Sea-level & Climate Change in NJ: Should I Sell My Shore House?

Ken Miller, Dept. Earth & Planetary Sciences, Rutgers

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NEW BRUNSWICK CAMPUS
School of Arts and Sciences

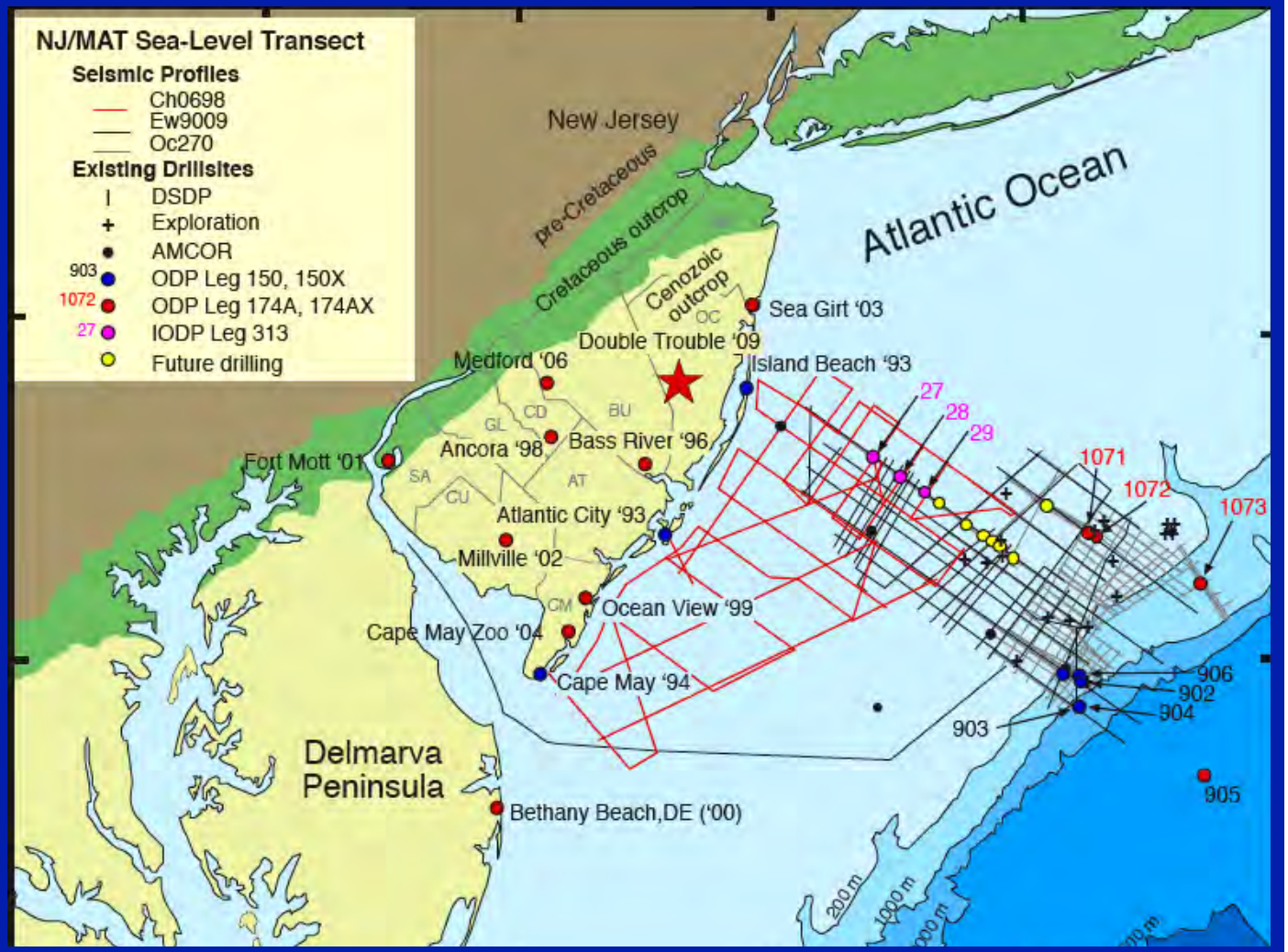
Jersey Roots, Global Reach

Hurricane Isabelle, Avalon, 9/18/2003

December Nor'easter, LBI, 12/1993

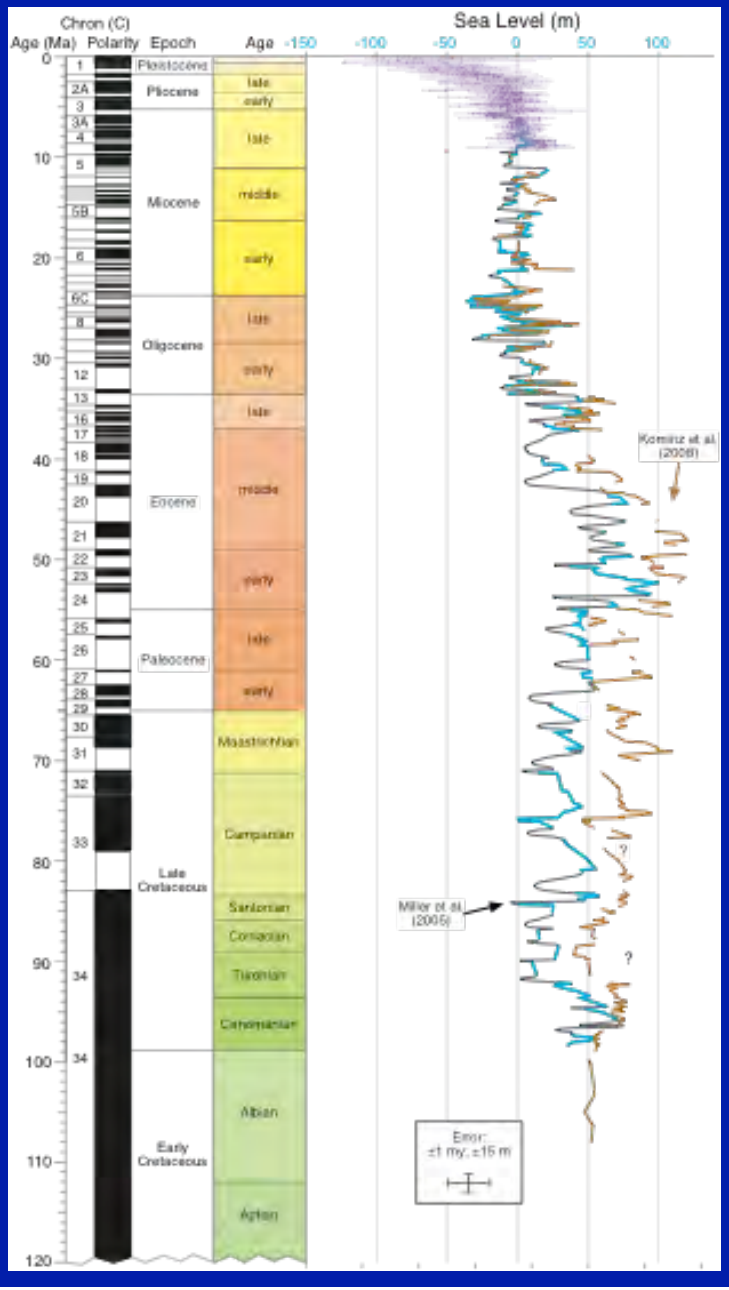
View of NY harbor, ice-free world (73 m = 200 ft rise)

New Jersey sea-level transect
3 seismic grids, onshore & offshore coreholes



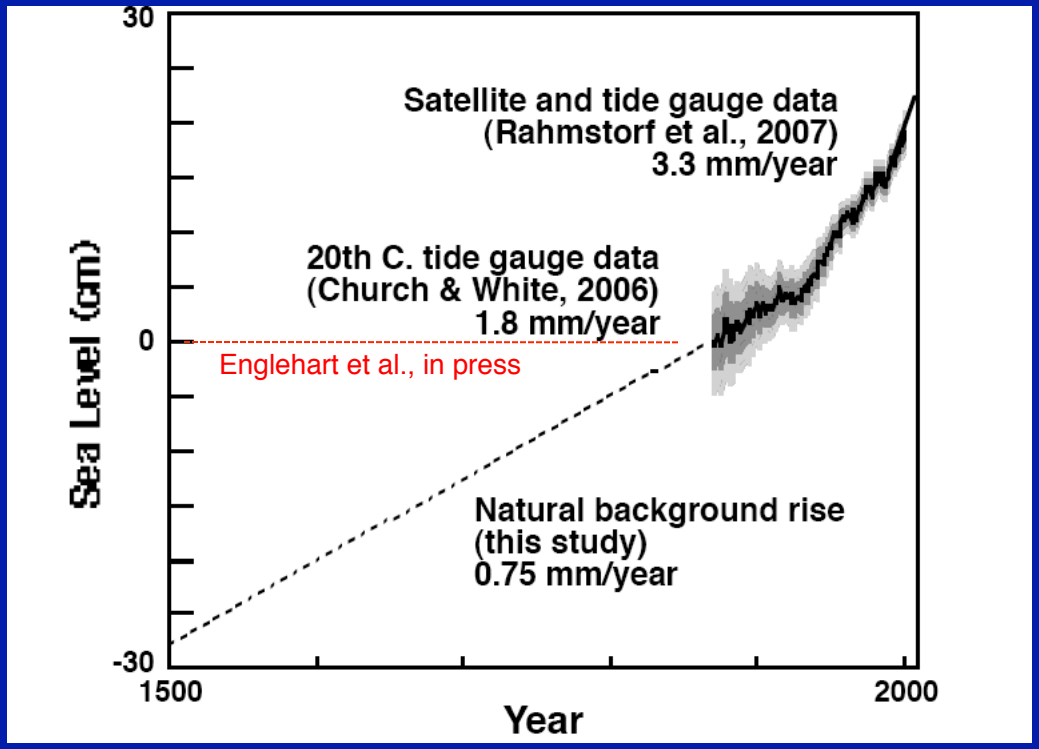
3 seismic grids x-shelf (*Ew9009*), OCS/slope (*Oc270*), nearshore (*CH0698)*

100 million years of sea-level changes



Is sea-level rise today part of natural cycle? No!
Sea level rose rapidly 400 ft from 20,000-3,000 years ago,
How fast, how far will sea level rise?

Ask Al Gore!



Clip from *An Inconvenient Truth*

Rise of 5 m (15 ft): time to sell??

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Flooding of NYC: *An Inconvenient Truth*

"If Greenland broke up and melted…this is what would happen to Manhattan. They can measure this precisely, just as the scientists could predict precisely how much water would breach the levee in New Orleans… the WTC memorial … would be underwater."

Al Gore

NYC after 5 m (15 ft) sea-level rise

Screenshot from the movie

How long to achieve Gore's 5 m rise?

