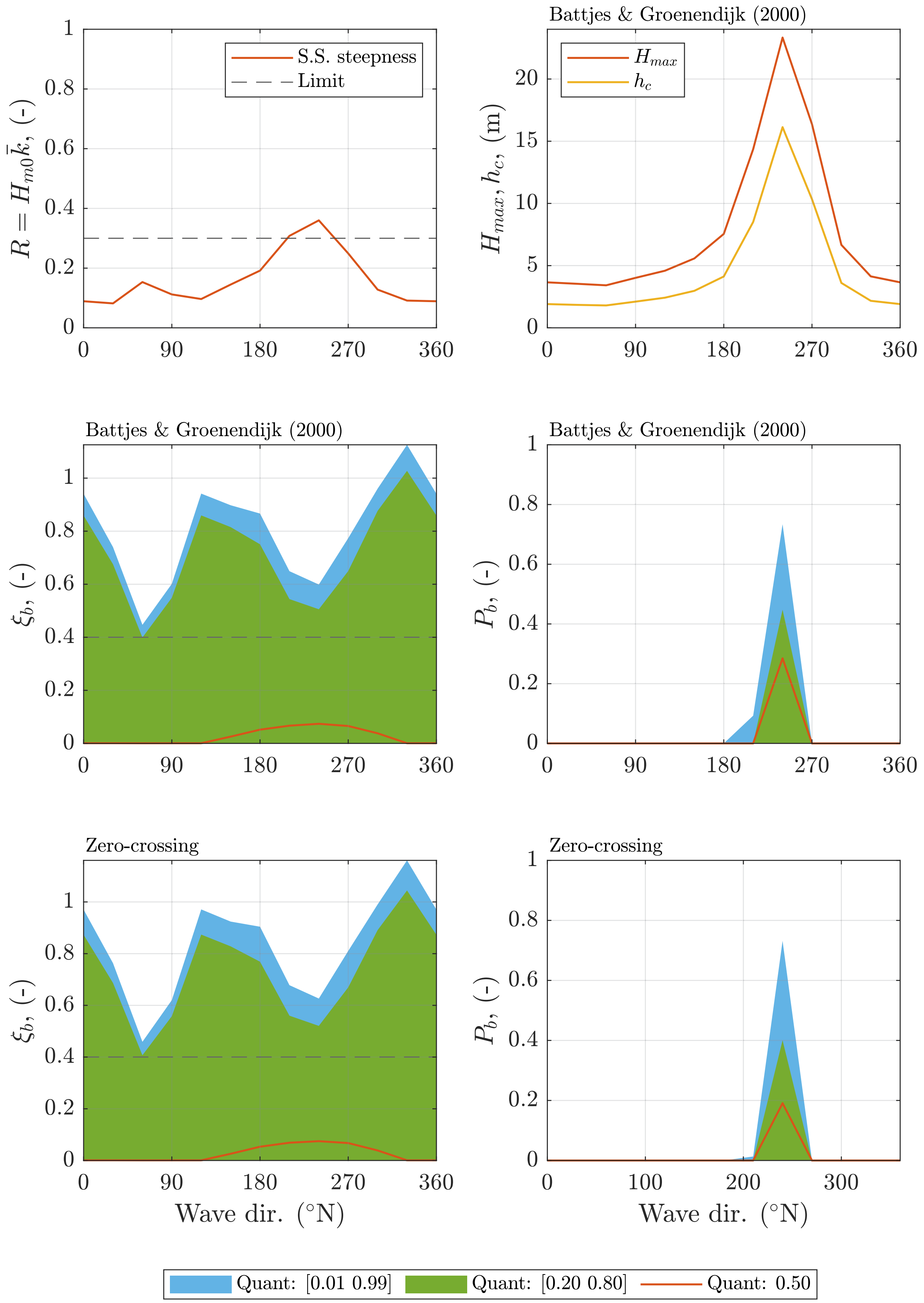
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG19
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.019d



