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Continuous monitoring of directional wave spectra and meteo-marine data aimed at the modeling of coastal erosion in the north eastern Adriatic Sea

R. CODIGLIA, D. VIEZZOLI, F. MORO, T. DI GAETANO, F. BRUNETTI, N. MEDEOT and G. FALLETI

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, OGS, Sgonico, Italy

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Abstract - The aim of this paper is to give an example of the application of the continuous monitoring of environmental data and numerical modeling in resolving the specific problem of coastal erosion. The example is part of a project in progress aimed at monitoring the coastline of the Lignano and Bibione beaches. Although these areas in the northern Adriatic Sea are not protected areas, they constitute the major natural resource of the local communities, and as such there is strong economic, social and political pressure to conserve them. Since 2001, a continuous monitoring of wave motion (DWR buoy) and of meteo-marine variables (MAMBO buoy) has been carried out in the Gulf of Trieste, to the south of the two beaches. This allows the application of a numerical model to obtain necessary information for the study of coastal erosion in the area. The evaluation of sediment transport using morphological data to compare several possible solutions aimed at reducing the phenomenon is currently being attempted. In this paper, some examples are given on the tidal numerical simulation in the Trieste Gulf, validated with the measured data and on the modeling of wave propagation in the same area. Since both, monitoring and the implementation of the models are in progress, the paper shows preliminary results.

1. Introduction

The continuous monitoring of meteo-marine data is an important activity in environmental studies, particularly when numerical models that forecast important environmental variables need to be calibrated and validated. In fact, whenever some environmental problem is tackled by means of numerical modeling, two fundamental steps are involved: data acquisition and

Corresponding author: R. Codiglia, Istituto Nazionale di Oceanografia Sperimentale, OGS, Borgo Grotta Gigante 42/c, 34010 Sgonico, Trieste, Italy; phone: +39 0402140206, fax: +39 0402140266; e-mail: rcodiglia@ ogs.trieste.it

model development. These two steps are strongly linked in that the continuous monitoring of significant parameters specific to the problem at hand is necessary to provide data for model input and to verify the results.

In the particular case of coastal erosion, several variables need to be continuously monitored: water currents, sea level, wave motion and meteorological parameters, in addition to bathymetric and morphological surveys. This monitoring is necessary to develop the numerical model that can predict the circulation, the wave propagation and the solid transport responsible for the coast line evolution. In this article, the results of a model that is related to these measurements in the northern Adriatic Sea (eastern Mediterranean) is described. The goal is to predict the evolution of the portions of the coastline comprising the Lignano and Bibione beaches on both, short - and long - time scales, and to provide simulations in the case of particularly intense weather events.

2. Real-time data acquisition

2.1. Wave motion

The wave motion in the area is monitored by a Datawell Directional Waverider (DWR) buoy. The DWR buoy is moored about 8 nautical miles south-west off Grado (Fig. 1), and it measures and transmits wave data and the directional wave spectrum every hour. The buoy is equipped with a tri-axial flux-gate compass and three accelerometers. It is supplied with

