

Sensitivity of the Antarctic ice sheets to the warming of MIS11c

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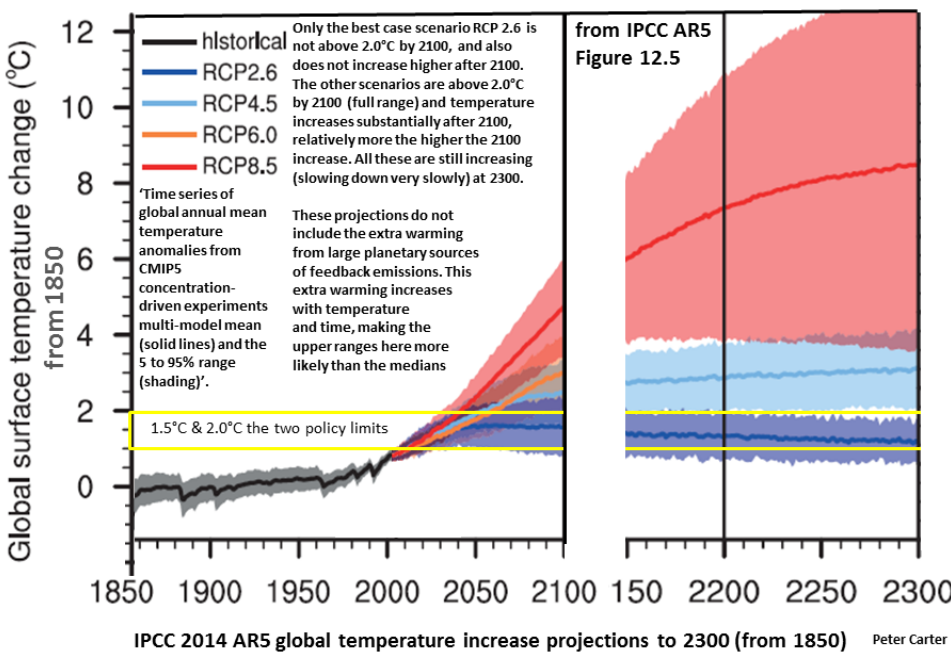
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Skip to slide 12 for the main findings!

