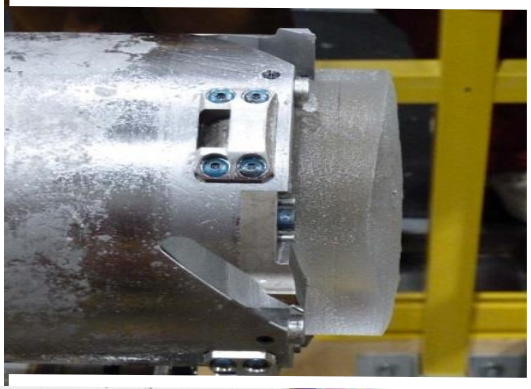
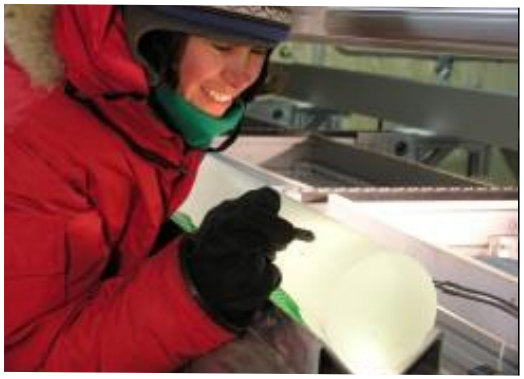
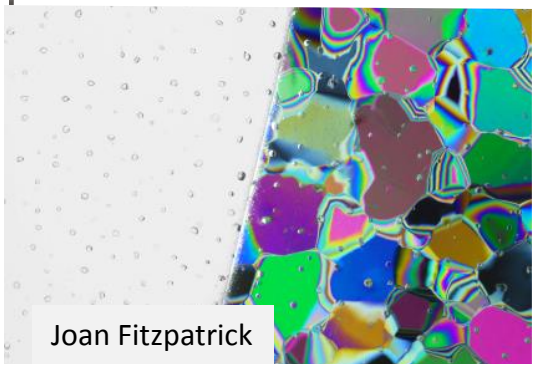
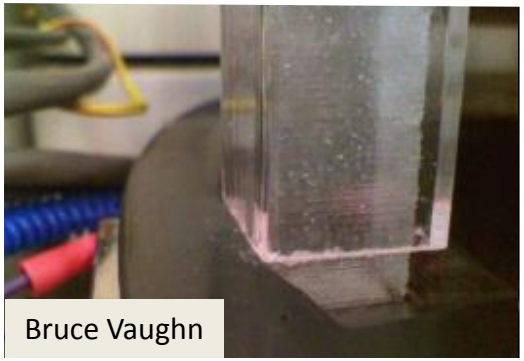
WAIS Divide Ice Core Project



