Ocean Model Development at Colorado State University

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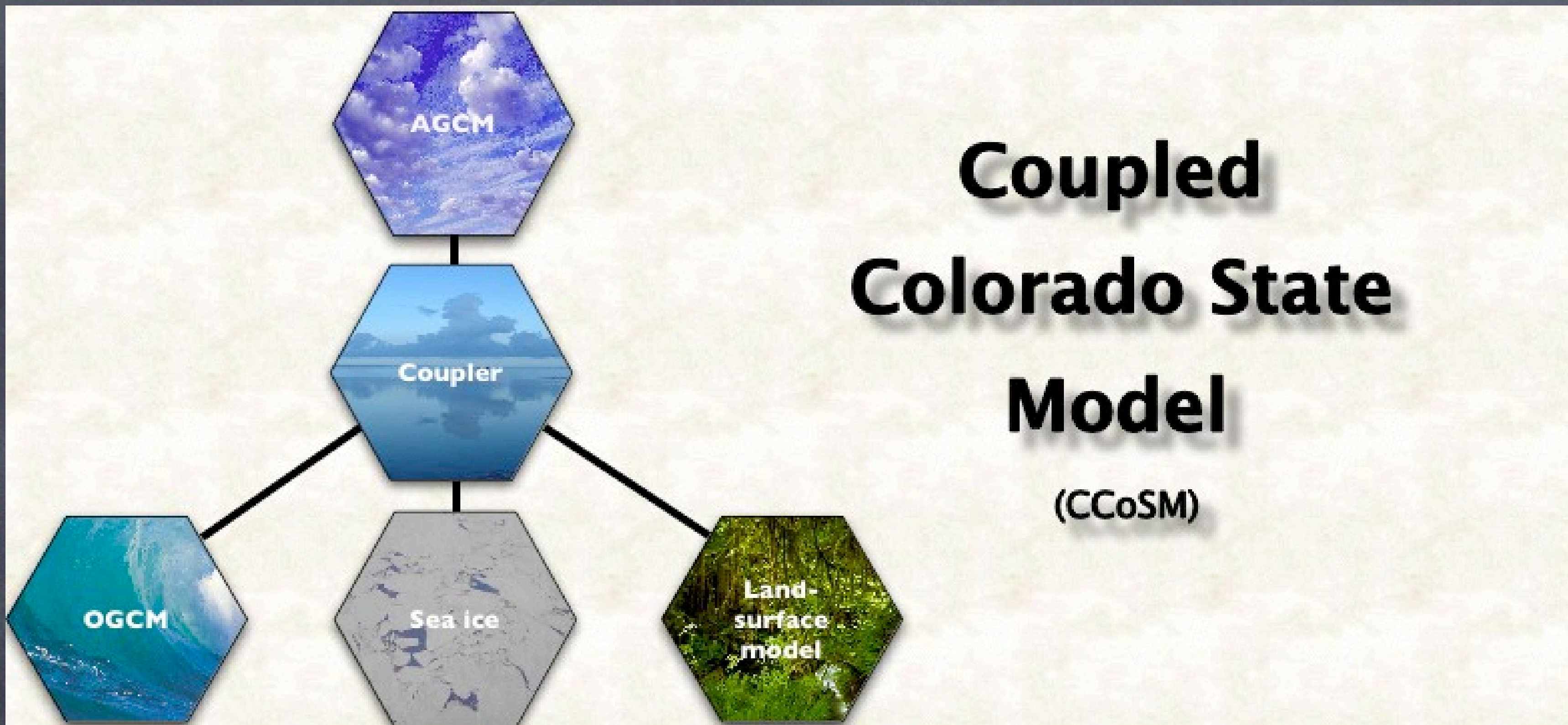
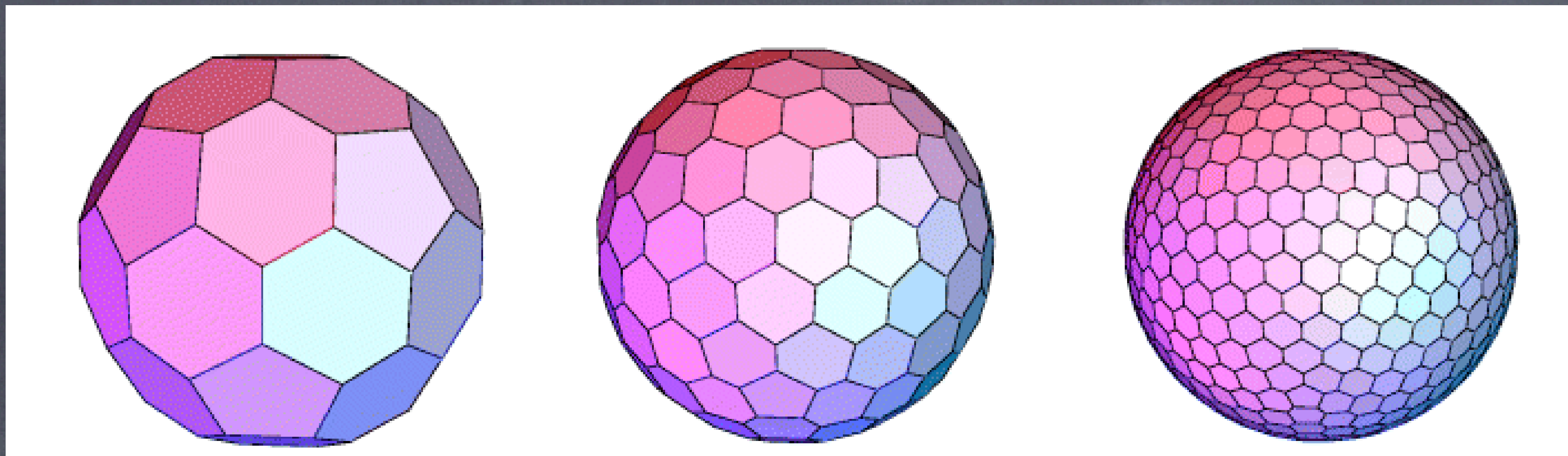
The ocean model development is part of a larger effort to construct a complete coupled climate model.

