NKG General Assembly 2014, September 1, 2014, Chalmers

Climate Change – the State of Science

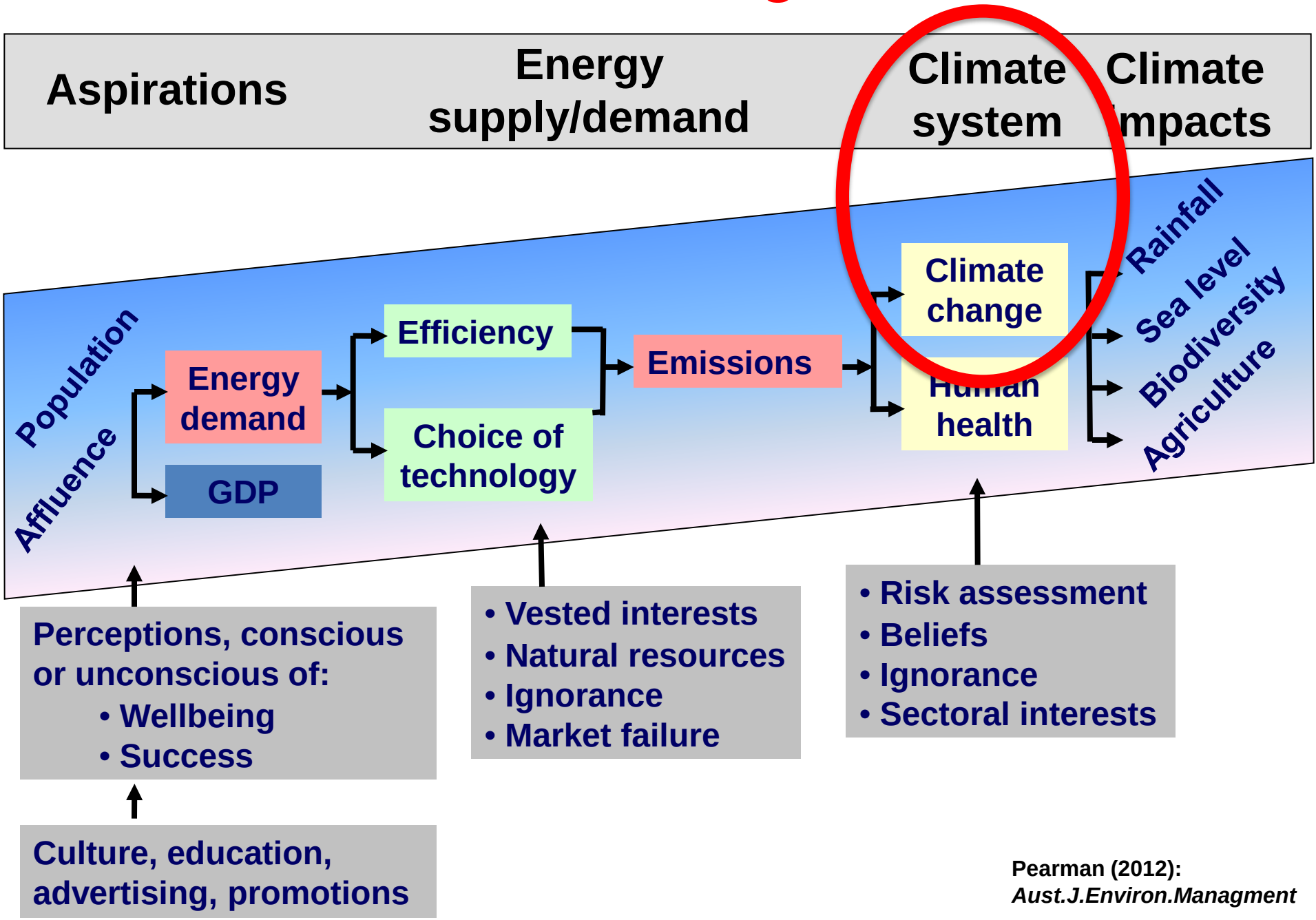
Deliang Chen
Department of Earth Sciences
University of Gothenburg, Sweden
http://rcg.gvc.gu.se/dc

Acknowledgement for few slides from: IPCC, A. Cazenave, J. Rockström

Outline

- Climate change-not just a physical issue
- A quick summary of IPCC AR5
- A closer look at sea level rise
- Future outlooks for climate science

The climate change issue



Pearman (2012):
Aust.J.Environ.Managment

IGBP: State of Science event in Stockholm for the IPCC AR5 WG1 report release, September 27, 2013

back

Key SPM Messages

19 Headlines

on less than 2 Pages

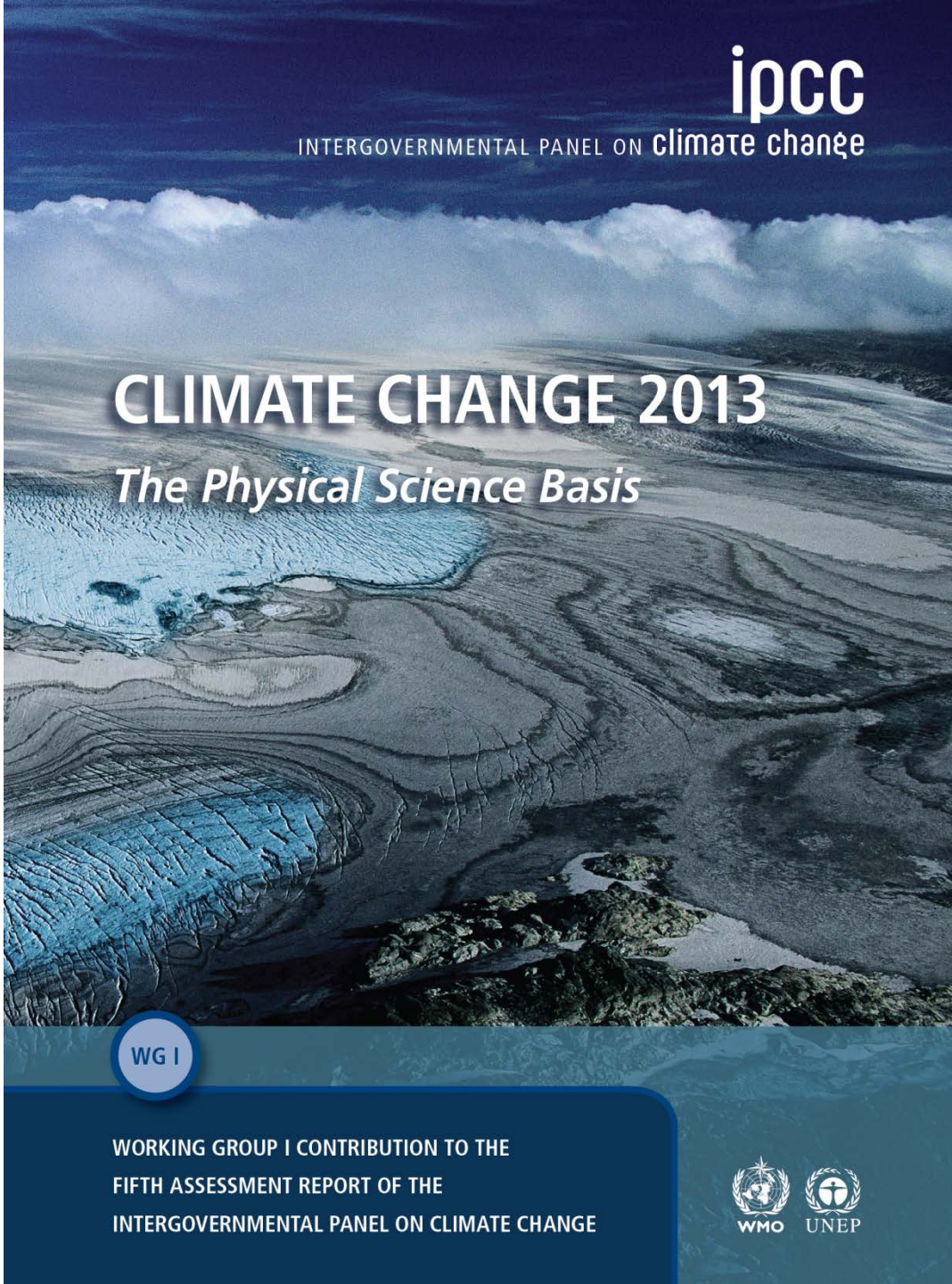
Summary for Policymakers
~14,000 Words

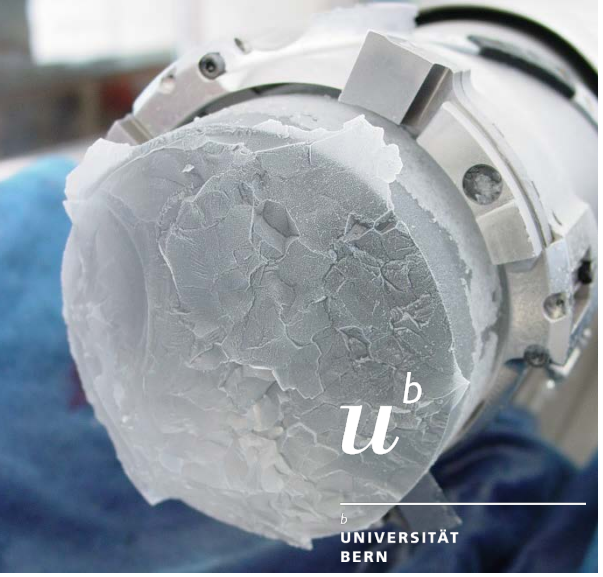
14 Chapters
Atlas of Regional Projections