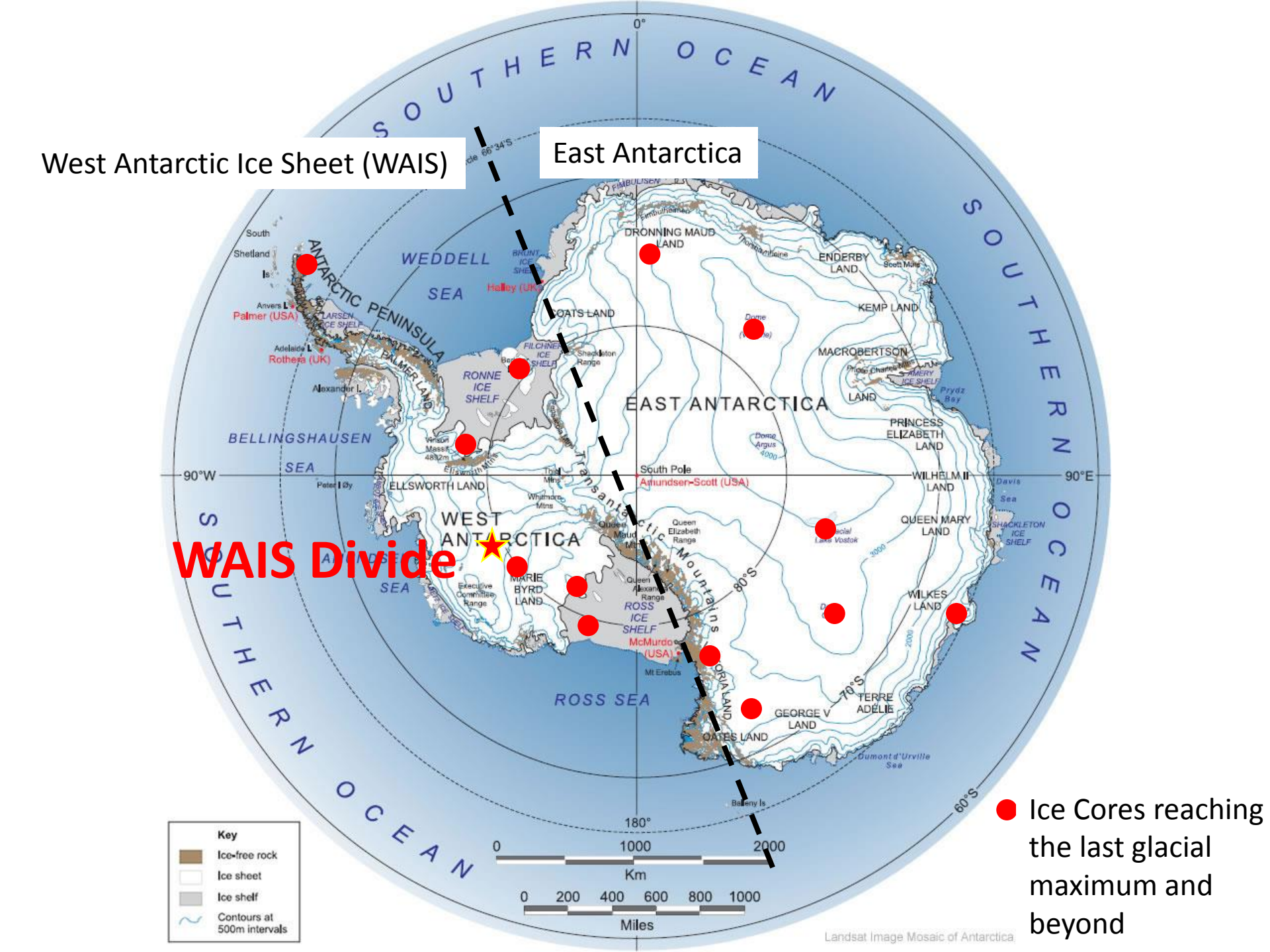




Joan Fitzpatrick

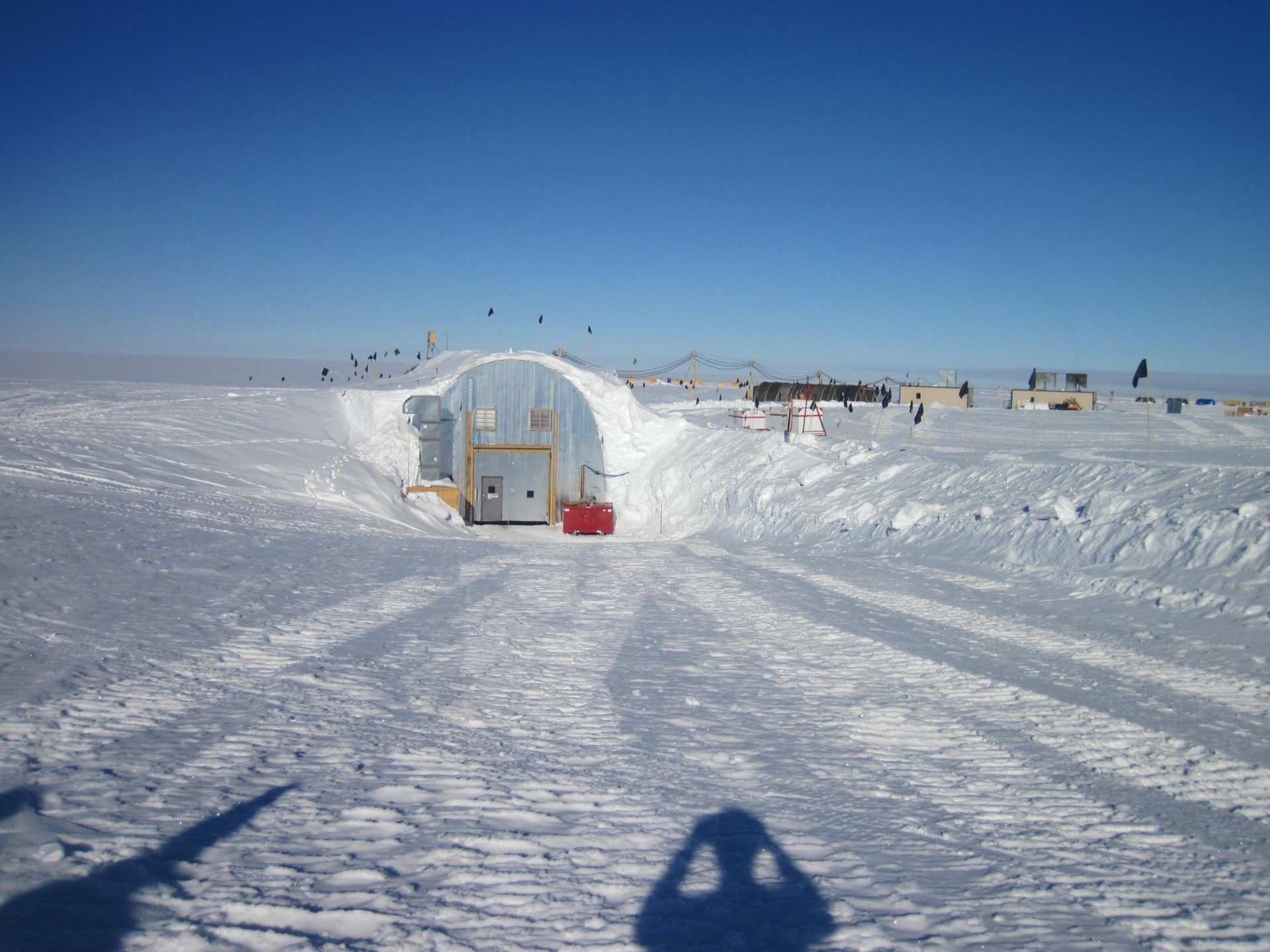


Bruce Vaughn

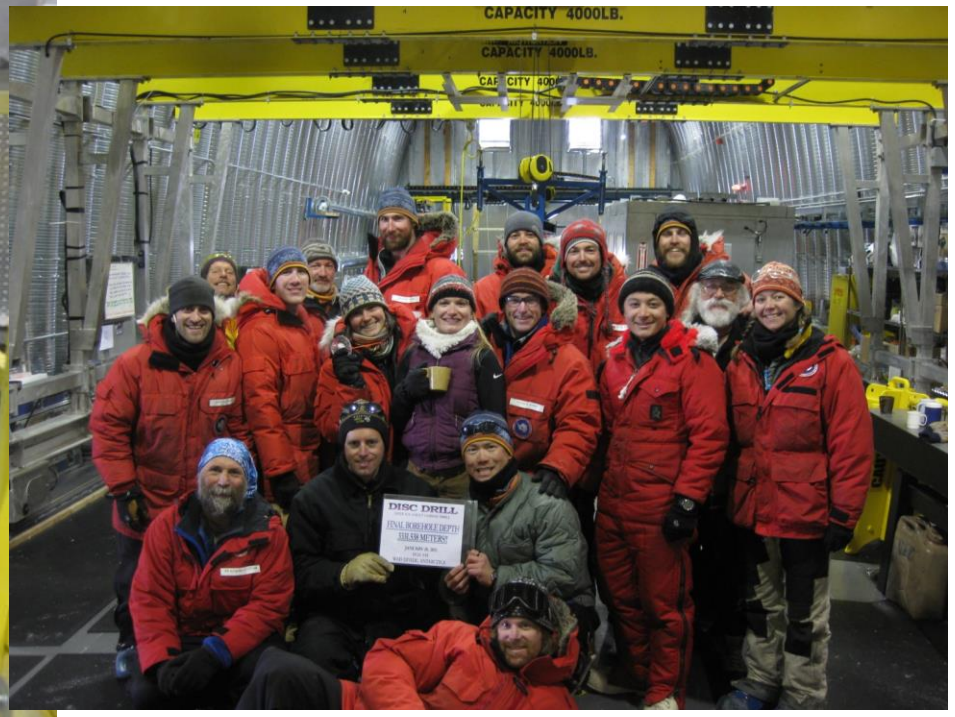


- Ice Cores reaching the last glacial maximum and beyond

Drill Arch




SAFETY


CAPACITY 4000LB.
CAPACITY 4000LB.
DISC DRILL
FINAL BOREHOLE DEPTH
XXXX.XM METERS!

Drill Arch will be completely buried

WAISCORES : History

1989: Included in **ICWG long term plan**

1992: Science plan for **WAISCORES Deep Ice Coring** (ICWG/Alley) “Inland Divide Site” and Siple Dome

2000: **WAISCORES: A Science and Implementation plan**

2002: **Proposal to build and test the drill**

2004: **Full project proposed**

2005: **Established WAIS Divide site**

2011: **Main hole completed**, replicate coring test

2012: **Replicate coring**

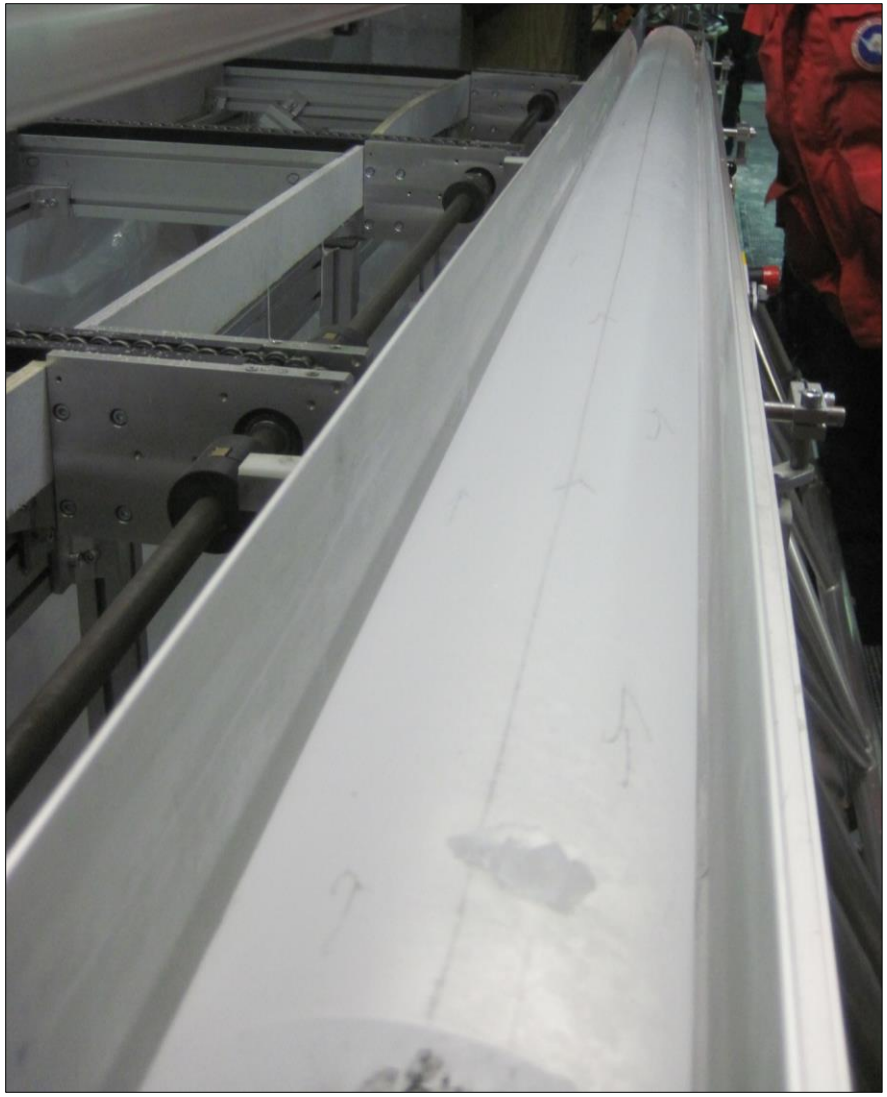
Ongoing: **Borehole Logging**

WAIS Divide Goals

~80,000 year record with high time resolution
Initiation of climate changes during the last glacial
North-South phasing of abrupt climate phasing
Greenhouse gas (particularly CO_2)
Holocene Variability
Microbial biology of the ice
Biology of the basal environment
Stability of WAIS

