Reconstructing 250 years of snow accumulation over West Antarctica

Brooke Medley[1], Liz Thomas[2]

[1]NASA GSFC, [2]BAS

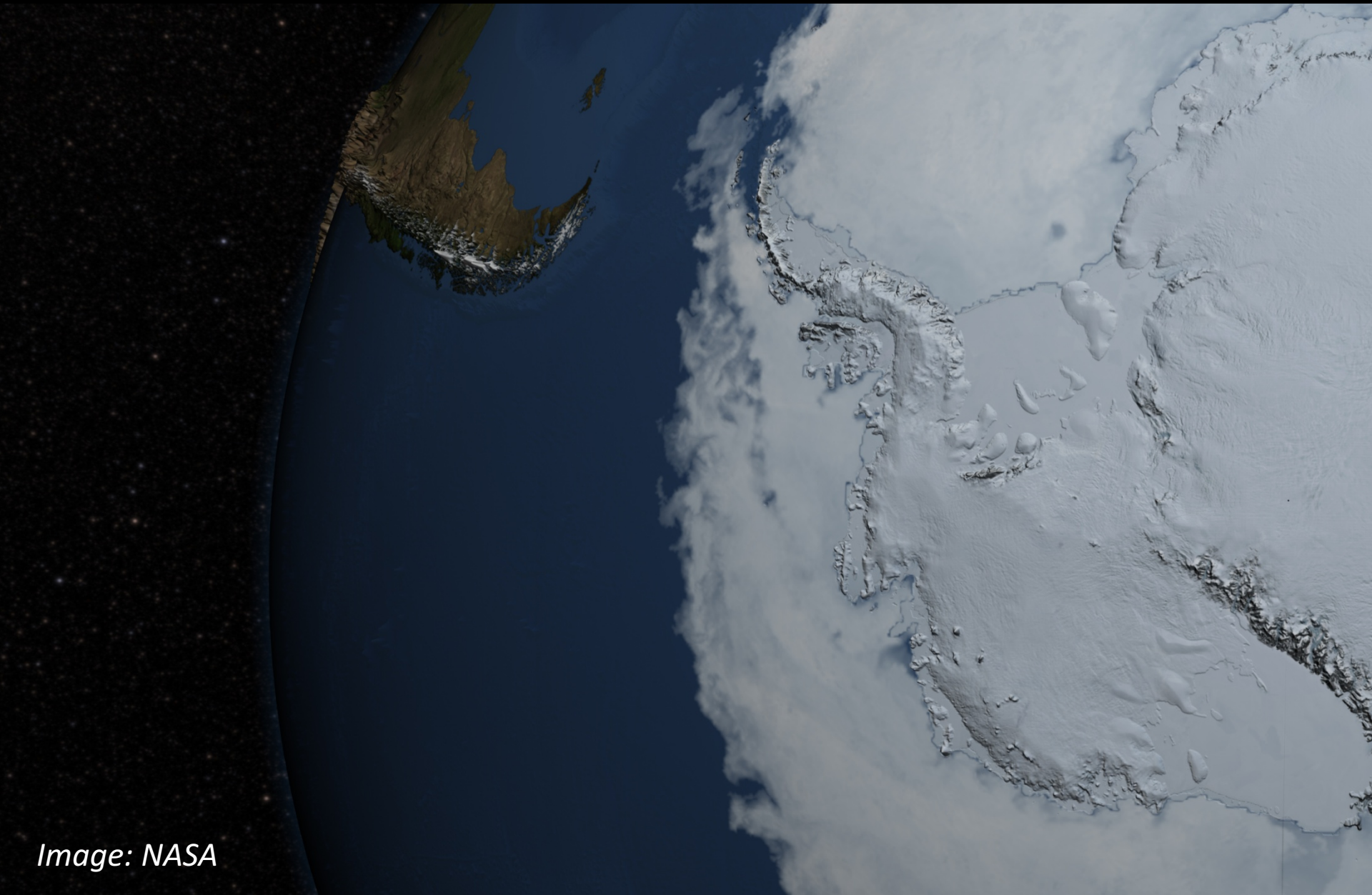
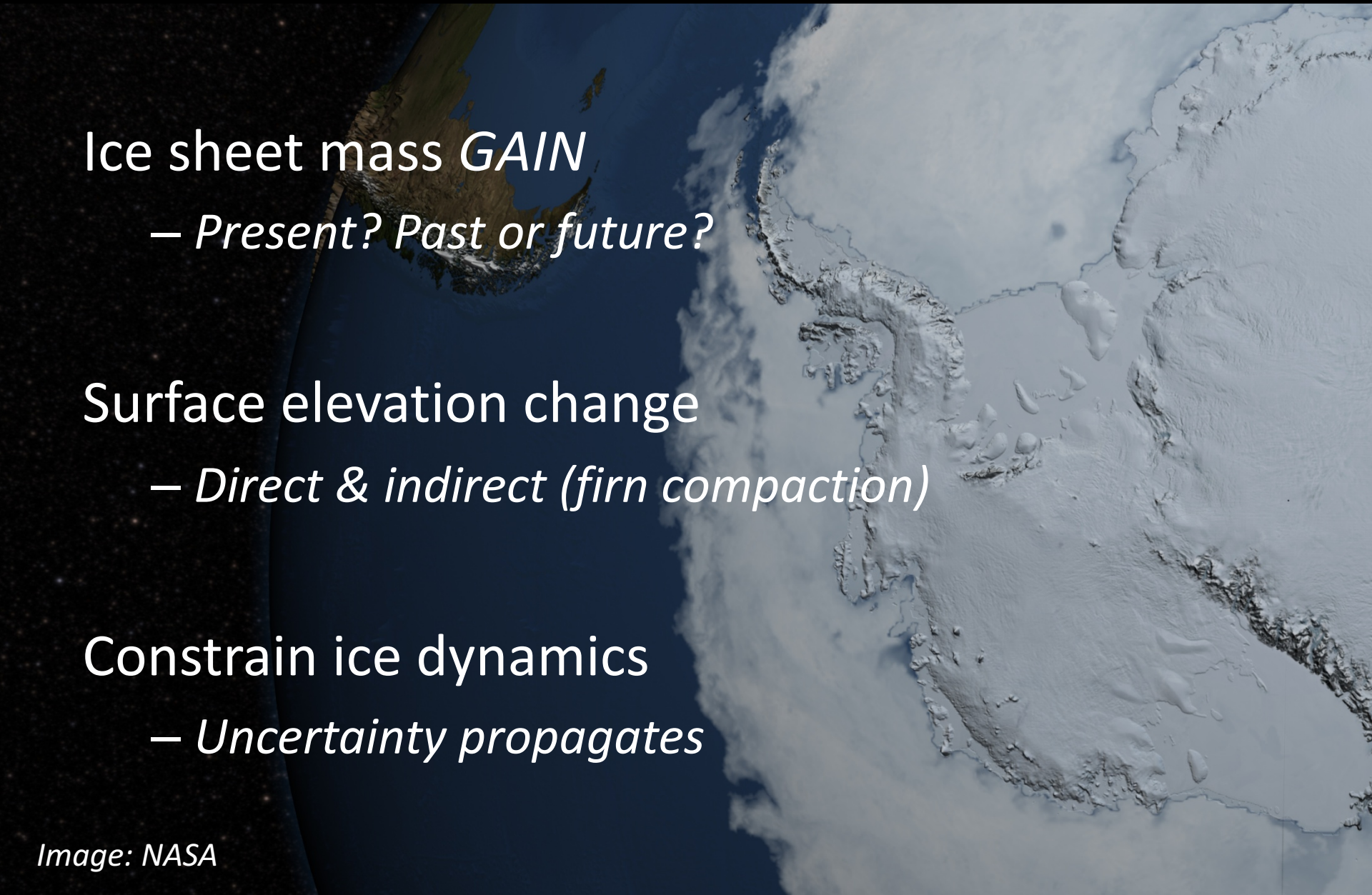


