

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Thy Physical Science Perspective of Climate Change

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IPCC AR5 LA Ch.4, CA Ch 10, 13, SPM, TS

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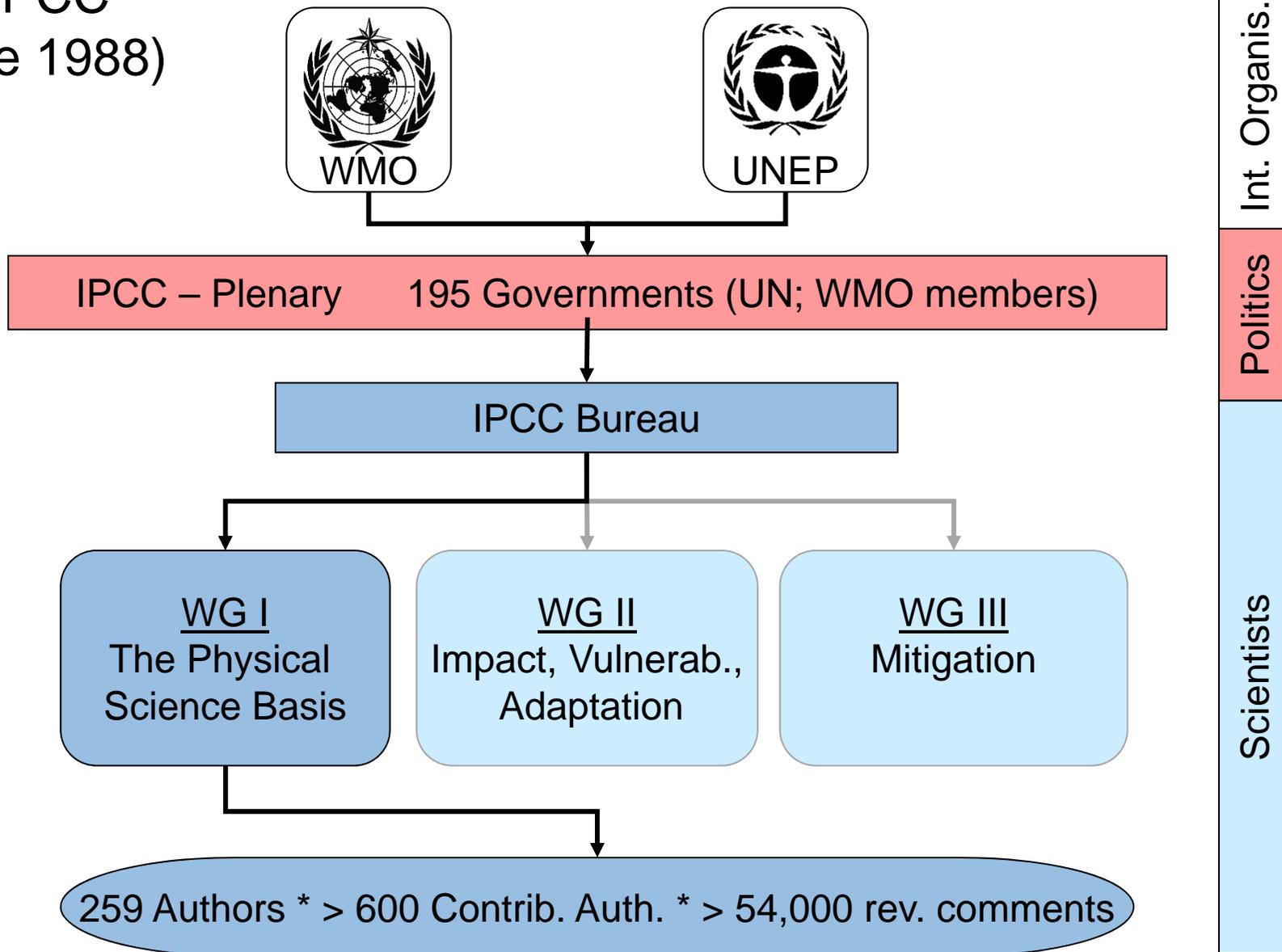
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**Limiting climate change will require
substantial and sustained reductions of
greenhouse gas emission**

**Human influence on the climate
system is clear**

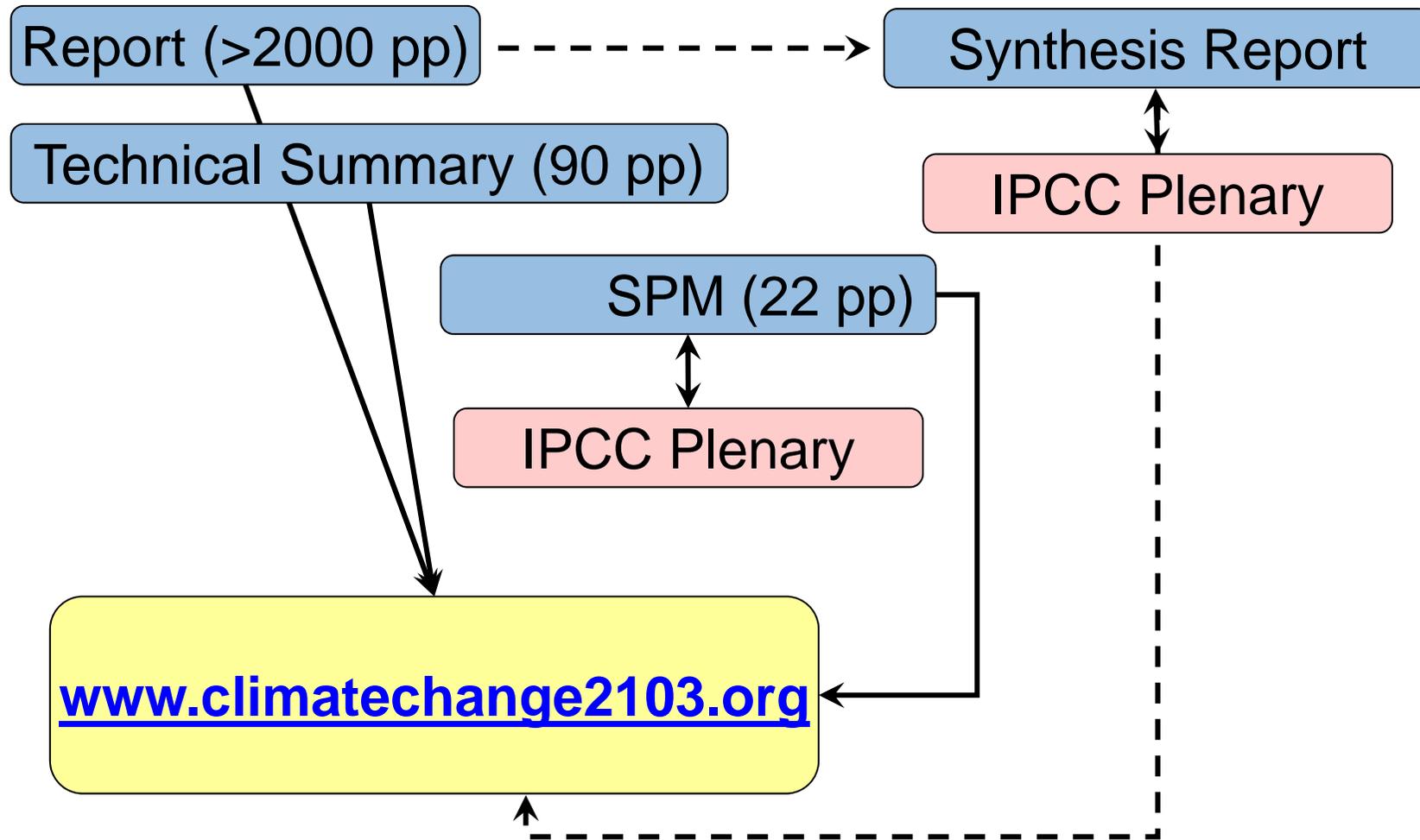
**Warming of the climate system is
unequivocal**

The IPCC (since 1988)



The IPCC Reports

Each WG 2010 – 2013/14:



Synthesis Report addresses the §2 of the UNFCCC

UNFCCC Art. 2: The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is **to achieve**, in accordance with the relevant provisions of the Convention, **stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.**

Such a **level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.**

AR5 SYR:

- **Human influence on climate change is clear**
- **Impact is detrimental and can get out of control if mitigation measures are not taken**
- **We have the means to keep the change within limits**

IPCC structure, procedures, products ** an analogy

- **Community Council**
 - Bridge
- **Expert Assessment**
- **Expert Team** (statics, traffic,...)
 - Additional experts' input
 - Administrative Experts input
- **Assessment report**
 - State of the bridge
 - Loading history
 - Future loading scenarios
 - Stability scenarios
- **Summary for Comm. Council**
 - **Iteration with Admin. Experts**

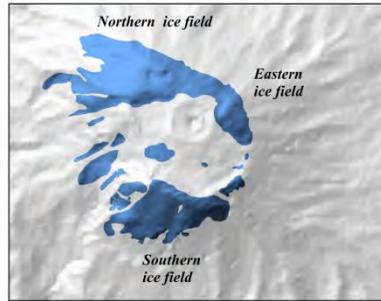
- **IPCC (195 Governments)**
 - Climate System
- **IPCC Report**
- **Writing Team**
 - Expert Reviews
 - Government Experts Reviews
- **Assessment reports**
 - State of Climate System
 - Forcing, Detection, Attribution
 - Future forcing scenarios
 - Climate change scenarios
- **Summary for Policy Makers**
 - **Iteration with Govnm. Experts**

Council Takes Action

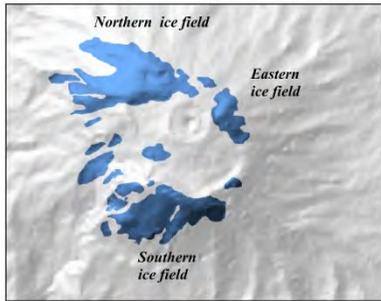
Policy Makers?



