

Climate and Human History

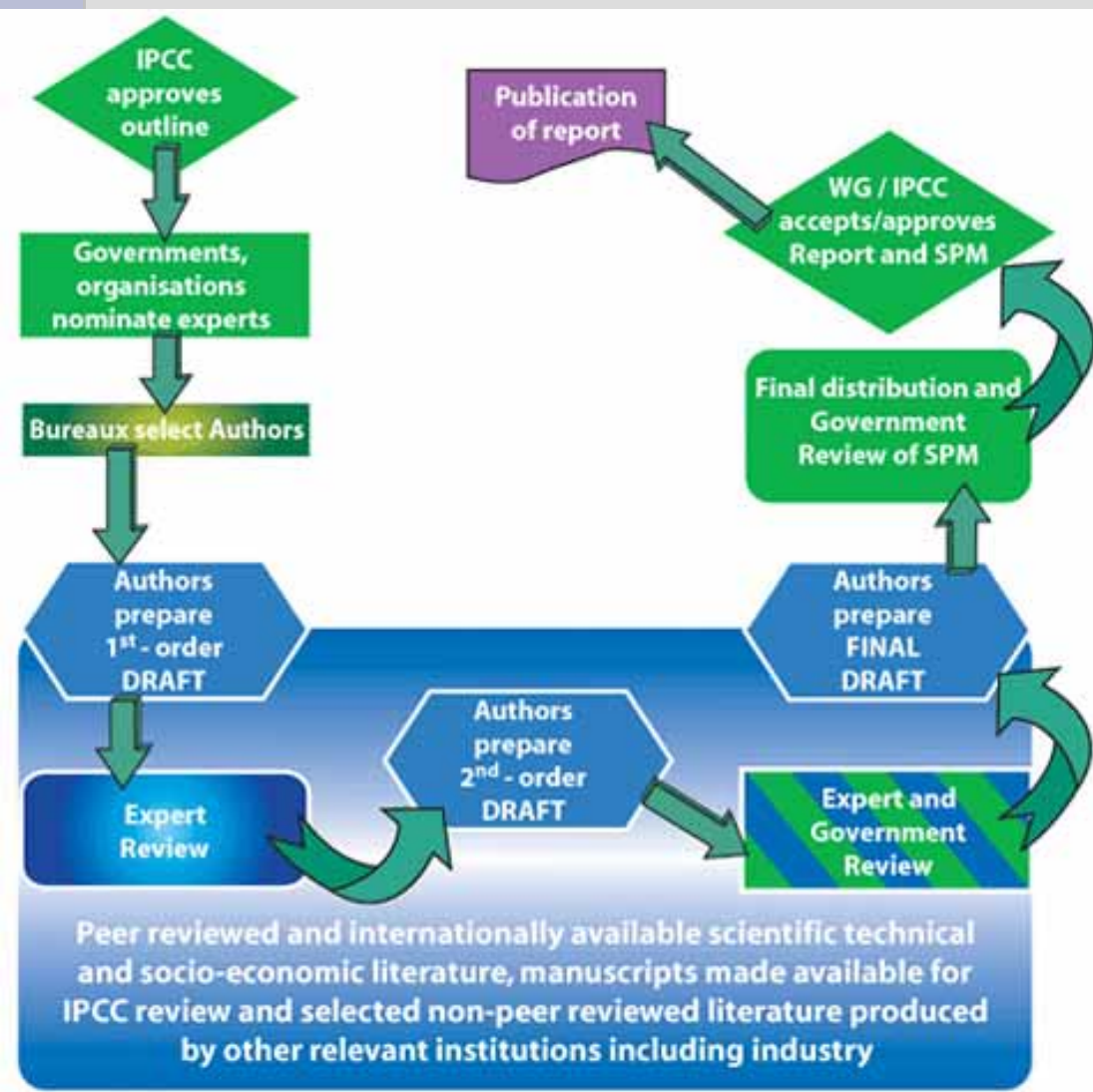
Stephan Matthiesen

1. Climate and climate history
2. The Ice Age
3. Farming and City States
4. The Roman Empire
5. Tang and Maya in the 10th century
6. Mediaeval Optimum and Little Ice Age
7. El Niño through the ages
8. Miscellaneous topics
9. Present and future changes
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)



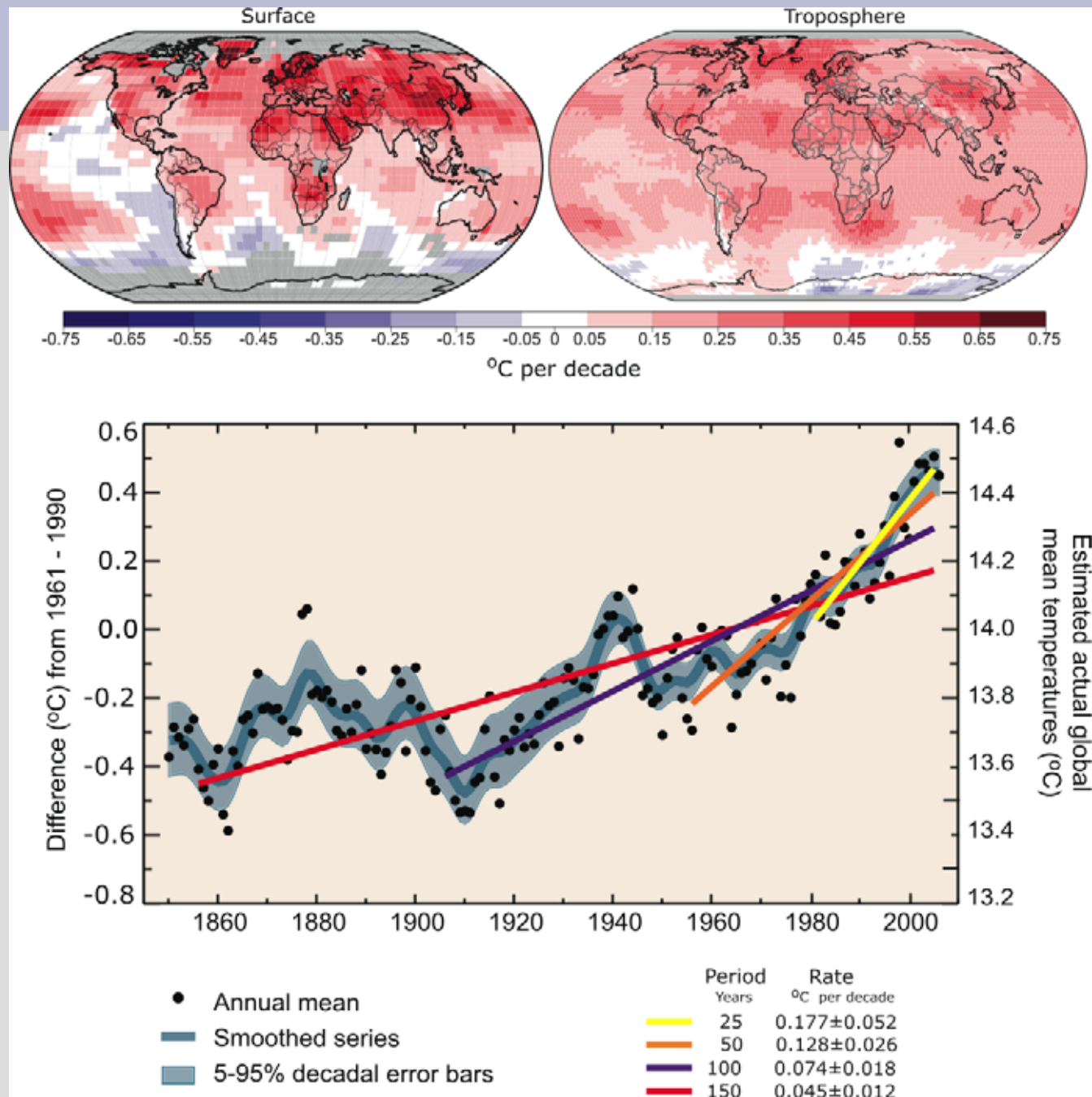
Working Groups:

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

Assessment Reports:

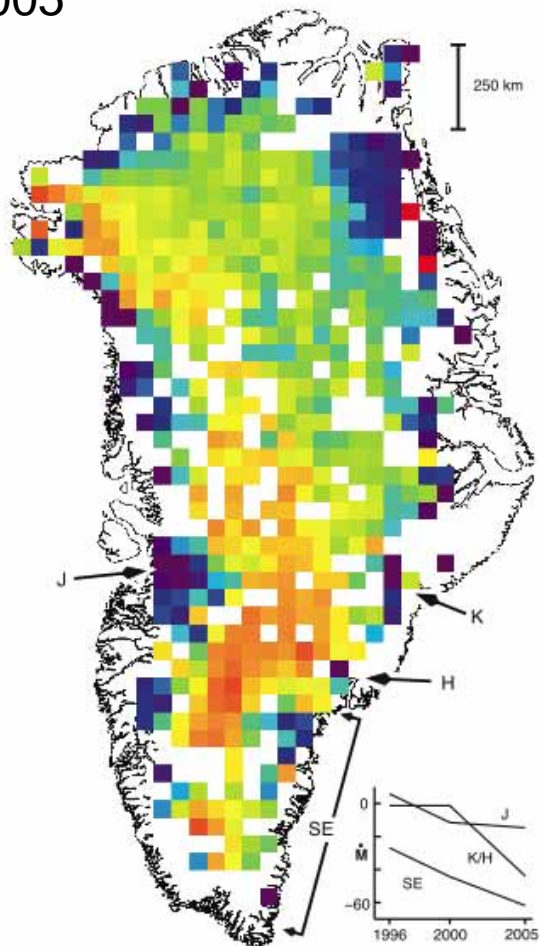
- 1990: FAR
- 1995: SAR
- 2001: TAR
- 2007: AR4

