2022 US AMOC Science Team Meeting

PennState College of Earth and Mineral Sciences

Department of Meteorology and Atmospheric Science

Centennial cooling in the subpolar North Atlantic forced by atmosphere

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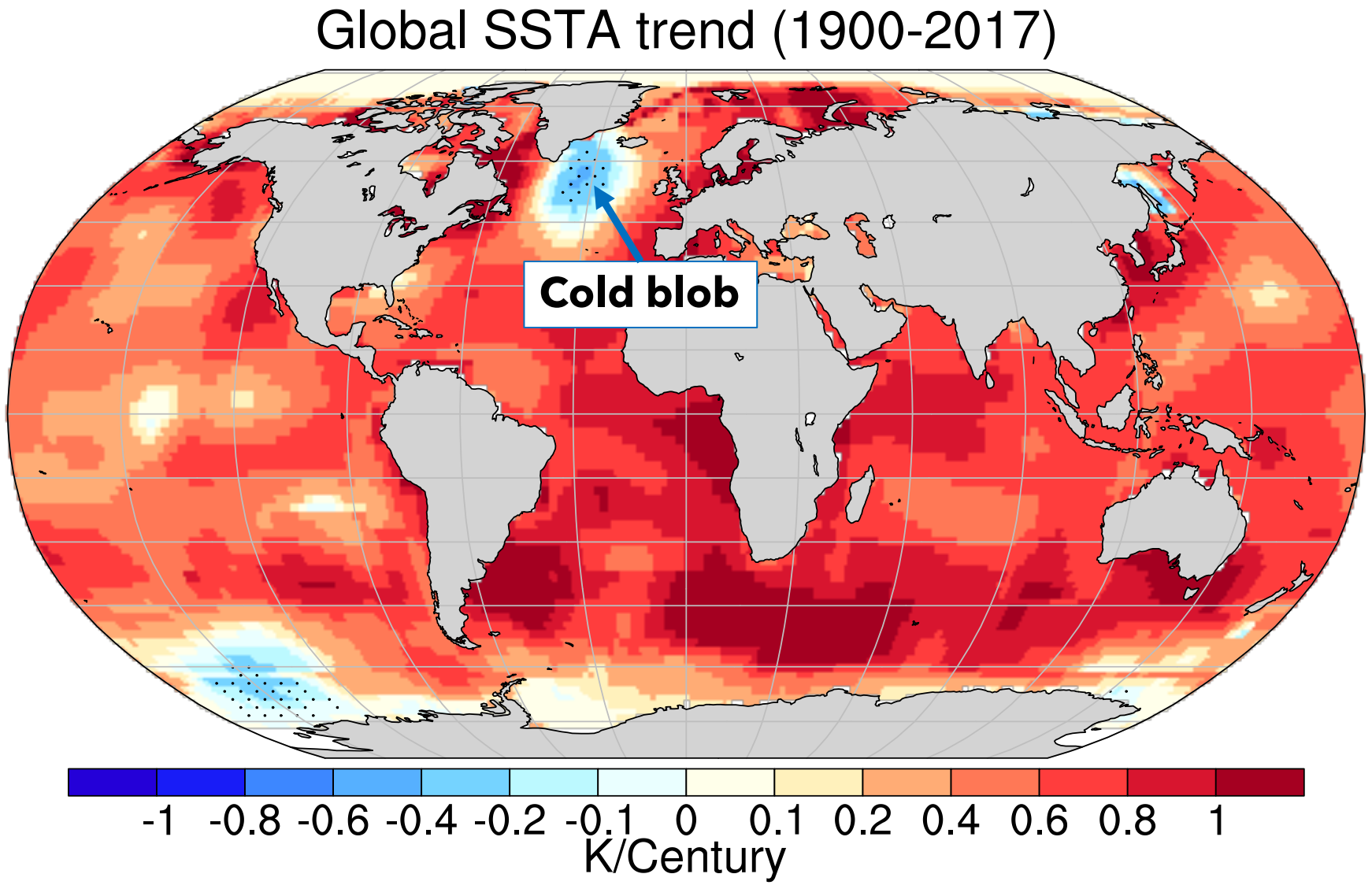
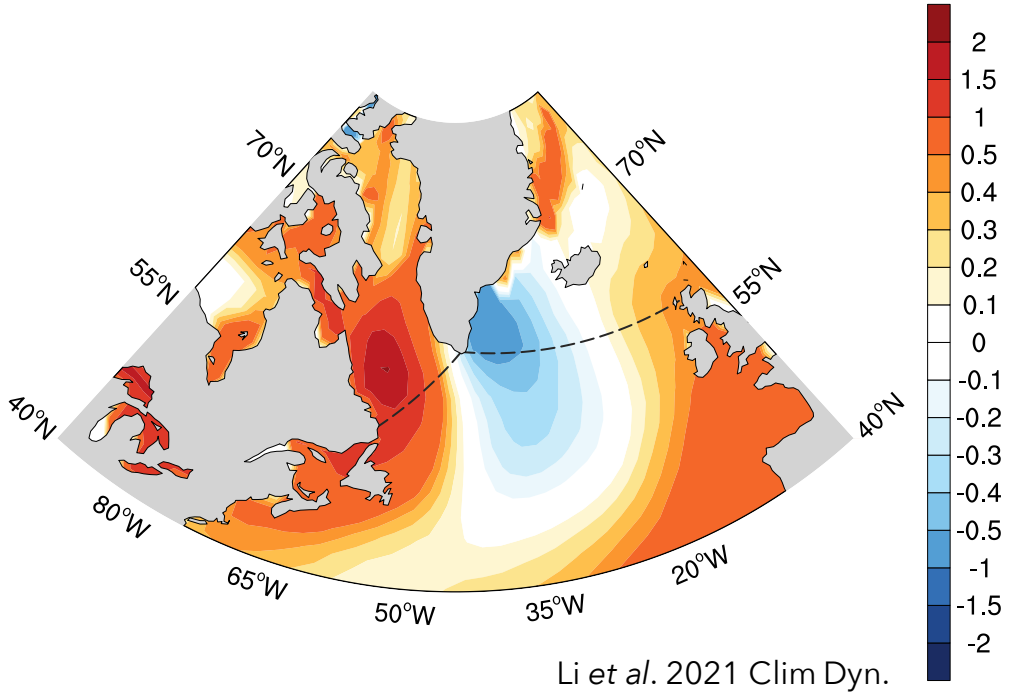
April 25, 2022 | Woods Hole, MA

