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Unforced AMOC variations modulated by Tropical Indian Ocean SST

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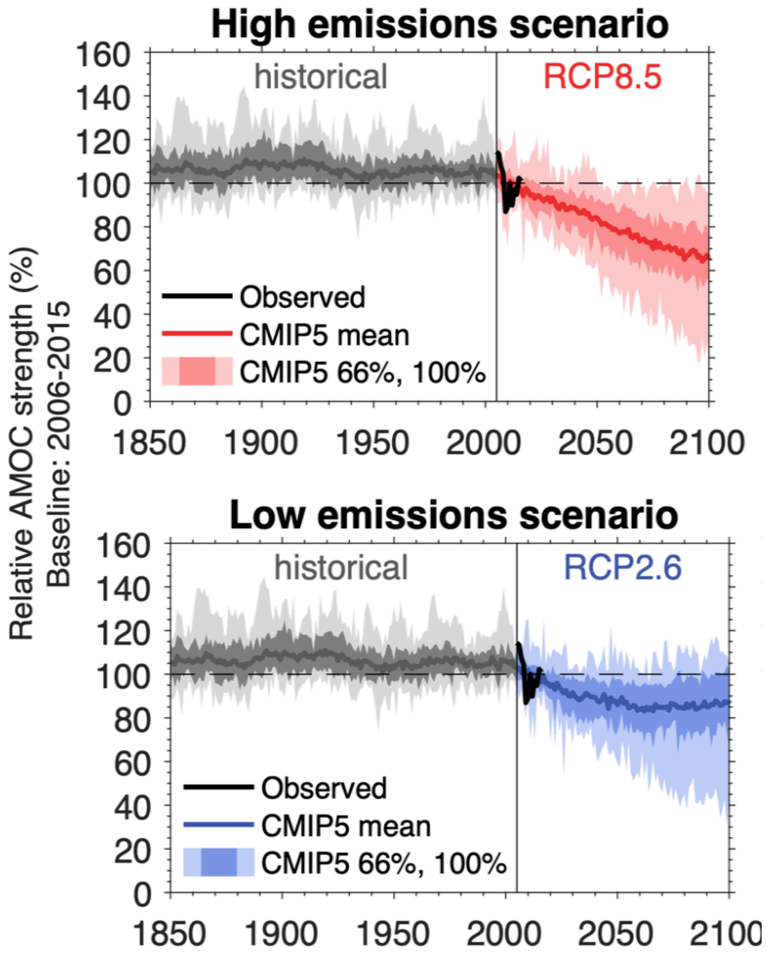
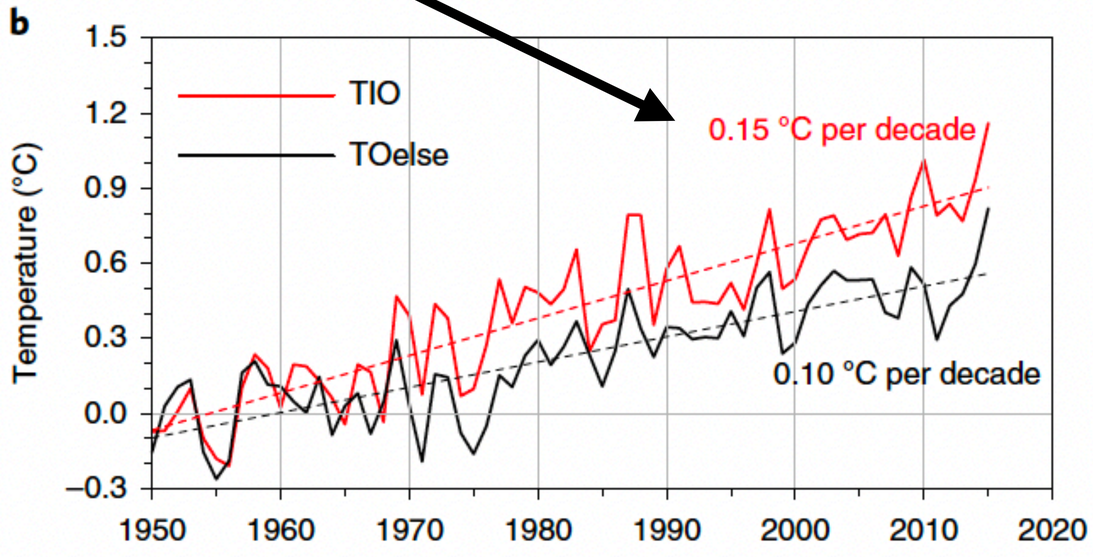
LOCEAN IPSL LMD cnrs INVESTISSEMENTS D'AVENIR ANR AGENCE NATIONALE DE LA RECHERCHE MAKE OUR PLANET GREAT AGAIN