Observations: Temperature

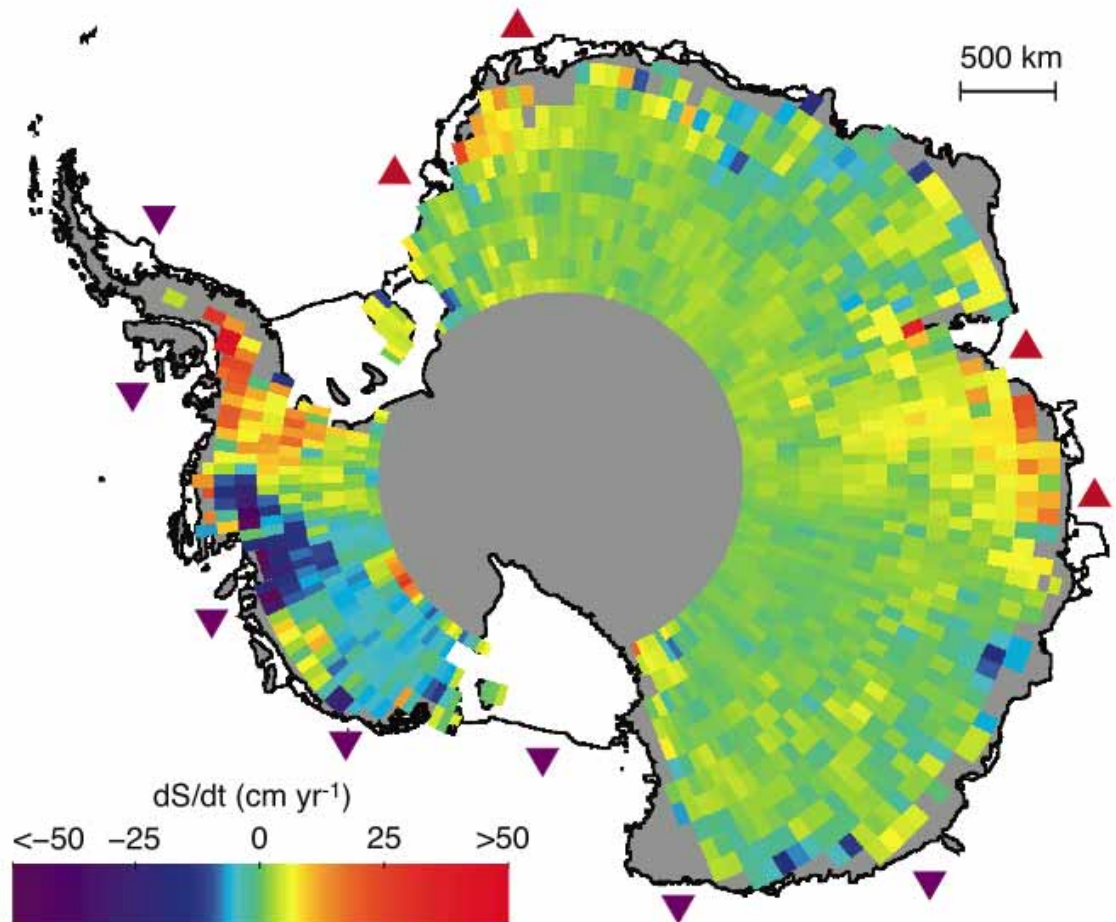


Observations: Ice thickness

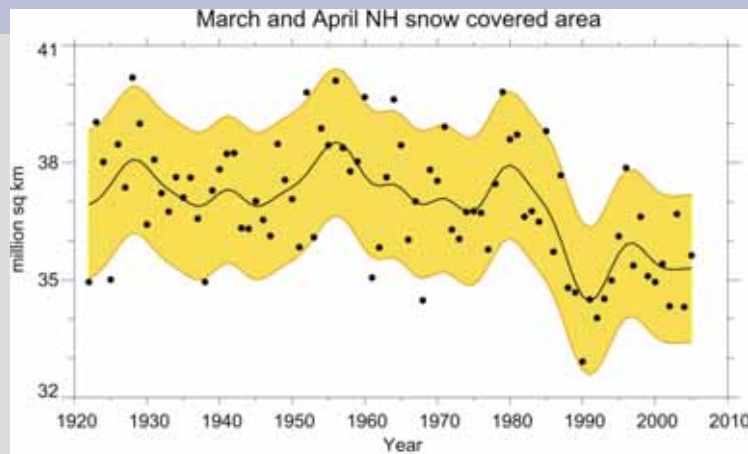
1989-2005



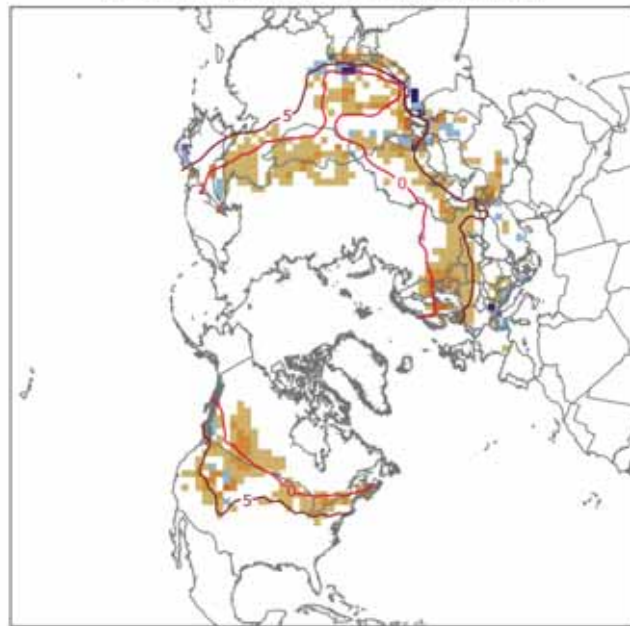
1992-2005



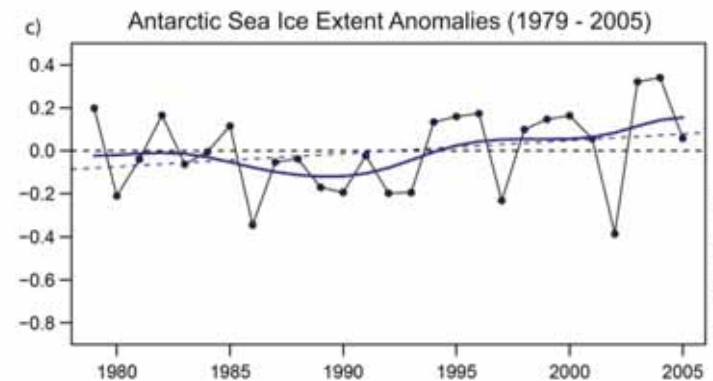
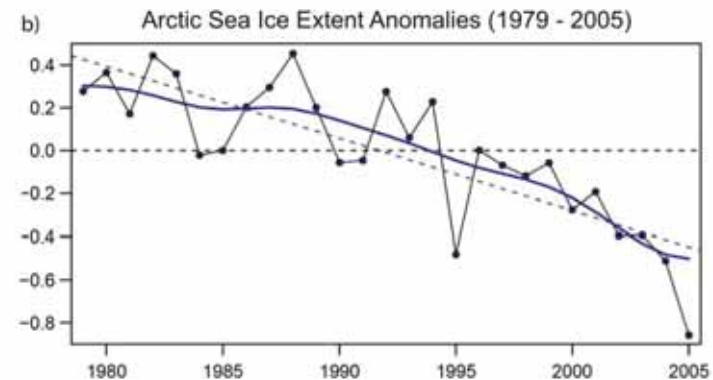
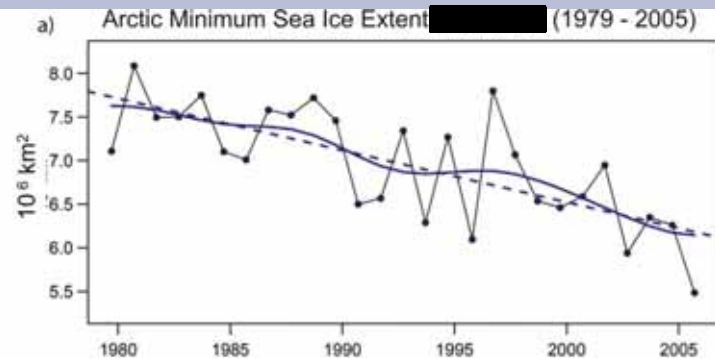
Snow cover and sea ice



March and April Snow Departure
(1988 through 2004) - (1967 through 1987)

