



Australian Centre for Excellence
in Antarctic Science

Subsurface warming of West Antarctic coastal waters linked to El Niño events

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



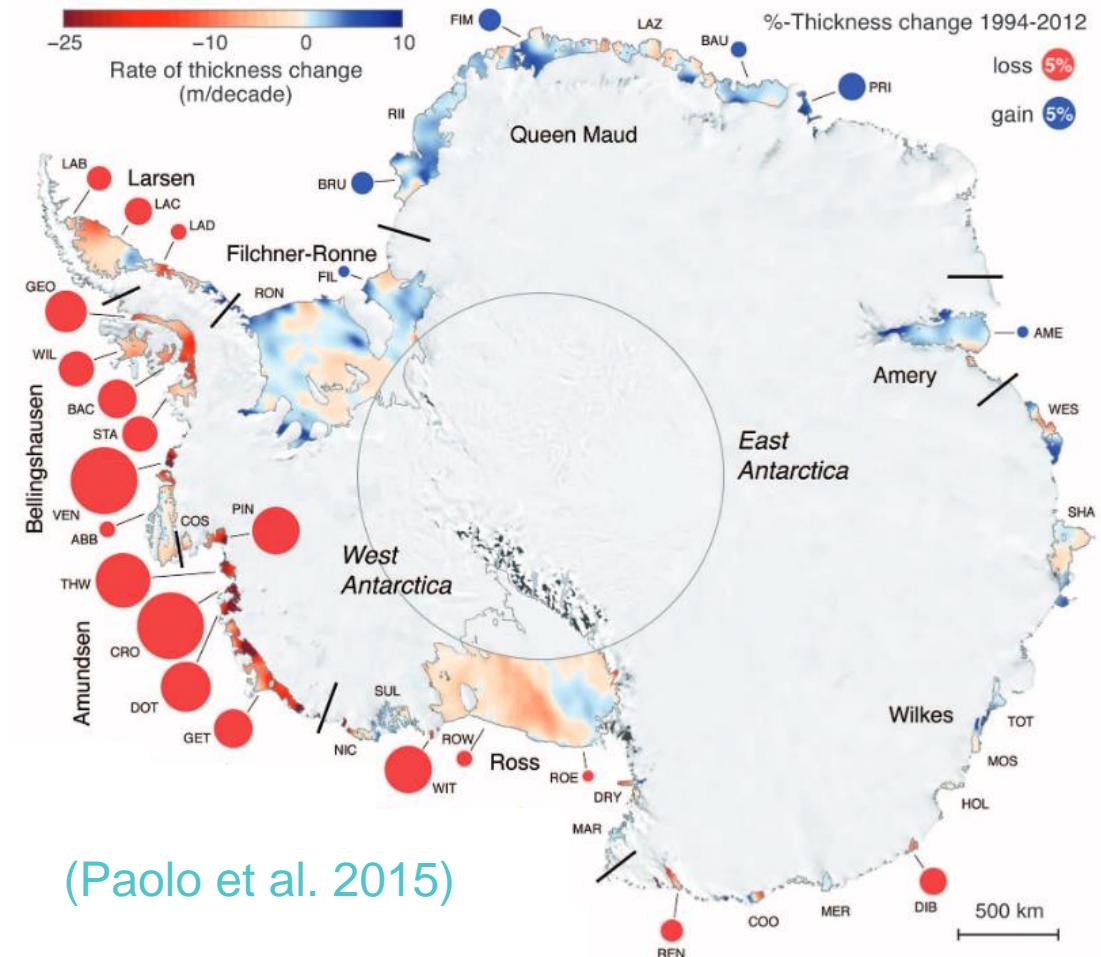
The Australian Centre for Excellence in Antarctic Science is a
Special Research Initiative funded by the Australian Research Council



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

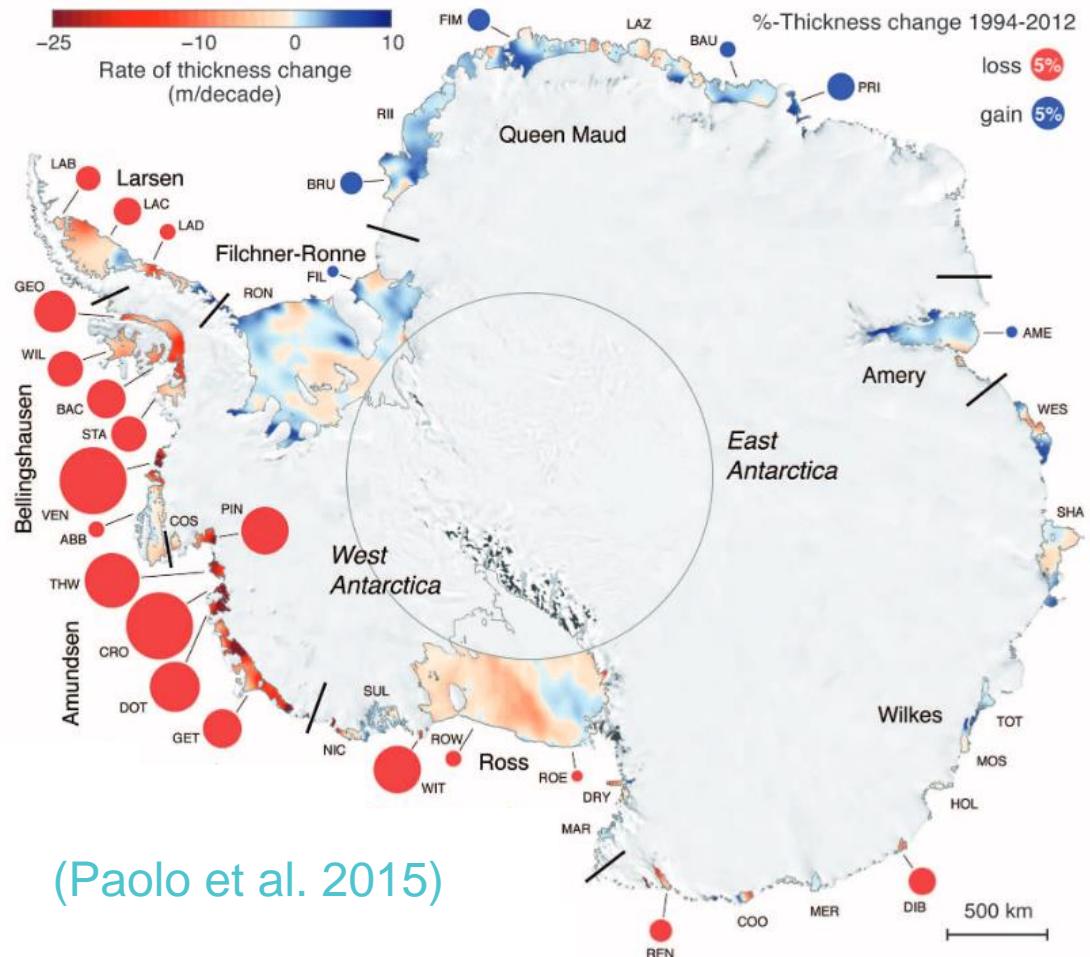
Background

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



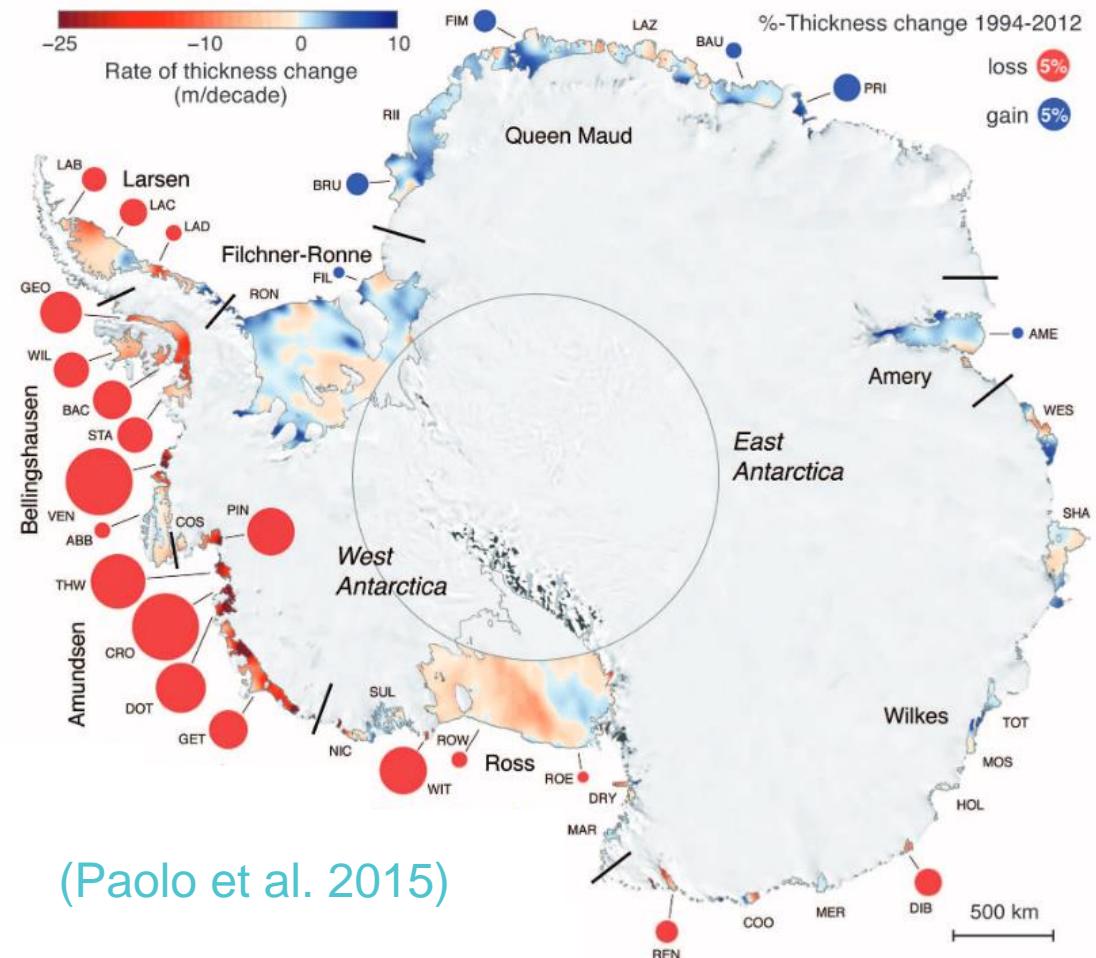
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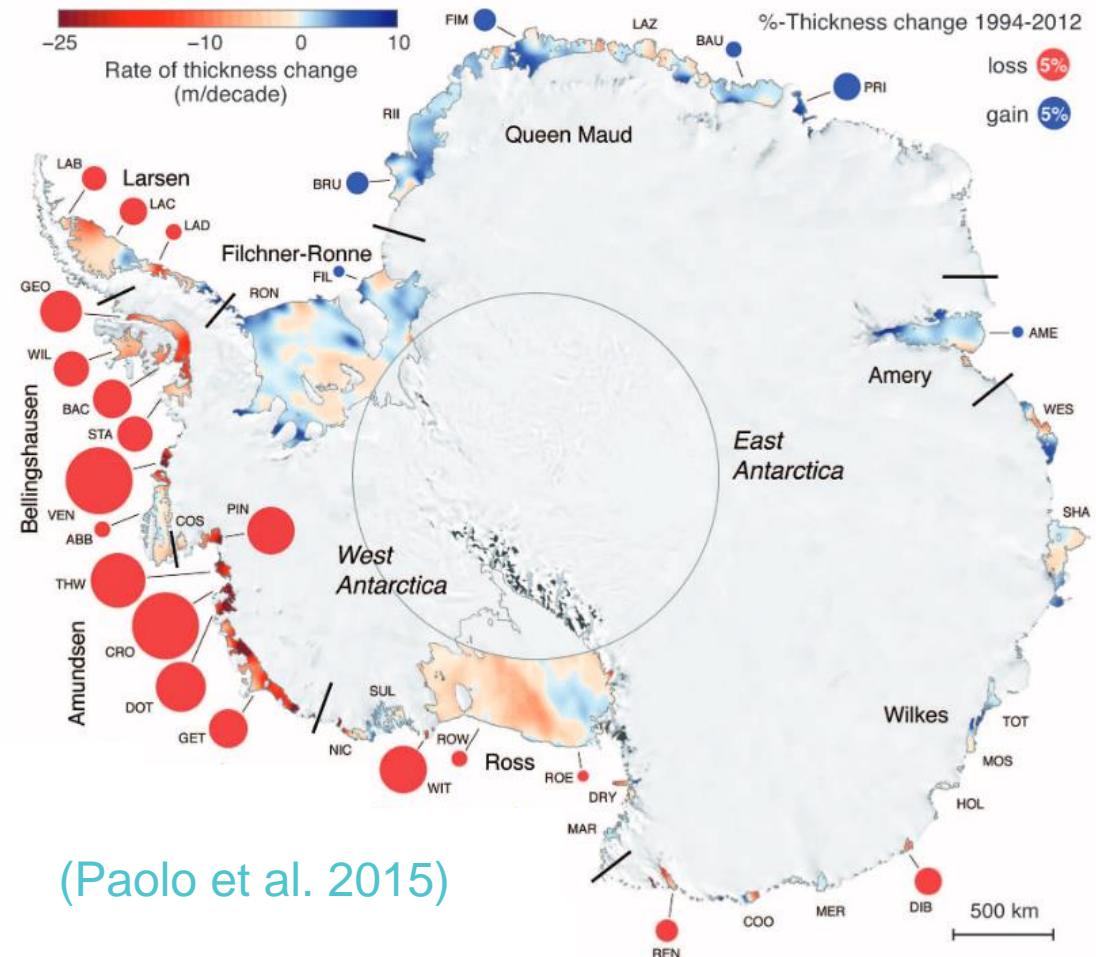
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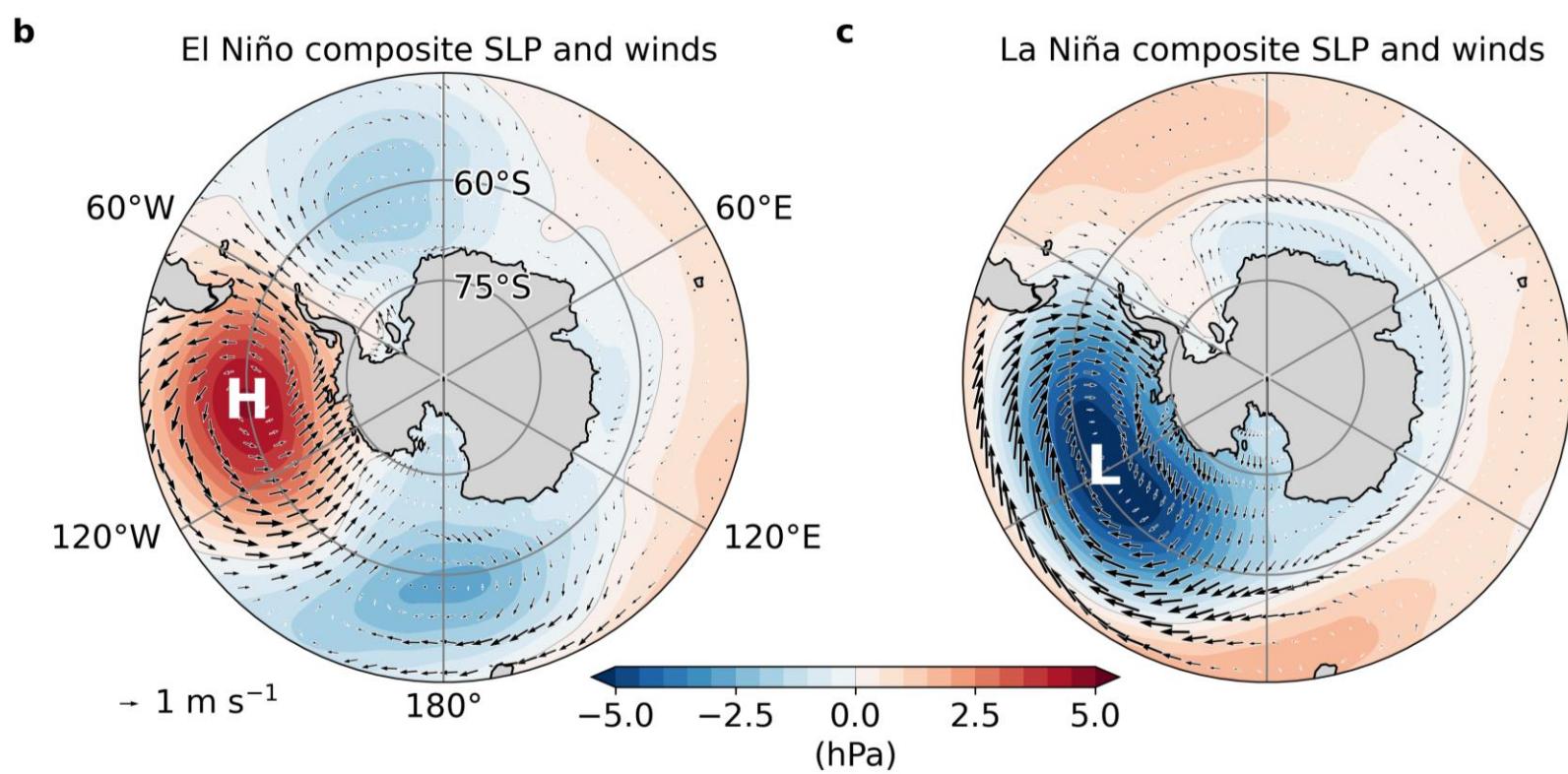


- How do El Niño & La Niña impact the West Antarctic shelf circulation?
- Which processes are responsible for warming & cooling on the shelf?

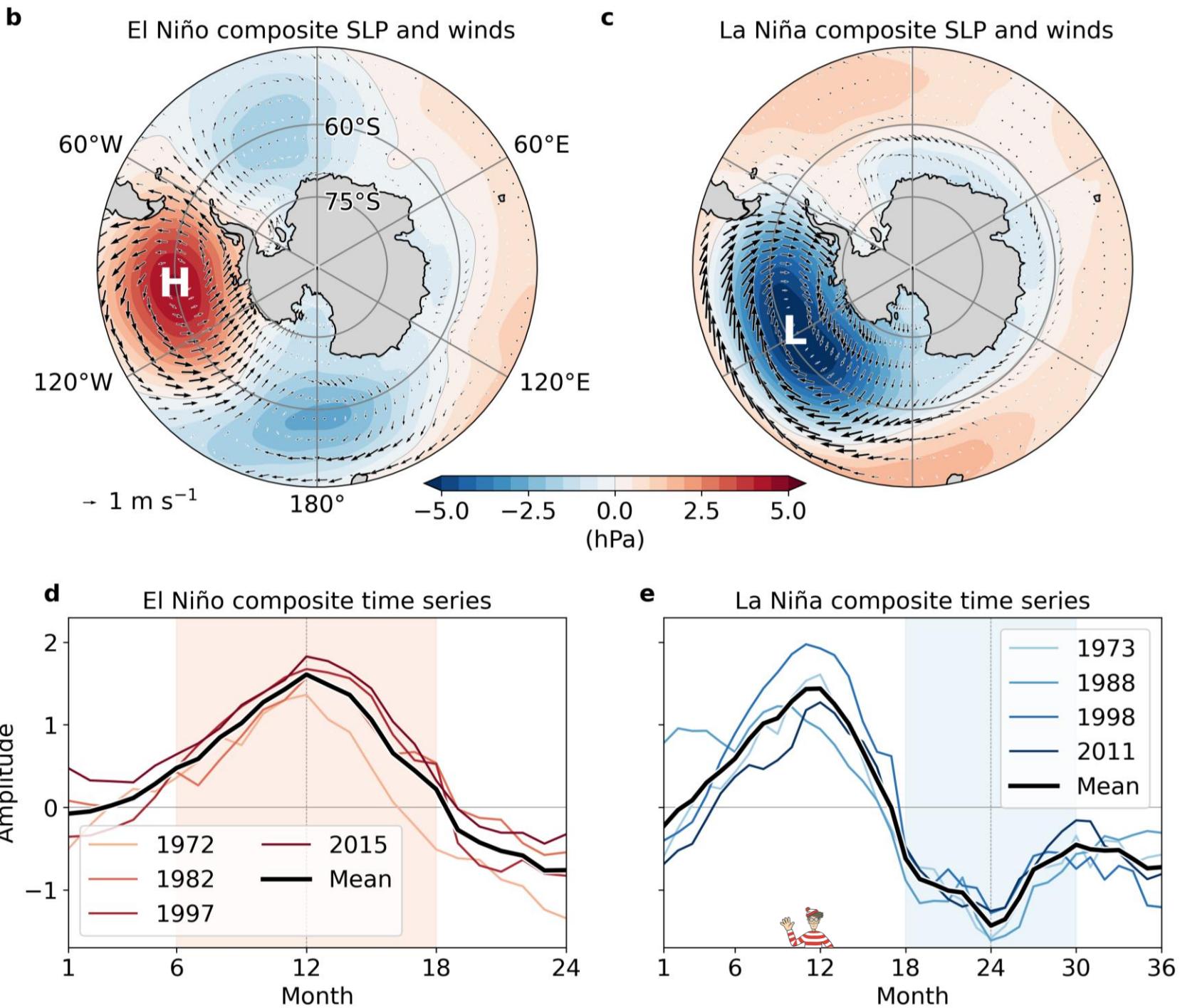
The method

- ACCESS-OM2-01 ([Kiss et al. 2020](#))
 - JRA55-do reanalysis ([Tsujino et al. 2018](#))
- RYF + ENSO anomalies

