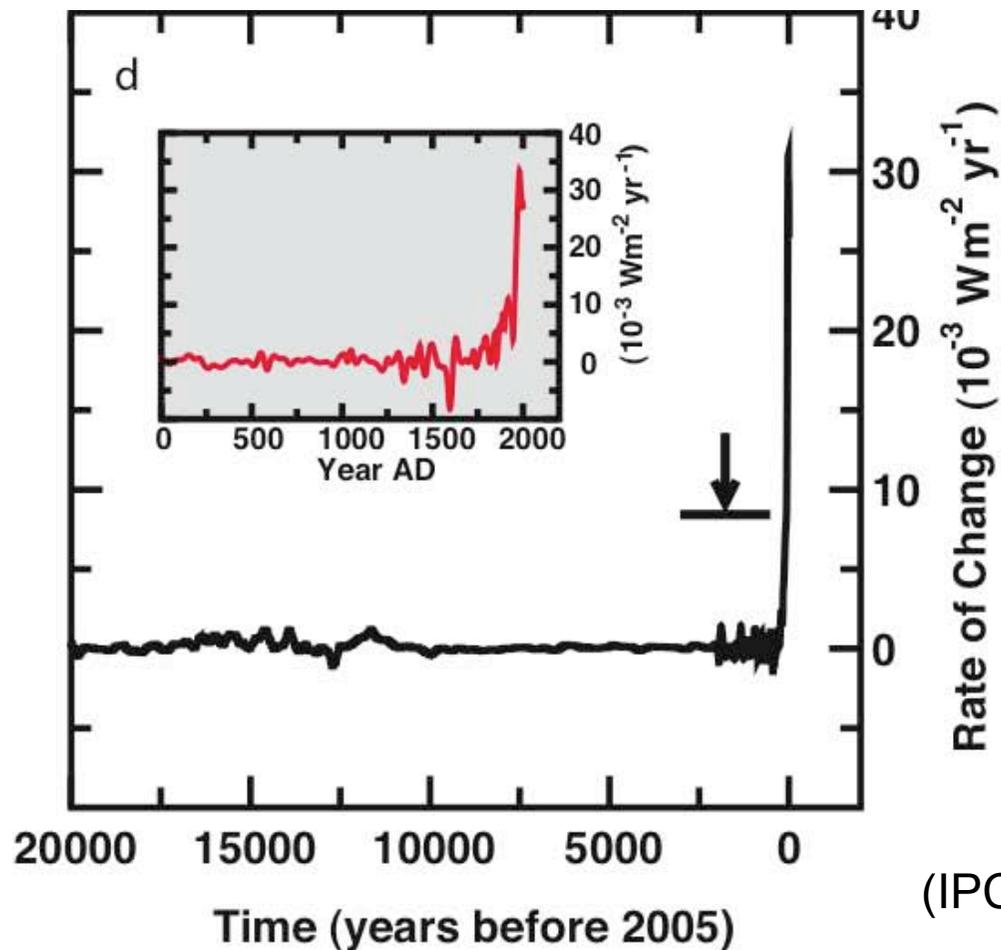


**Forum IPCC
Fourth Assessment Report**

**Paleoclimate and
Attribution of Causes**

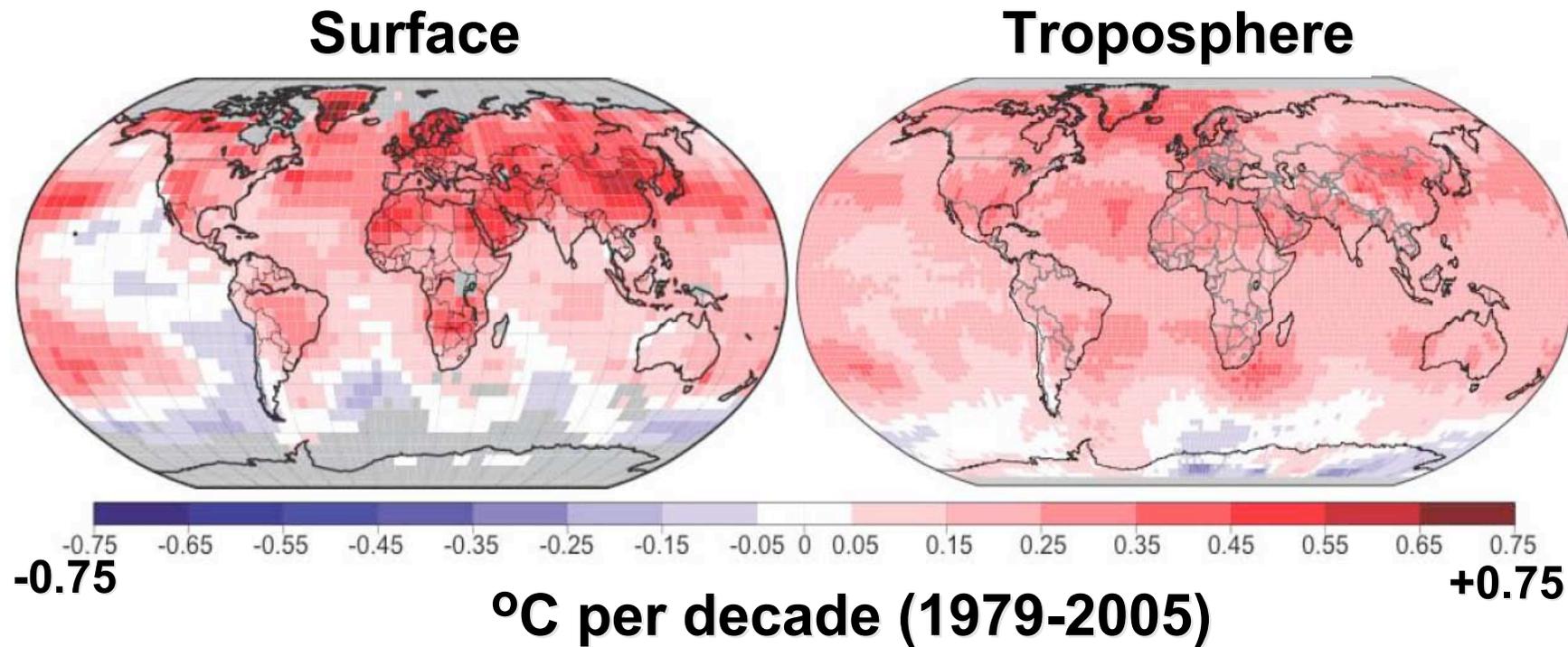
**Fortunat Joos
Climate and Environmental Physics
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The rate of increase in the combined radiative forcing from CO₂, CH₄ and N₂O during the industrial era is *very likely* to have been unprecedented in more than 10,000 years (SPM, 2007)



