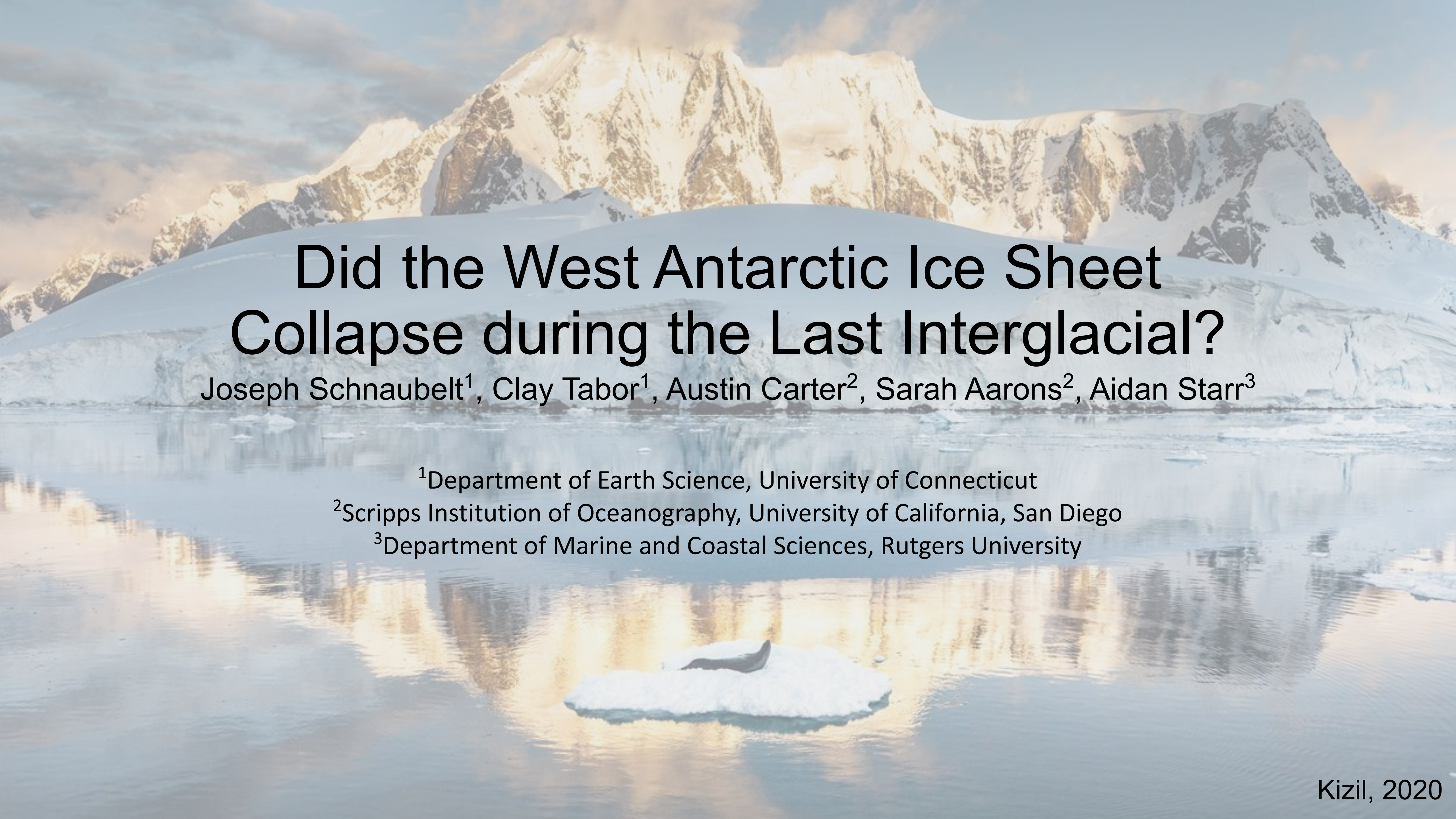


Did the West Antarctic Ice Sheet Collapse during the Last Interglacial?

Joseph Schnaubelt[1], Clay Tabor[1], Austin Carter[2], Sarah Aarons[2], Aidan Starr[3]

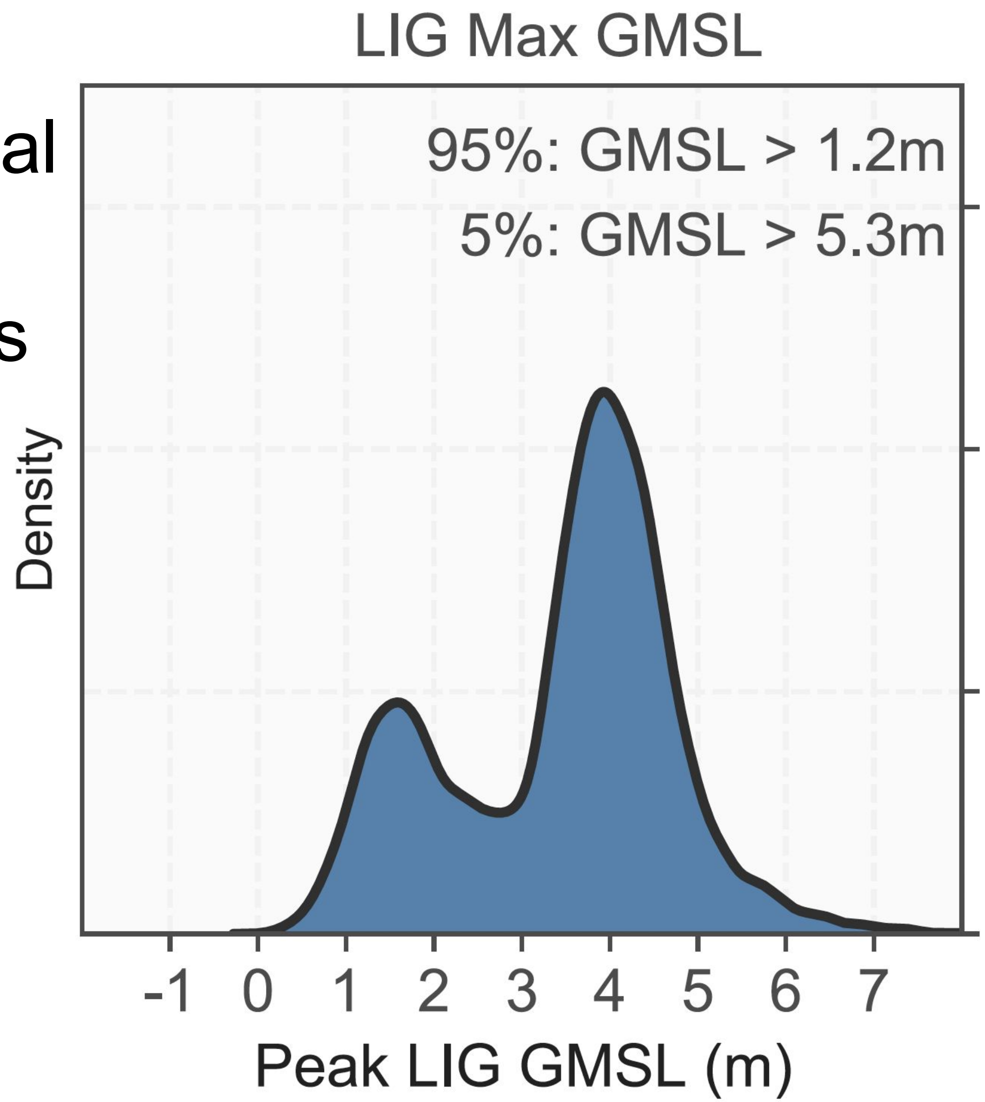
[1]Department of Earth Science, University of Connecticut
[2]Scripps Institution of Oceanography, University of California, San Diego
[3]Department of Marine and Coastal Sciences, Rutgers University

Kizil, 2020

The Last Interglacial (LIG)

The Last Interglacial (LIG)

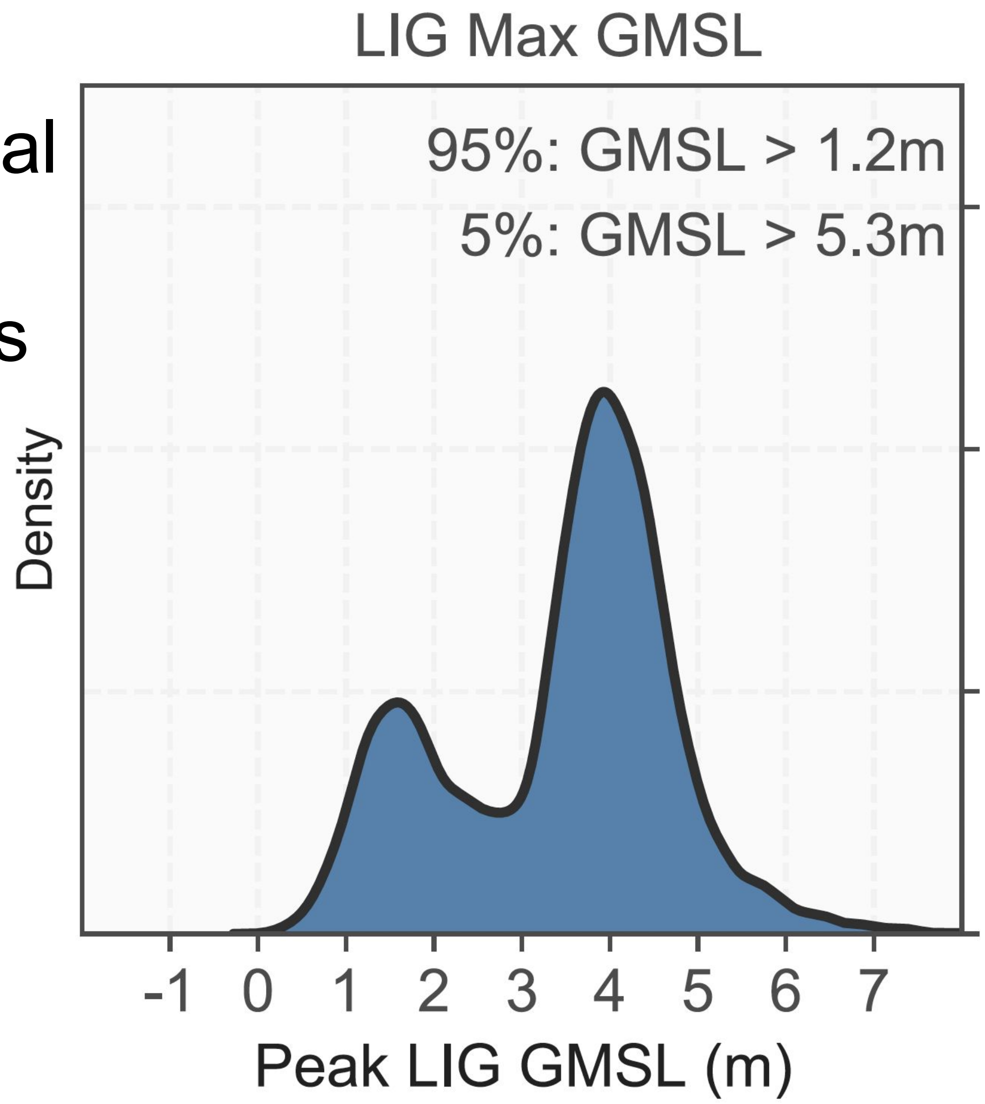
- Sea level 1.2-5.3 m higher than preindustrial (Dyer et al., 2021)
- Requires contributions from both ice sheets
- Proxy signatures allow for possibility of West Antarctic Ice Sheet Collapse



Dyer et al., 2021

The Last Interglacial (LIG)

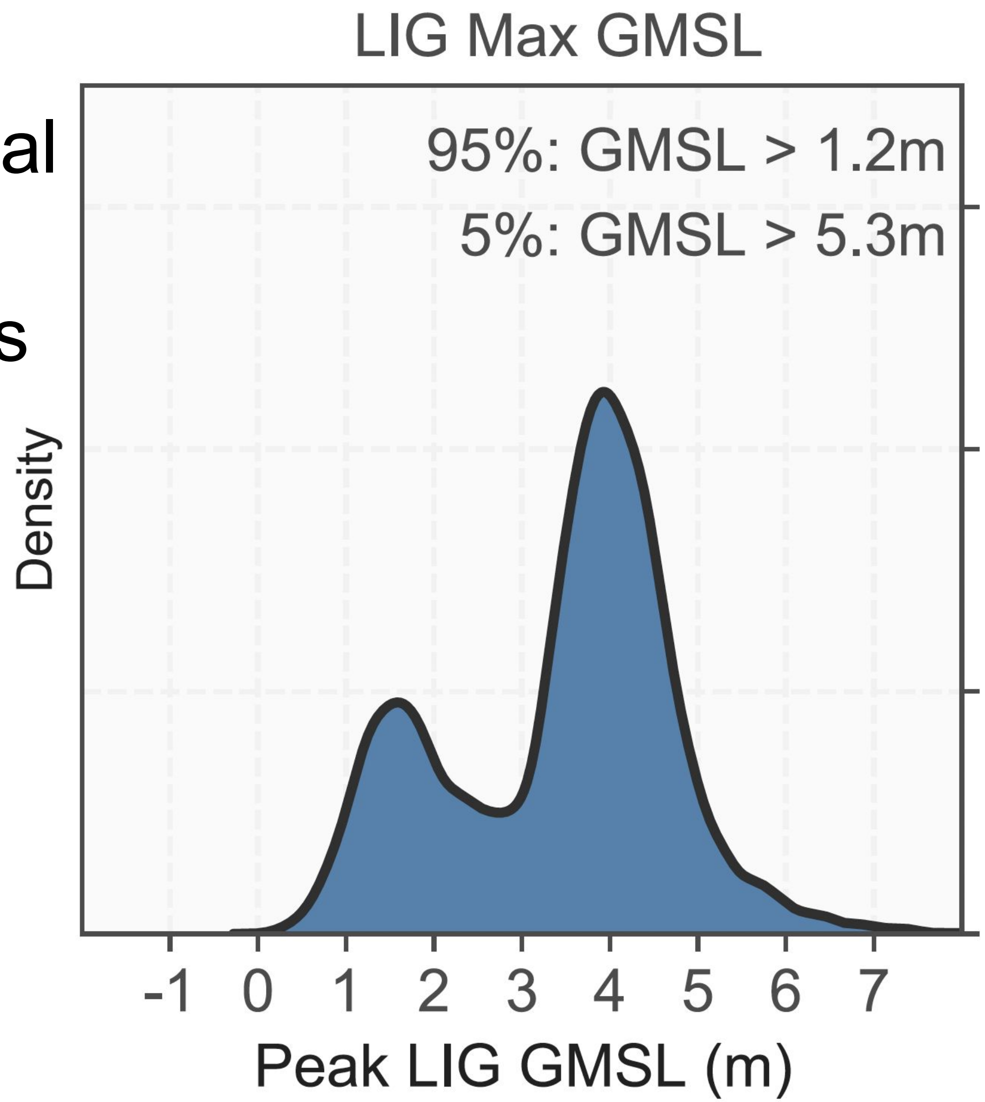
- Sea level 1.2-5.3 m higher than preindustrial (Dyer et al., 2021)
- Requires contributions from both ice sheets
- Proxy signatures allow for possibility of West Antarctic Ice Sheet Collapse
  - Water isotopes
  - Mineral dust
  - Ocean sediments



Dyer et al., 2021

The Last Interglacial (LIG)

- Sea level 1.2-5.3 m higher than preindustrial (Dyer et al., 2021)
- Requires contributions from both ice sheets
- Proxy signatures allow for possibility of West Antarctic Ice Sheet Collapse
  - Water isotopes
  - Mineral dust
  - Ocean sediments

