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# Scientific Facts on

# Climate Change

2001 Assessment

**Source document:**
IPCC (2001)

**Summary & Details:**
GreenFacts

## Level 2 - Details on Climate Change

Questions 1 to 6 are a faithful summary of the leading scientific consensus report produced in 2001 by the Intergovernmental Panel on Climate Change (IPCC):
*"Summary for Policymakers of the Third Assessment Report"*

The full Digest is available at: https://www.greenfacts.org/en/climate-change-ar3/

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- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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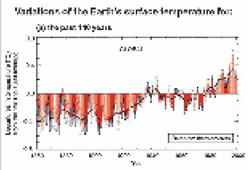
# 1. Has the climate changed during the 20th century?

## 1.1 Has the world warmed?

An increasing number of observations indicates that the world has warmed:

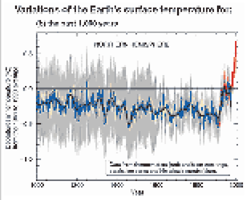
*1.1.1* The average surface temperature has increased over the 20th century by about 0.6C (± 0.2°C). This increase occurred mainly from 1910 to 1945 and 1976 to 2000. The increase is larger at night time and over land area.



Variations of the Earth's surface temperature over the last 140 years. [see Annex 18, p. 36]

It is likely[7] [see Annex 6, p. 23] that in the Northern Hemisphere, over the past 1000 years:

- the temperature increase in 20th century was the largest,
- the 1990s was the warmest decade and 1998 the warmest year.



Variations of the Earth's surface temperature over the last 1000 years. [see Annex 18, p. 36]

*1.1.2* Temperatures have risen during the past four decades in the lowest 8 kilometers of the atmosphere.

*1.1.3* Snow cover and ice extent have decreased.

*1.1.4* The sea level has risen by 10 to 20 cm (4 to 8") during the 20th century. Ocean temperature has increased since the late 1950s.

See also summary of changes in IPCC TS figure 7a [see Annex 12, p. 30]

## 1.2 What other climate changes have been observed?

- Precipitation is likely[7] [see Annex 6, p. 23] to have increased in the 20th century in some land areas and decreased in others.
- It is likely[7] [see Annex 6, p. 23] that there has been some increase in cloud cover.
- It is very likely[7] [see Annex 6, p. 23] that there has been less extreme low temperatures and slightly more extreme high temperatures.
- There have been more warm episodes of the El Niño since the mid-1970s.
- There were relatively small global increases in severe drought or severe wetness over the century but an increase in droughts in some regions in recent decades.

See also summary of changes in IPCC TS figure 7b [see Annex 12, p. 30]

## 1.3 What aspects of our climate have NOT changed?

- No warming is apparent in some parts of the Southern Hemisphere oceans and parts of Antarctica.
- No systematic rainfall change over the Southern Hemisphere.
- No significant trends of Antarctic sea-ice extent.
- No clear change in tropical and extra-tropical storm intensity and frequency or in the frequency of tornadoes, thunder days, or hail events.

See also summary of changes in IPCC TS figure 7b [see Annex 12, p. 30]

# 2. What causes this climate change?

## 2.1 Are human activities modifying the atmosphere?

Changes in climate are the result of both internal variability within the climate system and external factors (both natural and anthropogenic).Human emissions are significantly modifying the concentrations of some gases in the atmosphere (see historical record in Figure 2 [see Annex 10, p. 27] ). Some of these gases are expected to affect the climate by changing the earth's radiative balance, measured in terms of radiative forcing (see estimates in Figure3 [see Annex 11, p. 29] ):

*2.1.1* Greenhouse gases, which have a global effect, tend to warm the earth surface by absorbing some of the infrared radiation it emits.

- The principal anthropogenic greenhouse gas is carbon dioxide ($CO_2$),whose concentration has increased by 31% since 1750 to a level which is likely[7] [see Annex 6, p. 23] to have not been exceeded for 20 million years. This increase is predominantly due to fossil fuel burning, but also to land-use change, especially deforestation.
- The other significant anthropogenic greenhouse gases are methane ($CH_4$) (151% increase since 1750, 1/3 of $CO_2$'s radiative forcing), halocarbons such as CFCs and their substitutes (100% anthropogenic, 1/4 of $CO_2$'s radiative forcing) and nitrous oxide ($N_2O$) (17% increase since 1750, 1/10 of $CO_2$'s radiative forcing).

*2.1.2* Anthropogenic aerosols, which have a regional effect, are short-lived and mostly tend to cool the earth down.

*2.1.3* Known natural factors such as changes in solar irradiance and volcanic eruptions are expected to have only made small contributions to radiative forcing over the past century.

See historical records in Figure 2 [see Annex 10, p. 27] and radiative impact in Figure 3 [see Annex 11, p. 29]

## 2.2 How well is climate change understood?

*2.2.1* Complex computer models are used to predict future climate. Understanding of climate processes and their incorporation in computer models has improved. Although such models still cannot simulate all aspects of climate, confidence in their ability to provide useful projections has increased. They can now better reproduce the 20th century global warming , using both natural and anthropogenic forcing (see Figure 4 [see Annex 13, p. 30] ).

*2.2.2* However further research is required to improve the ability to detect, attribute and understand climate change, to reduce uncertainties and to project future climate changes.

## 2.3 To what extent is climate change due to human activities?

In light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years (i.e., about half of the warming over the last 120 years) is likely[7] [see Annex 6, p. 23] to have been due to the increase in greenhouse gas concentrations.

The warming over the past 100 years is very unlikely[7] [see Annex 6, p. 23] to be due to internal variability alone and is unlikely[7] [see Annex 6, p. 23] to be entirely natural in origin.

# 3. What climate changes are expected for the future?

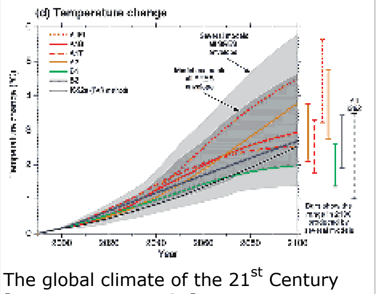
## 3.1 What emission scenarios are projected?

**Human influences will continue to change atmospheric composition throughout the 21st century.**

Several emission scenarios were developed by the IPCC, using various hypotheses for the developments in population, technology, income, regional wealth differences... (see the summary for 6 of them [see Annex 16, p. 34] ). These scenarios were fed into computer models to make projections of atmospheric concentrations of greenhouse gases and aerosols, and hence of future climate changes (see Figure 5 [see Annex 17, p. 34] ).

## 3.2 What climate changes are projected for the 21st century?

**Global average temperature and sea level are projected to rise under all IPCC scenarios during the 21st century.**



The global climate of the 21st Century [see Annex 17, p. 34]

- The average global surface temperature is projected to increase by something between 1.4 and 5.8°C (2.5 to 10°F) over the period 1990 to 2100. This wide range is equally due:
  - to the level of greenhouse gases emissions supposed by each scenario
  - to the response of the individual computer model used (see Figure 5d [see Annex 17, p. 34] )
- The projected rate of warming is very likely[7] [see Annex 6, p. 23] to be the fastest in at least the last 10,000 years.
- It is very likely[7] [see Annex 6, p. 23] that nearly all land areas will warm more rapidly than the global average, particularly those at high northern latitudes in the cold season (see map [see Annex 15, p. 32] ).
- Precipitation is projected to increase, with larger year to year variations, especially in mid- to high northern latitudes and Antarctica in winter (see map [see Annex 2, p. 20] ).
- Some extreme events are expected to increase in severity (see Table 1 [see Annex 3, p. 21] ). For some others, there is not enough information to make confident projections.

- Most models show weakening of the ocean thermohaline circulation. This would reduce the temperature increase in high latitudes of the Northern Hemisphere.
- Northern Hemisphere snow cover and sea-ice extent are projected to decrease further, as well as glaciers and ice caps. The Antarctic ice sheet is likely[7] [see Annex 6, p. 23] to gain mass while the Greenland ice sheet is likely[7] [see Annex 6, p. 23] to lose mass. It is very unlikely[7] [see Annex 6, p. 23] that there will be a loss of grounded West Antarctic ice raising substantial the sea level.
- Sea level is projected to rise by something between 9 and 88 cm (3.5 to 35") between 1990 and 2100, due primarily to thermal expansion and loss of ice. This wide range is due mostly to model uncertainties (see Figure 5e [see Annex 17, p. 34] ).

## 3.3 What climate changes are projected for future centuries?

**Anthropogenic climate change will persist for many centuries.**

- Emissions of long-lived greenhouse gases (i.e., $CO_2$, $N_2O$, PFCs, $SF_6$) have a lasting effect on atmospheric composition and climate. Even after greenhouse gas concentrations have stabilized, global average surface temperatures would continue rising at a reduced rate.
- Global mean surface temperature increases and rising sea level from thermal expansion of the ocean are projected to continue for hundreds of years after stabilization of greenhouse gas concentrations (even at present levels).
- Ice sheets will continue to react to climate warming and contribute to sea level rise for thousands of years after the climate has stabilized. For instance, a Greenland warming of 5.5°C, if sustained for 1,000 years, would likely[7] [see Annex 6, p. 23] result in a sea level rise of about 3 meters.

# 4. What are the likely consequences of climate change?

## 4.1 Has climate change already started to affect us?

*4.1.1* Regional changes in climate, particularly increases in temperature, have already affected a diverse set of physical and biological systems in many parts of the world.

Examples include: shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid- to high-latitude growing seasons, poleward and altitudinal shifts of plant and animal ranges, declines of some plant and animal populations, and earlier flowering of trees, emergence of insects and egg-laying in birds.

Regarding human systems, there are preliminary indications that some social and economic systems may have been affected by the recent increasing frequency of floods and droughts in some areas.

## 4.2 How potentially could climate change affect us?

*4.2.1* **Natural systems** can be especially vulnerable to climate change because of limited adaptive capacity. While some species may benefit from climate change, existing risks of extinction could increase for some more vulnerable species. The risk of damage will increase with the magnitude and rate of climate change.