(IPCC, 2007, Fig. TS-2)

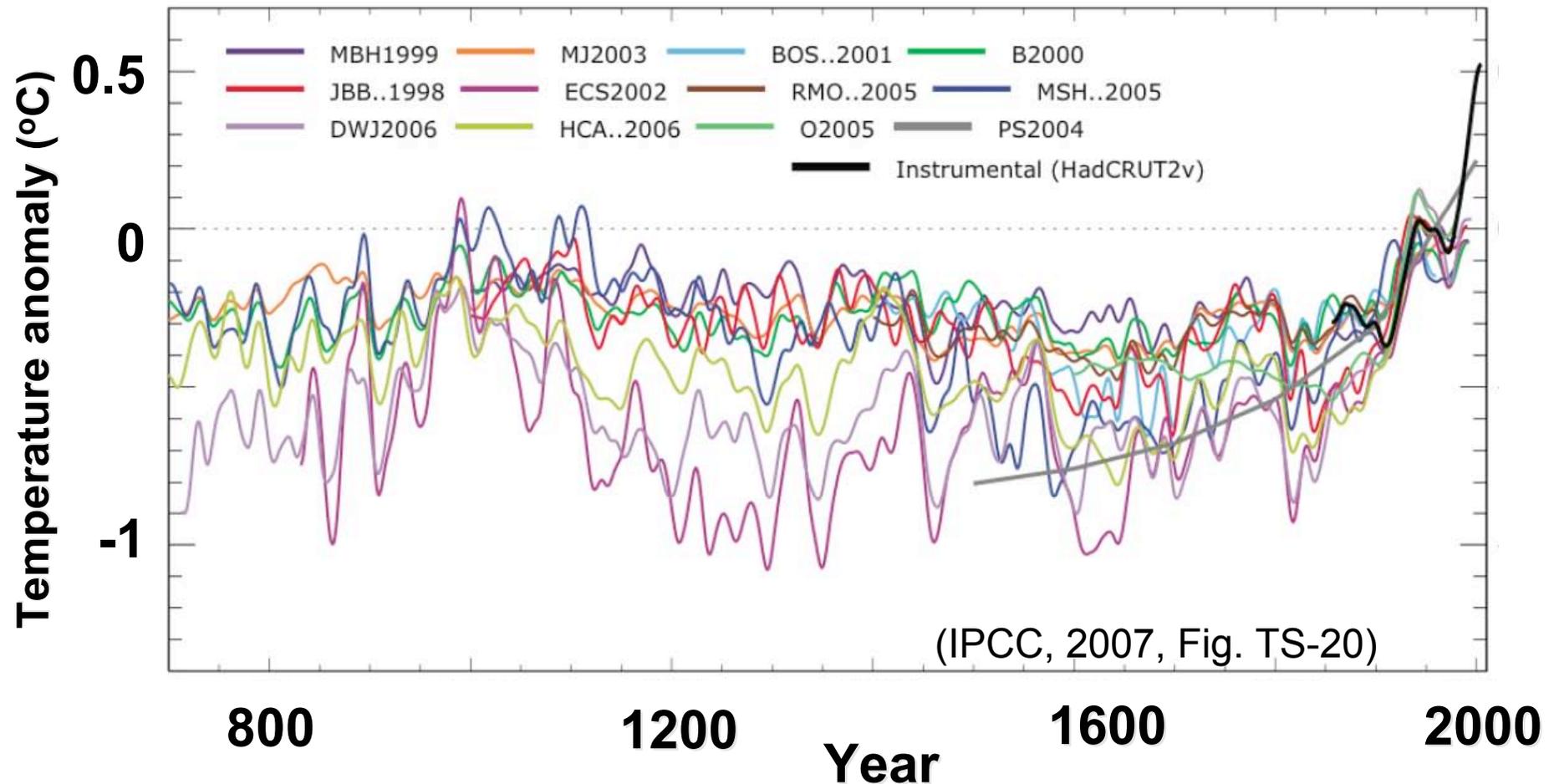
Warming of the climate system is unequivocal, ... (SPM, 2007)



