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ARTICLE

TIDAL CURRENTS MODEL OF PERSIAN GULF

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ABSTRACT

One of the elementary and effective aspects associated to the formation of hydrodynamic conditions and characteristics of coastal regions is the tide. Tide is the basic and most compulsory information in order to study on sedimentation, erosion and morphological changes in beaches, coastal flooding, and is moreover very obliging for shoreline management. In this article, it is tried to practice on MIKE21-HD-FM as a mathematical model to predict tide in Persian Gulf coast areas. Forecasting the tidal currents will be conceivable by utilizing the hydrographic information of seabed, tidal specifications of the stations and measured water level in tidal stations. The results presented that the model has been well simulated the documented pattern of fluctuations in water level in both Bahman port and Salakh port stations. It is revealed that there are no significant differences in model results based on diverse coefficients bed resistance. After ensuring the calibration of tidal model in Persian Gulf, the tidal fluctuations records were introduced in calibration model in 2011 in Jask in order to produce the relevant information. The results exposed that the output of the model is a respectable match with the measured values.

KEY WORDS
Tide, MIKE21, Persian Gulf

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INTRODUCTION

The tide is one of the main factors influencing in formation of situations and characteristics of hydrodynamic coastal areas. In this paper, the water level fluctuations and the tide flow patterns in the Persian Gulf were investigated. The results of these studies will assist us in sedimentation, erosion, coastal morphological changes, coastal flooding studies and shoreline management. It should be mentioned that the main tool in order to achieve this model is the mathematical modeling of tidal wave and by expending these models, the ability to calculate and determine the pattern of flow rate and water level changes caused by tides will be provided. Thus, in the first step, the main work and its procedures were described and then in the second step, the establishment of simulation model was presented and finally, the evaluation results were discussed. Ershadi et al. [3] focused on field data in their studies that included changes in water level, speed and direction of currents, hydrography, boundaries and software MIKE21, tried to simulate tidal currents in Tiab lake in 2013. In their study, it was clear that by analyzing the tidal flow simulation in the lake it was clear that they got a great model and good results by comparing between the output of the mentioned model and the field data. Chen et al. [1] tried to utilize three-dimensional model called semi-implicit Eulerian–Lagrangian finite-element in order to model the water levels and tidal flow in the Taiwan Strait in 2013,and it should be mentioned that according to this model, they determined potential sites on the way to use tidal currents' energy. The cited model used nine tidal elements (M2, S2, N2, K2, K1, O1, P1, Q1 and M4) to be conducted in open borders. The results revealed that this model is competent to predict the tidal flow. In addition, it should be declared that in relation to the researches, the highest tidal currents occurred in Penghu channel in Taiwan Strait. Jasmi et al. [4] tried to focus on Arvand river to analyze the tidal flow in this zone. MIKE11 was the unsteady mathematical model stablished in this study to simulate hydraulic changes in Arvand river. In the direction of simulating the data, they tried to practice on the water level changes in the middle of the Arvand river and in river inputs. Via this data, the model was calibrated and in the next step the tide and flood conditions were assisted to determine the water depth and flow velocity in diverse parts of the river. The results indicated that the roughness coefficient of the river was between 0.048 and 0.055.

Another study represented by Babo et al. [2] analyzed and simulated the tidal currents in Kachachh in 2005 that is located in the southwest of India and they exact model they were working with was the mathematical MIKE21 model. The outcomes of the modeling were obtained by field data that were measured at three dissimilar times. The model outcomes displayed good agreement with field data and it expressed that the model output was capable of simulating the tidal currents.

Additional research related to Azmoudeh and Tourian [6] published the study that is linked to the tidal changes in water surface of Gulf of Oman and Persian Gulf and they got the data from the TOPEX Poseidon satellite in almost eleven years besides they collected the coastal tide gauge information by employing Fourier analysis method and finally, they model estimated the results in least squares of tidal components that was placed in a larger period of four hours. later, the mean sea levels and the tidal model were regulated and in the following phase, and in advance, the mean sea level map and the tidal amplitude and phase components maps were determined for four components presented as s2, M2, K2 and O1.