Introduction

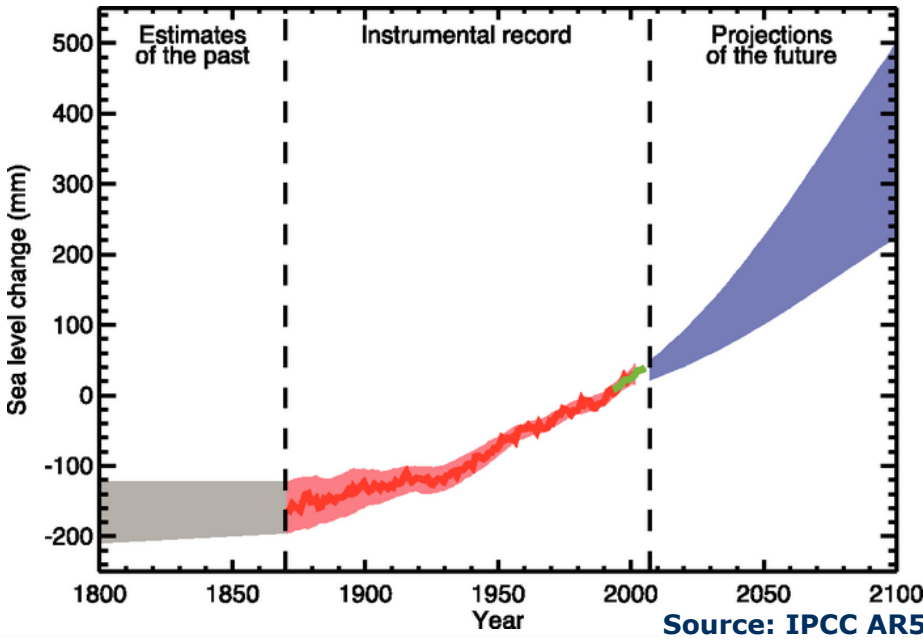
Climate is changing

IPCC AR5 temperature increases 1850-2300



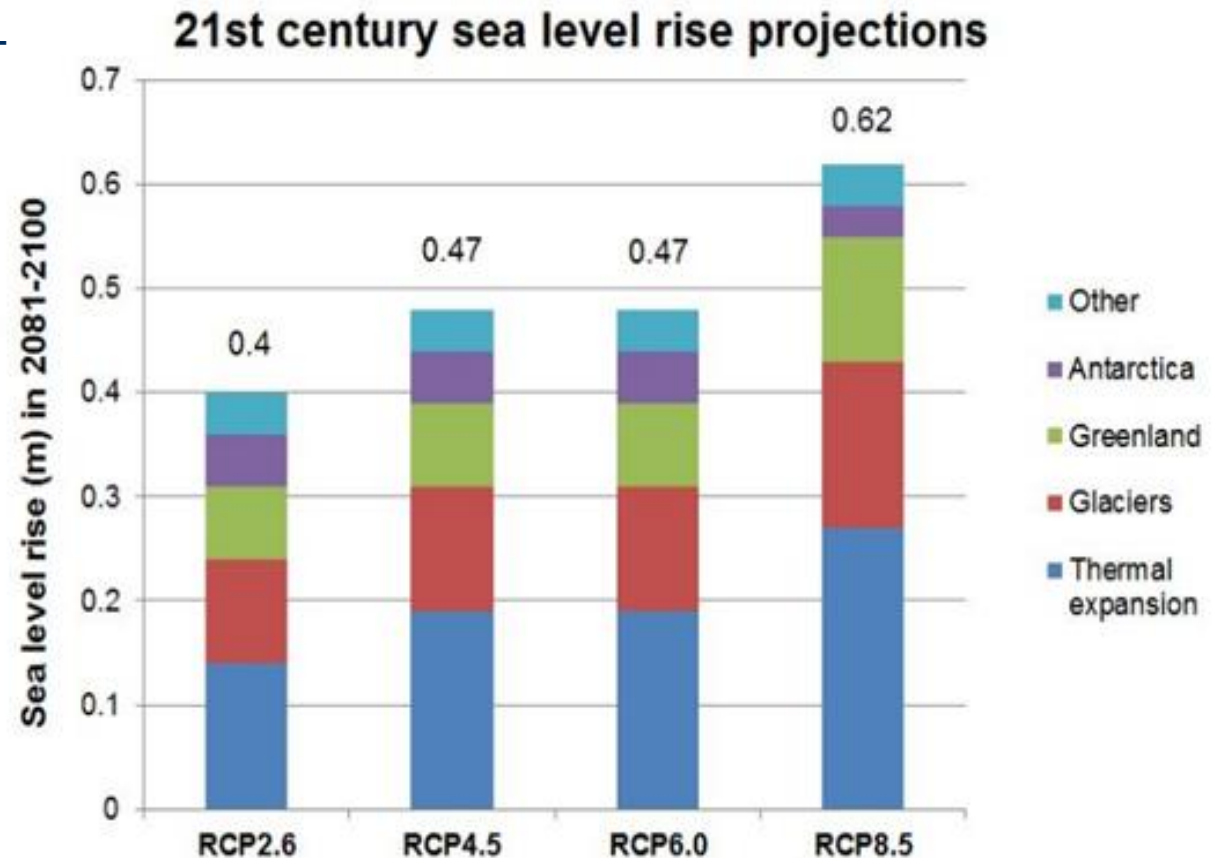
Credits in the image

Sea level is rising!



Introduction

In the near future (2100 CE), thermal expansion seems to be the dominant factor to sea-level rise...



Source: CarbonBrief (after IPCC AR5)

Introduction



Garbe et al. (2020)

... but ice sheets have the potential to contribute much more, considering longer multi-centennial time scales (Pattyn & Morlighem, 2020), and could have crossed decisive tipping points (e.g. Garbe et al., 2020, King et al., 2020).

Potential contributions to sea level (Morlighem et al., 2017; 2020):

