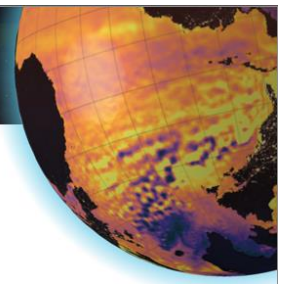
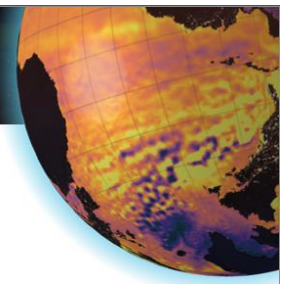


Towards a lightweight global ocean forecasting system: Development of "Mazu" Ocean Models in China

Since 2016, collaborated efforts have been made by the National Marine Environmental Forecasting Center of China to develop the "Mazu" series of ocean forecasting models for storm surges, ocean circulations, surface waves and tsunamis. "Mazu" is worshiped as a Chinese sea goddness who protects the fishermen from marine hazards. "Mazu" series ocean models includes the Mass Conservation Ocean Models (MaCOM), Finite Volume Wave Model (FVWAM), China Tsunami Model (CTSU v2), and Parallel Model for Storm Tide (PMOST v3). All these models are GPU-accelerated, which enables them to conduct global, high-resolution forecasting in a portable computing device. "Mazu" is an ongoing project with the final vision to replace the existing operational ocean modeling systems. Two of the main components of the "Mazu" models, the MaCOM and FVWAM, are introduced in more details below. The MaCOM is established from the primitive equations, with the aim to simulate global and regional ocean circulations. MaCOM is a non-Boussinesq ocean model with the pressure coordinate as the vertical coordinate, which can predict long-term sea level change in response to heating and cooling with accuracy. The model includes a two-equation GLS turbulence closure model to describe vertical mixing processes. To meet the operational requirement, MaCOM features 'carbon-friendly', and a series of high-performance computing technologies have been implemented to lower its energy consumption, including full elimination of land points, load-balancing MPI decomposition, asynchronous I/O, and GPU acceleration. A global 1/12-degree ocean modeling can be conducted in a portable server with 4 or 8 GPUs. The ongoing works on the latest version of MaCOM include development on a sea ice module using a three-layer sea ice thermodynamics and a elastic-visco-plastic rheology, as well as coupling with CoSiNE ecosystem model. The FVWAM is an unstructured-grid finite-volume spectral wave model. It replaced the traditional spherical latitude-longitude grid with the Spherical Centroidal Voronoi Tessellation (SCVT) grid (Hexagon grids), with the purpose of better fitting coastal topographic features and extending the wave forecasts to high-latitude polar regions. Finite-volume method is adopted to solver the wave action equation with flux-based and energy-conserved discrete algorithms. The source-scheme is based on the WAM model. Another main feature of the FVWAM is that all its computing-demanding components are GPU-accelerated, with a significant performance increase compared with its original CPU



version. The computing time of a 7-day global 1/10-degree wave modeling is reduced to only 15 minutes in a single-node server installed with 8 NVIDIA A100 GPUs.

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