The outcomes expose that the used technique is well able to model the tidal currents. Rabiee far et al. [5] evaluated water level in Shahid Rajaee port in almost eleven years and in the end they got a numerical model in 2007 that could determine tide regime in any location in the heart of the sea. In their study, they practiced on MIKE21 software to have a harmonic analyze (linear regression) on the main domains of the

tide and in the end, they compared their results. The outcomes presented that the numerical model used in this project was well capable of calculating tidal regime.

Area of Study

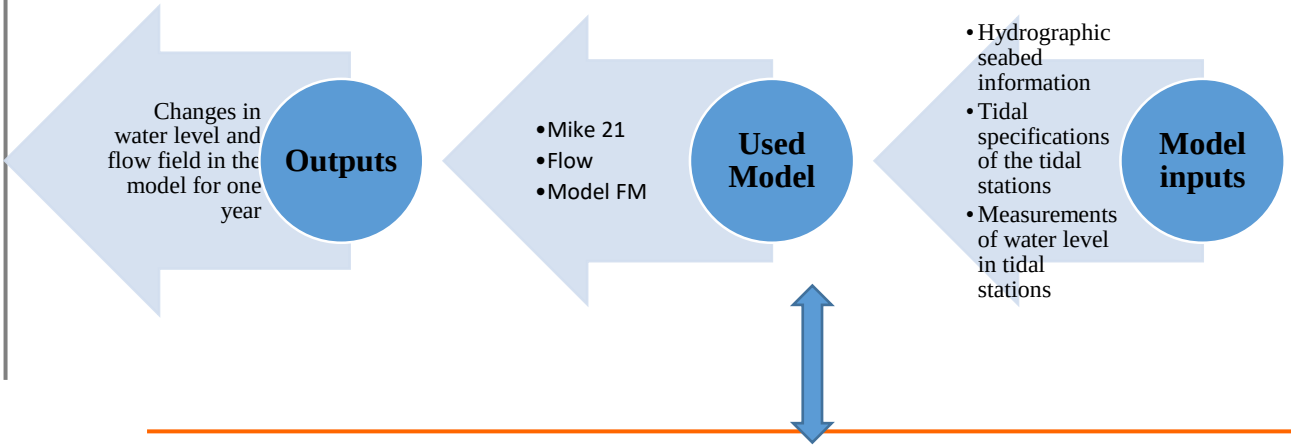
Persian Gulf is at 24 to 30 degrees 30 minutes' north latitude and 48 to 56 degrees 25 minutes' east longitude from Greenwich meridian. Persian Gulf is located between Strait of Hormuz and Gulf of Oman, through which is linked to the high seas and it extends in an area of 225,000 square kilometers, which has dissimilar latitudes. The minimum width of water is 180 kilometers and the maximum width is 300 kilometers. The length of the Persian Gulf from the beginning of the Arvand River to the Strait of Hormuz is 900 kilometers. The depth of the water of the Persian Gulf is on average between 50 and 80 meters in the east and in the west it is approximately 10 to 30 meters. [Fig. 1] displays the location of the study area.

Fig. 1: The location of the study area.

METHODS

Presenting MIKE21-HD-FM model

In this paper, MIKE21-HD-FM which is a mathematical model is applied to forecast the tide in the Persian Gulf coast. In mathematical modeling of tidal wave propagation, there are two-dimensional horizontal equations in the shallow water that are used as the averaged flow equations in depth. These equations consist of a mass conservation equation and momentum conservation equations (in two horizontal dimension) and via this system of equations, it will be possible to calculate the three unknown elements of water depth (h) and the two components of speed at which are in Cartesian coordinates. The goal is to get the best model to predict fluctuations in water level. In order to gain this, in the first step a comprehensive tidal model for the Persian Gulf was prepared and in the next step based on the comparison of model results with measured water level fluctuations at several tidal stations in the Gulf the general model has been calibrated. [Fig. 2] shows how the model of tidal in Persian Gulf works.



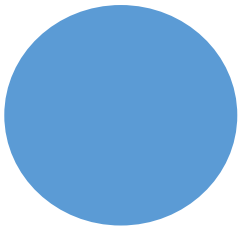


Fig. 2: The procedure of the comprehensive tidal model in Persian Gulf.

In addition, by using the calibrated model, tidal currents in the Gulf were simulated for one year. At that point, by evaluating the results of the comprehensive model at several stations, it assured the comprehensive model's operation.

Used Information

First of all, it should be declared that data collection is one of the most imperative parts in this study. In this section, in order to get a set of basic and necessary information, we will introduce this information and their sources.

