

Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009



Hurricanes and Climate Change

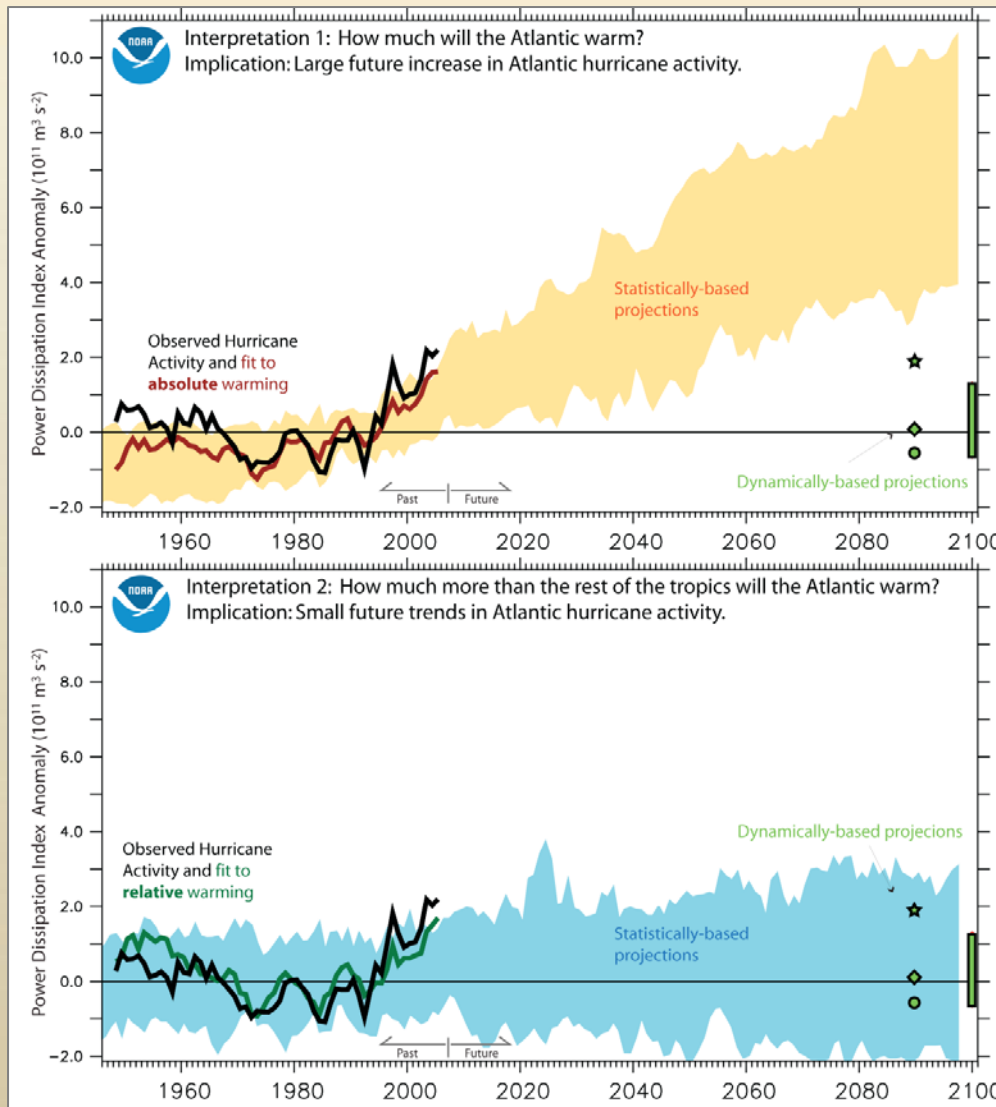
Presented by
Tom Knutson

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Statistical projections of 21st century Atlantic hurricane activity have a very large dependence on the predictor used.



