Towards Attribution of Hurricane Activity Changes

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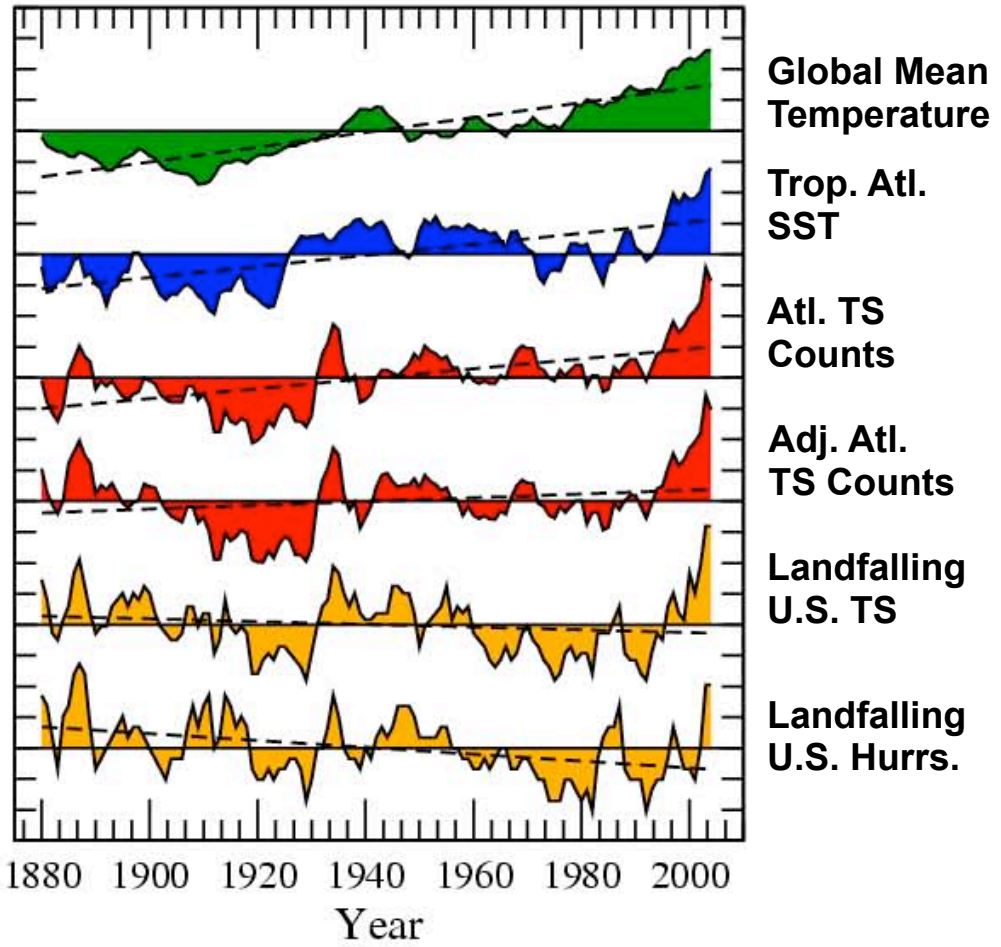
1-GFDL; 2-Princeton/AOS; 3-U. Miami; 4-U. Wisc.-Milw.; 5-Old Dominion U.

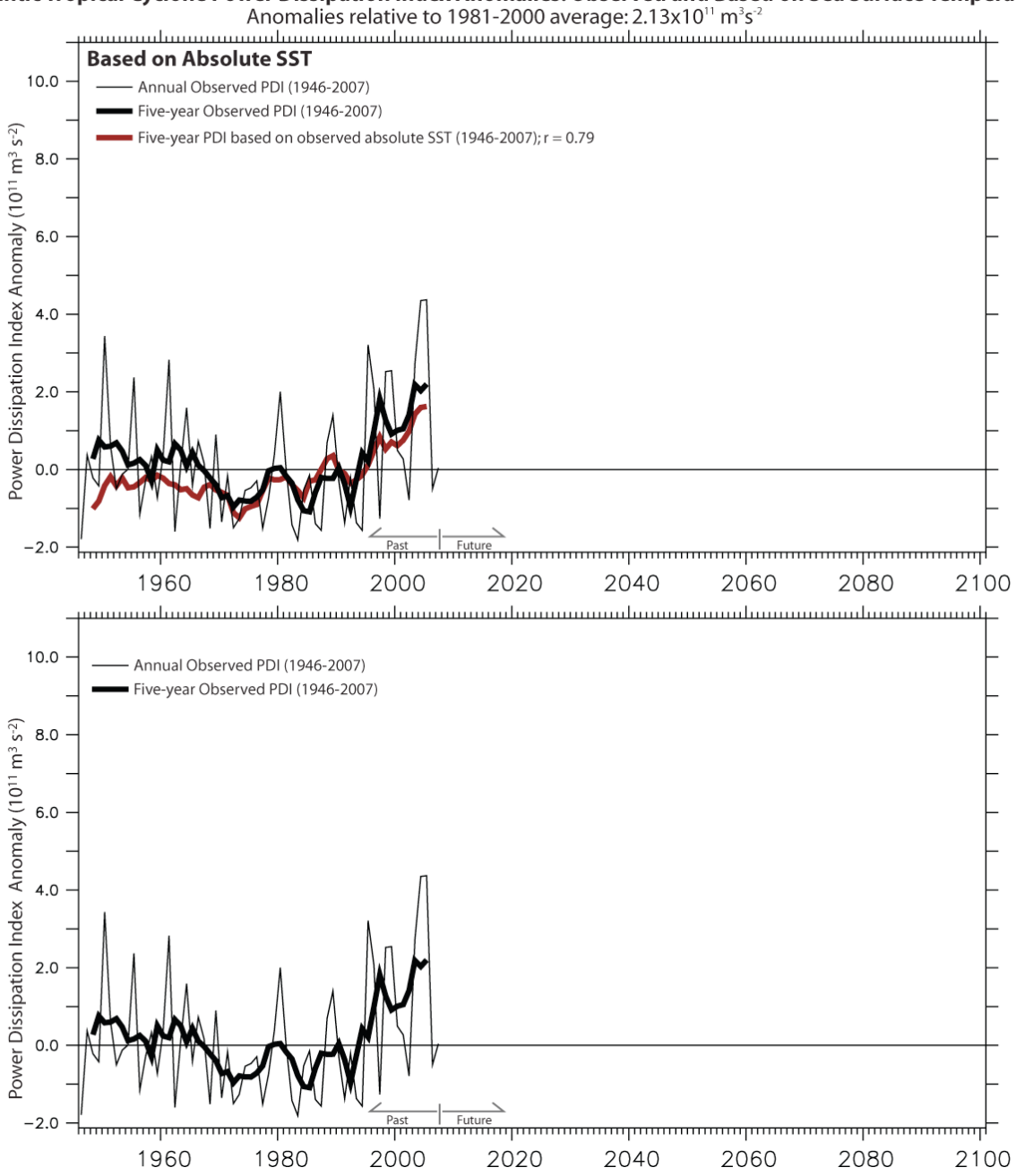
- How do we attribute?
  - Two part attribution: A -> B ; B -> Hurricanes
- Can we say what drove recent Atlantic increase?

