The tropical impacts of projected Arctic and Antarctic sea ice loss

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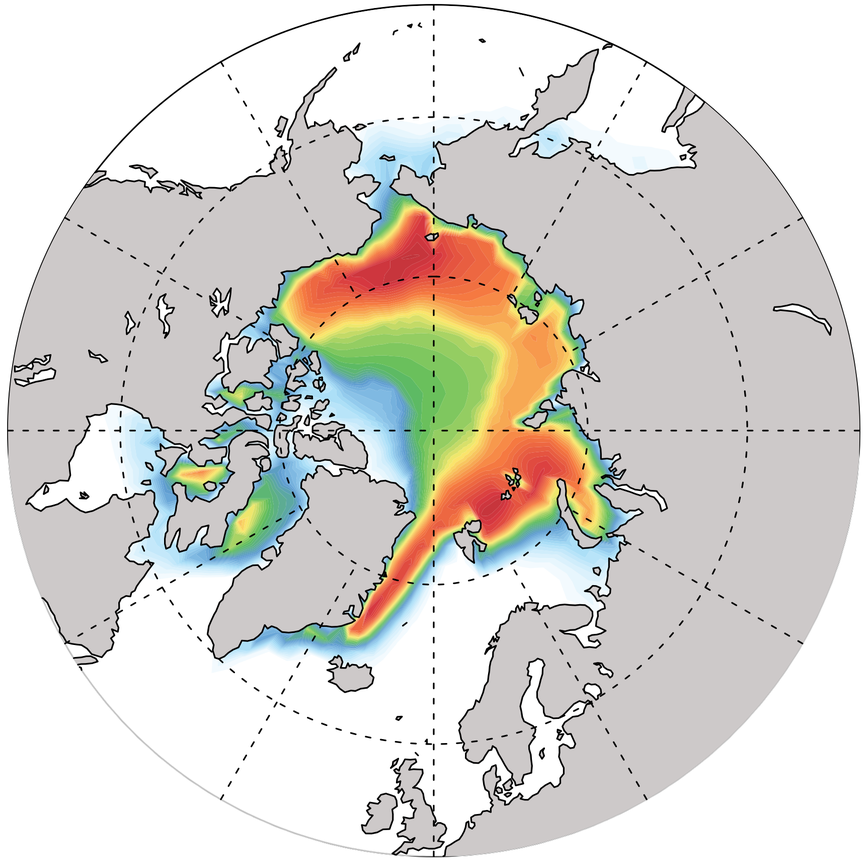
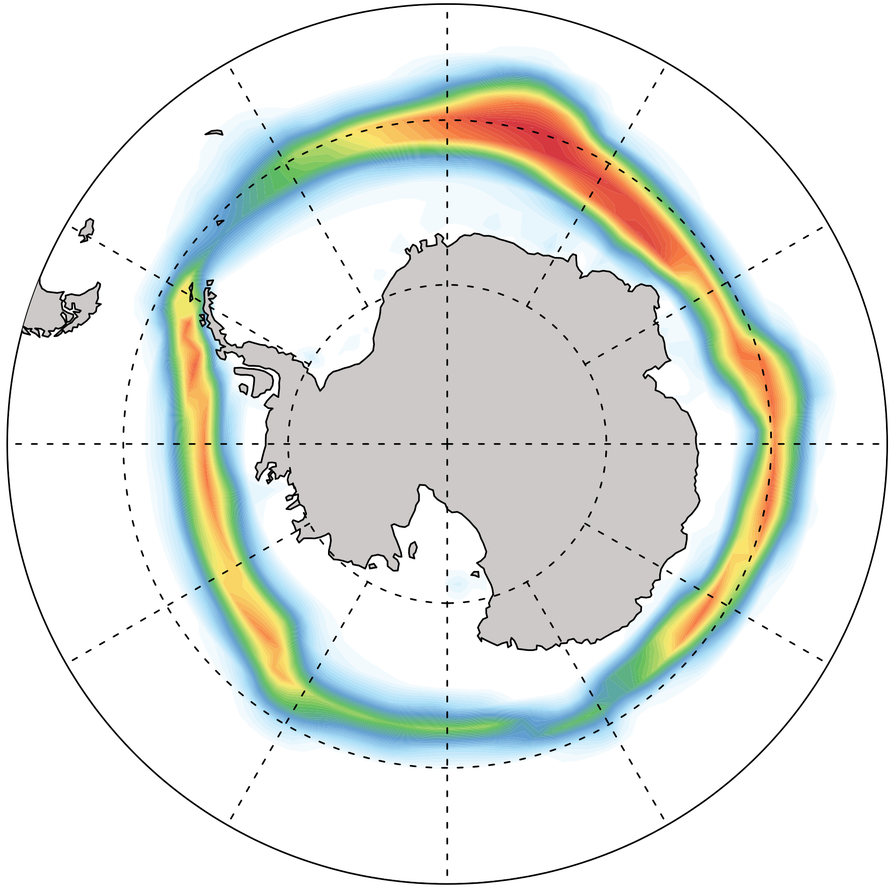
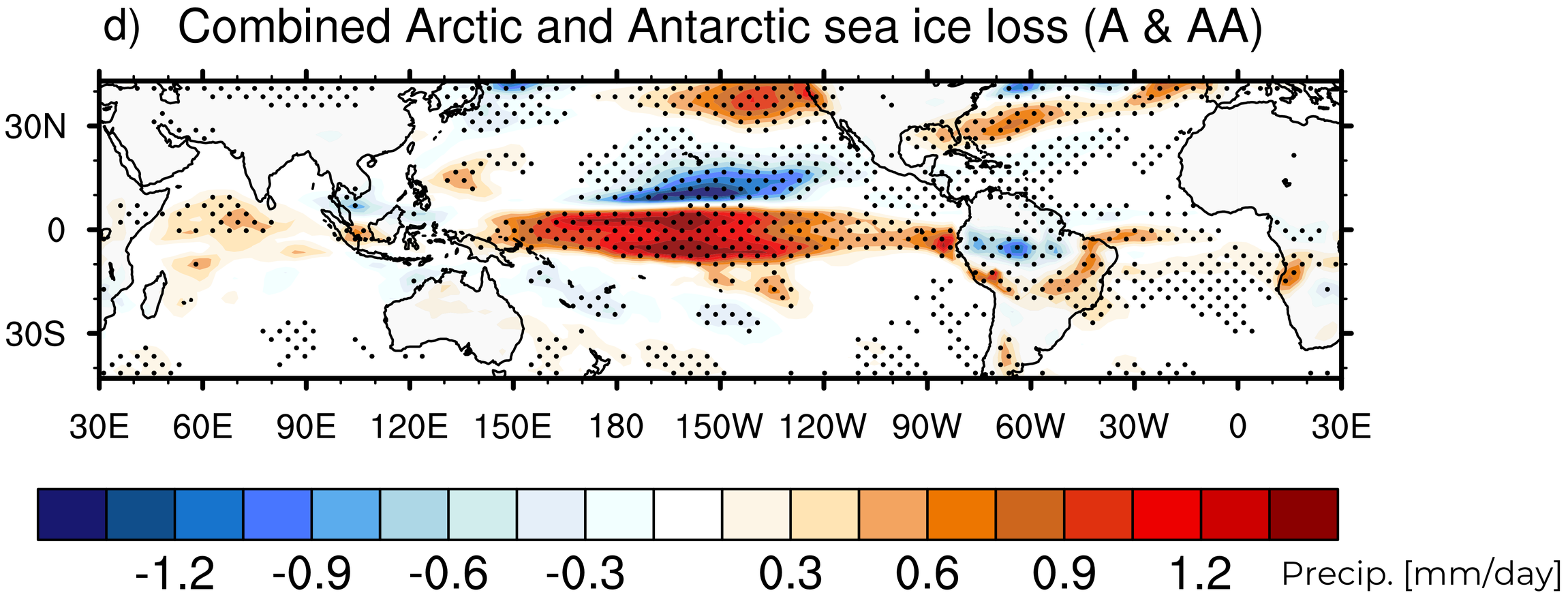
IN THE CITY OF NEW YORK

