Climate Change and Wind

Gabriel A. Vecchi

NOAA/GFDL, Princeton, NJ USA

- How and why has “wind” changed?
- How do we expect “wind” to change?
- Need to be conscious of scale:
  - Global-scale wind changes
  - Changes in wind events (extremes):
    - Hurricanes/Typhoons/Cyclones
    - Mid-latitude storms
    - Tornados, etc…

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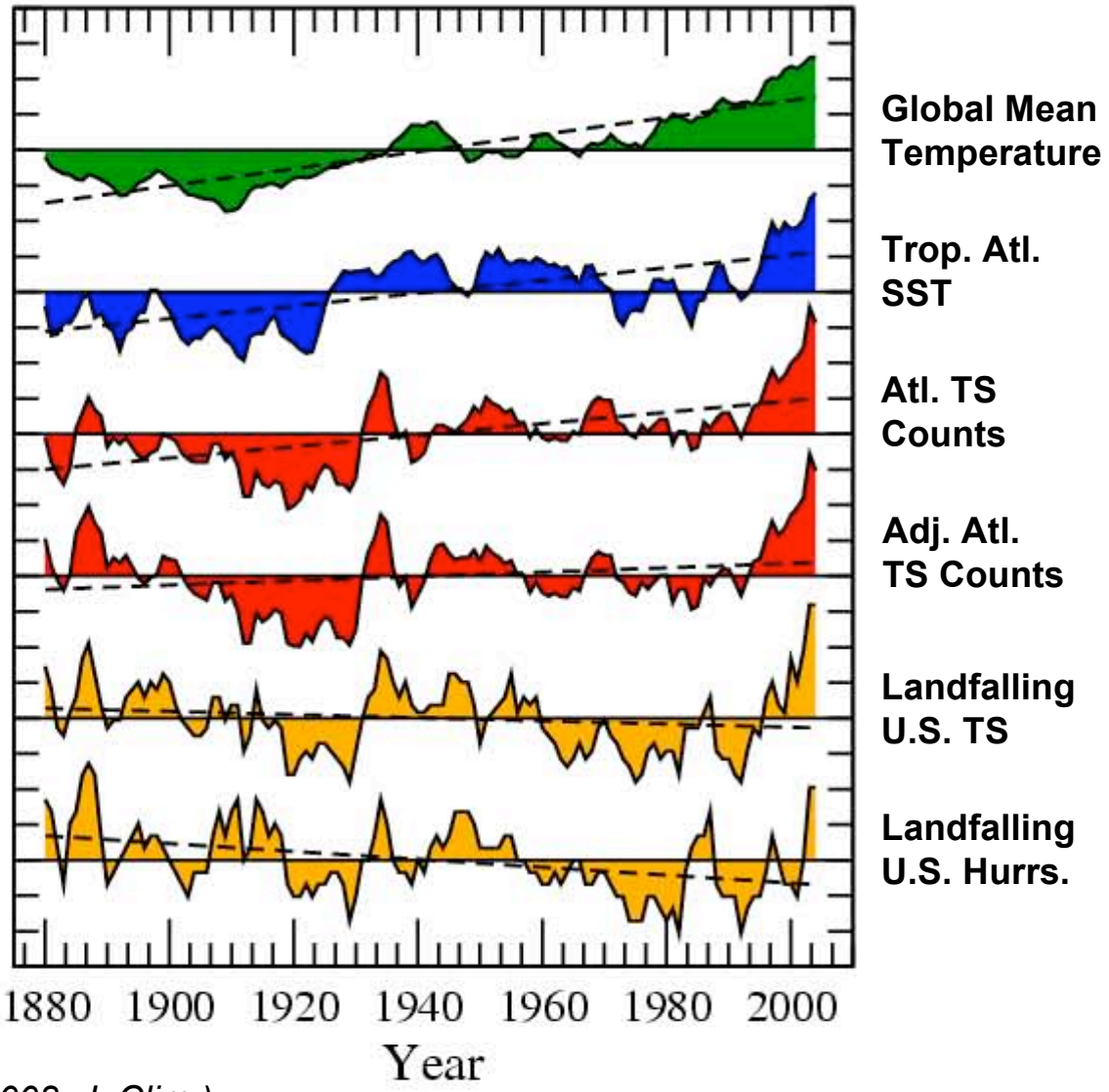
Requirements to assess/project cyclone activity changes

Interconnected, complement/limit each other.

- Well-defined measure of activity.
- Observations:
  - As homogeneous as possible
  - Uncertainty assessment
- Comprehensive dynamical models:
  - Capable of reproducing obs.
  - Play mix-and-match with forcings
- Understanding:
  - Theoretical framework
  - Idealized experiments

