Fingerprints of the Forced Responses to Anthropogenic Aerosols in the Ocean

Jia-Rui Shi

- SST responses (Jia-Rui Shi, Young-Oh Kwon, Susan Wijffels, 2022)
- OHC responses (J.-R. Shi, S. Wijffels, Y.-O. Kwon, Shang-Ping Xie, in revision)

2023 CESM Workshop

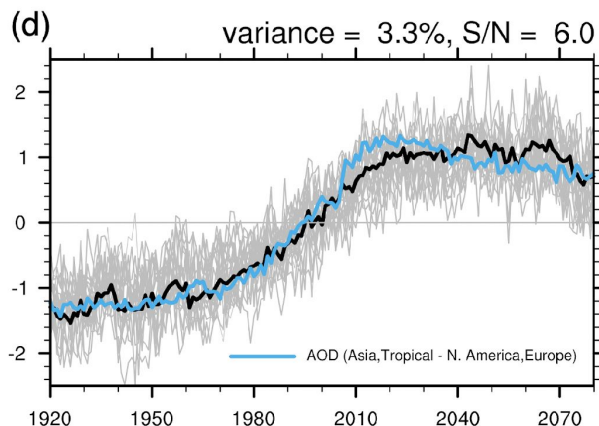# Forced SST Responses:

CESM1 Large Ensemble Simulations (1920-2080):

$$AER_i = (XAER_i - XAER_{em}) + (LENS_{em} - XAER_{em})$$
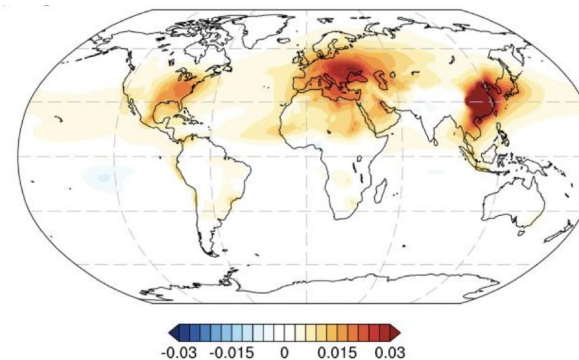
Signal-to-noise maximizing pattern analysis:
In this method, the extracted patterns are associated with the maximization of the **ratio of signal (e.g., variance of ensemble mean) to the total variance (from all ensemble members)** (Déqué 1988; Schneider & Griffies 1999; Ting et al. 2009; Wills et al. 2020).
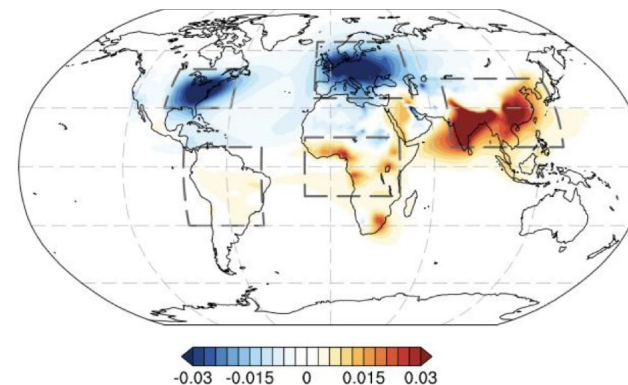
First Two Modes (Forced Patterns)
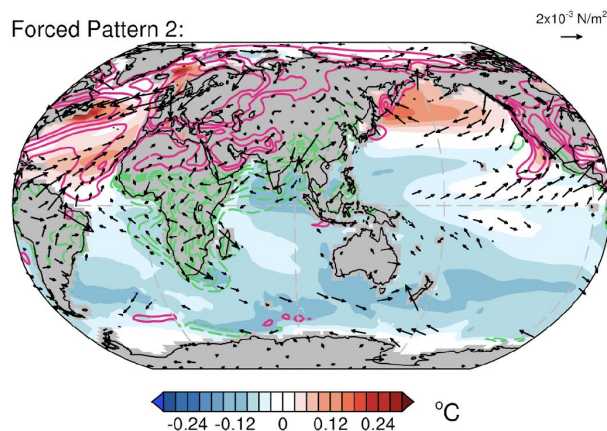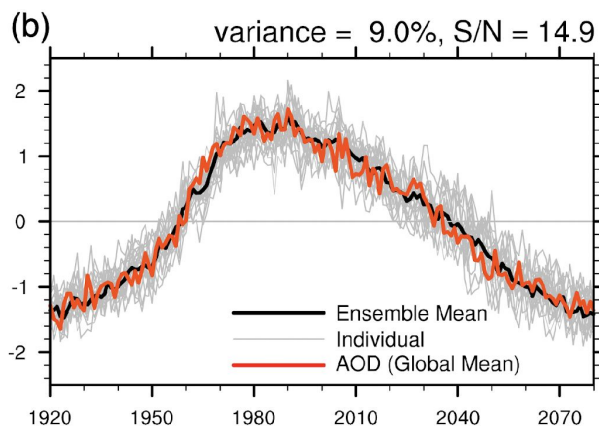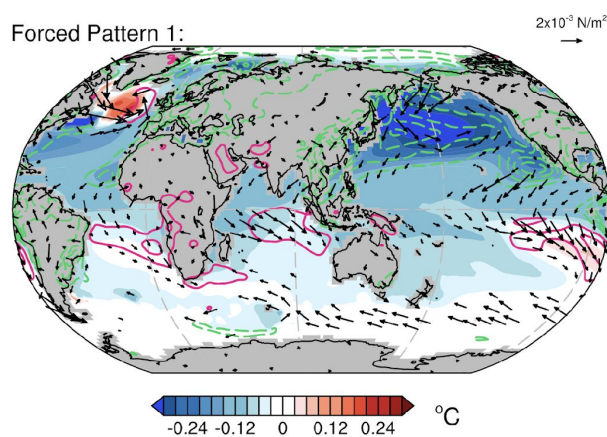
Regressions of AOD

