

Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009



Atmospheric Dynamics – Introduction and Overview

Presented by
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Major themes and questions weaving through this section:

Can we improve regional climate change projections?

Development of high resolution atmospheric models to date is very encouraging.

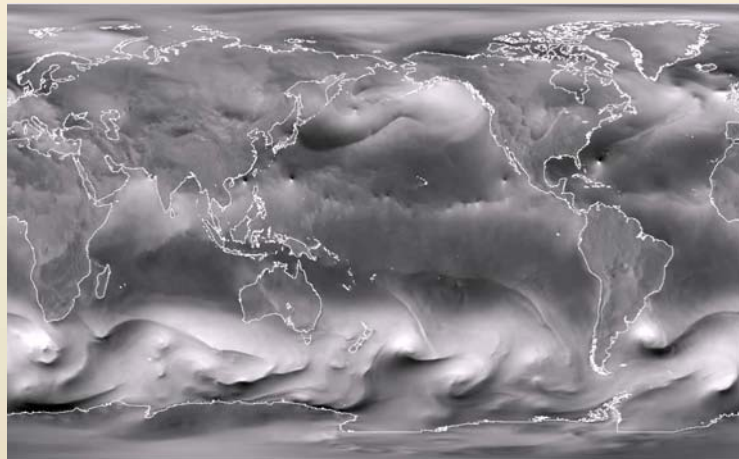
Can our models provide useful projections of changes in extreme weather events?

We are making rapid progress on the effects of warming on tropical cyclones.

How does research into atmospheric dynamics interface with our model development process?

Several examples illustrate the importance of these connections.

A variety of high resolution atmospheric models are under development



**Cn => cubed-sphere grid with
n x n points in each face of cube**

HIRAM2.1

C90/100km

C180/50km

C360/25km

hydrostatic

non-hydrostatic

C720/13km

C2000/5km

Alternative sub-grid closures
being actively pursued
to optimize model at
different resolutions

M180 AM2.1/LM2 (NARCCAP)
=> C90 and C180 AM2.1/LM3

Lin, Zhao, Wyman, Held, Lau, ...

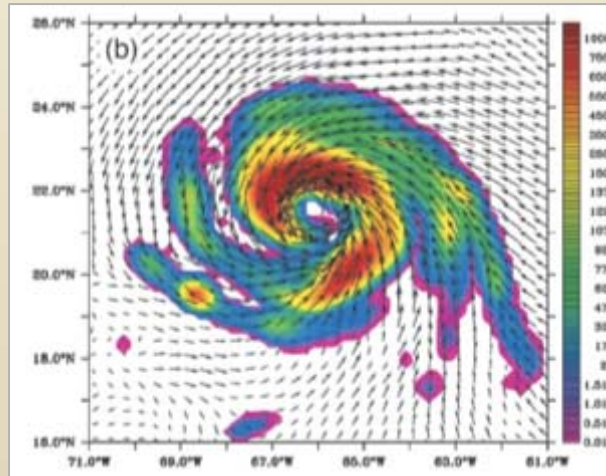
Ongoing tropical cyclone/global warming modeling at GFDL

Zetac regional
model of Atlantic
hurricane season



Downscaled with
GFDL hurricane prediction system
(coupled, multiple mesh)

Rotating
radiative-convective
equilibrium



C360/720
track/intensity
forecasts

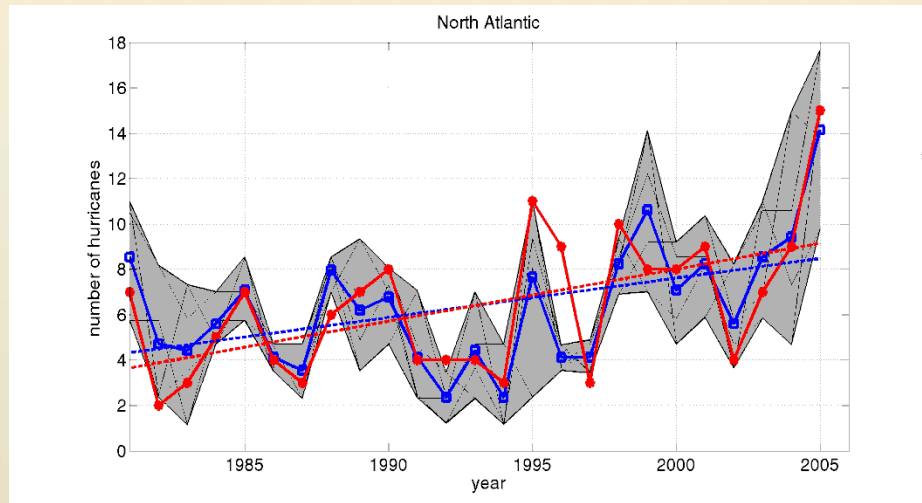
C90
global model

C180
global model

A sampling of ongoing research on atmospheric dynamics with a spectrum of models

- Are there useful idealized geometries in which to study hurricane genesis and intensity?
- How sensitive is tropical precipitation to extratropical thermal forcing (aerosols, ice sheets)?
- What determines the position of the midlatitude surface westerlies?