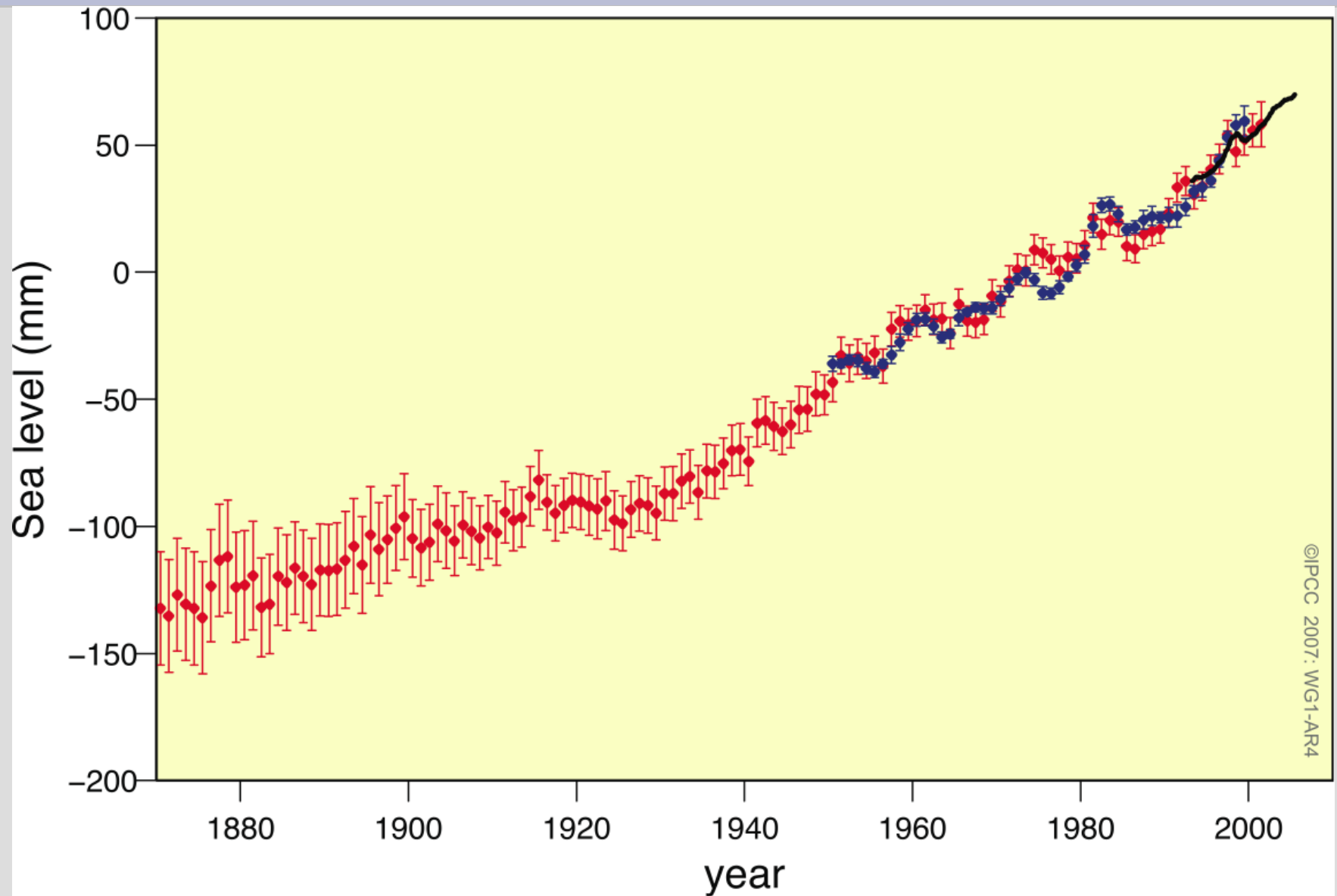


-36 - -26 -25 - -16 -15 - -6 -5 - 5 6 - 15 16 - 25 26 - 38

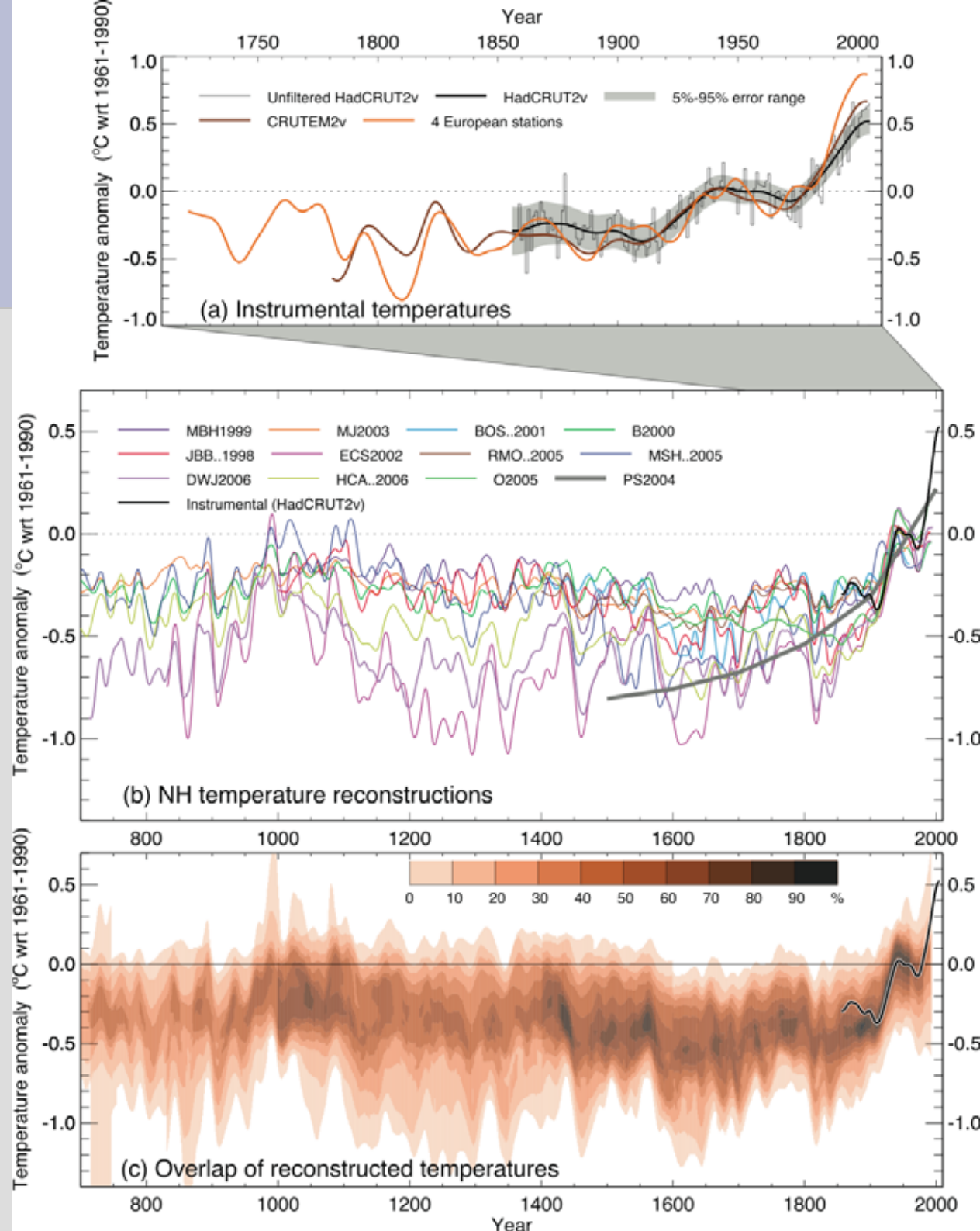


©IPCC 2007: WG1-AR4

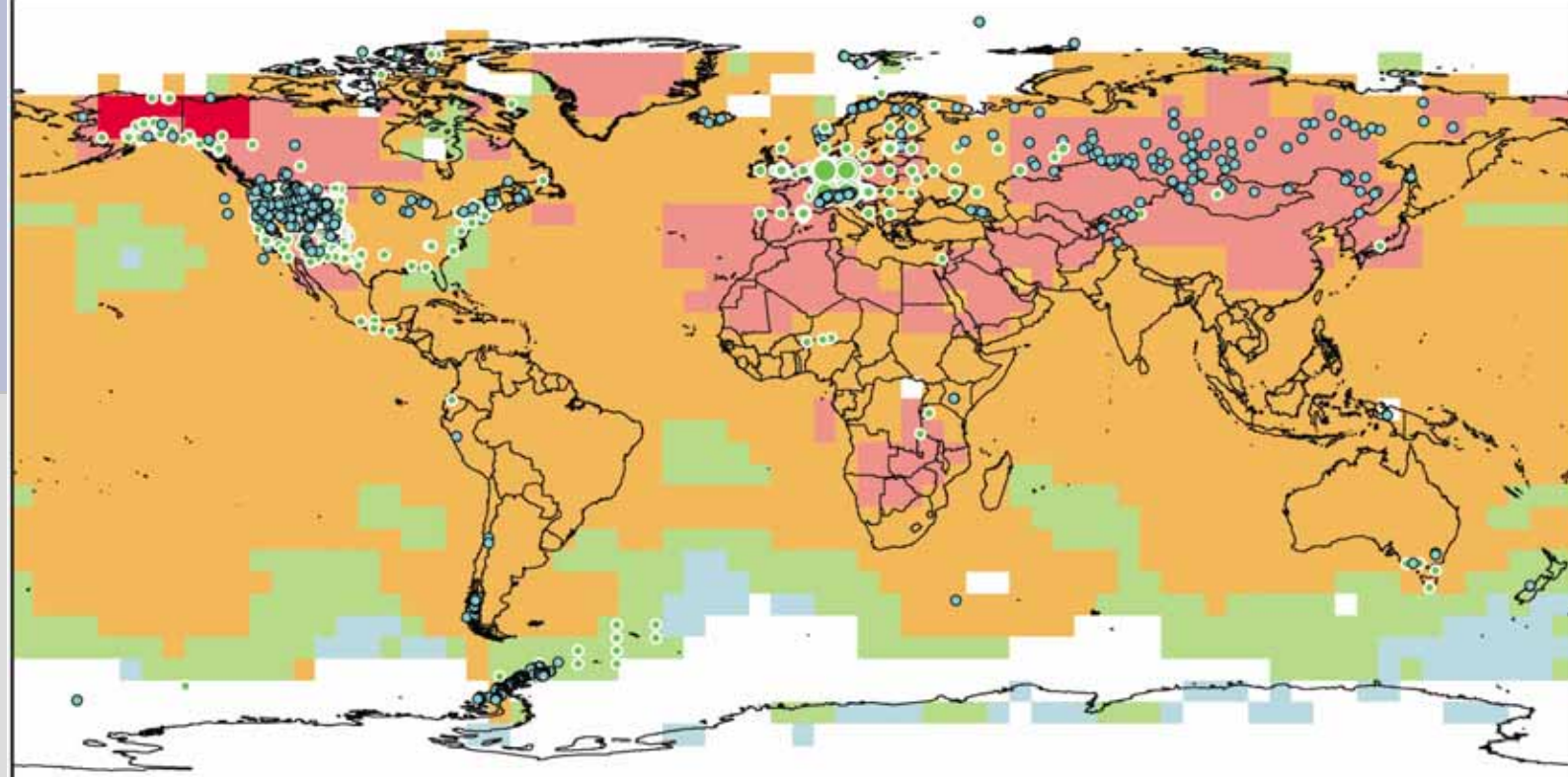
Sea level



Observations of recent and past changes



Observed biological and physical indicators

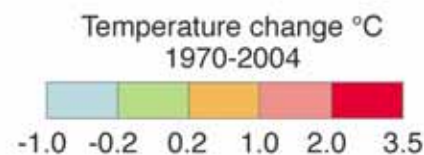


NAM	LA	EUR ^{28,115}	AFR	AS	ANZ	PR*	TER ^{28,586}	MFW**	GLO ^{28,671}
355 455	53 5	119	5 2	106 8	6 0	120 24	764	1 85	765
94% 92%	98% 100%	94% 89%	100% 100%	96% 100%	100% -	91% 100%	94% 90%	100% 99%	94% 90%

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



Physical Biological

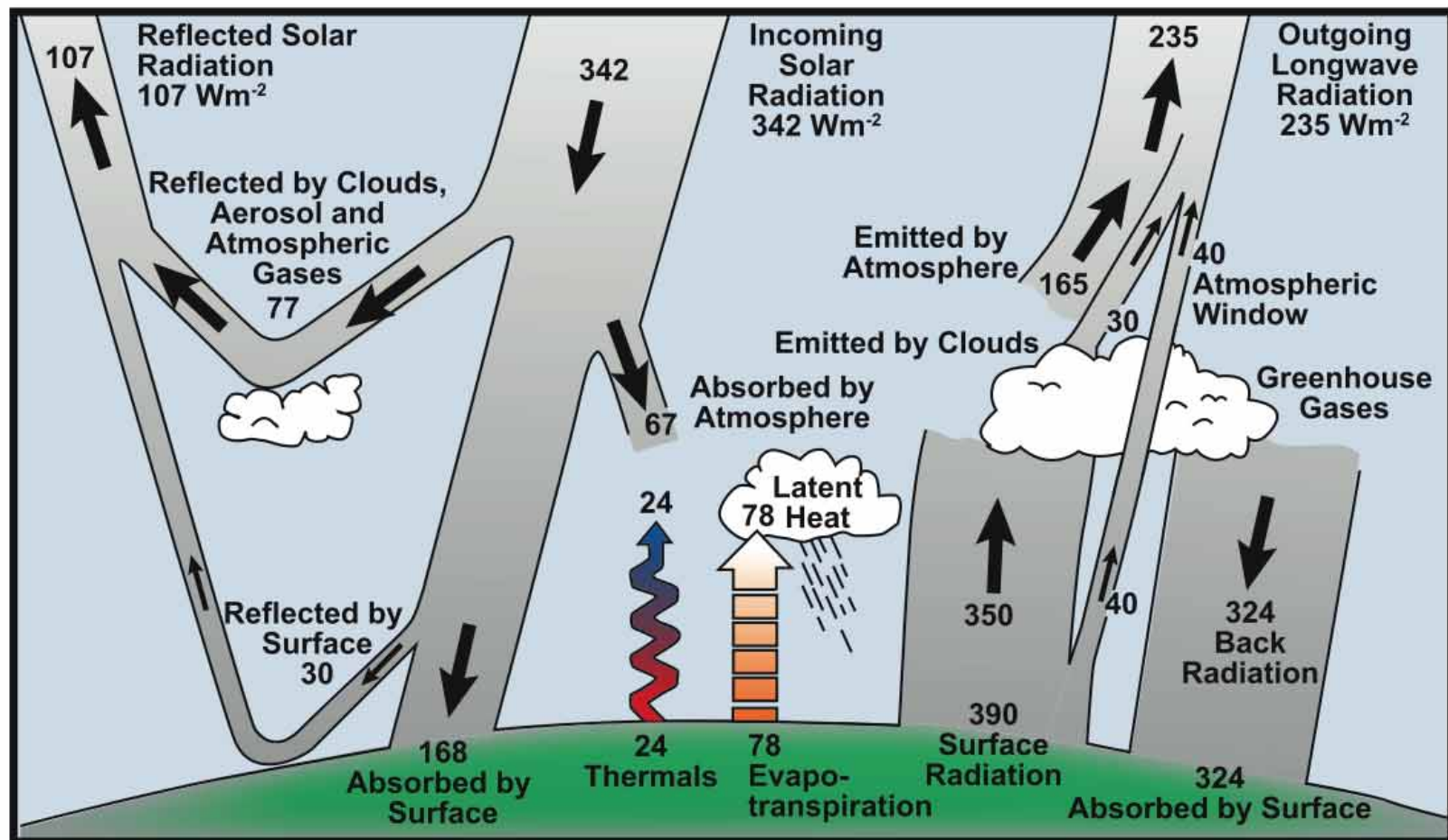
Physical	Biological
Number of significant observed changes	Number of significant observed changes
Percentage of significant changes consistent with warming	Percentage of significant changes consistent with warming

* Polar regions include also observed changes in marine and freshwater biological systems.

** Marine and freshwater includes observed changes at sites and large areas in oceans, small islands and continents.

*** Circles in Europe represent 1 to 7,500 data series.

Greenhouse Effect



Greenhouse Effect

Solar incoming radiation

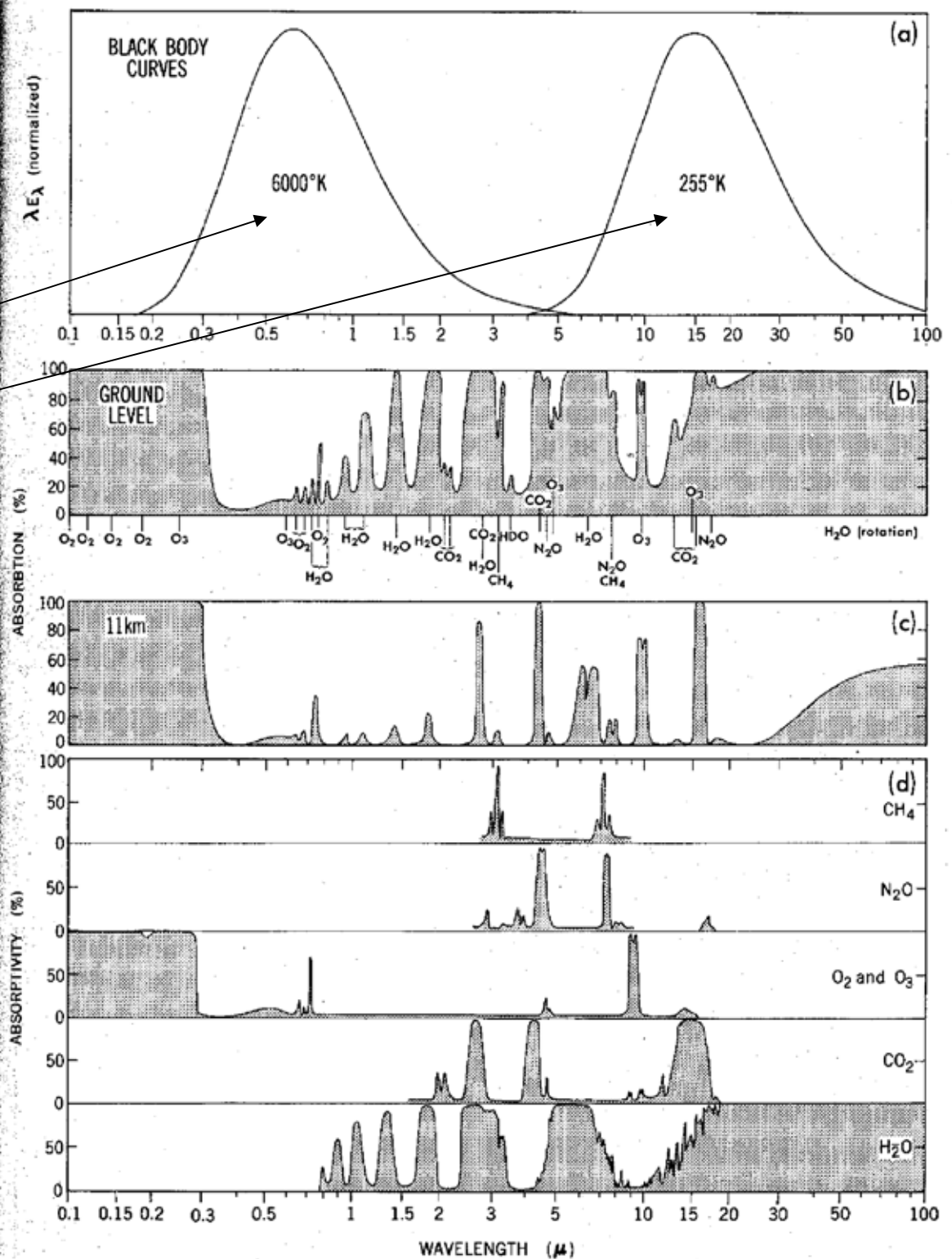
Outgoing thermal rad.

Absorption in Atmosphere

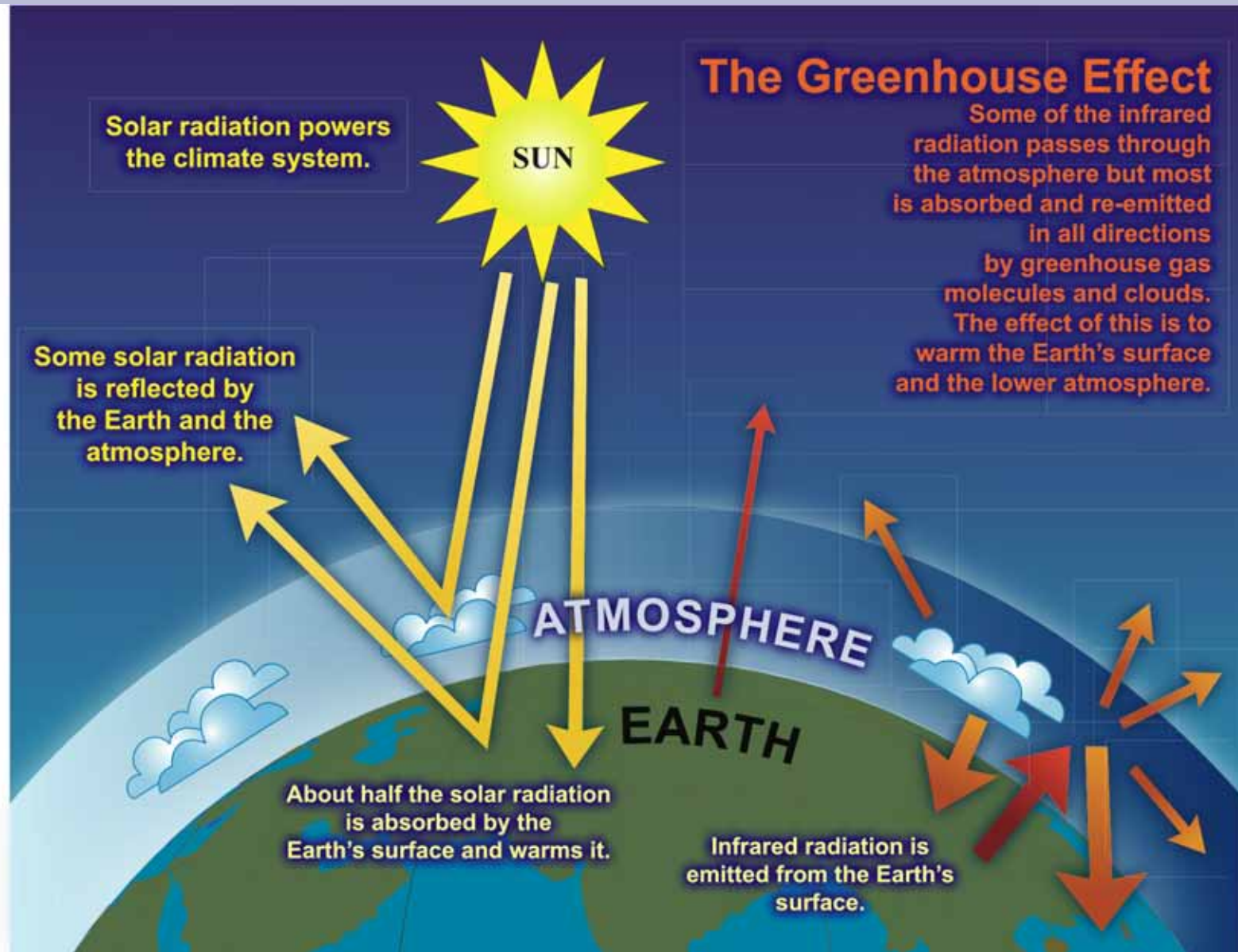
Absorption

CO₂

H₂O



Greenhouse Effect



Discovery of the Greenhouse effect

1820s: Joseph Fourier (theoretical idea)