The Arctic is only half the story

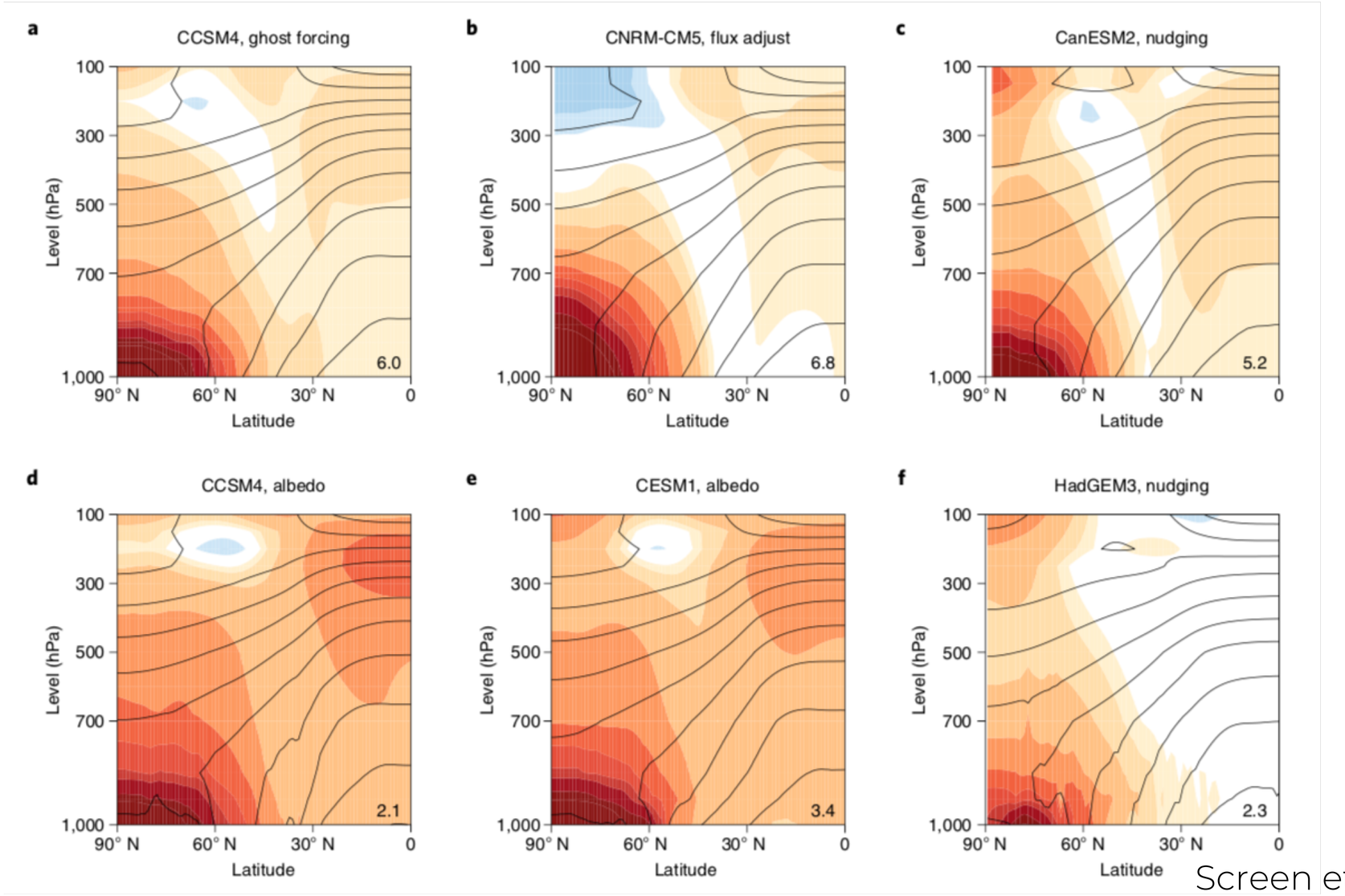




Both Arctic and Antarctic sea ice loss will have important tropical impacts

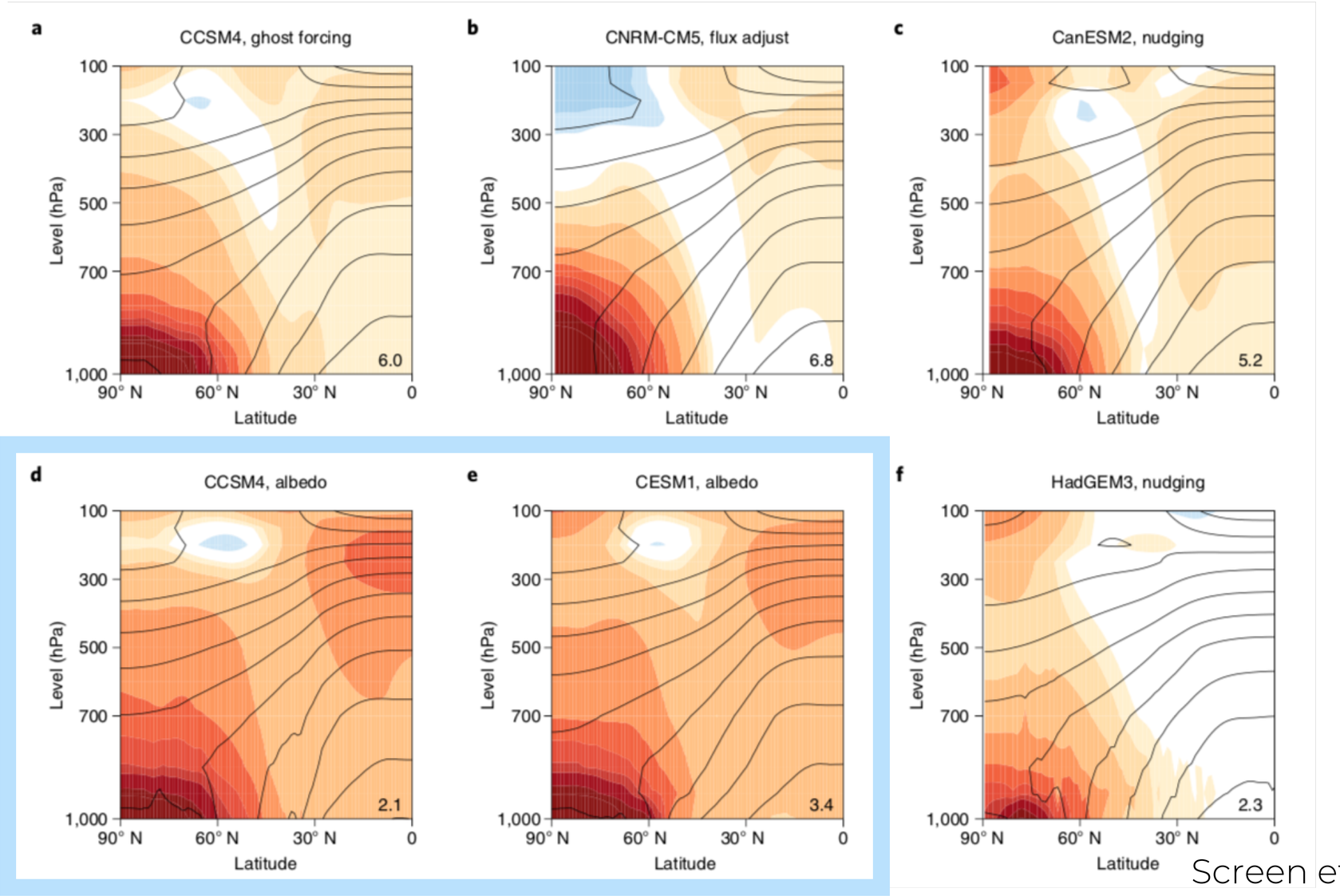


Motivation



Screen et al., 2018 [Nat. Geosci.]

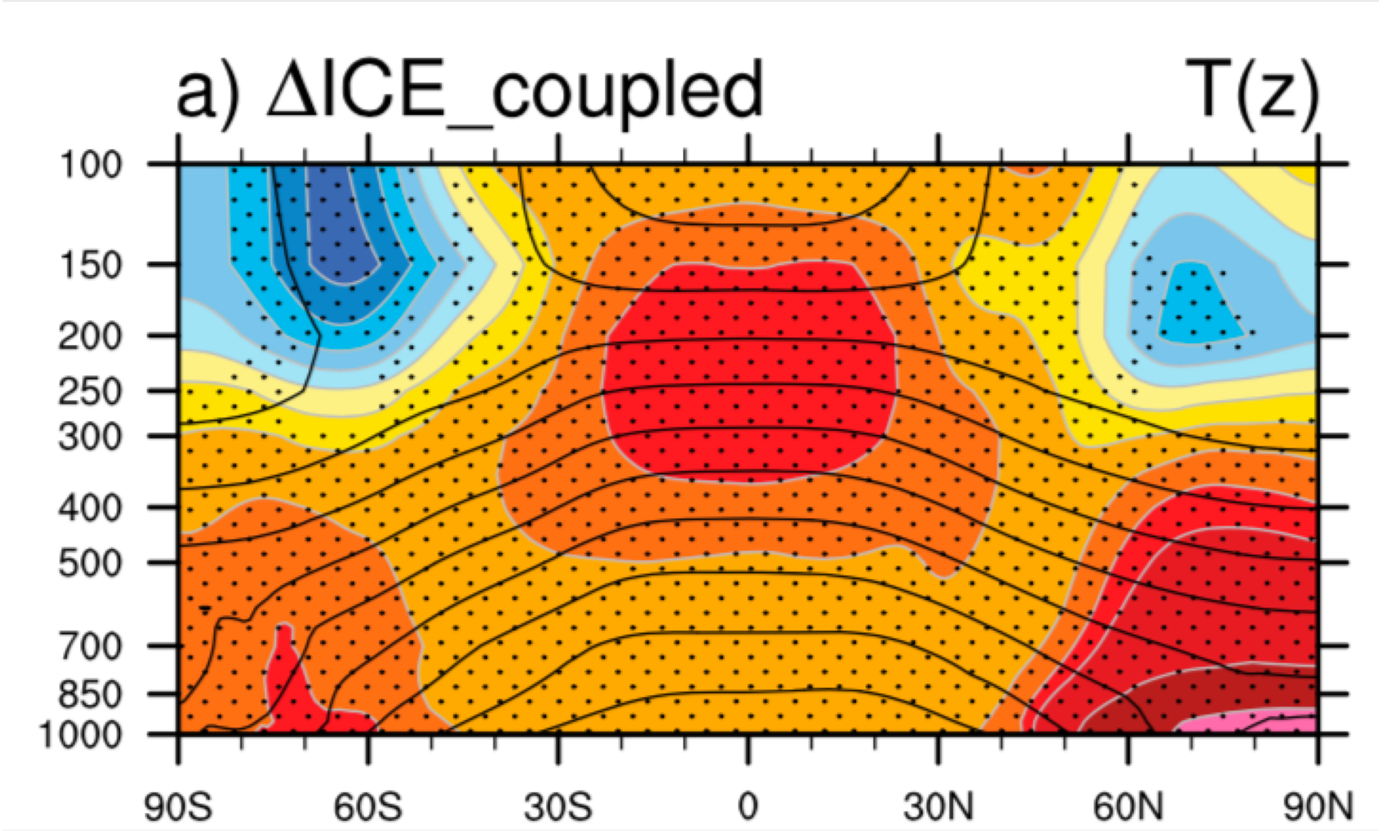
Motivation



Screen et al., 2018 [Nat. Geosci.]

Tropical impacts of Arctic sea ice loss

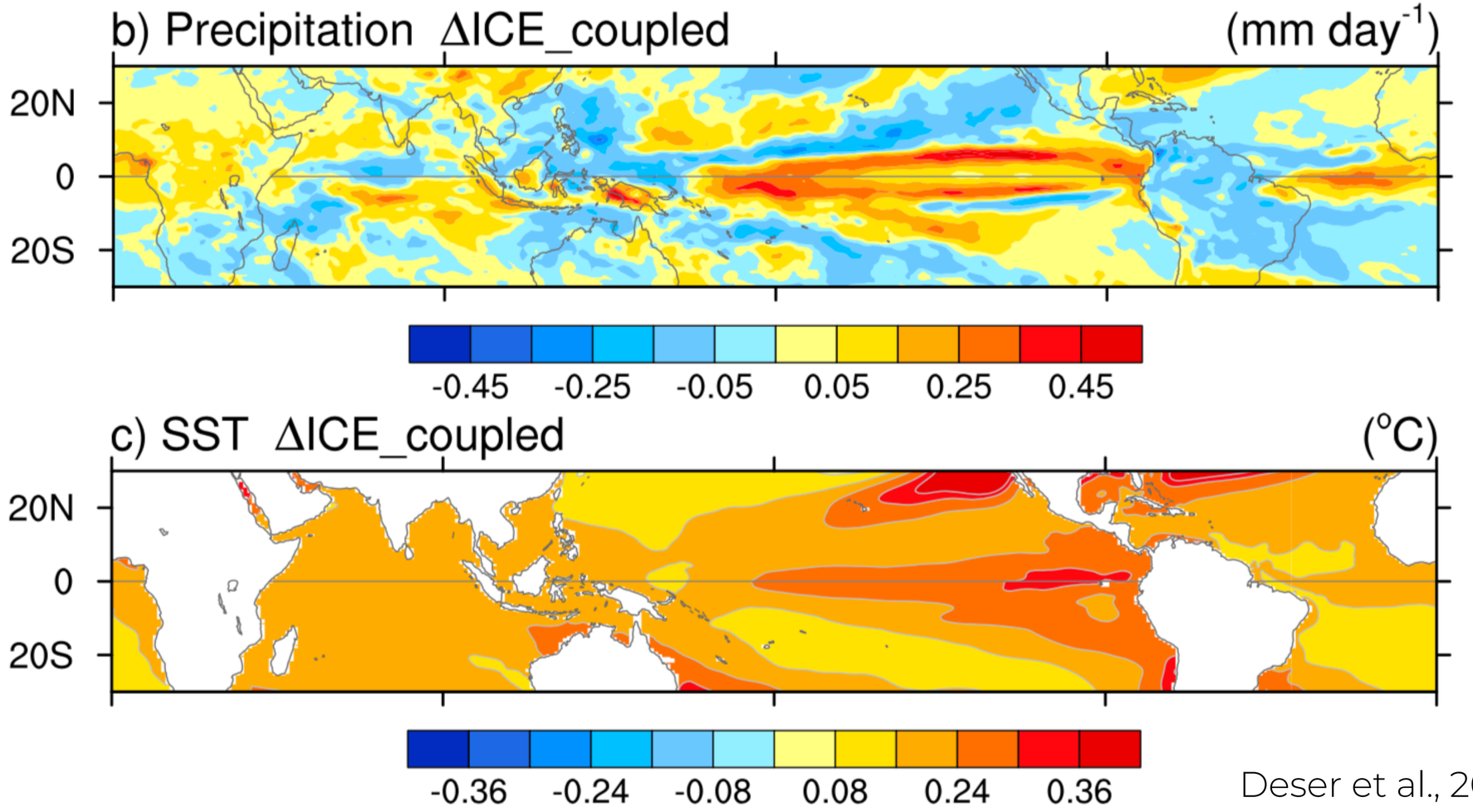
- Projected Arctic sea ice loss shown to have important global effects ('mini global warming signal')



Deser et al., 2015 [J. Climate]