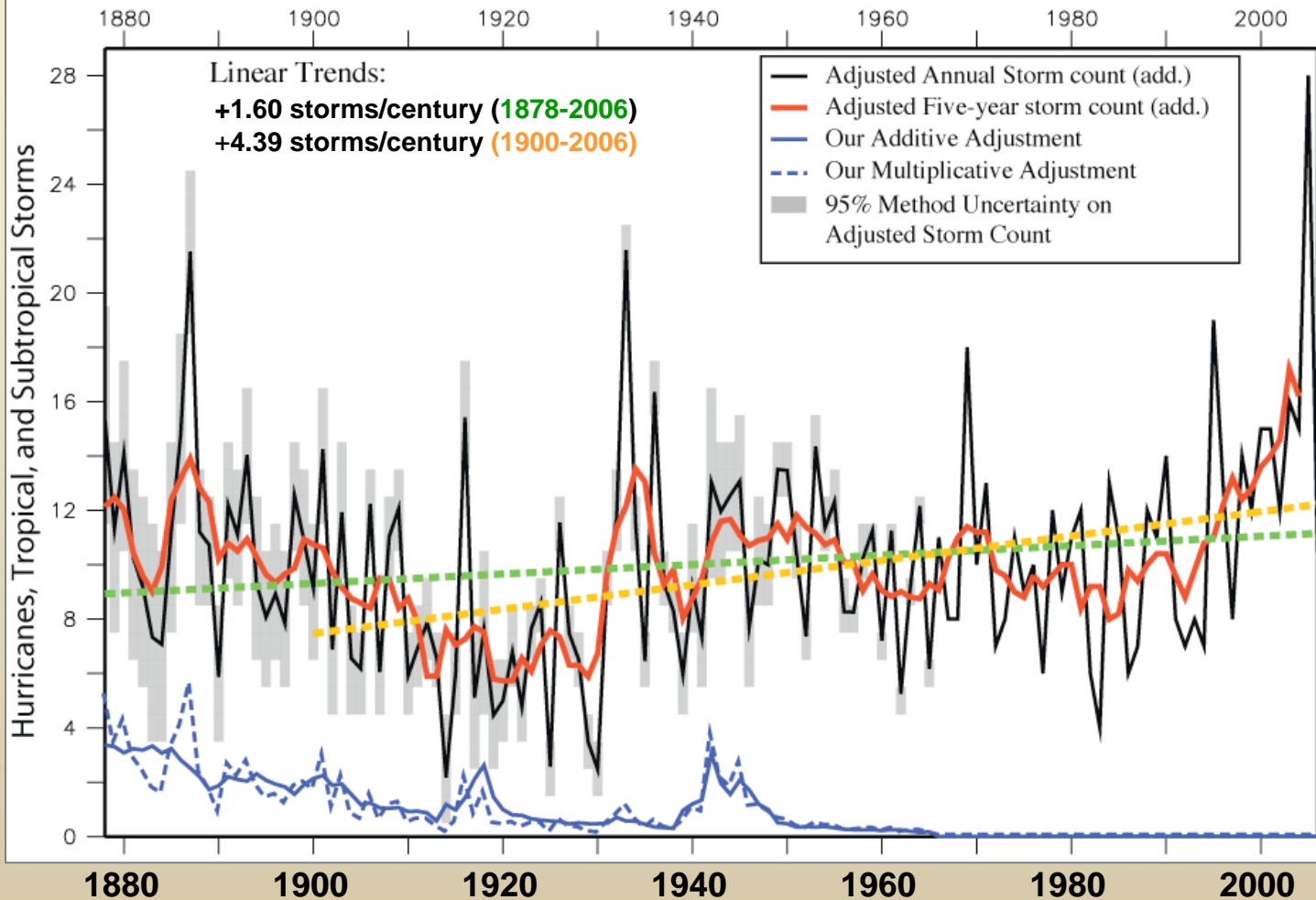
Projection 1: Absolute SST

Projection 2: Relative SST

Source: Vecchi et al. Science (2008)

Atlantic Tropical Storm counts show no significant trend from 1878 after adjusting for 'missing storms' based on ship track densities.