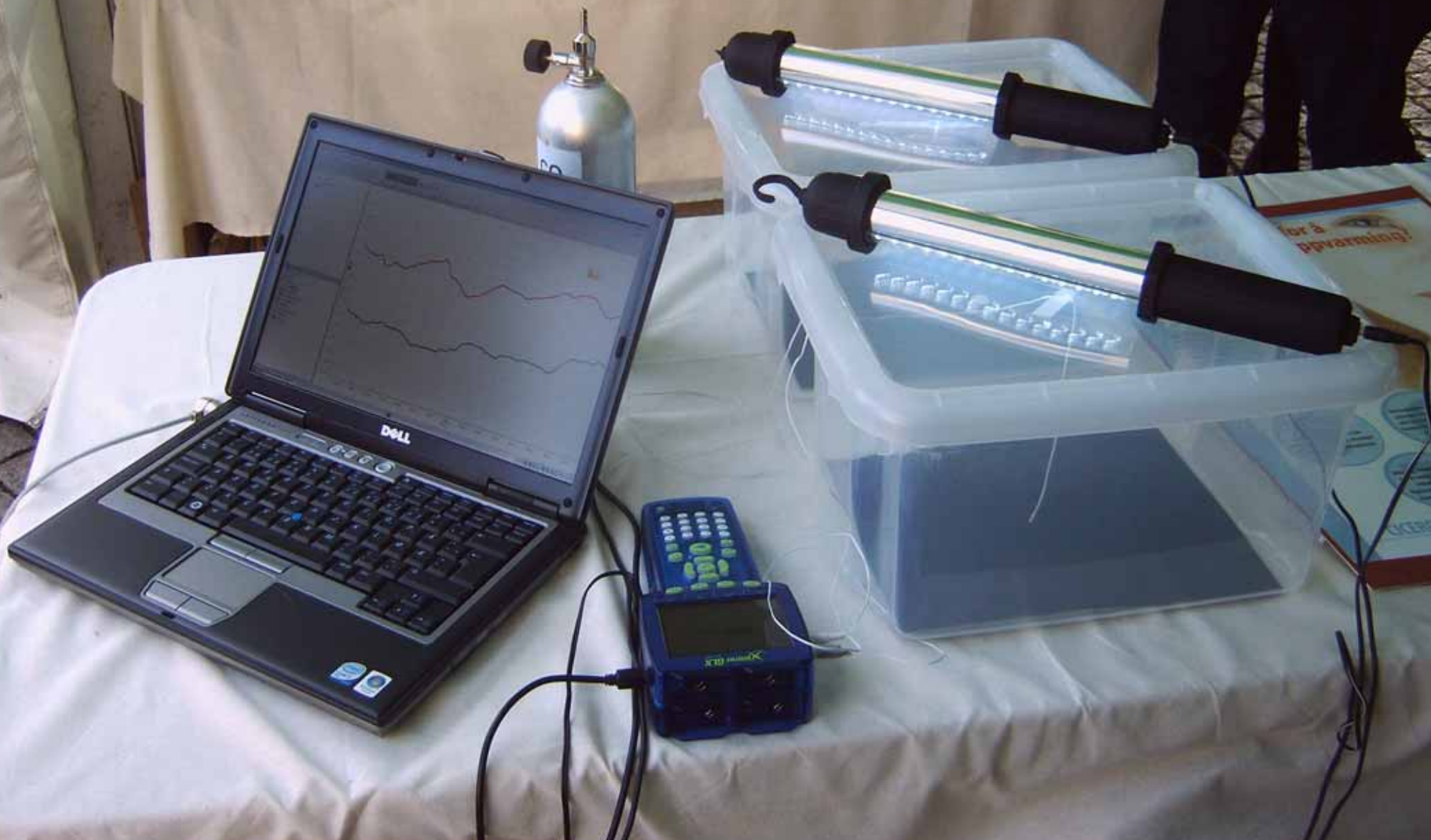
1859: John Tyndall
(experiments with CO_2 and H_2O)

1896 Svante Arrhenius
(interested in ice ages, calculated that cutting CO_2 by half would lower temperature by $4^\circ\text{-}5^\circ\text{C}$)

