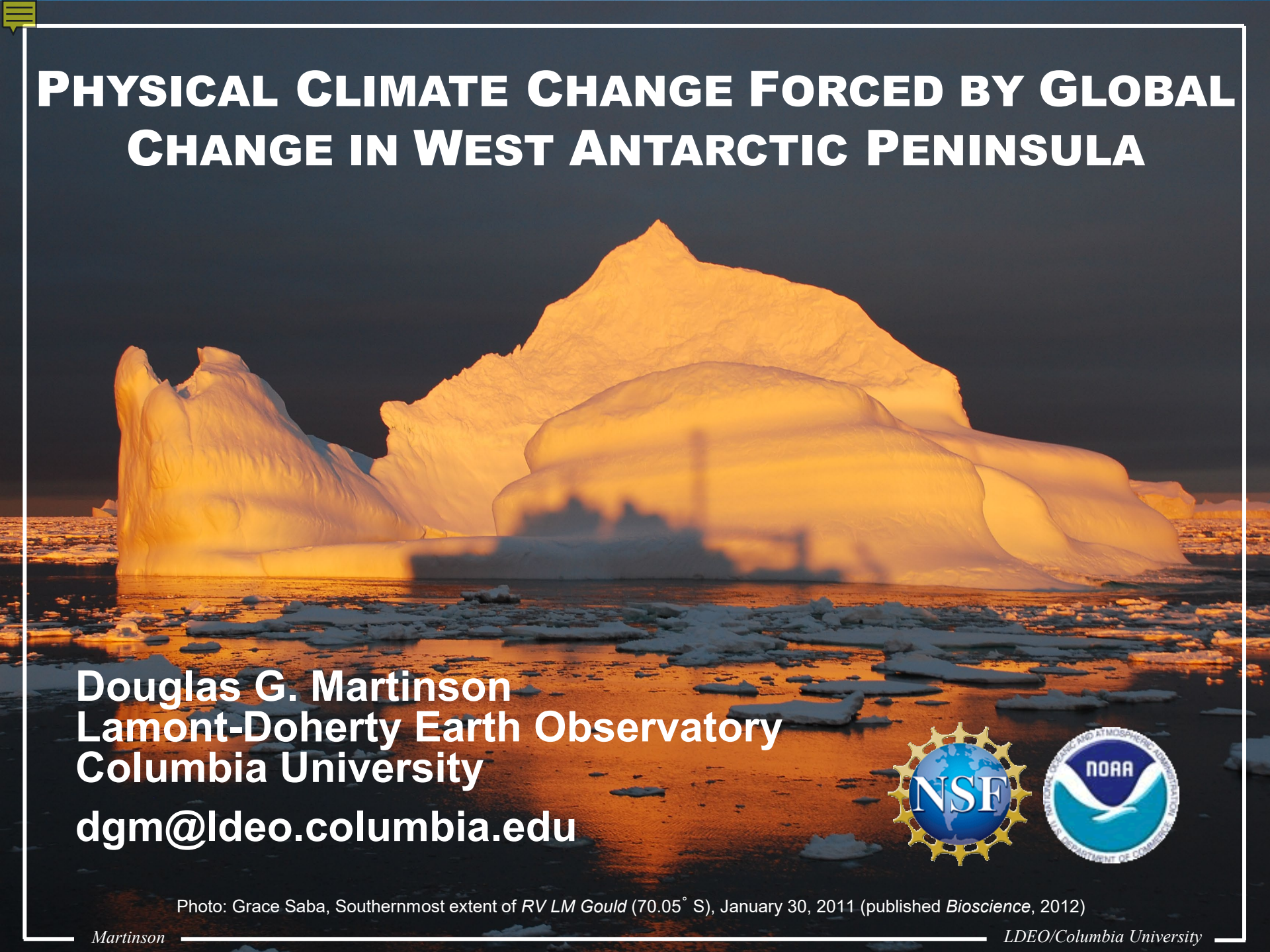
Physical Climate Change Forced by Global Change in West Antarctic Peninsula

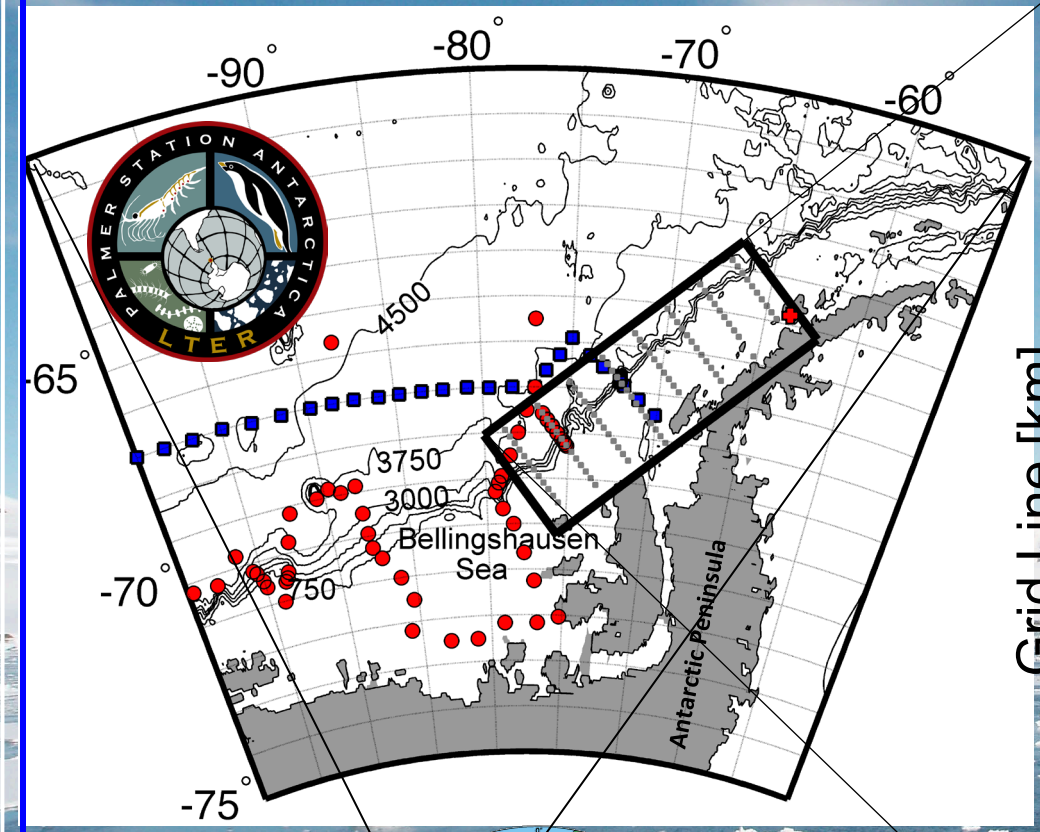


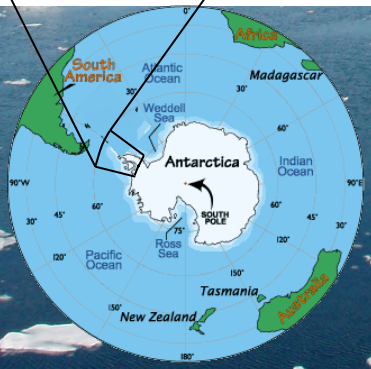
Douglas G. Martinson
Lamont-Doherty Earth Observatory
Columbia University

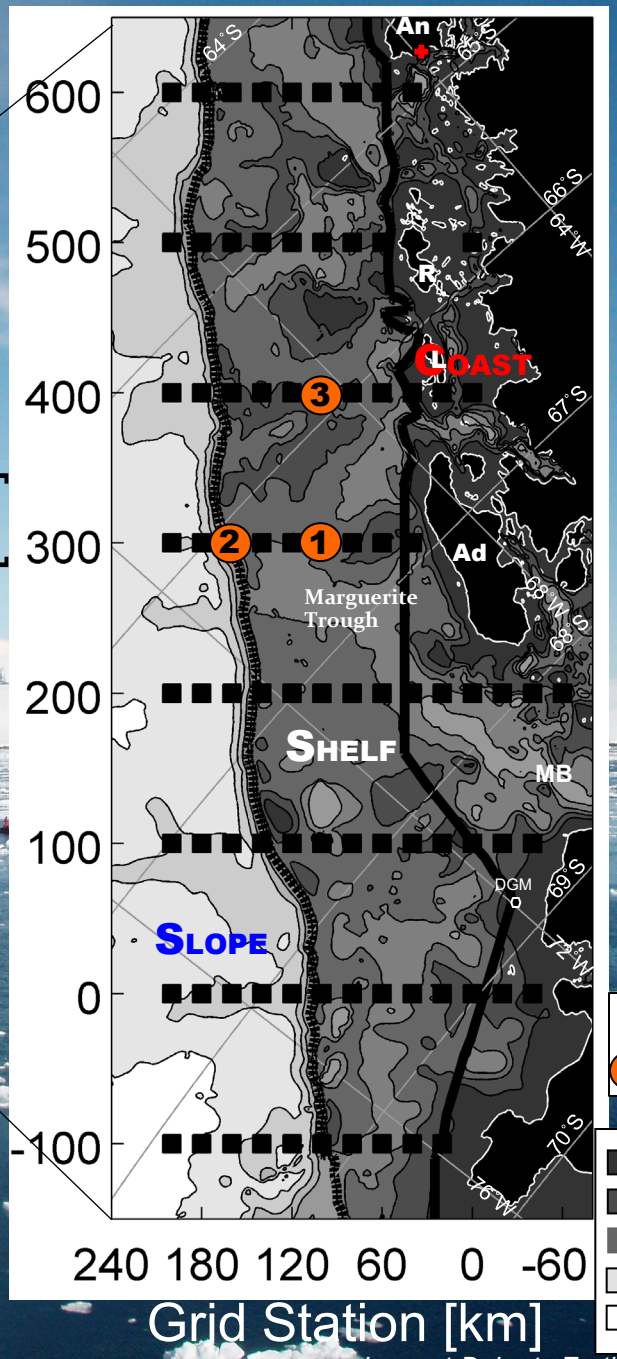
dgm@ldeo.columbia.edu

Photo: Grace Saba, Southernmost extent of *RV LM Gould* (70.05° S), January 30, 2011 (published *Bioscience*, 2012)

