CLIMATE CHANGE
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Climate Change: Science

Earth's climate has always changed.

In fact, it is only thanks to the influence of solar energy and a continual flux of atmospheric gases that life was ever able to evolve on the planet in the first place.

Nevertheless, for at least 100 years - since the Swedish scientist Svente Arrhenius first identified a possible serious problem with the way mankind has been using the atmosphere since the rise of "civilsation" - climate change has become increasingly accepted as representing possibly the most serious threat mankind has ever had to face.

Tackling the threat is urgent, and solutions will not be found until both the causes and their solutions are understood. This is as true for policy makers as much as the general public who are the people who will ultimately be most affected. The situation is complicated by the fact that there are at least three phrases currently used- sometimes almost interchangeably - whenever the subject is discussed.

Climate Change:

This phrase describes most accurately the situation currently under way. It is something we all face for the foreseeable future, even if remedial action is taken right now.

Climate is sometimes described as "the average of the weather".

We generally think of "the climate" as representing the ensemble of local meteorological conditions (wet, dry, warm, cold etc) throughout the year in any particular locality or region.

Thus, a particular profile of seasonality becomes associated as "normal" with a particular part of the world. This assessment is compiled, by and large, of average seasonal variability considered over the course of a year, usually as remembered by living memory.

Any "average" may always consist of a wide range of individual variables.

The term "climate change" therefore conveys accurately the current situation wherein patterns of local weather and seasonality are undergoing profound and rapid change in most parts of the world.

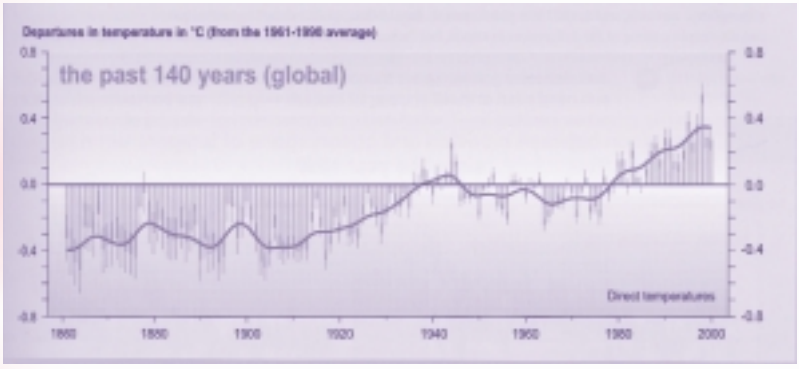
It is, in fact, the *rate* of change of climate that constitutes the major threat to ecosystems and the people and species that they support.

Global Warming:

This term actually describes the underlying mechanism driving current climate change. It is now accepted that the world's atmosphere is in fact warming and that a general trend of atmospheric warming has been under way for over 150 years. Nevertheless, within this 150 years, there have always been periods when it has been possible for people to argue that in fact, global cooling is actually taking place. This is part of any natural variability, wherein long-term averages will always be subject to (and contain) shorter-term counter-cycles. The term "global warming" is therefore accurate if one considers the general tendency of the planet over the last 150-200 years, but may not necessarily have been true for all of that period. (See Fig.1)

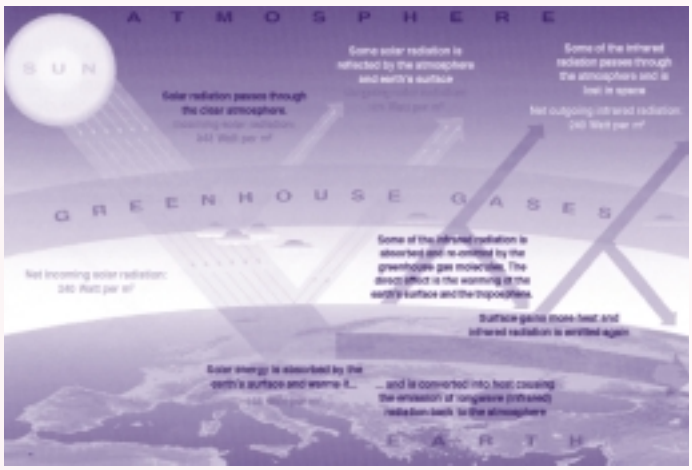
Fig. 1

Variations of the Earth's surface temperature for...