54,677 Review Comments
by 1089 Experts

2010: 259 Authors Selected

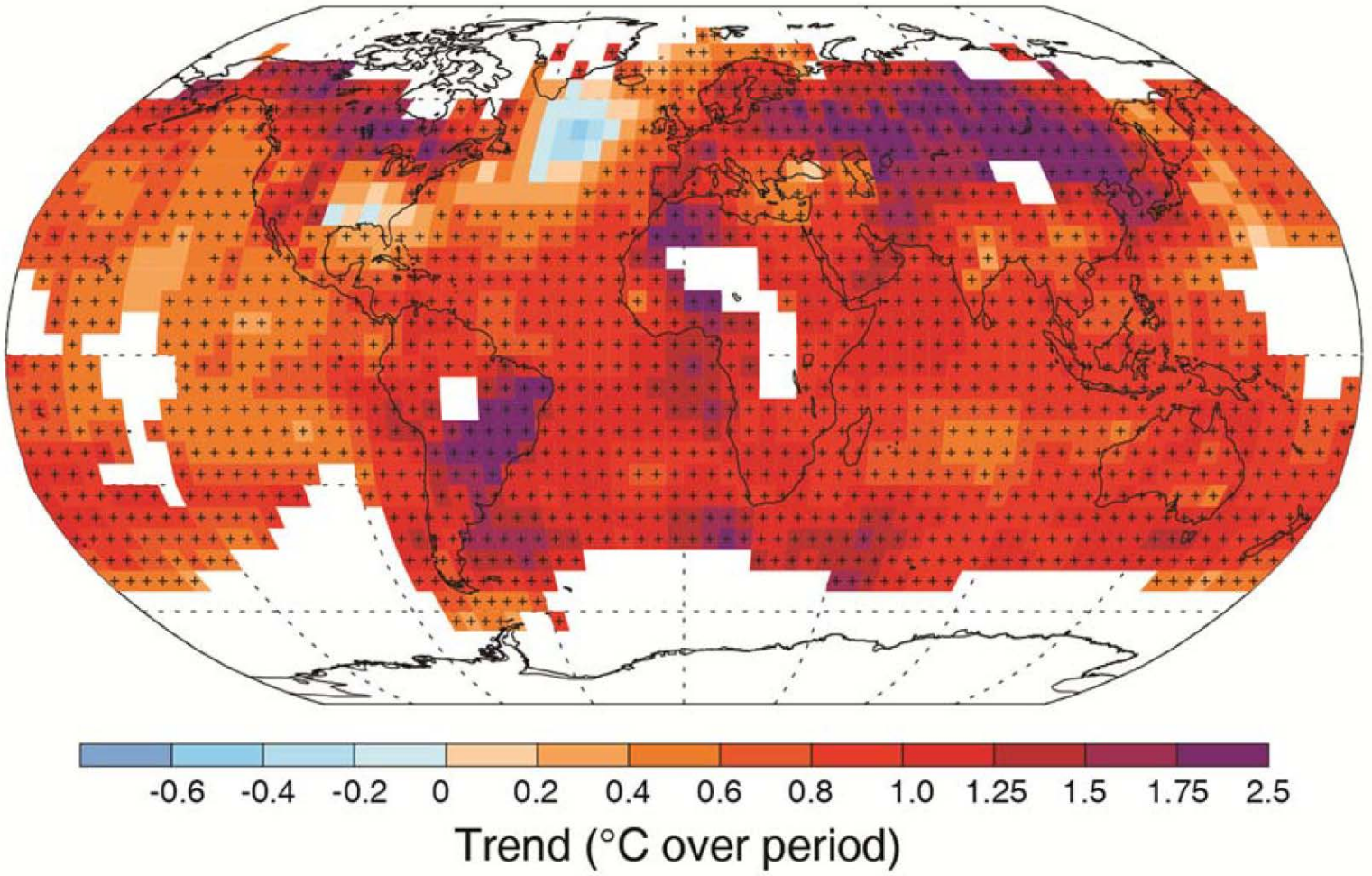
2009: WGI Outline Approved



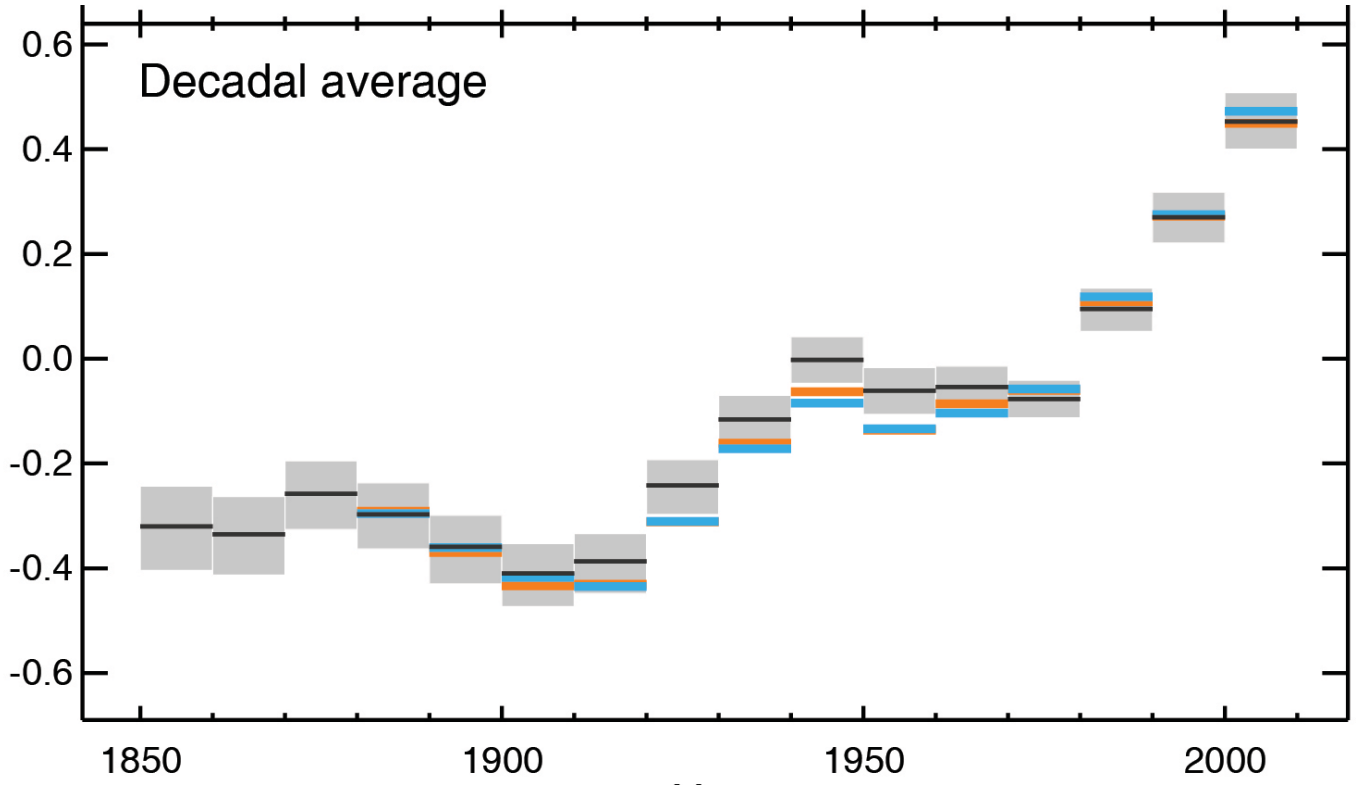


(Lüthi et al.,2008, NOAA)

The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years.



Warming (1901-2012) in the climate system is unequivocal

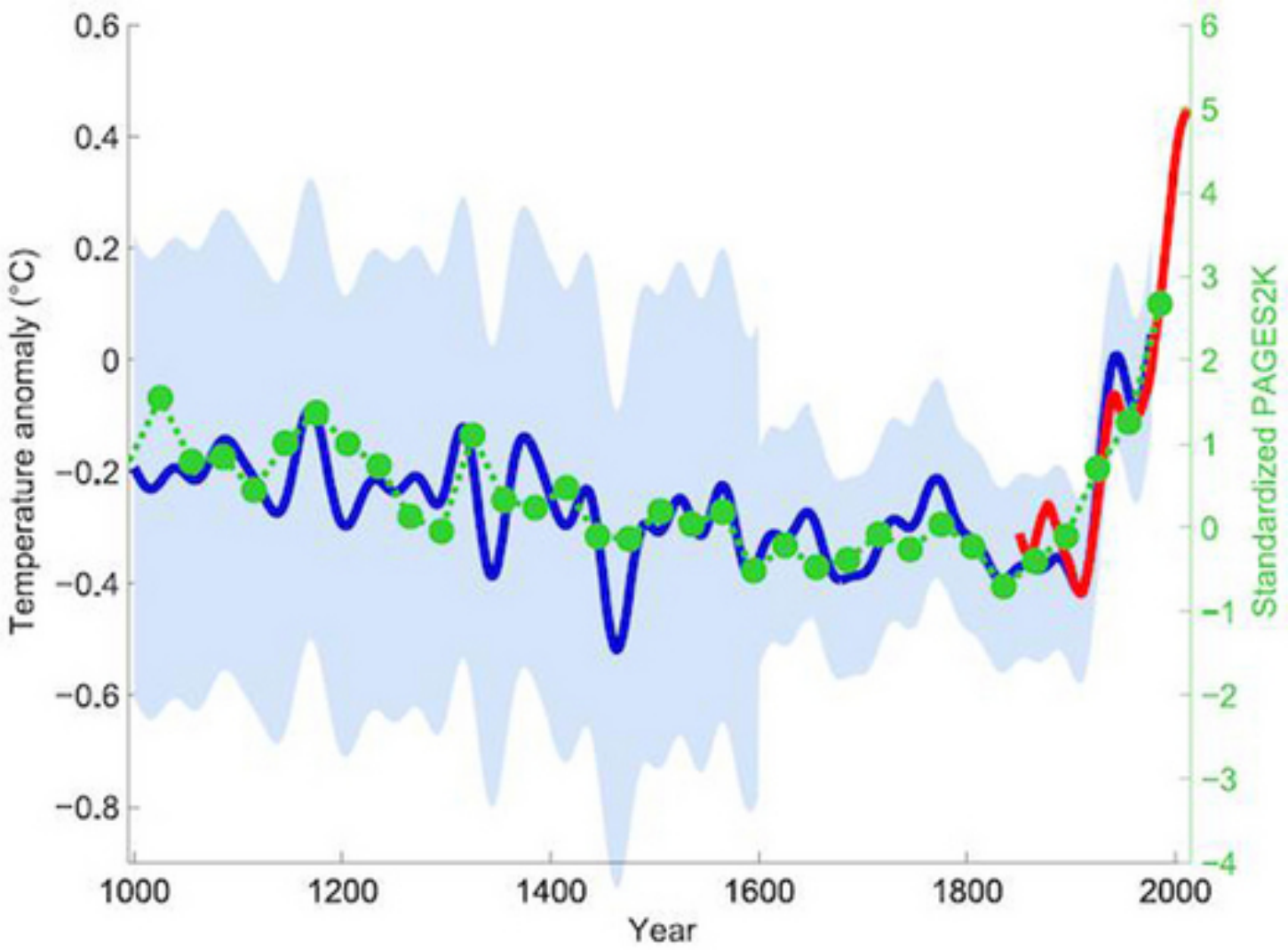


Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.

In the Northern Hemisphere, 1983–2012 was *likely* the warmest 30-year period of the last 1400 years (*medium confidence*).

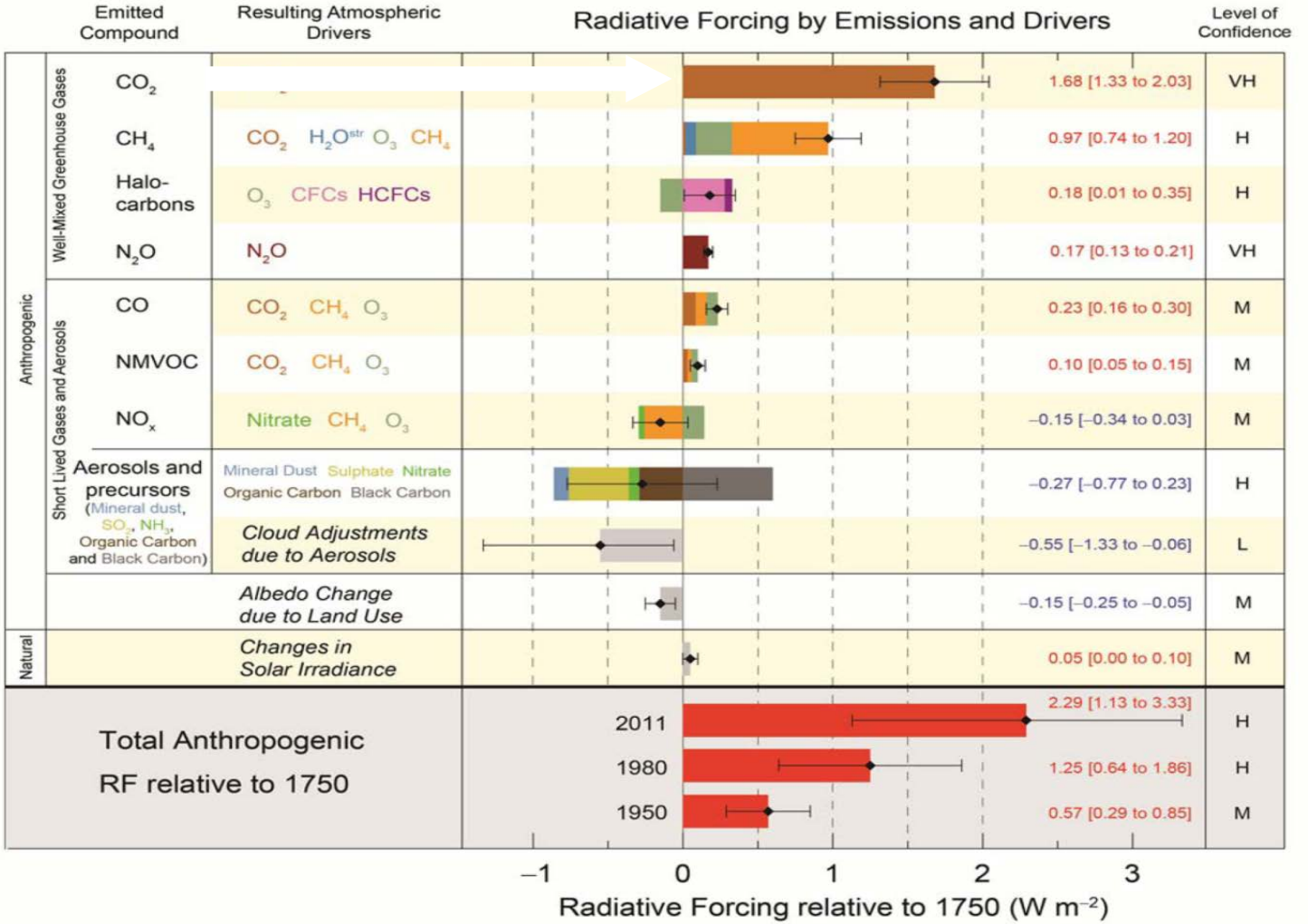
Global temperature over the last 1000 years:

Green dots show the 30-year average of a reconstruction. The red curve shows the global mean temperature based on instruments. In blue is the original hockey stick of Mann, Bradley and Hughes (1999), with its uncertainty range (light blue). Graph by Klaus Bitterman.

