

Update on Climate Science Research: Overview

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Key Issues & Topics

- Background
- Current evidence of climate change
- Evidence for human influence on climate
- Uncertainty in forecasts



Background

■ Global Climate Change Chronology

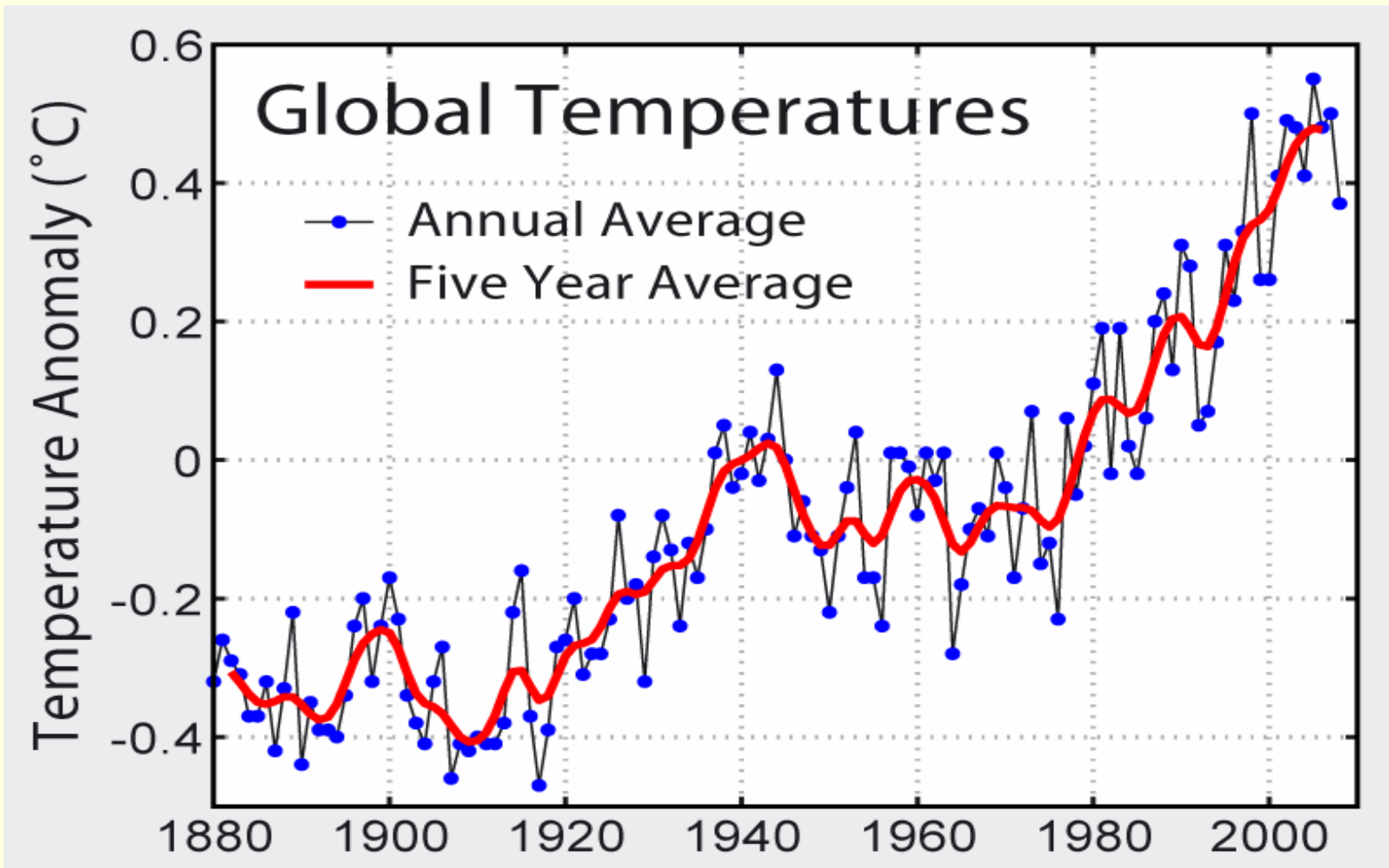
- 1824: First Greenhouse Effect Paper – Fourier
- 1896: First Calcs for Doubling of CO₂ (5-6°C)
Arrhenius
- 1950s: Computer-Aided Global Climate Modeling Begins
- 1979: Academy of Sciences estimates 1.5-4.5°C from doubling
- 1990: 1st Intergovernmental Panel on Climate Change (IPCC) Report
- 2007: 4th IPCC Report



