Ocean Code Development at GFDL 2013

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Outline

1. MOM and GOLD development
2. Community ocean Vertical Mixing (CVMix)

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MOM5 and GOLD

- MOM5 (level model)
  - Public release October 2012
  - ~ 15 test cases including CM2.1 (IPCC AR4) and ESM2M (IPCC AR5)
  - Open access on mom-ocean.org with community contributions
  - B + C grid capabilities
- GOLD: Generalized Ocean Layered Dynamics (layered isopycnal model)
  - Public release September 2012 via Google code (http://code.google.com/p/gold-omod/)
  - Successful implementation of global Earth System Model ESM2G (IPCC AR5)
  - Minimal amounts of numerically induced diapycnal mixing (e.g., Ilicak et al, Ocean Modelling 2012)
  - Coupled with idealized ice-sheet/shelf model with moving grounding lines (e.g., Goldberg et al., JGR 2012).

MOM6 ≈ GOLD + MOM5

GFDL ocean code development will unify capabilies from MOM5 with GOLD.

- Motivation
  - Wide range of time scales
    - seasonal
    - decadal
    - centennial
  - Wide range of space scales
    - mesoscale eddy resolving for global climate
    - regional ice shelf - ocean interactions with moving grounding line
  - Increasingly comprehensive coupled models
    - biogeochemistry
    - ecosystems
    - ice shelves
    - surface ocean waves
- MOM6 will employ state of the science numerics and physics key to
  - Respecting integrity of ocean water-masses
  - Capturing transient climate fluctuations
  - Predicting climate variations
  - Projecting future climate change
  - Conservation in presence of moving land-sea boundaries.

Path to MOM6

MOM6 will incorporate GFDL-GOLD's functionality for generalized vertical layers, and will retain a direct link to scientifically important MOM5 configurations (i.e., geopotential/pressure coordinate model applications).

- C-grid with Arbitrary Lagrangian-Eulerian dynamical core
- Conservative wetting/drying
- Subcycling option for tracers to allow for longer time steps
- Suite of level & layer physics
- Wide suite of diagnostic methods (budgets, water mass analysis, etc.)
- Regional applications via open boundary options and hooks to GOTM
- MOM6 touchstone configuration for GFDL climate efforts
  - $1/4^\circ$ pressure-coordinate analog to GFDL-CM2.5 (MOM5)
  - July 2013 internal GFDL release
- Main developers
  - Adcroft: dynamical core
  - Hallberg: dynamical core and physics
  - Griffies: physics and analysis
  - GFDL Modeling Services programmers: software infrastructure
- Full public release TBD

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1 MOM and GOLD development

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Mission

What is our mission?

- Provide transparent, robust, flexible, well documented, shared Fortran code for use in parameterizing ocean vertical mixing processes.
- A consensus of closures that return a vertical diffusivity, viscosity, and possibly a non-local transport, with the closures robust enough to withstand large time steps.
- Fortran modules used in a stand-alone manner or incorporated into ocean models.
- Development within a community of scientists and engineers who make use of CVMix modules for a variety of research needs.
- CVMix modules will be freely distributed under GPLv2 using an open source methodology.

Motivation

Why we are considering this project?

- Scientists at GFDL, LANL, and NCAR are overwhelmed with the needs of developing global model configurations using state-of-the-science physical parameterizations.
  - We wish to share the load for physical parameterization coding/testing.
- Shared parameterizations in various model configurations will facilitate understanding model differences.
  - Facilitate moving beyond the “show-and-tell” phase of CMIP and CORE.
  - Understanding model differences at the process level is key to improving climate models.

Vision

What is our vision?

- Scientists will share code used to parameterize ocean vertical mixing, providing added scrutiny to the code integrity and allowing for easier comparison of various parameterizations.
- Process modelers will incorporate new parameterizations into CVMix to optimize distribution of their ideas to the wider research community.
- Research will be stimulated by availability of schemes for testing in a suite of process and large-scale models.
- As CVMix matures, it will be followed by community code for lateral parameterizations, such as mesoscale and submesoscale eddy schemes.

Why not GOTM?

Why not use GOTM?[1]