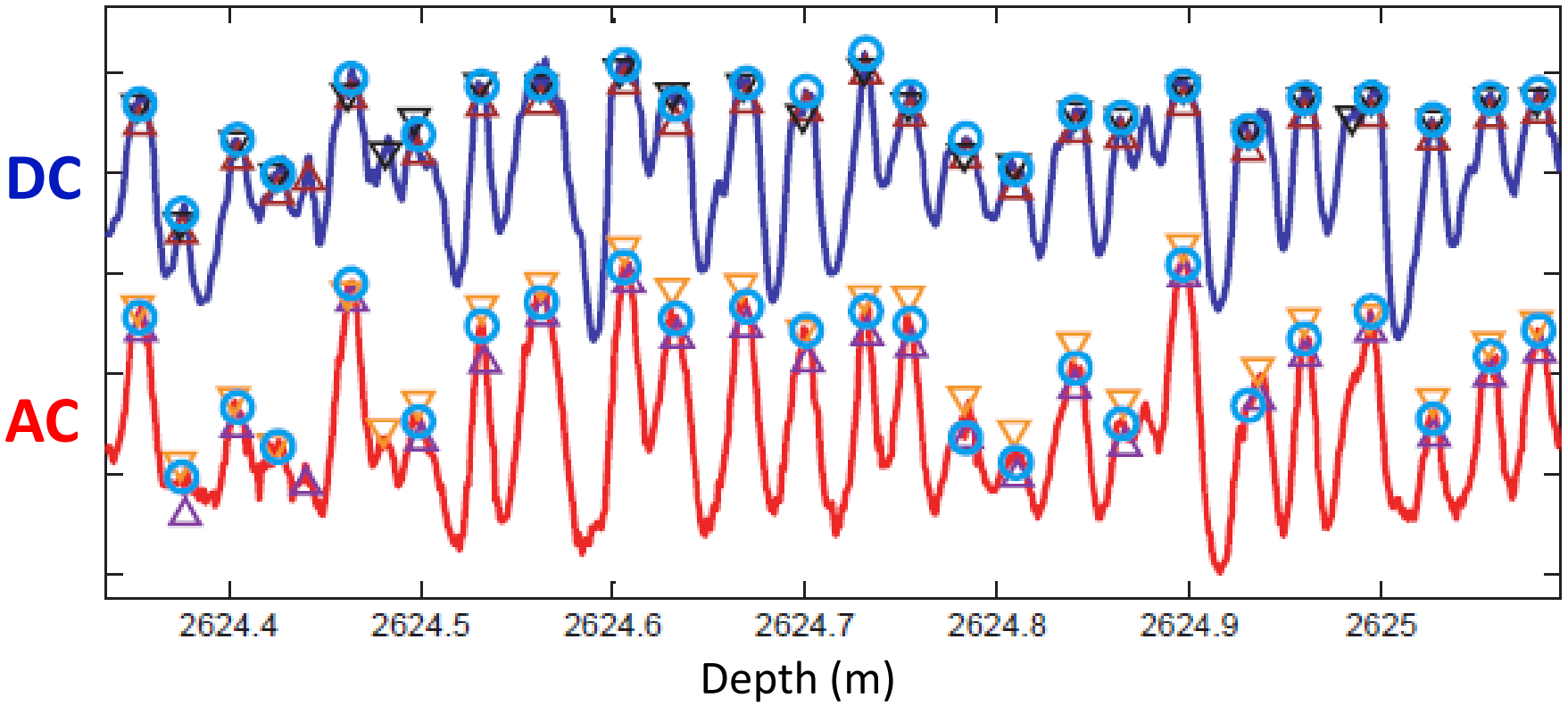
High time resolution, ~80,000 years

Oldest ice is 68,000 years



High time resolution, ~80,000 years

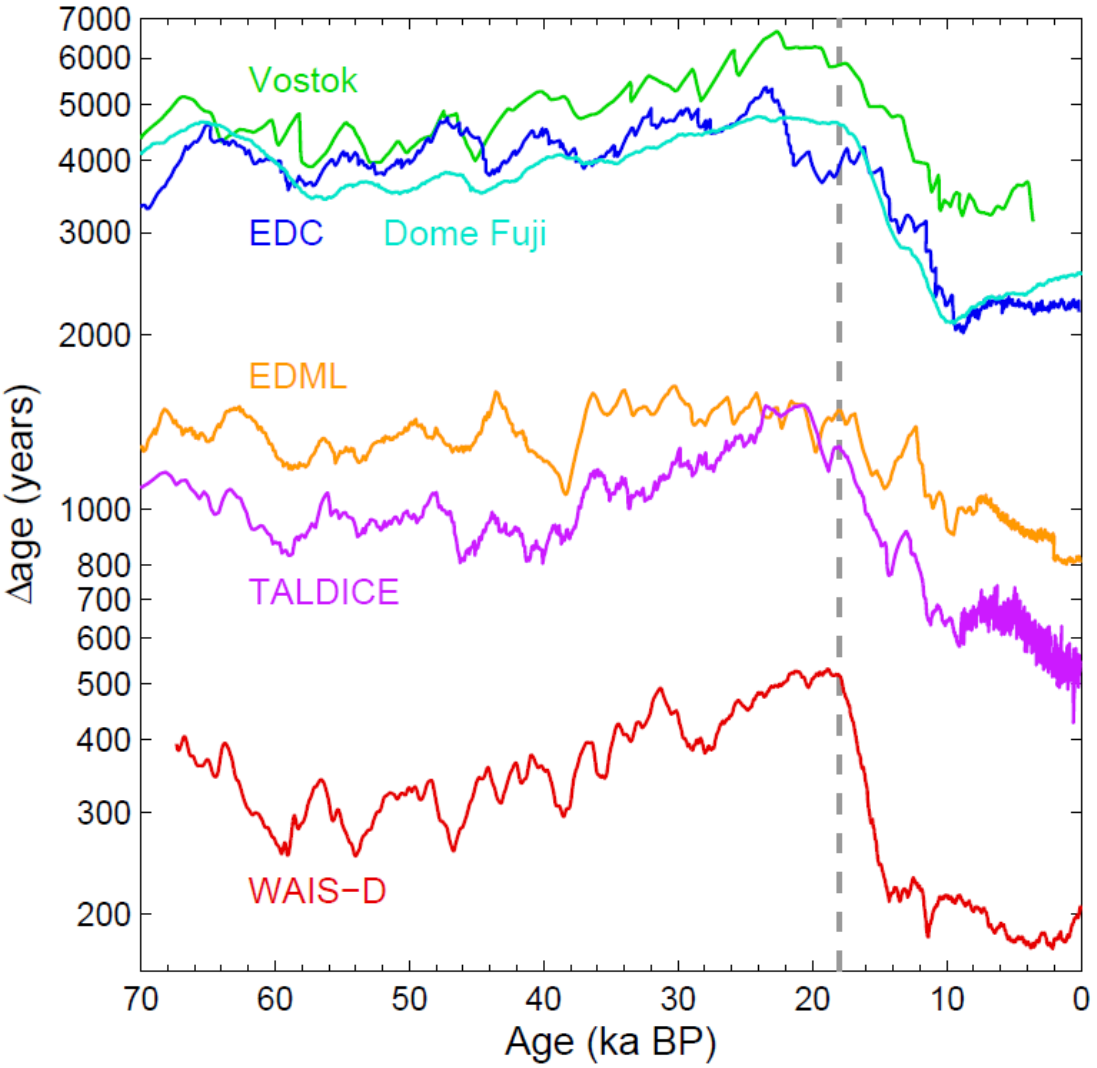
Annual resolution to 31 ka



~26,000 years ago

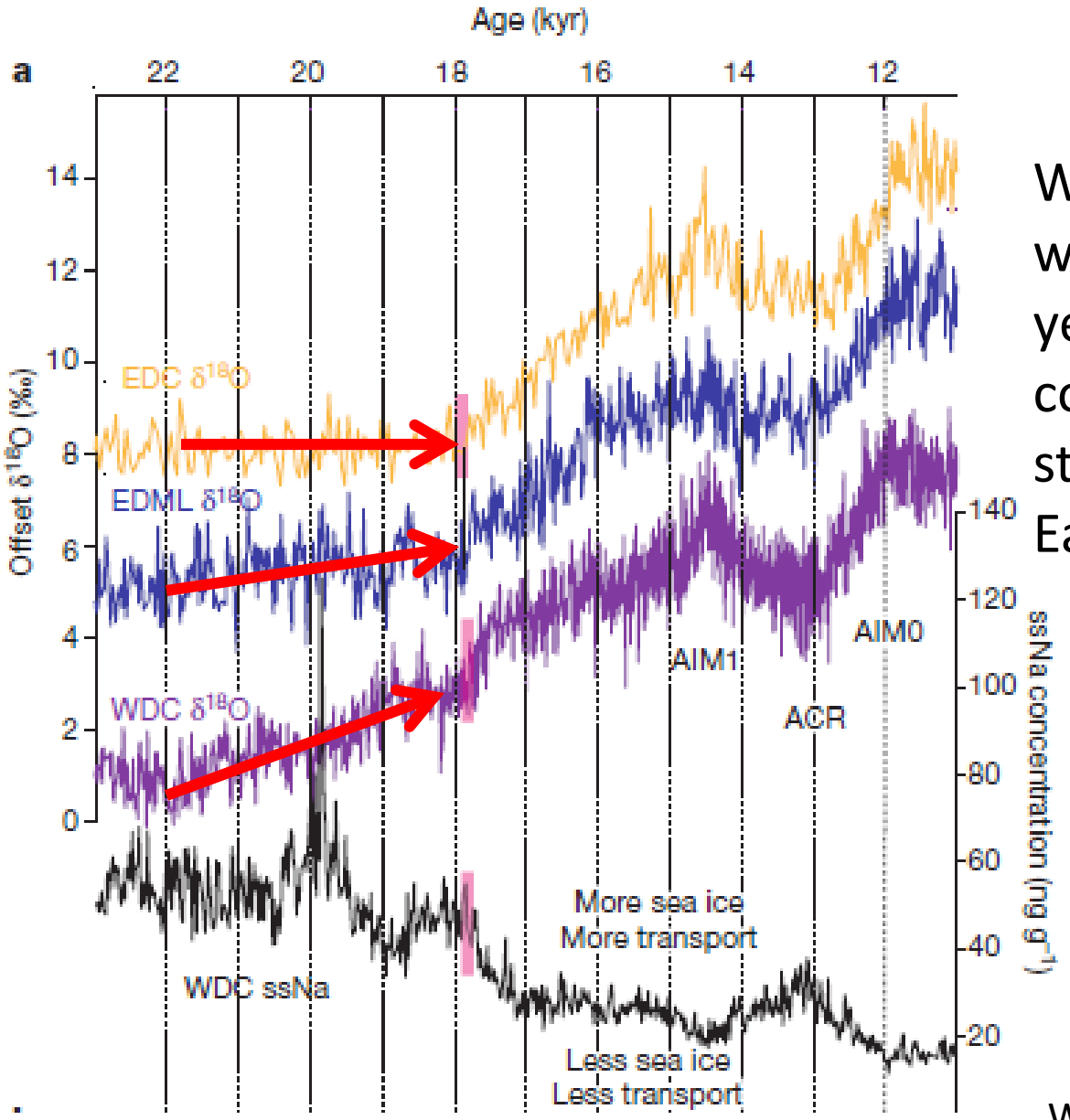
High time resolution, ~80,000 years

Gas-age ice-age difference < 500 years



Allows precise comparisons between hemispheres

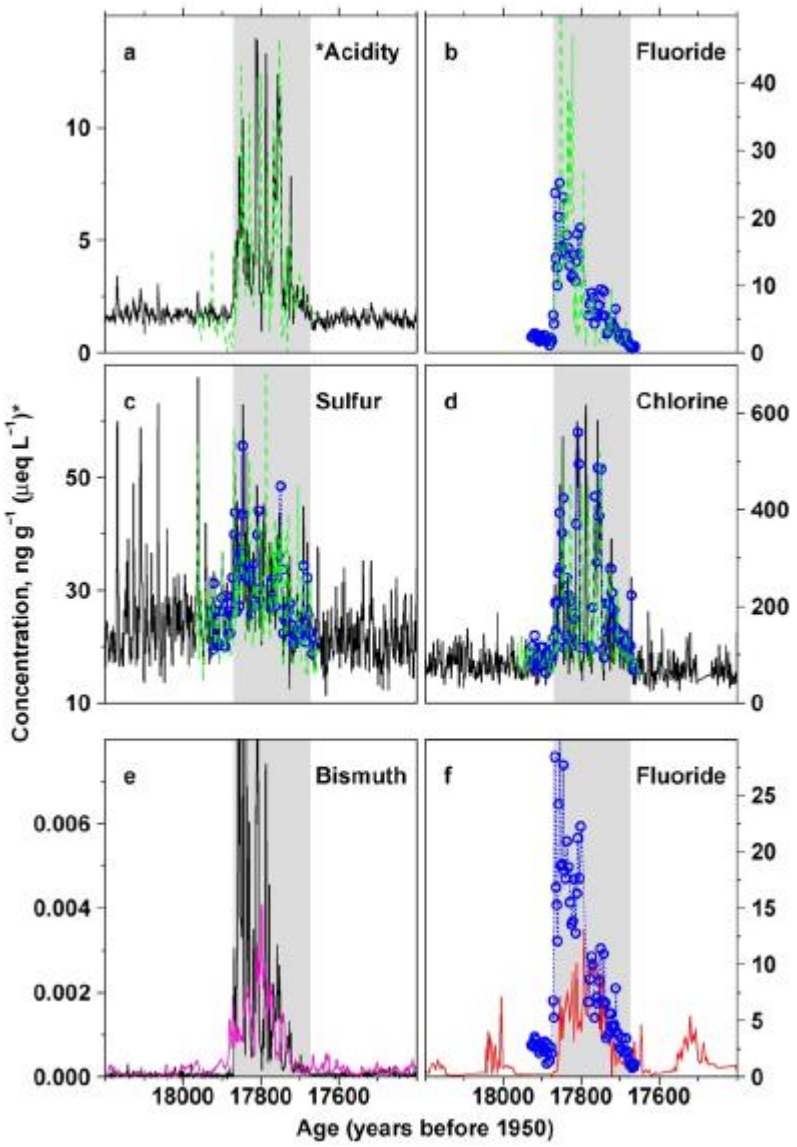
Initiation of climate changes during the last glacial



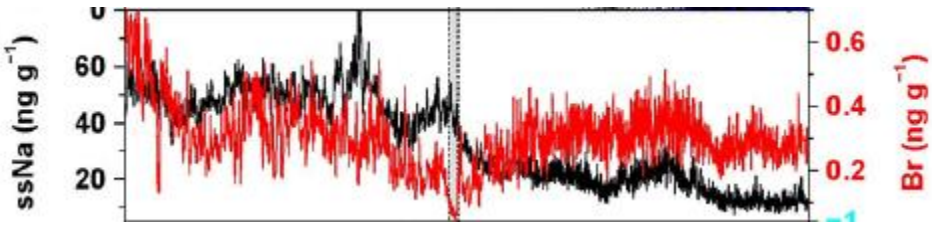
WAIS Divide begins warming thousands of years before commonly accepted start of deglaciation in East Antarctica

