

Climate and Human History

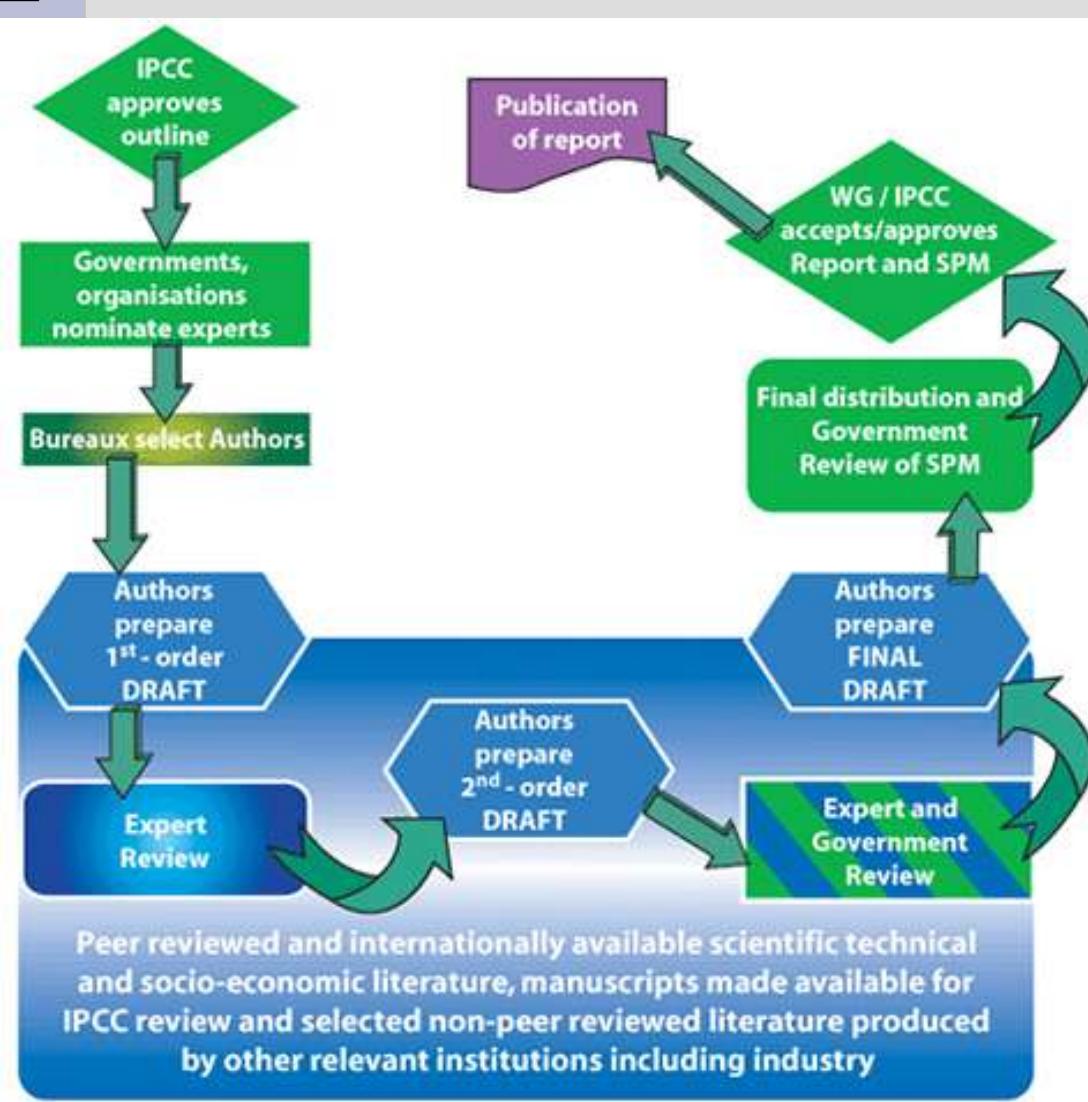
Stephan Matthiesen

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|------|--------------------------------------|
| 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)



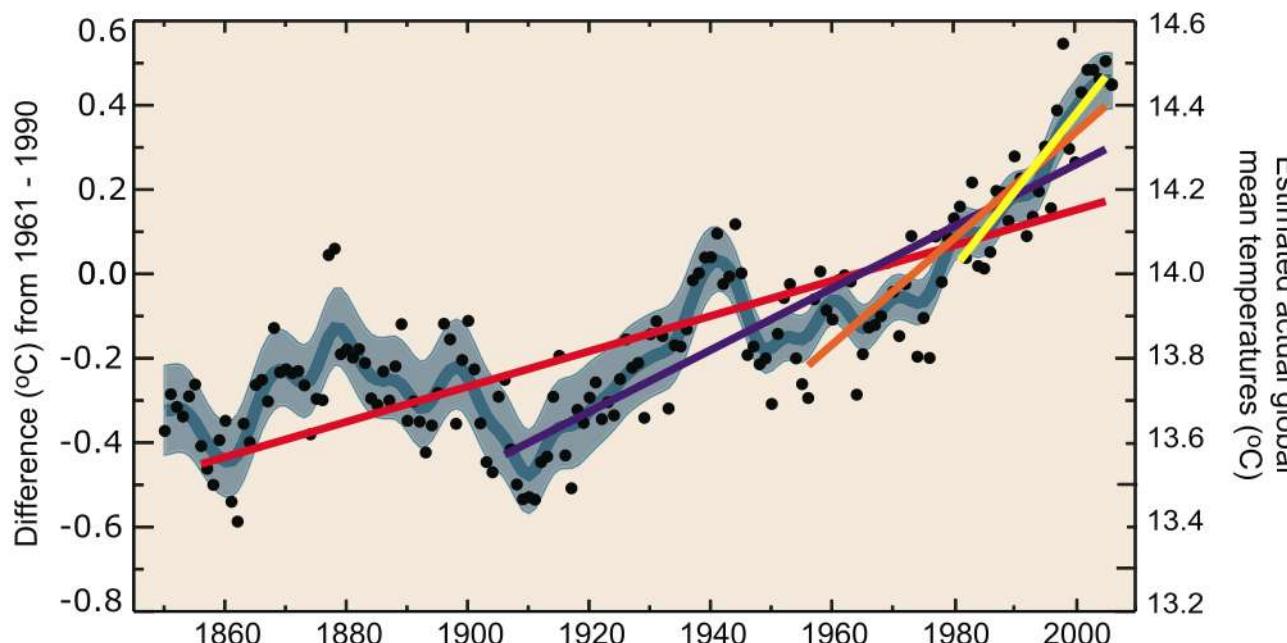
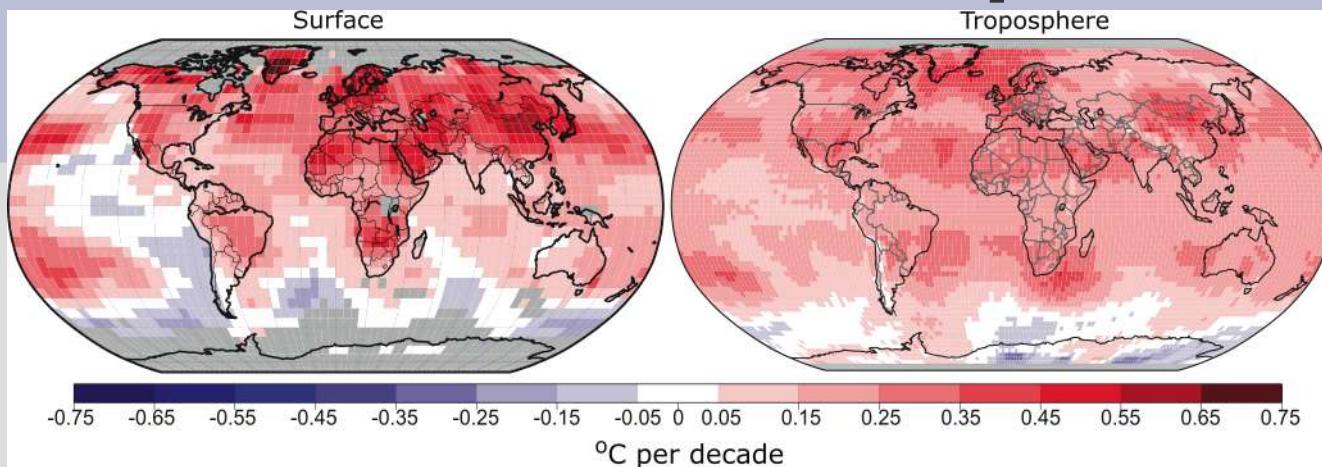
Working Groups:

- 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

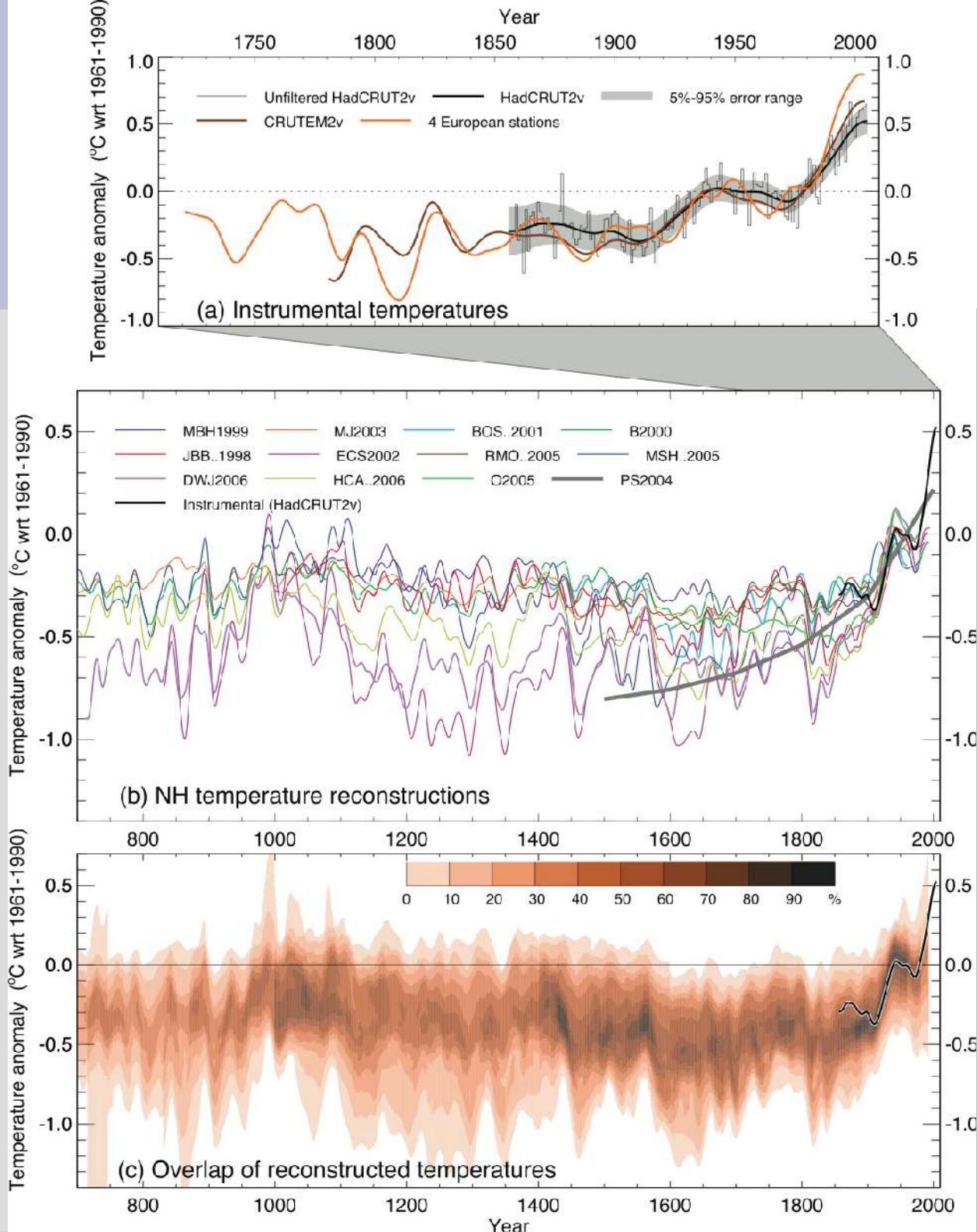
Observations: Temperature



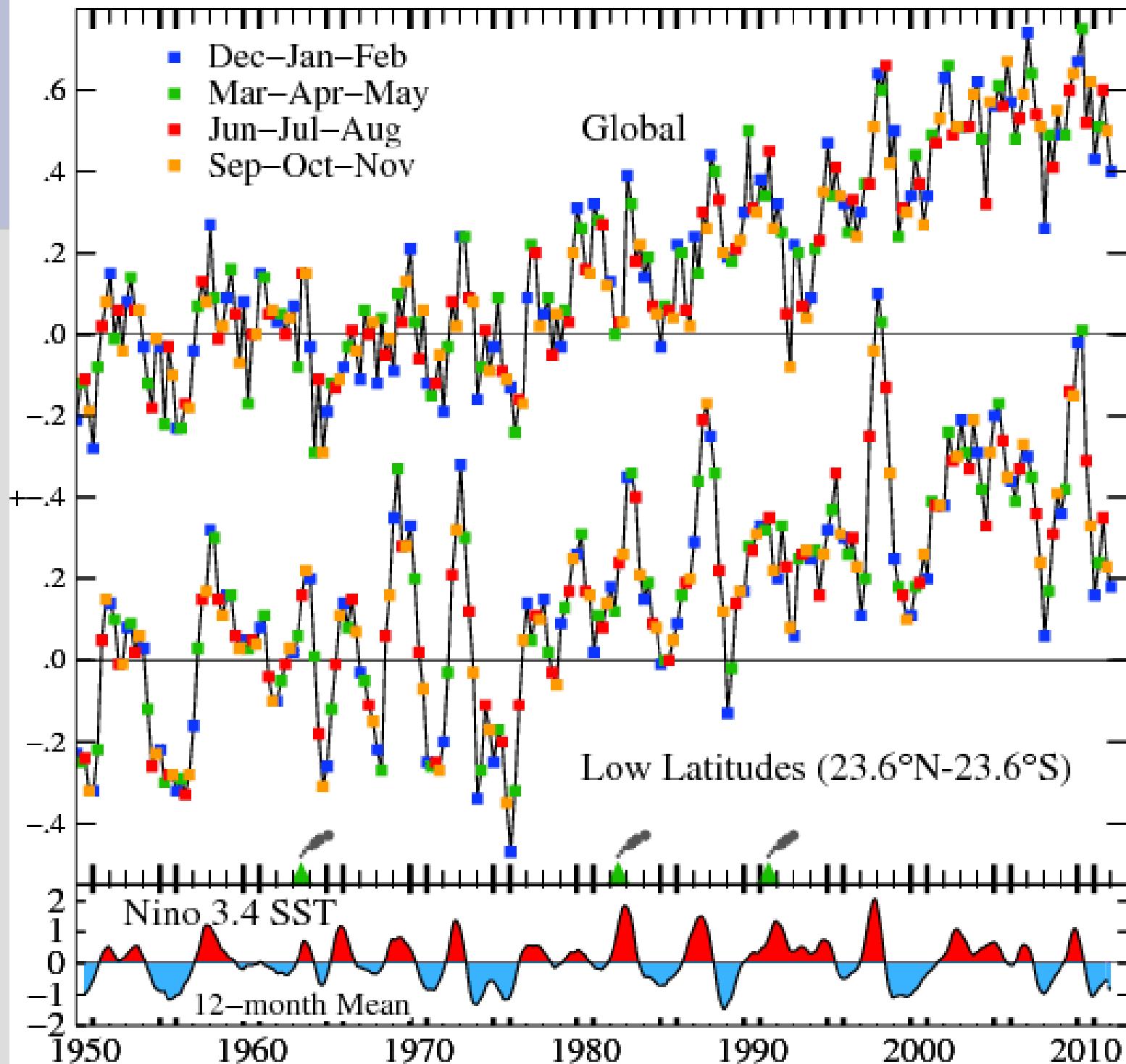
- Annual mean
- Smoothed series
- 5-95% decadal error bars

Period Years	Rate °C per decade
25	0.177±0.052
50	0.128±0.026
100	0.074±0.018
150	0.045±0.012

