Some Recent Applications of the Observed Extra-Tropical AMOC Fingerprint

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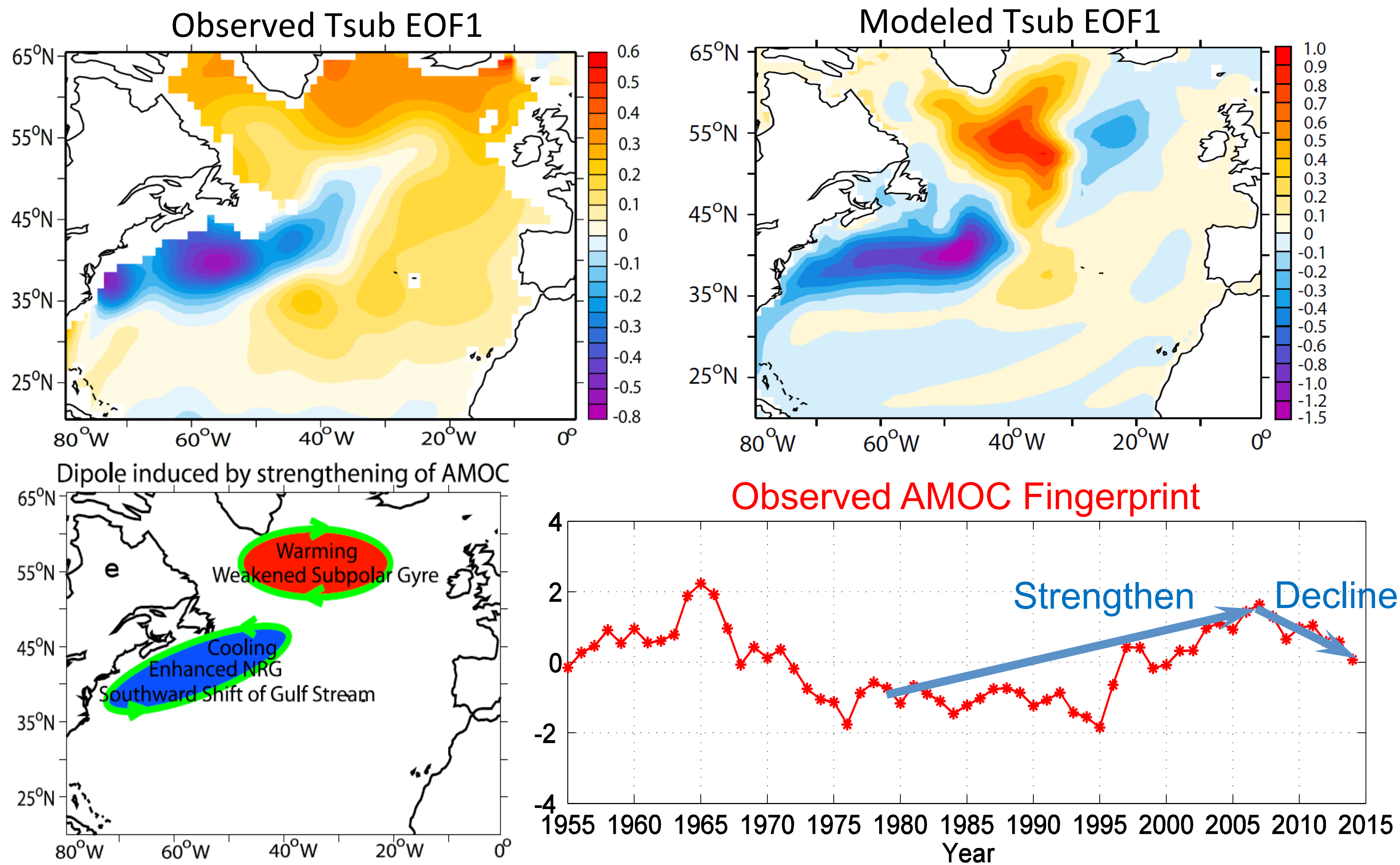
Introduction

Extra-tropical AMOC Fingerprint:
Leading Mode of Subsurface Temperature (or Upper Ocean Heat Content)



Zhang, 2008, GRL

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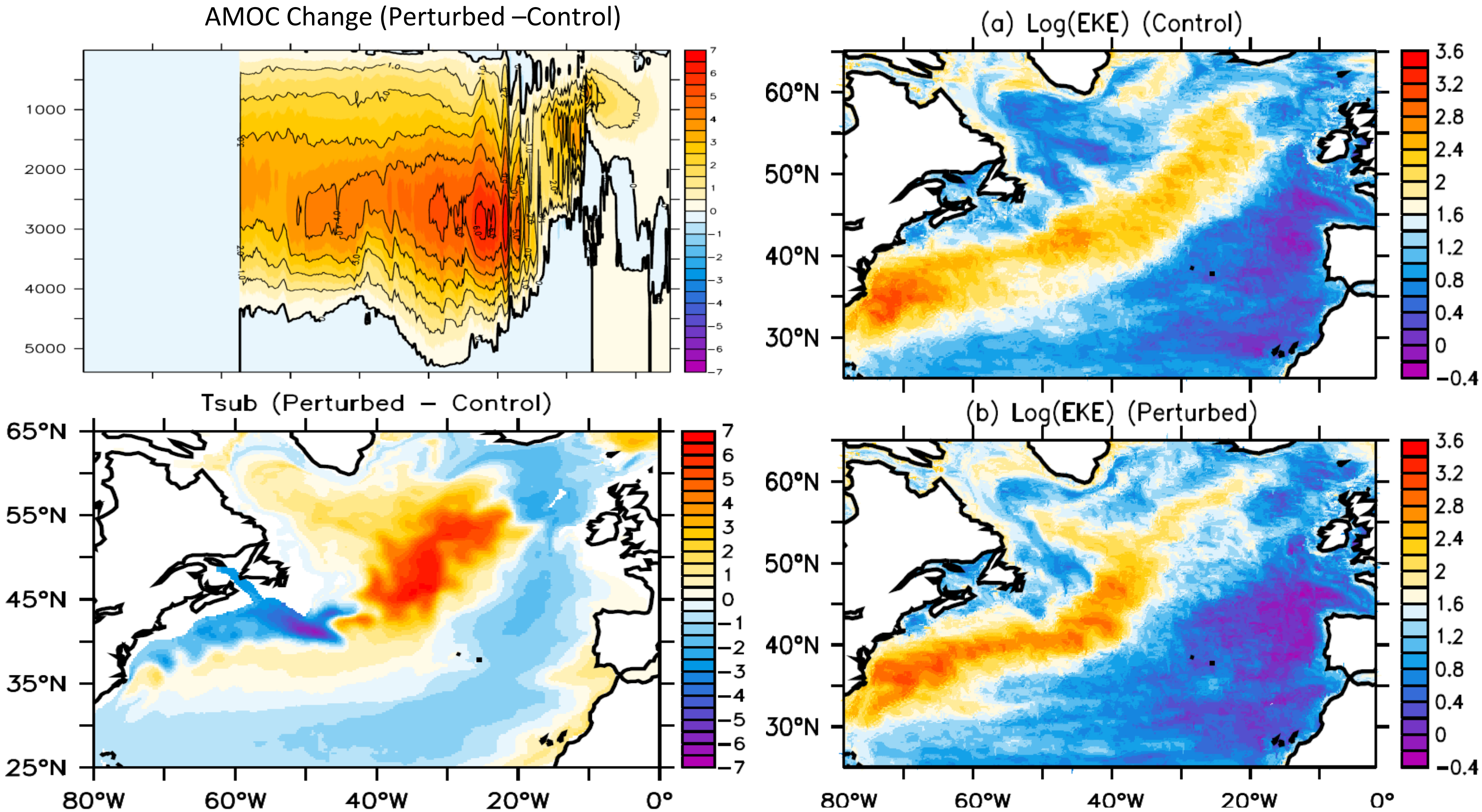
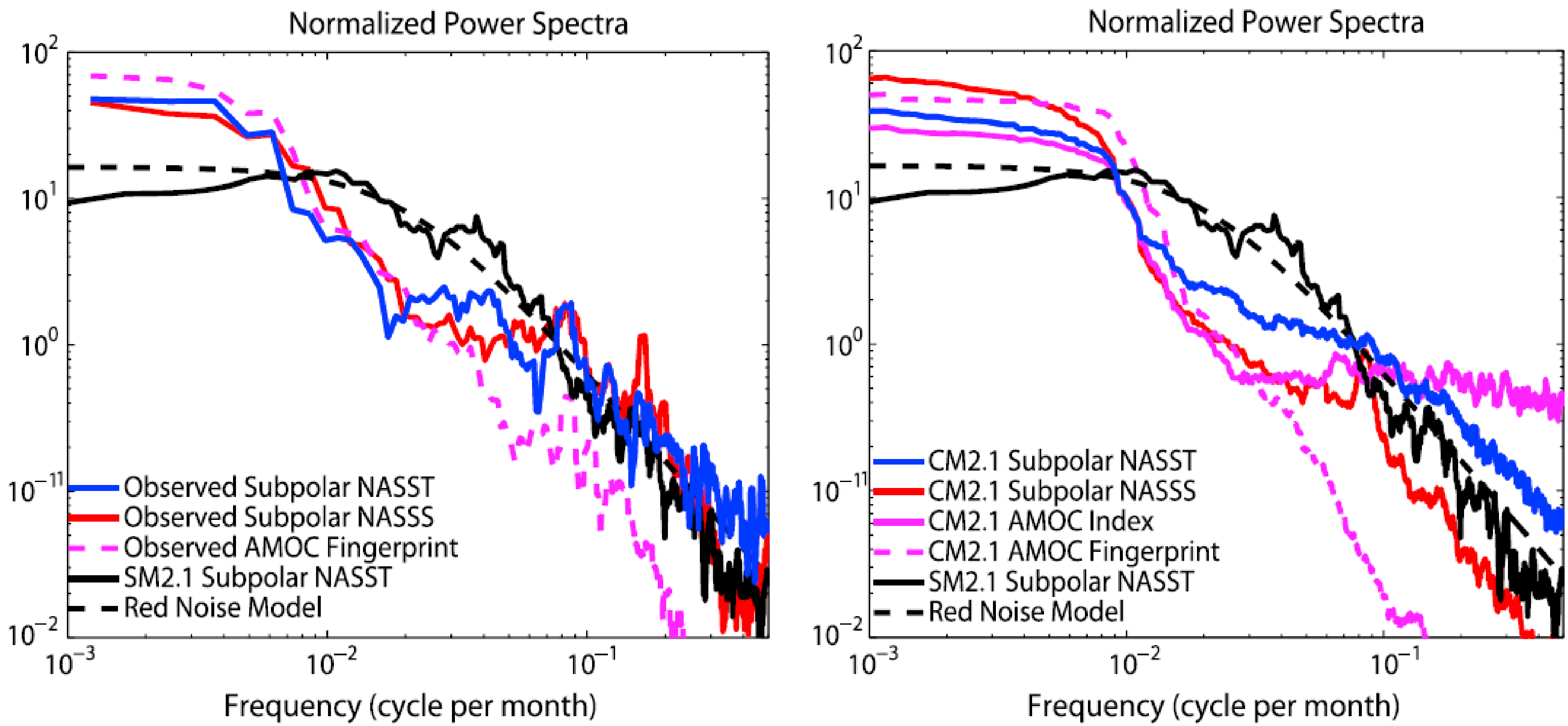