First FP: Global (NH) Mean Effect

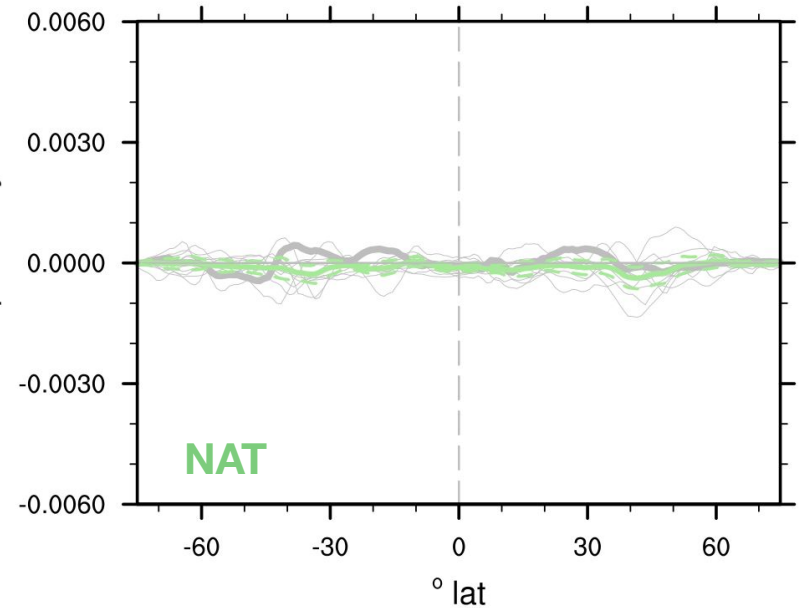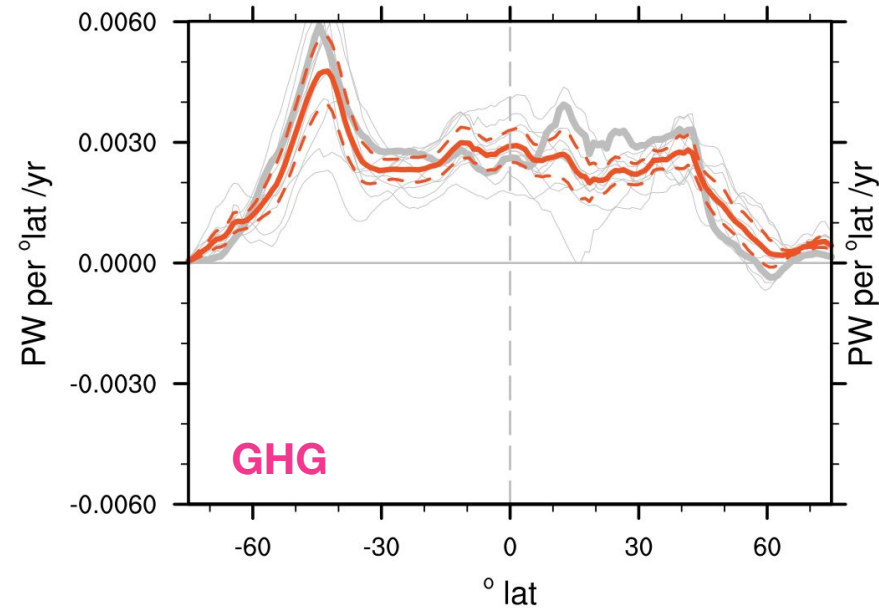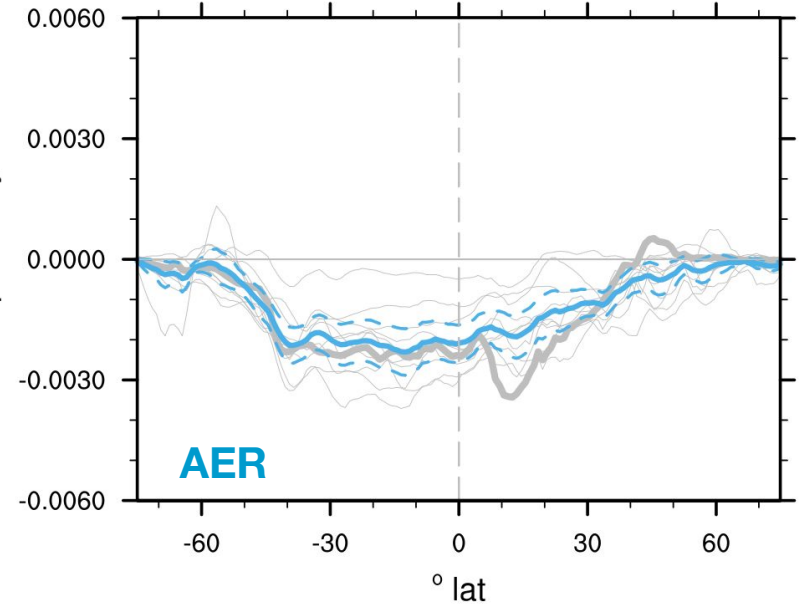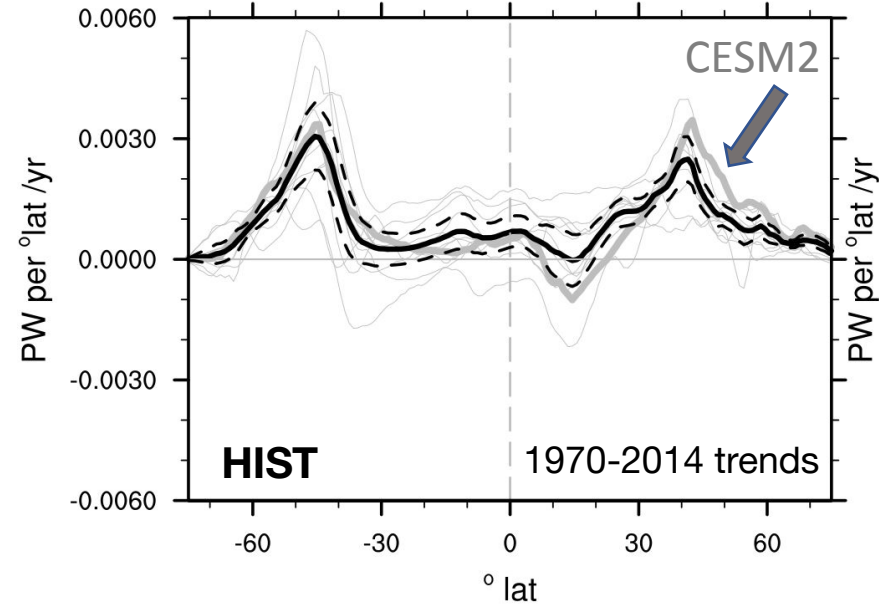Second FP: Aerosol Transition Effect

