

Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009



Ocean Modeling Synthesis and Future Directions

Presented by
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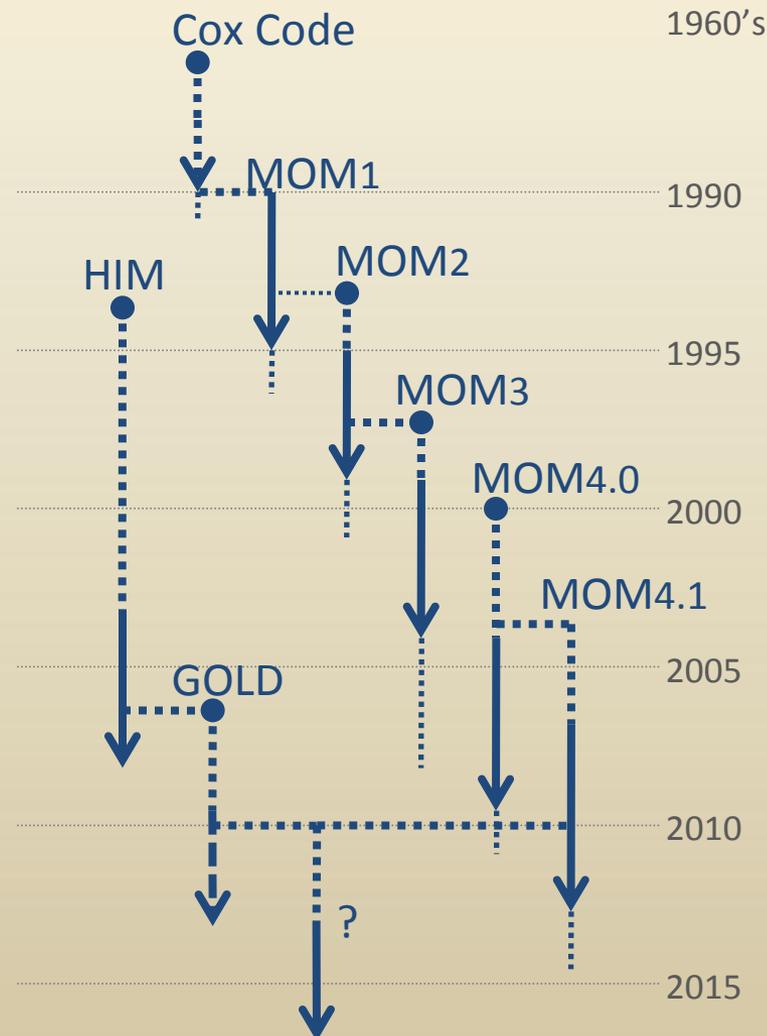
Major GFDL Oceanographic Activities

- 1. Coupled climate model ocean configuration development**
 - GFDL has developed two new state-of-the-art ocean climate models
 - CM2M updates CM2.1 with improved numerics and more physical parameterizations, keeping GFDL at the leading edge of ocean climate modeling
 - CM2G is a true landmark – the first isopycnal coordinate ocean climate model of comparable verisimilitude to its Z-coordinate counterpart
 - The combination of CM2M and CM2G is a powerful tool for increasing our predictive understanding of the ocean's role in climate – a key part of NOAA's mission

Major GFDL Oceanographic Activities

2. Ocean model capability & code development

- GFDL continues to generate significant new innovations in ocean modeling capabilities
 - Builds on a 50-year ocean modeling legacy.
 - Is of widespread value to NOAA's mission and the world
- An orderly synchronization of MOM and GOLD ocean model development efforts within a single unified code base is ongoing



Major GFDL Oceanographic Activities

3. Process studies & parameterization development

- Physically-based parameterizations which can respond to changing ocean conditions are key to credible future climate projections
- With our collaborators, GFDL has made great progress in developing new parameterizations suitable for use in global ocean climate models, based on detailed study of key processes
- Success of the two Ocean Climate Process, resulting in significant improvements to GFDL's ocean climate models, validates the CPT paradigm