Tropical impacts of Arctic sea ice loss

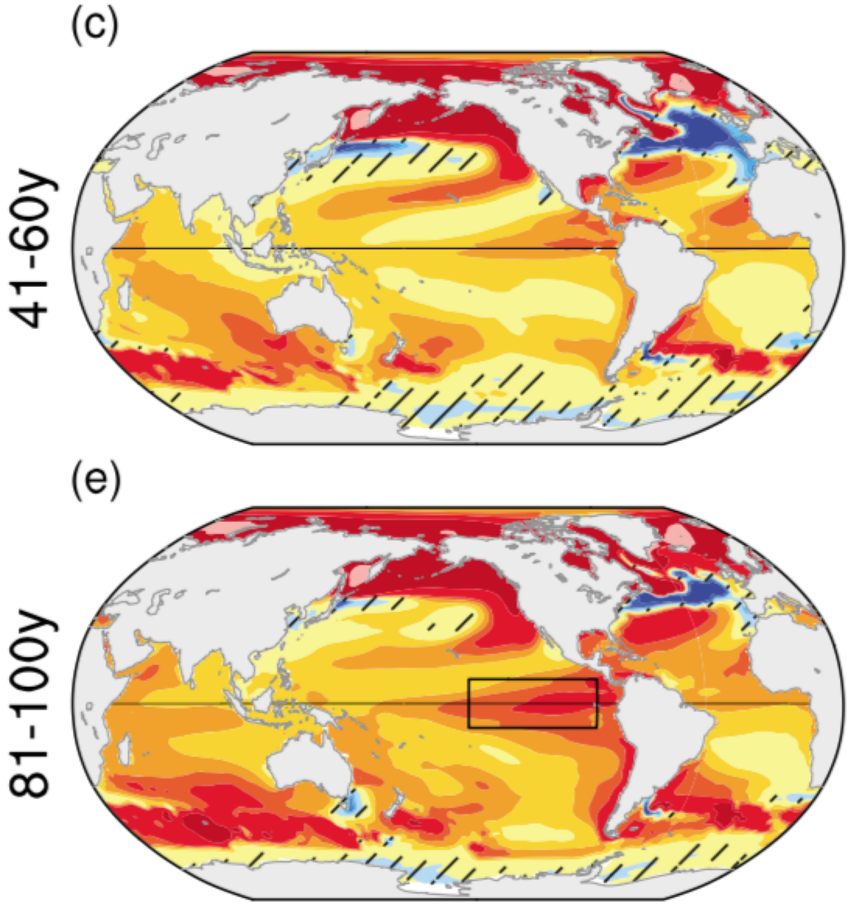
- There is a clear tropical response to projected Arctic sea ice loss



Deser et al., 2015 [J. Climate]

Tropical impacts of Arctic sea ice loss

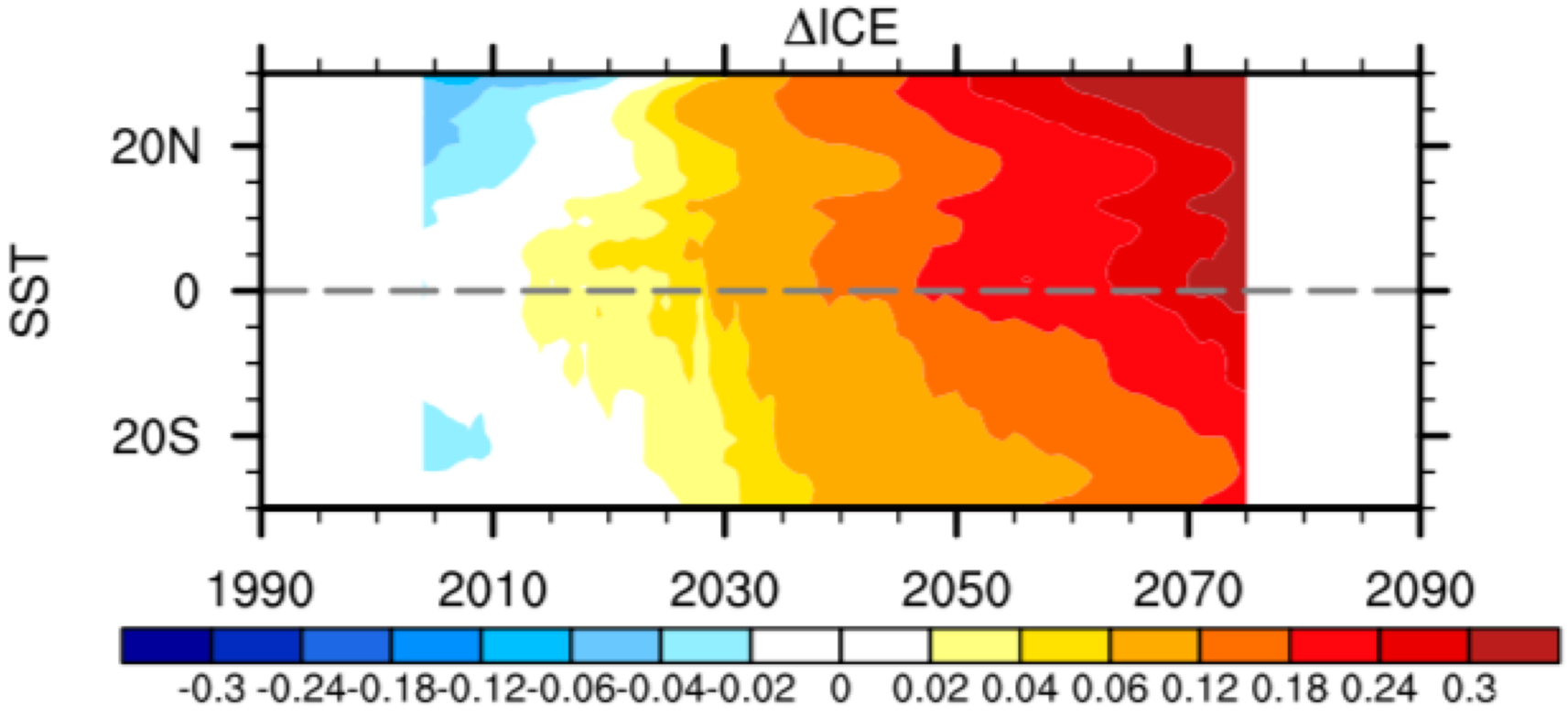
- This tropical response emerges after a large instantaneous amount of Arctic sea ice loss after ~30 years.



Wang et al., 2018 [GRL]

Tropical impacts of Arctic sea ice loss

- When realistic, transient Arctic sea ice loss is imposed, the tropical response is still robust but takes longer to detect.



Sun et al., 2018 [J. Climate]

Aims

Address the following questions:

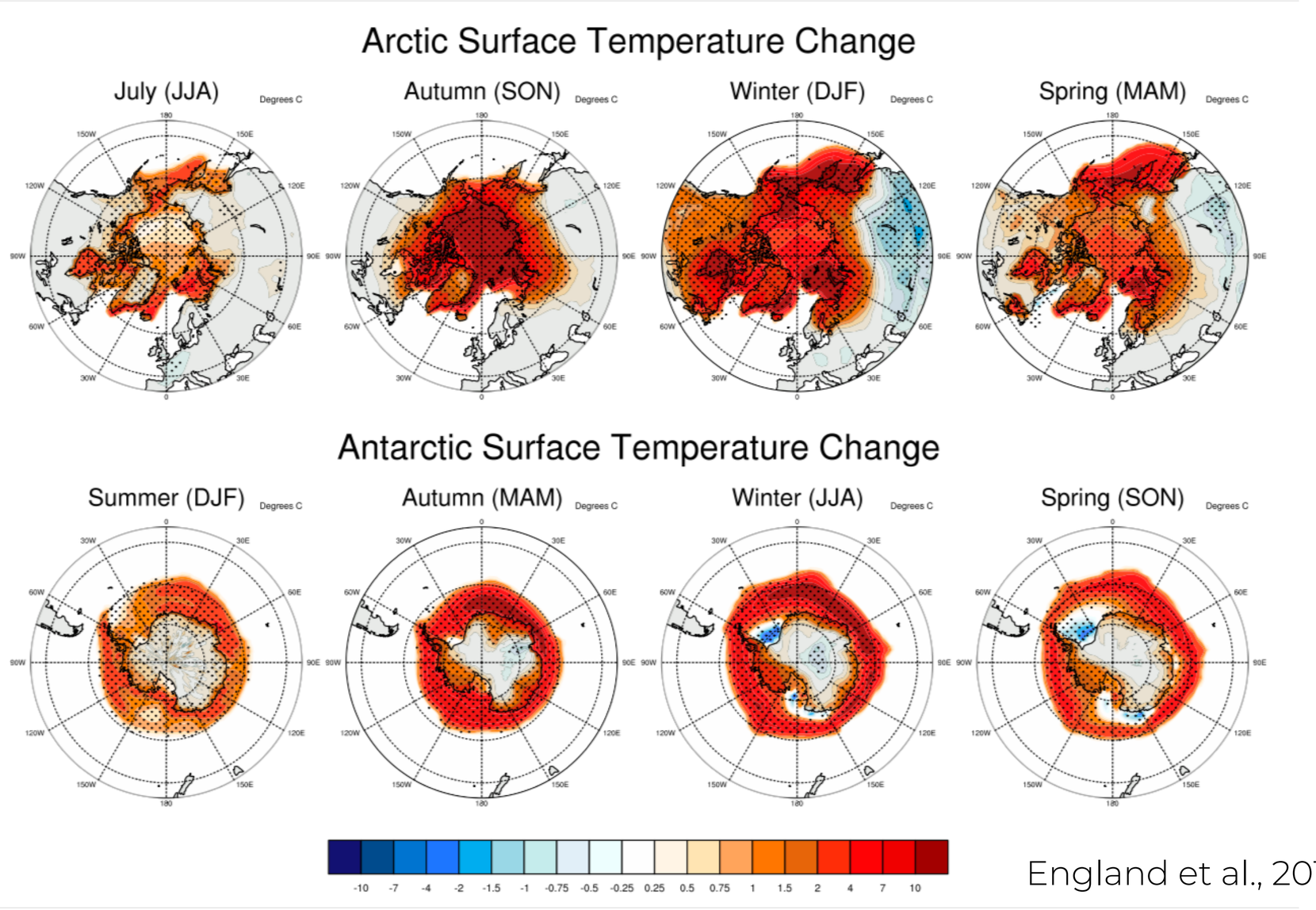
- Is there an important tropical response to Antarctic sea ice loss?
- If so, does it reinforce or weaken the tropical response to Arctic sea ice loss?

Previous work

- Atmosphere-only runs with WACCM to investigate the effect of projected end of the century Arctic and Antarctic sea ice loss
- Without ocean coupling, response is limited to mid- and high-latitudes.

England, M., L. Polvani, and L. Sun (2018), Contrasting the Antarctic and Arctic atmospheric response to projected sea ice loss in the late 21st Century, *Journal of Climate*, **31**, 6353-6370, doi: 10.1175/JCLI-D-17-0666.1

Previous work



England et al., 2018 [J. Climate]

Model

Community Earth System Model (CESM)
Whole Atmosphere Community Climate Model (WACCM):

- High top model which participated in CMIP5
- Simulates climatological Arctic and Antarctic sea ice conditions well
- Ran in fully coupled mode
- 2° by 2.5° horizontal resolution
- 66 vertical levels with model lid extending up to lower thermosphere

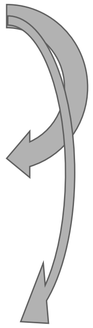
Experimental setup

- Perform four time-slice experiments, each for 350 years, discarding first 100 years
- Target future sea ice conditions averaged from three members of WACCM run out to 2100 under RCP 8.5 conditions.
- Sea ice is perturbed using the ghost forcing method (see Deser et al., 2015 [*J. Climate*]; Tomas et al., 2016 [*J. Climate*]; Screen et al., 2018 [*Nat. Geosci.*])
- All other forcings (CO_2, ODSs etc.) are kept at 1955 values.