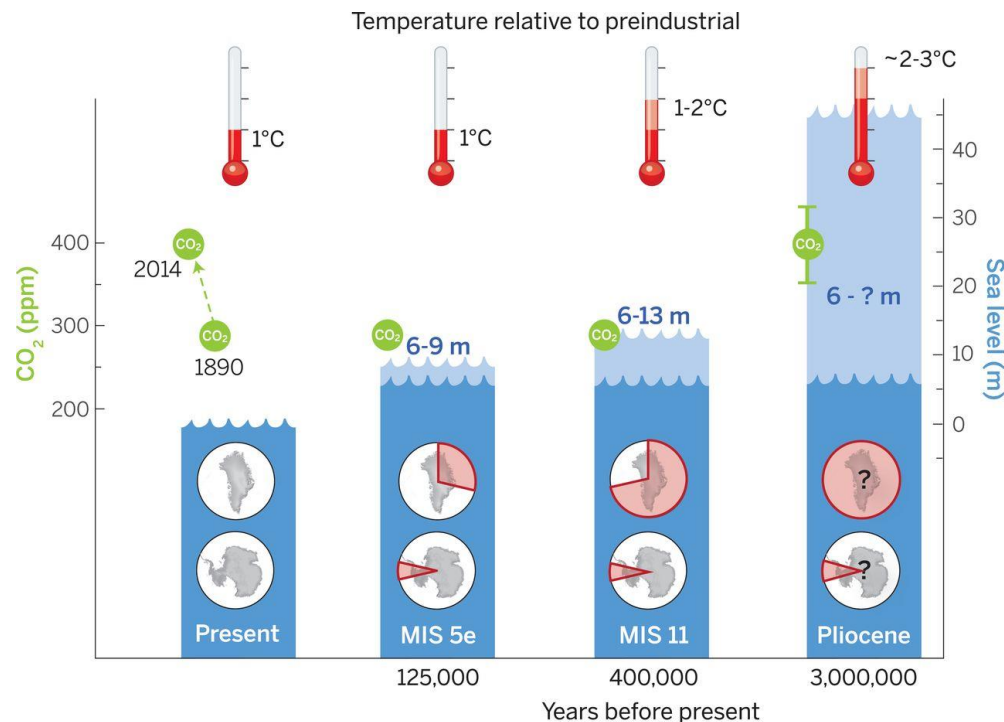
- Greenland: 6.5 m
- West Antarctica (and Peninsula): 5.6 m
- East Antarctica: 52.2 m

In this study, we focus on the **Antarctic Ice Sheet (AIS)**

Motivation

Past interglacials can be seen as naturally forced possible analogues to future conditions of our climate and ice sheets.

Within these periods, **marine isotopic substage 11c (MIS11c, 424-394 thousand years ago, ka)** is a good candidate for analysis.



Dutton et al. (2015)

Why MIS11c?

- Closest analogue to present-day climate
- Longest interglacial in the Quaternary
- Lack of information and no consensus on Antarctica's response to the extensive warming period

Aim

Questions we wanted to answer:

- How did the AIS respond to the warming of MIS11c in terms of:
 - AIS minimum configuration
 - Timing
 - Potential sea level contribution
- What was the main driver of the changes in the AIS volume?
 - Warming duration
 - Peak temperature
 - Changes in precipitation
 - Changes in the oceanic forcing

Methods

Ice sheet model (SICOPOLIS)

Forcing:

Climate model results (CCSM3) scaled by isotope curves
(Glacial Index method)

