Antarctic Ice Sheet discharge drives large scale, long-term Southern Ocean changes

Tessa Gorte (she/her/hers)

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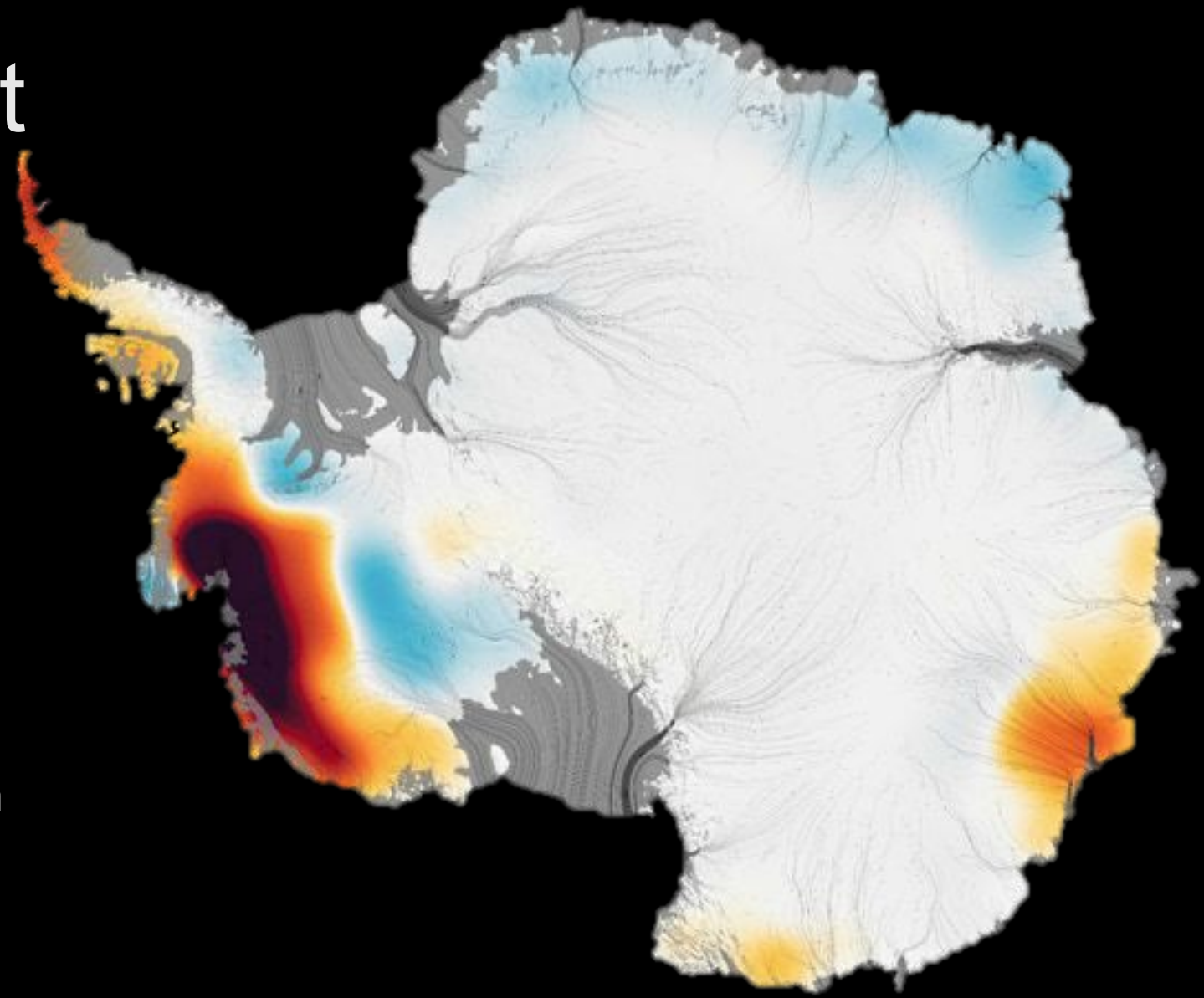
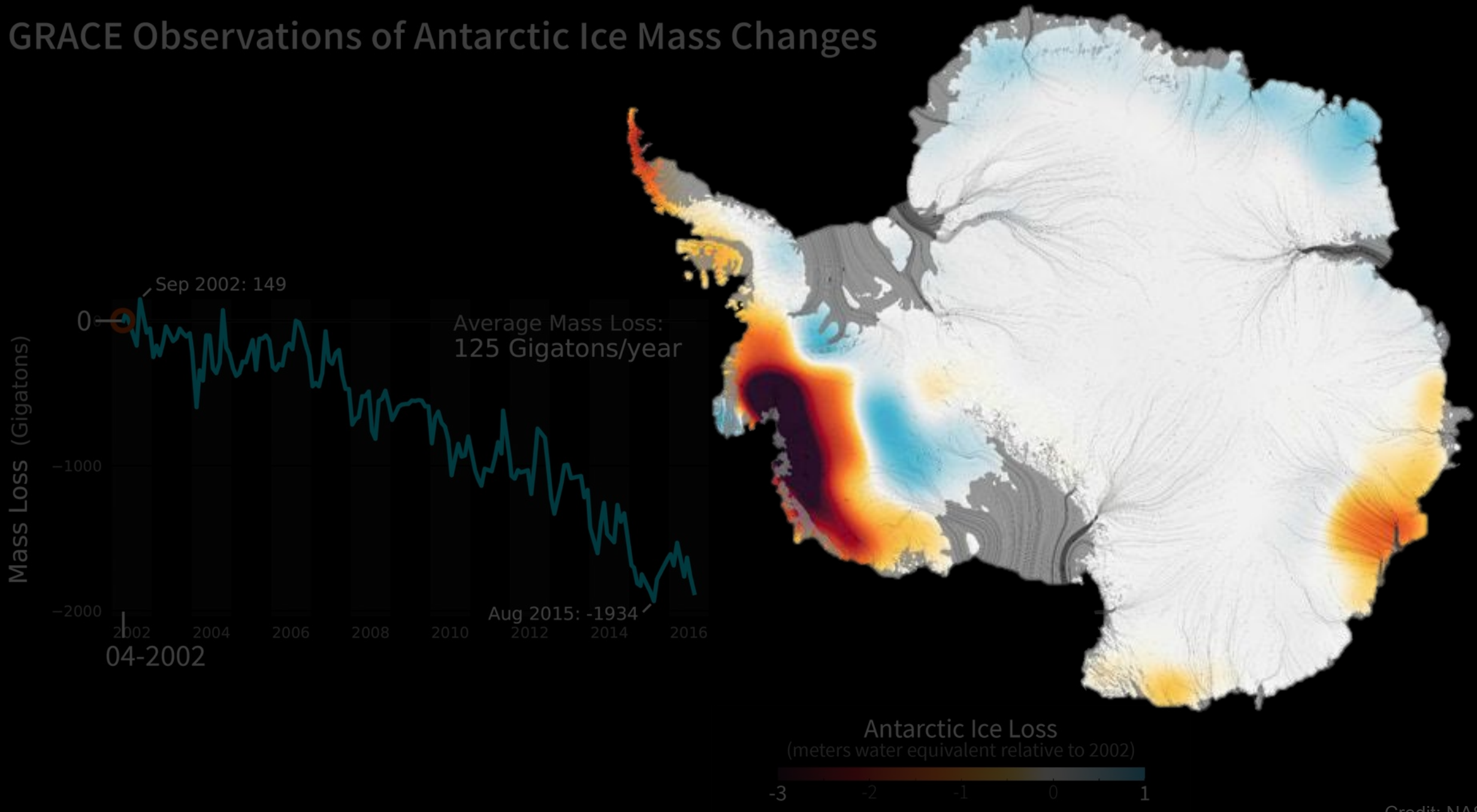


