On the Cause of the Great North Atlantic Hurricane Drought of the Late 20th Century

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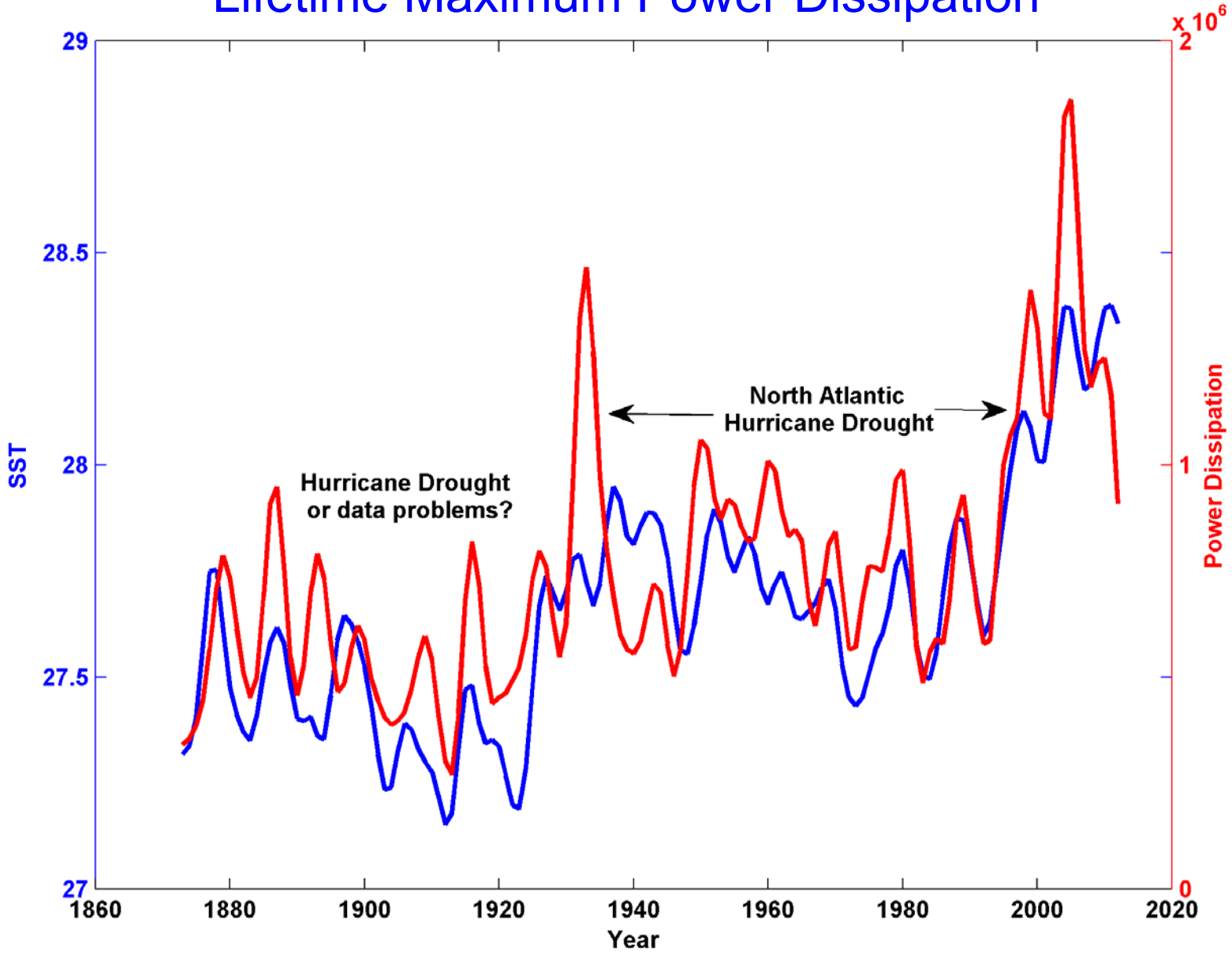
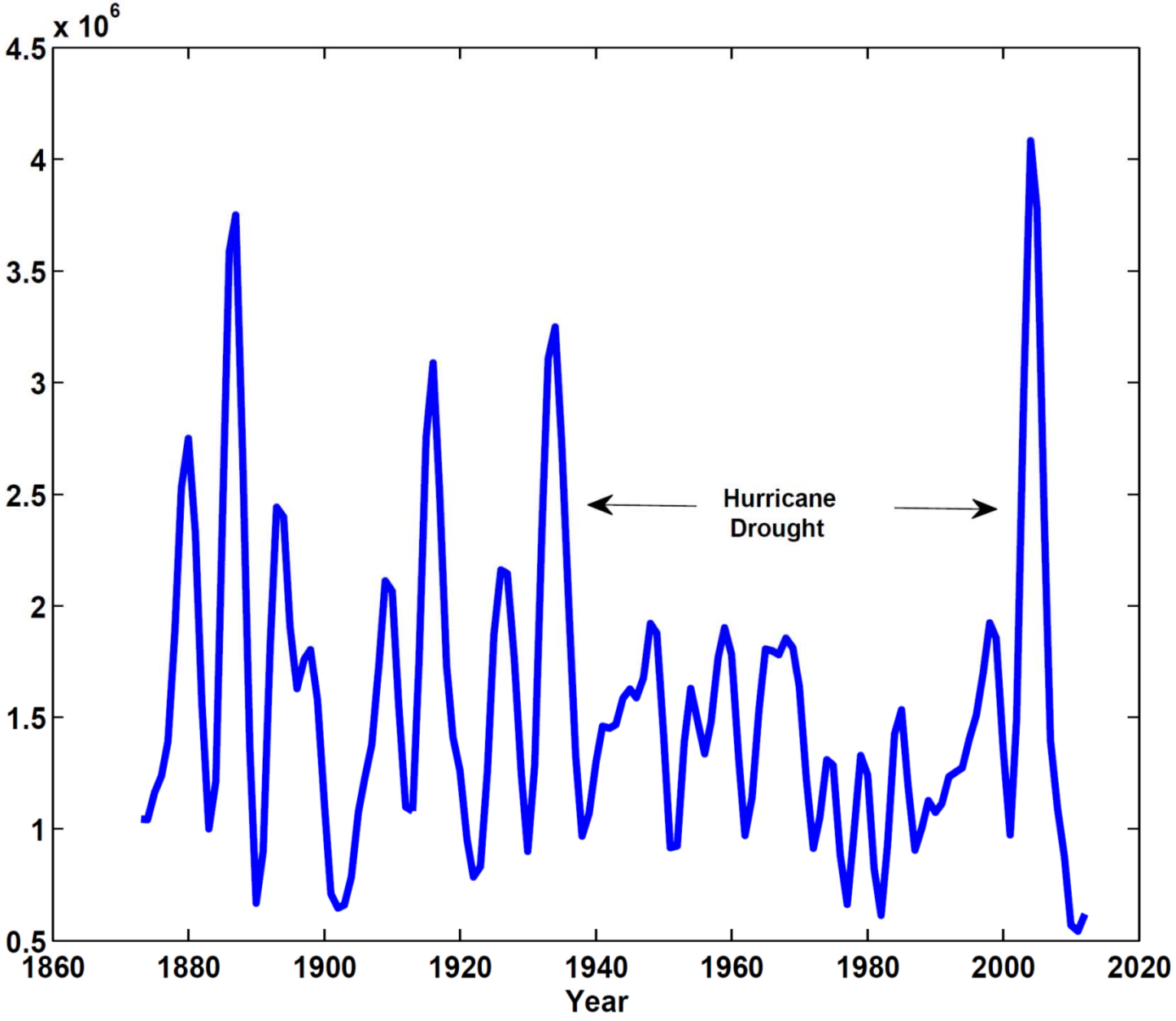
August-October Tropical Atlantic SST and Storm Lifetime Maximum Power Dissipation



