Progress toward an ESRL earth system model: Coupling FIM to an isopycnal-icosahedral ocean

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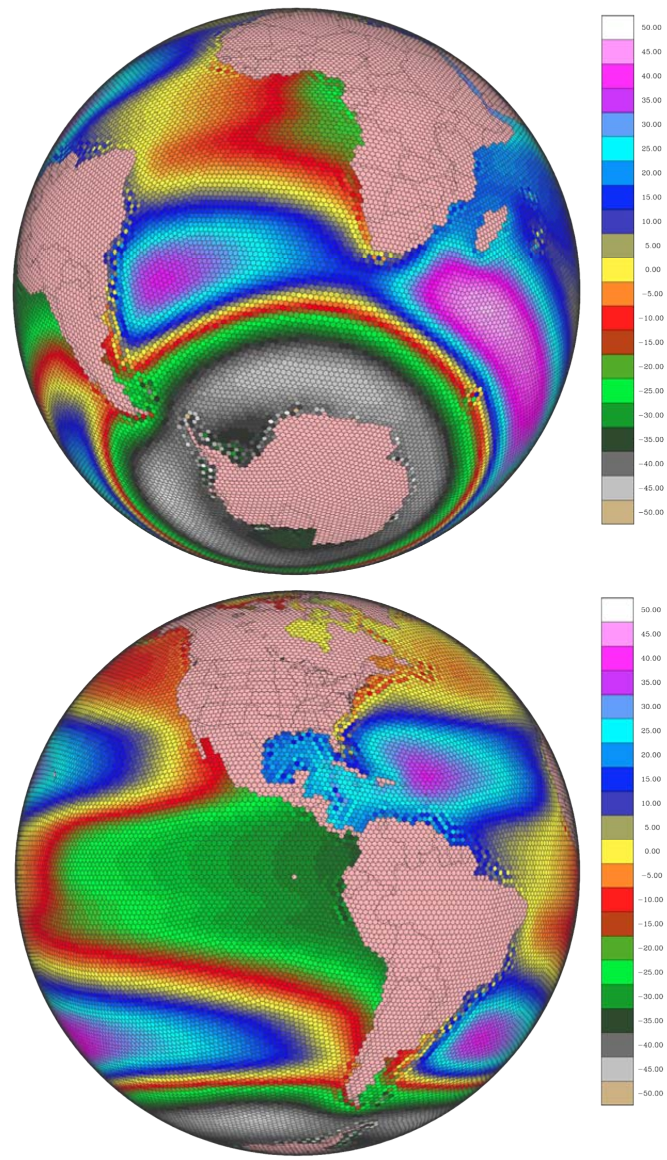
1. **Introduction** – Grid nesting is common in weather modeling, but grid discontinuities are usually kept away from the region of interest. Strangely, the practice of joining different grids at z=0 is common in coupled ocean-atmosphere modeling, even though the air-sea interface is arguably the principal "region of interest." The ocean model we are coupling to FIM uses the same horizontal grid as FIM. Hence, there is no need to rely on "flux couplers" with their often conflicting accuracy and conservation demands.

2. **Typical ocean model development stages** – Numerical issues arising in the simulation of weakly stratified flow on a rotating planet are best dealt with by adhering to the following sequence of development steps:

   A. wind-forced, single-layer, flat-bottom ocean;
   B. expansion to multiple layers;
   C. introduction of variable bottom depth;
   D. separation of barotropic and baroclinic motion (an efficiency issue);
   E. introduction of T and S as prognostic variables;
   F. addition of surface buoyancy fluxes (heat, fresh water).

3. **Ocean model choice** – The decision to discretize the ocean model on an icosahedral grid implied that the finite-difference equations had to be written from scratch. To minimize this effort, we chose a HYCOM-like model because of its **mathematical similarity** to FIM. Being a layer model, HYCOM has the same mix of dependent and independent variables as FIM and solves essentially the same set of prognostic equations. This allows us to make use of the existing FIM dynamic core and of the software engineering innovations built into FIM.

4. **Present state** – We are currently working on step D (separation of barotropic and baroclinc motion). Shown here are sample results from step C (multi-layer, wind-forced model with realistic topography).



*Two figures showing sea surface height (SSH) at the end of a 5-yr spinup of a **4-layer** isopycnic ocean forced by time-invariant zonally averaged zonal wind stress extracted from FIM initial conditions. Horizontal resolution ~120 km (G6). Note high SSH in subtropical anticyclones (purple), lower SSH in eastern tropical Atlantic and Pacific (green), lowest SSH around Antarctica (grey). Speckling in coastal regions indicates that noise associated with massless layers on the shelf is still a problem.*