Credit: NASA

GRACE Observations of Antarctic Ice Mass Changes



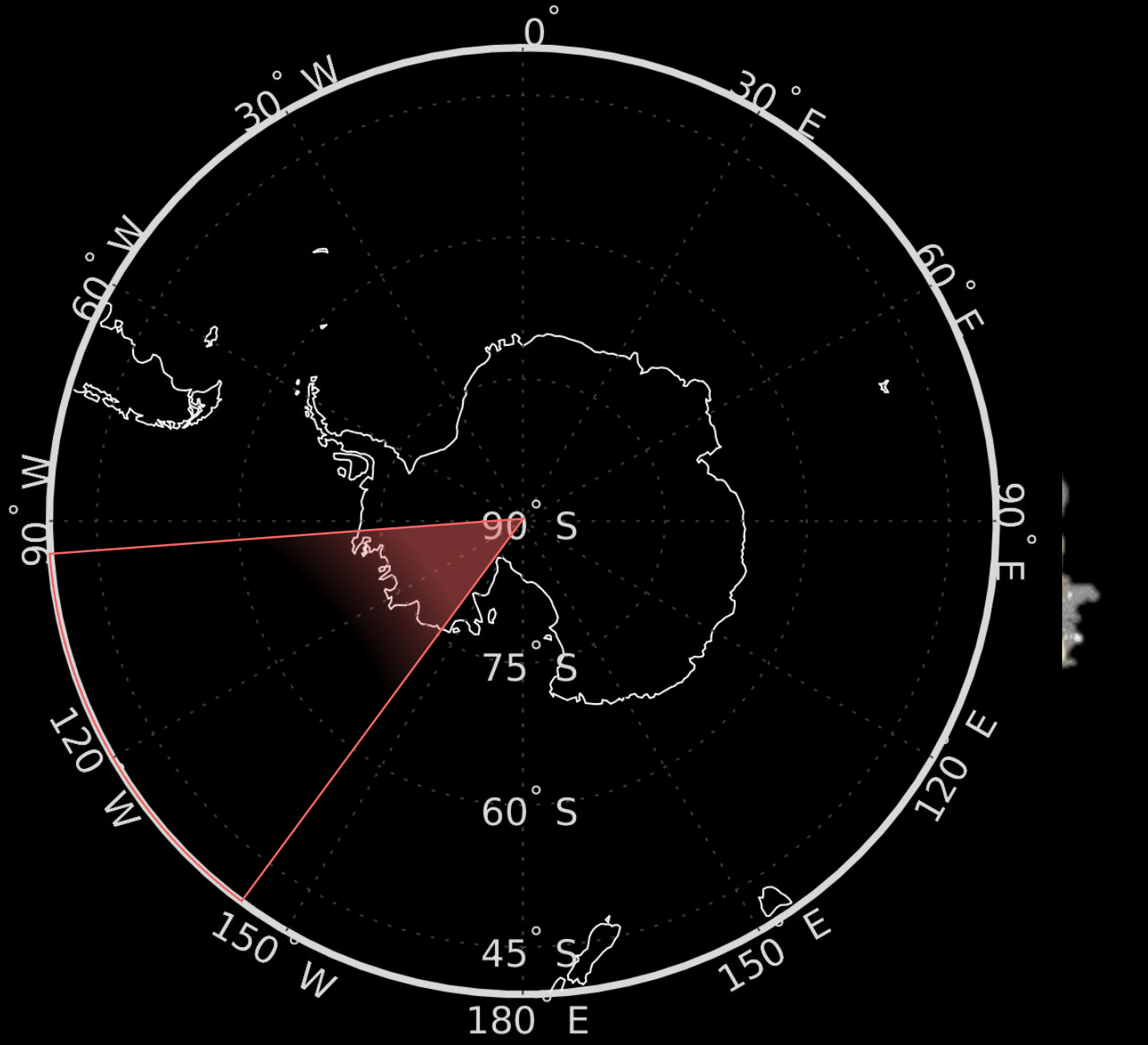
Credit: NASA

This mass loss is difficult to represent in climate models

▶

Limits our understanding of AIS*-SO** interactions

What happens if we rewrite the model forcing to match real-world observations?



