Our Changing Climate: The Underlying Role of Biogeochemistry

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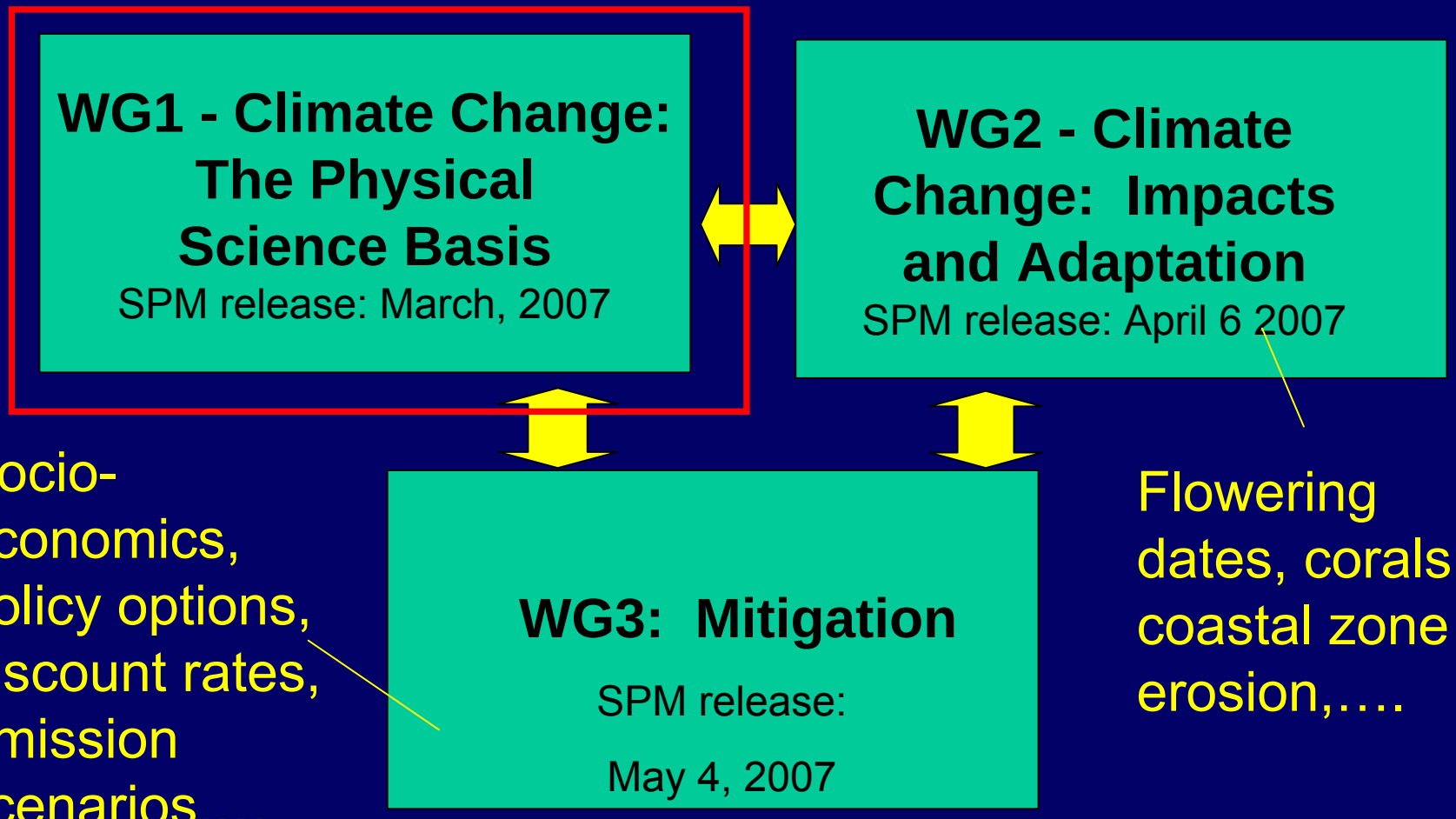
September 11, 2007

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)
Working Group I

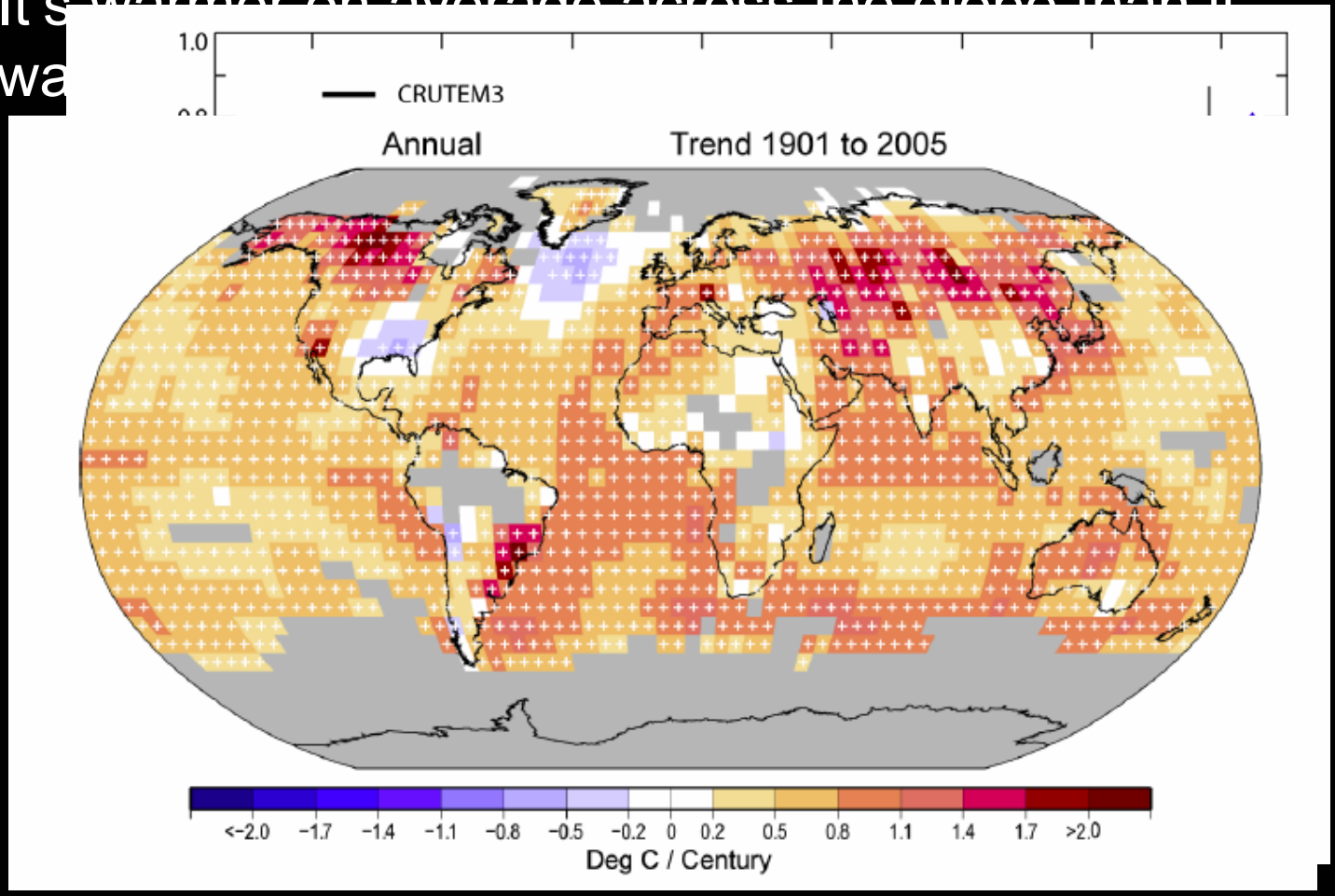


Interactions guided by respective scopes, available literature, and practicalities of the timeline and workload.