In the perturbed experiment using a high resolution coupled model (GFDL CM2.5), a stronger and deeper-penetrating Nordic Sea overflow leads to a stronger and deeper AMOC, and the dipole temperature response (AMOC fingerprint)

Zhang et al., 2011, JGR Oceans

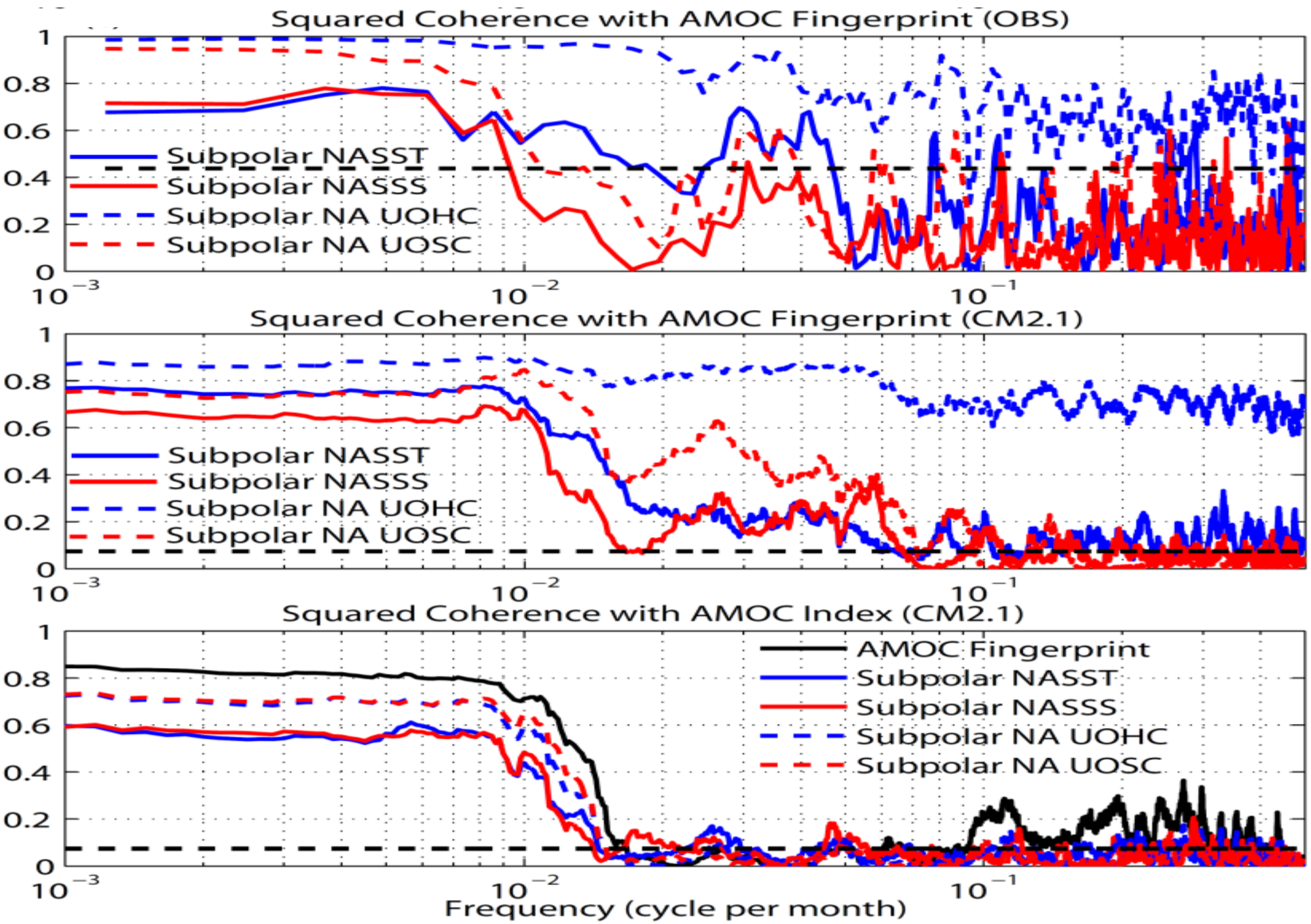
Application of the AMOC Fingerprint on the Mechanism of AMV



Zhang, 2017, GRL

The normalized power spectra of subpolar NASST/NASSS anomalies closely resemble those of the AMOC fingerprint at low frequency in both observations and CM2.1 simulation