Ensemble runs

- Isotope curves

Dome C (EDC)
Dome Fuji (DF)
Vostok
LR04

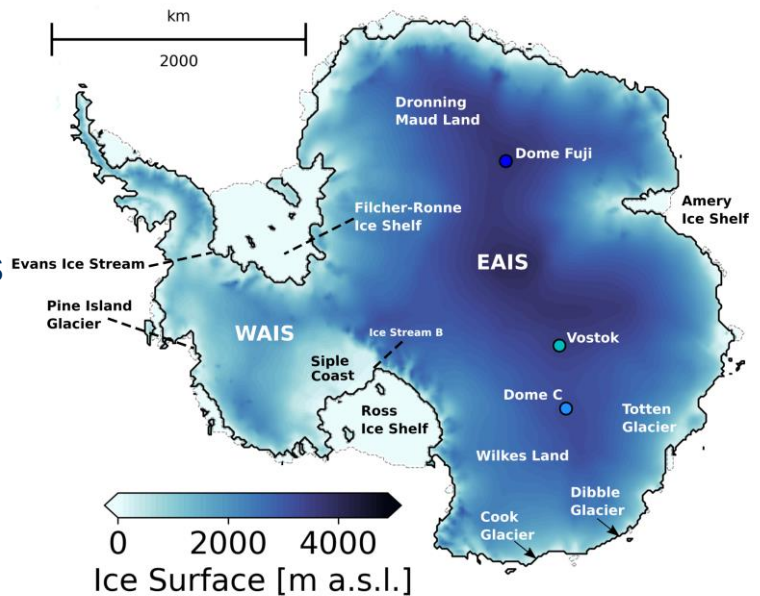
- Scaling procedure

- Temporal resolution

- Sea-level reconstructions

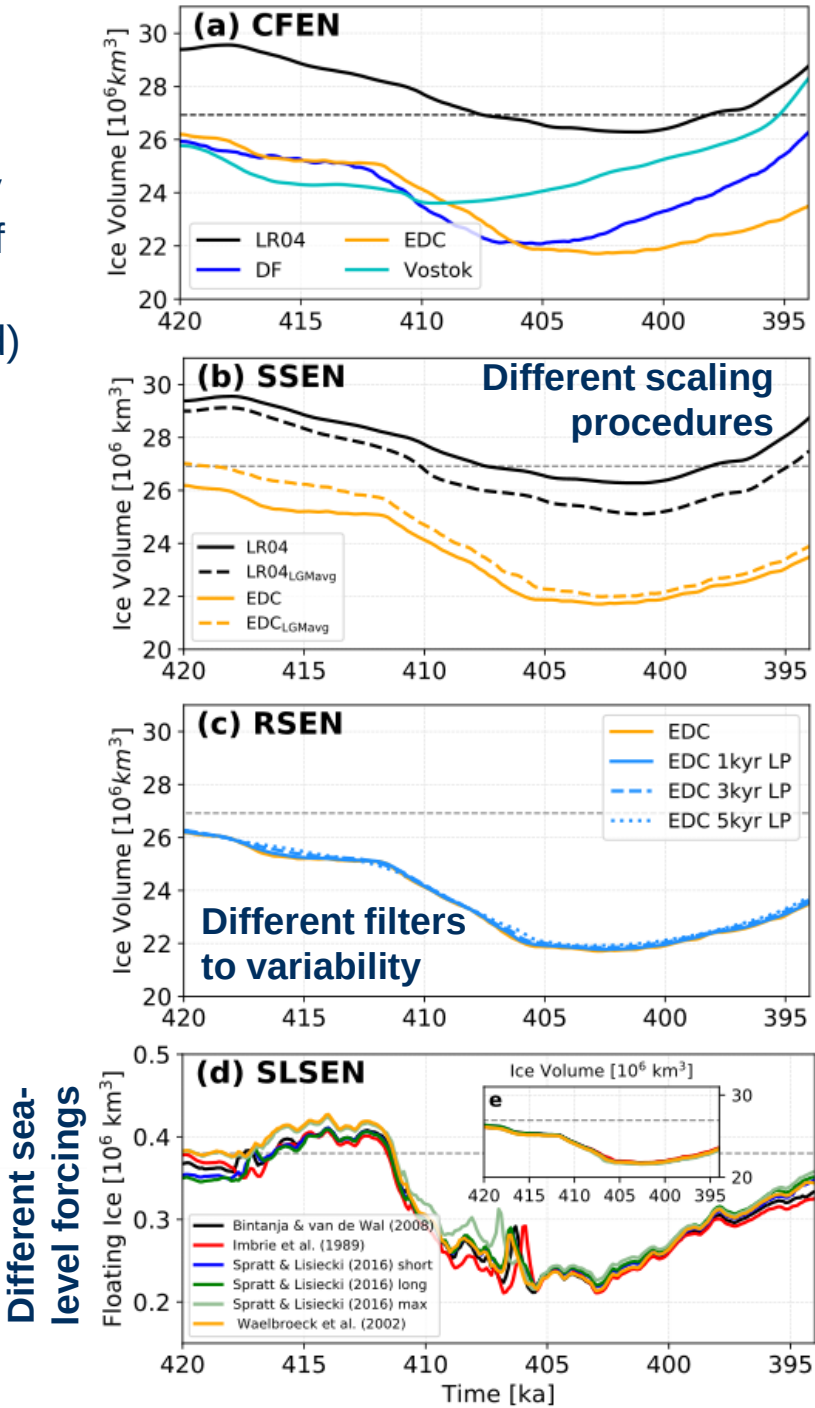
- Starting configuration

Bintanja & van de Wal (2008)
Spratt & Lisiecki (2016)
Waelbroeck et al. (2002)
Imbrie et al. (1989)



