

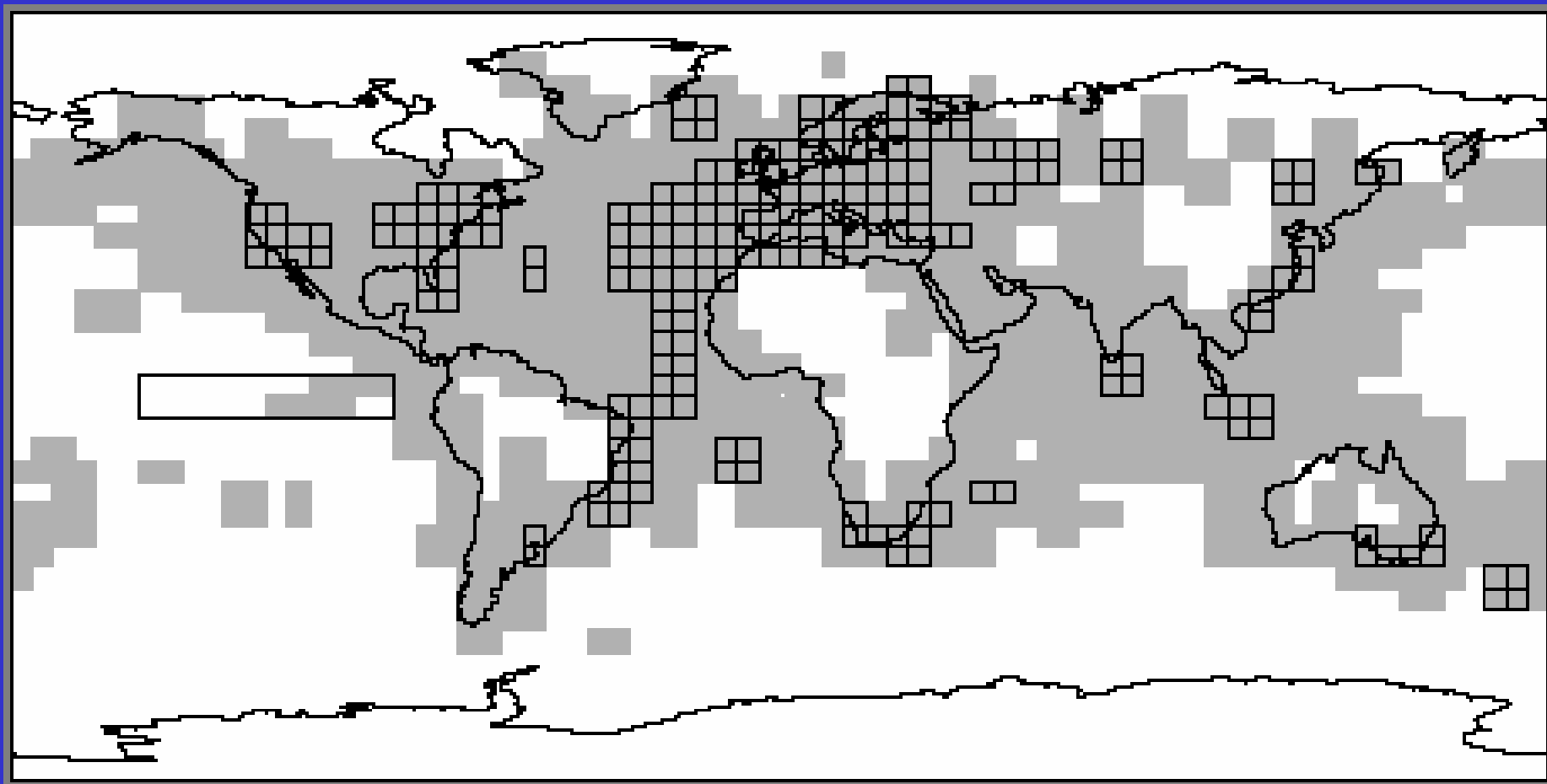
The Scientific Case for Global Warming and its Causation: Paleoclimate Evidence

Michael E. Mann

*Departments of Meteorology and Geosciences and
Earth and Environmental Systems Institute (EESI)
And Director, Earth System Science Center
Penn State University*

AMS briefing on *'Scientific Case for Global Warming and its Causation: The
Multiple Lines of Evidence'*
Capitol Hill, Washington, DC
Jan 31, 2007

