

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

IPCC AR5 WG1

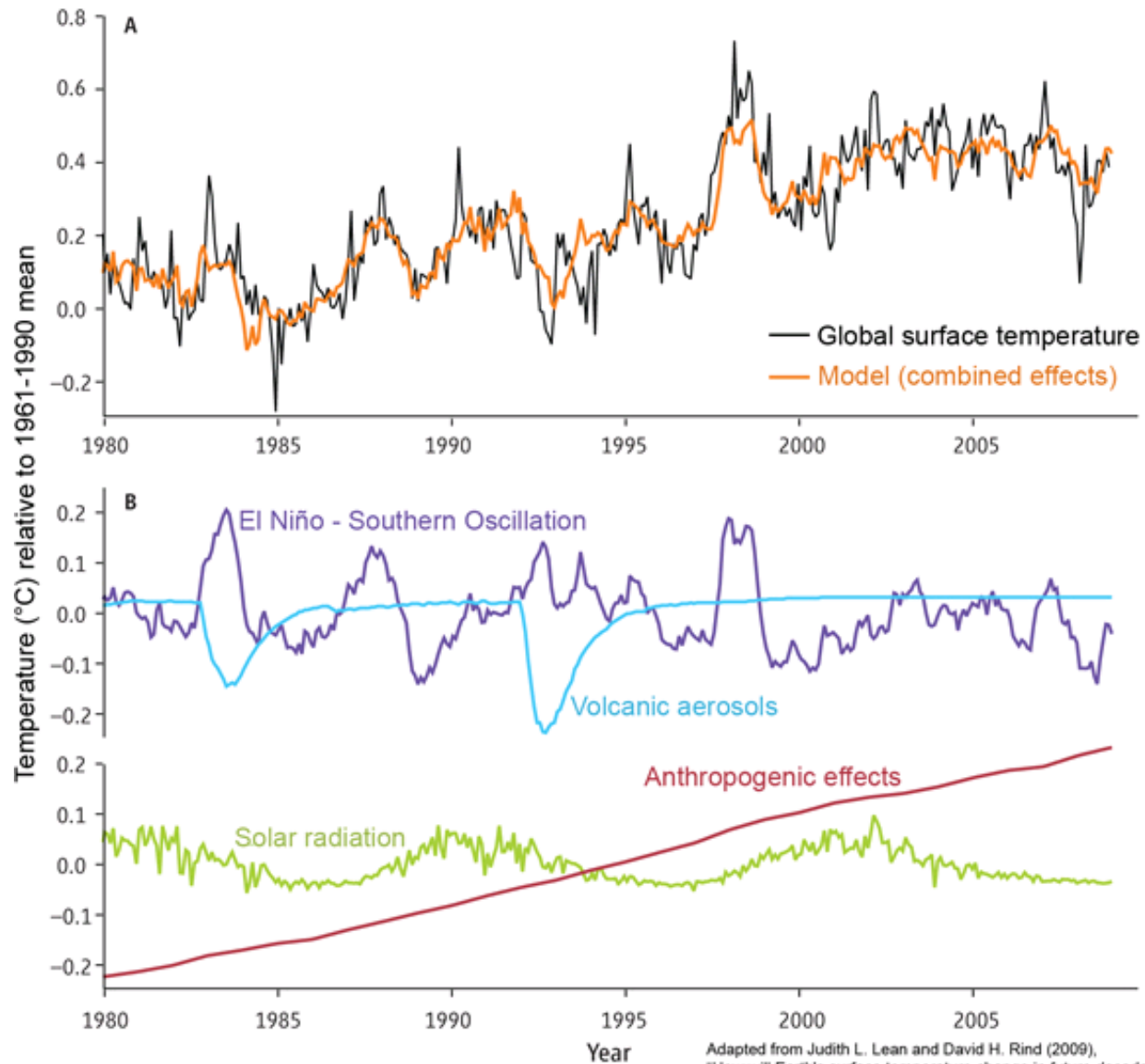
Georg Kaser

Institut für Meteorologie und Geophysik, Innsbruck
Centre for Climate and Cryosphere
IPCC LA Ch.4, CA Ch 10, 13, TS, SPM

5. Österreichischer MeteorologInnentag, 7.11.2013

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The energetic state and the surface temperature of a body



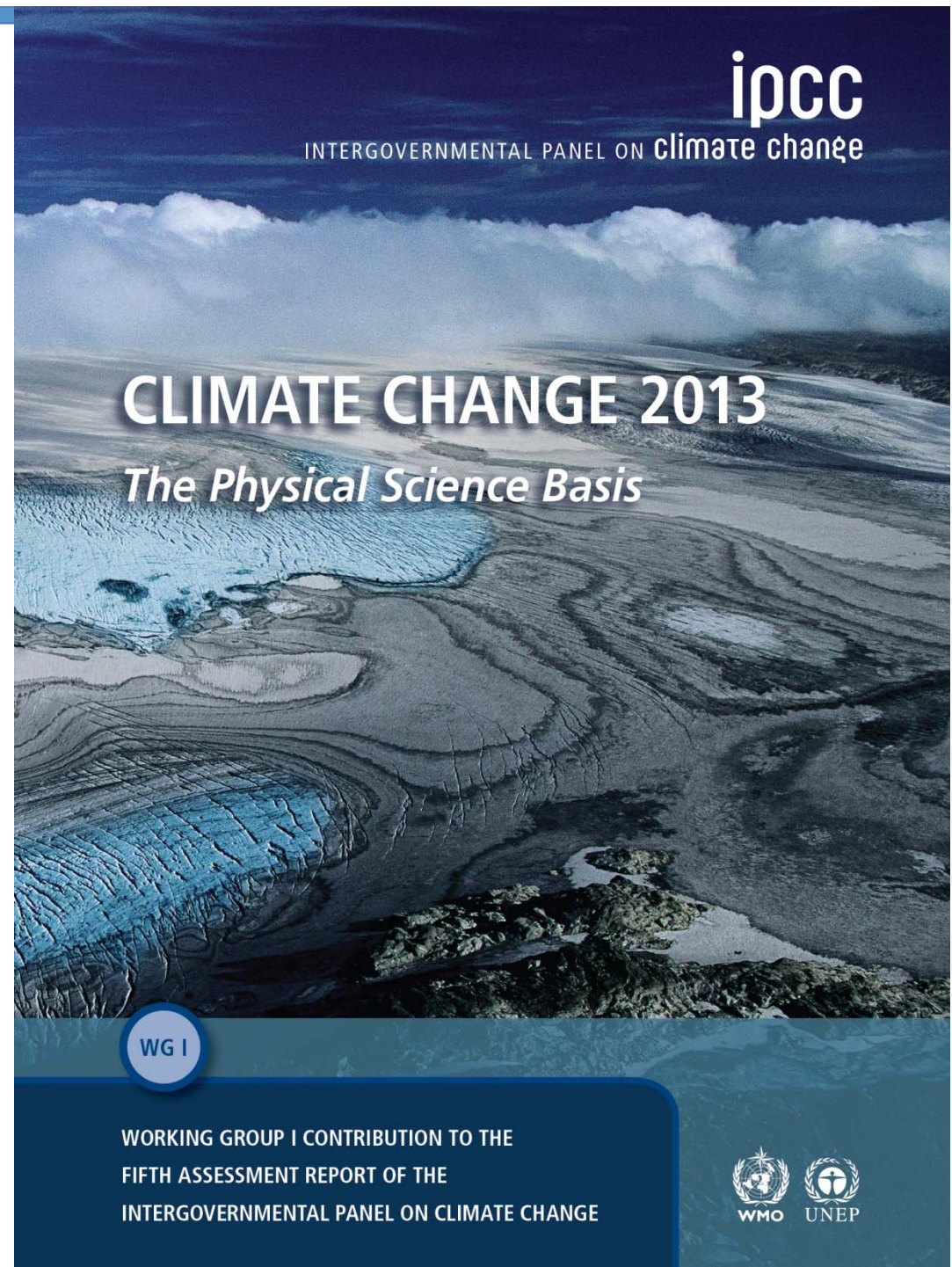
Spencer Weart:
<http://www.aip.org/history/climate/summary.htm>

Summary for Policy Makers
ca. 14,000 words (22 p.)

AR5 WG1: appr. 2000 p.

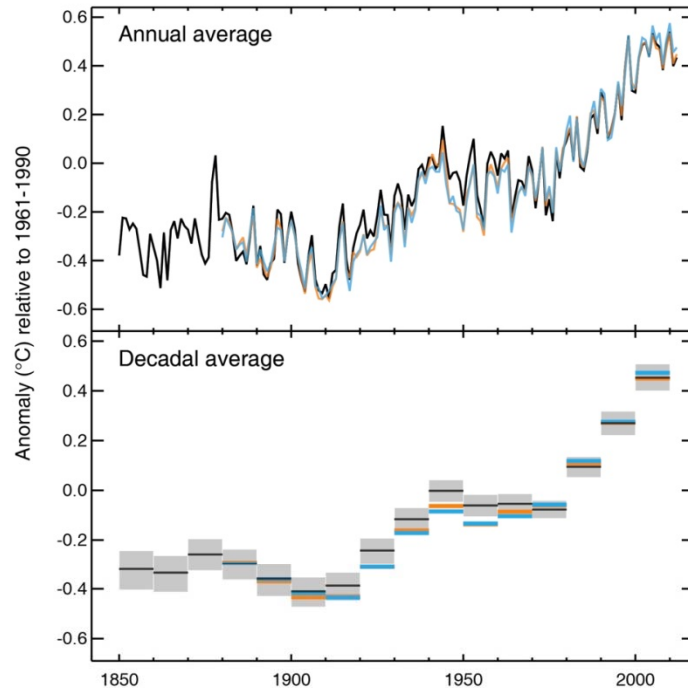
DIAGNOSES

IPCC AR5 Working Group I
Climate Change 2013: The Physical Science Basis



(a)

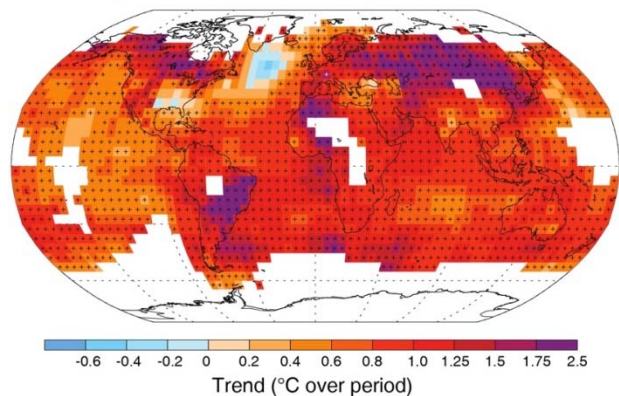
Global average surface temperature 1850–2012



The globally averaged combined land and ocean surface temperature data as calculated by a linear trend, show a warming of **0.85 [0.65 to 1.06] °C**, over the period **1880–2012**, when multiple independently produced datasets exist.