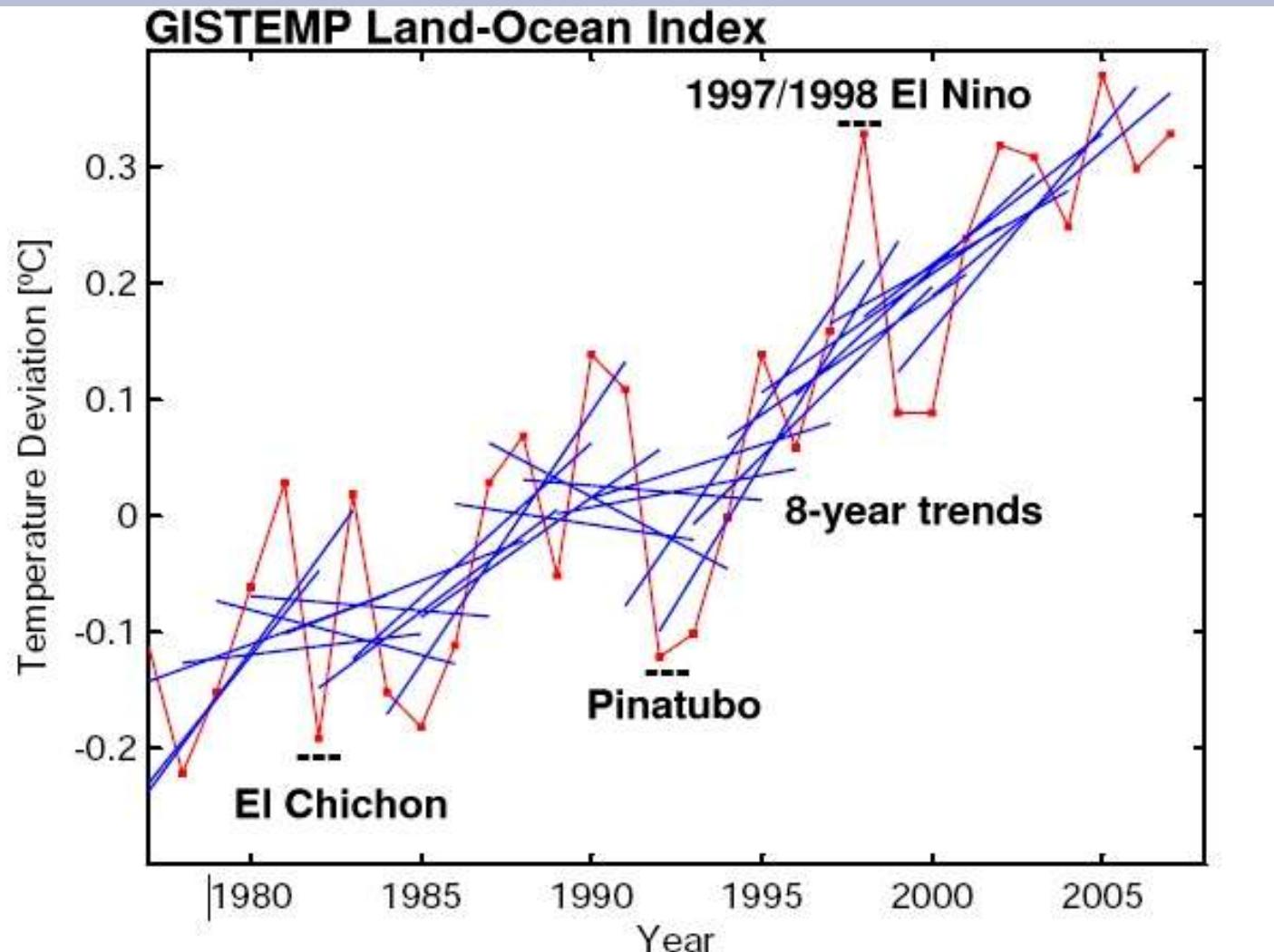
Observed changes



Temperature Anomaly (°C): Seasonal Resolution



Trends and statistical significance



red: observations
blue: trends for 8-year periods

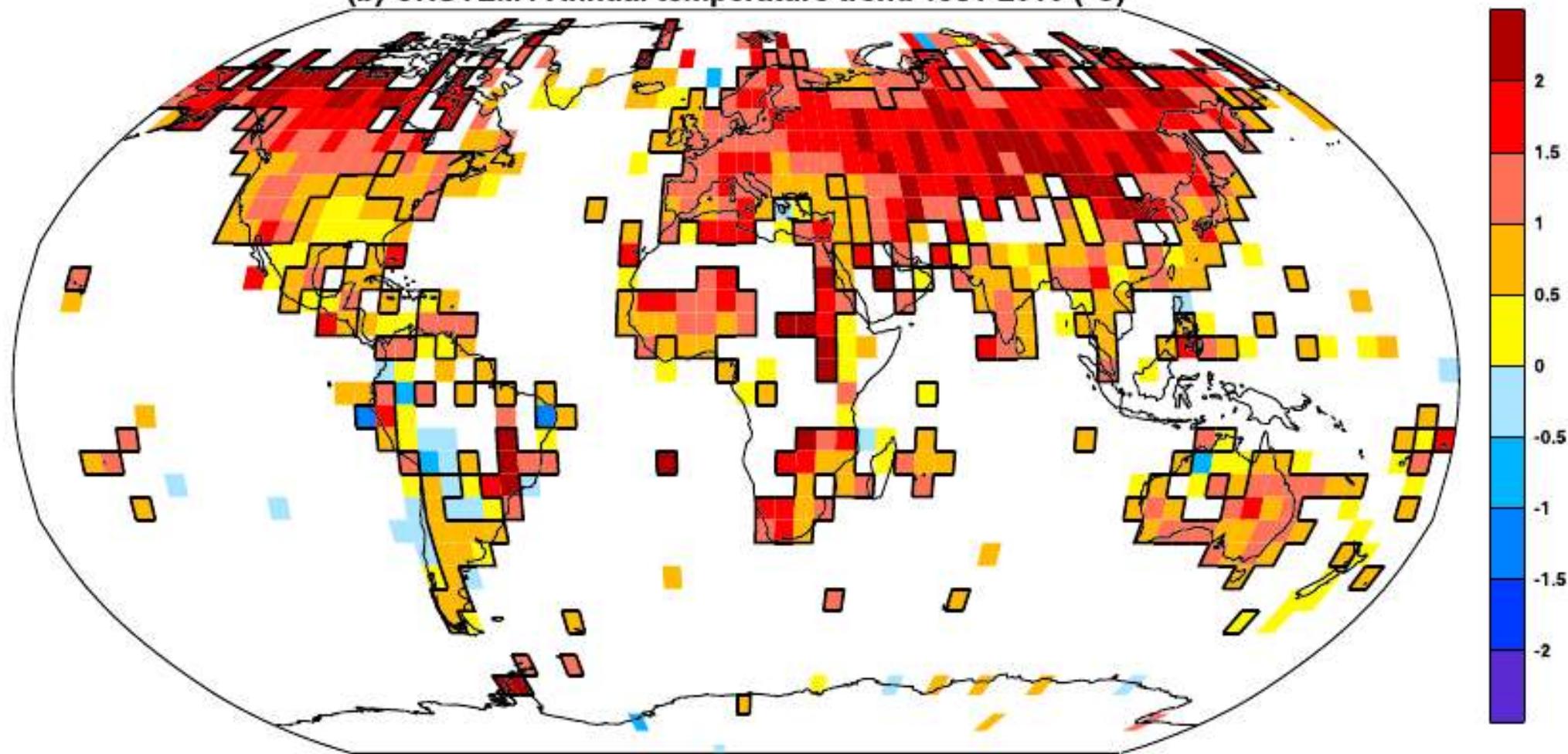
variability makes short-term trends difficult to interpret

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

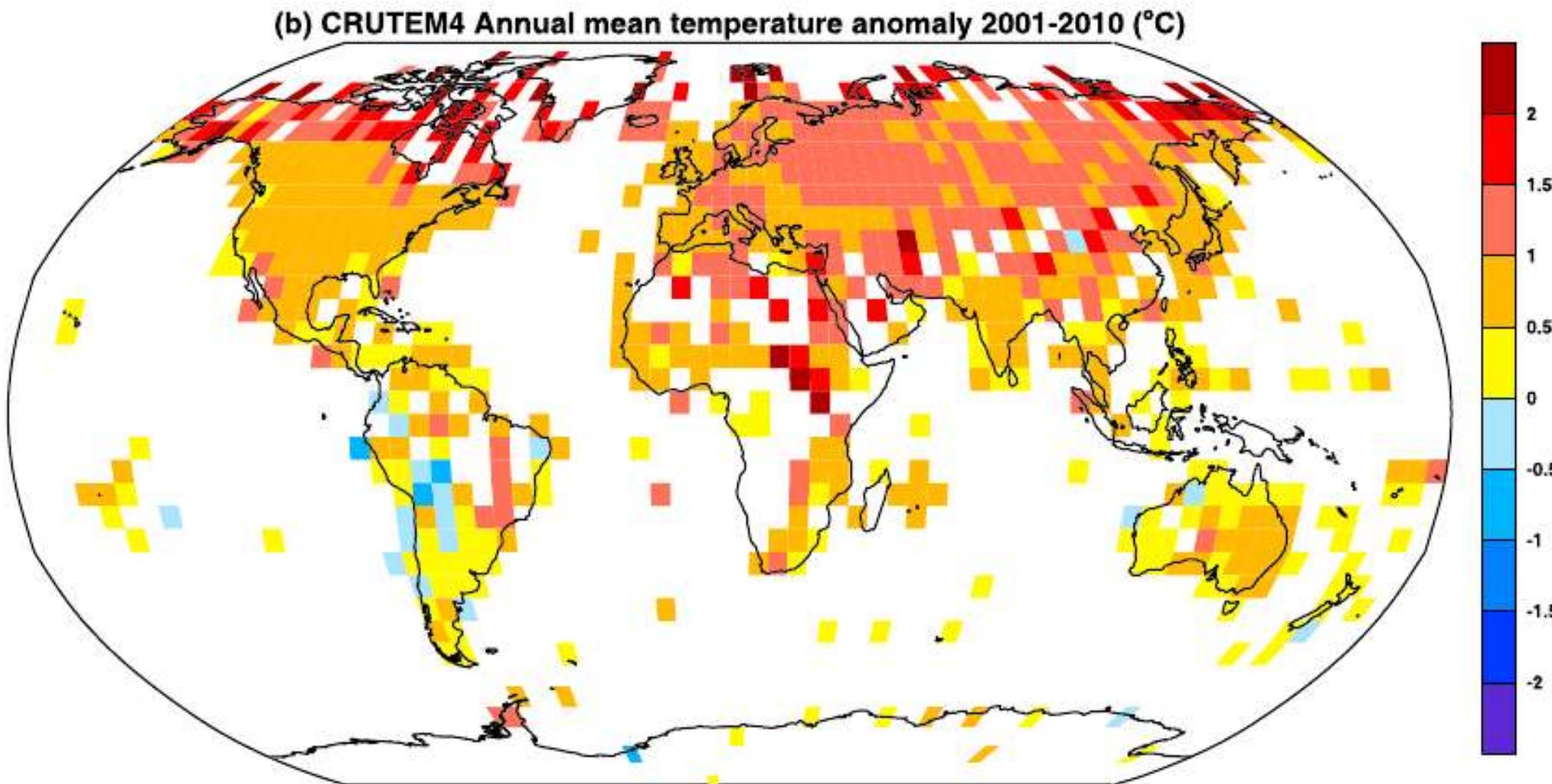
This is different from everyday language (where significant often means large or important)!!

Temperature trend 1951-2010

(b) CRUTEM4 Annual temperature trend 1951-2010 ($^{\circ}\text{C}$)