The guiding principles of this project are to use geodesic grids in all model components, to use floating vertical coordinates where appropriate, and to integrate the develop process across components.



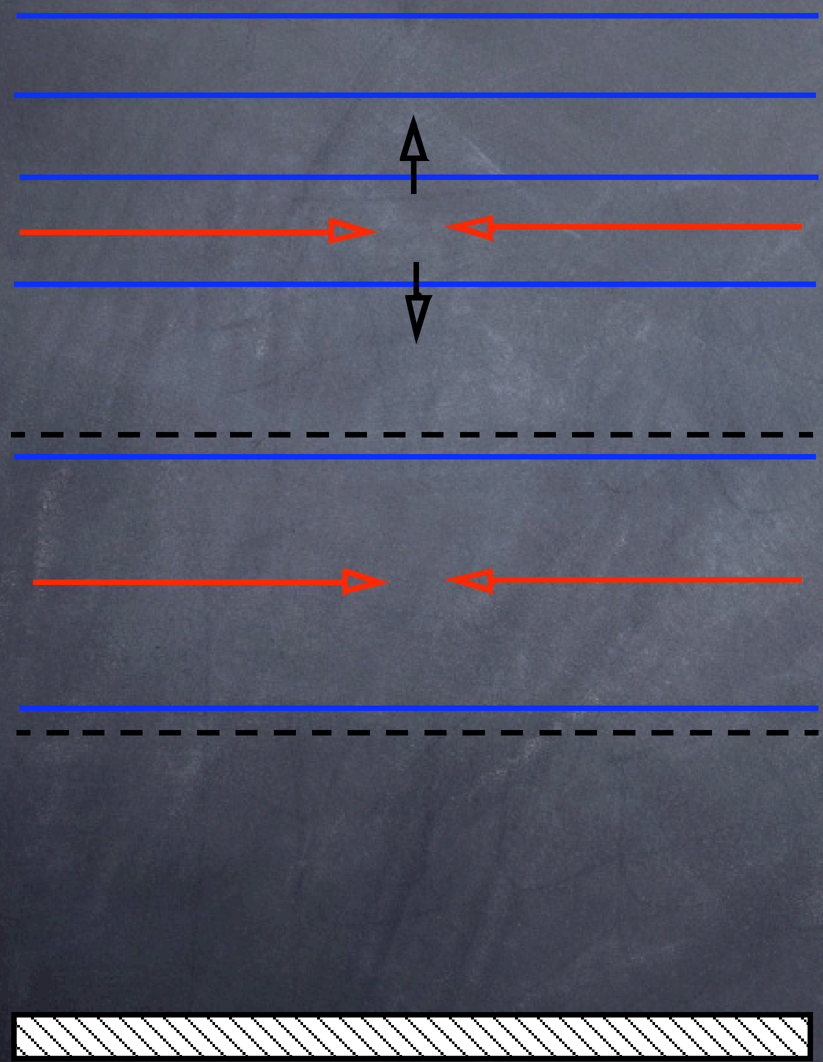
This project includes researchers from CSU, NPS, LANL, and UCLA.



Geodesic grids have several nice properties:

1) no pole problem, regardless of where the land is.
2) quasi-uniform, area varies less than 5% globally.
3) isotropic, superior simulation of geostropic adjustment.
4) uniform, equally applicable to all model components.

The vertical coordinate is chosen to be an Arbitrary Lagrangian Eulerian (ALE) coordinate. Formulated at and adopted from LANL.