The warming Tropical Indian Ocean (TIO)



IPCC SROCC

- AMOC is expected to decline due to anthropogenic climate change with potential wide-ranging impacts
- TIO warms faster than rest of the tropical ocean (rTIO)



Hu & Fedorov (2019)

Are the TIO warming and AMOC connected?

Tropical Indian Ocean influence on AMOC?

nature climate change
LETTERS
https://doi.org/10.1038/s41558-019-0566-x

Indian Ocean warming can strengthen the Atlantic meridional overturning circulation

Shineng Hu[1*] and Alexey V. Fedorov[2,3]

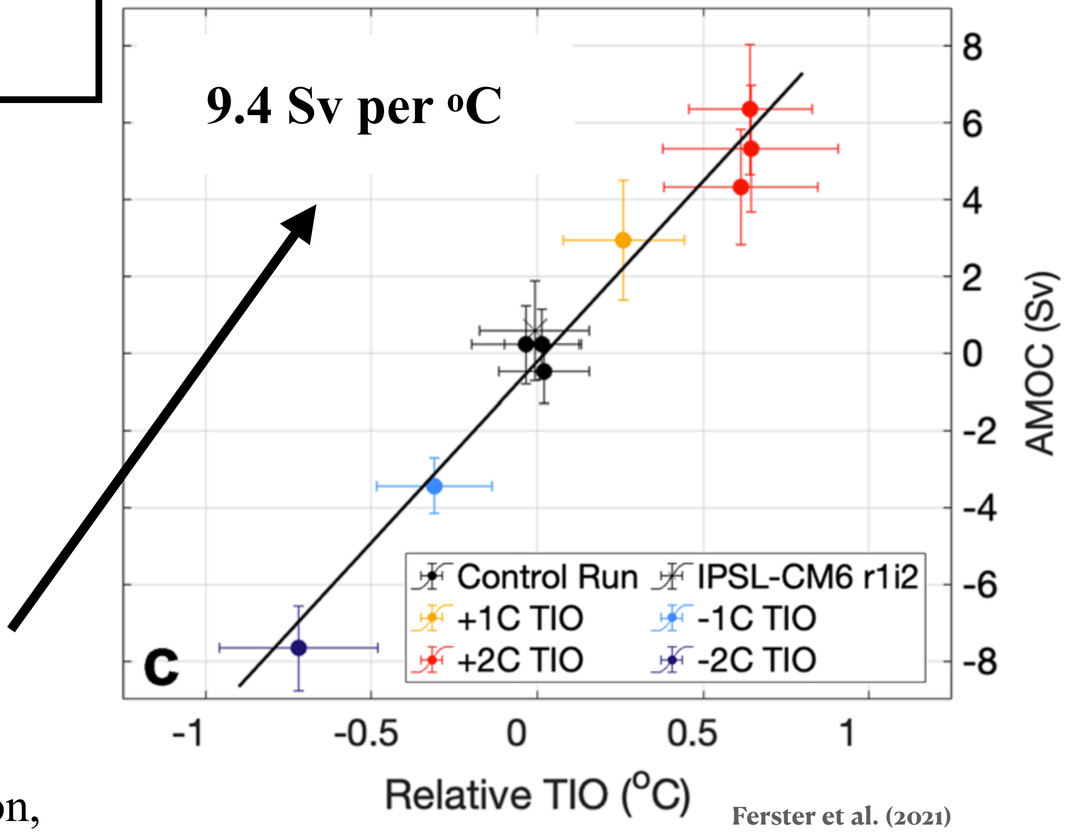
Climate Dynamics
https://doi.org/10.1007/s00382-021-05813-w