Forced Ocean Heat Content (OHC) Responses:

Whether, where, and when do anthropogenic aerosol-driven signals appear in OHC in reality or all-forcing runs?

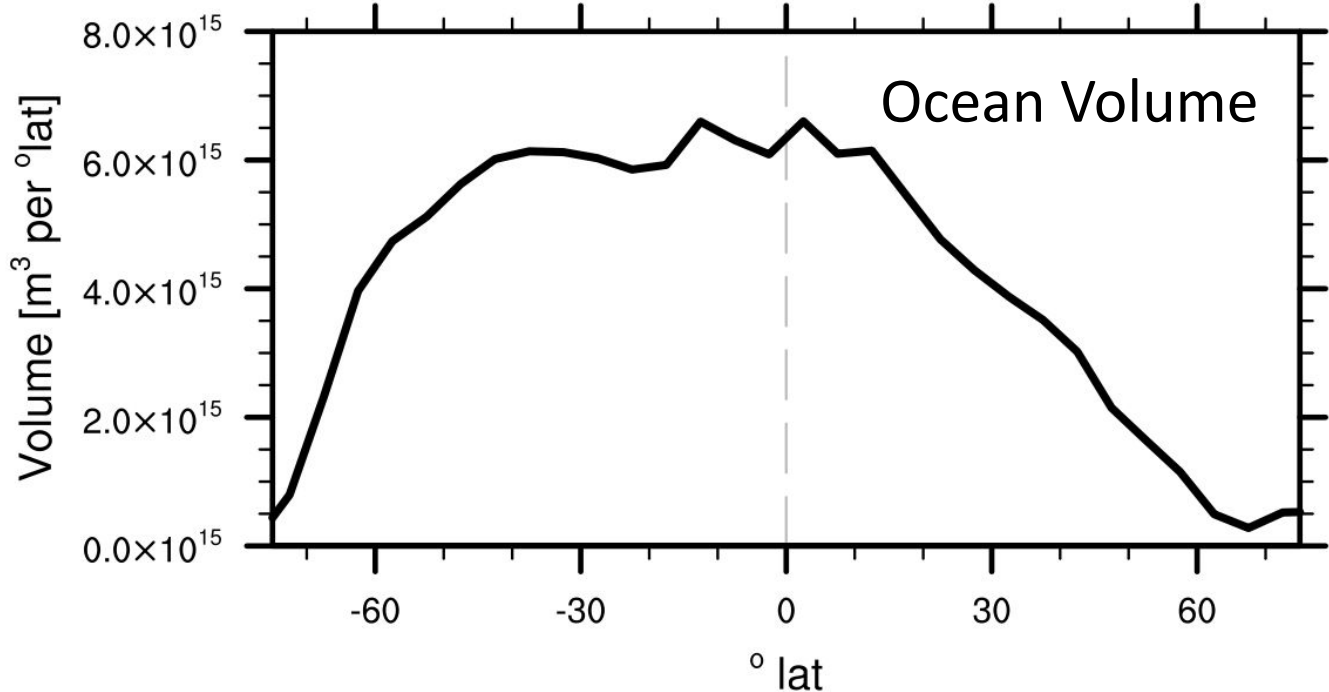CMIP6 historical all-forcing (HIST) and single-forcing runs (AER, GHG, NAT) from 11 models.