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



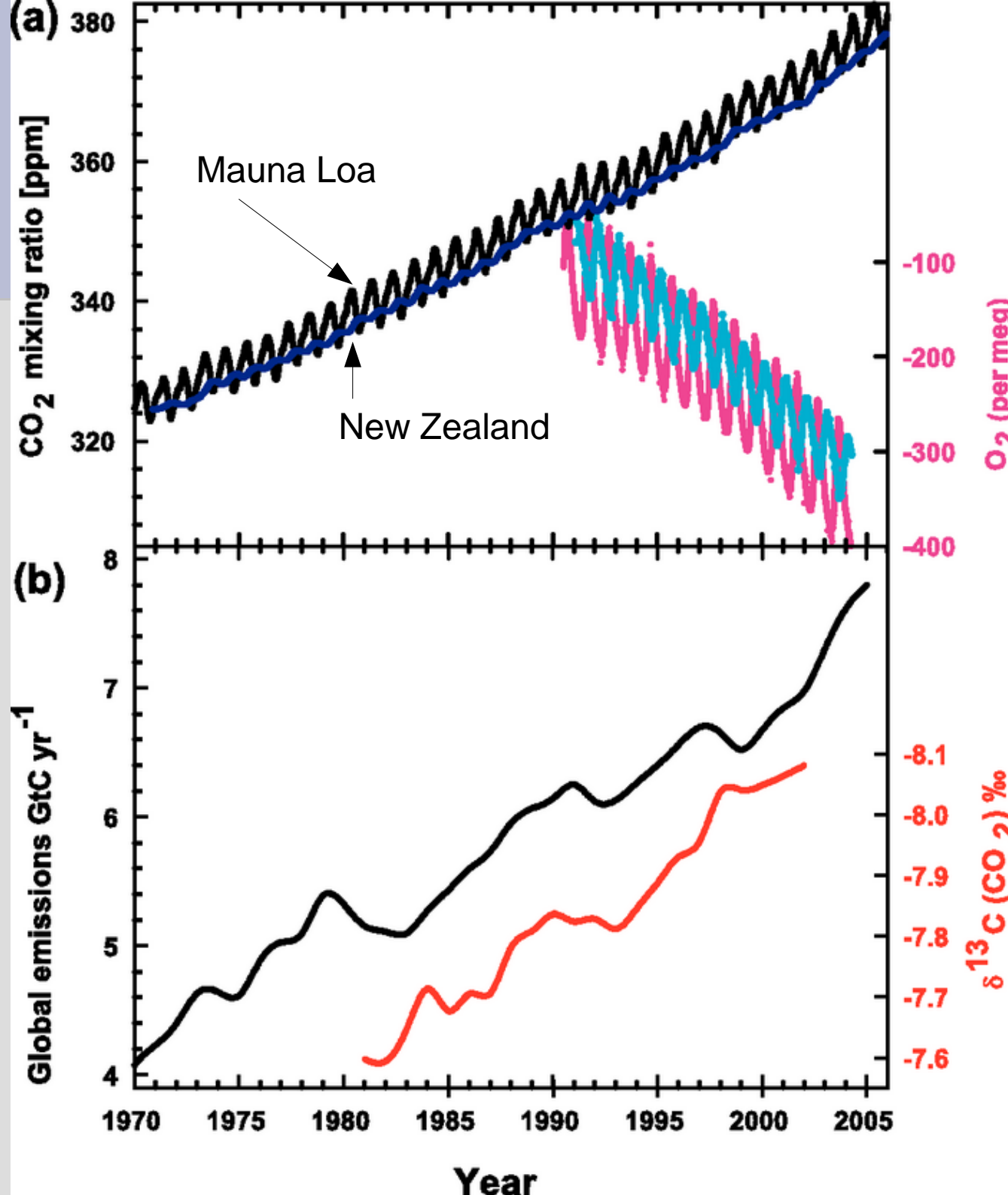
Greenhouse experiment



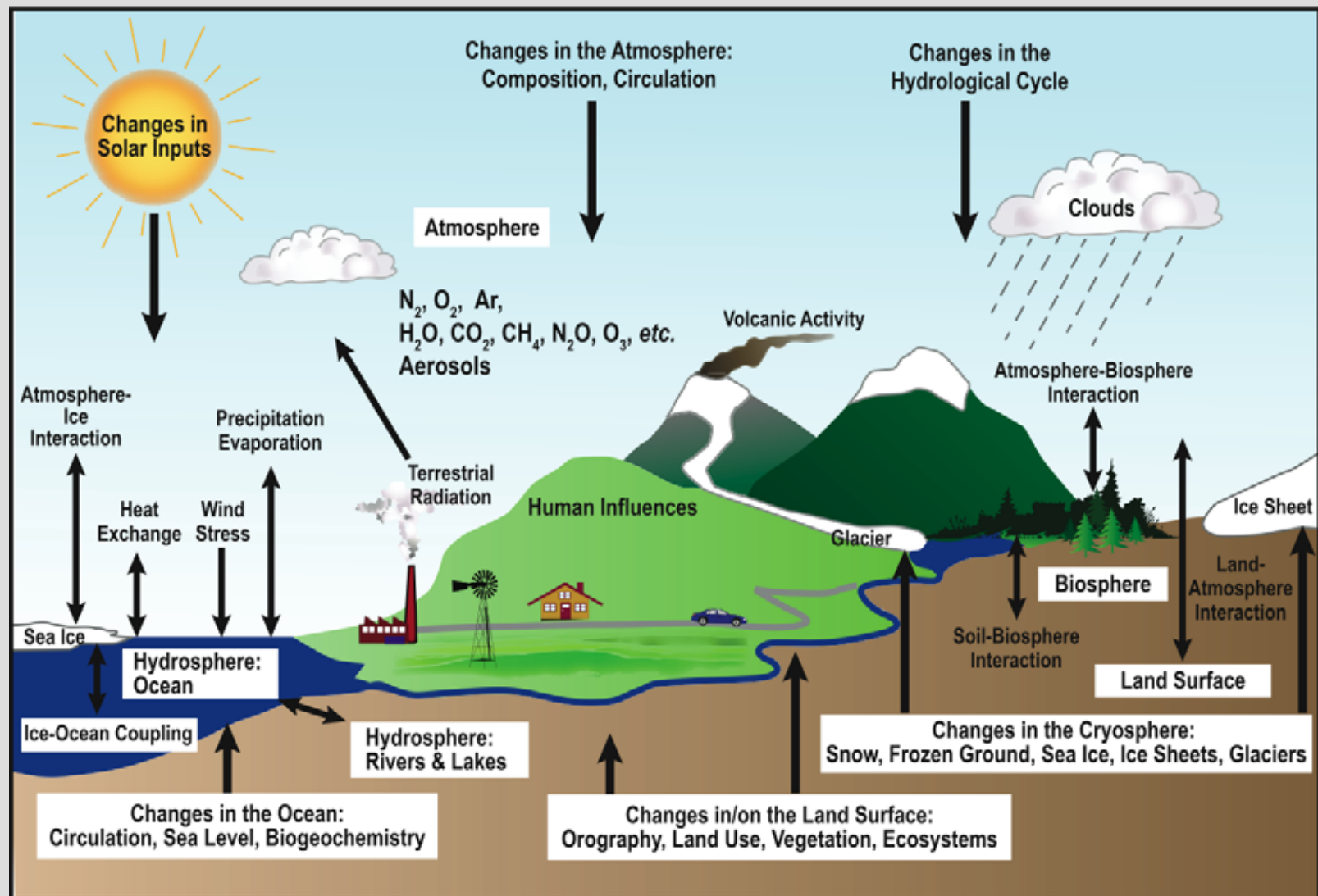
Atmosph. CO₂

Calculated emissions
from fossil fuels and
cement production

AR4 WG1 Fig 2.3

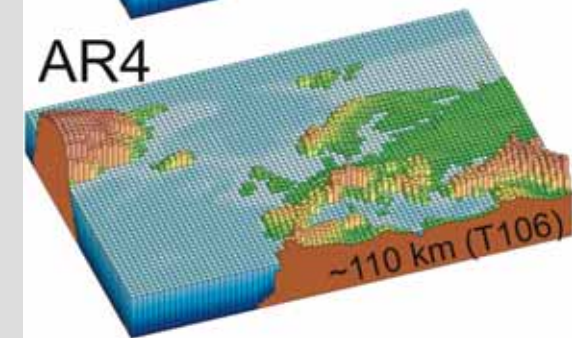
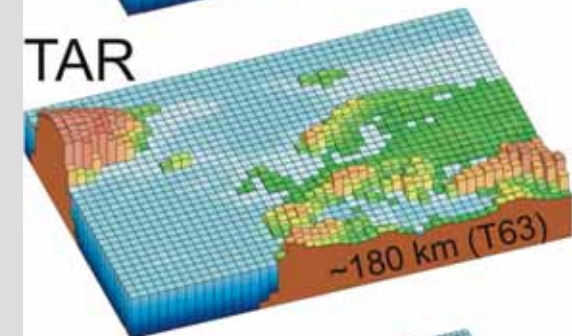
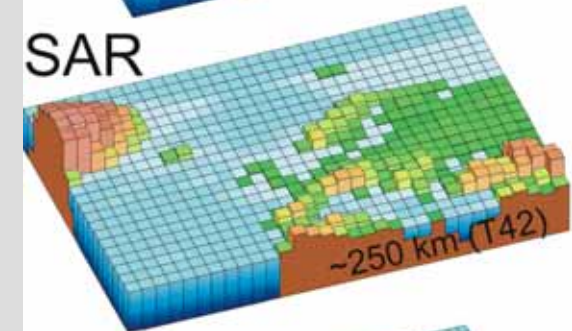
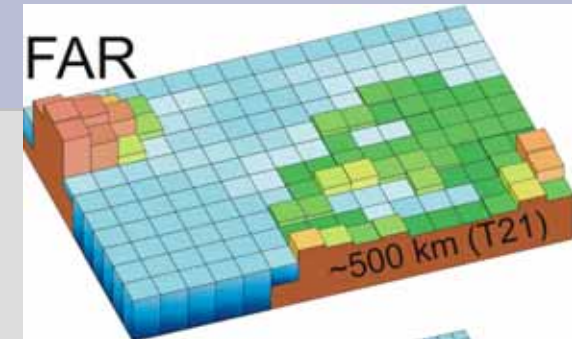
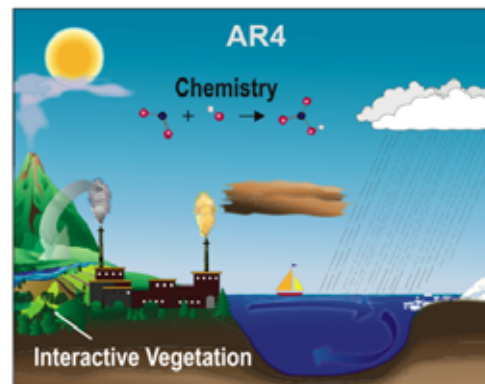
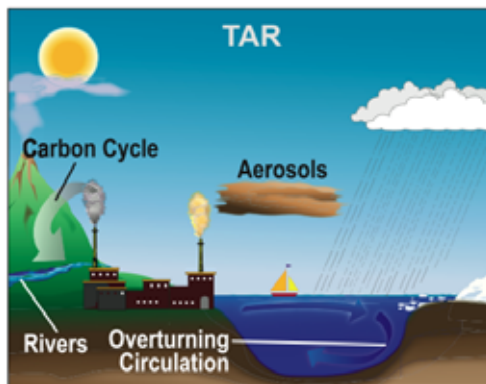
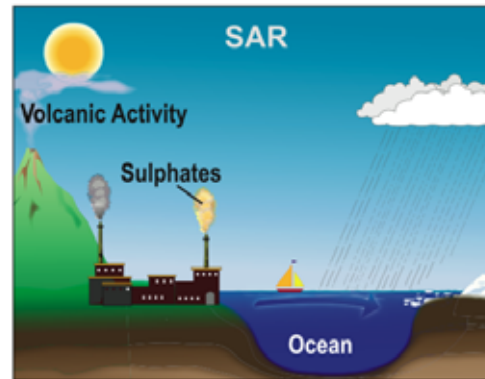
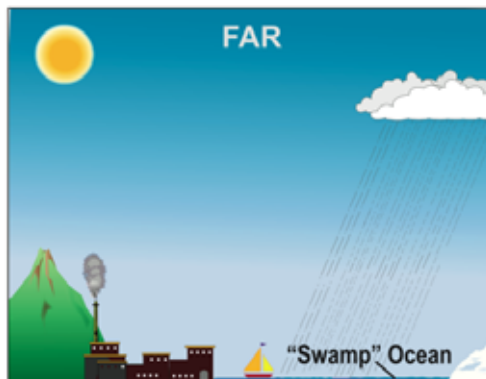
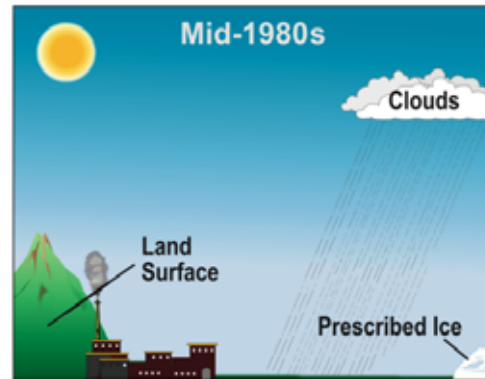
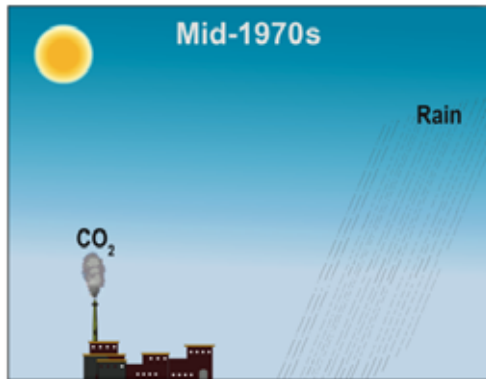