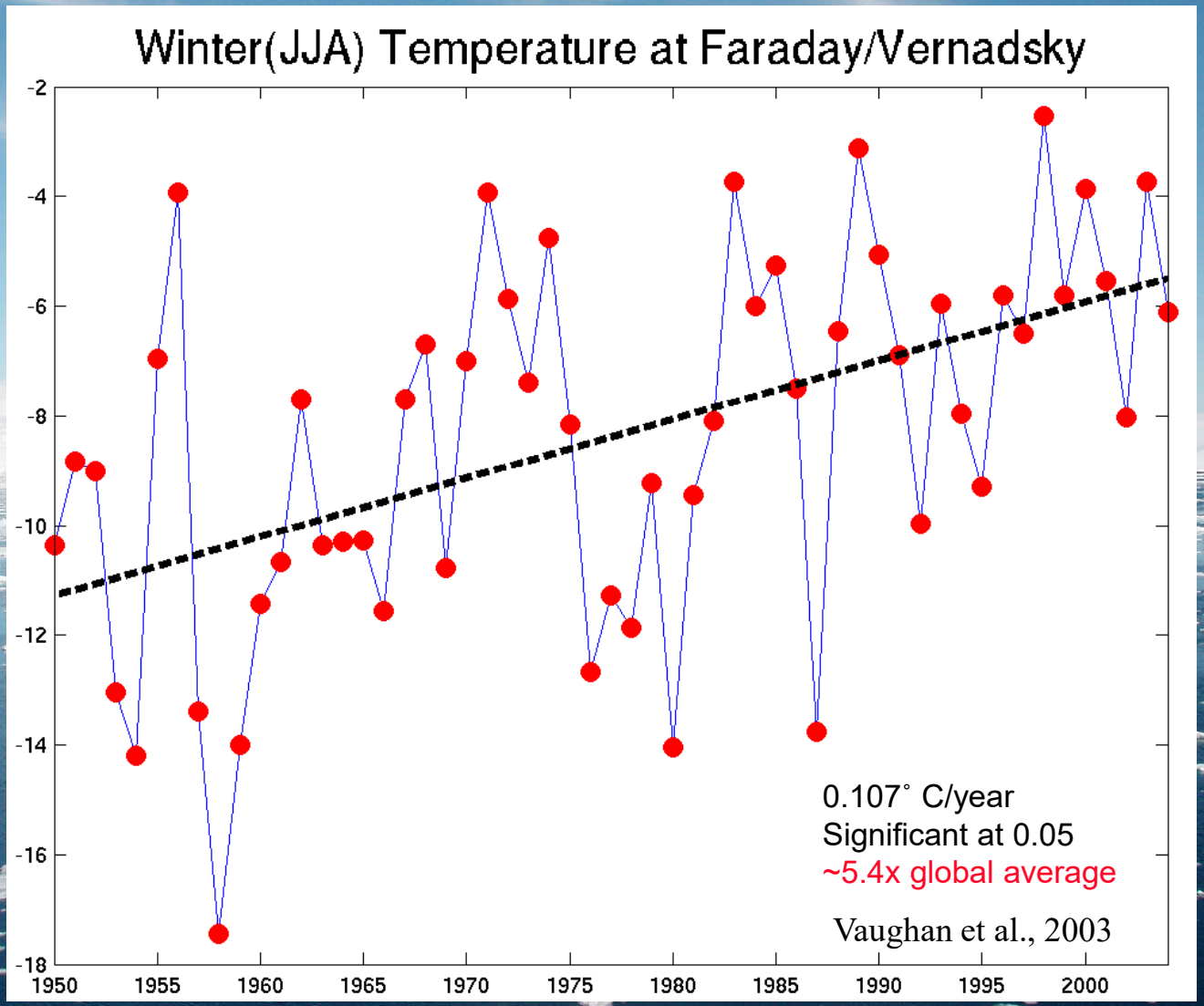
PAL LTER Grid (1992-present)
WOCE S04P: WAP ACC (February 1992)
NBP94-04: Bellingshausen Slope (March 1994)



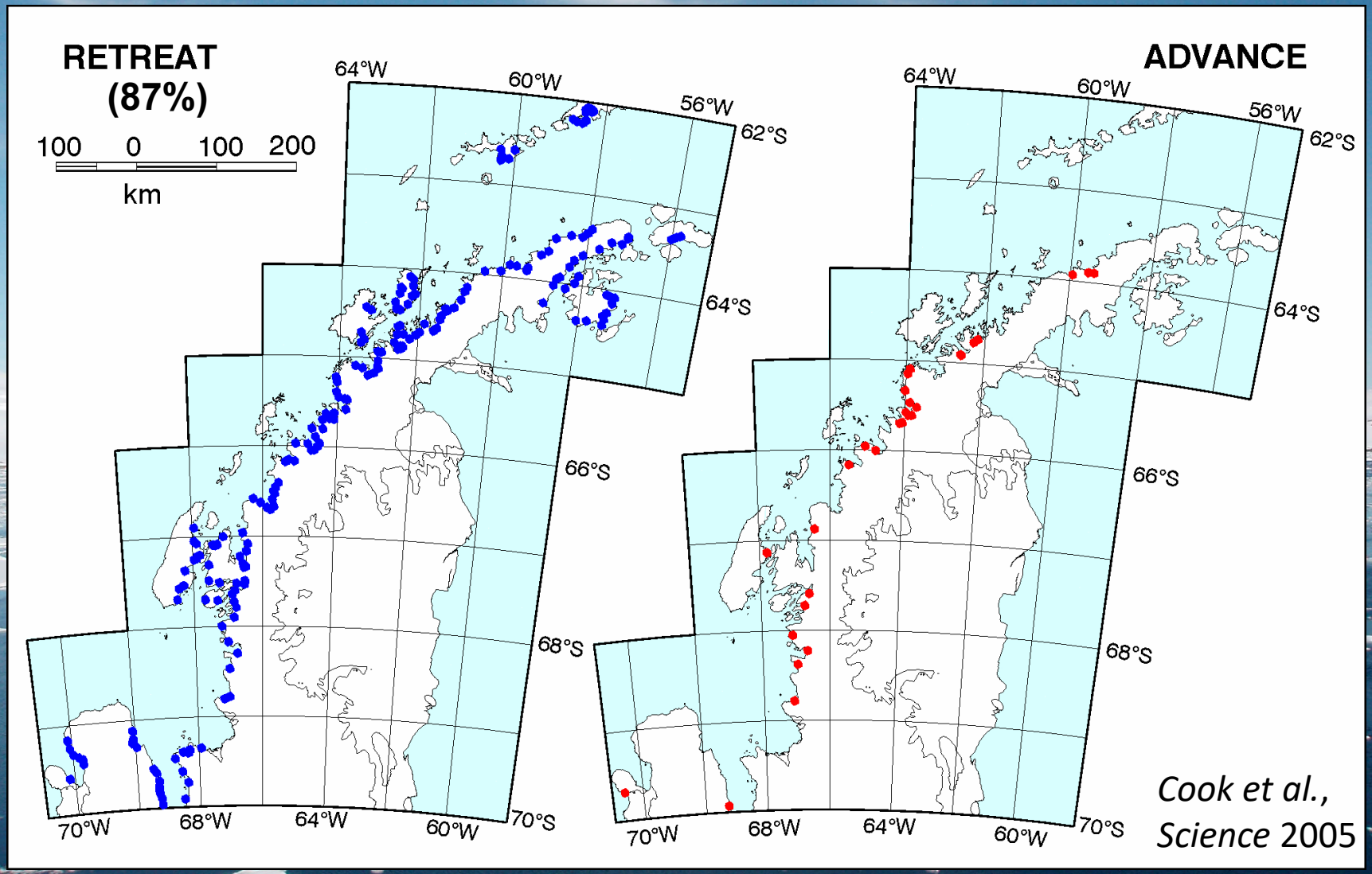




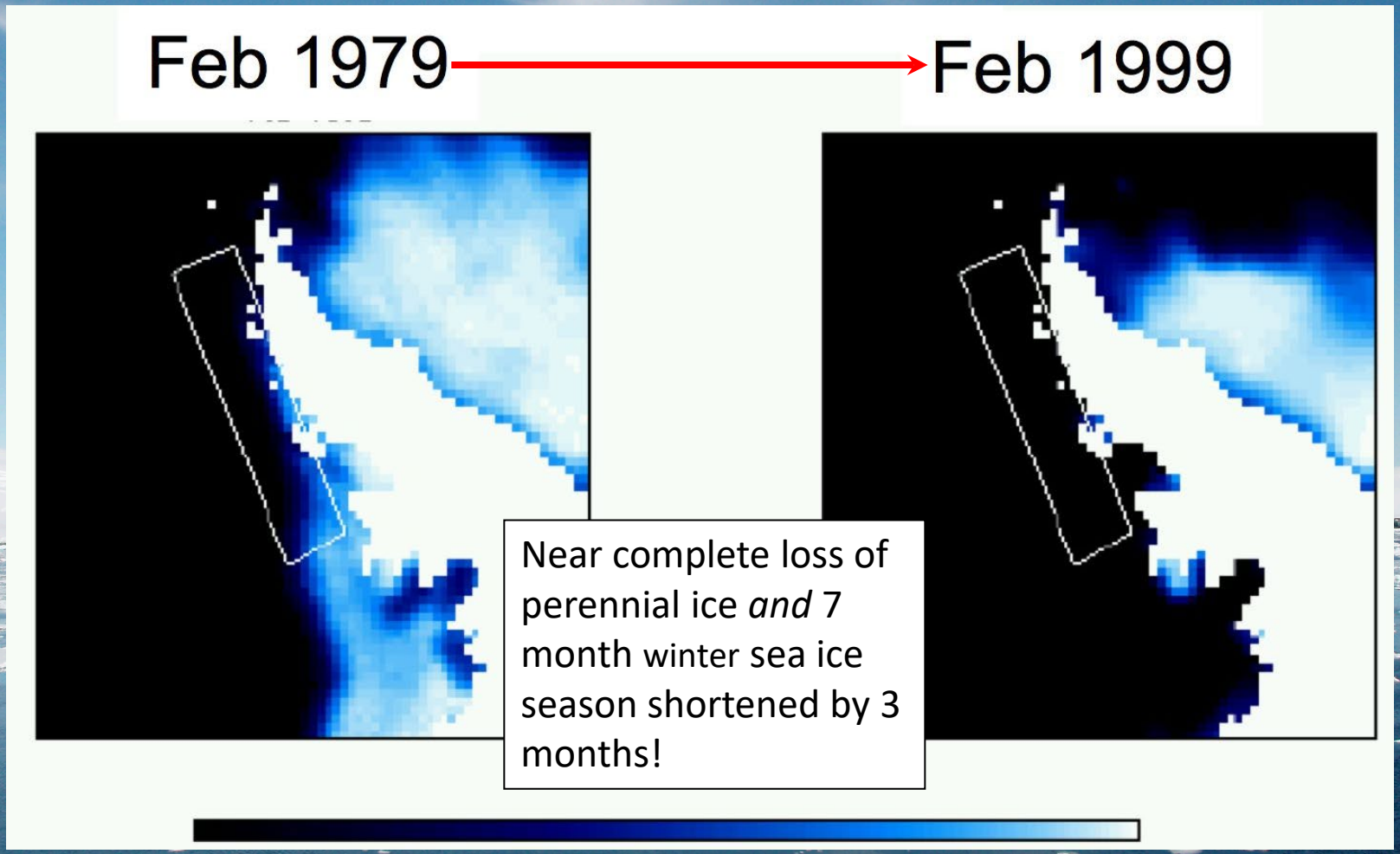
Recent Rapid Regional Warming
(Most extreme *winter* warming on Earth)