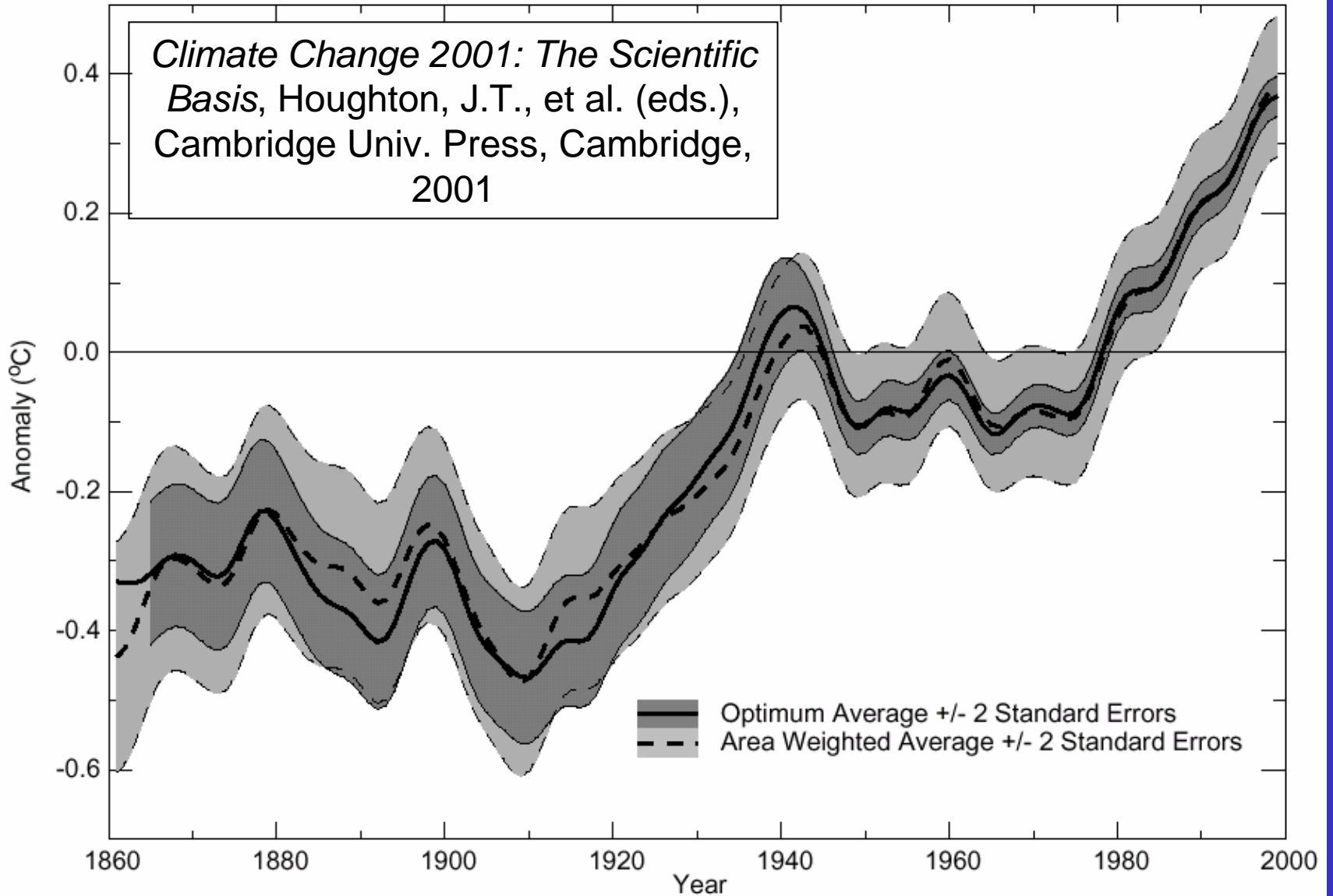
Observed Surface Temperature Changes



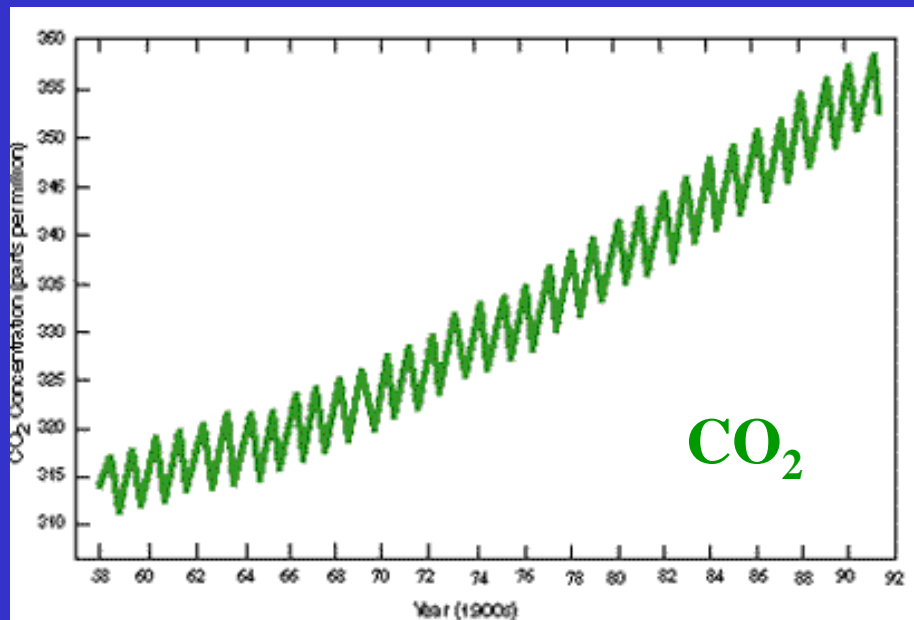
Gray: back to beginning of 20th century

Boxes: back to mid 19th century

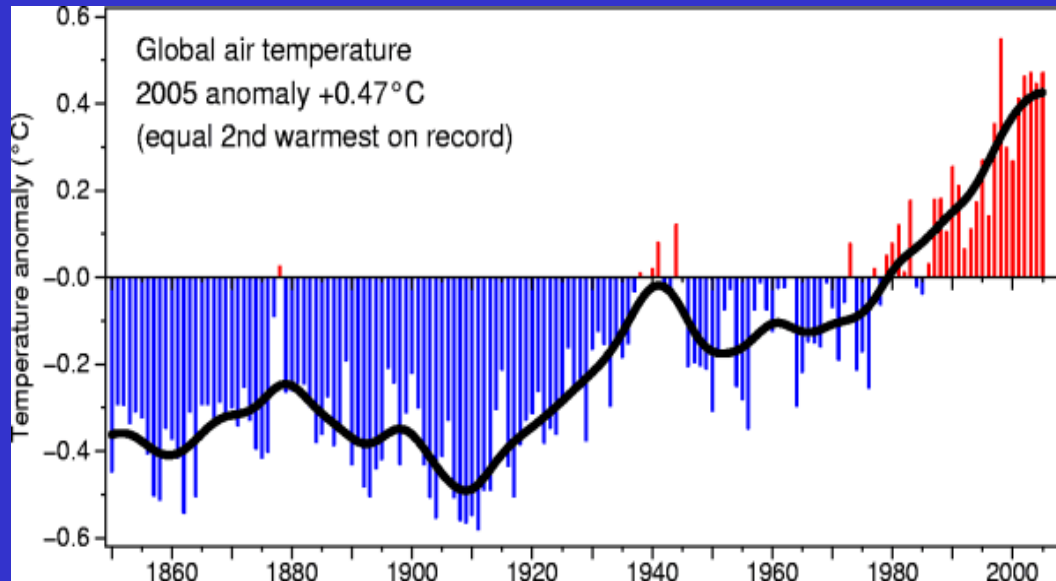
Observed Surface Temperature Changes



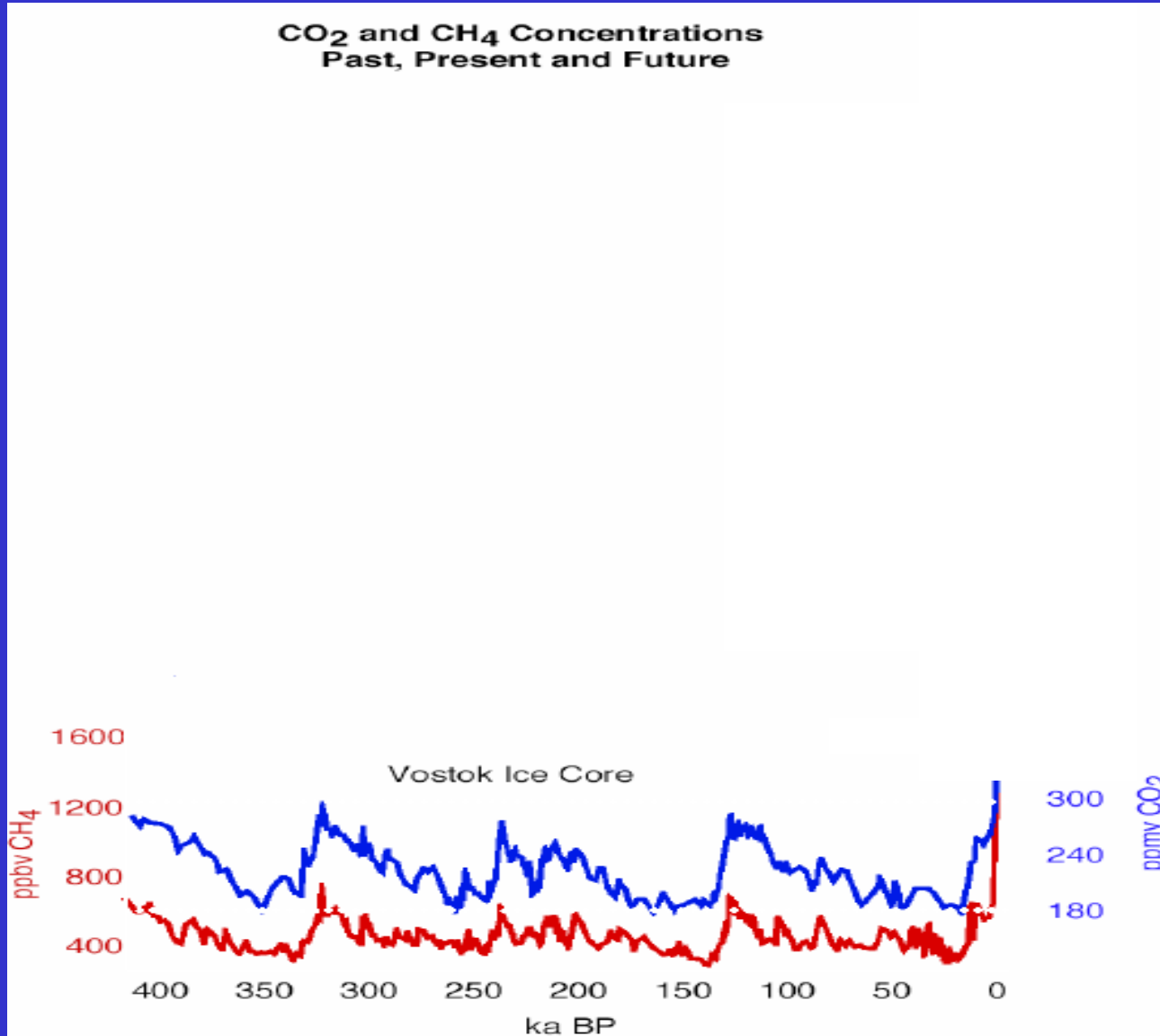
Greenhouse Gases and Warming



Related?



