Antarctica and Global Change – keeping up with the Science

In a nutshell -

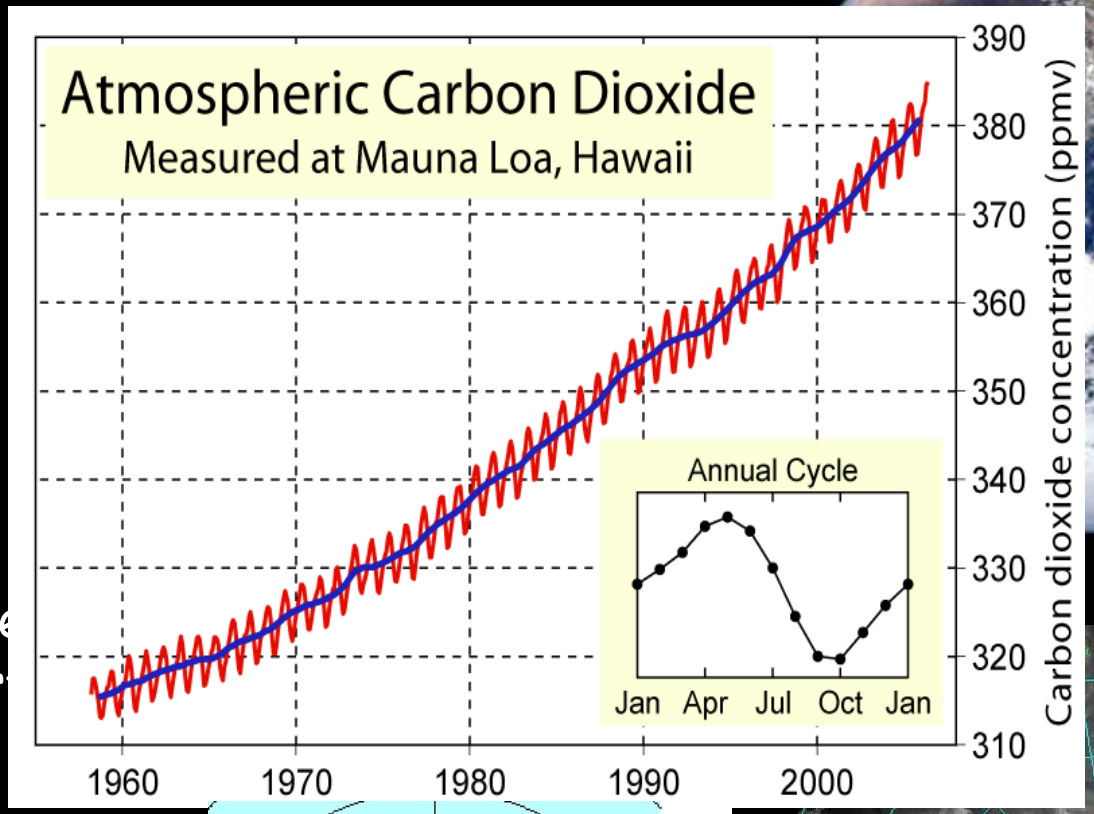
- Climate change/global change/global warming underway
- Caused by rising human-induced GHG emissions (esp CO_2) (C budget, C isotopes, decline in atmos O)
- Variable in time and space so <u>trends</u> important

Elements of Climate System work on different time scales

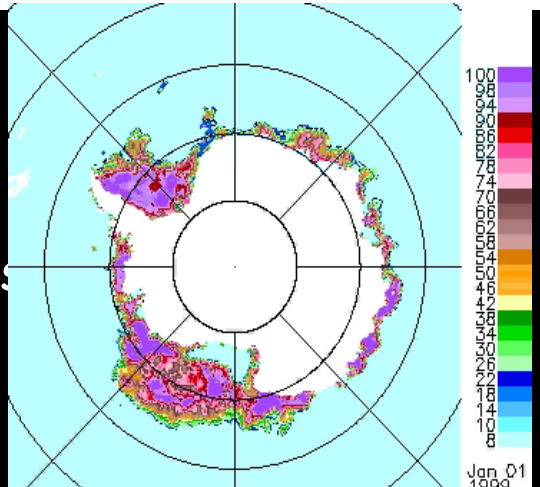
CO_2 driver
(rising trend)

