

# 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.

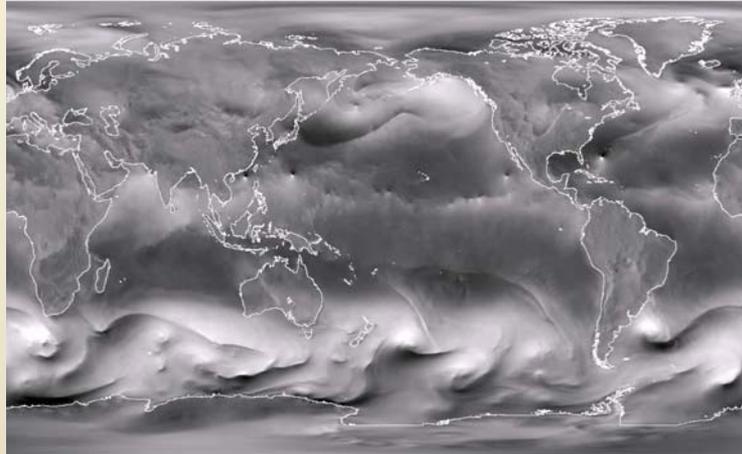
## **Can our models provide useful projections of changes in extreme weather events?**

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



$C_n \Rightarrow$  cubed-sphere grid with  $n \times n$  points in each face of cube

**HIRAM2.1**

C90/100km

C180/50km

C360/25km

hydrostatic



non-hydrostatic

C720/13km

C2000/5km

**M180 AM2.1/LM2 (NARCCAP)**

**$\Rightarrow$  C90 and C180 AM2.1/LM3**

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

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

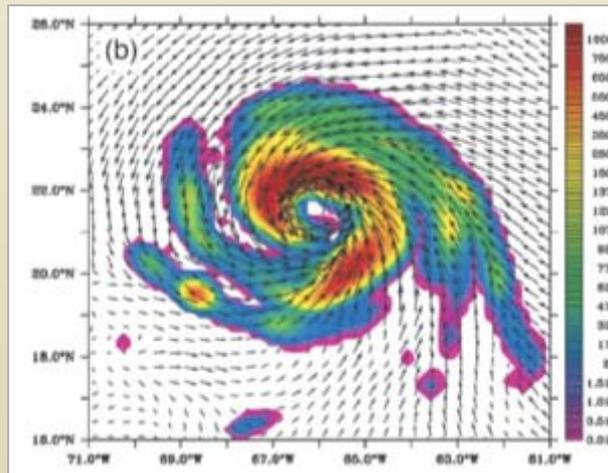
# Ongoing tropical cyclone/global warming modeling at GFDL

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

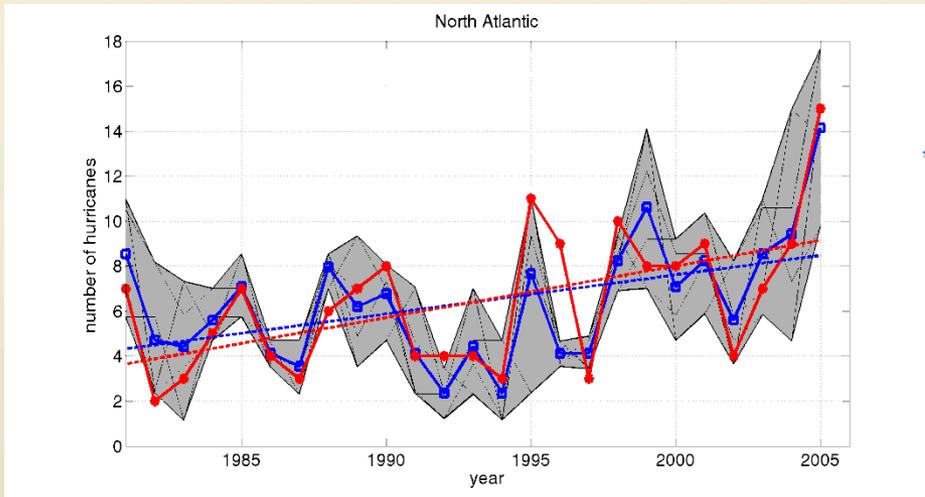
C90  
global model

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?