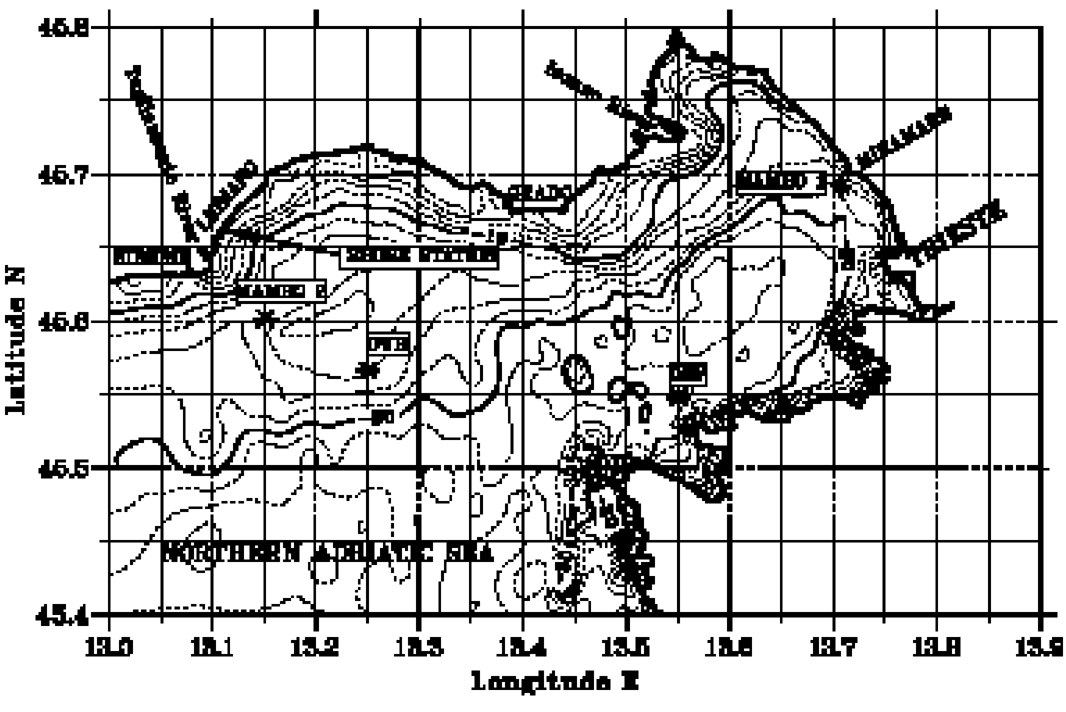

Fig. 1 - Location of the instruments.

on-board data analysis software (Datawell, 2001). The method of analysis for the waves is a classic zero-up crossing in the time domain and moment evaluation in the frequency domain. A significant parameter of interest is the spectral peak value which indicates the sea state and the characteristics of the wave motion field over a reasonably long period of time.

2.2. Meteorological and marine data

Two other buoys, MAMBO1 and MAMBO2, measure meteorological variables (wind speed and direction, and air temperature) and provide profiles of salinity and temperature at regular intervals. MAMBO1 is moored close to the marine reserve of Miramare (Trieste), while the MAMBO2 is moored about 3 nautical miles from the Tagliamento River mouth (Fig. 1). The latter is a strategic position from the perspective of the planned activity. Both the buoys are able to transfer data in real-time through the GSM system.

2.3. Near-shore measurements

Near-shore pressure and current measurements are acquired close to the structure nominated Pagoda, about 300 m from the Lignano beach. The pressure measurements in this case are required to obtain information regarding the near-shore wave motion. These measurements are necessary to the calibration and validation of the numerical models close to the coast.

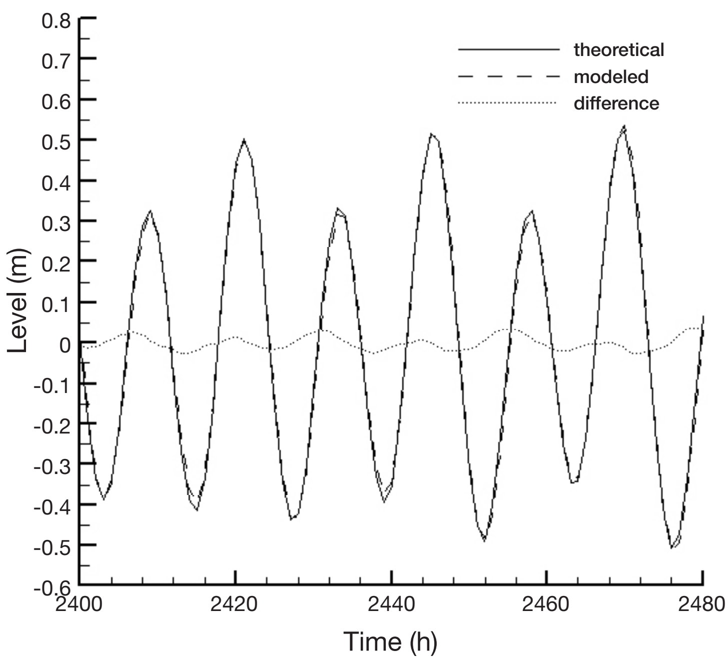

Fig. 2 - Tide simulation in Trieste.