Each model has more than 1 realization. Totally, +50 realizations are used.

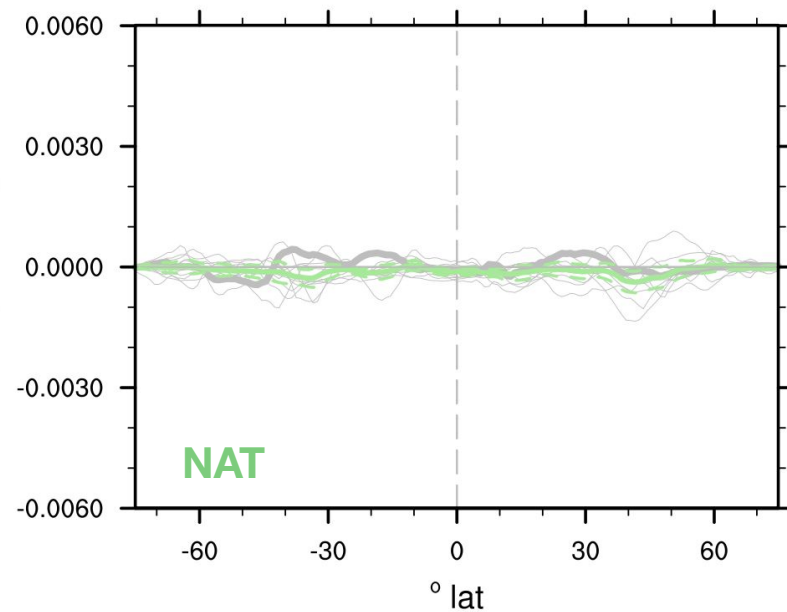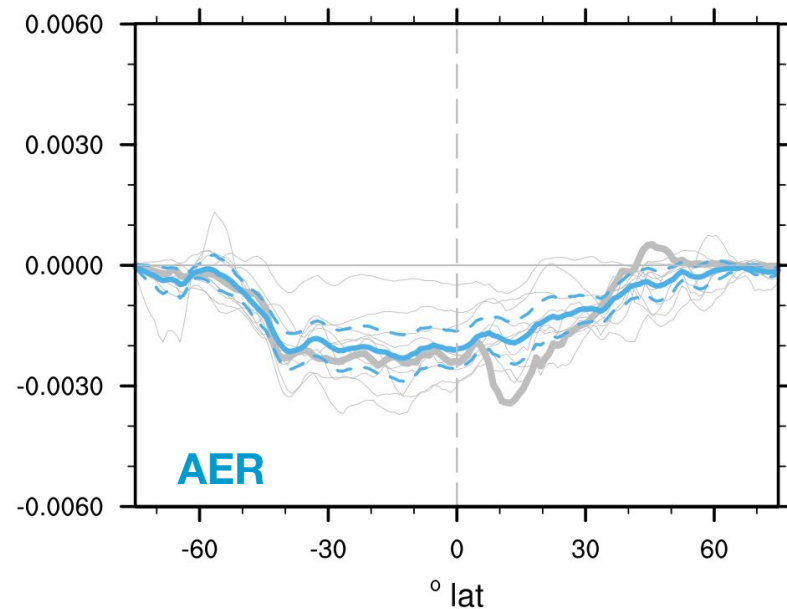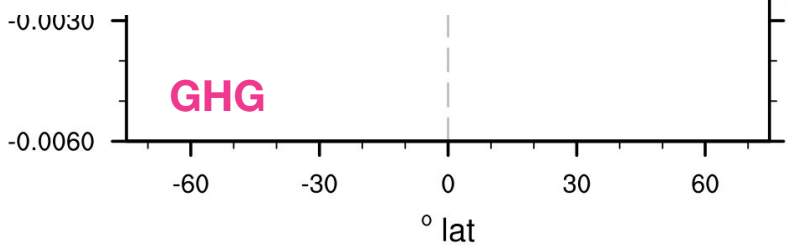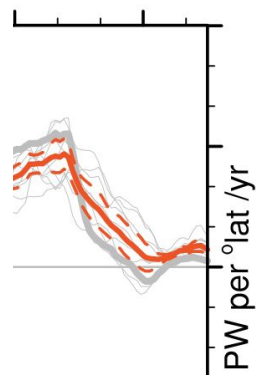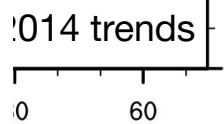The OHC drift from piControl is subtracted from the forced simulations.
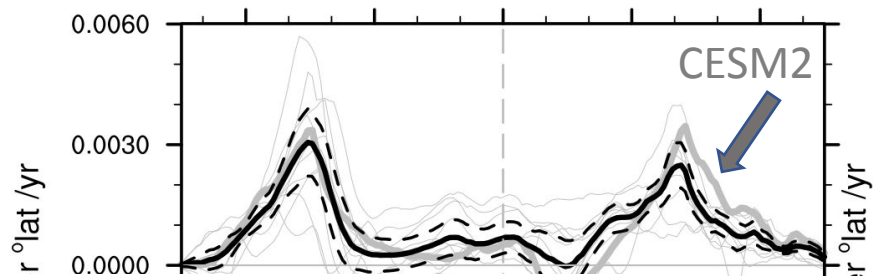
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Forced OHC Responses:

