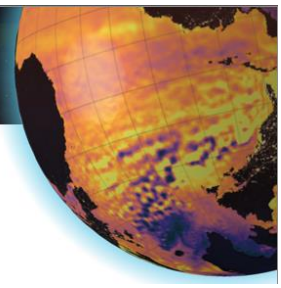
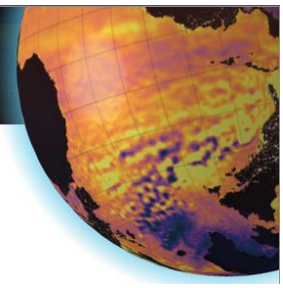


An Introduction to MaCOM and its application to operational oceanography

The Mass Conservation Ocean Model (MaCOM) is a numerical ocean model developed by the National Marine Environmental Forecasting Center (NMEFC) of China, based on the non-Boussinesq momentum equations in the pressure coordinate system. In volume conservation models, the total volume of the world oceans is constant, which means that the sea level predicted by these models is the virtual sea surface height. This is because the global mean sea level is always zero by the model definition. In order to account for global changes in sea level resulting from warming and the influx of freshwater due to glacial melting, correction terms must be calculated. Models based on mass conservation can predict the actual sea surface height in a more straightforward manner, as they do not require the calculation of correction terms. In addition to the pressure coordinate system, MaCOM also supports the height coordinate system, which enables the accurate representation of bathymetry in coastal applications. The fundamental dynamic framework encompasses a spherical approximation of the Earth, a thin layer approximation of seawater, a hydrostatic balance approximation, and a vector invariant momentum equation with a time-splitting method for a barotropic equation. The model employs a second-order turbulent kinetic energy and turbulent kinetic energy dissipation rate transport equation to address the diapycnal mixing problem. The parameterisation scheme of Shao (2020) is employed for lateral mixing along the neutral surface. A non-linear free surface (r-star) and a three-order non-linear direct space-time advection scheme are also employed in MaCOM. In order to facilitate the use of a variety of model meshes, MaCOM reorganises all horizontal compute grids into a one-dimensional line, akin to the unstructured grid model. Consequently, MaCOM is readily capable of supporting a variety of mesh types, including latitude-longitude, tripolar, and cubic sphere. It is anticipated that the SCVT mesh will also be supported in the near future. The GPU-accelerated feature, based on OpenACC, enables MaCOM to run high-resolution operational systems on a small compute system. The China Global Ocean Forecasting System (CGOFS), which is based on MaCOM, runs on 4 A800 GPU Cards every day, is capable of operating at a resolution of 1/12 degree. The one-year (2022) forecast performance evaluation utilising the GOV IV-TT (The GODAE Oceanview Intercomparison and Validation Task Team) Class 4 standard method revealed the following: The vertical structure test of the MaCOM model



indicates that the root mean square error (RMSE) is approximately 0.6 degrees Celsius. The root mean square error (RMSE) of the sea surface height anomaly of the MaCOM model is approximately 0.05 m.

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