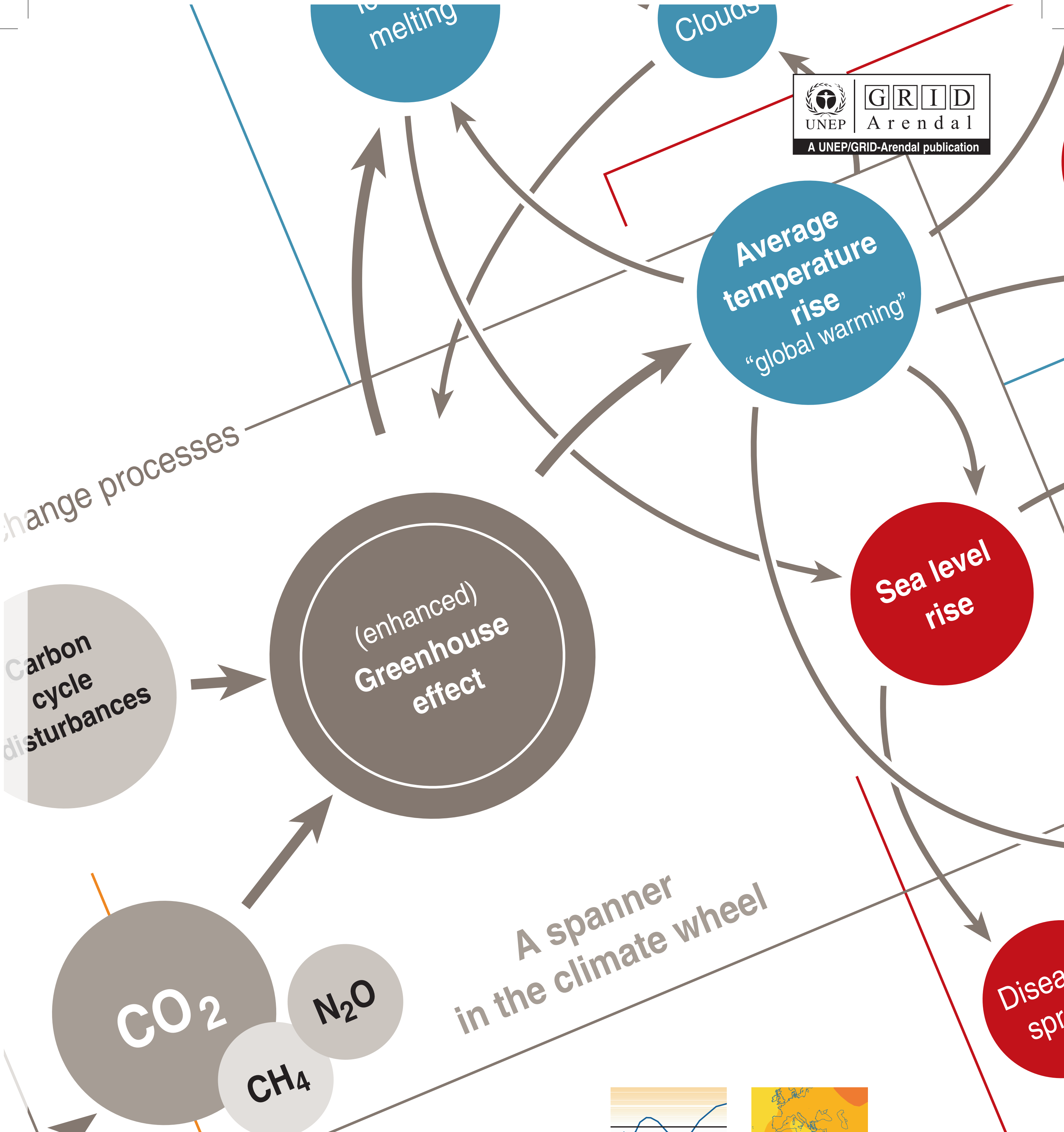

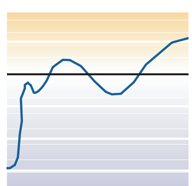

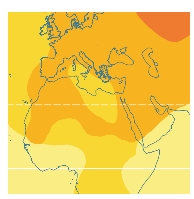

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Vital Climate Change Graphics

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UNEP

foreword / preface

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Foreword

The last edition of ***Vital Climate Graphics***, published in 2000, suggested that the world may have been witnessing the early signs of global climate change. Since then, the global scientific community has collected and analysed more data and refined its computer-based models. The newest evidence confirms that the planet is indeed warming and that the growing emissions of greenhouse gases are the likely cause. We often associate climate change with extreme events, such as the destructive hurricanes or heat waves that seem to be reported in the media so frequently. The consequences, however, will also include gradual and less dramatic changes in environmental conditions. Over the longer term, such changes could produce more coastal erosion, droughts and coral bleaching and the spread of mosquito-borne diseases to new regions. The recently released Arctic Climate Impact Assessment, the most detailed assessment to date of changes in the polar climate, indicates that the Arctic is warming at twice the global average. Already we are witnessing the widespread melting of glaciers, the thinning of sea ice and rising permafrost temperatures.

As we try to formulate our response to climate change, as concerned citizens, policy makers or business leaders we need accessible and easily understood information. This ***Vital Climate Graphics*** package seeks to translate the incredibly complex subject of climate change into material that can be useful to a broad range of readers.

This edition of ***Vital Climate Graphics*** is based on the Third Assessment Report, which was published by the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC) in 2001.

Klaus Töpfer, Executive Director
United Nations Environment Programme

Preface

Vital Climate Graphics was first published in 2000 by the United Nations Environment Programme (UNEP) and GRID-Arendal (www.vitalgraphics.net). Based on the findings of the Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change (IPCC), it presented a collection of graphics focussing on the environmental and socio-economic impacts of climate change

This second edition, launched in February 2005, is based on the Third Assessment Report (TAR) of the IPCC that was published in 2001. The publication of this second edition was prompted by the popularity of the first edition and the obvious need for providing updated information to our readers. The contents of this publication are also accessible on the Internet (www.grida.no), where all the graphics are reproduced in data formats that could be downloaded for further use.

Etablished in 1988 by the United Nations Environment Programme (UNEP)and the World Meteorological Organization (WMO), the IPCC is the world's most authoritative scientific and technical source of climate change information. Its assessments provided an essential basis for the negotiation of the United Nations Framework Convention on Climate Change (UNFCCC) and of the Kyoto Protocol. With these agreements now in effect, it is vital that the IPCC's findings are communicated more effectively to a wide range of decision-makers. The IPCC's work also needs to be made more readily accessible to the general public.

For years, UNEP has been involved in disseminating information for decision-making and promoting awareness of climate change. In cooperation with the Convention Secretariat, UNEP is actively promoting the implementation of Article 6 of the Convention, which addresses public awareness, education and training. GRID-Arendal plays a major role in assisting UNEP in carrying out these tasks.

I take this opportunity to thank the following members of the GRID-Arendal staff who helped prepare this report: Elaine Baker, Rob Barnes, Emmanuelle Bournay, Lars Haltbrekken, Cato Litangen, Jarle Mjaasund, Philippe Rekacewicz, Petter Sevaldsen and Janet Fernandez Skaalvik.

I also thank Dr. Renate Christ, Secretary of the IPCC, Svein Tveitdal, Director of UNEP's Division for Environmental Conventions (DEC) and Division for Environmental Policy Implementation (DEPI), and Arkady Levintanus, Head of the Atmosphere and Desertification Conventions Unit of UNEP's DEC, and Michael Williams, Head of UNEP's information Unit for Conventions for their valuable inputs on this report.

I acknowledge with gratitutde the financial support provided by UNEP's Division for Environmental Conventions in the preparation of this report.

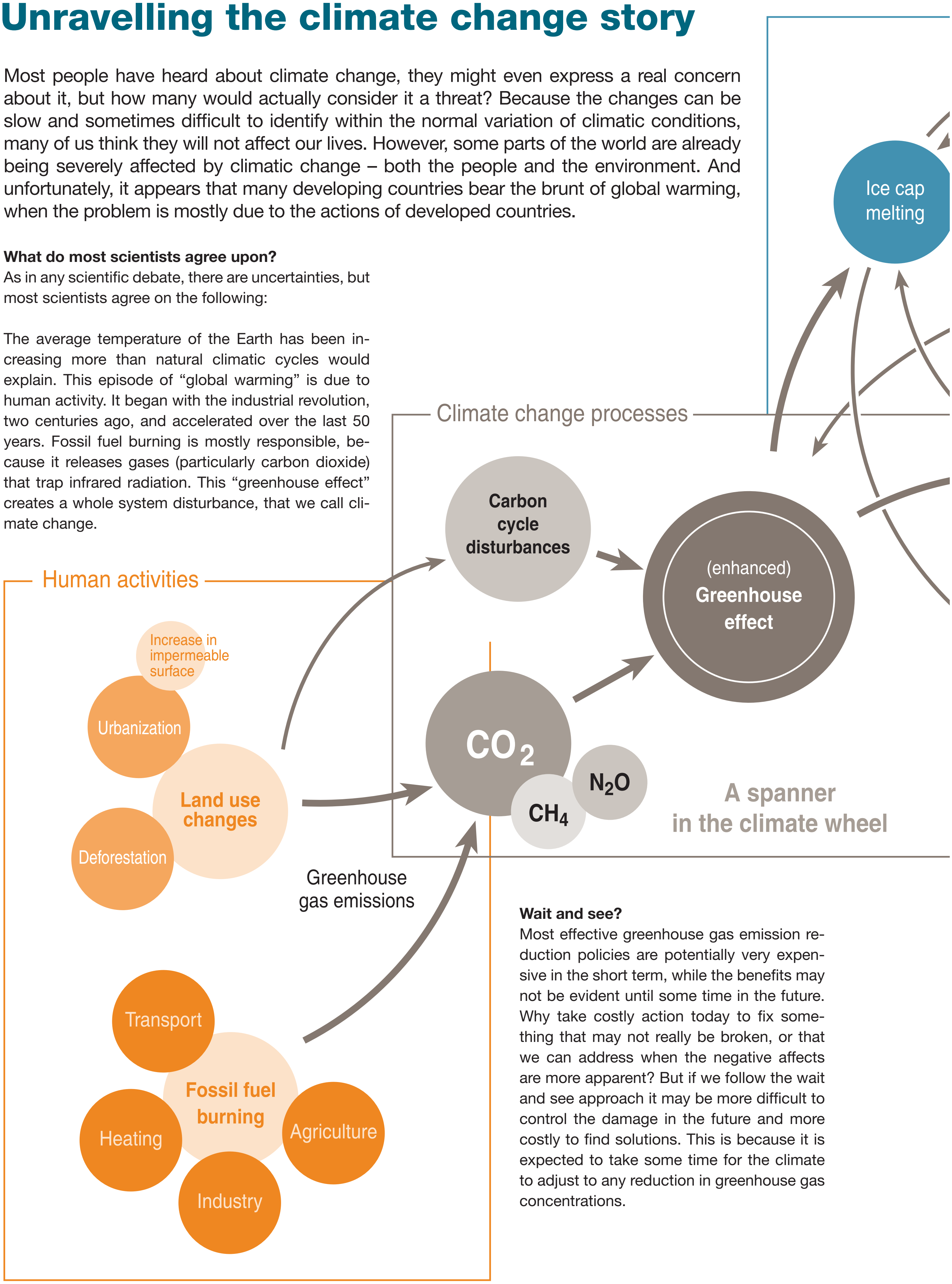
Steinar Sørensen, Managing Director
GRID-Arendal

Unravelling the climate change story

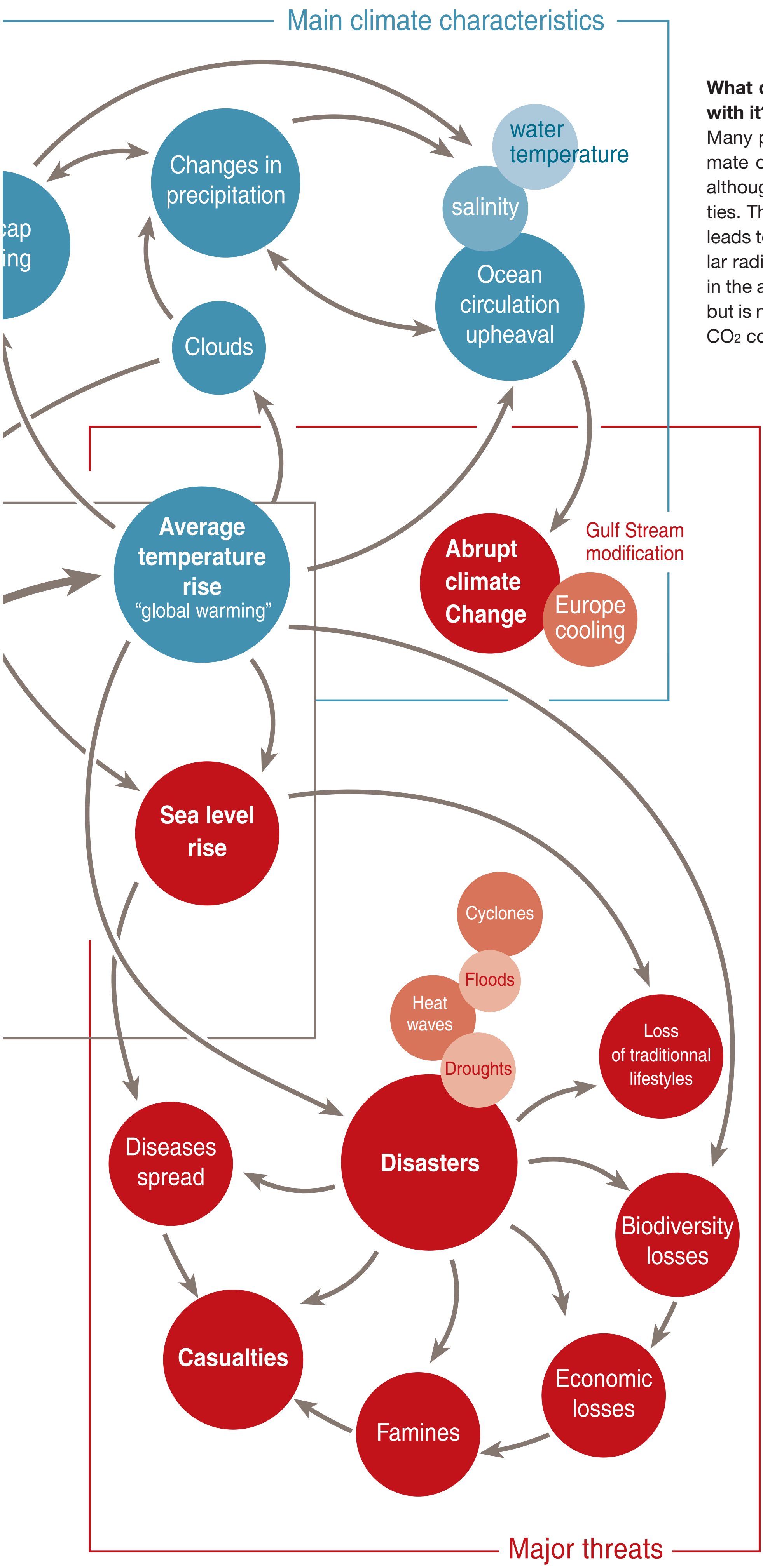
Most people have heard about climate change, they might even express a real concern about it, but how many would actually consider it a threat? Because the changes can be slow and sometimes difficult to identify within the normal variation of climatic conditions, many of us think they will not affect our lives. However, some parts of the world are already being severely affected by climatic change – both the people and the environment. And unfortunately, it appears that many developing countries bear the brunt of global warming, when the problem is mostly due to the actions of developed countries.

