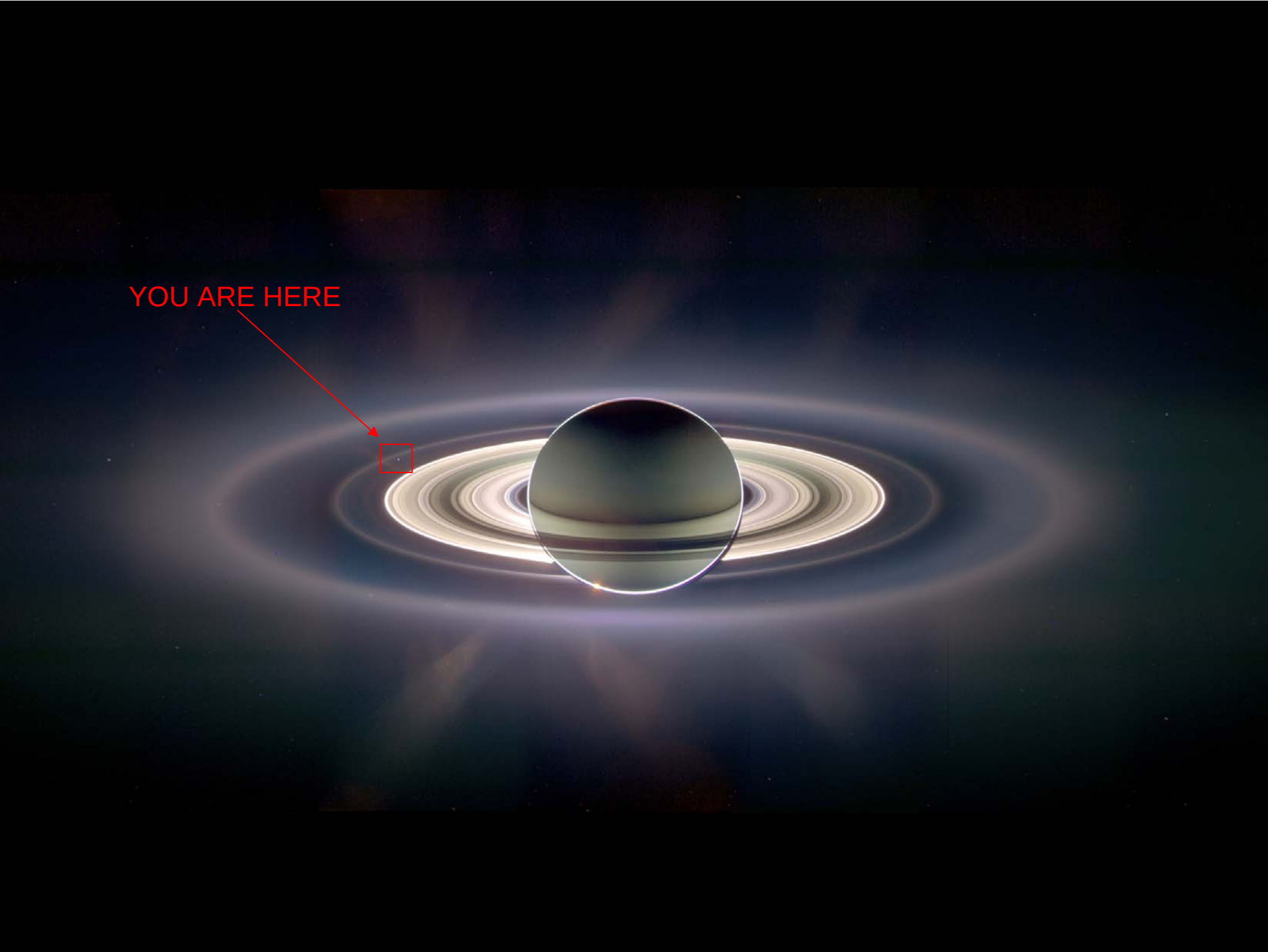
National Aeronautics and Space Administration