Sensitivity of the Atlantic meridional overturning circulation and climate to tropical Indian Ocean warming

Brady S. Ferster[1] · Alexey V. Fedorov[1,2] · Juliette Mignot[1] · Eric Guilyardi[1,3]

- The tropical Indian Ocean influences (TIO) the tropical Atlantic ITCZ through an atmospheric teleconnection
  - *Anomalous sea surface salinity and temperature propagate to the subpolar North Atlantic through ocean pathways*
- Model sensitivity experiments (CESM/IPSL) warming/cooling TIO suggest a robust influence of relative TIO (rTIO) on AMOC
- So far unidentified in observations due to (i) lacking AMOC observation, (ii) mix of forcing & internal signals

Relationship of the rTIO - AMOC
In IPSL-CM6A-LR

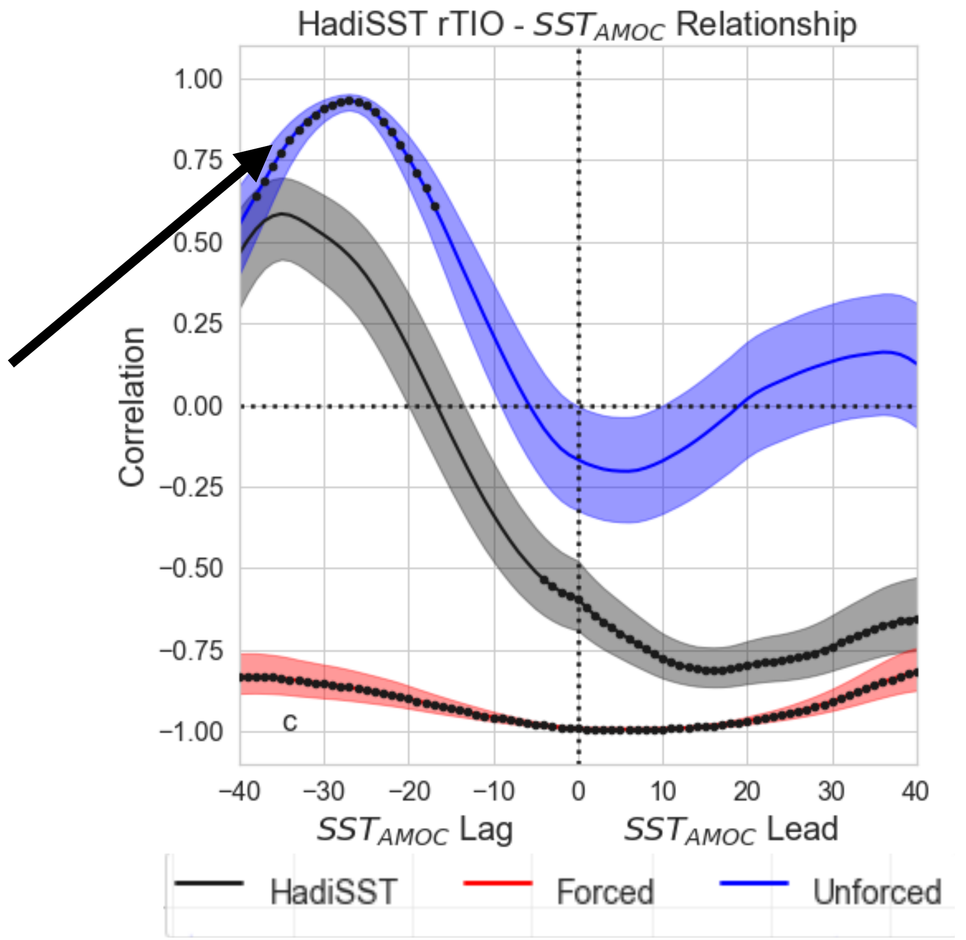


Ferster et al. (2021)

