Climate Change:

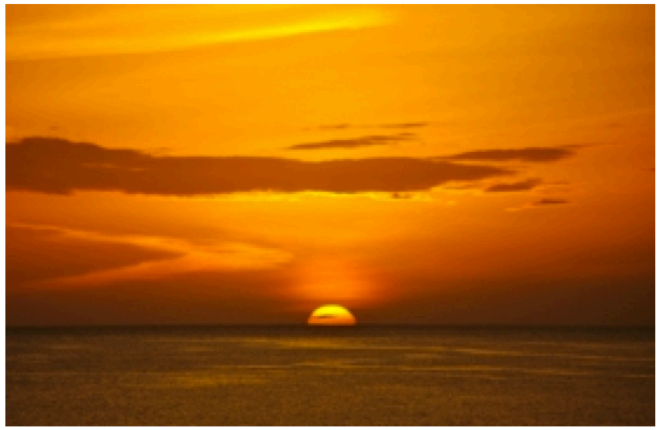
Observations and Projections

2014 Officially Hottest Year on Record

The Japanese declare 2014 one for the record books thanks to global warming

January 5, 2015 | By Brian Kahn and Climate Central

It's official: 2014 has taken the title of hottest year on record. That ranking comes courtesy of data released Monday by the Japan Meteorological Agency (JMA), the first of four major global temperature recordkeepers to release their data for last year.

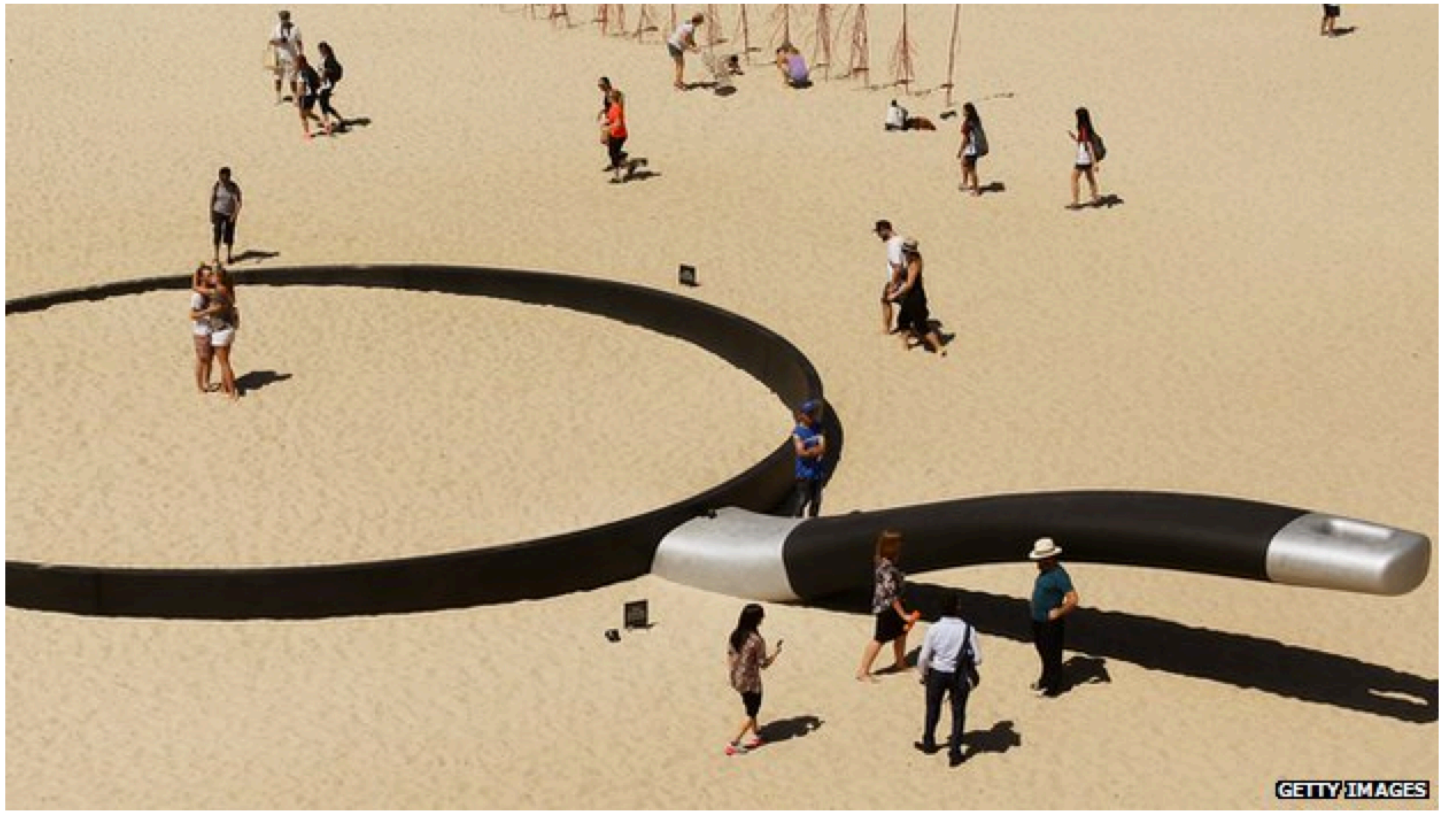


The upward march of the world's average

The upward march of the world's average temperature since 1891 is a trademark

2014 warmest year on record, say US researchers

By Mark Kinver
Environment reporter, BBC News



A sculpture called "We're fryin' out here" at a beach in Sydney

2014 was the warmest year on record, with global temperatures 0.68C (1.24F) above the long-term average, US government scientists have said.

Related Stories

2015 is warmest year on record, NOAA and NASA say

By Brandon Miller, CNN senior meteorologist

Updated 5:55 PM ET, Wed January 20, 2016

Story highlights

The high temperatures were fueled by record El Niño and climate change, NASA says

December became the first month to reach 2-degrees Fahrenheit above average

(CNN) — Last year was the Earth's warmest since record-keeping began in 1880, the U.S. National Oceanic and Atmospheric Administration and NASA said Wednesday.

It's been clear for quite some time that 2015 would steal the distinction of the hottest year from 2014, with 10 out of the 12 months last year being the warmest respective months on record -- and those records go back 136 years.

While it wasn't necessarily a surprise that 2015 finished in first place, its margin of victory was startling -- it lapped the field, with the average temperature across the entire planet 1.62˚F (0.90˚C) above the 20th century average, more than 20% higher than the previous highest departure from average.

No scientific body of national or international standing maintains a formal opinion dissenting from any of these main points. The last national or international scientific body to drop dissent was the American Association of Petroleum Geologists which in 2007 updated its statement to its current non-committal position.

The American Association of Petroleum Geologists revised their position because

. Members have threatened to not renew their memberships… if AAPG does not alter its position on global climate change... And I have been told of members who already have resigned in previous years because of our current global climate change position… The current policy statement is not supported by a significant number of our members and prospective members.

The IPCC
International Panel on Climate Change

The IPCC
International Panel on Climate Change

CLIMATE CHANGE 2014
Synthesis Report

Summary for Policymakers

Edited by

The Core Writing Team
Synthesis Report

IPCC

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Chairman
Unit
IPCC

Leo Meyer
Head, Technical Support

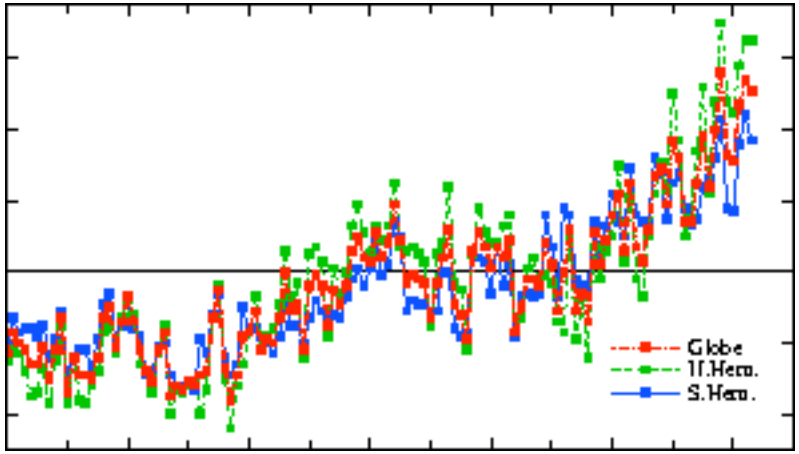
IPCC

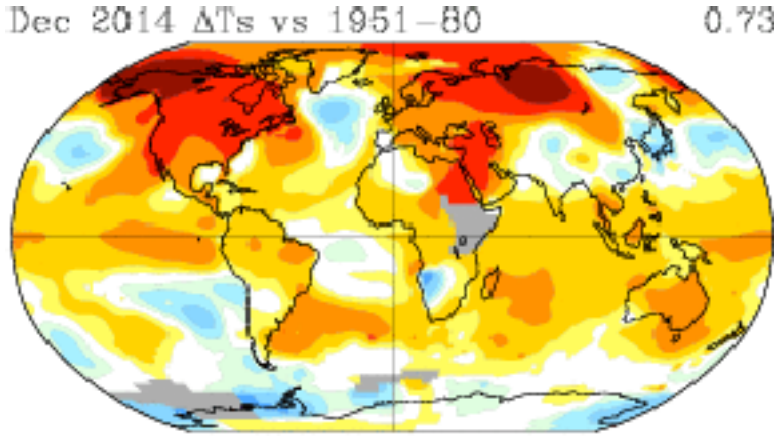
The IPCC
International Panel on Climate Change

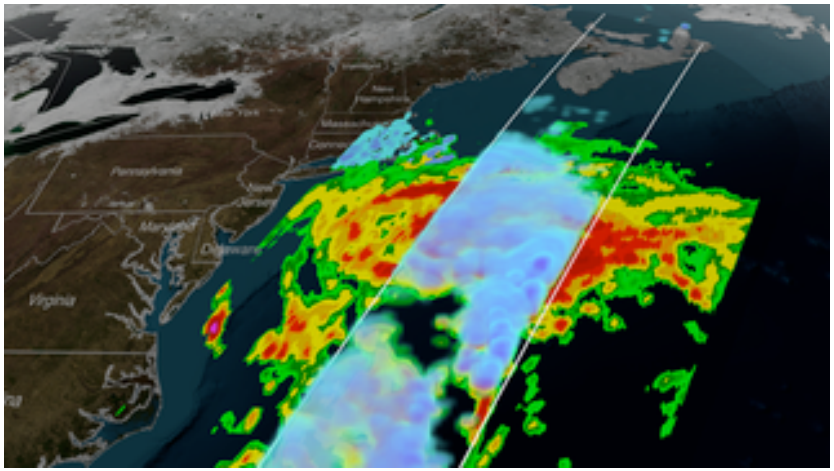
The warming of the climate system is unequivocal, as
is now evident from observations of increases in global average
air and ocean temperatures, widespread melting of snow and ice, and rising
global average sea level.

