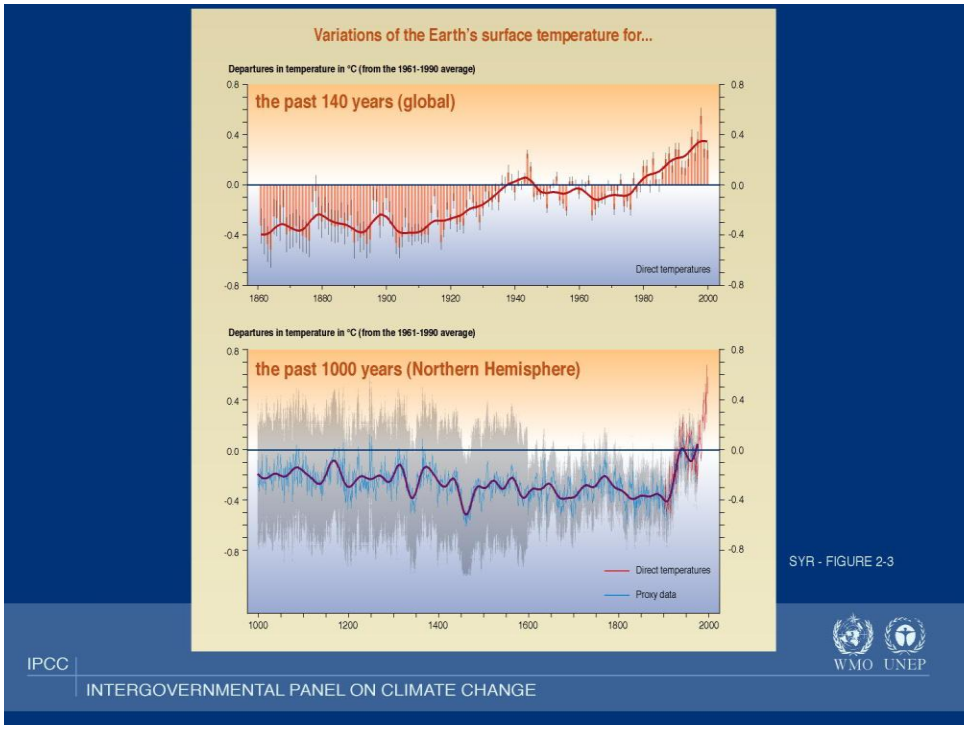
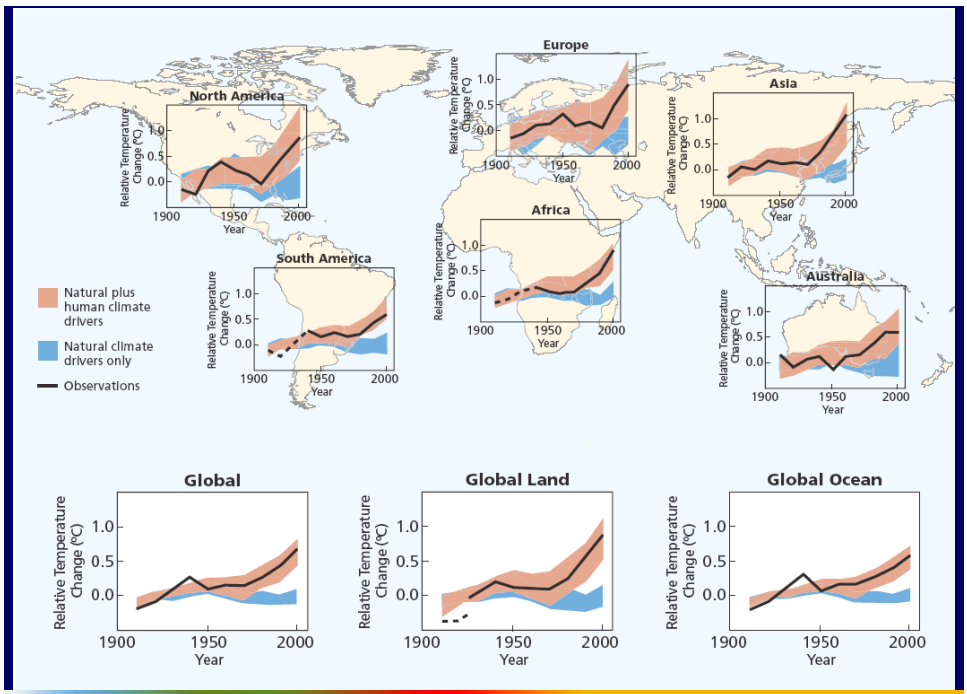
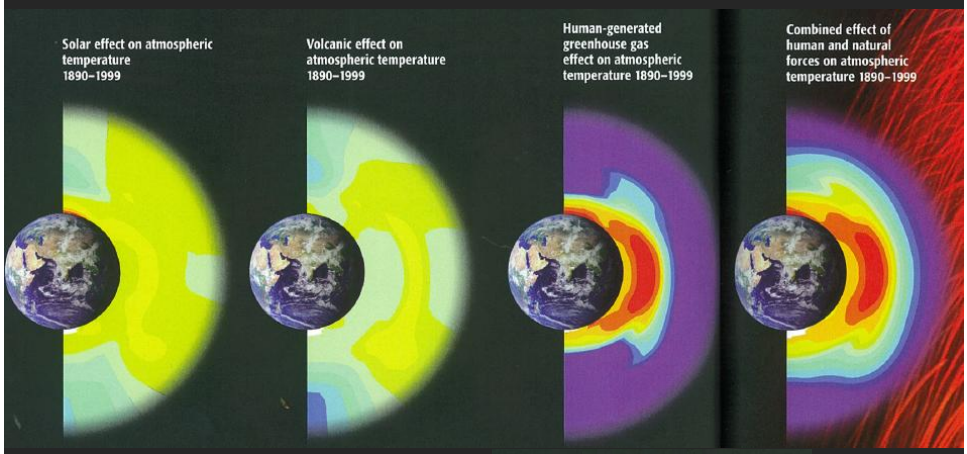




