BREAKWATER DESIGN EXERCISE

PART 1

1. INTRODUCTION

Welcome to the breakwater design exercise for the units Design of Dams, Dikes and Breakwaters part of CIEM 4220 and Shore Protection and Breakwaters part of CIEM 3210. The assignments are split in two (HE: CIEM 321) or three (HOS: CIEM 4220) parts and this document describes the details of the first part common for both modules. The aim of this **part** is to become acquainted with nearshore wave propagation using SWAN and extreme waves analysis. For this assignment you have to analyse a given database of offshore wave conditions, extrapolate these to derive design conditions, and practice transforming these to nearshore conditions using SWAN. Your work will be evaluated and you will be given a "pass" or "fail" mark. A "pass" is required to participate in the second (and third) part of the exercise. In case of a "fail" mark, you will have to upgrade your report after a meeting with the responsible lecturer to proceed to the second part.

2. DATASETS – EXERCISE PART 1

The exercise will be done in groups consisting of three students. For the first part of the exercise, each group has a unique **dataset**, **bottom profile and location**, **return period** (R [years]) and **wave angle** (ϕ [∘]), as indicated in Table 1.

The SWAN model requires information concerning bathymetry, boundary conditions (e.g. incoming waves at offshore boundaries), and wind forcing. Details regarding the input data used for this exercise are given below:

- Bathymetric data were obtained from the European Marine Observations and Data Network (EMODnet[1]) bathymetry portal with a resolution of about 100 m x 100 m. These data have been pre-processed and the file 'bathymetry_swan.dep' must be used to run your simulations. Figure 1 shows the bathymetric data, where this

[1] https://emodnet.ec.europa.eu/geoviewer/

information is in the horizontal reference system based on the European Terrestrial Reference System 1989 ensemble ETRS89 / UTM zone 32N (EPSG:25832).

- The wave data used to perform this exercise was obtained from the ERA5 global reanalysis dataset provided by the European Centre for Medium-Range Weather Forecasts (ECMWF[2]). The reanalysis dataset is derived by data assimilation, which is the combination of model data and observational sources with global coverage. The spatial resolution of the grid cells for atmospheric quantities is 0.25◦ x 0.25◦ (approximately 30 x 30 km). For this exercise, three time series close to the target areas were selected, as illustrated in Figure 1. These time series covers a period of 84 years (1940-2024) and sea state variables such as spectral significant wave heights (H_{m0}), peak wave period (T_p) and peak wave direction (D_p) should be used to characterise the extreme wave climate. The coordinate of the extraction point locations for the wave data are shown in Table 3.
- You must make your own decision regarding the wind speed in SWAN. Choose a value that corresponds reasonably well with your wave boundary conditions. Remember that you have wind speed information in your dataset, so you can use that information to choose an appropriate value.
- You can assume that the design water level for your nearshore transformation is +1.0 m NAP.

Finally, you can assume that the toe of your breakwater is located at $z_{toe}=-6$ m NAP, which is the location of your nearshore study sites (Table 2). Your dataset may contain data from different directions and different meteorological forcings, as well as a mixture of 'swell' and 'wind sea' conditions. It is up to you to filter or split your dataset, as discussed during the lectures, in a way that you think is appropriate. Here, you only have to make an extreme value analysis for **one-directional** sector and wave type, it is up to you to provide the reasoning for the selection. If, after filtering, you are left with more than one directional sector or type, just select the one that you think will give the highest extreme waves at the toe of the structure and carry on with that sector/type only.