Oceanic cooling in a warming climate

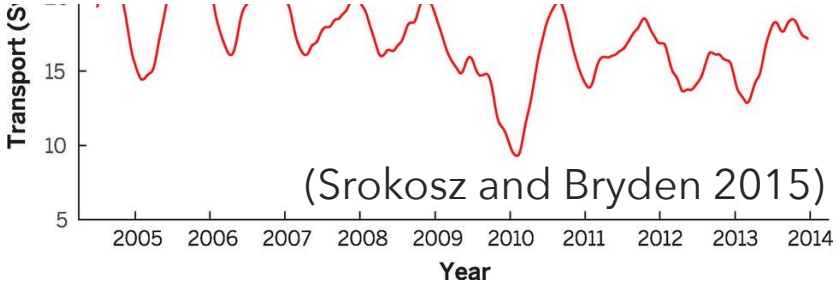


Atlantic Meridional Overturning Circulation paradigm

Observed sea surface temperature trend

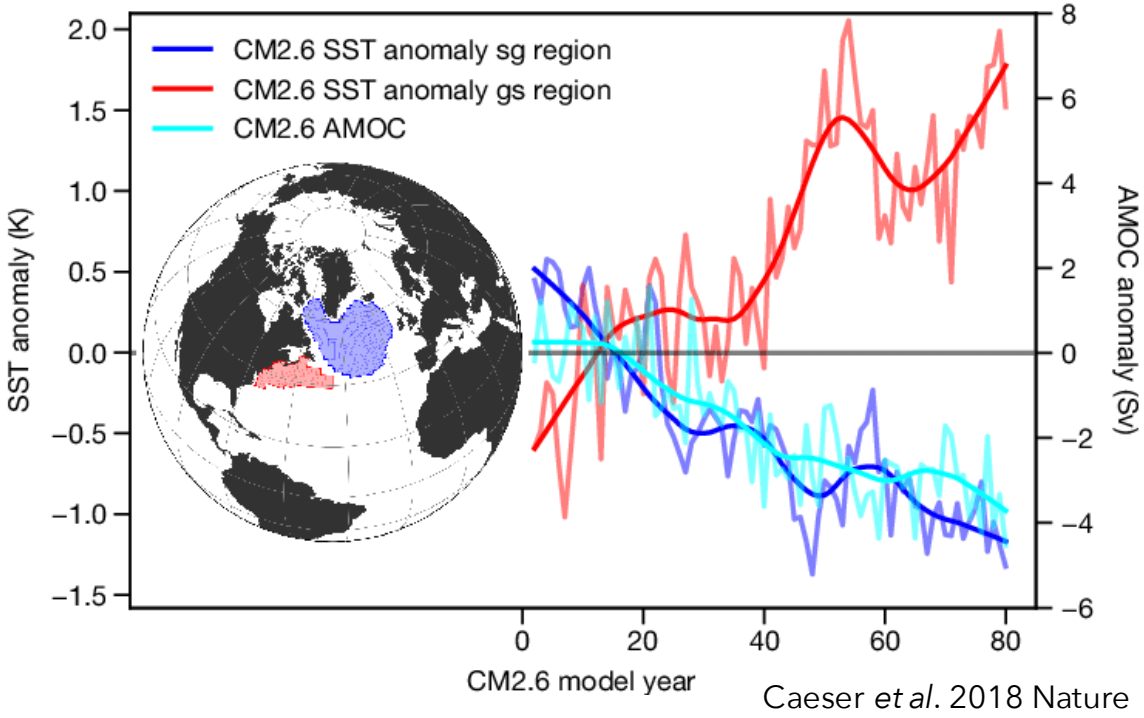


Li *et al*. 2021 Clim Dyn.



(Srokosz and Bryden 2015)