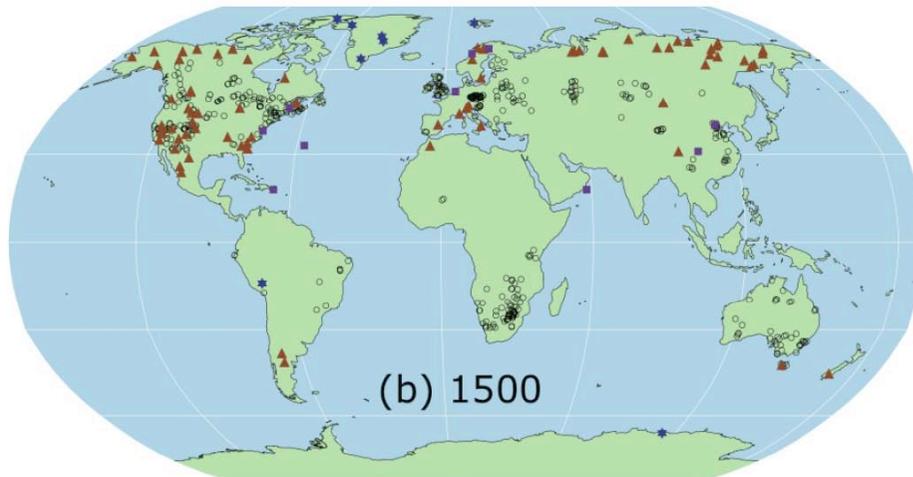
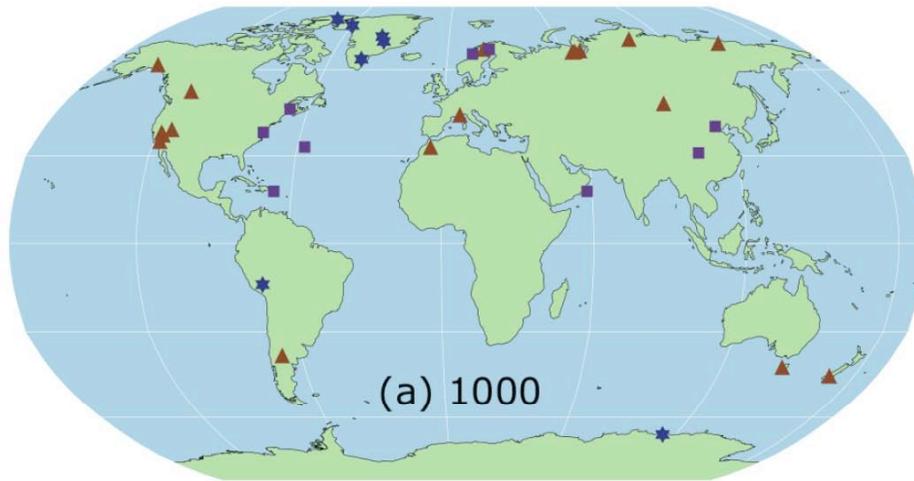
(IPCC, 2007, Fig. TS-6)

New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates that are similar to those of the surface temperature record and are consistent within their respective uncertainties, largely reconciling a discrepancy noted in the TAR. (SPM, 2007)

Northern Hemisphere temperature reconstructions



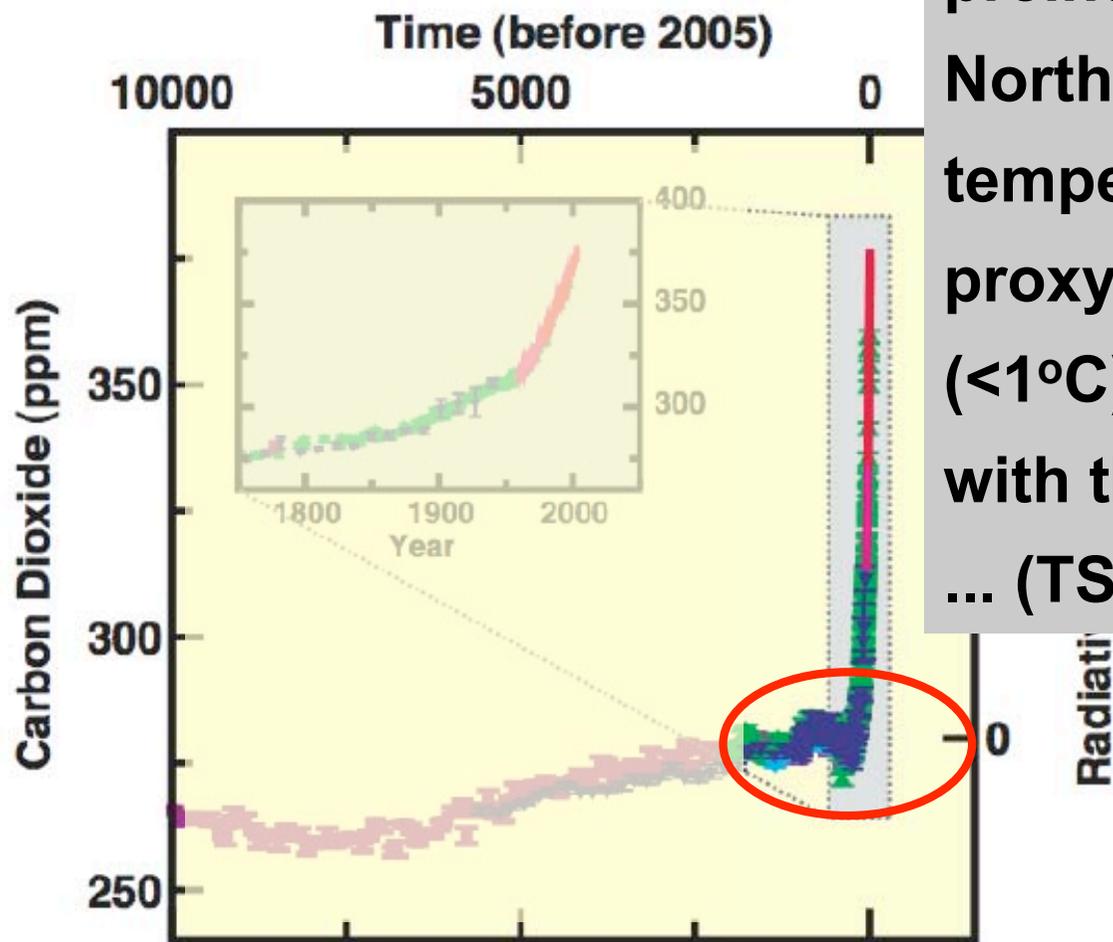
Paleoclimate information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1300 years (SPM, 2007)



