
# Increased risk of near term global warming level due to a recent AMOC weakening

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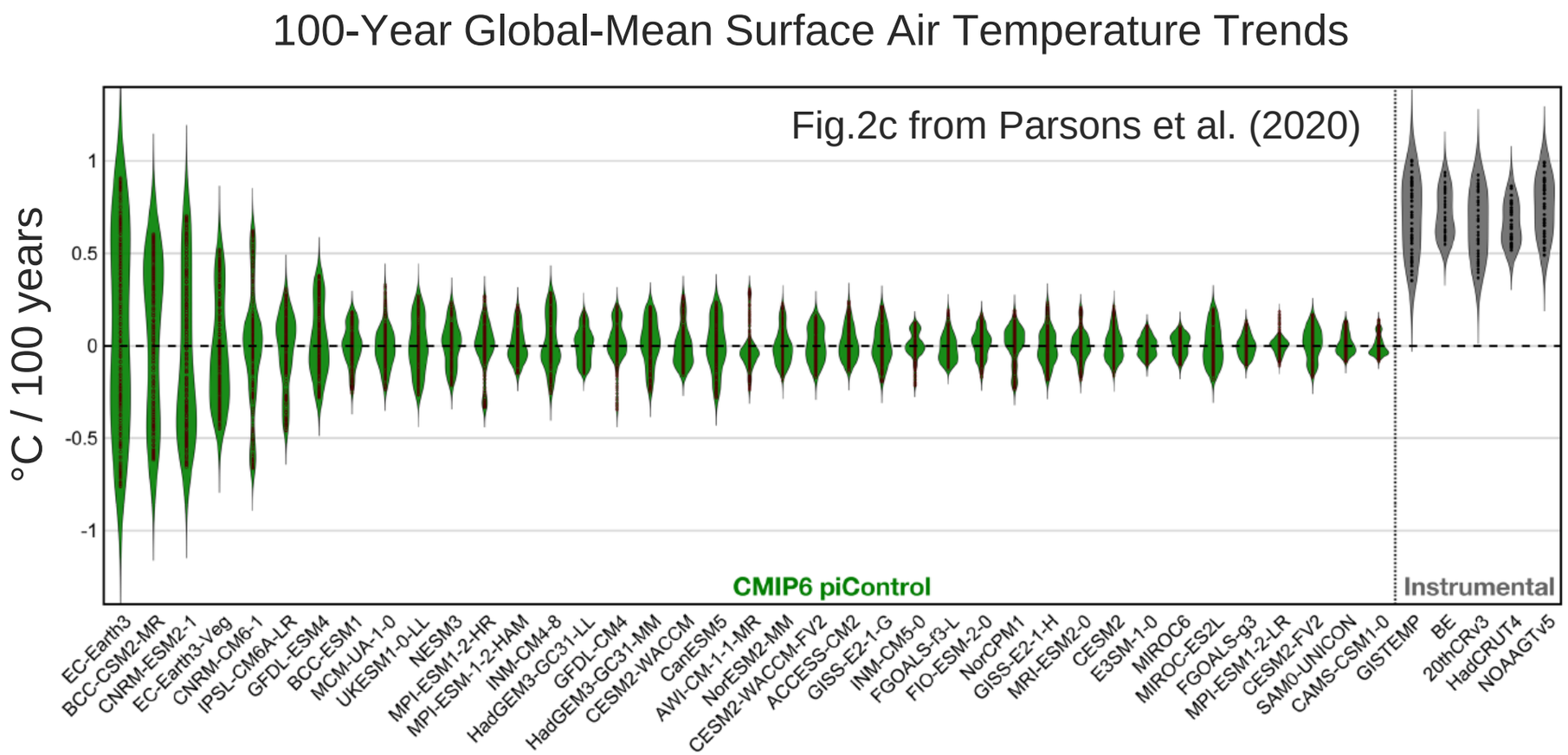
CONSTRAIN

# Context

- Some CMIP6 models are characterized by a relatively high low-frequency internal climate variability in comparison to their CMIP5 counterparts (Parsons et al., 2020).



# Context

- Some CMIP6 models are characterized by a relatively high low-frequency internal climate variability in comparison to their CMIP5 counterparts (Parsons et al., 2020).

- Such variability might have strong implications, as it can temporarily enhance or reduce the long-term imprints of externally forced climate change.

- Using the IPSL ensemble of extended historical simulations, we investigate the influence of multi-centennial internal climate variability on the Global near-Surface Air Temperature (GSAT) warming since the middle of the 20th century.