WAIS Divide Project Members, 2013, Nature

Initiation of climate changes during the last glacial



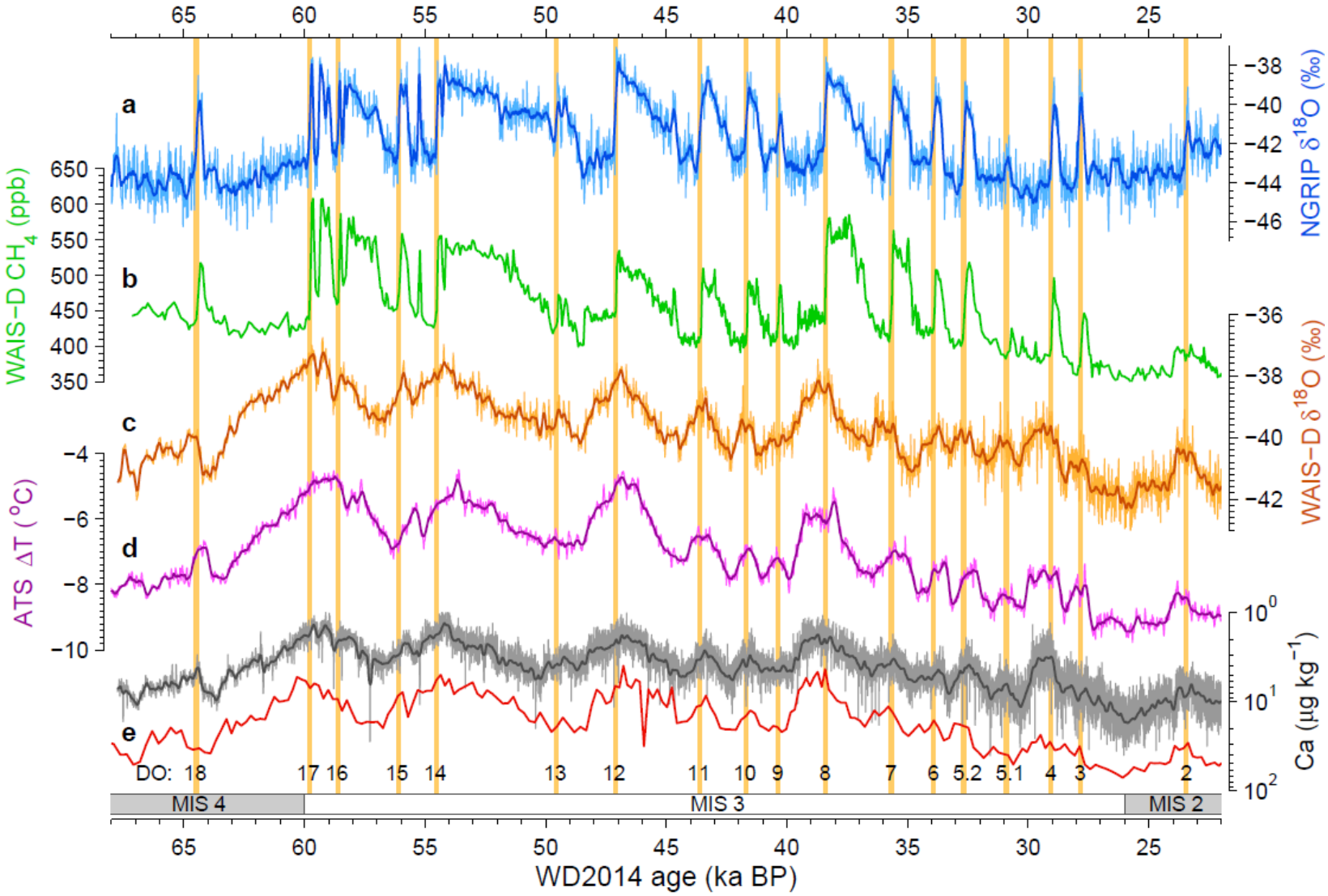
200 year Halogen rich volcanic event



Creates ozone hole as evidence by drop in bromine

McConnell et al., in review, Nature

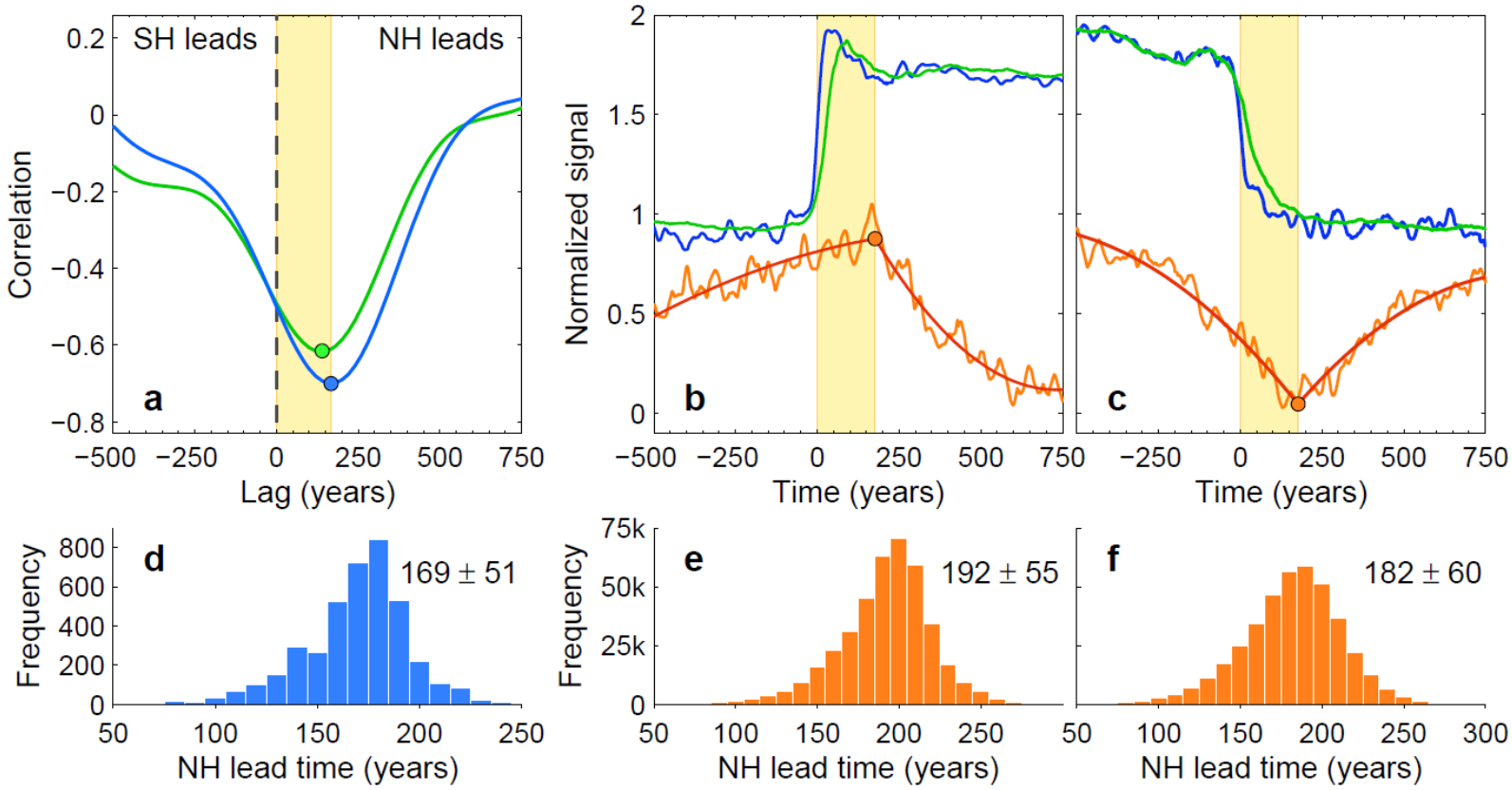
North-South Phasing of Abrupt Climate Change



Vertical lines show times of abrupt climate change

WAIS Divide Project Members,
In review, Nature

North-South Phasing of Abrupt Climate Change