Locations of temperature-sensitive proxy records

(IPCC, 2007, Fig. TS-20)

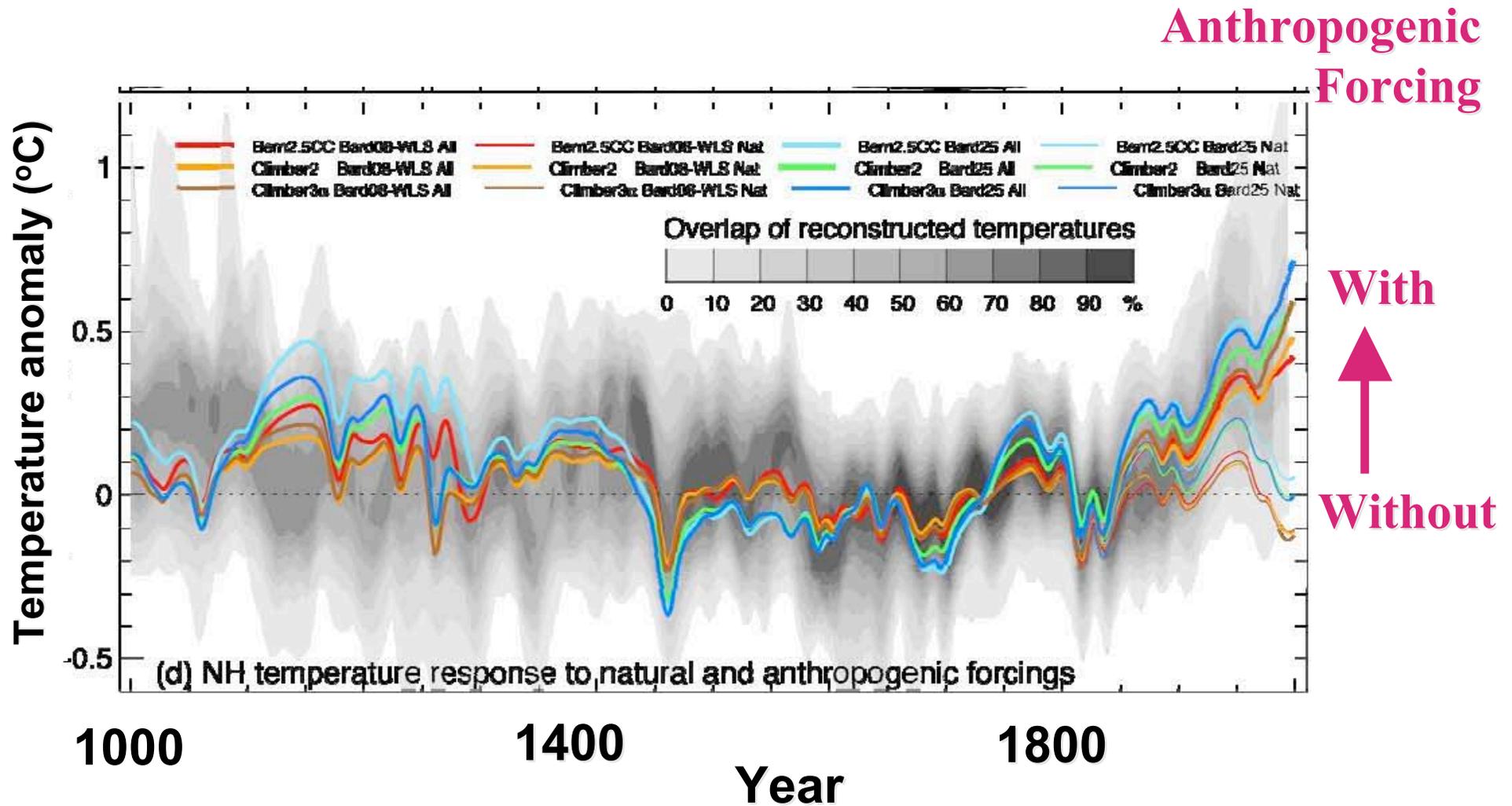
Average Northern Hemisphere temperatures during the second half of the 20th century were *very likely* higher than during any other 50-year period in the last 500 years and *likely* the highest in at least the past 1300 years (SPM, 2007).



