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Young Surveyors European Meeting
European Young Surveyors
together for tomorrow's challenges

17-18 October

Lisbon, Portugal

Global Climate Change

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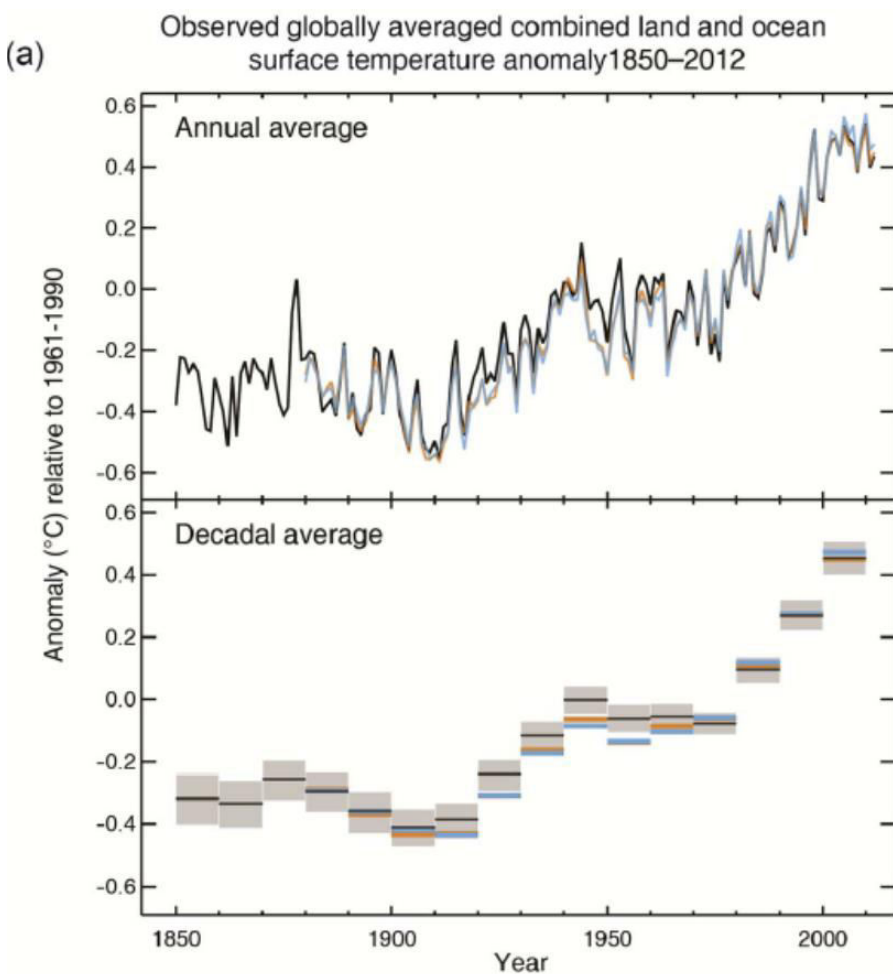
IPCC 5th Assessment Report for Climate Change 2013:

The Physical Basis

Observed Changes in the Climate System

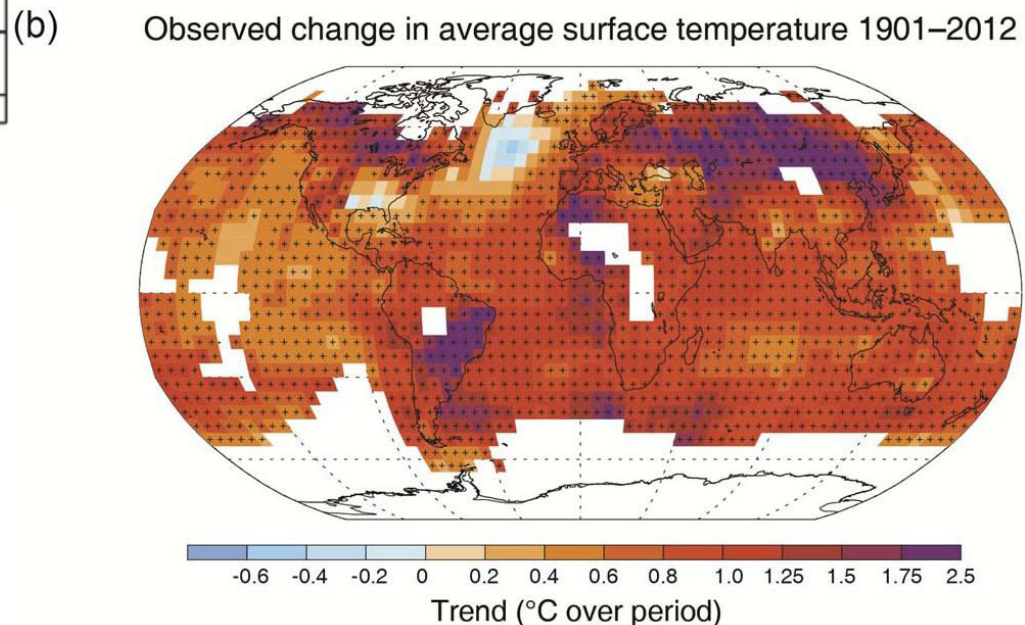
Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.

The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.



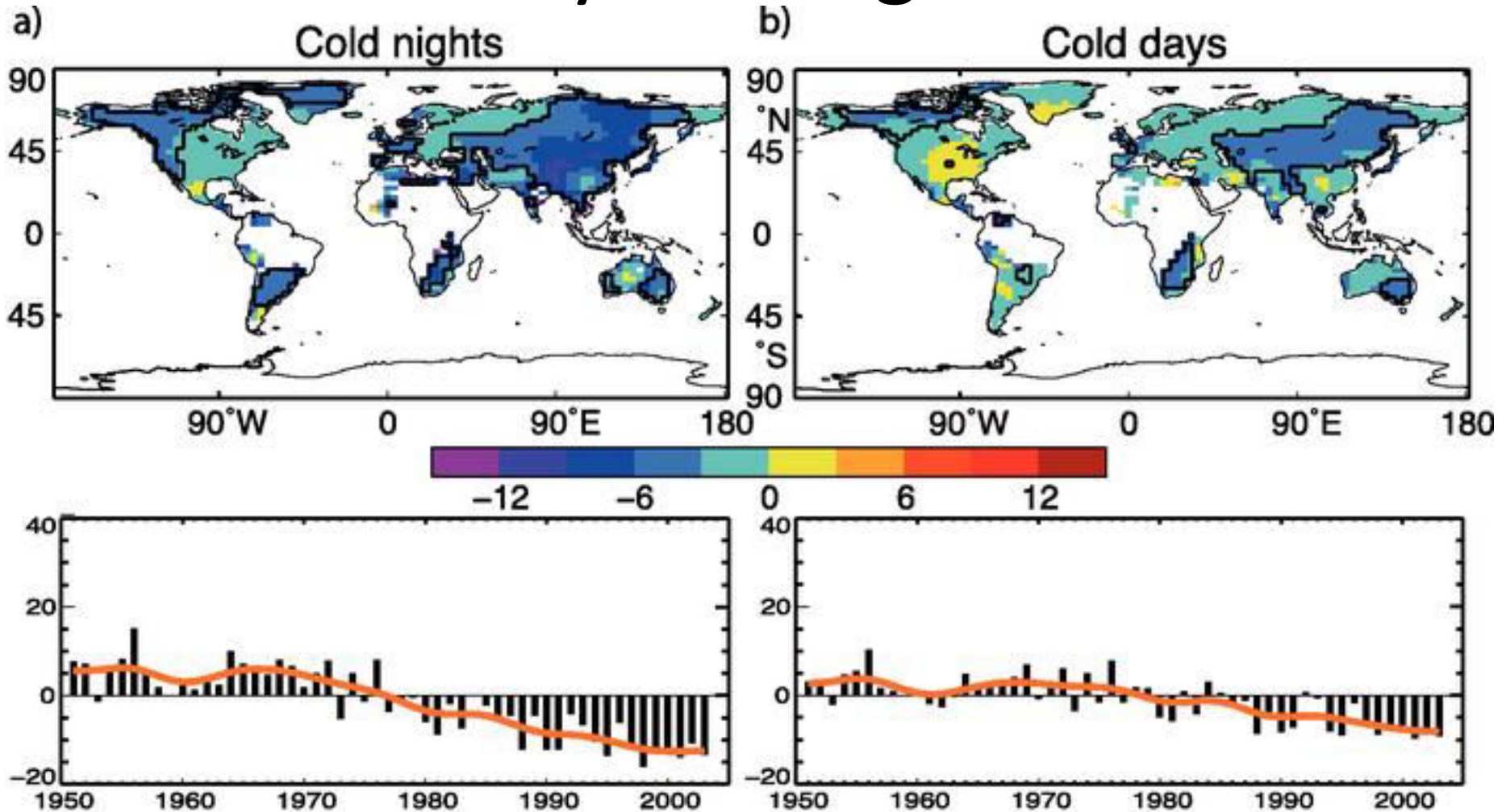
Each of the last three decades has been successively warmer at the Earth's surface than any receding decade since 1850.

In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1400 years



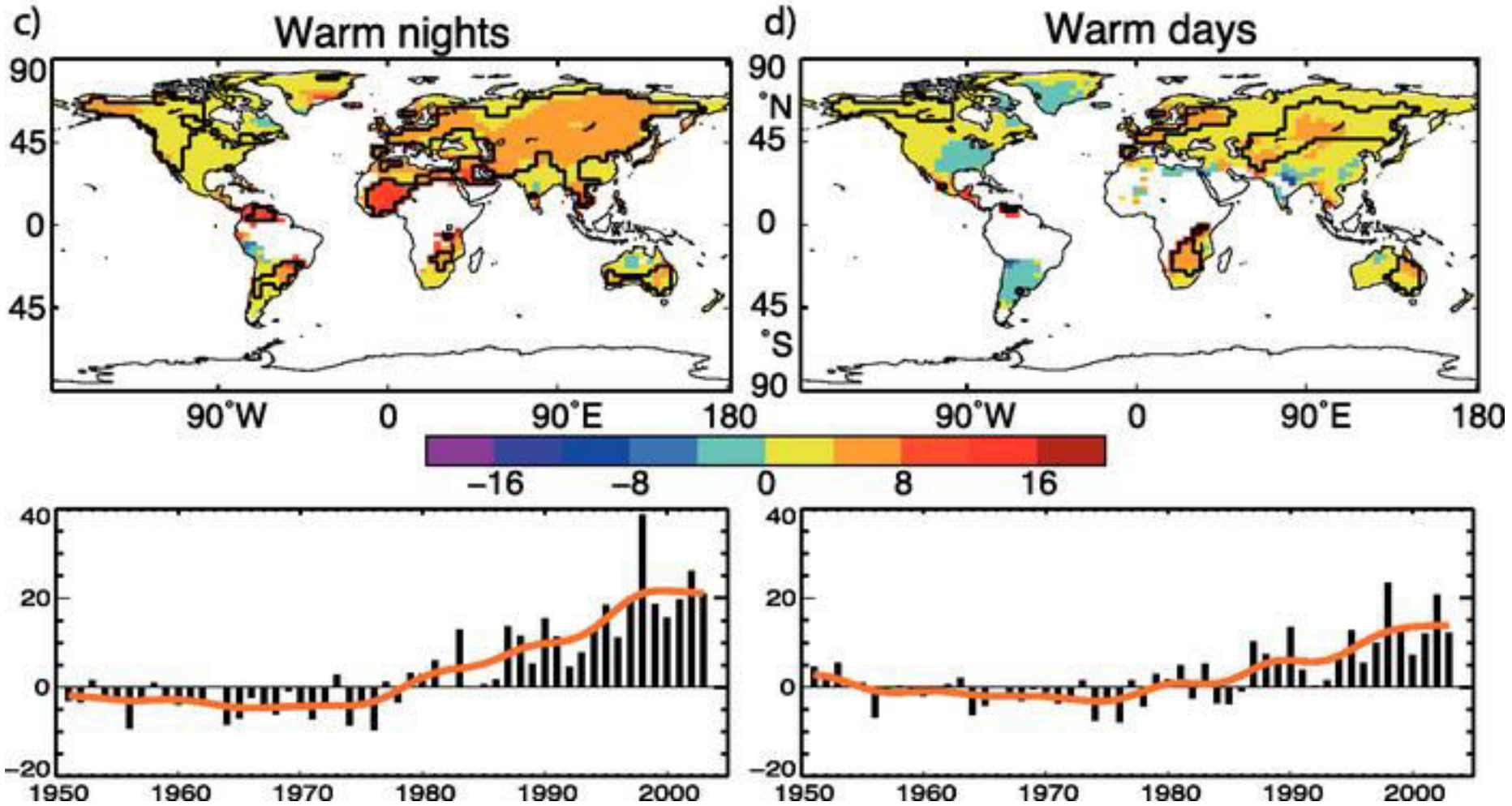
Atmosphere Temperature

Days vs. Nights



Observed trends (days per decade) for 1951 to 2003 in the frequency of extreme temperatures (defined based on 1961 to 1990 values)

