Operational modelling for supporting and characterising the Marine Renewable Energies in Western Iberia

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Abstract

Marine renewable energies comprise a vast number of technologies including tidal, waves and offshore wind technologies. Operational modelling could contribute to support the development of such activities in several ways. An implementation of the WaveWatch III ® model for the Portuguese Continental Coast for the period 2000-2010 was validated and used to estimate the wave power resource. The same configuration has been used to provide forecasts for marine renewable energy for the Energymare and Turnkey projects.

Keywords: Marine Renewable Energies, waves, operational modelling, forecast, resource assessment

1. Introduction

Marine renewable energies comprise a vast number of technologies including tidal, waves and offshore wind technologies. Operational modelling could contribute to support the development of such activities in several ways. Through atmospheric, wave and hydrodynamic models, the areas with enough energetic resource for these industries could be identified. Furthermore, operation and maintenance services rely on the sea conditions that operational modelling is able to provide through forecast services. These forecasts could also be valuable for the survivability of the installed devices as extreme events could be identified and thus the possible damage could be reduced by taking measures. Moreover, operational modelling could evaluate the amount of energy that would be available and how much could be produced by the devices thus the electric system would be more efficient in accommodating the generated energy. Due to the limited scope of this paper, only the main results for the wave energy resource evaluation will be discussed here.

2. Waves modelling

In order to model the wave generation, propagation and dynamics the NOAA WAVEWATCH III (R) Model V3.18 was used.

2.1 Modelling domains

In the case of the Portuguese coast, swell waves are generated on the western side of the Atlantic Ocean. For that reason, three nested levels with increasing resolution -0.5, 0.25 and 0.05 degrees- were defined to simulate the waves arriving to the Portuguese coast (Figure 1). Covering, the North Atlantic Ocean (Nat), the southwest part of Europe (SWE) and the Portuguese continental coast (PCC) respectively.

Two bathymetric sources were combined to populate all levels grids: the EMODNet Hydrography portal (http://www.emodnet-hydrography.eu) completed by the 30” resolution global bathymetry data SRTM30_PLUS (Becker *et al*., 2009) for regions where EMODNet data were absent.

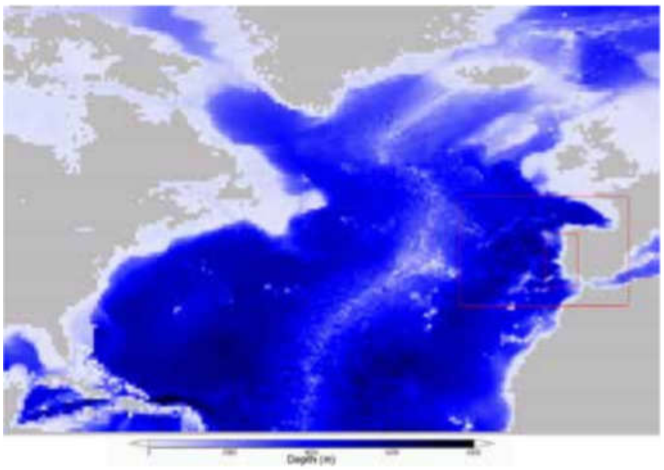

Figure 1 Grids used for modelling the waves arriving to the Continental Portuguese coast. Nested domains are indicated by the red squares.

2.2 Meteorological forcing

The wave energy resource was evaluated for the period 2000-2010. The NCEP FNL Operational Model Global Tropospheric Analyses, continuing from July 1999 with 1 degree of horizontal resolution (NCEP/NWS/NOAA/U.S. Department of Commerce, 2000)) was used to feed the wave model with winds intensities and direction.

3. Results

3.1 Model Validation

Historical wave parameter observations are scarce in the Portuguese coast. For the selected period, three stations were used from the Instituto Hidrográfico (IH) from Portugal and five stations from Puertos del Estado (PdE) in Spain covering different periods (Table I).

The observed data were compared with hourly model time series. Coefficients of determination (R^2) were obtained for each station and for significant wave height (H_s) and for wave average period (T_m) (Table I). The obtained values show a great agreement for the H_s variable for the entire area of study with R^2 values comprised between 0.79 and 0.92. On the other hand, the model, with the current version and configuration, showed a lower capacity for calculating the average period with R^2 values from 0.75 to 0.20. The capacity of the model to estimate both variables is better in open exposed coastal areas while decreased in wave sheltered areas.