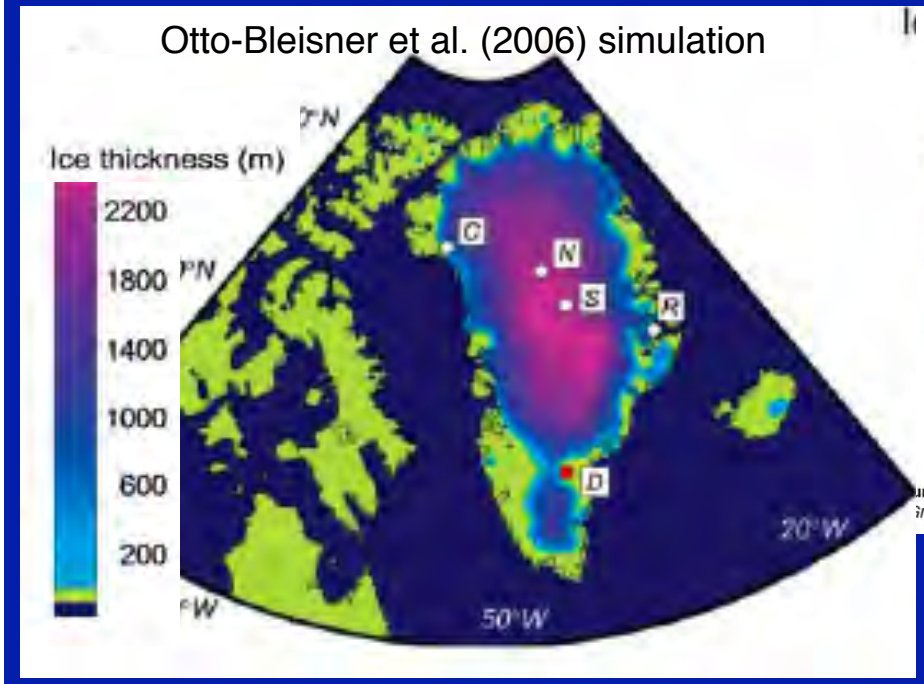
= sea level 125,000 y ago:

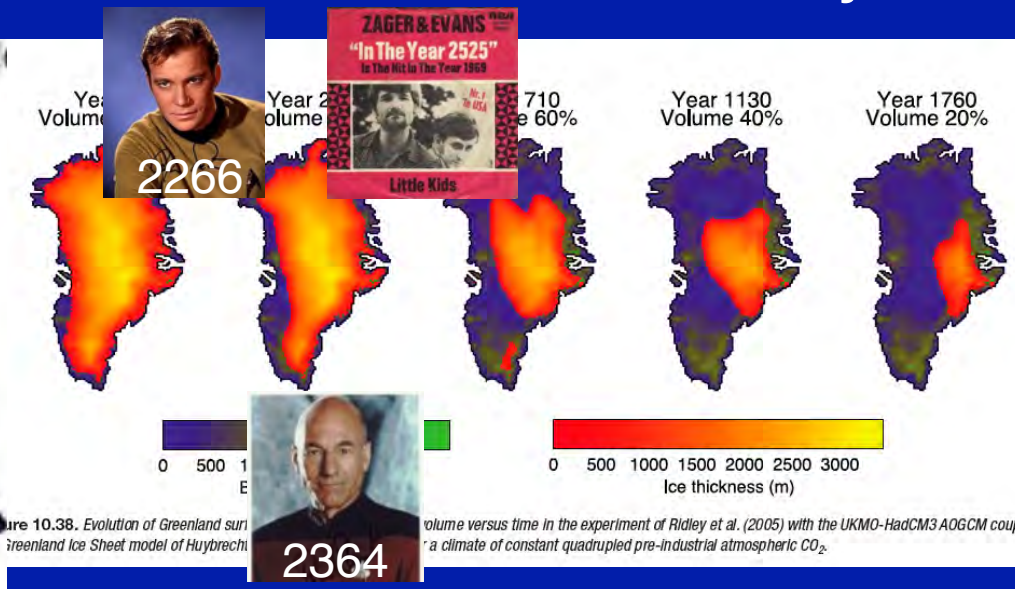
IPCC (intergovenrmental Panel Climate Change)

IPCC 2007: 700-1000 yr

New: Greenland surging, much sooner, but >>100 yr

Otto-Bleisner et al. (2006) simulation





2007 2300 2700 3100 3800 AD

125,000 y ago last interglacial

The future: IPCC (2007)

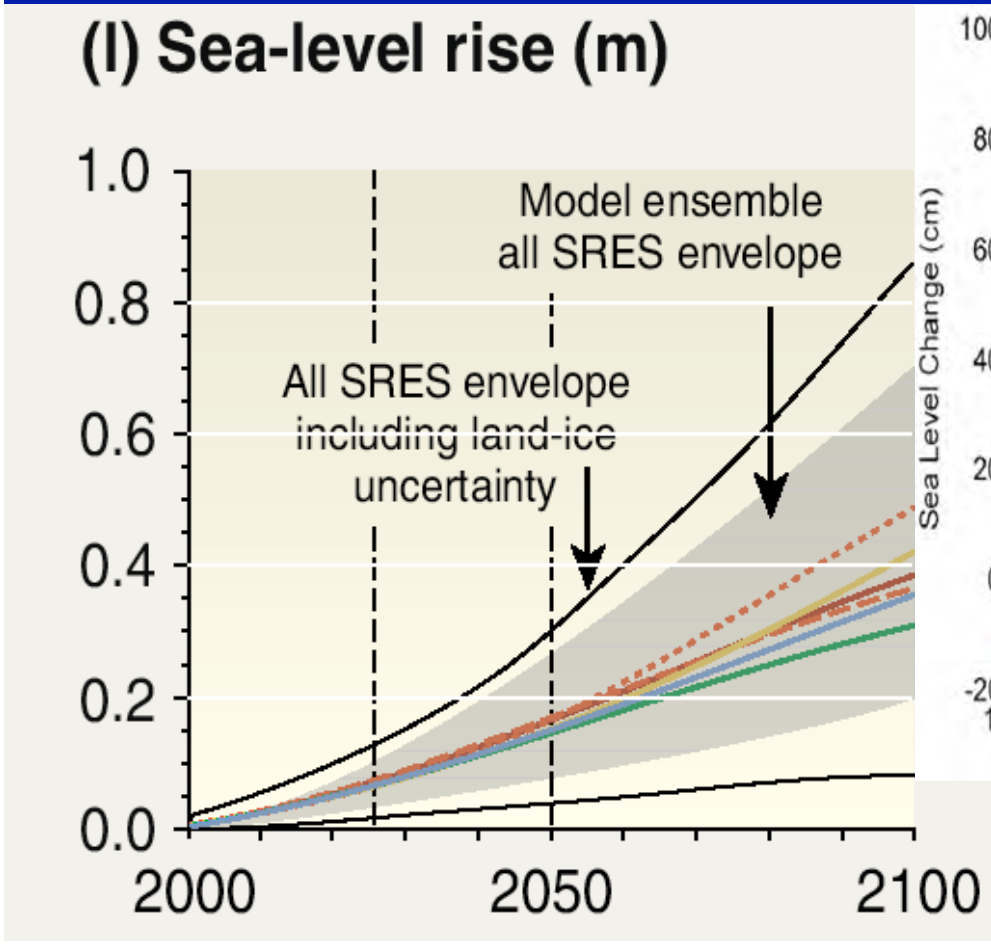
Sea-level forecast: IPCC 2001 & 2007

40 cm (1.25 ft) rise by 2100, 1 m (3.3 ft) by 2200

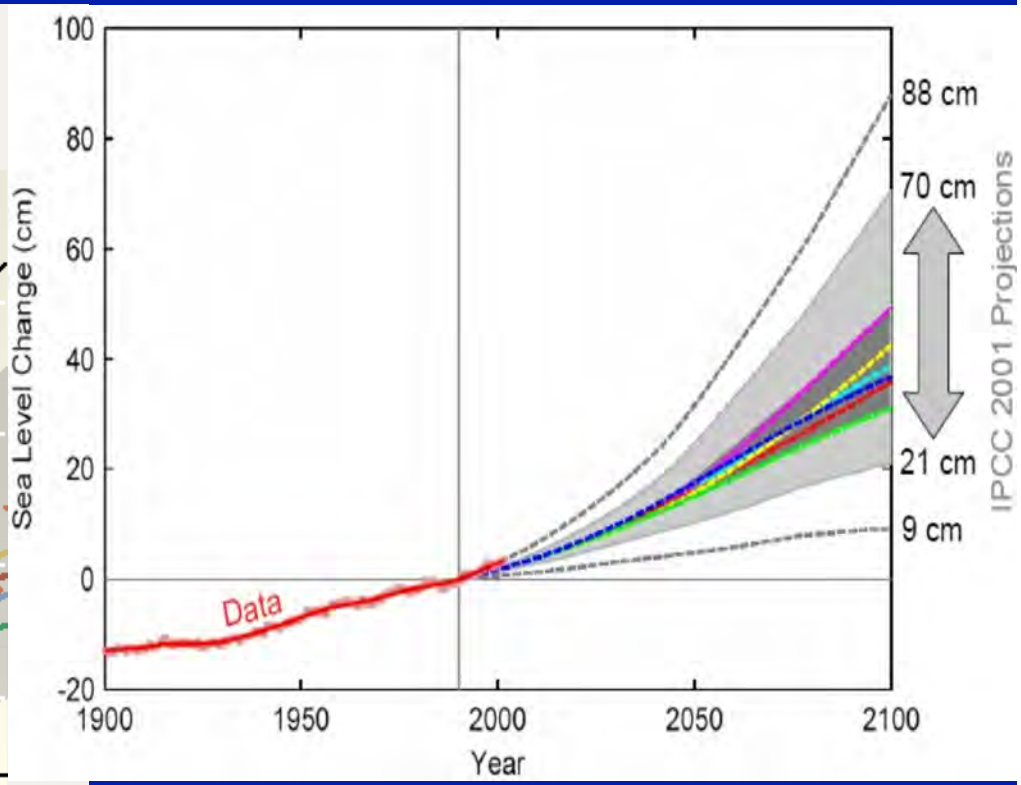
IPCC 2001 error estimate: 20-80 cm (0.7 to 2.6 ft)

IPPC 2007 error: 20-60 cm (does not include ice sheet melting)

2001



2007



http://www.realclimate.org/images/sealevel_1.jpg

IPCC misunderstood by press

Jonathan Gregory surprised at press reaction to 2007 AR4 report "reduction" in amount of sea-level rise to < 60 cm by 2100 since table indicates it excludes melting in Greenland and Antarctica

Table from AR4 report

Case	Temperature Change (°C at 2090-2099 relative to 1980-1999) [a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

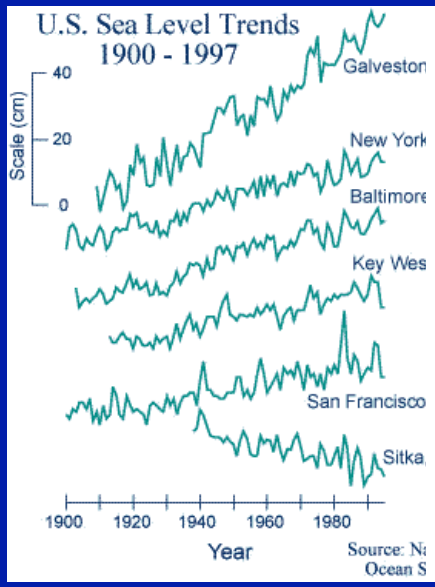
Model-based range excluding future rapid dynamical changes in ice flow