What do most scientists agree upon?
As in any scientific debate, there are uncertainties, but most scientists agree on the following:

The average temperature of the Earth has been increasing more than natural climatic cycles would explain. This episode of "global warming" is due to human activity. It began with the industrial revolution, two centuries ago, and accelerated over the last 50 years. Fossil fuel burning is mostly responsible, because it releases gases (particularly carbon dioxide) that trap infrared radiation. This "greenhouse effect" creates a whole system disturbance, that we call climate change.



Wait and see?
Most effective greenhouse gas emission reduction policies are potentially very expensive in the short term, while the benefits may not be evident until some time in the future. Why take costly action today to fix something that may not really be broken, or that we can address when the negative affects are more apparent? But if we follow the wait and see approach it may be more difficult to control the damage in the future and more costly to find solutions. This is because it is expected to take some time for the climate to adjust to any reduction in greenhouse gas concentrations.



What does the hole in the ozone layer have to do with it?
Many people relate the hole in the ozone layer to climate change when they are two different problems, although they both occur as a result of human activities. The main concern with ozone depletion is that it leads to increased exposure to harmful, ultraviolet solar radiation at the Earth’s surface. Decreasing ozone in the atmosphere does have an effect on the climate, but is not as influential as other factors (like increasing CO_2 concentrations).

Where can I find information on climate change?
Like arguments about cloning or genetically modified organisms, the climate change debate is complex and people wanting to participate in it need to dedicate time and effort. Sifting through the mountain of scientific information available and becoming familiar with all the disciplines involved is almost impossible for individuals. The Intergovernmental Panel on Climate Change (IPCC) compiles and compares information from a multitude of sources, with the aim of producing a balanced and comprehensive account.

Information about climate change is accessible on the following websites:

Intergovernmental Panel on Climate Change
www.ipcc.ch

United Nations Framework Convention on Climate Change:
www.unfccc.int

United Nations Environment Programme:
www.unep.org

UNEP/GRID-Arendal:
www.grida.no/climate

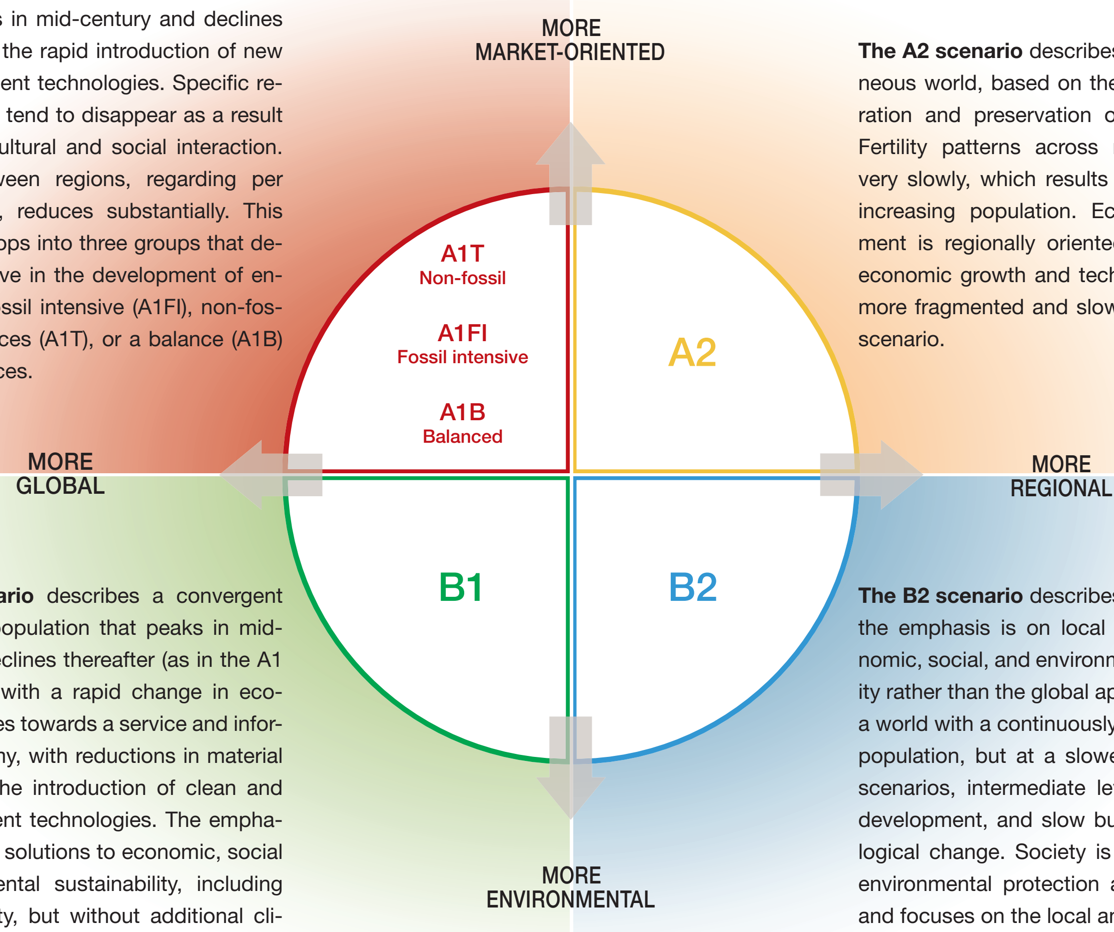
Climatewire (a climate news portal):
www.climatewire.org

Back to the future: The science of building scenarios

We cannot anticipate everything, but we try to assemble as many of the pieces as possible in order to predict the future. The science – or the art – of building scenarios requires a degree of control over a wide range of factors, all intricately linked. It is like a game, where we have to guess how changing one thing will affect the whole. Some elements appear simple – it is easy to imagine that rising atmospheric temperatures will melt the sea ice and cause sea level to rise, perhaps threatening coastal populations – but at what speed and what intensity and will this start a chain reaction of new calamities?

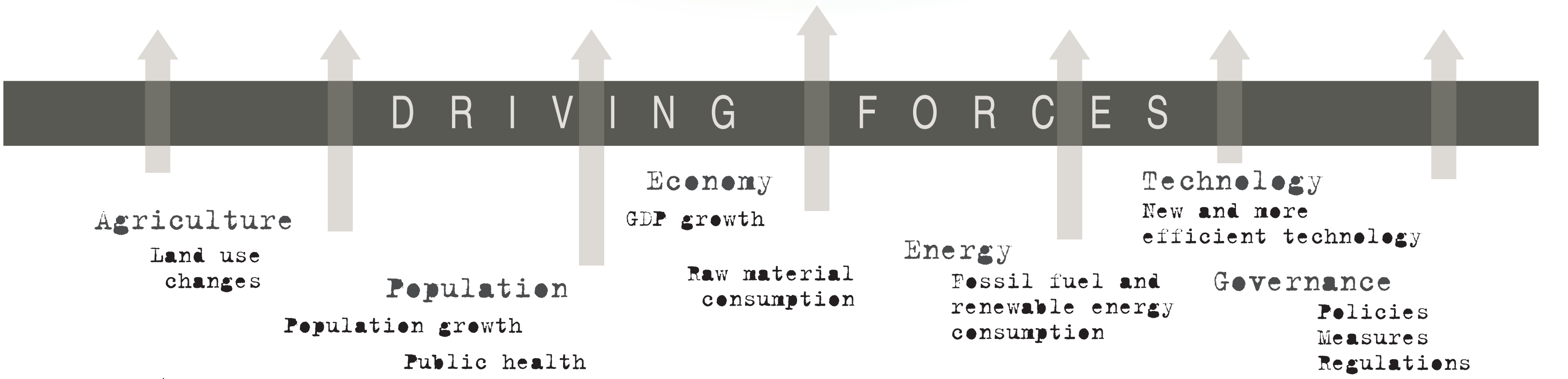
The A1 scenario describes a future world of very rapid economic growth, a global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Specific regional patterns tend to disappear as a result of increased cultural and social interaction. The gap between regions, regarding per capita income, reduces substantially. This scenario develops into three groups that describe alternative in the development of energy supply: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance (A1B) across all sources.

The A2 scenario describes a very heterogeneous world, based on the continued separation and preservation of local identities. Fertility patterns across regions converge very slowly, which results in a continuously increasing population. Economic development is regionally oriented and per capita economic growth and technological change more fragmented and slower than in the A1 scenario.



The B1 scenario describes a convergent world with a population that peaks in mid-century and declines thereafter (as in the A1 scenario), but with a rapid change in economic structures towards 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.

The B2 scenario describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability rather than the global approach in B1. It is a world with a continuously increasing global population, but at a slower rate than other scenarios, intermediate levels of economic development, and slow but diverse technological change. Society is oriented towards environmental protection and social equity, and focuses on the local and regional level.



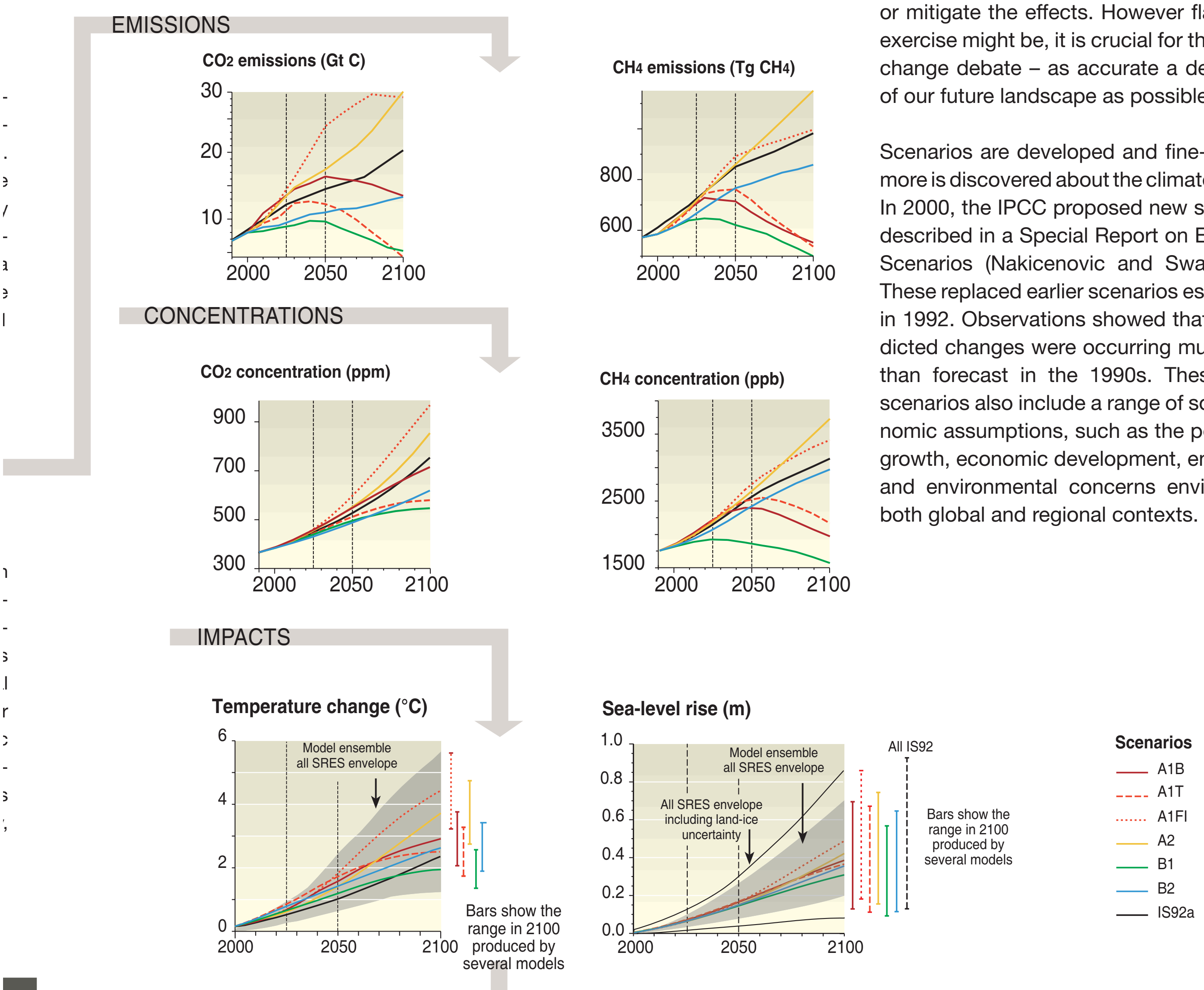
Choose your own weather

You were dreaming of a perfect future world – longer summers, milder winters, greener grass – maybe the IPCC has invented it for you. They have proposed four sets of scenarios, each with a different answer to the fundamental question: will the 21st century be more and more industrialised, or more and more environmentally friendly?

Inventing new worlds

To invent the future, the references we have are the present – and the past. We build scenarios on the bases of existing or past trends and behaviour, and in this respect, they might teach us more about present processes than about future expectations. For example, we don't know what is around the corner in terms of new technologies – technologies that could accelerate the impacts or mitigate the effects. However flawed the exercise might be, it is crucial for the climate change debate – as accurate a description of our future landscape as possible.

Scenarios are developed and fine-tuned as more is discovered about the climate system. In 2000, the IPCC proposed new scenarios, described in a Special Report on Emissions Scenarios (Nakicenovic and Swart 2000). These replaced earlier scenarios established in 1992. Observations showed that the predicted changes were occurring much faster than forecast in the 1990s. These newer scenarios also include a range of socio-economic assumptions, such as the population growth, economic development, energy use and environmental concerns envisaged in both global and regional contexts.



The scenario IS92A is from IPCC's Second Assessment Report (1995) and it assumes that world population grows to 11.3 billions by 2100, economic growth continues at 2.3%-2.9% per annum, and no active steps are taken to reduce CO_2 emissions.

