EXTREME OCEANIC EVENTS IN THE LAGOON OF VENICE SIMULATED BY AN ATMOSPHERIC/OCEANIC MODEL

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Abstract
A very high resolution oceanic model forced by a regional atmospheric model is used to investigate, under realistic conditions, storm surges observed in the Lagoon of Venice and scenarios of sea level variations related to local manifestations of larger scale climatic changes.
Keywords : Adriatic Sea, Lagoons, Tides, Circulation Models, Atmospheric Input.

The hydrodynamics induced by tidal, wind and atmospheric pressure forcing, in an oceanic region including the Adriatic sea as well as the lagoon of Venice, was investigated using an oceanic and an atmospheric numerical model (Figure 1). The adopted approach is required in order to realistically model those storm surge events in the Adriatic sea that, leading to high water levels in the lagoon of Venice, pose a threat to the city of Venice ("acqua alta"). In fact, these events are due to the simultaneous occurrence of large astronomical tides, seiches, and strong atmospheric pressure gradient in the region [1].

The atmospheric model (BOLAM) is a hydrostatic regional model based on the primitive equations, which are solved on a regular horizontal grid on 42 vertical sigma levels. The main forcing is provided by the ECMWF TL511 model and the simulations are performed with two different discretizations, namely 20 km and 5 km grid step. In particular, the simulations performed with the higher resolution permit an accurate description of topographically generated wind intensifications, including Bora wind events, which are known to exert a noticeable influence on the dynamics of the northern Adriatic basin [2].

The oceanic model is based on curvilinear, boundary fitted coordinates and, due to a technique for the treatment of numerical movable boundaries, allows one to simulate the coastal flooding and dry up with great accuracy [3], as it provides a complete solution of the elliptic equations for elevation in a morphologically complex domain. Since the curvilinear discretization permits to vary the mesh size to focus on specific hydrodynamic features, the grid resolution was increased in the northern area and in the lagoon of Venice (maximum grid resolution O(50m)), in order to achieve a satisfactory description of small scale circulation features. The hydrodynamical model was first optimized for the prediction of the astronomical tides in a homogeneously spaced set of gauges.

The model results were compared with a dataset made by measurement of the Italian APAT network and with literature data [4, 5]. The results are in excellent agreement with the data, the error in prediction being of the same order of state of the art models for the area [4, 6]. Different numerical experiments were carried out in order to test the sensitivity of the hydrodynamic model to the input provided by the atmospheric one. In particular, the effect of different horizontal resolution of the meteorological model and the frequency at which the meteorological forcing is updated in the oceanic model was investigated. The oceanic-atmospheric model was then applied to the simulation of a series of exceptionally high tides observed between November 25, 2005, and December 10, 2005 in the lagoon of Venice. This period was characterized by the, almost daily, occurrence of surges with maximum elevations higher than 80 cm, which is considered the alert threshold for "acqua alta". Observed phenomena induced by Bora winds inside the lagoon and in the outer coastal area were captured. In particular, the strong horizontal gradient of the water level inside the lagoon caused by the Bora wind was correctly reproduced as well as the maximum difference in the sea surface elevation between two locations on the main axis. Moreover, the model correctly reproduced the current intensification and the evolution of the sea surface level along the coast of the north Adriatic sea induced by the Bora.

Based on the above findings, the modeling approach was used for investigating the consequences of larger scale climatic changes on sea level variation. This analysis was carried out by forcing the model with atmospheric forcing intensification according to scenarios proposed by the IPCC.

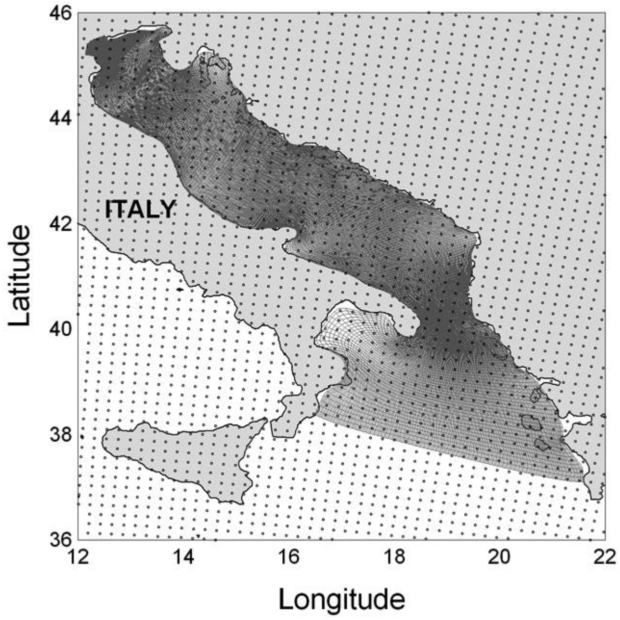

Fig. 1. Hydrodynamic (gridded plot) and atmospheric (circle plot) model domains.

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