Unforced Relative TIO related to SST_{AMOC}

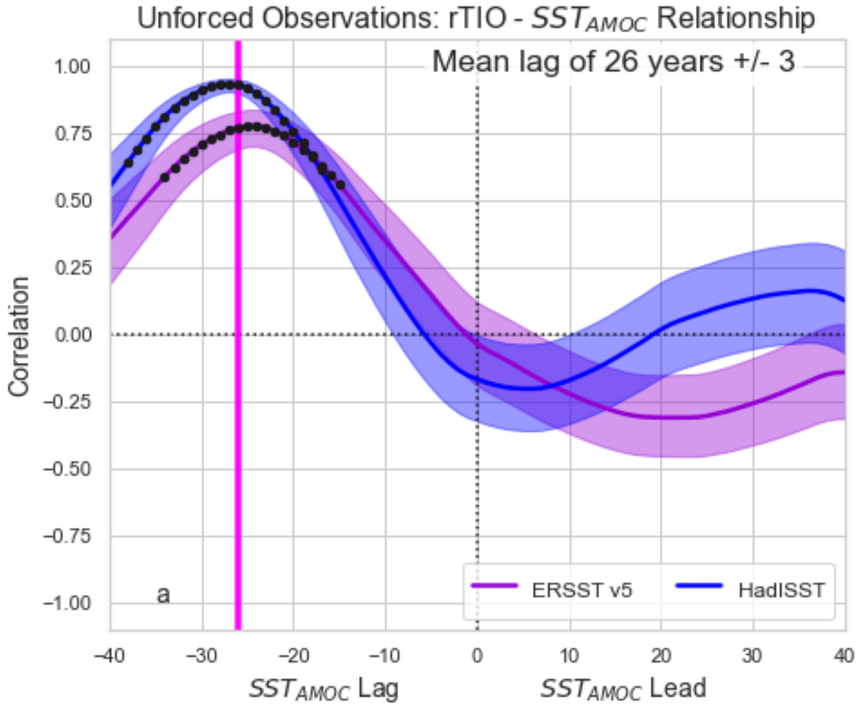
Here: Use SST proxy to estimate observed AMOC & separation of forcing and internal variability

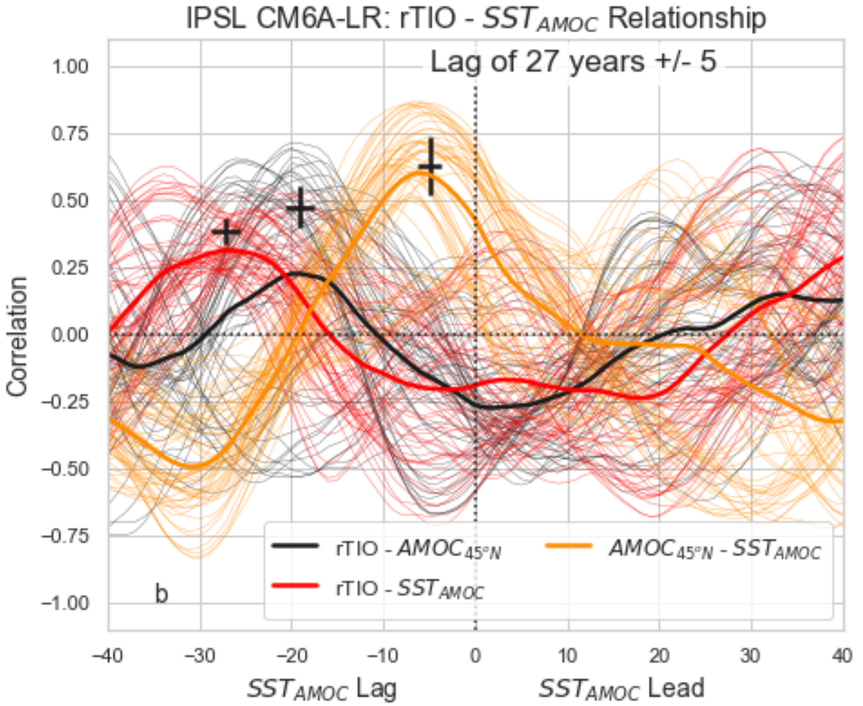
- Examine relative roles of forcing and unforced variability
- Unforced : Remove the rescaled CMIP6 ensemble mean SST for each grid-cell (Qasmi et al., 2017; Guo et al., 2019; Smith et al., 2019)
- SST_{AMOC} : Subpolar SST-fingerprint index to represent AMOC
- Unforced relative TIO leads the Unforced SST_{AMOC} index by 27 years (r=0.93)
- Separating the forced signal from HadiSST identifies a clear relationship