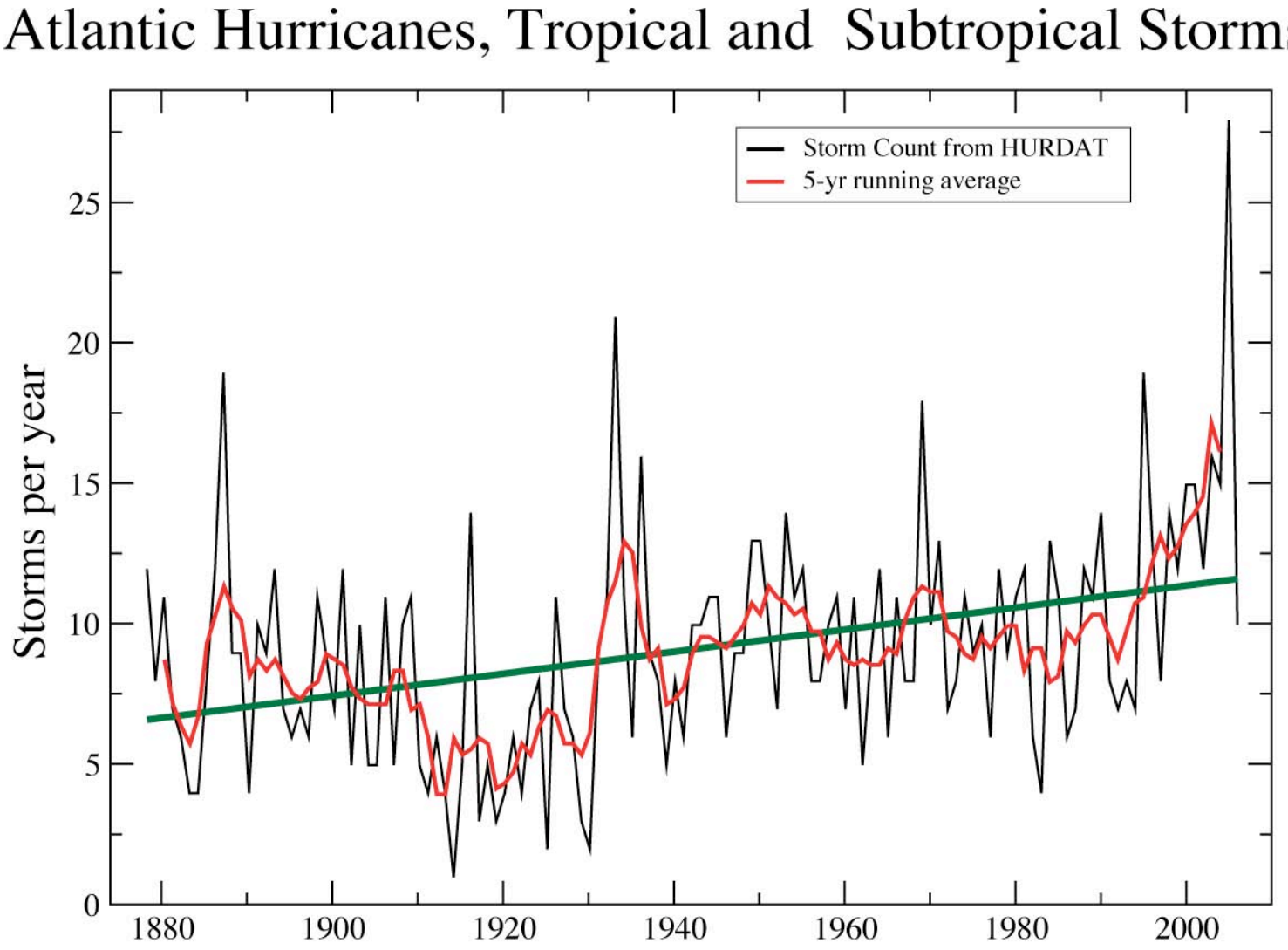
Measure of Activity

- Which measure?
  - Integrated intensity
  - Hurricane count
  - Landfalling storm count
  - Shifts in mean intensity
  - Extremes in intensity
  - Extremes in intensity at landfall
  - Landfall fraction
  - …
- Must balance demand with current scientific capability.
  - Obs, models and theory limit.
- How to communicate differences?



Vecchi and Knutson (2008, J. Clim.)

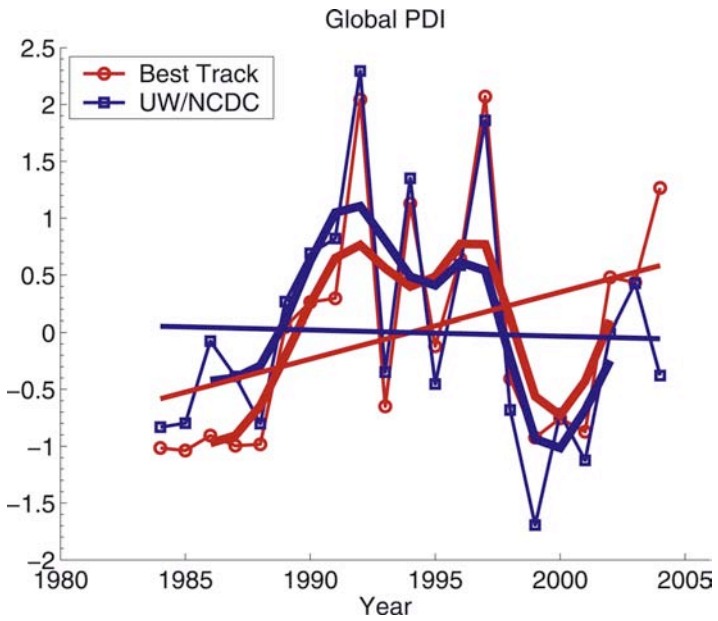
Increase in recorded Atlantic storms: is it real?



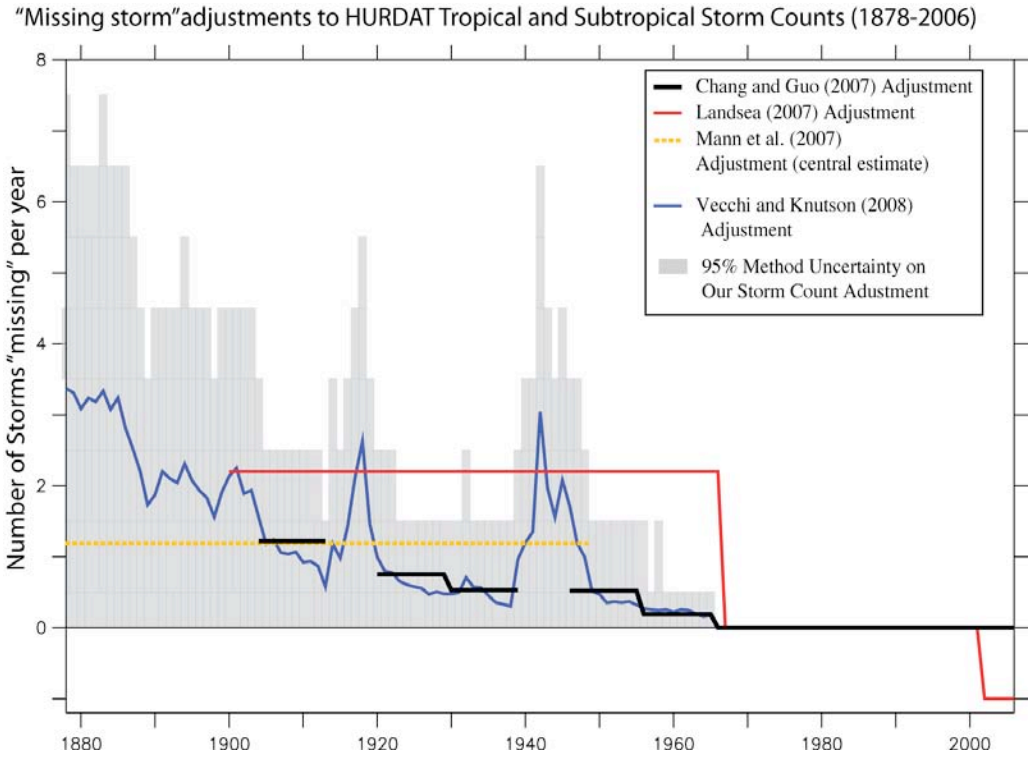
From Vecchi and Knutson (2008, J.Climate)

Observations

- Hurricane databases **NOT** built as climate data records.
- Efforts must continue to:
  - Identify issues
  - Homogenize when possible
  - Estimate uncertainty