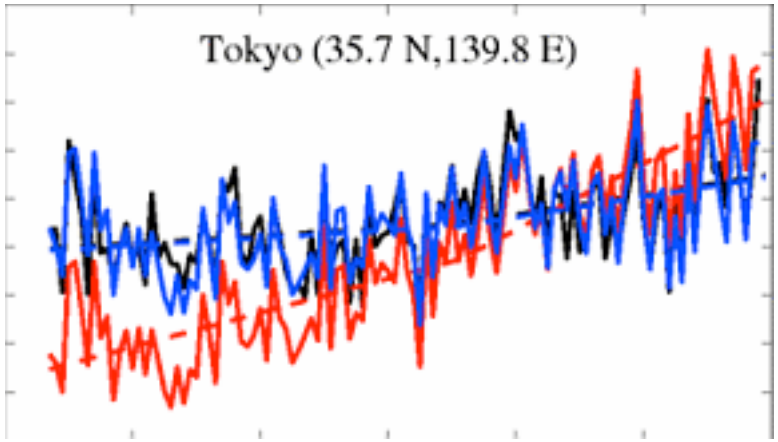
2007

National Aeronautics and Space Administration
Goddard Institute for Space Studies





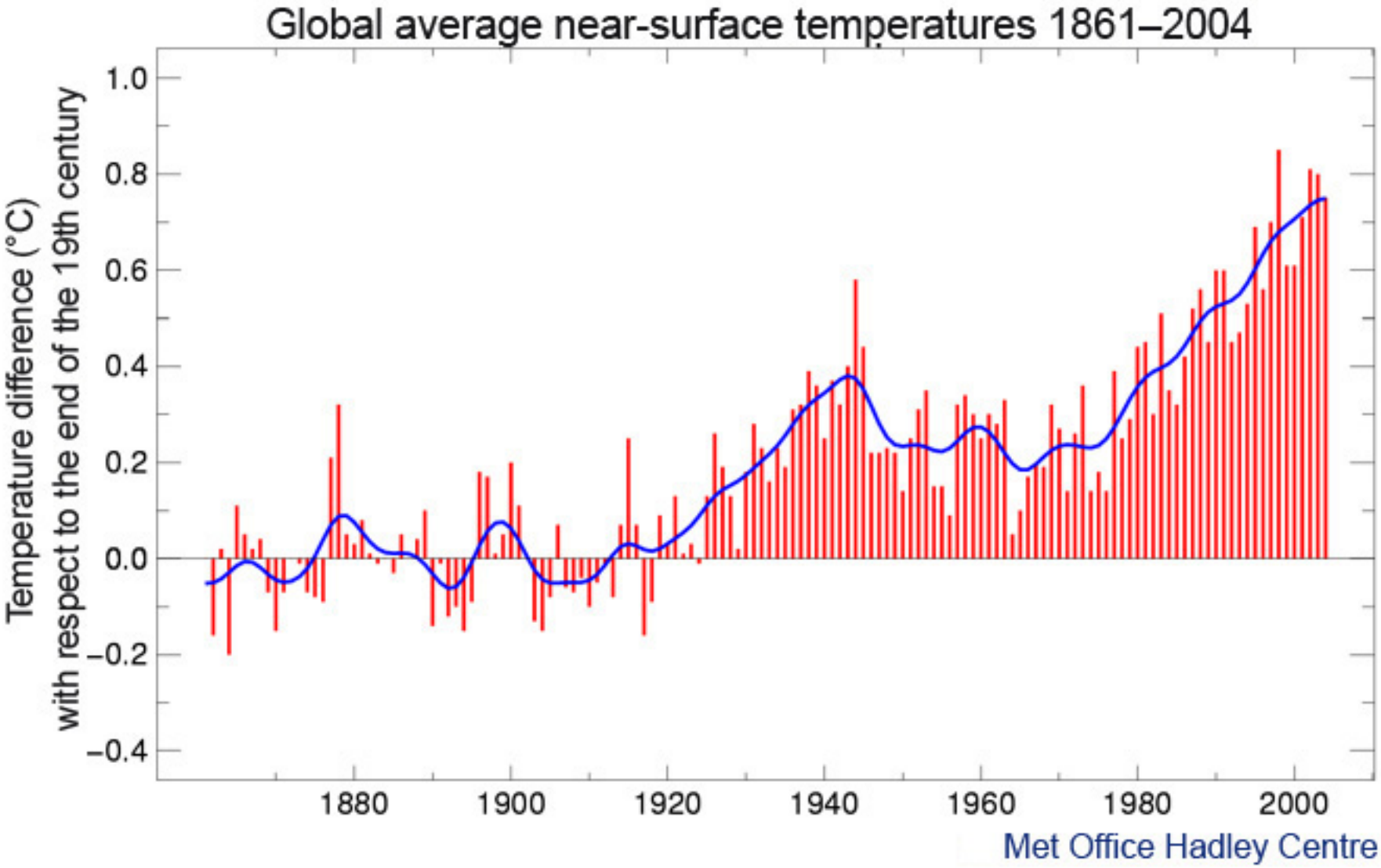




National Aeronautics and Space Administration
Goddard Institute for Space Studies

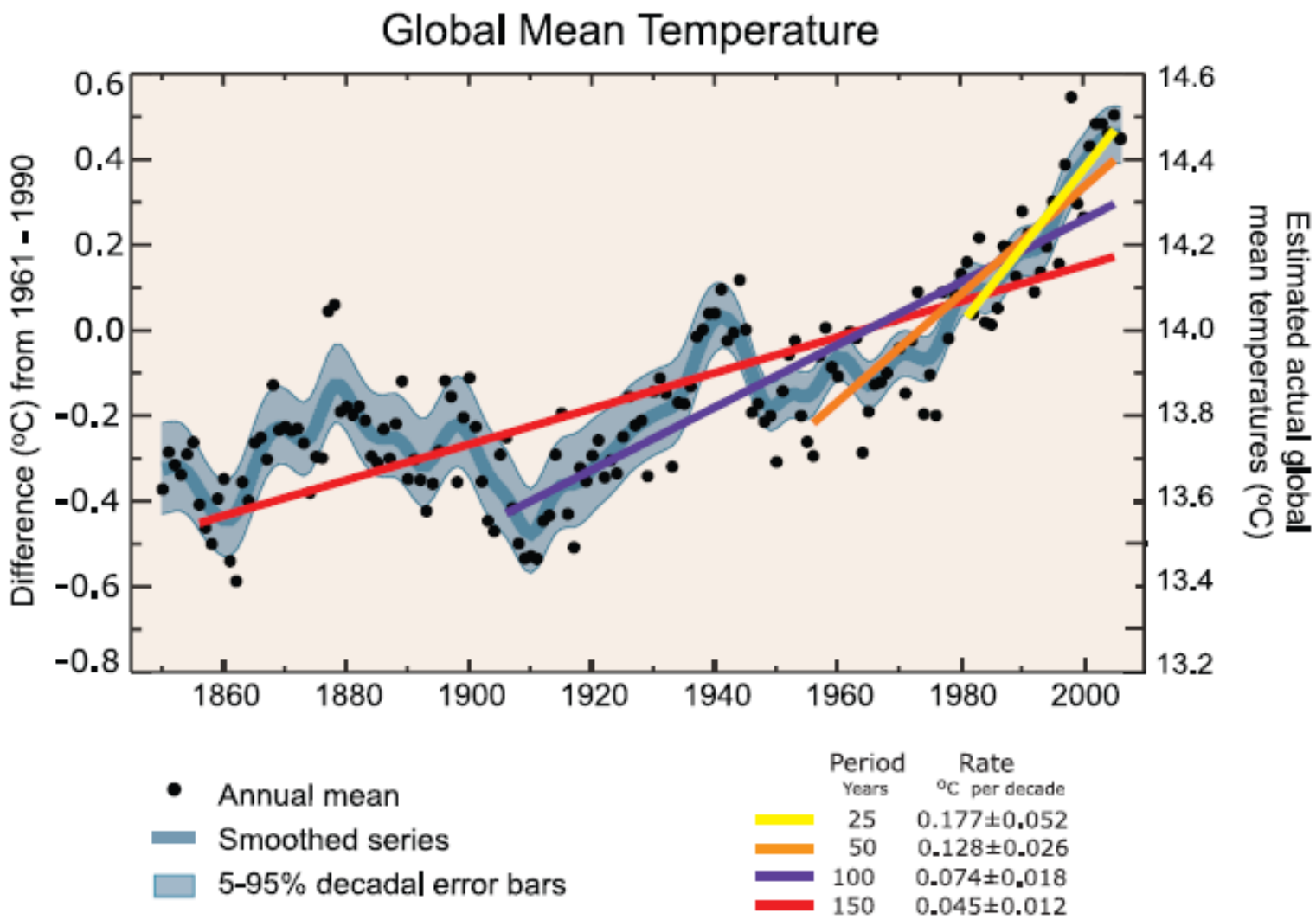
Five-Year Global Temperature Anomalies from 1880 to 2012

Observed Global Warming



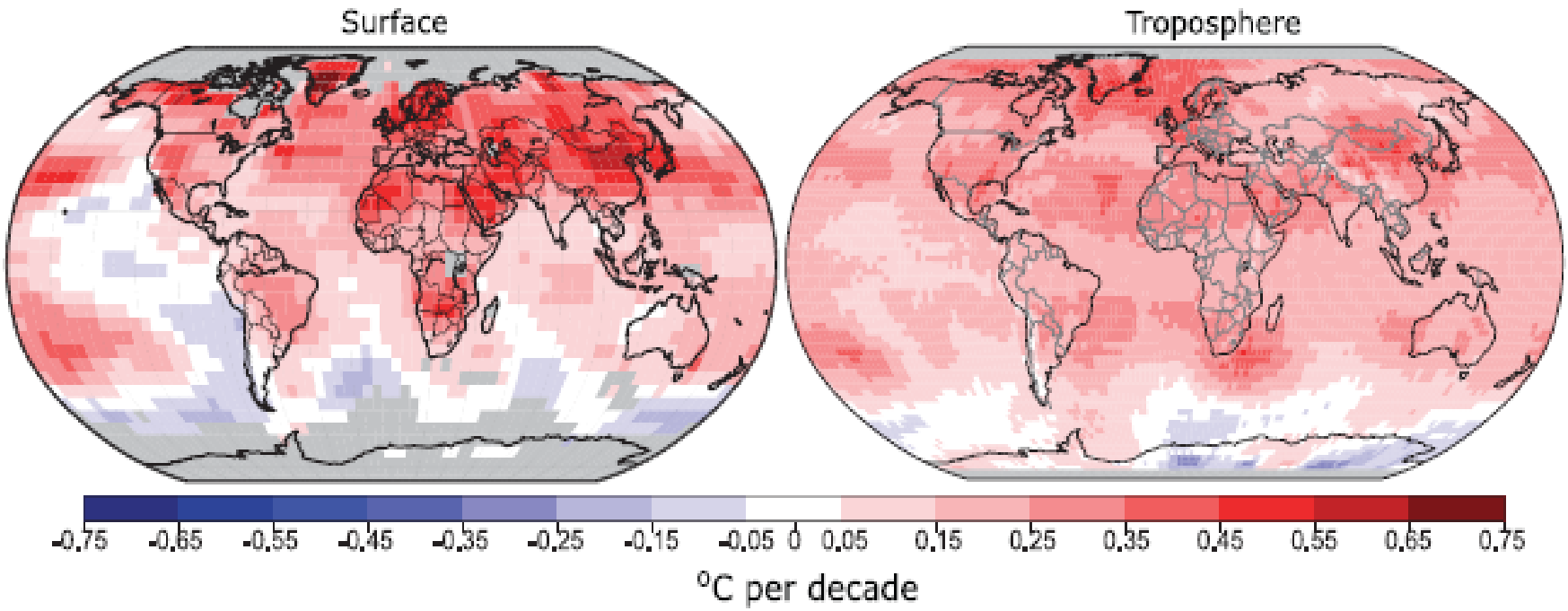
Hadley Centre for Climate Prediction and Research

Observed Global Warming



Trenberth et al., 2007

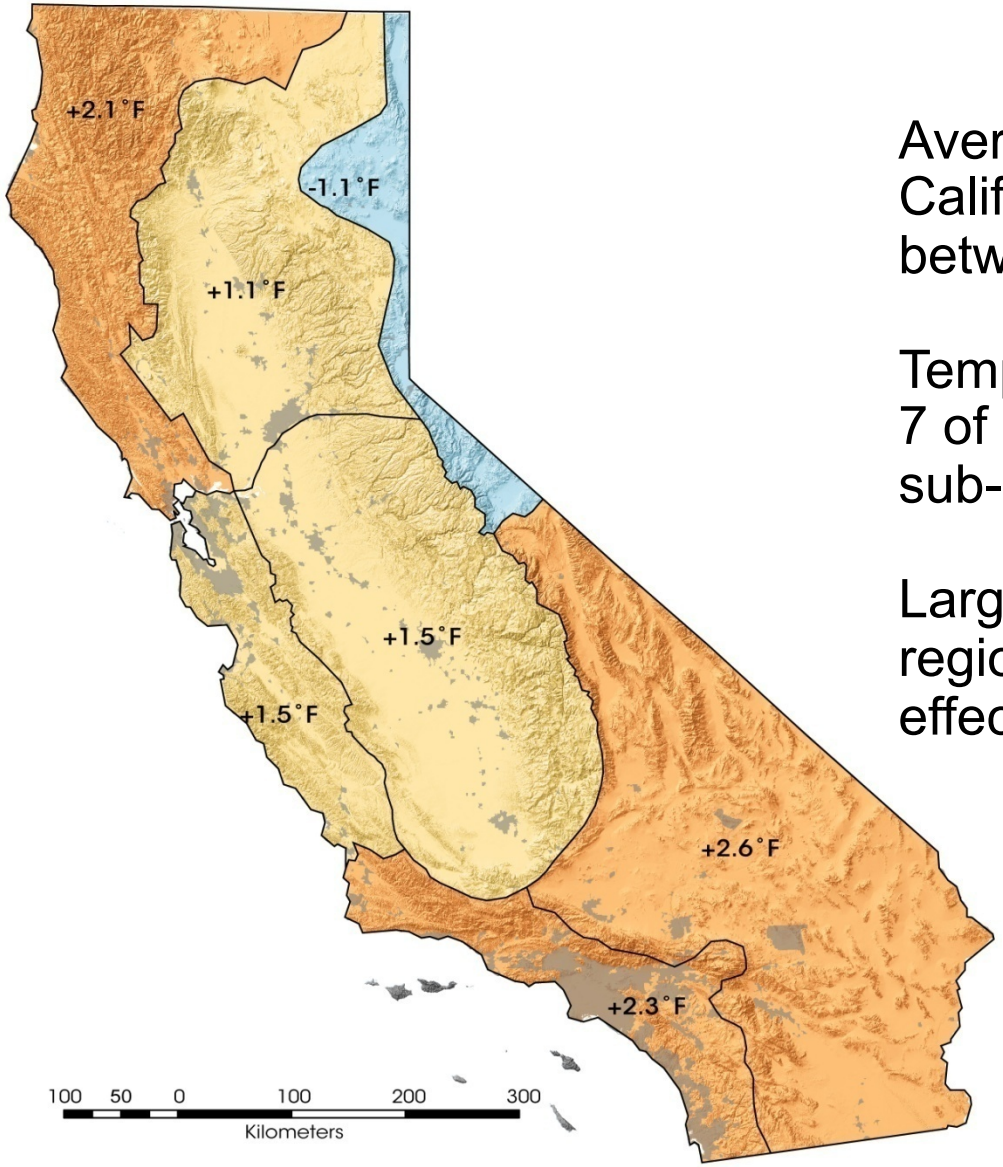
Observed Global Warming



Patterns of linear global temperature trends from 1979 to 2005 estimated at the surface, and for the troposphere from the surface to about 10 km altitude, from satellite records. Grey areas indicate incomplete data.