[2] https://cds.climate.copernicus.eu

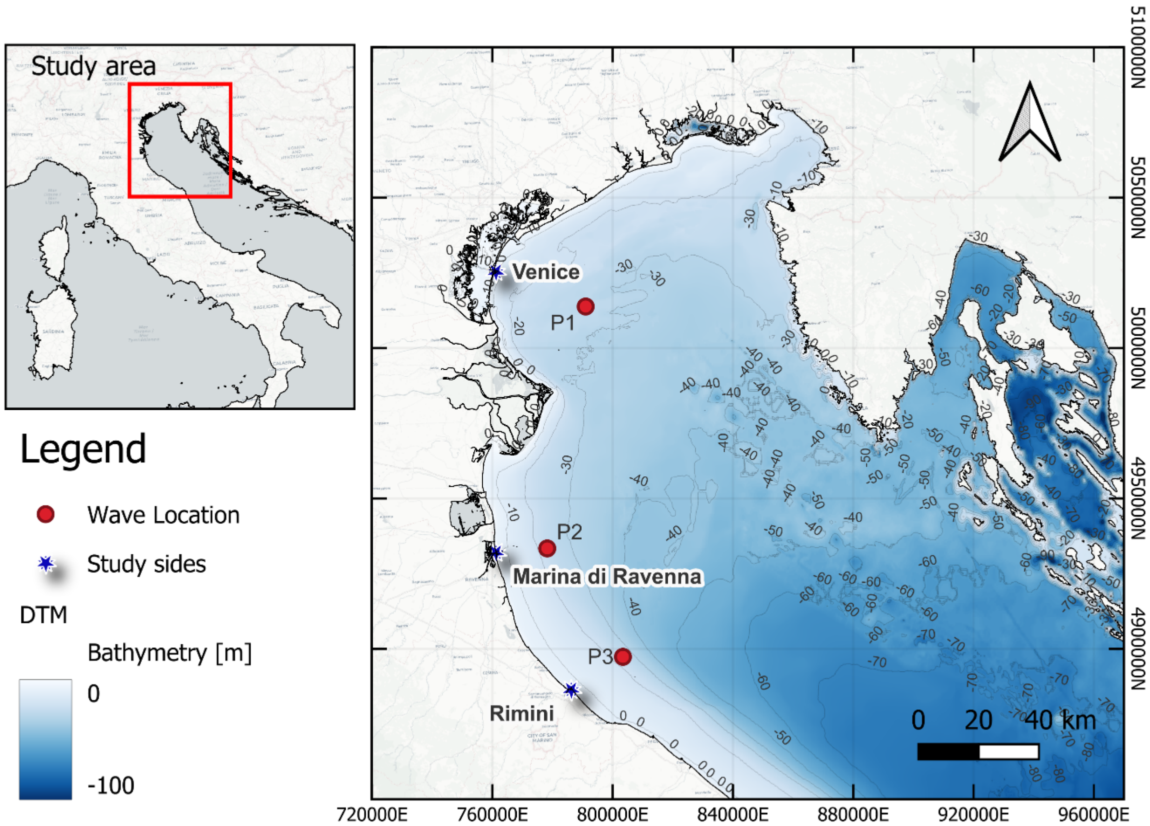

Table 2: Study sites.

Name	X	Y
Rimini	786216	4886340
Marina di Ravenna	761192	4931934
Venice	761153	5025309

Table 3: Wave locations.

Id	Latitude	longitude	X	Y	Depth
P1	45,000000000000000	13,000000000000000	791027	5013796	27
P2	44,500000000000000	12,500000000000000	778245	4933370	24
P3	44,000000000000000	13,000000000000000	803411	4897322	25

Figure 1: Bathymetric map of the study area and dataset location at UTM zone 32N (EPSG:25832).

3. QUESTIONS – EXERCISE PART 1

You are provided with a database (timeseries) of observed off-shore wave conditions at the locations displayed in Figure 1 and Table 3 (P1-P3). These are the locations that you should use for the propagation in SWAN of the identified extreme wave conditions. To complete the assignment the following questions should be answered:

Q1.1 Analyse this dataset, using the methods discussed in lecture 3 and appendix A of the lecture notes, and predict the design H_s for the return periods up to R=1000. Use a variety of extreme value distributions (Exponential, Gumbel, Weibull and GPD). Produce a graph like Figure A.7 of the lecture notes (reproduced as in Figure 2).

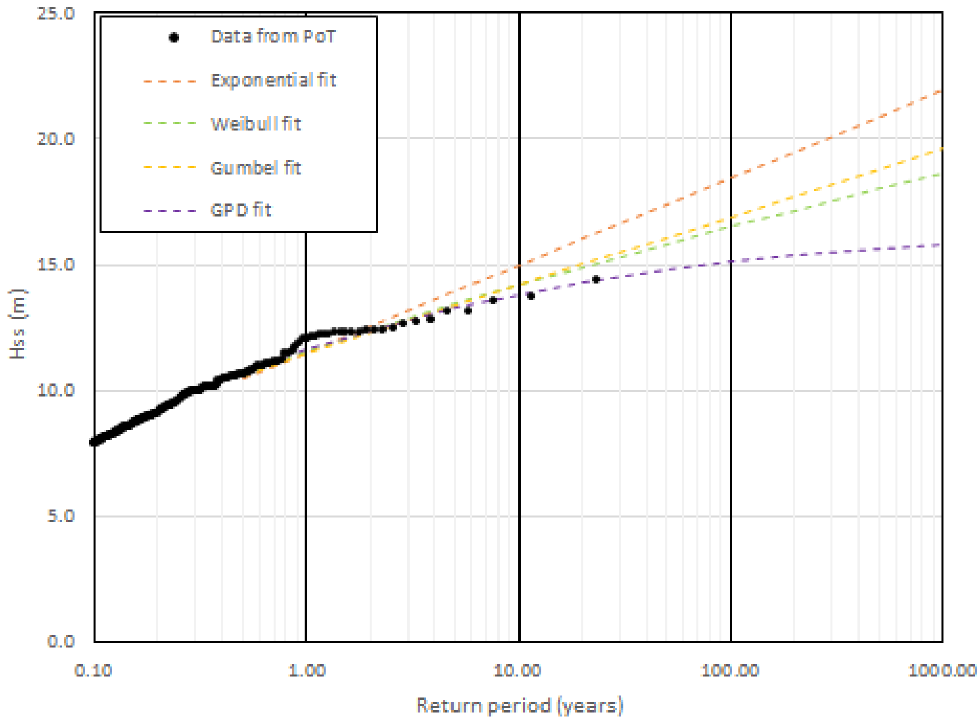

Figure 2: Example of answer to Q1.1.