U.S. Landfall Power Dissipation



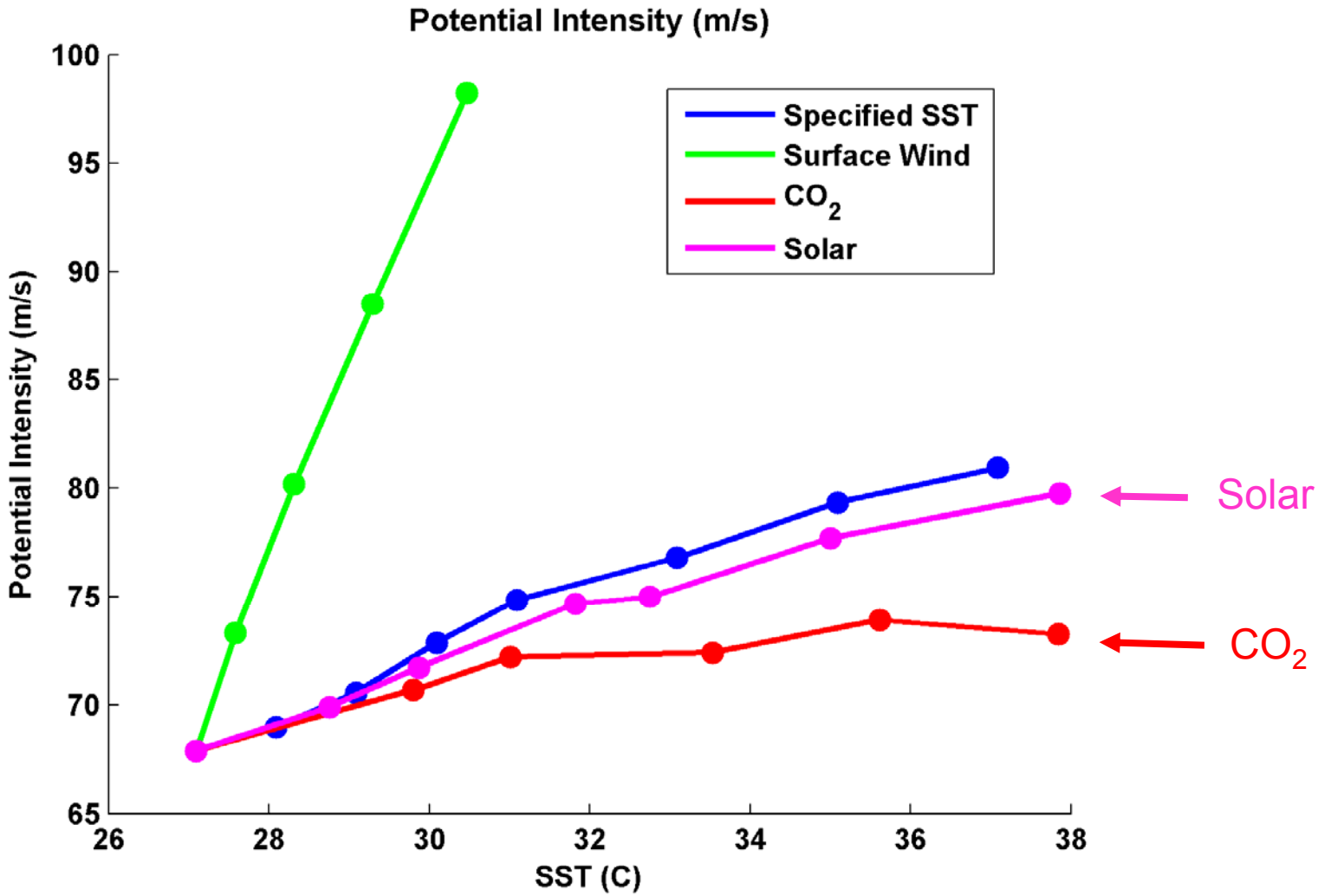
Sulfate Aerosols and North Atlantic Hurricanes

