

Maurice Huguenin

how it started



how it's going



ETH zürich



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

MeteoSwiss



WOODS HOLE
OCEANOGRAPHIC
INSTITUTION



Disclaimer: It was more like this



Acknowledgment of Country



Mindil Beach, Darwin, AU

Acknowledgment of Country



- **Bedegal people**
- sovereignty has never been ceded
- climate justice for First Nations people





ACEAS

Australian Centre for Excellence
in Antarctic Science

Subsurface warming of the West Antarctic continental shelf linked to El Niño events

Maurice F. Huguenin, Ryan M. Holmes, Paul Spence and
Matthew H. England



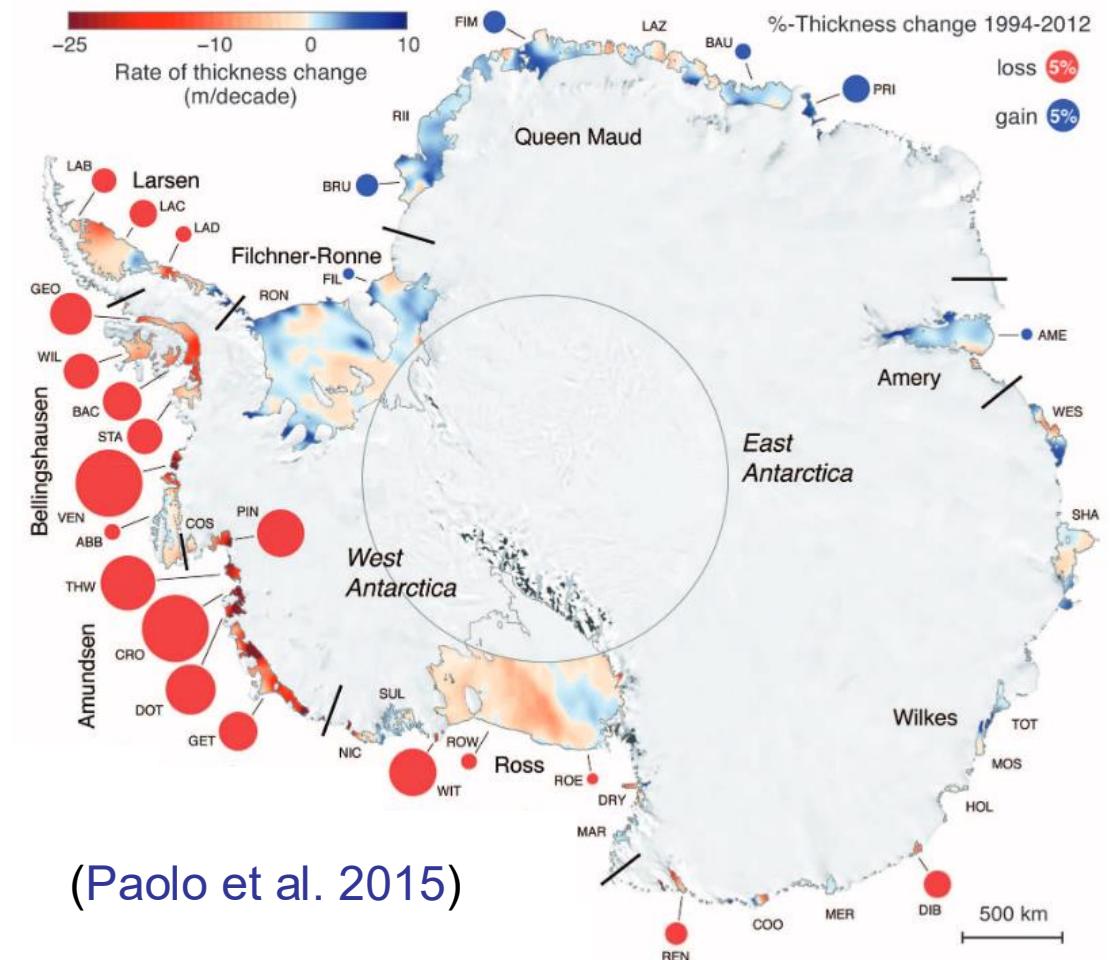
Australian Government
Australian Research Council

The Australian Centre for Excellence in Antarctic Science is a
Special Research Initiative funded by the Australian Research Council



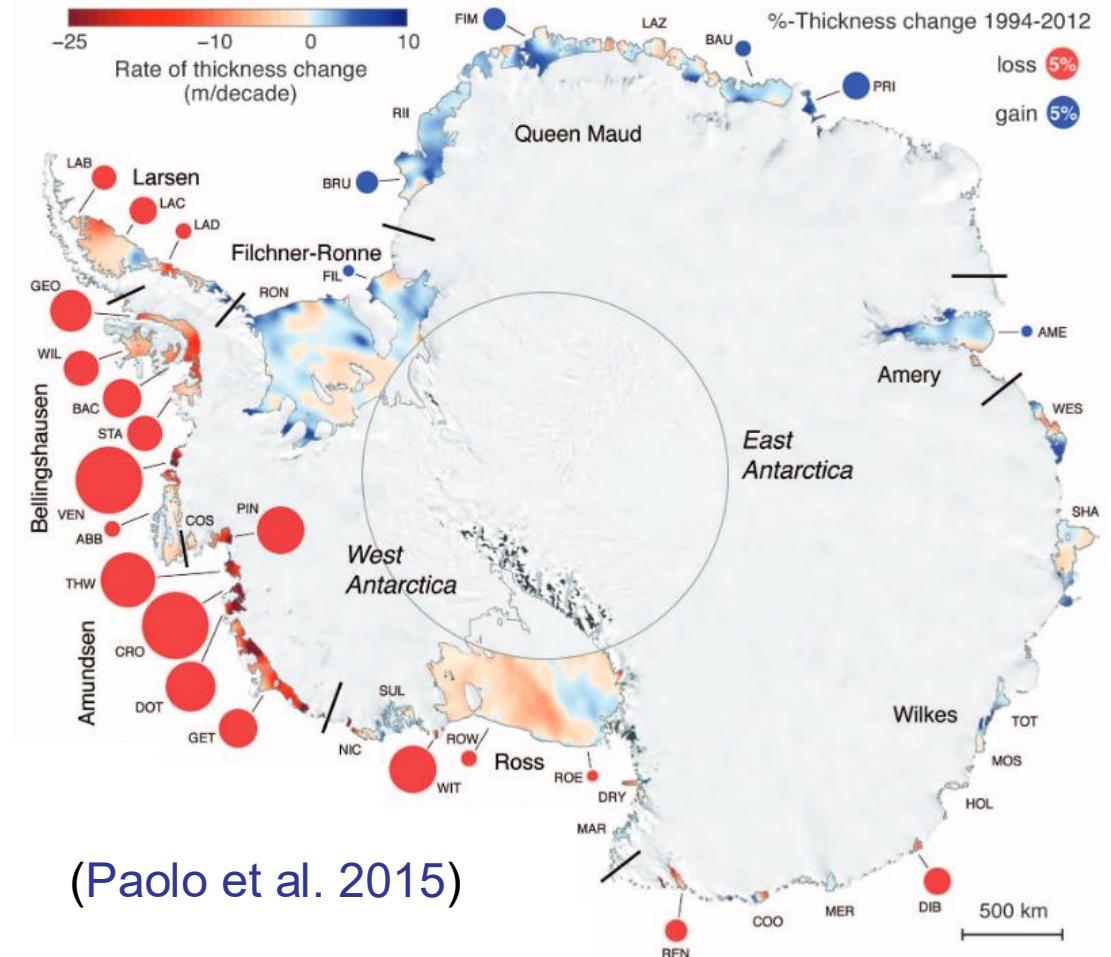
This research was supported by the Australian Research Council Special Research Initiative, Australian Centre for Excellence in Antarctic Science (Project Number SR200100008)

Background



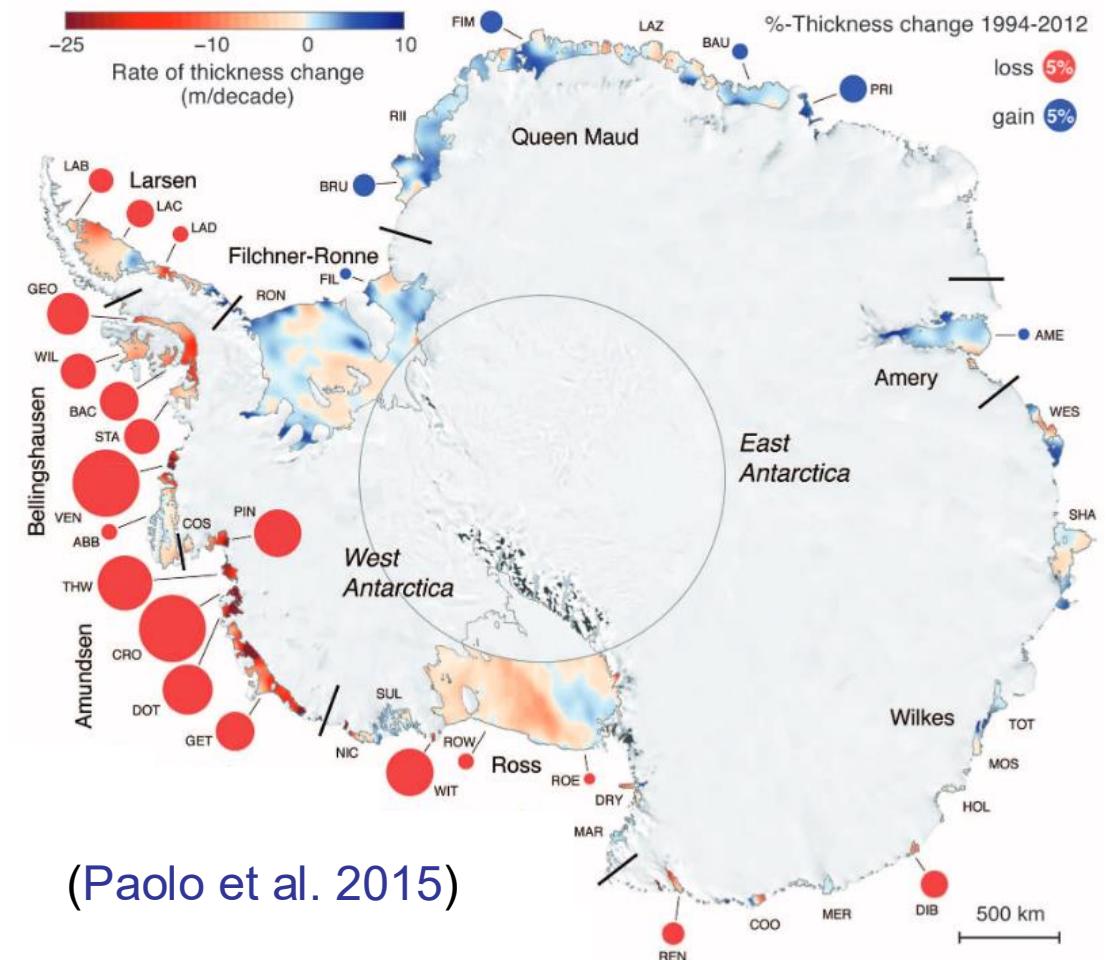
Background

- Volume loss from Antarctic ice shelves is accelerating ([Paolo et al. 2015](#))



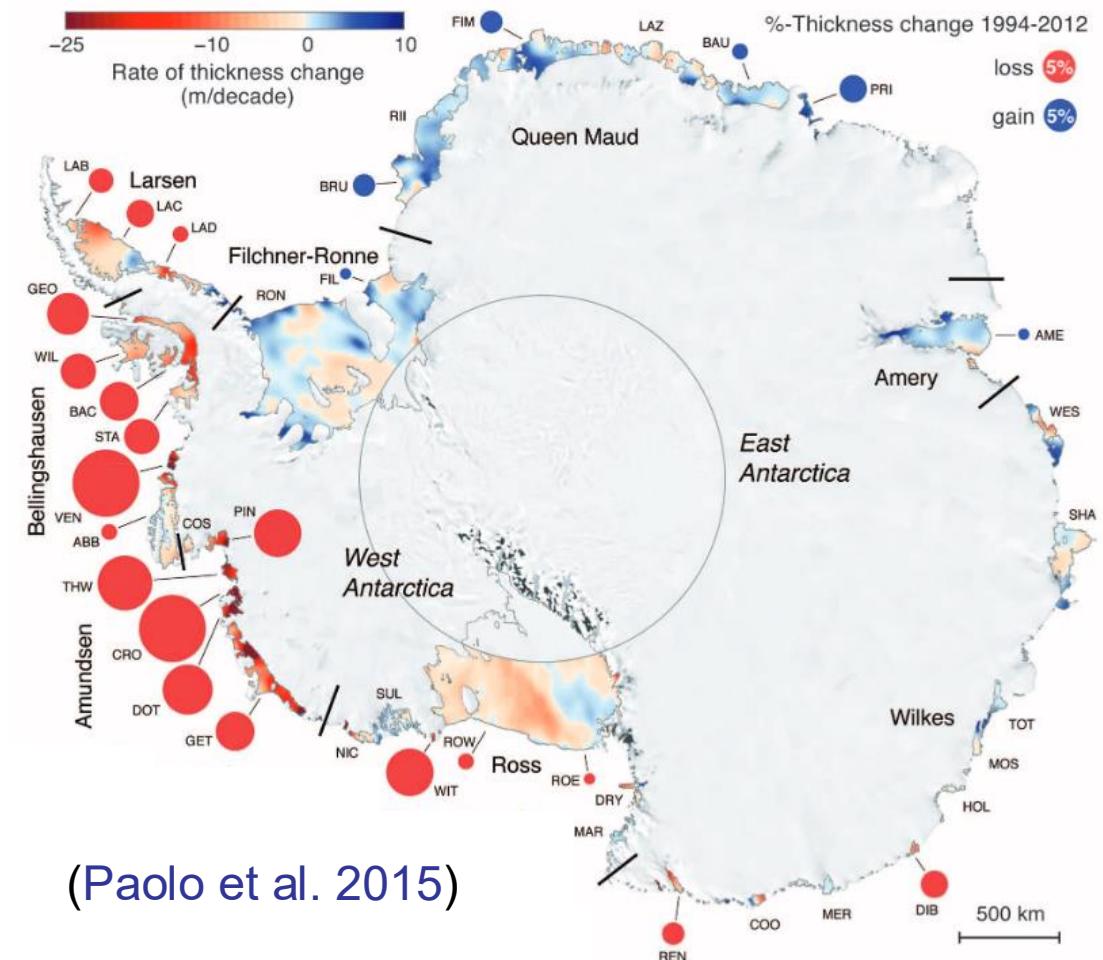
Background

- Volume loss from Antarctic ice shelves is accelerating ([Paolo et al. 2015](#))
- Ice loss influenced by internal climate variability and anthropogenic forcing ([Holland et al. 2019](#))



Background

- Volume loss from Antarctic ice shelves is accelerating ([Paolo et al. 2015](#))
- Ice loss influenced by internal climate variability and anthropogenic forcing ([Holland et al. 2019](#))
- El Niño: ↑height but ↓mass of West Antarctic ice shelves ([Paolo et al. 2018](#))



The questions

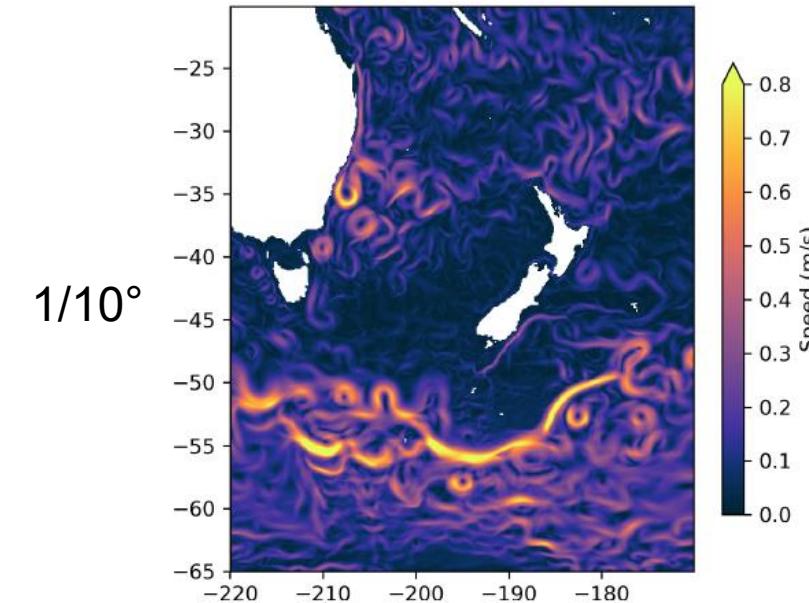
- How do El Niño & La Niña impact the West Antarctic shelf circulation?
- What processes are responsible for warming and cooling on the shelf?

The questions

- How do El Niño & La Niña impact the West Antarctic shelf circulation?
- What processes are responsible for warming and cooling on the shelf?

The method

- ACCESS-OM2 ([Kiss et al. 2020](#))
 - 1/10° configuration
 - JRA55-do reanalysis ([Tsujino et al. 2018](#))



Kiss et al. (2019)

- Repeat-year forcing spin-up
- ENSO anomalies on top

Forcing for the idealised simulations

Repeat-year forcing [t , x , y]

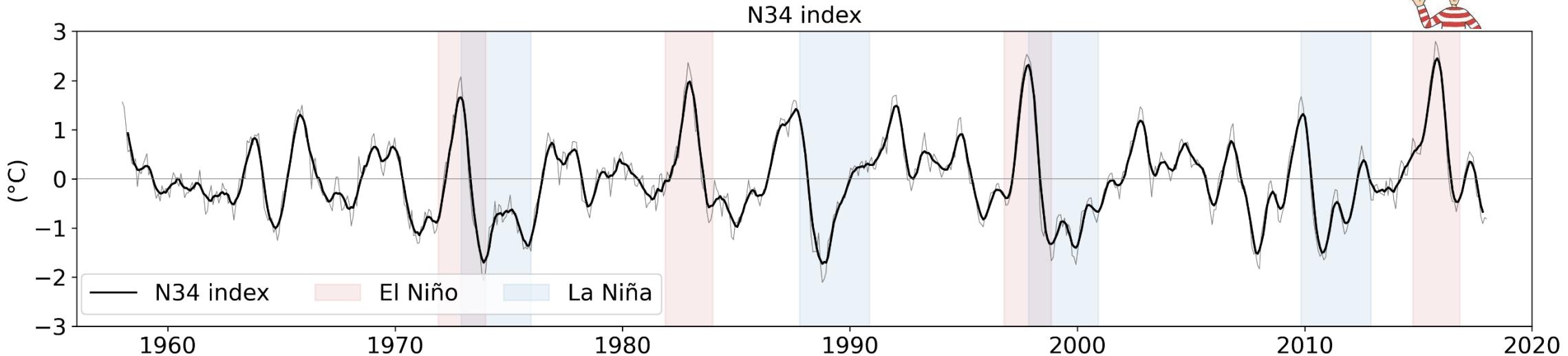
Forcing for the idealised simulations

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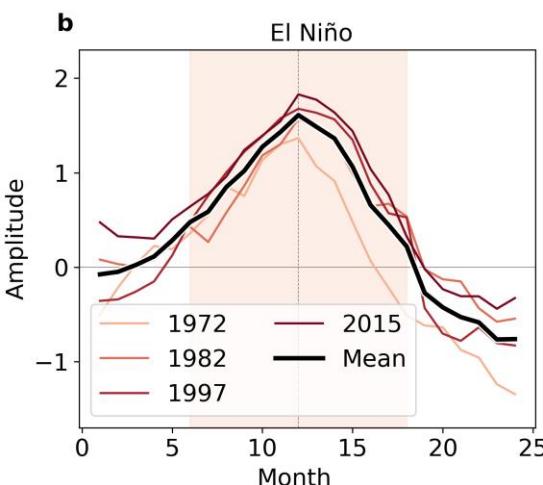
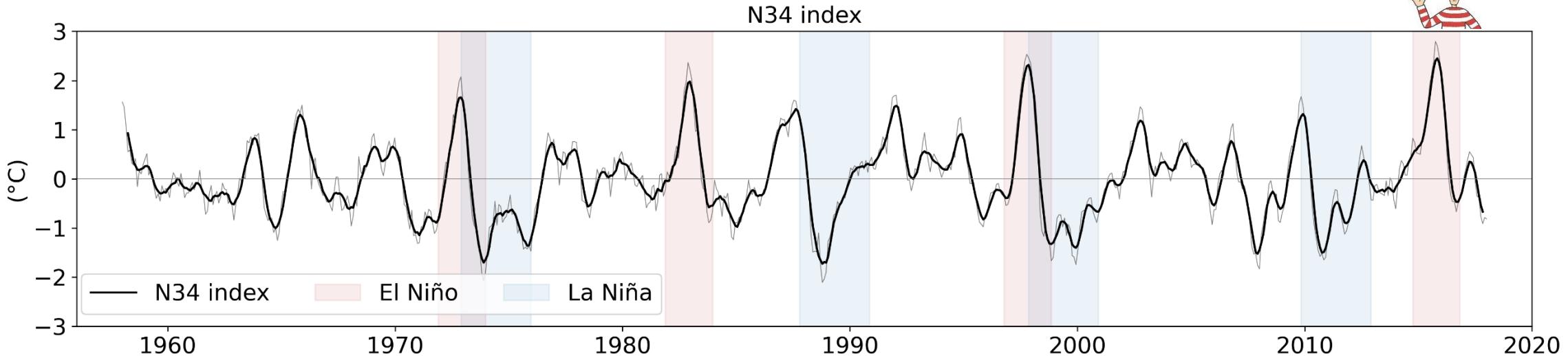
+

ENSO anomalies (time series [t] \times spatial pattern [x,y])

