NIVMAR : A SPANISH STORM SURGE FORECAST SYSTEM

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Abstract

The NIVMAR system was developed in 1998 by Puertos del Estado to provide sea level predictions for the Spanish harbours which included also the meteorological forcing. This is particularly important for the Mediterranean coast, due to the small range of the tide. The system is based on the operational running of an ocean circulation model (which performs the prediction of the meteorological residuals), and the use of the tide gauge data both to obtain the astronomical prediction in the harbour and to validate the system. A description is made of the model, data transmission and near real time verification, this one fundamental to correct and improve the quality of the predictions. Examples of the good operation of the system in Mediterranean harbours are presented.

keywords: sea level, circulation models, western Mediterranean

Introduction

The HAMSON is a three dimensional and finite difference ocean circulation model developed by the IFM (Institute fur Meereskunde, Hamburg) and Puertos del Estado (1, 2, 3). It can take into account the tides, wind, atmospheric pressure, heat fluxes and baroclinic gradients inside the ocean. It has been applied to a large variety of scales and phenomena.

On the other hand Puertos del Estado is responsible for a permanent tide gauges network (REDMAR) (http://www.puertos.es/Mareas/index.html) that consists of 14 acoustic sensors along the Spanish coast, most of them in operation since mid 1992. Three of the stations are located at Western Mediterranean harbours: Barcelona, Valencia and Málaga. The tide gauges provide 5-min sea level data that are transmitted to the central station in Puertos del Estado, where the data are quality controlled and analysed (4).

Description of the system

The Nivmar system consists of a set of different applications and programs that makes use of the barotropic and vertically integrated version of the HAMSON model. The model domain covers an area extending from 20°N to 48°*N* in latitude and from 34°W to 30°*E* in longitude (all the Western Mediterranean). The bathymetry employed, based on the DTM5 data set (4), was built by using a variable grid size scheme in order to reduce the number of computational points. The region from 25°*N* to 48°*N* and from 20°*W* to 30°*E* keeps a constant resolution of 10'x15'. The grid size in the rest of the domain is increased progressively to the boundaries.

The HAMSON is executed twice a day using the output from the INM (Instituto Nacional de Meteorología) application of HIRLAM (5) to give the meteorological sea levels with a forecast horizon of 48 hours. The meteorological data consist of 6 hourly fields of pressures and winds at 10 m, with 0.5°x0.5°resolution.

The ocean model run really covers a period spanning from 12 hours before the starting time to 48 hours later. Data from REDMAR tide gauges are used, allowing the system to correct systematic errors in the mean sea level due to physical processes that are not included in the ocean model (i. e. steric height).

The tide predictions obtained from analysis of the tide gauge data are added to the meteorological sea level component given by the HAMSON model in order to have a 48 hours forecast of the total sea level. Results from NIVMAR are placed on a massive storage system (Unitree) and distributed through the web (http://www.puertos.es/Nivmar).

Table 1: Statistical comparison of measured and simulated residuals. Nr: number of records; X mean value of the measured residuals; rmse: Root Mean Square Error; rmax: maximum error; m and b: slope and interception of the linear fit and CI: Correlation Index.

Estación	Nr	X	rmse	rmax	m	b	CI
Bilbao	3648	7.89	5.66	21.03	0.82	1.44	0.90
Santander	3571	9.30	5.72	24.73	0.88	1.14	0.91
Gijón	3382	-0.68	6.13	19.70	0.88	-0.08	0.89
La Coruña	3648	17.58	5.89	20.69	0.81	3.30	0.92
Vigo	3614	15.23	5.04	20.86	0.81	2.82	0.95
Bonanza	3483	11.59	10.17	66.93	0.44	6.54	0.80
Málaga	3648	11.63	5.14	26.12	0.69	3.66	0.86
Valencia	3612	11.84	5.75	17.38	0.63	4.42	0.85
Barcelona	3630	10.88	5.14	20.04	0.71	3.15	0.89
Tenerife	3610	9.20	4.24	17.08	0.64	3.35	0.77
Las Palmas	3392	6.73	3.70	11.60	0.65	2.34	0.83

Validation of the system

The Nivmar system was validated with data from the REDMAR tide gauge network. A very stormy period was chosen for validation (November 1995 to March 1996), which is the PROMISE Spanish Coast Data Set Period.

The mean value of the simulated series was modified to the value of the measured one. These techniques are usually employed in hindcast studies of surge simulations (6). Table 1 shows a statistical comparison between simulated and measured series in different stations of the REDMAR. Validation of the system for other harbours in the Mediterranean sea was proposed within MedGLOSS project and is under development.

Near real time verification

When predicting the sea level a problem is found to relate the "datum" of the measured series and the one of the simulated series at a particular station. The technique employed consists of matching the means of the last measured data at the tide gauge and the mean of the prediction (7). In this way the information provided by the tide gauge for the recent past is used to improve the quality of the predictions, by incorporating the long-term variability not reproduced by the model.

The use of the Nivmar system is particularly important in our Mediterranean coast, due to the nearly negligible amplitude of the tide. For the three stations located in this sea (Málaga, Valencia and Barcelona), this simple scheme of assimilation is already working. In Figure 1 an example of the near real time verification performed twice a day is shown for Barcelona harbour.

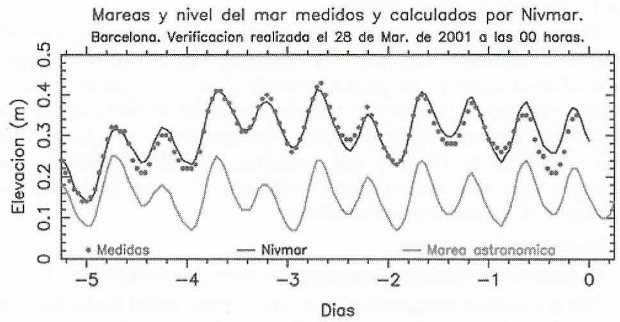

Figure 1: Example of the operation of the system in Barcelona.

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