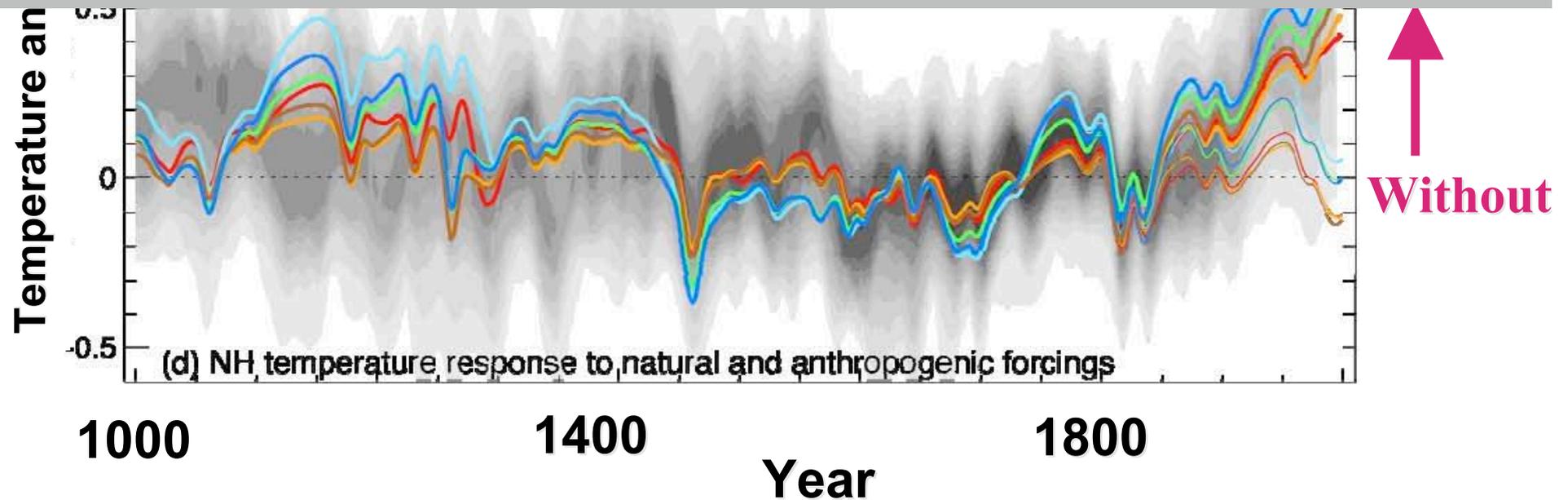
The amplitudes of the preindustrial decadal-scale Northern Hemisphere temperature changes from the proxy-based reconstructions ($<1^{\circ}\text{C}$) are broadly consistent with the ice core CO_2 record, ... (TS, 2007)

(IPCC, 2007, Fig. SPM-1)

Simulated temperatures with and without anthropogenic forcing and with weak or strong solar irradiance variations

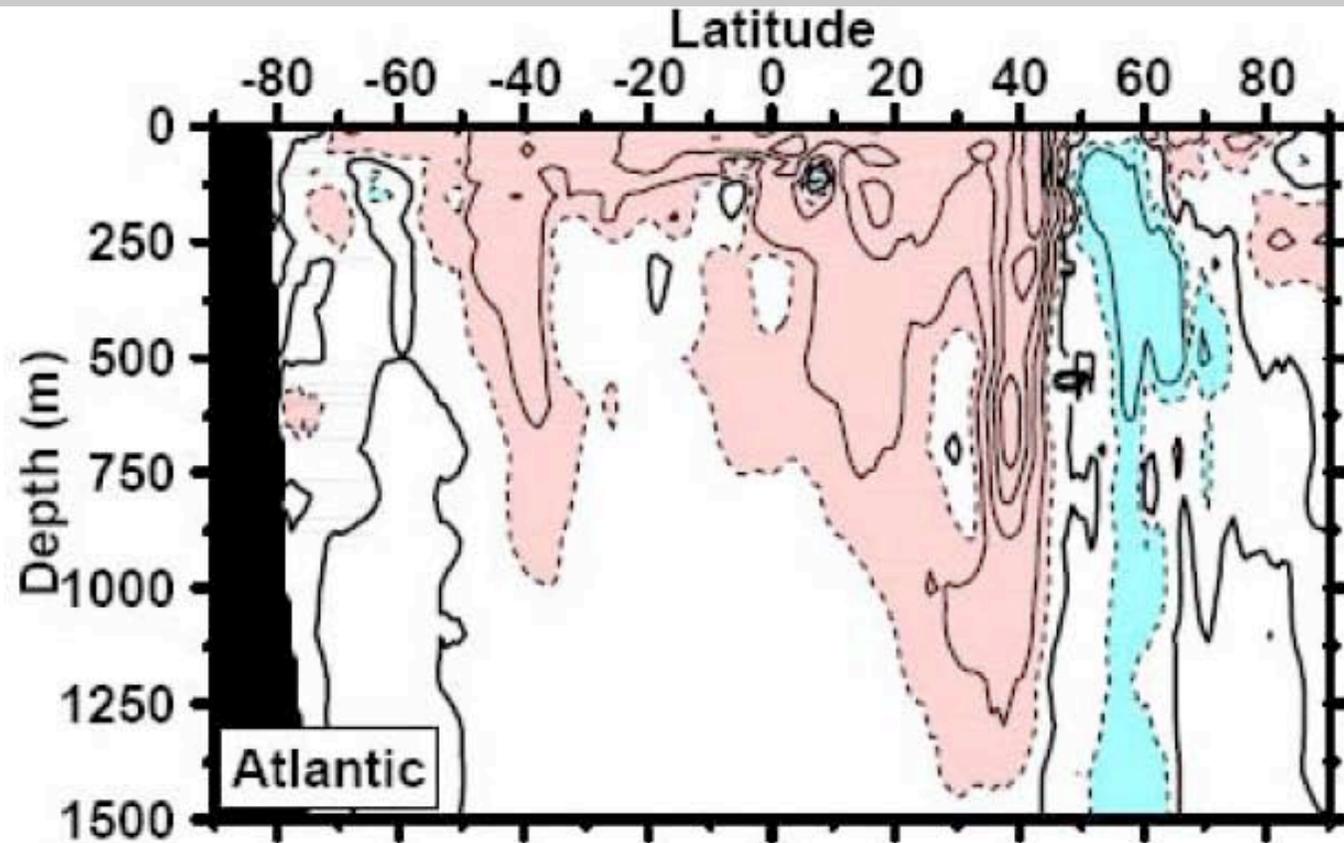


A significant fraction of the reconstructed NH interdecadal temperature variability over at least the seven centuries prior to 1950 is *very likely* attributable to volcanic eruptions and changes in solar irradiance, and it is *likely* that anthropogenic forcing contributed to the early 20th century warming evident in these records (SPM, 2007)