- Threat to population living in coastal zones
- Decrease of croplands
- Increase of extreme events
- Extention of area with parasitic diseases

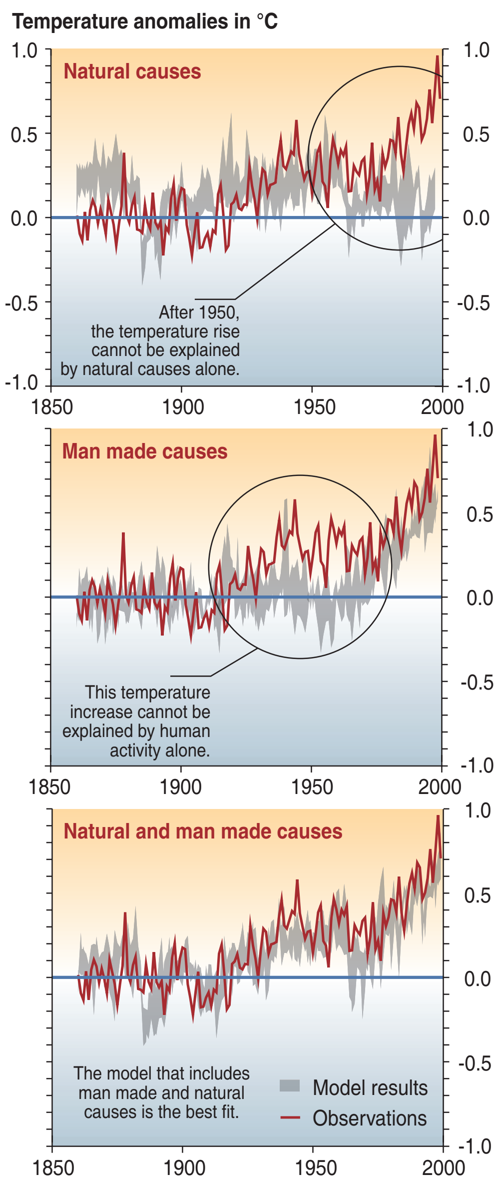
It’s getting hot in here

The global average surface temperature has increased over the 20th century by about 0.6 degrees Celsius. This increase in temperature is likely to have been the largest for any century in the last 1000 years.

Evidence from tree ring records, used to reconstruct temperatures over this period, suggests that the 1990s was the warmest period in a millennium.

It is very likely that nearly all land areas will warm more rapidly than the global average, particularly those at high northern latitudes in the cold season. There are very likely to be more hot days; fewer cold days, cold waves, and frost days; and a reduced diurnal temperature range.

Comparison between modeled and observed temperature since 1860



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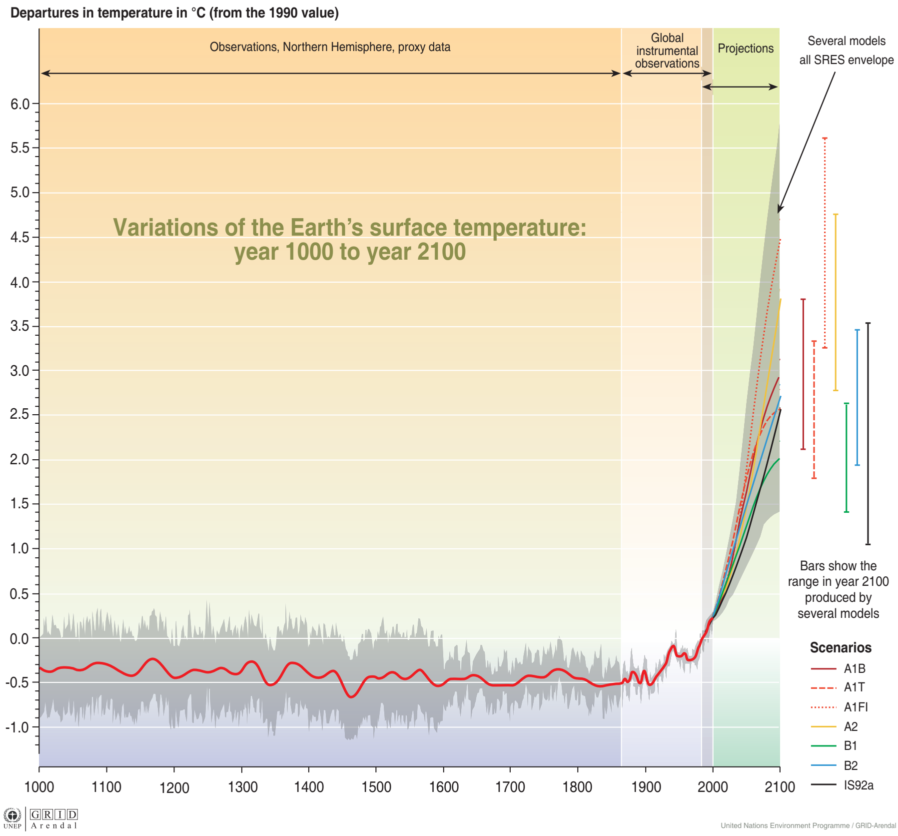


Natural versus man made

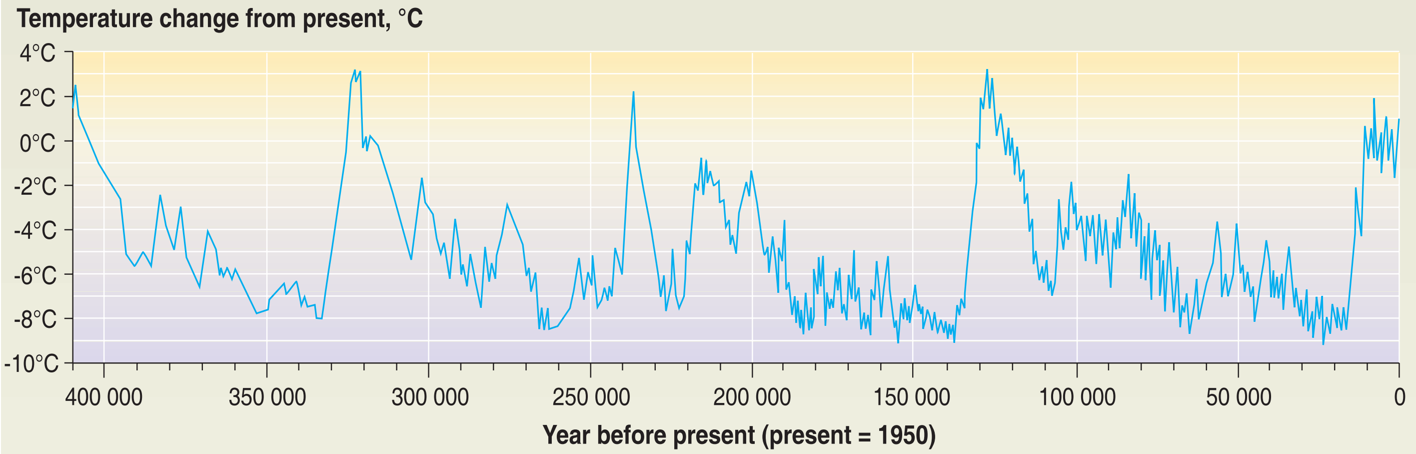
There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities. It is unlikely that the warming is to be entirely natural. Reconstructions of climate data from the last 1,000 years also indicate that this 20th century warming was unusual and unlikely to be the response to natural forcing alone. Volcanic eruptions and variation in solar irradiance do not explain the warming in the latter half of the 20th century, but they may have contributed to the observed warming in the first half.

As we can see from models of temperature changes caused by natural forcing, we should have observed a decrease in the global average temperature lately, but we have not. We have observed an increase.

A climate model can be used to simulate the temperature changes that occur from both natural and anthropogenic causes. The simulations in a) were done with only natural forcings: solar variation and volcanic activity. In b) only anthropogenic forcings are included: greenhouse gases and sulfate aerosols. In c) both natural and anthropogenic forcings are included. The best match is obtained when both forcings are combined, as in c.

Temperature and CO_2 concentration in the atmosphere over the past 400 000 years (from the Vostok ice core)

The information presented on this graph indicates a strong correlation between carbon dioxide content in the atmosphere and temperature. A possible scenario is when anthropogenic emissions of greenhouse gases bring the climate to a state where it reverts to the highly unstable climate of the pre-ice age period. Rather than a linear evolution, the climate follows a non-linear path with sudden and dramatic surprises when greenhouse gas levels reach an as-yet unknown trigger point.



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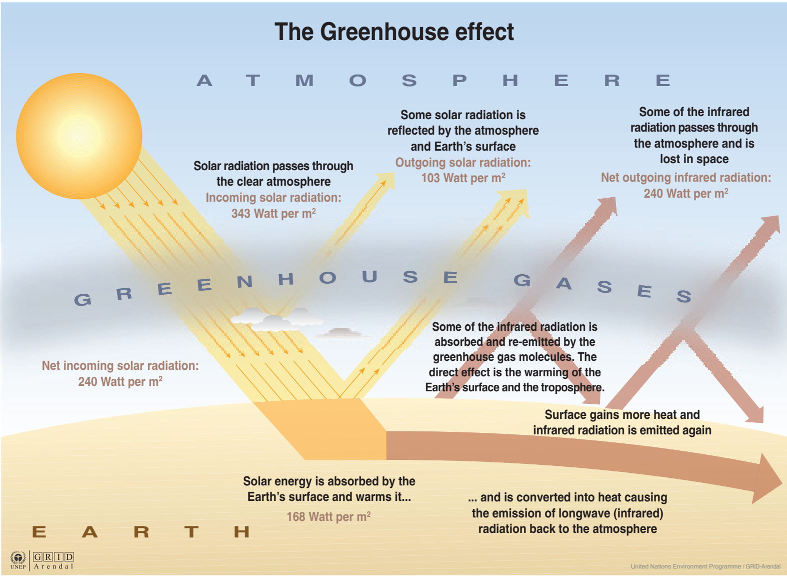
Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3 June), pp 429-436, 1999.

Cooling or heating, a balancing act

Every year the sun delivers an average of 340 watts of energy to every square metre of the Earth. To produce this amount of energy we would need 440 million large electric power plants, each generating 100 million watts of power (NASA).

It would get uncomfortably hot on Earth with all this energy, but fortunately for us, the amount of heat we receive from the sun is balanced by heat radiated back into space by the atmosphere. Radiative forcing is the change in the balance between radiation coming into the atmosphere and radiation going out. A positive radiative forcing tends on average to warm the surface of the Earth, and negative forcing tends on average to cool the surface. Greenhouse gases, for example, produce positive radiative forcing – they trap outgoing terrestrial (infrared) radiation, which causes a temperature rise at the Earth's surface – the "greenhouse effect". In contrast, negative radiative forcing from clouds and aerosols, which can reflect back into space, acts as a cooling mechanism.



Sources: Okanagan University College, University of Oxford, EPA, IPCC.

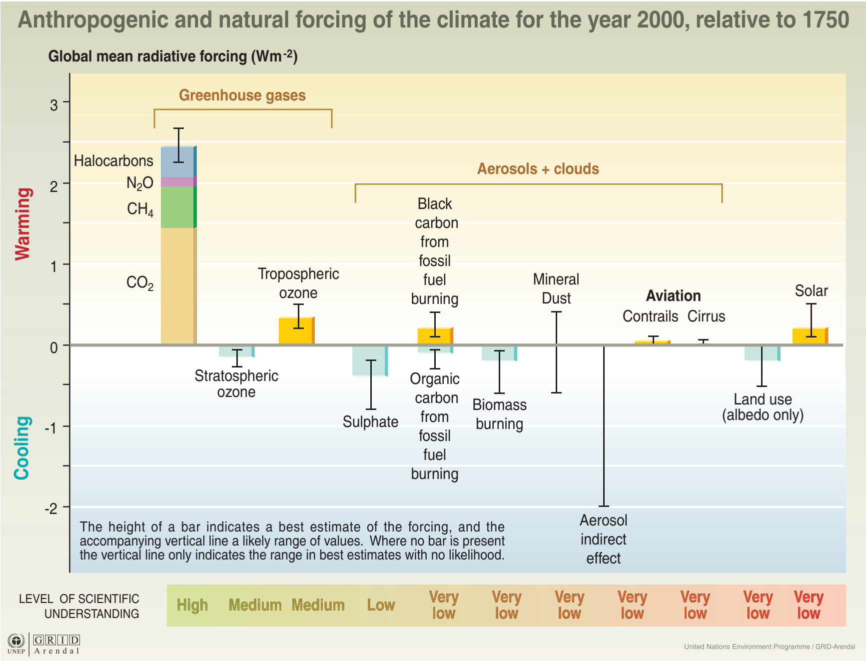
Radiative forcing

The radiative forcing from the increase in anthropogenic greenhouse gases since the pre-industrial era is positive (warming) with a small uncertainty range; that from the direct effects of aerosols is negative (cooling) and smaller; whereas the negative forcing from the indirect effects of aerosols (on clouds and the hydrologic cycle) might be large but is not well quantified. Key anthropogenic and natural factors causing a change in radiative forcing from year 1750 to year 2000 are shown in this figure, where wide, colored bars mark the factors whose radiative forcing can be quantified. Only some of the aerosol effects are estimated here and denoted as ranges. Other factors besides atmospheric constituents -- solar irradiance and land-use change -- are also shown. Stratospheric aerosols from large volcanic eruptions have led to important, but short-lived, negative forcings (particularly during the periods 1880-1920 and 1960-1994), which are not important over the time scale since the pre-industrial era and not shown. The sum of quantified factors in the figure is positive, but this does not include the potentially large, negative forcing from aerosol indirect effects.

The enhanced greenhouse effect

Greenhouse gases are a natural part of the atmosphere. Without these gases the global average temperature would be around -20ºC. The problem we now face is that human actions – particularly burning fossil fuels (coal, oil and natural gas) and land clearing – are increasing their concentrations. The more of these gases there are, the more heat is trapped. This is known as the enhanced greenhouse effect. Naturally occurring greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Greenhouse gases that are not naturally occurring include hydro-fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6), which are generated in a variety of industrial processes.

On average, about one-third of the solar radiation that hits the Earth is reflected back into space. The land and the oceans mostly absorb the rest, with the remainder trapped in the atmosphere. The solar radiation that strikes the Earth's surface heats it up, and as a result infrared radiation is emitted.



The main greenhouse gases

Name	Pre-industrial concentration (ppmv *)	Concentration in 1998 (ppmv)	Atmospheric lifetime (years)	Main human activity source	GWP **
Water vapour	1 to 3	1 to 3	a few days	-	-
Carbon dioxide (CO_2)	280	365	variable	fossil fuels, cement production, land use change	1
Methane (CH_4)	0,7	1,75	12	fossil fuels, rice paddies waste dumps, livestock	23
Nitrous oxide (N_2O)	0,27	0,31	114	fertilizers, combustion industrial processes	296
HFC 23 (CHF_3)	0	0,000014	260	electronics, refrigerants	12 000
HFC 134 a (CF_3CH_2F)	0	0,0000075	13,8	refrigerants	1 300
HFC 152 a (CH_3CHF_2)	0	0,0000005	1,4	industrial processes	120
Perfluoromethane (CF_4)	0,00004	0,00008	> 50 000	aluminium production	5 700
Perfluoroethane (C_2F_6)	0	0,000003	10 000	aluminium production	11 900
Sulphur hexafluoride (SF_6)	0	0,0000042	3 200	dielectric fluid	22 200

* ppmv = parts per million by volume, ** GWP = Global warming potential (for 100 year time horizon).