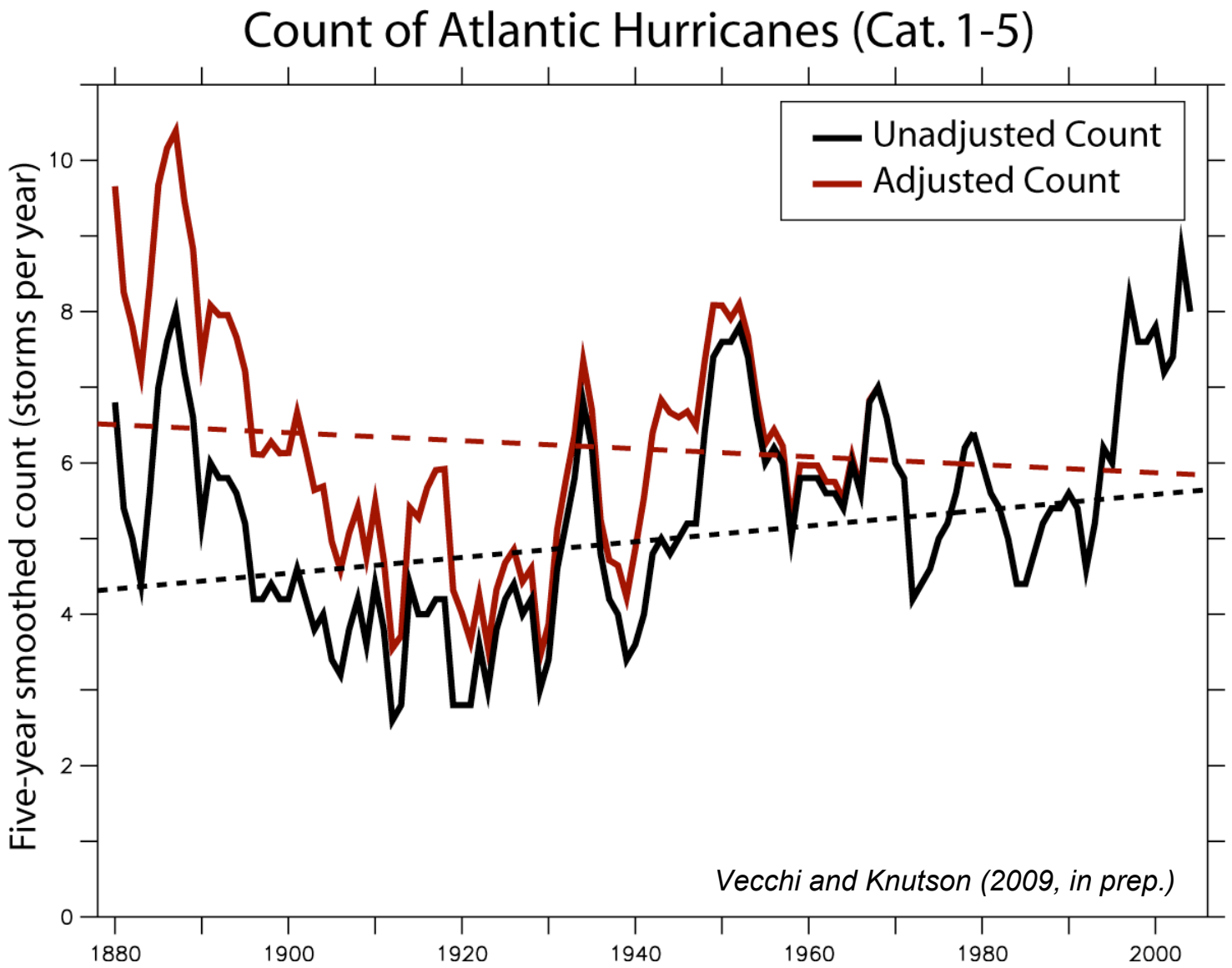


Kossin et al (2007, GRL)

