THERMOHALINE OCEAN CIRCULATION IN MAKRAN COASTS-IRAN
by

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ABSTRACT

Ocean currents are generated by earth's rotation and gravity, winds, ocean floor topography and density differences in water masses caused by salinity and temperature variations. These currents move through the ocean and control the oceanic climate. Currents in Makran region are affected by Arabian Sea and Indian Ocean.
In this paper, the pattern of ocean currents in the Makran beaches is studied. Therefore, in the first step, the tidal flow has been studied in the study area. The results show that tidal creeks do not play a significant role in the flow of the region. Therefore, in the next step, the effects of wind and salinity and heat are added to the model. The results show that most of the currents in the area are affected by local winds. However, adding the effects of salinity and heat and formation of thermohaline currents can improve the pattern of currents in the area.

1. INTRODUCTION

After the tidal current created by gravitational force of the Sun and the Moon, the second most dominant reason for surface ocean currents is circulation of the air in the closest layers of the atmosphere to the Earth (wind).
Currents in Gulf of Oman are affected by Arabian Sea and Indian Ocean. Reviewing available literature indicates that due to 120-day-duration monsoon and tropical storms in the Arabian Sea and Indian Ocean, surface ocean currents are extremely affected by winds [1].
Also the results of the studies, showed that the Ekman drift driven by the monsoon winds overwhelms the geostrophic flow at the surface in the western Arabian Sea and during the summer season, Ekman drift dominates over most of the Arabian Sea. During the winter monsoon, geostrophic dominates, and Ekman drifts modulates the geostrophic current [2,3,4].
According to literature reviews and considering significance of ocean currents in Makran Coasts of Iran, in this study a comprehensive 3D numerical modeling for evaluation of ocean surface currents and thermohaline circulations is accomplished. In order to gain appropriate perception of different effective phenomenon, first of all, tidal currents are modelled and after that wind and salinity concepts and values are added to the model.

2. STUDY AREA

The presented modeling covers parts of the Arabian Sea, Gulf of Oman and Makran coasts located in furthermost south-east of Iran (Fig. 1). Currents measurements are also conducted in south-east part of Iranian Coasts along the Makran coast. Deployment (layout) of current meters is based on the segment of not only covering all the study area but also help studying the characteristics of the currents in the region of interest. Measuring stations are distributed in east from Guatr Bay (at the boundaries of Iran and Pakistan) to Meydani Estuary in the west of the monitored region (Fig. 2). Based on the available measurement data, simulations are carried out for 2015/04/01 to 2015/09/15 time interval.

3. HYDRODYNAMIC MODEL SET-UP

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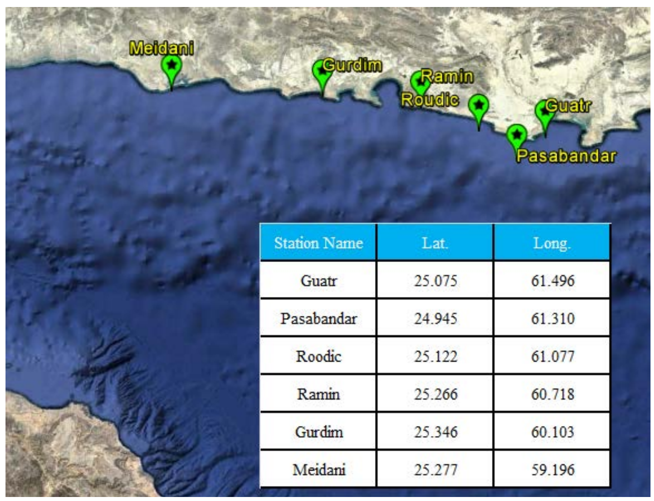
A 3D modelling of currents, based on solving four fundamental equations of Momentum, Continuity, Salinity and temperature has been performed. Irrotational vortices both in surface and depth are also accounted in simulations. The model bathymetry and mesh is shown in Fig. 3.

