MODELING 3D DENSITY-DRIVEN FLOW IN A COMPLEX TWO-STRAIT, THREE-SEA SYSTEM

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The Turkish Strait System (TSS) is comprised of the Aegean, Marmara, and Black Seas interconnected by the Bosphorus and Dardanelles Straits. The extreme salinity and density differences between the fresh, light waters of the Black Sea and the saline, dense waters of the Aegean Sea drive two-layer flow through both straits and the intermediary, comparatively shallow Marmara Sea. Complexities in the geometry, topography and dynamics throughout the TSS present a formidable challenge in the application of numerical models.

The Advanced CIRCulation Model, ADCIRC, a finite element model based on unstructured grids, is applied to the TSS at resolutions of ~10m to simulate the two-layer, estuarine flow in the narrow straits. Initial conditions and open water forcing are supplied by a regional application (~1 km resolution) of the HYbrid Coordinate Ocean Model, HYCOM, which encompasses the entire Black Sea to the eastern Mediterranean Sea. Three deep depressions of over 1 km depth in the Marmara Sea occur in the midst of a broad, shallow shelf creating sharp changes in bathymetry over short horizontal distances. This geometry poses a challenge for ADCIRC's terrain-following, generalized, stretched coordinate system applied in the vertical. This study examines the importance of horizontal and vertical mesh resolution in overcoming numerically enhanced mixing, due to the steep bathymetry gradients in the Marmara Sea. Moreover, the distribution of sigma surfaces over the water column is considered in relation to its influence on the computed two-layer flow. Although HYCOM generally provides a considerably good solution for the dynamics in TSS, it cannot resolve flow in the narrow straits because of the coarse resolution of the model. In a system largely driven by internal density differences, the initialization of the density structure within the ADCIRC model is crucial for realistic simulations. Model representation of the two-layer flow within the straits is evaluated by comparing three sources for the initial condition. The first form of the initial condition is derived from available observations, a second created using climatological conditions, and the third is extracted from the regional HYCOM solution. Model performance for each numerical implementation considered above is assessed by comparison to observations obtained during the TSS08 and TSS09 Sea Trials in Sep. 2008 and Feb. 2009.