Temperature anomaly of decade 2001-2010

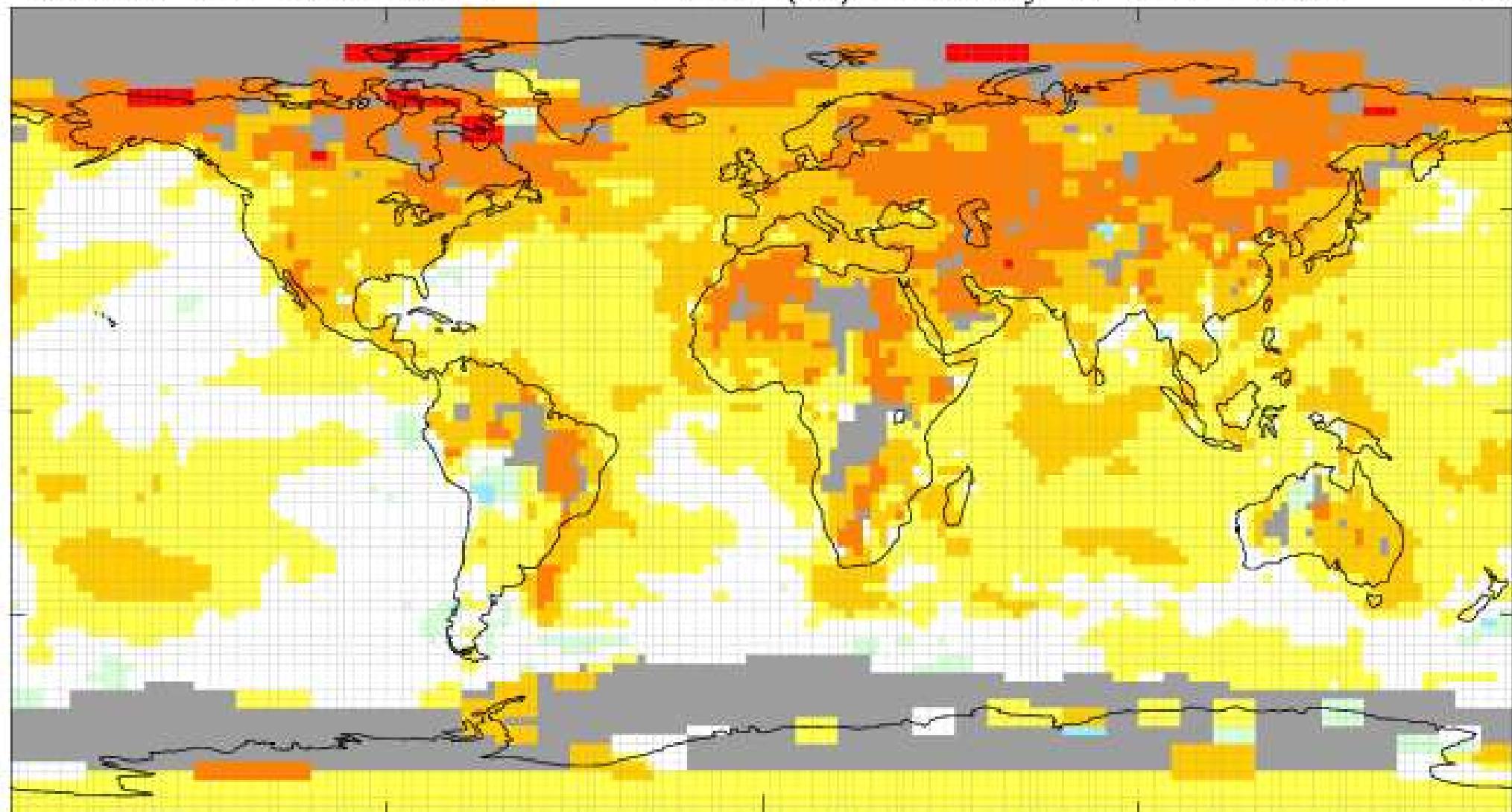


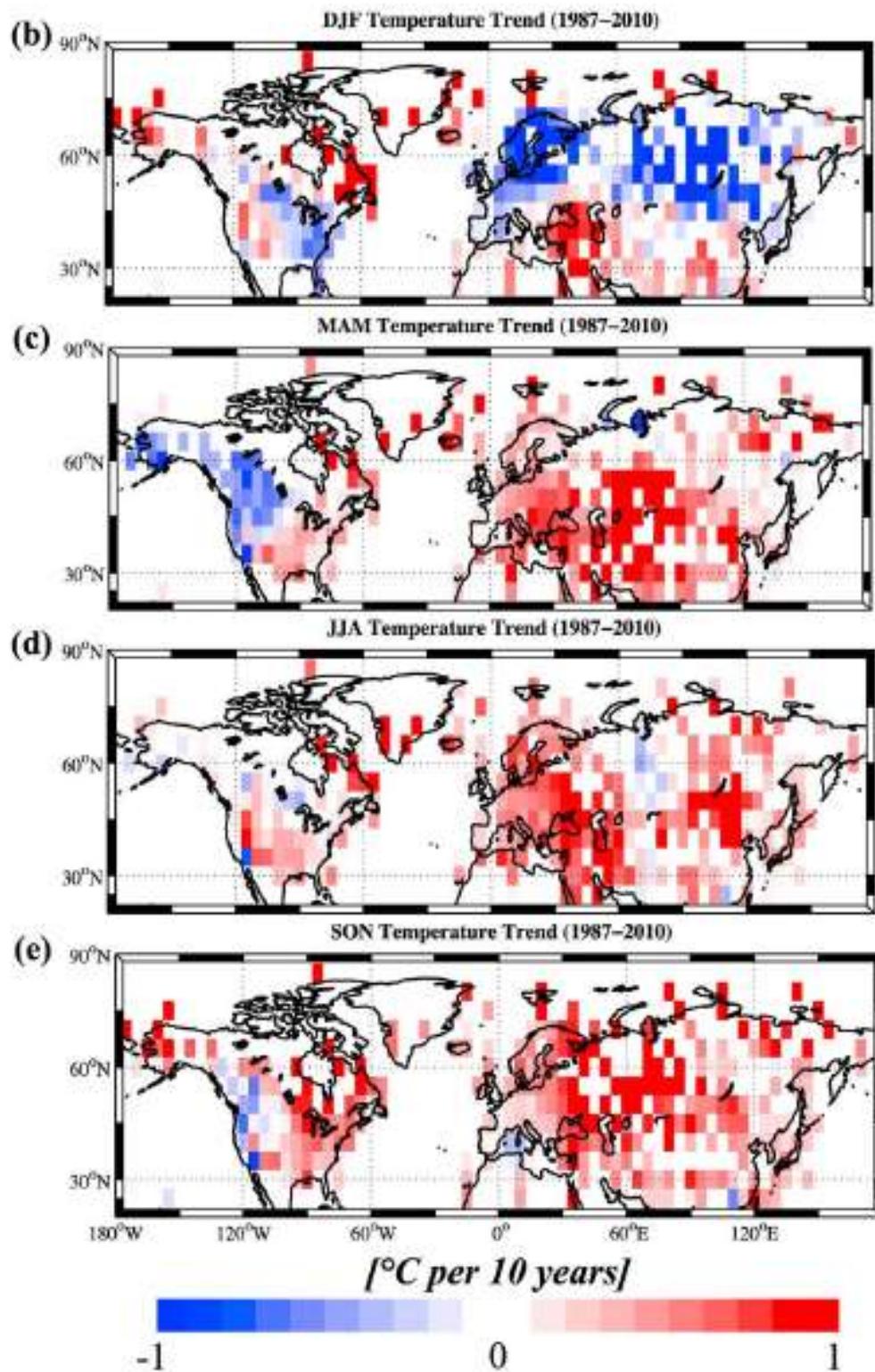
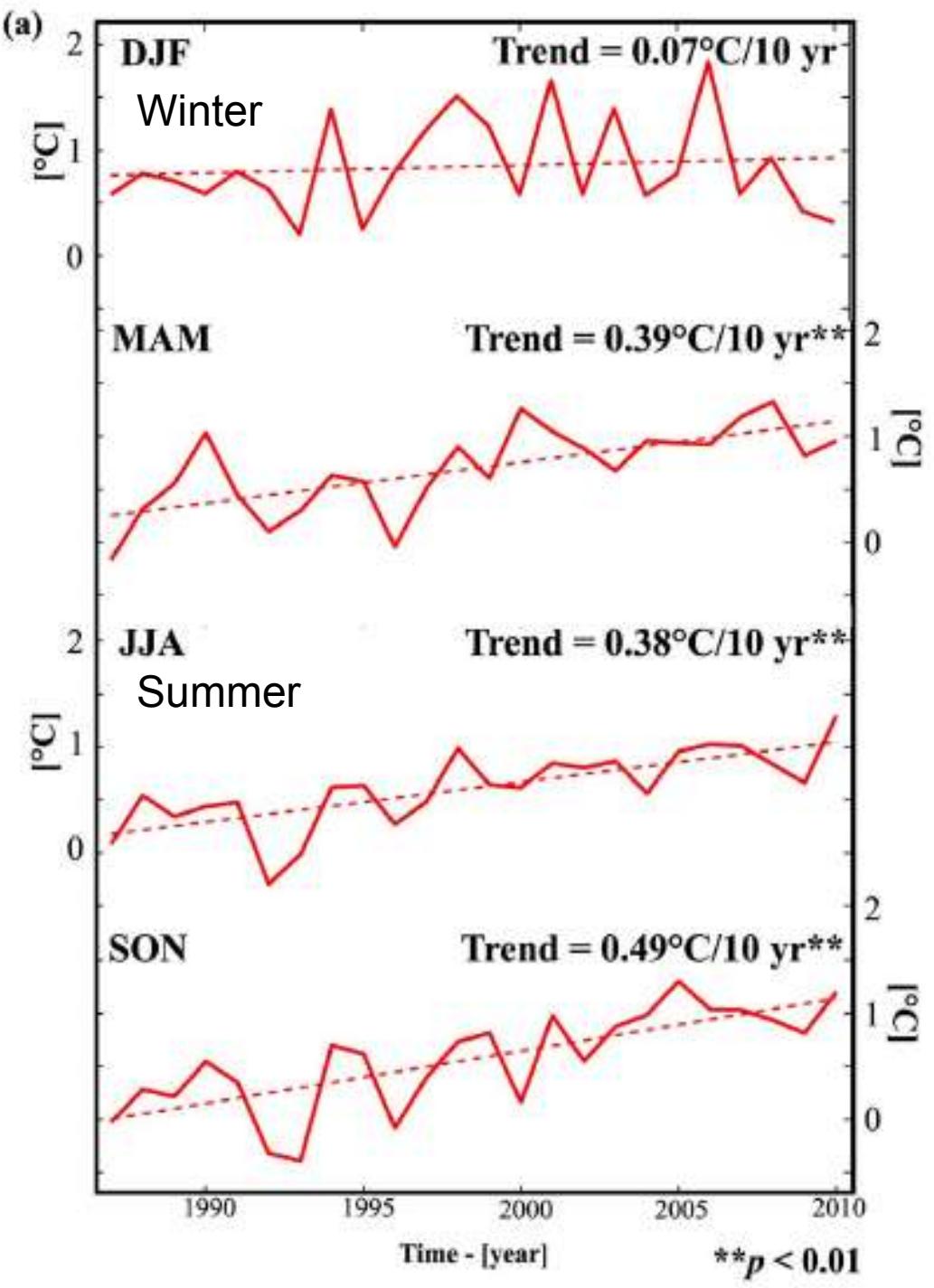
Temperature anomaly

Annual J-D 2001–2010

L-OTI($^{\circ}$ C) Anomaly vs 1961–1990

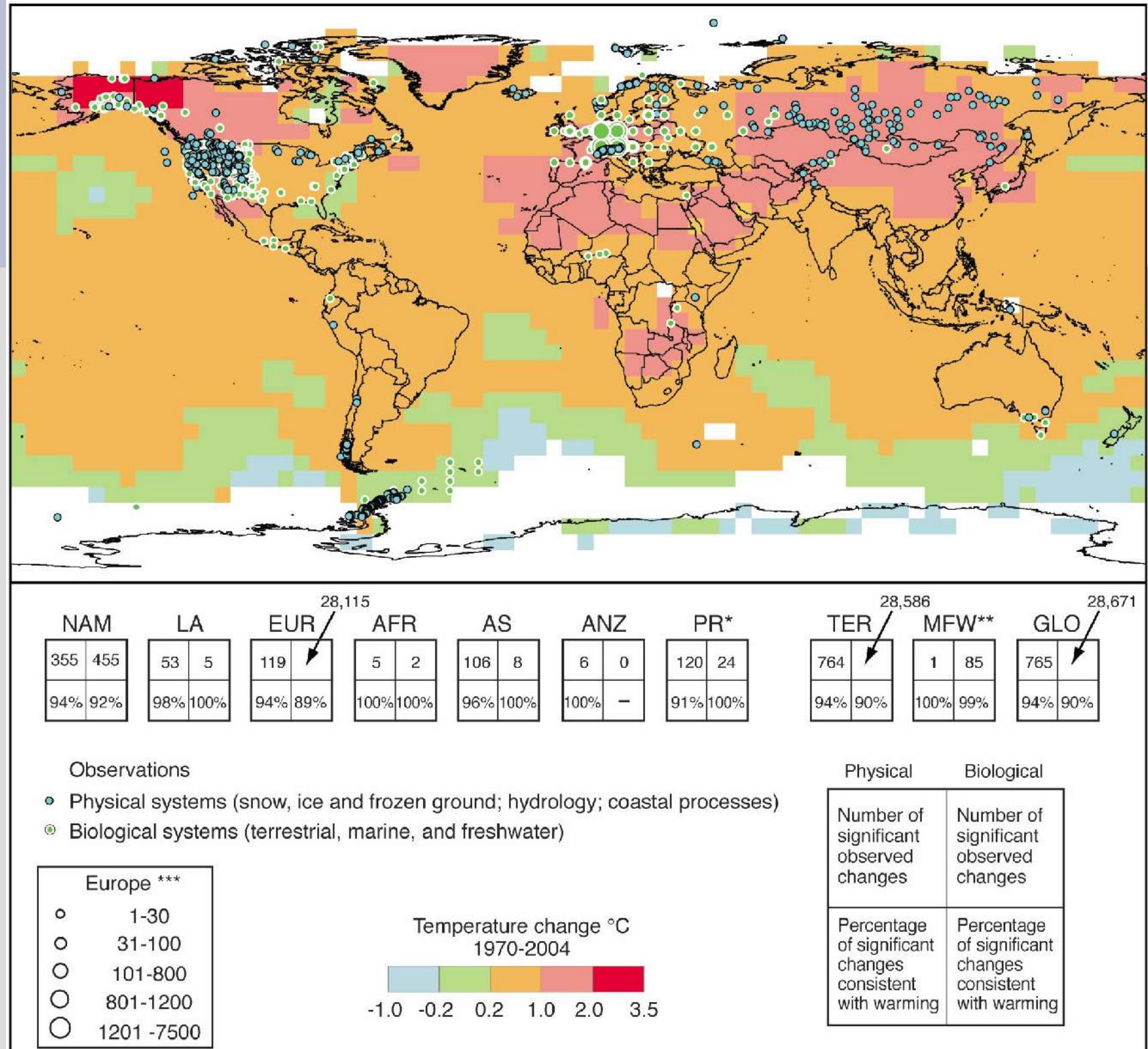
.45



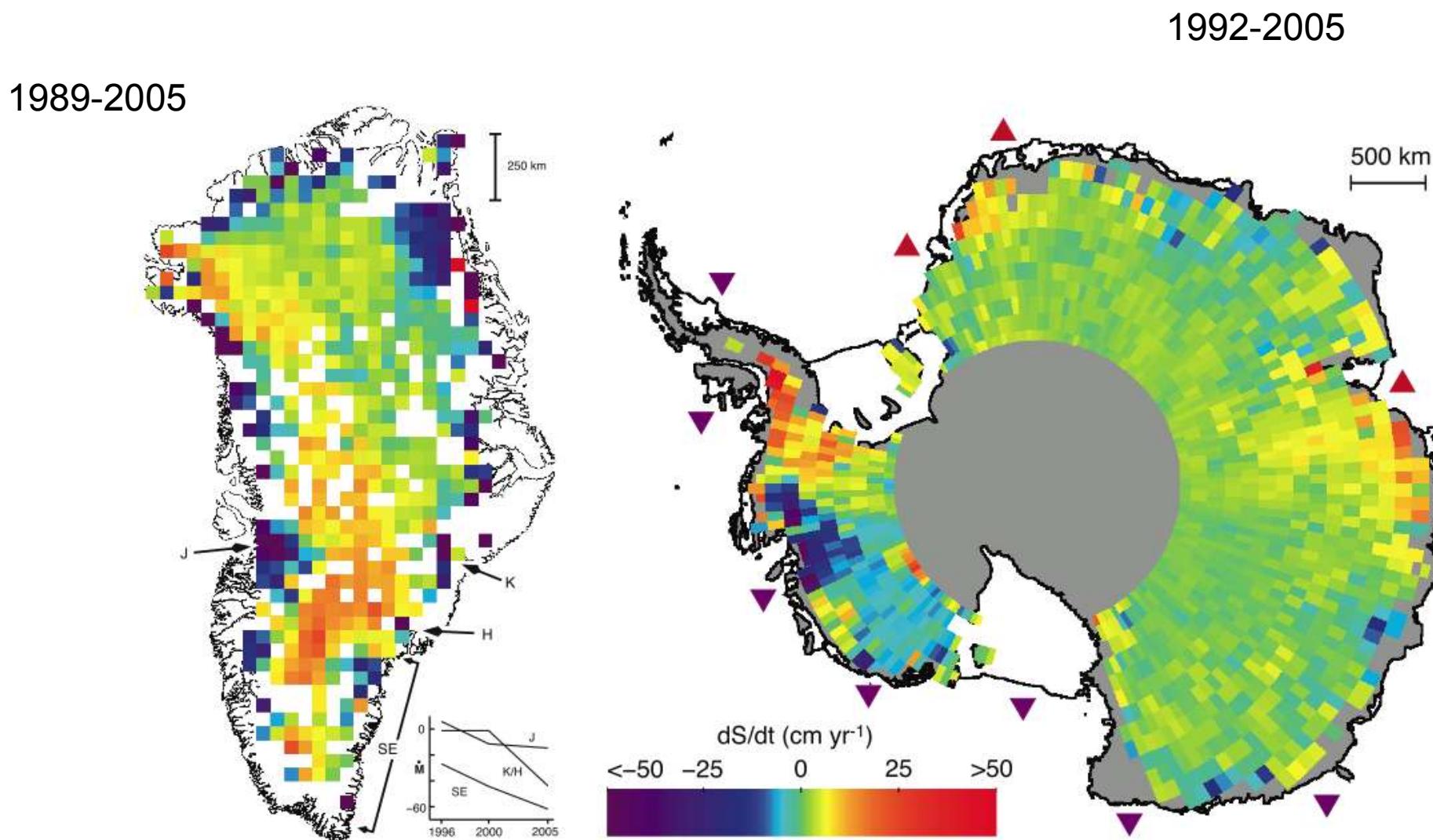


90% of
observed
biological
and physical
indicators
consistent
with warming

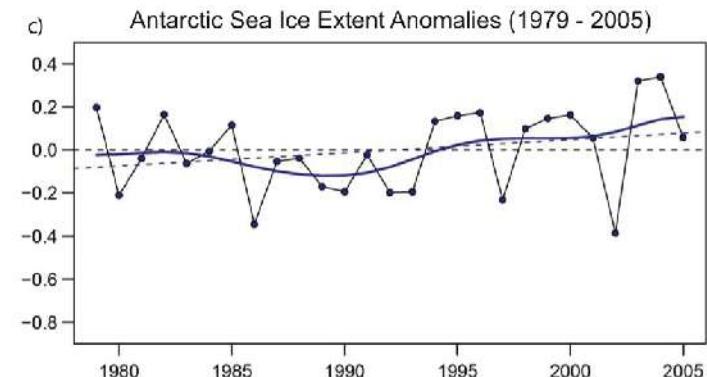
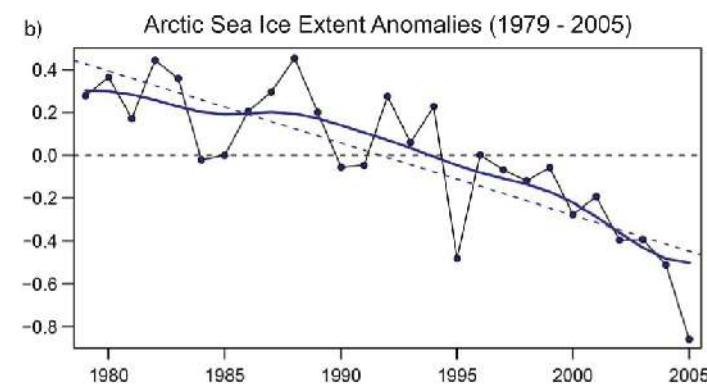
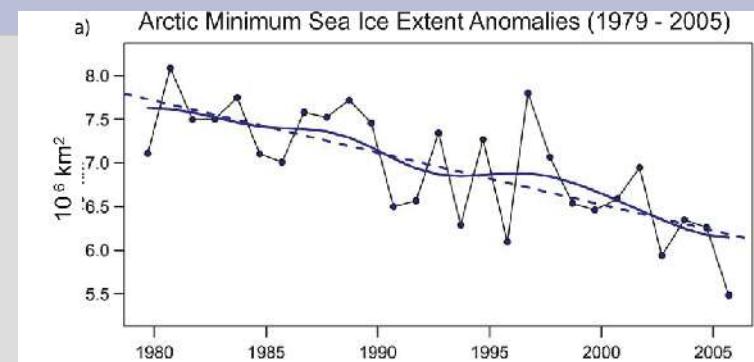
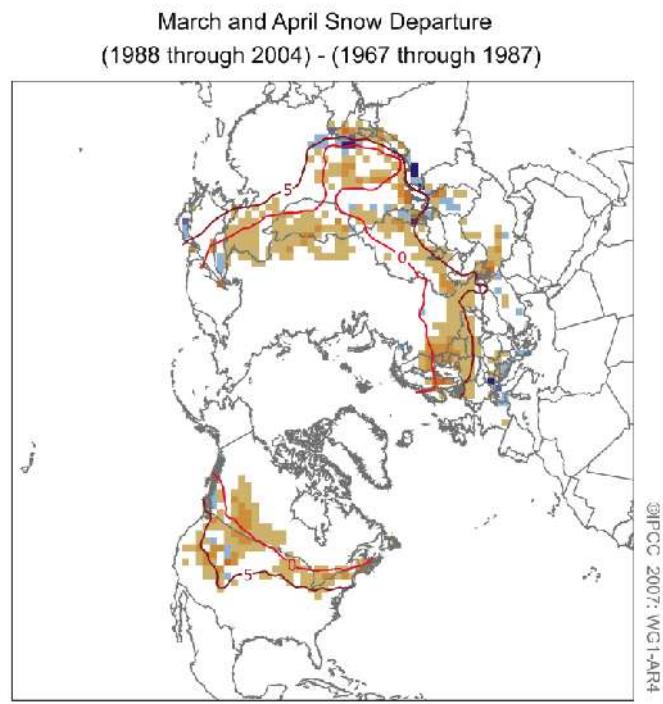
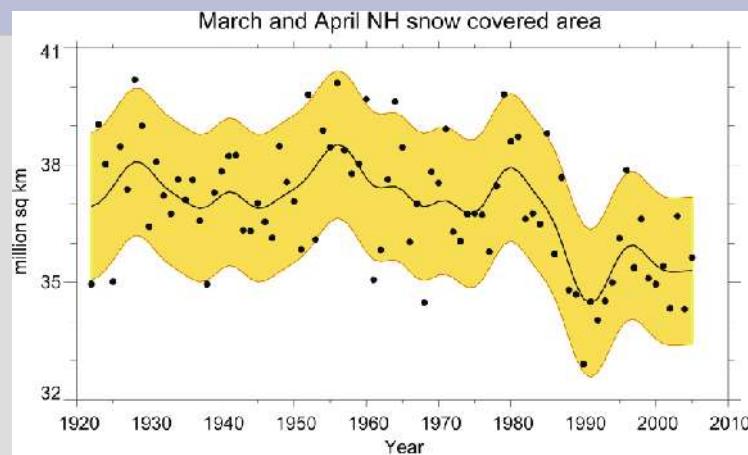
NAM etc:
continents
Ter: terrestrial
MFW: marine&
fresh water
GLO: global