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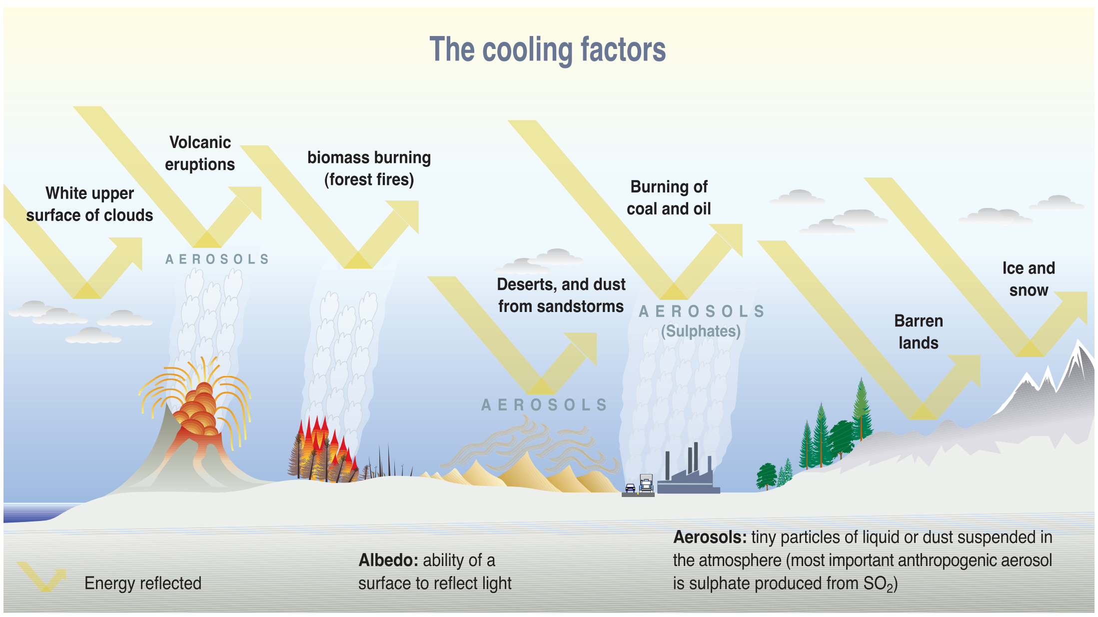
Water vapour is the most abundant greenhouse gas. However, human activities have little direct impact on its concentration in the atmosphere. In contrast, we have a large impact on the concentrations of carbon dioxide, methane and nitrous oxide. In order to be able to compare how different gases contribute to the greenhouse effect, a method has been developed to estimate their global warming potentials (GWP). GWPs depend on the capacity of greenhouse gas molecules to absorb or trap heat and the time the molecules remain in the atmosphere before being removed or broken down. GWPs can be used to define the impact greenhouse gases will have on global warming over different time periods – usually 20 years, 100 years and 500 years. The GWP of carbon dioxide is 1 (constant for all time periods) and the GWPs of other greenhouse gases are measured relative to it. Even though methane and nitrous oxide have much higher GWPs than carbon dioxide, because their concentration in the atmosphere is much lower, carbon dioxide remains the most important greenhouse gas, contributing about 60% to the enhancement of the greenhouse effect (Houghton *et al* 2001).

Cloud makers

Clouds can either heat or cool the Earth, depending on their altitude and size. An experiment carried out in the 1980s found that in general clouds tend to cool the planet. If we remove all the clouds from the atmosphere the average temperature is estimated to increase by approximately 11°C (NASA). However, one particular "man made" cloud type is implicated in global warming. Water vapour emitted by aircraft, referred to as condensation trails, produces high altitude ice clouds. Like cirrus clouds, these cold wispy trails trap heat, effectively warming the atmosphere. Increasing air travel means that more of these warming clouds will be produced.

The cooling effect

Increasing greenhouse gases in the atmosphere can warm the planet, but other factors can cool it. These include aerosols in the atmosphere, such as volcanic ash, soot, dust and sulphates. Small aerosol particles are very effective at reflecting incoming solar radiation back into space and consequently cooling the Earth. Increasing the area of reflective surfaces can also lead to cooling (referred to as increasing albedo). Deforestation is an example, as the exposed ground is more reflective than the forest canopy. Increasing snow cover acts in the same way, as snow and ice are more reflective than the land or the ocean.



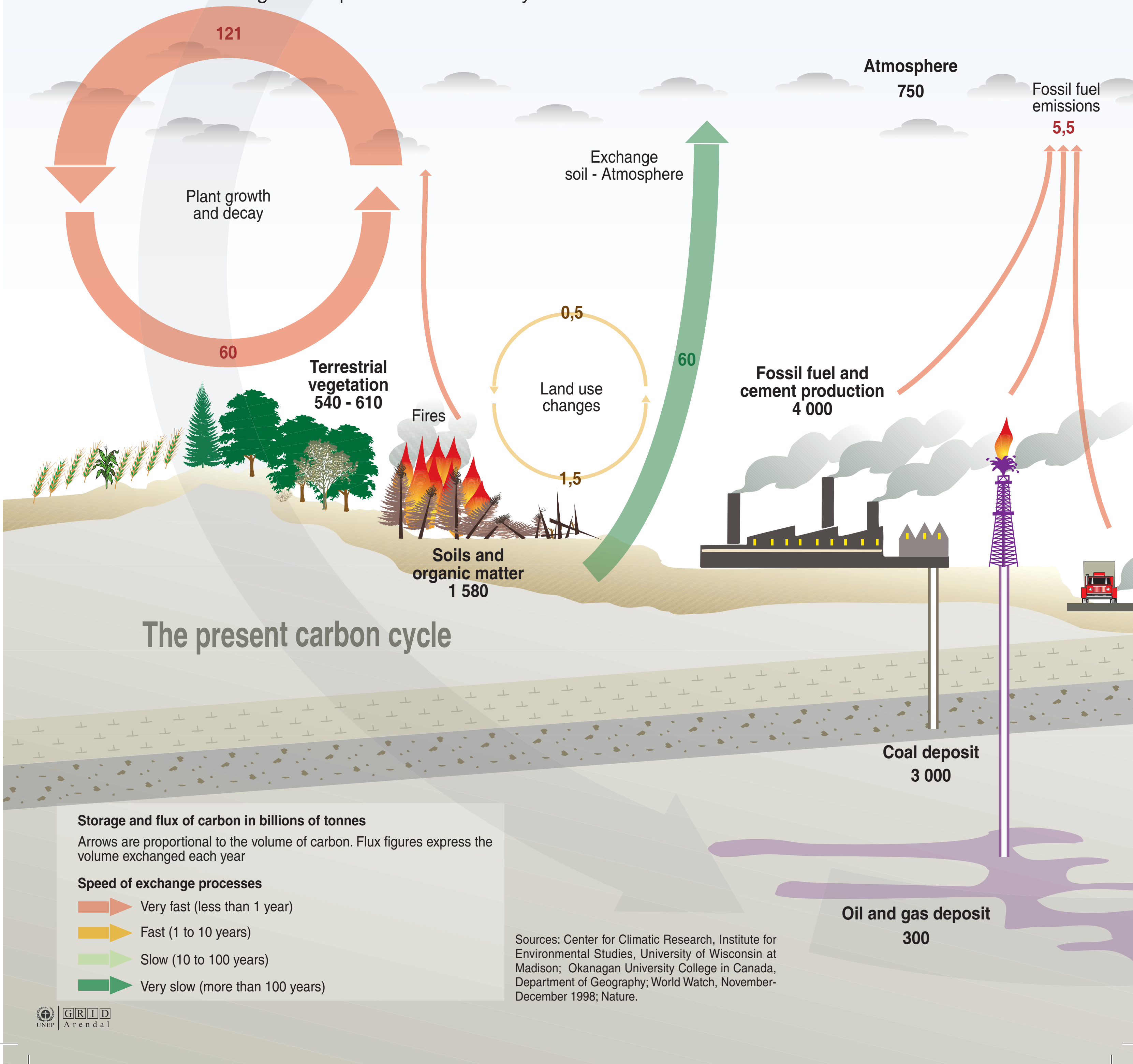
Sources: Radiative forcing of climate change, the 1994 report of the scientific assessment working group of IPCC, summary for policymakers, WMO, UNEP; L.D. Danny Harvey, Climate and global environmental change, Prentice Hall, pearson Education, Harlow, United Kingdom, 2000.

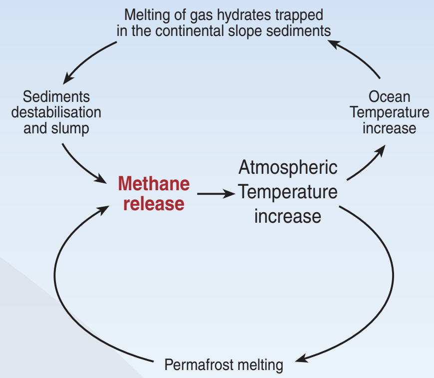
United Nations Environment Programme / GRID-Arendal

Carbon, carbon everywhere

Carbon is one of the most abundant elements in the Universe. It is the basis of all organic substances, from fossil fuels to human cells. On Earth, carbon is continually on the move – cycling through living things, the land, ocean, atmosphere, and even the Earth's interior. In some areas it moves quickly, in others it takes eons. The fast part of the cycle includes us – from birth to death and decomposition in perhaps 80 years – whereas carbon locked in marine sediments may remain undisturbed for millions of years.

What happens when humans start driving the carbon cycle? We have seen that we can make a serious impact – rapidly raising the level of carbon in the atmosphere. But we really have no idea what we are doing. At the moment we don't even know what happens to all the carbon we release from burning fossil fuel. Obviously a lot of it goes into the atmosphere, but every year we loose track of between 15 and 30% (NASA). Scientists speculate that it is taken up by land vegetation, but no one really knows. This sort of uncertainty makes it doubly difficult to predict the outcome of tampering with something as complex as the carbon cycle.





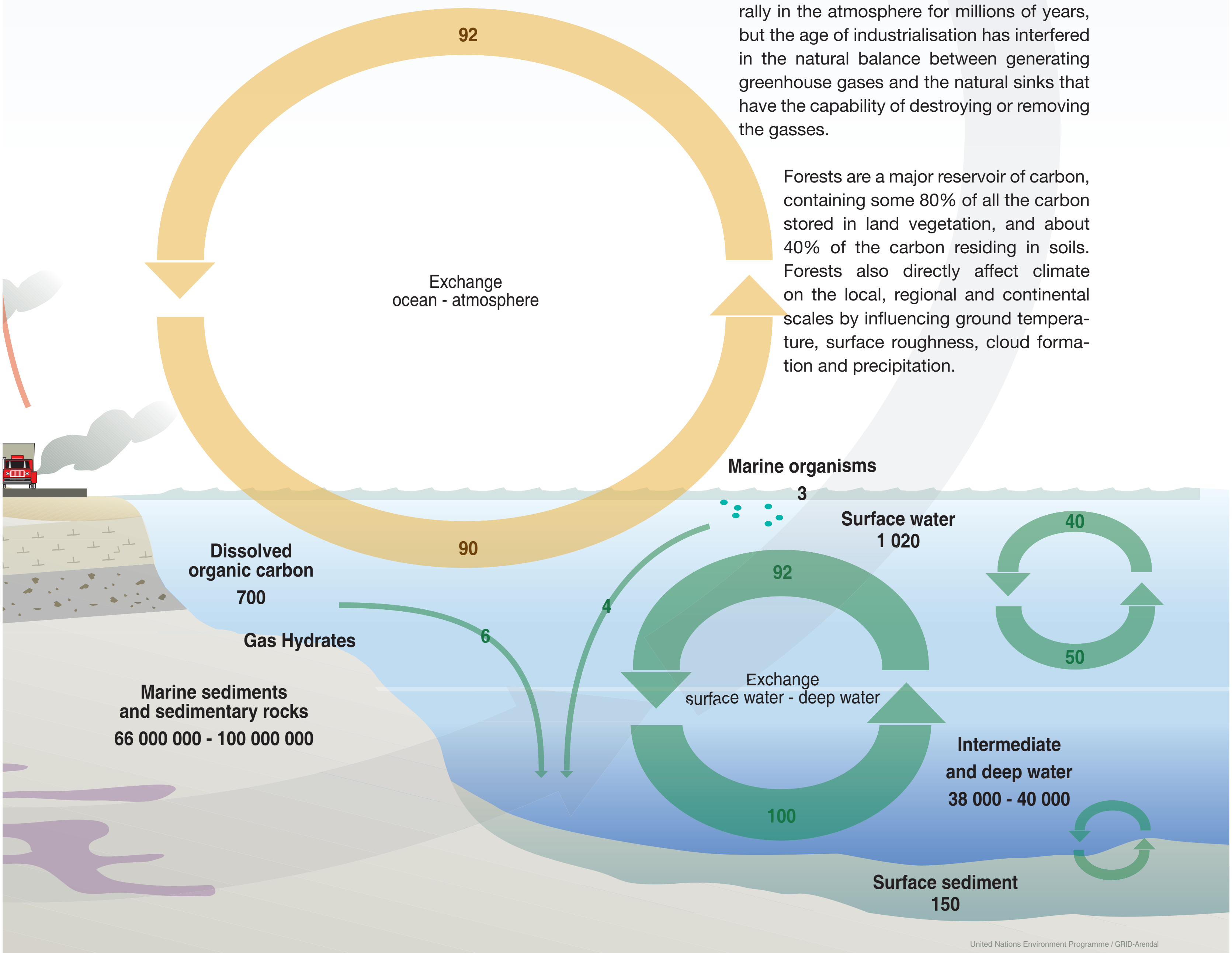
It's killed before, will it kill again?
The amount of carbon released from burning fossil fuels is nothing compared to what might be in store for us. Lying at the bottom of the oceans and buried in the Arctic permafrost, are huge quantities of frozen methane. These "gas hydrates" are kept solid by the combination of low temperature and high pressure. Estimates suggest that there is almost twice the amount of carbon stored in this frozen reservoir than found in all known fossil fuel reserves (USGS). Increasing atmospheric and ocean temperatures could destabilise the hydrates, allowing the release of methane – a greenhouse gas, 21 times more potent than CO_2. As more methane is released, temperatures climb further, releasing even more gas and driving the system into a runaway catastrophe.

Despite the evidence of global warming and the known greenhouse characteristics of methane, interest in gas hydrates as a potential energy source continues to accelerate. Many governments, such as the U.S., Japan, Korea, Canada, India, Norway and Australia are actively funding research programes. Japan has been the most active, drilling two off-shore exploration wells.