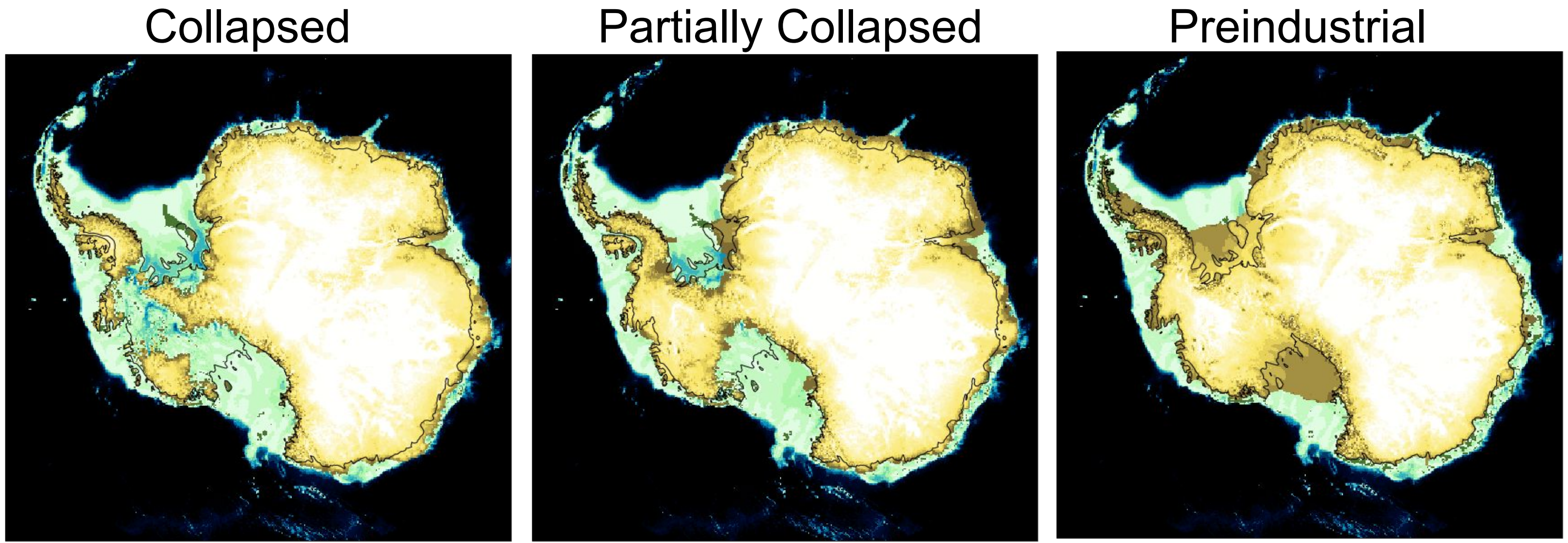


Dyer et al., 2021

Motivation: ***Understand West Antarctic Ice Sheet collapse during the LIG***

Methods

- Water Isotope enabled Community Earth System Model (iCESM) (~2° horizontal resolution land/atmosphere) (Brady et al., 2019)
- PMIP4 boundary conditions (Otto-Bliesner et al., 2021)
  - 127ka solar configuration
  - GHGs: CO_2: 275 ppm, CH_4: 685 ppb, NO_2: 255 ppb
- 3 different West Antarctic Ice Sheet (WAIS) topographies



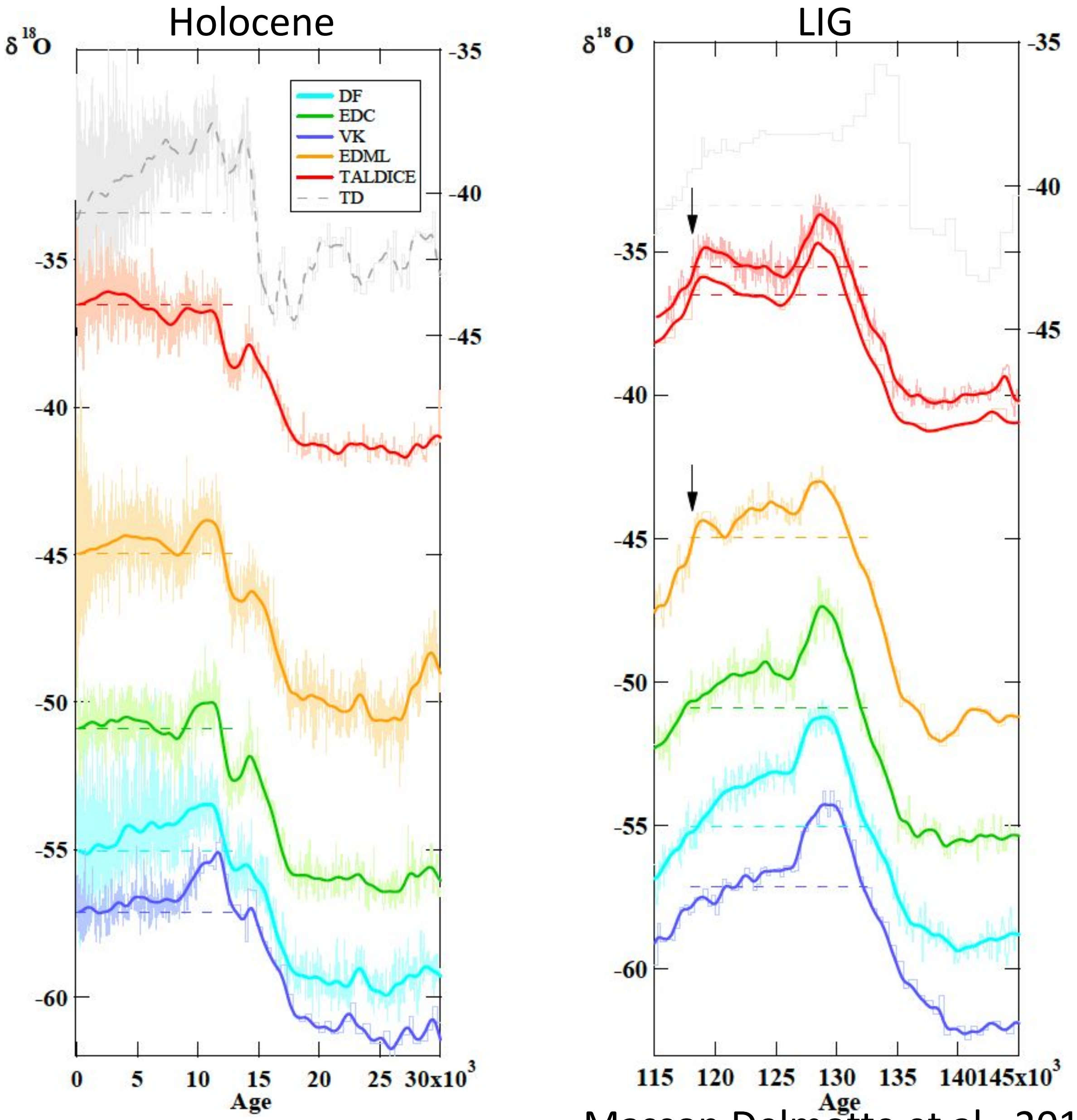
Sutter et al., 2019

A tale of three proxies

- **Water Isotopes**
- Mineral Dust
- Ocean Sediments

Ice core $\delta^{18}O$ signal

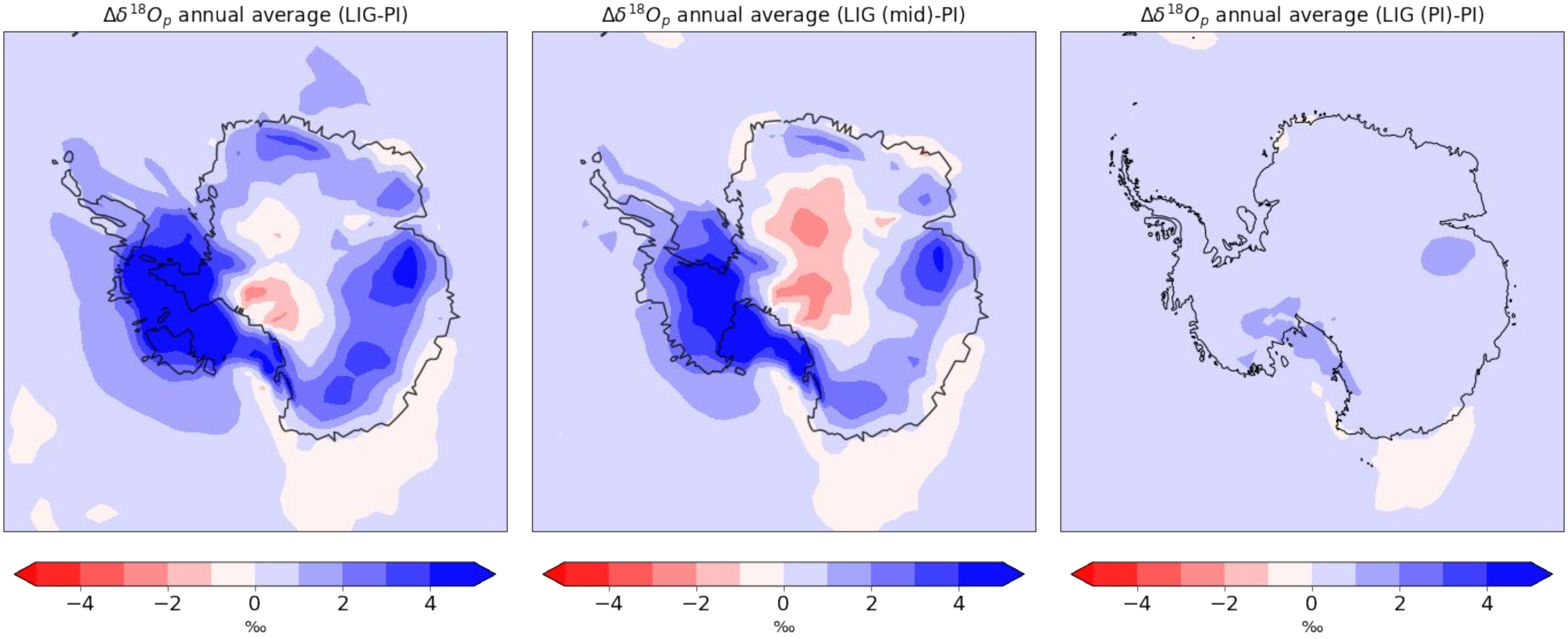
- $\delta^{18}O$ signal allow for possibility of West Antarctic Ice Sheet Collapse
- Glacial/Interglacial Plateaus in Holocene
- Anomalous peak in LIG



Masson Delmotte et al., 2016

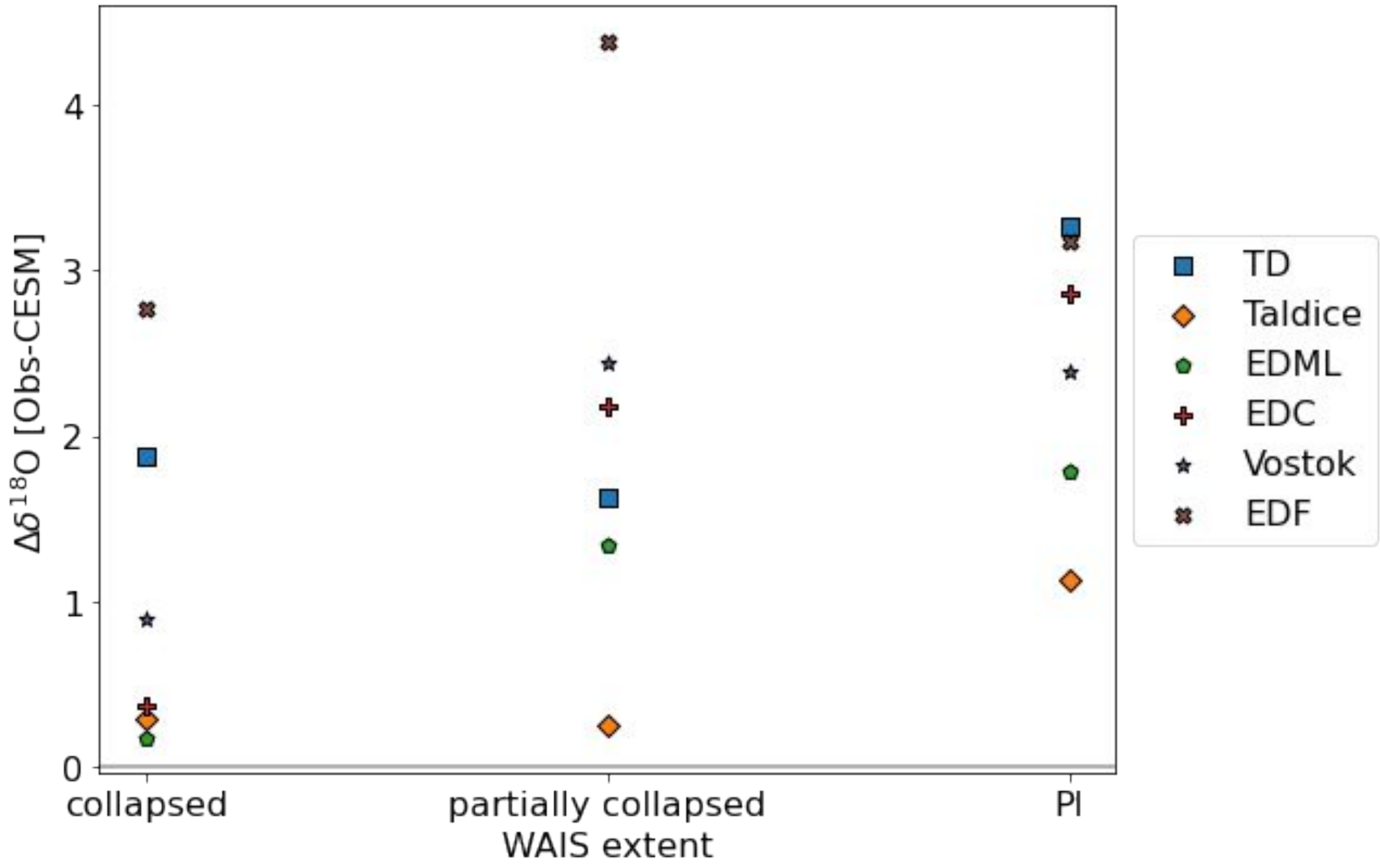
Modeled $\delta^{18}O$ signal

Modeled $\delta^{18}O$ signal



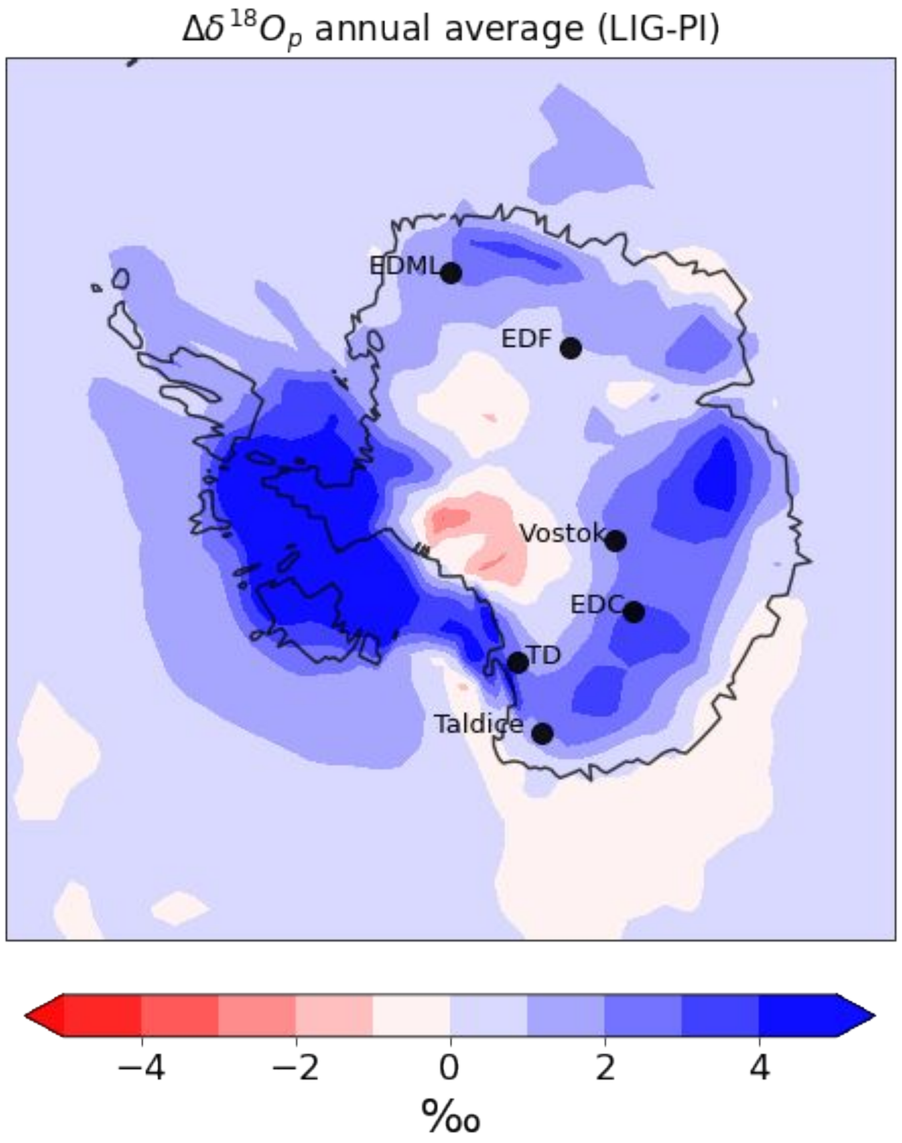
How does this compare to the record?