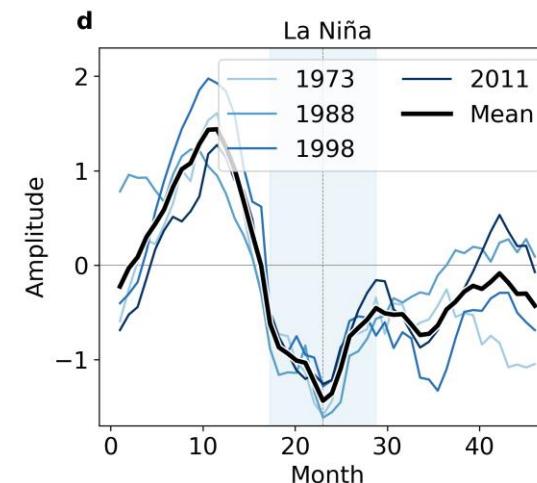
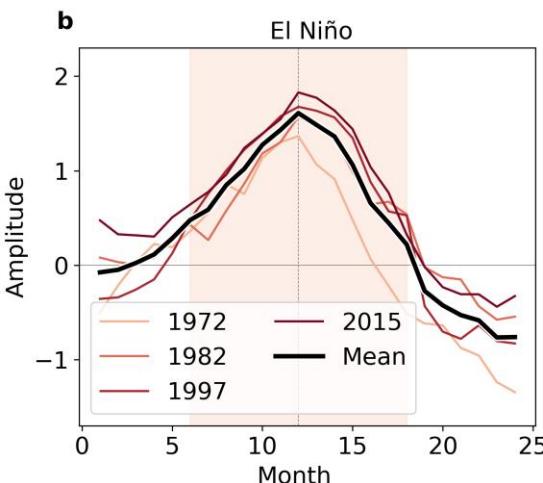
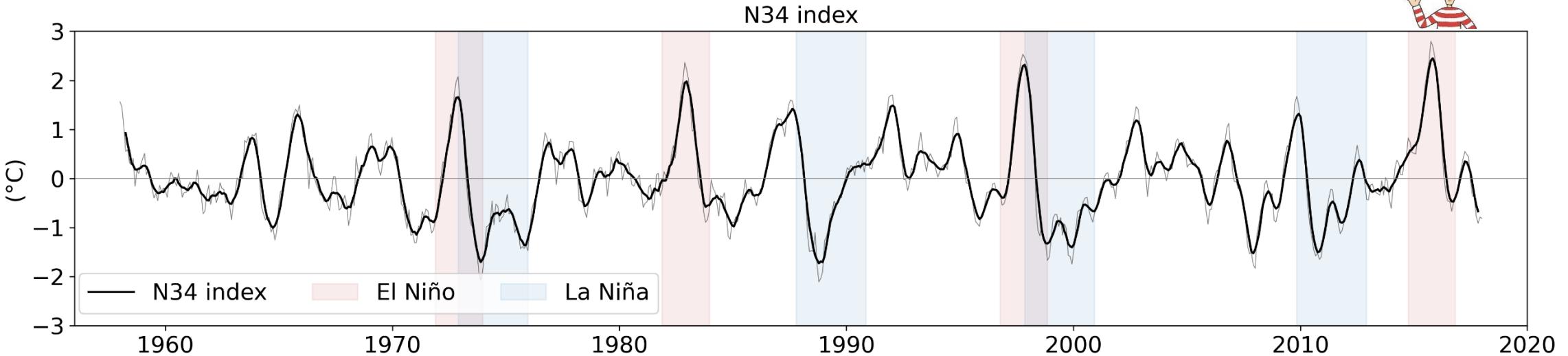
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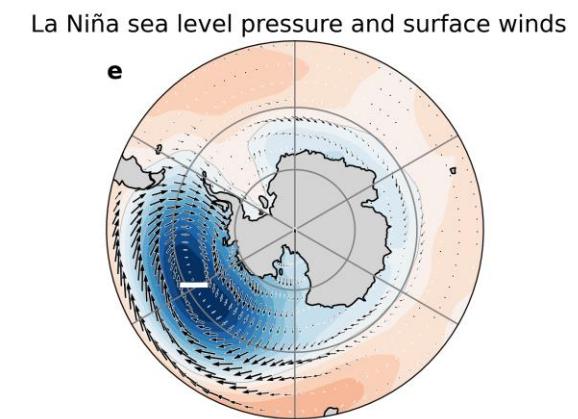
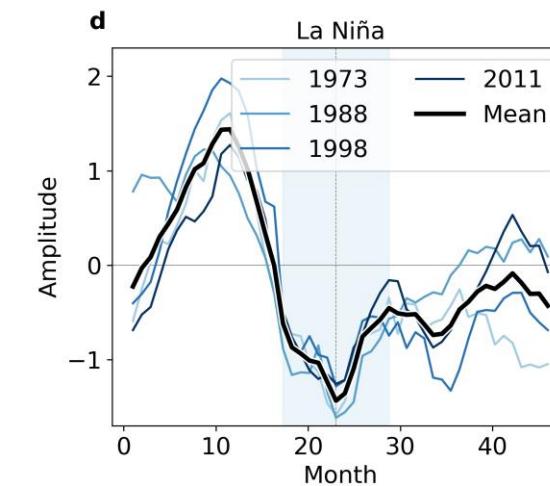
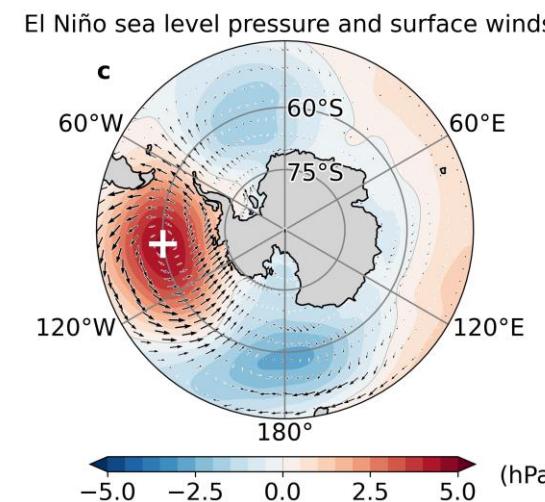
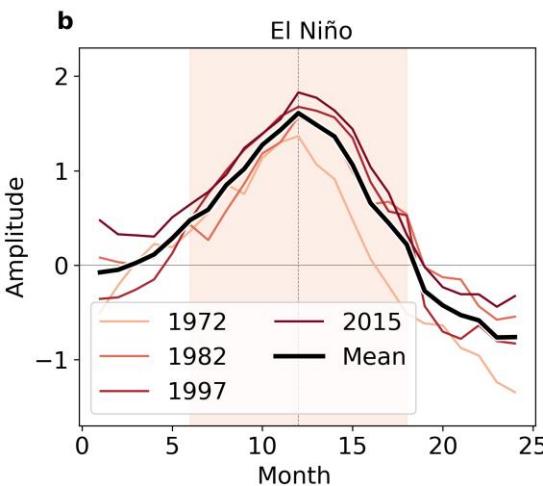
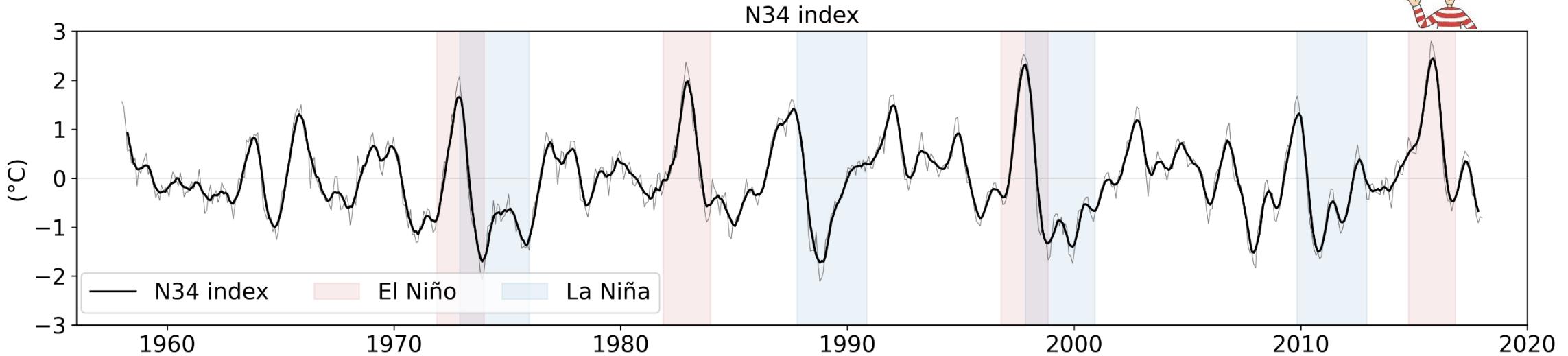
Forcing for the idealised simulations



Forcing for the idealised simulations

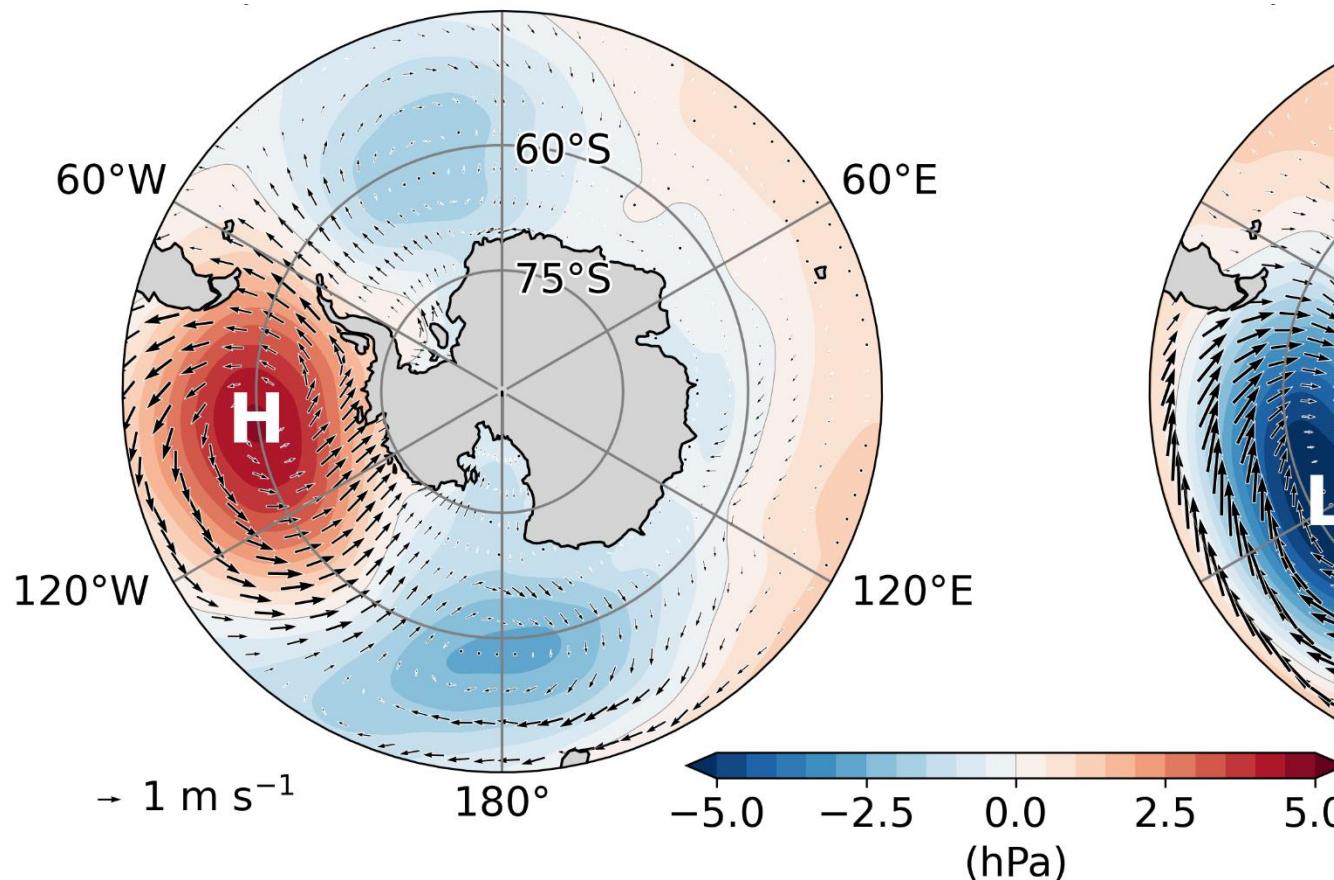


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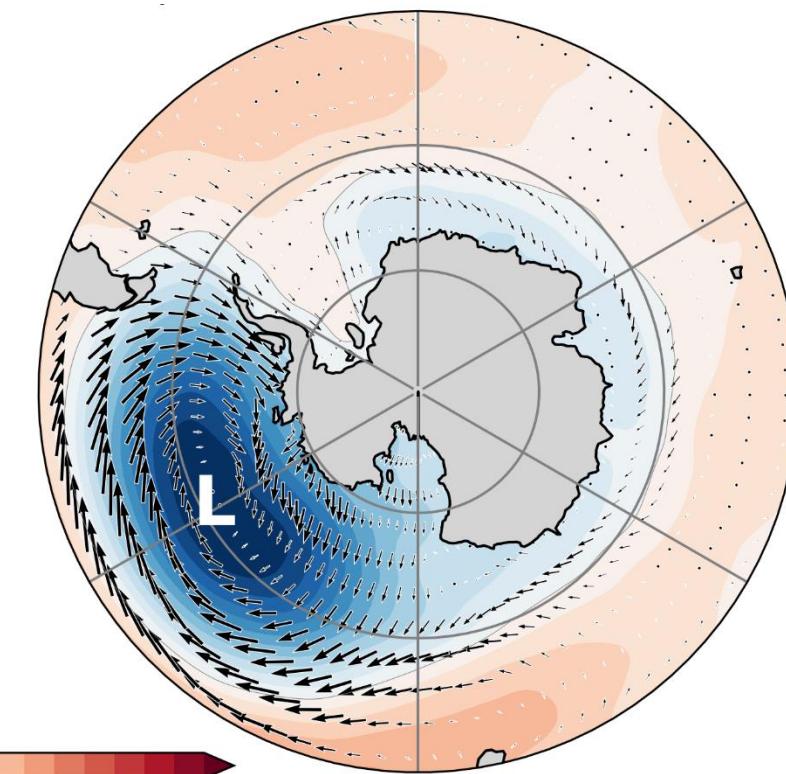


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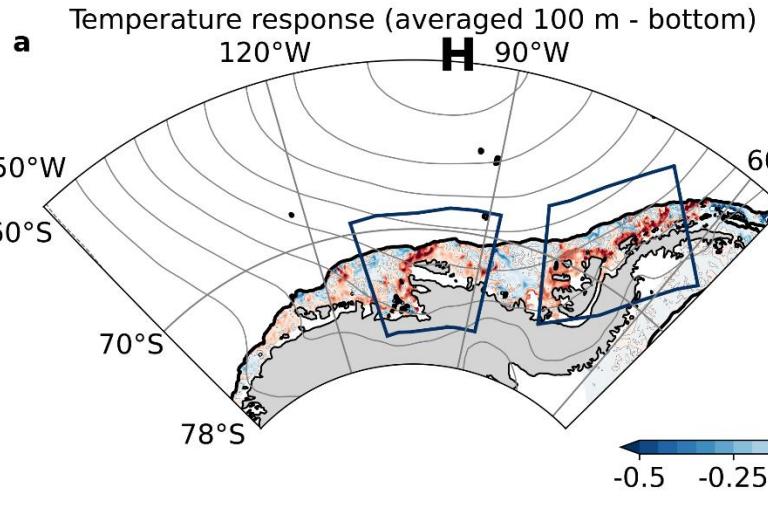
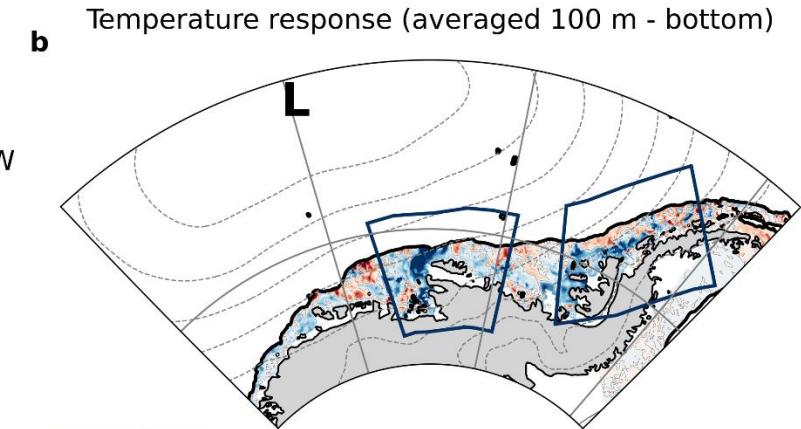
El Niño sea level pressure and surface winds



La Niña



Shelf response to ENSO forcing

El Niño simulation**La Niña simulation**

isopycnals

0°C isotherm

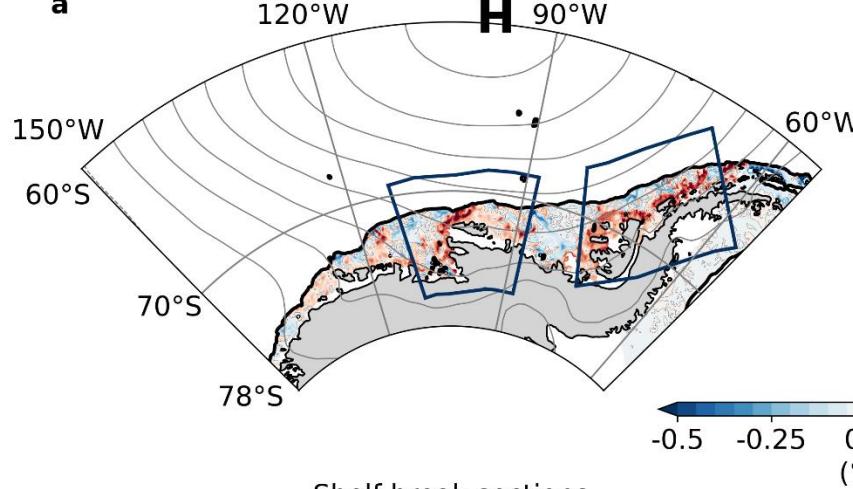
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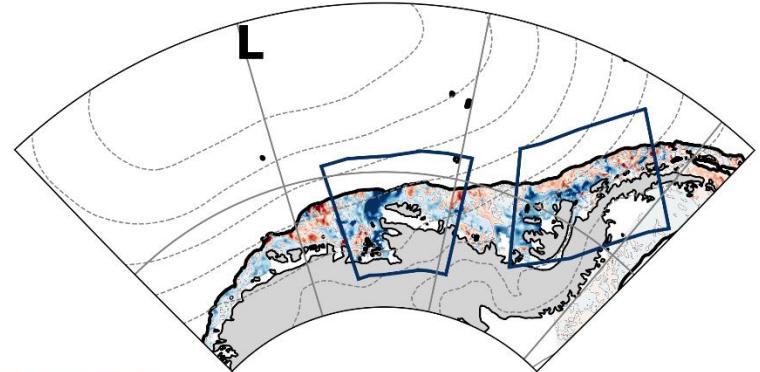
El Niño simulation

a Temperature response (averaged 100 m - bottom)

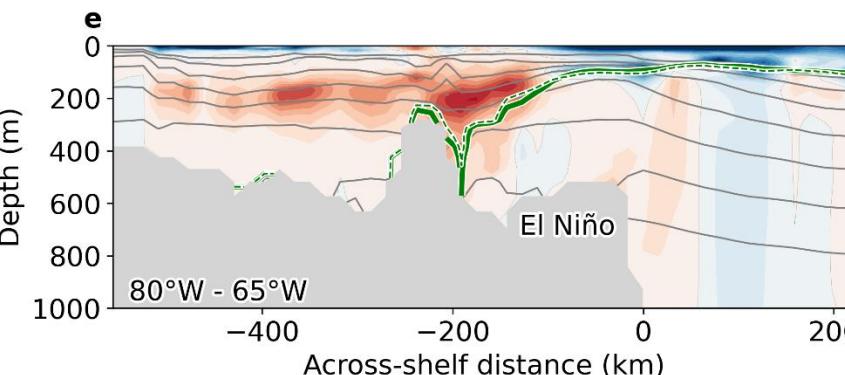
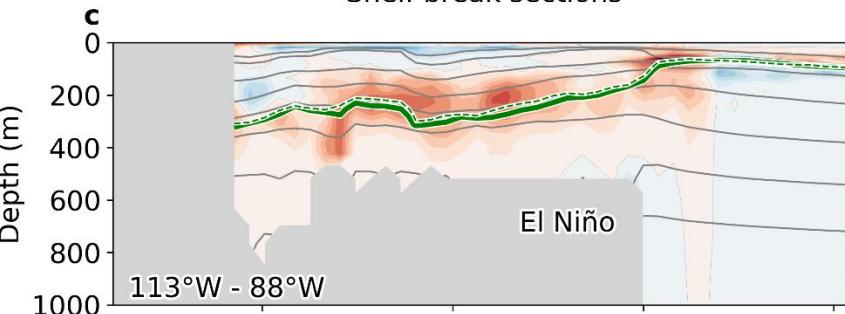


La Niña simulation

b Temperature response (averaged 100 m - bottom)