Experiments

Atmosphere-only runs

Experiment	Arctic	Antarctic	Years
Control	1955-69	1955-69	150
Melt Arctic	2085-99	1955-69	150
Melt Antarctic	1955-69	2085-99	150



$\Delta Arctic$

$\Delta Antarctic$

England et al., 2018 [*J. Climate*]

Experiments

Atmosphere-only runs

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Control	1955-69	1955-69	150
Melt Arctic	2085-99	1955-69	150
Melt Antarctic	1955-69	2085-99	150

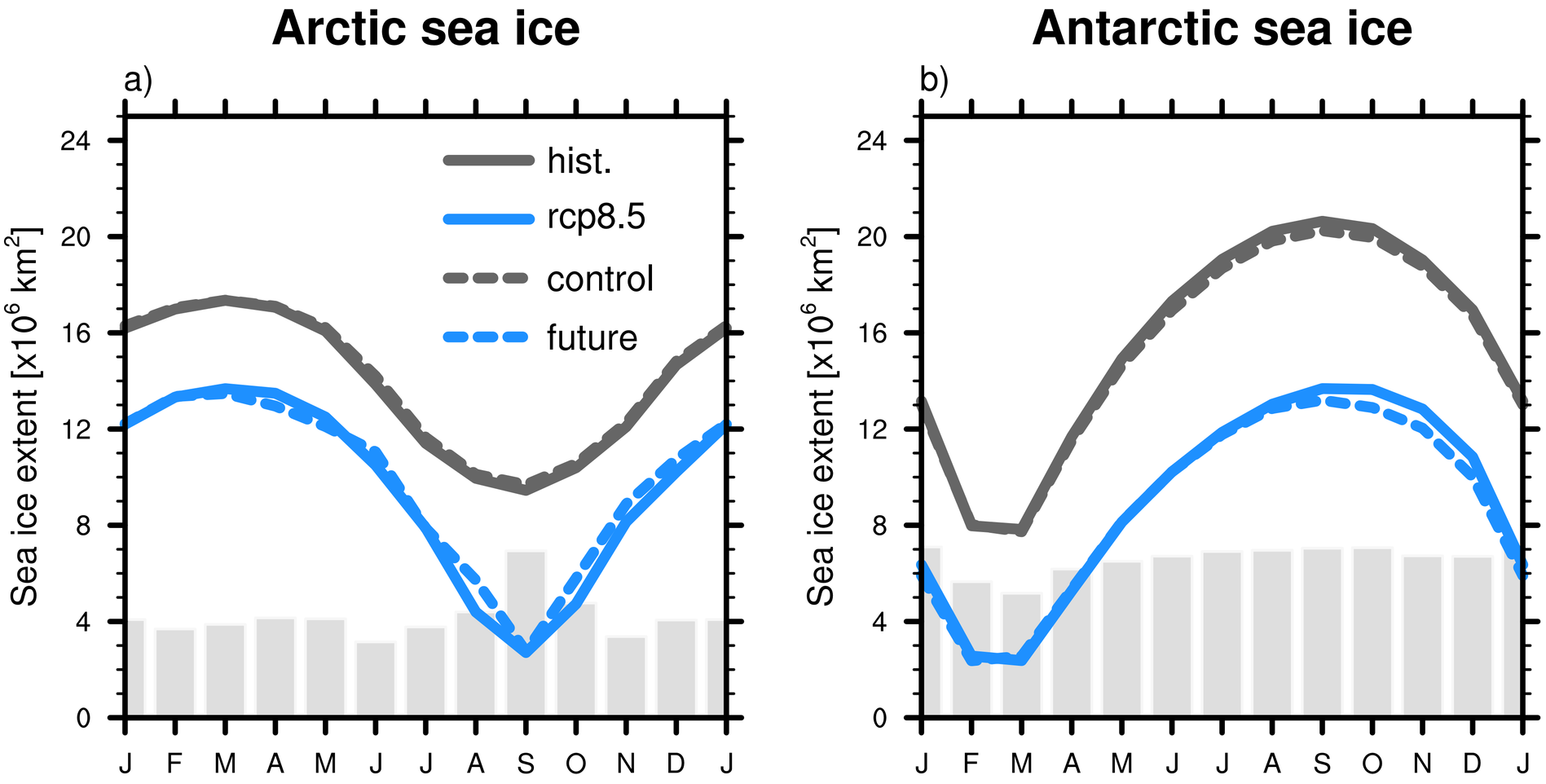
England et al., 2018 [*J. Climate*]

Fully coupled runs

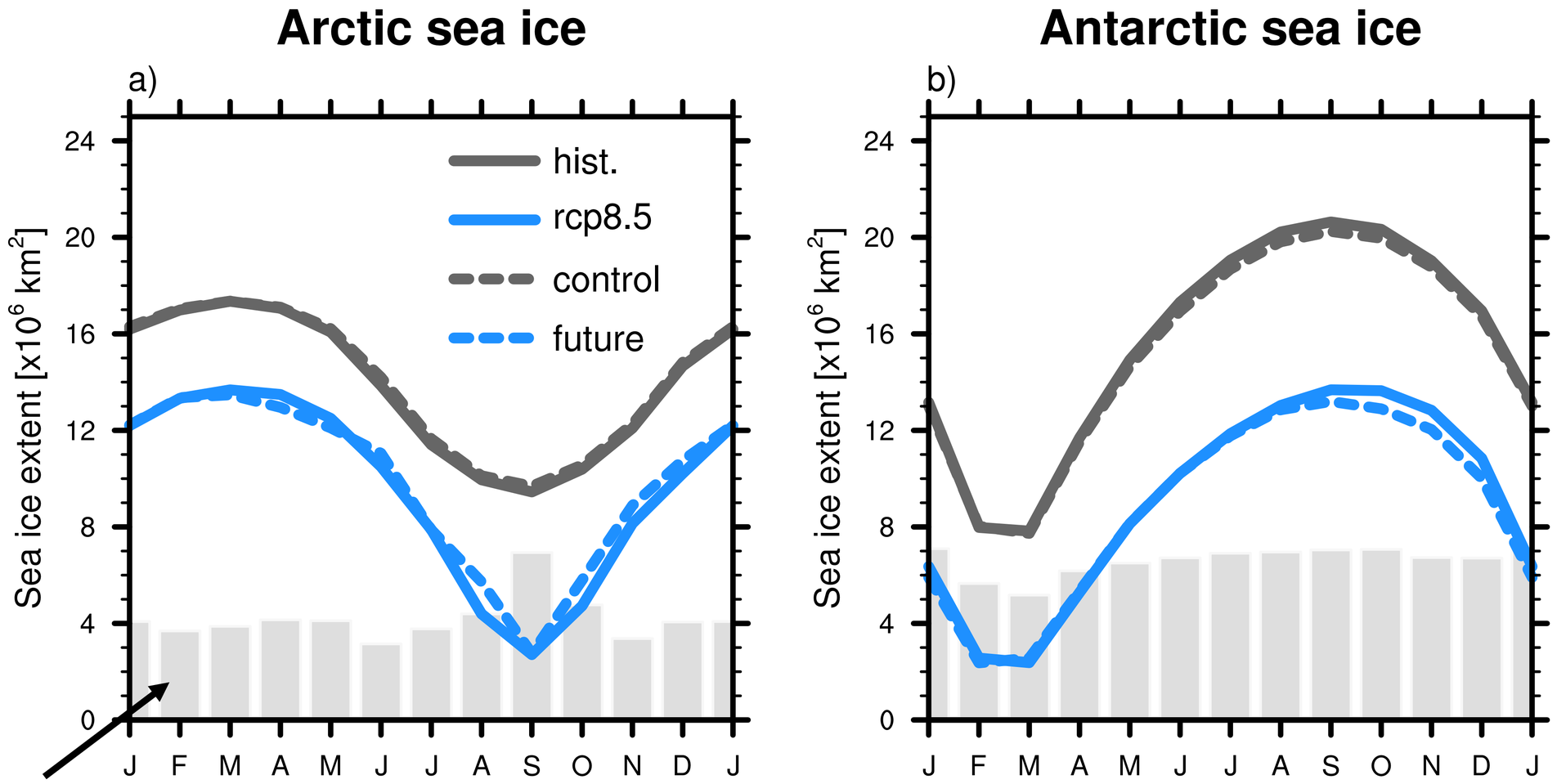
Experiment	Arctic	Antarctic	Years
Control	1955-69	1955-69	250
Melt Arctic	2085-99	1955-69	250
Melt Antarctic	1955-69	2085-99	250
Melt both	2085-99	2085-99	250

England et al., [*in prep*]

Sea ice loss


Arctic sea ice
a)
Sea ice extent [x10^6 km^2]
24
20
16
12
8
4
0
hist.
rcp8.5
control
future
J F M A M J J A S O N D J
Antarctic sea ice
b)
Sea ice extent [x10^6 km^2]
24
20
16
12
8
4
0
J F M A M J J A S O N D J

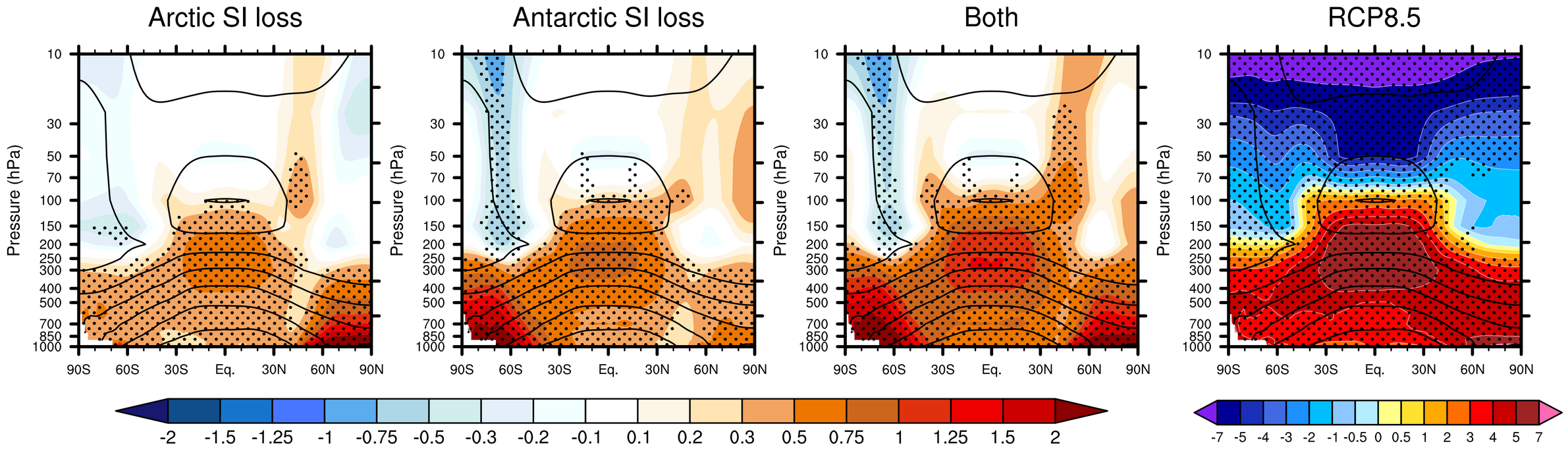
Sea ice loss



Sea ice loss

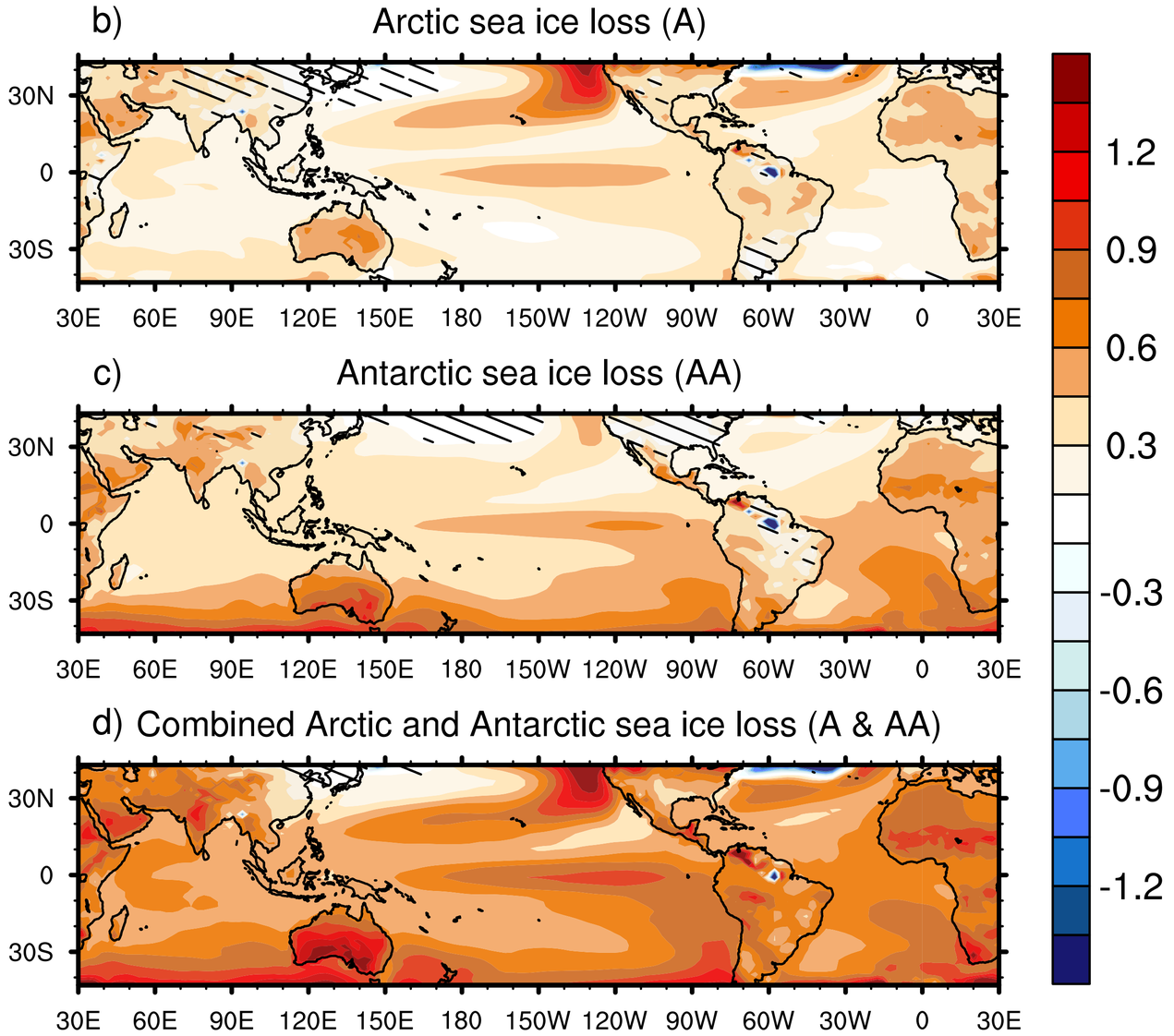
Temp. response

Annual mean temperature response



England et al., [*in prep*]