Days vs. Nights

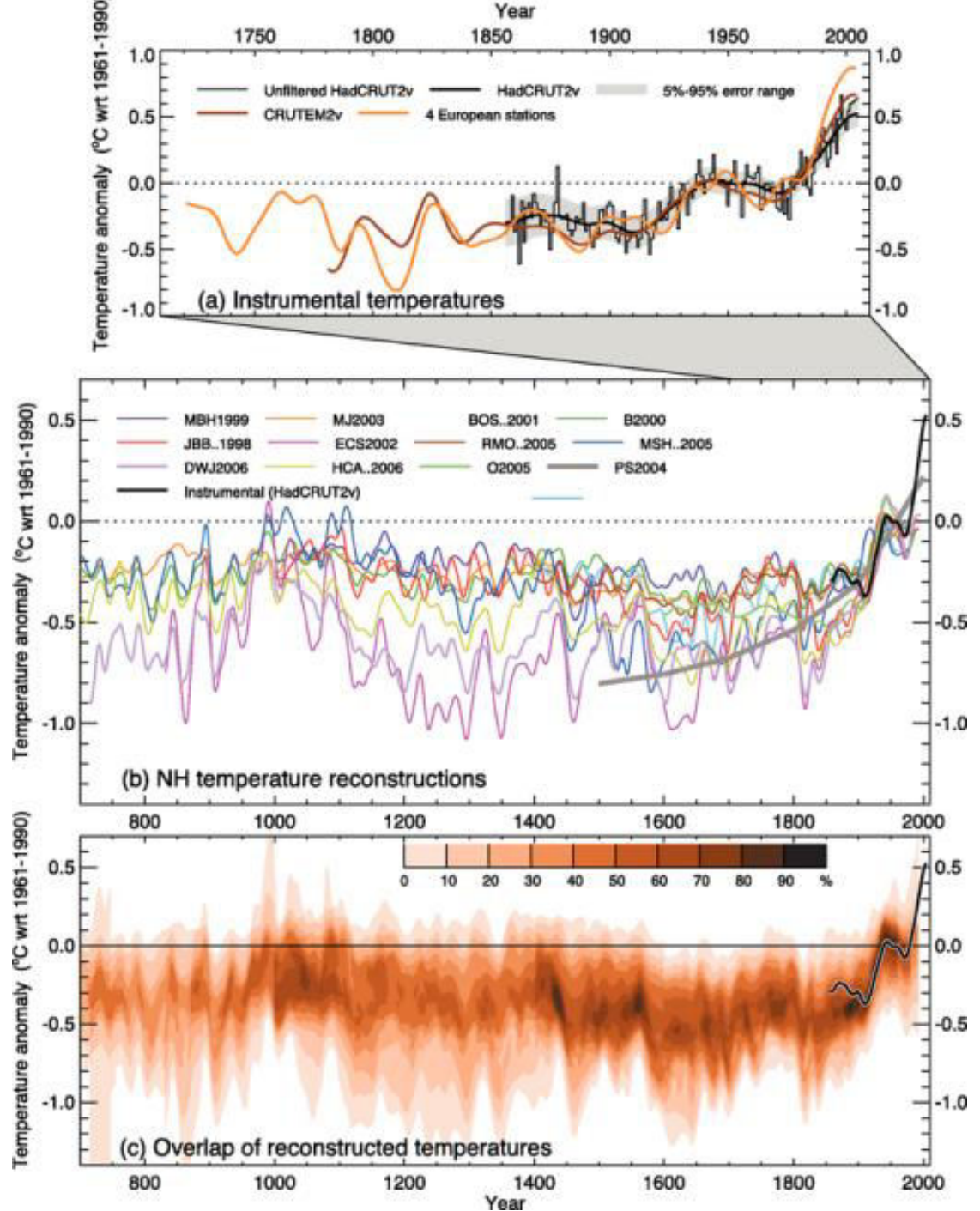


The number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale. It is likely that the frequency of heat waves has increased in large parts of Europe, Asia and Australia.

Last 1300 yrs

*anomalies (°C) from the
1961 to 1990 mean*

IPCC- 2007

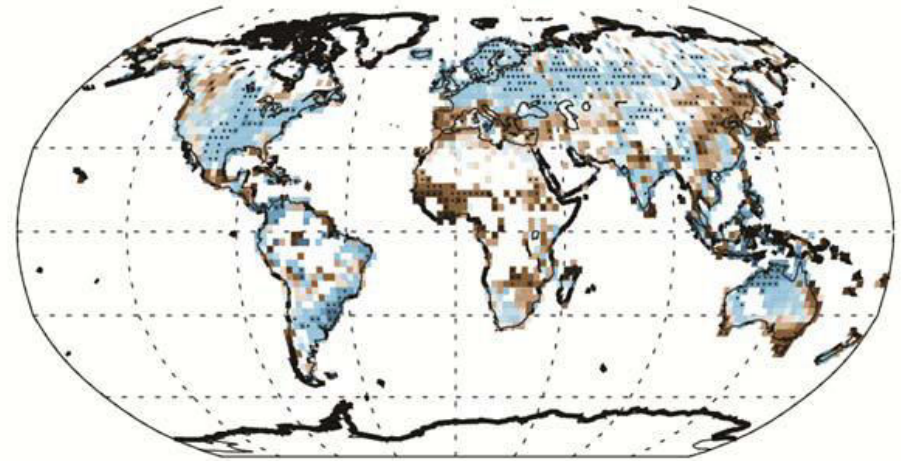
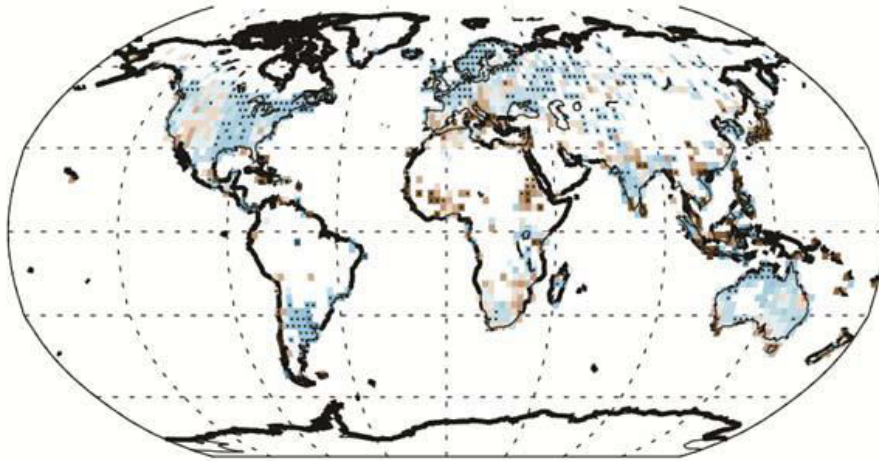


Atmosphere - Precipitation

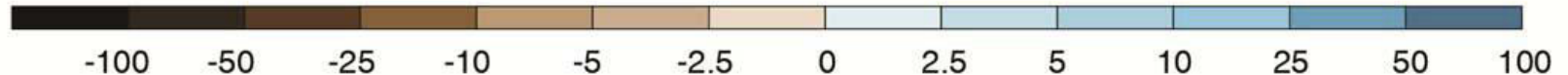
Observed change in precipitation over land

1901–2010

1951–2010



IPCC - 2013



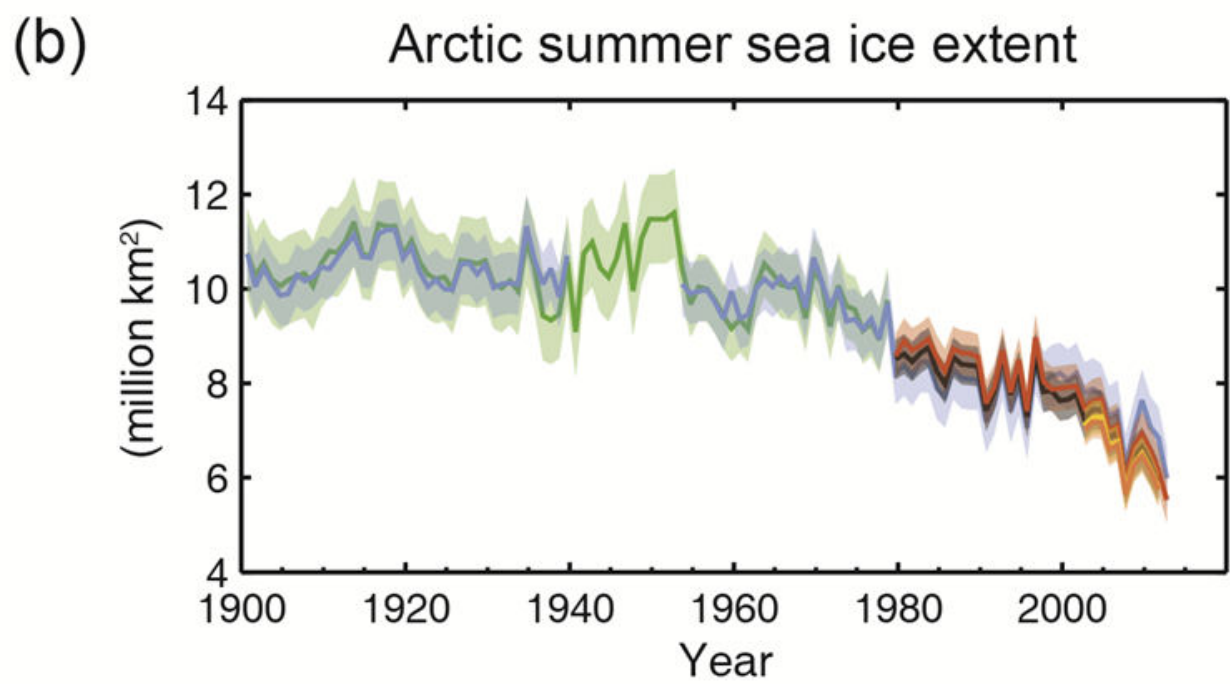
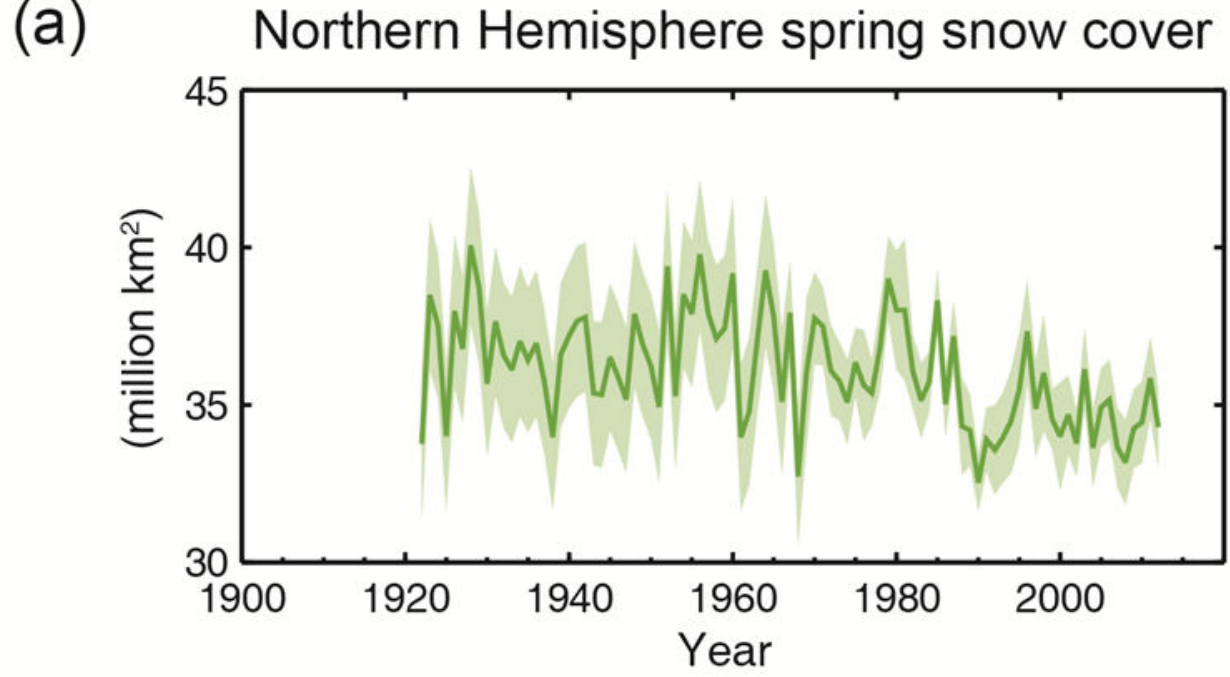
Trend (mm/year/decade)

Extremes

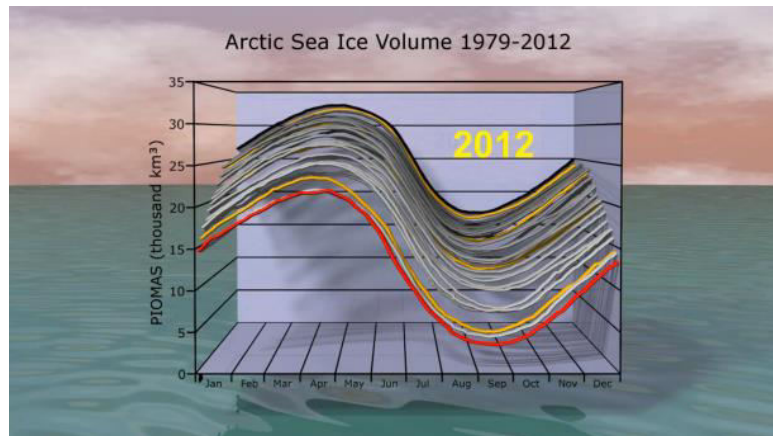
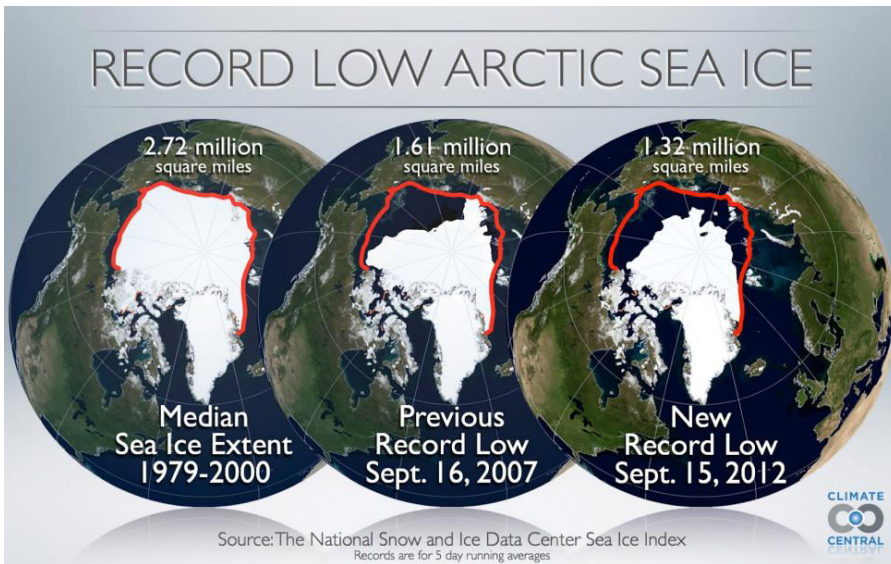
More land regions where the number of heavy precipitation events has increased than where it has decreased.