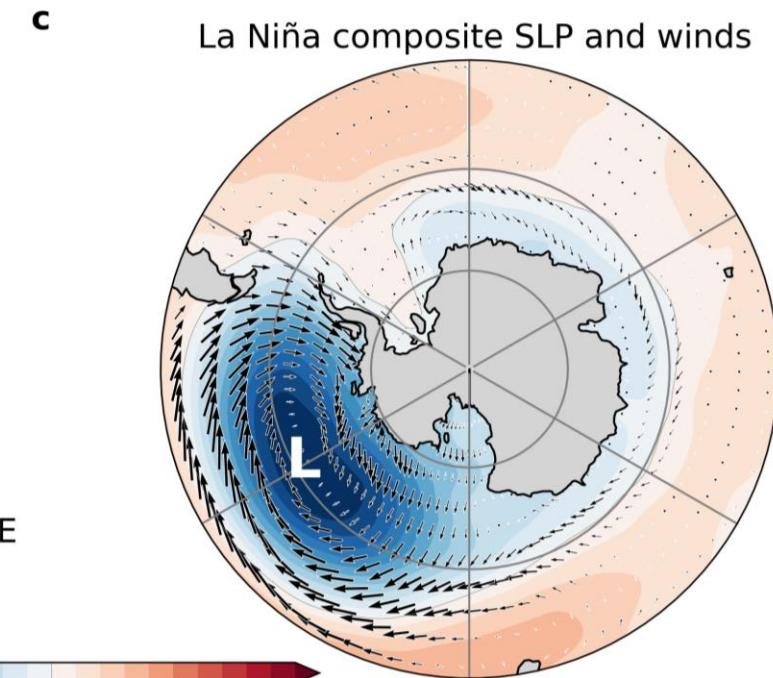
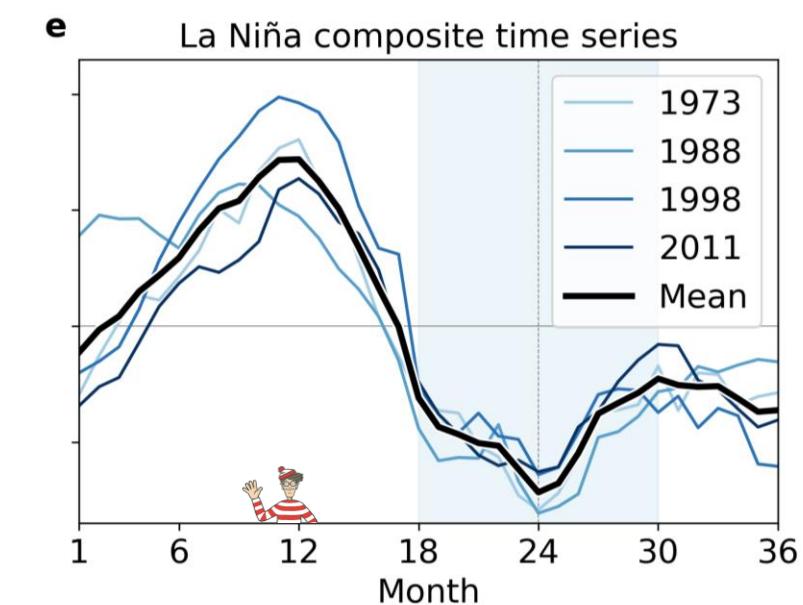
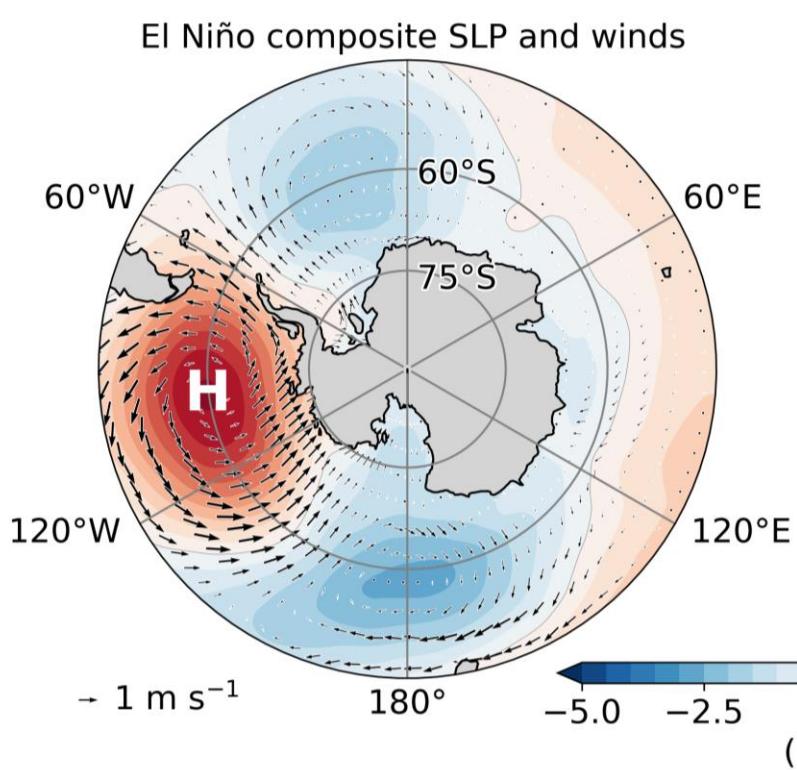
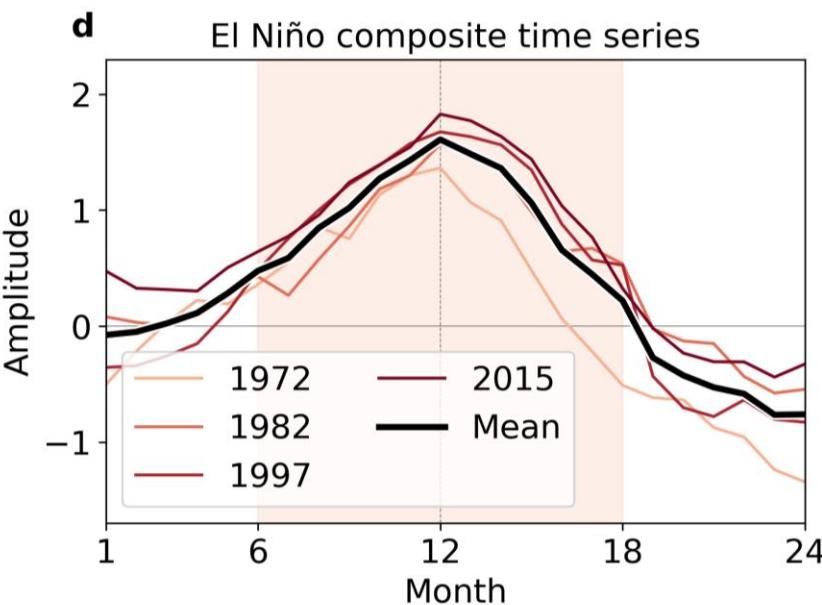
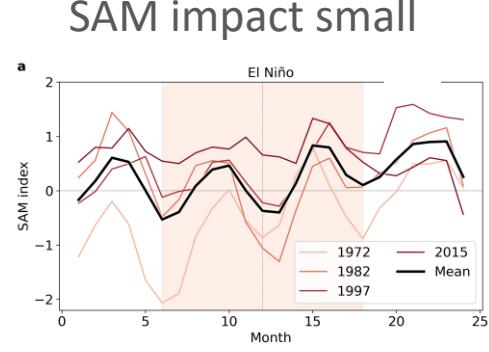
Forcing for the idealised ENSO simulations



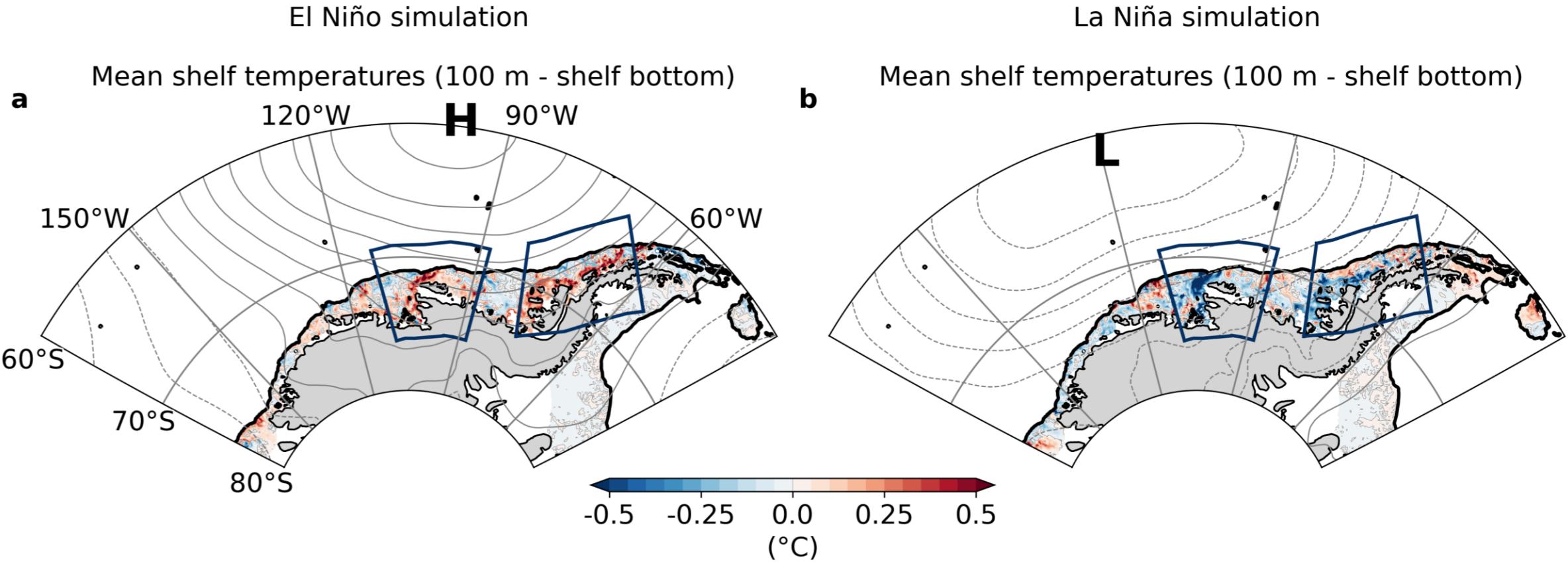
Forcing for the idealised ENSO simulations



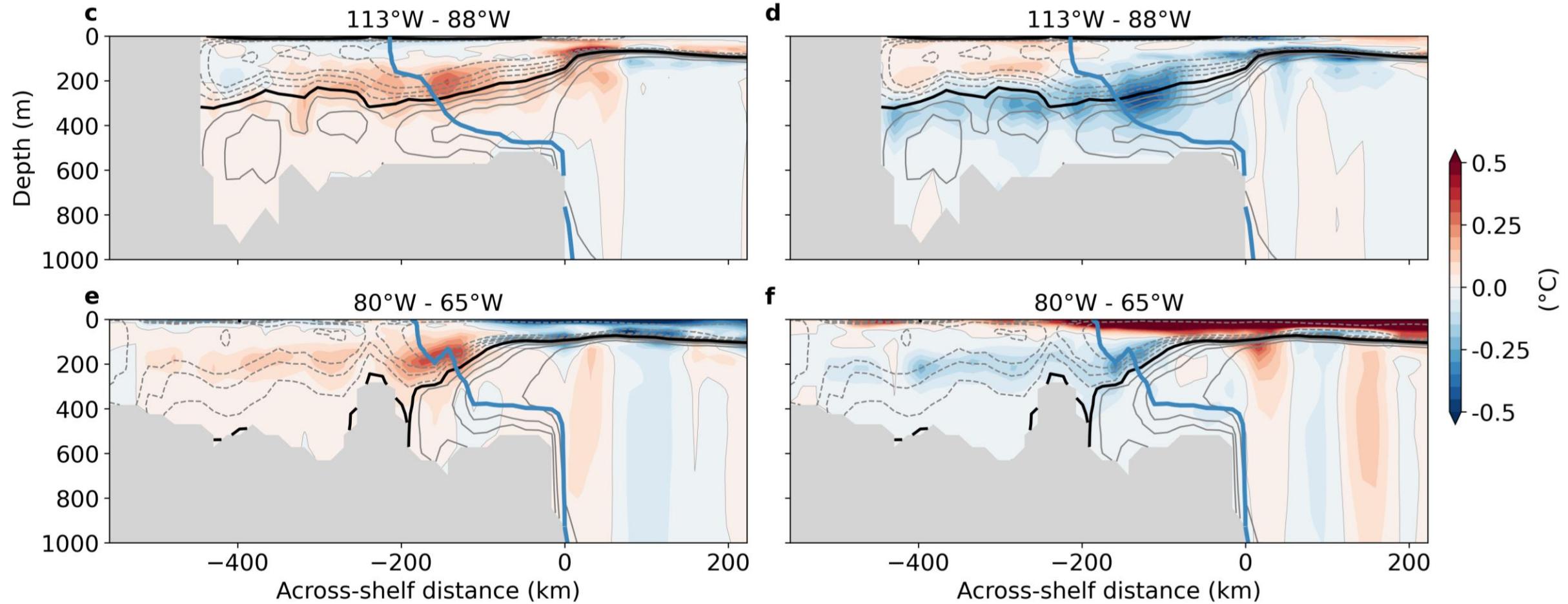
Forcing for the idealised ENSO simulations



Response of the West Antarctic shelf to peak ENSO

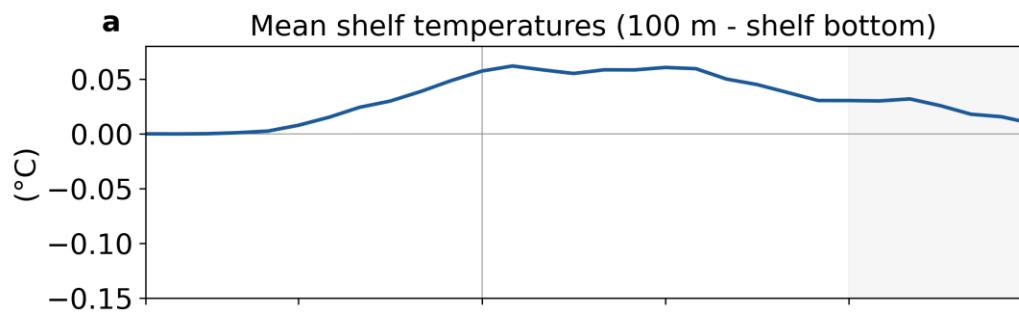


Response of the West Antarctic shelf to peak ENSO

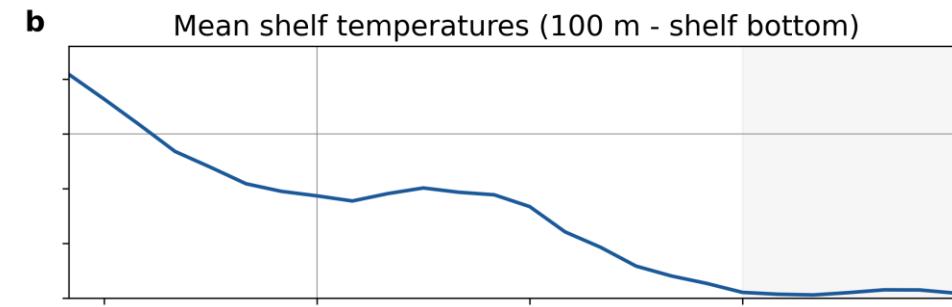


The shelf heat budget during ENSO

El Niño simulation

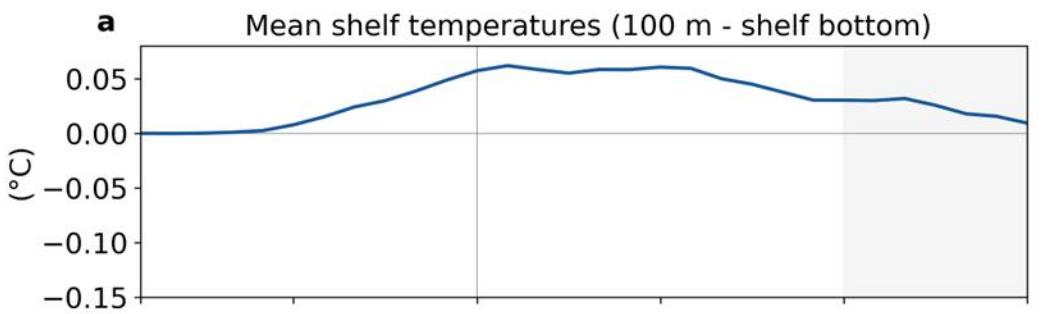


La Niña simulation

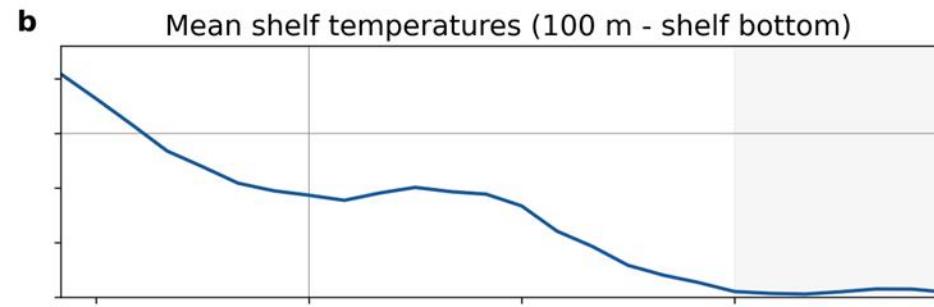


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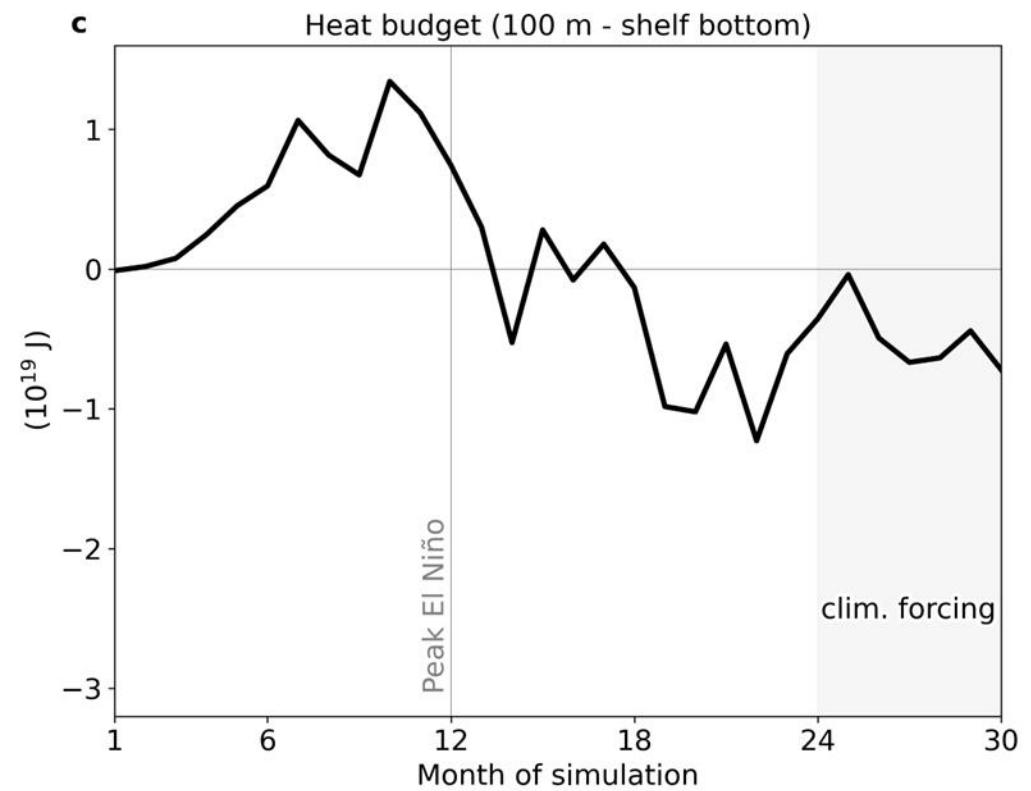
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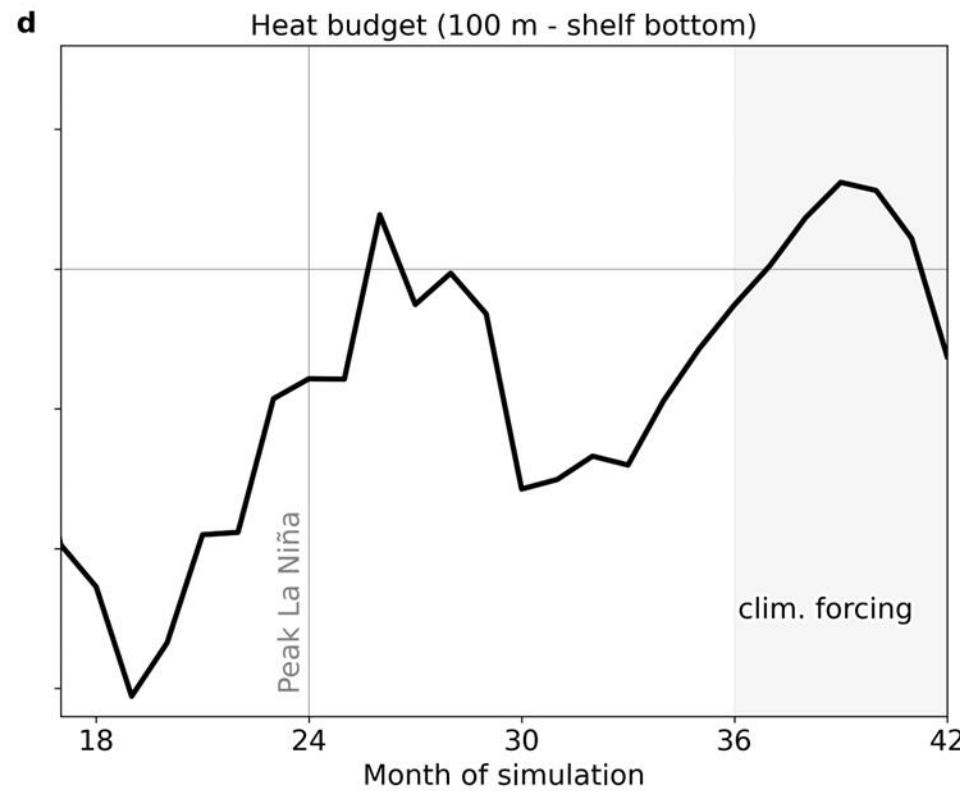
La Niña simulation



