Exploring the contributions of single atmospheric forcings on Antarctic sea ice trends using large ensembles

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Within the SH WG

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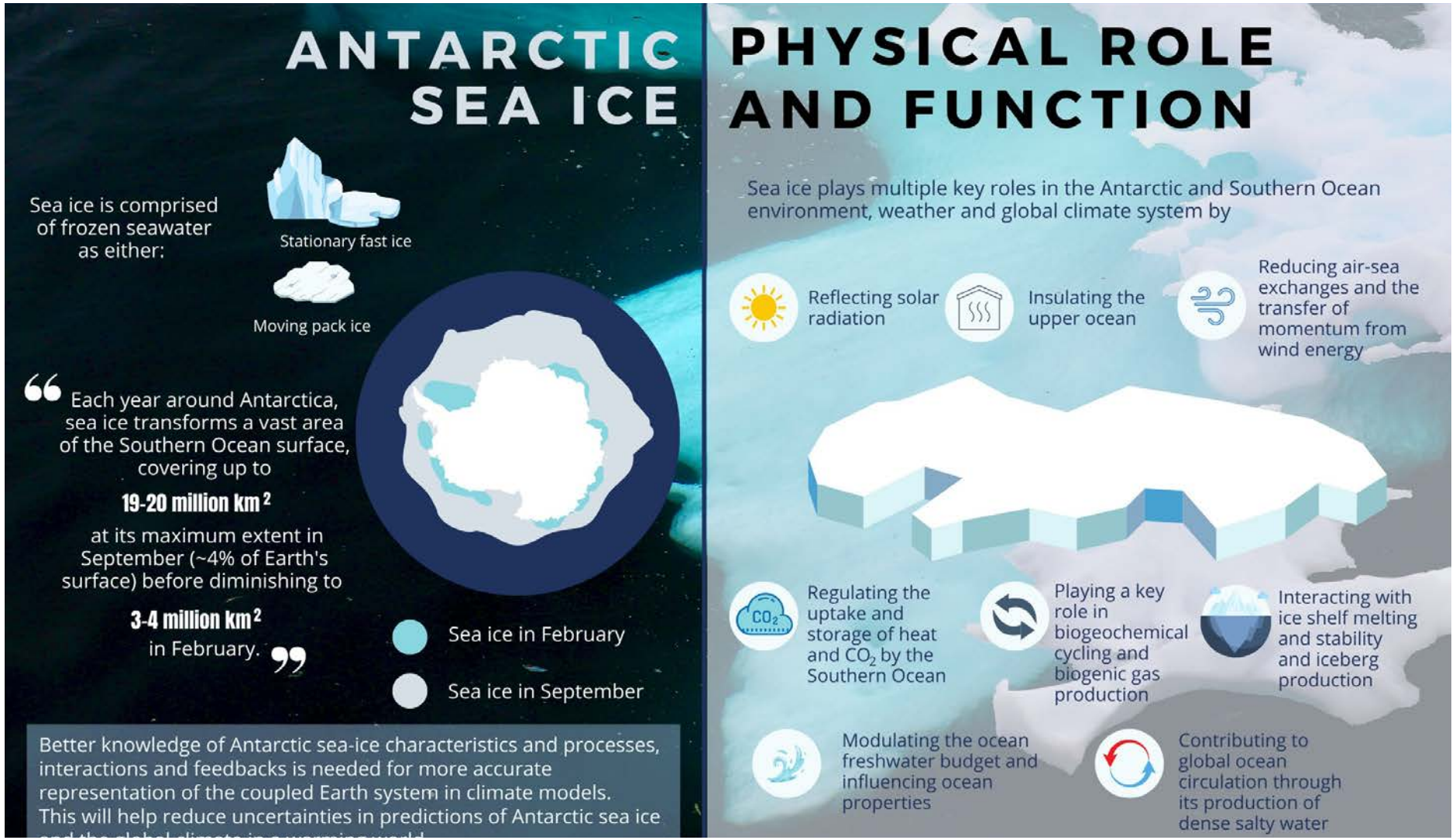
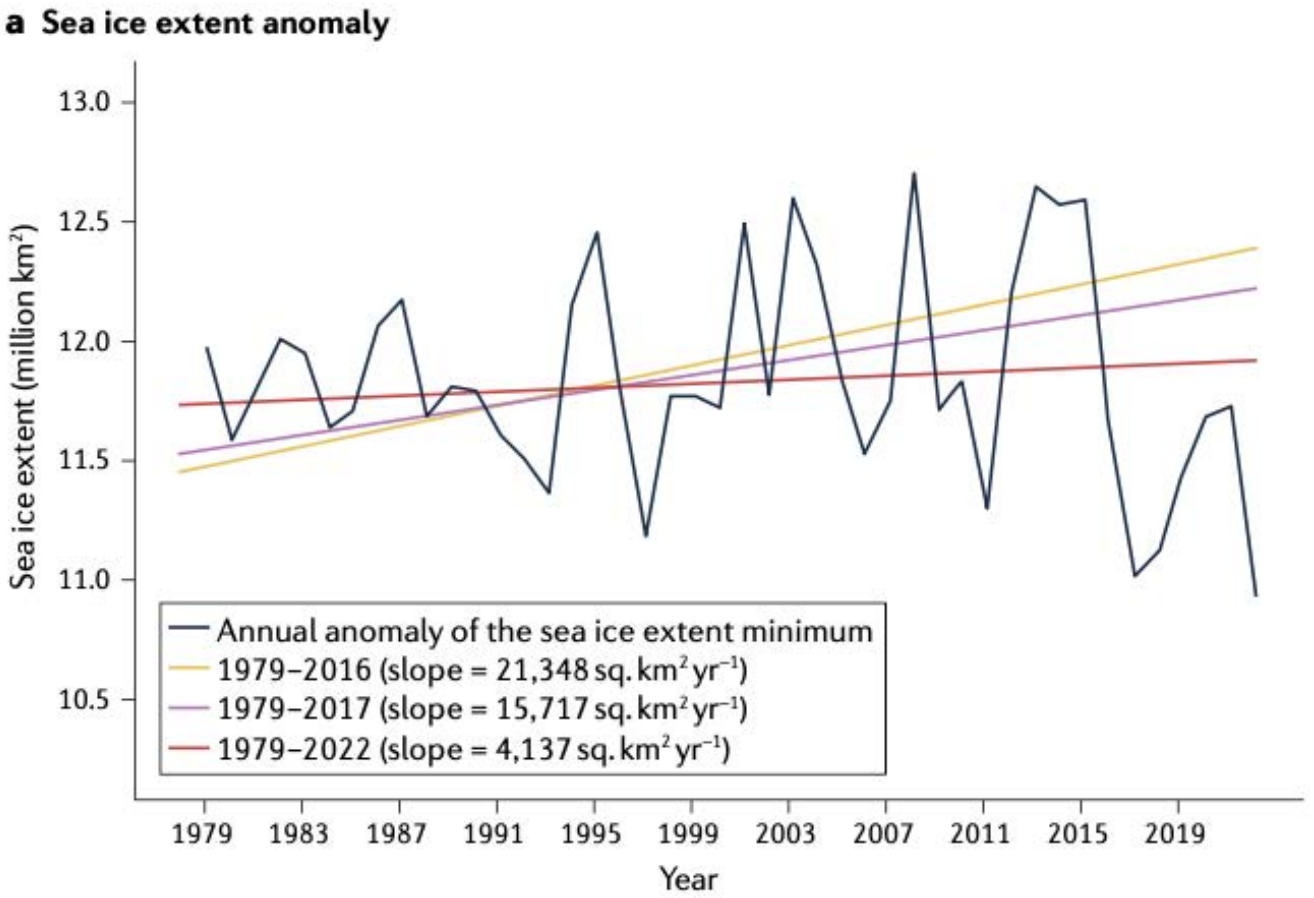
Introduction