*4.2.2* **Human systems** that are sensitive to climate change include mainly water resources; agriculture (especially food security) and forestry; coastal zones and marine systems (fisheries); human settlements, energy, and industry; insurance and other financial services; and human health. Vulnerability varies with geographic location, time, and social, economic, and environmental conditions. Some effects will be adverse [see https://www.greenfacts.org/en/climate-change-ar3/l-3/climate-change-4.htm#4p2] but some others beneficial [see https://www.greenfacts.org/en/climate-change-ar3/l-3/climate-change-4.htm#4p2].

## 4.3 What other major impacts could climate change possibly have?

Some extreme events such as droughts, floods, heat waves, avalanches, and windstorms are projected to increase in frequency and/or severity, others such as cold spells are projected to decrease. The damage, hardship, and death caused is also expected to increase with global warming (see Figure SPM-2 [see Annex 4, p. 21] ). The impacts are expected to fall disproportionately on the poorer regions.

There is a potential for large-scale and possibly irreversible impacts but this risk has yet to be reliably quantified. Examples include:
- slowing of the warm North Atlantic currents,
- large reductions in the Greenland and West Antarctic Ice Sheets and
- accelerated global warming due to releases of terrestrial carbon from permafrost regions and methane from hydrates in coastal sediments.

The likelihood of many of these changes is probably very low but is expected to increase with the rate, magnitude, and duration of climate change.

*See Table SPM-1 [see https://www.greenfacts.org/en/climate-change-ar3/l-3/climate-change-4.htm#3p3]: Examples of impacts resulting from projected changes in extreme climate events.*

## 4.4 What should be done?

Adaptation could reduce adverse impacts of climate change and enhance beneficial impacts, but will incur costs and will not prevent all damages. It is necessary to complement mitigation efforts with adaptation.

Based on a few published estimates, global warming of up to a few degrees C would produce:

- Net economic losses in many developing countries (low confidence[6] [see Annex 7, p. 24] ); the higher the warming the greater the losses (medium confidence[6] [see Annex 7, p. 24] ).
- A mixture of economic gains and losses (low confidence[6] [see Annex 7, p. 24] ) in developed countries, and losses for larger temperature increases (medium confidence[6] [see Annex 7, p. 24] ).
- Decreases in world gross domestic product (GDP) of a few percent (low confidence[6] [see Annex 7, p. 24] ), and increasing net losses for larger increases

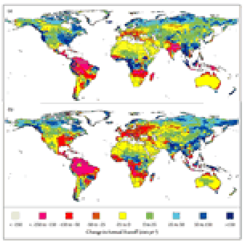
in temperature (medium confidence[6] [see Annex 7, p. 24] ) (see Figure SPM-2 [see Annex 4, p. 21] ).

Policies that lessen pressures on resources, improve management of environmental risks, and increase the welfare of the poorest could simultaneously advance sustainable development and equity, enhance adaptive capacity, and reduce vulnerability to climate and other stresses.

# 5. How could Climate Change affect us in the future?

## 5.1 What would be the effects on and vulnerability of the natural systems?

### *5.1.1* Hydrology and Water Resources


Changes in Water Runoff [see Annex 5, p. 22]

Most scenarios project **increases** in annual mean streamflow in high latitudes and southeast Asia, and **decreases** in central Asia, the area around the Mediterranean, southern Africa, and Australia.

The population living in **water-stressed areas** is projected to increase. **Floods** could increase in many regions. However, water management could be applied to adapt to the changes.

### *5.1.2* Agriculture and Food Security

Crop yield responses to climate change vary widely, depending upon many parameters. Increased $CO_2$ concentration can stimulate crop growth and yield, yet that benefit may not always overcome the adverse effects of excessive heat and drought . Crop yields are projected to increase in mid-latitude regions for less than a few degrees C warming, and to decrease in all other cases.

### *5.1.3* Terrestrial and Freshwater Ecosystems

In certain ecosystems or biomes, species composition and dominance would change. Distributions, population sizes, population density, and behavior of **wildlife** have been, and will continue to be, affected directly by changes in global or regional climate and indirectly through changes in vegetation.

Fish distributions would move towards the poles, along with loss of habitat for cold- and cool-water fish and gain in habitat for warm-water fish. Extinction risks should increase for endangered or vulnerable freshwater fish species.

A small amount of climate change would increase global timber supply in developing countries.

### *5.1.4* Coastal Zones and Marine Ecosystems

Impacts on **oceans** would include increases in sea surface temperature and mean global sea level, decreases in sea-ice cover, and changes in salinity, wave conditions, and ocean circulation.

Many **coastal areas** should experience more flooding, accelerated erosion, loss of wetlands and mangroves, and seawater intrusion into freshwater sources. **Coastal ecosystems** such as coral reefs, atolls and reef islands, salt marshes and mangrove forests would be affected to varying degrees.

## 5.2 What would be the effects on and vulnerability of the human systems?

### *5.2.1* Human Health

The geographic range would spread for many **infectious diseases** like malaria and dengue (which currently impinge on 40-50% of the world population).

**Heat-wave** related deaths and illness episodes are expected to increase, but reduced winter deaths would outnumber increased summer deaths in some temperate countries.

Any increase in **flooding** would increase the risk of drowning, diarrheal and respiratory diseases, and, in developing countries, hunger and malnutrition.

For each anticipated adverse health effect there is a range of social, institutional, technological, and behavioral adaptation options to lessen that impact.

### *5.2.2* Human Settlements, Energy, and Industry

Human settlements would be affected by climate change in **three major ways**: economic productivity, infrastructure and population health or migration.

The most widespread direct risk is **flooding and landslides**. The number of people who would be flooded by coastal storm surges would increase several fold.

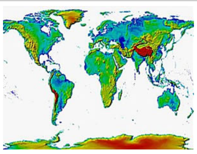
### *5.2.3* Insurance and Other Financial Services

The costs of ordinary and extreme weather events have increased rapidly in recent decades. Part of this increase is linked to socioeconomic factors, such as population growth, increased wealth, and urbanization in vulnerable areas, and part is linked to climatic factors such as the observed changes in precipitation and flooding events.

Climate change would place upward pressure on insurance premiums and/or lead to certain risks being reclassified as uninsurable.

## 5.3 How does climate change vulnerability vary across regions?

The vulnerability of human populations and natural systems to climate change differs substantially across regions and across populations within regions.



**Click on the different areas of the map to obtain summaries of the adaptive capacity, Vulnerability and Key Concerns for each region**

# 6. How could greenhouse gas emissions be reduced?

## 6.1 How is Climate Change a unique problem?

Climate change[2] [see Annex 8, p. 25] is a problem with unique charateristics. It is global, long term (up to centuries), and involves complex interactions between climatic, environmental, economic, political, institutional, social and technological processes. Alternative development paths[4] [see Annex 8, p. 25] can result in very different greenhouse gas emissions.

Climate change mitigation[1] [see Annex 8, p. 25] would both be affected by, and have impacts on, broader socio-economic policies and trends, such as those relating to development, sustainability and equity.

Key considerations of climate change mitigation options concern the differences in the distribution of technological, natural and financial resources among and within nations and regions, and between generations, as well as differences in mitigation costs.

Lower emissions scenarios would require different patterns of energy resource development.

## 6.2 What are the options for reducing greenhouse gas emissions?

*6.2.1* Since 1995, there has been significant and faster than anticipated technical progress in greenhouse gas emissions reduction. The **options** over the next 20 years would include improving energy efficiency for buildings, transport and manufacturing, conversion to natural gas for energy supply, as well as low-carbon energy supply systems such as biomass, wind, nuclear and hydroelectric power systems, the reduction of methane and nitrous oxide emissions in agriculture and, with some applications, the minimization of fluorinated gas emissions (see Table SPM.1 [see Annex 14, p. 32] for estimates; half of these potential emissions reductions may be achieved with direct benefits exceeding direct costs).

*6.2.2* **Forests and agricultural lands** provide significant carbon mitigation potential, which would not necessarily be permanent but it may allow time for other options to be further developed and implemented. The global potential could be in the order of 100 GtC by 2050, equivalent to about 10% to 20% of the fossil fuel emissions during that period.

*6.2.3* Social learning and innovation, as well as changes in institutional structures could contribute to climate change mitigation. **Changes in collective rules and individual behavior** may have significant effects on greenhouse gas emissions, but would take place within complex institutional, regulatory and legal settings.

## 6.3 What would be the costs of implementing the Kyoto Protocol?

*6.3.1* **Estimates of cost and benefits** of mitigation actions differ because of (i) how welfare is measured, (ii) the scope and methodology of the analysis, and (iii) the underlying assumptions built into the analysis, including: changes in demographics, economic growth, personal mobility, technological and fiscal innovations, the level and timing of mitigation actions, implementation measures, and financial computations.

*6.3.2* Some sources of greenhouse gas emissions could be limited at no cost or with a negative net social cost, by bringing **benefits** such as: reduction of market or institutional imperfections that impede cost-effective measures, societal benefits from reductions in air pollution ("ancillary benefits"), and reductions in existing distortionary taxes financed by emission taxes or permits ("revenue recycling").

*6.3.3* **For developed countries**, the cost estimates to implement the Kyoto Protocol vary between studies and regions and depend strongly upon the assumptions regarding the use of the Kyoto mechanisms. Most studies project GDP reductions in 2010 of about 0.2% to 2% without emission trading and of about 0.1% to 1.1% with emission trading.

*6.3.4* The cost of stabilizing $CO_2$ concentrations by 2100 increases significantly as the concentration stabilization level declines.

*6.3.5* Some industries are likely to suffer from greenhouse gas reduction efforts, such as: coal, possibly oil and gas, and certain energy-intensive sectors such as steel production. Others are likely to benefit, such as renewable energy industries and services.

*6.3.6* **Developing countries** would also be affected by the implementation of the Kyoto Protocol:

- Oil-exporting countries would see a reduction in their oil revenue.
- Other countries may be affected by a reduction in their exports to developed countries,
- but may benefit economically from some relocation of carbon-intensive industries (carbon leakage).

## 6.4 What are the ways and means for mitigation?

The successful implementation of greenhouse gas mitigation options needs to overcome many technical, economic, political, cultural, social, behavioral and/or institutional barriers which prevent the full exploitation of the technological, economic and social opportunities of these mitigation options.