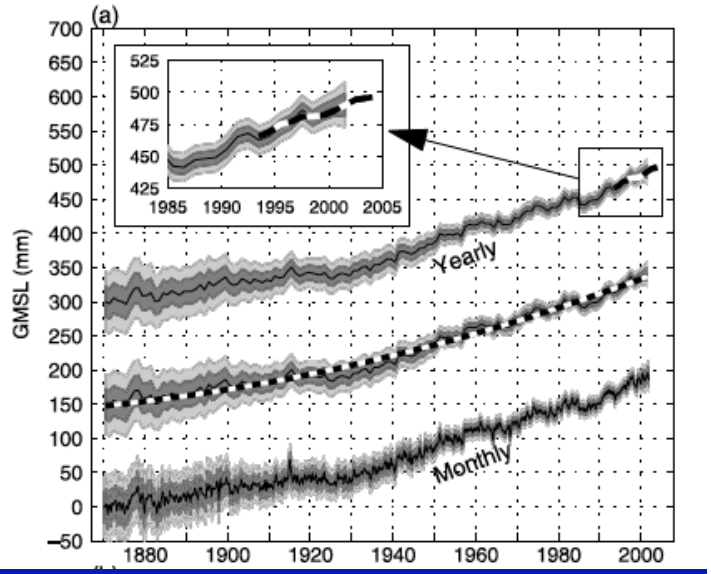
Global sea level is rising

20th Century ~1.8 mm/yr tide gauges Church & White (2006)

18 cm 20th century

= 7 inches = 0.6 ft





Satellite data

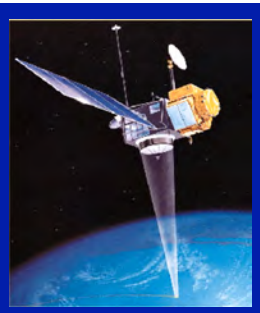
2.8±0.4 mm/yr '93-03

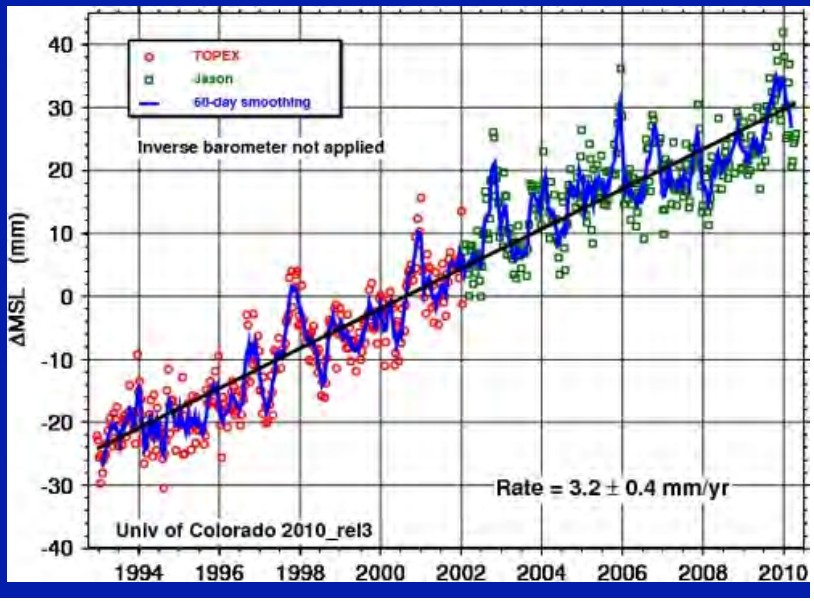
3.3±0.4 mm/yr '93-06

2.5 mm/yr '93-06

3.2±0.4 '93-10 http://sealevel.colorado.edu/

12 inches per 100 yr



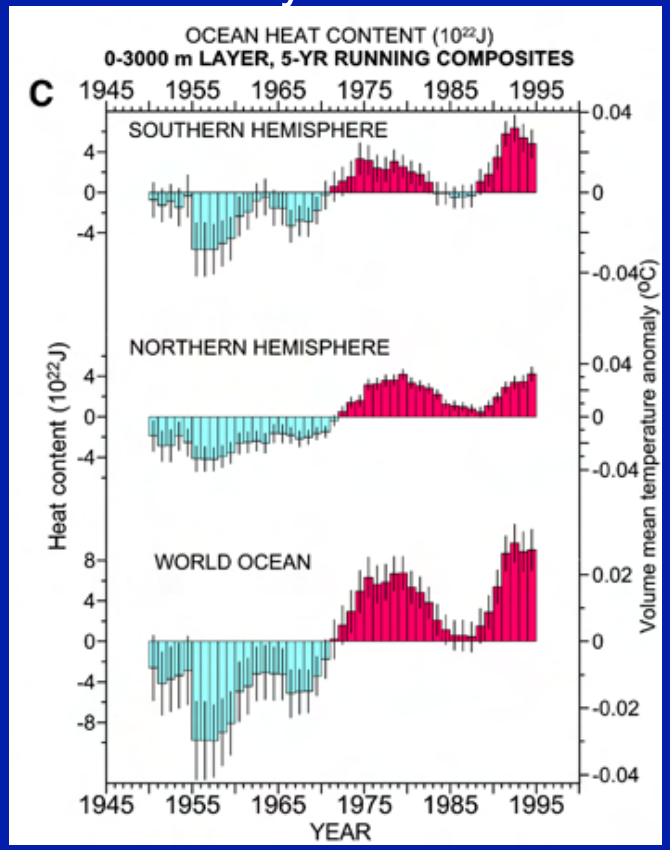


Why Is global sea level is rising today?

Thermal Expansion: ocean has gained heat

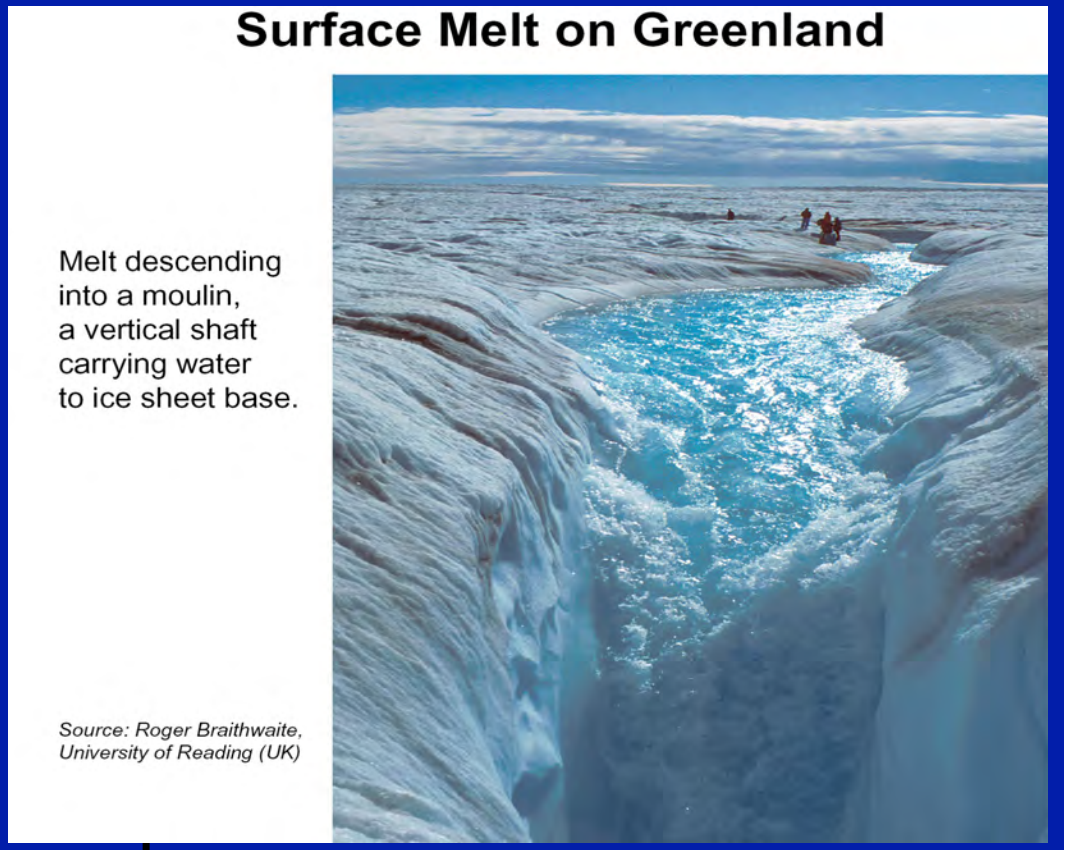
Warmer water less dense global 20th century warming ~0.6°C

1.6 mm/yr sea-level rise

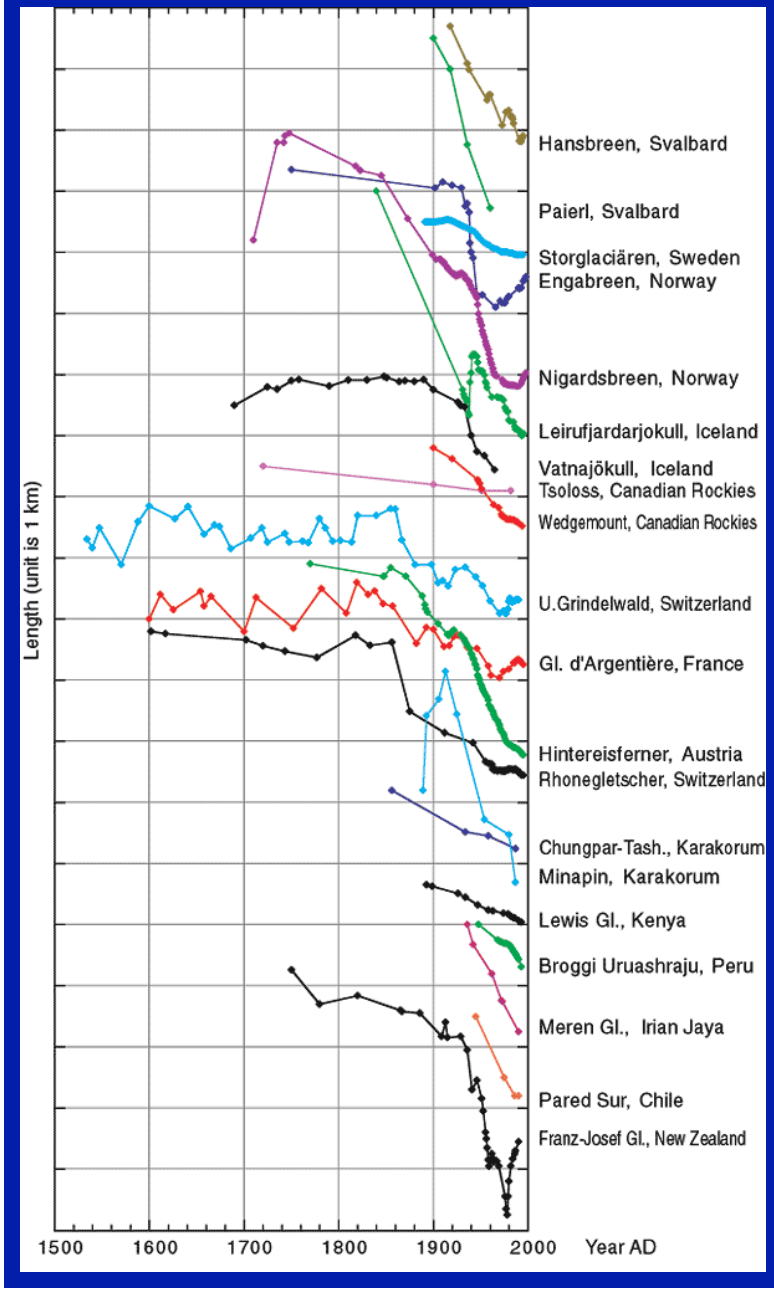


Melting Glaciers & Ice Caps:

Melting land ice adds to ocean volume, not sea ice



Why Is global sea level Is rising today?



