

Northern Hemispheric (NH) Ice Loss: A Hidden Driver of Antarctic Ice Sheet (AIS) Instability

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1 Introduction

Coupled climate-ice-sheet modeling is still in its developing stage, and **feedback processes** between **ice sheets** and **climate** are still **not yet fully understood** [1].

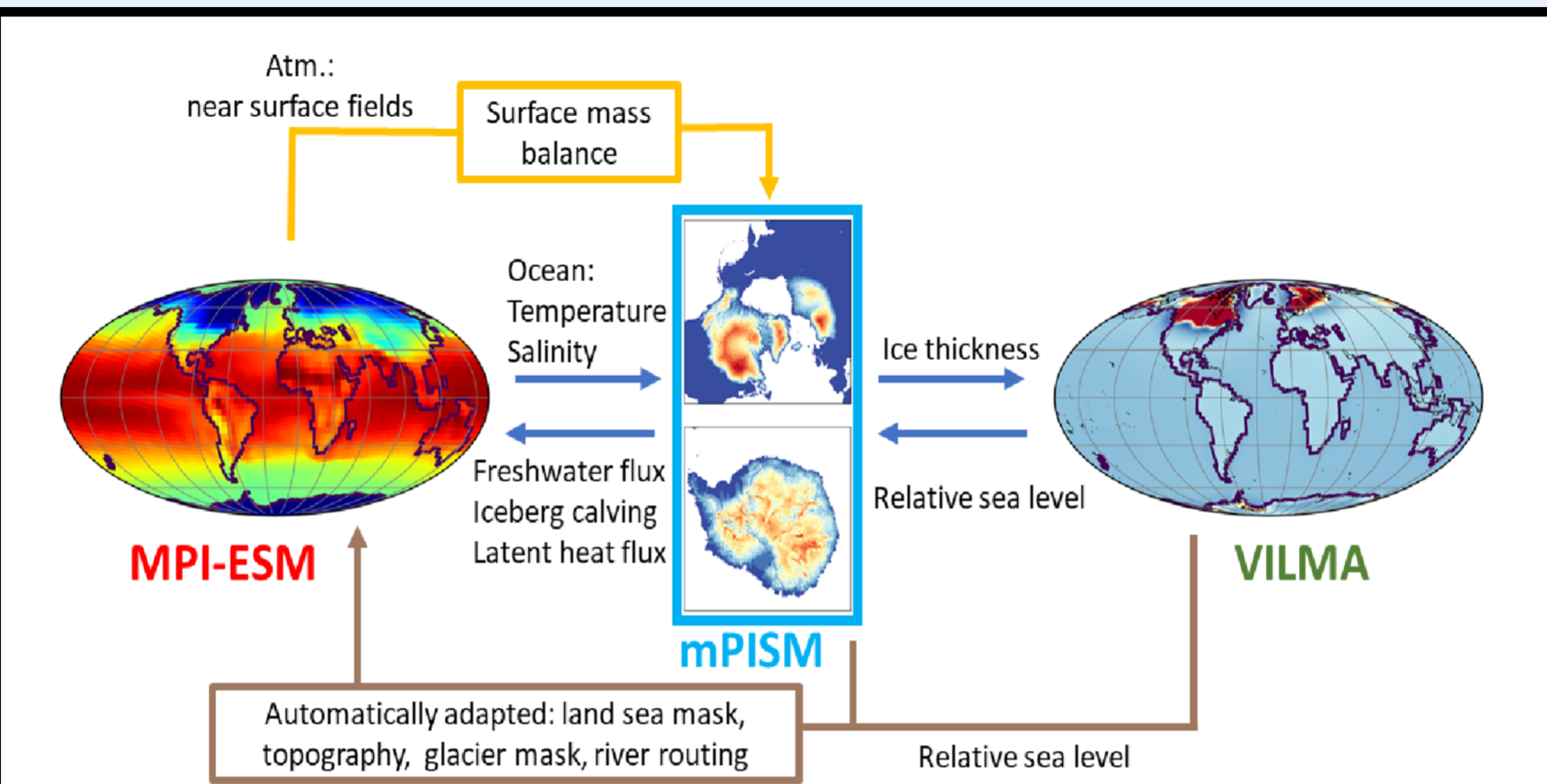


Fig. 1: Schematic of the model framework MPI-ESM/mPISM/VILMA with its individual components MPI-ESM, mPISM, and VILMA and the information exchange between the components

We investigate the **influence** of NH ice sheet distribution on AIS dynamics with a **coupled climate-ice-sheet model**.