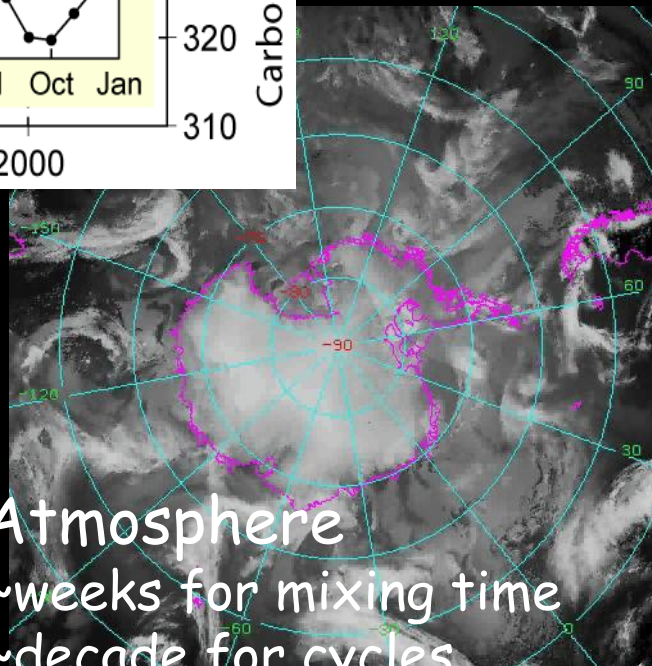
modulated by
Biosphere
(annual cycles)

Oceans
~centuries for dee
~multi-year for "sur



Cryosphere
- annual sea ice cycles
- millennial ice sheet cycles





Atmosphere
~weeks for mixing time
~decade for cycles

Antarctica and Global Change – keeping up with the Science

Core problem: How to make sound projections of future changes

Ancillary problem: How to draw on the most up-to-date science

Issues: Rate may be accelerating through feedbacks
Response time to "forcing" varies from years to centuries

Focus: Recent evidence of Antarctic ice sheet sensitivity to rising CO2 levels from:

1. ice shelf observations
2. satellite-based mass balance measurements
3. paleoclimate observations and ice sheet modeling

See also ASOC review of West Antarctic Ice Sheet behaviour (ATME 2010 IP 7)