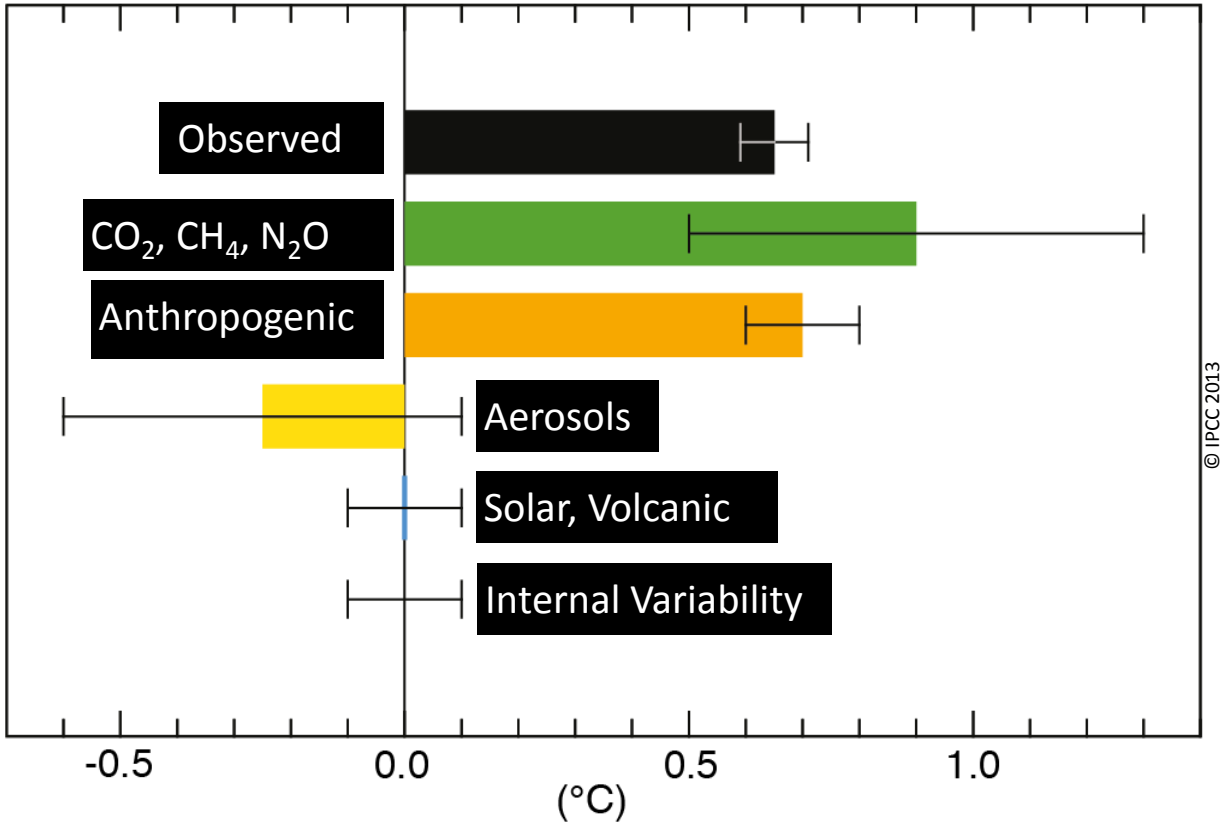


Anthropogenic influence on climate is generally warming

Radiative forcing (RF)

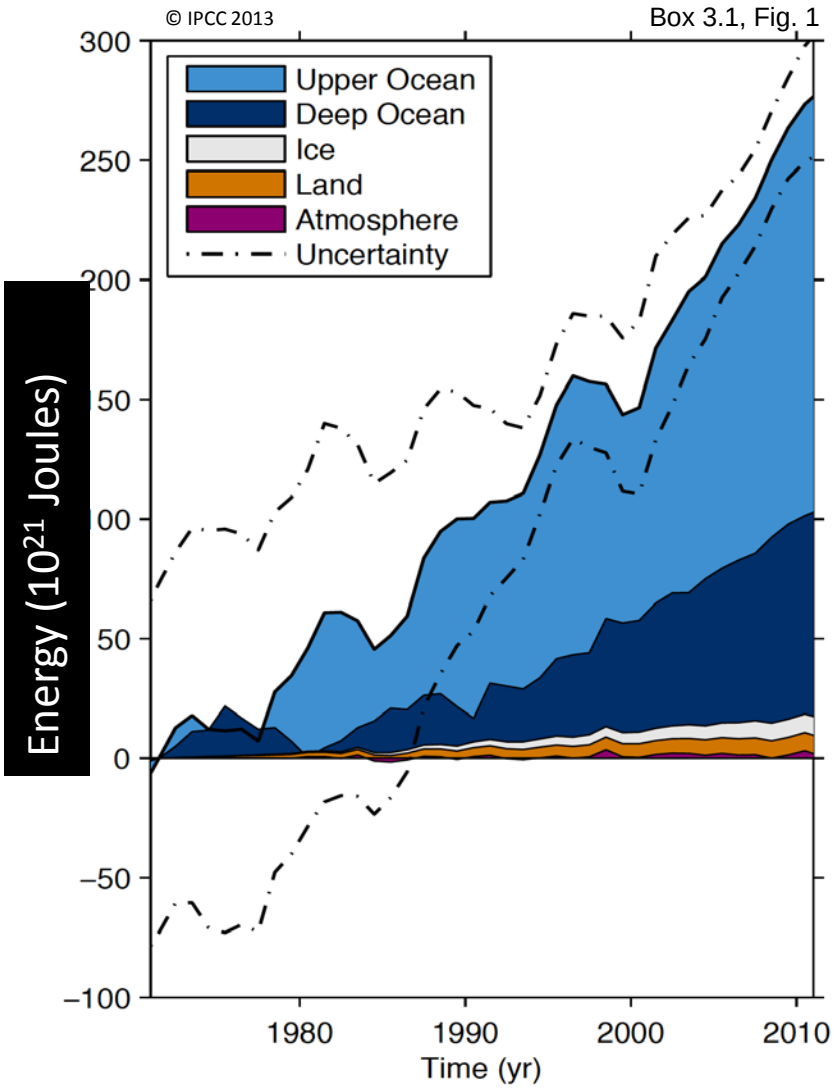


- The total anthropogenic RF for 2011 relative to 1750 was 2.29 [1.13 to 3.33] W m^{-2}, higher than that reported in AR4 for the year 2005, and two orders higher than the RF value of the solar irradiance 0.05 [0.00 to 0.10] W m^{-2}.
- RF has increased more rapidly since 1970 than during prior decades



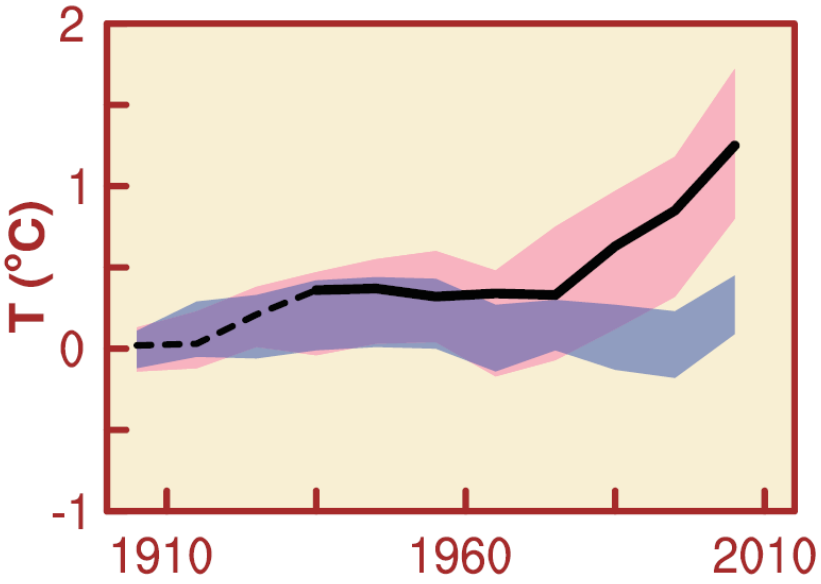
The observed warming 1951−2010 is approximately 0.6°C to 0.7°C.

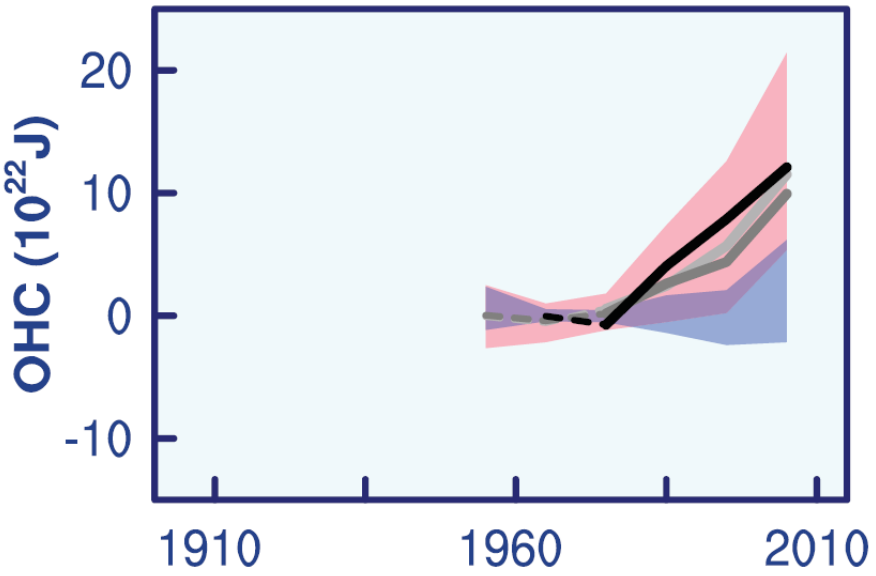
It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.



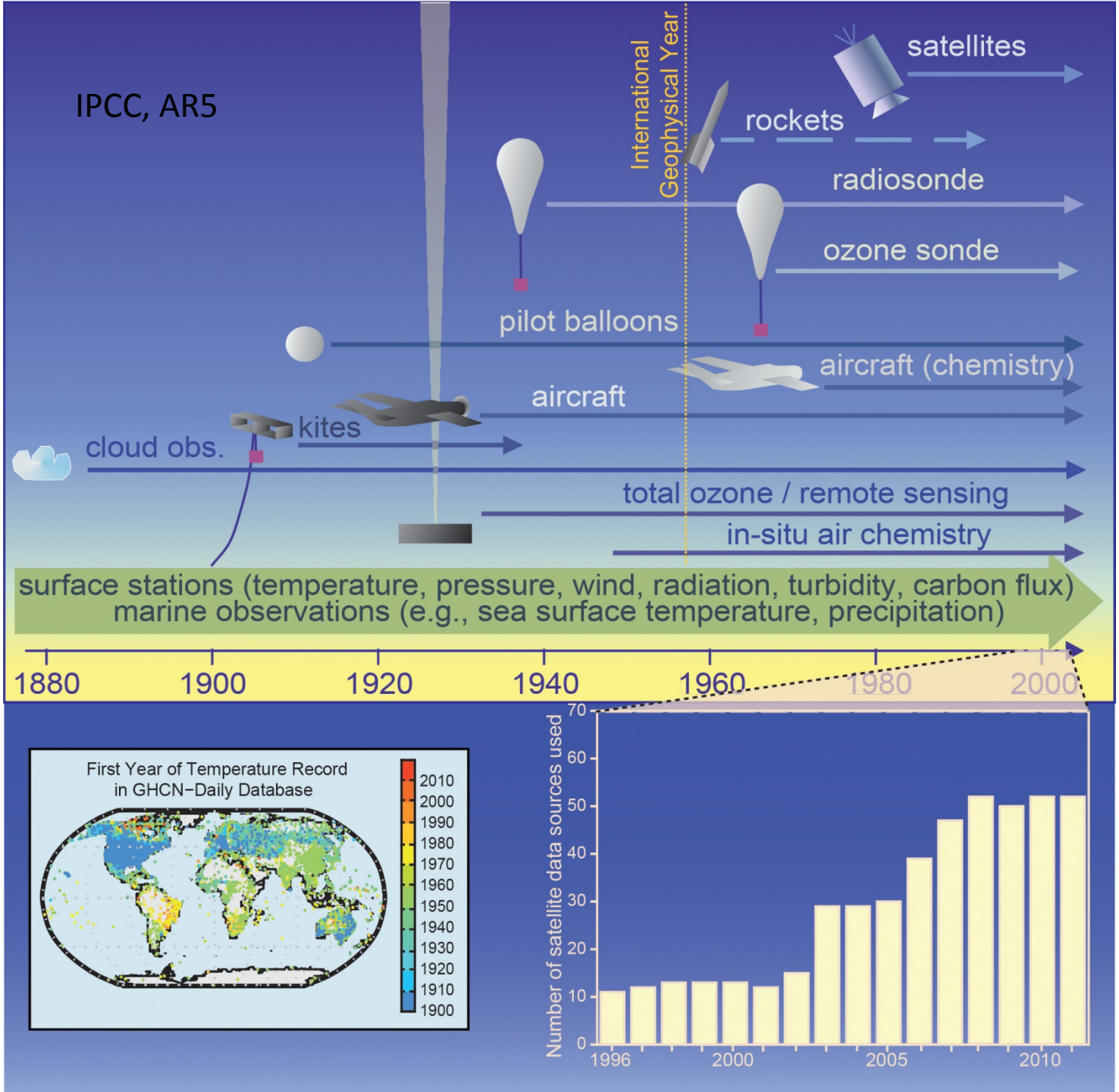
Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (*high confidence*).