- Geometry of the study area

The boundary between the land and the sea in Persian Gulf were extracted from the Mike C-map digital data. This information gathered from some of the islands in the Persian Gulf borders, such as Qeshm, Kish, Hormuz, Lark, Bahrain and so on. The scale of the data is1: 250,000.

- Hydrography information of the study area

One of the essential information for any kind of hydrodynamic simulation is the depth journalism or hydrographic information about the limitations and the boundaries of the study. For this purpose, the entire Persian Gulf hydrographic information was gathered from the Mike C-map digital information bank. The scale of the data is1: 250,000.

- Tidal information

All the information needed in calibration and evaluation of modeling results like any vital info in any simulation is numerical. Due to this purpose, all of the tidal information recorded in the Jask station in 2011 are prepared in a shape of a time series with the time step of 30 minutes from the water level fluctuations of the lowest water level in the Chart Datum. The most suitable information gathered in this year is related to Salakh, Bahman and Loft ports and will be used as a data for the calibration model.

Also, in the direction of having a greater scrutiny on calibration accuracy, it is needed to use the predicted results from the tide levels in three stations that are Shahid Rajaee, Lengeh and Kangan ports, which are made from the site of the mapping organization. The timeframe of these points is in November 2011. The location of the places used in the calibration model is exposed in [Fig. 3].

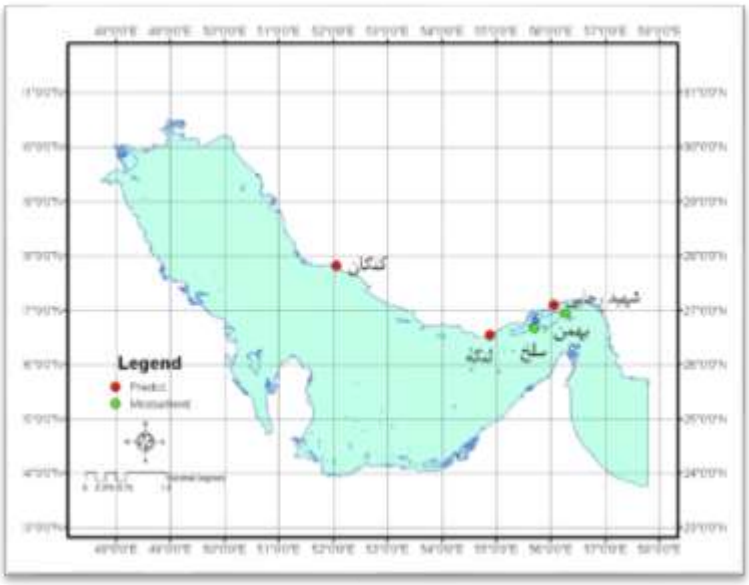


Fig. 3: The location of the places used in calibration of the tidal model.

RESULTS

Establishing up the comprehensive tidal model of Persian Gulf

In the model presentation, the minimum step time parameter value is 0.01 and the maximum time step is 15 seconds and the maximum allowable courant number is 0.5. One of the adjustments related to the model is actions related to the effects of Coriolis. Due to the size of the investigative area, the effect of these forces will be noticeable on the output results. [Fig. 4] expresses the output from running the model.

