Geophysical Research Abstracts
Vol. 14, EGU2012-308, 2012
EGU General Assembly 2012

Simulation of density-driven current in a semi-enclosed bay in the Yellow Sea by a robust diagnostic model with synchronous observation data

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Using synchronous observation data of water temperature and salinity collected by multi ships in summer and a three dimensional robust diagnostic model, we calculated density-driven current in the Jiaozhou Bay (JZB), a semi-enclosed bay in the Yellow Sea. Special attention was paid on the influences of intra-tidal variations in water temperature and salinity on density-driven current. The observation data show that the maximum spatial and temporal variations in water temperature and salinity are over 2.0°C and 2.0, respectively. The diagnostic model shows that density-driven current has a maximum value of $\sim$0.1m/s and is stronger than tide-induced residual current in some areas of JZB. The density-driven current in the JZB features with strong interaction between gravitational circulation and bathymetry. For example, we can easily find that an intrusion of high-density water in deep area and outflow of low-density water in shallow area. The density current over the scour pit at bay mouth presents divergences in surface layer and convergences in bottom layer. The results of diagnostic model depend closely on the quality of observation data. The tide averaged water temperature and salinity, which were designed to remove intra-tidal variations from the synchronous observation data, can be used to simulate the density-driven current. The scaling analysis indicates that the intra-tidal variations in baroclinic horizontal pressure gradient may be not very important to density-driven current. However, if non-synchronous data collected by single ship over the bay were used to drive the diagnostic model, the simulated flow field is not consistent with that calculated by synchronous data. The cause is that the non-synchronous data at different stations were collected in different tidal phases. The intra-tidal variations in density field results in significant error in density gradient, which can induce a wrong flow field that is at the same order as the real density-driven current.