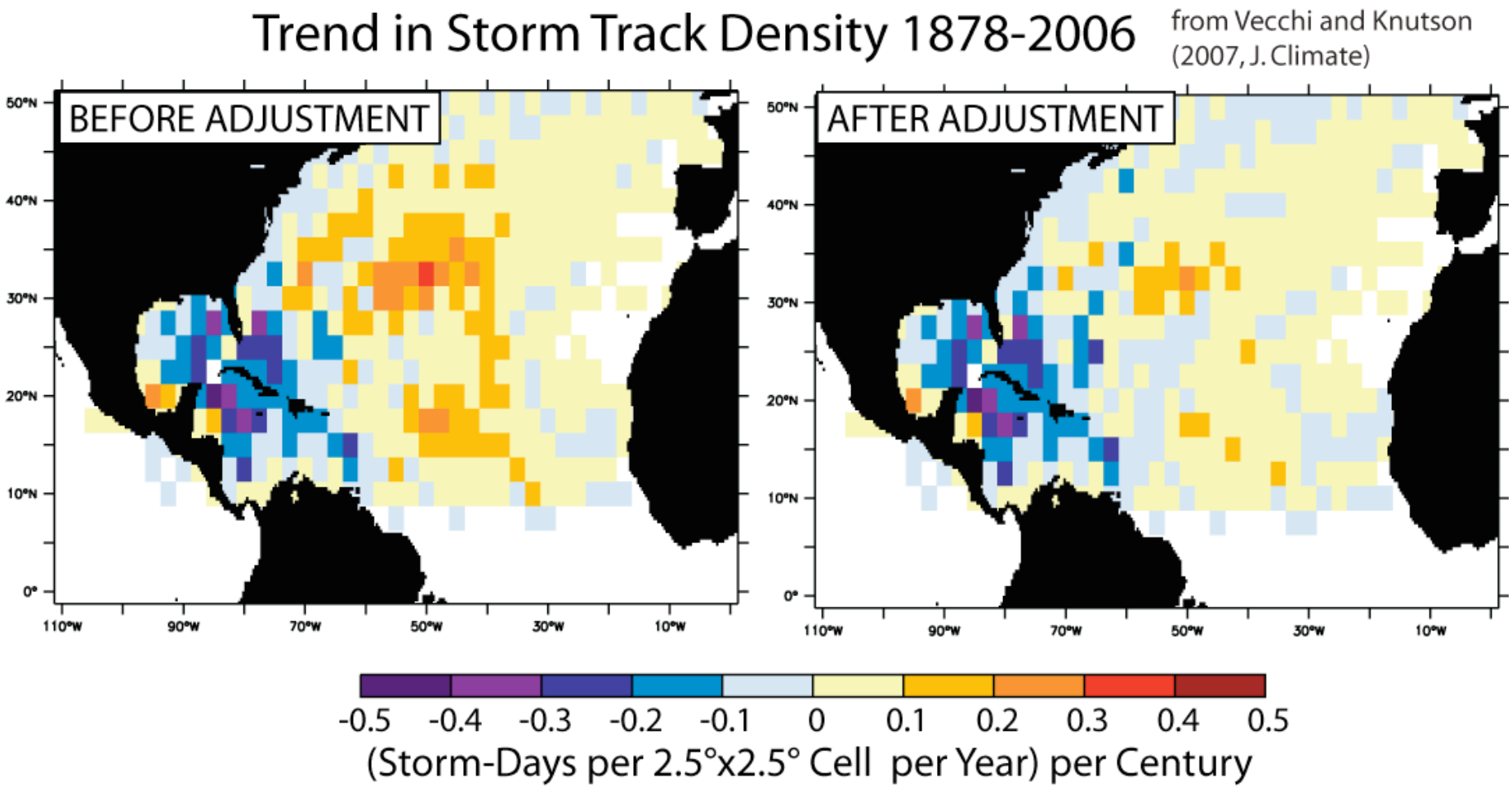


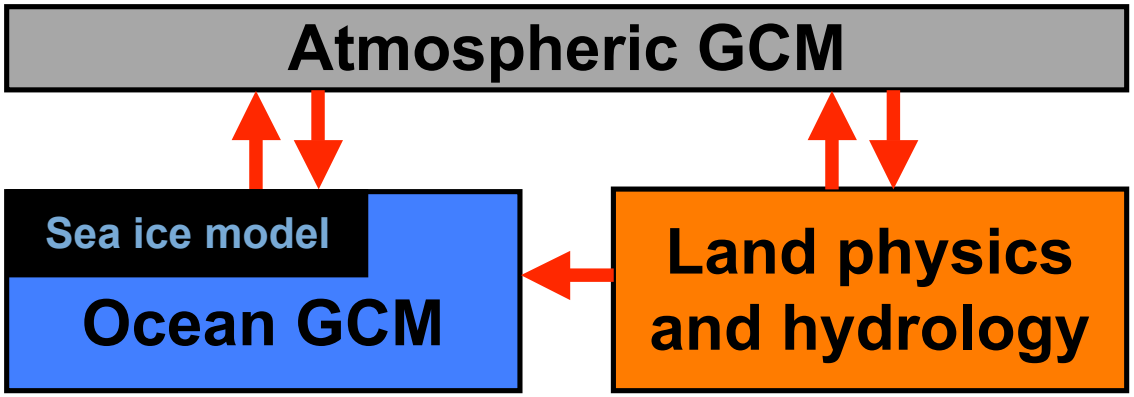
Vecchi and Knutson(2008, J. Clim.)