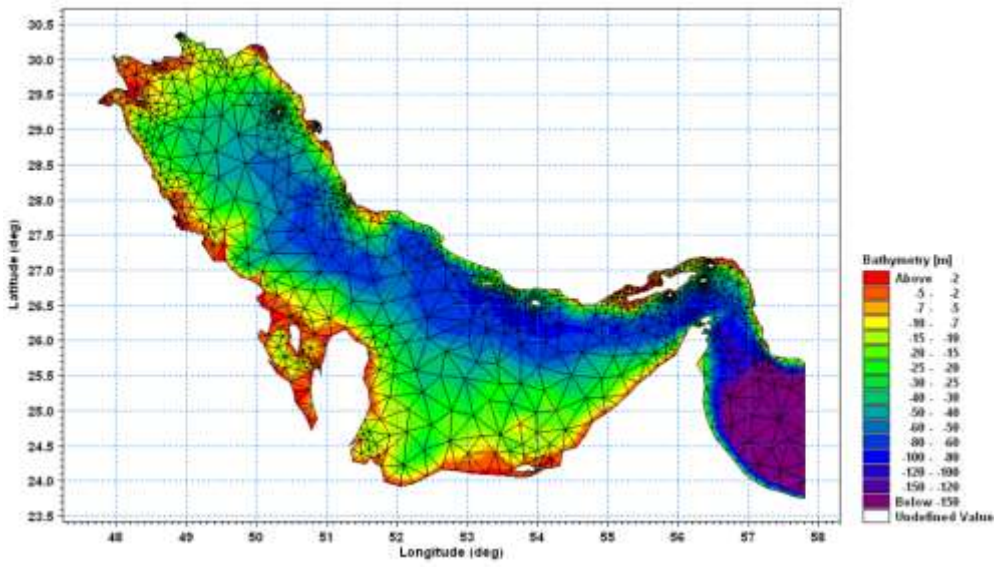


Fig. 4: A comprehensive tidal model of the Persian Gulf.

Calibration of the comprehensive tidal Gulf model

The obtained model is implemented for different values of resistance substrate that are 32, 40, 50 and 55 and the results were compared to the values sensitivity. Therefore, the results of the model in each of these scenarios were compared with the measured corresponding data related to the Salakh and Bahman ports and the predicted values from the Shahid Rajaee, Lengeh and Kangan ports.

The model is responsible for calculating the water level fluctuations in Salakh and Bahman ports and later the results were compared as shown in [Fig. 5].

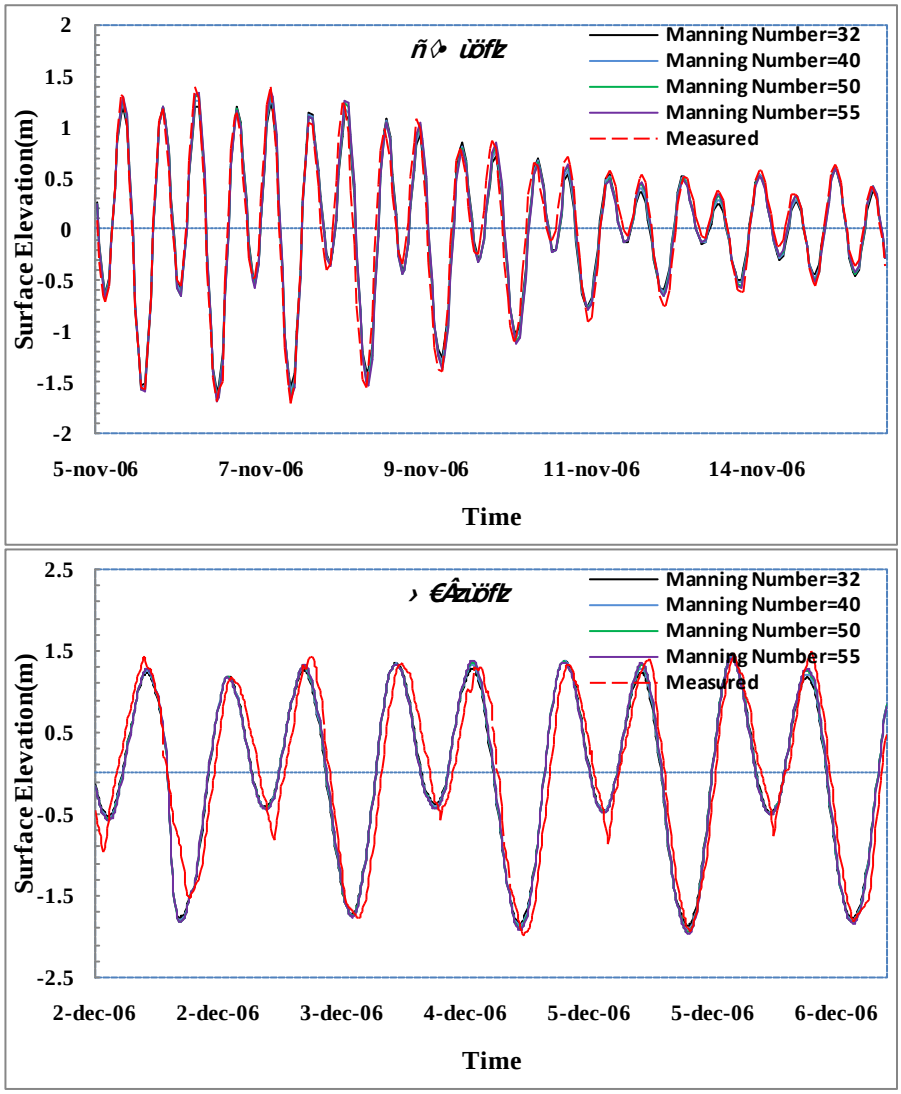


Fig. 5: the comparison between the simulated water level fluctuations and the corresponding measured values in Salakh and Bahman ports.