(a) Atlantic HURDAT Storms (Adjusted for Estimated Missing Storms) 1878-2006



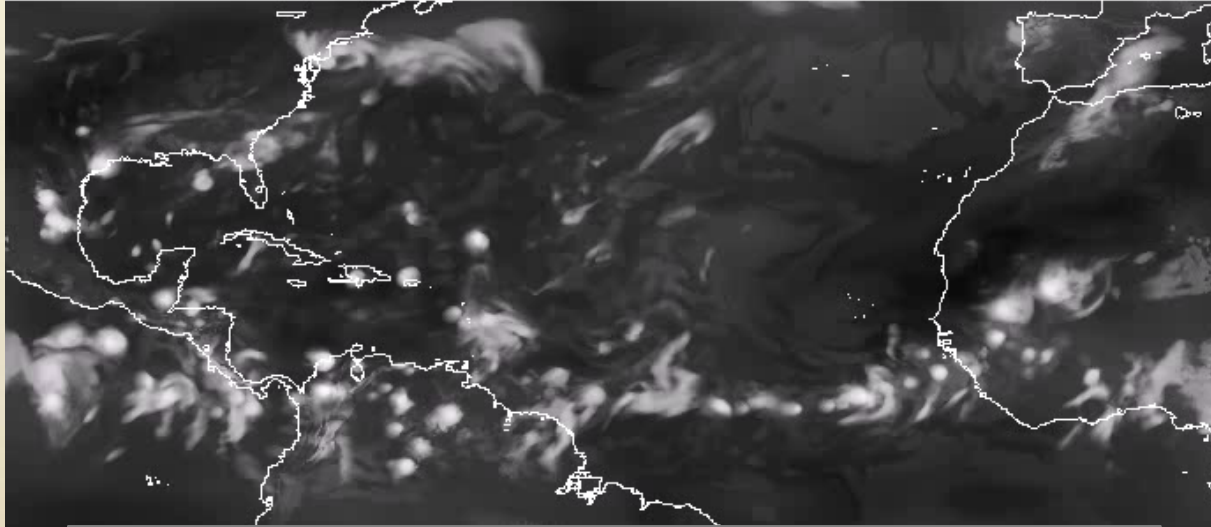
Trend from 1878-2006:
Not significant
($p=0.05$, 2-sided tests, computed p -val ~ 0.2)

Trend from 1900-2006:
Is significant at $p=0.05$ level

Source: Vecchi and Knutson, *J. Climate*, 2008.

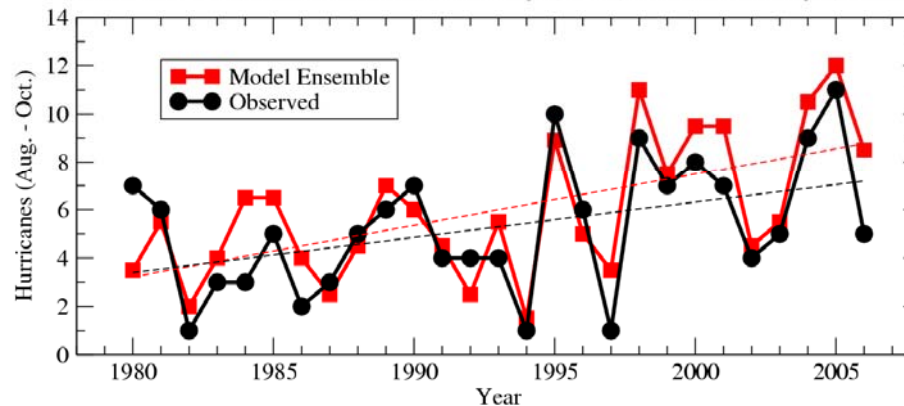
Zetac Regional Model reproduces the interannual variability and trend of Atlantic hurricane counts (1980-2006)

18-km grid model nudged toward large-scale (wave 0-2) NCEP Reanalyses



Atlantic Hurricanes (1980-2006): Simulated vs. Observed

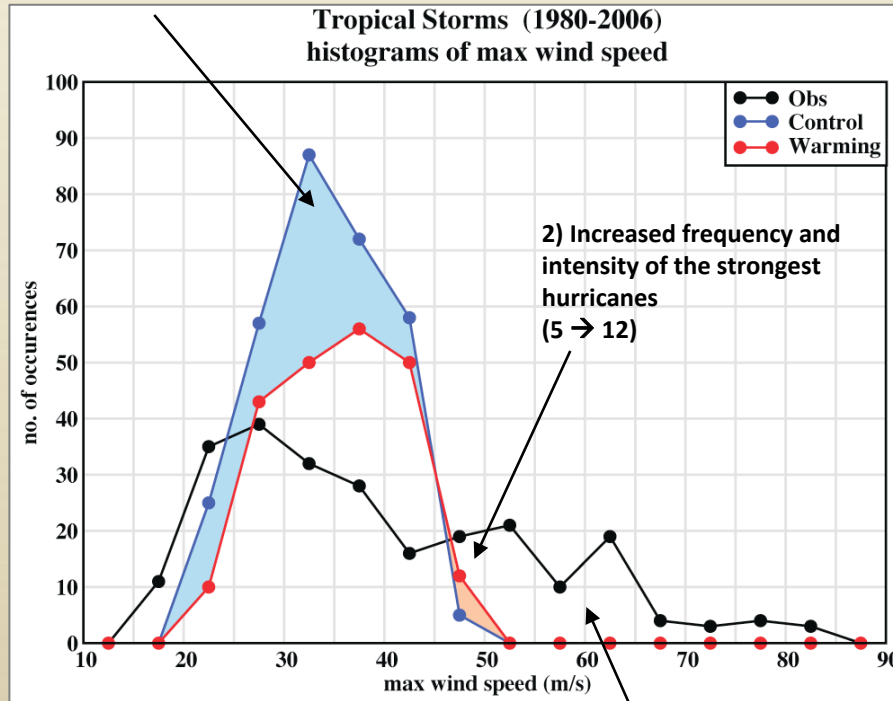
Correlation = 0.84; Linear trends: +0.21 storms/yr (model) and +0.15 storms/yr (observed).