1. Ice shelf observations

West Antarctic ice sheet and CO_2 greenhouse effect: a threat of disaster

J. H. Mercer

Institute of Polar Studies, The Ohio State

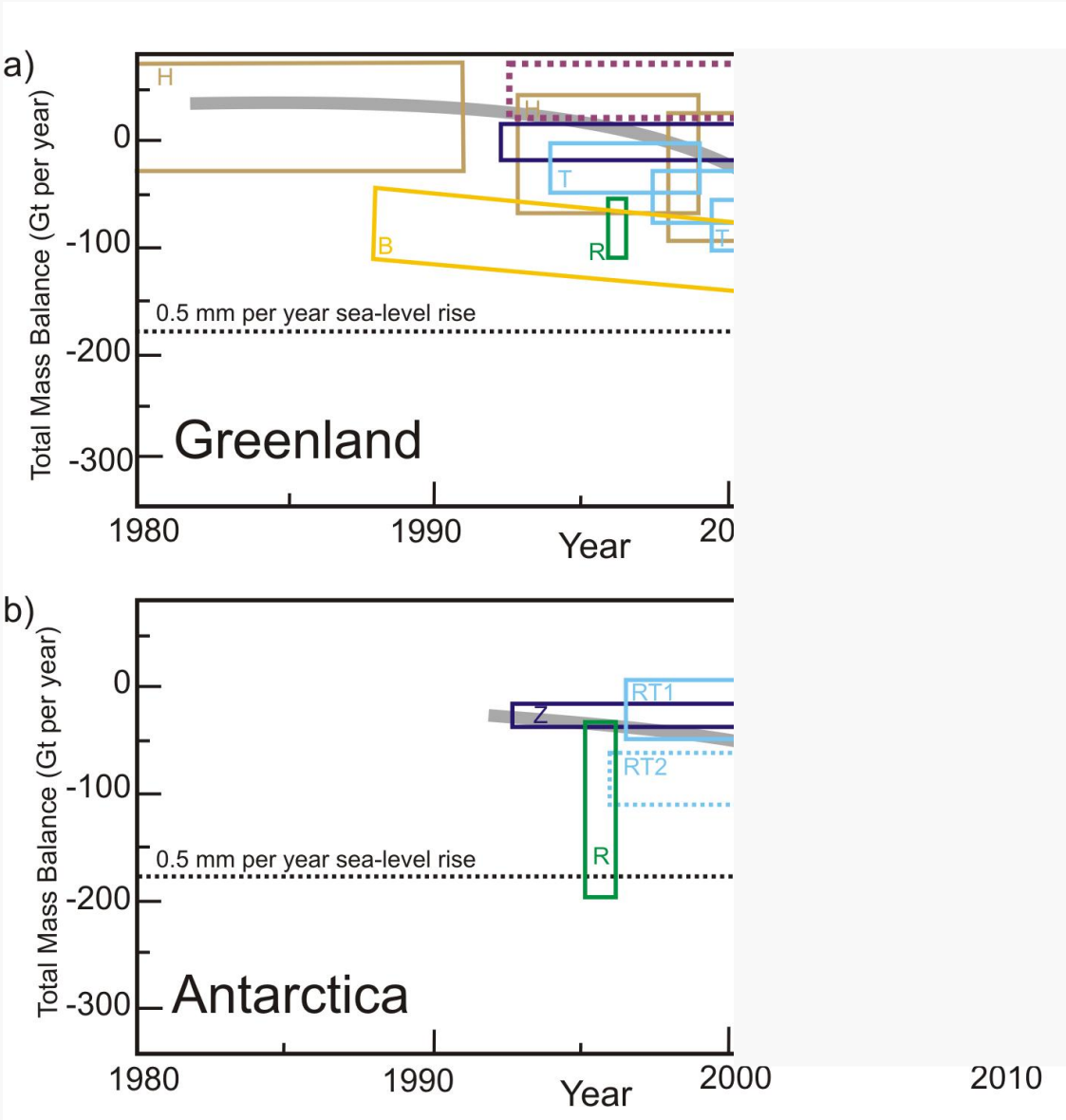
Nature, 1978
271, 321-324

We find that dynamic thinning of glaciers now reaches all latitudes in Greenland, has intensified on key Antarctic grounding lines, has endured for decades after ice-shelf collapse, penetrates far into the interior of each ice sheet and is spreading as ice shelves thin by ocean-driven melt. Pritchard and others, 2009, Nature.

In recent decades, seven out of twelve ice shelves around the Antarctic Peninsula have either retreated significantly or have been almost entirely lost.
Cook and Vaughan, 2009, The Cryosphere

Fig. 3 *a*, Antarctic ice cover today, and *b*, after a 5–10 °C warming.