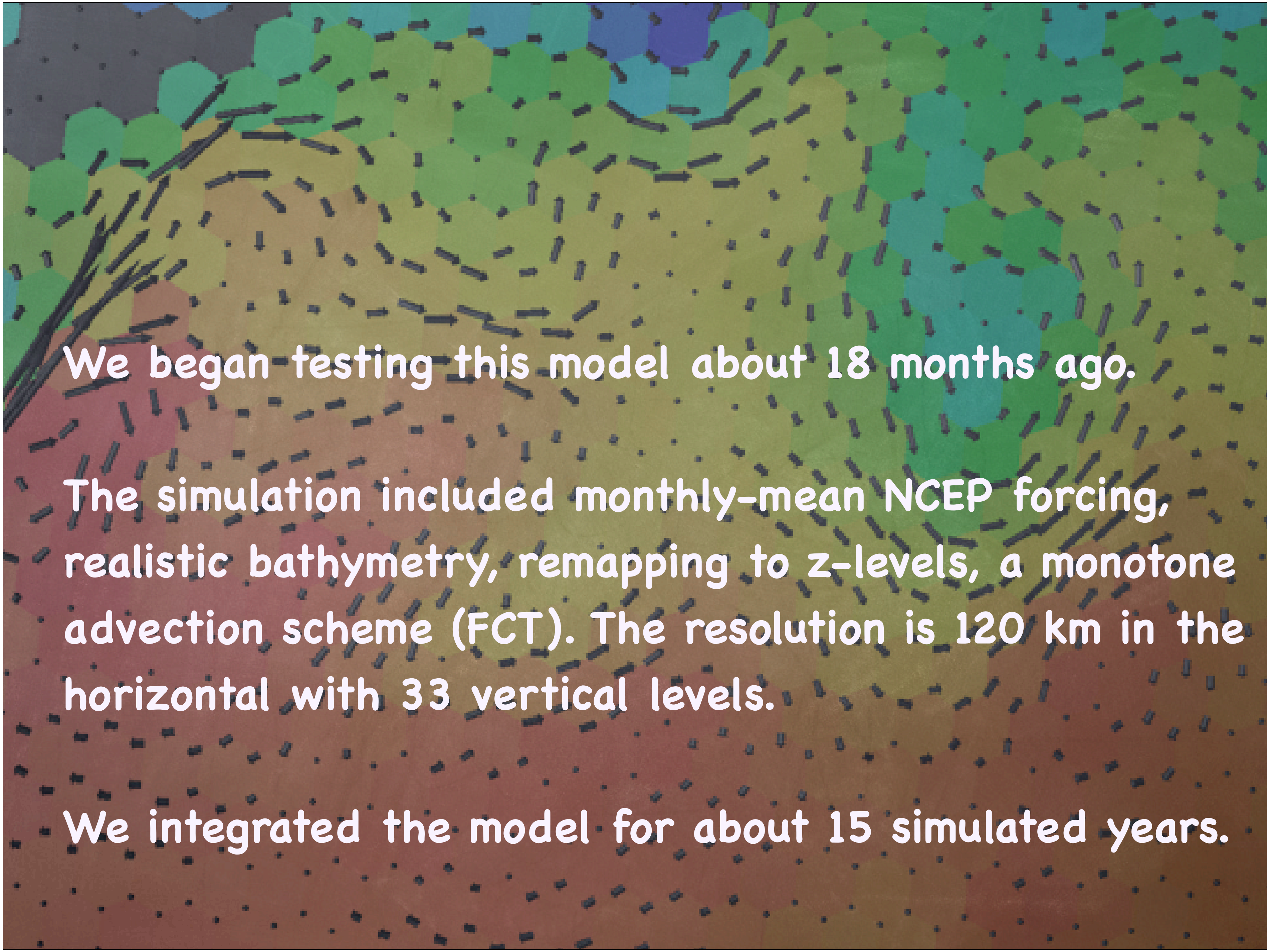


ALE coordinates can mimic fixed z-level Eulerian coordinates by forcing mass across coordinate surfaces to maintain a uniform layer thickness.

Alternatively, ALE coordinates can mimic floating or Lagrangian coordinates by allowing the layer to inflate while requiring zero mass flux across the coordinate surface.

ALE coordinates accommodate any blending of the Eulerian and Lagrangian limits.

Since the vertical coordinate is largely independent of the horizontal discretization, we are working closely with the HYPOP effort in this area.

