Climate Variability and Change
Past, Present and Future
An Overview

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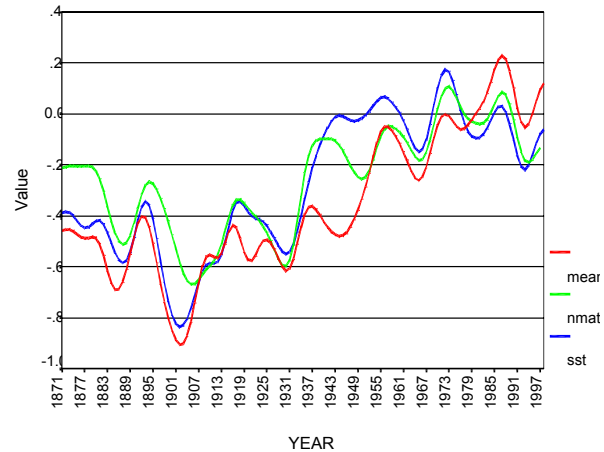
INTERNATIONAL WORKSHOP ON REDUCING VULNERABILITY OF AGRICULTURE AND FORESTRY TO CLIMATE VARIABILITY AND CLIMATE CHANGE

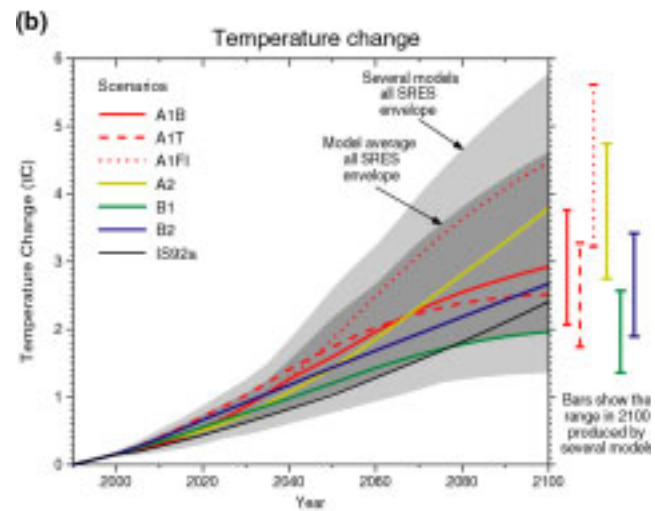
LJUBLJANA, Slovenia, 7-9 October 2002

Climate Variability and Change

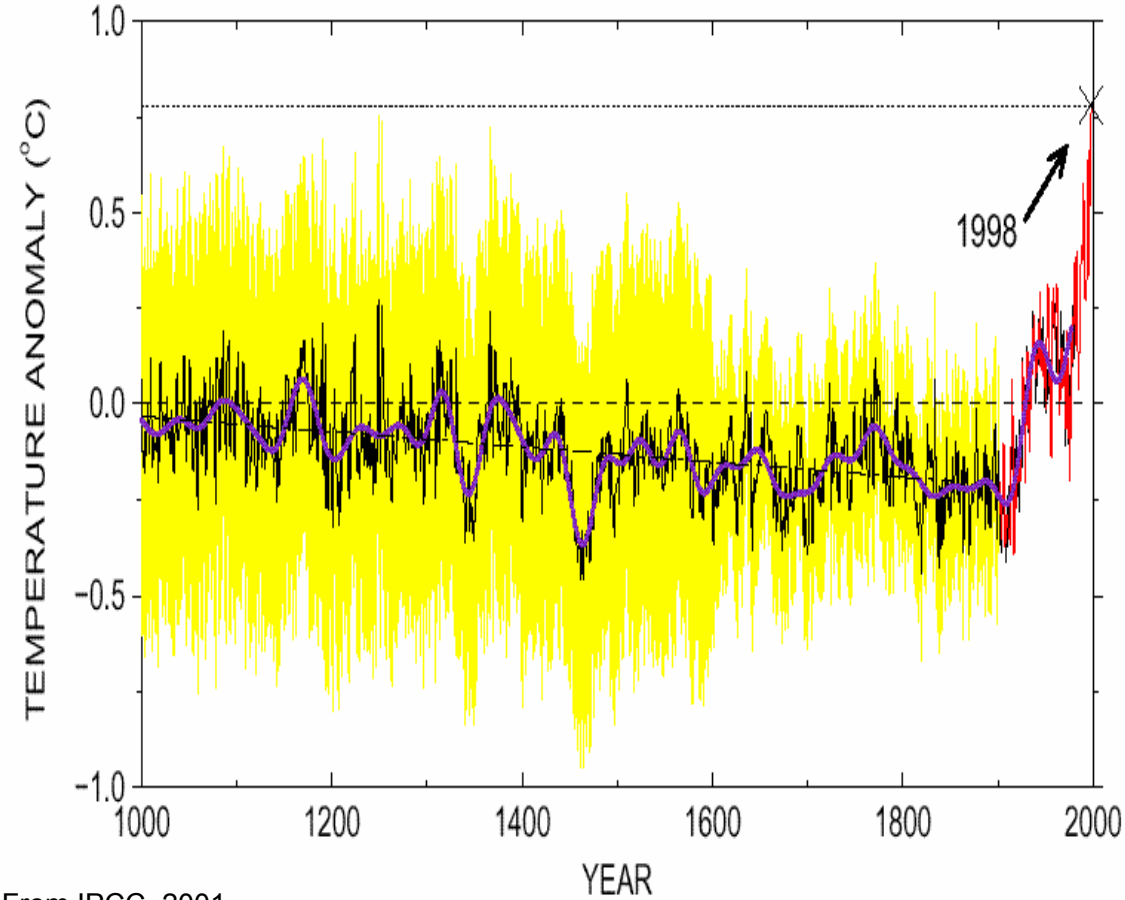
Past, Present and Future – An Overview

- **Introduction**
- **Past Climate**
- **Present Climate and its Variability**
- **Future Climate**
- **Implications for Agriculture and Forestry**
- **Conclusions**





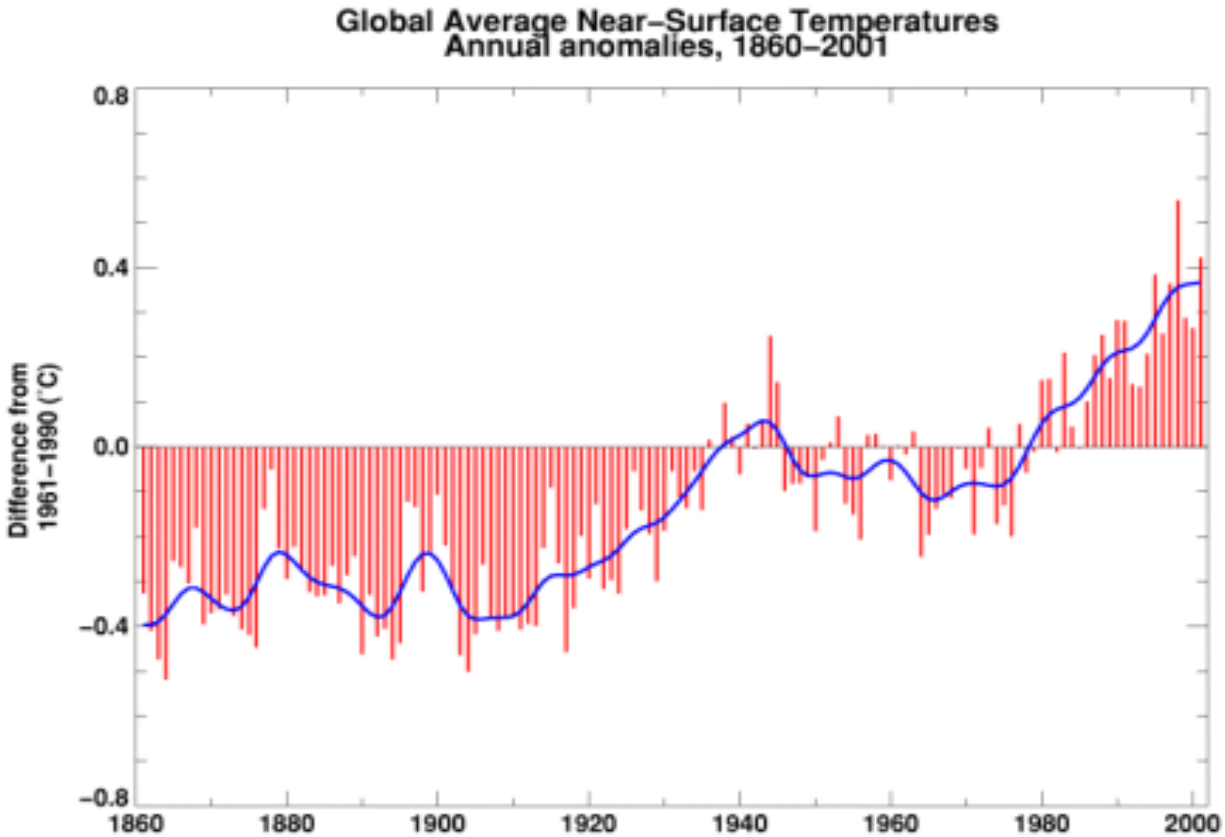
Past Climate – the last millennium



From IPCC, 2001

- There is a cooling trend of about 0.2°C culminating around 1900
- Evidence for the Southern Hemisphere is quite sparse
- It is likely the Northern Hemisphere that the 1990s was the warmest decade, and 1998 the warmest year