Introduction

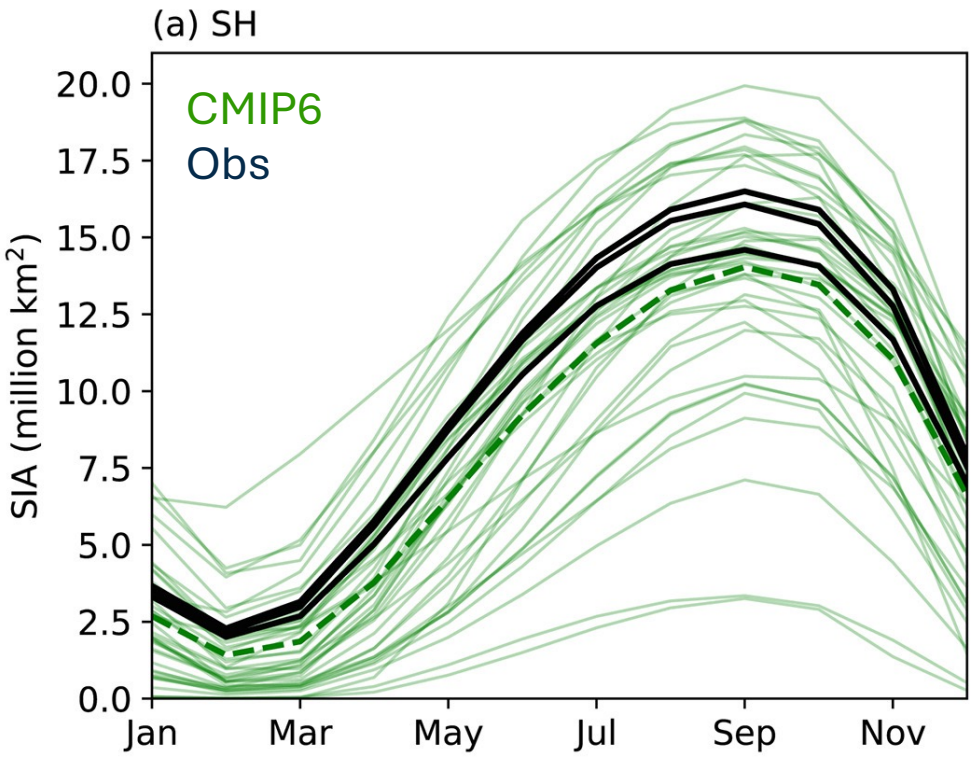
Positive trend in Antarctic SIE 🤔 → Many factors, experiments with single forcings can help! 😃