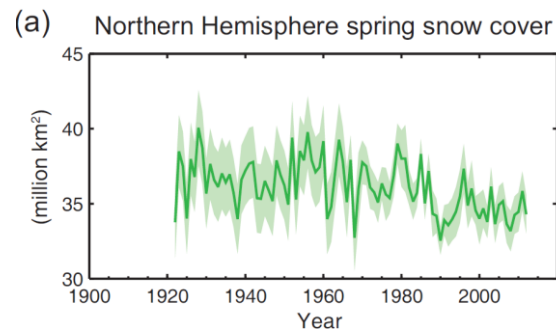
(b)

Change in average surface temperature 1901–2012

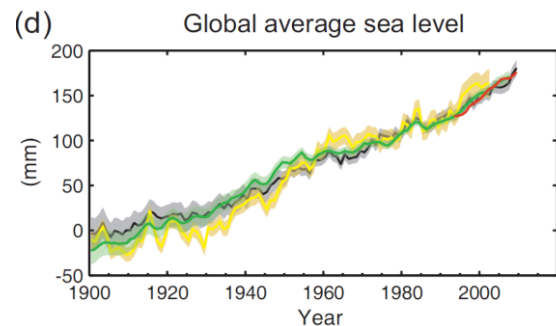
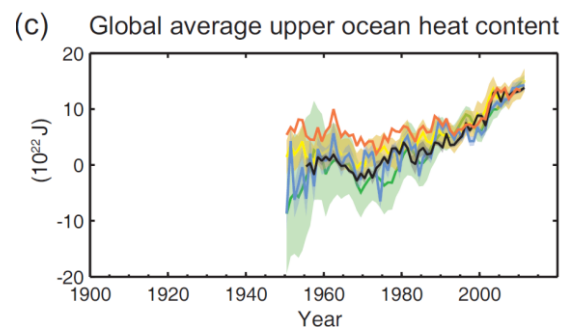
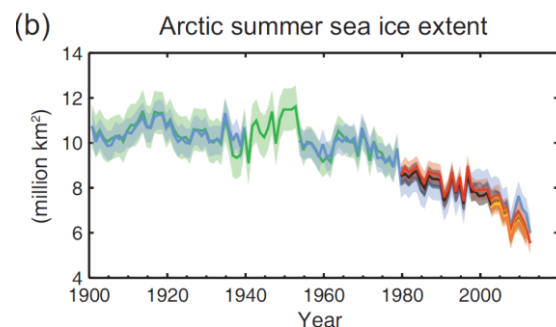


In addition to **robust multi-decadal warming**, global mean surface temperature exhibits substantial **decadal and interannual variability**. Due to natural variability, trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long-term climate trends. **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)⁵. {2.4}**

IPCC AR5 WG1 SPM (2013)



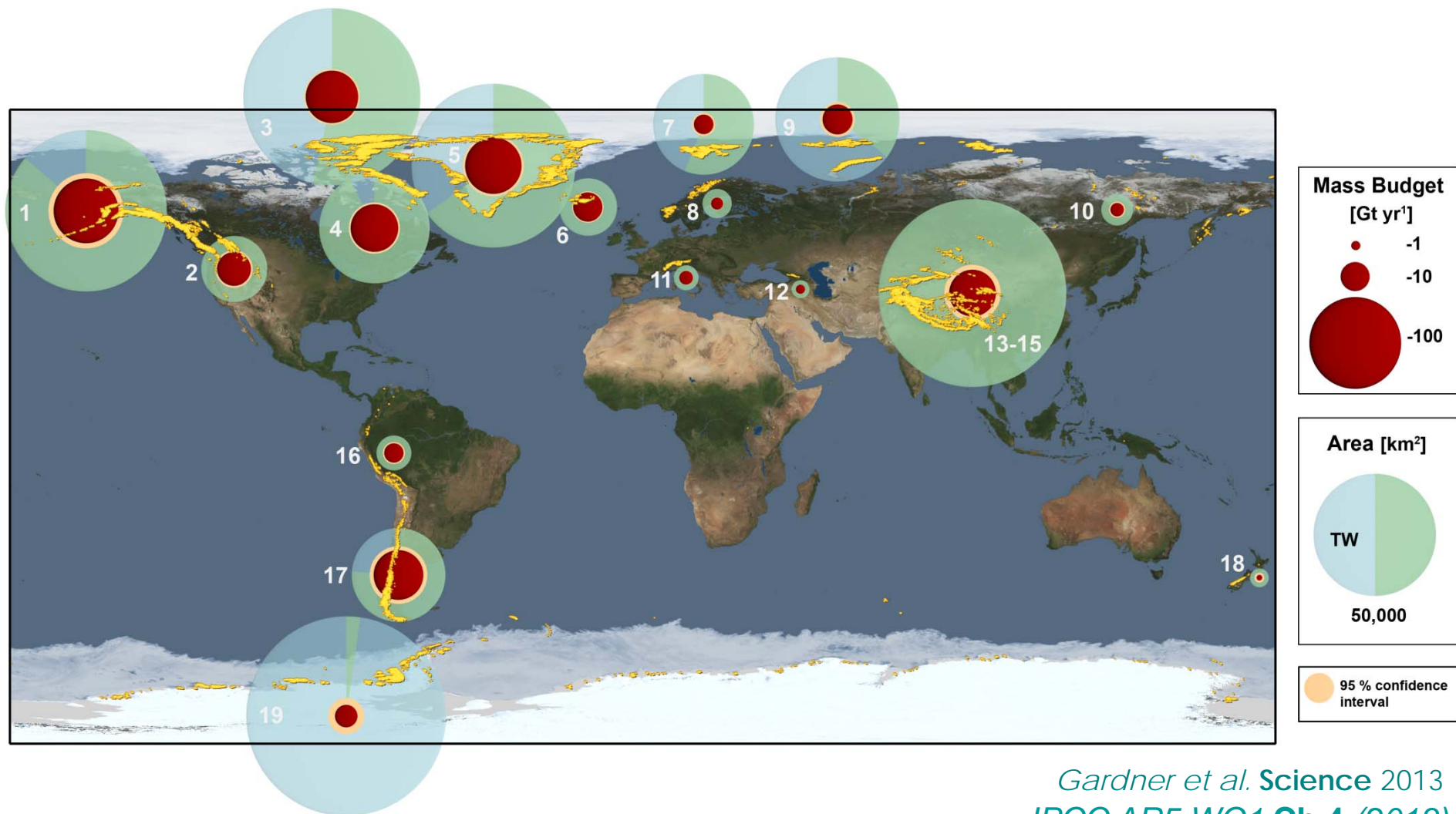
Observations provide multiple lines of evidence for changes in the ocean and the cryosphere



The climate system is out of balance: it is accumulating energy. More than 90% is stored in the ocean.

IPCC AR5 WG1 SPM (2013)

Glaciers 2003 - 2009

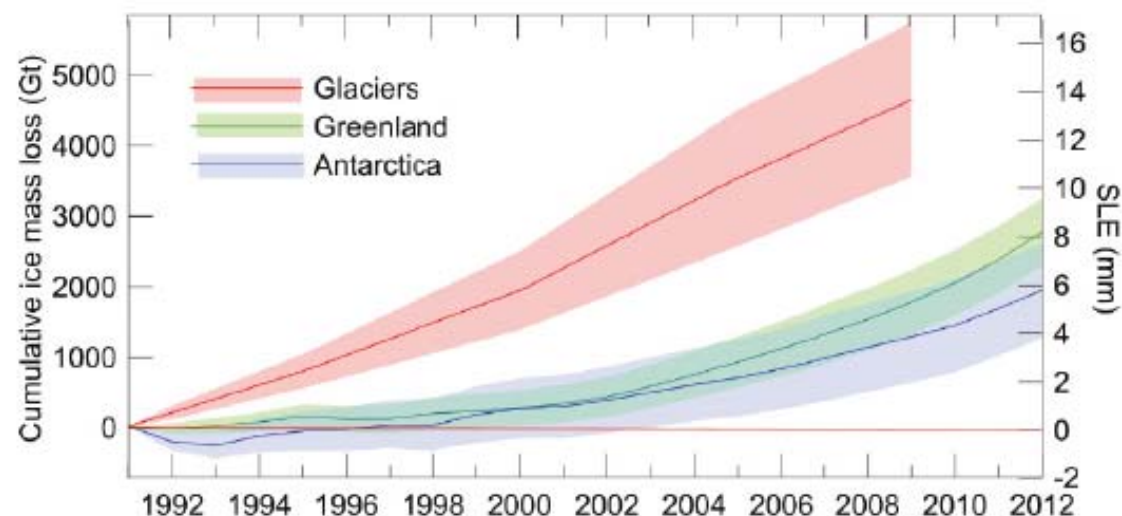


Gardner et al. Science 2013
IPCC AR5 WG1 Ch.4 (2013)

Contribution to sea level rise in 1993-2010

Ocean warming:	38%
Changes in glaciers:	28%
Greenland ice sheet:	10%
Antarctic ice sheet:	10%
Land water storage	14%

IPCC AR5 WG1 TS (2013)



Observed Sea Level Rise 1001-2010

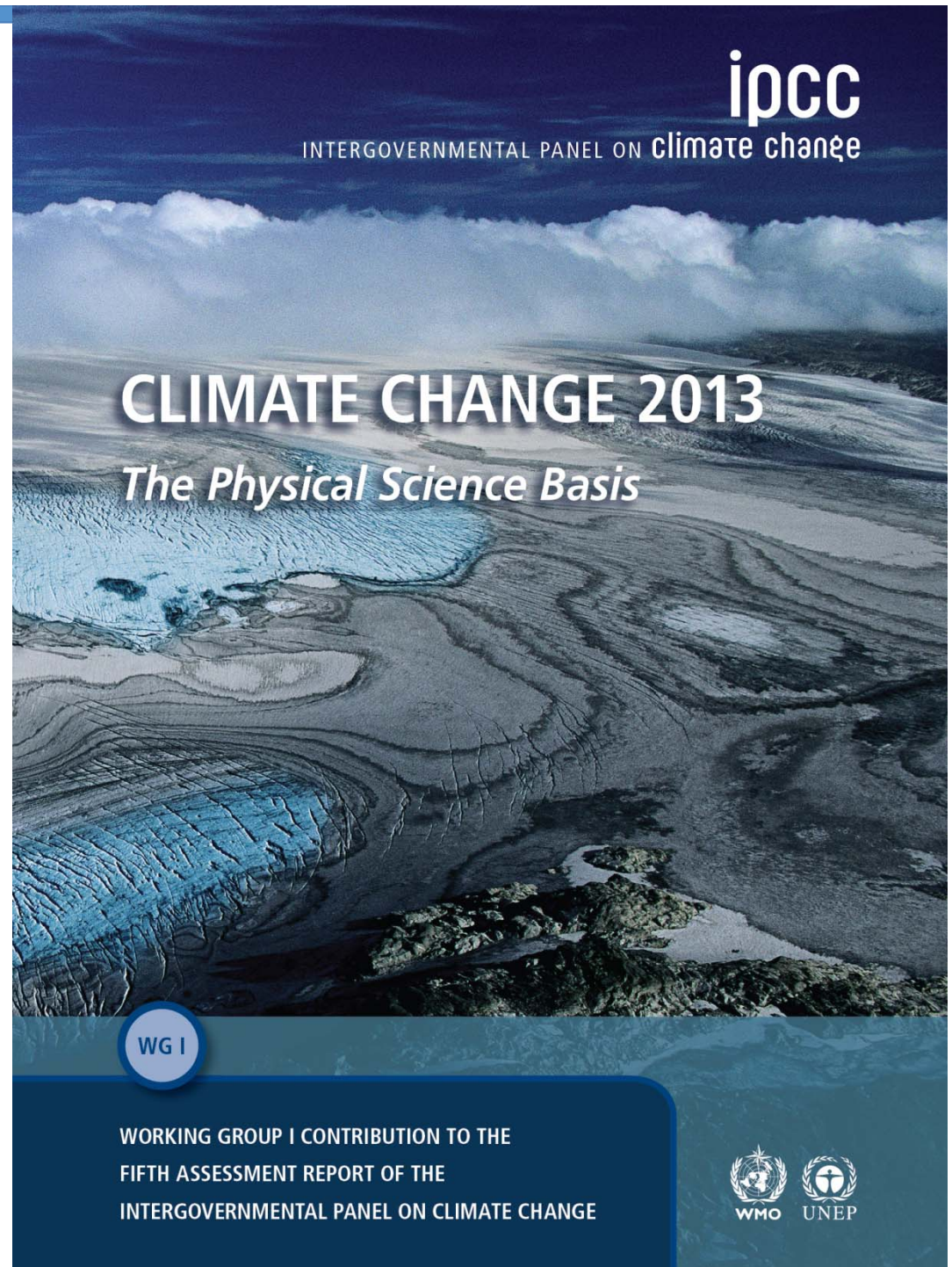
Mean rates: 1.7 [1.5 to 1.9] mm/yr 1901 – 2010
2.0 [1.7 to 2.3] mm/yr 1971 – 2010
3.2 [2.8 to 3.6] mm/yr 1993 – 2010 (*all very likely*)

In the well measured time period 1993-2010, global mean sea level is consistent with the sum of observed contributions (*high confidence*)

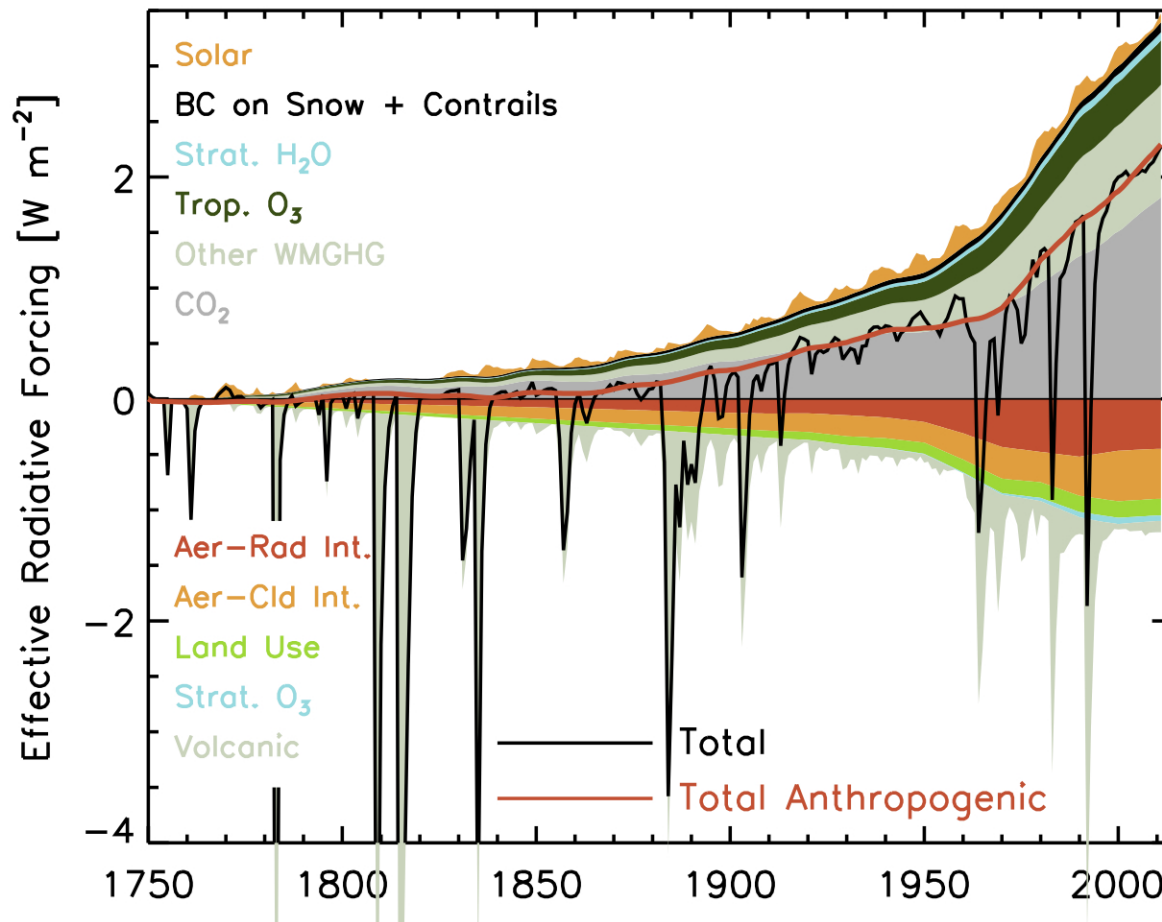
FORCING
Detect. – Attrib.

