EGU General Assembly 2020

South Atlantic Salinity Pileup indicating Remote Response of Weakening Atlantic Overturning Circulation under Anthropogenic Warming

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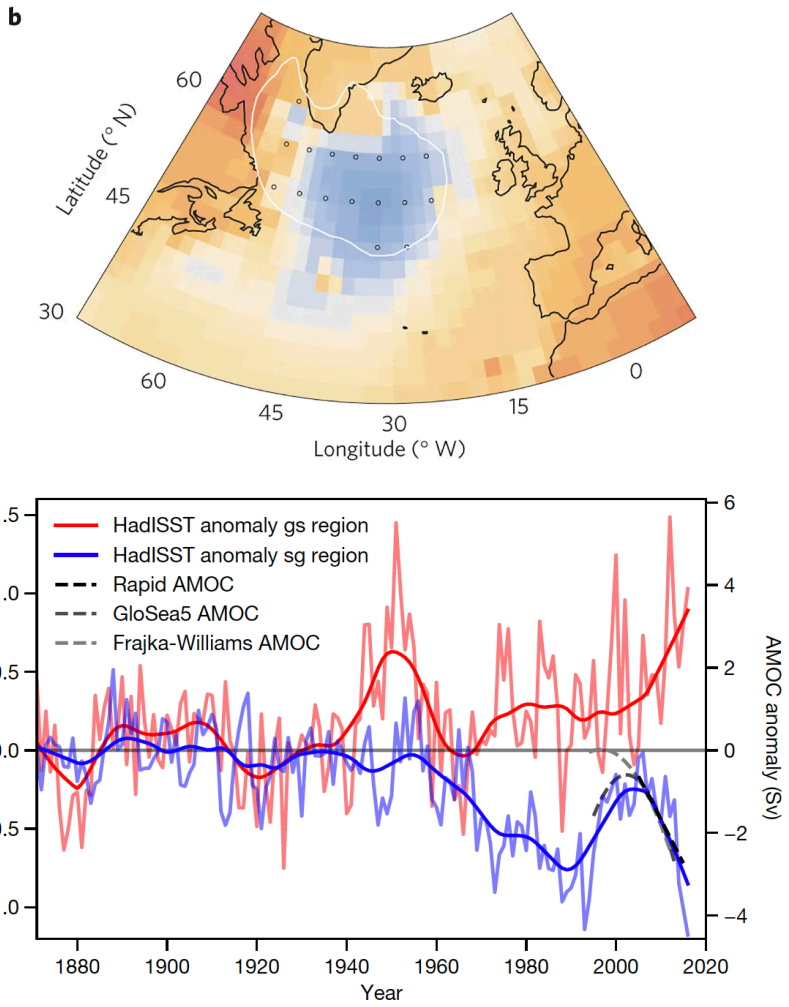
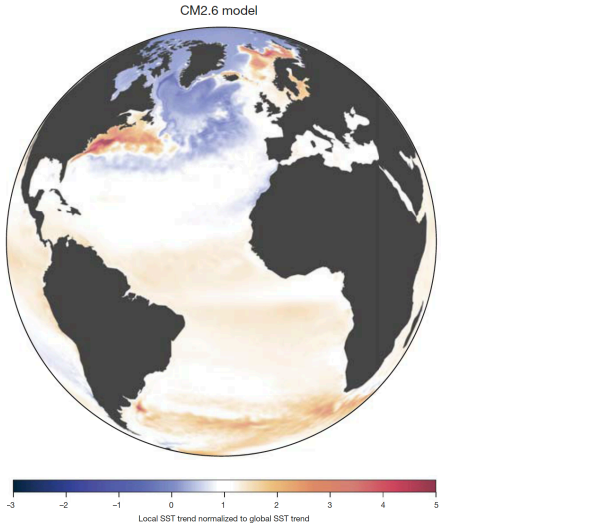
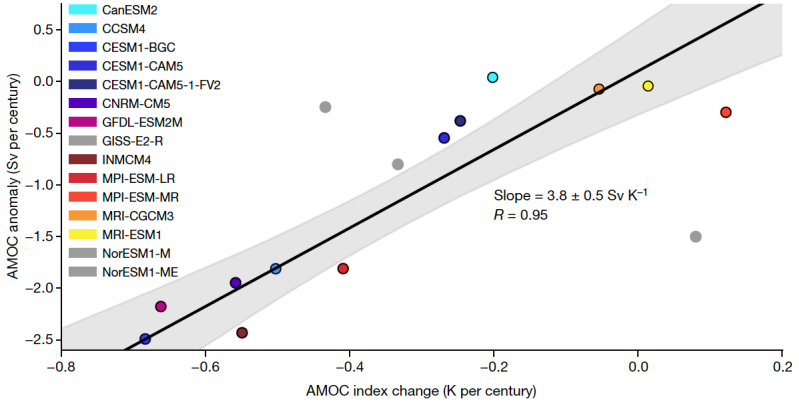
Local AMOC fingerprint--North Atlantic "warming hole"