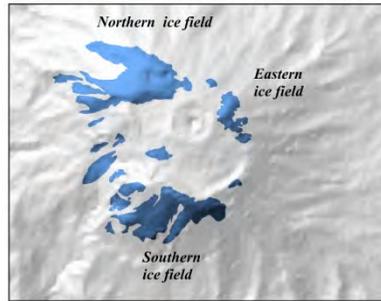
(a) 1912



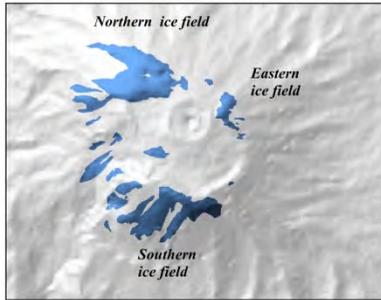
(b) 1962



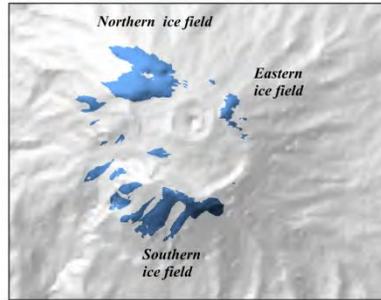
(c) 1975



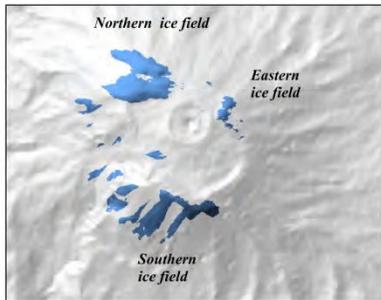
(d) 1984



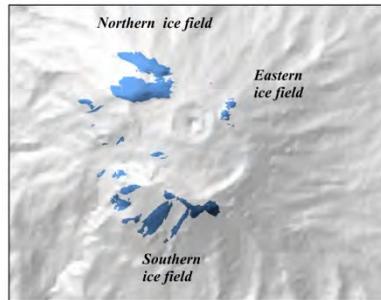
(e) 1992



(f) 2000



(g) 2003

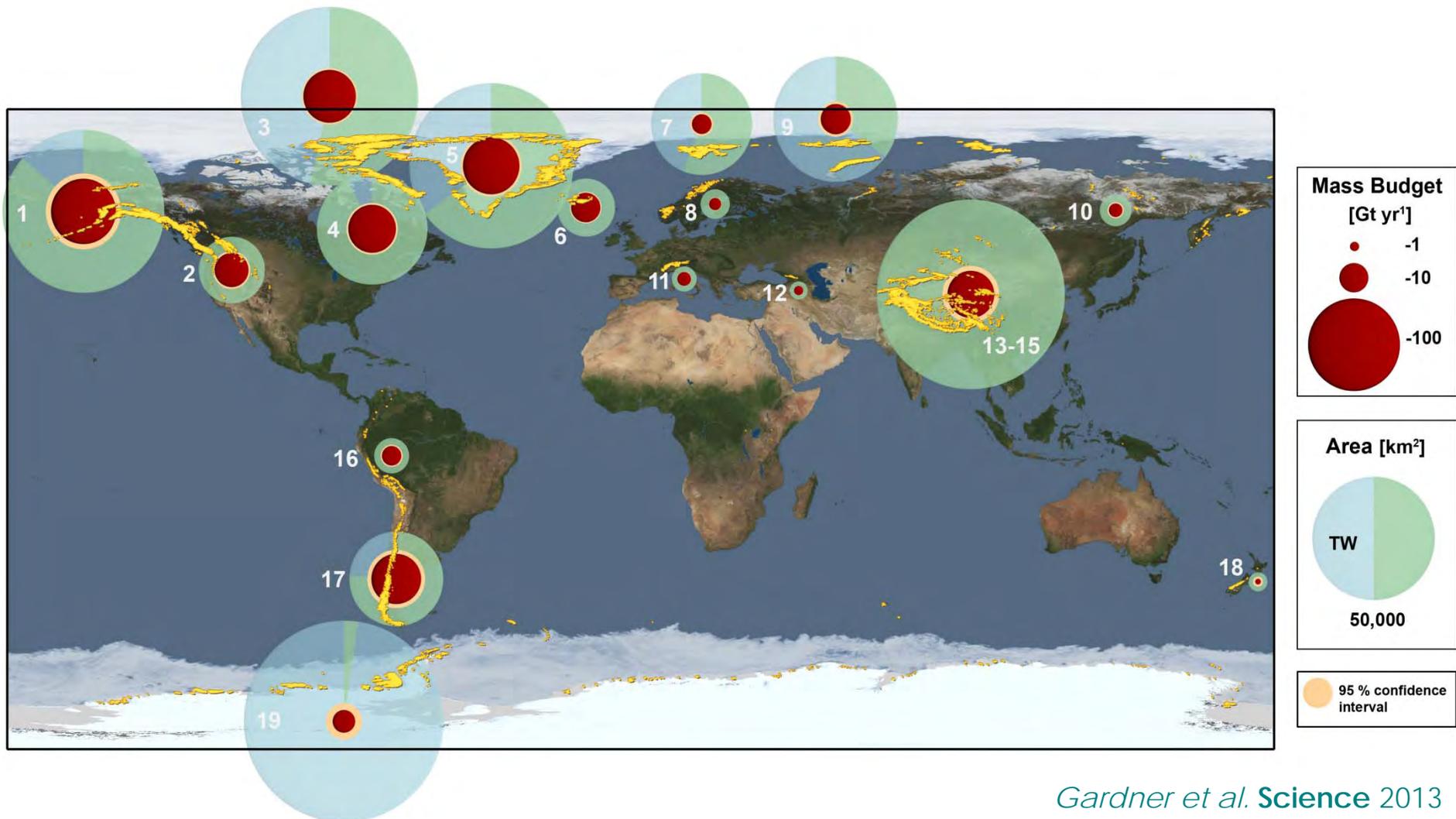


(h) 2011



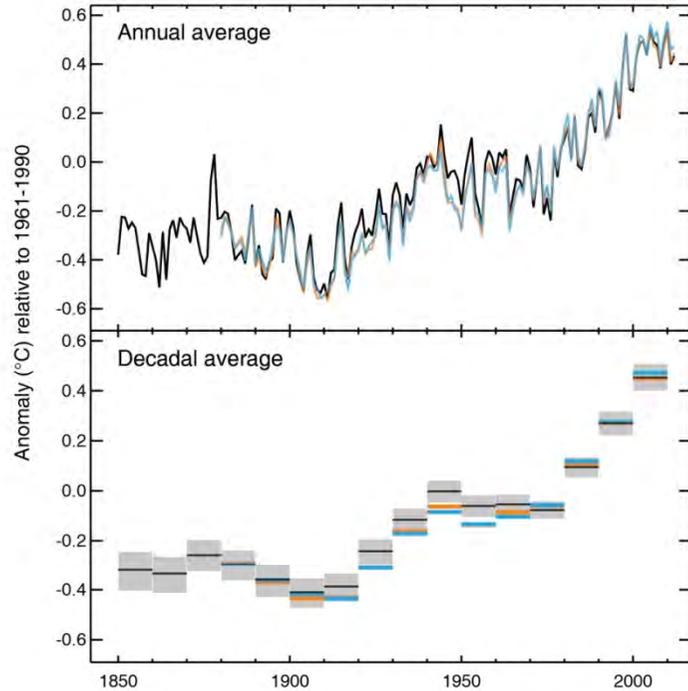
Cullen et al. (2013)

Glacier mass loss 2003 - 2009

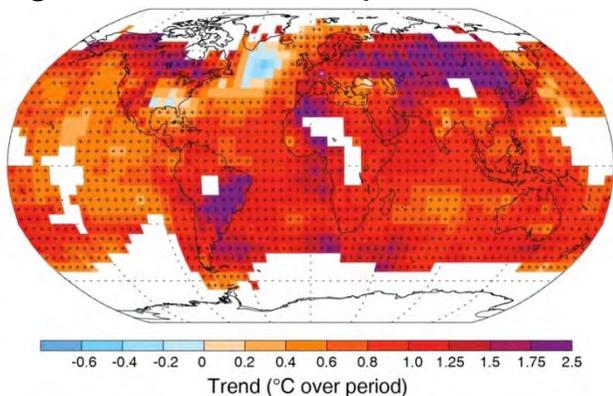


*Gardner et al. Science 2013
IPCC AR5 WG1 Ch.4 (2013)*

Glob. average surface temp. 1850 - 2012



Change in av. surf. temp. 1901 - 2012



Observed changes

.. **robust multi-decadal warming**, ... substantial **decadal and interannual variability**. ... trends ... very sensitive to beginning and end dates

As one example, the rate of warming over the past 15 years (1998–2012; 0.05 [–0.05 to +0.15] °C per decade), which begins with a strong El Niño, is smaller than the rate calculated since 1951 (1951–2012; 0.12 [0.08 to 0.14] °C per decade). {2.4}

IPCC AR5 WG1 SPM (2013)

If our Earth was a solid sphere ...



Jožef Stefan (1835-1893)

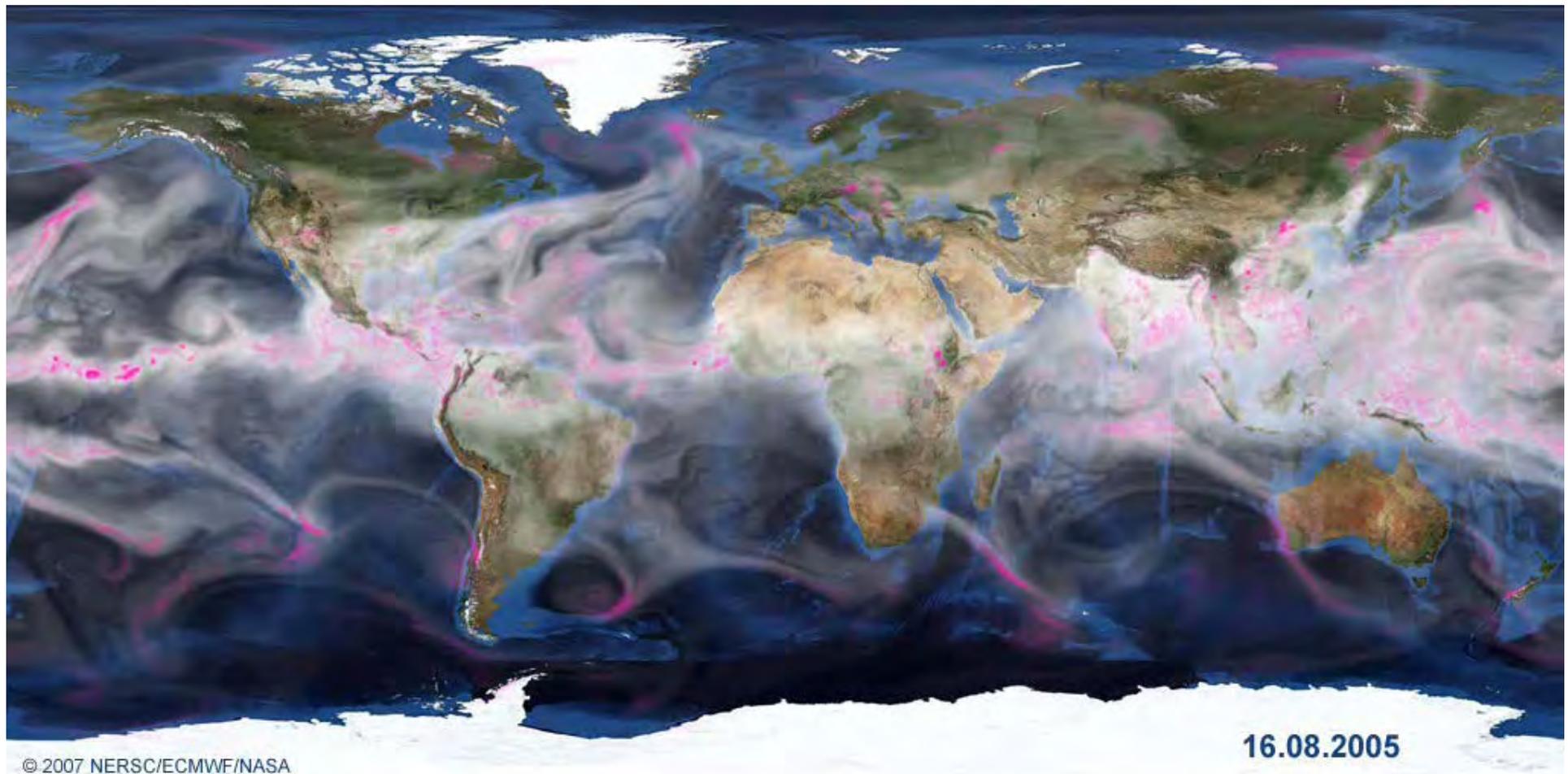


Ludwig E. Boltzmann (1844-1906)

$$E \text{ [W m}^{-2}\text{]} = \epsilon \sigma T_s^4$$

... its surface temperature T_s [K] would be the only „climate variable“, expressing the energetic state of the „system“.