Measure of Activity

- Which measure?
  - Hurricane count
  - Landfalling storm count
  - Extremes in intensity
  - Shifts in mean intensity
  - Integrated intensity
- Must balance demand with current ability to detect/ attribute.
  - Obs, models and theory limit.
- Must communicate differences



Vecchi and Knutson (2008, J. Clim.)



Observed Activity
Absolute MDR SST

If causal, can attribute.

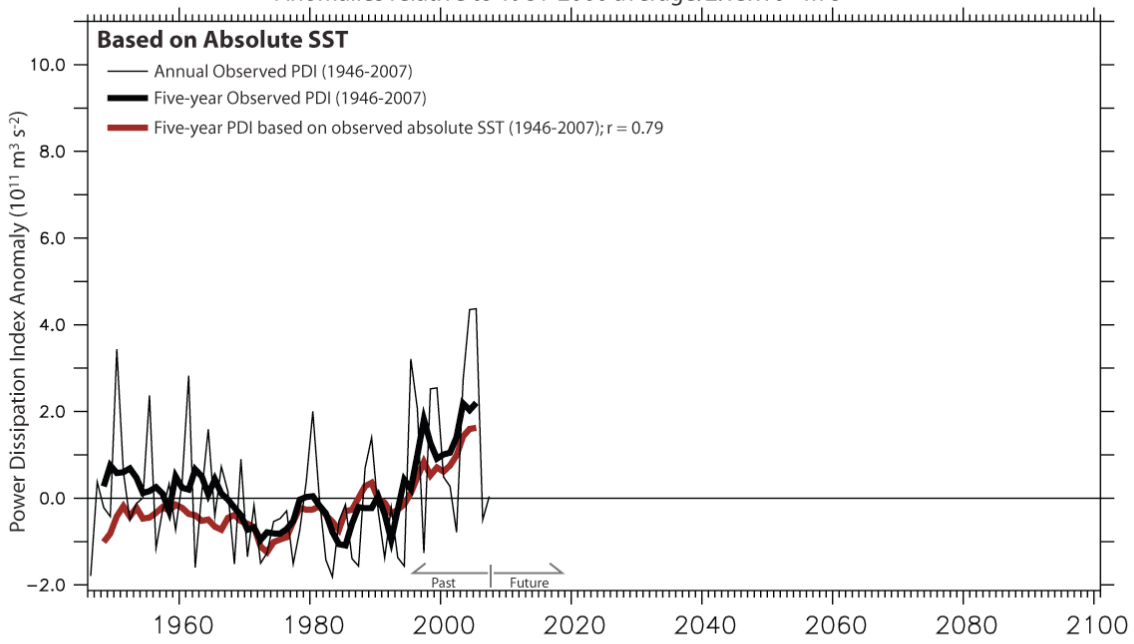
e.g. CCSP-3.3

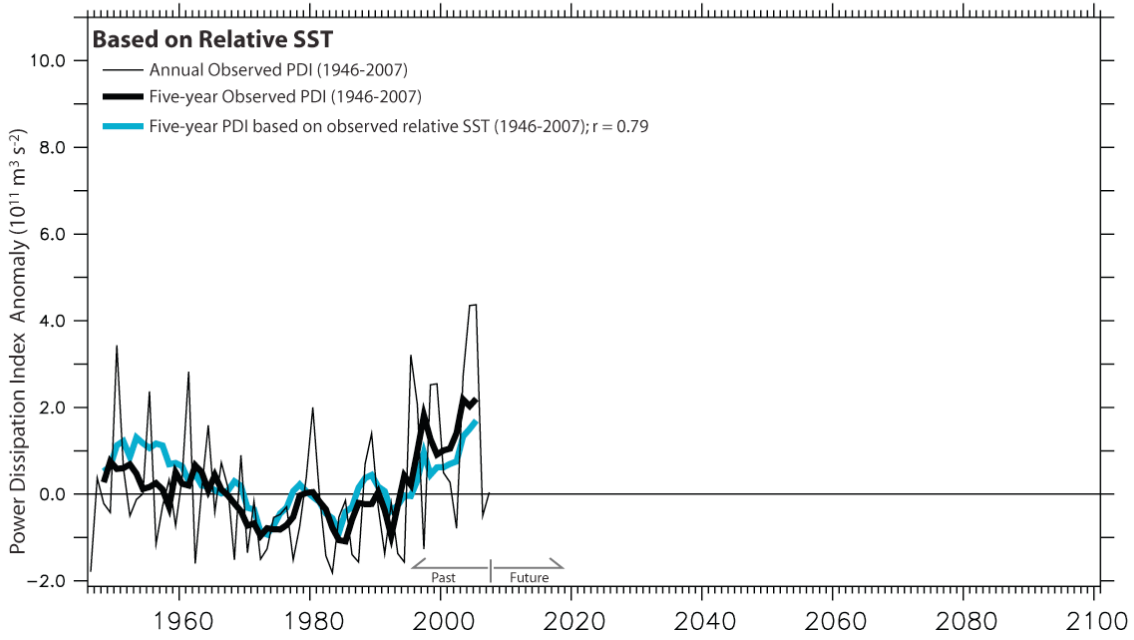
Storm count*duration has been principal control of historical PDI changes (Maue and Hart (2007))

Vecchi, Swanson and Soden (2008, Science)

Atlantic Tropical Cyclone Power Dissipation Index Anomalies: Observed and Based on Sea Surface Temperature

Anomalies relative to 1981-2000 average: 2.13×10^{11} $m^3 s^{-2}$





Observed Activity

Absolute MDR SST

If causal, can attribute.