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As shown in this [Fig.5], the tidal model in Persian Gulf is well talented to simulate the recorded water level fluctuation patterns in both of Bahman and Salakh ports. It is clear that there are no significant differences in model results for different coefficients of the bed resistance.

[Fig. 6] shows the comparison between the calculated water level fluctuations based on the model and the corresponding predicted values related to the mapping organization focused on the Shahid Rajaee, Lengeh and Kangan ports in November. The amount of 50 were nominated for bed resistance.

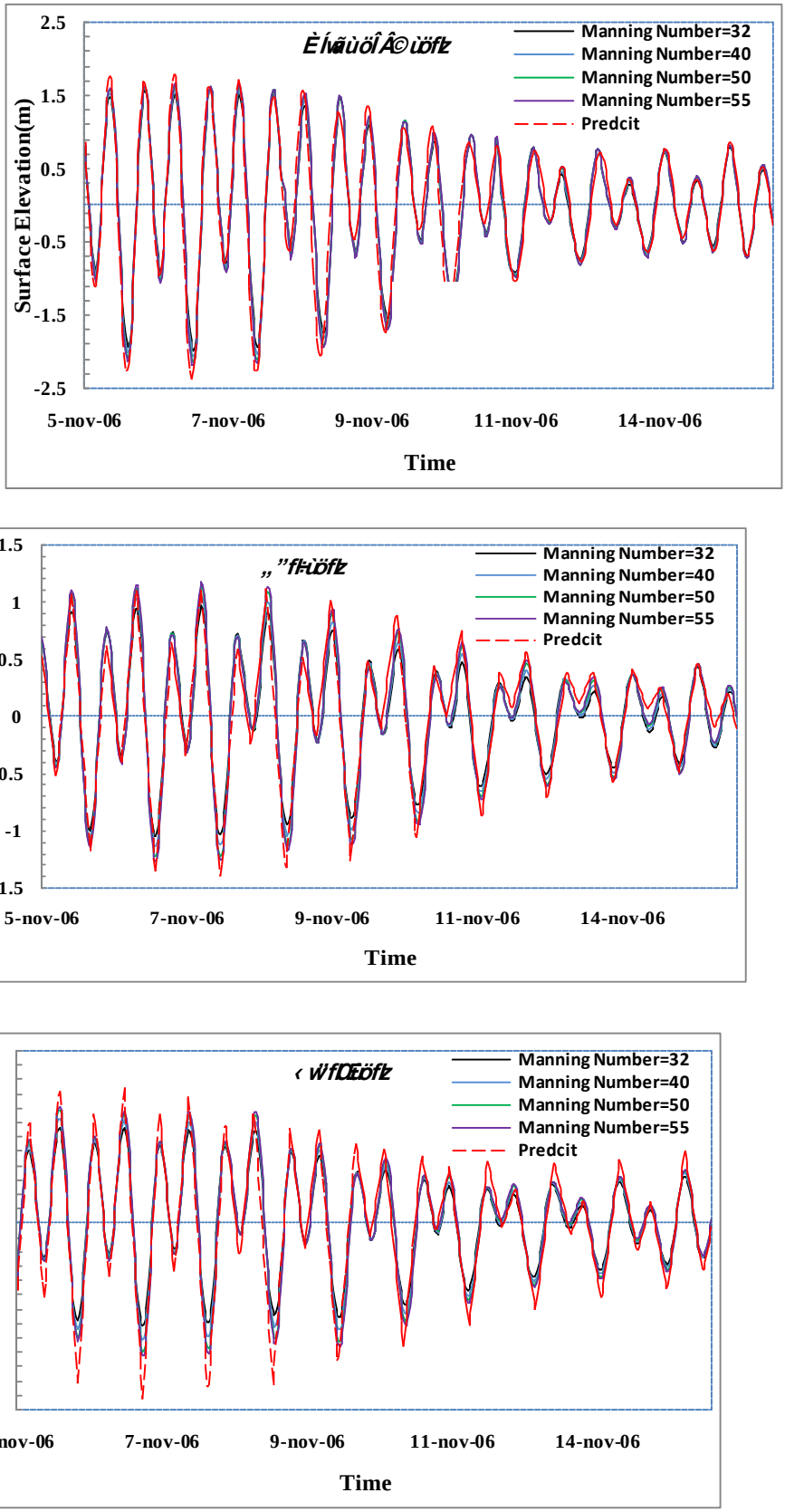