Evolution Of Scientific Mainstream Position

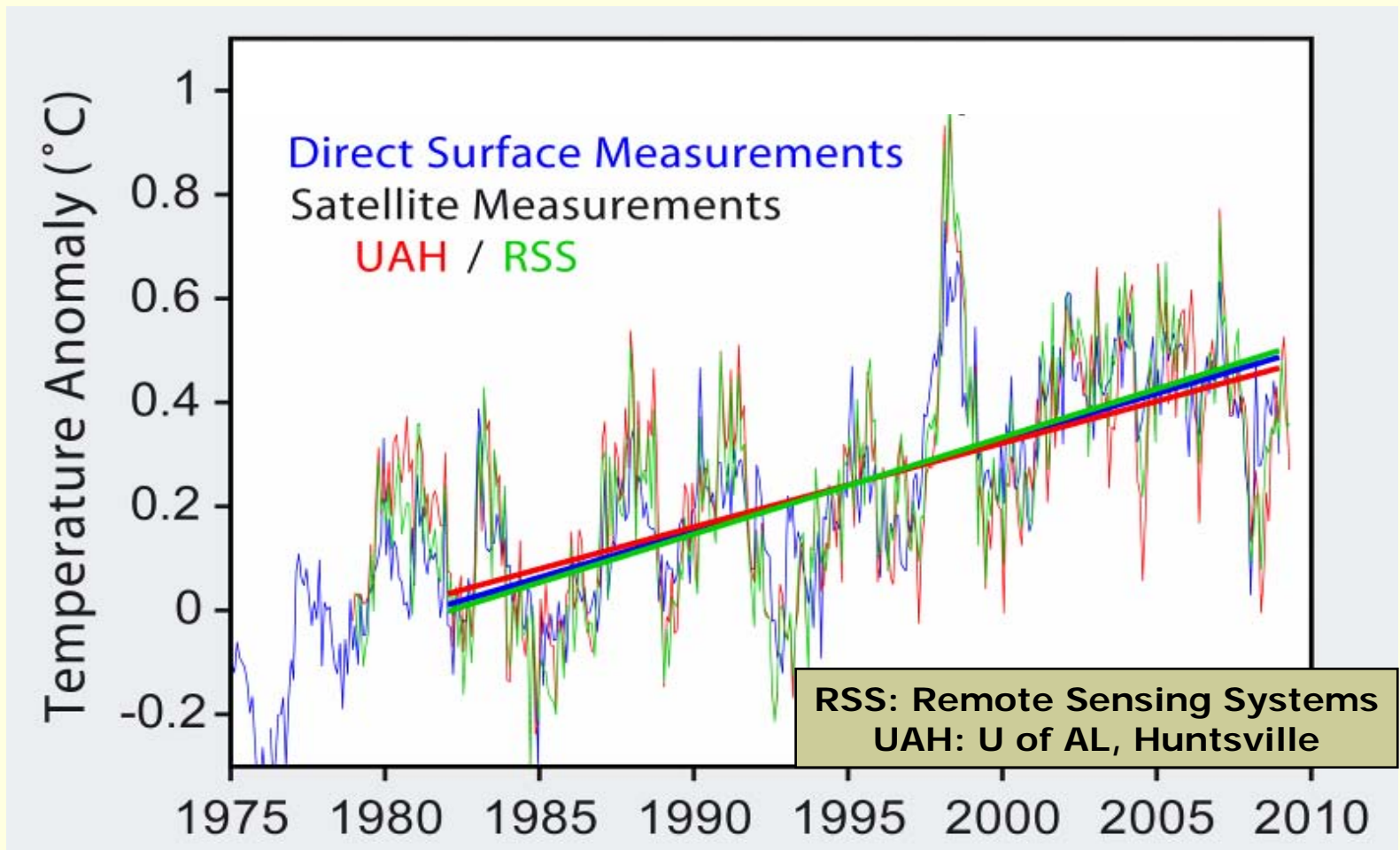
- IPCC (1990):
 - ... growth in greenhouse gas emissions may lead to significant increases in global temperature ...
- IPCC (1996):
 - ... balance of evidence suggests a discernable human influence on global climate
- IPCC (2001):
 - ... greenhouse gases produced mainly by burning of fossil fuels are likely to have contributed substantially to observed warming over the past 50 years
- IPCC (2007)
 - ... >90% chance that most of the observed increase in globally averaged temperatures since the mid-20th century is due to the observed increase in anthropogenic greenhouse gas levels

The Global Instrumental Record



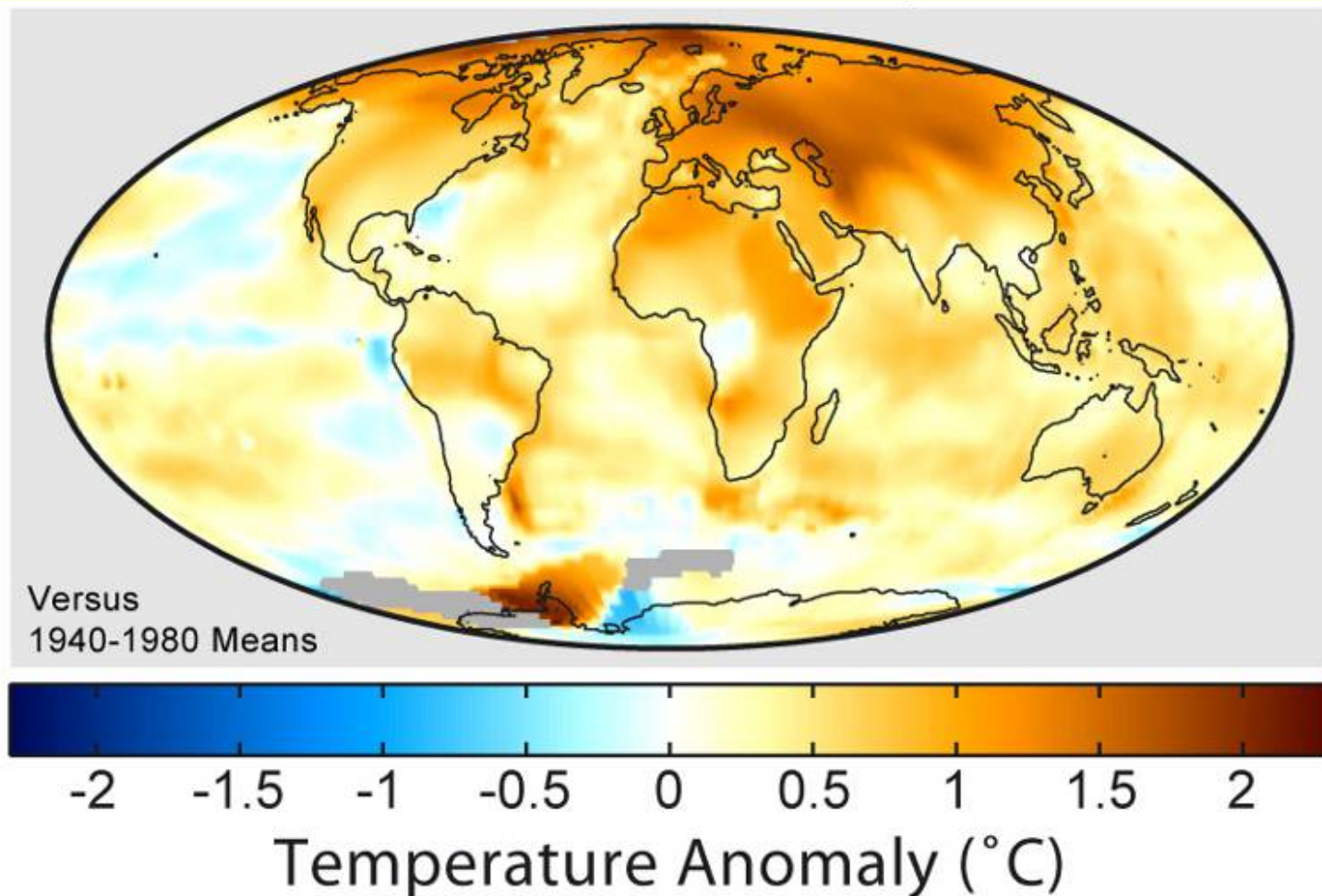
http://en.wikipedia.org/wiki/Global_warming & references contained therein