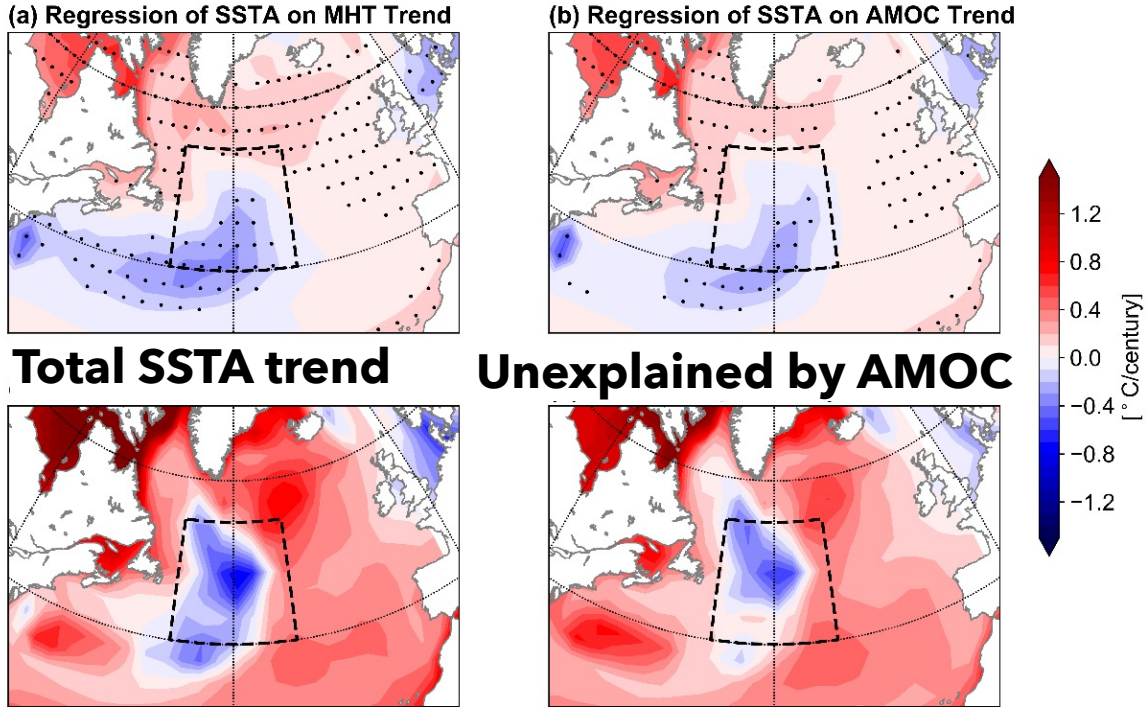
AMOC fingerprint

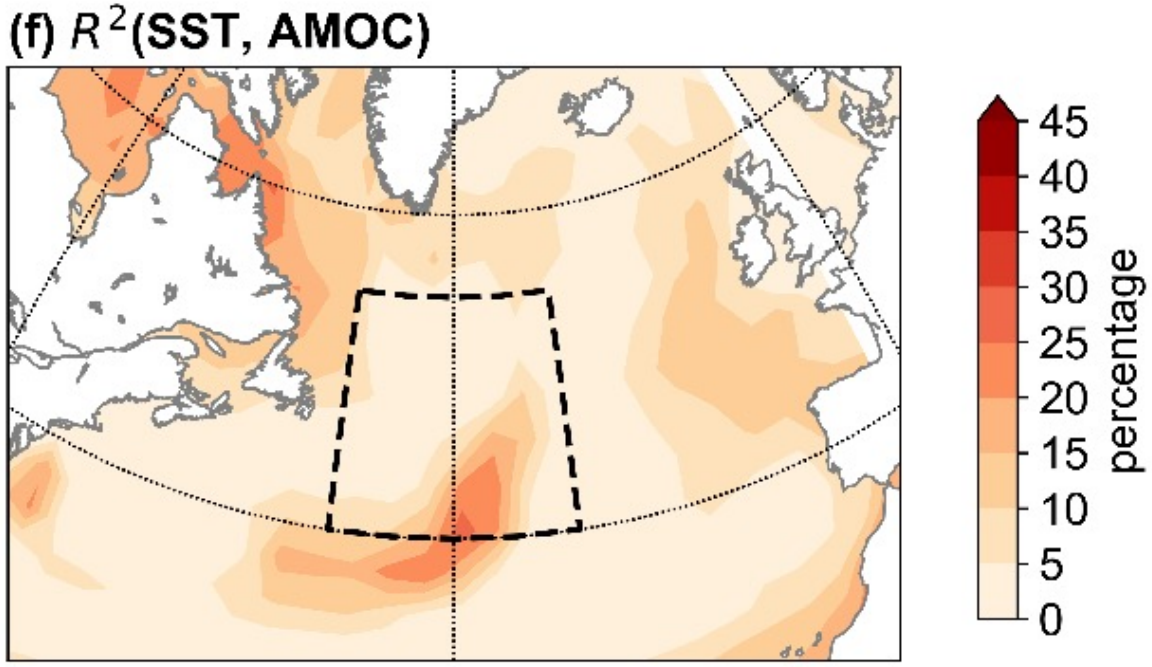


Caeser *et al*. 2018 Nature

Limited role of AMOC to cold blob

Insights from a global climate model



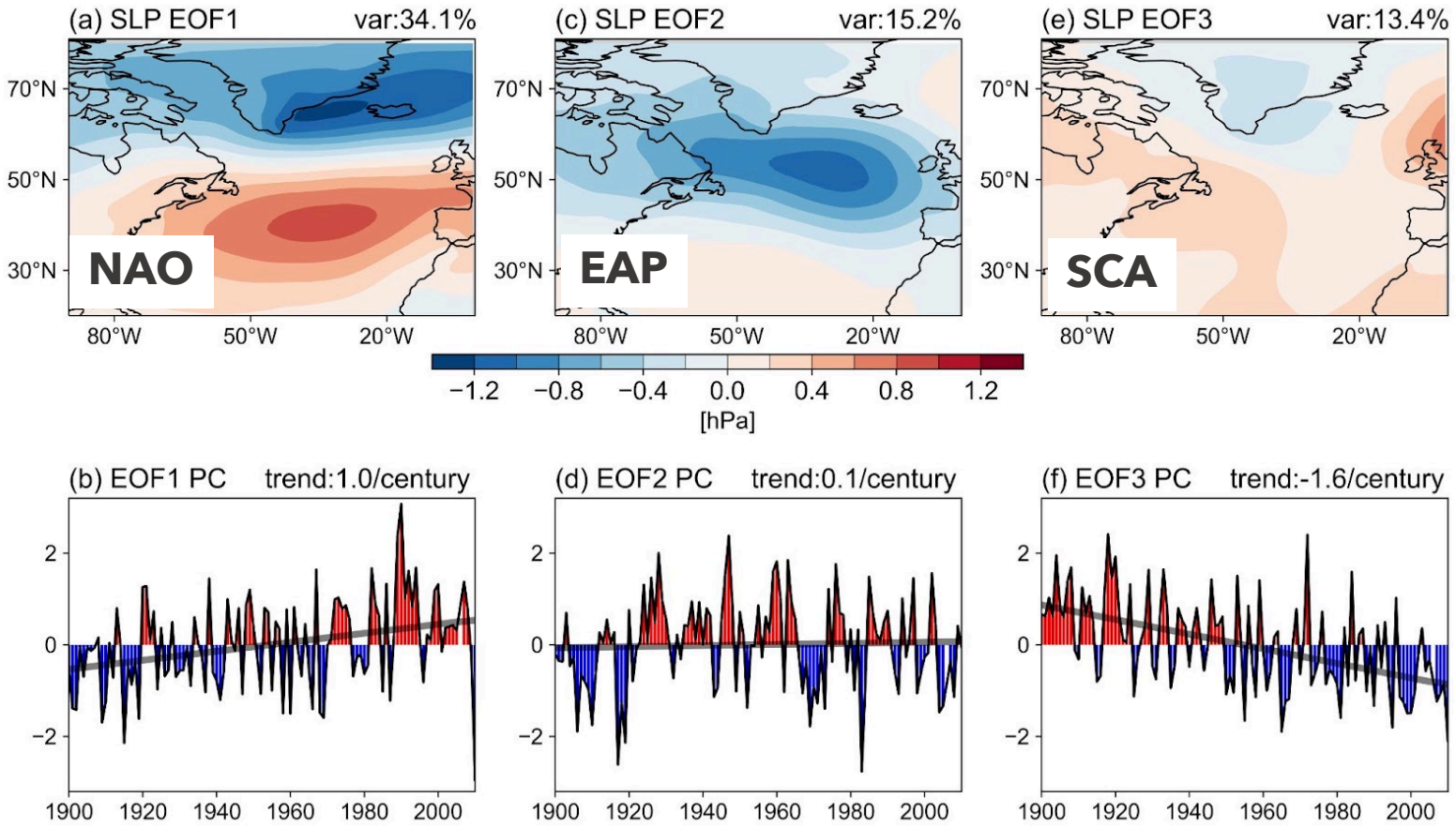


Fan *et al*. 2021 JGR-Ocean

- AMOC slowdown only makes a marginal contribution to past century's cooling trend in the subpolar North Atlantic.