Trenberth et al., 2007

California – Observations (1950 – 2000)



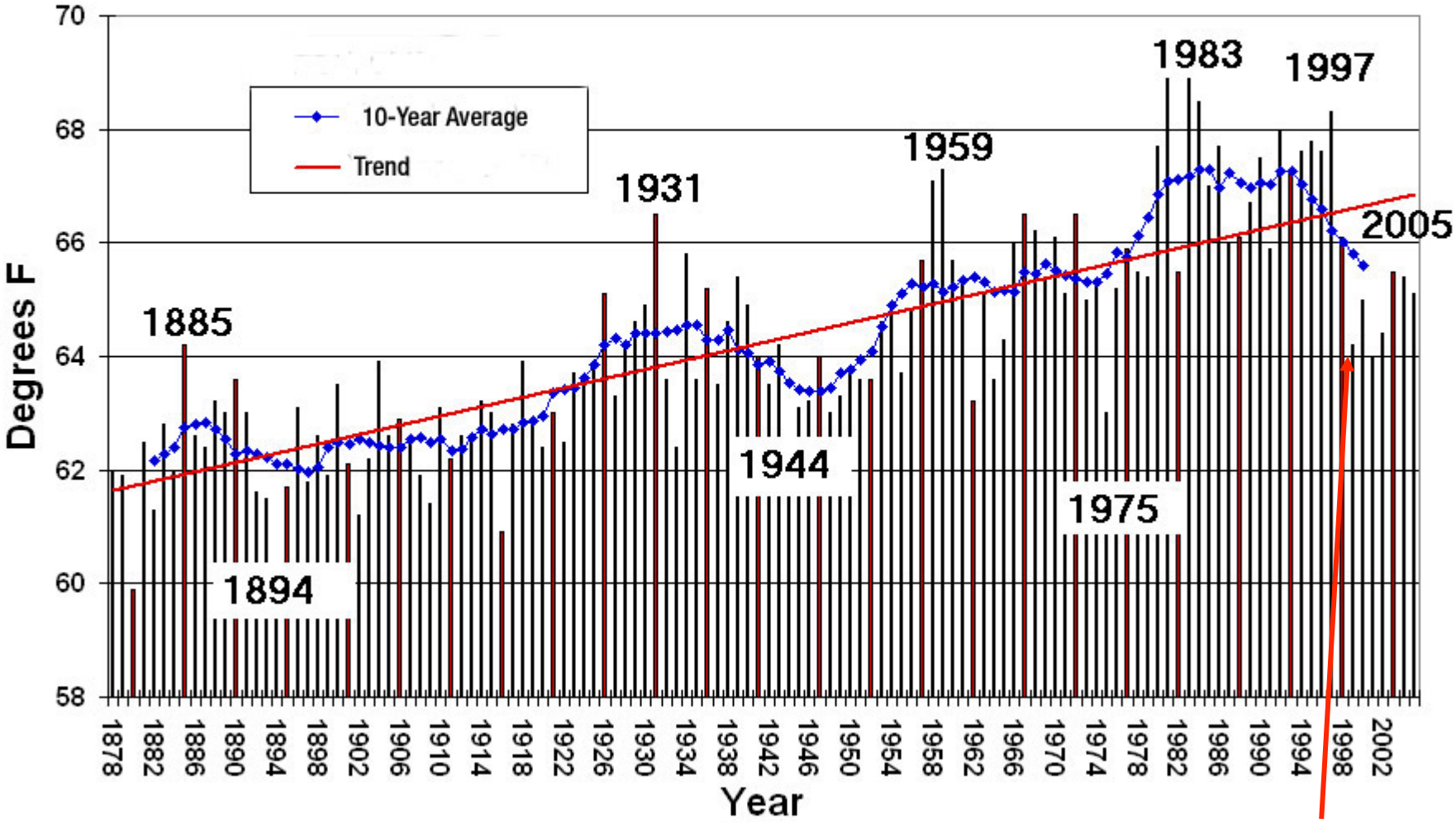
Average temperatures in California rose nearly 2 ^{o}F between 1950 and 2000.

Temperatures rose in 6 out of 7 of the state's major climatic sub-regions.

Larger increases in urban regions – urban heat island effect.

Medina and Patzert, , http://earthobservatory.nasa.gov/IOTD/view.php?id=7596

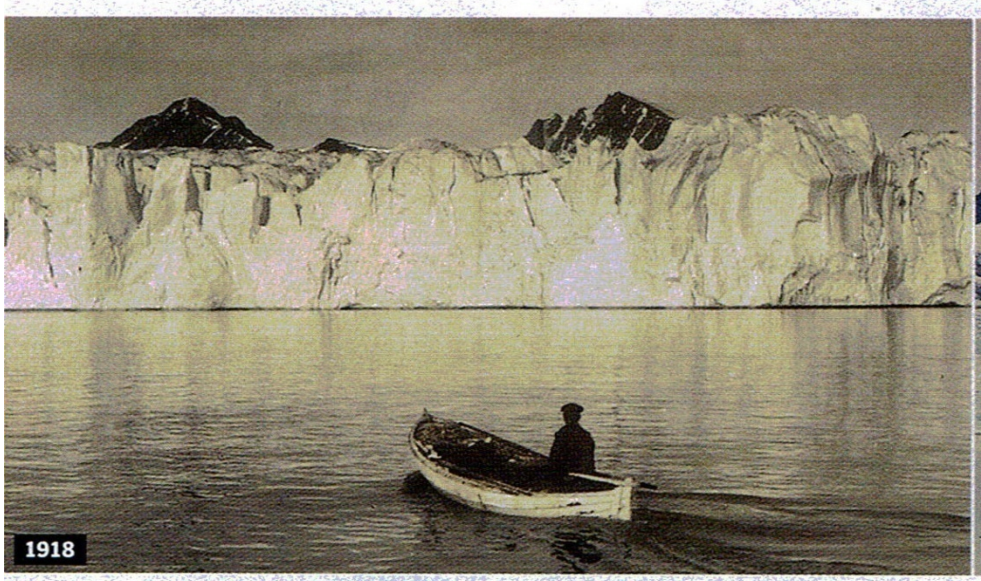
Los Angeles Civic Center (USC Campus)
Average Annual Temperature (1878-2005)



Station moved in 1999

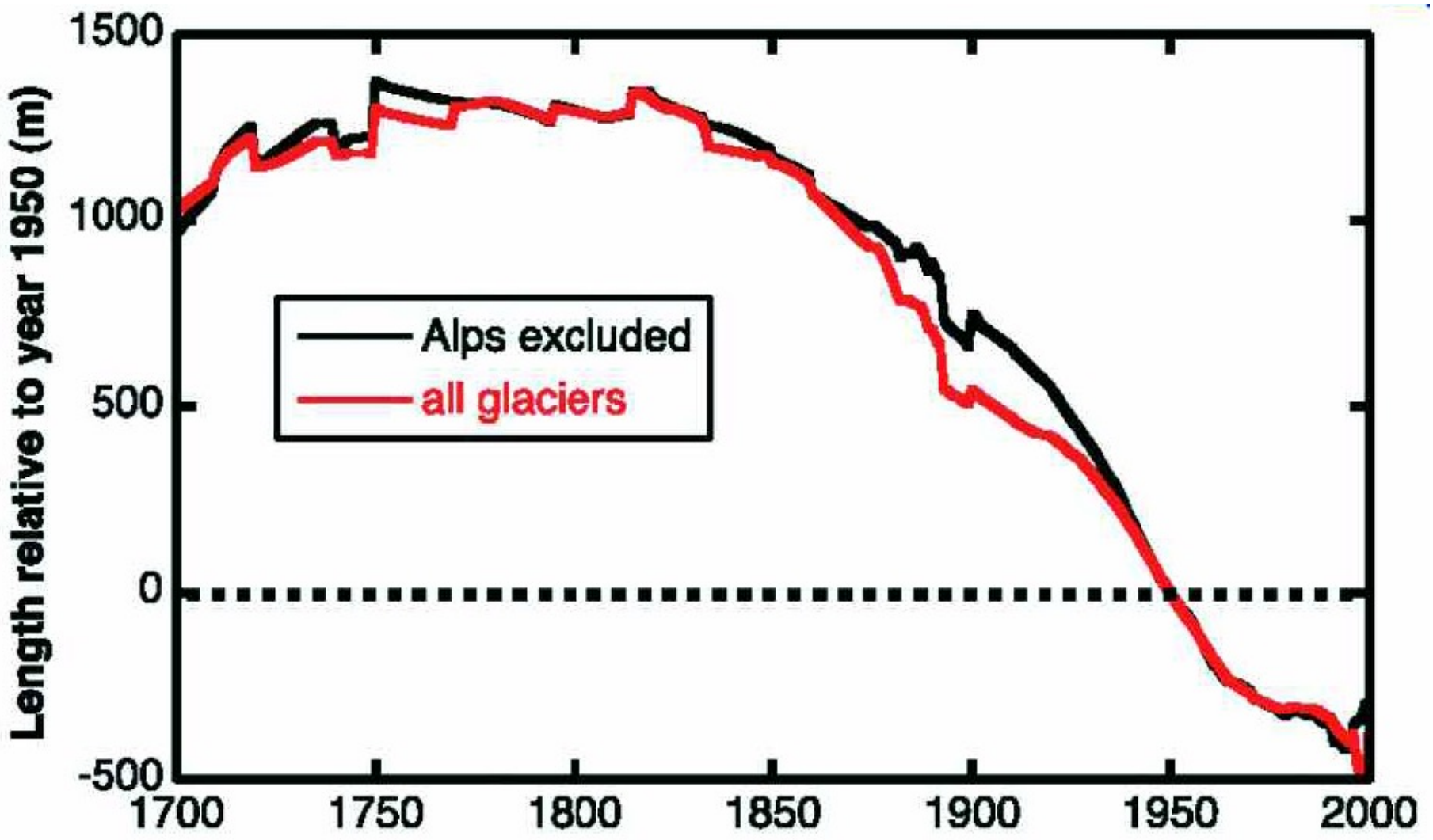
Evidence for global warming?

Glaciers all over the planet are disappearing at faster rates than scientists expected. Austria's Pasterze glacier (above) has retreated almost two miles already.



The accelerated melting of glaciers, such as the Kongsfjorden in Norway (above), increases the rate at which sea levels rise.