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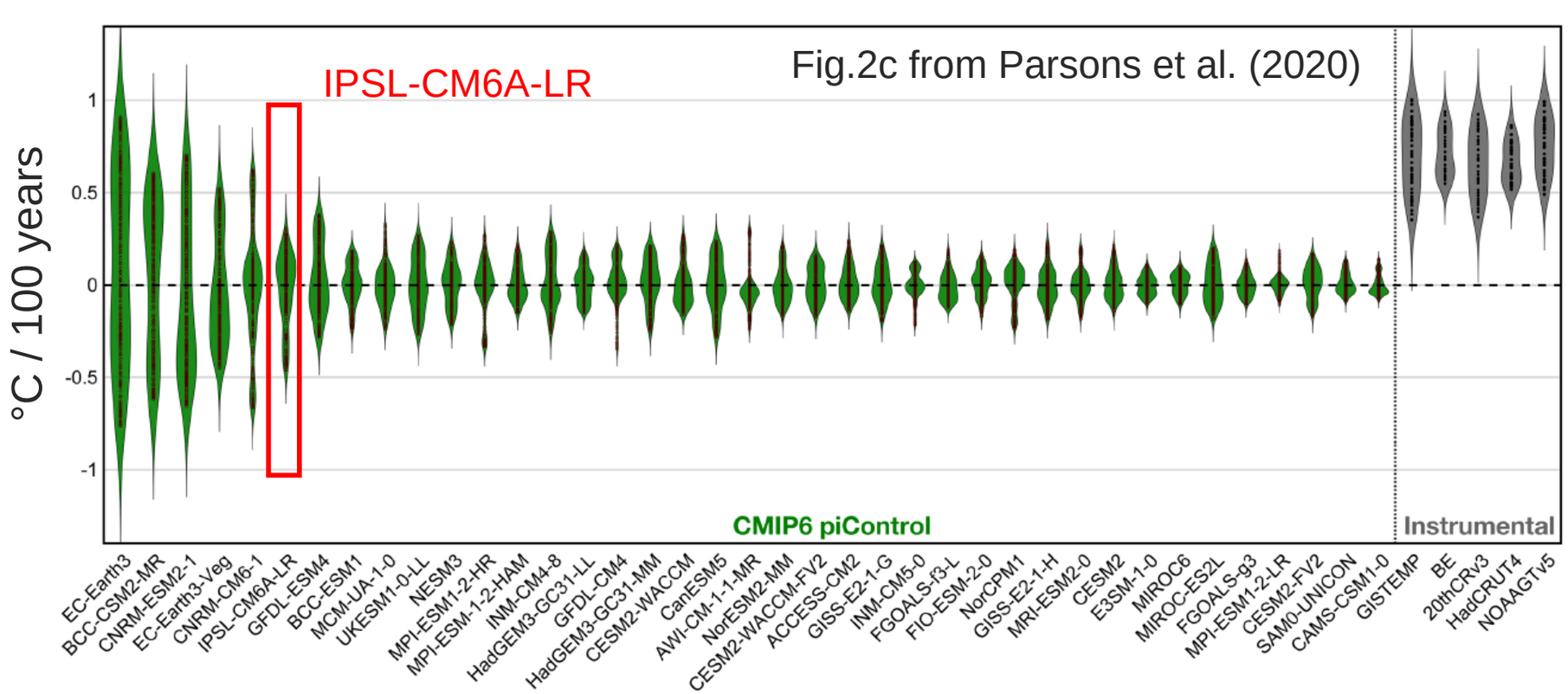
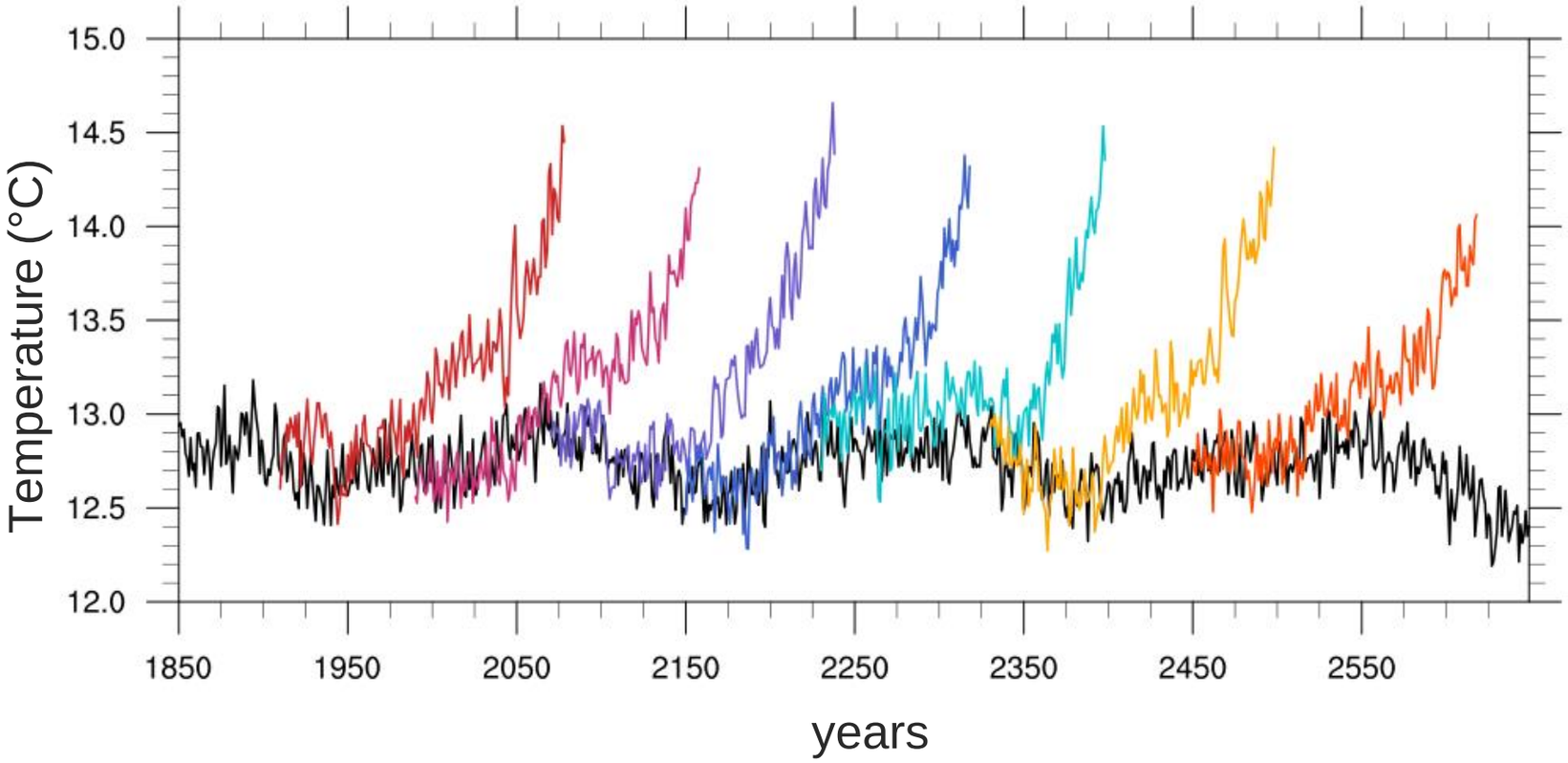
100-Year Global-Mean Surface Air Temperature Trends