(IPCC, 2007, Fig. 6.14)

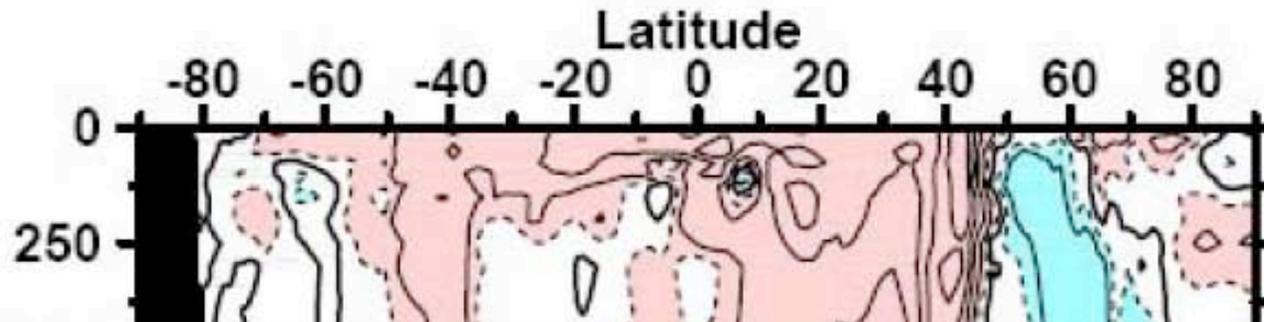
The world ocean has warmed since 1955, accounting over this period for about 90% of the changes in the energy content of the Earth's climate system. (TS, 2007)



 warming $> 0.025^{\circ}\text{C}$ per decade

 cooling $< -0.025^{\circ}\text{C}$ per decade

(IPCC, 2007, Fig. 5.3)

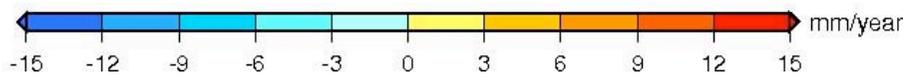
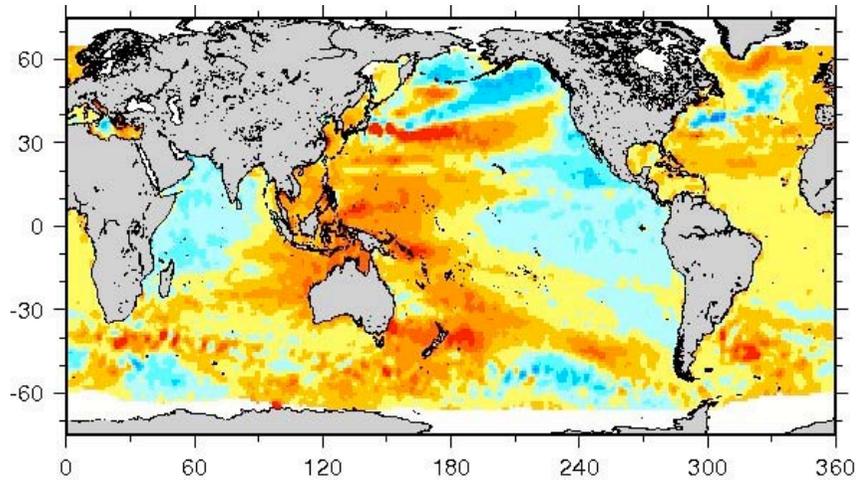


The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past 50 years can be explained without external forcing and *very likely* that it is not due to known natural causes alone. (SPM, 2007)

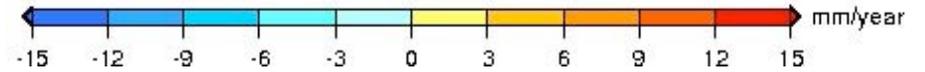
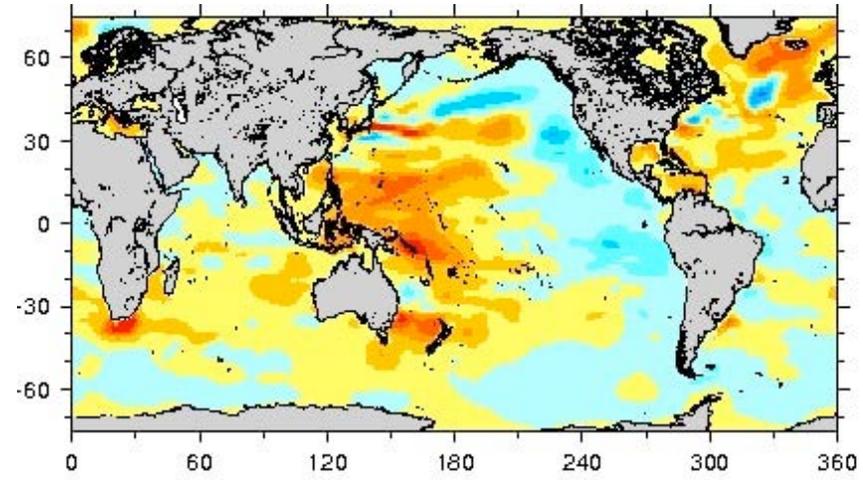
 warming $> 0.025^{\circ}\text{C}$ per decade

 cooling $< -0.025^{\circ}\text{C}$ per decade

(IPCC, 2007, Fig. 5.3)