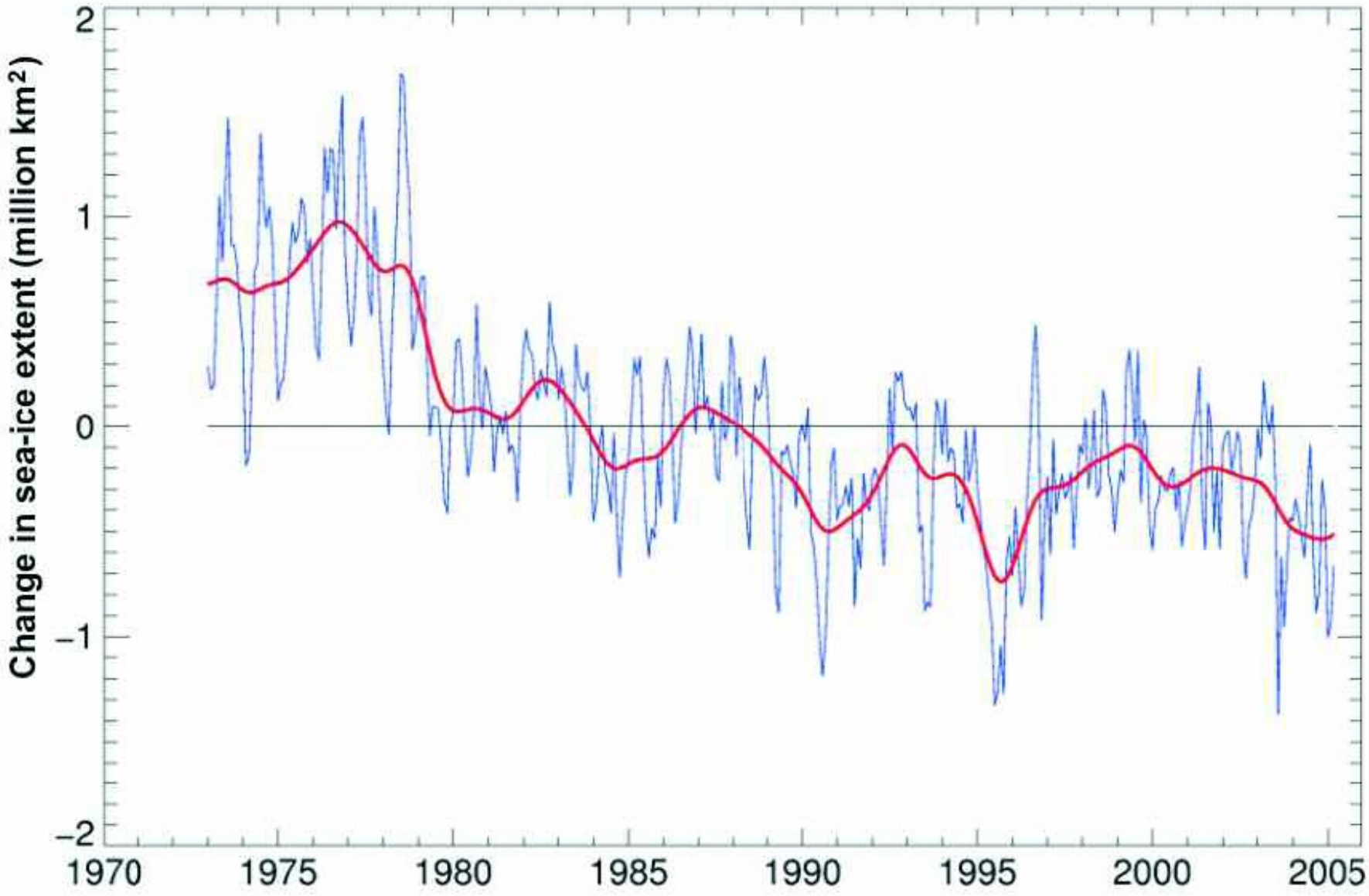
Retreat of glaciers



Oerlemans, 2005.

Hadley Centre for Climate Prediction and Research

Decrease in Arctic Sea-Ice



Hadley Centre for Climate Prediction and Research

Chasing Ice

It's like watching Manhattan breaking apart in front of your eyes
The largest iceberg calving ever filmed

After weeks of waiting, the filmakers witnessed 7.4 cubic km of ice crashing off the Ilulissat glacier in Greenland.

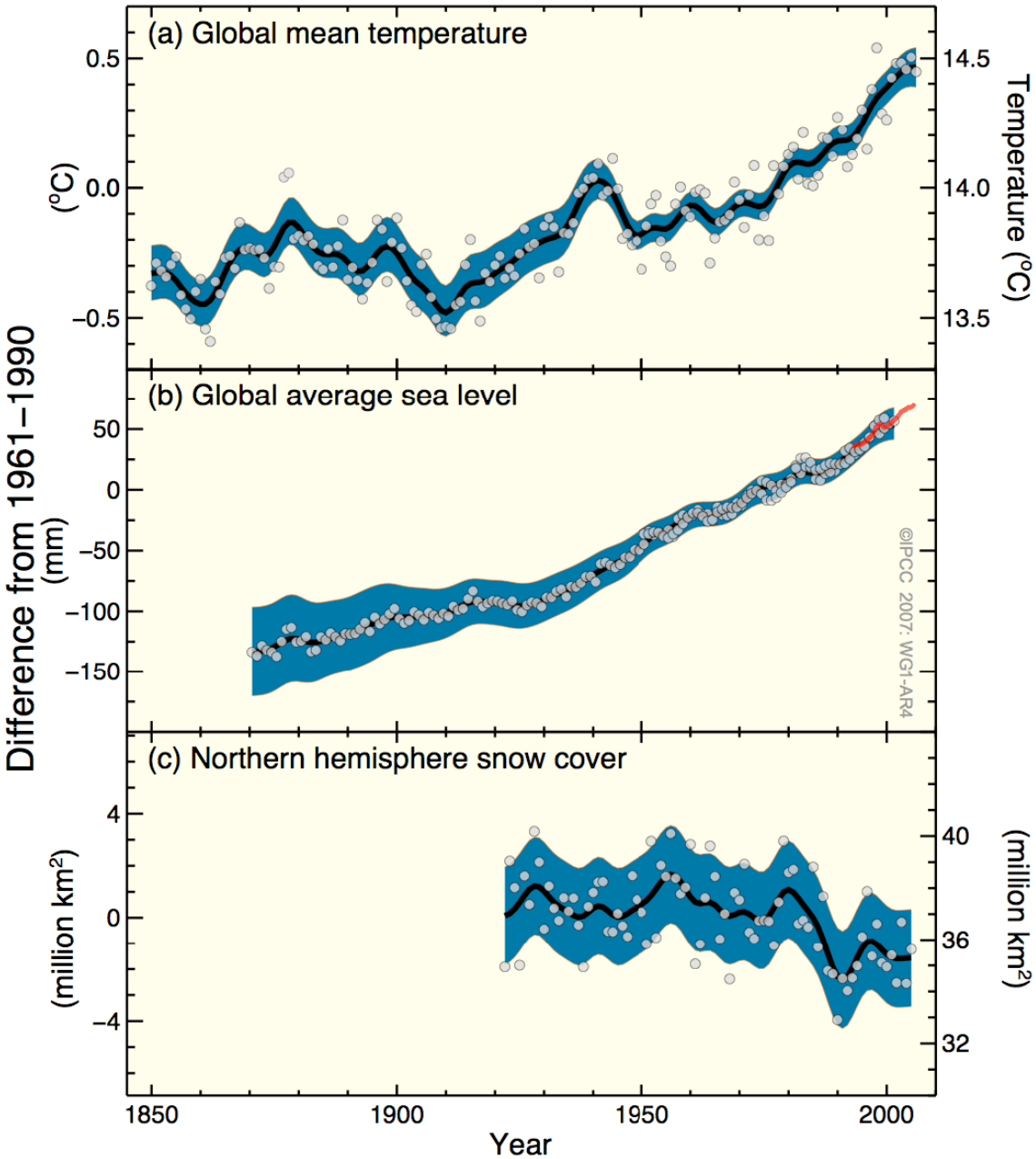
James Balog

The miracle and the horror

Arctic Sea Ice Observations

(requires internet; 6 mins)

Observed Changes in Sea Level, Temperature and N.H. Snow Cover



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University press, 2007). http://www.ipcc.ch

Climate Change Explained

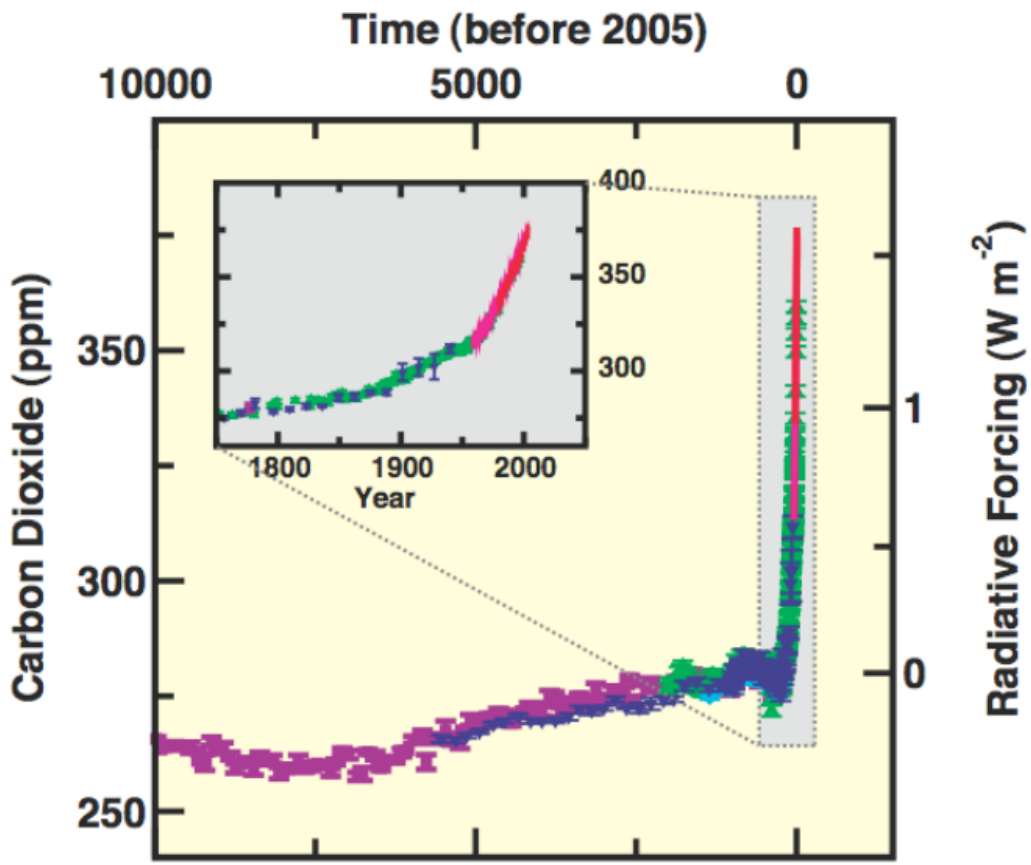
National Academy of Sciences explains global warming

(requires internet; 26 mins)

Projections

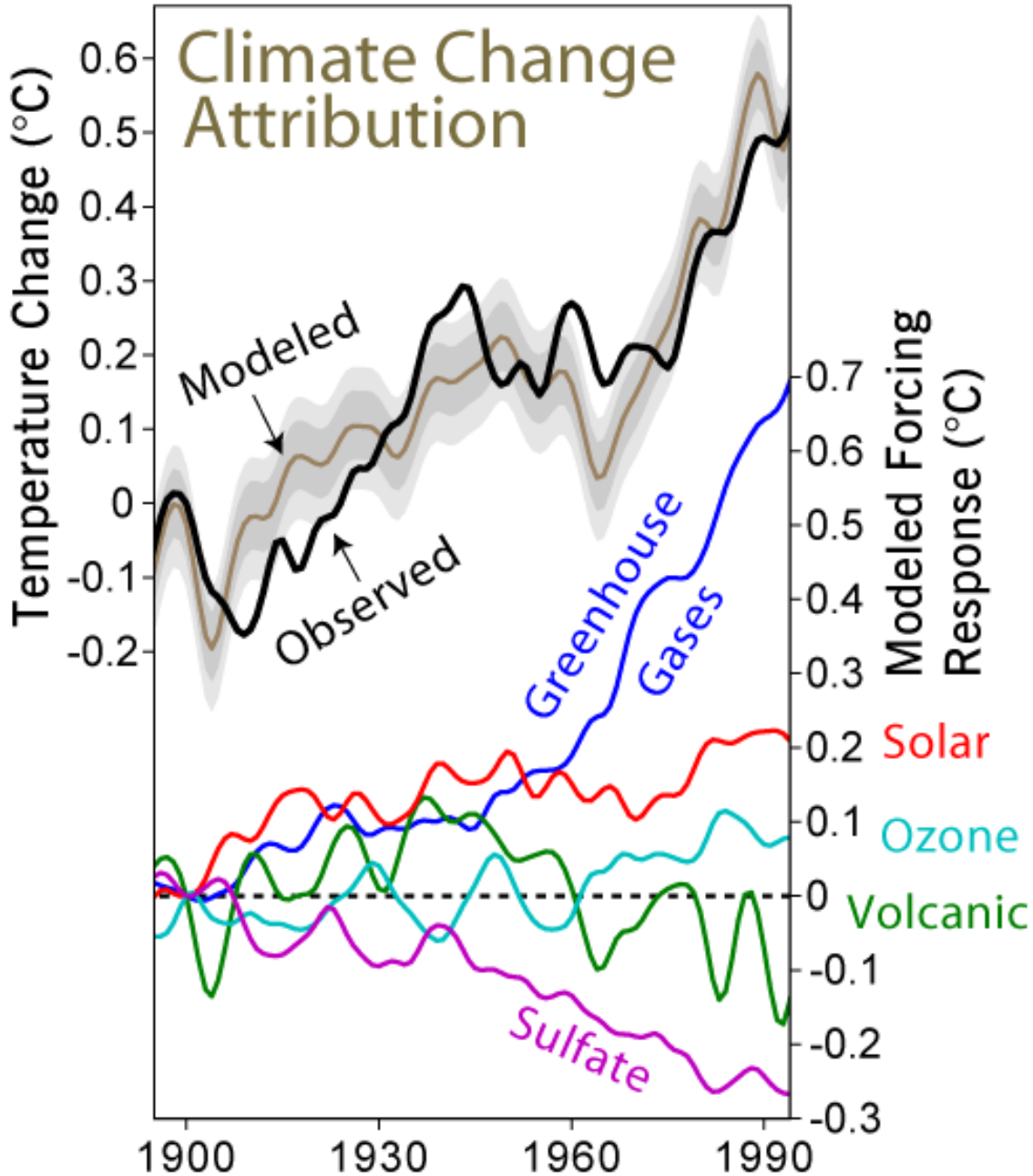
Greenhouse Gases

water vapor, carbon dioxide, methane, nitrous oxide, ozone.