Relative MDR SST

If causal, cannot attribute.

Vecchi, Swanson and Soden (2008, Science)

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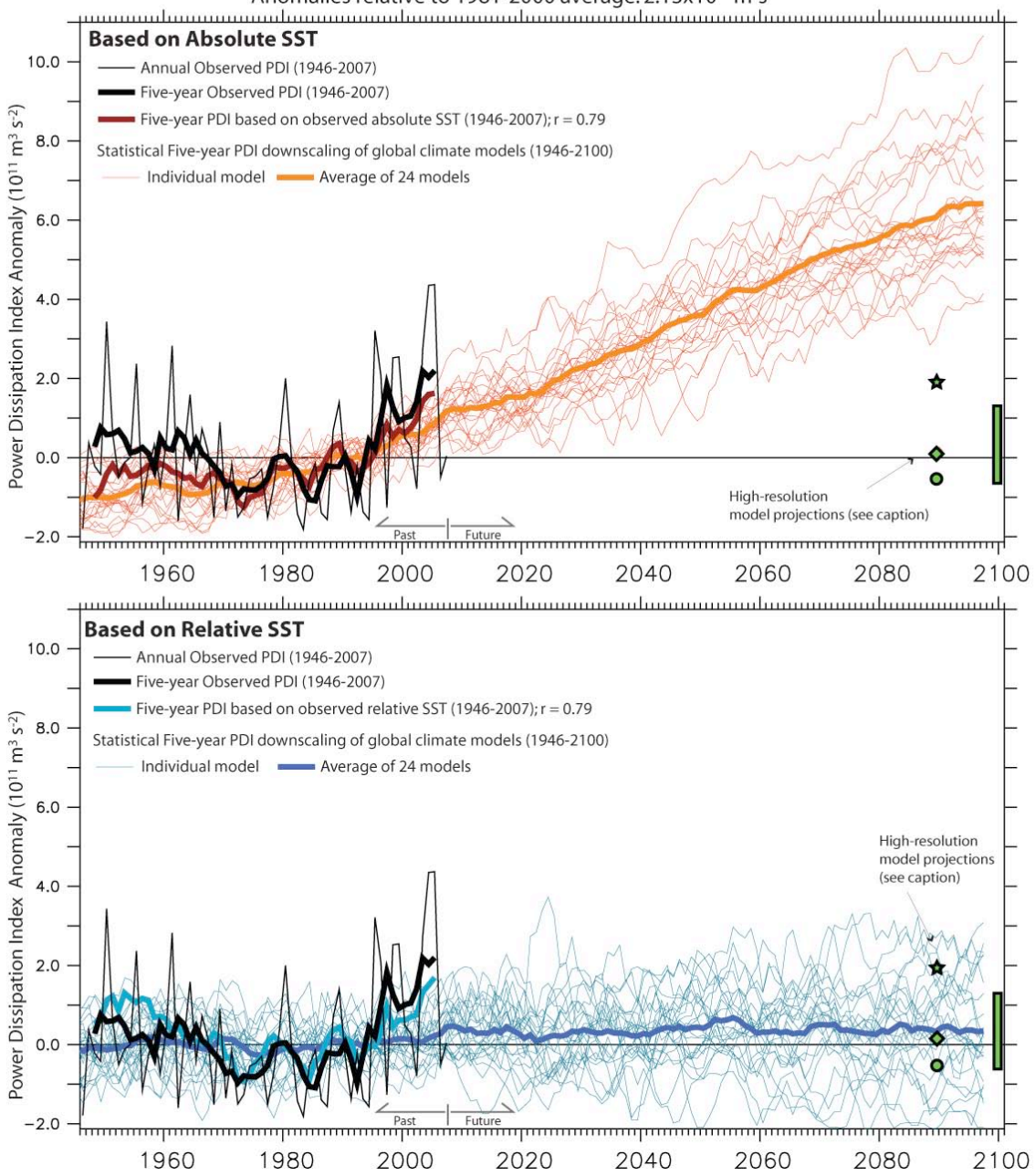


Observed Activity

Absolute SST

Model Abs. SST

High-resolution model activity change

Emanuel et al (08),Knutson et al (08)
Oouchi et al (06),Bengtsson et al (07)

Relative SST

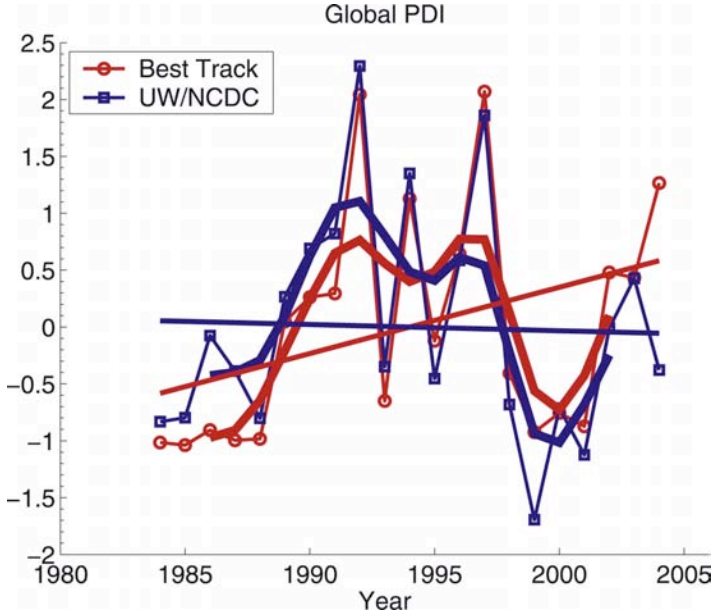
Model Rel. SST

Vecchi, Swanson and Soden (2008, Science)