- During the late 20th Century, global aerosol radiative forcing is thought to be of the same order as CO_2 radiative forcing

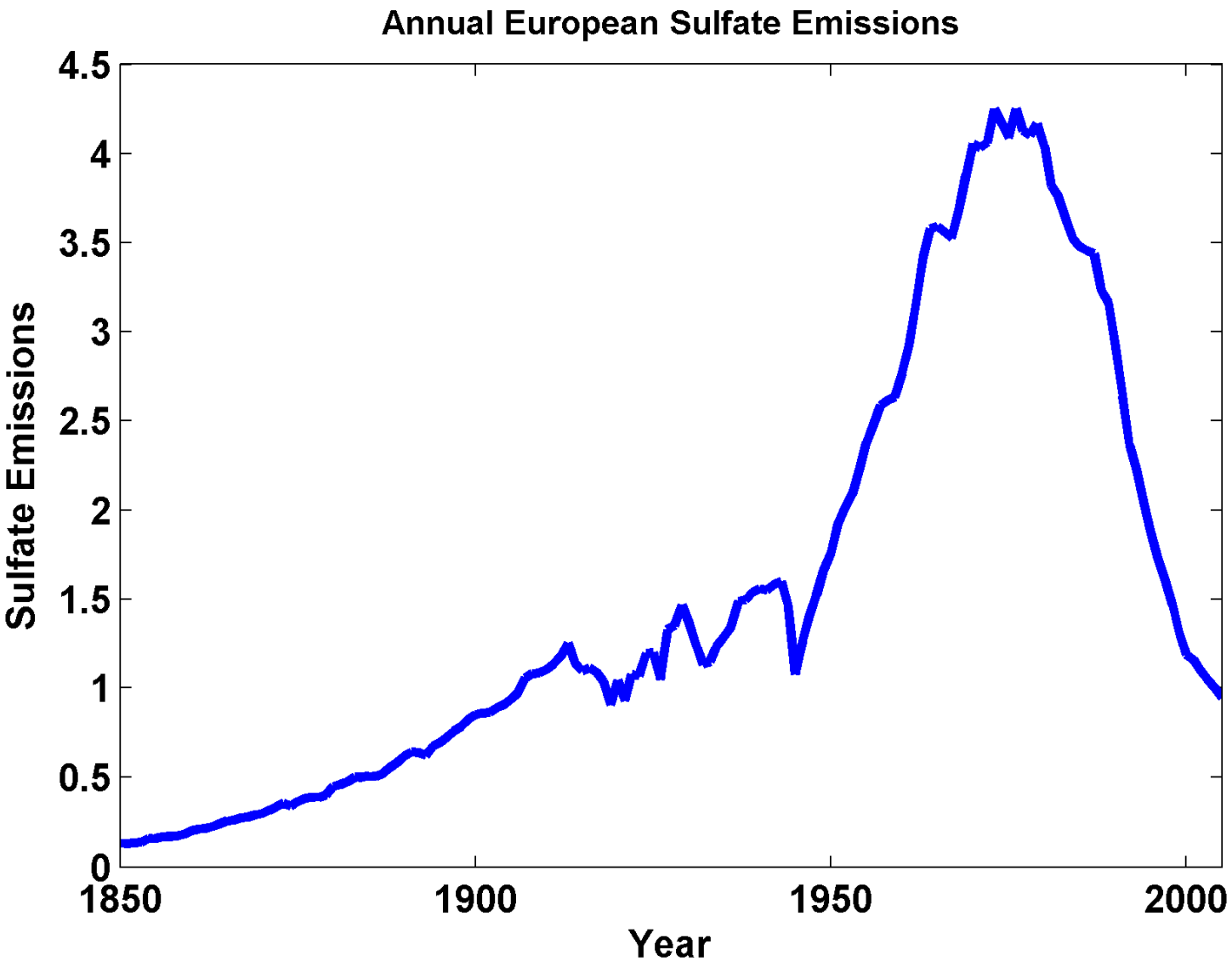
- Per unit sea surface temperature change, shortwave forcing is roughly twice as effective as longwave forcing in changing potential intensity