Earth Science and Climate Change

Dr. Mary L. Cleave

February 7, 2007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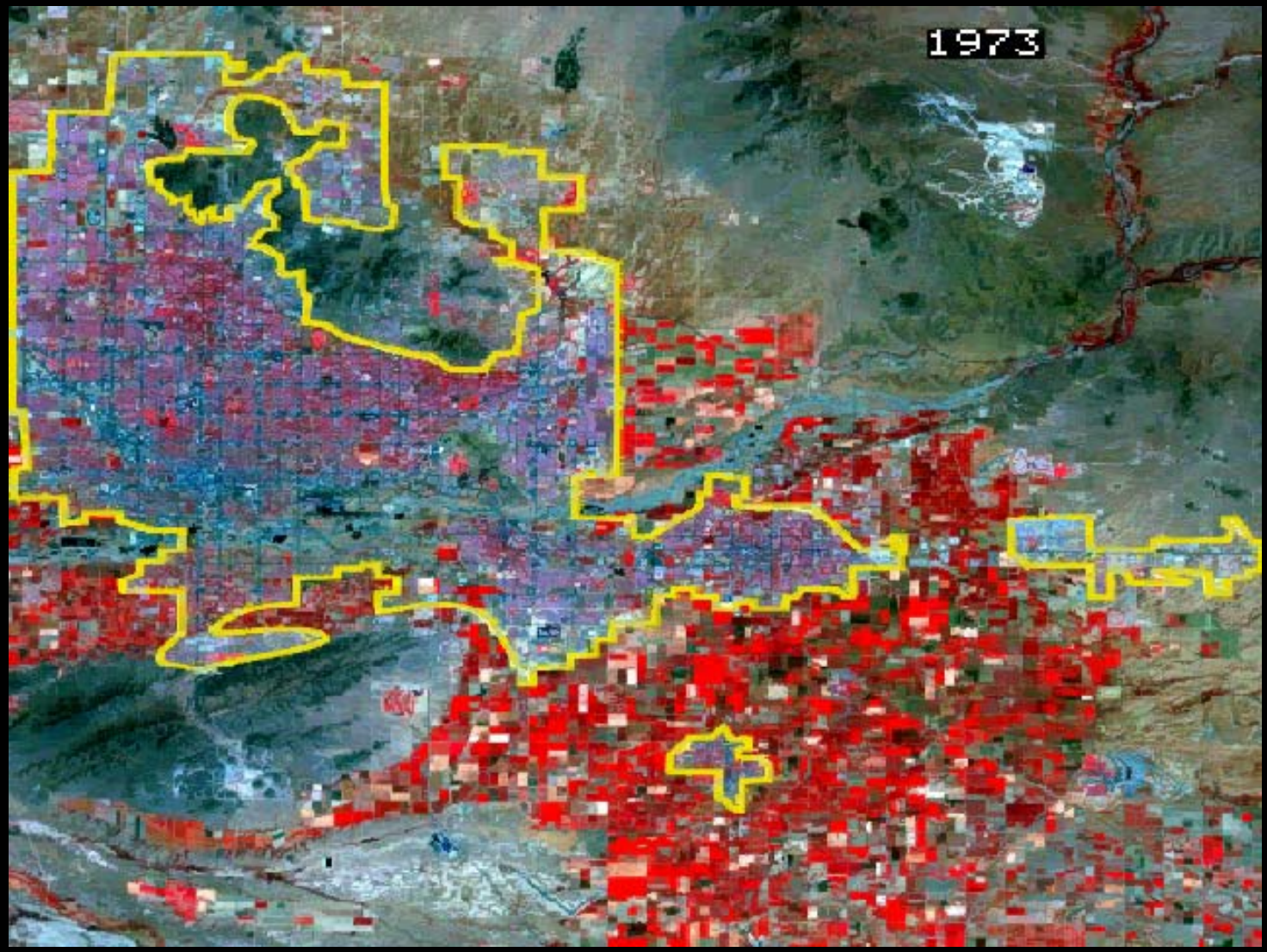
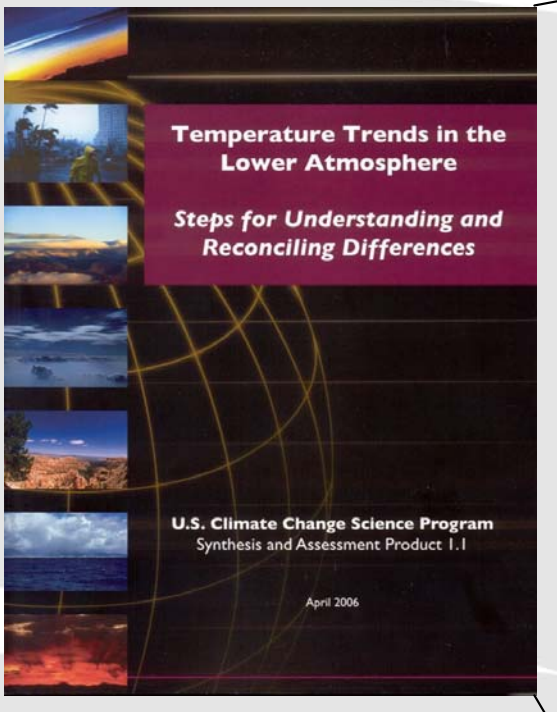
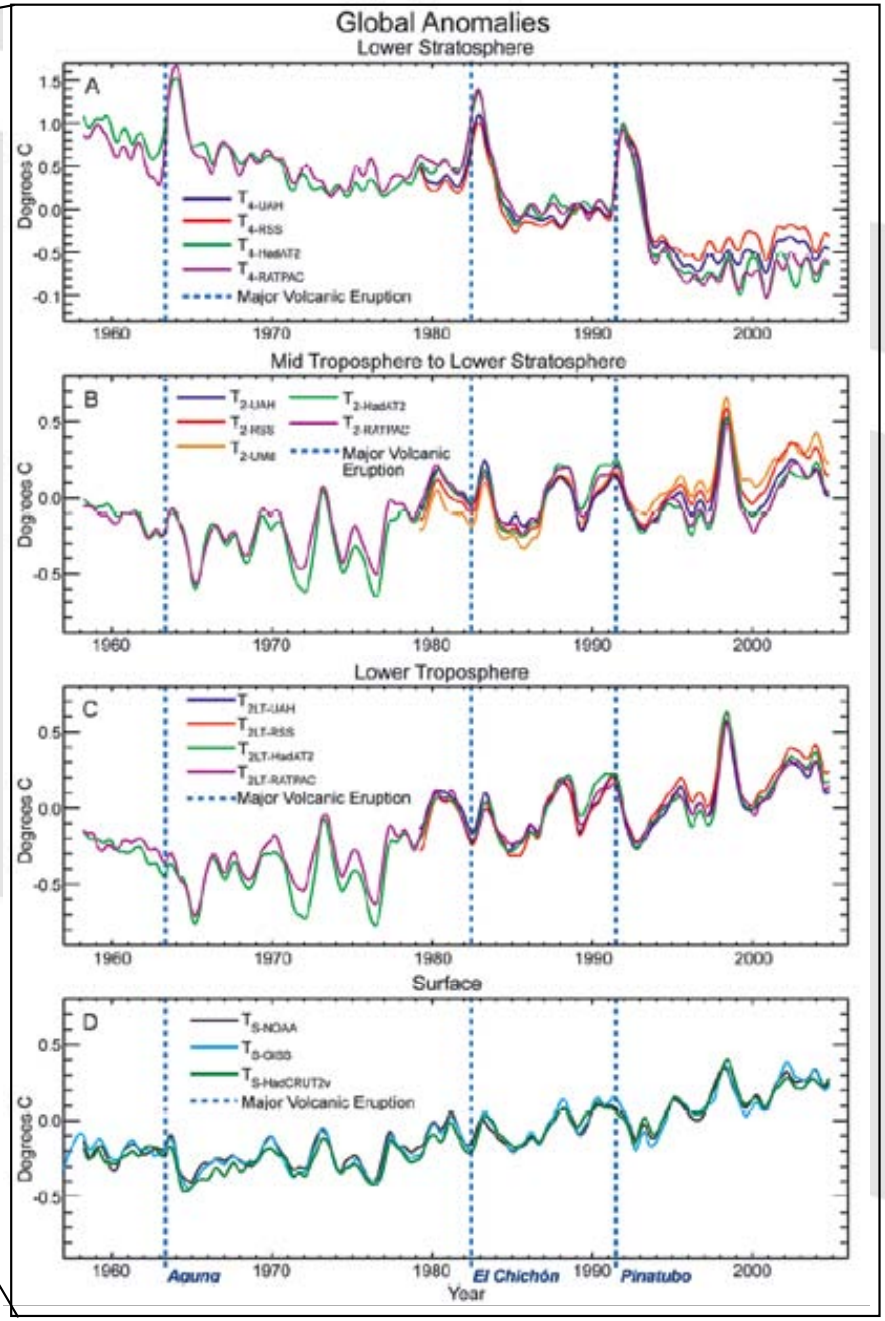
Land Use Changes Over Time



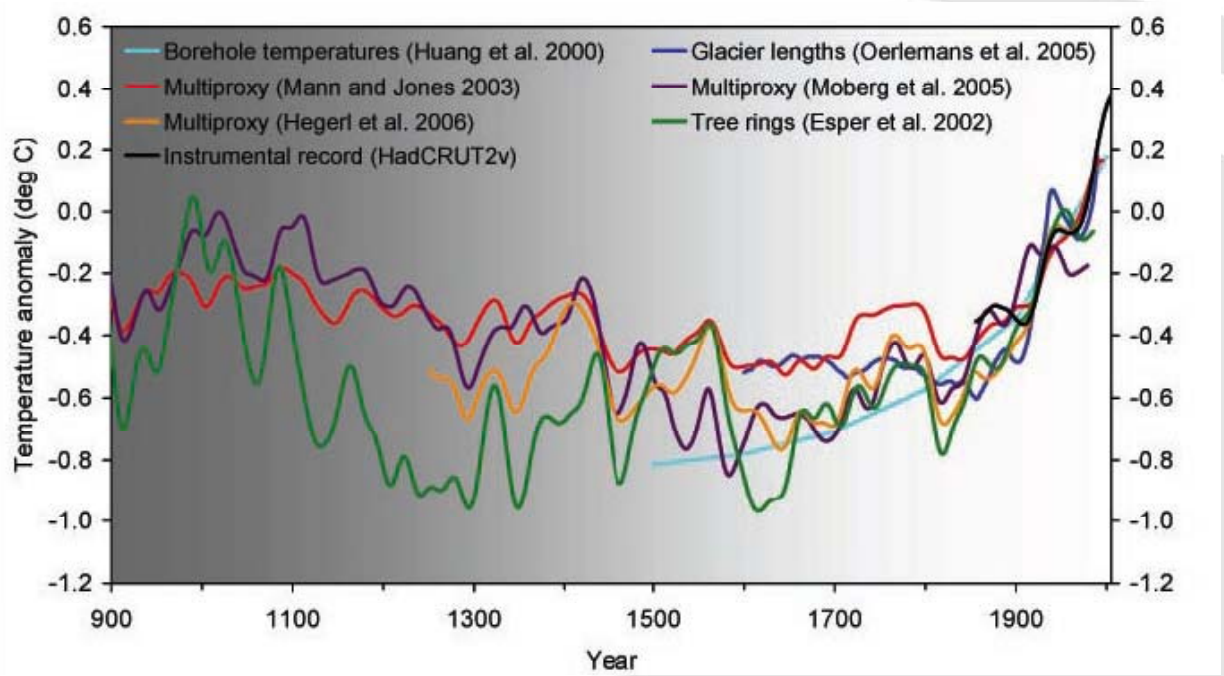
Lingering Doubts on Temperature Trends Have Been Resolved