Application of the AMOC Fingerprint on the Mechanism of AMV



Zhang, 2017, GRL

High coherence between AMOC fingerprint and subpolar NA SST/SSS, upper ocean heat/salt content (UOHC/UOSC) at low frequency (in both observations and CM2.1 simulation) supports the AMOC-AMV linkage

Multidecadal Atlantic Hurricane Activity

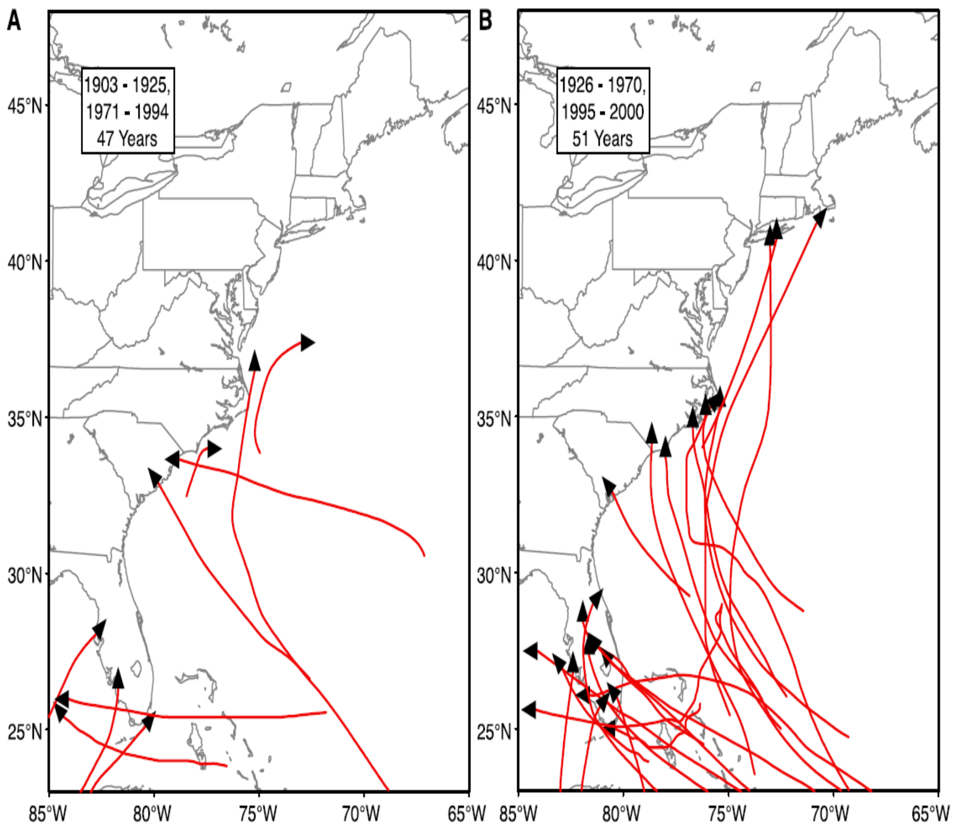
Negative AMV Phase

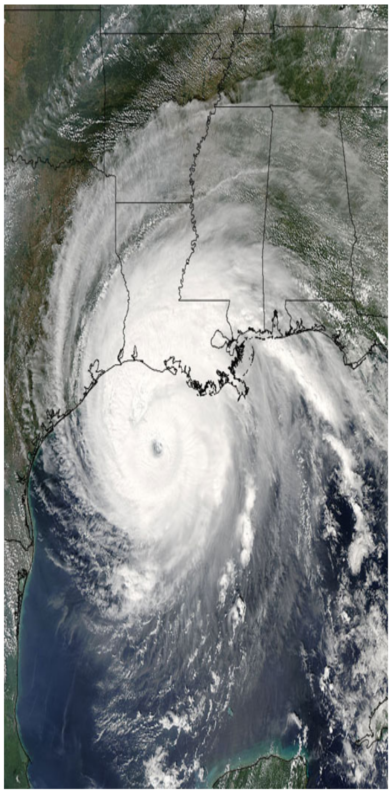
Cold North Atlantic

Positive AMV Phase

Warm North Atlantic

Hurricane Rita,
Sept. 23, 2005.
(NASA)



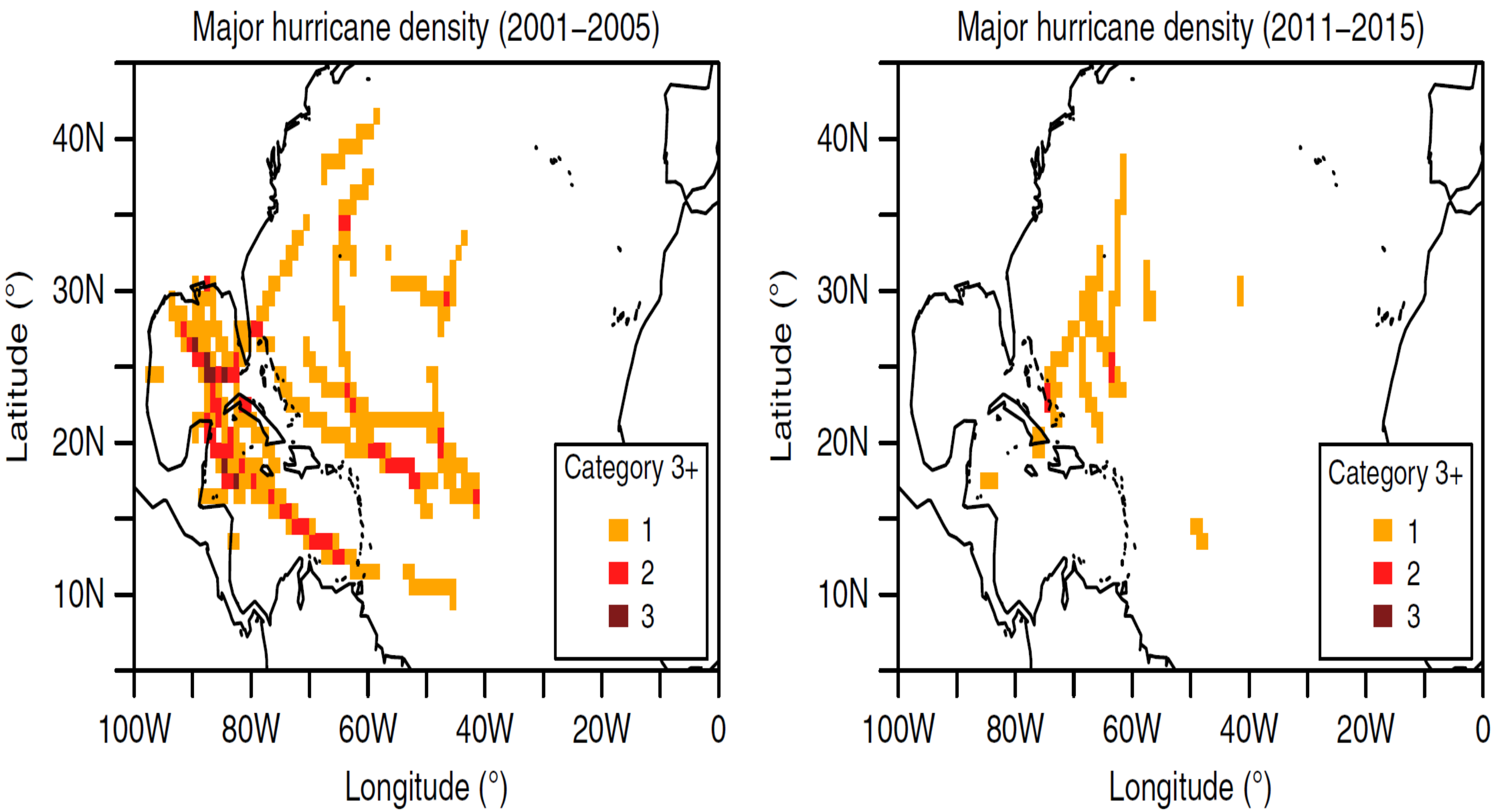


Goldenberg et al. 2001, Science

Contrast of U.S. East Coast major hurricane landfalls during the negative (left) and positive (right) AMV phase