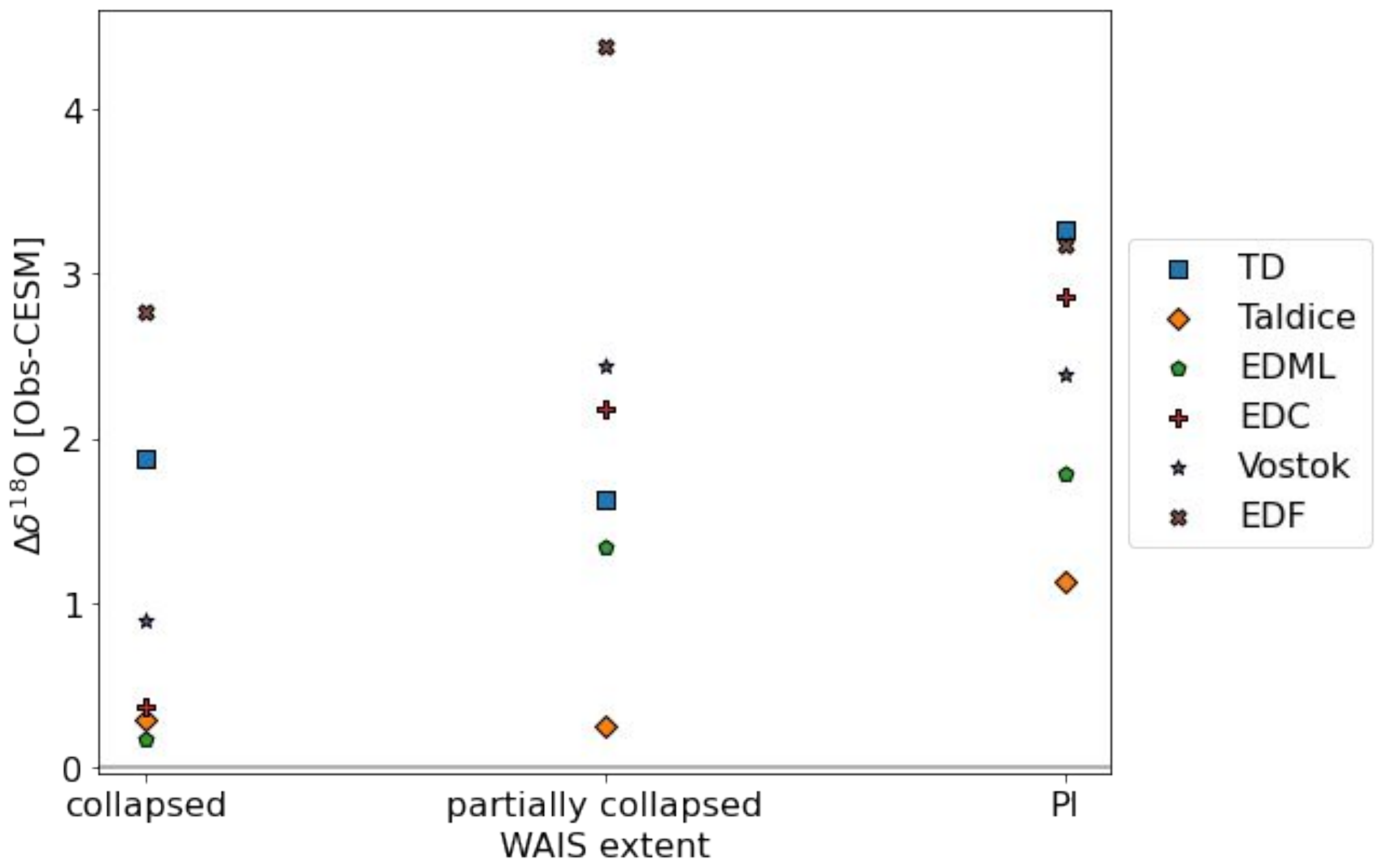
How does this compare to the record?



Masson Delmotte et al., 2016

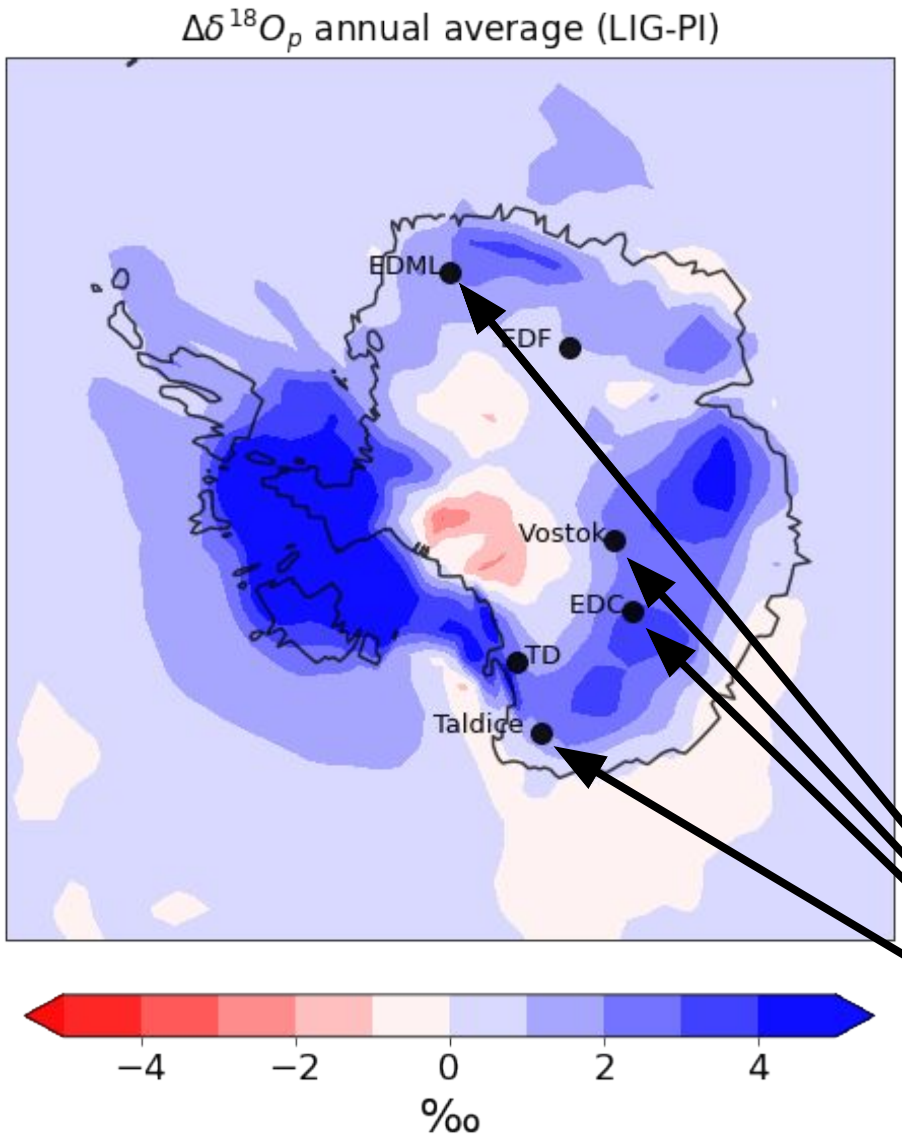
How does this compare to the record?

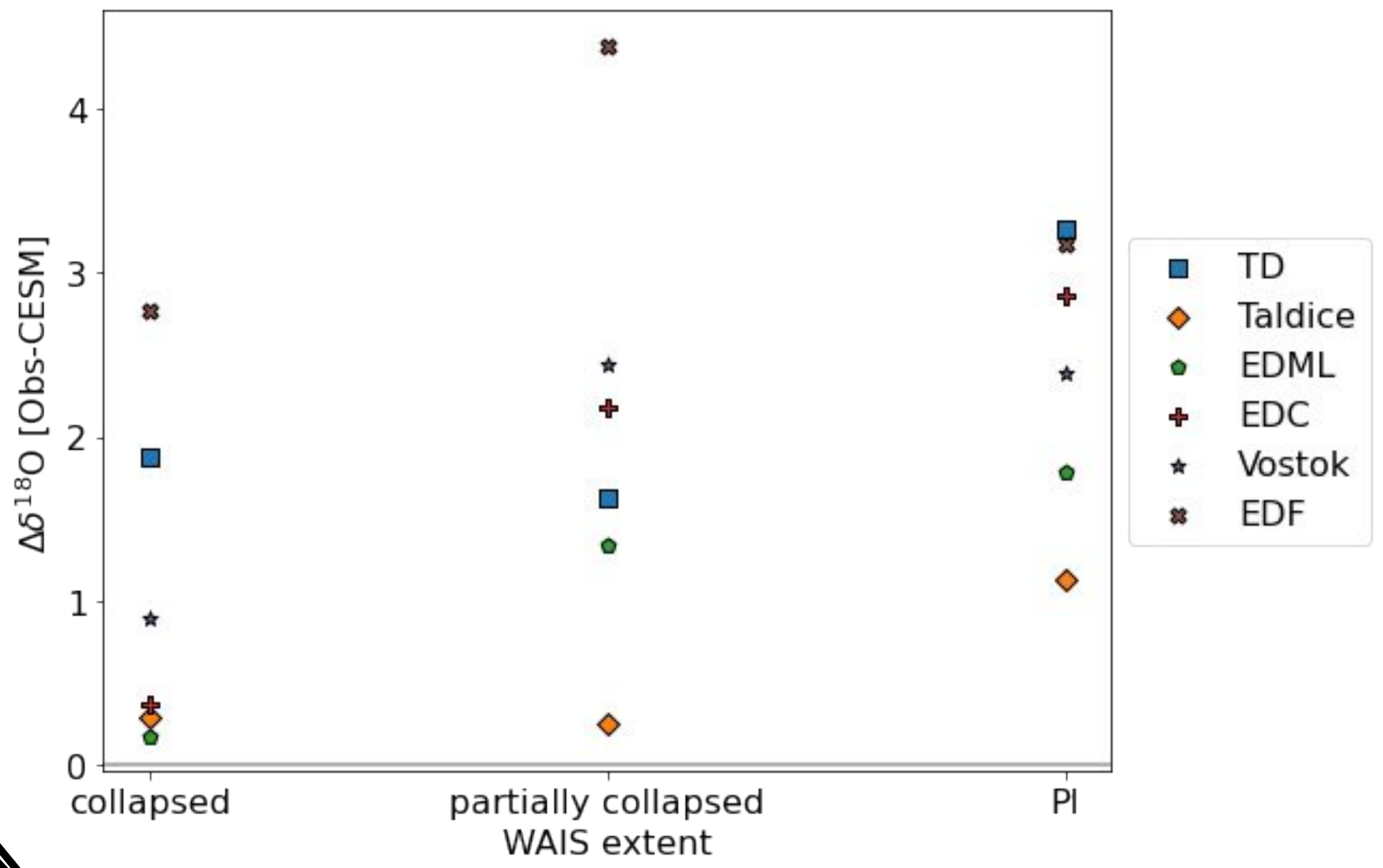




Masson Delmotte et al., 2016

How does this compare to the record?

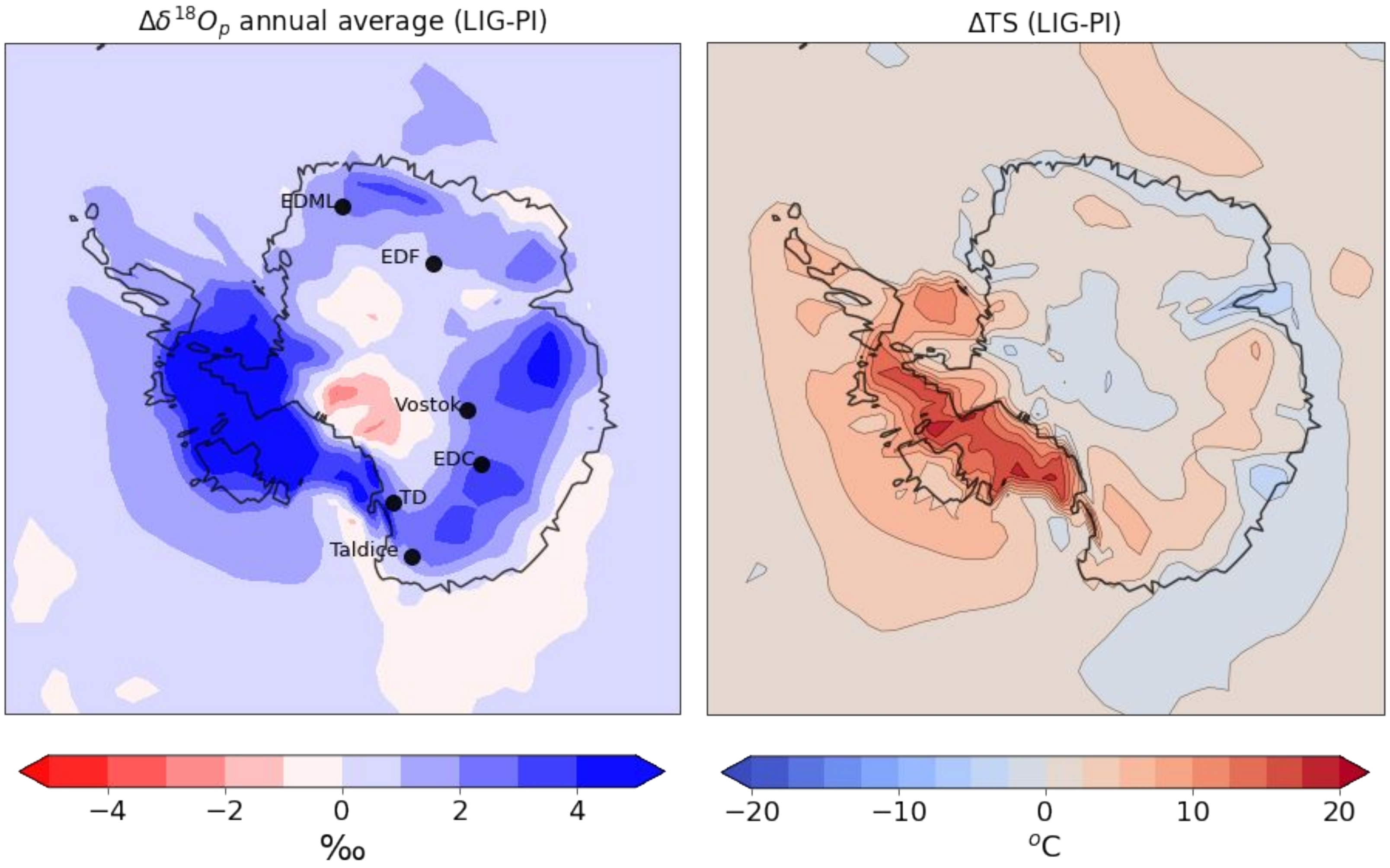




within 1 ‰

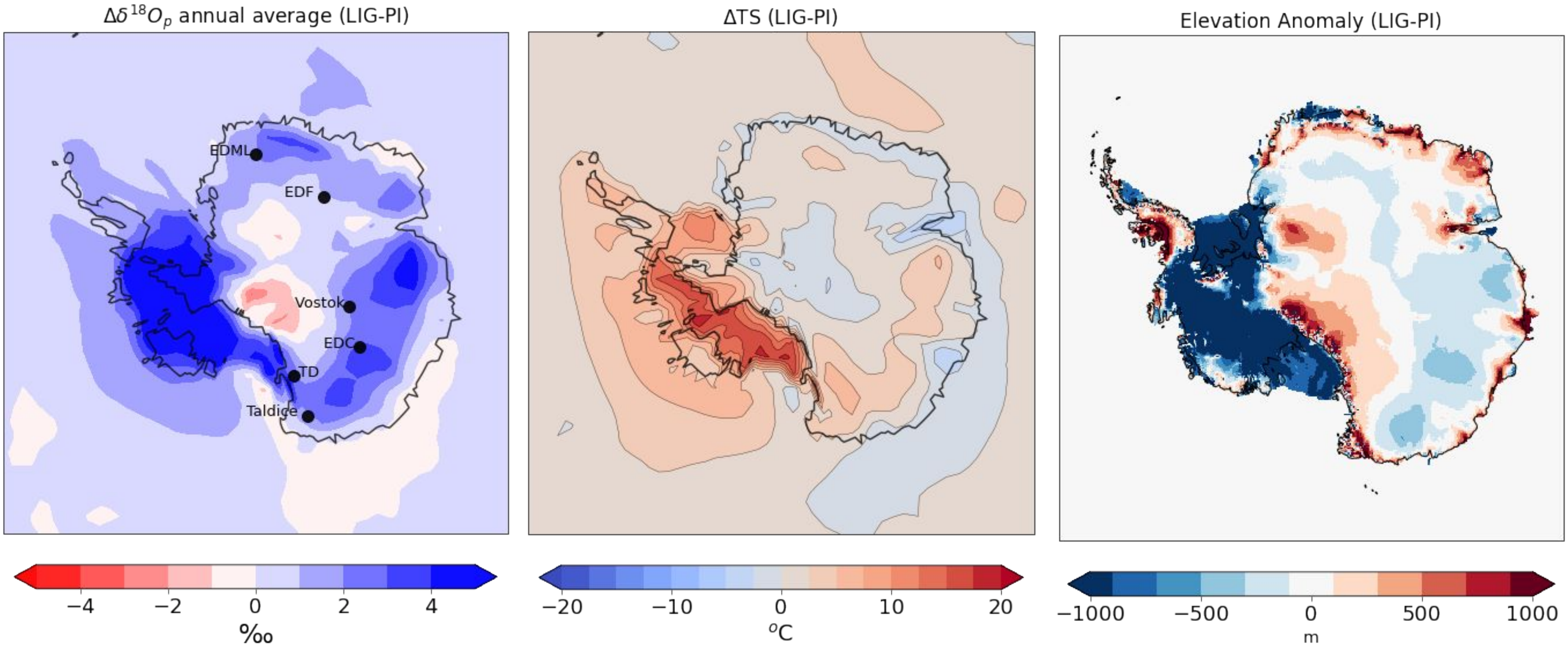
Masson Delmotte et al., 2016

Why does $\delta^{18}O$ change so much?