# IPSL ensemble of extended historical simulations

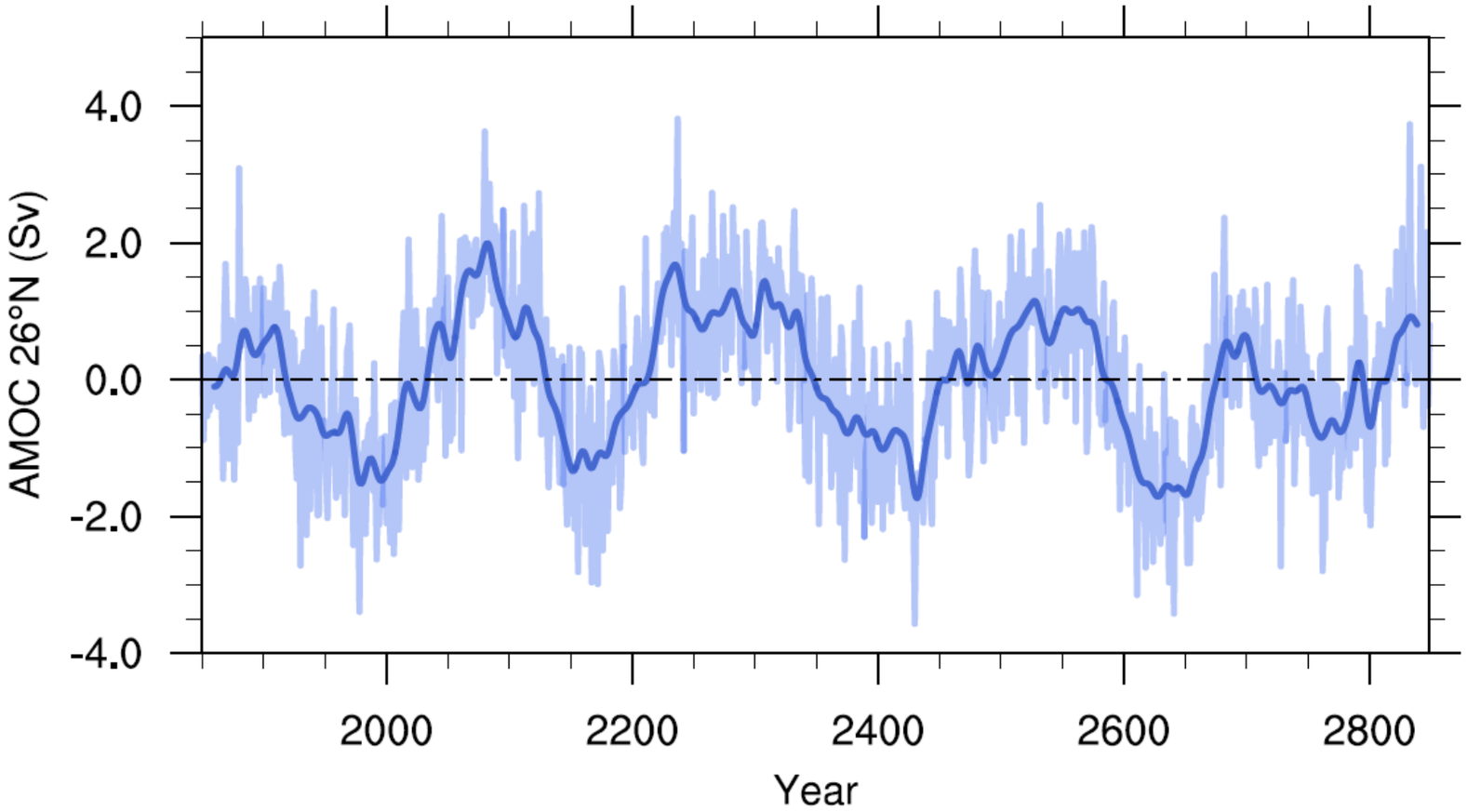
- Performed with IPSL-CM6A-LR, 32 historical simulations available over the 1850-2014 period and extended until 2059 using SSP2-4.5 + constant ozone (2014 climatology)
- Include all natural and anthropogenic external forcings
- Differ only by their initial conditions




Global near-Surface Air Temperature (GSAT) from the piControl simulation of IPSL-CM6A-LR (black) and from the several historical simulations of the IPSL ensemble (colors)

# Low-frequency internal variability in IPSL-CM6A-LR

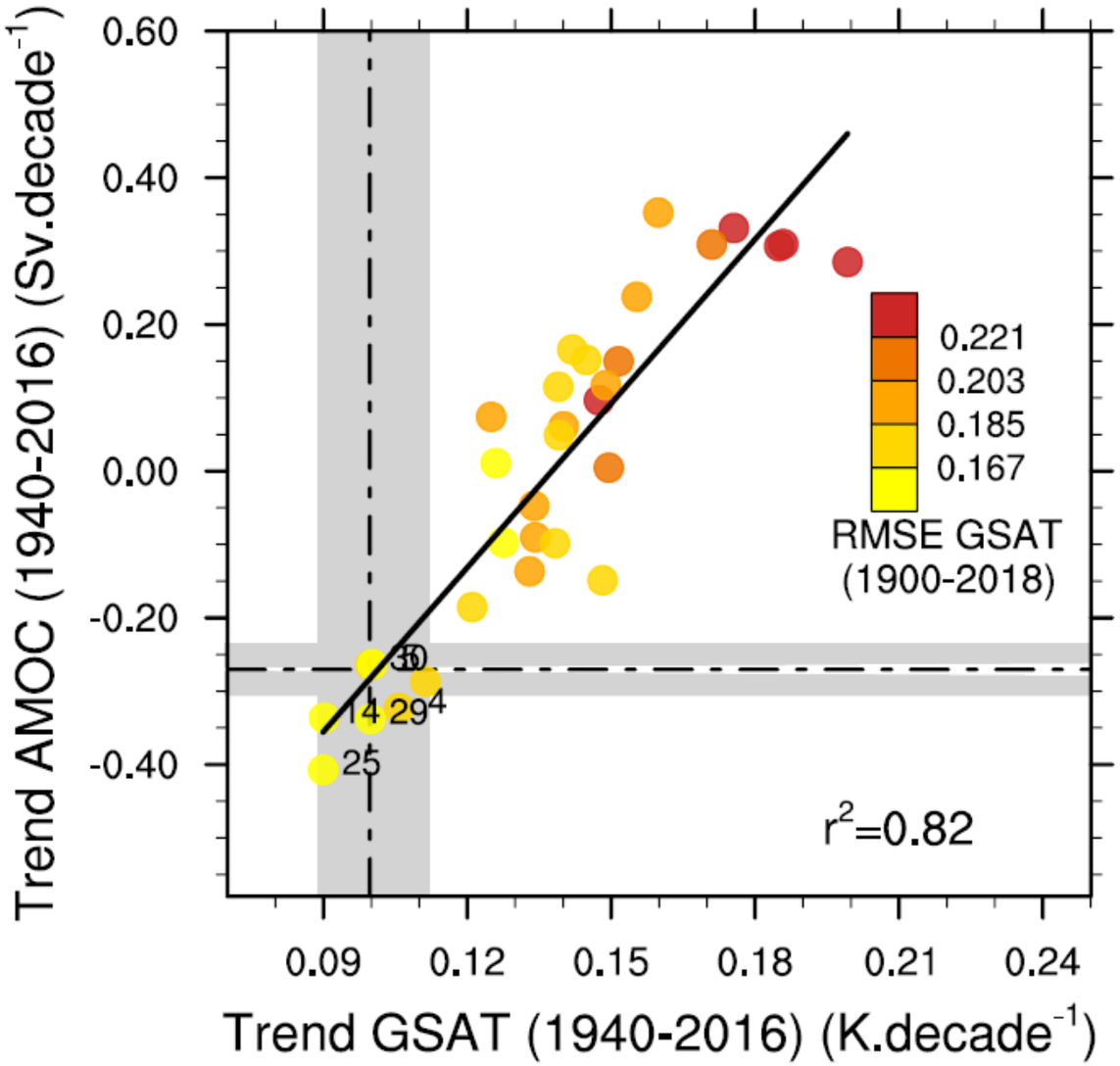
- Strong quasi-bicentennial variability of the Atlantic Meridional Overturning Circulation (AMOC) in the piControl simulation of IPSL-CM6A-LR (Jiang et al., 2021)