Uncontrollable global warming may seem unlikely, but scientists are increasingly convinced it has happened before. During the Permian, 250 million years ago, volcanoes in Siberia spewed masses of carbon dioxide into the atmosphere. The global warming that is thought to have ensued, is the prime suspect in the greatest mass extinction of all time – wiping out 95% of all life forms on the planet. Evidence from rocks suggests that temperatures during this time rose by 5°C – one of the IPCC scenarios predicts that we could see a 6°C increase by the end of the century.

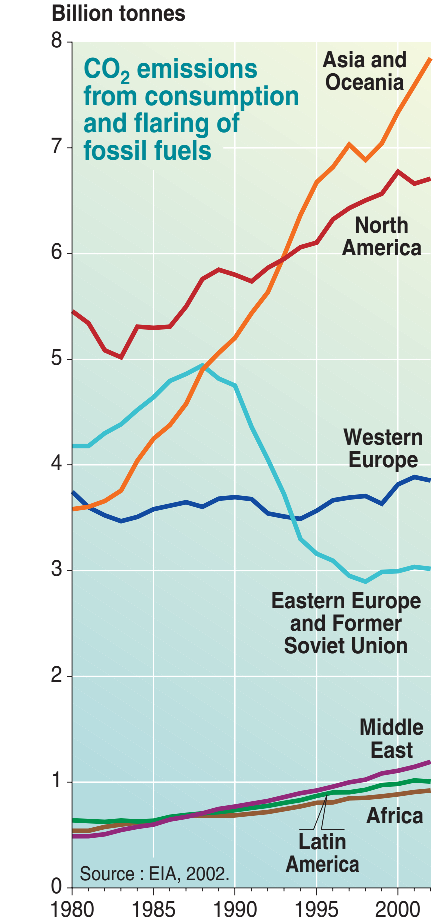
The carbon storage
Greenhouse gases have been present naturally in the atmosphere for millions of years, but the age of industrialisation has interfered in the natural balance between generating greenhouse gases and the natural sinks that have the capability of destroying or removing the gasses.

Forests are a major reservoir of carbon, containing some 80% of all the carbon stored in land vegetation, and about 40% of the carbon residing in soils. Forests also directly affect climate on the local, regional and continental scales by influencing ground temperature, surface roughness, cloud formation and precipitation.



Emissions continue to increase

Since pre-industrial times, the atmospheric concentration of greenhouse gases has grown significantly. Carbon dioxide concentration has increased by about 31%, methane concentration by about 150%, and nitrous oxide concentration by about 16% (Watson *et al* 2001). The present level of carbon dioxide concentration (around 375 parts per million) is the highest for 420,000 years, and probably the highest for the past 20 million years.



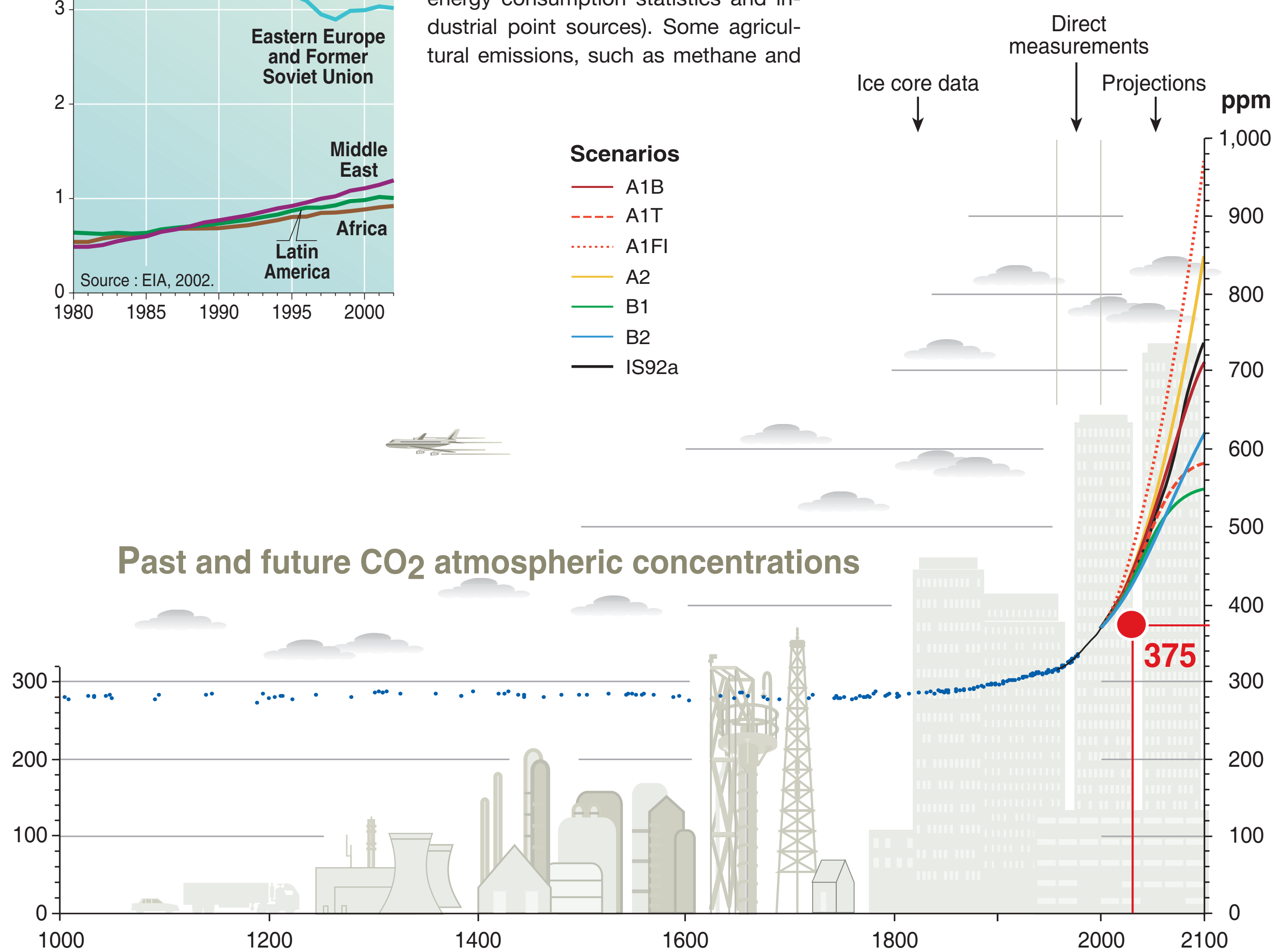
Emissions reporting

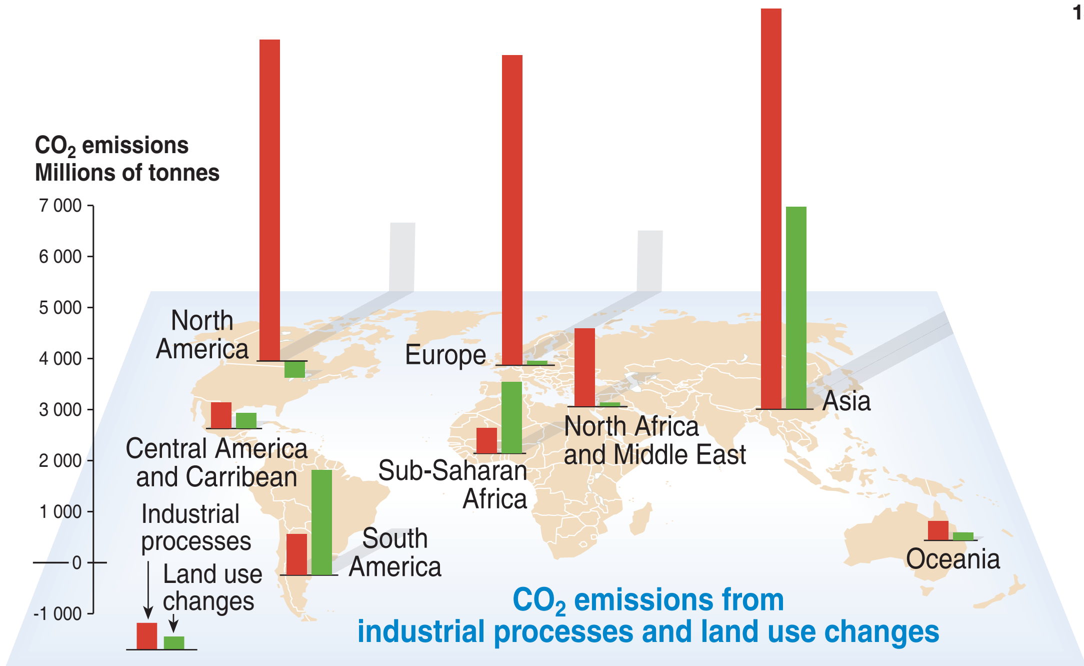
Central to any study of climate change is the development of an emissions inventory that identifies and quantifies a country's primary anthropogenic sources and sinks of greenhouse gas. The IPCC has prepared guidelines for compiling national inventories. The major greenhouse gases are included within six sectors: Energy; Industrial Processes; Solvent and Other Product Use; Agriculture; Land Use Change and Forestry; and Waste.

Emissions are not usually monitored directly, but are generally estimated using models. Some emissions can be calculated with only limited accuracy. Emissions from energy and industrial processes are the most reliable (using energy consumption statistics and industrial point sources). Some agricultural emissions, such as methane and nitrous oxide carry major uncertainties because they are generated through biological processes that can be quite variable.

Contributing to emissions

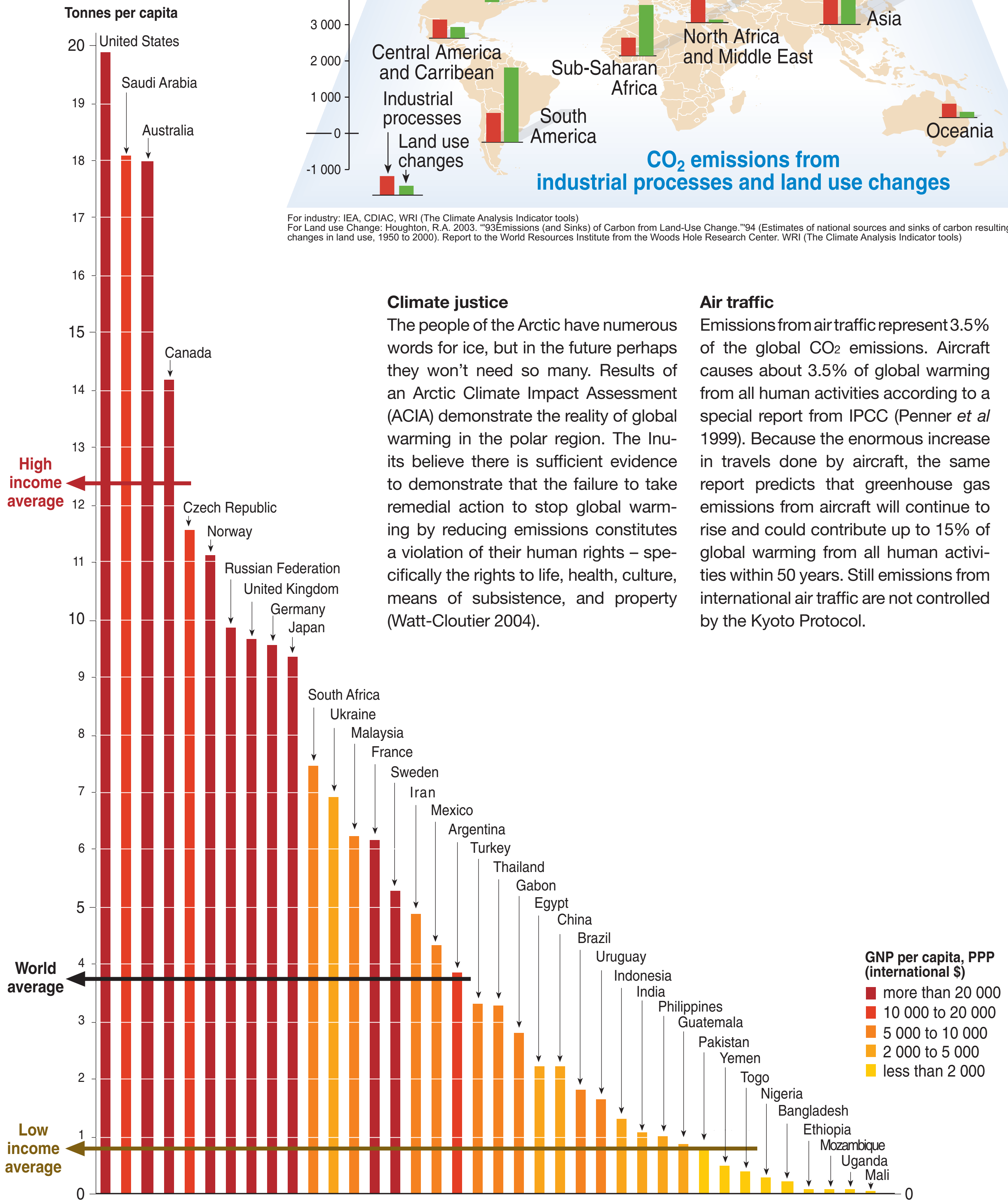
Historically the developed countries of the world have emitted most of the anthropogenic greenhouse gases. The U.S. emits most in total, and is one of the countries with highest emissions per capita. China is the second largest emitter, but has very low emissions per capita. Over the last 20 years, industrial development has led to a rapid rise in the volume of emissions from Asia, but on a per capita basis, emissions in this region are still at the bottom of the global scale.





For industry: IEA, CDIAC, WRI (The Climate Analysis Indicator tools)
For Land use Change: Houghton, R.A. 2003. "'93Emissions (and Sinks) of Carbon from Land-Use Change."'94 (Estimates of national sources and sinks of carbon resulting from changes in land use, 1950 to 2000). Report to the World Resources Institute from the Woods Hole Research Center. WRI (The Climate Analysis Indicator tools)

CO_2 Emissions in 2002



Source : World Bank, online database, 2004.

Climate justice

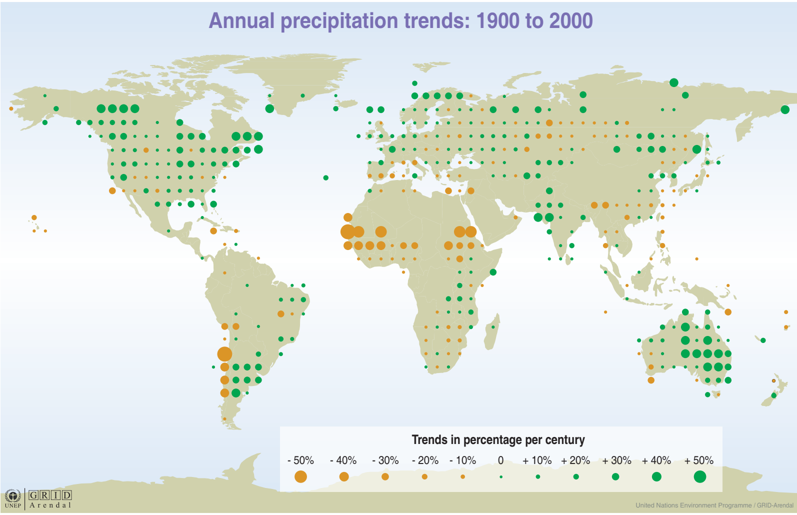
The people of the Arctic have numerous words for ice, but in the future perhaps they won't need so many. Results of an Arctic Climate Impact Assessment (ACIA) demonstrate the reality of global warming in the polar region. The Inuits believe there is sufficient evidence to demonstrate that the failure to take remedial action to stop global warming by reducing emissions constitutes a violation of their human rights – specifically the rights to life, health, culture, means of subsistence, and property (Watt-Cloutier 2004).