- Much of the interannual variability of aerosol forcing over the tropical North Atlantic in summer is thought to be owing to the interaction of sulfate aerosols of European origin with African dust (Li-Jones and Prospero, 1998)

Variation of Potential Intensity with Ocean Heat Flux, Surface Wind Speed, CO_2, and Solar Forcing

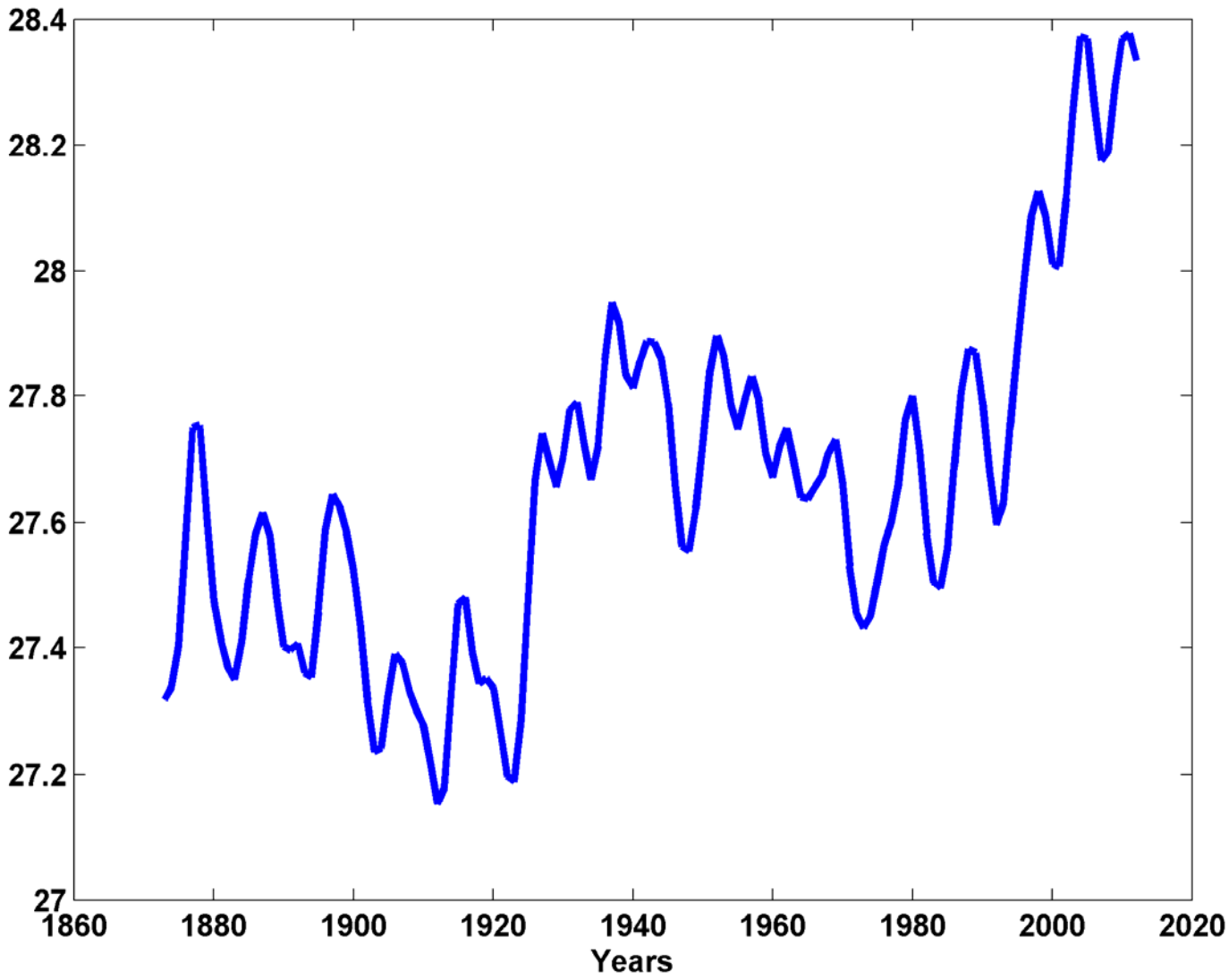


Emanuel, K., and A. Sobel, 2013: Response of tropical sea surface temperature, precipitation, and tropical cyclone-related variables to changes in global and local forcing. *J. Adv. Model. Earth Sys.*, **5**, doi:10.1002/jame.20032



From Smith et al., *Atmos. Chem. Phys*, 2011

August-October Tropical North Atlantic SST



Hypothesis:

- Multi-decadal variability of North Atlantic hurricane activity in the late 20th Century is owing to variations in shortwave and longwave radiative forcing

- Residual quasi-decadal hurricane variability is owing to a natural oscillatory mode of the North Atlantic, nominally equivalent to the Atlantic Multi-Decadal Oscillation (AMO)