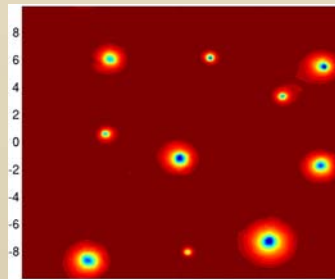
Tropical storm models in idealized geometries provide important insights into tropical cyclogenesis



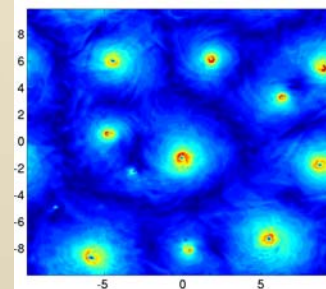
Zhao, Held, Lin, Vecchi, in review

Held and Zhao, JAS, 2008

Surface pressure

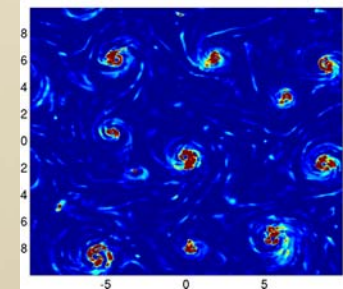


Surface wind speed



20,000 X 20,000km
 $f = 10N$

Precipitation



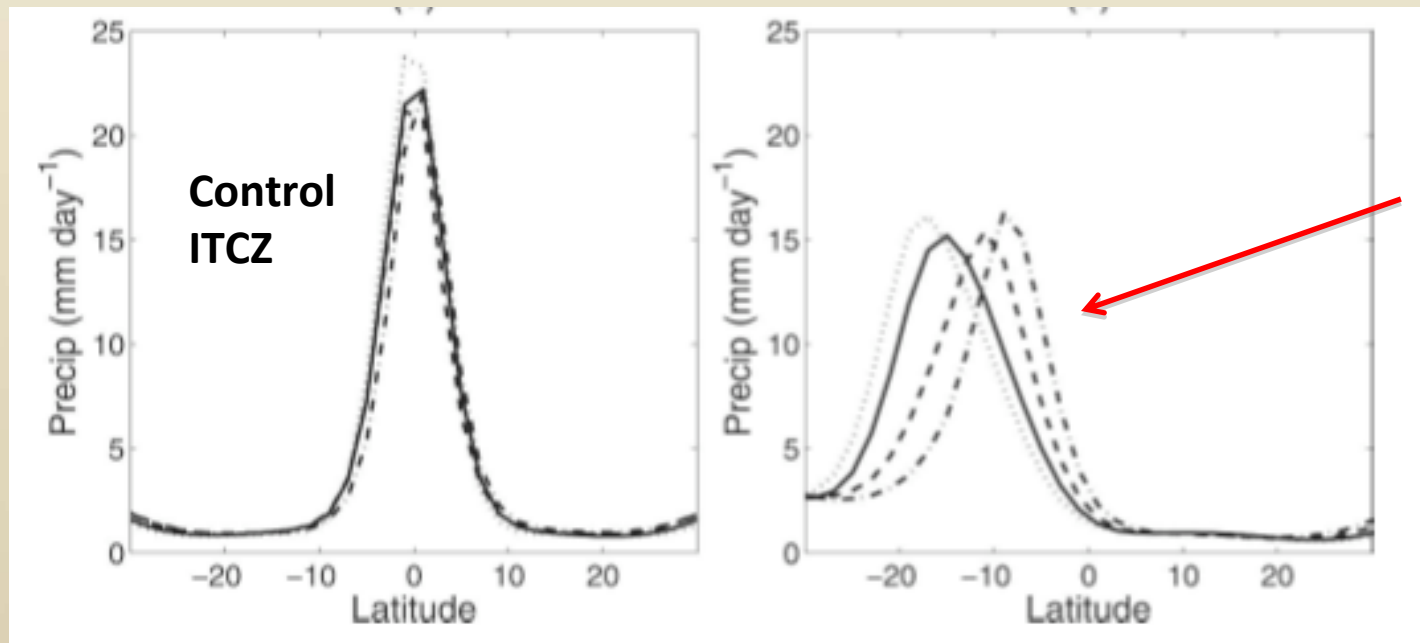
These two models are identical, except that:
one has realistic geometry and boundary conditions;
the other is homogeneous and doubly periodic on an f-plane

The response of tropical rainfall to high latitude heating/cooling is very sensitive to cloud feedbacks

(Important for response to aerosols, ice age ice sheets, variations in Atlantic overturning)