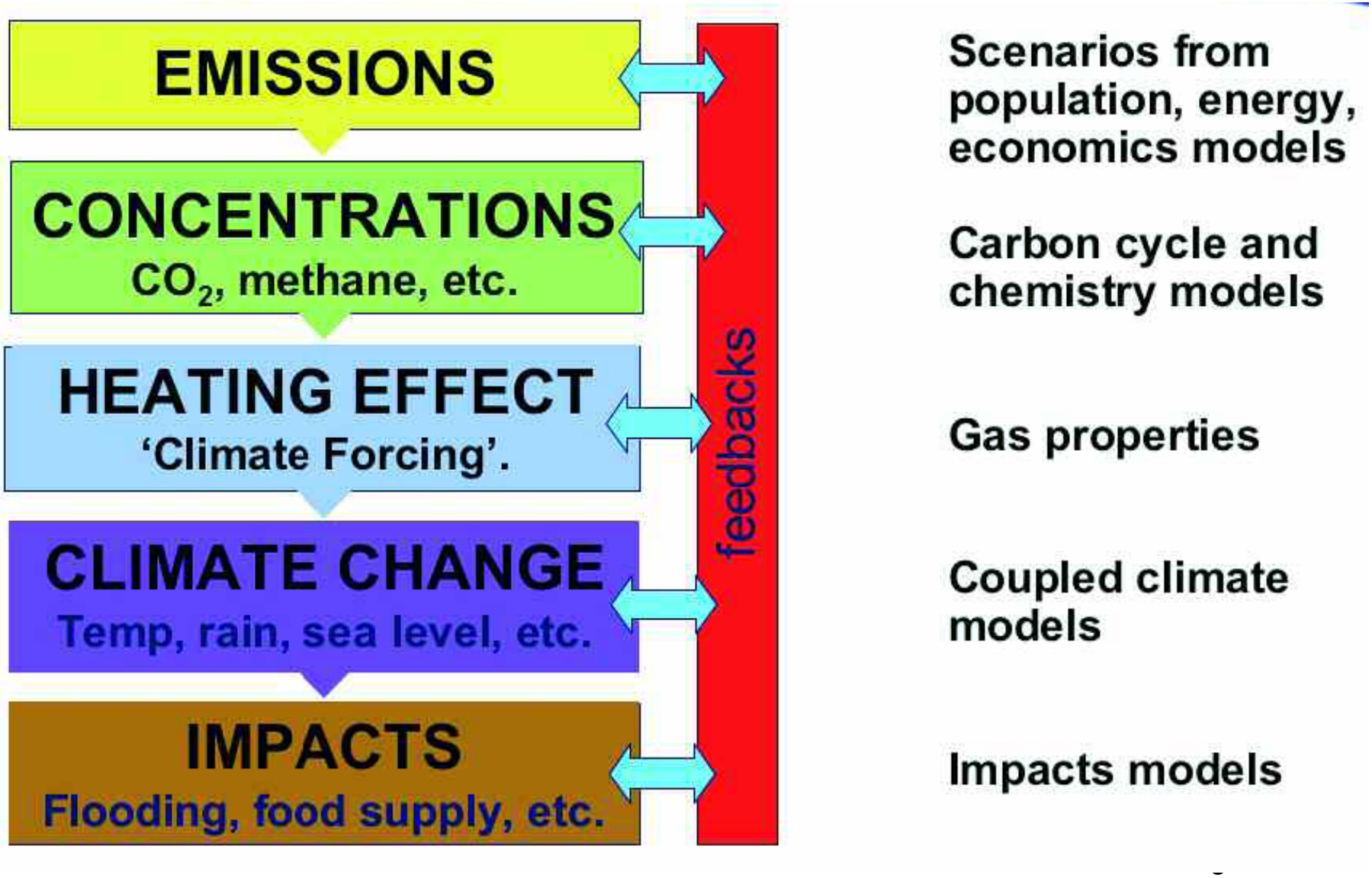
Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University Press. http://www.ipcc.ch

•When all components are included it is the GHG that create agreement between models and observations.



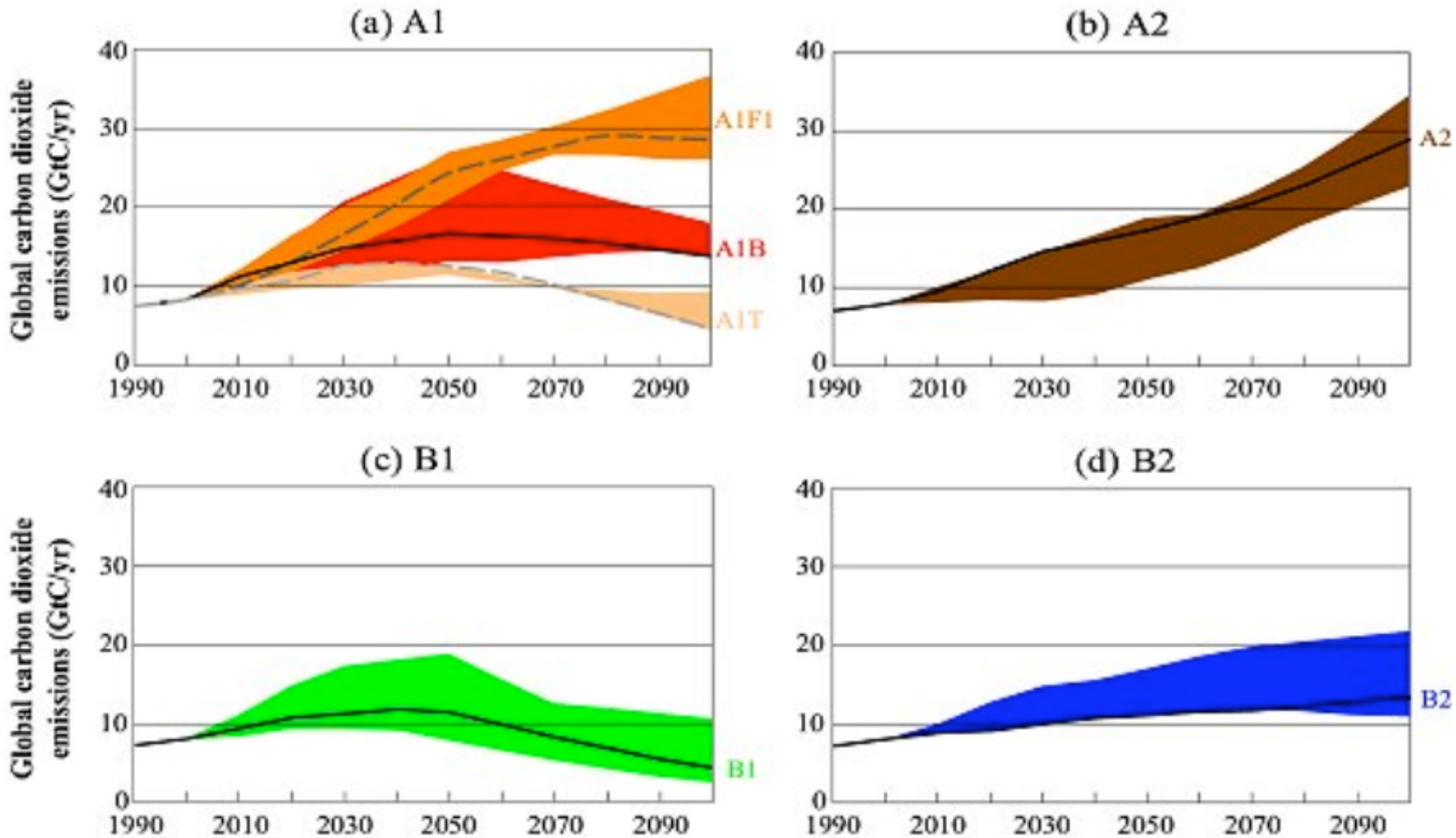
Meehl et al. (2004)