3. Preliminary results and discussion

The development of the numerical model is currently in progress. It was decided to use three known and tested models, adapting them to the specific situation. First, an appropriate computational grid was chosen. Then, the bathymetric survey was fitted to this grid, and the astronomical tide together with the consequent tidal circulation was simulated over the entire Adriatic basin by the Princeton Ocean Model (POM). This model is a sigma-coordinate, free-surface, primitive equation ocean model which includes a turbulence sub-model. It was developed in the late 1970's by Blumberg (1983) and Mellor (1998), with subsequent contributions from others. The model has already been used for modeling estuaries and coastal areas. In the present application, a stretched computational grid that extends over the Adriatic Sea has been used. In this way, a good resolution of about 800-1000 m was obtained close to the area of interest. The open boundary condition (sea level and velocity) has been imposed from outside the Adriatic basin with a grid step of about 12-13 km.

A preliminary test of POM was performed to obtain the seiches in the Adriatic Sea, and the results were compared with historical data (Manca et al., 1974). This comparison has evidenced a very good agreement between simulated and observed seiches for the entire Adriatic Sea validating the correct choice for the bathymetric data set, the grid type and the bottom friction

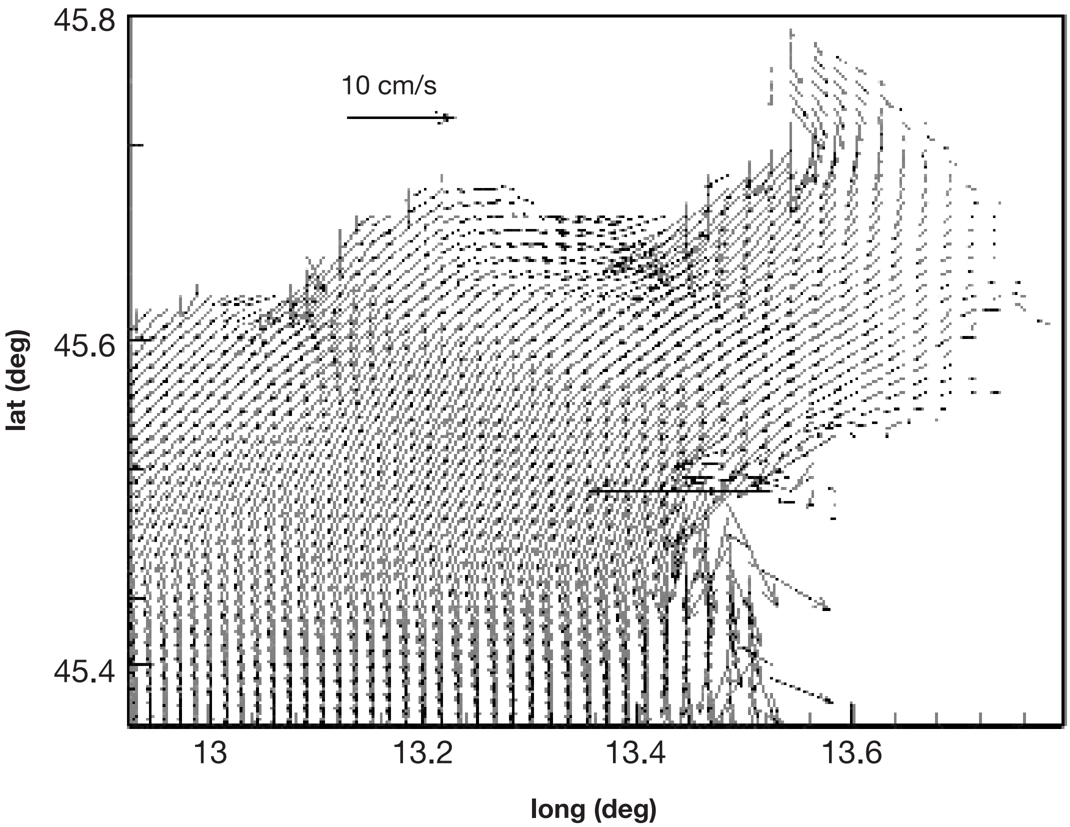

Fig. 3 - Computed tidal circulation.

parameterization. Successively, a number of simulations were performed to tune both, separately and jointly to the seven major tidal constituents. For the tidal forcing at the open boundary, initial values from Tsimplis et al. (1995) were applied, and then they were subsequently adjusted.