Observation



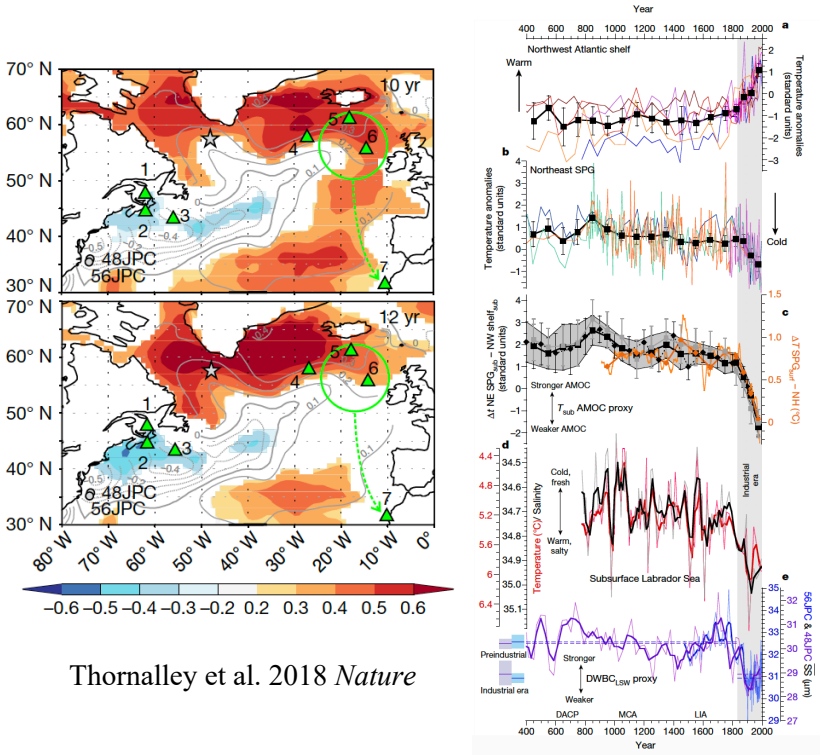
Anthropogenic warming simulation



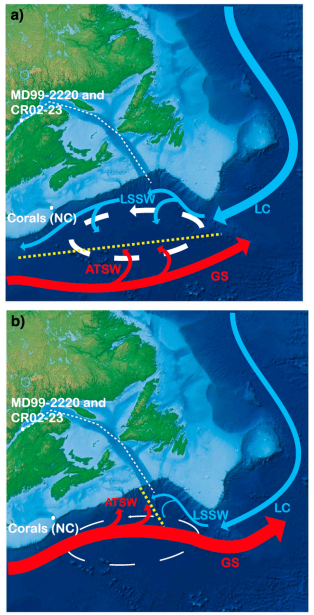


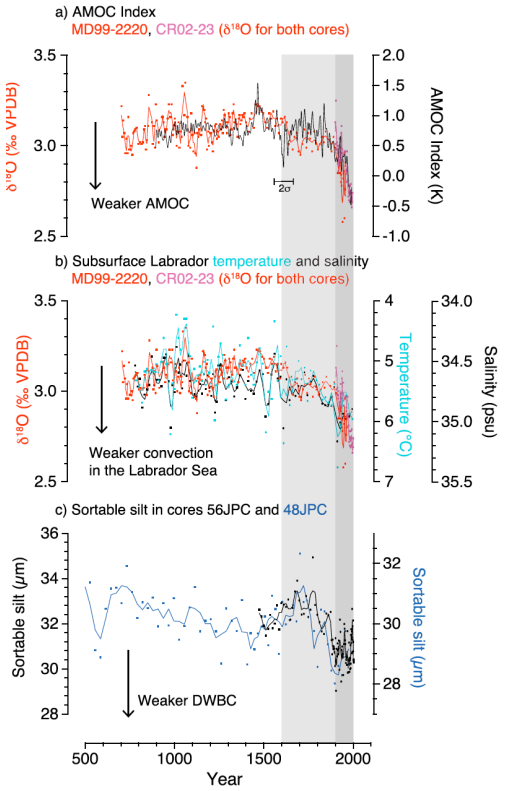
Rahmstorf et al. 2015 *Nat.Clim.Chang.;* Caesar et al. 2018 *Nature*