Is the rTIO - SST_{AMOC} relationship robust?

- Unforced ERSSTv5 and HadiSST have similar rTIO - SST_{AMOC} relationships
- IPSL-CM6A piControl to address robustness, mechanism, and representation of AMOC by SST_{AMOC}
  - IPSL-CM6A is separated into 150-year segments to compare with observation
  - The rTIO leads the SST_{AMOC} by ~27 years (robust relationship, significant using bootstrap method)
- $AMOC_{45N}$ and SST_{AMOC} strong relationship at ~5 year lag

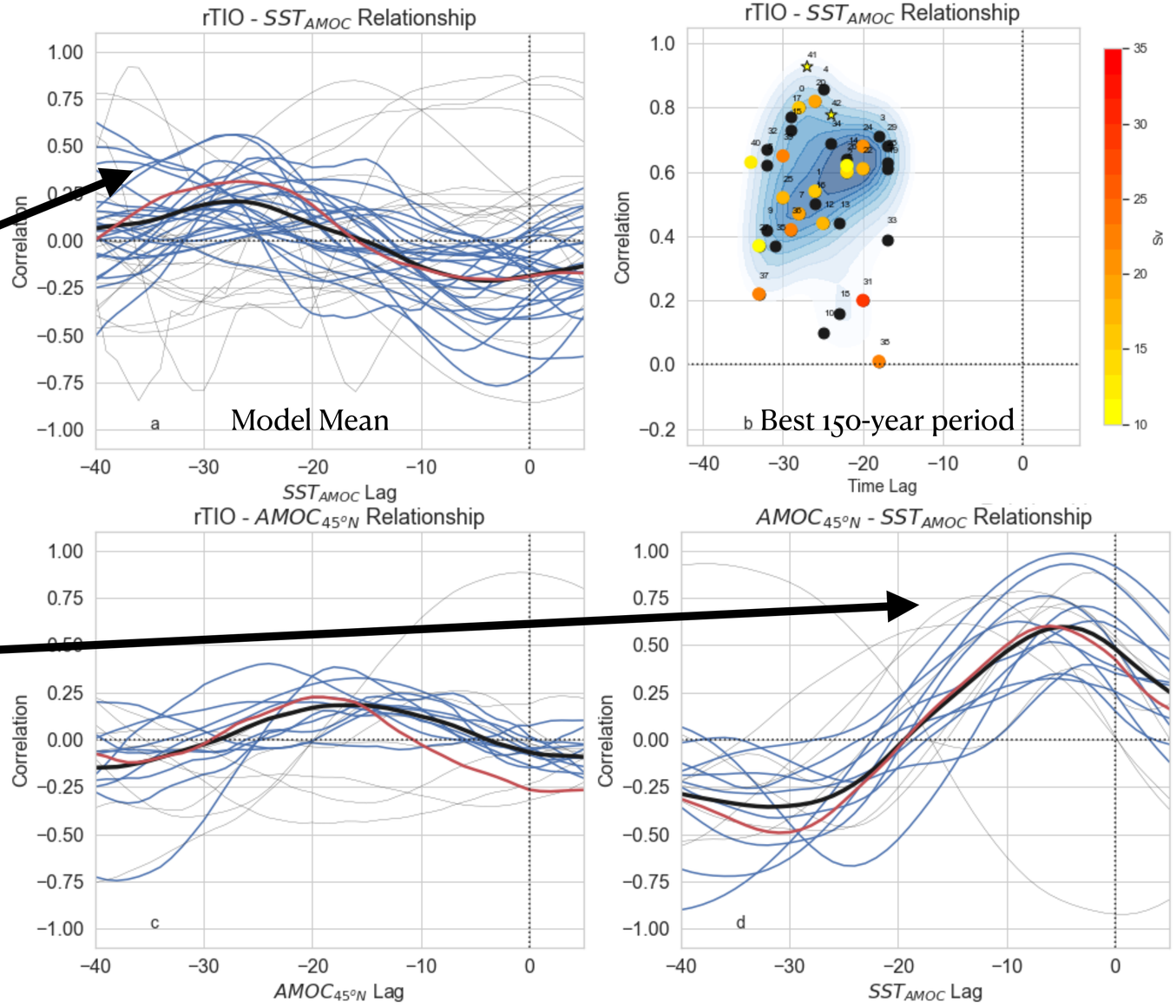




A somewhat robust feature across CMIP6

CMIP6 piControl simulations

- Relationship weaker in some models, large spread
- rTIO-AMOC relationship is strongly model dependent
- Almost all models reproduce the rTIO-AMOC link in one 150 year period
- Strong confidence in the pattern of AMOC-SST_{AMOC} -> ~5 year lag
  - The SST_{AMOC} index captures unforced natural variability of AMOC in models