Figure 1: Study area



Station Name	Lat.	Long.
Guatr	25.075	61.496
Pasabandar	24.945	61.310
Roodic	25.122	61.077
Ramin	25.266	60.718
Gurdim	25.346	60.103
Meidani	25.277	59.196

Figure 2: Measurement stations

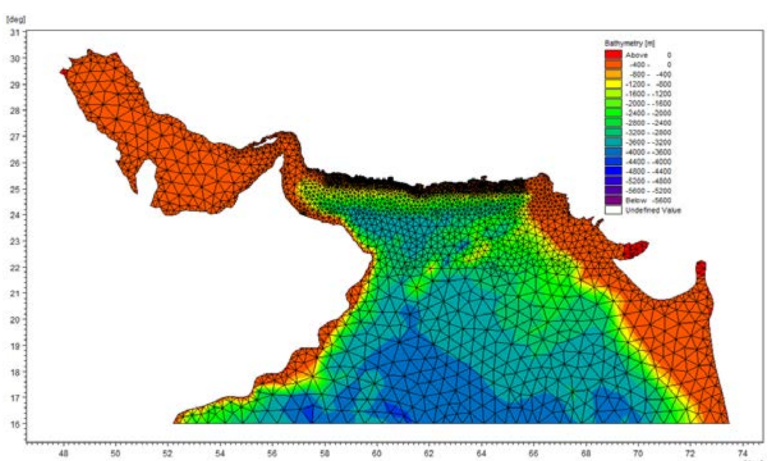


Figure 3: Hydrodynamic model mesh and bathymetry

3.1 Model inputs

Initial and boundary conditions are chosen in a manner to ensure the highest possible spatial and temporal resolution. Water level and current speed boundary conditions are respectively extracted from OTPS Global Model and HYCOM Global Model 2D in depth. 3D time-series data of salinity and temperature are also provided from HYCOM. Atmospheric parameters required for current modeling are adapted from wind models previously executed in WRF for the study area. Being benefited from the available measurement data, model was optimized and calibrated.

4. TIDAL MODELING

At the first, a tidal current modeling was carried out by excluding impressions of other parameters due to the significance of astronomical tide and its unique feature.

4.1 Model Calibration

The tidal model was calibrated using tidal current and water level data obtained from the AWAC and RBR instruments which were deployed in measurement stations. The model was run originally without wind and other forcing for over a one month period and the simulated current and tidal levels compared with the measured data. Figure 4 illustrates that the surface elevation and tidal current compares well, however the value simulated tidally generated currents were very different from the recorded currents. Therefore, It can be concluded the ocean currents in the study area is not affected by tidal current.