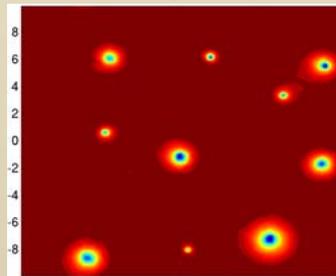
# Tropical storm models in idealized geometries provide important insights into tropical cyclogenesis



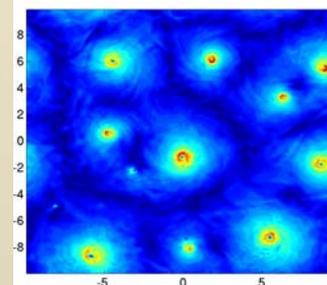
Zhao, Held, Lin, Vecchi, in review

Held and Zhao, JAS, 2008

Surface pressure

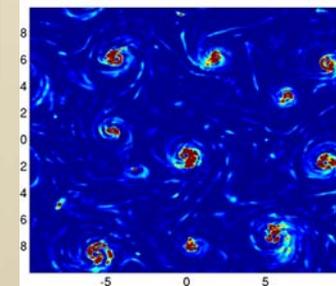


Surface wind speed



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

Precipitation



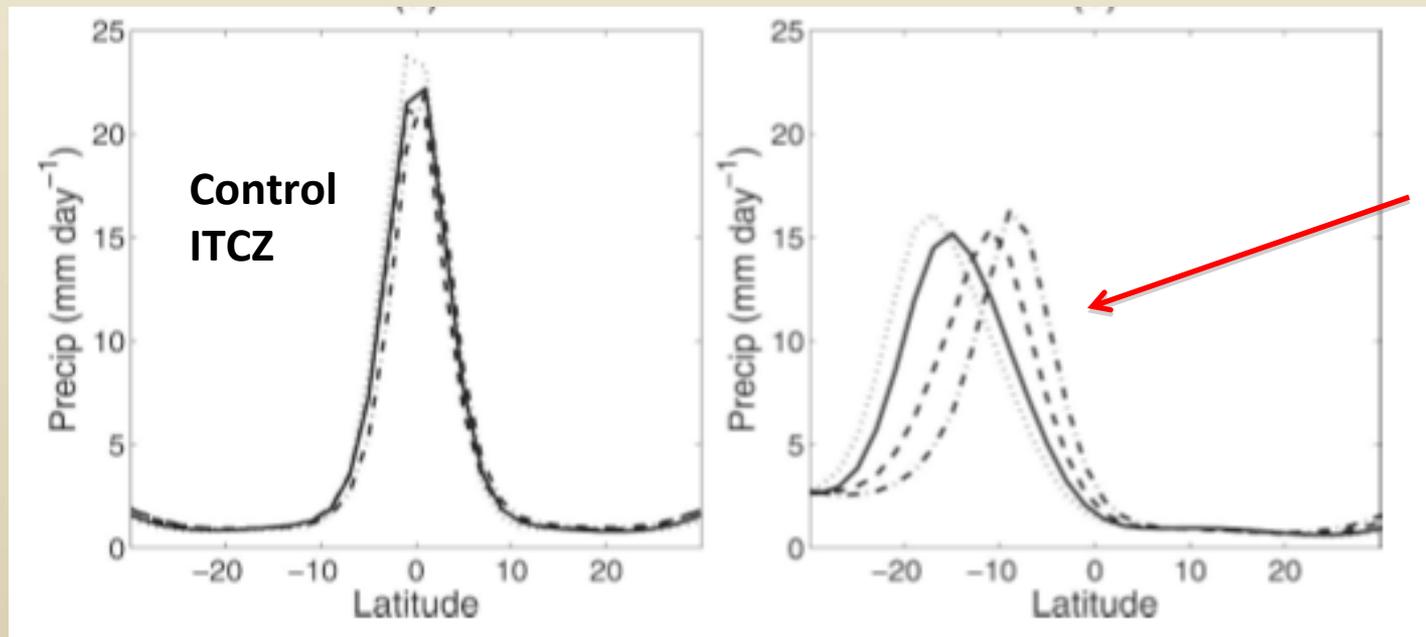
These two models are identical, except that:  
one has realistic geometry and boundary conditions;  
the other is homogeneous and doubly periodic on an f-plane