Shelf break sections

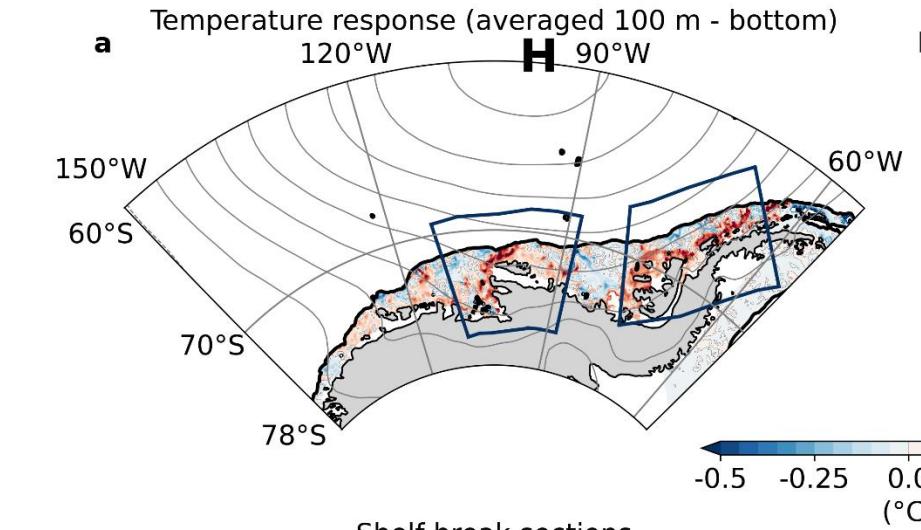


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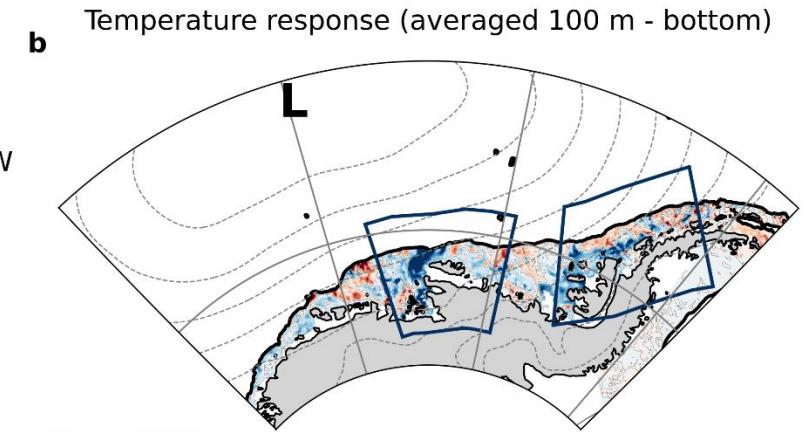
isopycnals

0°C isotherm

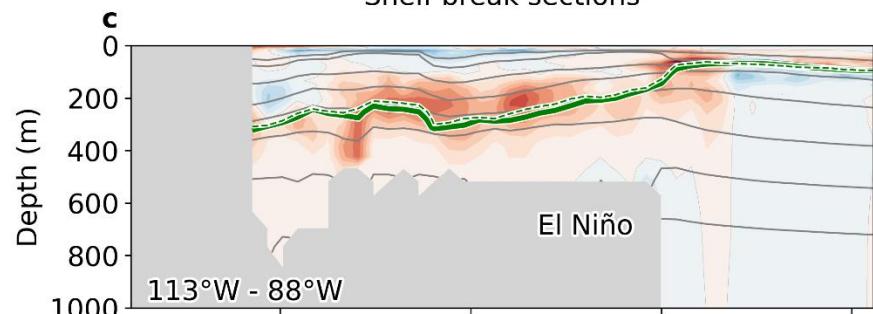
El Niño simulation



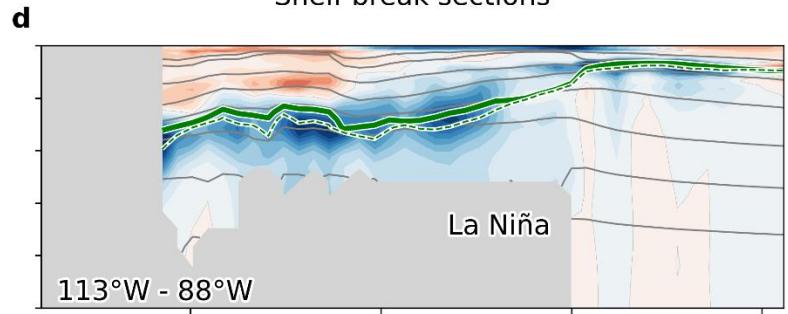
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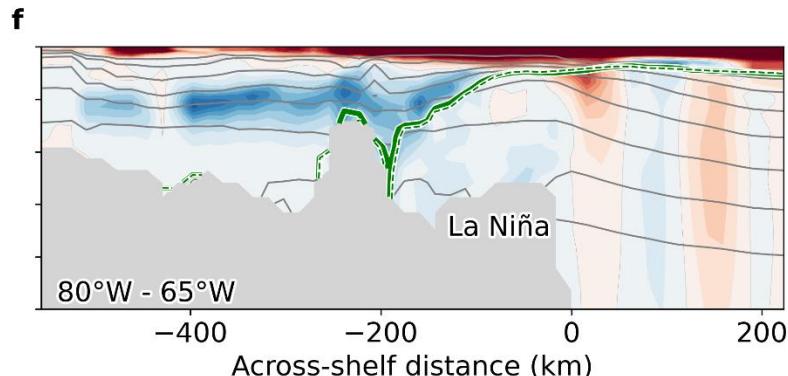
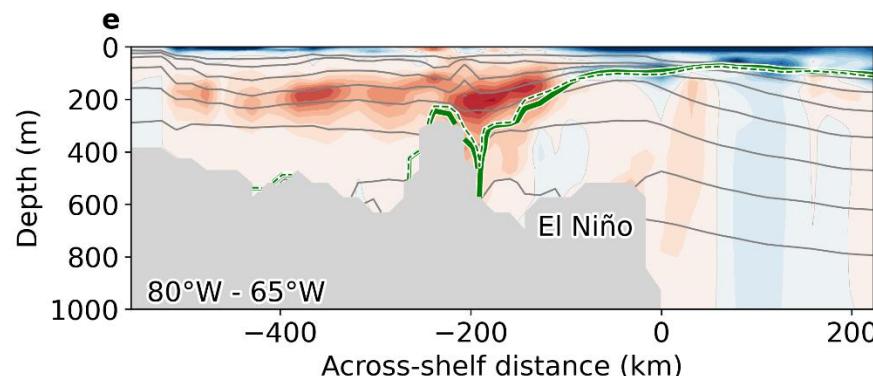
Shelf break sections



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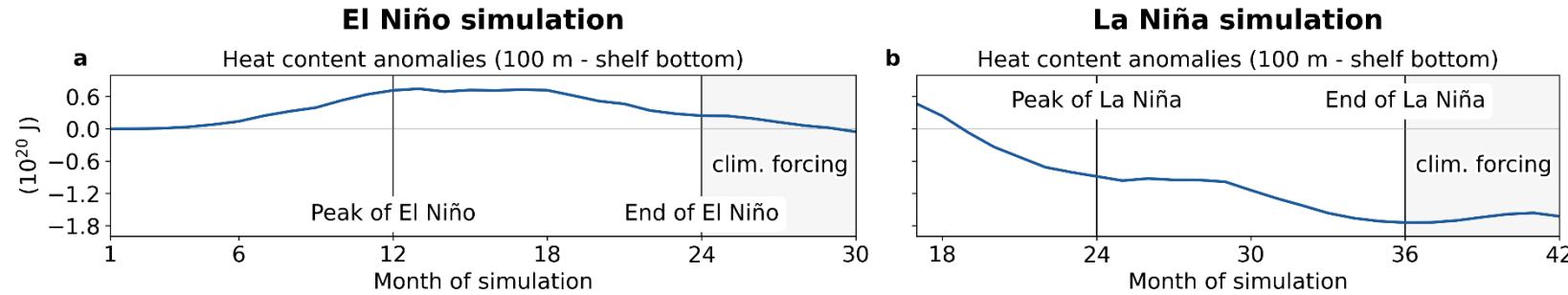
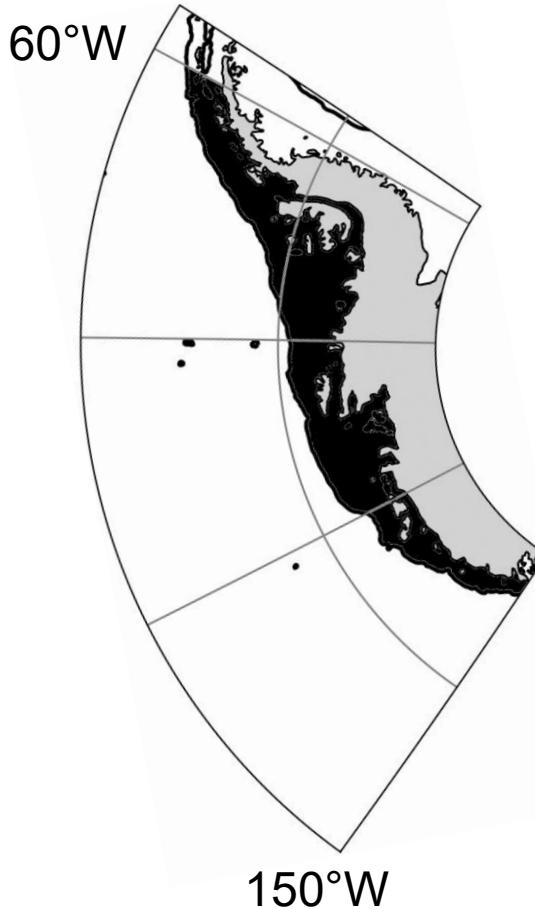