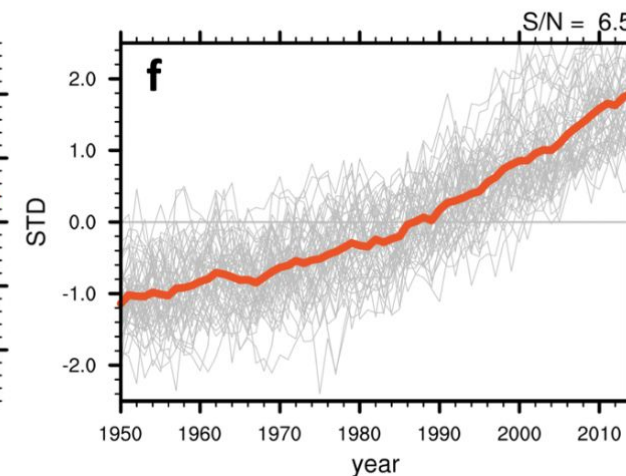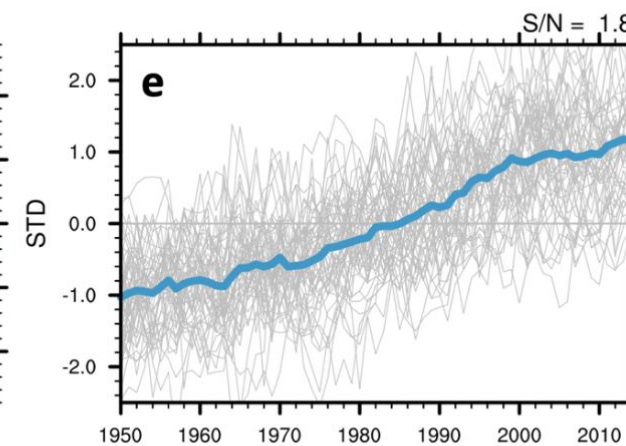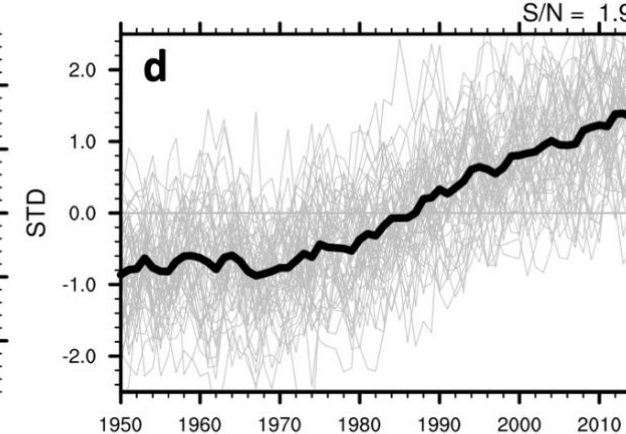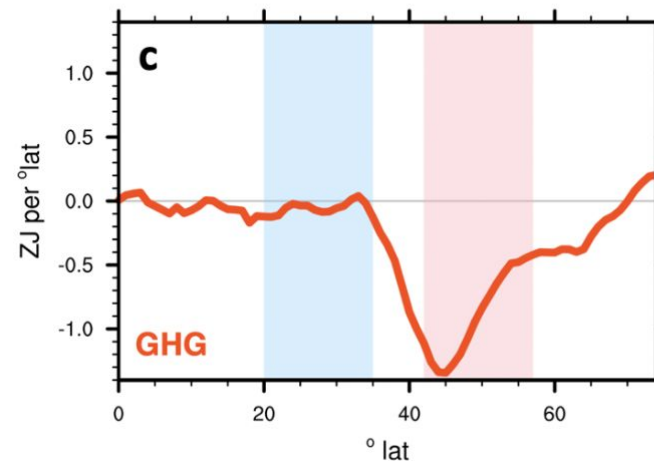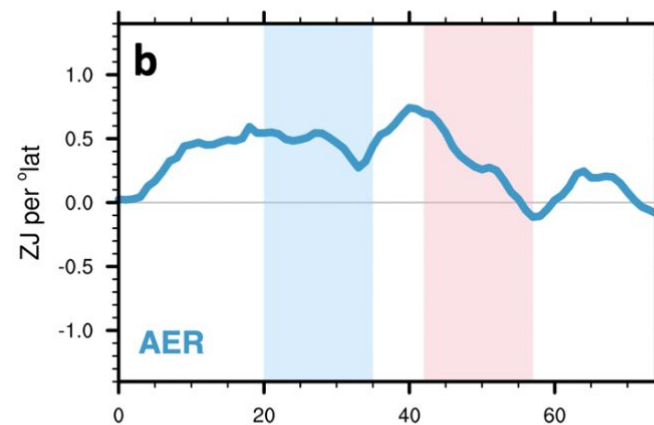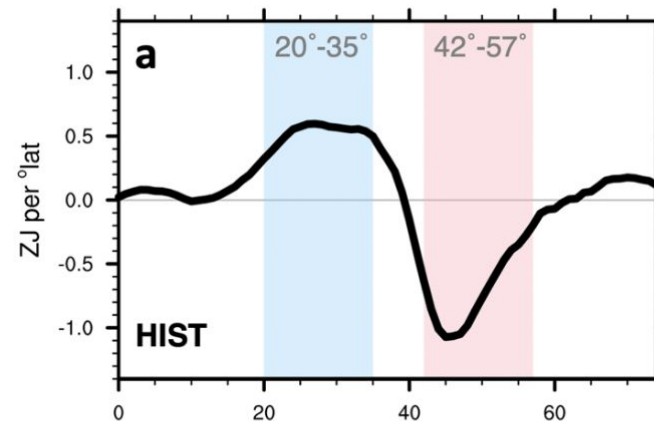**"minus" computation** is useful to extract aerosol forced signal.

