Model Development for GFDL's Next Generation Climate and Earth System Models

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Geophysical Fluid Dynamics Laboratory Review

May 20 – May 22, 2014

GFDL Model Development diversified after AR4

CM2 (CMIP3/AR4 model) evolved in numerous directions in past 8 years

• ESM2M,ESM2G	carbon cycle, ocean model
• CM2.1, FLOR	seasonal-decadal initialized forecasts
• CM3	aerosols, chemistry, stratosphere
• HiRAM	high resolution, tropical storms
• CM2.5, CM2.6	high resolution coupled models

GFDL Strategic Science Plan, 2011:

endorsed goal of high resolution Earth System Model combining strengths of GFDL's diverse modeling streams

Diversification => consolidation => diversification => …….

GFDL has a Model Development Team (MDT)

Goal of the MDT:

In the 2013-2016 time frame, design and develop GFDL's best attempt at a climate model suitable for

a) projection of climate change up to several hundred years into the future,

b) attribution of climate change over the past century,

c) prediction on seasonal to decadal time scales

keeping in mind the needs for improved regional climate information and assessments of diverse climate impacts.

The model will be capable of running from emissions in regard to both the carbon cycle and aerosols.

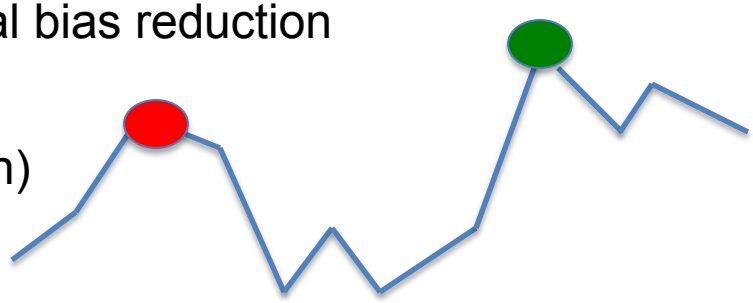
Initial Considerations

Where do we start?

Want to give some young GFDLers the opportunity to develop ideas that might result In significant advances in modeling

Need balance between innovation and incremental bias reduction

(keep in mind the roughness of the fitness function)

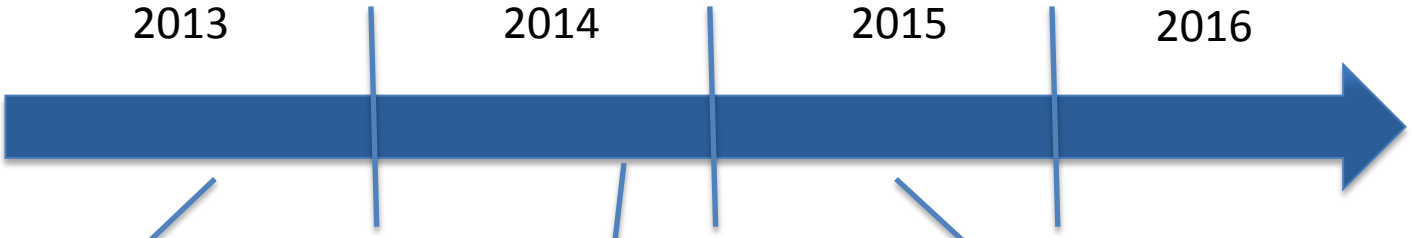


Initial focus on physical climate systems:

- Focus in the atmosphere on clouds/convection
- Focus in the ocean on new dynamical framework – MOM6

- Chose to start with an atmosphere combining features of AM3 and HiRAM

MDT Timeline



Atmosphere/Land development in AMIP mode
MOM6 CM2.-5-like config
Exploratory atmos-ocean coupling
Atmos physics code cleanup