Local AMOC fingerprint--Other subpolar proxies



Thornalley et al. 2018 *Nature*

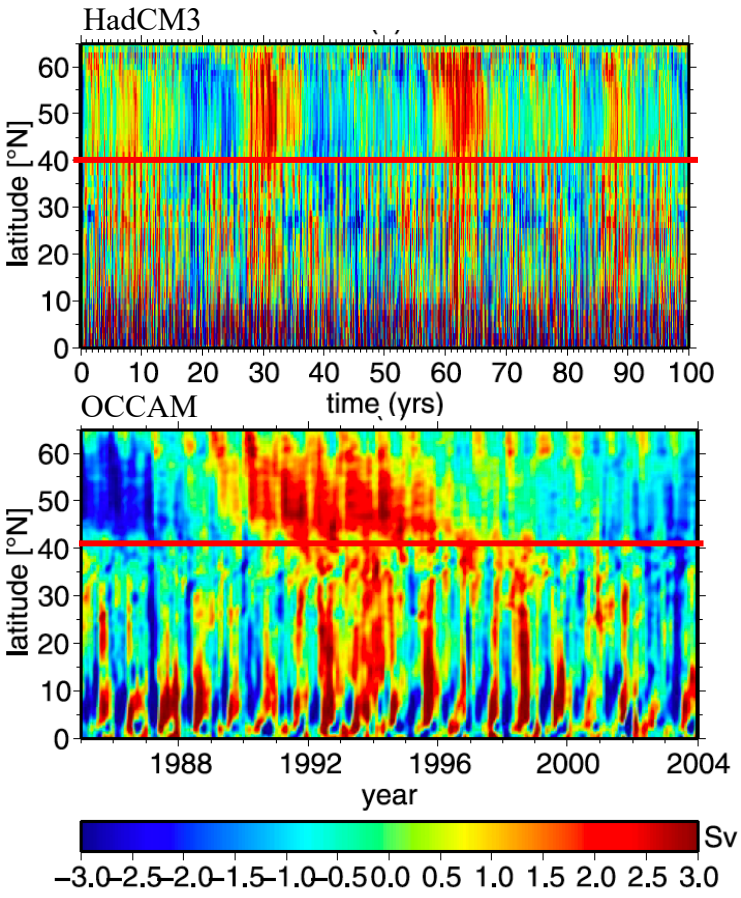




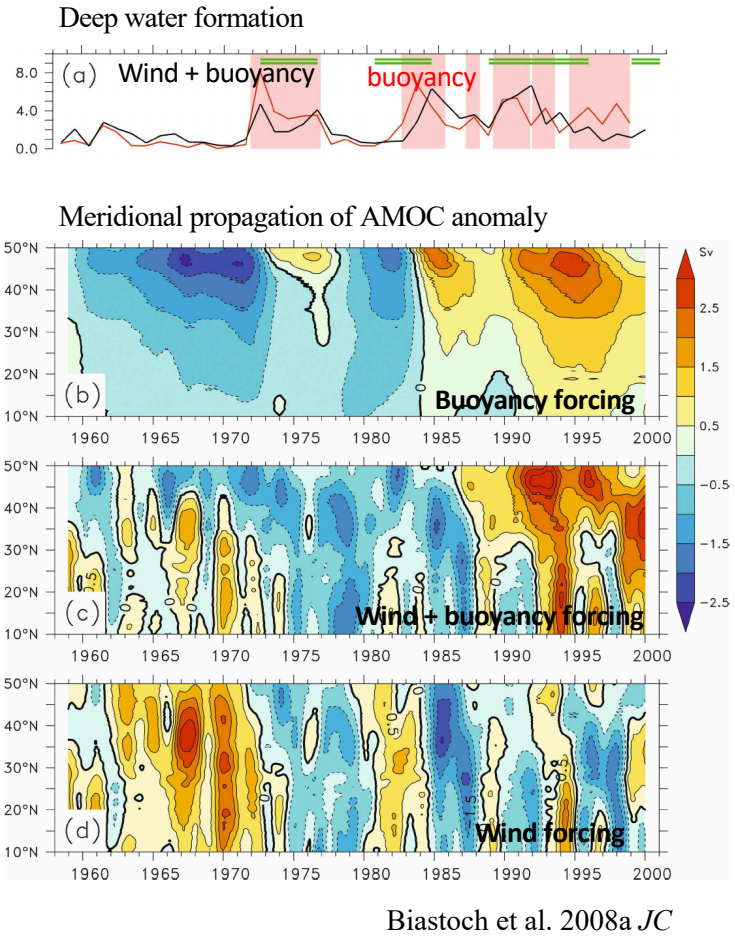
Thibeau et al. 2018 *GRL*

- All these fingerprints are **confined locally** in subpolar North Atlantic.
- They all indicate a weakening AMOC but with **uncertainties on timing**.

Remote AMOC fingerprint?