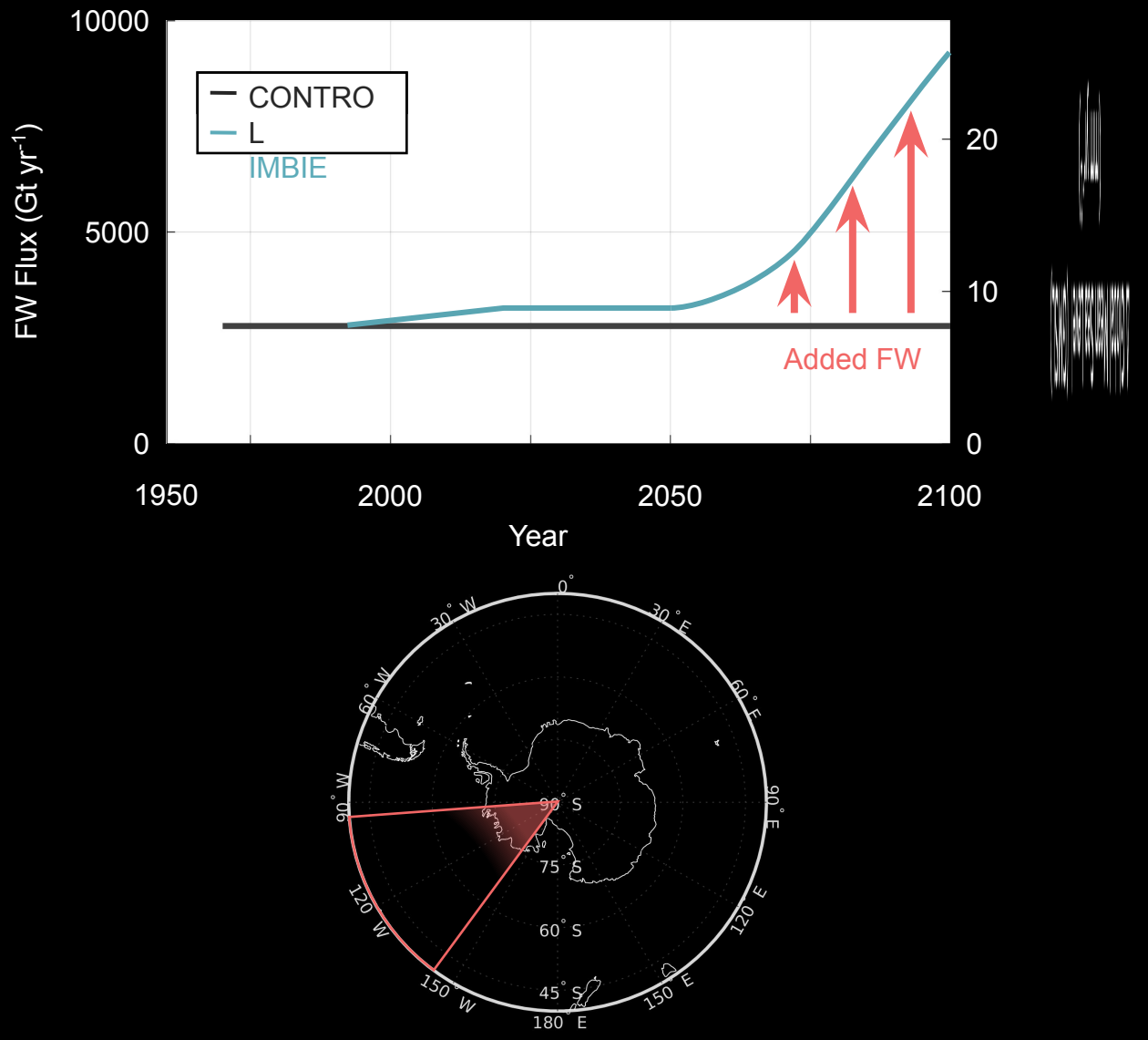
*Antarctic Ice Sheet

**Southern Ocean

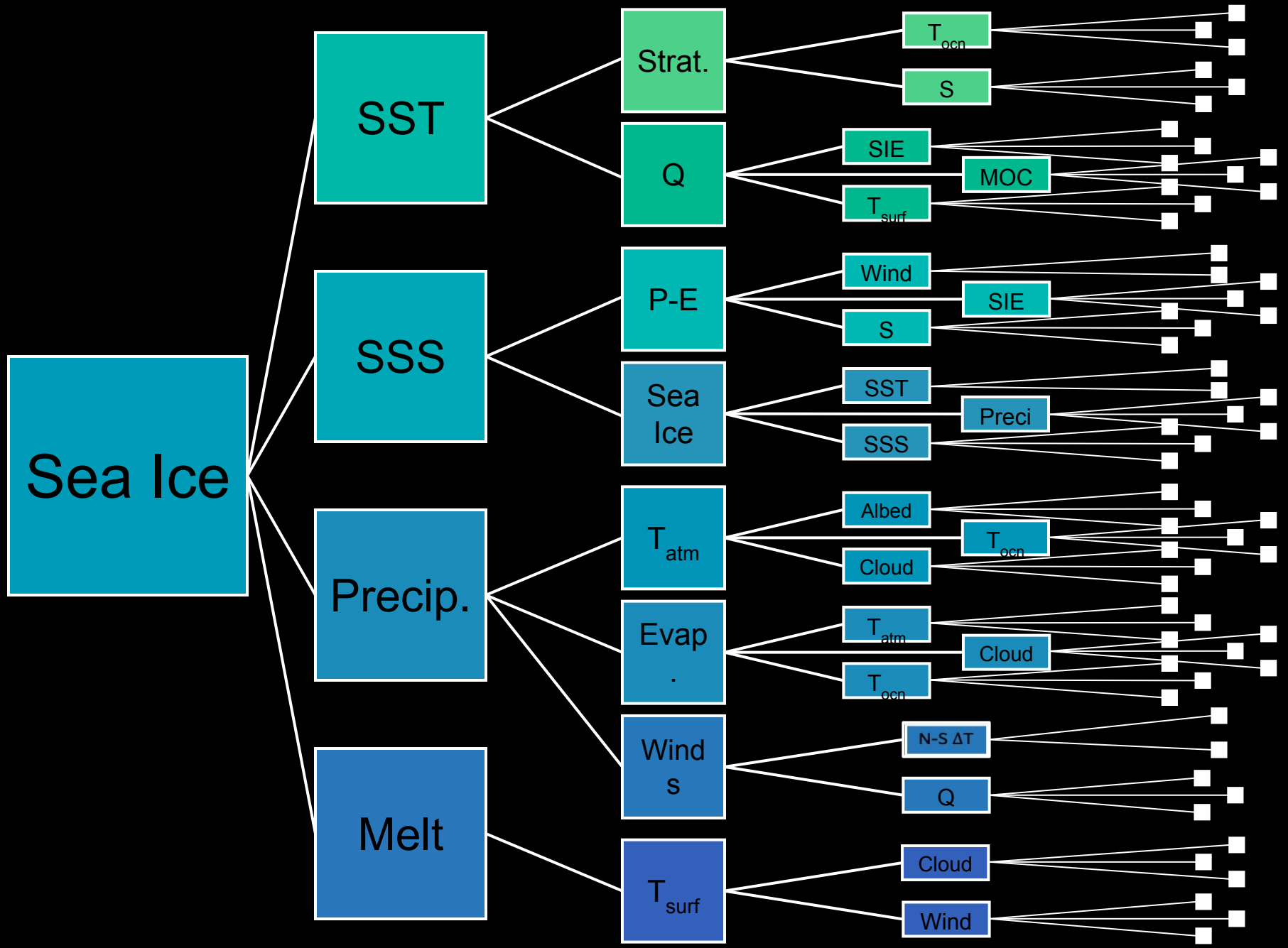
Community Earth System Model version 2 (CESM2)