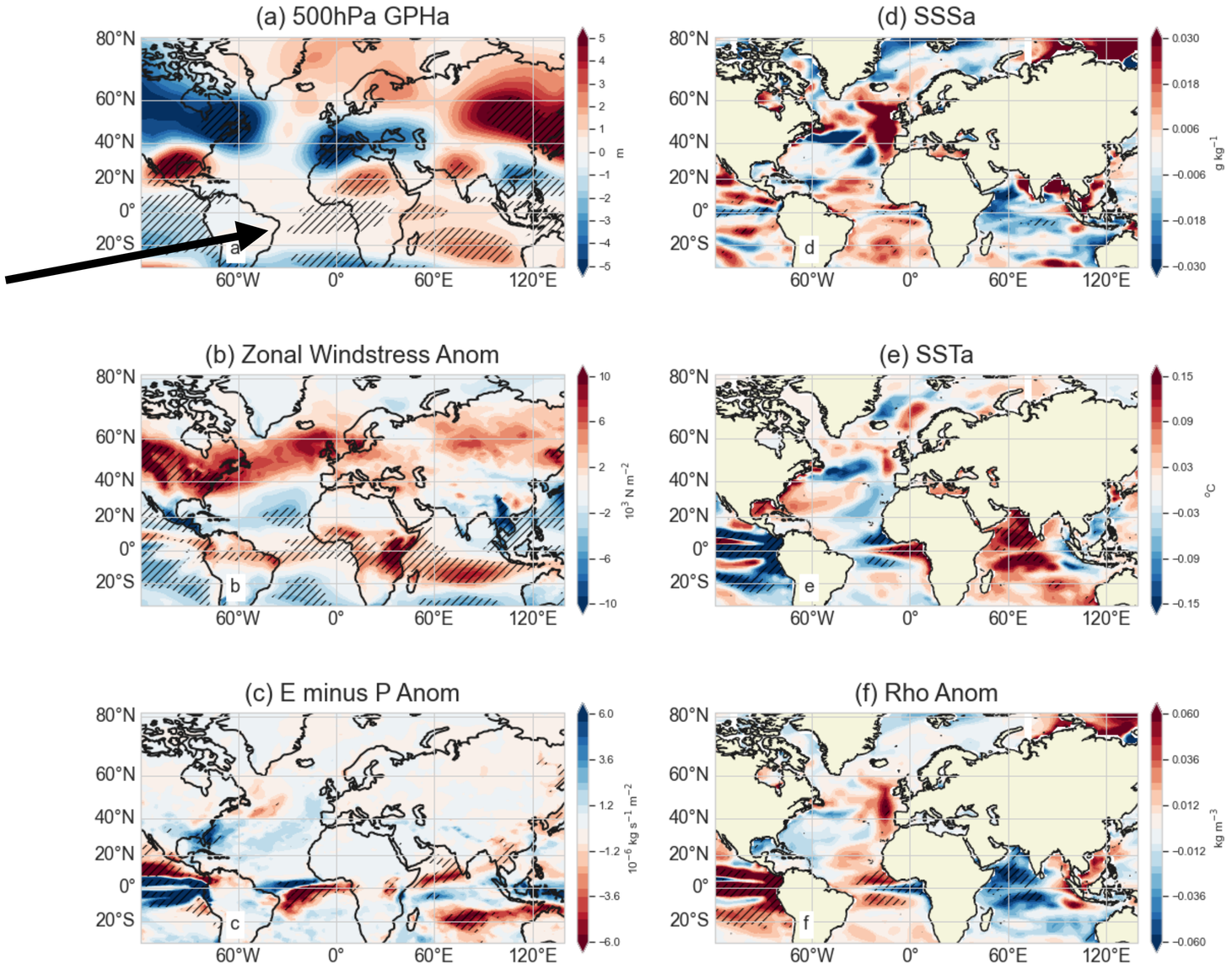


How is the rTIO - AMOC link accomplished?

IPSL-CM6A-LR piControl

- Teleconnection rTIO - tropical Atlantic
- Shift of ITCZ -> temperature/rainfall -> density of surface water
- Northward propagation
- Affects deep convection, which drives AMOC

**Detailed discussion of the teleconnection in Hu & Fedorov 2019; Ferster et al., 2021*



Take Home Messages

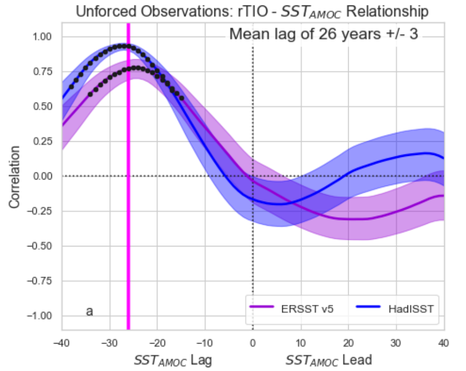
- There is an observed relationship between the tropical Indian Ocean and North Atlantic SST -> a rTIO effect on multidecadal AMOC variability