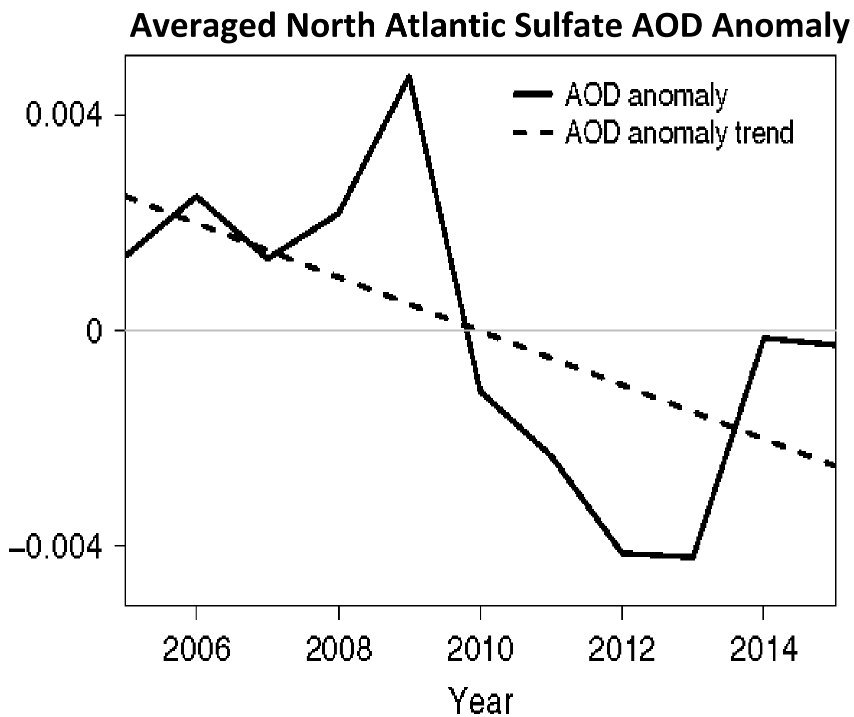
Observed Decline of Atlantic Major Hurricane Frequency Over the Recent Decade

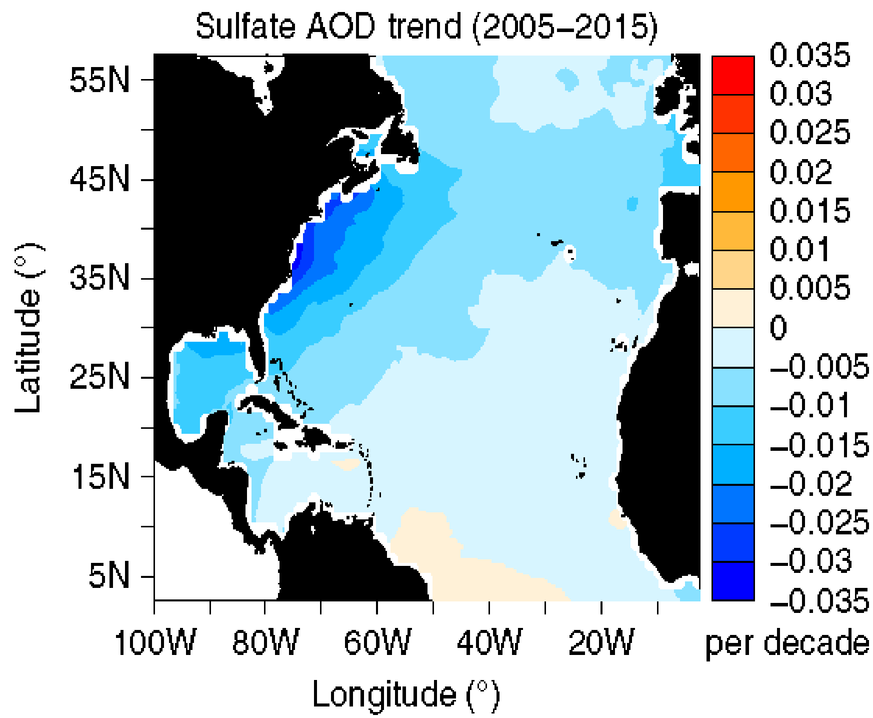
Observed Atlantic major hurricane track density maps



Yan, Zhang, and Knutson, 2017, Nature Communications

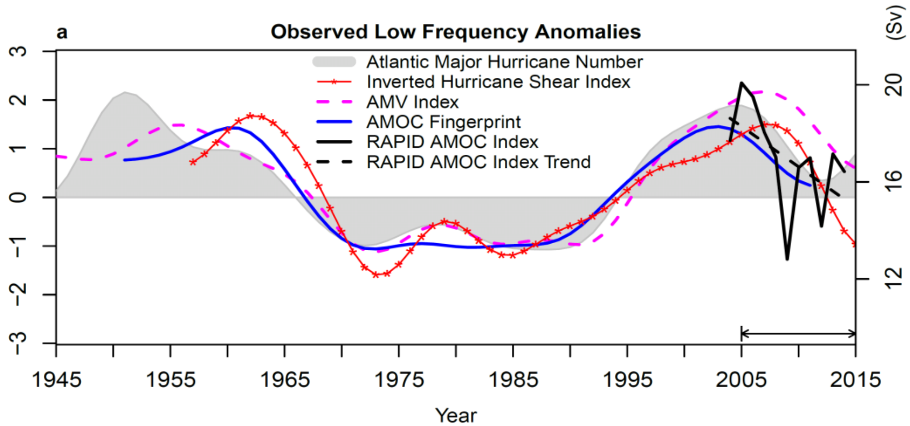
Decline of North Atlantic Sulfate Aerosol Optical Depth (AOD) over the Recent Decade

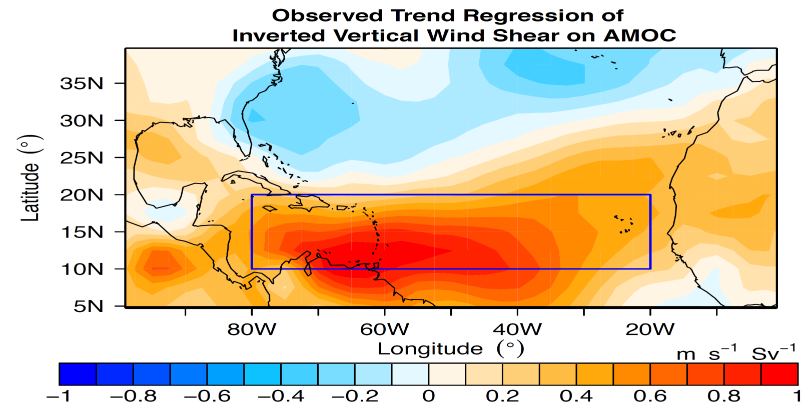




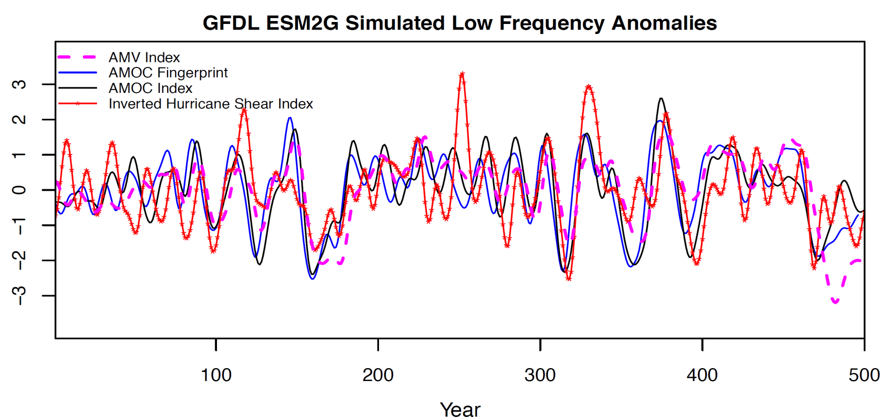
Yan, Zhang, and Knutson, 2017, Nature Communications