DIAGNOSES

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Climate Change 2013: The Physical Science Basis



Radiative Forcing: Time evolution



- Except volcanic, changes gradual
- Anthro faster since ~1970, CO_2 largest every decade since 1960s
- Time-averaged natural forcing small

IPCC AR5 WG1 (2013)

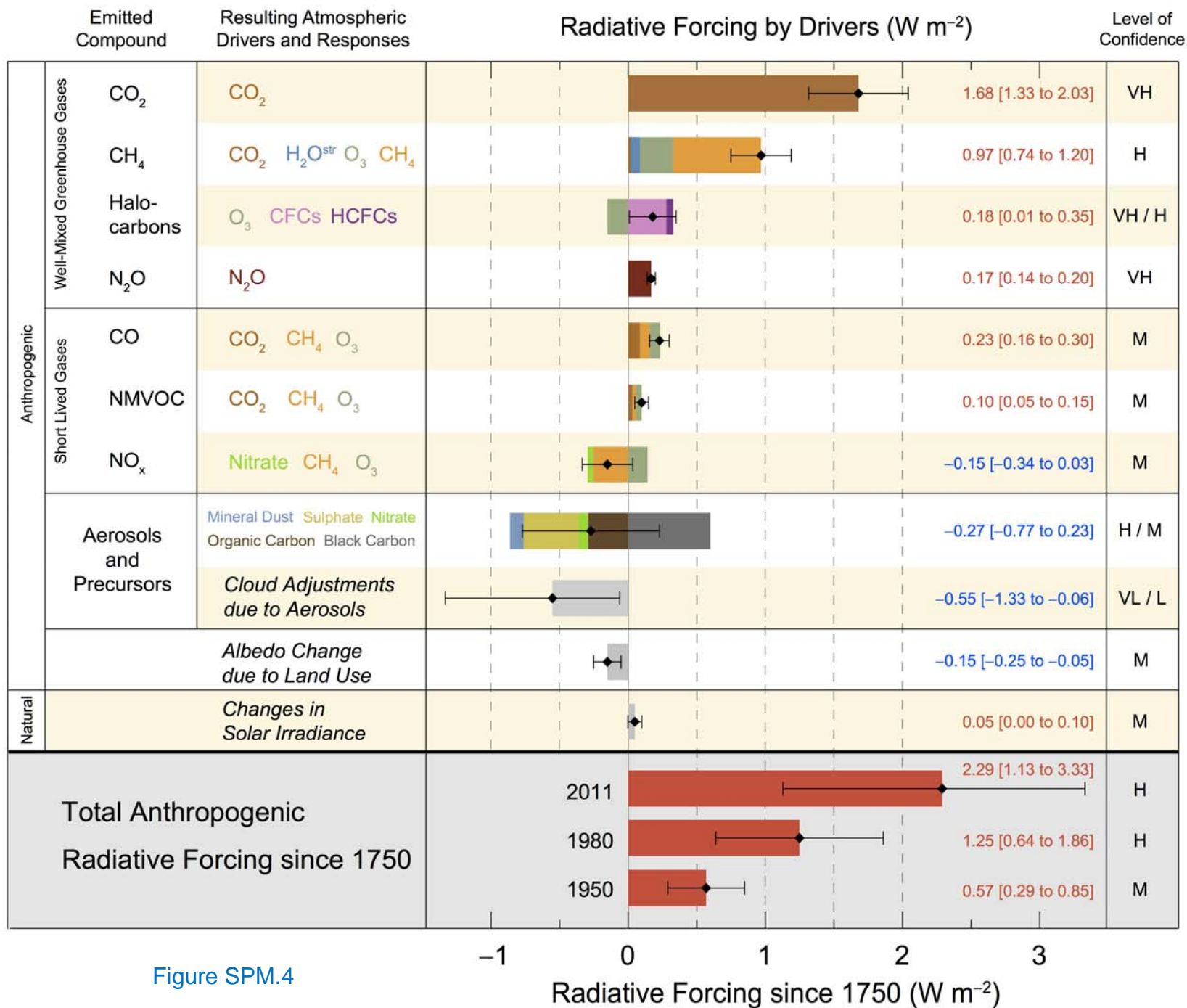
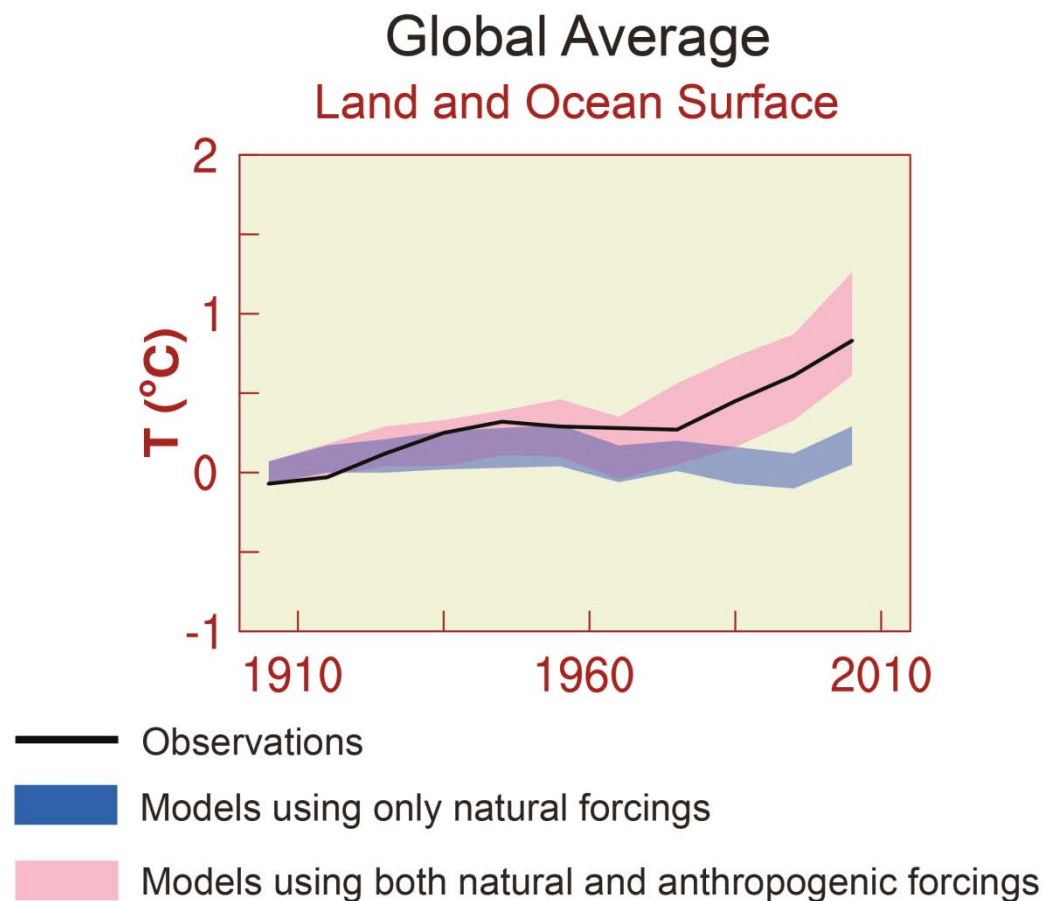


Figure SPM.4

IPCC AR5 WG1 SPM (2013)

Detection and Attribution

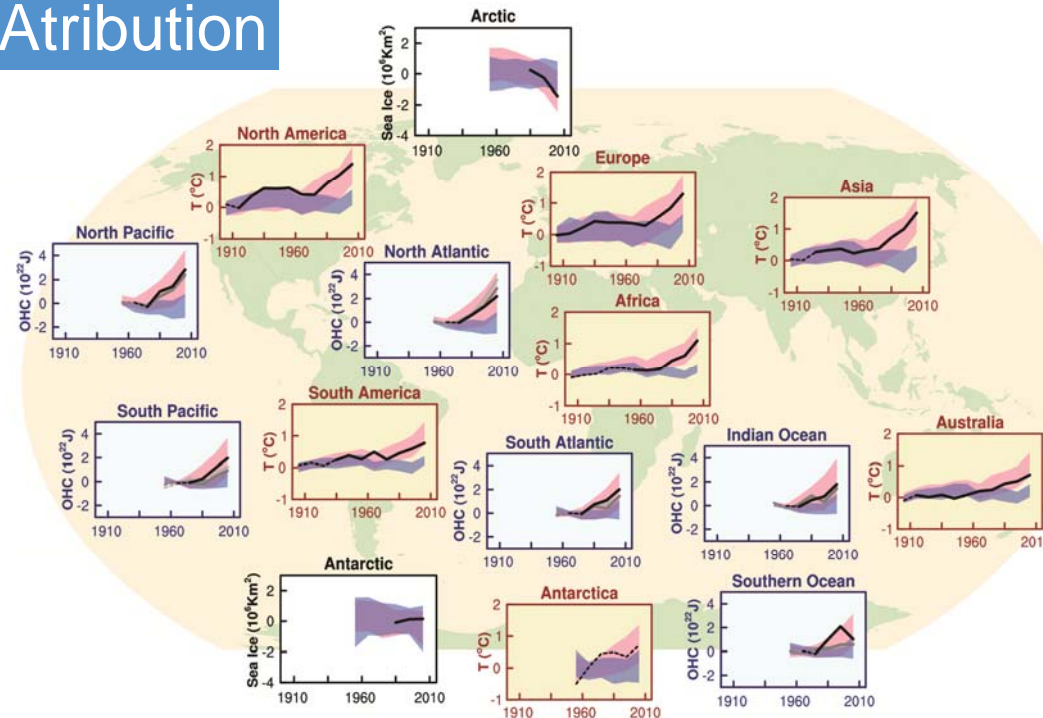
Observed warming consistent with simulations that include anthropogenic factors



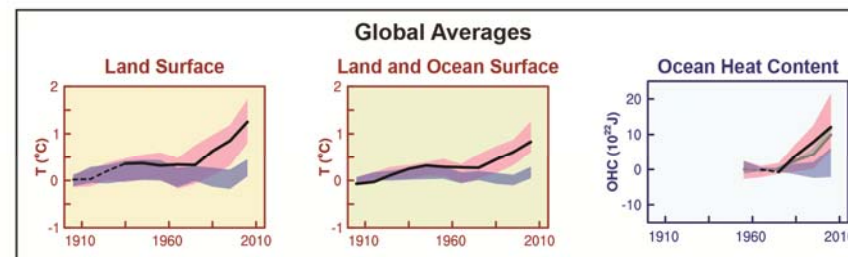
IPCC AR5 WG1 SPM (2013)