Surface And Satellite Temperatures



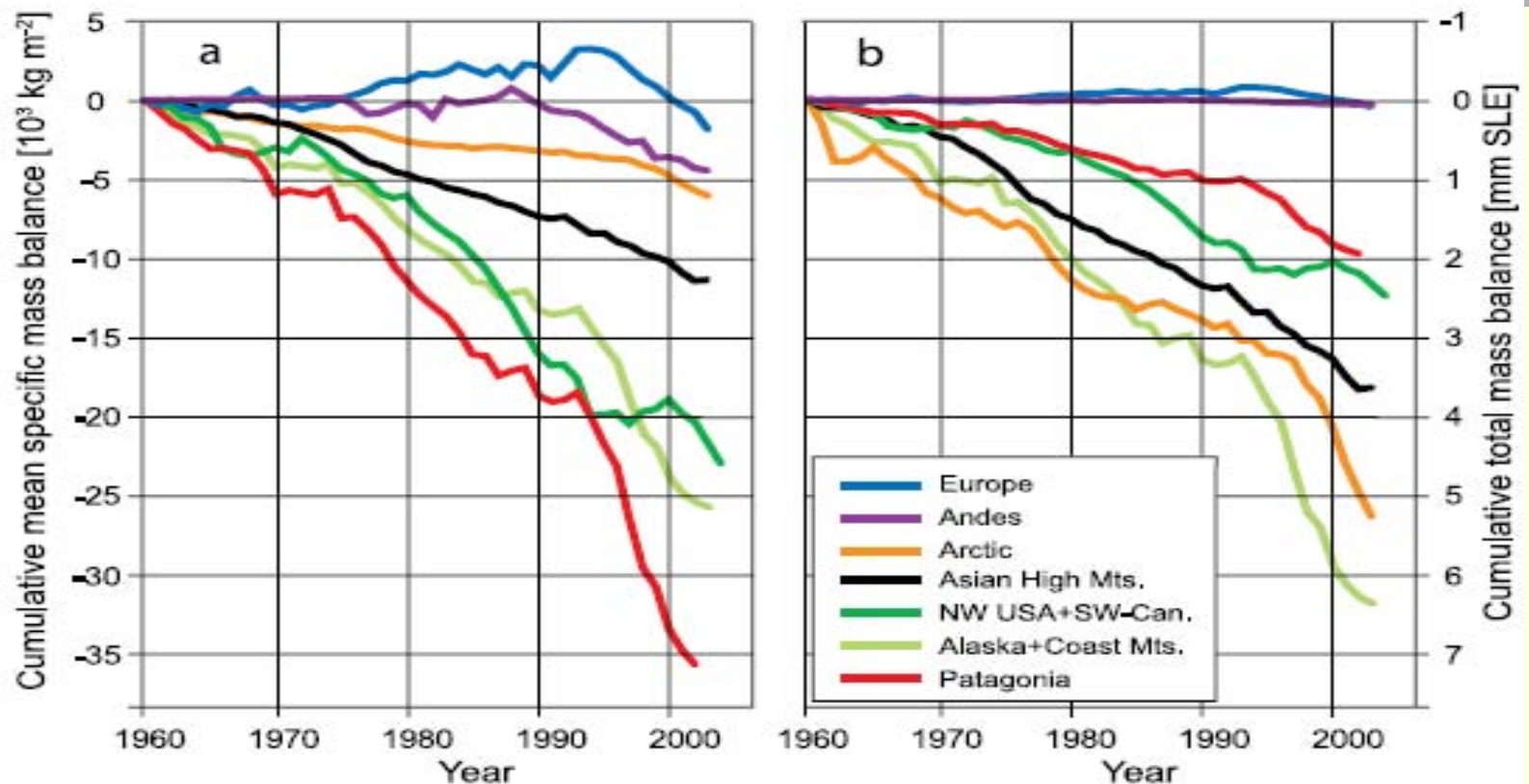
http://en.wikipedia.org/wiki/Global_warming & references contained therein