Wh … if
the … n
re … se

CONTROL	IMBIE*
Constant AIS freshwater (FW) forcing from 1970-2100	Increasing AIS FW forcing from 1992-2100 based on satellite observations (1992-2020) and model output (2021-2100)



*Ice sheet Mass Balance Inter-comparison Experiment


Sea Ice
SST
SSS
Precip.
Melt
Strat.
Q
P-E
Sea Ice
T atm
Evap .
Wind s
T surf
T ocn
S
SIE
MOC
T surf
Wind
SIE
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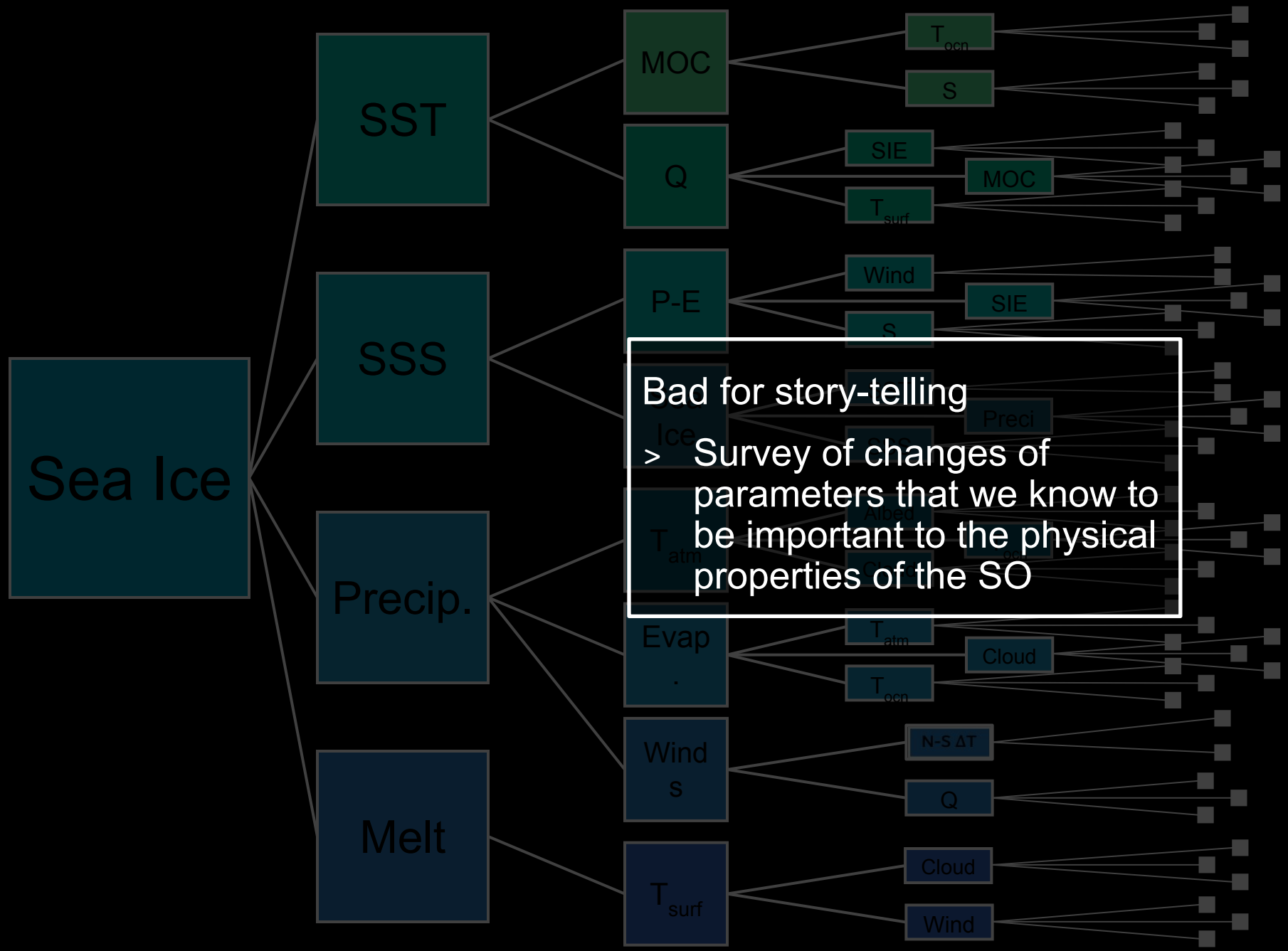
Cloud
T atm
Cloud
T ocn
N-S ΔT
Q
Cloud
Wind



Bad for story-telling

> Survey of changes of parameters that we know to be important to the physical properties of the SO

Stratification

Bad for story-telling

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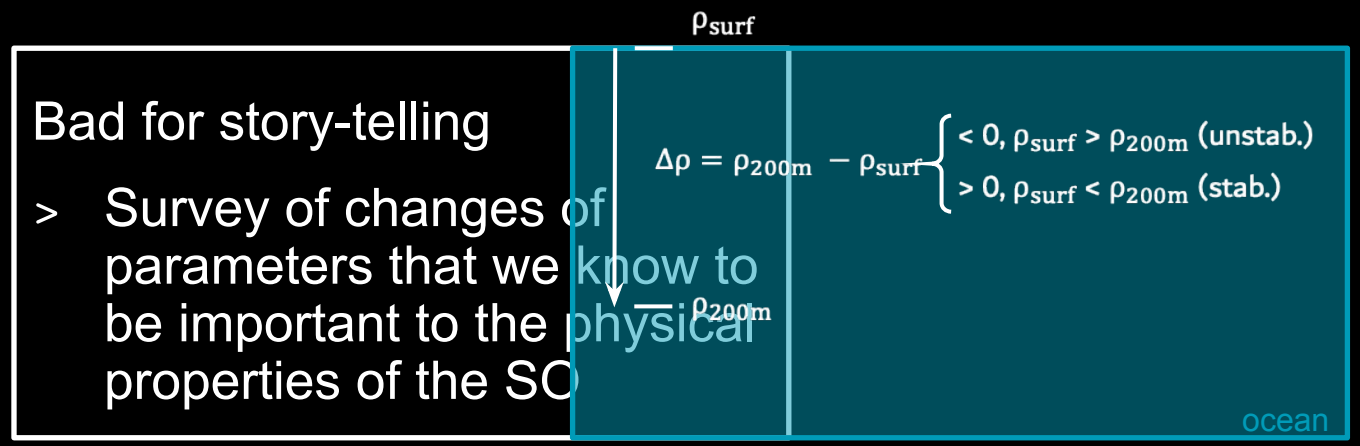