Strengthening of evidence for human influence on climate since AR4

Detection and Attribution

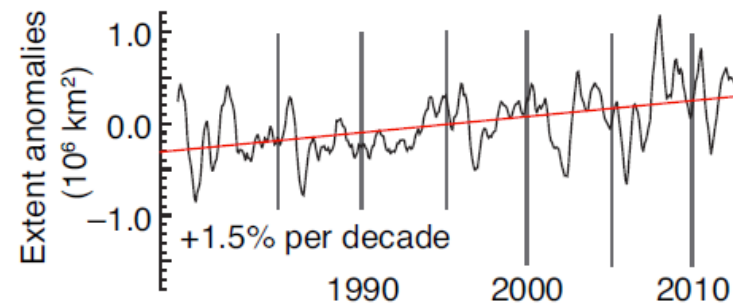
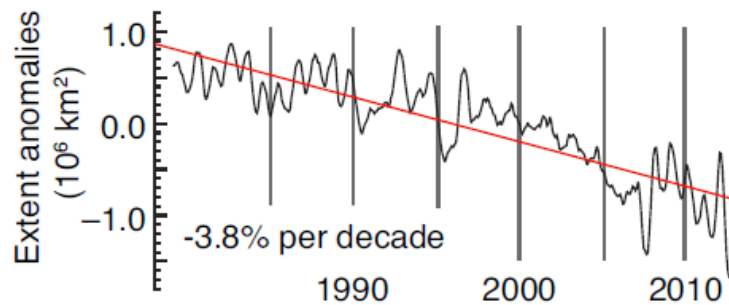
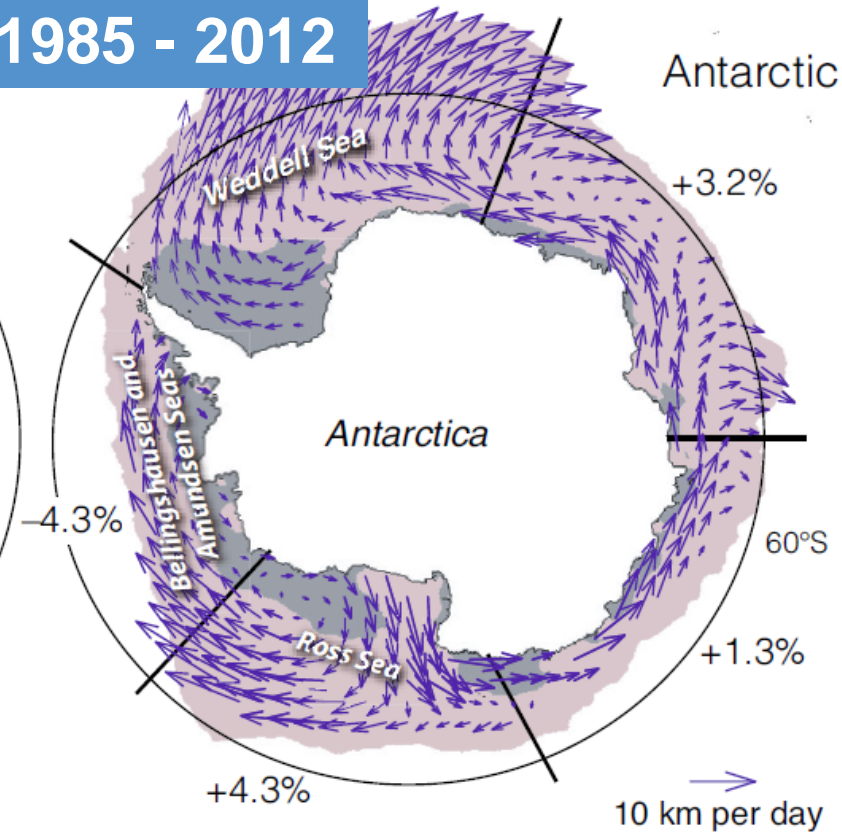
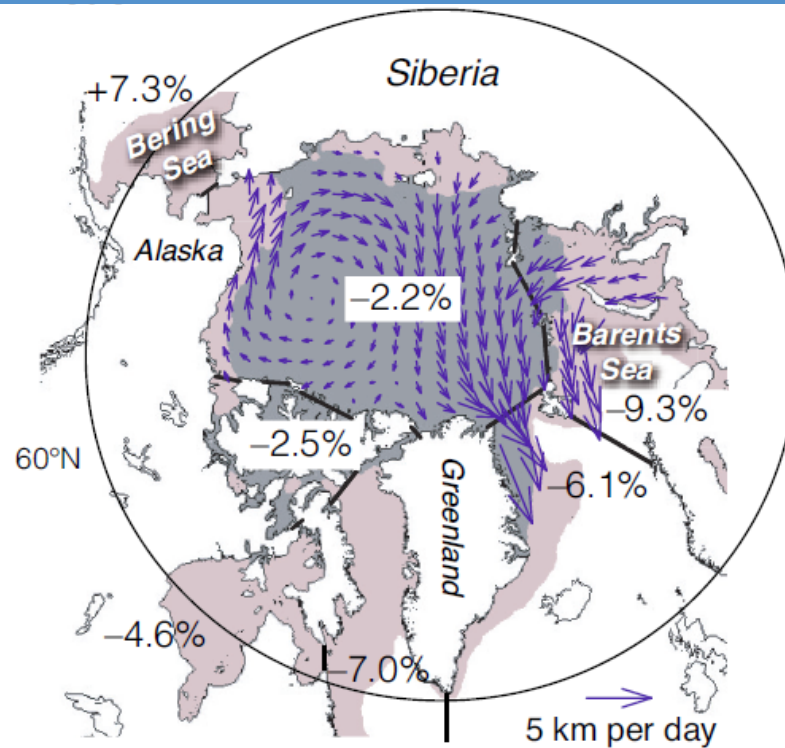


IPCC AR5 WG1 SPM (2013)



— Observations
■ Models using only natural forcings
■ Models using both natural and anthropogenic forcings

Arctic and Antarctic Sea Ice 1985 - 2012

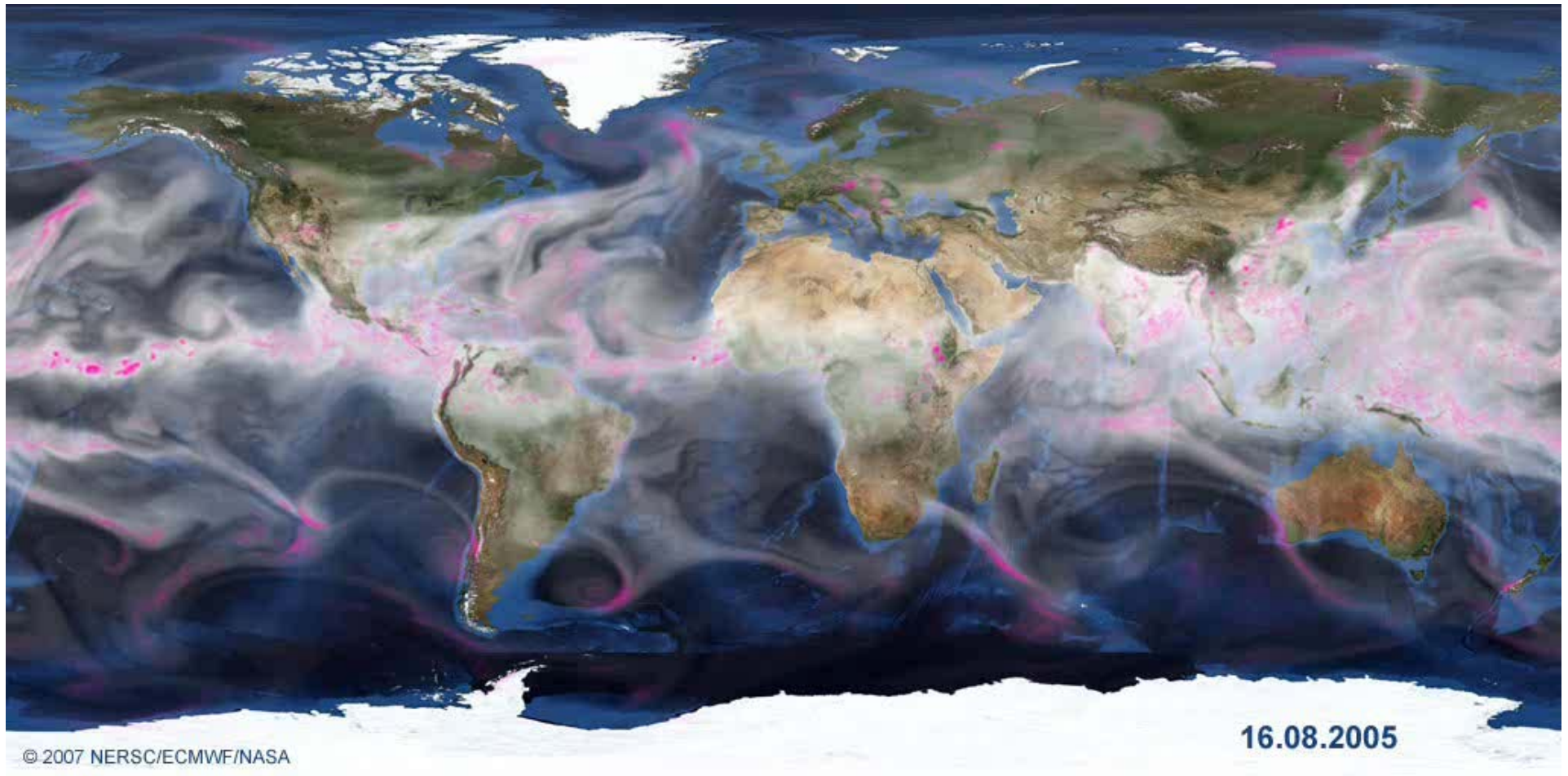


IPCC AR5 WG1 Ch.4 (2013)

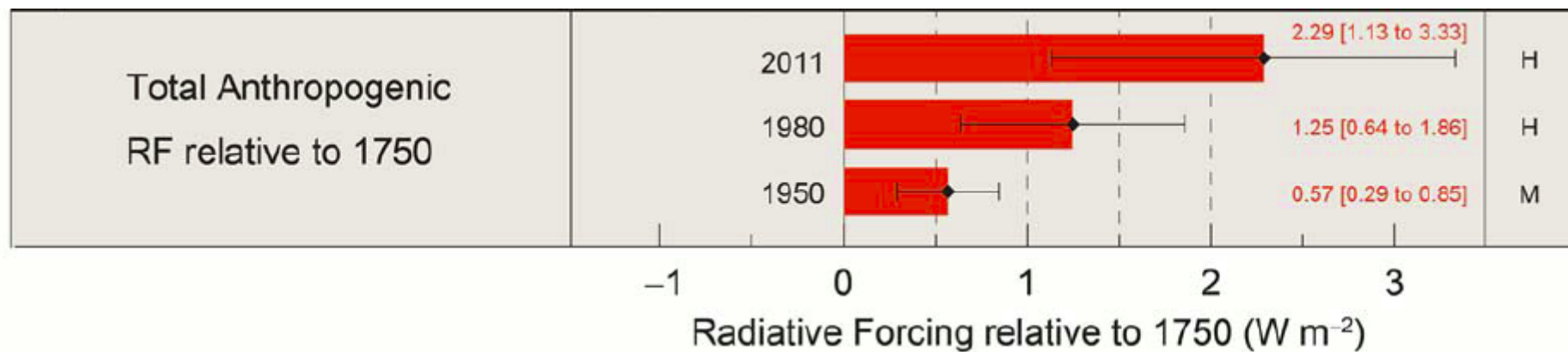
ipcc
INTERGOVERNMENTAL PANEL ON climate change



A dynamic System 16.8. – 29.11.2005



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



IPCC AR5 WG1 SPM (2013)