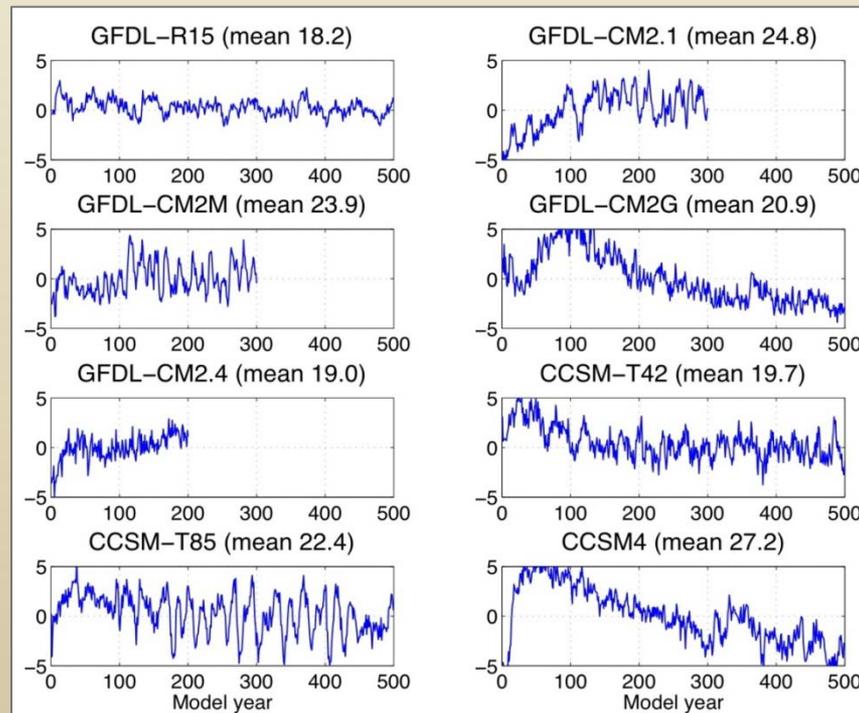
Major GFDL Oceanographic Activities

4. Studies of the ocean's role in climate & paleoclimate

- GFDL pioneered the idea of the long-term overturning ocean circulation as nearly adiabatic, wind-driven and turbulent
- This new paradigm has profound implications for:
 - the fate of anthropogenic heat & carbon
 - the cycling of biogeochemical tracers
 - the nature of the ice-ages
- The full implications of this paradigm shift are still being explored

Grand Questions

- **Eddies:** What is the role of the ocean mesoscale eddy field in the large-scale circulation, and how does this affect climate change, biogeochemistry, and detection & attribution?
- **Overturning:** Is the ocean's overturning (e.g., AMOC, Southern Ocean) well understood based on today's coupled climate models?