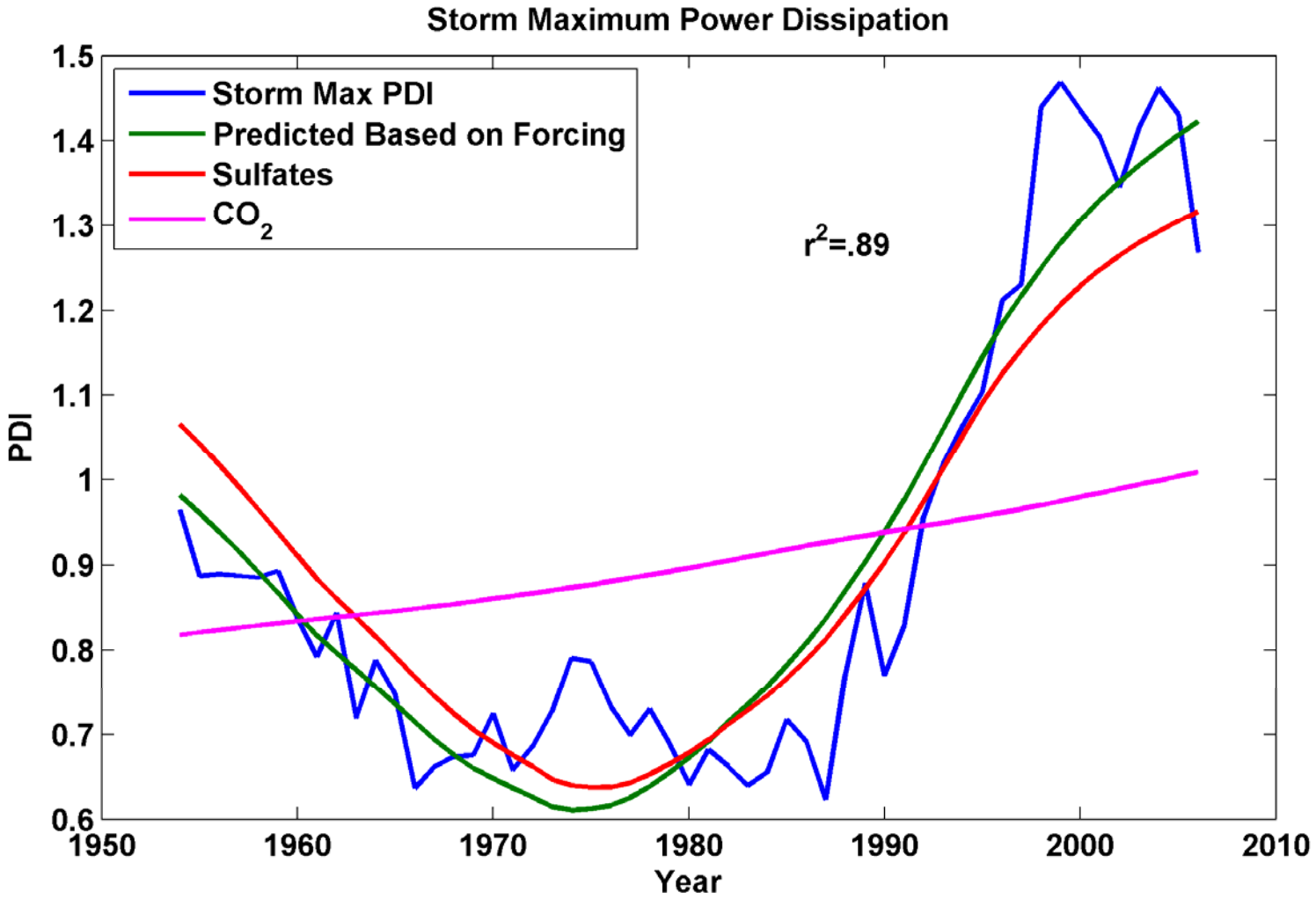
Test:

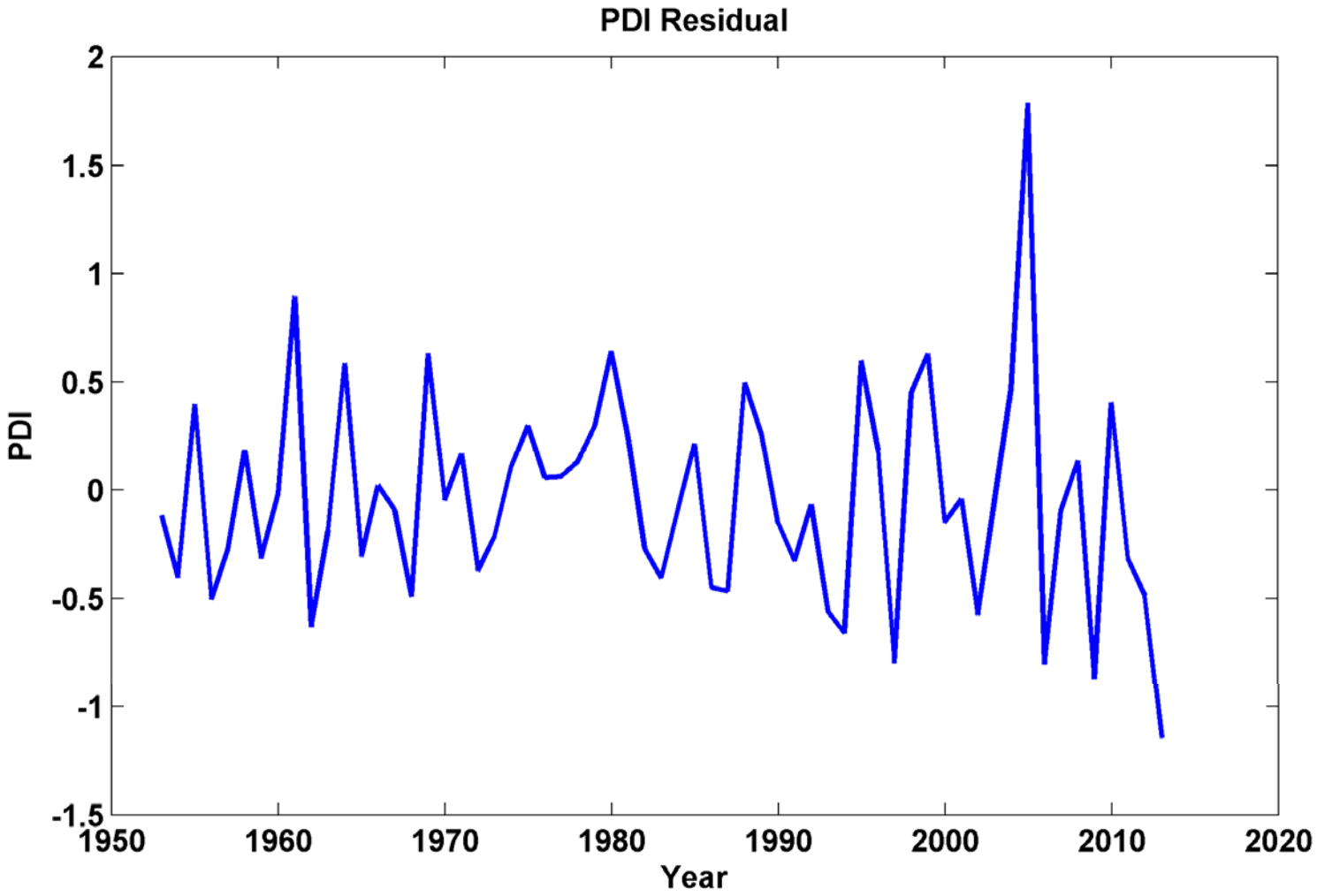
- Separate North Atlantic Storm Maximum Power Dissipation into two parts: a) Long-period variability (**10-year running average**) and b) quasi-decadal variability (**residual**)

- Use multiple linear regression to regress long-period signal onto 2-year lagged log(CO_2) and European sulfate emissions

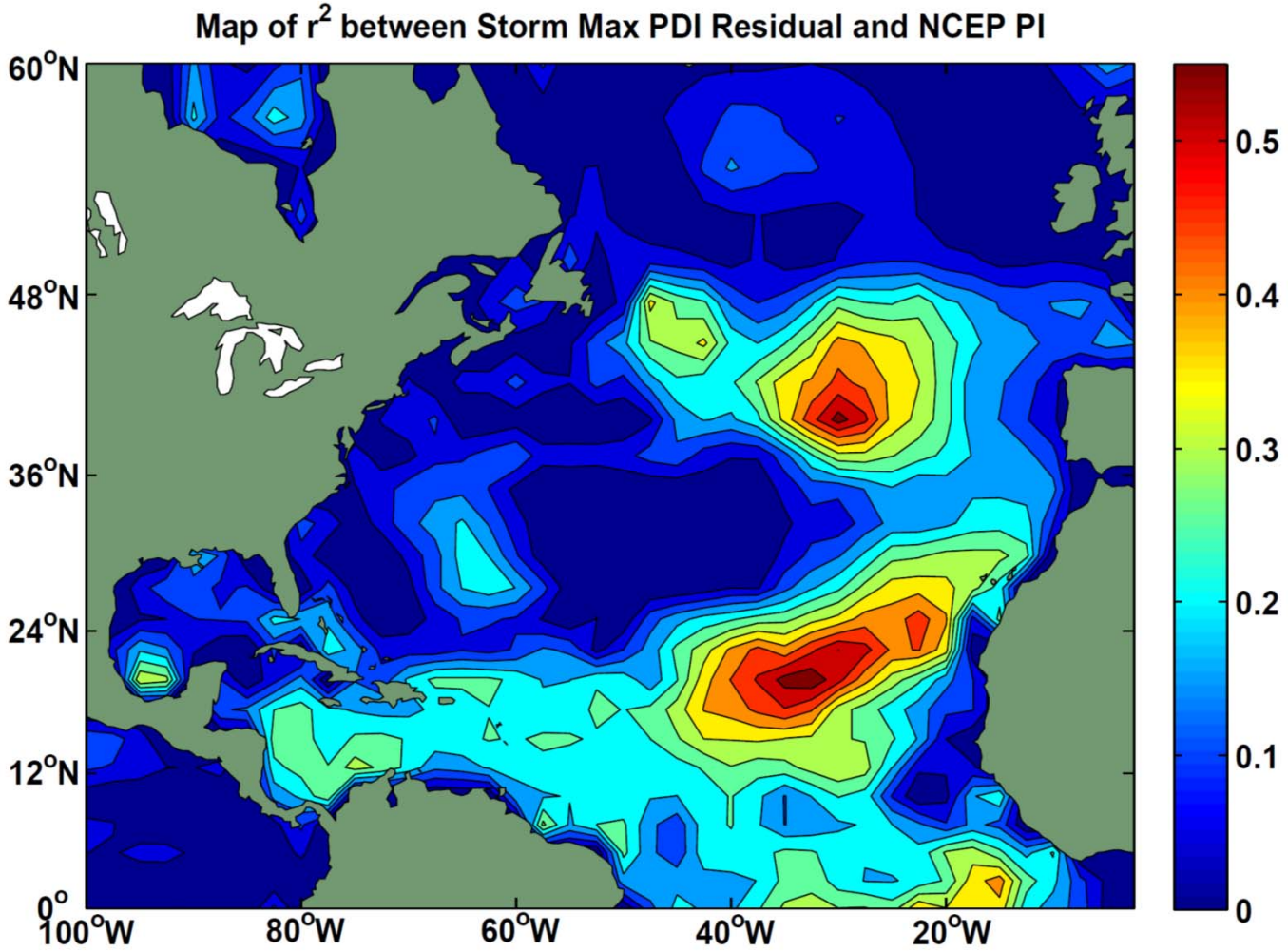
- Correlate residual (quasi-decadal) signal in storm maximum power dissipation with North Atlantic potential intensity from NCEP reanalysis

