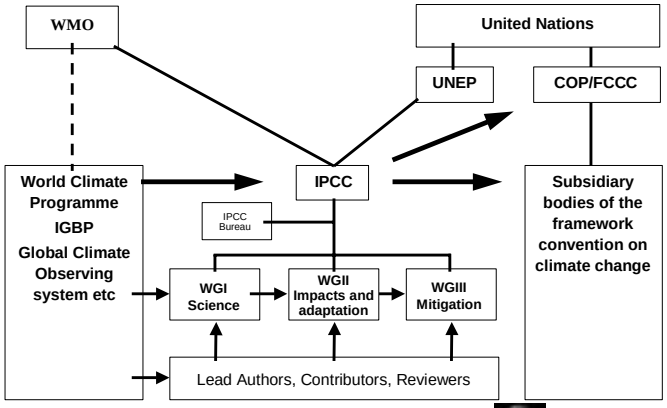
Lecture 13: IPCC Summary For PolicyMakers: WG1-Science

- ***I***ntergovernmental ***P***anel on ***C***limate ***C***hange
- Main Conclusions of the SPM

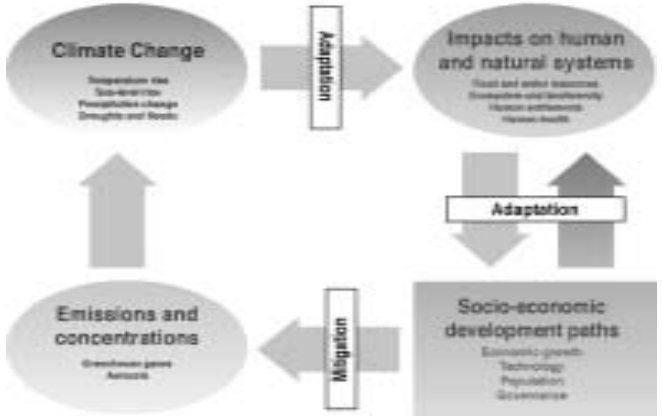
IPCC Web Site

http://www.ipcc.ch

Structure of IPCC 1997 – 2001



(adapted from IPCC website; presented by Sir John Houghton)



Climate Change 2001: The Scientific Basis

WGI contribution to IPCC Third Assessment Report

Summary for Policymakers (SPM)

Approved 'sentence by sentence' by WGI plenary (99 Governments and 45 scientists)

The Scientific Basis (Technical Summary)

14 chapters; 120 Lead Authors 515 Contributing Authors 4621 References quoted

ESS11 Prof. Jin-Yi Yu

Contents

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Understand and Project Our Climate System

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Major Conclusions in SPM

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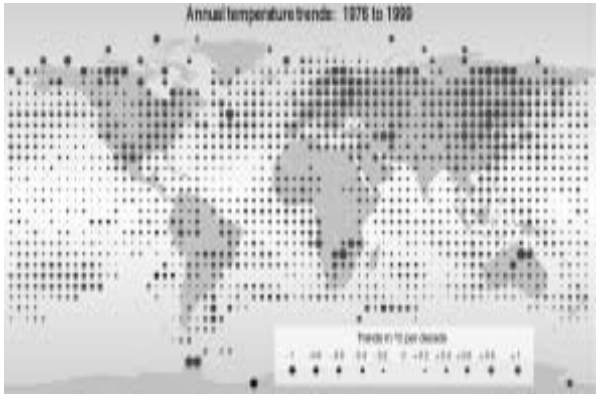
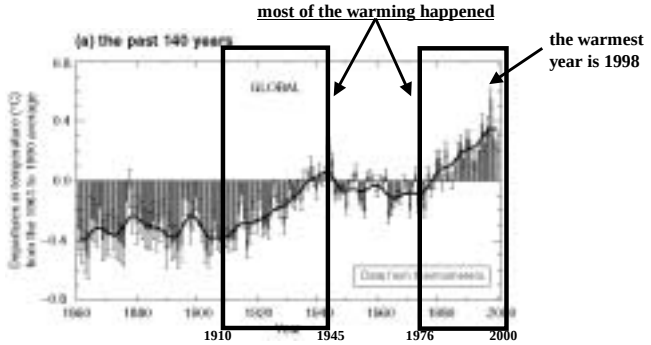
Evidences of Global Warming and Other Changes

