

**Considerazioni su quattro decenni di ricerca sul
cambiamento climatico e le risorse idriche:
questioni controverse,
convinzioni comuni, azioni e illusioni**

***Considerations about four decades of research on
climate change and water resources: debates,
agreements, actions and illusions.***

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The main concern raised by global warming is that climatic variations alter the water cycle; indeed, in many cases, the data show that the hydrological cycle is already being impacted

OVERVIEW

- *Debates*

- *Agreements*

- *Illusions*

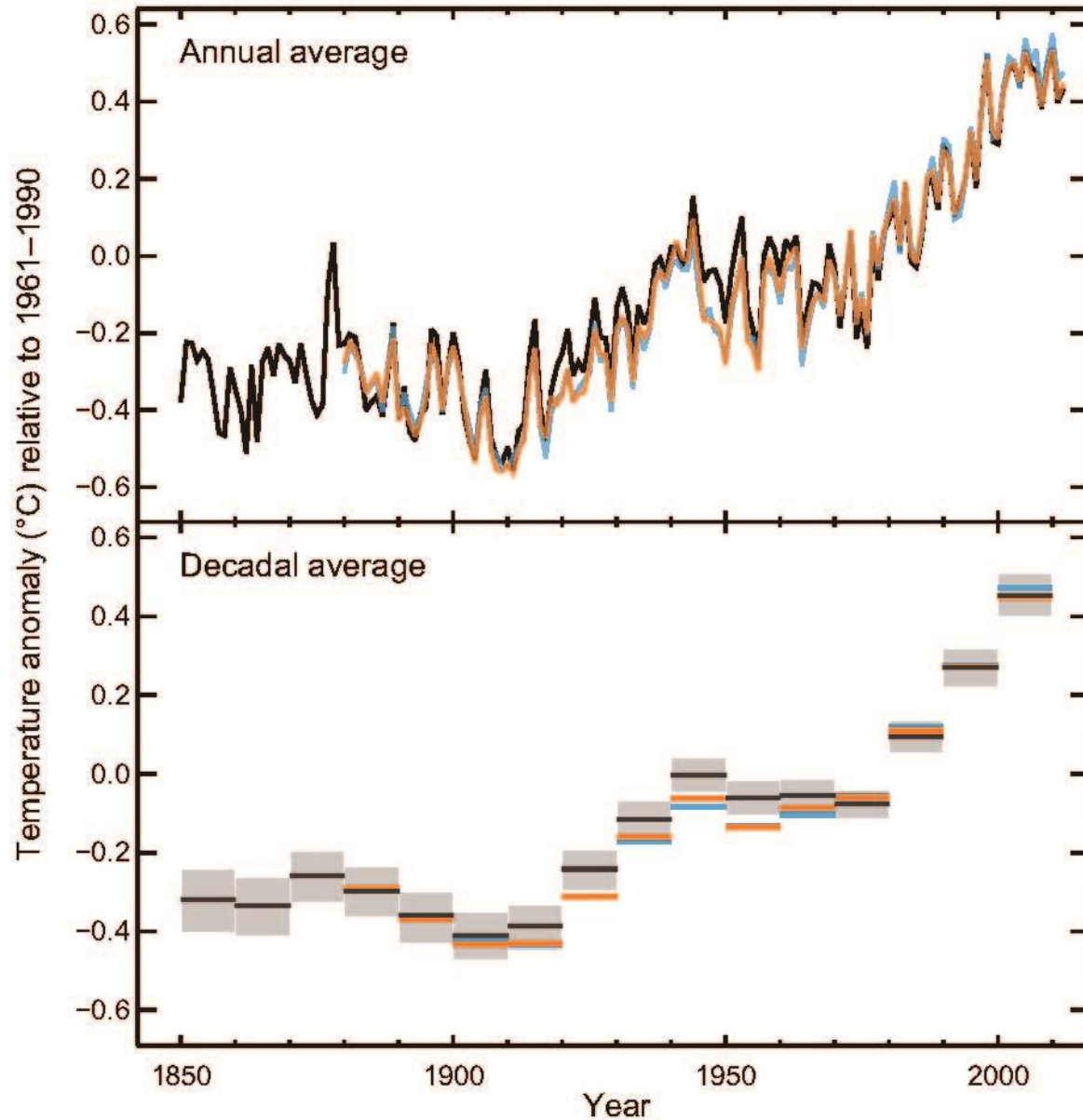
- *Actions*

“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”

IPCC 2013

Observed globally averaged combined land and ocean surface temperature anomaly 1850–2012

(a)



(IPCC, 2013)

EARLY DEBATES (after Weart, 1997):

Arrhenius (1896), Chamberlin (early 1910s), Callendar (1938): Carbon dioxide influences the climate.

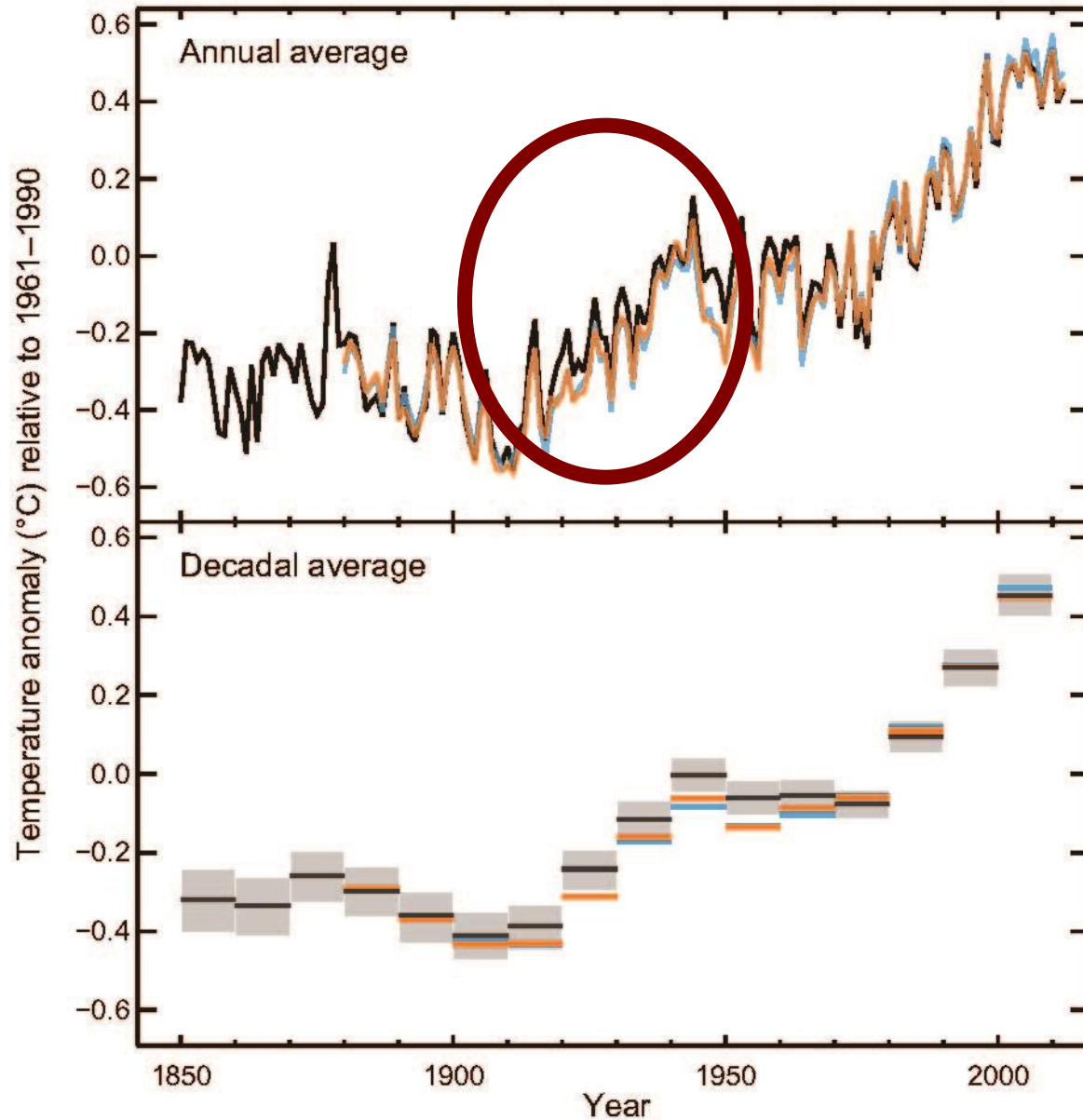
Blair, (1942): "We can say with confidence the climate is not influenced by the activities of man except locally and transiently." (*Climatology, General and Regional*, Prentice-Hall.)

Brooks (1951): [The theory that carbon dioxide would change the climate] was abandoned when it was found that all the long-wave radiation [that might be] absorbed by CO₂ is [already] absorbed by water vapor. The recent global increase of temperature was a normal fluctuation".

Compendium of Meteorology, American Meteorological Society, Boston (1951)

Observed globally averaged combined land and ocean surface temperature anomaly 1850–2012

(a)



(IPCC, 2013)

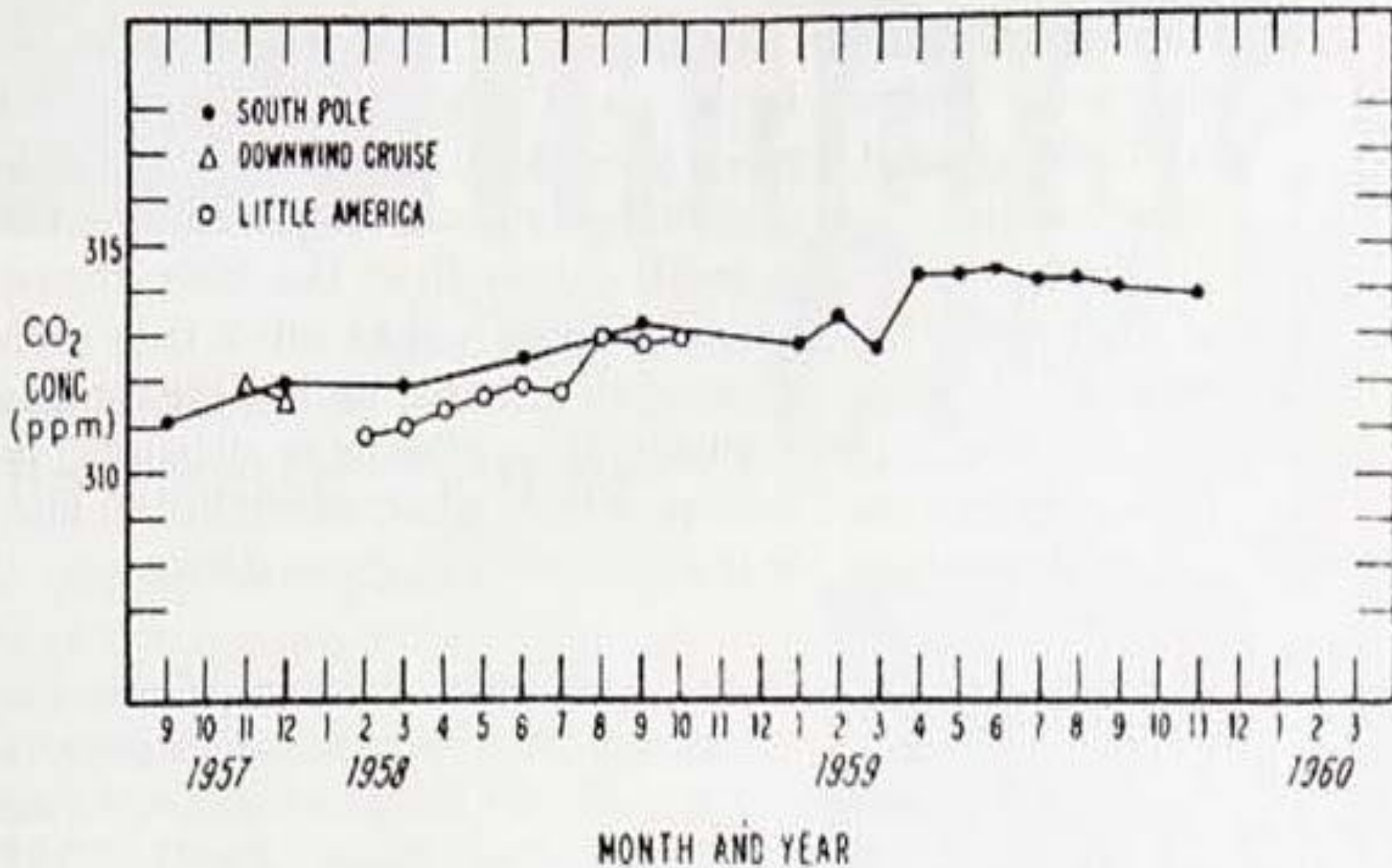
DEBATES (after Weart, 1997):

Plass (1956): adding CO₂ to the atmosphere would mean more infrared radiation would be intercepted (Qtly. J. Roy. Meteorological Soc.).