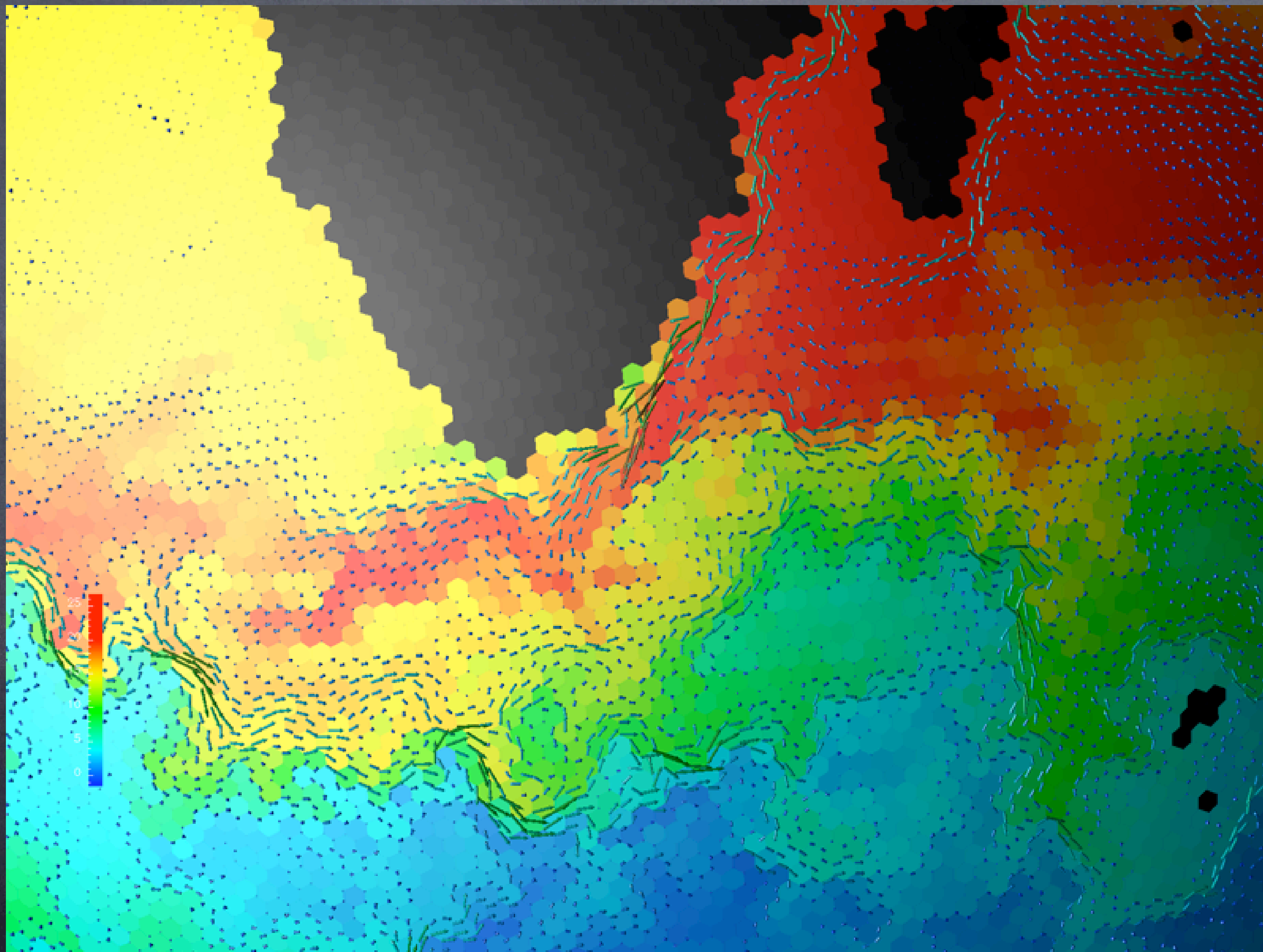


We began testing this model about 18 months ago.

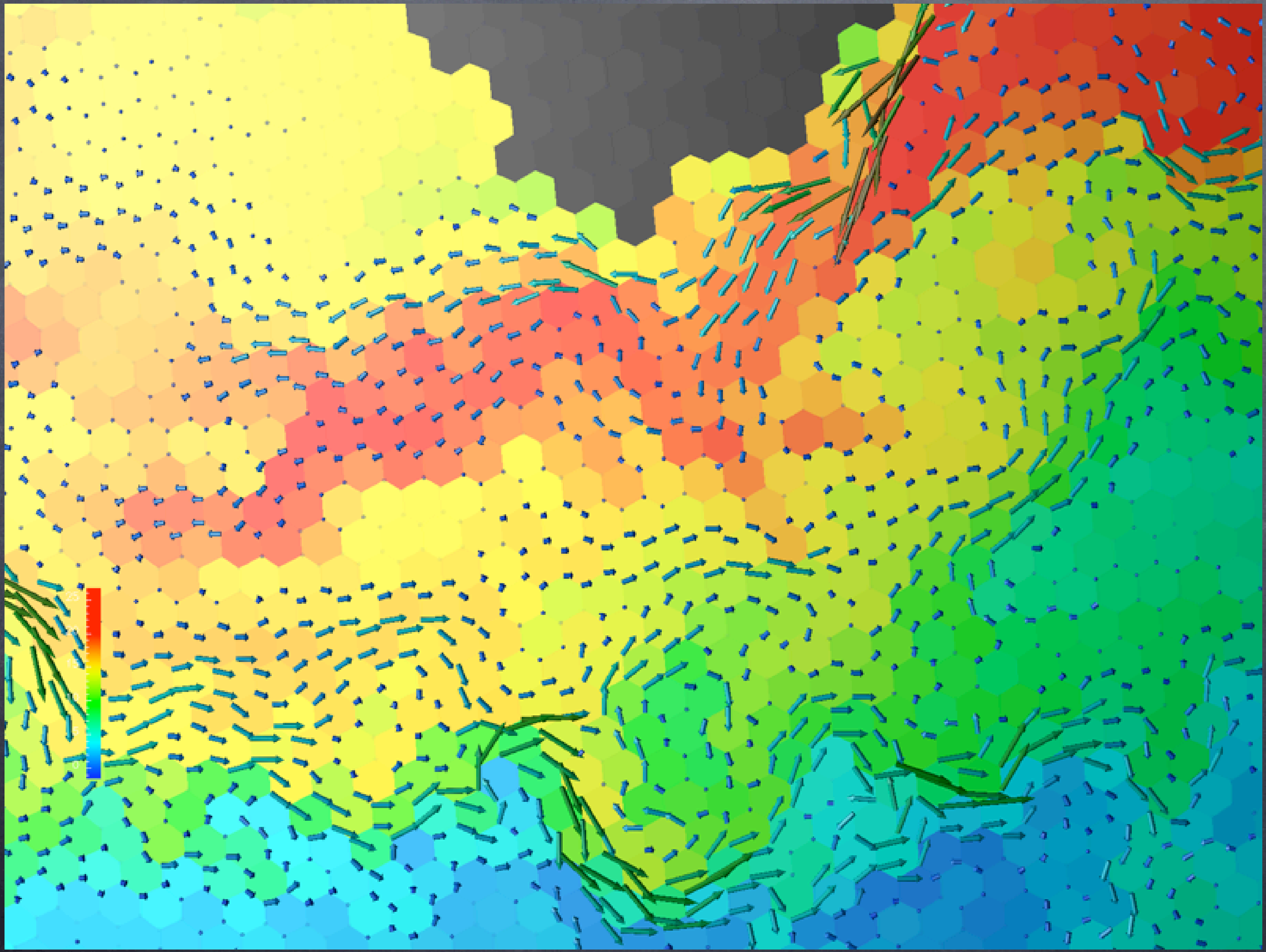
The simulation included monthly-mean NCEP forcing, realistic bathymetry, remapping to z-levels, a monotone advection scheme (FCT). The resolution is 120 km in the horizontal with 33 vertical levels.