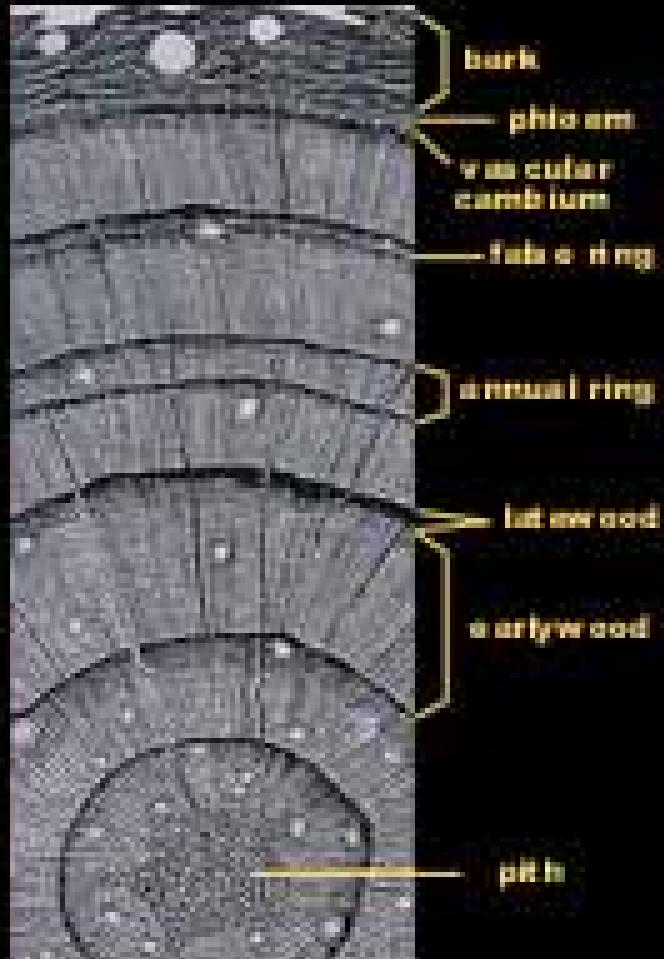
ENHANCED GREENHOUSE EFFECT?



TREE RINGS



Cross Section of a Conifer



CORALS



ICE CORES



VARVED LAKE SEDIMENTS



HISTORICAL DOCUMENTS

Auicenna.

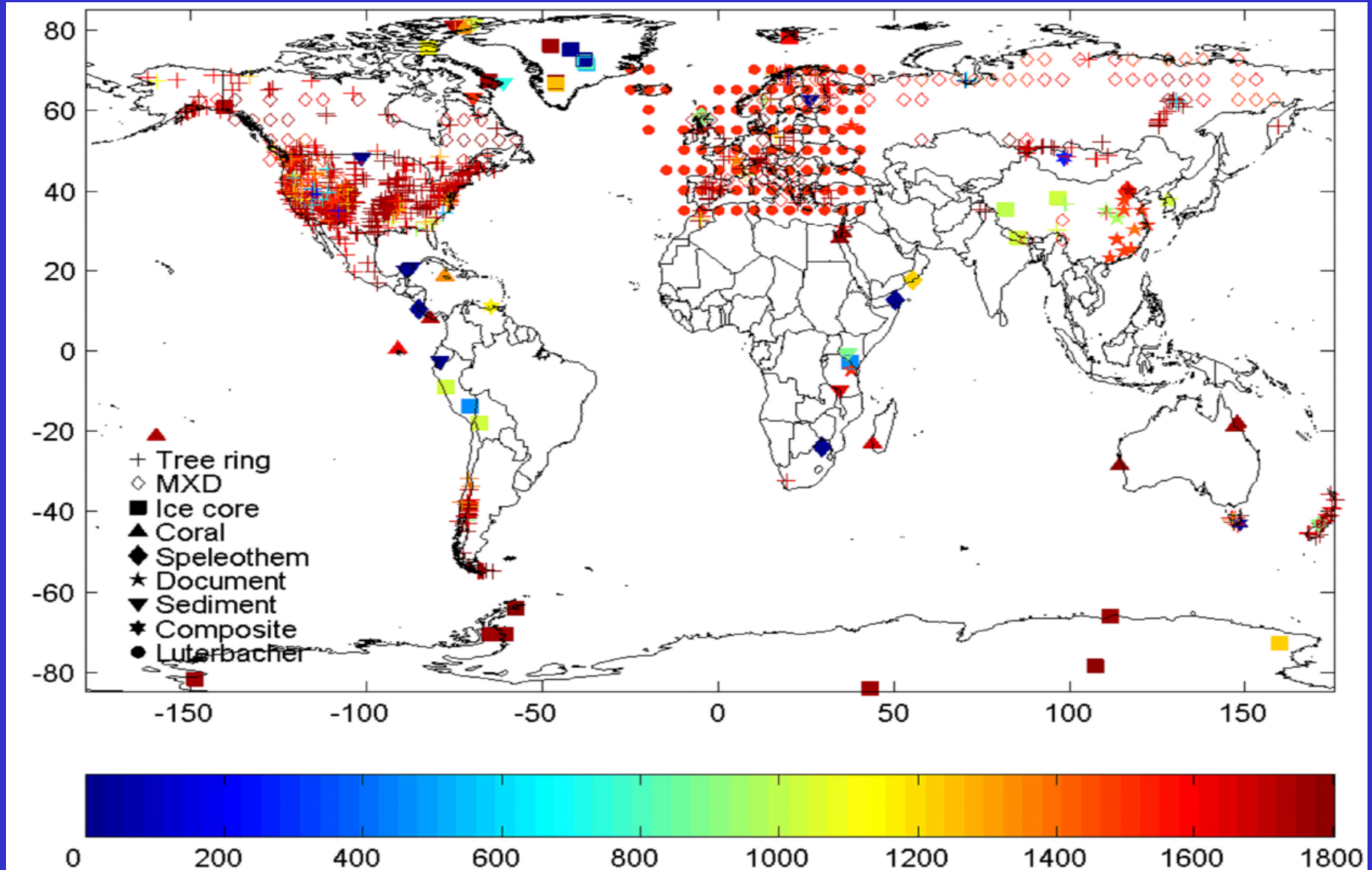
Manch ghere leer will ich dir gäben/
Den volg nach/frisch dir ein liden.
Im Jenner ein Bidi dhalt By dir/
Doch off dem Dum mußt lassen schter.
Vnd denn binnach wol nemmen acht/
Was dir all Monar dinges krafft.

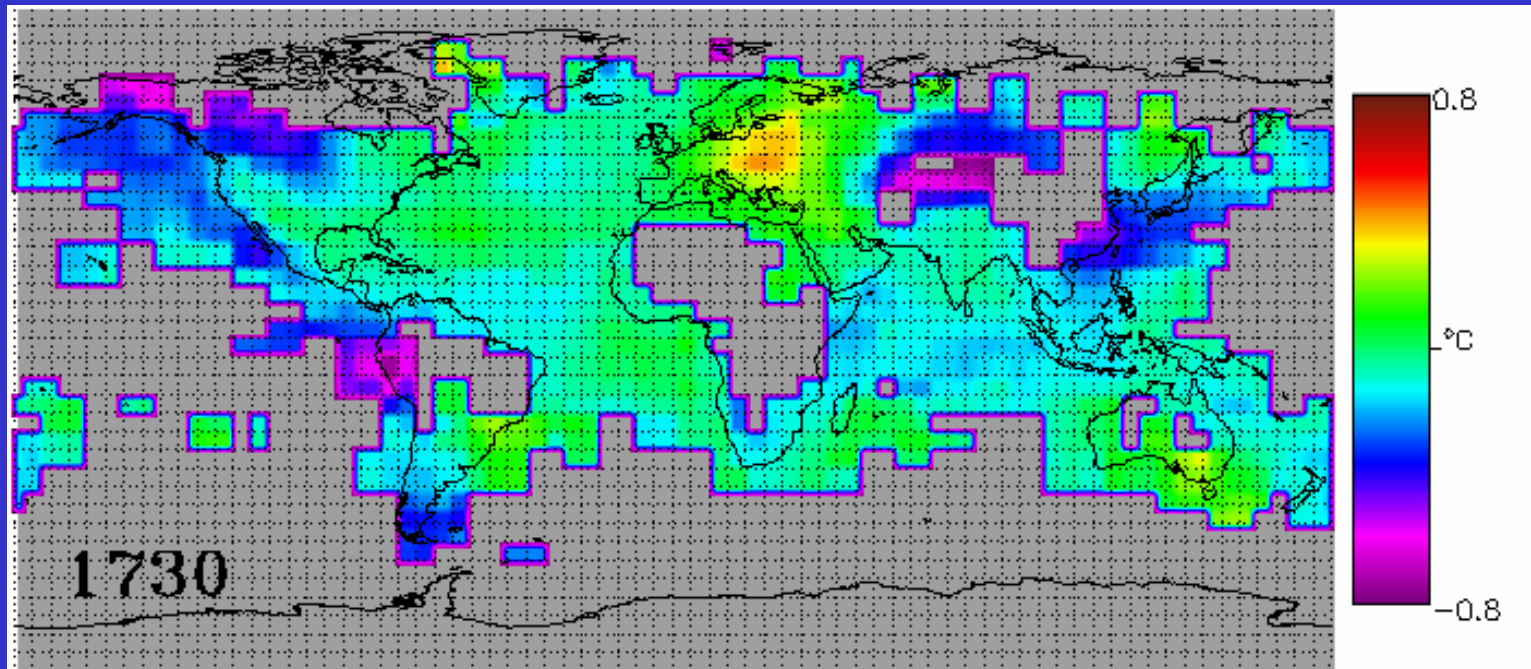
1 gar gure hale von edigen liden
2 gar gure hale noch mit dem liden
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31 gar gure hale noch mit dem liden



FROST FAIR ON THE THAMES IN THE REIGN OF CHARLES II.