Regional Model

1) Decreased frequency of tropical storms (-27%) and hurricanes (-18%).

The regional model projects a **decrease** in Atlantic hurricane and tropical storm **frequency** for late 21st century, downscaling from an IPCC A1B climate change scenario (18-model ensemble):

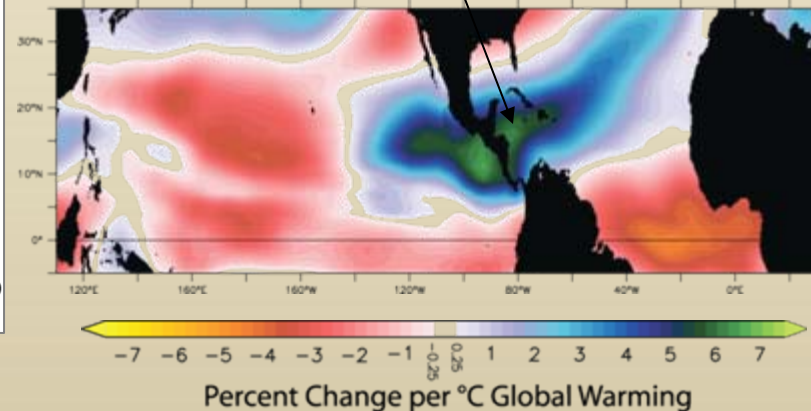


2) Increased frequency and intensity of the strongest hurricanes (5 → 12)

3) Caveat: the regional model does not simulate hurricanes as strong as those observed.

Source: Knutson et al., 2008, Nature Geoscience.

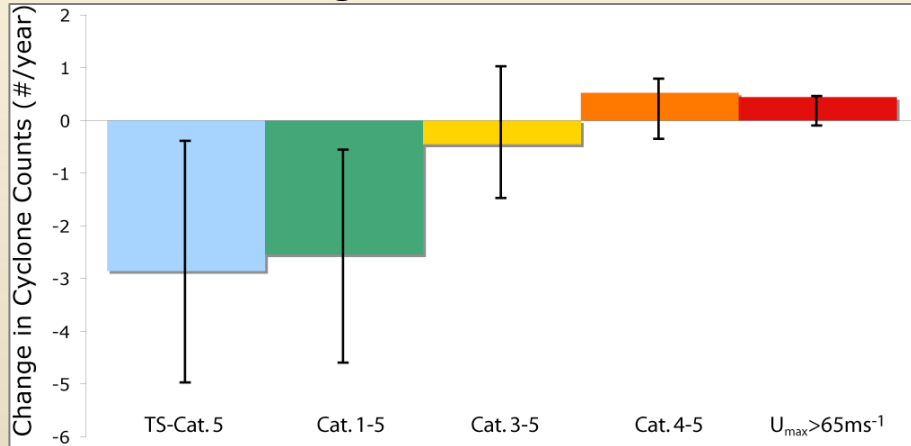
Global models project increased vertical wind shear over the (warmer) Caribbean