- ❑ Temperature
- ❑ Precipitation
- ❑ Snow / Ice Cover
- ❑ Sea Level
- ❑ Circulation
- ❑ Extremes

The Land and Oceans Have Warmed

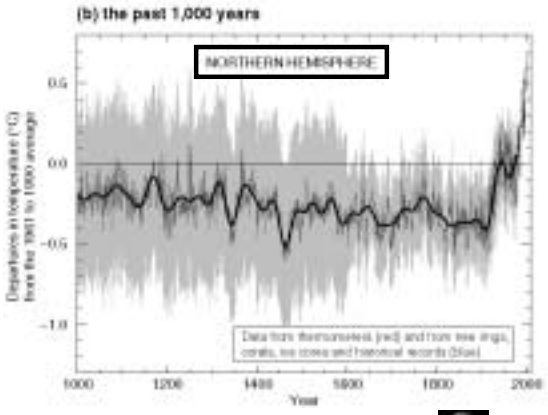


Global Surface Temperature

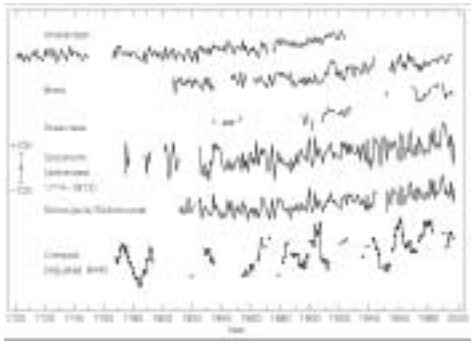


The global average surface temperature has increased over the 20th century by about 0.6˚C.

Compared to the Past 1000 Years

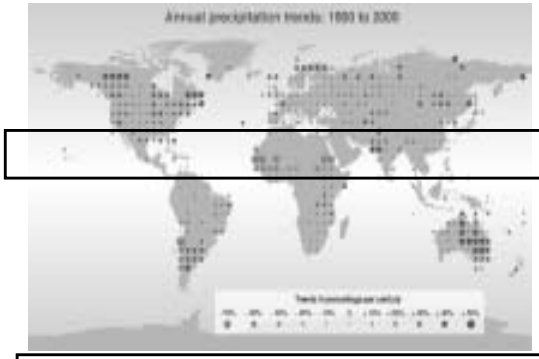


Global Sea Level Has Risen



Tidal gauge data show that global average sea level rose between 10 and 20 cm during the 20th.

Precipitation Patterns Have Changed

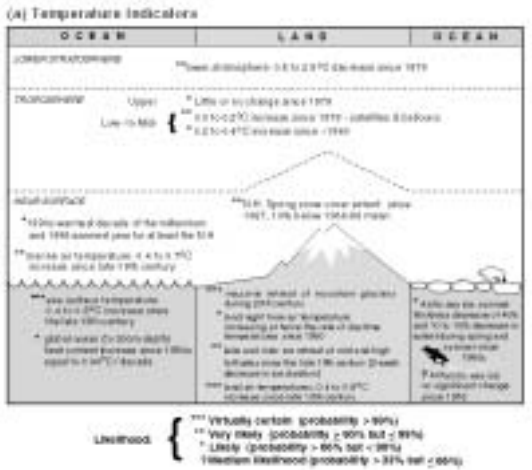


Rainfall maybe decreased over much subtropical lands.

It is likely that precipitation has increased by 0.5 to 1% per decade in the 20th century over most mid- and high latitudes of the N.H. continents.