Source: IPCC *Climate Change 2007: The Physical Science Basis*—Summary for Policymakers.

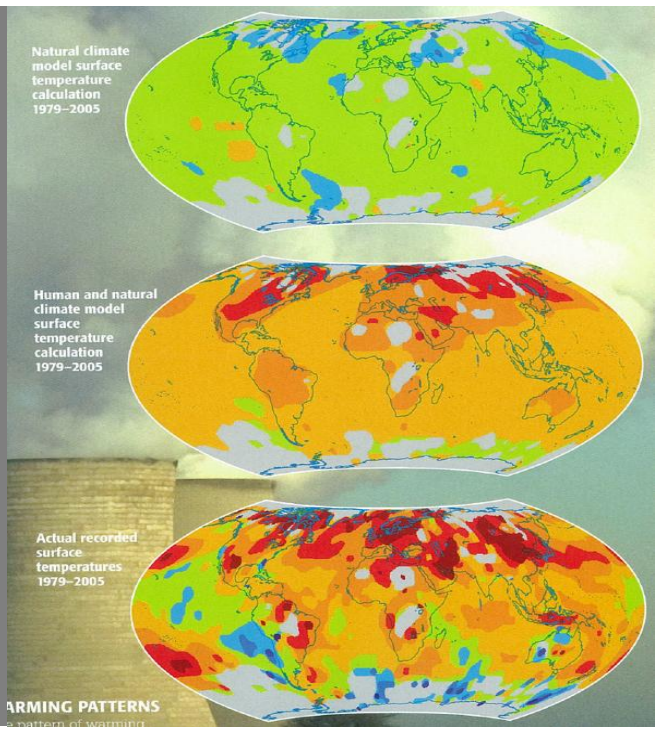
Atmospheric Fingerprints 1890-1999



Mann & Kump, 2008

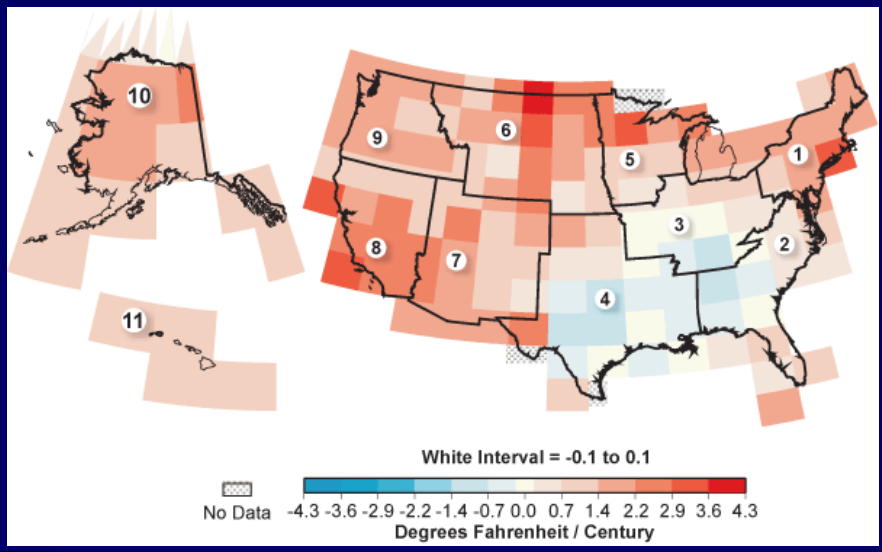
"Fingerprints"