Lapse Rate □ Higher temperature = enriched $\delta^{18}O$

Why does $\delta^{18}O$ change so much?



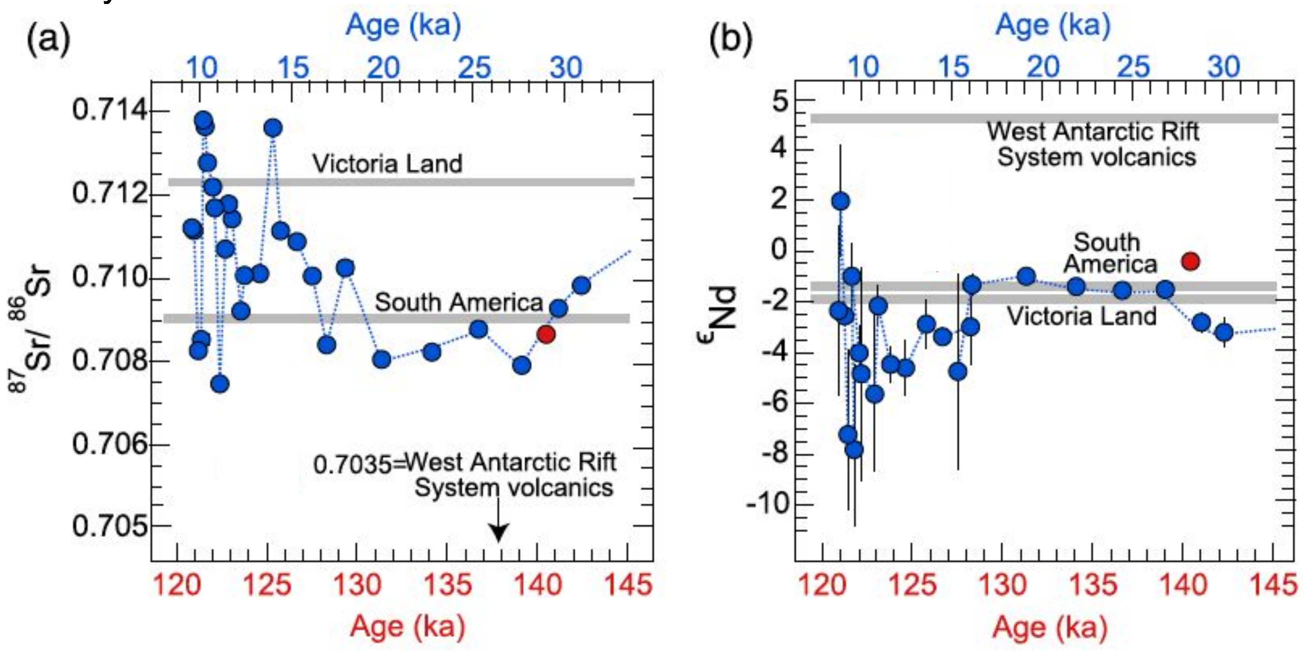
Lapse Rate □ Higher temperature
= enriched $\delta^{18}O$

A tale of three proxies

- Water Isotopes
- **Mineral Dust**
- Ocean Sediments

Ice Core Dust

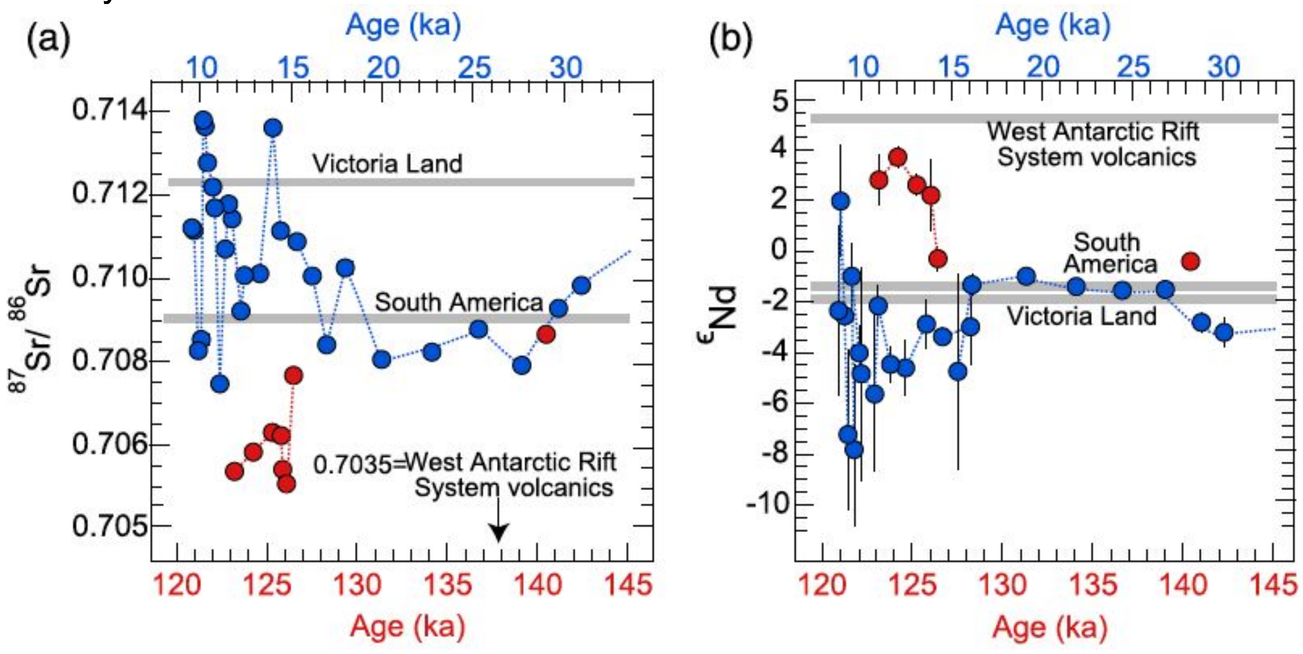
Taylor Glacier



Aarons et al., 2018

Ice Core Dust

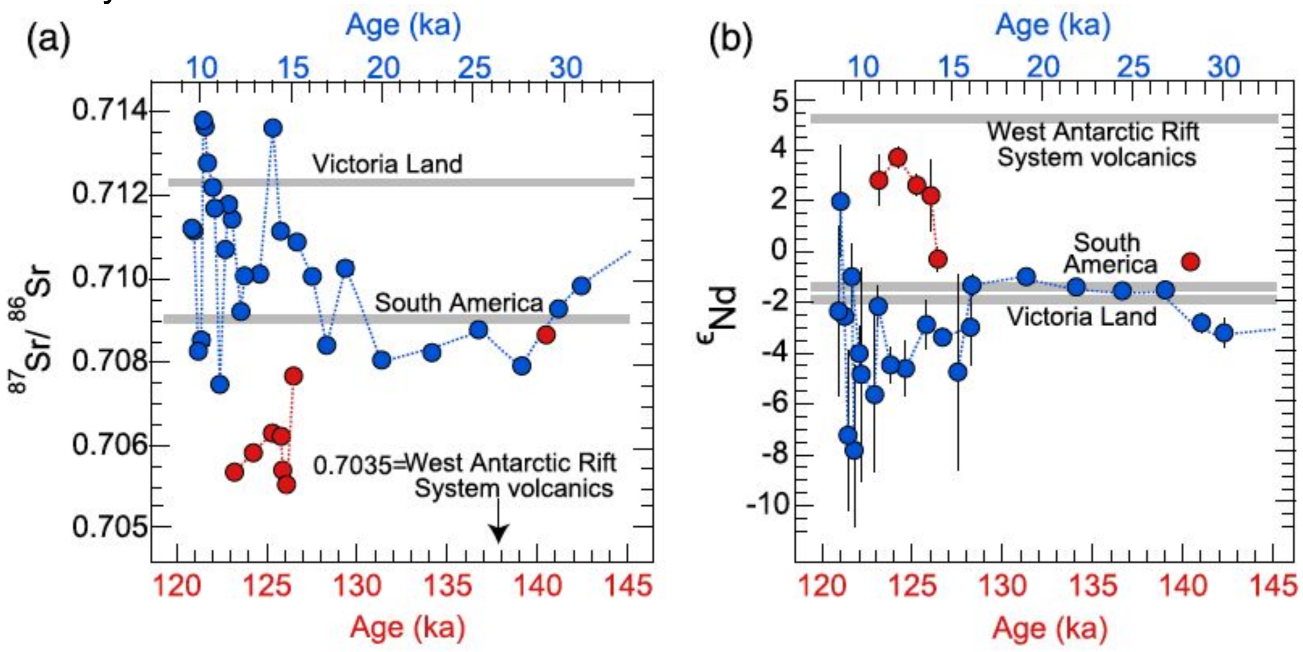
Taylor Glacier



Aarons et al., 2018

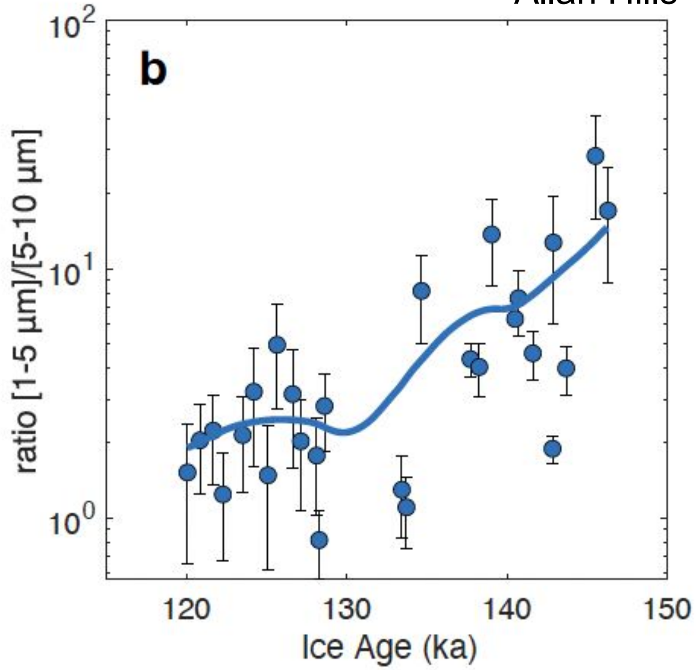
Ice Core Dust

Taylor Glacier



Aarons et al., 2018

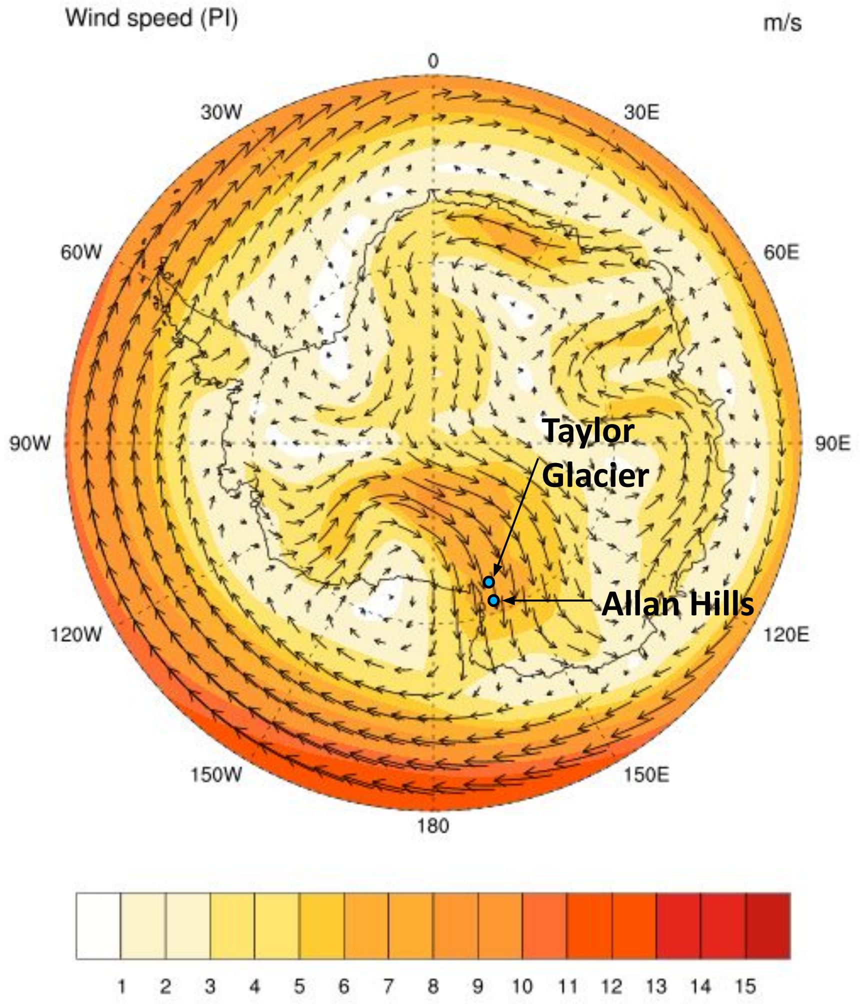
Allan Hills



Carter et al., in prep

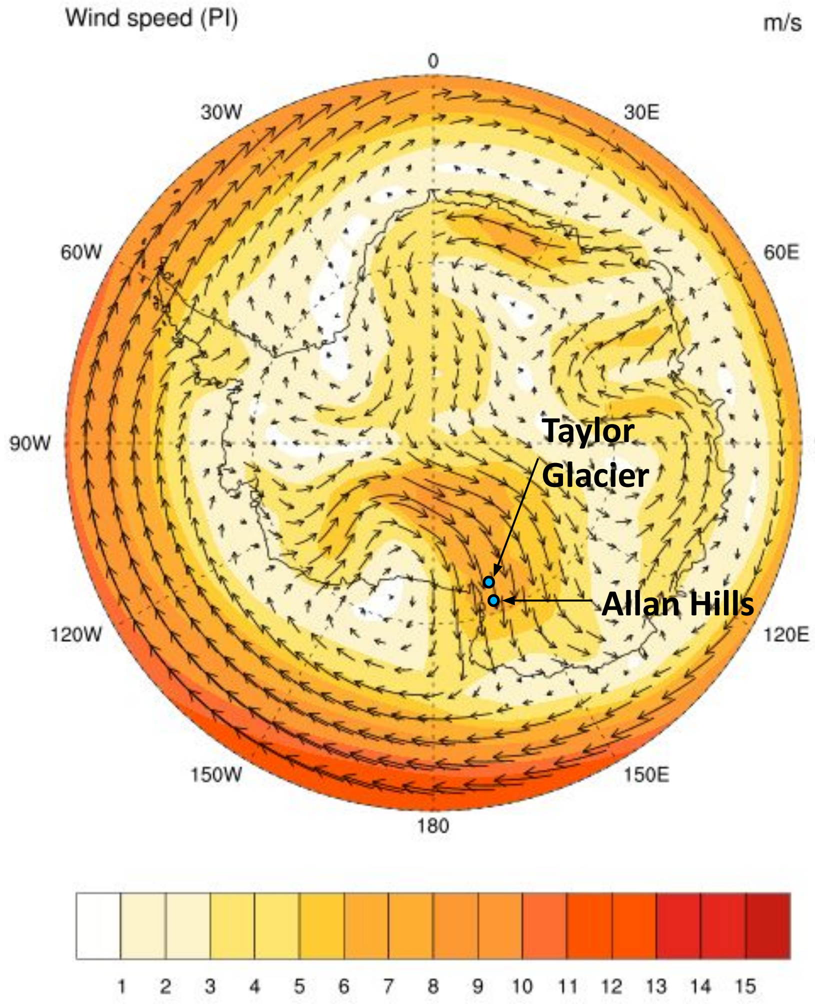
- Decrease in dust sourced from South America
- Increase in dust sourced locally
- Change in regional circulation