Heat budget (100 m - shelf bottom)

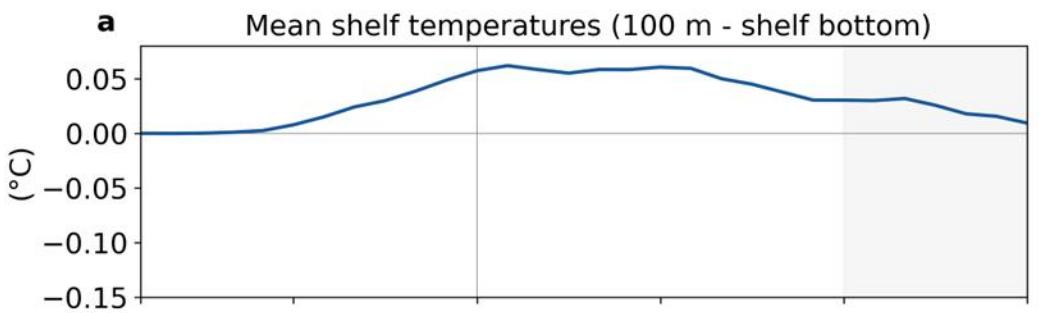


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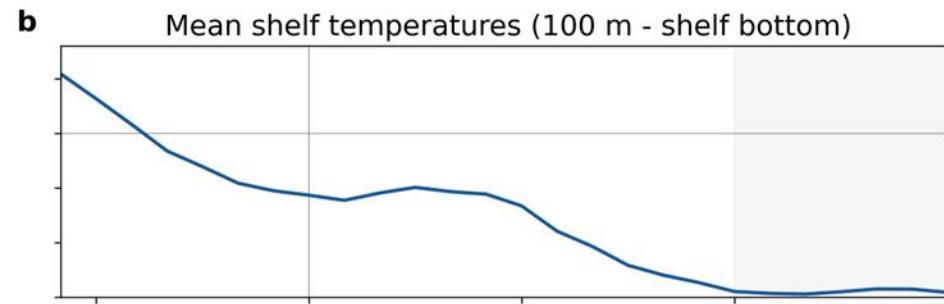


The shelf heat budget during ENSO

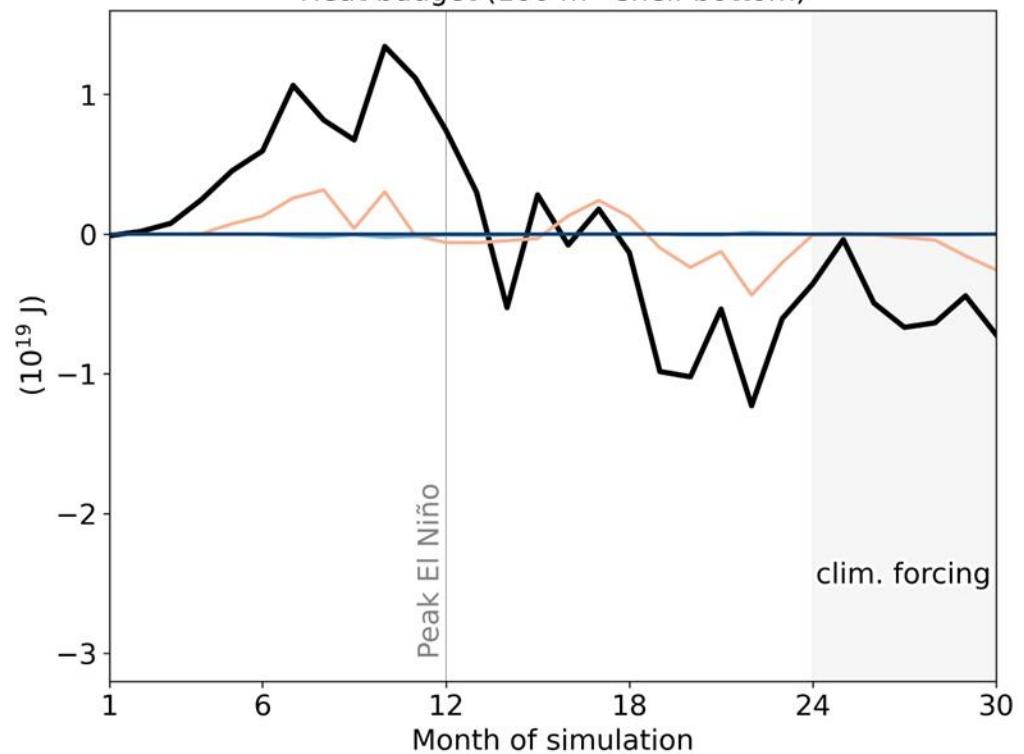
El Niño simulation



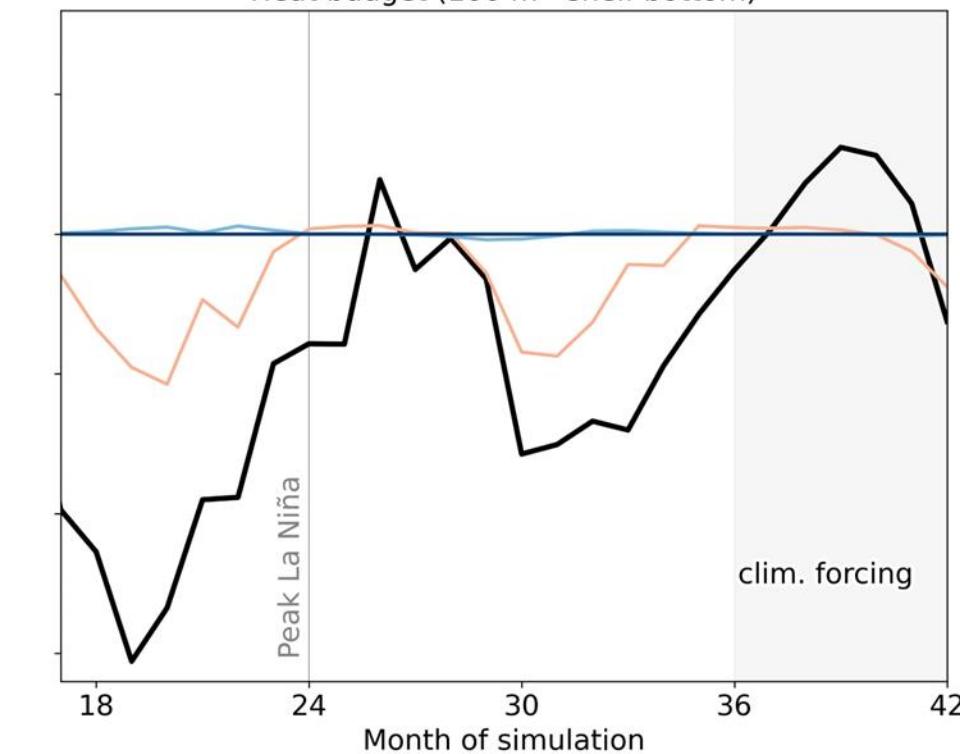
La Niña simulation



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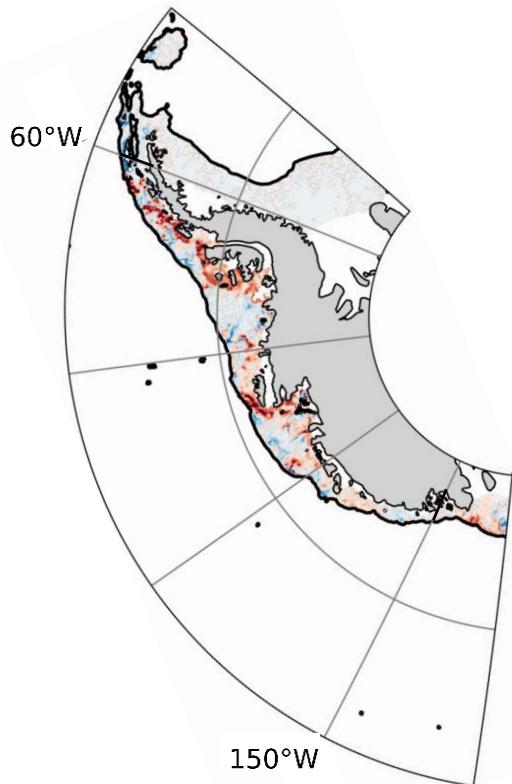


Heat budget (100 m - shelf bottom)

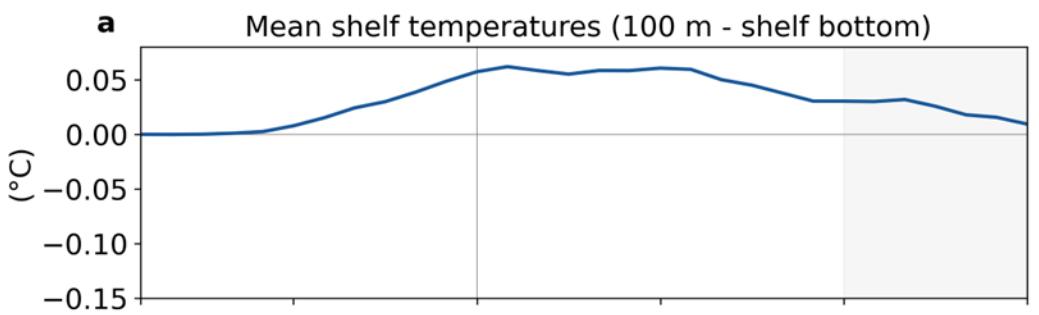


— Change in heat content — Surface forcing — Surface volume
— Vertical mixing

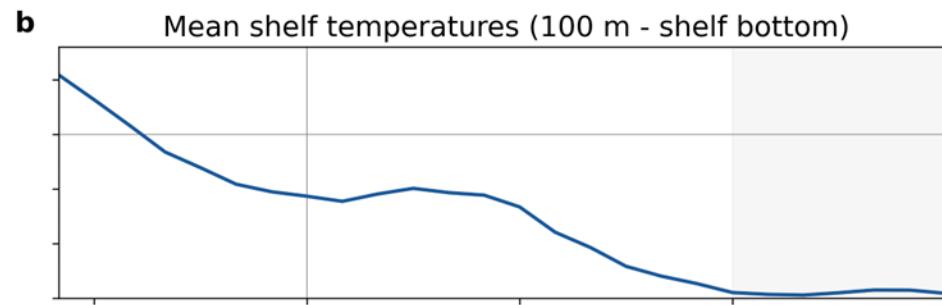
The shelf heat budget during ENSO



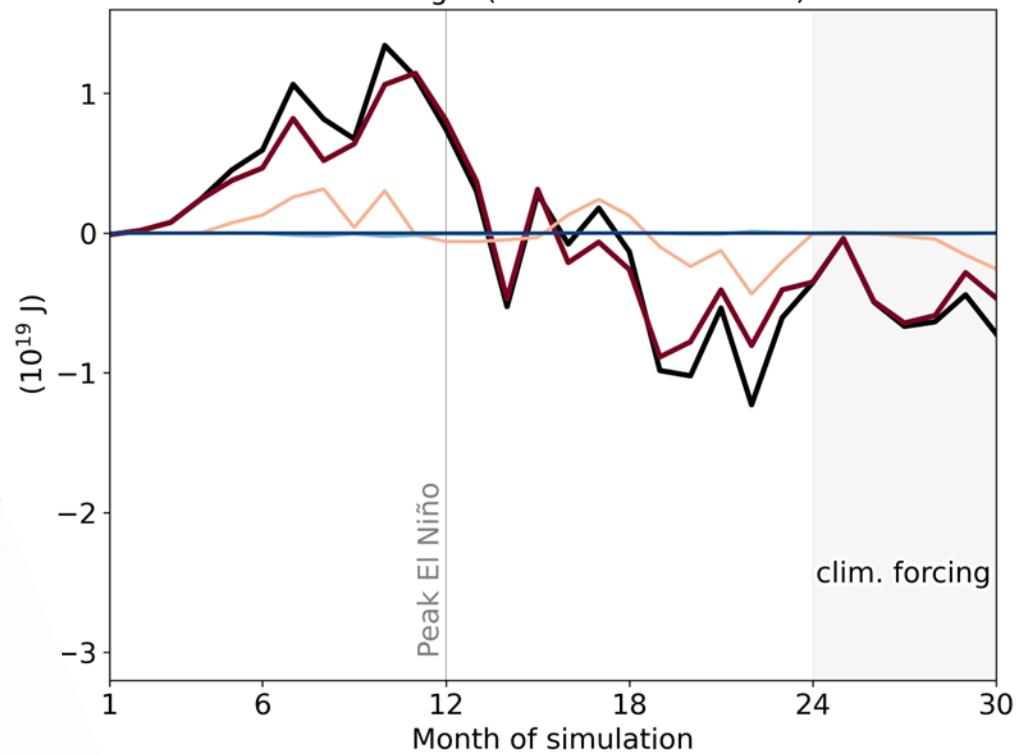
El Niño simulation



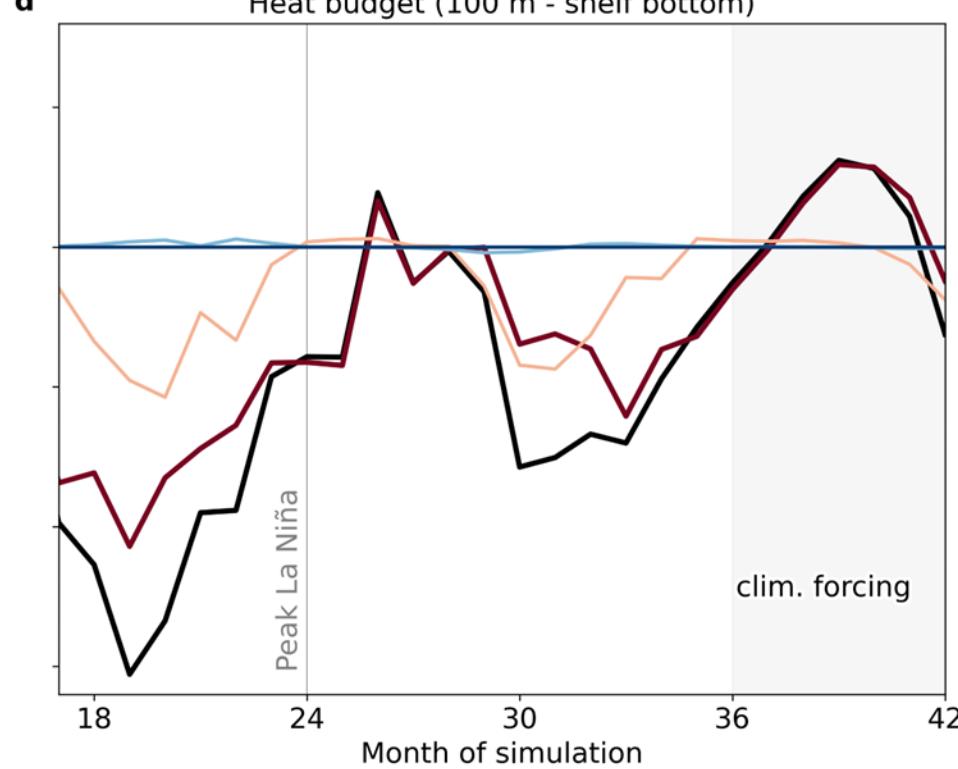
La Niña simulation



Heat budget (100 m - shelf bottom)

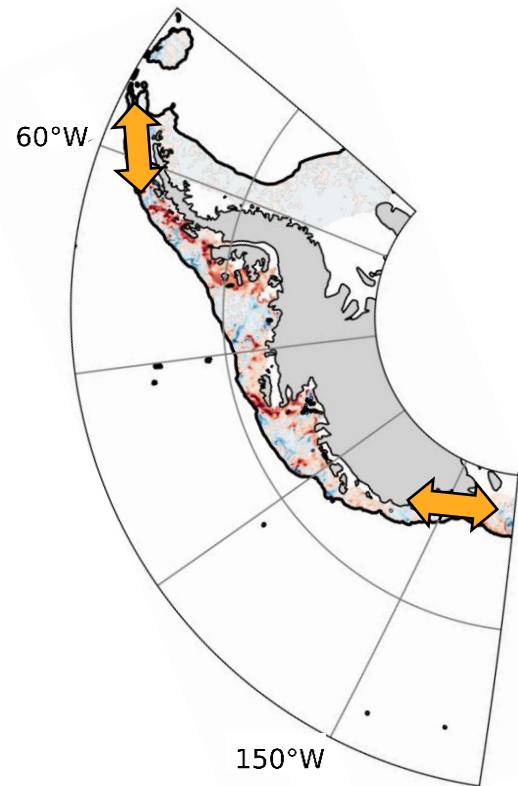


Heat budget (100 m - shelf bottom)

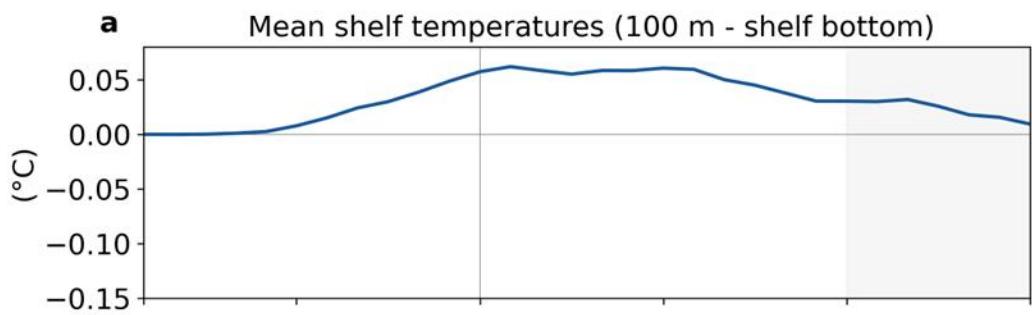


— Change in heat content
— Heat transport convergence
— Vertical mixing
— Surface volume
— Surface forcing

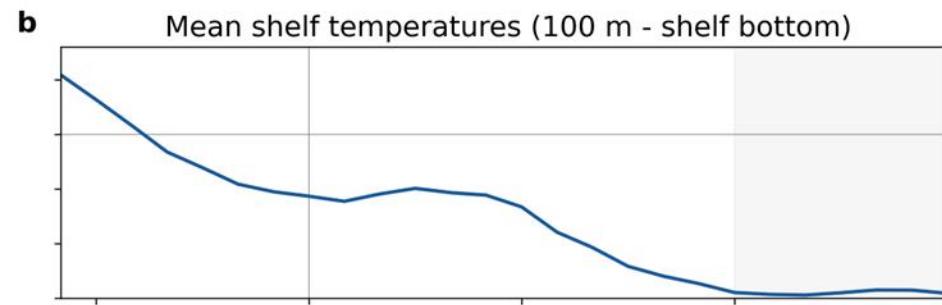
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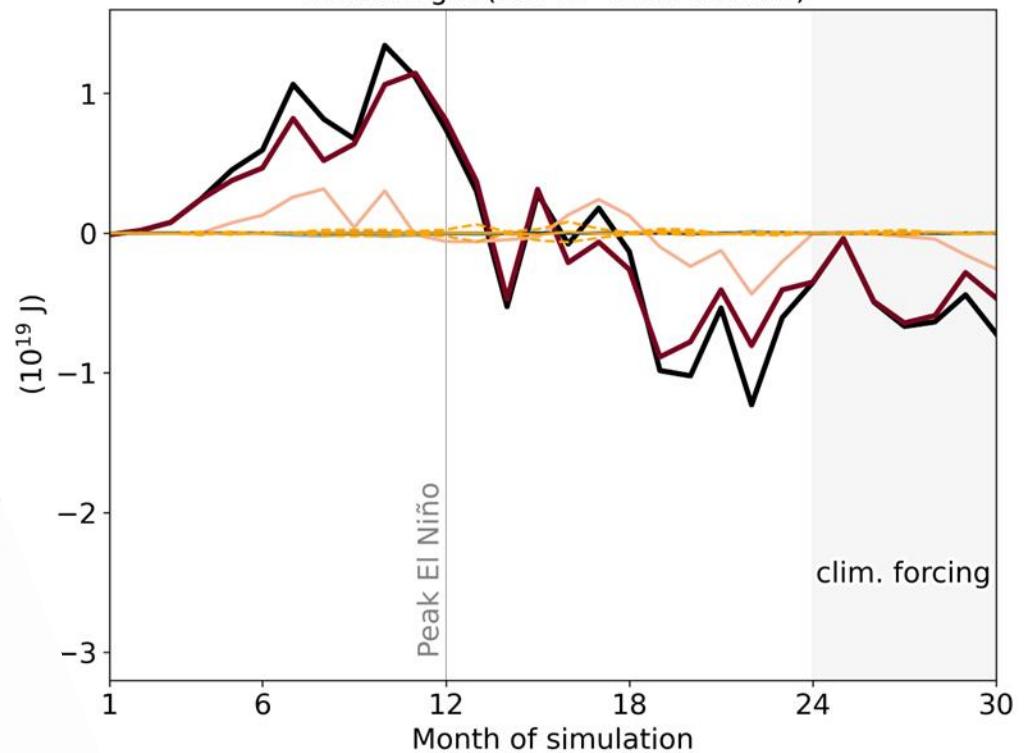
El Niño simulation