Melting Glaciers



Severe Change in Sea Ice



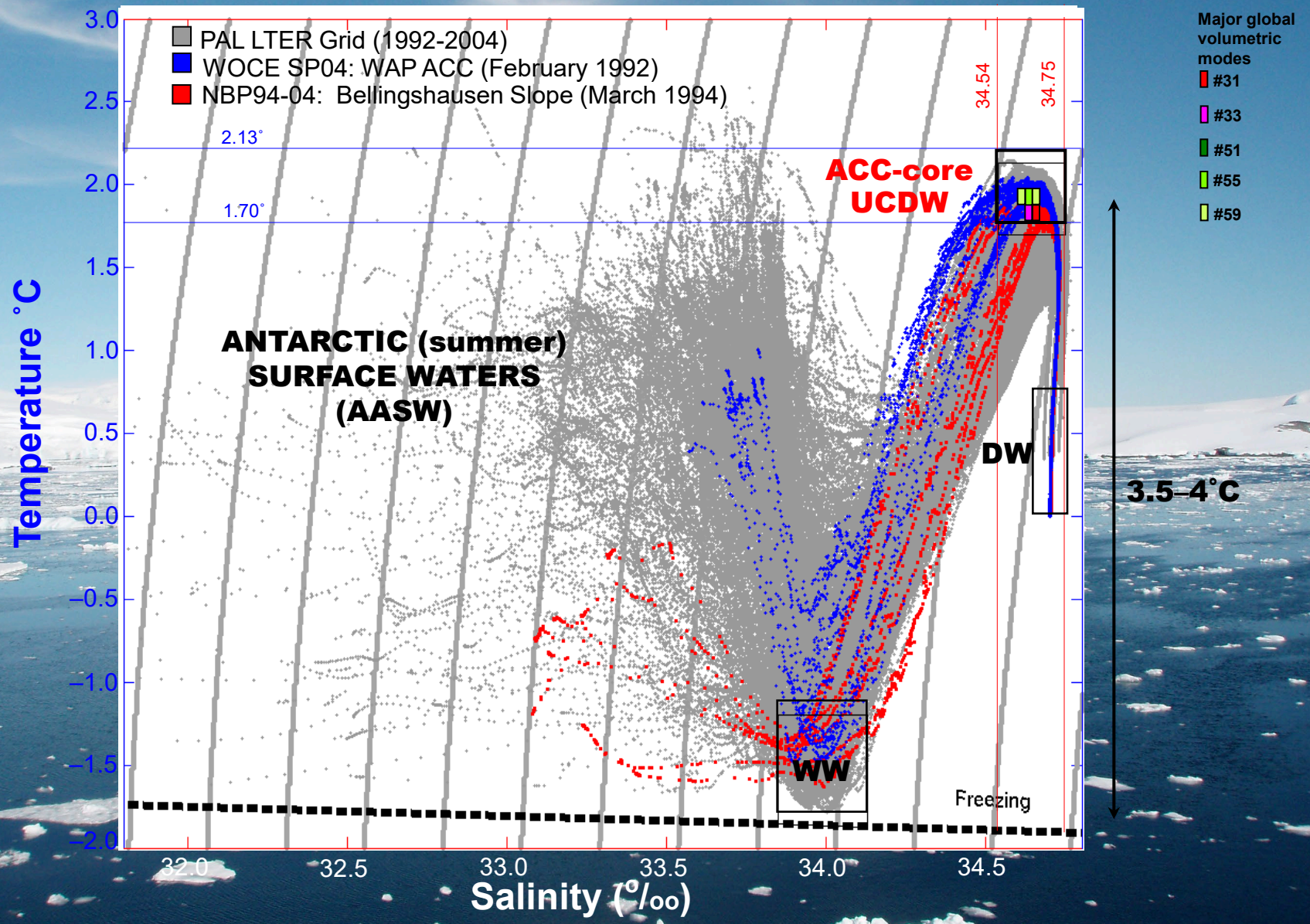
Stammerjohn et al., 2006

Adelie penguin colonies going extinct!

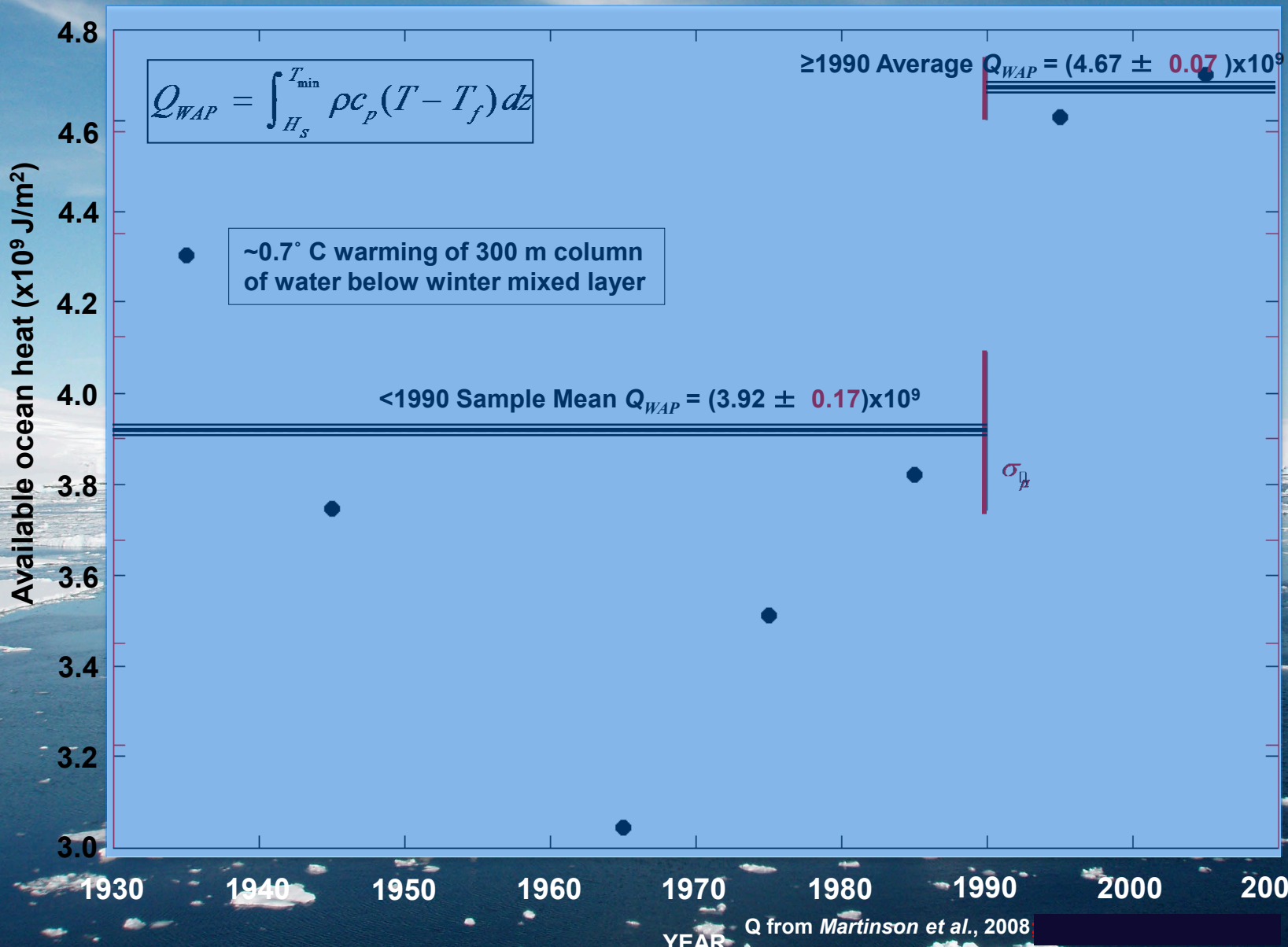
Decrease in breeding pairs:
15,200 (1974) to 3,500 (2007)

Source of *winter* heat

(atmosphere is frigid & sun near horizon; suggests ocean)

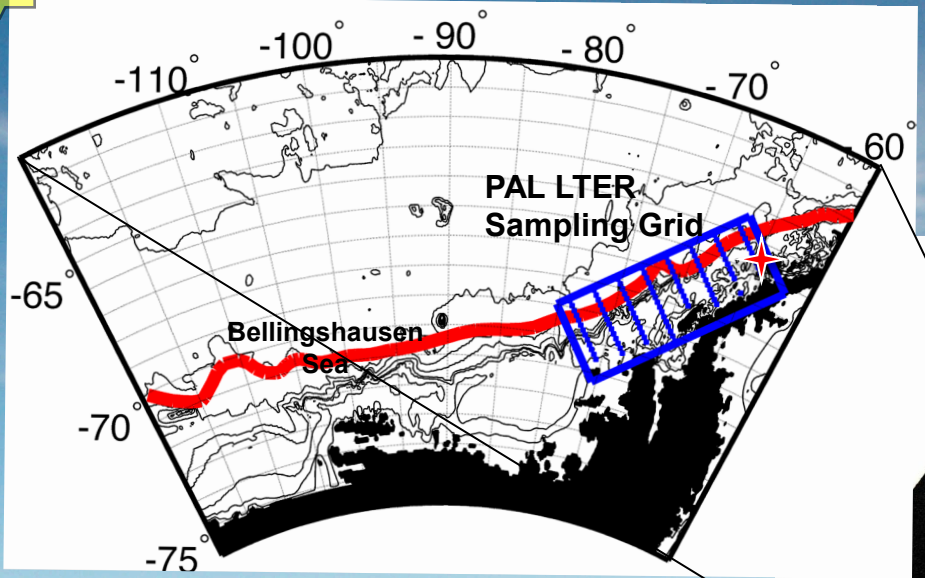


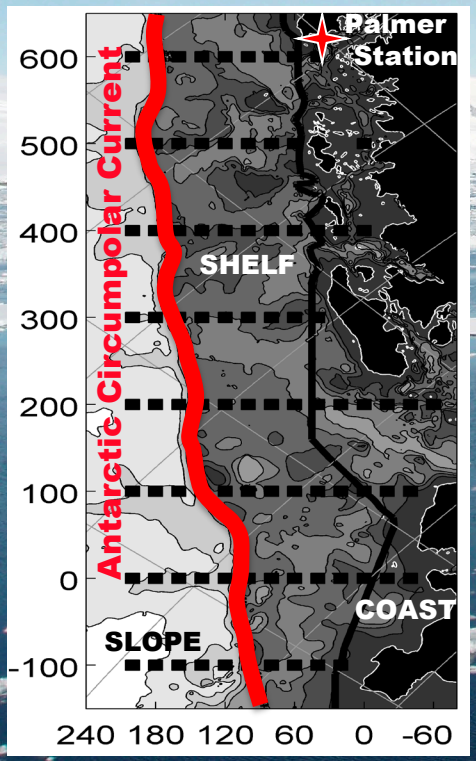
Most worrisome change (re. society) is warming and direct delivery to ice shelves of Upper Circumpolar Deep Water (UCDW)