1st CCSP Synthesis & Assessment Report: "This significant discrepancy no longer exists because errors in the satellite and radiosonde data have been identified and corrected. New data sets have also been developed that do not show such discrepancies"



Temperature Increases in the Last Few Decades are Unprecedented in the Last Millennium

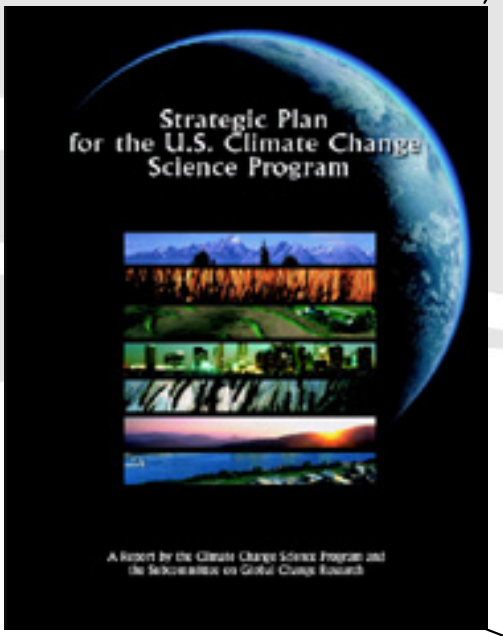


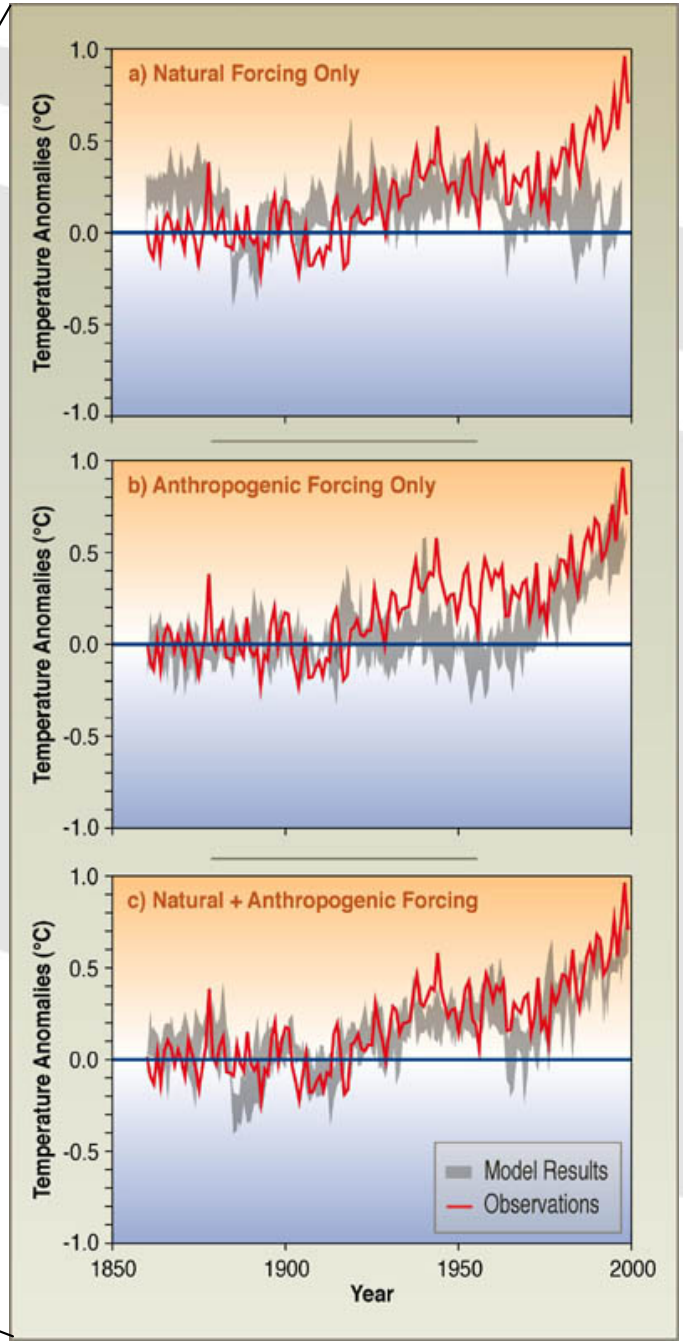
This conclusion of three paleo-climate researchers in 1999 was questioned in some quarters, but was recently confirmed in a Congressionally-chartered 2006 NRC report Surface Reconstructions for the Last 2000 Years

More recently, the five warmest years on record globally have all occurred since 1998, and all but one of the warmest twenty years occurred since 1983.

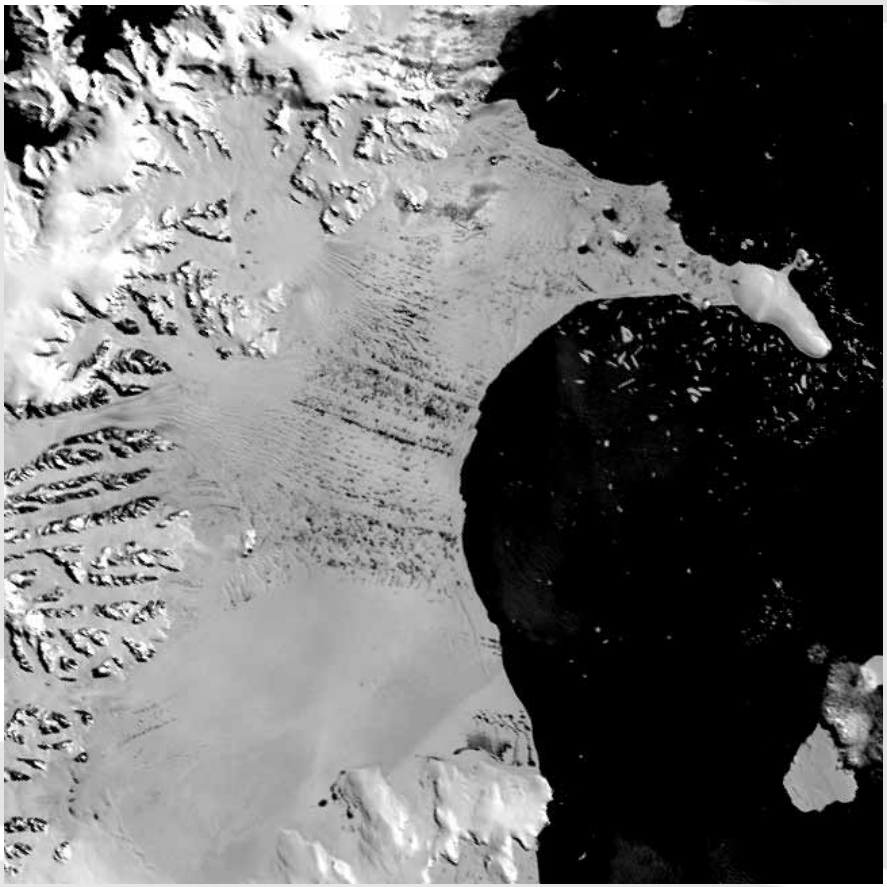
The Evidence Establishes the Connection Between Greenhouse Gas Emissions and Rising Temperatures