Temp. response



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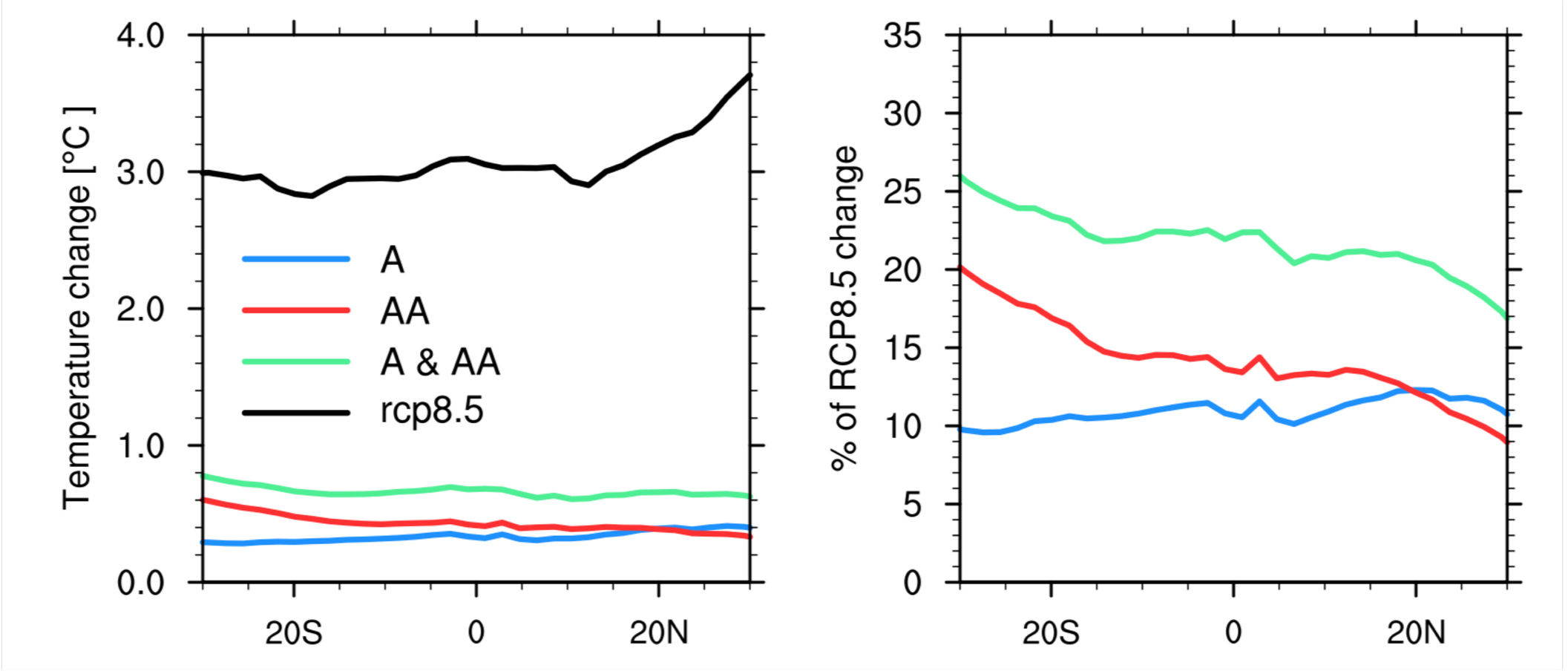
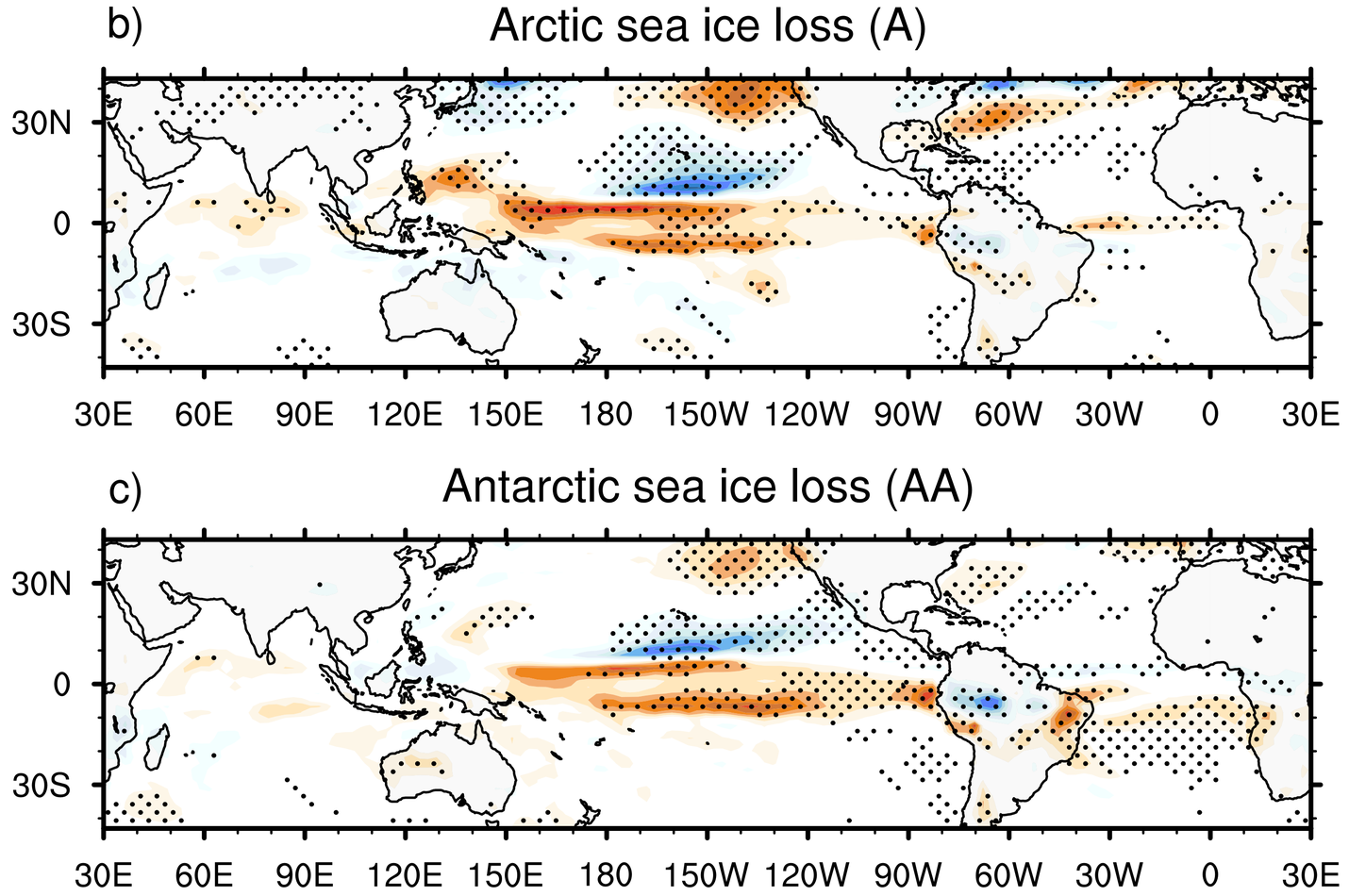
Temp. response



England et al., [*in prep*]

Precip. Response in DJF



England et al., [*in prep*]

