Understanding the recent changes in summer atmospheric circulation on the Northern Hemisphere: the roles of external forcing and sea surface temperature variability.

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1. Uneven Warming During Summer:

Z200 GPH shows a **wave-5 like pattern**, where the regions of **strongest GPH increases match the regions with strongest summer warming**. (H. Teng, et al., 2022)

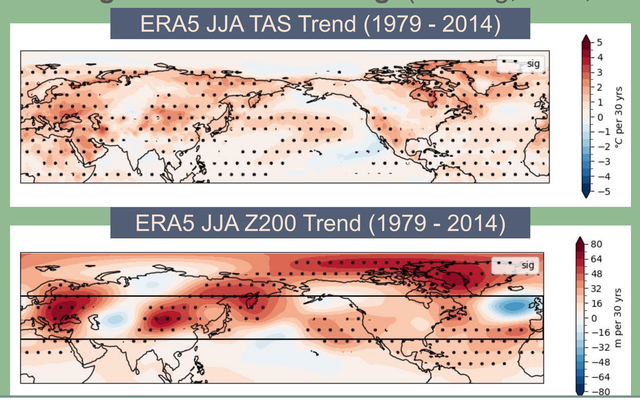


Figure 1: ERA5 TAS and Z200 GPH JJA trends (1979 - 2014).

This work studies the role that different **external forcings** and **SST variability** have in driving the observed and currently not understood changes in atmospheric circulation.

2. Methods

Datasets:

LESFMIP ensemble (Smith et al., 2022):
- Fully coupled
- Prescribed **isolated** forcings

At least 10 runs per model

AMIP6 ensemble (Eyring et al., 2016):
- Atmosphere only
- **Prescribed SSTs** and forcings.

At least 3 runs per model

Filter internal variability

Processing

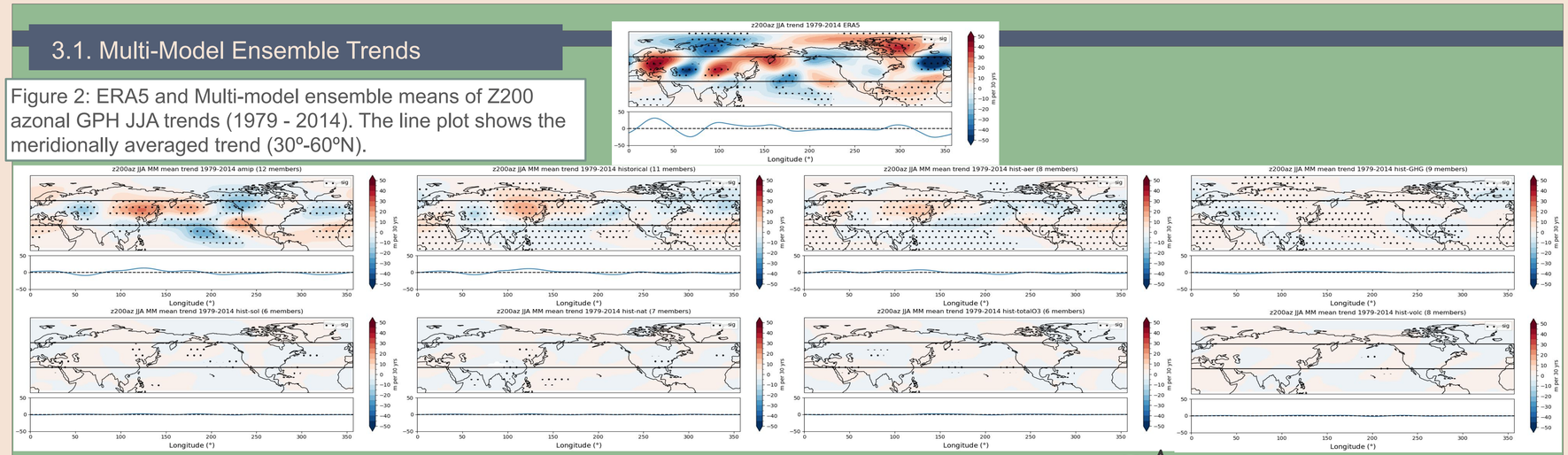
Trends in summer (JJA) of azonal component of Z200 (Done to remove imprint of general thermal expansion of atmosphere and offset model bias) of:
- Each **individual** run
- Each **model** mean
- Each **multi-model** mean