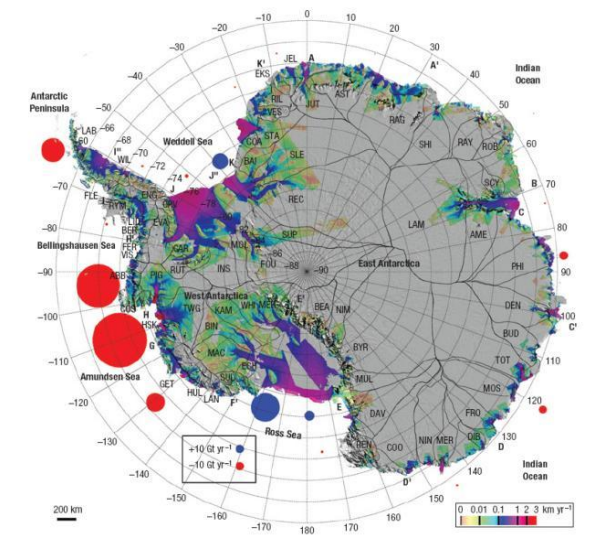
2. Satellite mass balance measurements



Modified from IPCC 2007 for Bertler and Barrett in press, Ice Sheets chapter in J Dodson (ed.) "Changing Climates, Earth Systems and Society" - includes all references used for the diagram

2. Sea level projections

Based on satellite imagery

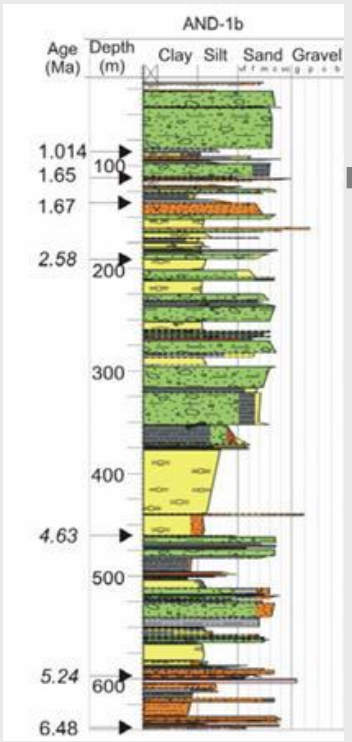


Rignot et al, Nature, 2008
mass loss increased 75%
from 1996-2006.

Source of rise	*1903-2003 IPCC 2007*	*1993-2003 IPCC 2007*	*2000-2100 Pfeffer et al. 2008*		TOTAL RISE POSSIBLE *IPCC 2007*
Thermal expansion		1.60	3.0	300 mm	300 mm for 3 C incr.
Glaciers/ice-caps		0.77	3.6*	360 mm	100-400 mm
Greenland ice sheet		0.21	3.6*	360 mm	7,000 mm
Antarctic ice sheet		0.21	3.9*	380 mm	57,000 mm
Sum – mm/year		**2.8mm**	**14.0*mm**	**1400mm**	**~65,000 mm**
Observed total - mm/year	**1.3mm**	**3.1mm**	***midpoint of high/low rates**	**TOTAL TO 2100**	**TOTAL RISE POSSIBLE**

Table. Past rates and future projections for sea level rise (mm/year), compared with potential sea level rise from persistent global warming.

3. Paleoclimate obs and ice sheet modeling

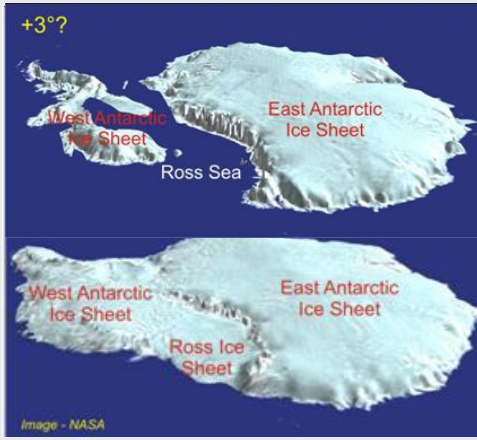


Age

0-1 Ma

1-6 m.y.