Image: NASA

A key component



Ice sheet mass *GAIN*

– *Present? Past or future?*

Surface elevation change

– *Direct & indirect (firn compaction)*

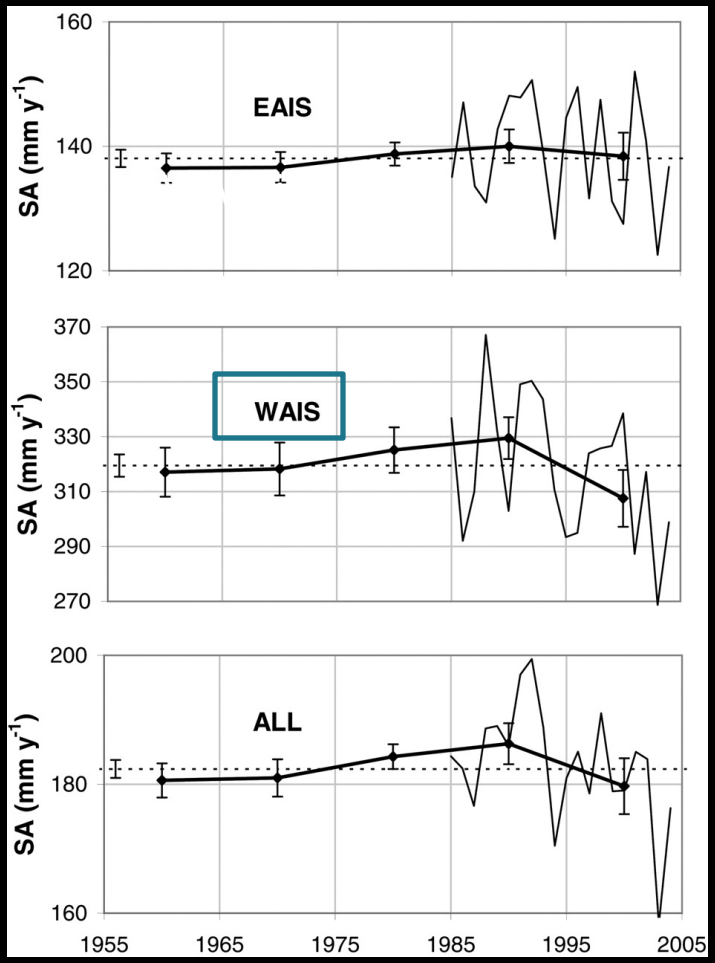
Constrain ice dynamics

– *Uncertainty propagates*

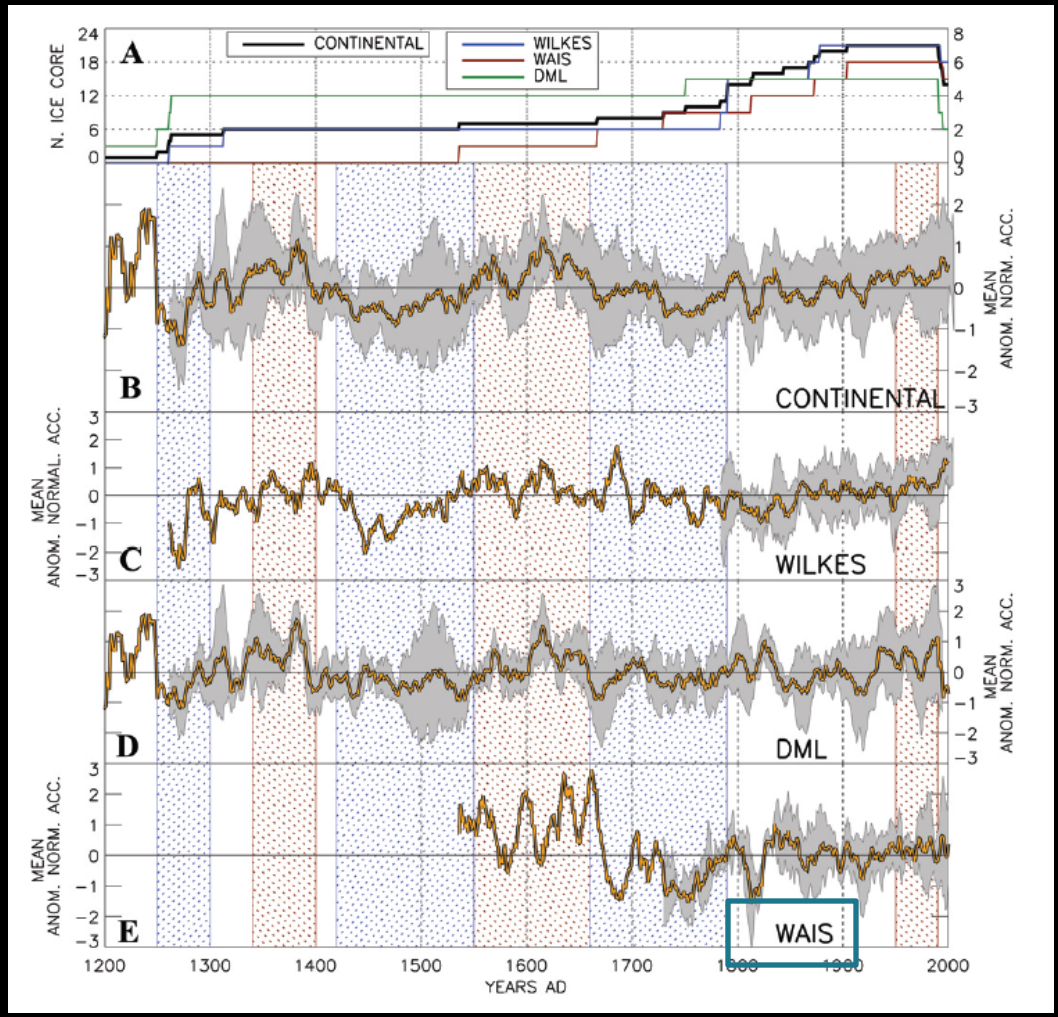
Image: NASA

What do we know?

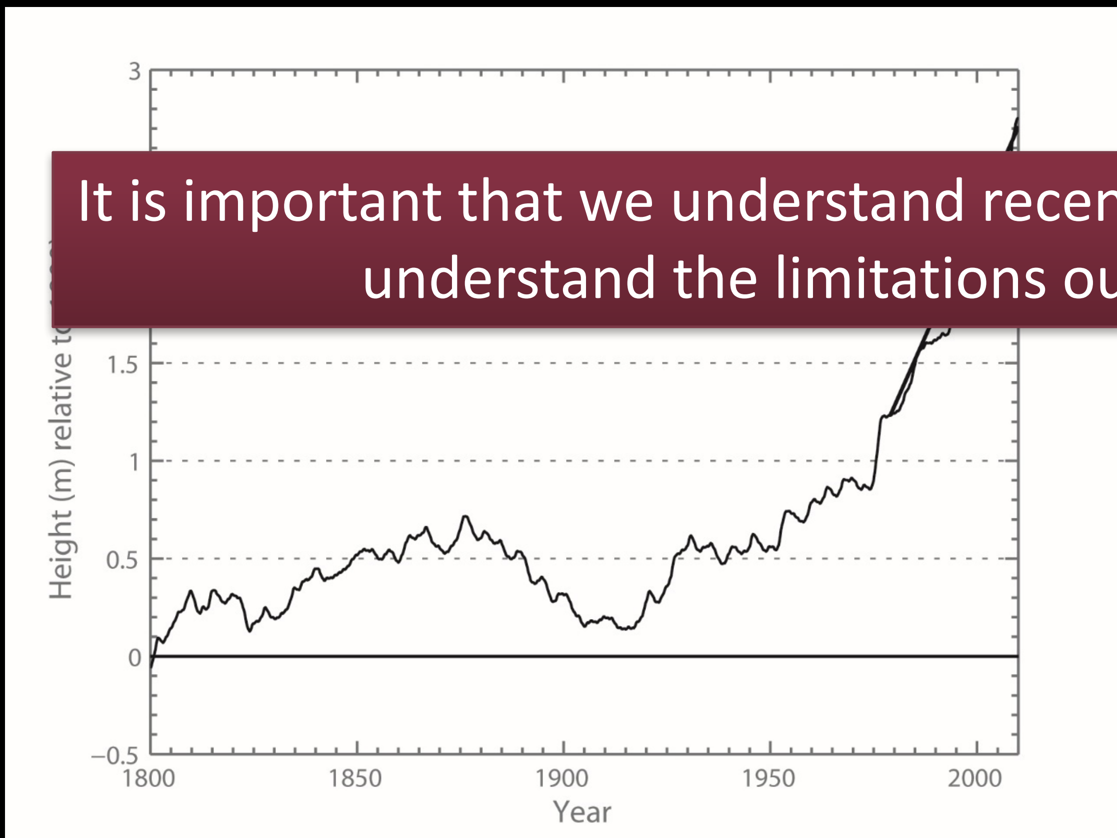
Monaghan et al., *Science*, 2006



Frezzotti et al., *Cryosphere*, 2013



Firn has a memory ☹



arly 2000 years,

Height change derived using the IMAU-FDM forced by the firn

It is important that we understand recent surface changes, so we understand the limitations our techniques!

1979-2010: +4.7 cm/year

This trend is NOT PRESENT when simply using the 1979-2010 surface climate to force the FDM

Monaghan *et al.* (2006) technique

Create a gridded accumulation product through combination of firn core records & atmospheric fields