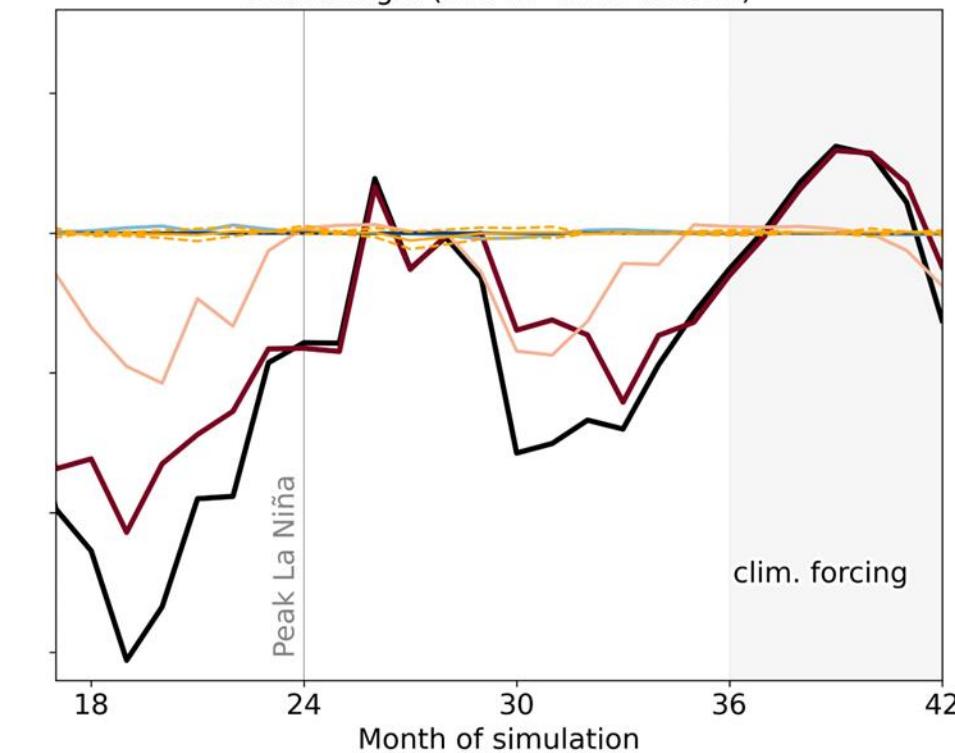
La Niña simulation



Heat budget (100 m - shelf bottom)

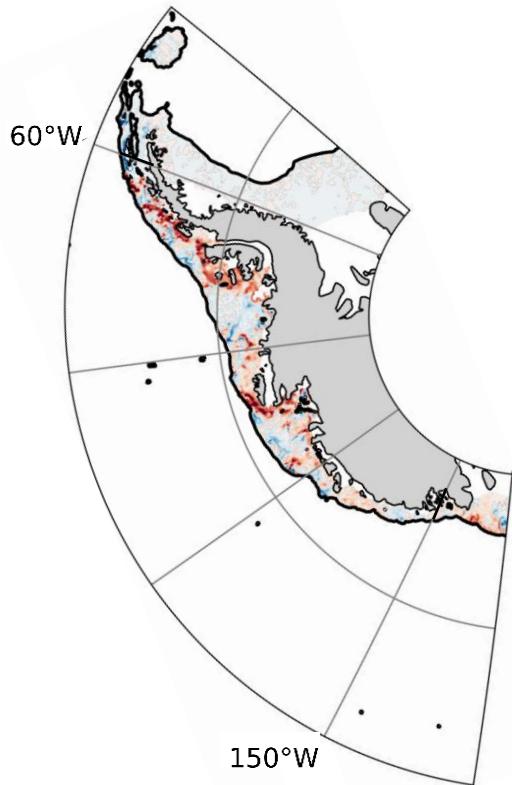


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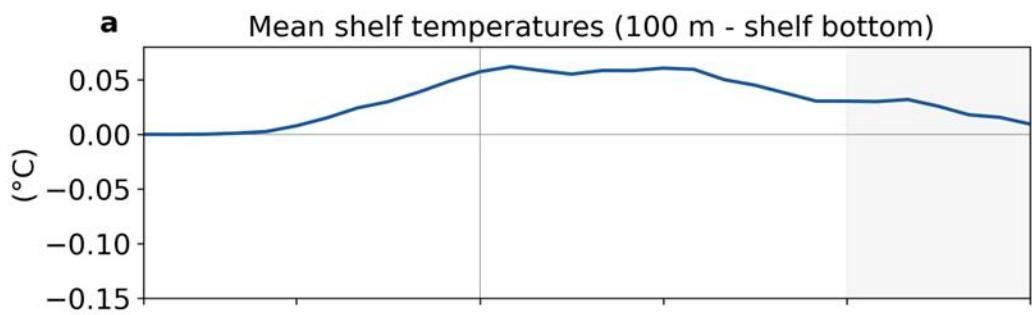


- Change in heat content
- Heat transport convergence
- Vertical mixing
- Surface forcing
- Surface volume
- Along-shelf heat flux
- Uncertainty limits of along-shelf heat flux

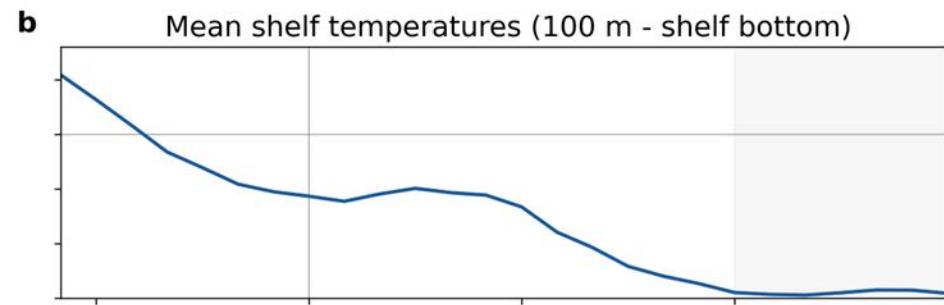
The shelf heat budget during ENSO



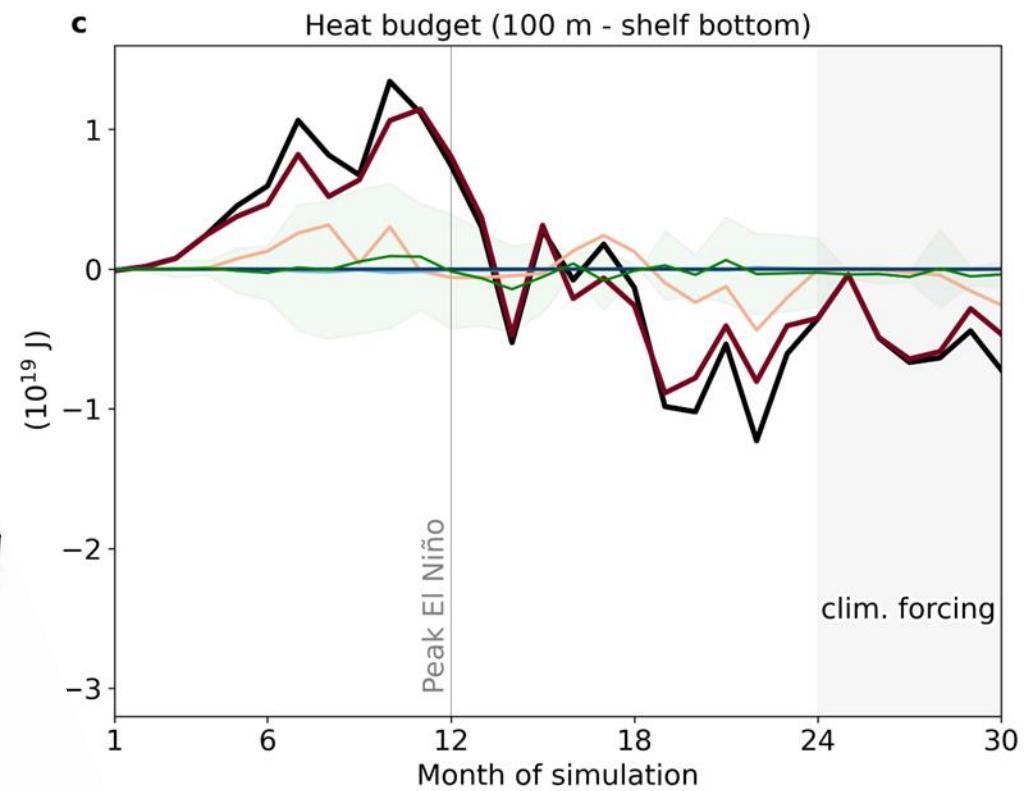
El Niño simulation



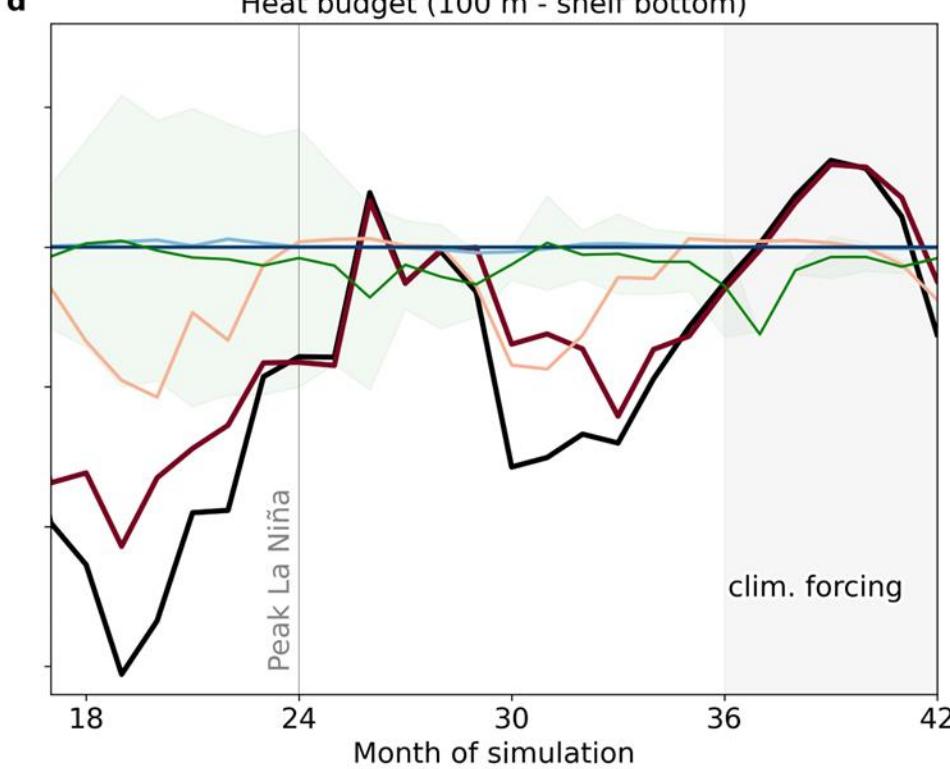
La Niña simulation



Heat budget (100 m - shelf bottom)



Heat budget (100 m - shelf bottom)



- Change in heat content
- Heat transport convergence
- Vertical mixing
- Surface forcing
- Surface volume
- Vertical heat flux
- Uncertainty limits of vertical heat flux

Calculating heat fluxes across sections

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$$\phi_z = \rho_0 C_p \int \Theta w \Big|_{100 \text{ m}} dA$$

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$$\underbrace{(\overline{\Theta} + \Theta')(\overline{w} + w')}_{EN \text{ simulation}} - \underbrace{\overline{\Theta}\overline{w}}_{RYF}$$

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$$\underbrace{(\bar{\Theta} + \Theta')(\bar{w} + w')}_{EN \ simulation} - \underbrace{\bar{\Theta}\bar{w}}_{RYF} = \bar{\Theta}\bar{w} + \bar{\Theta}w' + \Theta'\bar{w} + \Theta'w' - \bar{\Theta}\bar{w}$$

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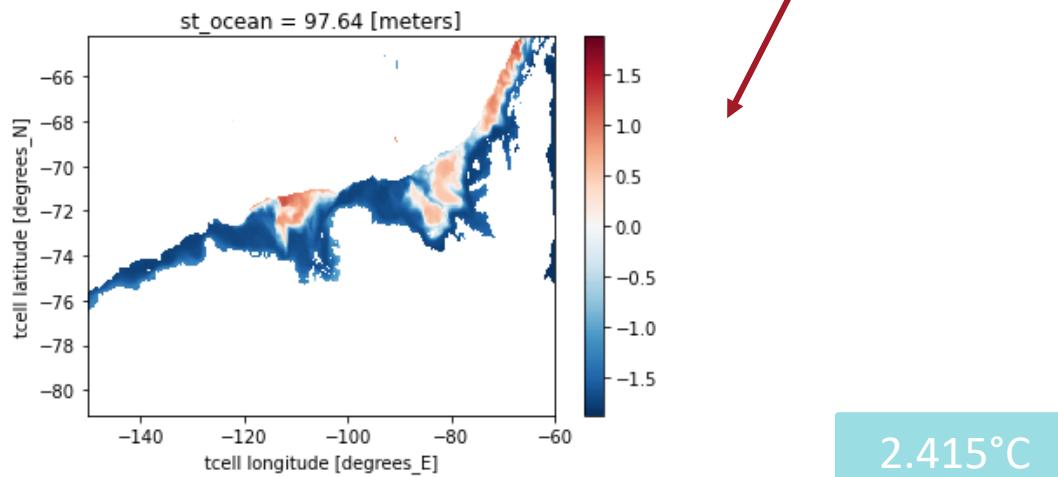
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Calculating heat fluxes across sections

$$\phi_z = \rho_0 C_p \int \Theta w \Big|_{100 \text{ m}} dA \pm \rho_0 C_p \int \frac{(\Delta\Theta)^{\max}}{2} w \Big|_{100 \text{ m}} dA$$

Calculating heat fluxes across sections

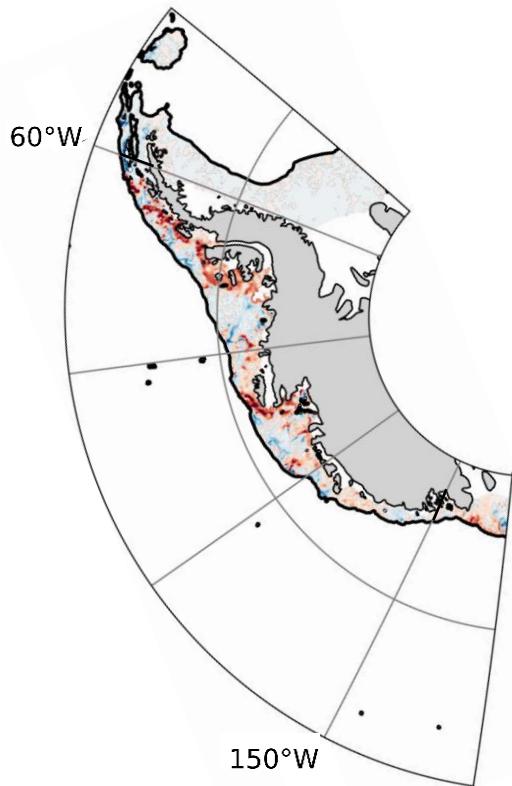
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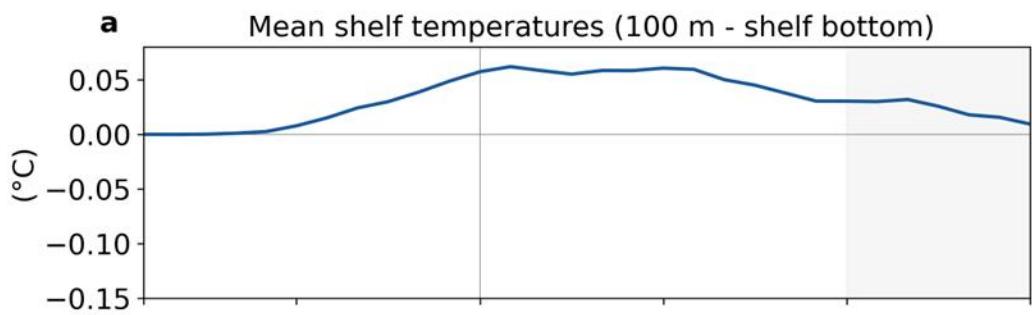
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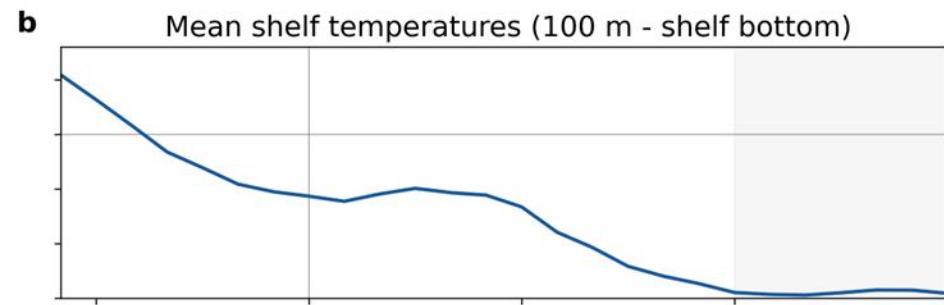
The shelf heat budget during ENSO



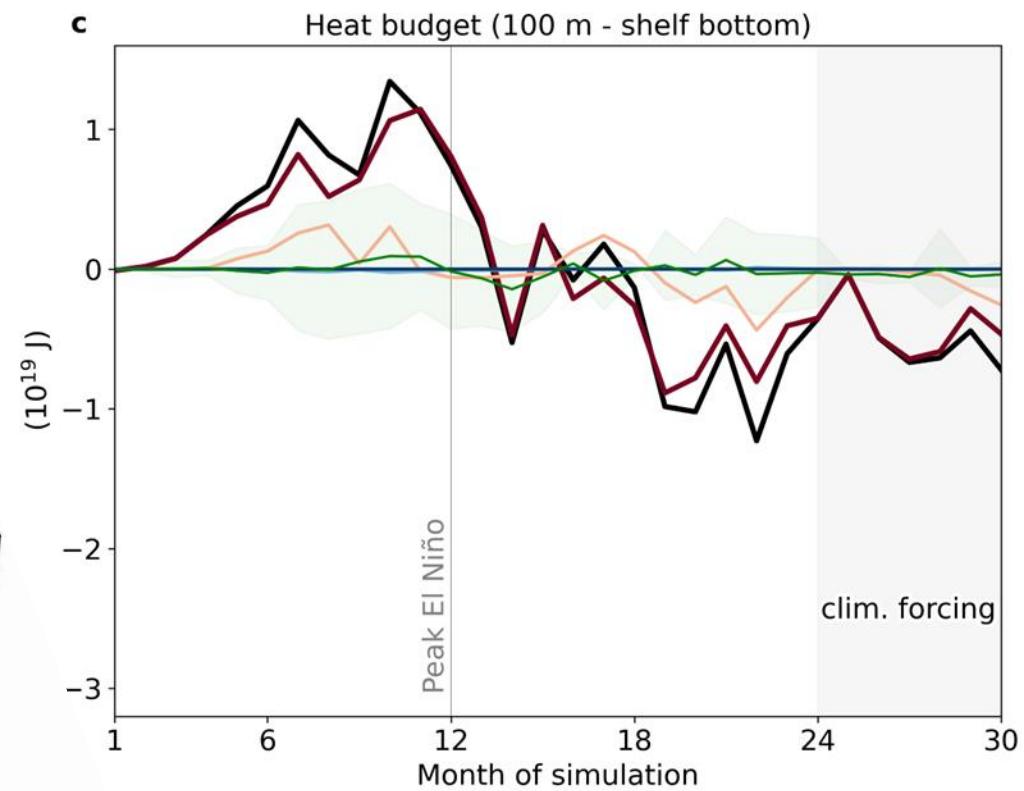
El Niño simulation



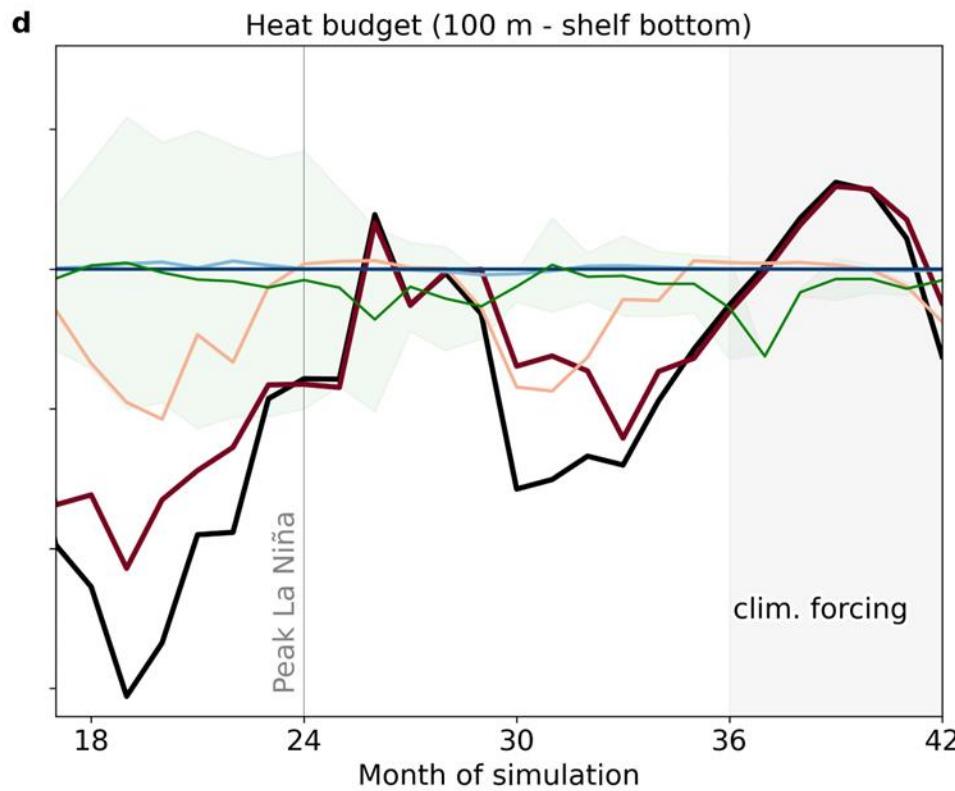
La Niña simulation



Heat budget (100 m - shelf bottom)