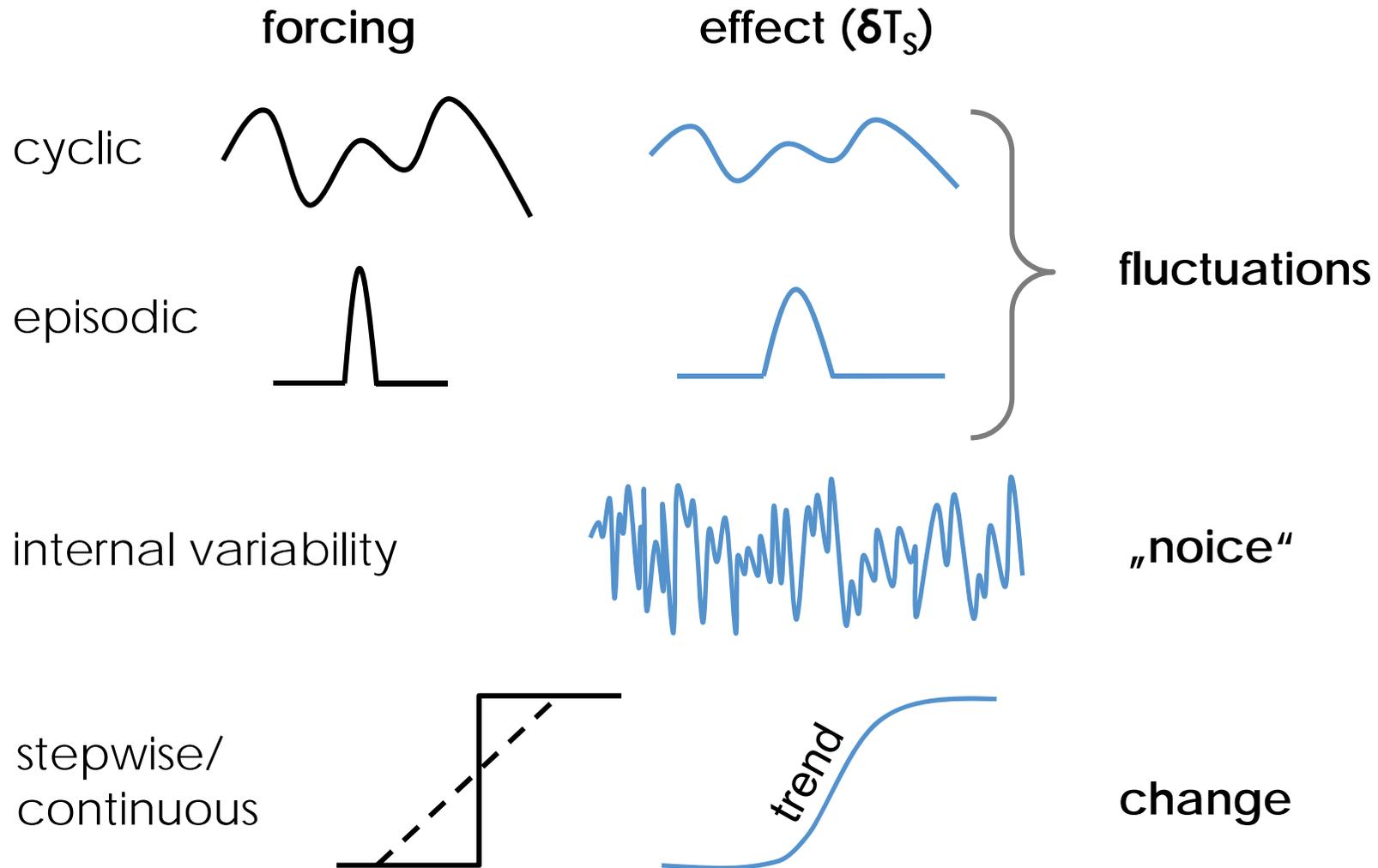
A highly dynamic system



Atmospheric moisture (white) & condensates (pink) * Aug – Nov 2005

<http://www.bjerknes.uib.no/pages.asp?id=1709&kat=97&lang=2>

Climate fluctuations, climate change

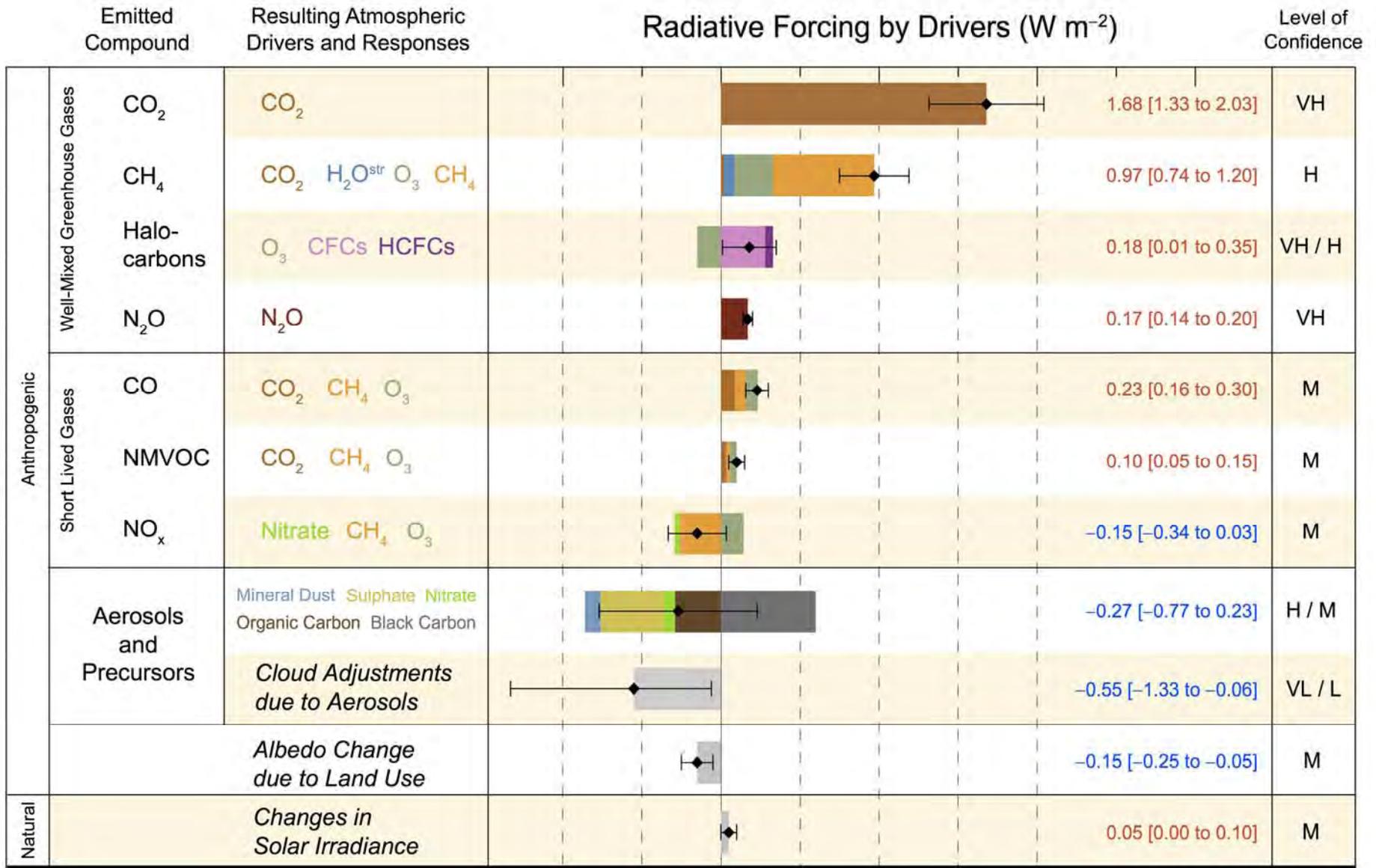


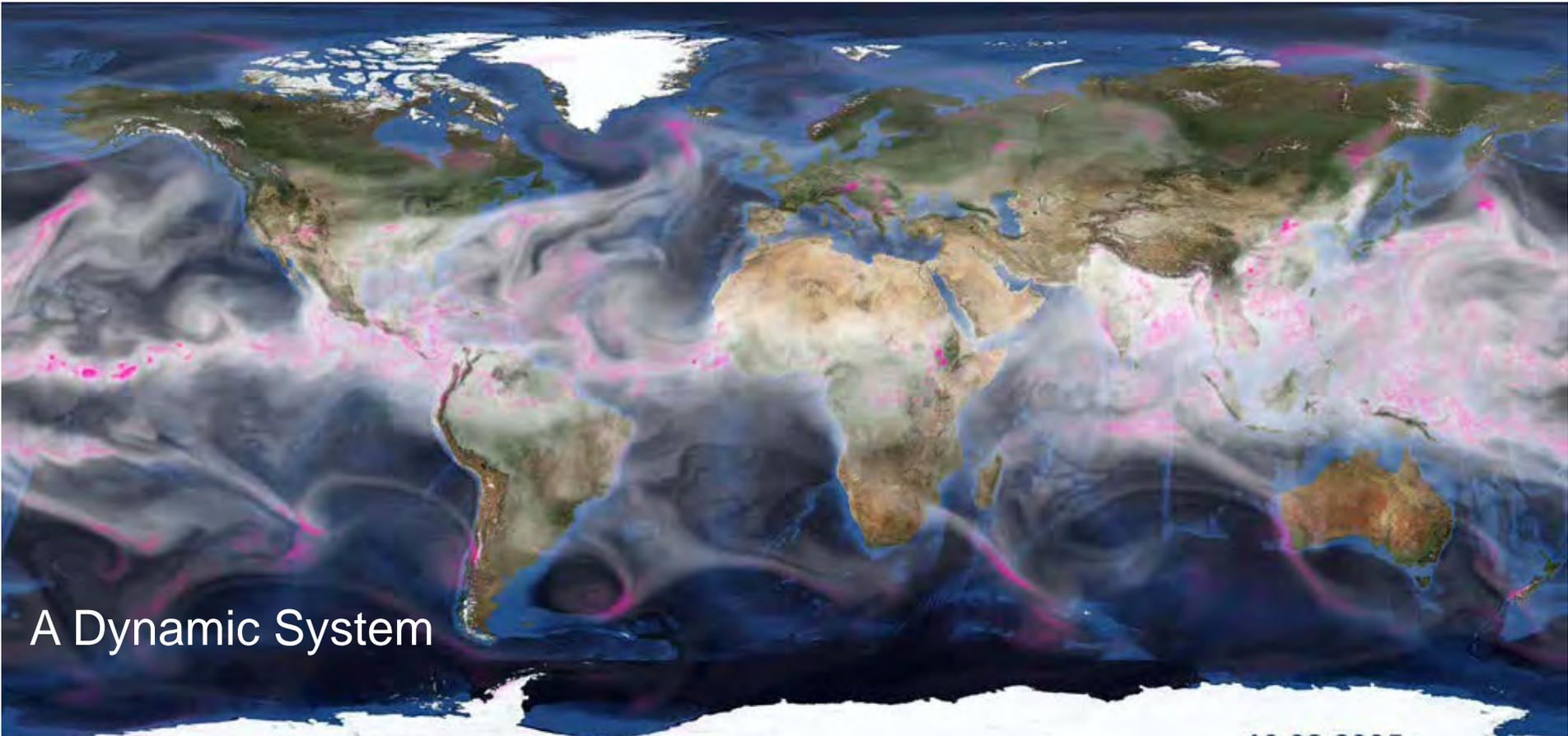
Climate change:

... a change in the state of the climate that persists for an extended period, typically decades or longer

Climate change may be due to **natural internal processes** or **external forcings**, or to **persistent anthropogenic changes** in the **composition of the atmosphere** or in **land use**.

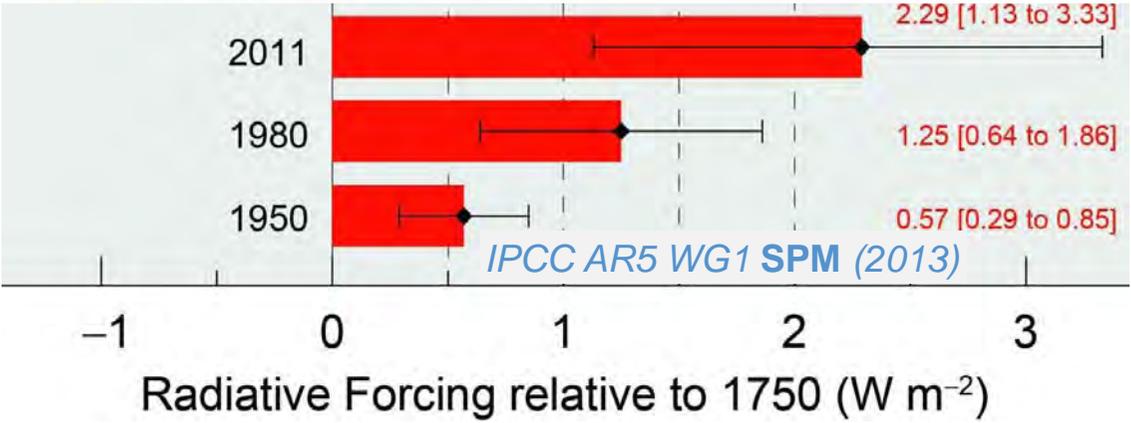
IPCC AR4/5 WG1 Glossaries (2007; 2013)





A Dynamic System

© 2007 NERSC/ECMWF/NASA <http://www.bjerknes.uib.no/pages.asp?id=1709&kat=97&lang=2> 16.08.2005



93% Ocean warming
 3% warming the land
 1% warming the atmosphere
3% melting of ice