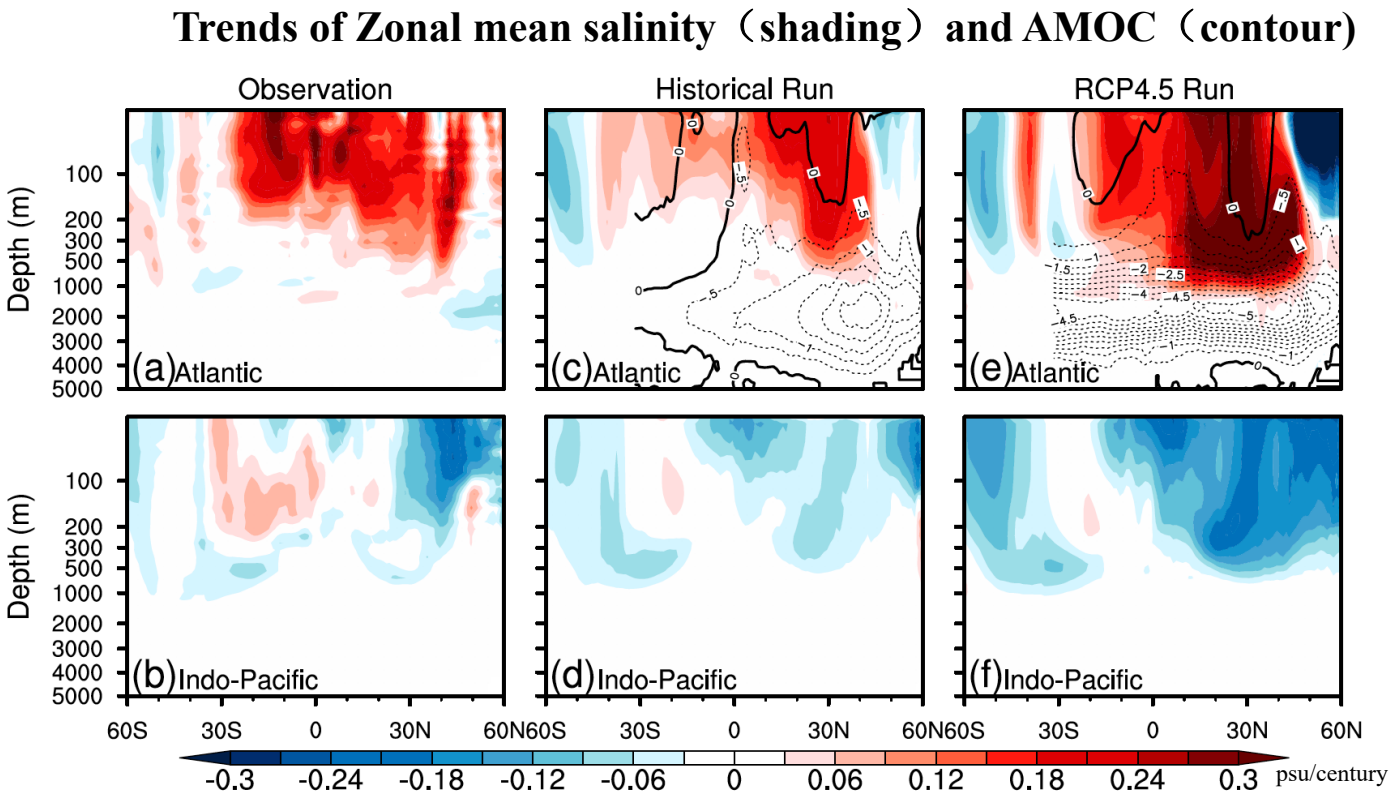
Bingham et al. 2007 *GRL*



Biastoch et al. 2008a *JC*

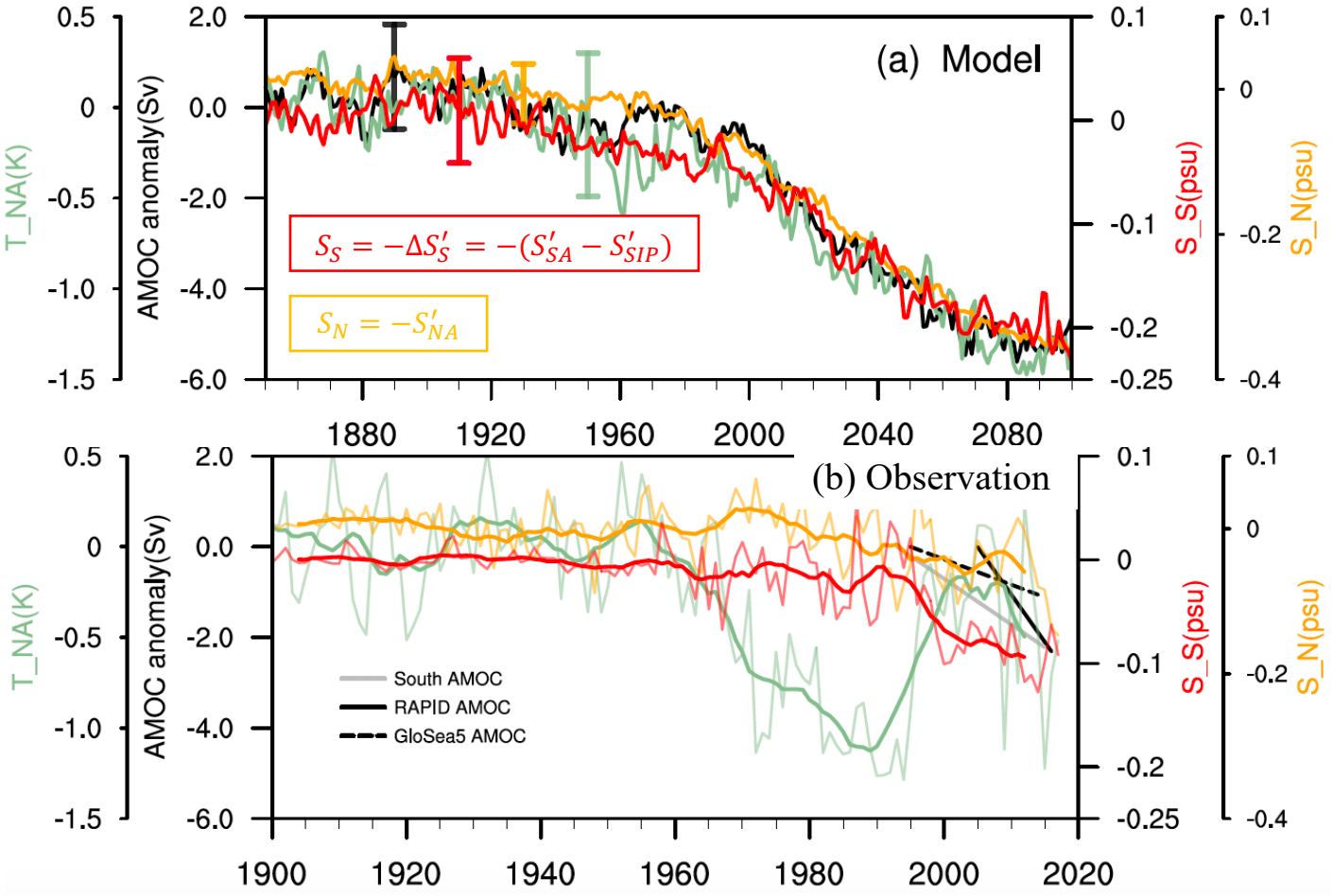
Model studies show that buoyance-forced AMOC anomaly is able to propagate southward coherently, against the distortion by variable wind forcing. Considering the ongoing AMOC weakening is mainly forced by slowing increasing heat flux over subpolar North Atlantic, this buoyancy-forced anomaly may have reached remotely outside North Atlantic.