1998-2008 Mean Temperatures



http://en.wikipedia.org/wiki/Global_warming & references contained therein

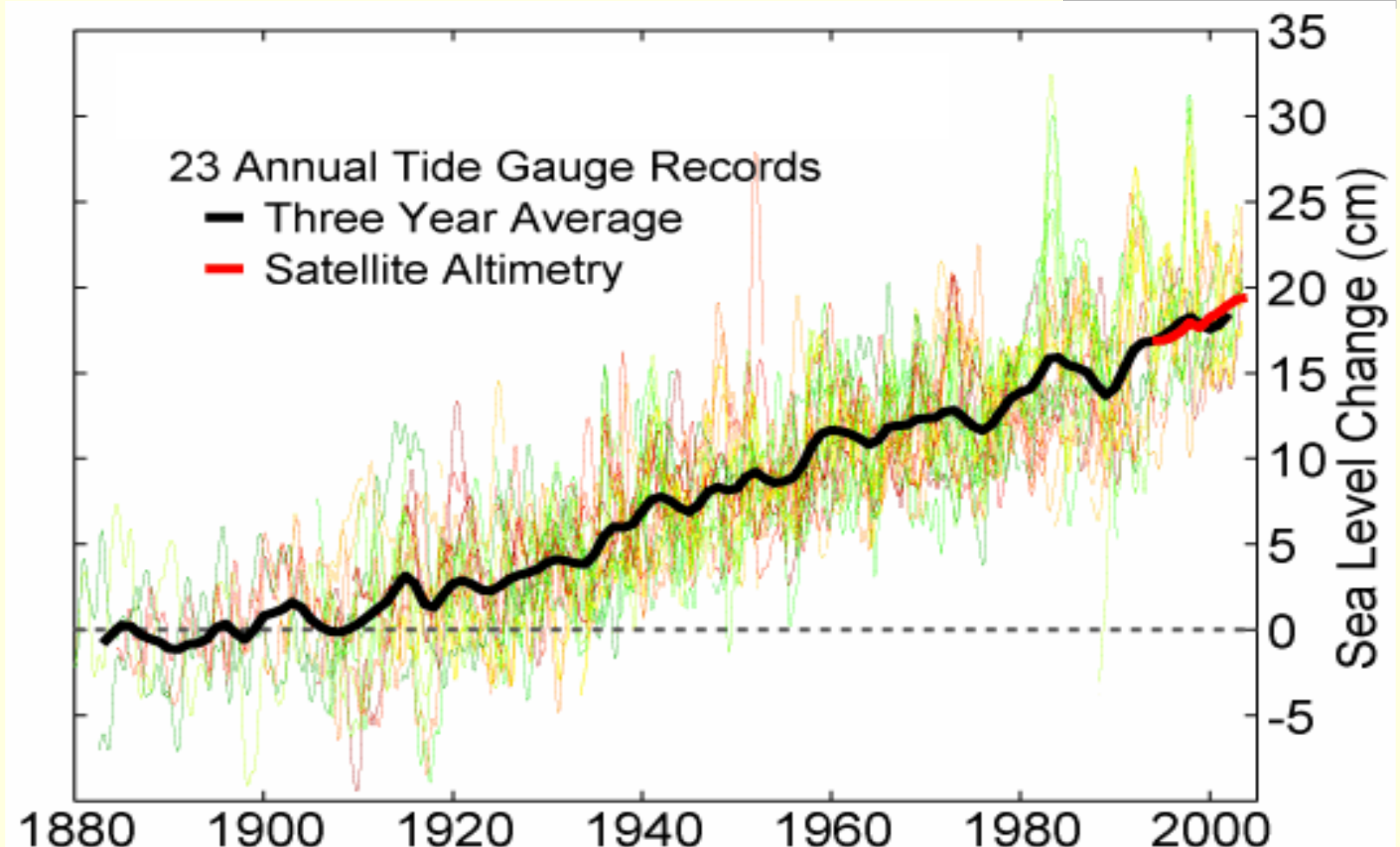
World Wide Glacial Retreat



During the period 1960-1990, glaciers contributed 0.37 ± 0.16 millimeters per year to sea level while during 1990-2004, the contribution increased to 0.77 ± 0.22 millimeters per year

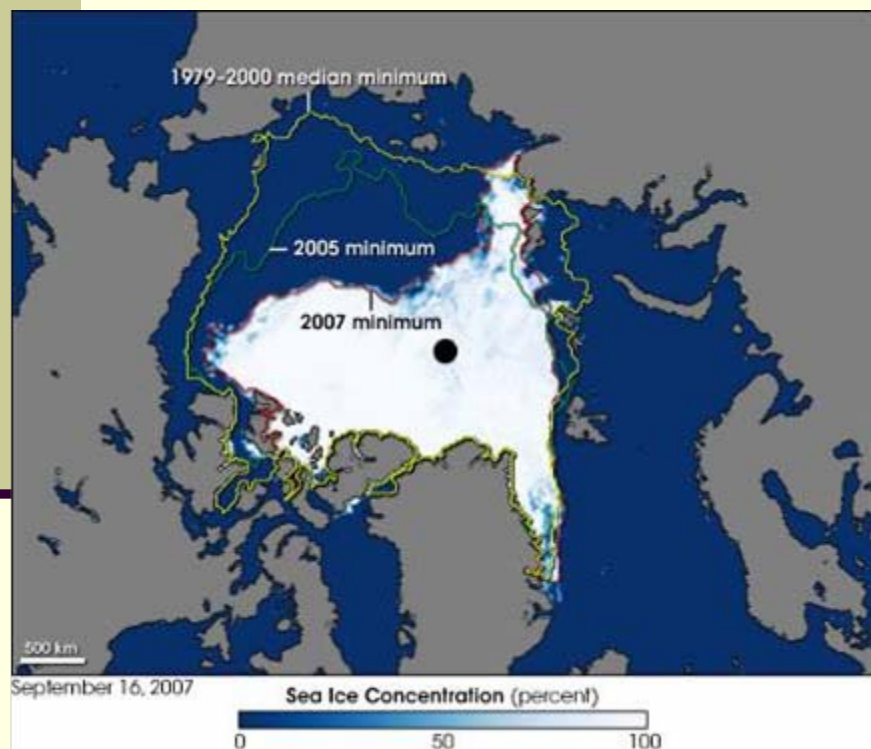
Dyurgerov and Meier, 2007. As cited by J. Walsh in "The Arctic in the IPCC Fourth Assessment Report," presented at the Arctic Forum, Arctic Research Consortium of the U.S. Annual Meeting, May 23-24, 2008.