Helen M. Cox, 2010



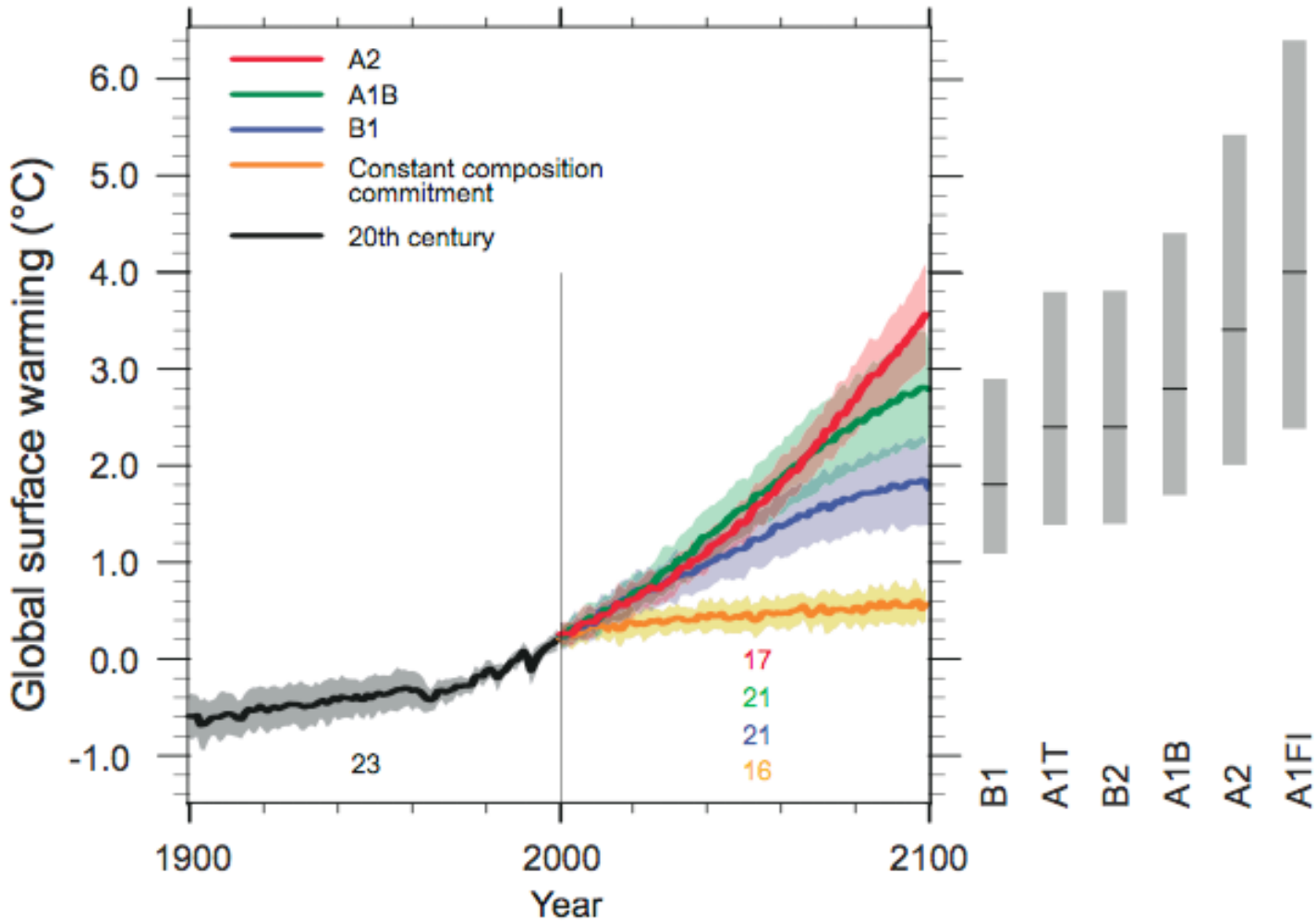
Source: Sato et al, GISS, NASA

SRES emissions projections, by storyline



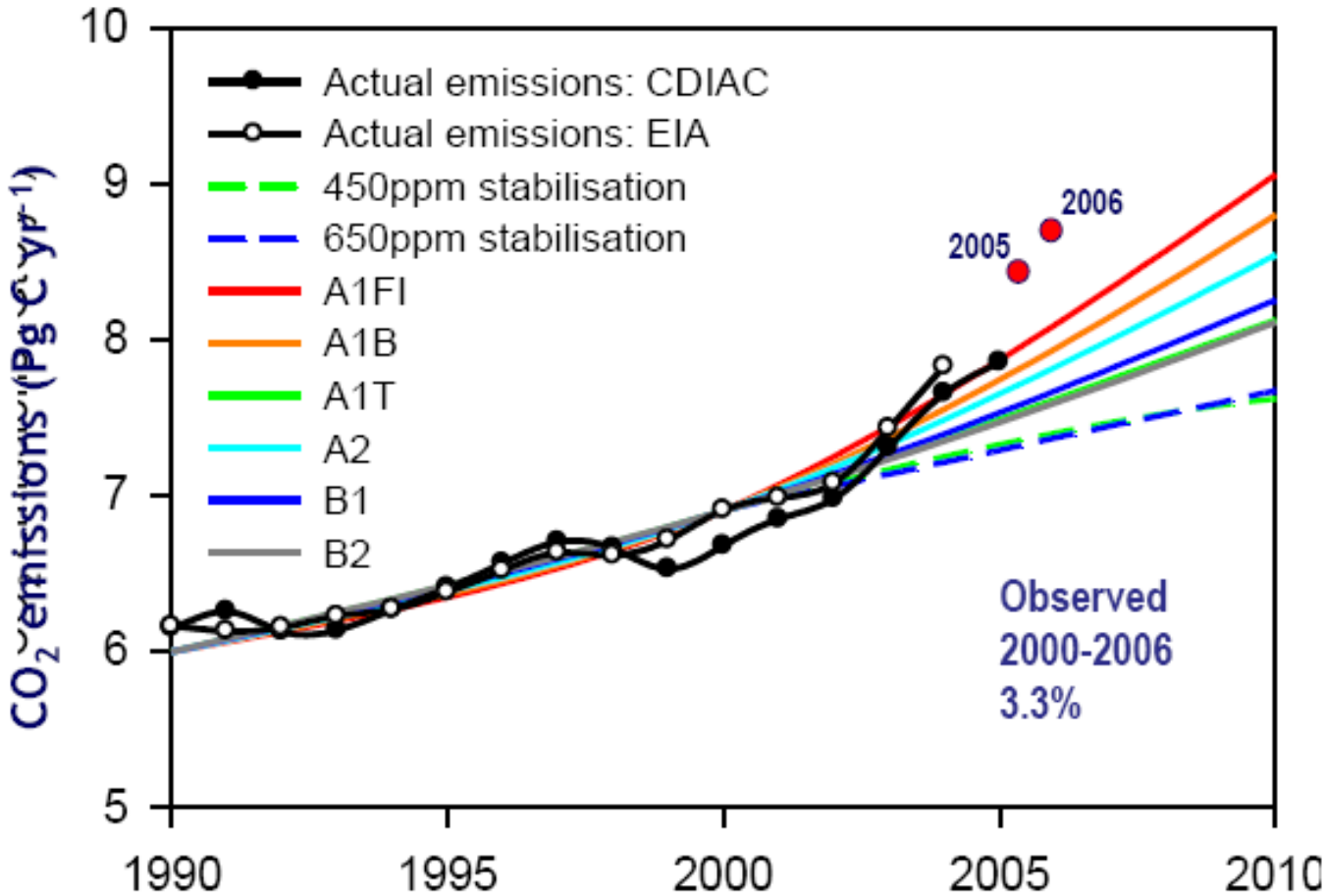
Global Averages of Surface Warming

(relative to 1980-99)



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University press, 2007). http://www.ipcc.ch

Annual worldwide CO_2 emissions have grown faster than any of the IPCC 2001 scenarios



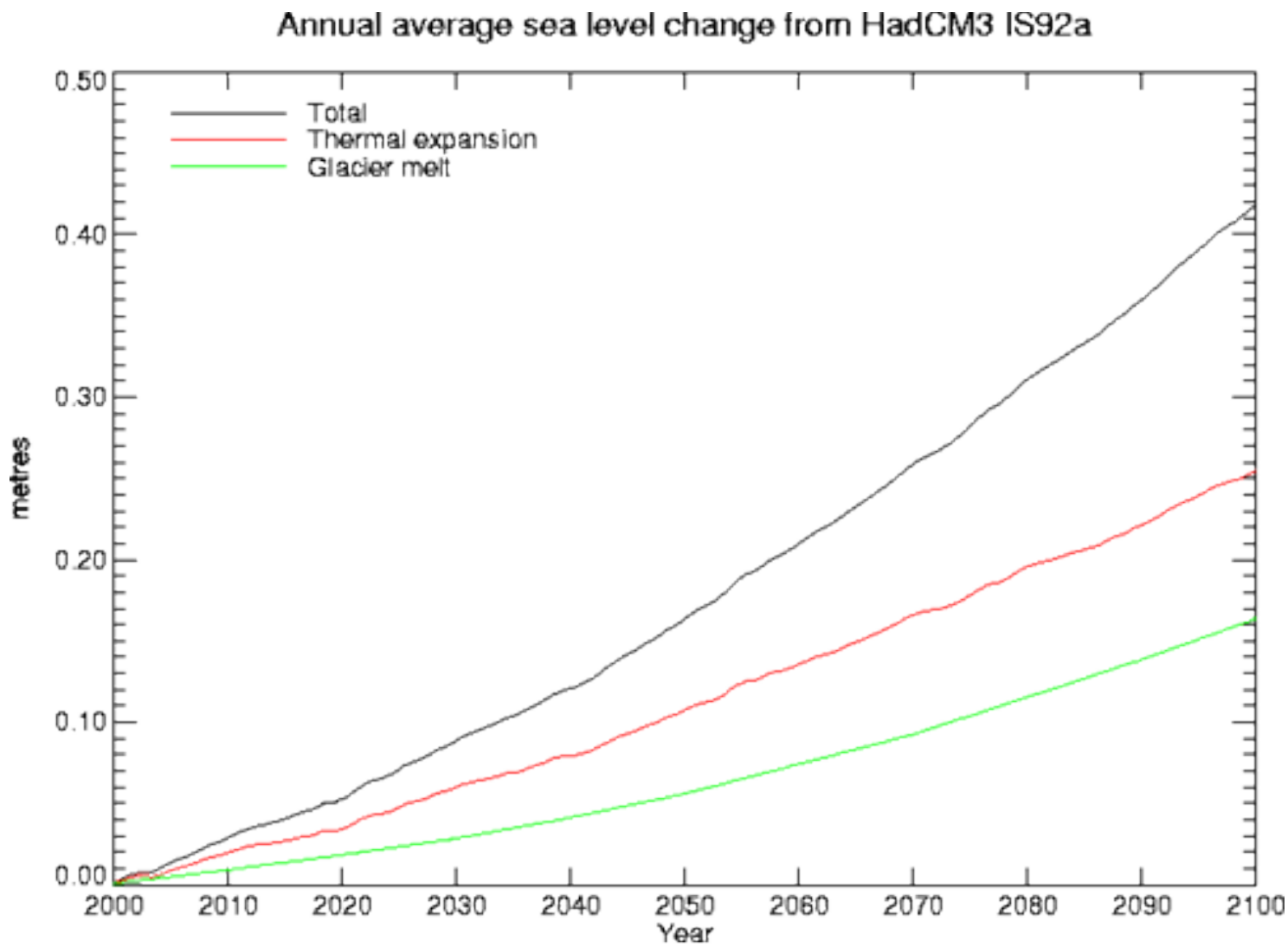
Helen M. Cox, 2010

Global Projections of Climate Change (UK Met Office)

or

http://www.youtube.com/watch?v=7KQ-cAqwtXs

(same but higher res.; requires internet)



16”

Temperature increases cause sea level rise through thermal expansion and melting of land glaciers.

Hadley Center for Climate Prediction and Research, UK

Projected Changes in Sea Level

"Projections of global sea-level rise by 2100 range from 20 cm to as much as 2 m, and sea level will not stop rising then. For civilization, the stakes are high. Without adaptation, a rise by 0.5 m would displace 3.8 million people in the most fertile part of the Nile River Delta. A rise by 2 m could displace 187 million people globally . Credible projections of sea-level rise in the 21st century are essential for devising adaptation or mitigation measures. Yet, present estimates of future sea-level rise are too imprecise to inform such decisions."

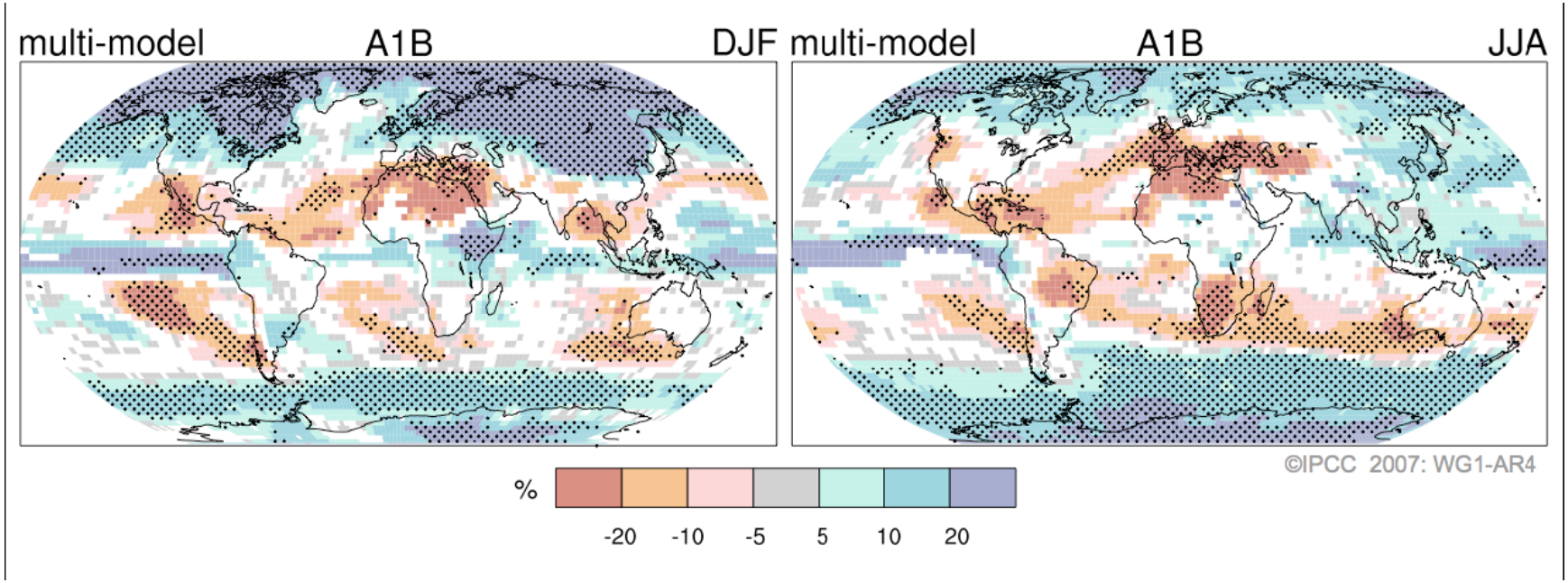
Willis and Church (Science, 2012)

Colbert Report: Sink or swim

(requires internet; 5 mins)