$\Delta\rho/\Delta z$ over the top 200 m of the SO

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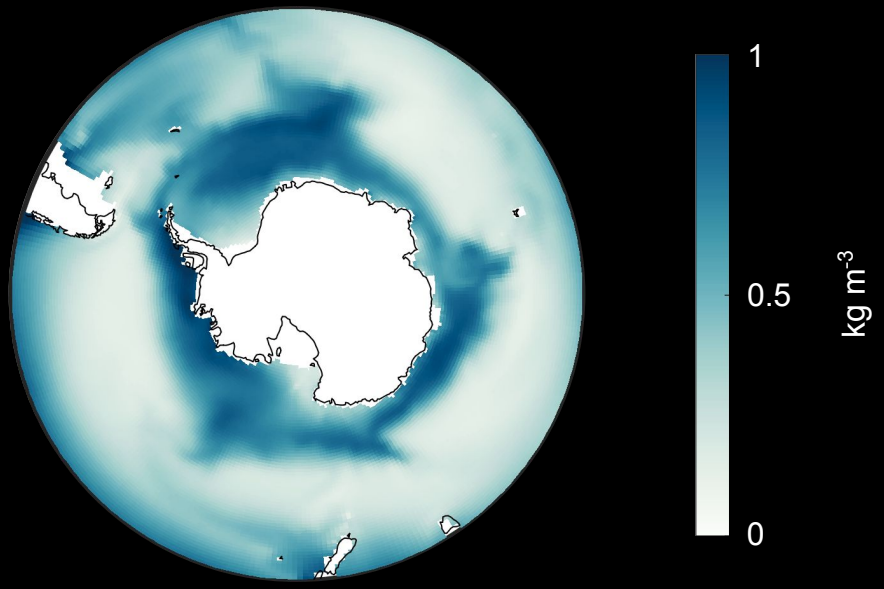
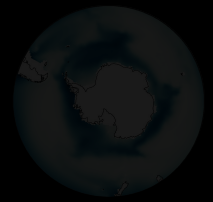


$\Delta\rho/\Delta z$ over the top 200 m of the SO

More positive: stronger stratification

Plotted: 1991 mean state

Stratification



Ideal Age

Bad for story-telling

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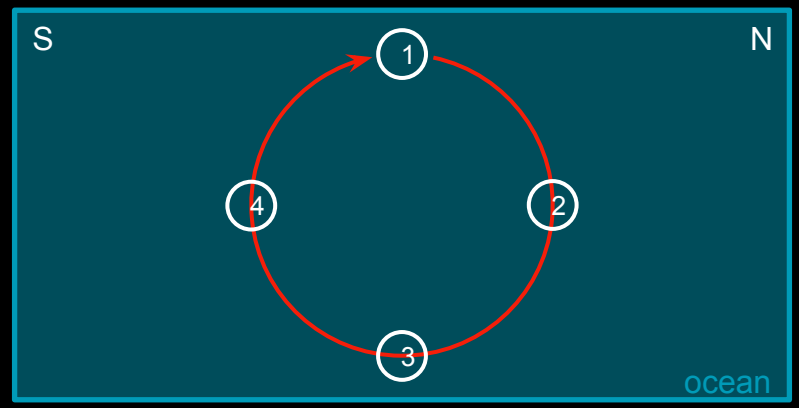
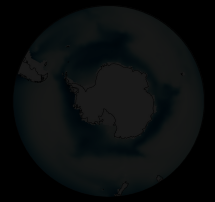


≡ The last time a water parcel was in contact with the atmosphere

Stratification



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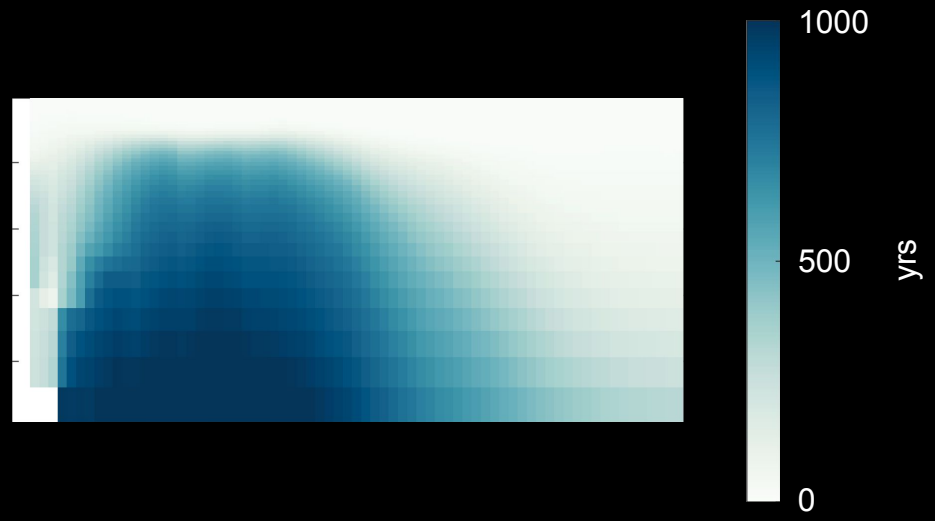

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Plotted: 1991 mean state

Stratification

Ideal Age

Temperature Profile

Bad for story-telling

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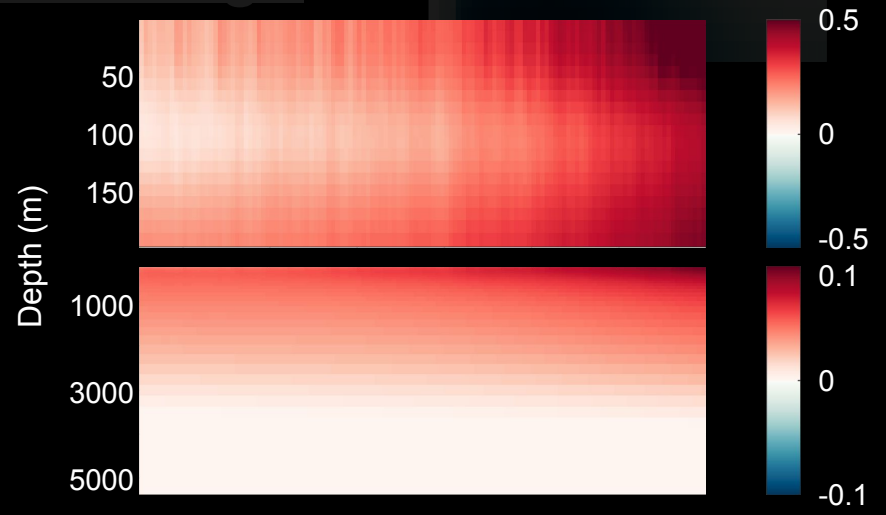
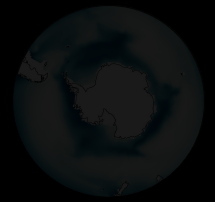