The final results – although unreliable close to the open boundary – were acceptable for the middle and north Adriatic when compared to the measured data: the difference was always less than 5% for the sea elevation. Fig. 2 shows an example of the simulated tidal elevation with respect to the predicted sea-surface elevation at Trieste (Stravisi, 1983). Fig. 3 shows a snapshot of the tidal circulation that was obtained for the gulf and its surroundings.

The SWAN model (Booij et al., 1999; Ris et al., 1999) was chosen to simulate the propagation, toward the coast, of the energy action, using the wave data measured by the DWR buoy. The model is able to take into account the dissipative-refractive mechanisms due to the interaction with the bottom, the refracting current field and the dissipative-generative effects due to the local wind. In this way it is able to compute the characteristic wave parameters near shore, the bottom velocity and the radiation stress responsible of the along shore current and the sand transport.

A significant accuracy in the results is expected due to the high quality of the supplied bathymetry. An example of a test case for an hypothetical south-west wind is shown in Fig. 4, where maps of period and of significant wave height are plotted.

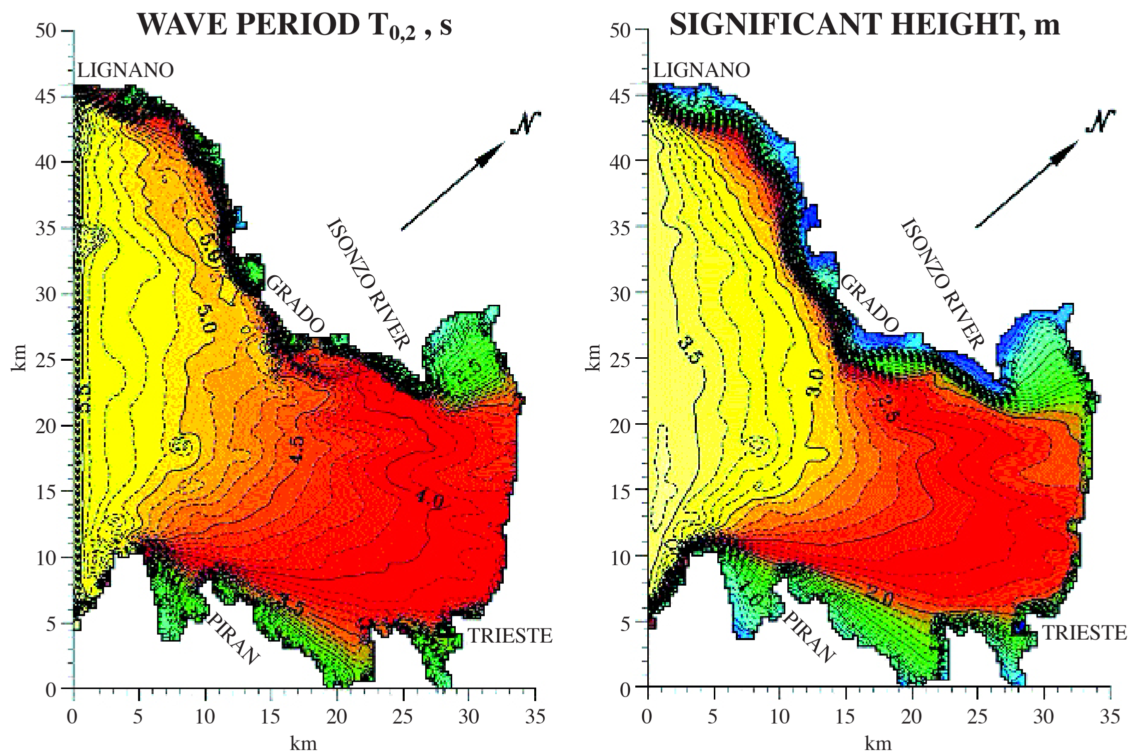

Fig. 4 - Wave propagation computed by SWAN.

Finally, the results obtained from the models must be considered as preliminary. In fact, many factors influence the wave propagation in the area: Viezzoli and Cavalieri (1996) showed the refracting action of the current induced by the ENE wind (Bora) on the waves coming from SE (Scirocco).

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