Human and Natural Impacts on Climate, 1975-2005



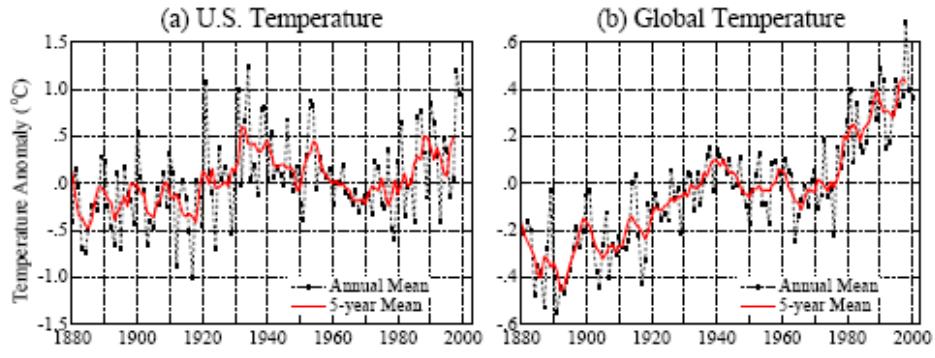
Mann & Kump, 2008

U.S. Mean Temperature Trends: 1901 - 2003



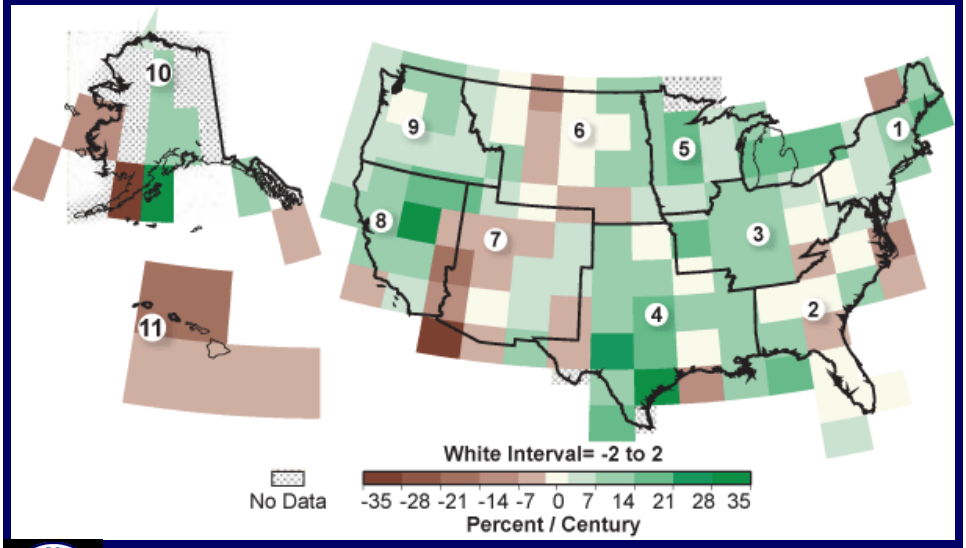
Data courtesy NOAA's National Climatic Data Center

