Geophysical Research Abstracts
Vol. 16, EGU2014-11030, 2014
EGU General Assembly 2014

Numerical model of circulation and residence times in the Persian Gulf

Fearghal O'Donncha and Emanuele Ragnoli
IBM Research, Ireland (feardonn@ie.ibm.com)

The Persian Gulf is a semi-enclosed, marginal sea that is exposed to arid, subtropical climate. As a consequence of the extreme climate, evaporation is greater than freshwater inflow resulting in a net loss of water and associated, reverse flow, estuarine circulation as the highly saline waters exit the basin through the Straits of Hormuz, into the Gulf of Oman. Because of their consistent direction, these density currents are central in the distribution and removal of pollutants from the gulf. Tidal forcing impacts circulation in the region, particularly on smaller scales of length and time. Wind forcing can be significant, particularly the Shamal weather phenomenon; wind that sets in with great abruptness and force, and is related to synoptic weather systems to the Northwest.

Output from high resolution (∼1km) numerical simulations, using NEMO (Nucleus for European Modelling of the Ocean), provide insight into the physical oceanography of the region. The model was forced by 0.75° European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric data and tidal constituents extracted from the Oregon State University Tidal Prediction Software (OTPS/TPXO). Model results permit a detailed examination of the three primary forcing processes, namely: tidal forces, wind forces, and density differences.

To assess fundamental model performance, results are compared with two historical observation datasets: (1) a comprehensive dataset of velocity and CTD measurements collected by Reynolds (1993) and (2) time series measurements recorded in the Strait of Hormuz from December 1996 to March 1998 by Johns et al. (2003). Model results exhibit close agreement to field values validating the model for a more detailed analysis of circulations patterns within the gulf.

To better elucidate the dominant forcing processes, classical tidal analysis decomposed the flow currents by fitting the flow profile to a finite set of sinusoids at specific frequencies related to astronomical parameters. The resultant time-series comprised tidal harmonic constituents and residuals composed of primarily density-driven and wind-driven (near surface) currents. To further decompose the residual currents time series are further filtered based on the differing scaling times of both wind-driven (days) and density-driven (weeks) flows. The resulting datasets enable a comprehensive classification of the relative influence of tides, wind and density effects across the domain.

As a summary measure of circulation within the region, the model was used to compute the residence time for a water parcel in the gulf. Several transport time scales were calculated, including the average residence time and variations across the region. Residence statistics provide several insights into circulation in the gulf, in particular, knowledge of circulation patterns through the Straits of Hormuz, regional variation of residence times from North-South, and the impacts of wind and density-driven circulation on particle renewal within the domain.