Adjustment changes sign of hurricane count trend

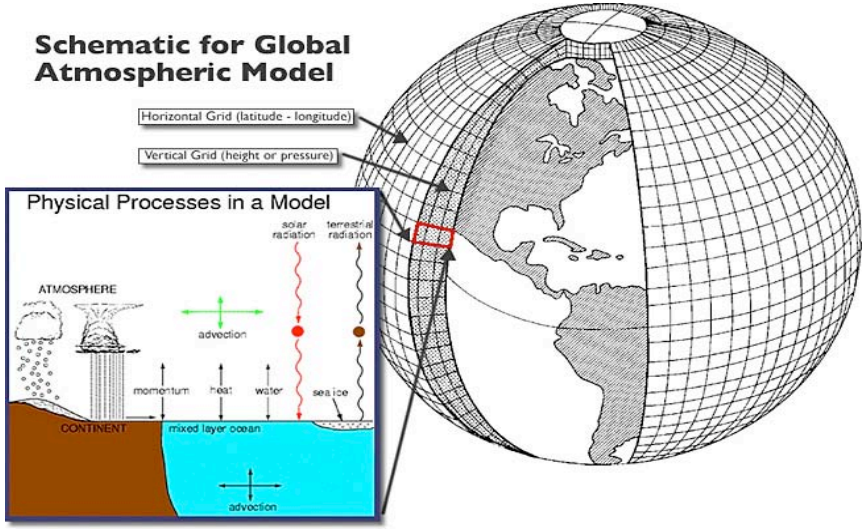


Observed Atl. storm density trend heterogeneous



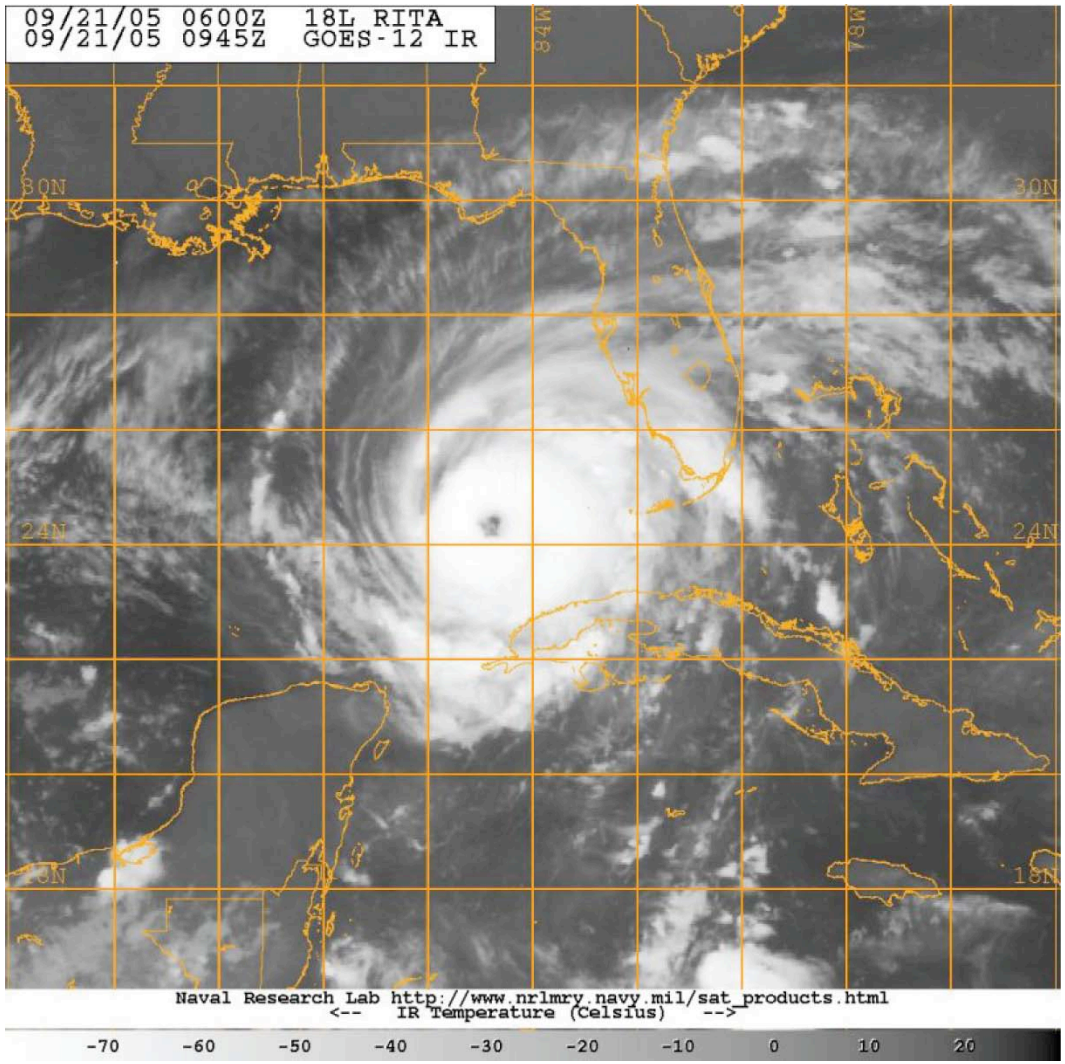


Global climate models give us guidance about changes climate system.



CADDR, Tokyo, Japan
Gabriel Vecchi, NOAA/GFDL, Princeton, NJ

But, current computing power limits ability of global climate models to represent hurricanes



Hurricane Rita (2005): orange grid is representative of current ***global*** climate model resolution.

Size of grid limited by power of computers.

Nonetheless, tropical storms are affected by ***large-scale*** conditions that today's climate models ***can*** represent.

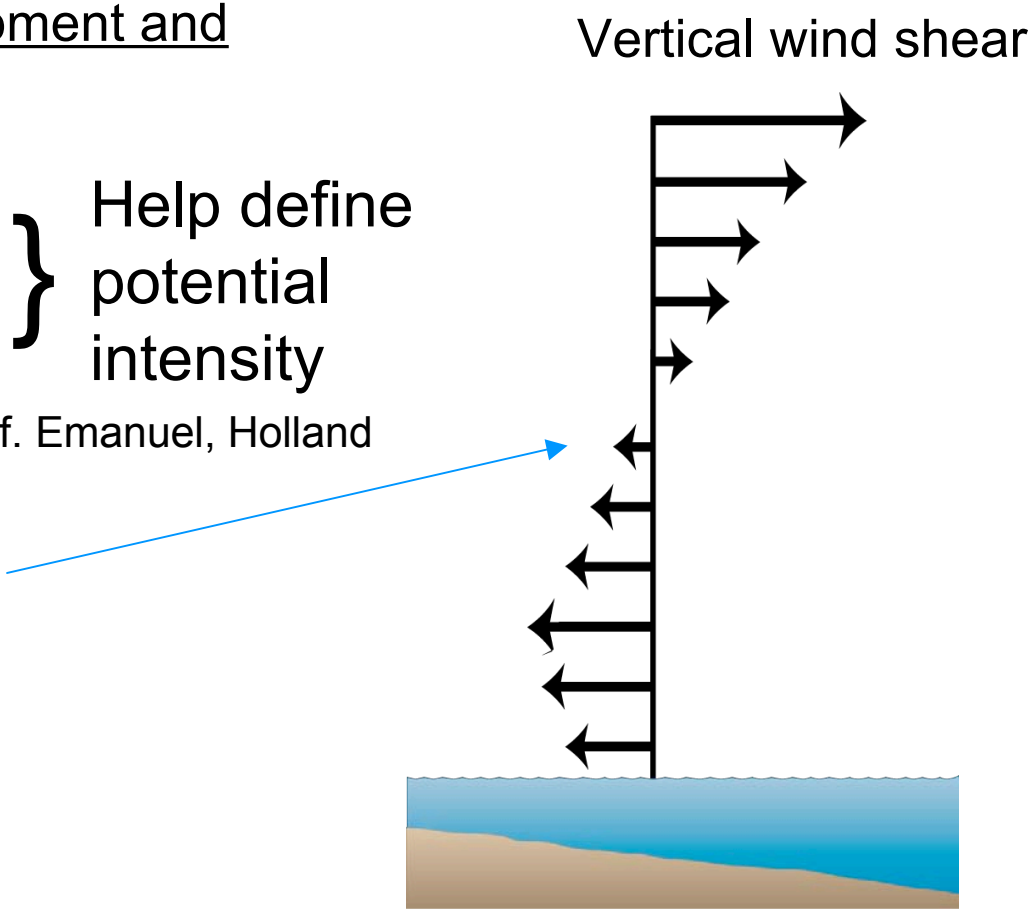
<u>Factors that favor storm development and intensification</u>:

- Warm ocean surface
- Cool upper atmosphere

} Help define potential intensity

cf. Emanuel, Holland

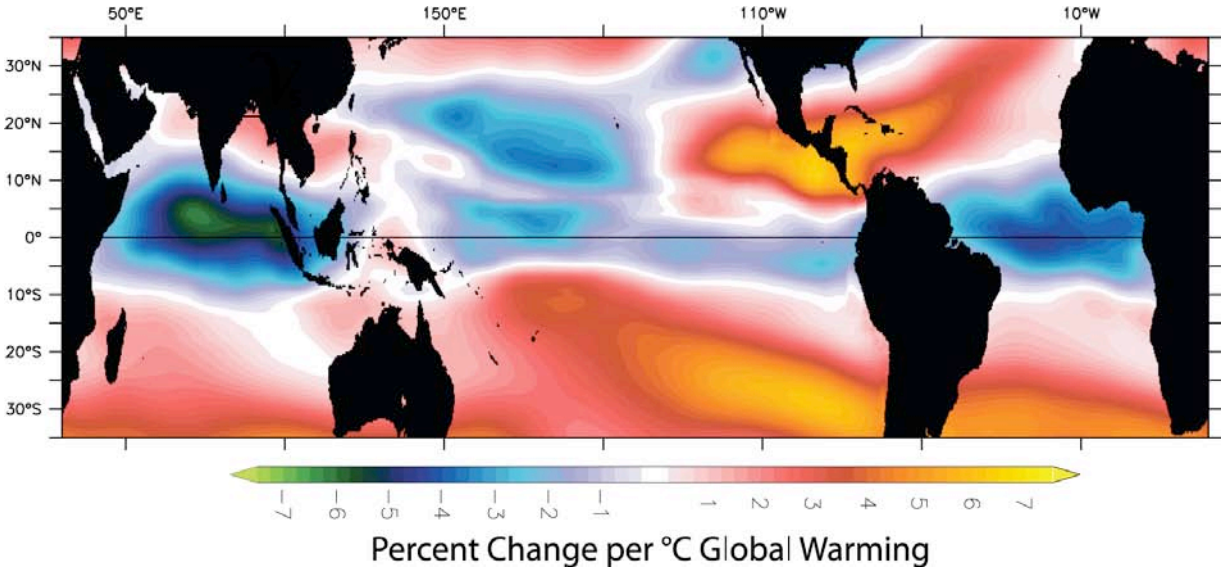
- Low vertical wind shear
- Moist middle atmosphere
- etc.