*6.4.1* The portfolio of government **climate policy instruments** may include: emissions/carbon/energy taxes, tradable or non-tradable permits, provision and/or removal of subsidies, deposit/refund systems, technology or performance standards, energy mix requirements, product bans, voluntary agreements, government spending and investment, and support for research and development.

*6.4.2* The effectiveness of climate change mitigation could be enhanced when climate policies are integrated with the non-climate objectives of national and sectorial policy development, to achieve the long-term changes required by both sustainable development and climate change mitigation.

*6.4.3* **Coordinated actions** among countries and sectors may help to reduce mitigation costs, address competitiveness concerns, potential conflicts with international trade rules, and carbon leakage.

*6.4.4* Climate change decision-making is essentially a sequential process under general uncertainty. The relevant question is not "what is the best course for the next 100 years", but rather "what is the best course for the near term given the expected long-term climate change and accompanying uncertainties". More rapid near-term action would decrease environmental and human risks associated with rapid climate changes.

*6.4.5* Any **international regime** could be designed in a way that enhances both its efficiency and its equity. The development of an effective regime on climate change must give attention to sustainable development and non-economic issues.

## 6.5 What in the current knowledge needs to be improved?

The priorities for narrowing gaps between current knowledge and policy-making needs are:

- Further exploration of the regional, country and sector specific potentials of technological and social innovation options.
- Economic, social and institutional issues related to climate change mitigation in all countries.
- Methodologies for analysis of the potential of mitigation options and their cost, with special attention to comparability of results.
- Evaluating climate mitigation options in the context of development, sustainability and equity.

# 7. Are recent extreme weather events due to global warming?

## 7.1 What extreme events could global warming explain?

As the world warms, some extreme climate events, like the frequency of heat waves and very heavy precipitation, are expected to increase, but some others remains uncertain. Moreover, it is not possible to link any particular weather or climate event definitively to global warming.

## 7.2 Is the occurrence of extreme temperatures increasing?

In some regions where good data are available, there have been some significant increases and decreases in extreme temperatures over time. For example, there have been fewer extremely low minimum temperatures in several areas. As global temperatures rise, extremely high temperatures are expected to be more frequent.

## 7.3 Are precipitation levels changing?

As the Earth warms, an increase in the frequency of extreme precipitation events and droughts is expected. In some regions, an increase in precipitation has been observed, but there is no evidence in other regions of a worldwide rise in droughts.

## 7.4 Are storms affected by global warming?

Blizzards and snow storms may actually increase in intensity and frequency in some colder locations and decrease in temperate latitudes.

The frequency of intense extra-tropical storms has increased in the northern North Atlantic and decreased in the southern North Atlantic, but it remains uncertain whether these are related to global warming.

No apparent long-term trends have been observed in the total number of tropical storms including hurricanes, typhoons and cyclones. There is little consensus about how global warming will affect their intensity and frequency in the future.

# 8. Do man-made greenhouse gases matter compared to water vapor?

## 8.1 How do gases affect the earth's temperature?

The earth's surface temperature would be about 34°C (61°F) colder than it is now if it were not for the natural heat trapping effect of greenhouse gases like carbon dioxide, methane, nitrous oxide, and, the most important one, water vapor.

## 8.2 What is the human contribution?

Greenhouse gases concentrations have been stable over the past 10 000 years until several of them started increasing with industrialization. Without control measures, these man-made gases are expected to produce over the next 50 to 100 years a heat-trapping effect equivalent to more than a doubling of the pre-industrial carbon dioxide level.

## 8.3 How could water vapor amplify global warming?

Warmer air contains more water vapor. Since water vapor is itself a greenhouse gas, global warming could be further enhanced by the increased amounts of water vapor.

## 8.4 What is the role of clouds?

Clouds affect the heat balance of the Earth by reflecting sunlight (a cooling effect) and trapping infrared radiation (a heating effect). Their response to global warming remains a major uncertainty in determining the magnitude and distribution of climate change.

# 9. Can ecosystems adapt to Climate Change?

## 9.1 Are ecosystems less adaptable now to Climate Change?

Ecosystems might not adapt to climate change as they had done in earlier periods because:

- the rate of climate change is projected to be faster than in the previous 10 000 years;
- human activities have altered many ecosystems;
- pollution has increased.

## 9.2 Is the speed of Climate Change detrimental to ecosystems?

Because the temperatures are expected to change faster, plants may be required to migrate to more suitable areas faster than their maximum migrating speed. This would result in:

- changes in species composition and flora degradation, which may accelerate climate change;
- a degradation of natural wildlife habitats, which may increase the prevalence of pest species.

## 9.3 Has man affected the adaptability of ecosystem?

Humans activities are occupying larger portions of land, resulting in fewer large contiguous ecosystems. Therefore, some species may not be able to effectively migrate to more suitable locations.

Also, many species are already weakened by air pollution. And although the increased $CO_2$ concentration should be beneficial to many plants, its net effect on ecosystem productivity could be limited by other factors.

## 9.4 Which ecosystems would be the most affected?

Higher latitude and coastal ecosystems are most likely to experience the most severe effects from climate change.

# Annex

# Annex 1:
# Adaptive Capacity, Vulnerability, and Key Concerns by Region



## Adaptive Capacity, Vulnerability, and Key Concerns in Africa

- "Adaptive capacity of human systems in Africa is low due to lack of economic resources and technology, and vulnerability high as a result of heavy reliance on rain-fed agriculture, frequent droughts and floods, and poverty. [5.1.7] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/039.htm#517]
- Grain yields are projected to decrease for many scenarios, diminishing food security, particularly in small food-importing countries (medium to high confidence6). [5.1.2] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/038.htm#512]
- Major rivers of Africa are highly sensitive to climate variation; average runoff and water availability would decrease in Mediterranean and southern countries of Africa (medium confidence6). [5.1.1] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/038.htm#511]
- Extension of ranges of infectious disease vectors would adversely affect human health in Africa (medium confidence6). [5.1.4] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/039.htm]
- Desertification would be exacerbated by reductions in average annual rainfall, runoff, and soil moisture, especially in southern, North, and West Africa (medium confidence6). [5.1.6] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/039.htm#516]
- Increases in droughts, floods, and other extreme events would add to stresses on water resources, food security, human health, and infrastructures, and would constrain development in Africa (high confidence6). [5.1] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/038.htm#51]
- Significant extinctions of plant and animal species are projected and would impact rural livelihoods, tourism, and genetic resources (medium confidence6). [5.1.3] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/038.htm#513]
- Coastal settlements in, for example, the Gulf of Guinea, Senegal, Gambia, Egypt, and along the East-Southern African coast would be adversely impacted by sea-level rise through inundation and coastal erosion (high confidence6). [5.1.5] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/039.htm#515] "

*Source: IPCC TAR SPM of WG II pages 14-17*

## Adaptive Capacity, Vulnerability, and Key Concerns in Asia

- "Adaptive capacity of human systems is low and vulnerability is high in the developing countries of Asia; the developed countries of Asia are more able to adapt and less vulnerable. [5.2.7] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#527]
- Extreme events have increased in temperate and tropical Asia, including floods, droughts, forest fires, and tropical cyclones (high confidence6). [5.2.4] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#524]
- Decreases in agricultural productivity and aquaculture due to thermal and water stress, sea-level rise, floods and droughts, and tropical cyclones would diminish food security in many countries of arid, tropical, and temperate Asia; agriculture would expand and increase in productivity in northern areas (medium confidence6). [5.2.1] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/040.htm#521]
- Runoff and water availability may decrease in arid and semi-arid Asia but increase in northern Asia (medium confidence6). [5.2.3] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#523]
- Human health would be threatened by possible increased exposure to vector-borne infectious diseases and heat stress in parts of Asia (medium confidence6). [5.2.6] [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#526]
- Sea-level rise and an increase in the intensity of tropical cyclones would displace tens of millions of people in low-lying coastal areas of temperate and tropical Asia; increased intensity of rainfall would increase flood risks in temperate and tropical Asia (high confidence6). [5.2.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#525] and Table TS-8 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#tabts8]]
- Climate change would increase energy demand, decrease tourism attraction, and influence transportation in some regions of Asia (medium confidence6). [5.2.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#524] and 5.2.7 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm#527]]

- Climate change would exacerbate threats to biodiversity due to land-use and land-cover change and population pressure in Asia (medium confidence6). Sea-level rise would put ecological security at risk, including mangroves and coral reefs (high confidence6). [5.2.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm]]
- Poleward movement of the southern boundary of the permafrost zones of Asia would result in a change of thermokarst and thermal erosion with negative impacts on social infrastructure and industries (medium confidence6). [5.2.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/041.htm]]"

*Source: IPCC TAR SPM of WG II pages 14-17*

# Adaptive Capacity, Vulnerability, and Key Concerns in Australia and New Zealand

- "Adaptive capacity of human systems is generally high, but there are groups in Australia and New Zealand, such as indigenous peoples in some regions, with low capacity to adapt and consequently high vulnerability. [5.3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/042.htm] and 5.3.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/043.htm#535]]
- The net impact on some temperate crops of climate and $CO_2$ changes may initially be beneficial, but this balance is expected to become negative for some areas and crops with further climate change (medium confidence6). [5.3.3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/043.htm#533]]
- Water is likely to be a key issue (high confidence6) due to projected drying trends over much of the region and change to a more El Niño-like average state. [5.3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/042.htm] and 5.3.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/043.htm]]
- Increases in the intensity of heavy rains and tropical cyclones (medium confidence6), and region-specific changes in the frequency of tropical cyclones, would alter the risks to life, property, and ecosystems from flooding, storm surges, and wind damage. [5.3.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/043.htm#534]]
- Some species with restricted climatic niches and which are unable to migrate due to fragmentation of the landscape, soil differences, or topography could become endangered or extinct (high confidence6). Australian ecosystems that are particularly vulnerable to climate change include coral reefs, arid and semi-arid habitats in southwest and inland Australia, and Australian alpine systems. Freshwater wetlands in coastal zones in both Australia and New Zealand are vulnerable, and some New Zealand ecosystems are vulnerable to accelerated invasion by weeds. [5.3.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/043.htm#532]]"