Atlantic “salinity pileup”--Patterns



In the view of basin mean, from surface to thermocline, salinity of subtropical Atlantic(10~34º N/S) increases more compared with other basins(“salinity pileup” in subtropical Atlantic basin).

Atlantic “salinity pileup”--Time series

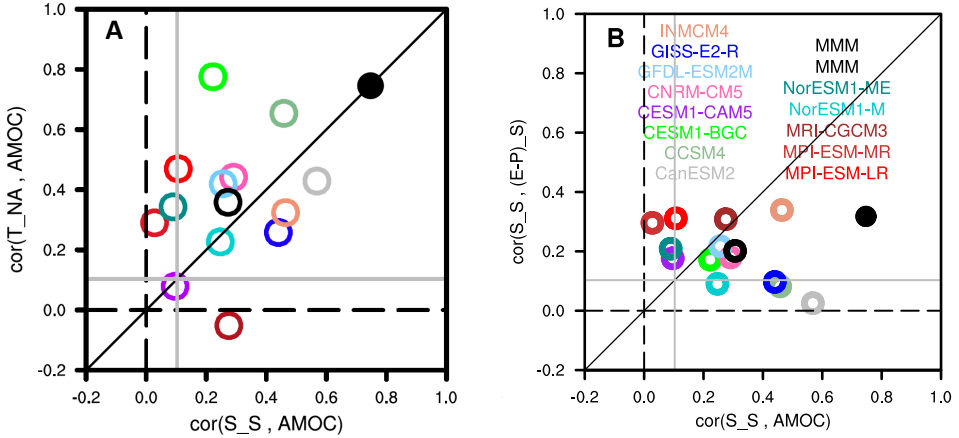


- In models, evolutions of two “salinity pileup” indices are consistent with AMOC and its ”warming hole” fingerprint under anthropogenic warming.
- In observations, the trends of salinity pileups are also consistent with AMOC measurements and reconstructions.

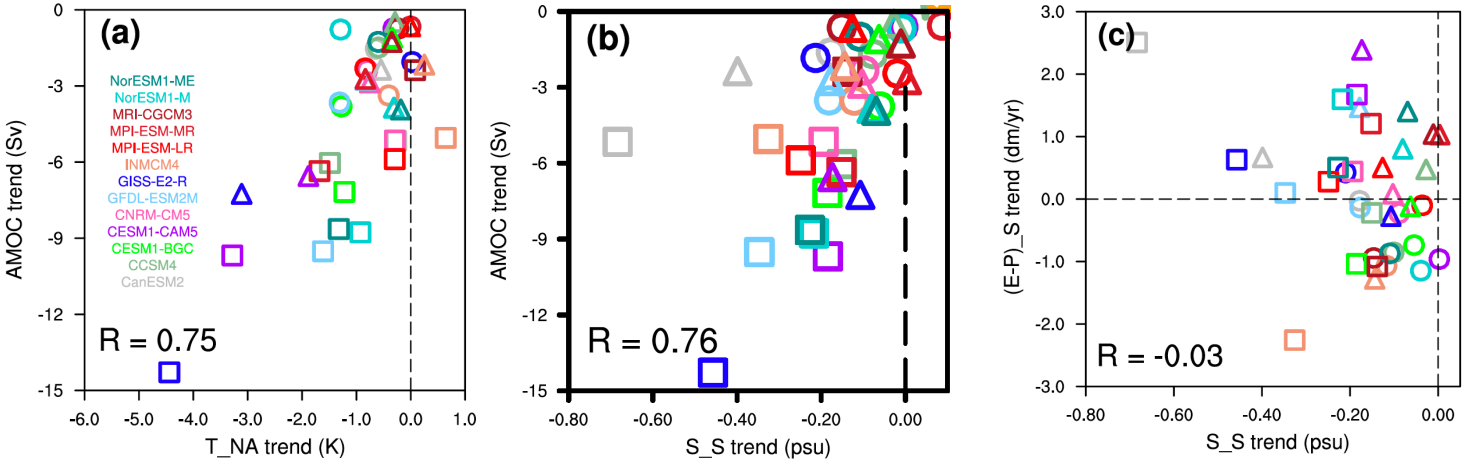
South Atlantic "salinity pileup"(S_S)--Correlation analysis