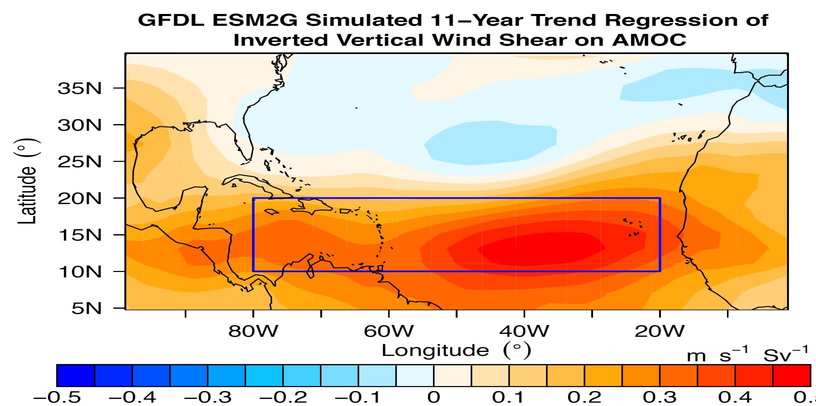
Application of the AMOC Fingerprint on the Multidecadal Variability of Atlantic Major Hurricane Frequency





Observations show coherent multidecadal variations among the Atlantic major hurricane frequency, AMOC fingerprint, AMV Index, and Inverted Hurricane Shear Index. The observed decline of the Atlantic major hurricane frequency during 2005–2015 is associated with the directly observed AMOC weakening



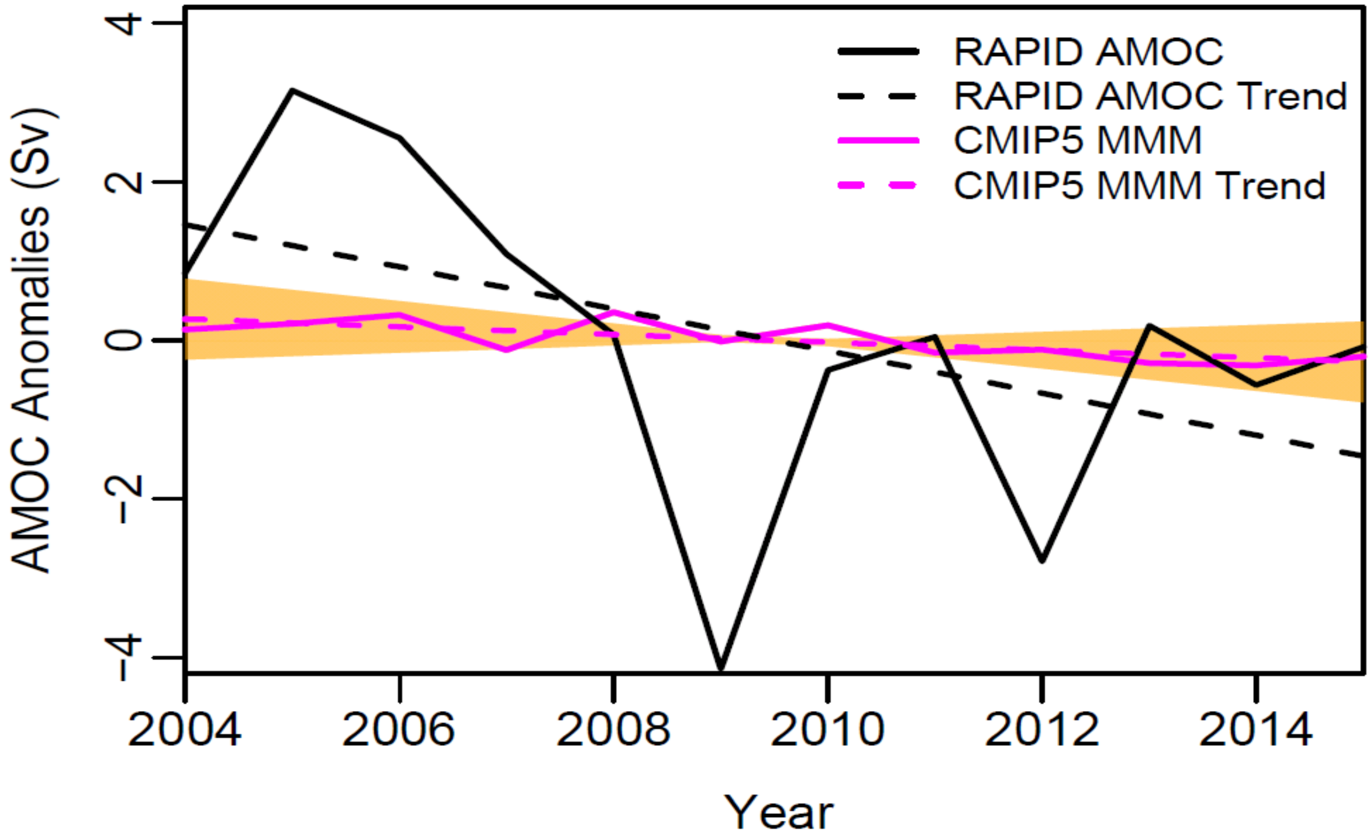


Coherent variations among AMOC Index/fingerprint, AMV Index, and Inverted Hurricane Shear Index in GFDL-ESM2G control simulation suggest an important role of AMOC in the AMV and the multidecadal variability in the Atlantic major hurricane frequency

Yan, Zhang, and Knutson, 2017, Nature Communications

Recent AMOC Decline is Dominated by Natural Variability

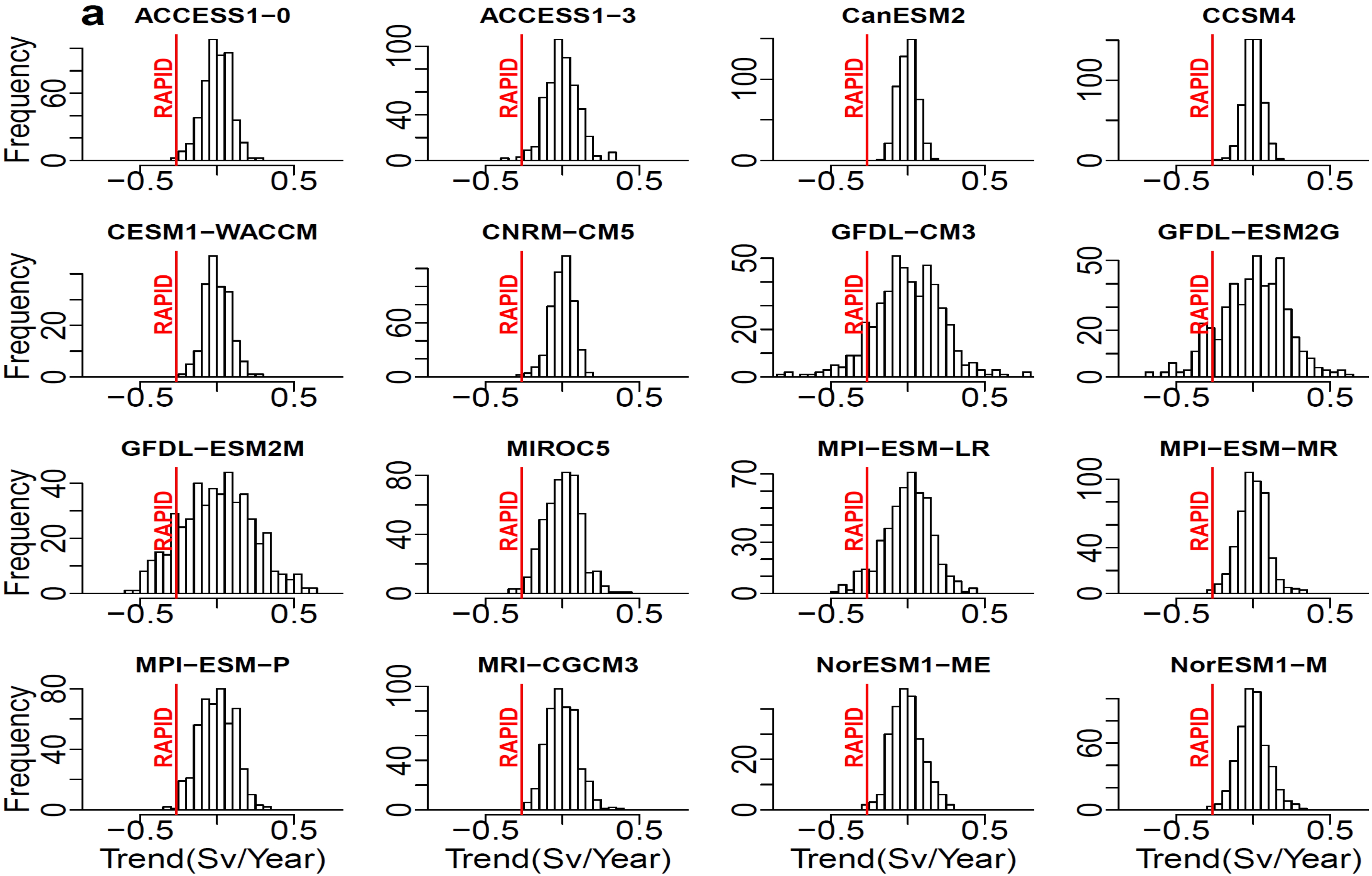
Observed and simulated AMOC anomalies at 26°N for the period 2004-2015