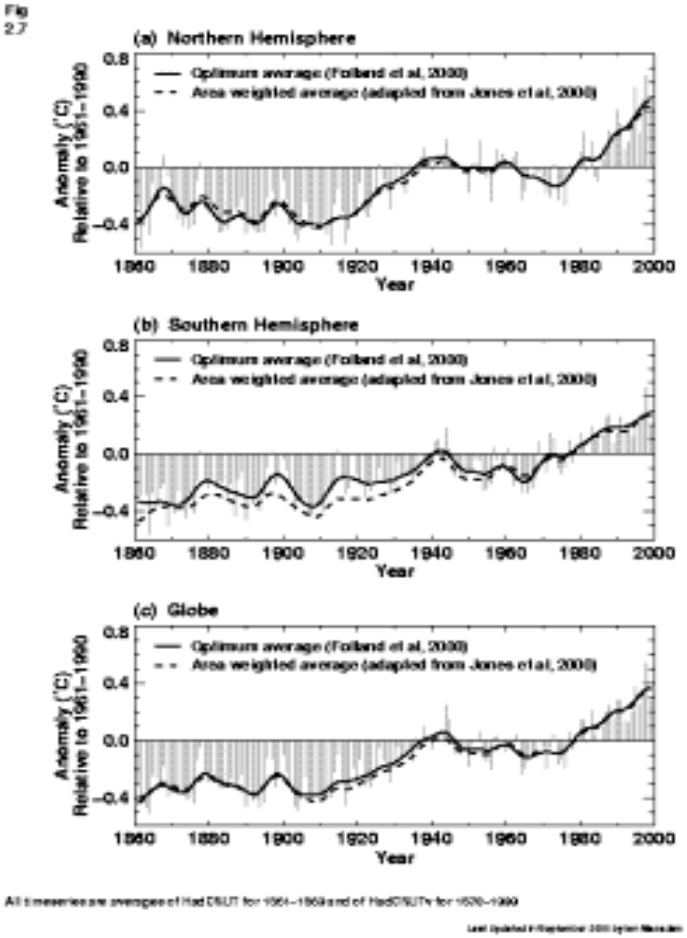
Past Climate – the observed record



From Hadley Centre, 2002

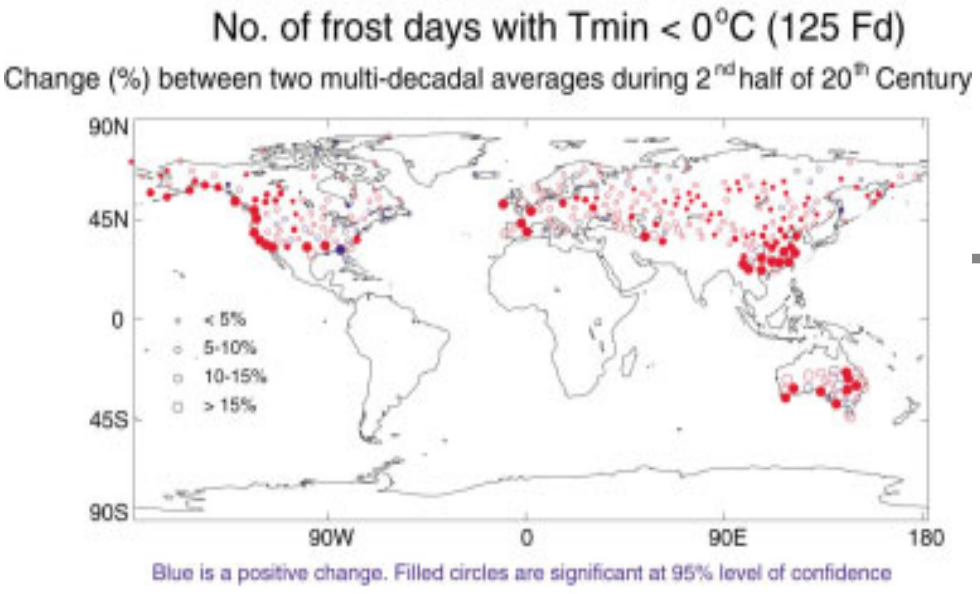
- Global temperatures have increased by about 0.6°C over the 20th century
- Very likely that the 1990s was the warmest decade, 1998 the warmest year

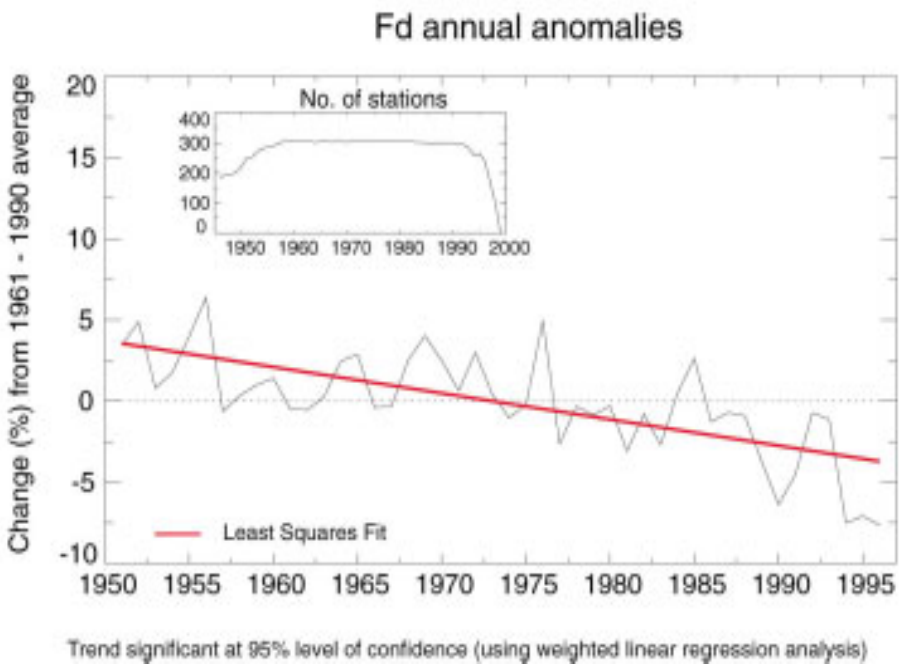
Past Climate – the observed record



- In the Northern Hemisphere, two periods of warming occur : 1920 – 1940, and 1975 onwards, slight cooling in between
- Southern Hemisphere does not show much warming early 20th century, but warms from the 1970s