Source: IPCC Synthesis Report 2001

Fig. 2



Source: UNFCCC "Caring for Climate"

Greenhouse Effect:

The "greenhouse effect" is entirely responsible for the fact that Earth has a climate in the first place. The composition of the various gases that make up the planetary atmosphere has always played a critical role in regulating global temperature. Temperature is a crucile variable in terms of environmental conditions on the ground in so far as plant and animal species are concerned (including humans).

The earth's climate is driven by a continuous flow of energy from the sun. This energy arrives mainly in the form of visible light. About 30% is immediately scattered back into space, but most of the remaining 70% passes down through the atmosphere to warm the earth's surface. The earth sends this energy back out into space in the form of infrared radiation. Being much cooler than the sun, the earth does not emit energy as visible light. Instead, absorbed ultraviolet light is then re-emitted back into space as infrared (thermal) radiation (See Fig.2).

Greenhouse gases (GHG's) act as insulation by blocking initially outgoing infrared radiation from escaping directly into space.

GHG's therefore act like a blanket to keep the earth's surface some 20°C warmer than it would be if the atmosphere contained only oxygen and nitrogen. By and large, it is fair to say that the greater the concentration of these gases is in the atmosphere, the thicker the blanket becomes. As more and more greenhouse gases are produced, the planet becomes warmer and warmer.

The combination of trace gases that cause this natural greenhouse effect together comprise less than 1% of the atmosphere. (See Table 1). Their levels are determined by a balance between sources and sinks. (Sources are processes that generate greenhouse gases. Sinks are processes that destroy or remove them.

The three principal GHG's, Carbon dioxide (CO_2), Methane, (CH_4) and Nitrous oxide (N_2O) have been

Table 1. The main greenhouse gases.

Greenhouse gas	Pre-Industrial Concentration	Atmospheric Concentration (*Note 5)	Atmospheric Lifetime (Years)	Principal Anthropogenic Sources	Greenhouse Warming Potential	Contribution to current warming
Carbon dioxide (CO_2)	280 ppm	368 ppm	Variable. (50-200)	Fossil fuels. Deforestation. Cement	1	53%
Methane (CH_4)	700 ppb	1,750 ppb	12-15	Fossil fuels Livestock Waste Rice paddies	21	17%
Nitrous oxide (N_2O)	275 ppb	316 ppb	120	Fertiliser. Industrial processes. Aircraft & cars.	310	5%
CFC-12 (CCl_2F_3)	0	0.5 ppb	102	Coolants Foams	6,200-7,100	}
HCFC-22 ($CHClF_2$)	0	0.1 ppb	12	Coolants	1,300-1,400	} F-gas } total
Perfluor-methane (CF_4)	0	0.07 ppb	50,000	Aluminium production	6,500	} } = 12% }
Sulphur hexaflouride (SF_6)	0	0.03 ppb	3,200	Electrical insulation & cooling fluids	23,900	} }

*Notes: (1) Greenhouse warming potential (GWP) is for 100 year time horizon. (2) Atmospheric residence of CO_2 is variable due to variable rates of sink uptake. (3) GWP for methane includes indirect effects on tropospheric ozone and stratospheric water vapour. (4) GWP for fluorinated gases includes indirect effects on stratospheric ozone. (5) * Concentrations are year 2000 for CO_2, CH_4 , N_2O. F-gas concentrations are for1994. (6) Remaining 13% contribution to warming is due to tropospheric ozone (O_3) Sources: IPCC, Reseau Action Climat, France*

present naturally in the atmosphere for millions of years. Humans however, are affecting the concentrations of these gases in the atmosphere by introducing new sources or by interfering with natural sinks, thus contributing to an enhanced greenhouse effect, global warming and current and future climate change.

Carbon dioxide (CO_2) is currently responsible for over 60% of the enhanced. greenhouse effect if forcing from water and tropospheric ozone (O_3) is excluded.

CO_2 occurs naturally in the atmosphere. However, the burning of coal, oil, and natural gas releases the carbon stored in fossil fuels. Carbon, combined with oxygen during the process of combustion then results in a CO_2.emission. Similarly, deforestation --the cutting down of trees and vegetation (whether for combustion or for agricultural clearance) - releases CO_2 from the carbon stored in trees.