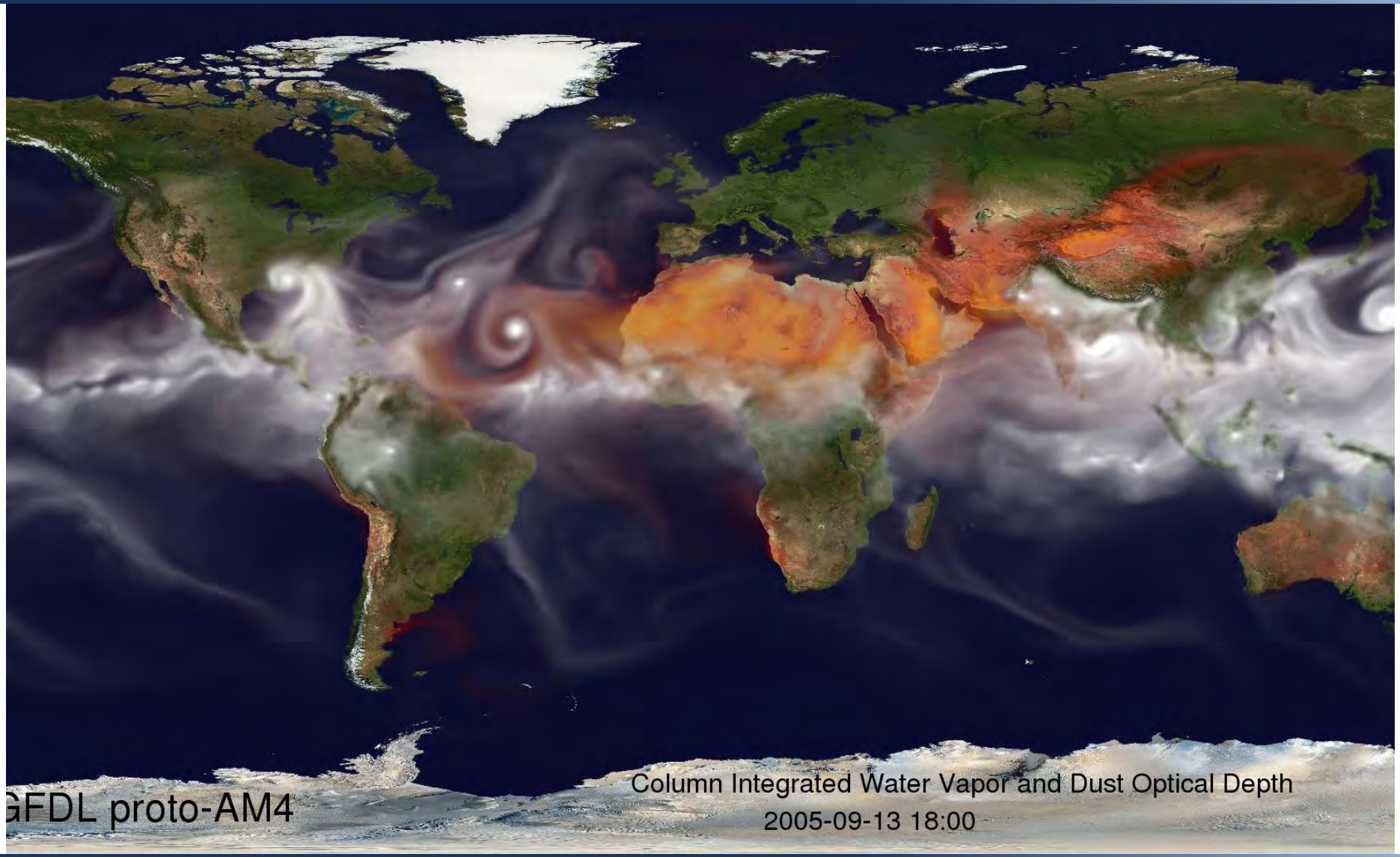
Continued physical model development
Carbon cycle, ocean biogeo, etc
Alternative resolutions

Continued Atmos/Land development AMIP and coupled mode
MOM6 configurations + mesoscale eddy closures

MDT structure:

- Steering Committee
- Working Groups (Atmosphere, Ocean most active initially)
- Diagnostic and Evaluation Team

Example of capabilities we are working towards:
Aerosols plus hurricanes: [dust (orange) and column water vapor (white)]



New model configurations

Target horizontal resolution for CM4/ESM4:
50 km atmosphere + ¼ degree ocean (MOM6)

determined by

1) Lab's experience regarding resources needed to develop and utilize a model for centennial-scale climate projections:
at least 5 years/day throughput on no more than 1/8 of computational resource