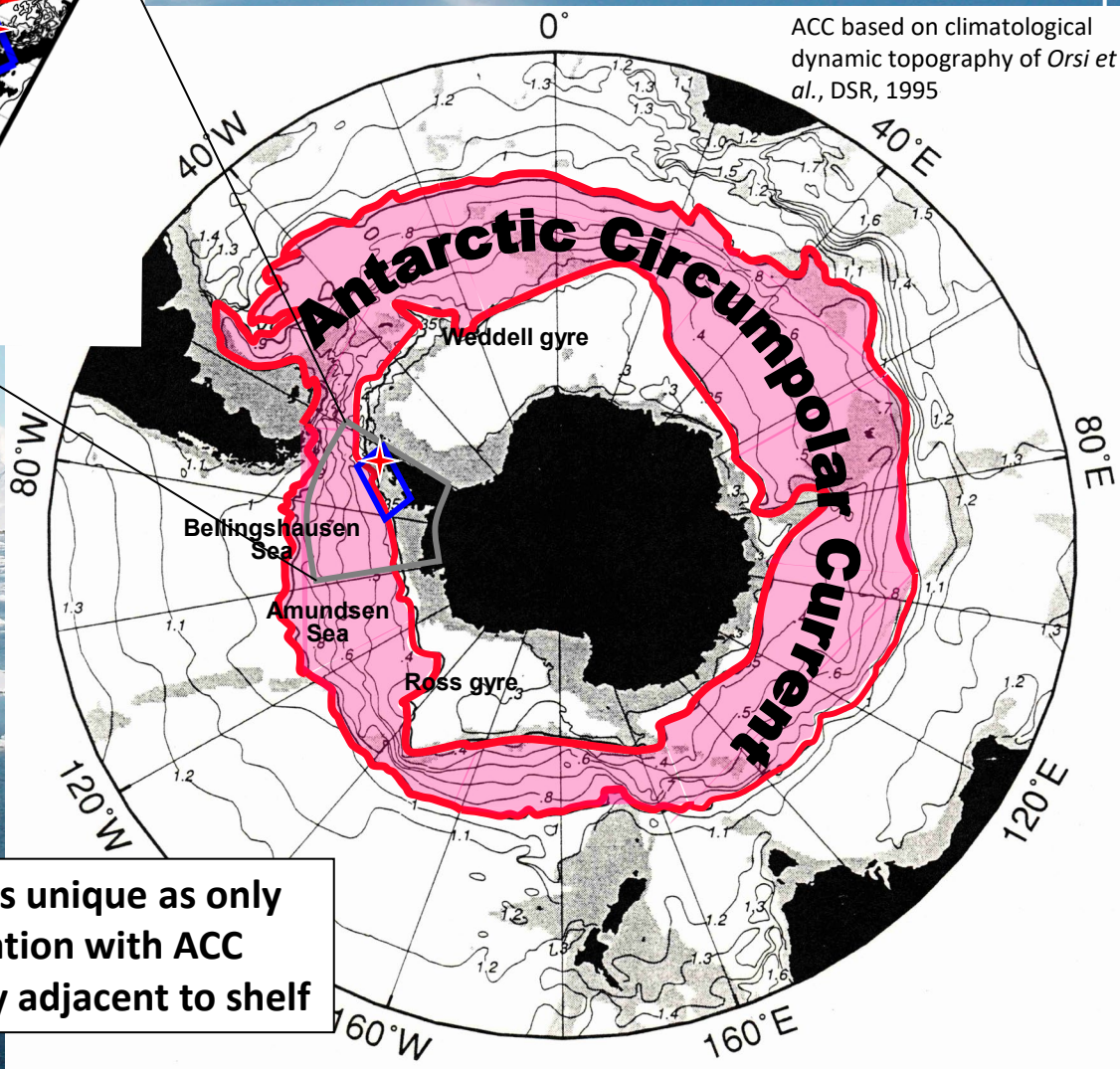


Q from *Martinson et al.*, 2008

Study Site



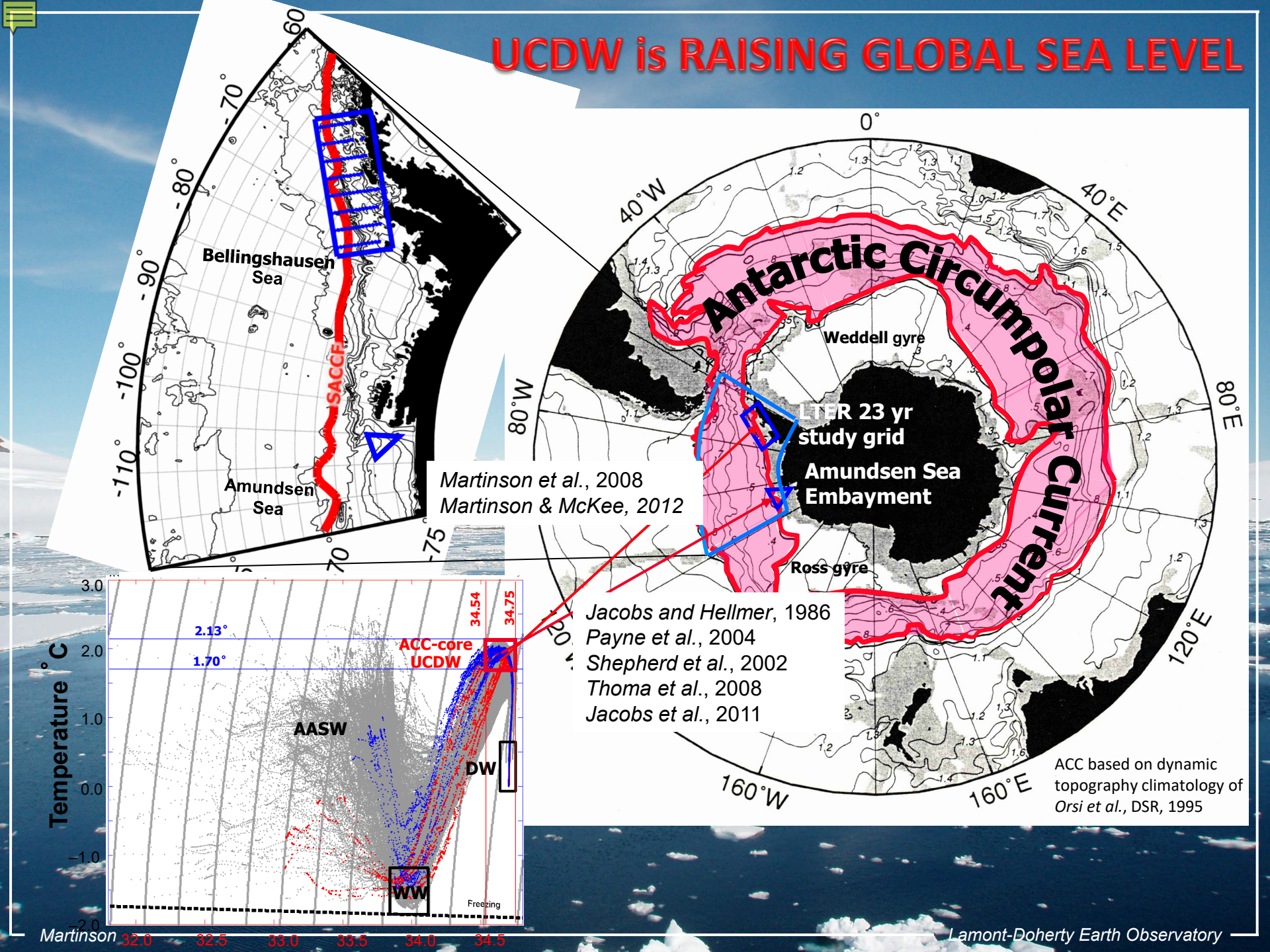




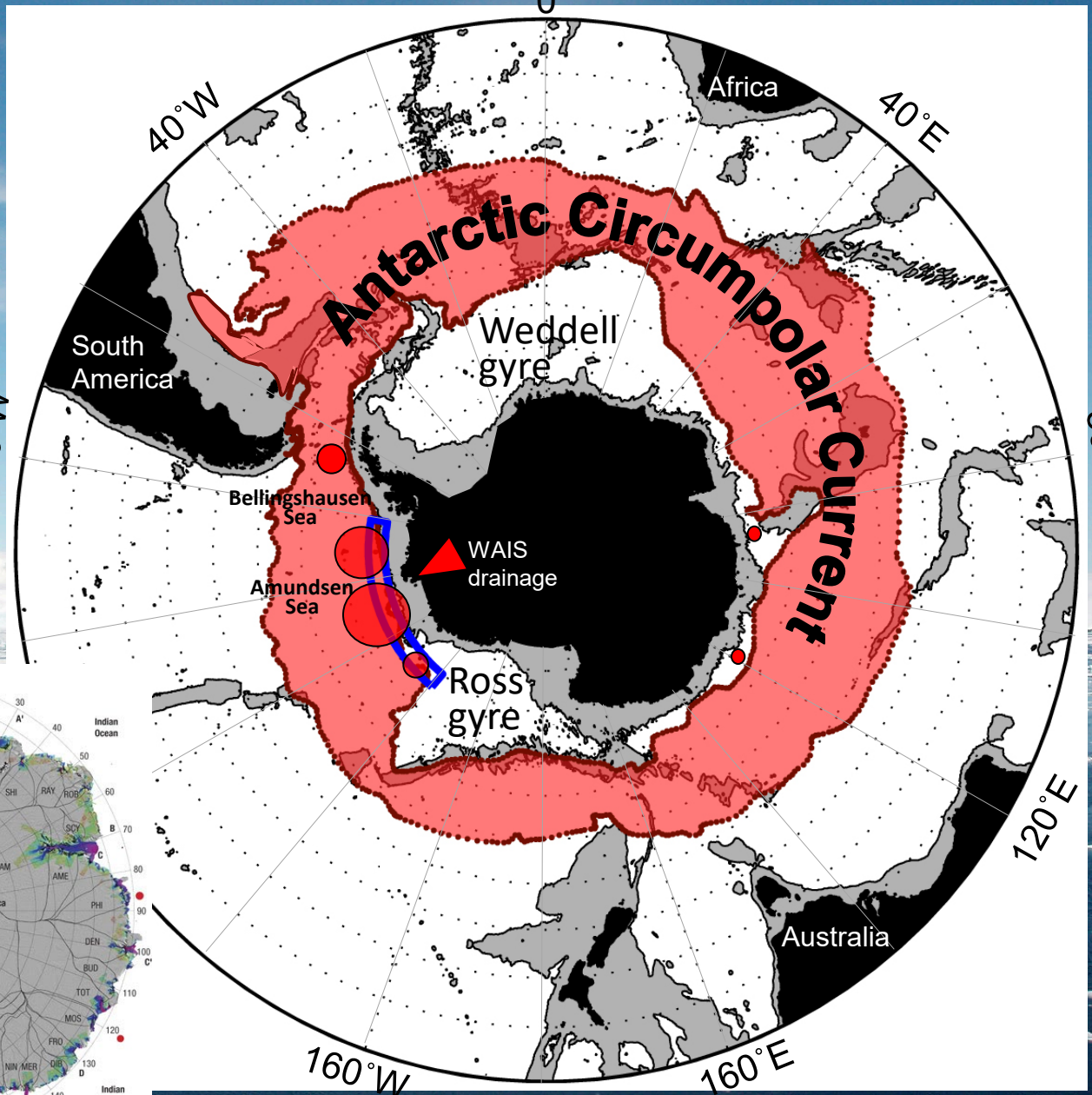
ACC based on climatological dynamic topography of *Orsi et al.*, DSR, 1995