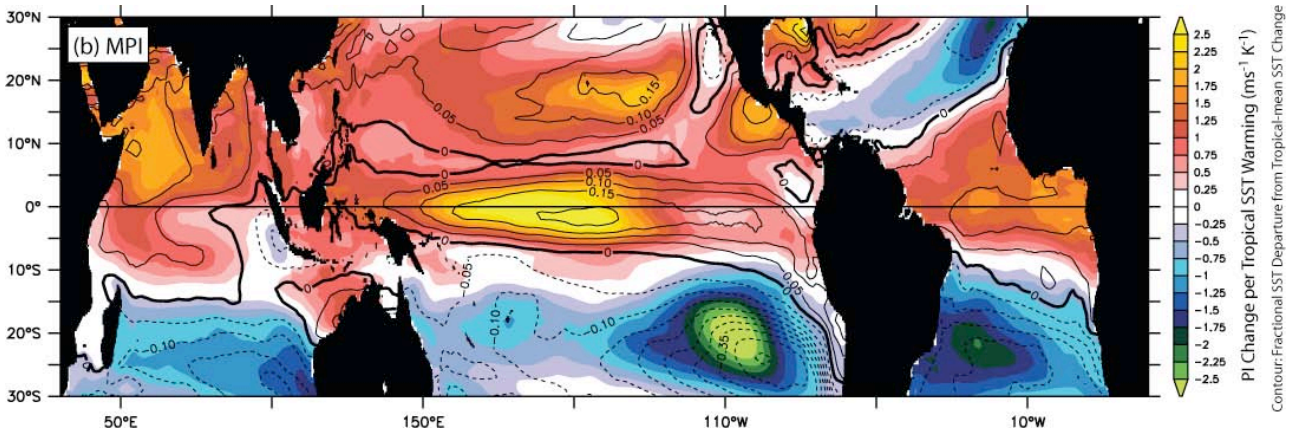
Model Projections of 21st Century Changes

Change in Wind Shear (acts to damp storms)

Regions of shear increase and decrease



Adapted from Vecchi and Soden (2007, Geophys. Res. Lett. and Nature)

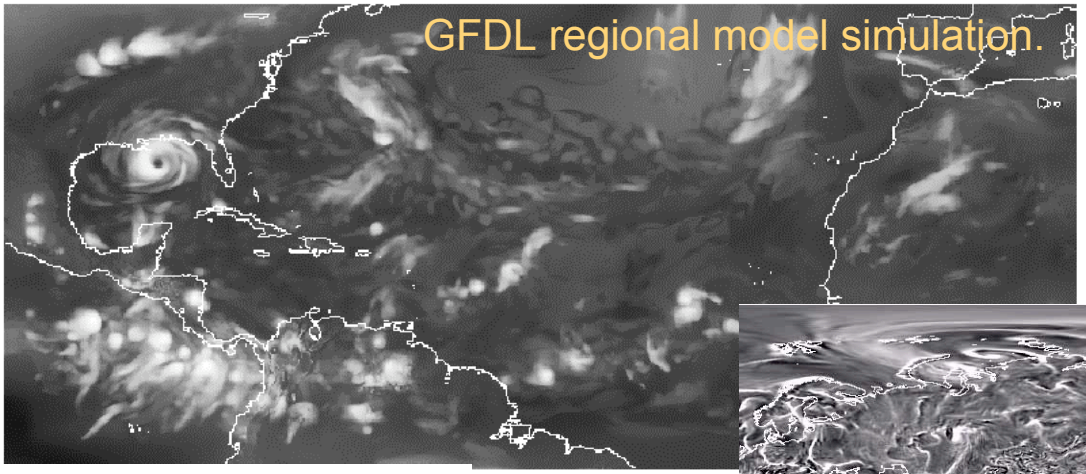


Models project mixed changes in potential intensity.

Change in Potential Intensity (acts to strengthen storms)

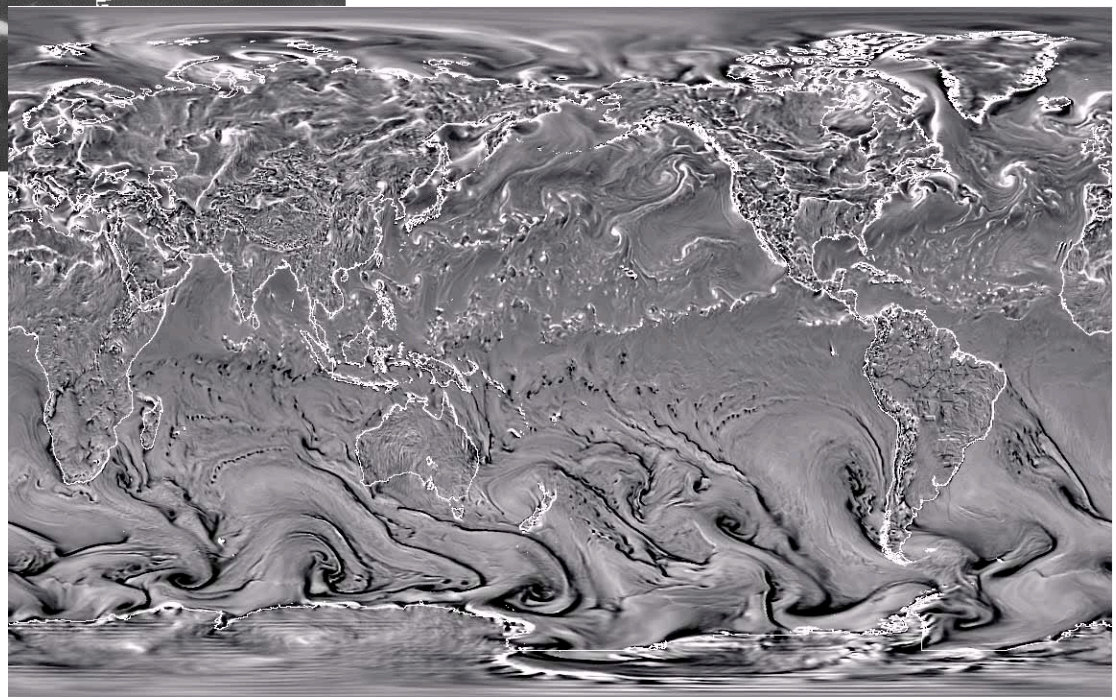
High-Resolution Comprehensive models

Assess TC sensitivity to climate change in a physically-consistent manner



Knutson et al (2007, BAMS)

Models ranging in 100km to 18km resolution.