Other Climate Changes

- The snow cover has decreased by about 10% since the late 1960s.
- Northern hemisphere spring and summer sea-ice extent has decreased by about 10 to 15% since the 1950s.
- El Nino phenomenon has been more frequent, persistent, and intense since the mid-1970s.
- No significant trends of Antarctic sea-ice extent are apparent since 1978.
- No systematic changes in the frequency of tornadoes, thunder days, or hail events are evident in the limited areas analyzed.



Major Conclusions in SPM

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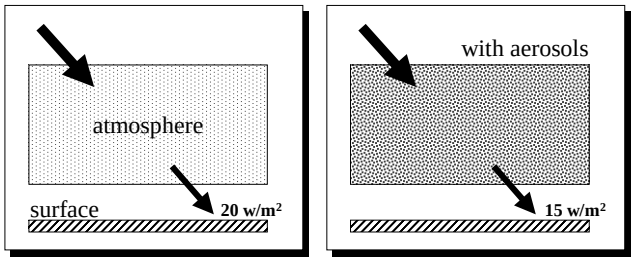
Emissions of Greenhouse Gases and Aerosols

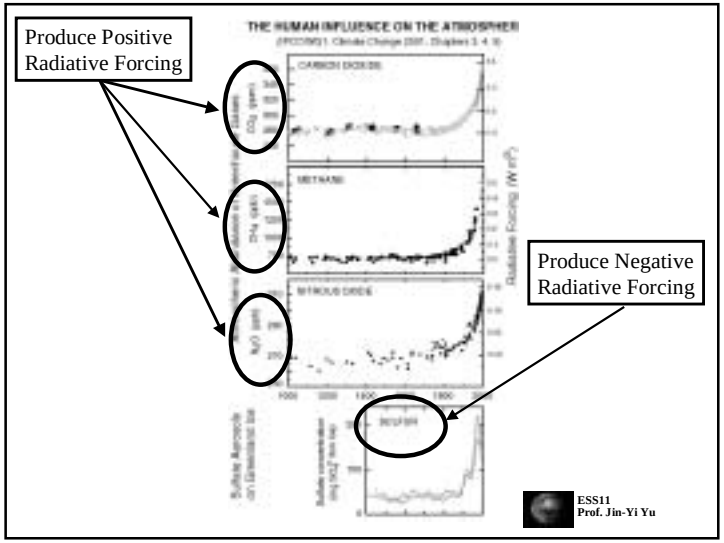
- Concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities.
- Anthropogenic aerosols are short-lived and mostly produce negative radiative forcing.

Radiative Forcing



radiative forcing of the aerosols = 15-20 = -5 w/m²

- *Radiative forcing* is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system, and is an index of the importance of the factor as a potential climate change mechanism. It is expressed in Watts per square metre (Wm^{-2}).



Increase of CO_2 Concentration

- The atmospheric concentration of carbon dioxide (CO2) has increased by 31% since 1750. The present CO2 concentration has not been exceeded during the past 420,000 years and likely not during the past 20 million years. The current rate of increase is unprecedented during at least the past 20,000 years.
- About three-quarters of the anthropogenic emissions of CO2 to the atmosphere during the past 20 years is due to fossil fuel burning. The rest is predominantly due to land-use change, especially deforestation.
- Currently the ocean and the land together are taking up about half of the anthropogenic CO2 emissions. On land, the uptake of anthropogenic CO2 very likely exceeded the release of CO2 by deforestation during the 1990s.

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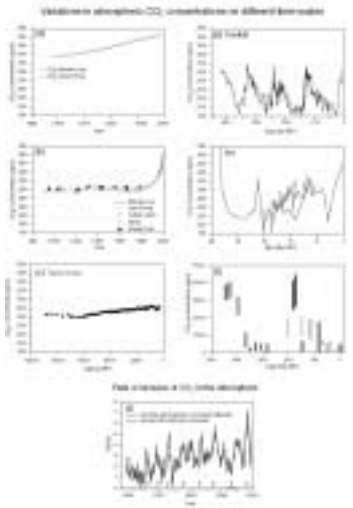

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Increase of N_2O Concentration

- The atmospheric concentration of nitrous oxide (N2O) has increased by 46 ppb (17%) since 1750 and continues to increase. The present N2O concentration has not been exceeded during at least the past thousand years.
- About a third of current N2O emissions are anthropogenic (e.g., agricultural soils, cattle feed lots and chemical industry).