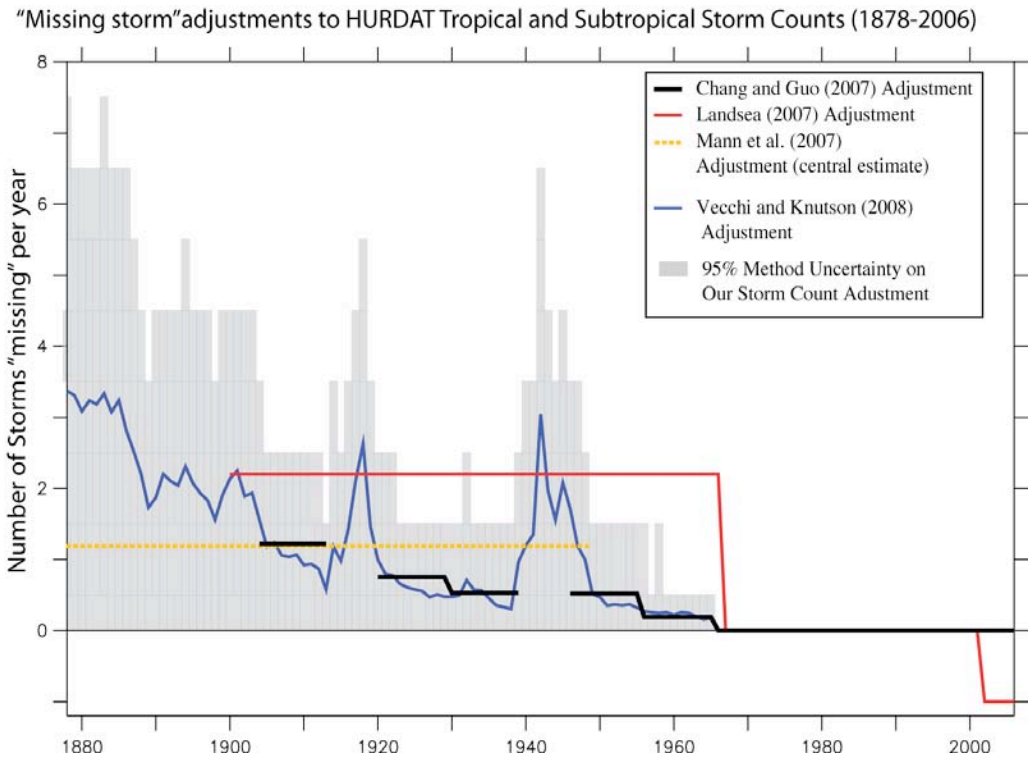
Gabriel Vecchi, NOAA/GFDL, Princeton, NJ

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)



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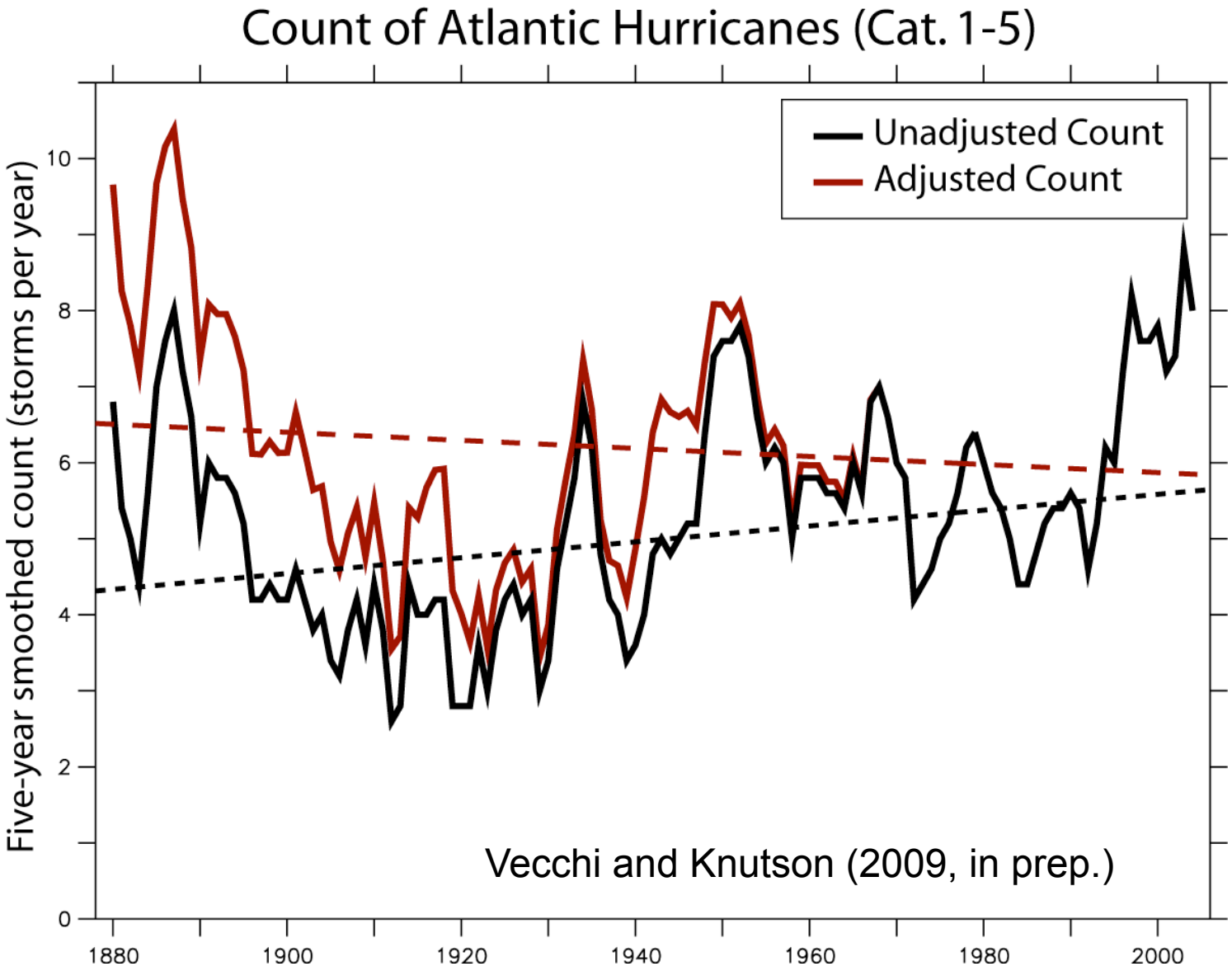