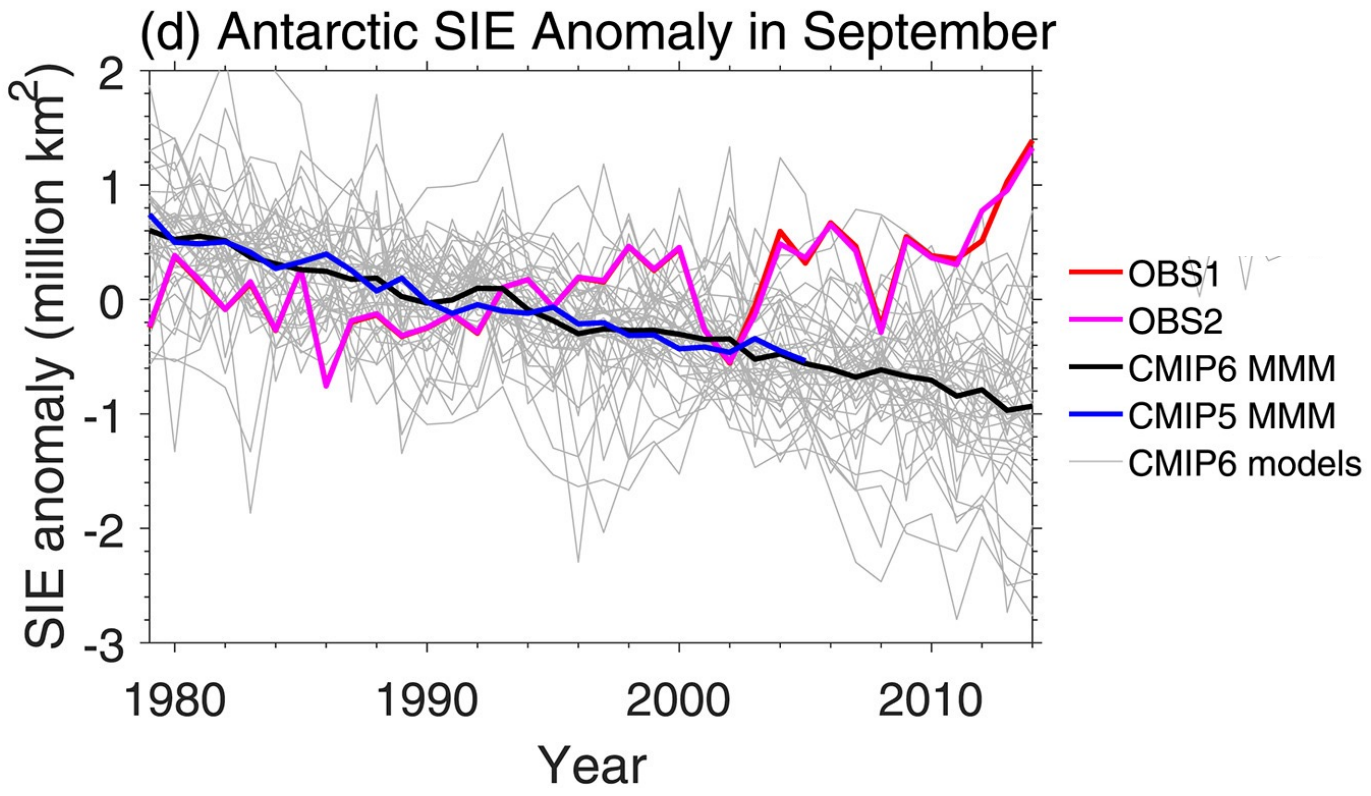
Raphael and Handcock 2022

Introduction

⚠️ Warning: models have limitations in the Southern Ocean…



Roach et al. 2020



Shu et al. et al 2020

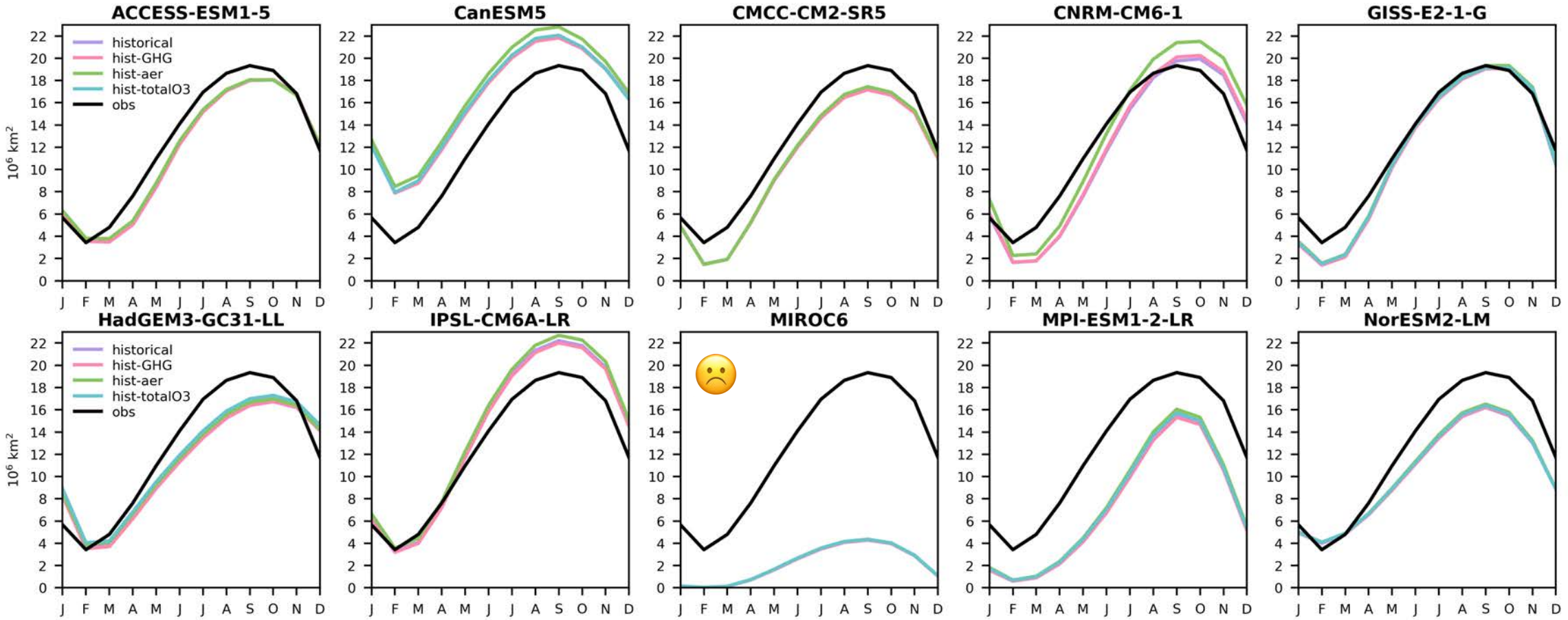
Methods

Model	Experiments			
	Historical	hist-GHG	hist-aer	hist-totalO3
ACCESS-ESM1-5	40	10	10	
CanESM5	65	50	30	10
CMCC-CM2-SR5	10	10	10	
CNRM-CM6-1	30	10	10	
GISS-E2-1-G	40	40	40	40
HadGEM3GC31-LL	55	55	55	50
IPSL-CM6A-LR	33	10	10	
MIROC6	50	50	10	10
MPI-ESM1-2-LR	50	30	30	30
NorESM2-LM	43	23	23	20

Table from Leandro's presentation

Methods

Climatological cycle of total SIE



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~~MIROC6~~	~~50~~	~~50~~	~~10~~	~~10~~
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- 9 models
- 5 with totalO3 experiment

Table from Leandro's presentation

Methods

Forcing responses: Difference between 1980-2014 (present) and 1850-1884 (pre-industrial).

Multi-model mean: equal weight for each model.

Model Agreement: stippling when >80% models match.

Timeseries: 1850 to 2014

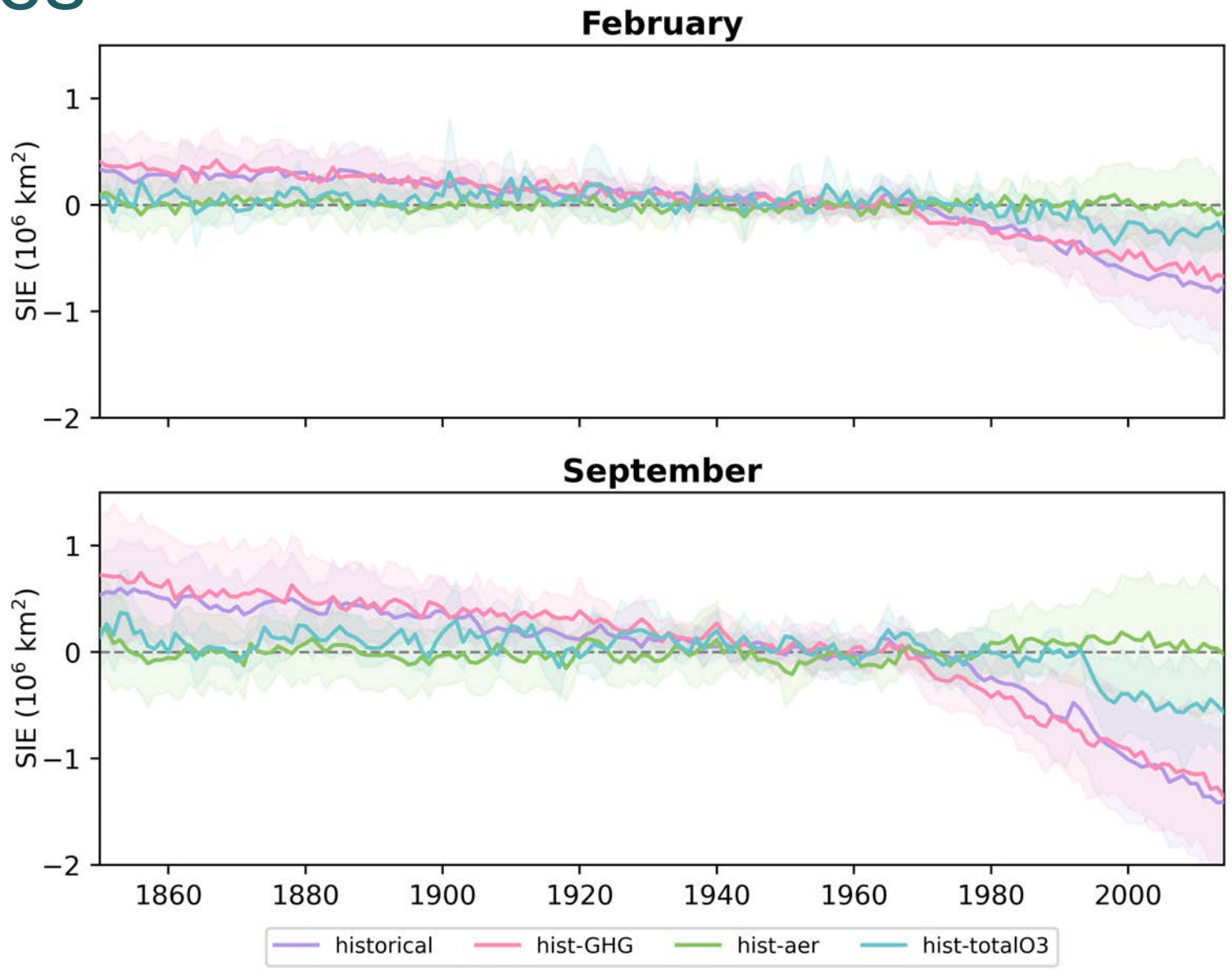
Trends: 1980-2014, compared with observations (OSI-SAF)

Adapted from Leandro's presentation

Results: time series

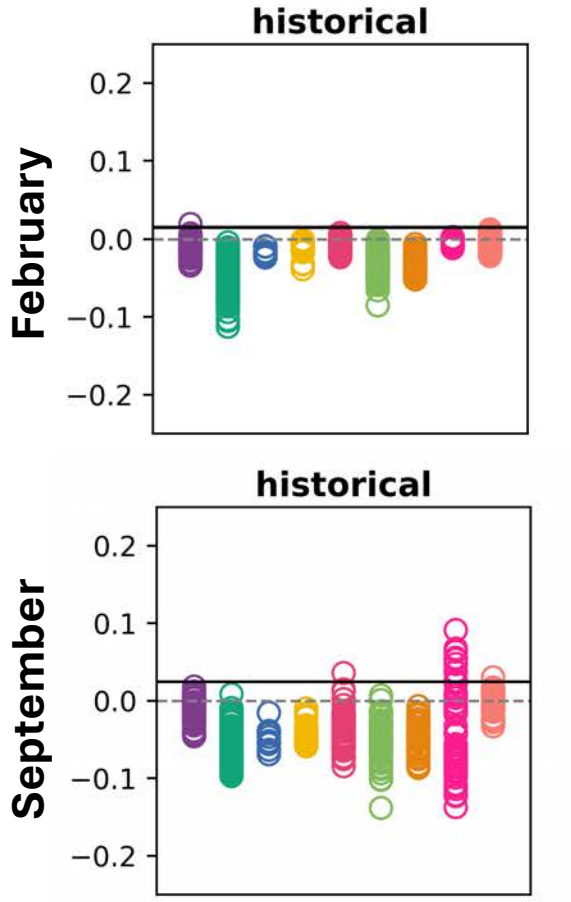
MMM of SIE anomalies at the annual minimum (February) and maximum (September)