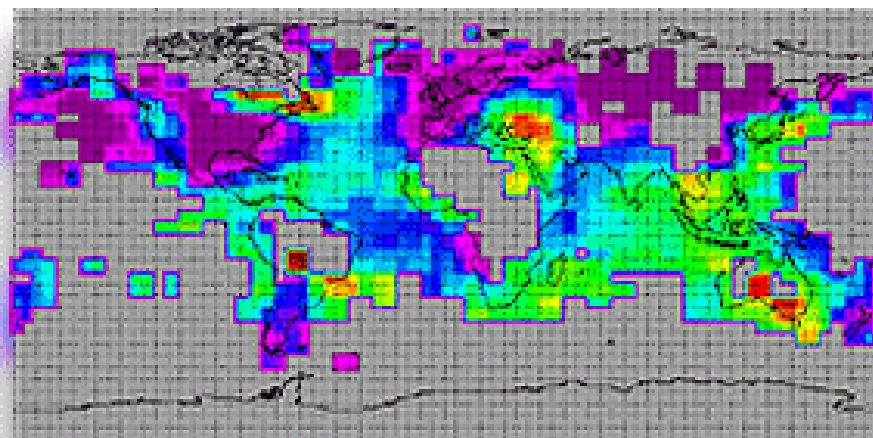
Available High-Resolution Climate Proxy Records





RECONSTRUCTED
GLOBAL
TEMPERATURE
PATTERNS

1816
("A Year Without A Summer")



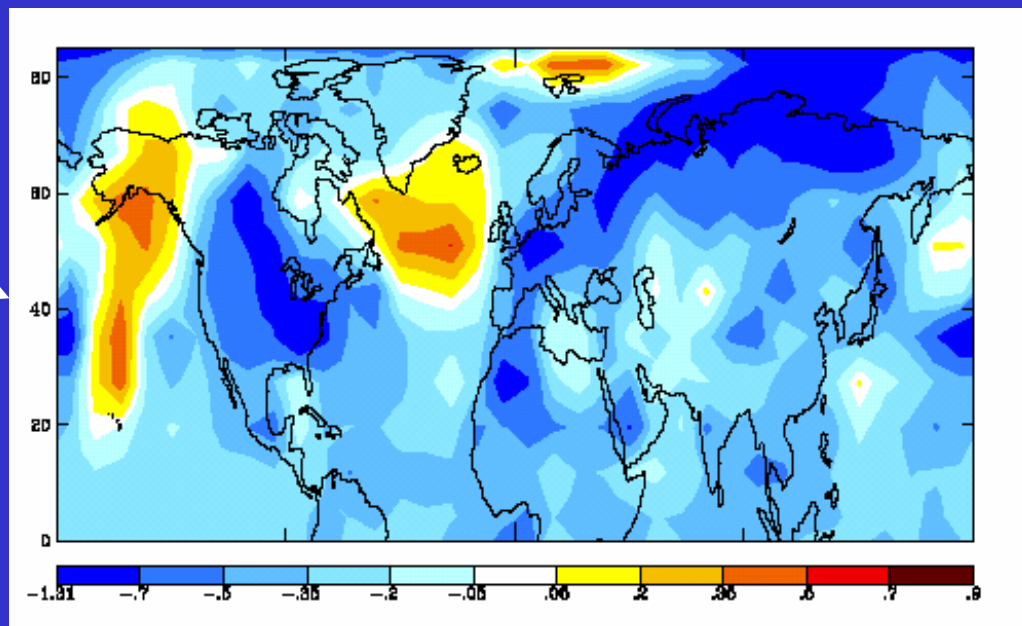
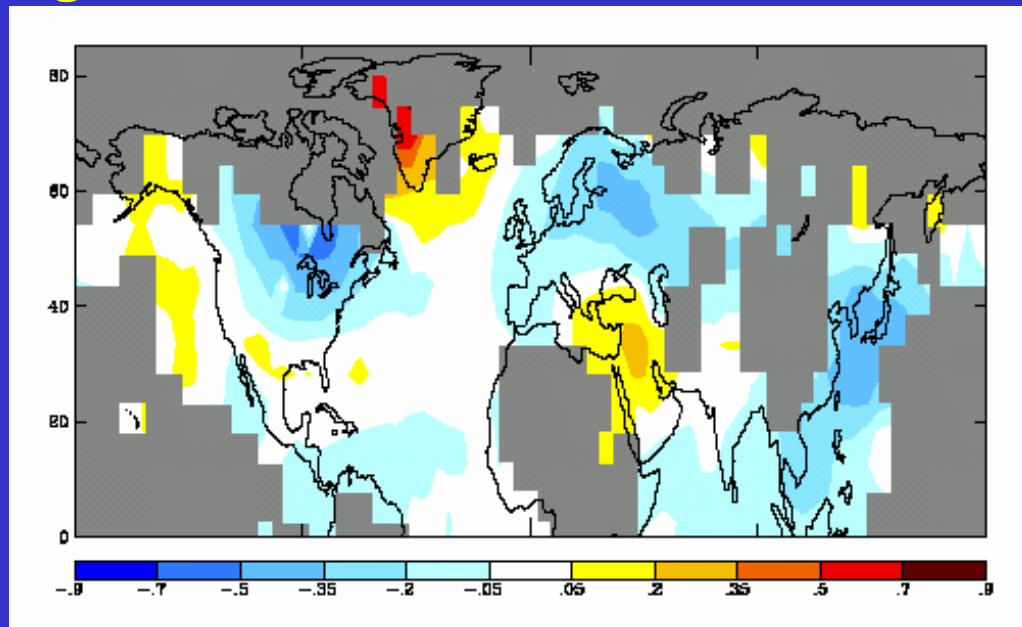
Comparisons of Spatial Patterns can provide the greatest physical Insight...