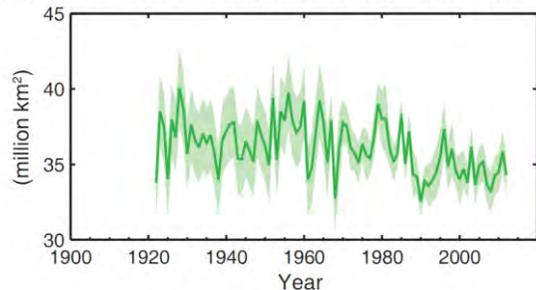
ipcc

INTERGOVERNMENTAL PANEL ON climate change

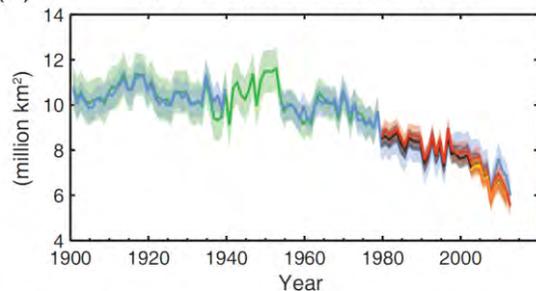


Observed Changes 1901-2012

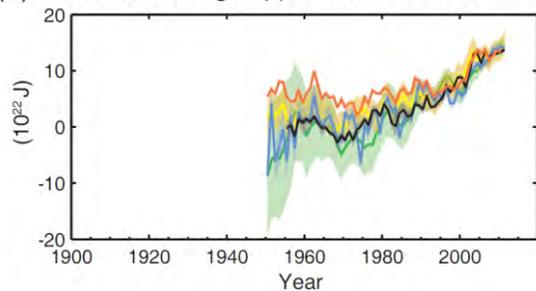
(a) Northern Hemisphere spring snow cover



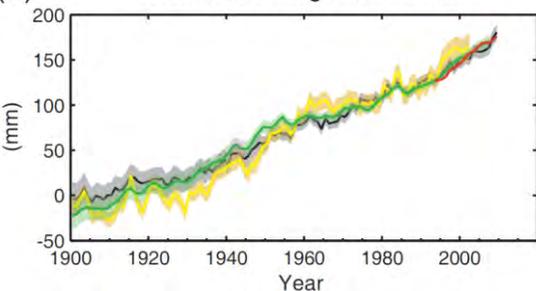
(b) Arctic summer sea ice extent



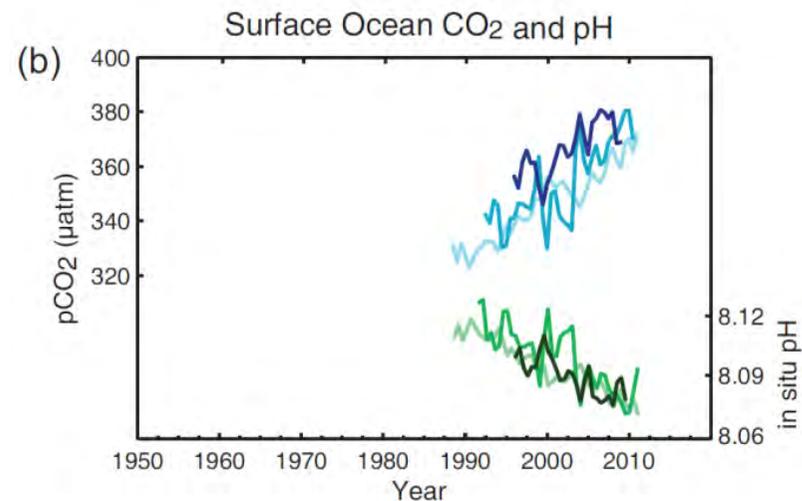
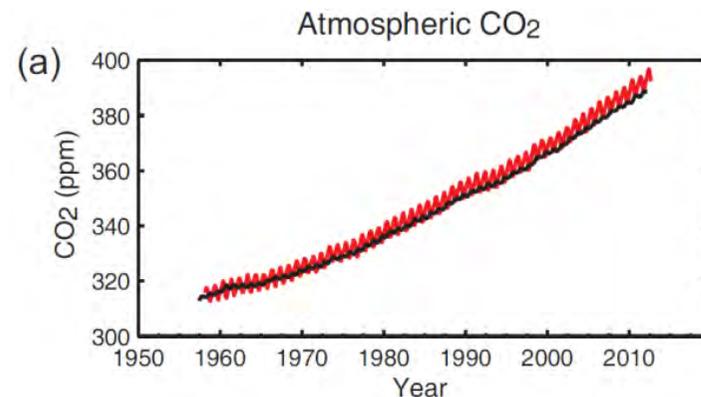
(c) Global average upper ocean heat content



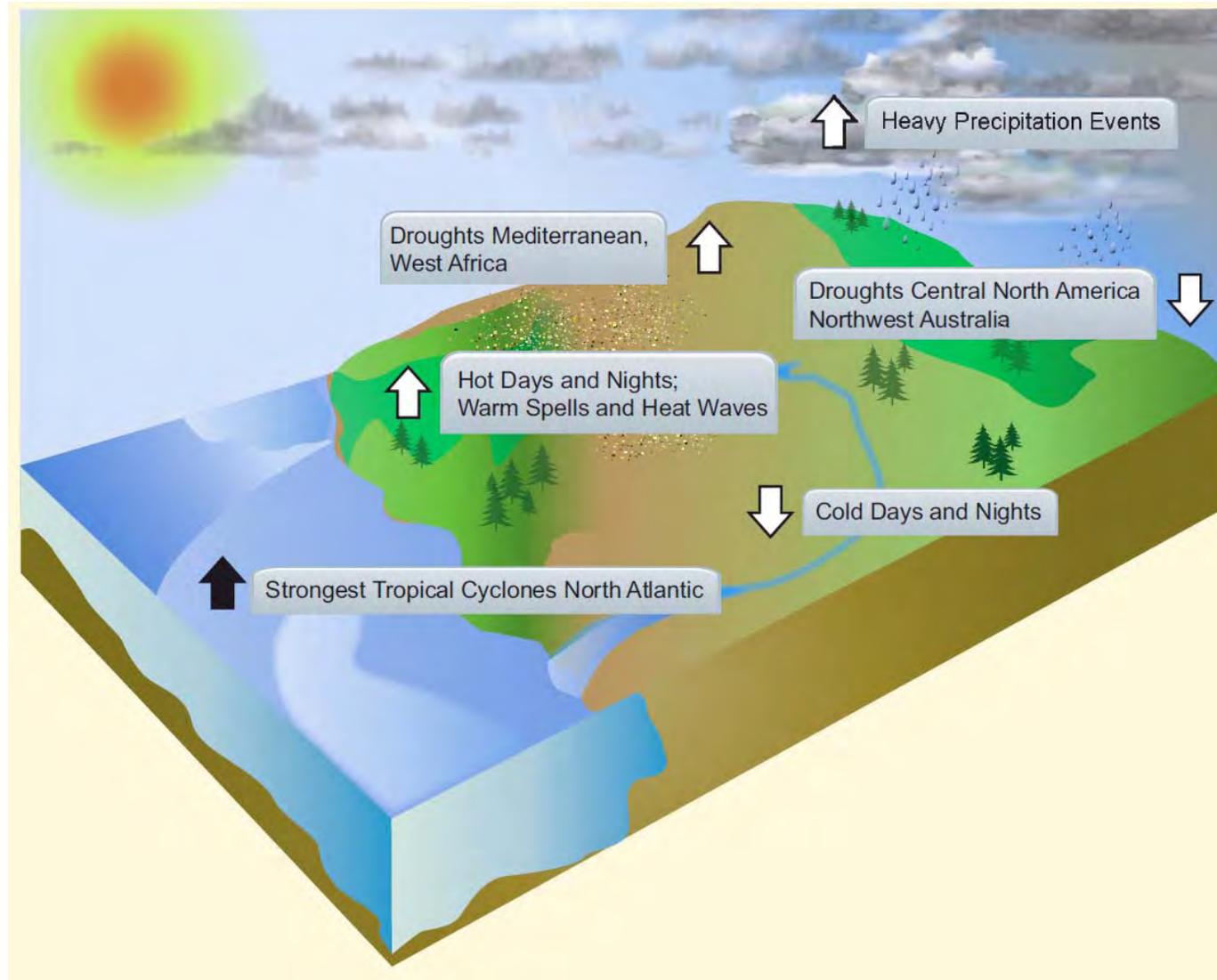
(d) Global average sea level



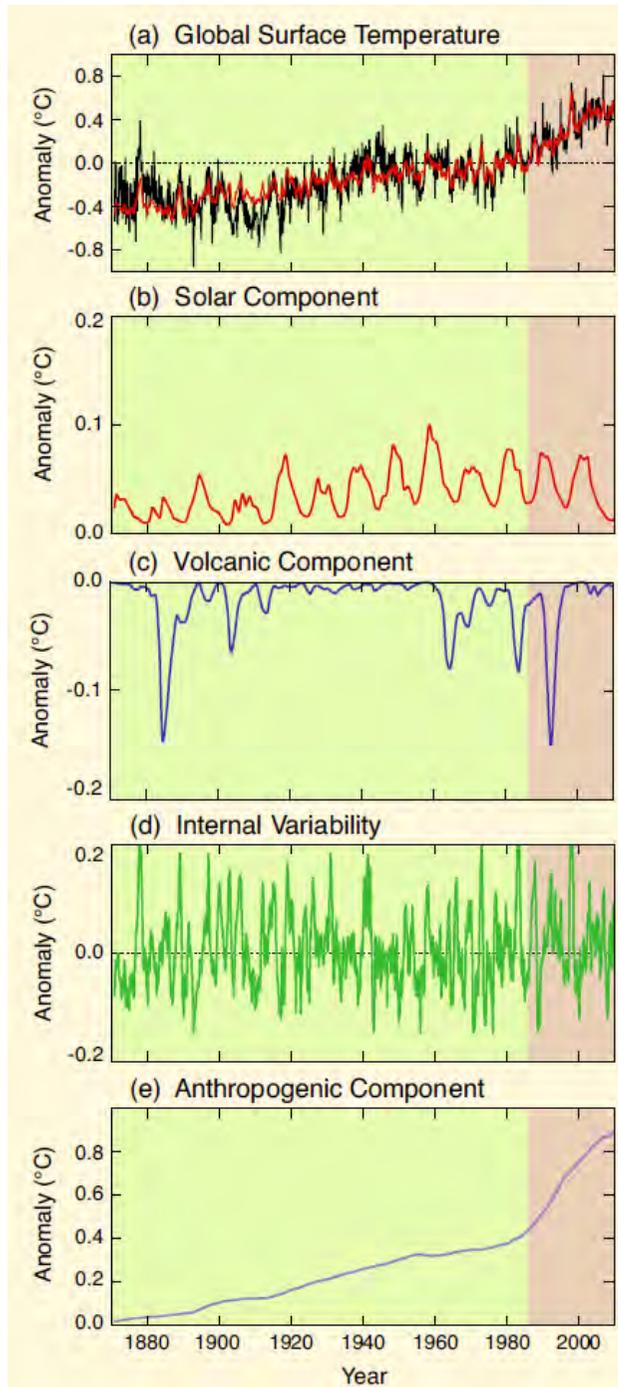
IPCC AR5 WG1 SPM (2013)



