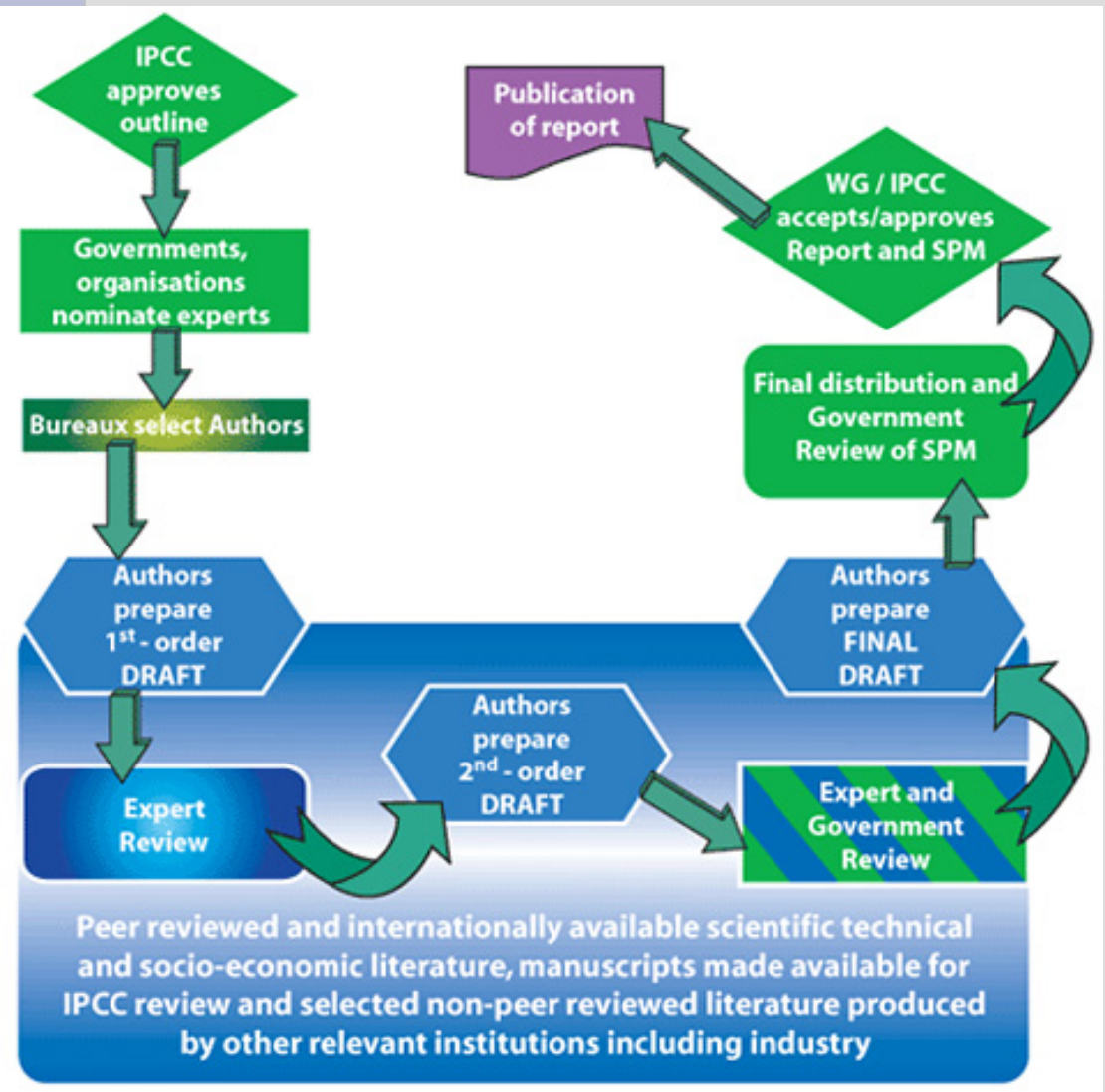
Climate and Human History
Stephan Matthiesen

19/1	1. Climate and climate history
26/1	2. The Ice Age
2/2	3. Farming and City States
9/2	4. The Roman Empire
16/2	5. Tang and Maya in the 10th century
23/2	6. Mediaeval Optimum; Little Ice Age
1/3	7. El Niño through the ages
8/3	8. Miscellaneous topics
15/3	**no class!**
22/3	9.Current and future changes
29/3	10. Summary and re-cap

Climate Change: What are the questions?

- Observation:
  - Is the climate changing?
  - Are recent changes comparable to past changes?
- Attribution:
  - What causes these changes? Human activity?
- Projections:
  - How will the climate change in future?
- Impacts:
  - How are different societies affected?
- Mitigation and adaptation:
  - What can we do to reduce the impacts?
  - What can we do to adapt to them?

Intergovernmental Panel on Climate Change (IPCC)



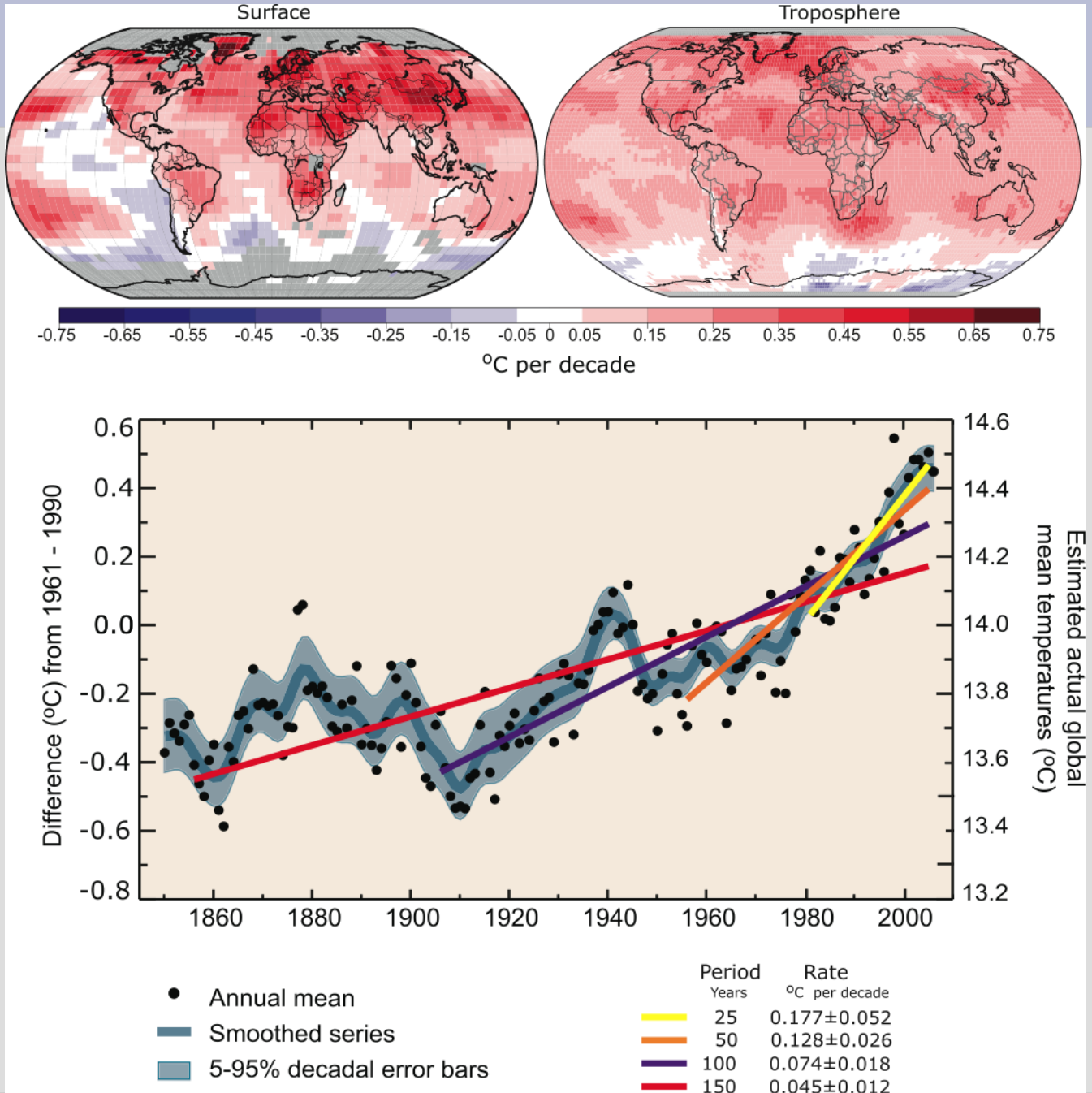
Working Groups:

- WG I: The Physical Science Basis
- WG II: Impacts, Adaptation and Vulnerability
- WG III: Mitigation of Climate Change

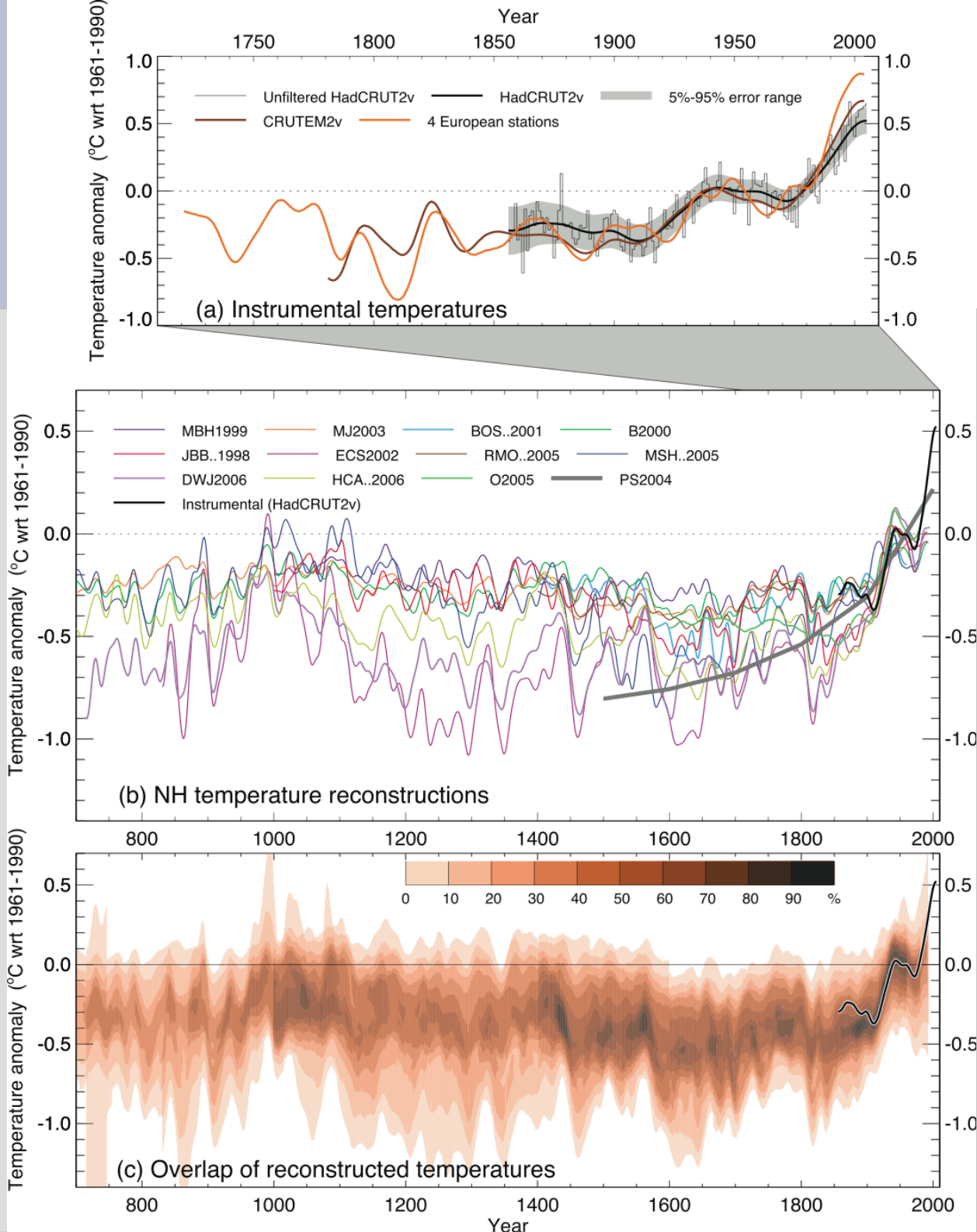
Assessment Reports:

- 1990: FAR
- 1995: SAR
- 2001: TAR
- 2007: AR4

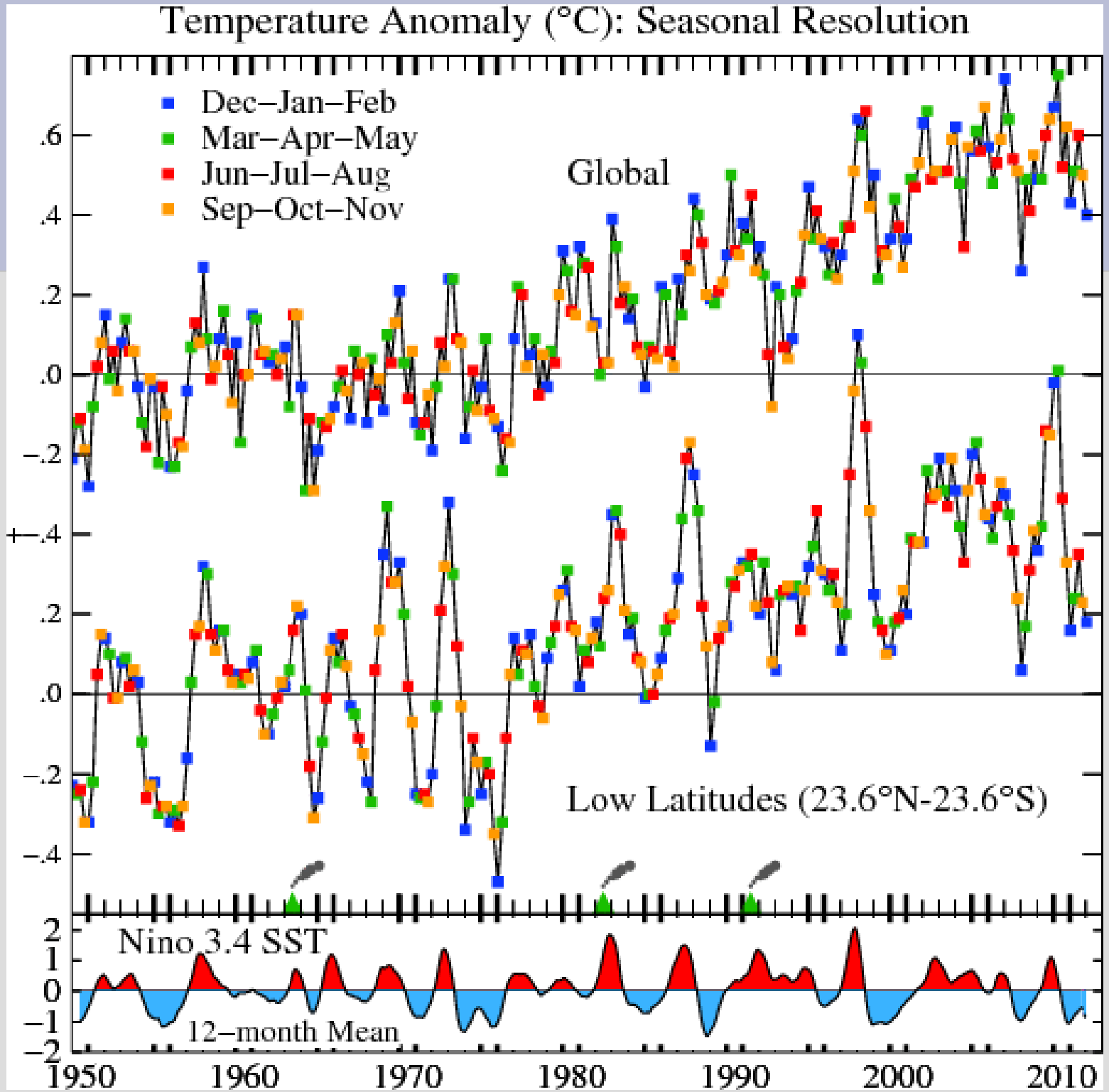
Observations: Temperature



Observed changes

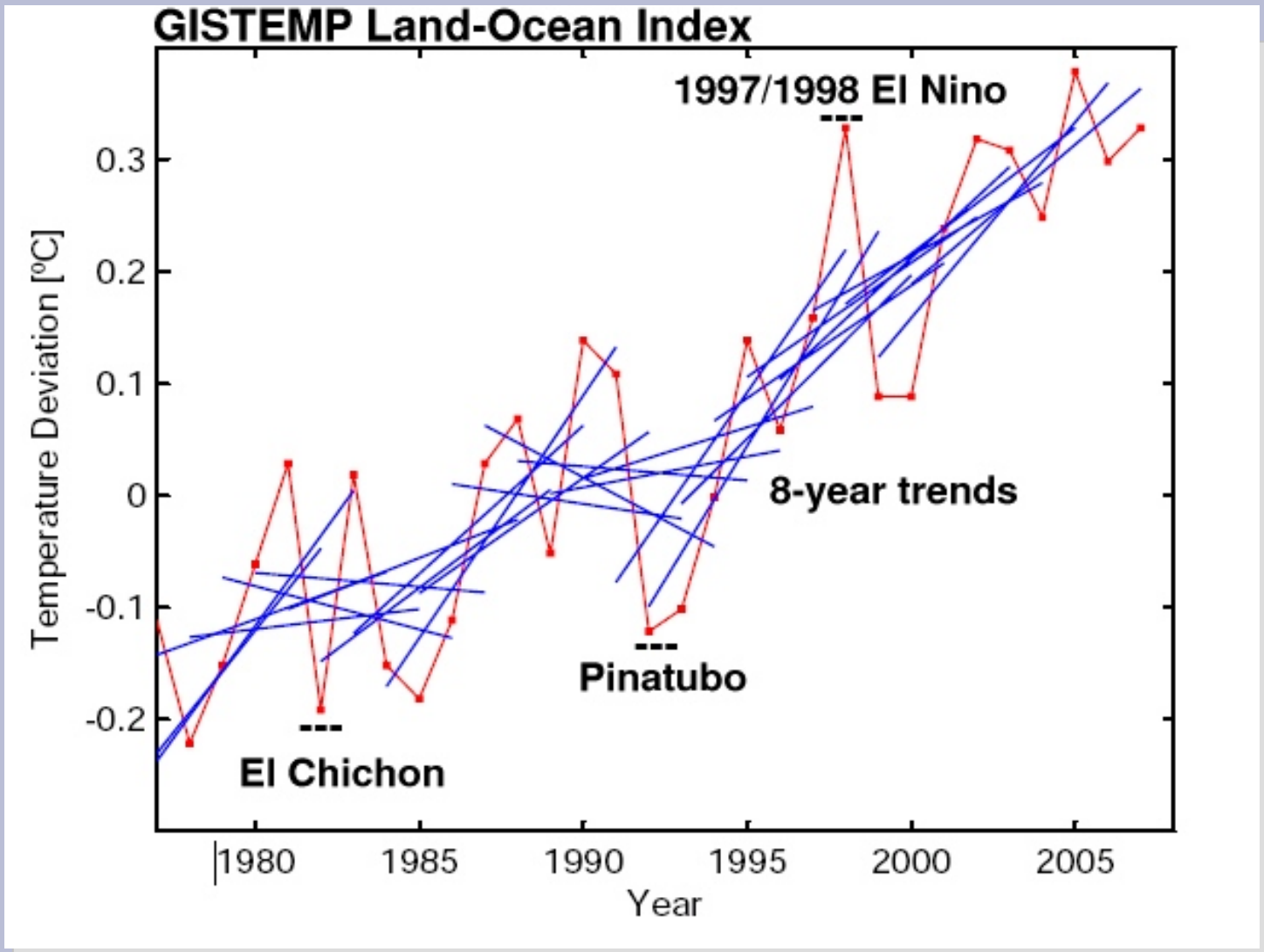


anomaly:
difference (deg C)
compared to mean
of 1961-1990



NASA GISS
http://data.giss.nasa.gov/gistemp/

Trends and statistical significance



http://www.realclimate.org/index.php/archives/2008/01/uncertainty-noise-and-the-art-of-model-data-comparison/

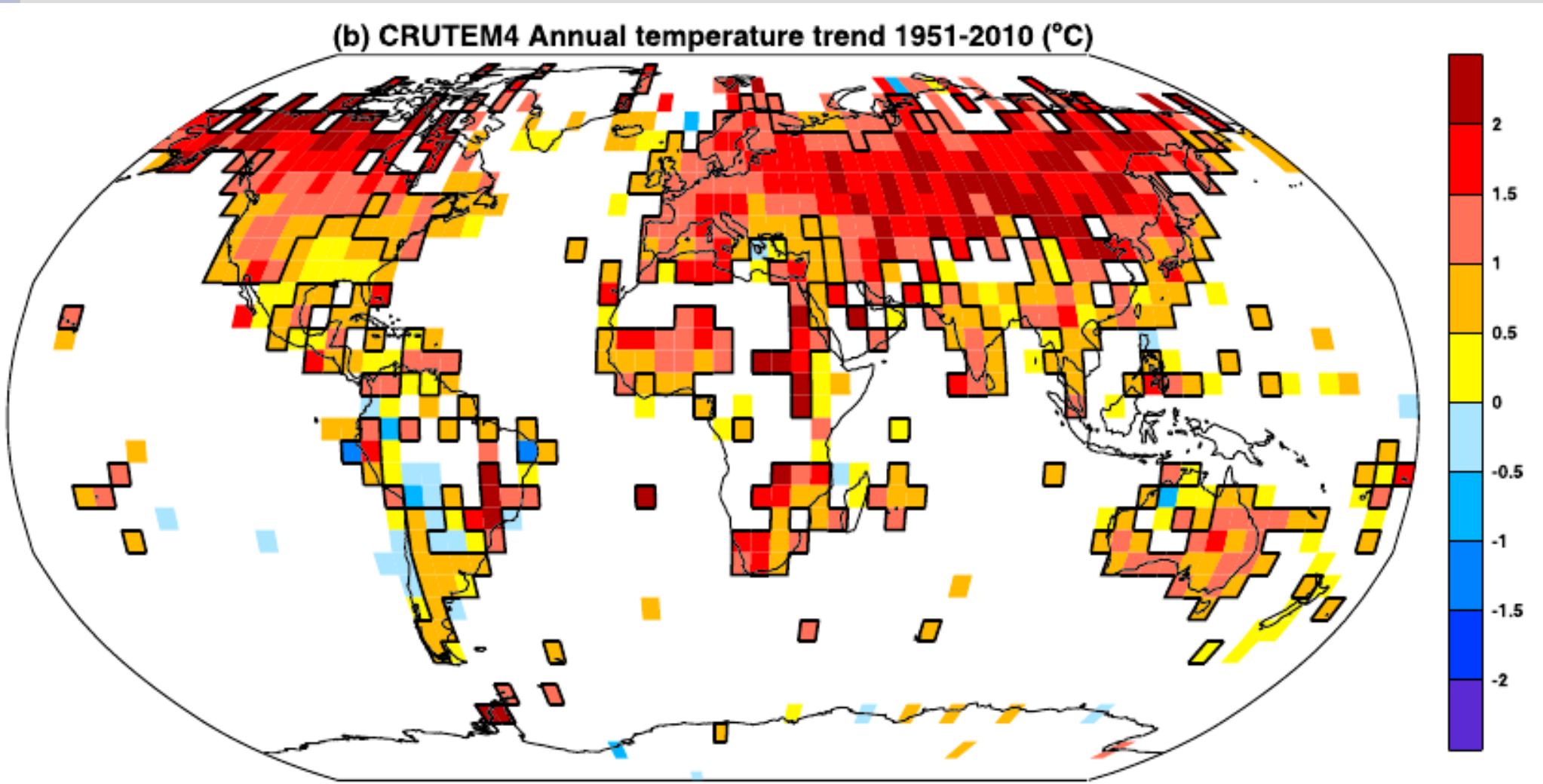
red: observations
blue: trends for 8-year periods

variability makes short-term trends difficult to interpret

Significance:
In statistics, a result is called **statistically significant** if it is unlikely to have occurred by chance.

This is different from everyday language (where significant often means large or important)!!