Motivation: changes to the atmosphere

North Atlantic atmospheric circulation pattern

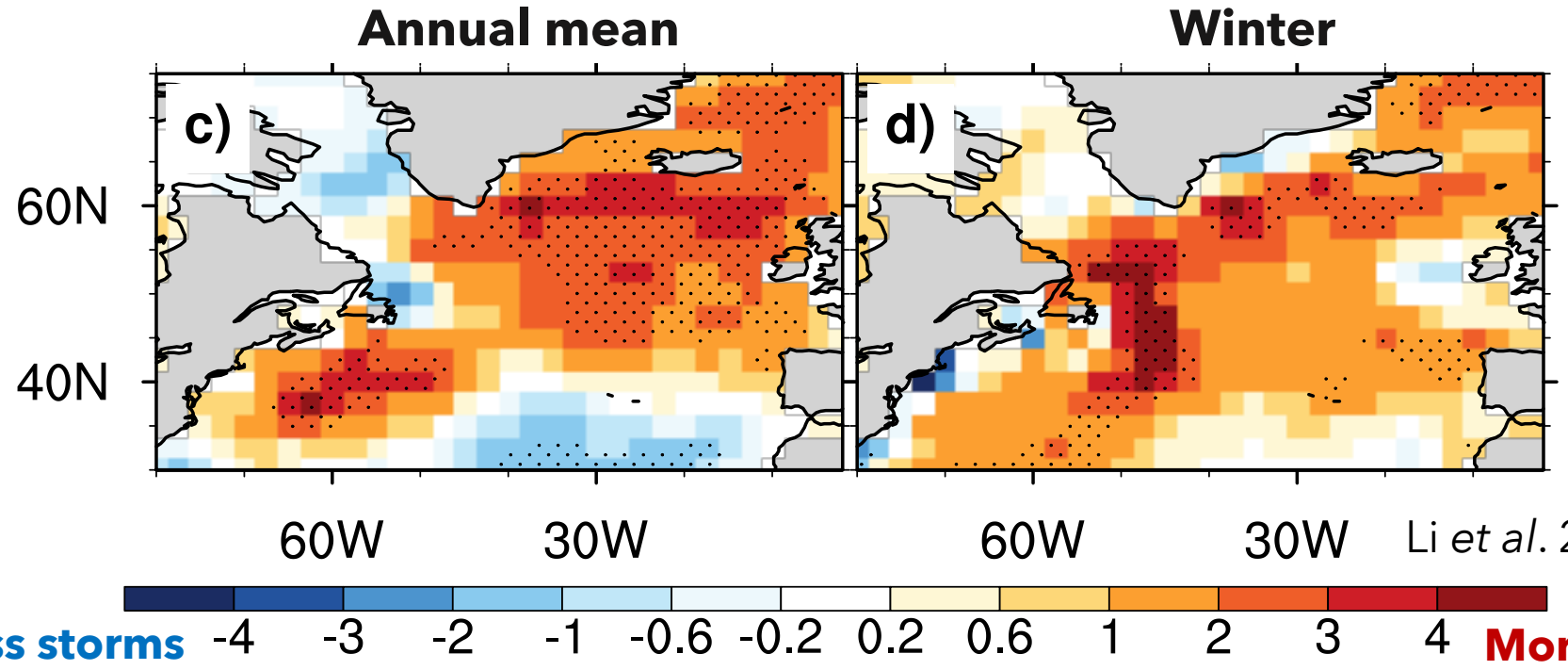


Fan *et al*. 2022a In Prep.

Motivation: changes to the atmosphere

100-year trend in North Atlantic storminess

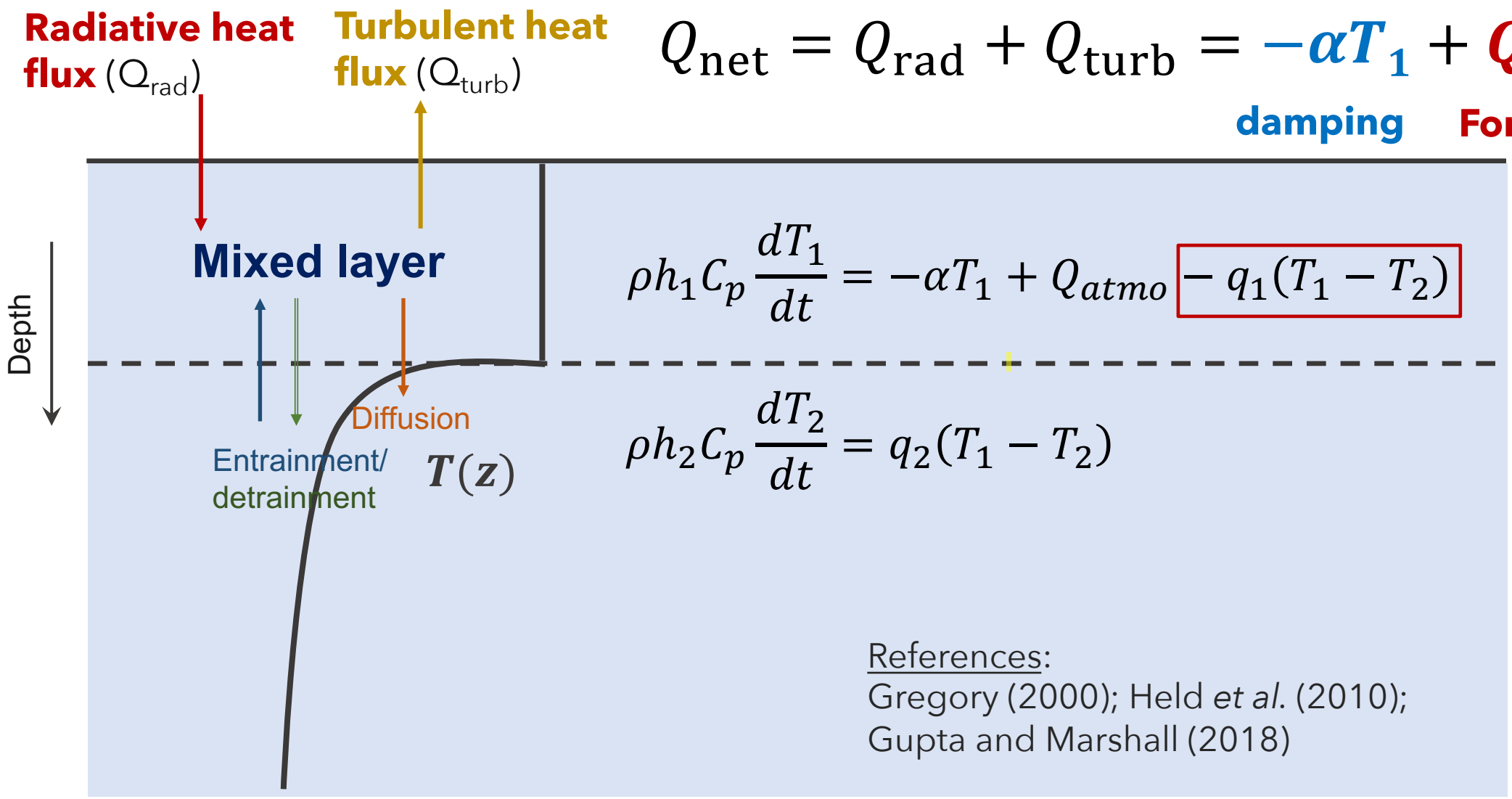
Storminess calculated by atmospheric eddy kinetic energy