*AMOC at 26°N anomaly (Sv) relative to the whole period*

- A strong AMOC phase in IPSL-CM6A-LR is associated with a larger Arctic sea ice loss, a warmer North Atlantic Ocean, and a warmer Northern Hemisphere

# Relationship between GSAT and AMOC trends

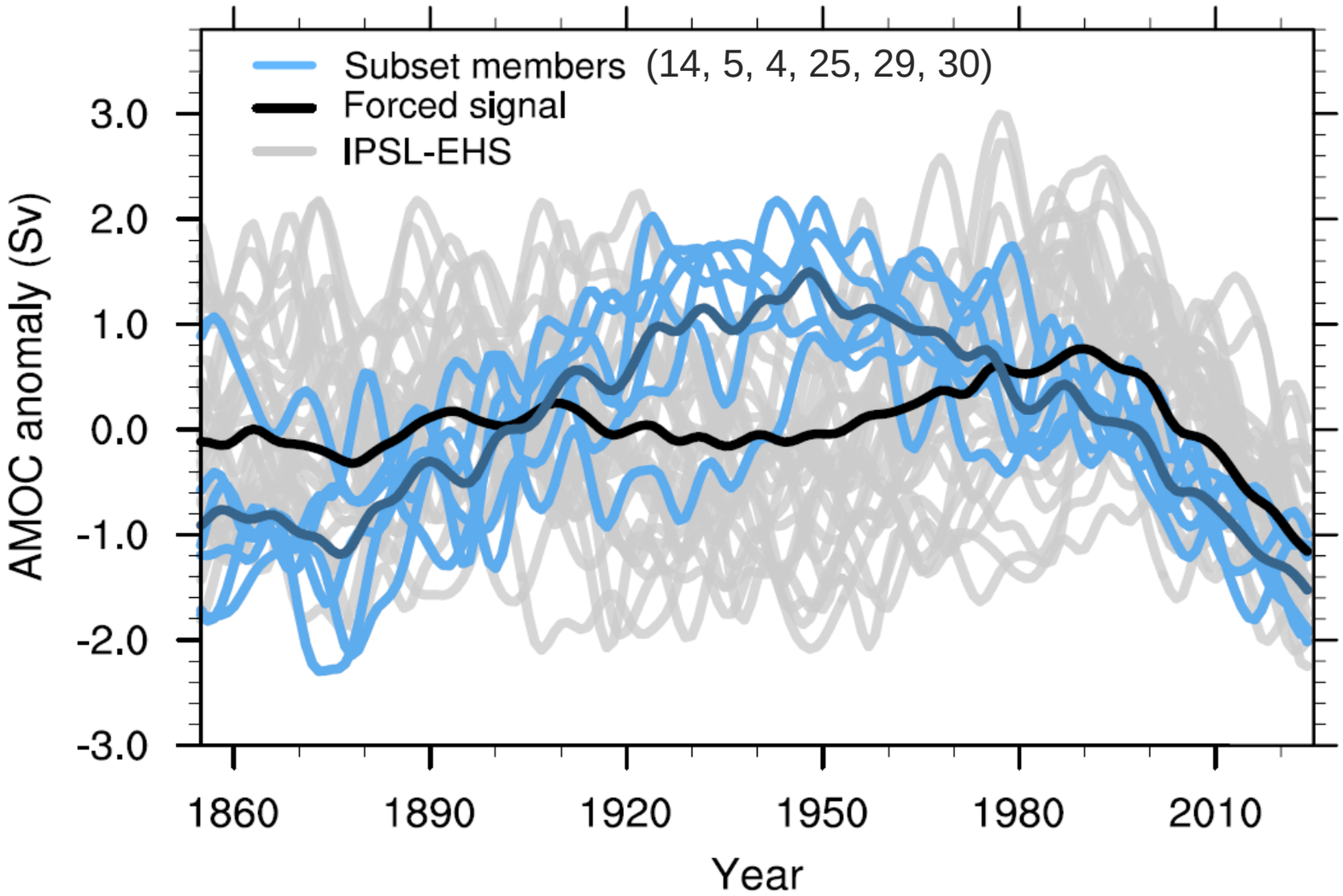



- Significant positive relationship between AMOC and GSAT trends (Student t-test, *p*-value<0.1)
- Members with the weakest GSAT warming → strongest AMOC weakening and conversely
- Members with the best match to the observations (warming + RMSE) → AMOC weakening → consistent with a recent AMOC reconstruction from Caesar et al., (2018)

**Observations: - GSAT (Cowtan and Way, 2014)**
**Observations: - AMOC reconstruction (Caesar et al., 2018)**
● **Historical simulations from the IPSL ensemble**

# AMOC evolution of the subset of members

*Low-pass filtered AMOC strength anomaly (1850-2018)*




- Important role of internal variability in these variations
- The AMOC weakening suggested by a recent AMOC reconstruction might be internally-driven