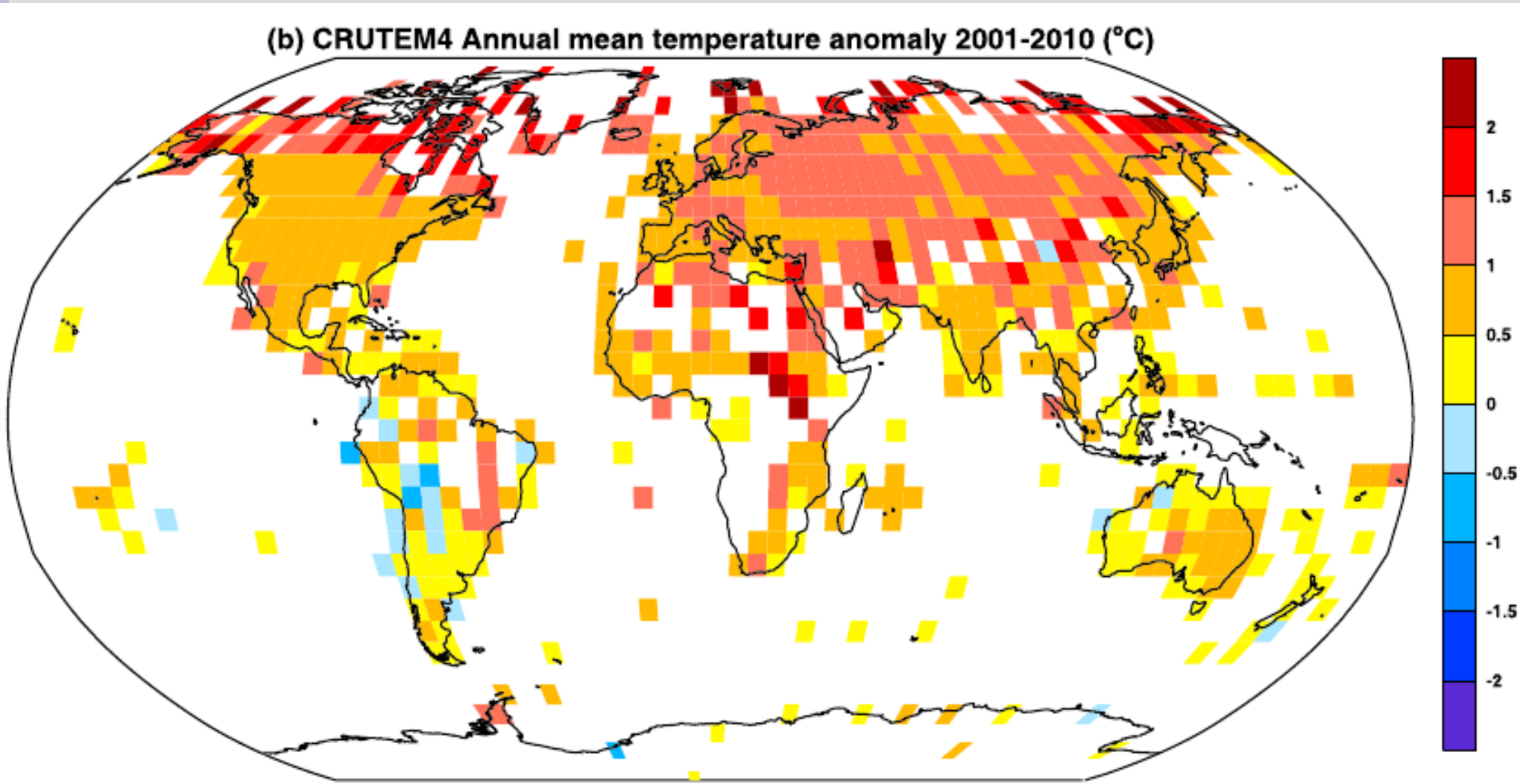
Temperature trend 1951-2010



deg C over 60yrs

Jones et al (2012), JGR

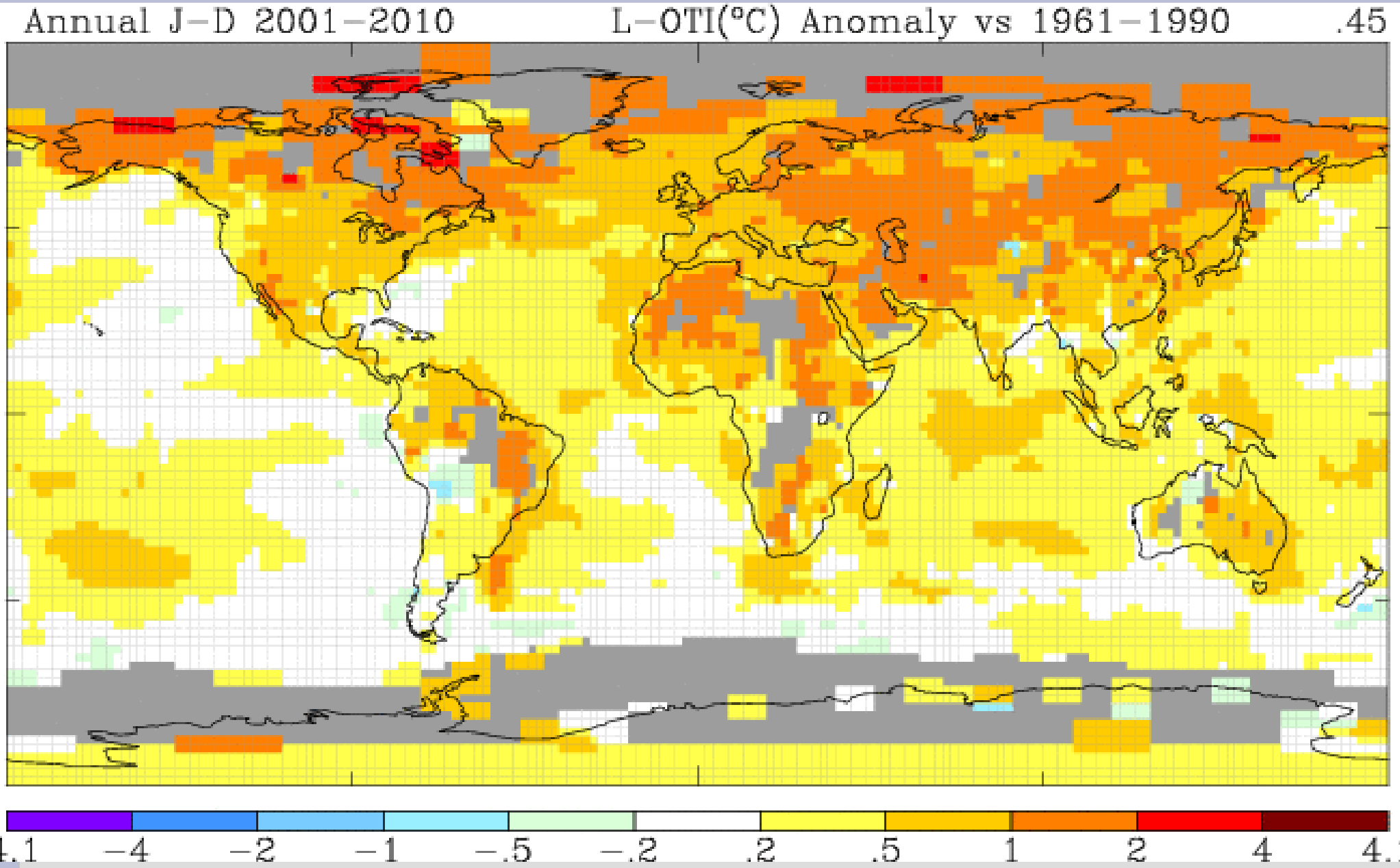
Temperature anomaly of decade 2001-2010



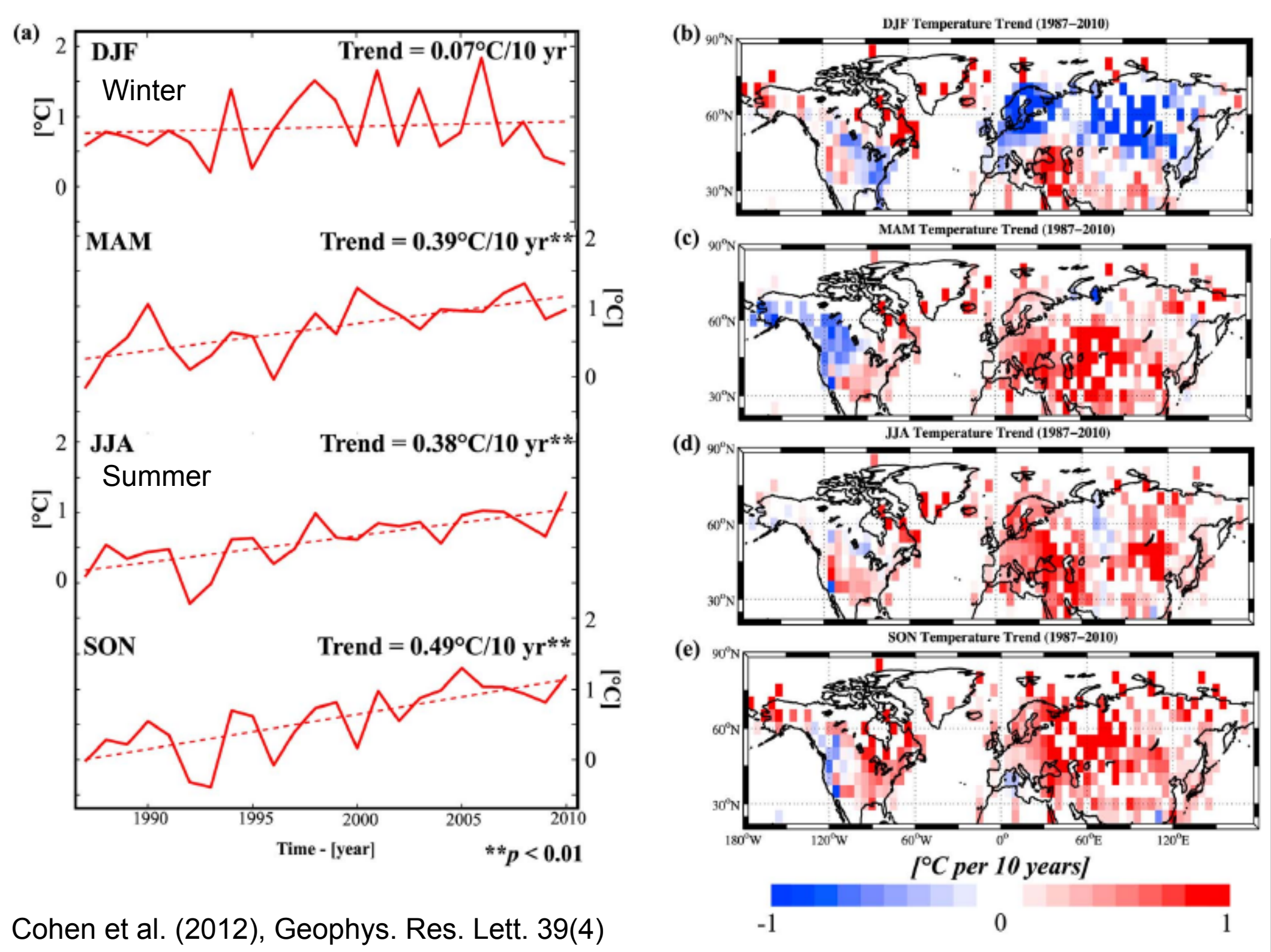
Jones et al (2012), JGR

anomaly: difference (deg C) compared to mean of 1961-1990

Temperature anomaly

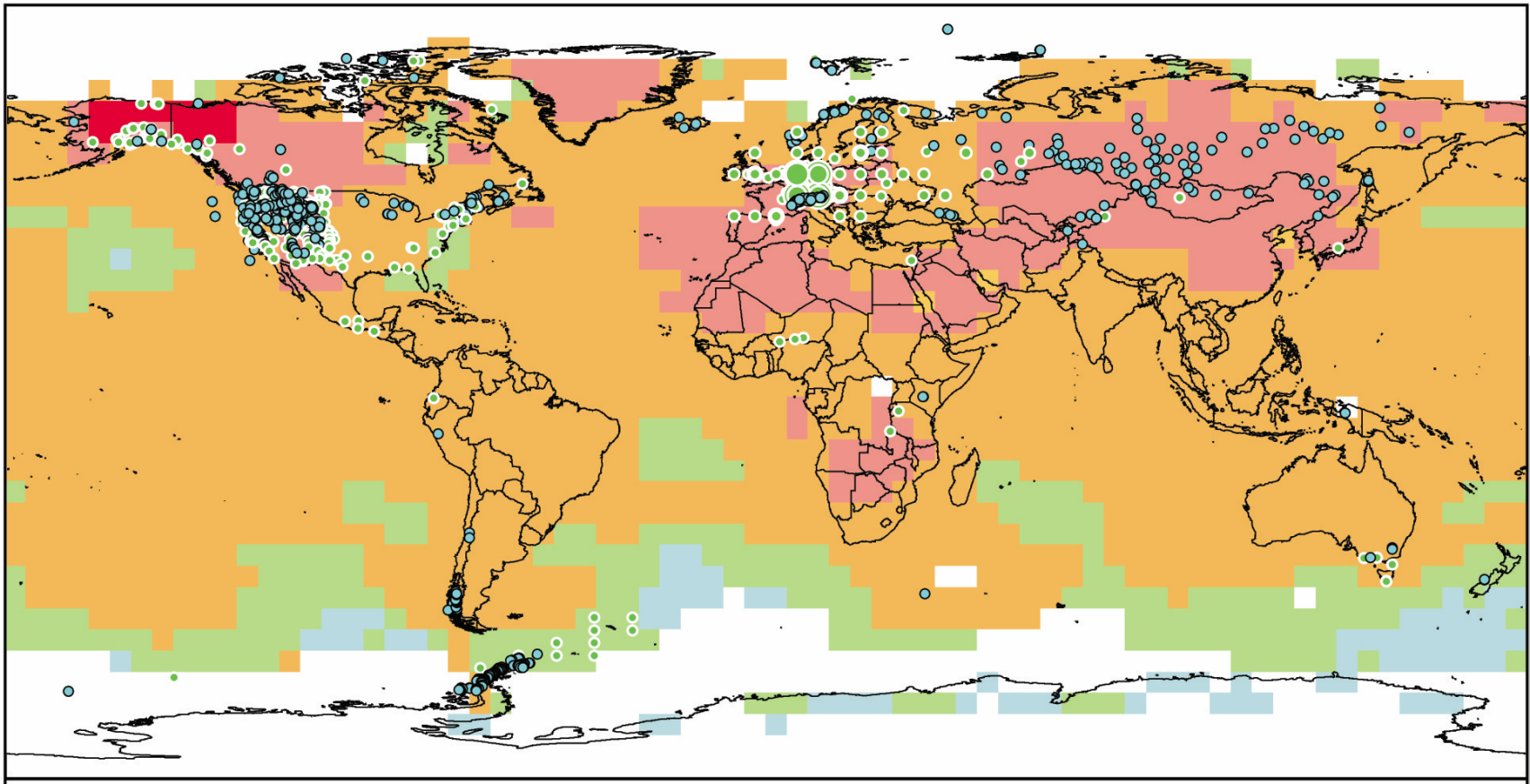


NASA GISS http://data.giss.nasa.gov/gistemp/



Cohen et al. (2012), Geophys. Res. Lett. 39(4)

90% of observed biological and physical indicators consistent with warming



NAM		LA		EUR (28,115)		AFR		AS		ANZ		PR*		TER (28,586)		MFW**		GLO (28,671)	
355	455	53	5	119		5	2	106	8	6	0	120	24	764		1	85	765	
94%	92%	98%	100%	94%	89%	100%	100%	96%	100%	100%	–	91%	100%	94%	90%	100%	99%	94%	90%

NAM etc: continents
Ter: terrestrial
MFW: marine& fresh water
GLO: global

Observations
- Physical systems (snow, ice and frozen ground; hydrology; coastal processes)
- Biological systems (terrestrial, marine, and freshwater)

Europe ***
1-30
31-100
101-800
801-1200
1201 -7500

Temperature change °C
1970-2004

-1.0 -0.2 0.2 1.0 2.0 3.5

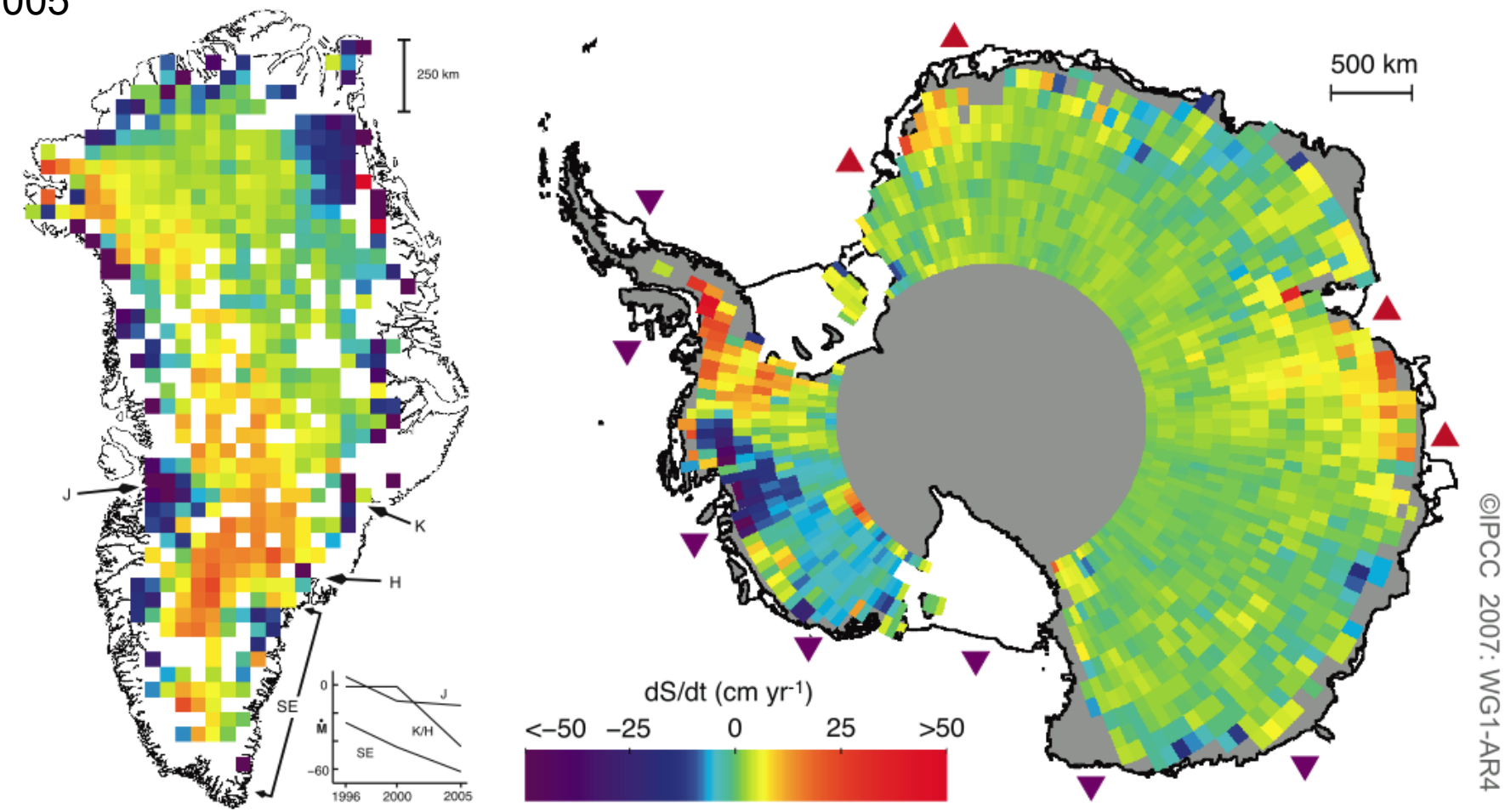
Physical	Biological
Number of significant observed changes	Number of significant observed changes
Percentage of significant changes consistent with warming	Percentage of significant changes consistent with warming