El Niño

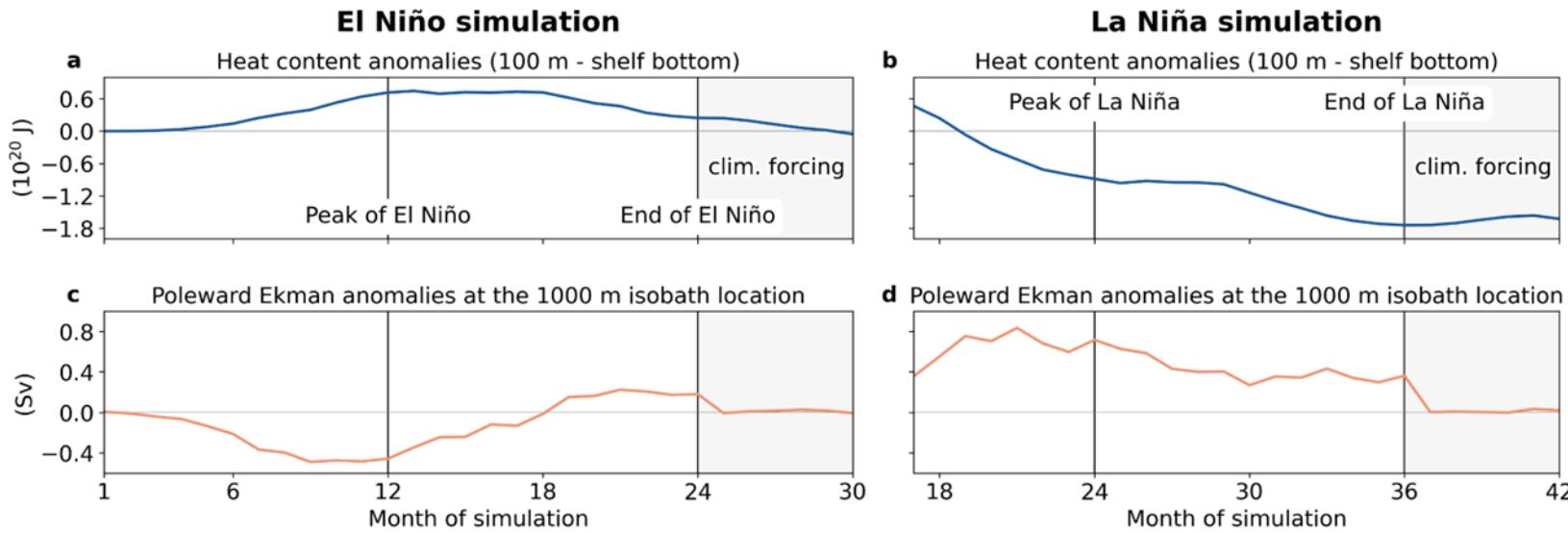


The subsurface heat budget

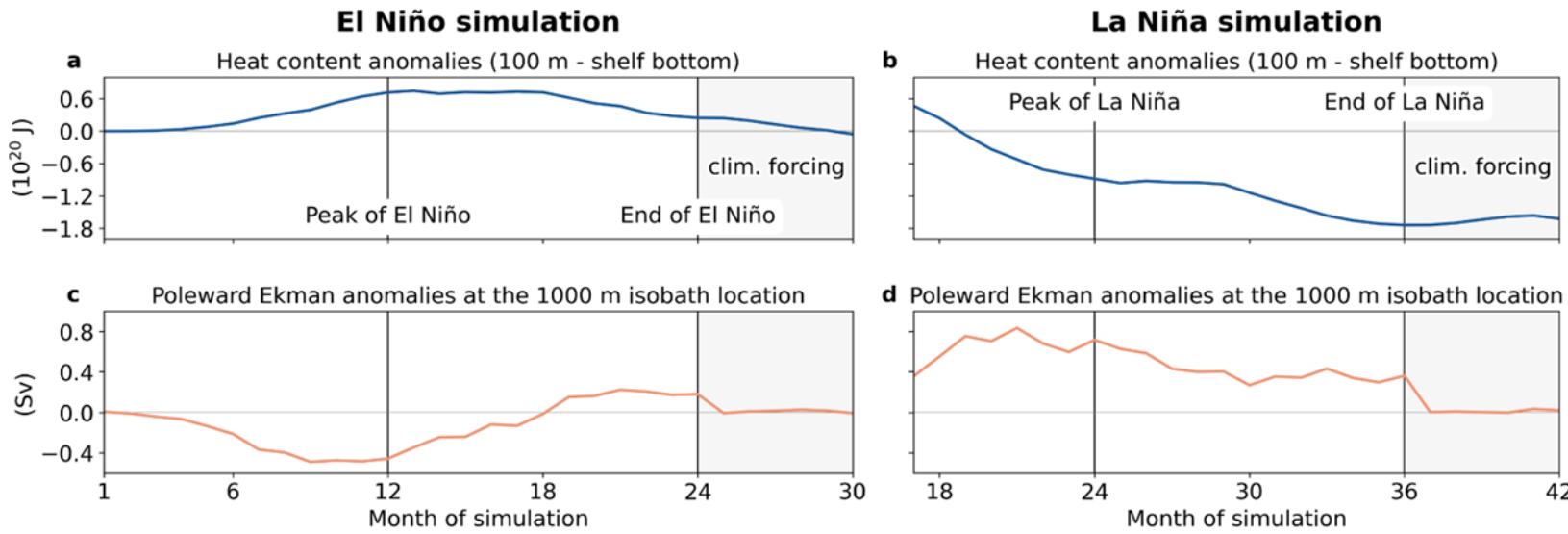
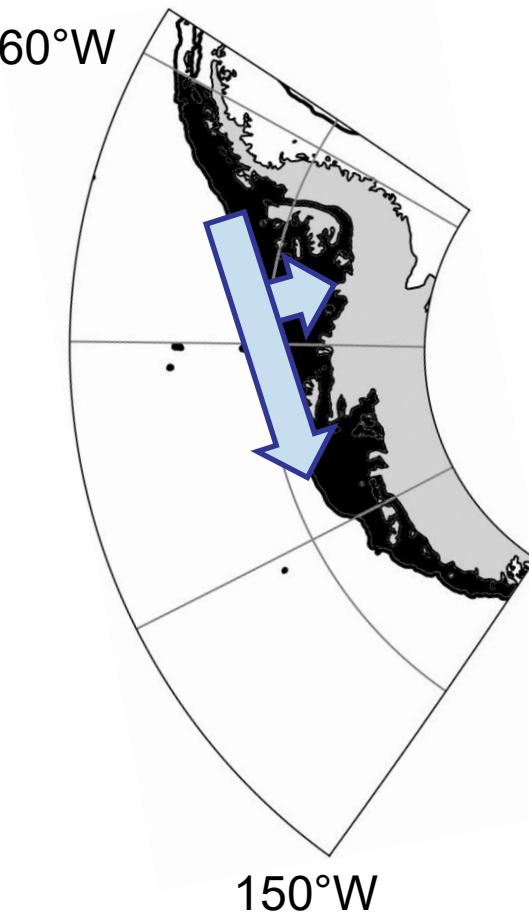
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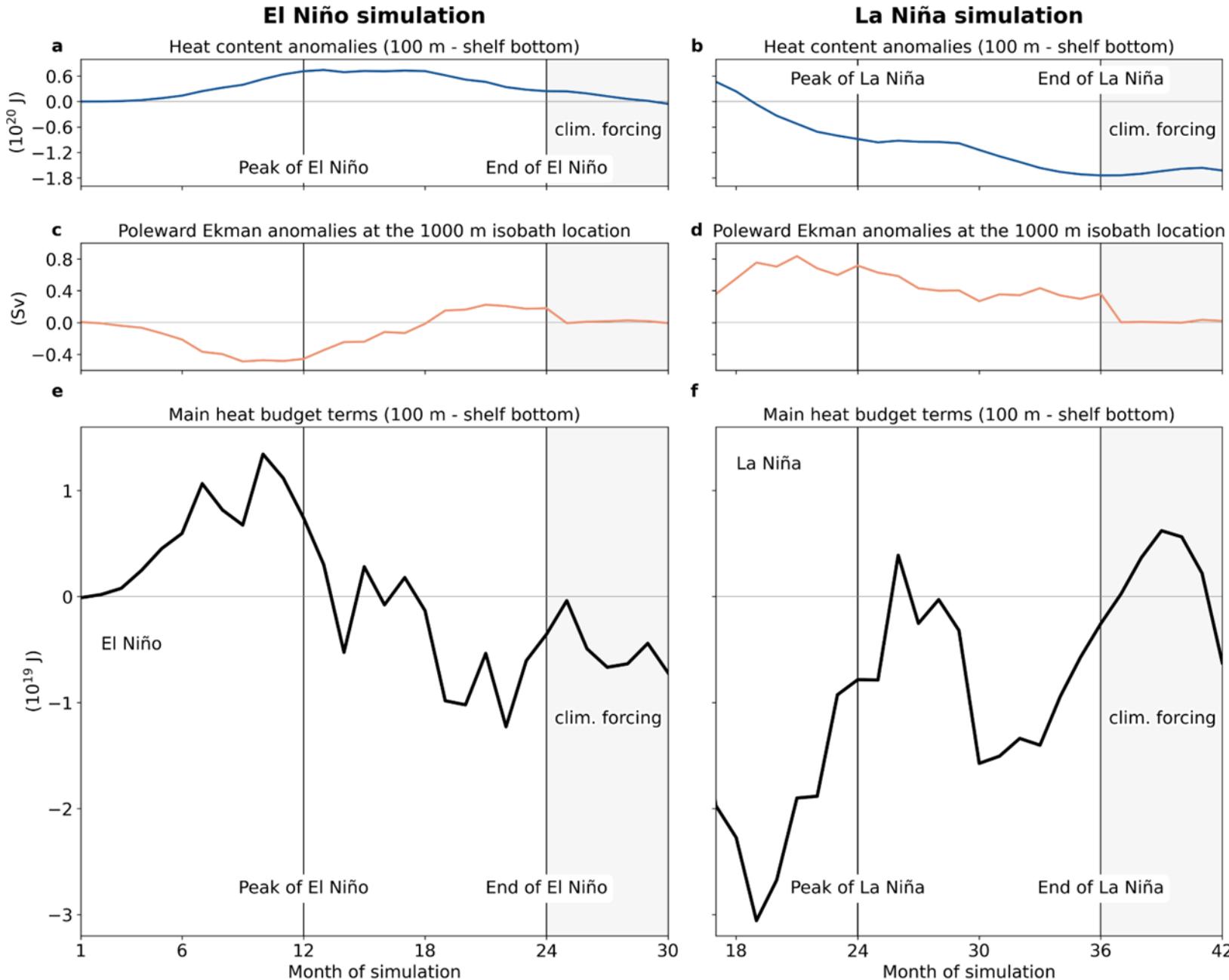
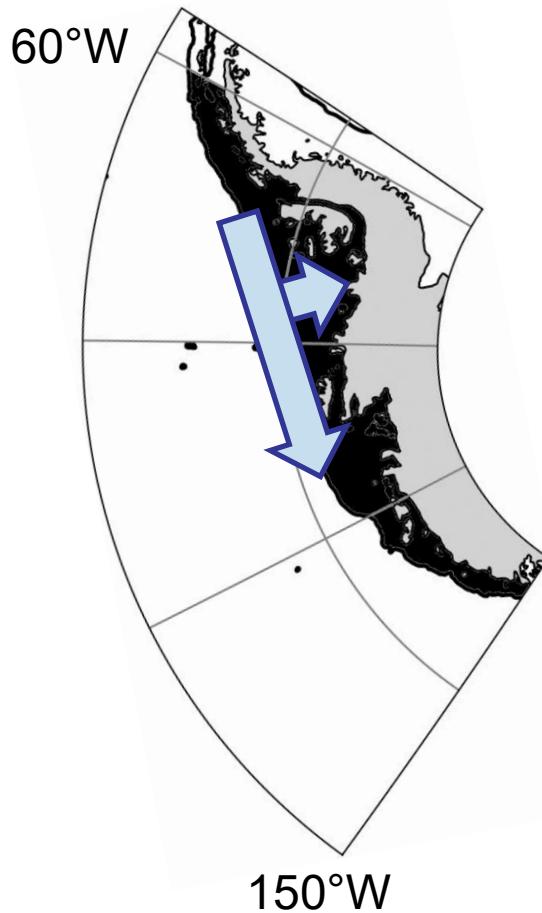
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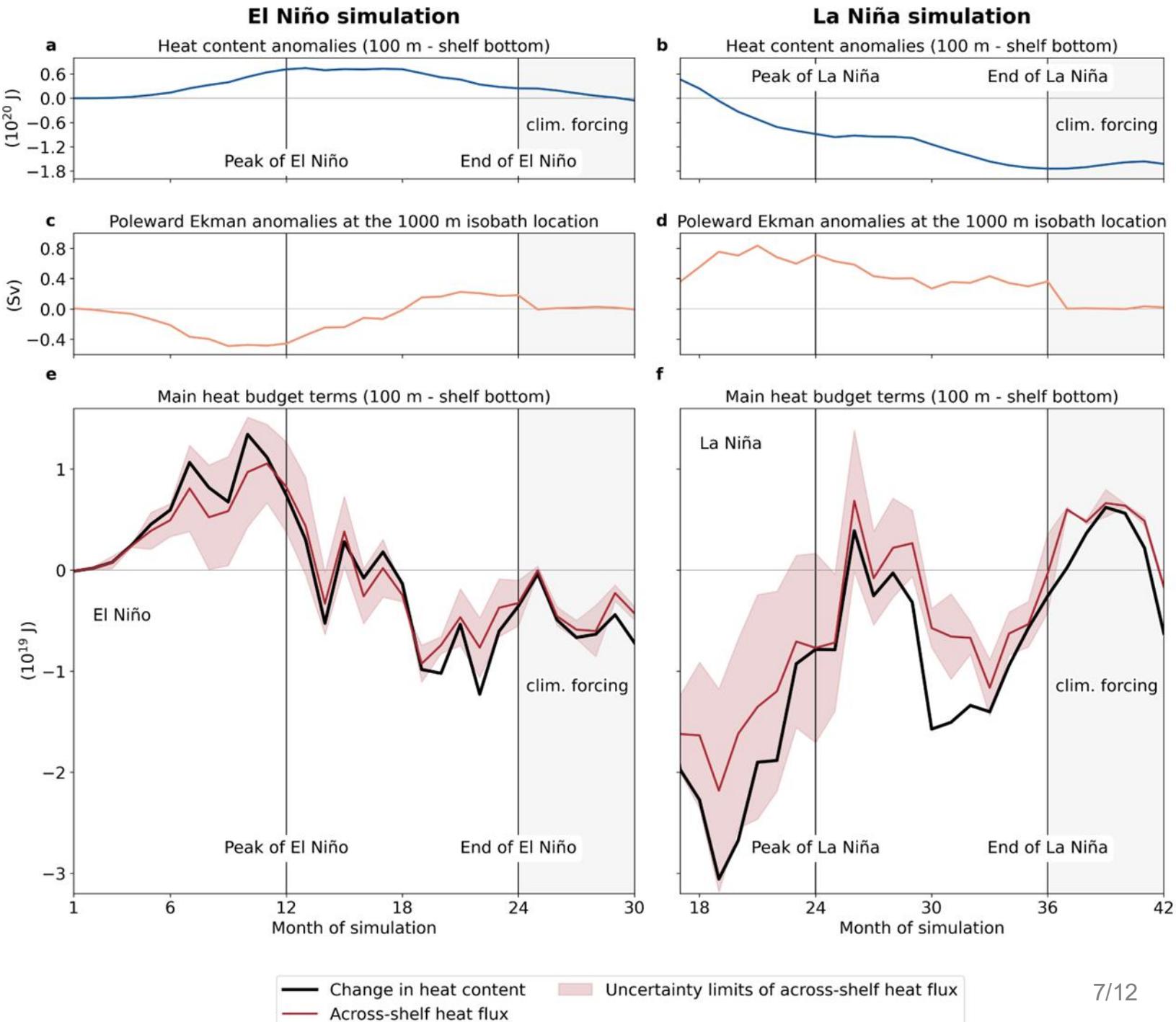
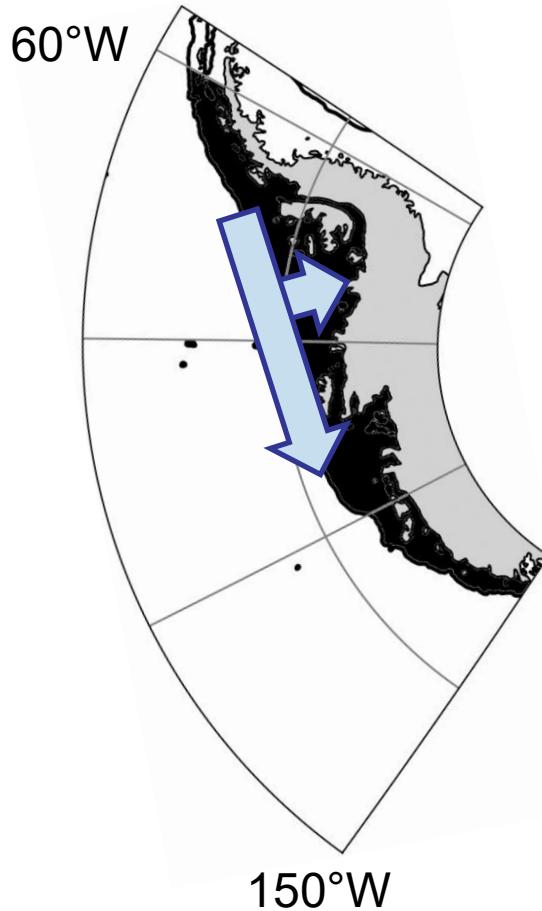
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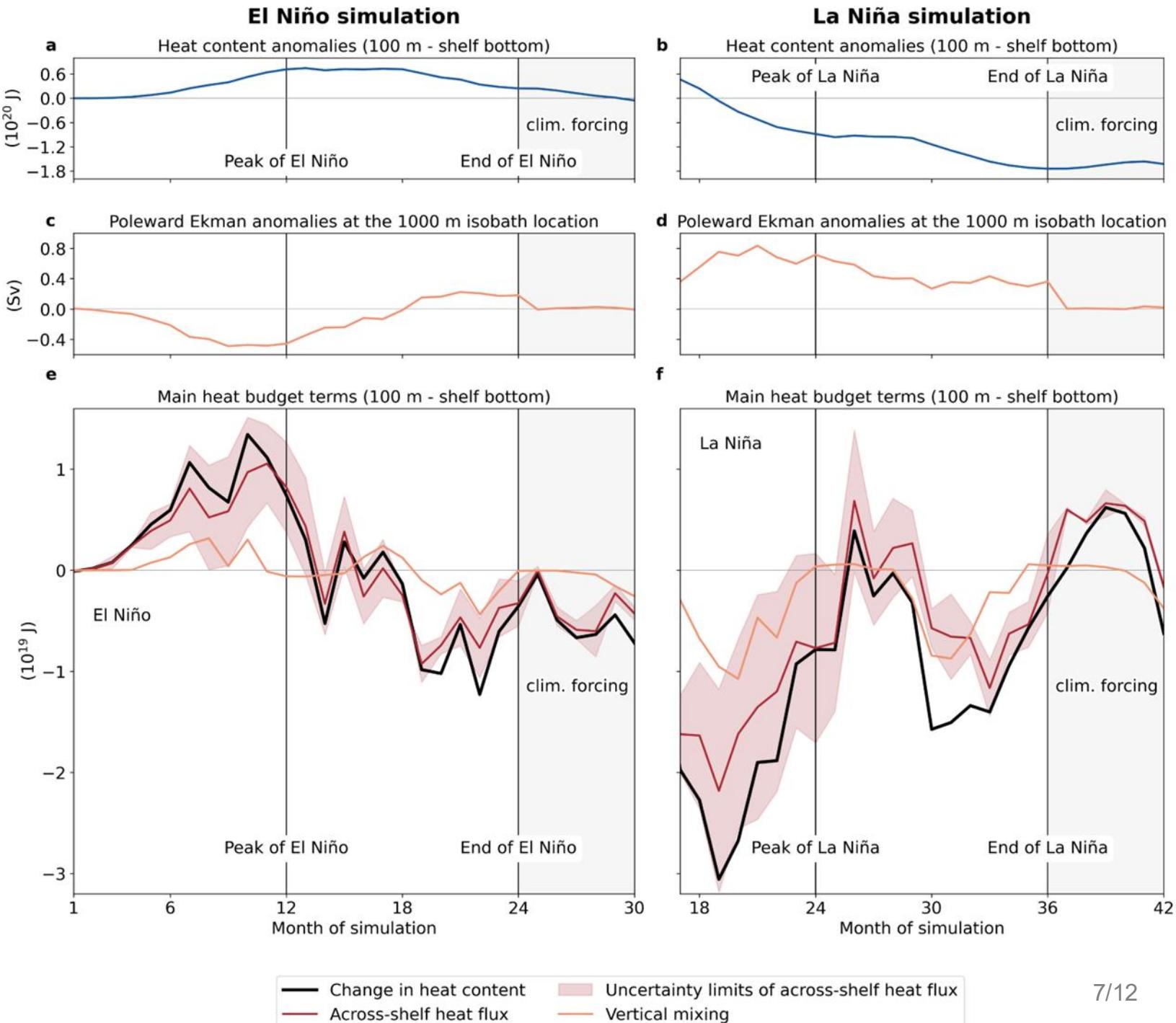
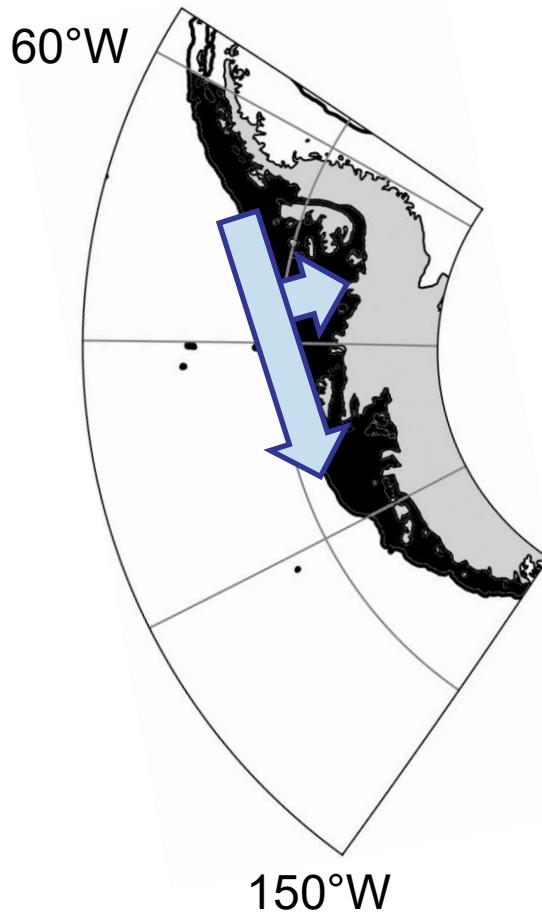
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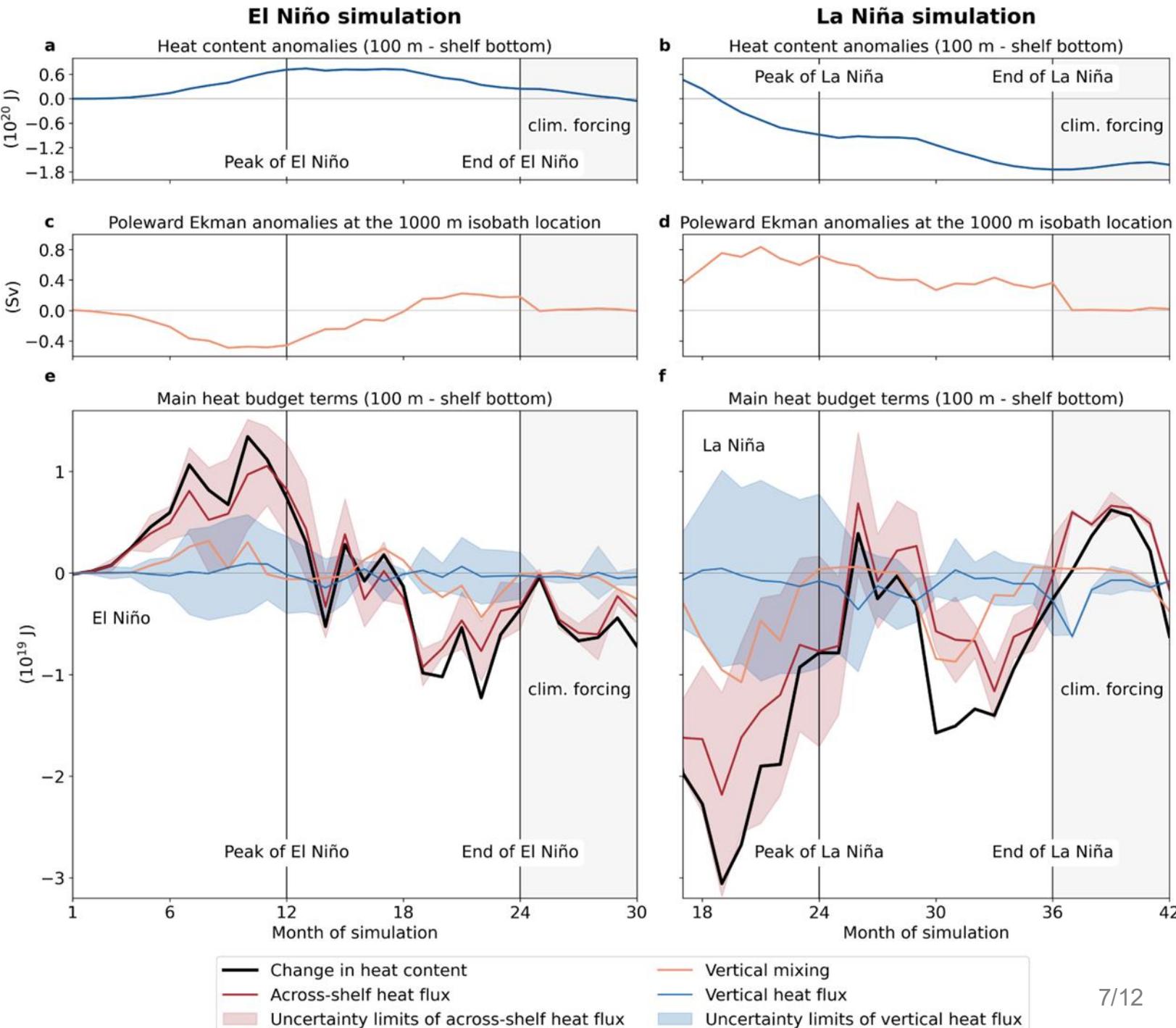
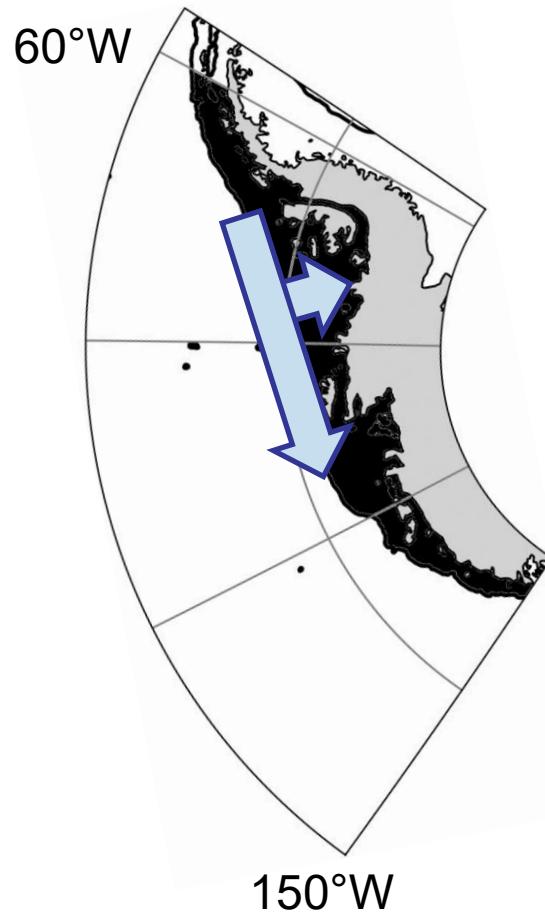
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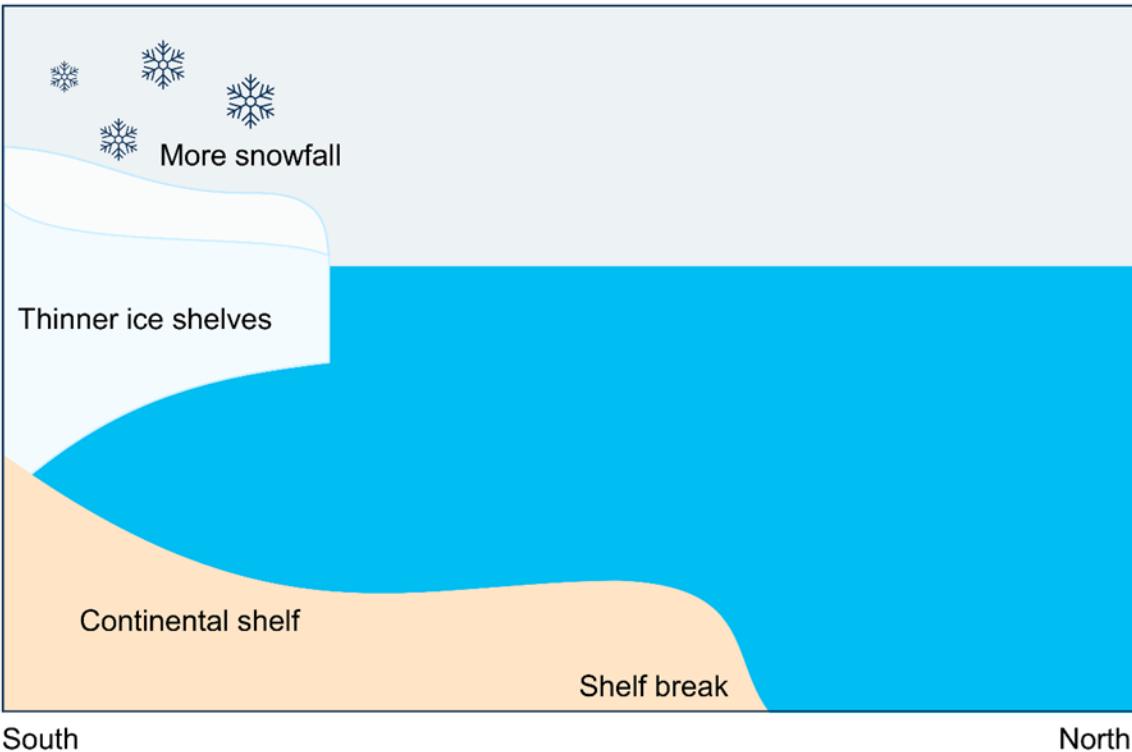
The subsurface heat budget