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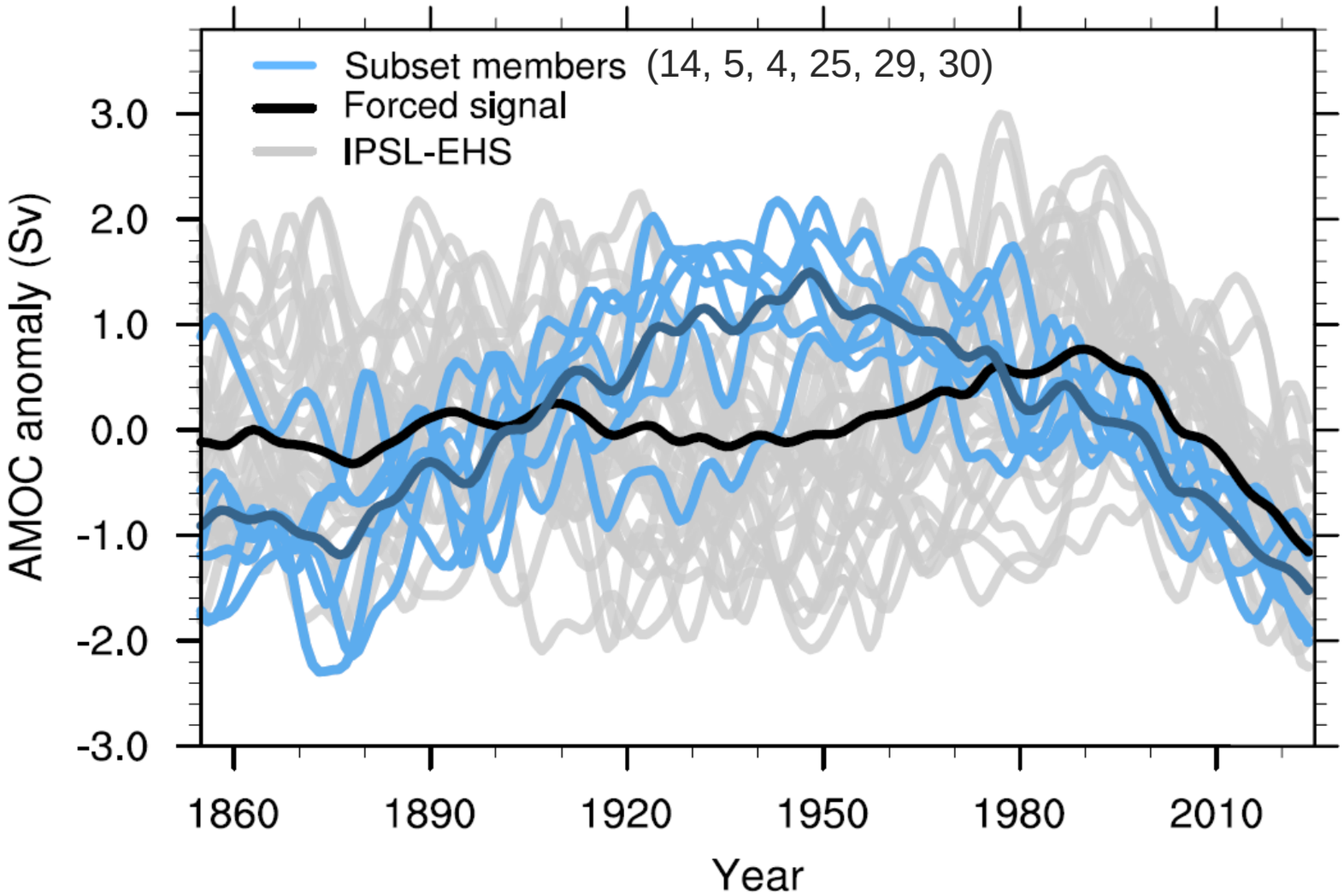



- Important role of internal variability in these variations
- The AMOC weakening suggested by a recent AMOC reconstruction might be internally-driven

→ Hypothesis: this AMOC weakening may have damped a part of the anthropogenic warming in the real world since the middle of the 20th century

# Lines of evidence from AMOC fingerprints

→ Use of 4 observable AMOC fingerprints:

1. Sea Surface Temperature (SST) over the North Atlantic Subpolar Gyre (Caesar et al. 2018)

2. Atlantic Multidecadal Variability (AMV) → Basin-wide low-frequency internal climate variations in the North Atlantic SST (Cassou et al. 2018)

3. Ocean heat content (OHC) index based on the difference between the Newfoundland and the North Atlantic Subpolar Gyre regions (Zhang, 2008)

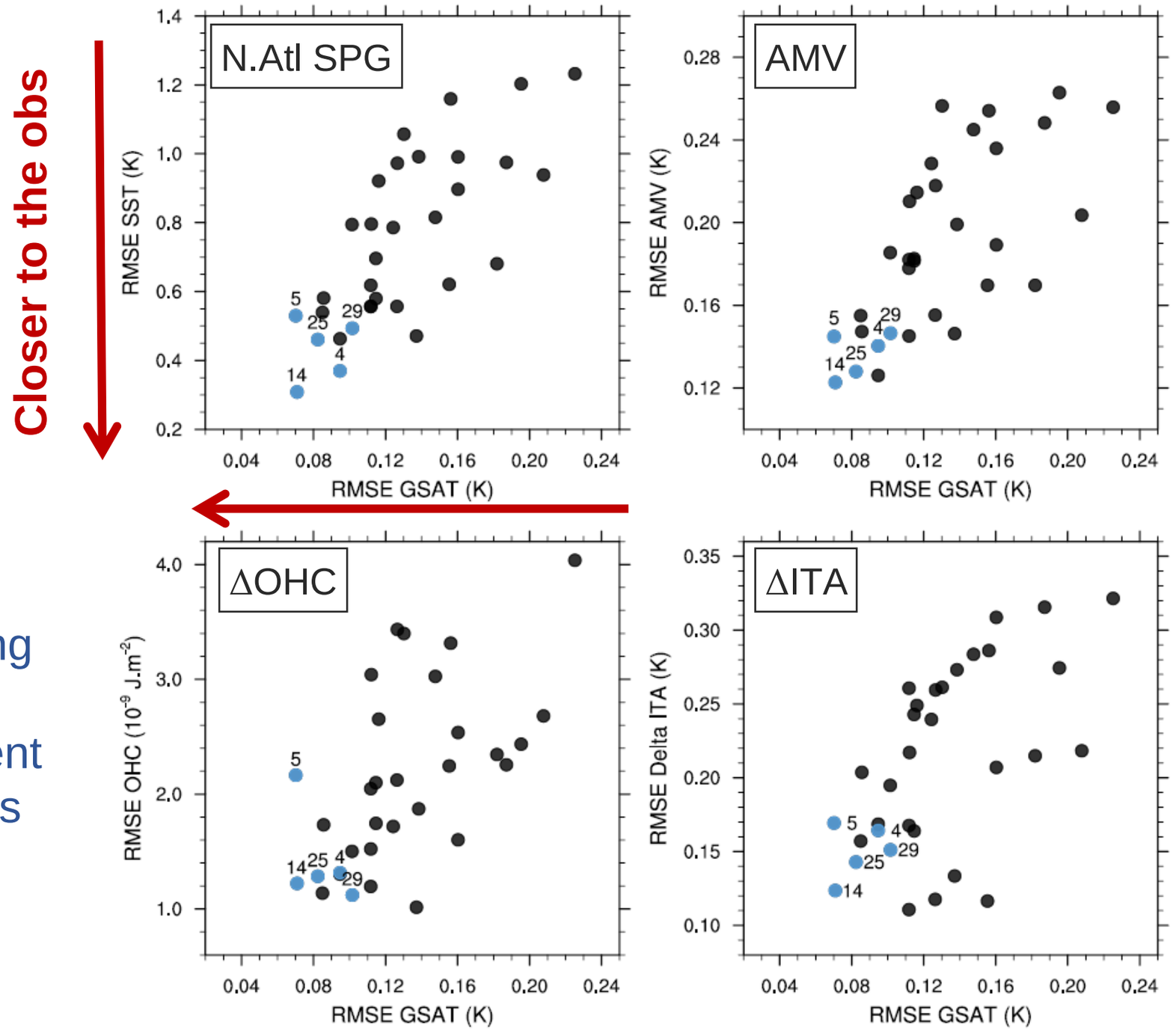
4. Difference in mean surface temperature between the Northern and the Southern hemisphere (Marshall et al. 2014)