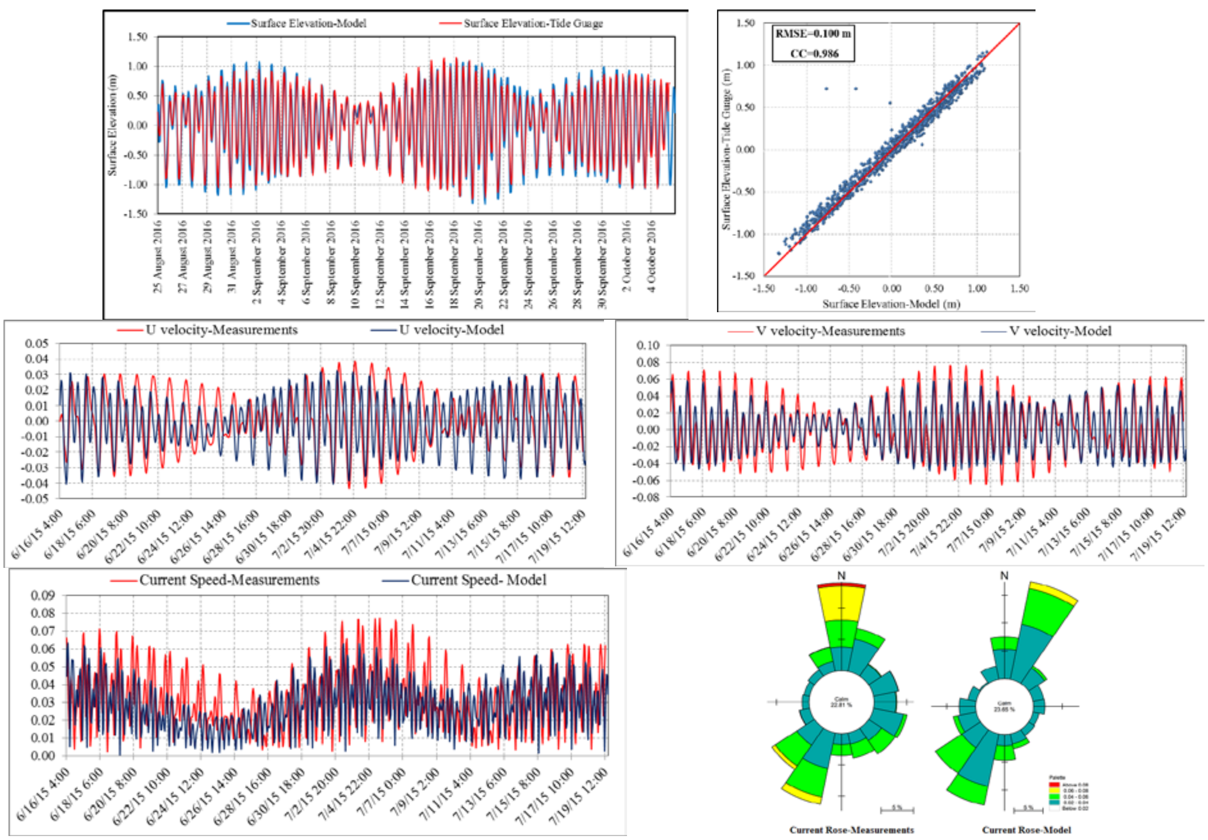


Figure 4: Comparison of predicted and observed surface elevation and tidal current speed at Roudic station

5. OCEAN CIRCULATION MODELING

In the next step, wind and salinity-temperature forces were added to the tidal model, respectively. Taking this approach, improved compatibility the ocean current results of numerical simulation and measurements.

5.1 Model Calibration

In order to provide confidence in the ocean current model results a comparison between model results and measured data in the study area has been undertaken. In this case the calibration was carried out by comparing model results against current measurements (Fig. 5-Fig. 6). The results show that the model is able to accurately predict the ocean current conditions in the area.

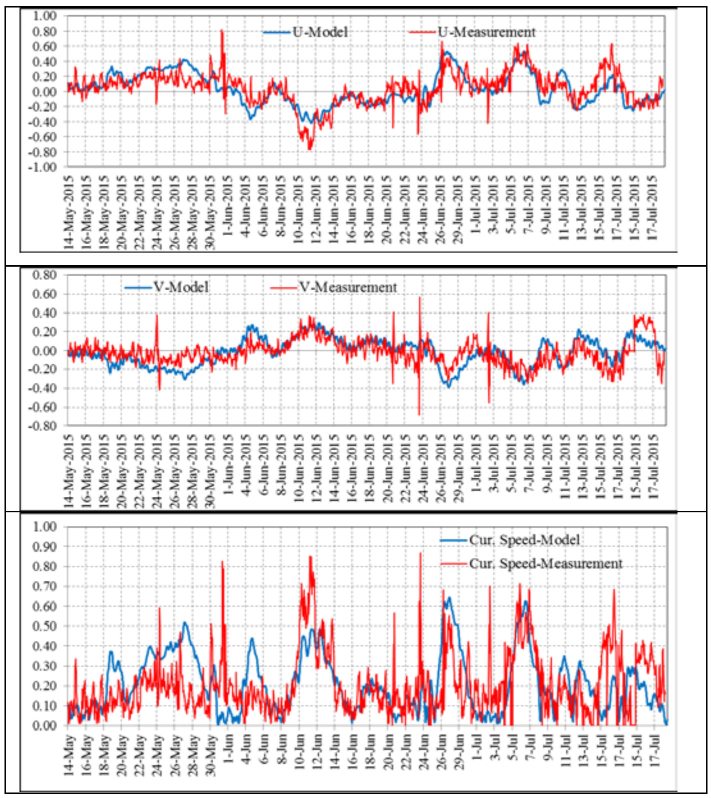


Figure 5: Comparison of predicted and observed ocean current speed at Roudic station