IPCC AR4 WGII Fig. SPM 1

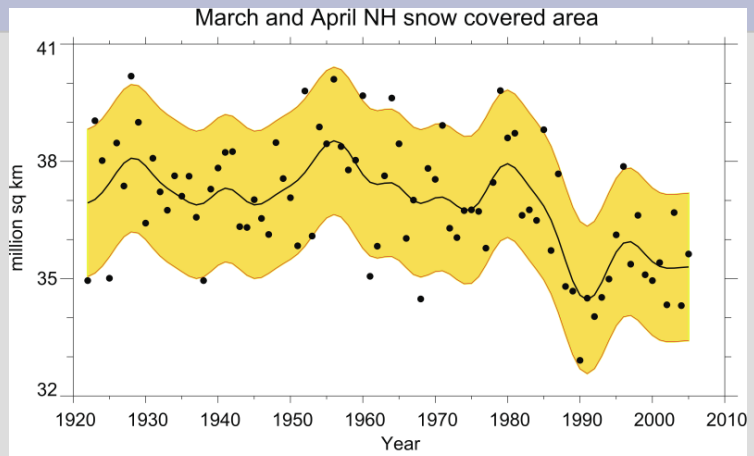
Observations: Ice thickness

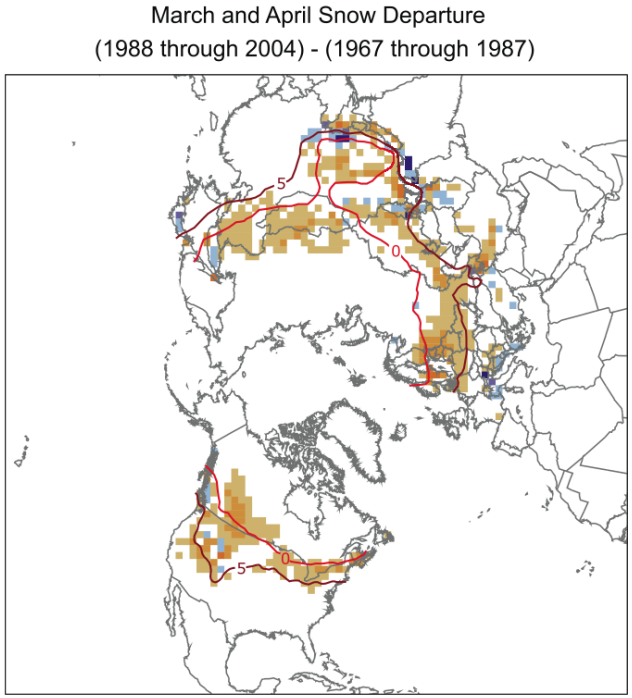
1989-2005

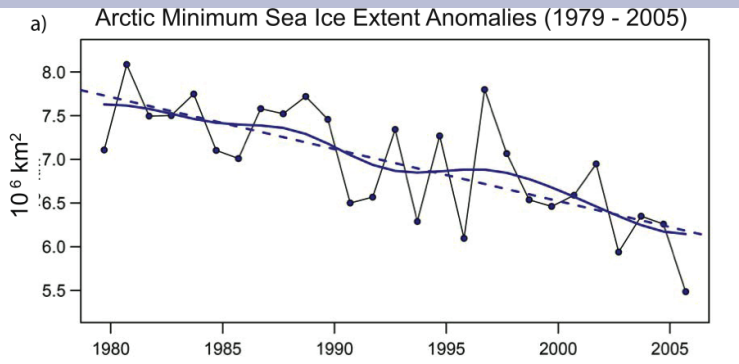
1992-2005

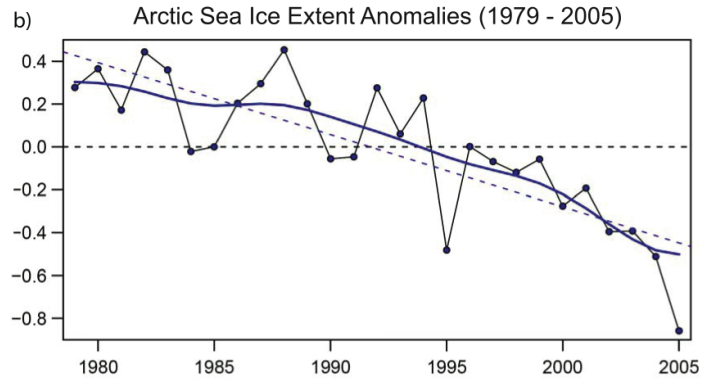


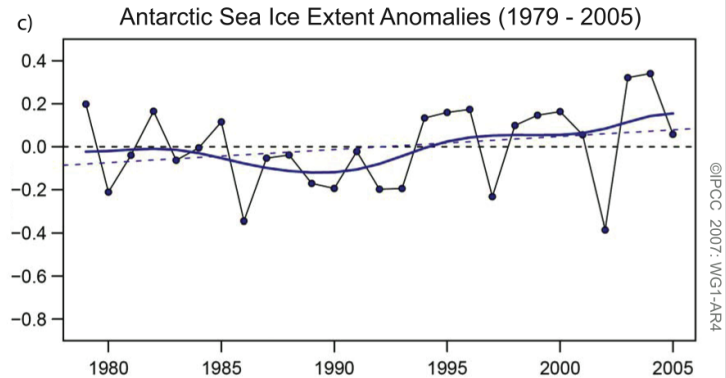
Snow cover and sea ice



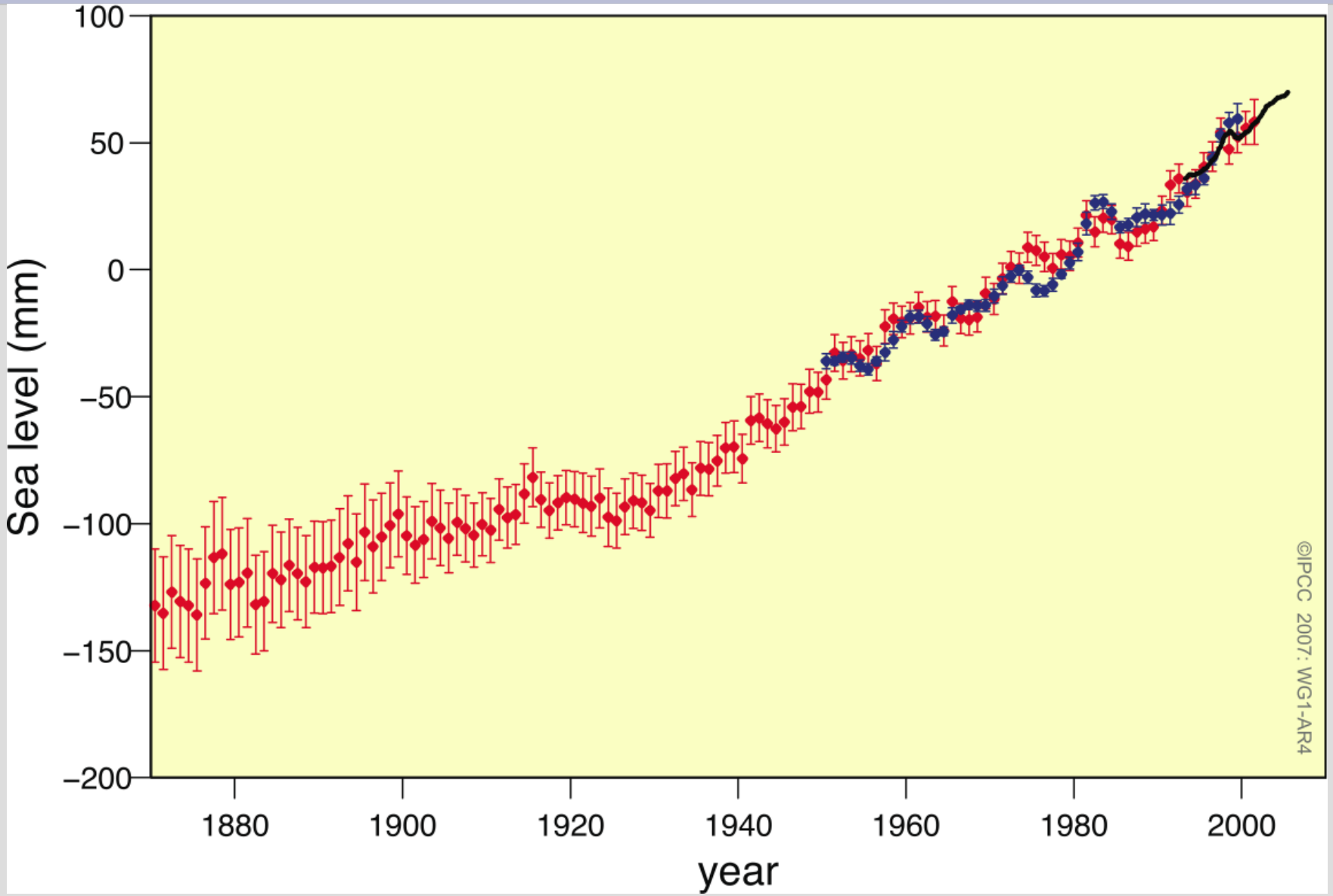




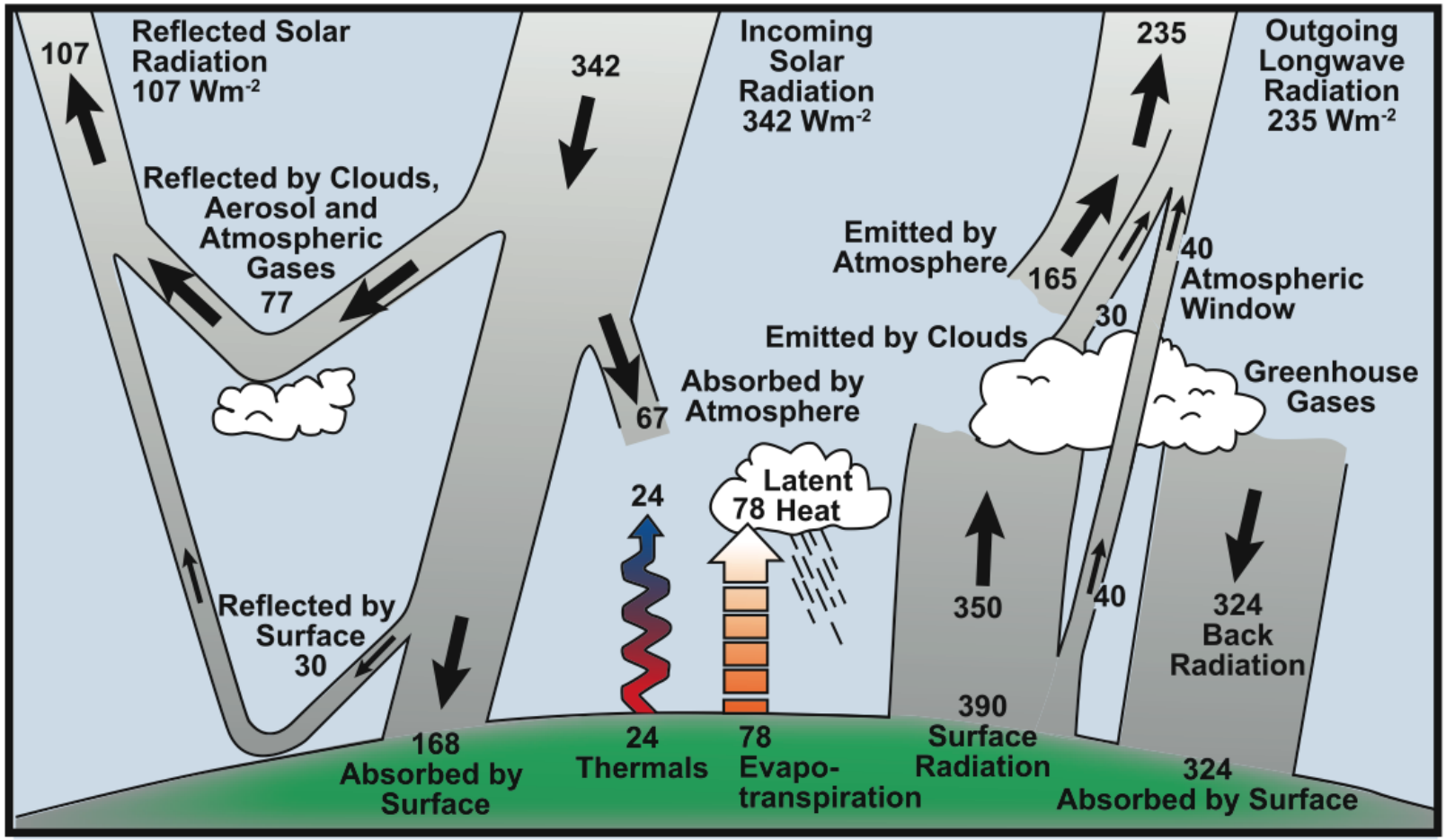




Sea level


100
50
0
−50
−100
−150
−200
Sea level (mm)
1880
1900
1920
1940
1960
1980
2000
year
©IPCC 2007: WG1-AR4

Greenhouse Effect



Greenhouse Effect

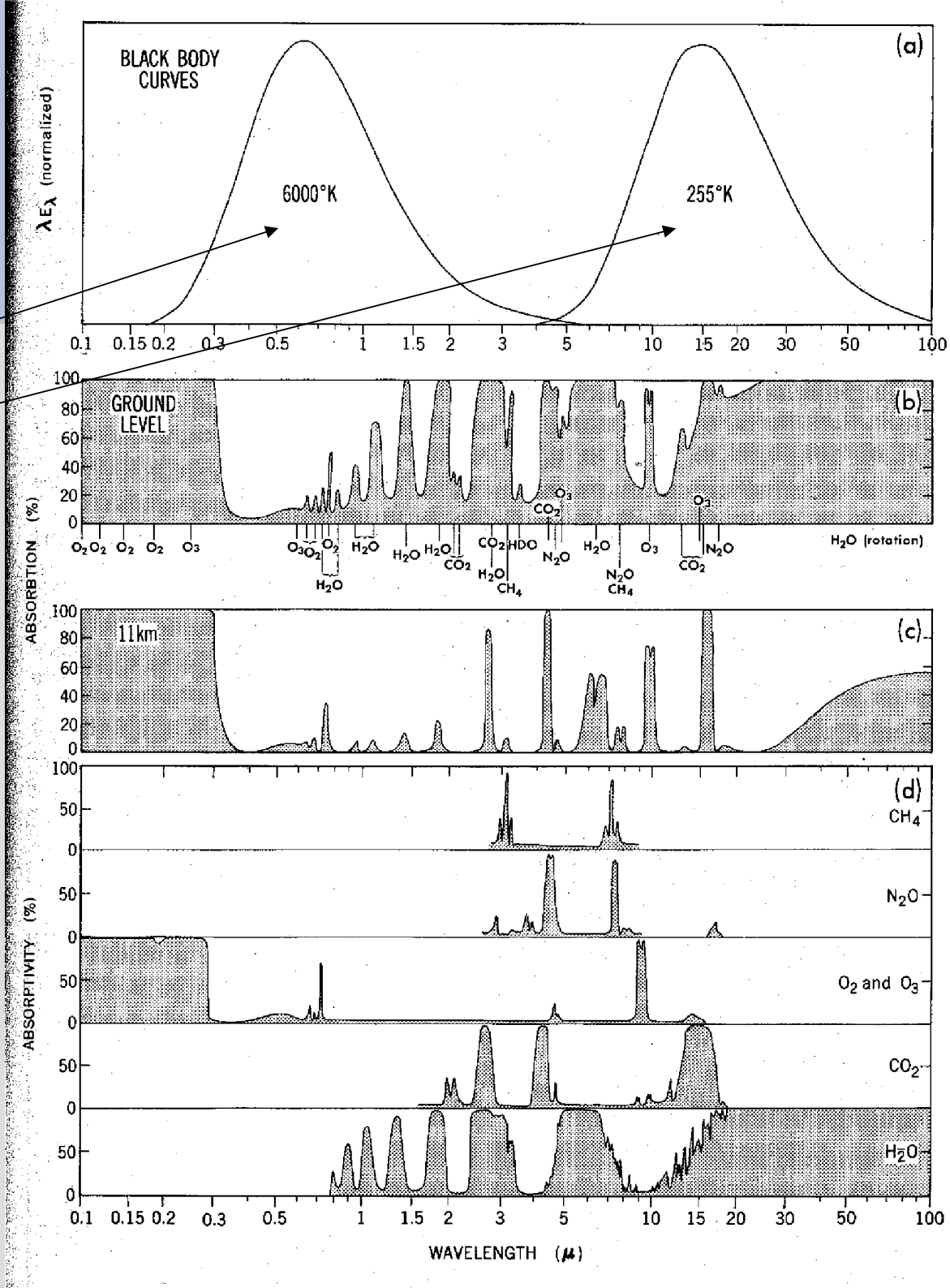
Solar incoming radiation

Outgoing thermal rad.

Absorption in Atmosphere

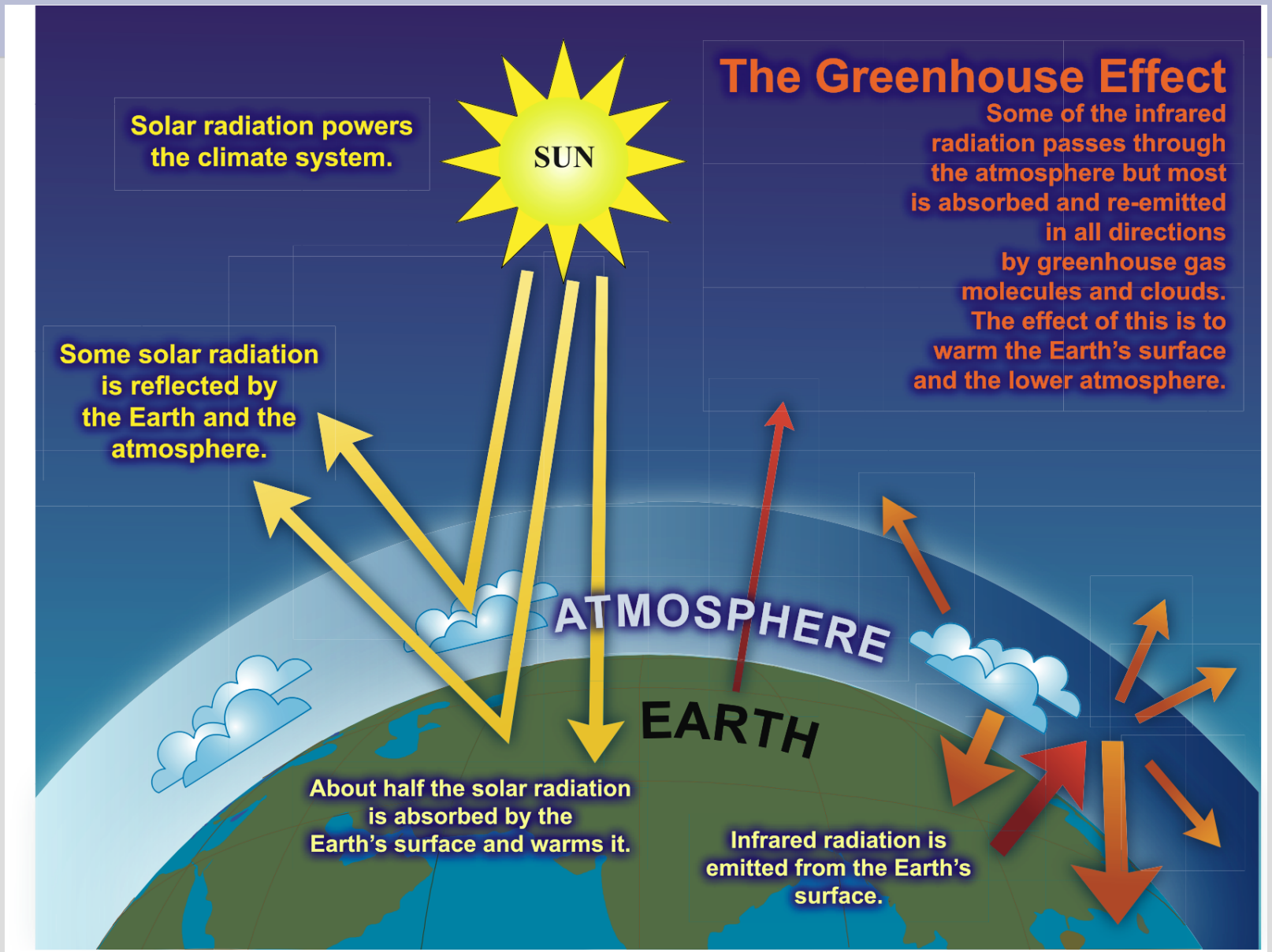
Absorption CO2

H2O



Peixoto&Oort (1992)

Greenhouse Effect



Discovery of the Greenhouse effect

1820s: Joseph Fourier (theoretical idea)
1859: John Tyndall
(experiments with CO_2 and H_2O)
1896 Svante Arrhenius
(interested in ice ages, calculated that cutting CO_2 by half would lower temperature by 4°-5°C)