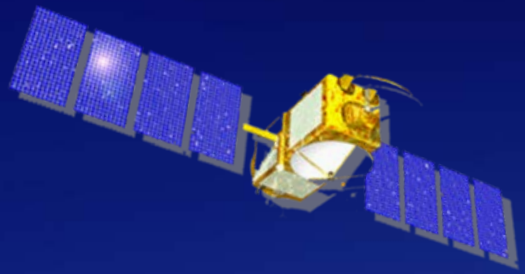
- During 1971-2010, more than 60% of the net energy increase in the climate system is stored in the upper ocean (0-700m),
- About 30% is stored in the ocean below 700 m

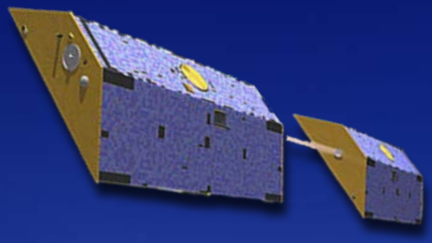




Human influence on the climate system is clear

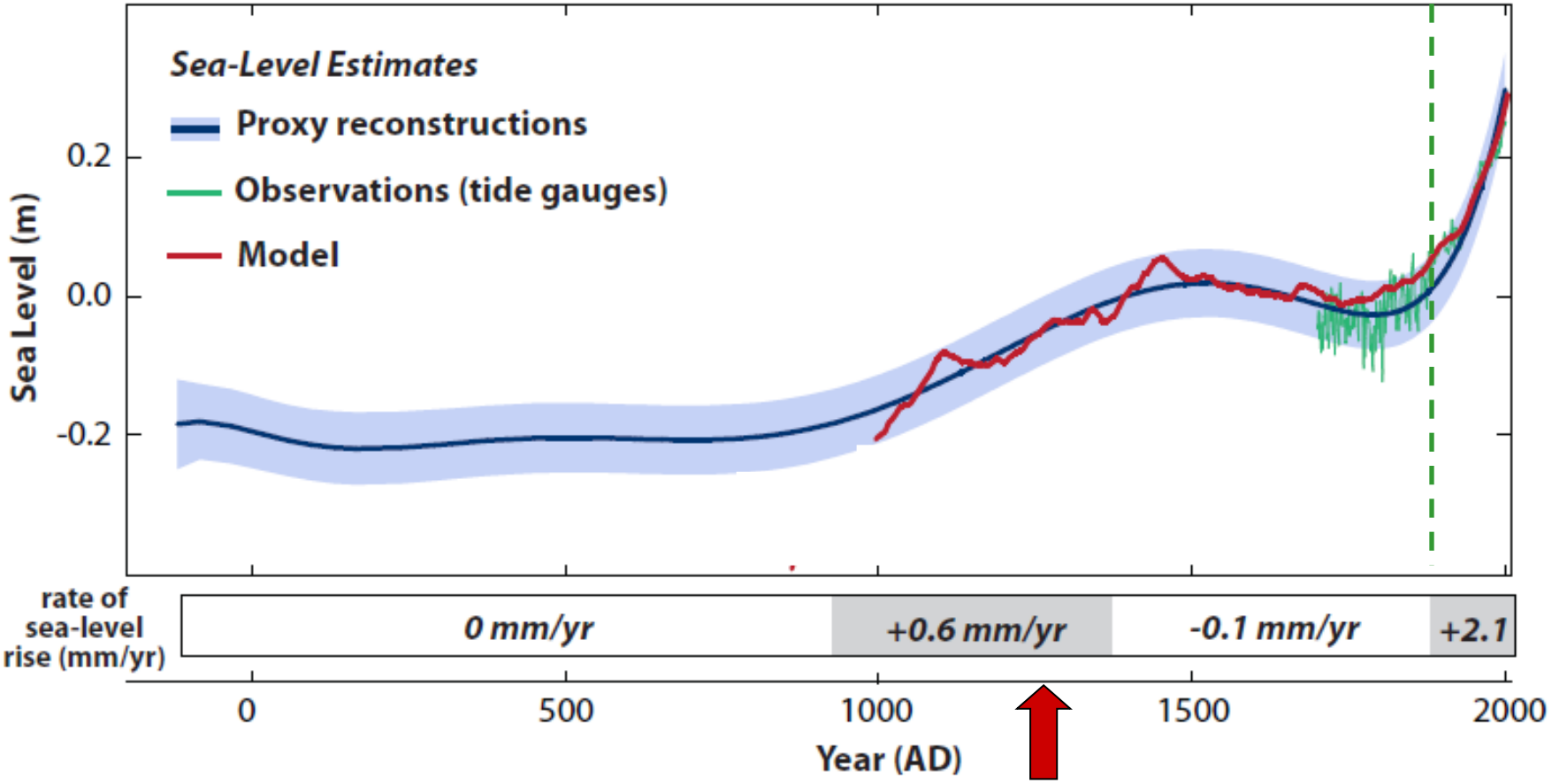

IPCC, AR5
International Geophysical Year
satellites
rockets
radiosonde
ozone sonde
pilot balloons
aircraft (chemistry)
aircraft
kites
cloud obs.
total ozone / remote sensing
in-situ air chemistry
surface stations (temperature, pressure, wind, radiation, turbidity, carbon flux)
marine observations (e.g., sea surface temperature, precipitation)
1880
1900
1920
1940
1960
1980
2000
First Year of Temperature Record
in GHCN−Daily Database
2010
2000
1990
1980
1970
1960
1950
1940
1930
1920
1910
1900
Number of satellite data sources used
70
60
50
40
30
20
10
0
1996
2000
2005
2010





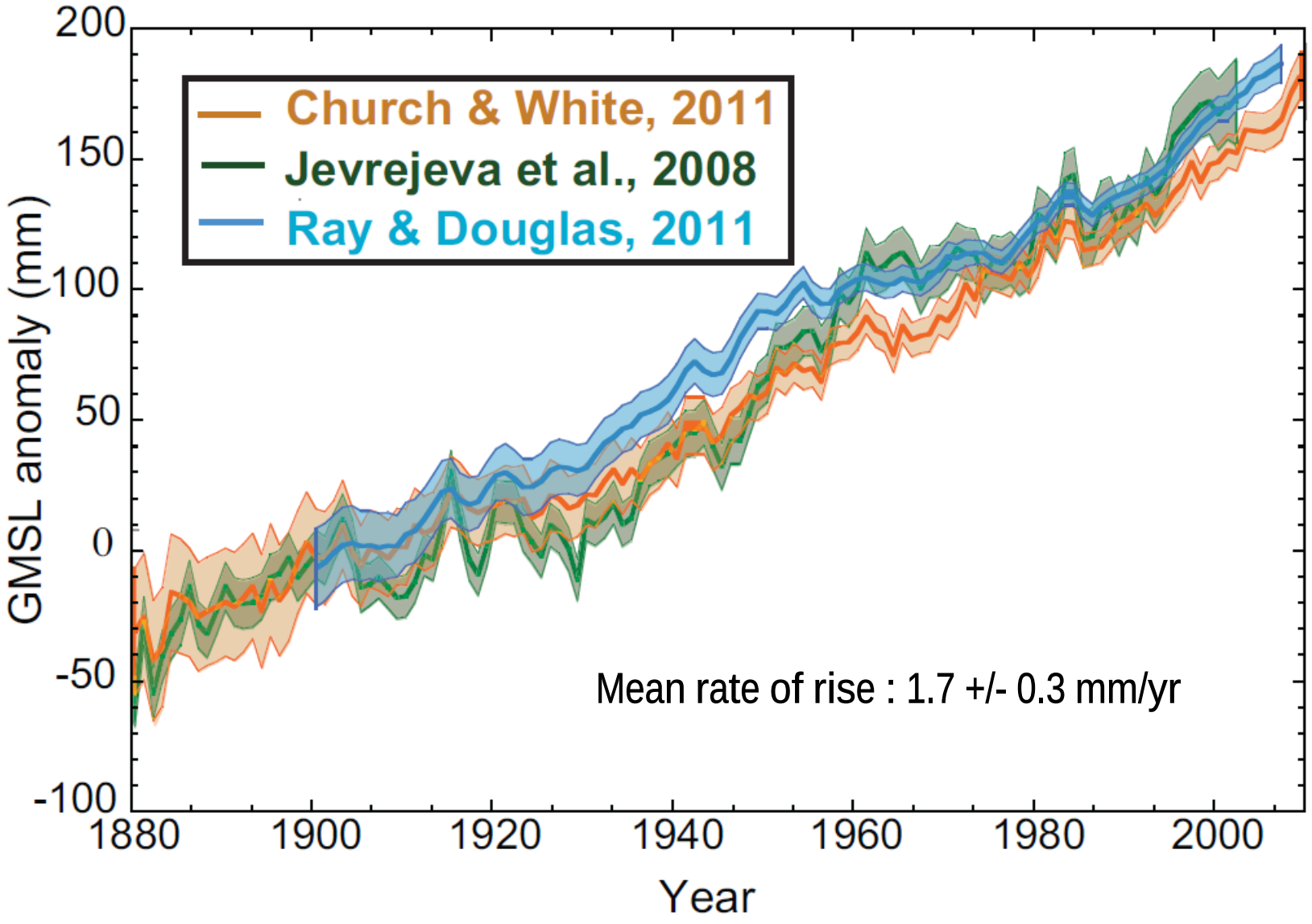
Sea level changes

Evolution of the mean sea level over the last 2000 years

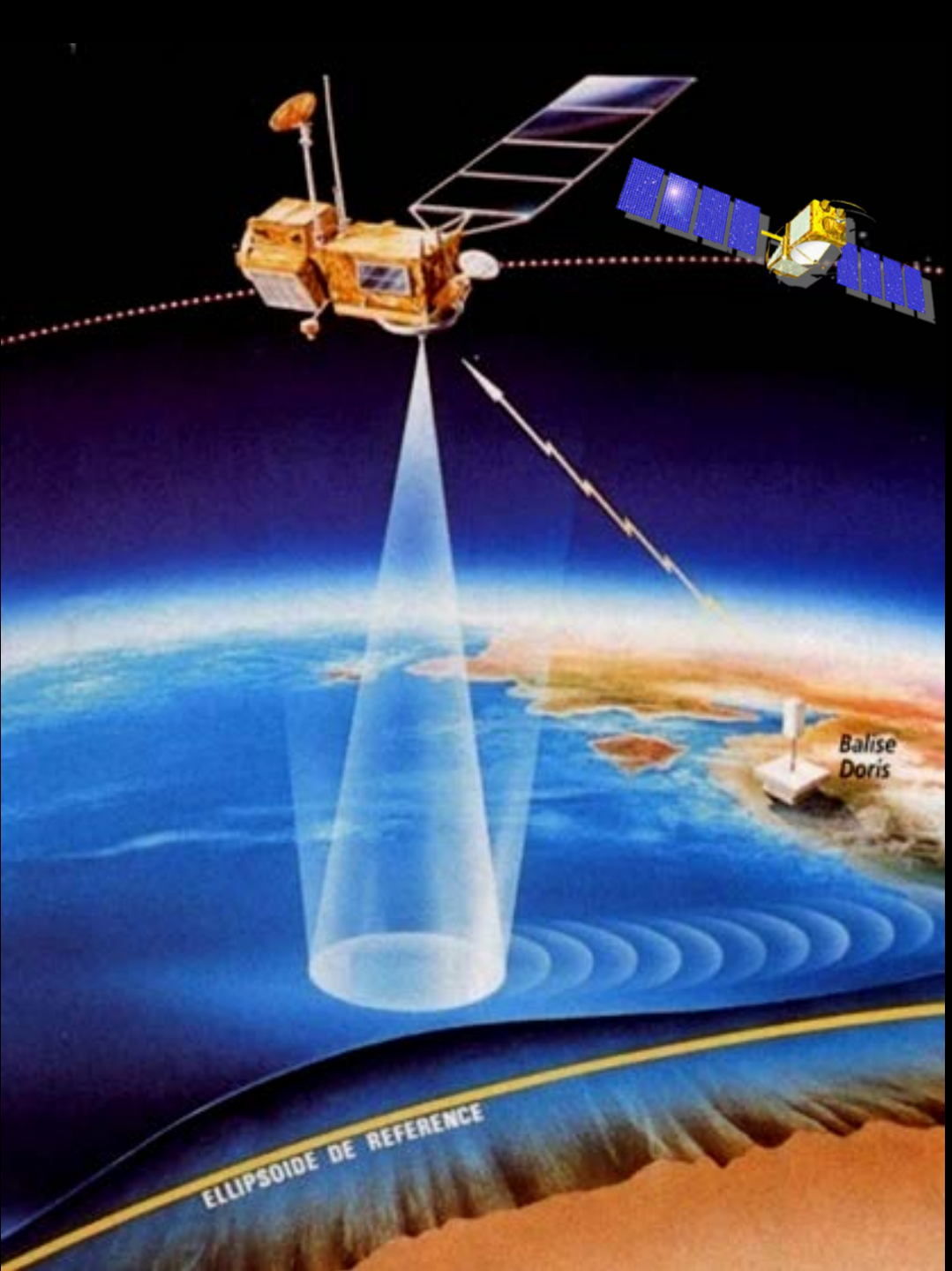


Kemp et al. (2011)

