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OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Response of the AMOC to reduced solar radiation – the modulating role of atmospheric-chemistry

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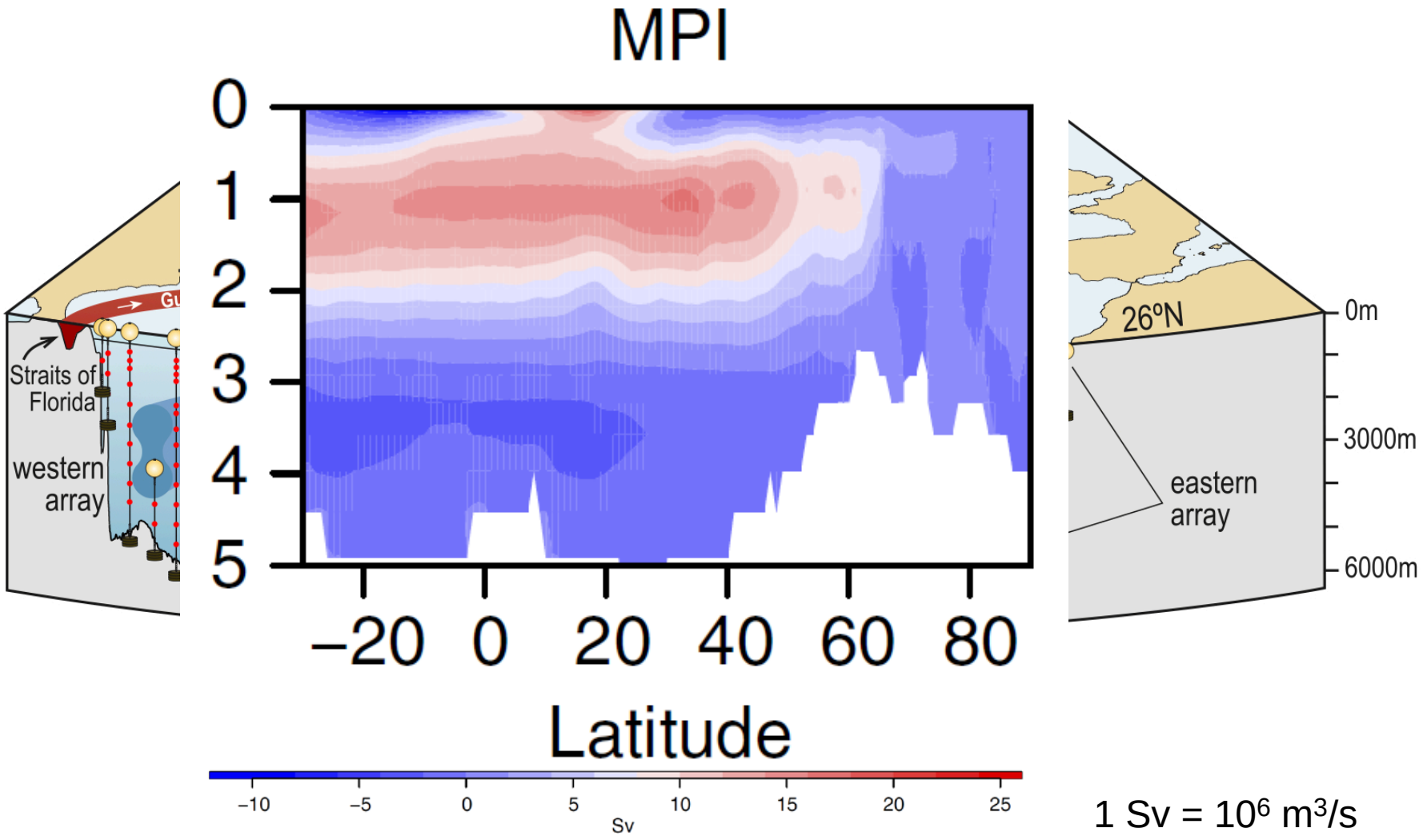
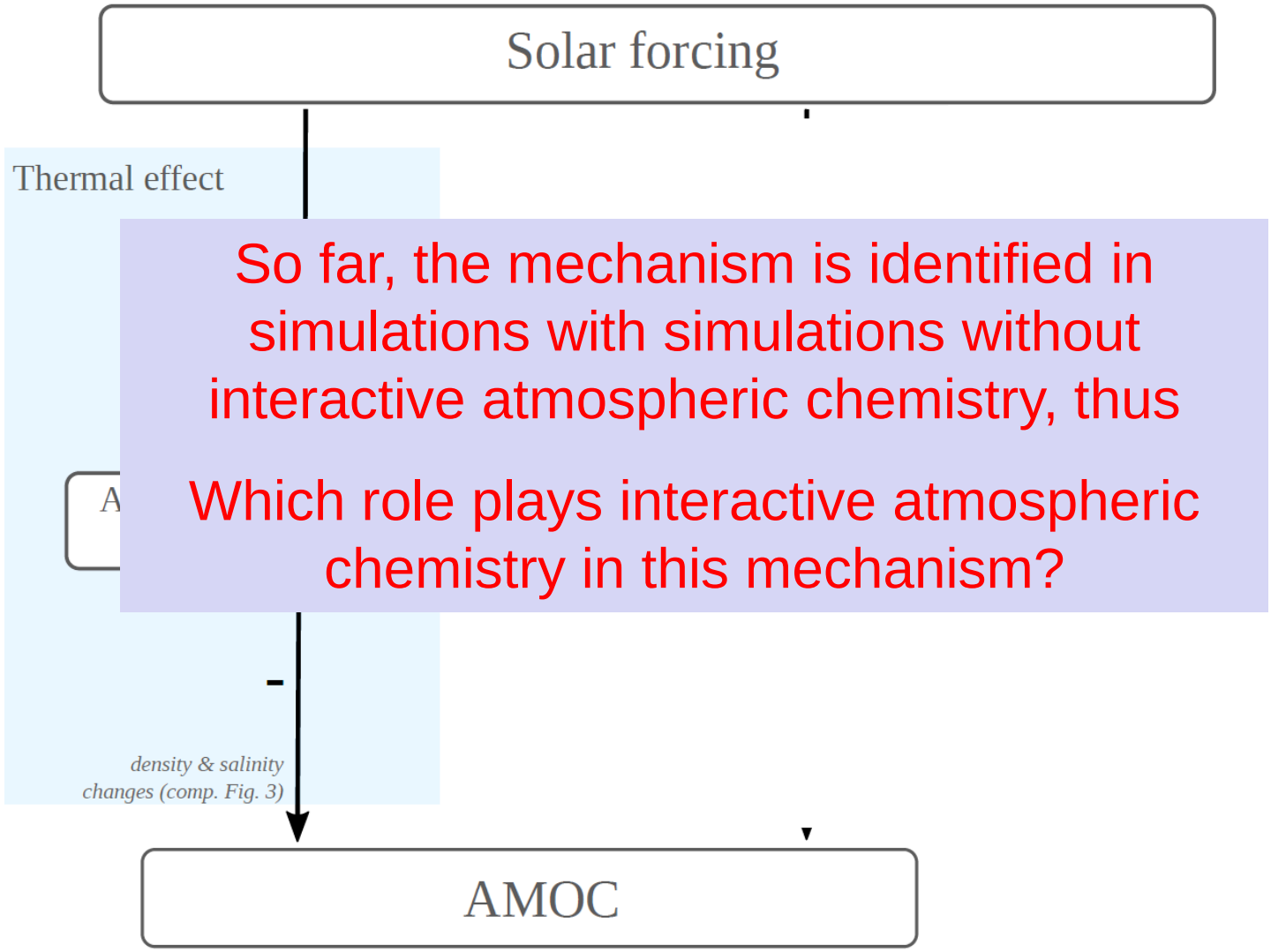
AMOC



1 Sv = 10^6 m^3/s

Mechanism of solar influence to AMOC



So far, the mechanism is identified in simulations with simulations without interactive atmospheric chemistry, thus

Which role plays interactive atmospheric chemistry in this mechanism?