Suess & Revelle (1955, 1956) found in the atmosphere very small traces of CO₂ produced by fossil fuels. Negligible effects

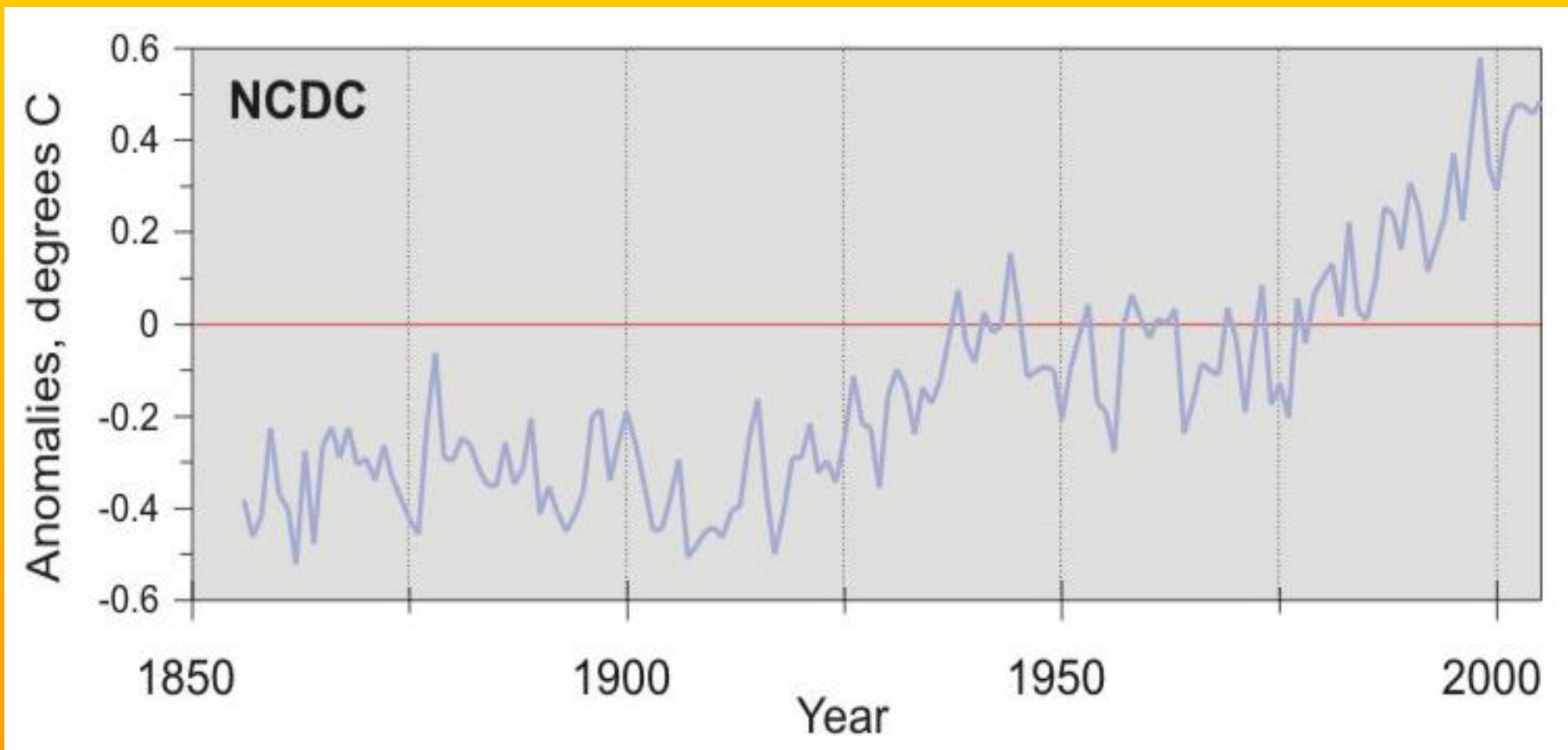
Objection: carbon dioxide does not accumulate in the atmosphere, as the oceans soak it up as fast as it is produced (opinion with no reliable data, as the instruments of early 1950s were not precise enough)

Keeling, in 1960, showed that an increase of CO₂ was visible after only two years of measurements in Antarctica. (Tellus 12, 200, 1960.)



(From C. Keeling (1980): *Tellus* 12, 200. – as reported in Weart (1997):*Phys. Today* 50(1), 34; doi: 10.1063/1.881664)

So, since 1960, it was clear that CO₂ was increasing in the atmosphere due to fossil fuels combustion, as well as other “greenhouse” gases (CH₄ etc.)



(NOAA: <http://www.ncdc.noaa.gov/paleo/globalwarming/instrumental.html>)

So, since 1960, it was clear that CO₂ was increasing in the atmosphere due to fossil fuels combustion, as well as other “greenhouse” gases (CH₄ etc.)

IPCC 2013:

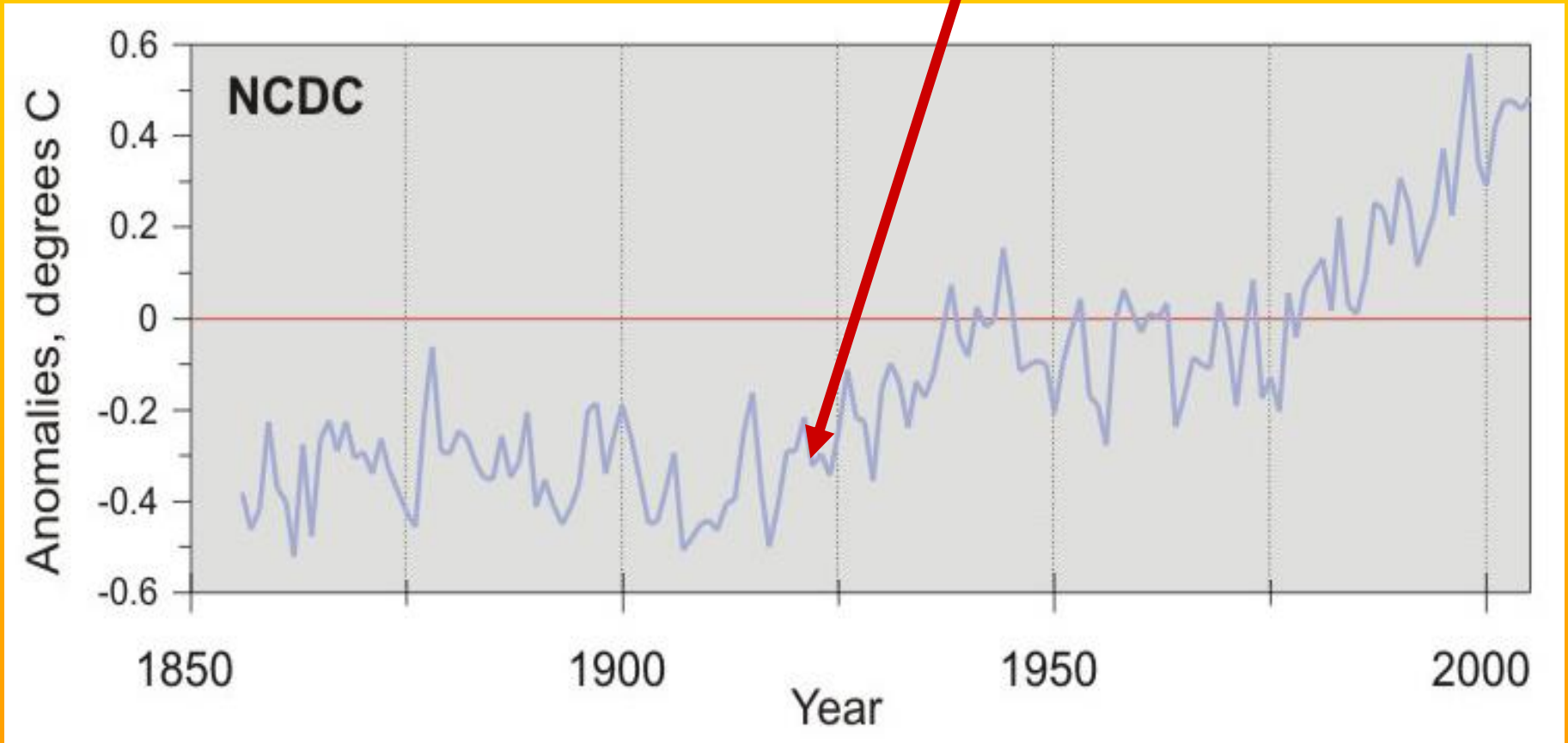
It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together.

Most of the people involved in the issue, believes that the climate is changing, but a not negligible minority asserts that:

- greenhouse gas concentrations have resulted in a reduction in the Earth's ability to cool to outer space, but most of the warming is due to natural causes (just for example cf. Spencer, 2013);
- the warming to be expected is small (no more than 1 – 2 °C) no matter which actions are taken (or not taken);
- decreasing the CO₂ emissions is costly and would have little effects;
- GCMs are flawed and overestimate the future warming.

Discussions very hard and “out of track” with people emotionally involved

Sharp temperature increase after ~ 1925, while CO₂ increased steadily since the early 1800s



(NOAA: <http://www.ncdc.noaa.gov/paleo/globalwarming/instrumental.html>)

- Some 85 per cent of volcanoes are unseen and unmeasured yet these heat the oceans and add monstrous amounts of CO₂ to the oceans.

- Plimer I. (2009). ["Vitriolic climate in academic hothouse | The Australian"](http://www.theaustralian.com.au).
www.theaustralian.com.au. Retrieved 24 May 2010. "Some 85 per cent of volcanoes are unseen and unmeasured yet these heat the oceans and add monstrous amounts of CO₂ to the oceans. Why have these been ignored?"