*Source: IPCC TAR SPM of WG II pages 14-17*

# Adaptive Capacity, Vulnerability, and Key Concerns in Europe

- "Adaptive capacity is generally high in Europe for human systems; southern Europe and the European Arctic are more vulnerable than other parts of Europe. [5.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm] and 5.4.6 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#546]]
- Summer runoff, water availability, and soil moisture are likely to decrease in southern Europe, and would widen the difference between the north and drought-prone south; increases are likely in winter in the north and south (high confidence6). [5.4.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#541]]
- Half of alpine glaciers and large permafrost areas could disappear by end of the 21st century (medium confidence6). [5.4.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#541]]
- River flood hazard will increase across much of Europe (medium to high confidence6); in coastal areas, the risk of flooding, erosion, and wetland loss will increase substantially with implications for human settlement, industry, tourism, agriculture, and coastal natural habitats. [5.4.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#541] and 5.4.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#544]]
- There will be some broadly positive effects on agriculture in northern Europe (medium confidence6); productivity will decrease in southern and eastern Europe (medium confidence6). [5.4.3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#543]]
- Upward and northward shift of biotic zones will take place. Loss of important habitats (wetlands, tundra, isolated habitats) would threaten some species (high confidence6). [5.4.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#542]]
- Higher temperatures and heat waves may change traditional summer tourist destinations, and less reliable snow conditions may impact adversely on winter tourism (medium confidence6). [5.4.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/044.htm#544]]"

*Source: IPCC TAR SPM of WG II pages 14-17*

## Adaptive Capacity, Vulnerability, and Key Concerns in Latin America

- "Adaptive capacity of human systems in Latin America is low, particularly with respect to extreme climate events, and vulnerability is high. [5.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm]]
- Loss and retreat of glaciers would adversely impact runoff and water supply in areas where glacier melt is an important water source (high confidence6). [5.5.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm#551]]
- Floods and droughts would become more frequent with floods increasing sediment loads and degrade water quality in some areas (high confidence6). [5.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm]]
- Increases in intensity of tropical cyclones would alter the risks to life, property, and ecosystems from heavy rain, flooding, storm surges, and wind damages (high confidence6). [5.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm]]
- Yields of important crops are projected to decrease in many locations in Latin America, even when the effects of $CO_2$ are taken into account; subsistence farming in some regions of Latin America could be threatened (high confidence6). [5.5.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm#554]]
- The geographical distribution of vector-borne infectious diseases would expand poleward and to higher elevations, and exposures to diseases such as malaria, dengue fever, and cholera will increase (medium confidence6). [5.5.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm#555]]"

*Source: IPCC TAR SPM of WG II pages 14-17*

## Adaptive Capacity, Vulnerability, and Key Concerns in North America

- "Coastal human settlements, productive activities, infrastructure, and mangrove ecosystems would be negatively affected by sea-level rise (medium confidence6). [5.5.3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm#553]]
- The rate of biodiversity loss would increase (high confidence6). [5.5.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/045.htm#552]]
- Adaptive capacity of human systems is generally high and vulnerability low in North America, but some communities (e.g., indigenous peoples and those dependent on climate-sensitive resources) are more vulnerable; social, economic, and demographic trends are changing vulnerabilities in subregions. [5.6 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm] and 5.6.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm#561]]
- Some crops would benefit from modest warming accompanied by increasing $CO_2$, but effects would vary among crops and regions (high confidence6), including declines due to drought in some areas of Canada's Prairies and the U.S. Great Plains, potential increased food production in areas of Canada north of current production areas, and increased warm-temperate mixed forest production (medium confidence6). However, benefits for crops would decline at an increasing rate and possibly become a net loss with further warming (medium confidence6). [5.6.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm#564]]
- Snowmelt-dominated watersheds in western North America will experience earlier spring peak flows (high confidence6), reductions in summer flows (medium confidence6), and reduced lake levels and outflows for the Great Lakes-St. Lawrence under most scenarios (medium confidence6); adaptive responses would offset some, but not all, of the impacts on water users and on aquatic ecosystems (medium confidence6). [5.6.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm#562]]
- Unique natural ecosystems such as prairie wetlands, alpine tundra, and cold-water ecosystems will be at risk and effective adaptation is unlikely (medium confidence6). [5.6.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm#565]]
- Sea-level rise would result in enhanced coastal erosion, coastal flooding, loss of coastal wetlands, and increased risk from storm surges, particularly in Florida and much of the U.S. Atlantic coast (high confidence6). [5.6.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm#561]]
- Weather-related insured losses and public sector disaster relief payments in North America have been increasing; insurance sector planning has not yet systematically included climate change information, so there is potential for surprise (high confidence6). [5.6.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm#561]]
- Vector-borne diseases—including malaria, dengue fever, and Lyme disease—may expand their ranges in North America; exacerbated air quality and heat stress morbidity and mortality would occur (medium confidence6); socioeconomic factors and public health measures would play a large role in determining the incidence and extent of health effects. [5.6.6 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/046.htm#566]]"

*Source: IPCC TAR SPM of WG II pages 14-17*

## Adaptive Capacity, Vulnerability, and Key Concerns in the Polar Regions

- "Natural systems in polar regions are highly vulnerable to climate change and current ecosystems have low Adaptive capacity; technologically developed communities are likely to adapt readily to climate change, but some indigenous communities, in which traditional lifestyles are followed, have little capacity and few options for adaptation. [5.7 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/047.htm]]
- Climate change in polar regions is expected to be among the largest and most rapid of any region on the Earth, and will cause major physical, ecological, sociological, and economic impacts, especially in the Arctic, Antarctic Peninsula, and Southern Ocean (high confidence6). [5.7 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/047.htm]]
- Changes in climate that have already taken place are manifested in the decrease in extent and thickness of Arctic sea ice, permafrost thawing, coastal erosion, changes in ice sheets and ice shelves, and altered distribution and abundance of species in polar regions (high confidence6). [5.7 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/047.htm]]
- Some polar ecosystems may adapt through eventual replacement by migration of species and changing species composition, and possibly by eventual increases in overall productivity; ice edge systems that provide habitat for some species would be threatened (medium confidence6). [5.7 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/047.htm]]
- Polar regions contain important drivers of climate change. Once triggered, they may continue for centuries, long after greenhouse gas concentrations are stabilized, and cause irreversible impacts on ice sheets, global ocean circulation, and sea-level rise (medium confidence6). [5.7 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/047.htm]]"

*Source: IPCC TAR SPM of WG II pages 14-17*

# Adaptive Capacity, Vulnerability, and Key Concerns in the Small Island States

- "Adaptive capacity of human systems is generally low in small island states, and vulnerability high; small island states are likely to be among the countries most seriously impacted by climate change. [5.8 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm]]
- The projected sea-level rise of 5 mm yr-1 for the next 100 years would cause enhanced coastal erosion, loss of land and property, dislocation of people, increased risk from storm surges, reduced resilience of coastal ecosystems, saltwater intrusion into freshwater resources, and high resource costs to respond to and adapt to these changes (high confidence6). [5.8.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm#582] and 5.8.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm#585]]
- Islands with very limited water supplies are highly vulnerable to the impacts of climate change on the water balance (high confidence6). [5.8.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm#584]]
- Coral reefs would be negatively affected by bleaching and by reduced calcification rates due to higher $CO_2$ levels (medium confidence6); mangrove, sea grass bed, and other coastal ecosystems and the associated biodiversity would be adversely affected by rising temperatures and accelerated sea-level rise (medium confidence6). [4.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/034.htm] and 5.8.3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm#583]]
- Declines in coastal ecosystems would negatively impact reef fish and threaten reef fisheries, those who earn their livelihoods from reef fisheries, and those who rely on the fisheries as a significant food source (medium confidence6). [4.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/034.htm] and 5.8.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm#584]]
- Limited arable land and soil salinization makes agriculture of small island states, both for domestic food production and cash crop exports, highly vulnerable to climate change (high confidence6). [5.8.4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm#584]]
- Tourism, an important source of income and foreign exchange for many islands, would face severe disruption from climate change and sea-level rise (high confidence6). [5.8.5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/048.htm#585]]

*Source: IPCC TAR SPM of WG II pages 14-17*

- Because the available studies have not employed a common set of climate scenarios and methods, and because of uncertainties regarding the sensitivities and adaptability of natural and social systems, the assessment of regional vulnerabilities is necessarily qualitative.
- The regions listed in Table SPM-2 are graphically depicted in Figure TS-2 of the Technical Summary [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/021.htm]."

*Source: IPCC TAR SPM of WG II pages 14-17*

# Annex 2:
# Analysis of inter-model consistency in regional relative warming

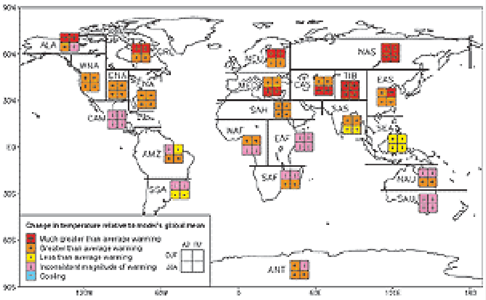



**Figure 21**: Analysis of inter-model consistency in regional relative warming (warming relative to each model's global average warming). [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figts-21.htm]

Regions are classified as showing either

- agreement on warming in excess of 40% above the global average ('Much greater than average warming'),
- agreement on warming greater than the global average ('Greater than average warming'),
- agreement on warming less than the global average ('Less than average warming'), or
- disagreement amongst models on the magnitude of regional relative warming ('Inconsistent magnitude of warming').

There is also a category for agreement on cooling (which never occurs).

A consistent result from at least seven of the nine models is deemed necessary for agreement. The global annual average warming of the models used span 1.2 to 4.5°C for A2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/029.htm#storyb2] and 0.9 to 3.4°C for B2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/029.htm#storyb2], and therefore a regional 40% amplification represents warming ranges of 1.7 to 6.3°C for A2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/029.htm#storyb2] and 1.3 to 4.7°C for B2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/029.htm#storyb2].