Sea-level 1993-2003 (Satellite)



Thermal expansion 1993-2003

(IPCC, 2007, Fig. 5.15)

Rate of Sea Level Rise (mm per year)

1993 - 2005

Thermal expansion
 Glaciers and Ice Caps
 Greenland Ice Sheet
 Antarctic Ice Sheet

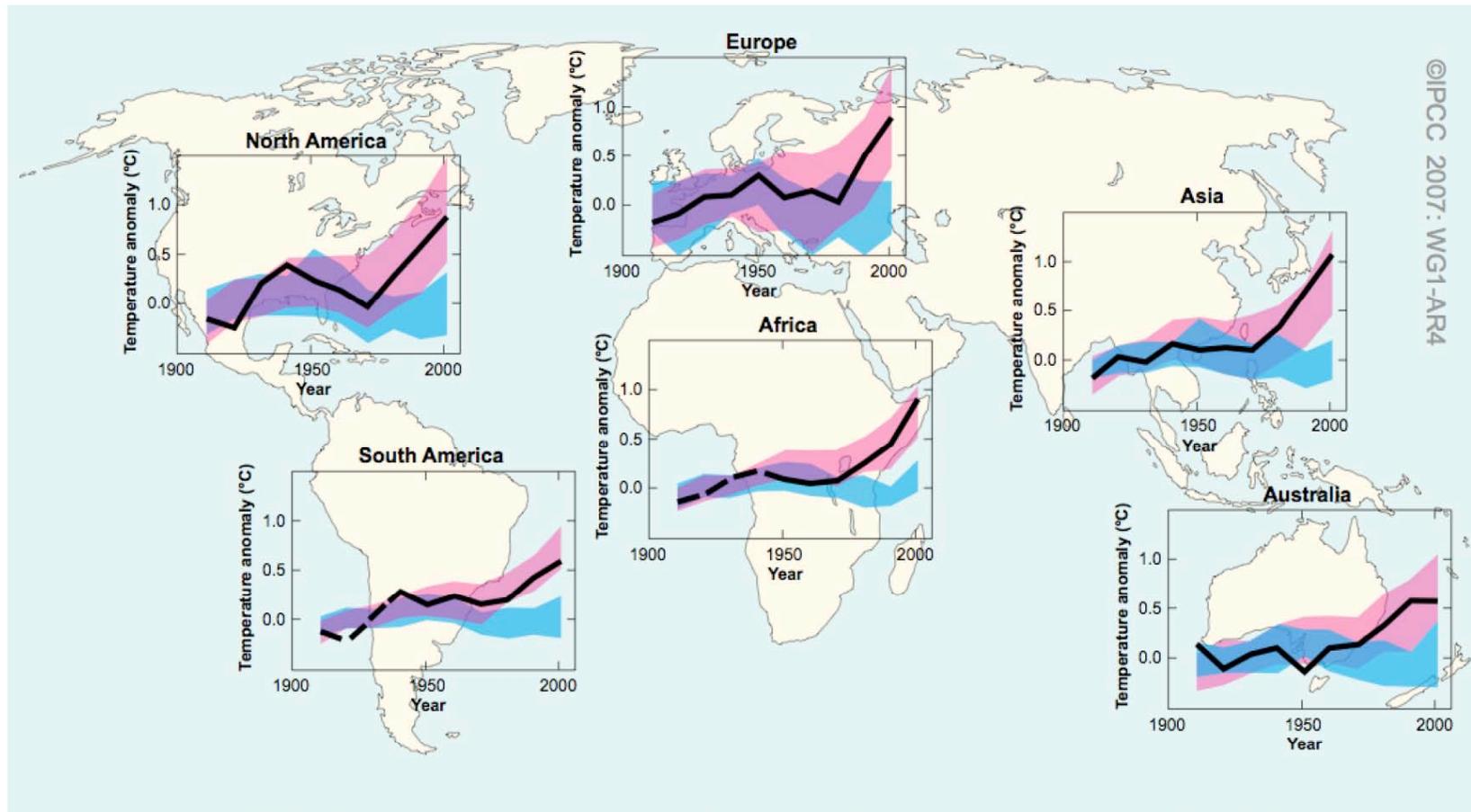
1.6 ± 0.5
 0.77 ± 0.22
 0.21 ± 0.07
 0.21 ± 0.35

Sum of contributions
 Observed total

2.8 ± 0.7
 3.1 ± 0.7

(IPCC, 2007, Tab. SPM-2)

Coupled Models are able to simulate the observed temperature evolution on each of six continents