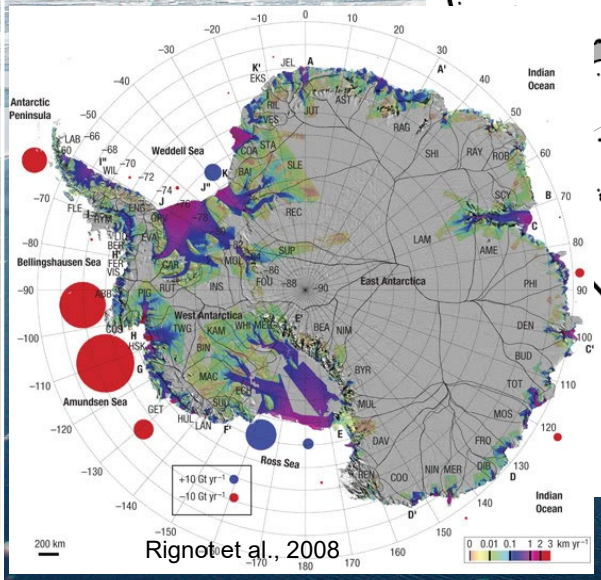
WAP is unique as only location with ACC directly adjacent to shelf

UCDW is RAISING GLOBAL SEA LEVEL



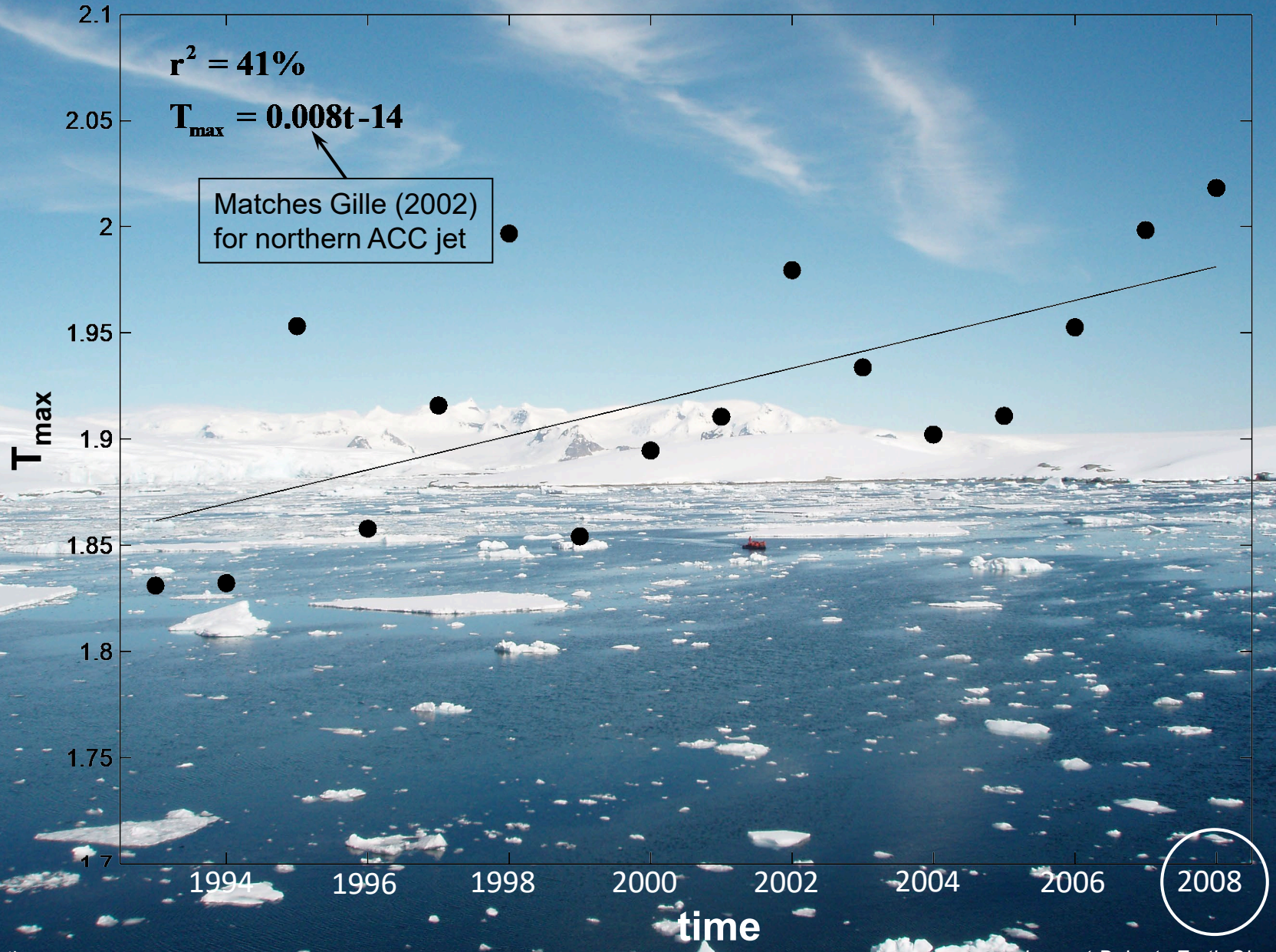
10 gigatons per year



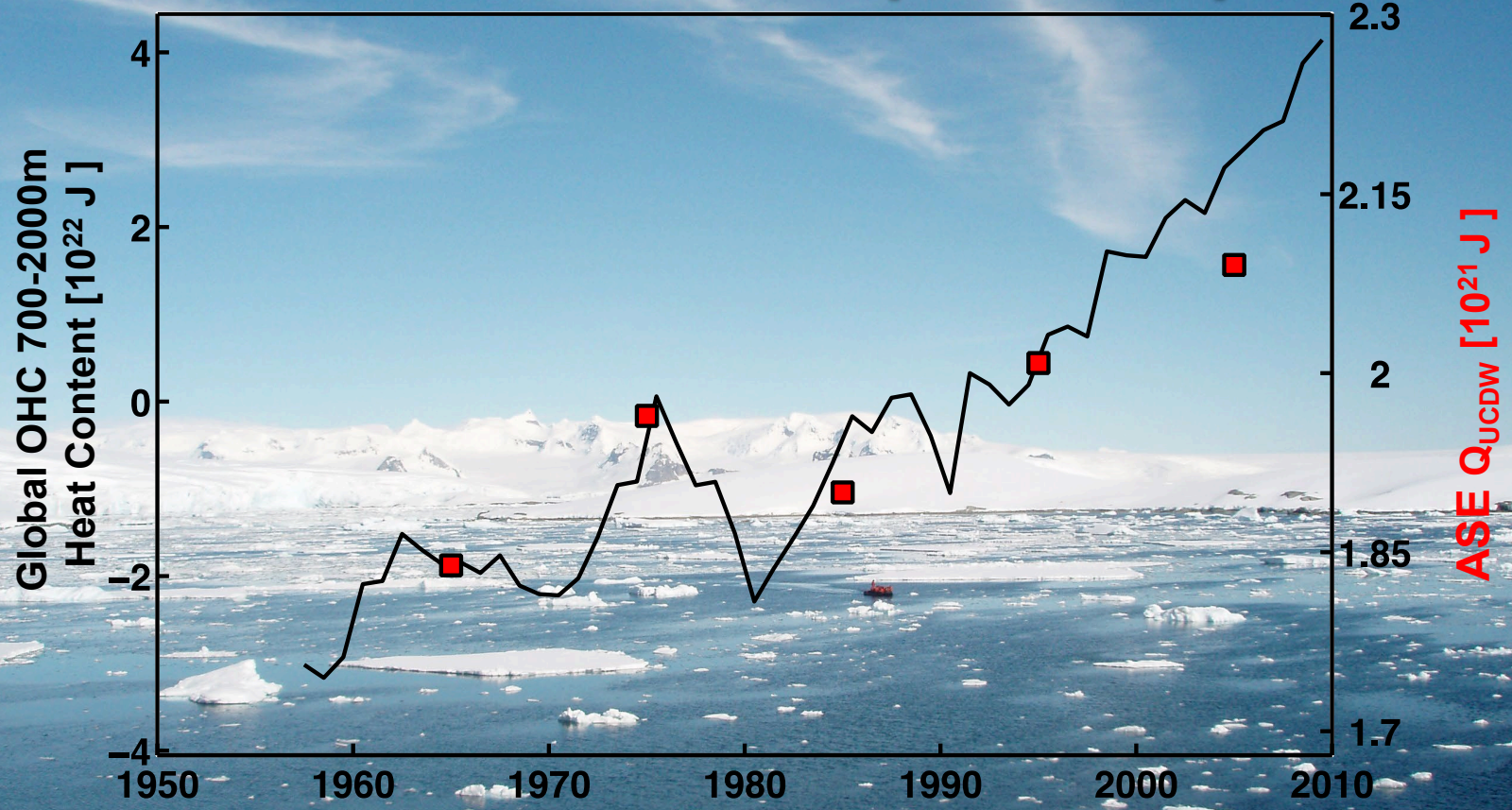


Rignot et al., 2008

UCDW warming with time (as delivered by ACC)