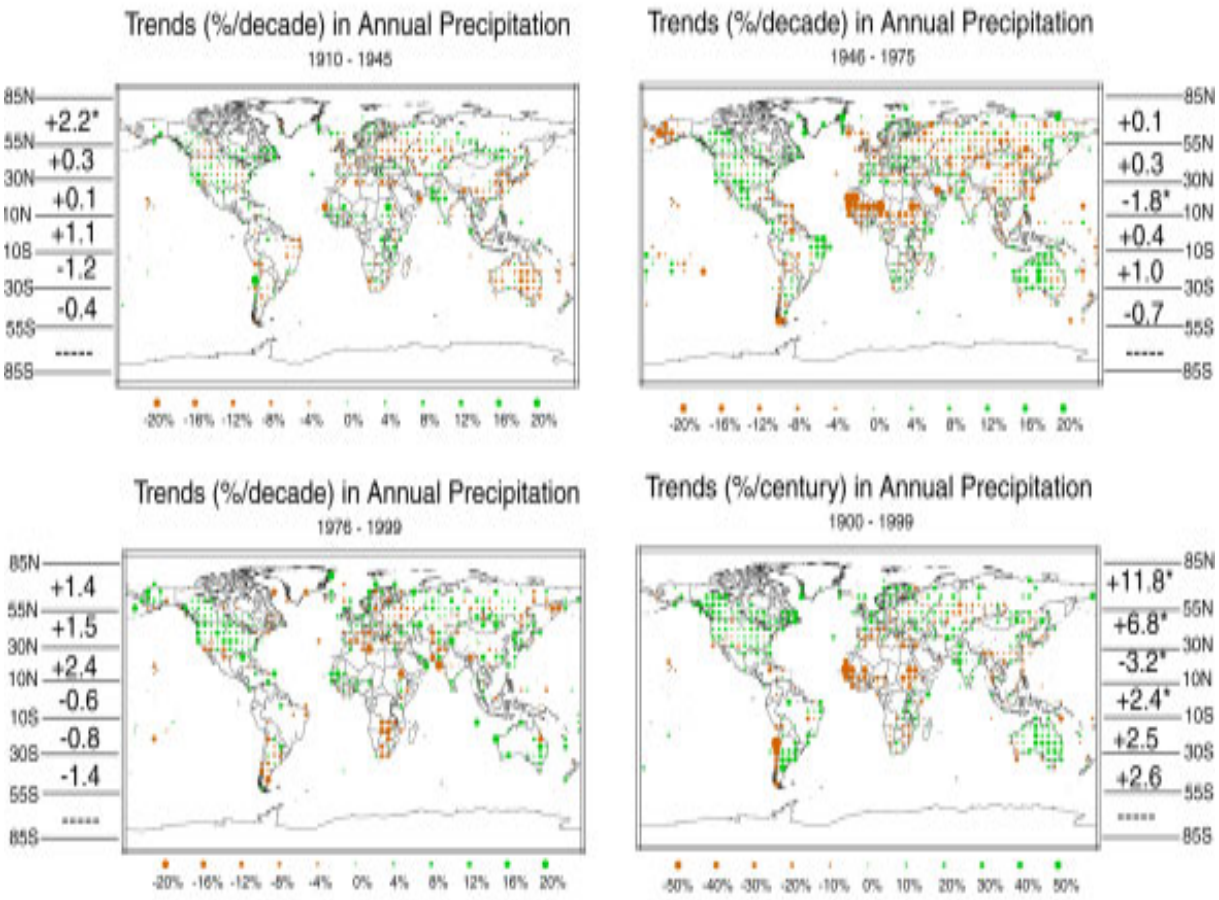
Present Climate – the observed record



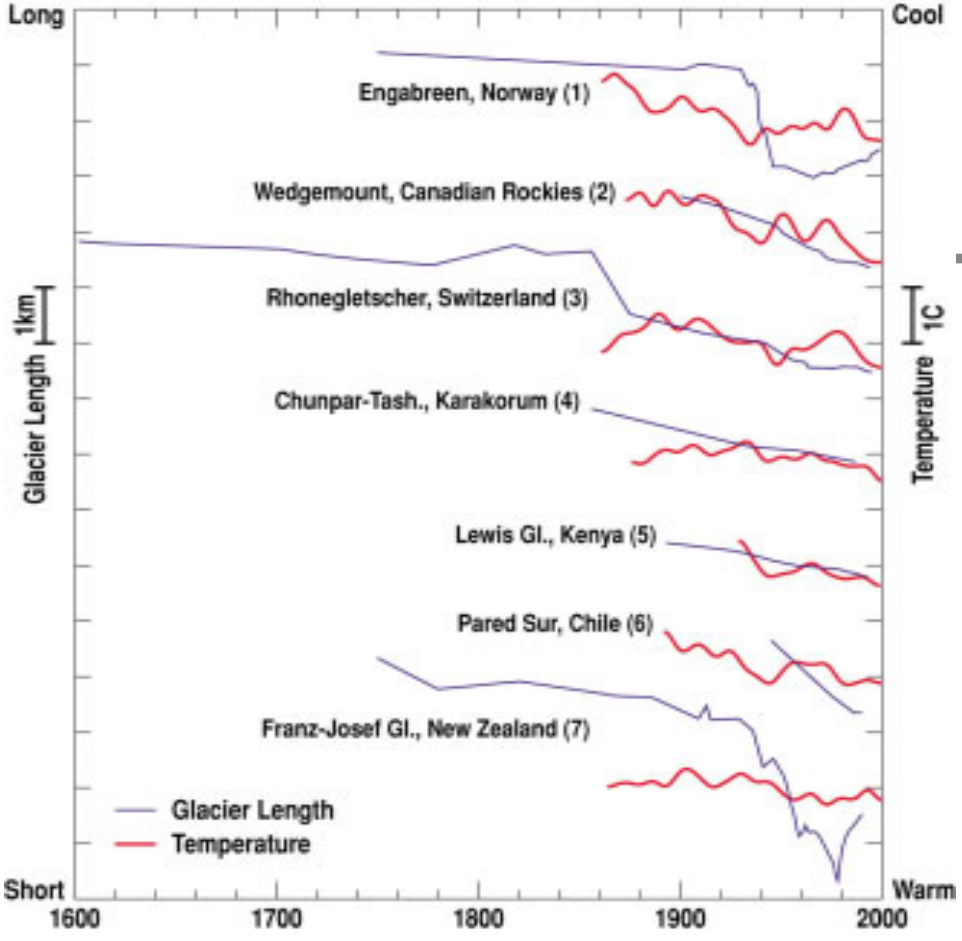


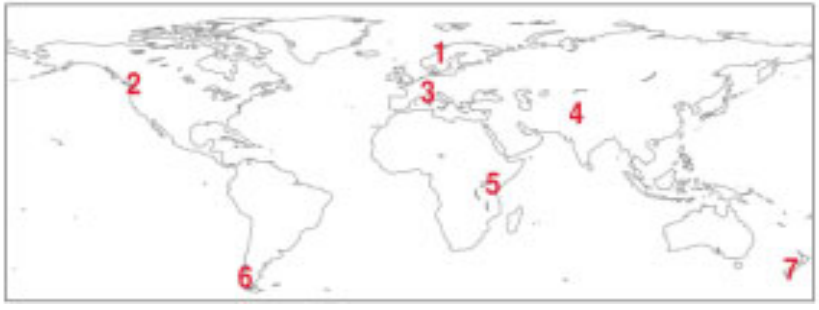
- Night time temperatures over land have increased twice the rante of daytime temperatures
- The freeze-free season has lengthened in many mid- and high latitude regions
- Globally the number of frost days has reduced in the order of 20 percent

Present Climate – the observed record



- Global land precipitation has increased by 2 percent
- Over mid and high latitudes of the Northern Hemisphere precipitation increased 7 to 12 percent
- Precipitation has decreased in the northern sub-tropics





Present Climate

SNOW AND ICE EXTENT HAVE DECREASED

There has been a widespread retreat of mountain glaciers in non-polar regions during the 20th century

Satellite data show a very likely decrease of about 10% in the extent of snow cover since the late 1960s

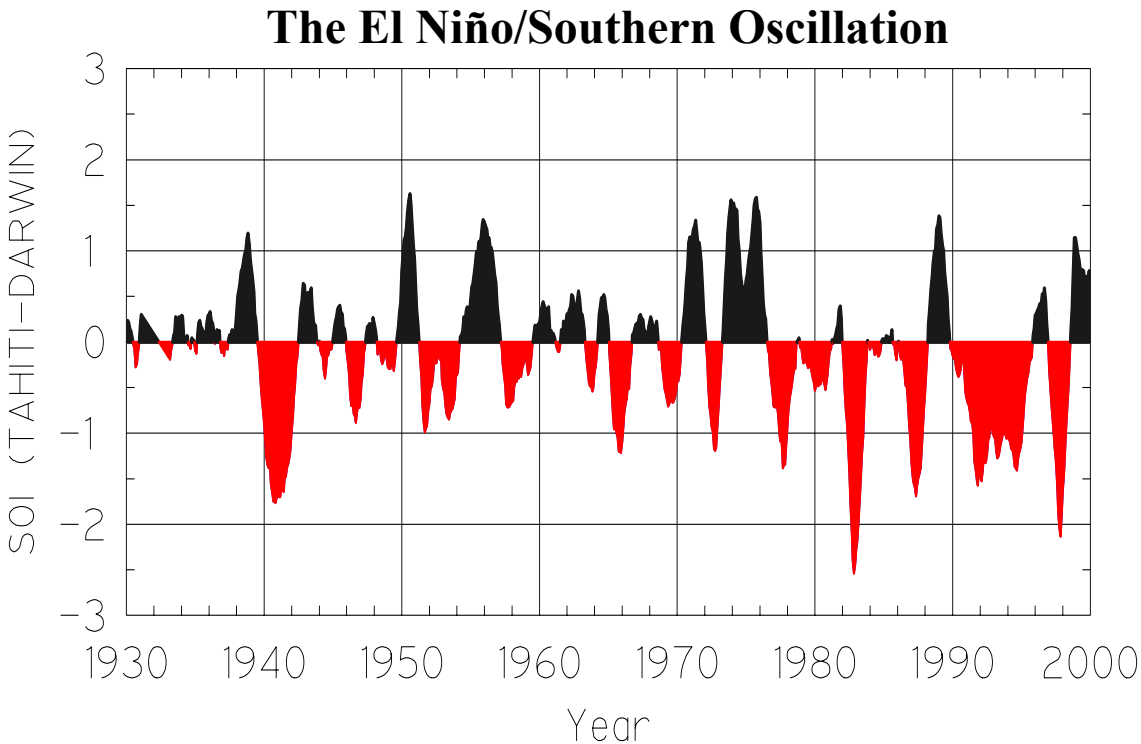
40% decline in snow and ice in the Southern Alps