- Overall decrease in all experiments, except hist-aer
- More dramatic response in September



Results: trends 1980-2014

SIE trend in February and September in the single members

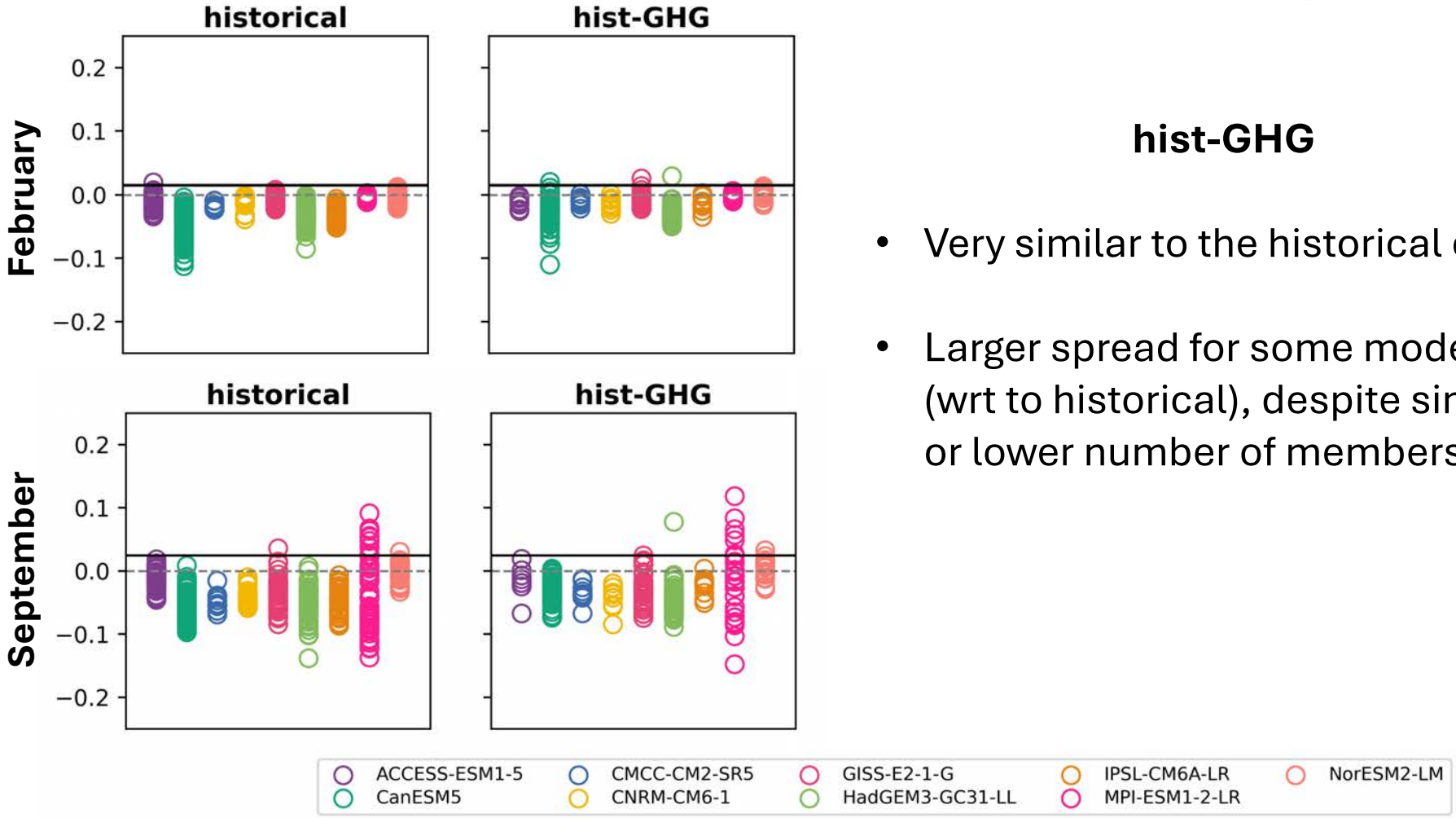


historical

- Most members do **not** capture the observed trend and simulate a negative one 😢
- ...But *some* show a positive trend!
- Larger spread in September

Results: trends 1980-2014

SIE trend in February and September in the single members

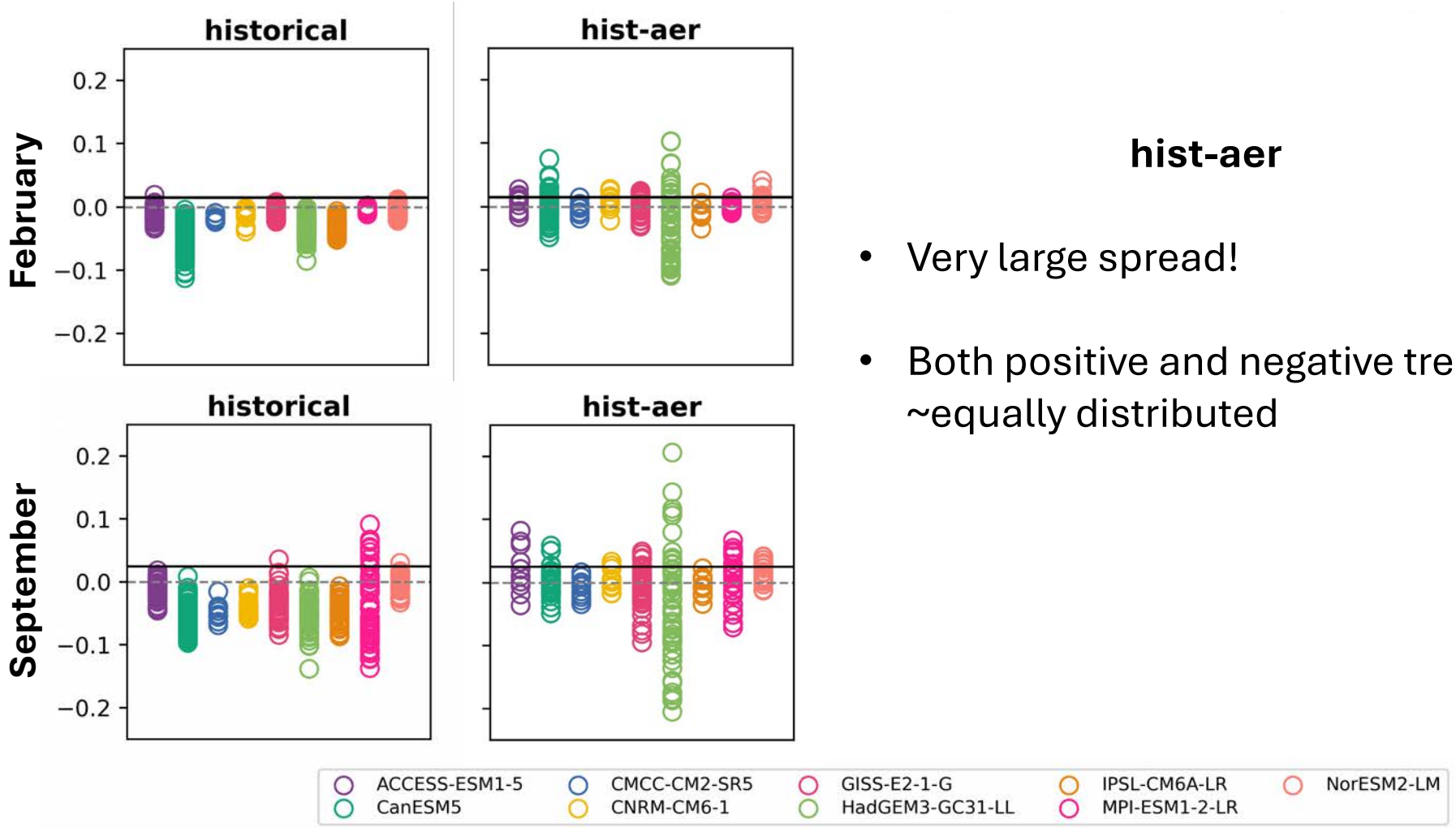


hist-GHG

- Very similar to the historical exp
- Larger spread for some models (wrt to historical), despite similar or lower number of members