- S_S is more related to AMOC rather than surface freshwater forcing (E-P).
- S_S is projected to intensify with global warming, along with further AMOC slowdown.

Historical annual correlations(1861-2018)



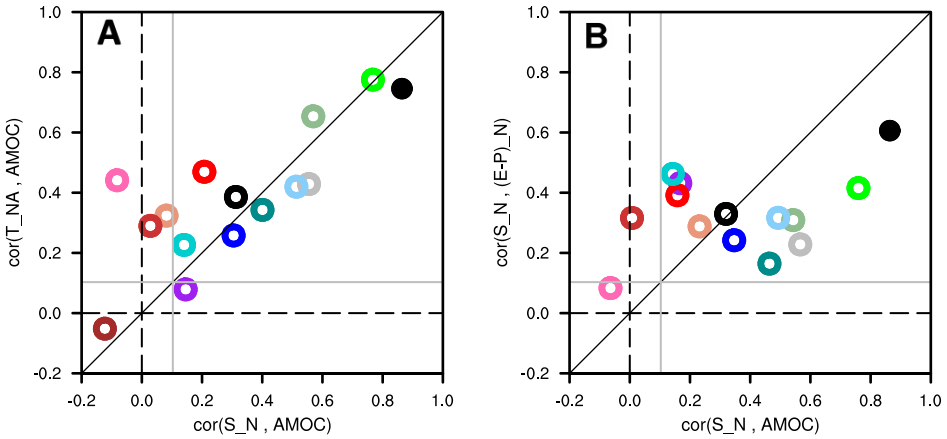
Trend correlations (Hist ◯ RCP4.5 △ RCP8.5 □)



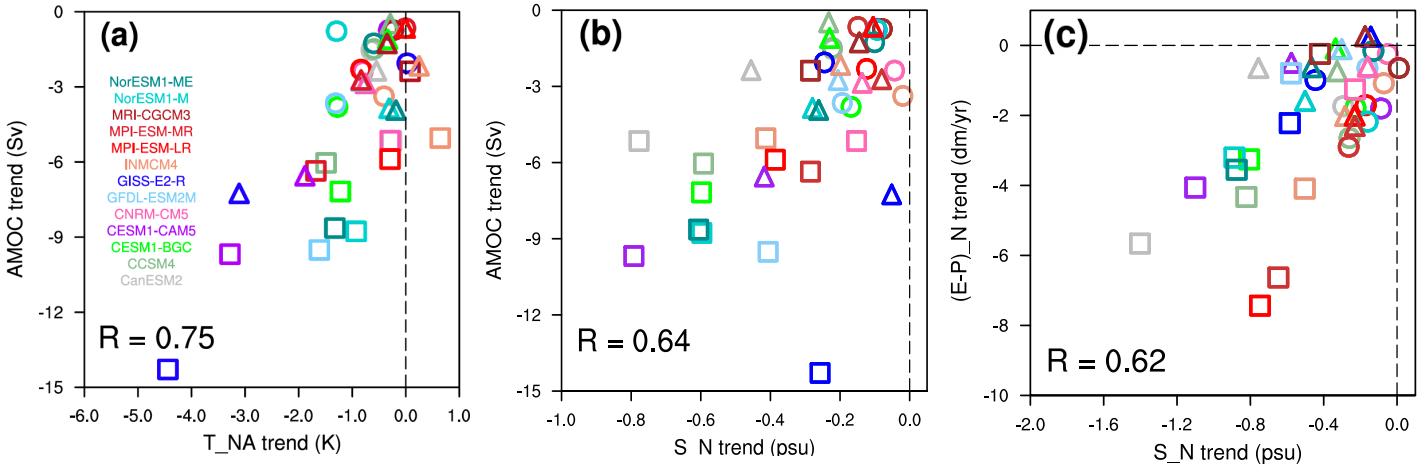
North Atlantic "salinity pileup"(S_N)--Correlation analysis

- S_N is related to (E-P) as well as AMOC.
- S_N is projected to intensify with global warming, along with further AMOC slowdown and subtropical drier.