(NH - SH) Interhemispheric asymmetry is widely used.

Retaining one more dimension (latitudes) opens up a clear response distinction for the two major climate forcings.

$$\text{OHC}\big|_S^N(y) = \frac{\partial}{\partial t}\big(OHC(y = 0° \sim 90°N) - OHC(y = 0° \sim 90°S)\big)$$

Forced OHC|y and corresponding time series

Forced OHC Responses:

Aerosol-induced responses are sensitive to the analyzed period (Deser et al. 2020).

Temporal information is utilized below.

20°-35° lat OHC trend

Unhatched are significant:

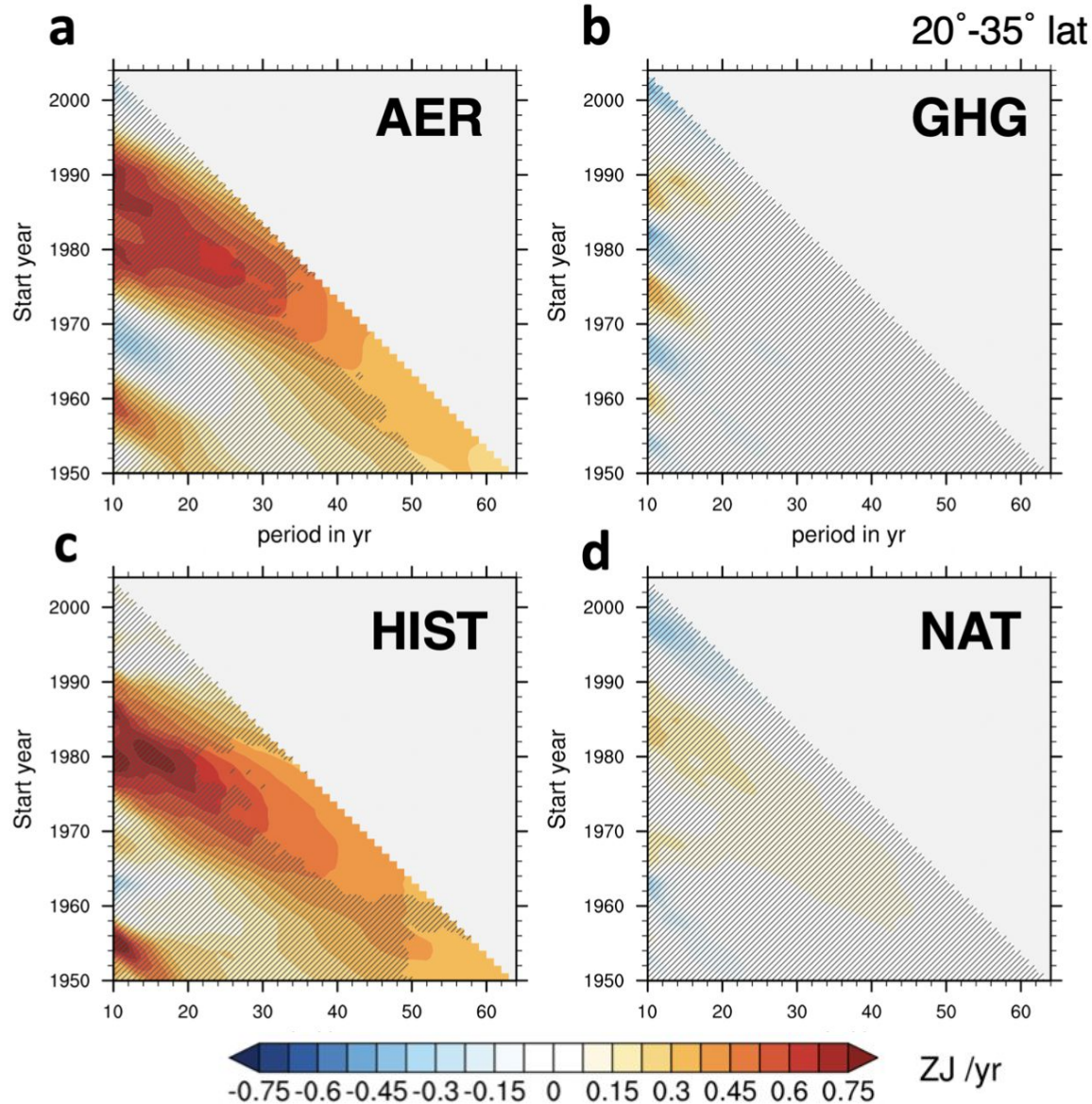>90% of individual simulations' trends are the same sign as the trend of the MMM.