Adjustment changes sign of hurricane count trend

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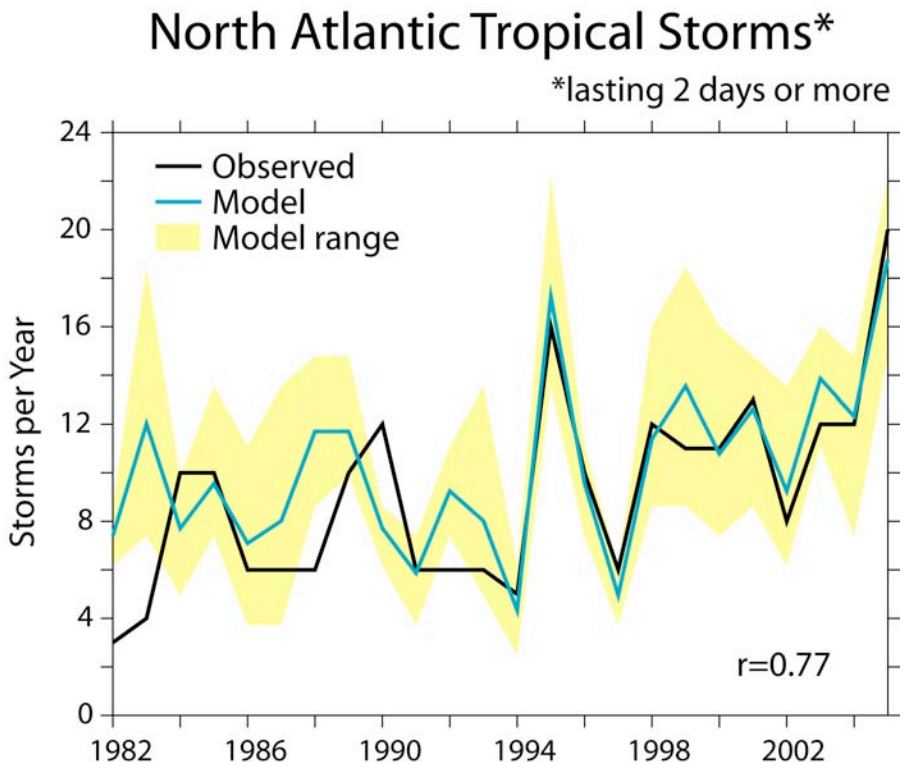
GFDL C-X HiRAM GCMs

Family of global atmospheric models designed for better-representing tropical cyclone frequency. **C90 - 1°,** C180=1/2°, C360=1/4°, C720=1/8°
Ref. Zhao et al (2009, J. Climate)



Explore C90 Model

Adapted from AM2 with:

- Deep convection scheme adapted from Bretherton, McCaa and Grenier (MWR, 2004)
- Cubed sphere dynamical core
- Changes to parameterizations of cloud microphysics
- C90 Atm. resolution of 1°x1°

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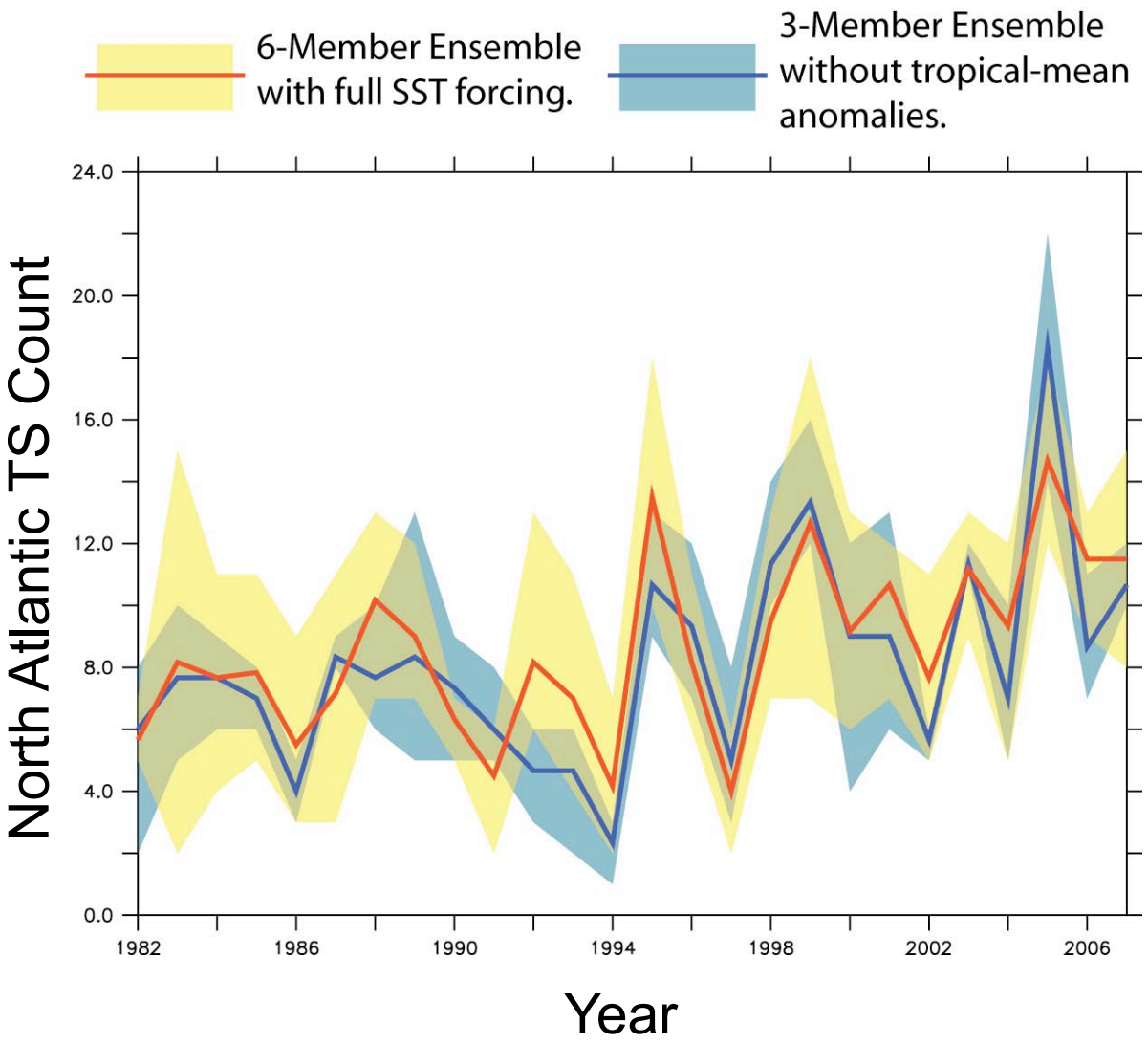
AGCM with and without tropical-mean SST change