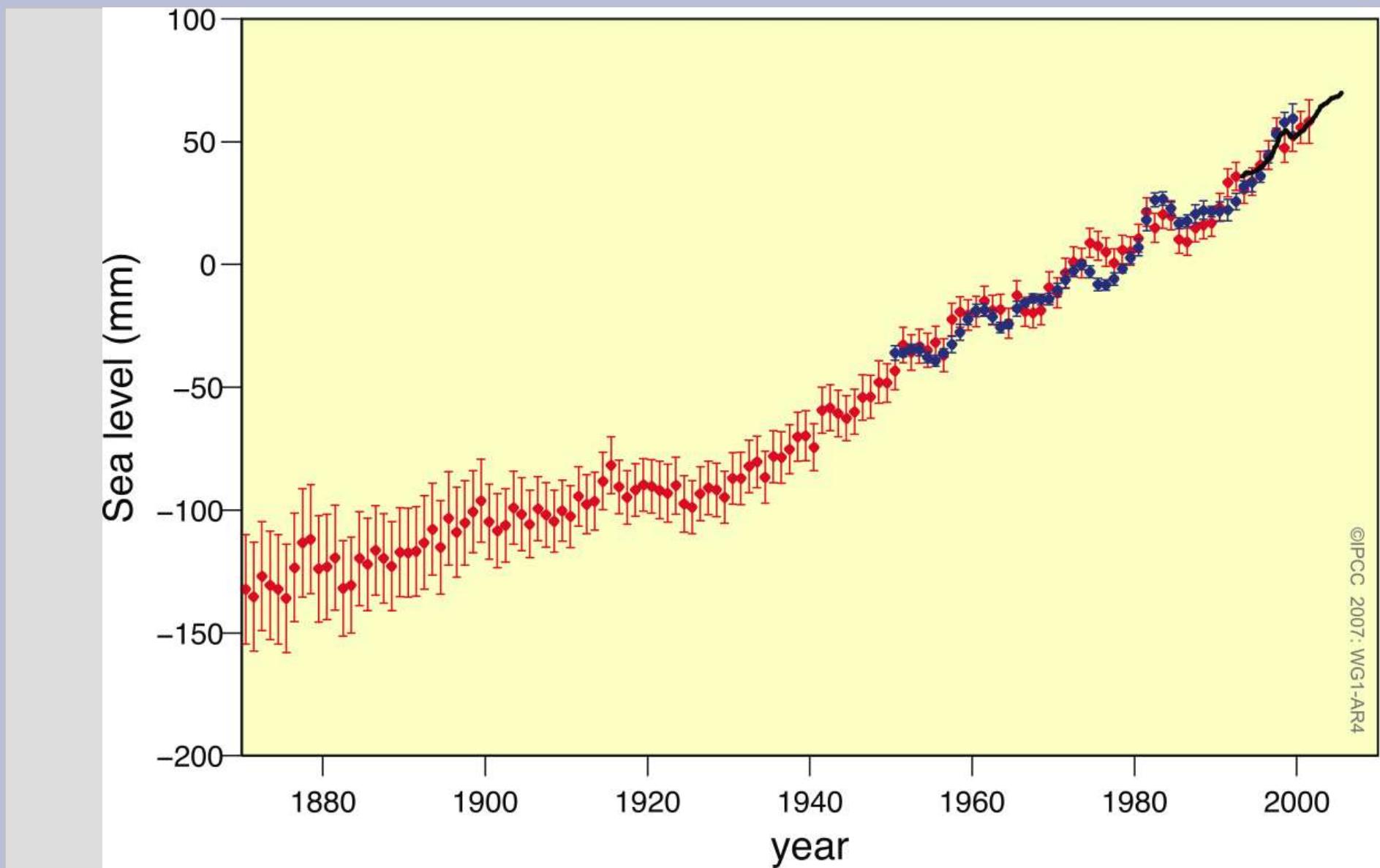
Observations: Ice thickness



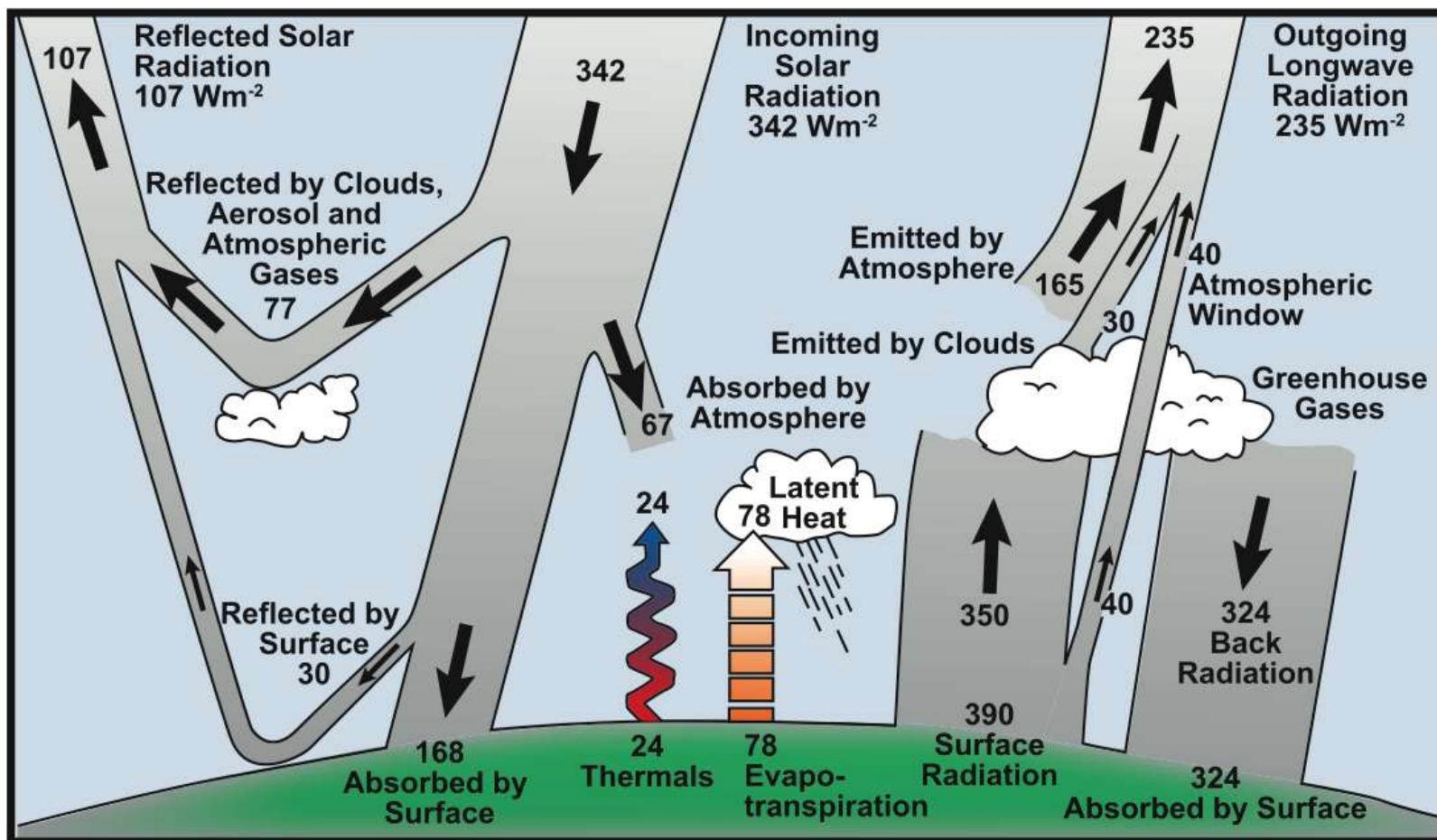
Snow cover and sea ice



Sea level



Greenhouse Effect



Greenhouse Effect

Solar incoming radiation

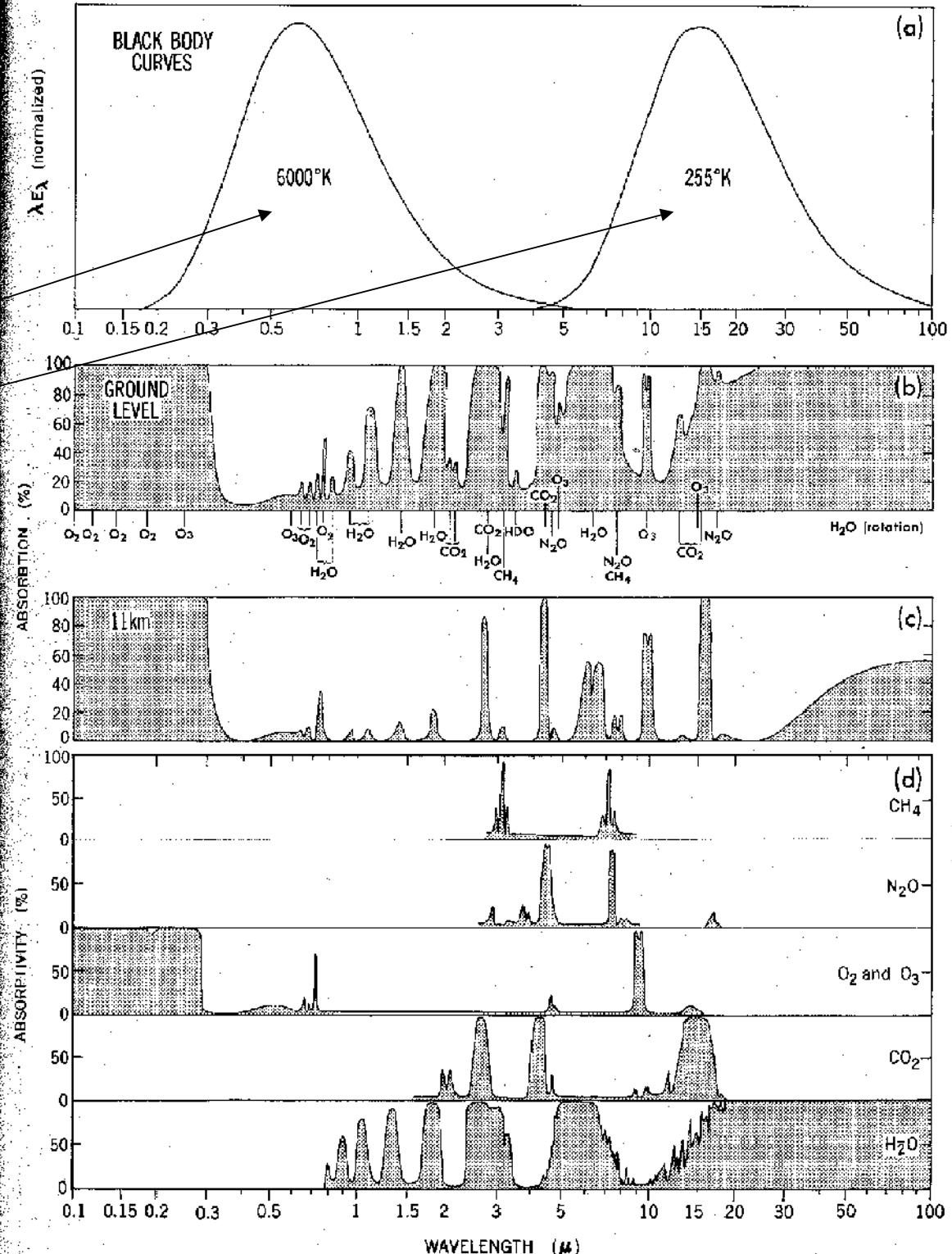
Outgoing thermal rad.

Absorption in Atmosphere

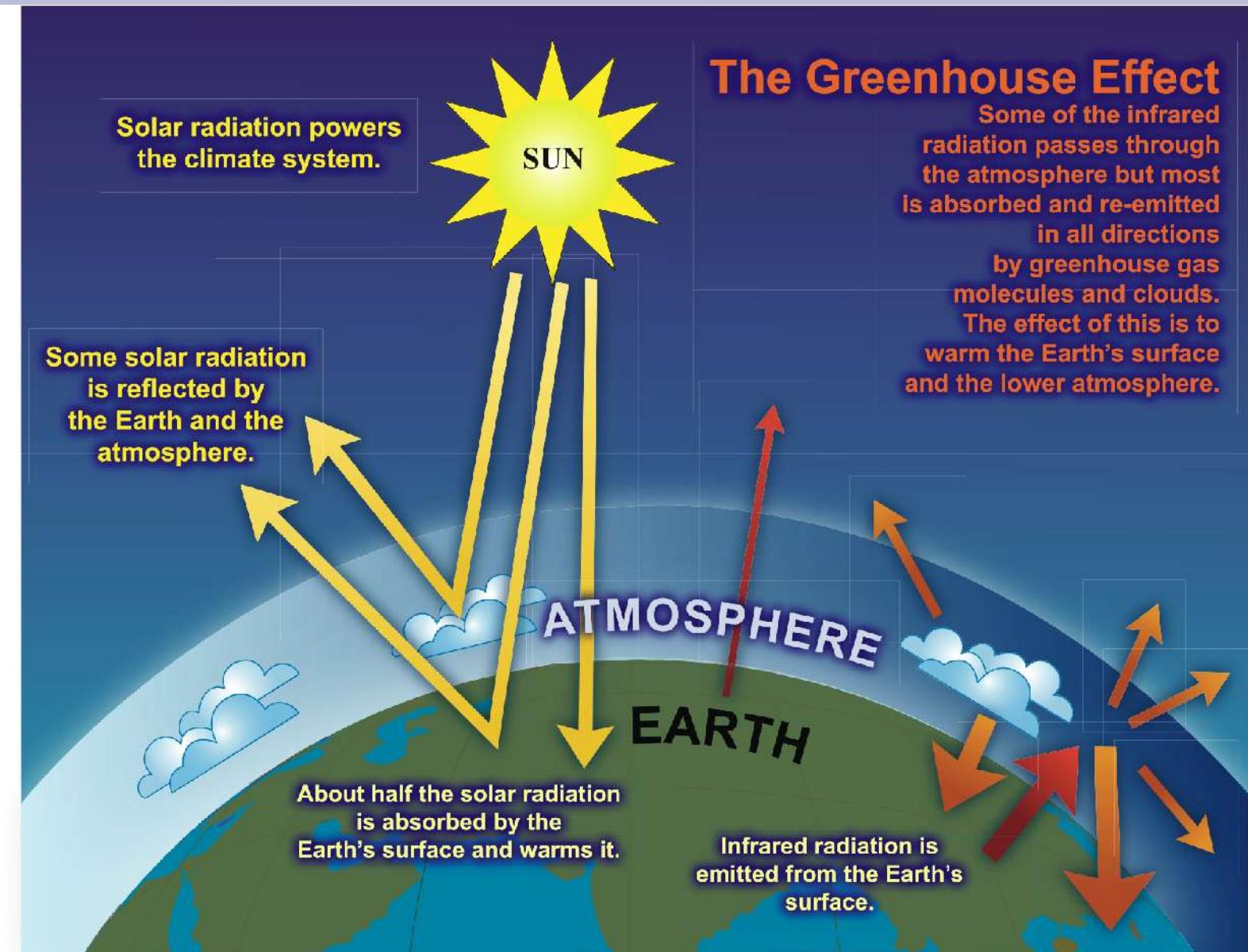
Absorption

CO₂

H₂O



Greenhouse Effect



Discovery of the Greenhouse effect

1820s: Joseph Fourier (theoretical idea)

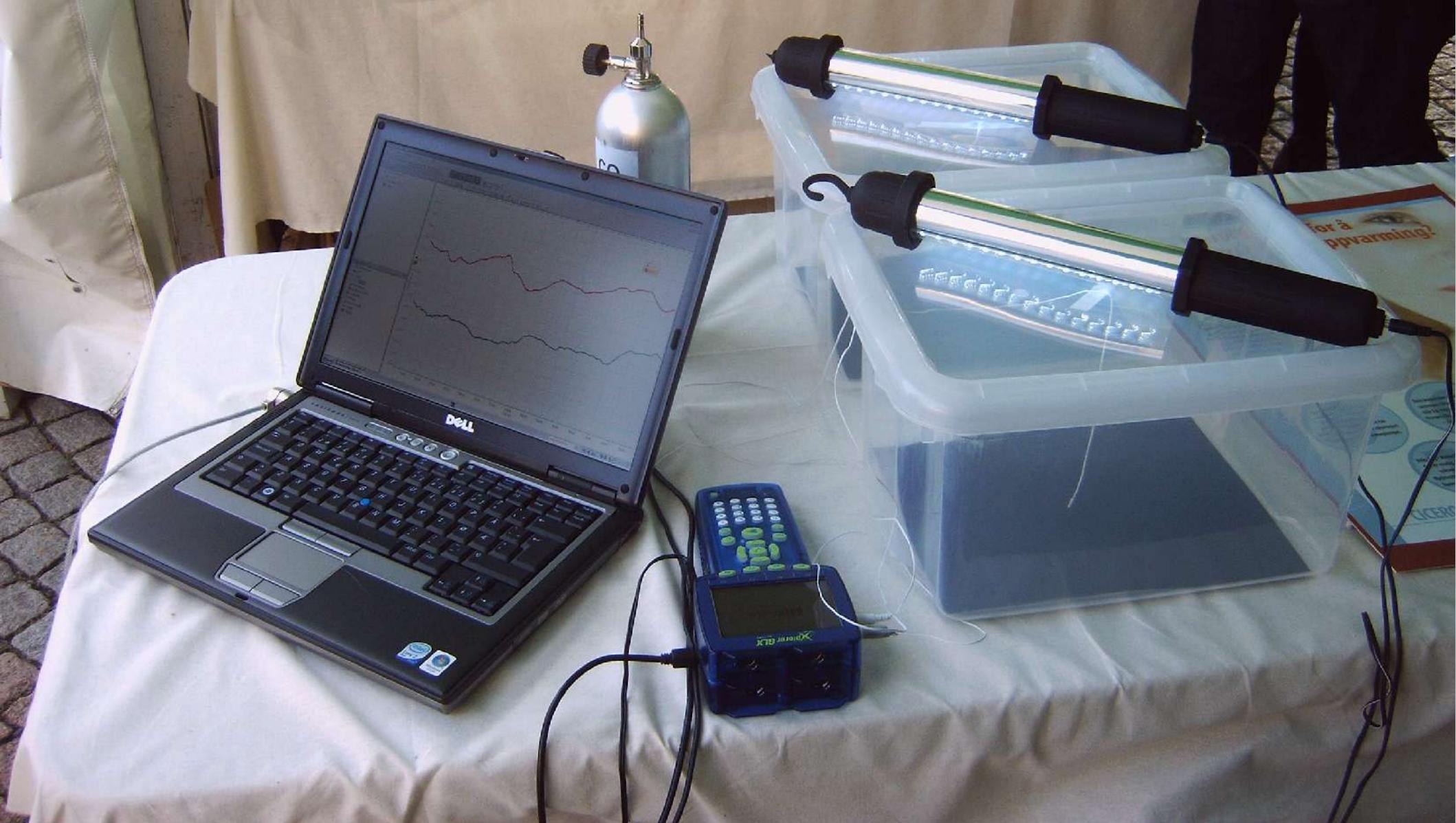
1859: John Tyndall
(experiments with CO₂ and H₂O)