CO₂ flux from Tyrrhenian Italy Aquifers ~ 2.4 Mt/yr

Gas emissions >> 2.1 Mt/yr

Map (estimated) > 9.1 Mt/yr

(Chiodini et al., 2004)

Natural CO₂ global emission ~ 637 Mt/yr

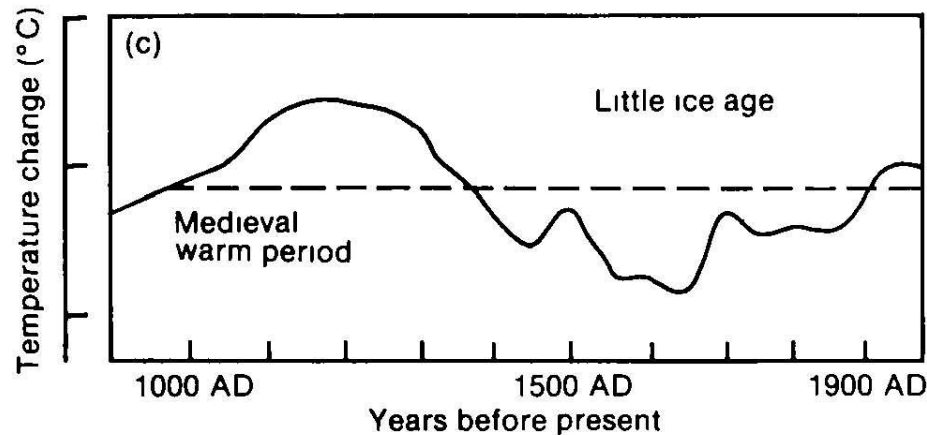
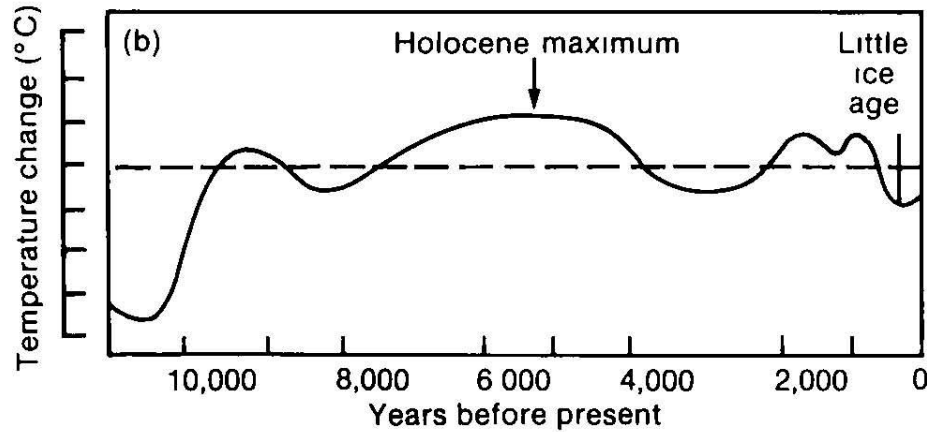
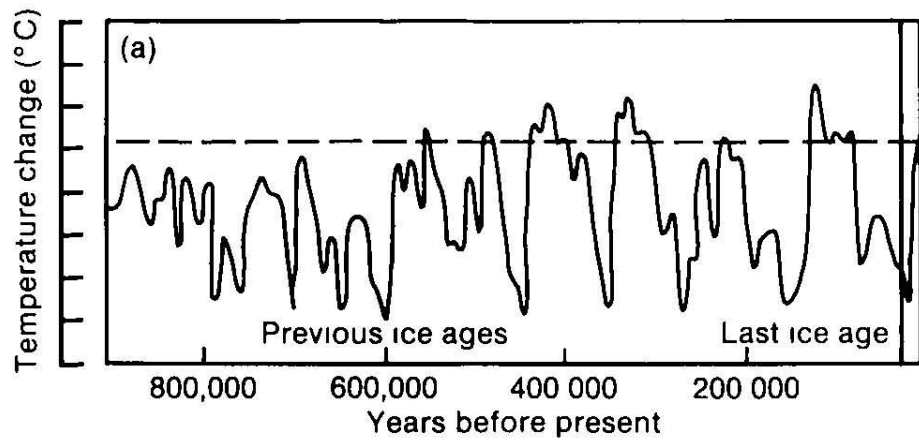
(Burton et al, 2013)

Anthropogenic CO₂ emission ~ 35000 Mt/yr

(Friedlingstein et al. 2010)

Natural ~ 1.8 % of Anthropogenic

- The “skeptics” consider the recent past climatic fluctuations a “proof” that the present warming is “natural” also.
- The answer of the “believers” is that the recent climate variations are small or not existing, as in the case of the so called “Medieval Warm Period” which in about two decades became “Medieval Climatic Anomaly”



Schematic diagrams of global temperature variations since the Pleistocene:

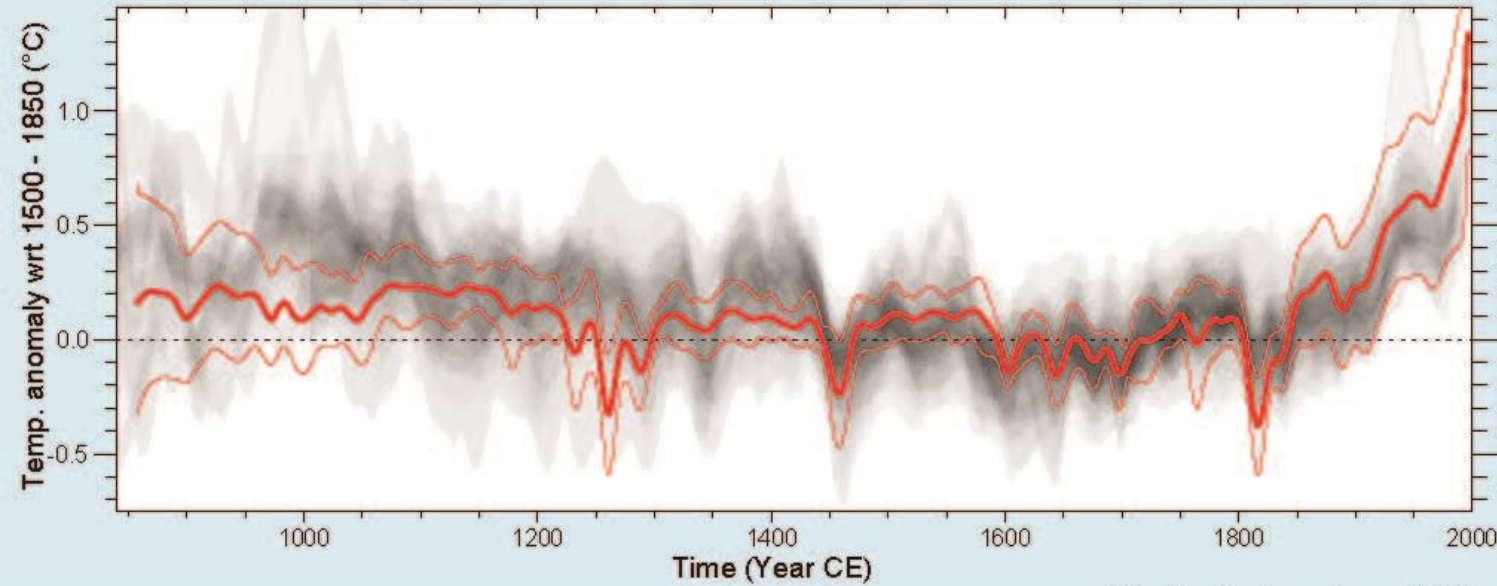
a) the last million years

b) the last ten thousand years

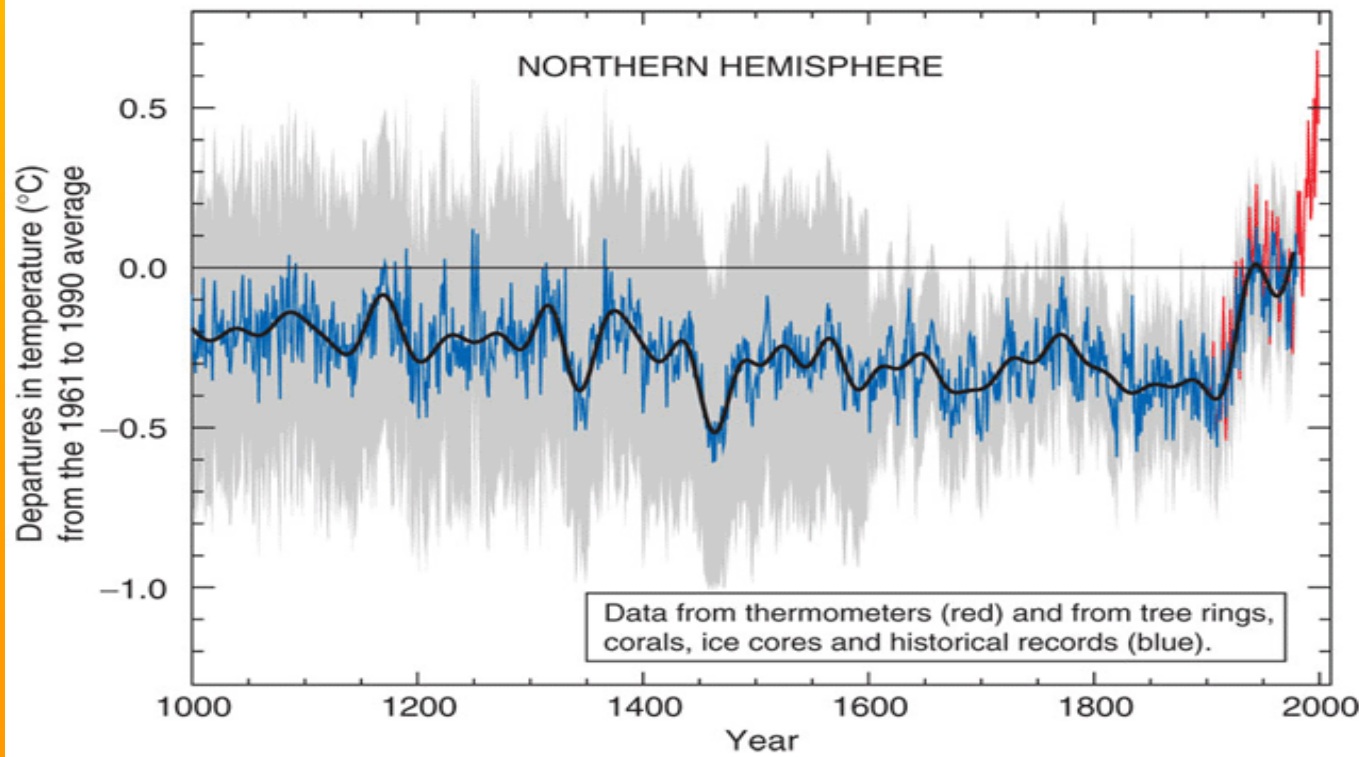
c) the last thousand years.