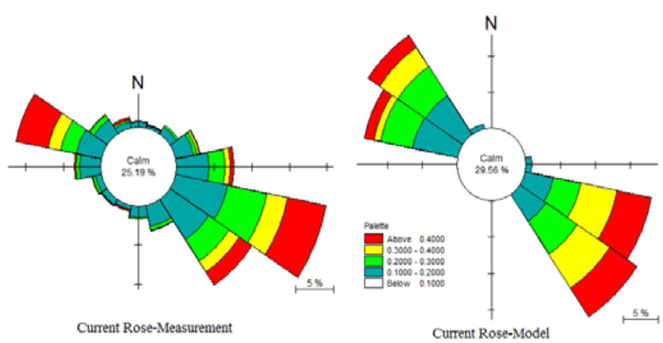
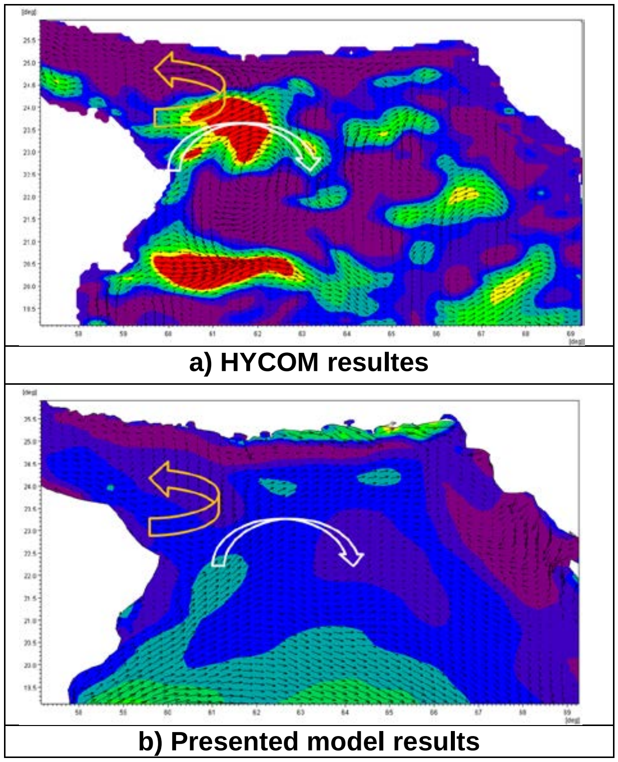


Figure 6: Comparison of predicted and observed current rose at Roudic station

6. Results

For example in Figure 7 is presented a general comparison of the results of the ocean circulation modeling and the HYCOM global model.



a) HYCOM resultes

b) Presented model results

Figure 7: A general Comparison of HYCOM results and presented model

7. Conclusion

Modeling tidal currents and wind currents shows that major currents of the region coincides with wind driven currents; but in this condition, cross-shore current speeds are not estimated precisely. Taking into account the properties of salinity and temperature points out that cross-shore current speeds are mostly influenced by these two features. With more precise cross-shore constituents resulted from models, the effect of thermohaline circulations are displayed. The intensity of this phenomenon is in direct proportion with wind speed strength in the study region. Approaching the Strait of Hormoz, the saline water exiting Persian Gulf causes a thermohaline gyre in high depths close to Arabian Sea. These thermohaline circulations show great impacts on the overall currents of the study region.

8. REFERENCES

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