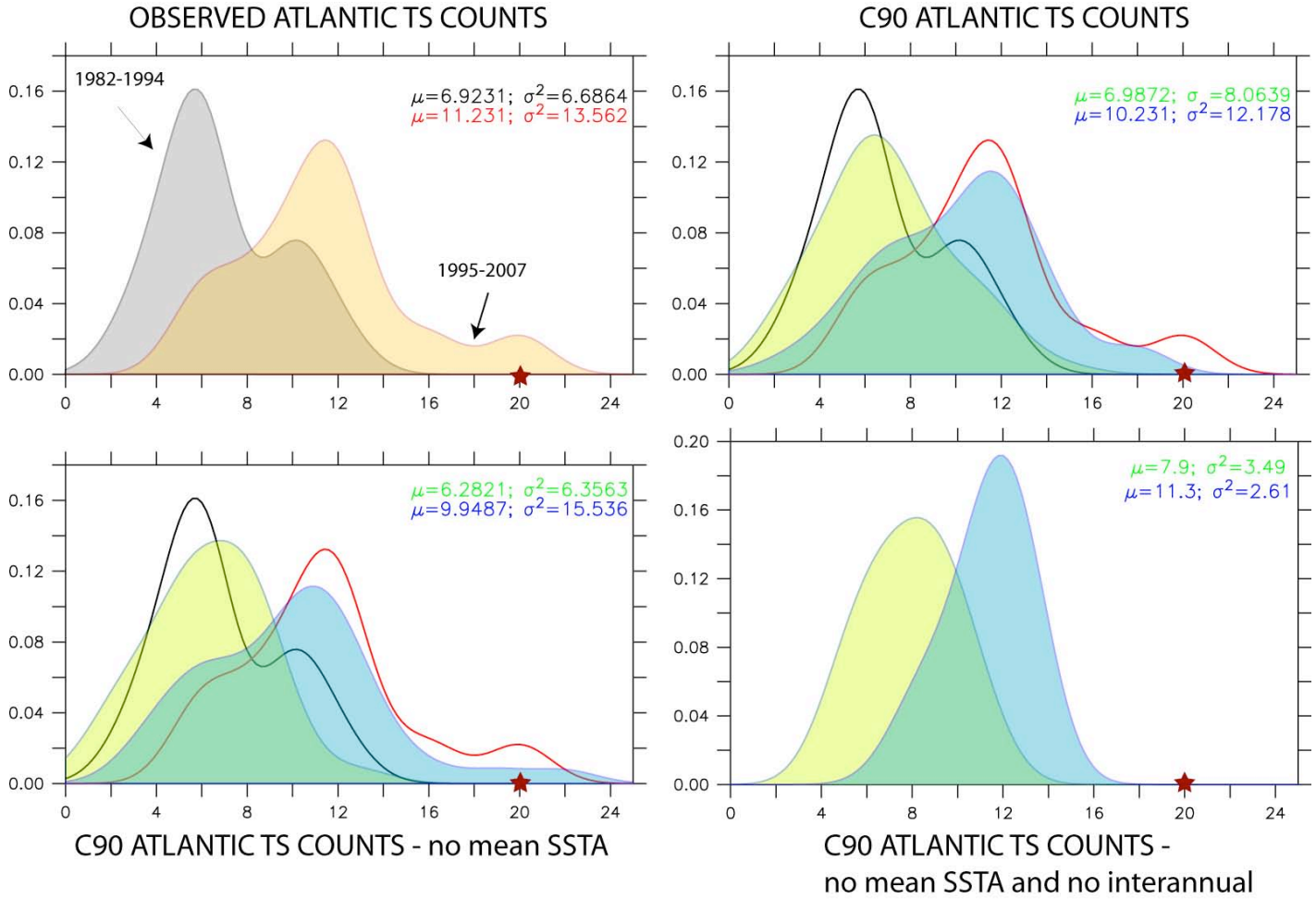
AGCM 1982-2007 North Atlantic tropical storm count not sensitive to removing tropical-mean SSTA forcing.

Vecchi et al (2009, in prep.)

1982-94 and 1995-2007 PDFs of NA TS Count*

* lasting two days or more

★ 2005 Observed



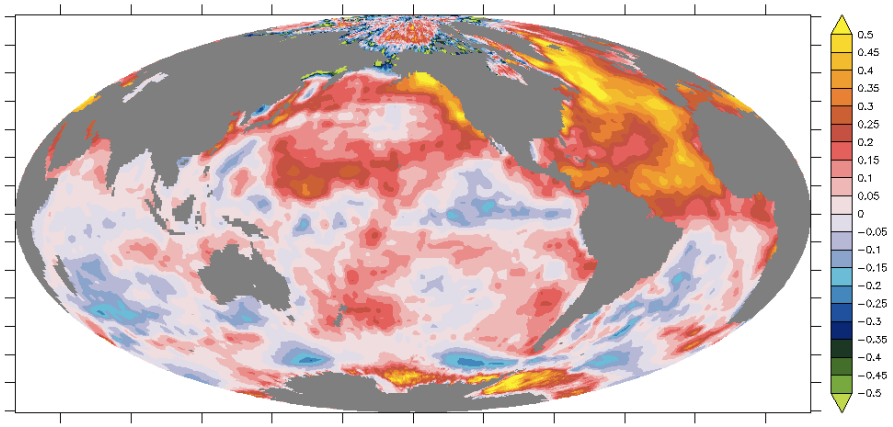
Vecchi et al (2009, in prep.)