20th century sea level rise



IPCC AR5

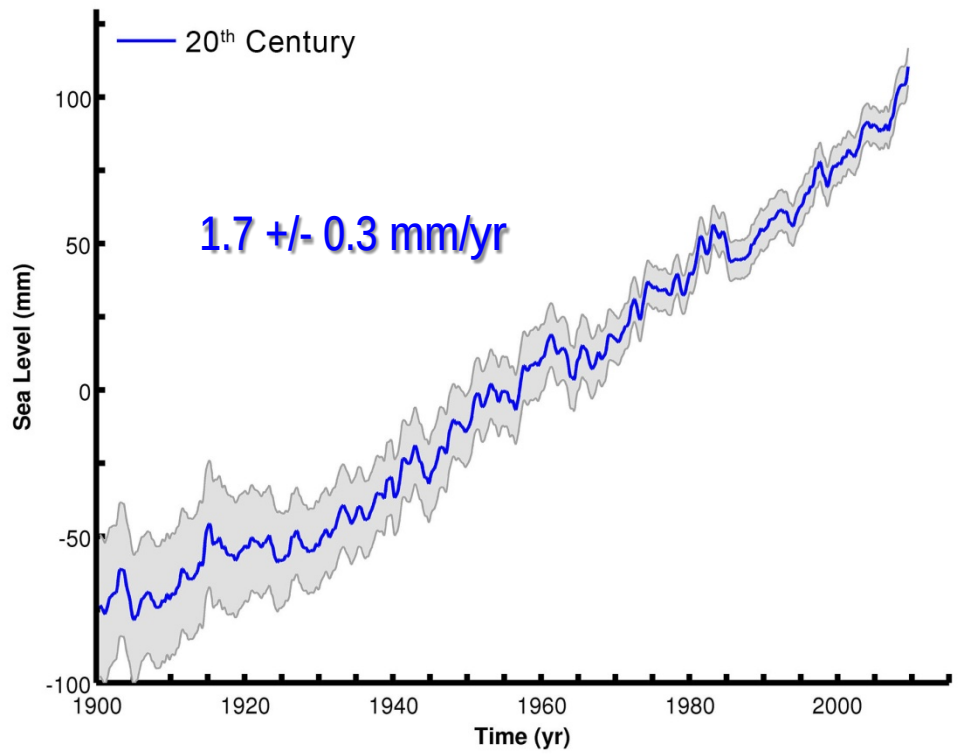


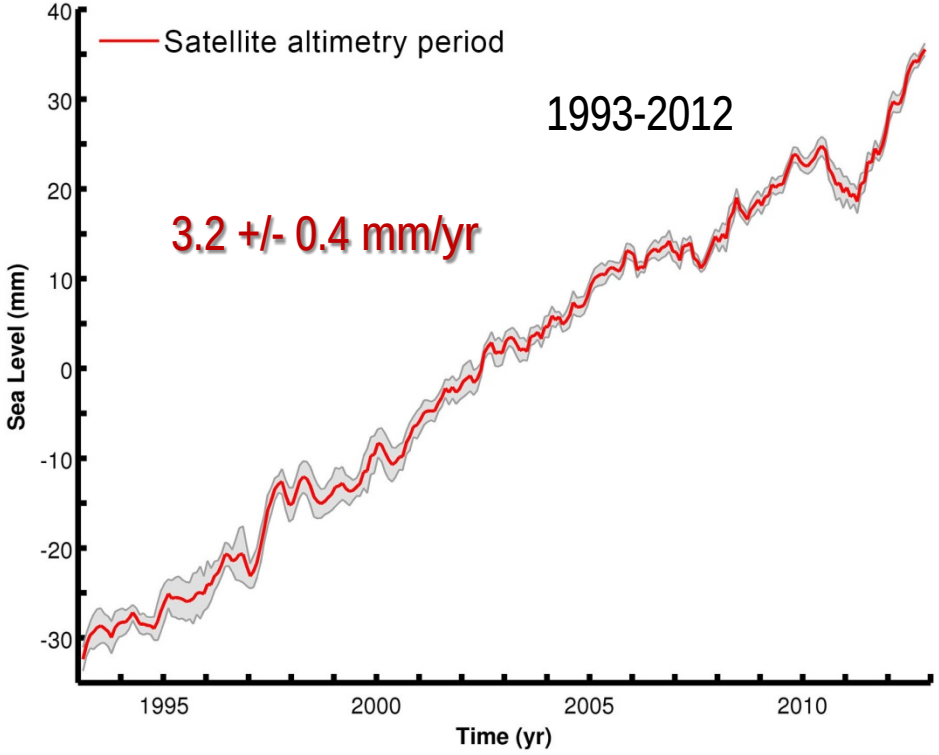
Since 1993
→ satellite altimetry

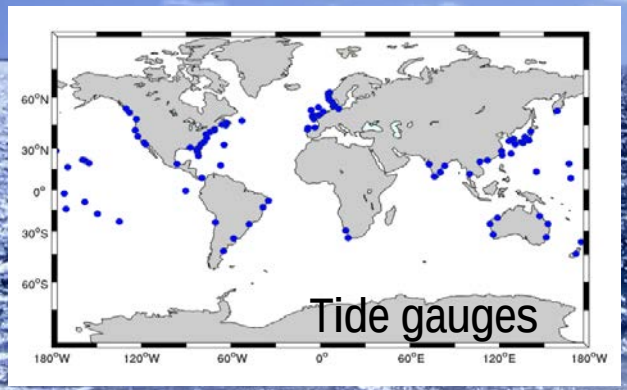
Sea surface height measurements
with 1-2 cm accuracy

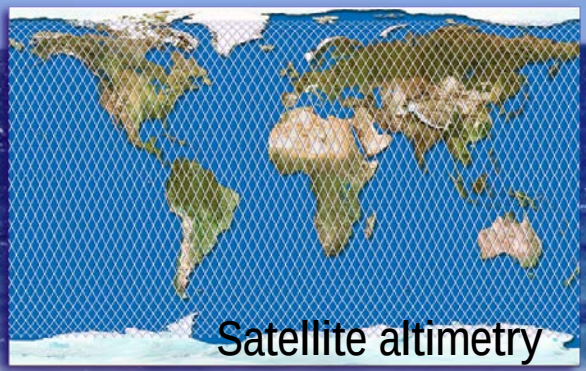
Global coverage of the oceans
in ~10 days

Sea level rise : 20th century and past 2 decades









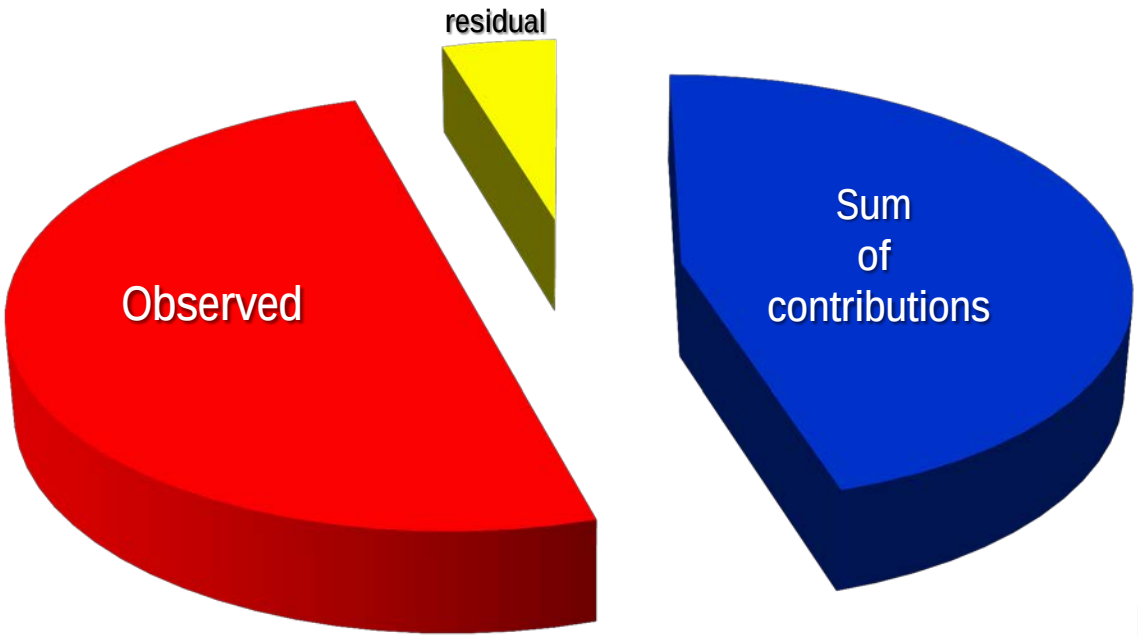
Question

- **Is sea level rise accelerating?**

Yes!

Church et al. (2013) concludes that « the increased rate of sea level rise since 1990 is not part of a natural cycle but a direct response to increased radiative forcing on the climate system »

Observed sea level budget during the altimetry era (1993-2010)
IPCC AR5

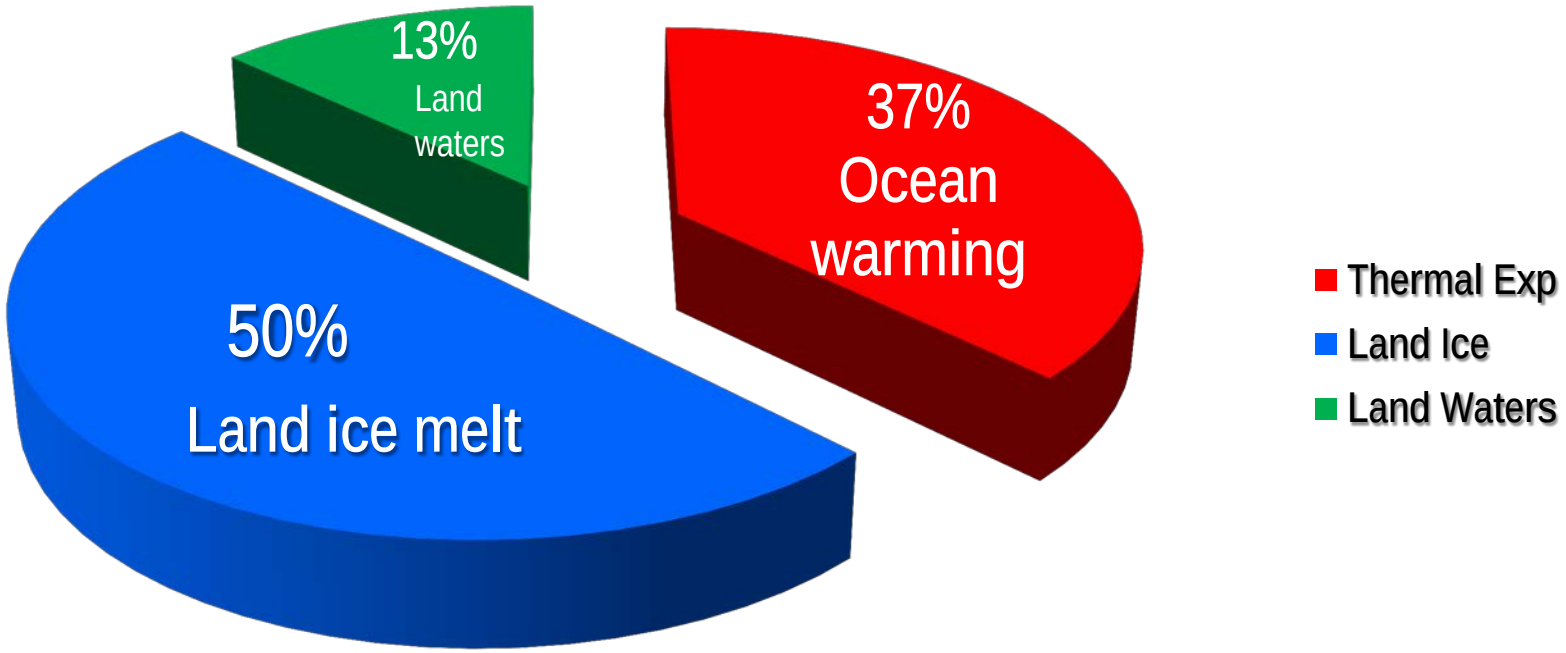


	Rate of rise
Sum Contrib.	2.8 +/- 0.5 mm/yr
Observed	3.2 +/- 0.4 mm/yr
Residual	0.4 mm/yr