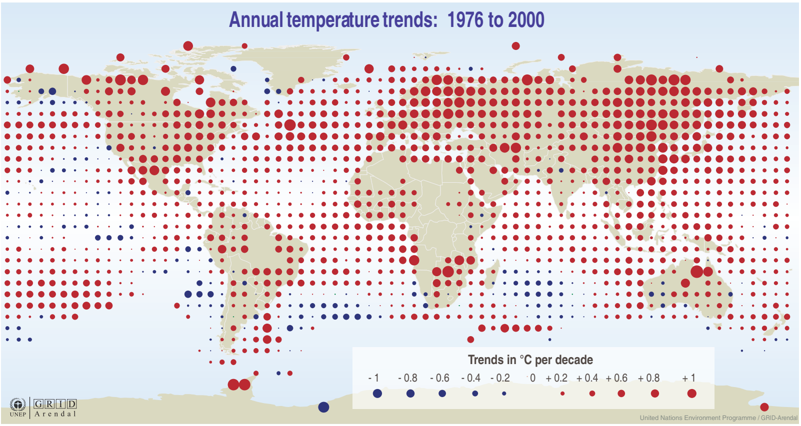
Air traffic

Emissions from air traffic represent 3.5% of the global CO_2 emissions. Aircraft causes about 3.5% of global warming from all human activities according to a special report from IPCC (Penner *et al* 1999). Because the enormous increase in travels done by aircraft, the same report predicts that greenhouse gas emissions from aircraft will continue to rise and could contribute up to 15% of global warming from all human activities within 50 years. Still emissions from international air traffic are not controlled by the Kyoto Protocol.

Changing weather

During the 20th century we have witnessed a change in precipitation trends, temperature trends and increased sea levels. It is very likely that the 20th century warming has contributed significantly to the observed rise in global average sea level and increase in ocean-heat content. Increasing global mean surface temperature is very likely to lead to changes in precipitation. Extreme events are currently a major source of climate-related impacts. For example, heavy losses of human life, property damage, and other environmental damages were recorded during the El Niño event of the years 1997-1998.

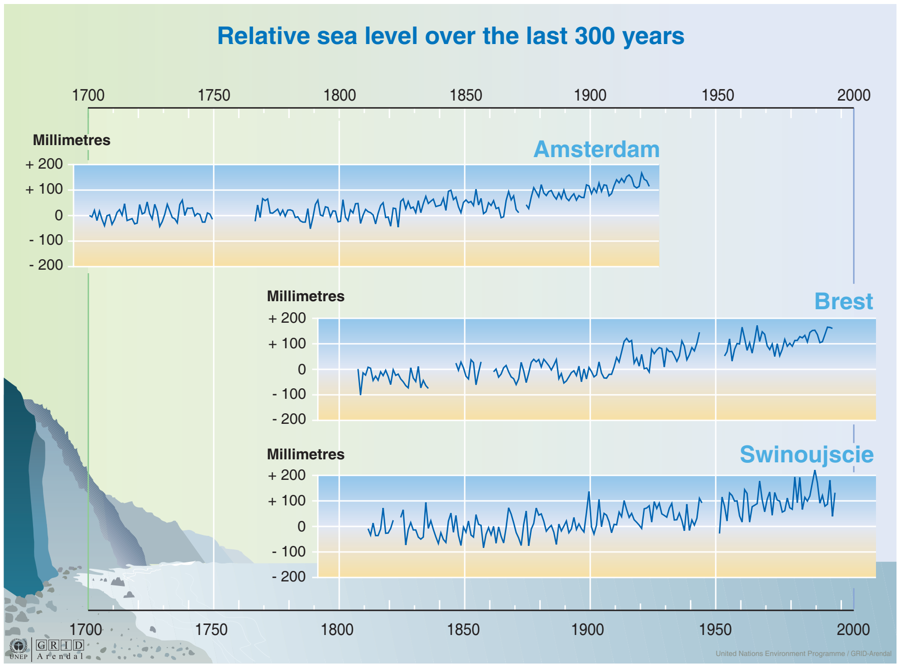




Precipitation has very likely increased during the 20th century by 5 to 10% over most mid- and high latitudes of the Northern Hemisphere continents, but in contrast, rainfall has likely decreased by 3% on average over much of the subtropical land areas. There has likely been a 2 to 4% increase in the frequency of heavy precipitation events in the mid- and high latitudes of the Northern Hemisphere over the latter half of the 20th century. There were relatively small long-term increases over the 20th century in land areas experiencing severe drought or severe wetness, but in many regions these changes are dominated by inter-decadal and multi-decadal climate variability with no significant trends evident over the 20th century.

Over the 20th century there has been a consistent, large-scale warming of both the land and ocean surface, with largest increases in temperature over the mid- and high latitudes of northern continents. The warming of land surface faster than ocean surface from the years 1976 to 2000 is consistent both with the observed changes in natural climate variations, such as the North Atlantic and Arctic Oscillations, and with the modelled pattern of greenhouse gas warming.

It is very likely that the 20th century warming has contributed significantly to the observed rise in global average sea level. Warming drives sea-level rise through thermal expansion of seawater and widespread loss of land ice. Based on tide gauge records, after correcting for land movements, the average annual rise was between 1 and 2 mm during the 20th century. The very few long records show that it was less during the 19th century. The observed rate of sea-level rise during the 20th century is consistent with models. Global ocean-heat content has increased since the late 1950s, the period with adequate observations of subsurface ocean temperatures.



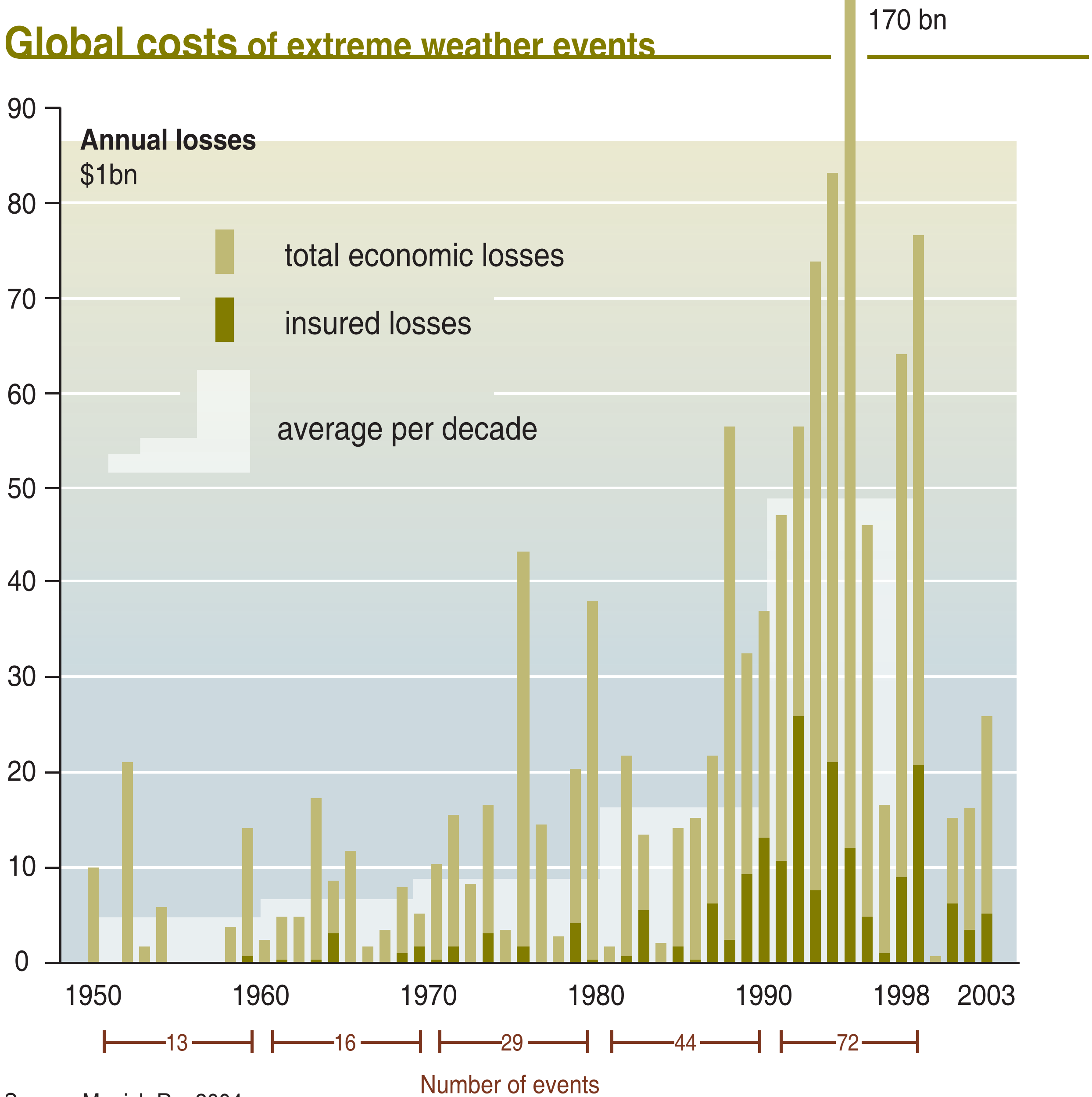
A limited number of sites in Europe have nearly continuous records of sea level spanning 300 years and show the greatest rise in sea level over the 20th century. Records shown from Amsterdam, The Netherlands, Brest, France, and Swinoujscie, Poland, as well as other sites, confirm the accelerated rise in sea level over the 20th century as compared to the 19th.

Extreme weather

The number of weather-related catastrophic events has risen three times faster than the number of non-weather-related events, despite generally enhanced disaster preparedness.

The economic losses from catastrophic weather events have risen globally tenfold (inflation adjusted) from the 1950s to the 1990s, much faster than can be accounted for with simple inflation. The insured portion of these losses rose from a negligible level to about 23% in the 1990s. The total losses from small, non-catastrophic weather-related events (not included here) are similar. Part of this observed upward trend in weather-related disaster losses over the past 50 years is linked to socio-economic factors (e.g., population growth, increased wealth, urbanisation in vulnerable areas), and part is linked to regional climatic factors (e.g., changes in precipitation, flooding events).

Global costs of extreme weather events



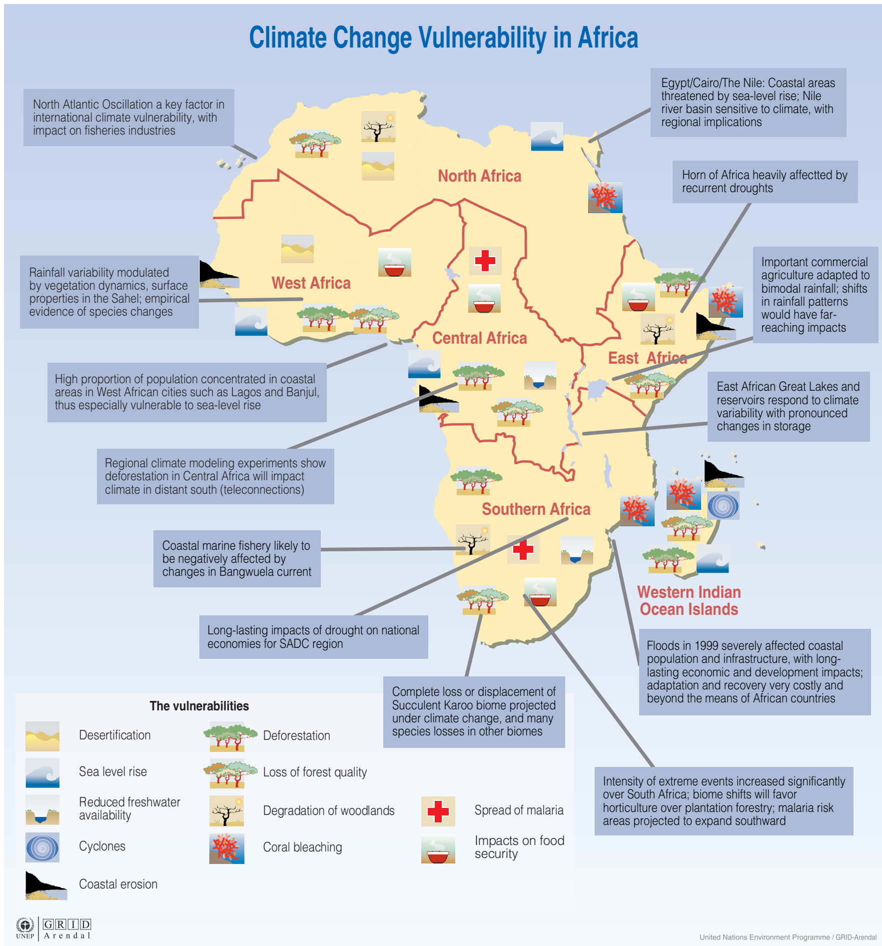
Source: Munich Re, 2004.

Adaptation and mitigation

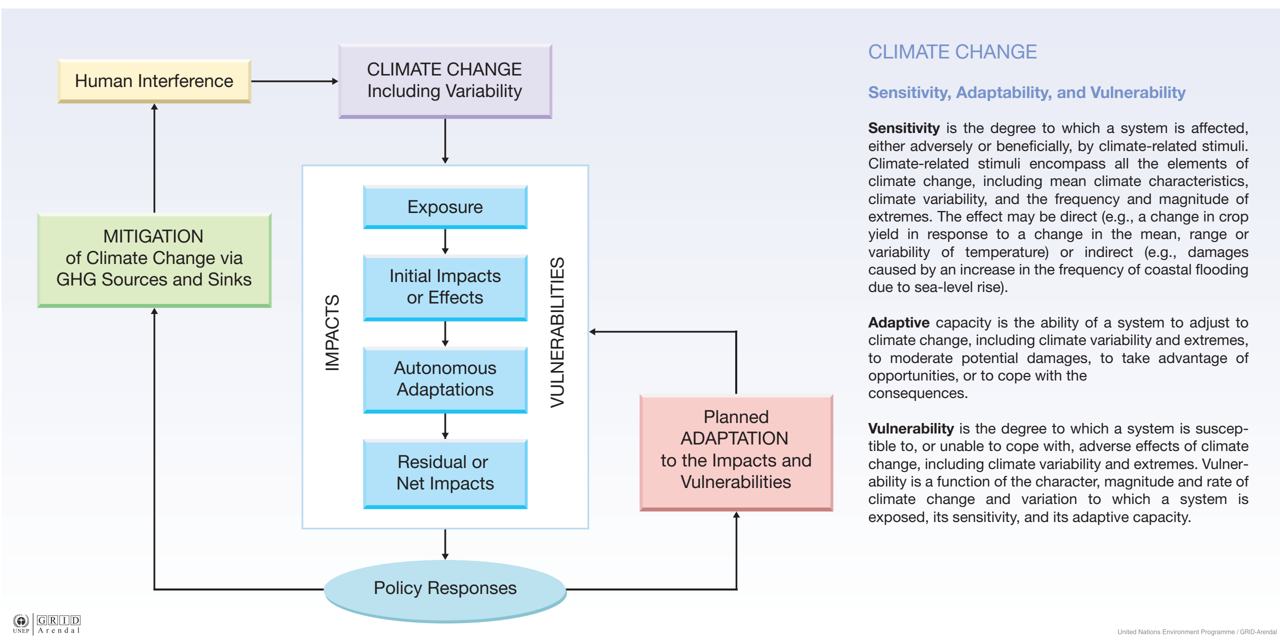
When we are talk about climate change in our modern setting, we refer to changes brought about by industrialisation as seen in the increased use of energy sources that emit harmful gases into the atmosphere. These gases have a warming effect that effects climate patterns.