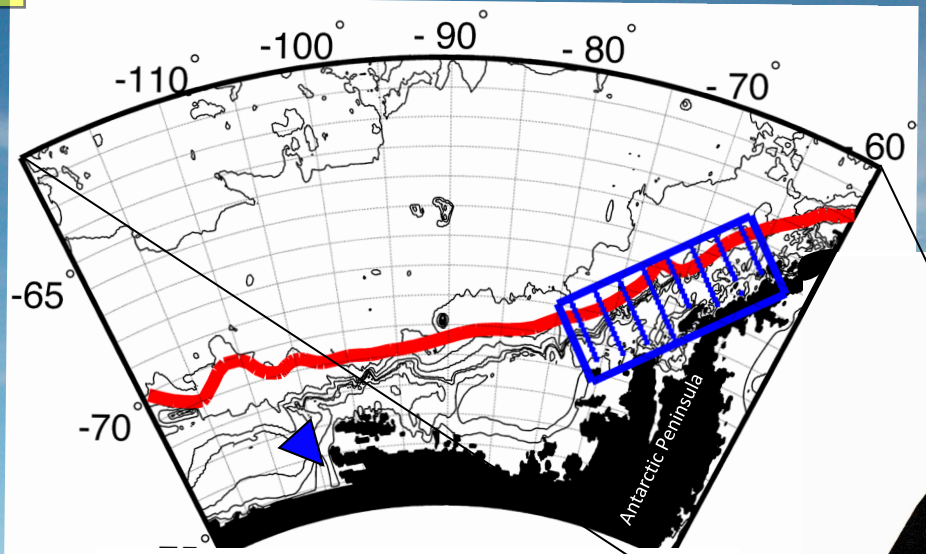
New 700-2000m Global Ocean Heat Content (vs ASE)

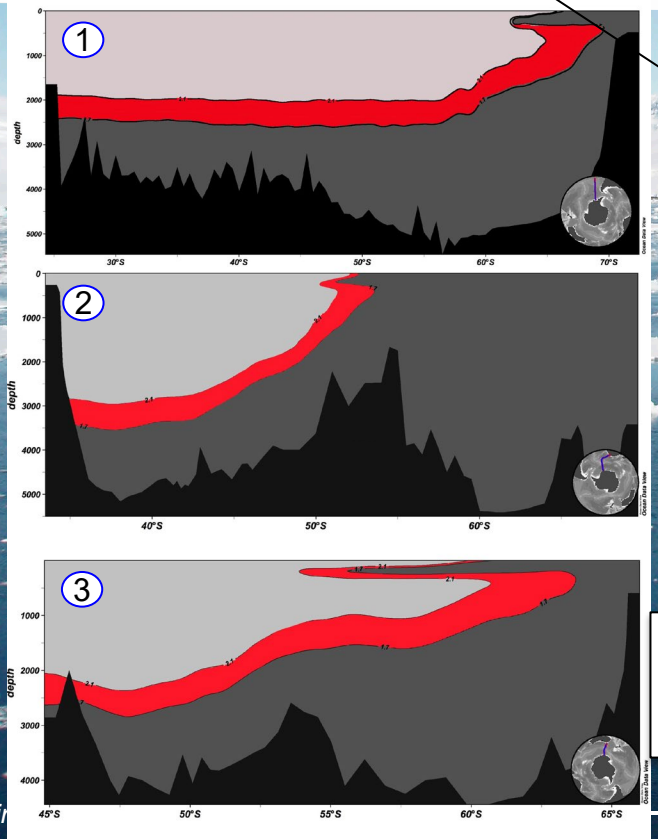


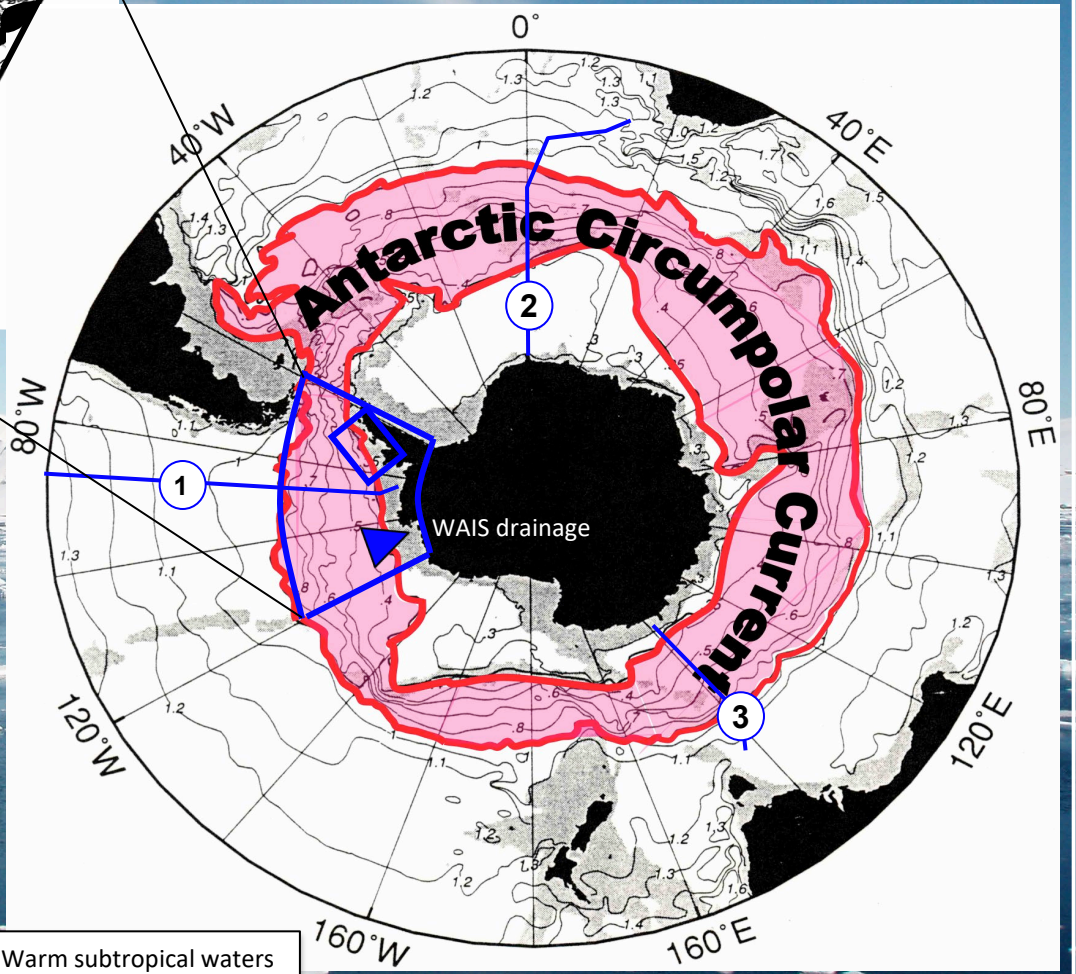
NOAA/NESDIS/NODC Ocean Climate Laboratory
Levitus et al., 2012

$$Q_{UCDW} = \int_{WW}^{-300} \rho c_p [T(z) - T_f] \, dz$$

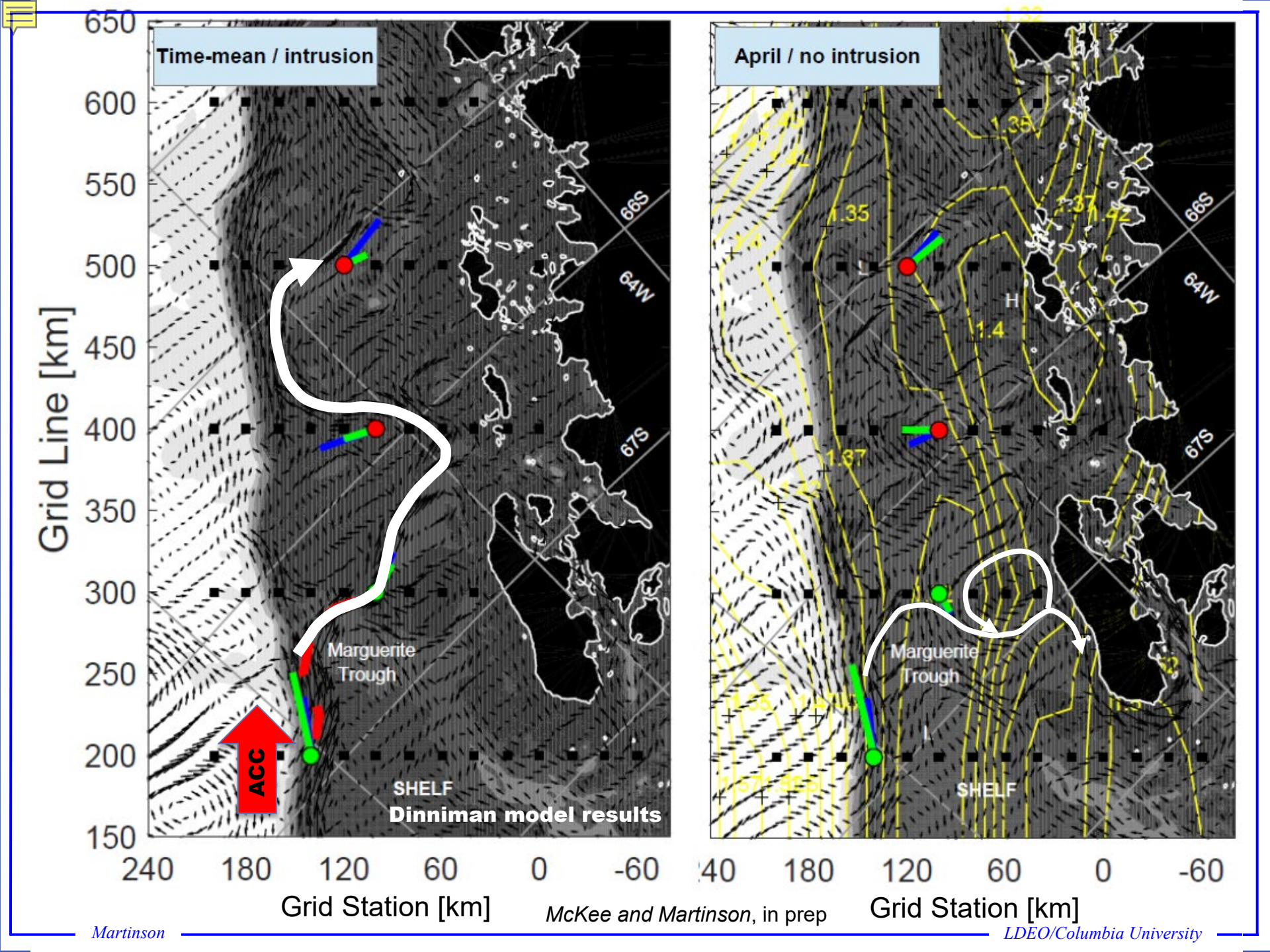
UCDW forms in South Pacific and moves south into ACC as part of global energy balance