IPCC assesses research but *doesn't conduct research*.

WG1, WG2, and WG3 reports are now available at www.ipcc.ch. Full synthesis report to be released November 7, 2007.

It's warmer on average across the globe than it was



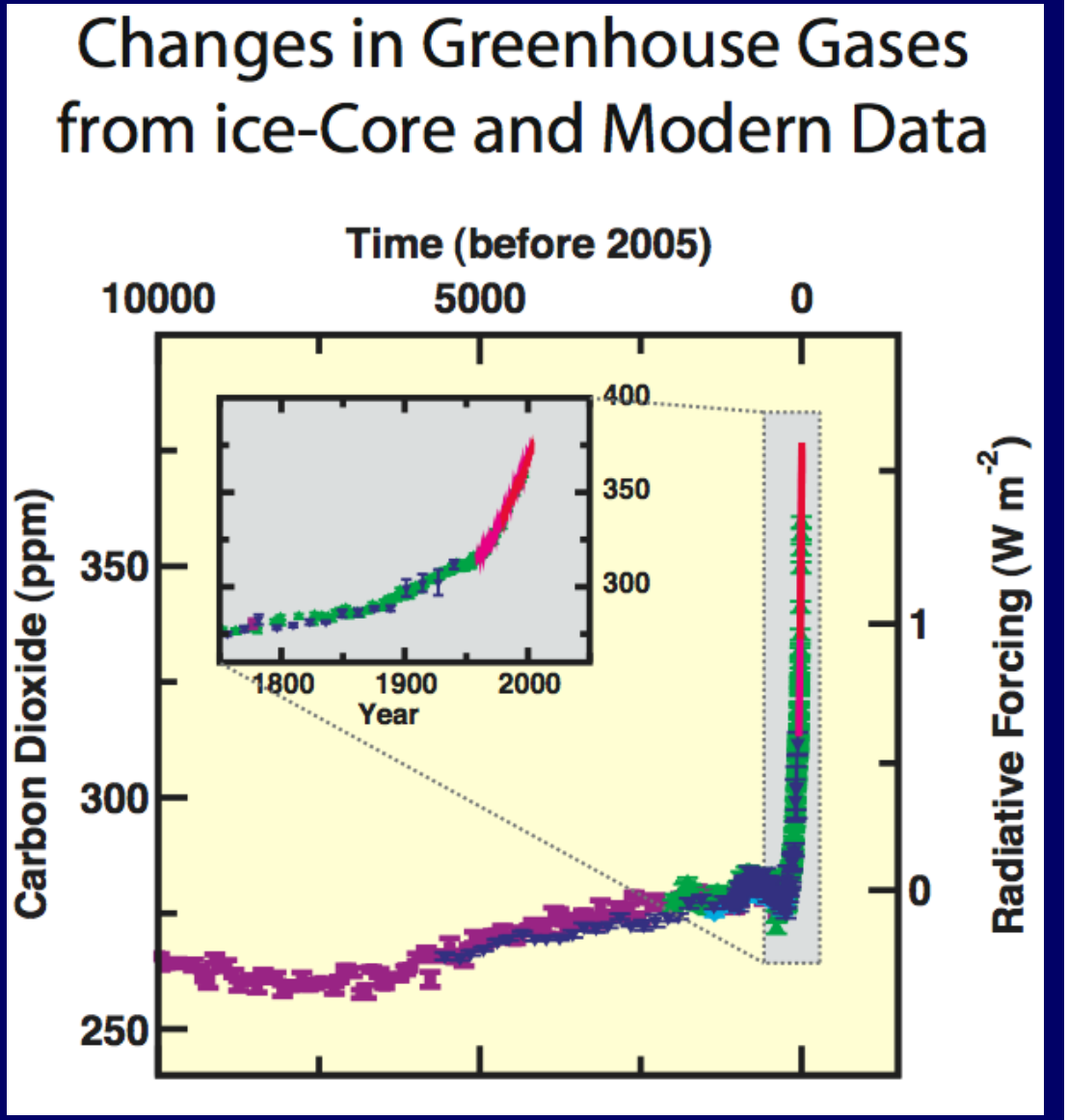
Rank	Year
1	2005[1]
1	1998[1]
3	2002
4	2003
5	2004
6	2001
7	1997
8	1990
9	1995
10	1999
11	2000
12	1991
13	1987
14	1988
15	1994
16	1983
17	1996
18	1944
19	1989
20	1993

Globally averaged, the planet is about 0.75°C warmer than it was in 1860, based upon dozens of high-quality long records using thermometers worldwide. Calibration and sampling issues have been meticulously dealt with, and they need to be: it's a slow effect over very broad scales.

Do we have reason to believe this is due to human activity? Or is it natural?

Human and Natural Drivers of Climate Change

- Dramatic rise in the industrial era
- Largest growth rate of CO_2 seen over the last ten years (1995-2005) than in any decade at least since direct measurements began (1960).