In Africa this has lead to shifts in rain patterns over the years. African communities are more vulnerable to changes in rainfall and other aspects of climate. Most activities and planning are tied to the seasons. The fact that climate change has resulted in unpredictable seasons has resulted in crop failures.

Africa's development is mostly linked to rain-fed agriculture as opposed to irrigation. Rural communities have relied on predictable rainfall patterns for their crops, and whole economies are driven by this activity. Changes in rainfall patterns have implications for other aspects of life, including health. Unexpected flooding gives rise to parasites in the water that may in turn cause epidemics like cholera. When the highlands get warmer mosquitoes are able to survive, and they conquer these areas too. The consequence is the spread of malaria. Studies have also shown that the glaciers of Mount Kilimanjaro and Mount Kenya are greatly reduced. Yet it is well known that these glaciers are the



Sources: Anna Ballance, 2002.



source of streams and rivers, and are also very important for the rain.

These are examples of Africa's sensibility to climate change, and the new situation can only be improved through adaptation. The continent itself contributes to the emissions of harmful gasses, but just about 10% of world's total. It is quite obvious that there is little Africa can do in terms of mitigation. The continent is dependent on the will of emitting countries in the West in terms of reductions, but still reductions are not due to have any impact for the next 50 years.

Therefore, the focus on controlling emissions through international agreements and new technology in energy production and industries must be combined with strong efforts in minimizing damage through adaptation schemes. The most vulnerable ecological and socio-economic systems are those with the greatest sensitivity to climate change and with the least ability to adapt to new situation. As vulnerability defines the extent to which climate change may damage or harm a system, it depends not only on the system's sensibility, but also on its ability to adapt. Thus traditional knowledge should be complemented by new research and climate change considerations must be an integrated element of the nation's development agenda.

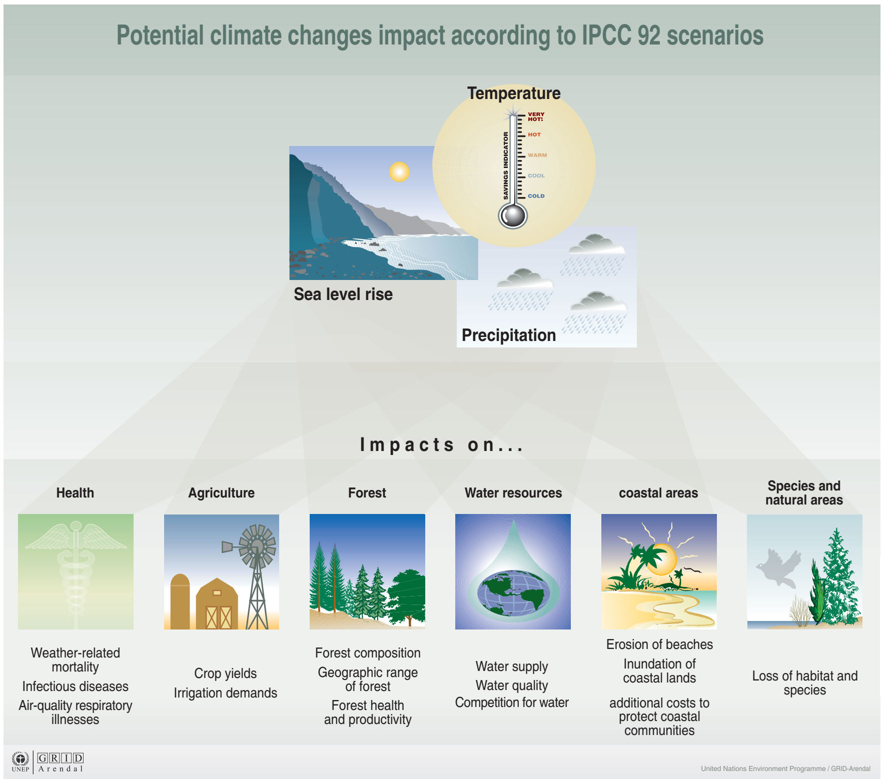
How to finance adaptation?

The Global Environment Facility (thegef.org) is an independent financial entity and the financial mechanism for the international conventions on environment issues, like the the United Nations Framework Convention on Climate Change (UNFCCC).

The Convention defines the mechanism for the provision of financial resources to developing countries. It also specifies that the financial mechanism, GEF, shall function under the guidance of, and be accountable to, the Conference of the Parties (COP), which shall decide on its policies, programme priorities, and eligibility criteria related to the Convention.

Financial resources for the implementation of the Convention are available through the GEF Trust Fund, the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF) and the Adaptation Fund (once the Kyoto Protocol enters into force). Funding is also available through bilateral, regional and multilateral channels.

GEF Trust Fund is the main funding channel for climate change projects in developing countries. Since 1991, it provided approximately US$1.8 billion in grants for climate change activities. In addition more than US$ 9 billion was provided through co-financing from bilateral agencies, recipient countries and the private sector.



Source: United States environmental protection agency (EPA).

Sources:

- Professor Paul Desanker interview by Churchill Otieno in the East African (newspaper), 13th December 2004.
  Climate Change Information Kit, published by UNEP and UNFCCC, October 2001.
- http://unfccc.int/cooperation_and_support/funding/items/2807.php
- http://thegef.org/Projects/Focal_Areas/focal_areas.html
- http://www.unep.org/gef/content/activity_climate.htm

We're in this together

The International community is dealing with global climatic issues on two levels – stabilising greenhouse gas concentrations in the atmosphere and understanding the mechanisms of climate change. Different approaches are taken to address these two core issues, and each is managed by a separate United Nations organisation.

United Nations Framework Convention on Climate Change (UNFCCC)

Stabilising greenhouse gas concentrations calls for political motivation. The United Nations Framework Convention on Climate Change (UNFCCC) encourages intergovernmental efforts to address climate change. The Convention, which is currently ratified by 186 countries (the "Parties"), calls on its members to work towards "stabilising atmospheric concentrations of greenhouse gases at a level that would prevent human-induced actions from leading to dangerous interference with the climate system". Member countries meet annually at the Conference of the Parties (COP). They have formulated an environmental agreement – the Kyoto Protocol, which, unlike the Convention, obligates all rich countries that have ratified the Protocol, to limit their greenhouse gas emissions between 1990 and 2010.

Intergovernmental Panel on Climate Change (IPCC)

Understanding the mechanisms of climate change, its potential impacts and developing answers, requires international scientific cooperation. The Intergovernmental Panel on Climate Change (IPCC) brings together researchers from all over the world, organized into three working groups. Their task is to assess the huge volume of climate change related material published in the scientific literature and condense it into comprehensive and objective reports, detailing the current state of knowledge. To provide a balanced view, participants in the process are drawn from a broad range of organizations, including universities, public and private research laboratories, industry and non-governmental organizations. All suitably qualified researchers, from any relevant discipline, are eligible to contribute to the process. Almost all countries are members of the IPCC, which meets once a year to approve the reports and determine future directions. Each member country has one vote – the United States has as much say as Tajikistan. Much of the material in this publication is based on the findings presented in the Third Assessment Report (TAR) on Climate Change completed in 2001. The next full assessment report is due to be published in 2007. The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the IPCC in 1988, at the urging of the seven leading industrial nations.

Setting the limits – The Kyoto Protocol

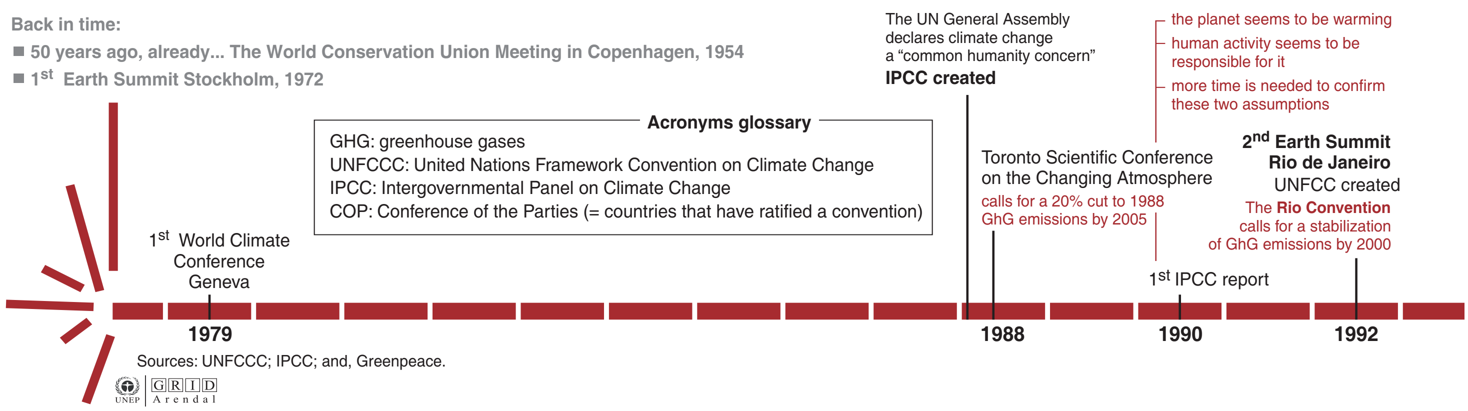
In 1997 world leaders adopted the Kyoto Protocol requiring rich countries to reduce their greenhouse gas emissions to 5.2% below the 1990 level, calculated as an average over the period 2008-2012. Under the Kyoto Protocol the rich countries have different targets, that in sum adds up to a reduction of 5.2%. For example, the European Union aims for an 8% cut in total, Germany committed to a 21% cut and the United Kingdom to 12.5%, while Greece is allowed to increase their emissions by 25% and Spain an increase by 15%.

For the treaty to take effect, it had to be ratified by developed countries whose carbon dioxide emissions represented 55% of the 1990 total. Late in 2004, Russia decided to ratify it, and it will now enter into force in 2005. Some countries, including Australia and the United States have not ratified the Protocol.

However, a large number of climate specialists believe that even if the 5.2% Kyoto reduction target is reached, it will not have a great impact on global warming. But the Kyoto Protocol is a very important first step for the world in fighting climate change. In 2005, the climate change negotiators will have to start talking about what will happen after the first Kyoto period.

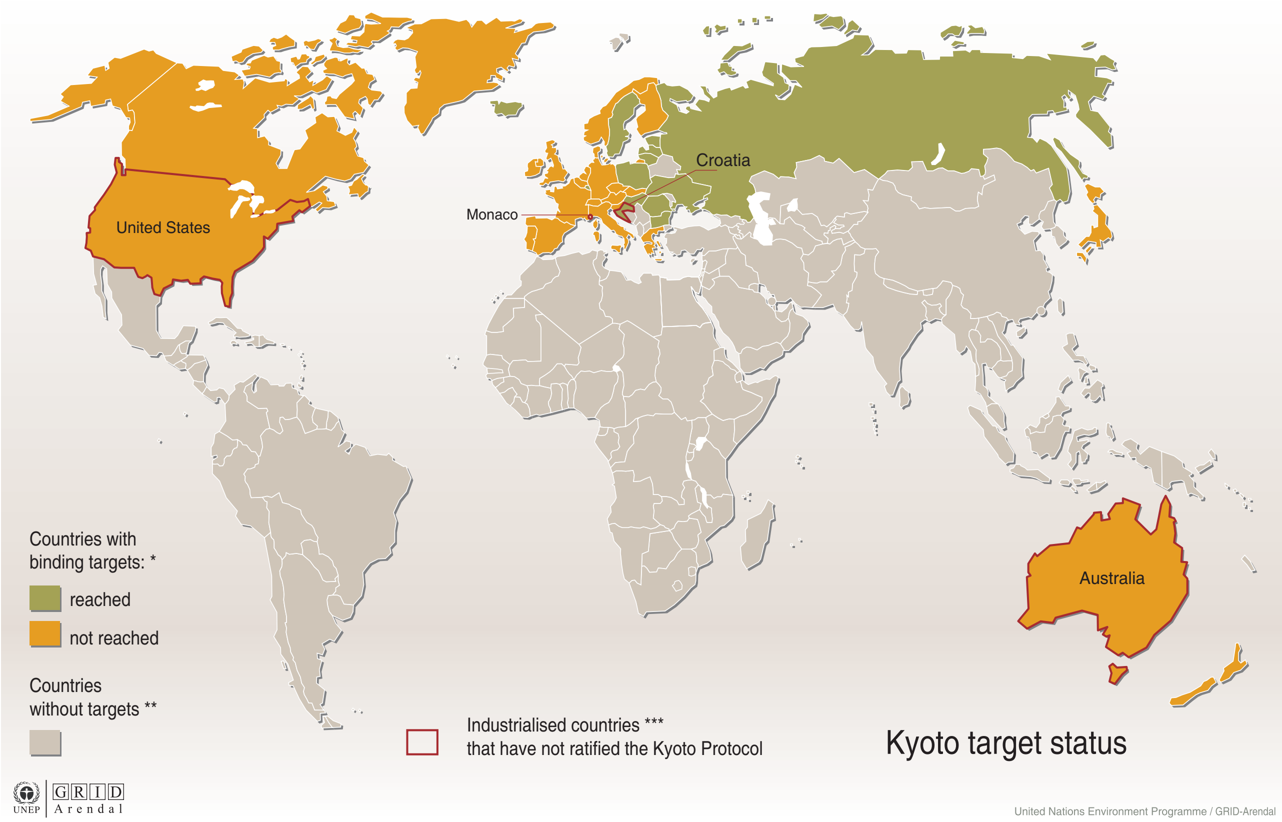
Emissions' trading has started

Under the Kyoto Protocol developed countries will have some flexibility in how they make their emission reductions. In particular, an international emission-trading regime will be established allowing industrialised countries to buy and sell emissions credits amongst themselves. They will also be able to acquire emission reduction units through the Joint Implementation (JI) mechanism by financing certain kinds of projects in other developed countries like the



Sources: UNFCCC; IPCC; and, Greenpeace.