[Based on Chapter 10 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/373.htm], Box 1 , Figure 1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/385.htm#box101]]

# Annex 3:
# Facts on environmental matters

*Source: IPCC TAR TS of WG1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/032.htm#tabTechSum4]*

**Table 1**: Estimates of confidence in observed and projected changes in extreme weather and climate events. The table depicts an assessment of confidence in observed changes in extremes of weather and climate during the latter half of the 20th century (left column) and in projected changes during the 21st century (right column)[a]. This assessment relies on observational and modelling studies, as well as physical plausibility of future projections across all commonly used scenarios and is based on expert judgement (see Footnote 4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/fnts.htm#4]). [Based upon Table 9.6 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/368.htm#tab96]]

| ***Confidence in observed changes (latter half of the 20th century)*** | ***Changes in Phenomenon*** | ***Confidence in projected changes (during the 21st century)*** |
|---|---|---|
| Likely | **Higher maximum temperatures and more hot days over nearly all land areas** | Very likely |
| Very likely | **Higher minimum temperatures, fewer cold days and frost days over nearly all land areas** | Very likely |
| Very likely | **Reduced diurnal temperature range over most land areas** | Very likely |
| Likely, over many areas | **Increase of heat index 12 over land areas** | Very likely, over most areas |
| Likely, over many Northern Hemisphere mid- to high latitude land areas | **More intense precipitation events**[b] | Very likely, over most areas |
| Likely, in a few areas | **Increased summer continental drying and associated risk of drought** | Likely, 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 intensitiesc** | Likely, over some areas |
| Insufficient data for assessment | **Increase in tropical cyclone mean and peak precipitation intensities**[c] | Likely, over some areas |

**a** For more details see Chapter 2 (observations) and Chapters 9, 10 (projections).

**b** For other areas there are either insufficient data or conflicting analyses.

**c** Past and future changes in tropical cyclone location and frequency are uncertain.

*Source: IPCC TAR TS of WG1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/032.htm#tabTechSum4]*

# Annex 4:
# Figure SPM-2 - Reasons for Concern

Risks per Degree of Climate Change

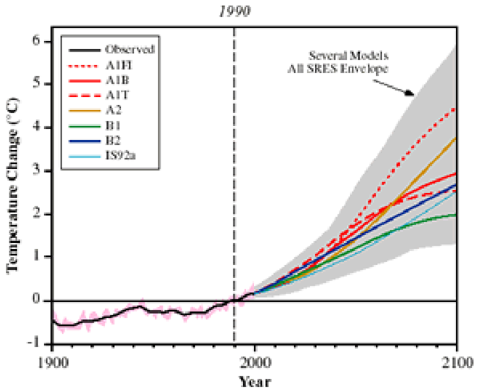



Figure SPM-2 - Reasons for Concern [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/figspm-2.htm]

**Figure SPM-2: Reasons for concern about projected climate change impacts.**

The risks of adverse impacts from climate change increase with the magnitude of climate change. The top part of the figure displays the observed temperature increase relative to 1990 and the range of projected temperature increase after 1990 as estimated by Working Group I of the IPCC for scenarios from the Special Report on Emissions Scenarios.

The bottom panel displays conceptualizations of five reasons for concern regarding climate change risks evolving through 2100. White indicates neutral or small negative or positive impacts or risks, yellow indicates negative impacts for some systems or low risks, and red means negative impacts or risks that are more widespread and/or greater in magnitude.

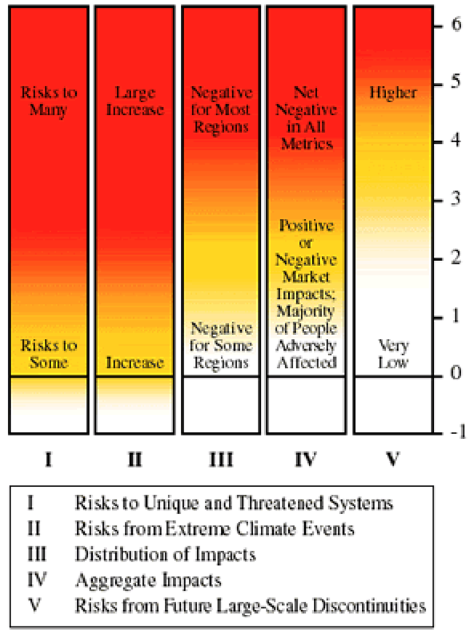



Figure SPM-2 - Reasons for Concern [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/figspm-2.htm]

The assessment of impacts or risks takes into account only the magnitude of change and not the rate of change. Global mean annual temperature change is used in the figure as a proxy for the magnitude of climate change, but projected impacts will be a function of, among other factors, the magnitude and rate of global and regional changes in mean climate, climate variability and extreme climate phenomena, social and economic conditions, and adaptation."

*Source & © IPCC TAR SPM of WG II [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/008.htm]*

## Annex 5:

## Figure SPM-3 - Projected Changes in Annual Runoff

**Figure SPM-3**: Projected changes in average annual water runoff by 2050, relative to average runoff for 1961-1990, largely follow projected changes in precipitation. Changes in runoff are calculated with a hydrologic model using as inputs climate projections from two versions of the Hadley Centre atmosphere-ocean general circulation model (AOGCM) for a scenario of 1% per annum increase in effective carbon dioxide concentration in the atmosphere: (a) HadCM2 ensemble mean and (b) HadCM3. Projected increases in runoff in high latitudes and southeast Asia, and decreases in central Asia, the area around the Mediterranean, southern Africa, and Australia are broadly consistent across the Hadley Centre experiments, and with the precipitation projections of other AOGCM experiments. For other areas of the world, changes in precipitation and runoff are scenario- and model-dependent."

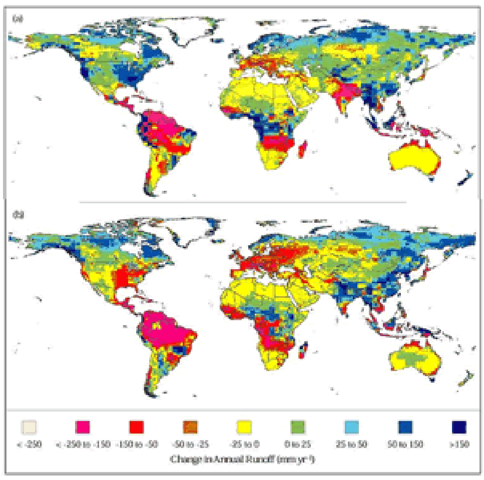


Figure SPM-3 - Projected Changes in Annual Runoff [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/figspm-3.htm]

*Source & © IPCC TAR SPM of WG II [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/011.htm]*

## Annex 6:
## Footnotes for the Summary for Policymakers of IPCC Working Group 1

*Source & © IPCC TAR SPM of WG1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/fnspm.htm]*

**1** Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

**2** In total 122 Co-ordinating Lead Authors and Lead Authors, 515 Contributing Authors, 21 Review Editors and 420 Expert Reviewers.

**3** Delegations of 99 IPCC member countries participated in the Eighth Session of Working Group I in Shanghai on 17 to 20 January 2001.

**4** The IPCC Second Assessment Report is referred to in this Summary for Policymakers as the SAR.

**5** Generally temperature trends are rounded to the nearest 0.05°C per unit time, the periods often being limited by data availability.

**6** In general, a 5% statistical significance level is used, and a 95% confidence level.

**7** In this Summary for Policymakers and in the Technical Summary, the following words have been used where appropriate to indicate judgmental estimates of confidence: virtually certain (greater than 99% chance that a result is true); very likely (90-99% chance); likely (66-90% chance); medium likelihood (33-66% chance); unlikely (10-33% chance); very unlikely (1-10% chance); exceptionally unlikely (less than 1% chance). The reader is referred to individual chapters for more details.

**8** 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).

**9** ppm (parts per million) or ppb (parts per billion, 1 billion = 1,000 million) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. For example: 300 ppm means 300 molecules of a greenhouse gas per million molecules of dry air.

**10** Complex physically based climate models are the main tool for projecting future climate change. In order to explore the full range of scenarios, these are complemented by simple climate models calibrated to yield an equivalent response in temperature and sea level to complex climate models. These projections are obtained using a simple climate model whose climate sensitivity and ocean heat uptake are calibrated to each of seven complex climate models. The climate sensitivity used in the simple model ranges from 1.7 to 4.2°C, which is comparable to the commonly accepted range of 1.5 to 4.5°C.

**11** This range does not include uncertainties in the modelling of radiative forcing, e.g. aerosol forcing uncertainties. A small carbon-cycle climate feedback is included.

**12** Heat index: A combination of temperature and humidity that measures effects on human comfort.

*Source & © IPCC TAR SPM of WG1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/fnspm.htm]*

## Annex 7:
## Footnotes for the Summary for Policymakers of IPCC Working Group II

*Source & © IPCC TAR SPM of WG II [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/fnspm.htm]*

1 Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. Attribution of climate change to natural forcing and human activities has been addressed by Working Group I.

2 The report has been written by 183 Coordinating Lead Authors and Lead Authors, and 243 Contributing Authors. It was reviewed by 440 government and expert reviewers, and 33 Review Editors oversaw the review process.

3 Delegations from 100 IPCC member countries participated in the Sixth Session of Working Group II in Geneva on 13-16 February 2001.

4 A more comprehensive summary of the report is provided in the Technical Summary, and relevant sections of that volume are referenced in brackets at the end of paragraphs of the Summary for Policymakers for readers who need more information.

5 There are 44 regional studies of over 400 plants and animals, which varied in length from about 20 to 50 years, mainly from North America, Europe, and the southern polar region. There are 16 regional studies covering about 100 physical processes over most regions of the world, which varied in length from about 20 to 150 years. See Section 7.1 of the Technical Summary for more detail.

6 In this Summary for Policymakers, the following words have been used where appropriate to indicate judgmental estimates of confidence (based upon the collective judgment of the authors using the observational evidence, modeling results, and theory that they have examined): very high (95% or greater), high (67-95%), medium (33-67%), low (5-33%), and very low (5% or less). In other instances, a qualitative scale to gauge the level of scientific understanding is used: well established, established-but-incomplete, competing explanations, and speculative. The approaches used to assess confidence levels and the level of scientific understanding, and the definitions of these terms, are presented in Section 1.4 of the Technical Summary. Each time these terms are used in the Summary for Policymakers, they are footnoted and in italics.

7 Details of projected climate changes, illustrated in Figure SPM-2, are provided in the Working Group I Summary for Policymakers.