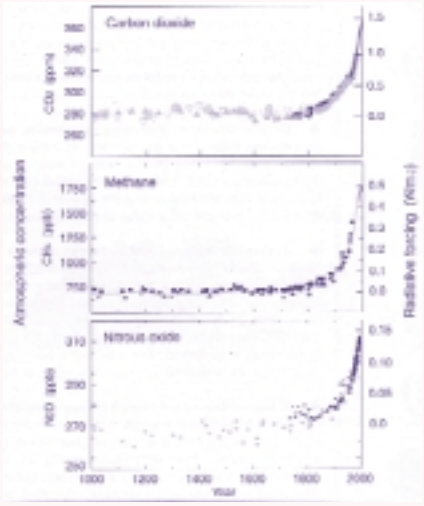
Both of these processes represent a source of CO_2 from human activity (anthropogenic CO_2) and contribute to both global warming and climate change.

Current annual emissions of carbon dioxide from human activity amount to over 25 billion metric tonnes of carbon dioxide.

Fig. 3

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

Global atmospheric concentrations of three well mixed greenhouse gases



Source: UNFCCC "Climate Change Information Kit"

Fig. 4 **Temperature and CO_2 concentration in the atmosphere over the past 400,000 years (from the Vostok ice core)**

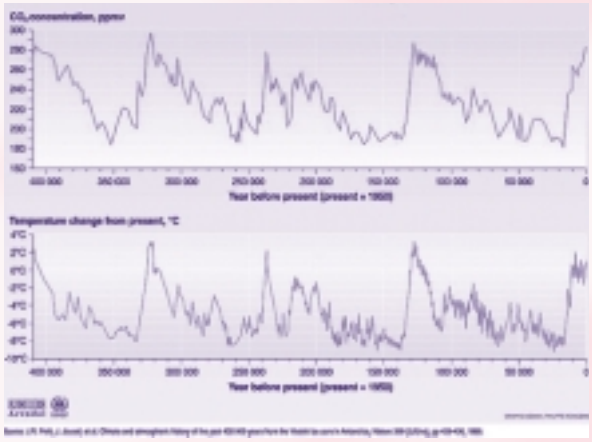
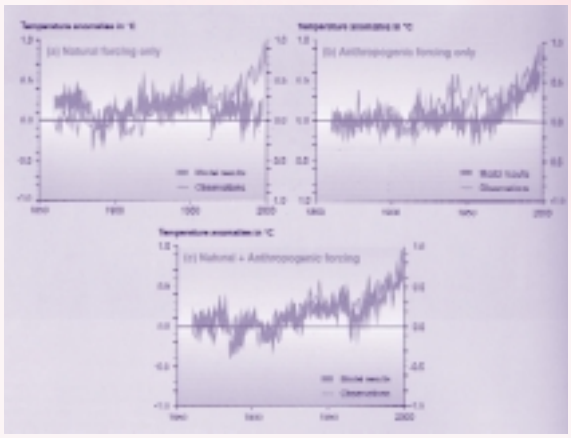


Fig. 5

Comparison between modeled and observations of temperature rise since the year 1860



Source: IPCC Synthesis Report 2001

This amounts to almost 1% of the total mass of carbon dioxide already in the atmosphere. It means that pre-industrial concentrations of CO_2 can be expected to have doubled well within 70 years, even if emissions were to be stabilised today - something which has been achieved in very few countries in the world.

CO_2 levels appear to have varied by less than 10% during the 10,000 years before industrialization. In the 200 years since 1800 concentrations of the three main greenhouse gases in the atmosphere have all risen by over 30% (See Fig 3)

This represents a persistent and worrying trend towards inexorably rising future temperatures and associated effects (See Climate Change Leaflet 2, Impacts). Concentrations and temperatures are so closely related it almost represents a "lock step" as atmospheric proxy data records from Lake Vostok ice cores so elegantly demonstrate (See Fig. 4).

The way climate has changed over the 20th century is consistent with what we would expect as a result of increases in greenhouse gases and aerosols (See Fig. 5).

Overall, there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities (See Table 2).

Earth's climate, has, in average terms, been relatively stable over the entire period of the last 5,000-6,000 years -generally considered as the period