Results: trends 1980-2014

SIE trend in February and September in the single members

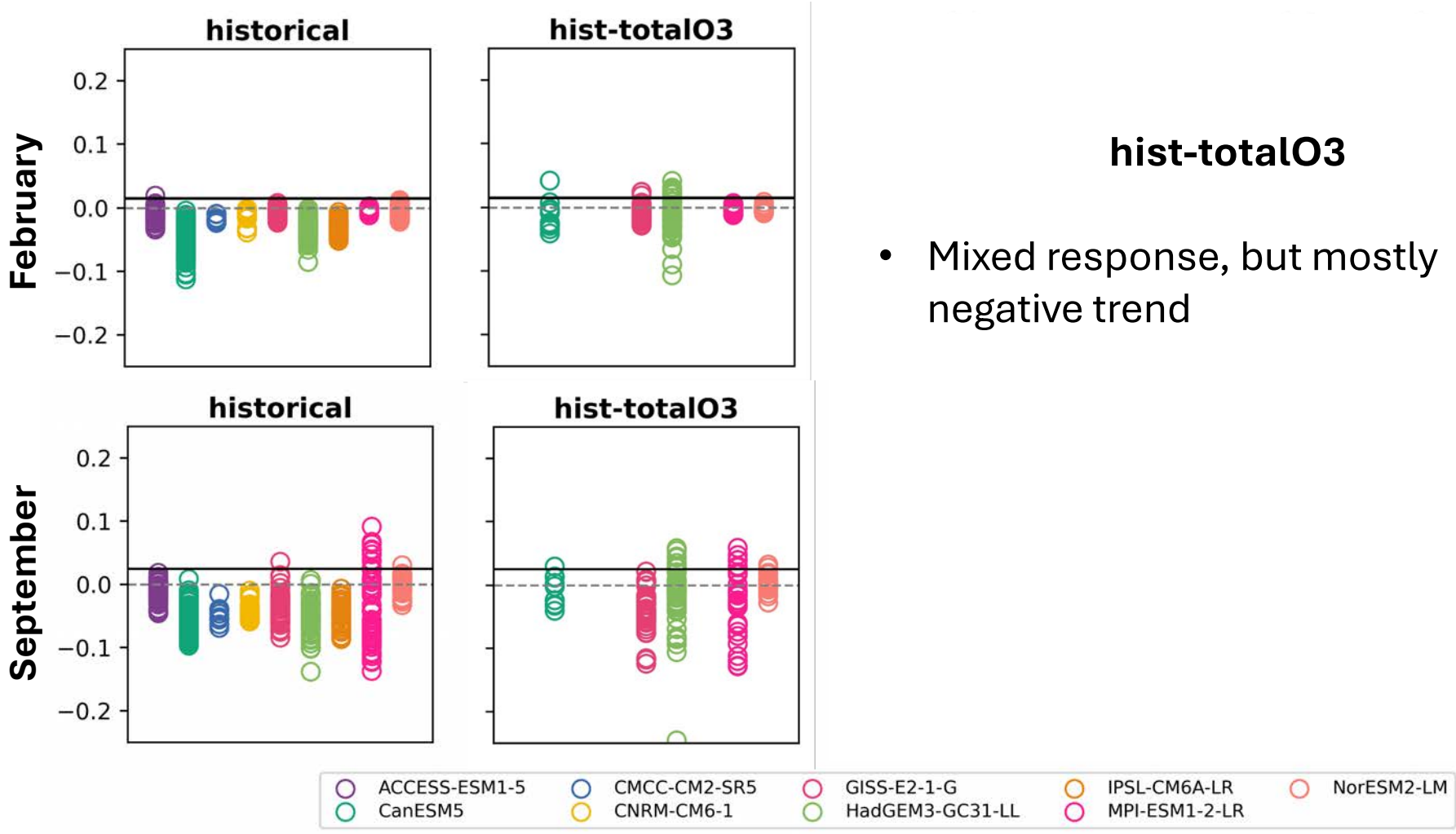


hist-aer

- Very large spread!
- Both positive and negative trends, ~equally distributed

Results: trends 1980-2014

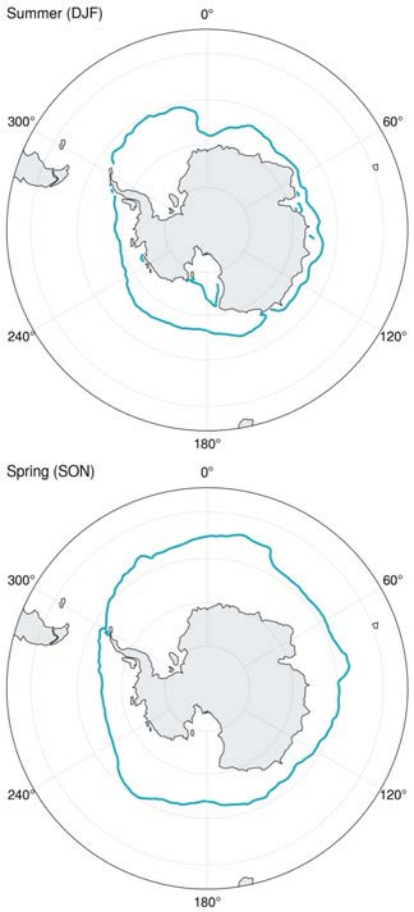
SIE trend in February and September in the single members