8 Details of projected contributions to sea-level rise from the West Anarctic Ice Sheet and Greenland Ice Sheet are provided in the Working Group I Summary for Policymakers.

9 Global mean temperature change is used as an indicator of the magnitude of climate change. Scenario-dependent exposures taken into account in these studies include regionally differentiated changes in temperature, precipitation, and other climatic variables.

10 Eight studies have modeled the effects of climate change on these diseases, five on malaria and three on dengue. Seven use a biological, or process-based approach, and one uses an empirical, statistical approach.

*Source & © IPCC TAR SPM of WG II [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/fnspm.htm]*

## Annex 8:

## Footnotes for the Summary for Policymakers of IPCC Working Group III

*Source & © IPCC TAR SPM of WG III [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/fnspm.htm]*

**1** Mitigation is defined here as an anthropogenic intervention to reduce the sources of greenhouse gases or enhance their sinks.

**2** Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the UNFCCC, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

**3** Section numbers refer to the main body of the Report.

**4** In this report "alternative development paths" refer to a variety of possible scenarios for societal values and consumption and production patterns in all countries, including but not limited to a continuation of today's trends. These paths do not include additional climate initiatives which means that no scenarios are included that explicitly assume implementation of the UNFCCC or the emission targets of the Kyoto Protocol, but do include assumptions about other policies that influence greenhouse gas emissions indirectly.

**5** Approaches to equity have been classified into a variety of categories, including those based on allocation, outcome, process, rights, liability, poverty, and opportunity, reflecting the diverse expectations of fairness used to judge policy processes and the corresponding outcomes (Sections 1.3, 10.2).

**6** Emissions from all regions diverge from baselines at some point. Global emissions diverge earlier and to a greater extent as stabilization levels are lower or underlying scenarios are higher. Such scenarios are uncertain, do not provide information on equity implications and how such changes may be achieved or who may bear any costs incurred.

**7** Reserves are those occurrences that are identified and measured as economically and technically recoverable with current technologies and prices. Resources are those occurrences with less certain geological and/or economic characteristics, but which are considered potentially recoverable with foreseeable technological and economic developments. The resource base includes both categories. On top of that, there are additional quantities with unknown certainty of occurrence and/or with unknown or no economic significance in the foreseeable future, referred to as "additional occurrences" (SAR, Working Group II). Examples of unconventional fossil fuel resources include tar sands, shale oil, other heavy oil, coal bed methane, deep geopressured gas, gas in acquifers, etc.

**8** "Known technological options" refer to technologies that exist in operation or pilot plant stage today, as referenced in the mitigation scenarios discussed in this report. It does not include any new technologies that will require drastic technological breakthroughs. In this way it can be considered to be a conservative estimate, considering the length of the scenario period.

**9** Ancillary benefits are the ancillary, or side effects, of policies aimed exclusively at climate change mitigation. Such policies have an impact not only on greenhouse gas emissions, but also on resource use efficiency, like reduction in emissions of local and regional air pollutants associated with fossil fuel use, and on issues such as transportation, agriculture, land-use practices, employment, and fuel security. Sometimes these benefits are referred to as "ancillary impacts" to reflect that in some cases the benefits may be negative.

**10** In this report, as in the SAR, no regrets opportunities are defined as those options whose benefits such as reduced energy costs and reduced emissions of local/regional pollutants equal or exceed their costs to society, excluding the benefits of avoided climate change.

**11** A voluntary agreement is an agreement between a government authority and one or more private parties, as well as a unilateral commitment that is recognized by the public authority, to achieve environmental objectives or to improve environmental performance beyond compliance.

**12** Many other studies incorporating more precisely the country specifics and diversity of targeted policies provide a wider range of net cost estimates (Section 8.2.2).

**13** Annex II countries: Group of countries included in Annex II to the UNFCCC, including all developed countries in the Organisation of Economic Co-operation and Development.

**14** Annex B countries: Group of countries included in Annex B in the Kyoto Protocol that have agreed to a target for their greenhouse gas emissions, including all the Annex I countries (as amended in 1998) but Turkey and Belarus.

**15** Many metrics can be used to present costs. For example, if the annual costs to developed countries associated with meeting Kyoto targets with full Annex B trading are in the order of 0.5% of GDP, this represents US$125 billion (1000 million) per year, or US$125 per person per year by 2010 in Annex II (SRES assumptions). This corresponds to an impact on economic growth rates over ten years of less than 0.1 percentage point.

**16** Induced technological change is an emerging field of inquiry. None of the literature reviewed in TAR on the relationship between the century-scale $CO_2$ concentrations and costs, reported results for models employing induced technological change. Models with induced technological change under some circumstances show that century-scale concentrations can differ, with similar GDP growth but under different policy regimes (Section 8.4.1.4).

**17** See Figure SPM.1 for the influence of reference scenarios on the magnitude of the required mitigation effort to reach a given stabilization level.

**18** Spillover effects incorporate only economic effects, not environmental effects.

**19** Details of the six studies reviewed are found in Table 9.4 of the underlying report.

**20** These estimated costs can be expressed as differences in GDP growth rates over the period 2000–2010. With no emissions trading, GDP growth rate is reduced by 0.02 percentage points/year; with Annex B emissions trading, growth rate is reduced by less than 0.005 percentage points/year.

**21** These policies and measures include: those for non-$CO_2$ gases and non-energy sources of all gases; offsets from sinks; industry restructuring (e.g., from energy producer to supplier of energy services); use of OPEC's market power; and actions (e.g. of Annex B Parties) related to funding, insurance, and the transfer of technology. In addition, the studies typically do not include the following policies and effects that can reduce the total cost of mitigation: the use of tax revenues to reduce tax burdens or finance other mitigation measures; environmental ancillary benefits of reductions in fossil fuel use; and induced technological change from mitigation policies.

**22** Carbon leakage is defined here as the increase in emissions in non-Annex B countries due to implementation of reductions in Annex B, expressed as a percentage of Annex B reductions.

*Source & © IPCC TAR SPM of WG III [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/fnspm.htm]*

## Annex 9:
## Footnotes to Table SPM-1 (Question 6.2.2)

a - Buildings include appliances, buildings, and the building shell.

b - The range for agriculture is mainly caused by large uncertainties about $CH_4$, $N_2O$ and soil related emissions of $CO_2$. Waste is dominated by landfill methane and the other sectors could be estimated with more precision as they are dominated by fossil $CO_2$.

c - Included in sector values above. Reductions include electricity generation options only (fuel switching to gas/nuclear, $CO_2$ capture and storage, improved power station efficiencies, and renewables).

d - Total includes all sectors reviewed in Chapter 3 for all six gases. It excludes non-energy related sources of $CO_2$ (cement production, 160MtC; gas flaring, 60MtC; and land use change, 600-1,400MtC) and energy used for conversion of fuels in the end-use sector totals (630MtC). Note that forestry emissions and their carbon sinks mitigation options are not included.

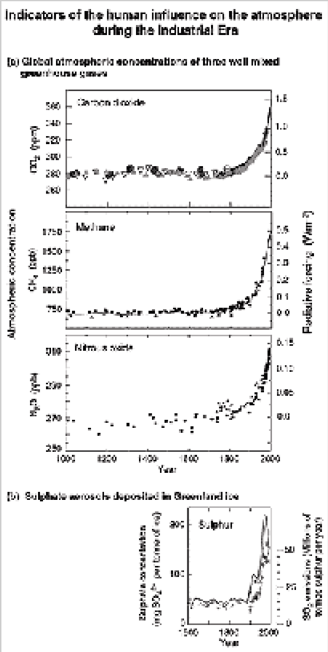
e - The baseline SRES scenarios (for six gases included in the Kyoto Protocol) project a range of emissions of 11,500–14,000$MtC_{eq}$ for 2010 and of 12,000–16,000$MtC_{eq}$ for 2020. The emissions reduction estimates are most compatible with baseline emissions trends in the SRES-B2 scenario. The potential reductions take into account regular turn-over of capital stock. They are not limited to cost-effective options, but exclude options with costs above US$100/$tC_{eq}$ (except for Montreal Protocol gases) or options that will not be adopted through the use of generally accepted policies.

*Source & © IPCC TAR SPM of WG III [see http://www.ipcc.ch/pdf/climate-changes-2001/mitigation/mitigation-spm-en.pdf]*

## Annex 10:

# Indicators of the human influence on the atmosphere during the Industrial Era

**Figure 2:**
Long records of past changes in atmospheric composition provide the context for the influence of anthropogenic emissions.




Indicators of the human influence on the atmosphere during the Industrial Era [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-2.htm]

**(a)** shows changes in the atmospheric concentrations of carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) over the past 1000 years. The ice core and firn data for several sites in Antarctica and Greenland (shown by different symbols) are supplemented with the data from direct atmospheric samples over the past few decades (shown by the line for $CO_2$ and incorporated in the curve representing the global average of $CH_4$). The estimated positive radiative forcing of the climate system from these gases is indicated on the right-hand scale. Since these gases have atmospheric lifetimes of a decade or more, they are well mixed, and their concentrations reflect emissions from sources throughout the globe. All three records show effects of the large and increasing growth in anthropogenic emissions during the Industrial Era.

**(b)** illustrates the influence of industrial emissions on atmospheric sulphate concentrations, which produce negative radiative forcing. Shown is the time history of the concentrations of sulphate, not in the atmosphere but in ice cores in Greenland (shown by lines; from which the episodic effects of volcanic eruptions have been removed). Such data indicate the local deposition of sulphate aerosols at the site, reflecting sulphur dioxide ($SO_2$) emissions at mid-latitudes in the Northern Hemisphere. This record, albeit more regional than that of the globally-mixed greenhouse gases, demonstrates the large growth in anthropogenic $SO_2$ emissions during the Industrial Era. The pluses denote the relevant regional estimated $SO_2$ emissions (right-hand scale). [Based upon (a) Chapter 3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/095.htm], Figure 3.2b [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/099.htm#tab32] ($CO_2$); Chapter 4 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/127.htm], Figure 4.1a and b [see http://www.grida.no/publications/other/

ipcc_tar/?src=/climate/ipcc_tar/wg1/134.htm#fig41] ( $CH_4$) and Chapter 4, Figure 4.2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/136.htm#fig42] ($N_2O$) and (b) Chapter 5, Figure 5.4a [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/180.htm#fig54]]"

*Source & © IPCC TAR SPM of WG I [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/006.htm]*

## Annex 11:
## Many external factors force climate change

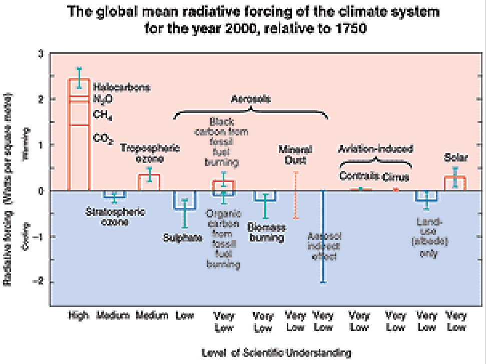



**Figure 3**: Many external factors force climate change. [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-3.htm]

These radiative forcings arise from changes in the atmospheric composition, alteration of surface reflectance by land use, and variation in the output of the sun. Except for solar variation, some form of human activity is linked to each.