Schematic

a

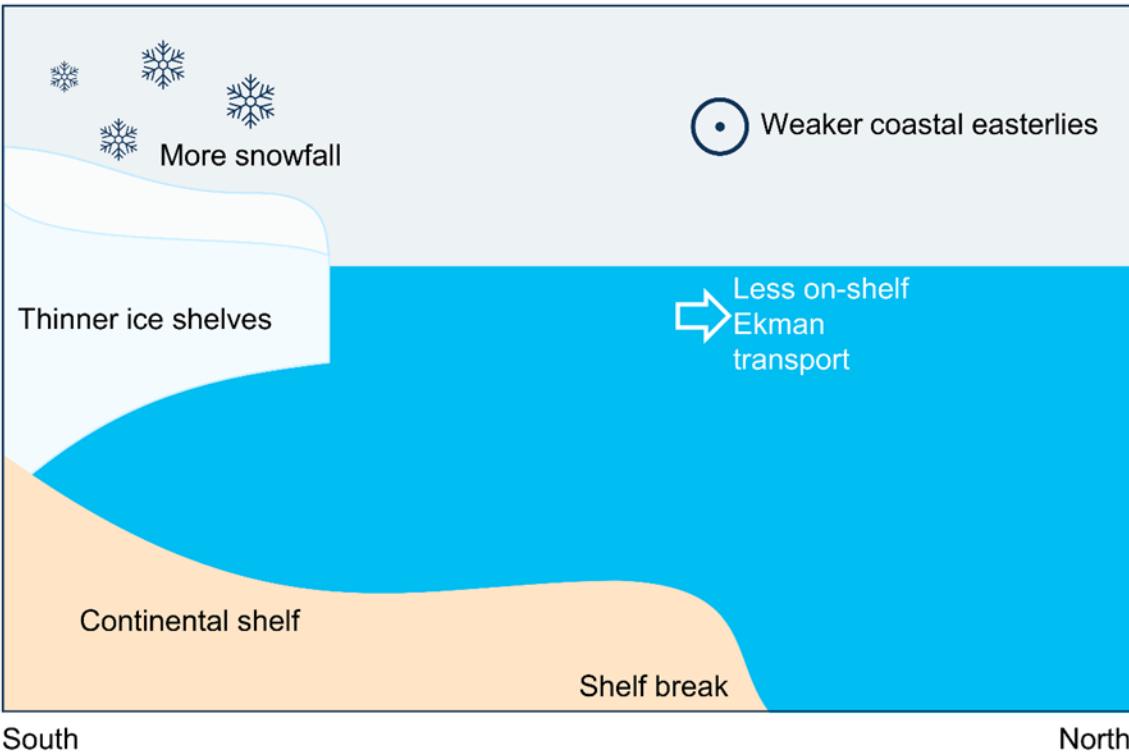
El Niño



Schematic

a

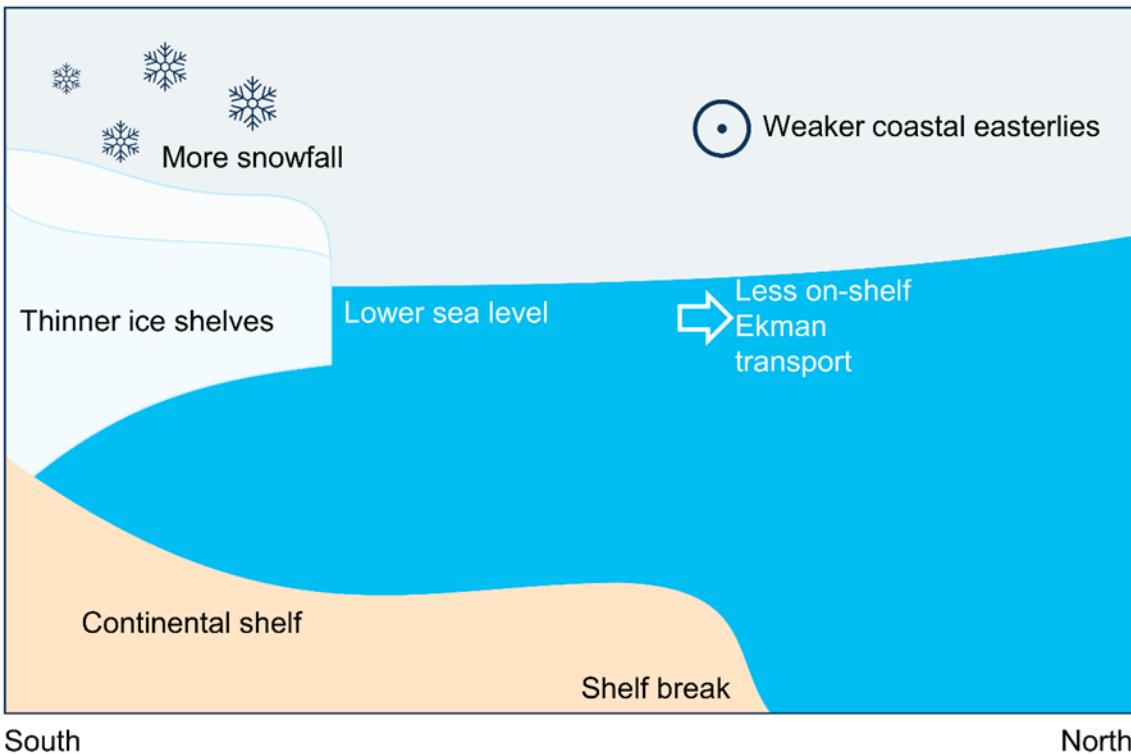
El Niño



Schematic

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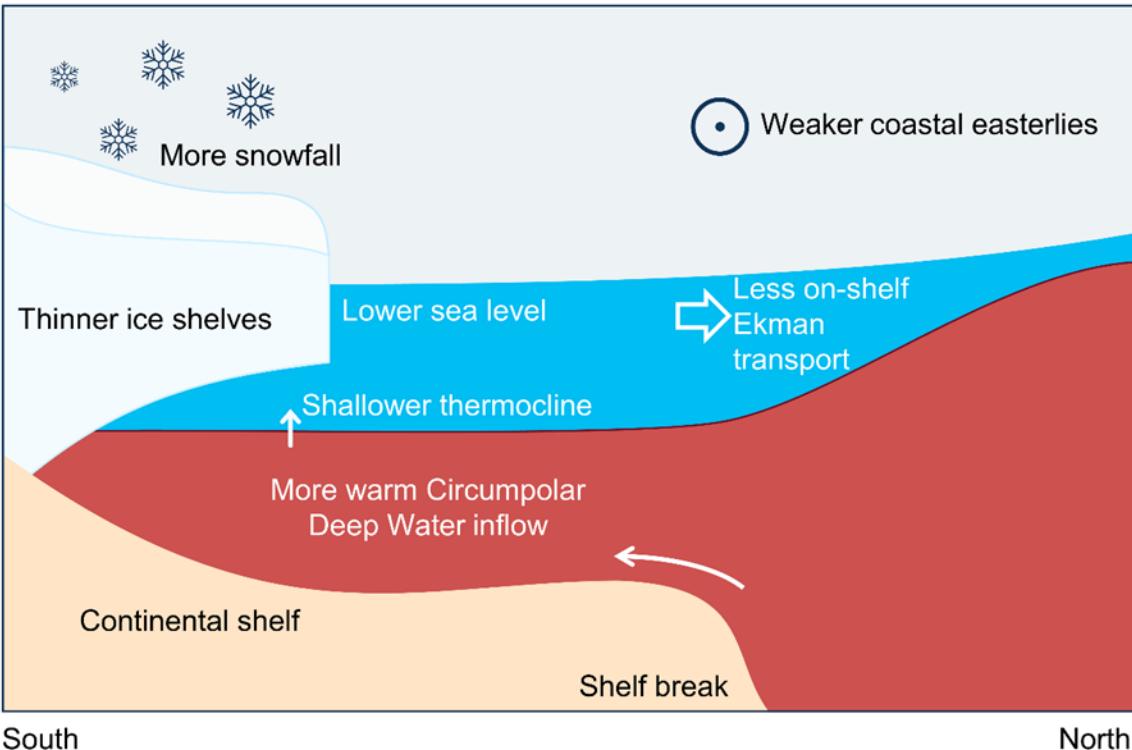
El Niño



Schematic

a

El Niño



South

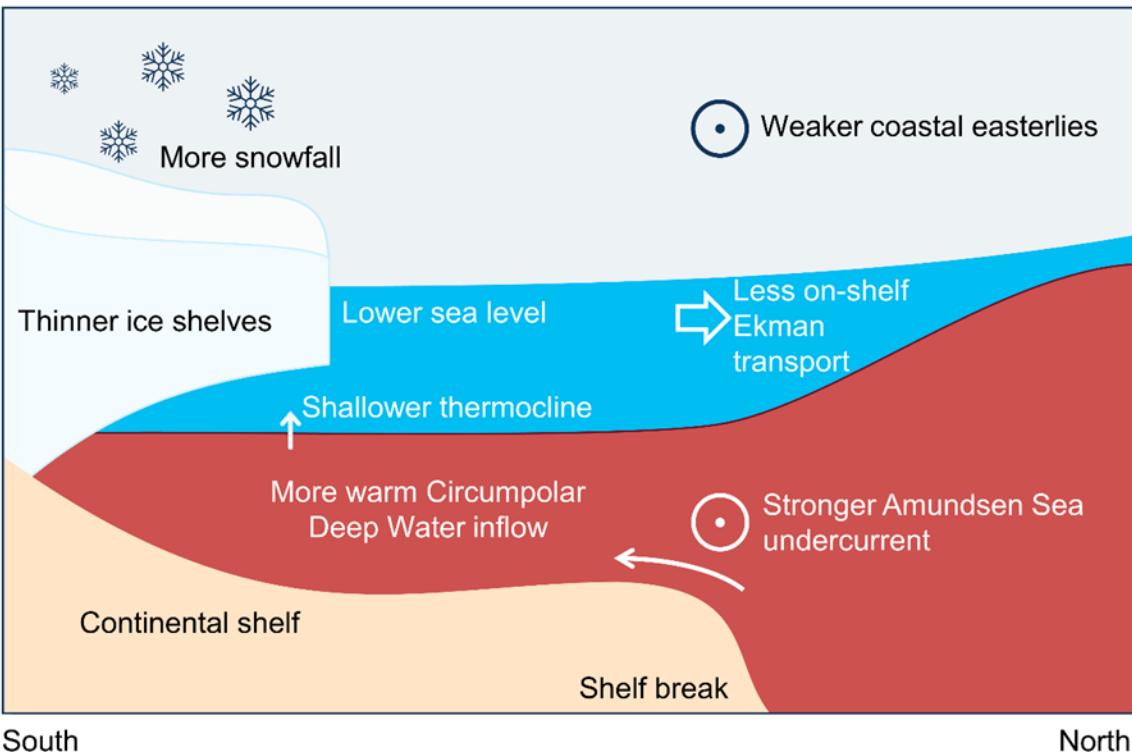
North

- *bottom Ekman response*
- *baroclinic adjustment*
- *Amundsen Sea undercurrent*
- *eddies*

Schematic

a

El Niño



South

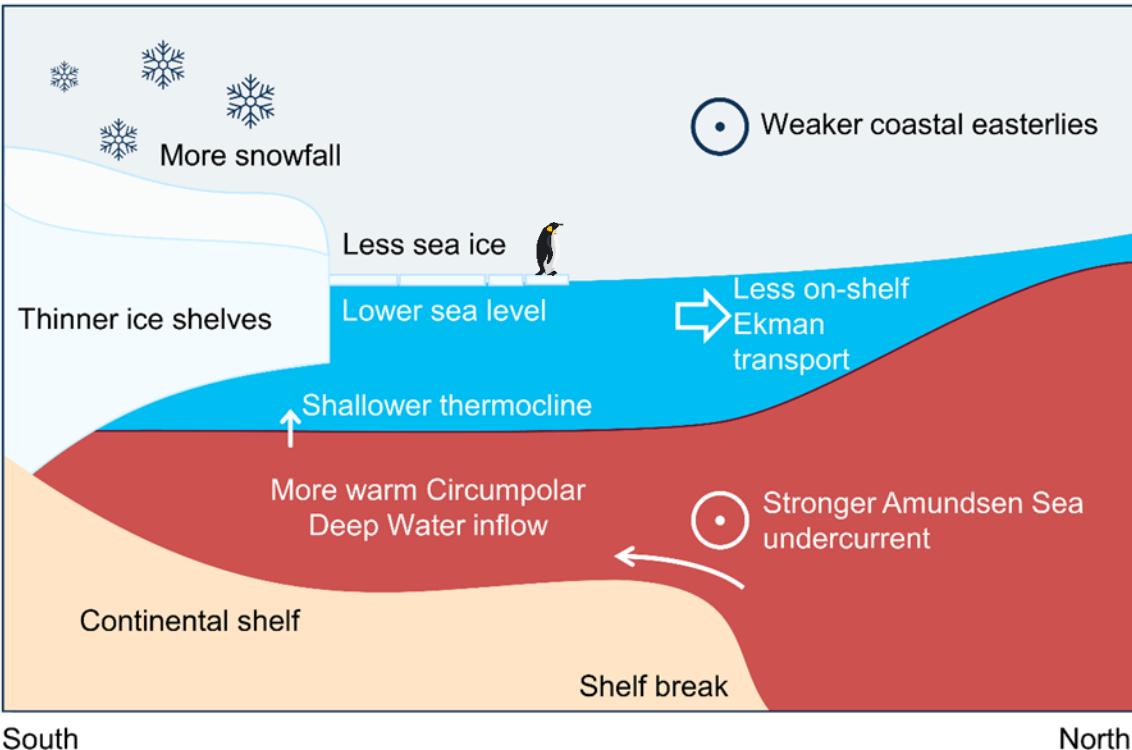
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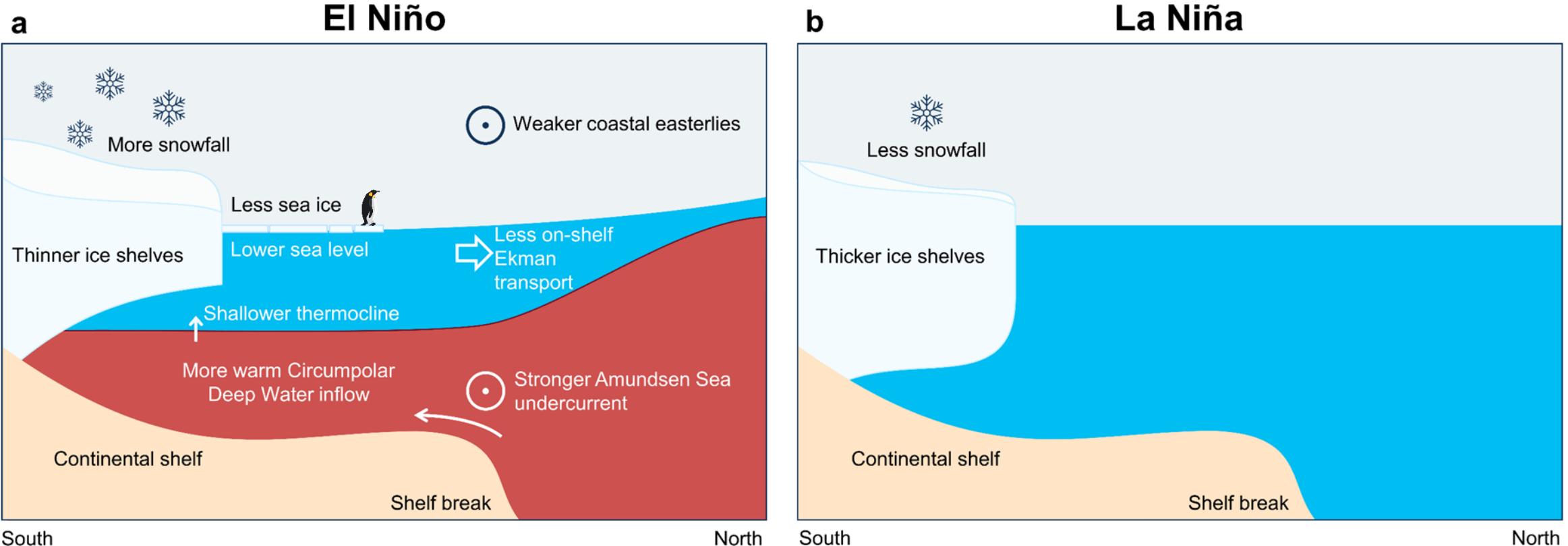


South

North

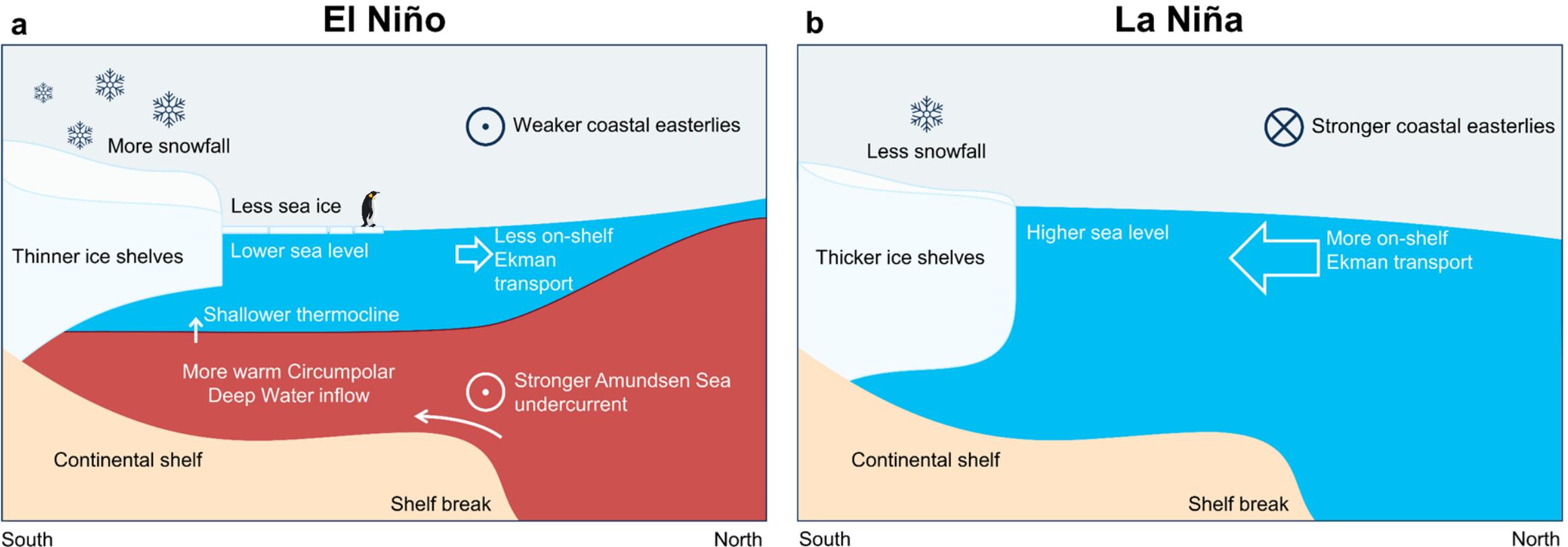
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Schematic



South

North

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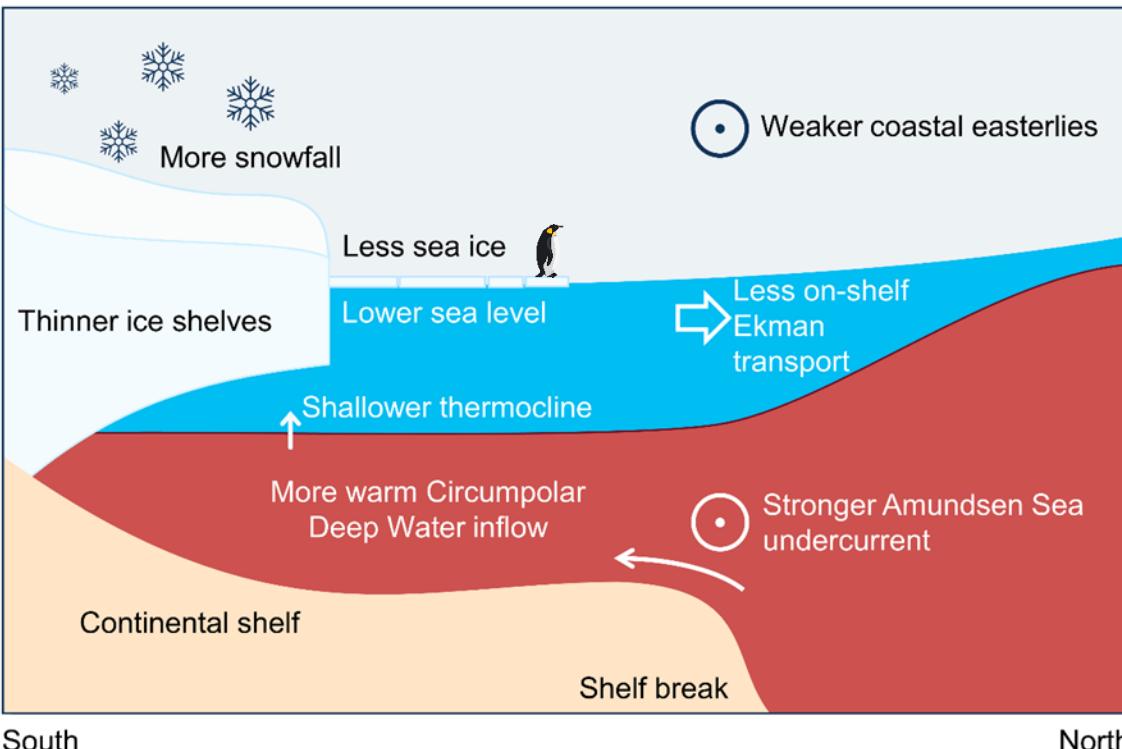
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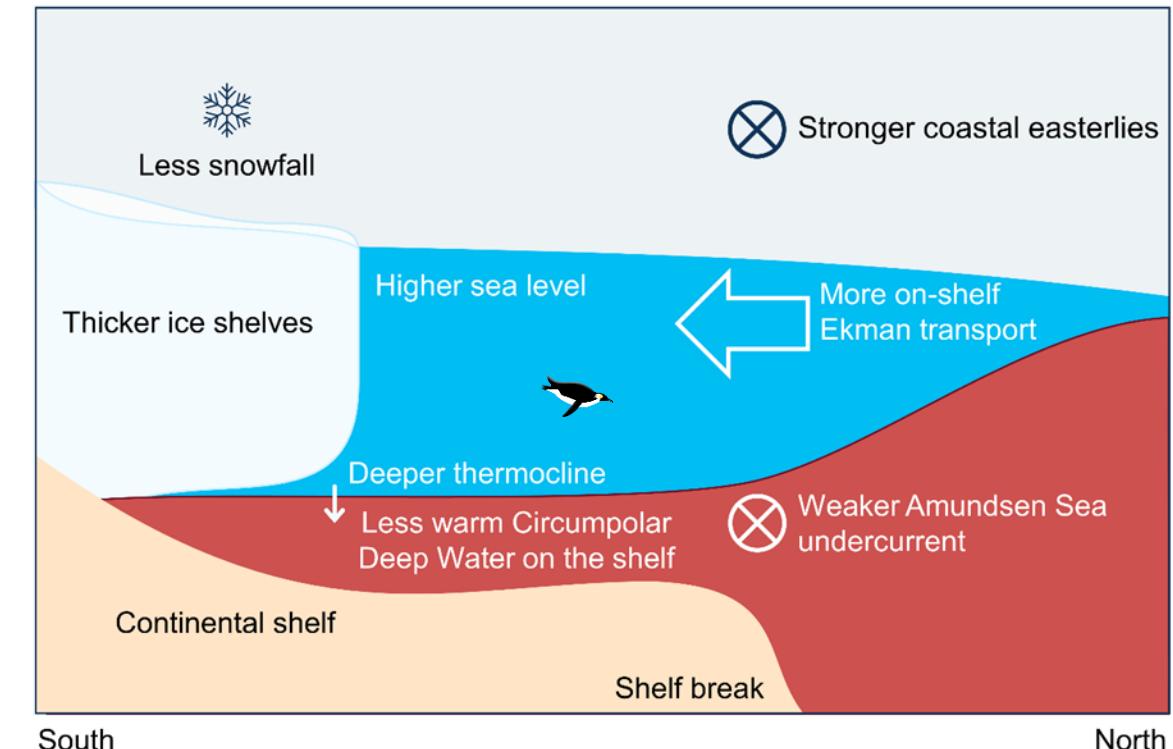
a