2 NH ice loss leads to local warming

Two simulations are performed:

- 1) **REF** simulates **realistic deglaciation** [2] (26 ka BP to 1850 CE), but retains excess NH ice at 8 ka BP.
- 2) **SENS** split off from REF at 8 ka BP and forced by **instantaneously removing excess NH ice**. The removed ice is not redistributed as meltwater to avoid AMOC shutdown

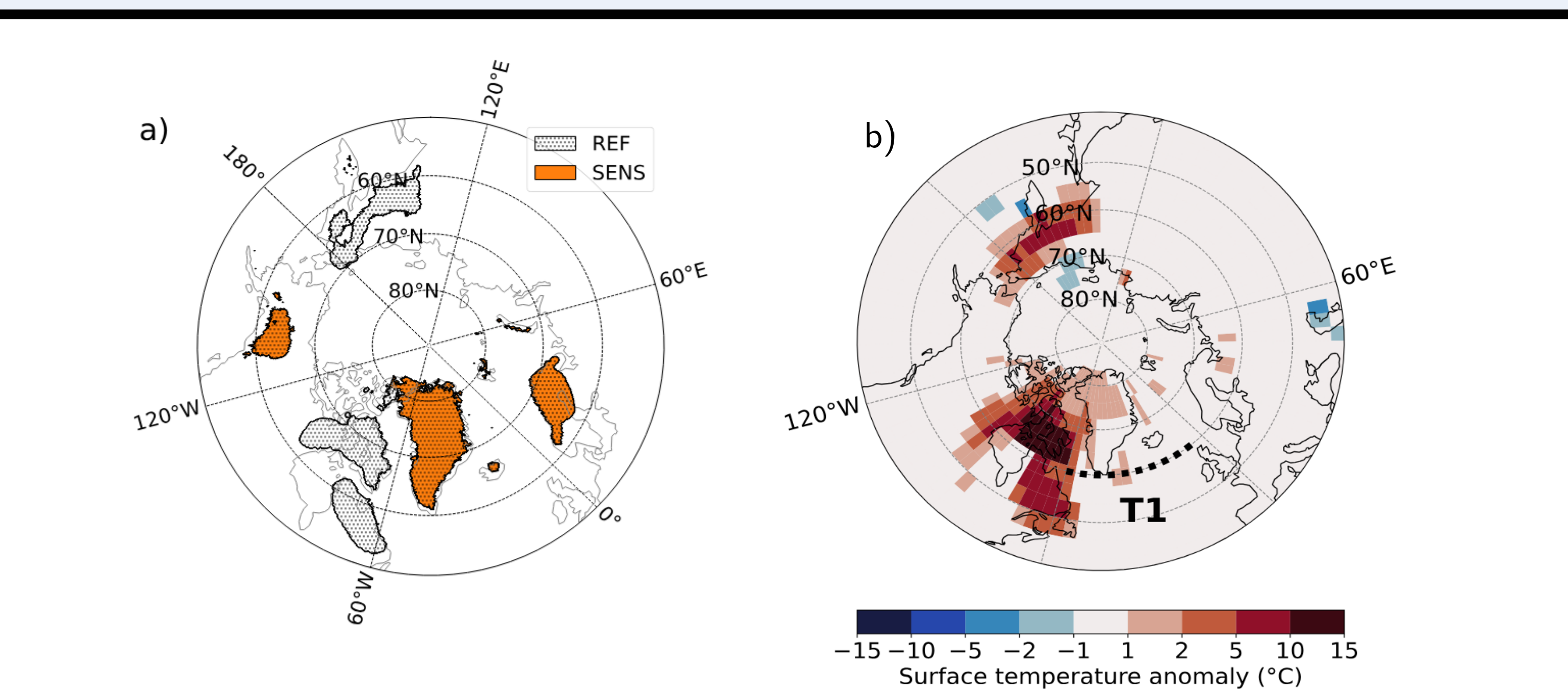


Fig. 2: (a) NH ice sheet distribution at 7990 years before present (YBP) for REF (black dotted area) and SENS (orange filled area). (b) Near-surface air temperature anomaly over the first 1000 years between SENS and REF.

Removing NH ice sheets increases local surface temperatures, due to the melt-elevation feedback and surface darkening. Higher summer surface air temperatures reduce ocean heat loss and **warm subsurface waters** in the North Atlantic.