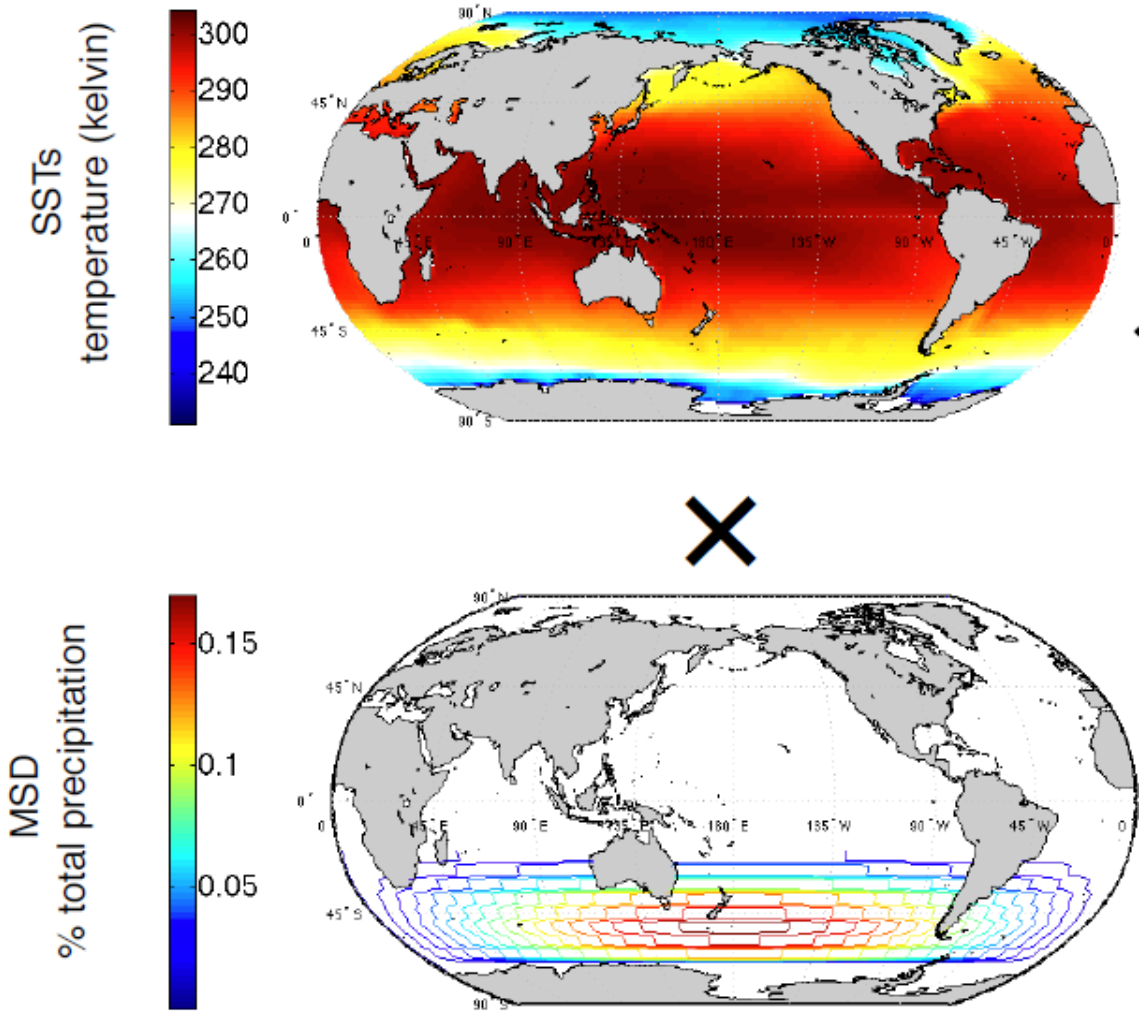
Antarctic temperature lags abrupt Northern Hemisphere changes by 200 years

Ocean processes dominate heat transport

WAIS Divide Project Members, In review, Nature

North-South Phasing of Abrupt Climate Change

Deuterium excess also shows a synchronous atmospheric response

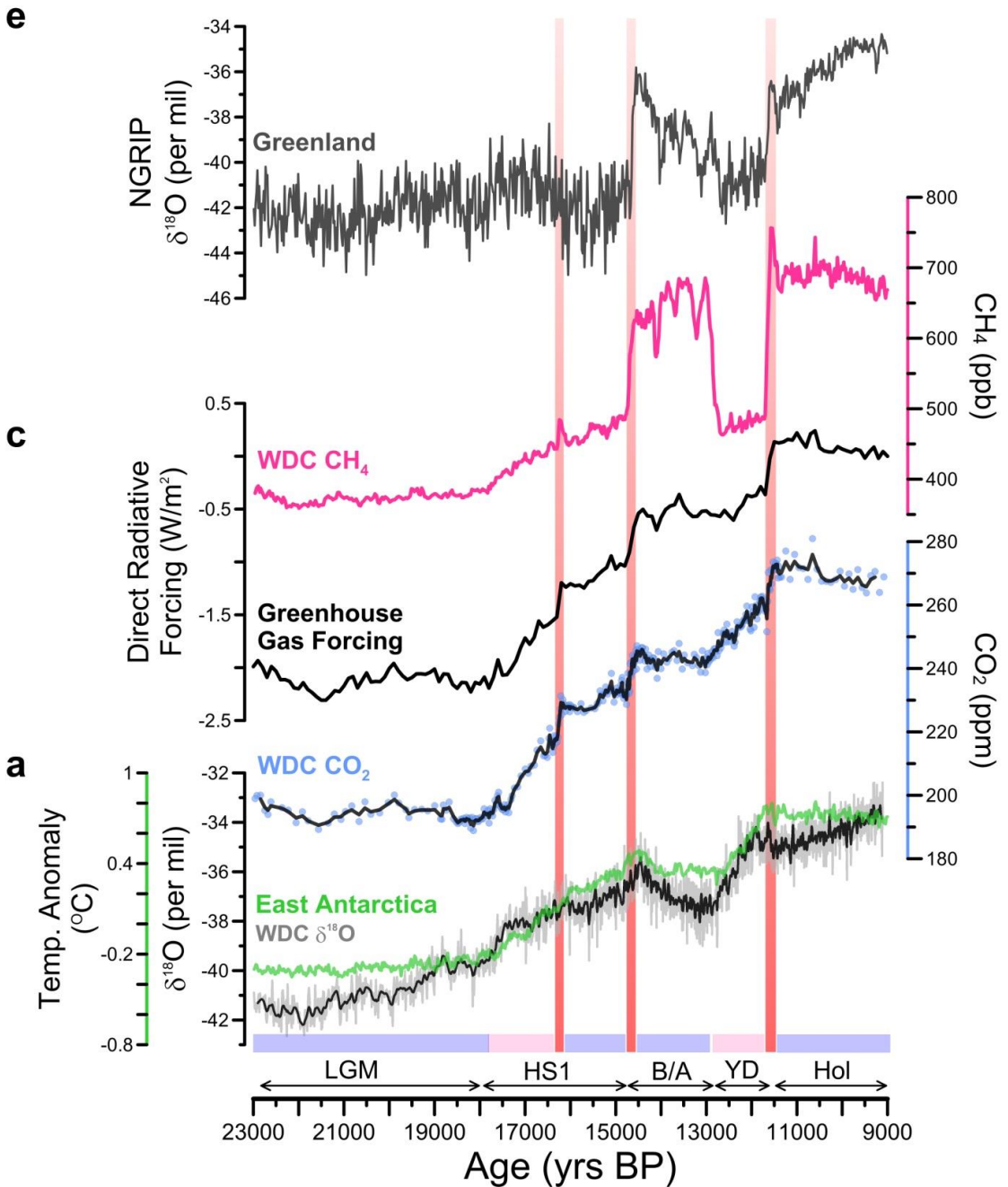


Centennial-scale oceanic response warms Southern Ocean sea surface temperatures

Synchronous shift in winds changes moisture source which is detected by deuterium excess