Modelling the Climate

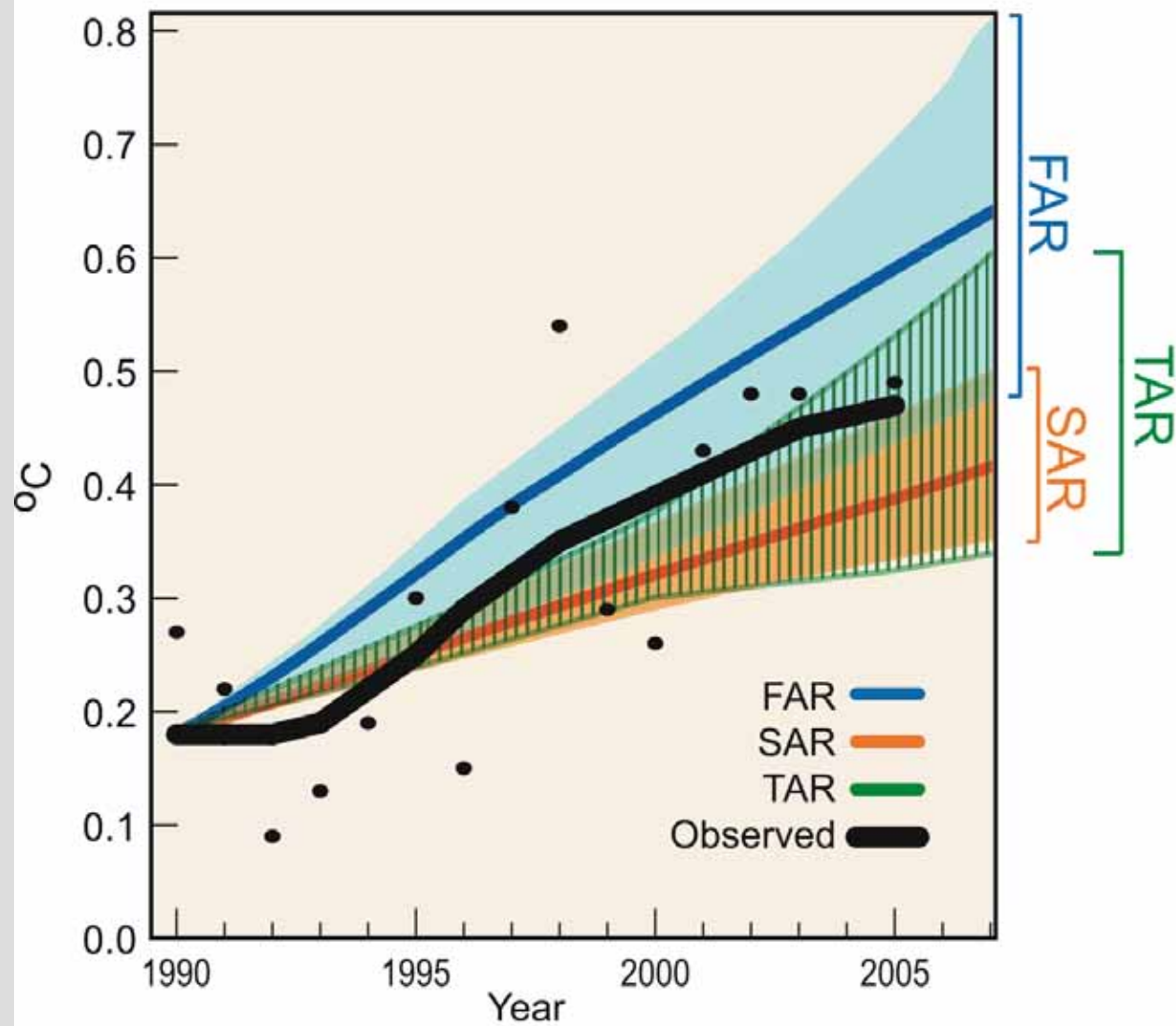


The World in Global Climate Models

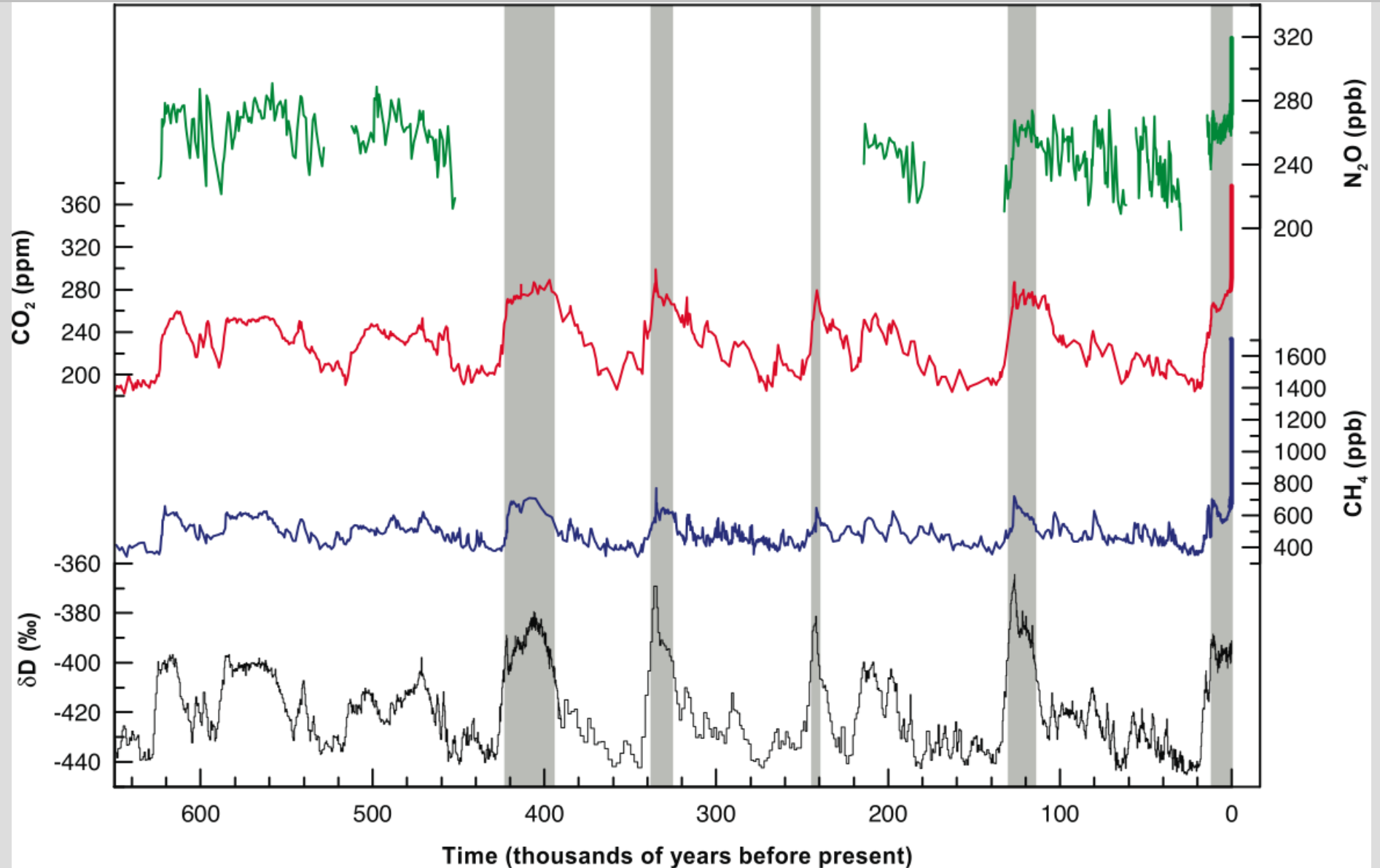
The World in Global Climate Models



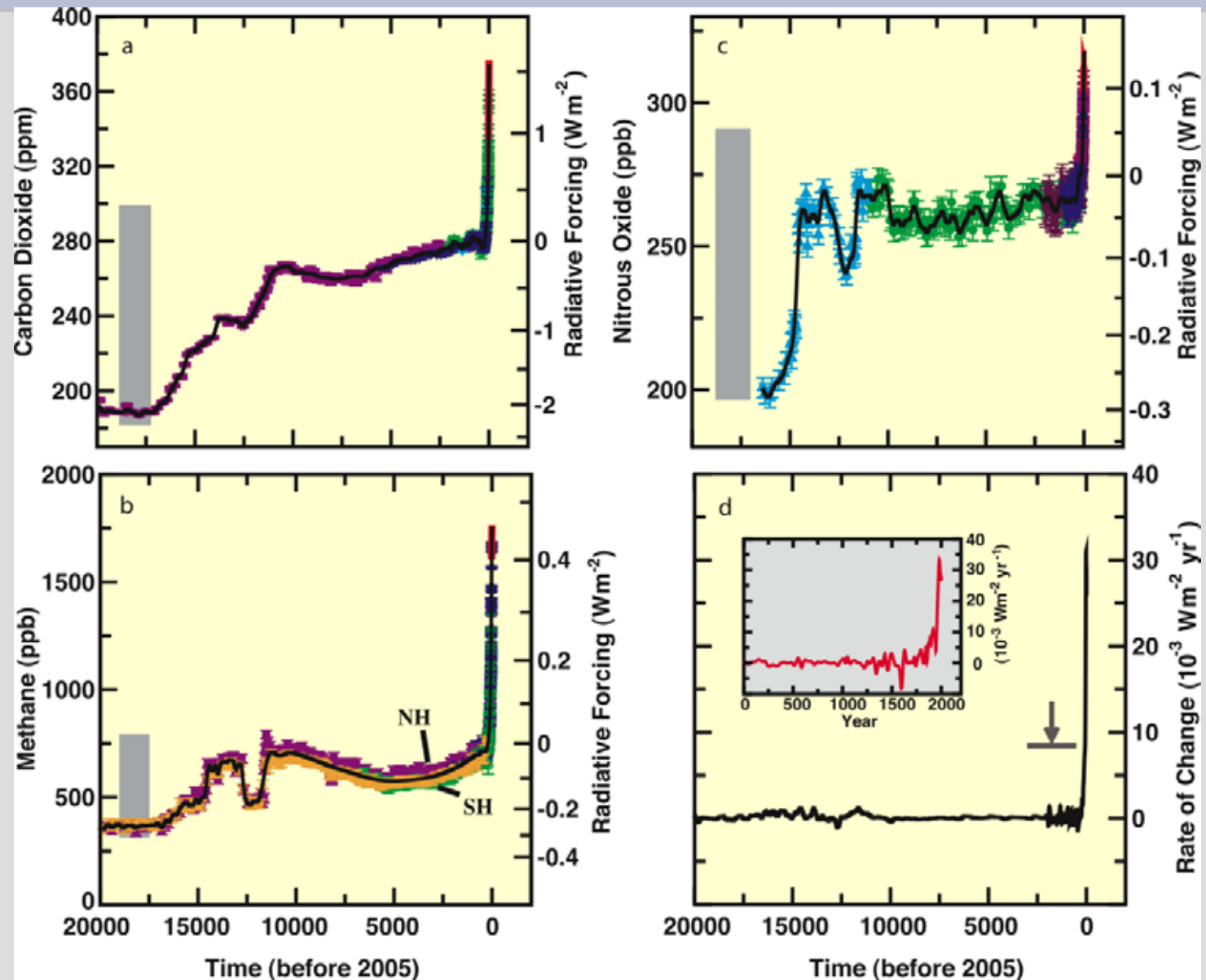
Model validation



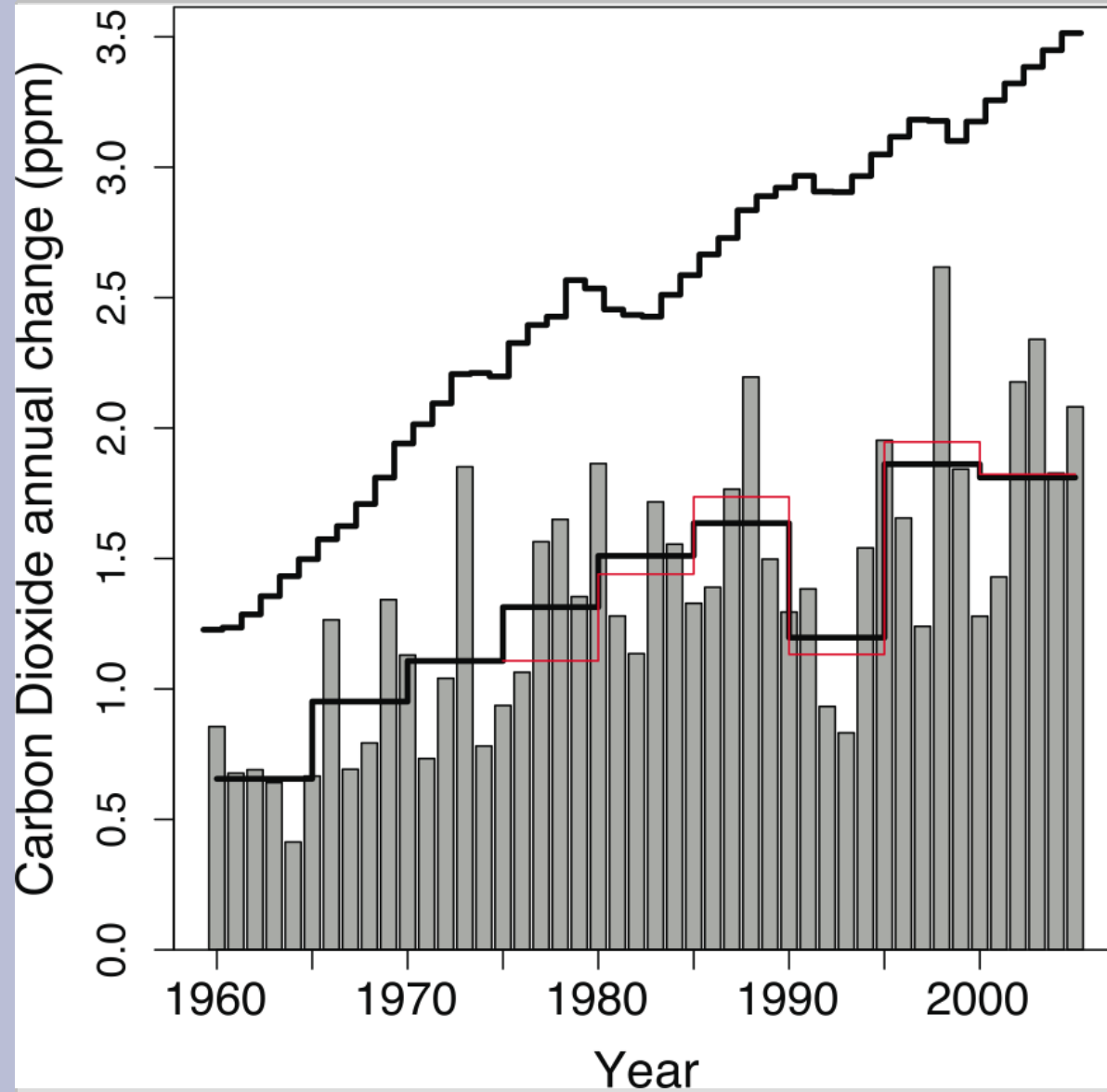
Greenhouse Gases



Greenhouse Gases



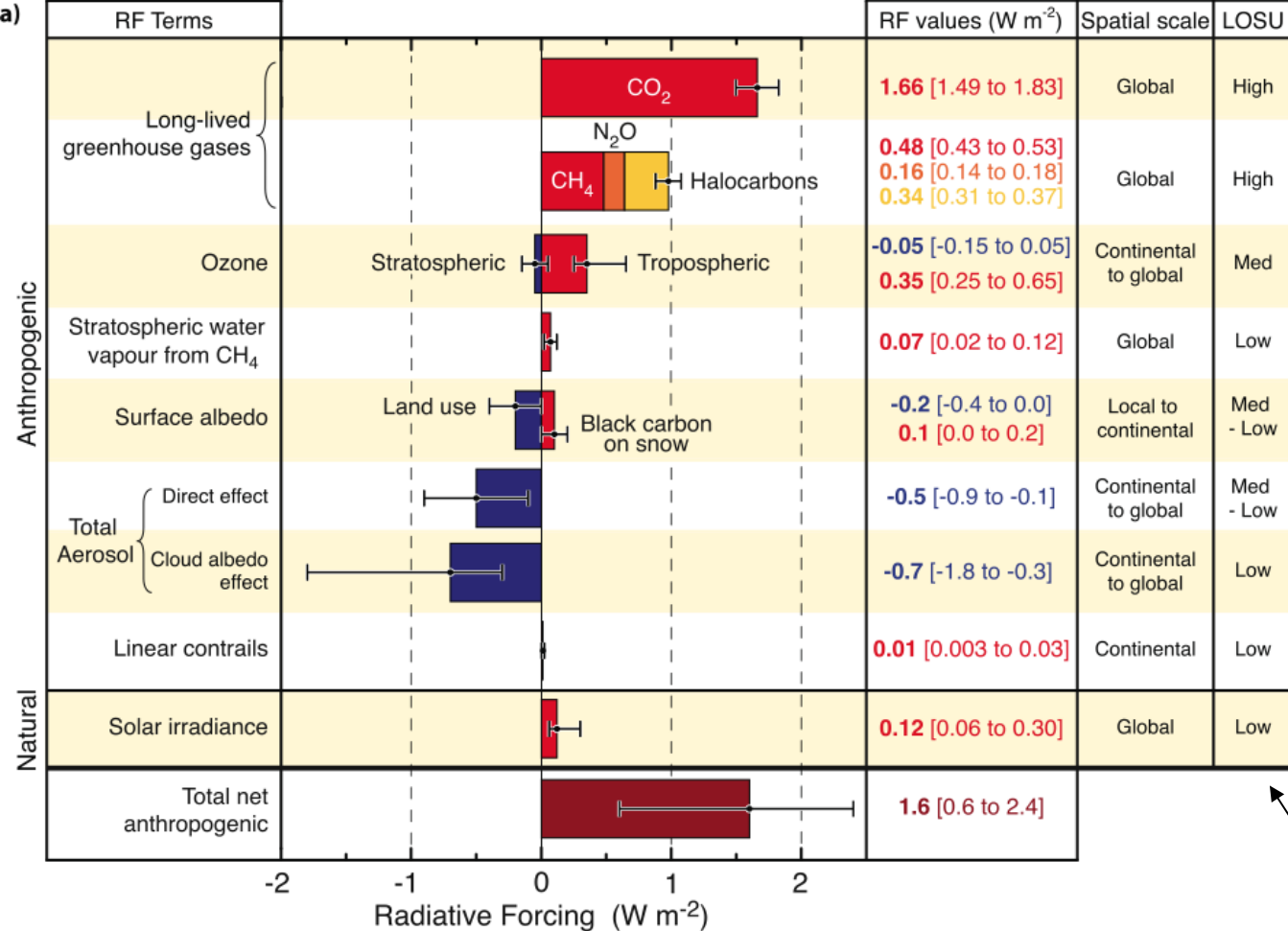
Carbon dioxide



Change expected
from fossil fuel burning

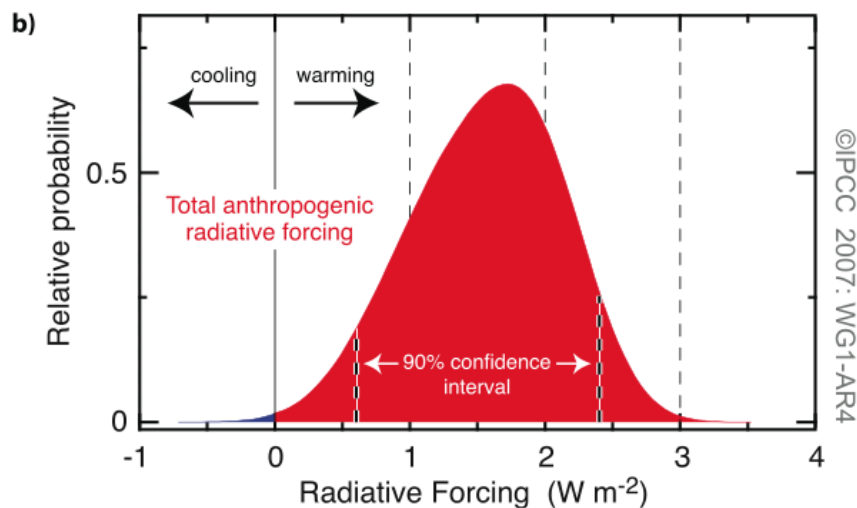
Actual change

Missing Sink?