Possibility for Regional Dust Transport

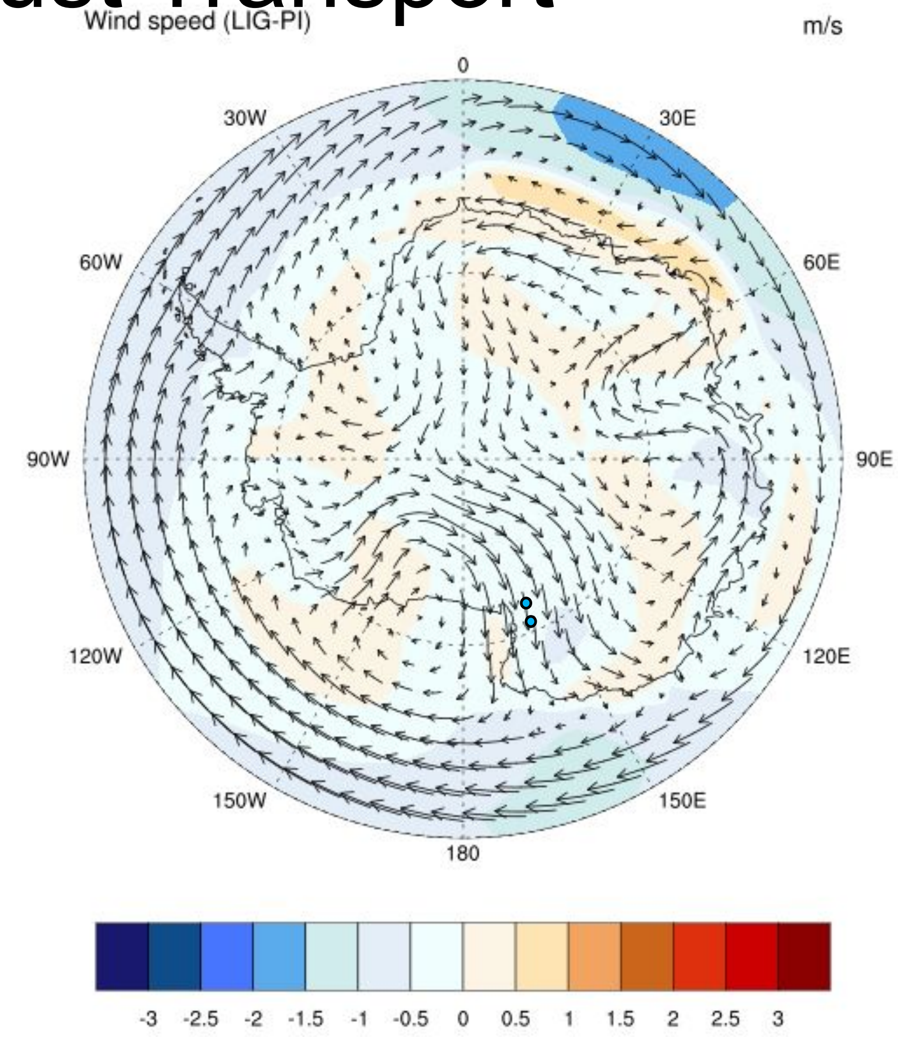


Preindustrial

Possibility for Regional Dust Transport

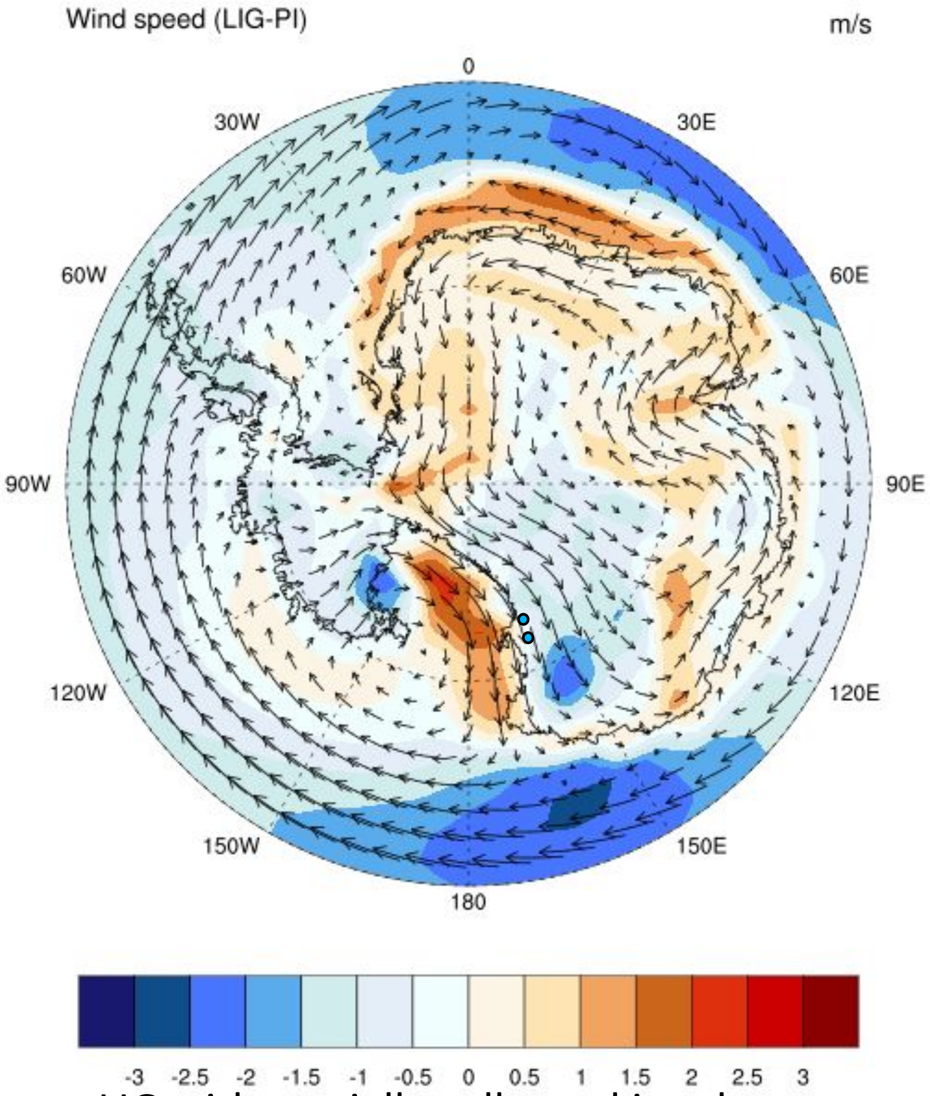


Preindustrial

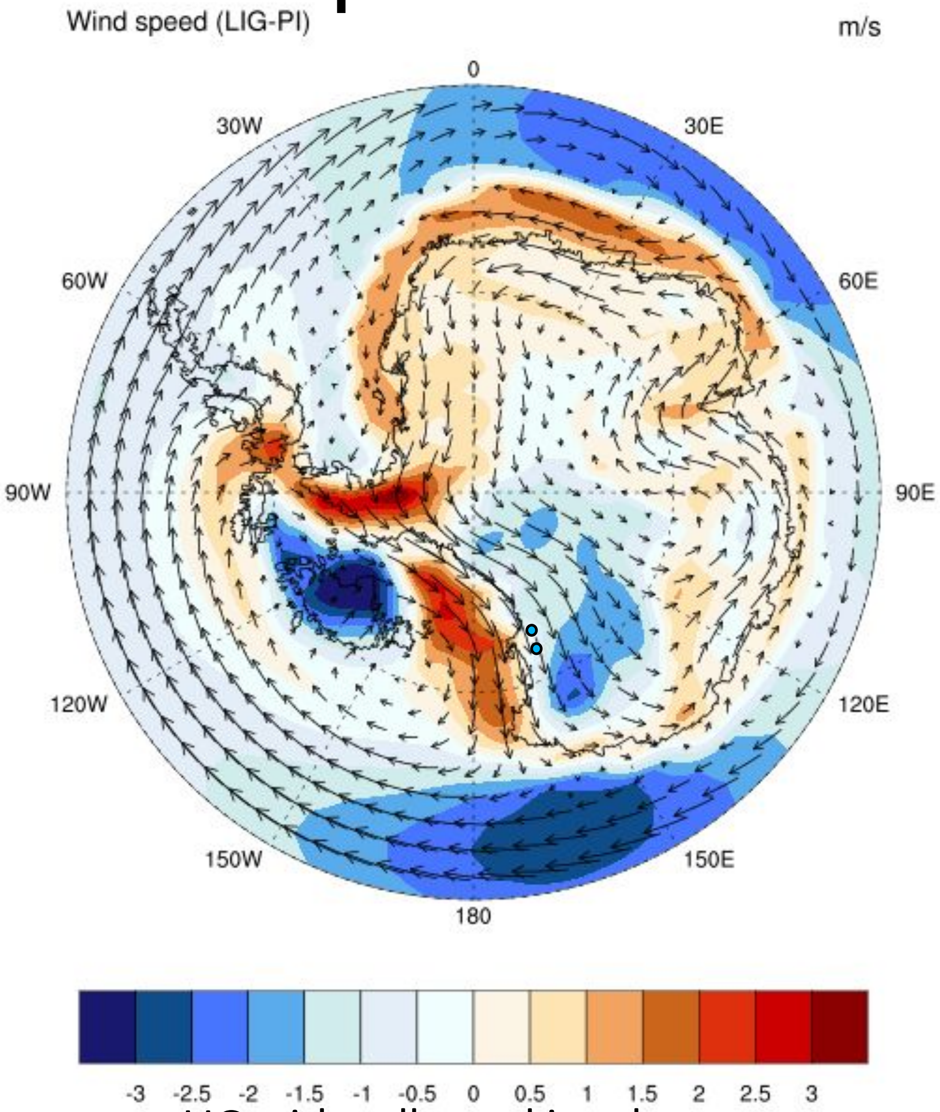


LIG with PI ice sheet

Possibility for Regional Dust Transport

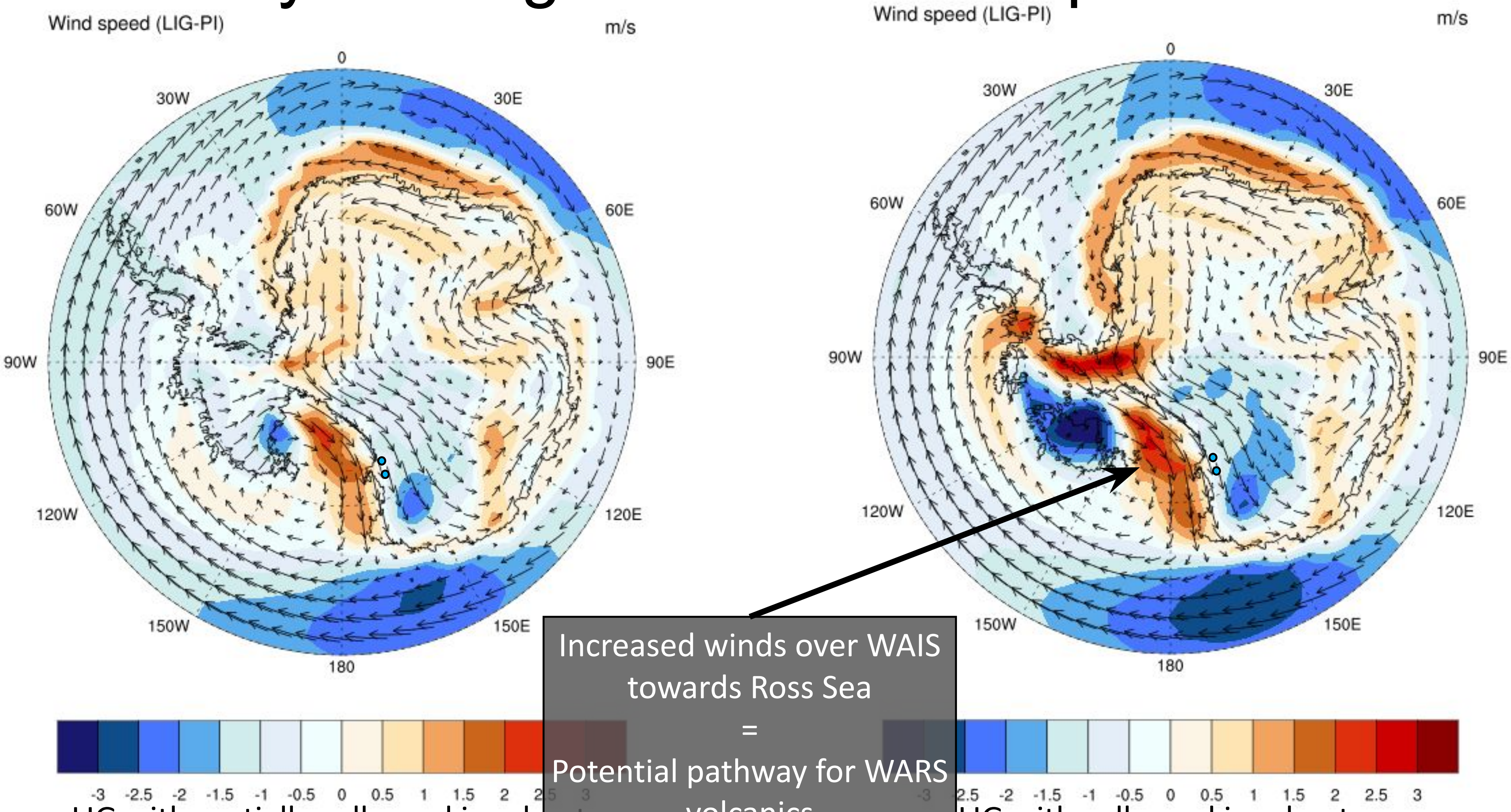


LIG with partially collapsed ice sheet



LIG with collapsed ice sheet

Possibility for Regional Dust Transport



LIG with partially collapsed ice sheet

LIG with collapsed ice sheet

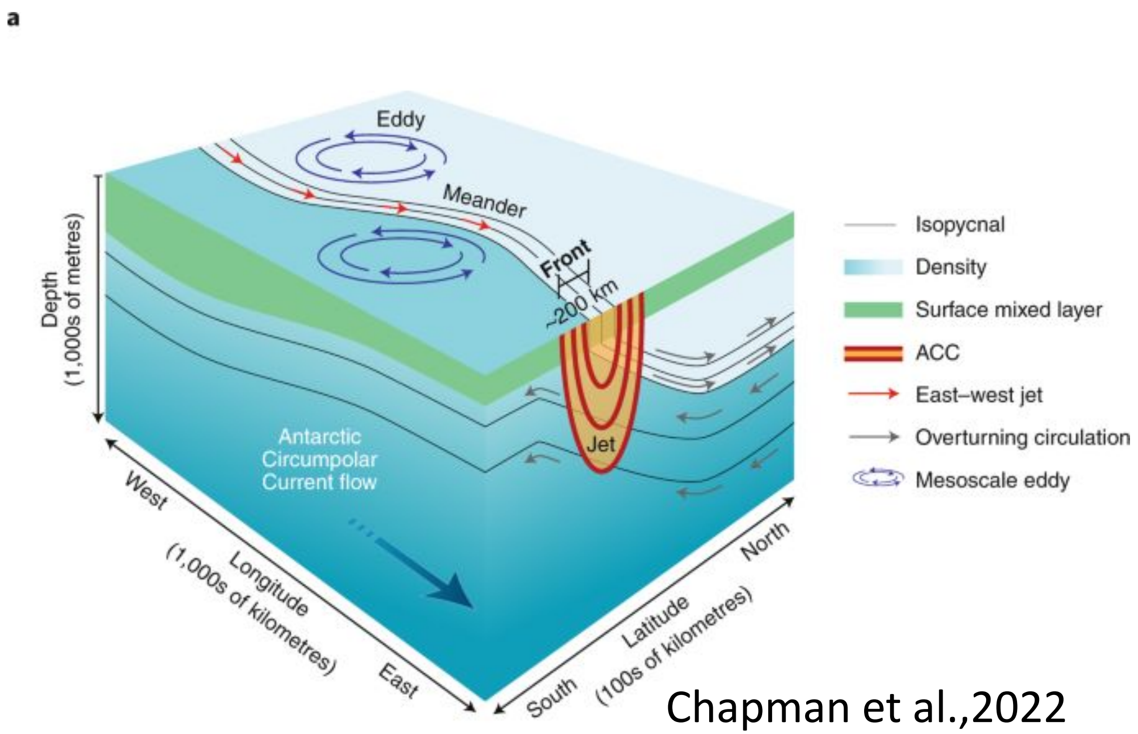
Increased winds over WAIS towards Ross Sea
=
Potential pathway for WARS volcanics