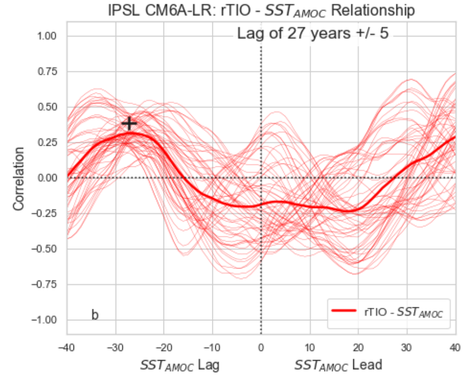
- Our results suggest a robust time lag between rTIO and SST_{AMOC} of around 26 years (observation and models)

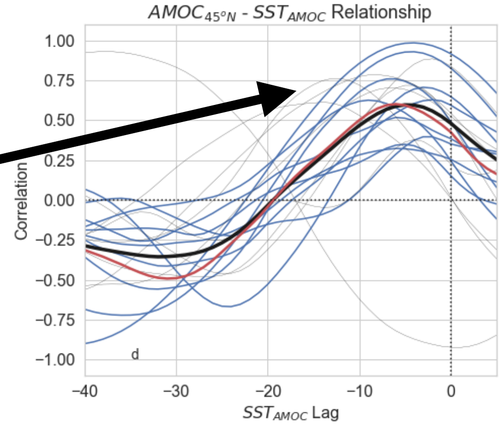
- Included in our EGU Poster - CMIP6 !

  - Strong agreement within CMIP6 models that AMOC and SST_{AMOC} index are correlated at ~5 year lag

  - The SST_{AMOC} index captures unforced natural variability of AMOC in models on decadal-multidecadal timescales







Thank you!

Ferster, Borchert, Mignot, Menary, Cassou, Fedorov: Multidecadal AMOC variability driven by tropical Indian Ocean SST. To be submitted.