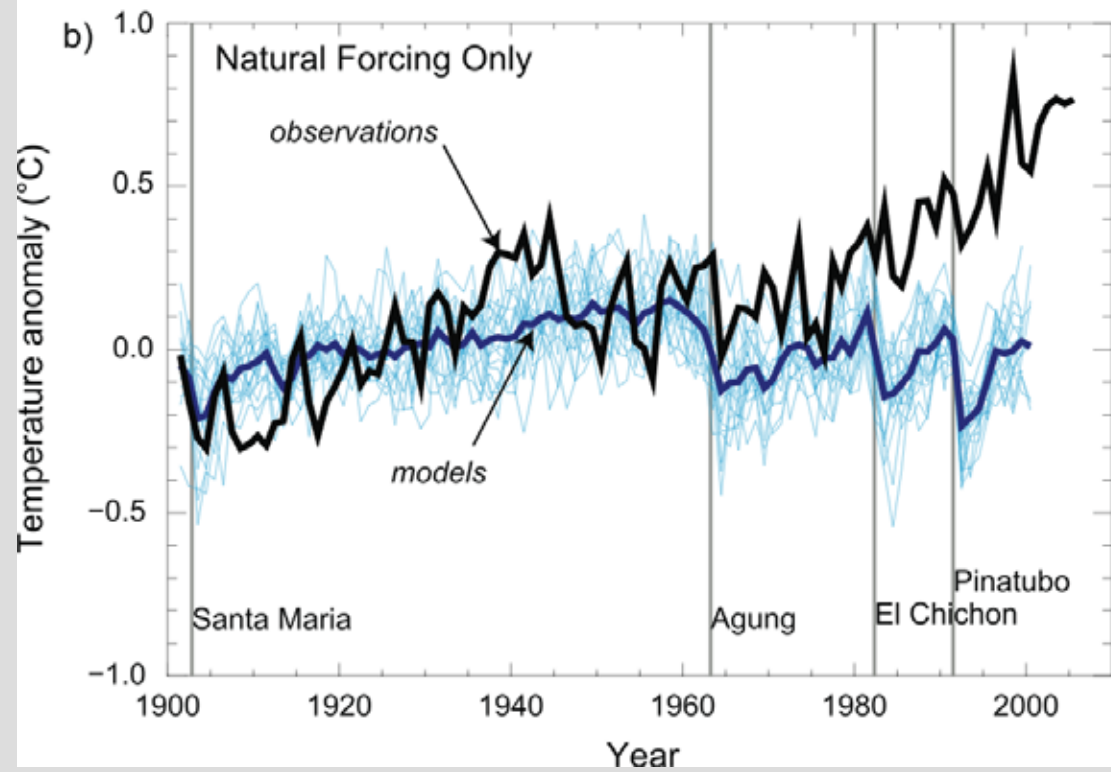
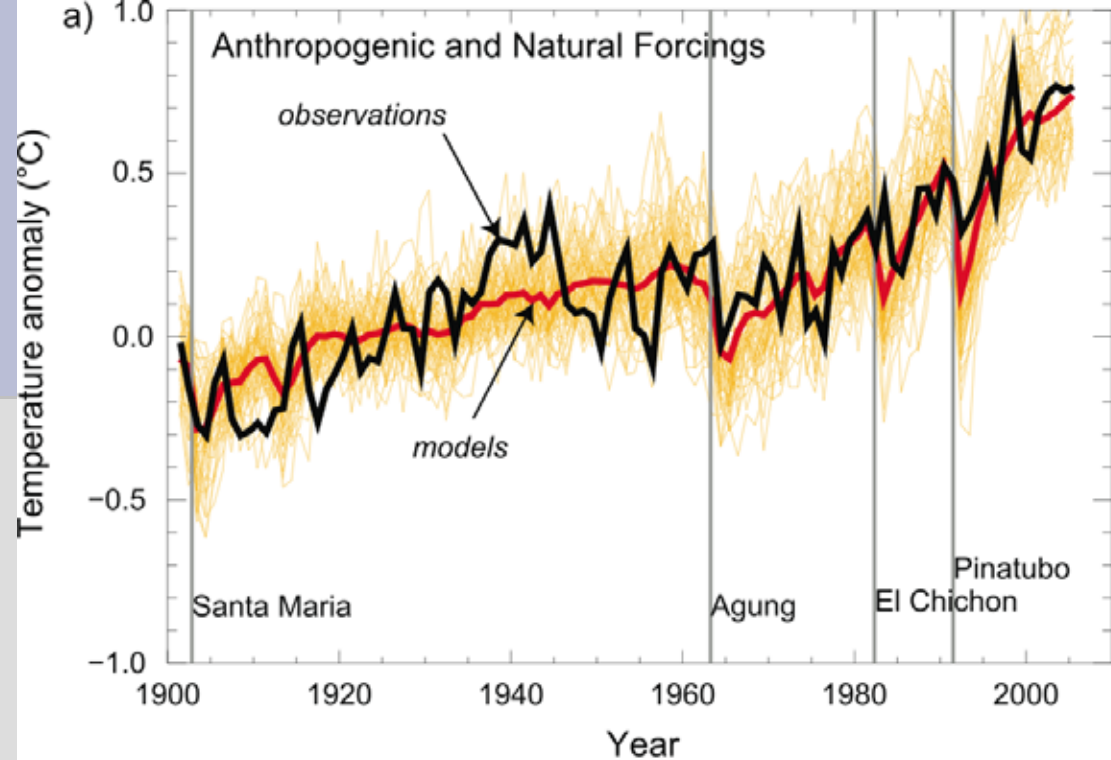


