MENO

Modelling Sea Waves

(2021/2022 academic year, 1º semester)

Project 1: Statistical and spectral analysis of waves

1. Introduction

The objective of the project is to perform statistical and spectral analysis of wave elevation time-series, both generated in laboratory and measured in the ocean.

Several files are provided in the folder “Buoy data”, containing timeseries of measurements of the movements (heave, pitch and roll) of a buoy deployed along the coast of Rio Grande do Sul, Brazil, at the position with coordinates Lat: 31.57, Lon: -49.87). The sampling interval is of 0.78 seconds. Files are available every hour, in text format (extension “.tsr”, it can be opened as a .txt or .ascii).
Only heave will be used in this part of the project to analyse the individual waves and its distributions, and to perform a spectral analysis using FFT and different methods of power spectra estimation.

Students are free to choose one dataset (one time series of 20 minutes at a specific hour). An FFT function, developed in Matlab, will be provided; to make it work the toolbox “signal” is needed (given in the dropbox, which must be unzipped added to matlab path). However students can use any software and program language to run the analyses, in any case, codes must be extensively commented to provide detailed explanation about the procedure adopted in each step.

Part 1: analysis of individual waves.

Using the given time series, calculate:

1. mean, dispersion (variance), skewness, and kurtosis (first four moments).
2. the distribution of the free surface elevation (taking ordinates of the whole data) and compare with the Gaussian distribution and Longuet-Higgins.
3. Identify Up-crossing and Down-crossing individual waves and associated periods. Represents the wave heights in a histogram and compare with the Rayleigh distribution.
4. Calculate the significant wave height ($H_{1/3}$) and significant wave period. Take the maximum wave height and compare with the significant wave height and the mean wave height.

Part 2: spectral analysis

1. Compute and plot the autocorrelation function from the time series;
2. Using FFT, calculate and plot the power spectrum
3. Reduce the noise of the resulting spectrum using the Daniell’s method (play with the smoothing as you prefer) and then using the Bartlett and Welch’s methods (partitioning the time-series using the degrees-of-freedom as you find more appropriate). Plot the relevant resulting spectra. Compare and discuss the differences involving the number of segments.

4. From final the spectrum you estimated (with Welch method), calculate:
   a) first 4 spectral moments.
   b) spectral bandwidth coefficient , where $\nu^2 = \frac{(m_0 m_2 - m_1^2)}{m_1^2}$.
   c) peak period T_P and significant wave height H_S from the spectrum.
   d) Compare $H_{1/3}$ obtained in time domain analysis with H_S from the spectrum.
5. Compare the final spectrum with one theoretical spectral model of your choice.

<u>Instructions</u>

The use of a programming language (e.g. Matlab) is strongly recommended to facilitate the calculations and the presentation of the several plots required.
The files and the matlab functions can be found at the following link:
https://www.dropbox.com/sh/36t2a7prhdwh00p/AACrR_Q1Pzb0ljeQyLHcKngBa?dl=0

Presentation of the results
A report must be prepared which should include, besides the results of the assigned problems, a brief yet clear description of the procedure and equations used. All results must be extensively discussed and related/justified with the theory discussed in class.
If programming languages or software are used for the resolution, the relative files, opportunely commented, have to be delivered in electronic format.

Deadline
The project must be delivered within November 26th 2021.
The documentation must be delivered in electronic version (no need to print) to Roberto Vettor by email: roberto.vettor@tecnico.ulisboa.pt.