Human and Natural Drivers of Climate Change

- **Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years**

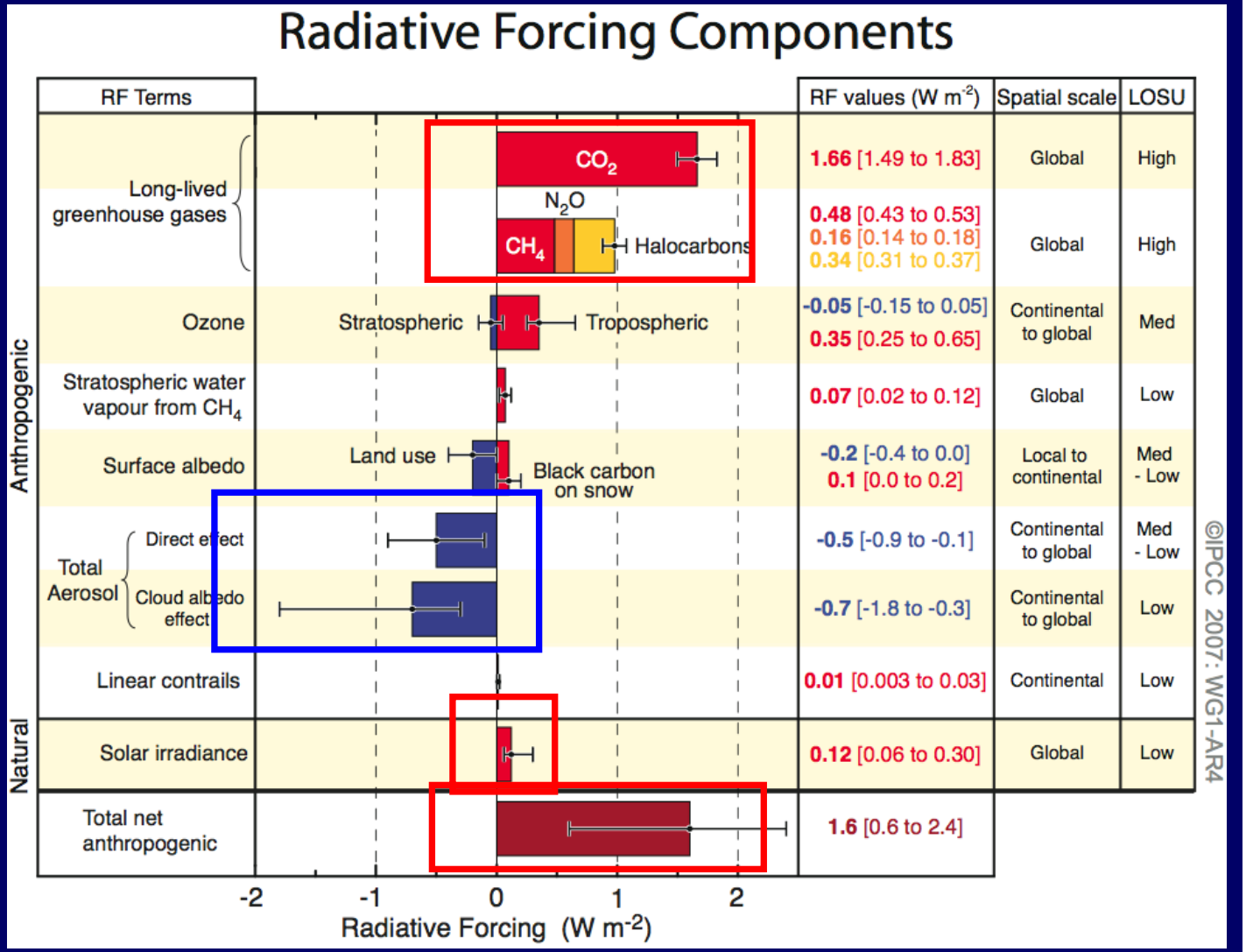
(see Figure SPM-1)

- **The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture. {2.3, 6.4, 7.3}**

Human and Natural Drivers of Climate Change

Major improvements in RF compared to IPCC (2001).

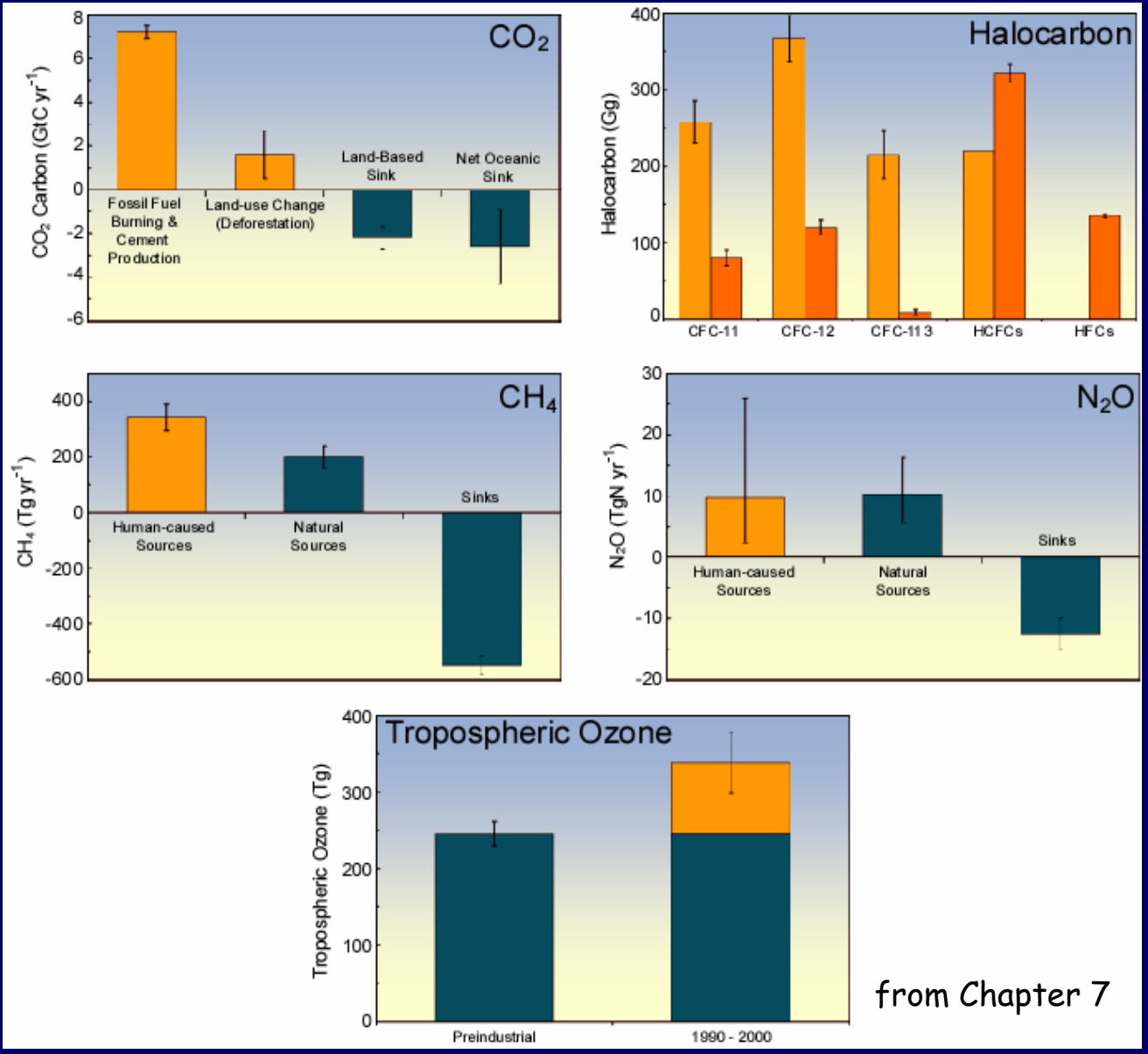
Now we can talk more confidently about “drivers”.



The understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report (TAR), leading to *very high confidence* that the globally averaged net effect of human activities since 1750 has been one of warming, with a radiative forcing of CO_2 +1.6 [+0.6 to +2.4] W m^{-}

very high confidence-9 out of 10 chance of being correct

Natural vs Human



from Chapter 7

Direct Observations of Recent Climate Change

- **Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level**

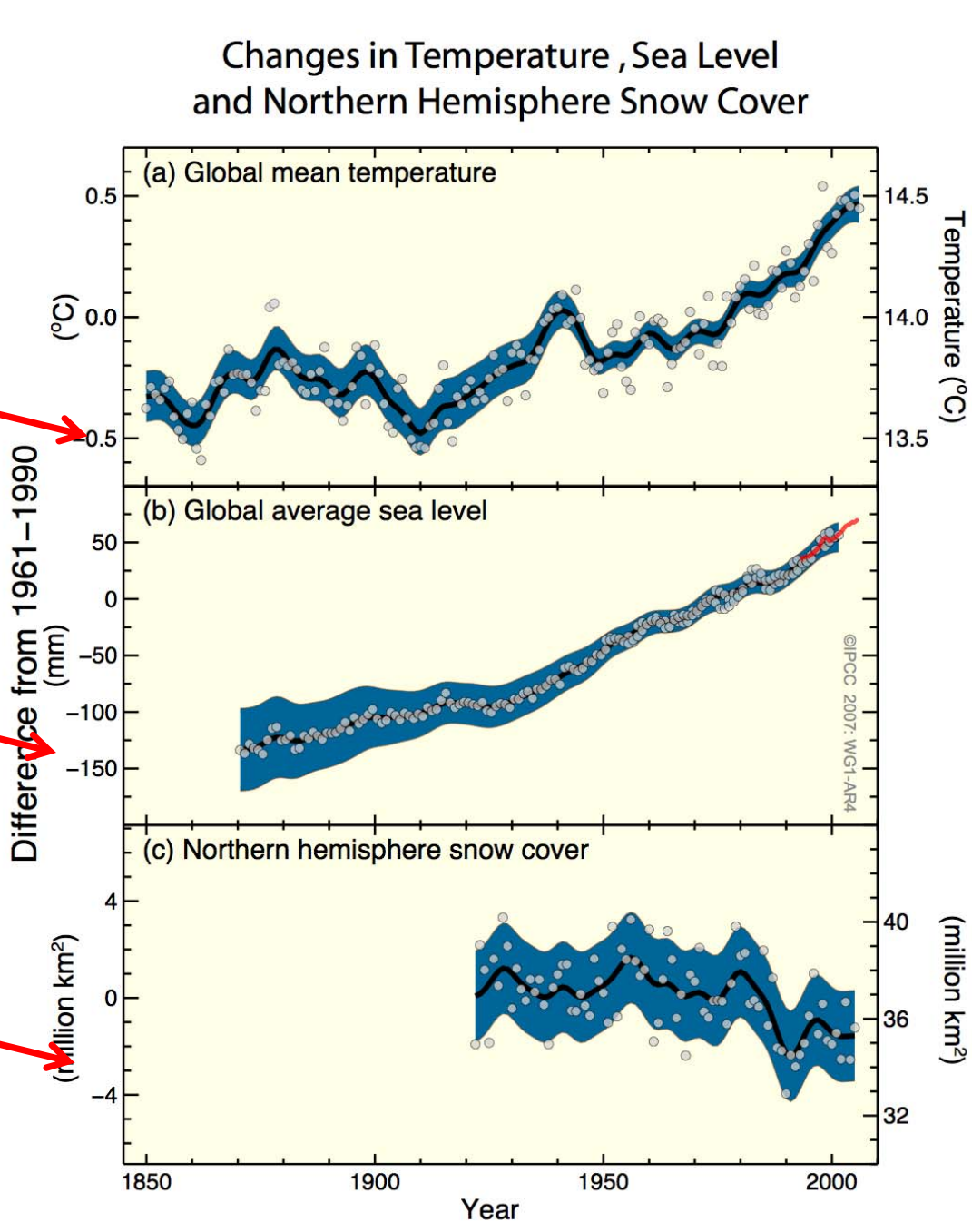
(see Figure SPM-3) {3.2, 4.2, 5.5}

Direct Observations of Recent Climate Change

Rising atmospheric temperature

Rising sea level

Reductions in NH snow cover

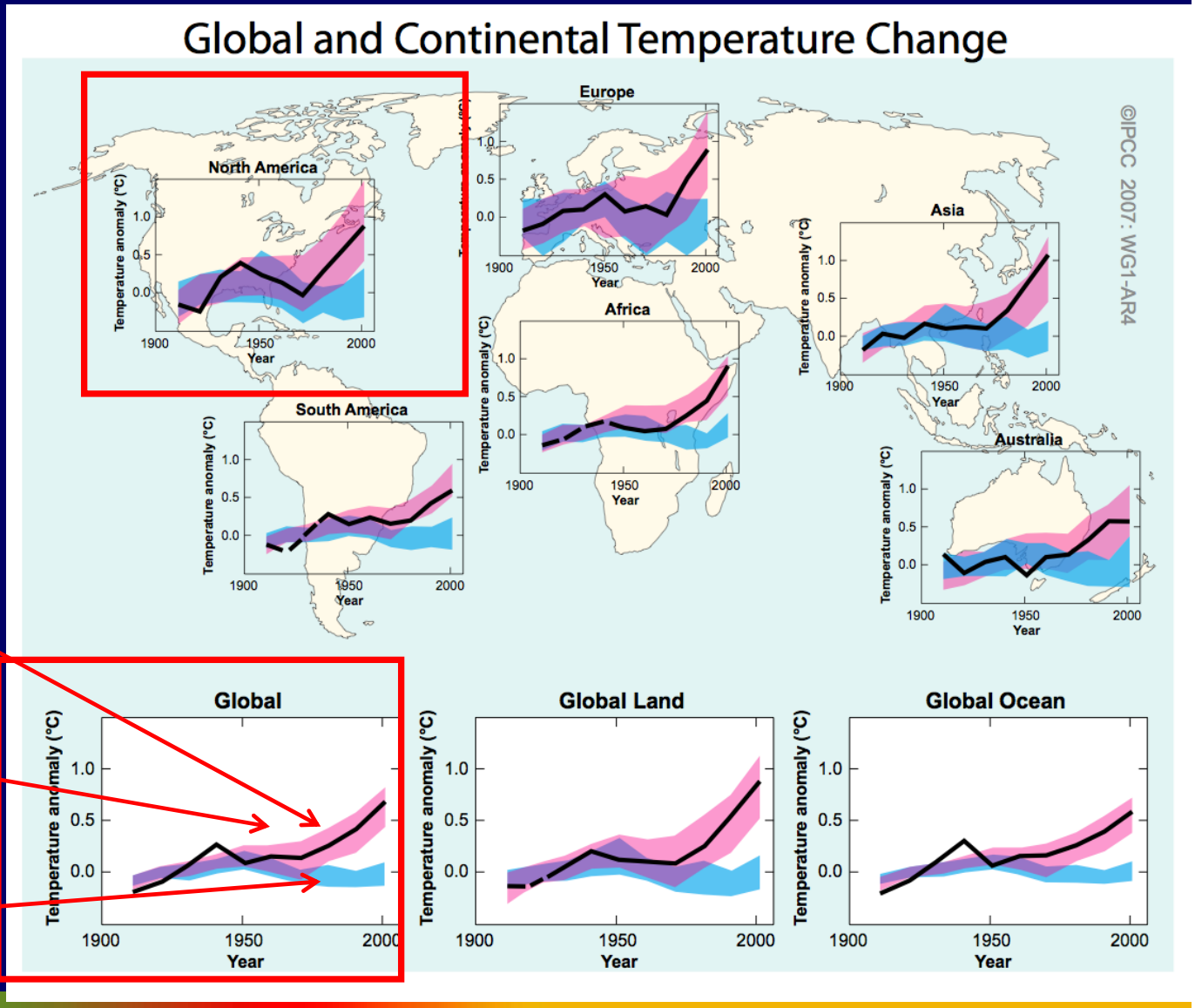


Direct Observations of Recent Climate Change

- At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed….
- These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones. {3.2, 3.3, 3.4, 3.5, 3.6, 5.2}
  - Tropical cyclones include hurricanes and typhoons.