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Increase of Methane Concentration

- The atmospheric concentration of methane (CH4) has increased by 151% (1060 ppb9) since 1750 and continues to increase.
- The present CH4 concentration has not been exceeded during the past 420,000 years.
- Slightly more than half of current CH4 emissions are anthropogenic (e.g., use of fossil fuels, cattle, rice agriculture and landfills).

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Halocarbon Concentration

- Since 1995, the atmospheric concentrations of many of those halocarbon gases that are both ozone-depleting and greenhouse gases (e.g., CFCl3 and CF2Cl2), are either increasing more slowly or decreasing, both in response to reduced emissions under the regulations of the Montreal Protocol and its Amendments.
- Their substitute compounds (e.g., CHF2Cl and CF3CH2F) and some other synthetic compounds (e.g., perfluorocarbons (PFCs) and sulphur hexafluoride (SF6)) are also greenhouse gases, and their concentrations are currently increasing.

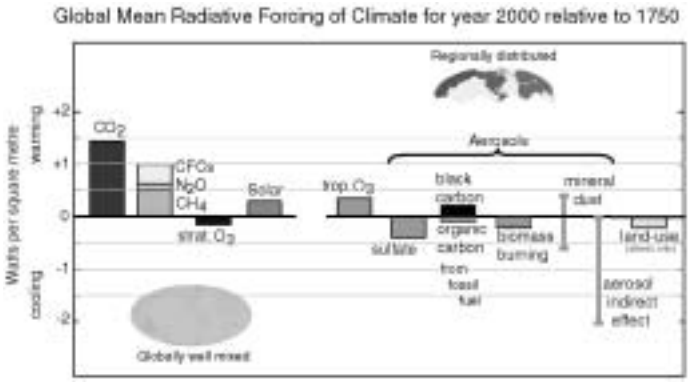
Ozone Concentration

- The observed depletion of the stratospheric ozone (O3) layer from 1979 to 2000 is estimated to have caused a negative radiative forcing (–0.15 Wm^{-2}).
- The total amount of O3 in the troposphere is estimated to have increased by 36% since 1750, due primarily to anthropogenic emissions of several O3-forming gases. This corresponds to a positive radiative forcing of 0.35 Wm^{-2}.

Anthropogenic Aerosols

- The major sources of anthropogenic aerosols are fossil fuel and biomass burning. These sources are also linked to degradation of air quality and acid deposition.
- In general, the direct radiative forcing of aerosols is negative (except for black carbon fossil).
- There is much less confidence in the ability to quantify the total aerosol direct effect, and its evolution over time.
- Aerosols also vary considerably by region and respond quickly to changes in emissions.
- In addition to their direct radiative forcing, aerosols have an indirect radiative forcing through their effects on clouds.
- There is now more evidence for this indirect effect, which is negative, although of very uncertain magnitude.

Radiative Forcing



Natural Factors of Radiative Forcing

- Since the late 1970s, satellite instruments have observed small oscillations due to the 11-year solar cycle. Mechanisms for the amplification of solar effects on climate have been proposed, but currently lack a rigorous theoretical or observational basis.
- Stratospheric aerosols from explosive volcanic eruptions lead to negative forcing, which lasts a few years. Several major eruptions occurred in the periods 1880 to 1920 and 1960 to 1991.
- The combined change in radiative forcing of the two major natural factors (solar variation and volcanic aerosols) is estimated to be negative for the past two, and possibly the past four, decades.