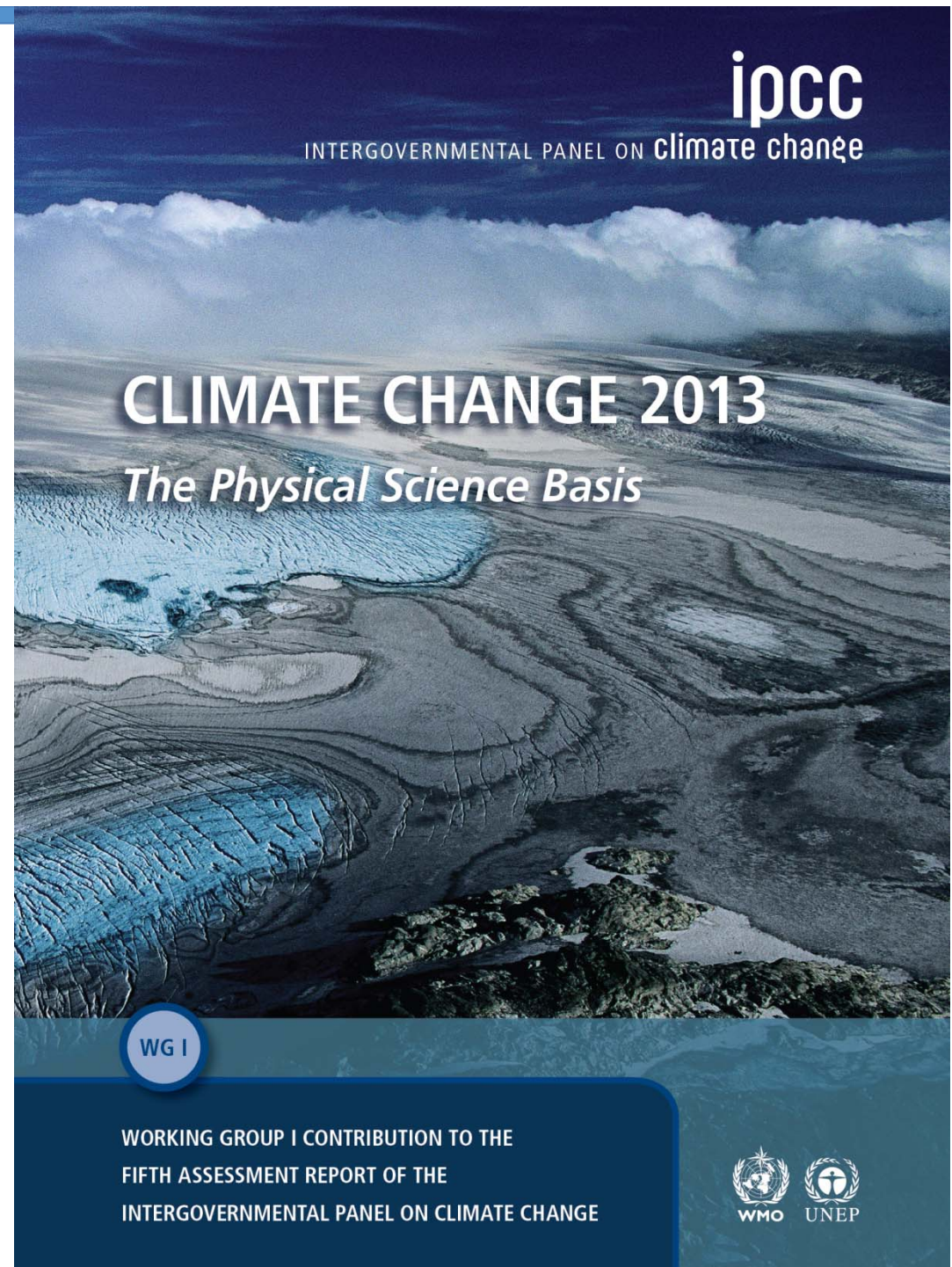
Projections ... ?

OPTIONS

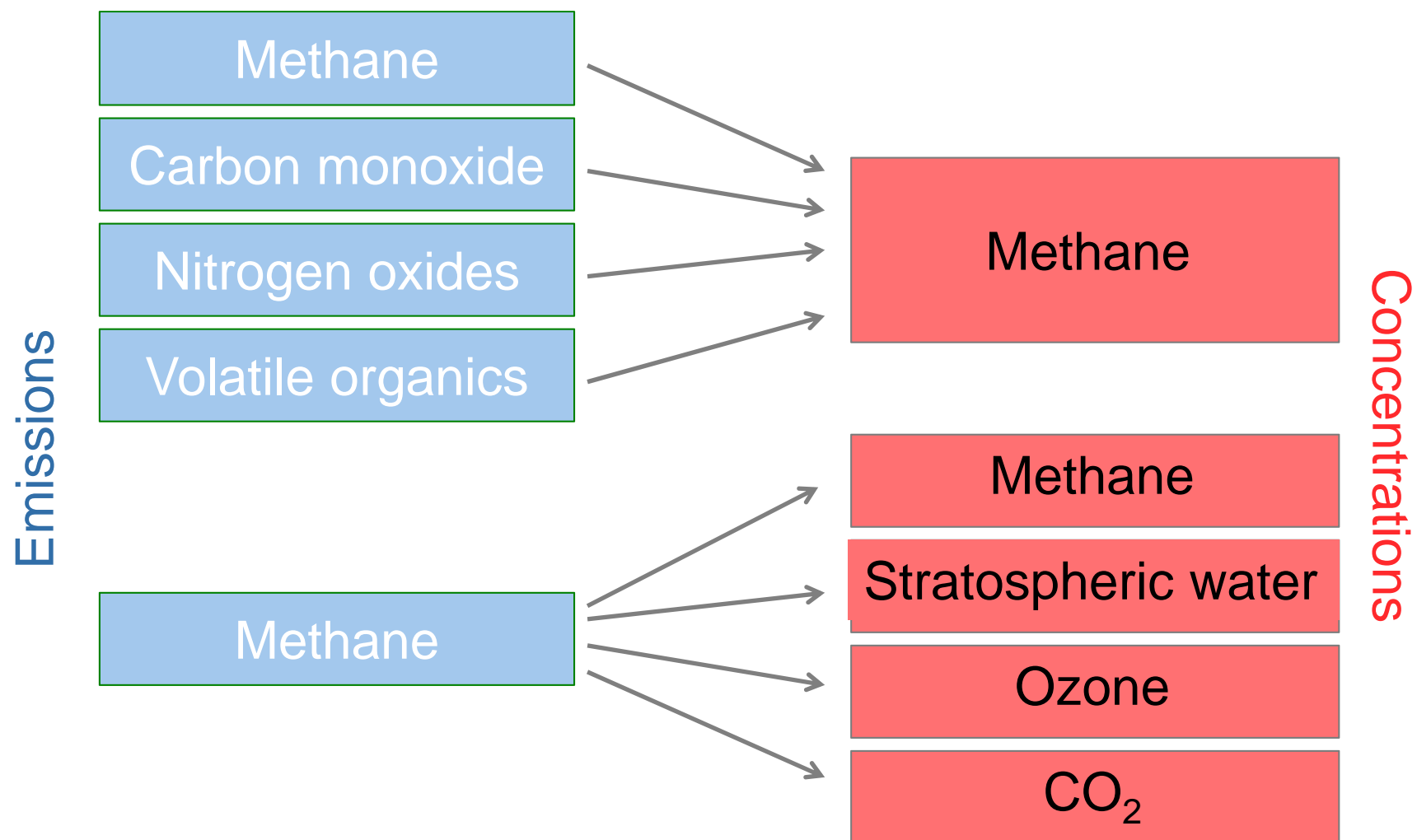
FORCING

DIAGNOSES

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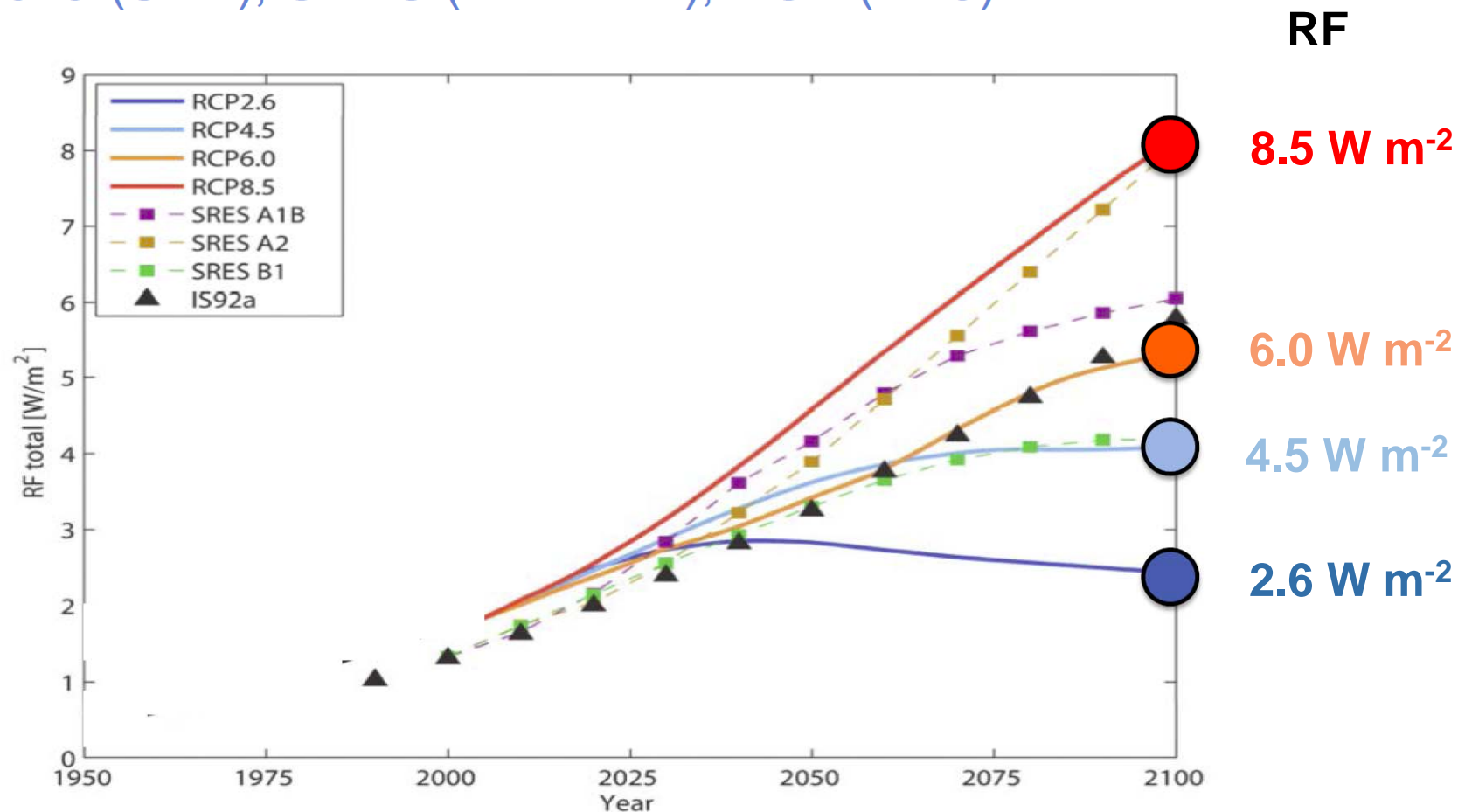
From Emission to Concentration * RCPs (2.6, 4.5 .. W m⁻² etc.)



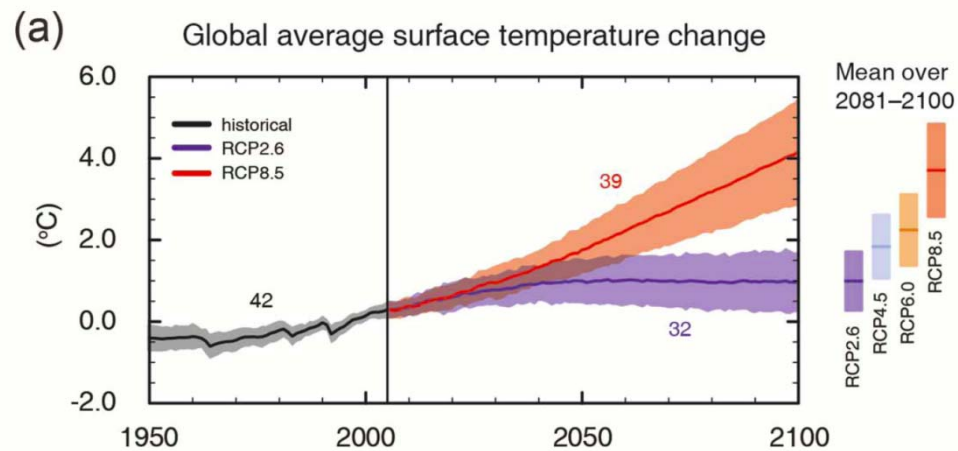
IPCC AR5 WG1 (2013)

Representative Concentration Pathways

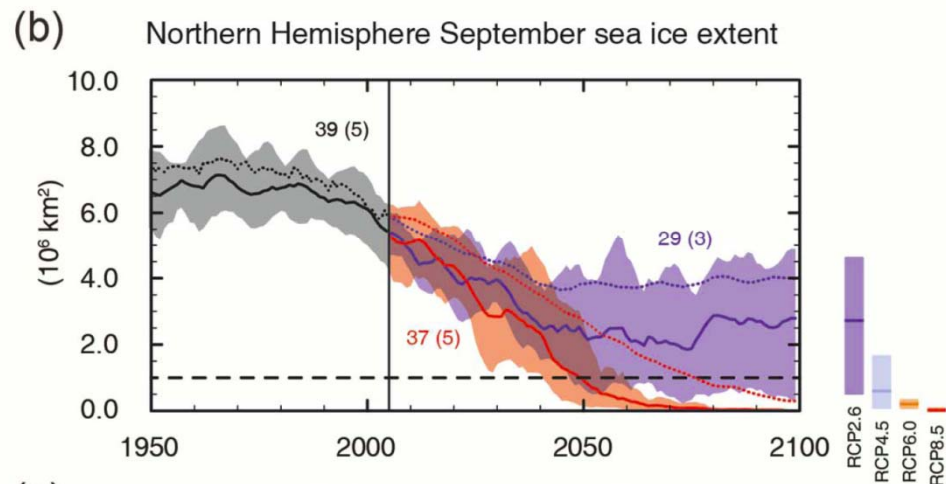
61060839
Total anthropogenic radiative forcing
IS92a (SAR), SRES (TAR/AR4), RCP (AR5)



