MAW, assignment2.

Part I (Wave energy conversion) [10 points]

Portugal has one of the most extreme wave climates in the world with big waves occurring especially in the winter. It creates an enormous energy potential but, at the same time, increases the operational risks.

The main goal of project 3 is to discuss the local wave climate and calculate the wave energy conversion considering different wave energy converters.

The exact position is illustrated in figure 1, latitude 39N longitude 9.5W, at 52 meters of water depth. The time-series of significant wave height (Hs), peak period (Tp) and peak direction were extracted from NOAA hindcast so a final text file was created and organized (NOAAwave_1979010100to2007123123.txt).

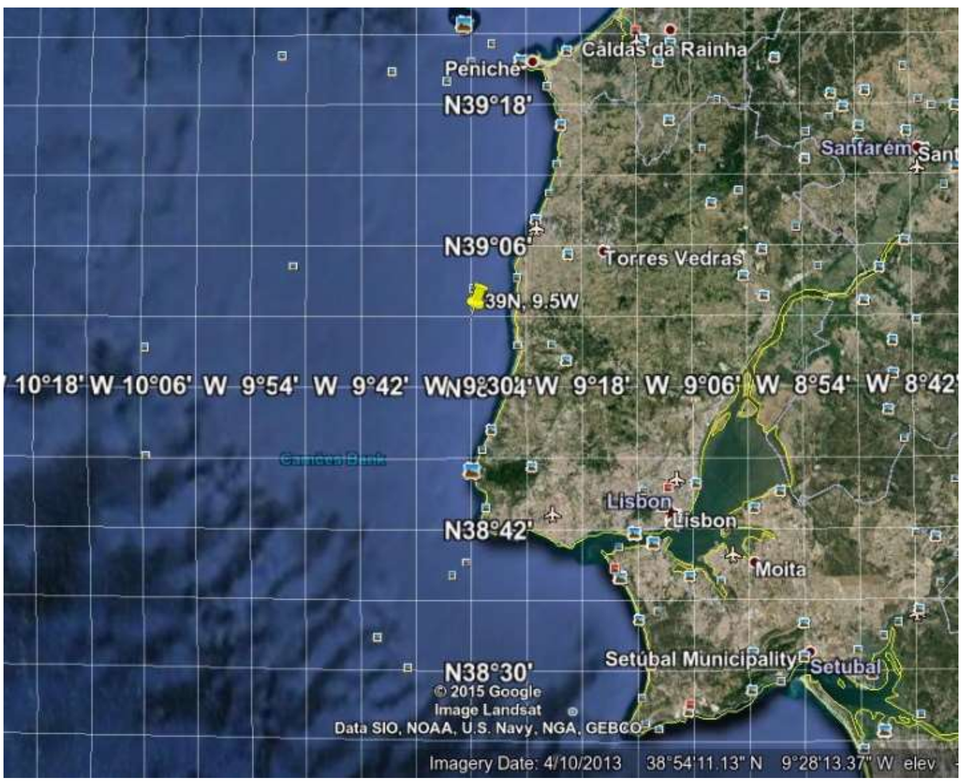


Figure 1 – Exact position of the time-series.

Based on the information above together with the input files calculate:

[Ex1: 2 points]

1) Scatter tables of: Hs vs Tp; Hs vs Dp; Tp vs Dp. You can select the proper bin size (Hs, Tp and Dp discretization) as you prefer. Discuss your results and summarize in few words the local wave climate.

[Ex2: 4 points]

2) The wave power per unit of crest length for the sea state (for deep water) is given as:

$$P_w = \frac{\rho g^2}{64\pi} H_s^2 T_e$$

With unit of $kW/_m$, where ρ is the water density (1.025 $kg/_{m^3}$), g is the gravity, H_s the significant wave height and T_e the energetic period. For a typical JONSWAP peak enhancement of $\gamma = 3.3$ the energetic period is:

$$T_e \approx 0.9T_p$$

2.1) Calculate the average wave power $\overline{P_w}$ for the whole time-series.