(IPCC 1990)

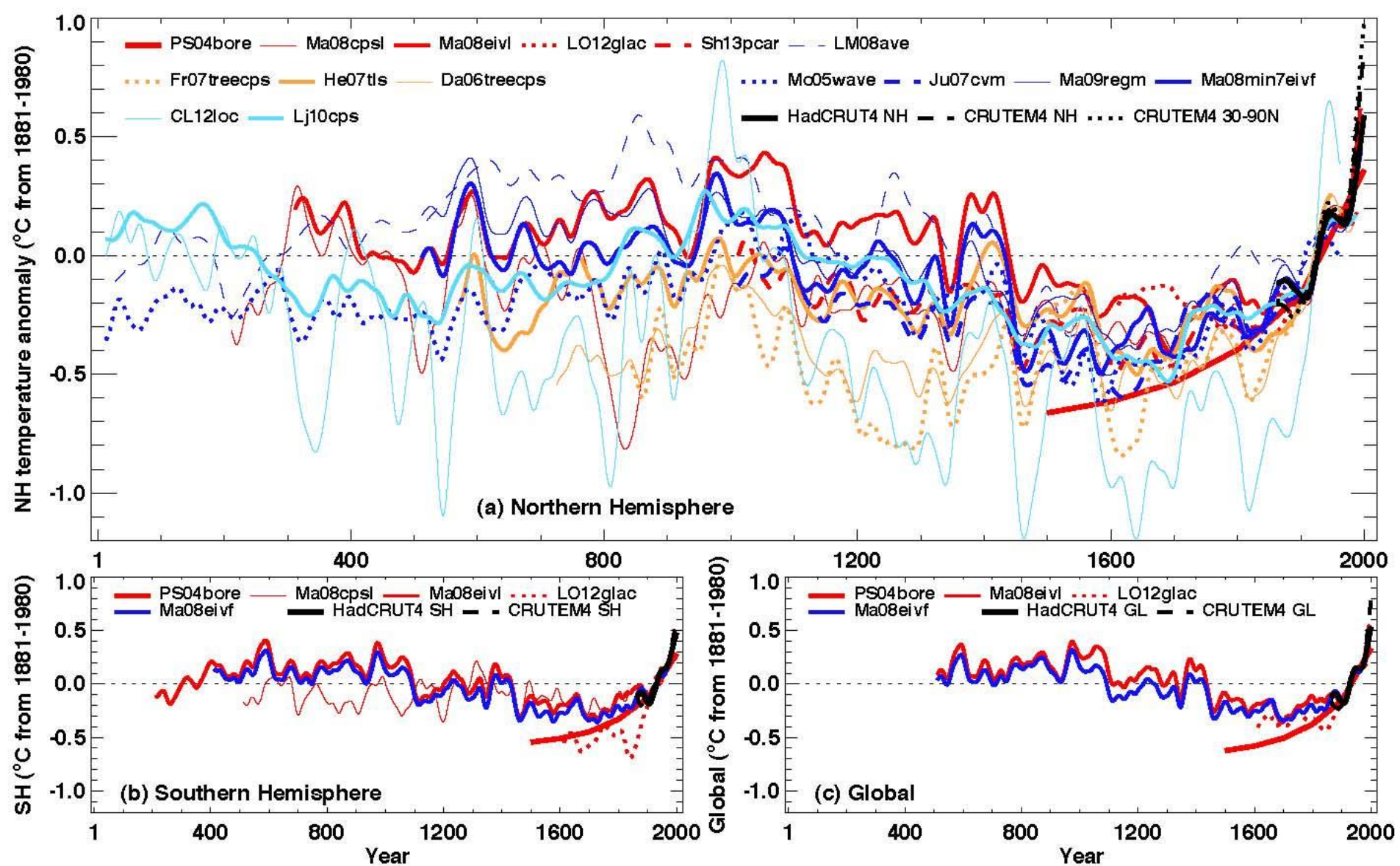
(b) Reconstructed (grey) and simulated (red) NH temperature



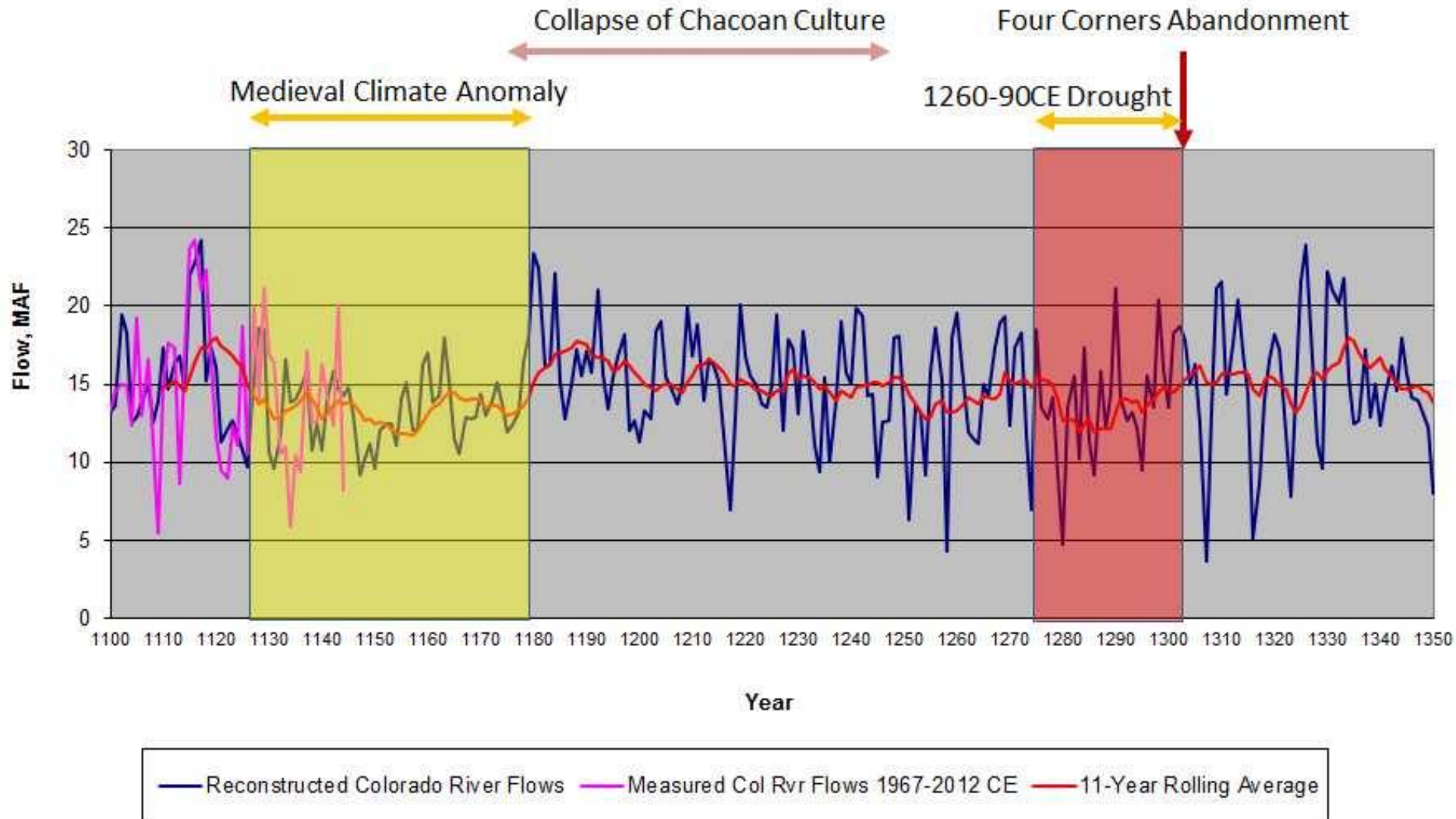
(IPCC, 2013)



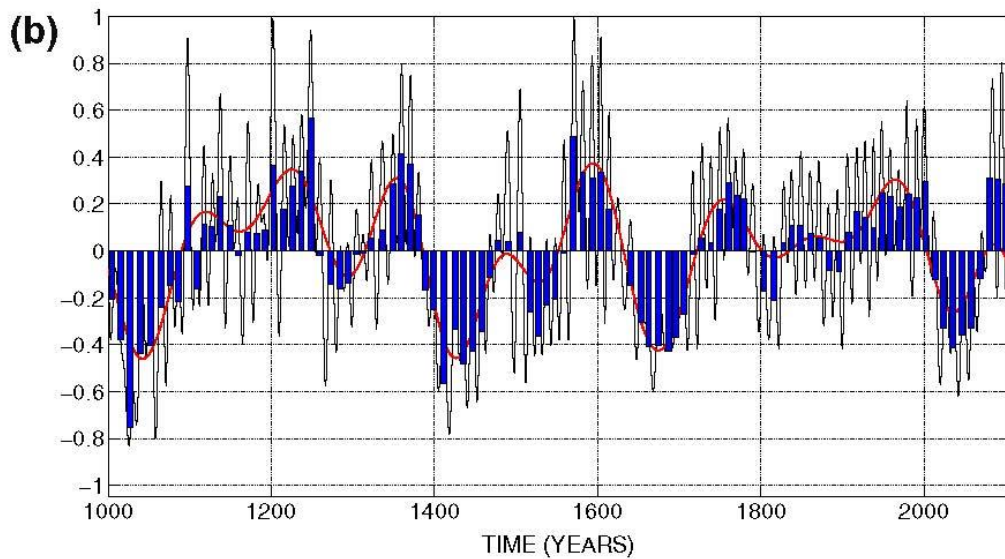
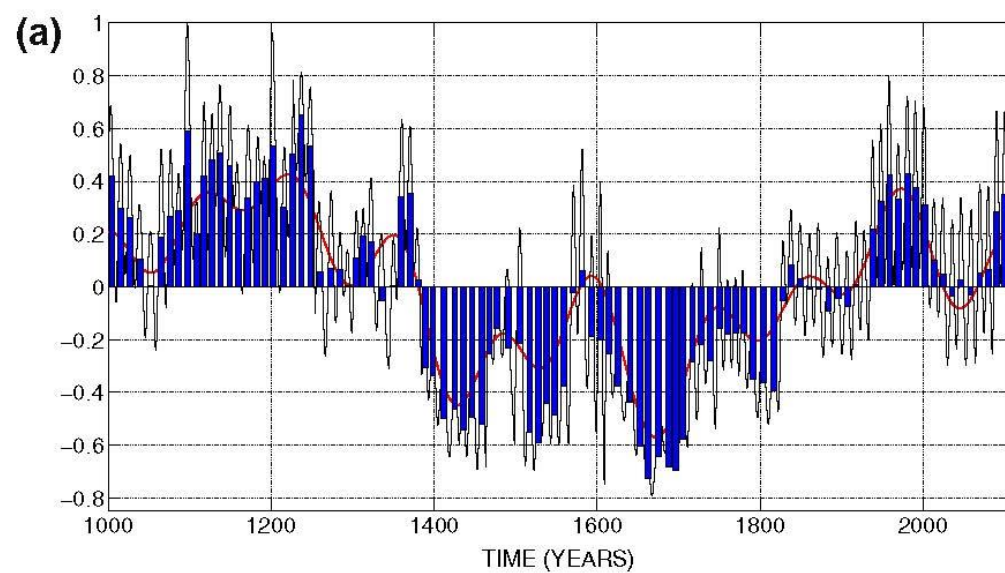
(IPCC, 2000)



Anthropologic Impacts of Drought Colorado River Flow (Water Year) 1100-1350 CE (Reconstructed) vs 1967-2012



Symmonds (2016) The Past, Present and Future of Water Security: Lessons from History. WWTAC-Coimbra.



- a) Herrera & Al. (2015): Reconstruction and prediction of the total solar irradiance: From the Medieval Warm Period to the 21st century. *New Astronomy*, Elsevier.
- b) Steinhilber and Beer (2013). Prediction of solar activity for the next 500 years. *Journal of Geophysical Research*.