Empirical

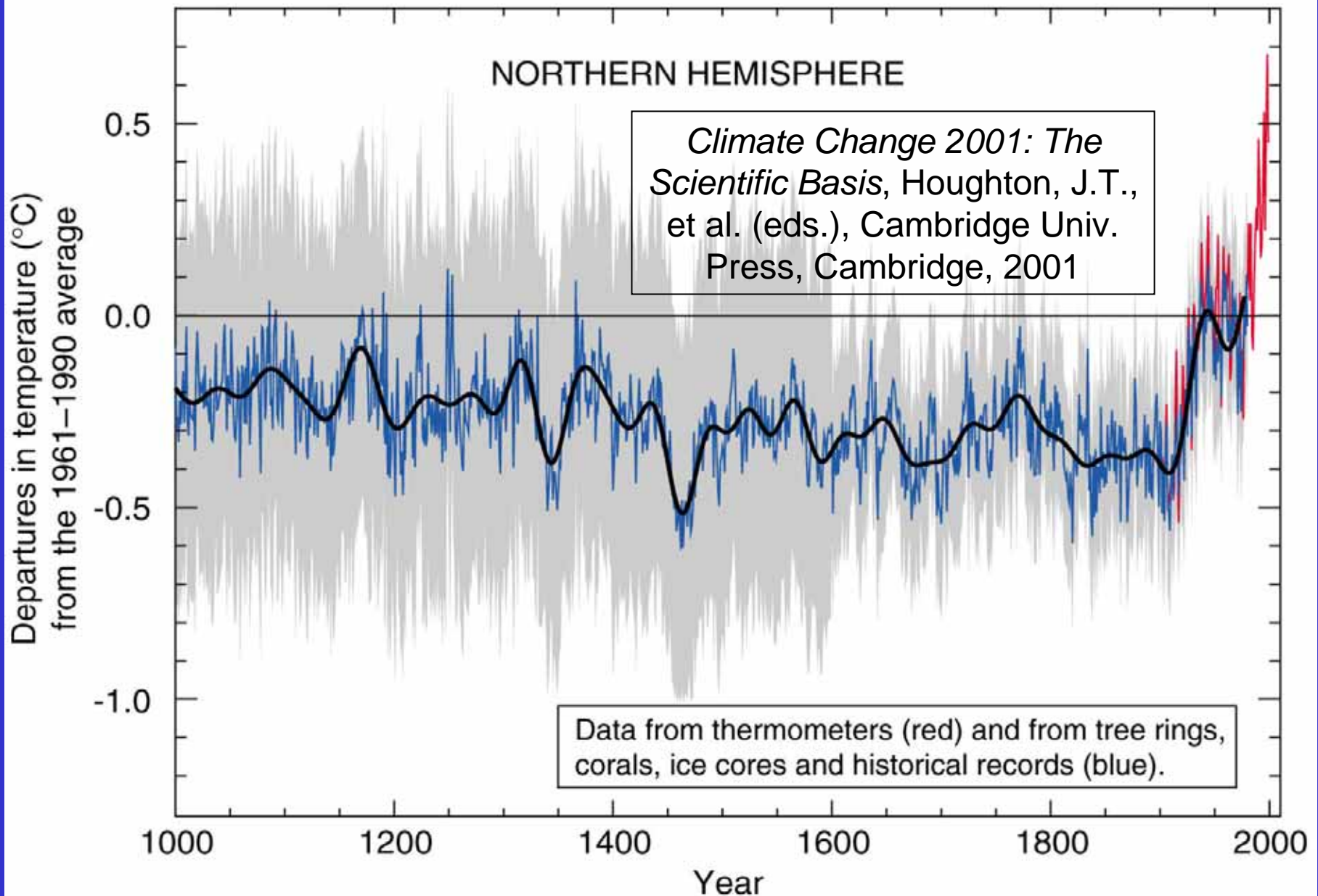
LIA winter cooling in Europe associated with an NAO trend due to solar irradiance changes, interacting w/ stratospheric atmospheric dynamics and chemistry

NASA/GISS Model

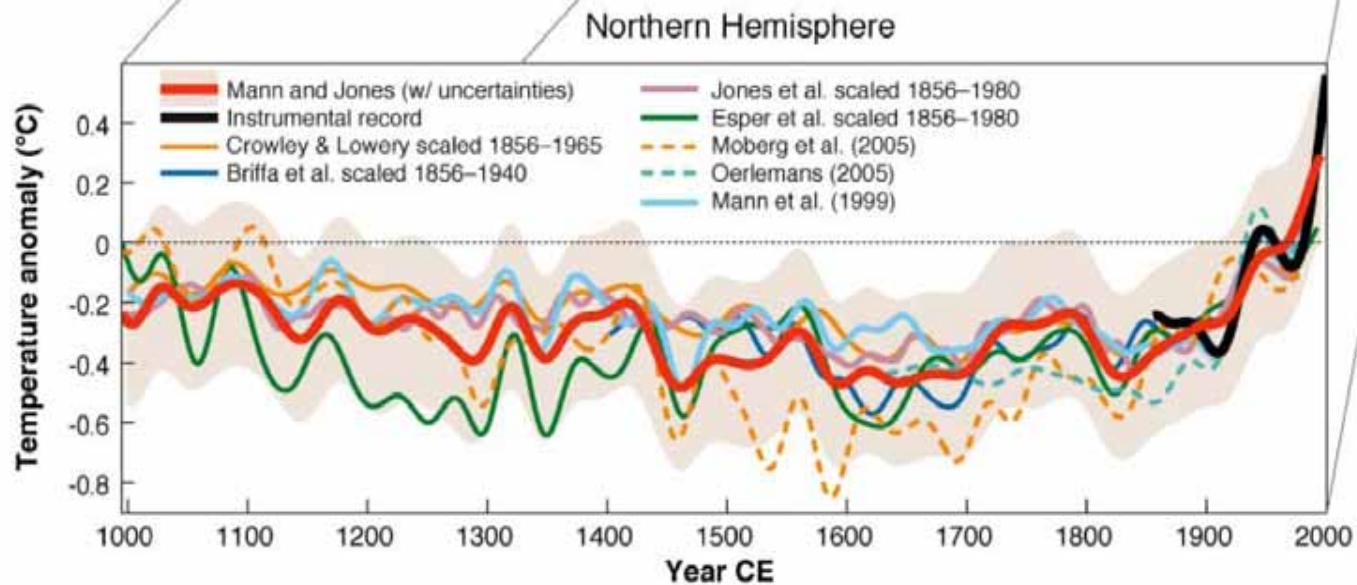
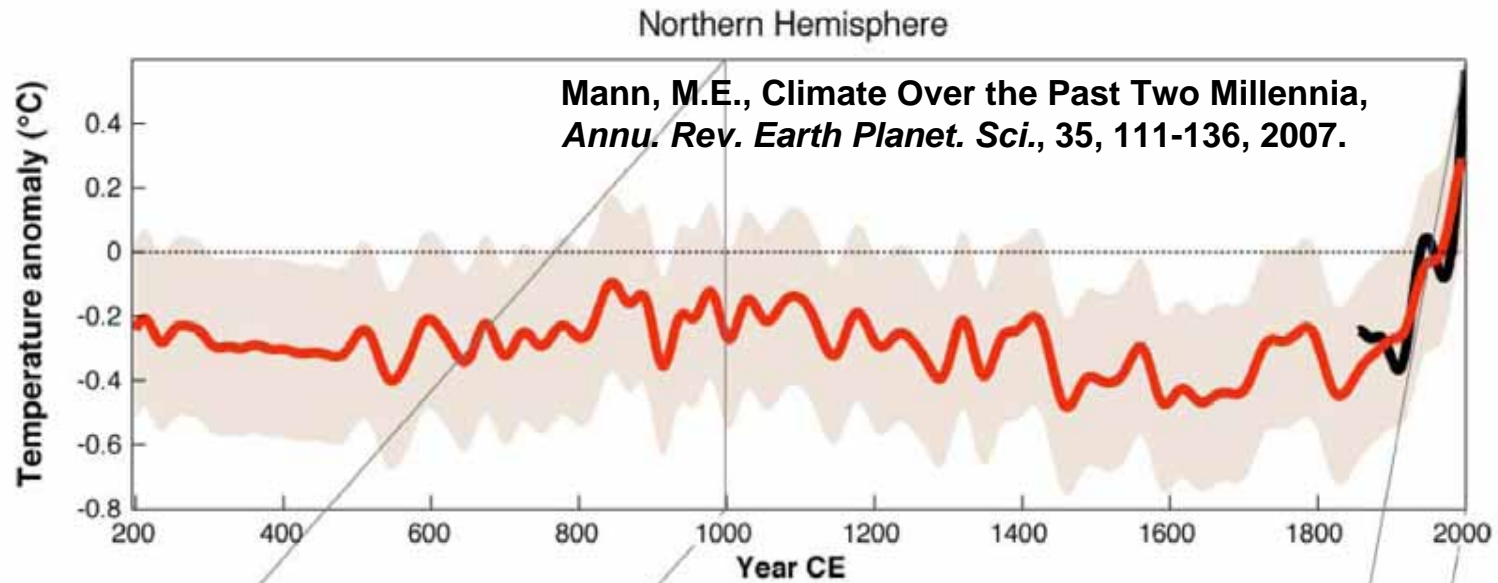
Shindell, D.T., Schmidt, G.A., Mann, M.E., Rind, D., Waple, A., Solar forcing of regional climate change during the Maunder Minimum, *Science*, 294, 2149-2152, 2001.