A tale of three proxies

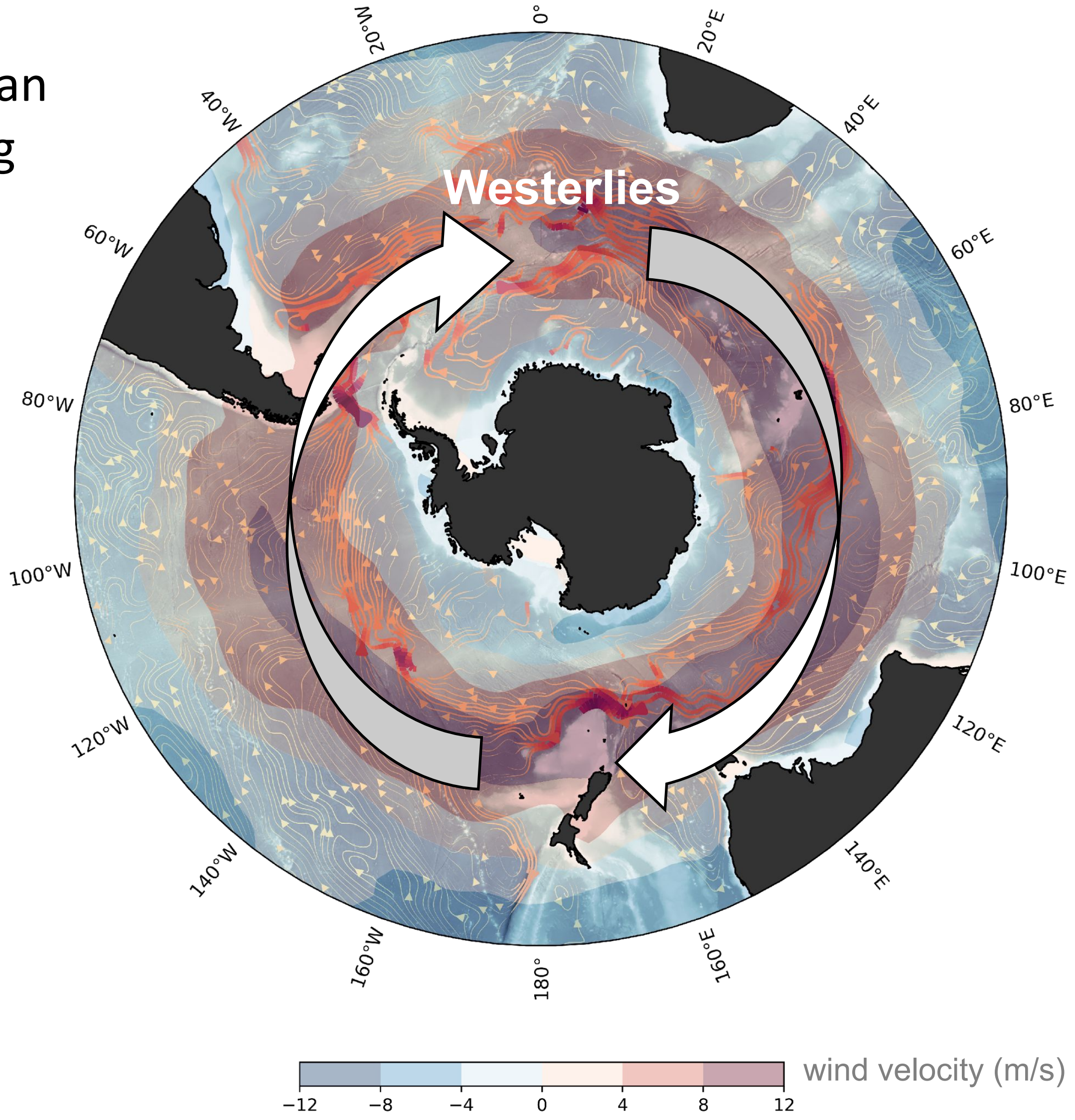
- Water Isotopes
- Mineral Dust
- **Ocean Sediments**

Antarctic Circumpolar Circulation

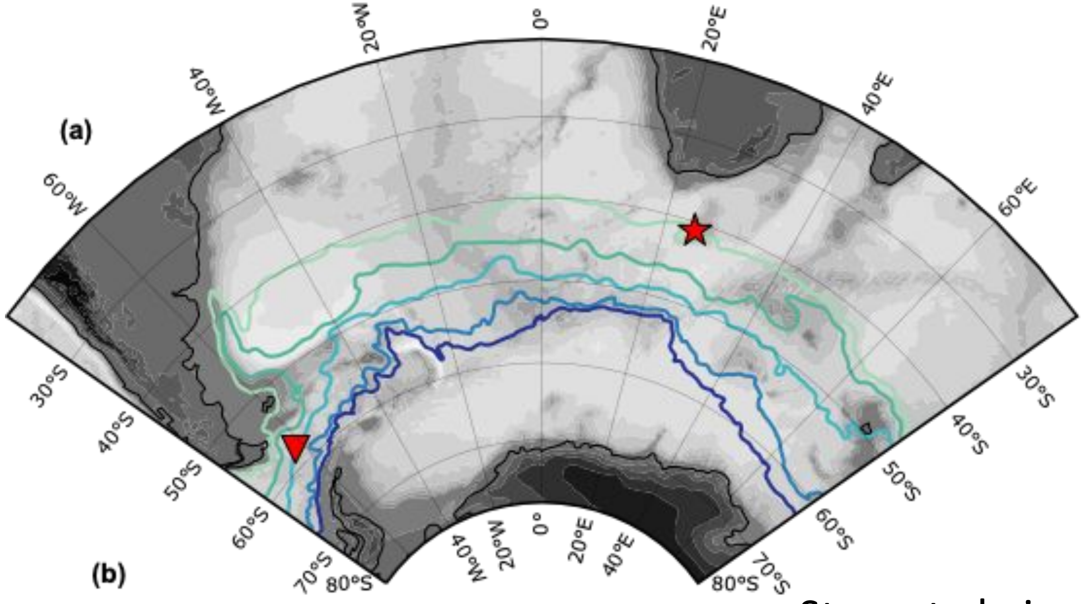
- Major zonal transport component of the Southern Ocean
- Largely driven by Westerly Winds and Buoyancy Forcing
- Major carbon sink



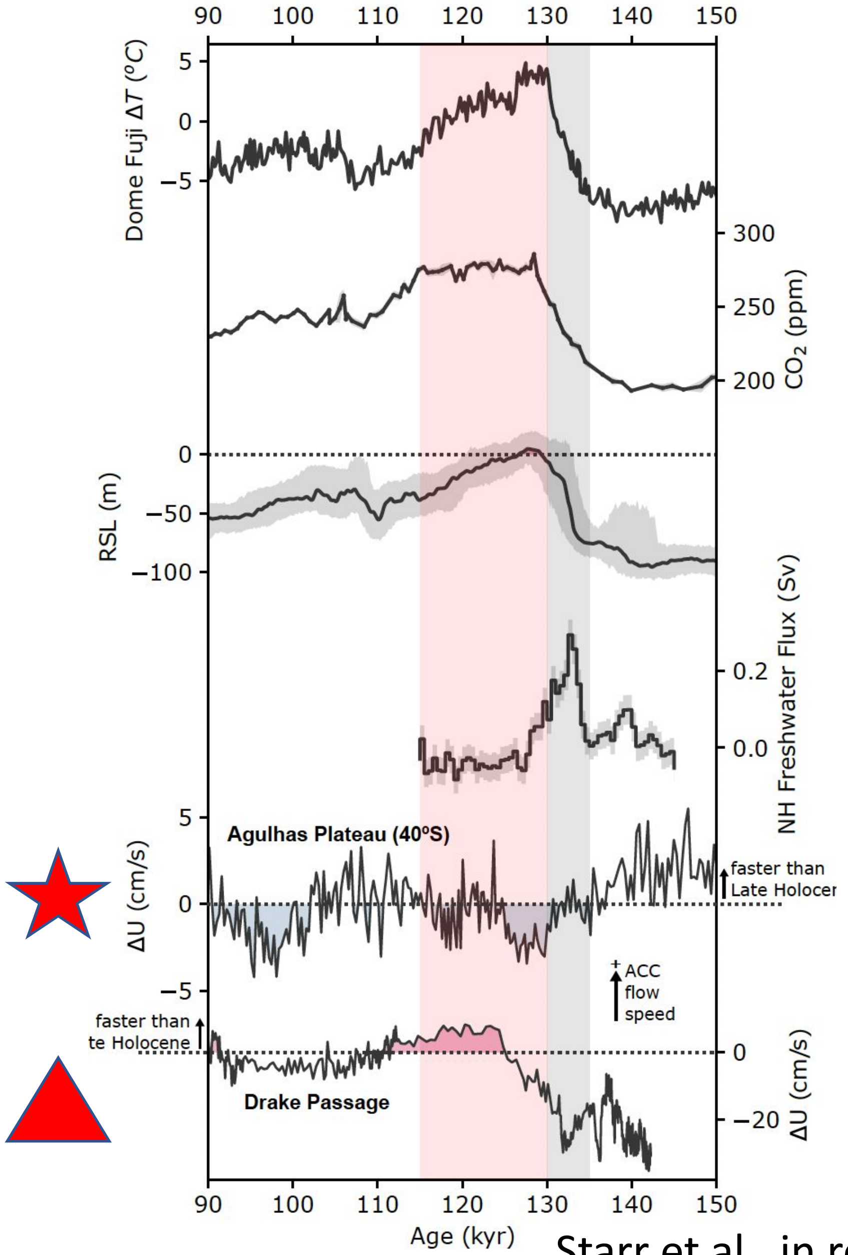
Chapman et al.,2022



Ocean Sediment Cores



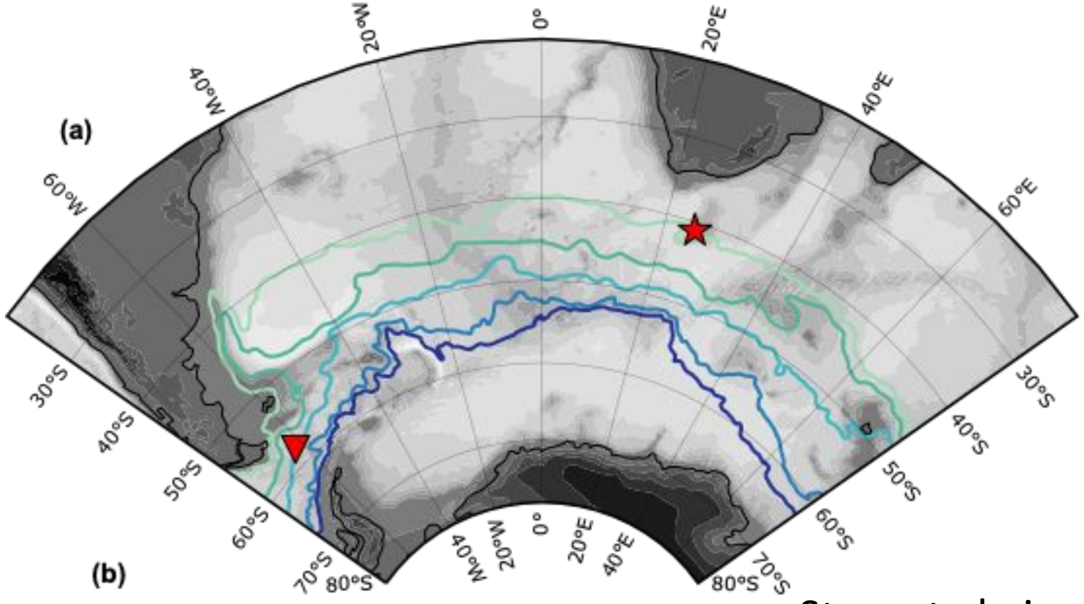
Starr et al., in review



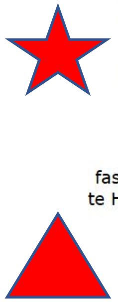
Starr et al., in review

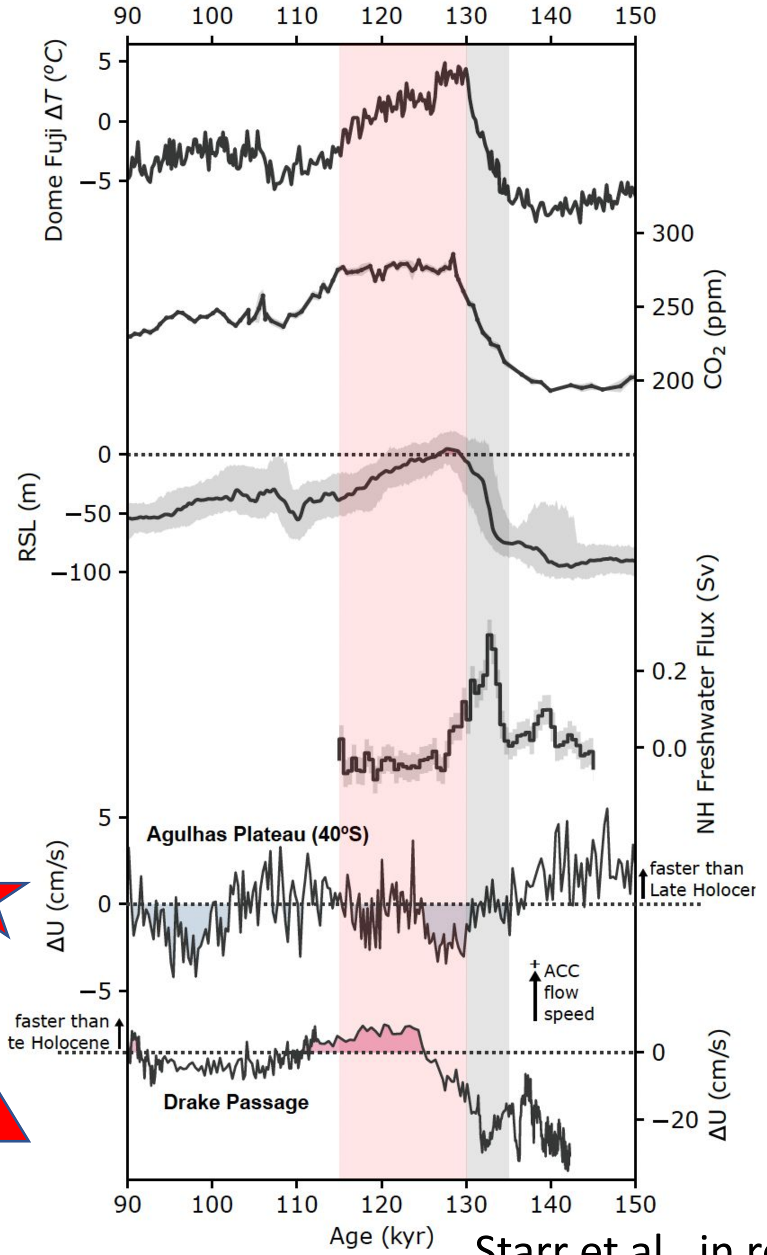
Ocean Sediment Cores

- Flow speed determined using Sortable Silt
  - 10-63 um range silt
  - Stronger near bottom flow = coarser silt
- Agulhas Plateau = Slower during LIG
- Drake Passage = Faster during LIG
- Antiphase behavior true for other Pleistocene Interglacials (BUT not all!)