El Niño



b

La Niña

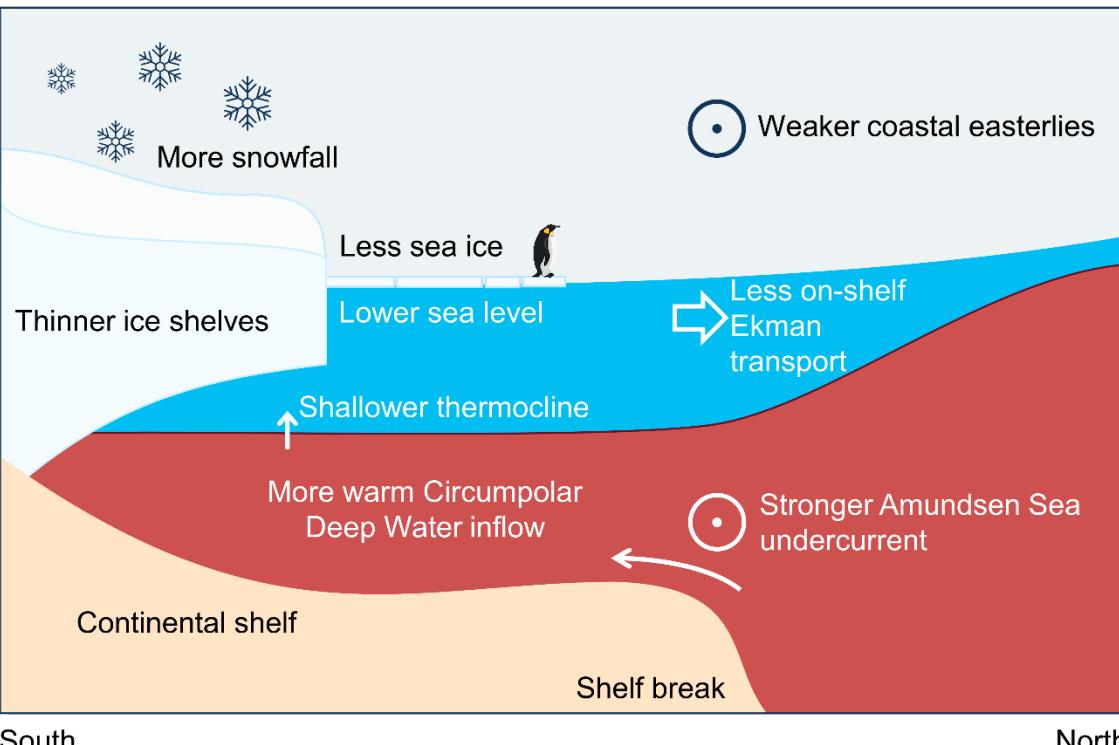


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Schematic

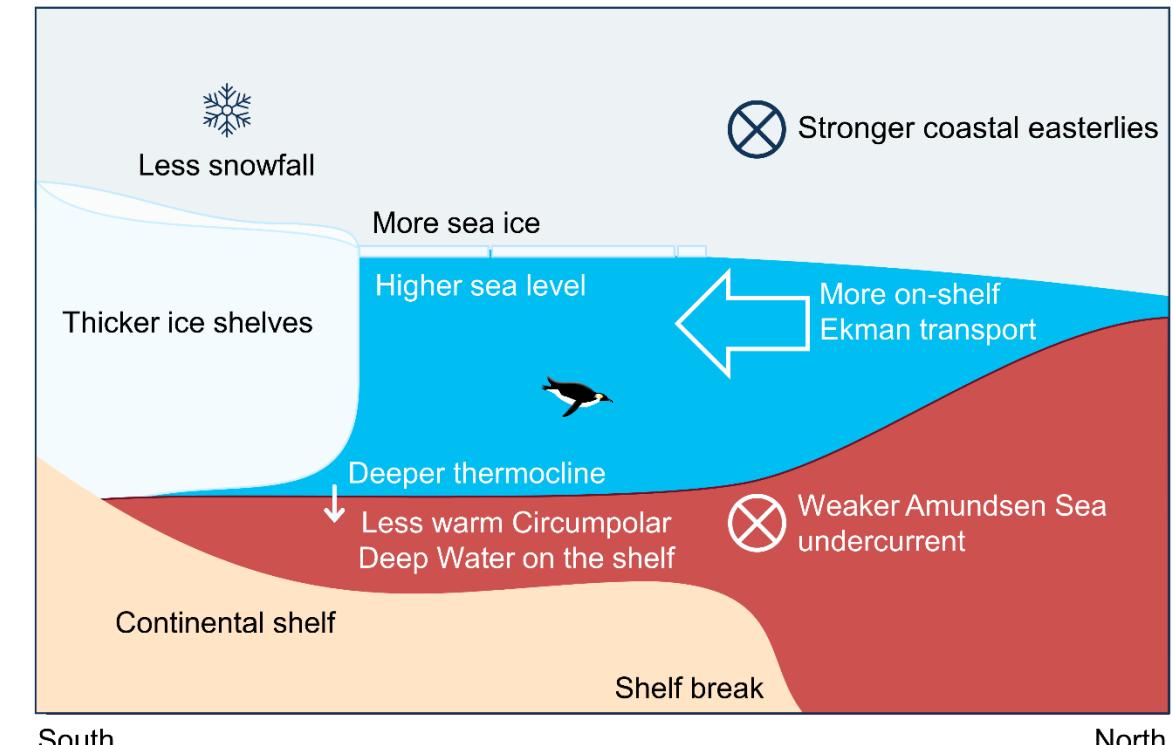
a

El Niño



b

La Niña



South

North

South

North

- *bottom Ekman response*
- *baroclinic adjustment*
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- *eddies*

...but wait, there's more!

Current project

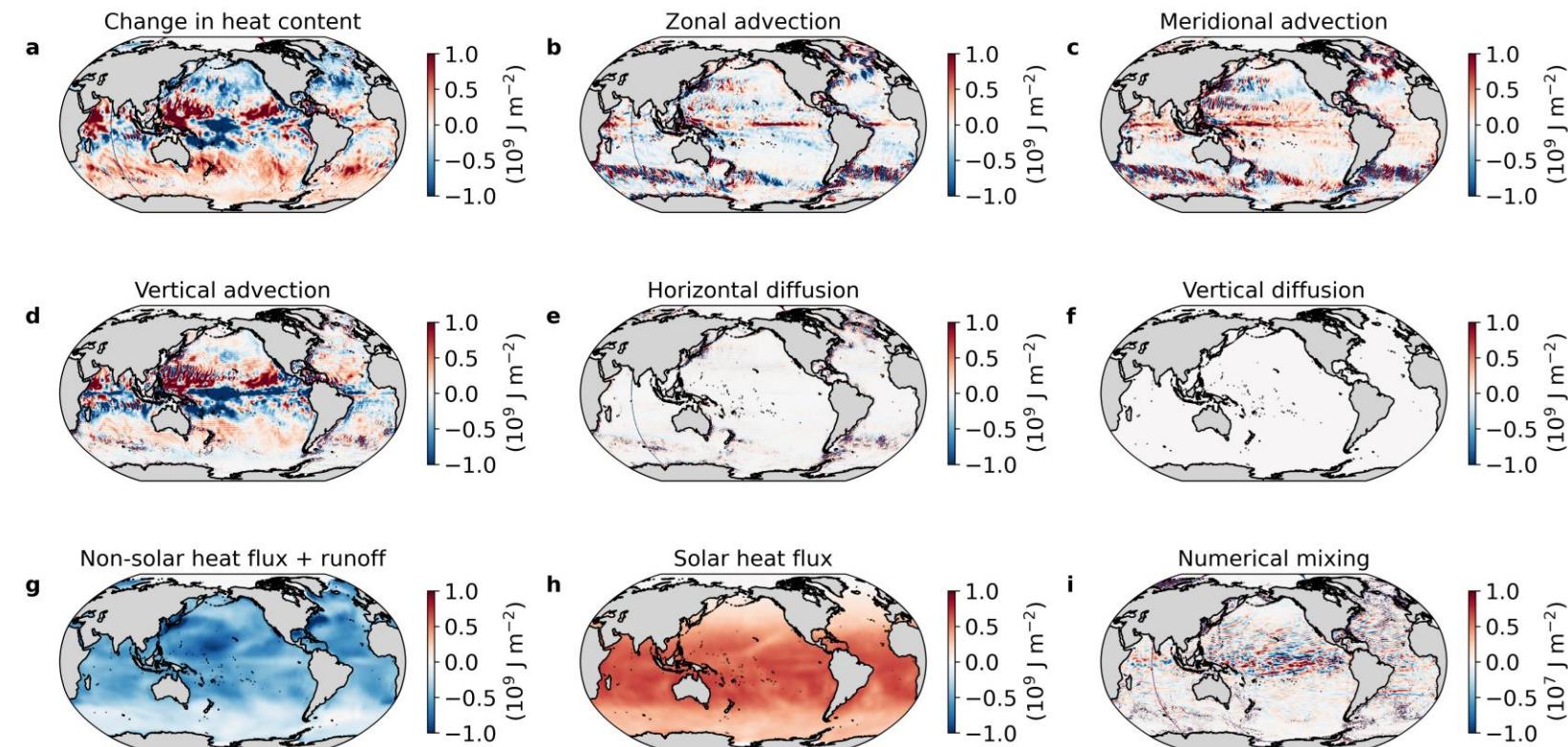
Eddy-parameterisation impacts on future ocean heat & carbon uptake

with Ivy Frenger

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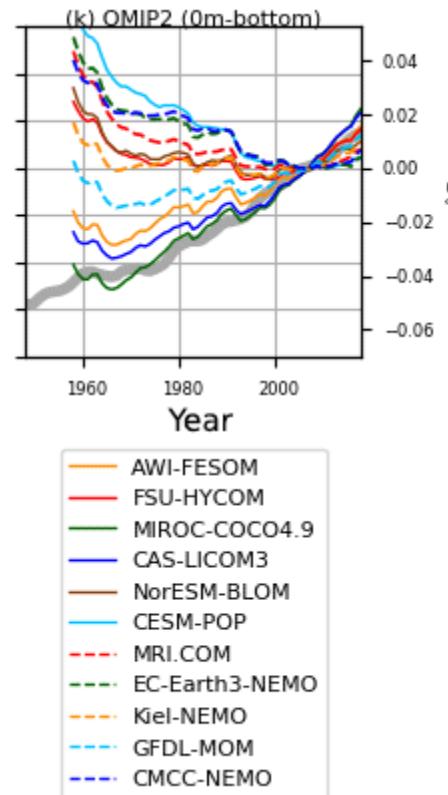
- FOCI-MOPS
- future scenarios w/ varying eddy mixing coefficients
- 1980-2014 period



Full OHC & DIC budgets

Future project

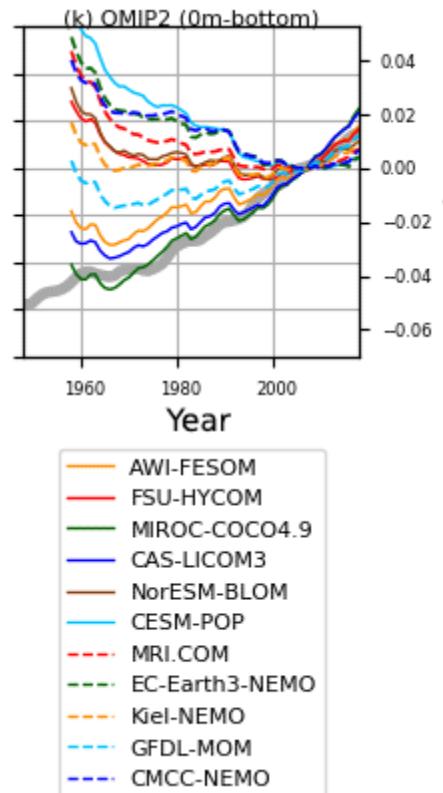
OMIP-2 models, anomalies
relative to 2005-09



Tsujino et al. (2020)

A new spin-up for ocean-sea ice models

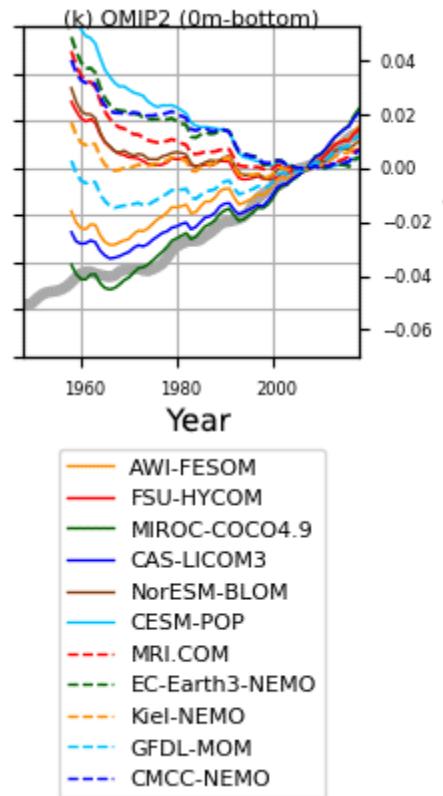
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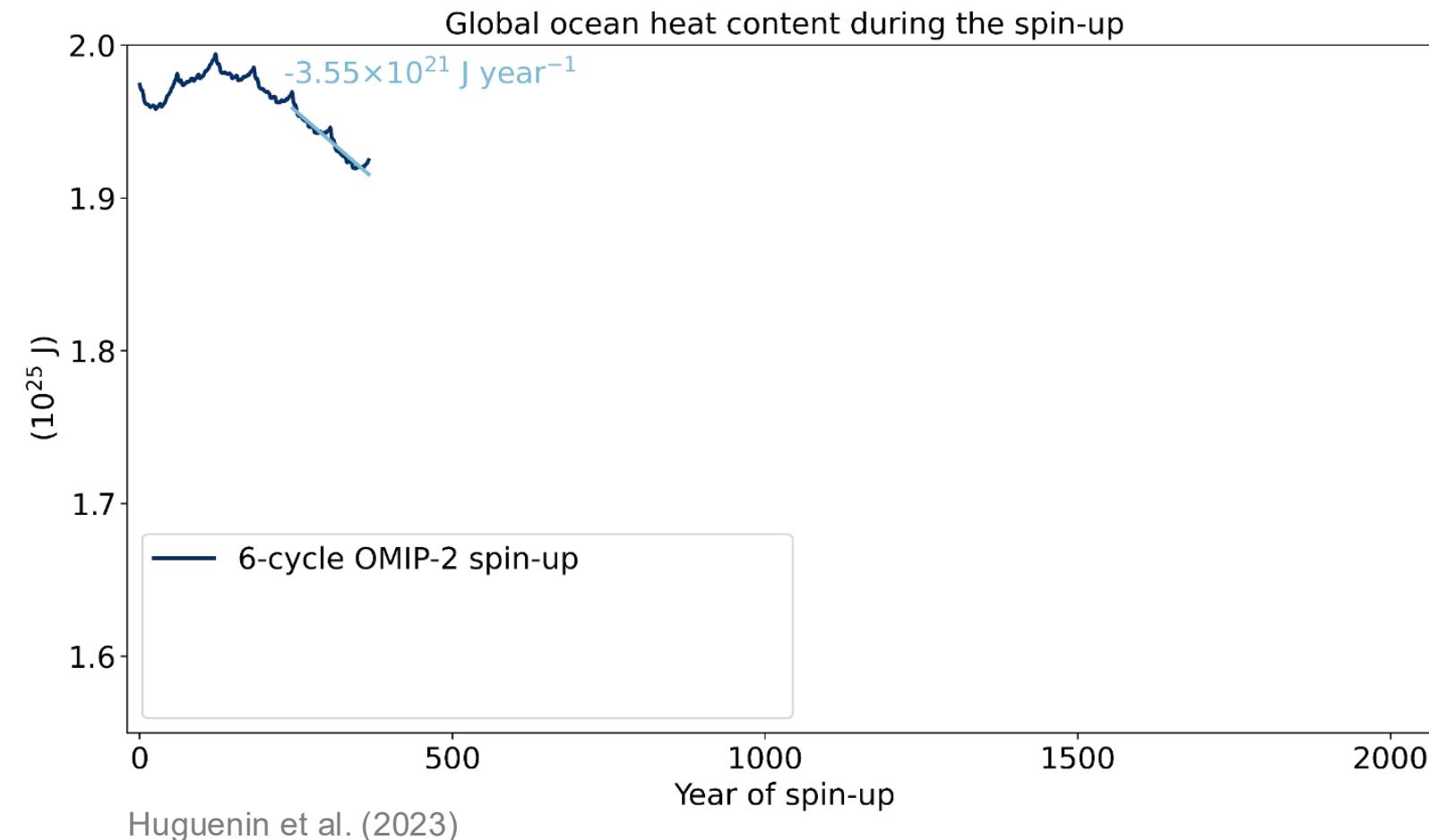
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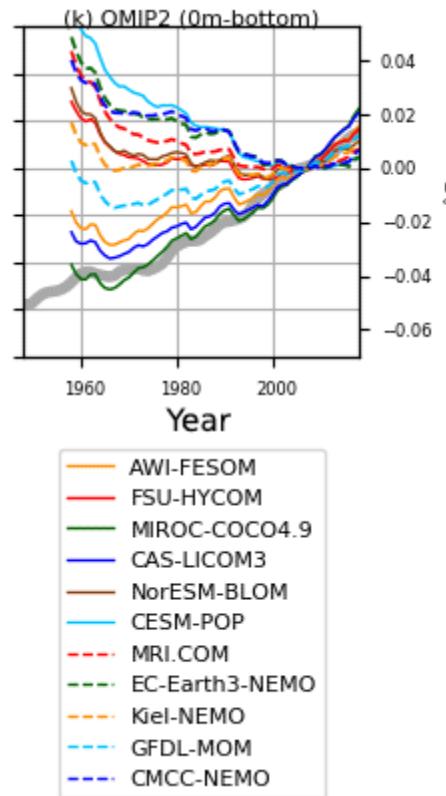


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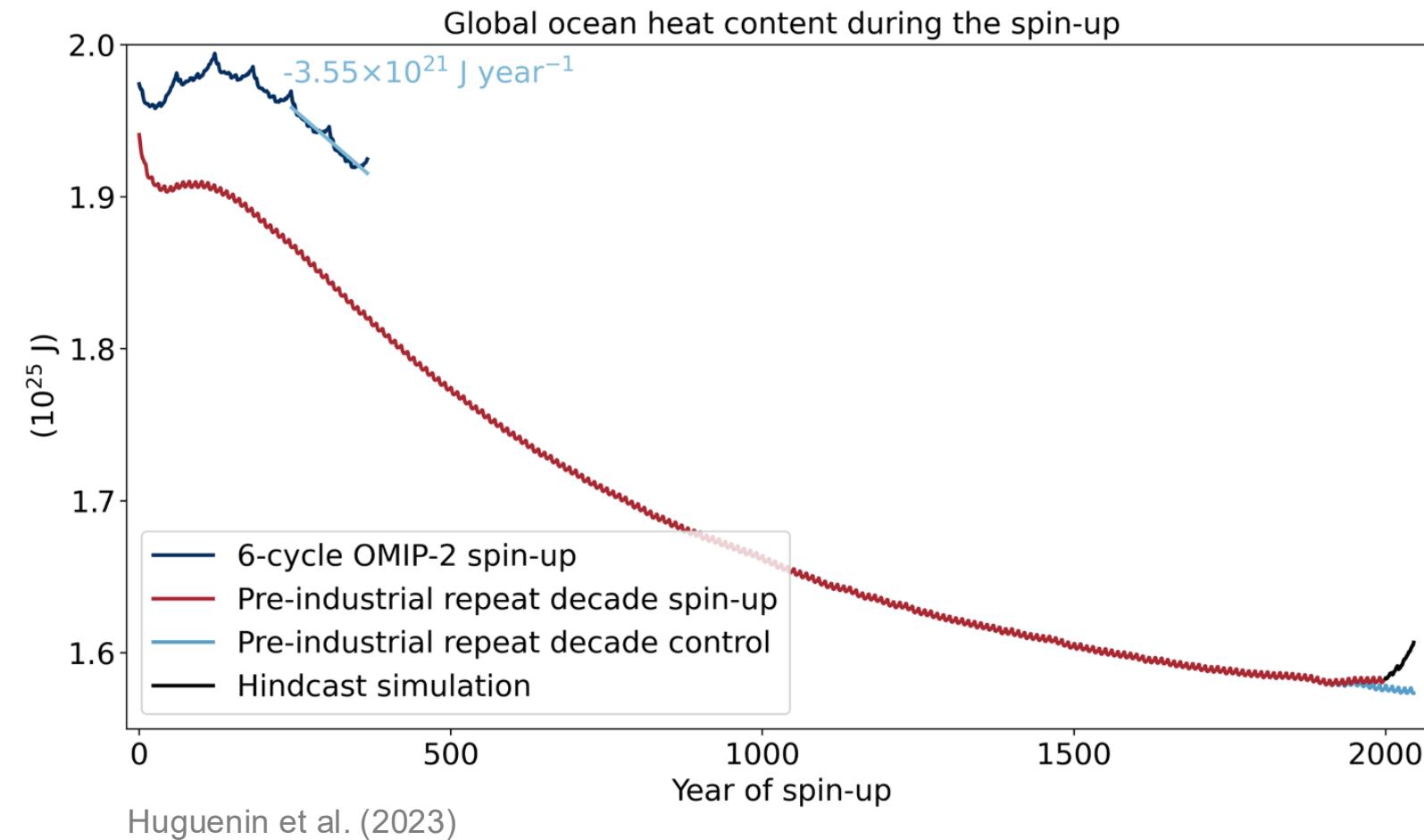


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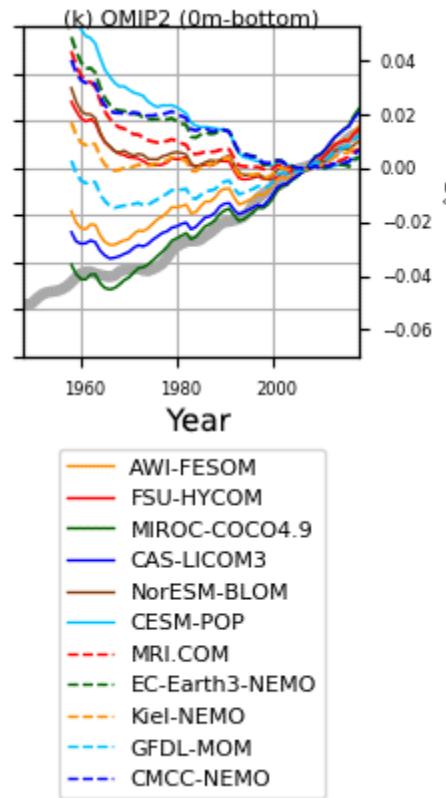