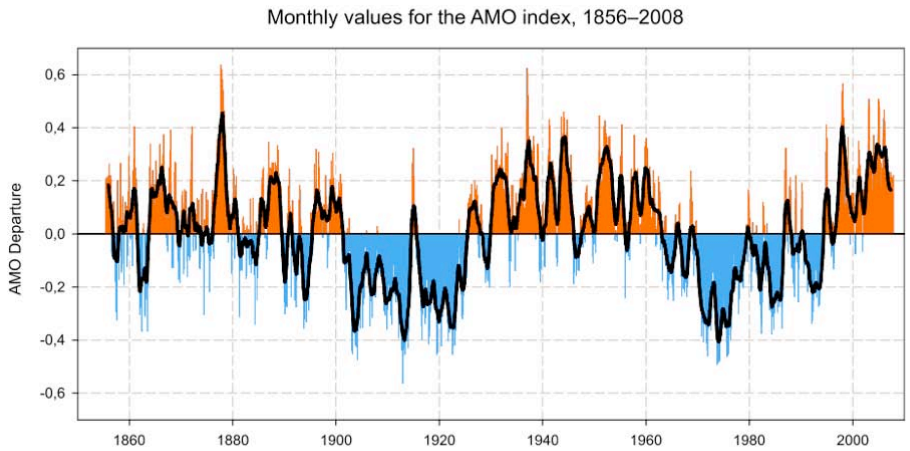
2005: decadal pattern of SSTA and interannual variability.

Shift in mean TS counts attributable to “AMO” SST change across 1994-1995

What drove this SST change? Internal variability? Aerosols? Combination?

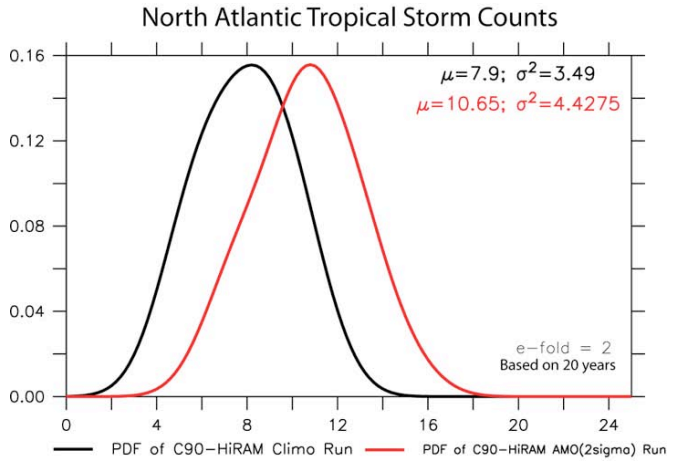
1995-2007 minus 1982-1994 “AMO” SSTA Forcing

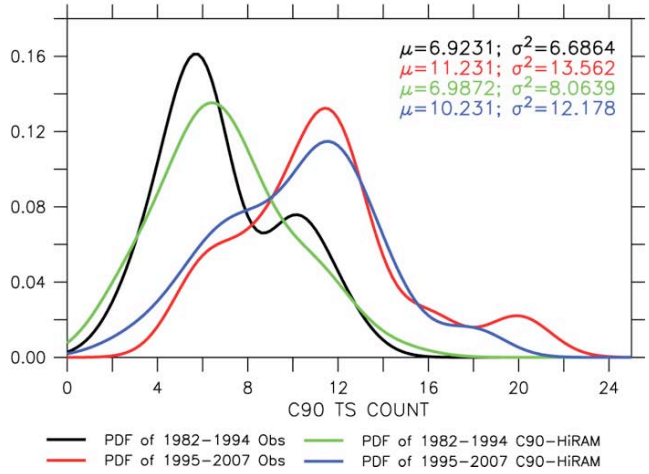




AMO Index: Regression of SST onto NA SST

Response to “AMO” forcing





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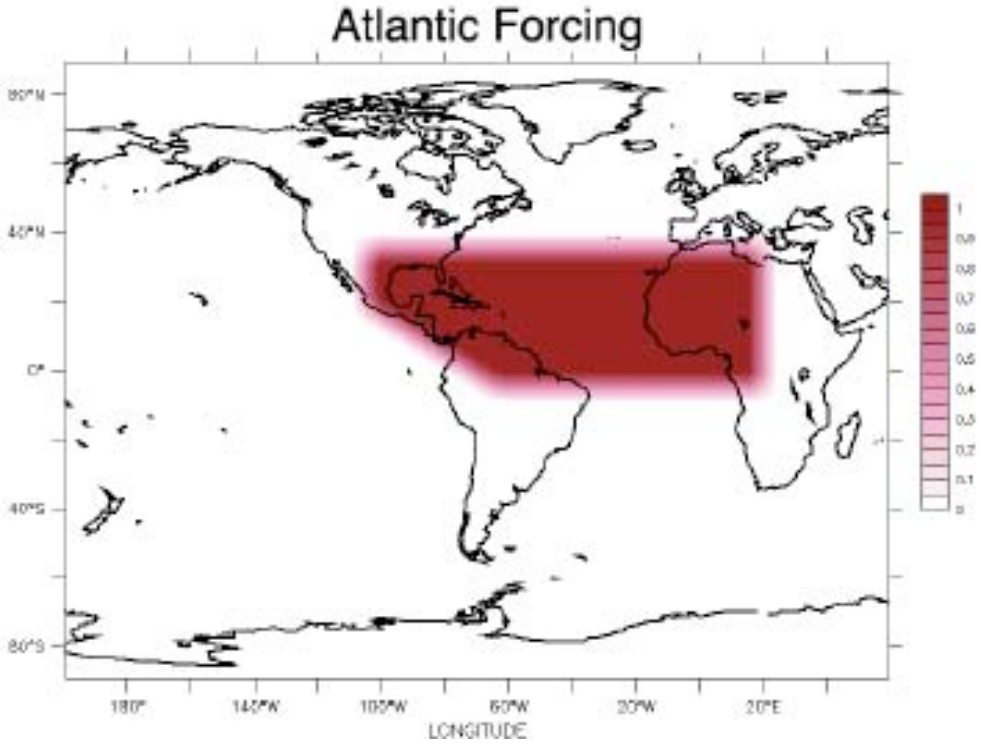
Conclusions