The rectangular bars represent estimates of the contributions of these forcings - some of which yield warming, and some cooling.

Forcing due to episodic volcanic events, which lead to a negative forcing lasting only for a few years, is not shown. The indirect effect of aerosols shown is their effect on the size and number of cloud droplets. A second indirect effect of aerosols on clouds, namely their effect on cloud lifetime, which would also lead to a negative forcing, is not shown. Effects of aviation on greenhouse gases are included in the individual bars.

The vertical line about the rectangular bars indicates a range of estimates, guided by the spread in the published values of the forcings and physical understanding. Some of the forcings possess a much greater degree of certainty than others. A vertical line without a rectangular bar denotes a forcing for which no best estimate can be given owing to large uncertainties. The overall level of scientific understanding for each forcing varies considerably, as noted.

Some of the radiative forcing agents are well mixed over the globe, such as $CO_2$, thereby perturbing the global heat balance. Others represent perturbations with stronger regional signatures because of their spatial distribution, such as aerosols. For this and other reasons, a simple sum of the positive and negative bars cannot be expected to yield the net effect on the climate system.

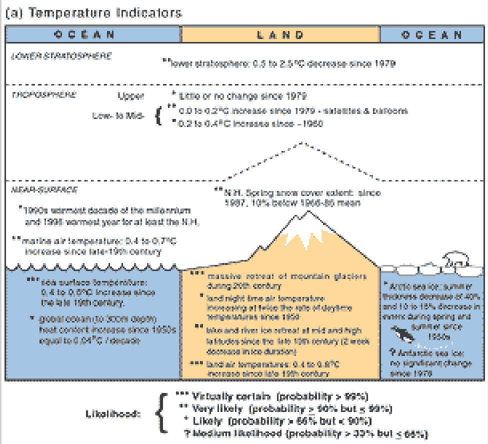
The simulations of this assessment report (for example, Figure 5) indicate that the estimated net effect of these perturbations is to have warmed the global climate since 1750.

[Based upon Chapter 6 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/245.htm#fig66], Figure 6.6 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/fig6-6.htm]]"

*Source & © IPCC TAR SPM of WG I [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/006.htm#figspm3]*

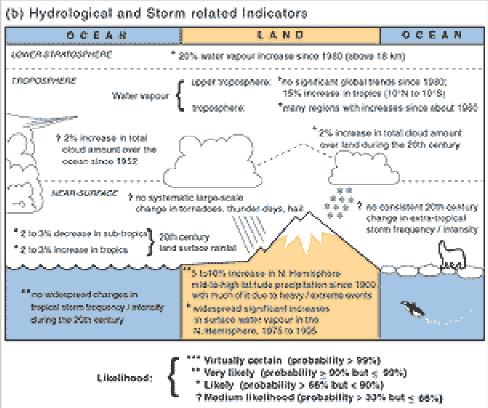
## Annex 12:

## Schematic of observed variations of the temperature indicators / the hydrological and storm-related indicators




[see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figts-7a.htm]

**Figure 7a**: Schematic of observed variations of the temperature indicators. [Based on Figure 2.39a]




[see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figts-7b.htm]

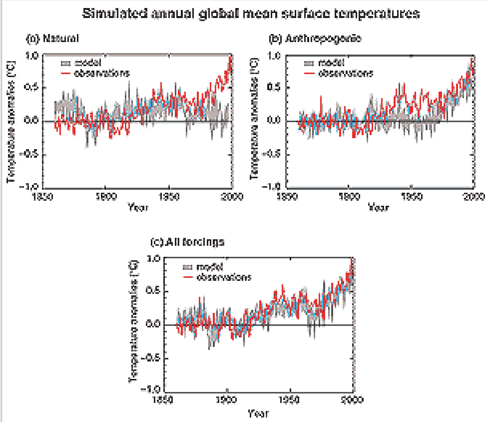
**Figure 7b**: Schematic of observed variations of the hydrological and storm-related indicators. [Based on Figure 2.39b]

*Source & © http://www.grida.no/climate/ipcc_tar/wg1/014.htm#figTechSum7*

## Annex 13:

## Simulated annual global mean surface temperatures

**Figure 4**: Simulating the Earth's temperature variations, and comparing the results to measured changes, can provide insight into the underlying causes of the major changes.




Simulated annual global mean surface temperatures [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-4.htm]

A climate model can be used to simulate the temperature changes that occur both from natural and anthropogenic causes. The simulations represented by the band in (a) were done with only natural forcings: solar variation and volcanic activity. Those encompassed by the band in (b) were done with anthropogenic forcings: greenhouse gases and an estimate of sulphate aerosols, and those encompassed by the band in (c) were done with both natural and anthropogenic forcings included. From (b), it can be seen that inclusion of anthropogenic forcings provides a plausible explanation for a substantial part of the observed temperature changes over the past century, but the best match with observations is obtained in (c) when both natural and anthropogenic factors are included. These results show that the forcings included are sufficient to explain the observed changes, but do not exclude the possibility that other forcings may also have contributed. The bands of model results presented here are for four runs from the same model. Similar results to those in (b) are obtained with other models with anthropogenic forcing."
[Based upon Chapter 12 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/439.htm], Figure 12.7 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/450.htm#fig127]]

*Source & © IPCC TAR SPM of WG1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/007.htm#figspm4]*

# Annex 14:

# Table SPM.1 Estimates of potential global greenhouse gas emission reductions in 2010 and in 2020

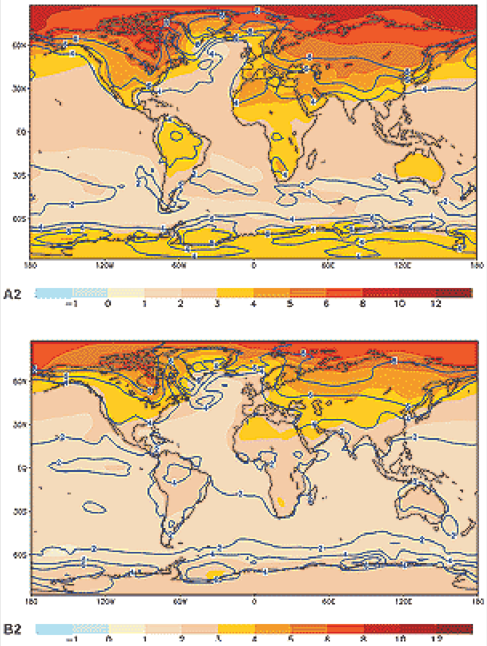
Table SPM.1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/006.htm]
Estimates of potential global greenhouse gas emission reductions in 2010 and in 2020
(Sections 3.3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/093.htm]>3.8 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/124.htm] and Chapter 3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/089.htm]Appendix)

| Sector | | Historic emissions in 1990 | Historic $C_{eq}$ annual growth rate in 1990-1995 | Potential emission reductions in 2010 | Potential emission reductions in 2020 | Net direct costs per tonne of carbon avoided |
|---|---|---|---|---|---|---|
| | | (MtCeq/yr) | (%) | (MtCeq/yr) | (MtCeq/yr) | |
| **Buildings** [a] [see Annex 9, p. 27] | $CO_2$ only | 1,650 | 1.0 | 700-750 | 1,000-1,100 | Most reductions are available at negative net direct costs. |
| **Transport** | $CO_2$ only | 1,080 | 2.4 | 100-300 | 300-700 | Most studies indicate net direct costs less than US$25/tC but two suggest net direct costs will exceed US$50/tC. |
| **Industry** | $CO_2$ only | 2,300 | 0.4 | | | |
| **-energy efficiency** | | | | 300-500 | 700-900 | More than half available at net negative direct costs. |
| **-material efficiency** | | | | ~200 | ~600 | Costs are uncertain. |
| **Industry** | Non- $CO_2$ gases | 170 | | ~100 | ~100 | $N_2O$ emissions reduction costs are US$0-US$10/t$C_{eq}$. |
| **Agriculture** [b] [see Annex 9, p. 27] | $CO_2$ only | 210 | | | | Most reductions will cost between US$0-100/t$C_{eq}$ with limited opportunities for negative net direct cost options. |
| | Non- $CO_2$ gases | 1,250-2,800 | n.a | 150-300 | 350-750 | |
| **Waste** [b] [see Annex 9, p. 27] | $CH_4$ only | 240 | 1.0 | ~200 | ~200 | About 75% of the savings as methane recovery from landfills at net negative direct cost; 25% at a cost of US$20/t$C_{eq}$. |
| **Montreal Protocol** | Non-$CO_2$ gases | 0 | n.a. | ~100 | n.a. | About half of reductions due to difference in study replacement applications baseline and SRES baseline values. Remaining half of the reductions available at net direct costs below US$200/t$C_{eq}$. |
| **Energy supply and conversion** [c] [see Annex 9, p. 27] | $CO_2$ only | (1,620) | 1.5 | 50-150 | 350-700 | Limited net negative direct cost options exist; many options are available for less than US$100/t$C_{eq}$. |
| **Total** | | 6,900–8,400[d] [see Annex 9, p. 27] | | 1,900–2,600[e] [see Annex 9, p. 27] | 3,600–5,050[e] [see Annex 9, p. 27] | |

*Source: IPCC TAR SPM of WG III [see http://www.ipcc.ch/pub/wg3spm.pdf]*

# Annex 15:

## The annual mean change of the temperature (colour shading) and its range (isolines)




[see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figts-20.htm]

**Figure 20**: The annual mean change of the temperature (colour shading) and its range (isolines) (Unit: °C) for the SRES scenario A2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/029.htm#storya2] (upper panel) and the SRES scenario B2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/029.htm#storyb2] (lower panel).