The frequency or intensity of heavy precipitation events has likely increased in North America and Europe.

Cryosphere



Melting Ice



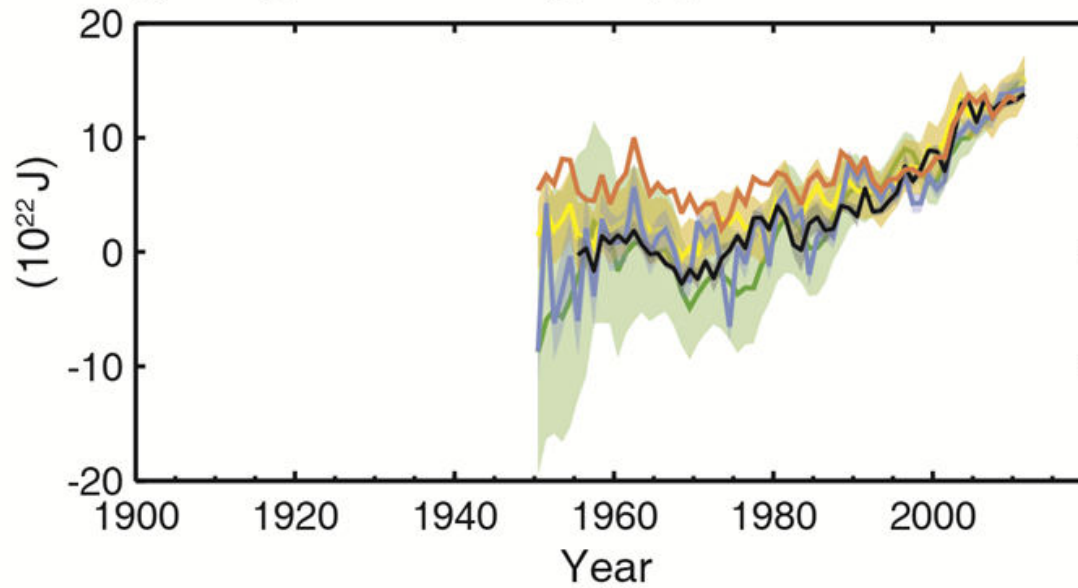
Since 1979, the volume of Summer Arctic Sea Ice has declined by **80%** and is accelerating.

The first ice-free summer in the Arctic Ocean is expected to happen between 2016 and 2022.

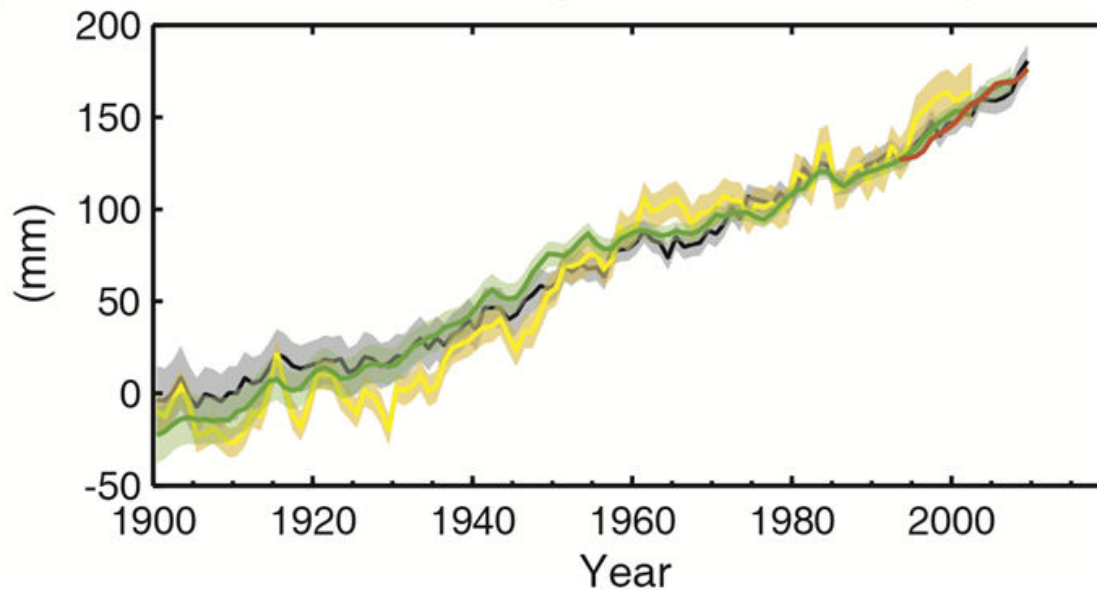
“The nine lowest maximum extents have occurred in the last nine years, since 2004,” Meier says.

Ocean

(c) Change in global average upper ocean heat content

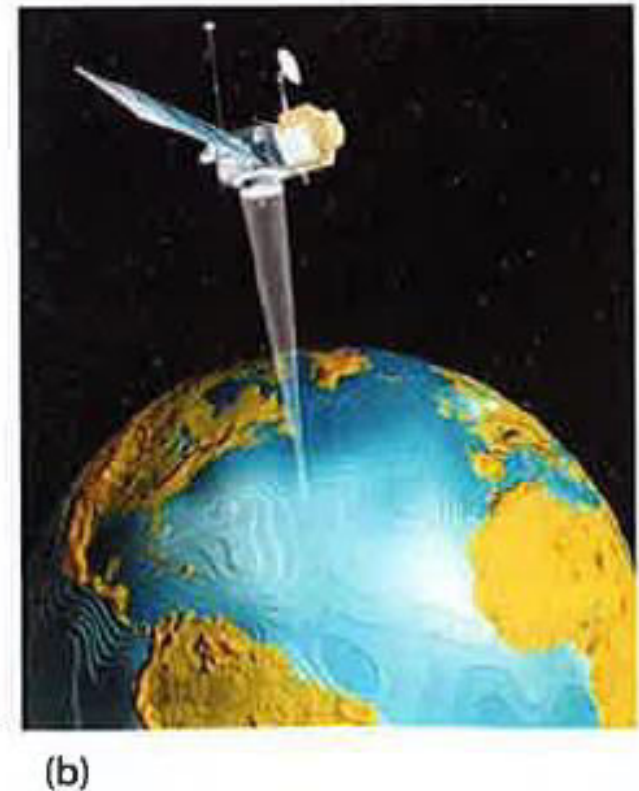
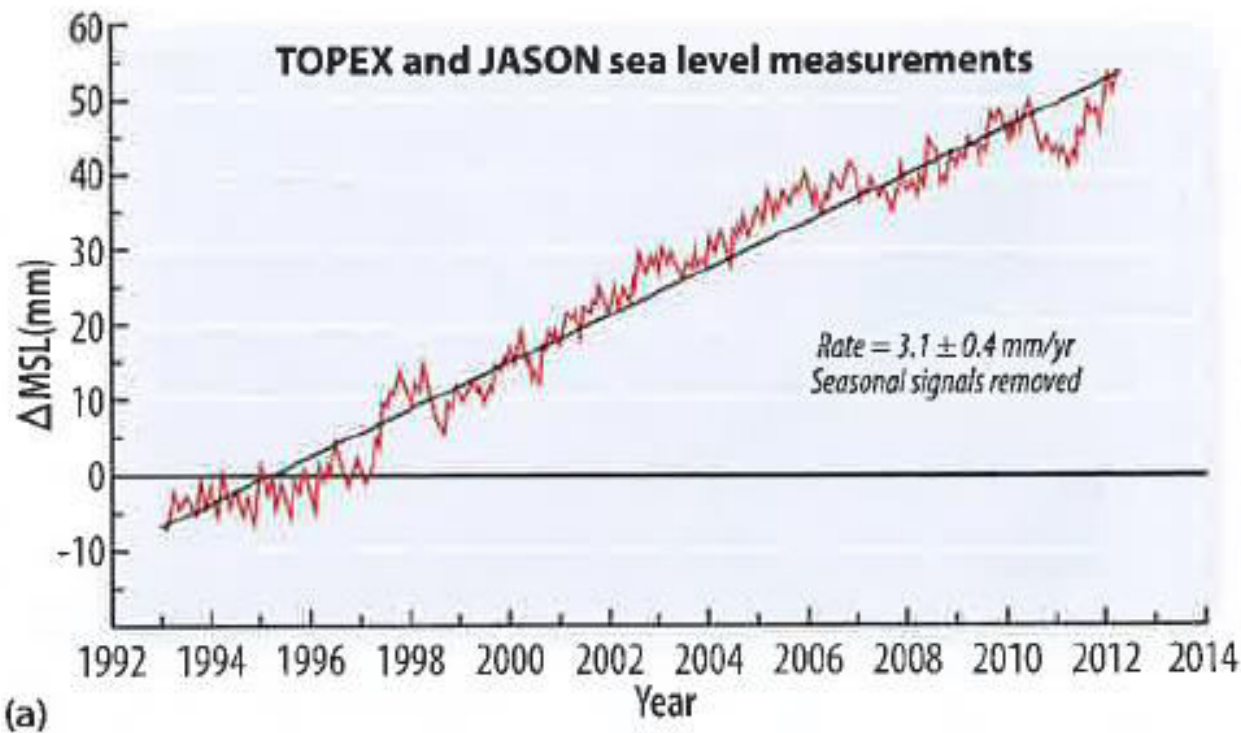


(d) Global average sea level change

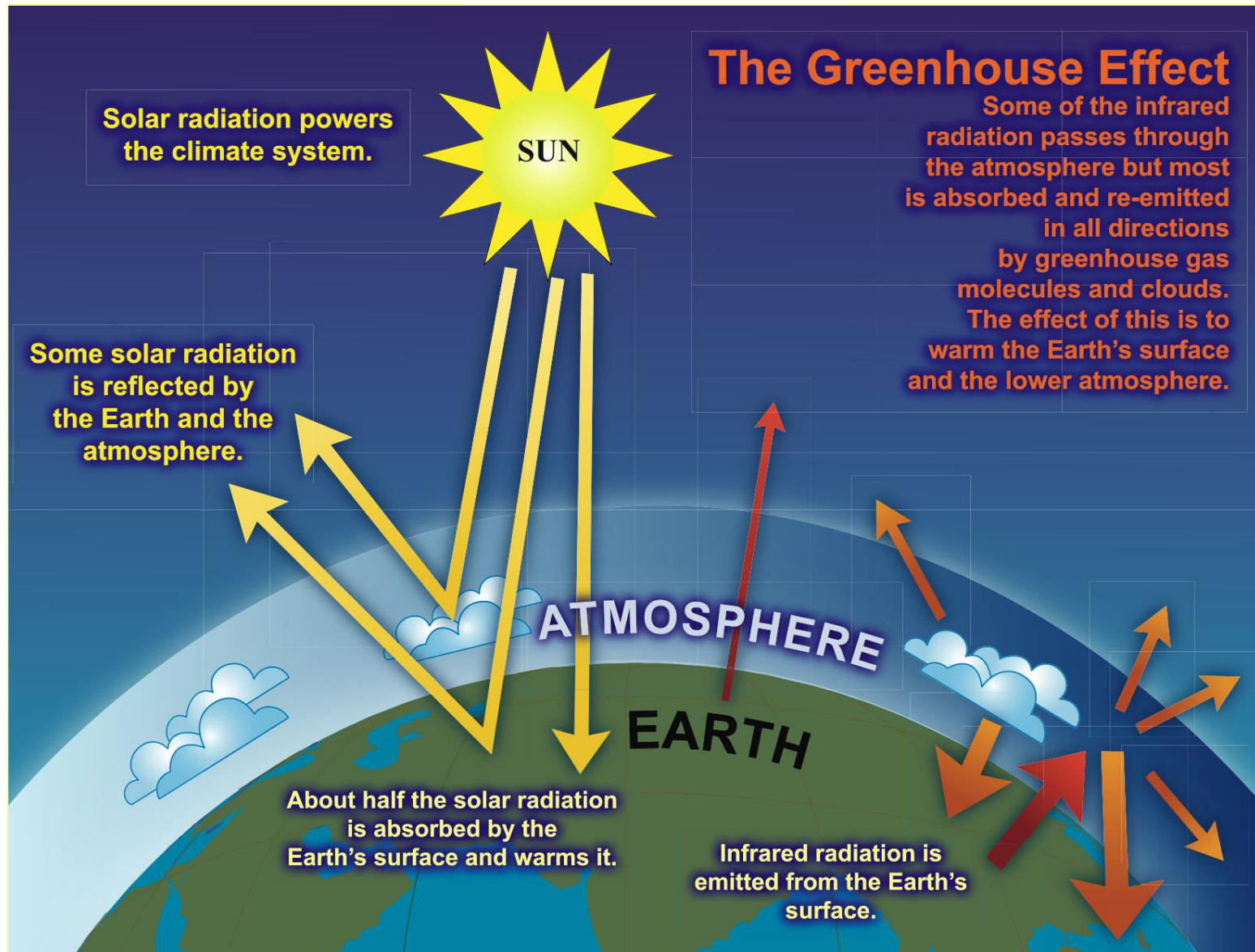


Sea Level

Warming + Melting = Sea Level Rise



▲ **Figure 2.7:** (a) A graph of recent sea level rise, measured from NASA's TOPEX and JASON satellite instruments, showing changes in sea level averaged over a 60-day period (blue line) and the overall trend (black line) of 3.1 millimeters per year (0.12 inches). Note the small decrease in sea level between 2010 and 2012. This developed after unusually wet weather globally increased the amount of rainwater stored on land in rivers, lakes, reservoirs, and groundwater. This temporary decrease in sea level soon recovered as all the extra water made its way back slowly to the oceans. (b) Launched in 1992, the TOPEX/POSEIDON satellite was the first mission to analyze sea surface topography with precision. It has since been replaced by the JASON-2 satellite launched in 2008.