Present Climate

"An increasing body of observations gives a collective picture of a warming world and other changes to the climate system"

Intergovernmental Panel on Climate Change, 2001

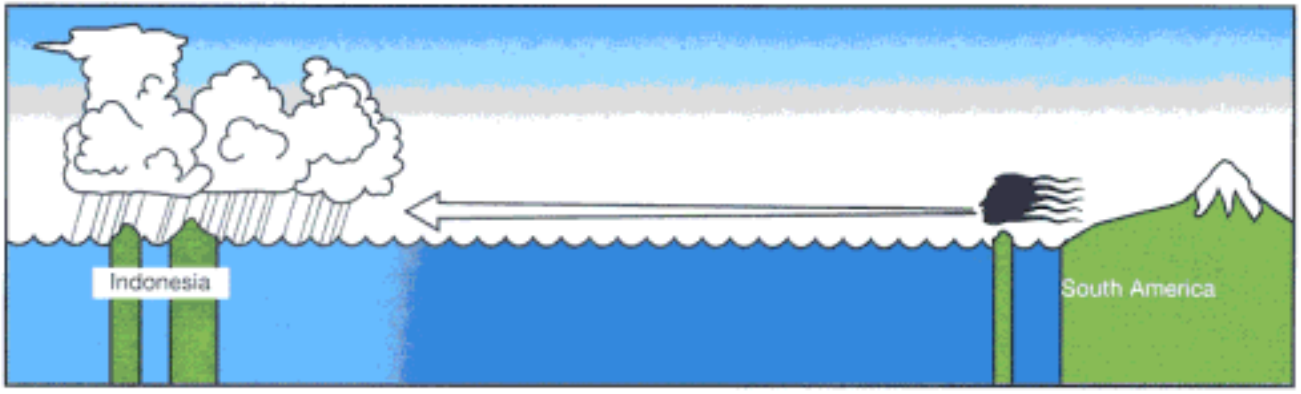
Present Climate and its Variability

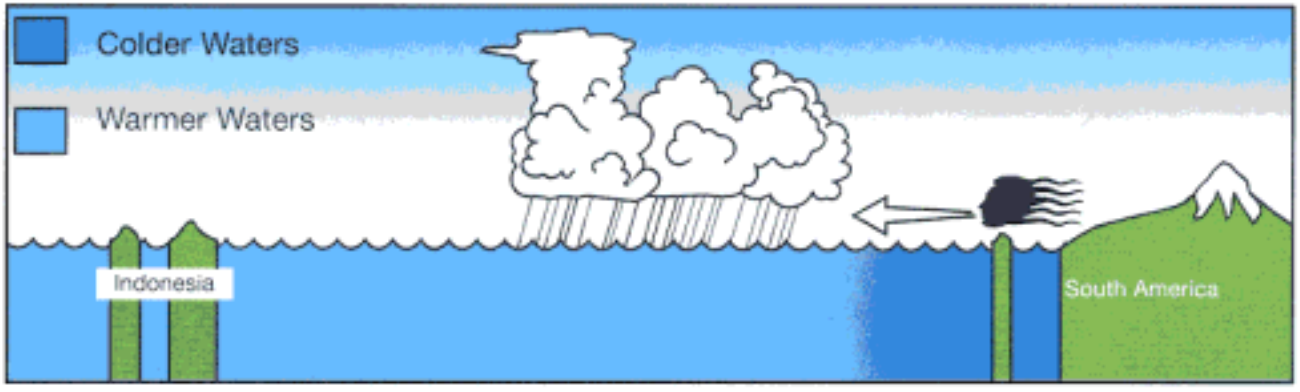


- Year-to-year variability between El Niño and La Niña
- A 3 - 5 year climate cycle of global importance driven out of the Pacific Basin