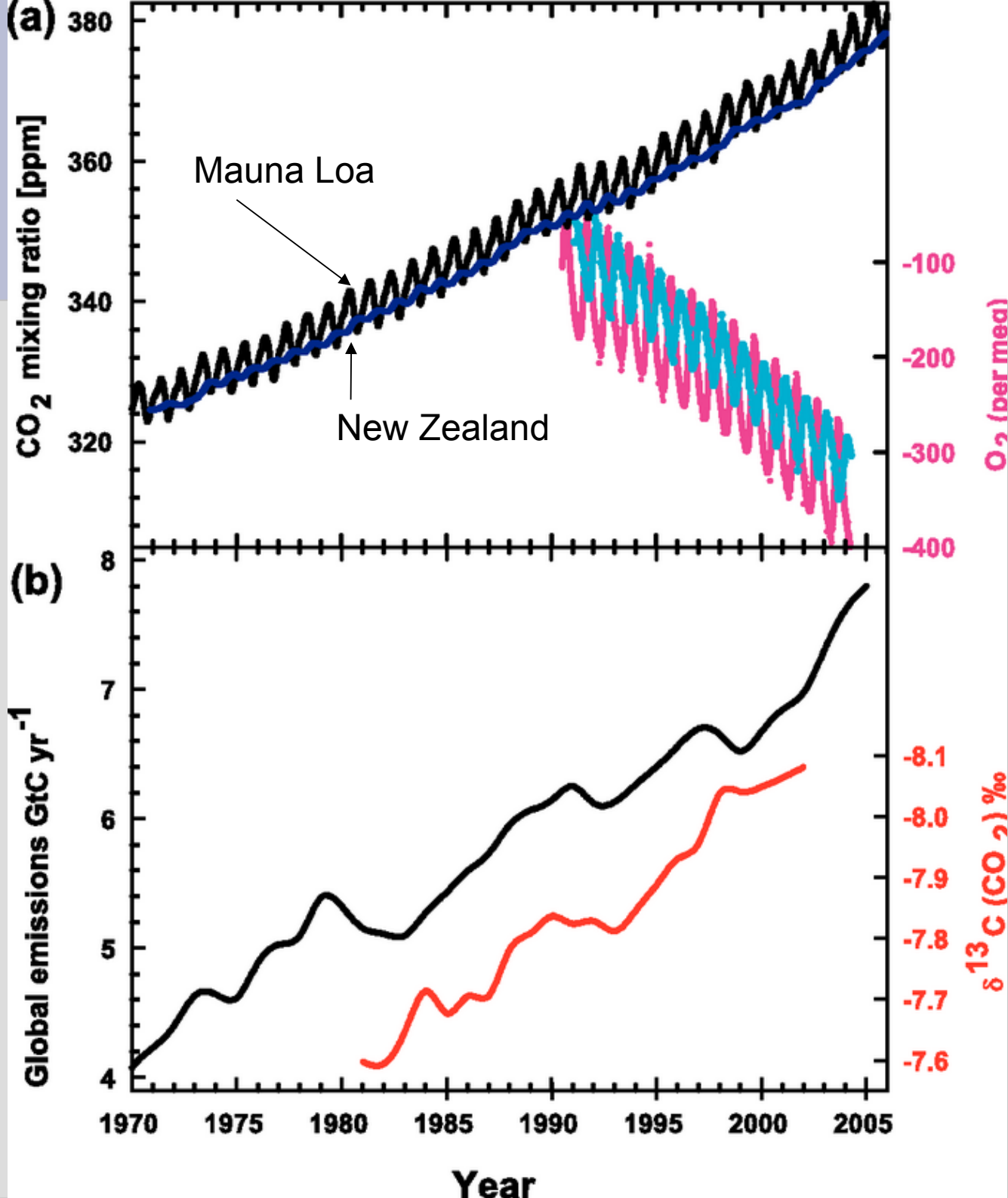
1938 Guy Stewart Callendar
(looked at historical measurements and found CO_2 increase by 10% and warming)