Li *et al*. 2021 Clim. Dyn.

- More storms pass by the subpolar North Atlantic, promote ocean surface to lose more heat and could thus **cool** the ocean surface

Methods: 2-box model of ocean heat balance



$$Q_{\text{net}} = Q_{\text{rad}} + Q_{\text{turb}} = -\alpha T_1 + Q_{\text{atmo}}$$

damping Forcing

$$\rho h_1 C_p \frac{dT_1}{dt} = -\alpha T_1 + Q_{atmo} \boxed{- q_1(T_1 - T_2)}$$

$$\rho h_2 C_p \frac{dT_2}{dt} = q_2(T_1 - T_2)$$

References:
Gregory (2000); Held *et al.* (2010);
Gupta and Marshall (2018)

Quantify SSTA trend forced by the atmosphere

$$\rho h_1 C_p \frac{dT_1'}{dt} = -\alpha T_1' + N(0,\sigma^2) + Q_{\text{atmo\_trend}} - q_1(T_1' - T_2') - q_1'(\overline{T_1} - \overline{T_2})$$

1 2 3 4

direct

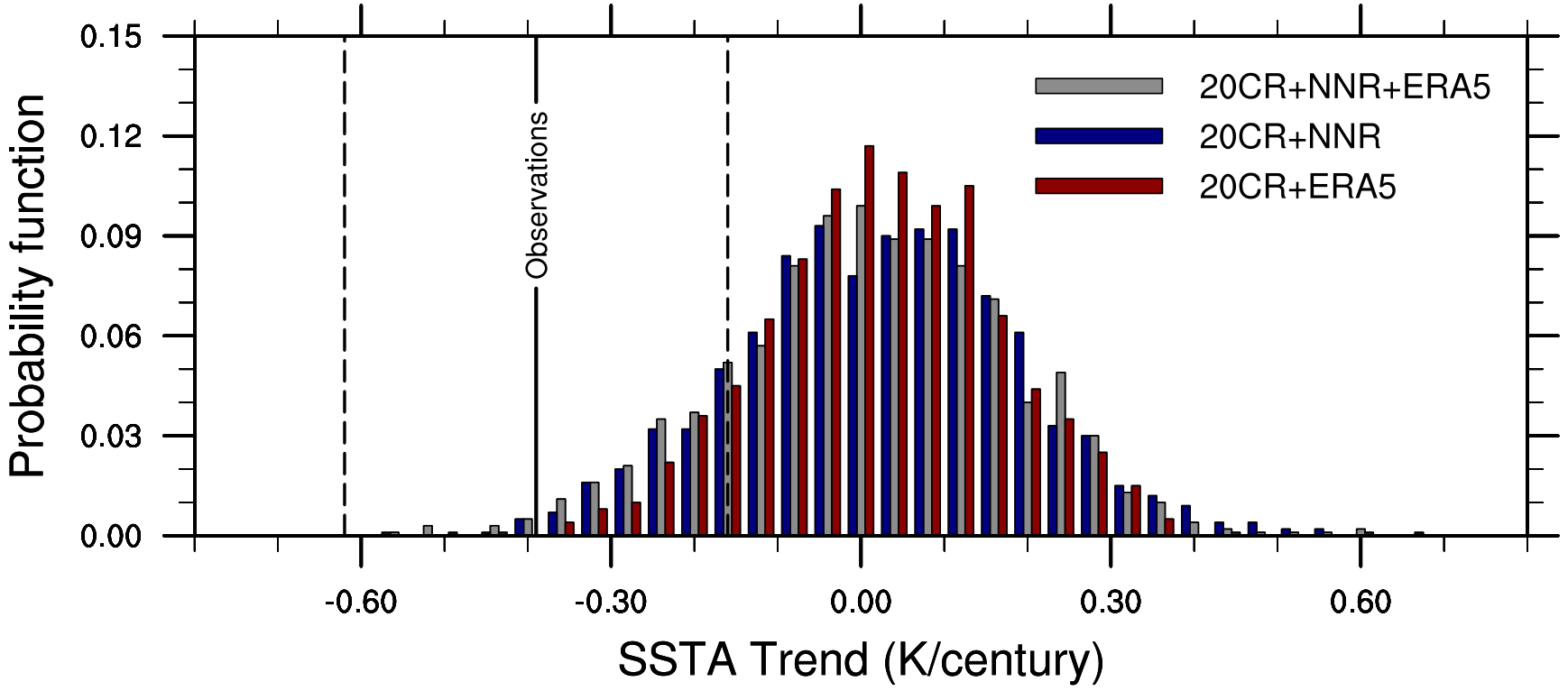
1: $N(0,\sigma^2)$	Atmospheric white noise
2: Q_{atmo_trend}	Trend in atmospheric forcing

indirect

3: $-q_1(T_1' - T_2')$	Temperature adjustment
4: $-q_1'(\overline{T_1} - \overline{T_2})$	Changes in surface-subsurface thermal coupling