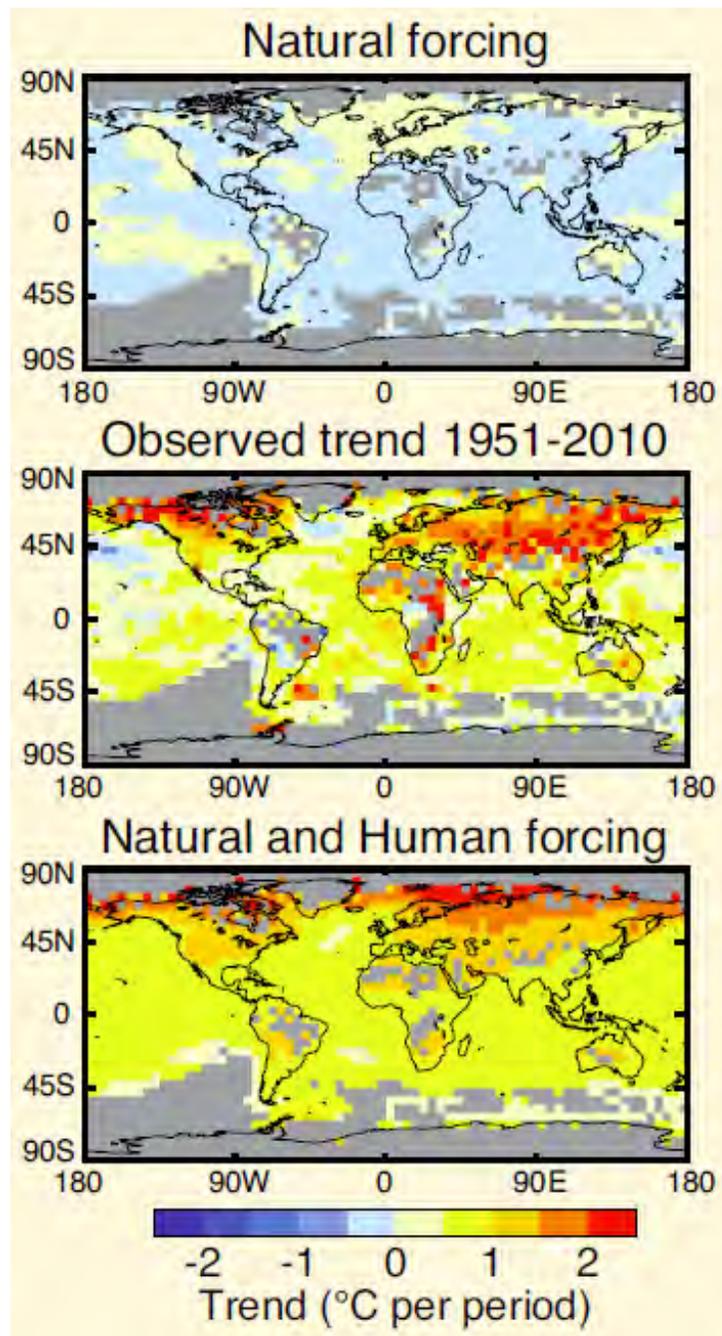
Observed changes in extremes



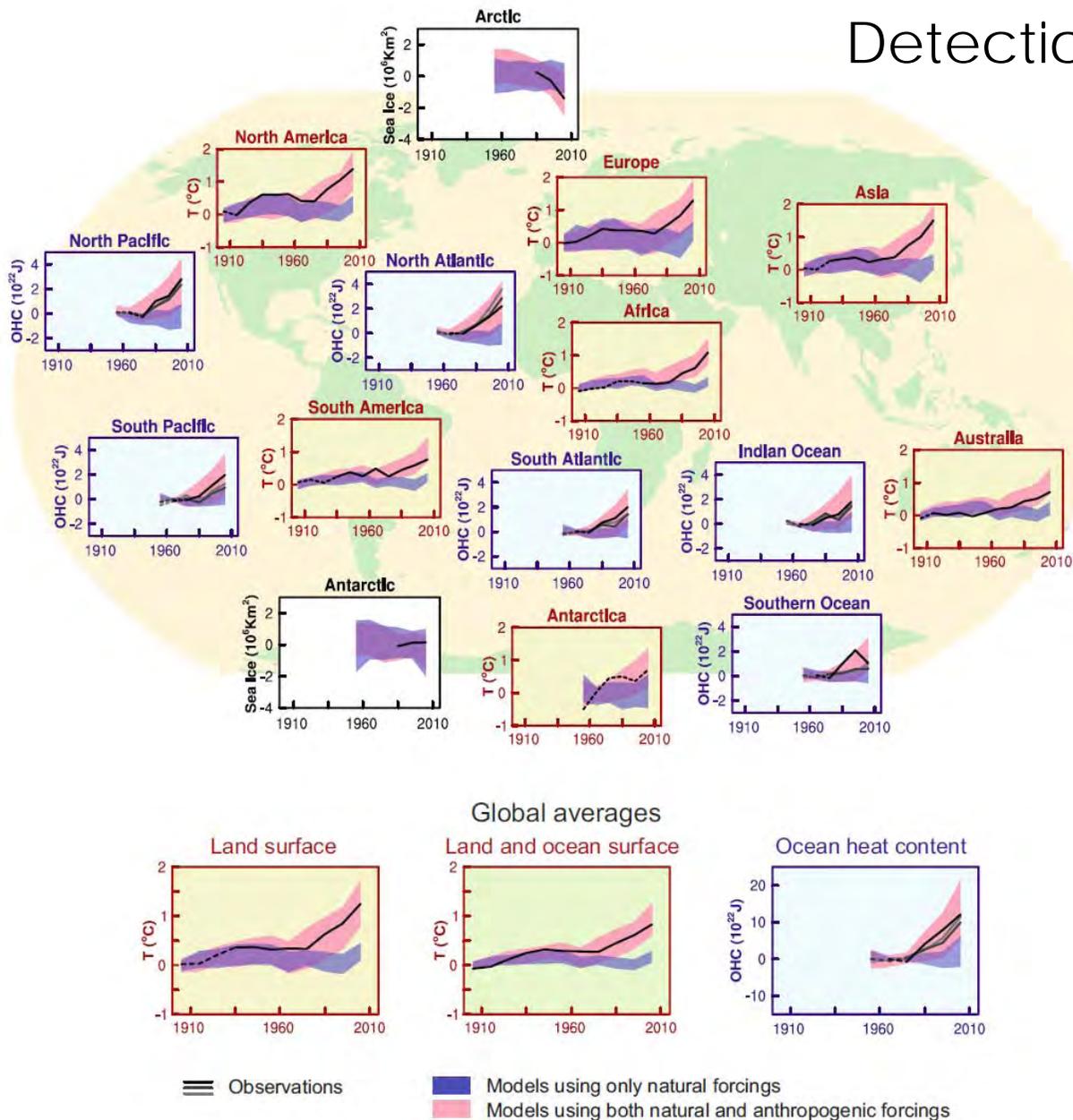
IPCC AR5 WG1 FAQ (2013)



IPCC AR5 WG1 Ch 5, 10 (2013)

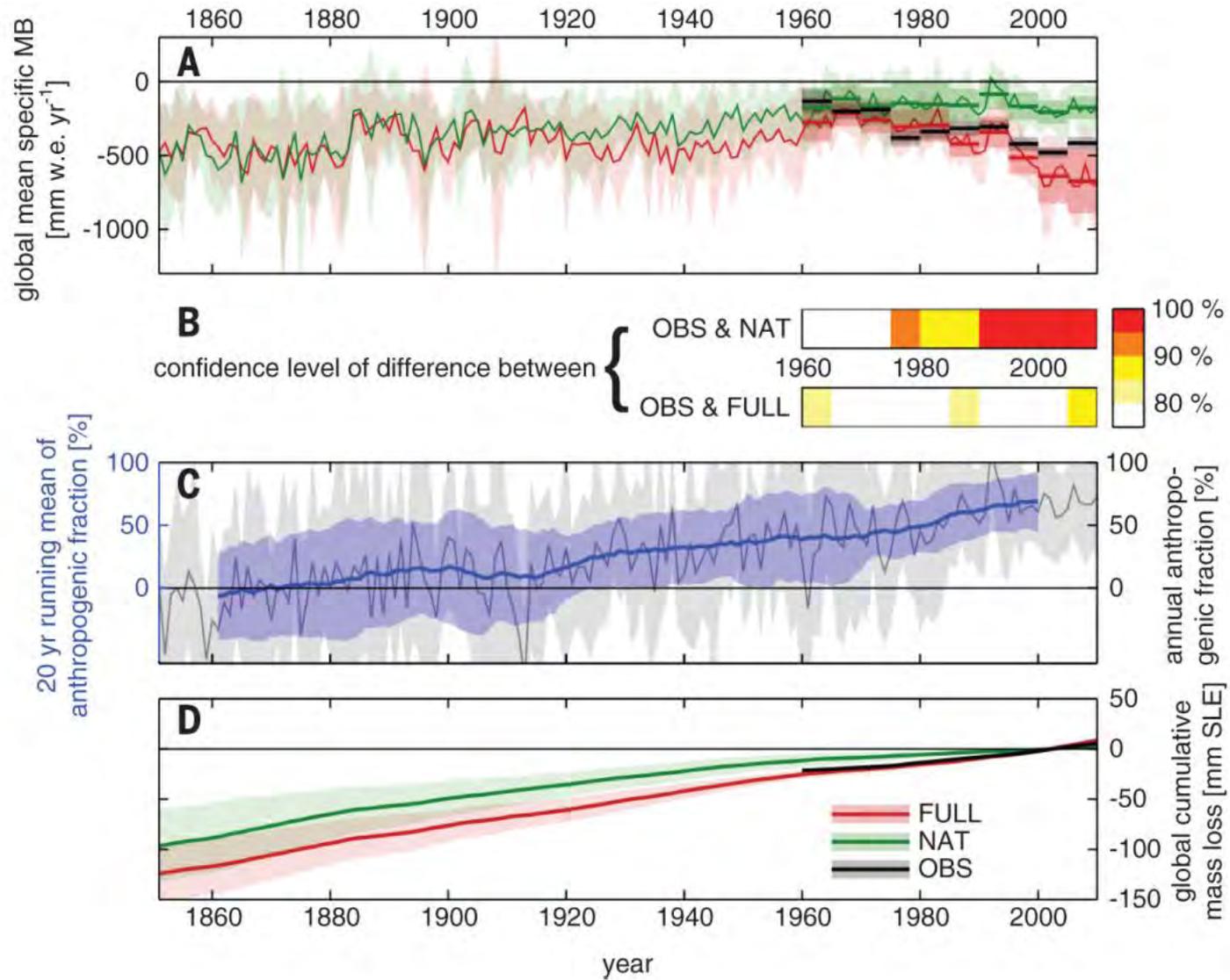


Detection & Attribution



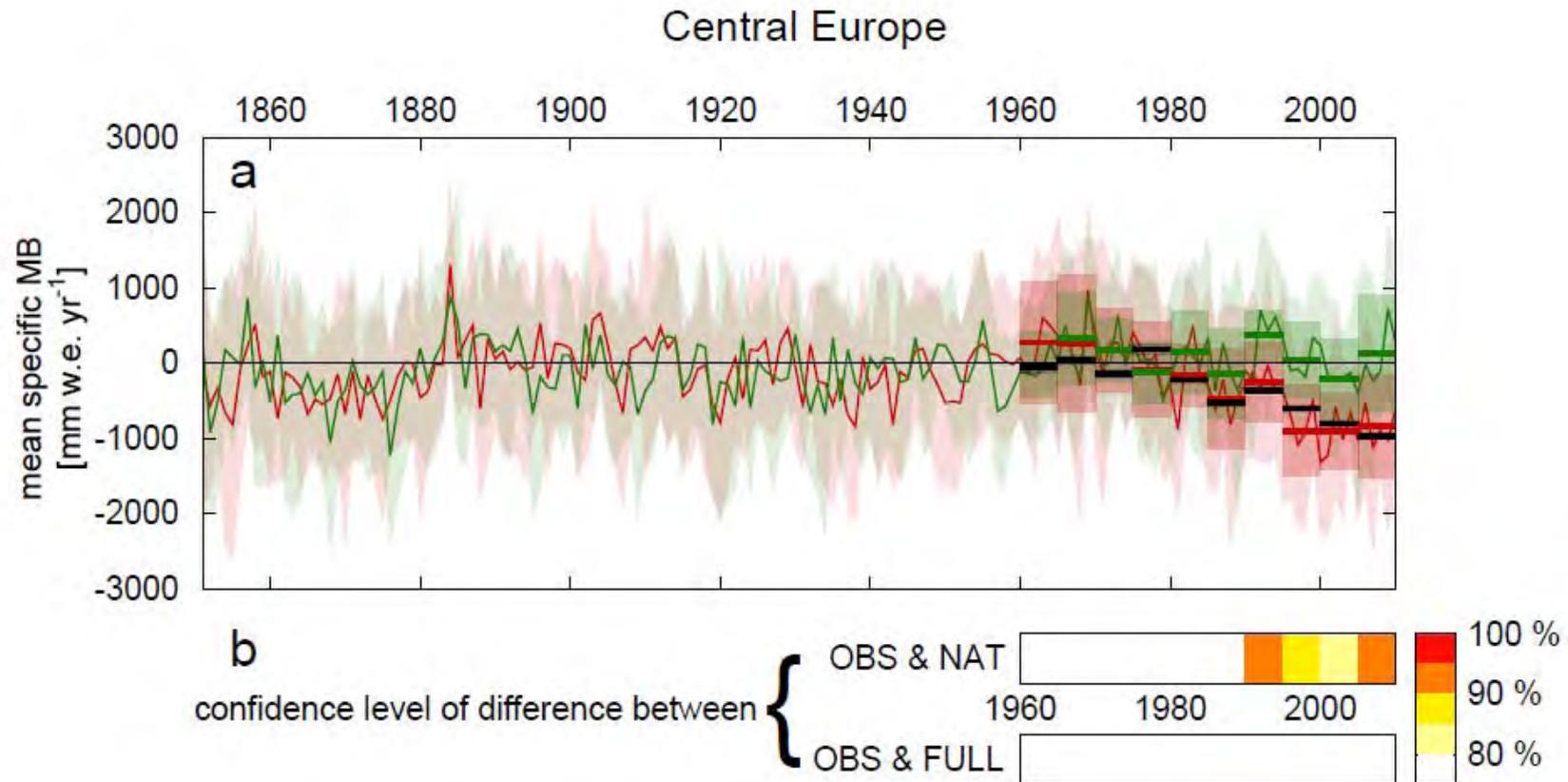
IPCC AR5 WG1 SPM (2013)