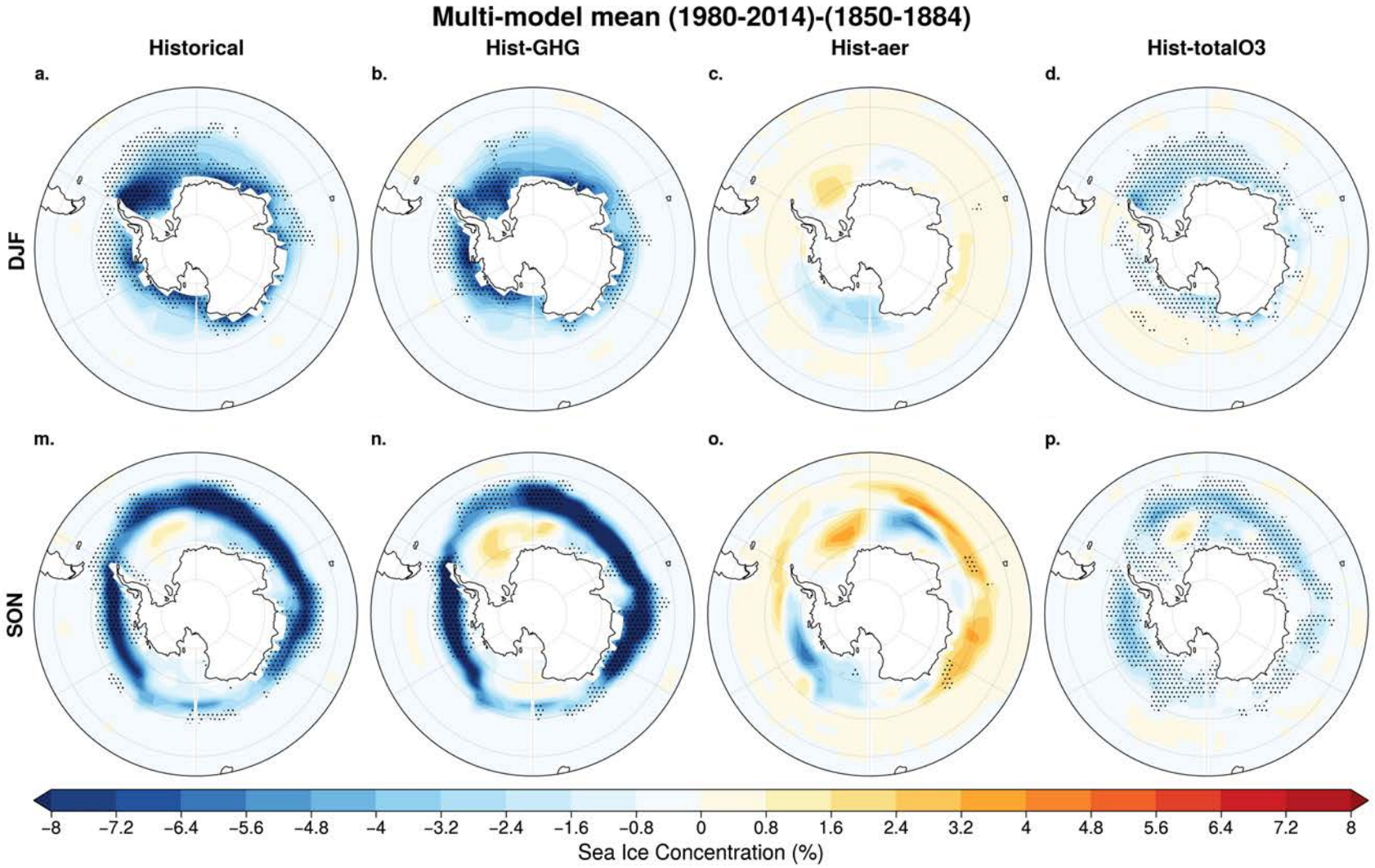
hist-totalO3

- Mixed response, but mostly negative trend

Results: SIC maps (present)-(pre-industrial)

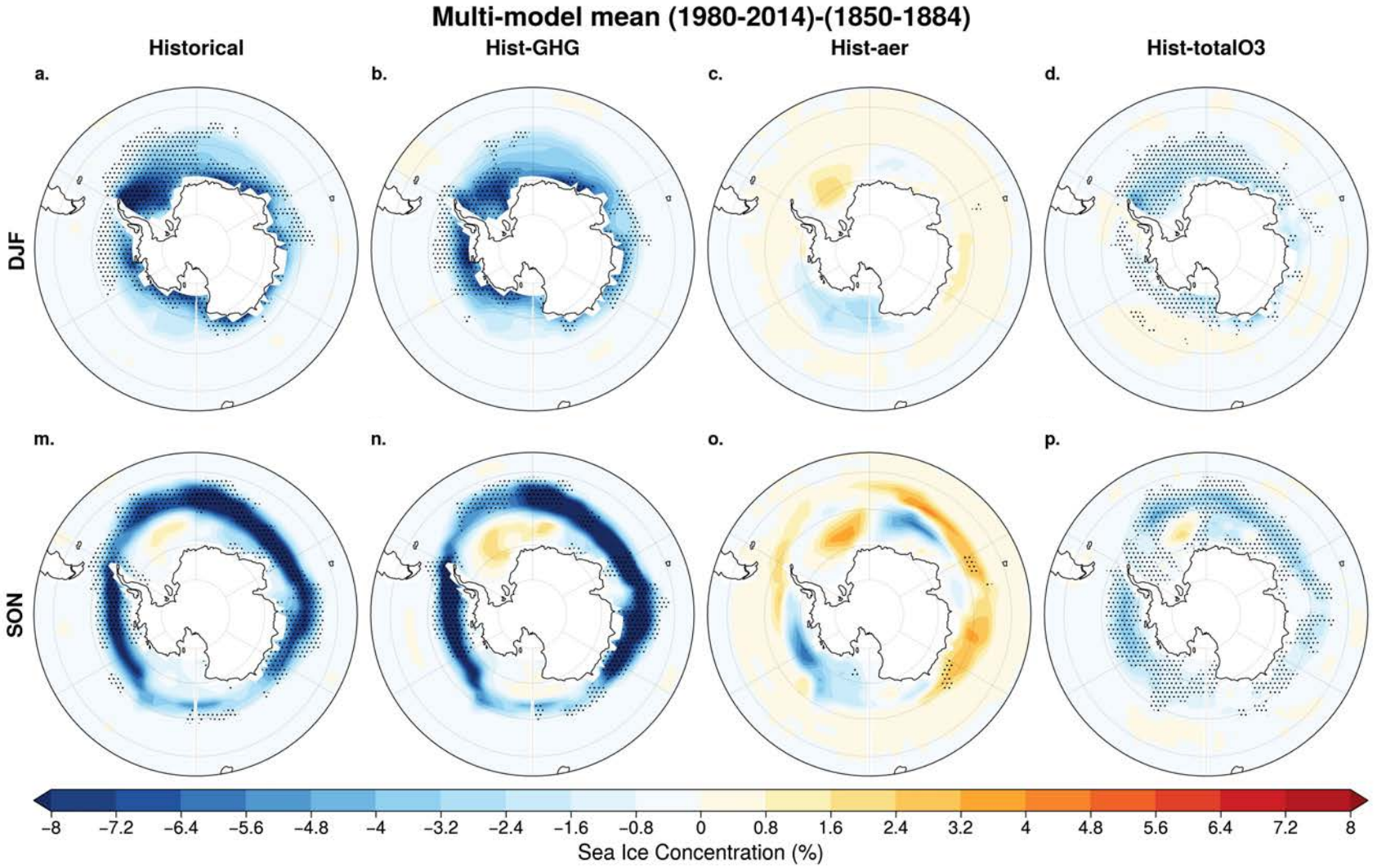


climatological sea ice edge from obs (1979-2014)



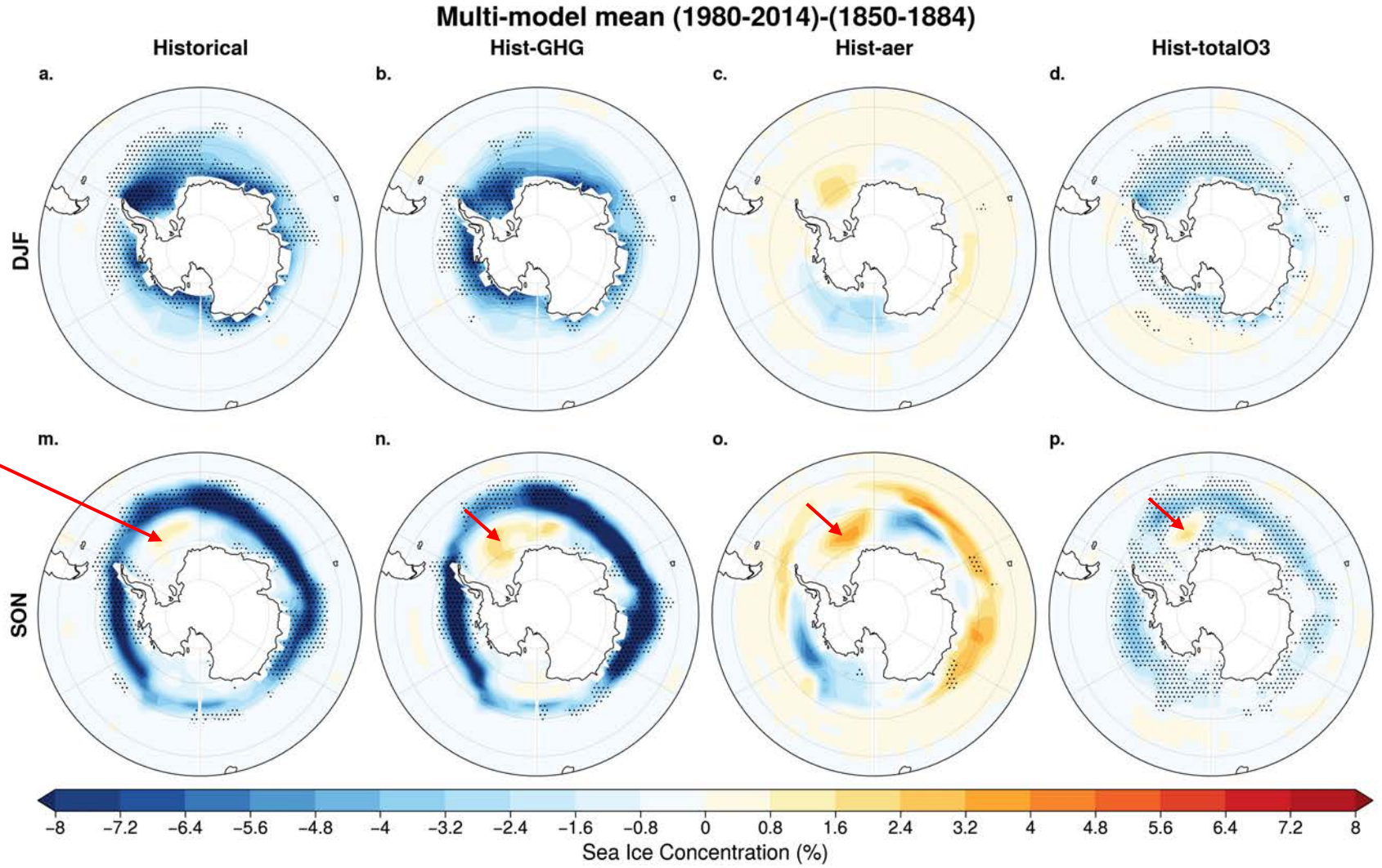
Results: SIC maps (present)-(pre-industrial)