Sea Level Rise

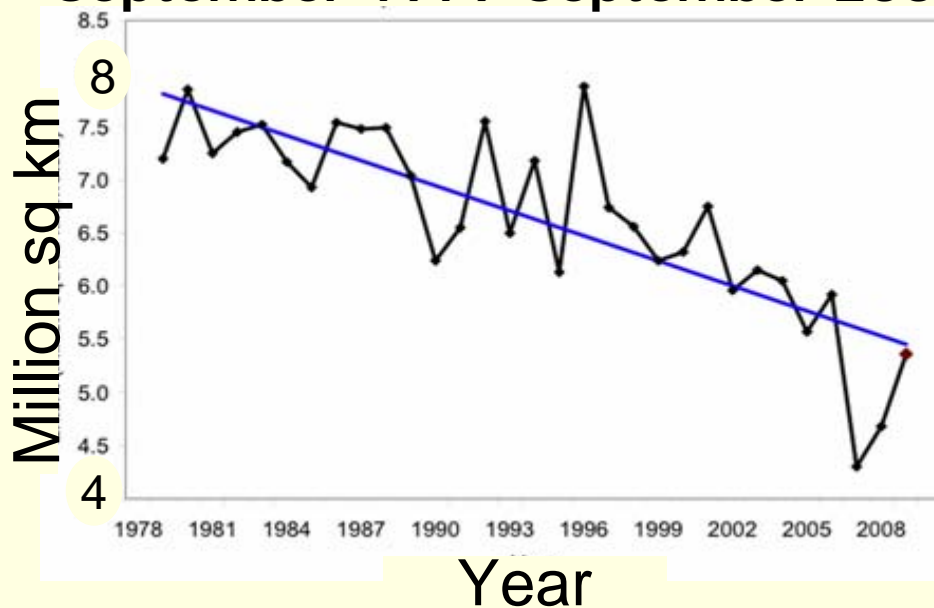


http://en.wikipedia.org/wiki/Sea_level_rise & references contained therein

Arctic Ocean Sea Ice Retreat



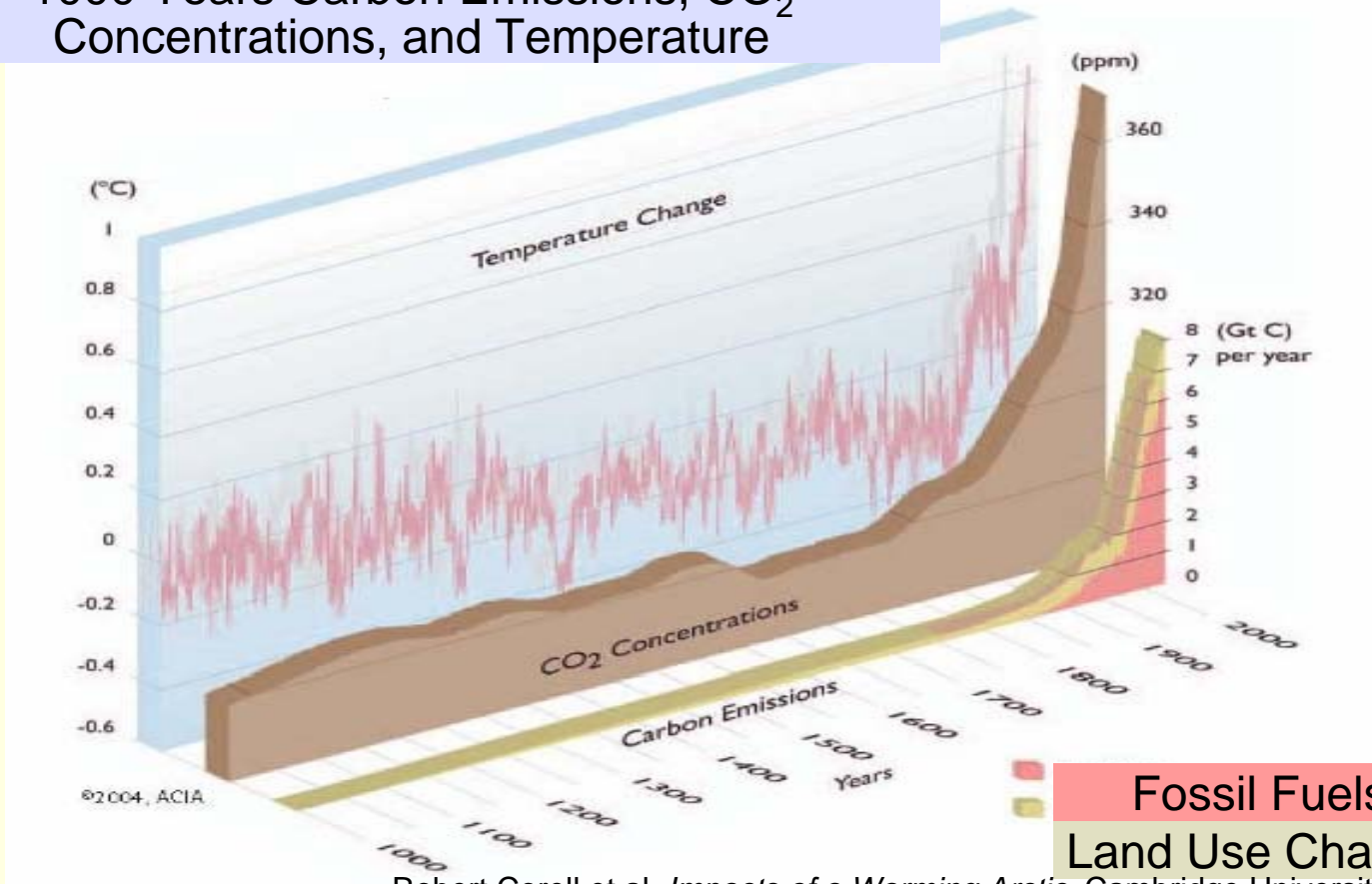
September Ice Minima
September 1979-September 2009



National Snow and Ice Data Center,
http://nsidc.org/news/press/20091005_minimumpr.html

Is The Warming Anthropogenic?