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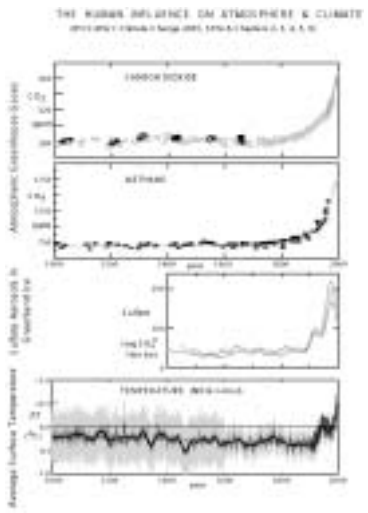

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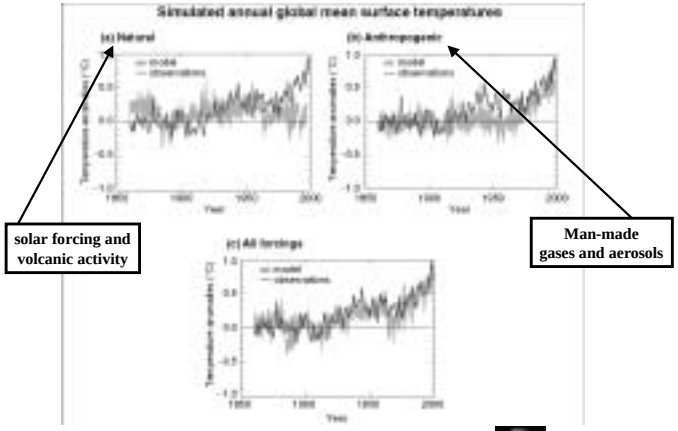
More Confidence in Climate Models



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Evidence of Global Warming

- Detection and attribution studies consistently find evidence for an anthropogenic signal in the climate record of the last 35 to 50 years.
- Simulations of the response to natural forcings alone (i.e., the response to variability in solar irradiance and volcanic eruptions) do not explain the warming in the second half of the 20th century.
- However, they indicate that natural forcings may have contributed to the observed warming in the first half of the 20th century.
- Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.

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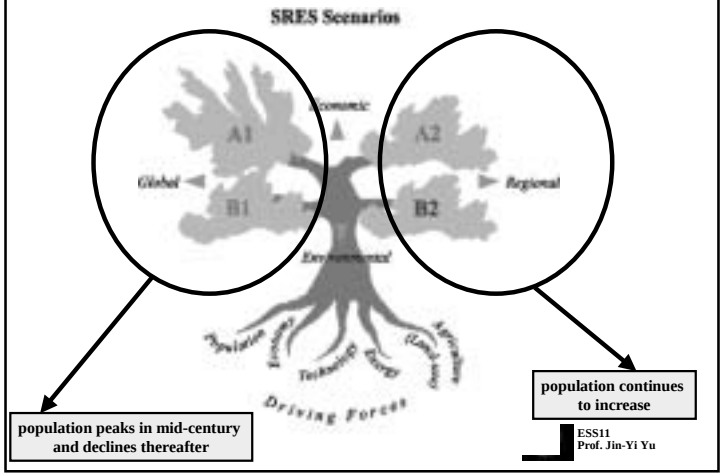
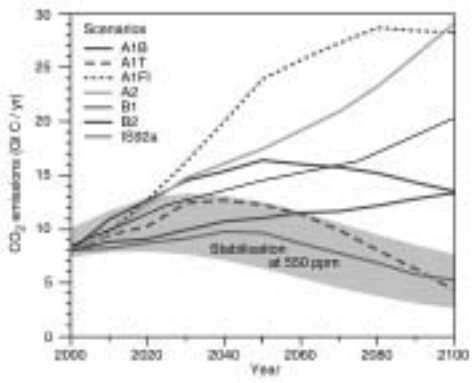
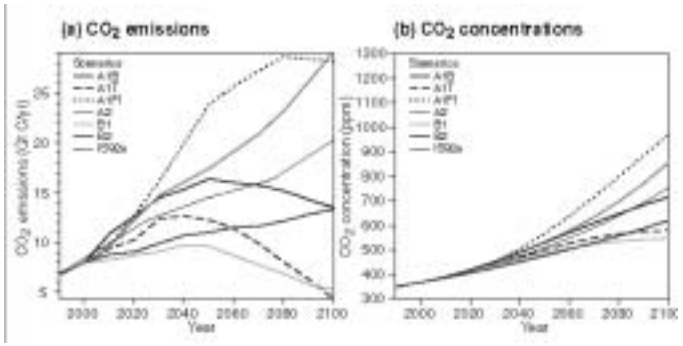
IPCC Special Report on Emission Scenarios (SRES)