- **historical & hist-GHG:** similar patterns, homogeneous decrease
- **hist-aer:** regional differences, lack of significance 😢
- **hist-totalO3:** small decrease



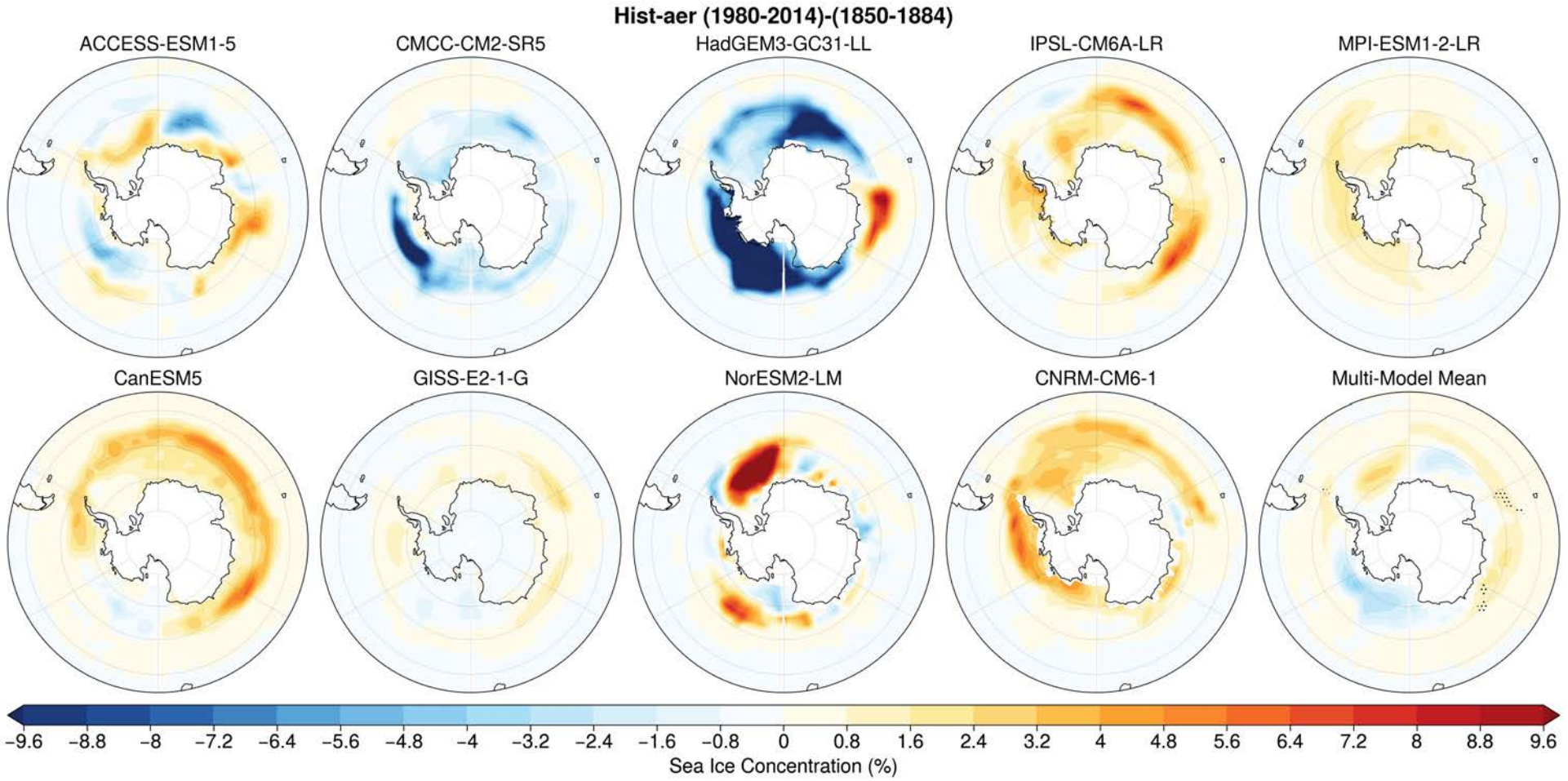
Results: SIC maps (present)-(pre-industrial)

Increase in Weddell Sea in all experiments, but not significant.

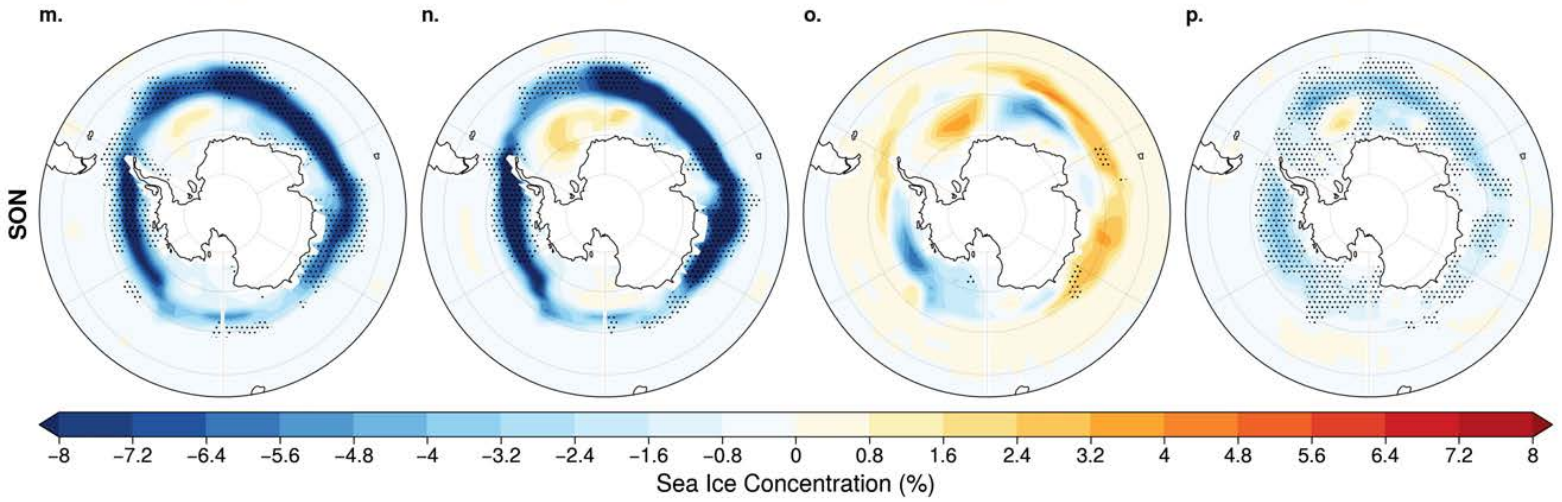


Results: SIC maps (present)-(pre-industrial)