La Niña and El Niño

La Niña

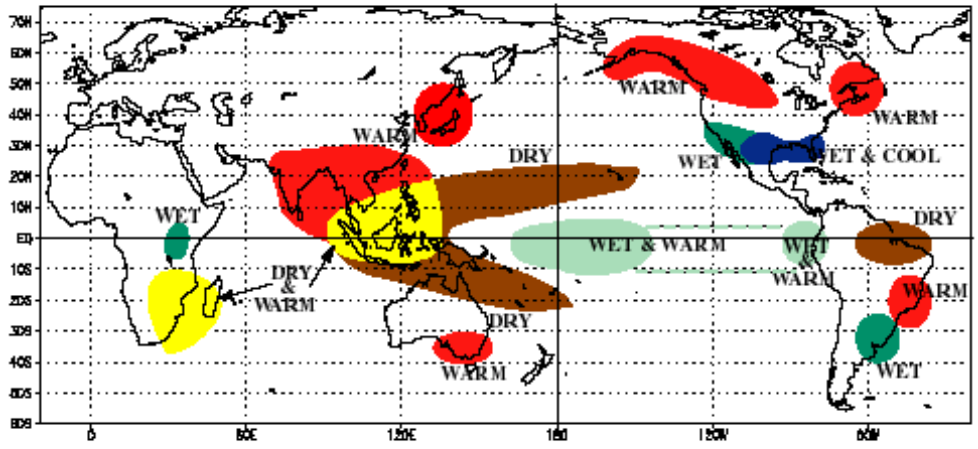




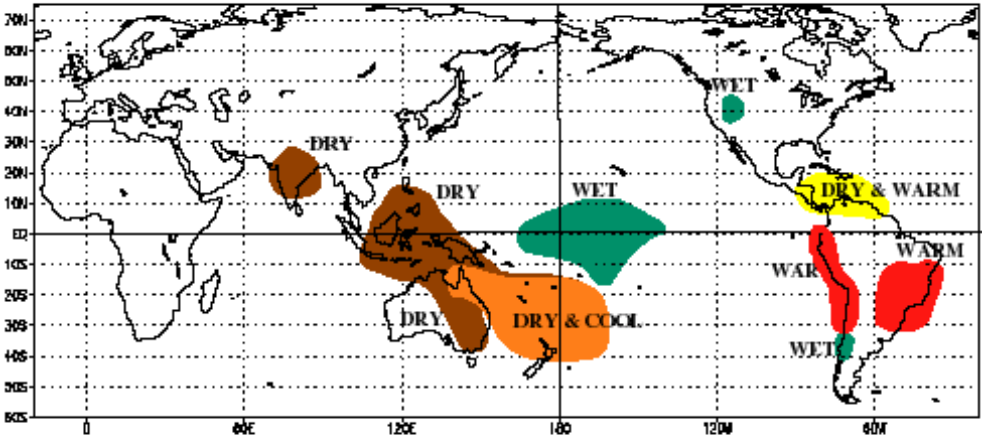
El Niño

NIWA
Taihoro Nukurangi

WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



WARM EPISODE RELATIONSHIPS JUNE - AUGUST

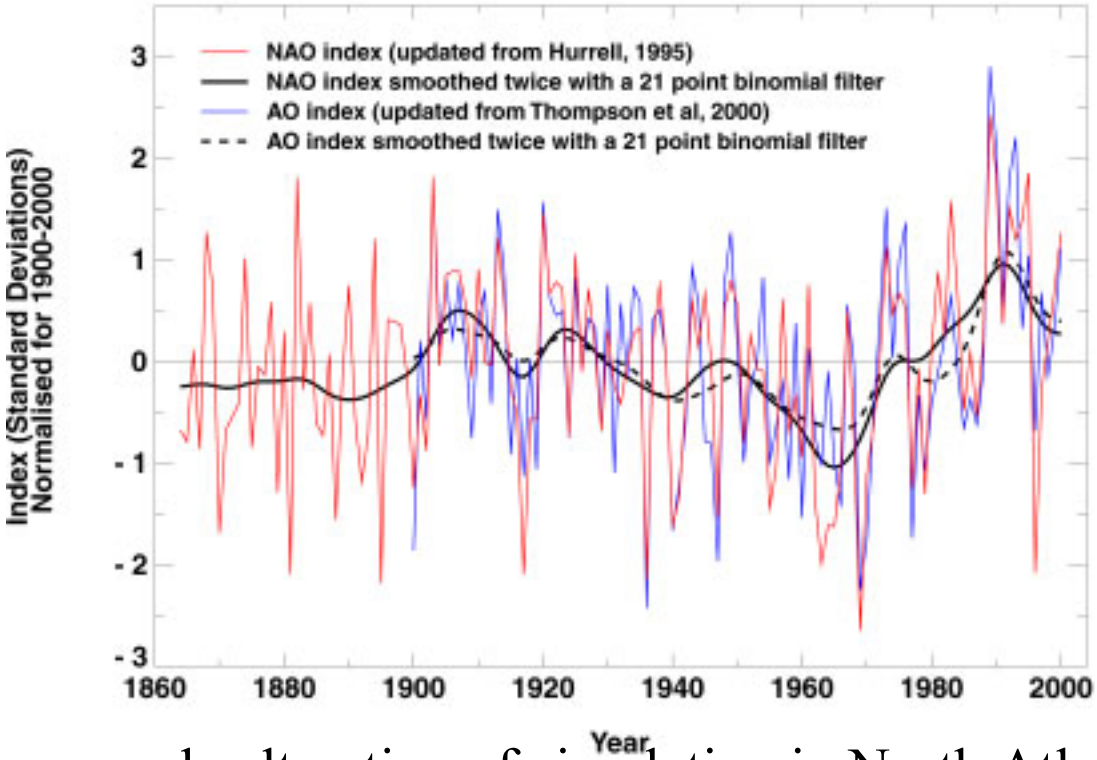


Climate Variability

ENSO Impacts

Climate Prediction Center
NCEP

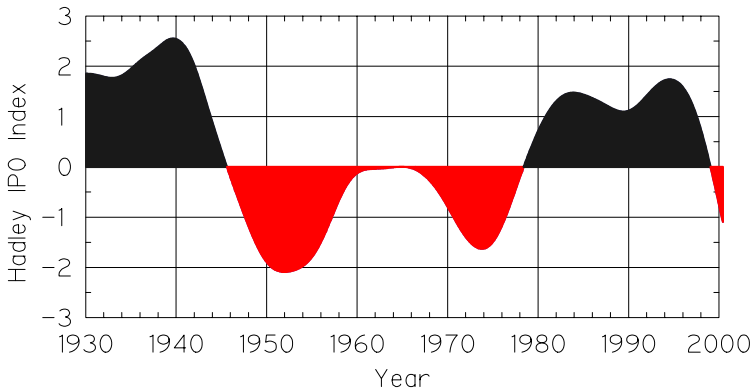
North Atlantic Oscillation

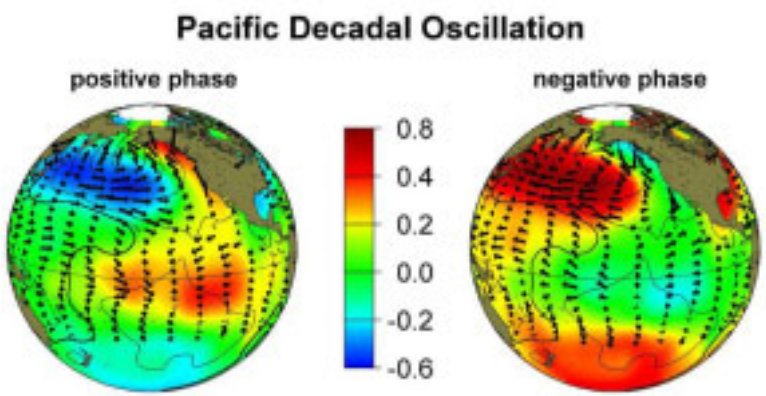


- Large scale alteration of circulation in North Atlantic
- Alters strength of westerlies in winter in the region

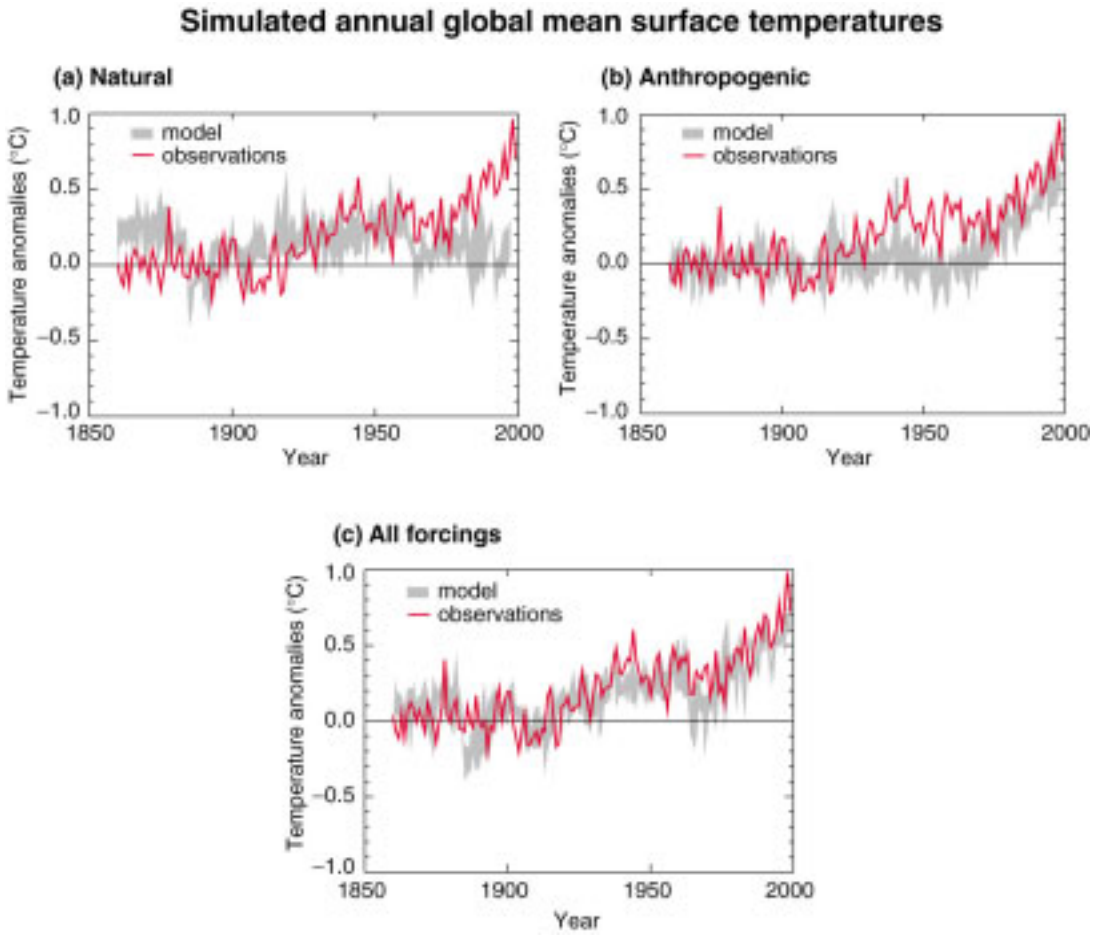
Interdecadal Pacific Oscillation

- Climate shifts driven by Interdecadal Pacific Oscillation (IPO)
- This is an 'ENSO' like feature of the climate system, but on longer time scales
- Pressures are lower than average in the North Pacific, extending to the east, and higher in the south west Pacific
- From 1922-46 and 1978-98 the IPO was positive, and negative from 1947-76