The greenhouse effect: early discoveries



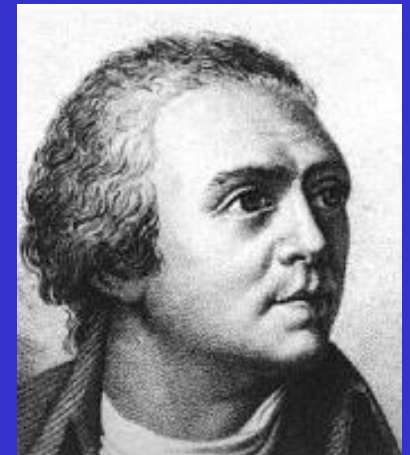
(www.nndb.com)

Edme Mariotte (1620-1684):

Sun's heat passes through glass, other heat does not (1681).

Horace Bénédict de Saussure (1740-1799):

Air in mountains does not trap heat as much as air in low-lying regions



(www.eoearth.org)



1824, Jean Baptiste Fourier

AMERICAN
JOURNAL OF SCIENCE, &c.

ART. I.—*General Remarks on the Temperature of the Terrestrial Globe and the Planetary Spaces*; by Baron FOURIER.*

Translated from the French, by Mr. EBENEZER BURGESS, of Amherst College.

THE question of terrestrial temperature, one of the most remarkable and difficult in natural philosophy, involves very different elements which require to be considered in a general light. I have

"greenhouse effect". He writes: "**The temperature [of the Earth] can be augmented by the interposition of the atmosphere**, because heat in the state of light finds less resistance in penetrating the air, than in re-passing into the air when converted into non-luminous heat."



Optical properties of atmospheric gases

1861, John Tyndall

PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

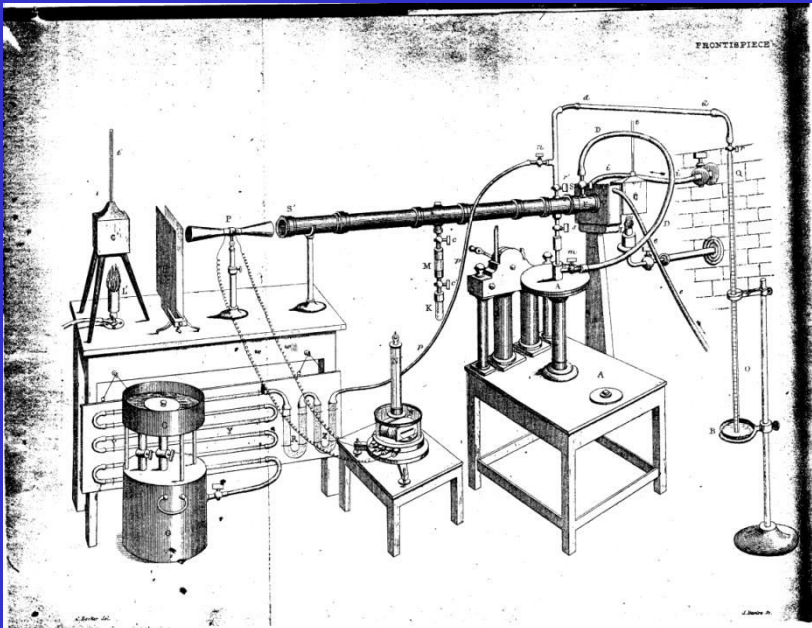
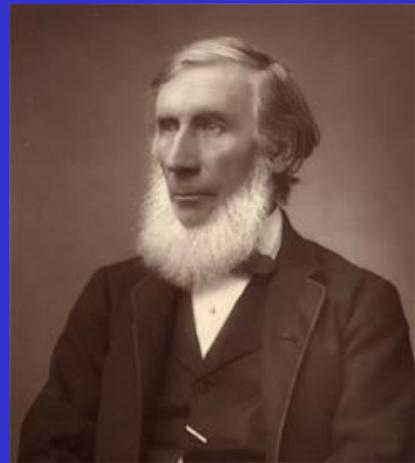
XXIII. *On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction.* The Bakerian Lecture. By JOHN TYNDALL Esq., F.R.S. &c.*

[With a Plate.]

Measured infrared radiation
absorption properties of atmospheric
molecules

Changing H_2O or CO_2 could cause
“all the mutations of climate which
the researches of geologists reveal”

Air	0
Oxygen	0
Nitrogen	0
Hydrogen	0
Carbonic oxide	12
Carbonic acid	18
Nitrous oxide	29
Olefiant gas	53



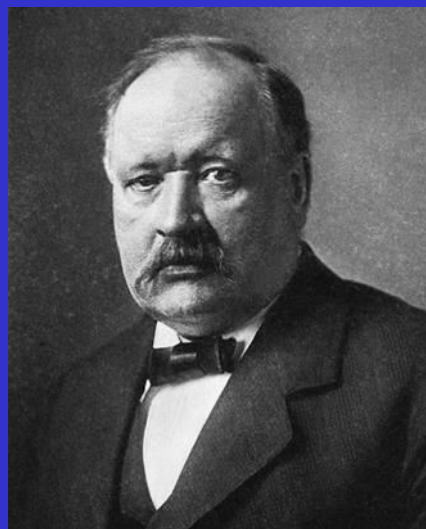


1896, Arrhenius
 CO_2

PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.



XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

40% \uparrow or \downarrow in CO_2 could explain advance & retreat of glaciers. ($2\times\text{CO}_2 \Rightarrow \Delta T \sim 4^\circ\text{C.}$) Human CO_2 emissions could prevent another ice age.

Nobel Prize - Chemistry (1903)

V. Geological Consequences.

I should certainly not have undertaken these tedious calculations if an extraordinary interest had not been connected with them. In the Physical Society of Stockholm there have been occasionally very lively discussions on the probable causes of the Ice Age; and these discussions have, in my opinion, led to the conclusion that there exists as yet no satisfactory hypothesis that could explain how the climatic conditions



551.510.4:551.521.3:551.524.34
THE ARTIFICIAL PRODUCTION OF CARBON DIOXIDE
AND ITS INFLUENCE ON TEMPERATURE

By G. S. CALLENDAR

(Steam technologist to the British Electrical and Allied Industries
Research Association.)

(Communicated by Dr. G. M. B. Dobson, F.R.S.)

In conclusion it may be said that the combustion of fossil fuel, whether it be peat from the surface or oil from 10,000 feet below, is likely to prove beneficial to mankind in several ways, besides the provision of heat and power. For instance the above mentioned small increases of mean temperature would be important at the northern margin of cultivation, and the growth of favourably situated plants is directly proportional to the carbon dioxide pressure (Brown and Escombe, 1905). In any case the return of the deadly glaciers should be delayed indefinitely.

As regards the reserves of fuel these would be sufficient to give at least ten times as much carbon dioxide as there is in the air at present.

Guy Stuart Callendar (1897-1964)

1938

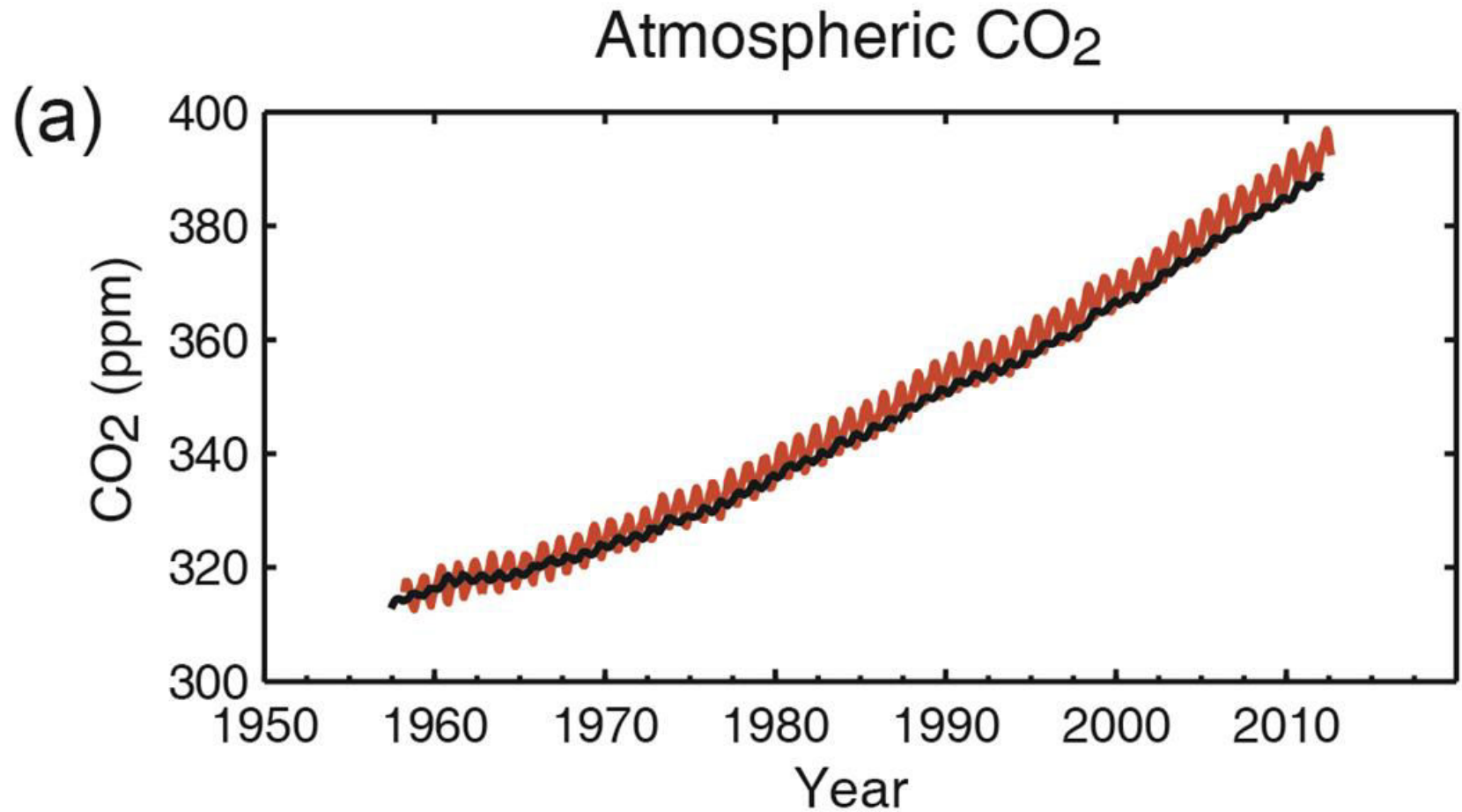


Must treat atmosphere as set of interacting layers, not a single slab.

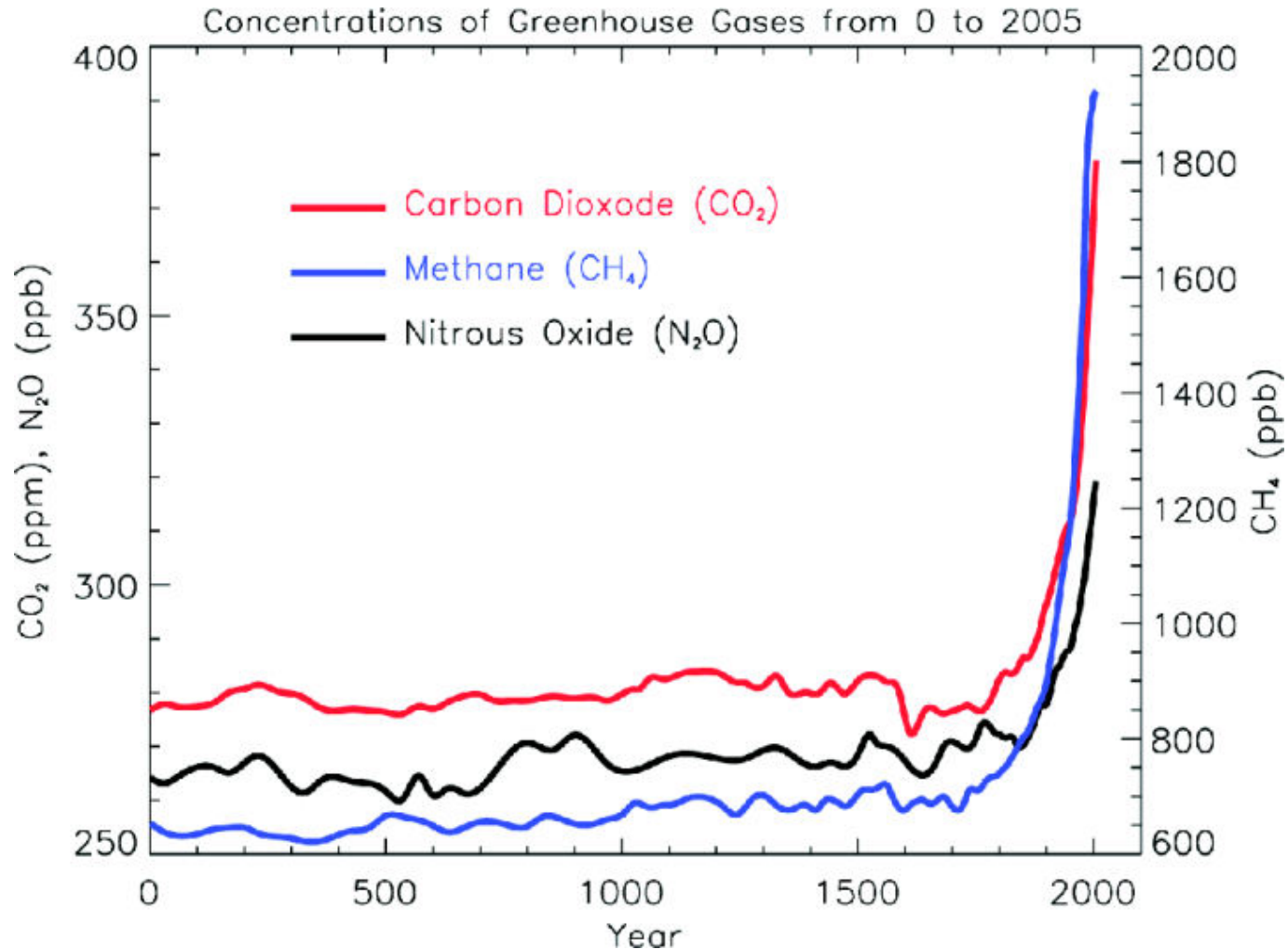
Speculated, with others, that ΔT over first part of

20th Century was anthropogenic.