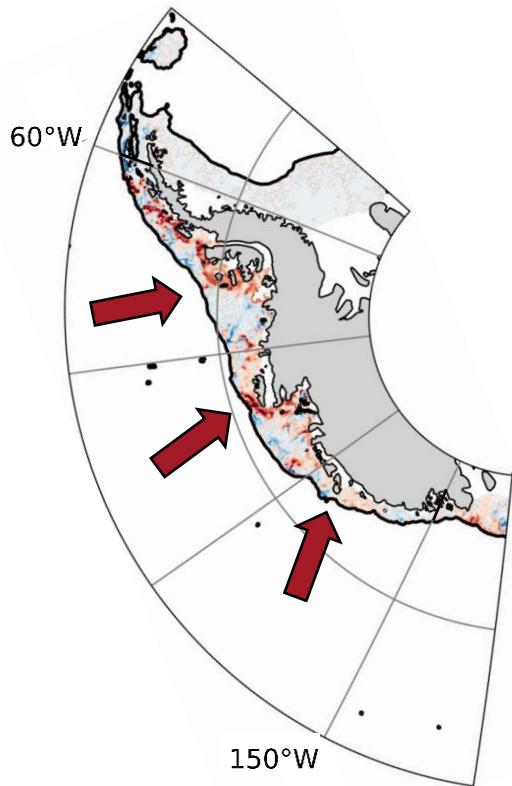


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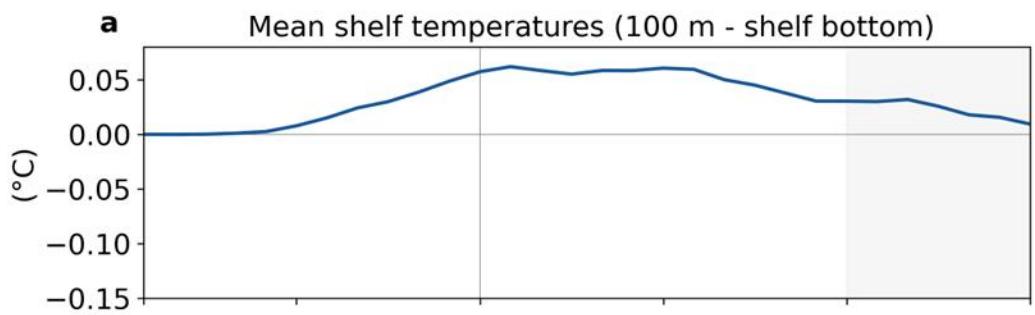


- Change in heat content
- Heat transport convergence
- Vertical mixing
- Surface forcing
- Surface volume
- Vertical heat flux
- Uncertainty limits of vertical heat flux

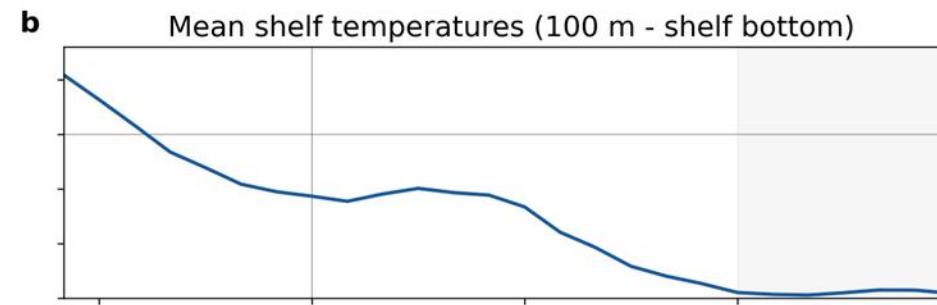
The shelf heat budget during ENSO



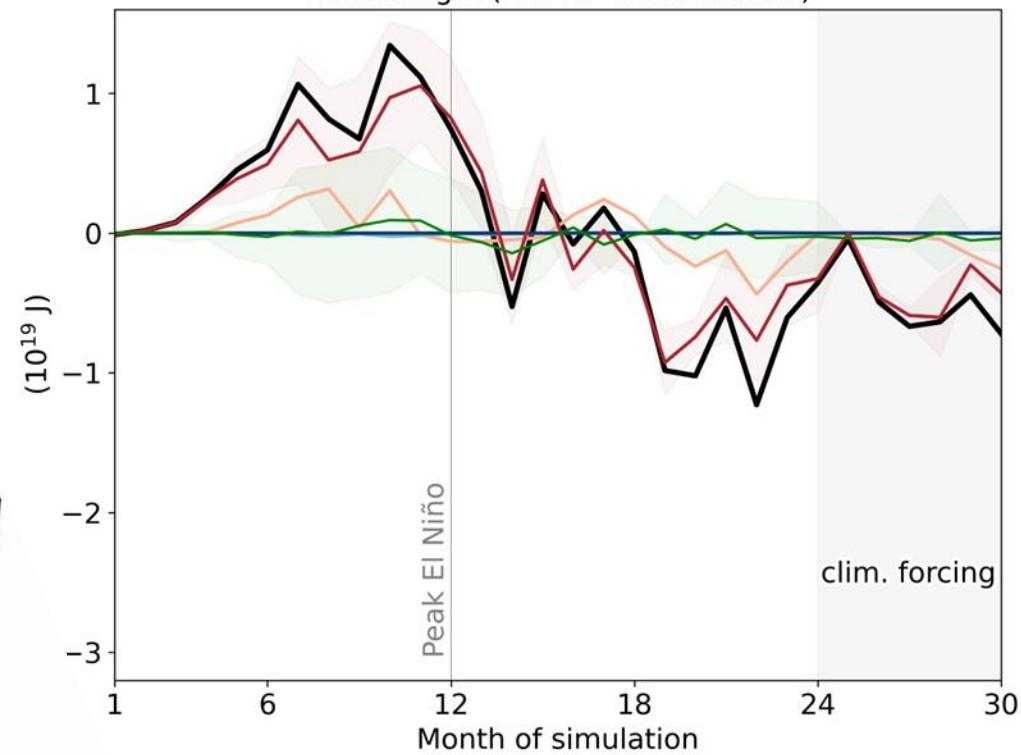
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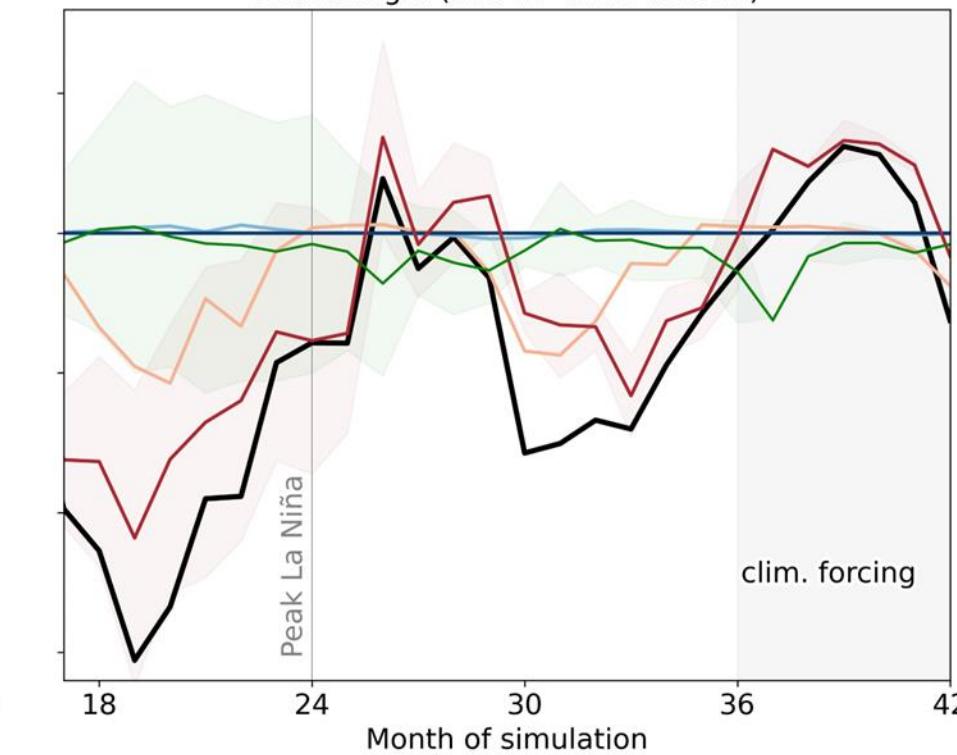
La Niña simulation



Heat budget (100 m - shelf bottom)



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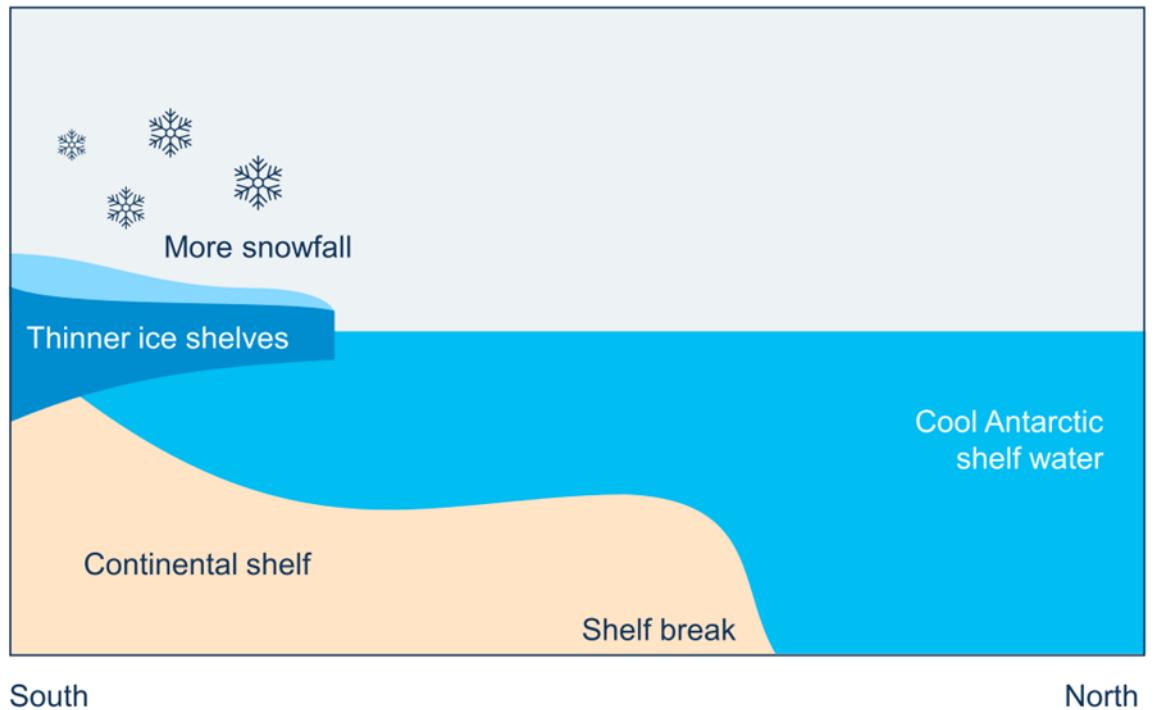


- Change in heat content
- Vertical mixing
- Surface forcing
- Surface volume
- Across-shelf heat flux
- Uncertainty limits of vertical heat flux
- Uncertainty limits of across-shelf heat flux

Summary schematic

a

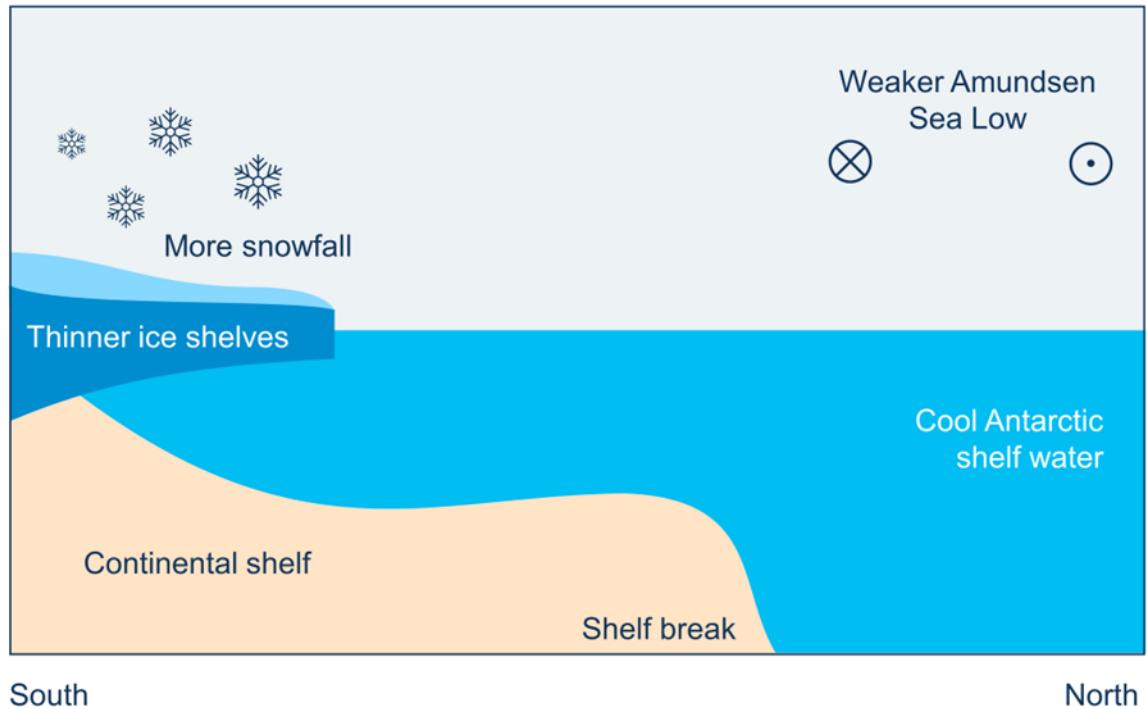
El Niño event



Summary schematic

a

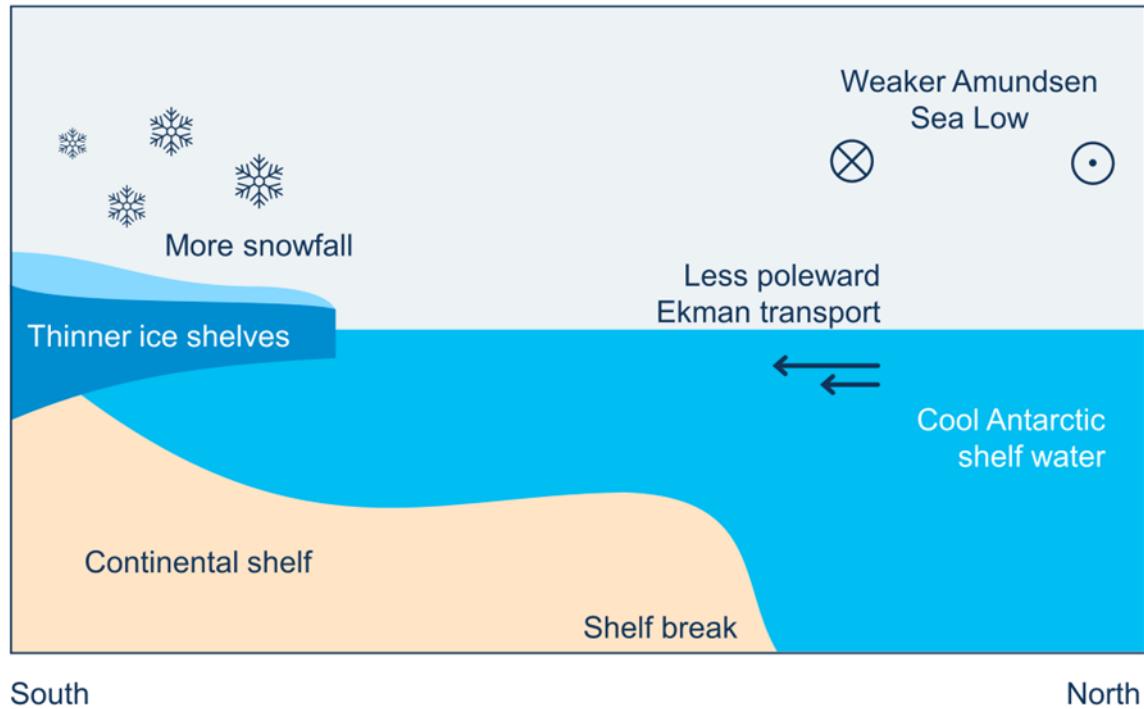
El Niño event



Summary schematic

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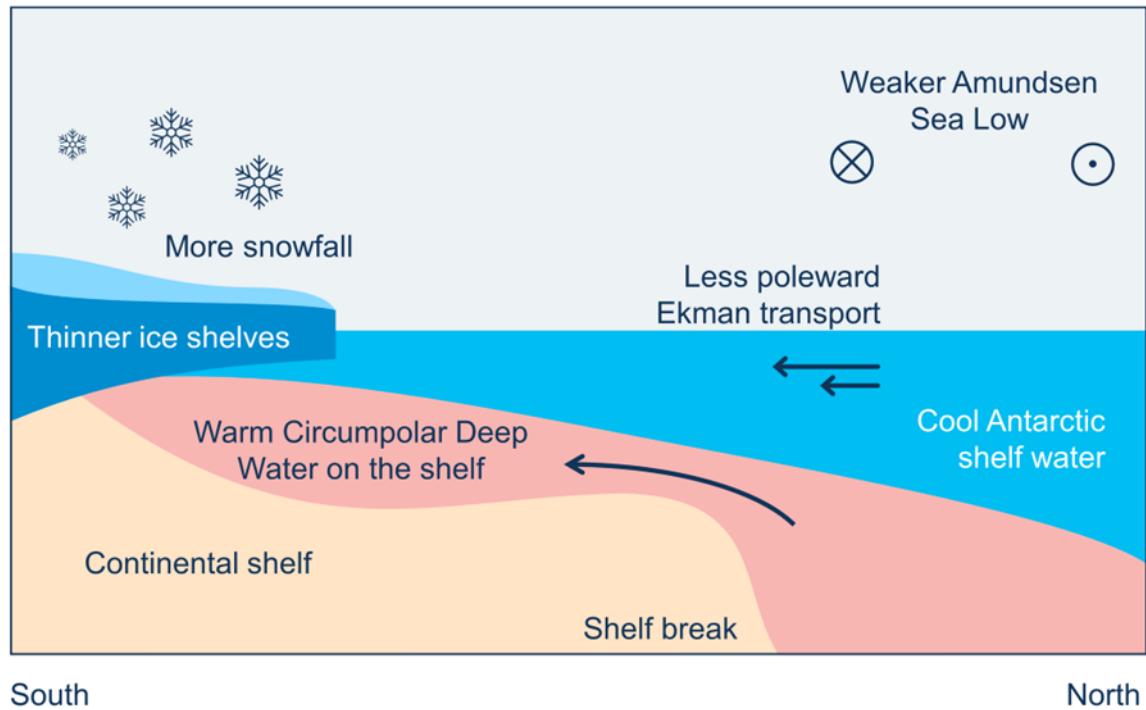
El Niño event