We integrated the model for about 15 simulated years.

Global simulation using a 40962 x 33 grid
YR 12, SST and Velocity, 175 m depth



Global simulation using a 40962 x 33 grid
YR 12, SST and Velocity, 175 m depth



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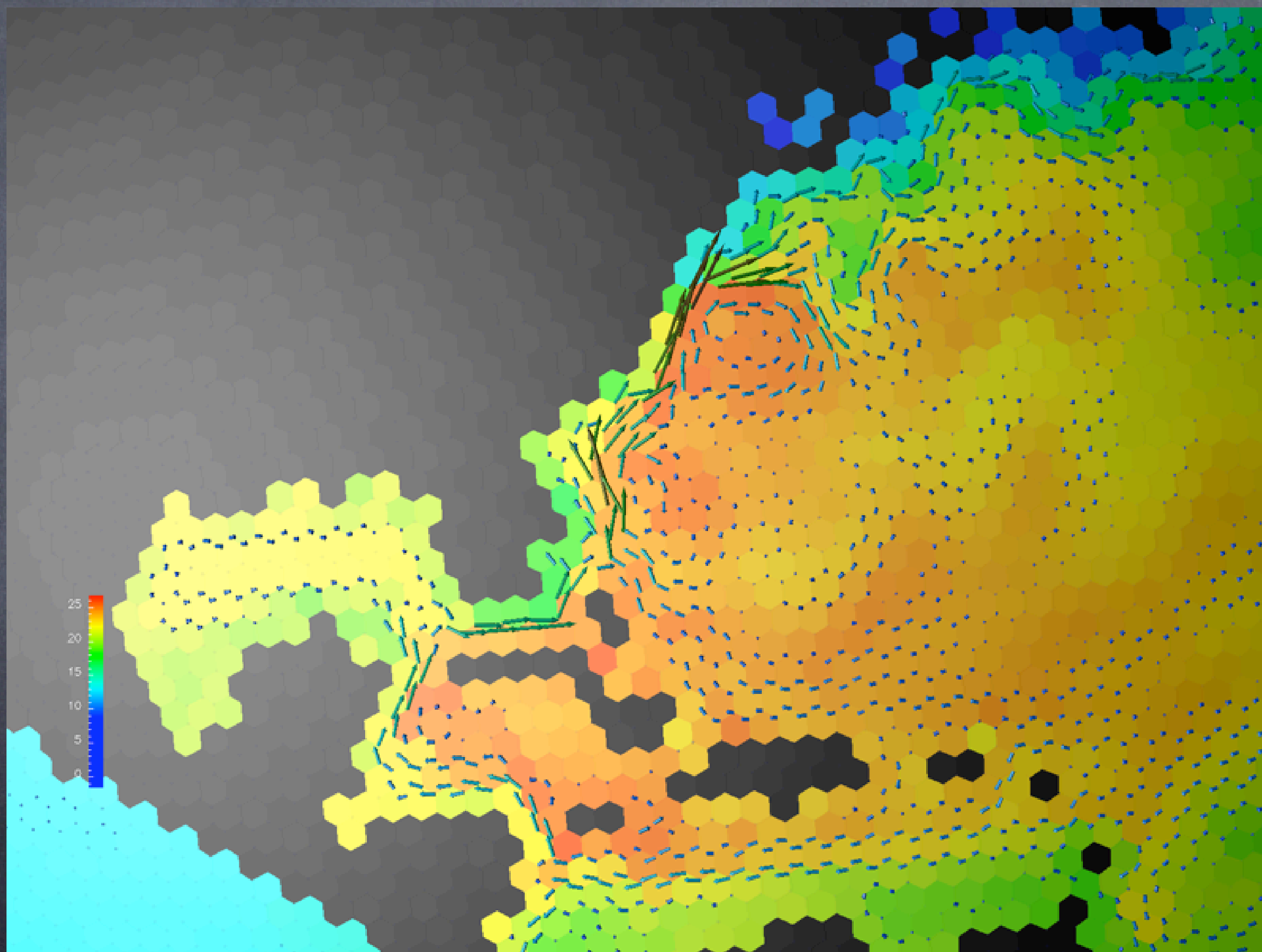
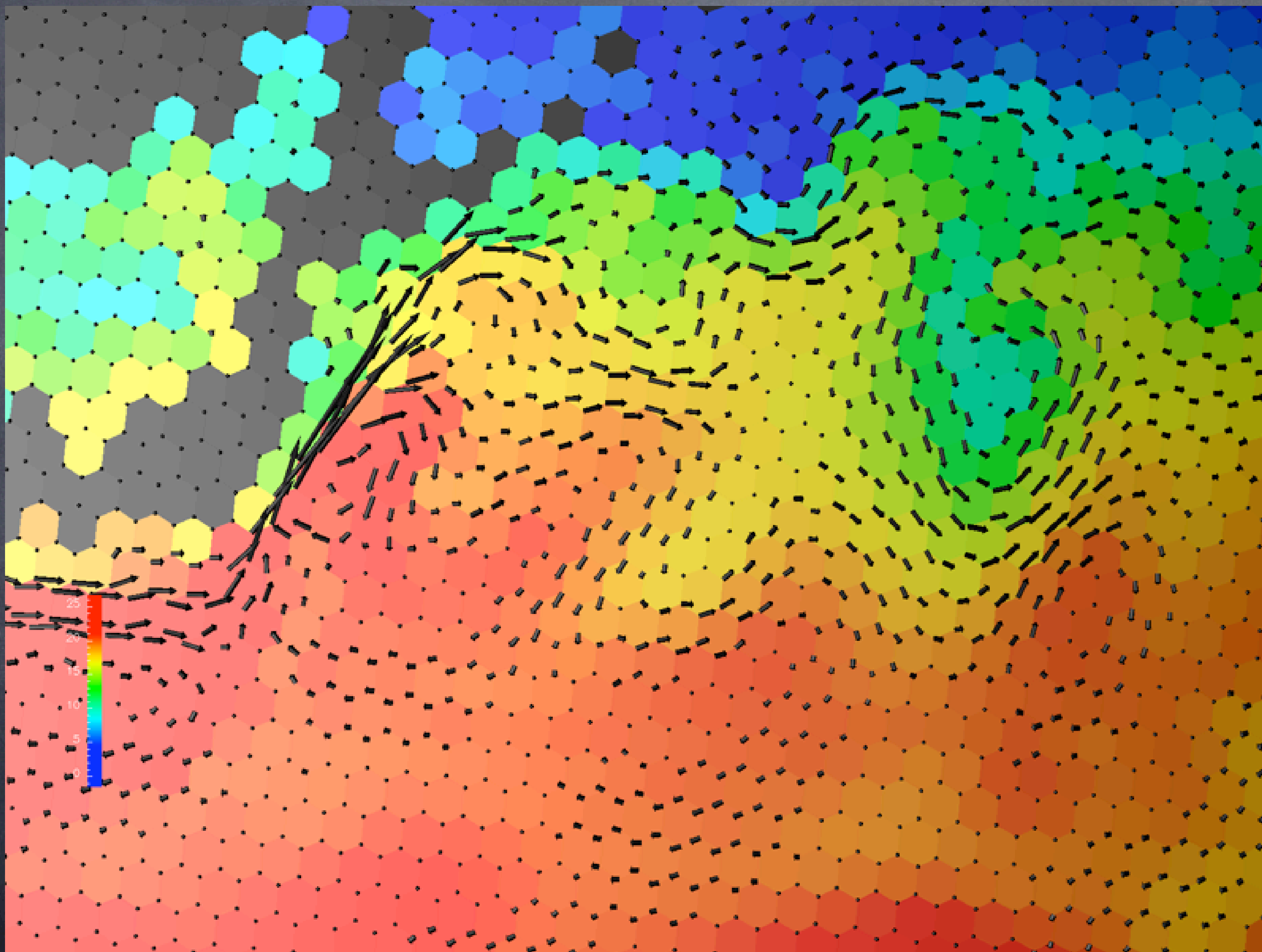