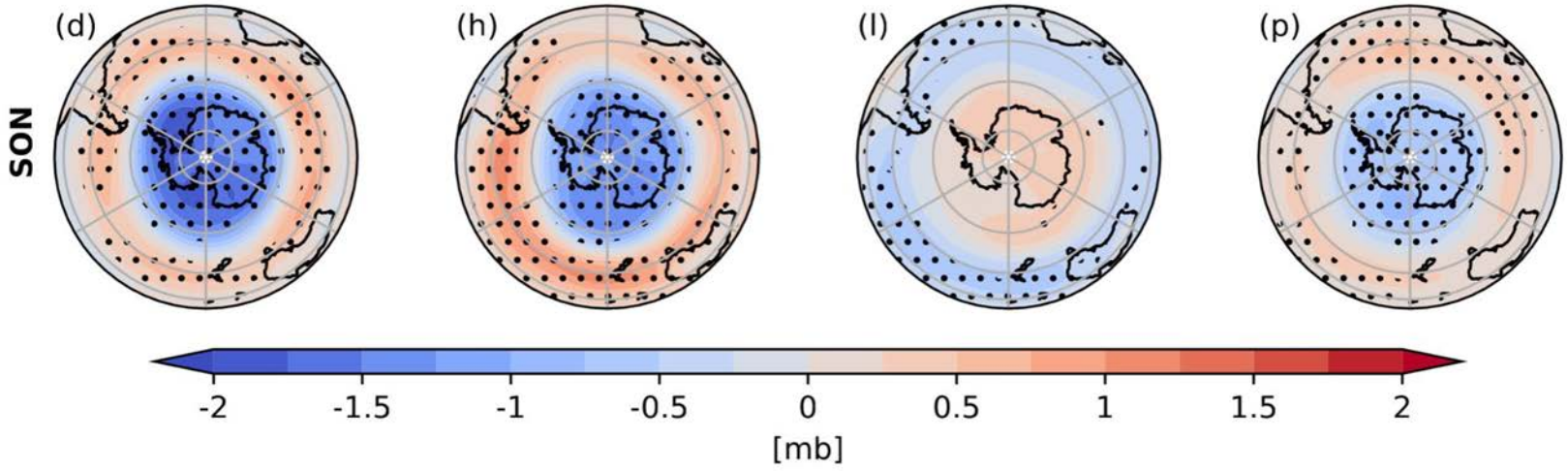
Single models (annual mean) in hist-aer



Results: comparison with atmosphere



Sea Level Pressure

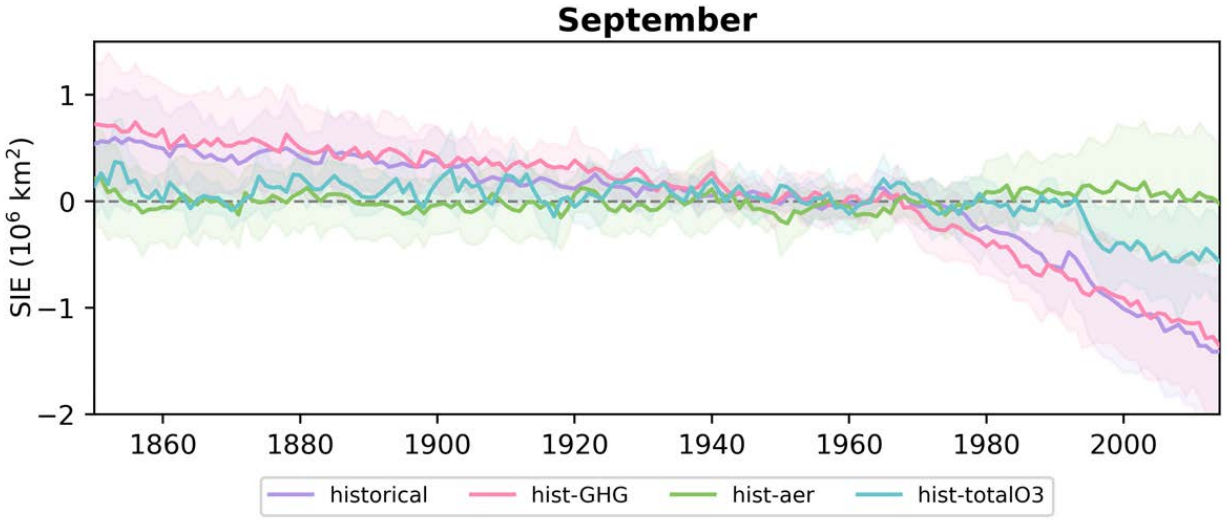


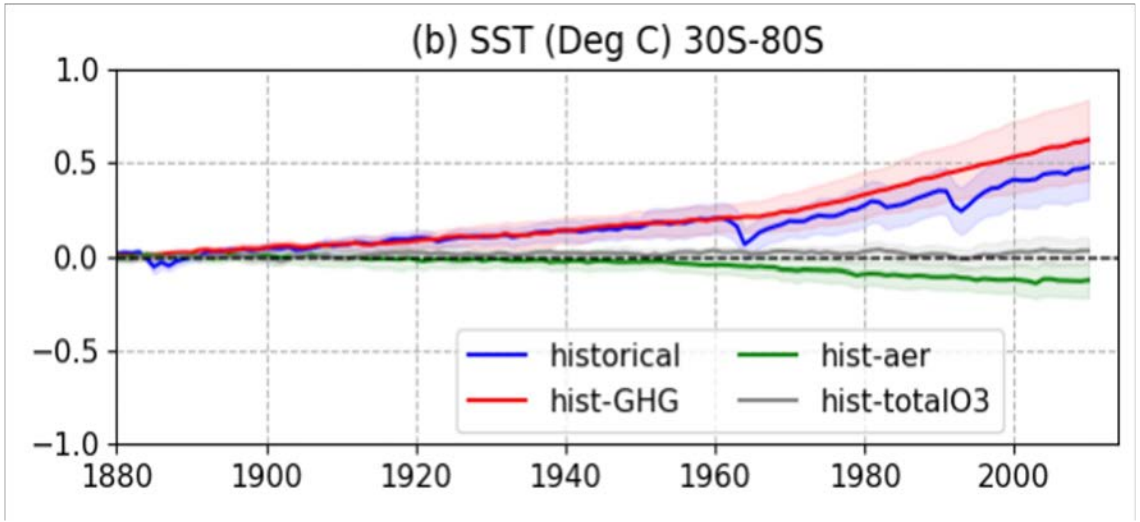
Courtesy of David Avisar/Chaim Garfinkel

- **historical, hist-GHG, hist-totalO3:** positive SAM-like response
- **hist-aer:** negative SAM, also lacking significance

→ See also Ghyslaine's talk on the SAM

Results: comparison with ocean





Courtesy of Hemant Khatri

- **historical, hist-GHG:** warming trend
- **hist-aer:** slight cooling
- **hist-totalO3:** no net trend, but because of dipolar pattern

Summary

- In the **“ models’ world”,** there is a decrease in sea ice in the present period:
  - The decrease is mostly driven by GHG ↓ ↓ ↓
  - Ozone contributes to the decrease ↓
  - Aerosols seem to have an opposite or neutral effect ↑=, but there is large uncertainty
- Sea ice response consistent with atmosphere (and ocean) responses

- It is challenging to apply these conclusions to the **“real world”,** since most models/members fail in capturing the observed positive trend…

- Still, we can learn a lot from these experiments!