BAROTROPIC TIDAL MODEL FOR THE BOMBAY HIGH, GULF
OF KHAMBHAT AND SURROUNDING AREAS

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ABSTRACT

A barotropic model is developed for the shelf region off the central west coast of India, which includes the regions of Bombay High and Gulf of Khambhat, in order to simulate tides and tidal currents in the region. The model is forced by a composite tide along its open boundary, which runs approximately parallel to the 200 m isobath, based on the results from global tidal models. Results of a month long simulation are analysed harmonically to separate the major constituents, namely, \( M_2, S_2, K_1 \) and \( O_1 \). A comparison of the computed amplitudes and phases with the observations (International Hydrographic Bureau, Monaco) show a fairly good agreement. A comparison of modelled currents with those observed at a few selected stations also indicate that the model reproduces the observed currents well. Our aim is to make use of the model to simulate the tidal constituents of the present paper is to make use of the model to simulate the tidal constituents, to describe the tidal circulation in the region and to examine to what extent the observed currents are tidally influenced in this region.

1. Introduction

The model domain (Fig.1) is the continental shelf region between north of Veraval in the northern side and Ratnagiri in the southern side respectively. This region, which includes the Bombay High and the Gulf of Khambhat, is of interest from a few considerations. The Gulf experiences tidal amplitudes that are amongst the largest observed on the west coast. The metropolitan city of Mumbai, which is located in the southeastern part of the region, discharges considerable amounts of industrial effluents and domestic sewage. India’s largest oilfield, the Bombay High, is located at the centre of the region. Fig.1 indicates that shelf width is maximum off the Gulf region. In this region, the knowledge of currents and their seasonal variability are lacking. The region being a shallow water region, the tides and local winds could play an important role in determining the circulation. Fernandes et al. (1993) found that currents in the Bombay High region are nearly barotropic, based on the current measurements made in December, 1981. Shetye et al. (1991) reported a poleward flowing surface current during winter along the west coast of India using hydrographic data.
In the present study, we make use of a numerical model, to investigate the role of tides in determining the circulation in the region. The model is barotropic and driven by tides. Though other processes such as local winds and effects of large-scale circulation could be important in determining the dynamics of the region, our first attempt is in examining the role of tides in the circulation of the region.

2. Model

The model used was recently developed in the institute for the simulation of tides. Only a brief description is given below and the details will be elaborated in subsequent papers. The model uses

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Fig. 1: Model domain
vertically integrated equations of momentum and continuity in cartesian co-ordinates. In the numerical solution, a finite difference Arakawa-C grid is employed with a leap-frog technique in time. In the application to the central west coast of India, the model domain is approximately parallel to the coast, with the 200 m isobath forming its open boundary. The northern and southern limits lie approximately north of Veraval and Ratnagiri respectively. The grid resolution is about 6.37 km, and the time step used is 36 sec.

Dahanu
(24-02-'96 to 29-02-'96)

Bombay High
(21-12-'81 to 29-12-'81)

Fig. 2: Comparison of computed currents with observed. (A) cross-shore velocities off Dahanu (B), (C) cross shore velocities at Bombay High, (D) alongshore Off Bombay.

alongshore velocities off Dahanu (C) cross-shore velocities at Bombay High (D) alongshore velocities at Bombay High

The model was forced with a composite tide, based on the prediction from the global tidal models (Le Provost et al., 1995), which make use of the altimeter data. The model was initially run for a period of 4 days for attaining spin-up. For the present runs, no winds were prescribed. The results of a month long
simulation were harmonically analysed for determining the amplitudes and phases of the major constituents, namely, $M_2$, $S_2$, $K_1$ and $O_1$. The results are compared with the available information on tidal constituents (International Hydrographic Review, Monaco and Vol.2, Admiralty Tide Tables) at about 33 stations in the region of the model domain.

Some currentmeter observations are available at Bombay High, which is at depth of about 80 m and off Dahanu, at a depth of 17 m. Separate model runs were made for the period, when these current observations are available and comparisons were made. (Fig.2)

3. Discussion

The model reproduces the amplitudes and phases of the major constituents fairly accurately within 5 cm in amplitudes and 10 degrees in phases on an average. However, in the case of a couple of stations inside the Gulf of Kambhat, such as Bhavnagar, the computed amplitudes show underestimates. This is due to the fact that, the Bhavnagar station lies inside a creek in the Gulf and tides become extremely high due to the geometric amplification inside the creek. In the present model, it was not possible to represent the creek because of the grid size limitations. In all other stations, the agreement was good.

A comparison of model results with observed currents at Bombay High and off Dahanu shows a good agreement. In the former, which is a shallow station, both the cross-shore and alongshore velocities show a good agreement with the observed, while in the latter, which is at about 80 m, even though cross-shore velocities are found to have a good agreement, the agreement is less conspicuous in alongshore velocities. This could be due to the fact that alongshore velocities are affected by winds, large-scale coastal currents etc. than tides alone.

In general, the results indicate strong influence of tides on the currents. However, these comparisons were made for the winter season. The data base on the observed currents in this region is poor in the other seasons.

In this part of the continental shelf, the tides get maximum amplification in the central region, approximately off Mumbai and the Gulf, due to the large shelf widths in this region. It is noteworthy that the amplification is maximum for the semi-diurnal tides than for the diurnal tides. A further study is needed to look into the causes of it.

REFERENCES

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