Global simulation using a 40962 x 33 grid

YR 12, SST and Velocity, 175 m depth

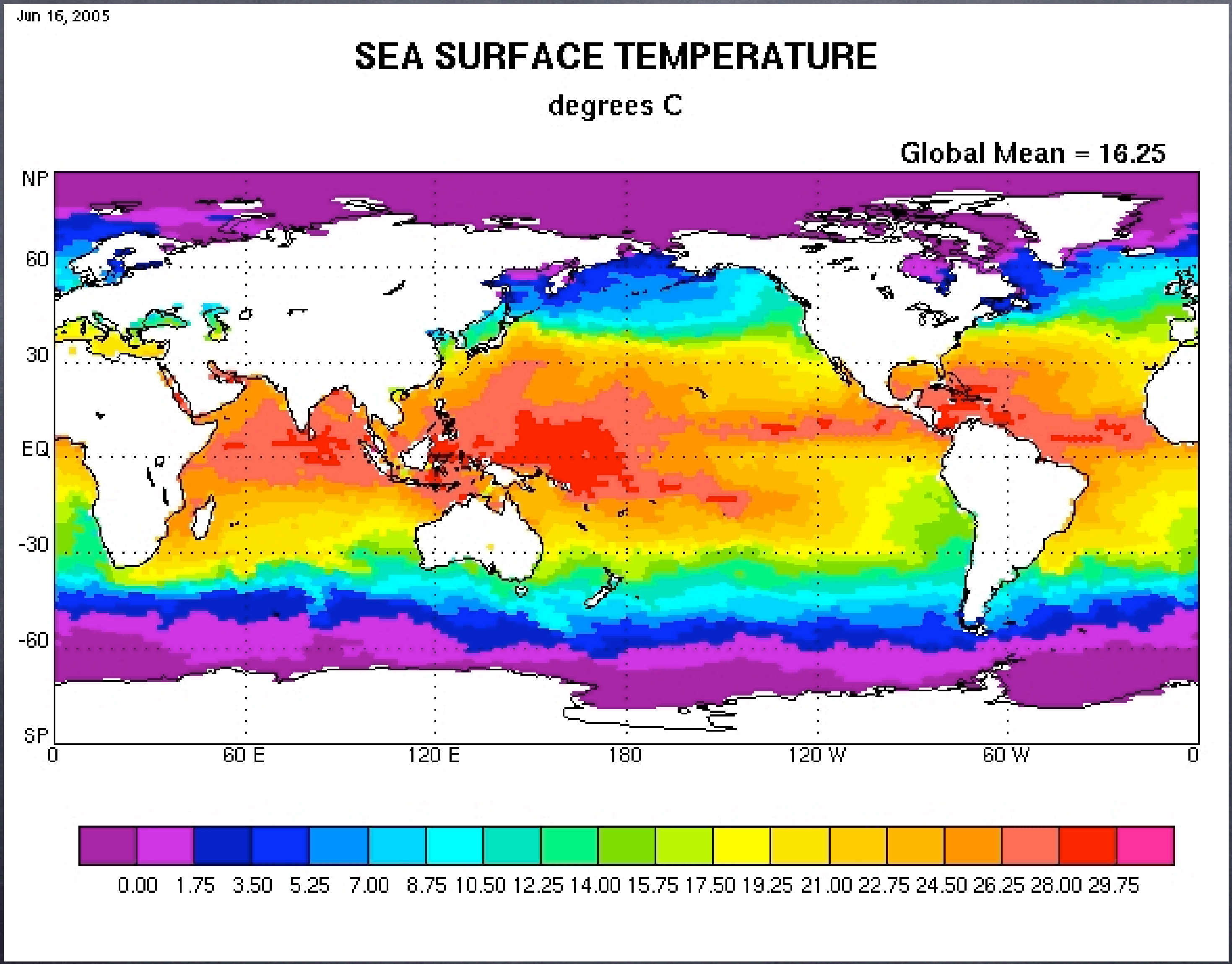


We then moved on and implemented KPP, an updated EOS, and a grid-generator algorithm to maintain isopycnal coordinates at depth. LANL was instrumental in helping us implement these features.