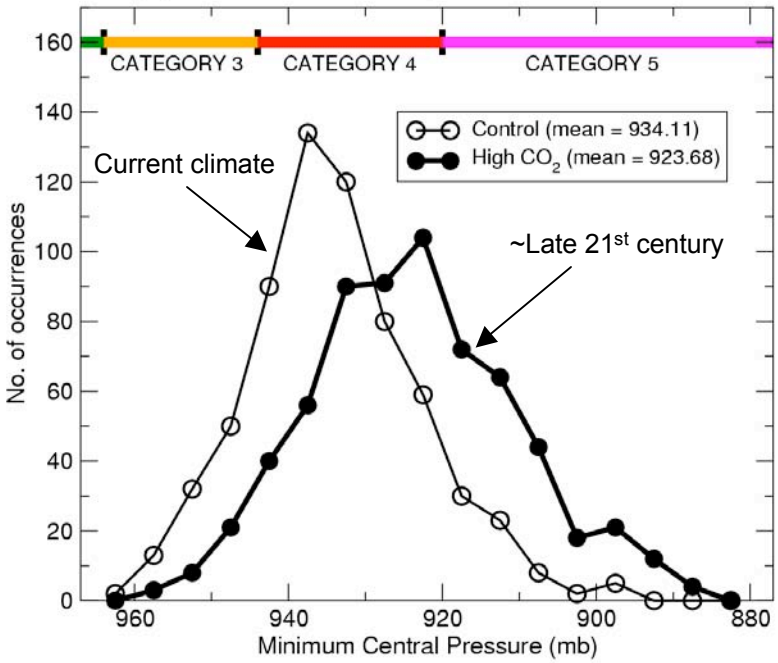


Zhao, Held, Lin and Vecchi (2009, J. Climate)

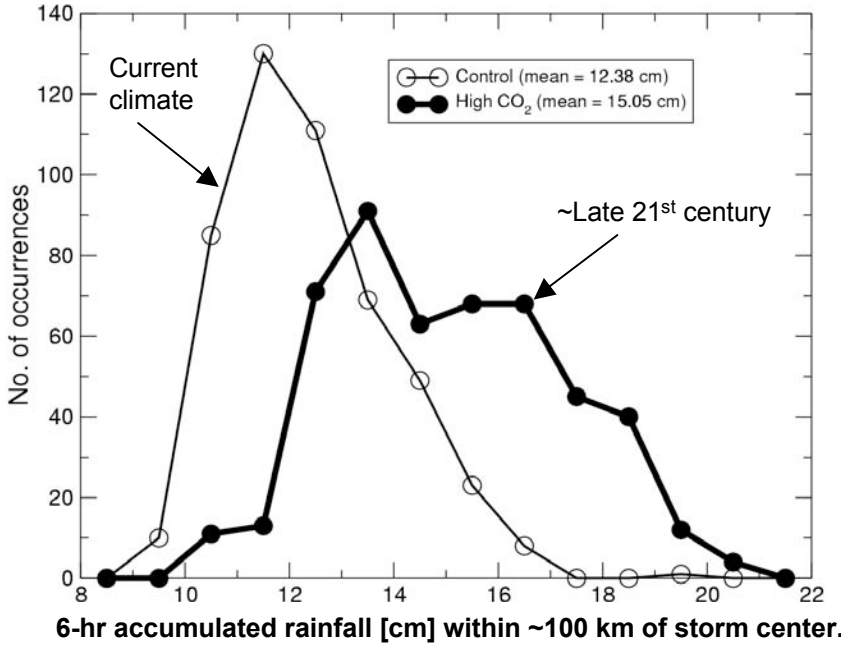
GFDL global model simulation.

Hurricane models project increasing hurricane intensities and rainfall rates with greenhouse climate warming ...

Hurricane Intensity



Hurricane Rainfall Rates



6-hr accumulated rainfall [cm] within ~100 km of storm center.

Sources: Knutson and Tuleya, *J. Climate*, 2004 (left);
Knutson and Tuleya, 2007; accepted for publication, Cambridge Univ Press (right).

Frequency of weakest storm projected to decrease.
Frequency of strongest storms may increase.