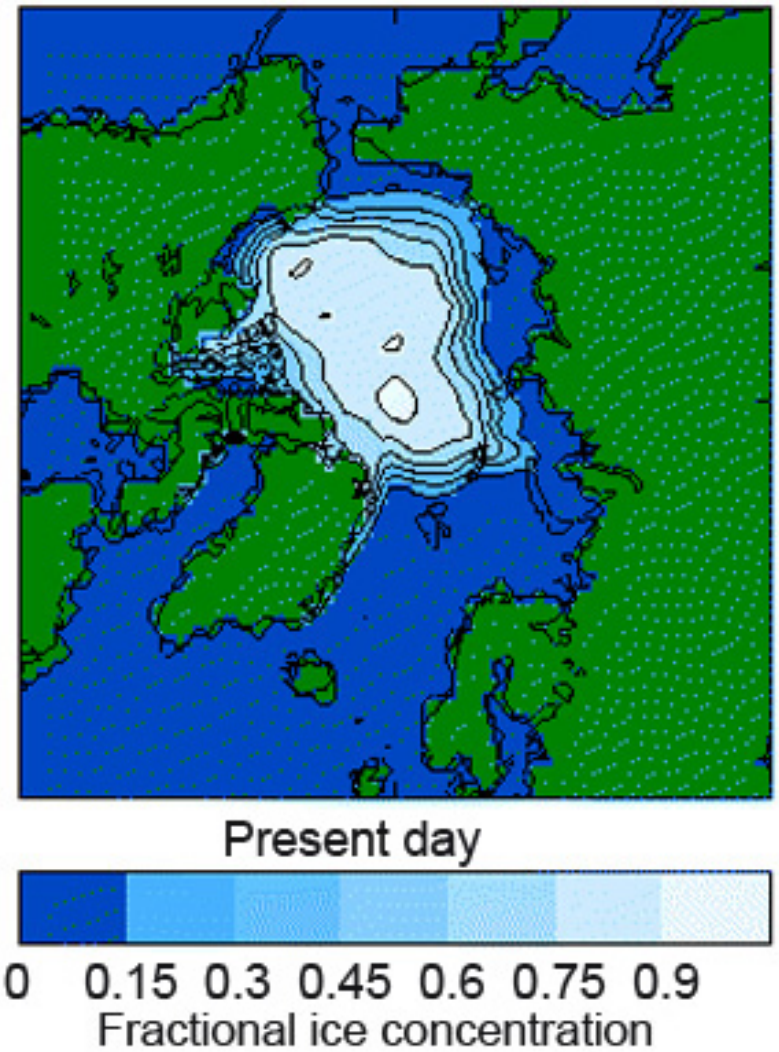
Projected Changes in Precipitation

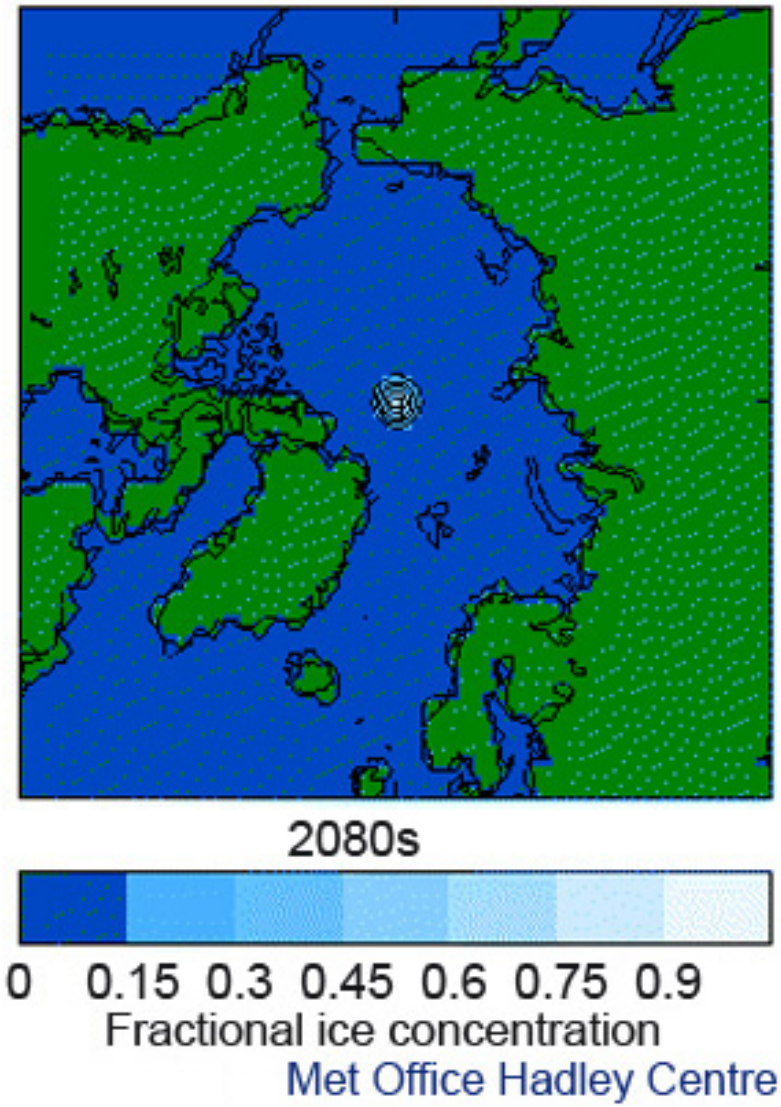
(for 2090-2099 relative to 1980-1999)



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University press, 2007). http://www.ipcc.ch

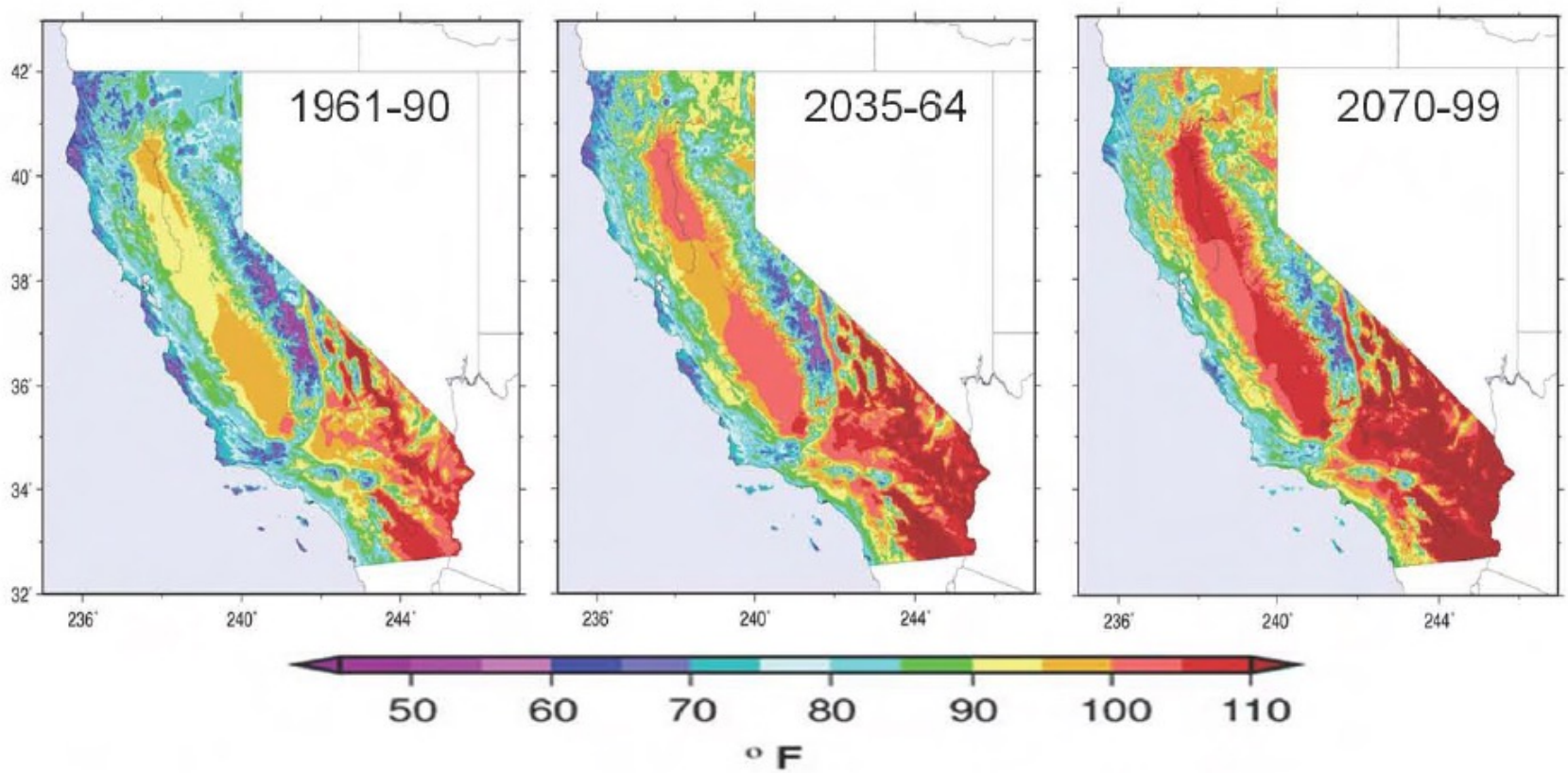
Arctic summer sea-ice could disappear by 2080s or before





Hadley Centre for Climate Prediction and Research

Figure 1. California Historical & Projected July Temperature Increase 1961-2099



From: *2009 California Climate Change Adaptation Strategy* Cayan et al., 2009

Global warming impacts are potentially huge, but most of these are not primarily from temperature itself.

Impacts on the hydrological cycle are the most far-reaching

Arctic sea ice will likely disappear completely in summer by the year 2037

Changes in the global distribution of heat and precipitation, and the addition to ocean waters of meltwater from sea ice and ice sheets may cause large scale changes to ocean circulation

more intense tropical cyclones

development has occurred on a massive scale in locations at or close to sea level so that our tolerance for any increase has greatly diminished.

Many countries, such as Bangladesh, China and India have huge populations living in low-lying coastal regions, inviting disaster from storm surges and typhoons

Himalayan glaciers feed the headwaters of the nine largest Asian rivers including the Ganges, the Yangtze, the Yellow, the Indus and the Brahmaputra and supply water to over 1 billion people living in India, Pakistan, Nepal, Bhutan, Bangladesh and China.

Should glacial recession continue at today's rates, the impacts from flooding and long-term water supply are likely to be devastating

Changes to Sierra snowfall: Without the reservoir capacity to store early runoff most of this will run straight to the ocean and be unavailable to supply freshwater to the southwest U.S. later in the year. This region includes the ten million people of Los Angeles County and the rich agricultural Central Valley, heavily reliant on irrigation from this source, and supplier of half of the nation's fruit and vegetables.

Difficult environmental choices must also be made to balance domestic, industrial and agricultural demands with those of fish and other aquatic creatures and the flow requirements for hydroelectric power generation.

Other Impacts

Agriculture – heat stress, higher water demand,
pests, disease

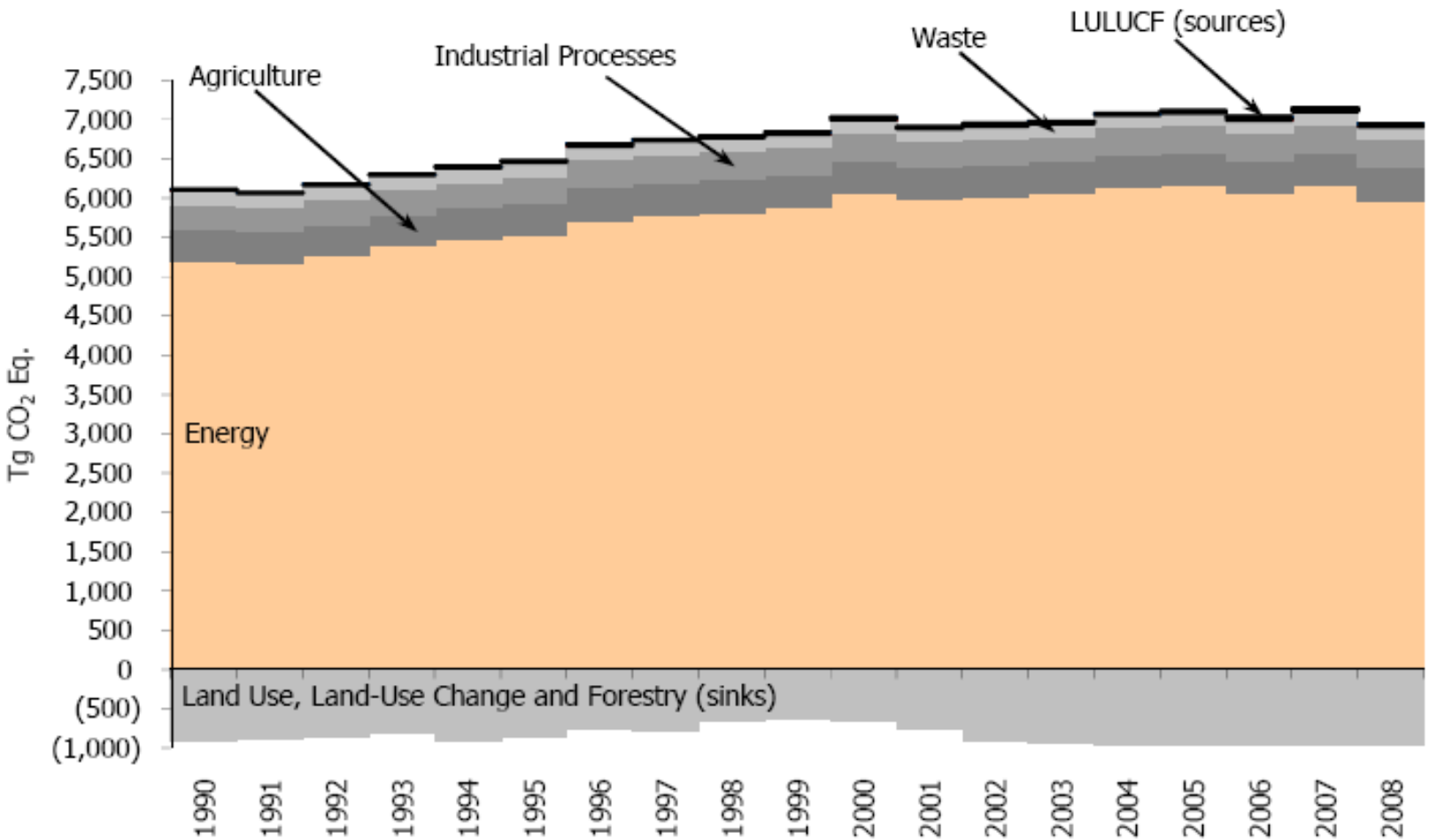
Wildfires

Coastal erosion, storm surges, flooding

Air pollution, health, disease

What do we do?