Melting Mountain Glaciers and Ice Caps:

Alpine glaciers 0.6 mm/yr

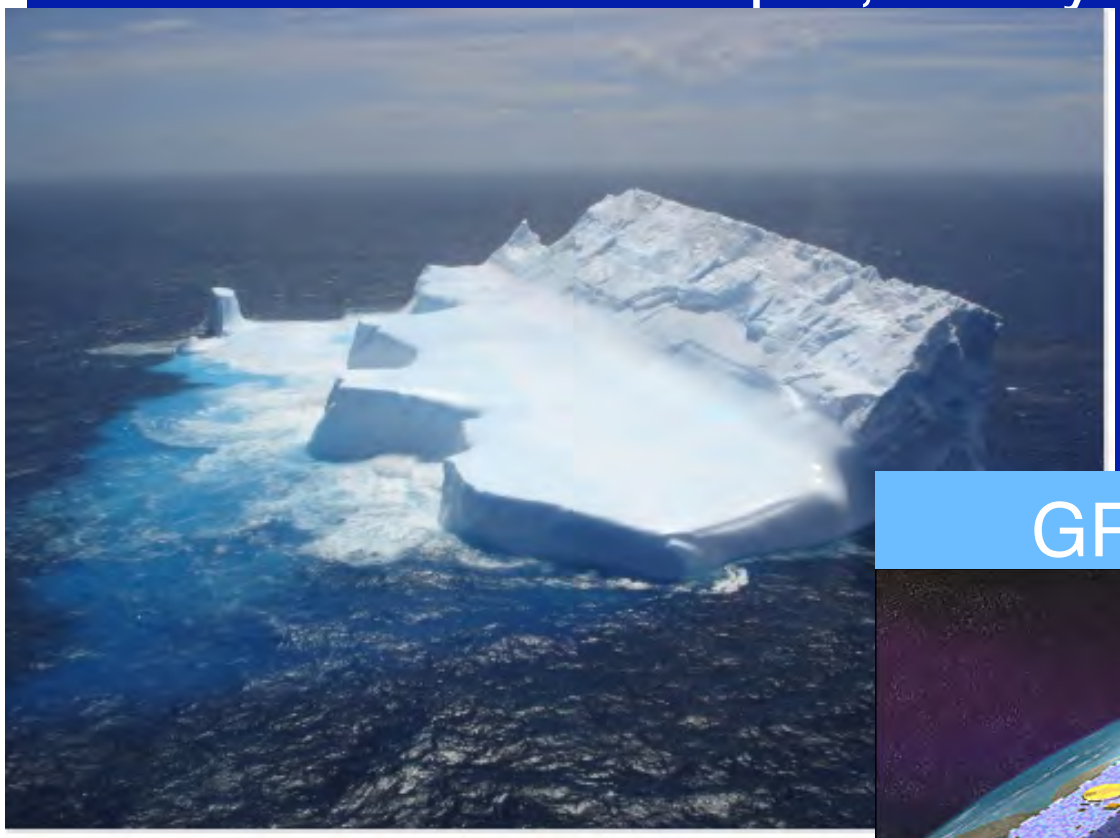
Greenland Ice Cap IPCC2001: near 0

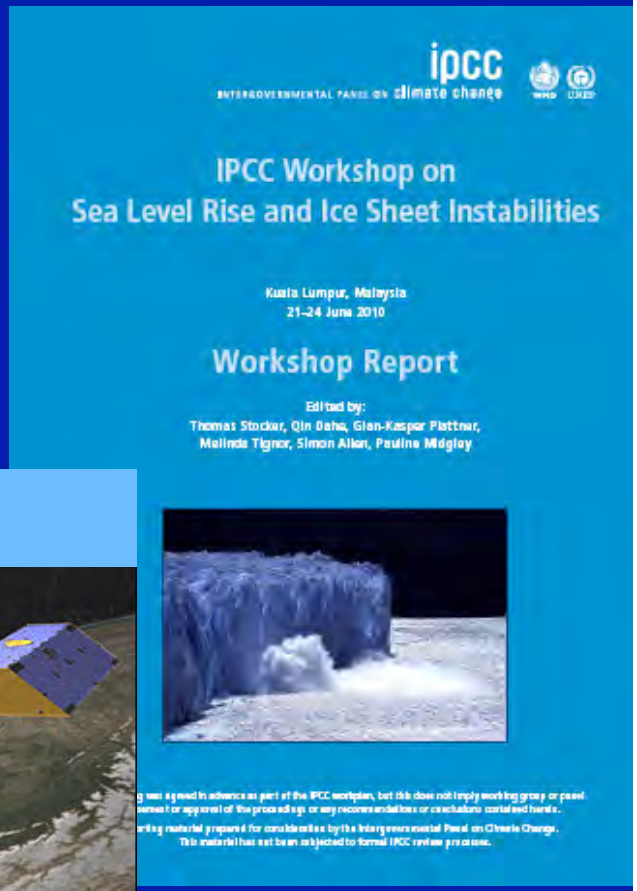
Cazenave & Nerem (2004): >0.15 mm/yr

New data: increased from 0.23 mm/yr 1996 to 0.6 mm/yr 2005 (Sterns & Hamilton 2007)

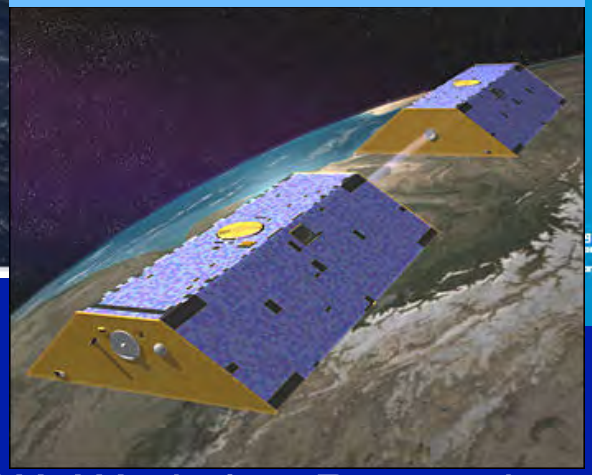
IPCC Workshop on Sea Level Rise and Ice Sheet Instabilities

Kuala Lumpur, Malaysia, June 2010



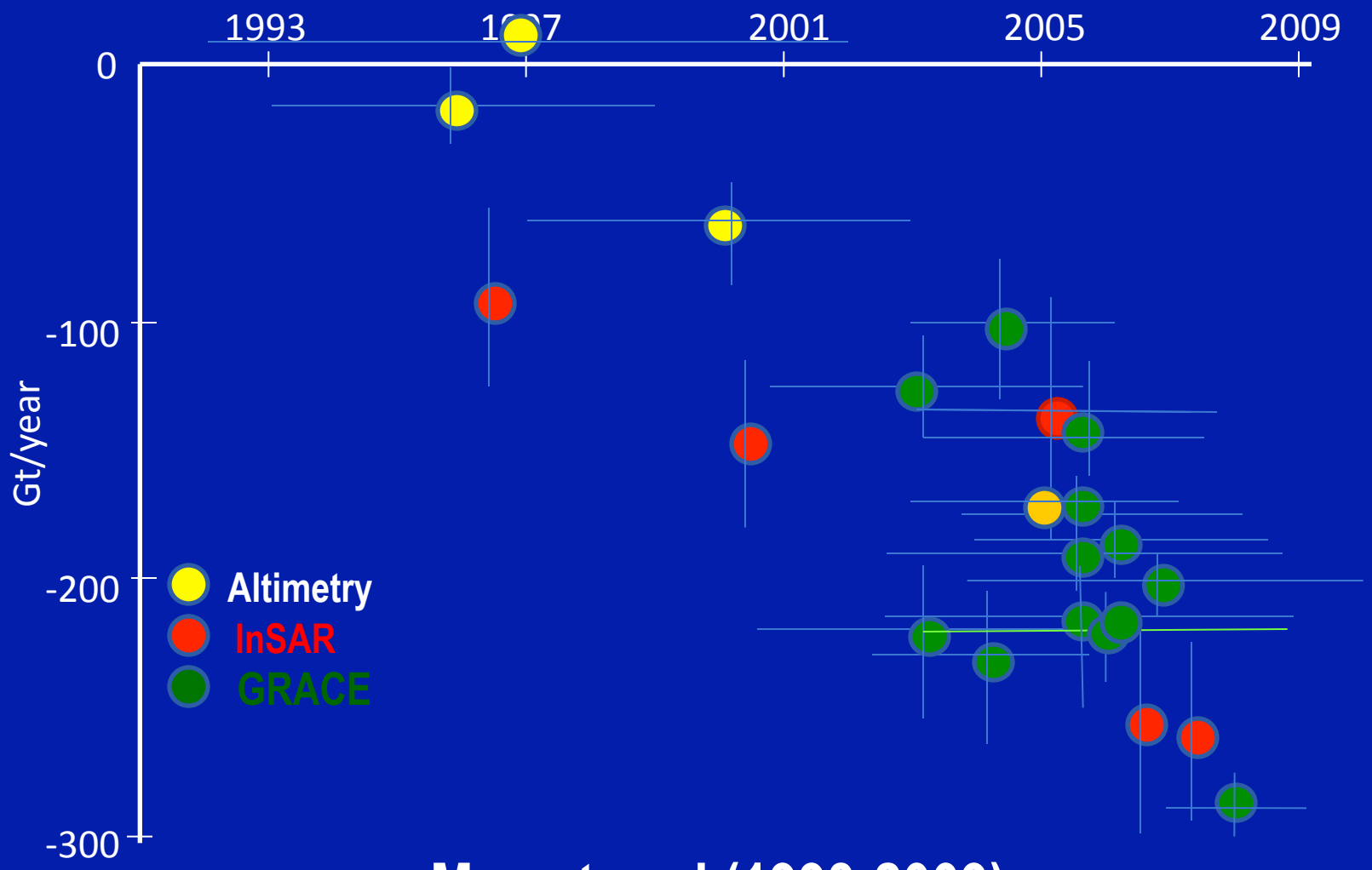


GRACE



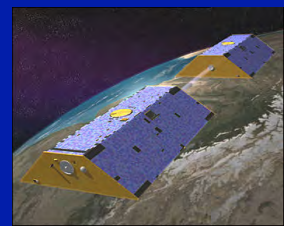
IPCC www.ipcc.ch/pdf/.../SLW_WorkshopReport_kuala_lumpur.pdf