Temperature Trends: 1880 to 2000



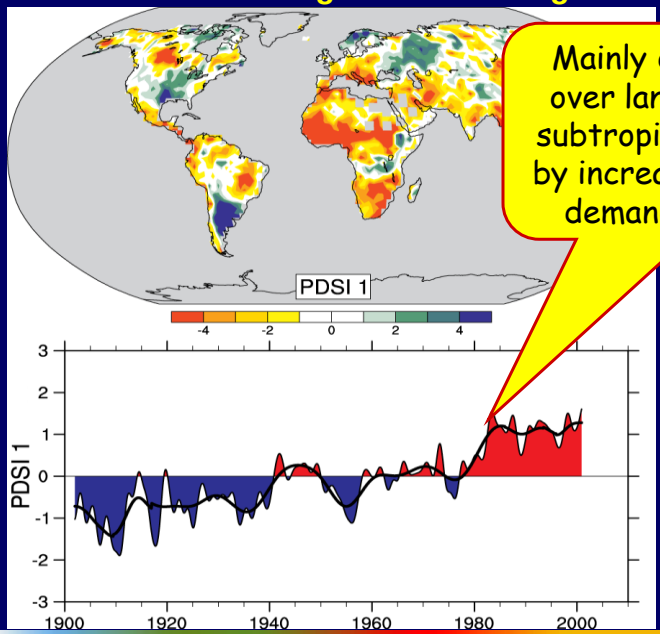
(Hansen et al., Journal of Geophysical Research, 2001)

U.S. Precipitation Trends: 1895 - 2003



Data courtesy NOAA's National Climatic Data Center

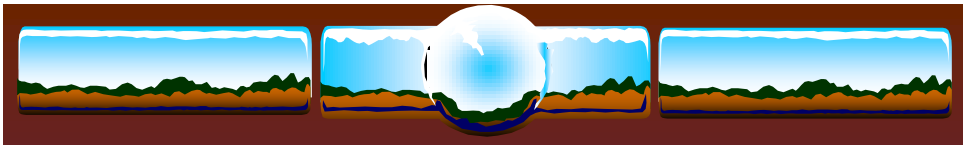
Drought is increasing most places



Mainly decrease in rain over land in tropics and subtropics, but enhanced by increased atmospheric demand with warming

Severity Index (PDSI) for 1900 to 2002.

The time series (below) accounts for most of the trend in PDSI



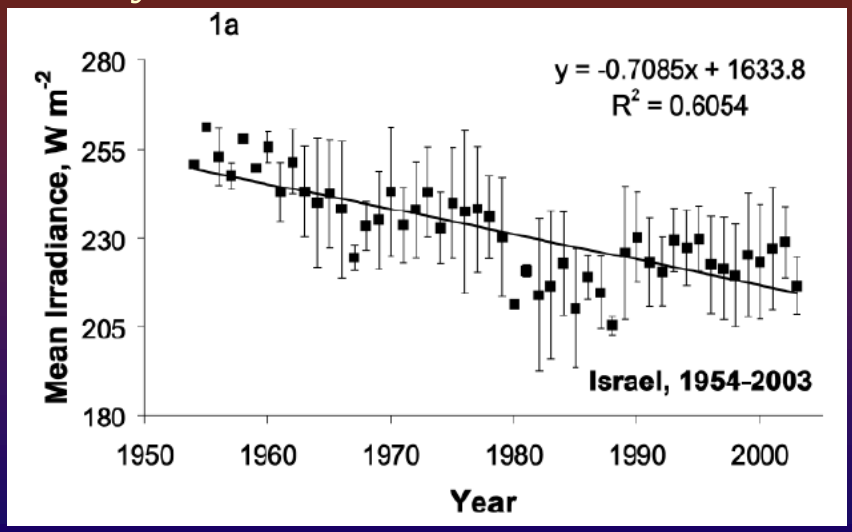
Global Dimming
or
"Long Term Trends in Solar Radiation"

Faith Ann Heinsch
NTSG, College of Forestry & Conservation
The University of Montana
February 28, 2006