# Lines of evidence from AMOC fingerprints

*Root mean square error (RMSE) of the four AMOC fingerprints and the GSAT, calculated over the 1900-2018 period*

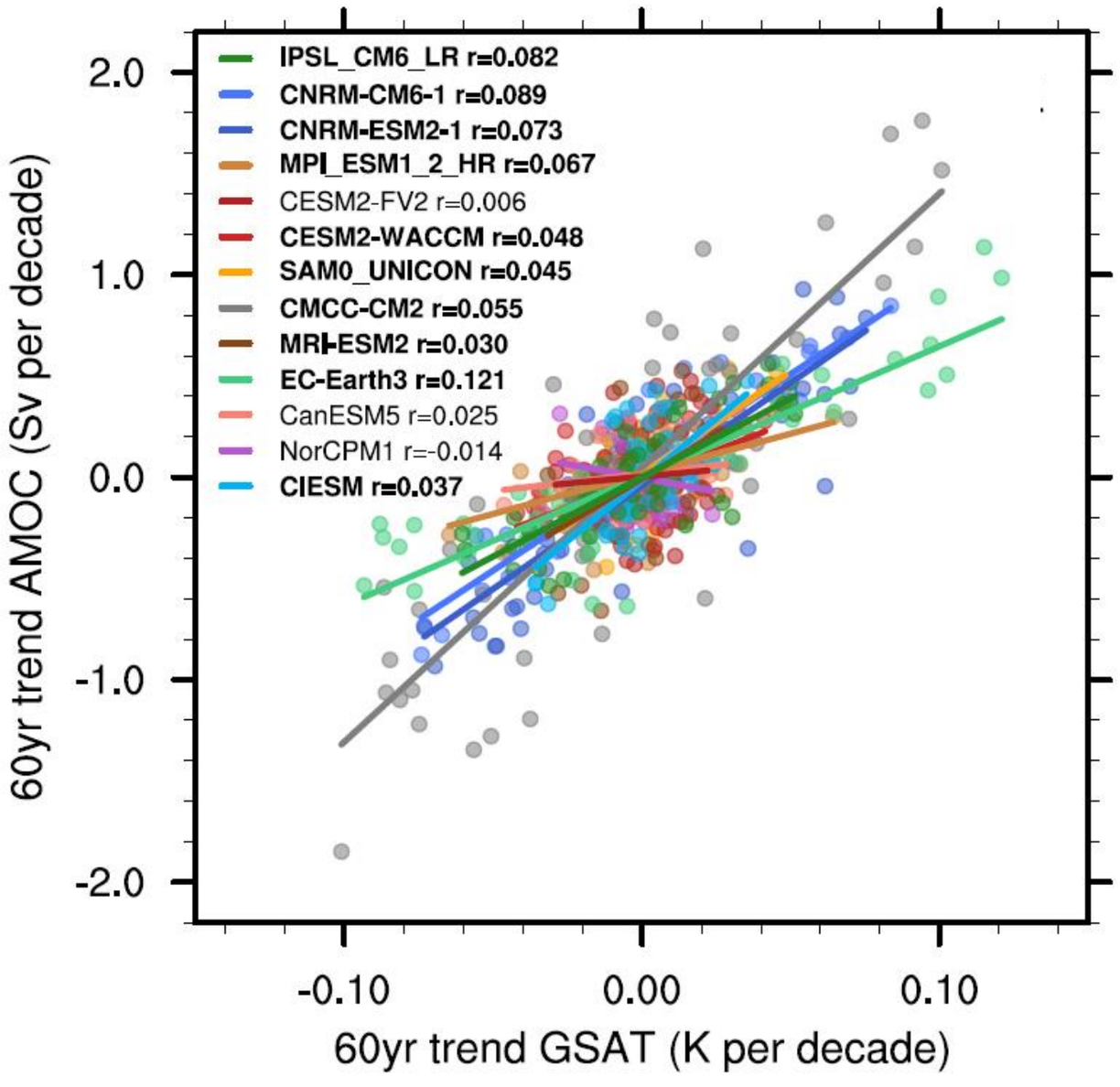
- Subset of members
- IPSL ensemble

- Subset of members = among the members with the best representation of the different observed AMOC fingerprints in comparison to the rest of the ensemble



# Does this relationship hold with other climate models ?

*Relationship between GSAT and AMOC 60-yr trends in CMIP6 pre-industrial control simulations*