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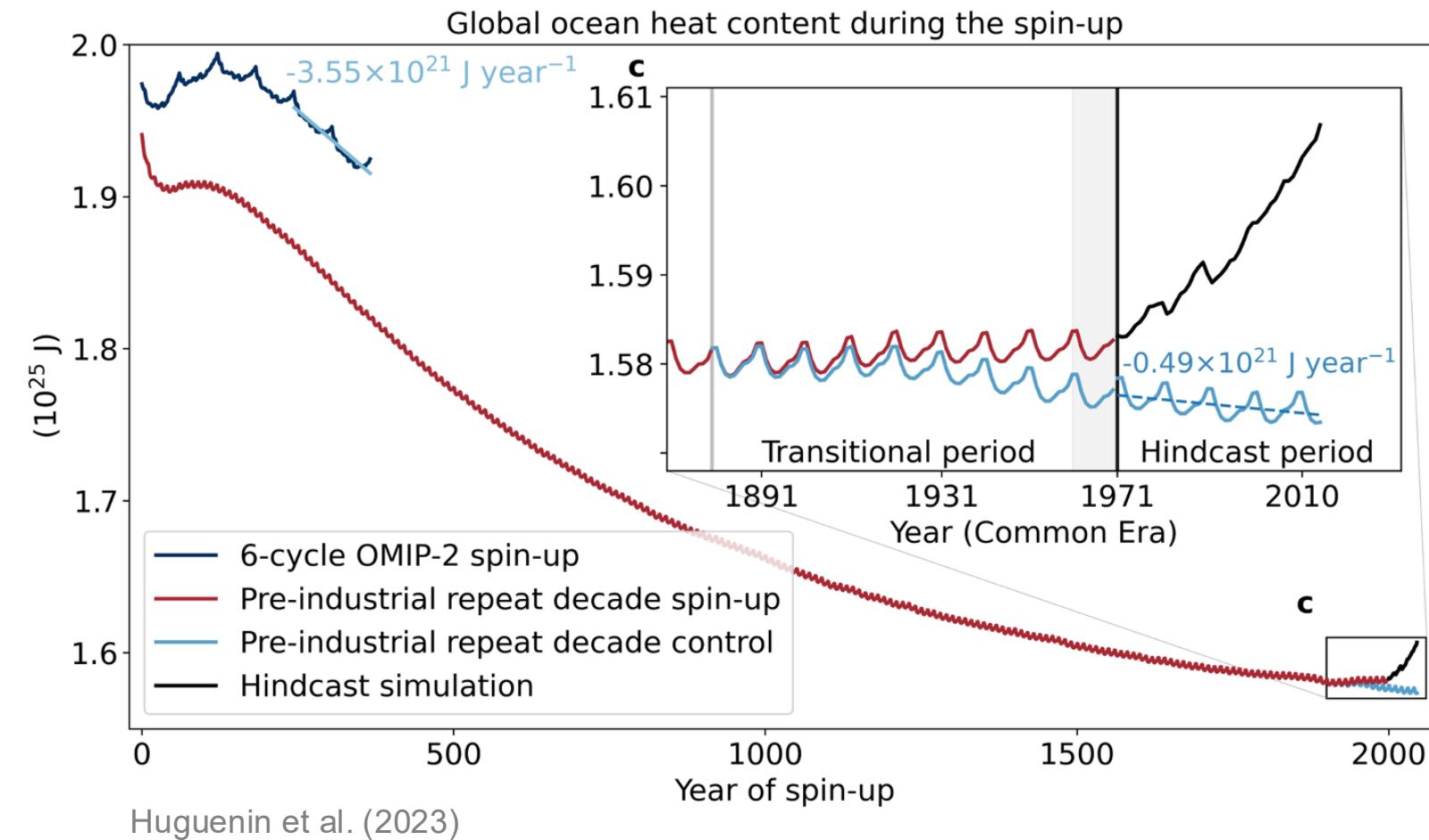


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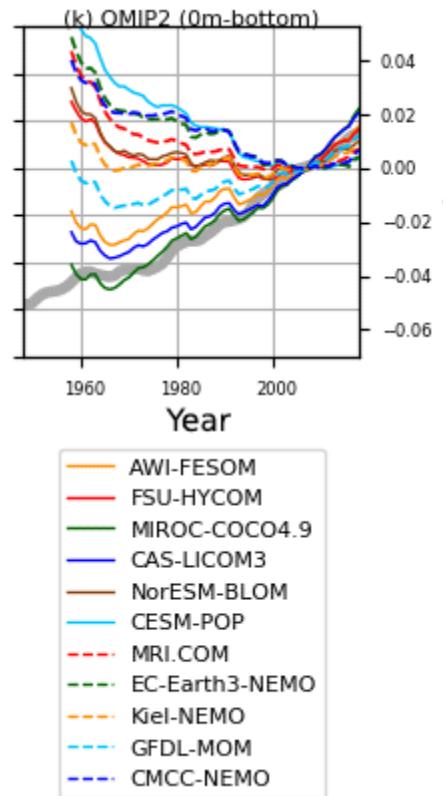


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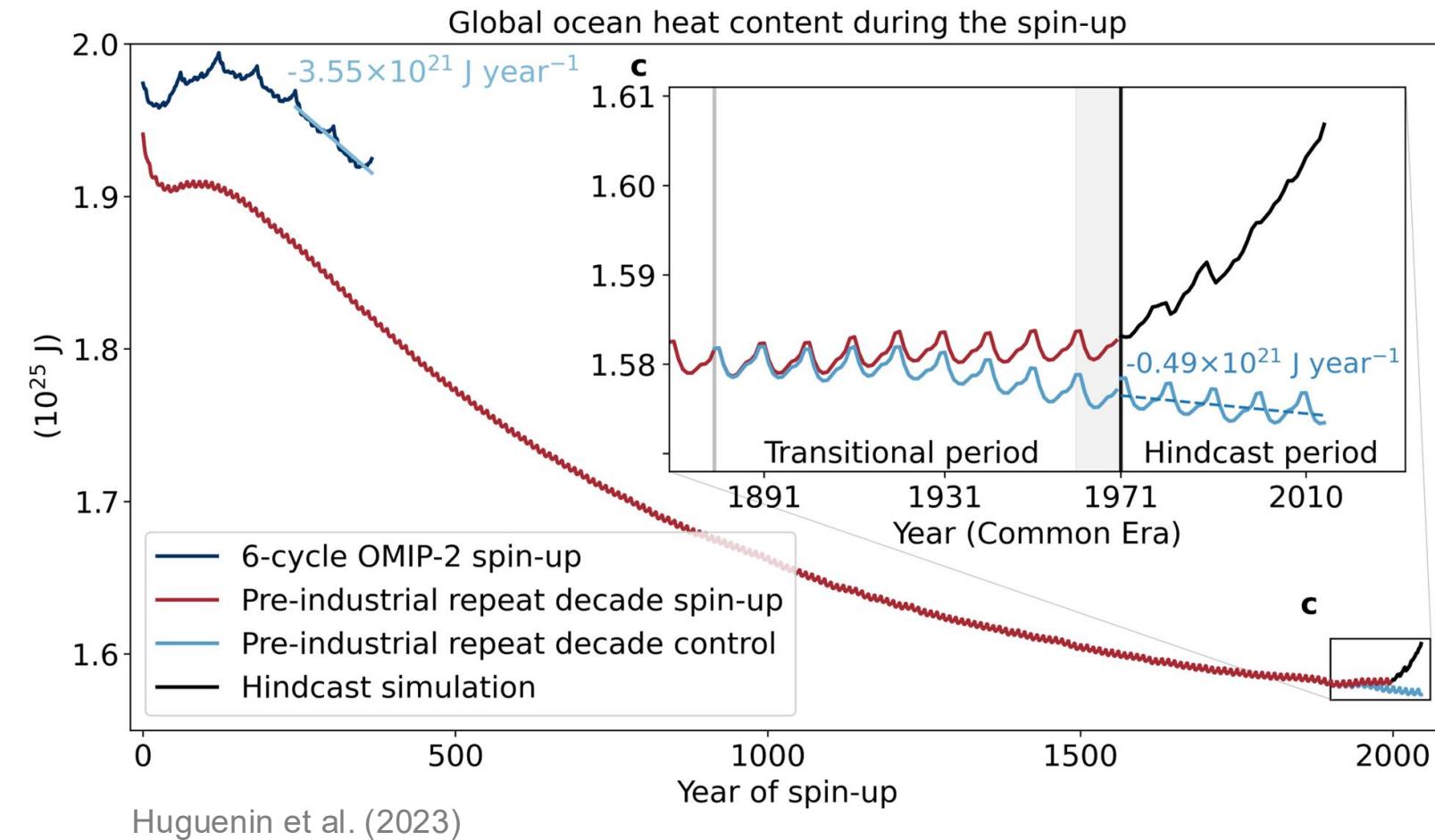


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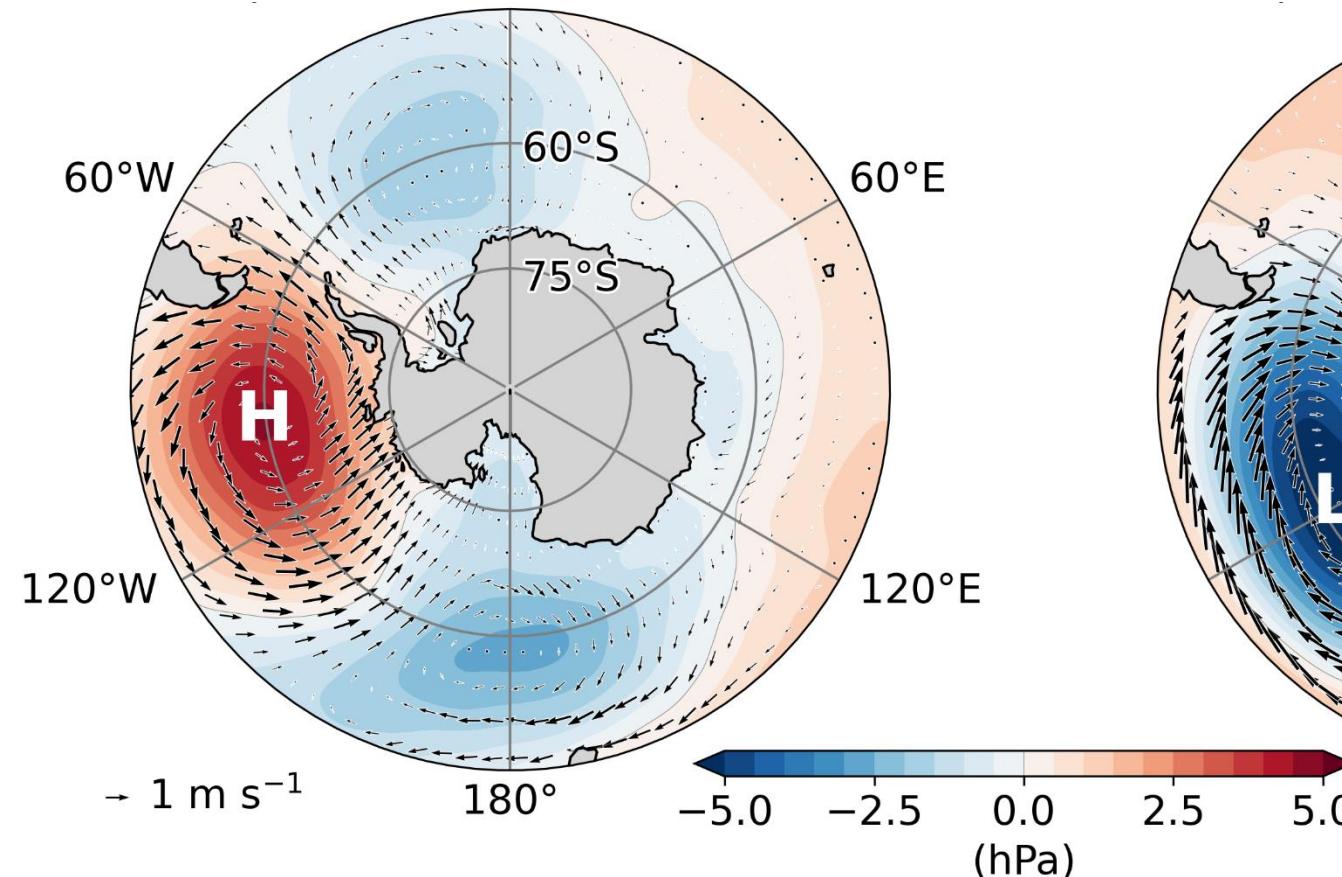
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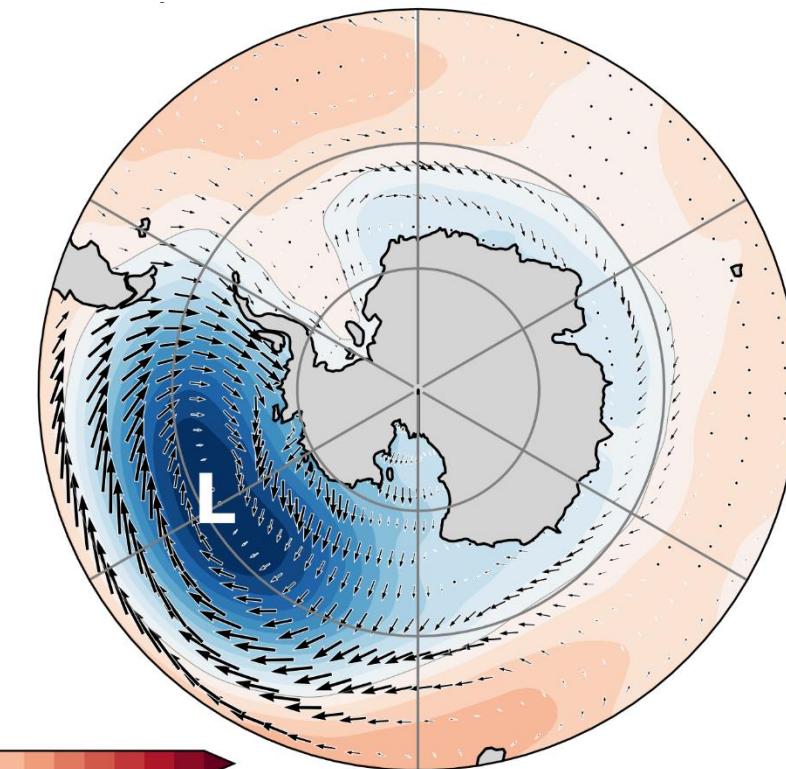
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El Niño sea level pressure and surface winds



La Niña

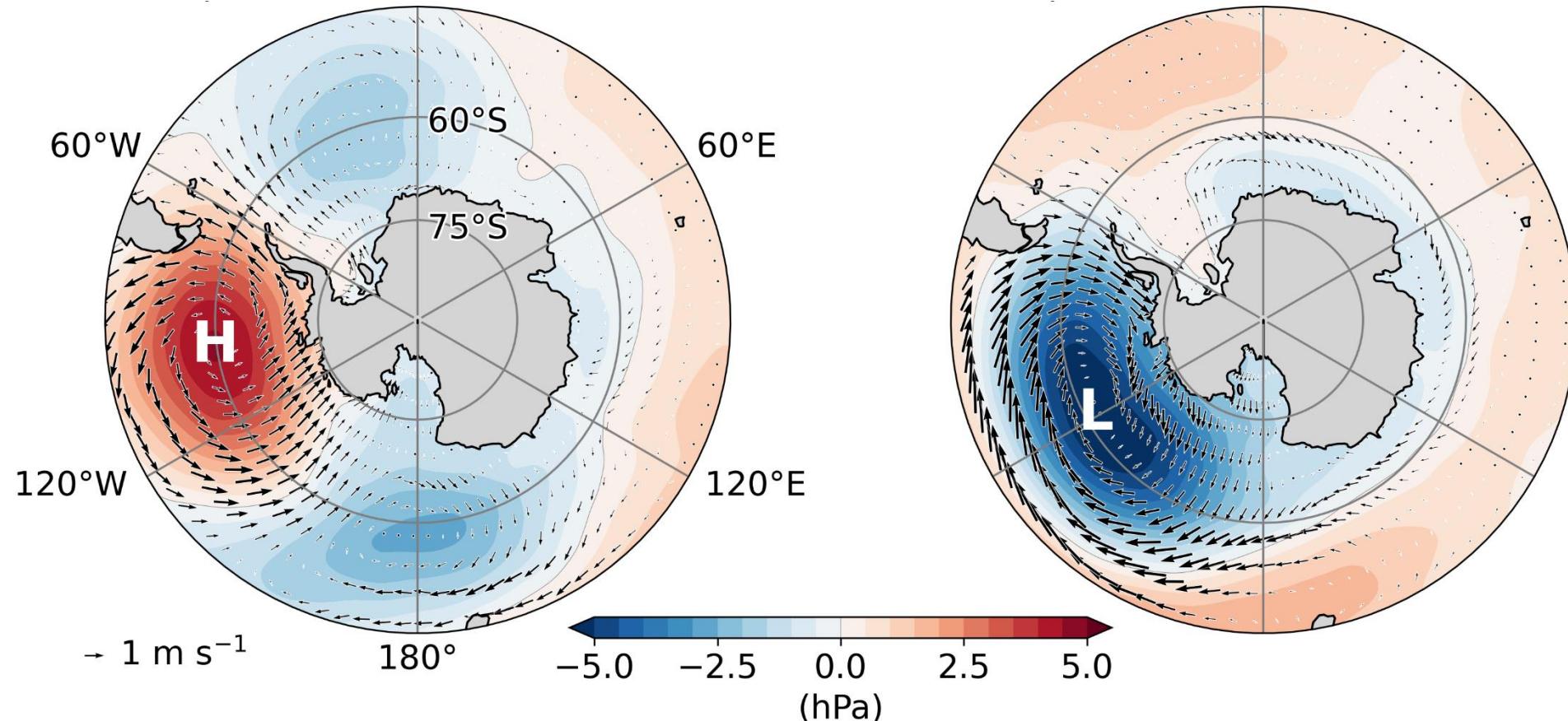


ENSO impacts on Southern Ocean BGC/spring bloom

with Pete Strutton from UNIVERSITY of TASMANIA



El Niño sea level pressure and surface winds



additional slides

Decadal Pacific impacts on dense shelf water formation

with Svenja Ryan, Caroline Ummenhofer & Matt England

Decadal Pacific impacts on dense shelf water formation

with Svenja Ryan, Caroline Ummenhofer & Matt England

- -40% DSW in Weddell Sea

(Zhuo et al. 2023)