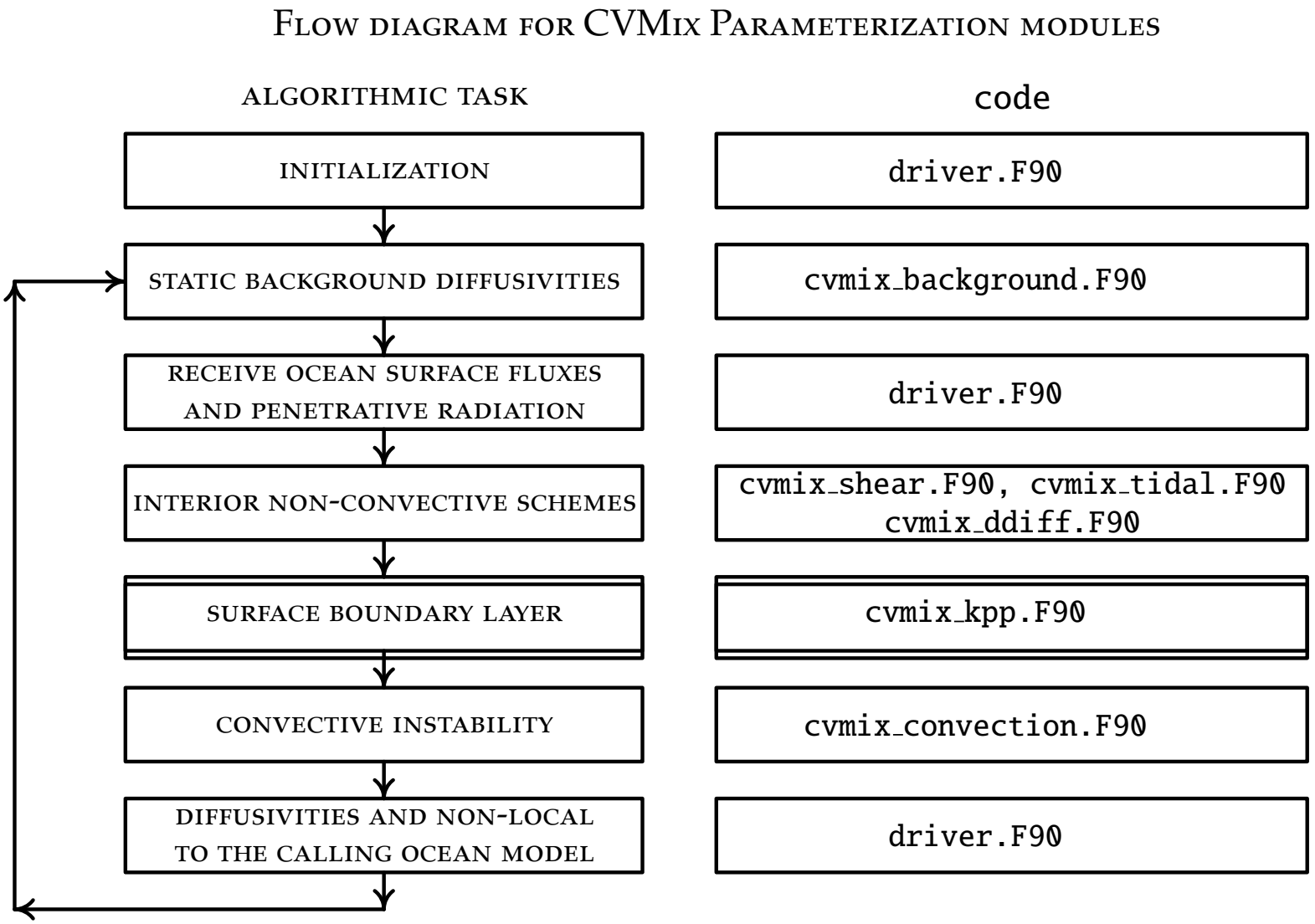
- Scientific Focus
  - CVMix focuses on closures used in the climate community.
  - GOTM focuses on higher order closures used in the coastal community.
- Control
  - We wish to control the aims and methods used for CVMix code.
- Understanding
  - Understanding of code comes best through doing the work oneself.
- Sharing experience and code may come
  - As CVMix matures, there will be opportunities to share experience and code with GOTM or other related projects.

[1] GOTM (General Ocean Turbulence Model) includes a suite of first and higher order closures for vertical mixing. It has been embraced by the coastal ocean modeling community.

Phase I CVMix parameterizations

- Static background mixing:
  - Bryan-Lewis (1979)
  - Henyey et al. (1986)
  - Schemes used in Jochum (2009)
- Shear induced mixing:
  - Pacanowski and Philander (1981)
  - Large et al (1994)
  - Jackson et al (2008)
- Tidally induced mixing:
  - internal tides: Simmons et al (2004) and Melet et al (2013)
  - bottom mixing: Legg et al (2006)
- Double diffusive processes:
  - as in Large et al (1994) and updates
- KPP surface boundary layer:
  - as in Large et al (1994) and updates (refactured relative to present implementations)
- Vertical convective mixing:
  - enhanced diffusivity with $N^2 < 0$

Flow diagram



The developers

Who are the active developers?

- Core team:
  - Mike Levy (NCAR): software engineer and chief hands-on programmer
  - Stephen Griffies (GFDL): MOM liason & physics/numerics documentation
  - Alistair Adcroft (GFDL): MOM liason
  - Bob Hallberg (GFDL): MOM liason
  - Gokhan Danabasoglu (NCAR): POP liason
  - Todd Ringler (LANL): MPAS liason
- Commitment from GFDL, LANL, and NCAR
  - To incorporate CVMix code to their new model configurations (MOM6, MPAS-ocean, and POP).
  - We anticipate all interested modelers at GFDL, LANL, and NCAR will have direct input to CVMix software, numerics, and physics.
  - We hope that over time, further input will ensue from the broader community.

Milestones

- Mar 2013:
  - Proto-type driver design
  - Implementation of Bryan-Lewis and Pacanowski/Philander
  - Use of CVMix versions of Pacanowski/Philander in POP and MPAS-ocean
- Jun 2013:
  - Initial implementation of KPP
  - Incorporation of double diffusion, tide mixing, and CVMix-KPP (boundary layer portion) to POP, MPAS, and MOM6
  - Theory and numerics documentation
- Dec 2013:
  - Public release of CVMix Phase I
  - Those wishing to participate as a developer before public release should contact me.