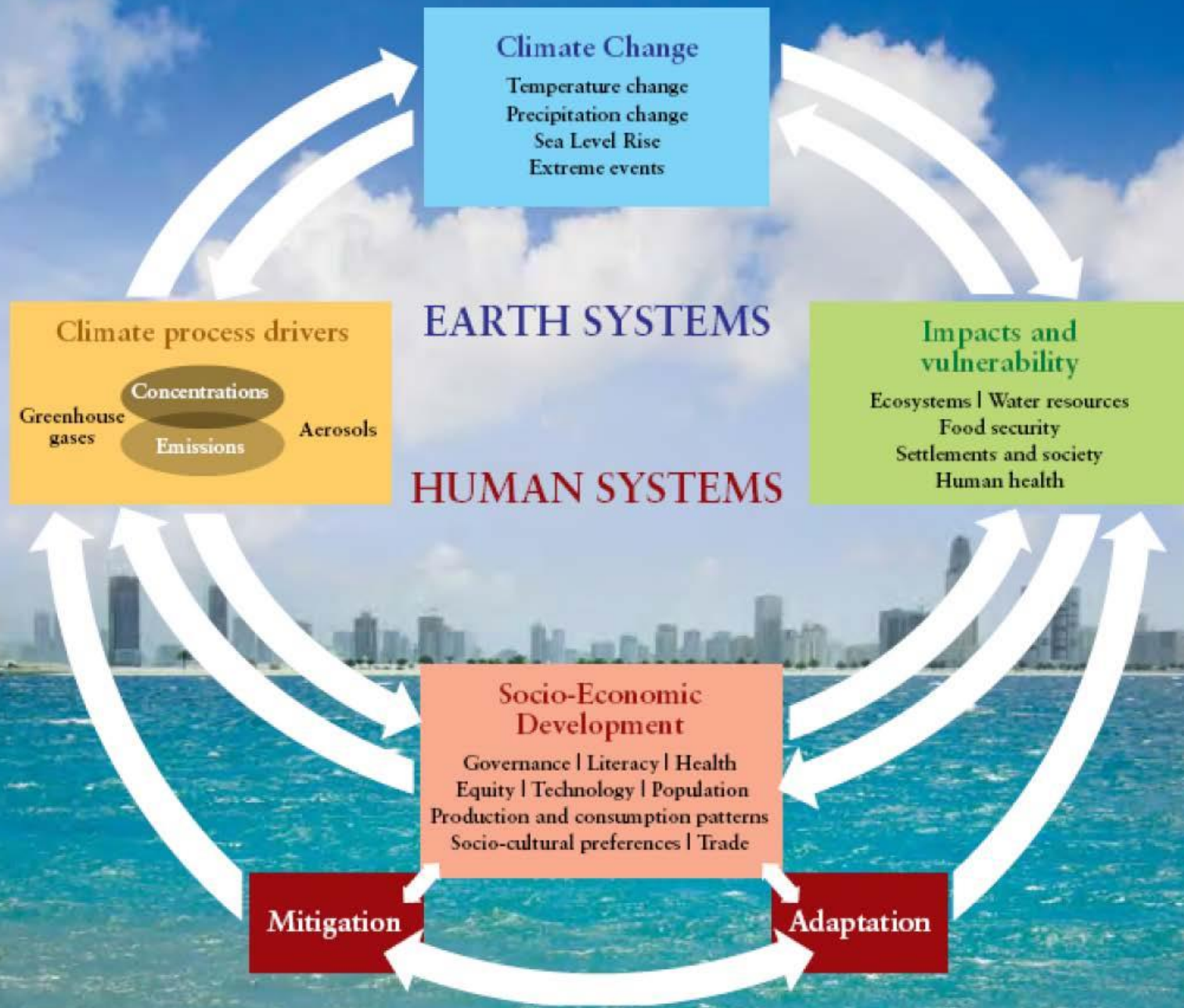


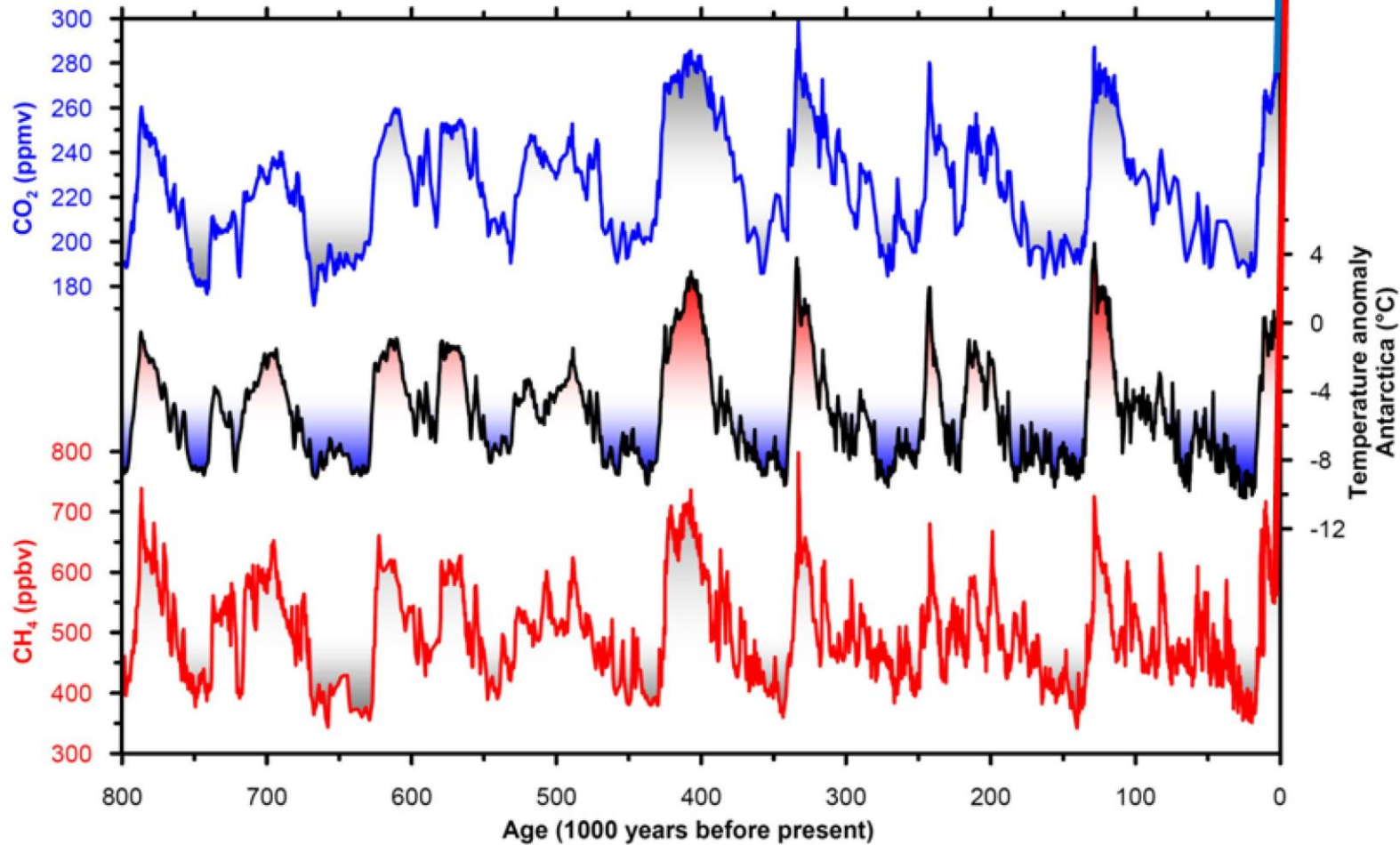
Figure 1. From the IPCC Expert Meeting Report: Towards New Scenarios - Technical Summary (2007)

The existence of a Medieval Warm Period does not prove anything about the effect of CO₂ on climate. Actually, it is likely that at present there is a natural warming period plus an anthropic effect.

Yesterday we got 400 ppm of CO₂ (ANSA NEWS)

1790 ppb

386 ppm



Agreement: the warming will keep going

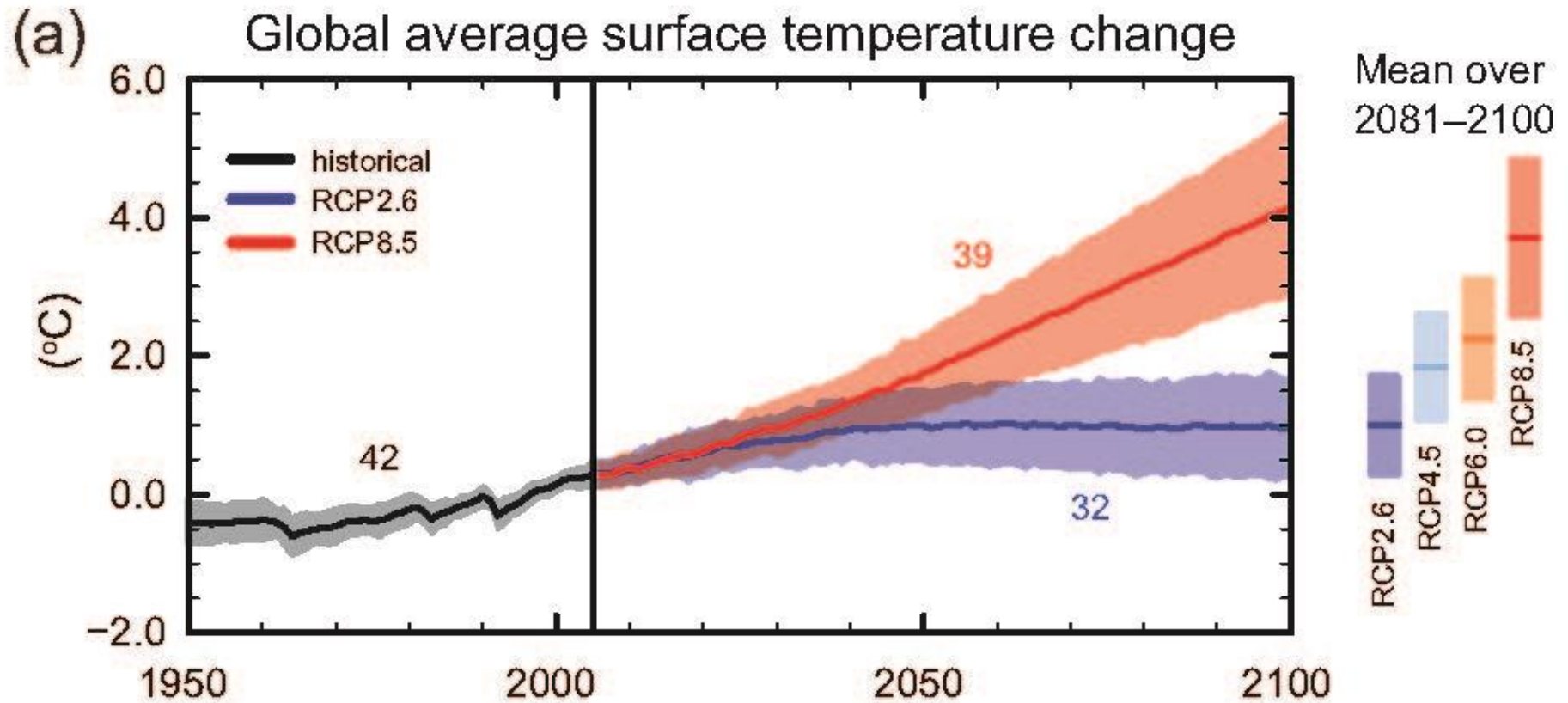
IPCC (2013): *Summary for Policymakers*. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the IPCC*, Cambridge University Press.