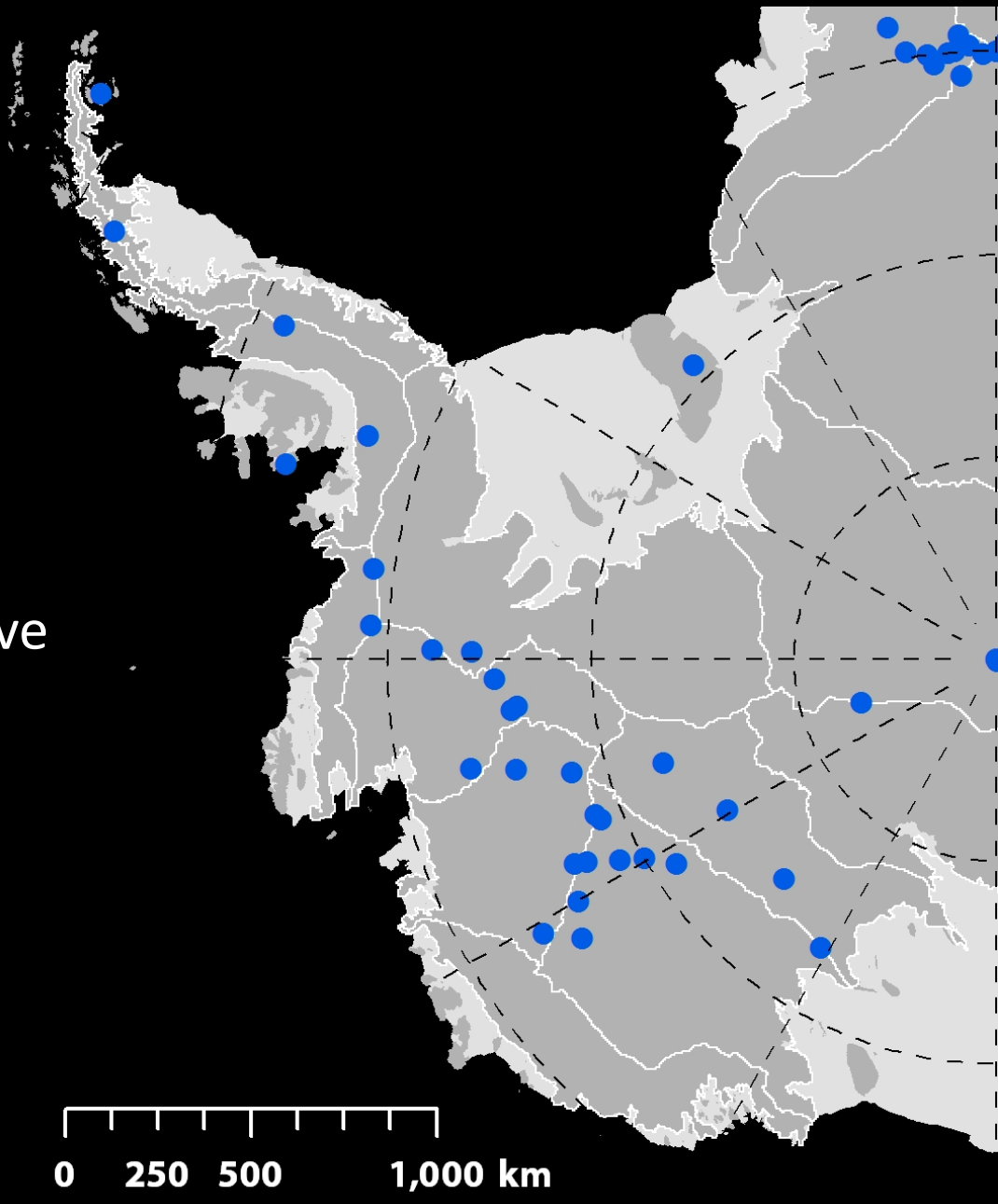
Time → cores

Space → atmospheric grids

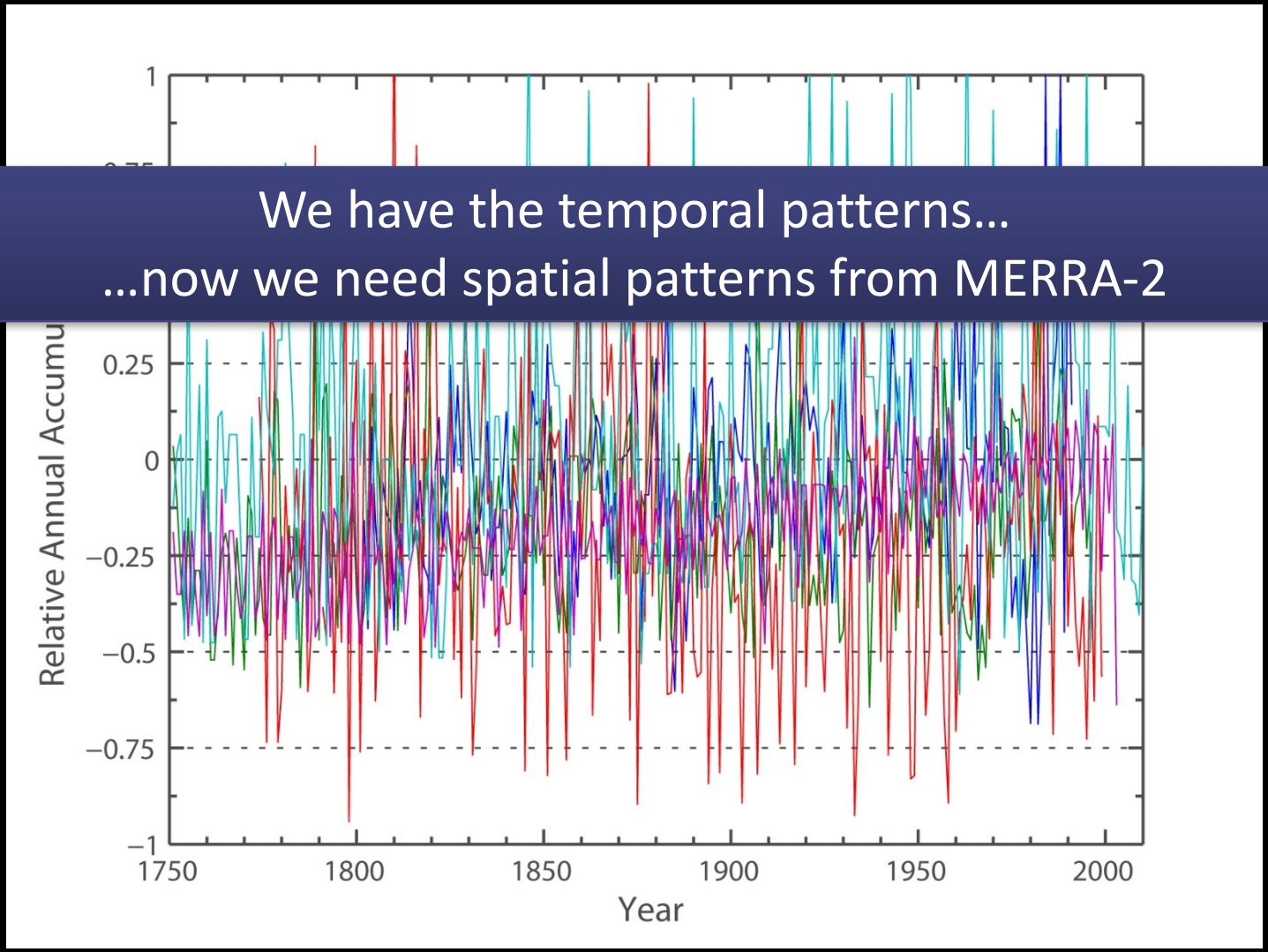
The result: Annual grids of accumulation since 1750

Core Data Set

- 81 annually resolved records (WAIS, EAIS, AP)
  - ~30 from WAIS
- Normalized records relative to the 1980-1989 avg