Atmospheric white-noise

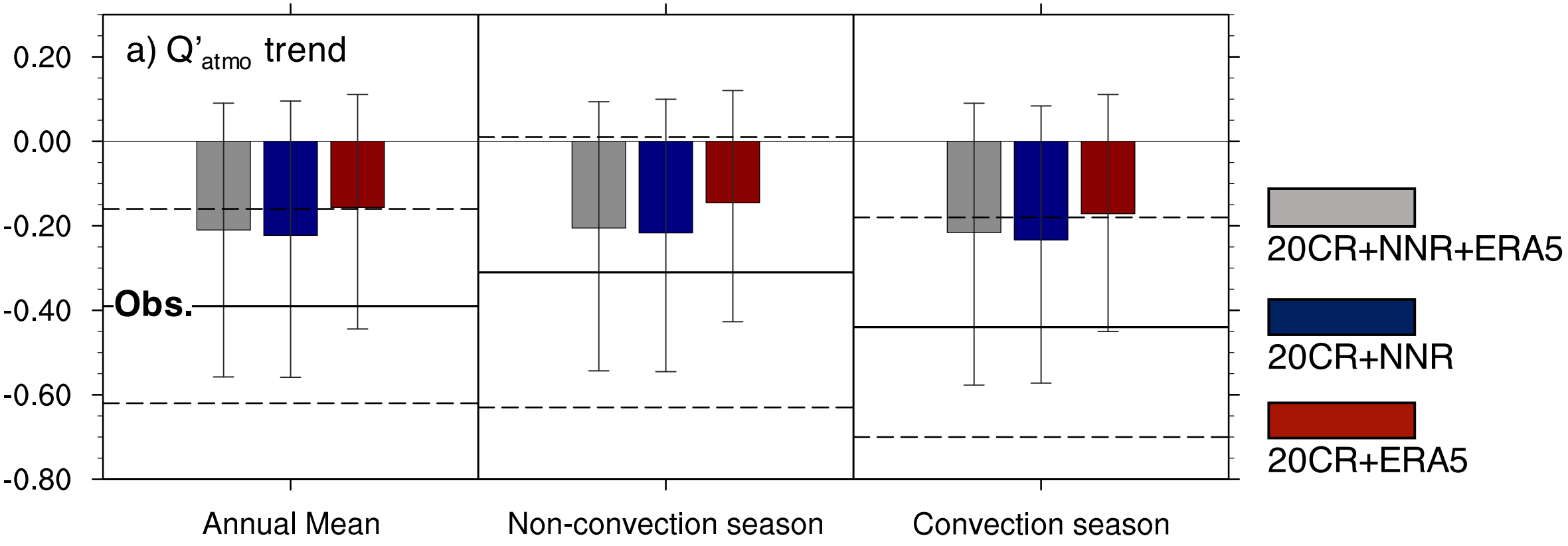
$$\rho h_1 C_p \frac{dT_1'}{dt} = -\alpha T_1' + N(0, \sigma^2)$$



- Atmospheric white noise has 17% of the chance to produce a centennial SST cooling trend comparable to observations.

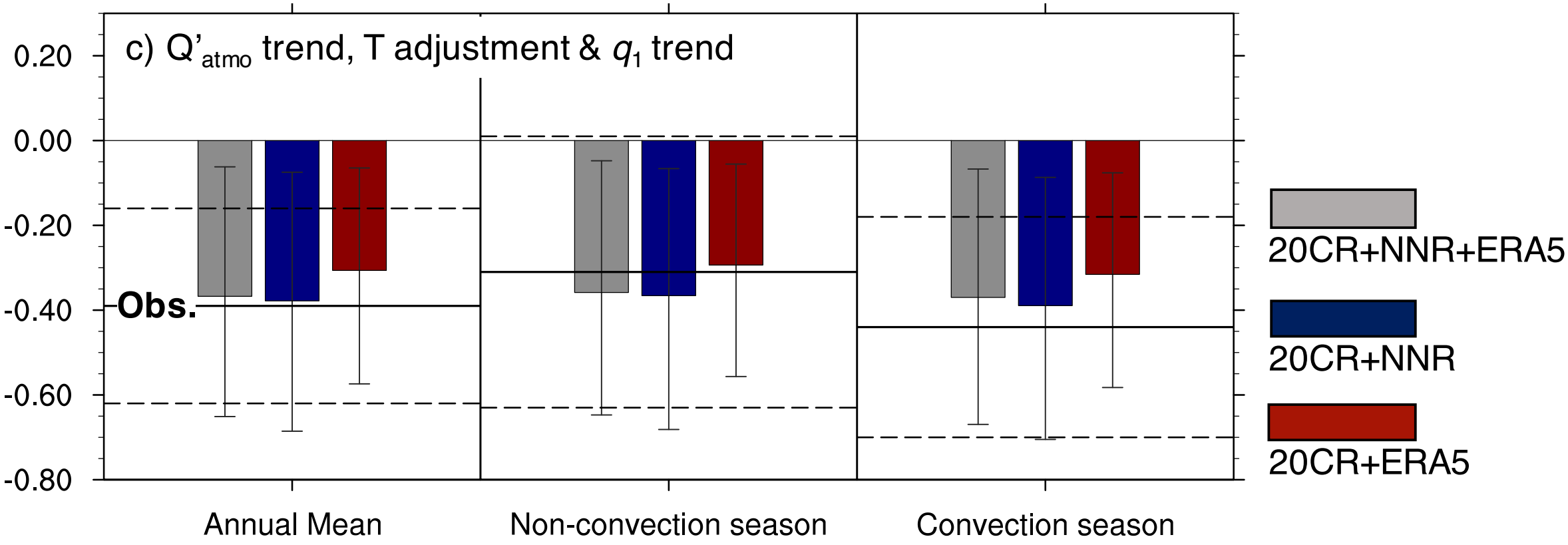
Cooling by atmospheric forcing

$$\rho h_1 C_p \frac{dT_1'}{dt} = -\alpha T_1' + N(0, \sigma^2) + \boldsymbol{Q_{\text{atmo\_trend}}}$$