The multi-model mean (MMM) AMOC anomalies at 26°N from CMIP5 historical and RCP4.5 combined simulations (purple solid line) has no significant declining trend over the same period

Yan, Zhang, and Knutson, 2018, GRL

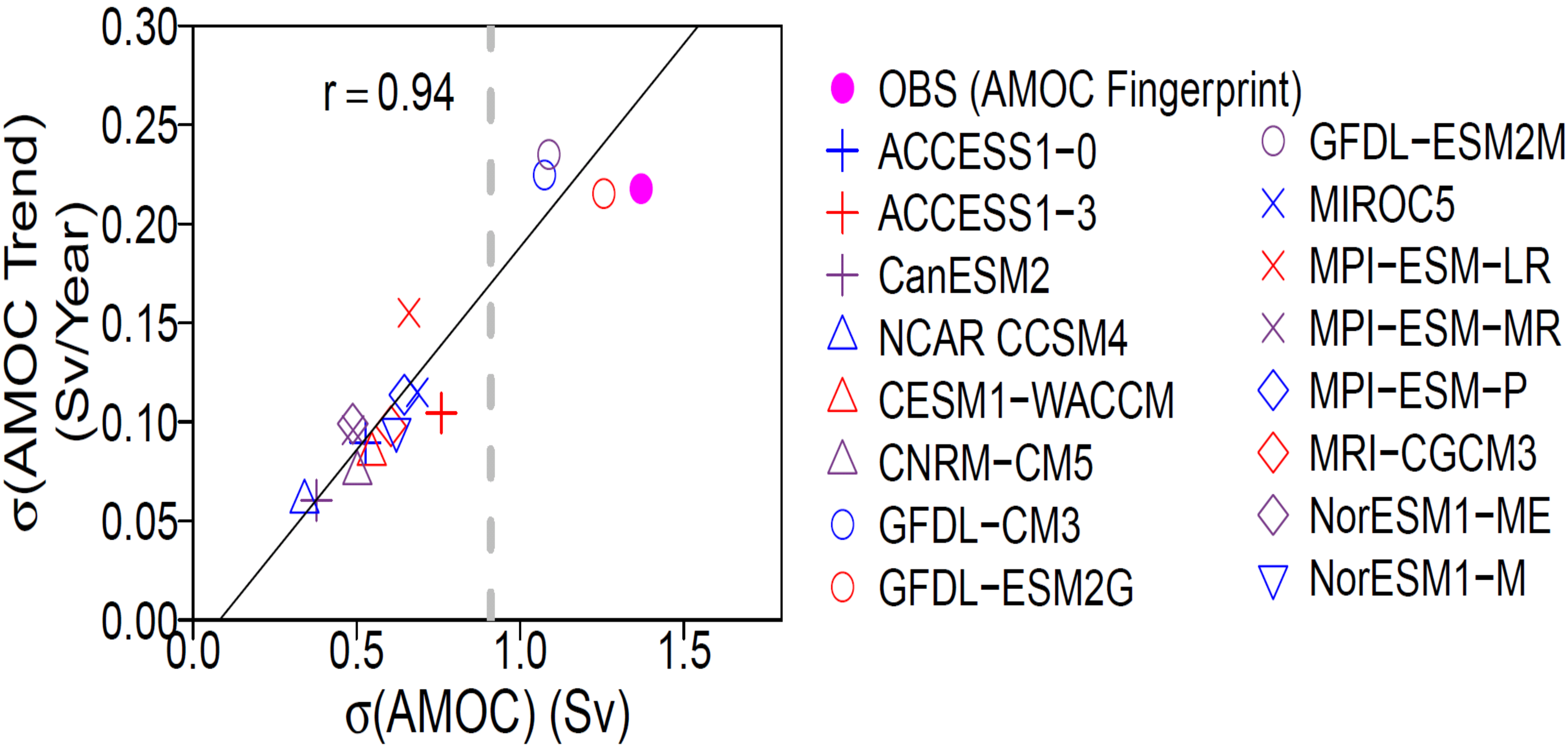
Underestimated Low-Frequency AMOC Variability in Most CMIP5 Models



Simulated 12-year AMOC trend distribution from each CMIP5 control simulation and the observed 12-year trend (red line) of the RAPID AMOC Index at 26°N for the period 2004–2015