Both SRES scenarios show the period 2071 to 2100 relative to the period 1961 to 1990 and were performed by OAGCMs.
[Based on Figures 9.10d and 9.10.e [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/351.htm#fig910]]

# Annex 16:
# The Emissions Scenarios from the Special Report on Emissions Scenarios (SRES)

The titles for each scenario were provided by GreenFacts and therefore do not correspond to the IPCC report

**A1. Rapid Global Growth Scenario.**The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

**A2. Regional Growth Scenario.** The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

**B1. Global Service Economy Scenario.** The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in midcentury and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

**B2. Increasing Population Scenario.** The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic evelopment, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

This page is a straight copy of the Summary for Policymakers of the Third Assessment Report done by Working Group I of the Intergovernmental Panel on Climate Change (IPCC), which can be found in PDF format in the box on page 18 of www.ipcc.ch/ipccreports/tar/vol4/english/pdf/wg1spm.pdf [see http://www.ipcc.ch/ipccreports/tar/vol4/english/pdf/wg1spm.pdf] or in HTML format at the bottom of www.grida.no/climate/ipcc_tar/wg1/008.htm [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/008.htm].

# Annex 17:
# The global climate of the 21st Century

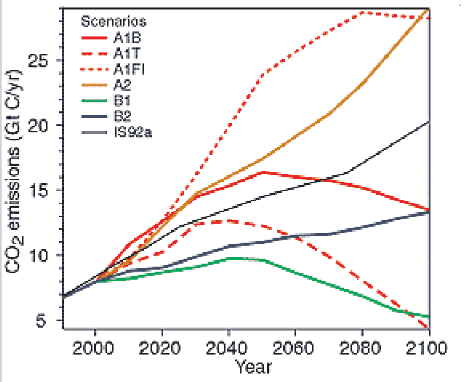
### The global climate of the 21$^{st}$ Century

(a) $CO_2$ emissions

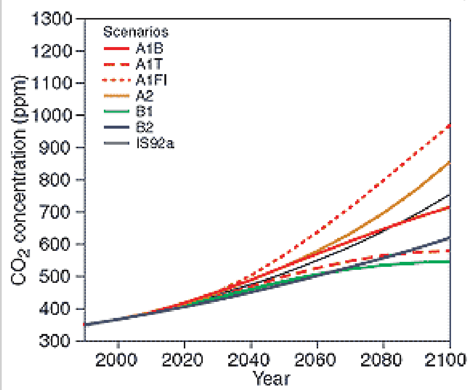
(b) $CO_2$ concentrations

(c) SO2 emissions

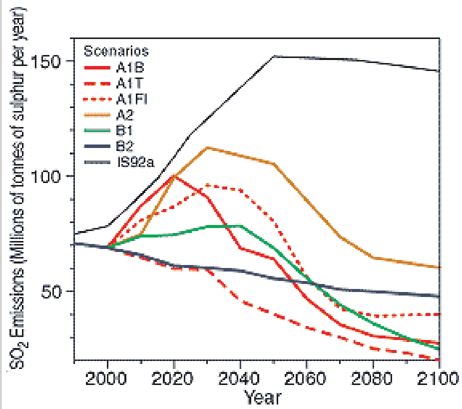
(d) Temperature change




The global climate of the 21st century [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-5.htm]




The global climate of the 21st century [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-5.htm]




The global climate of the 21st century [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-5.htm]

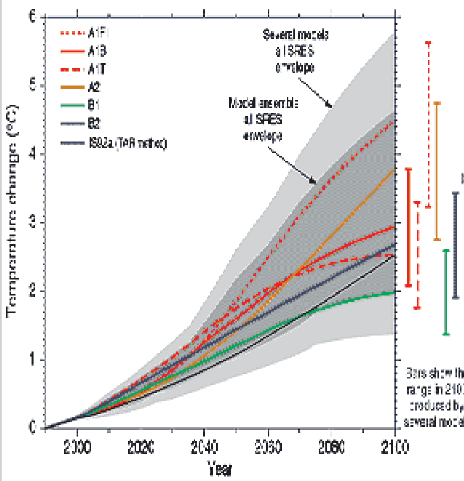
(e) Sea level rise

**Figure 5**: The global climate of the 21st century will depend on natural changes and the response of the climate system to human activities.

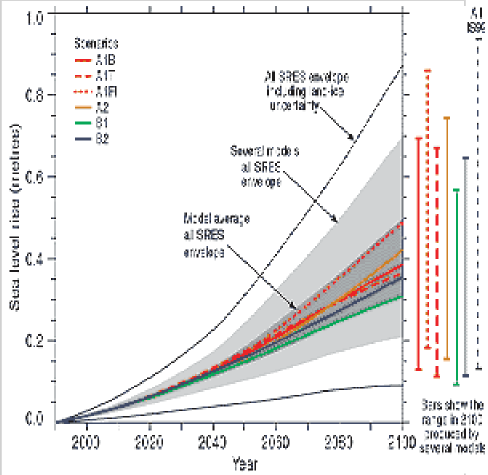
Climate models project the response of many climate variables - such as increases in global surface temperature and sea level - to various scenarios of greenhouse gas and other human-related emissions.

- (a) shows the $CO_2$ emissions of the six illustrative SRES scenarios, which are summarised in the box on page 18, along with IS92a for comparison purposes with the SAR.
- (b) shows projected $CO_2$ concentrations.
- (c) shows anthropogenic SO2 emissions. Emissions of other gases and other aerosols were included in the model but are not shown in the figure.
- (d) and (e) show the projected temperature and sea level responses, respectively. The "several models all SRES envelope" in (d) and (e) shows the temperature and sea level rise, respectively, for the simple model when tuned to a number of complex models with a range of climate sensitivities.

All SRES envelopes refer to the full range of 35 SRES scenarios. The "model average all SRES envelope" shows the average from these models for the range of scenarios. Note that the warming and sea level rise from these emissions would continue well beyond 2100. Also note that this range does not allow for uncertainty relating to ice dynamical changes in the West Antarctic ice sheet, nor does it account for uncertainties in projecting non-sulphate aerosols and greenhouse gas concentrations.




The global climate of the 21st century [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-5.htm]




The global climate of the 21st century [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-5.htm]

[Based upon

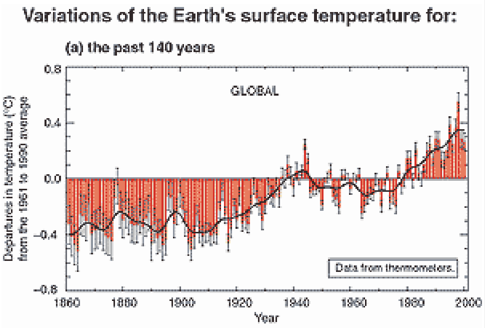
a. Chapter 3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/095.htm], Figure 3.12 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/123.htm#fig312],
b. Chapter 3 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/095.htm], Figure 3.12 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/123.htm#fig312],
c. Chapter 5 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/160.htm], Figure 5.13 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/208.htm#fig513],
d. Chapter 9 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/338.htm], Figure 9.14 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/353.htm#fig914],
e. Chapter 11 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/408.htm], Figure 11.12 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/429.htm#fig1112], Appendix II [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/519.htm]]"

*Source & © IPCC TAR SPM of WG1 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/008.htm#figspm5]*

## Annex 18:

## Variations of the Earth's surface temperature for :

**(a)** *the past 140 years*




Variation of the Earth's surface temperature for the past 140 years [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-1.htm]

***Figure 1a***: *Variations of the Earth's surface temperature over the last 140 years.*

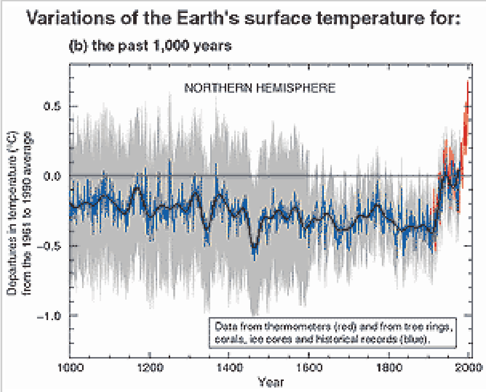
"The Earth's surface temperature is shown year by year (red bars) and approximately decade by decade (black line, a filtered annual curve suppressing fluctuations below near decadal time-scales).

There are uncertainties in the annual data (thin black whisker bars represent the 95% confidence range) due to data gaps, random instrumental errors and uncertainties, uncertainties in bias corrections in the ocean surface temperature data and also in adjustments for urbanisation over the land. Over both the last 140 years and 100 years, the best estimate is that the global average surface temperature has increased by 0.6 ± 0.2°C".
Based upon Chapter 2, Figure 2.7c [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/055.htm#fig27]

*Source & © IPCC TAR SPM of WG I [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-1.htm]*

**(b)** *The past 1,000 years*

***Figure 1b***: *Variations of the Earth's surface temperature over the last millennium.*




Variation of the Earth's surface temperature for [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/figspm-1.htm]

The year by year (blue curve) and 50 year average (black curve) variations of the average surface temperature of the Northern Hemisphere for the past 1000 years have been reconstructed from "proxy" data calibrated against thermometer data (see list of the main proxy data in the diagram).

The 95% confidence range in the annual data is represented by the grey region. These uncertainties increase in more distant times and are always much larger than in the instrumental record due to the use of relatively sparse proxy data. Nevertheless the rate and duration of warming of the 20th century has been much greater than in any of the previous nine centuries. Similarly, it is likely7 [see Annex 6, p. 23] that the 1990s have been the warmest decade and 1998 the warmest year of the millennium.
[Based upon Chapter 2 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/068.htm#fig220], Figure 2.20 [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/fig2-20.htm]]

*Source & © www.grida.no/climate/ipcc_tar/wg1/005.htm [see http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/005.htm]*