Q1.2 Discuss your results and make a choice between the predictions from the various extreme value distributions. Support your choice. Present your results in a table showing H_s for return periods of R = 1, 10, 50, 100, 500 and 1000 years.

Q1.3 Analyse the correlation between wave height (H_s) and wave period (T_p) and make a prediction for the corresponding wave period for each return period. Discuss your method and add your results to the table you made in Q1.2.

Q1.4 Make an estimation of the uncertainty in your prediction (for wave heights only) using the method that you want and think to be more appropriate. Provide the 95% confidence interval and add your results to the table you made in Q1.2.

Q1.5 Depending on your group number you have an assigned return period (R), make an offshore-nearshore transformation for these conditions using SWAN. Describe your method and report the resulting wave condition (wave height, period and direction) at the toe of the structure. Plot the graphs of the most important parameters as a function of the distance along a curve and a map of the three spectral variables: H_s, T_p and D_p. You can assume that the curve for the plot is aligned with D_p associated to your extreme wave condition. Also, plot the wave spectrum offshore and at the toe of the structure. How do the two compare? Finally, calculate the ratio $H_{2\%}/H_s$ at the toe of the structure from the hand calculation using the Battjes-Groenendijk method.

In the last lecture before the beginning of this part of the exercise we will also explain the details of this exercise and show a quick tutorial on SWAN. Produce a very brief report (max 4 pages A4, appendix are not allowed because are not needed for this first part) describing your methods and results. Clearly structure your report in correspondence with the above 5 questions.

The reports should be handed in by 12:00 on 14/5 by email to a.r.rodriguesbendo@tudelft.nl and a.antonini@tudelft.nl

Table 1: HOS - Exercise group.

	Name	**Surname**	**Student number**	**Location**	**R [years]**
Group HOS1	Ahmet	Tekin	6289487	**P1**	**50**
	Kashyfi	Salleh	6288421		
	Leila	Belkacem	6289533		
Group HOS2	Victor	Ameye	5522056	**P2**	**50**
	Martijn	Bruijn	5597277		
	Sanjeev	Ramsoekh	5534550		
Group HOS3	Gijs	Rietman	5348196	**P3**	**50**
	Peter	Ramondt	4800176		
	Duco	Buis	5173337		
Group HOS4	Siebren	Busch	5099358	**P3**	**150**
	Remo	Streule	6357490		
	Mila	Janssen	5270065		
Group HOS5	Kyriaki	Detsi	6291813	**P2**	**150**
	Victoria Kremer	Devesa	6299512		
	Tawfik	Manafikhi	5171466		
Group HOS6	Lena	ten Wolde	5402263	**P1**	**150**
	Saana	Taal	5380448		
	Mabel	Klein	5402115		
Group HOS7	Sarah	van Leeuwen	5138396	**P3**	**250**
	Anne Lynn	Houwen	5061695		
	Johannes	van Hooff	5171431		
	Matthias	Roest	5605660		
Group HOS8	Wouter	de Visser	5638801	**P1**	**250**
	Sem	Roozendaal	4959477		
	Noor	van Geffen	5458781		
Group HOS9	Max	Blankwater	4958063	**P2**	**250**
	Luc	de Wild	5158362		
	Cecilia	de Bruin	5402212		

Table 2: HE - Exercise group.

	Name	Surname	Student number	Location	R [years]
Group HE1	Josephine	Sloots	5058104	P3	5
	Twan	van Meijeren	5615321		
	Eveliina	Moonen	5231655		
Group HE2	Denise	Pierce	6117449	P1	5
	Rifa A.	Suaedi	6169708		
	Glenn	Reverda	4837738		
Group HE3	Margot	Giliam	5177863	P2	5
	Famke	Michielsen	5168724		
	Ties	ter Laan	5170273		
	Marijn	ten Zweege	5102405		
Group HE4	Anjali	Vas-Bhat	5043530	P1	100
	Ilja	de Goede	5357888		
	Isabel	van der Leijé	4904435		
Group HE5	Bauke	Velthuijs	5401445	P2	100
	Emma	Hendriks	5170443		
	Jelle	Gortemaker	5115051		
Group HE6	Floortje	van Ruth	5034965	P3	100
	Jochem	van den Brink	5400317		
	Hendrik	Heerdink	5121132		
Group HE7	Marianna	Diamanta	6301568	P2	500
	Nafsika	Litzerinou	6298958		
	Irham Adrie	Hakiki	5987474		
Group HE8	Job	Traas	5173140	P3	500
	Stefan	Kocken	5586992		
	Rens	Koreman	5606136		
	Joep	ten Dam	5390451		