Annual ice mass loss - Greenland

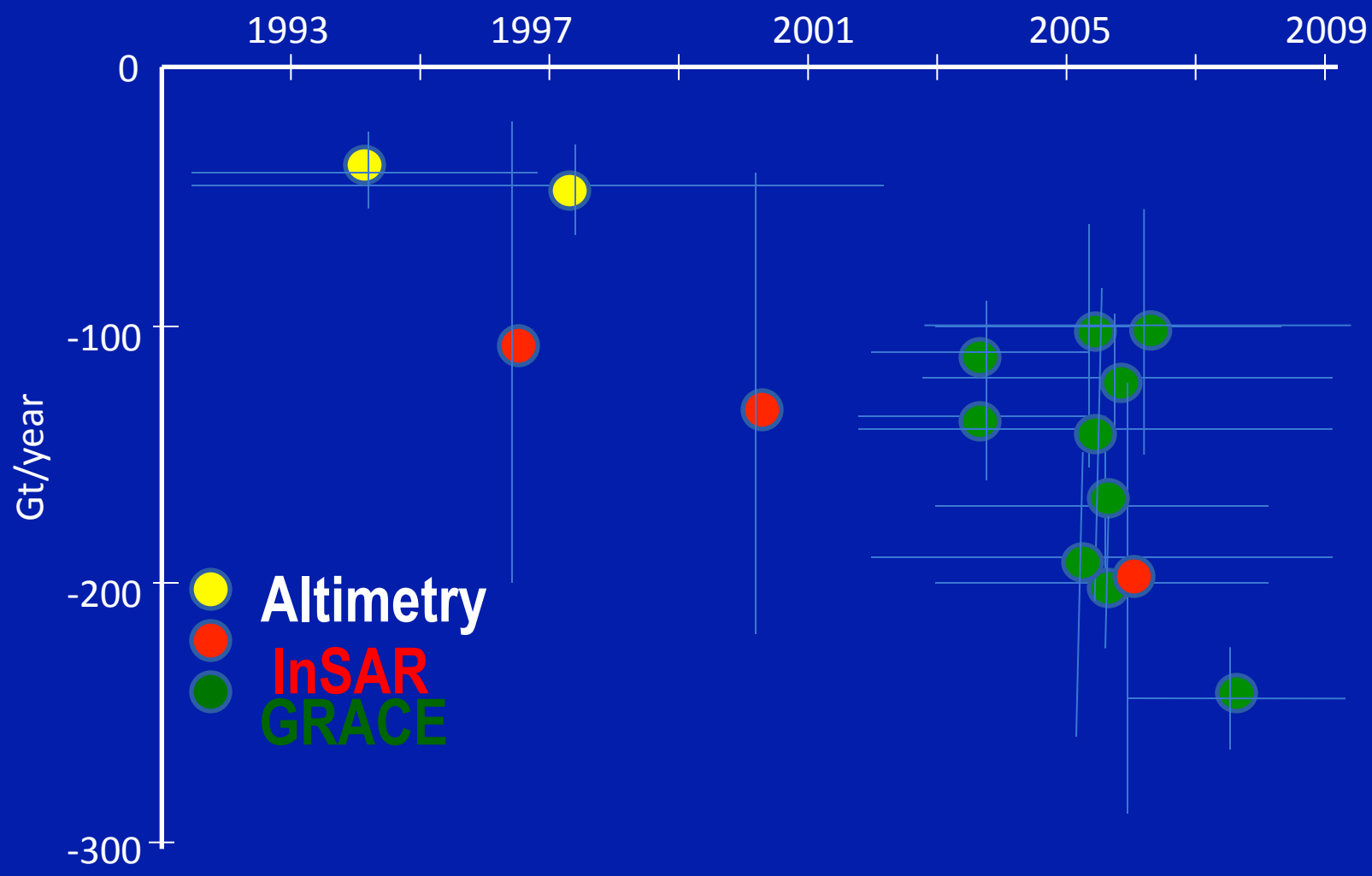


Mean trend (1993-2009)
~ 0.4-0.6 mm/yr sea level rise

Slide courtesy of A. Cazenave



Annual ice mass loss - Antarctica



Slide courtesy of A. Cazenave

Closing the budget

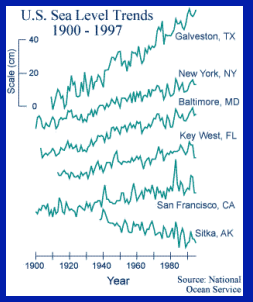
Tide gauge data 20th Century ~1.8 mm/yr

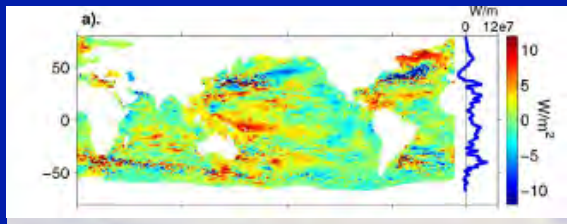
7 inches every 100 yr

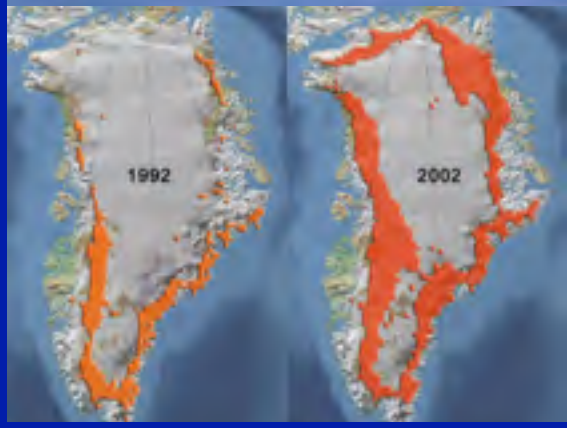
Satellite data, 3.2±0.4 '93-10

12.6 inches every 100

Warmer oceans	1.6 mm/yr
Alpine	0.6 mm/yr
Greenland	0.6 mm/yr
Antarctica	0.4 mm/yr
Total	3.2 mm/yr







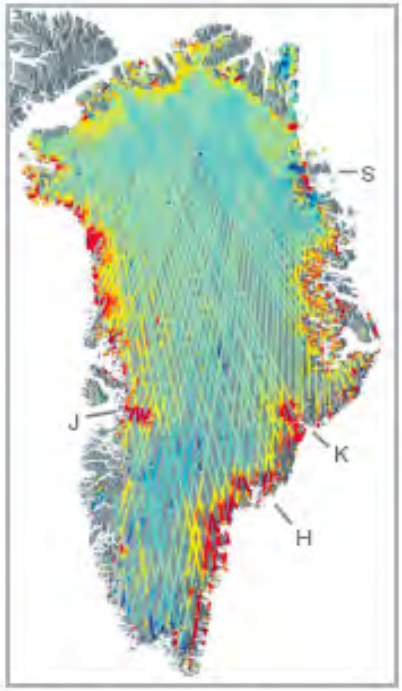
Slide by Ken Miller

Ice sheet melting

Extensive dynamic thinning on the margins of the Greenland and Antarctic ice sheets

Hamish D. Pritchard[1], Robert J. Arthern[1], David G. Vaughan[1] & Laura A. Edwards[2]

Greenland <7 m
W At. <5 m
E. Ant. Cook <12 m



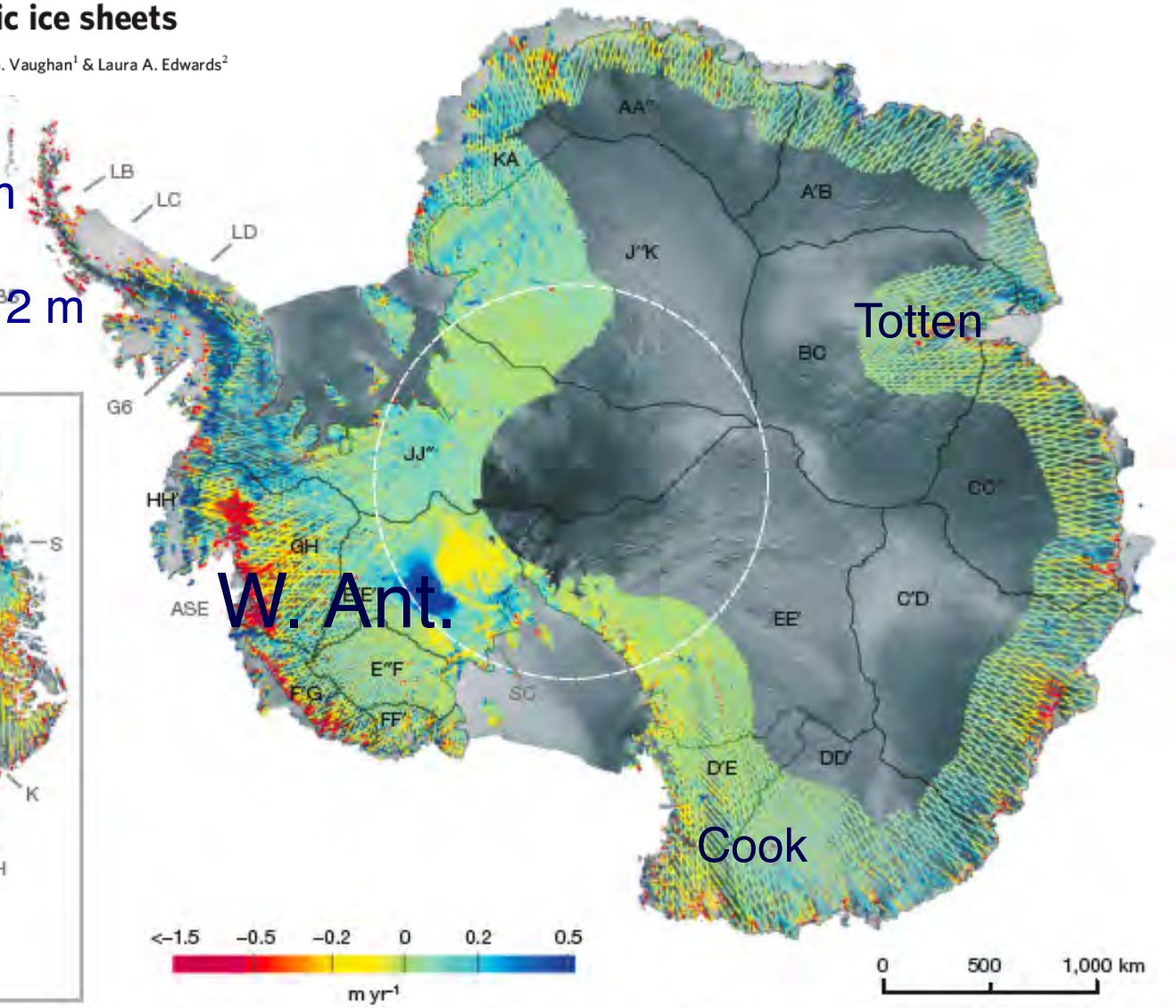
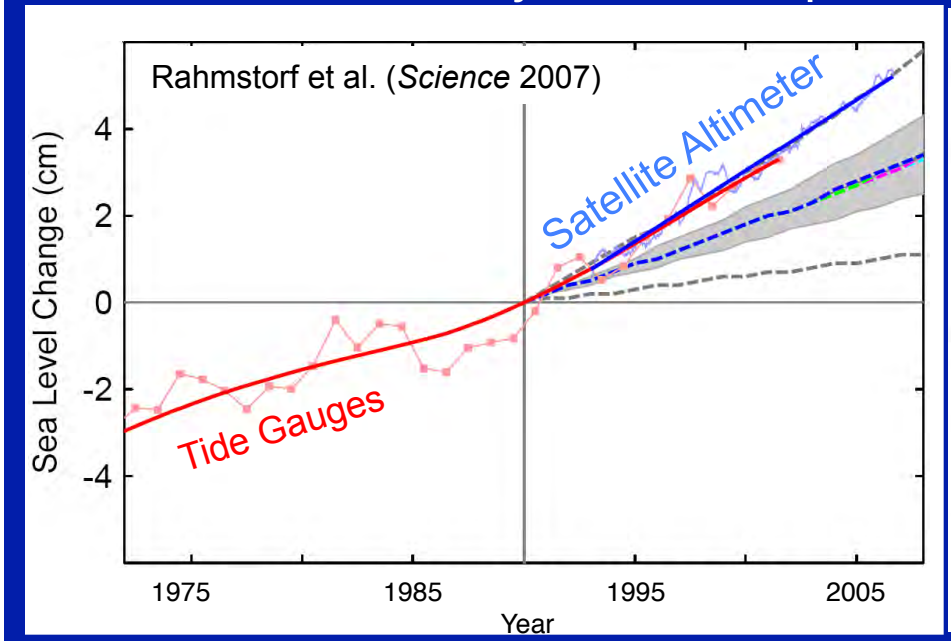