# 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)*

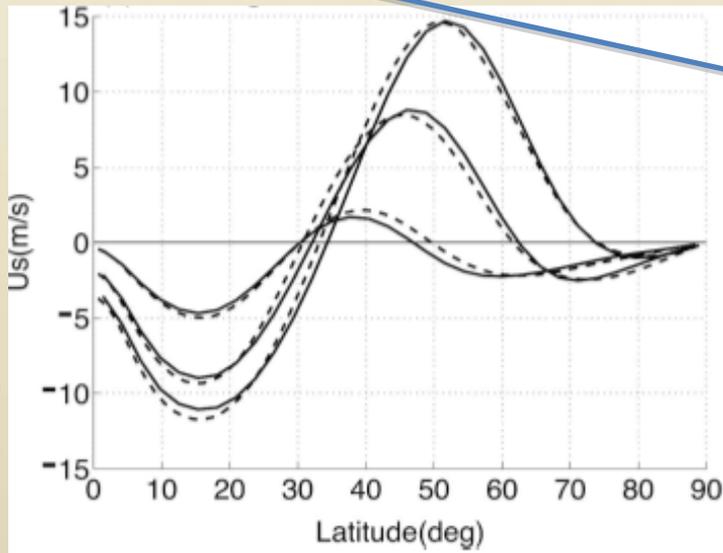
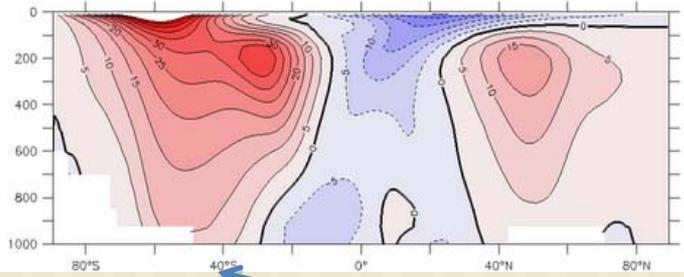
When the atmosphere is cooled in high latitudes in one hemisphere and warmed in the other, in an idealized “slab-ocean, aqua-planet” version of AM2:

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

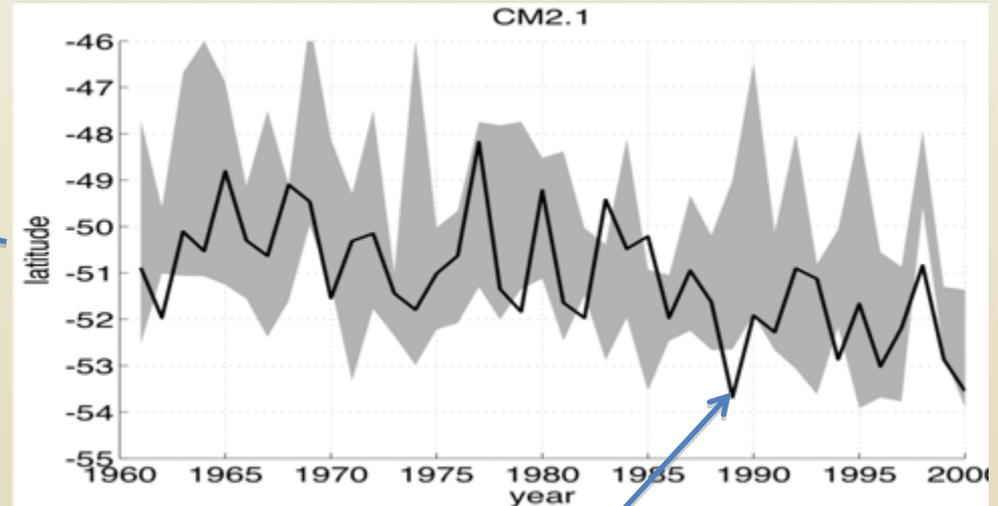


Response of different versions of the model

# 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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