Forcings

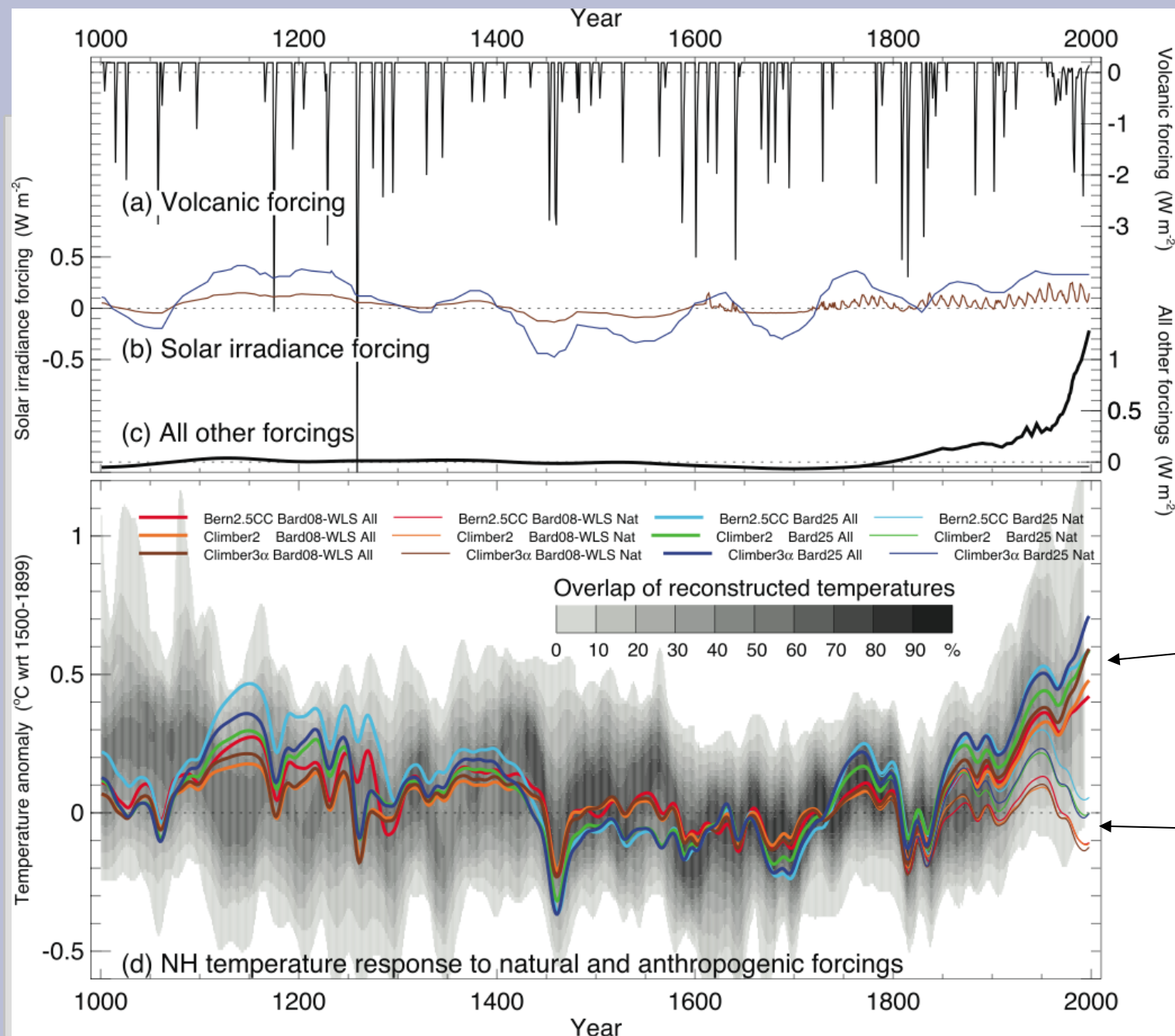
LOSU= Level of Scientific Understanding



Attribution of Climate Change



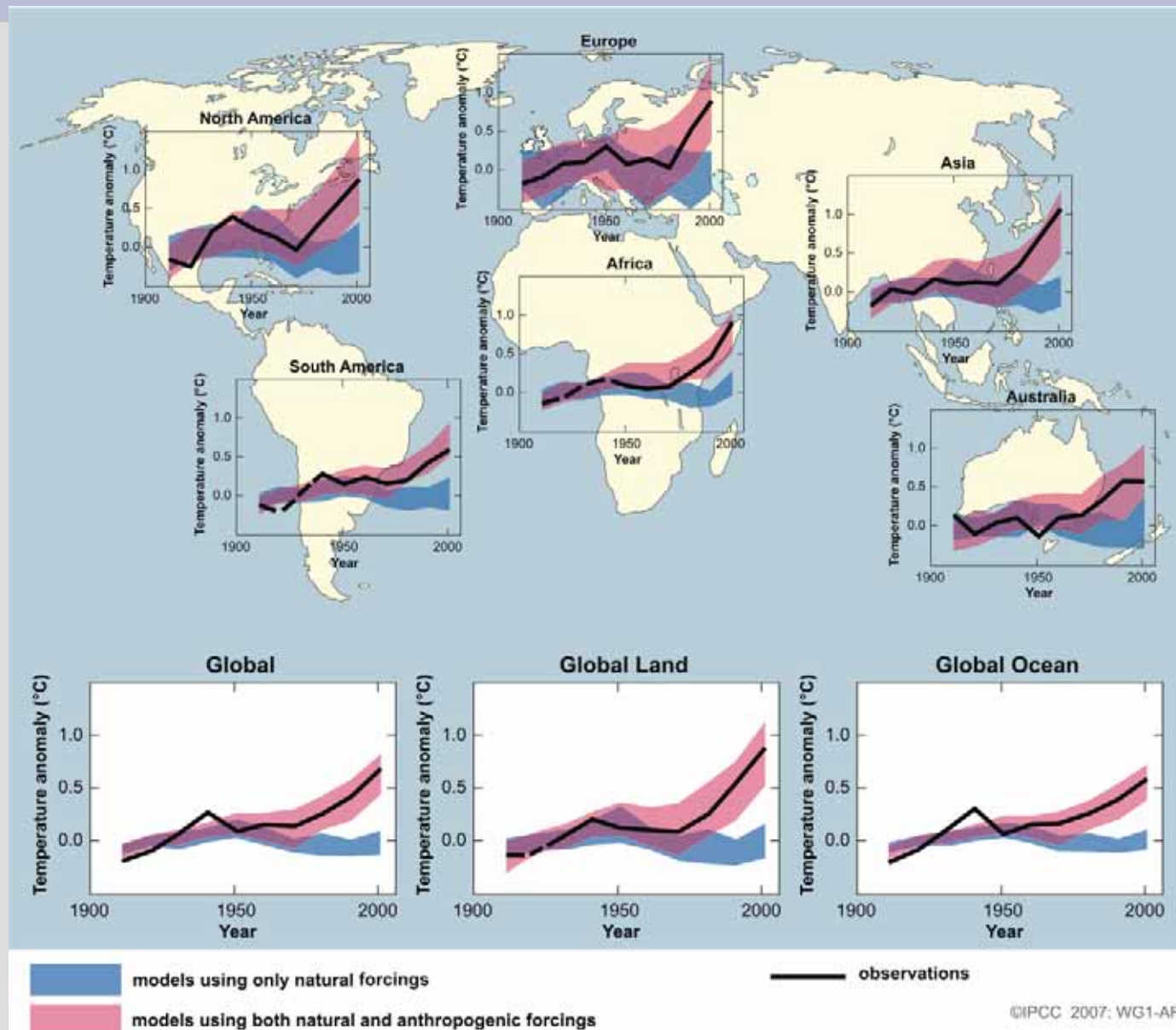
Attribution: natural/anthropogenic



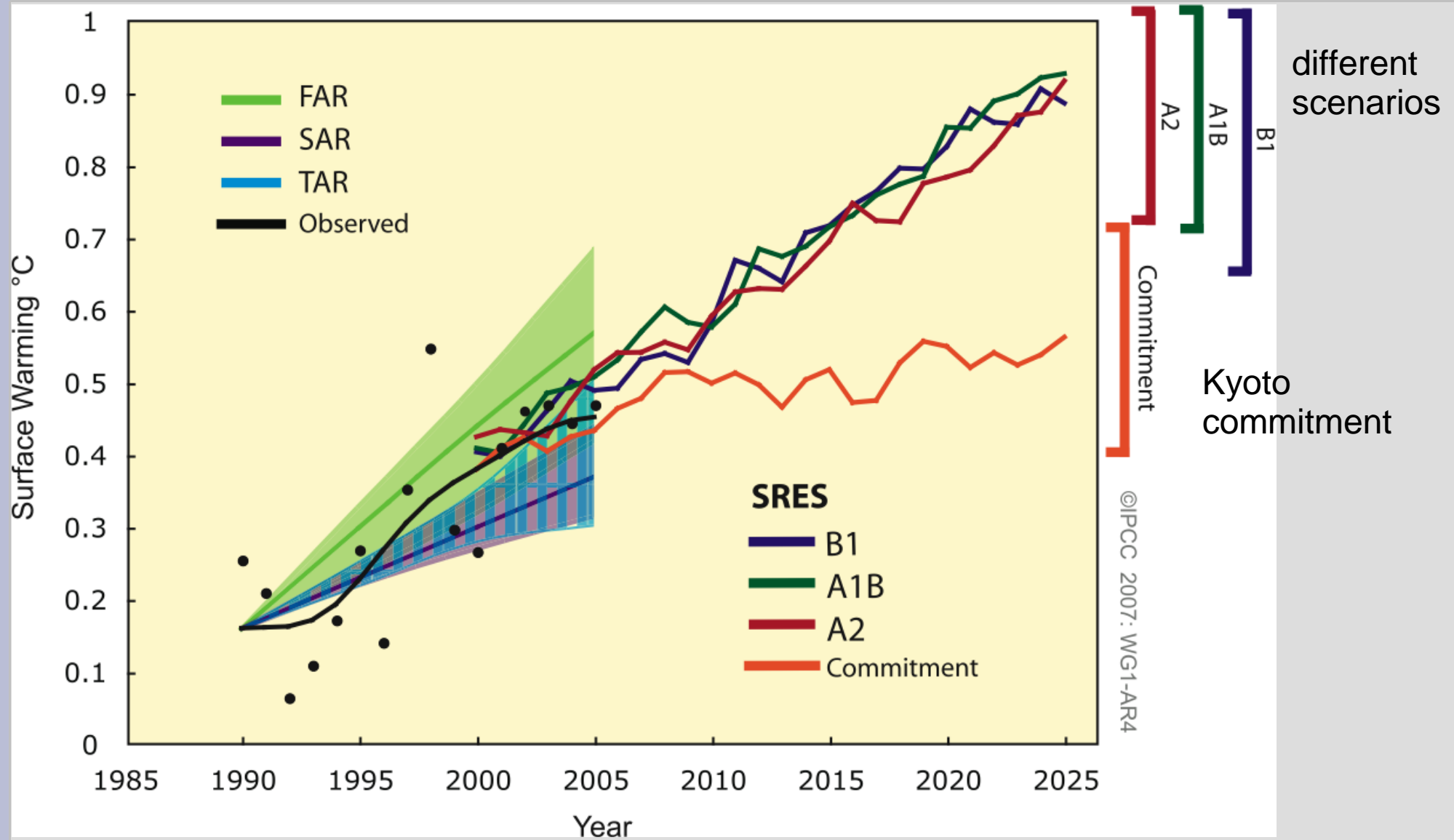
All forcings

Only natural forcings

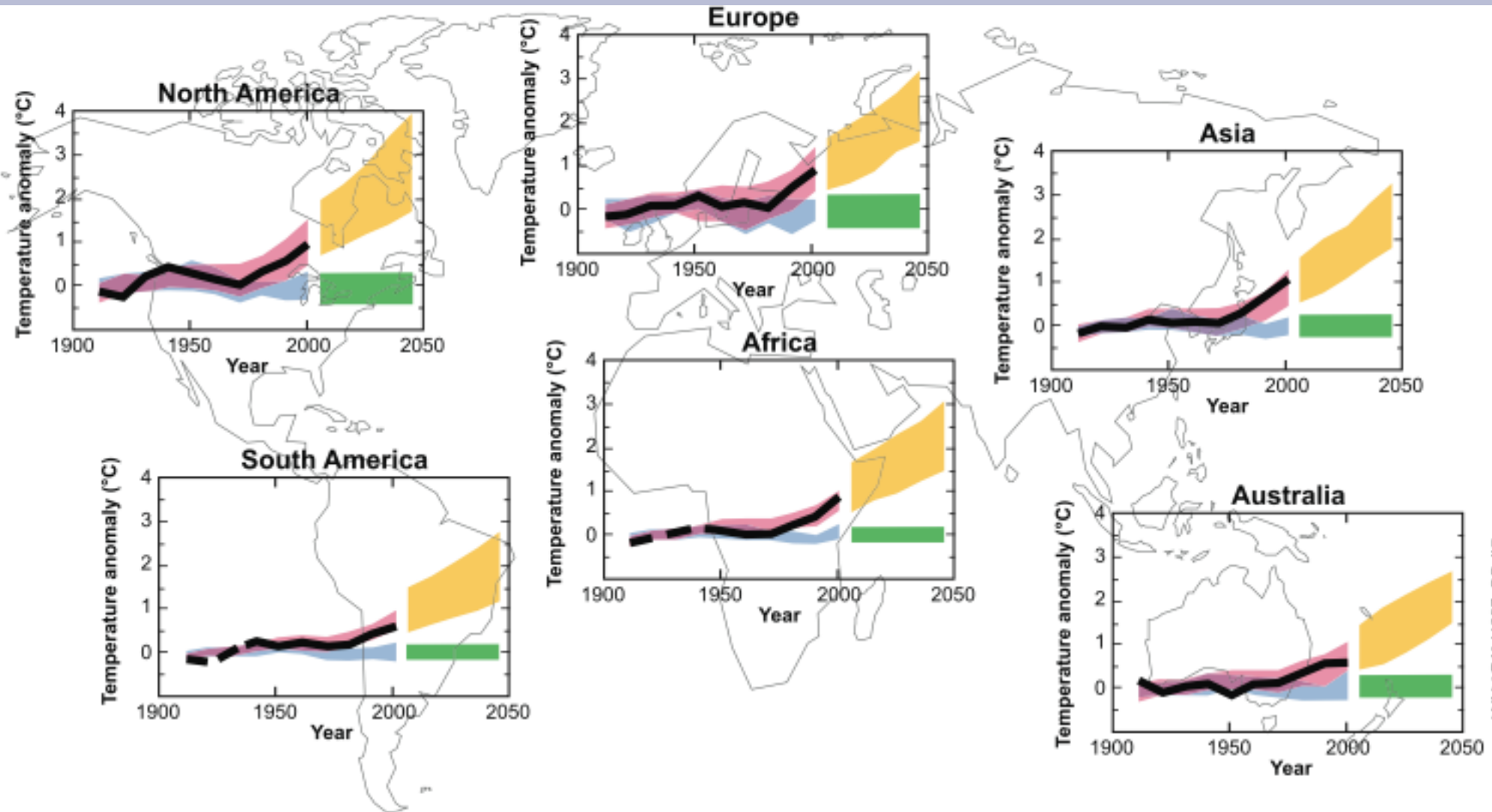
Attribution of Climate Change

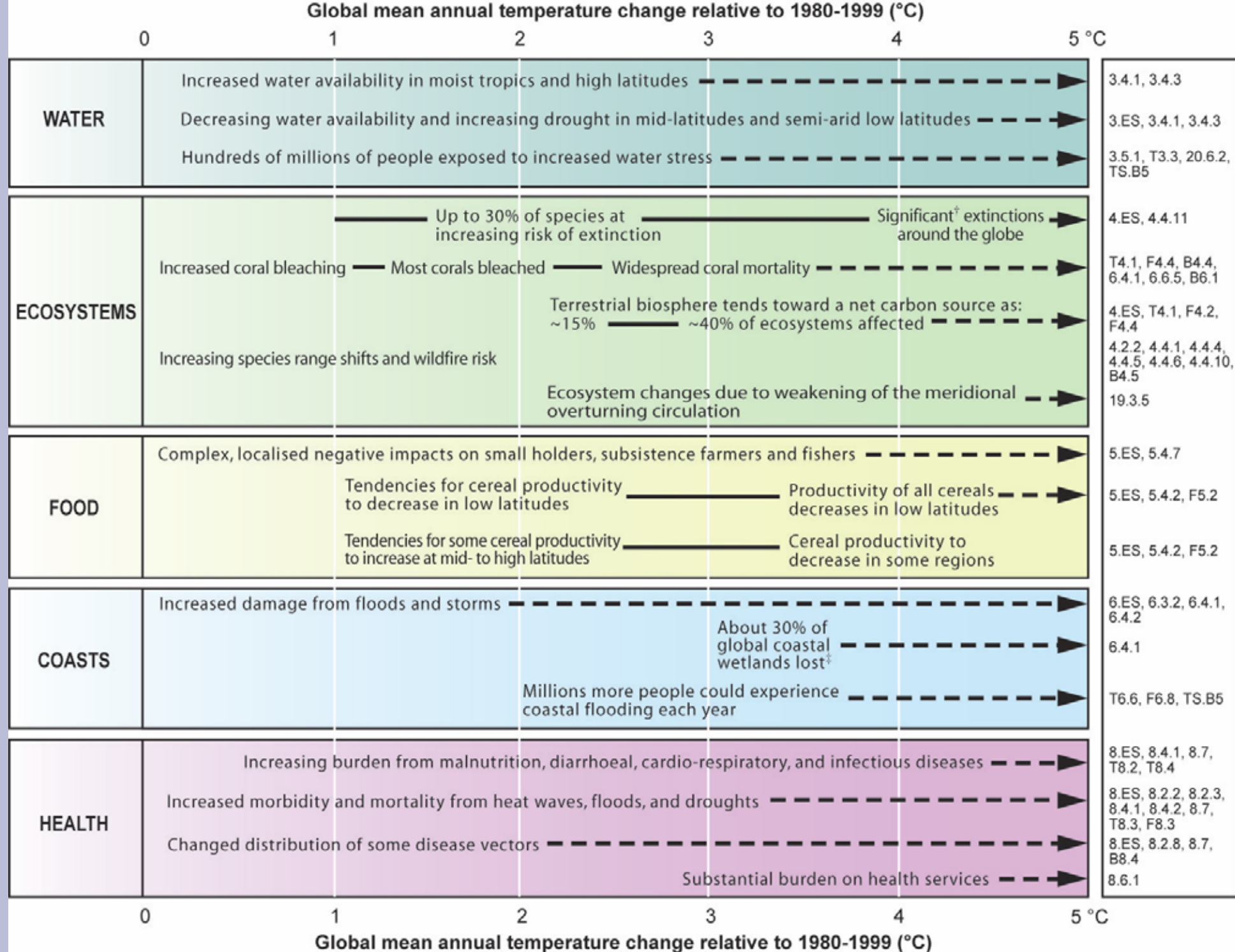


Projections



Projections

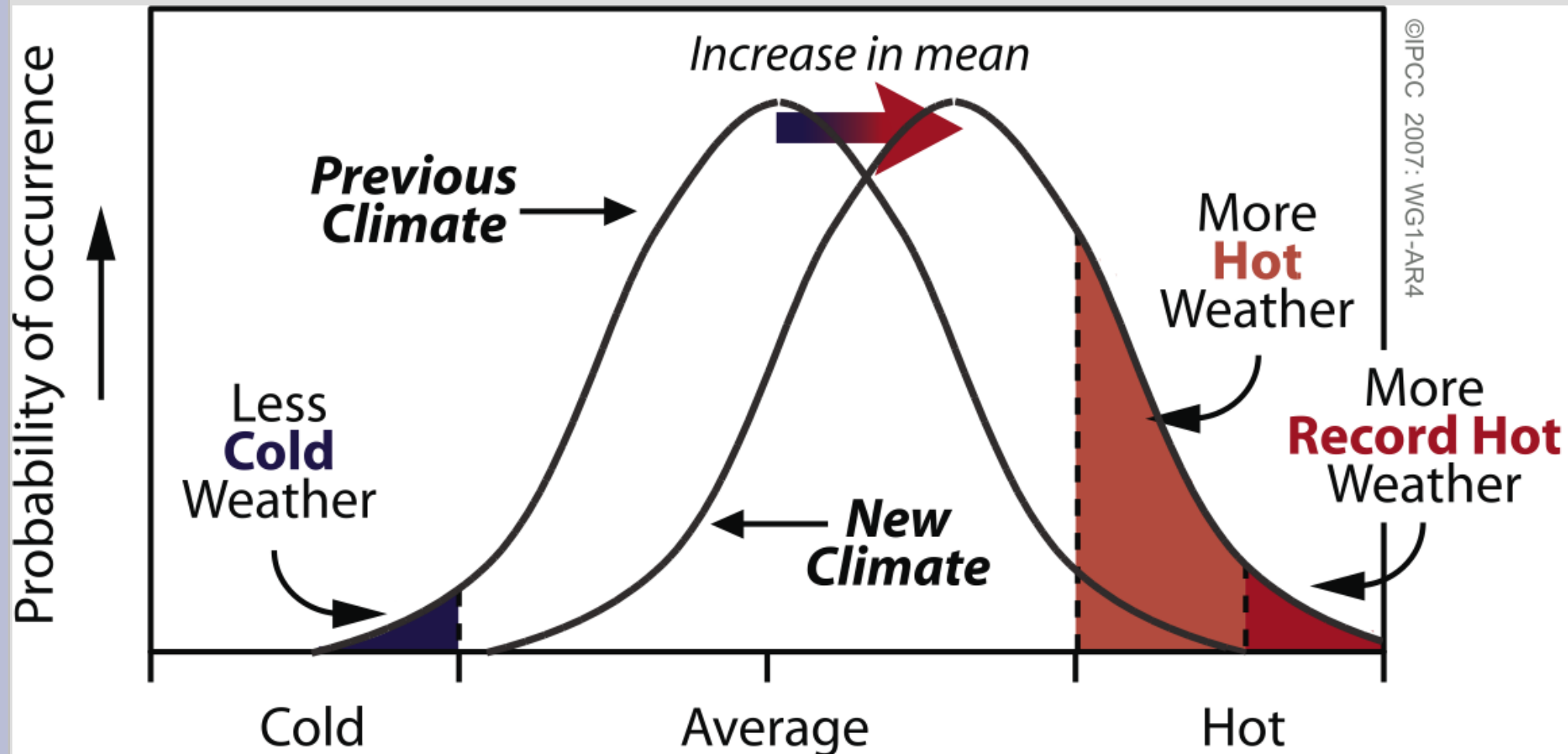




[†] Significant is defined here as more than 40%.

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

Extreme events



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)

Good Internet resource:

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