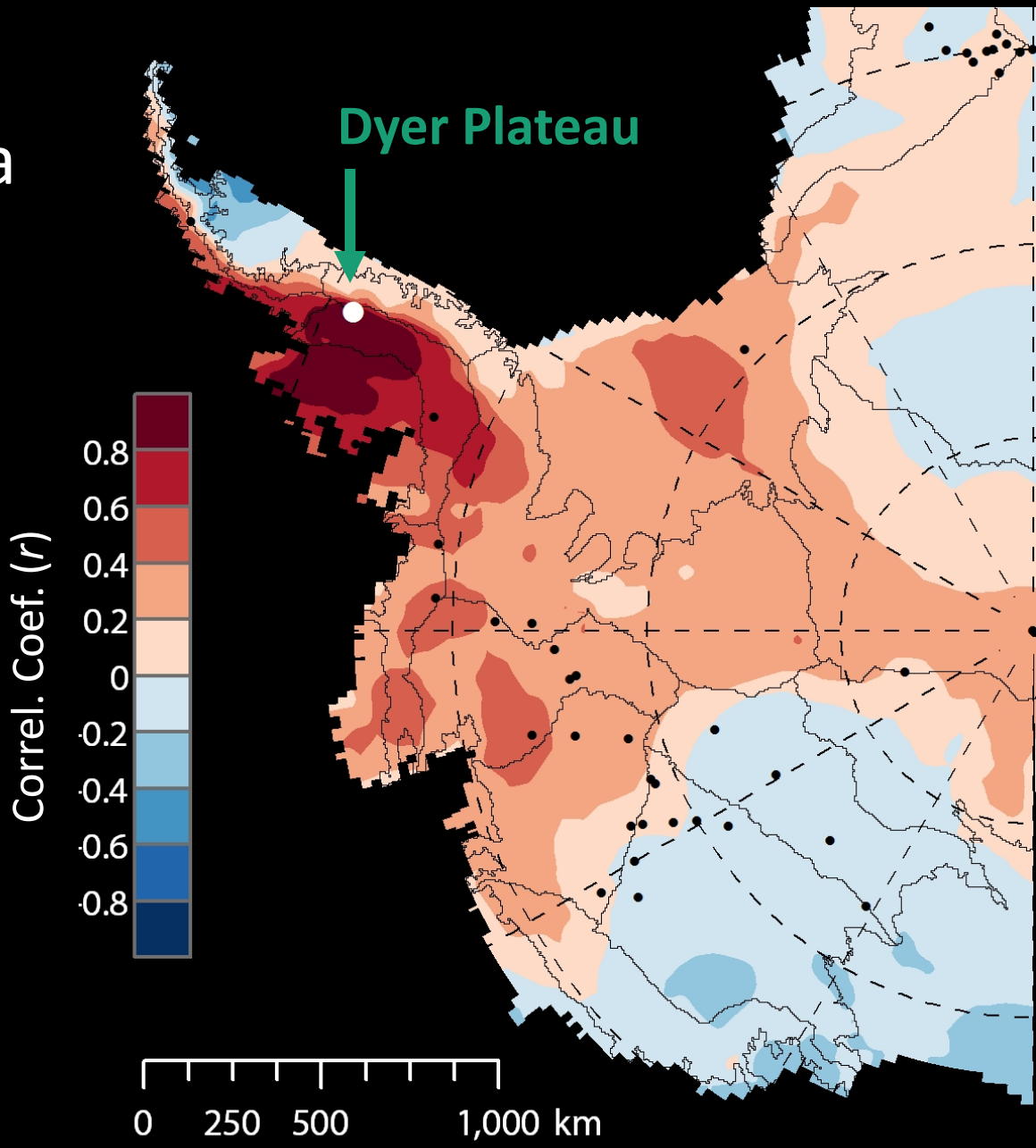


Five sample core records



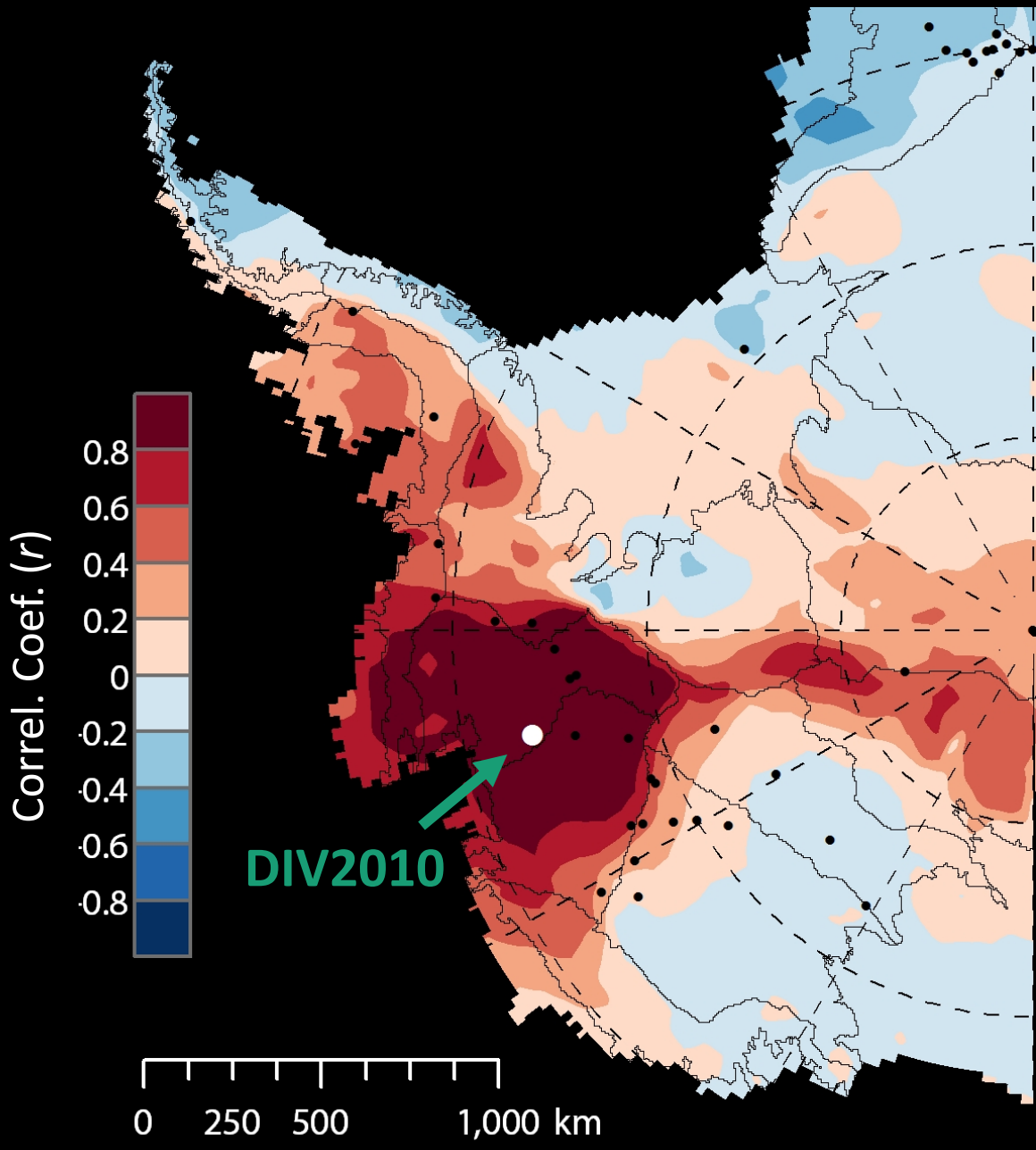
Correlation Map: Antarctic Peninsula

- Derive a correlation map for each core
- Used to take a weighted average of all records for each cell