Yan, Zhang, and Knutson, 2018, GRL

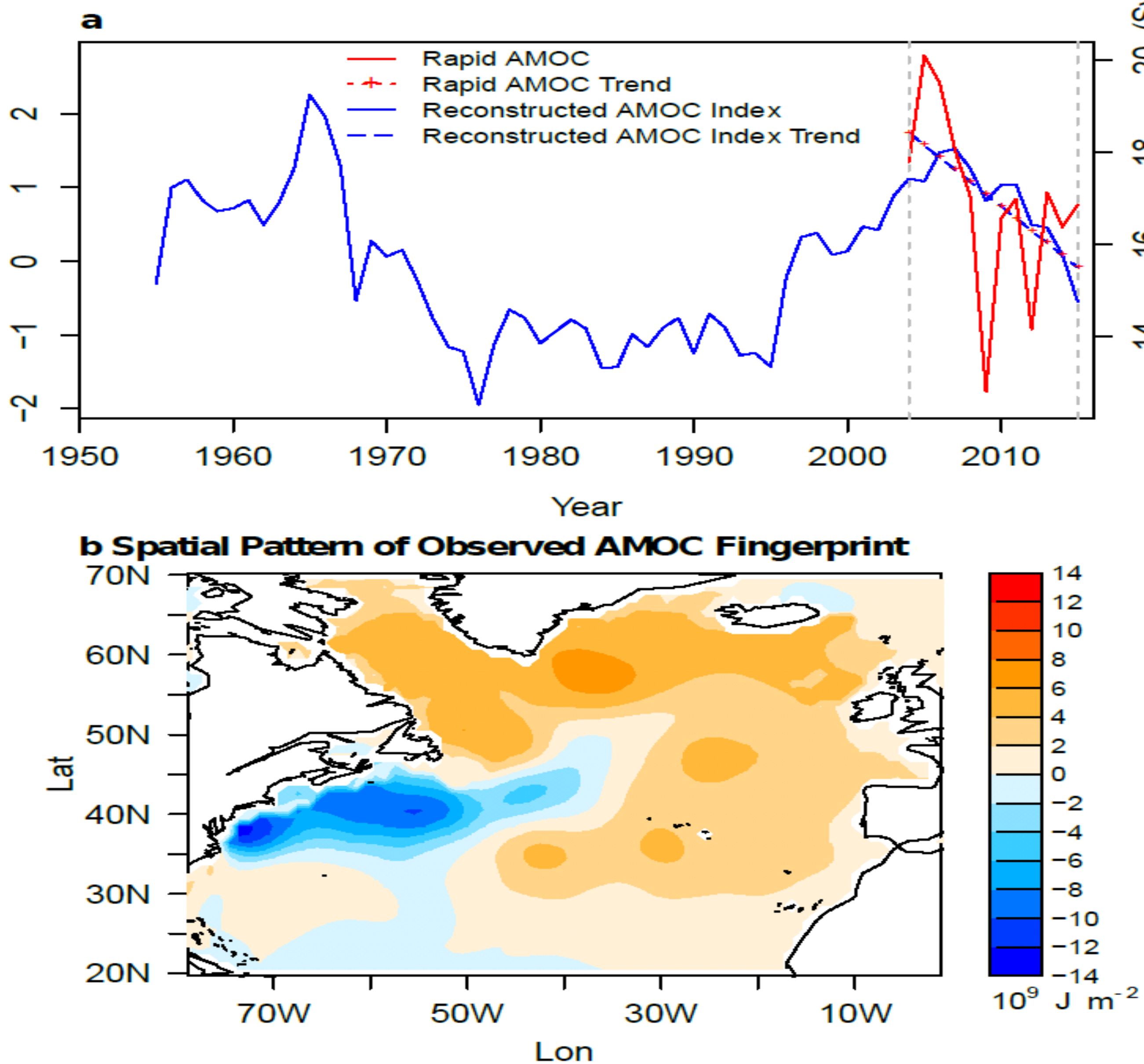
Underestimated Low-Frequency AMOC Variability in Most CMIP5 Models



Scatterplot of the standard deviations of 12-year AMOC trends versus the amplitudes of low-frequency AMOC variability (i.e., standard deviations of the 10-year low-pass filtered AMOC anomalies) in CMIP5 control simulations