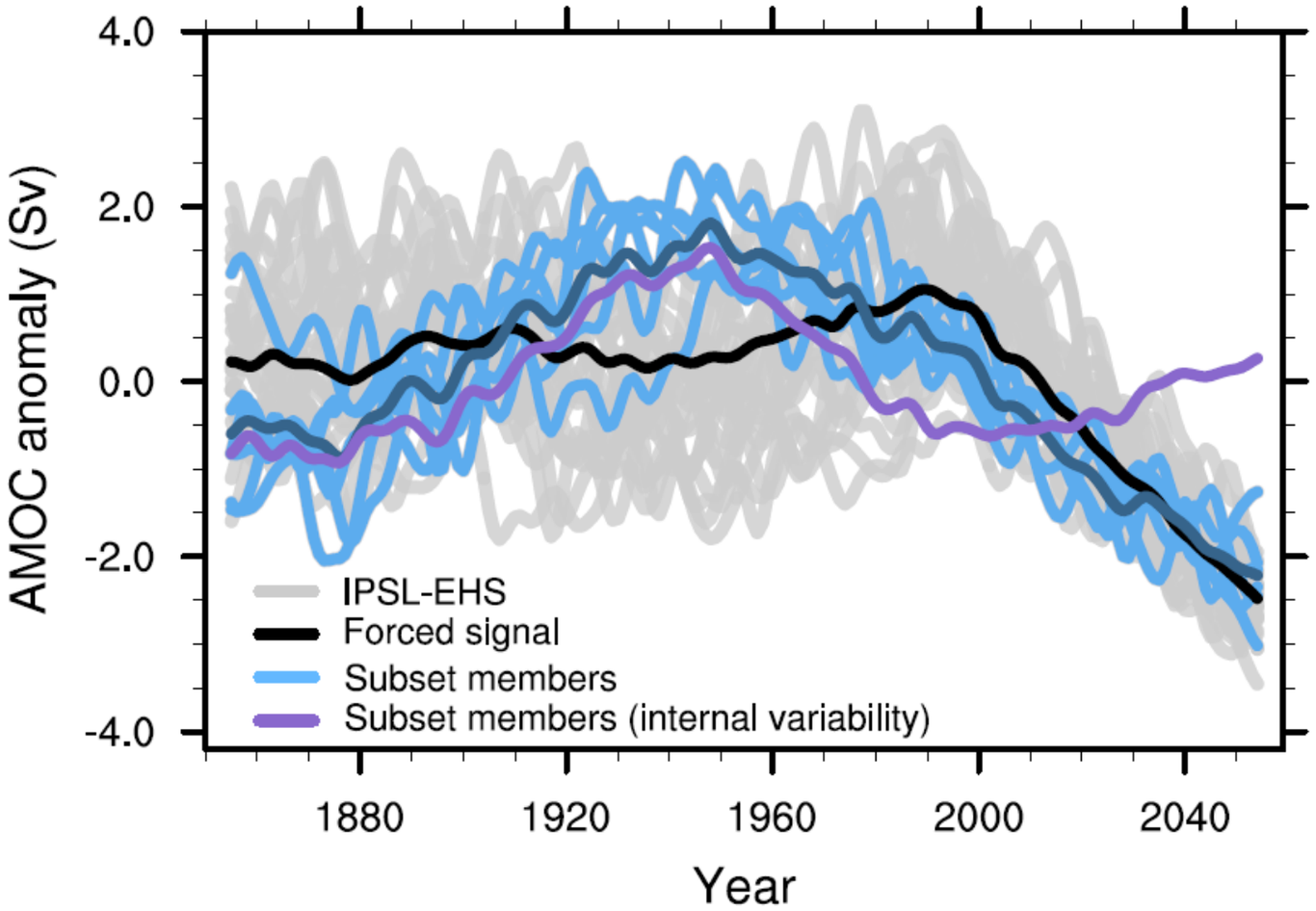


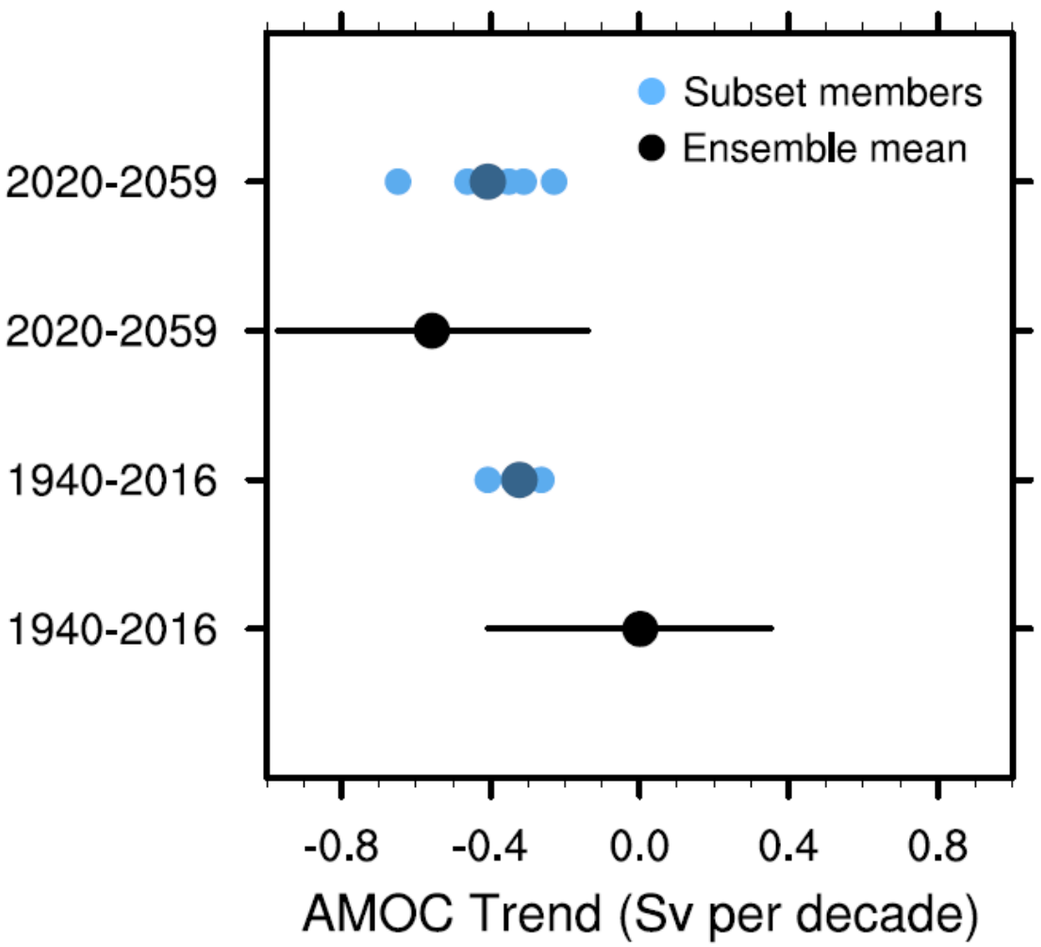

- Significant positive relationship between AMOC and the GSAT 60-year trends is found in the *piControl* simulation for 10 out of 13 other CMIP6 models analyzed

- This relationship between the AMOC and GSAT trends found in IPSL-CM6A-LR is rather widespread in CMIP6 models albeit with varying strength and range

Bold → regression significant with p-value<0.1 (Ebizusaki, 1997)