Present Climate and its Variability

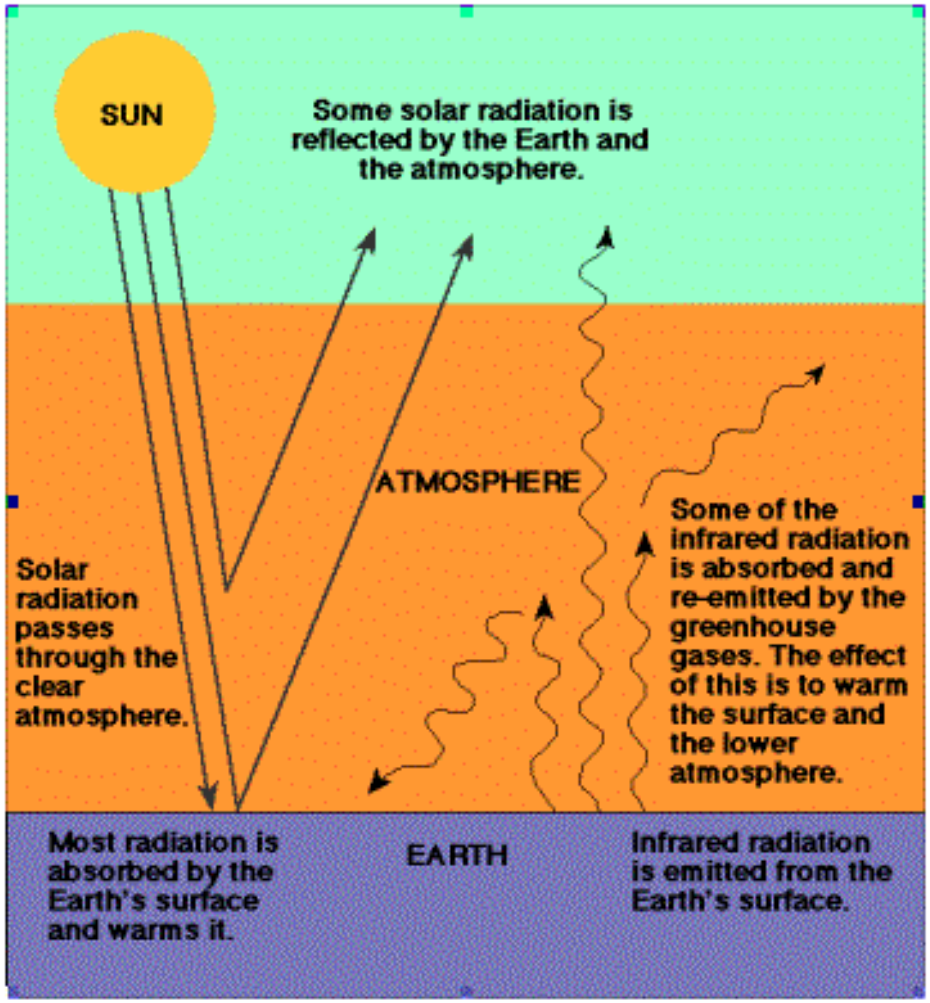


Present Climate and its Variability

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities"

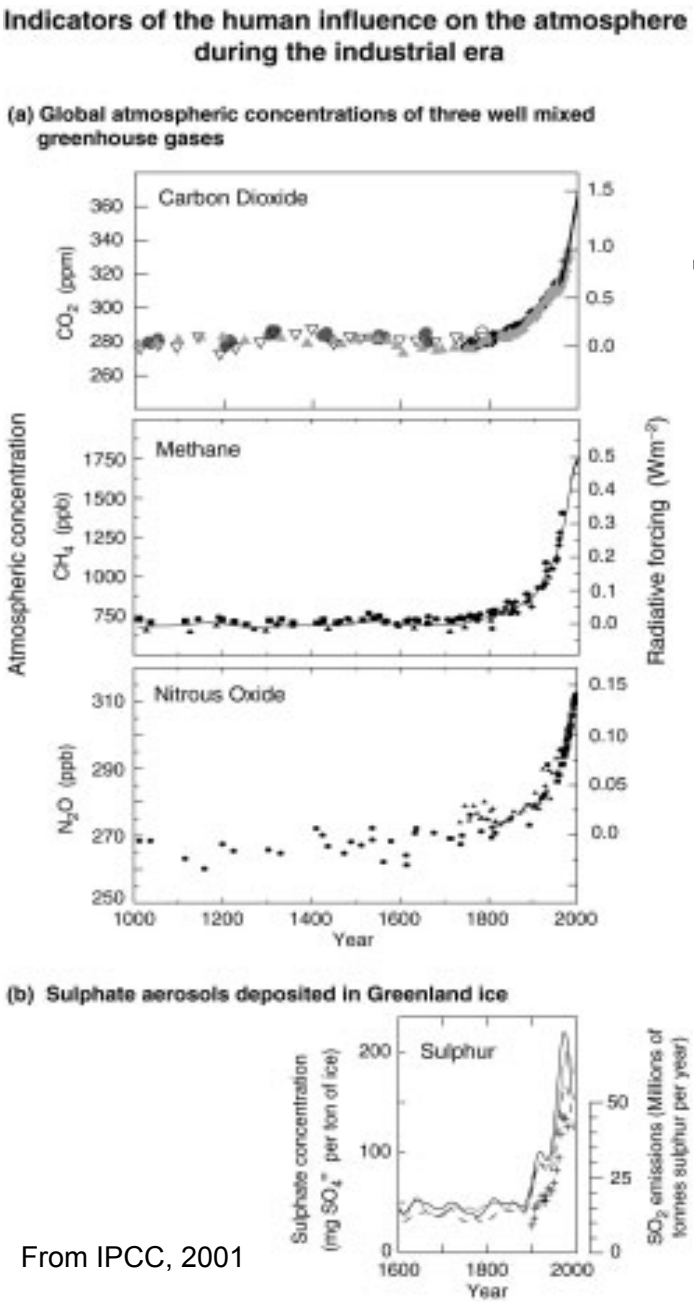
Intergovernmental Panel on Climate Change, 2001

Future Climate - The Enhanced Greenhouse Effect



Addition of greenhouse gases causes the surface of the earth and lower atmosphere to warm.

The Enhanced Greenhouse Effect



From IPCC, 2001

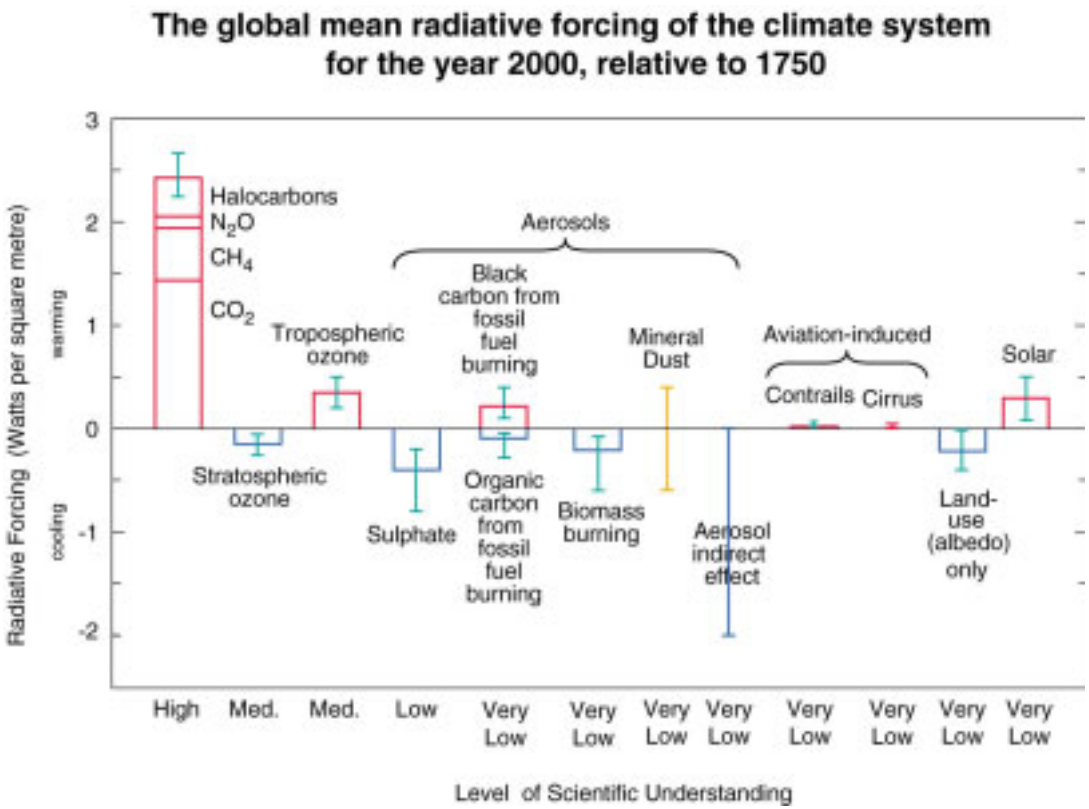
CONCENTRATIONS OF ATMOSPHERIC GREENHOUSE GASES HAVE CONTINUED TO INCREASE AS A RESULT OF HUMAN ACTIVITIES

Atmospheric concentration of CO_2 has increased 31% since 1750. Three-quarters of this in the past 20 years is due to fossil-fuel burning, one quarter mainly land-use changes

Atmospheric concentration of CH_4 has increased 151% since 1750.

Atmospheric concentration of N_2O has increased 17% since 1750.