1896 Svante Arrhenius
(interested in ice ages, calculated that cutting CO₂ by half would lower temperature by 4°-5°C)

1938 Guy Stewart Callendar
(looked at historical measurements and found CO₂ increase by 10% and warming)



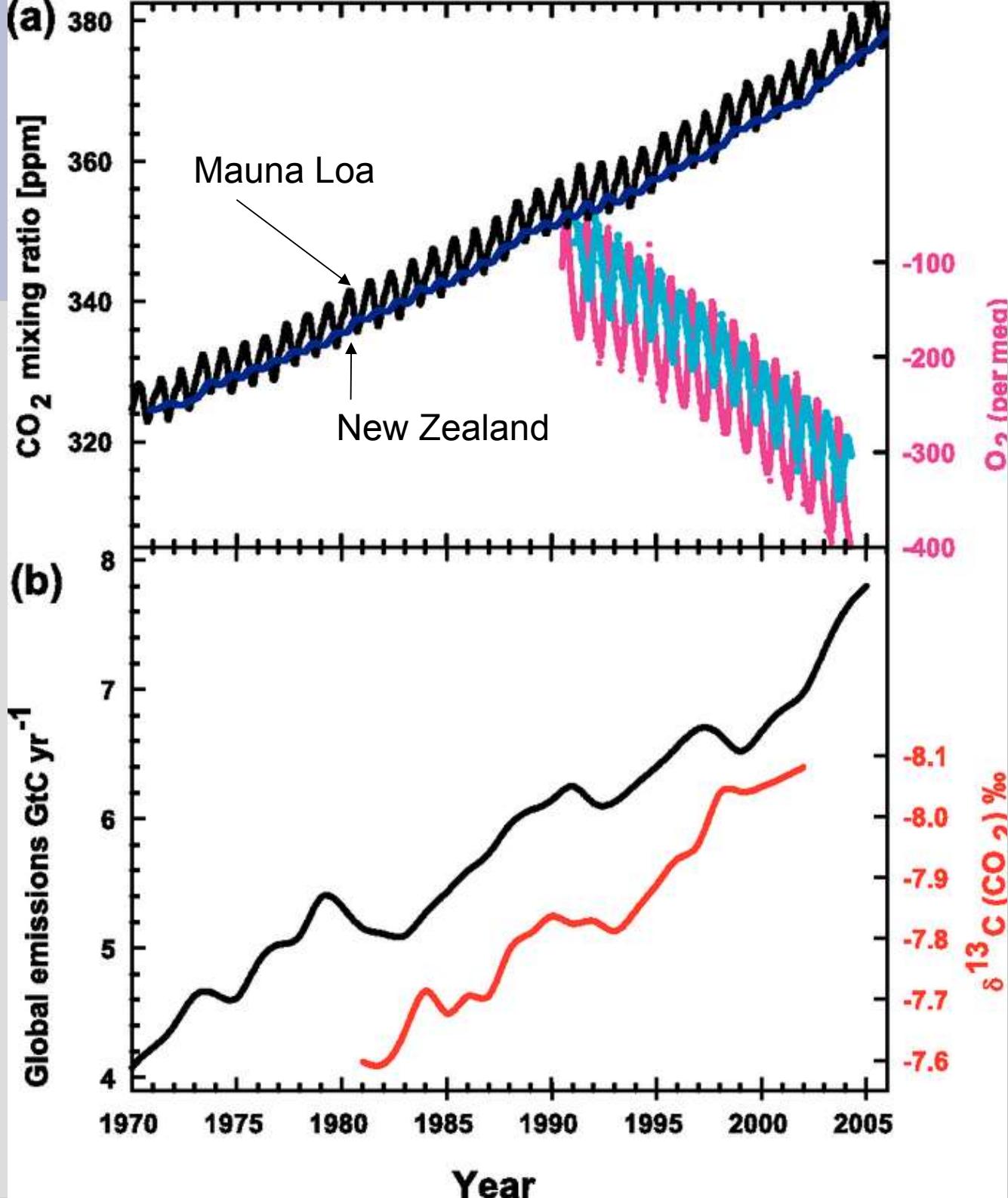
Greenhouse experiment



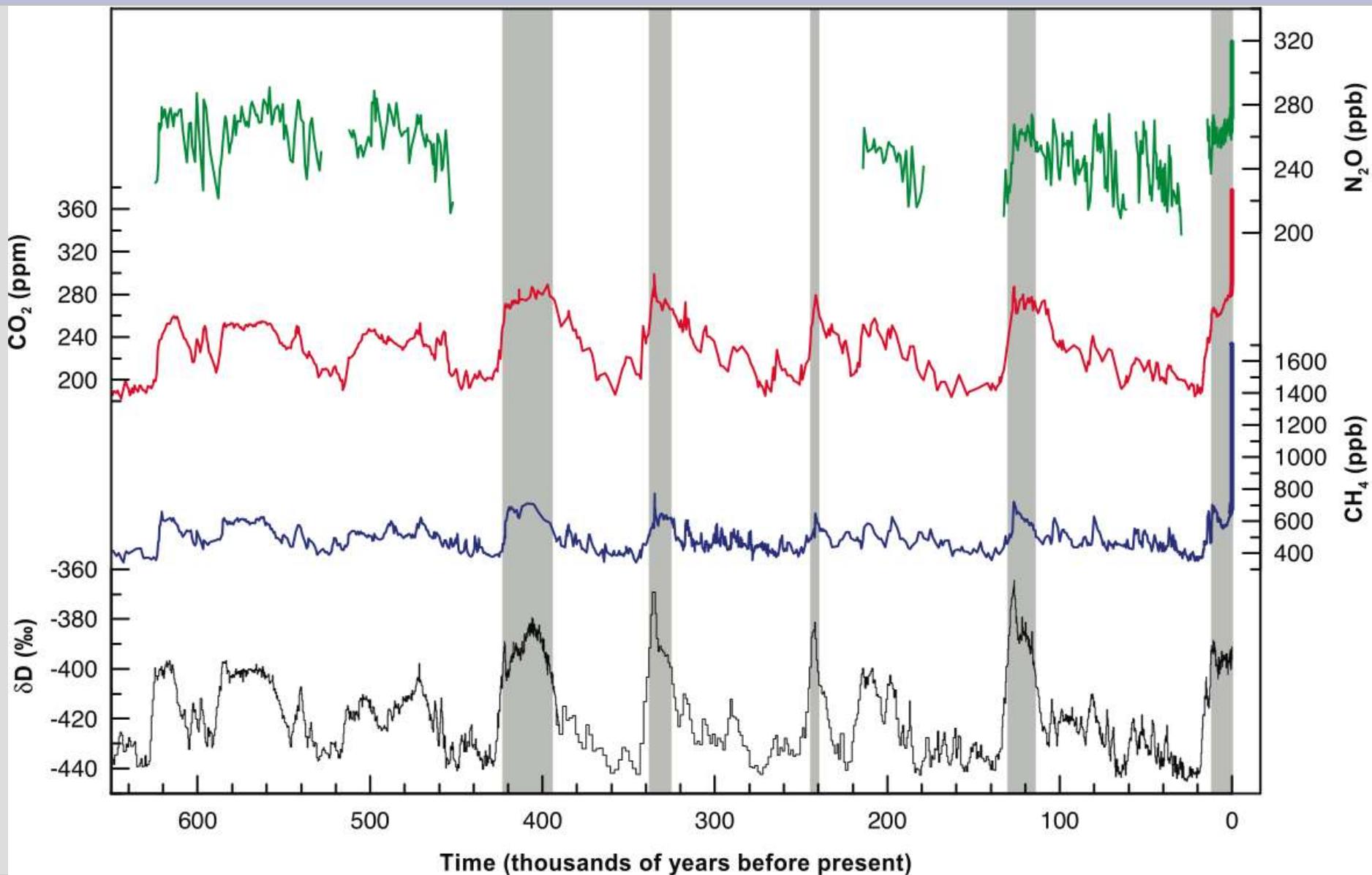
Atmosph. CO₂

Calculated emissions
from fossil fuels and
cement production

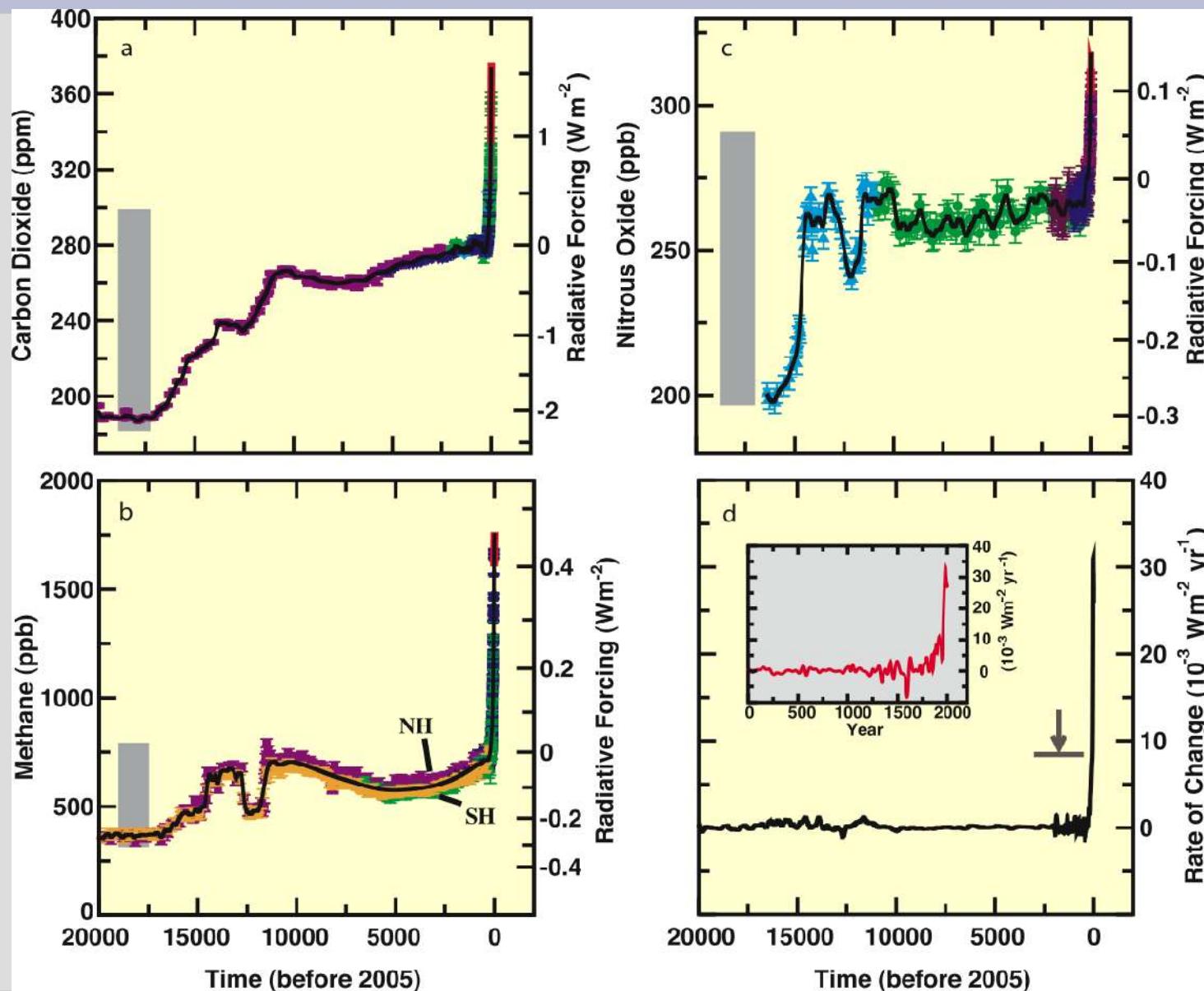
AR4 WG1 Fig 2.3



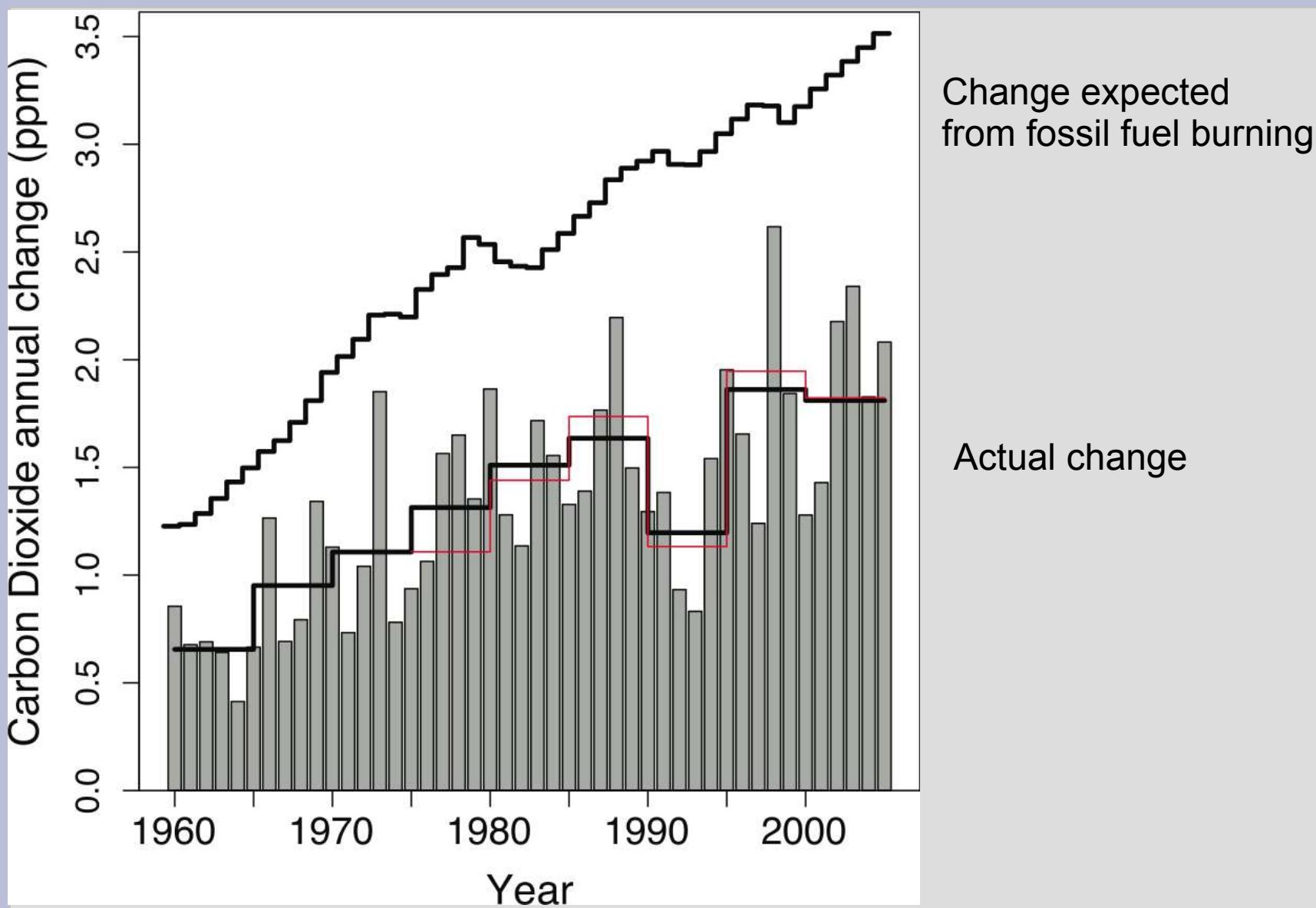
Greenhouse Gases



Greenhouse Gases

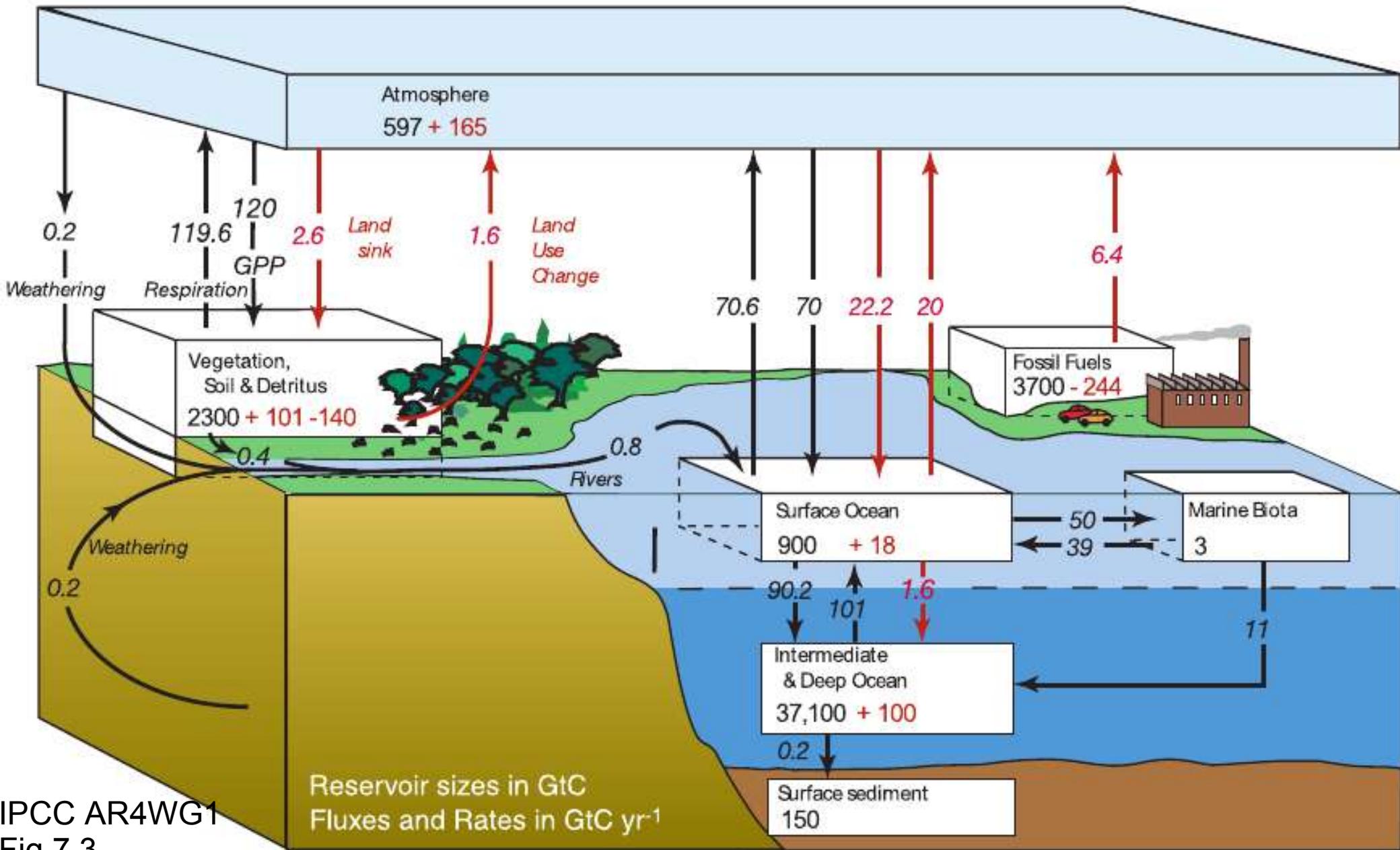


Carbon dioxide

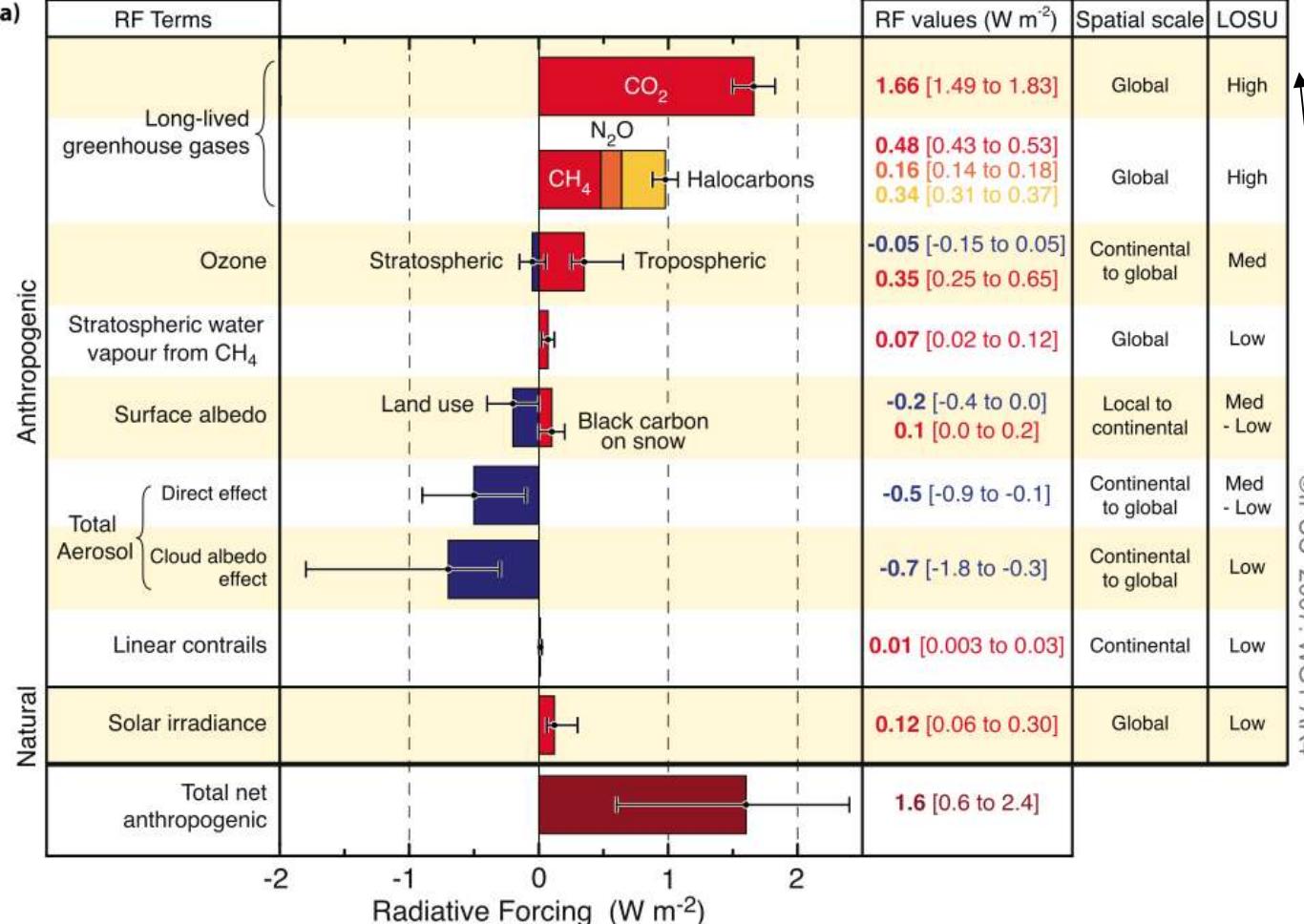


Global carbon cycle

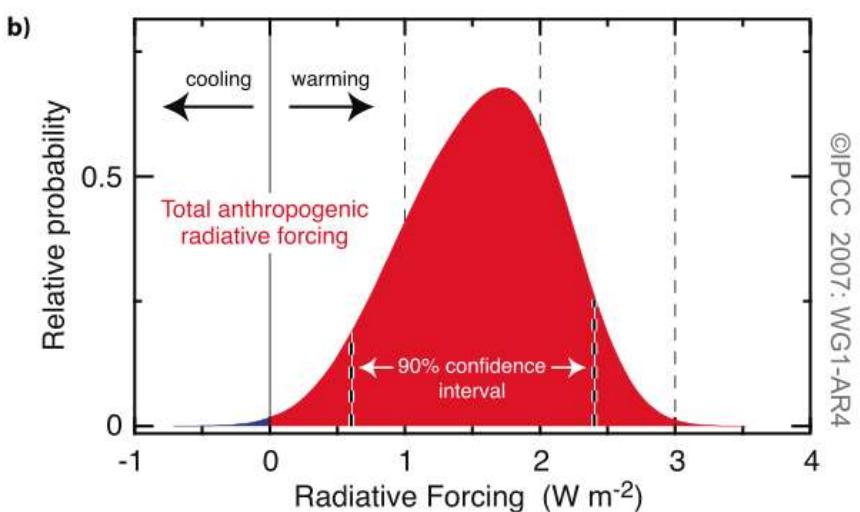
Billion tons per year (Gt/yr)
 black: pre-industrial „natural“