IPCC AR5 (AR4) WG1 (2013)

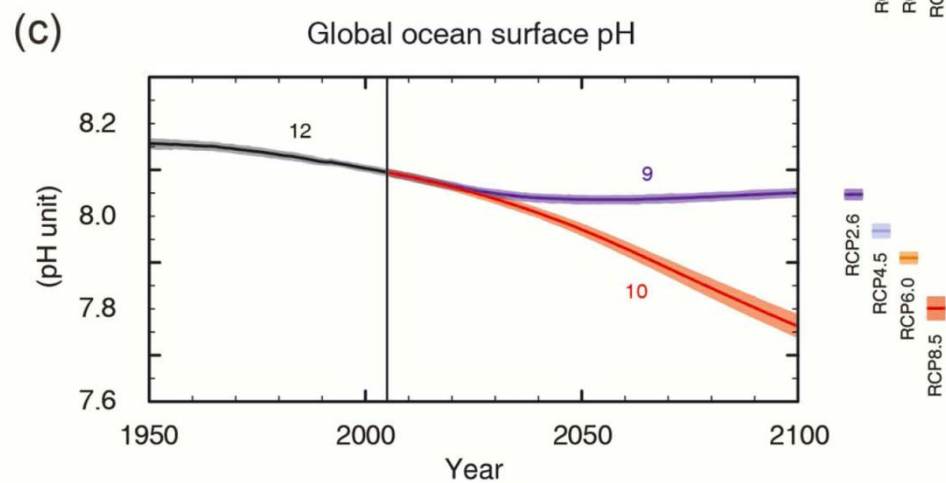


Glob. Mean Surface Temperature

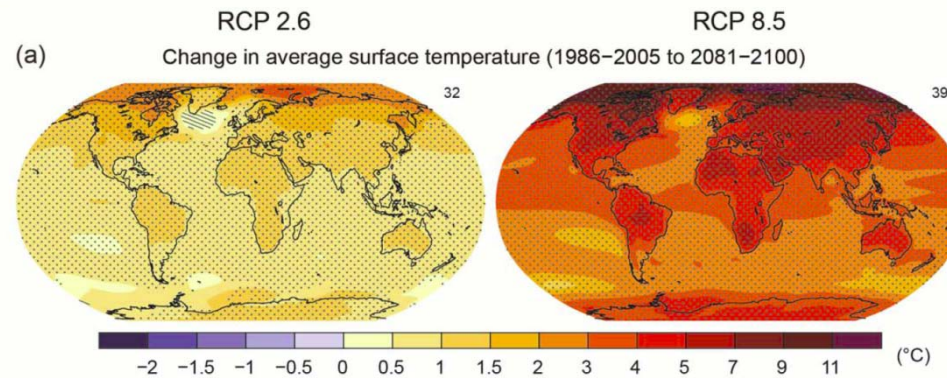


NH September Sea Ice Extent

IPCC AR5 WG1 SPM (2013)

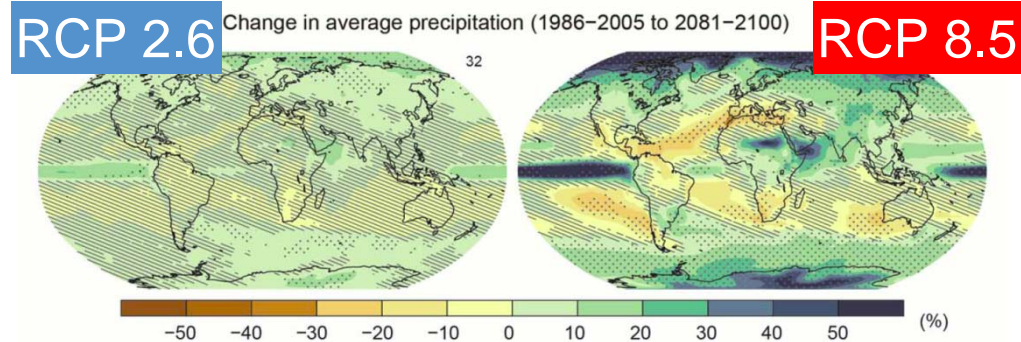


Glob. Ocean Surface pH

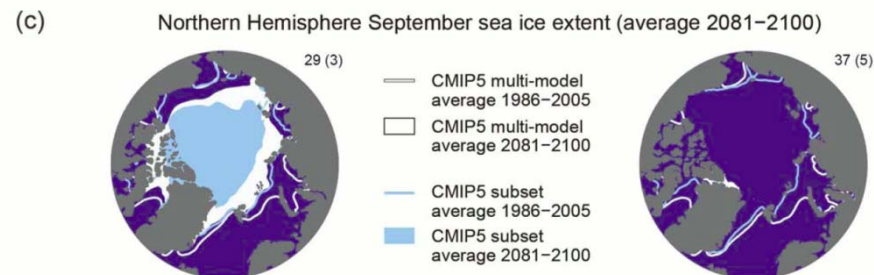


Regional distribution

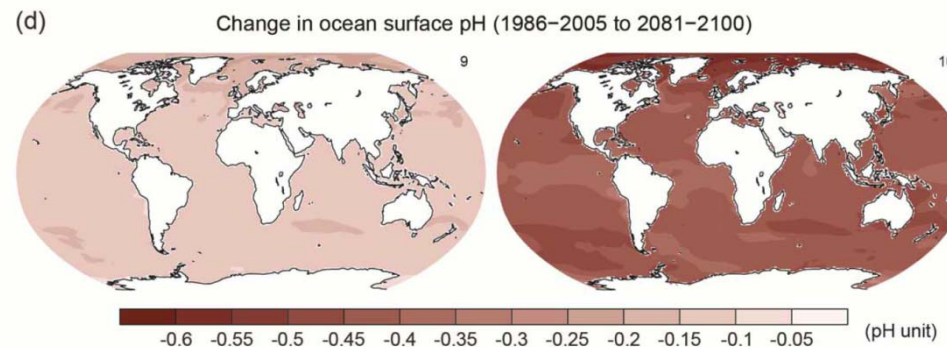
Surface Temperature



Precipitation



Arctic Sea Ice Extent

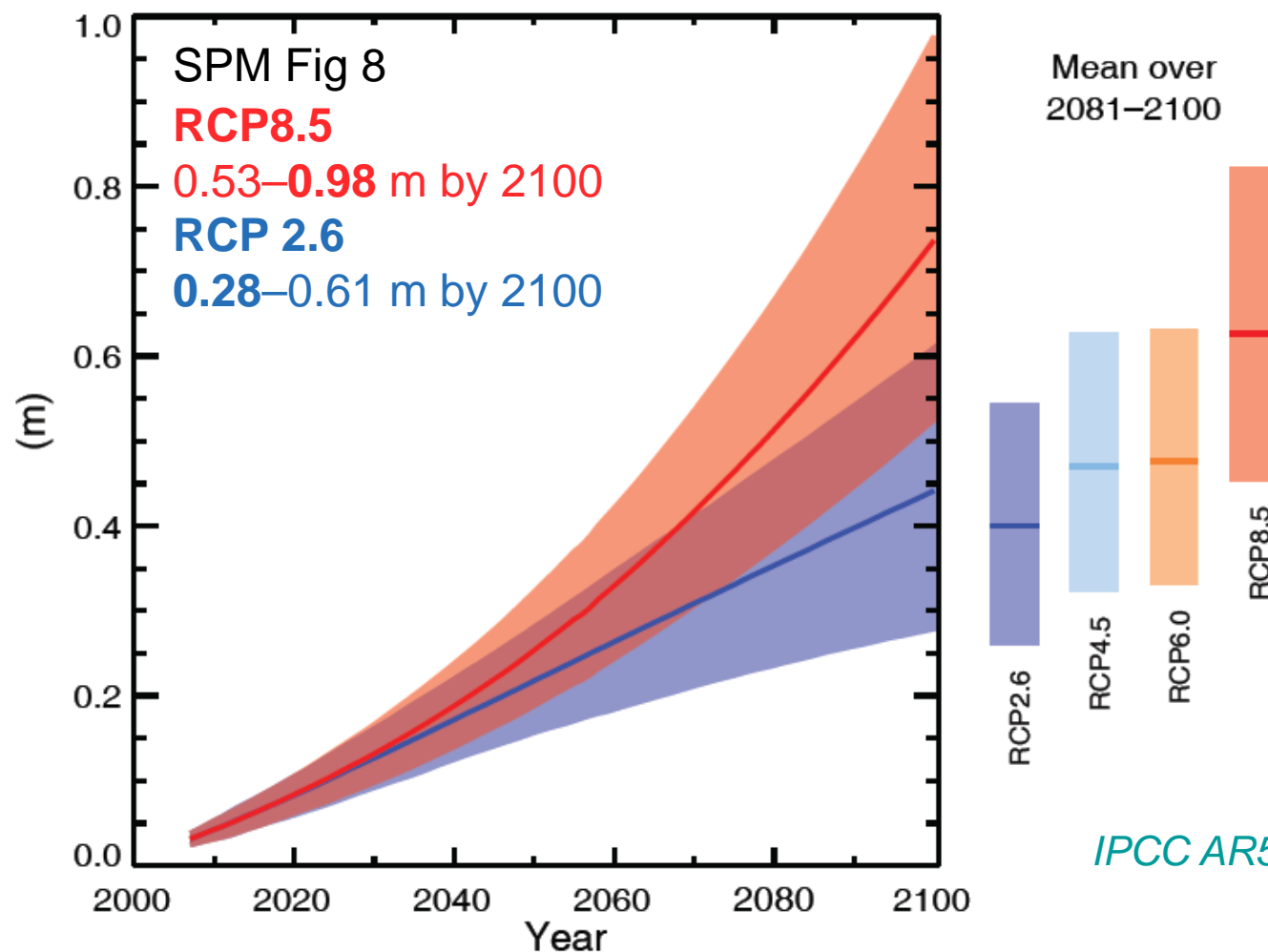


IPCC AR5 WG1 SPM (2013)

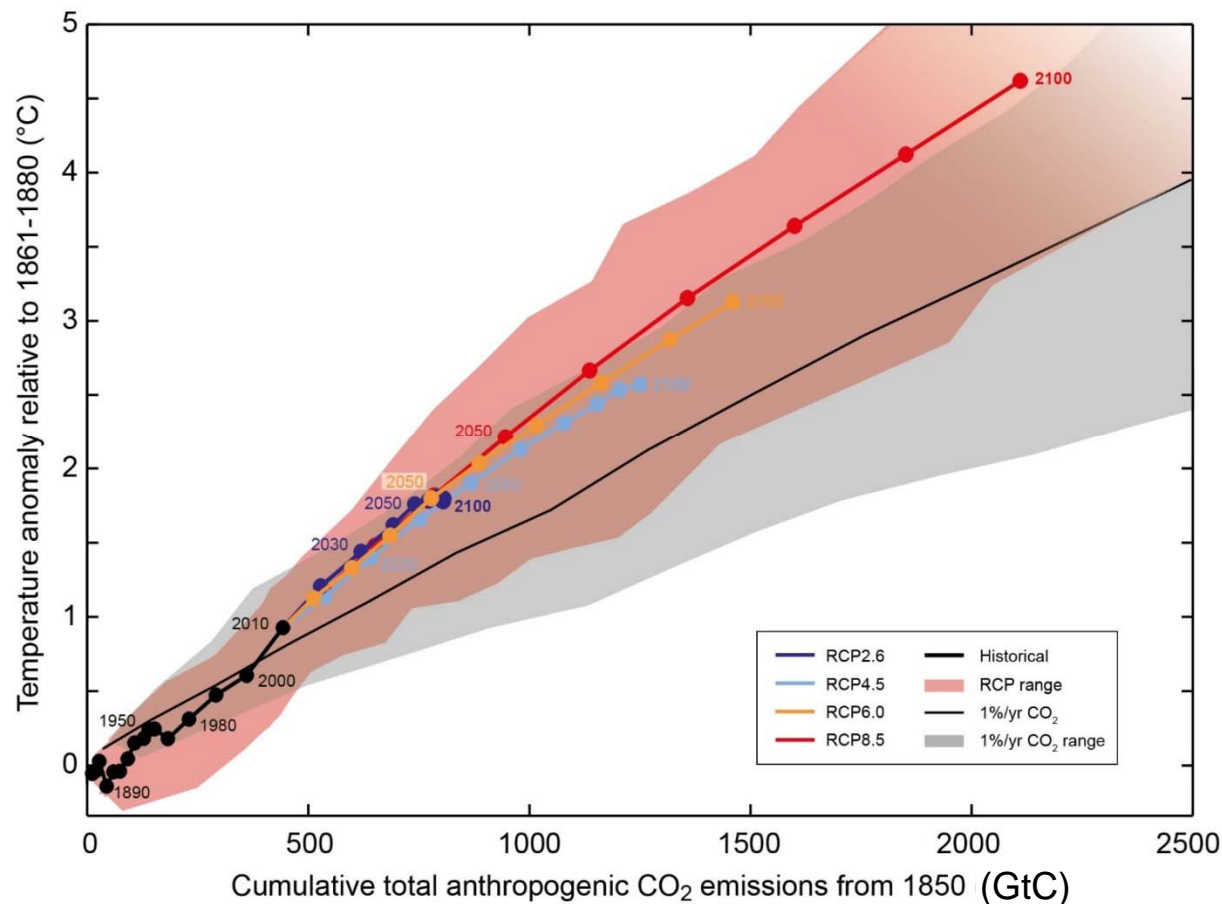
Ocean Surface pH

Projections of 21st-century GMSLR under RCPs

Medium confidence in likely ranges. Very likely that the 21st-century mean rate of GMSLR will exceed that of 1971–2010 under all RCPs.