Fig 6: Comparing the simulated water level with corresponding predicted values (in November).

The results of a comprehensive tidal model in the Persian Gulf

After ensuring the outcome of the calibration of tidal model in Persian Gulf, with the aim of producing relevant information, calibration model got access to work on the tidal fluctuations records related to the Jask port for the whole year of 2011 and consequently, the tidal fluctuations were simulated for one year in Persian Gulf. [Fig.7] is an example of the water level fluctuations of tidal modeling that is publicized by the comprehensive model in both flow and reflows in Persian Gulf.

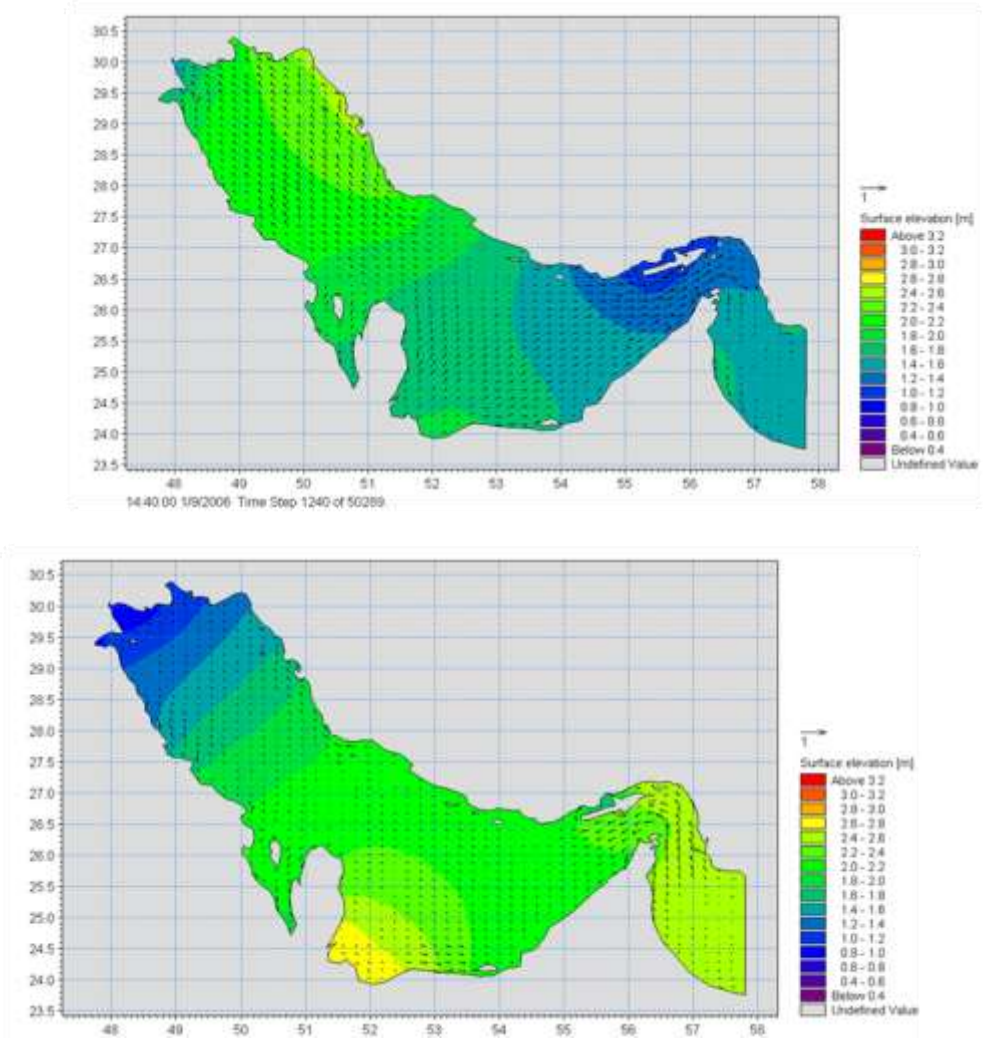
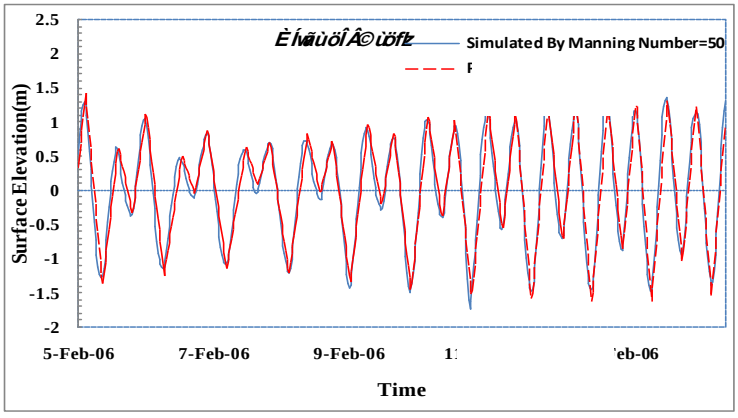