Results

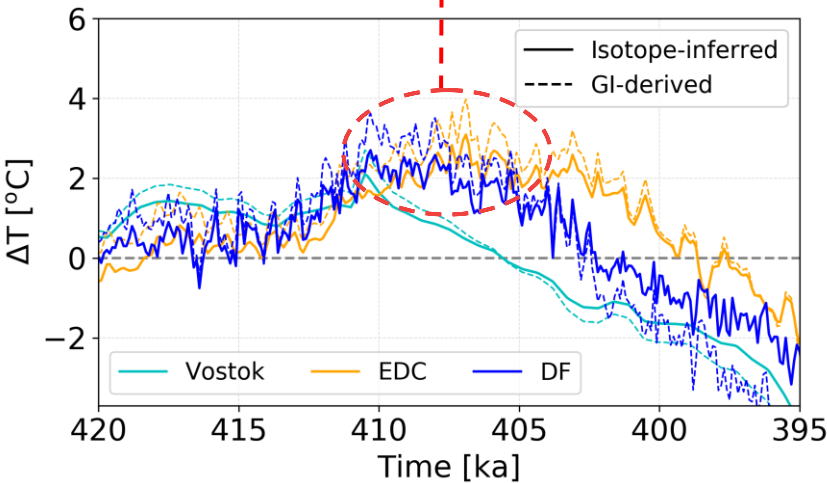
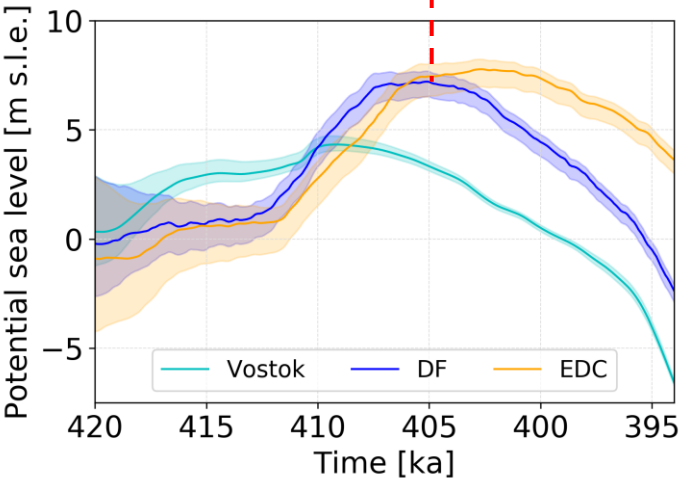
The choice of climate record (a) and of initial geometry played a much stronger role compared to the choice of reference points for scaling (b), centennial-scale variability (c), and different sea-level reconstructions (d)



Results

The choice of climate record (a) and of initial geometry played a much stronger role compared to the choice of reference points for scaling (b), centennial-scale variability (c), and different sea-level reconstructions (d)

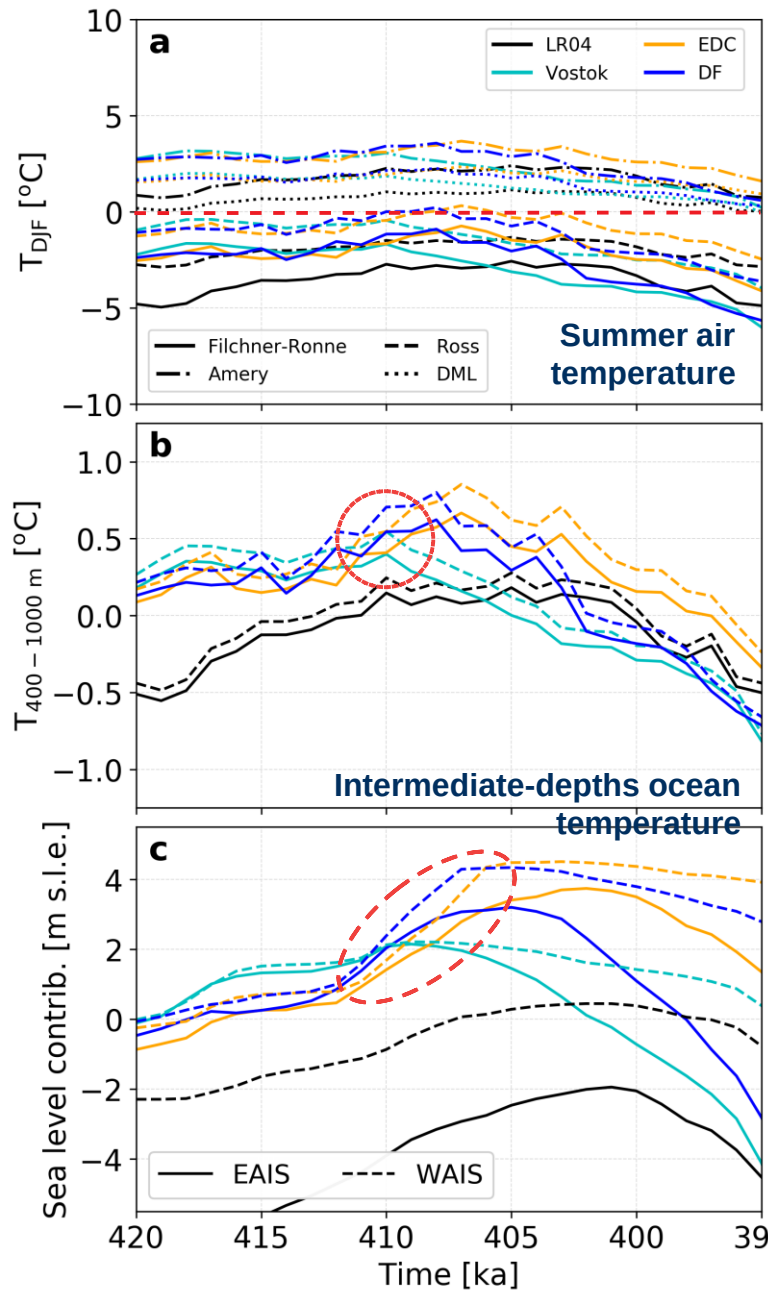
WAIS collapse happens in the long warming peak scenarios and is insensitive to the choice of initial geometry