When greenhouse gas emissions from human activities are added to the effects of natural variability in climate models, the model results closely match the observed (actual) changes in temperature.

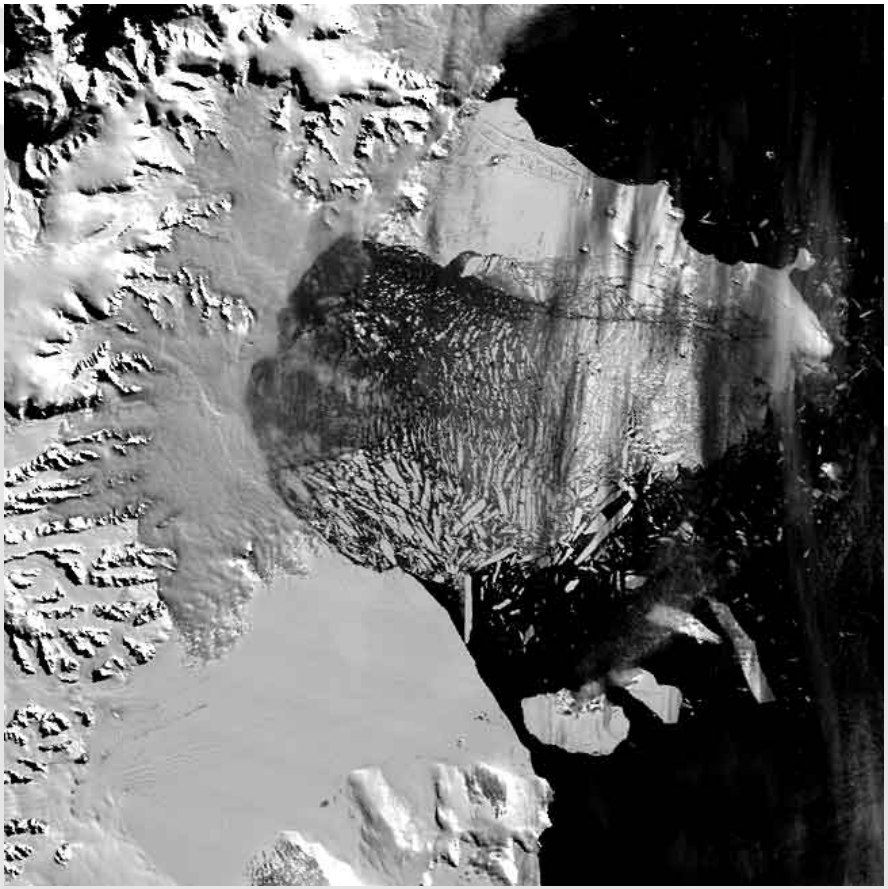




Recent Changes in Polar Ice Caps and Sea Ice Extent and in High-Latitude Glaciers are Dramatic…



