ON THE EFFECT OF WIND AND TIDES ON THE HYDRODYNAMICS OF THE TUNISIAN CONTINENTAL SHELF

Imene Ben Jaber [1], Jihene Abdennadher [2]* and Moncef Boukthir [3]
[1] IPEIT, University of Tunis
[2] UR11ES88, IPEIT, University of Tunis - jihene.abdennadher@ipeit.rnu.tn
[3] UR11ES88, IPEIT, University of Tunis

Abstract

The combined effect of tides and wind on the hydrodynamics of the Tunisian continental shelf is investigated by using a two-dimensional configuration of ROMS Model. The induced circulation is characterized by a strong current flowing the eastern Tunisian coast and by an anticyclonic structure in the gulf of Gabes. Meteorologically currents first follow the Tunisian coast and are detached to flow between 100 and 200m isobaths and from 13°E, they flow as a strong coastal current. Autumn and summer are mainly characterized by low eddy activity related primarily to the wind.

Keywords: Circulation, Wind, Tides, Tunisian Plateau, Adventure Bank

1. Introduction

Numerical models allow isolation of the tidal forcing influence on the generation of specific features associated to the water exchange between the gulfs of Gabes and Hammamet and the open sea. Previous investigations [1-3] demonstrate that eddies generated in tidal flows are transient and their spatial structure may vary considerably through the tidal cycle. In this work, we will study the combined effect of tides and wind on the hydrodynamics of the Tunisian continental shelf and we will quantify the contribution of each forcing in the circulation. In order to achieve these goals, a 2D, finite-difference hydrodynamic numerical model was applied to the eastern Tunisian coast. However we assume that the sea is homogeneous, which is physically realistic over most of the shelf during the winter periods but not during the summer months where regions of the shelf are stratified.

2. Modelling approach

We used the barotropic version of the Regional Ocean Modelling System (ROMS). It solves the primitive equations in an earth centred rotating environment, based on the Boussinesq approximation and hydrostatic vertical momentum balance. ROMS uses stretched, terrain-following coordinates in the vertical and orthogonal curvilinear coordinates in the horizontal. ROMS is a split-explicit, free-surface oceanic model, where short time steps are used to advance the surface elevation and barotropic momentum equations [4]. The horizontal grid selected for this study consists of 241×193 grid elements with a spacing of 1/32° in both longitudinal and latitudinal directions, which corresponds to 2,7 km in the latitude and 2,7–2,8 km in the longitude. The model bathymetry is deduced from Smith and Sandwell topography database [5] by a bilinear interpolation of the depth data onto the model grid. Annual and seasonal wind stress data based on satellite observations (**QUIKSCAT**) are used to calculate the meteorologically induced circulation on the shelf. Tidal forcing was implemented by setting the elevations of the major constituents in the region, M_2, S_2, N_2, K_1 and O_1 [6] along the four open boundaries, with the coefficients taken from a two-dimensional gravity-waves model of the Mediterranean [7].

3. Results

In order to determine the meteorologically induced circulation on the shelf, five separate simulations were performed, one for each season, and one using annual meteorological input. In each simulation, the model was run from a state of rest to a steady state with the appropriate meteorological forcing, and with the most important tidal components in the region along its open boundaries. The pure tidal simulation was also performed, from a state of rest for an identical period of time. The meteorologically induced circulation on the shelf was computed for the five simulations by removing the tidal signal. The basic data used in the calibration/validation of the model results comes mainly from the tide gauge measurements. The model results agreed well with existing tidal elevation and phase observations for all simulated constituents. Indeed, the rms amplitude error does not exceed 2 cm and the rms discrepancy of phase-lag is about 17.5°. The combined action of tides and wind does not significantly enhance the quality of the simulated tidal characteristics. Currents flow southward along the Tunisian coast and become more intense, mainly in the Gulf of Gabes which is filled by the east and west. The maximum current occurs during the winter period, and the minimum in summer, a period of weak wind. The wind has a fairly limited impact on the direction of the currents in the Gulf of Gabes. However, the direction of the currents in the Adventure Bank and Malta plateau changes from season to season due to the change of wind direction. The Gulf of Gabes, the Adventure Bank and the Malta plateau are the only zones with relatively strong currents. Residual (meteorologically) currents directly flow the Tunisian coast between 100 and 200m isobaths, becoming stronger southward and reach the Libyan coast where they are intensified. The eddy activity generated during summer and fall is mainly induced by wind. The circulation in the Gulf of Gabes is relatively weak throughout the year with an anticyclonic circulation in winter and autumn, while the Sfax-Kerkennah channel is subject to strong currents along the coast except in summer. The only areas of strong interaction between wind and tide are the Gulf of Gabes and the Adventure BanK.

References

1 - Imasato, N., 1983. What is tide-induced residual current? Journal of Physical Oceanography, 13, 1307–1317.
2 - Geyer, W.R., Signell, R.P., 1990. Measurements of tidal flow around ahead-land with a ship board acoustic Doppler current profiler, Journal of Geophysical Research 95, 3189–3197.
3 - Geyer, W.R., Signell, R.P., 1992. A reassessment of tidal dispersion. Estuaries, 15(2), 97–108.
4 - Shchepetkin, A., McWilliams, J., The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model. Ocean Model. 9, 347–404, 2005.
5 - Smith, W.H.F., and Sandwell, D.T., 1997: Global sea floor topography from satellite altimetry and ship depth soundings, Sciences, 277, 1956-1962.
6 - Carrère, L. and Lyard, F., 2003: Modeling the barotropic response of the global ocean to atmospheric wind and pressure forcing-comparisons with observations: Geophys. Let., Vol.30,NO.6,1275.
7 - Abdennadher, J., and Boukthir, M, 2006, "Numerical simulation of the barotropic tides in the Tunisian shelf and the Strait of Sicily", *J. Mar. Syst.*, 63, pp. 162-182.