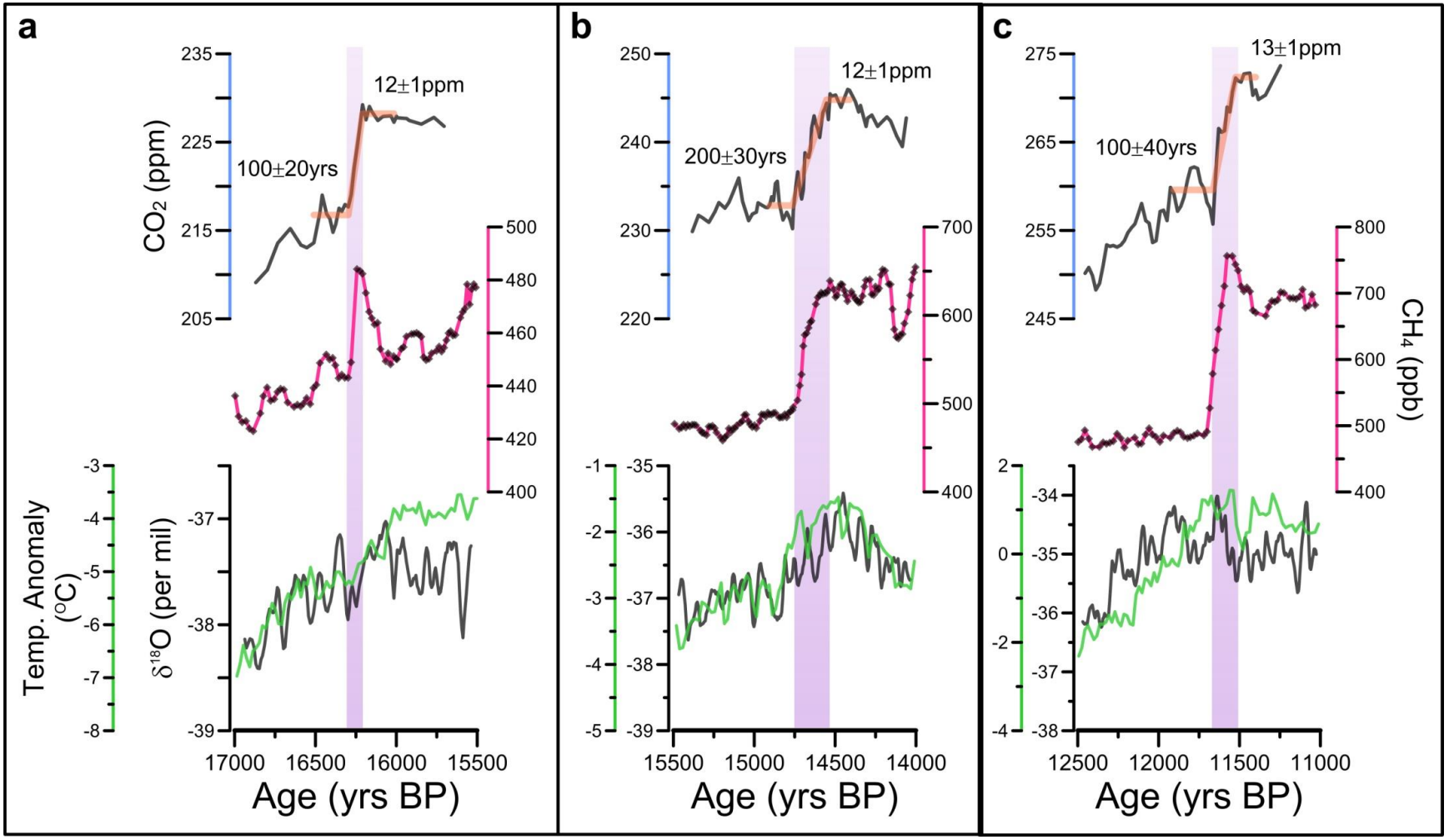
Brad Markle, in prep

Greenhouse Gases



Marcott et al.,
In press, Nature

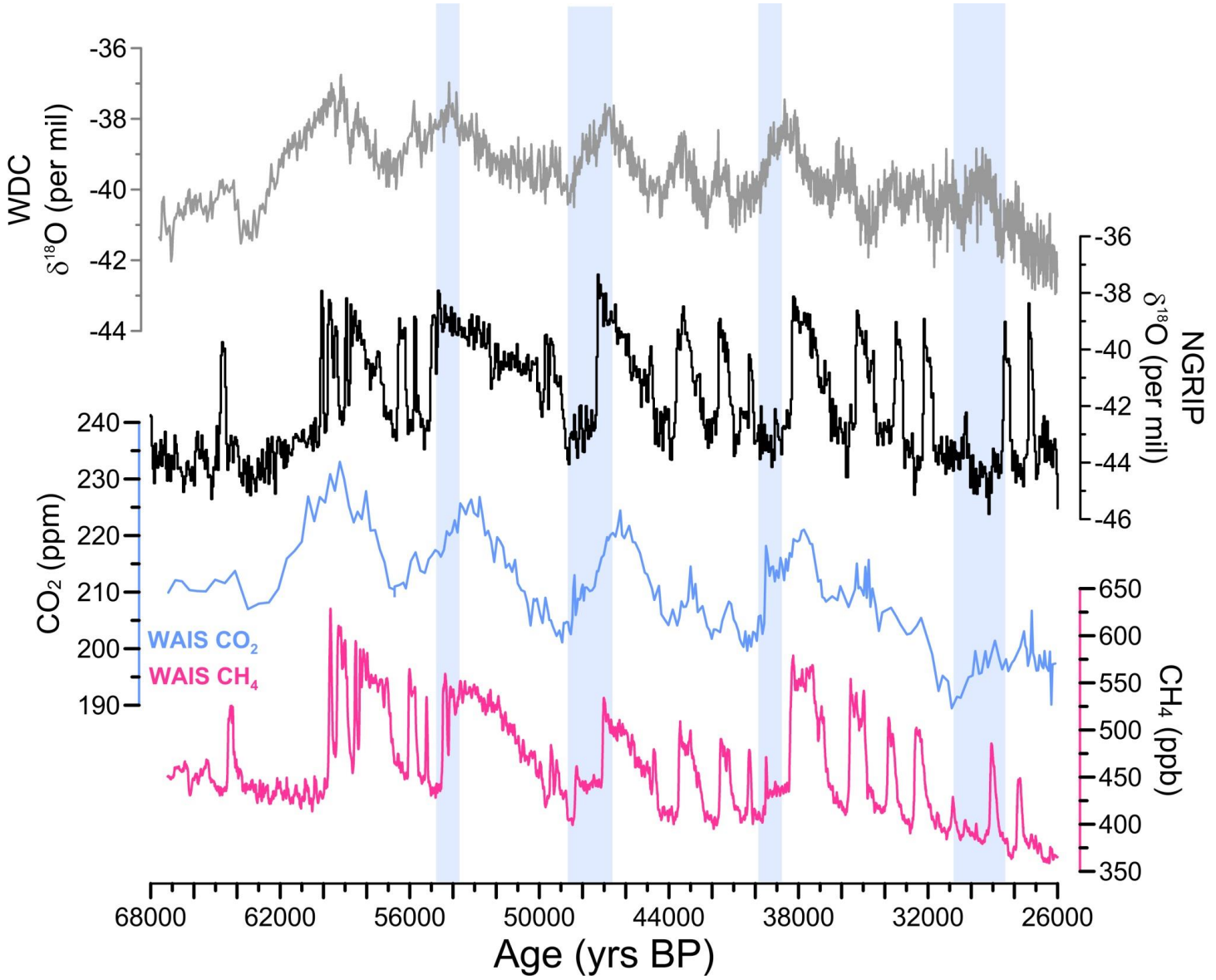
Greenhouse Gases



3 abrupt increases in CO2, exactly synchronous with methane increases, account for about half of glacial-interglacial rise