Outline

- Model / experimental design
- Thermal effect of the TSI on AMOC
- Dynamical effect
- Summary

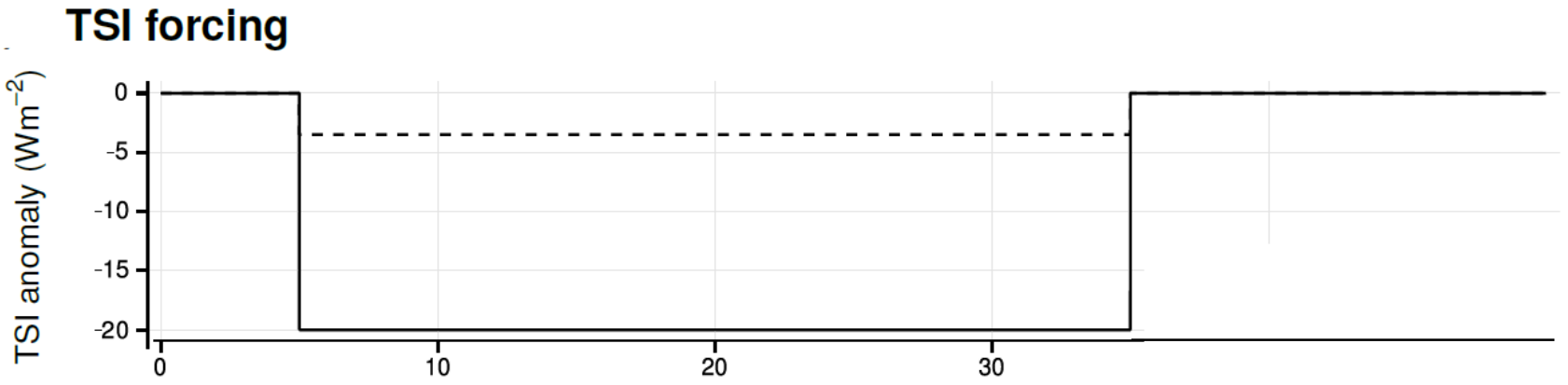
Model and experimental design

SOCOL-MPIOM Model: - ECHAM5 (T31, 39 levels, up to 0.01 hPa)

- MPIOM (nominal 3°, 40 level)
- MEZON (41 gas species with 200 gas-phase, 16 heterogeneous, and 35 photolytical reaction)

Experimental design: - Control and sensitivity simulations (10)

- Chemistry enabled /disabled
- Step-wise total TSI reduction of –3.5 (S1) and **–20Wm^{-2} (S2)**



Thermal effect

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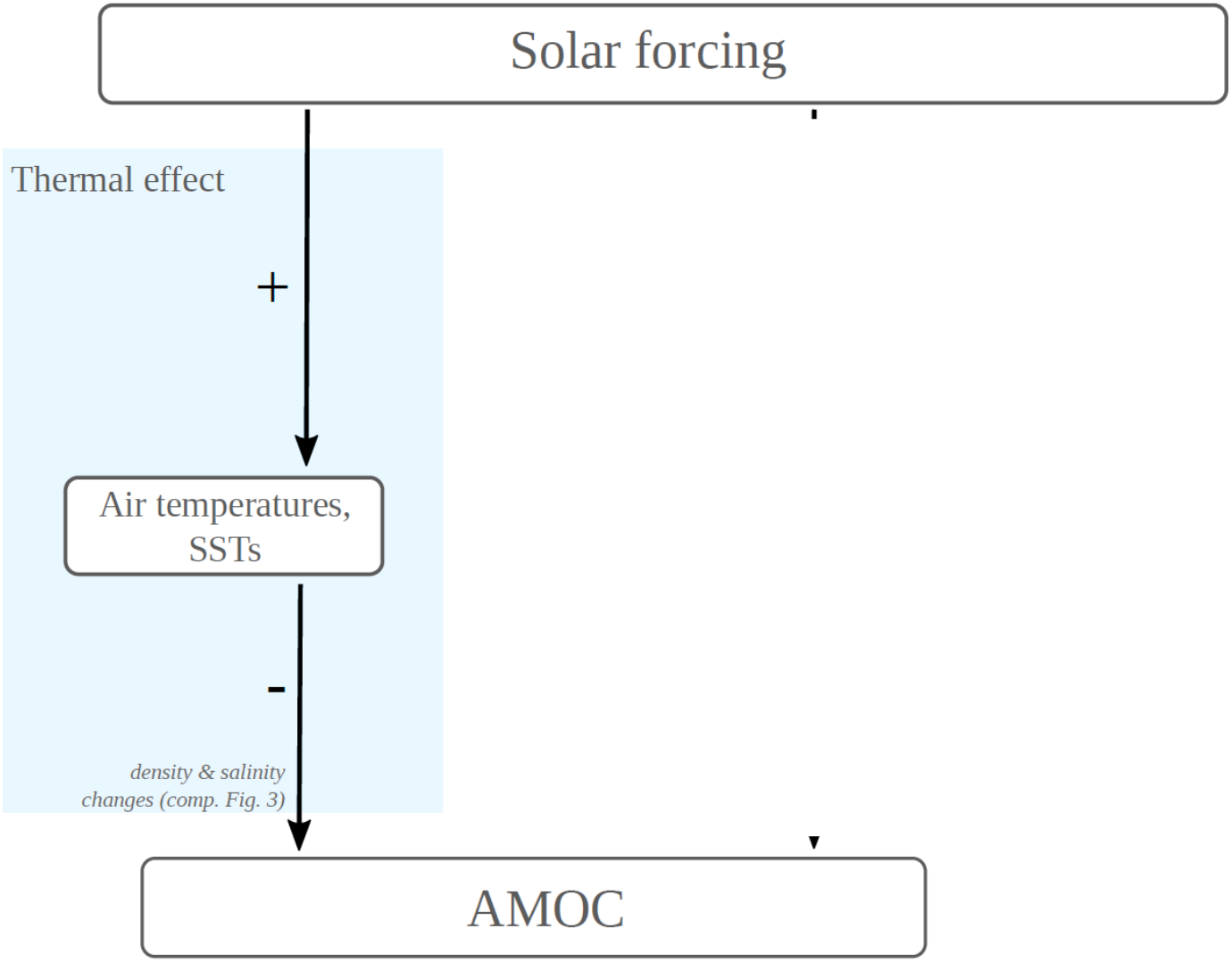
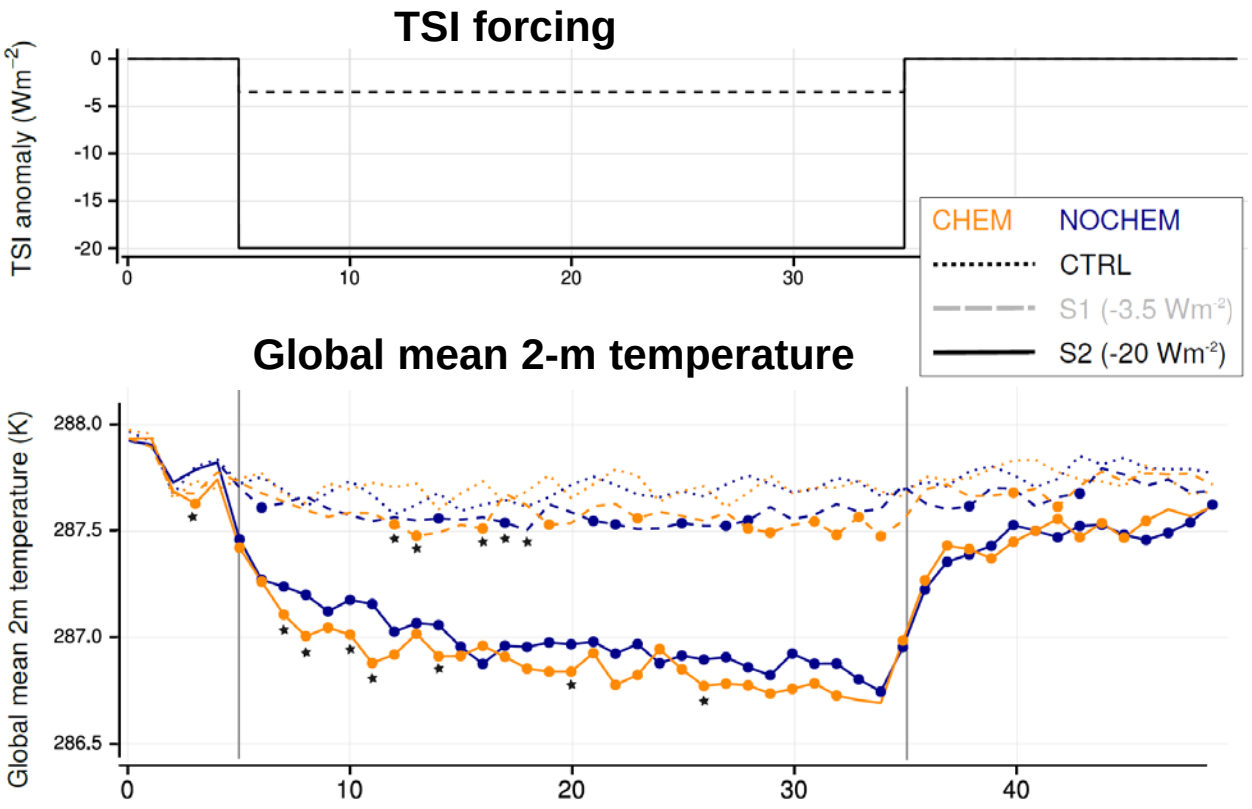