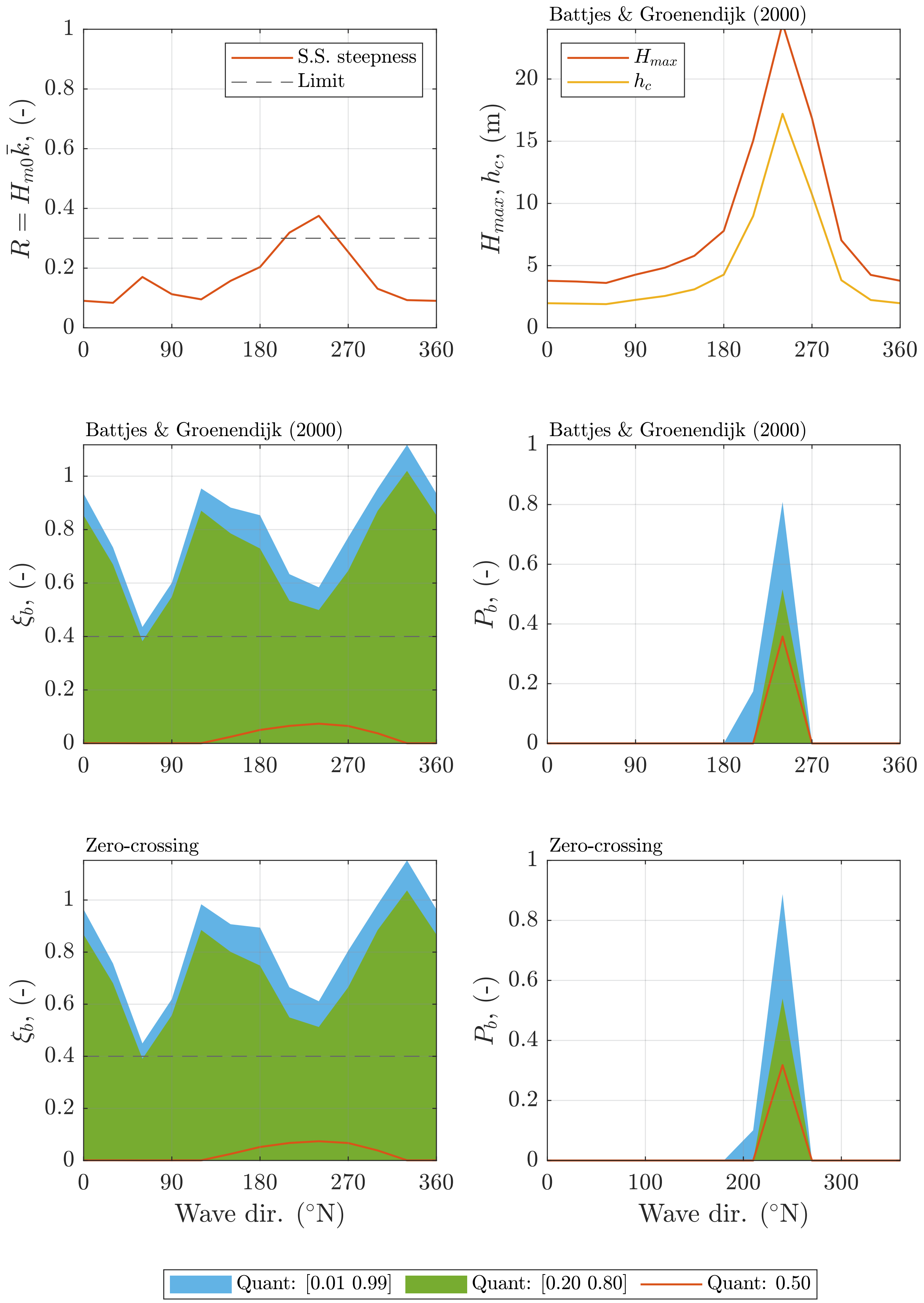
Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP1	WTG20
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.020a



Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP10	WTG20
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.020b



Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP50	WTG20
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.020c



Wave slamming probability and wave / crest height (top left & right), breaking type (Iribarren, center & bottom left) and breaking probability (center & bottom right)	RP100	WTG20
	Breaking wave assessment	
Skerd Rocks OWF - Deltares	11208193	Figure F.020d

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