Earth up to3 C warmer 2-5 m.y. ago



Atmospheric CO_2 <400 ppmv to 24 Ma

ANDRILL
McMurdo Ice Shelf core
Naish and others 2009

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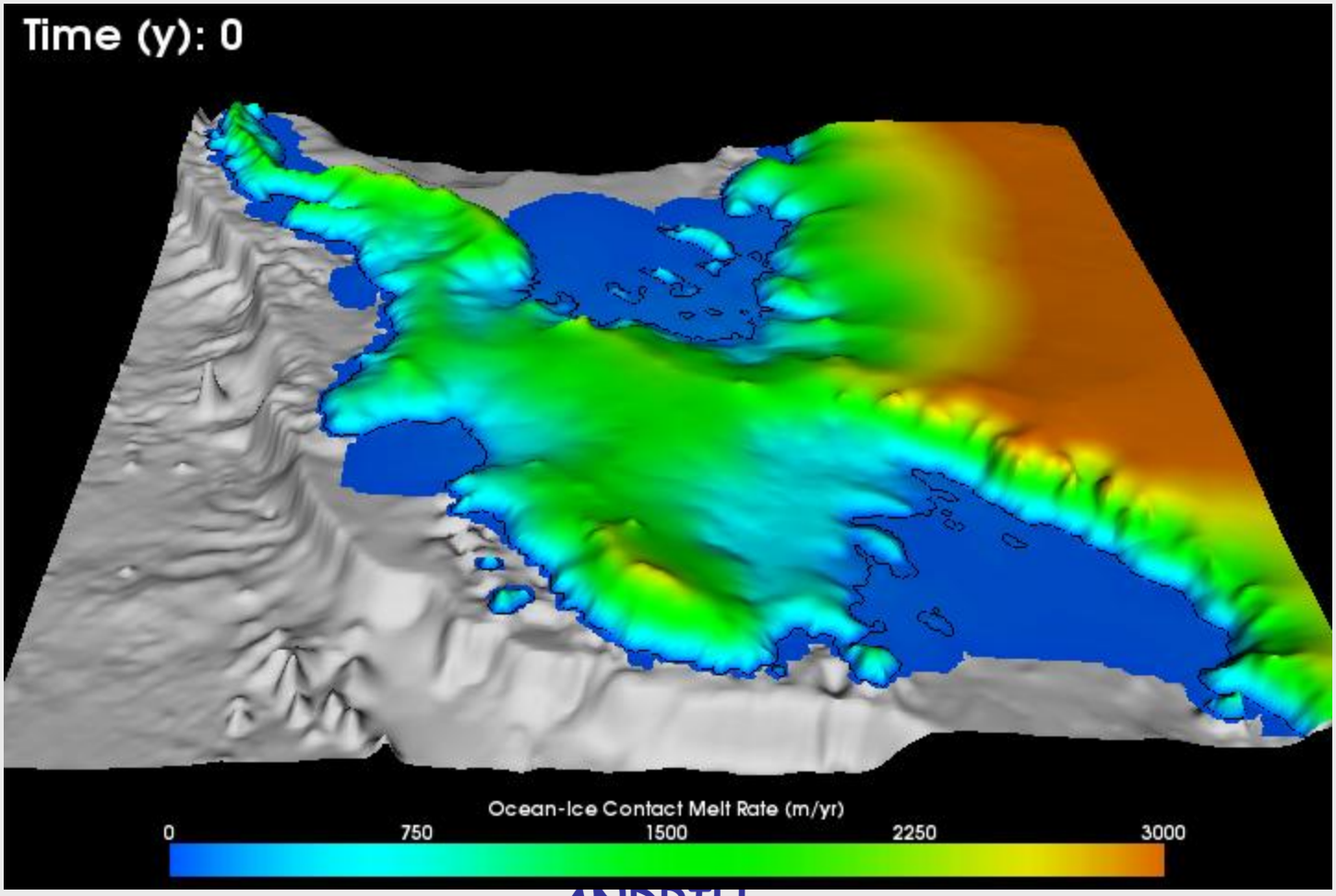