Projected CO2 Emissions



Projected CO2 Concentration



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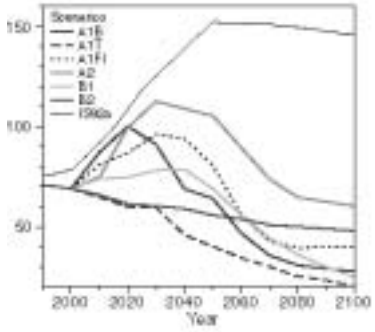
Projected Aerosol (SO2) Emissions



- The SRES scenarios include the possibility of either increases or decreases in anthropogenic aerosols depending on the extent of fossil fuel use and policies to abate polluting emissions.
- In addition, natural aerosols (e.g., sea salt, dust and emissions leading to the production of sulphate and carbon aerosols) are projected to increase as a result of changes in climate.

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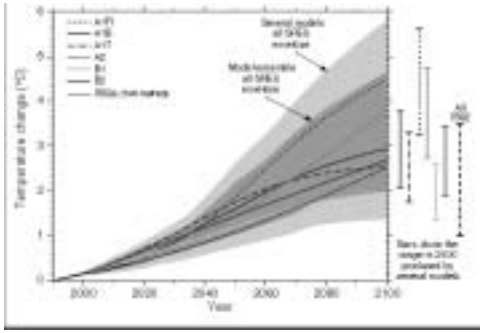
Projected Global Temperature



- The globally averaged surface temperature is projected to increase by 1.4 to 5.8°C over the period 1990 to 2100.

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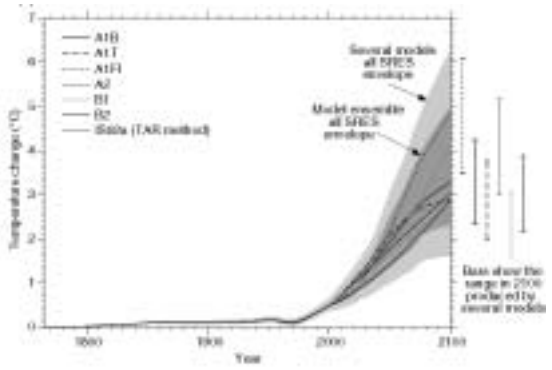
The projected warming is very likely to be without precedent during at least the last 10,000 years….



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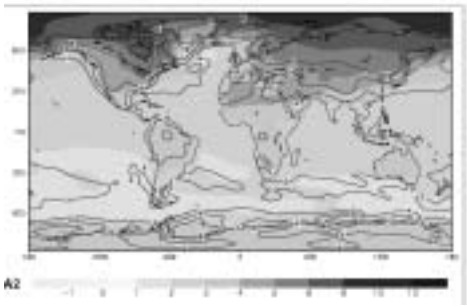
Global Distribution of The Warming



It s very likely that nearly all land areas will warm more rapidly than the global average, particularly those at northern high latitudes in the cold season.

Projected Precipitation

- Based on global model simulations and for a wide range of scenarios, global average water vapor concentration and precipitation are projected to increase during the 21st century.
- By the second half of the 21st century, it is likely that precipitation will have increased over northern mid- to high latitudes and Antarctica in winter.
- At low latitudes there are both regional increases and decreases over land areas.
- Larger year to year variations in precipitation are very likely over most areas where an increase in mean precipitation is projected.