January 31, 2002



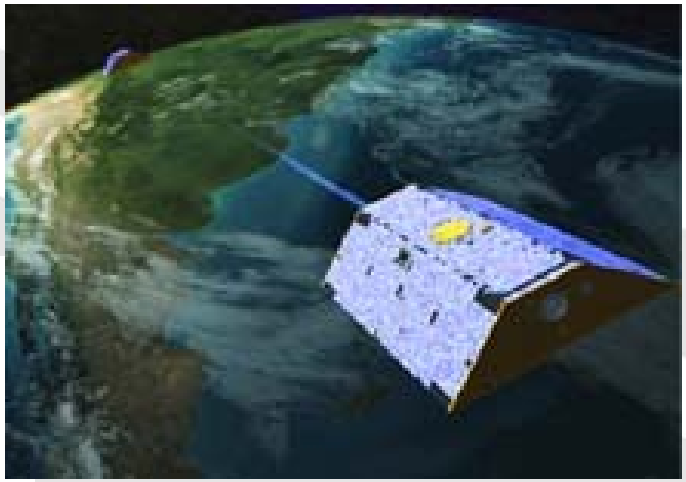
March 5, 2002

Terra satellite

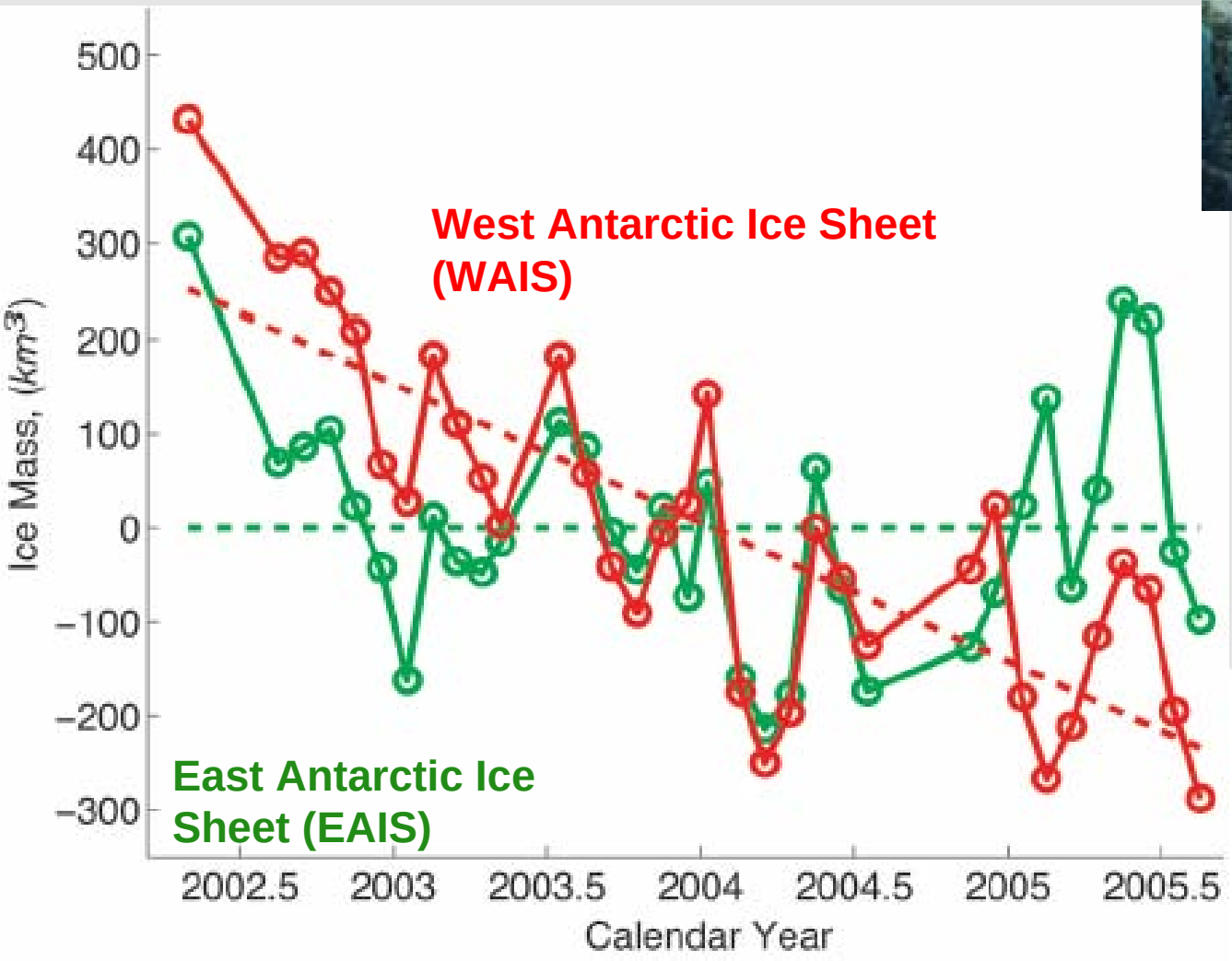
Until recently, it was believed that ice sheets change only slowly in response to climate change. But the vulnerability of ice sheets was made dramatically apparent when much of Antarctica's Larsen-B ice shelf collapsed in a matter of weeks in 2002.