Summary schematic

a

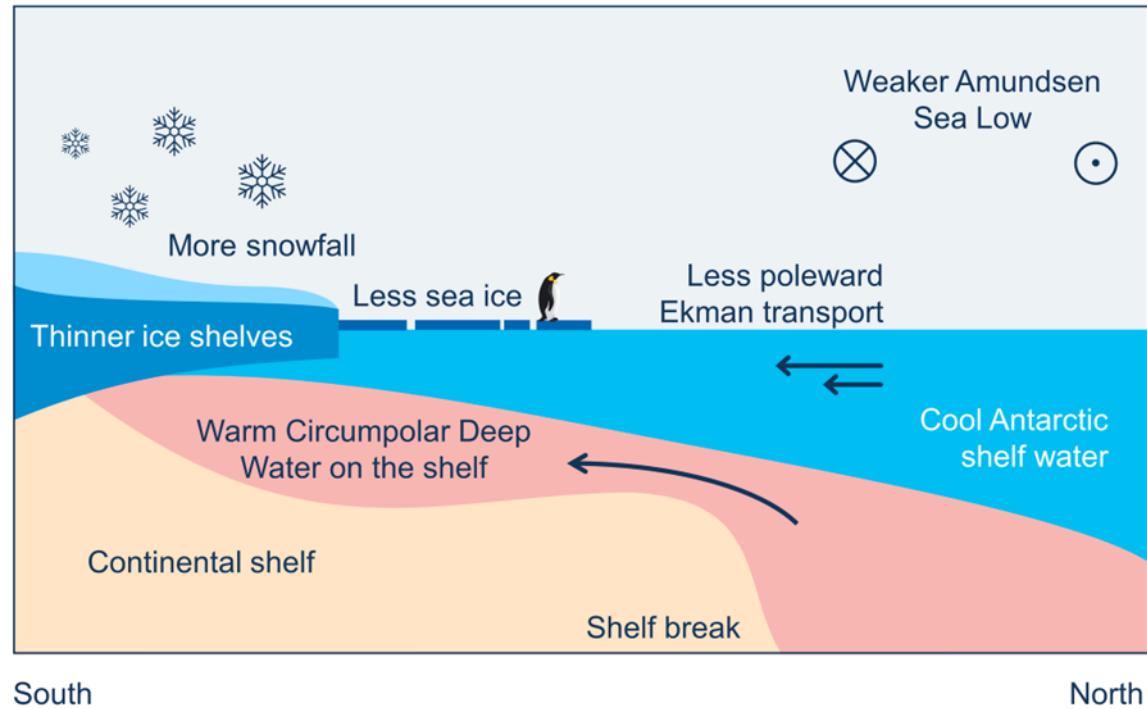
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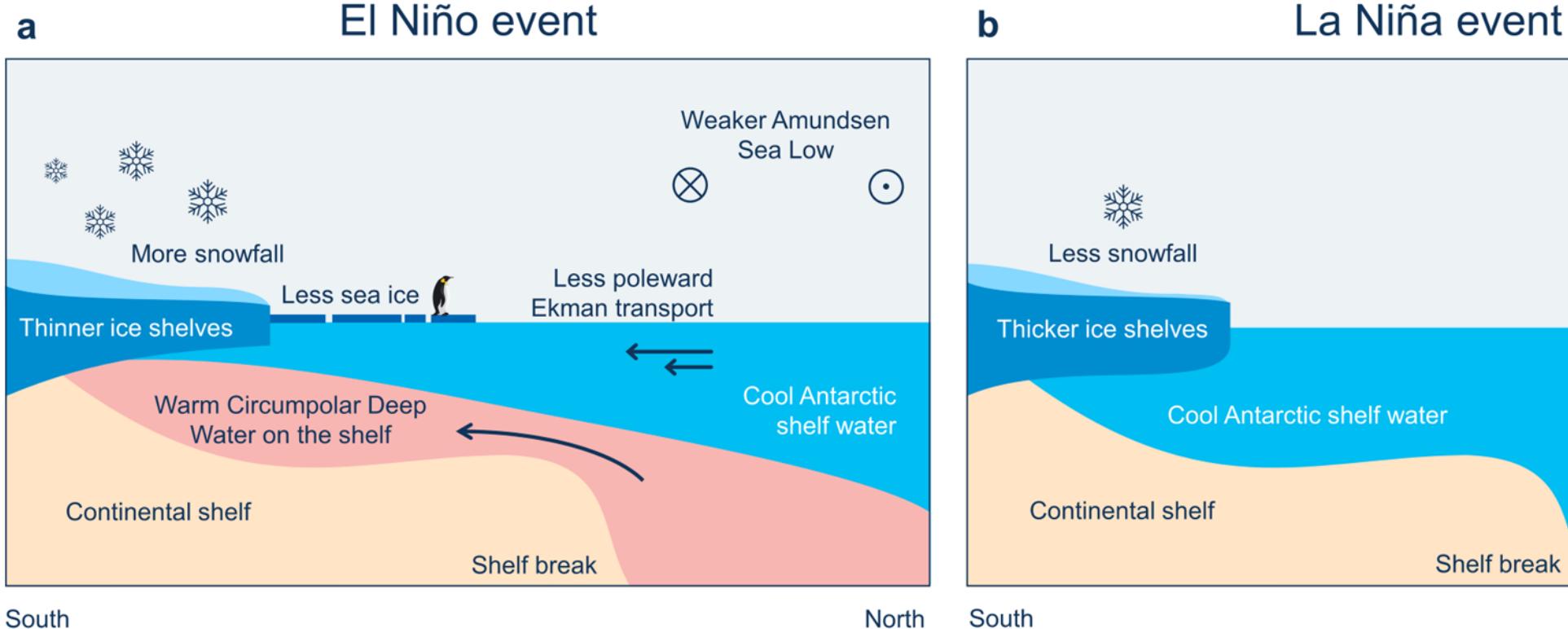
Summary schematic

a

El Niño event



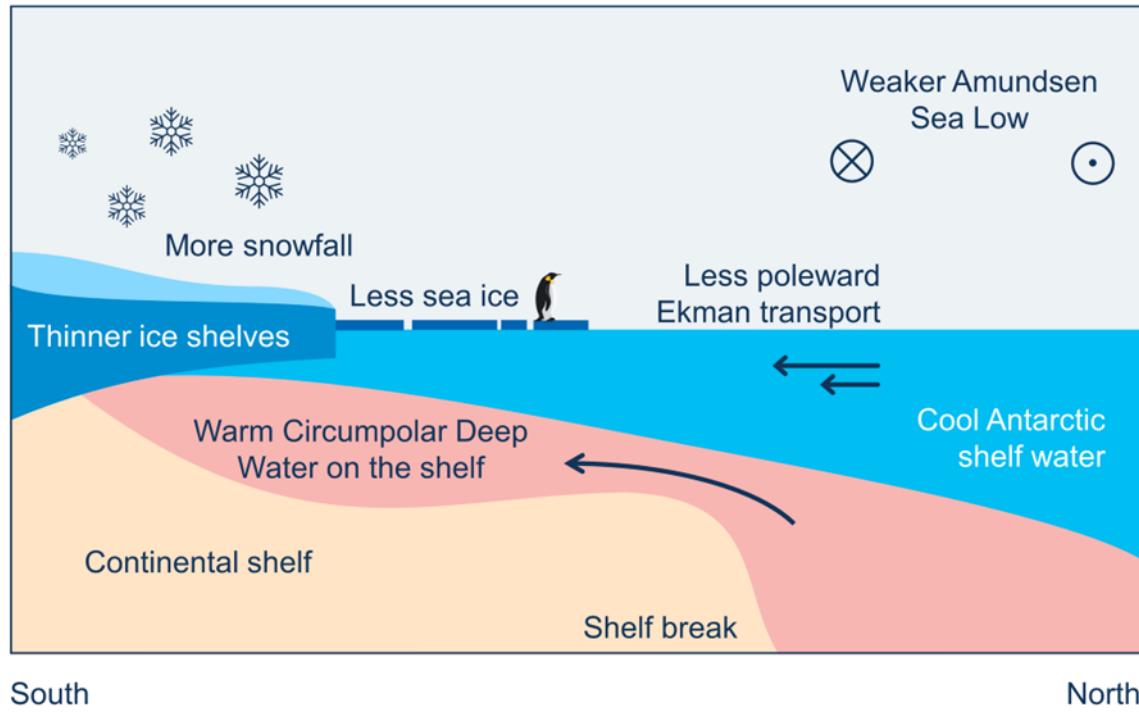
Summary schematic



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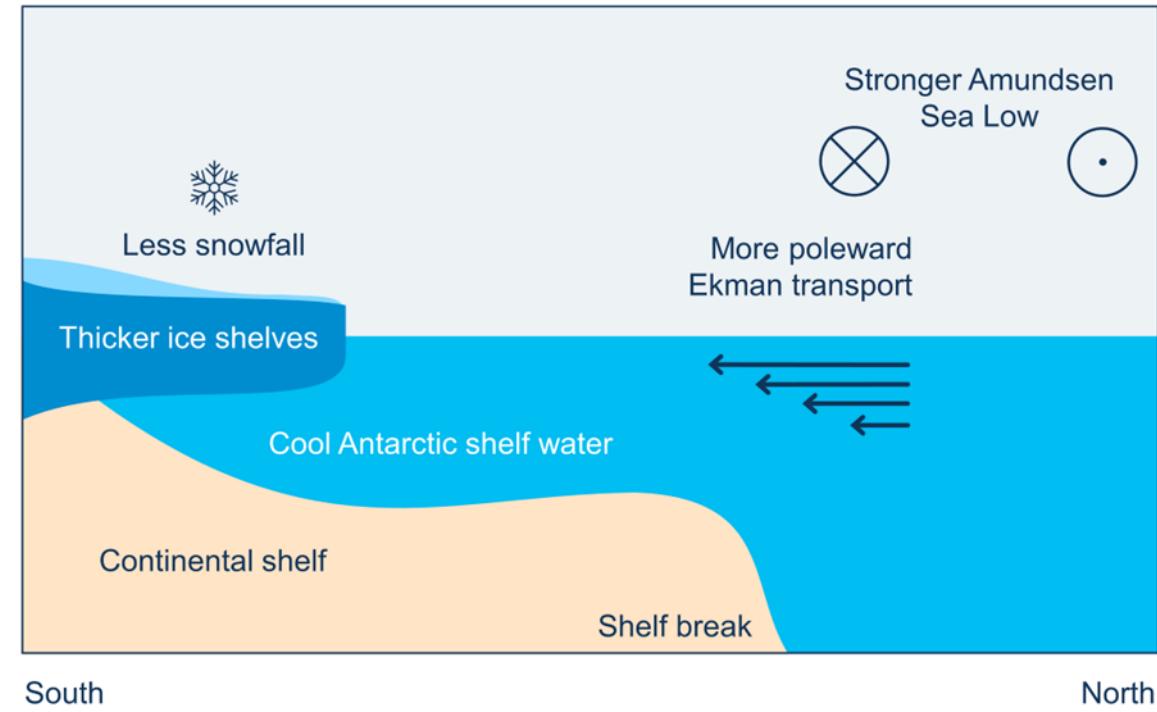
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El Niño event



b

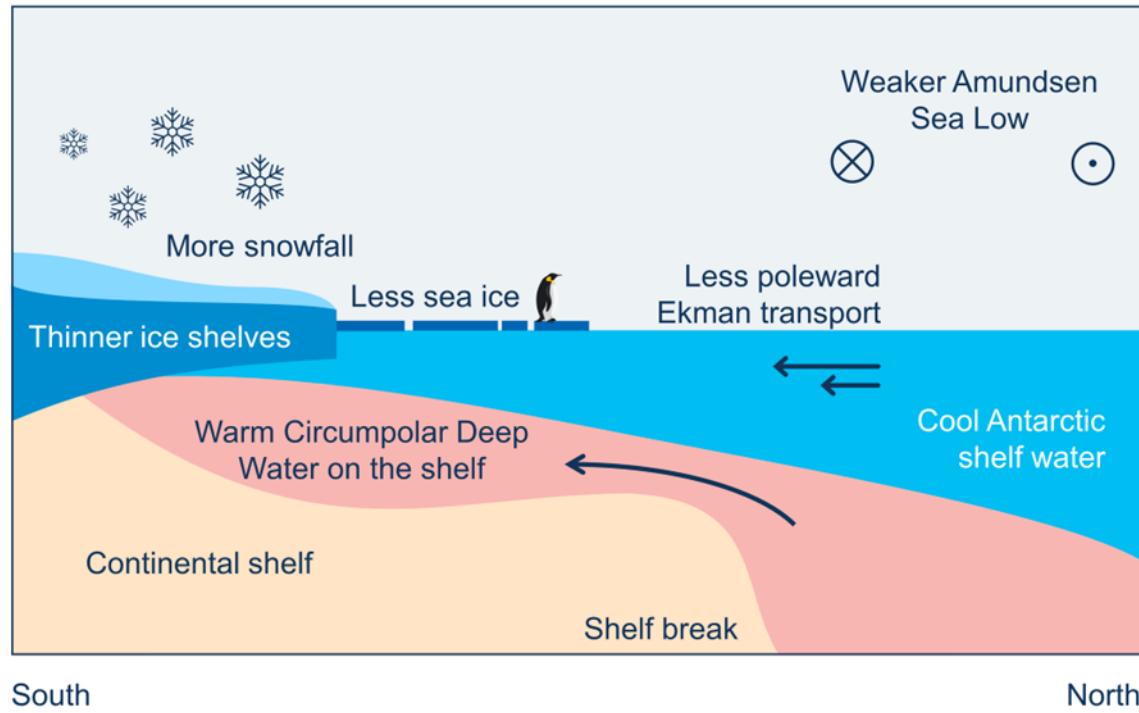
La Niña event



Summary schematic

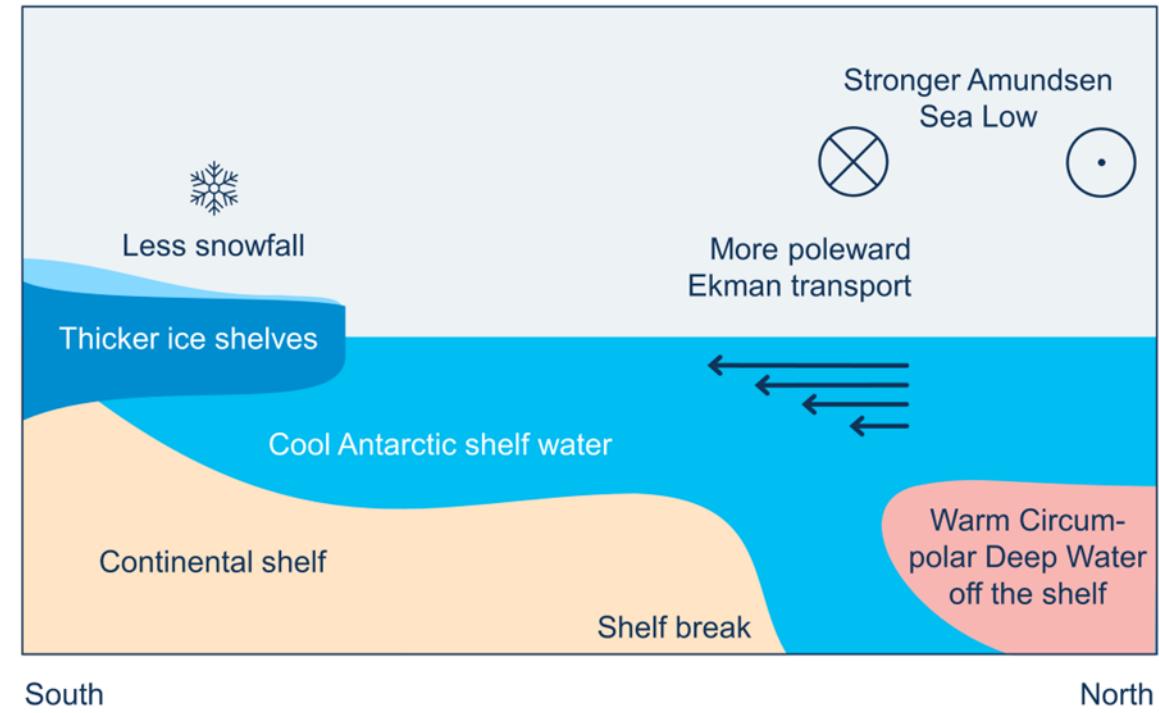
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El Niño event



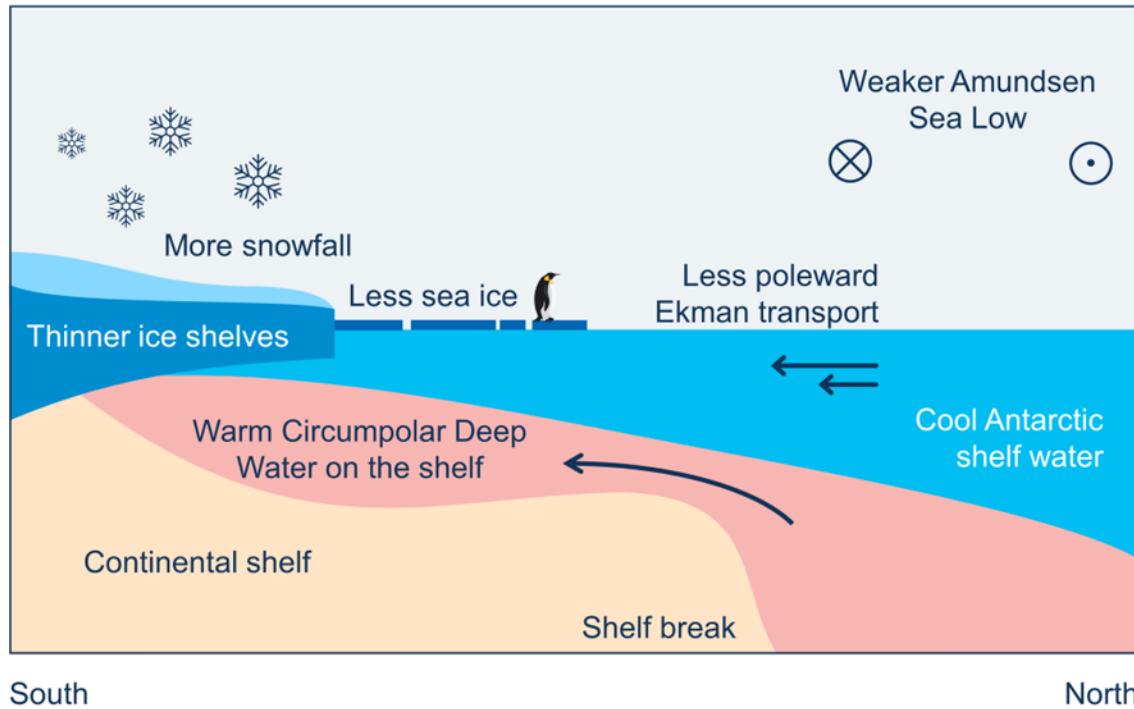
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La Niña event

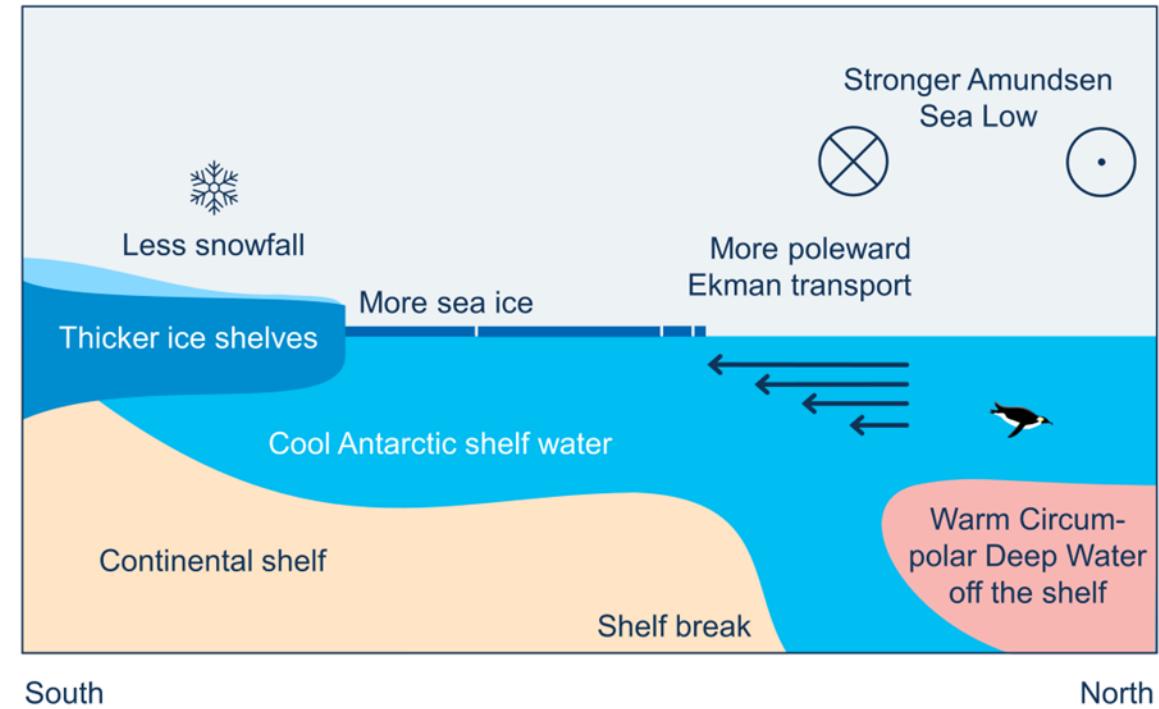


Summary schematic

a El Niño event



La Niña event



What's next?

What's next?

- 2 months left
 - writing preface & conclusion
 - editing and submitting ENSOAnt project



UNSW
SYDNEY

Climate Change Research Centre
School of Biological, Earth and Environmental Sciences

UNDERSTANDING RECENT
INTERANNUAL TO MULTI-DECADAL
GLOBAL AND REGIONAL OCEAN
TEMPERATURE CHANGE

A thesis submitted to attain the degree of
Doctor of Philosophy

MAURICE F. HUGUENIN

supervised by
Dr. Ryan M. Holmes and Prof. Dr. Matthew H. England

19th May 2023

What's next next?

What's next next?