IPCC AR5 WG1 SPM (2013)



IPCC AR5 WG1 SPM (2013)

To limit warming to *likely* less than **2° C** from CO₂ **alone**, total emissions since preindustrial need to be limited to **less than 1000 GtC**.

Accounting for non-CO₂ forcing as in **RCP2.6** reduces the allowed cumulative emissions to about **800 GtC**.

About 550 GtC were emitted by 2011

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Further Information
www.climatechange2013.org

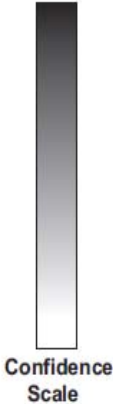
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Uncertainty language

Table 1. Likelihood Scale

Term*	Likelihood of the Outcome
<i>Virtually certain</i>	99-100% probability
<i>Very likely</i>	90-100% probability
<i>Likely</i>	66-100% probability
<i>About as likely as not</i>	33 to 66% probability
<i>Unlikely</i>	0-33% probability
<i>Very unlikely</i>	0-10% probability
<i>Exceptionally unlikely</i>	0-1% probability

Agreement ↑	High agreement Limited evidence	High agreement Medium evidence	High agreement Robust evidence
	Medium agreement Limited evidence	Medium agreement Medium evidence	Medium agreement Robust evidence
	Low agreement Limited evidence	Low agreement Medium evidence	Low agreement Robust evidence
Evidence (type, amount, quality, consistency) →			



Confidence Scale

IPCC structure, procedures, products ** an analogy

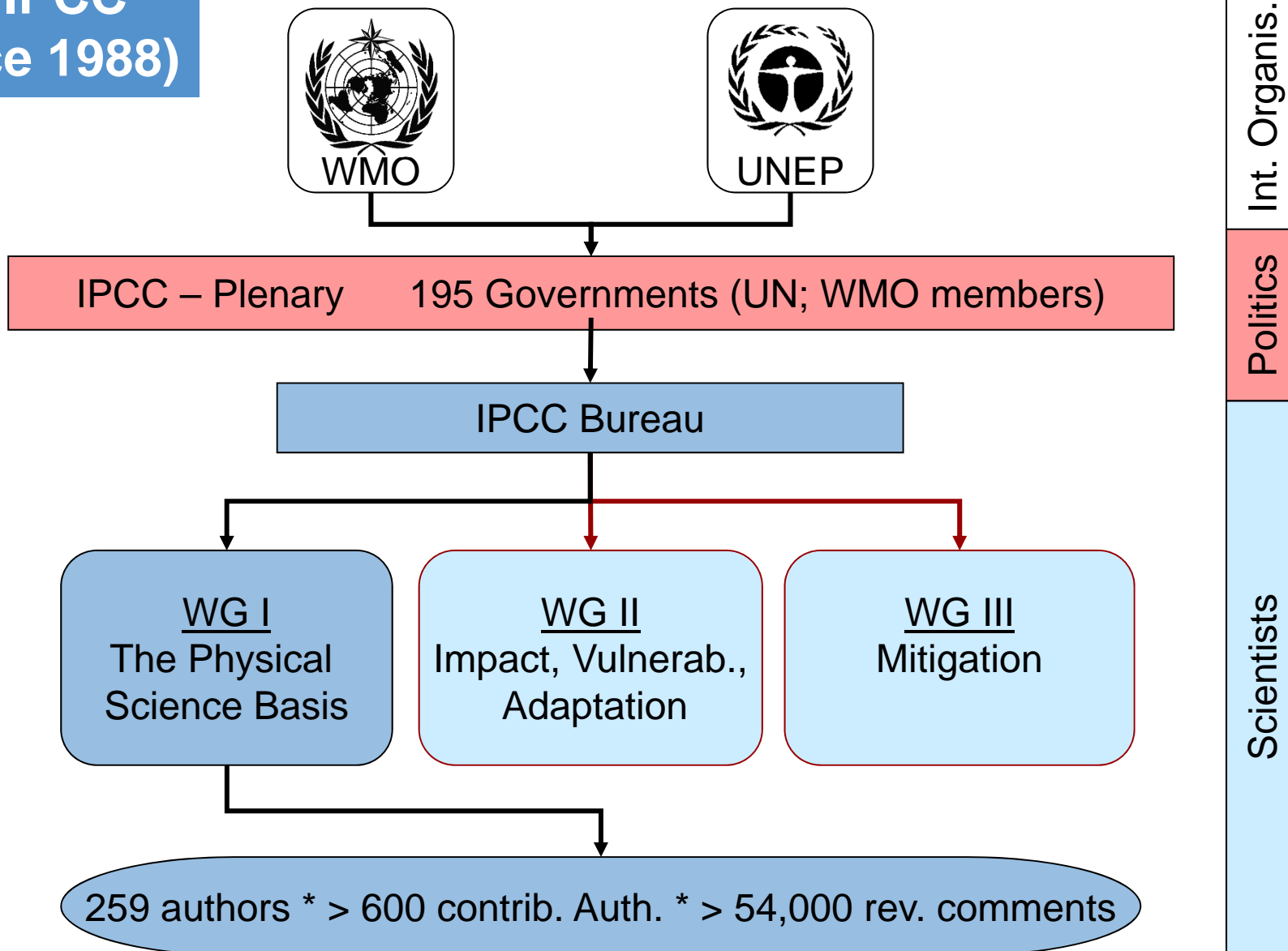
- **Community Council**
 - Bridge
- **Expert Assessment**
- **Expert Team** (statics, traffic,...)
 - Additional experts' input
 - Administrative Experts input
- **Assessment report**
 - State of the bridge
 - Loading history
 - Future loading scenarios
 - Stability scenarios
- **Summary for Comm. Council**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

Council Takes Action

- **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**

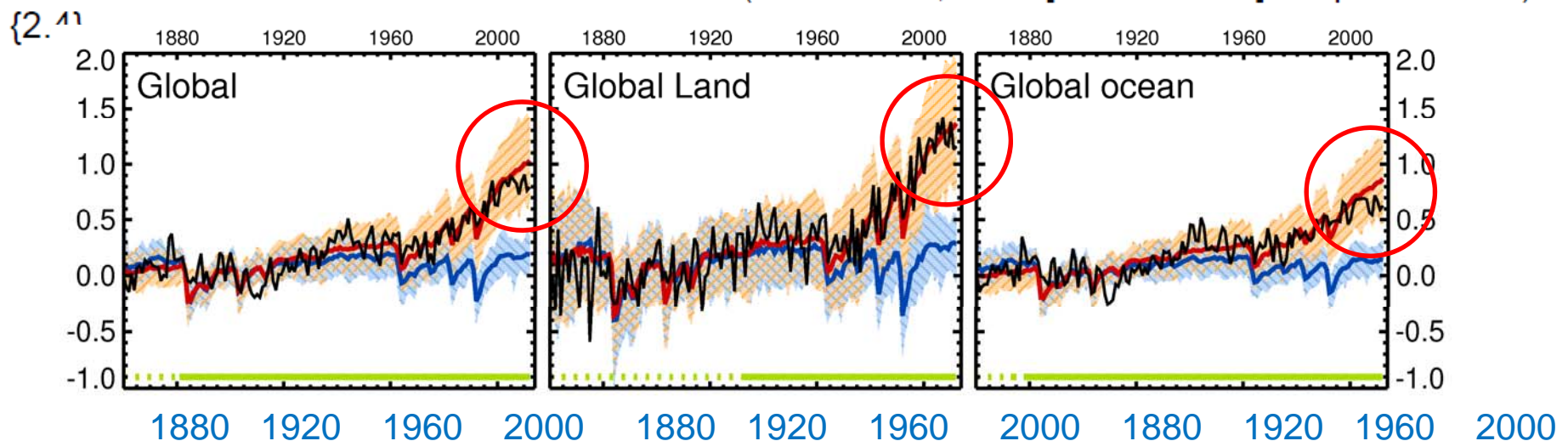
Policy Makers?

The IPCC (since 1988)



In addition to robust multi-decadal warming, global mean surface temperatures exhibit substantial decadal variability, despite the robust multi-decadal warming since 1901 (Figure SPM.1). Despite the first decade of the 21st century being the warmest on record (see Figure SPM.1), the rate of warming over the past 15 years (1998–2012; 0.05 [–0.05 to +0.15] °C per decade) is smaller than the trend since 1951 (1951–2012; 0.12 [0.08 to 0.14] °C per decade). Trends based on short records provide very uncertain estimates of long-term climate trends. (Figure SPM.1) {2.4.3}

In addition to robust multi-decadal warming, global mean surface temperature exhibits substantial decadal and interannual variability (see Figure SPM.1). Due to natural variability, trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long-term climate trends. 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)⁵.



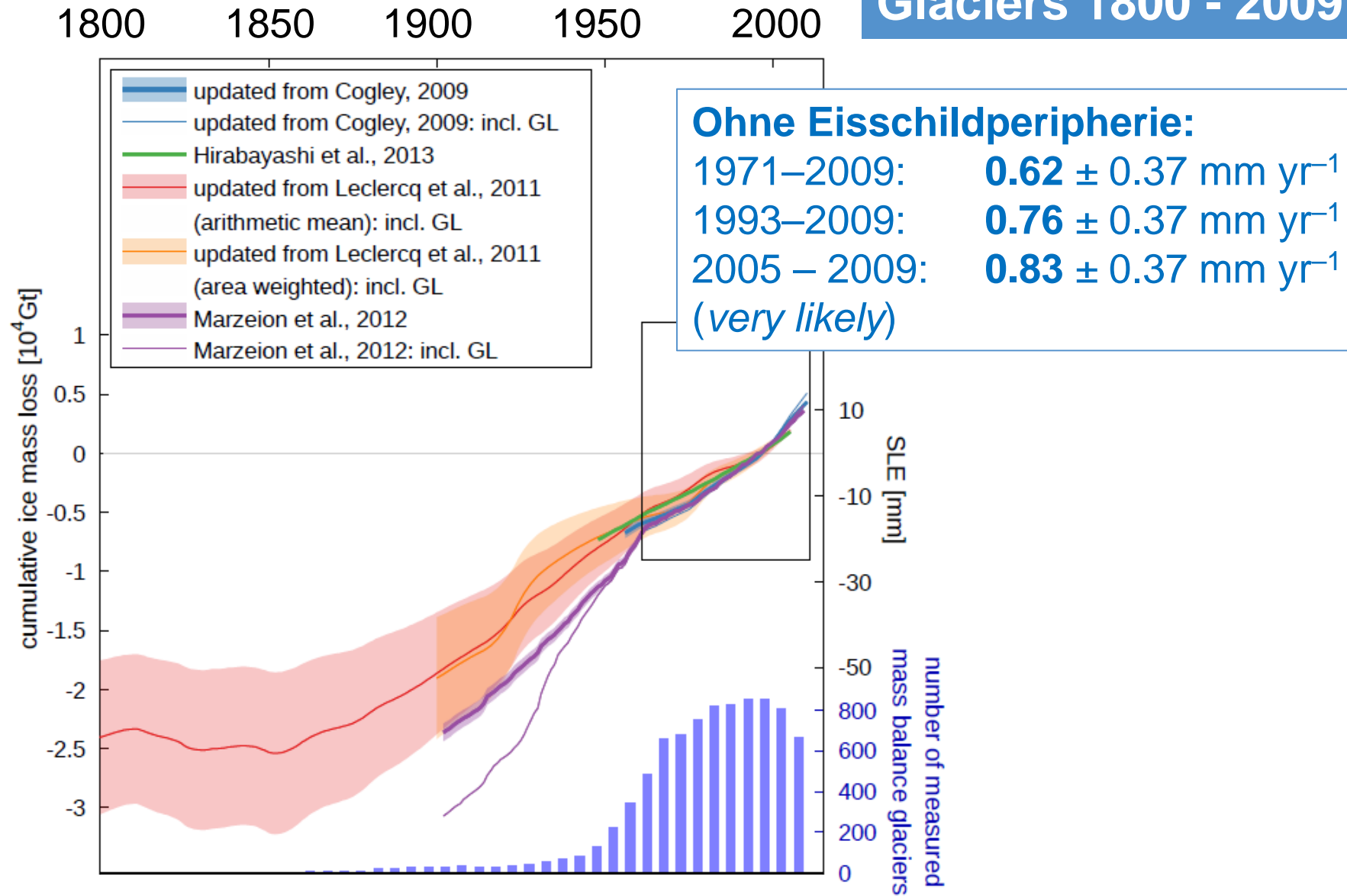
Working basis of IPCC (1998, 2003, 2006, 2011)

[...]