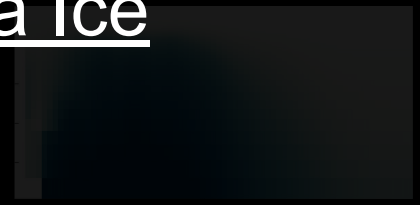
SO-averaged vertical temperature column

Stratification



Sea Ice

Ideal Age



Extent

Temperature Profile

Bad for story-telling

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Stratification

Ideal Age

Temperatu

Sea Ice

Thickness

Bad for story-telling

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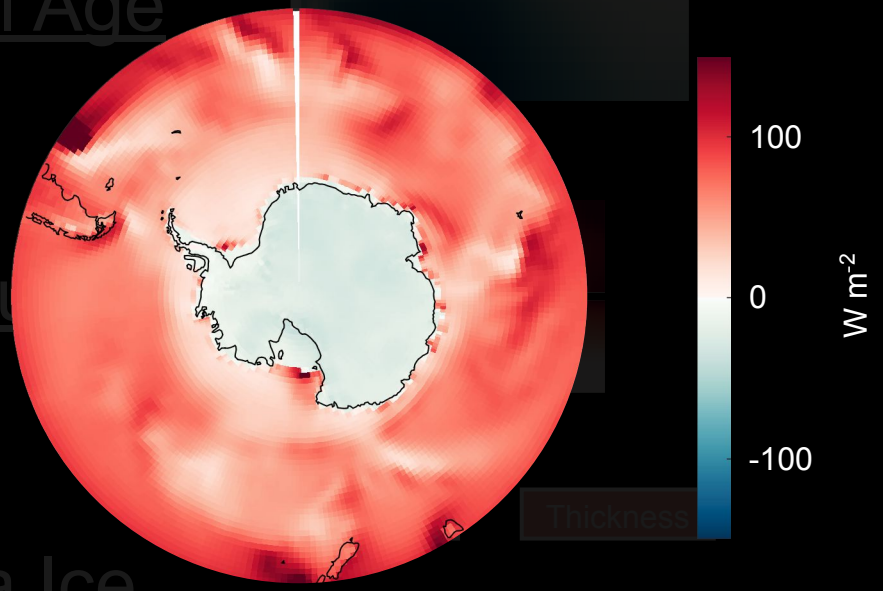
Heat Flux



Sensible + Latent

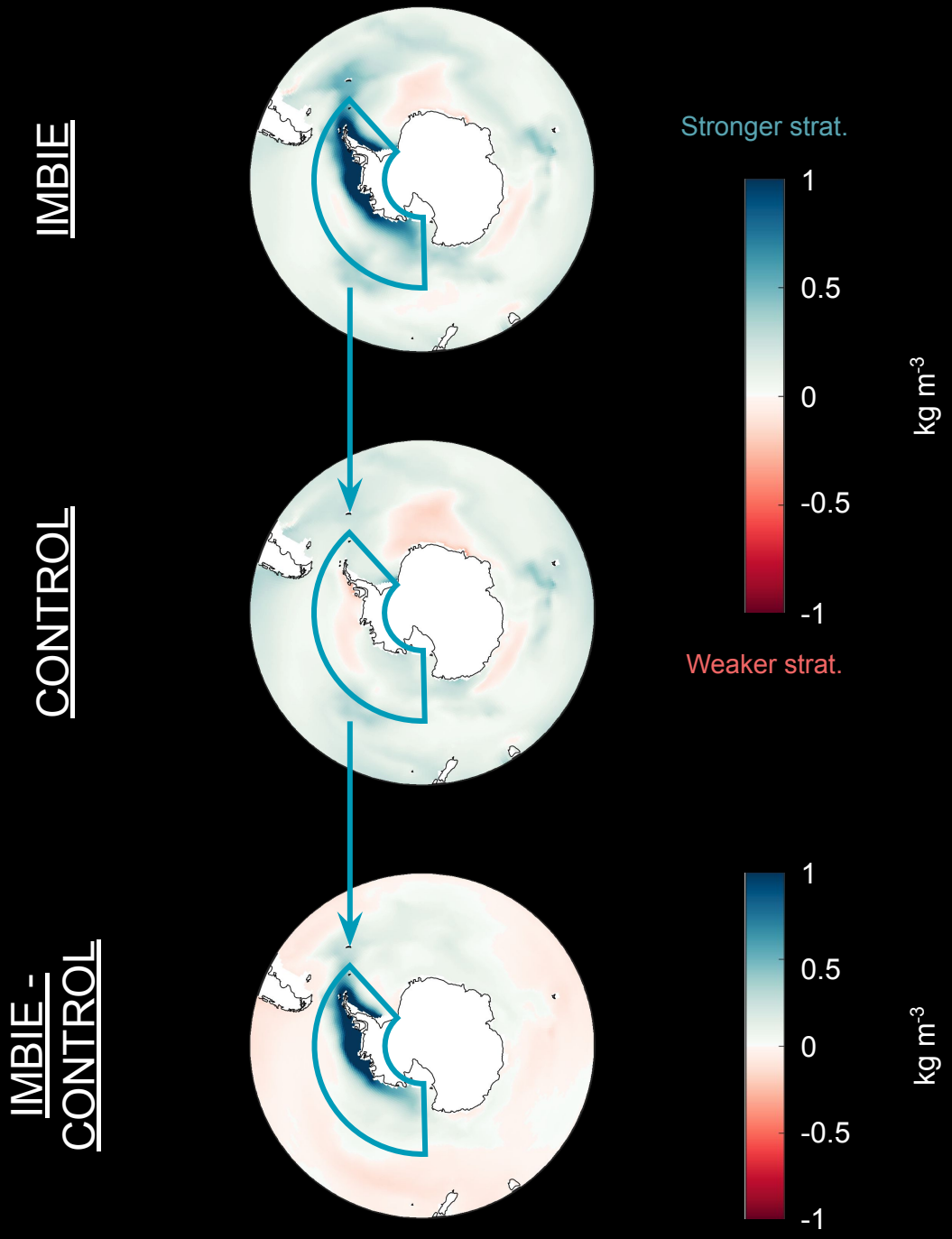
Positive ≡ into the ocean

Plotted: 1991 mean state

Stability

Adding FW to the surface ocean **strengthened** the stratification near the West Antarctic coast