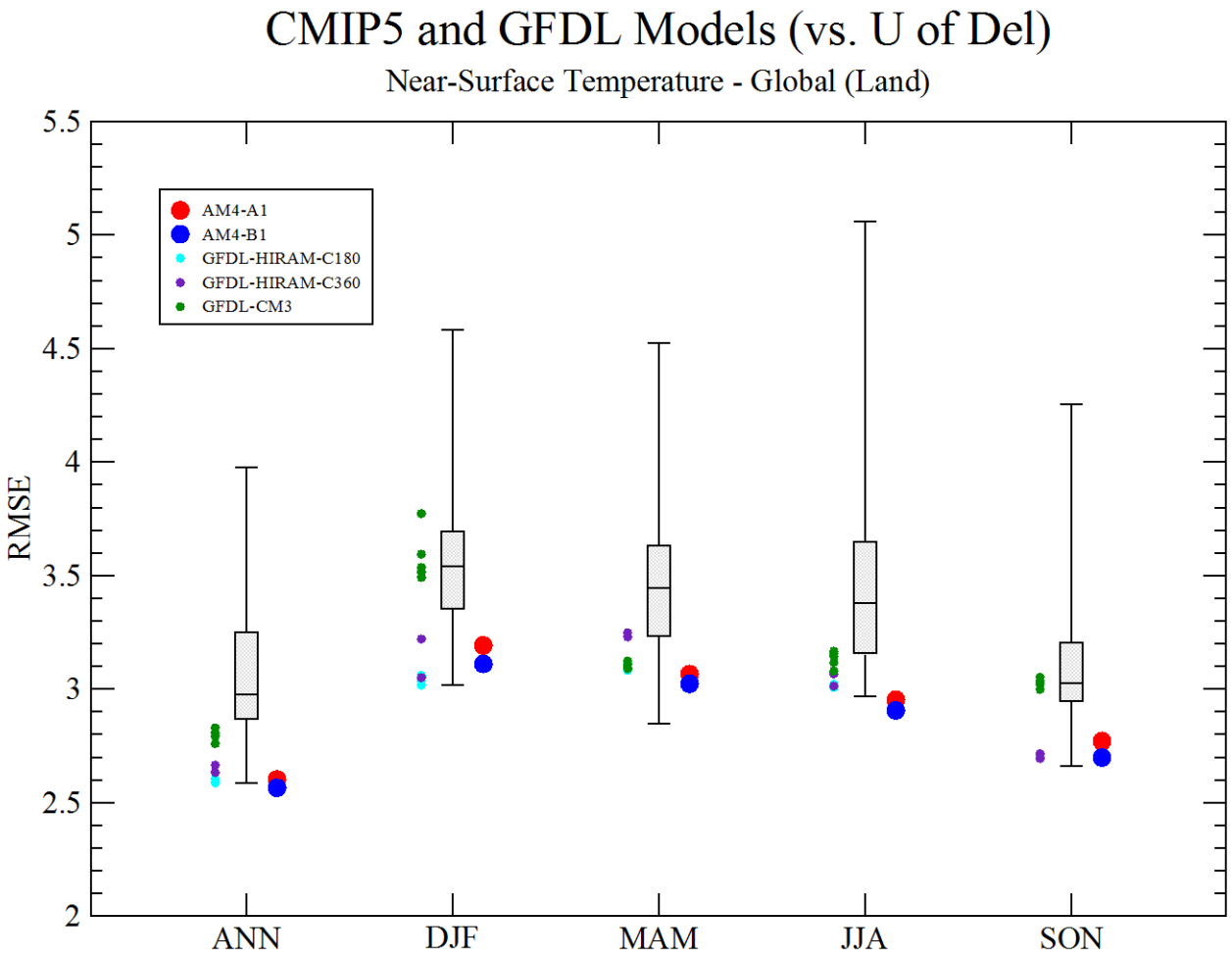
2) Existing computational resources

Will also be building

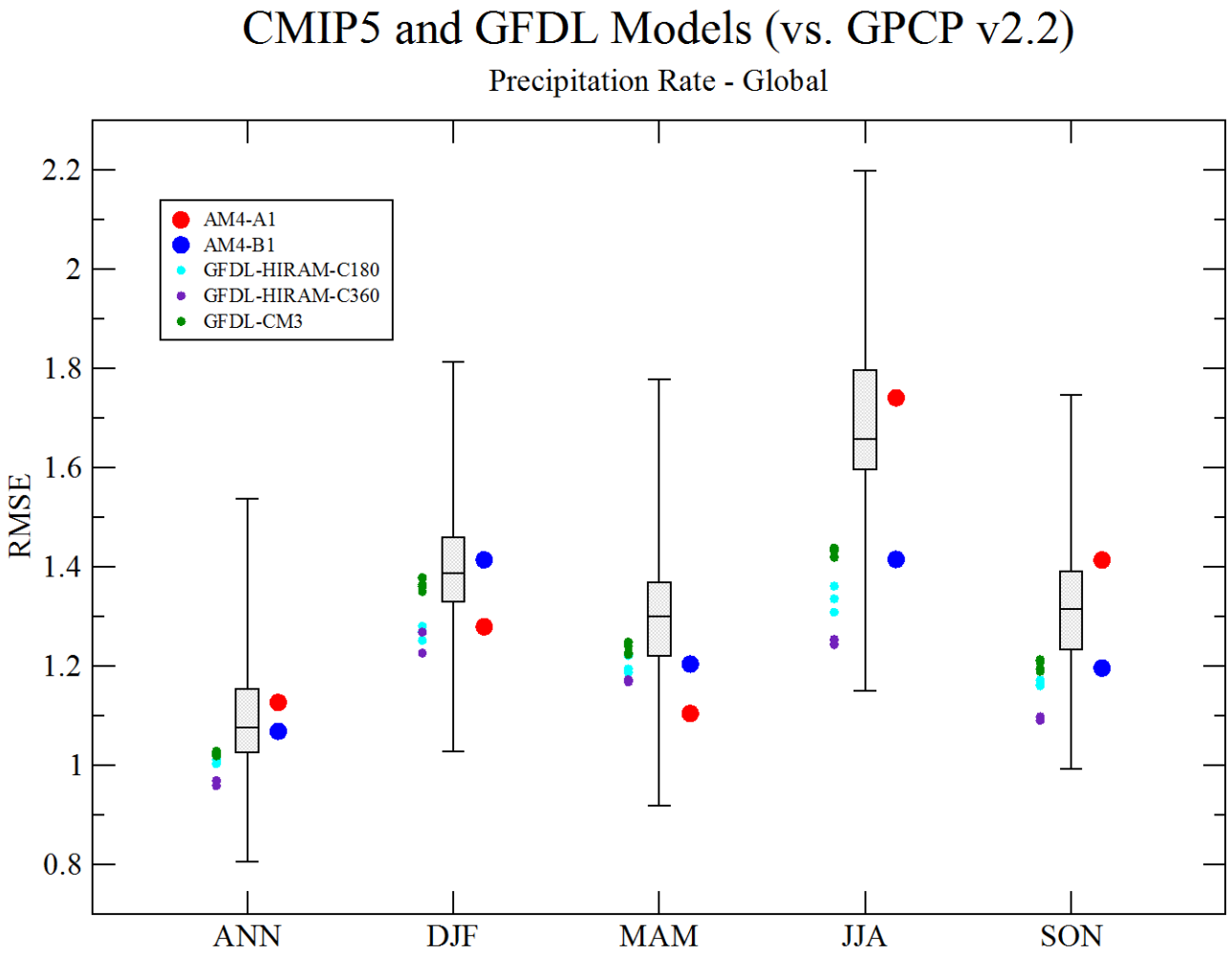
50km atmosphere + 1 degree ocean

100km atmosphere + 1/4 degree ocean

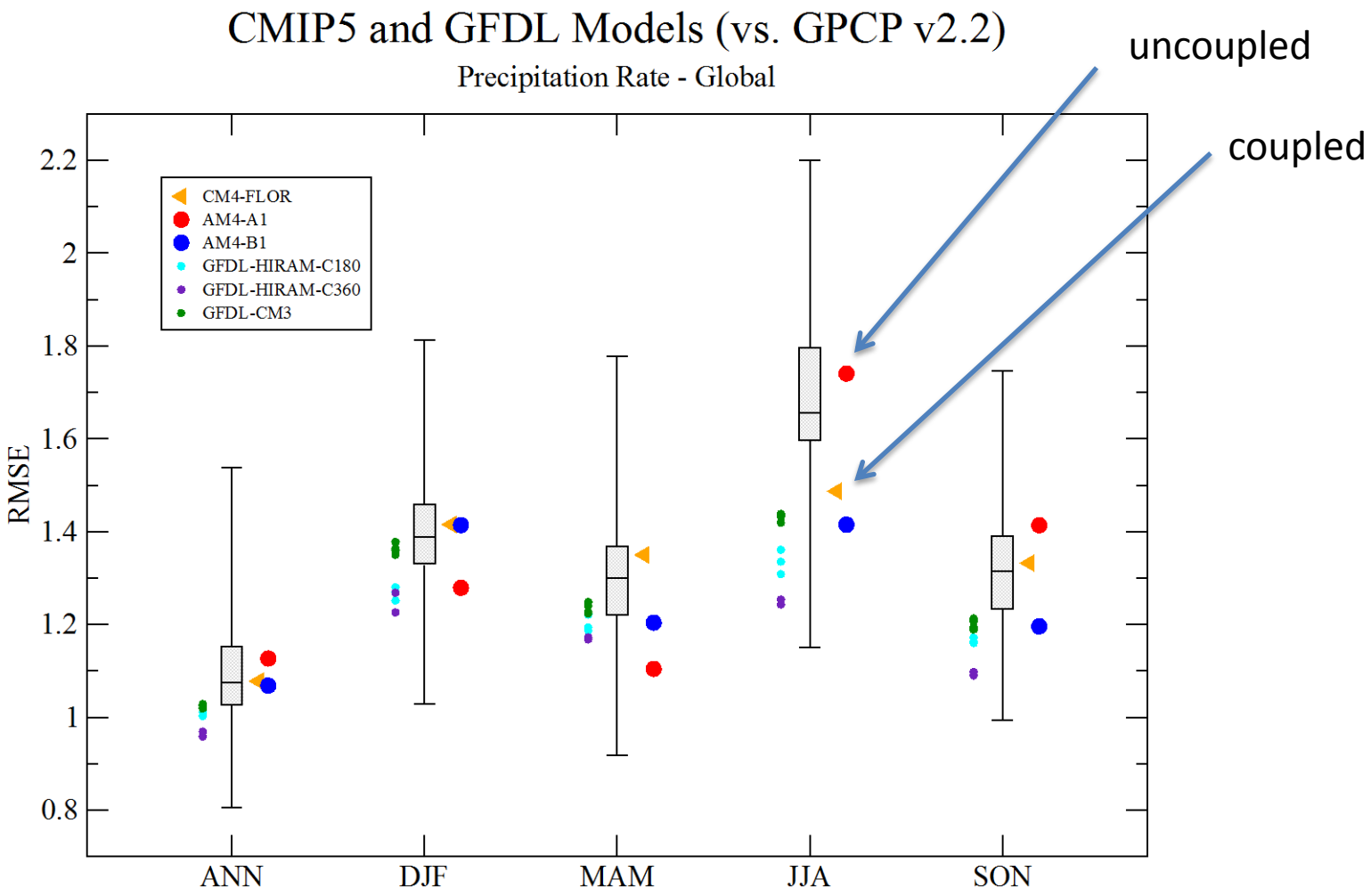
Example of comparison with CMIP5 AMIP Models: near surface air temperature



Example of comparison with CMIP5 AMIP Models: precipitation



Example of comparison with CMIP5 AMIP Models: coupling can improve the precipitation simulation – Why?



A Few of the challenges facing MDT

- Oceanic mesoscale eddies

Can we make a ¼ degree model look like an eddy-resolving model (CM2.6)?

- Aerosol/cloud interactions + cloud feedbacks

How do we best combine bottom-up (process-oriented) perspective and top-down constraints provided by 20th century observations?

- Atmospheric boundary layer/low cloud feedbacks

Are we in a position to incorporate a dramatically new type of boundary layer/shallow convection module similar to CLUBB?

- Software

Can we find more concurrency to improve wall clock performance so that we can increase comprehensiveness/resolution relevant to MDT goals

Summary

Development of new trunk model for GFDL – CM4/ESM4 – underway

Confident that this effort will consolidate gains made in the various modeling branches currently active within the lab

Quality of proto-AM4 simulations very encouraging
(Golaz and Zhao talks to follow)

First simulations coupled to MOM6 currently underway
(Adcroft talk to follow)

Development of new land hydrology, ecology/biogeochemical cycles on land and in ocean described in other sessions
(Milly, Dunne, Shevliakova, etc …)