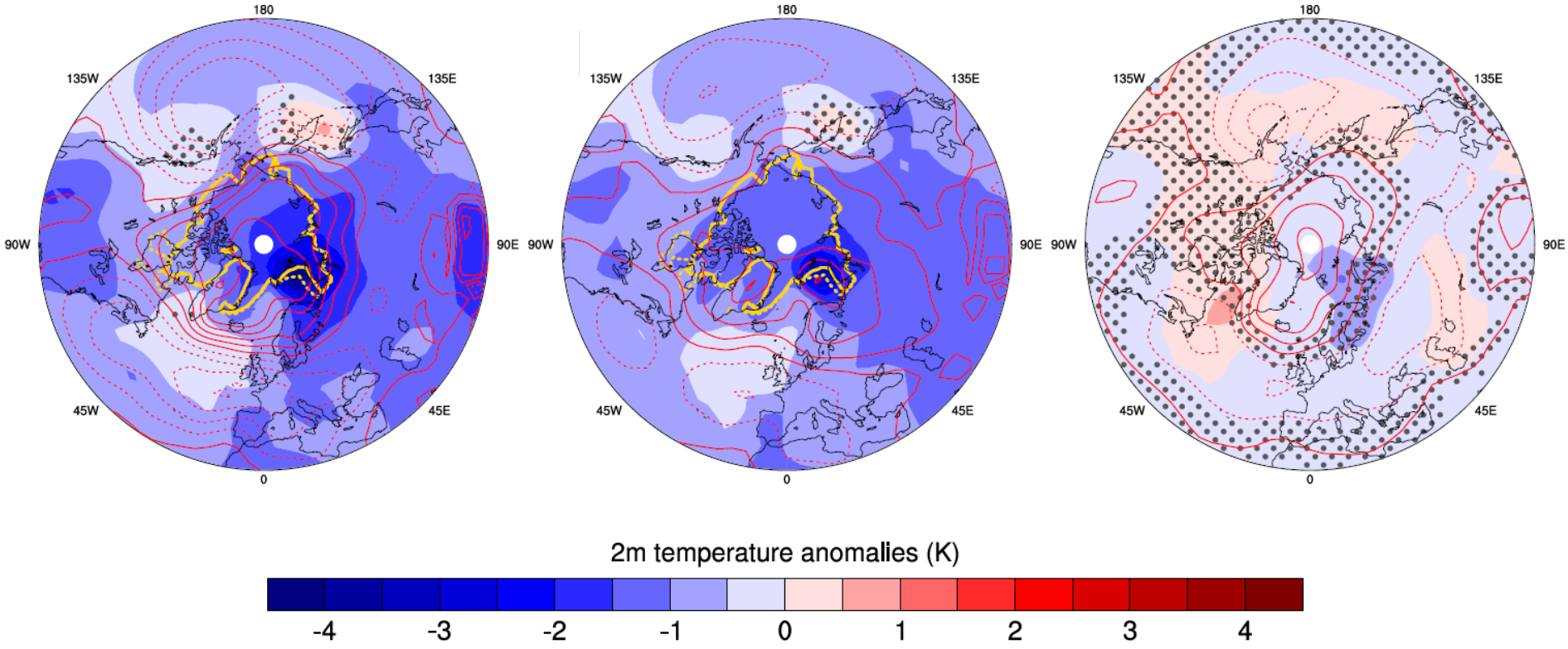
Thermal effect



Black star:

Difference between CHEM and NoCHEM is significant at the 5% level

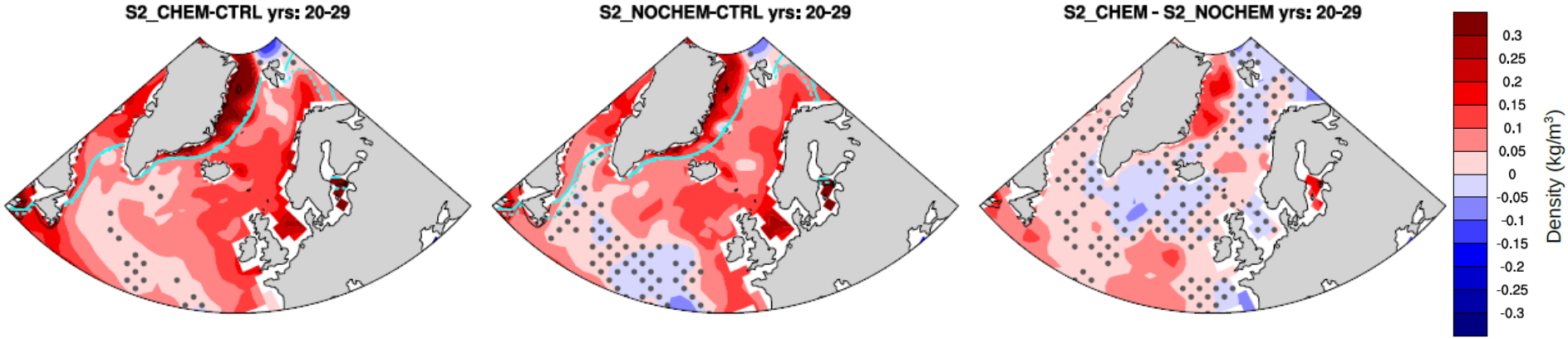
2-m temperature and SLP and response during SRR period



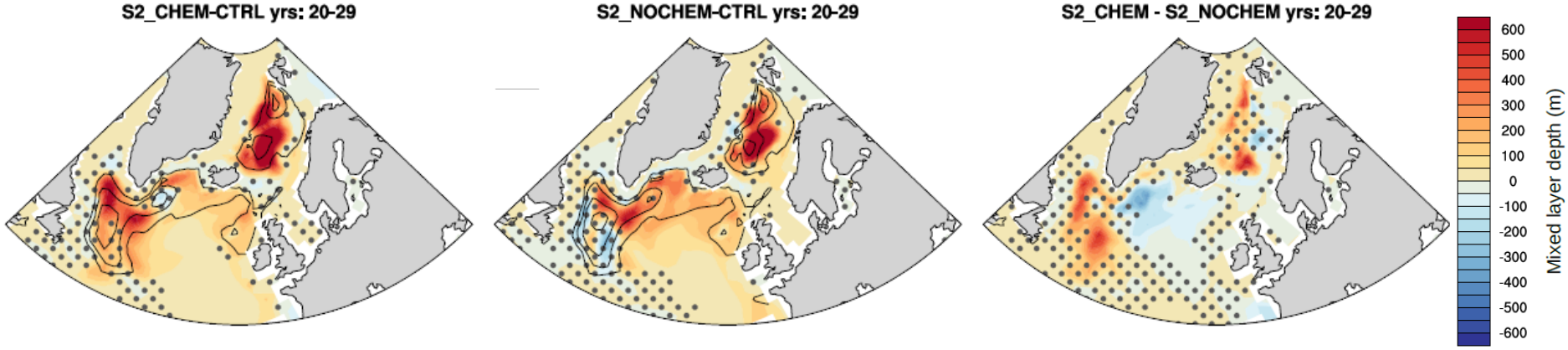
Stippling: NOT significant at the 5% level