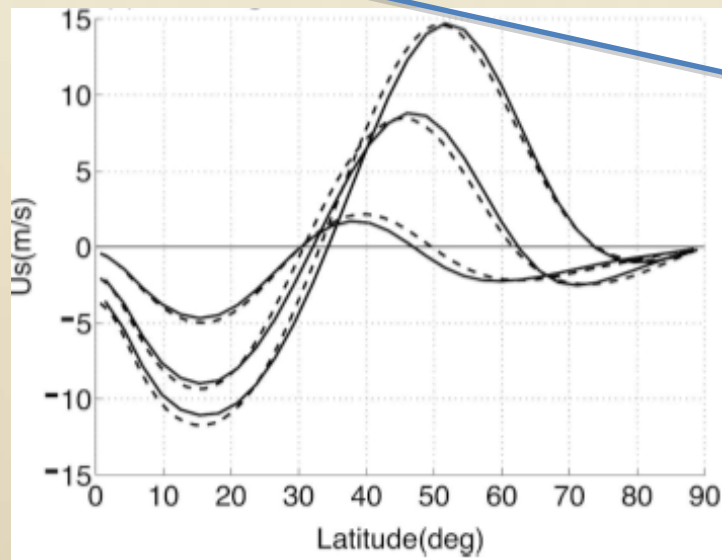
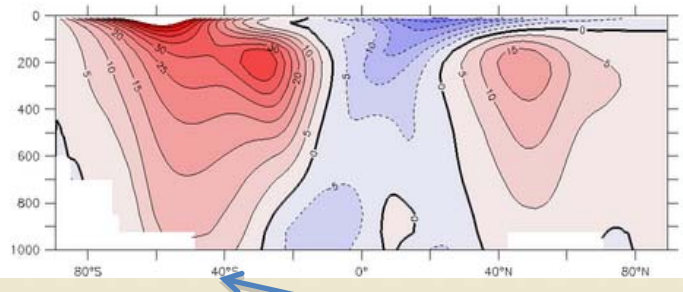
When the atmosphere is cooled in high latitudes in one hemisphere and warmed in the other, in an idealized “slab-ocean, aqua-planet” version of AM2:

the ITCZ moves to the warmed hemisphere, but the size of the movement is sensitive to cloud feedbacks (*Kang, Zhang, Held, Frierson*).

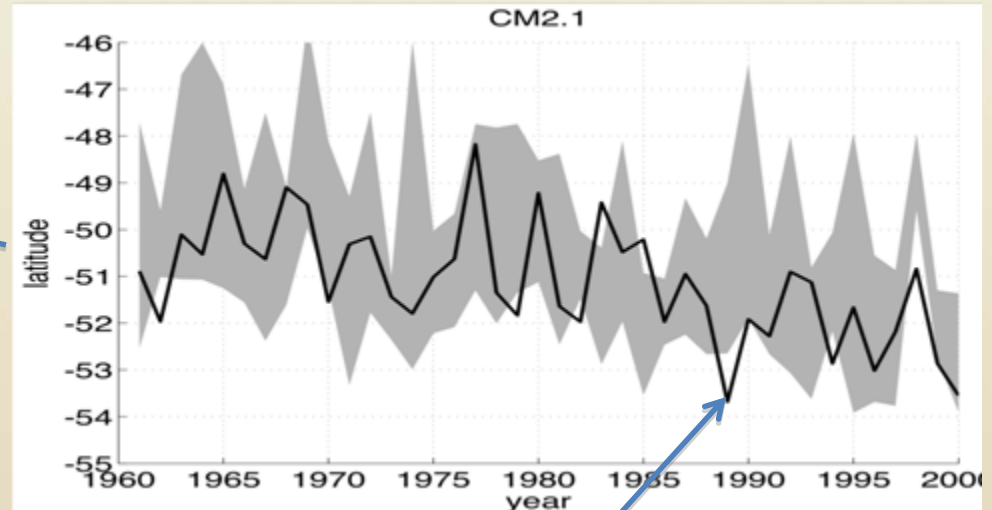


Response of
different versions
of the model

Stormtracks/droughts are linked to the latitude of surface westerlies; idealized models isolate factors that can alter this latitude



“Roaring 40’s” are moving polewards
Ozone hole or global warming?



observations

Surface westerlies move polewards as surface friction is reduced (*Chen, Held, Robinson, 2007*). Research suggests that, surprisingly, the same dynamics may be at play in both cases.

Upcoming talks in this section:

Morris Bender

The GFDL Hurricane Prediction System

Gabriel Lau

Some applications of high resolution atmospheric modeling

Ming Zhao

Global simulations of hurricane climatology/variability/change

Shian-Jiann Lin

Dynamical cores and seamless global/regional model development

Other key contributors: **Bruce Wyman, Steve Garner, Chris Kerr, Tim Marchok, Mary Jo Nath, Jeff Ploshay + students + post-docs**

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