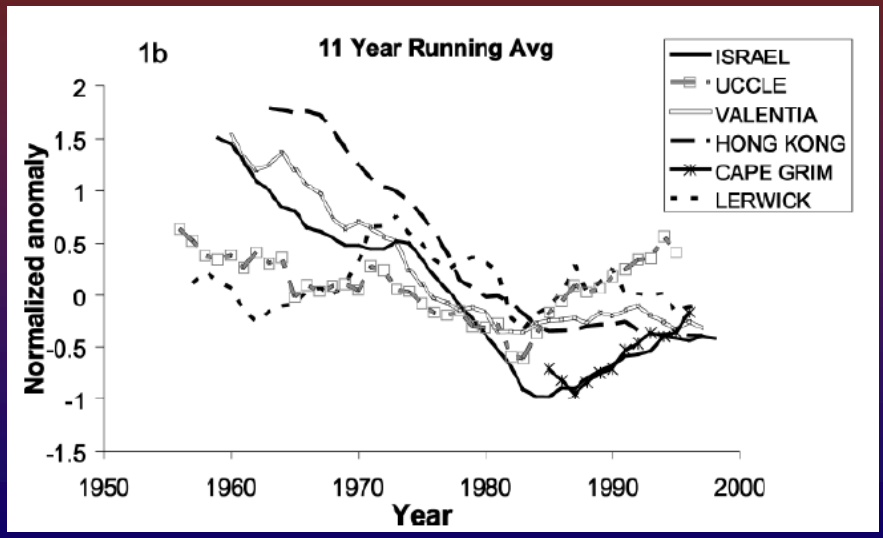
What is global dimming?

- **Global dimming** is the gradual reduction in the amount of global direct *irradiance* at the Earth's surface,
  - measurements began in the 1950s.
    - most data are from NH and all taken on land
    - Data quality?
- Effect varies by location
  - Worldwide: ~4% reduction during 1960–1990

50 years of Radiation Data - Israel



Incoming Shortwave Radiation
Anomalies in the annual mean



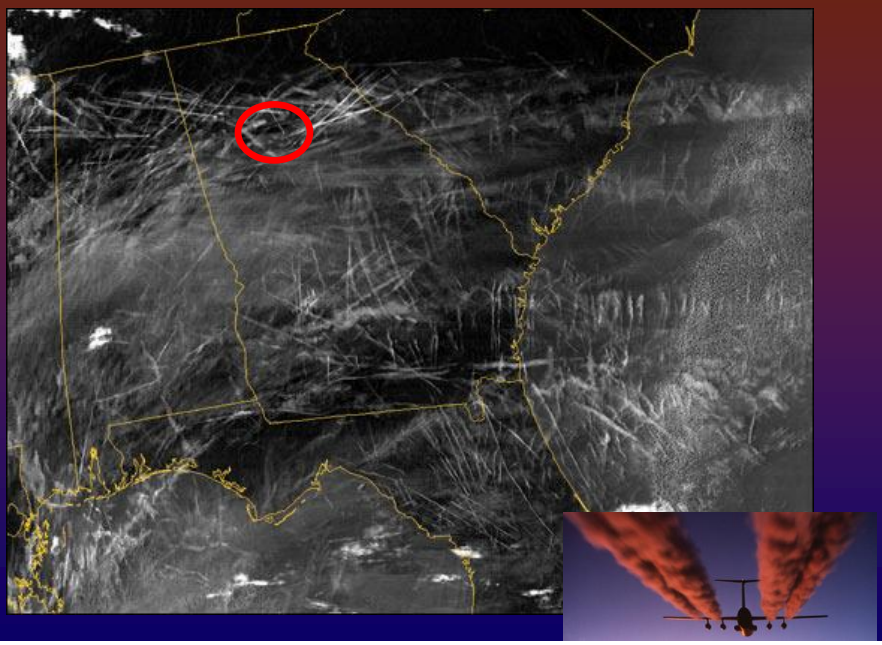
Supporting Evidence

- Worldwide decline in the "pan evaporation rate."
  - Sunlight, humidity, and wind are dominant factors