Detection & Attribution Glaciers



Marzeion et al. Science 2014

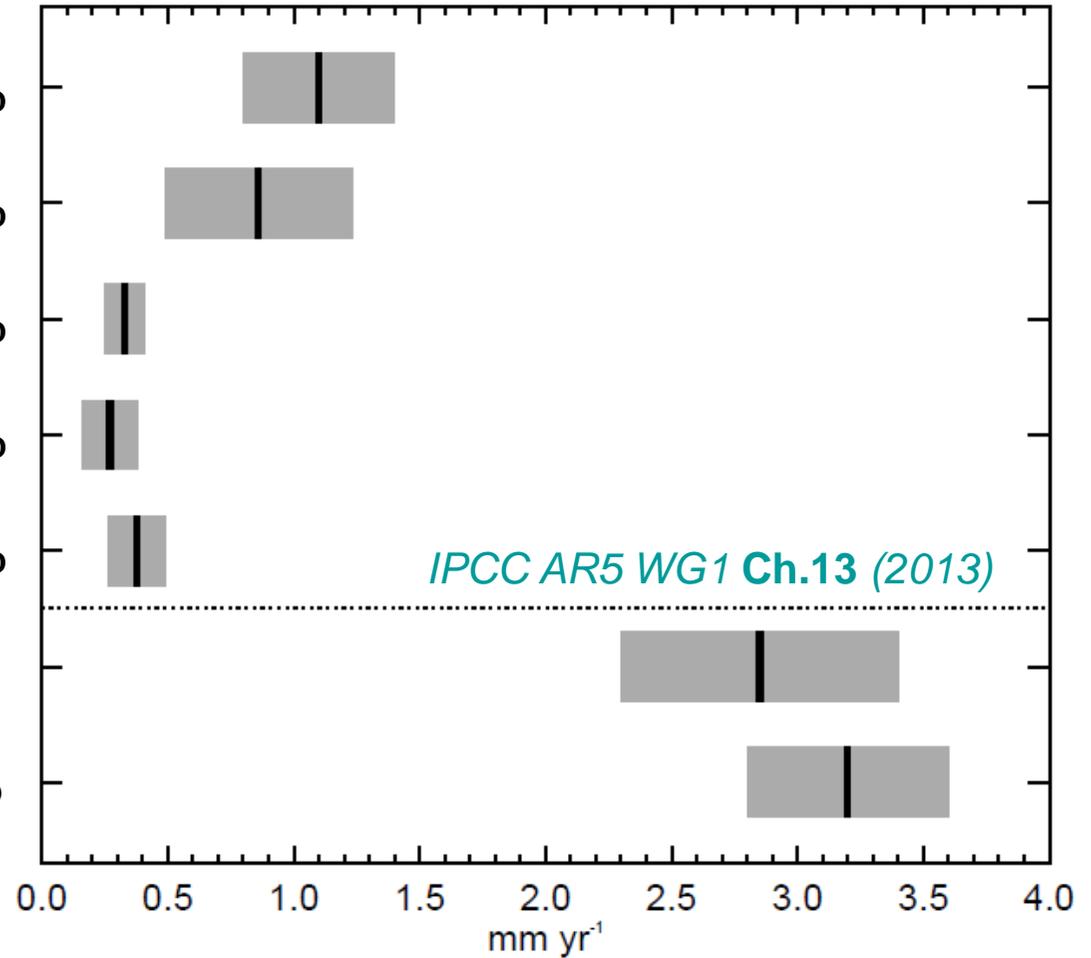
Detection & Attribution Glaciers



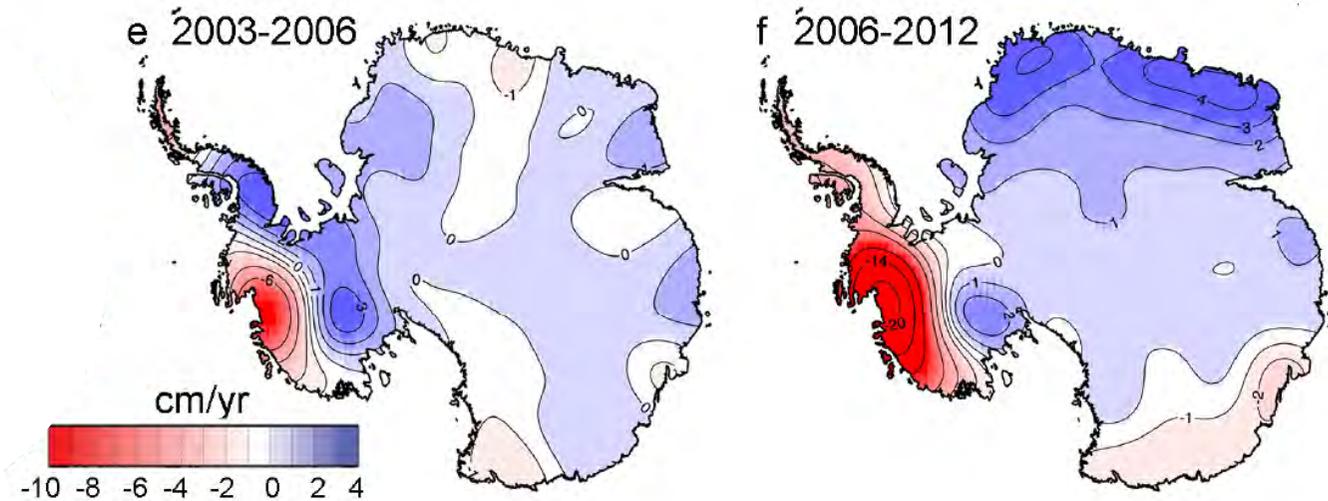
Marzeion et al. Science 2014

GMSLR 1993-2010: 3.2 mm/yr

Thermal expansion:	38%
Glaciers:	28%
Greenl. Ice Sheet:	10%
Antarct. Ice Sheet:	10%
Land water stor.:	14%
Total :	100%
Obs. GMSLR:	110%

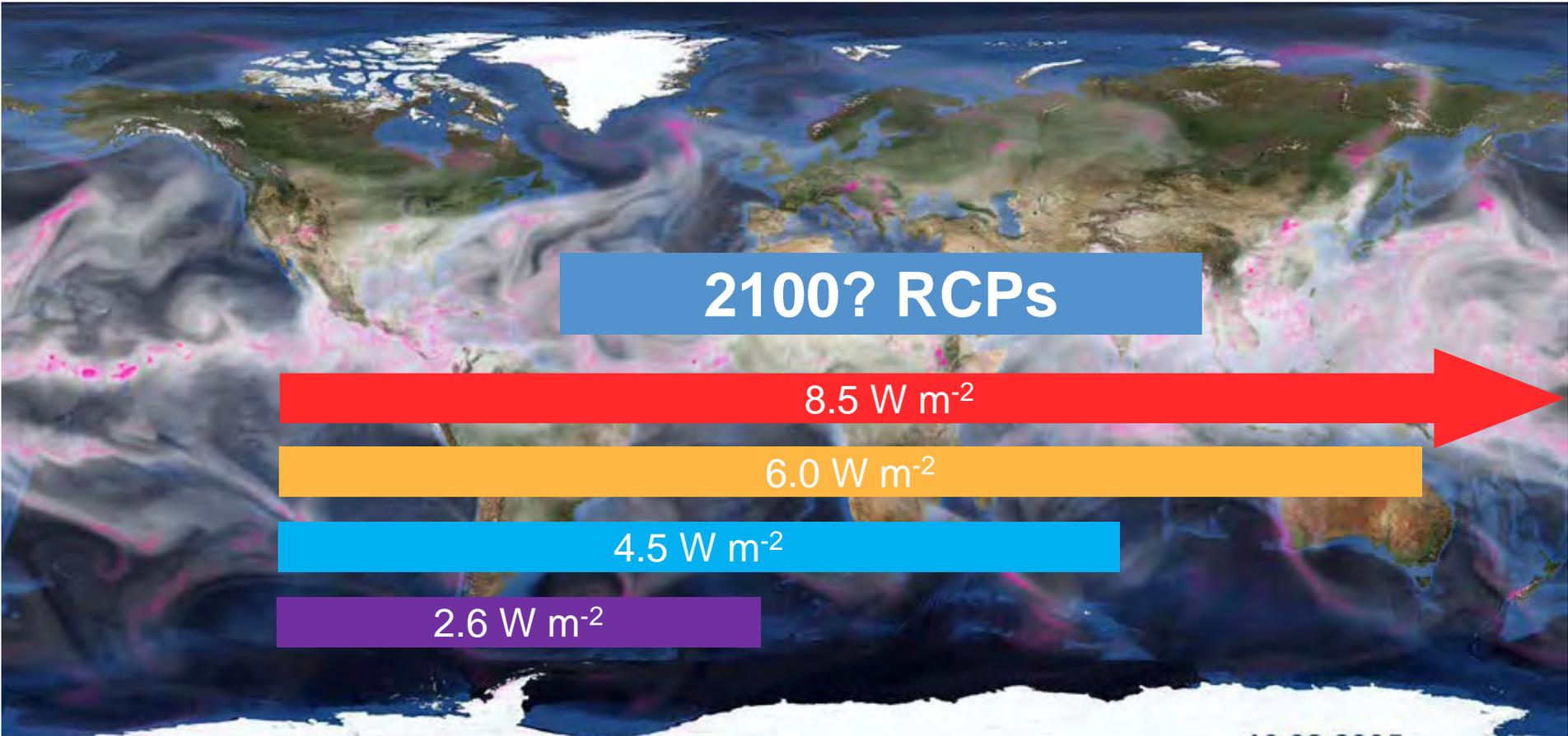


Antarctic Ice Sheet



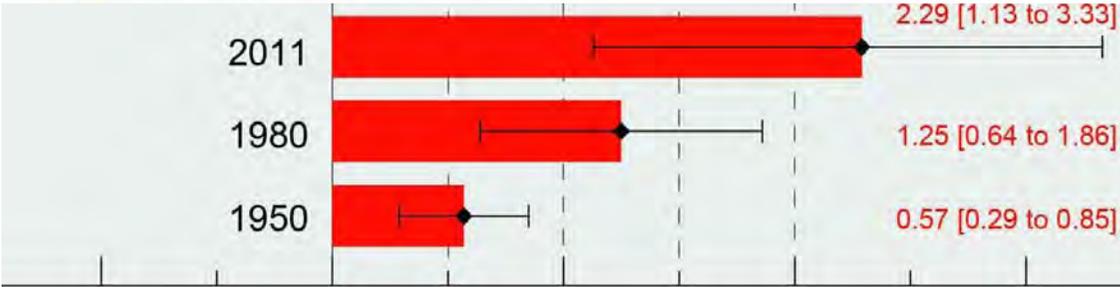
IPCC AR5 WG1 Ch.4 (2013)

Ice loss on Antarctic Peninsula and the Amundsen Sea Sector of West Antarctica, resulting from acceleration of outlet glaciers (break-off of shelf ice)