Thermal effect

Density in the first 220 m



Mixed layer depth



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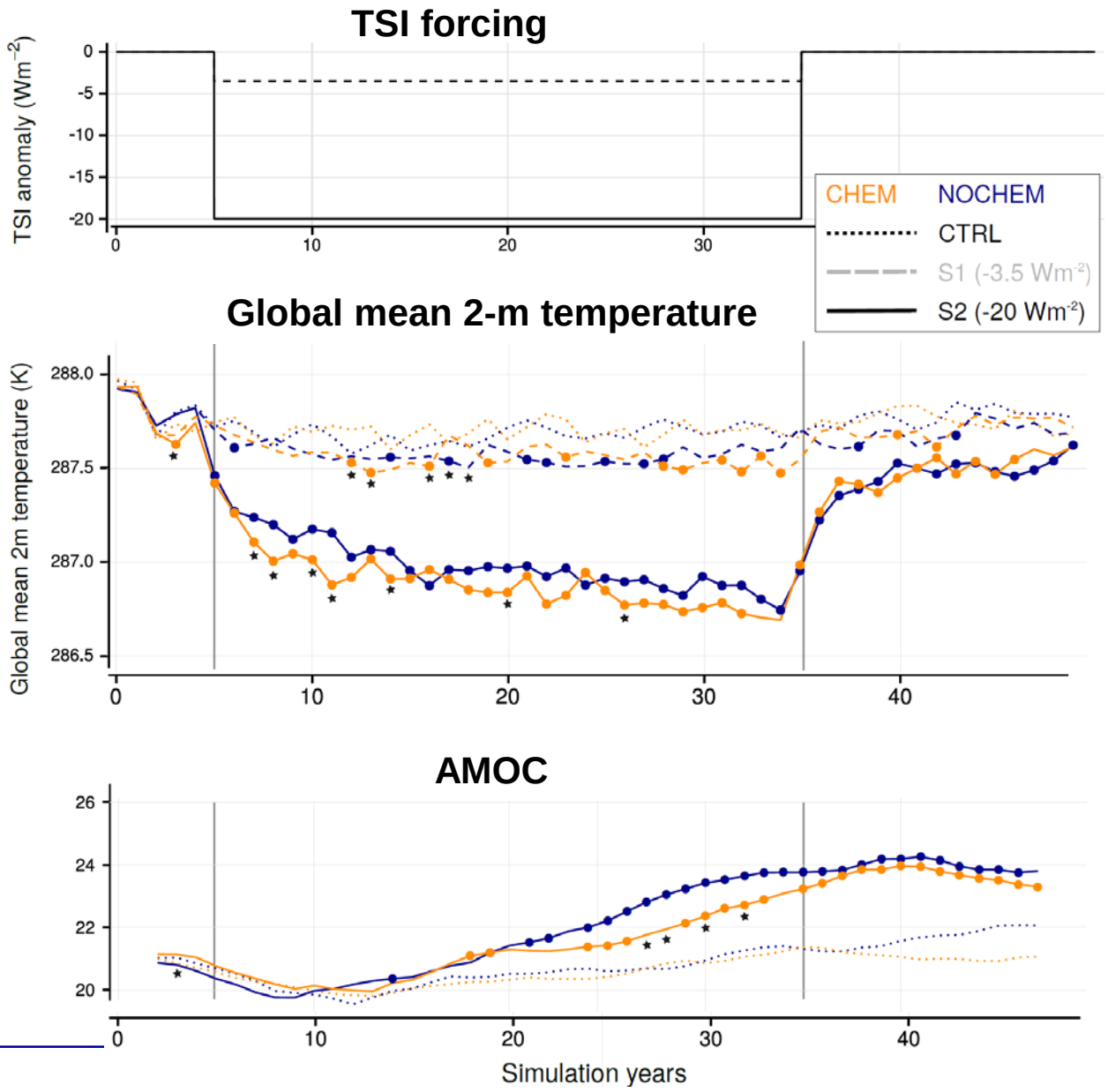
Thermal effect