Carbon and Other Biogeochemical Cycles



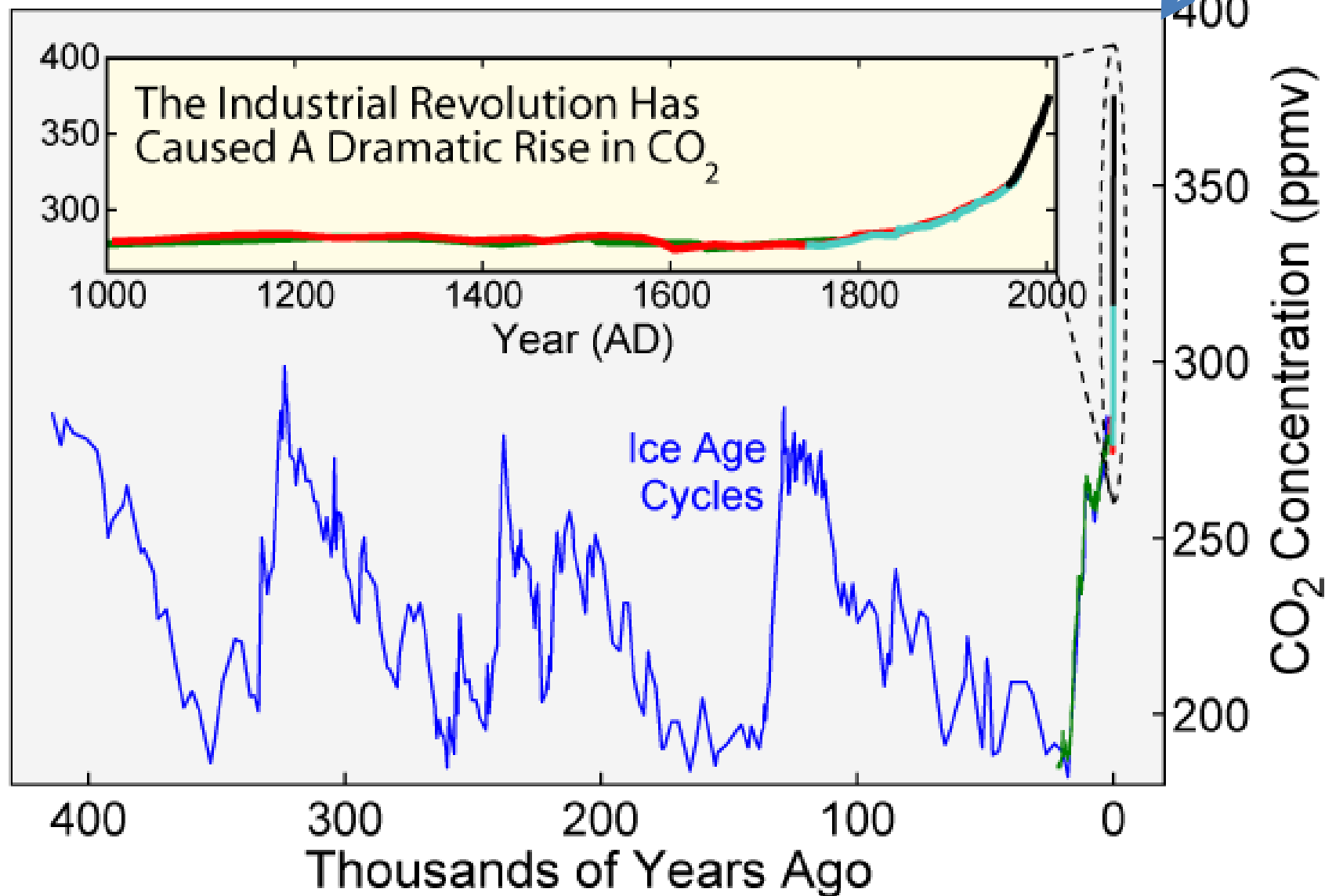
National Research Council - GHG



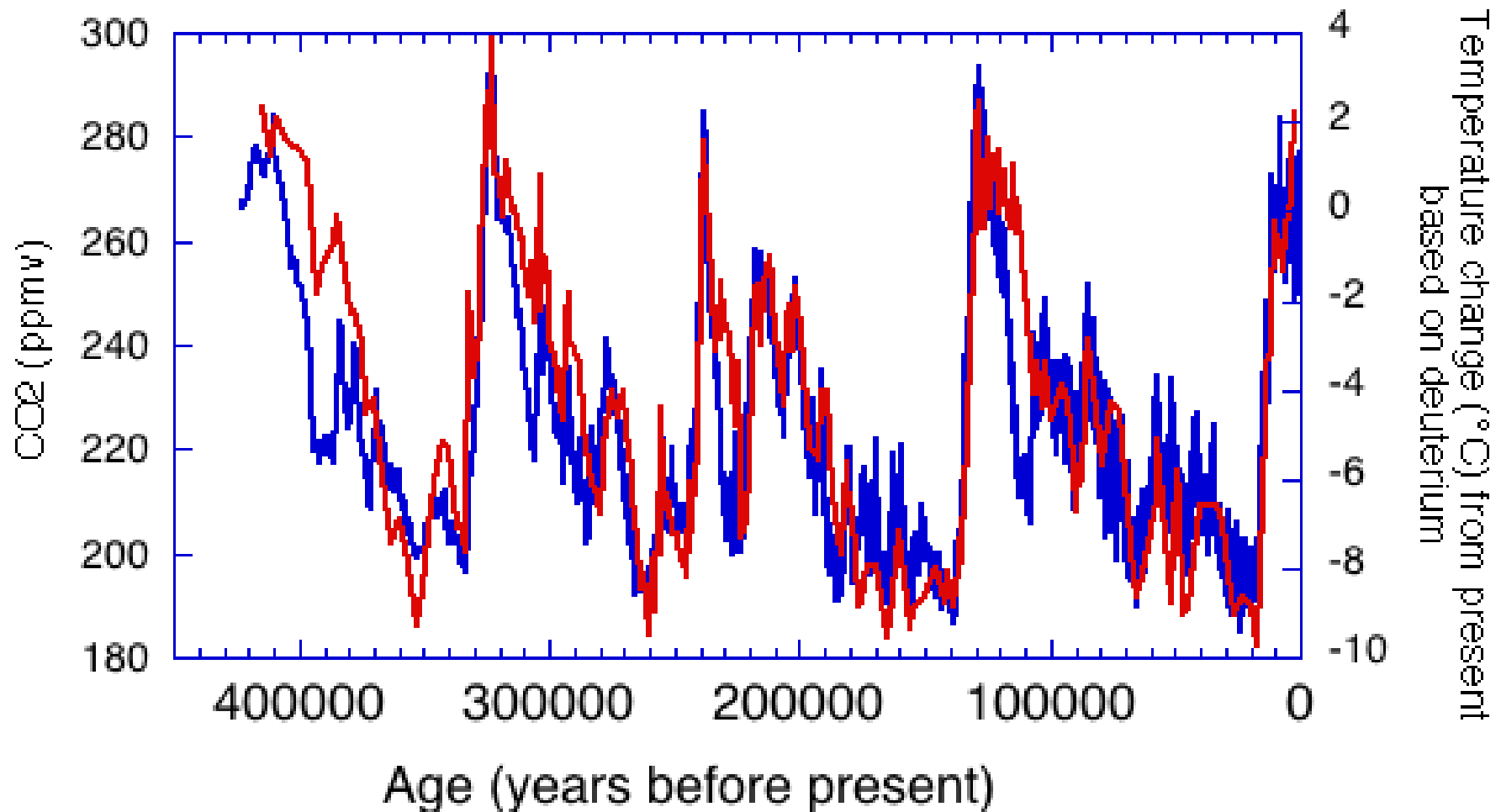
Analysis of air bubbles trapped in Antarctic ice cores show that, along with carbon dioxide, atmospheric concentrations of methane (CH₄) and nitrous oxide (N₂O) were relatively constant until they started to rise in the Industrial era. Atmospheric concentration units indicate the number of molecules of the greenhouse gas per million molecules of air for carbon dioxide and nitrous oxide, and per billion molecules of air for methane. **Source: U.S. Global Climate Research Program**

July 2013

Carbon Dioxide Variations



Temperature and CO₂

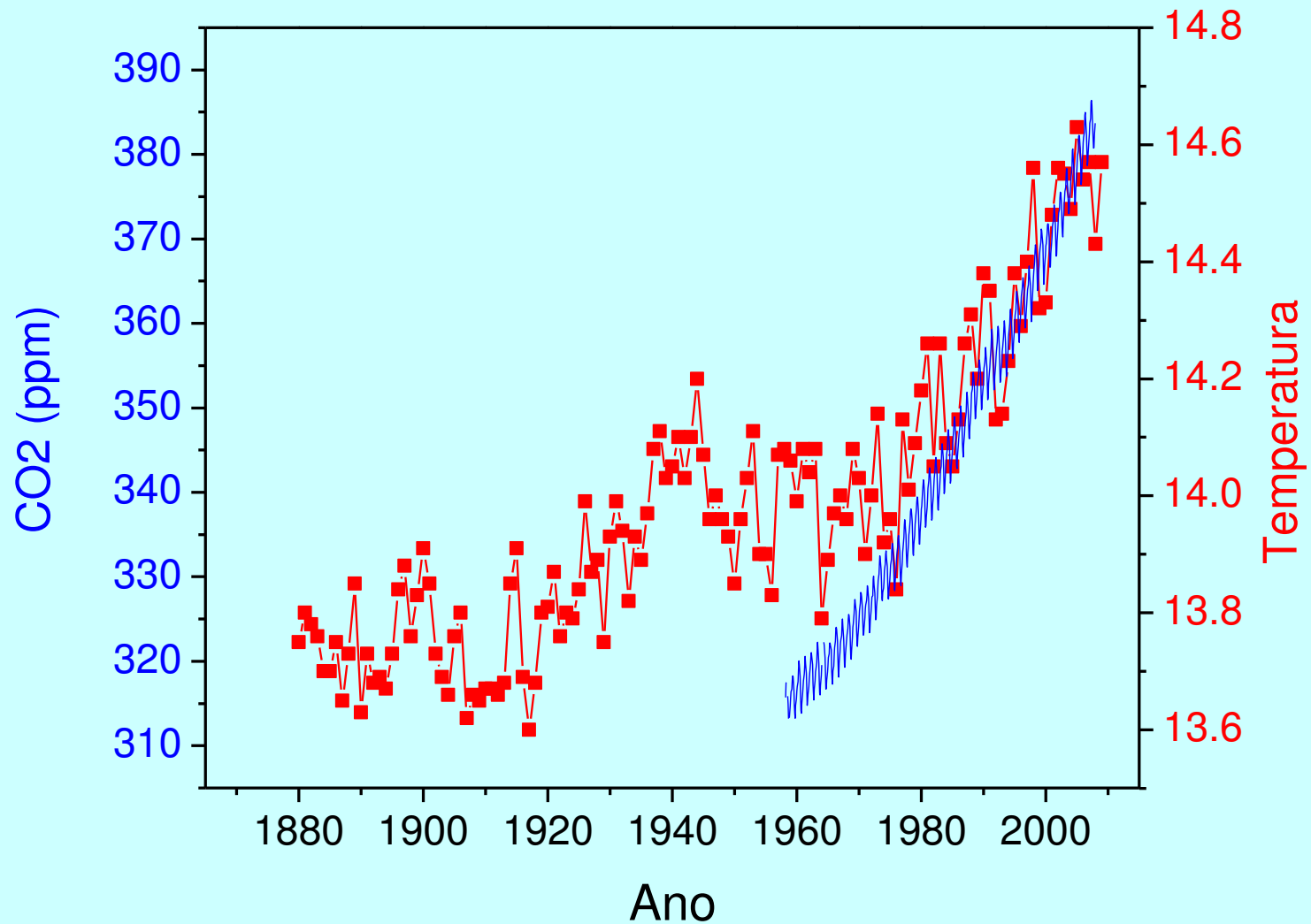


Temperature change (blue) and carbon dioxide change (red) observed in [ice core records](#) [Many other records are available](#)