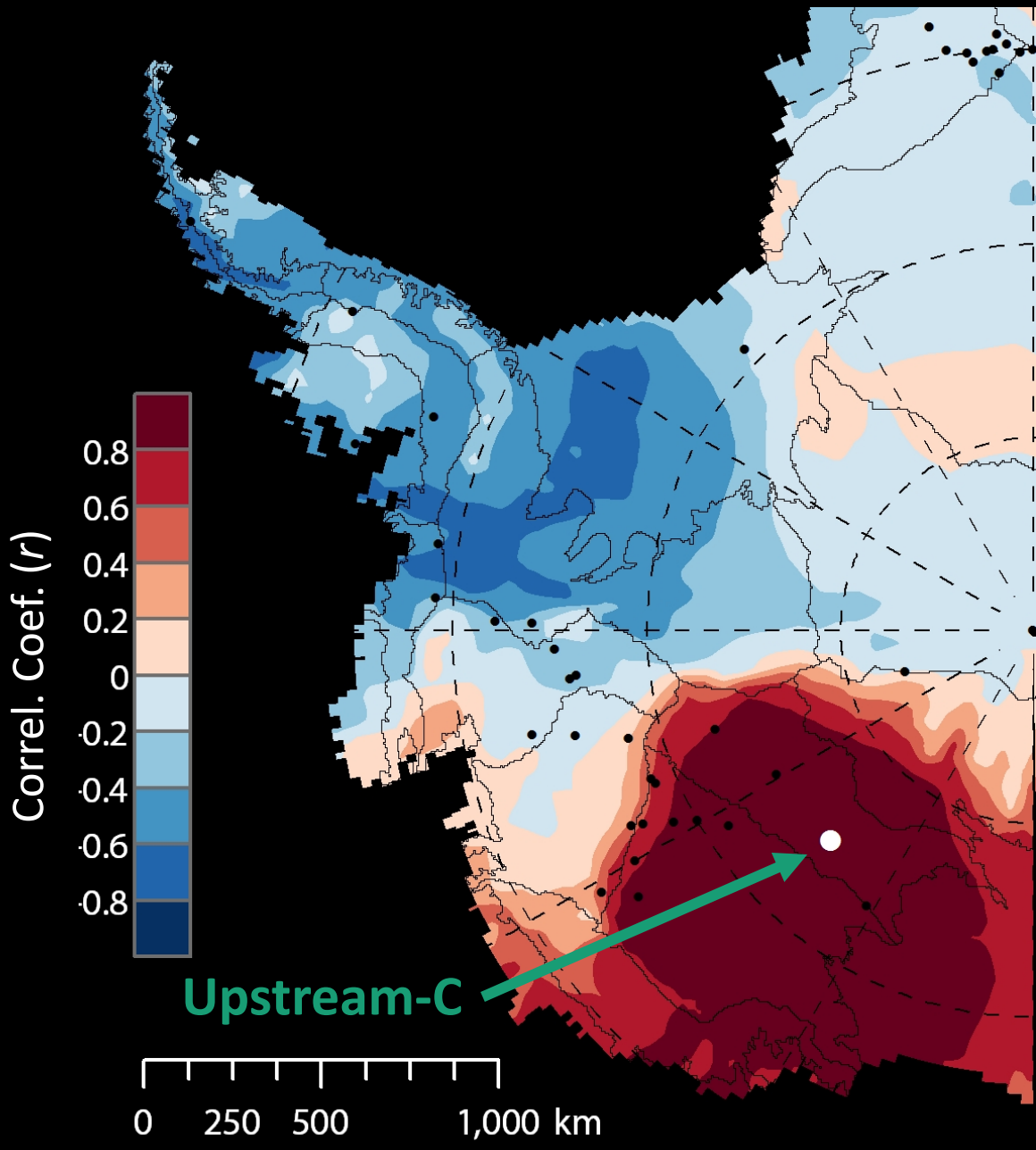
Correlation Map: Central WAIS

- Strongly related to drainage divides
- Connection to South Pole



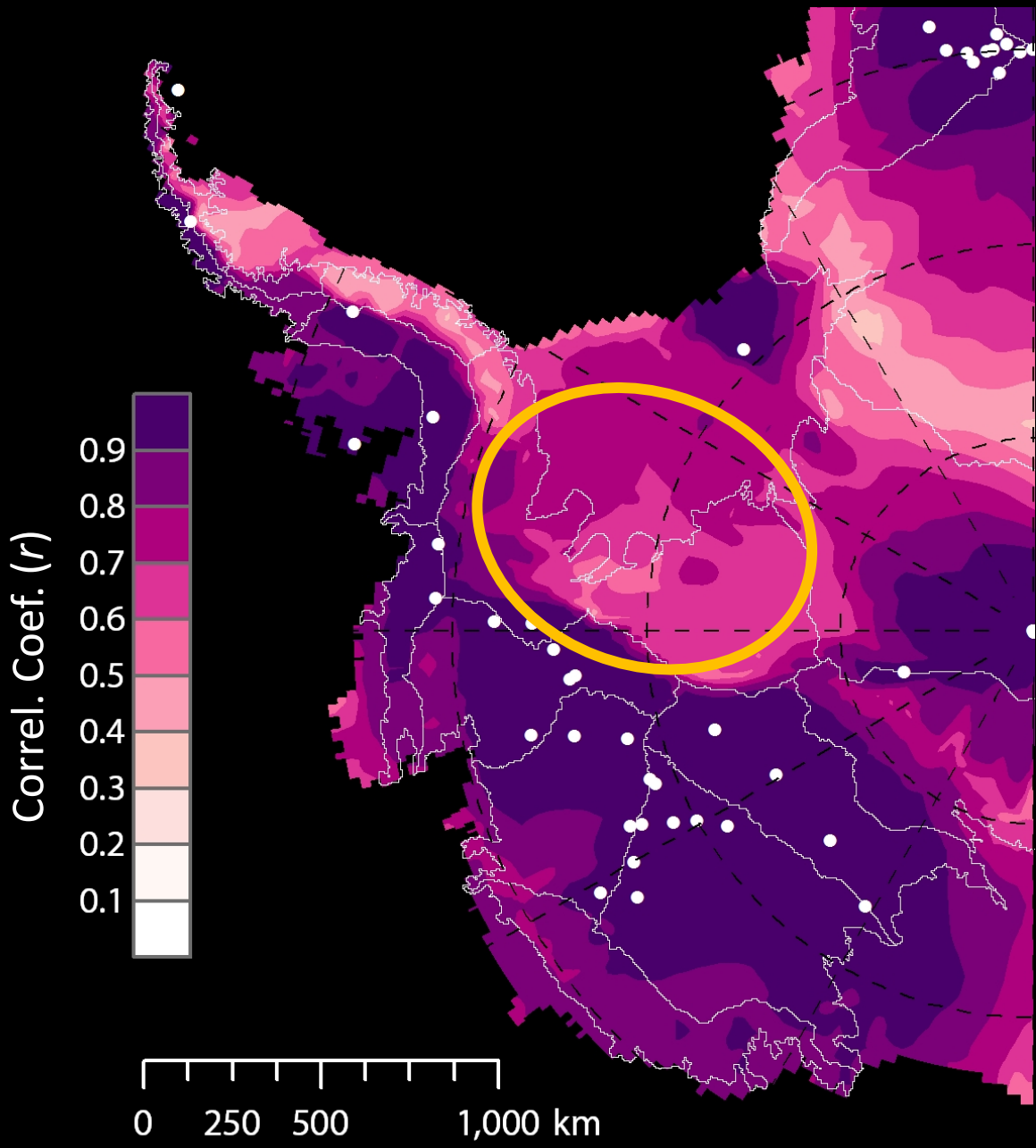
Correlation Map: Western WAIS

- Seesaw pattern with Eastern WAIS and AP



Maximum Correlation

- Max correlation with one of the cores
- Do our core records cover most of WAIS?
  - Yes!
- Need some cores? Or we're missing some!



- For each grid cell, weight *ALL* the core records by their r^2 values

- Creates 250-year time series for each grid cell!

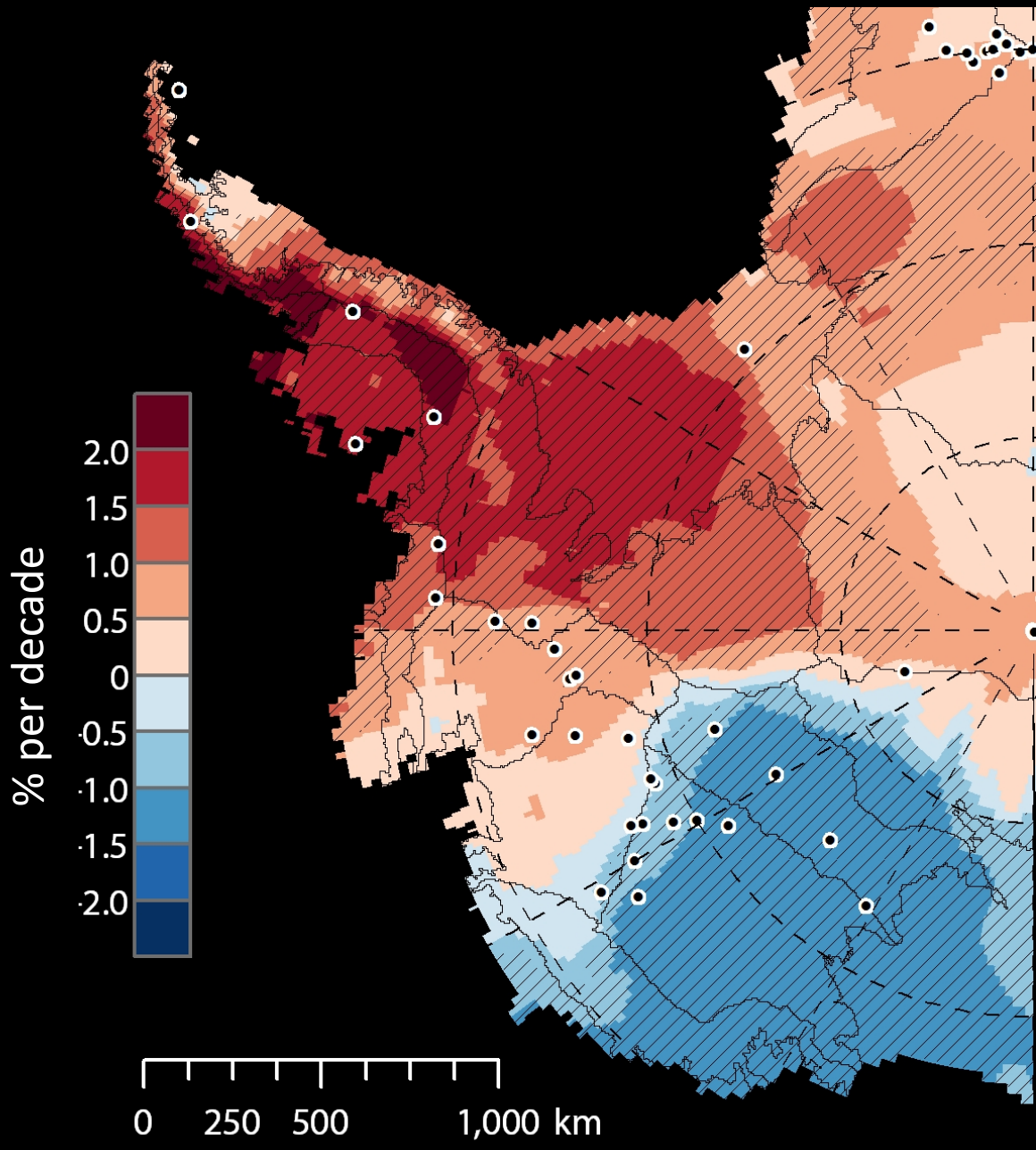
- Let's start with trends over the 20th century -