Fig. 7: Water level fluctuations and flow of the tide modeling.

At this stage, and so as to evaluate the results of the calibrated simulation model, again the water level fluctuations values were calculated by the model at the ports of Shahid Rajaee, lengeh and Kangan and later they will be compared with the corresponding predicted values in another period of time [Fig. 8].



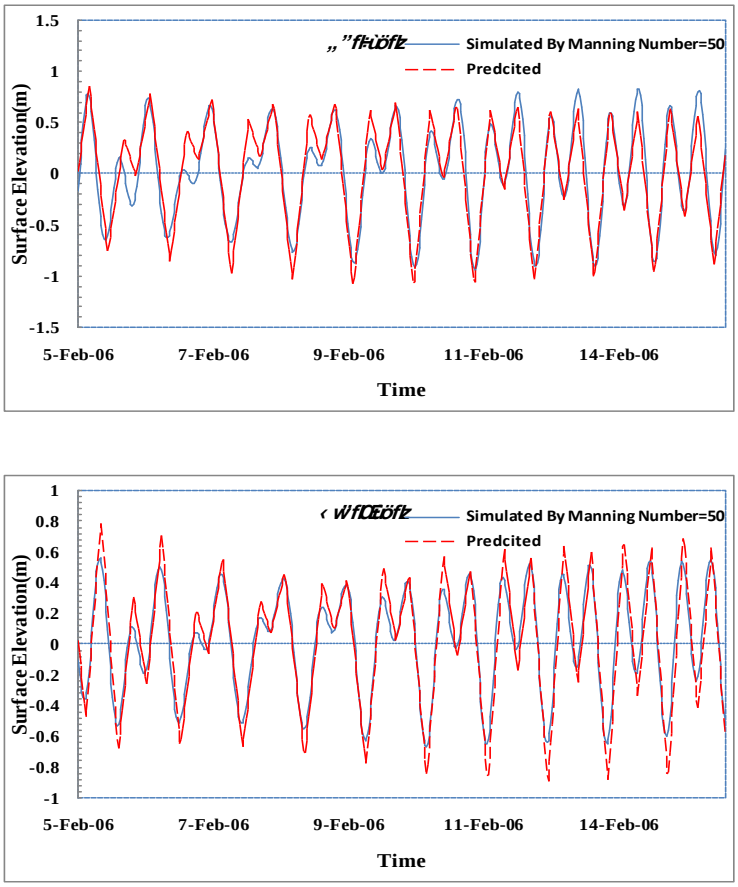


Fig. 8: Comparing the simulated water level with corresponding predicted values in February.

As seen in [Fig. 8], the results show noble correspondence.

DISCUSSION AND CONCLUSION

Results from the tidal Modeling in Persian Gulf show that flow and inflows of the tide can be easily calculated and predicted according to the mentioned modeling.

CONFLICT OF INTEREST
There is no conflict of interest.

ACKNOWLEDGEMENTS
None

FINANCIAL DISCLOSURE
None

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