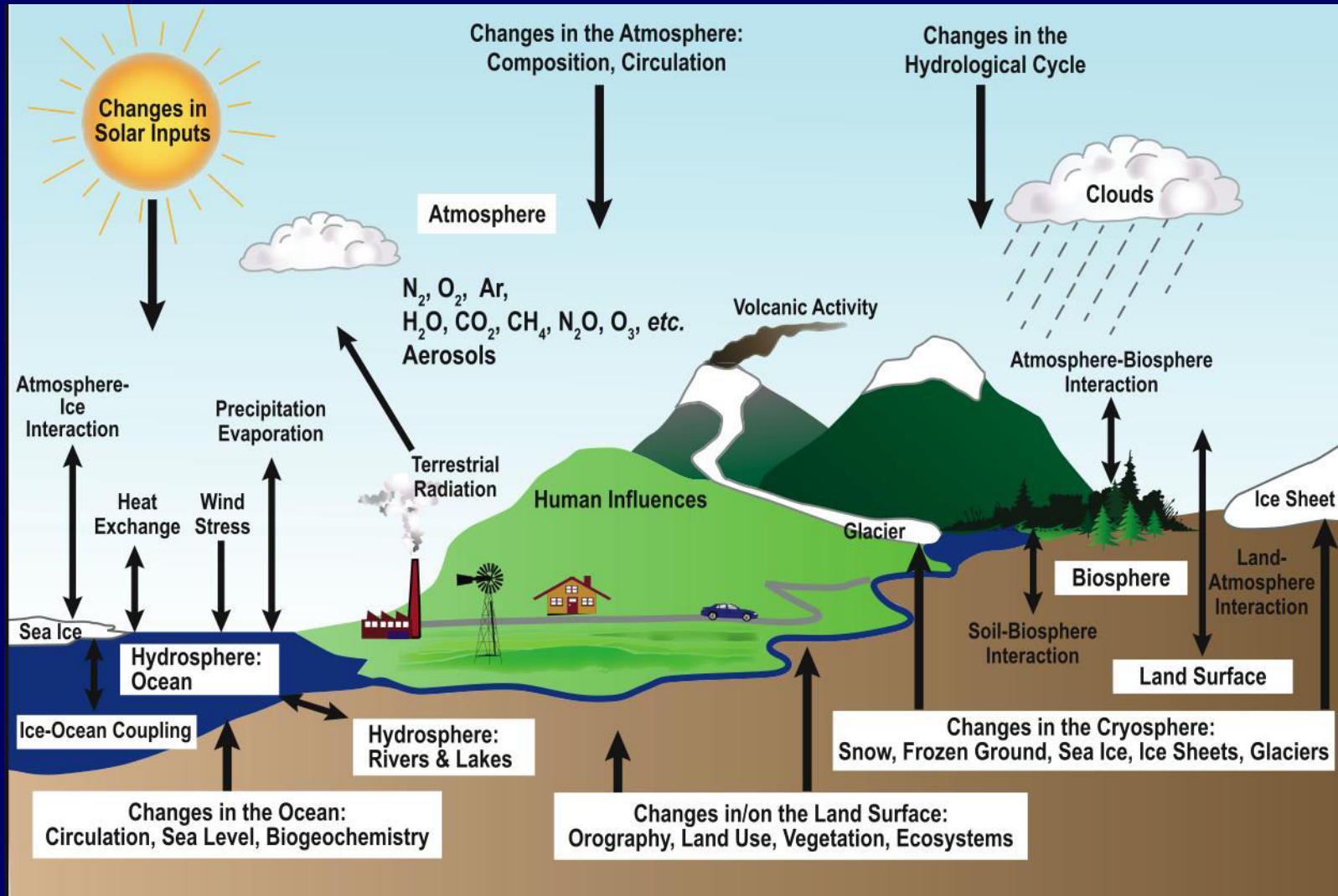


Temperature 1880-2009

CO2-1958-2009



The Climate System

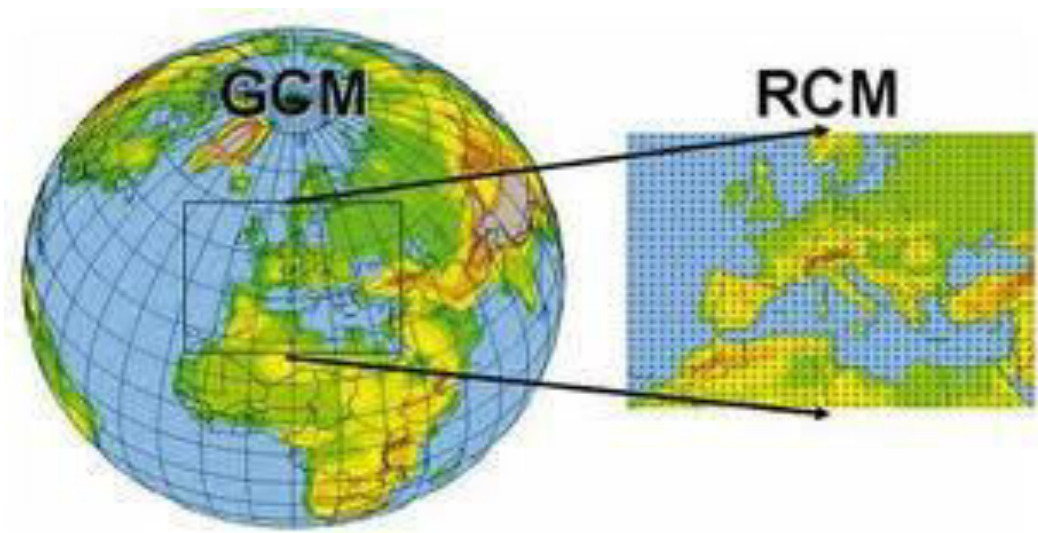
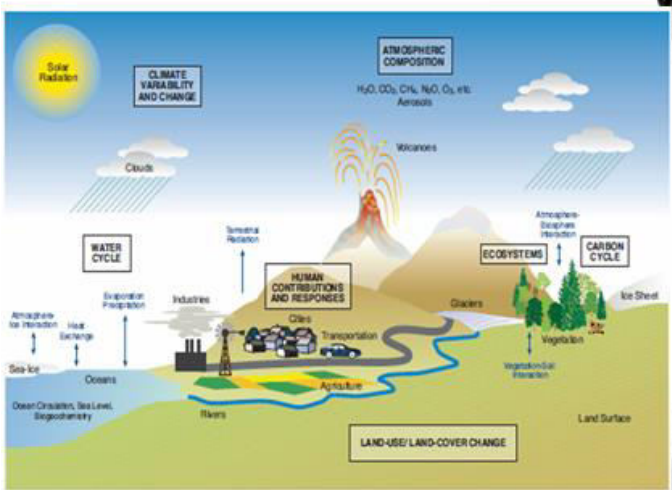
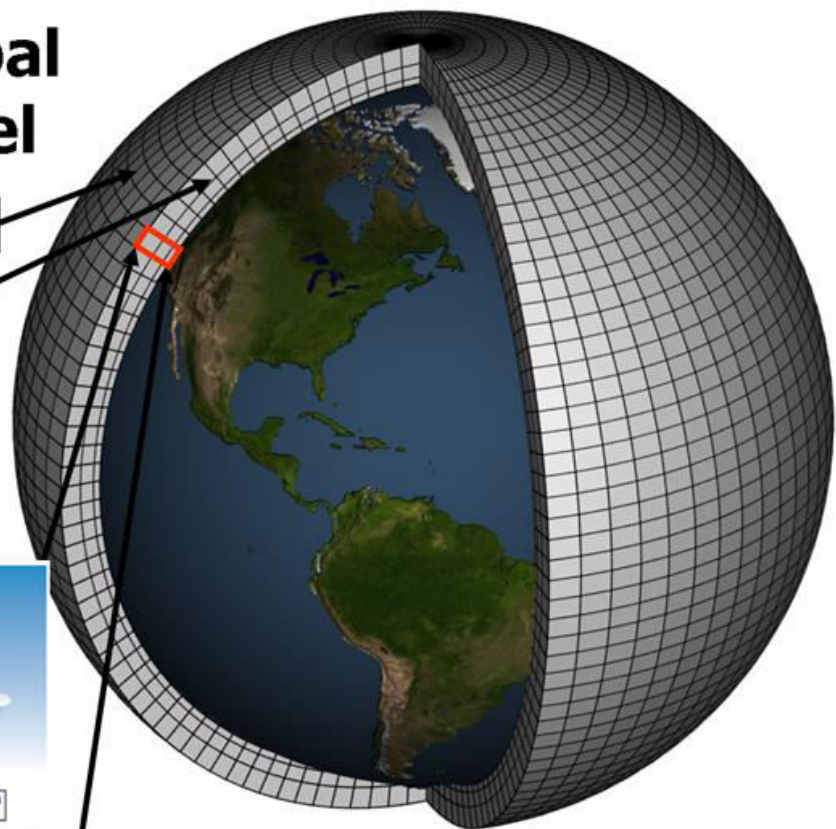


How do we simulate this?

Schematic for Global Atmospheric Model

Horizontal Grid (Latitude-Longitude)

Vertical Grid (Height or Pressure)



How Well Have GCMs performed?

Anthropogenic and natural forcings

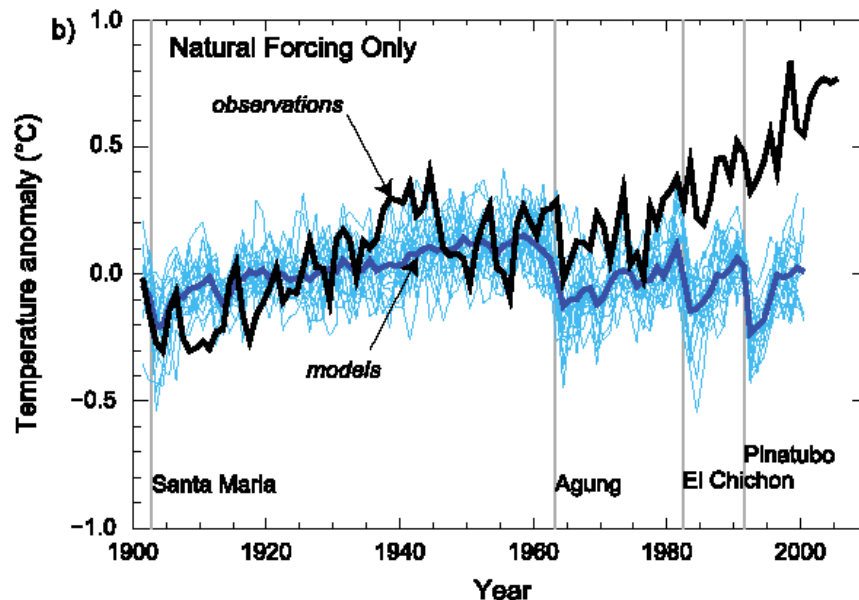
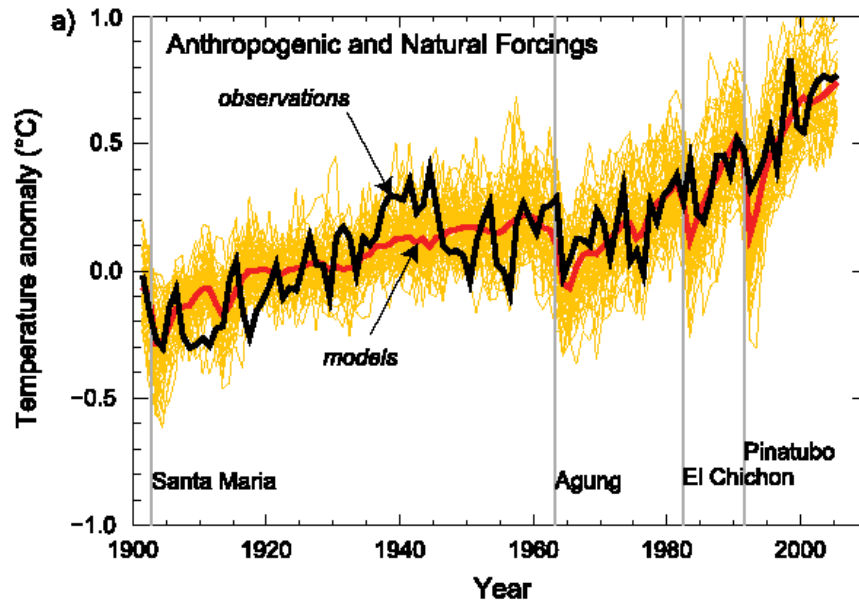
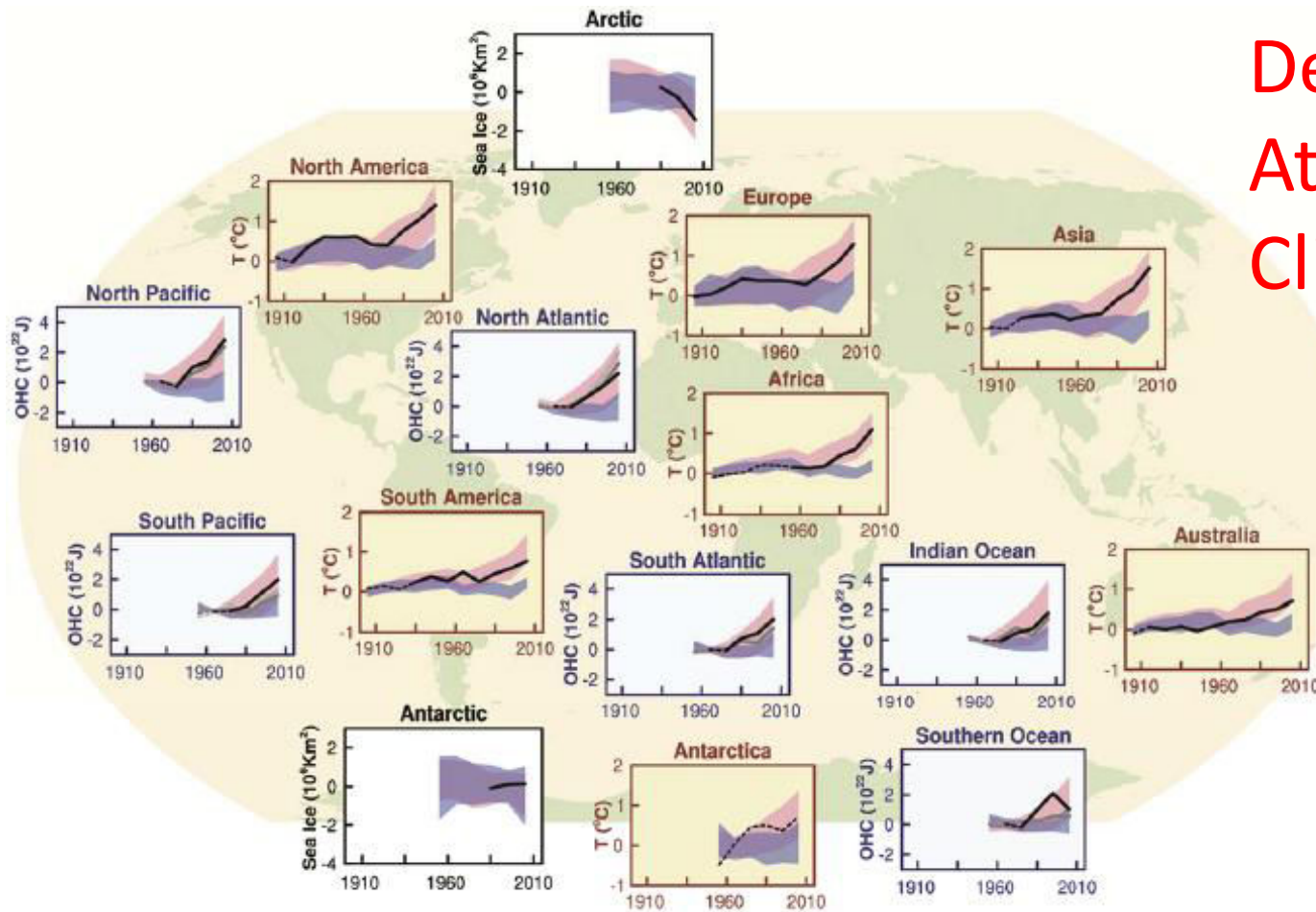
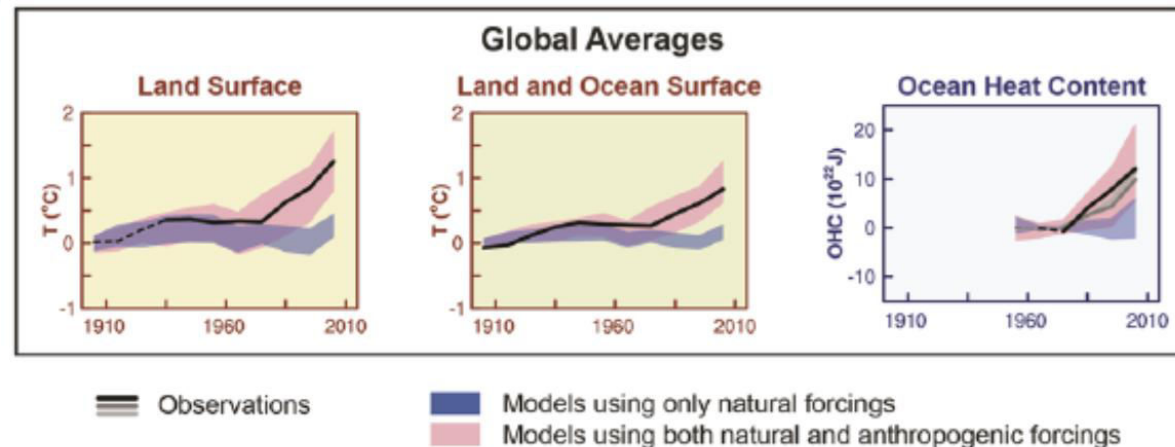


