Tidal dynamics with corrected volume transport at Sunda Shelf and Singapore Strait

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Connecting the Indian Ocean with the South China Sea and the Pacific Ocean, the Sunda Shelf displays a complicated transitional hydrodynamic characteristics. At daily timescale, water level and current in the shelf are governed by mixed diurnal and semidiurnal tides. At monthly timescale, mean sea level and seasonal volume transport are amplified by monsoonal winds from the South China Sea. In this study, we present the development of a high-resolution barotropic numerical model for the Sunda Shelf based on the Semi-implicit Eulerian–Lagrangian Finite-Element (SELFE) model. The computational domain includes western half of the South China Sea, Malacca Strait, Java Sea, and is focused on Singapore Strait. Topography complexity is resolved by merging the high-resolution bathymetry data from Jeppesen's C-MAP product and the General Bathymetric Chart of the Oceans One Minute Grid (GEBCO1). A fine unstructured mesh consisting of a half million (447974) elements is generated for the entire domain, with very fine elements (up to 100 meter) along the coast of the Singapore Strait. At open boundaries, the model is forced by FES2012 tide prediction. The model is calibrated at open boundaries based on mean sea level archived from AVISO satellite altimetry data to reproduce corrected monthly volume transport through Malacca, Singapore and Karimata Straits. Surface wind stress is taken into account using daily NCEP climatology downscaled by WRF model. The computed sea level agrees well with tide gauge records and consistent with tidal prediction softwares (TotalTide, MIKE21 and FES2012) at hourly and monthly scales. Computed tidal currents are well compared against ADCP measurements in the Singapore Strait. The mean discharge through the Karimata Strait is 1.3 Sv (1 Sv = 10^6 m^3/s) toward the south, with the maximum of 2.8 Sv in December-January and minimum of -0.8 Sv in July-August. The annual transport through the Malacca Strait is mainly westward, with the mean of 0.13 Sv and the peak of 0.53 Sv in January. The seasonal transport through the Singapore Strait reaches the highest of 0.15 Sv westerly in January and the lowest of 0.04 Sv eastwardly in June, with the annual average of 0.04 Sv. These estimates are consistent with results obtained in other studies.