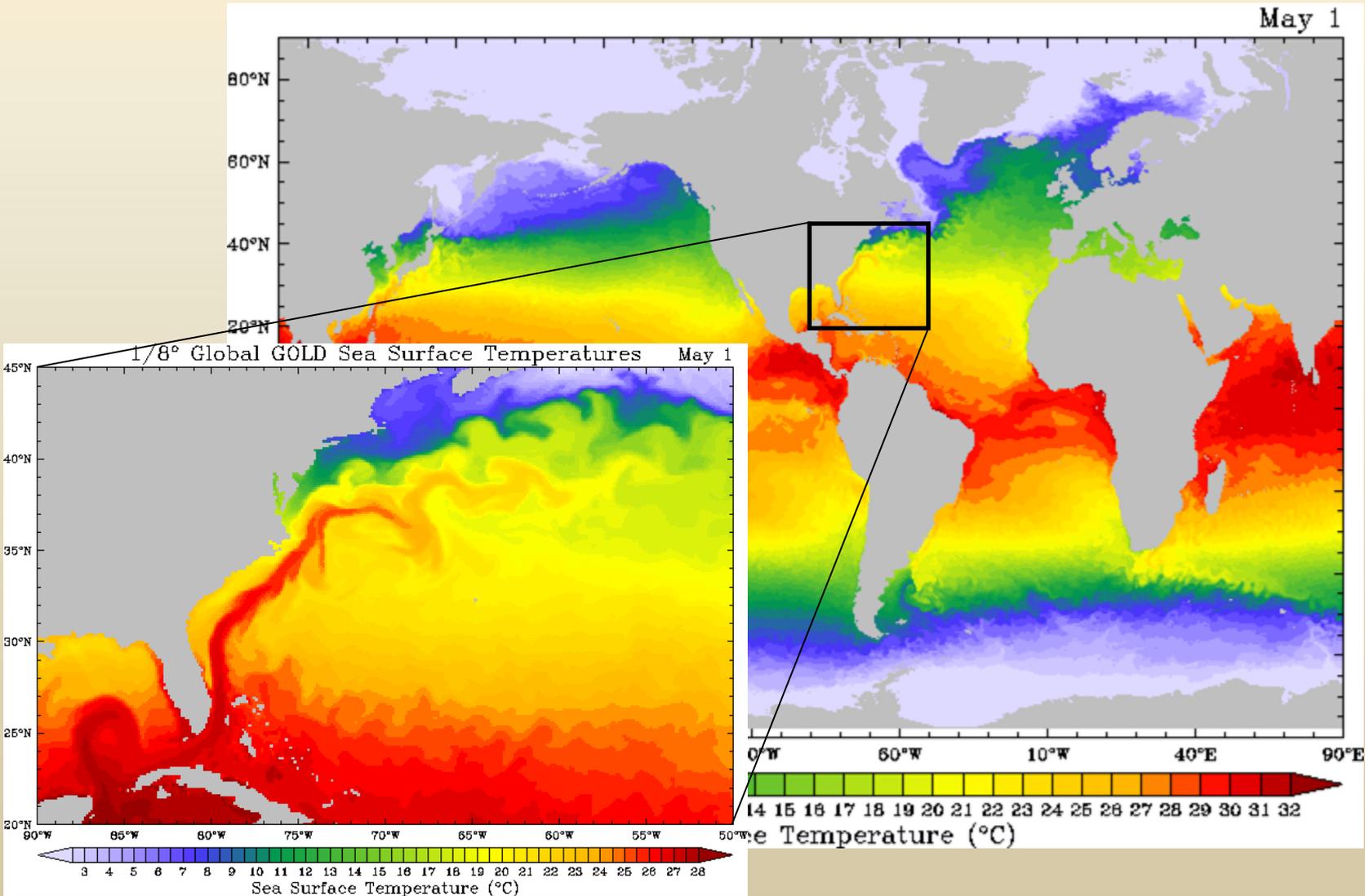
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- **Mixing:** What regulates ocean mixing & watermass structure?
 - Internal wave processes and unresolved 3-D turbulence
 - What are the rectified effects of the tides, and will they change with climate?
- **Sea level:** How quickly will sea level rise globally & regionally?
 - Ocean/ice-sheet interactions
 - Eddy & circulation regulated ocean heat uptake and distribution
 - Non-Boussinesq models for direct simulation

Organizing Activities for Future Work

- Comparative **analysis of CM2M & CM2G**
- Hierarchy of global **high-resolution ocean simulations** ($1/2^\circ$, $1/4^\circ$, $1/8^\circ$, $1/16^\circ$, ...) to resolve key processes, topographic constrictions and coastal waters
- Understanding & physically based representation of small-scale **oceanic processes**
- Credible projections of **sea-level rise**, including effects of ocean-ice interactions
- Continued **development of** cutting-edge climate-relevant **ocean models**, synchronizing current MOM & GOLD efforts in a single code base

Snapshot of SST from 1/8° Prototype Global Ocean Model Based on CM2G



The Need for High-Resolution Ocean Models is Emphasized in the Ocean Research Priorities Plan (NSTC JSOST, 2007)

Numerical ocean models are crucial tools for a wide range of questions (ORPP, p. 47)

- **High resolution global ocean modeling is central to the ORPP's Theme 4: "The Ocean's Role in Climate" and the near-term priority "Assessing Meridional Overturning Circulation Variability"**
 - Resolving the critical processes is crucial for reducing the uncertainty in projections.
 - The insight gained from the Global Ocean Observing System is maximized when the data is interpreted in the context of numerical models.
- **High resolution global ocean simulations are valuable in support of the other 5 ORPP Themes.**
 - Provide consistent boundary conditions for ultrafine regional models.
 - Provide estimates of variability in the conditions faced by ecosystems, marine operations, or processes affecting human health.

NOAA/GFDL is taking the lead in addressing the ORPP call for a coherent, comprehensive global modeling capability, manifest in robust and versatile high-resolution global ocean models.

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