Marcott et al.,
in press, Nature

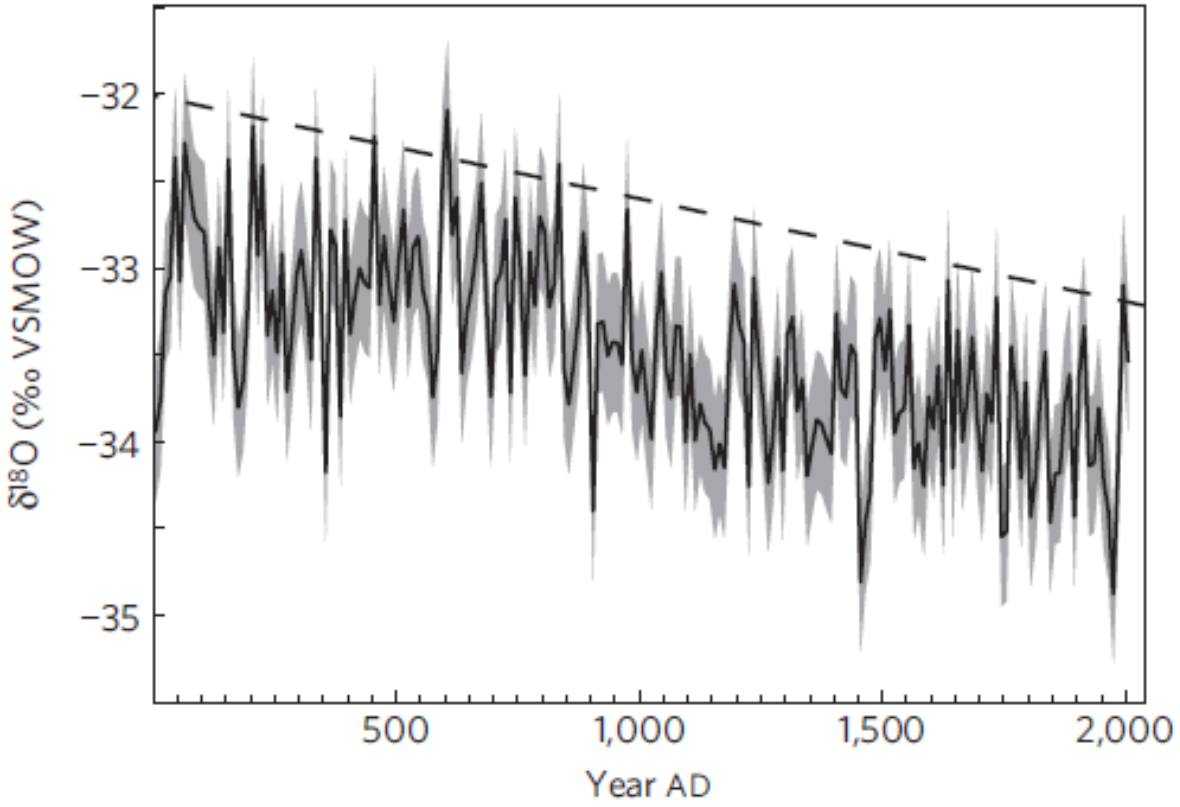
Greenhouse Gases



Abrupt CO2 increases also occur in the glacial period

Marcott et al., in prep

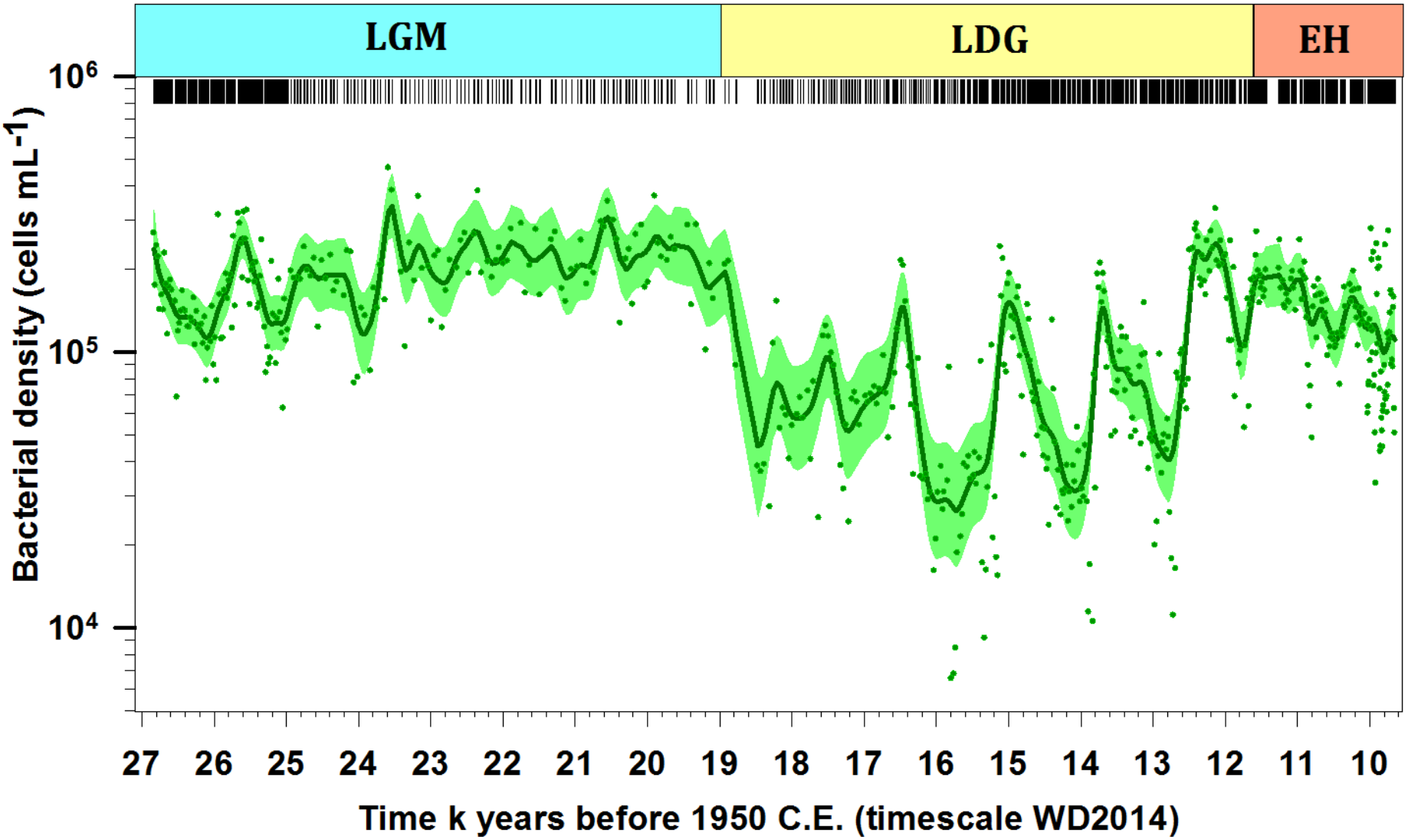
Holocene Variability



Modern isotopic warming rare but not unprecedented

Steig et al., 2013
Nature Geoscience

Microbiology of the Ice



Ibanez and Priscu, in prep.

Biology of the Basal Environment

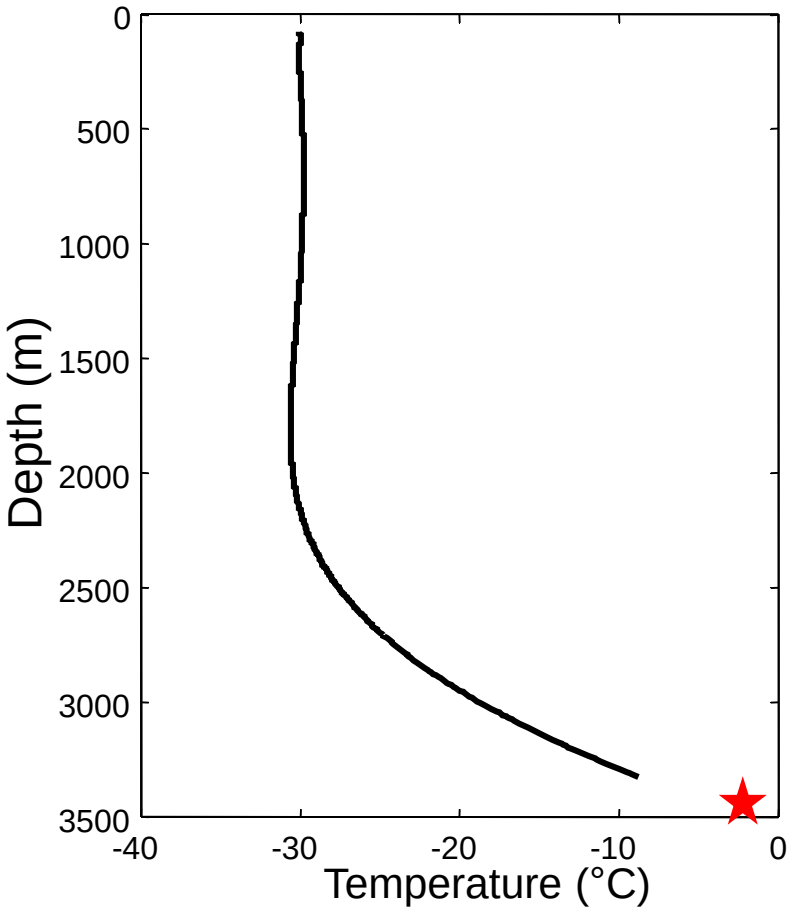
We didn’t try

Drilling was stopped ~50 m above the bed

Stability of West Antarctica

No information on whether WAIS collapsed in MIS5e because no old ice was recovered