Linearly regress European sulfates and log (CO_2) onto Storm Maximum Power Dissipation

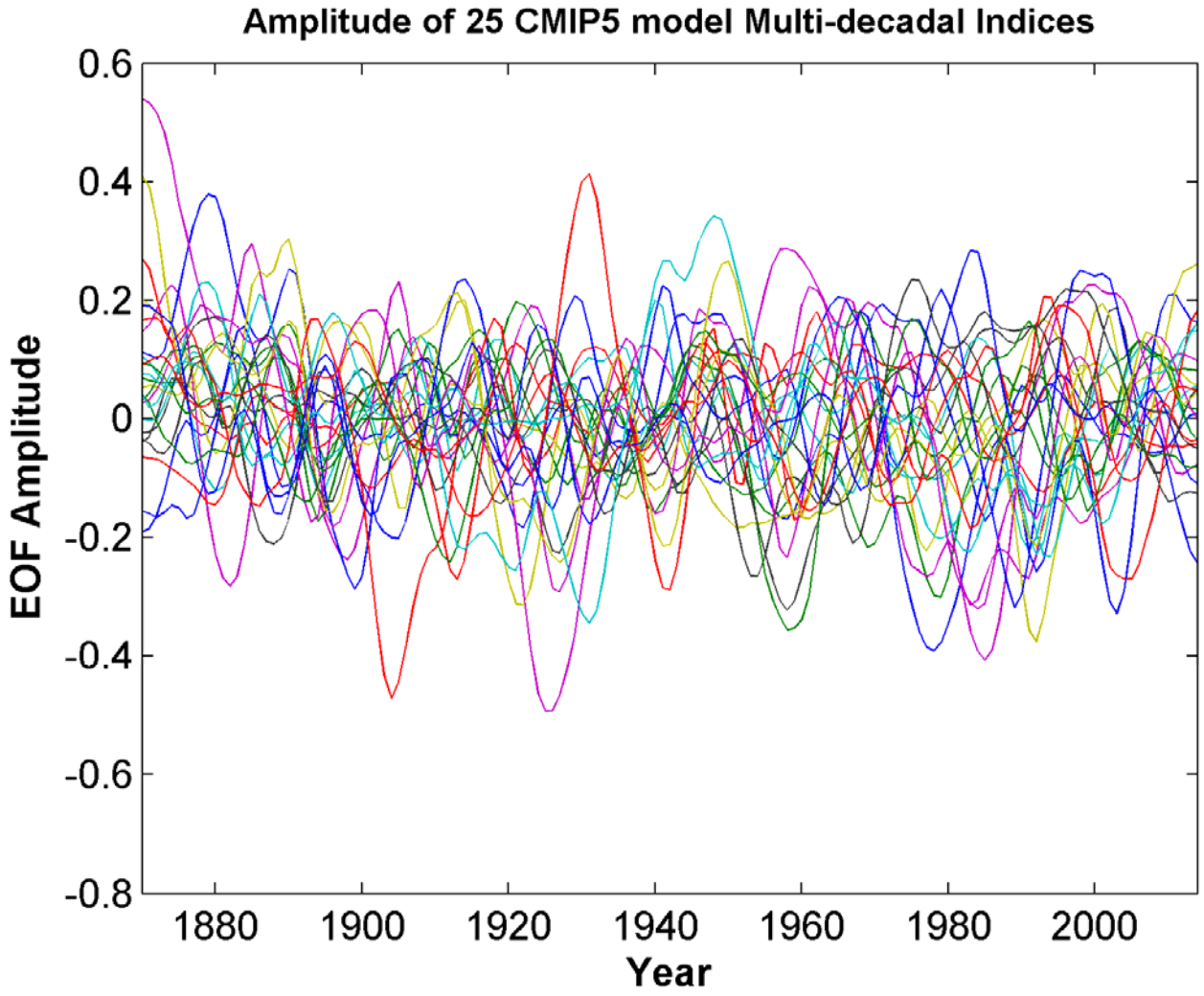




Spectral peak at ~6 years


Map of r2 between Storm Max PDI Residual and NCEP PI
60°N
48°N
36°N
24°N
12°N
0°
100°W
80°W
60°W
40°W
20°W
0.5
0.4
0.3
0.2
0.1
0

