Development of GFDL's next generation IPCC-class model

Presented by Isaac Held
for the Model Development Team

Frontiers in Climate and Earth System Modeling: Advancing the Science

Geophysical Fluid Dynamics Laboratory

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Model development diversified after AR4

CM2 (our AR4 model) evolved in numerous directions in past 7 years:

ESM2M, ESM2G:	carbon cycle
CM2.1 + data assimilation:	seasonal-decadal initialized forecasts
CM3:	aerosols, indirect effect, chemistry
HiRAM:	hi res atmosphere, tropical storms
CM2.5	hi res coupled model

5-10 year Strategic Science Plan, 2011:

endorsed goal of high resolution Earth System Model combining strengths of GFDL's multiple AR5 modeling streams

GFDL has formed a new Model Development Team (MDT)

Goal of the MDT

In the 2013-2016 time frame, we will 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.

MDT taps into large fraction of Lab's expertise

New MDT established in Dec 2012:

Steering Committee:
Isaac Held
Shian-Jiann Lin
Ron Stouffer
Rong Zhang
Steve Griffies
Yi Ming
V. Balaji
V. Ramaswamy (ex officio)

Working Group Leads

Chris Golaz	(Atmos)
Ming Zhao	(Atmos)
Alistair Adcroft	(Oceans)
Elena Shevliakova	(Land)
Chris Milly	(Land)

Diagnostic and Evaluation Team Heads:
Larry Horowitz, John Krasting

+ many other very active working group members

New model configurations are being tested

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

Determined by

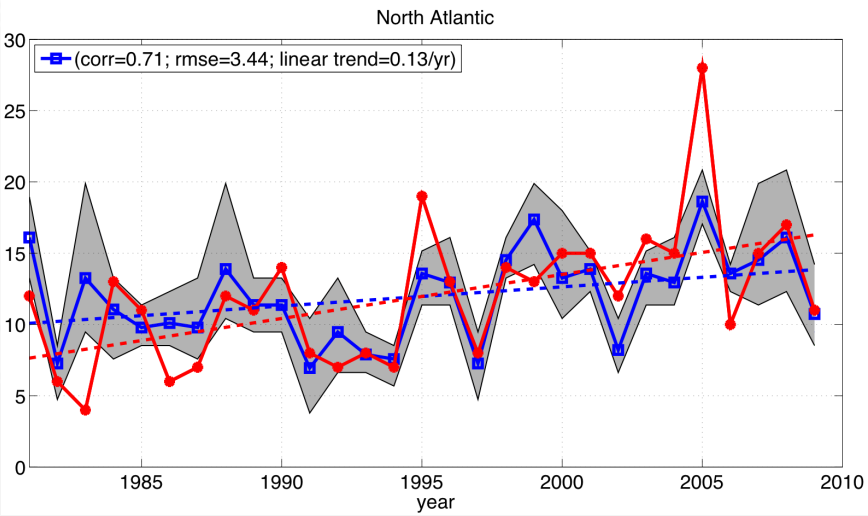
1) Lab's experience regarding resources needed to develop and utilize a model for centennial-scale climate projections:
at least 3-5 years/day throughput on no more than 1/8 of computational resource