Historical annual correlations(1861-2018)

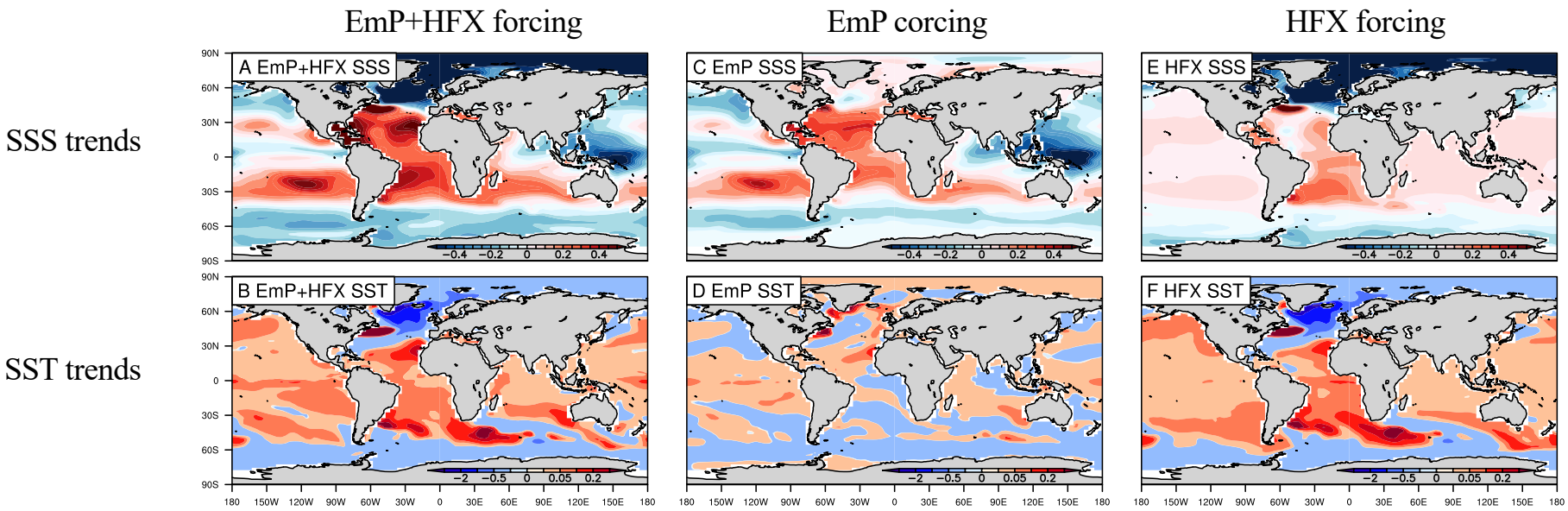


Trend correlations (Hist ◯ RCP4.5 △ RCP8.5 □)



South Atlantic “salinity pileup”--Mechanism

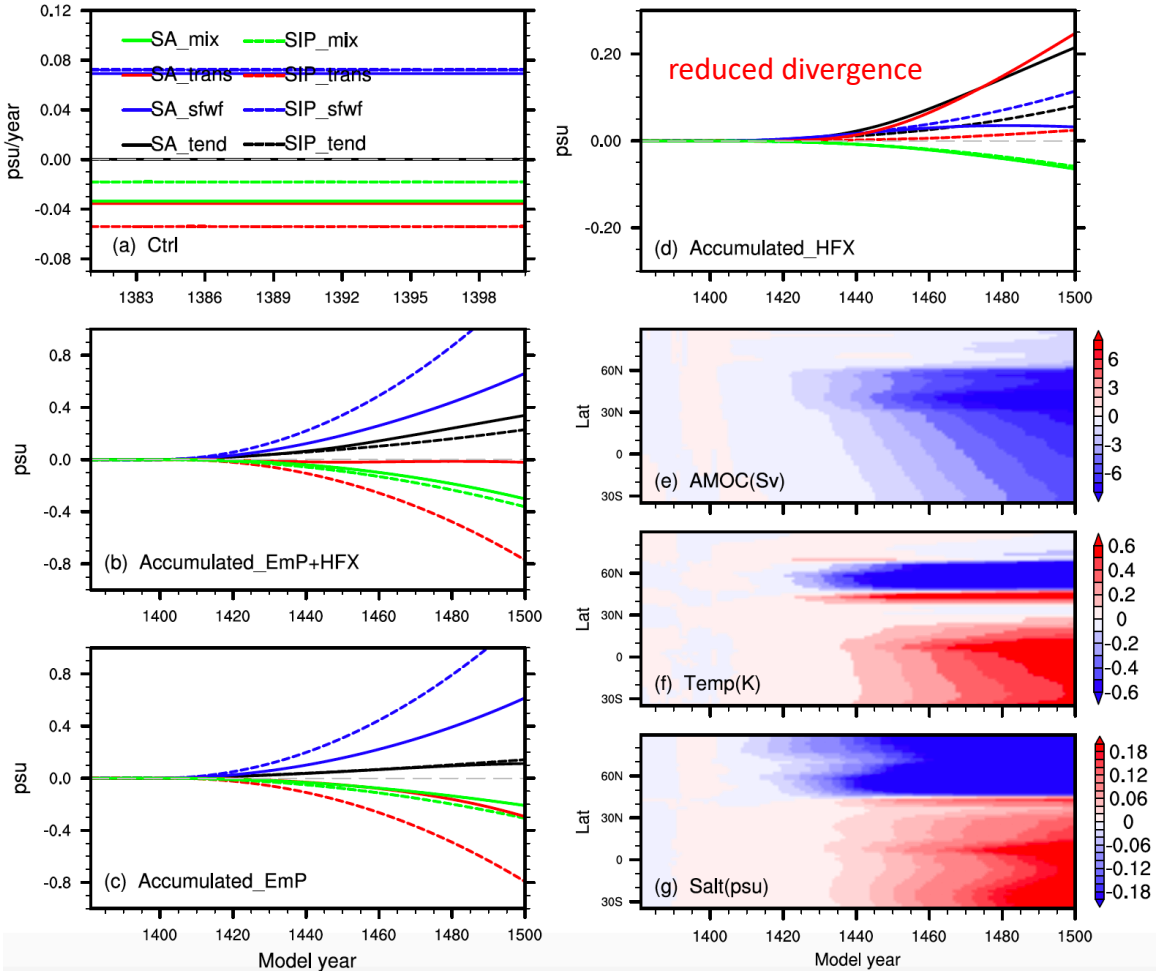
- **Model**: low resolution (~3 degree) POP2(ocean component for CCSM4 and CESM1)
- **Forcing set**
  - EmP: surface freshwater flux anomaly derived from RCP4.5 and increasing linearly in 100 year.
  - HFX: global uniform surface heat flux anomaly increasing linearly from 0 to 5W/m^2 in 100 year.
  - EmP+HFX: combine EmP and HFX forcing.