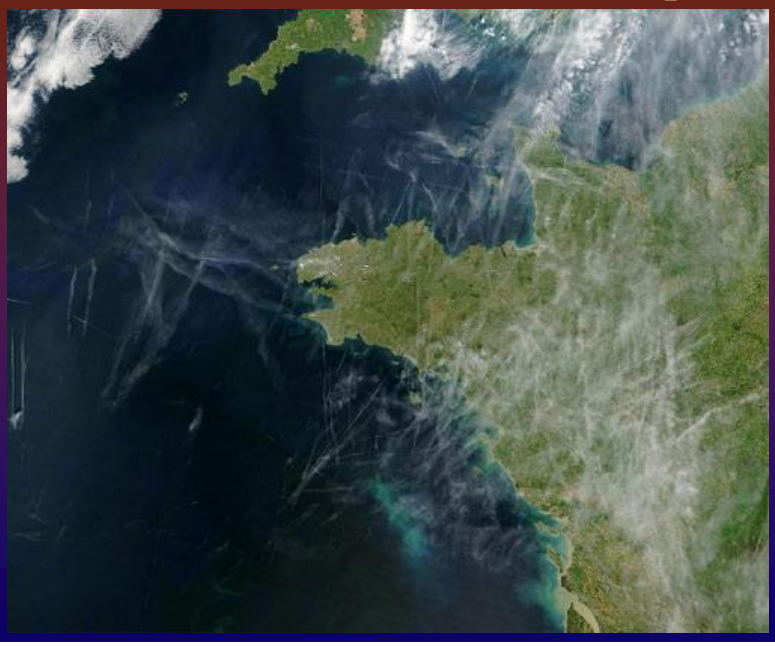
Where does it come from?

- Effect of global dimming is probably due *in part* to the increased presence of aerosol particles in the atmosphere.
  - Aerosol particles and other particulate pollutants absorb solar energy and reflect sunlight back into space.
  - Increased pollution, resulting in more particulates, creates clouds with a greater number of **smaller** droplets, making them more reflective.
- Global warming
  - Water vapor and cloud feedback
    - Same effect as aerosols, but different cause

Aircraft Contrails, Jan 29 2004 MODIS



Aircraft Contrails over Europe



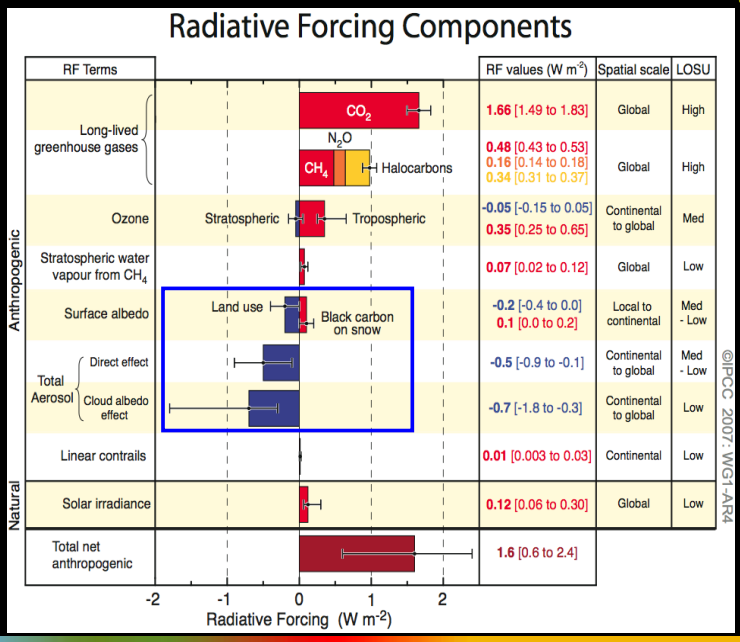
Effects are mostly regional

- Regions that are downwind from major sources of air pollution (specifically sulfur dioxide emissions) have generally cooled.
  - *may* help explain the cooling of the Eastern U.S. relative to the warming Western U.S.
- *Extreme* regional effect
  - the Sahel

Trend Reversal – 1990-2006

- The "dimming" trend had reversed
  - likely that part of this change, particularly over Europe, is due to decreases in pollution.
- Most developed nations have done more to reduce aerosols released into the atmosphere than to reduce CO_2 emissions.