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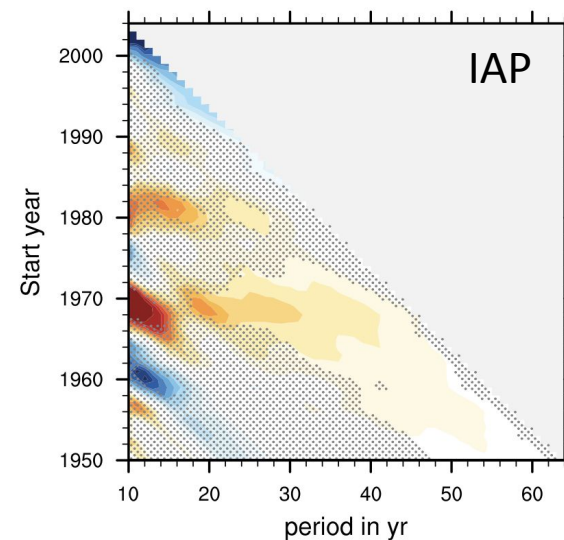
20°-35° lat OHC trend →

Observations

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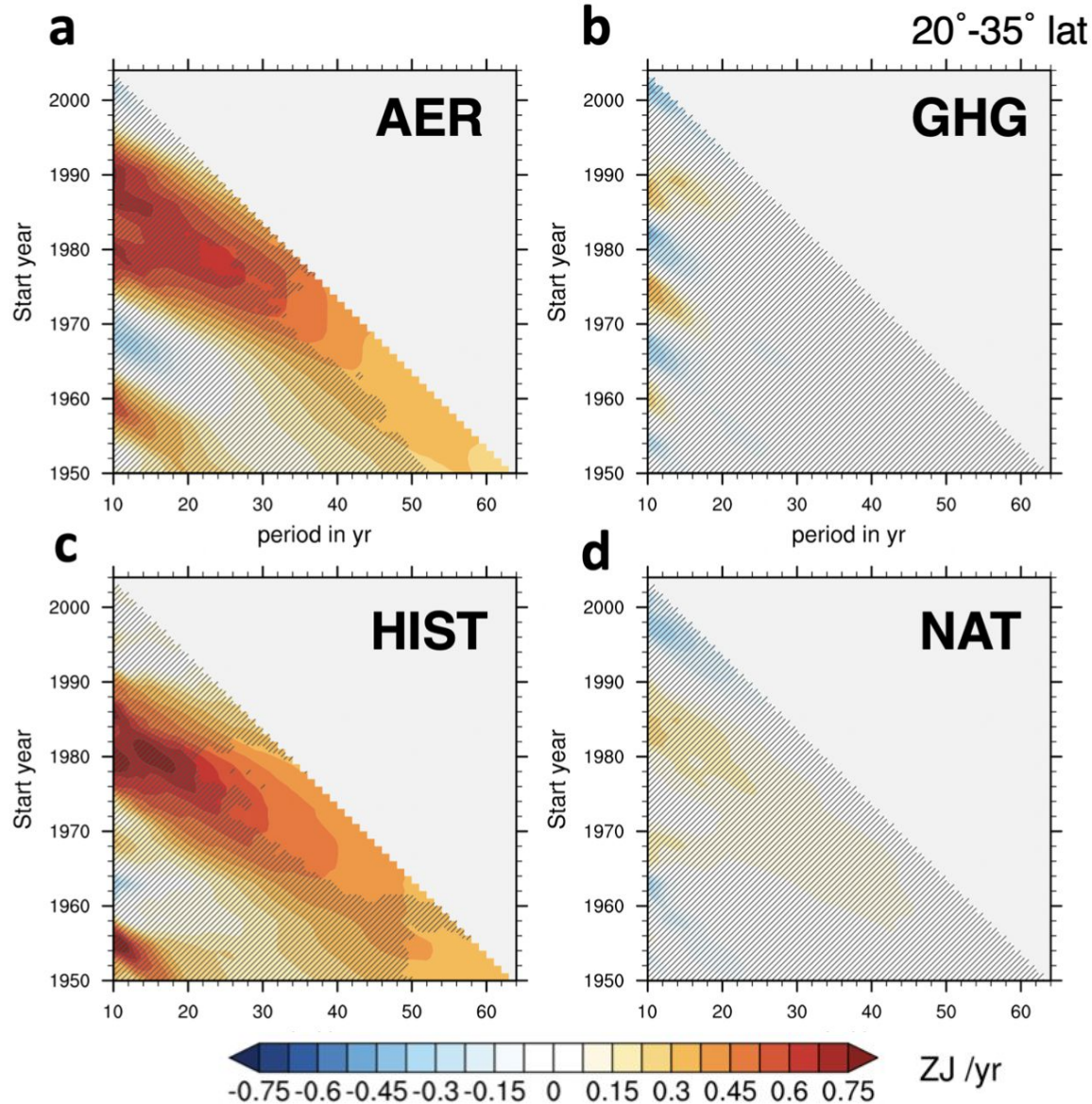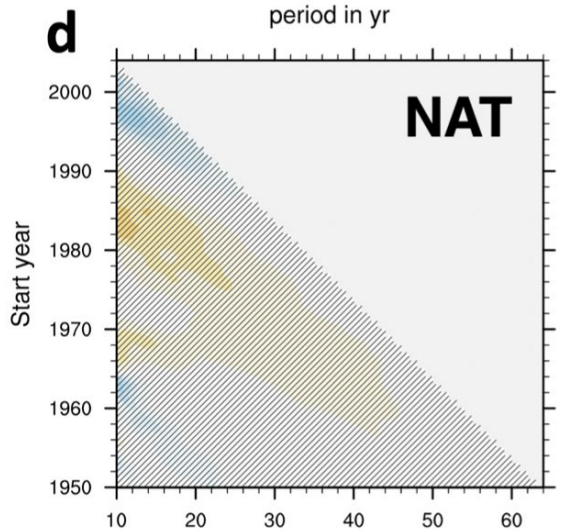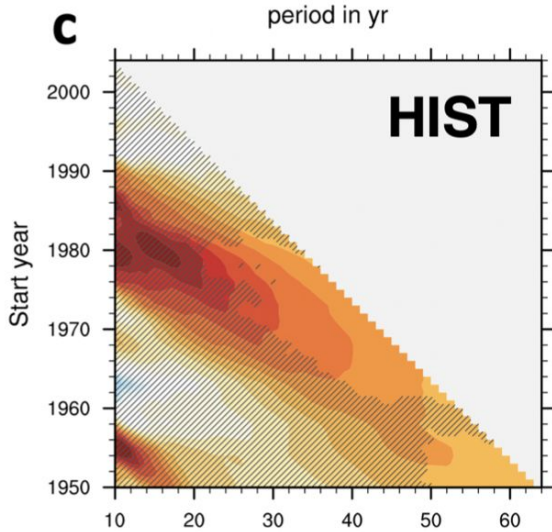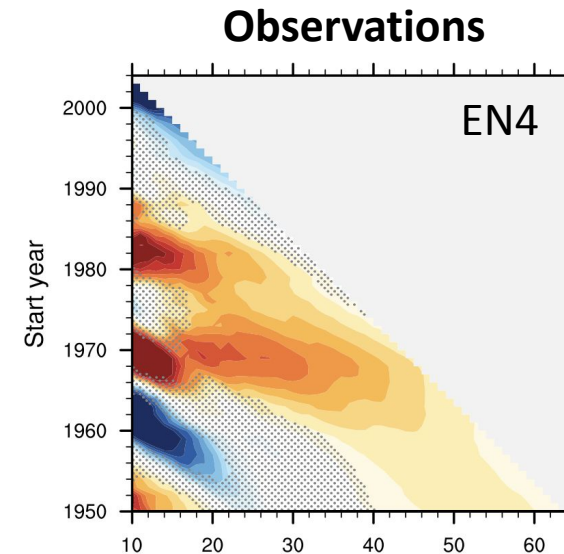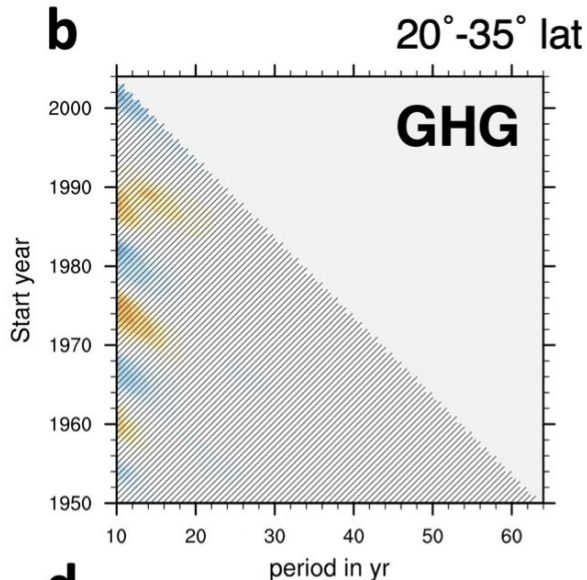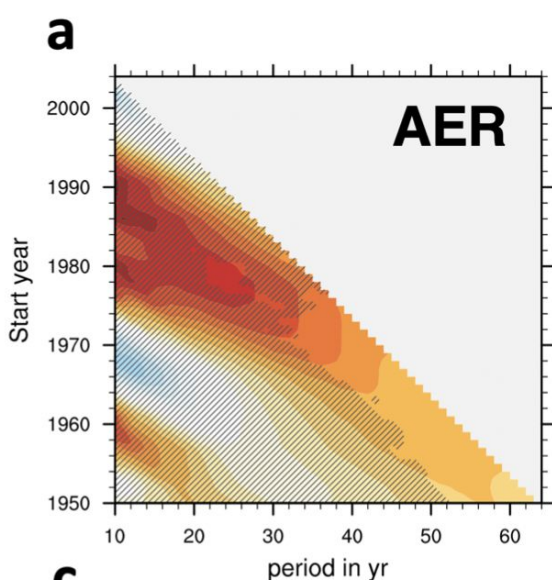**Temporal information is utilized below.**

**20°-35° lat
OHC trend** →

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Summary:

- AA-induced OHC fingerprint is detectable during the historical period, and the inclusion of temporal and spatial information is essential.

- The choice of the period is an important factor in obtaining a significant trend.

- The OHC responses would also be helpful in understanding the aerosol climate effect in the future.