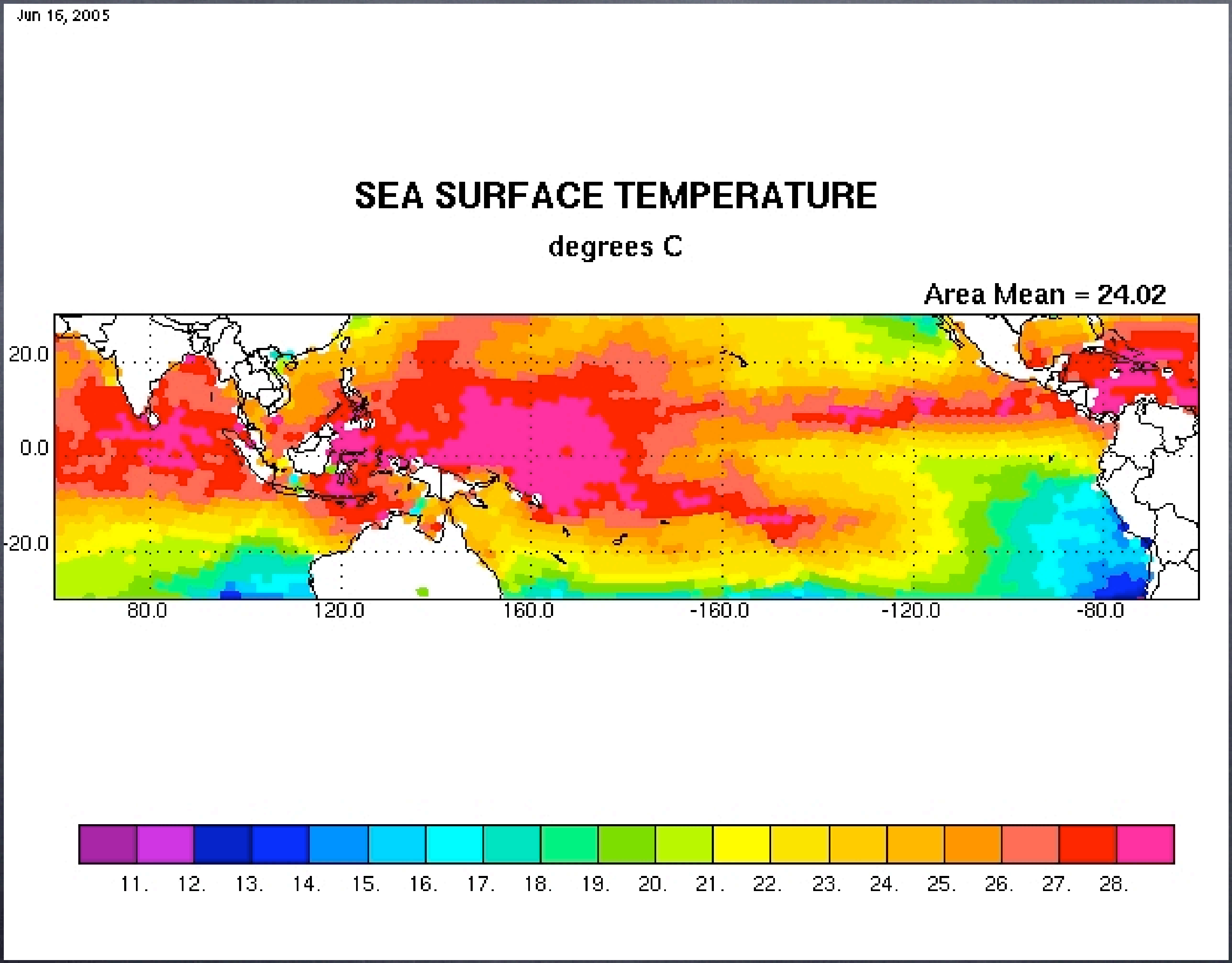
We are now conducting simulations with 6-hourly ECMWF bulk forcing (run through our flux coupler), using realistic bathymetry, remapping to isopycnals at depth, and with a monotone advection scheme (FCT). The resolution is 240 km in the horizontal with 33 vertical levels.