Understanding and Attributing Climate Change

Anthropogenic warming is likely discernible on all inhabited continents



Observed

Expected for all forcings

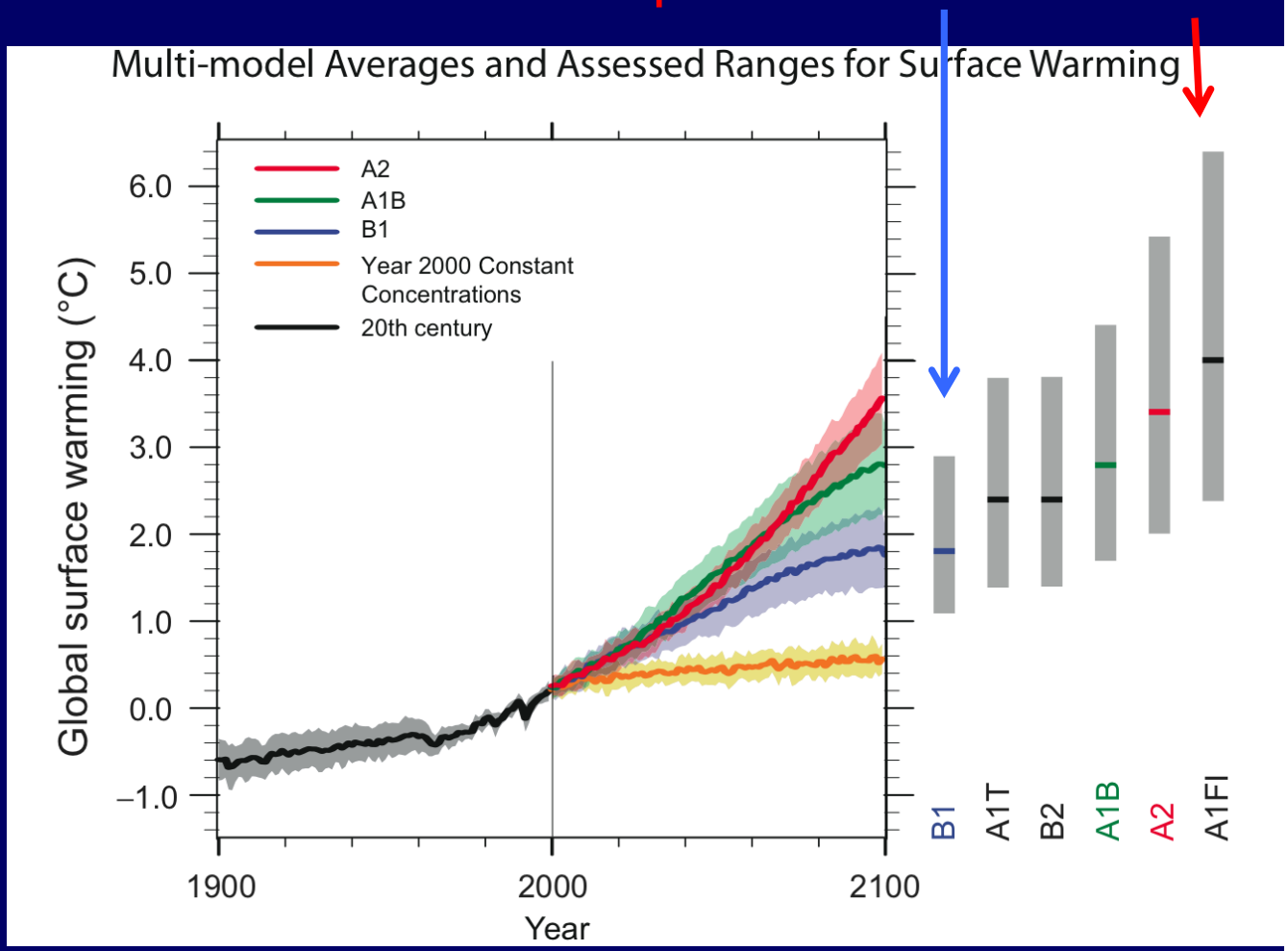
Natural forcing only

Projections of Future Changes in Climate

The future depends on human choices about emissions. Best estimates and likely ranges given now in IPCC for the first time.

600 ppmv CO2 equiv (B1) Best estimate is +1.8°C by 2100; likely 1.8-2.9°C further warming;

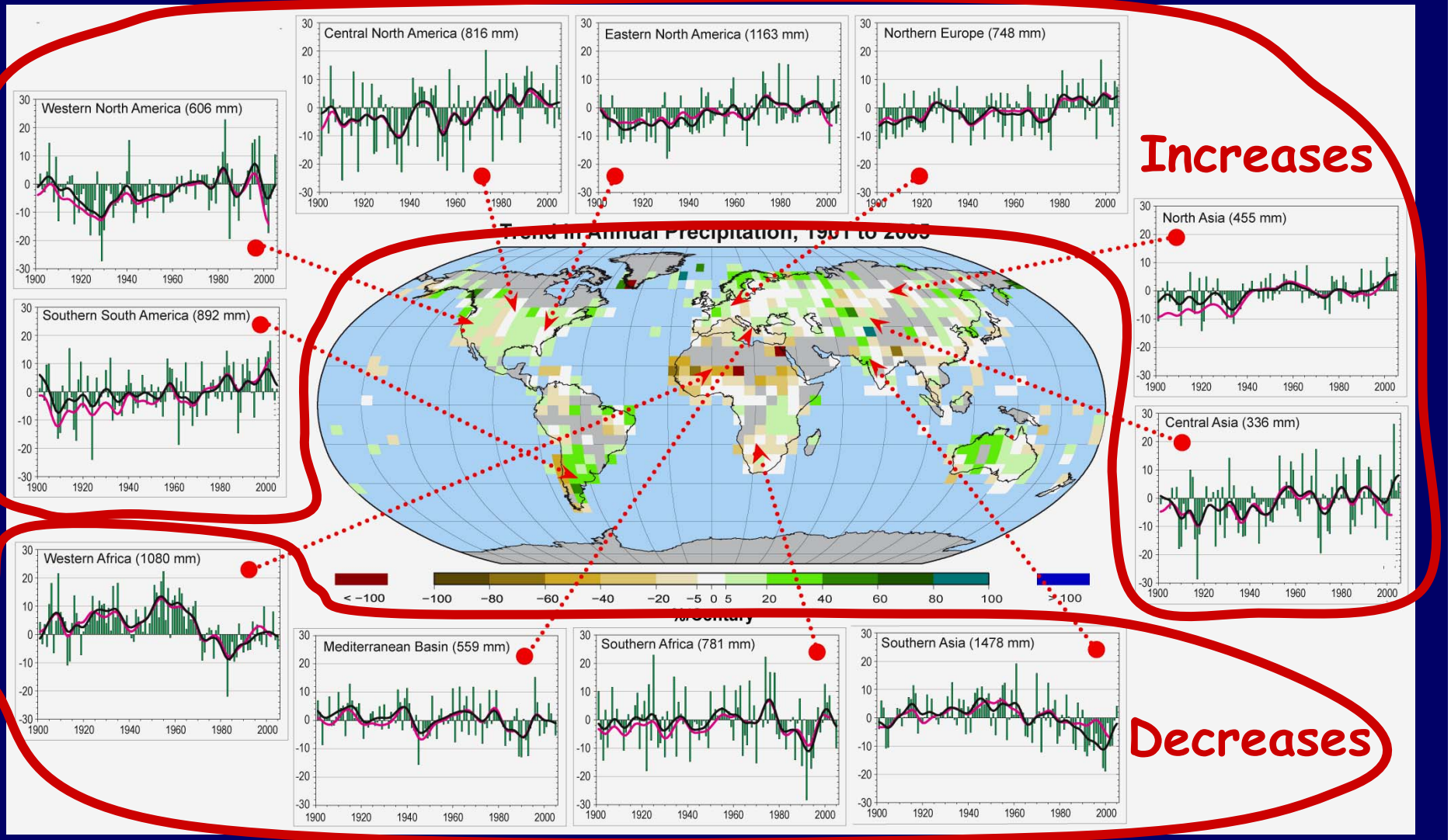
1550 ppmv (A1FI) Best 4°C [likely 2.4-6.4°C]



