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2D NUMERICAL SIMULATION OF THE TIDAL FLOW IN THE STRAIT OF GIBRALTAR

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Abstract:

The objective of this study is to simulate the tidal circulation in the Gibraltar Strait. Simulations of the tidal currents of this zone use the 2D version of the MECCA (Model for Estuarine and Coastal Circulation Assessment) model. These simulations are based on the depth-integrated dynamical equations of turbulent motion, and scaled for the geographical features of the Strait of Gibraltar. Equations are solved by using the implicit finite-differences techniques. The model incorporates the actual bottom topography and the effects of the Earth rotation. As forcing mechanism, the model uses the tidal heights prescribed along the open boundaries (Atlantic ocean and Alborian sea).
As first results, numerical experiments show that the model provides good results compared to the data available in the literature, in terms of the horizontal circulation and the oscillations of the sea surface with time.

Keywords: Tidal, Finite-Differences, Hydrodynamics, Gibraltar, Strait

Contents

1 Introduction

Straits and passages of the Mediterranean sea play an important role in controlling circulation though mass transport exchanges. The Mediterranean sea is a thermodynamic system which transforms the incoming Atlantic water into denser water masses through processes dependent on interaction with the atmosphere. The difference of density between the Mediterranean sea and the Atlantic ocean drives the mean mass transport through the Strait of Gibraltar. This transport contributes to the forcing of the cyclonic circulation of modified Atlantic water in both the Western and Eastern Mediterranean seas.

Various processes, at different timescales modify the mean flow through the Strait of Gibraltar. The mean flow shows seasonal and inter-annual variability, weekly modifications driven by the wind and by the atmospheric pressure differences between the Atlantic ocean and Mediterranean sea, semidiurnal variations due to strong tides and finally, on very short timescales, modifications due to the internal bores (internal wave reaching amplitudes of up 150 m).

The tidal forcing in the strait has been extensively studied and analyzed in past. On the basis data collected during the Gibraltar Experiment during $1985-1986$, [1] described the structure of barotropic M_2 tide and of the tidal transport through the strait, respectively, Bruno et al. [2], have described the vertical structure of the semidiurnal tidal current at the Camarinal Sill, while Wang [3], used a numerical model to study the tidal flow, internal tide as well as fortnightly modulation.

The purpose of this paper is to implement a $2D$ version the MECCA model applied to the Strait of Gibraltar. The objective of this modeling is to tempt to produce the major features of the tidal flow in this area. Note that this study is the first one of our laboratory concerning the circulation modeling of Strait of Gibraltar.

2 Physical oceanography of the Gibraltar Strait

2.1 General circulation

Hydrodynamics in the Strait of Gibraltar are driven by water masses characterized by their Mediterranean and Atlantic origin, which results in a complex circulation system. Due to evaporation losses in the Mediterranean sea (1cm/year) there is a continuous inflow of the surface water from the Atlantic ocean to the Mediterranean sea. After passing through the Strait of Gibraltar and mainly due to evaporation phenomena, water becomes more saline and denser. This baroclinic subinertial component, driven by internal pressure gradient is hydraulically controlled at the strait and which results in forces Eastward and Westward respectively driving the water masses [4]. Barotropic flows driven by astronomic tides [5] and by local wind and atmospheric pressure fluctuations contribute to the variability of this exchange [6] (due to the high correlation between the Mediterranean and Atlantic waters).
Because of the complexity of the northern coastline and the presence of numerous island, many small eddies and other local current form an essential part of the general circulation in the Strait of Gibraltar.