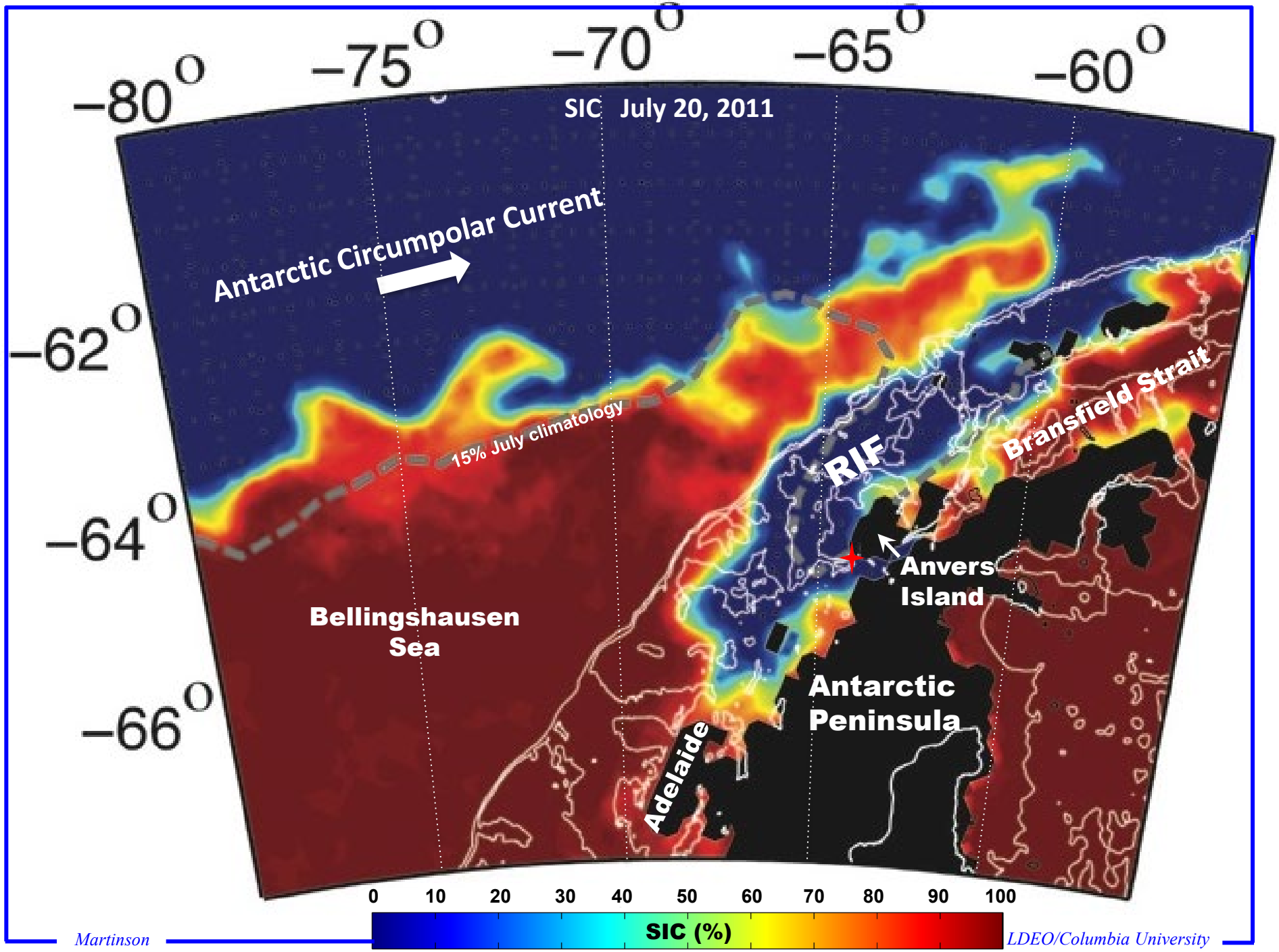




Warm subtropical waters
Layer of WAP UCDW
Cold polar waters



McKee and Martinson, in prep


−80°
−75°
−70°
−65°
−60°
SIC July 20, 2011
Antarctic Circumpolar Current
−62°
−64°
−66°
15% July climatology
RIF
Bransfield Strait
Anvers Island
Bellingshausen Sea
Antarctic Peninsula
Adelaide
0 10 20 30 40 50 60 70 80 90 100
SIC (%)

Questions?

Conclusions:

Warming of global ocean deep water has considerable potential for long term melting of Antarctic glacial ice — even if global warming is stopped, unlimited ocean heat is available for endless melt!

Sea level was several meters higher in the last interglacial period (125 kyrs ago), and we could be headed toward that previous stable state!

Lessons learned an what to do:

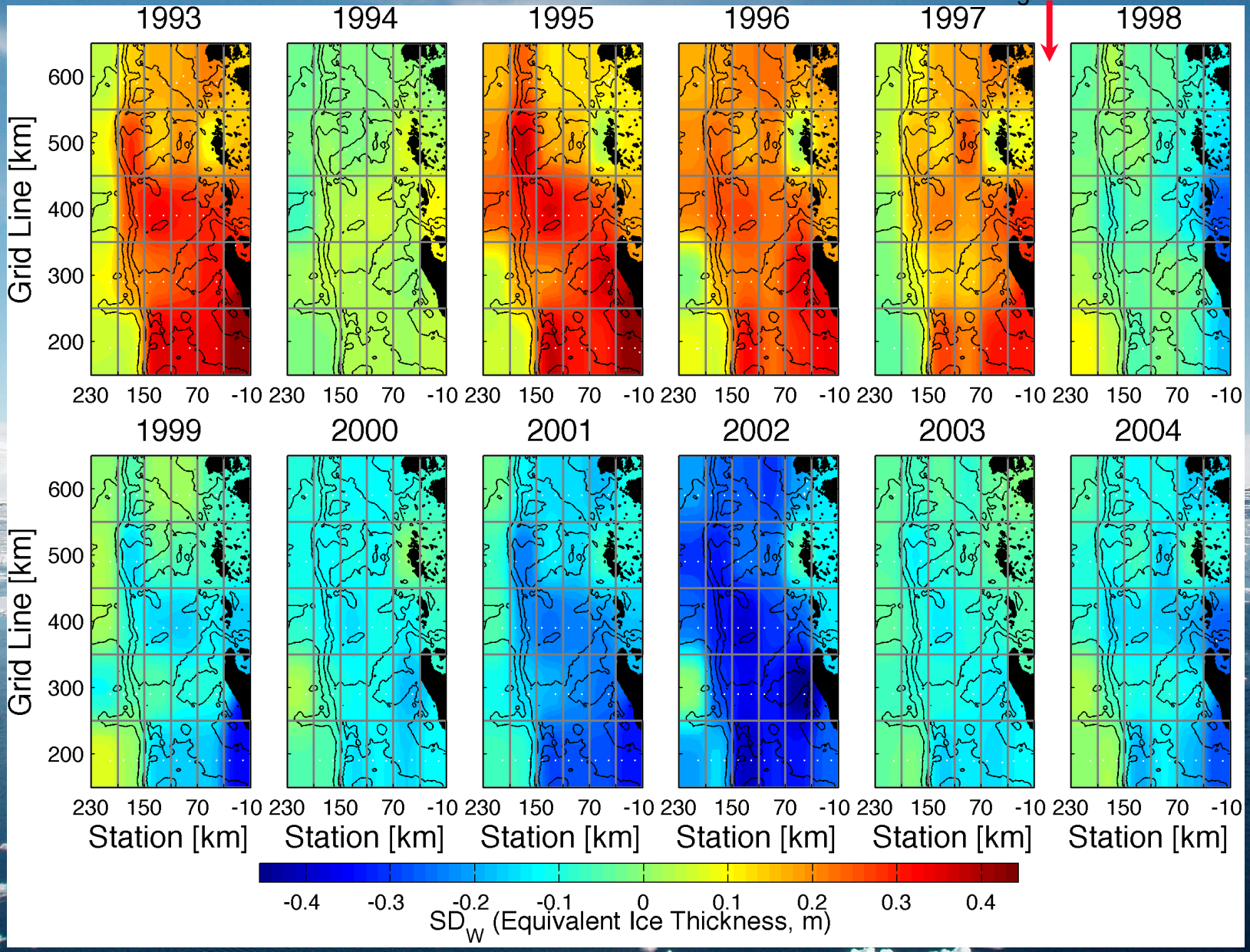
1. **don't mess with climate**
2. **buy a boat and learn to swim**

Photo: Zena Cardman, Jan 2009

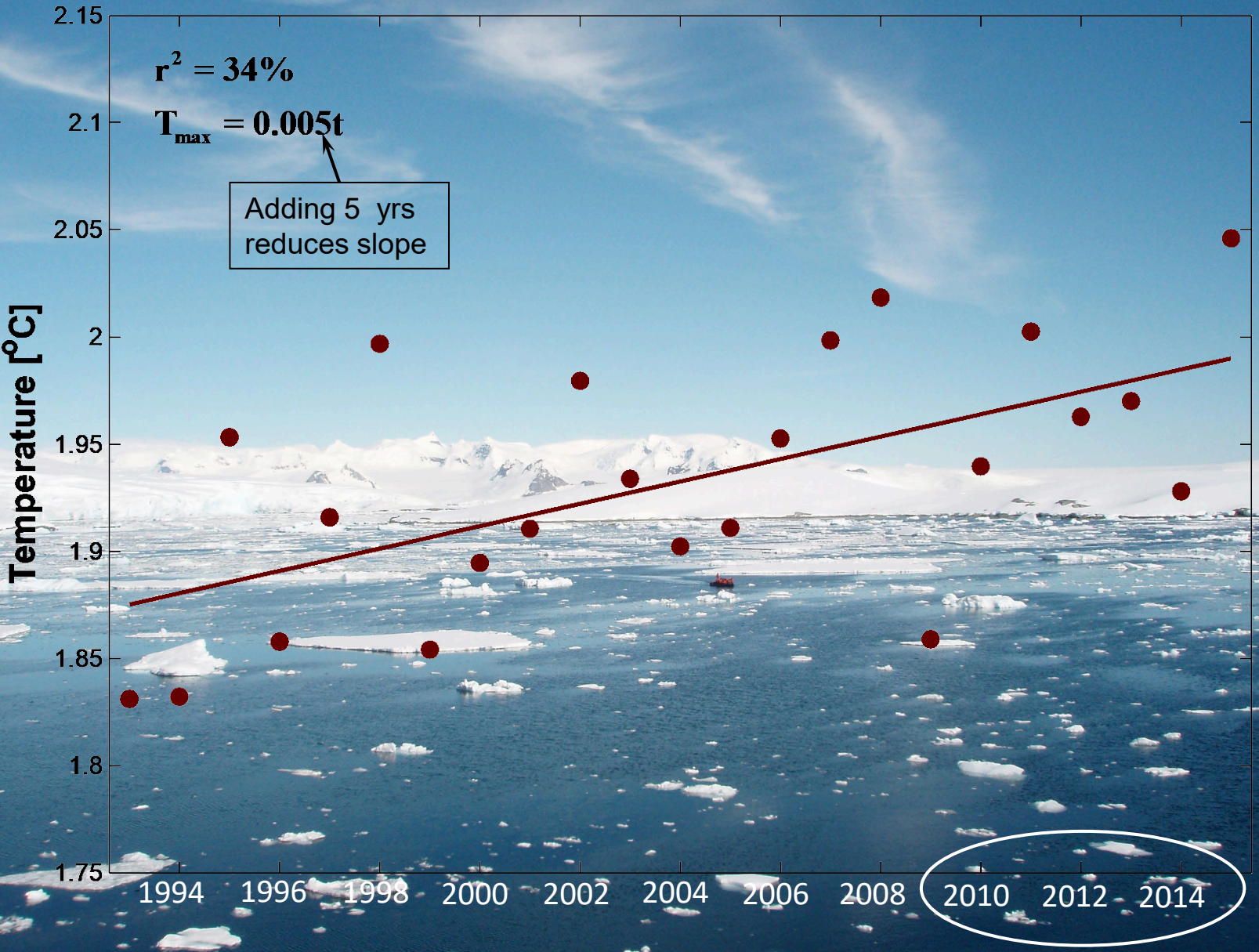
Grace Saba, 2013
Lamont-Doherty Earth Observatory