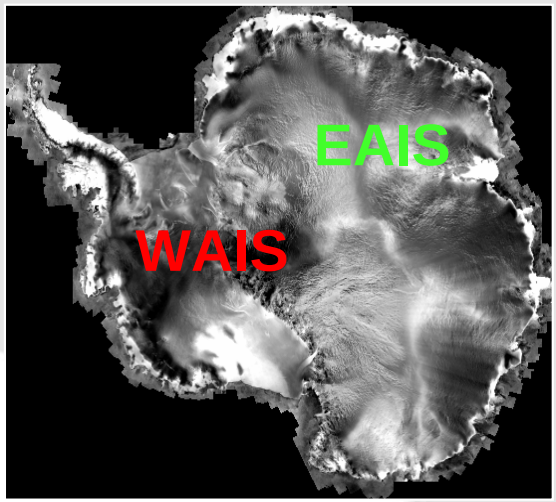
Antarctic Mass Balance From GRACE

Net sea level contribution:
0.4 ± 0.2 mm/yr
Similar estimate for Greenland



Twin GRACE Satellites

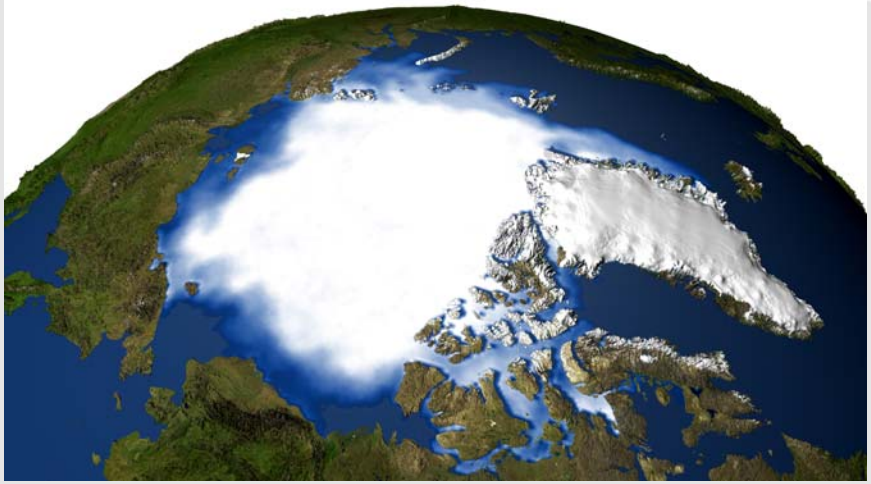




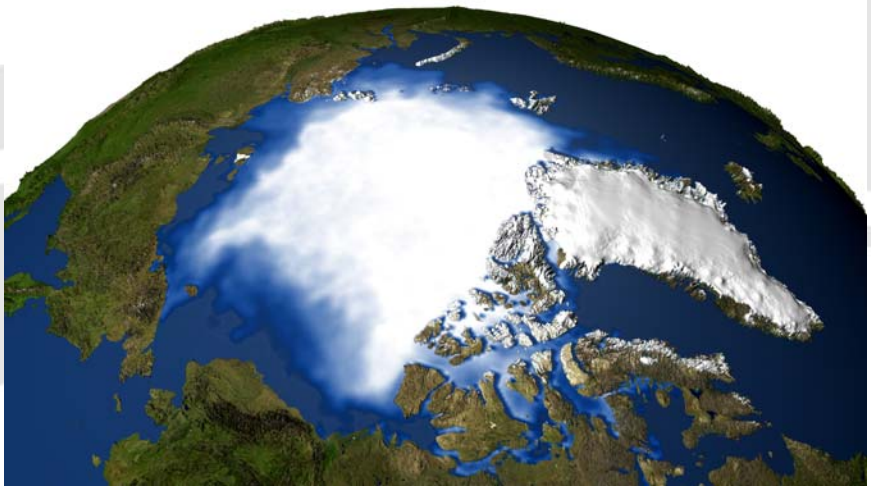
Velicogna and Wahr, Science, 2006

Perennial Sea Ice Cover

1979 - 1982 Mean



2000-2003 Mean



Source: NASA/GSFC Scientific Visualization Studio and J. Comiso

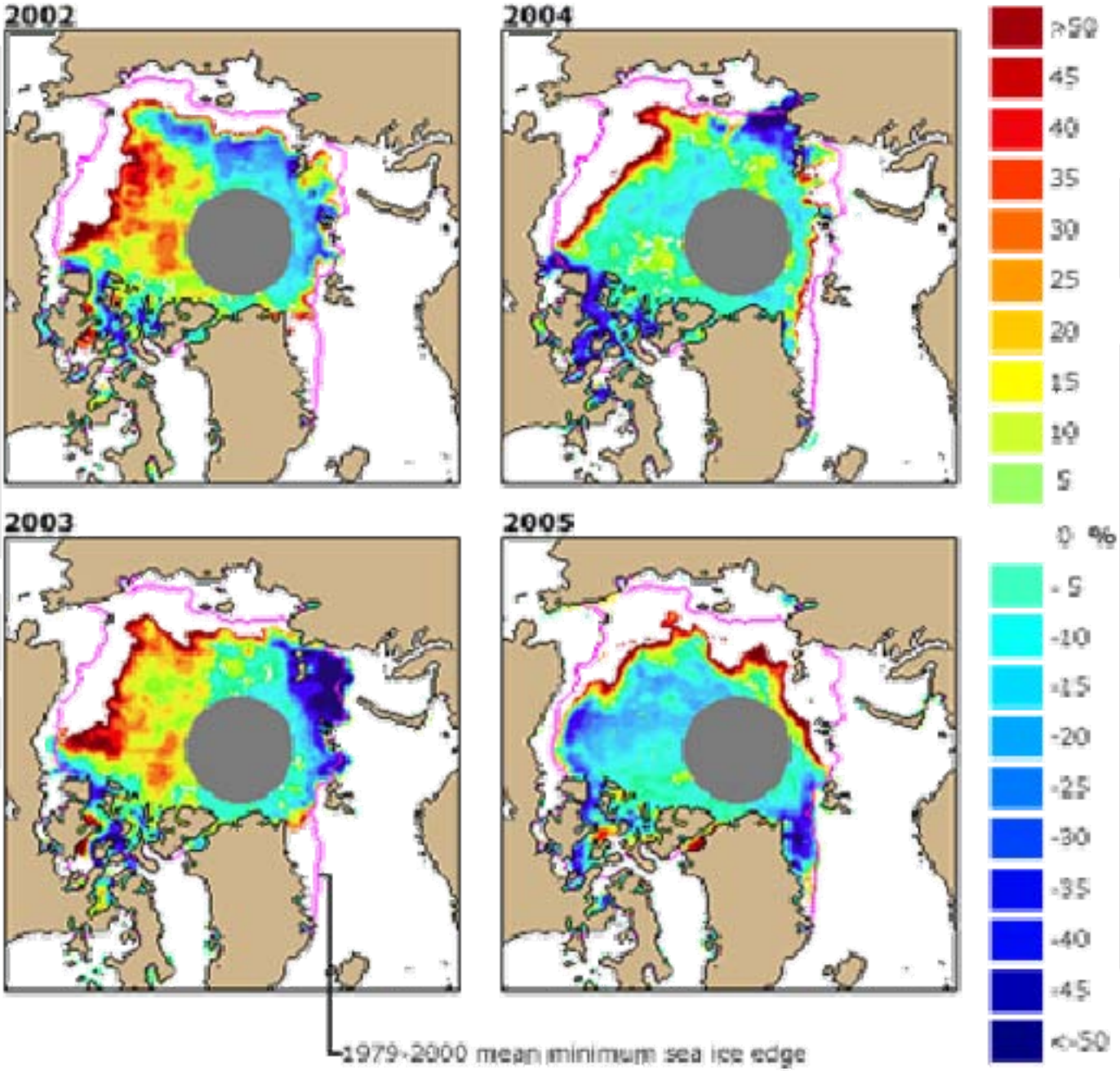
- Significant reduction in perennial sea ice cover over the last 25 years
- When replaced, it is with younger thinner ice that is vulnerable to melt
- We are NOT seeing these kinds of changes in Antarctica