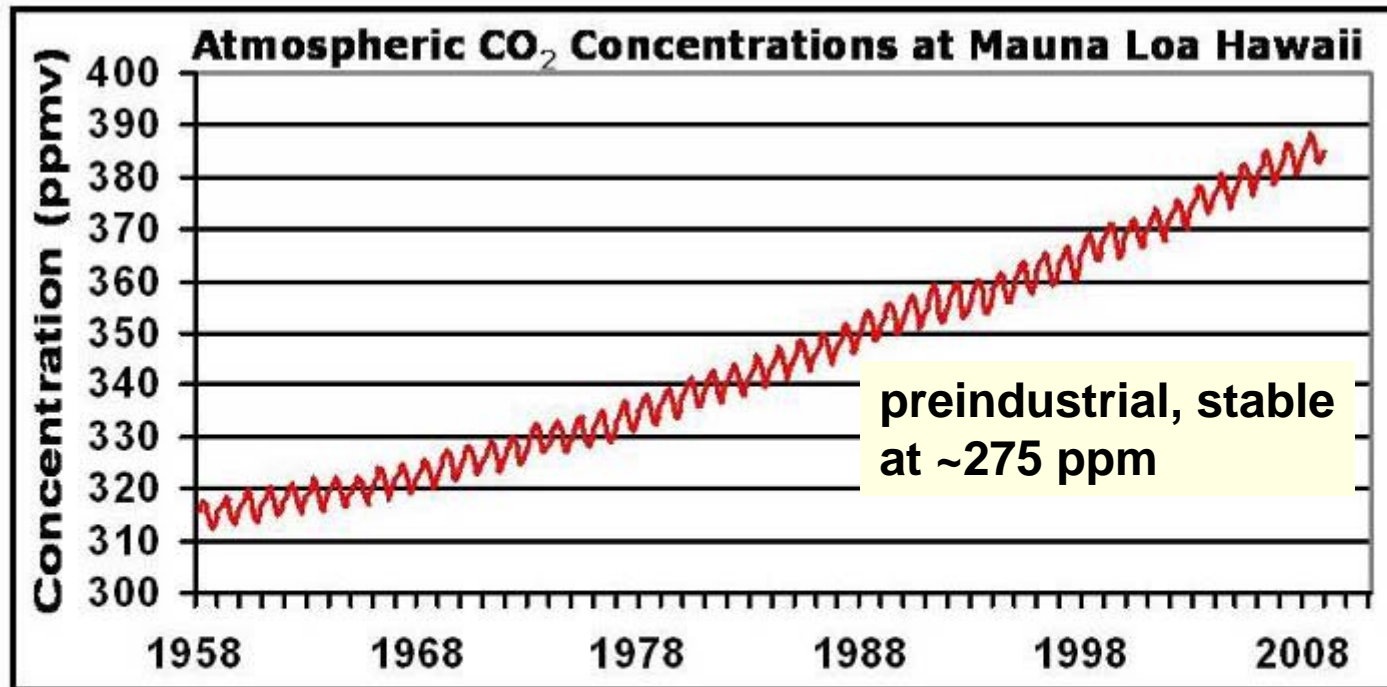
1000 Years Carbon Emissions, CO₂ Concentrations, and Temperature



Robert Corell et al, *Impacts of a Warming Arctic*, Cambridge University Press, 2004.