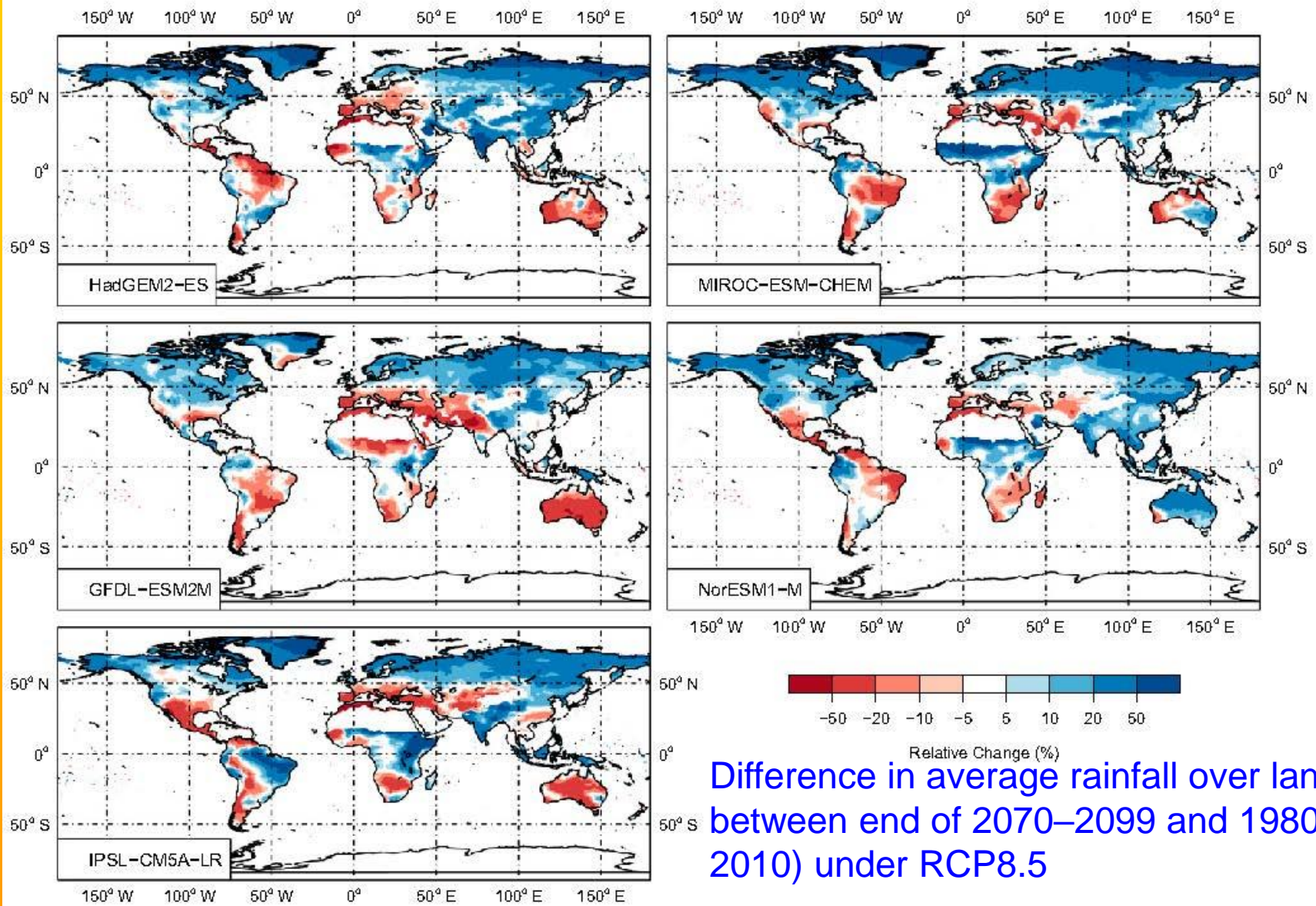
Michaels, P. J. (2005): *The Predictable Distortion of Global Warming by Scientists, Politicians, and the Media*. Cato Institute, pp. 271.

“(future) warming will be modest and can’t be stopped any way”, p. 3

SINGER, S. F. & AVERY, D. T. 2006. *Unstoppable Global Warming: Every 1500 Years*. Rowman & Littlefield Publishers, Inc., Lanham, MD.

Illusions (present capability to model properly the future climate)





Difference in average rainfall over land
between end of 2070–2099 and 1980–
2010) under RCP8.5

By improving climate models, the scientific community has made considerable progress in the past decades in its capability to project future climate and its impacts. **Nonetheless, important details about future climate remain uncertain.**

Committee on a National Strategy for Advancing Climate Modeling (2012): A National Strategy for Advancing Climate Modeling

On regional scales, the confidence in model capability to simulate surface temperature is less than for the larger scales. However, there is high confidence that regional-scale surface temperature is better simulated than at the time of the AR4.

There has been some improvement in the simulation of continental-scale patterns of precipitation since the AR4. At regional scales, precipitation is not simulated as well, and the assessment is hampered by observational uncertainties.

Climate models now include more cloud and aerosol processes, and their interactions, than at the time of the AR4, but there remains low confidence in the representation and quantification of these processes in models.

Rosenthal et al. (2014): Pacific Ocean Heat Content During the Past 10,000 Years. SCIENCE

Water masses linked to North Pacific and Antarctic intermediate waters were warmer by $2.1 \pm 0.4^\circ\text{C}$ and $1.5 \pm 0.4^\circ\text{C}$, respectively, during the middle Holocene Thermal Maximum than over the past century.

Both water masses were $\sim 0.9^\circ\text{C}$ warmer during the Medieval Warm period than during the Little Ice Age and $\sim 0.65^\circ$ warmer than in recent decades. ?????

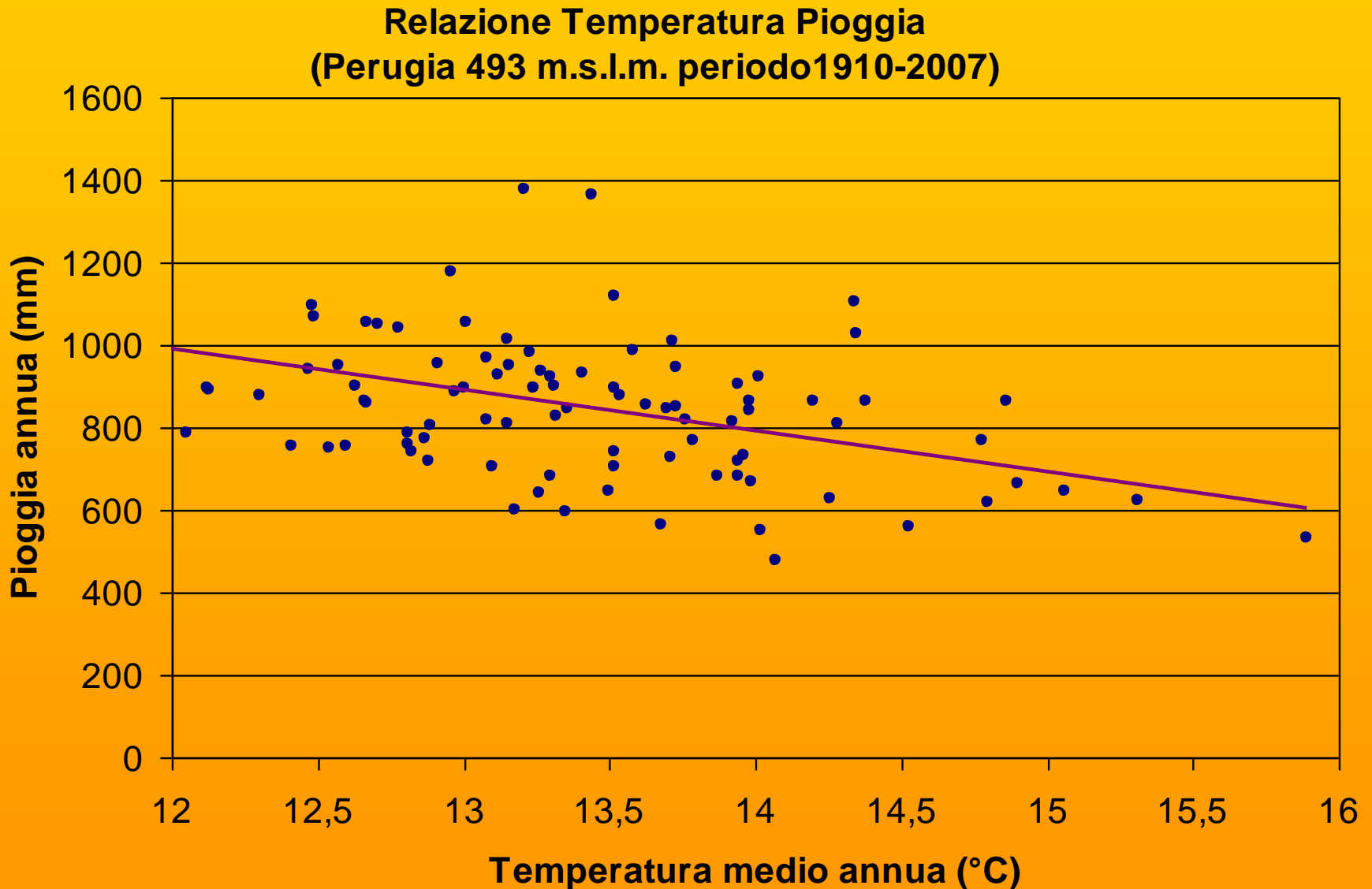
Uncertainty about the effects of understanding the differences between past and present particle formation and growth rates is crucial in quantifying the aerosol cooling effect.

..... A better understanding is needed of how the compositions of HOM (Highly Oxidized Multifunctional organic compounds) in vapour affect the molecular composition of particles, to establish the full life cycle of aerosols and their effects on the atmosphere.

Crippa C. (2016): Unexpected player in particle formation.