NOAA Weather Satellites

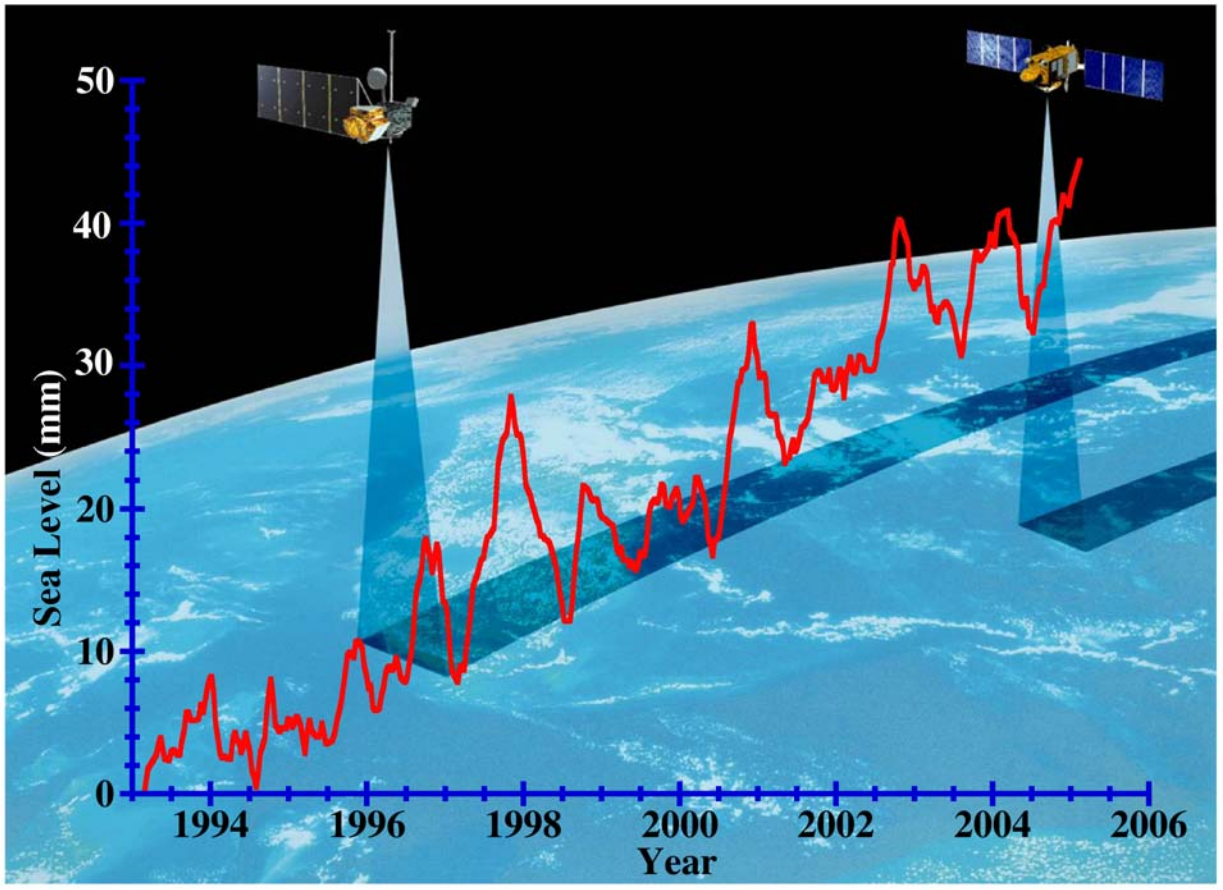
NASA's Aqua Satellite

September Sea Ice Conditions Compared to 1979-2000 Mean

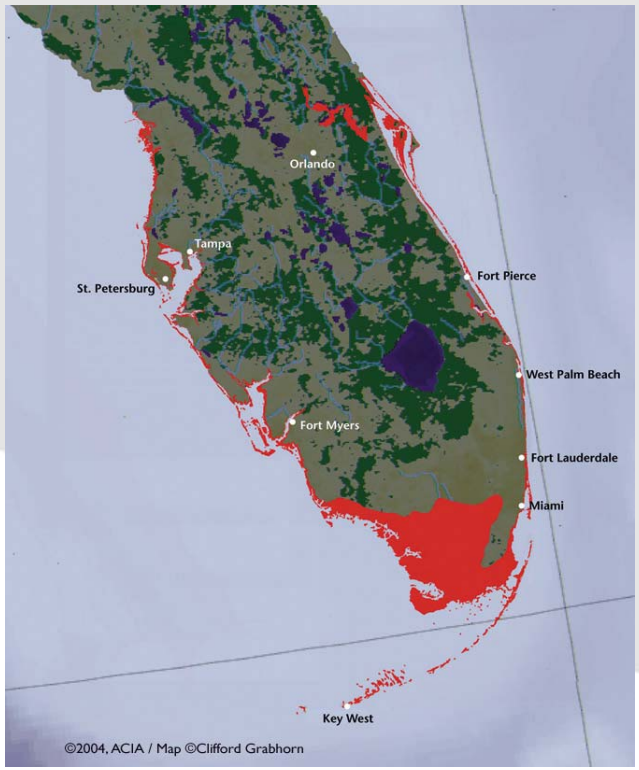
Sea ice conditions for September 2002, 2003, 2004, and 2005, derived from the NSIDC Sea Ice Index. Each image shows the concentration anomaly (key on right) and the 1979-2000 mean September ice edge (pink line). For each year, the ice edge is well north of its mean position off the coasts of Alaska and Siberia. Image provided by National Snow and Ice Data Center.



…With Potentially Large Implications for Sea Level Rise

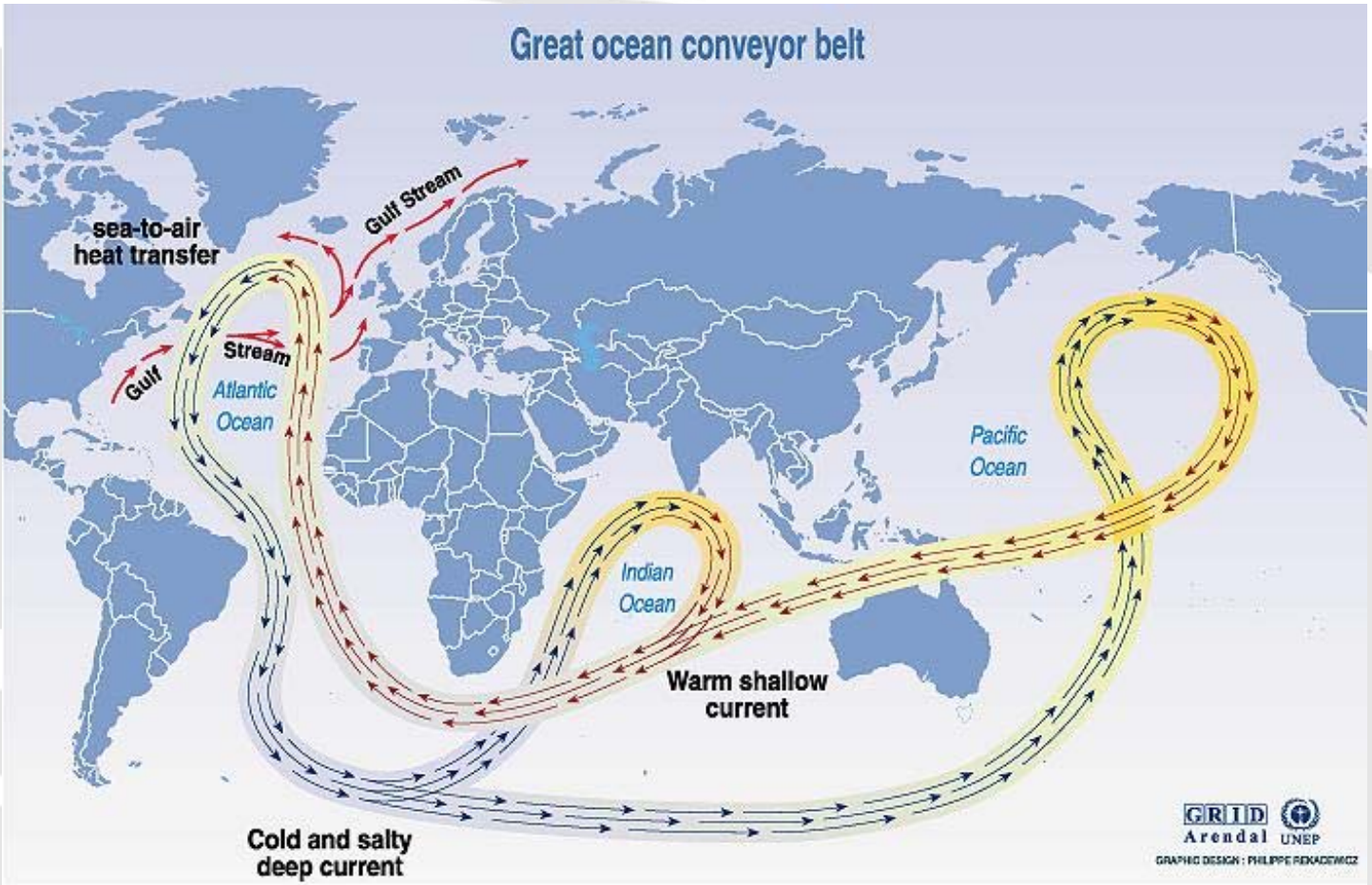


Sea level has been rising at a rate of 3 mm/year over the last decade



The costs associated with a 1 meter sea level rise are estimated to be in the hundreds of billions in the US alone, with more catastrophic impacts in more vulnerable societies.