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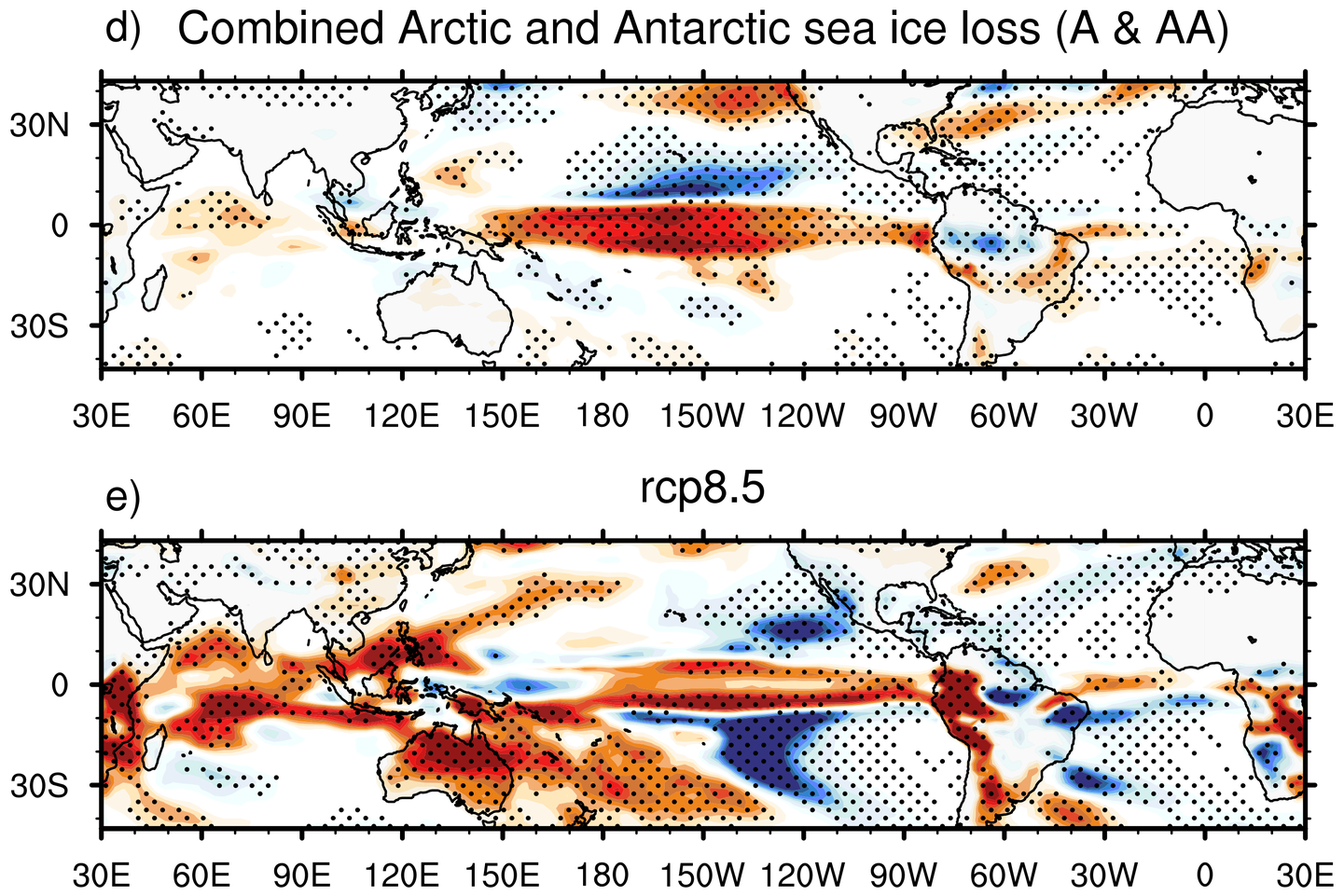
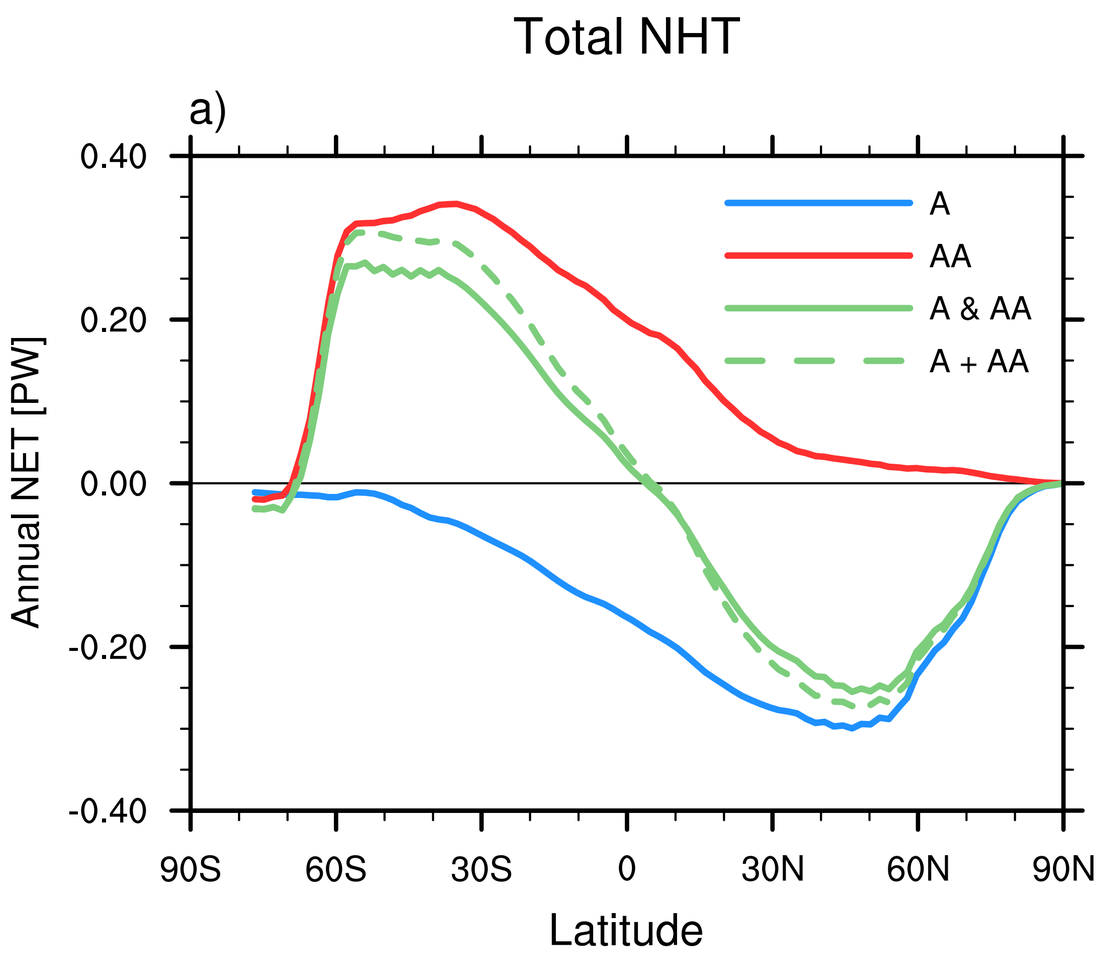
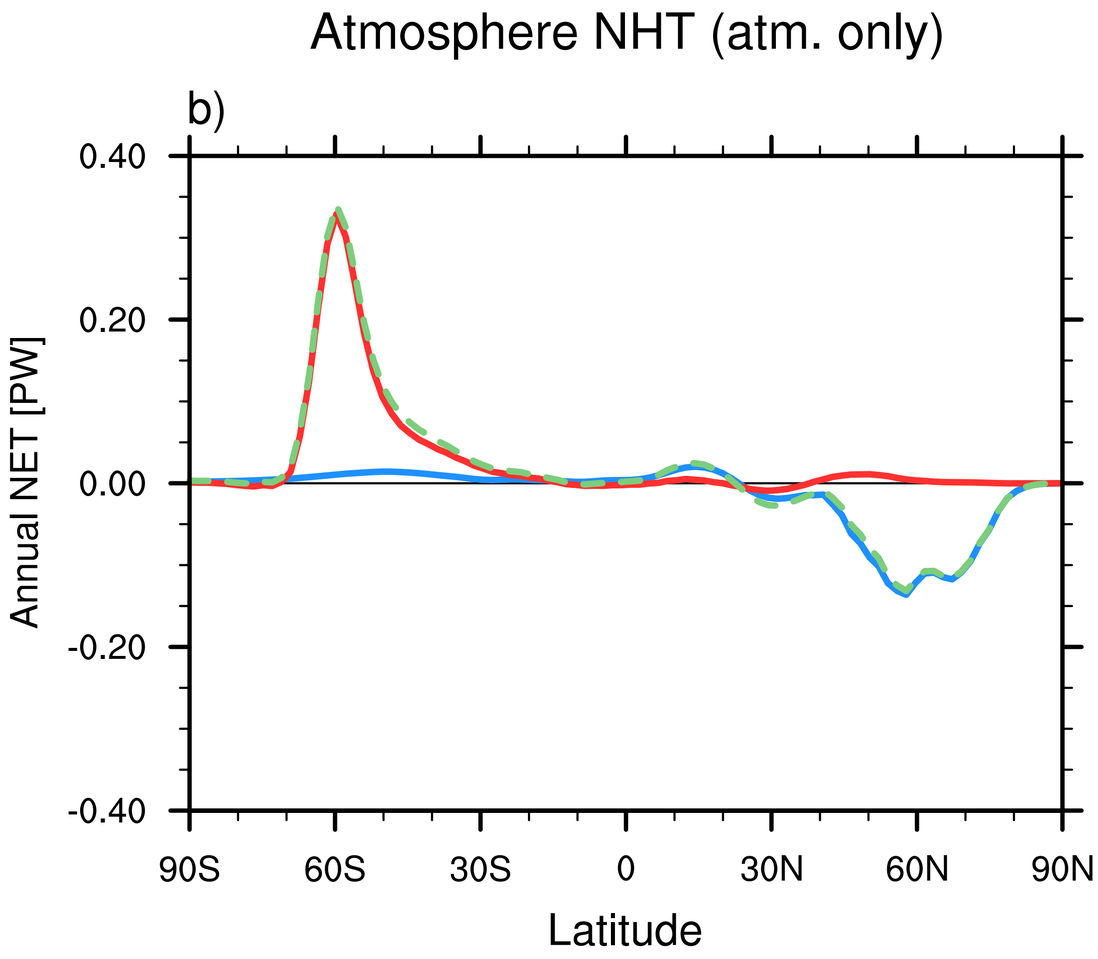


England et al., [*in prep*]

Northward Heat Transport





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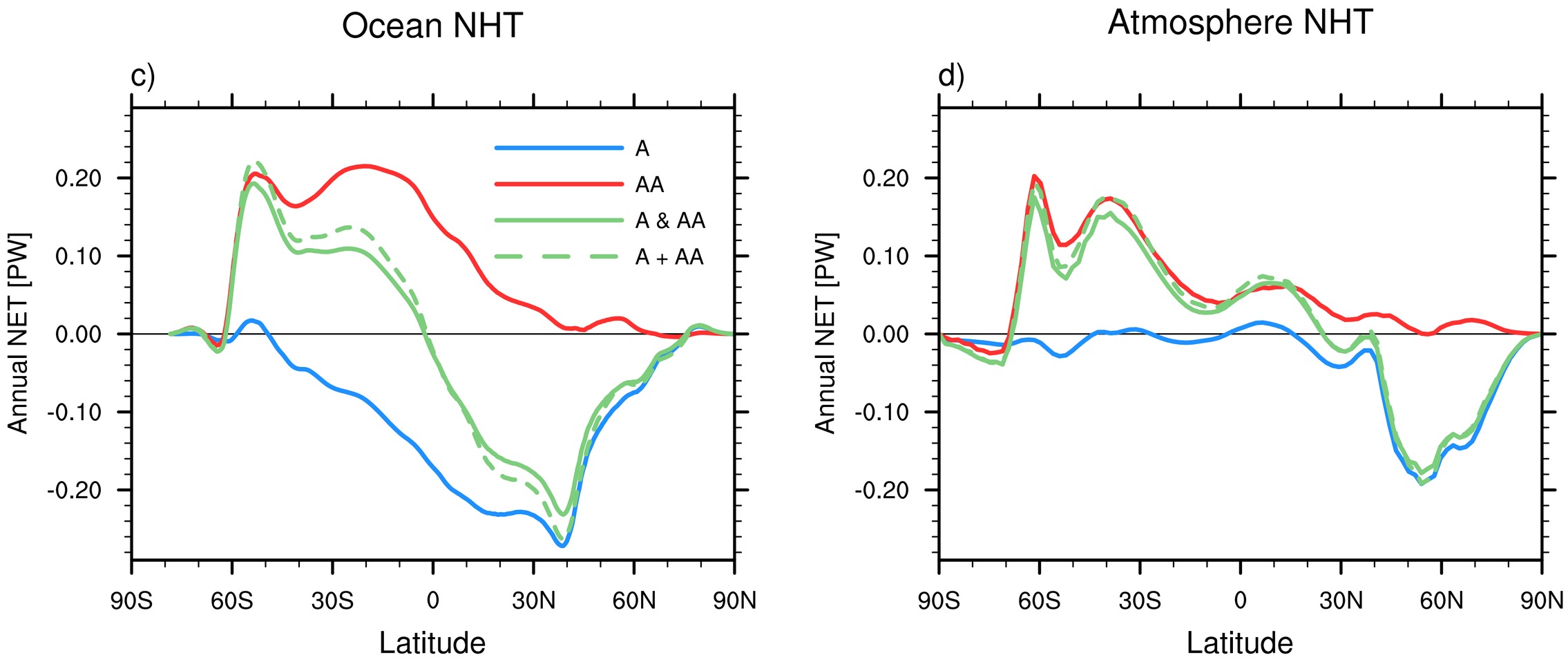


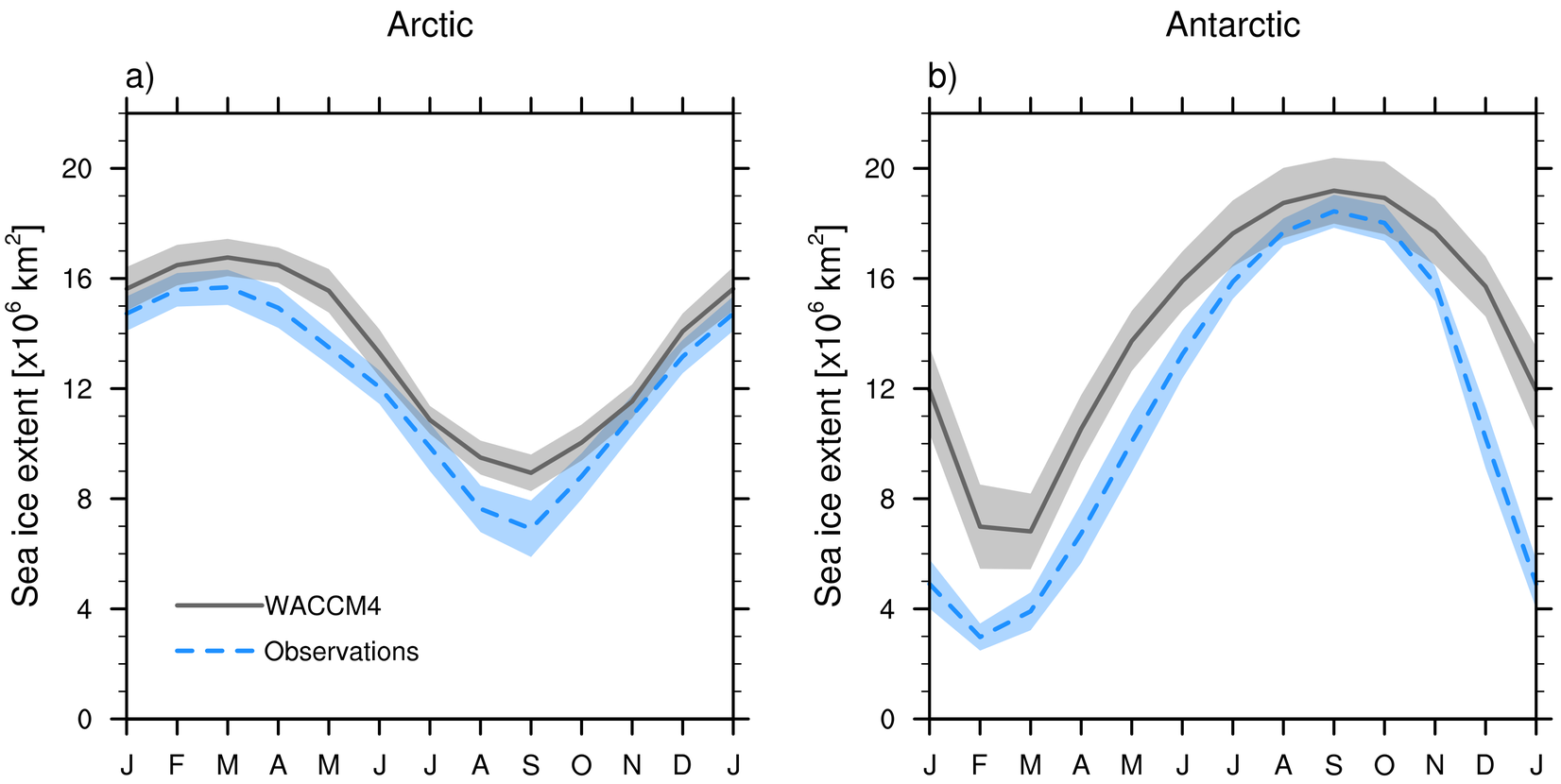
England et al., [*in prep*]

Summary

The tropical response to Antarctic sea ice loss is as large as the tropical response to Arctic sea ice loss.