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Dynamical effect

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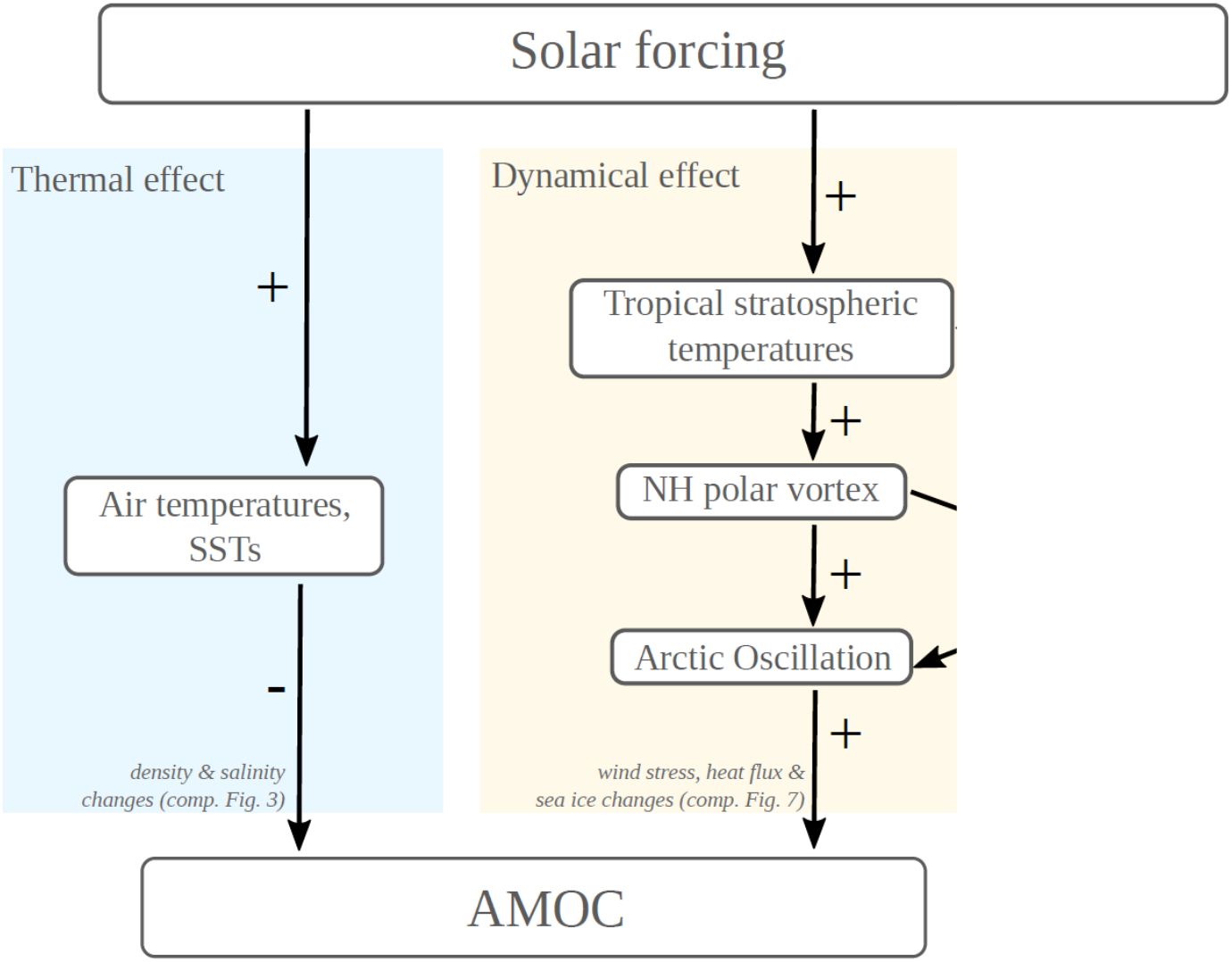
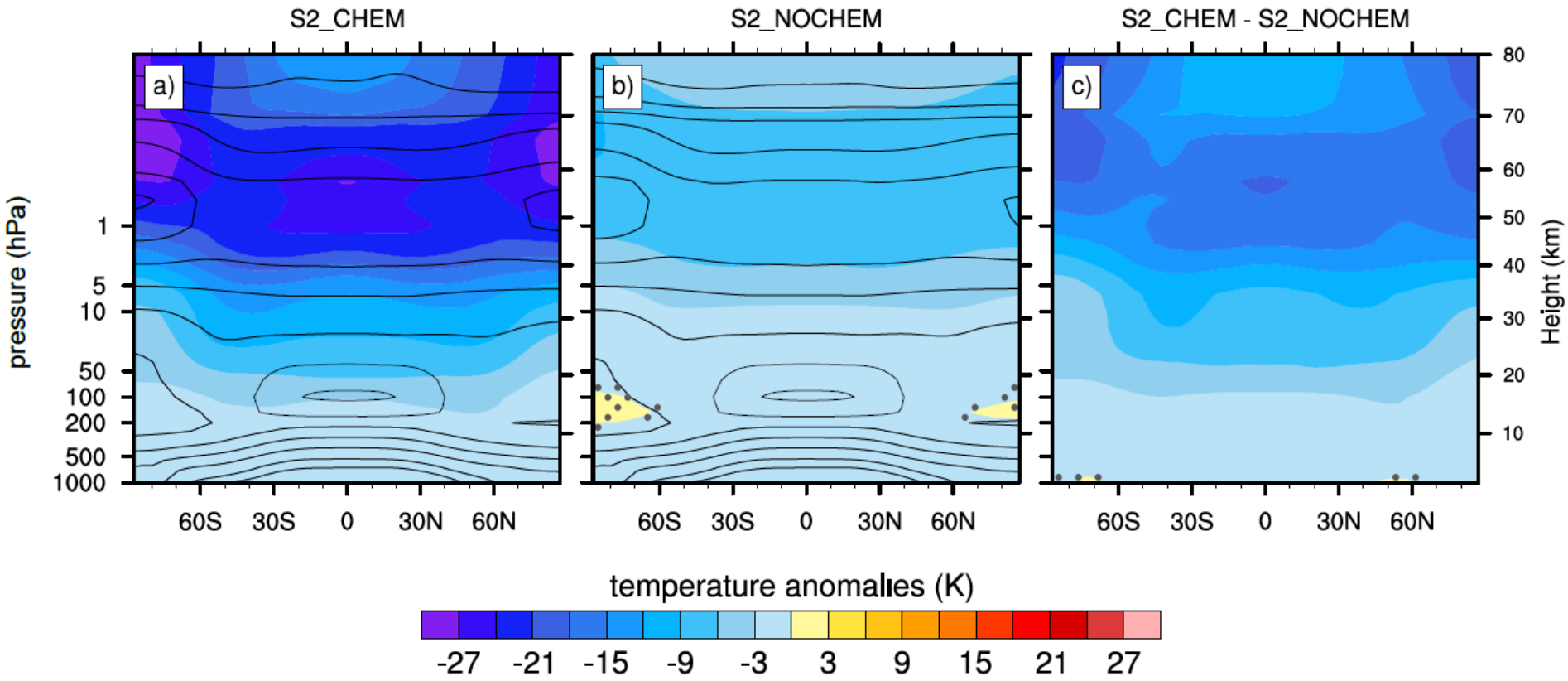


Dynamical effect

Temperature



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Dynamical effect

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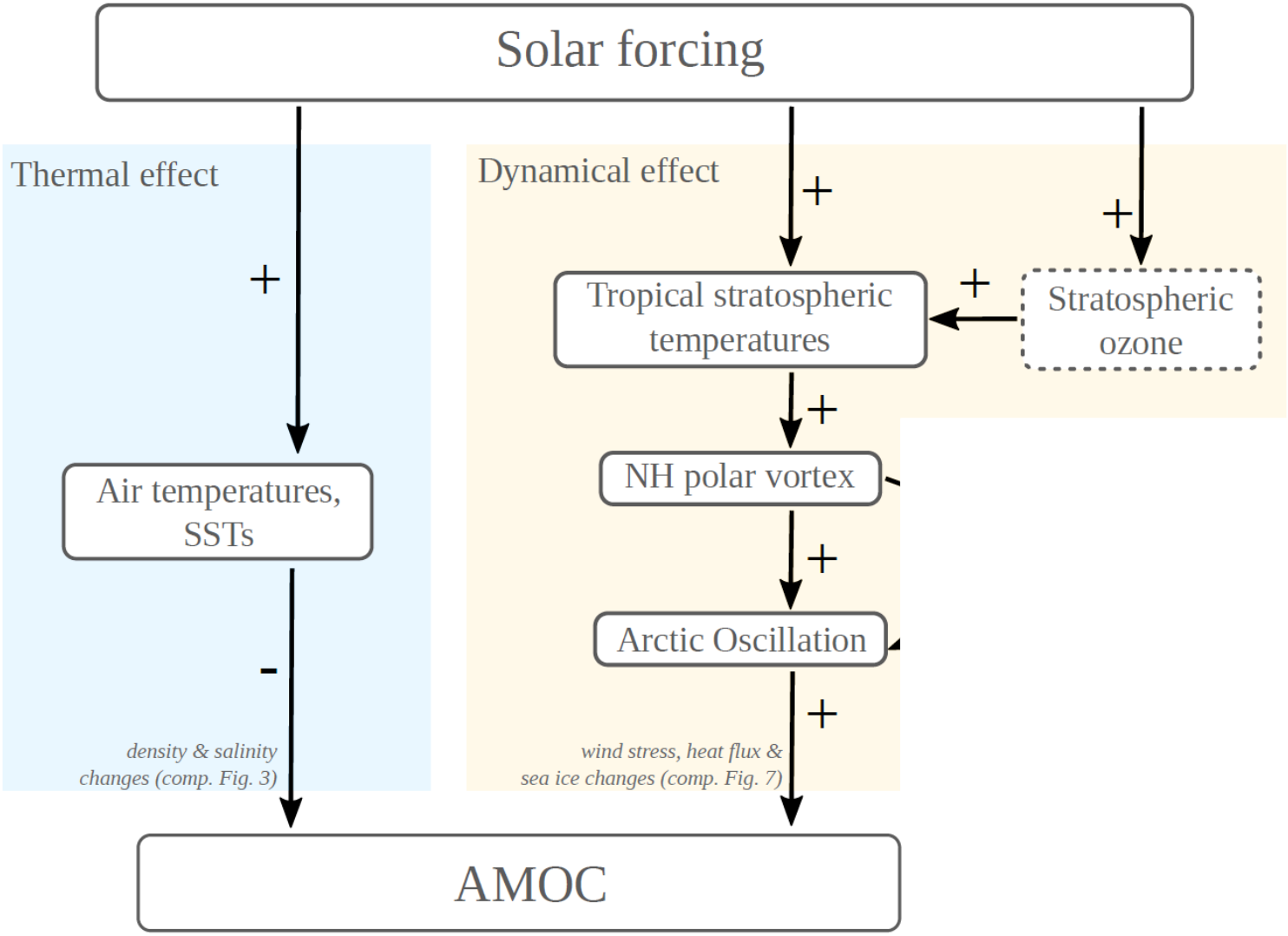