2.2) Calculate the wave power for each season ($\overline{P_w}^{winter}$, $\overline{P_w}^{spring}$, $\overline{P_w}^{summer}$, $\overline{P_w}^{autumn}$) using the average of Hs and Te per season and dividing the seasons as: Winter (December, January, February), Spring (March, April, May), Summer (June, July, August), Autumn (September, October, November). Discuss your results.

2.3) Using the same bin sizes of the scatter tables of item 1, calculate the normalized occurrence table of Hs vs Te. Multiplying the occurrence by the wave power P_w, obtain the final matrix of contribution to the wave power in each sea state. Which group of wave heights and periods provide the most occurrences? Which group of wave heights and periods provide the most energy contribution?

[Ex3: 4 points]

3) Three Wave Energy converters are available (AquaBuoy, Pelamis and Wave Dragon), with power matrices attached. Each bin of the matrix gives the power provided by the instrument in kW for the associated pair of H_s and T_e.

A way to estimate the electricity production of a WEC in a specific site is to associate the converter power matrix with the wave activity of the specific site. This relation is given by

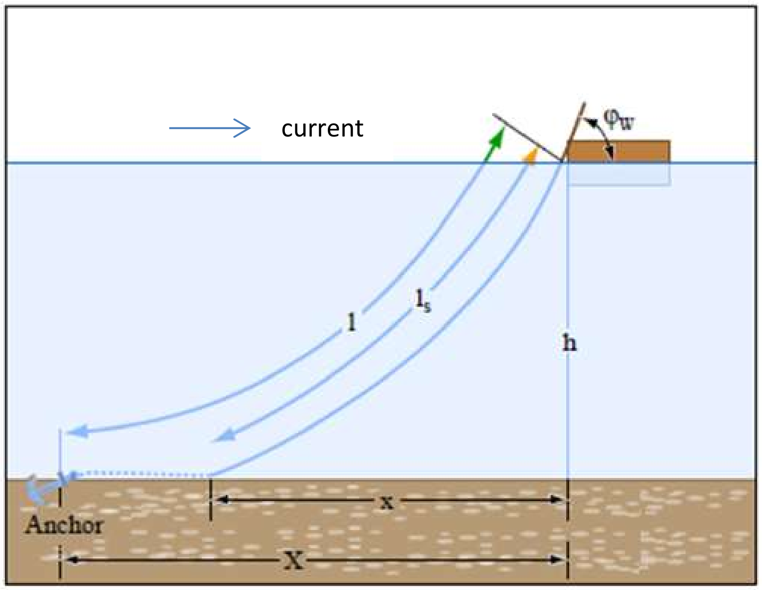
$$P_E = \frac{1}{100}\sum_{i=1}^{n_T}\sum_{j=1}^{n_H} p_{ij}.P_{ij}$$

Where p_{ij} is the energy percentage corresponding to the bin defined by the line i and the column j; and P_{ij} is the value from the given power matrix. Based on the equation above, calculate the total average electric power P_E for each instrument. Discuss your results.

Part II (Wave forces and mooring analysis of a buoy) [10 points]

A surface cylindrical buoy with 2.5 meters diameter is moored in a tidal flow with a chain weighing 800 N/m in the water with density (1025 $^{kg}/_{m^3}$). Knowing that the drag coefficient for the buoy is 0.9, and the current with 3m/s, the draft of the buoy is 10m, and assuming that

a) the top end of the mooring cable attached to the buoy is at the water surface
b) the buoy is quasi-static in the water



a) Calculate the horizontal wave force per unit length on the buoy at the water surface.
b) Estimate the total horizontal force acting on the buoy.
c) Neglecting the elasticity of the cable, what is the minimum length of the chain to maintain an angle of 45º at the fairlead? What is the horizontal distance from the touch down point to the fairlead? What is the tension at the buoy?
d) Considering the elasticity of the cable, what is the horizontal distance from the touch down point to the fairlead when the axial stiffness of the cable is 3240 KN?
e) Considering the above conditions, estimate the total mass of the buoy?