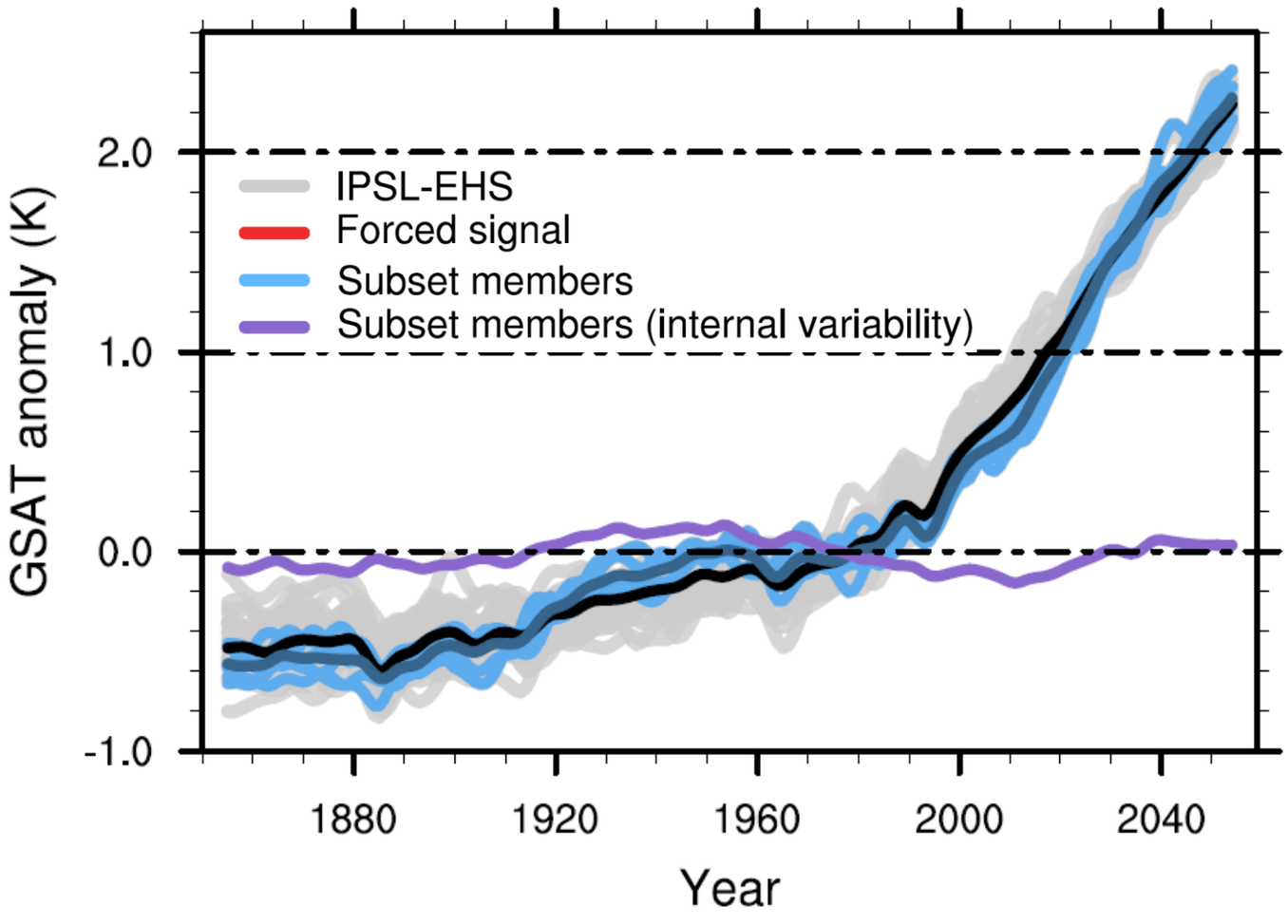
# Implication over the next decades for the AMOC

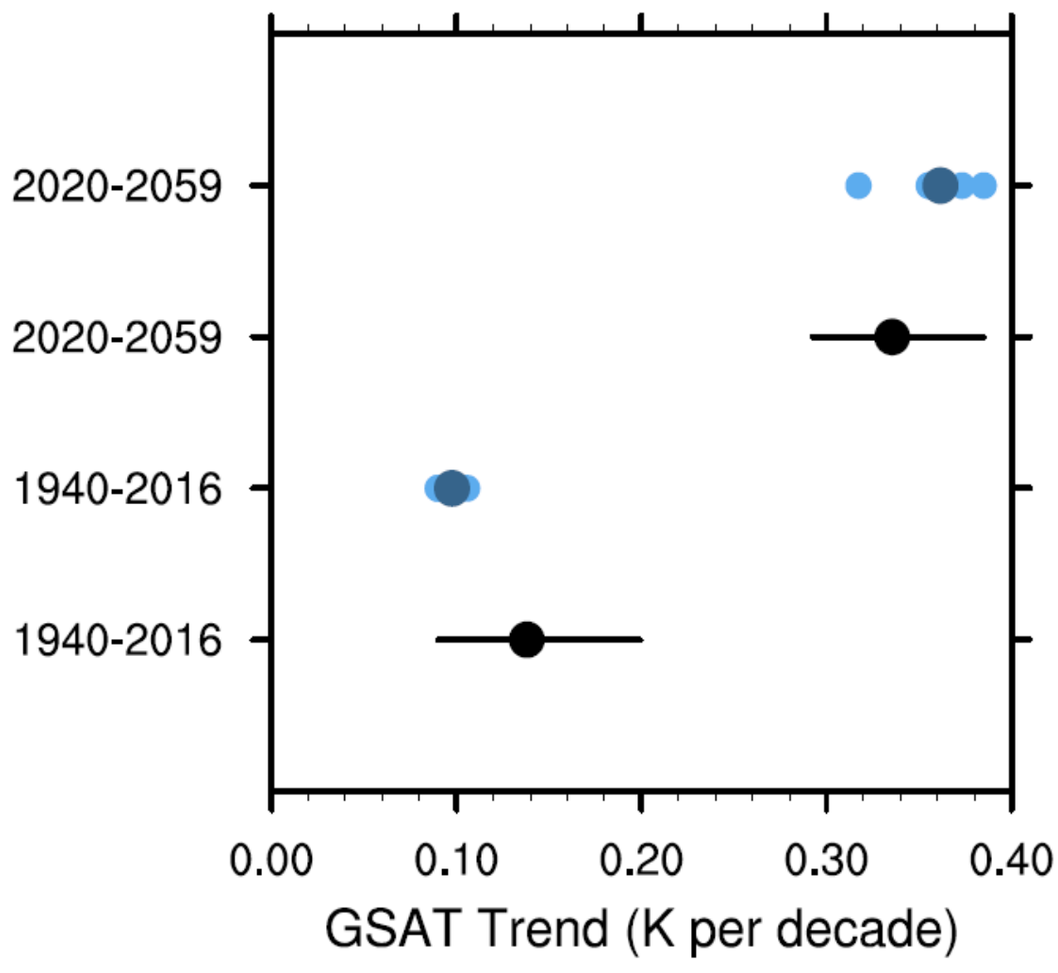



- Decrease of the AMOC internal variability since 2000s
- The subset of members experiences an internally-generated AMOC strengthening over the next few decades → limit the AMOC weakening induced by the external forcing

# Implication over the next decades for the GSAT




- Larger warming rate of about 0.37 K per decade relative to the IPSL ensemble mean of 0.34 K per decade over the next decades (2020-2059)
- Decrease of the GSAT internal variability over the next decades

# Conclusions and perspectives

- Our results suggest that a weakening of the AMOC since the mid-20th century, consistent with a recent reconstruction (Caesar et al., 2018), may have masked a fraction of the anthropogenic global warming.

- If true, this might mean that transient climate sensitivity estimated from the observational records, especially over the last 6-7 decades may be underestimated.

- The larger warming rate of the subset of members reinforces the risk of crossing the 2°C warming in the coming decades.

- The realism of this multi-centennial low-frequency internal variability found in some of the CMIP6 models is a crucial element of our results → Future studies to evaluate this realism, using PAGES2K database and last millennium simulations from CMIP6, would be of great interest

More details: Bonnet et al., (2021), Nature Communication, “Increased risk of near term global warming due to a recent AMOC weakening”