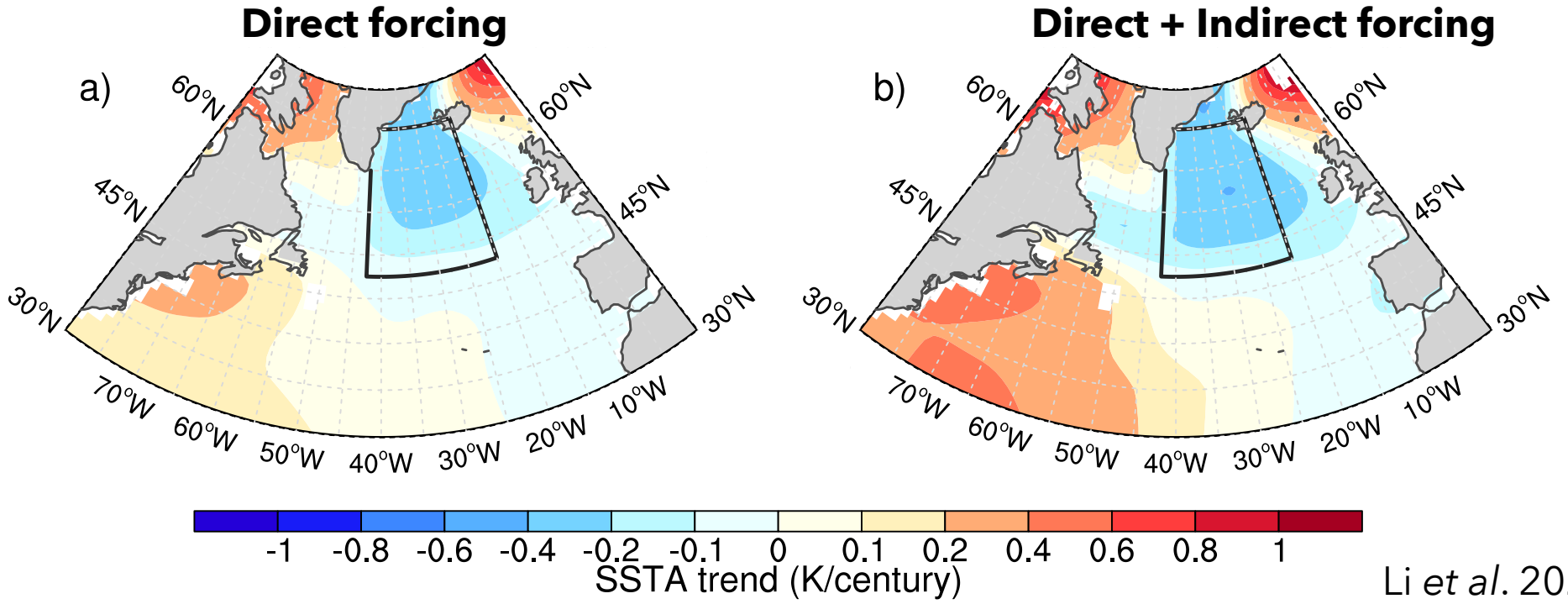
Indirect forcing by the atmosphere

$$\rho h_1 C_p \frac{dT_1'}{dt} = -\alpha T_1' + N(0,\sigma^2) + Q_{\text{atmo\_trend}} \; \mathbf{- q_1(T_1' - T_2') - q_1'(\overline{T_1} - \overline{T_2})}$$