Energy accounts for 80% of GHG emissions

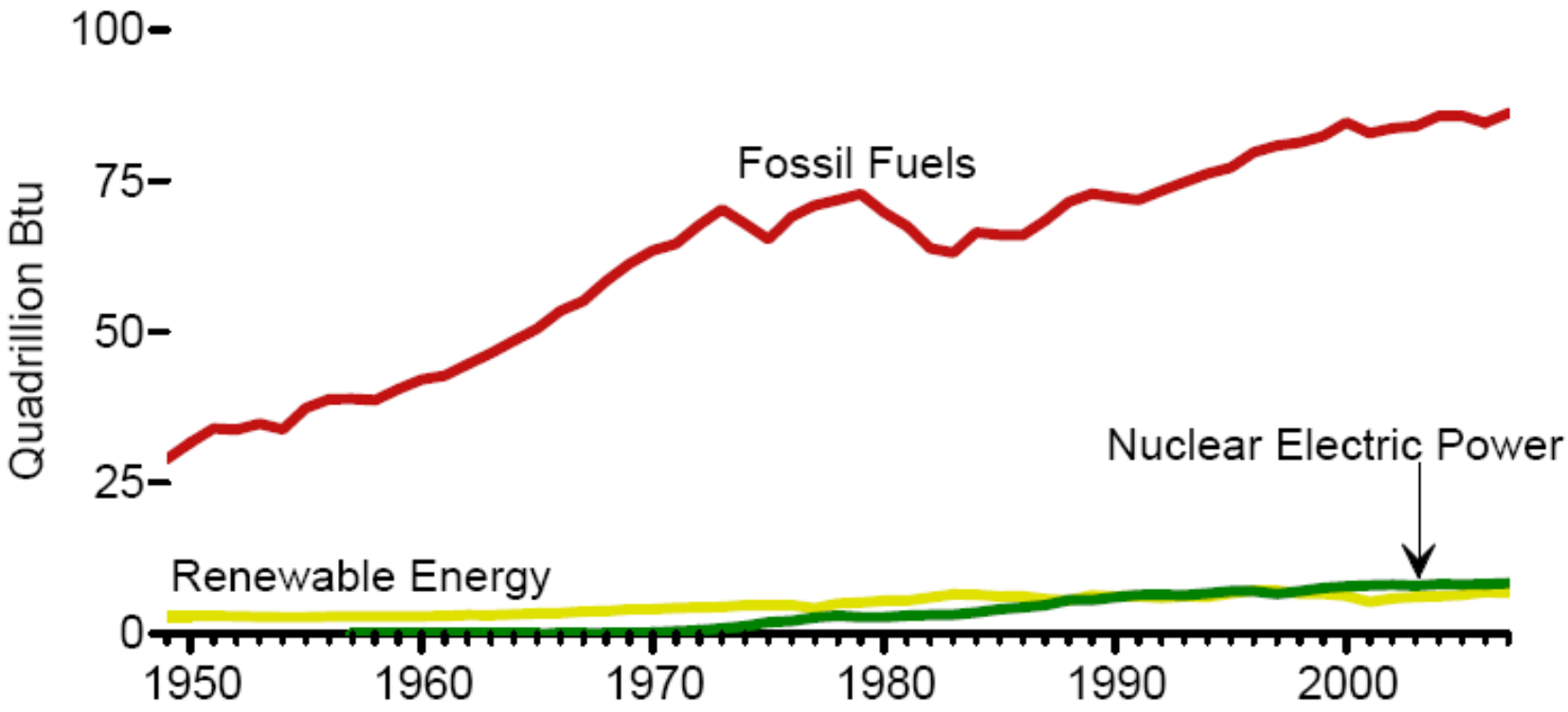


Note: Relatively smaller amounts of GWP-weighted emissions are also emitted from the Solvent and Other Product Use sector

Figure 2-4: U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector

http://epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010-Chapter-Trends.pdf

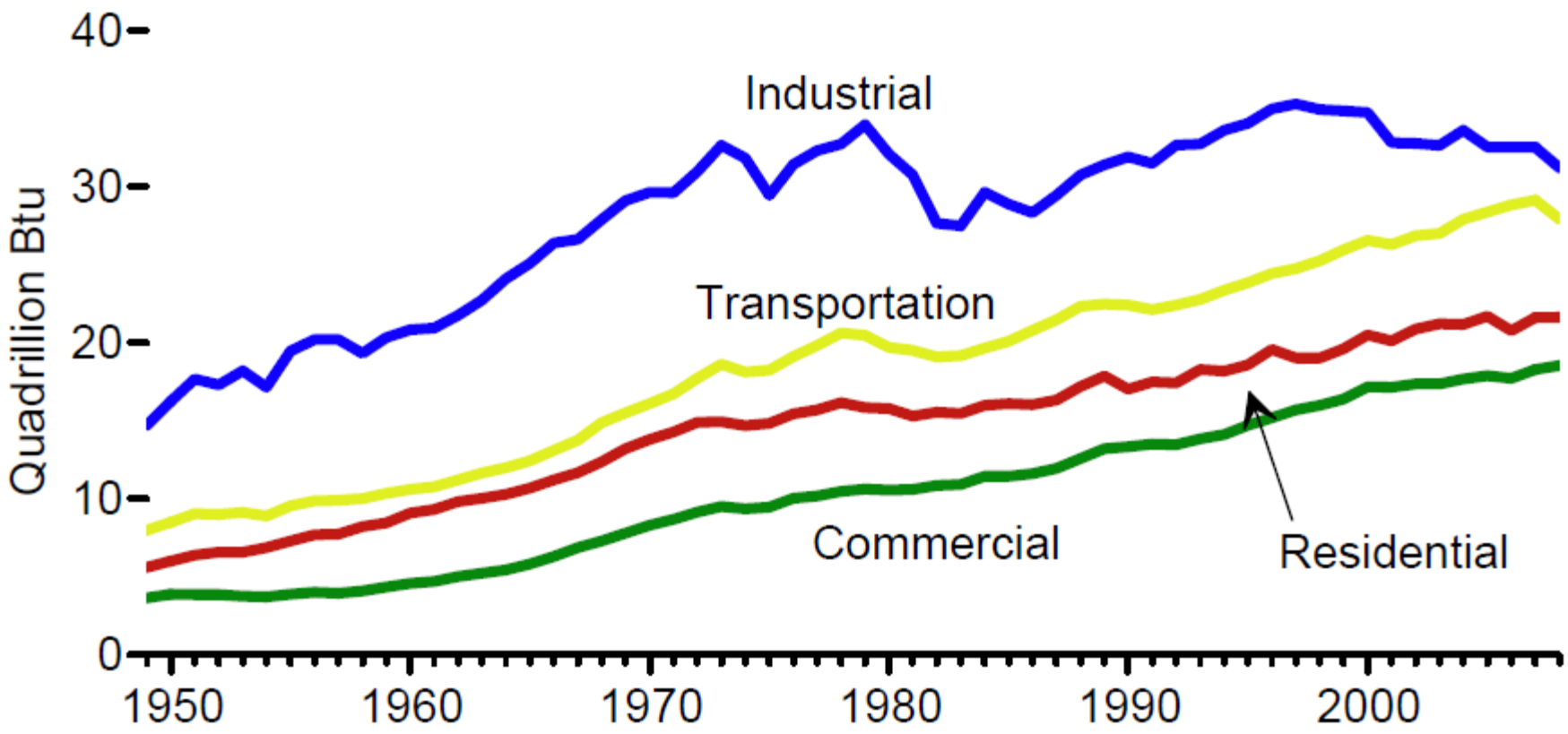
Primary Energy Consumption by Source



Source: Energy Information Administration / Annual Energy Review 2007

Helen M. Cox, 2010

Figure 7. Total Energy Consumption by End-Use Sector

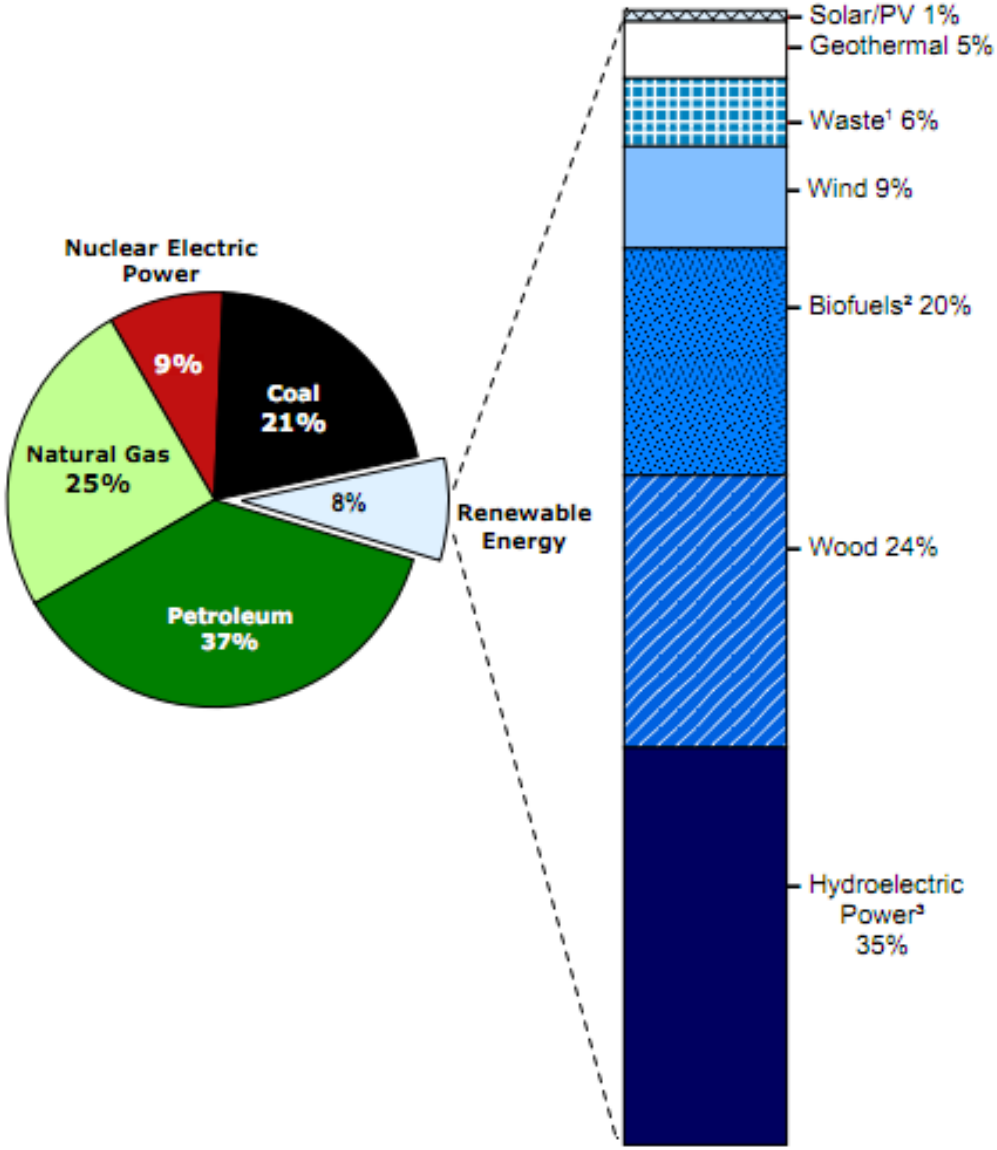


EIA Annual Energy Report, 2008

Helen M. Cox, 2010

Our Renewables Today

U.S. Energy consumption, 2009



Source: Energy Information Administration, 2011

Helen M. Cox, 2011

Climate change is inevitable but can be limited with the right policies.

Reduce energy use
Reduce waste
Reduce fertilizer use
Stop deforestation
Re-forest
Regulate GHG emission reductions

Incentivize GHG reductions –

Cap and Trade

Can it work?