**Note in 400K years CO2 has not exceed 300 ppmv
Rate of change exceeds anything ever observed**

CO₂ & Other GHG Atmospheric Concentrations Rising

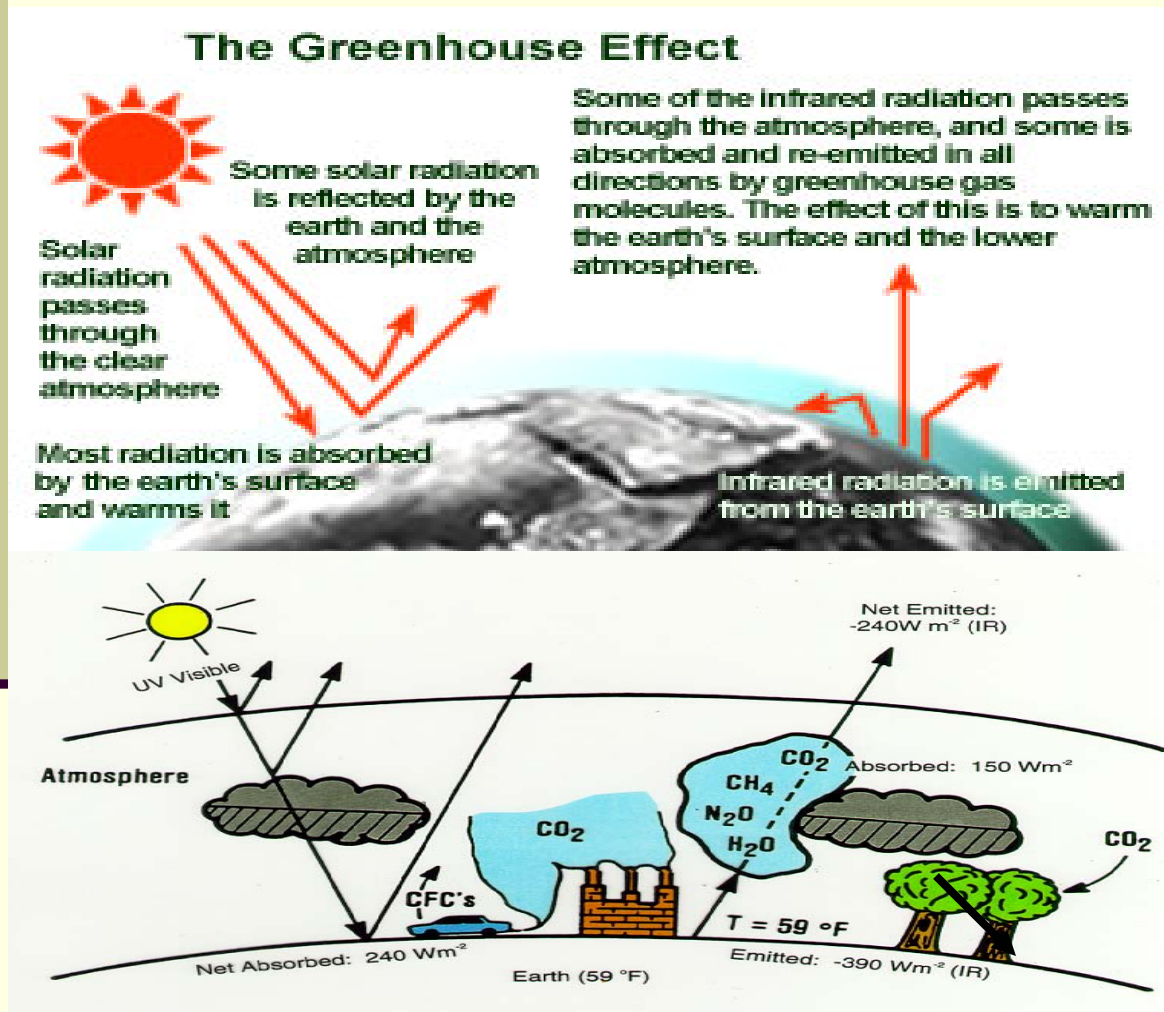


**Do we know the extra CO₂ is from fossil fuel combustion?
Yes, from isotopic composition.**

<http://cdiac.ornl.gov/trends/co2/graphics/SIOMLOINSITUTHRU2008.JPG>

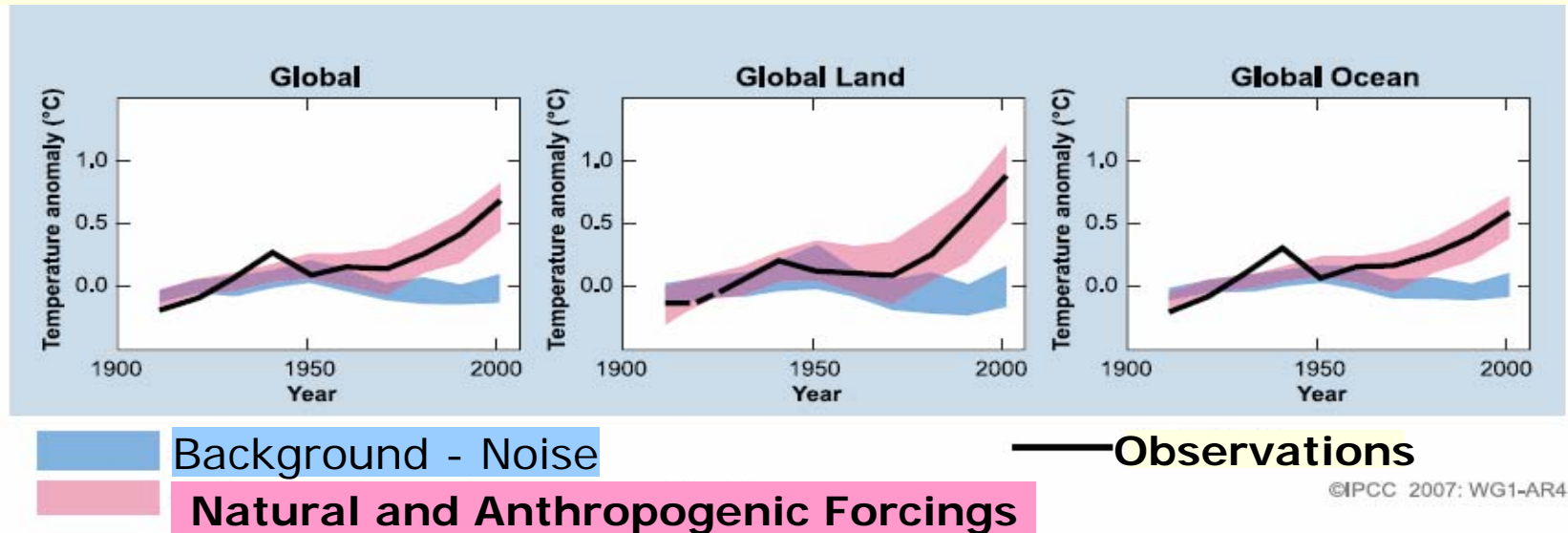
The Greenhouse Effect is Real

Without it the earth would be much colder



The Natural
Greenhouse
Effect
warmed the
planet by
 $\sim 33^\circ \text{C}$

Comparisons: Global Temperature Change



The Models Work Only When GHG Radiative Effects Are Included
19 simulations from 5 different climate models
5-95% Confidence Bands