Dynamical effect

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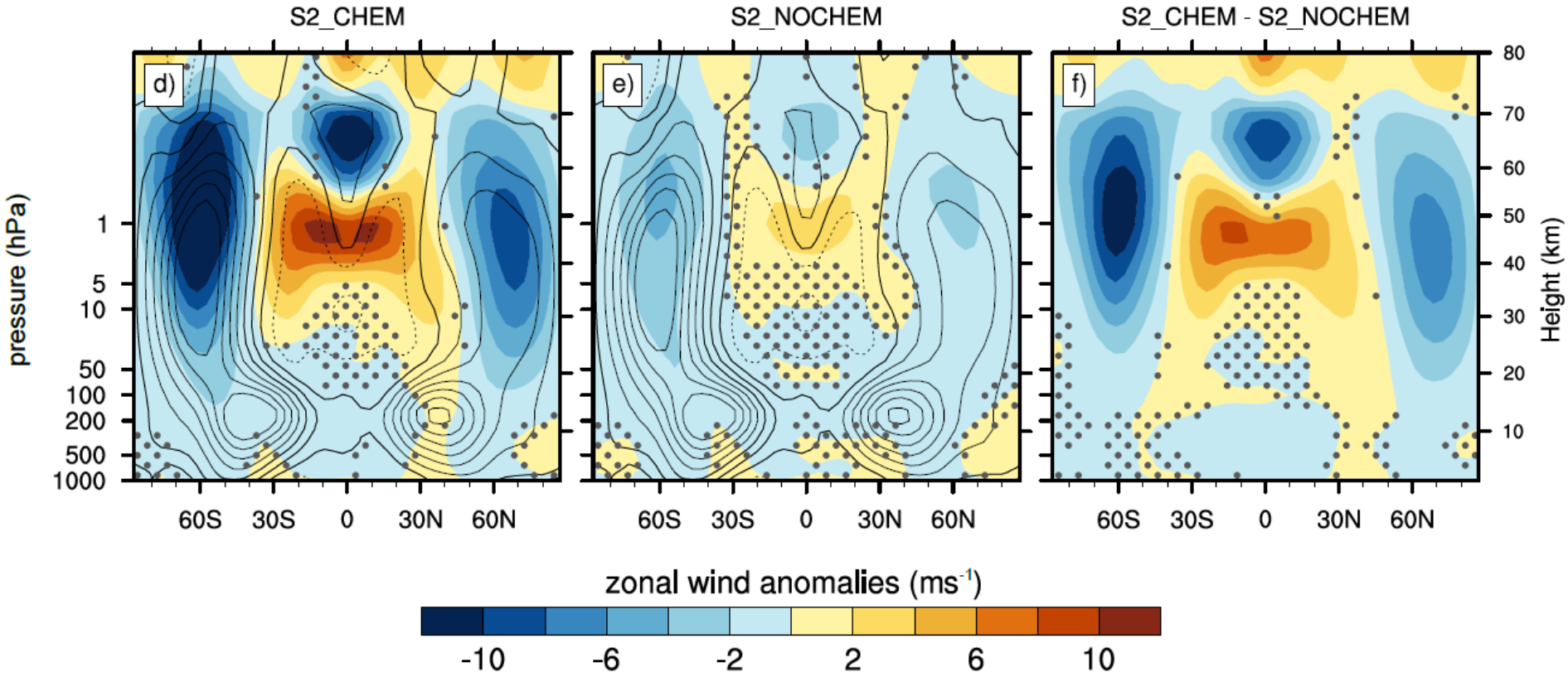
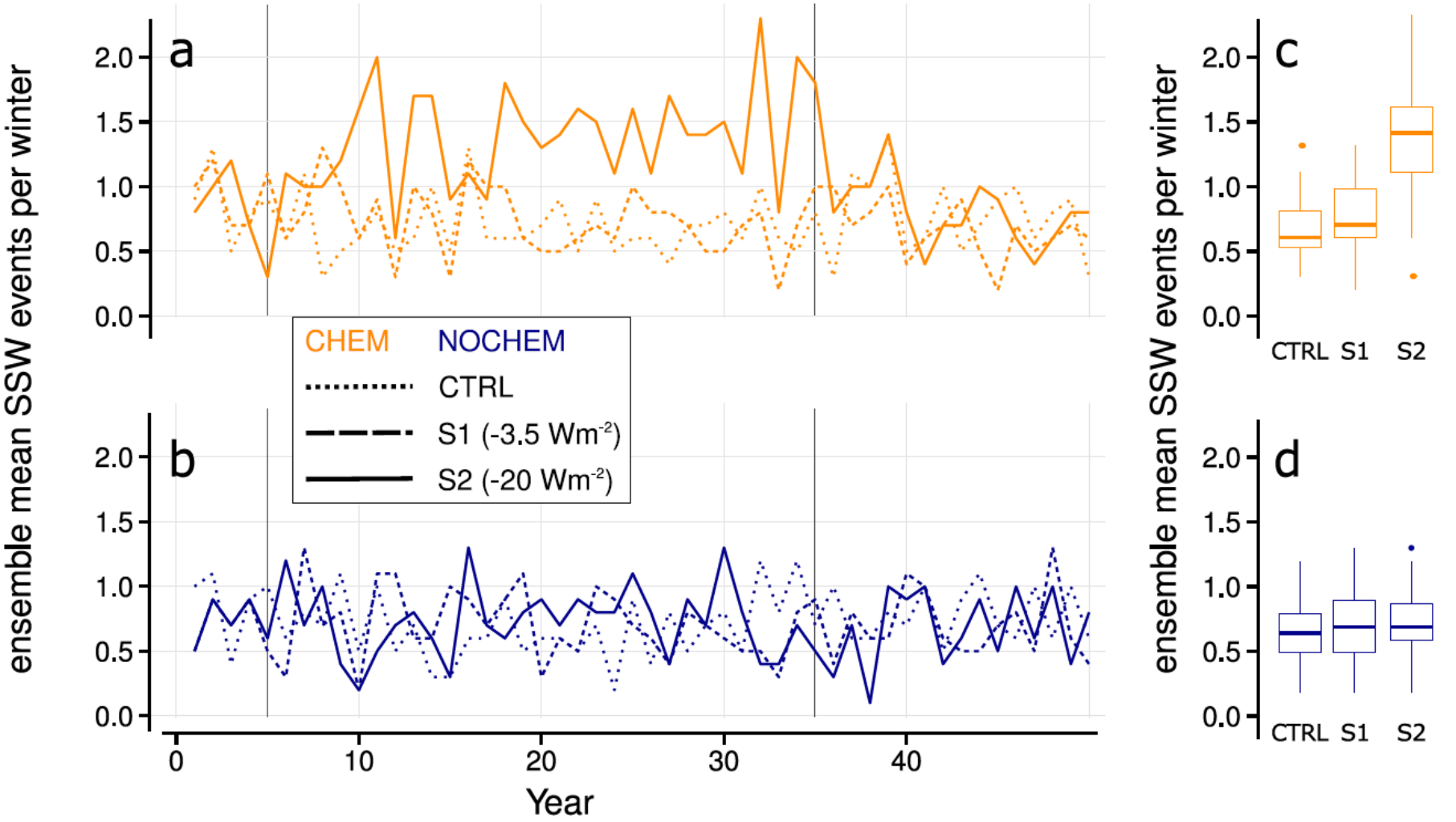
Zonal wind