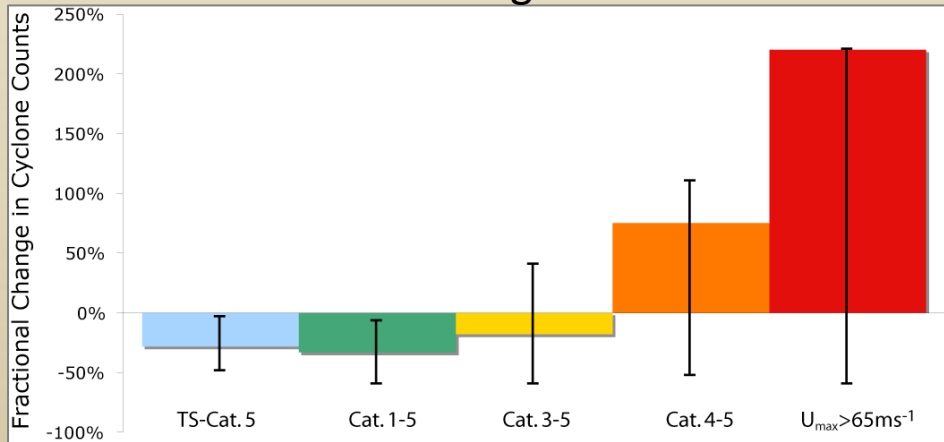
Source: Vecchi and Soden, Geophys. Res. Lett., (2007)

The GFDL hurricane model projects a large fractional increase in the occurrence of very intense Atlantic hurricanes in a warmer climate.

Change in Counts



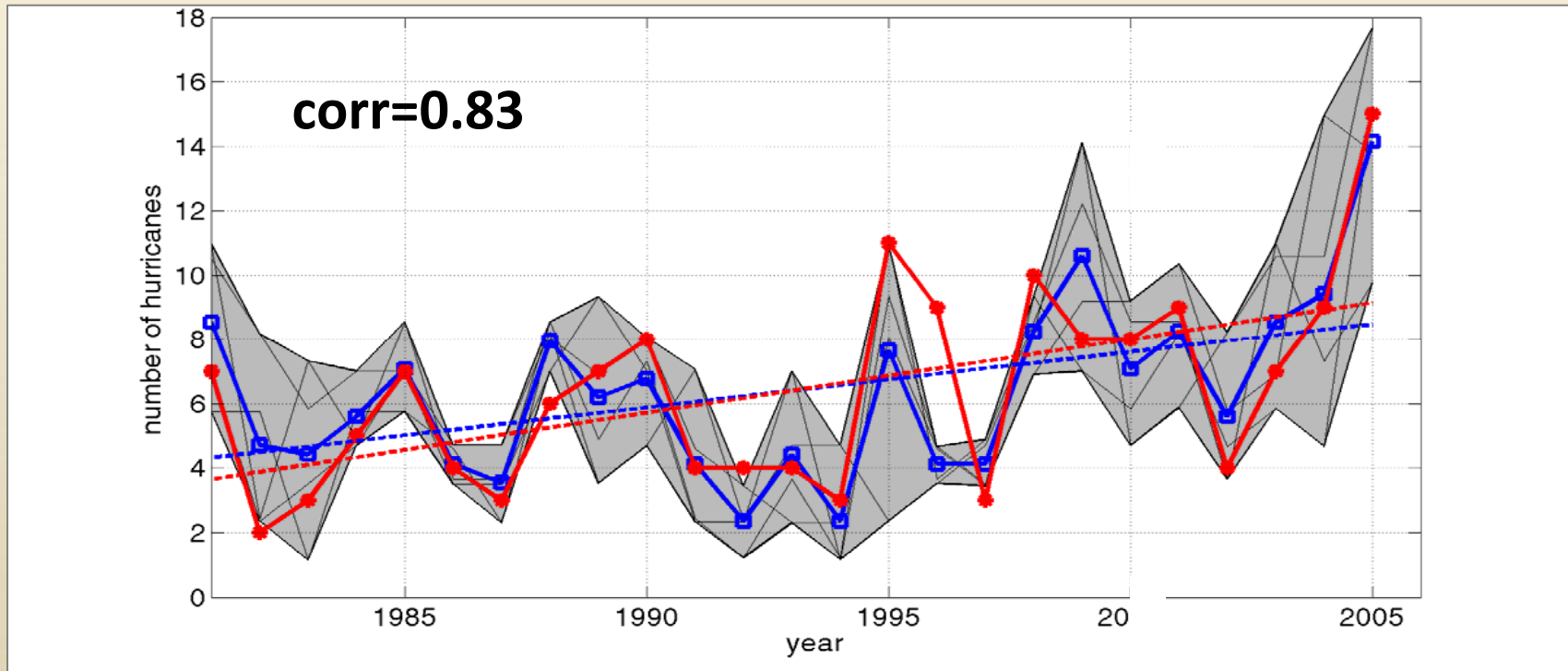
Percent Change



- All cases are downscaled from the Zetac regional model into the GFDL hurricane model, which can simulate hurricanes up to category 5 intensity.
- Colored bars show changes for 18 CMIP3 model ensemble; whiskers show range of changes across 4 individual CMIP models and the ensemble.