Century Trend: 1901-2000

Hatching: p-value < 0.01

Strong opposing trends between Eastern and Western WAIS

Not much change in central WAIS



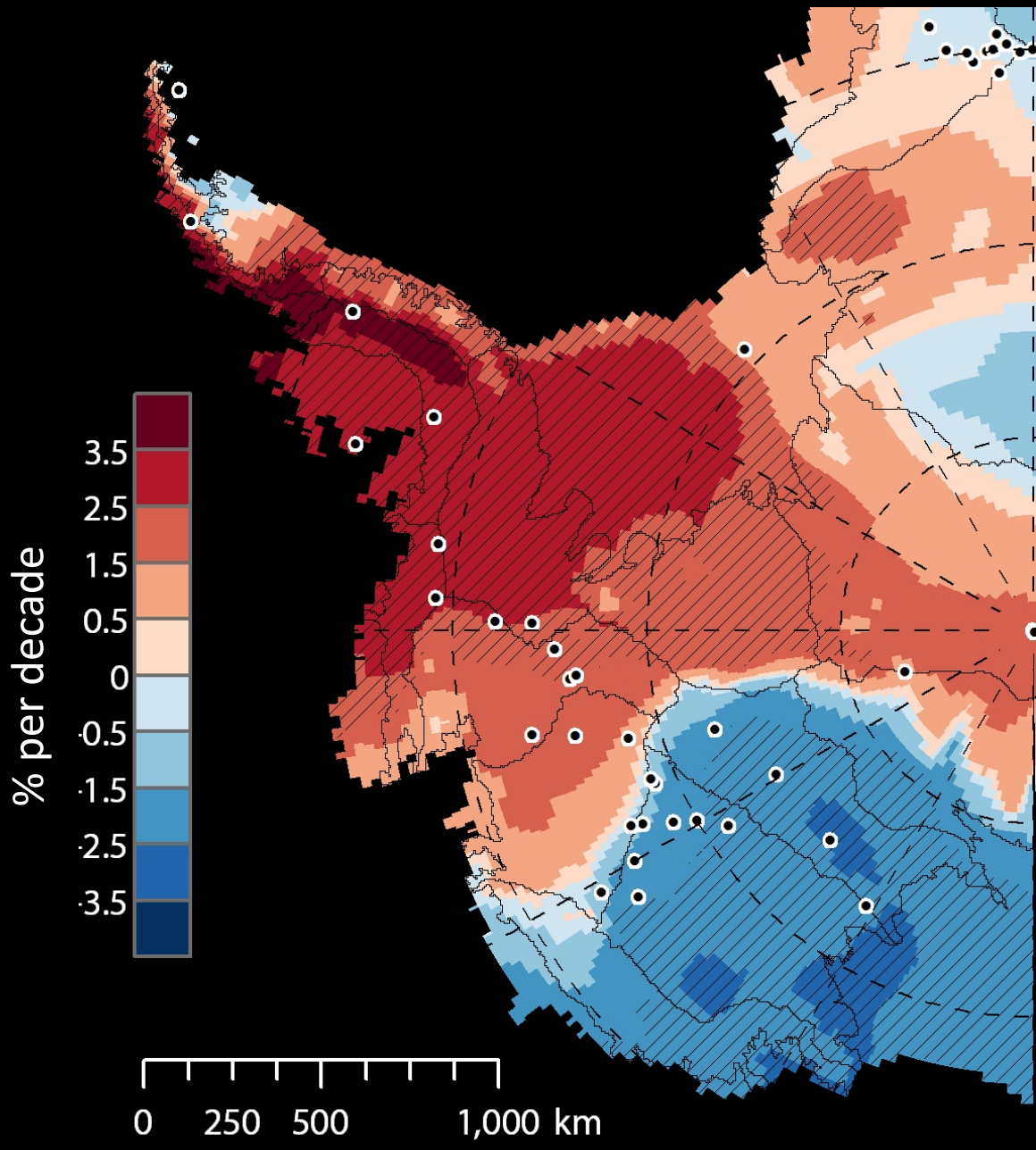
Mid-Century Trend: 1951-2000

Hatching: p-value < 0.01

Note scale change!

Strong(er) opposing trends between Eastern and Western WAIS

No significant change in central WAIS

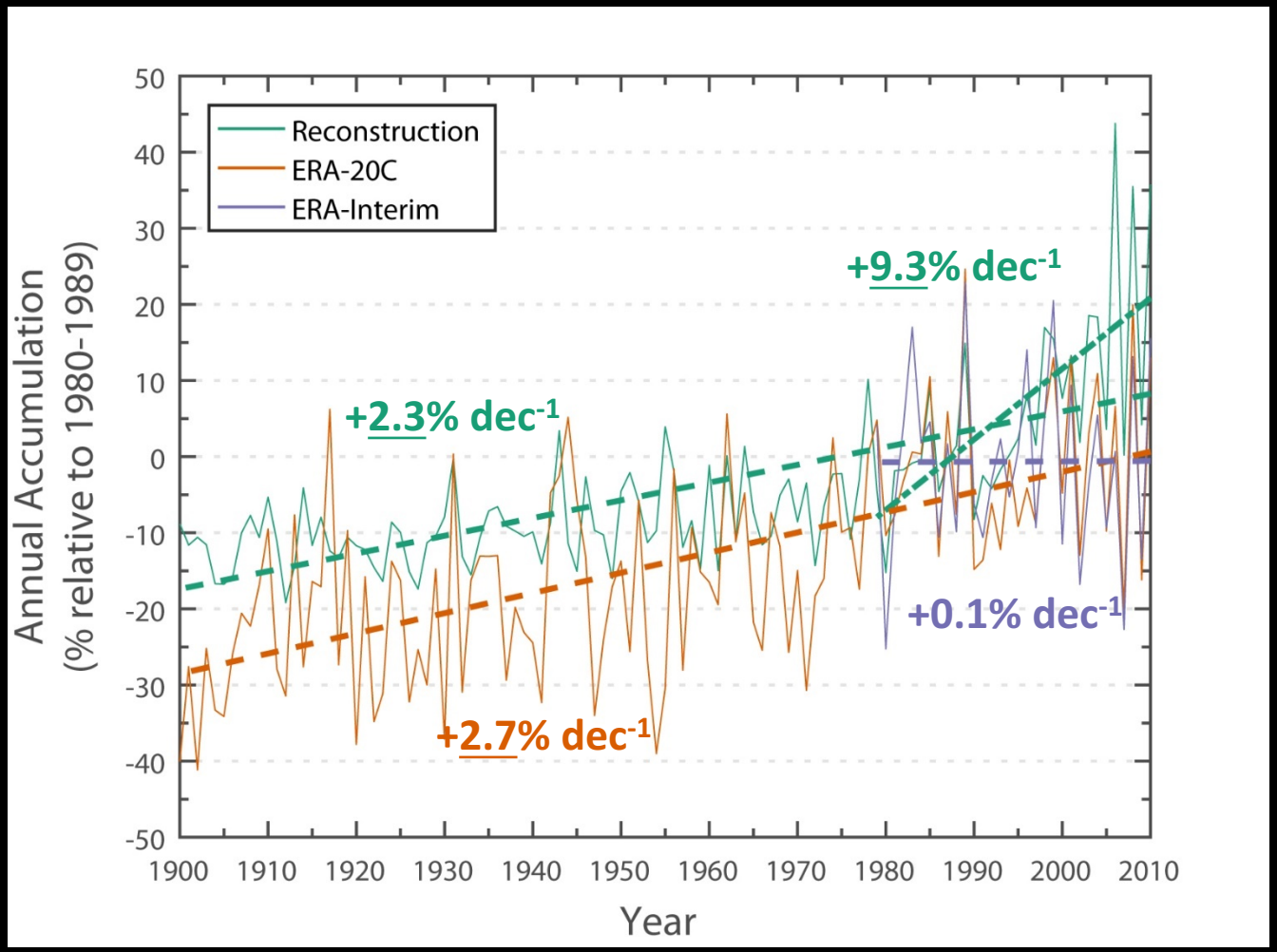


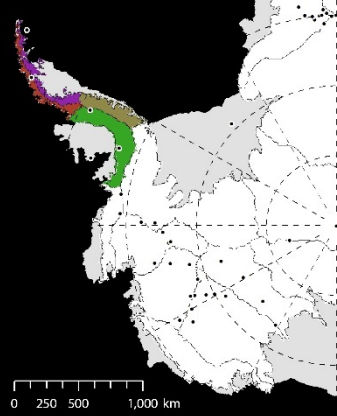
Comparisons with ECMWF products:

1. ERA-Interim reanalysis (1979-2015)
2. ERA-20C reanalysis (1900-2010)

   - Assimilated observations: surface pressure, winds (no satellite/upper-air data)

Antarctic Peninsula





Correlation Coef (*r*)