Starr et al., in review



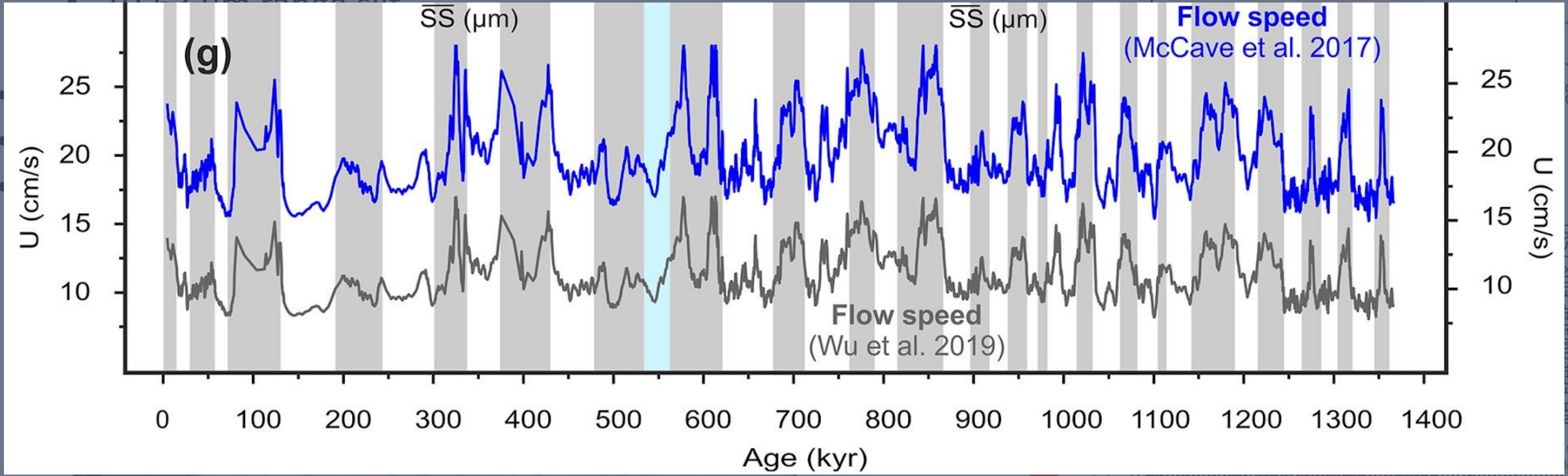


Starr et al., in review

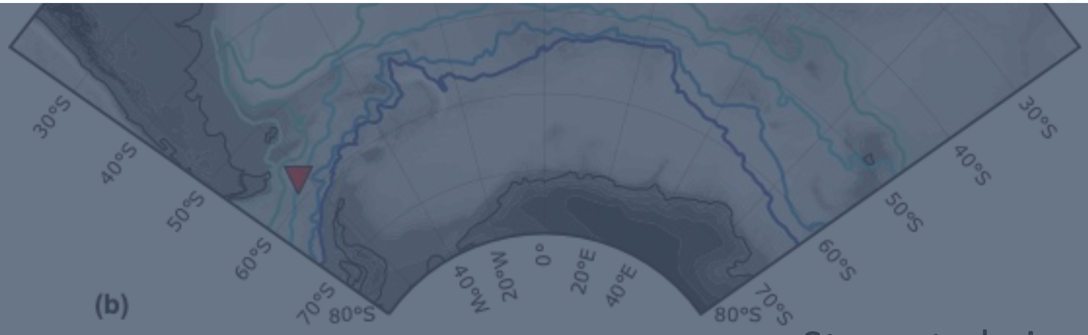
Ocean Sediment Cores

- Flow speed determined using Sortable Silt
  - 10-63 μm range silt

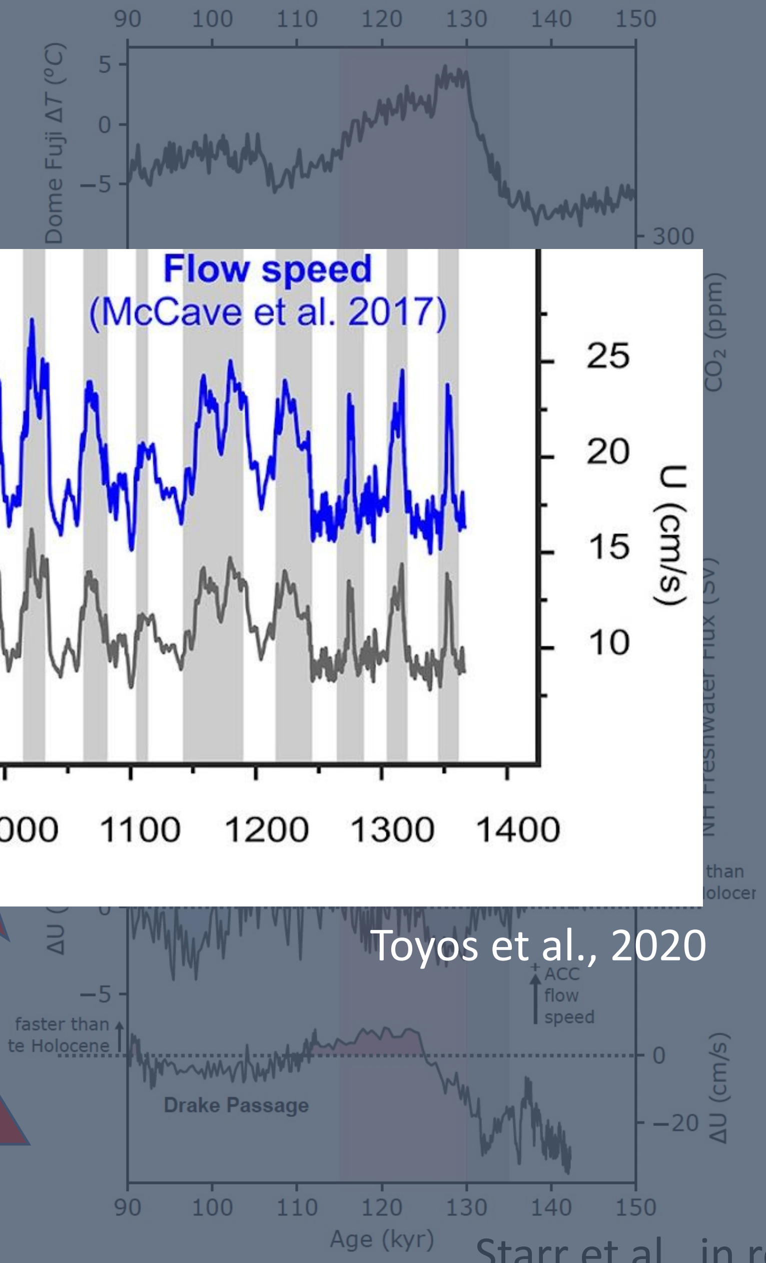
Drake Passage Sortable Silt



Toyos et al., 2020



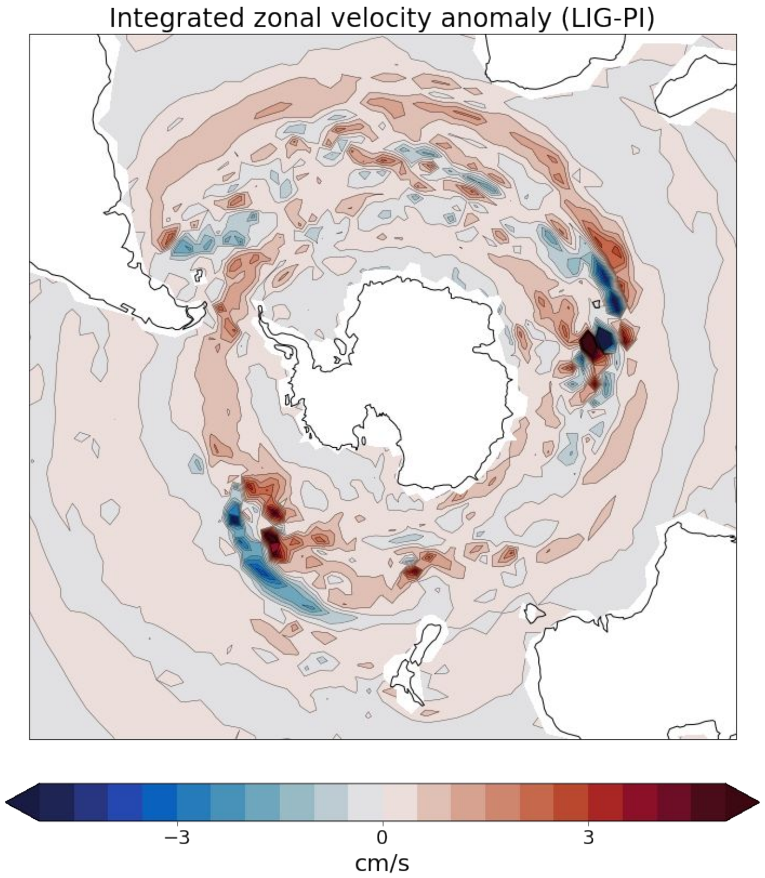
Starr et al., in review

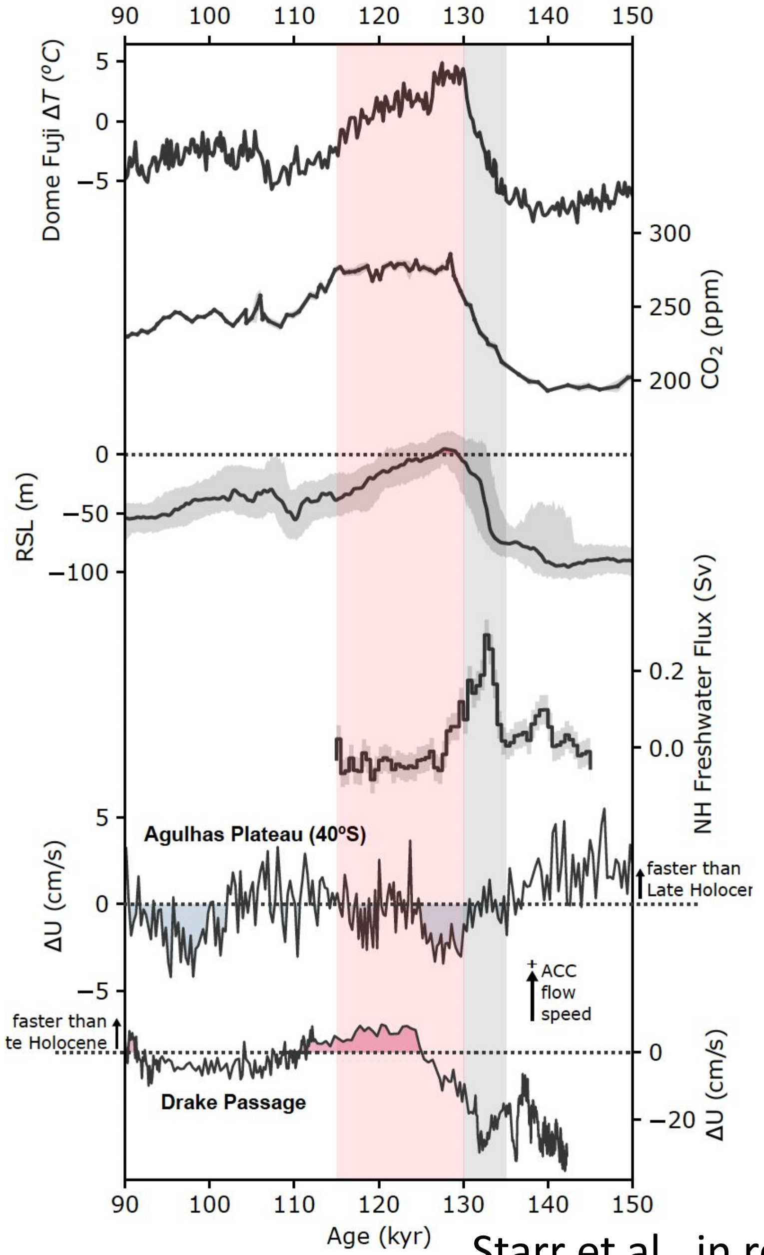


Starr et al., in review

What does the model say?

- LIG has a faster ACC independent of ice sheet extent

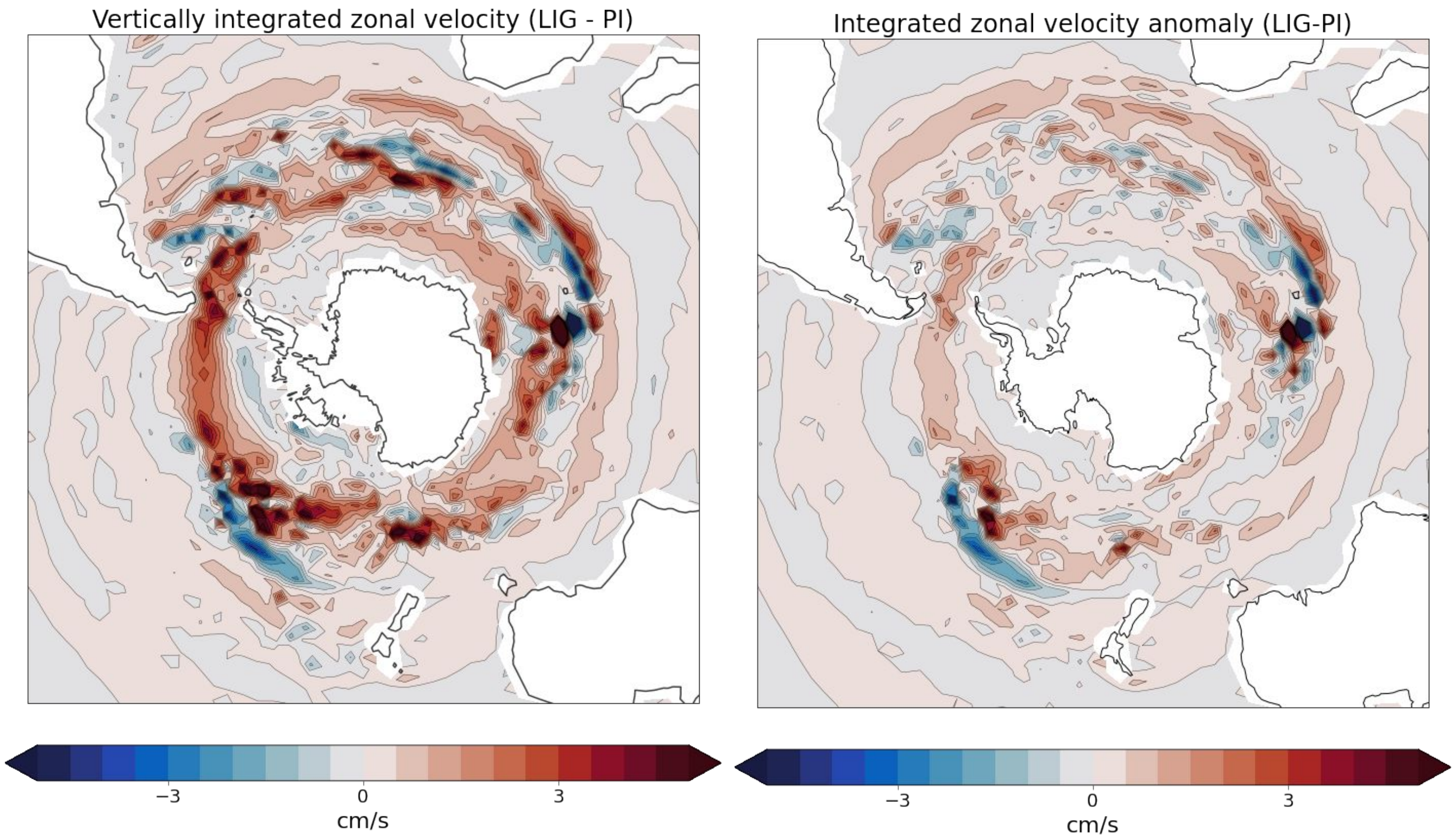


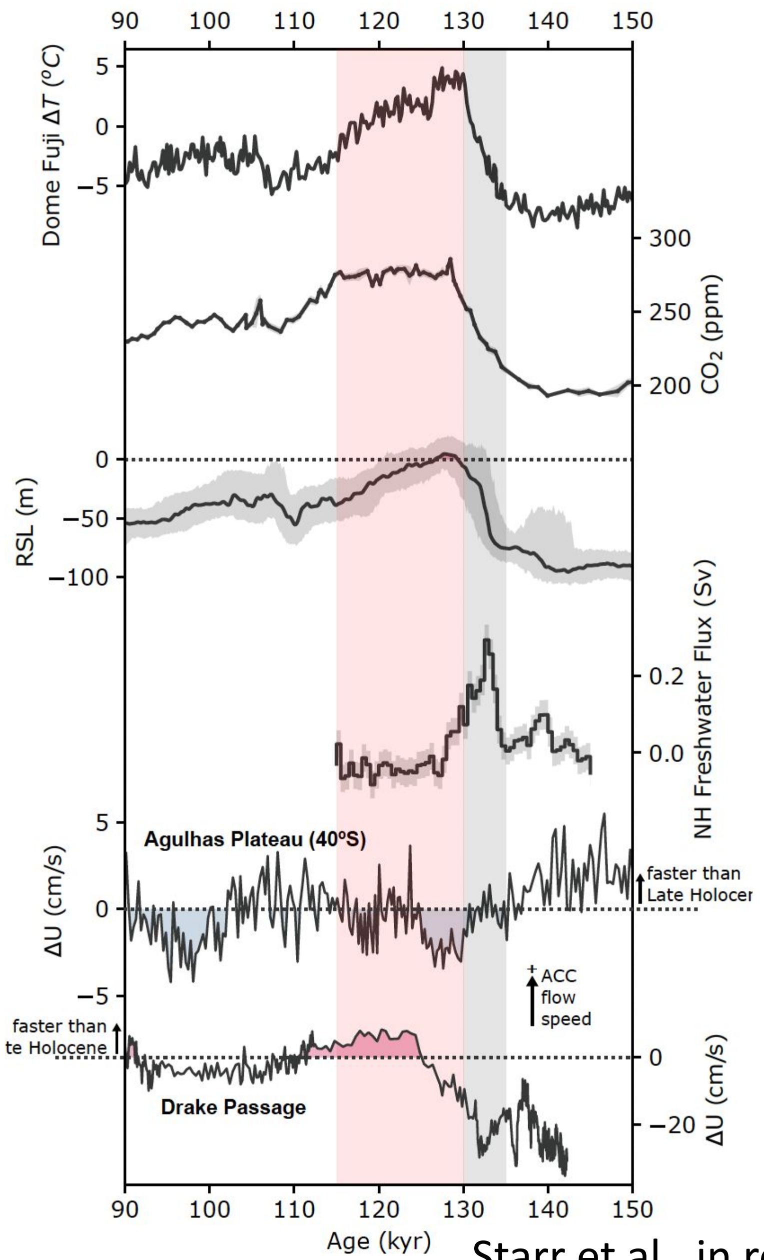


Starr et al., in review

What does the model say?