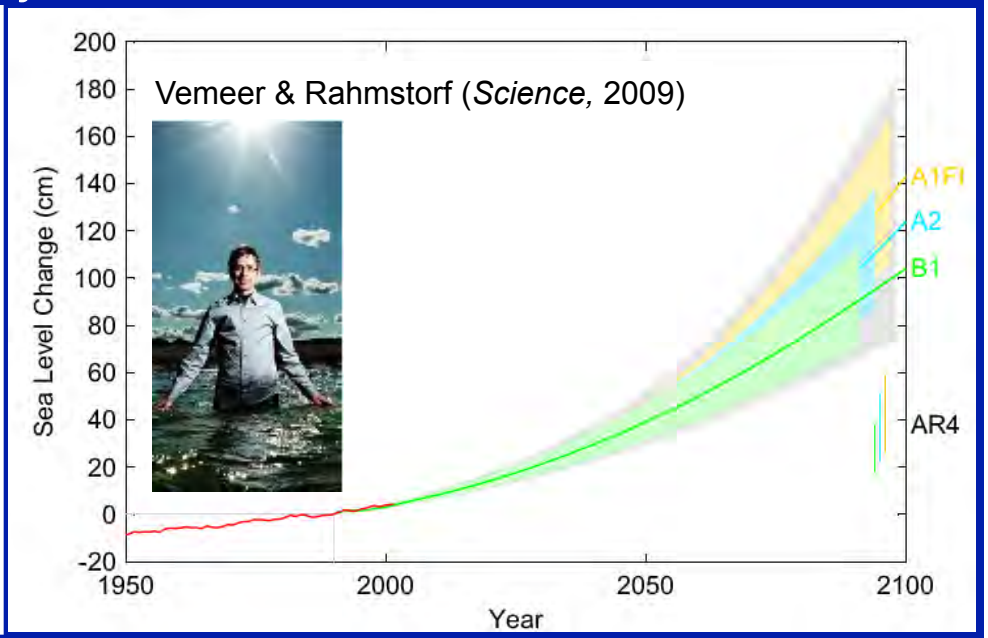
Figure 2 | Rate of change of surface elevation for Antarctica and Greenland. Change measurements are median filtered (10-km radius), spatially averaged (5-km radius) and gridded to 3 km, from intervals (Δt) of at least 365 d, over the period 2003–2007 (mean Δt is 728 d for Antarctica and 746 d for Greenland). East Antarctic data cropped to 2,500-m altitude. White dashed line (at 81.5° S) shows southern limit of radar altimetry measurements. Labels are for sites and drainage sectors (see text).

Sea level rise by 2100: 1.2±0.6 m

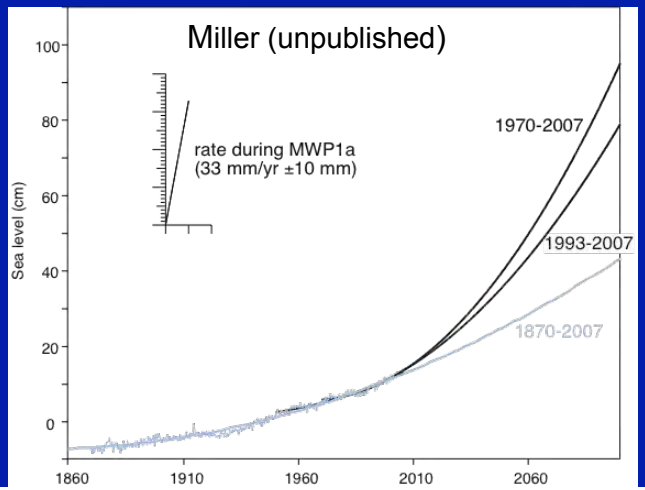
Not Gore's 5 m, not IPCC AR4 40±20 cm: >80 cm < 2 m global

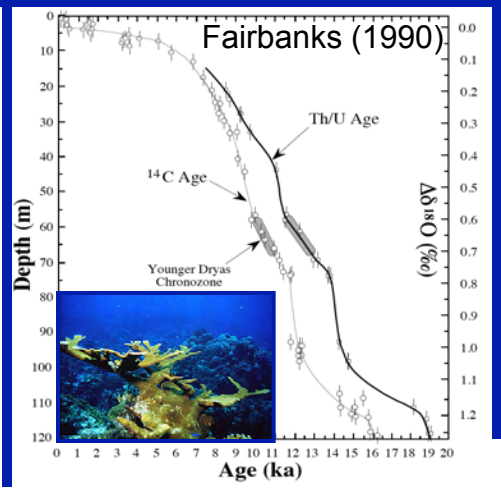
"Prediction is very difficult, especially if it's about the future." Niels Bohr