http://www.aip.org/history/climate/co2.htm

Greenhouse experiment

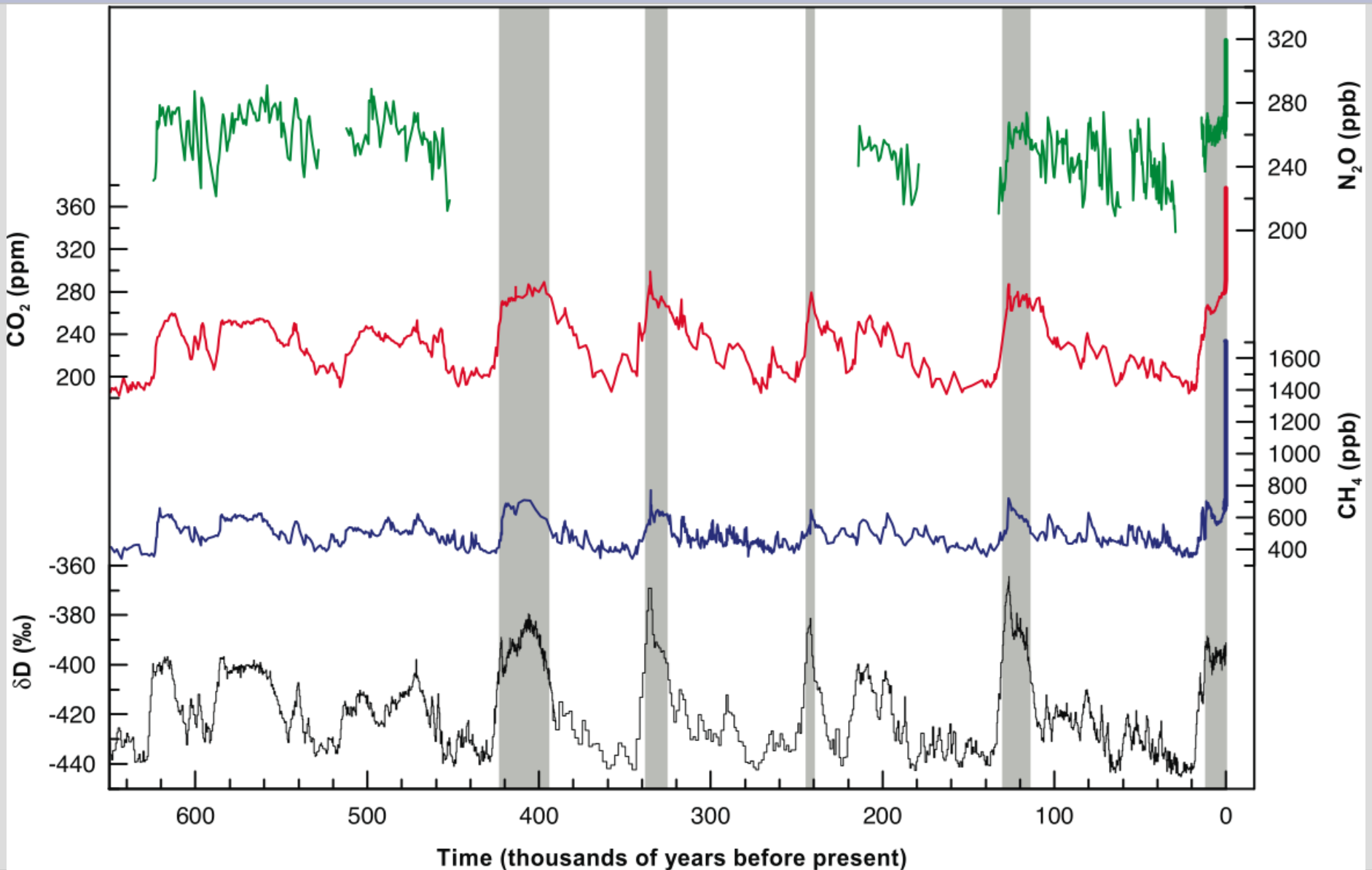
Atmosph. CO2

Calculated emissions from fossil fuels and cement production

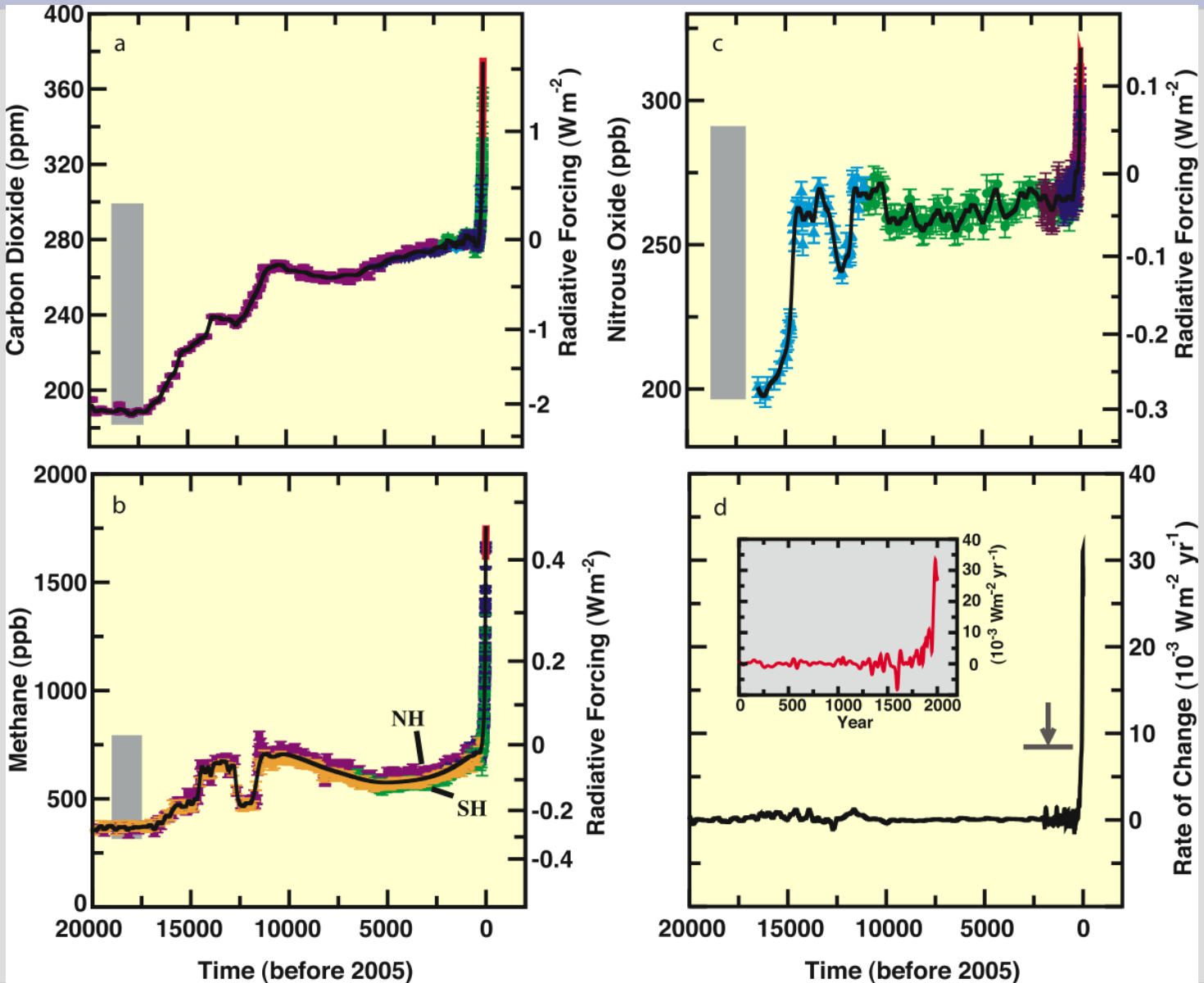


AR4 WG1 Fig 2.3

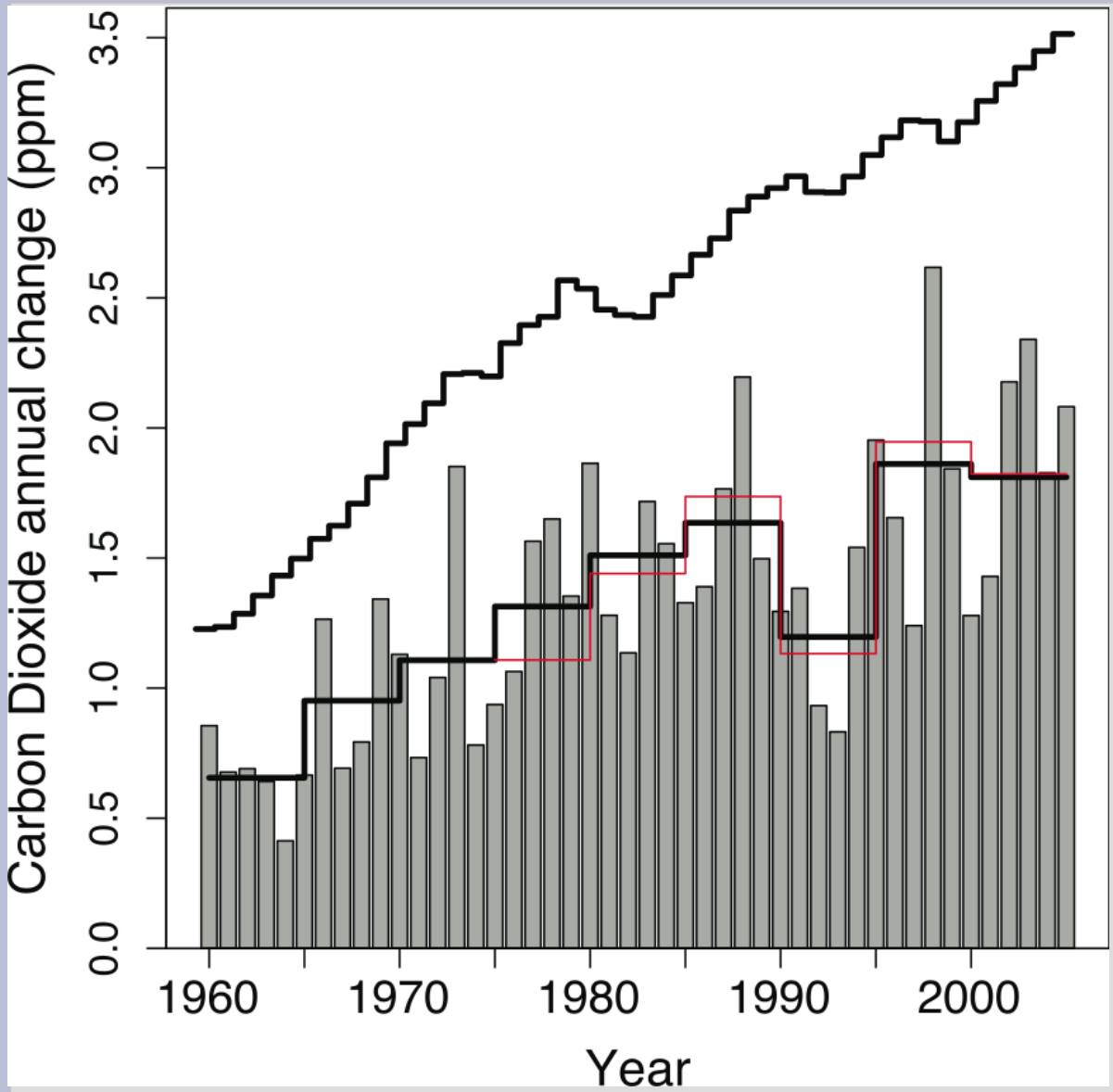
Greenhouse Gases



Greenhouse Gases



Carbon dioxide

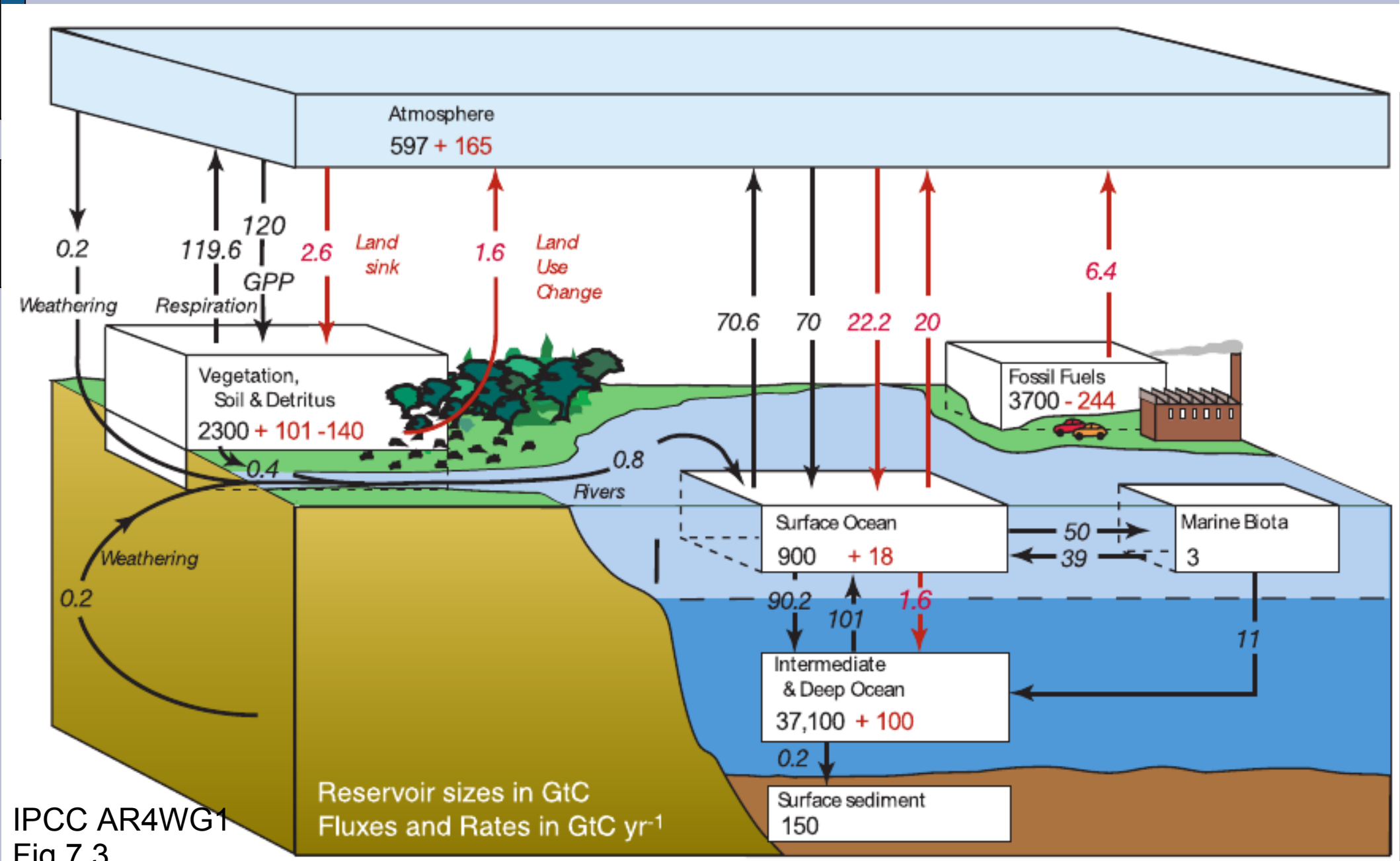


Change expected
from fossil fuel burning

Actual change

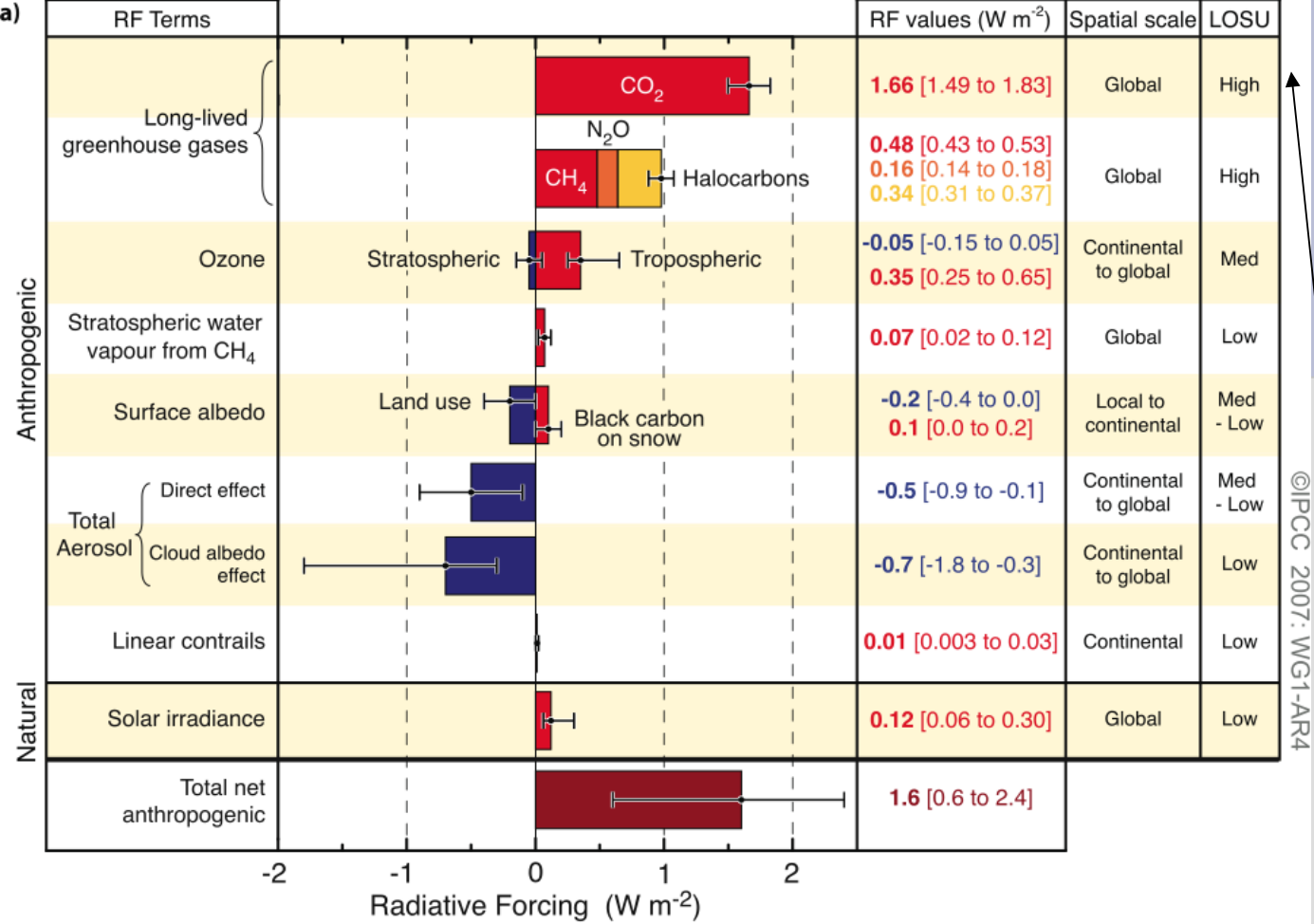
Global carbon cycle

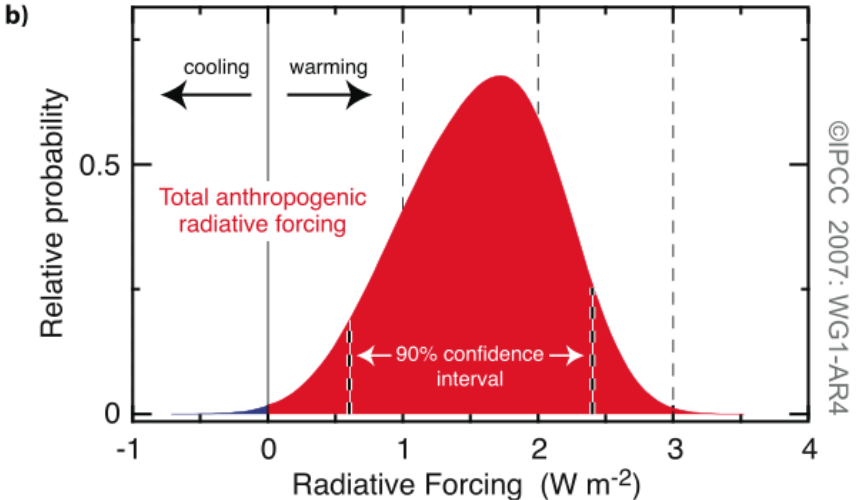
Billion tons per year (Gt/yr)
black: pre-industrial „natual“
red: additional anthopogenic



IPCC AR4WG1
Fig 7.3

Radiative Forcing

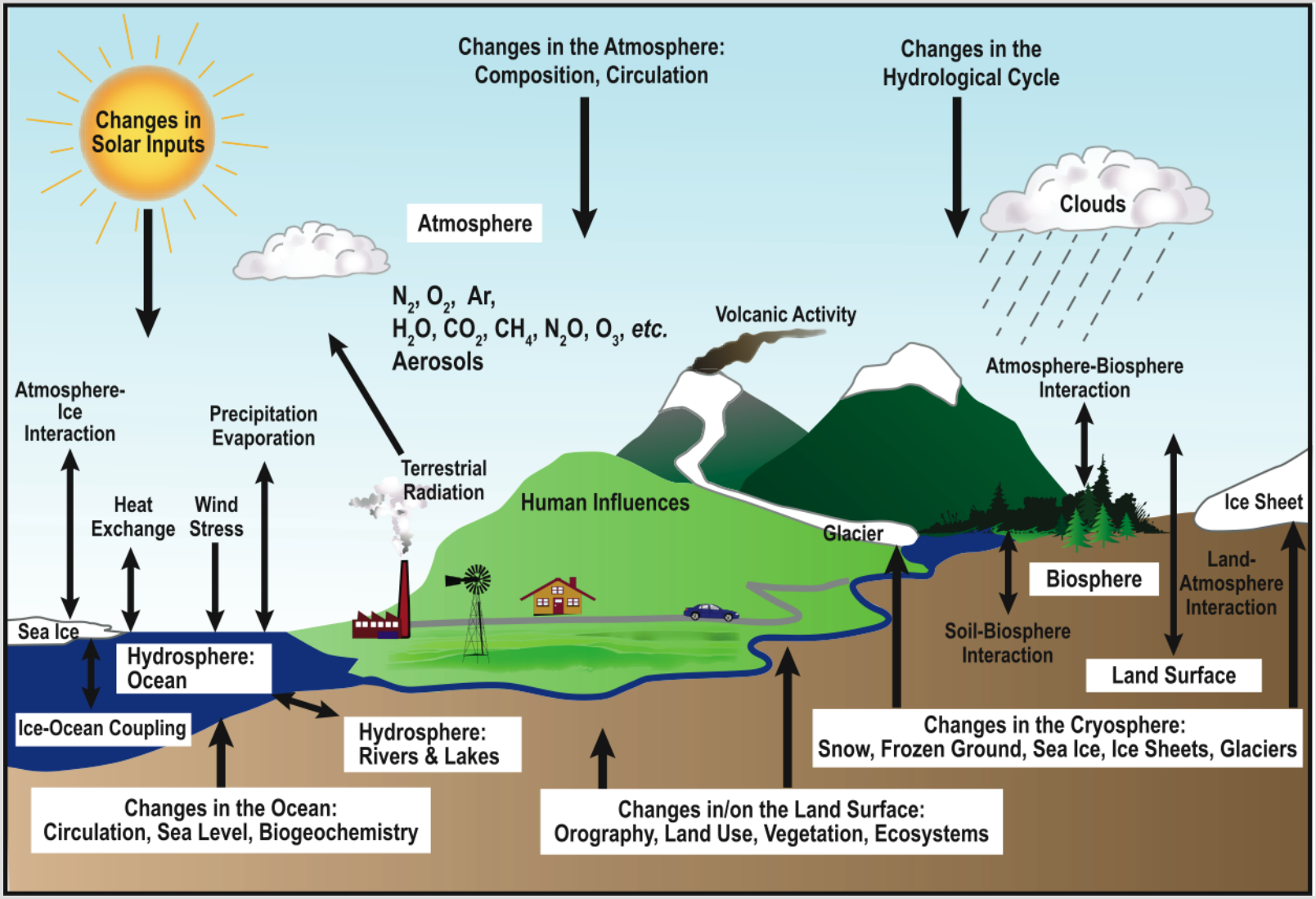




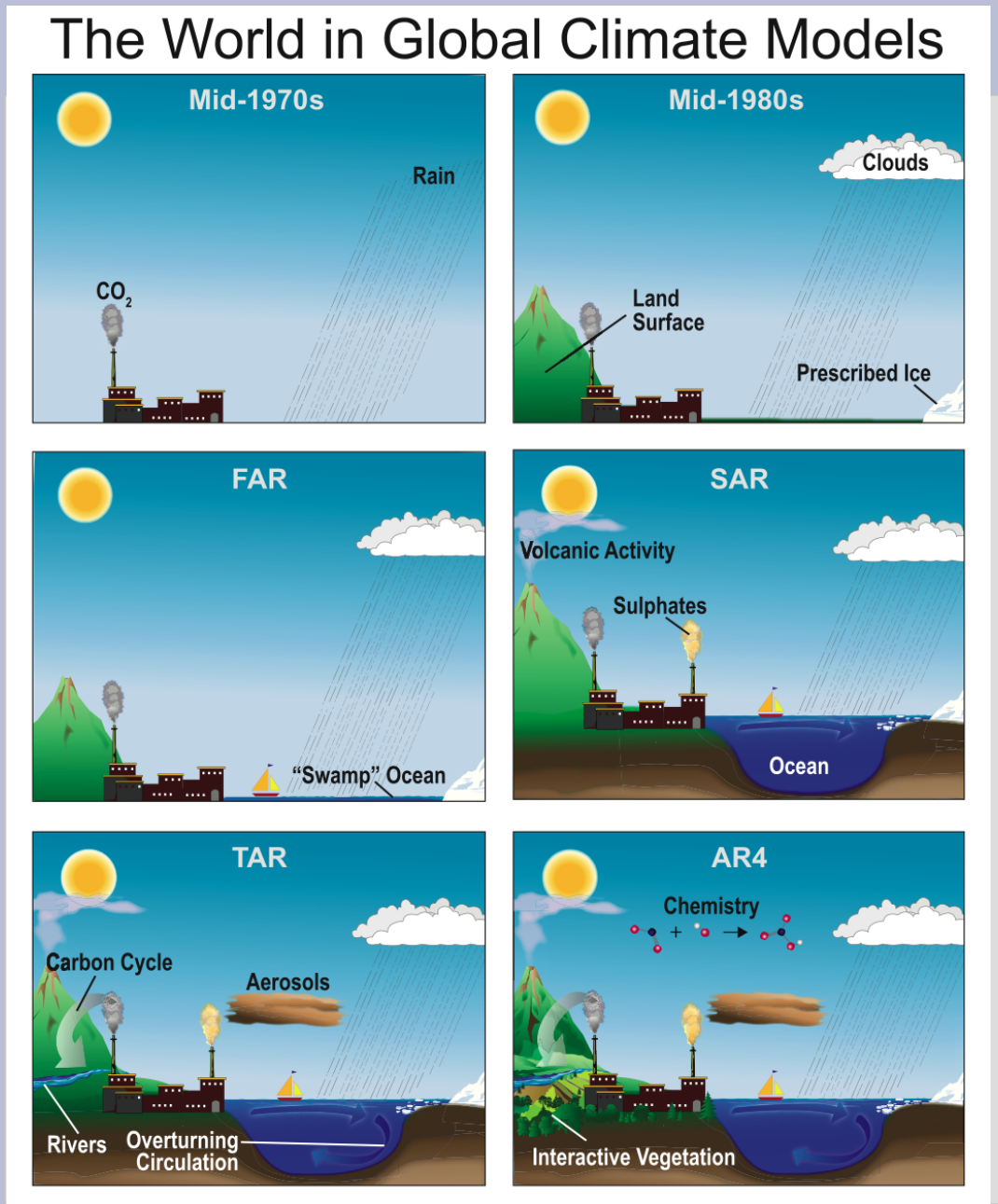
LOSU=
Level of
Scientific Understanding

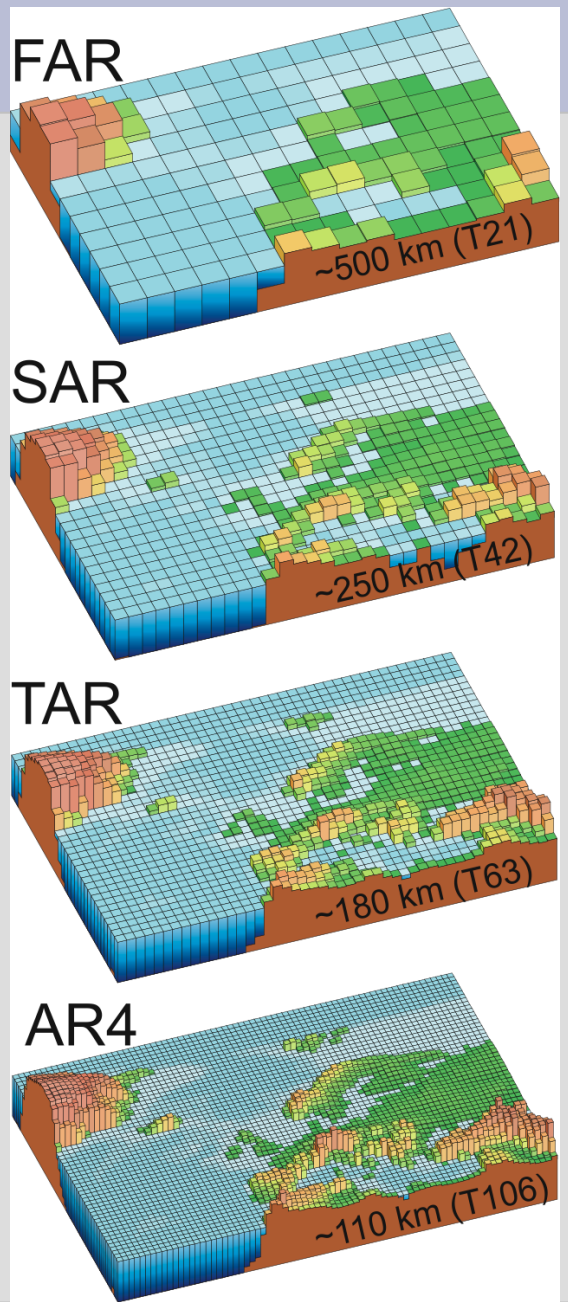
RF is the change in the net (downward minus upward) irradiance at the tropopause due to a change in an external driver of climate change (e.g change in concentration of carbon dioxide or the output of the Sun).