- ACCESS-OM2-01
- prescribed IPO phase anomalies

Decadal Pacific impacts on dense shelf water formation

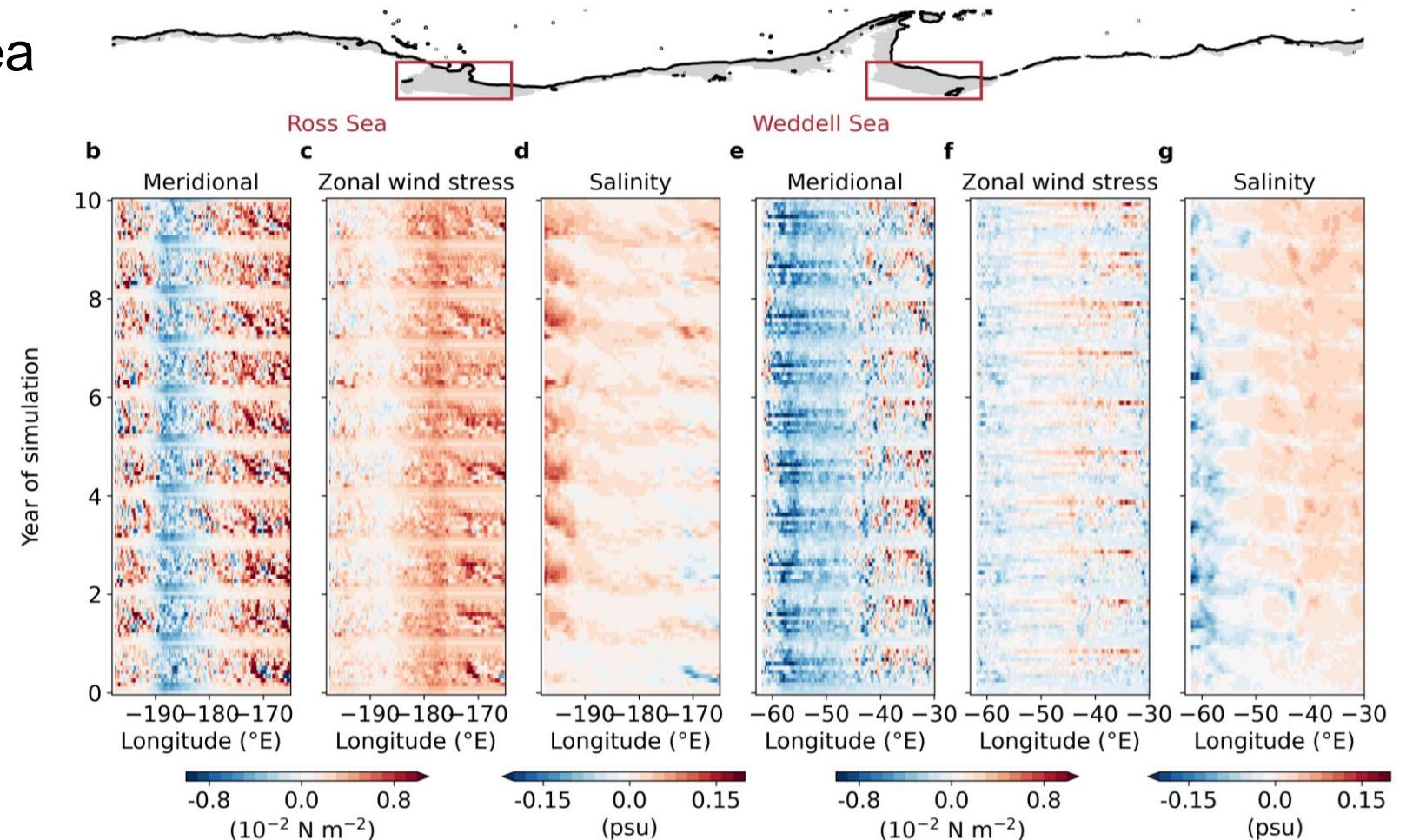
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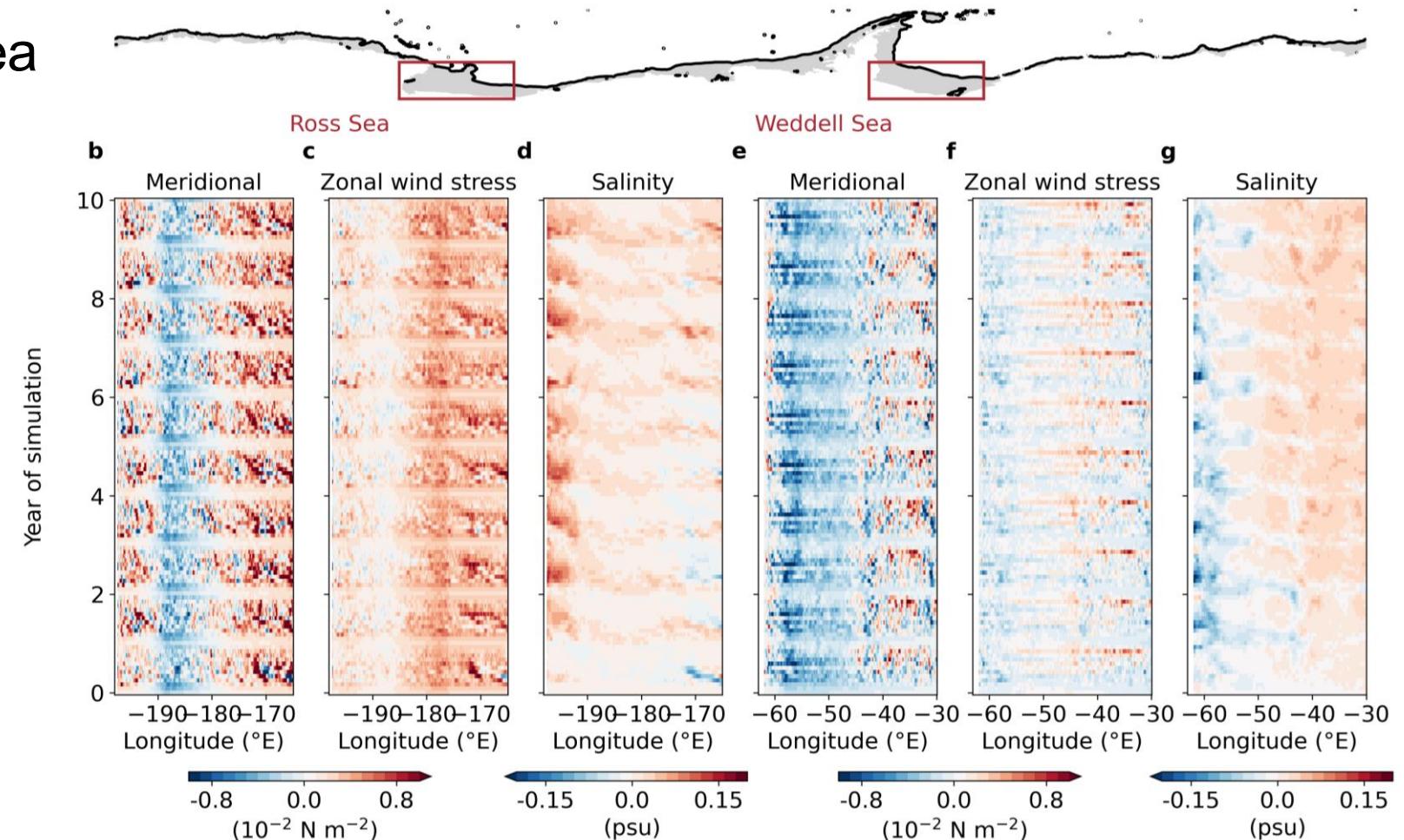
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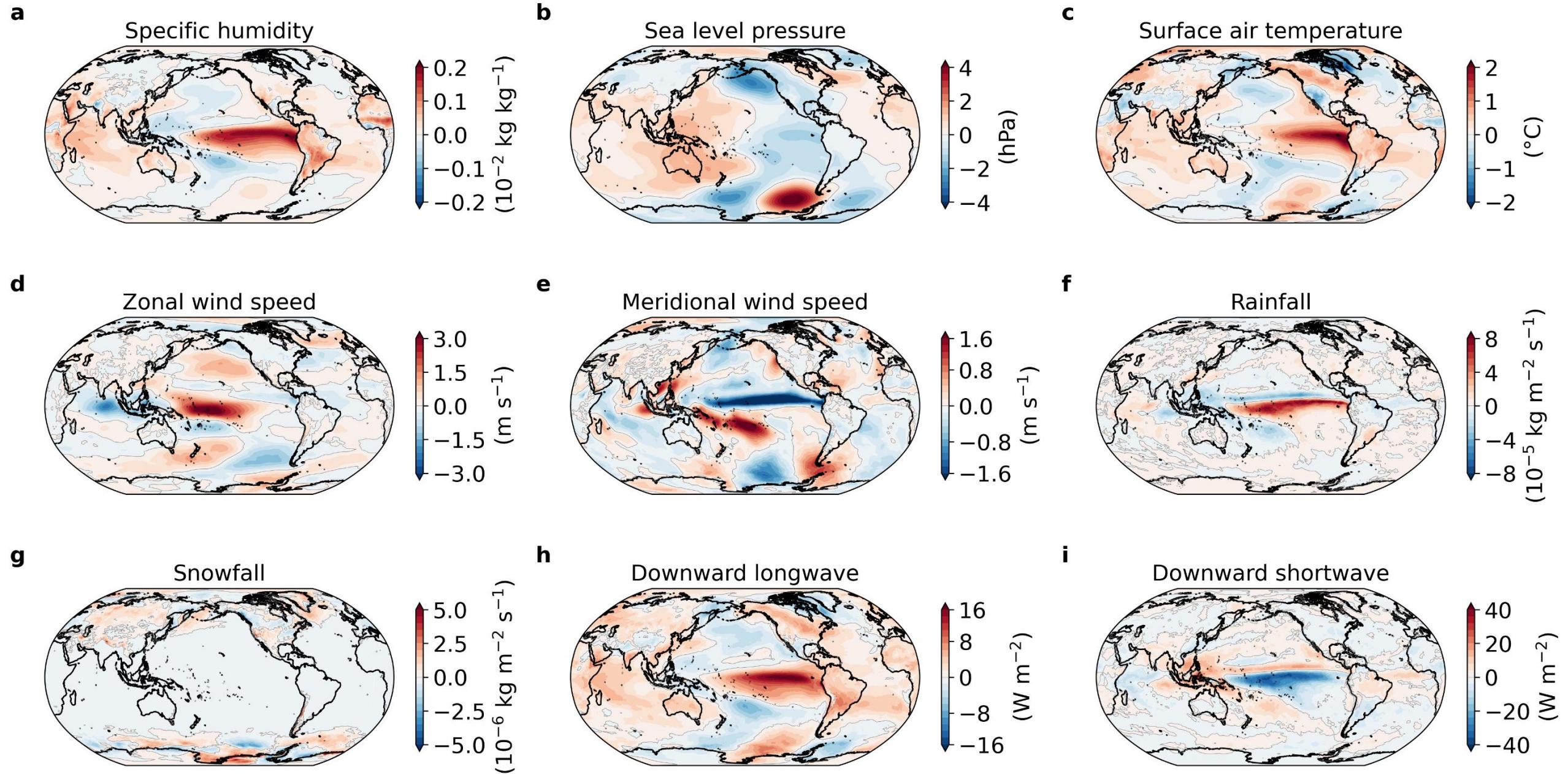
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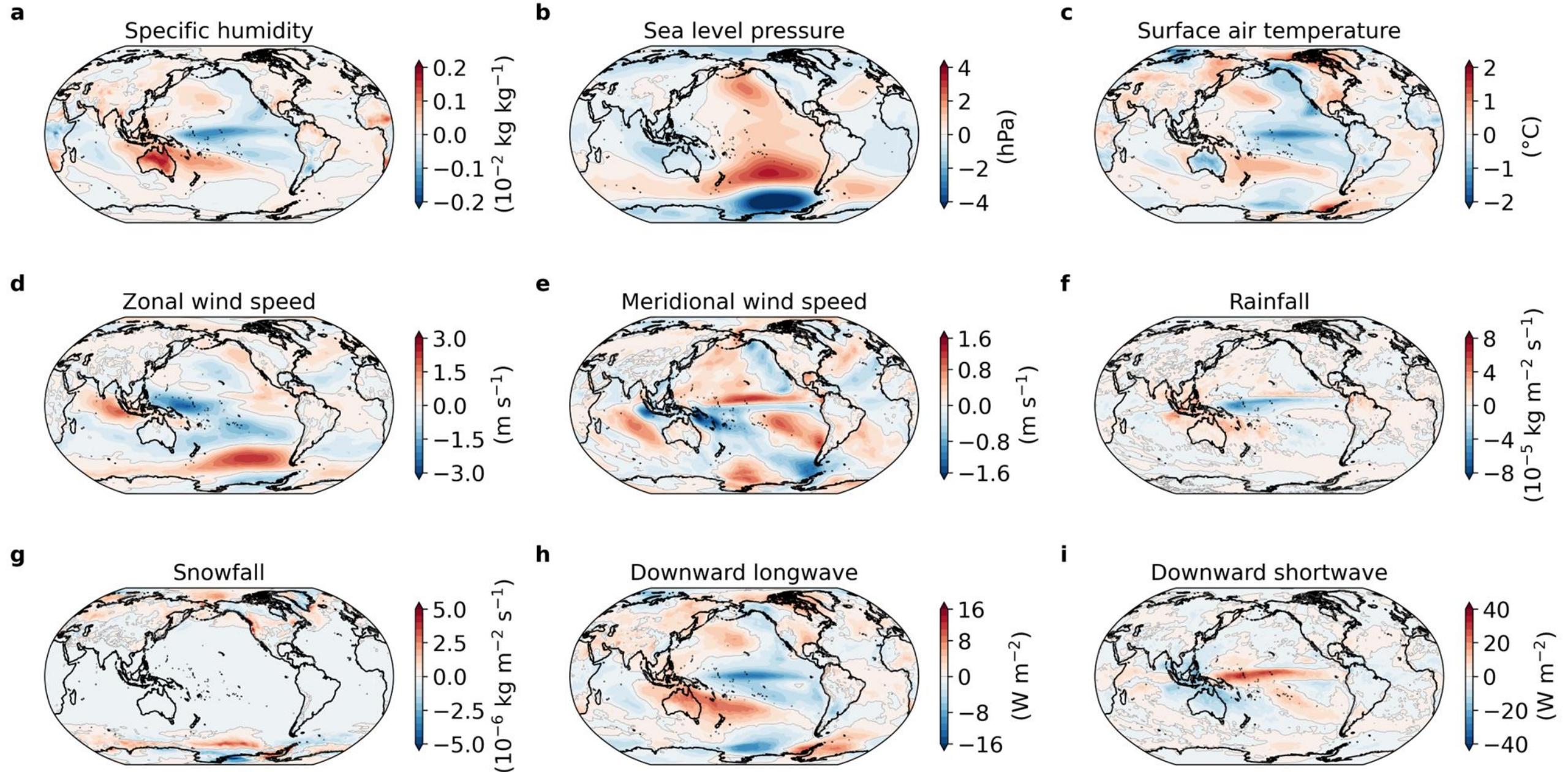
My data got deleted lol



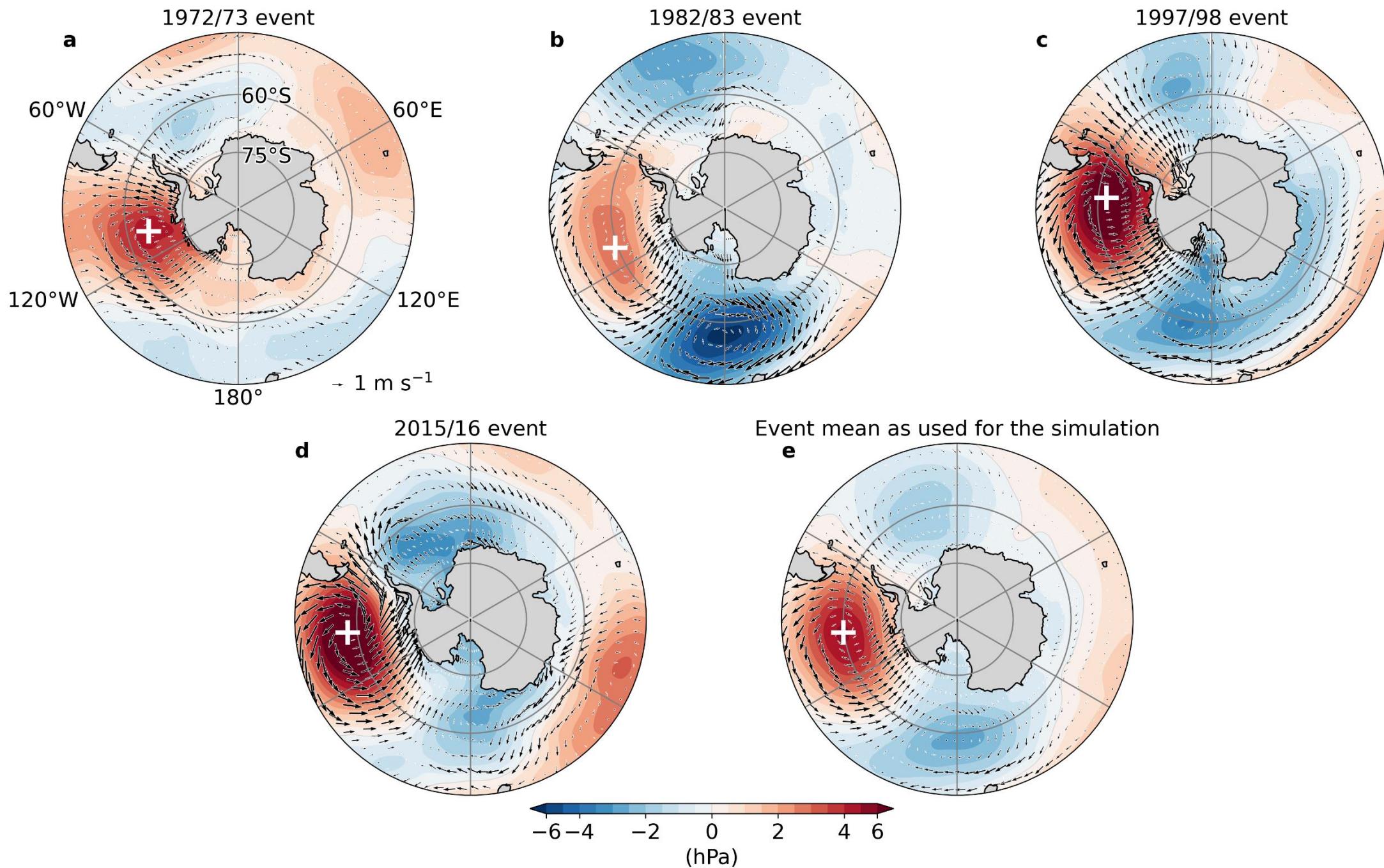
Spatial maps of El Niño anomalies



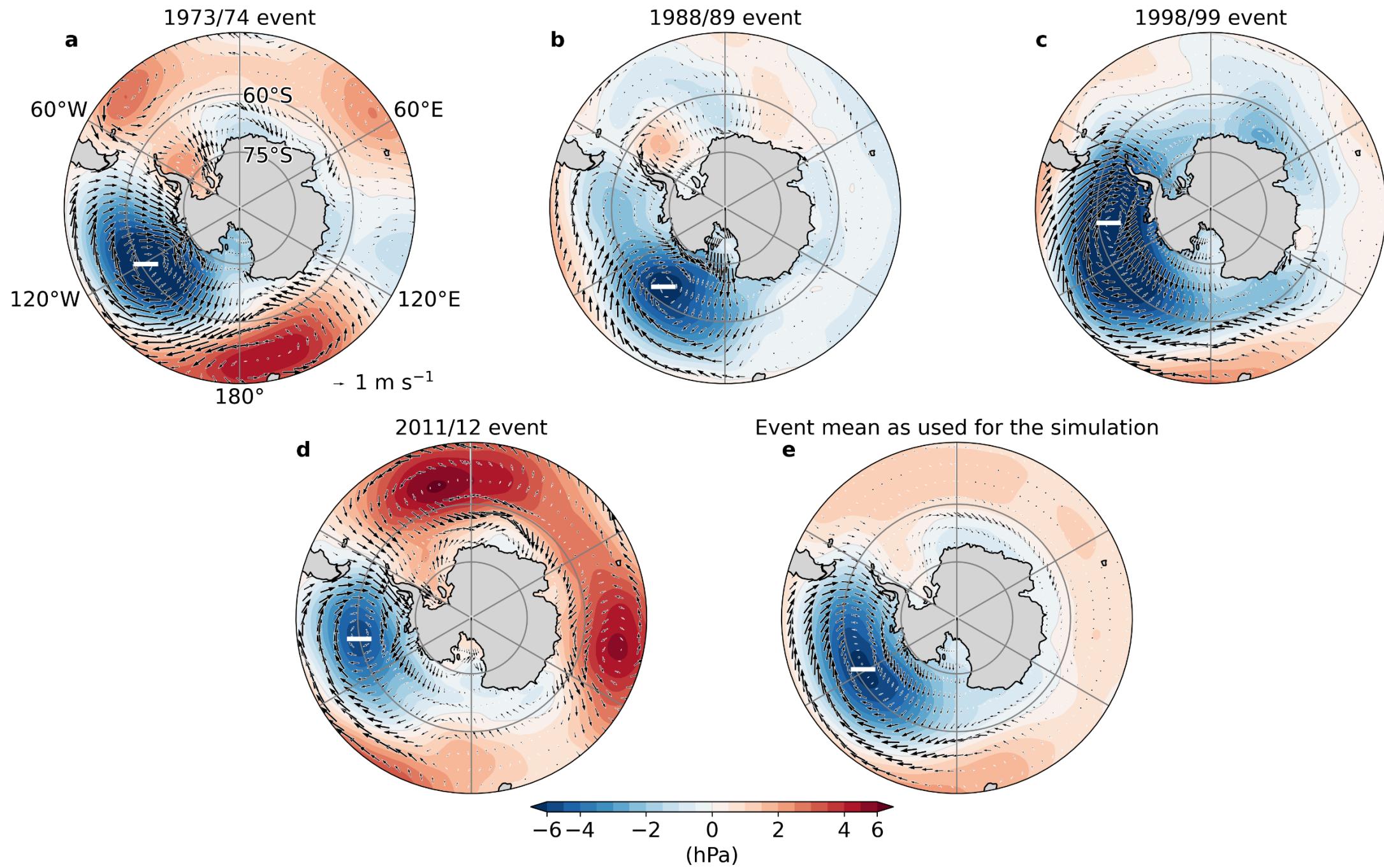
Spatial maps of La Niña anomalies



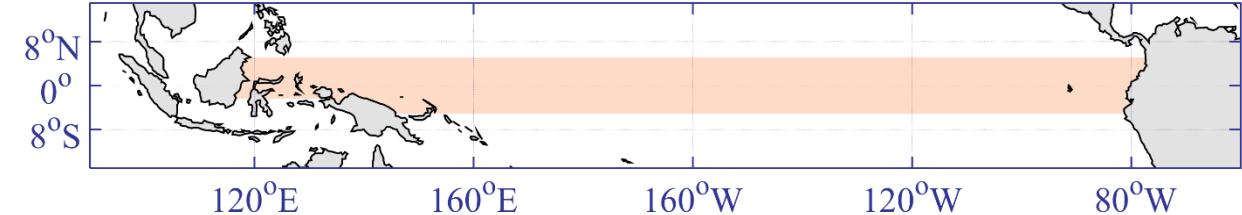
El Niño sea level pressure and surface wind anomalies



La Niña sea level pressure and surface wind anomalies



The warm water volume budget



$$\frac{dWWV}{dt} = \underbrace{\mathcal{T}_{5^\circ N + 5^\circ S} + \mathcal{T}_{ITF} + P - E + R}_{\text{adiabatic fluxes}} + \dots$$

Eddy Mixing

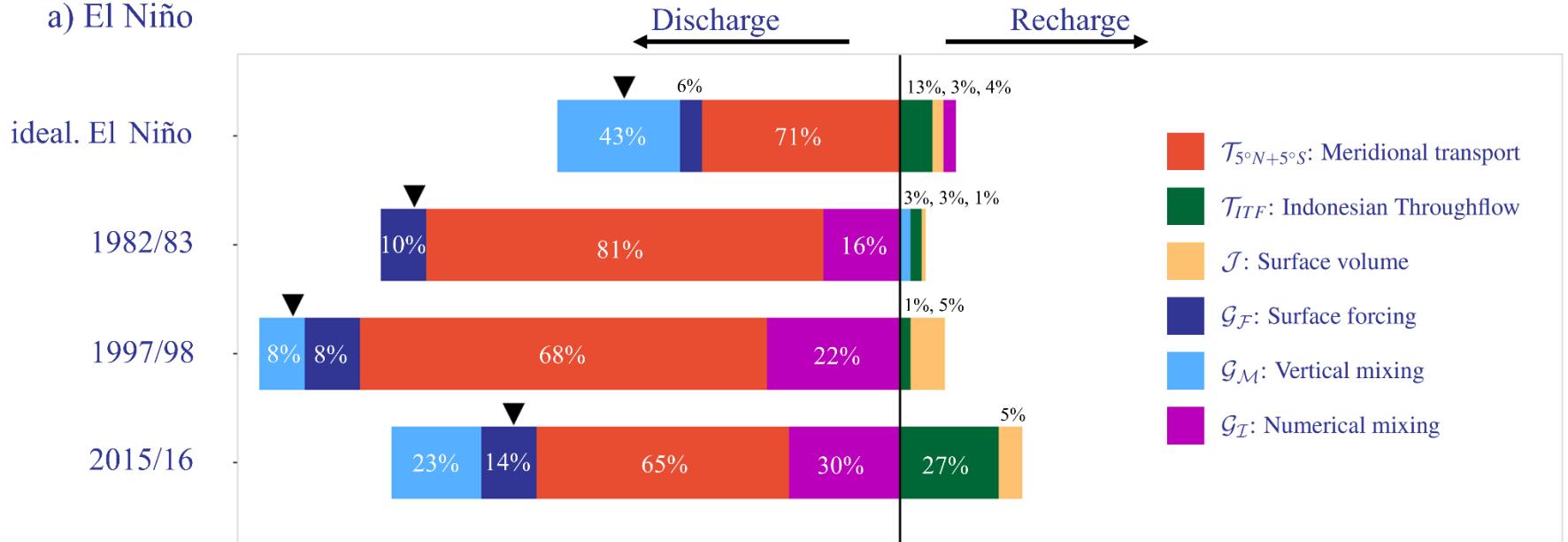
Numerical Mixing

Surface Forcing

Vertical Mixing

$$\underbrace{\frac{1}{\rho_0 \cdot C_p} \cdot \iint \frac{\partial \mathcal{F}}{\partial \Theta} \Big|_{20^\circ C} dA}_{\text{diabatic fluxes}} + \underbrace{\frac{1}{\rho_0 \cdot C_p} \cdot \iint \frac{\partial \mathcal{M}}{\partial \Theta} \Big|_{20^\circ C} dA}_{\text{diabatic fluxes}} + \mathcal{G}_{\mathcal{E}} + \mathcal{G}_{\mathcal{I}}$$

a) El Niño



b) La Niña