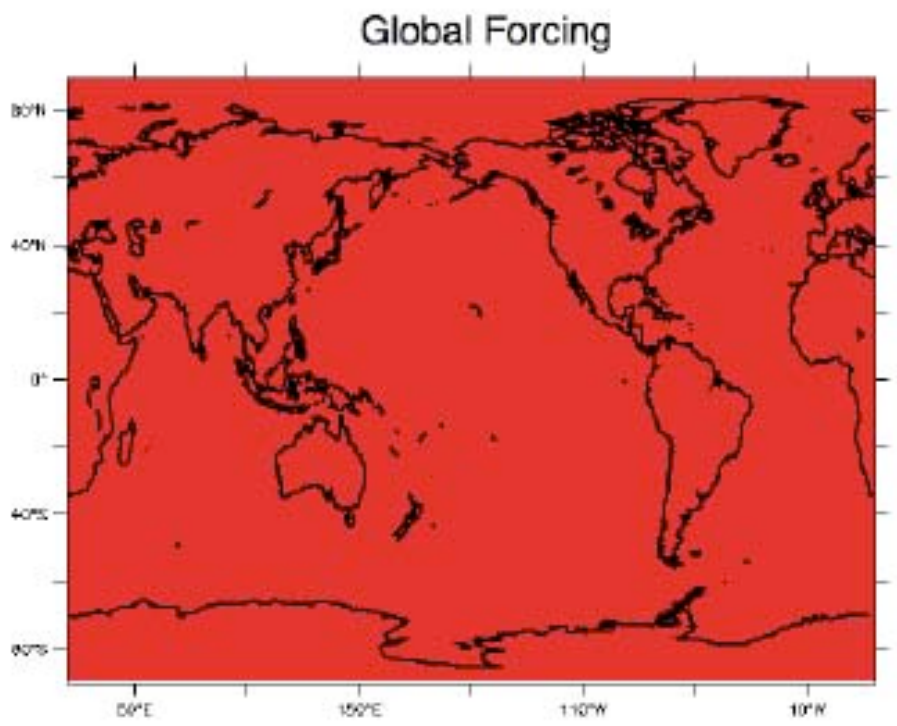
- It is premature to conclude that human activity--and particularly greenhouse warming--has already had a detectable impact on Atlantic tropical storm frequency or PDI.
- Atlantic TS frequency appears controlled by SST changes in the Atlantic relative those in other basins:
  - To attribute Atlantic TS changes need to attribute pattern of SST change (has not been done).
  - Same for prediction/projections: what controls regional SST patterns? (see LeLoup and Clement 2009, Xie et al 2009).
- Change in mean TS frequency across 1994-95 attributable to “AMO-ish” SST change
  - What drove SST?
  - What about shift in variance?

Idealized Forcing Experiments

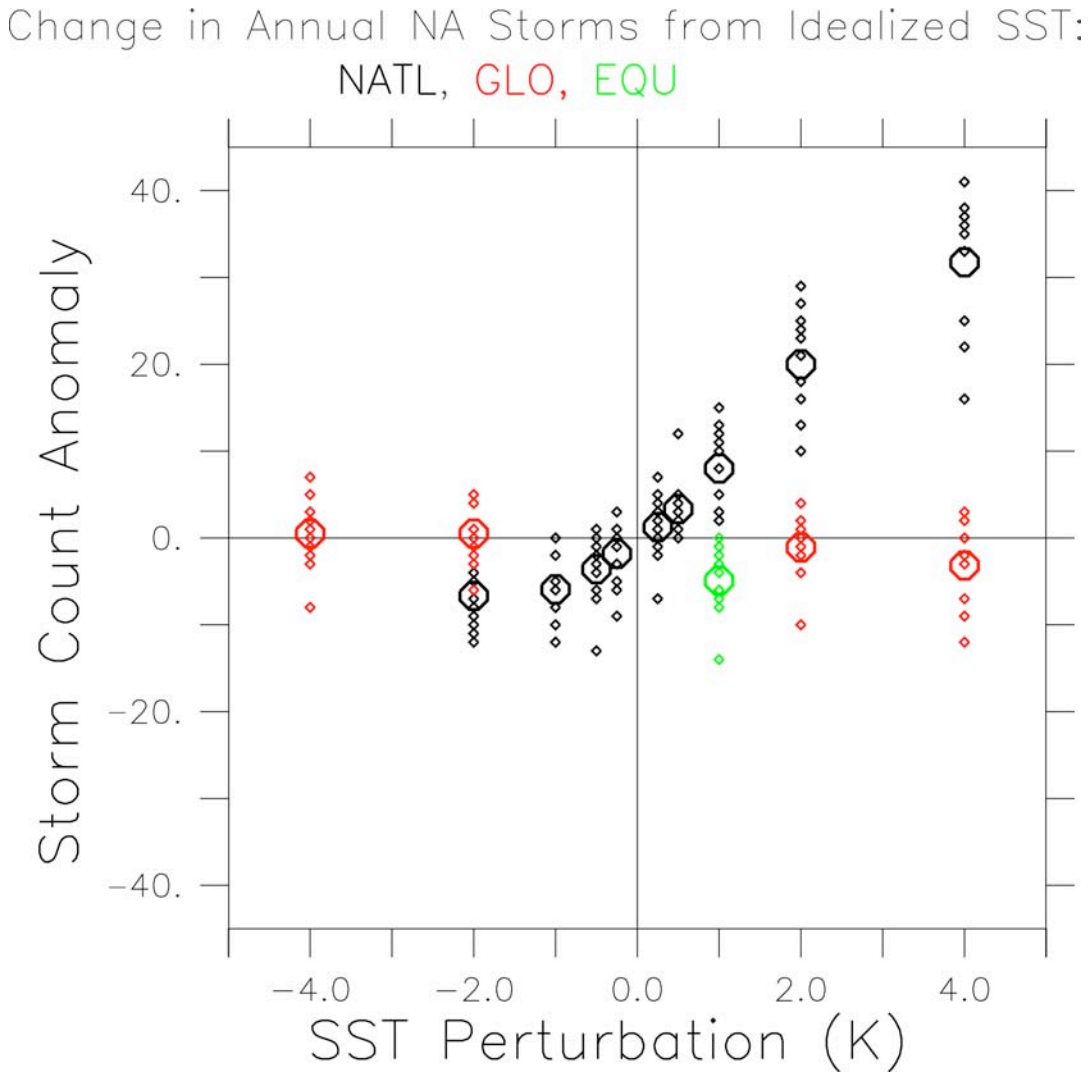
If local SST the dominant control, as opposed to relative SST:

- Similar Atlantic Response to Atlantic and Uniform F'cing
- Little Pacific Response to Atlantic compared to Uniform





North Atlantic Response to Idealized SST



Atlantic Forcing

Uniform Forcing

Near-equatorial Forcing

Similar TS frequency response to:
0.25° local warming
4° global cooling

Vecchi et al (2009, in prep.)