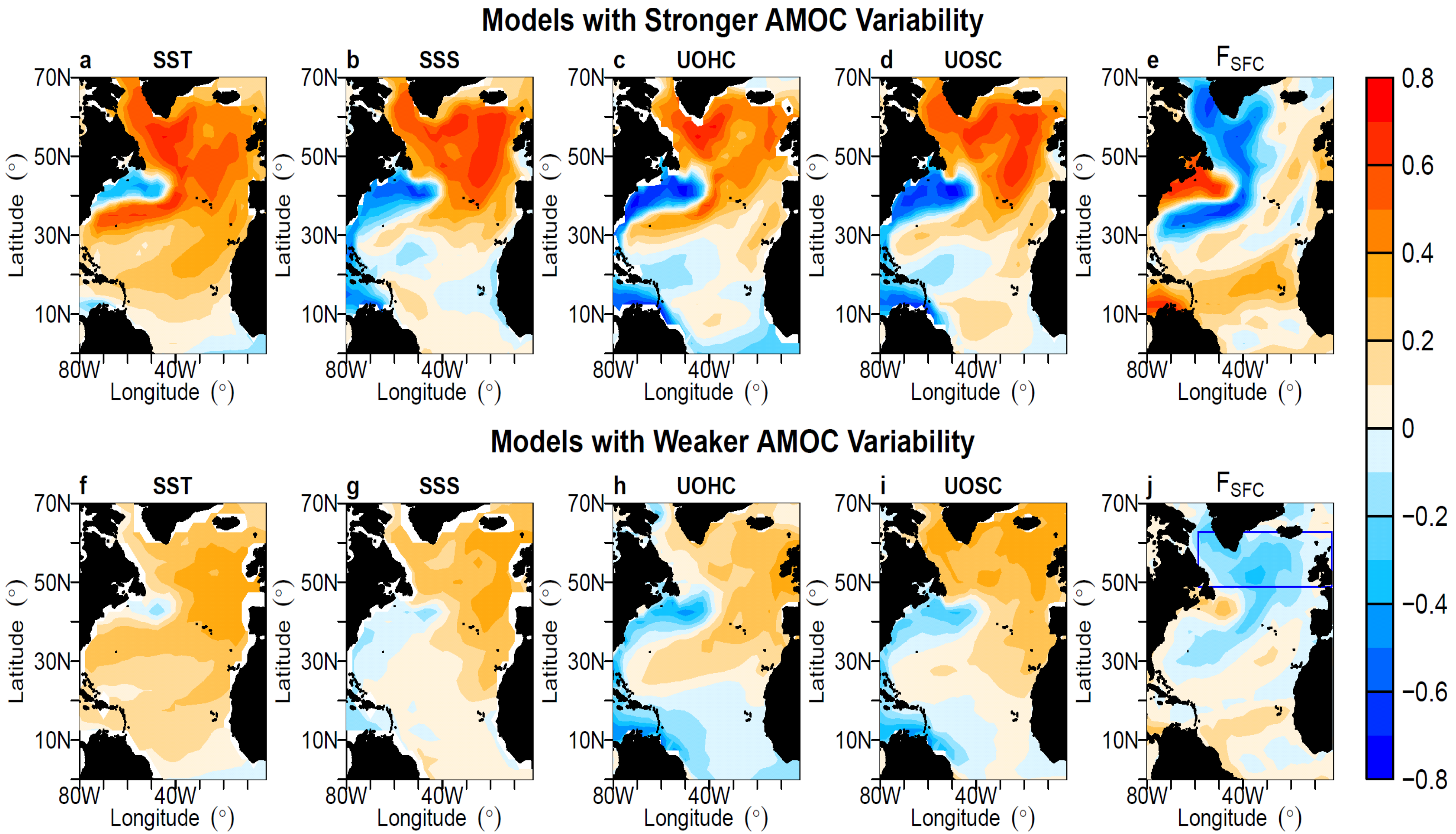
Yan, Zhang, and Knutson, 2018, GRL

Reconstructed AMOC Variability using the AMOC Fingerprint



Yan, Zhang, and Knutson, 2018, GRL

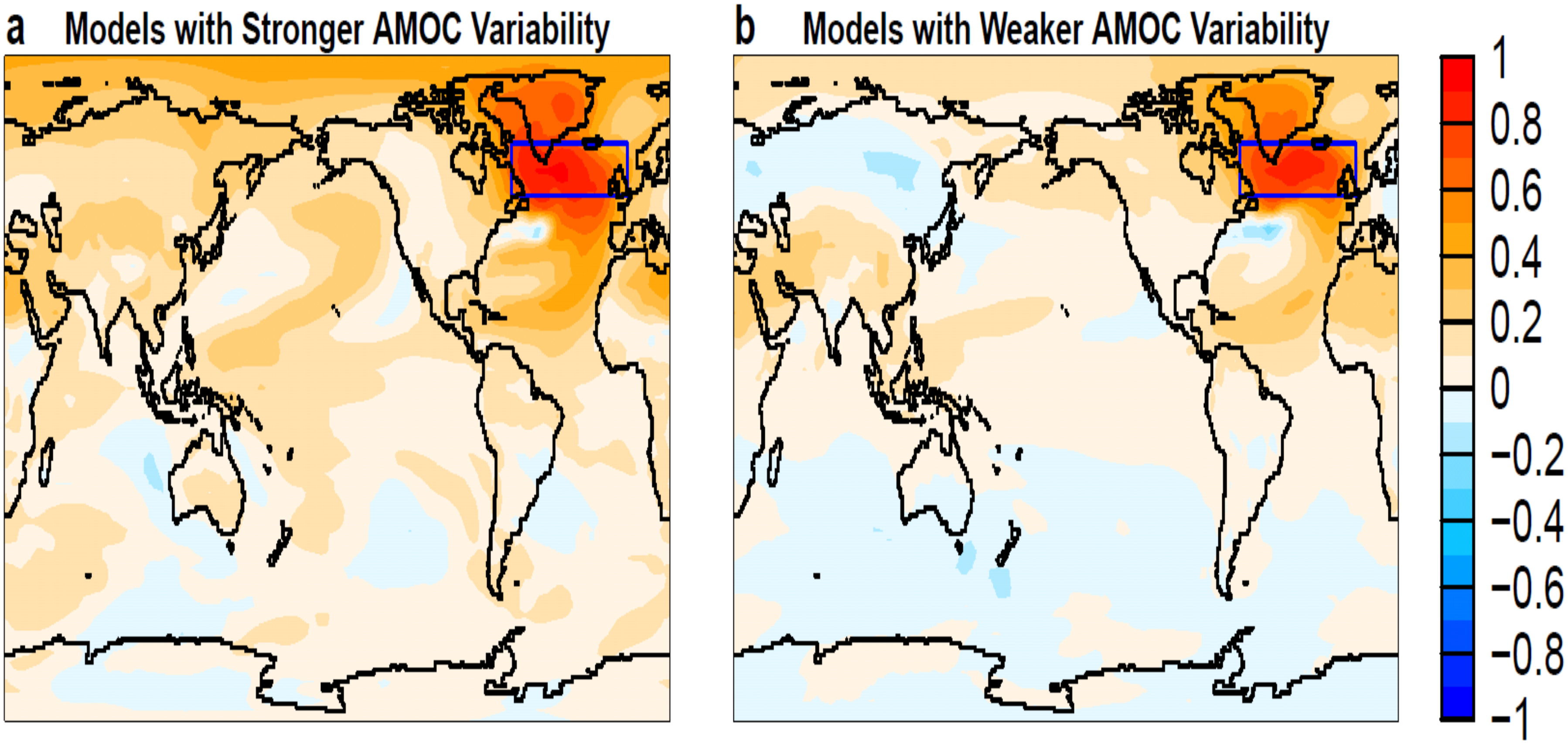
The Role of AMOC in AMV-Related Variables



Multiple model mean correlation maps between the 10-year low-pass filtered AMOC index and AMV-related variables (SST, SSS, UOHC, UOSC, F_{SFC})

Yan, Zhang, and Knutson, 2018, GRL

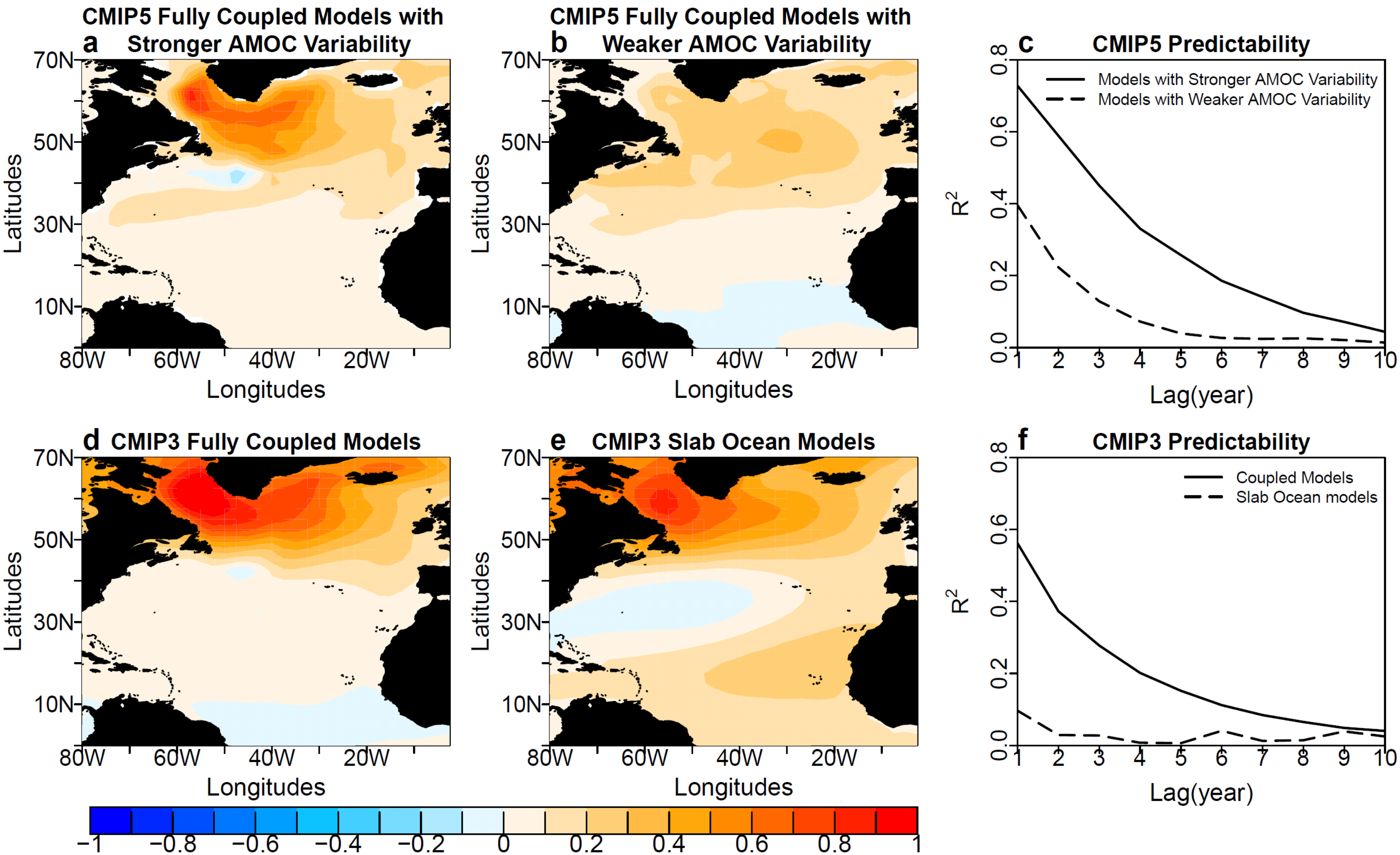
The Role of AMOC in Hemispheric-Scale Surface Air Temperature



Multiple model mean correlation maps between the subpolar AMV SST signal and the surface air temperature in CMIP5 control simulations

Yan, Zhang, and Knutson, 2018, GRL

The Role of AMOC in Atlantic Decadal Predictability



The most predictable patterns of SST and associated predictability in the North Atlantic, derived by maximizing the Average Predictability Time (APT) (Srivastava and Delsole, 2016)

Yan, Zhang, and Knutson, 2018, GRL

Summary

- At low frequency, the normalized power spectra of subpolar North Atlantic SST/SSS closely resemble those of the AMOC fingerprint, and there is high coherence between AMOC fingerprint and subpolar North Atlantic SST/SSS and UOHC/UOSC, indicating the important role of AMOC in AMV

- The observed decline of Atlantic major hurricane frequency during 2005–2015 is associated with a AMOC weakening over this period. Both observations and modeling results suggest an important role of AMOC in the multidecadal variability of Atlantic major hurricane frequency

- Models with relatively stronger (weaker) low-frequency AMOC variability have stronger (weaker) linkages between the AMOC and key variables associated with AMV, and between AMV and northern hemisphere surface air temperature

- The Atlantic decadal predictability is much higher in models with relatively stronger low-frequency AMOC variability, and much lower in models without AMOC variability

- The linkage between the AMOC and AMV, associated climate impacts and Atlantic decadal predictability are substantially hampered in many CMIP models due to the underestimation of the amplitude of low-frequency AMOC variability