N A T U R E | V O L 5 3 3 | 2 6 M A Y 2 0 1 6

Some times simple observations give results similar to those of complex models:

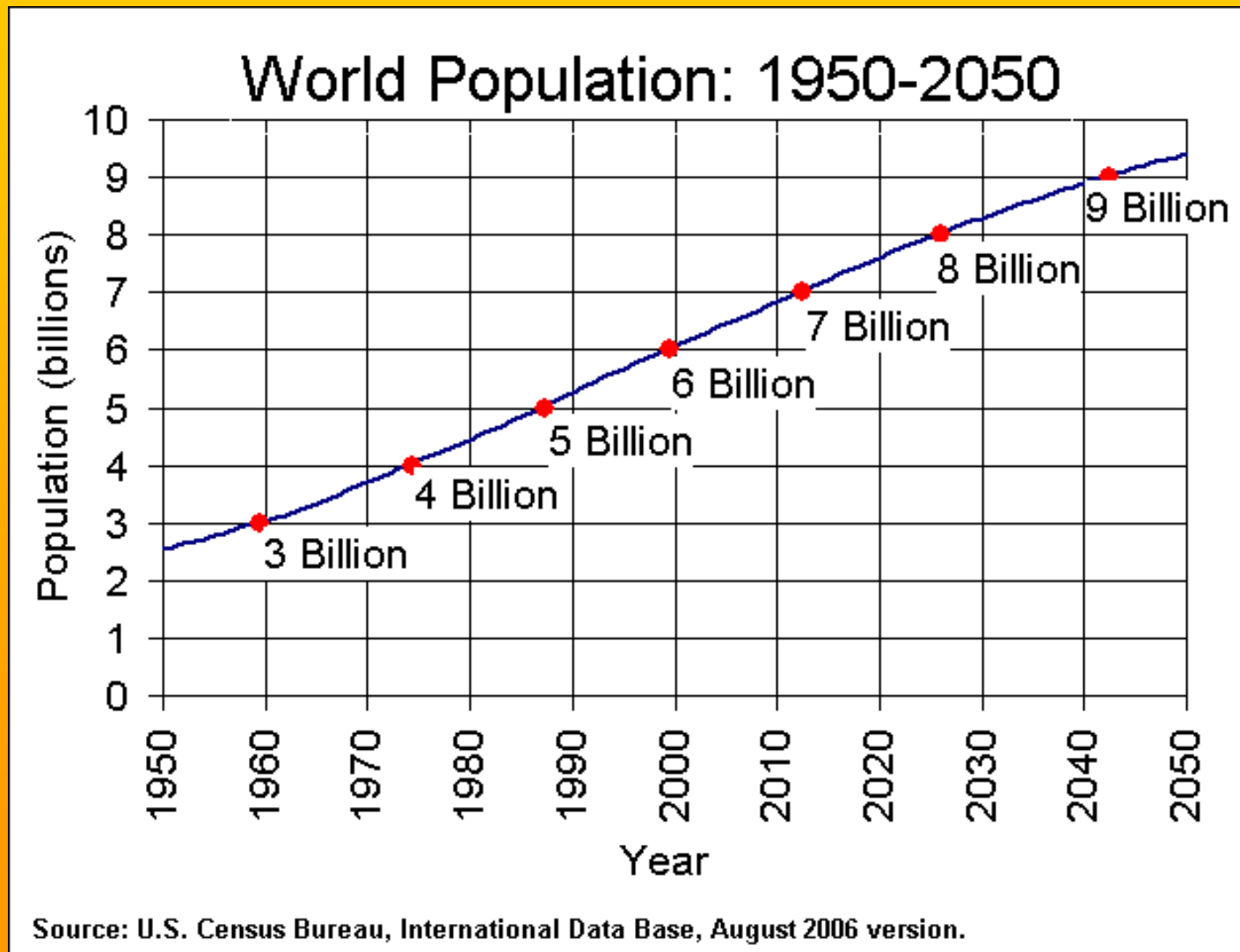


Climate Change is not the only problem about the water

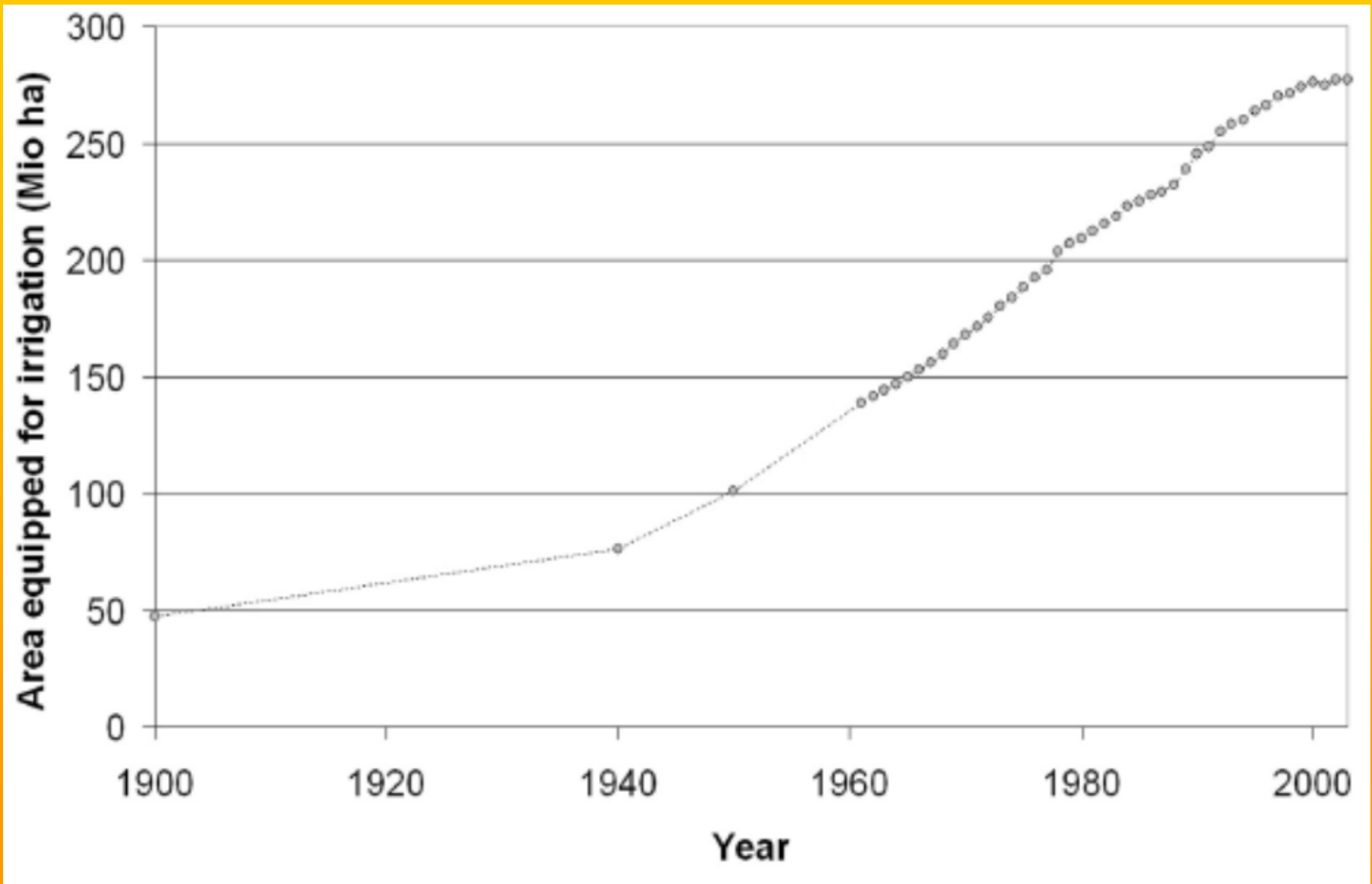
There are water problems even in the case there was no climate change

At present man activity impacts the water cycle more than climate change.

From the Water point of view, is global change the only large problem?



Global extent of area equipped for irrigation in the period 1900–2003 (data sources: SHIKLOMANOV 2000; FAOSTAT).



USA, Colorado: km² 110000 – 95% of the water is used





before 1970

after 1980

Average flow of Euphrates

1050 m³/s

253 m³/s

CONTRIBUTIONS TO WATER SCARCITY (1985-2025)

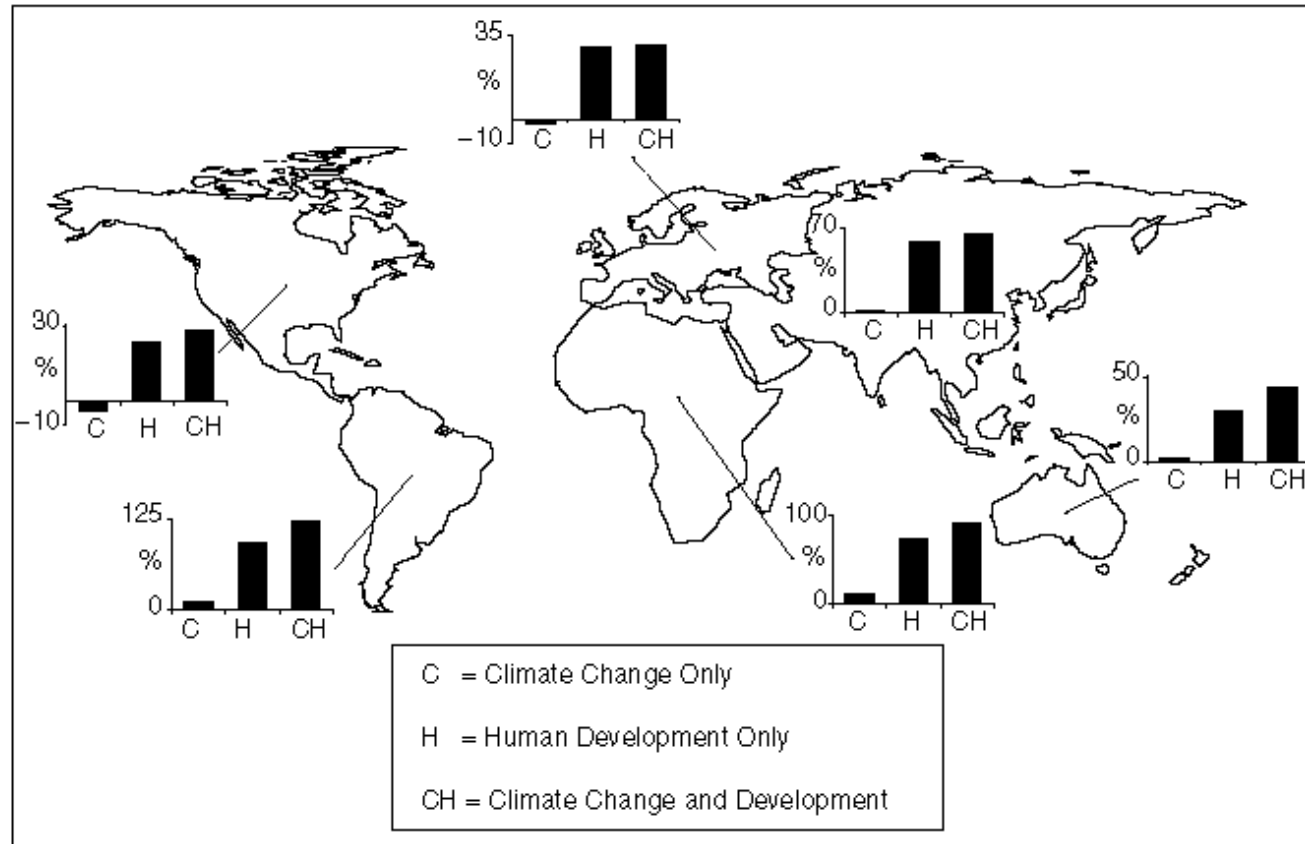
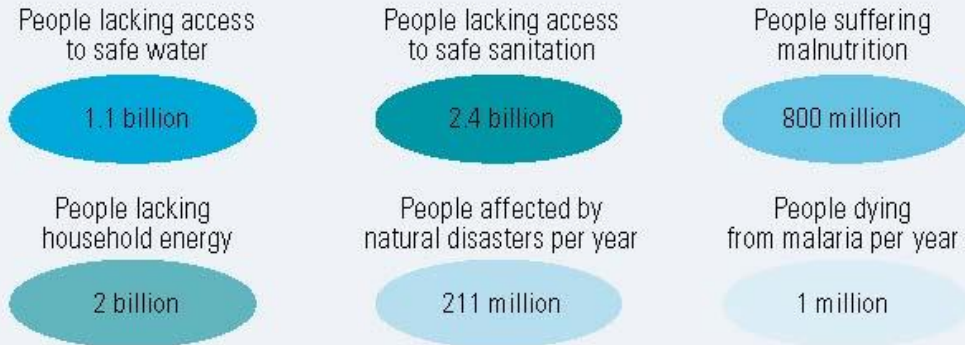


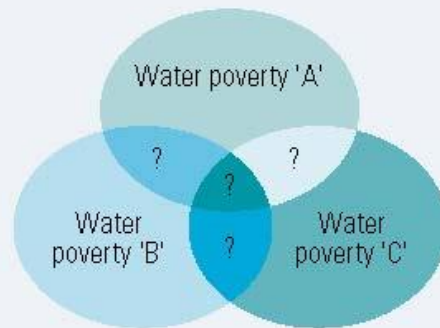
Figure 3. The change in relative water use (demand:supply ratio) by humans due to climate change, population growth/economic development, and their combination. The GIS-based global framework combined high-resolution (30' spatial) biogeophysical data sets and socioeconomic indicators to map the sensitivity of water resources to future sources of stress. Contrary to expectation, population growth and economic development—not global climate change—will be the predominant factors defining future water scarcity at continental and global scales. More complex interactions arise over individual regions, arguing for a fully global yet spatially resolved approach to the issue. Data from Vörösmarty *et al.* (2000)

Vorosmarty C. J. (2002). *Global change, the water cycle, and our search for Mauna Loa Hydrol. Process.* **16**, 135–139.