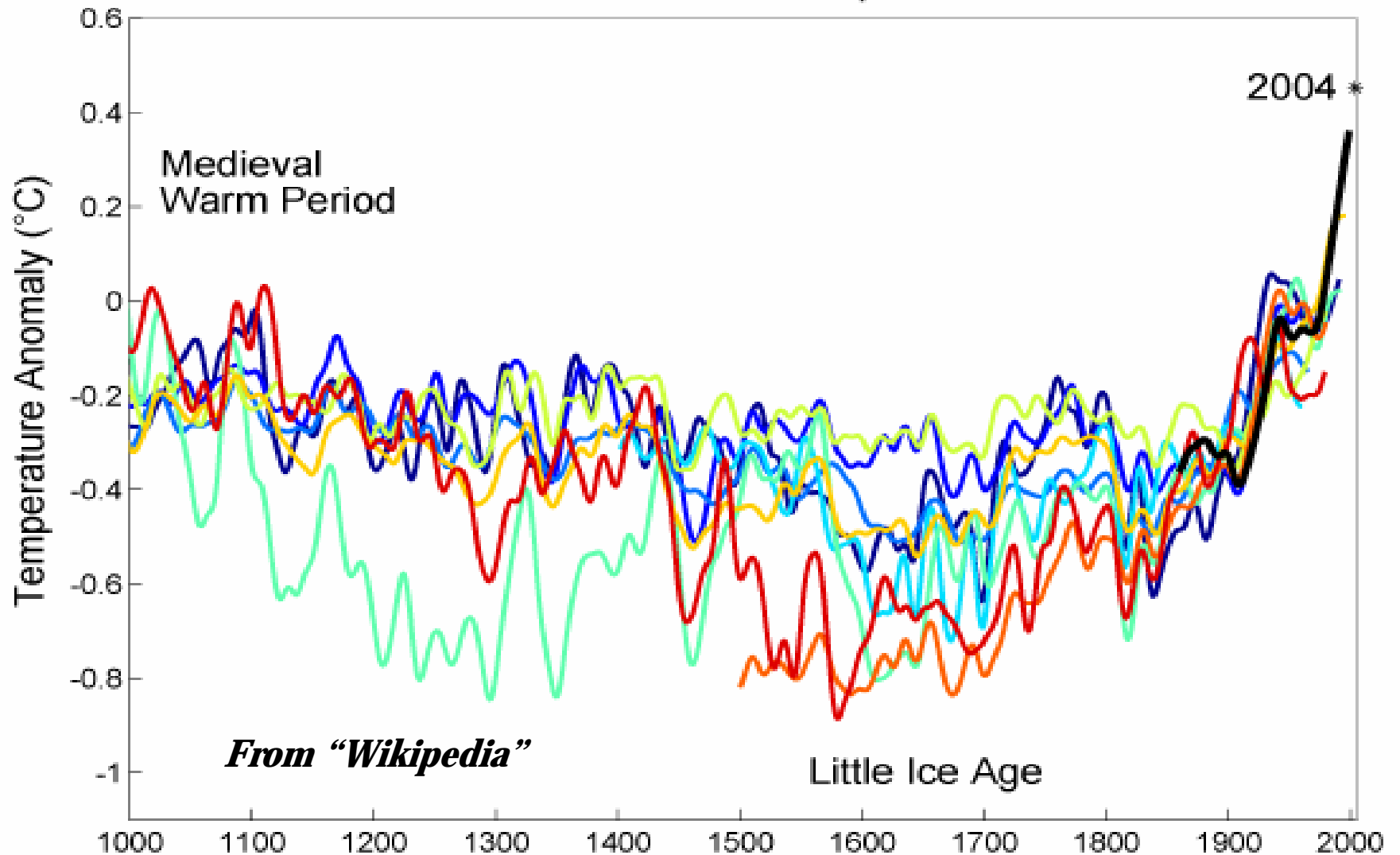
Reconstructed Surface Temperatures



Reconstructed Surface Temperatures



Reconstructed Temperature

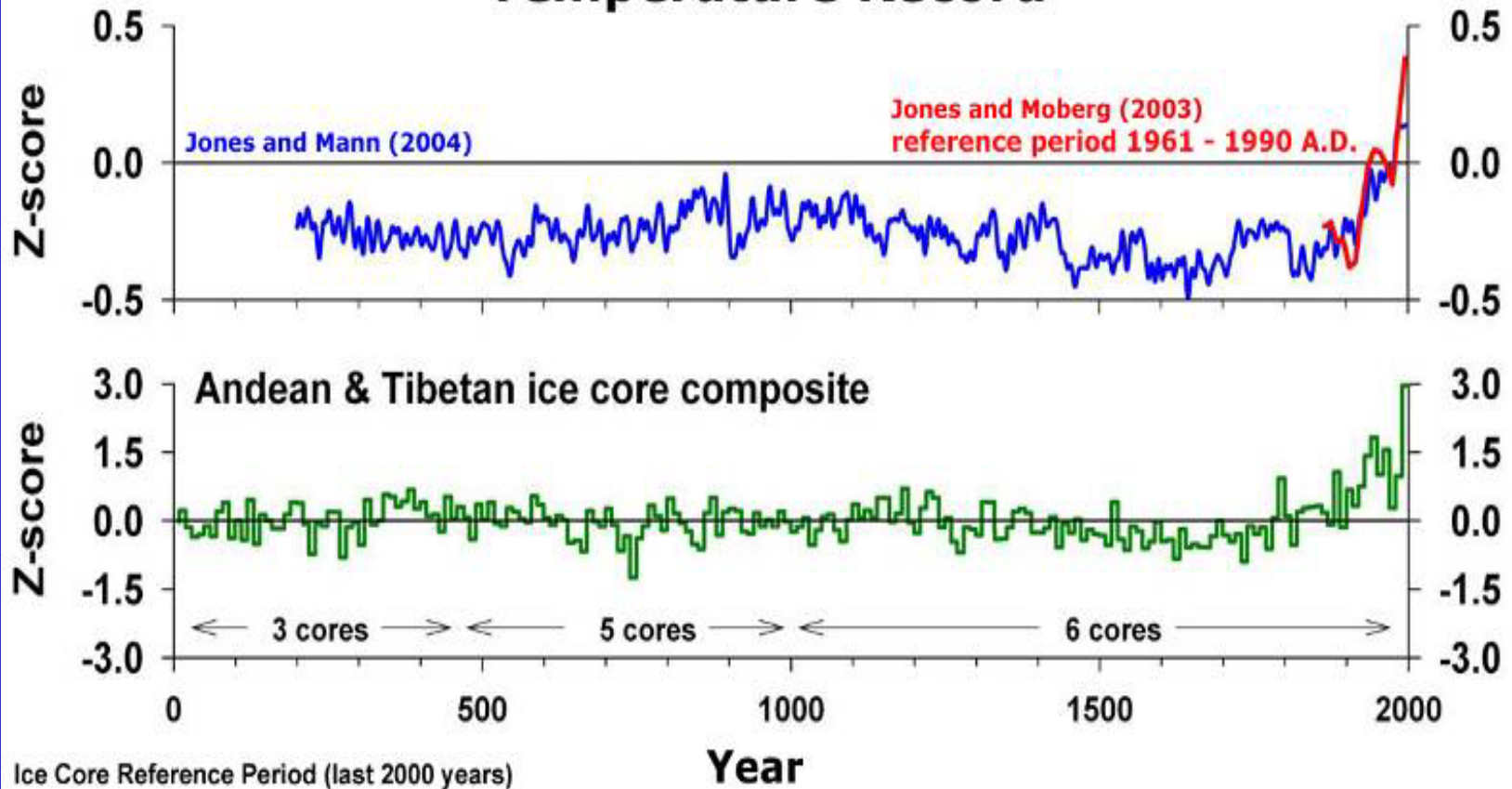


From "Wikipedia"

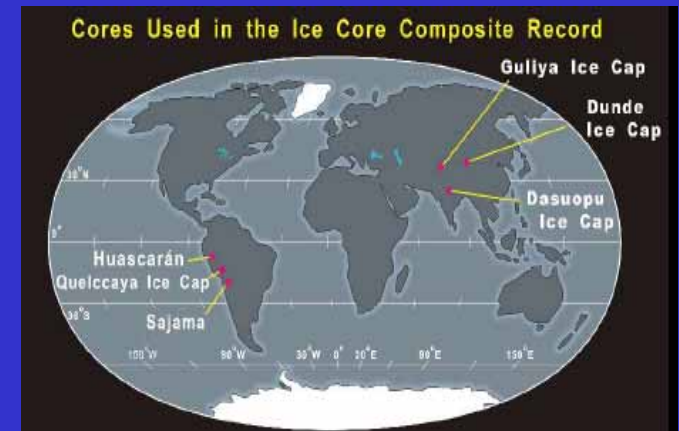
Little Ice Age

Reconstructions of Northern Hemisphere mean temperatures for the last 1000 years and instrumental record (black line)