 red: additional anthropogenic



Radiative Forcing

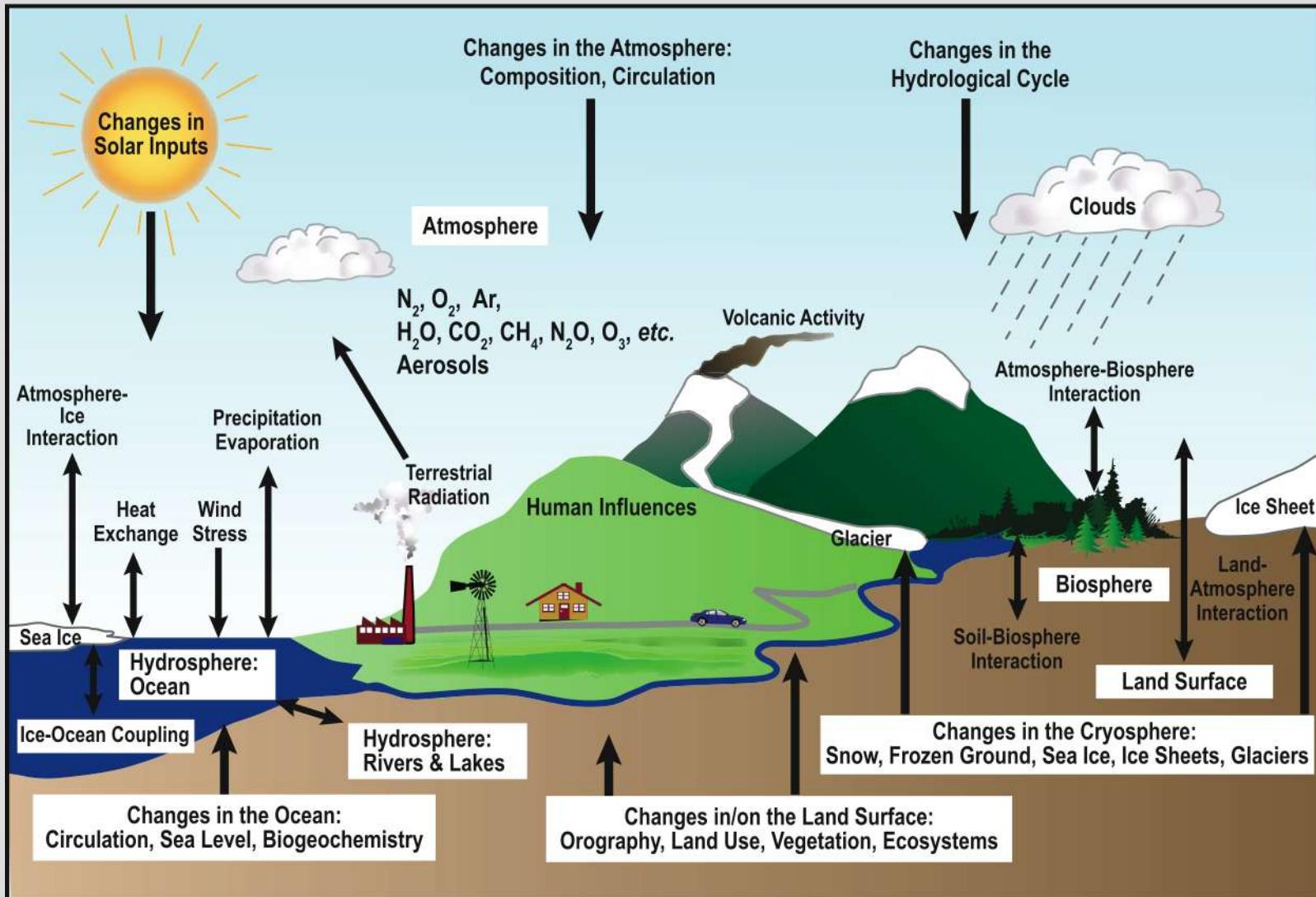


LOSU= Level of Scientific Understanding



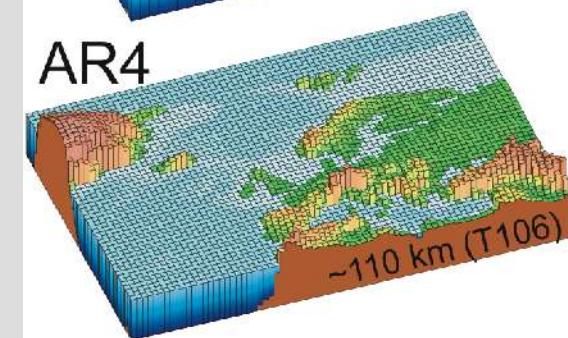
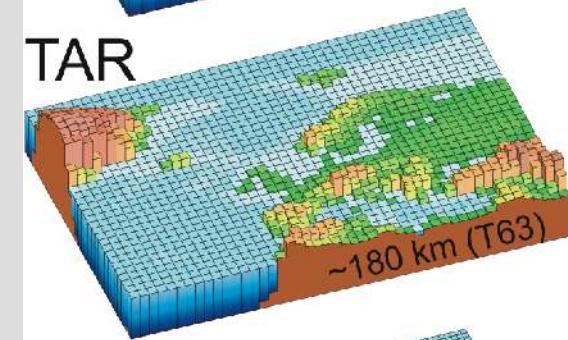
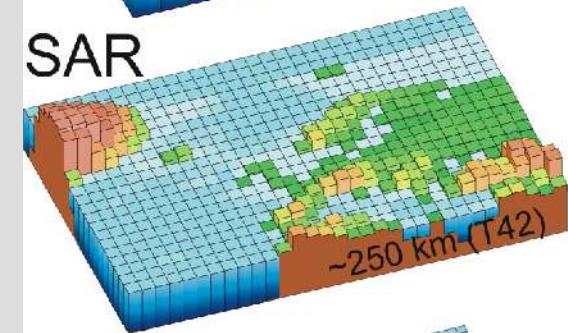
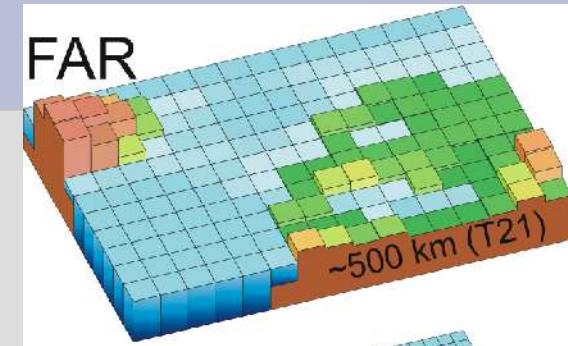
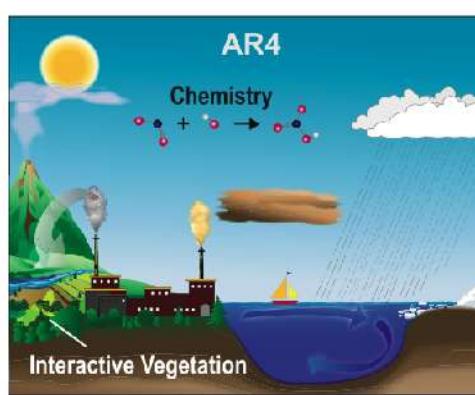
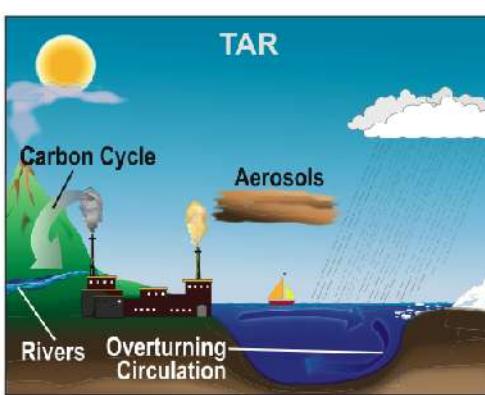
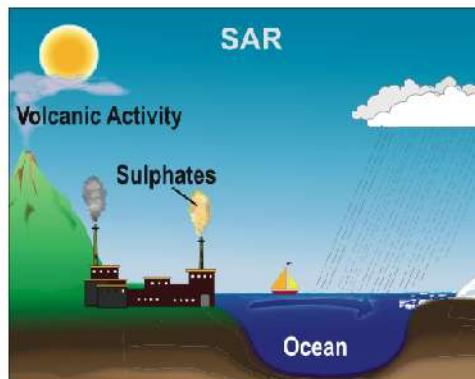
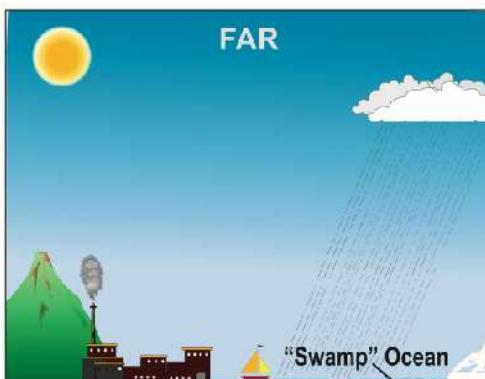
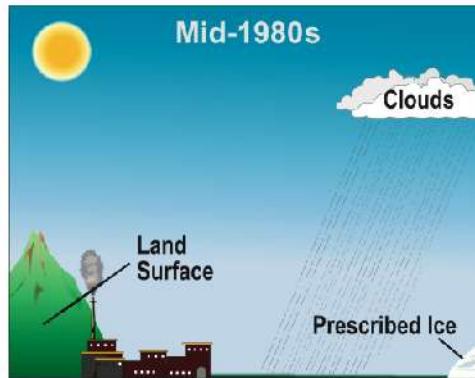
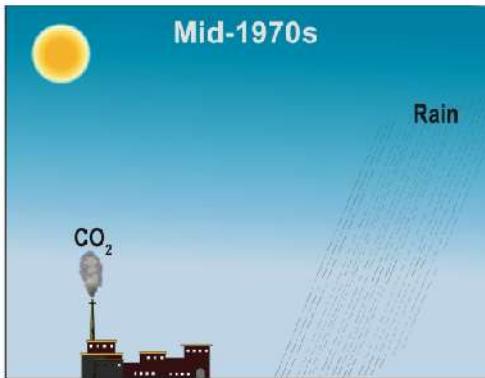
RF is the change in the net (downward minus upward) irradiance at the tropopause due to a change in an external driver of climate change (e.g. change in concentration of carbon dioxide or the output of the Sun).