Cold blob forced by the local atmosphere

Idealized model **without** an AMOC slowdown

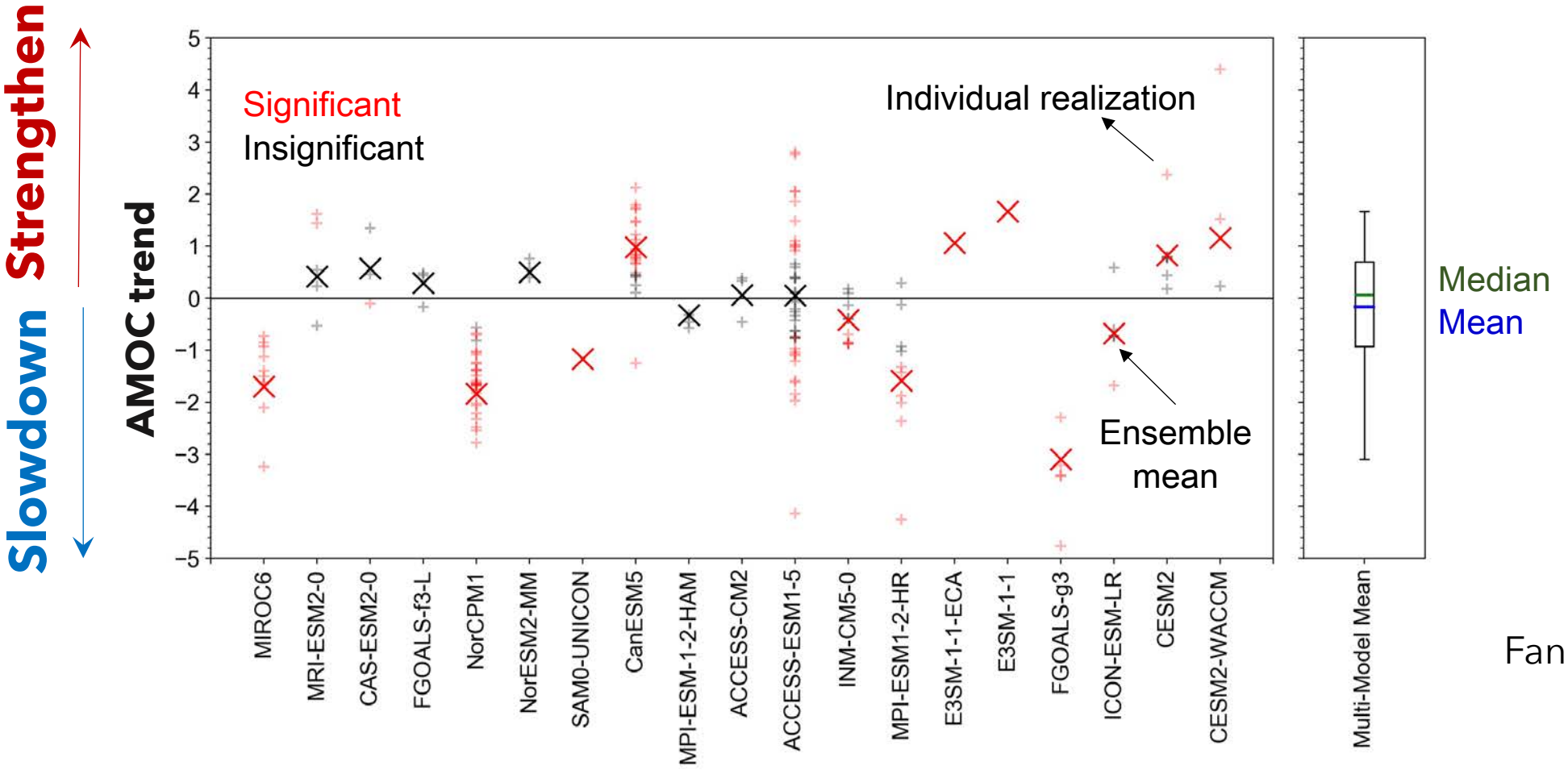


Li *et al*. 2021 Clim. Dyn.

- Idealized heat balance model reproduces the observed cold blob without considering an AMOC slowdown.

Ongoing work: AMOC slowdown?

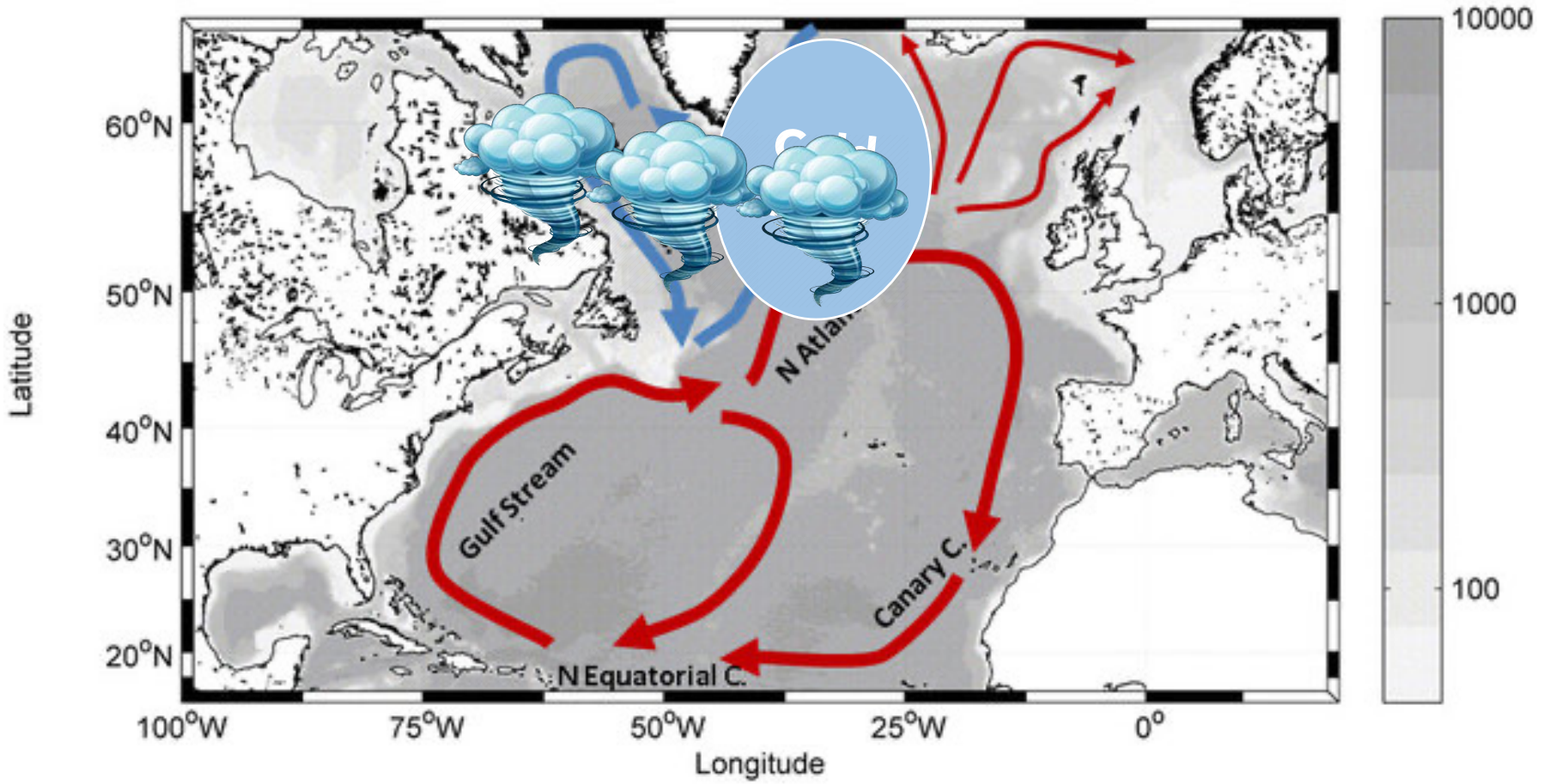
No model agreement on AMOC slowdown in the past century



Fan *et al*. 2022b In Prep.

Summary

North Atlantic cold blob can be generated without an explicit role of AMOC slowdown



Thank you!

- Fan, Y., J. Lu, and L. Li (2021): Mechanism of the Centennial Subpolar North Atlantic Cooling Trend in the FGOALS-g2 Historical Simulation, *JGR-Ocean*, **126**, e2021JC017511.
- Li, L., M. S. Lozier, and F. Li (2021): Century-long cooling trend in subpolar North Atlantic forced by atmosphere: an alternative explanation. *Clim Dyn*. **In Press**, https://doi.org/10.1007/s00382-021-06003-4