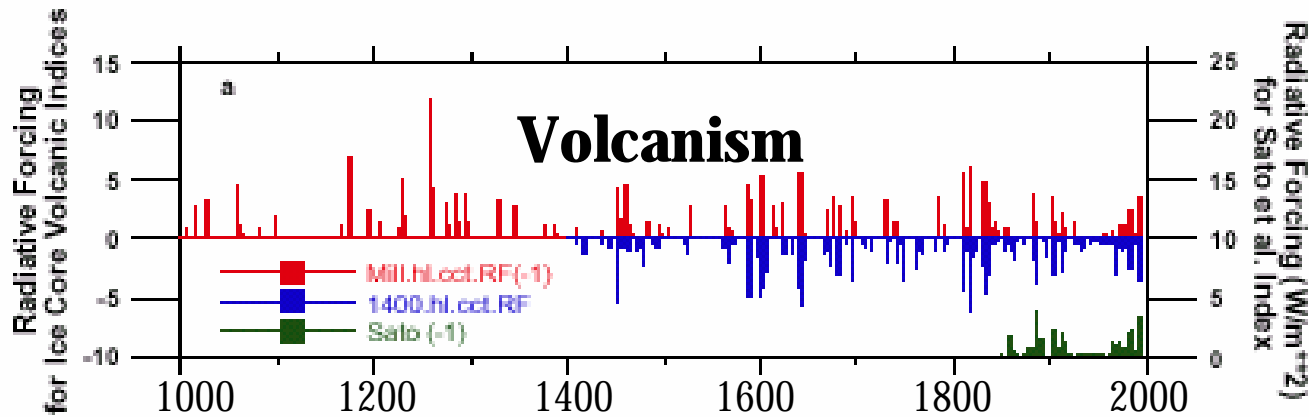
Temperature Record



Thompson, L. G., Mosley-Thompson, E., Davis, M. E., Lin, P. N., Henderson, K., and Mashiotta, T. A., 2003, Tropical glacier and ice core evidence of climate change on annual to millennial time scales, *Climatic Change*, v. 59, p. 137-155.



CLIMATE FORCINGS

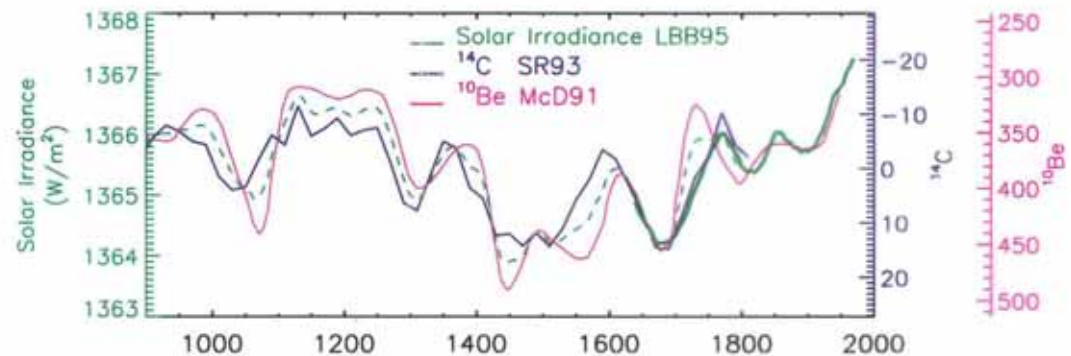
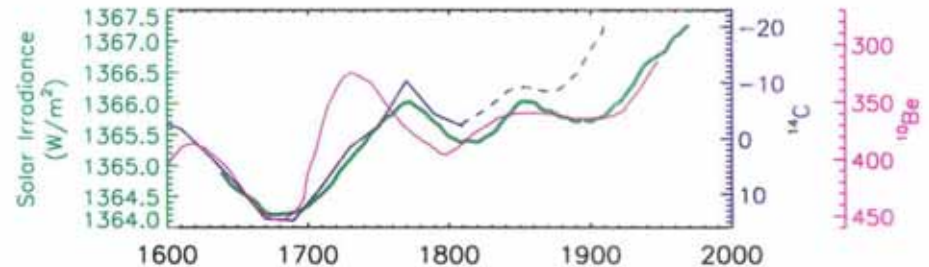


Natural

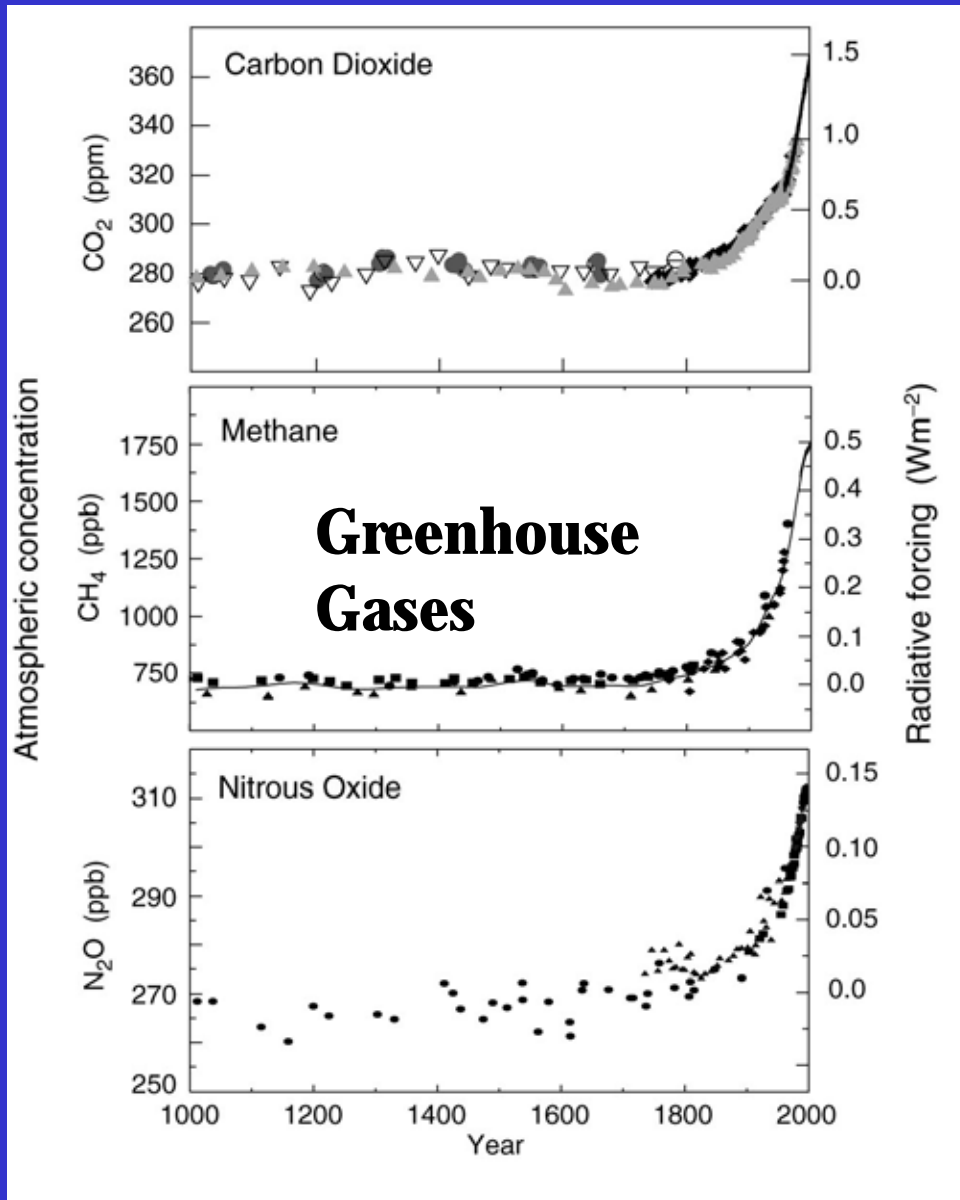
Crowley, T.J., Causes of Climate Change Over the Past 1000 Years, *Science*, 289 270-277, 2000.