IPCC AR5

Causes of sea level rise (altimetry era: last 2 decades)

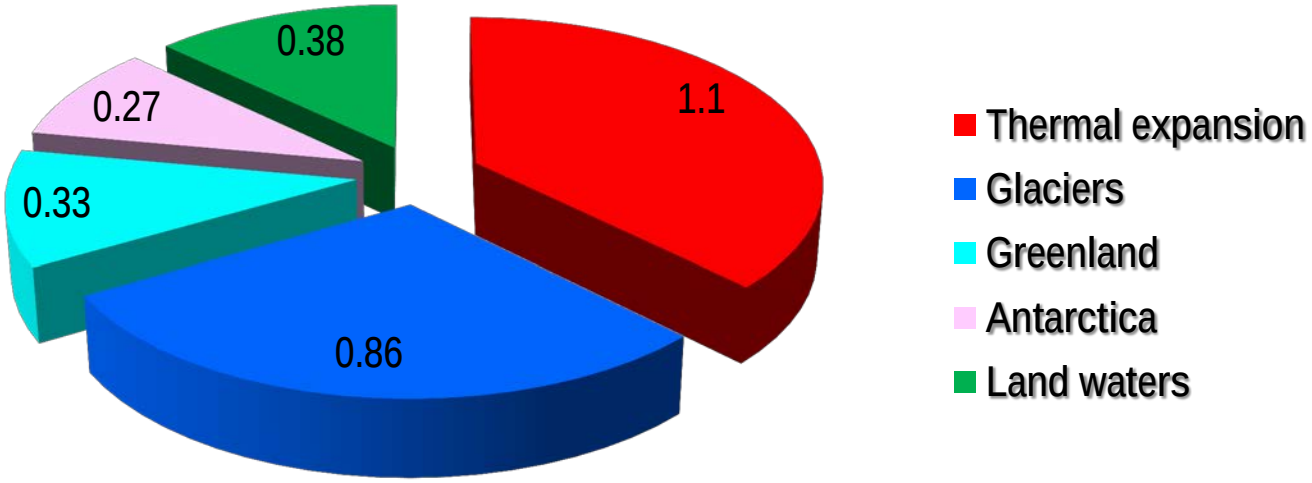
Individual contributions (in % of the observed rate of rise)



IPCC AR5

Observed sea level budget 1993-2010 (IPCC AR5)

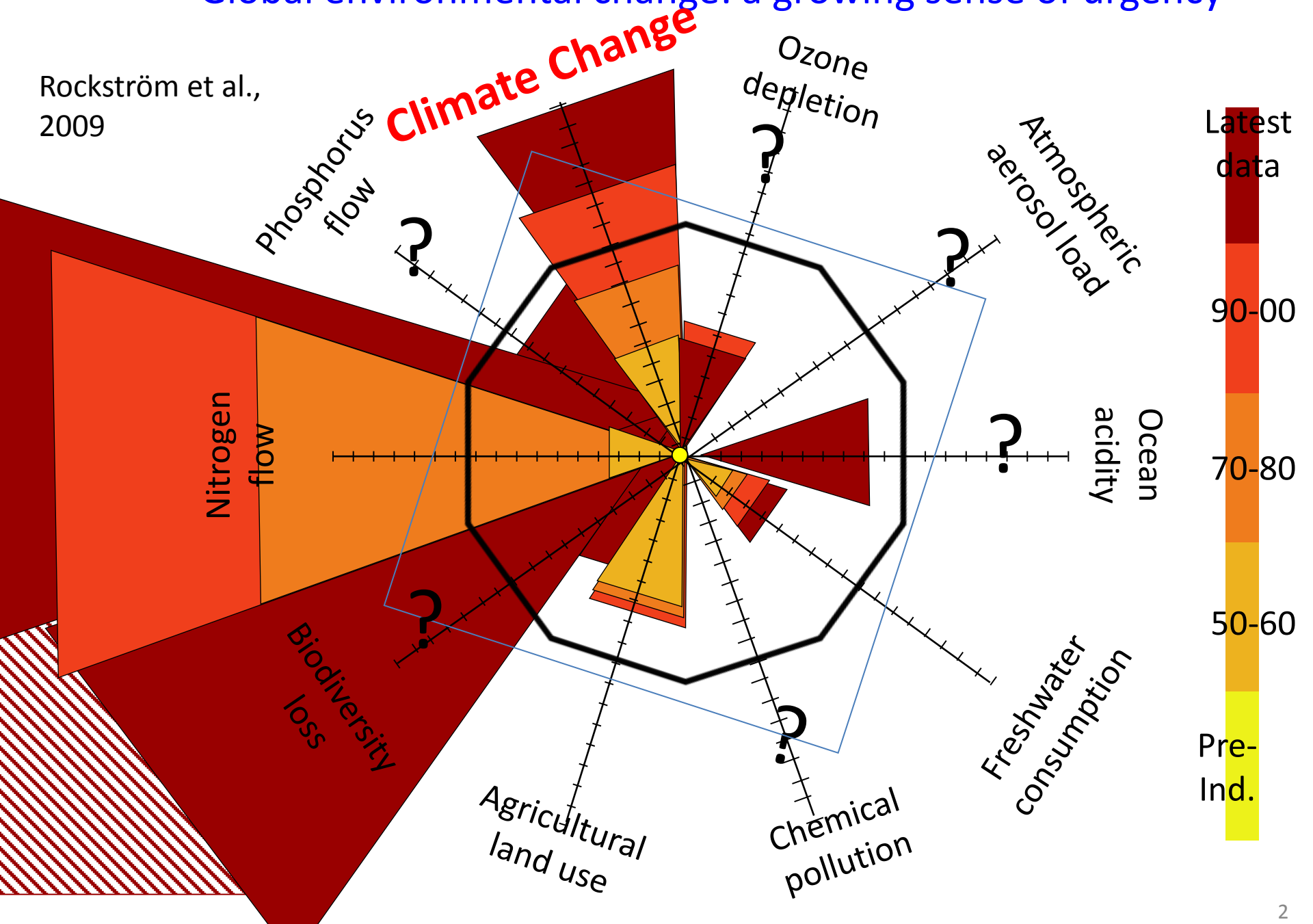
Individual contributions (mm/yr)



Sum of contributions : 2.8 +/- 0.5 mm/yr
Observed rate of rise: 3.2 +/- 0.4 mm/yr

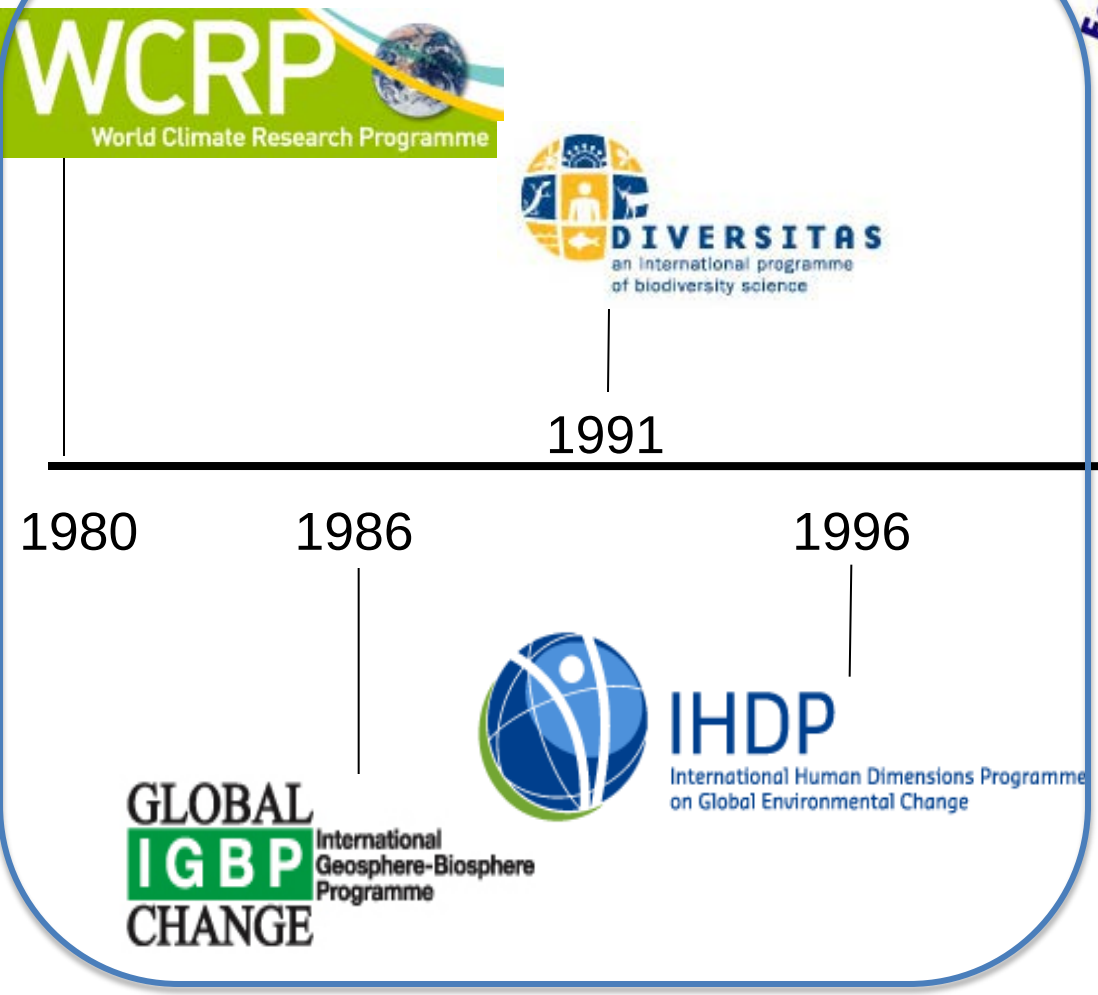
IPCC AR5

Global environmental change: a growing sense of urgency



Reactions of the global scientific community

four Global Environmental Change Programmes



1980 1986 1991 1996 2001 My ICSU time 2013

and their partnership towards transdisciplinary integrative science

Future Earth

all co-sponsored by ICSU

ENVIRONMENT AND DEVELOPMENT

Earth System Science for Global Sustainability: Grand Challenges

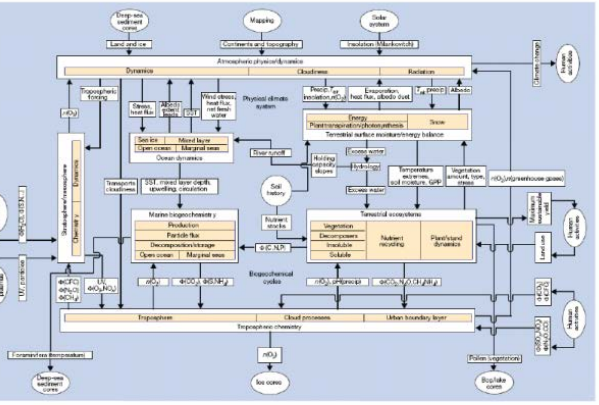
W. V. Reid,[1]* D. Chen,[2] L. Goldfarb,[2] H. Hackmann,[3] Y. T. Lee,[2] K. Mokhele,[4] E. Ostrom,[5] K. Raivio,[2] J. Rockström,[6] H. J. Schellnhuber,[7] A. Whyte[8]