Geologic record constrains maximum rates: MWP1a >30-40mm/yr



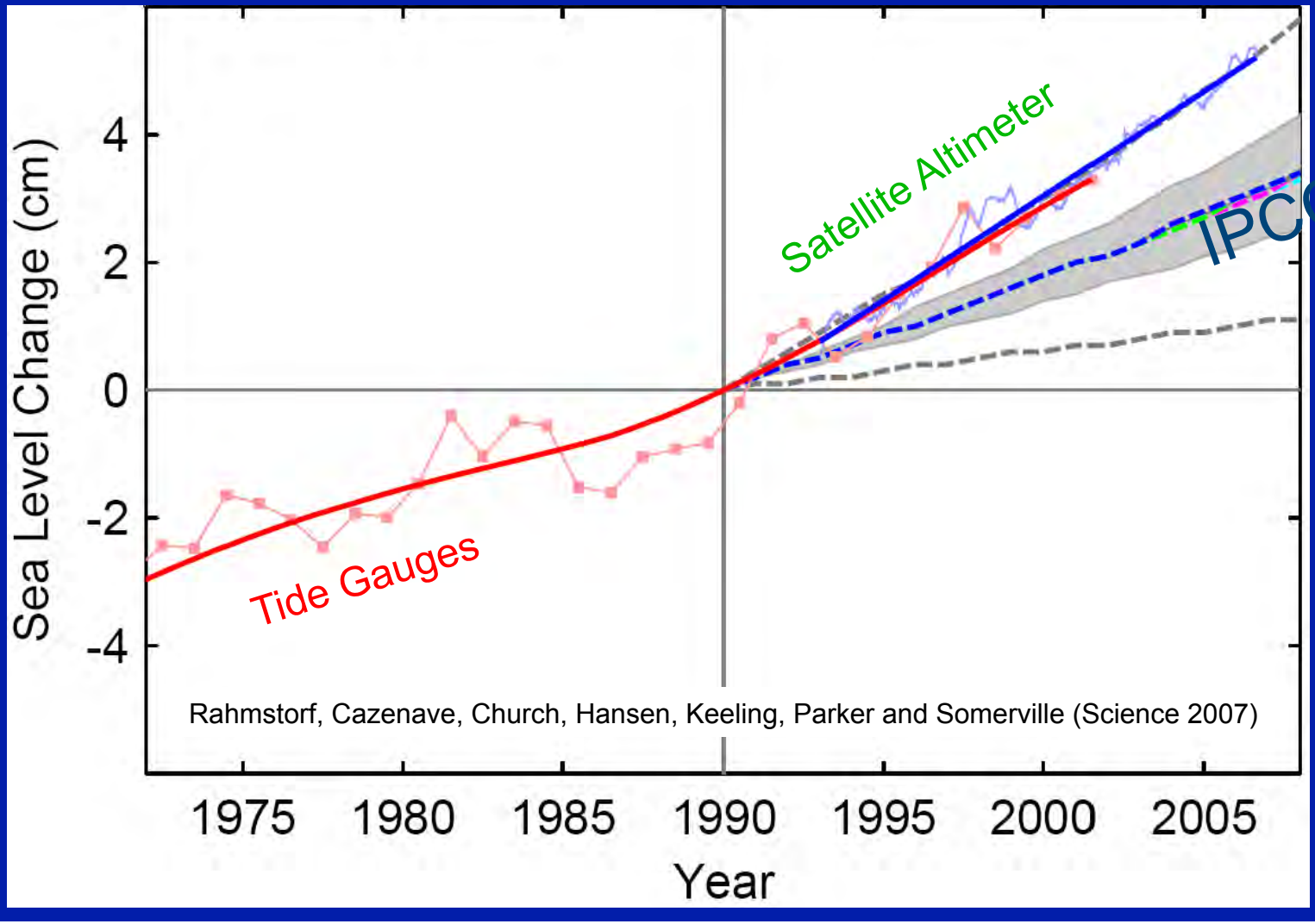


We are tracking high end predictions

Not a Gorian 5 m, but not IPCC2007 40±20 cm

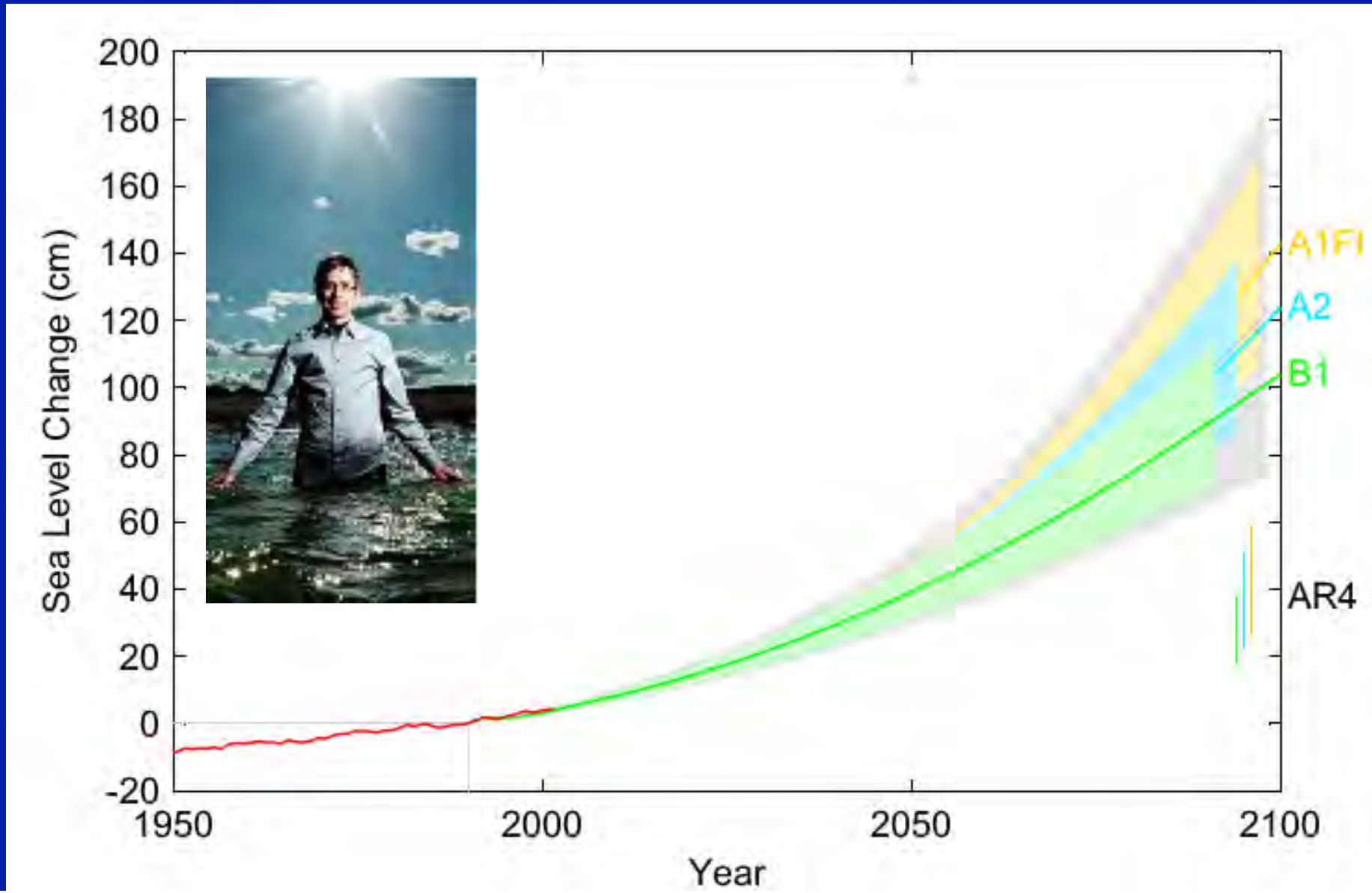
Best estimate >80 cm global; Rahmsdorf et al. (2007)

max. 1 m? 2m?? MWP1a maximium 47 mm/yr



Semi-empirical techniques of prediction

Vermeer and Rahmstorf: 1.4 m for A1F1 emissions scenario



Semi-empirical techniques of prediction

The groups who have published semi-empirical predictions were met with skepticism in Kuala Lumpur because they assume response of ice to warming be the same in the 21st century as in 20th

Movie is 25 x normal speed: Calving of Jakobshavn Isbræ = Jakobshavn Glacier = Sermeq Kujalleq after Jason Ammondson, University of Alaska

Denialists weigh in: "Sea level rise predictions are exaggerated. Professor Niklas Mörner, who has been studying sea level for a third of a century, says it is physically impossible for sea level to rise at much above its present rate, and he expects 4-8 inches of sea level rise this century, if anything rather below the rate of increase in the last century."

http://www.skepticalscience.com/sea-level-rise-predictions.htm

Nils-Axel Mörner

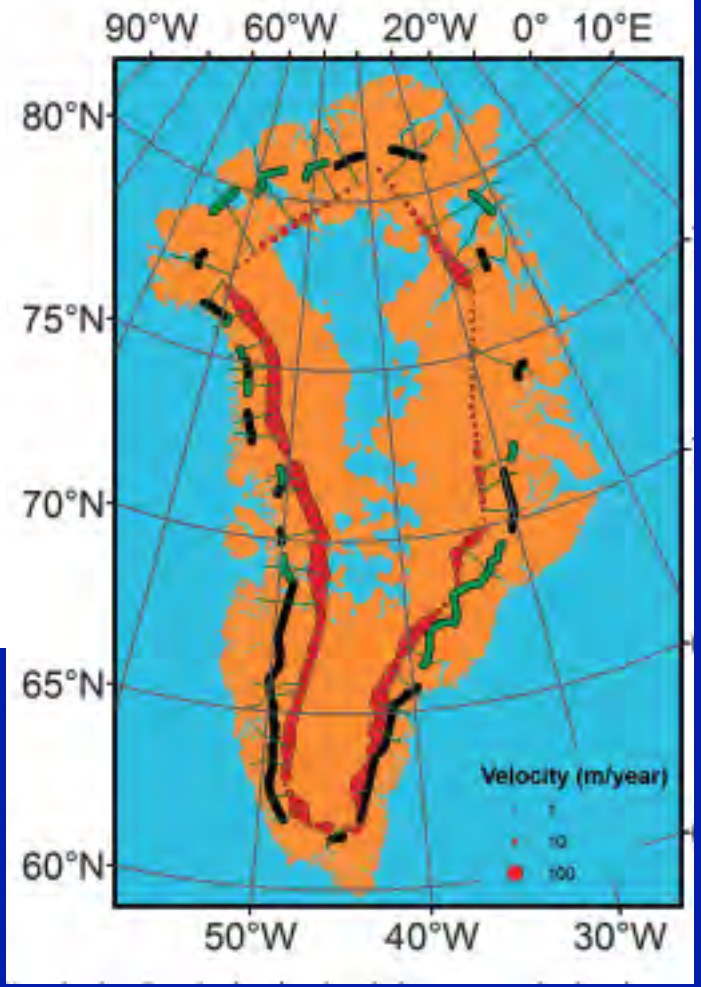
Ice sheets constrain 2100 melting to < 2 m

Kinematic Constraints on Glacier Contributions to 21st-Century Sea-Level Rise

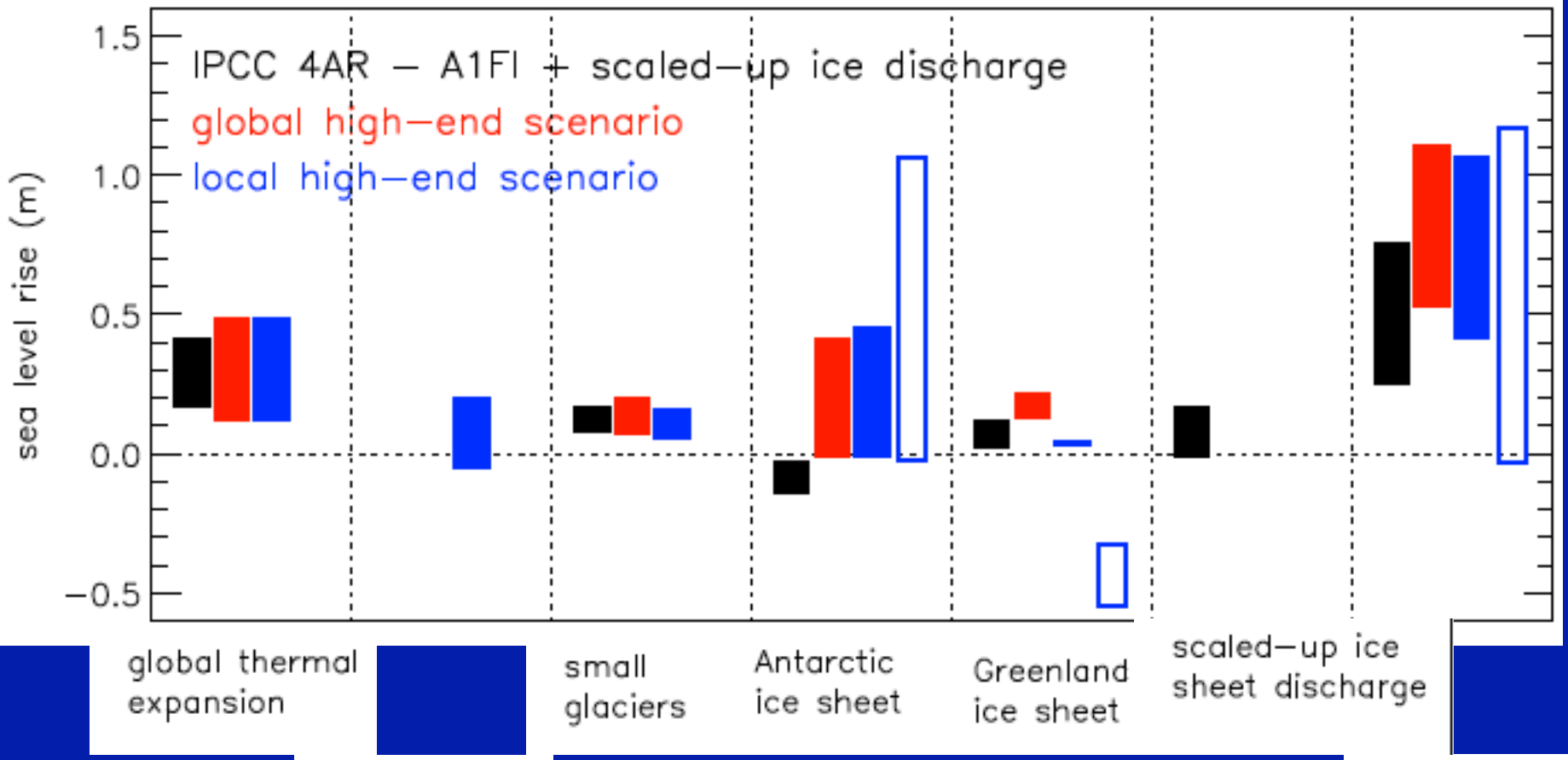
W. T. Pfeffer,[1]* J. T. Harper,[2] S. O'Neel[3]

On the basis of climate modeling and analogies with past conditions, the potential for multimeter increases in sea level by the end of the 21st century has been proposed. We consider glaciological conditions required for large sea-level rise to occur by 2100 and conclude that increases in excess of 2 meters are physically untenable. We find that a total sea-level rise of about 2 meters by 2100 could occur under physically possible glaciological conditions but only if all variables are quickly accelerated to extremely high limits. More plausible but still accelerated conditions lead to total sea-level rise by 2100 of about 0.8 meter. These roughly constrained scenarios provide a "most likely" starting point for refinements in sea-level forecasts that include ice flow dynamics.