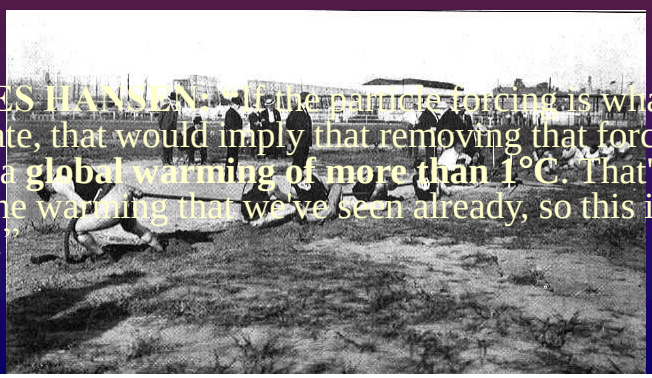
Human and Natural Drivers of Climate Change



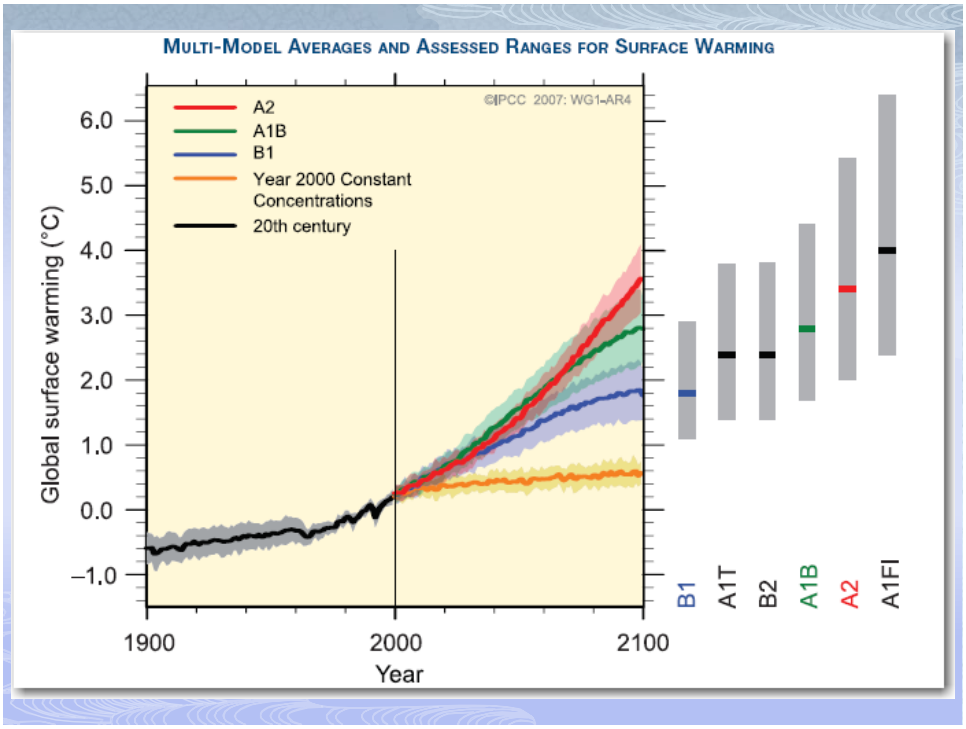
IPCC - WGI

Effects on Climate Systems

- Climate change, to the current date, appears to have been a tug of war, really, between two manmade pollutants.
  - greenhouse gases are pulling the system towards a warmer state (+2.6-3.0 W m^{-2})
  - particles from pollution that are cooling it down (-1.5 W m^{-2})



- **JAMES HANSEN**: "If the particle forcing is what we estimate, that would imply that removing that forcing would cause a **global warming of more than 1°C**. That's more than the warming that we've seen already, so this is a huge factor."


Multi-Model Averages and Assessed Ranges for Surface Warming
©IPCC 2007: WG1-AR4
A2
A1B
B1
Year 2000 Constant Concentrations
20th century
Global surface warming (°C)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
−1.0
1900
2000
2100
Year
B1
A1T
B2
A1B
A2
A1FI