2. The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they may need to deal objectively with scientific, technical and socio-economic factors relevant to the application of particular policies.
3. Review is an essential part of the IPCC process. Since the IPCC is an intergovernmental body, review of IPCC documents should involve both peer review by experts and review by governments.

[...]

Glaciers 1800 - 2009



IPCC AR5 WG1 Ch.4 (2013)

IPCC «headlines»

19 statements

< 2 pages

Summary for Policy Makers
ca. 14,000 words (22 pages)

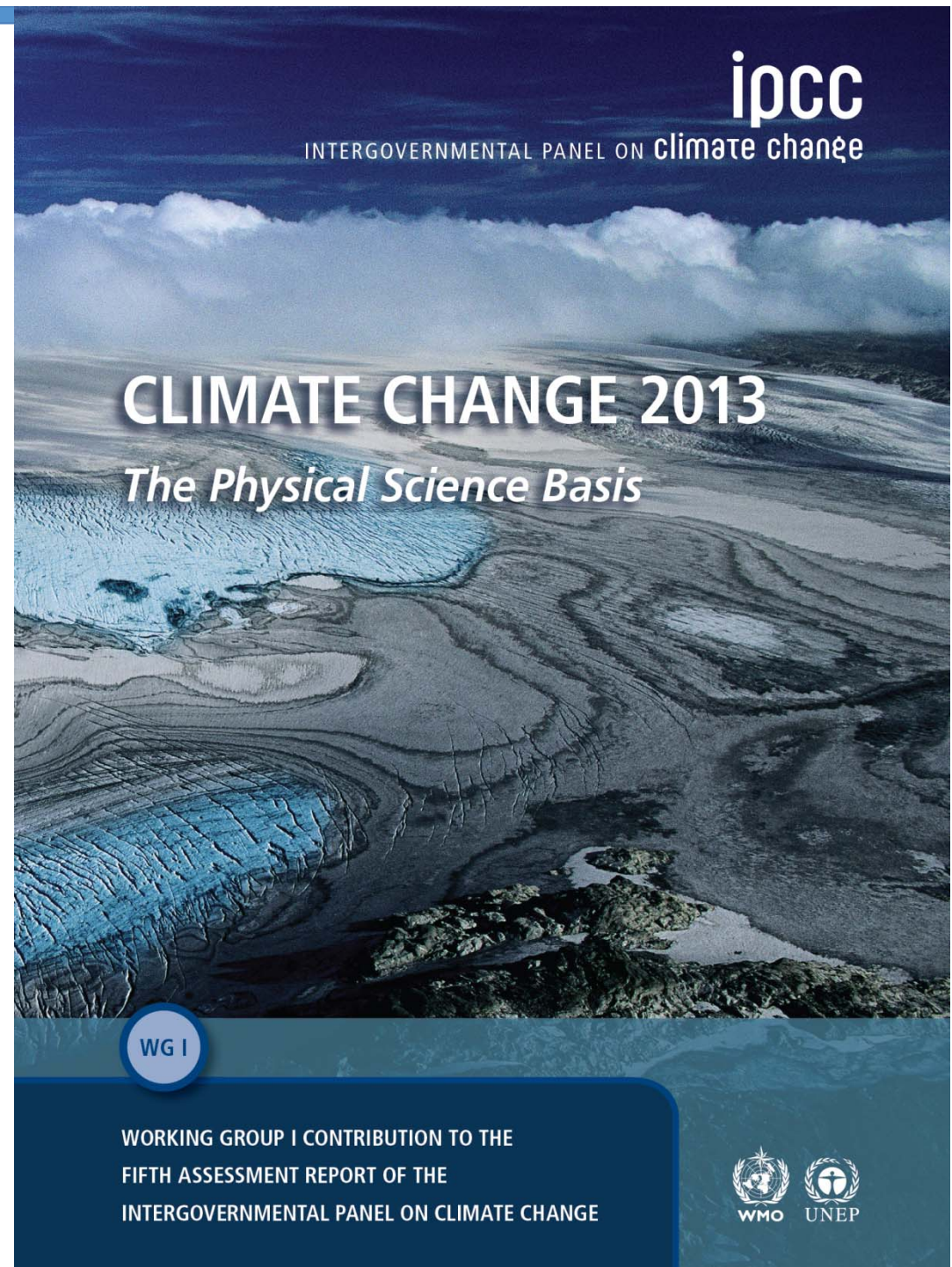
14 Chapters
Atlas with Climate Projections

54,677 comments
from 1089 experts

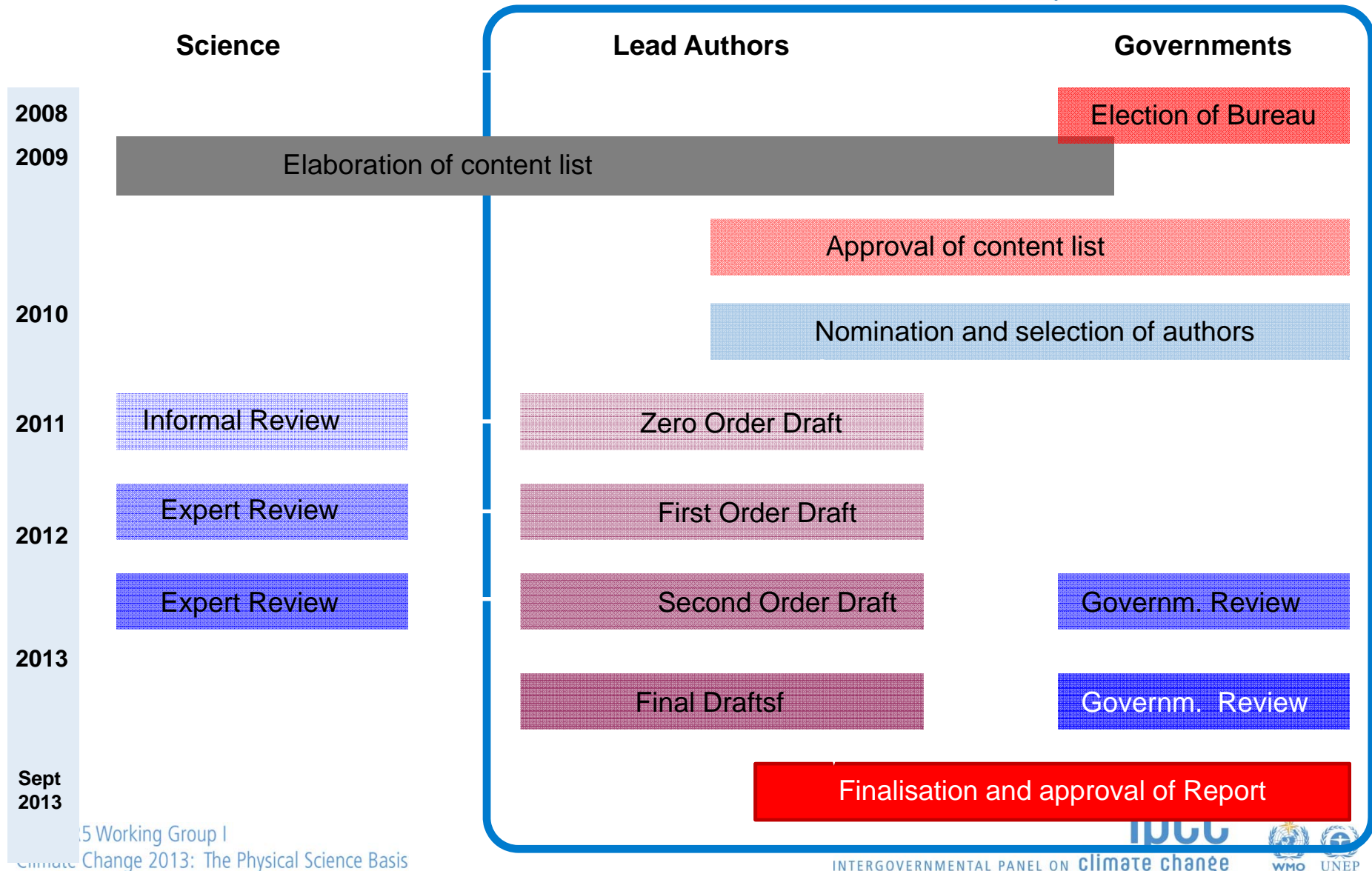
2010: 259 authors selected
from 39 countries

2009: Layout of WG1
accepted

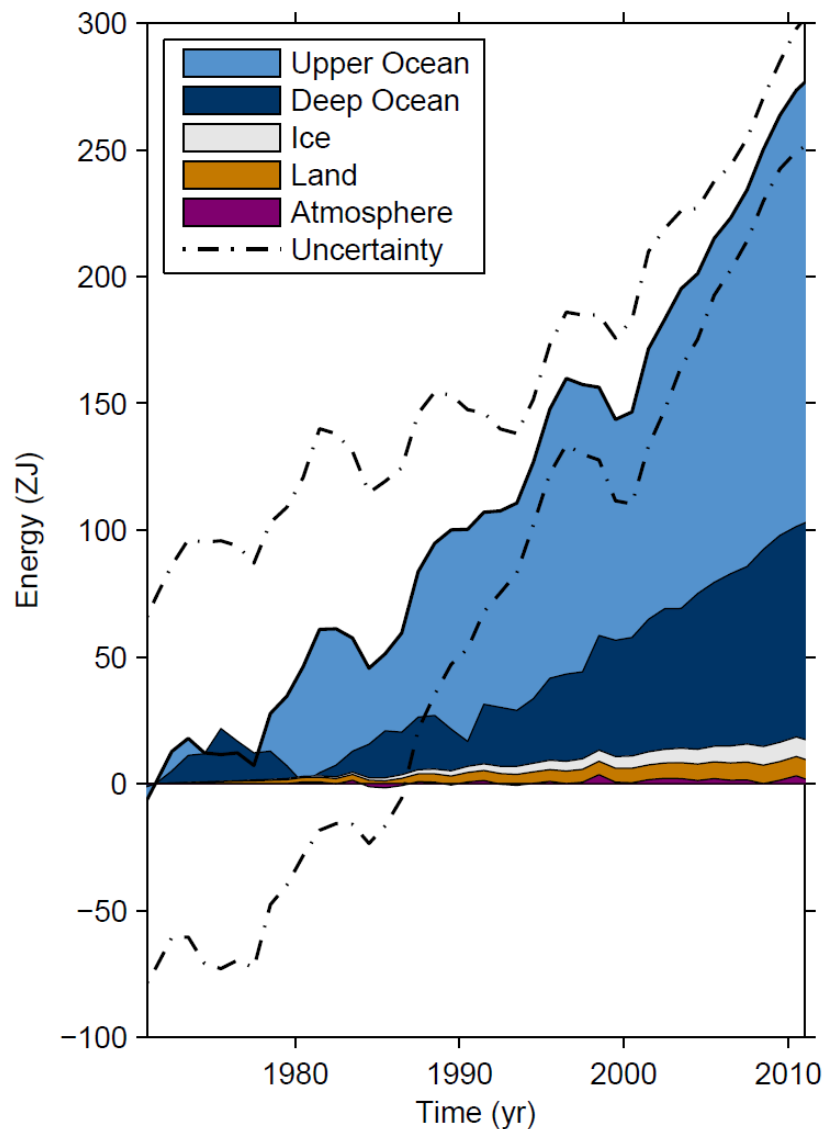
IPCC AR5 Working Group I
Climate Change 2013: The Physical Science Basis



The process of the IPCC WG1 AR5



Change in Global Energy Inventory 1971 - 2010



- ◆ Ocean warming : 93% of the increase in energy in Earth's climate system (*high confidence*)
- ◆ 3% go into warming the land,
- ◆ 1% into warming the atmosphere
- ◆ 3% into melting of ice (glaciers, ice sheets)

IPCC AR5 WG1 (2013)