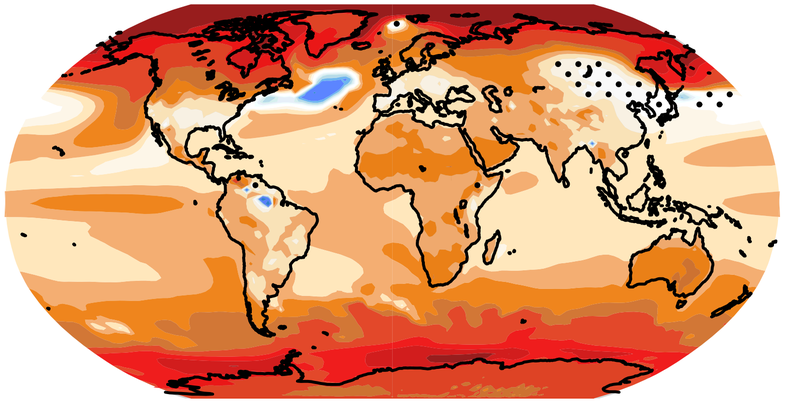
- Together, Arctic and Antarctic sea ice loss is ~ 25% of projected tropical surface temperature change and ~30% of precipitation change from RCP8.5
- The response to Antarctic sea ice loss is remarkably similar to the response to Arctic sea ice loss.
- The signal from the poles is mostly carried to the tropics by the ocean. Interestingly Antarctic sea ice loss, but not Arctic sea ice loss, causes some cross-equatorial atmospheric energy transport.

Sea ice climatology

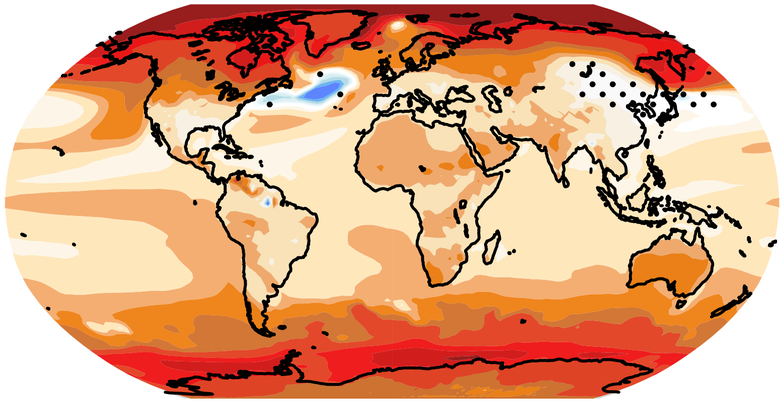


Additivity?

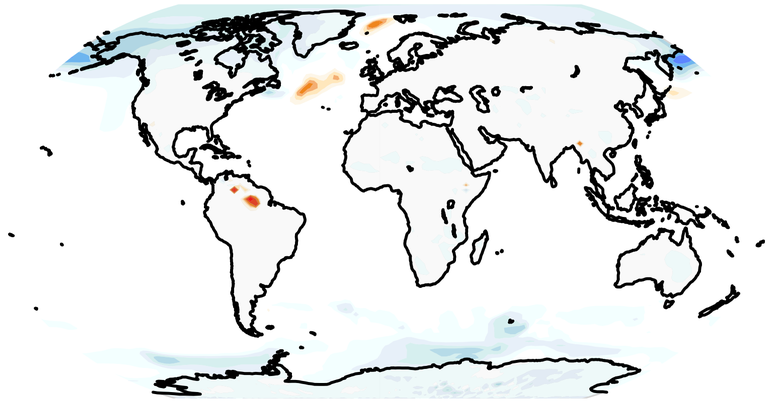
Additive

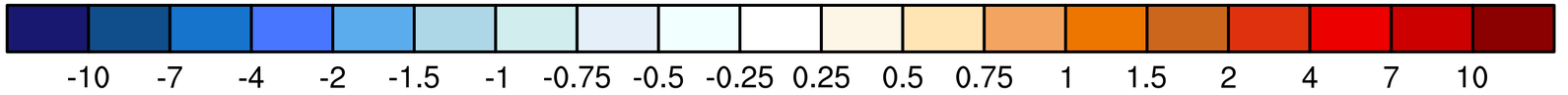


Full run



Error





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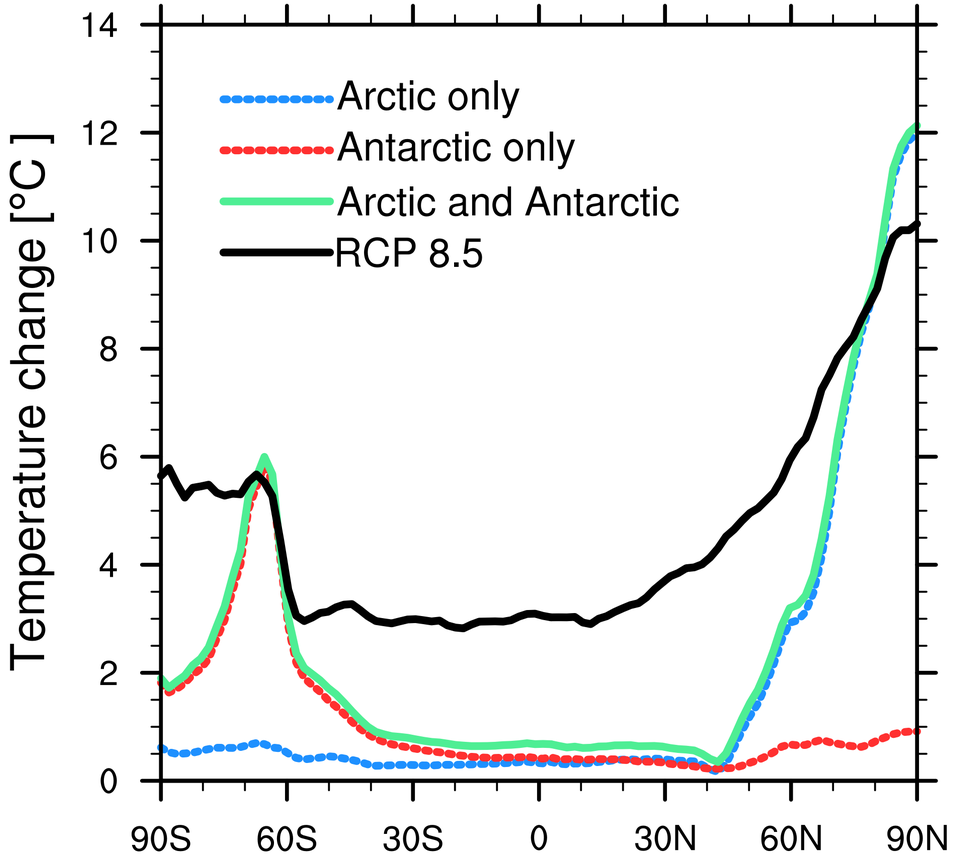
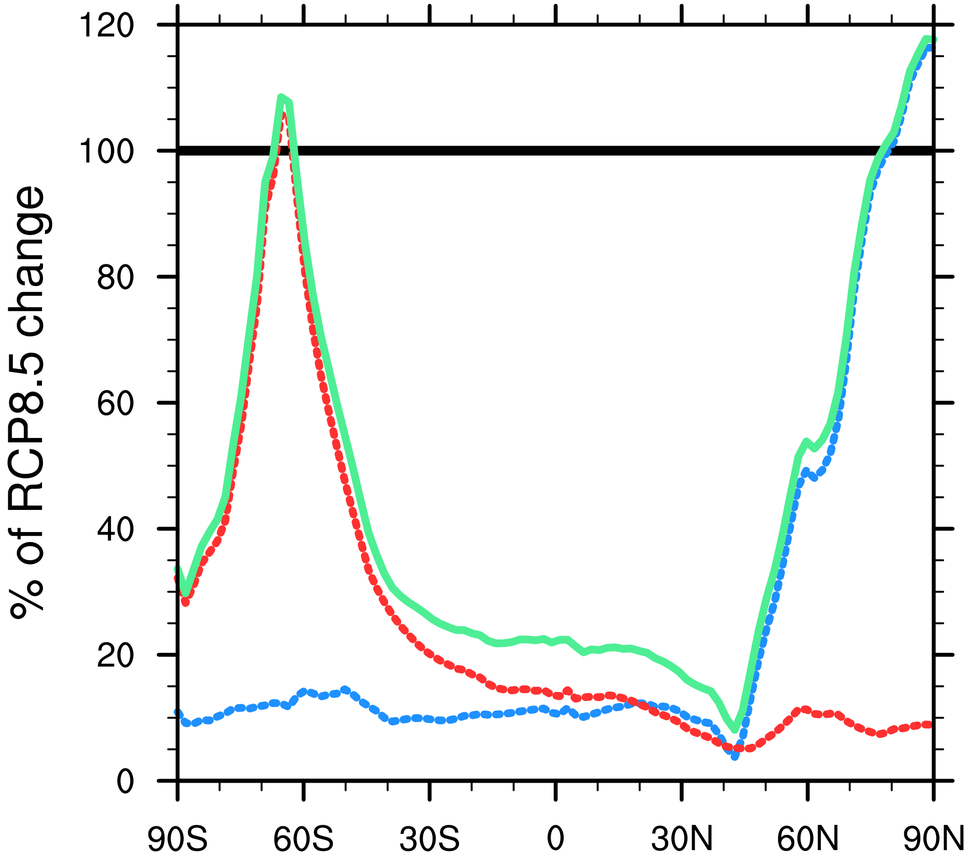
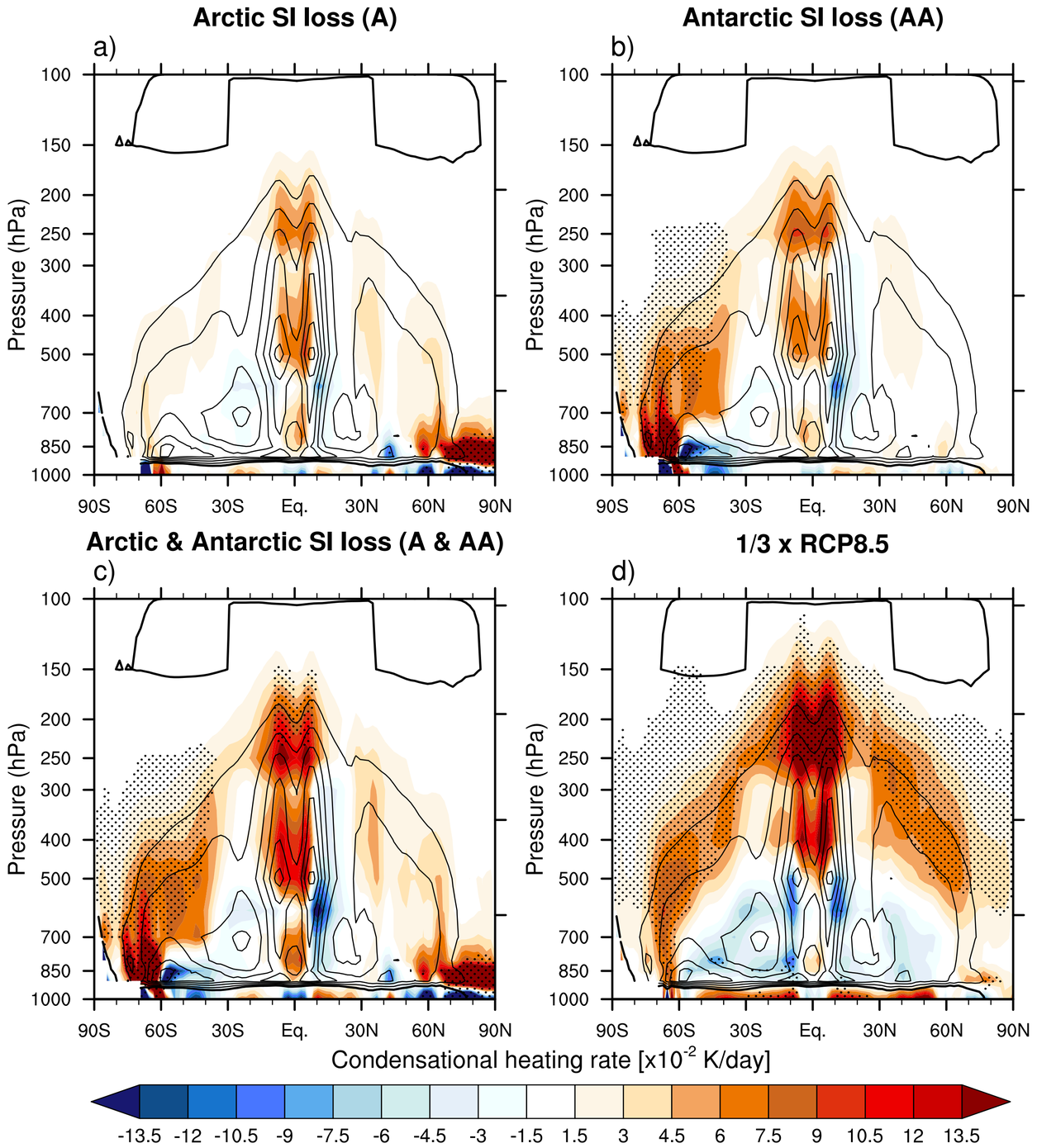
Temp. response