UNEP GRID Arendal



Source: UNFCCC, December 16 2004.

* "Annex B countries" of the Protocol, ** "Non-Annex I countries" of the Convention, *** "Annex I countries" of the Convention.

former Eastern European countries. In addition, a Clean Development Mechanism (CDM) for promoting sustainable development will enable industrialised countries to finance emission-reduction projects in developing countries and to receive credit for doing so.

Built on the mechanisms set up under the Kyoto Protocol the European Union (EU) has developed the largest company-level scheme for trading in CO_2 emissions, it includes 12,000 installations, accounting for around 45% of EU's total CO_2 emissions. The Emissions Trading Scheme (ETS) started in the 25 EU member states on 1 January 2005.

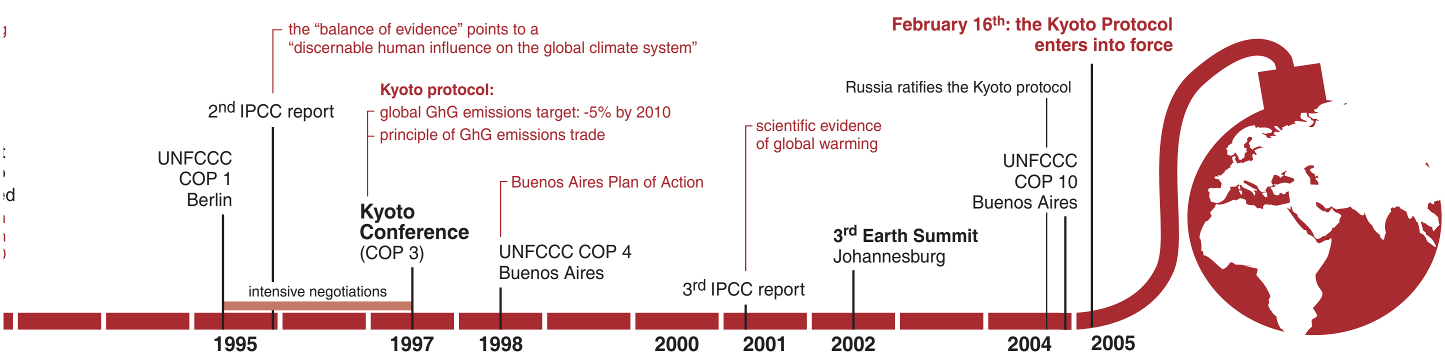
The ETS allows companies to use credits from Joint Implementation (JI) and the Clean Development Mechanism (CDM) to help them comply with their obligations under the scheme. The ETS allows the EU to achieve its Kyoto target at a cost between € 2.9 and € 3.7 billion annually. This is less than 0.1% of the EU's GDP. Without the scheme, compliance costs could reach up to € 6.8 billion a year.

First CDM projects approved

In early 2005, two CDM projects, one in Brazil and the other in Honduras, were approved. The project in Honduras produces power, which is sold to the national power utility in a run-off-river hydroelectric plant. The expected certified emission reductions from the project are projected by the developers to be approximately 178,000t of CO_2 equivalent over a crediting period of ten years.

The objective of the Brazilian project is to avoid methane emissions by collecting these emissions from landfills and produce electricity. It is expected to reduce emissions of 14,072 million tonnes CO_2 equivalents, over a 21-year credit period.

The use of these three flexible mechanisms is to be supplemental to domestic action. By 2005 each party included in Annex 1 shall have made demonstrable progress in achieving its commitments under the Kyoto Protocol.



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At what cost?

The Kyoto Protocol is only a first step towards combating climate change. Drastic reductions of greenhouse gas emissions are required to avoid the most threatening consequences of global warming. Concerns are raised that the price for the economy will be too high, but studies indicate that there will only be a small reduction in GDP to reach the Kyoto targets and that it is possible to stabilize the concentration of CO_2 at low costs.

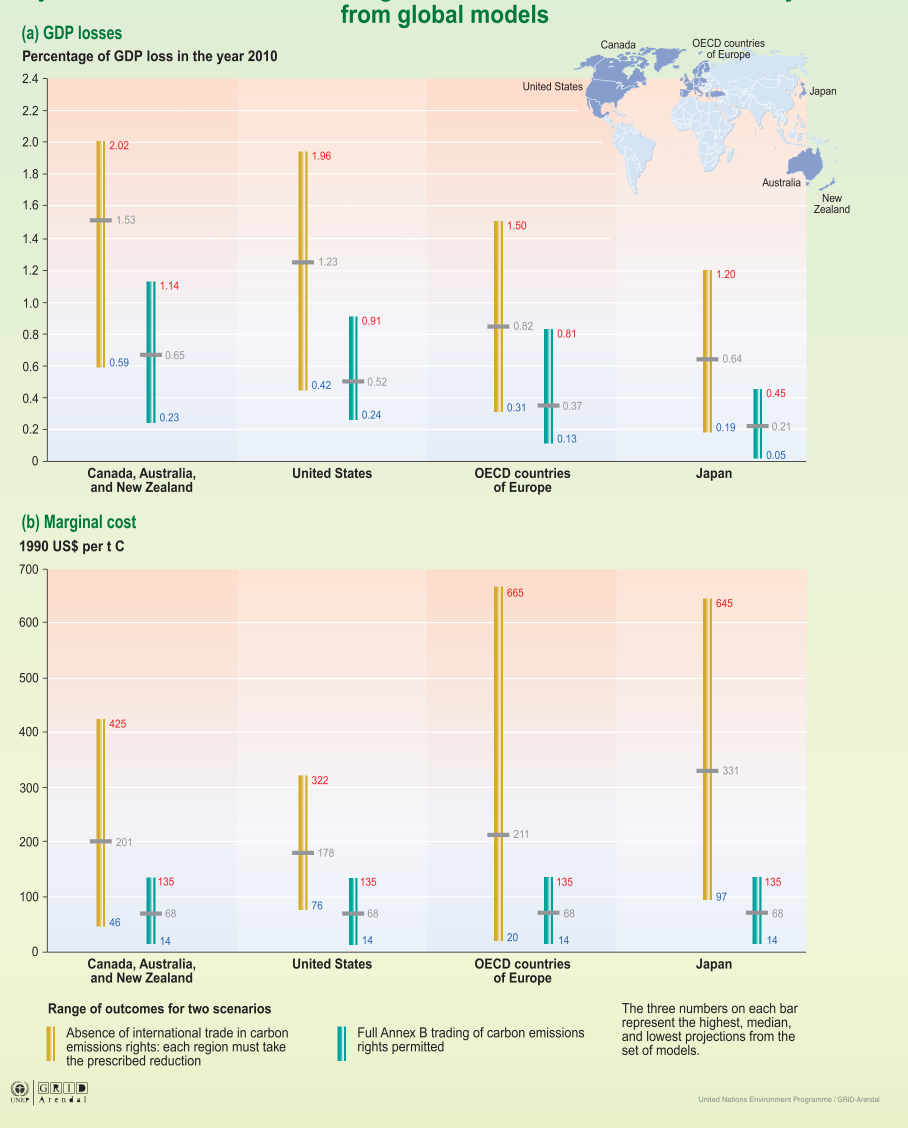
Small losses in GDP

The GDP loss in OECD countries of Europe will in 2010, be 0.13–0.81% if carbon trading is implemented. If carbon trading is not implemented, the loss will be 0.31–1.50%.

For the US the loss would be 0.42–1.96% if carbon trading is not implemented and 0.24–0.91% if it is implemented.

For most economies in transition, GDP effects range from negligible to a several percent increase, reflecting opportunities for energy-efficiency improvements not available to other Annex I countries. Under assumptions of drastic energy-efficiency improvement and/or continuing economic recessions in some countries, the assigned amounts may exceed projected emissions in the first commitment period. In this case, models show increased GDP due to revenues from trading assigned amounts. However, for some economies in transition, implementing the Kyoto Protocol will have similar impact on GDP as for other Annex I countries.

Projections of GDP losses and marginal cost in Annex II countries in the year 2010 from global models

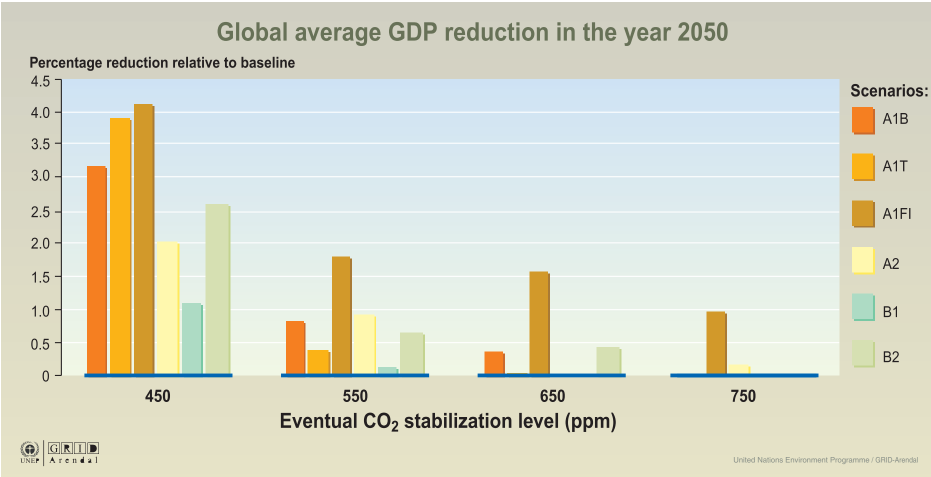


It is possible to stabilize concentrations at low costs.

Global average GDP might be reduced by 1–4% if we reduce the emissions of CO_2 so that we stabilize the concentration in the atmosphere at 450 ppmv. In 2003 the concentration was 375 ppmv. If we stabilise at higher concentration levels, the GDP reduction will be less.

The projected mitigation scenarios do not take into account potential benefits of avoided climate change.

Cost-effectiveness studies with a century time scale estimate that the mitigation costs of stabilizing CO_2 concentrations in the atmosphere increase as the concentration stabilization level declines. Different baselines can have a strong influence on absolute costs. While there is a moderate increase in the costs when passing from a 750 to a 550 ppmv concentration stabilization level, there is a larger increase in costs passing from 550 to 450 ppmv unless the emissions in the baseline scenario are very low.



Although model projections indicate long-term global growth paths of GDP are not significantly affected by mitigation actions towards stabilization, these do not show the larger variations that occur over some shorter time periods, sectors, or regions. These results, however, do not incorporate carbon sequestration, and did not examine the possible effect of more ambitious targets on induced technological change. Costs associated with each concentration level depend on numerous factors including the rate of discount, distribution of emission reductions over time, policies and measures employed, and particularly the choice of the baseline scenario. For scenarios characterized by a focus on local and regional sustainable development for example, total costs of stabilizing at a particular level are significantly lower than for other scenarios. Also, the issue of uncertainty takes on increasing importance as the time frame is expanded.

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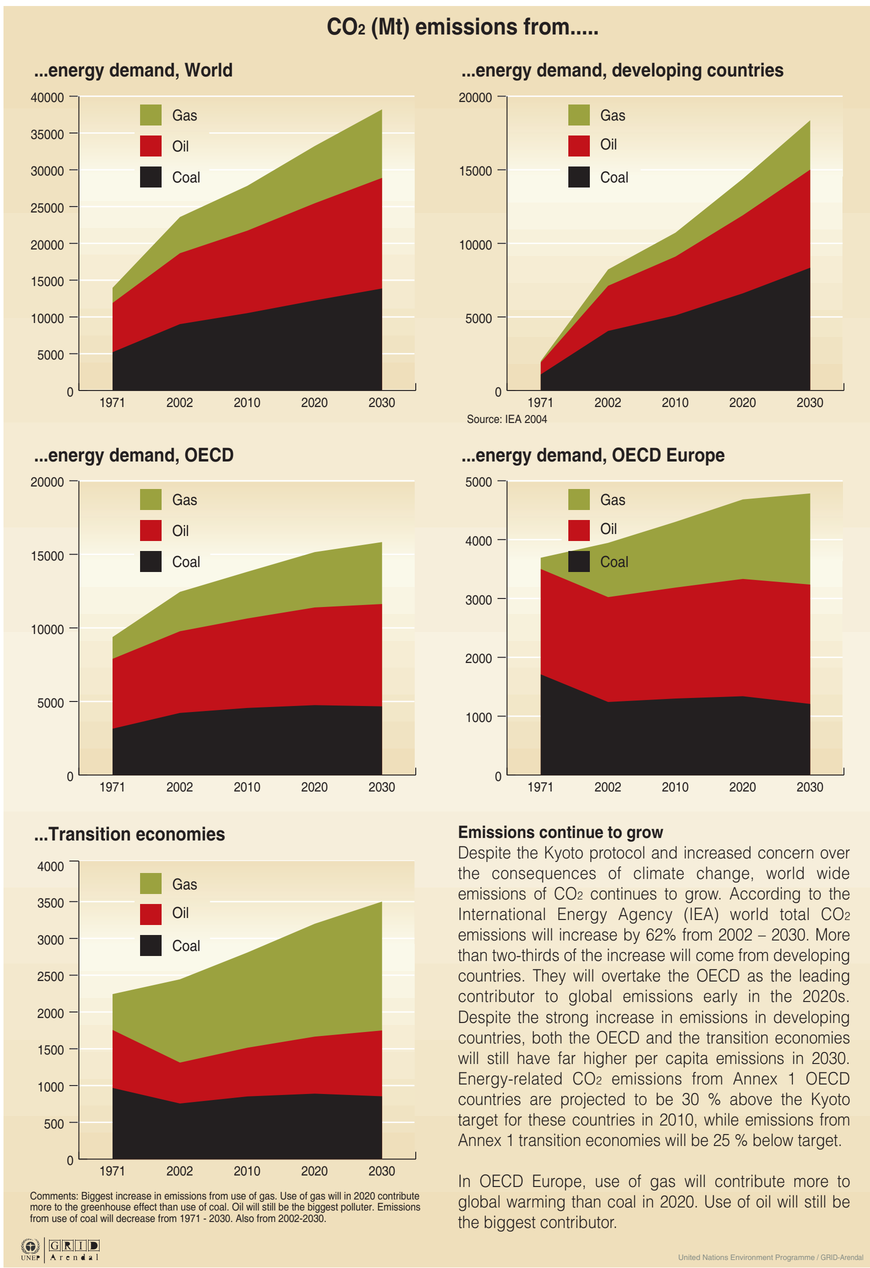

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The views expressed in this publication are those of the authors and do not necessarily represent those of the United Nations, the Intergovernmental Panel on Climate Change, or the collaborating centre UNEP/ GRID-Arendal, that has contributed to the development, production and distribution of this publication.

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