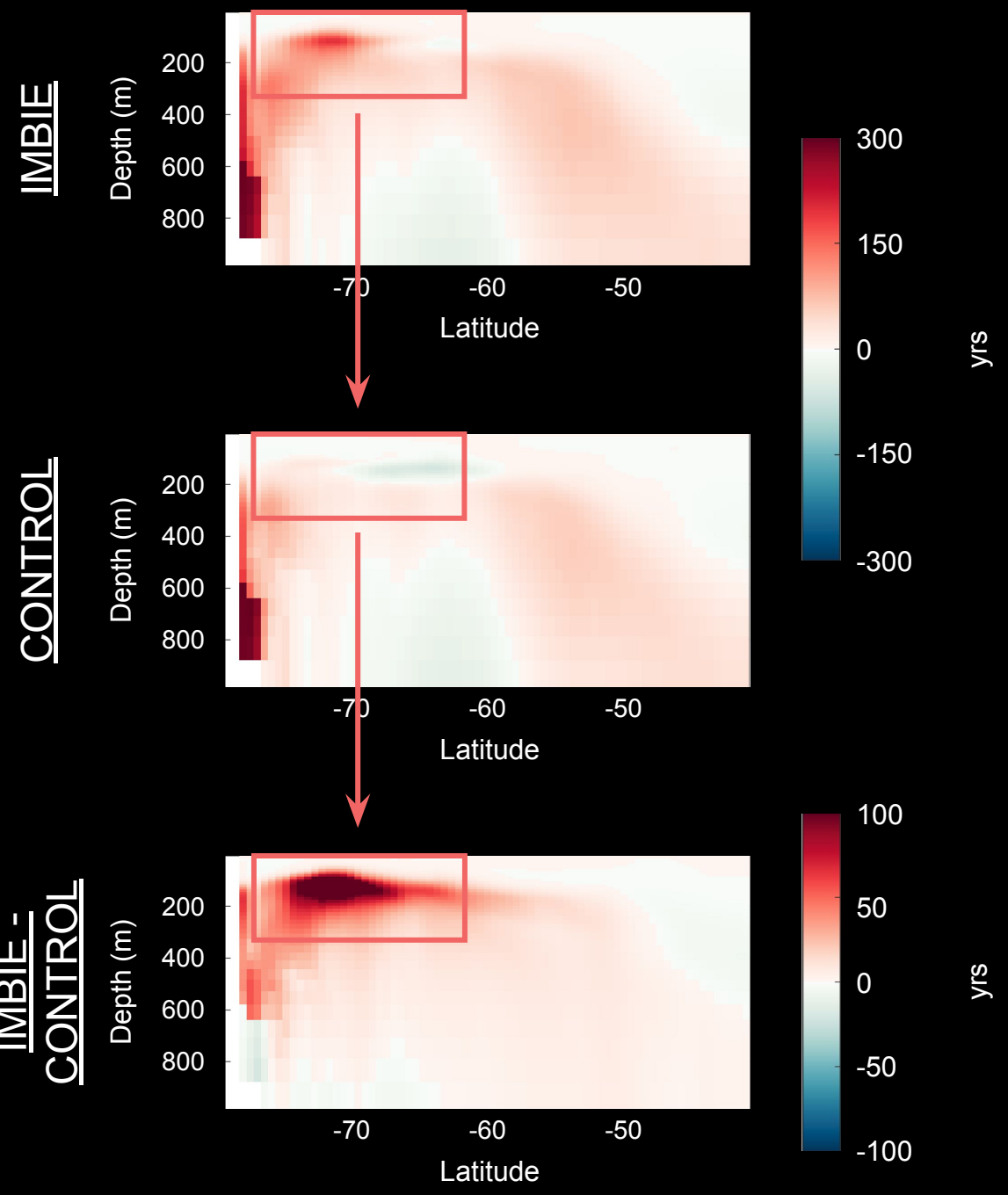
Plotted: final 15 years - first 15 years



Ideal Age (yrs)

Subsurface changes **increase** the ideal age of the upper SO by 14% on average

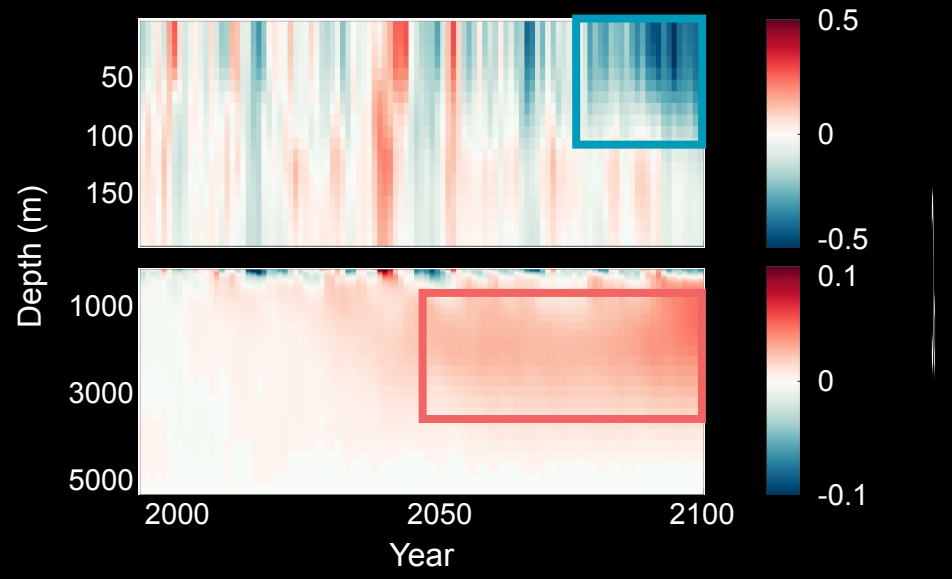
Plotted: final 15 years - first 15 years