The simulations now include a fully-prognostic sea-ice model developed by Stark, Lipscomb, Ringler and others.

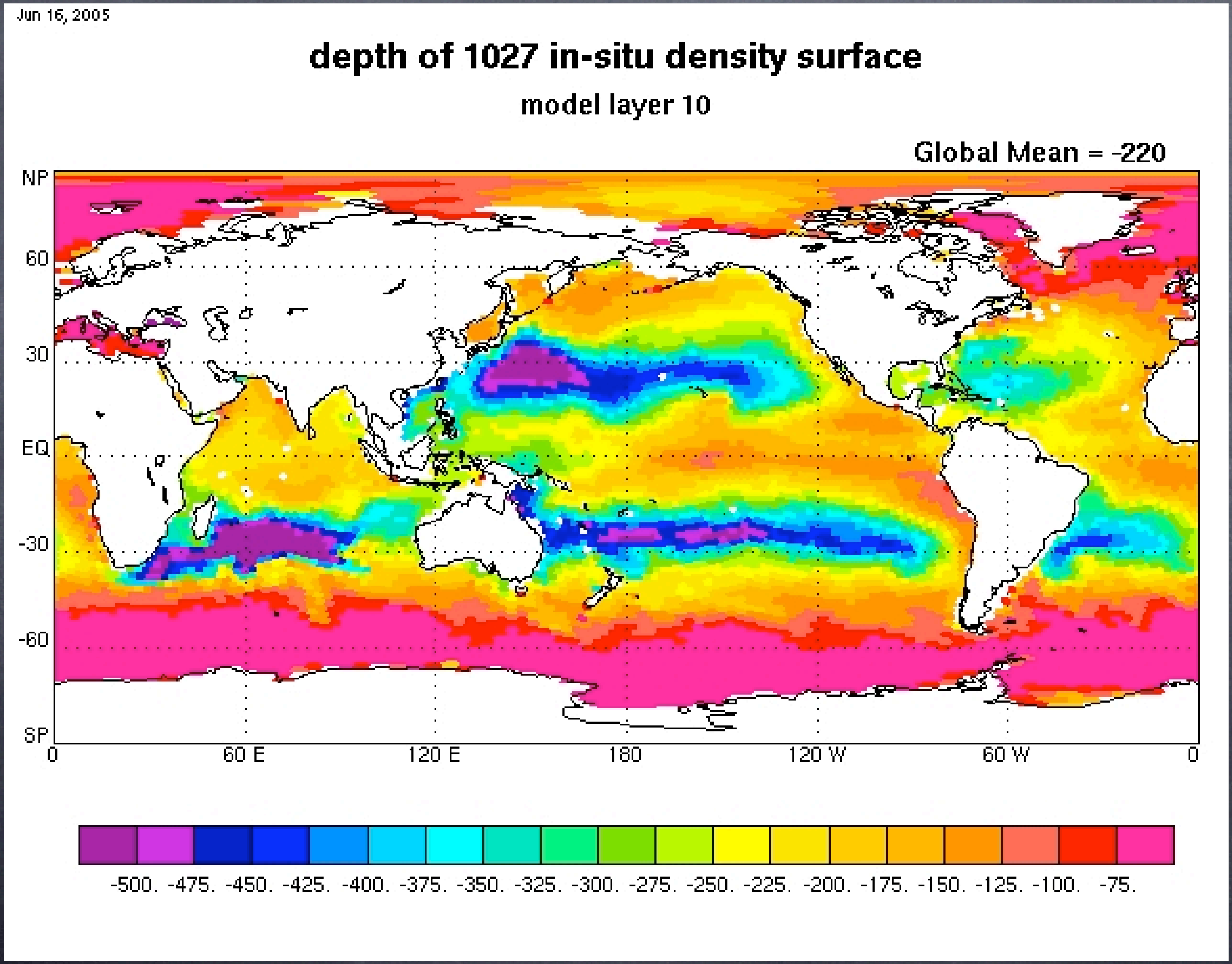
Global simulation using a 10242 x 33 grid near end of year 1



Global simulation using a 10242 x 33 grid near end of year 1



Global simulation using a 10242 x 33 grid near end of year 1



So how might this model fit into the CCSM framework?

In large part this will depend on community interest. We plan to complete the preliminary develop and submit a manuscript summarizing this work by the end of the year.

Parties interested in using this model, or pieces of it, should get in touch with us.

At a minimum, I see this model as adding to the genetic diversity of the ocean model suite.