16.08.2005

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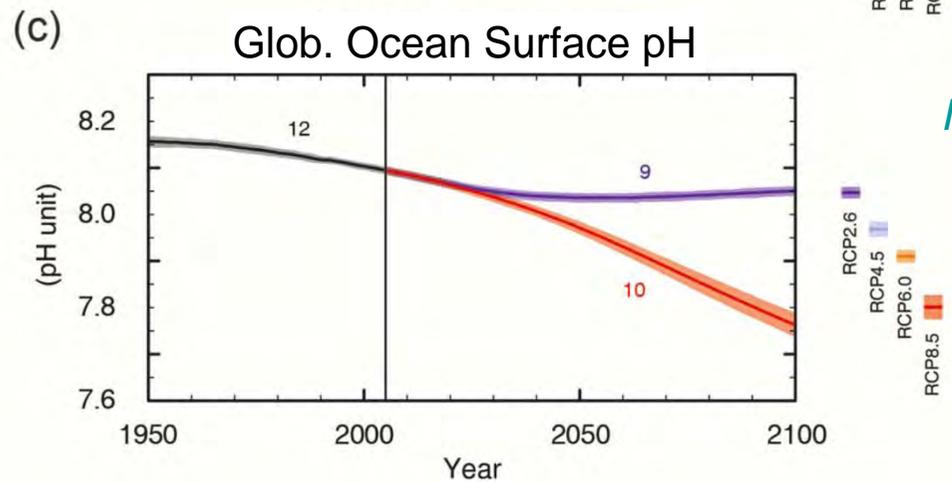
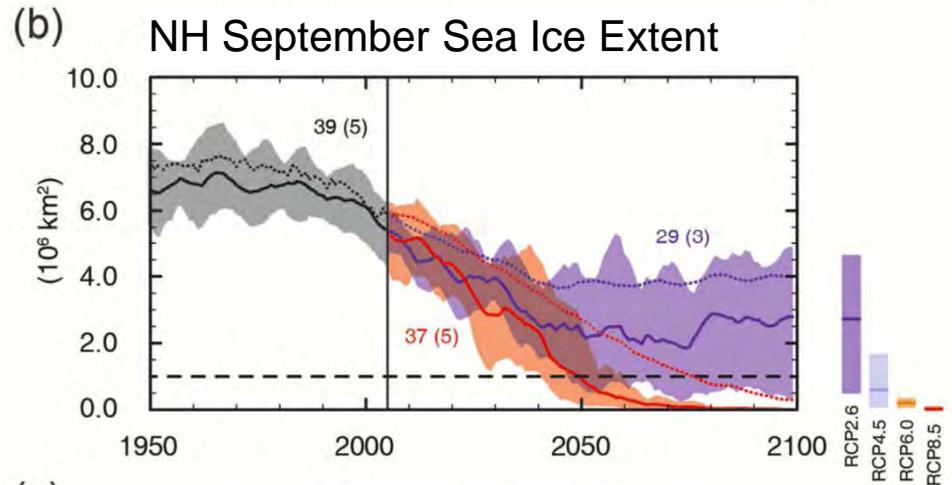
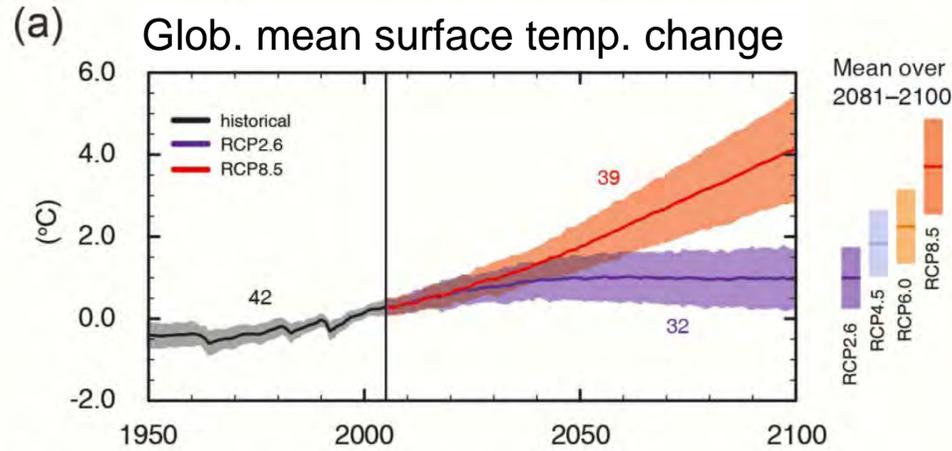


IPCC AR5 WG1 SPM (2013)

-1 0 1 2 3

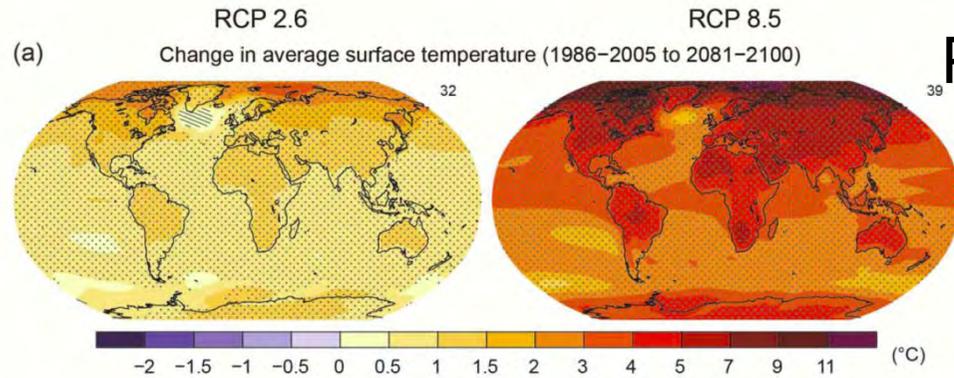
Radiative Forcing relative to 1750 (W m⁻²)

Projections to 2100

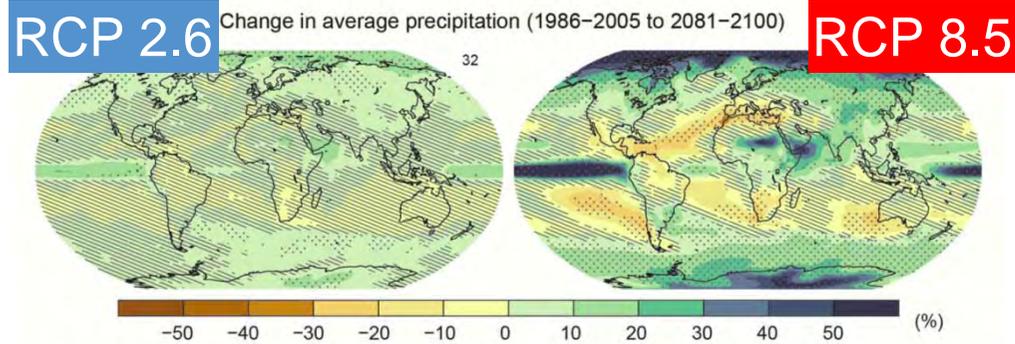


IPCC AR5 WG1 SPM (2013)

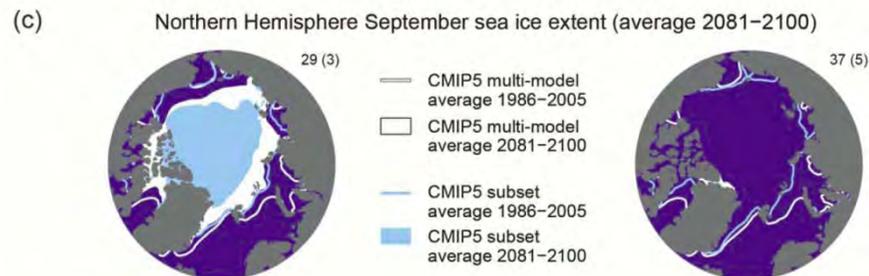
Projections - regional distribution



Surface Temperature

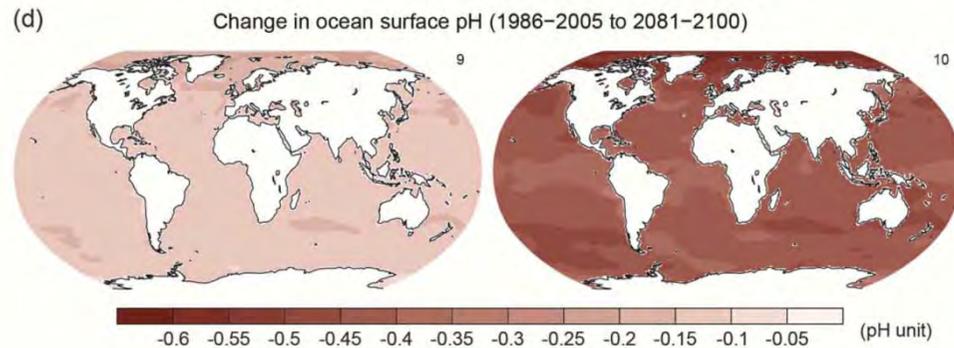


Precipitation



Arctic Sea Ice Extent

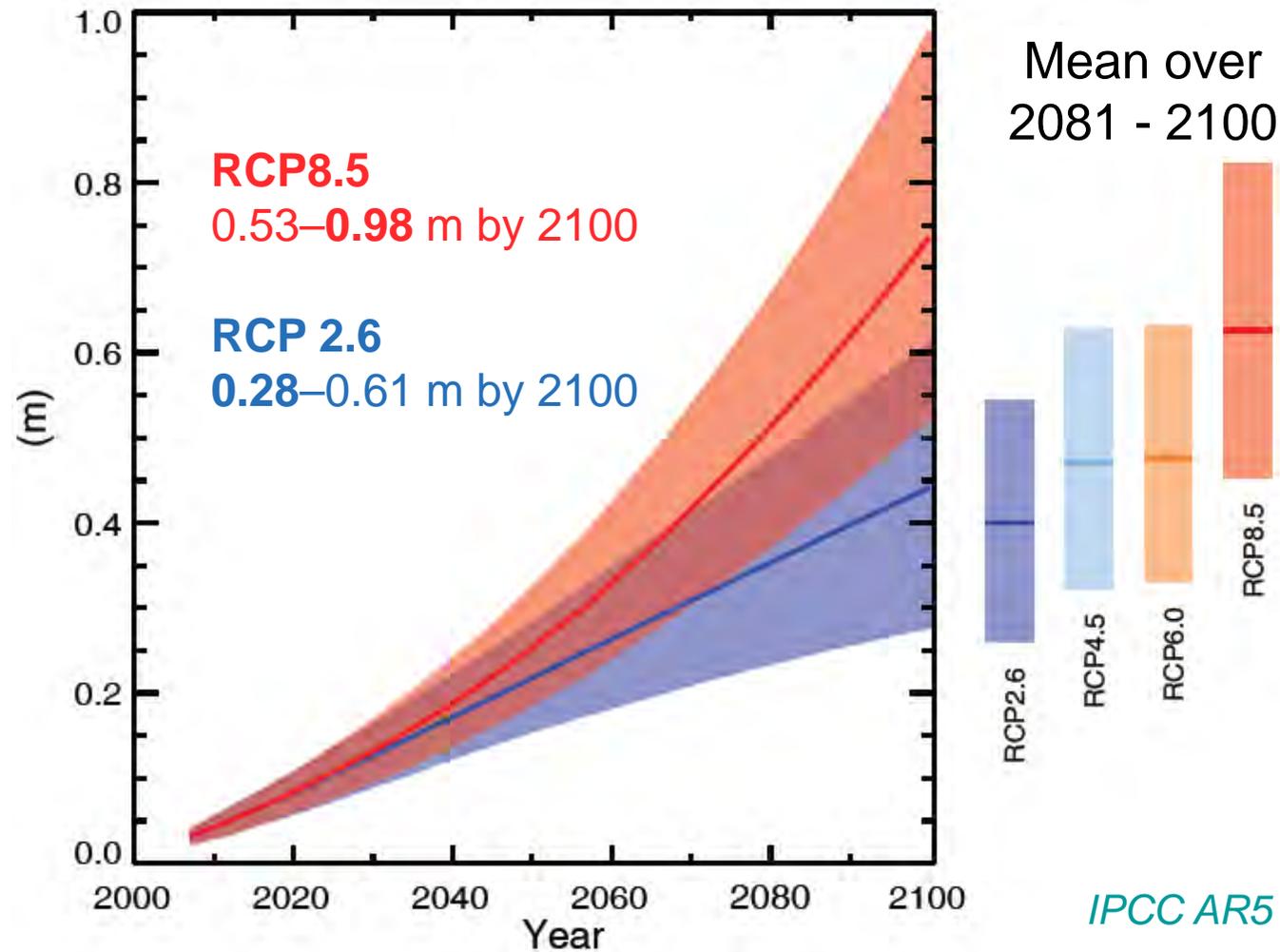
IPCC AR5 WG1 SPM (2013)