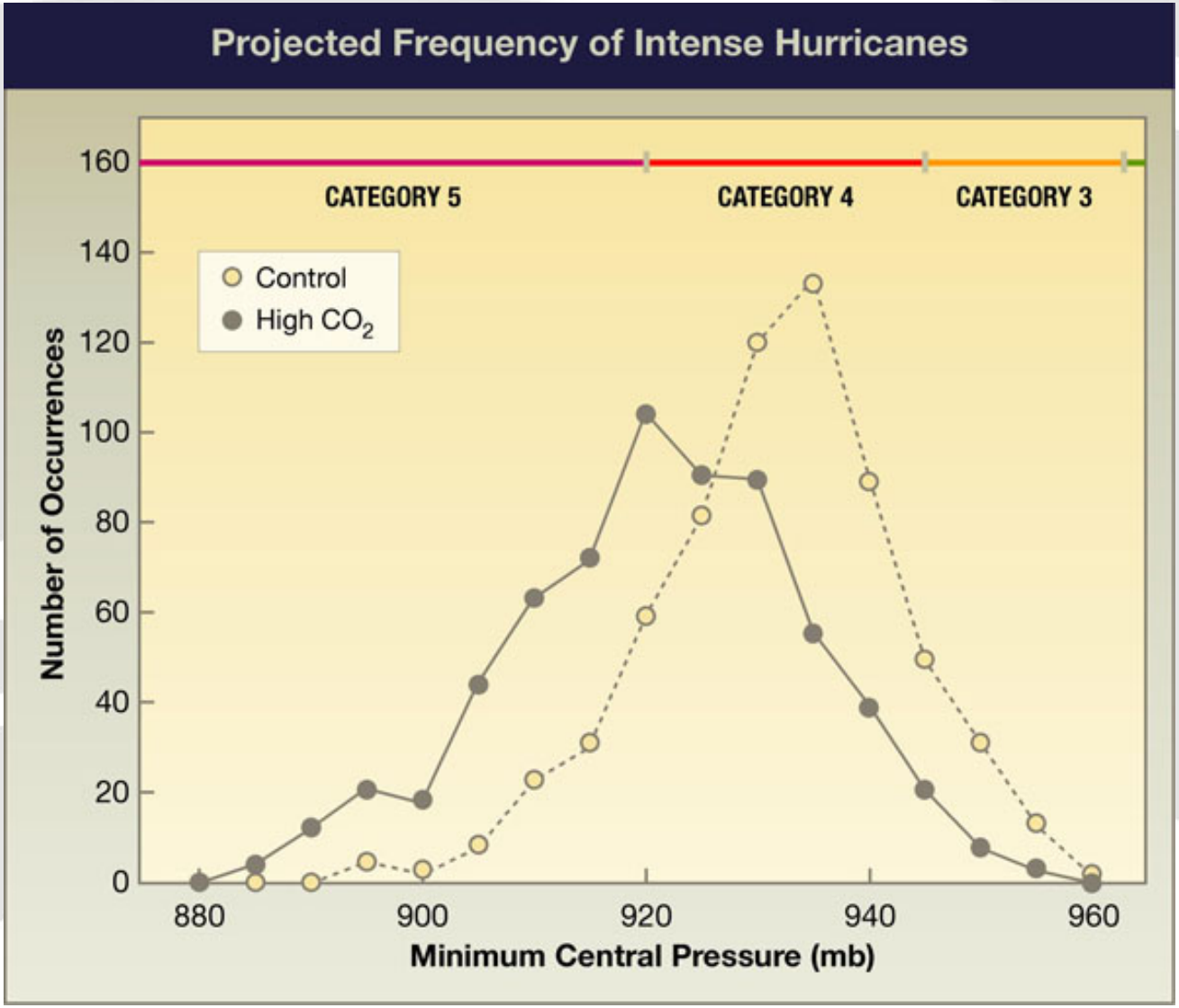
…and Potentially Climate-Altering Changes in Ocean Circulation



Source: Broecker, 1991, in Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Northern Europe has a mild climate compared to other regions of the same latitude because the Gulf Stream carries warm water northward. Significant melting in Greenland and surrounding areas could "freshen" the salt waters of the North Atlantic, disrupting this flow of warm waters to the north.

Rising Temperatures are Correlated with Increases in Hurricane Intensity

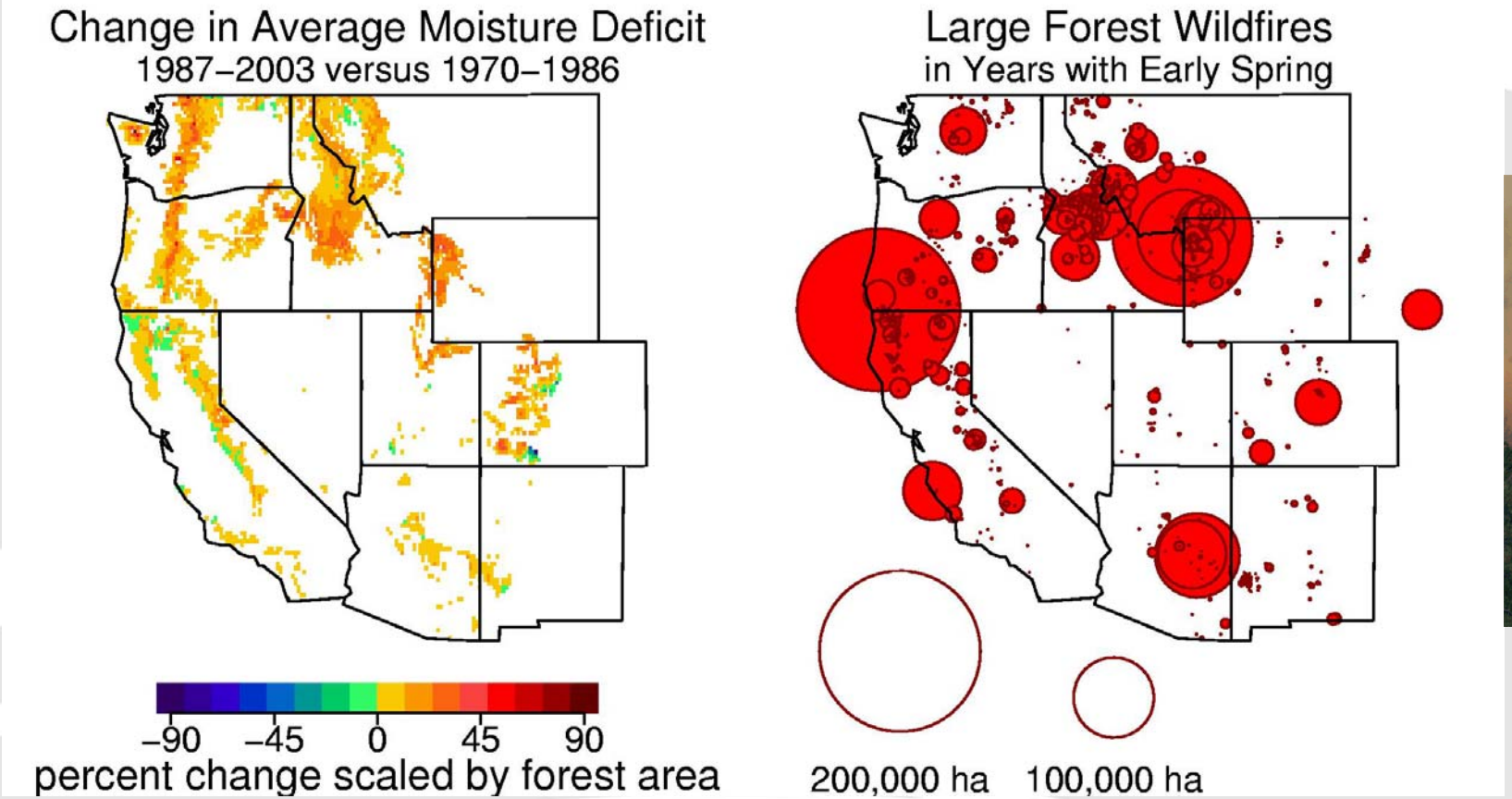


Credit: T. Knutson, NOAA/ Geophysical Fluid Dynamics Laboratory. [CCSP, 2006 (2)]

"This trend is due to both longer storm lifetimes and greater storm intensities…the record of net hurricane power is highly correlated with tropical sea surface temperatures…future warming may lead to an upward trend in tropical cyclone destructive potential…and a substantial increase in hurricane losses in the 21st century."

-- Kerry Emanuel, *Nature*, July 31, 2005

In the American West, Wildfire Season is Growing Longer and Wildfires are More Intense



In the August 18, 2006 journal *Science*, Steve Running writes that "higher spring and summer temperatures and earlier snowmelt are extending the wildfire season and increasing the intensity of wildfires in the western United States." He introduces an article by Westerling, et.al., which presents data showing that "since 1986, longer, warmer summers have resulted in a fourfold increase of major wildfires and a sixfold increase in the area of forest burned… "