Chapter V

Discussion and Conclusion

There are many studies employing hydrodynamic model to investigate the characteristic of the circulation patterns in the Gulf of Thailand. Focusing to the main forcing that were used in computation, wind and tide are frequently considered. In the case that wind was used, the values of wind speed for the Northeast and the Southwest monsoon were assumed as a steady flow such as in the studies of Nelasri (1979), Azamy and Yanaki (1991), and Snidvong and Sojisuporn (1997). While in the studies of Vongvisessomjai et al. (1978), and Archevarahuprok and Wongwises (1994) used averaged measured wind at some stations in the study area.

However, this study is one of the several efforts to try to simulate the ocean current in the Gulf of Thailand by utilizing wind and tide as the main forcing. This is the first time that the long-time averaged wind data over the whole Gulf from verified computational model are employed. The results of this study will not be compared to those in the other studies, but verified with measured current data from NRCT. The objective of verification is to make the confidence before the computed currents are applied as the tidal current input in the oil spill trajectory model.

The verification of the hydrodynamic model

The verification of hydrodynamic model shows good comparisons between measured and computed current at Rayong, Ko Sichang, Pechaburi, and Hua Hin, while poor comparisons occur at Ko Chang, Ko Tao, and Nakorn Srithammarat. At these latter stations, the measured currents seem stronger than computed current, and there are very much phase lagging between both current directions. It can be described that current from NRCT are measured by current meters deployed at 3-4 m beneath sea surface, thus, this data is only as the current at surface layer, while the computed current from hydrodynamic model is the depth-averaged current. For this reason, at the stations in the Upper Gulf where the depth is very shallow, surface current can be used as the depth-averaged current. While the depth of the stations at the lower part of the Gulf is much deeper, thus the disagreement of measured and computed current at these stations has occurred. To confirm the reason that there is the difference between surface and depth-averaged current, the results of three-dimensional hydrodynamic model are mentioned. The studies of Sojisuporn (1985), and Yanaki (1994) showed that there is the variation of current speed and direction in each layer of the same water column. And when the currents in every layer are integrated and then averaged, this value tends to be weaker than that of the surface current. However, this reason can not be explained for a special case of the verification at Ko Chang. Although this station locates at the area of shallow depth, the comparison stills show disagreement. This result may be come from the effect of grid positioning and shape of Ko Chang that is defined inappropriately, thus the boundary of this island may be retard the flow at this station.

The time series plot of current data, especially in the magnitude charts, show effect of tide on the characteristic of current in the Gulf. The fluctuation of spring and neap tide can be noticed from the difference in range of the current magnitude. This means that the tidal or water elevation at the open boundary is very important, because it is converts to the current that originates the patterns of short time or instantaneous current. In this study, because of the lacking of measured tidal data, the water elevations at the open boundary have to be calculated. At the border grids of the open boundary, the water elevations were calculated by harmonic analysis, but for the other grids between them, linearly interpolation was employed. So, it is clear that the error from the open boundary can occur from two points, one is from the accuracy of harmonic computation and another from the processing of linearly interpolation. This error will make mistake to the periods of ebbing and flooding time predicted by the hydrodynamic model, and it can be seen in the form of phase lacking in the time series plots.

The circulation patterns in the Gulf of Thailand

In this study, from the vector field charts of the monthly mean current shown for studying in the circulation patterns in the Gulf of Thailand, it is found that wind is one of the significant forces generating the long-term circulation. Although the no-wind condition of hydrodynamic model operation didn't be done in the study, it can be mentioned about the important of the wind to the circulation patterns, because if the charts of the monthly mean wind and the current vector fields are compared in each the same month, it is found that the direction of the current speed agree to those of the wind speed. Especially, in the Upper Gulf, this agreement is shown very clearly.

From the monthly mean of current vector field, they show agreement between wind force and current patterns. The net force of wind blowing over the Gulf is the important factor generating several patterns of the circulation. It can be seen in the month that have wind flowing from the same-direction but different in the internal pattern. For example in November and December, there are the wind blowing from the northeast, but in December wind field in the southern part are stronger than in the northern part, while in November, they seem steady. The results of this difference appear in the difference of the monthly mean current in November and December. It seems to have a big clockwise gyre in the Central Gulf in December, while it doesn't have in November.

It is apparent that the calculated circulation will be more accurate, if the good wind data are employed in the hydrodynamic model. Trying to use the long time averaged wind as the computational input in this study, is one of several ways to find out that whether it can be used for more accuracy in computation or not by verification with the measured results. However, the comparison between the results from averaged and real time wind should be studied in the future to investigate that if there is no difference between these results, that means, the averaged wind data can be used instead of the real time wind.

There is a study that should be named here to assure the important of wind to the circulation patterns in the Gulf. It is the report of Wolanski, Wattayakorn, and King (1994) studying about the water circulation and pollutant transport in the Gulf of Thailand. In this study, the finite-difference, alternate-direction, implicit numerical model was applied to the entire Gulf. There are two conditions to be investigated. First, the influence of forcing from the South China Sea circulation was included in model by forcing at its open boundary with a current. It was found that this affected the circulation only in the Lower Gulf. But, for the condition that model was run with simultaneous wind and tide forcing, and verified the results against the measured and predicted tidal data, it showed favorable comparison.