3 NH Ocean Warming propagates to the Southern Ocean

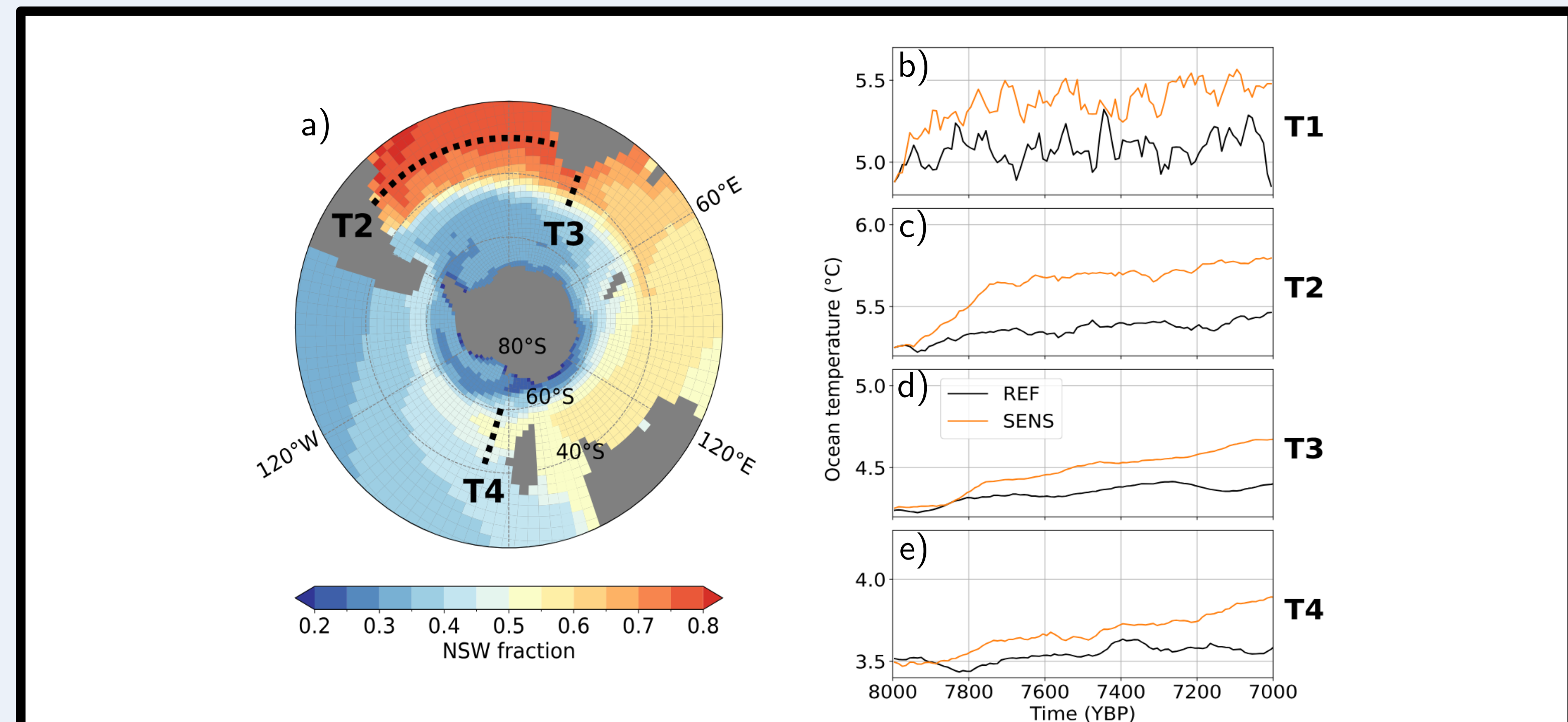


Fig. 3: (a) Mean NSW fraction in the Southern Ocean between 1800 and 2500 m depth. (b-e) Ocean temperature between 1800-2500 m depth at transects T1, T2, T3, T4

The **warmer Northern Sourced Water (NSW)** propagates southward through the Atlantic Ocean and **enters the Southern Ocean**, where it mixes with other water masses.