Figure 23.1: Multiple burdens of water poverty



Generic image to represent the number of people experiencing water poverty in more than one of its multiple dimensions (3 dimensions only are illustrated)



Source: WWAP Secretariat.

Climatic disasters (i.e droughts) causes more deaths than all other natural disasters together



Illusion:

**do government/societies/people act coherently
with these problems??**

- **Measurement of Hydrometeorological data:**

In South America measurement stations passed from 4267 a 390 in the period 1989 – 2006 (LORENZ & KUNSTMANN, 2012)

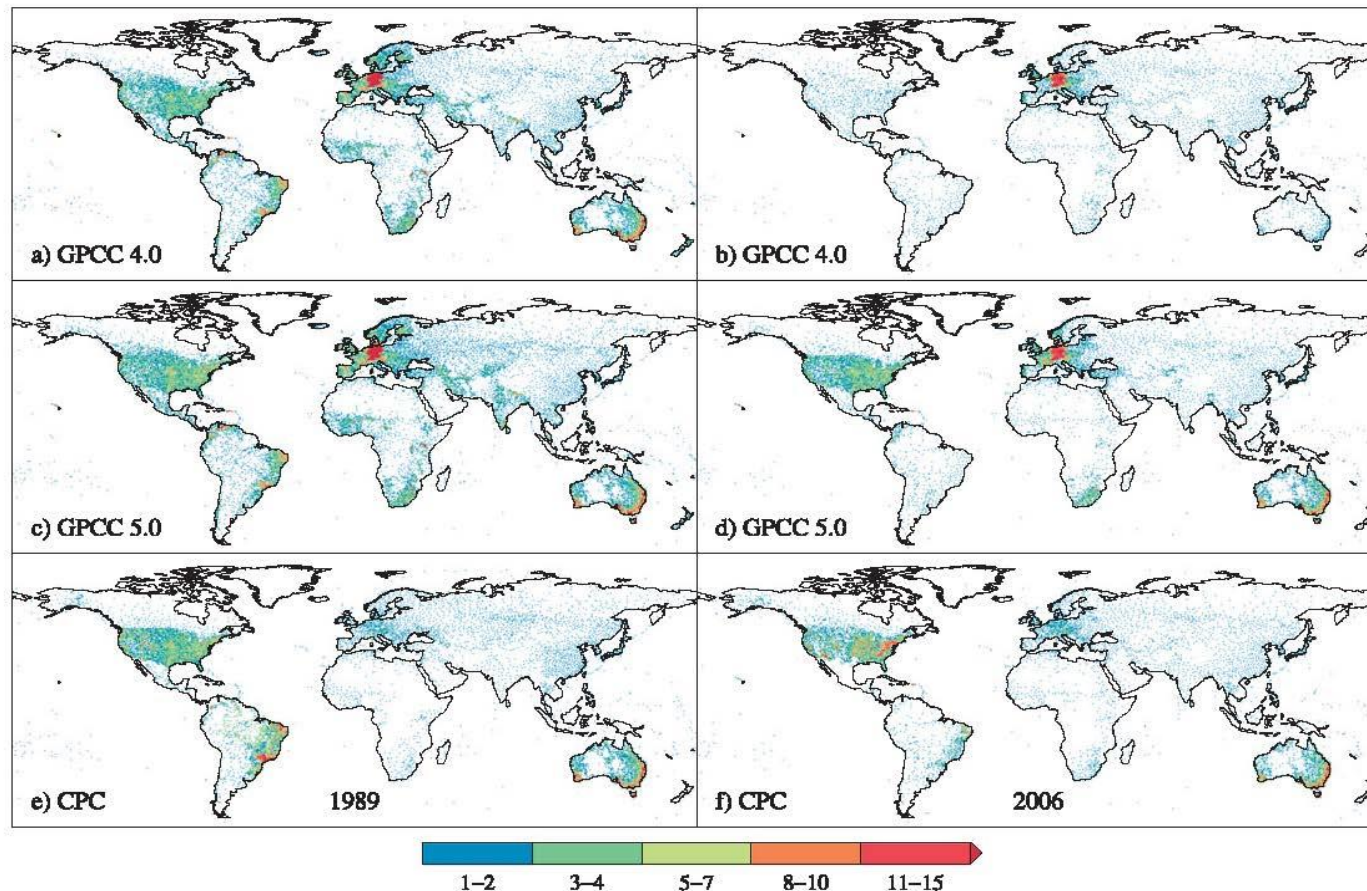
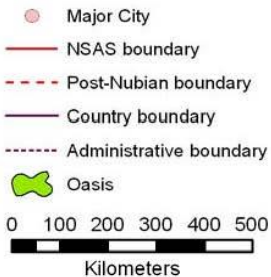
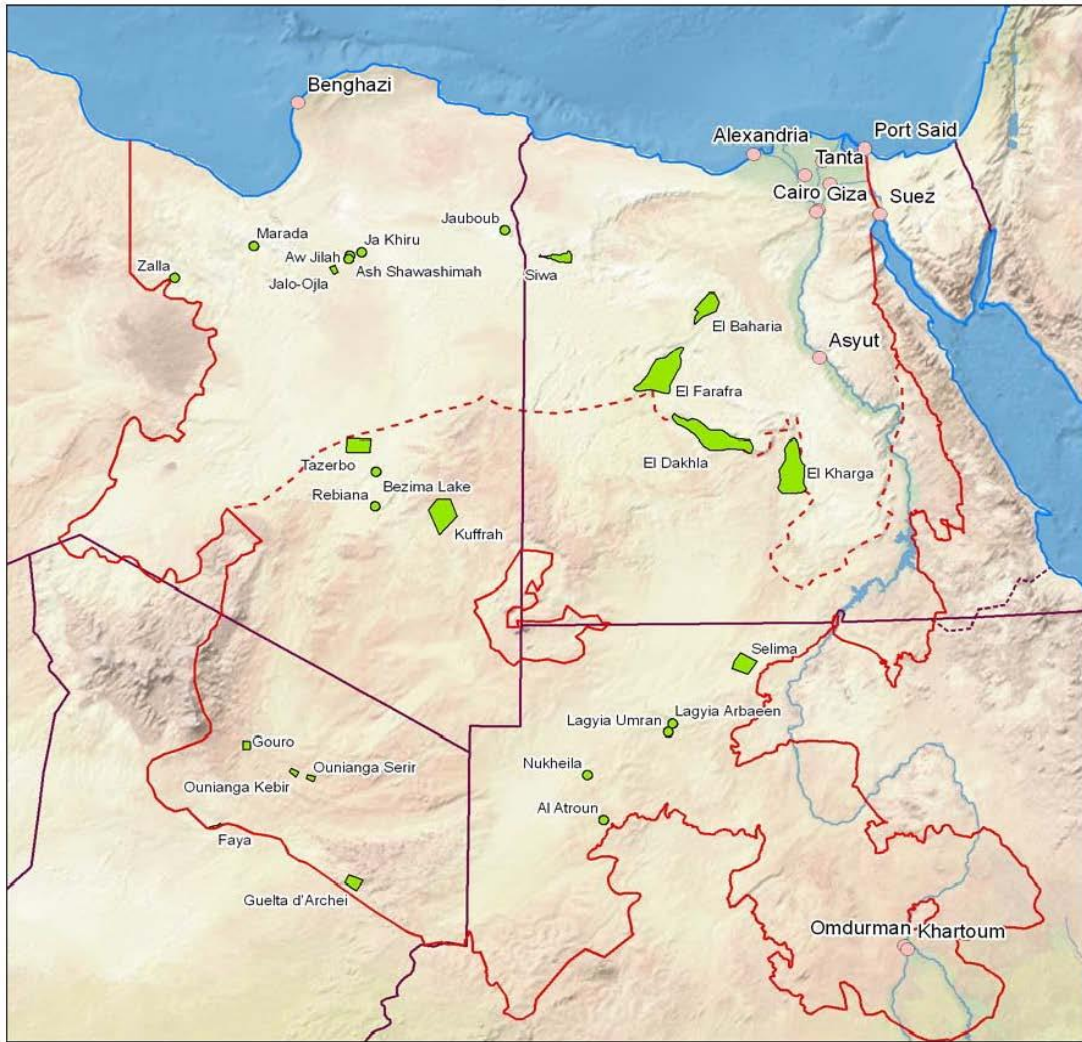


FIG. 3. Number of monitoring stations per $0.5^\circ \times 0.5^\circ$ grid cell in (a),(c),(e) January 1989 and (b),(d),(f) December 2006 for the (a),(b) GPCC v4.0; (c),(d) GPCC v5.0; and (e),(f) CPC datasets. A good spatial coverage with observation stations can be observed over North America (GPCC v5.0 and CPC) and Europe (GPCC v4.0 and v5.0), while the number of gauges over North America is significantly reduced in GPCC v4.0. Over most of the tropical regions like the Congo or Amazon basin, high-latitude regions, and large parts of Asia, the three datasets use a maximum of 1–2 gauges per grid cell, whereas some areas are completely ungauged.



Sources:
CEDARE (1998), data supplied by the project counterparts and GoogleEarth satellite imagery,
ESRI Data & Maps, UNGIWG.

Projection:
Equidistant Conic, Origin: 26.5E, 24N; Standard Parallels: 18E, 24E; WGS84 datum

Disclaimer:
The designations employed and the presentation of material on this map do not imply
the expression of any opinion whatsoever on the part of the Secretariat of the United Nations
and the International Atomic Energy Agency concerning the legal status of any country, territory,
city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Remark:
Boundaries are only shown for NSAS countries. Dashed line designates administrative boundary.

Decades of researches
estimated 135000 km³ of
fossil fresh water

About 2500 water wellsp, down
to 1000 m.

Milions of Euros lost in the
desert due to the war.

(Alker, 2008; IAEA, 2010)

ACTIONS

Regardless of the quality of knowledge of the future climate, we know that there is a water crisis now, and it will get worse in the future. And we already know what should be done.

- Public financing of research to decrease the use of fossile fuels (petrol is going to end up any way)
- Stringent rules against pollution and water waste
- Rational irrigation

Investing in research in fields not fully exploited from a technical point of view:

- desalinization**

- artificial recharge of aquifers with flood waters and purified waters (MAR: Managed Aquifer Recharge).**

- water scarcity and traditional techniques for water resource management (for instance rain harvesting)**

- Research on more modern management of springs
- More research about the recovery of the fresh water which now drains from the continents into the sea: a figure in the range of 2000 - 12000 km³ / year goes unused to the sea (Lvovich, 1970; Speidel & Agnew, 1988).
- Implementation and maintenance of reliable networks of hydrometeorological data measurements.



THANK YOU