Figure TS.23. (a) Global mean surface temperature anomalies relative to the period 1901 to 1950, as observed (black line) and as obtained from simulations with both anthropogenic and natural forcings. The thick red curve shows the multi-model ensemble mean and the thin lighter red curves show the individual simulations. Vertical grey lines indicate the timing of major volcanic events. (b) As in (a), except that the simulated global mean temperature anomalies are for natural forcings only. The thick blue curve shows the multi-model ensemble mean and the thin lighter blue curves show individual simulations. Each simulation was sampled so that coverage corresponds to that of the observations. [Figure 9.5]

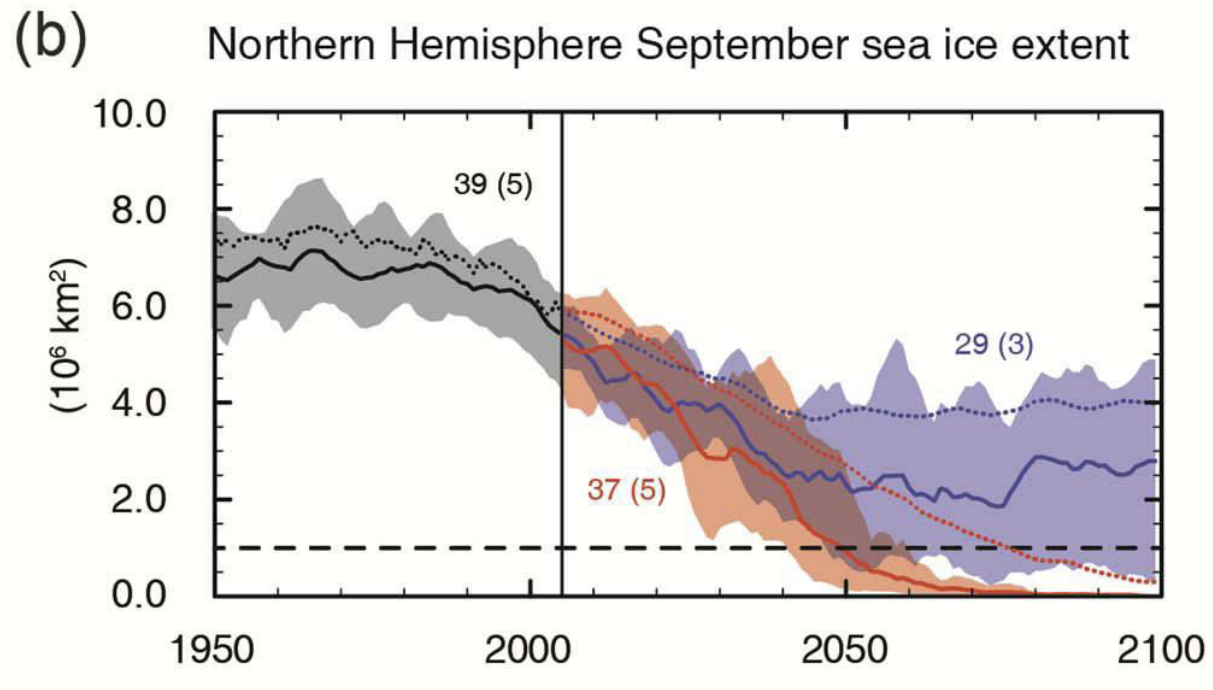
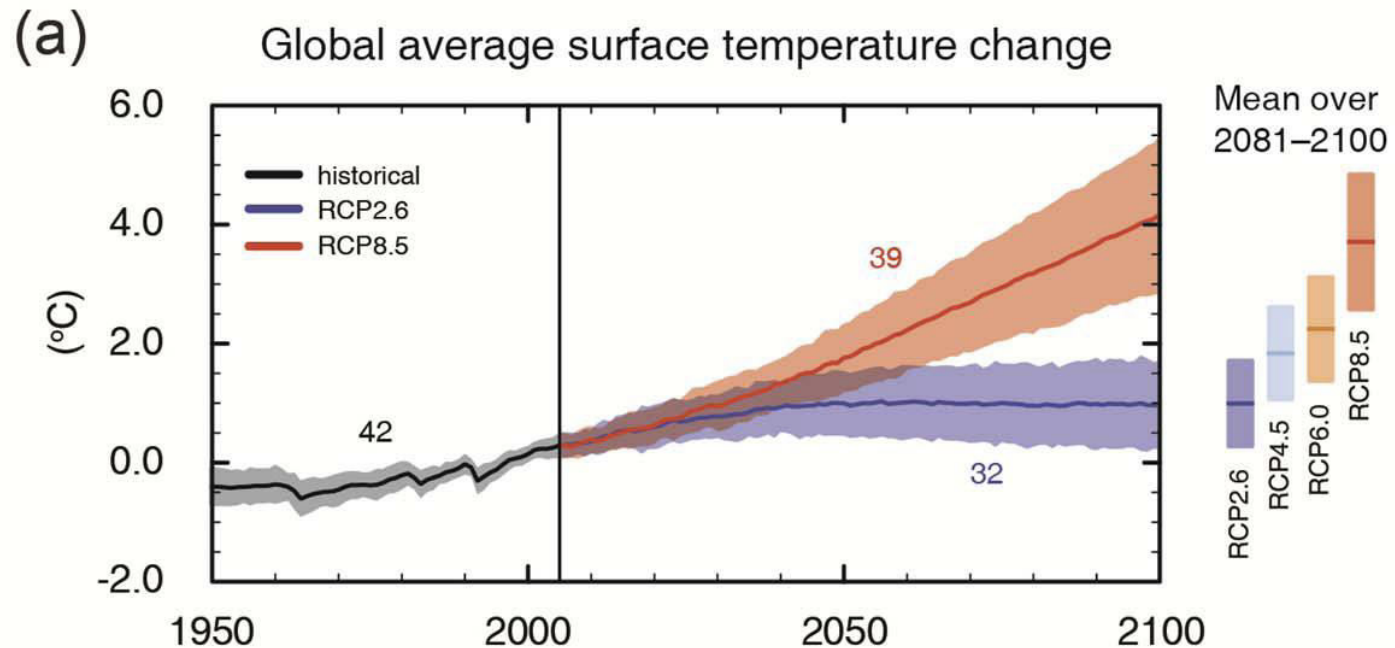
Detection and Attribution of Climate Change



Human influence on the climate system is clear



Future Climate Change

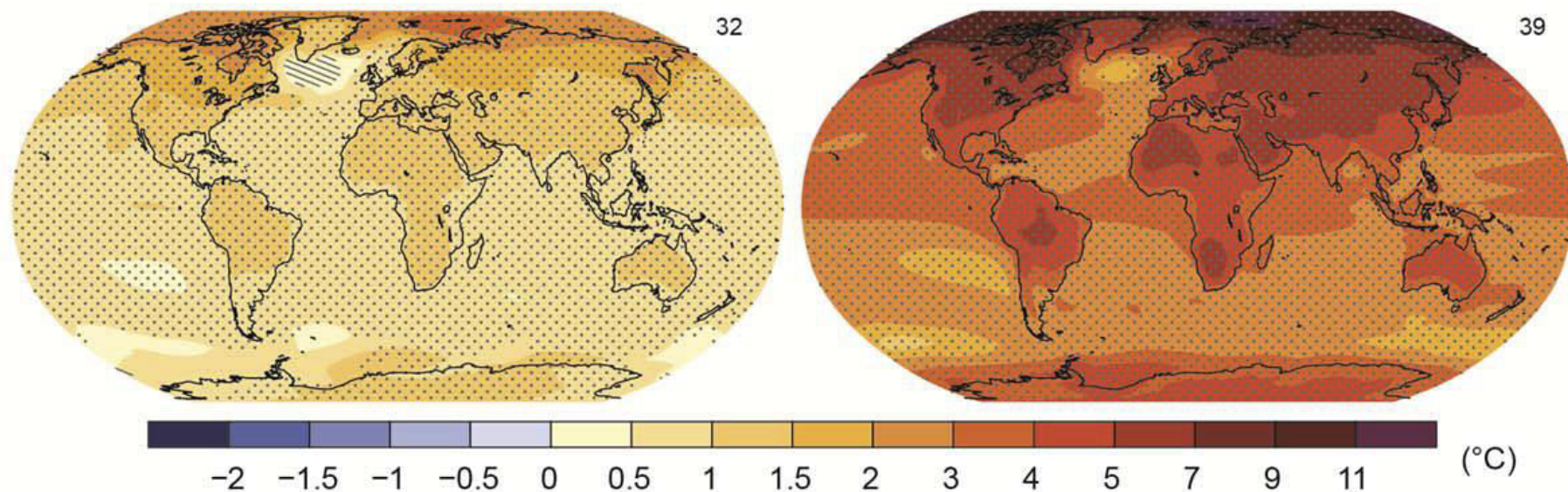


RCP 2.6

RCP 8.5

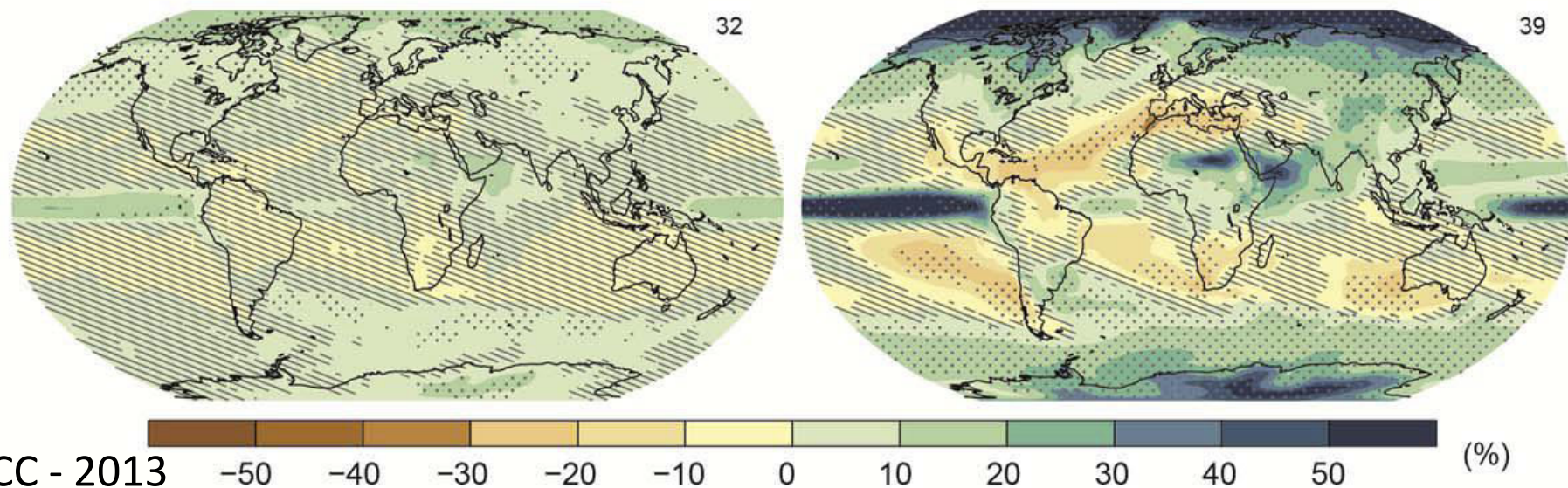
(a)

Change in average surface temperature (1986–2005 to 2081–2100)



(b)

Change in average precipitation (1986–2005 to 2081–2100)