For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios.

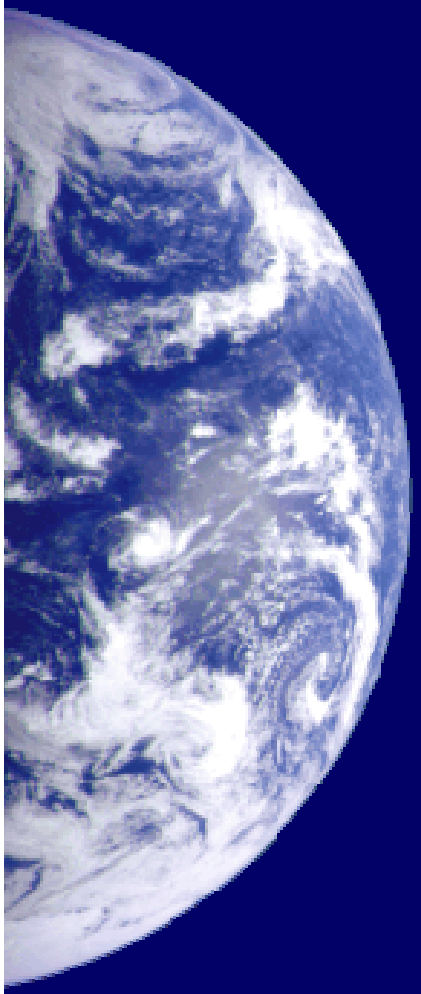
Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected.

Land precipitation is changing significantly over broad areas



Smoothed annual anomalies for precipitation (%) over land from 1900 to 2005; other regions are dominated by variability.

Conclusions



- The concentration of carbon dioxide is now 379 ppm and methane is over 1774 ppb, both very likely much higher than any time in at least 650,000 years (during which carbon dioxide remained between 180 and 300 ppm and methane between 320 and 790 ppb).

- The recent rate of change is dramatic and unprecedented; increases in carbon dioxide never exceeded 30 ppm in 1,000 years -- yet now carbon dioxide has risen by 30 ppm in just the last 17 years.

- It is very likely that the increase in the combined radiative forcing from carbon dioxide, methane and nitrous oxide has been at least six times faster between 1960 to 1999 than over any 40 year period during the two millennia prior to the year 1800.

- On average, present-day tropospheric ozone has increased 38% since pre-industrial times, and the increase results from atmospheric reactions of short-lived pollutants emitted by human activity.

ESSL

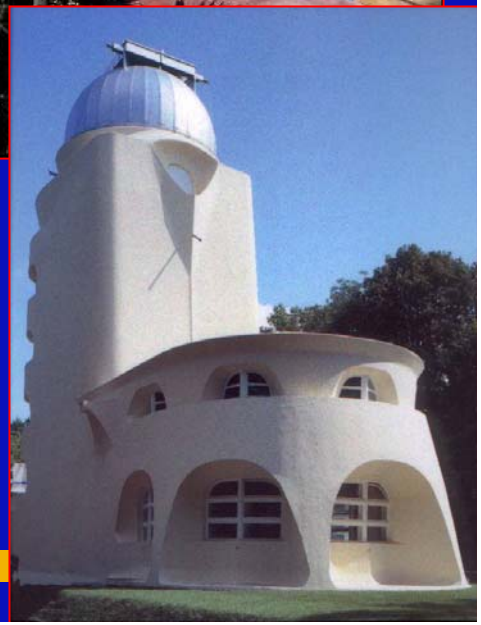
NCAR

What is the relevance to NADP?

- **Biogeochemistry is central to climate change, both as a driver and receiver of climate change.**
- **Changing wet and dry deposition are key global changes and play a central role in ecosystem impact on both land and water.**
- **NADP successfully collects quality data and makes it publicly available.**
- **Deposition measurements are cost-effective. They play an important role in documenting global change and will be central to considering both climate change and the other changes, including water and air pollution.**

Consultation, Scoping, and Some Procedural Matters of the AR4

- Government suggestions on outline solicited (twice)
- Two scoping meetings: Participation by 42 distinguished scientific experts (including chairs of World Climate Research Program and International Geosphere Biosphere Program) from 19 countries, with leadership by WG co-chairs.
- Outline formally approved by Govts in Nov, 2003
- Authors nominated by Govts, chosen by WG1 co-chairs and vice-chairs; 25% of WG1 authors have had their highest degree for less than 10 years. 75% of authors were not authors of the TAR. There are 35% more DC/EIT authors among them than in TAR.
- Technical Support Unit organizes meetings, collates comments, provides editorial support, etc.