Modelling the Climate

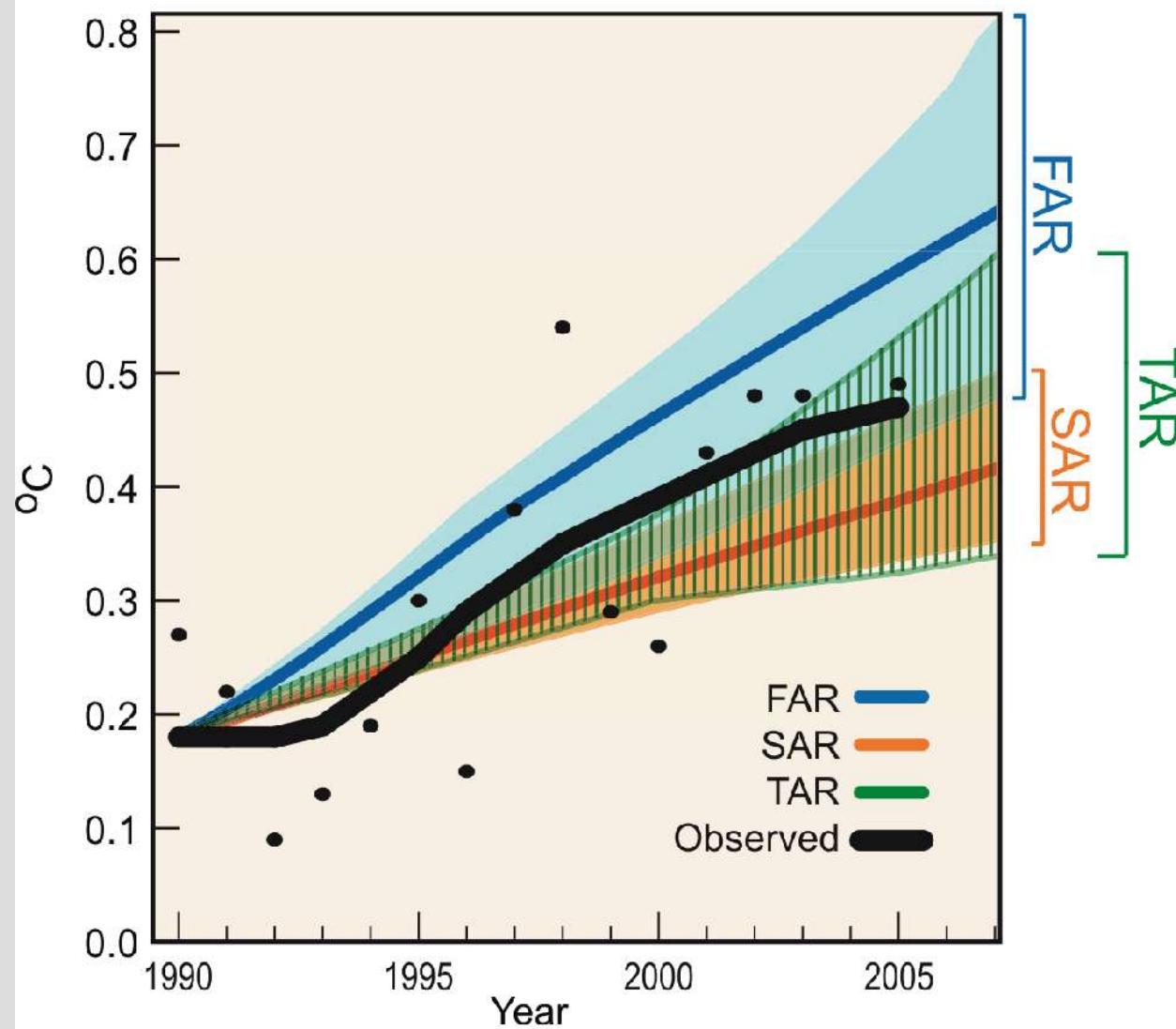


The World in Global Climate Models

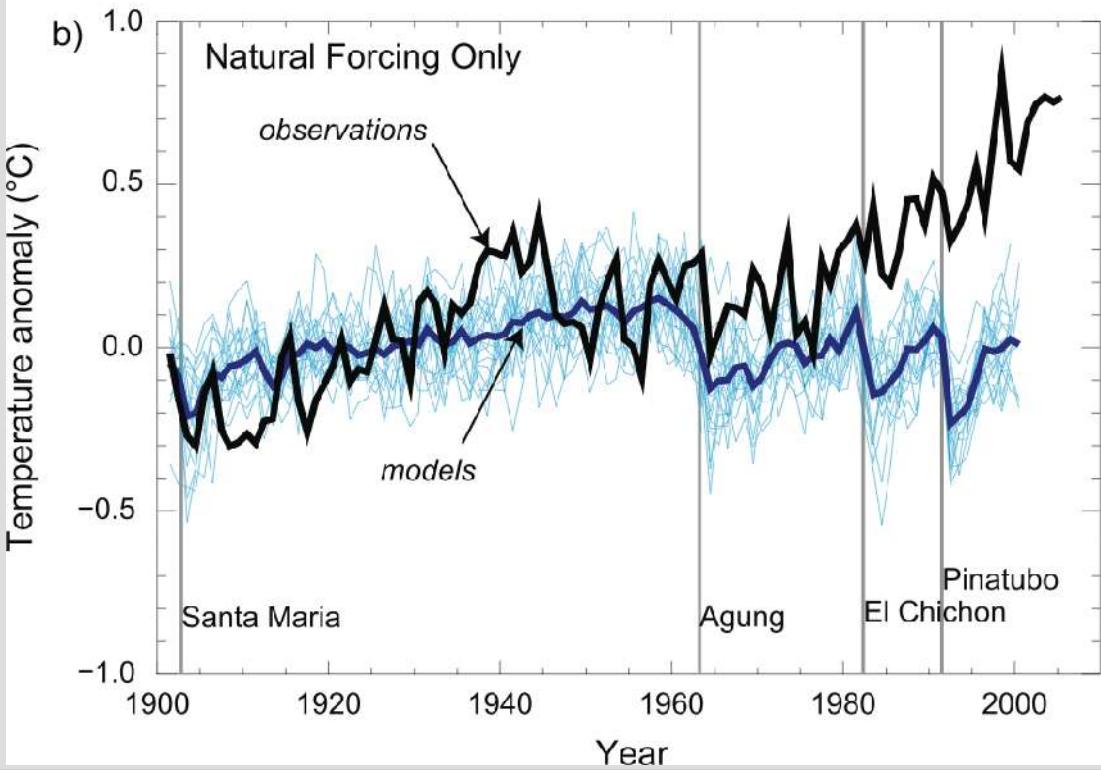
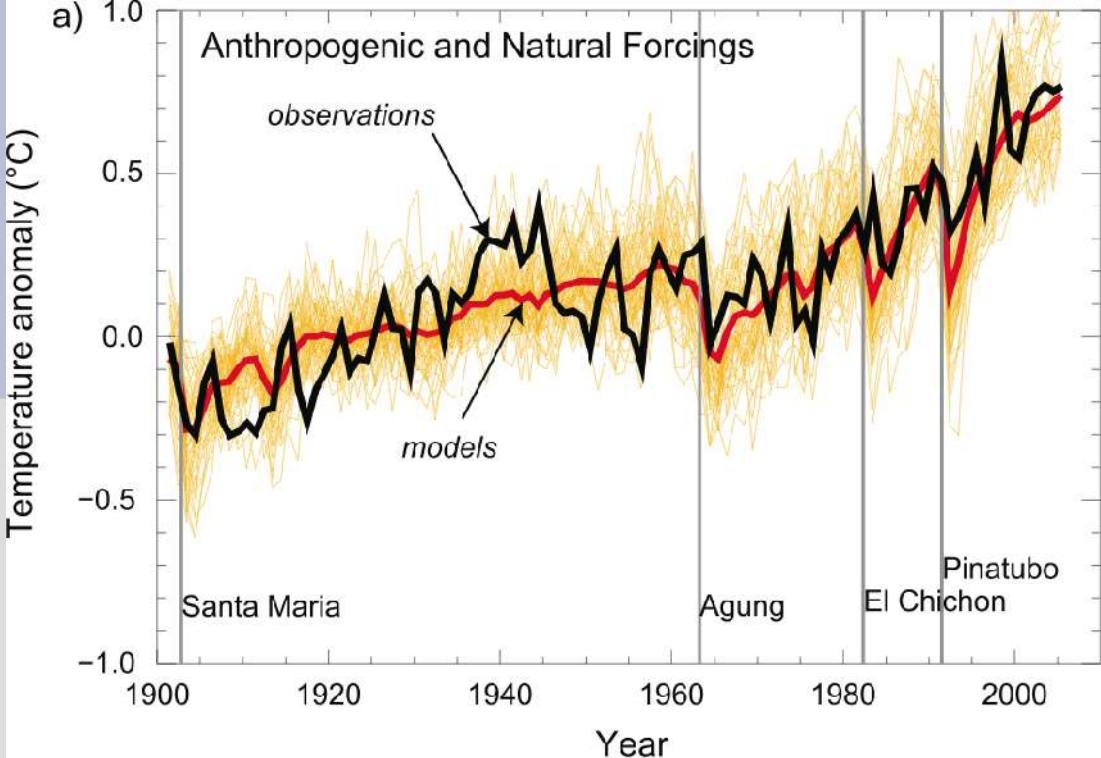
The World in Global Climate Models