Postdoc in Coupled Ocean-Atmosphere-Ice Feedbacks at the Antarctic Margin

with Matt & Caroline Ummenhofer



one year at CCRC

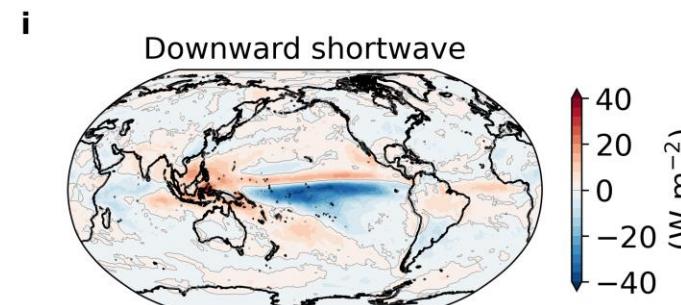
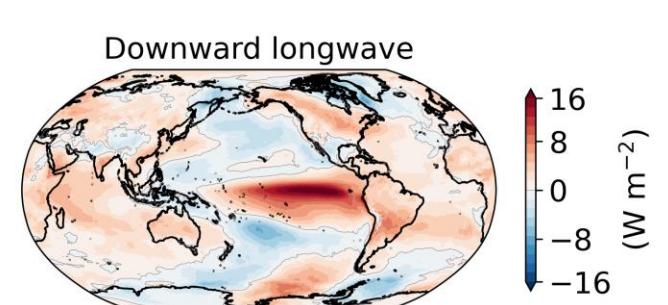
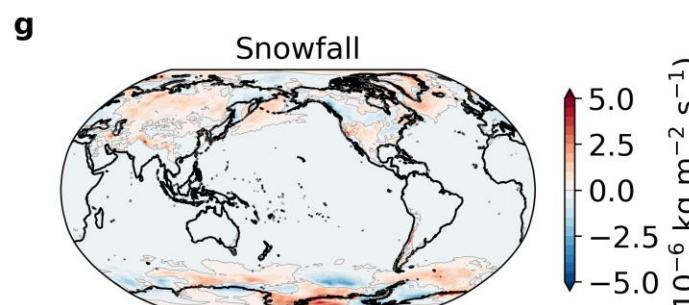
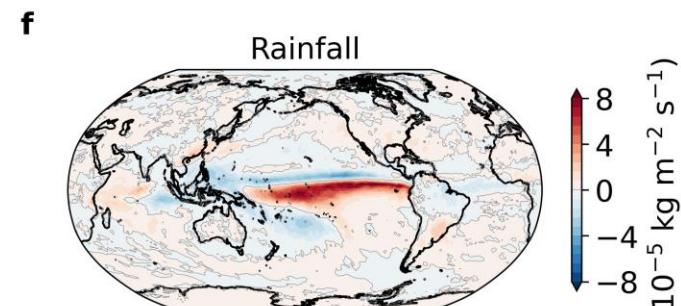
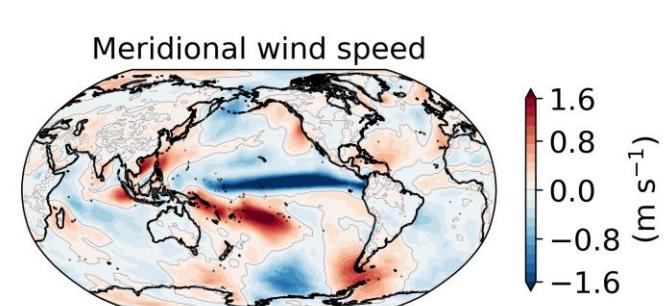
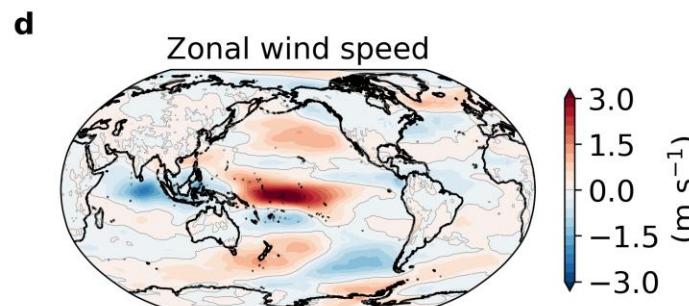
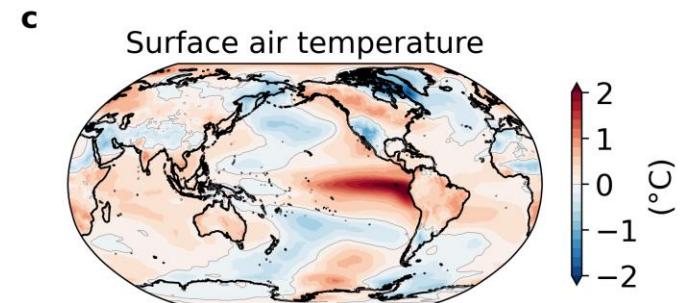
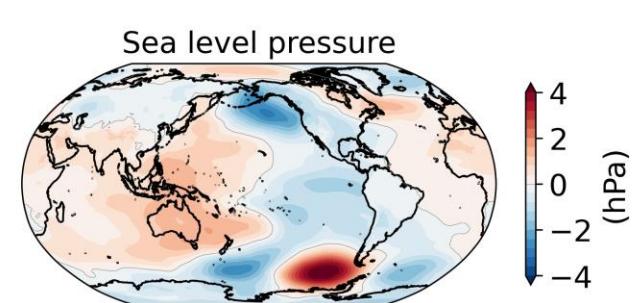
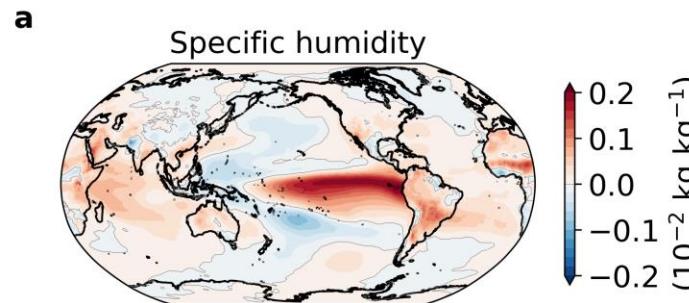


one year at WHOI

15:00.00					

Forcing for the idealised ENSO simulations

Spatial maps of El Niño anomalies



Subsurface warming of West Antarctic coastal waters linked to El Niño events

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Key Points:

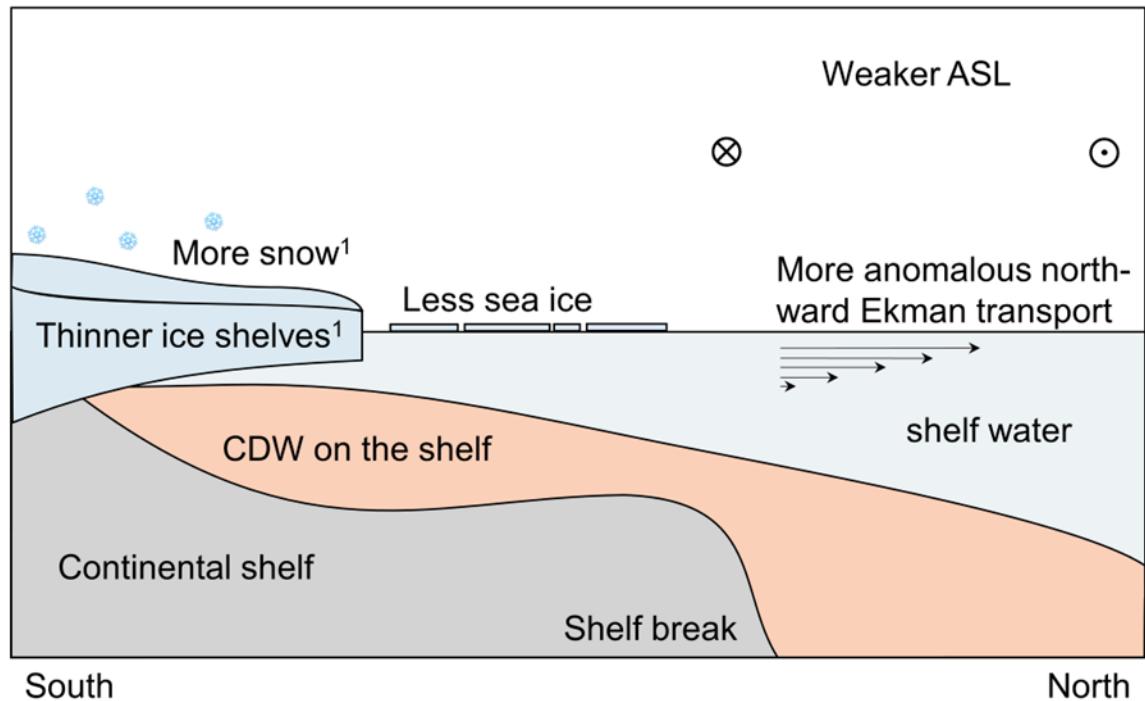
- El Niño-Southern Oscillation impacts the West Antarctic shelf circulation through its modulation of the Amundsen Sea Low
- During El Niño, weaker coastal easterlies reduce poleward Ekman transport and cause upwelling of warm Circumpolar Deep Water onto the shelf
- These warm water masses on the shelf can cause rapid basal melting of West Antarctic ice shelves, accelerating global sea level rise

More slides

Summary

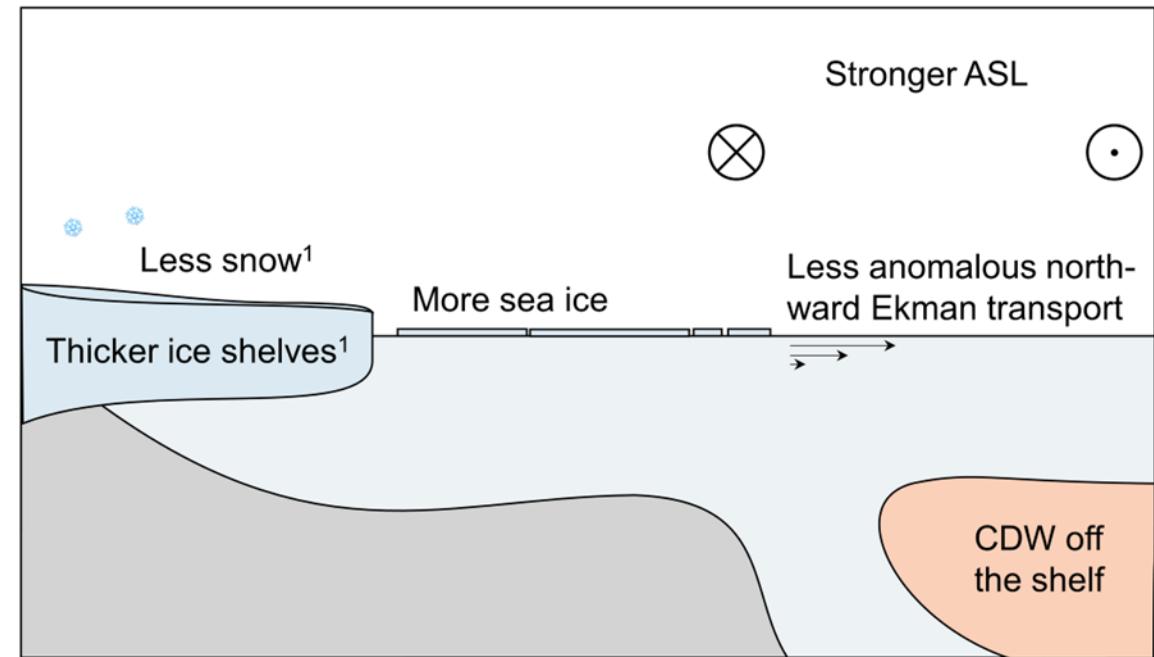
a

El Niño



b

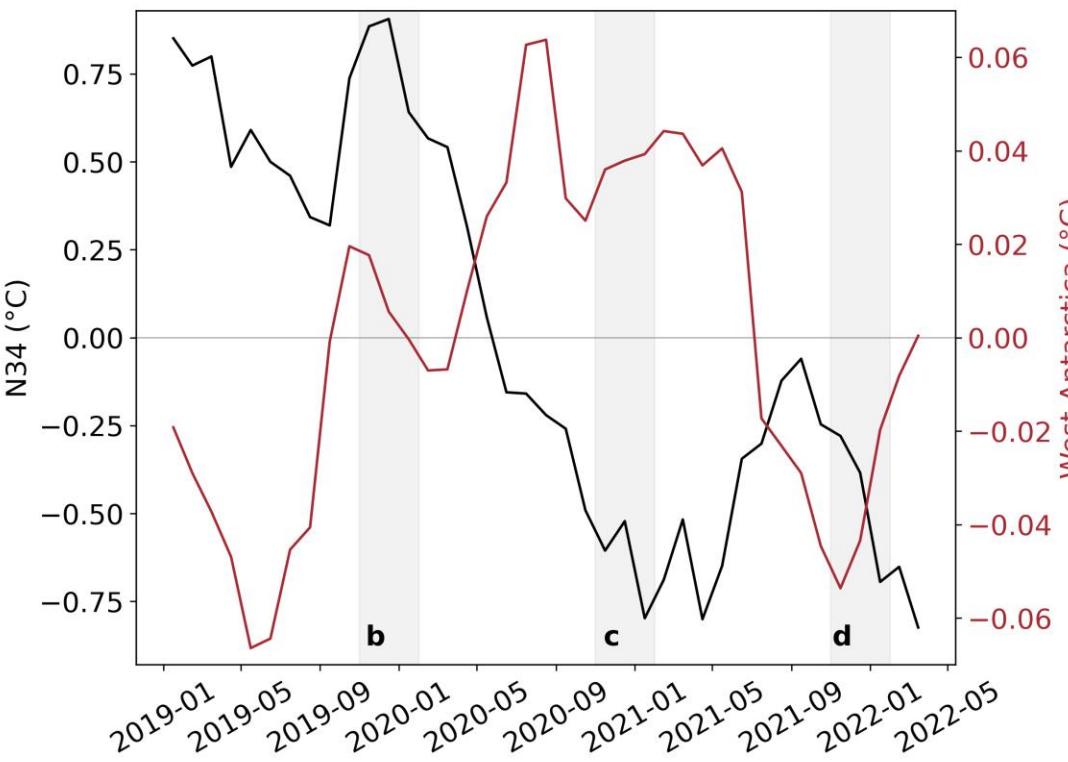
La Niña



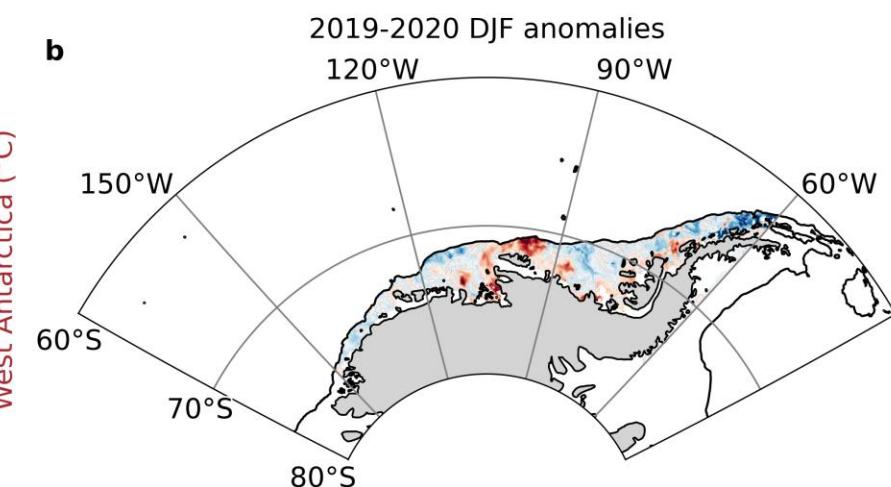
¹Key findings in Paolo et al. (2018)

La Niña³

a N34 index and West Antarctic shelf temperature anomalies



b



2019-2020 DJF anomalies

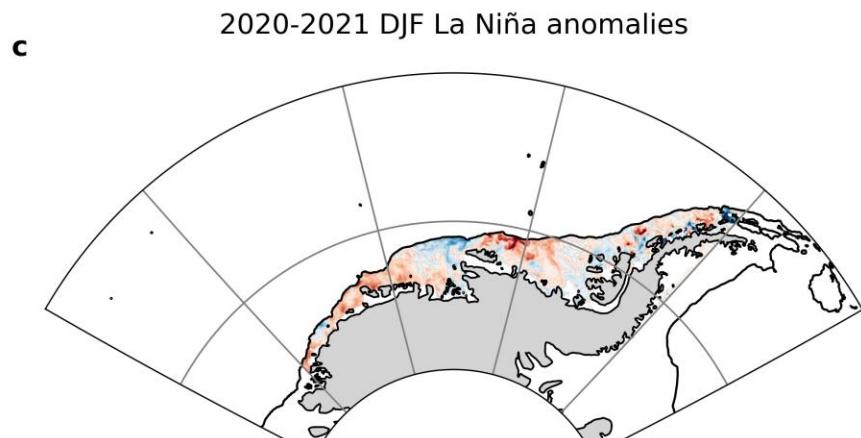
120°W

90°W

60°W

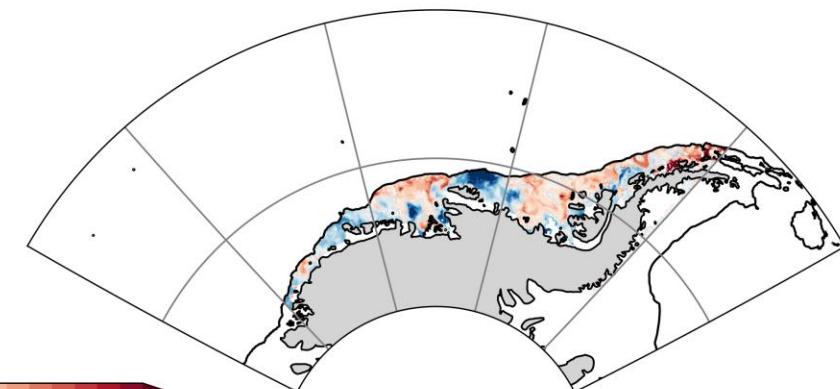
d

2021-2022 DJF La Niña anomalies



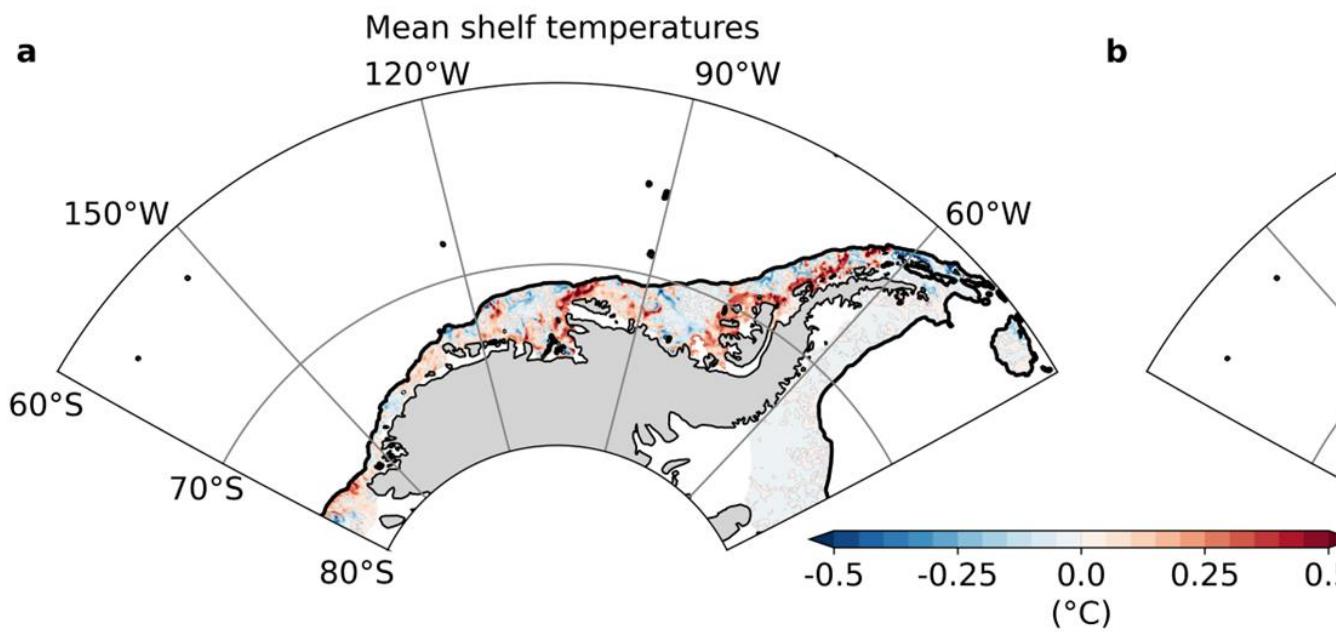
-0.4 -0.2 0.0 0.2 0.4
(°C)