From the study of Wolanski et al. (1994), there is a very interesting point that should be considered. Besides wind and tide, the effect of current flowing into the Gulf of Thailand from the South China Sea was studied. Although the result showed that this force affected the circulation only in the Lower Gulf, it can not be ignored because it concern with the residual circulation in the area that it reaches. This is the one that should be studied in the future.

The results of the oil spill trajectory model

Initially, when the predicted position of drifted cards in the sea by the oil spill trajectory model is compared to the result from the field experiment, the difference between both appears. The result of the oil spill trajectory model prediction show that the oil slick will move to the north, while from measurement, the drift cards moved down to the southwest after releasing for 3 hours, and then moved up to the north, a little to the east. Focusing on the results of computation, because measured wind is used as input in the oil spill trajectory model, the difference between measured and computed positions especially after releasing for 3 hours should not come from wind data, but from the background current. It can be mentioned like this because it is only another input used for computation. However, when the computational results are analyzed carefully, it is found that the magnitude of wind speed at 12 m/s in direction of 195 degrees from north will generate Stokes drift at 0.204 m/s in the same direction of wind, and Ekman current at 0.168 m/s in direction of 48 degrees from north. If there are the net current moving to the measured position of the drifted cards, the magnitude of background current will be more than 0.168 m/s in the opposite direction of Ekman current (228 degrees from north). This diagnosis showed that this difference might not be come from background or residual current, because such strong magnitude of background current is impossible to occur in general. So, the difference in the position of drifted cards should come from the instantaneous or tidal current that didn't be included in computation. This is the reason, why the tidal current data should be added in the oil spill trajectory model.

The oil spill trajectory model is run again but in this time the tidal current is included in computation. Although the predicted positions of drifted cards by model are not exact to the measurement, the better prediction can be seen from this operation. It is apparent from the prediction of oil spill model that at 3 hours after releasing, drifted cards are transported to the south while the measurement is at the southwest. After that the positions of prediction and measurement are very nearer especially at 15:00 (figure 86). It is obvious that the cause of changing in predicted positions is from the tidal current. Because if the vector field charts of tidal current in the Upper Gulf on March 30, 1995 are considered, it can be found that there is ebbing from 6:00 to 12:00 (figure 82-84), and flooding starts after that. Very strong flooding can be seen at 15:00 (figure 85). These results are consistent to the predicted positions of drifted cards discussed above.

Coursing of error in prediction by the oil spill trajectory model after including the computed tidal current may be come from 2 points. First, because the effect from Ko Sichang is not considered in hydrodynamic and the oil spill trajectory model, thus the shear stress from Ko Sichang that can retard the current flowing and may be change the current direction is not included in computation. For this reason, the oil spill trajectory model should be tested in many areas to confirm this conceiving in the future. And for another reason of error is point to the space of grid size of model. Although the oil spill trajectory model gives output at every minute in space, it reads current data used as input at every 1/10 degree or 6 minutes. It is very clearly that this error can come from the input current data read from inappropriate position and this mistaken can cause error in computation.

Conclusions

A two-dimensional hydrodynamic model employing ADI finite difference technique is applied to compute current in the Gulf of Thailand. The 8-years averaged wind from 1980 to 1988, tidal elevation at the open boundary computed by harmonic analysis, and averaged depth from navigation chart of the Royal Thai NAVI are used as input in computation. After that the current data from hydrodynamic model are used as input in the oil spill trajectory model to calculate the path of spilled oil after being leaked in the sea and the result from this computation is compared to the result from field experiment. From these studies, they can lead to the following conclusion:

1. The prediction of oil spill in the Gulf of Thailand will be more accurate if the computed tidal current is included in calculation by the oil spill trajectory model.
2. Wind is one of the significant forces effecting on the pattern of the long-term circulation in the Gulf of Thailand.

3. The accuracy of water elevation along open boundary used as computational input in hydrodynamic model is very important in calculation of the instantaneous current.
4. Verification between measured from NRCT and computed current from hydrodynamic model is good at Rayong, Ko Sichang, Petchaburi, and HuaHin, while poor comparison occur at Ko Chang, Ko Tao, and Nakorn Srithammarat.

Recommendations

For application of hydrodynamic model, besides this model can be utilized in prediction of spilled oil in the sea, it can be directly applied for several studies such as the transport of phytoplankton or larvae, and coastal erosion. However, this hydrodynamic model should be developed for more accuracy in calculation of circulation in the Gulf of Thailand, because the result from model will be employed as an important database to use in computation of these studies. Nevertheless, to increase the effectiveness, the following suggestions and studies are recommended.

1. The forces from the South China Sea should be studied to investigate that how can it effect to the circulation pattern in the Gulf of Thailand.
2. The difference between current generated by averaged and real time wind should be studied in the future to investigate that whether the averaged wind can be used instead of the real time wind or not.
3. The oil spill trajectory model should be tested in several areas especially in the area of no tidal effect to find that whether it has to include the tidal current in computation by oil spill model in those areas.