3.2 Wave Energy

Wave power (P) was estimated using the formula for deep water (Figure 2):

$$P = 0.49 * H_s^2 * T_m$$

obtaining kilowatts (kW) per meter of wavefront length. Once this formula is applied to the PCC domain for the 2000-2010 period, we obtain the wave power distribution for the study area.

4. Discussion

Wave power distribution shows a clear gradient with a NW-SE orientation. Maximum values around 50 kWm^{-1} are found in the open ocean off the Northern coast while minimum values are located in the areas sheltered by geographic features from this direction i.e. the Tagus and Sado estuarine mouths and the Algarve southern coast. On average the Portuguese coastal area has a wave power around 30 kWm^{-1} though this value presents a strong seasonality. Values obtained were in agreement with the ones obtained by Pontes *et al*. (2003). Regarding the difficulty to forecast the period and with H_s being more relevant to the wave power estimation and the area of interest for wave energy in areas exposed to the coast we consider that the current approximation is valid for characterizing the waves resource in the Portuguese continental coast.

Table I List of observing stations and its source (PdE: Puertos del Estado and IH: Instituto Hidrográfico), location in terms of latitude and longitude, validation period and coefficient of correlation (R^2) for the significant wave height (H_s) and the average period (T_m)

Station Name	Domain	Latitude	Longitude	Data Period	H_s R^2	T_m R^2
Estaca de Bares (PdE)	SWE	44.06 N	7.62 W	Jan 2002-Dec 2009	0.92	0.75
Cabo de Peñas (PdE)	SWE	43.73 N	6.19 W	Jan 2002-Dec 2009	0.89	0.71
Villano-Sisargas (PdE)	SWE	43.49 N	9.21W	Jan 2002-Dec 2009	0.90	0.74
Silleiro (PdE)	PCC	42.12 N	9.40 W	Jan 2002-Dec 2009	0.91	0.69
Leixoes (IH)	PCC	41.18 N	8.70 W	Jan 2008-Dec 2009	0.91	0.61
Sines (IH)	PCC	37.95 N	8.89 W	Jan 2008-Dec 2009	0.90	0.61
Faro (IH)	PCC	36.90 N	7.90 W	Jan 2008-Dec 2009	0.80	0.20
Cadiz (PdE)	SWE	36.84 N	6.98W	Dec 2008-Dec 2009	0.79	0.31

The same configuration has been used to implement a forecast wave service using a GFS forecast product with higher resolution and which results can be accessed at http://forecast.maretec.org/

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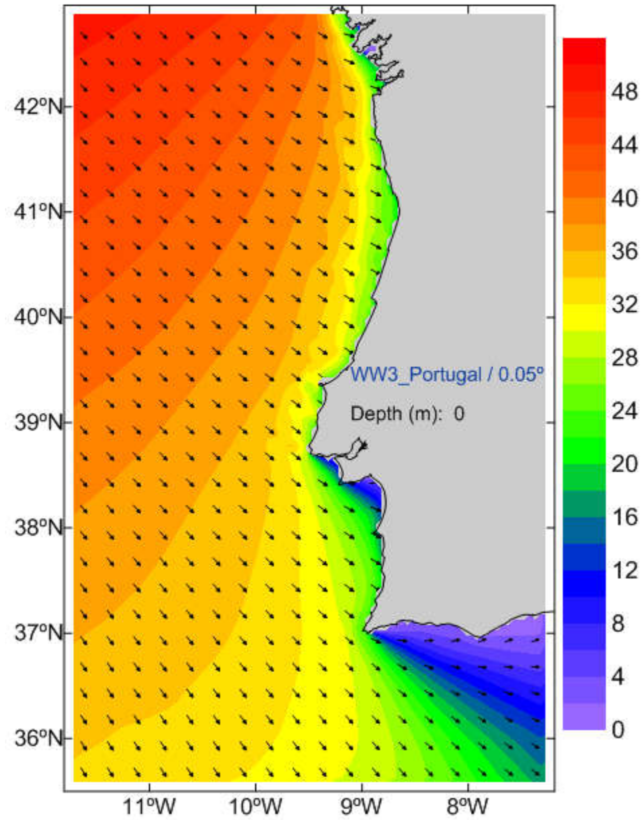

Figure 2 Wave power in kWm^{-1} for the PCC domain, mean wave direction is indicated by the arrows.

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