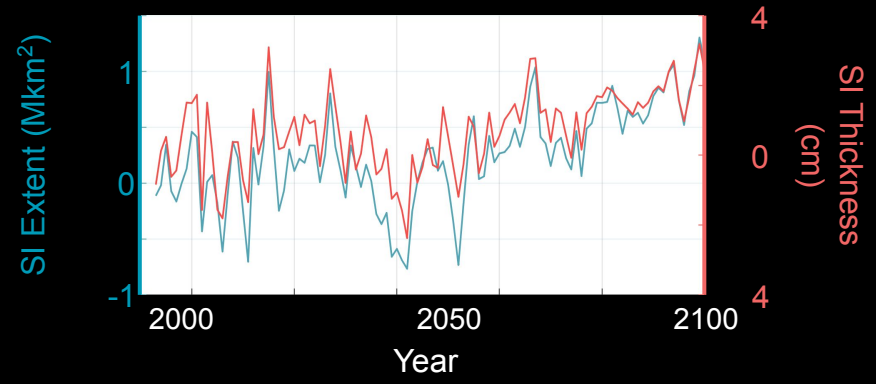


Temperature	IMBIE simulation has a significantly **cooler surface and upper ocea**

Plotted: IMBIE - CONTROL

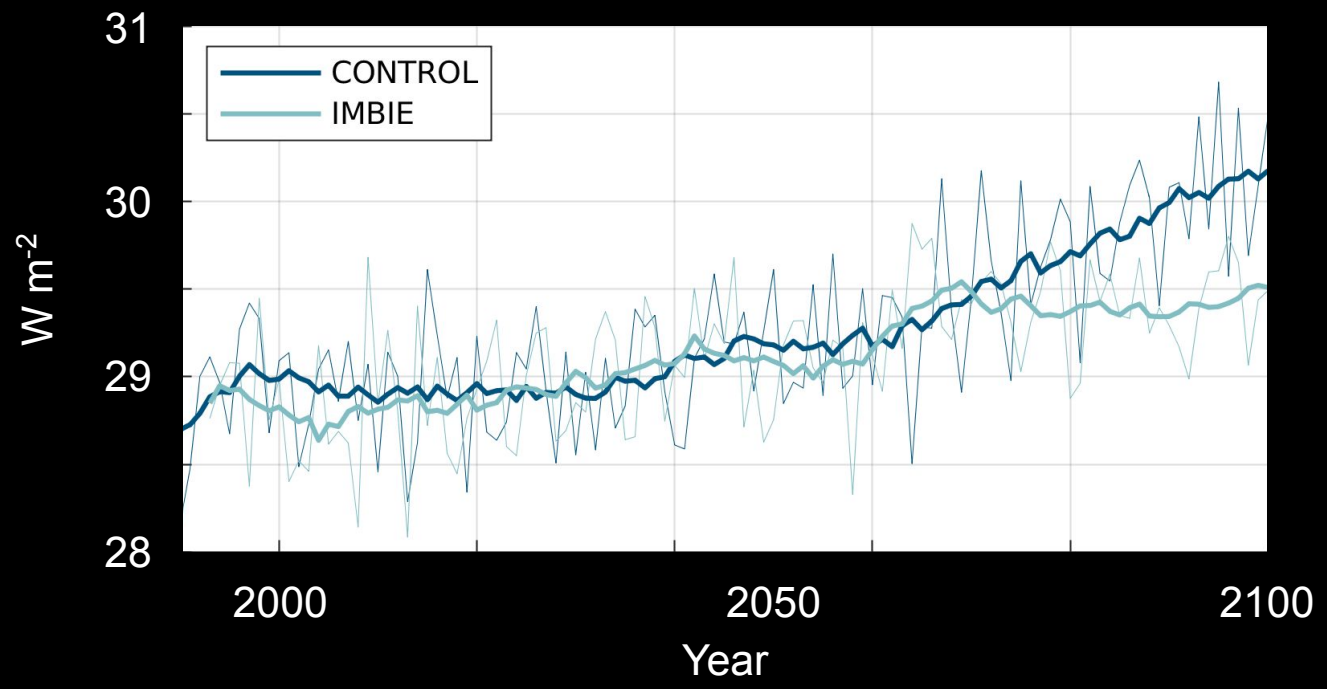
Sea Ice Extent and Thickness	By 2100, the IMBIE simulation has **0.8 Mkm^2 more SO sea ice coverage** that is **~2.5 cm thicker on average**





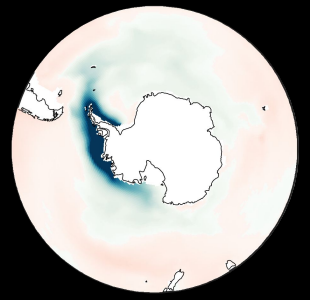
Heat Flux (W m^{-2})

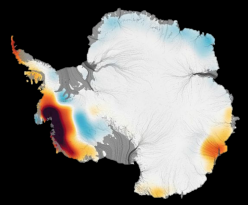
Both simulations see an increase, **less** heat is taken up by the ocean due to the addition of FW



Density

SO surface freshening **strengthened the vertical density gradient** in the top 200 m along the entire West Antarctic coastline





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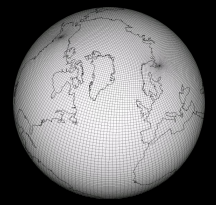

CONTROL	Δ	IMBIE
Constant AIS FW		Spatiotemporally heterogeneous AIS FW

Density

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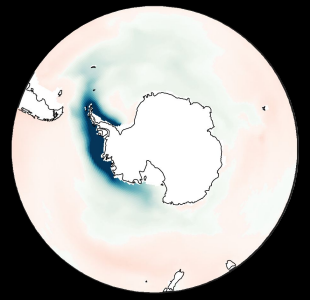


Ideal Age

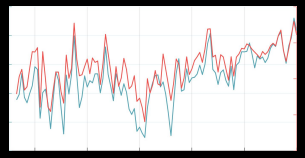
The **ideal age of the upper SO increases by 14%** on average due to circulation changes

Temperature

Adding freshwater to the surface ocean changes the vertical temperature structure; **cooling the surface & upper ocean** and **warming**

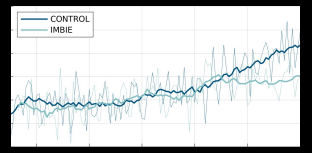
Sea Ice

SO sea ice is both thicker and more extensive (~10%) as a result of the added FW



Heat Flux

While more heat fluxes into the ocean in a warming climate, adding FW to the coastal SO results in **less ocean heat uptake**



Including active/realistic ice sheet components in global climate models is imperative for predicting centuries-long changes to our Earth climate system