Modelling the Climate

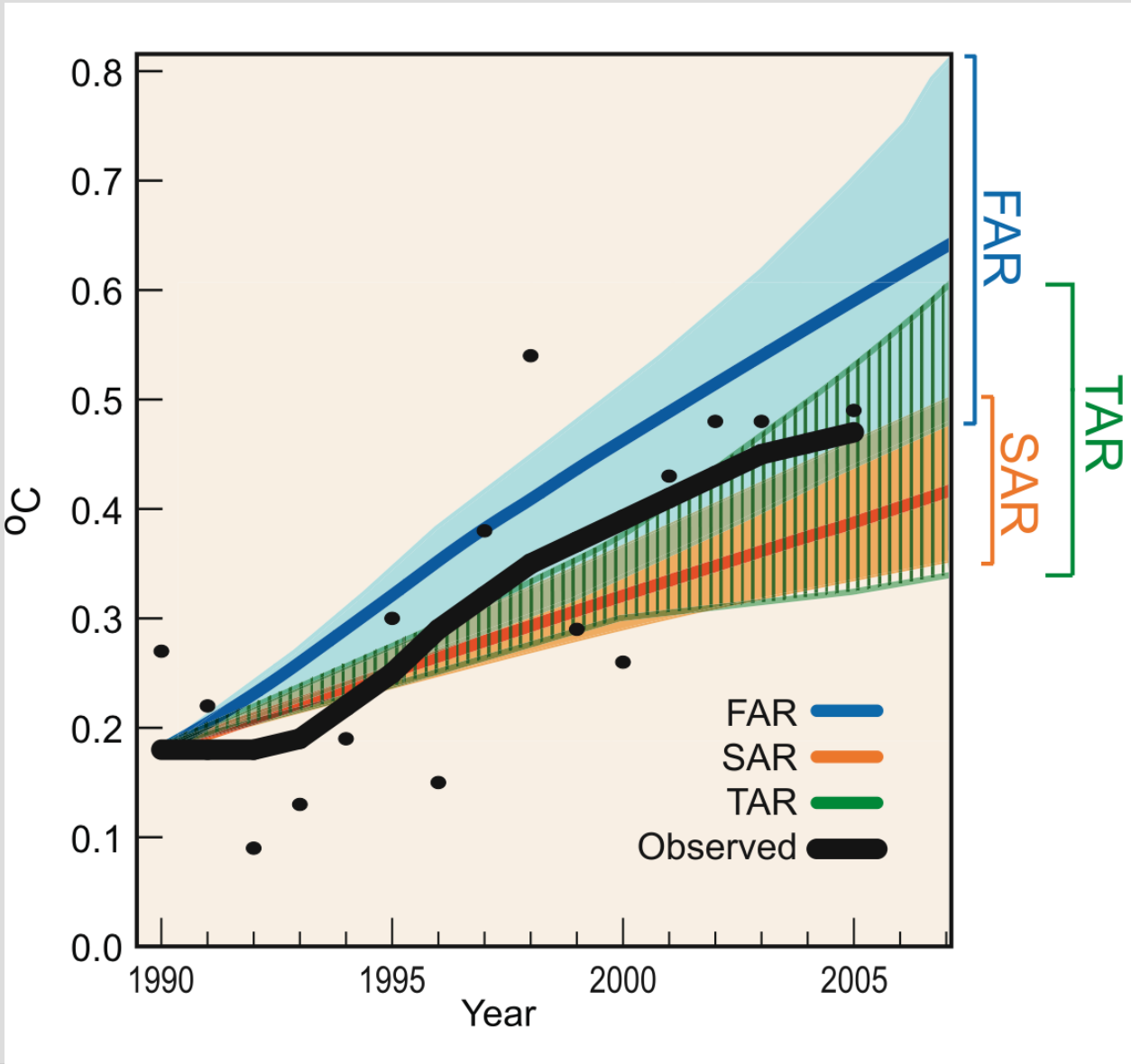


The World in Global Climate Models

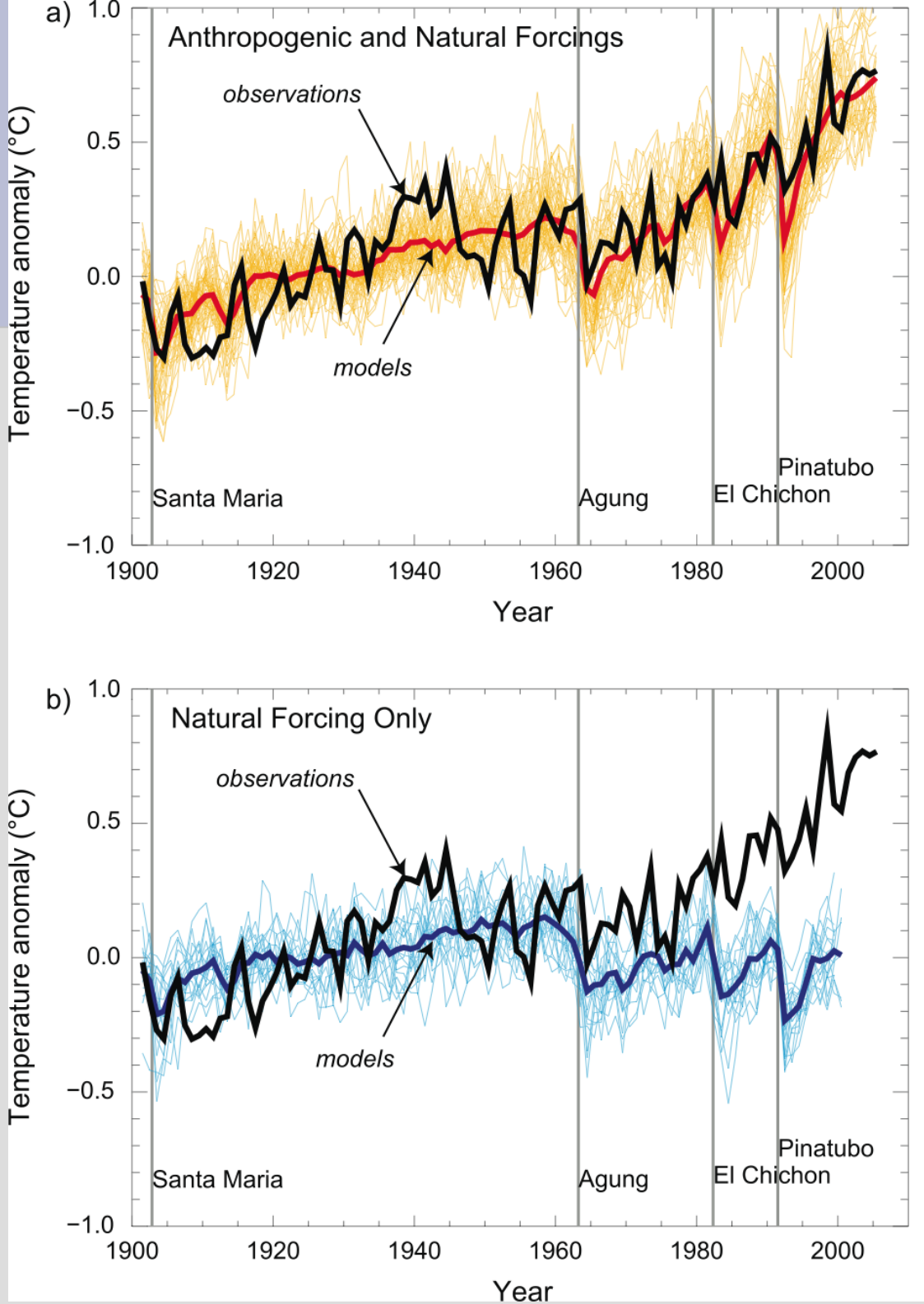




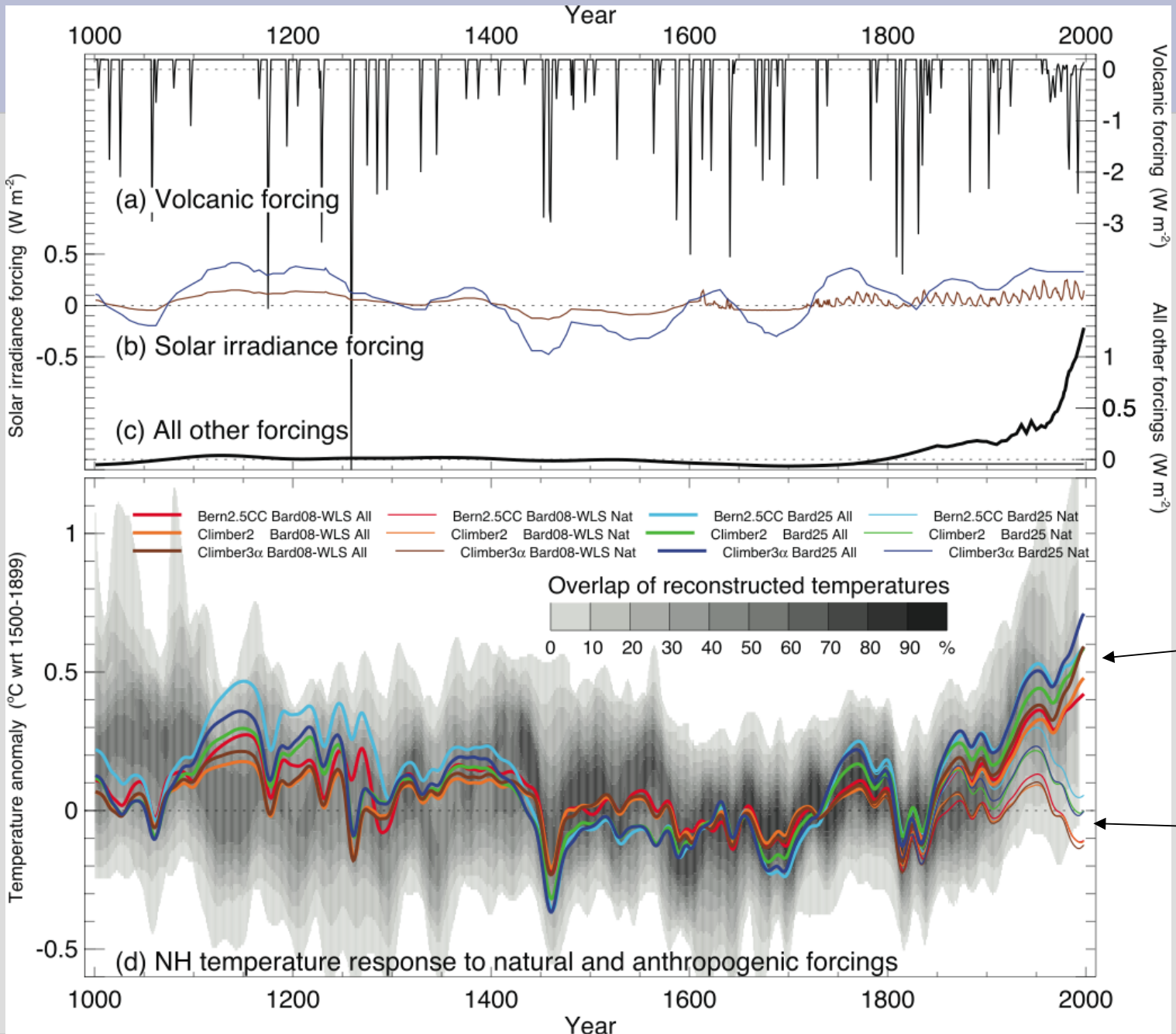
Model validation



Attribution of Climate Change



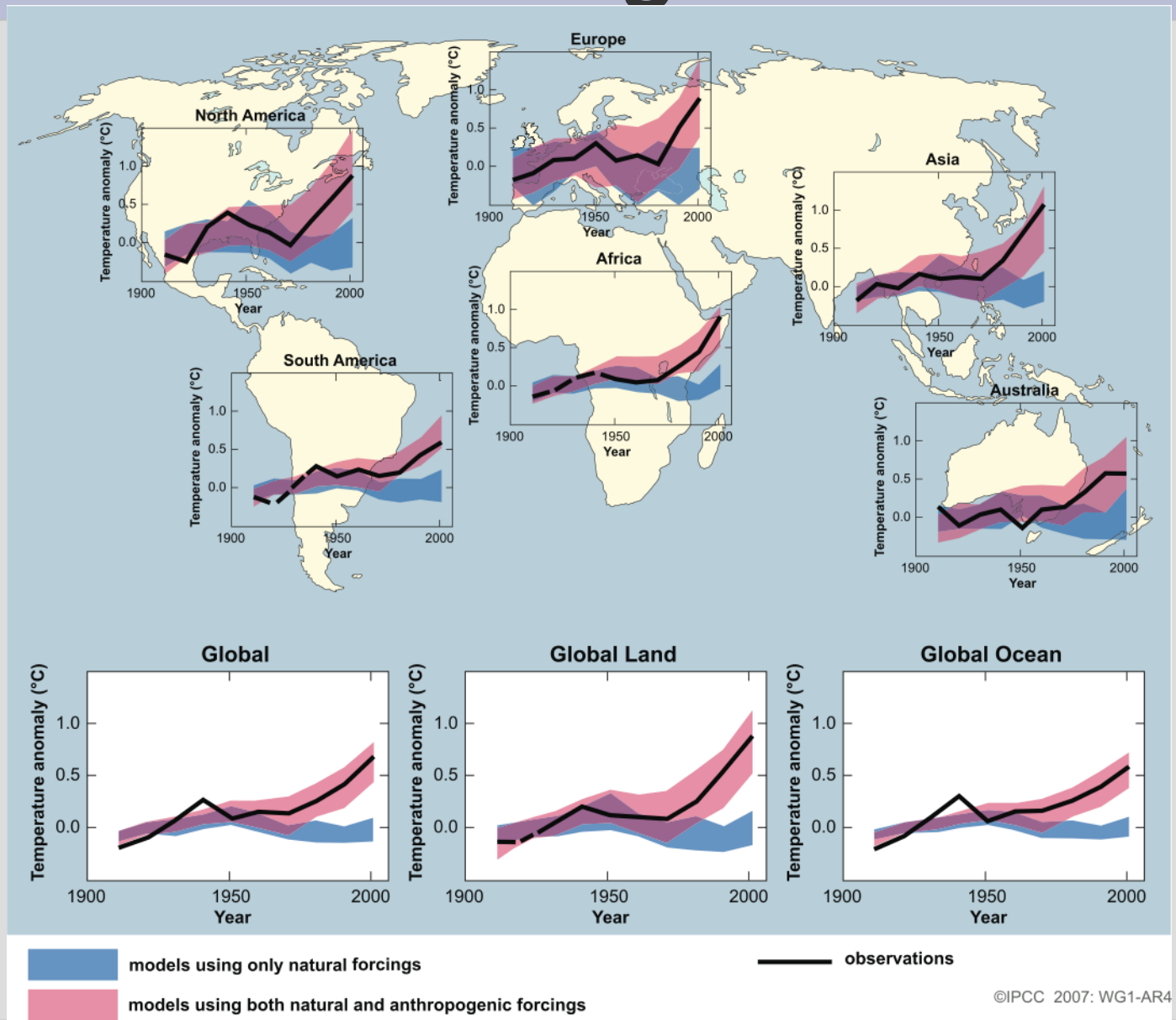
Attribution: natural/anthropogenic



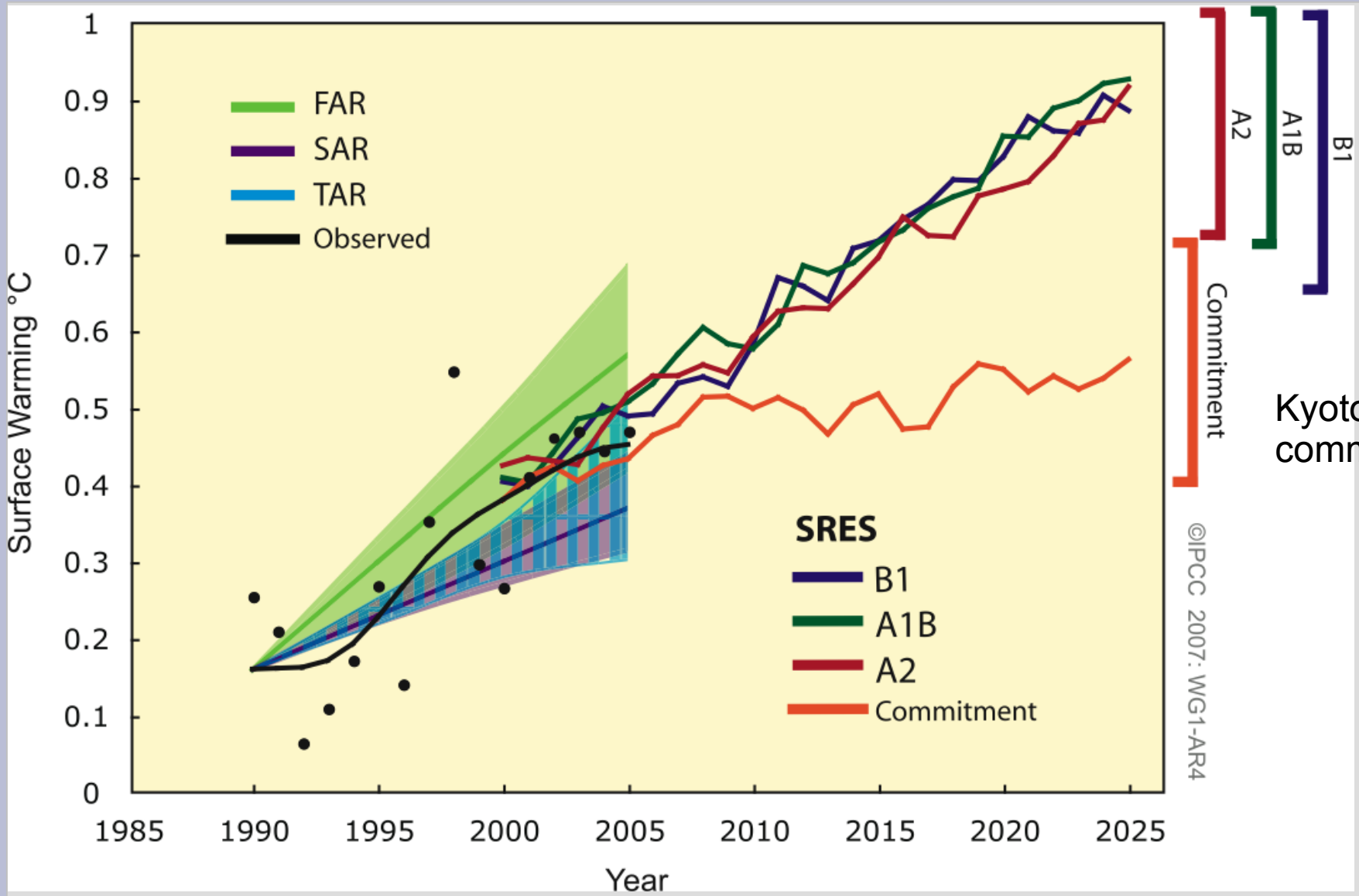
All forcings

Only natural forcings

Attribution of Climate Change



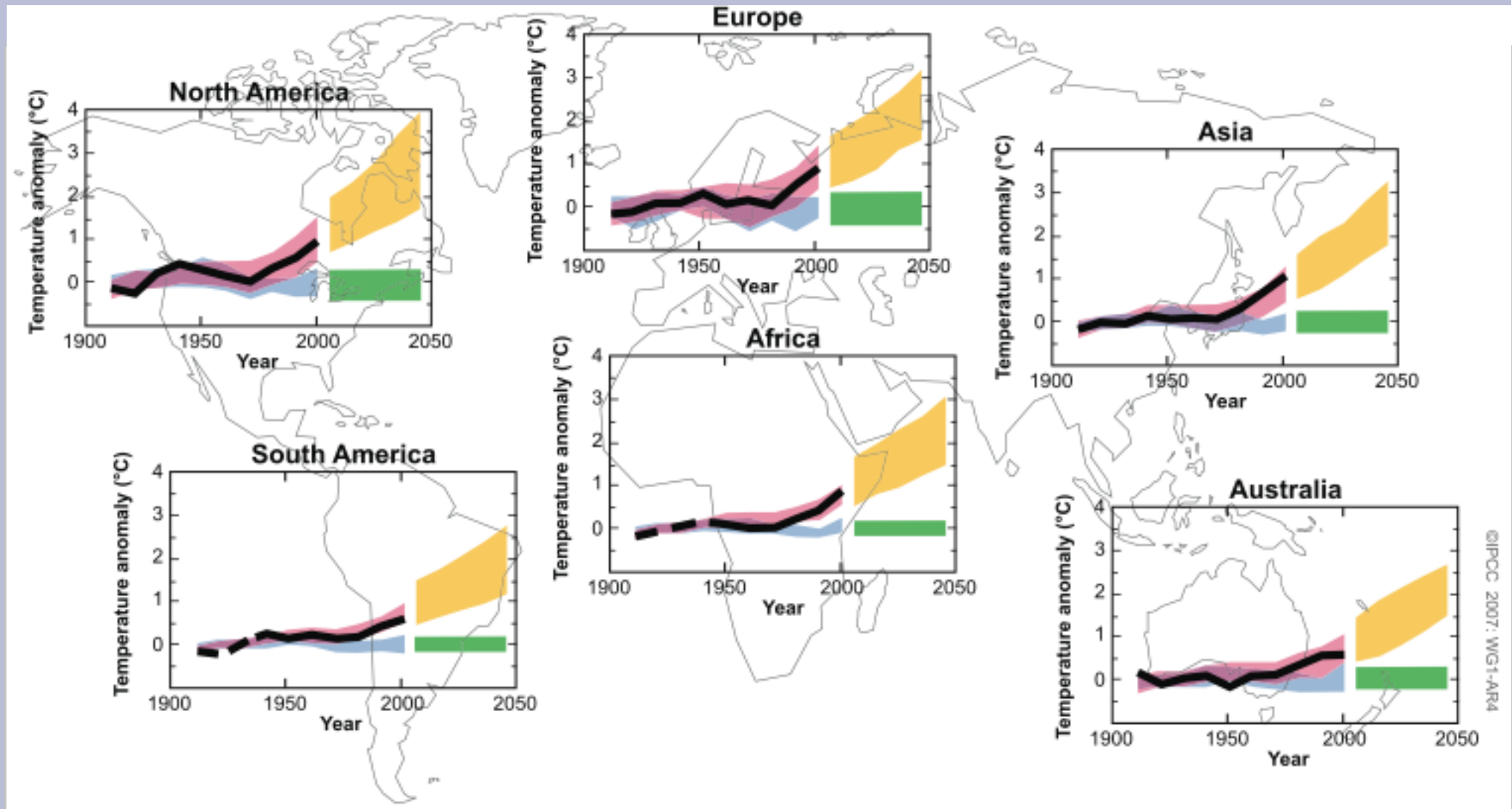
Projections

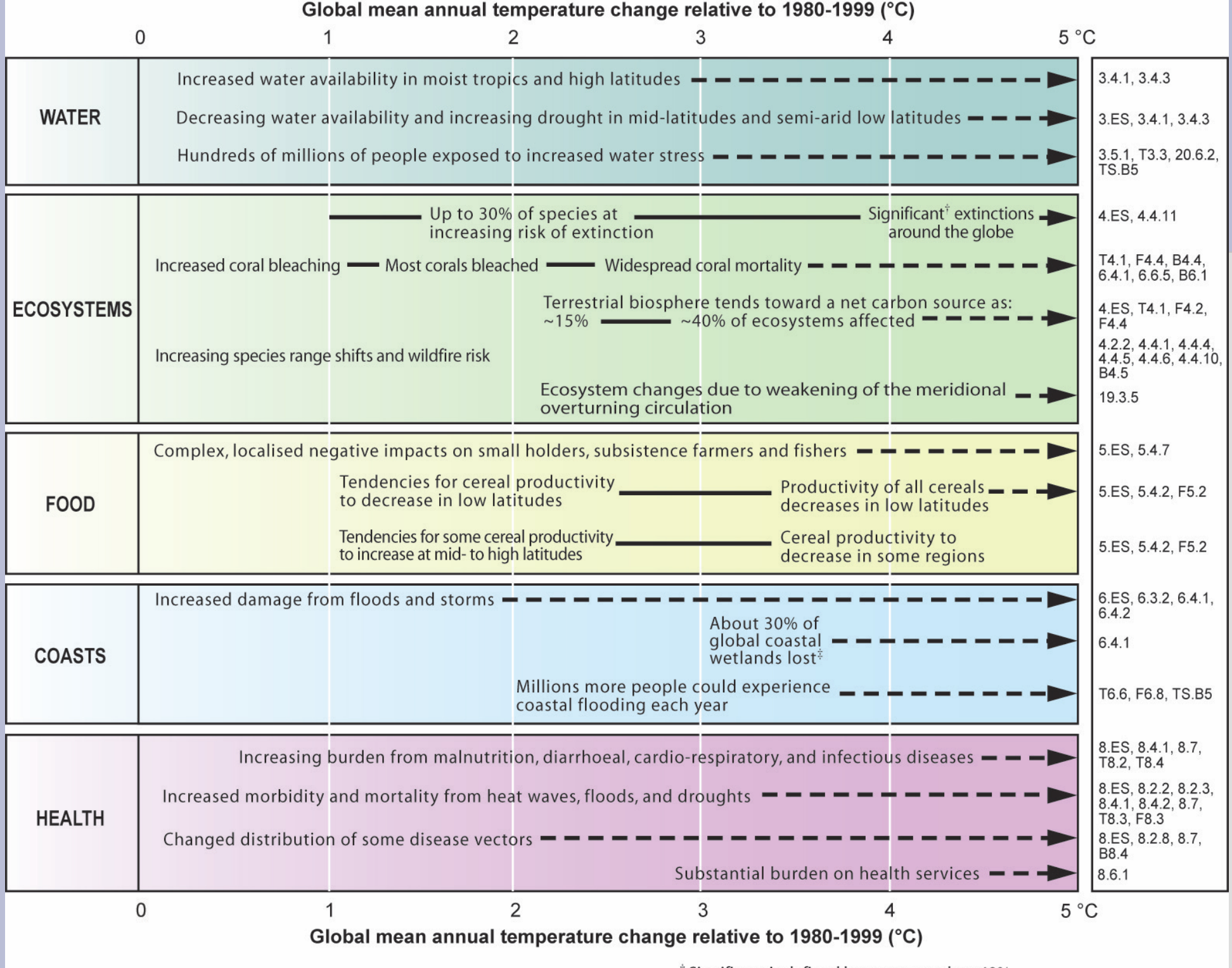


different scenarios

Kyoto commitment

Projections



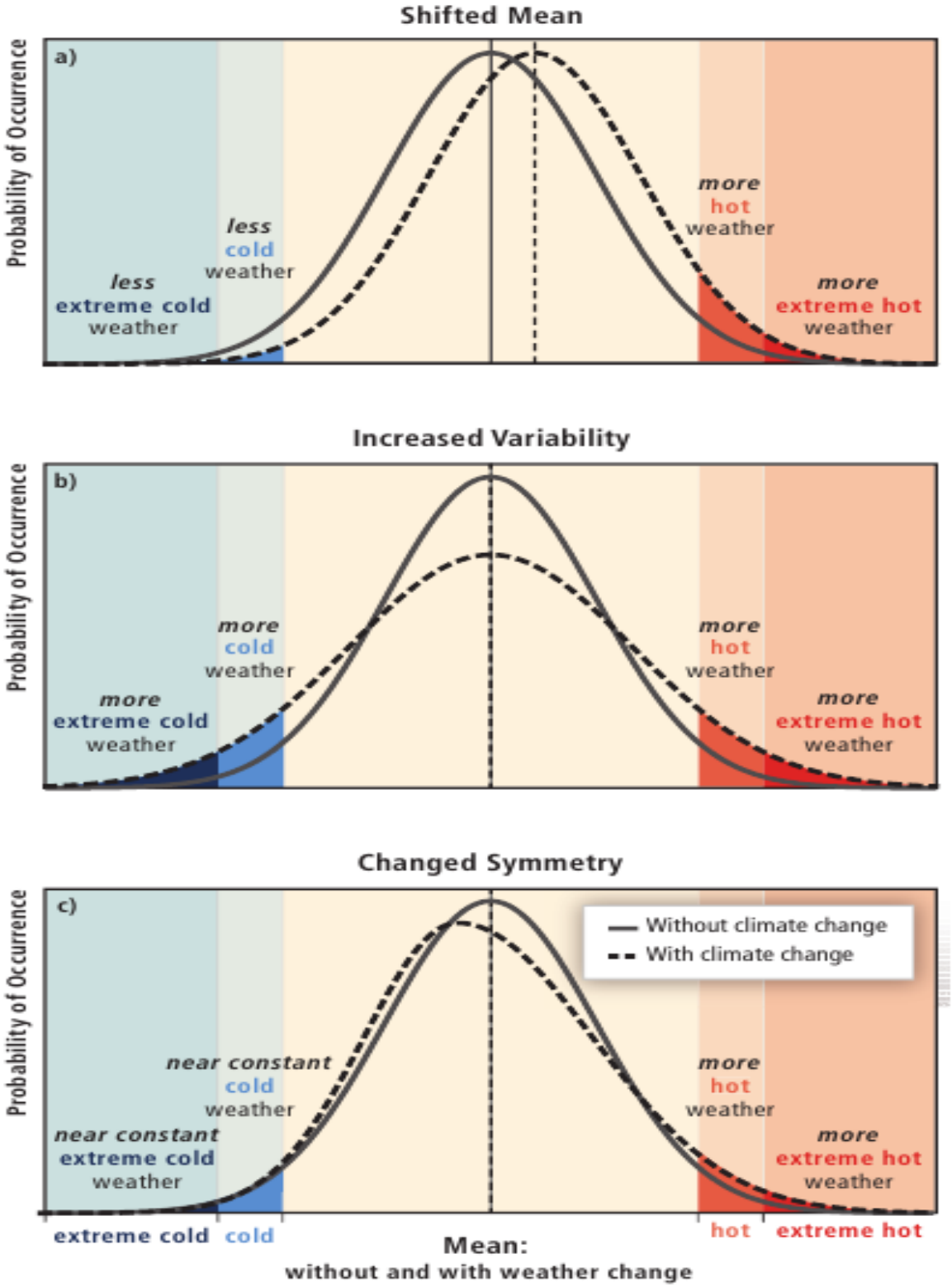


† Significant is defined here as more than 40%.

‡ Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

Extreme events

Effect of change in temperature on extremes



Extreme events

- IPCC: Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)
- Launch&press conference on 28 March (next week)
- Summary for Policymakers and Generic Presentation available at: http://www.ipcc-wg2.gov/SREX/

Literature

IPCC (2007): The Scientific Basis. IPCC WG1 AR4 Report (online: http://www.ipcc.ch/)
Useful and readable summaries:

- Summary for Policymakers (18 pages)
- Frequently Asked Questions (35 pages)
- Technical Summary (74 pages)

Data and plotting:
http://data.giss.nasa.gov/gistemp/ (NASA)
http://woodfortrees.org/ (Paul Clark, software developer)

Real Climate (http://www.realclimate.org)