4 Repeated warm water intrusions trigger a runaway retreat of the AIS

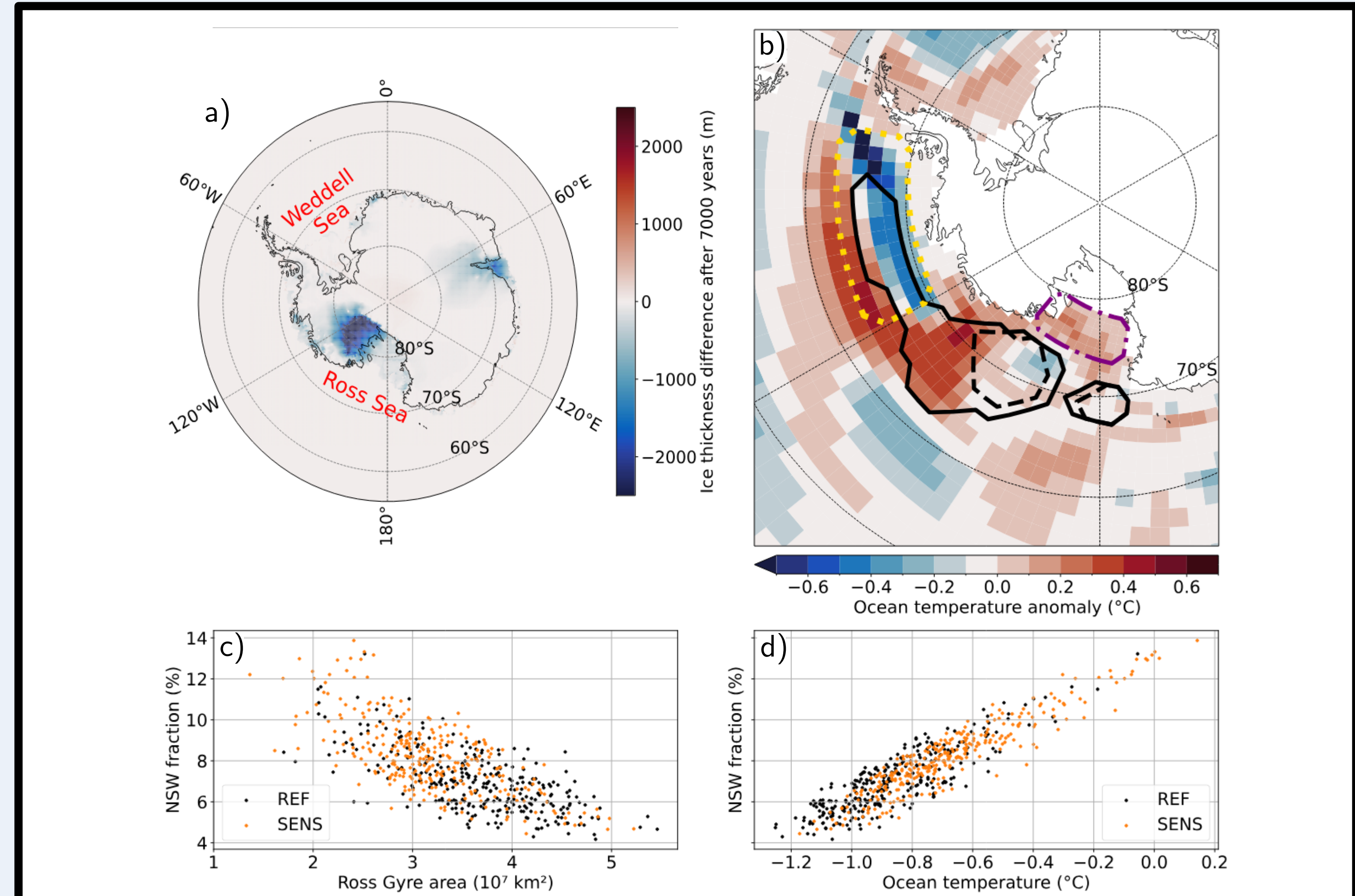


Fig. 4: (a) Ice thickness anomaly after 7000 years between SENS and REF. (b) Mean ocean temperature anomaly between the strong and weak states of the Ross Gyre at 223-488 m depth for 8-5 ka BP. Contours indicate the average Ross Gyre's extent during strong (solid) and weak states (dashed). (c) Relationship between Ross Gyre area and NSW fraction. (d) Relationship between ocean temperature and NSW fraction. (c) and (d) are computed from 8-5 ka BP at 223-488 m depth in the purple dash-dotted region in (b).

Internal oscillations of the Ross Gyre modulate warm NSW intrusions under the Ross ice shelf. A **smaller Ross Gyre** circulates **more NSW** under the Ross ice shelf, while a **larger Ross Gyre shields** the Ross ice shelf **from NSW intrusions**. **Repeated warmer NSW intrusions** destabilize the Ross sea ice shelf and **trigger a runaway retreat** of the AIS.

Coupled climate-ice-sheet sensitivity simulations reveal: Northern Hemisphere ice loss accelerates Antarctic retreat through a chain of feedbacks, uncovering a new teleconnection with potential for abrupt, interhemispheric tipping cascades.

References & Affiliations

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[1] Fyke et al. (2018). Reviews of Geophysics, 56(2), 361-408.
[2] Mikolajewicz et al. (2025). Climate of the Past, 21(3), 719-751.

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