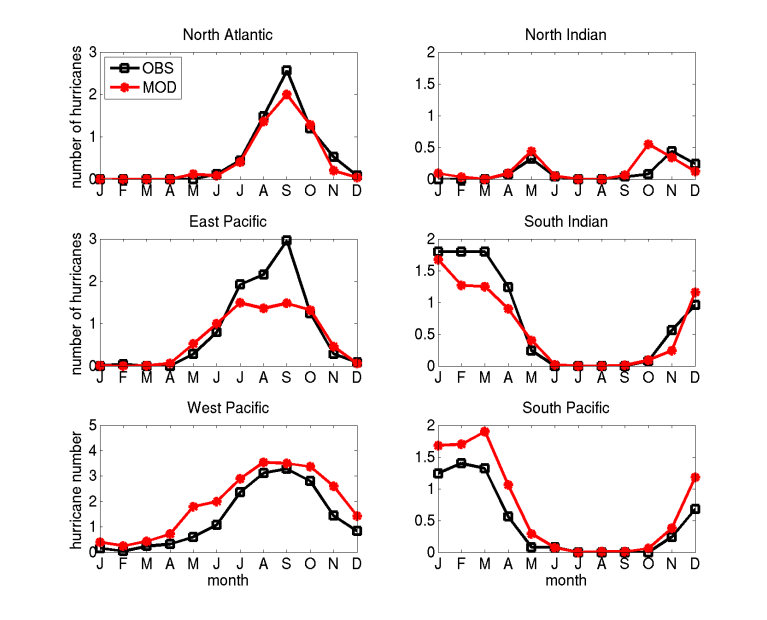
2) the GAEA computational resource

Increases in hardware resources and significant software development would allow us to redefine this trunk model towards higher resolution and/or greater comprehensiveness, e.g. full eddy-resolving ocean resolution; more complete stratosphere/troposphere chemistry module

Our AR5 models have redefined our metrics

HiRAM Atmosphere/land 50 km model
S-J- Lin, Ming Zhao





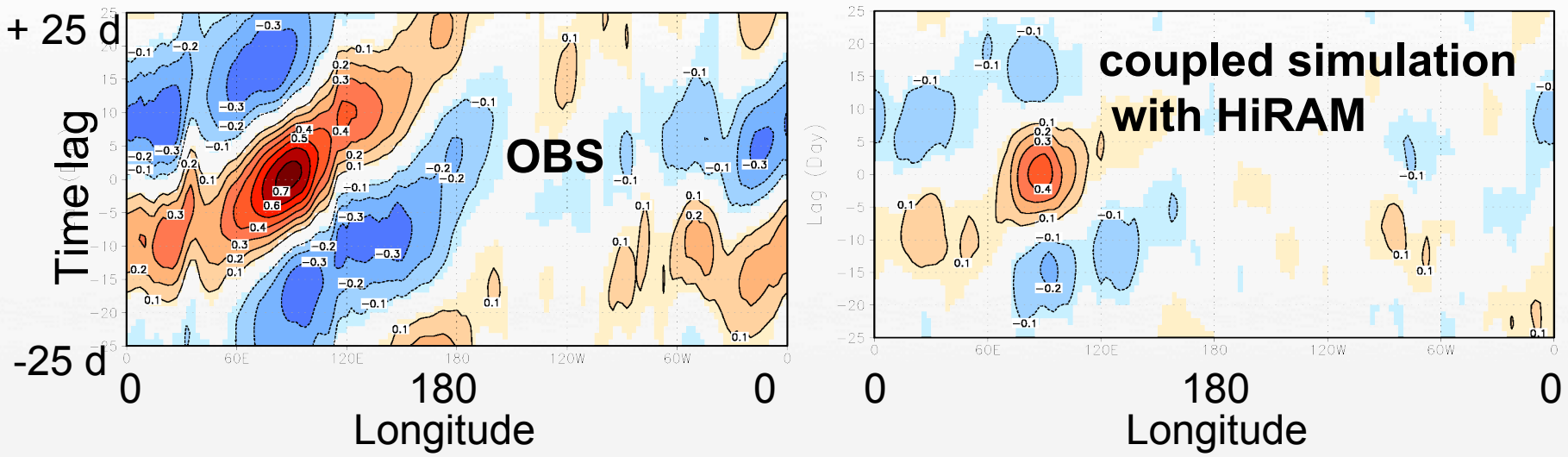
tropical cyclones in North Atlantic over last 30 years

Seasonal cycle of hurricanes in different ocean basins

Example: Hurricane frequency

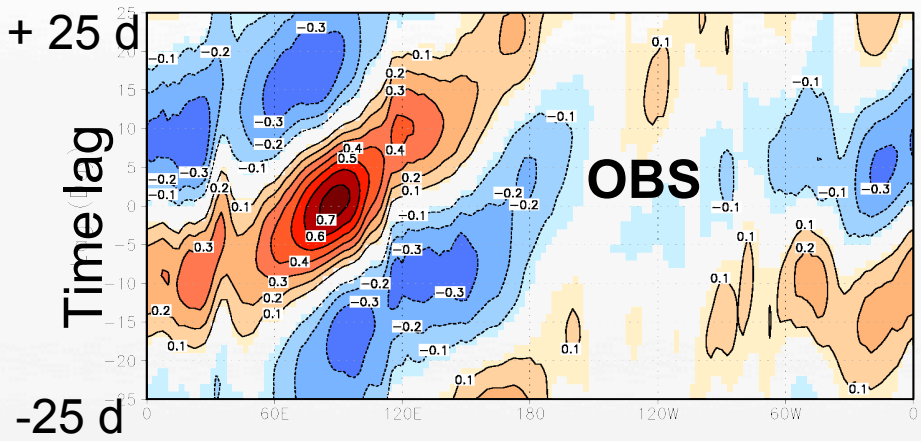
Example of important metric: Madden-Julian Oscillation(MJO)