Projected Extreme Events

Confidence in observed changes (latter half of the 20th century)	Changes in Phenomenon	Confidence in projected changes (during the 21st century)
Likely[1]	Higher maximum temperatures and more hot days over nearly all land areas	Very likely[1]
Very likely[1]	Higher minimum temperatures, fewer cold days and frost days over nearly all land areas	Very likely[1]
Very likely[1]	Reduced diurnal temperature range over most land areas	Very likely[1]
Likely[1], over many areas	Increase of heat index[2] over land areas	Very likely[1], over most areas
Likely[1], over many Northern Hemisphere mid- to high-latitude land areas	More intense precipitation events[3]	Very likely[1], over many areas
Likely[1], in a few areas	Increased summer continental drying and associated risk of drought	Likely[1], over most mid-latitude continental interiors. (Lack of consistent projections in other areas)
Not observed in the few analyses available	Increase in tropical cyclone peak wind intensities[4]	Likely[1], over some areas
Insufficient data for assessment	Increase in tropical cyclone mean and peak precipitation intensities[4]	Likely[1], over some areas

Projected El Nino Activity

- Current projections show little change or a small increase in amplitude for El Niño events over the next 100 years.
- Even with little or no change in El Niño amplitude, global warming is likely to lead to greater extremes of drying and heavy rainfall and increase the risk of droughts and floods that occur with El Niño events in many different regions.

Projected Monsoon Variability

- It is likely that warming associated with increasing greenhouse gas concentrations will cause an increase of Asian summer monsoon precipitation variability.
- Changes in monsoon mean duration and strength depend on the details of emission scenario.

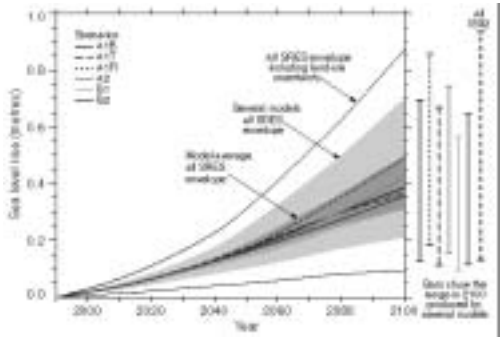
Projected Thermohaline Circulation

- Most models show weakening of the ocean thermohaline circulation which leads to a reduction of the heat transport into high latitudes of the Northern Hemisphere.
- The current projections using climate models do not exhibit a complete shut-down of the thermohaline circulation by 2100.
- Beyond 2100, the thermohaline circulation could completely, and possibly irreversibly, shut-down in either hemisphere if the change in radiative forcing is large enough and applied long enough. scenarios.

Projected Snow/Ice Cover

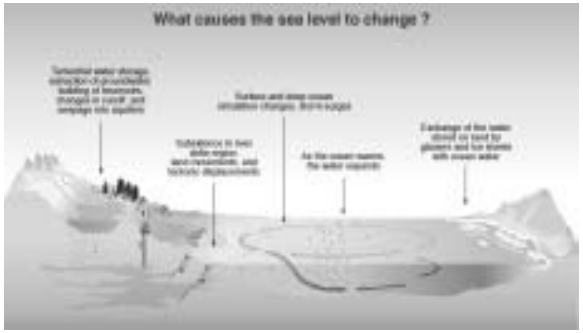
- Northern Hemisphere snow cover and sea-ice extent are projected to decrease further.
- Glaciers and ice caps are projected to continue their widespread retreat during the 21st century.
- The Antarctic ice sheet is likely to gain mass because of greater precipitation, while the Greenland ice sheet is likely to lose mass because the increase in runoff will exceed the precipitation increase.

Projected Sea-Level Change



- Global mean sea level is projected to rise by 0.09 to 0.88 metres between 1990 and 2100, for the full range of SRES scenarios.

Sea Level Change and Global Warming



Climate-induced increases in sea level are caused by thermal expansion of the oceans and melting of land ice and ice sheets

Global Warming and Sea-Level Change