ANDRILL
Pollard and DeConto [2009]
unpublished

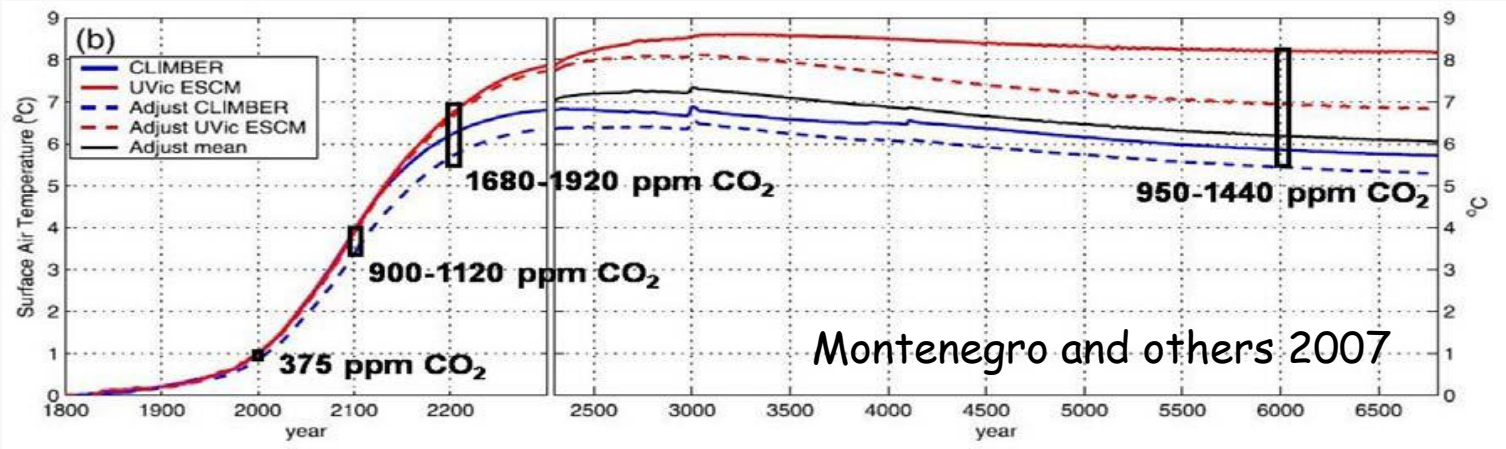
Summary

1. Recent research indicates ice sheets are responding faster than projected a decade ago.

2. Whether ice sheets will continue to accelerate is unclear
   - there are sound reasons to expect they will

3. Recognising worst case scenarios important
   but leaves open the issue of practical responses

4. Key issue is communication
   - among scientists
   - between scientists, managers, governments
   - to the wider community



Technical text

The Antarctic ice sheet is known to respond slowly to large and sustained climate changes, but the new awareness that it can also respond rapidly to other changes makes it difficult to attribute a particular change in the ice sheet to a particular causal event or events such as recent/anthropogenic climate change. The inescapable fact is that ice sheet behaviour manifests itself as the superposition of multiple responses on multiple time scales to multiple environmental changes.

Further complicating the situation is that we do not know the changes that were occurring in the ice sheet prior to the period of satellite observations (which in the case of ice sheets began in earnest in 1992), let alone a century ago, and we have very little knowledge as to whether natural changes in the ice sheet over past millennia were smooth or step-wise and abrupt. The context for current changes must be understood by inference. Caution must be used in extrapolating current changes into the future. SCAR ACCE 2009 p 288

34. The changes result from warming of the sea beneath the ice shelves connected to the glaciers. The stronger winds associated with the more positive SAM drive warm Circumpolar Deep Water up against the western Peninsula coast and the Amundsen Sea coast. SCAR ACCE 2009 p 19