Towards Attribution of Hurricane Activity Changes

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\textsuperscript{1-GFDL; 2-Princeton CEE; 3-U. Miami}

Can we say what drove recent Atlantic increase?

How do we attribute?

Two part attribution: A -> B ; B -> Hurricanes

2011 ASLO Meeting
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

Observed Activity
Absolute Atlantic Temperature
If causal: can attribute

Vecchi, Swanson and Soden (2008, Science)
Two Temperature Predictors of Atlantic Hurricane Activity

Vecchi, Swanson and Soden (2008, Science)

Observed Activity
Absolute Atlantic Temperature
If causal: can attribute

Observed Activity
Relative Atlantic Temperature
If causal: cannot attribute
TWO STATISTICAL PROJECTIONS OF ATLANTIC HURRICANE ACTIVITY

Observed Activity
Absolute Atlantic Temperature

Observed Activity
Relative Atlantic Temperature

Vecchi, Swanson and Soden (2008, Science)
...Add Dynamical Projections of Atlantic Hurricane Activity

- Observed Activity
  - Absolute Atlantic Temperature
  - Relative Atlantic Temperature

Dynamical Model Projections

Vecchi, Swanson and Soden (2008, Science)
Recorded NA Hurricanes Show Clear Increase

But was there really an increase?


Data Archeology and Paleo-proxy Indicators Complement Instrumental Records (e.g., Nyberg et al. 2007, Chennoweth and Divine 2008, Mann et al. 2009)
West Atlantic has seen century-scale decrease in hurricanes

1878-2008 Trend in Hurricane Occurrence

Vecchi and Knutson (2011, in press J. Clim.)
ATtribution of Recent TS Frequency Increase in North Atlantic

100km GFDL-HiRAM AGCM recovers recent NATS Trend when forced with HadISST.v1 SST

What aspect of SST drove increase?

Vecchi, Zhao and Held (2011, in prep.)

2005 Observed

2005: decadal pattern of SSTA and interannual variability.

Vecchi, Delworth, Zhao and Held (2011, in prep.)
Shift in mean TS counts attributable to “AMO” SST change across 1994-1995

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


Response to “AMO” forcing

AMO Index: Regression of SST onto NA SST

Vecchi, Delworth, Zhao and Held (2009, in prep.)
Statistical Projections of 21st Century NATS Trends (model based on difference Atlantic to Tropical SST)

Stat. model recovers high-res models

Stat. model projects small changes of differing sign

Villarini et al (2011, in press)
Recent increase not robustly "FORCED" in CMIP3 Models

Recent trends in statistical hurricane model applied to CMIP3 20c3m runs

Vecchi et al. (2011, in prep.)
Conclusions

• It is premature to conclude that human activity (particularly greenhouse warming) has already had a detectable impact on Atlantic tropical storm and hurricane frequency or PDI.

• Atlantic TS frequency appears controlled by SST changes in the Atlantic relative those rest of tropics:

To attribute Atlantic TS changes need to attribute pattern of SST change (has not been done).


• Change in mean TS frequency across 1994-95 attributable to “AMO-ish” SST change

What drove SST pattern? What about shift in variance? Interannual variability important.
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°**


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°
IDEALIZED FORCING

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
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.)