Ocean Surface pH

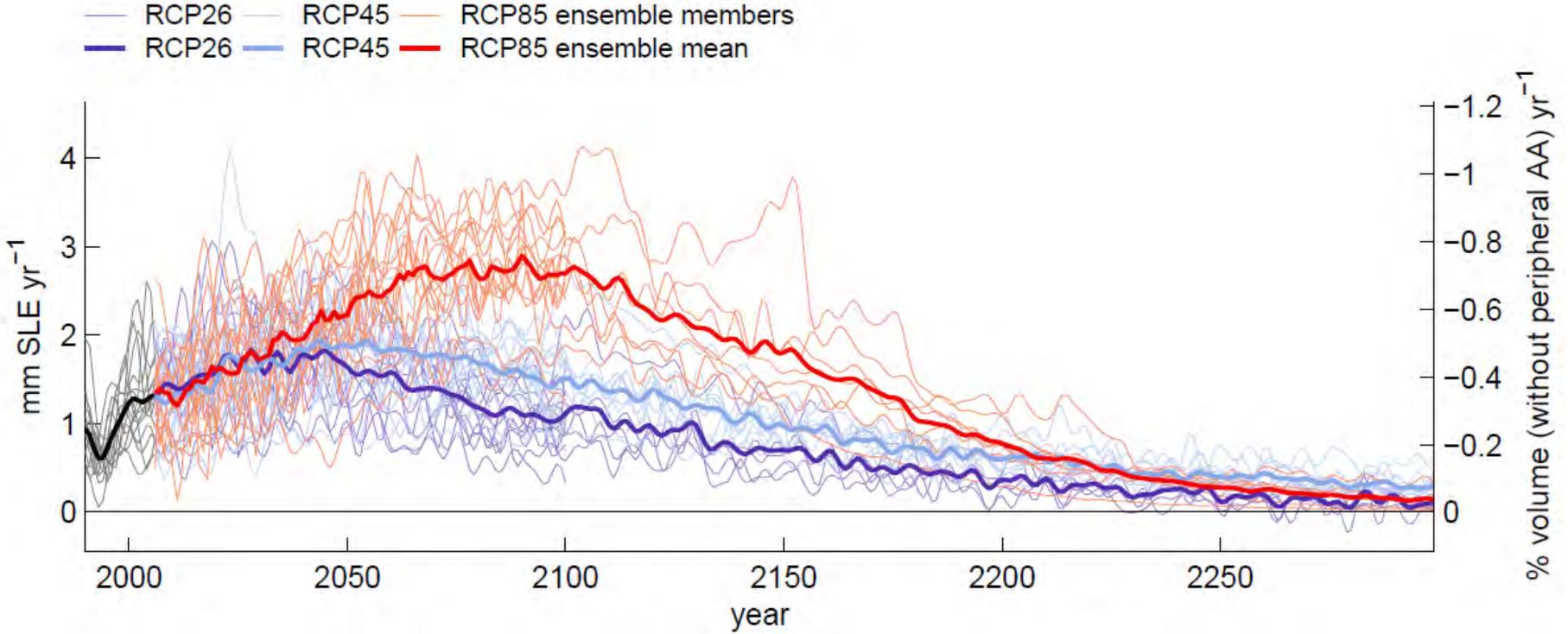
Global Mean Sea Level Rise until 2100

GMSLR will exceed that of **1971-2010** under all RCPs.



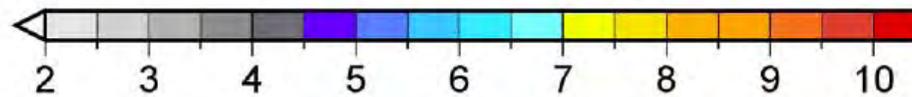
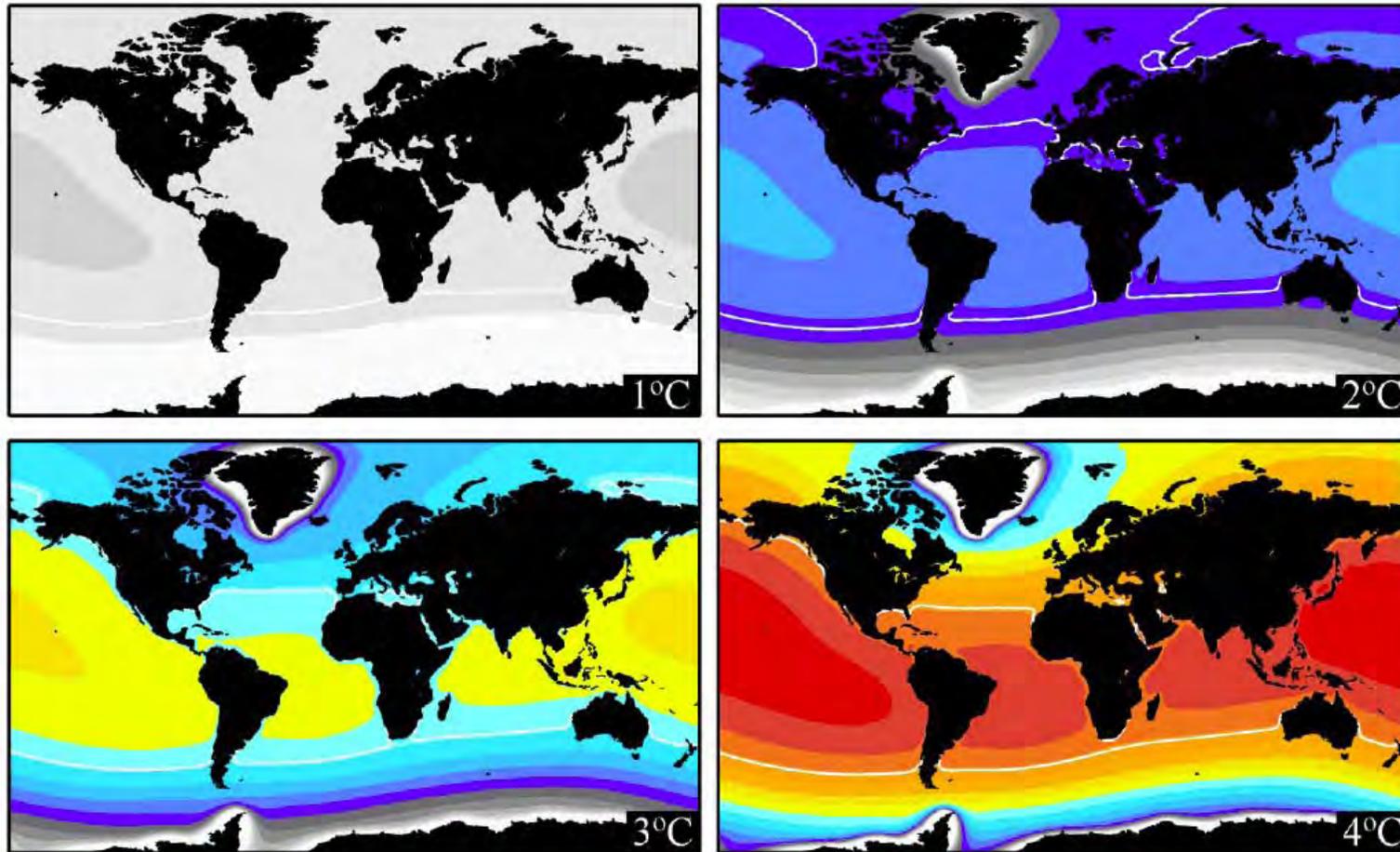
IPCC AR5 WG1 SPM (2013)

The future of the glaciers



Marzeion et al. TC 2012

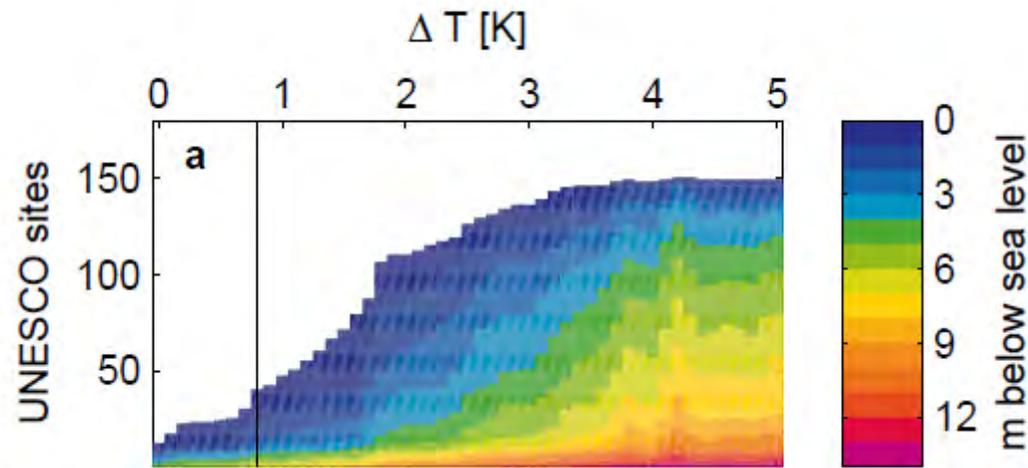
Sea Level Scenarios



Sea Level (m)

Levermann et al. PNAS (2013)

UNESCO Cultural Heritage Sites



1 – 1,5% Land
5 – 10% Population

Marzeion and Levermann (2014)

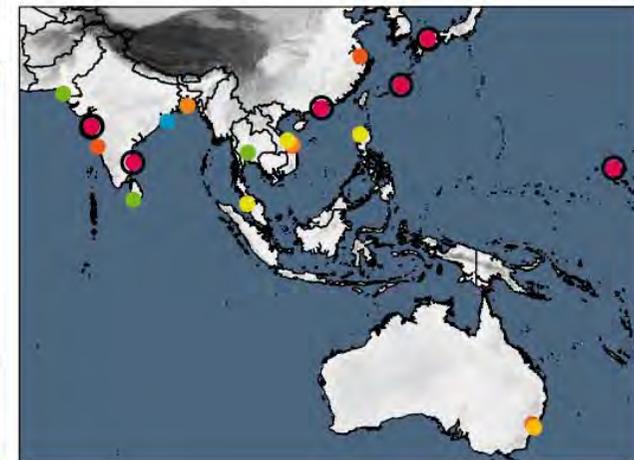
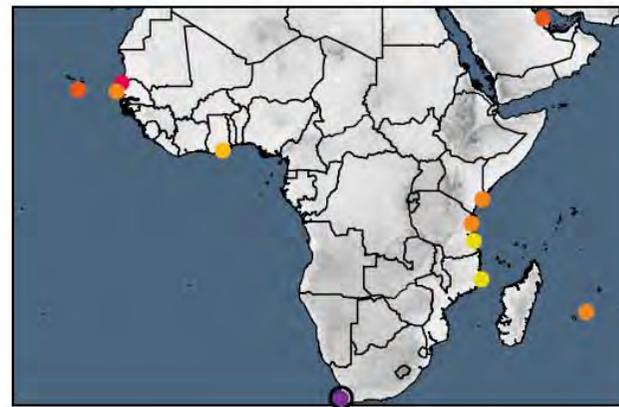
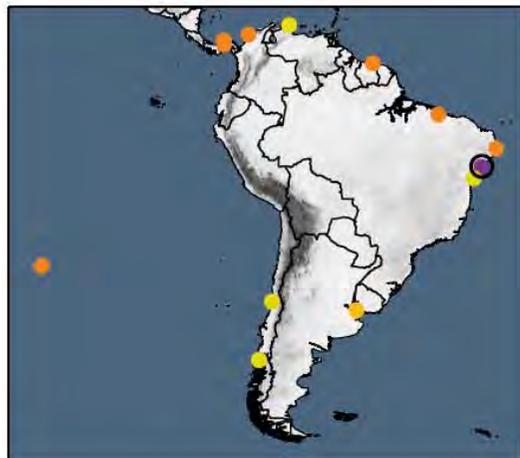
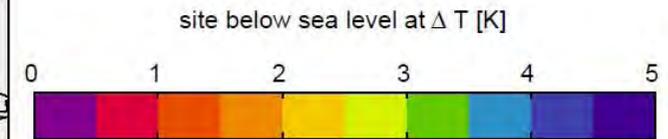




Foto: B. Marzeion

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Further Information
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