Source: Bender et al., 2009, manuscript in preparation

GFDL HIRAM (50-km grid global model) reproduces Atlantic hurricane interannual variability and trend (1981-2005) using observed SSTs alone



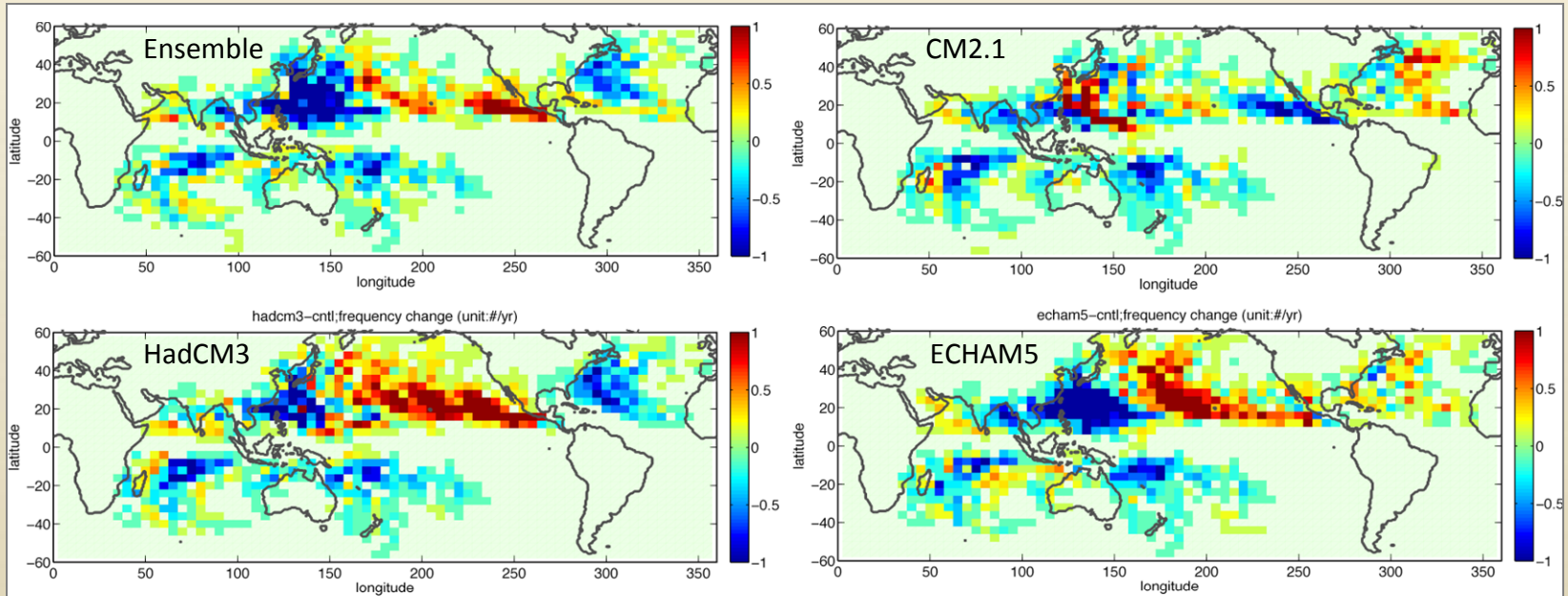
Red: observations
Blue: HIRAM ensemble mean
Shading: model uncertainty

Hurricane counts are normalized by a time-independent multiplicative factor

Zhao et al, submitted to J. Climate, 2009.

Late 21st Century Hurricane Activity Changes

GFDL 50-km HIRAM, using four projections of late 21st Century SSTs.



Red/Yellow = increase
Blue/Green = decrease

Unit: Number per year. Ensemble: 18 CMIP3 models

- Regional increases/decreases much larger than global-mean.
- Pattern depends on details of SST change.

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

Main Conclusions

- **It is premature to conclude that human activity--and particularly greenhouse warming--has already had a detectable impact on Atlantic hurricane activity**
- **Latest modeling projections suggest that future greenhouse warming may gradually decrease the overall number of hurricanes in the Atlantic, but that the occurrence of rarer, most intense hurricanes may increase by a substantial fraction**
- **There are substantial differences in future hurricane activity projections depending on the global climate model chosen for downscaling--an important remaining source of uncertainty**

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