- LIG has a faster ACC independent of ice sheet extent
- Faster with a collapsed ice sheet

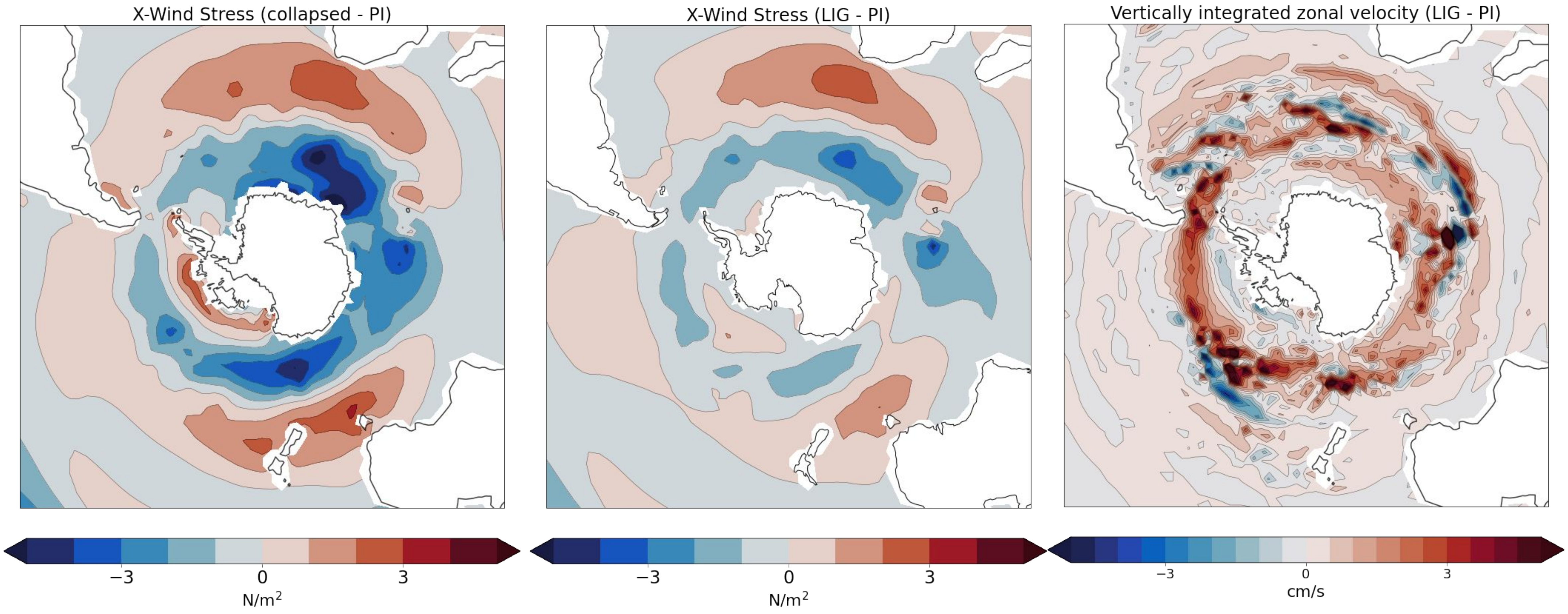




Starr et al., in review

Why does the ACC speed up in the first place?

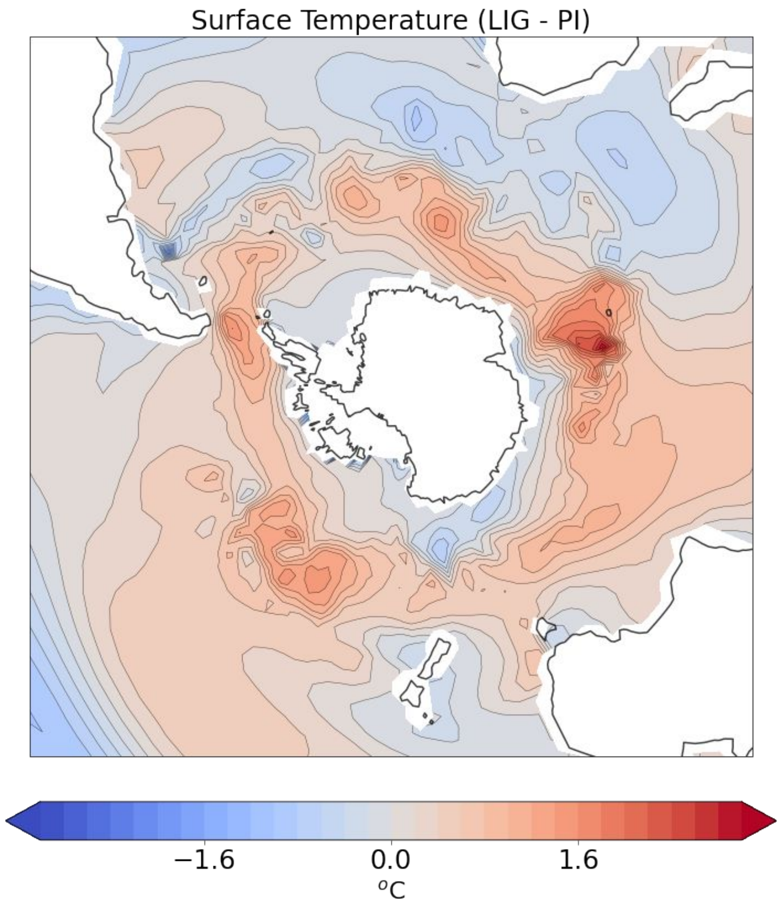
- Not due to the westerly winds

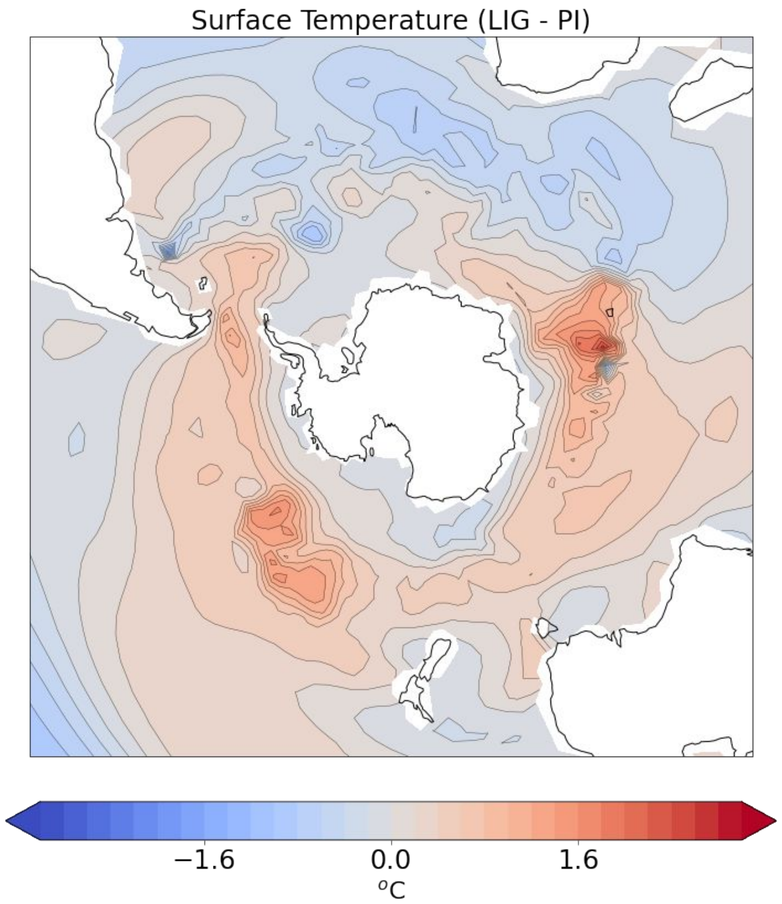


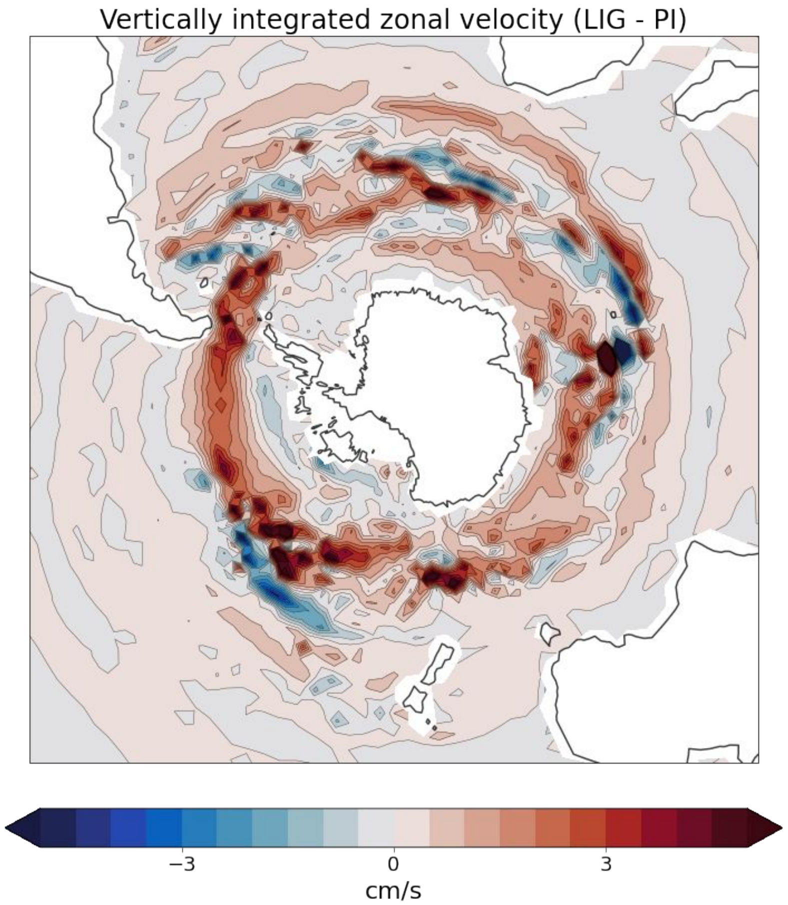
Why does the ACC speed up in the first place?

- Not due to the westerly winds
- INSTEAD… due to buoyancy forcing Ocean heat uptake = warmer southern ocean
- Warmer ocean = sharper density gradient more geostrophic mass transport

$$V_g = -\frac{R}{\rho f}\int k \times \nabla_p T dp$$



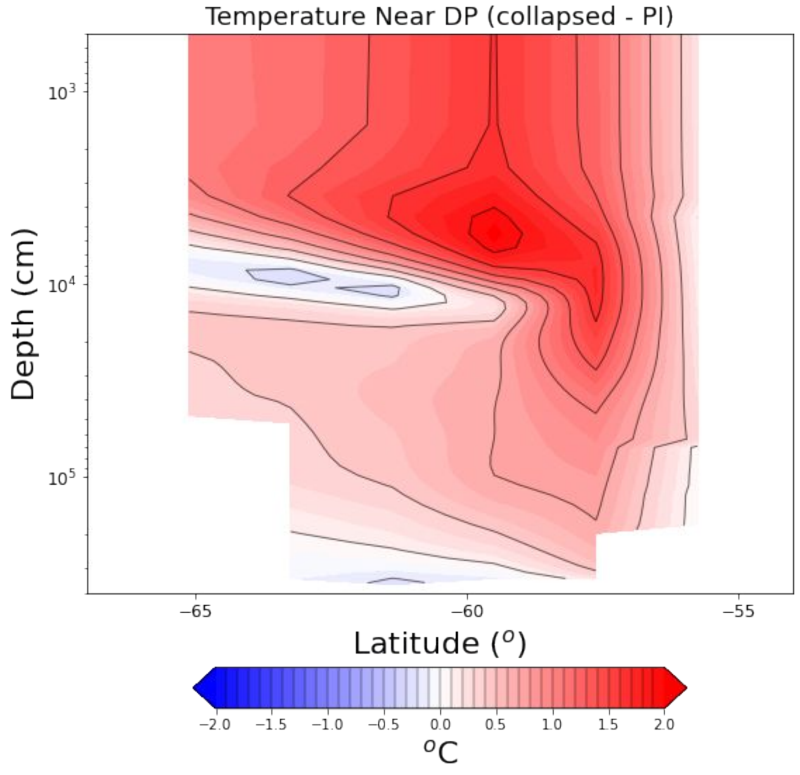


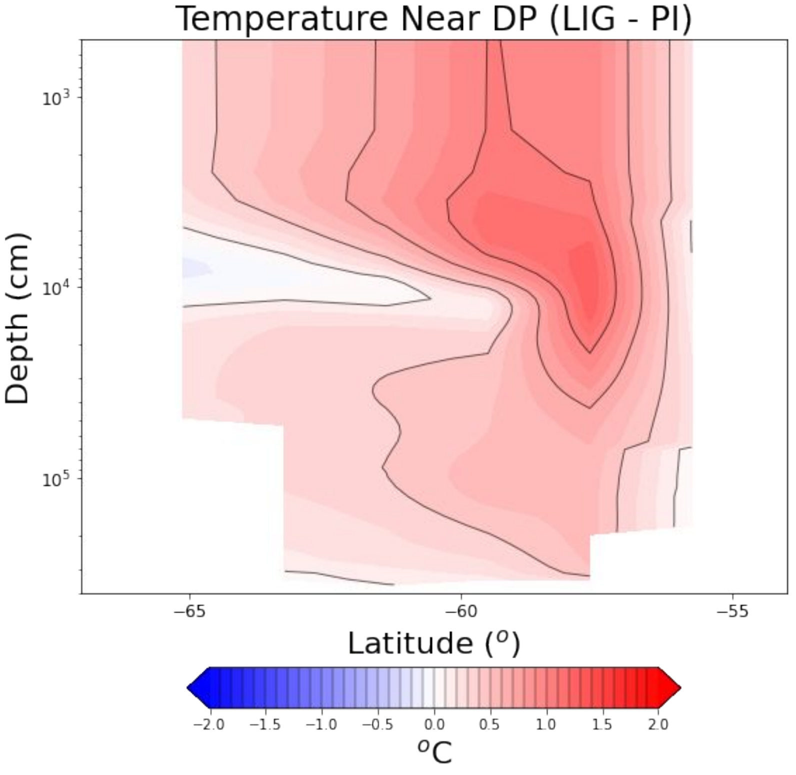


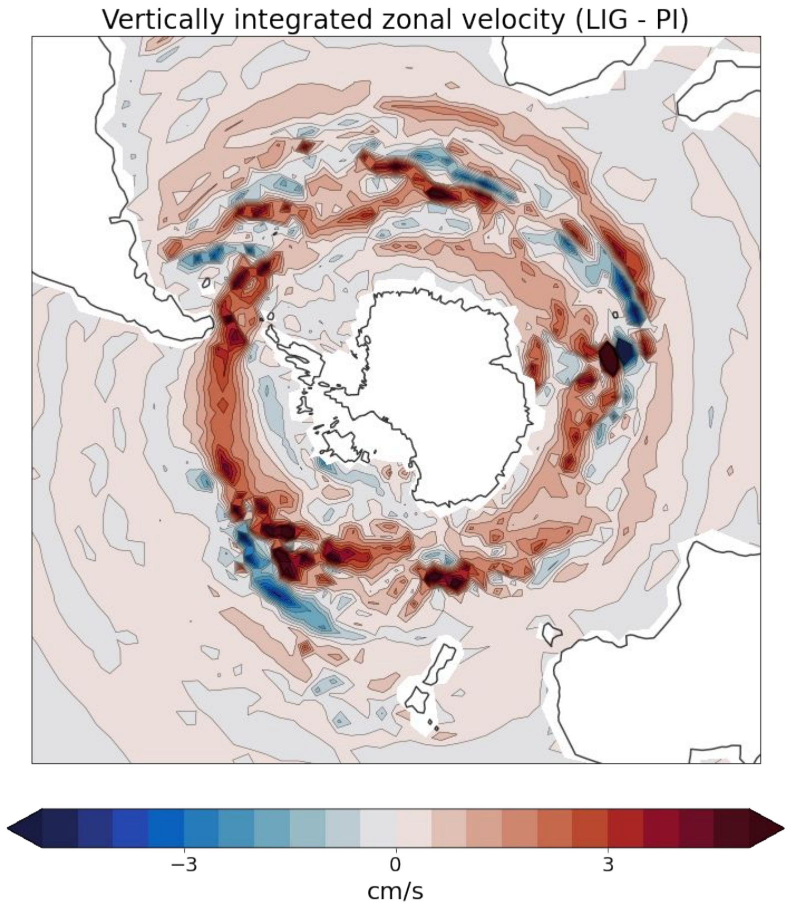
Why does the ACC speed up in the first place?

- Not due to the westerly winds
- INSTEAD… due to buoyancy forcing □ Ocean heat uptake = warmer southern ocean
- Warmer ocean = sharper density gradient □ more geostrophic mass transport

$$V_g = -\frac{R}{\rho f}\int k\times\nabla_p T dp$$







Conclusions

- WAIS collapse seems to match:
  - Water Isotopes
  - Mineral Dust pathways
  - Ocean Sediments
- Antarctic topography plays an important role in regional atmospheric and oceanic circulation

Conclusions

- WAIS collapse seems to match:
  - Water Isotopes
  - Mineral Dust pathways
  - Ocean Sediments
- Antarctic topography plays an important role in regional atmospheric and oceanic circulation

Looking Ahead

- Continue to spin up model + branch to higher resolution
  - Model may not be fully in equilibrium
  - Higher resolution can influence signals
  - Alter vegetation
- Freshwater flux experiments
- Study additional MIS 5e + MIS 6 time slices (120 ka, 127 ka, 135 ka, 140 ka)
- Passive dust tracers

Conclusions

- WAIS collapse seems to match:
  - Water Isotopes
  - Mineral Dust pathways
  - Ocean Sediments
- Antarctic topography plays an important role in regional atmospheric and oceanic circulation

Looking Ahead

- Continue to spin up model + branch to higher resolution
  - Model may not be fully in equilibrium
  - Higher resolution can influence signals
  - Alter vegetation
- Freshwater flux experiments
- Study additional MIS 5e + MIS 6 time slices (120 ka, 127 ka, 135 ka, 140 ka)
- Passive dust tracers

This work is funded by NSF. The simulations are run on the Cheyenne supercomputer, which is sponsored and maintained by NSF.

Questions?

Email: joseph.schnaubelt@uconn.edu