12 NOVEMBER 2010 VOL 330 SCIENCE www.sciencemag.org

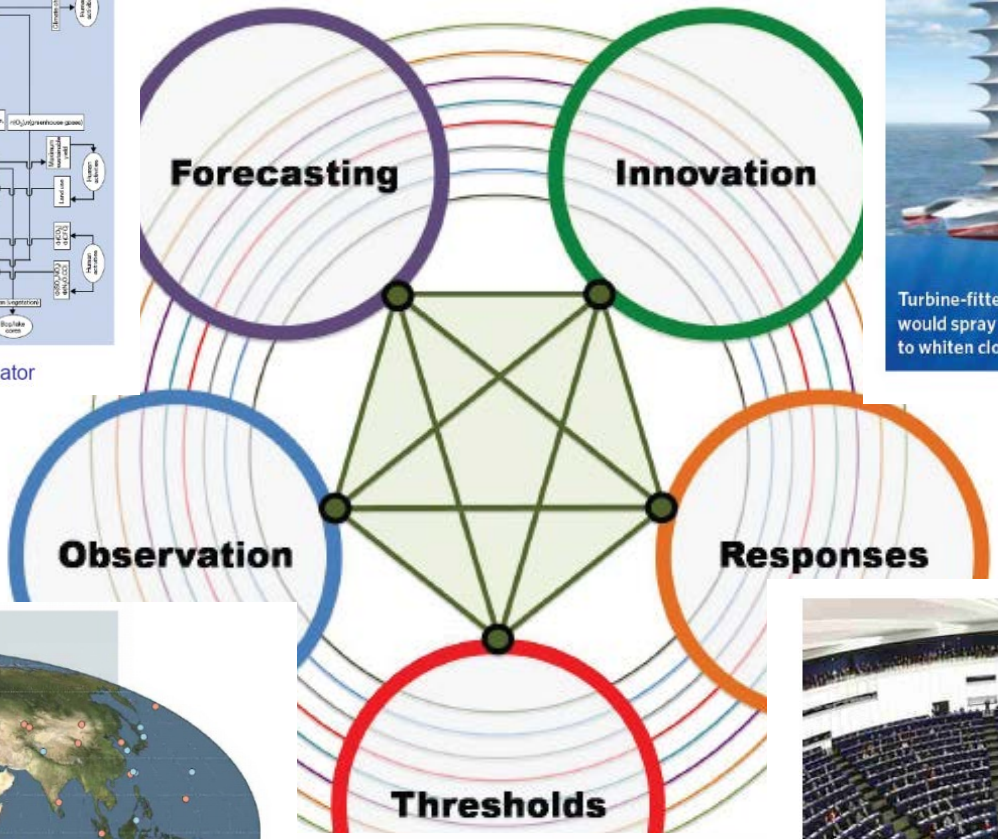
Published by AAAS

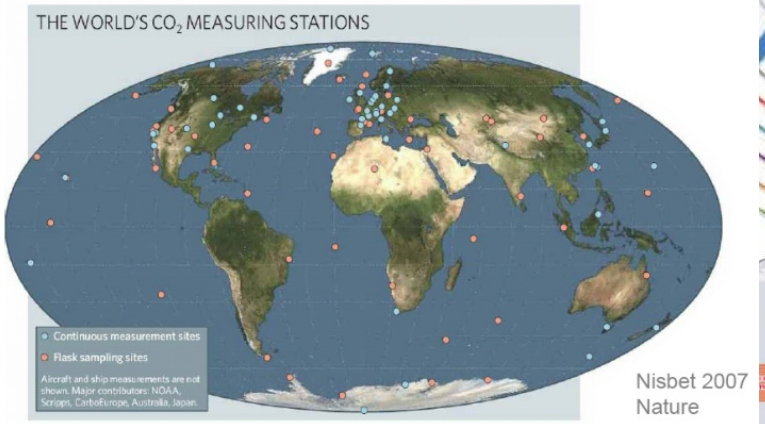
The concept and design principle of **Future Earth**

Visioning: the five Grand Challeng

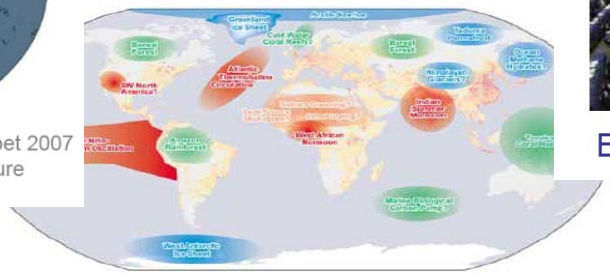


"Wiring diagram" (1985) → Earth System Simulator





Nisbet 2007
Nature



after Lenton et al. 2008

Earth Governance

Climate community's response: BAMS2010

AN EARTH-SYSTEM PREDICTION INITIATIVE FOR THE TWENTY-FIRST CENTURY

BY MELVYN SHAPIRO, JAGADISH SHUKLA, GILBERT BRUNET, CARLOS NOBRE, MICHEL BÉLAND, RANDALL DOLE, KEVIN TRENBERTH, RICHARD ANTHES, GHASSEM ASRAR, LEONARD BARRIE, PHILIPPE BOUGEAULT, GUY BRASSEUR, DAVID BURRIDGE, ANTONIO BUSALACCHI, JIM CAUGHEY, DELIANG CHEN, JOHN CHURCH, TAKESHI ENOMOTO, BRIAN HOSKINS, ØYSTEIN HOV, ARLENE LAING, HERVÉ LE TREUT, JOCHEM MAROTZKE, GORDON MCBEAN, GERALD MEEHL, MARTIN MILLER, BRIAN MILLS, JOHN MITCHELL, MITCHELL MONCRIEFF, TETSUO NAKAZAWA, HARALDUR OLAFSSON, TIM PALMER, DAVID PARSONS, DAVID ROGERS, ADRIAN SIMMONS, ALBERTO TROCCOLI, ZOLTAN TOTH, LOUIS UCCELLINI, CHRISTOPHER VELDEN, AND JOHN M. WALLACE

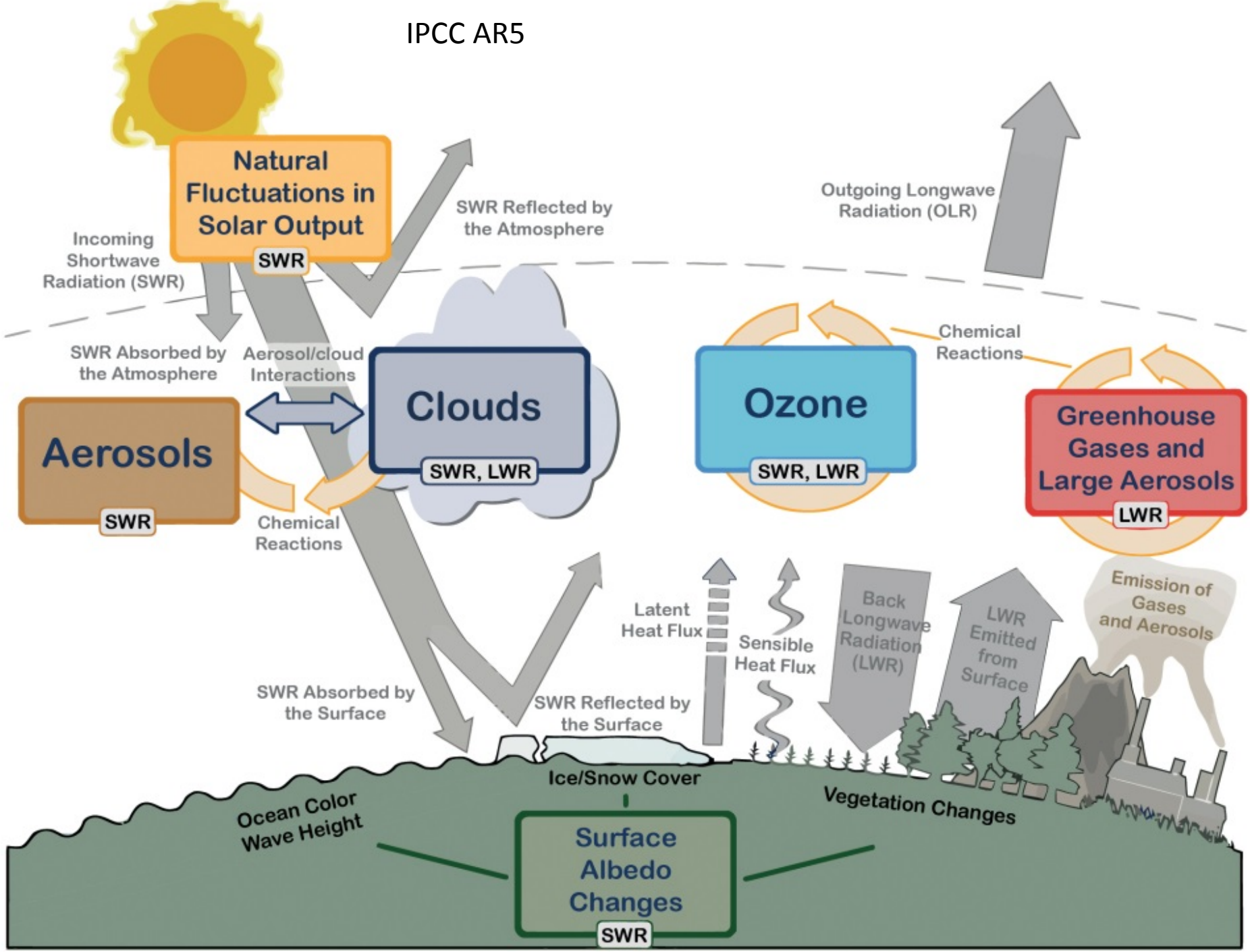
An international interdisciplinary initiative to accelerate advances in knowledge, prediction, use, and value of weather, climate, and Earth system information.

Future of Climate Science

- Research will be increasingly tied to improving **predictive capabilities**, especially seasonal to decadal time scales
- The forecasting products will grow substantially
- More comprehensive models
- More emphasize on regional and/or higher spatial resolution climate information
- The connection between climate and specific impacts on natural and human systems will require **a more comprehensive approach** to environmental research.