Solar

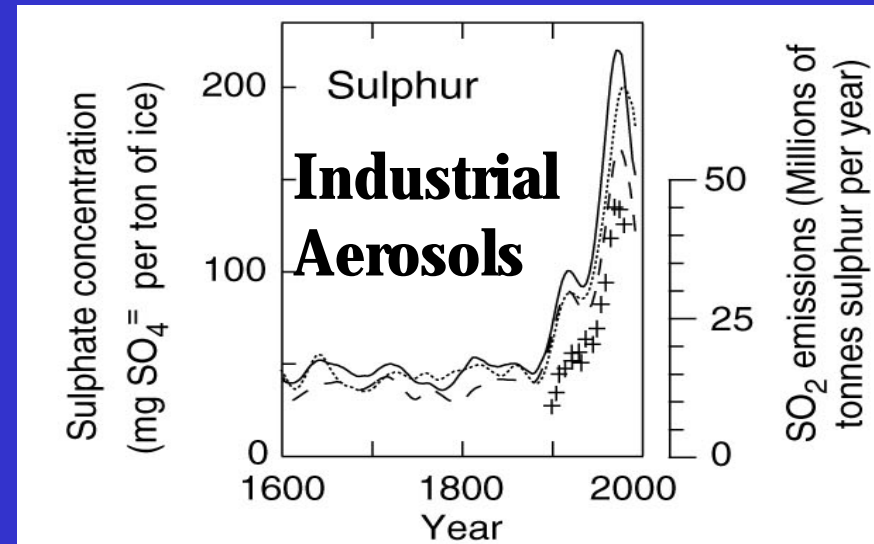
Cosmogenic Isotopes & Solar Irradiance



CLIMATE FORCINGS

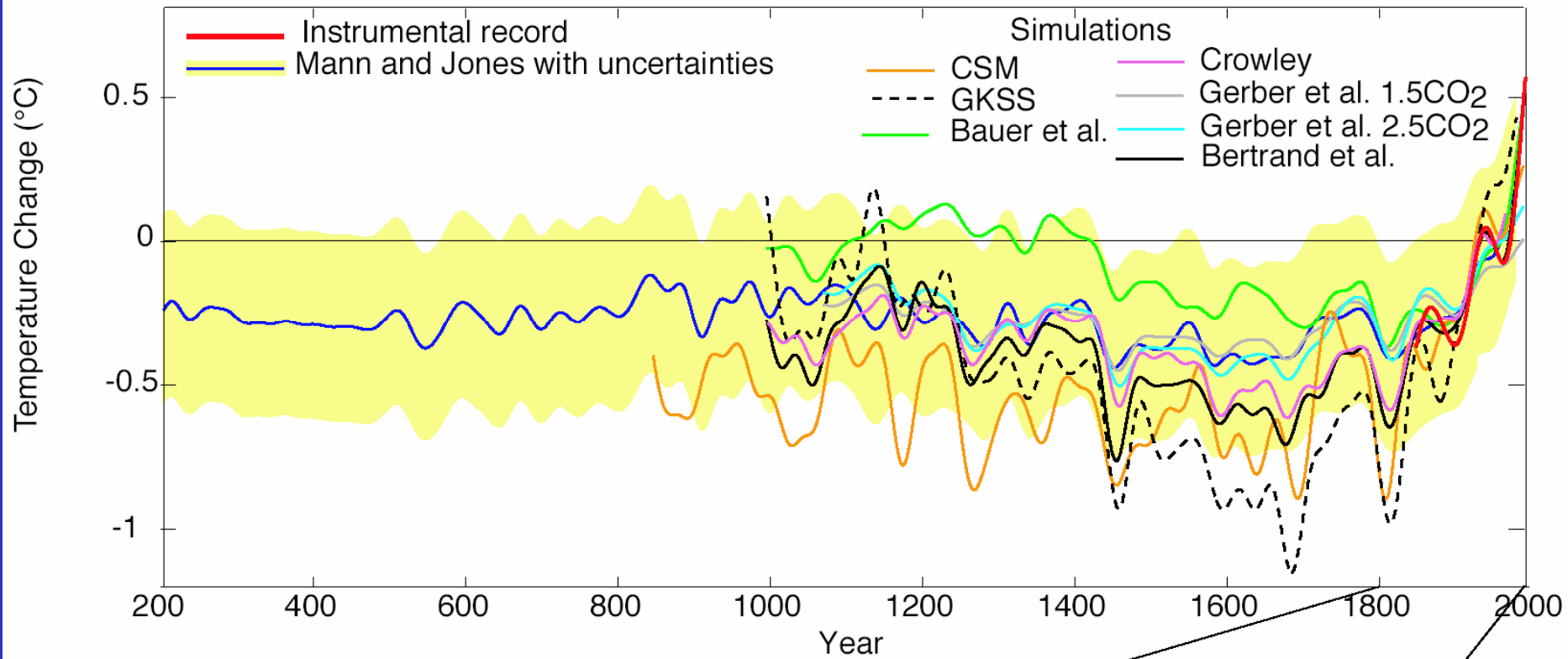


Anthropogenic



Climate Change 2001: The Scientific Basis, Houghton, J.T., et al. (eds.), Cambridge Univ. Press, Cambridge, 2001

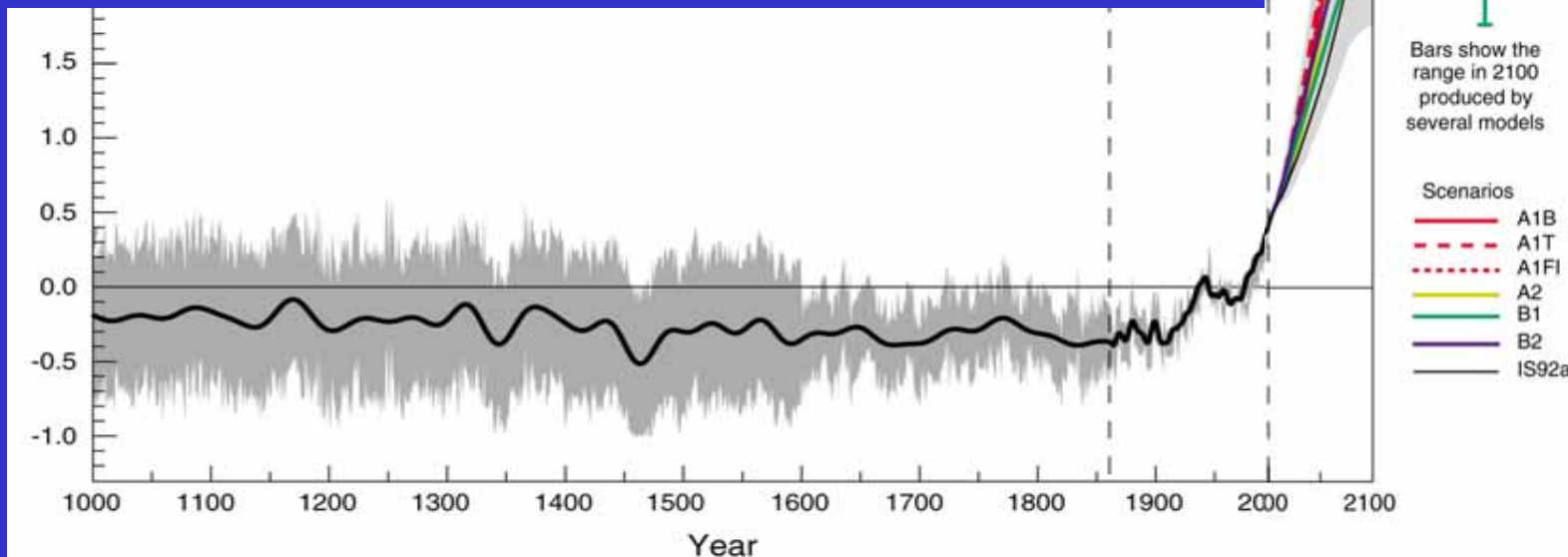
Model Simulations



Jones, P.D., Mann, M.E., *Climate Over Past Millennia*, *Reviews of Geophysics*, 42, RG2002, doi:10.1029/2003RG000143, 2004.

Future Surface Temperatures Trends?

Climate Change 2001: The Scientific Basis,
Houghton, J.T., et al. (eds.), Cambridge Univ.
Press, Cambridge, 2001



CONCLUSIONS

- Recent global surface temperatures are unprecedented in a long-term context
- It is difficult to explain the recent surface warming in terms of natural climate variability
- Recent surface warming *is* largely consistent with simulations of the effects of anthropogenic influence on climate

A banner image for RealClimate featuring a large, bright orange sun on the left, a dark, silhouetted building in the background, and a blue body of water with white-capped waves in the foreground.

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Climate science from climate scientists

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Gavin Schmidt, Michael Mann

**Eric Steig, William Connolley, Ray Bradley, Stefan Rahmstorf,
Rasmus Benestad, Caspar Ammann, Thibault de Garidel,
David Archer, Ray Pierrehumbert**