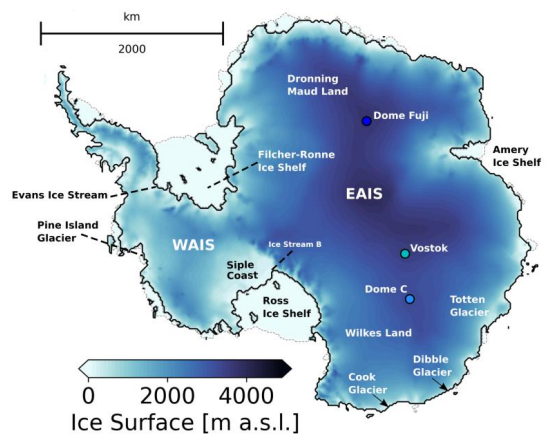
On-site temperature comparison between the isotope reconstruction (isotope-inferred) and the climate scaling reconstruction (GI-derived)

Range given by initial geometries

Results & discussion



Little changes in atmospheric forcing, still below zero over Ross and Filchner-Ronne ice shelves



Oceanic forcing rises quickly after 412 ka

The dominant forcing!

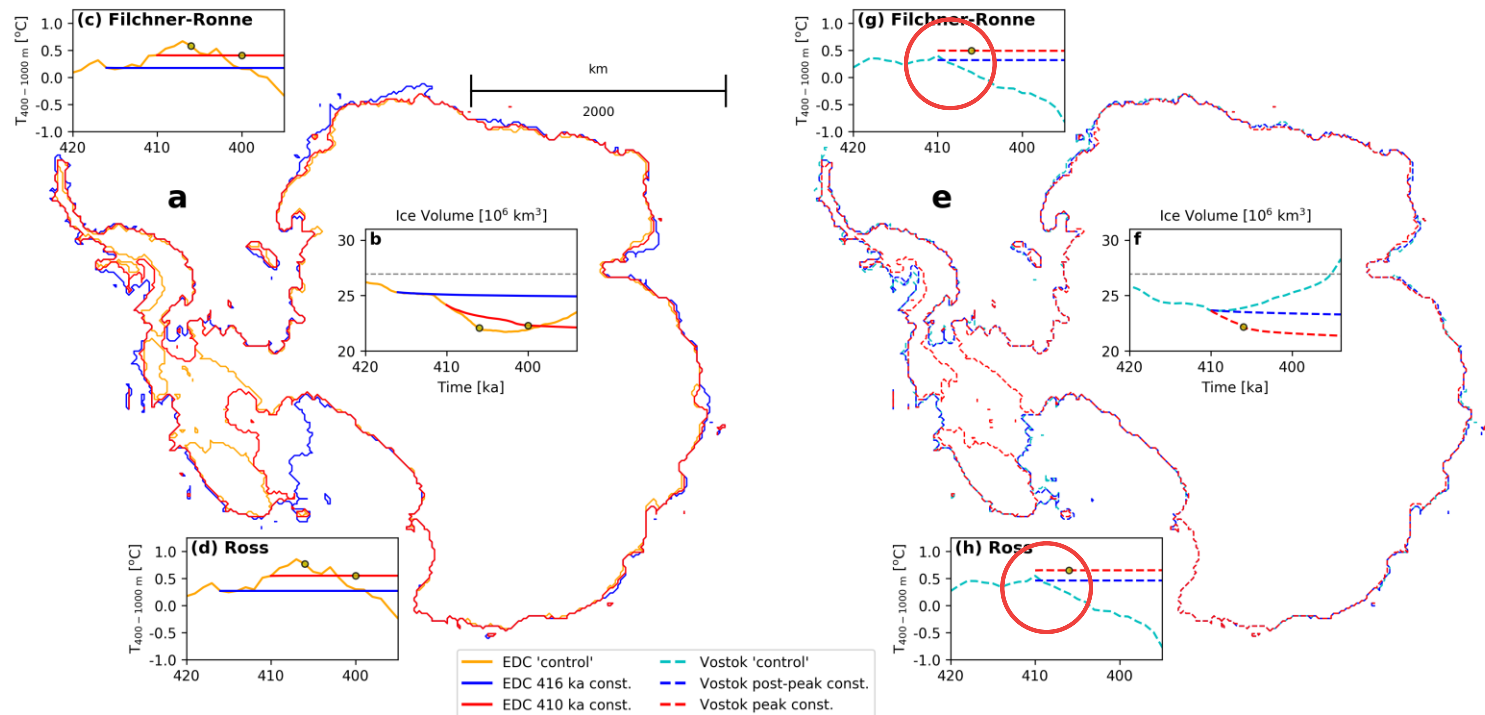
Mostly affects West Antarctica (WAIS)

Results & discussion

Testing thresholds in ocean temperature for WAIS collapse

Comparing conditions pre- and post-tipping point at 412 ka for EDC (left) and longer peak durations for Vostok (right) experiments

Yellow points mark the time of WAIS collapse



WAIS collapse vs. no collapse after climate is kept constant

Conclusions