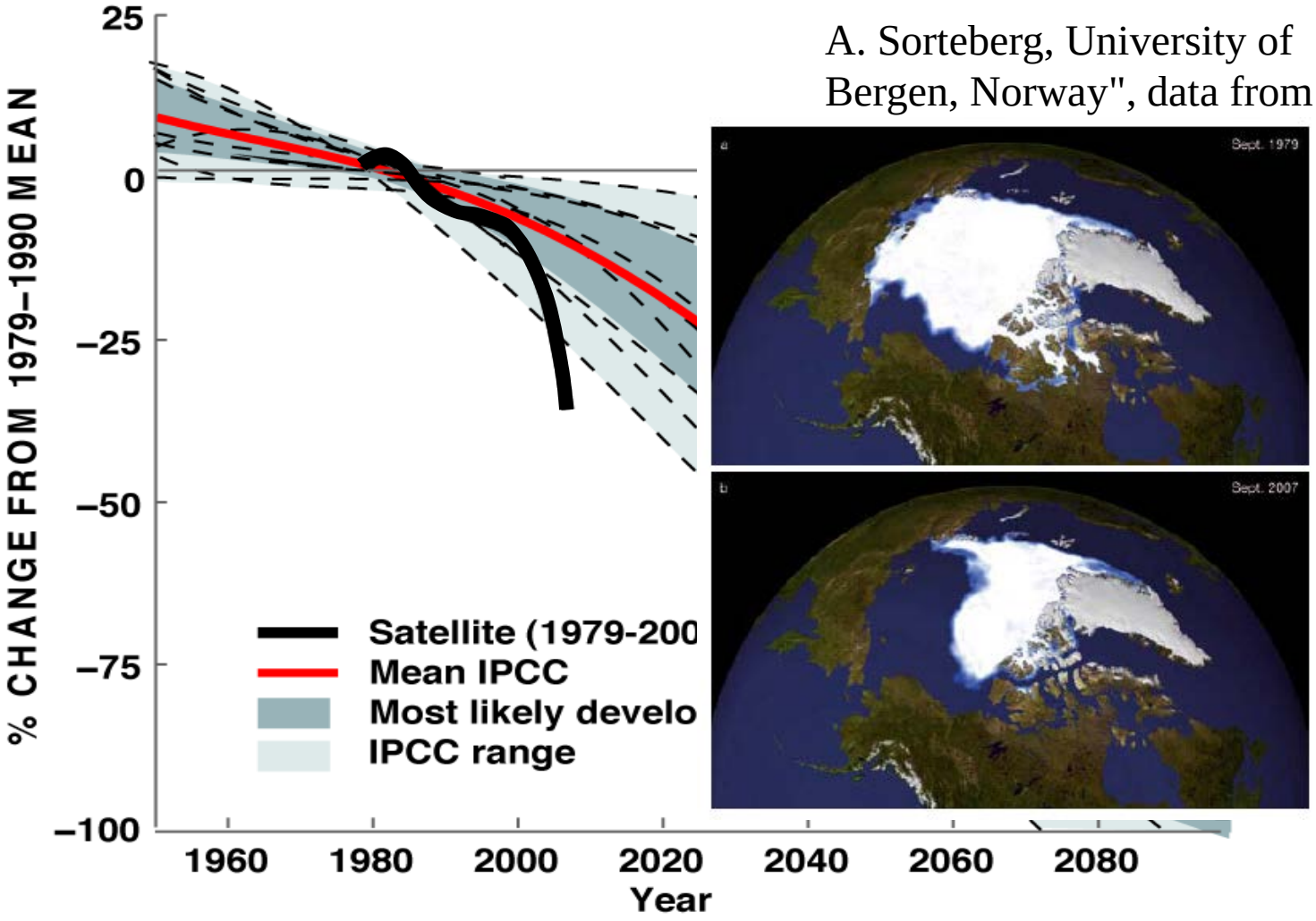
b

IPCC AR5

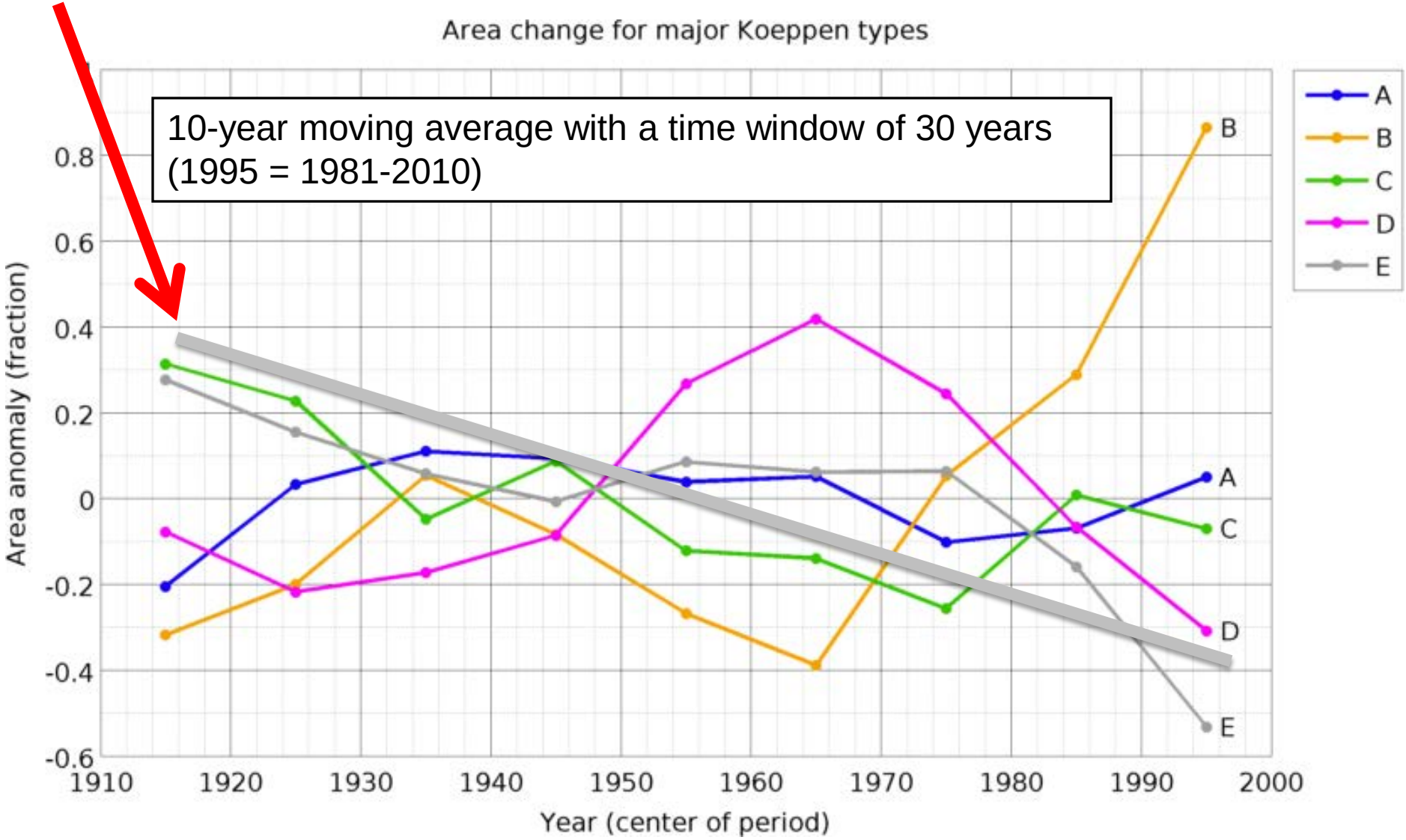

Natural Fluctuations in Solar Output
SWR
Incoming Shortwave Radiation (SWR)
SWR Reflected by the Atmosphere
Outgoing Longwave Radiation (OLR)
SWR Absorbed by the Atmosphere
Aerosol/cloud Interactions
Clouds
SWR, LWR
Chemical Reactions
Ozone
SWR, LWR
Chemical Reactions
Greenhouse Gases and Large Aerosols
LWR
Aerosols
SWR
Chemical Reactions
Latent Heat Flux
Sensible Heat Flux
Back Longwave Radiation (LWR)
LWR Emitted from Surface
Emission of Gases and Aerosols
SWR Absorbed by the Surface
SWR Reflected by the Surface
Ice/Snow Cover
Ocean Color Wave Height
Vegetation Changes
Surface Albedo Changes
SWR

Crossing unexpected abrupt tipping points

A. Sorteberg, University of Bergen, Norway", data from

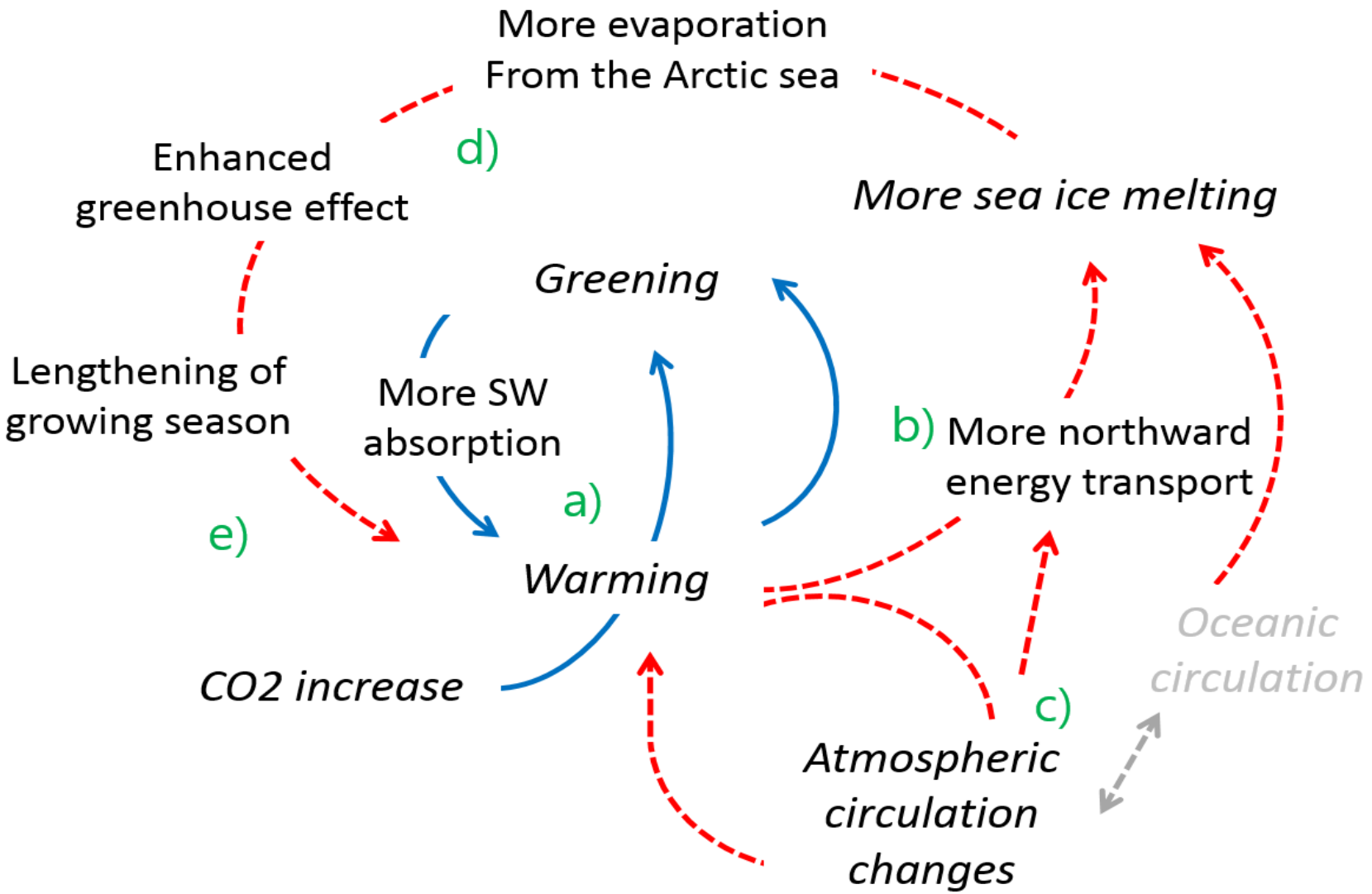


E-the pole type has been shrinking!

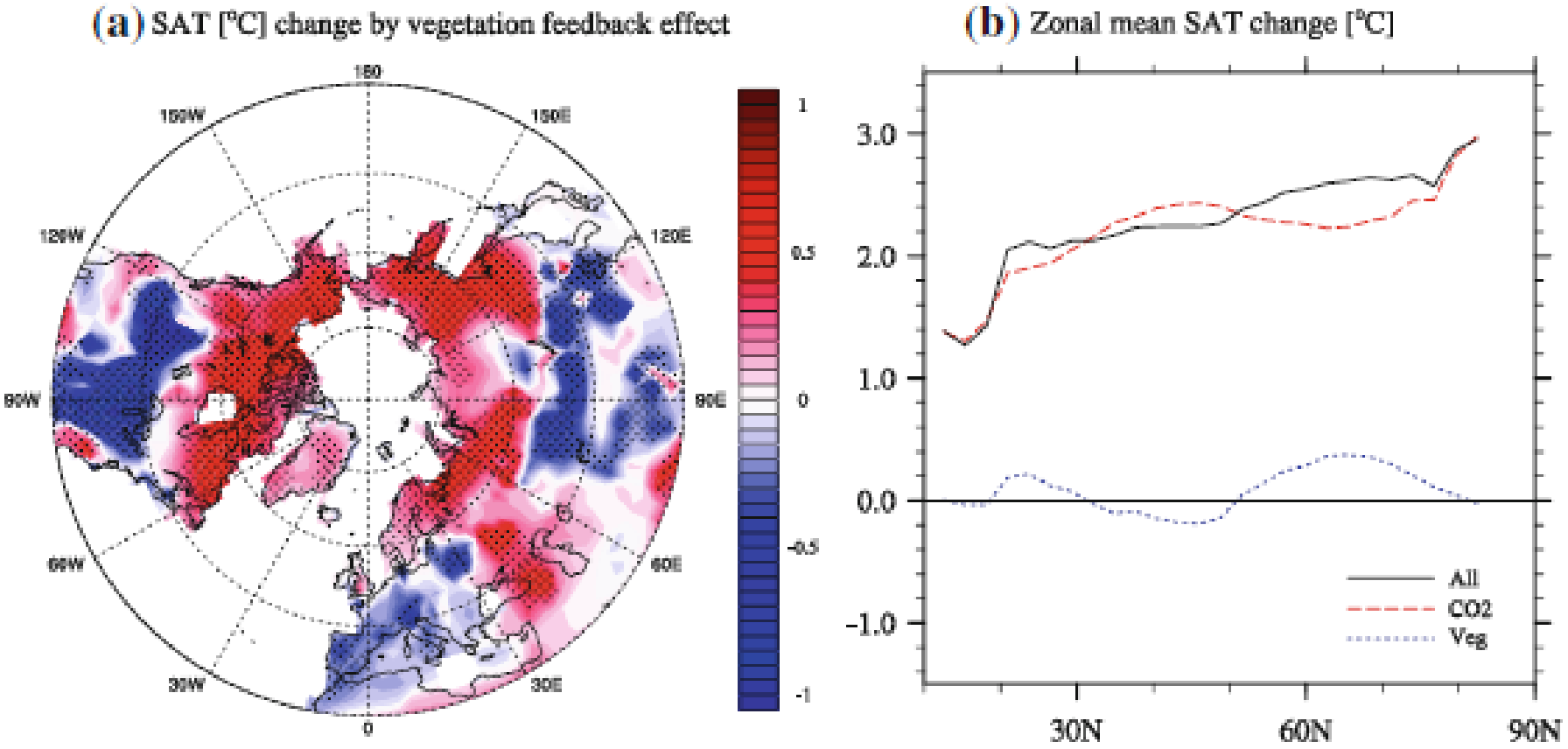


Chen and Chen, 2013

Possible vegetation-climate feedbacks?



Current global climate models (GCMs) (e.g. those used by IPCC AR5) usually do not consider dynamic vegetation. What if the vegetation will change under a warming and CO2 rich world? –Jeong et al., 2012



Additional temperature change due to added vegetation feedback under 2*CO2

End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© Photograph by Scott Olson/Getty Images