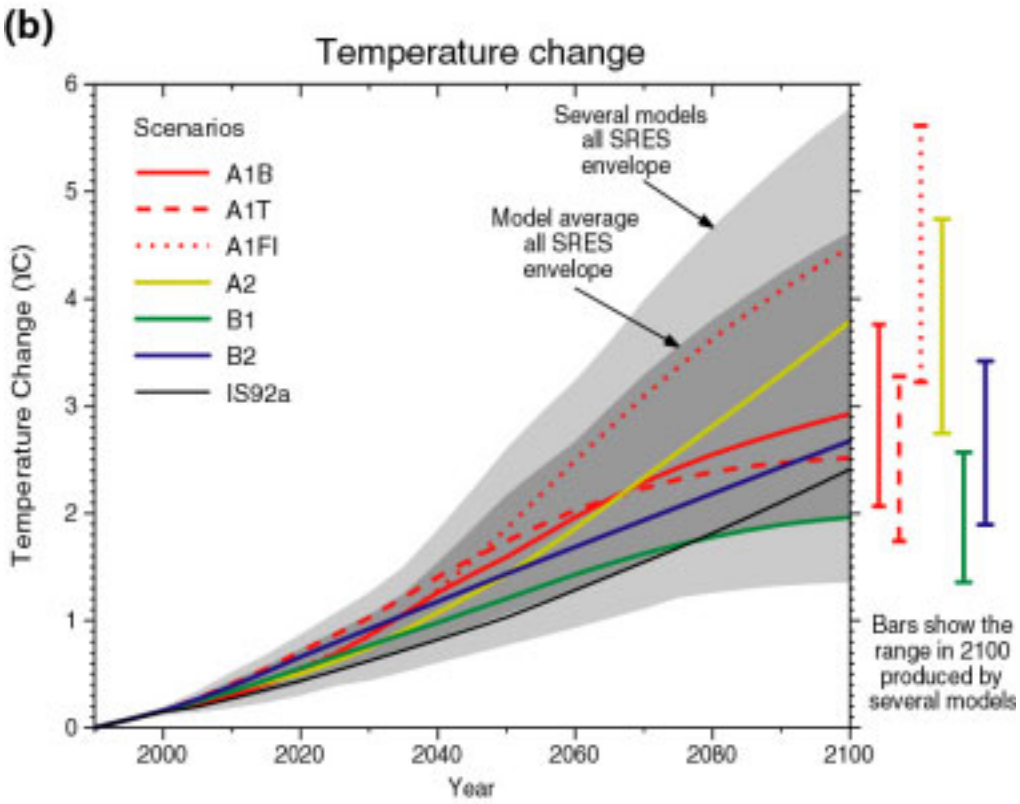
The Enhanced Greenhouse Effect



- Radiative forcing increases due to well-mixed greenhouse gases is 2.43 Wm2. These are long-lived
- Radiative forcing from aerosols is -0.5 Wm2. Aerosols vary considerably by region and respond quickly to changes in emissions
- Natural factors have made small contributions during the 20th century

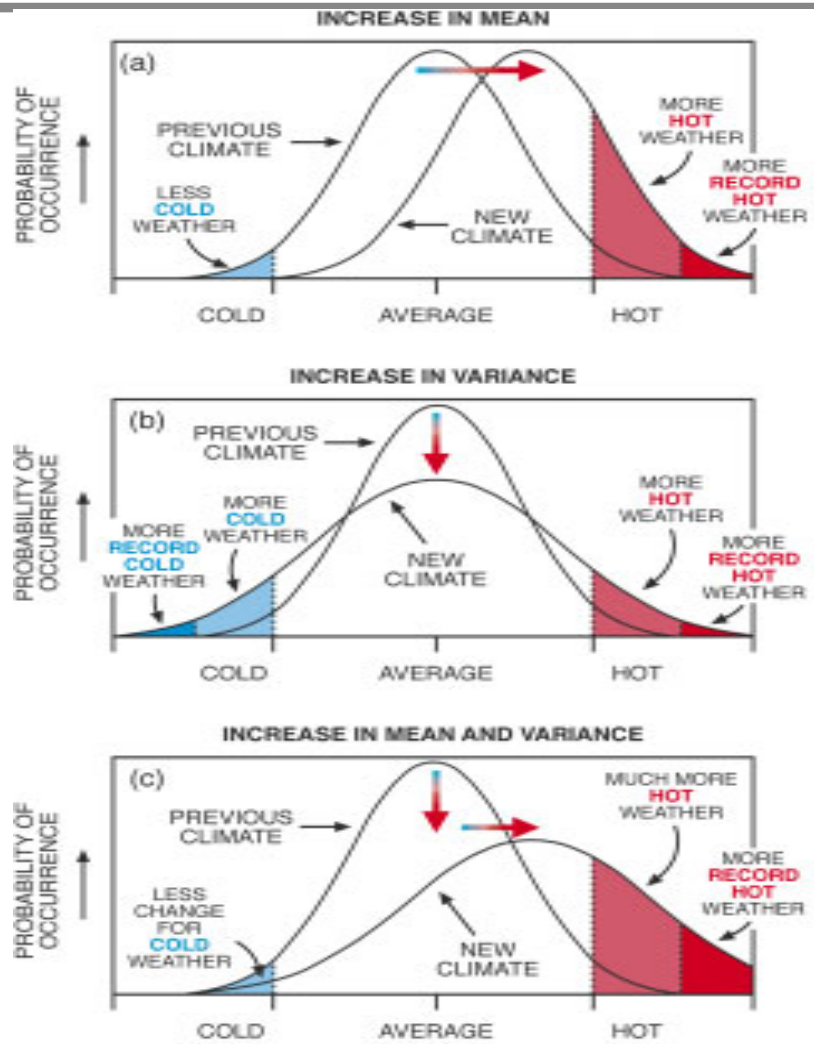
From IPCC, 2001

Future Climate - Temperature projections



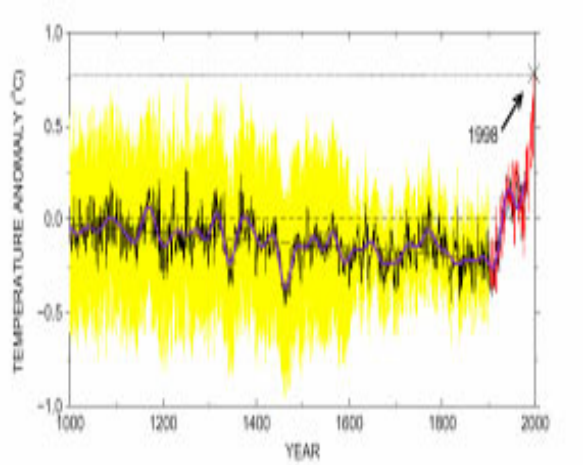
- Globally averaged surface temperature is projected to increase by 1.4 to 5.8°C 1990 to 2100 - for the full range of 35 SRES scenarios
- Temperature increases are greater than the IPCC 1995 report, due to lower sulphur dioxide emissions
- The projected rate of warming is much larger than the observed changes during the 20th century, and is very likely to be without precedent during at least the last 10,000 years

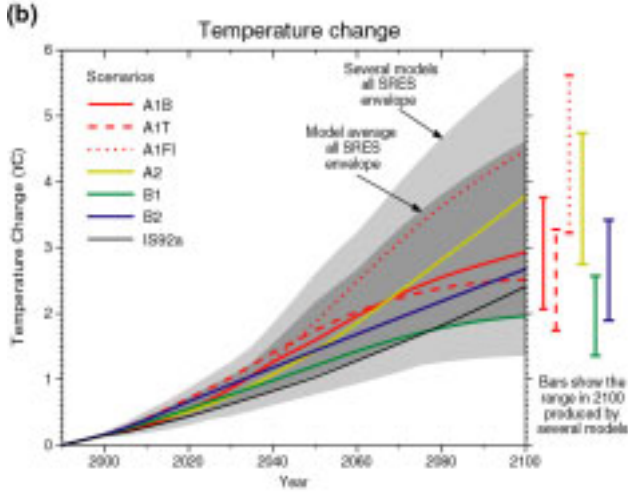
Future Climate - Precipitation and Extreme Events



- Global average water vapour concentration and precipitation are projected to increase, with larger year to year variations very likely.
- More hot days and less frost days are very likely
- More heavy rainfall events are likely over many areas
- Increase in tropical cyclone peak wind intensities are likely over some areas

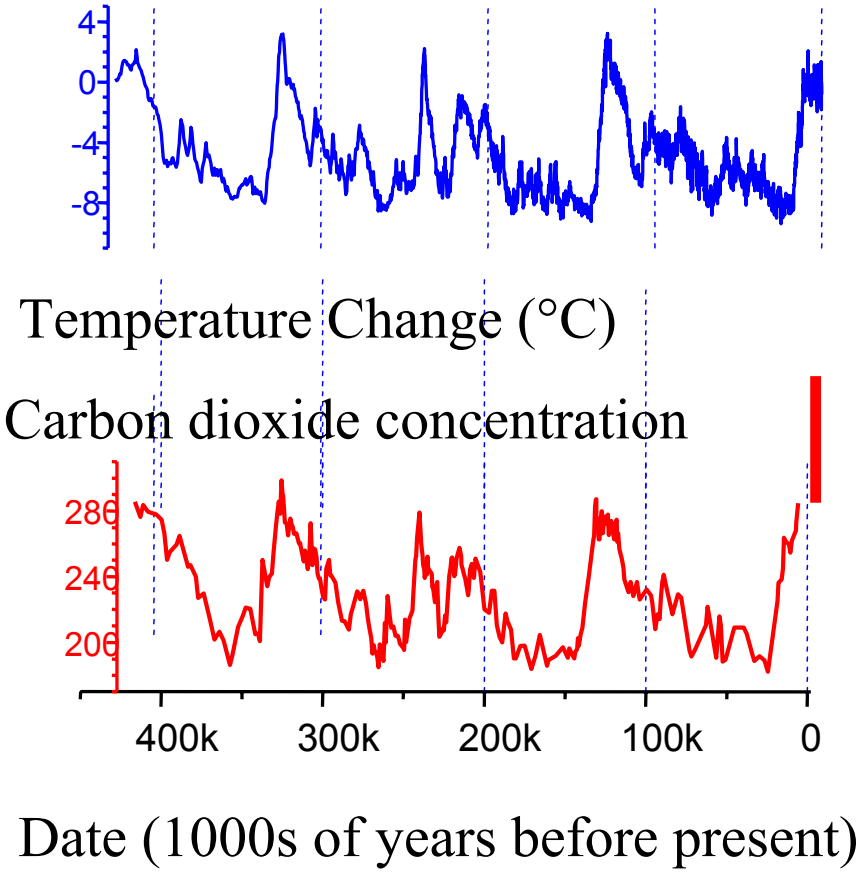
Implications for Agriculture and Forestry