Control: 11.1 /yr

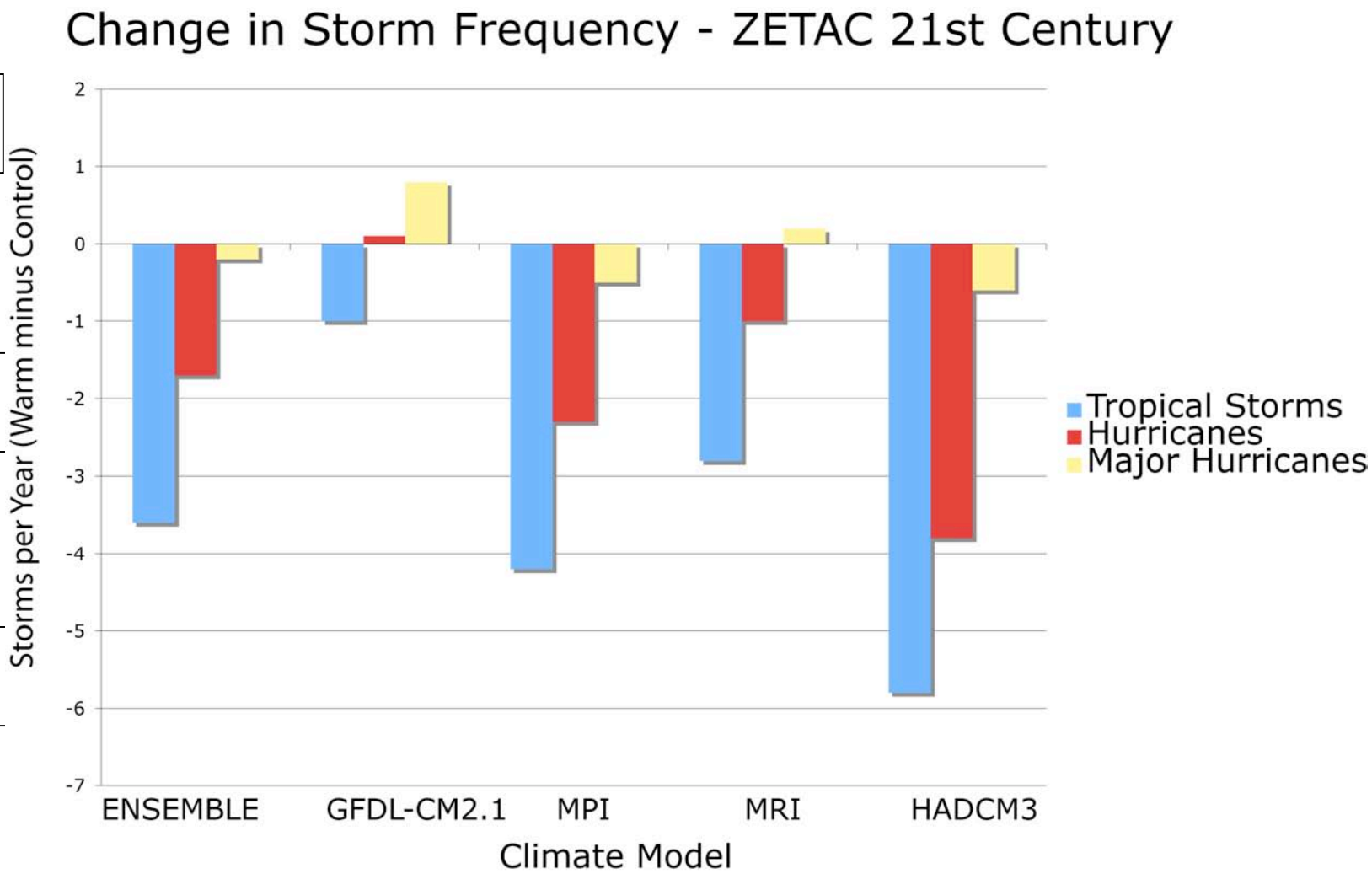
Tropical Storms:
Range: -9% to -52%
Ensemble: -20%

Control: 6.5 /yr

Hurricanes:
Range: +2% to -58%
Ensemble: -26%

Control:1.4 /yr

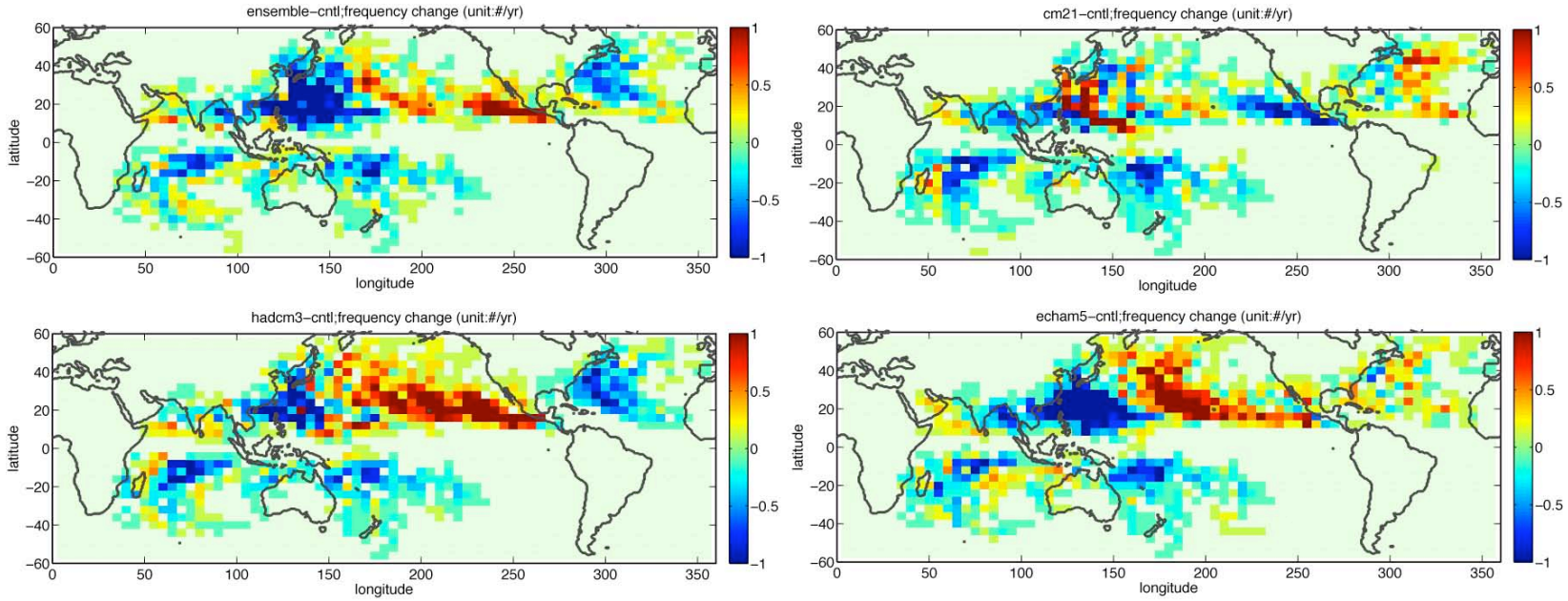
Major Hurricanes:
Range: +57% to -43%
Ensemble: -14%



Adapted from Knutson et al (2008, Nature Geosci.)

21st Century Hurricane Activity Change

Based on four projections of 21st Century Ocean temperatures.



Red/yellow = increase
Blue/green = decrease

Zhao, Held, Lin and Vecchi (2009, J. Climate)

Regional increase/decrease much larger than global-mean.

Pattern depends on details of ocean temperature change.

Summary/points for discussion

- What type of information most relevant to DRR and risk assessment? (may not be outside of current scientific limitations)
- Observations:
  - Data issues and short records.
  - Need to assess causes of observed changes in dynamical framework.
- Multiple factors affect change in hurricane activity:
  - Pattern of temperature changes is key.
- Projected changes depend on measure chosen, *e.g.:*
  - Atlantic TC Frequency: projected **decrease**
  - Atlantic TC Intensity: projected **increase**
- Spatially heterogeneous changes in global storm activity.
- Year-to-year and decade-to-decade variations will still exist.
- Sea level rise: even same storm greater potential impact.
- Still topic of vigorous scientific inquiry.

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