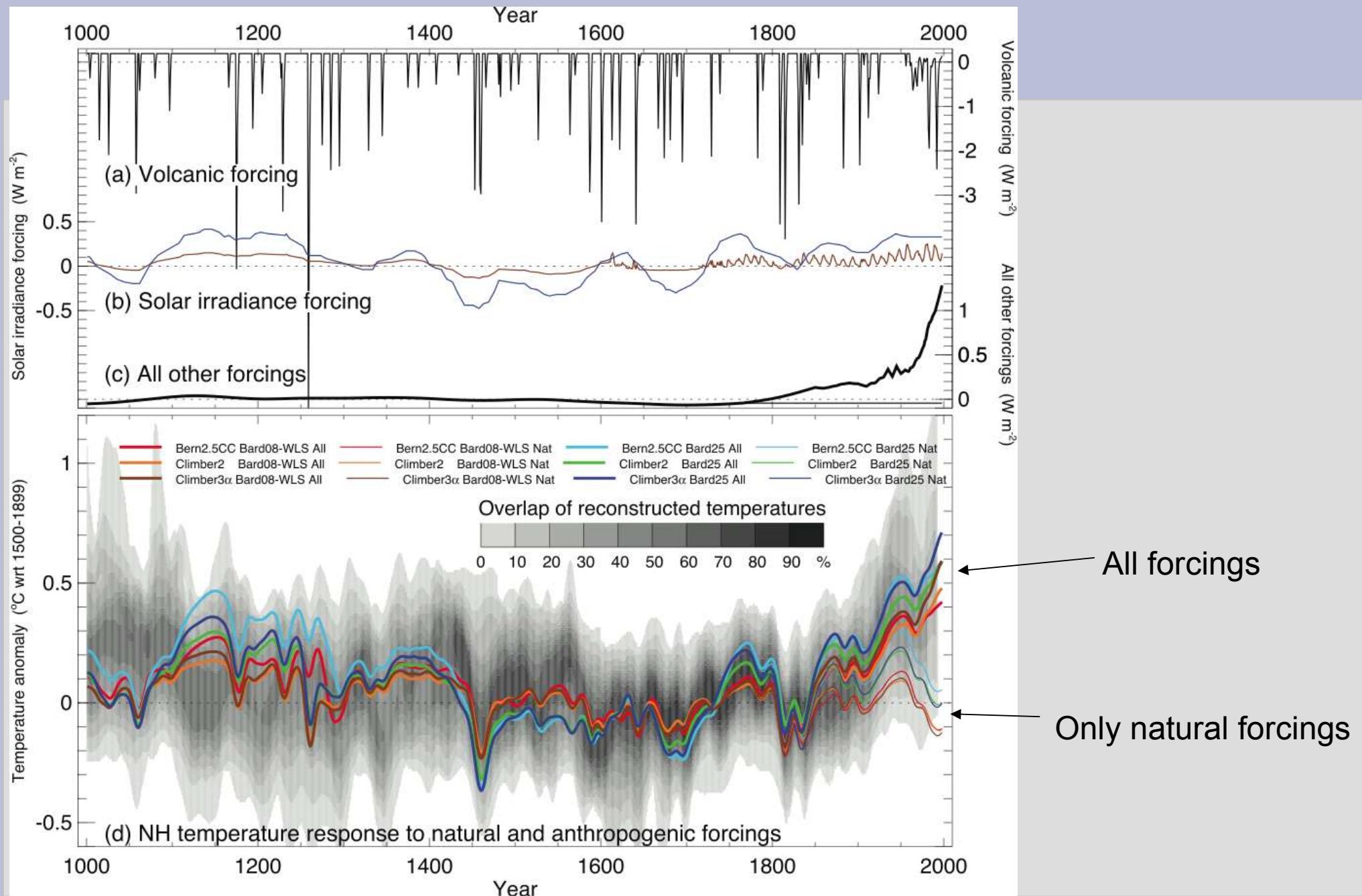
Model validation



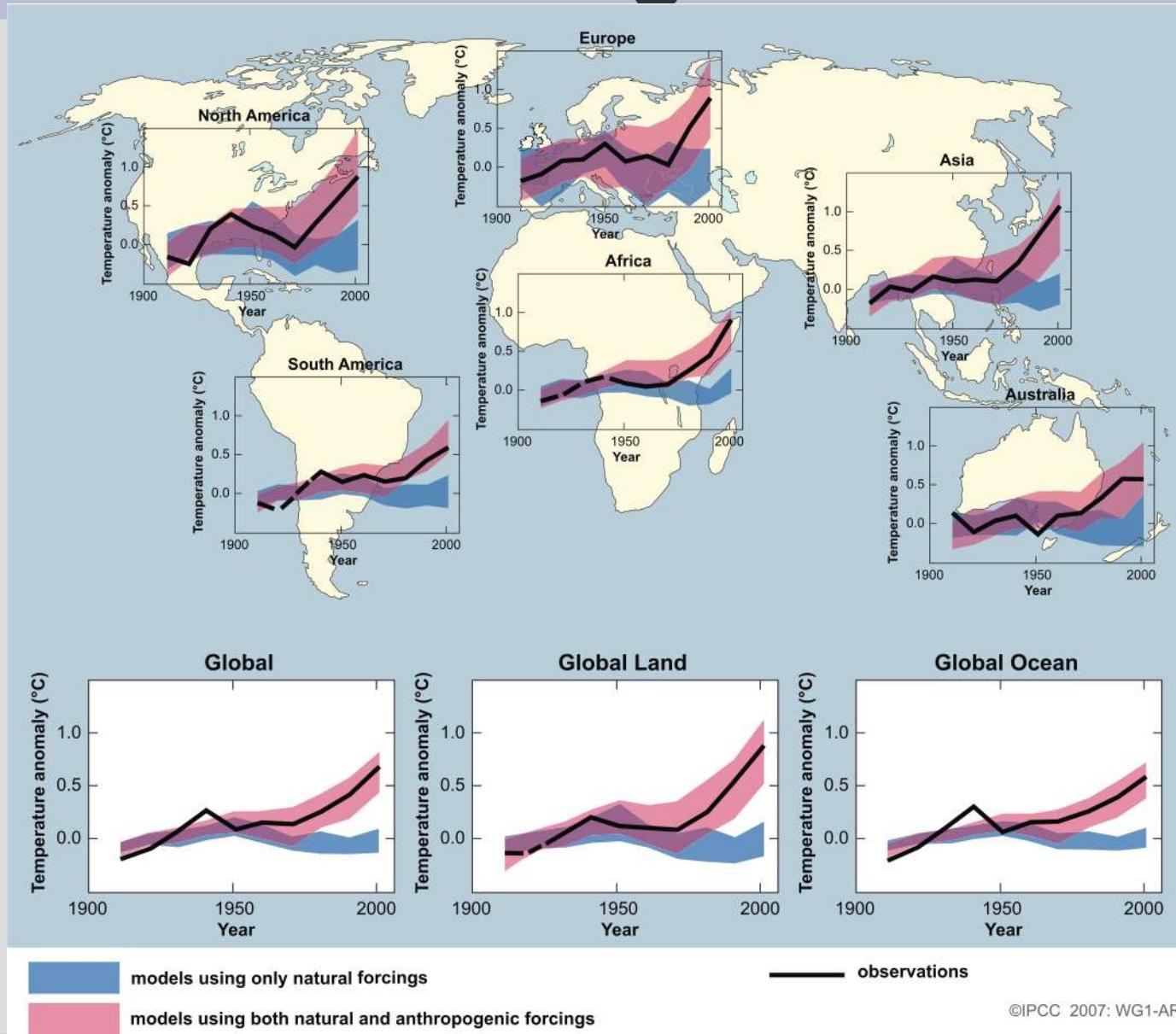
Attribution of Climate Change



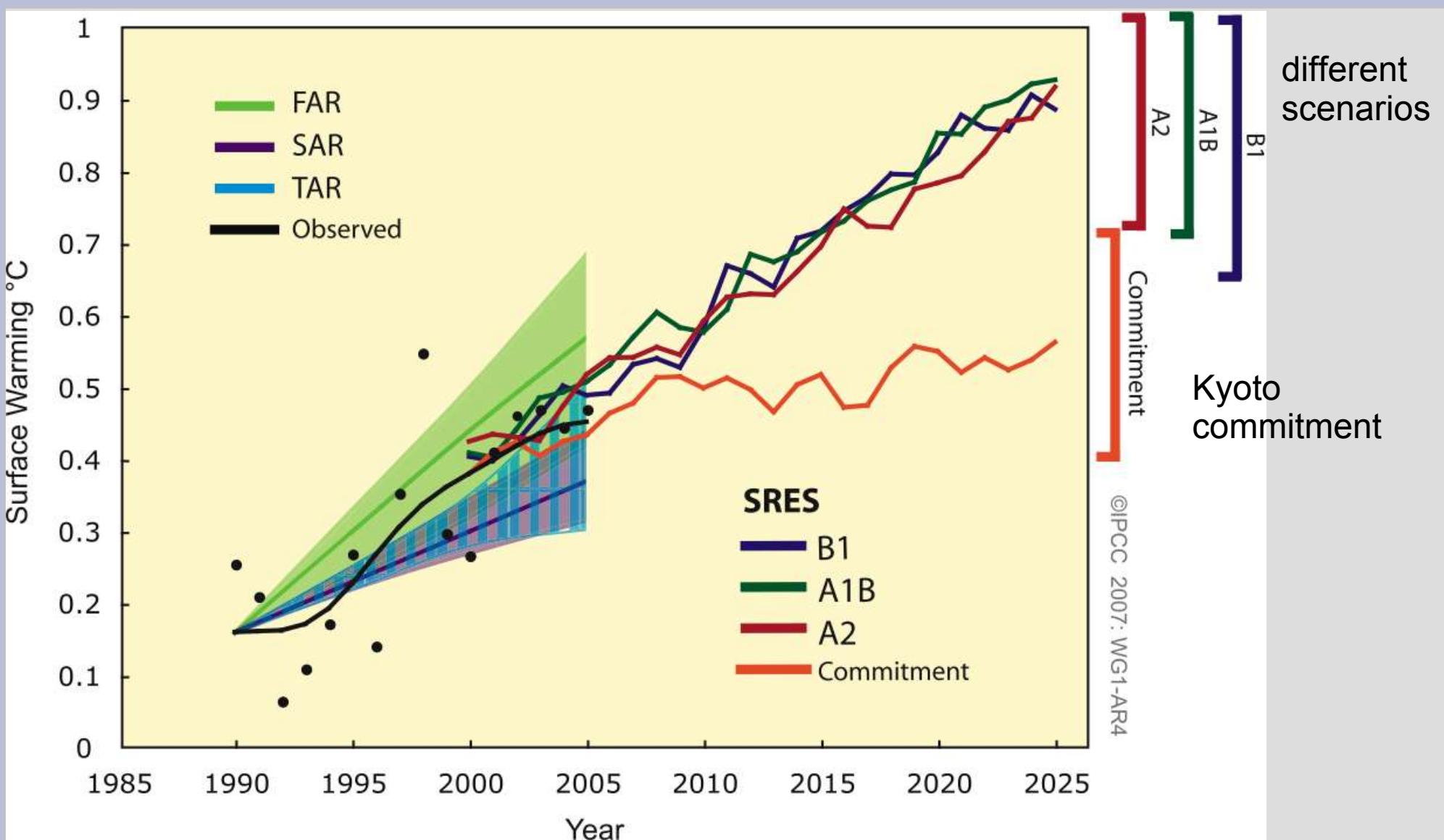
Attribution: natural/anthropogenic



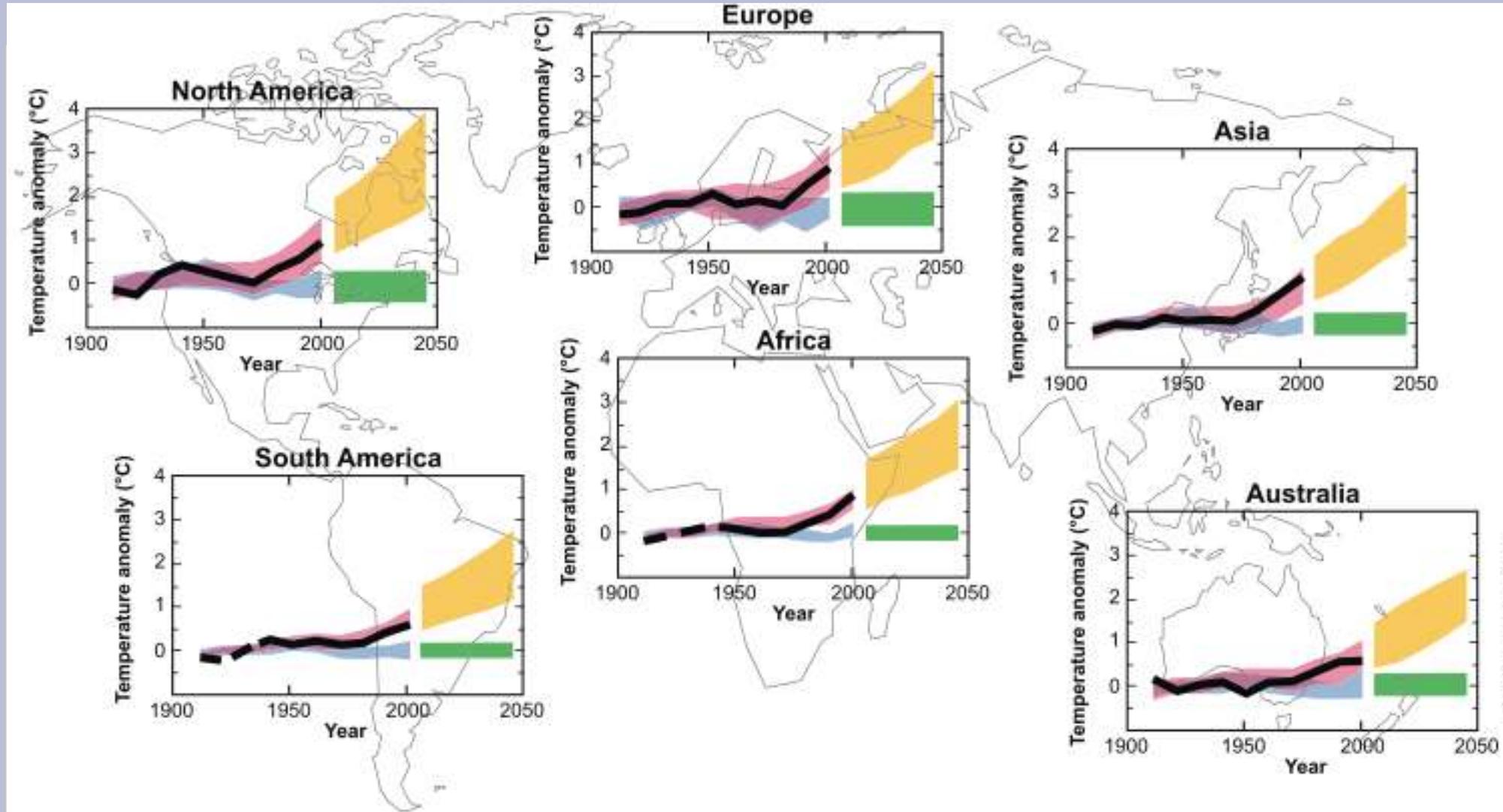
Attribution of Climate Change



Projections



Projections



models using natural forcing only

models using both anthropogenic and natural forcings

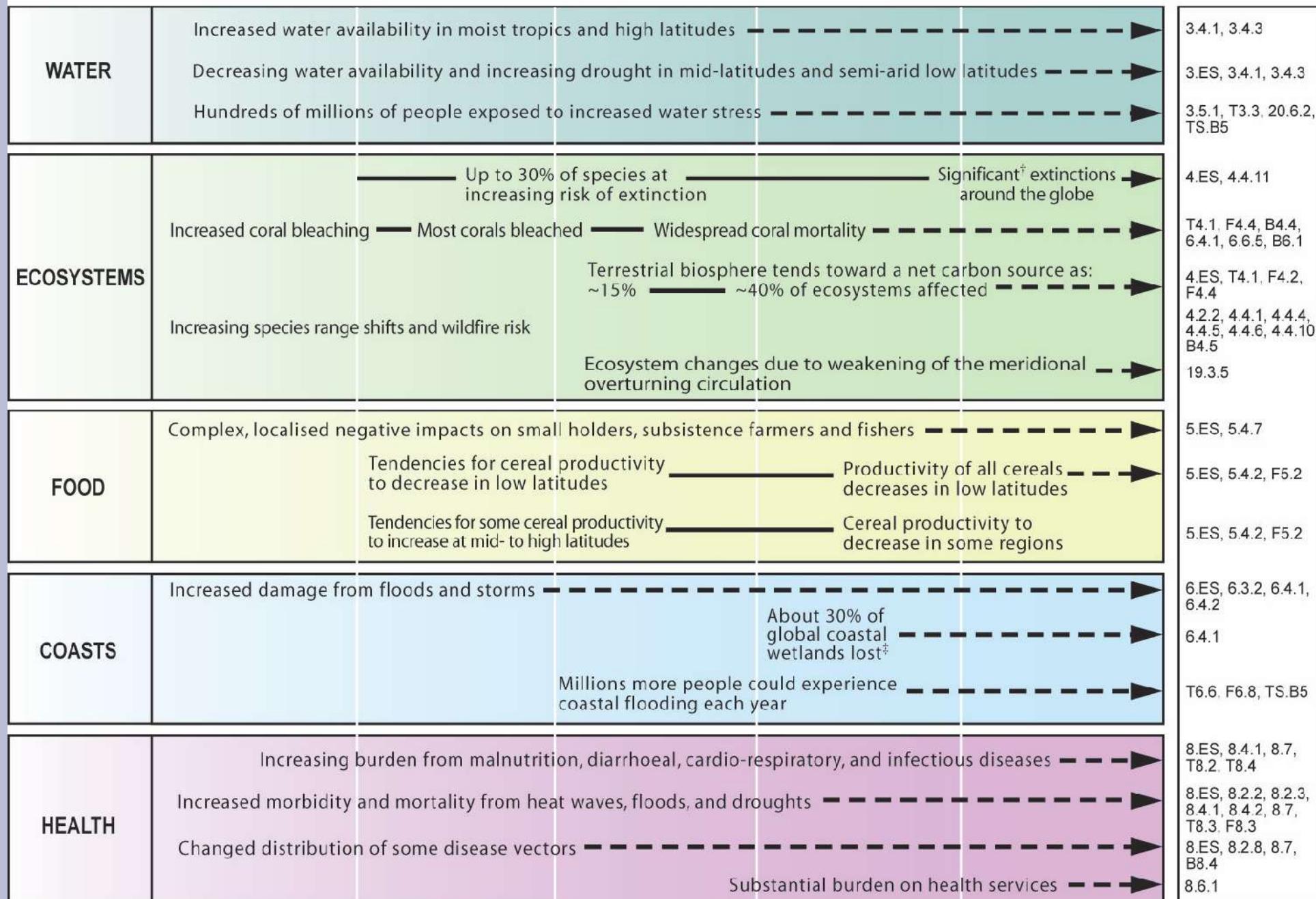
projected changes (A1B scenario)

range of anomalies with natural forcing only in 20th century simulations

observations

Global mean annual temperature change relative to 1980-1999 (°C)

0 1 2 3 4 5 °C



0 1 2 3 4 5 °C

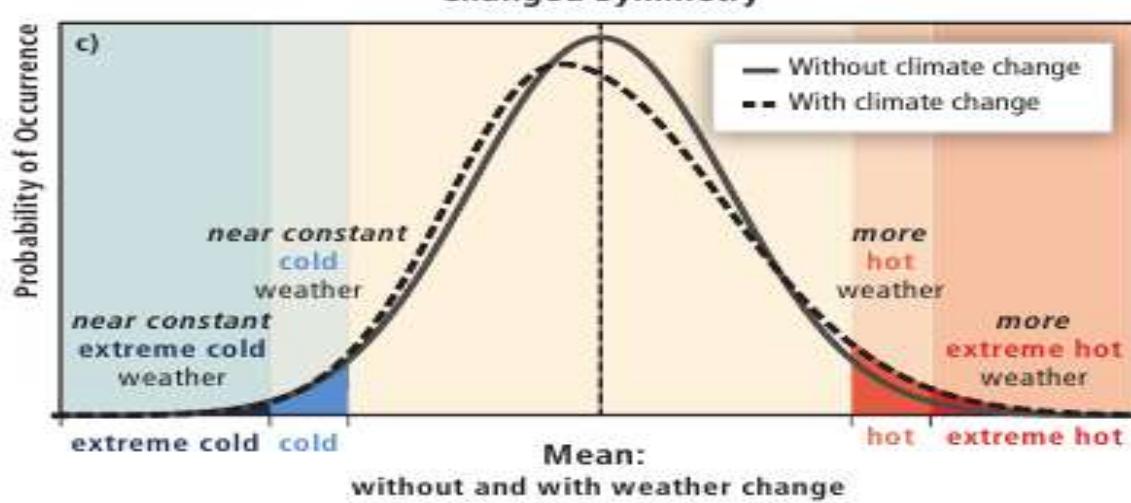
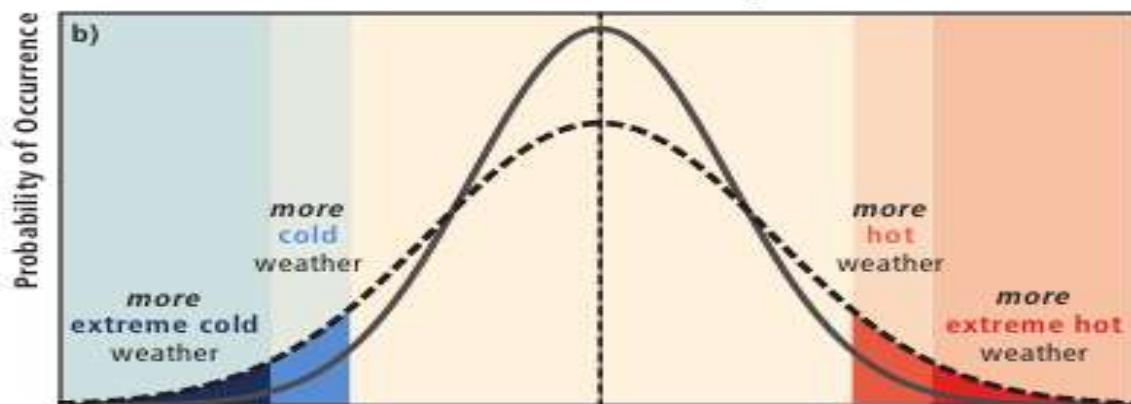
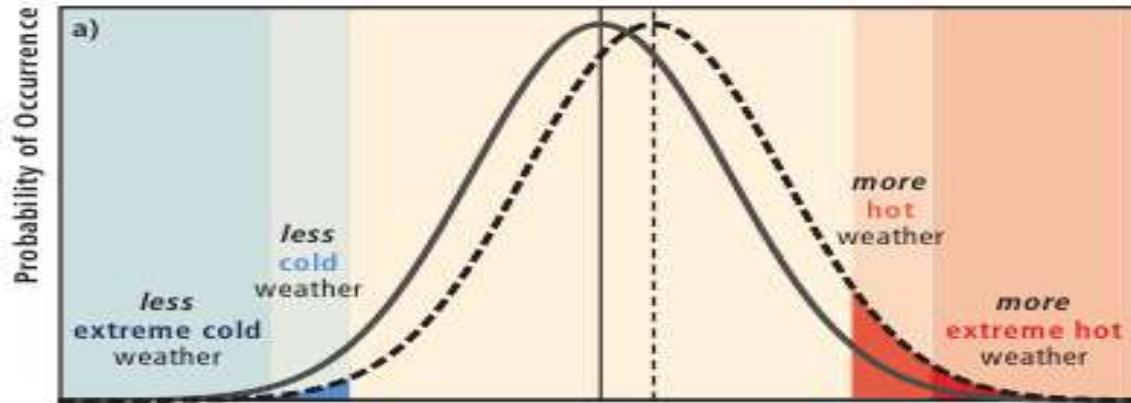
Global mean annual temperature change relative to 1980-1999 (°C)

[†] 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>)