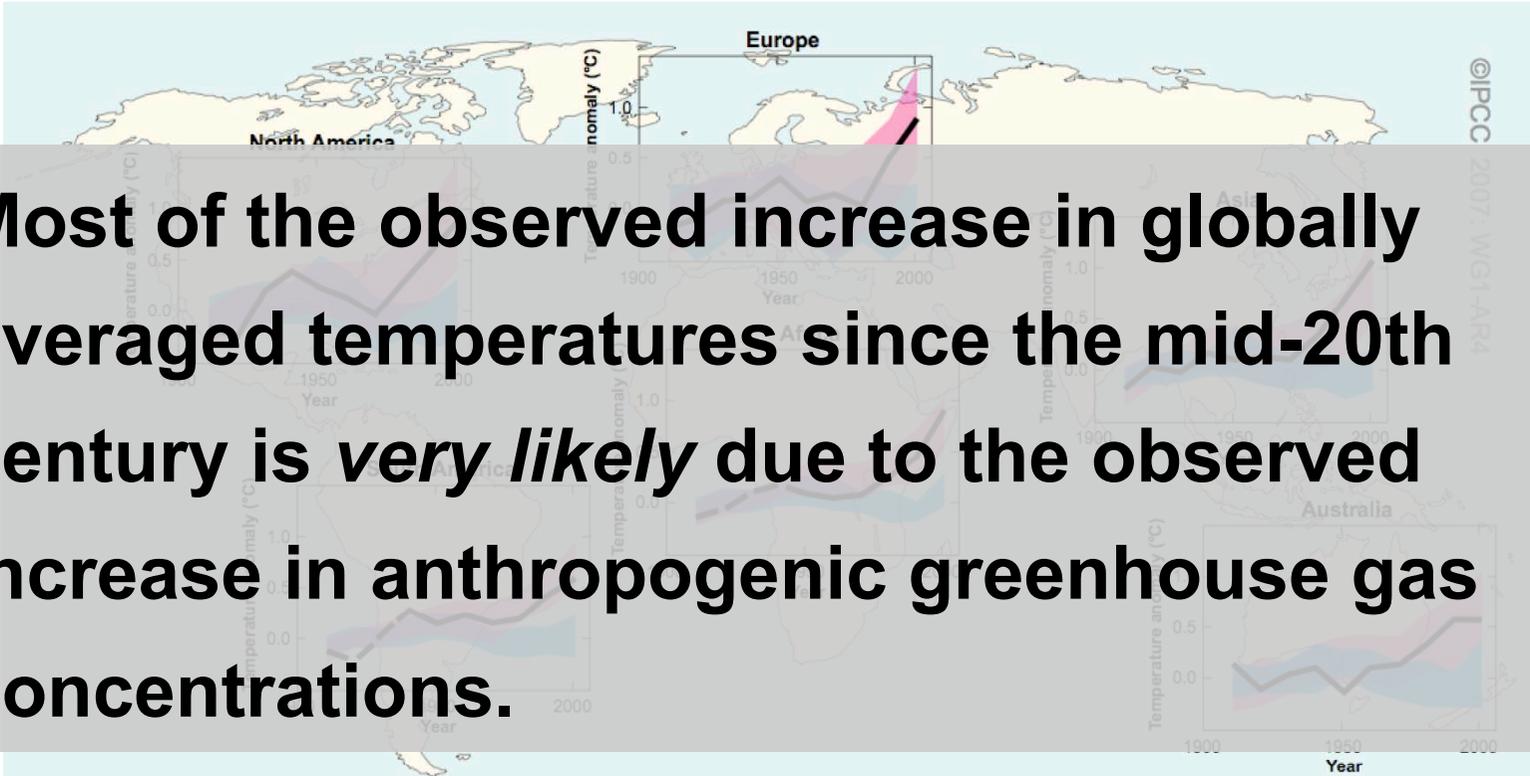
 Klimamodelle, die nur natürliche Antriebskräfte berücksichtigen

 Klimamodelle, die natürliche und menschliche Antriebskräfte berücksichtigen

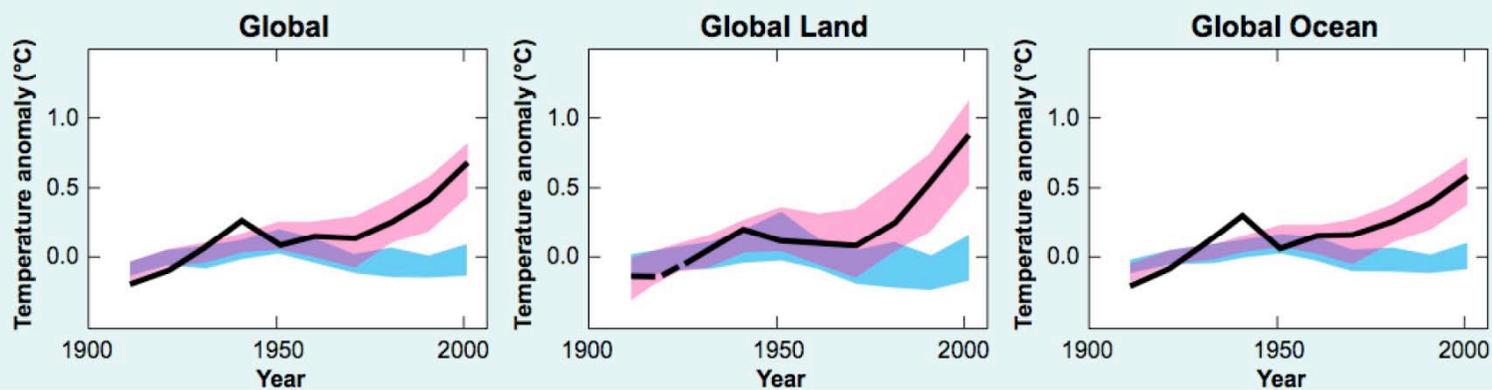
 Beobachtungen

©IPCC 2007:

(IPCC, 2007, Fig. SPM-4)



Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.



(IPCC, 2007, Fig. SPM-4)

Thank you