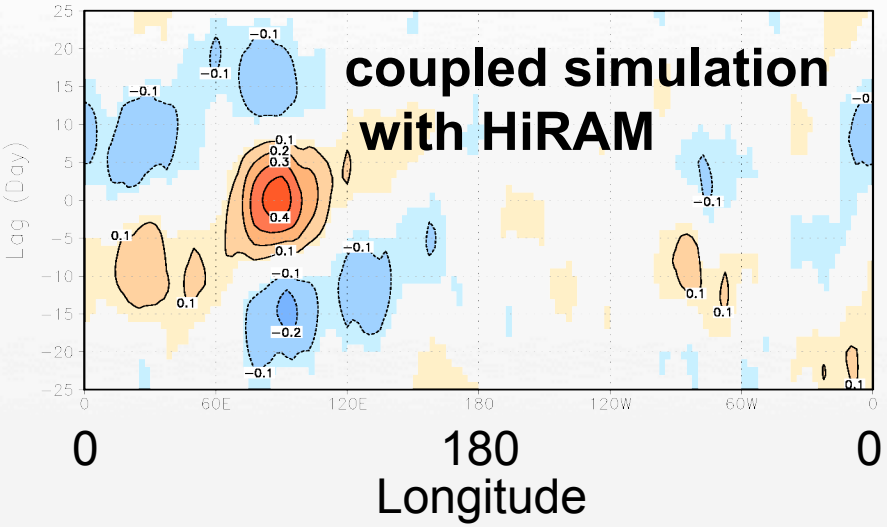
Equatorial outgoing longwave radiation; correlation(time lag, longitude)
(US CLIVAR MJO standard diagnostic)

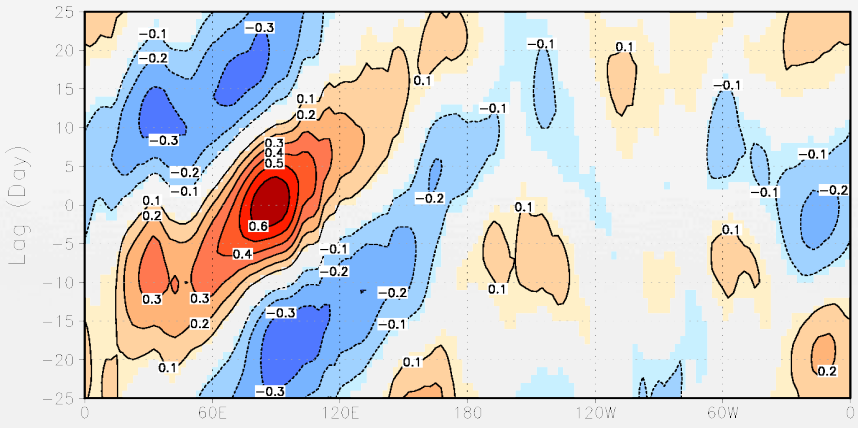


Recent progress: MJO in new atmospheric configuration

Equatorial outgoing longwave radiation; correlation(time lag, longitude)
(US CLIVAR MJO standard diagnostic)







coupled simulation with alternative convection scheme (Ming Zhao)

A few examples of challenges facing the MDT

Oceanic mesoscale eddies

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

Aerosol/cloud interactions

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 complexity/resolution relevant to MDT goals

Challenges for the MDT and GFDL

How do we entrain as much of the Lab's expertise as possible into the MDT process without impacting individual and small group initiatives?

How do we best entrain expertise outside of the lab into model development? (Climate Process Teams have been helpful, especially on oceanic side)

How do we balance the need for interim models of more immediately utility with developments that have much longer gestation times

How do we optimize new software development/new hardware both for expanding our "trunk" model and for research with very different resolutions/complexity/ensemble sizes