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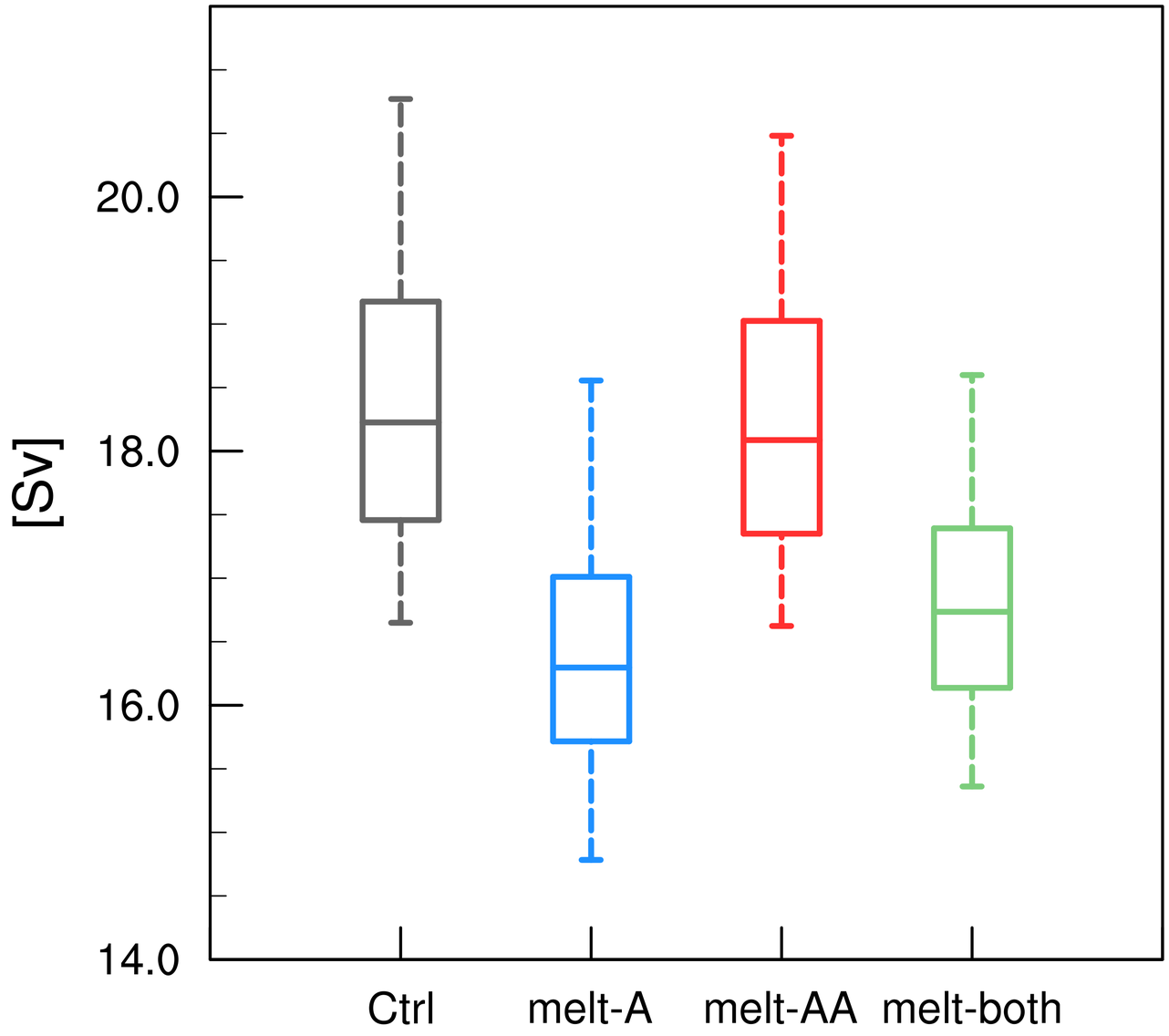
AMOC strength



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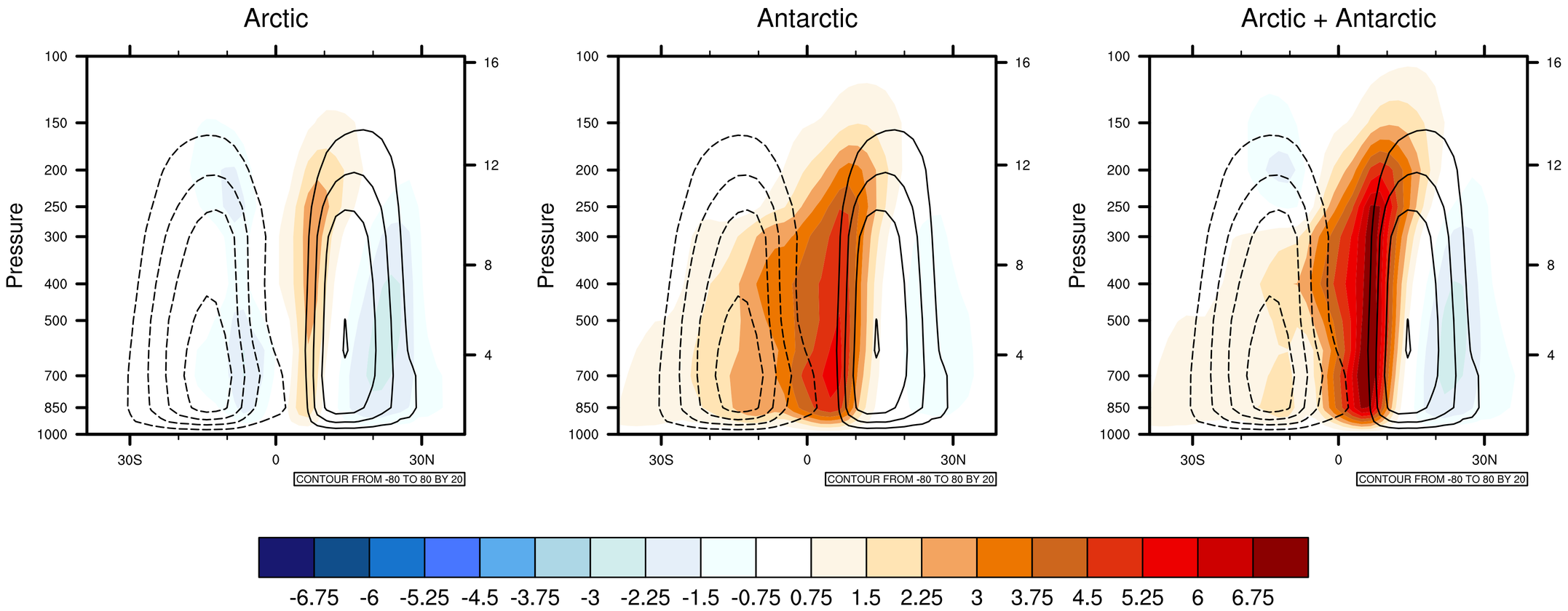

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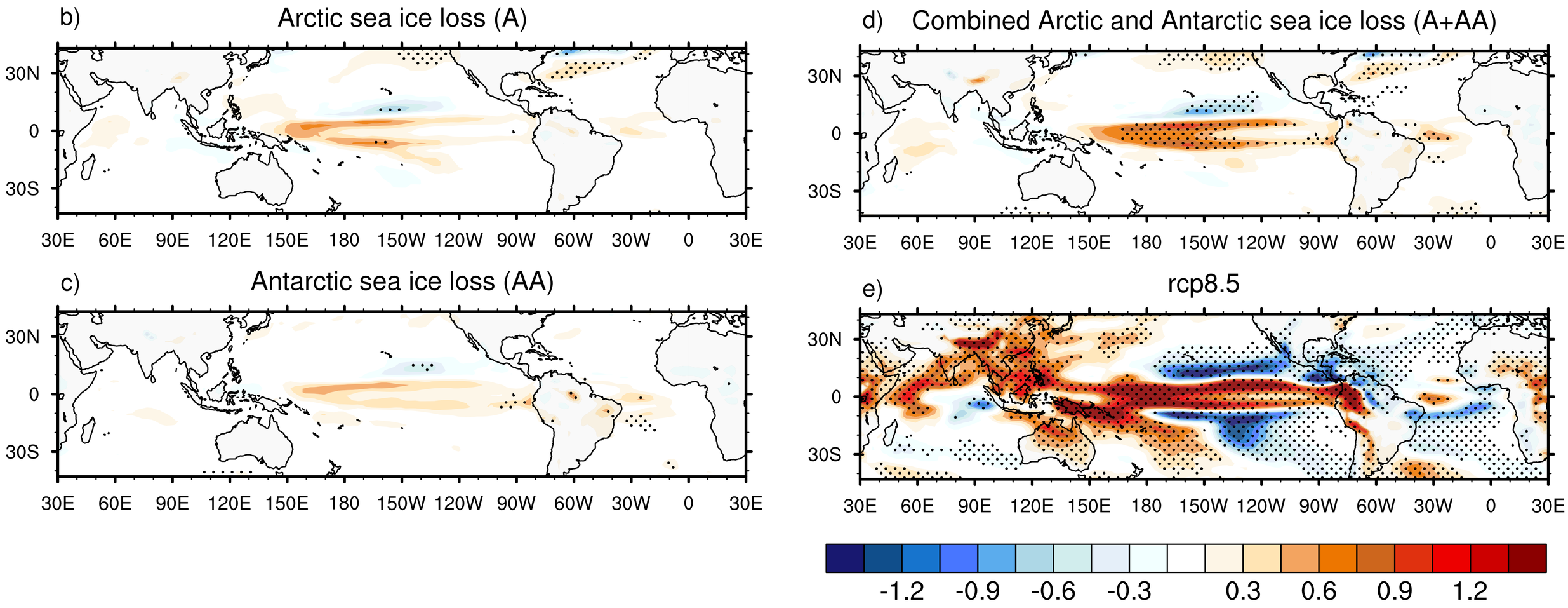

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