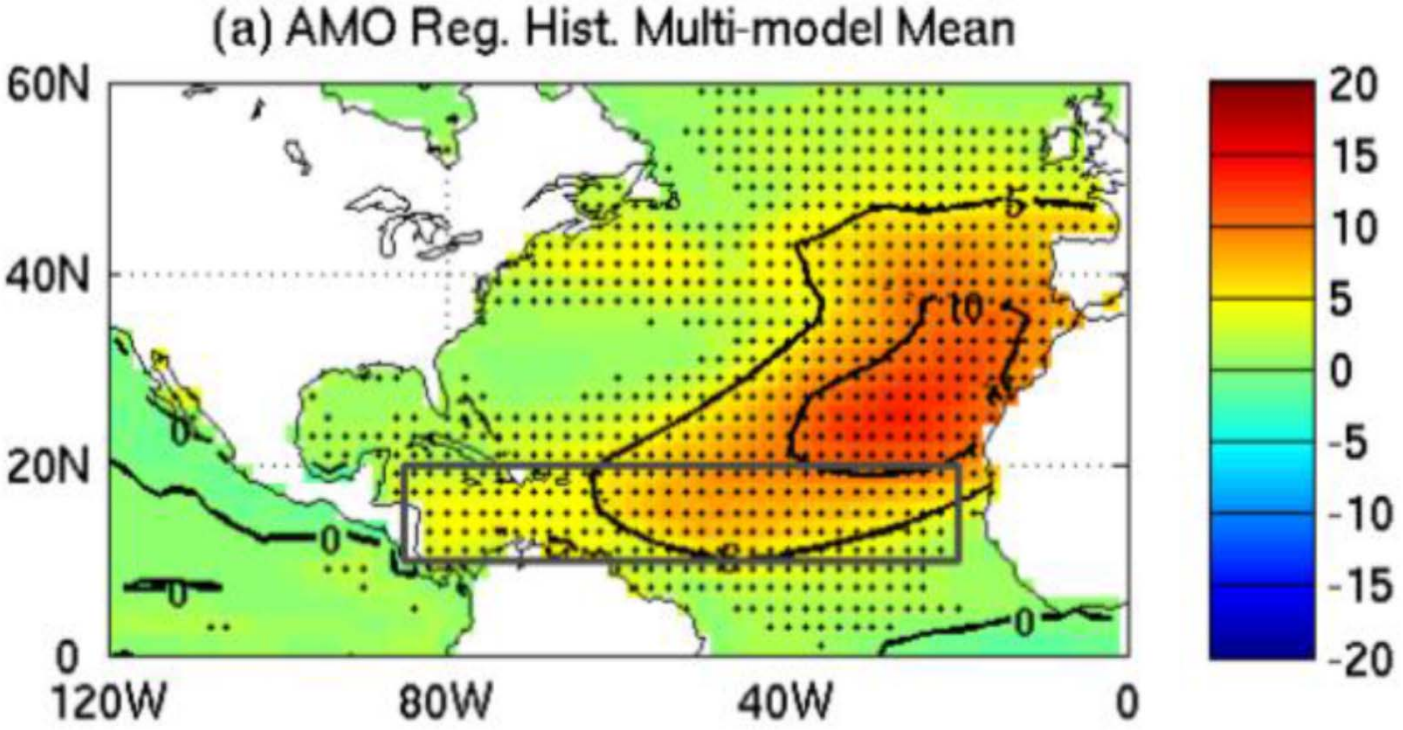
Multi-decadal Variability in 25 CMIP5 Climate Models



Spectral peaks from 5 to 20 years

From Ting et al, *J. Climate, in press*. Data courtesy Mingfang Ting.

CMIP5 multi-decadal signal regressed onto potential intensity



From Ting et al., *J. Climate, in press*

Summary

- Variations in solar radiation ~twice as effective in reducing PI as longwave trapping, per unit decrease in SST
- Sulfates measured in Barbados are mostly of European origin
- Peak in European sulfate emissions coincided with minimum in North Atlantic TC power dissipation and SST
- CO_2 and sulfate emissions explain ~90% of long-period variations in North Atlantic power dissipation
- Pattern of strong, quasi-decadal residual signal strongly resemble pattern of unforced, coupled GCM simulations
- **Evidence supports idea that quasi-decadal variations in North Atlantic TC activity are the result of a natural coupled oscillation while the Great North Atlantic Hurricane Drought was likely caused by European sulfate emissions**