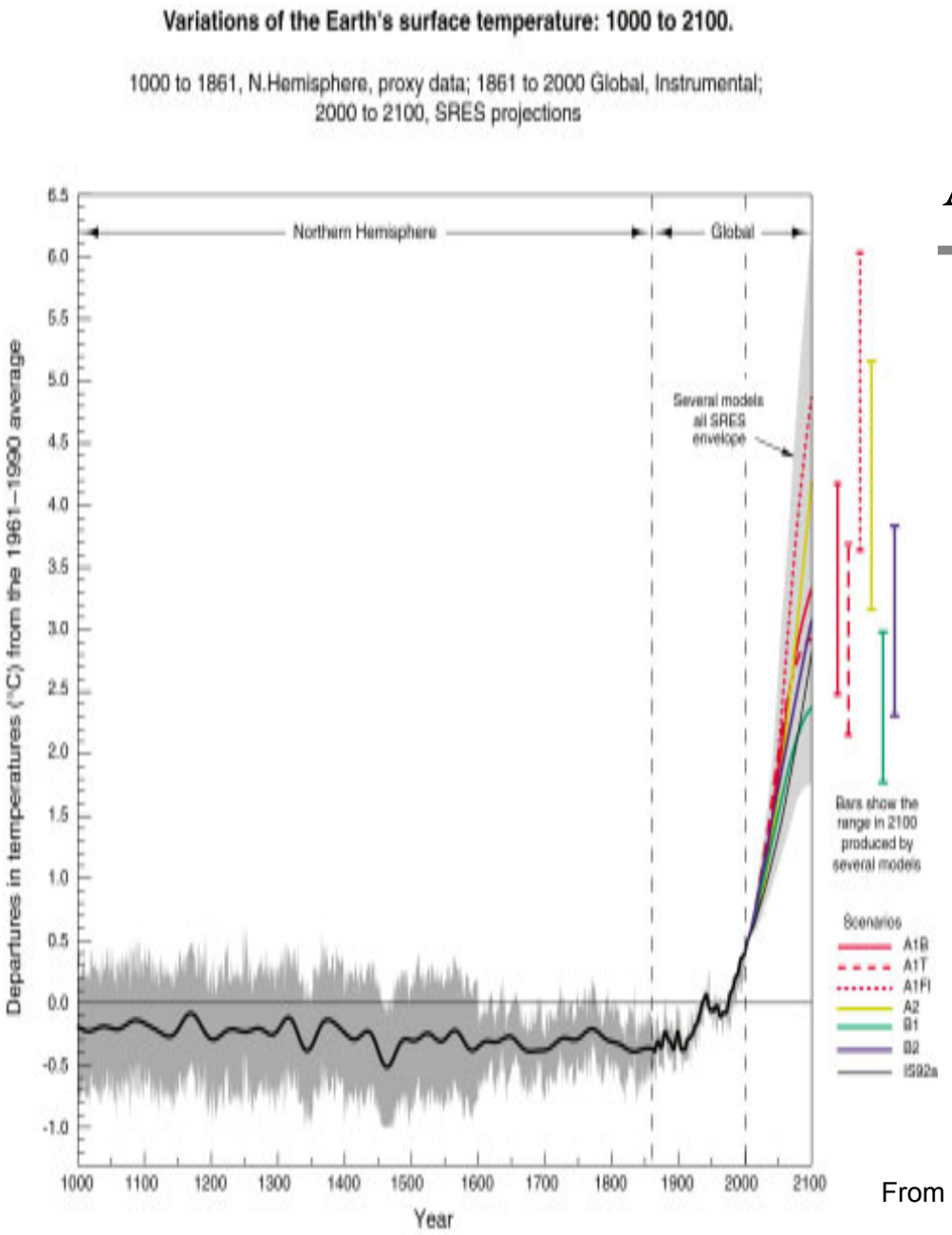
- Throughout agrarian settlement climate has varied and civilizations have either adapted, or not survived
- Variability over historical time is in the order of 0.5°C and locally 1°C on century time scales, with ENSO causing natural variability through time
- The projected rate of warming for the 21st century is much larger than the observed changes during the 20th century, and is very likely to be without precedent during at least the last 10,000 years – the 90% range is 2 to 4.5°C

2 Implications for Agriculture and Forests



- UNFCCC – ultimate aim of this Convention is to prevent dangerous climate change
- Natural greenhouse effect keeps earth at a temperature equable for planetary processes to operate
- Over the last 420,000 years climate has varied by about 5°C between ice ages and interglacials
- The most rapid change has been about 1°C per century

Implications for Agriculture and Forests

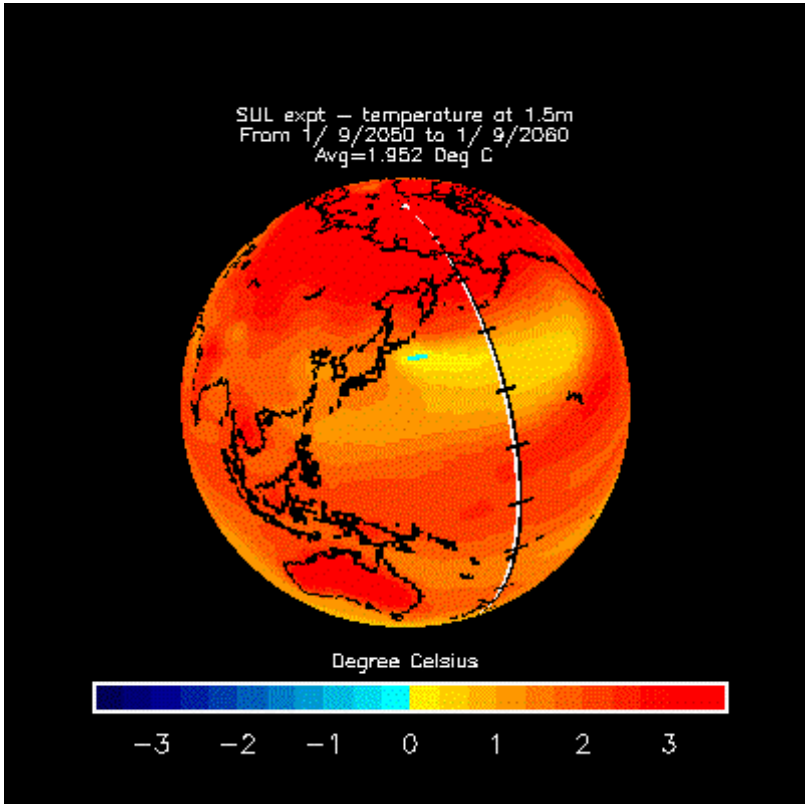


- Climate, agriculture and forestry are all linked
- Current rate of global warming at 2000 is 2°C per century – likely to be disruptive to agriculture and forestry
- Thus global warming because of human activities are posing the potential of dangerous climate change

"Global average temperature and sea level are projected to rise under all IPCC SRES scenarios"

From IPCC,2001

Climate Change and Variability - Conclusions



UK Met Office Climate Model

2050 - 2060

- **Climate change and variability have occurred throughout time**
- **In the time of settlement (last 10,000 years) changes have been quite small**
- **Projected 20th century increases from about 2 to 4.5°C, with extremes increasing**
- **Variability because of ENSO, NAO and IPO will continue, but will be superimposed on unprecedented global warmth**
- **These are the climatic challenges faced by agriculture and forestry during the 21st century**

Conclusions

Reducing Vulnerability:

Whatever we do, climate change is inevitable during the 21st century
The rate of climate change will be rapid

Integrating preparedness for increasing climate variability and change