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# 3-D numerical simulation of tidal flow in Bohai Bay and Yellow Sea

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*Bohai Bay and Yellow Sea*

The Bohai Bay and Yellow Sea area covers a wide continental shelf surround by northeast China and Korea, about 1000 km from west to east and 800 km from north to south. In recent decades, the rapid economics and population growth in the cities area around Bohai Bay has made great change in it's eco-system. Large amounts of daily discharge of nutrients and pollution have been disposing into the bay while new harbor area, oil production and chemical industries have been rapidly developed in coastal area. As urban centers continue to grow around the margins of major water bodies, serious environmental problems multiply. Therefore, the research on the hydrodynamics of this sea area is of great concern.

*Computation condition*

The object area of the present study includes Bohai Bay and Yellow Sea, locate in 117°-127° E, and 34° - 41° N. Figure 1 illustrates this computation domain. The size of the horizontal grids is 22860 m × 232210 m. Vertically, we apply 7 layers which are 4,4,4,8,12,14,16 m from surface, respectively. Bohai bay is a shallow water basin with very mild-slop beaches, and its mean water depth is less than 10 m. The tidal range is typically 3 m to 4 m and the residual current is less than 0.1 m/s. On the other hand, Yellow Sea is relatively deep and has complicated geometry. In the Korean coast line, the tidal range of Yellow Sea may reach 19 m. In the present study, ODEM, a three-dimension numerical model, is used to compute the tidal flow in the object area. In this computation, we set the boundary at 34° N, where we consider two major tidal constituents, The semi diurnal $M_2$ tidal constituents and the diurnal component $K_1$.

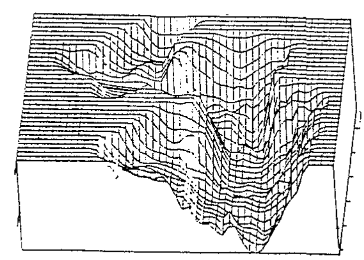
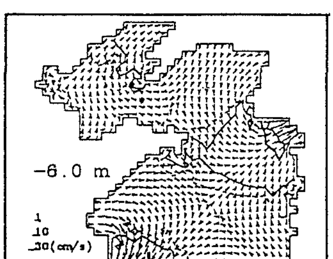


Figure 1 Computation domain



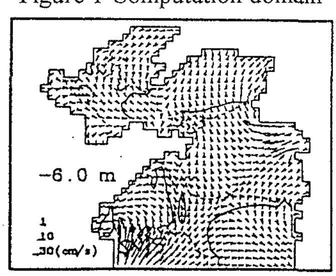




Figure 2 The residual flow generated by $M_2$ tidal constituents, (a) flood tide (b) ebb tide.

Key word: 3-D Model, tidal constituents, residual current, Bohai Bay, Yellow Sea.
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*Numerical simulation*

At the first step we compute the tidal flow generated by $M_2$ and $K_1$, separately. The computation time is six tides. The results show reasonable agreement with the observation data. However, due to the complicate coastal line in the western Korean coast, the result of maximum tidal amplitude from our numerical model (140-150cm) seems less the observed ones which is about180cm-200cm. What is more, according to the computation results based on $M_2$ tide constituent, the average inflow volume from Bohai Bay to Yellow Sea counts about $1.5 \times 10^{11}$ $m^3$ / day, and outflow is $1.9\times 10^{11}$ $m^3$ / day. Such result proves that in the strait between Bohai Bay and Yellow Sea, the water exchange is very weak. Figure 2 illustrates the residual flow generated by $M_2$ (6 m under the surface), Fig 2 (a) shows the flood tide (after 66 hours computation), while Fig 2 (b) shows the ebb tide (after 72 hours computation).

In addition, we also compute the mix tide flow of $M_2$ and $K_1$ tidal constituents. The computation time is 10 days. Figure. 3 illustrate the amplitude of the mix tide in the object area. The results show that the tide amplitude in west Korean coast reach 200cm (maximum value is 300cm in certain location). Nevertheless, at the same position the amplitude of only $M_2$ tide is 90 cm and only $K_1$ is 25cm, and the simple sum of $M_2$ and $K_1$ tidal amplitude is just about 120 cm which is significantly less than that of the mix tide. At the coast of Bohai Bay, however, the amplitude of the mix tide is simply the sum of $M_2$ and $K_1$ tide. The reason of such difference, may due to the high water depth in the Korean coast. By conducting the residual flow computation of the mix tide. Figure. 4 shows the residual current of the mix tide (6 m under water surface). From the computation result of mix tide, we find significant increasement in velocity comparing the residual current caused by only $M_2$ and only $K_1$ tidal constituents. In addition Bohai Bay seems receive just little amount of inflow from Yellow Sea, while the flow direction seems very unstable in the strait .

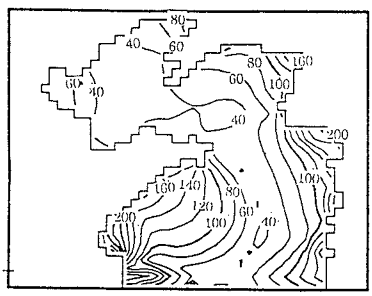


Figure 3 The $M_2$ & $K_1$ mix tide amplitudes.

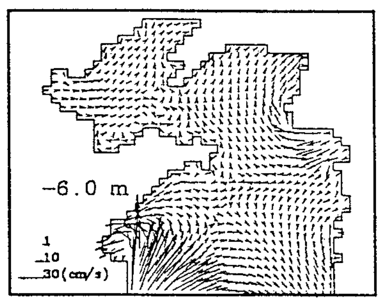


Figure 4 Residual flow of the mix tide of $M_2$& $K_1$

*Conclusion*

In the present study, by using ODEM, a three-dimension numerical model, the tidal flow in Bohai Bay and Yellow Sea has been well reproduced. Flow direction, velocity and phases are under reasonable simulation, while the water exchange between Bohai Bay and Yellow Sea is calculated. The semi diurnal $M_2$ tidal constituents play a dominant role in Yellow Sea. In addition, the diurnal component, $K_1$, also show strong effects, especially in the strait area. In the Korea coast, since the water is deep, the tidal ranges reach very high value. From Bohai Bay to Yellow Sea, the residual flows contribute very little in water exchange, it makes the Bohai Bay, an enclosed bay area, suffer serious problems of water pollution.