Stippling: NOT significant at the 5% level

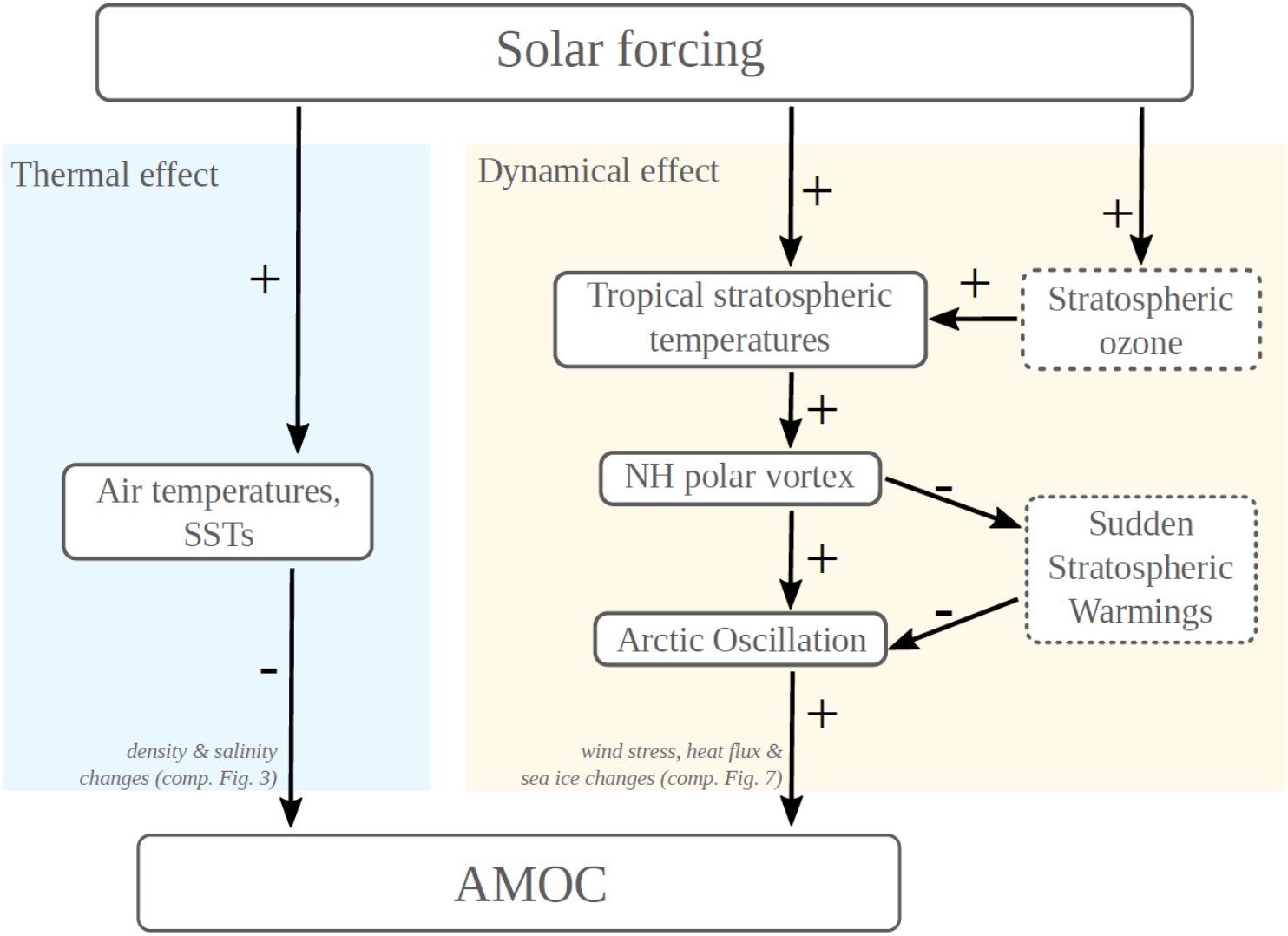
Dynamical effect

Sudden stratospheric warming events (SSW) per winter (Nov. - Mar.)