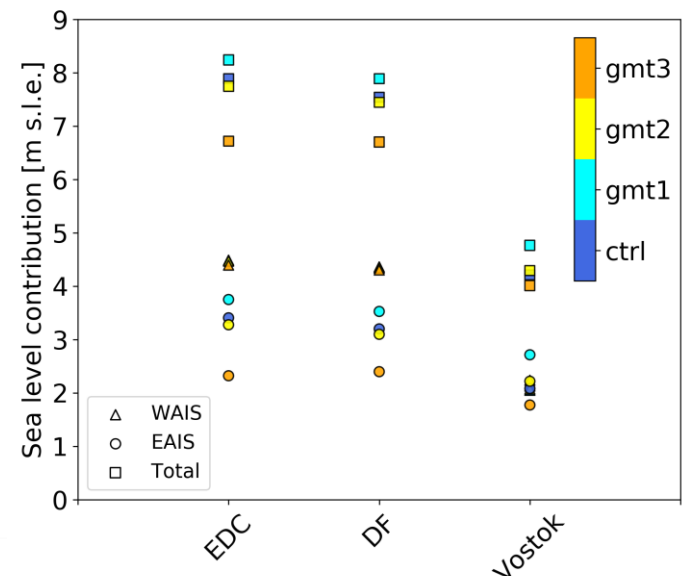
Questions we wanted to answer:

How did the AIS respond to the warming of MIS11c in terms of:

- **AIS minimum configuration:** WAIS collapse is dependent on the choice of climate forcing; EAIS depends on the initial condition
- **Timing:** WAIS collapses after the ocean is above a temperature threshold ($0.4\text{ }^{\circ}\text{C}$ above PI) for ca. 4 kyr
- Potential sea level contribution:
 - **Full range:** 4.0 to 8.2 m s.l.e.
 - **WAIS collapse:** 6.7 to 8.2 m s.l.e.

What was the main driver of the changes in the AIS volume?

- **Warming duration**
- Peak temperature
- Changes in precipitation
- **Changes in the oceanic forcing**



Sea-level maximum contribution
in each experiment

Thank you for your time!!

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