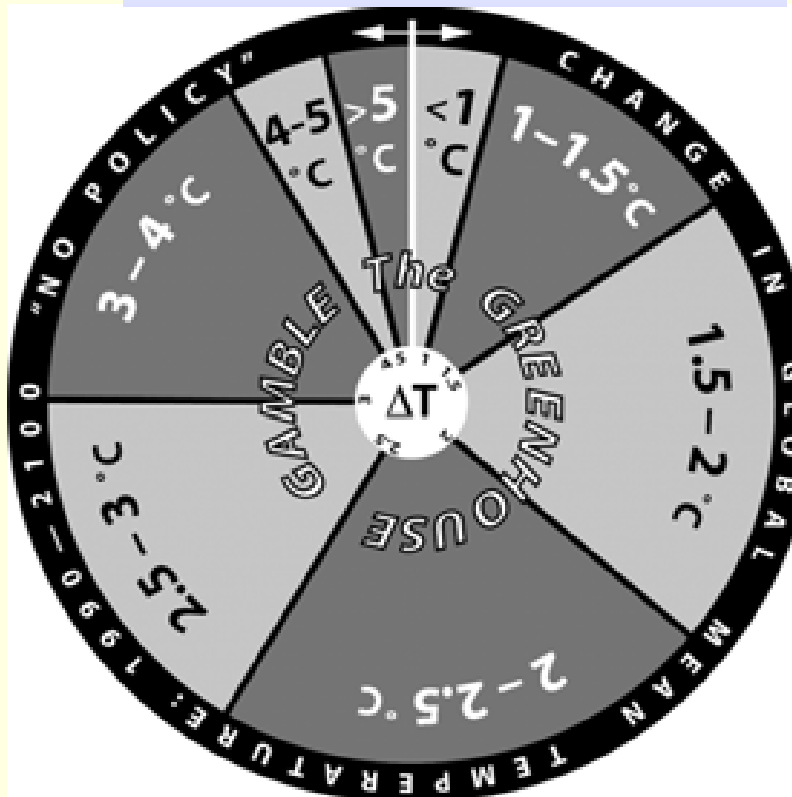
**IPCC 2007 Conclusion: warming *Very Likely*
Anthropogenic (>90% certain)**

IPCC Fourth Assessment Report, WG I, *Climate Change 2007: The Physical Science Basis, Summary for Policy Makers* (February, 2007) http://www.ipcc.ch/WG1_SPM_17Apr07.pdf

The Greenhouse Gamble

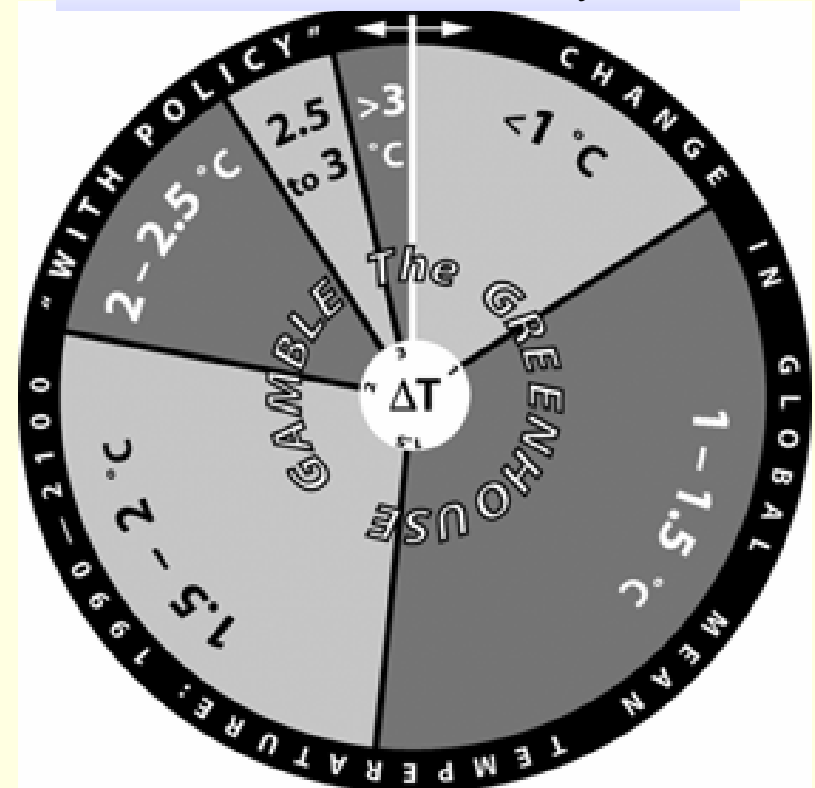
Webster, et al Climate Change, 2003

~25% >3°C increase by 2100



No Policy

Low % >3°C increase by 2100



With Policy to hold less than doubling



**Thank you for your
attention**



References

- http://en.wikipedia.org/wiki/Global_warming & references contained therein
- Dyurgerov and Meier, 2007. As cited by J. Walsh in "The Arctic in the IPCC Fourth Assessment Report," presented at the Arctic Forum, Arctic Research Consortium of the U.S. Annual Meeting, May 23-24, 2008.
- http://en.wikipedia.org/wiki/Sea_level_rise & references contained therein
- National Snow and Ice Data Center,
http://nsidc.org/news/press/20091005_minimumpr.html
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- <http://cdiac.ornl.gov/trends/co2/graphics/SIOMLOINSITUTHRU2008.JPG>
- T.M.L. Wigley et al, *Temperature Trends in the Lower Atmosphere – Understanding and Reconciling Differences*, U.S. Climate Change Science Report, 2006.
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http://www.ipcc.ch/WG1_SPM_17Apr07.pdf
- G. Roe and M. Baker, "Why is Climate Sensitivity So Unpredictable?", *Science* 318, 629, 2007.
- Webster, M., et al; *Uncertainty analysis of climate change and policy response*, *Climate Change*, 61, 295-320, 2003.