Backup

Surface Meltwater



UCDW warming is slowing down



Problem

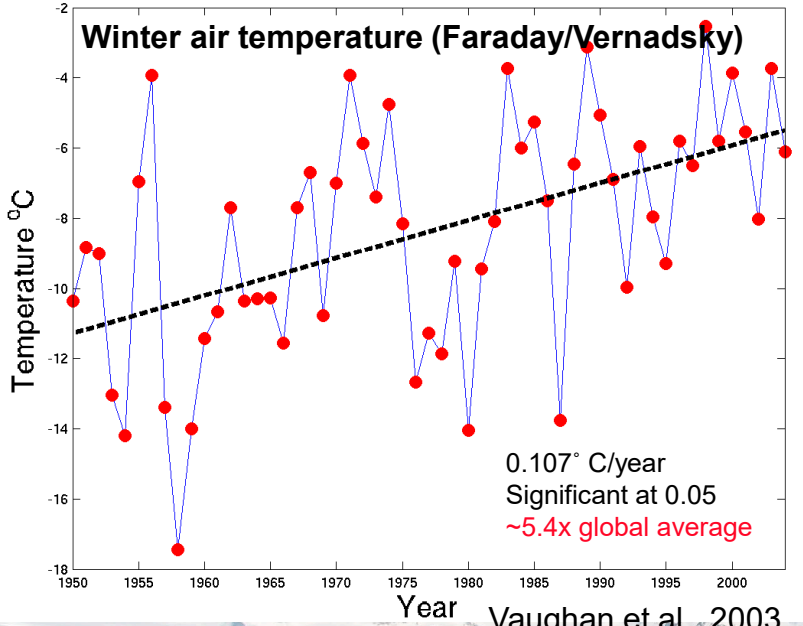
UPPER CIRCUMPOLAR DEEP WATER (UCDW) **forms somewhere in the South Pacific.**

Transport **of this warmed water from South Pacific to the south is part of the Southern Ocean circulation (Earth's need to contribute more heat to Antarctic)**

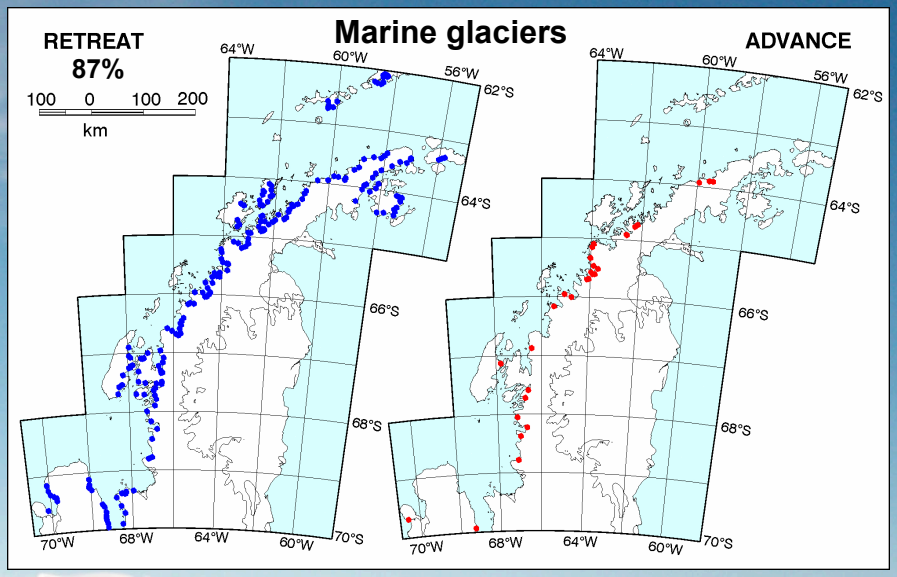
This is part of global energy balance—it will not change unless Earth starts spinning backwards, or some equally unlikely major change.

If such changes do occur, we probably won't be as worried about global warming anymore

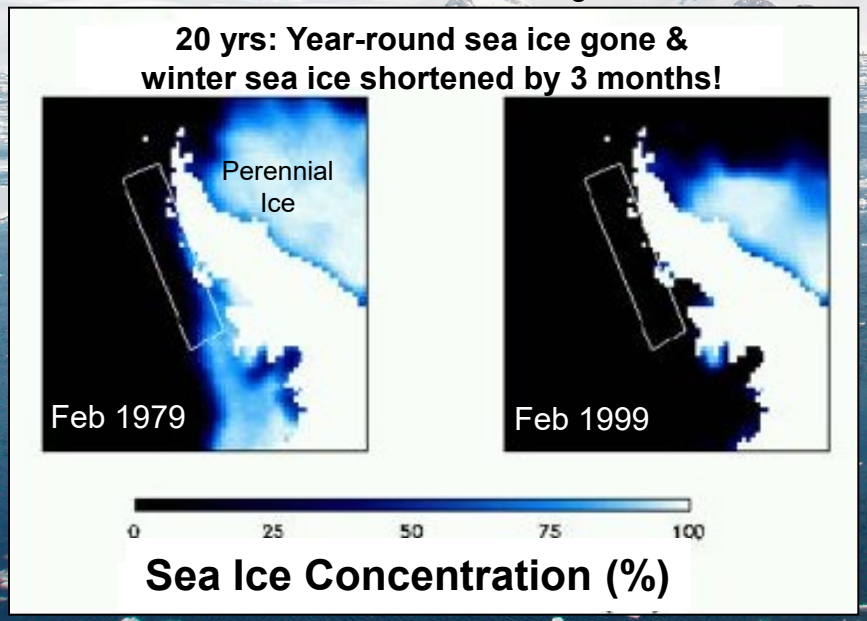
Climate Change on West Antarctic Peninsula



Vaughan et al., 2003

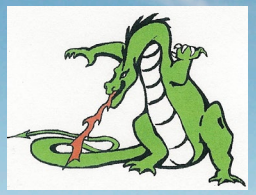


Cook et al., 2005



Stammerjohn et al., 2007

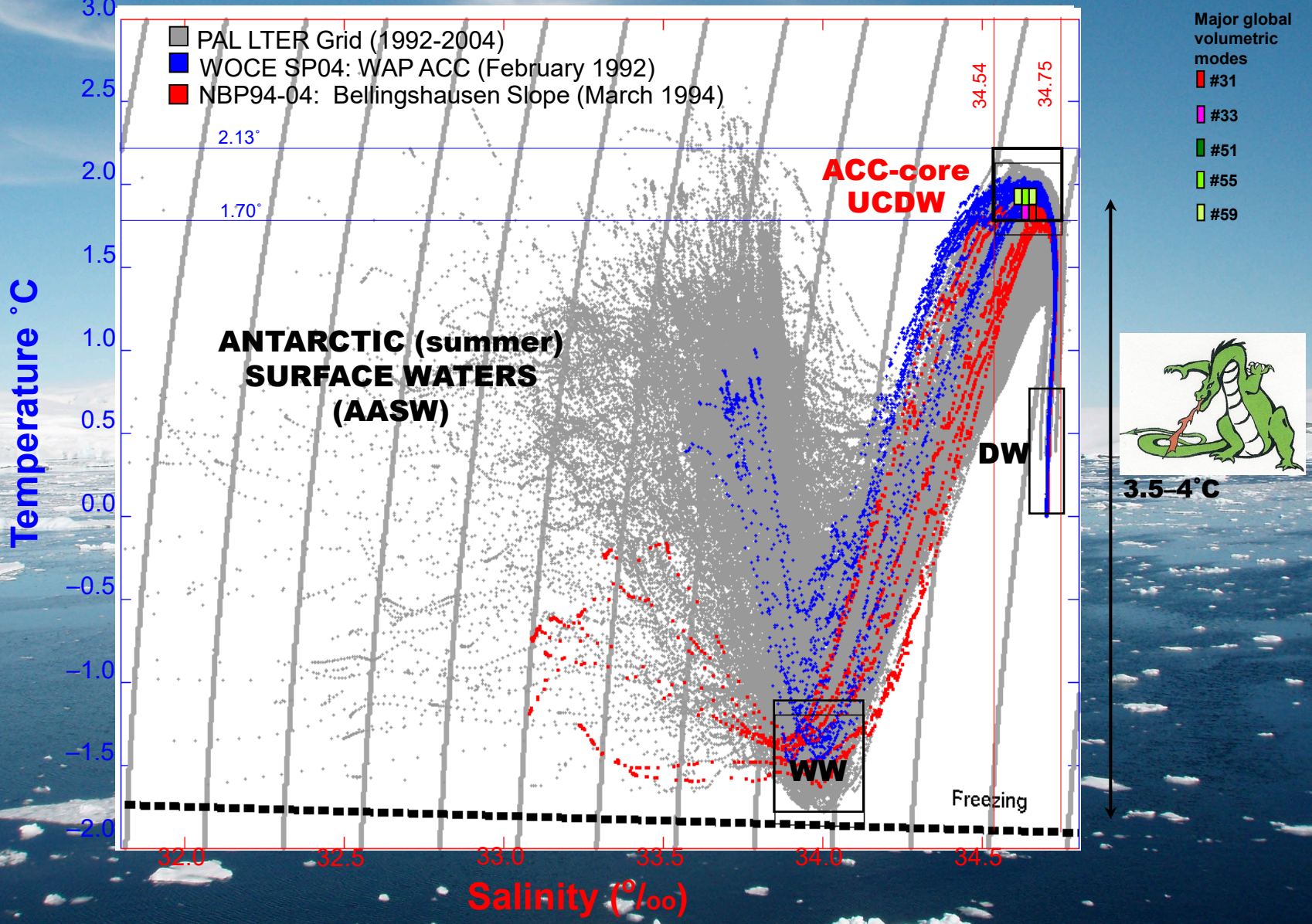
Fraser et al., 2008



3.5–4˚C

Source of *winter* heat

(atmosphere is frigid & sun near horizon; suggests ocean)



Antarctic Study Site