Projections of Future Changes in Climate

- **Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century. {10.3}**

Very likely: > 90% probability

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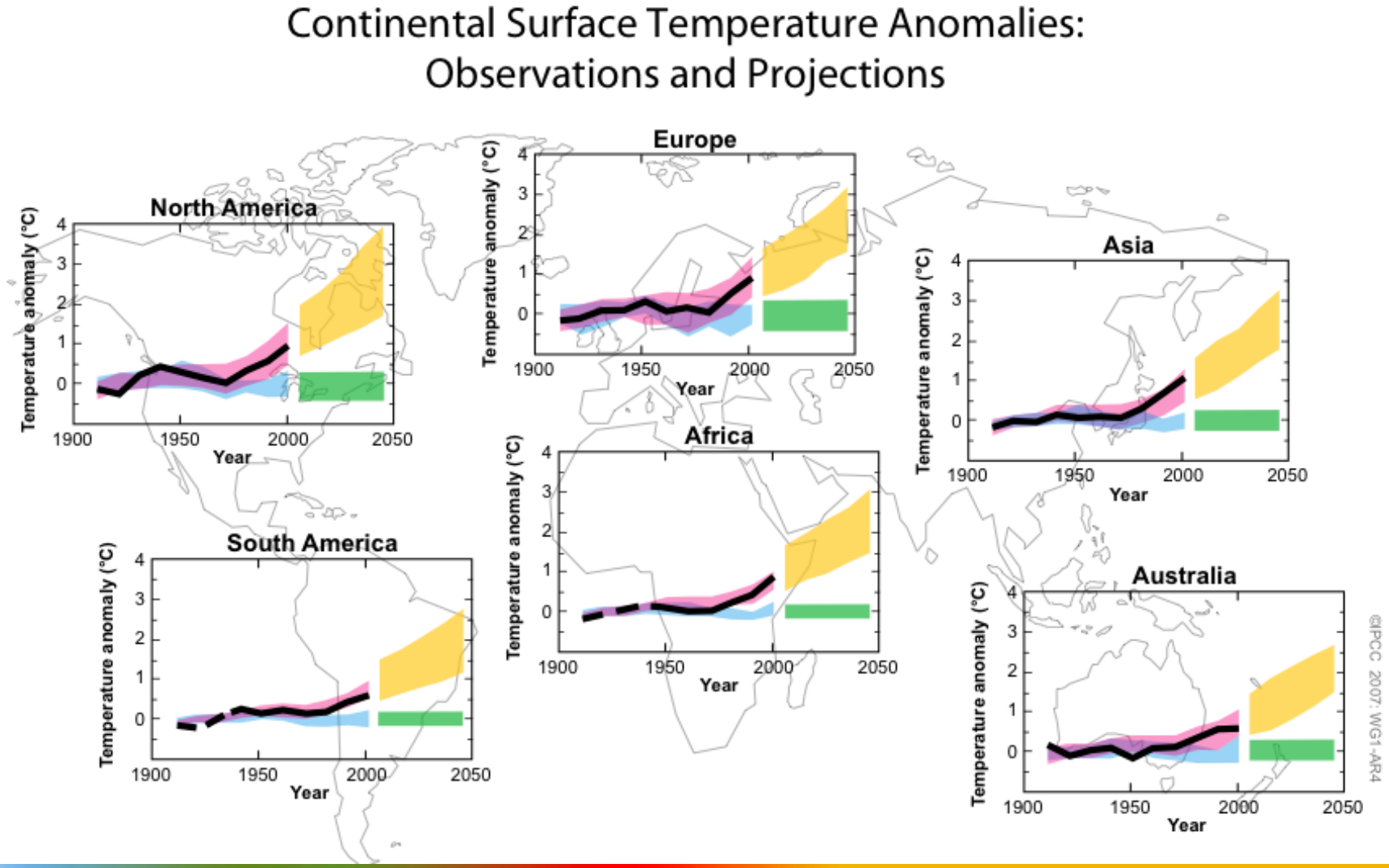
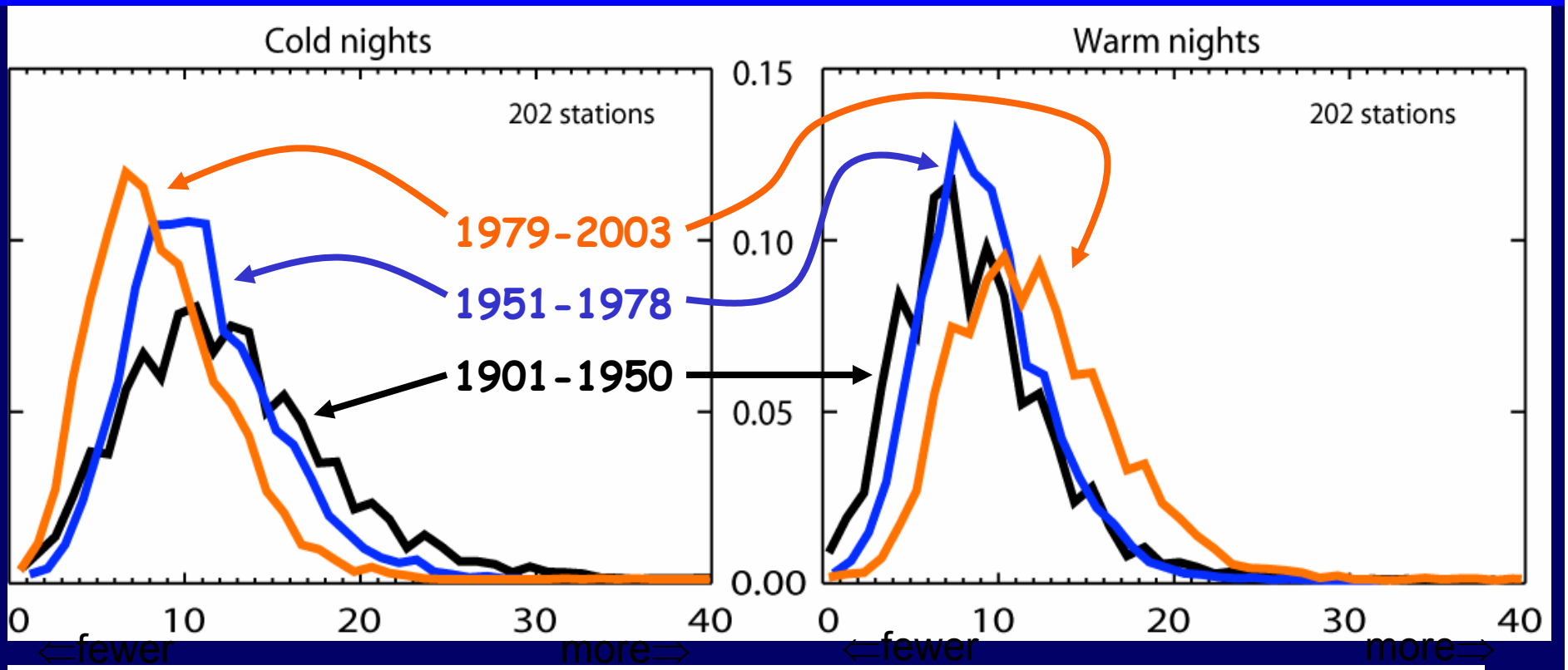
A different climate averaged over each continent by 2050