	SLR equivalent (mm)		
	Low 1	Low 2	High 1
Greenland			
Dynamics	93	93	467
SMB	71	71	71
Greenland total	165	165	538
Antarctica			
PIG/Thwaites dynamics	108		394
Lambert/Amery dynamics	16		158
Antarctic Peninsula dynamics	12		59
SMB	10		10
Antarctica total	146	128	619
Glaciers/ice caps			
Dynamics	94		471
SMB	80		80
GIC total	174	240	551
Thermal expansion	300	300	300
Total SLR to 2100	785	833	2008



High end scenarios 2100: < 1.1 m

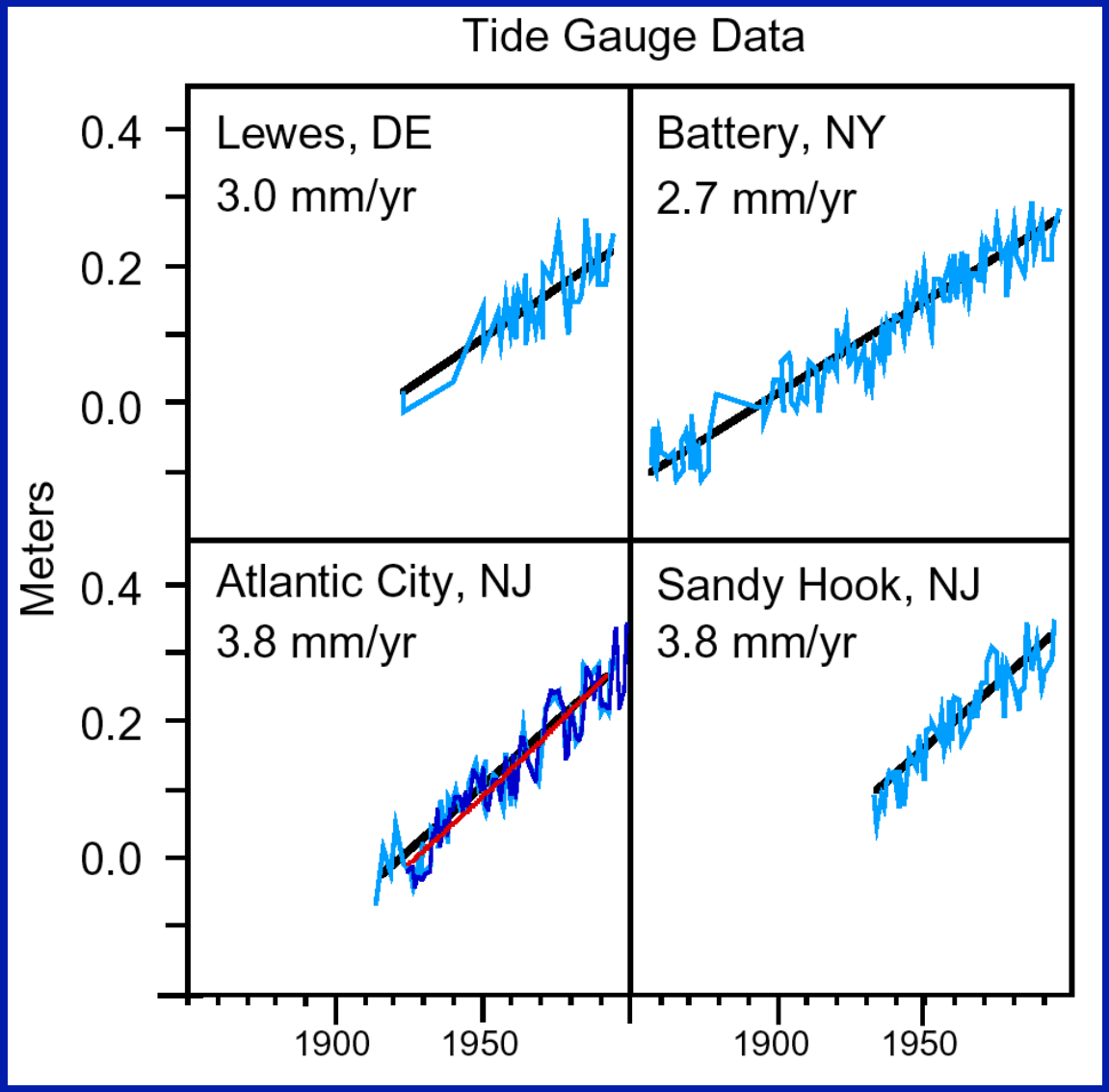


Exploring high-end scenarios for local sea level rise to develop flood protection strategies for a low-lying delta - the Netherlands as an example

C. A. Katsman · A. Sterl · J. J. Beersma · H. W. van den Brink · J. A. Church · W.

Katsman et al., 2011, *Climate Change*

Global, Regional, and Local Effects



Modified after Psuty and Collins (1986)

NY/NJ/DE region
higher sea-level rise

Processes:

- Global (eustatic) rise
  1.8 mm/yr
- Regional subsidence
  flexural unloading
  Laurentide removal
  1 mm/yr
- Local subsidence
  due to water withdrawal
  & compaction
  1 mm/yr

Should I Sell My Shore House?

My shore house is an island during three “100-year” storms:
Hallloween ‘91, Dec. ‘92, Oct. ‘05

Should I Sell My Shore House?

Don't sell: insure!
global >80 cm (2.4 ft) by 2100
NJ >-100 cm (>3 ft)
NJ > 1 ft by 2050

View of NY harbor in an ice-free world
(73 m rise)

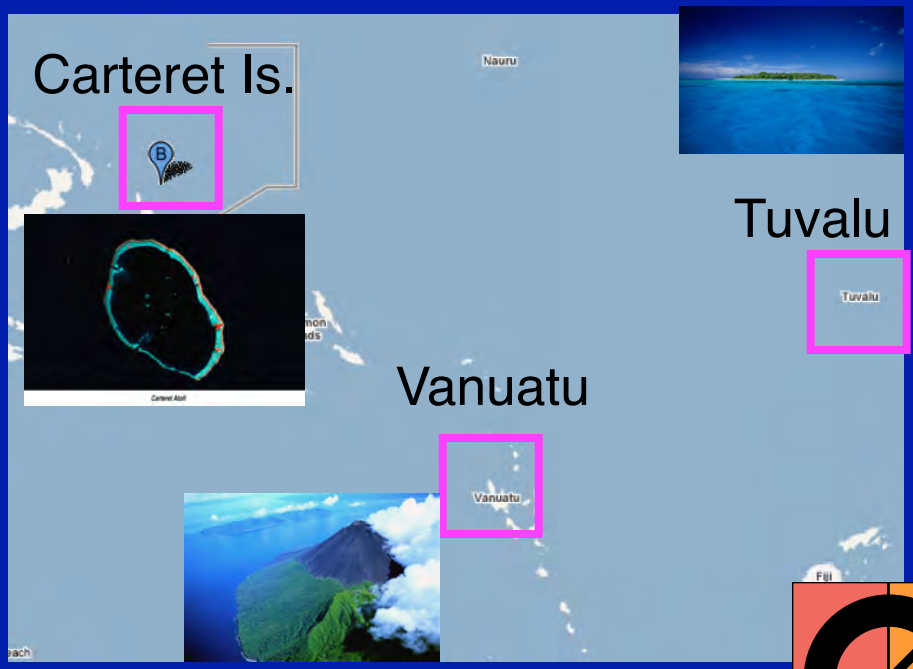
More beach erosion, rollback

More cost to replenish

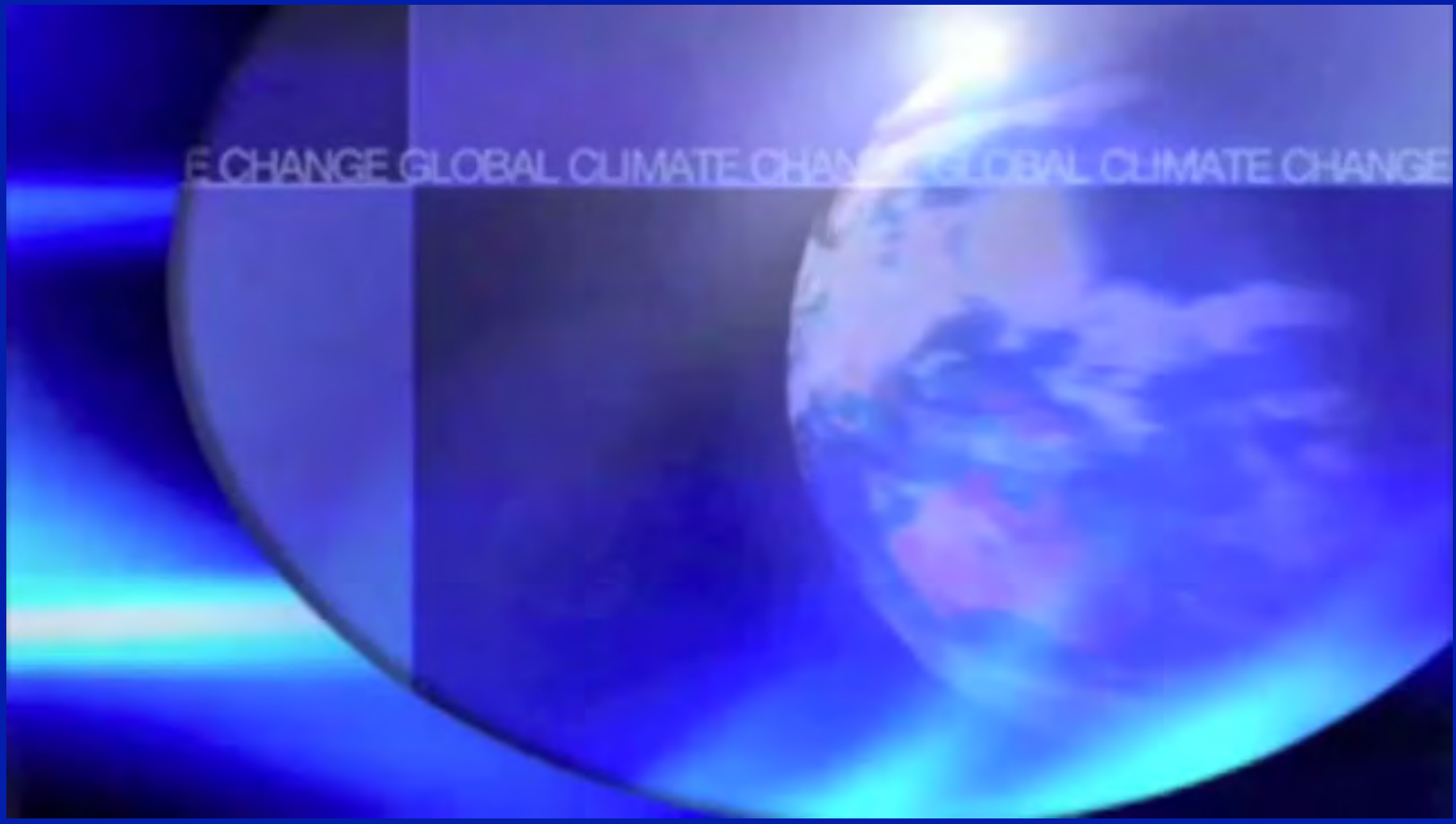
Loss of marshland

Increased storm intensity?

What about those coming behind?



Gore vs. Fox News



Peter Sinclair's Crock of the week:
http://www.youtube.com/watch?v=kffsux-ifKk