Compared spatial patterns to ERA5 reanalysis using **Pearson Pattern Correlation** on mid-latitudes (30-60ºN).

3. Model Response:

3.1. Multi-Model Ensemble Trends

Figure 2: ERA5 and Multi-model ensemble means of Z200 azonal GPH JJA trends (1979 - 2014). The line plot shows the meridionally averaged trend (30º-60ºN).



3.2. Multi-Model Ensemble Pattern Correlation

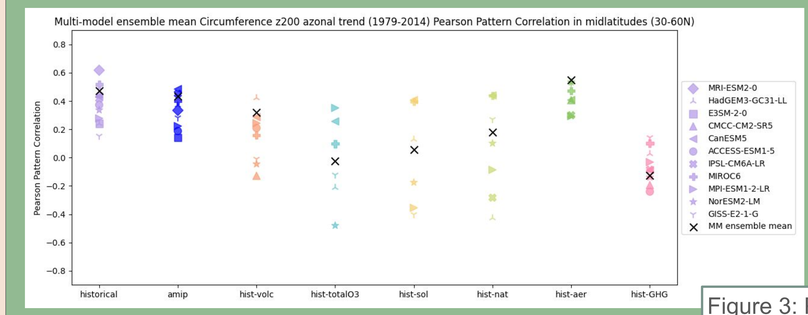


Figure 3: Pattern correlation of ensemble means to ERA5.

Models show **distinct** behaviours for each forcing.

AMIP6 simulations do not perform better than LESFMIP historical runs.

Aerosol forcings account for most of the pattern correlation shown by historical forcings.

Forcings play a role in modulating this atmospheric response.

Atmospheric trend may **not be driven by SST** variations.

Recent trends (at least partially) **driven by aerosol** forcings and GHG do not play a significant role.

3.3. Single Member Pattern Correlation

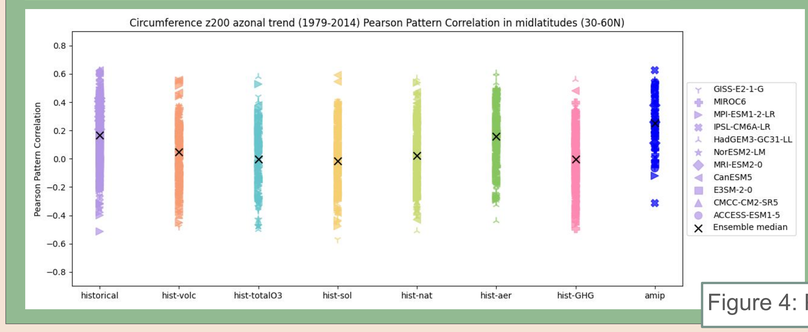


Figure 4: Pattern correlation of single runs to ERA5.

Very **large spread** in responses across individual ensemble members.

Large **spread in AMIP** runs.

Internal variability plays an important role in modulating the atmospheric trend.

Substantial internal variability based on our analysis cannot be linked to SST variations.

4. Main Takeaways

1. Response may be driven by **aerosol forcings**.
2. Internal variability likely modulates the trends.
3. We found **no link** between SST variations and Z200 trends.

References:

Teng, H., et al., 2022: J. Climate, 35, 3479–3494.
Smith DM, et al., 2022: Front. Clim. 4:955414.
Eyring, V., et al., 2016: Geosci. Model Dev., 9, 1937–1958.

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