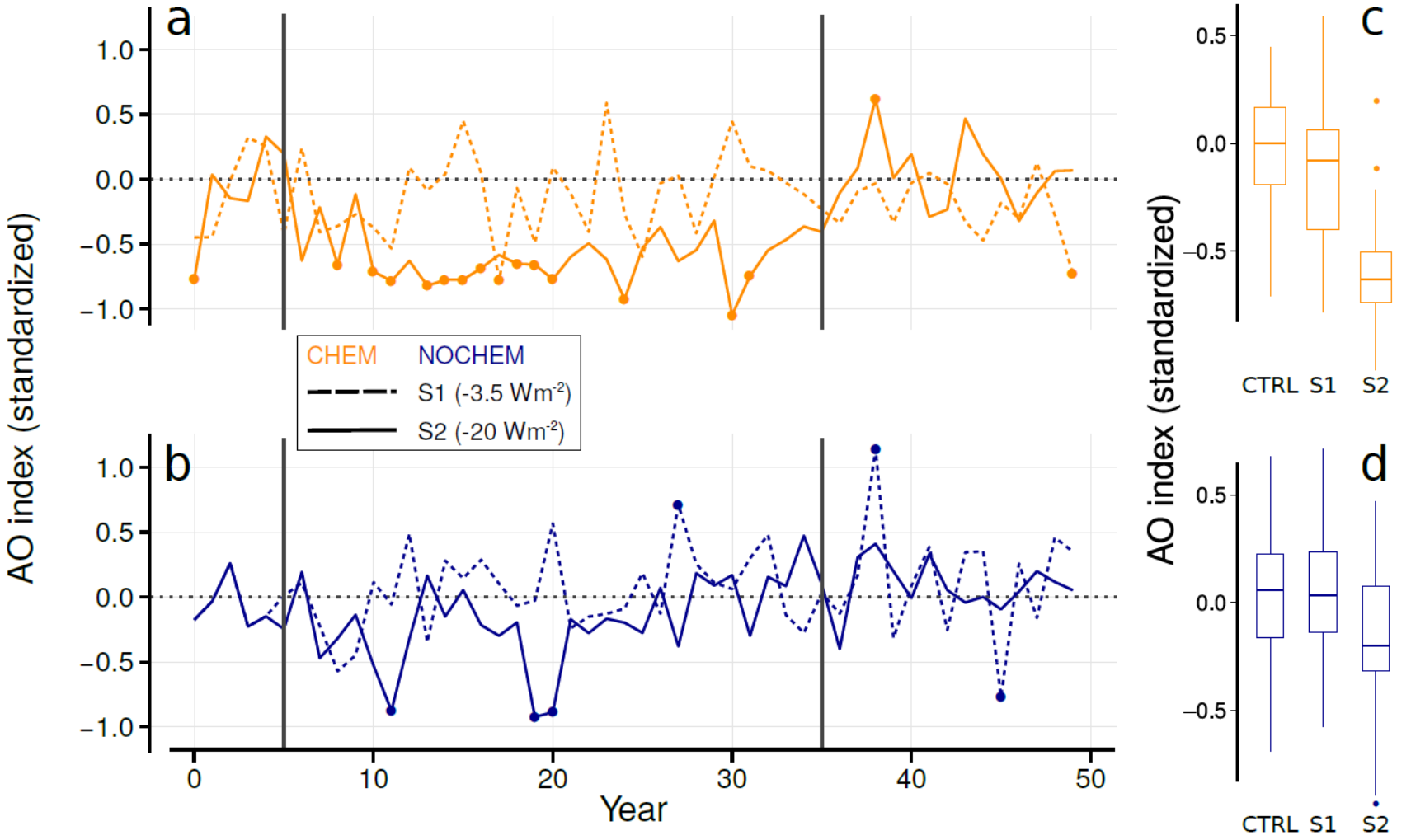
Dynamical effect

Mechanism of solar influence to AMOC



Dynamical effect

AO index



Dynamical effect

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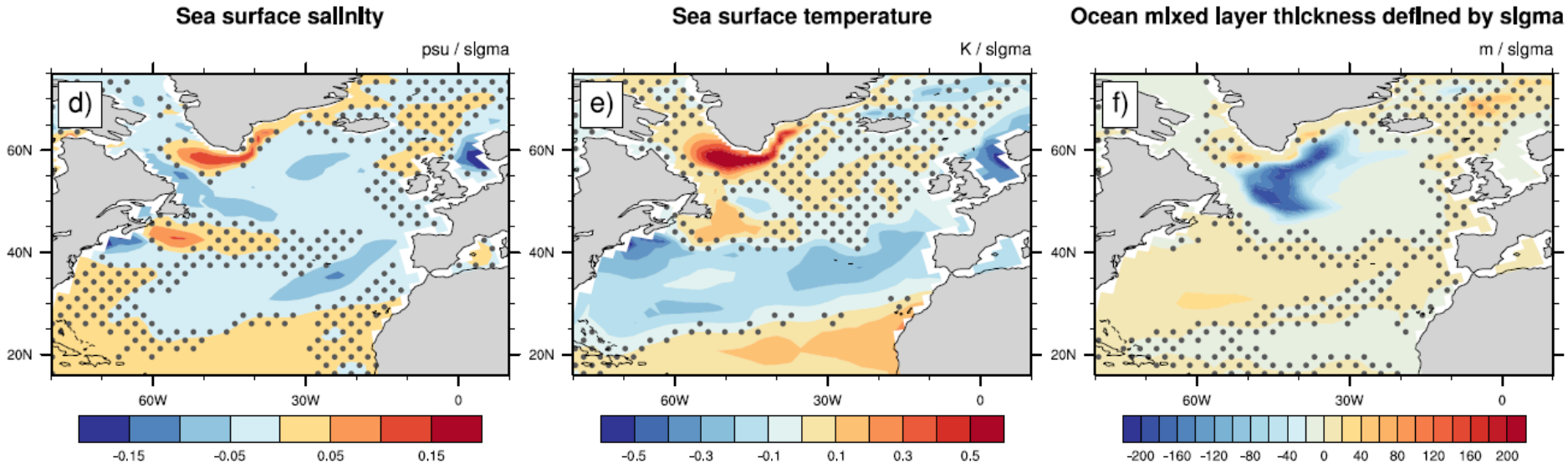
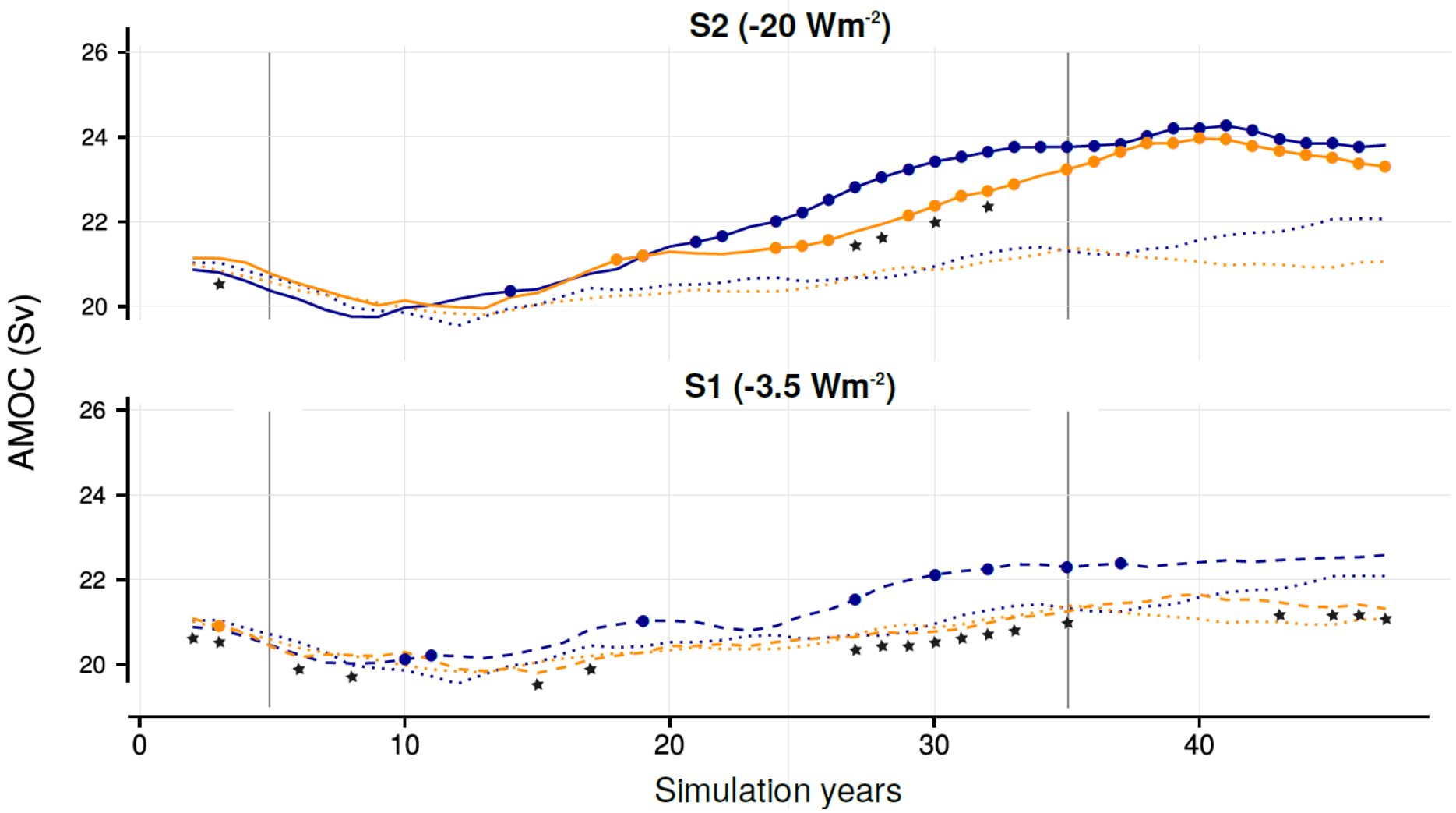
Influence of AO index during winter (Nov. – Mar.) on

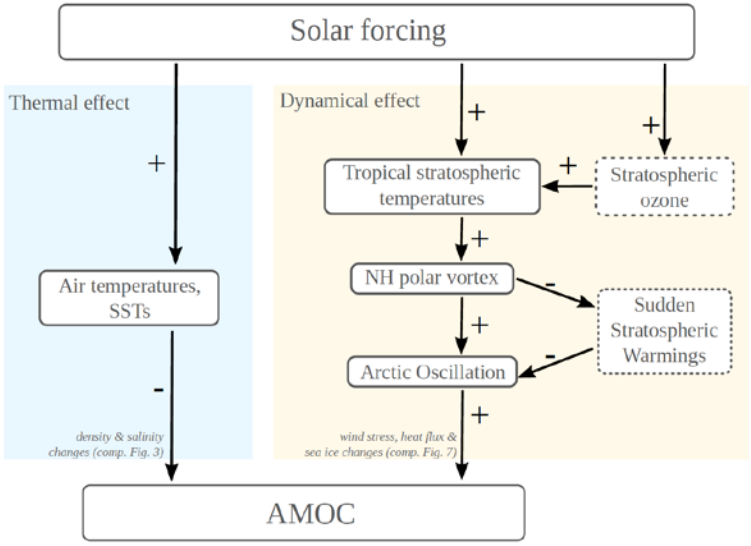


AMOC


S2 (-20 Wm-2)
S1 (-3.5 Wm-2)
AMOC (Sv)
26
24
22
20
0
10
20
30
40
Simulation years

Summary

- ✓ Solar forcing has an impact on ocean circulation
  - ✓ Thermal direct effect:
    Neg. TSI leads to positive AMOC
  - ✓ Dynamical effect involving stratosphere-troposphere interaction:
    Neg. TSI leads to neg. AO and this to neg. AMOC



- ✓ Atmospheric chemistry **enhance** the dynamical effect.

- ➢ **Models without atmospheric chemistry overestimate the AMOC response to TSI changes**

Related publications

- AMOC response:

  Muthers, S., C. C. Raible, E. Rozanov, and T. F. Stocker 2016: Response of the overturning to solar forcing and the modulating role of atmospheric chemistry. *Earth System dynamics*, **revised**.

- Stratopsheric age of air:

  Muthers, S., A. Kuchar, A. Stenke, J. Schmitt, C. C. Raible, and T. F. Stocker, 2016: Stratospheric age of air variations between 1600-2100. *Geophys. Res. Lett.*, **43** 5409--5418.

- Volcanic effect:

  Muthers, S., F. Arfeuille, C. C. Raible, and E. Rozanov 2015: The impact of volcanic aerosols on stratospheric ozone and the Northern Hemisphere polar vortex: Separating radiative from chemical effects. *Atmos. Chem. Phys.*, **15**, 11461-11476.

Dynamical effect

Mechanism of solar influence to AMOC