Warm nights are increasing; cold nights decreasing

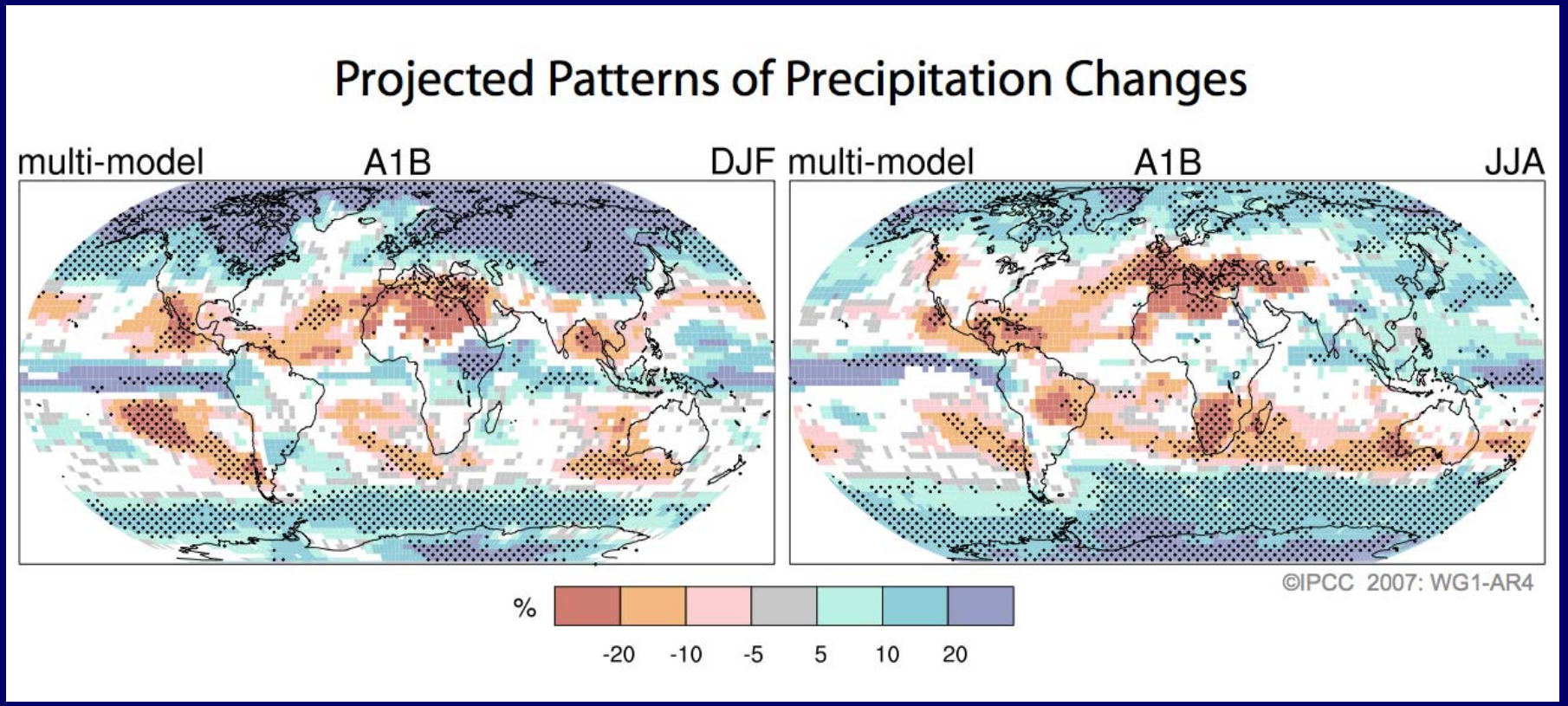


10th (left) and 90th (right) percentiles

Frequency of occurrence of cold or warm temperatures for 202 global stations with at least 80% complete data between 1901 and 2003 for 3 time periods:

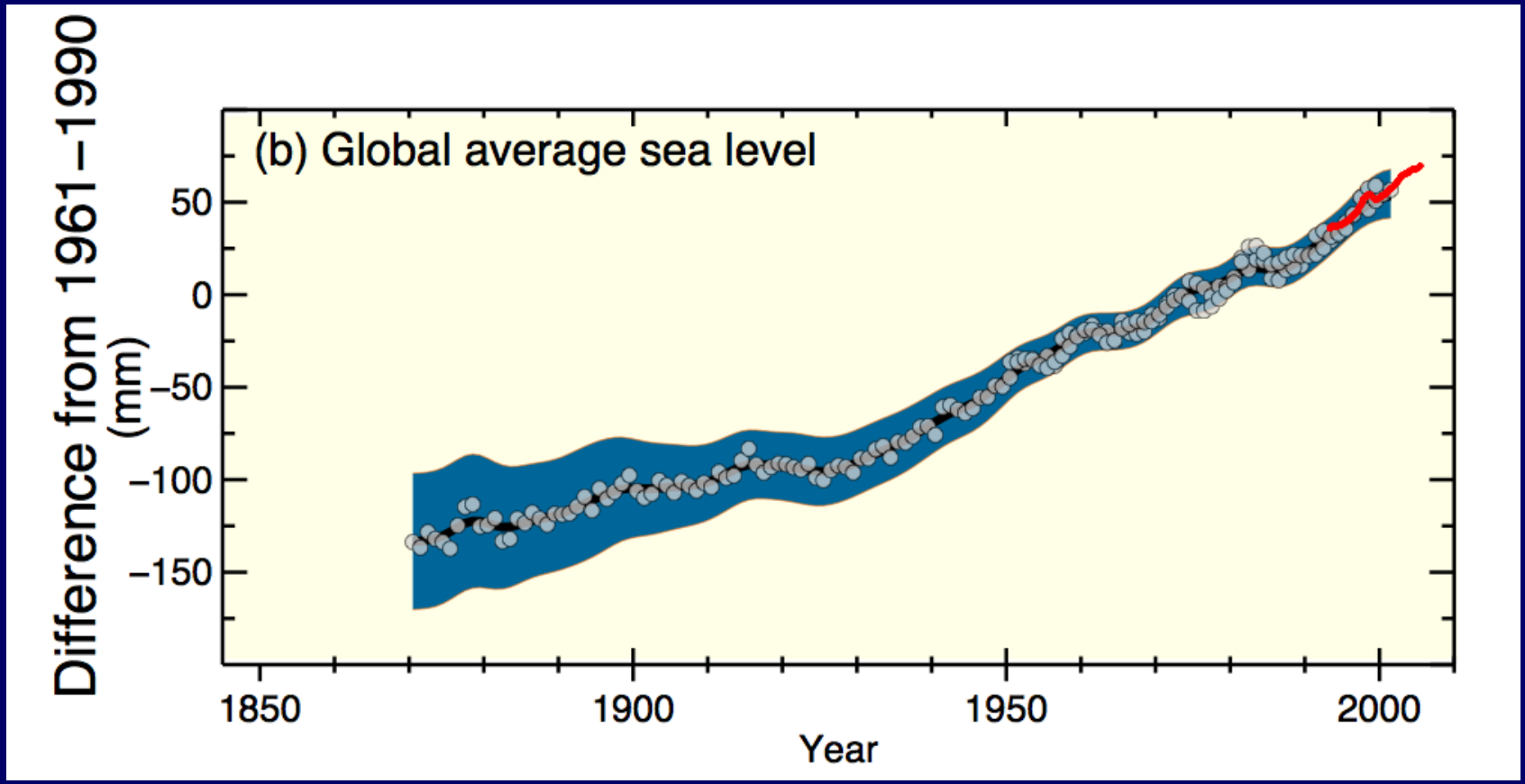
1901 to 1950 (black), 1951 to 1978 (blue) and 1979 to 2003 (orange).

Projections of Future Changes in Climate



Brand new in AR4: Drying in much of the subtropics, more rain in higher latitudes, continuing the broad pattern of rainfall changes already observed.

Sea level is rising in 20th century



SPM-3b

Rates of sea level rise:

- 1.8 + 0.5 mm yr^{-1}, 1961-2003
- 1.7 + 0.5 mm yr-1, 20th Century
- 3.1 + 0.7 mm yr^{-1}, 1993-2003;
  nb some previous decades similar

Likelihood vs Confidence

Distinct concepts

Likelihood	≠	Level of Confidence
The chance of a defined outcome occurring in the physical world. Is estimated, using appropriate information about probability and expert judgment.		The degree of understanding and/ or consensus among experts. Is a statement about the basis for the expert judgment.

Attribution

- Asks whether observed changes are consistent with
- ☑ expected responses to forcings
- ☒ inconsistent with alternative explanations

Observed

Models with only solar and volcanic forcing