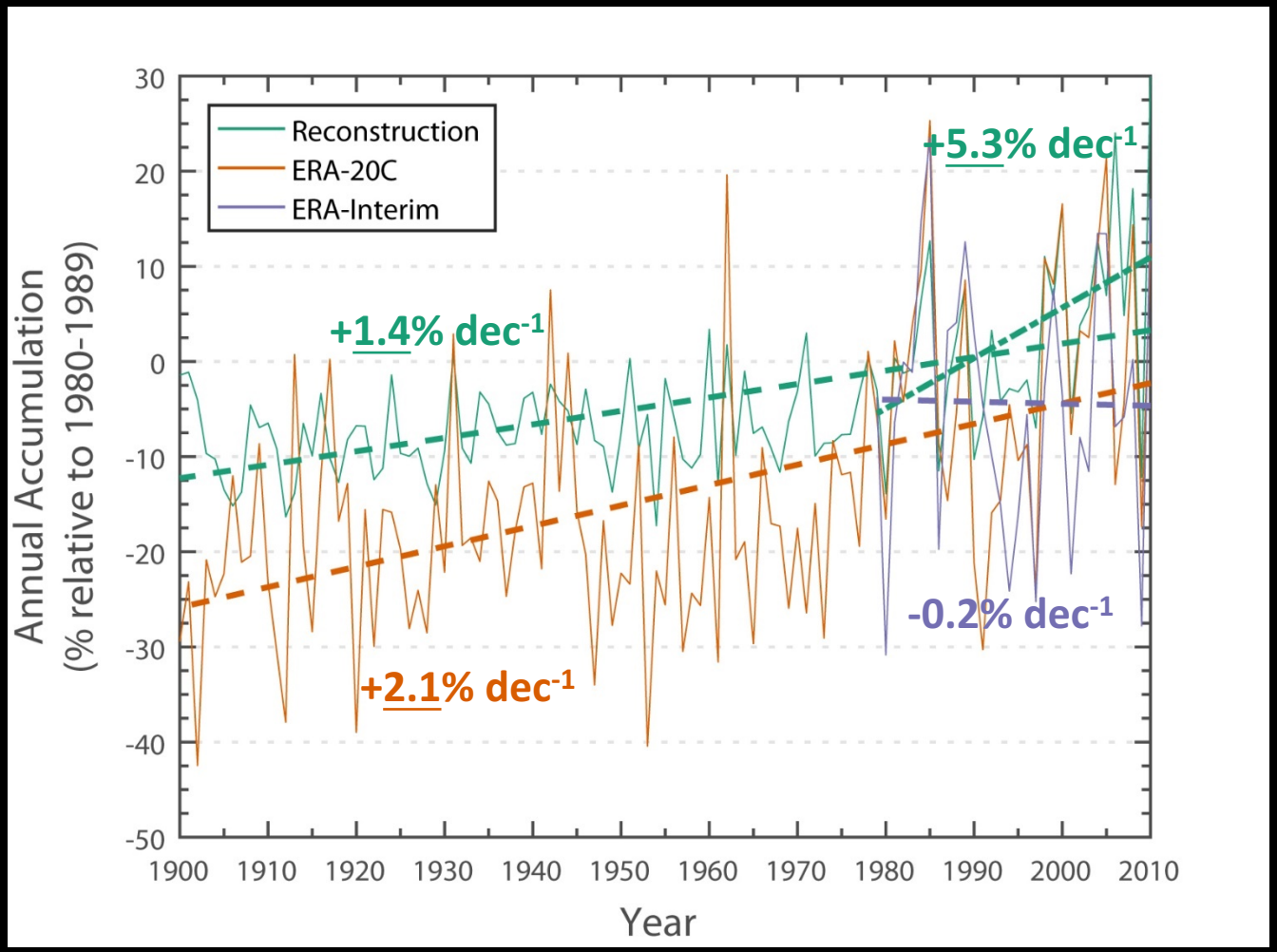
1900 – 2010:
0.44, p << 0.01

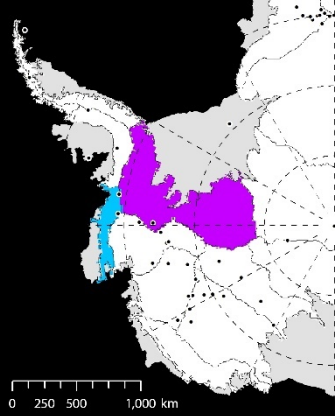
1979 – 2010:
0.68, p << 0.01

Based off of detrended time series

Underline: p < 0.01

Eastern WAIS





Correlation Coef (*r*)

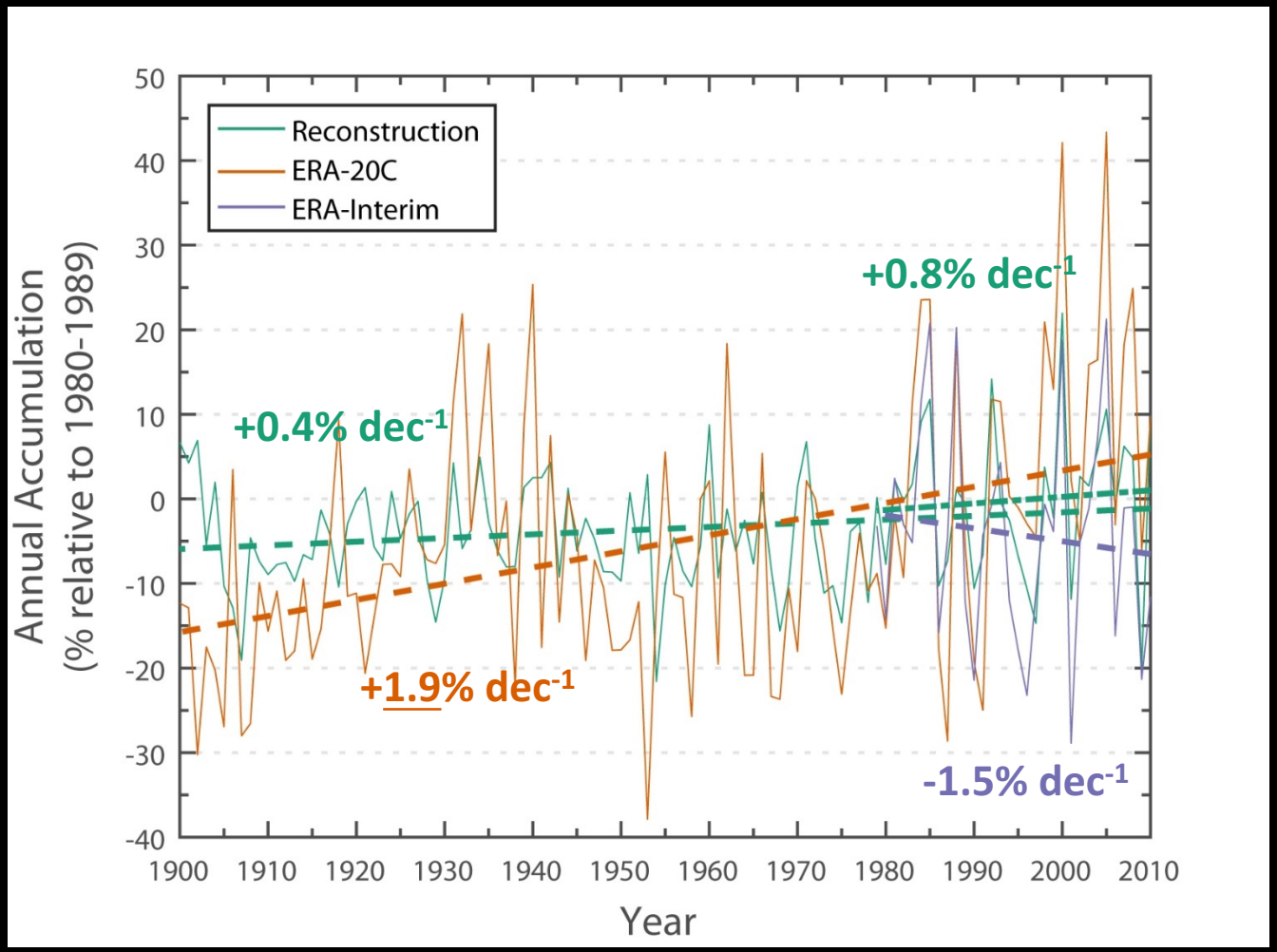
1900 – 2010:
0.49, p << 0.01

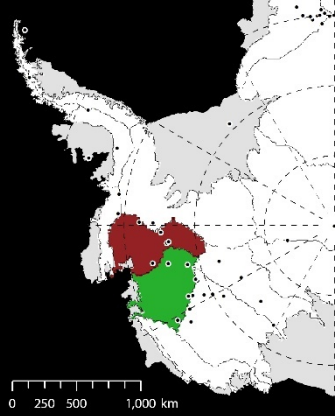
1979 – 2010:
0.73, p << 0.01

Based off of detrended time series

Underline: p < 0.01

Central WAIS





Correlation Coef (*r*)

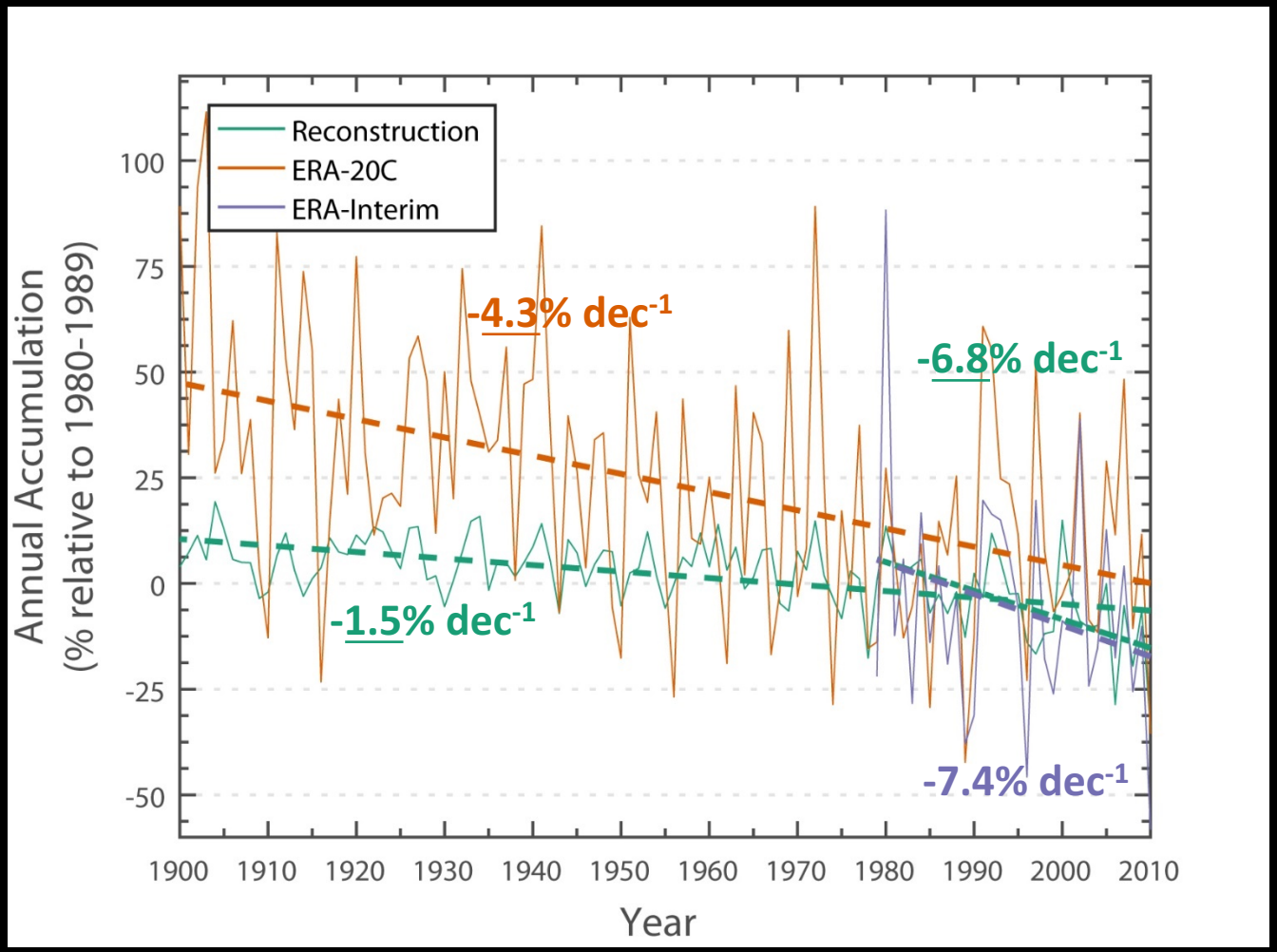
1900 – 2010:
0.51, p << 0.01

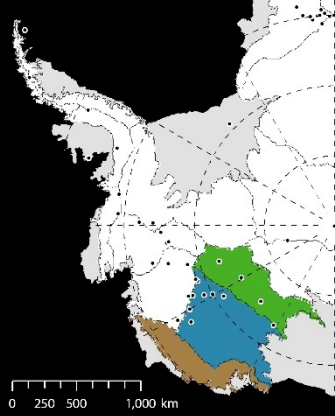
1979 – 2010:
0.78, p << 0.01

Based off of detrended time series

Underline: p < 0.01

Western WAIS





Correlation Coef (*r*)

