Numerical Simulation of Lagrangian Particles Motion in the Yellow Sea

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論 文 内 容 の 要 旨

The Lagrangian particles motions in the Yellow Sea are studied on the basis of a series of high-resolution numerical experiments. That is because, comparing with the Eulerian framework, the Lagrangian phenomena of the circulation have not been well examined in this area. For instance, the mechanisms and the predictions of the green-tide events, which have occurred frequently in the southwestern Yellow Sea during recent summers, have been trended unsatisfactorily.

In the first half of this study, the responses to tidal and/or wind forces of Lagrangian trajectories and Eulerian residual velocity field in the upper layers of the southwestern Yellow Sea are investigated. All of the characters of the water masses, including the thermocline and the position of the surface and subsurface water masses, are simulated well by the numerical model, implying that the present model has captured the essential dynamics of the current systems. The simulated tidal harmonic constants agree well with observations and existing studies. The numerical experiment reproduces the long-range southeastward Eulerian residual current over the sloping bottom around the Yangtze Bank which also shown in previous studies.

However, the modeled drifters deployed at the northeastern flank of the Yangtze Bank in the simulation move northeastward, crossing over this strong southeastward Eulerian residual current rather than following it. Additional sensitivity experiments reveal that the influence of the Eulerian tidal residual currents on Lagrangian trajectories is relatively weaker than that of the wind driven currents in the upper layer of the southwestern Yellow Sea. This result is consistent with the northeastward movement of ARGOS surface drifters actually released in the same region.

Further experiments suggest that the quadratic nature of the bottom friction is the crucial factor, in the southwestern Yellow Sea, for the weaker influence of the Eulerian tidal residual currents on the Lagrangian trajectories. The simulation result demonstrates that the Lagrangian trajectories do not follow the Eulerian residual velocity fields in the shallow coastal regions of the southwestern Yellow Sea. In other words, the Lagrangian residual current in representing the inter-tidal mass transport is more accurate comparing with the Eulerian residual velocities.

In the second part of this thesis, combined with the in situ hydrographic observation data from the Korea Oceanographic Data Center (KODC), significant southward seasonal migrations of Yellow Sea Bottom Cold Water (YSBCW) are simulated successfully. The possible source and the 3-D pathway of the YSBCW are quantitatively calculated using the two-way Lagrangian particle tracking method (PTM). The dynamical factors of the YSBCW seasonal migration are also investigated by numerical modeling.

The trajectories of the modeled drifters show that, the subsurface cold heavy water masses, from the northern part of the Yellow Sea and the southern part of the Sea of Bohai, sink into deeper layers gradually with the southward movement since spring to summer. The southward extensions gradually gather speed from February to July or August. Until September or early of October, the cold-water masses reach the southernmost location; they even can affect the southwest region of Cheju Island.

Furthermore, the results of the additional sensitivity experiments demonstrate that the tides are the primary forcings for the deep circulation in the Yellow Sea. The summer southerly wind and strong solar radiation, causing the inter-annual variations of the currents, are also demonstrated to effectively contribute to the southward migration of the YSBCW. While, the effect from the Changjiang (Yangtze) River discharge is insensitive. On the other hand, the seasonal migrations of the YSBCW are less affected by the meteorological forcings during previous wintertime.

Consequently, the simulation results suggest that the Lagrangian trajectories do not follow the Eulerian residual velocity fields in the shallow coastal regions. In other words, streamlines of the Eulerian residual velocities and the Lagrangian trajectories (path lines) can be significantly different in coastal seas, and the difference should not be ignored as demonstrated in this study. The Lagrangian residual circulation should be considered as the base of the dynamics in a coastal sea. To accurately embody the mass transport in the shallow region of the Yellow Sea, the Lagrangian framework of circulation should be paid more attention, comparing with the Eulerian residual velocity