North Atlantic “salinity pileup” is mostly driven by (E-P) forcing while **South Atlantic “salinity pileup”**(along with North Atlantic warming whole) is mostly driven by **AMOC weakening** induced by slow increasing heat flux resembling anthropogenic warming.

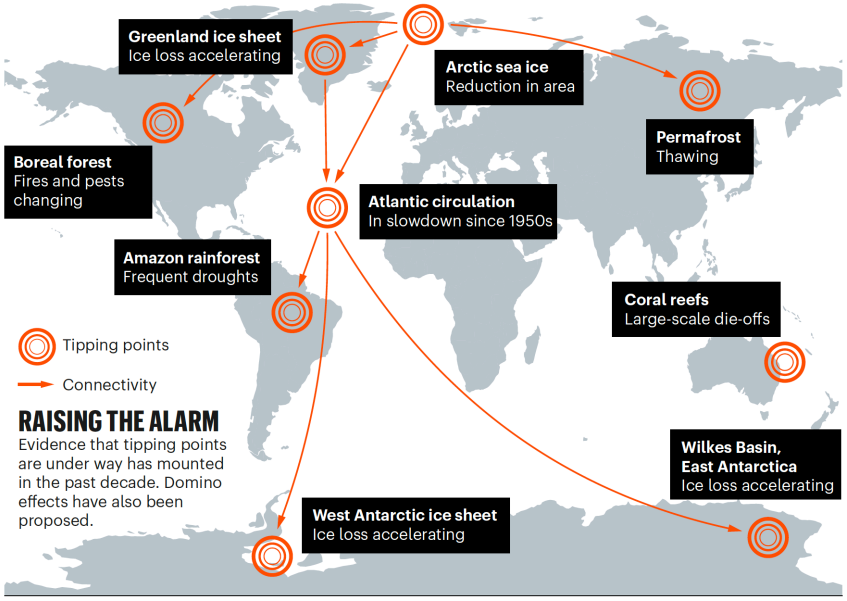
South Atlantic “salinity pileup”--Mechanism

Upper 300m ocean salinity budget in sensitivity exp.



- Under global warming, the **weakening AMOC reduces the salinity divergence** and then leads to a “salinity pileup” remotely in the South Atlantic. The “salinity pileup” in North Atlantic, however, is mainly driven by surface freshwater forcing and is less relevant to AMOC(not shown).
- AMOC weakening under surface heat flux forcing is able to **occur all the way into the South Atlantic**.

South Atlantic “salinity pileup”--Conclusion and Implications



Lenton et al. 2019 *Science*

- ❖ Our study provides the first evidence of AMOC slowdown under anthropogenic warming **remotely in the South Atlantic**, far beyond the subpolar North Atlantic, and this remote echo of AMOC is projected to intensify with global warming, along with further AMOC slowdown.
- ❖ This remote response provides an observational evidence consistent with previous modeling studies on the **meridionally coherent response of AMOC** from the subpolar North Atlantic to the South Atlantic under buoyance forcing.

- ❑ Furthermore, our AMOC indicator is directly related to the salinity in the South Atlantic and therefore may have implication for the freshwater export, and in turn, stability of AMOC; the increased “salinity pileup” in the upper ocean of South Atlantic may increase the freshwater export by AMOC, leading to a **more unstable AMOC in the future**.

Thanks!