c

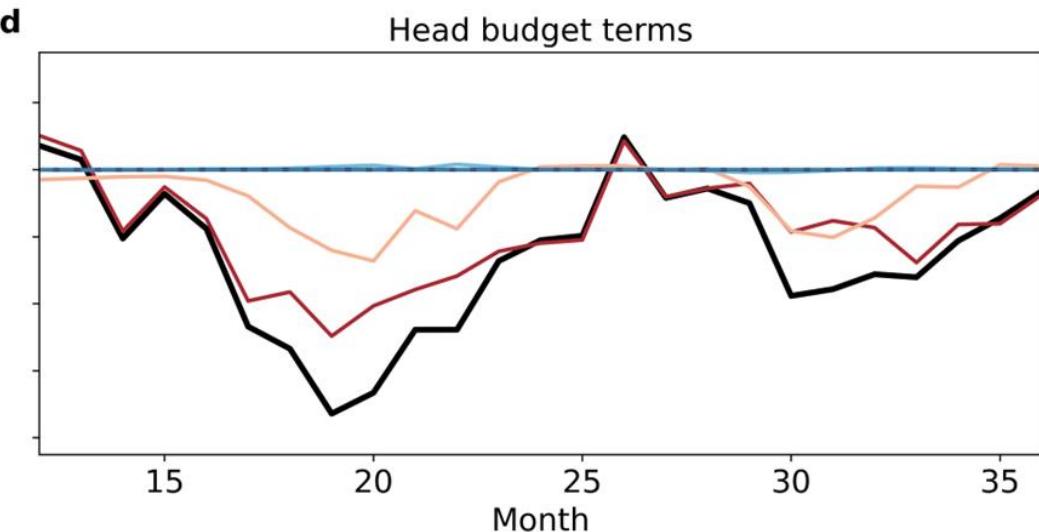
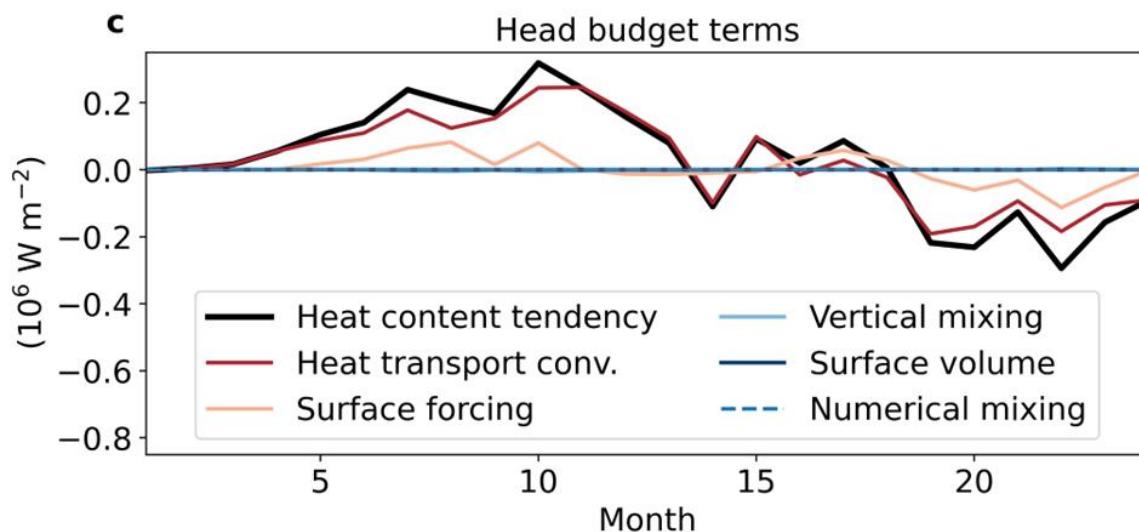
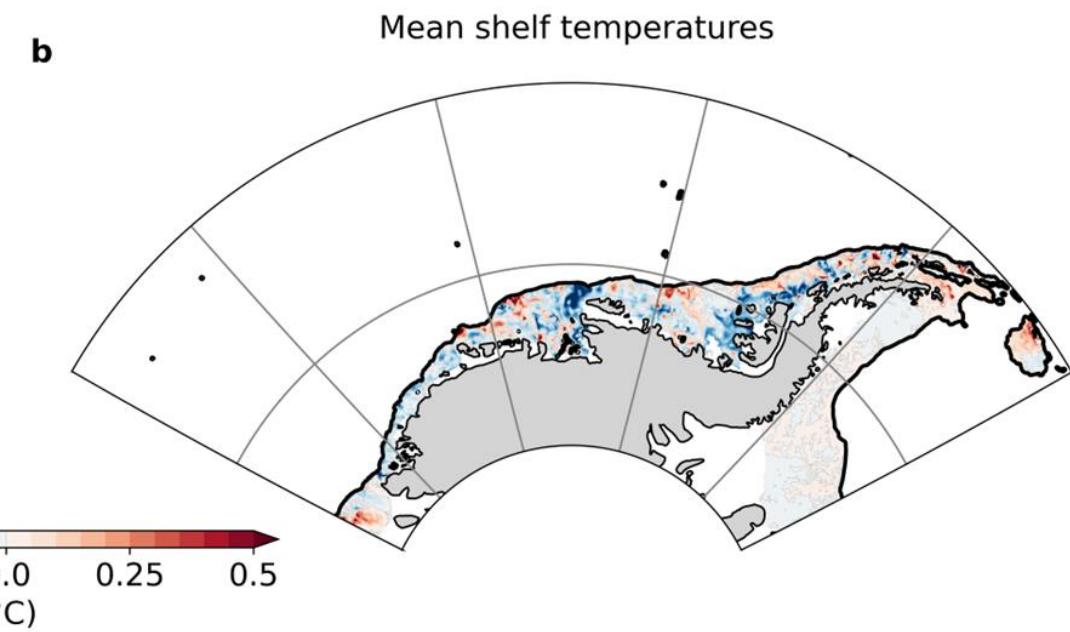


Response to ENSO forcing

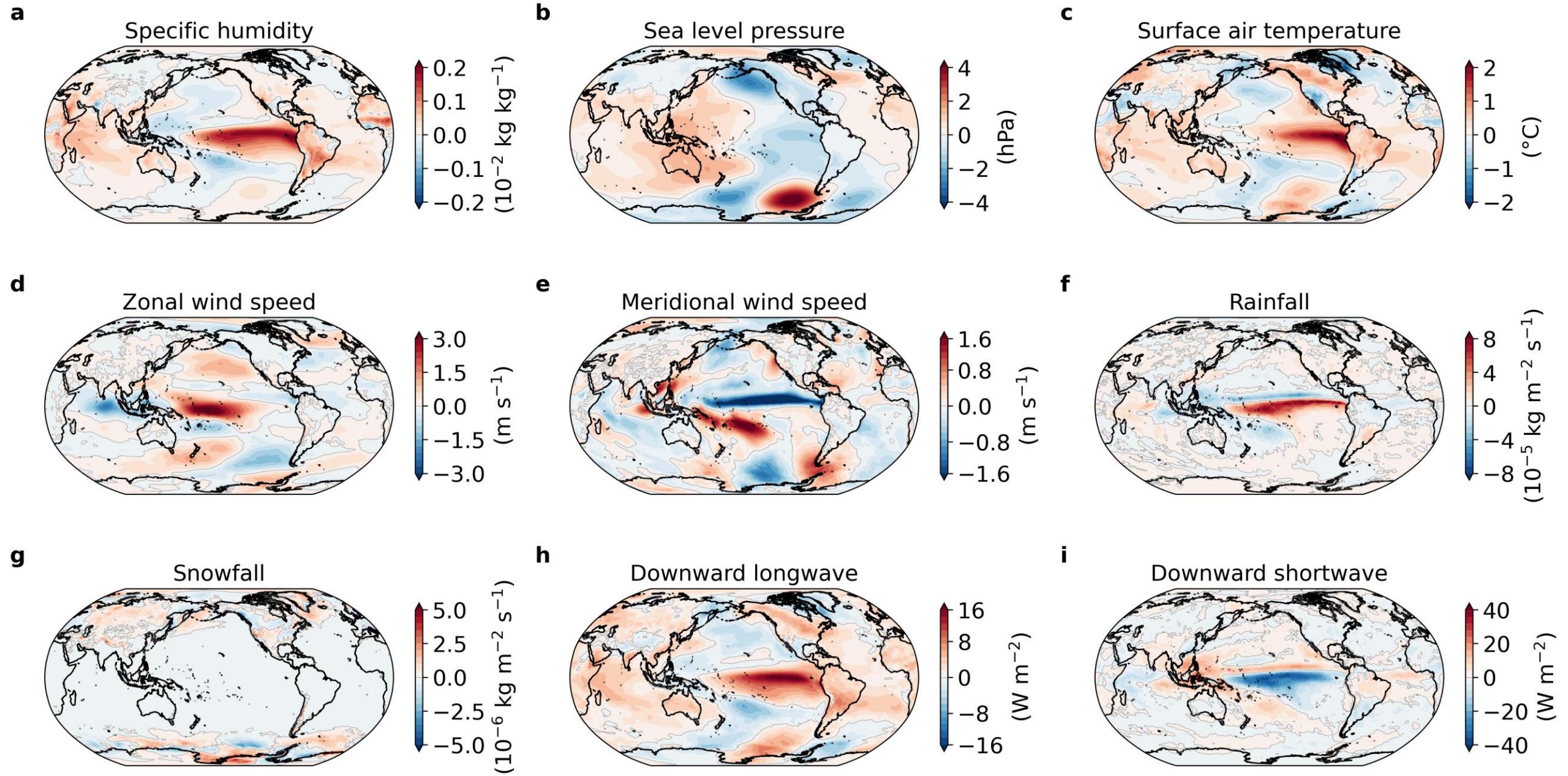
El Niño



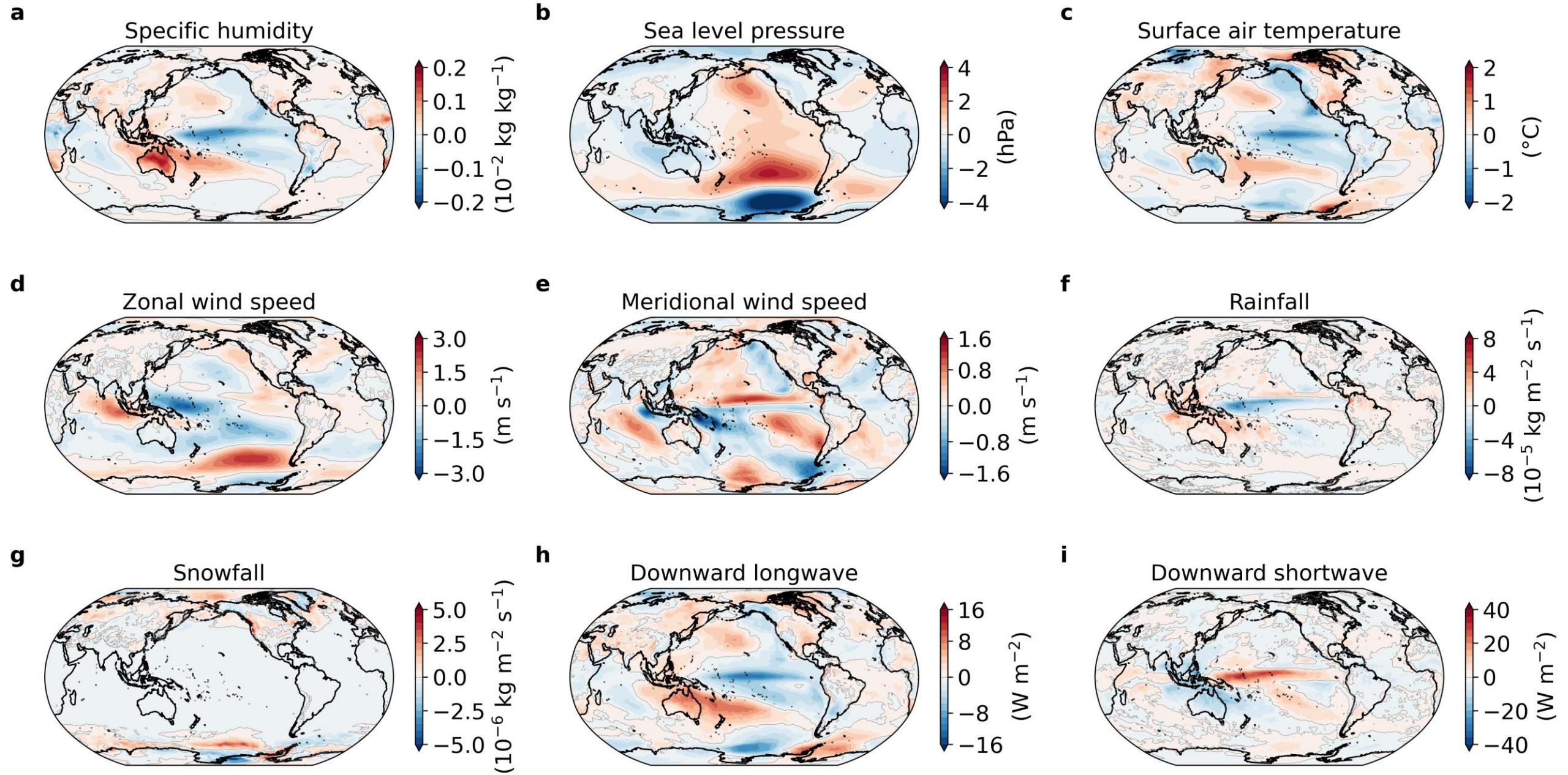
La Niña



Spatial maps of El Niño anomalies

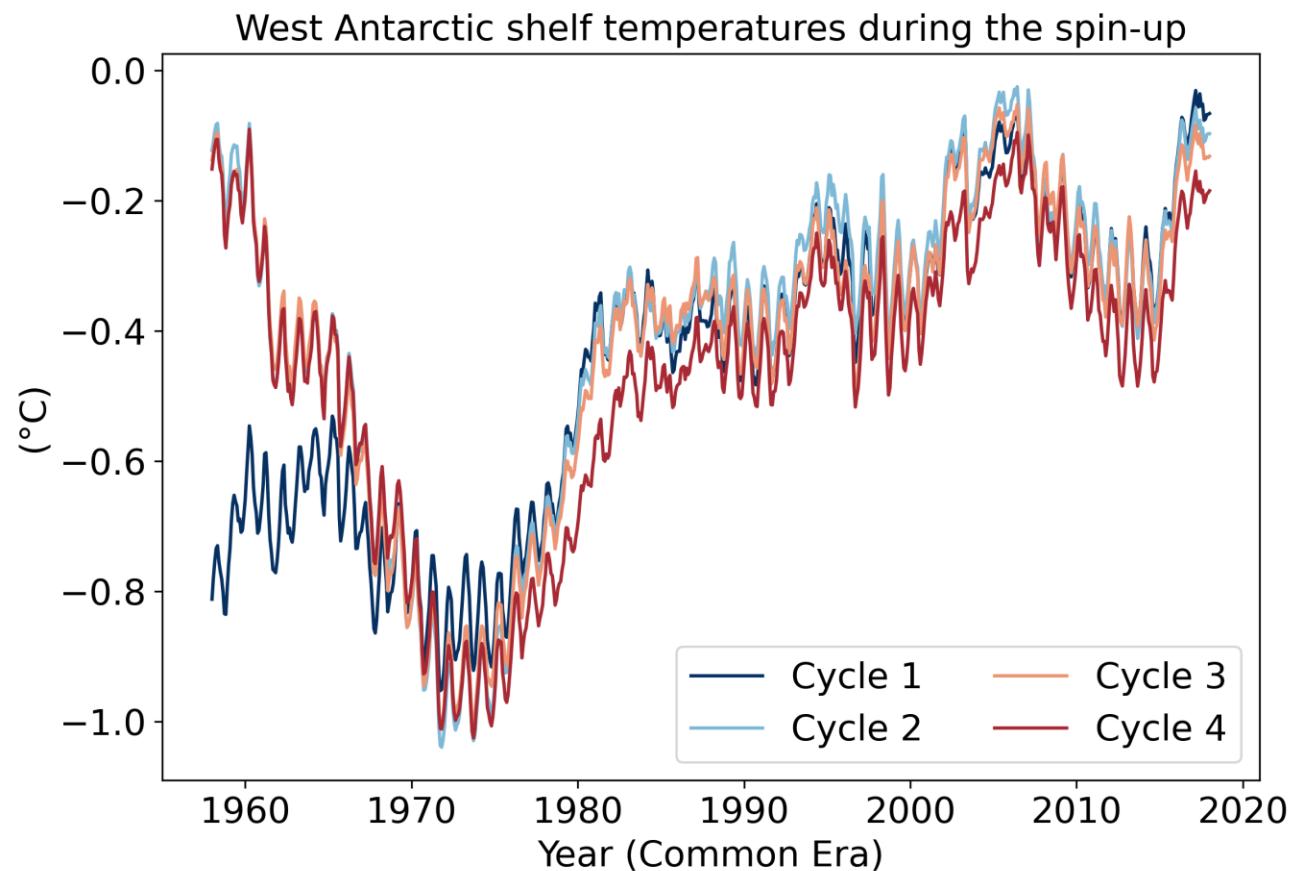


Spatial maps of La Niña anomalies

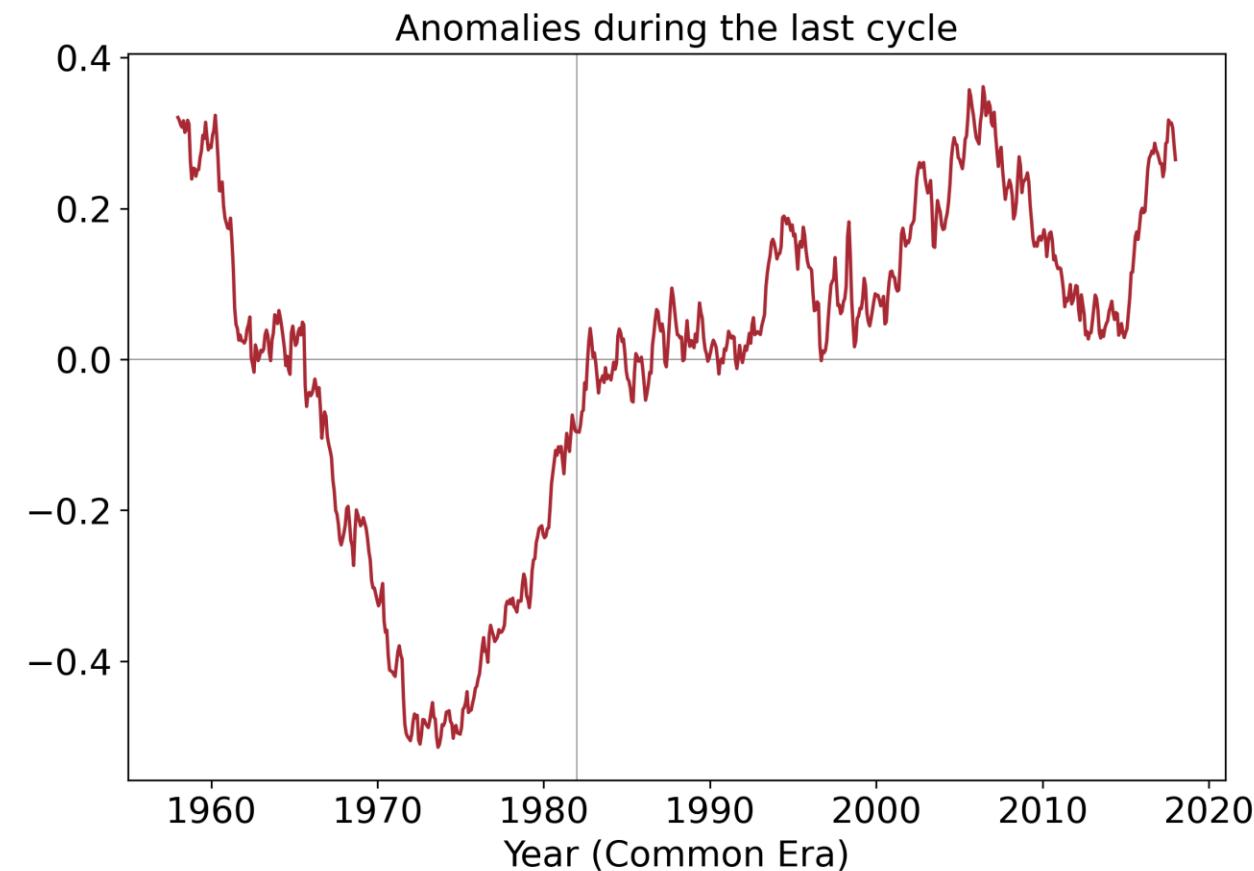


West Antarctic shelf temperatures during the spin-up

a

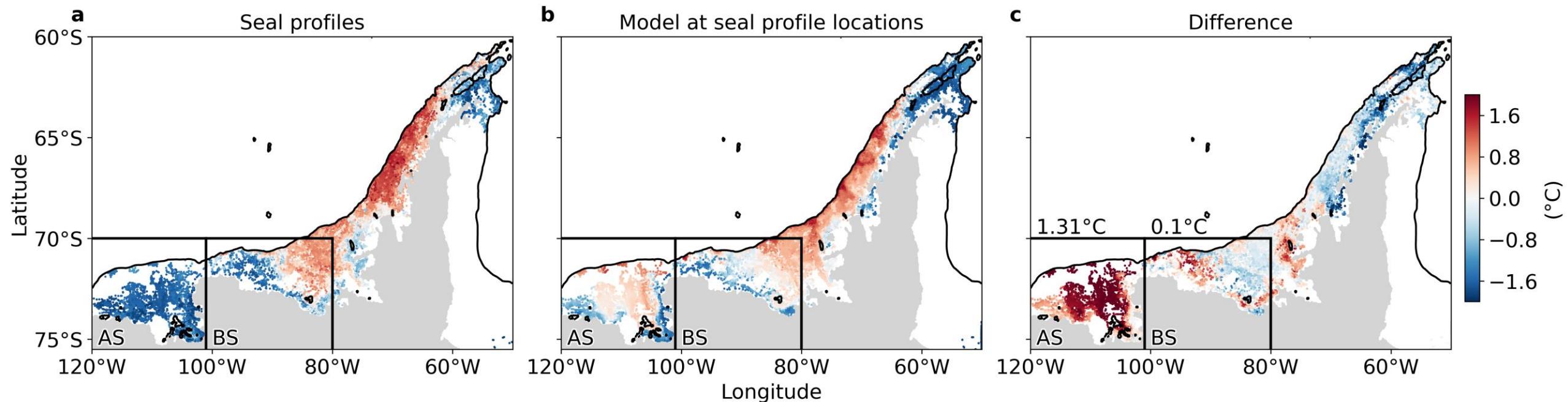


b



Model evaluation with MEOP

200 m temperatures, 01. 02. 2005 - 31. 10. 2015



Model evaluation with SOSE