RCP2.6

RCP8.5

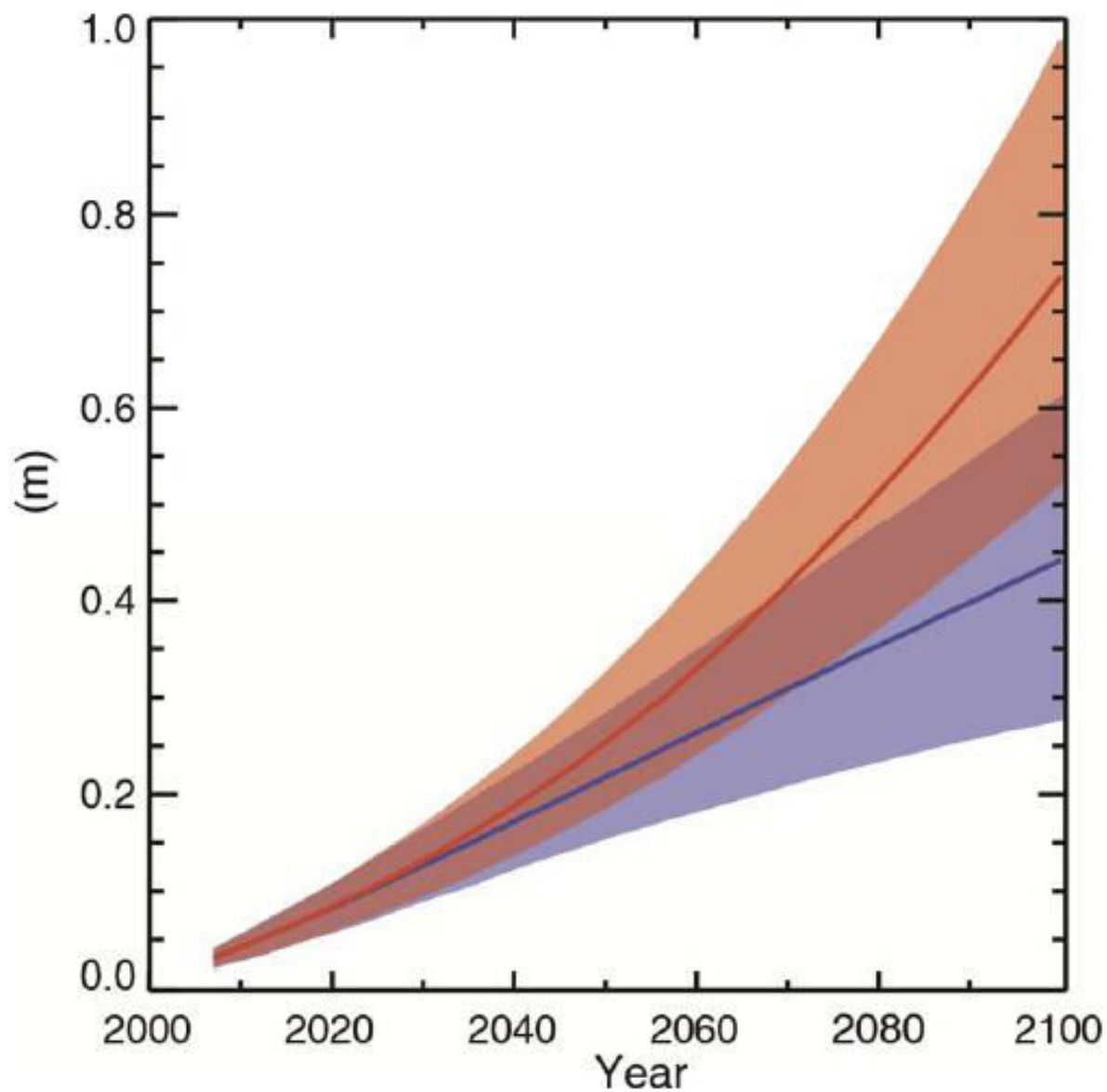
Northern Hemisphere September sea ice extent (average 2081–2100)



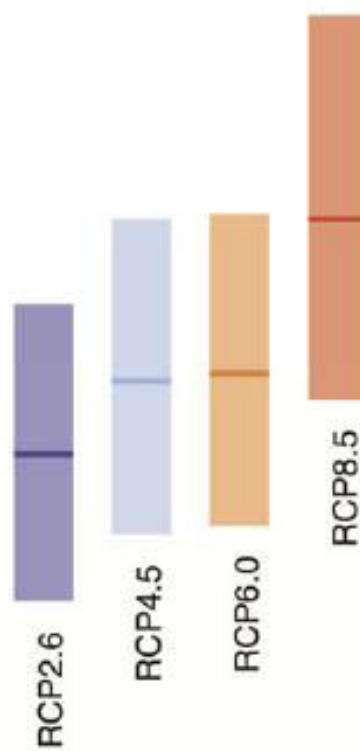
- CMIP5 multi-model average 1986–2005
- CMIP5 multi-model average 2081–2100
- CMIP5 subset average 1986–2005
- CMIP5 subset average 2081–2100



Global mean sea level rise



Mean over
2081–2100



SCIENCE
CONNECTIONS →

EXTREME WEATHER & CLIMATE CHANGE

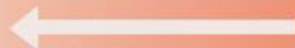
→ Strongest Scientific Evidence Shows Human-Caused Climate Change Is Increasing Heat Waves and Coastal Flooding



TORNADOES



HURRICANES

SEVERE
DROUGHTSEXTREME
PRECIPITATION
EVENTSCOASTAL
FLOODINGHEAT
WAVESLimited
EvidenceStrong
EvidenceStrongest
Evidence

**young technicians
engineers of surveying and
geographical information technologies**

play a major role

**on monitoring and diagnosing the impacts of
climate change and support decision makers to
mitigate and adapt to climate change**

Thank you!

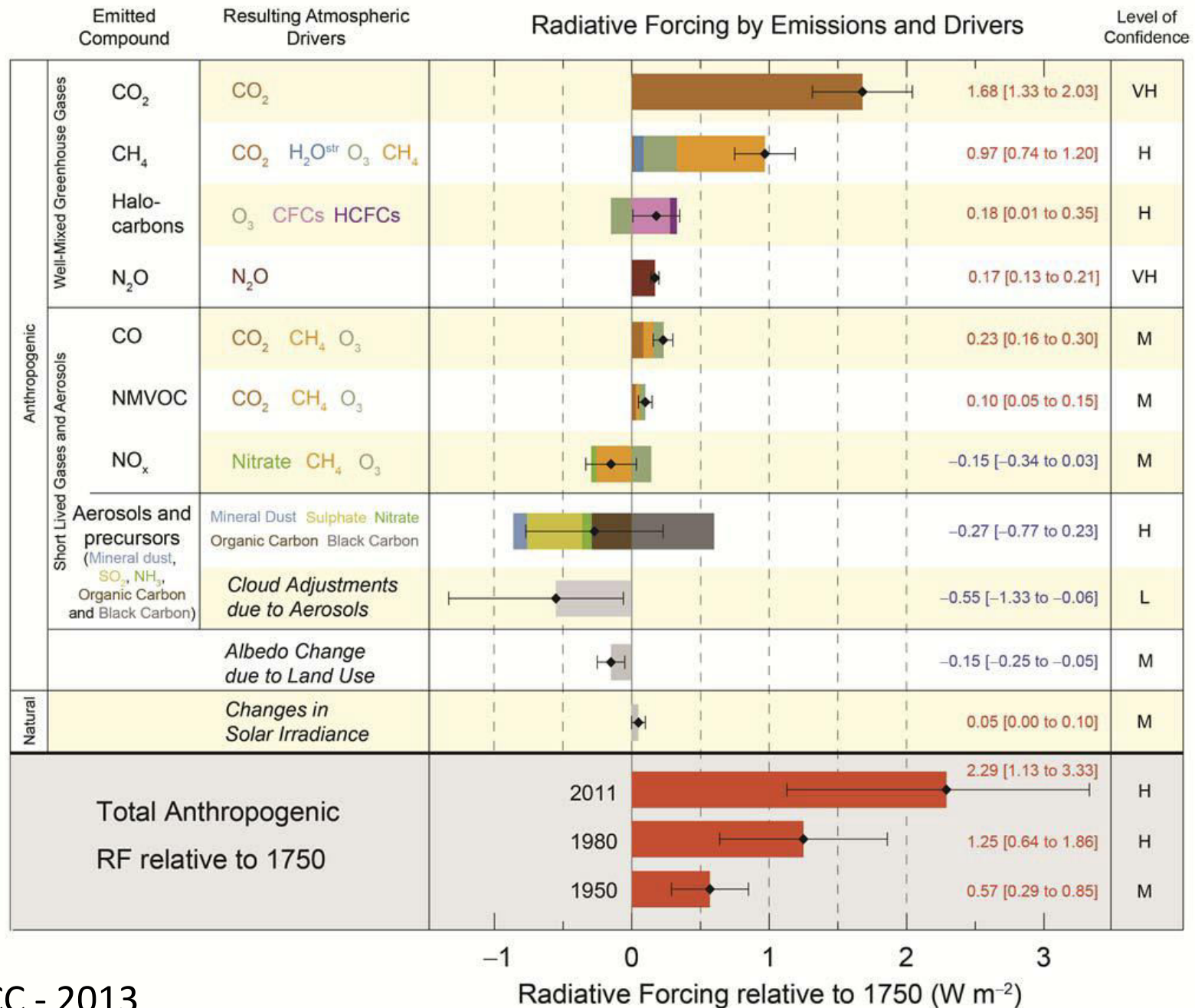
		2046–2065		2081–2100	
Variable	Scenario	mean	likely range ^c	mean	likely range ^c
Global Mean Surface Temperature Change (°C) ^a	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
		mean	likely range ^d	mean	likely range ^d
Global Mean Sea Level Rise (m) ^b	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

Scenario	Cumulative CO ₂ Emissions 2012–2100 (in GtC ^a)	
	Mean	Range
RCP2.6	270	140 to 410
RCP4.5	780	595 to 1005
RCP6.0	1060	840 to 1250
RCP8.5	1685	1415 to 1910

Notes:

(a) 1 Gigatonne of carbon corresponds to 3.67 GtCO₂.

Drivers of Climate Change



Evaluation of Climate Models

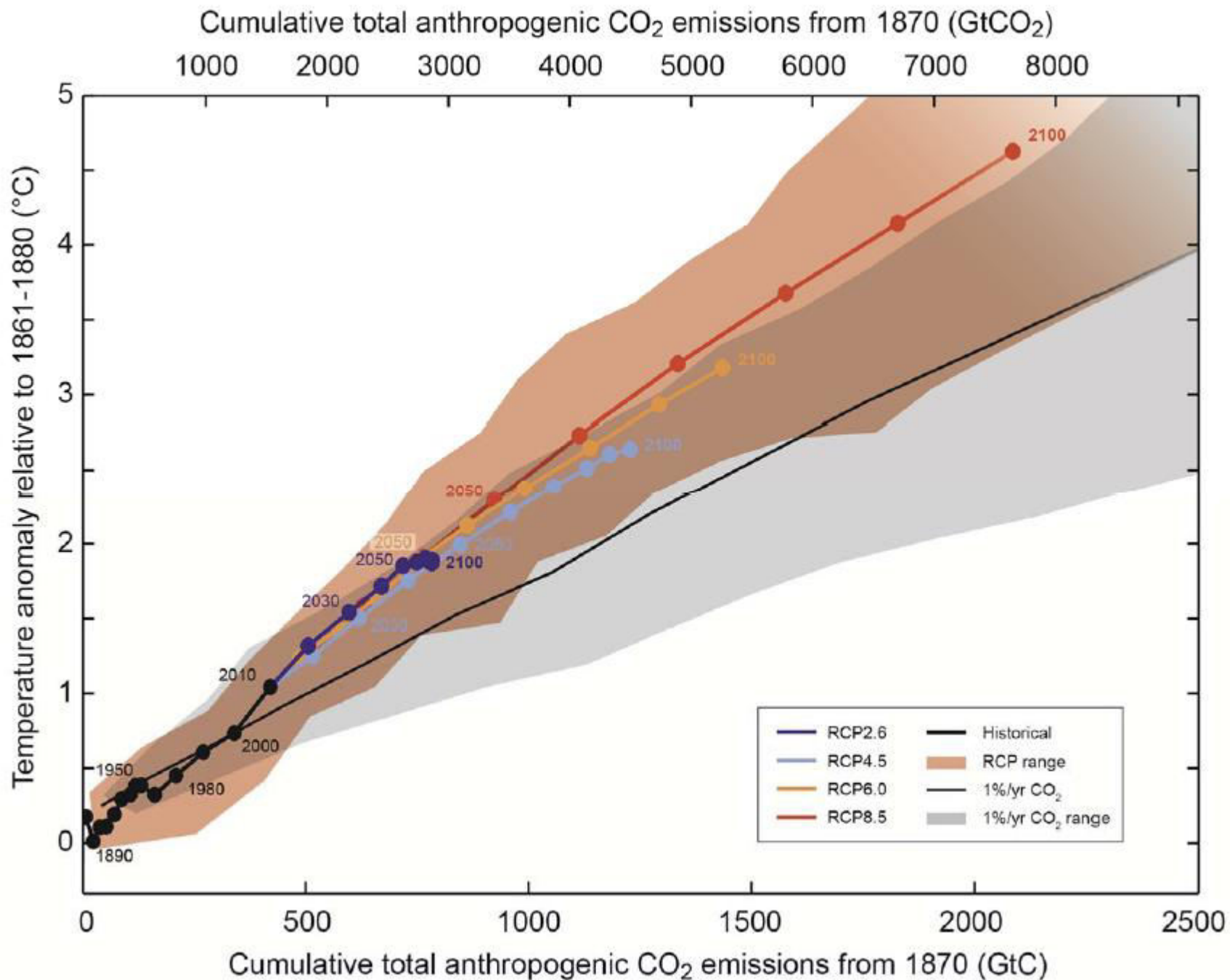
Climate models have improved since the AR4. Models reproduce observed continental-scale surface temperature patterns and trends over many decades, including the more rapid warming since the mid-20th century and the cooling immediately following large volcanic eruptions (very high confidence).

Mudança Climática Global

- A Terra está em aquecimento:
 - Como sabemos?
 - O que sabemos?
- **Razões e incertezas quanto às causas da MC:**
 - O que é o sistema climático?
 - o efeito de estufa é um tema científico recente?
 - O que é o efeito de estufa?
 - Como simulamos o sistema climático?
 - Quais as projecções para o futuro?
 - Onde vêm os gases de estufa?

Global Climate Change

- Earth is Warming
 - How do we know?
 - What do we know?
- How confident are hypotheses about causes?
 - What are greenhouse gases?
 - Where do they come from, and how do we know?
- Most common claims of the skeptics
 - T's are going down, not up
 - This warming is just part of a natural cycle
 - CO₂ is good for plants



What determines the Climate ?

Earth's Orbit