Stability of West Antarctica



$$w = \left[\frac{k}{\rho c_p} \left(\frac{\partial^2 T}{\partial z^2} \right) - b \frac{k}{\rho c_p} \left(\frac{\partial T}{\partial z} \right)^2 - \frac{\partial T}{\partial t} + \frac{1}{\rho c_p} Q \right] / \frac{\partial T}{\partial z}$$

Use heat equation to calculate vertical velocity

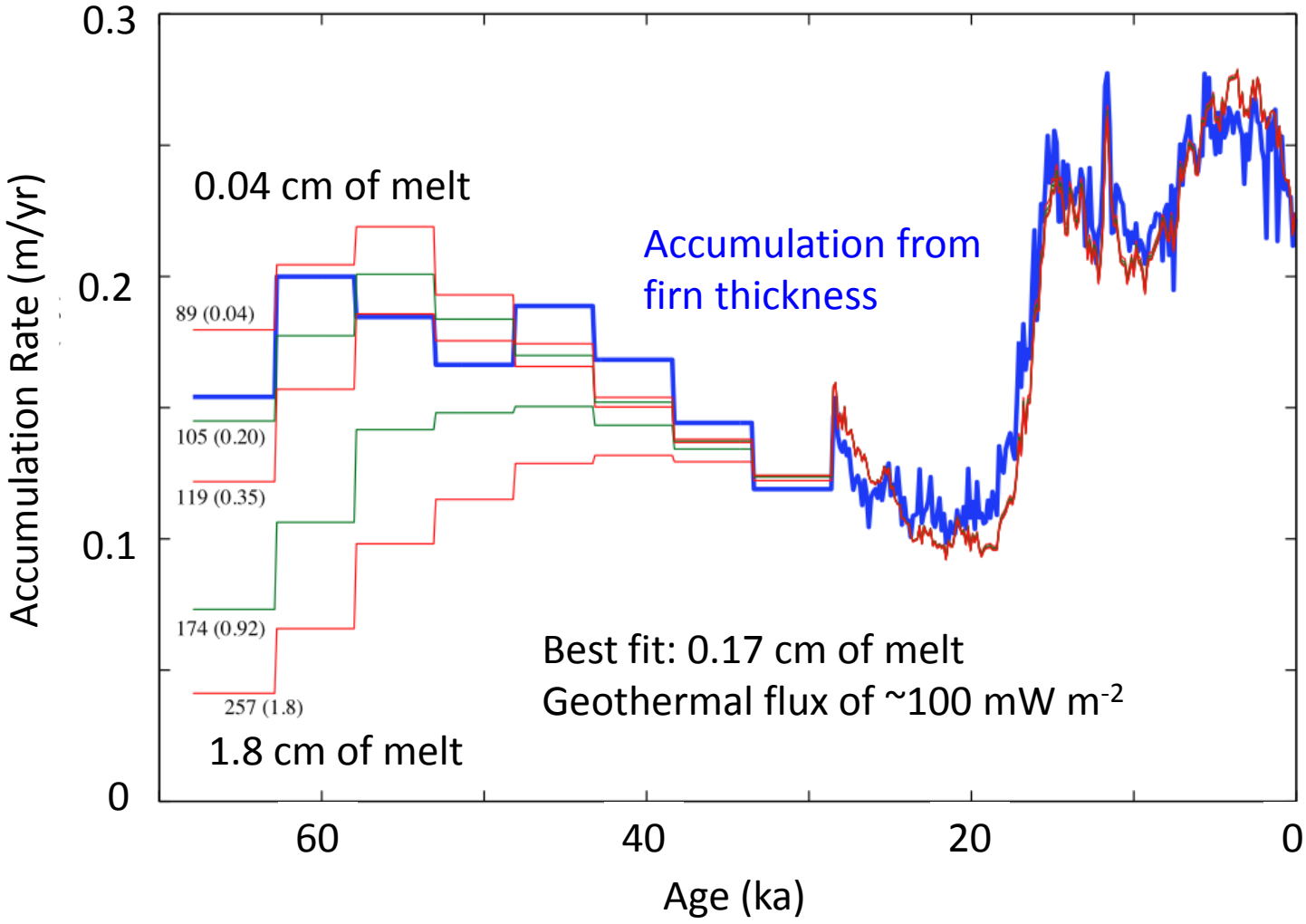
Basal melt rate of ~1 cm per year

Geothermal flux of ~180 mW m^{-2}

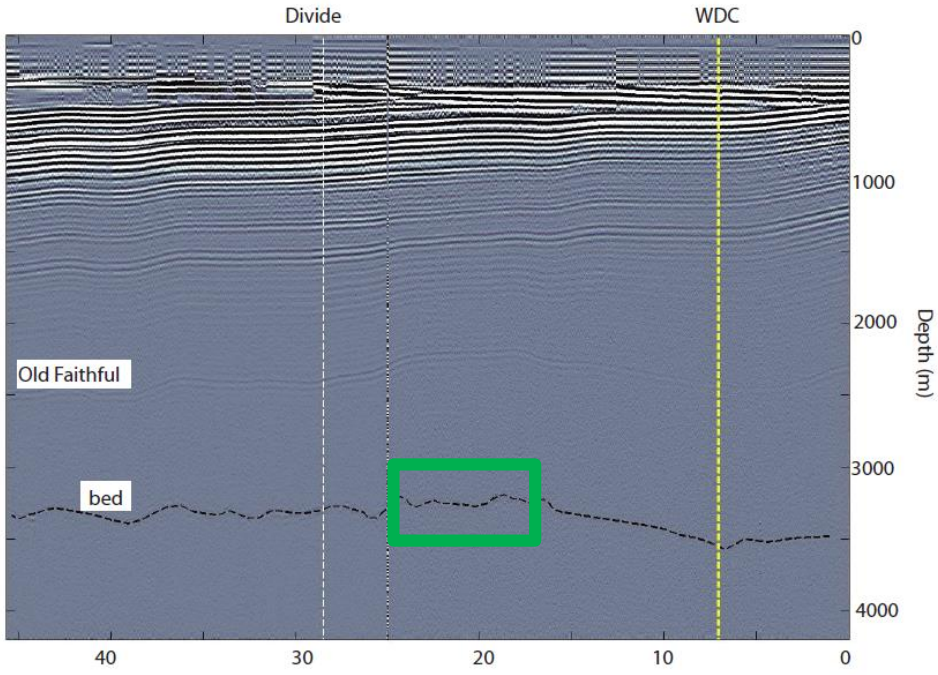
Stability of West Antarctica

But then we drilled 70 m more of ice

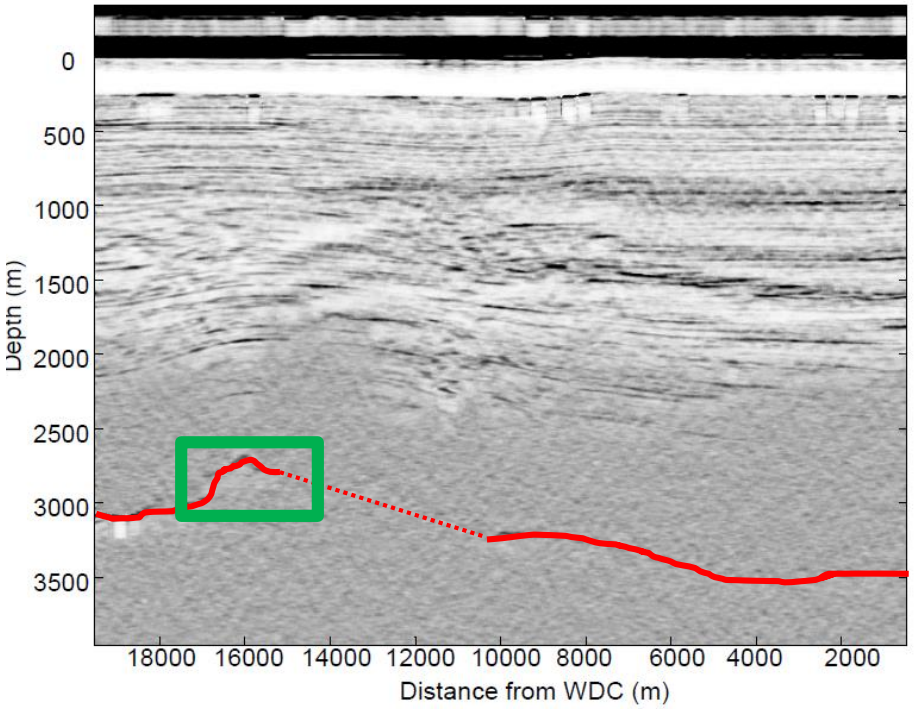
And the deep layers are strained more than expected



Stability of West Antarctica



a Distance along radar line (km)



Complex basal topography may be complicating analyses

Definitely melting, but by how much?
Geothermal flux between 100 and 200 mW m^{-2}

Future Ice Coring Efforts

Funded
2014/2015 and 2015/2016 – 1500 m South Pole Ice Core

In planning
2018 – Previous Interglacial (Hercules Dome) deep core
2022 – Amundsen Coast change (Coastal Domes)
2024 – 1.5 Million Year Old Ice

Art

WAIS Divide Reliquary

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