1900 – 2010:
0.24, p = 0.01

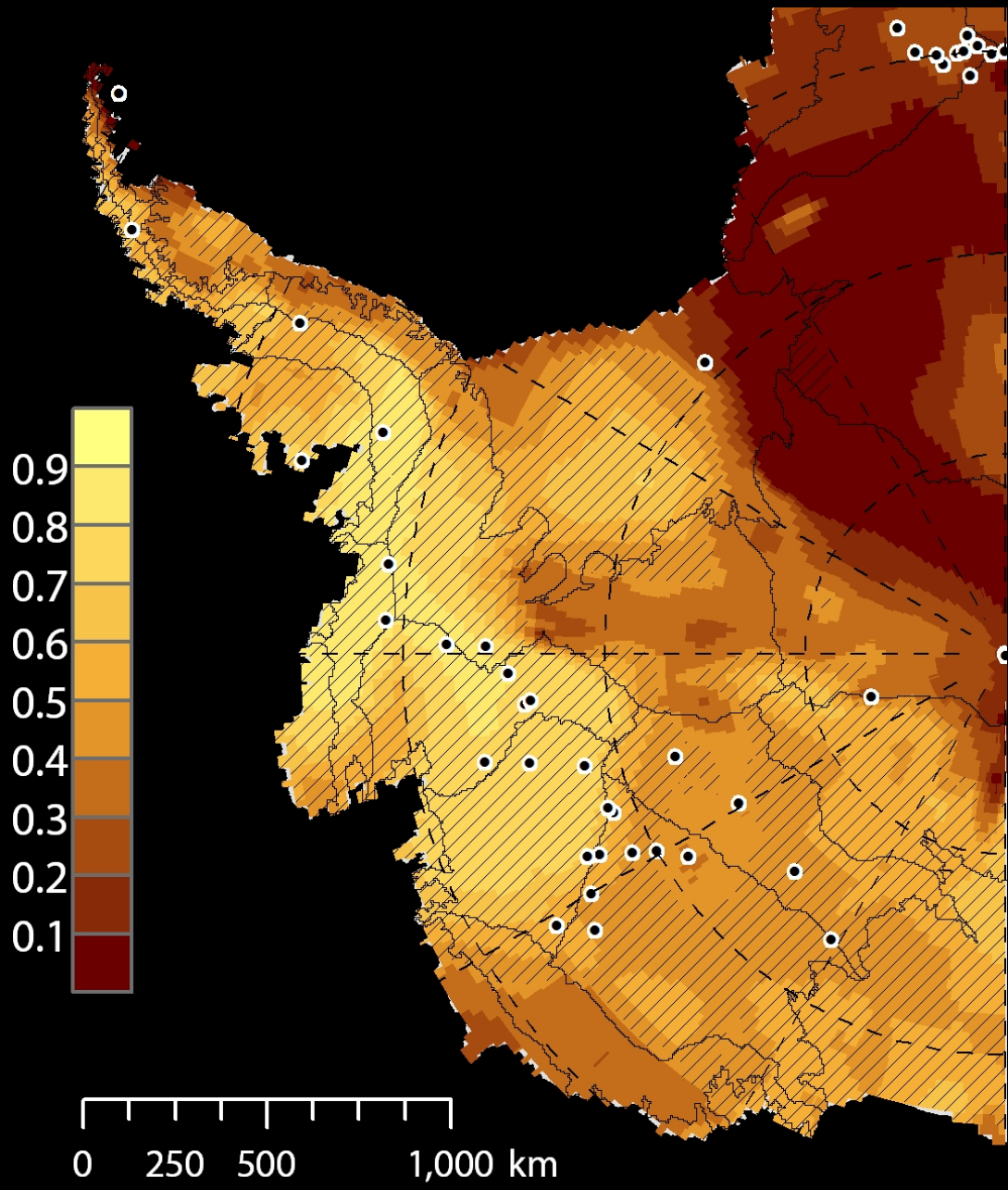
1979 – 2010:
0.48, p < 0.01

Based off of detrended time series

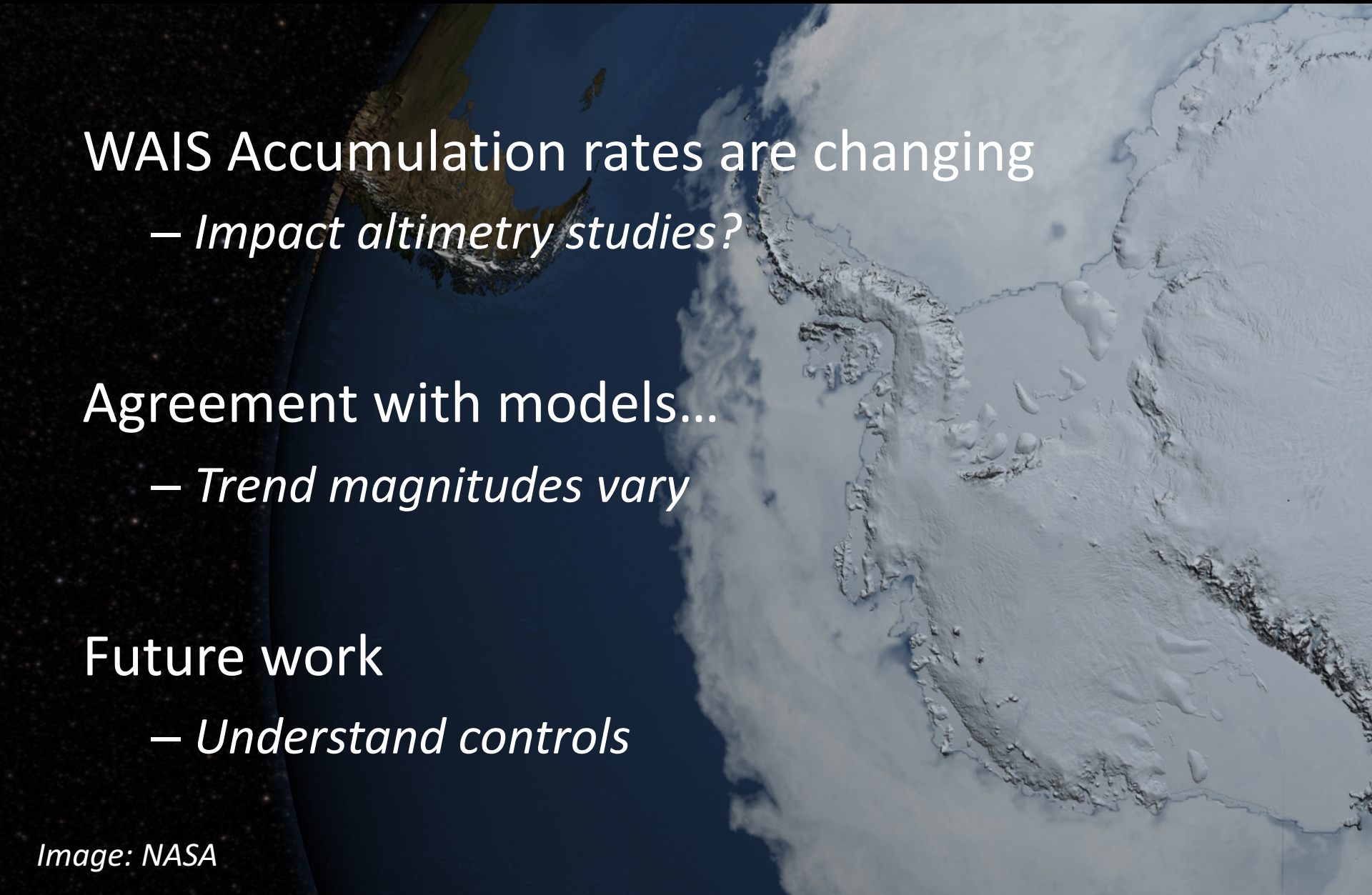
Underline: p < 0.01

Comparison with ERA-Interim

- Reconstruction is strongly correlated with ERA-Interim over most of WAIS
- Regions of low correlation are where cores are sparse
- Weaker correlation in W. WAIS is due to the lack of recent cores



Summary



WAIS Accumulation rates are changing

– *Impact altimetry studies?*

Agreement with models…

– *Trend magnitudes vary*

Future work

– *Understand controls*

Image: NASA

Thanks!

The many hardworking field/lab teams that collected/analyzed the firn cores

Stefan Ligtenberg, IMAU

WAIS Workshop Organizing Committee

NASA/NSF Funding