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Are observed changes in the concentration of carbon dioxide in the atmosphere really dangerous?

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Abstract

Statements made by the United Nations Intergovernmental Panel on Climate Change (IPCC) have been used to put pressure on governments to formulate policies in response to the perceived threat of the climate change resulting from a build up of greenhouse gases in the atmosphere. The Kyoto Protocol proposed by the United Nations calls for industrialized countries to cut greenhouse gas emissions by five percent from 1990 levels by the year 2012. The enormity of the perceived economic consequences of this has led to intense arguments between governments over the appropriateness of reduction targets. But the real reason behind the failure to agree on a global climate treaty is disagreement on tradeoffs between the economic and environmental risks involved.

Contrary to the IPCC predictions, global temperature has not risen appreciably in the last 20 years. Most surface temperature data free from the influence of surrounding buildings and roads show no warming. Data from satellites support this. Sea level has been rising since the end of the last ice age, long before industrialization, but historical records show no acceleration in sea level rise in the twentieth century. Increases in carbon dioxide appear to pose no immediate danger to the planet. The gas is not a pollutant.

An understanding of global warming hinges on the answers to certain key questions. Is global climate warming? If so, what part of that warming is due to human activities? How good is the evidence? What are the risks? The task of answering these questions is hindered by widespread confusion regarding key facets of global warming science. The confusion has given rise to several fallacies or misconceptions. These myths and misconceptions, and how they relate to the above questions, are explained. Although the future state of global climate is uncertain, there is no reason to believe that catastrophic change is underway. The atmosphere may warm due to human activity, but if it does, the expected change is unlikely to be much more than 1 degree Celsius in the next 100 years. Even the climate models promoted by the IPCC do not suggest that catastrophic change is occurring. They suggest that increases in greenhouse gases are likely to give rise to a warmer and wetter climate in most places; in particular, warmer nights and warmer winters. Generally, higher latitudes would warm more than lower latitudes. This means milder winters and, coupled with increased atmospheric carbon dioxide, it means a more robust biosphere with greater availability of forest, crops and vegetative ground cover. This is hardly a major threat. A more likely threat is policies that endanger economic progress. The negative effect of such policies would be far greater than any change caused by global warming. Rather than try to reduce innocuous carbon dioxide emissions, we would do better to focus on air pollution, especially those aspects that are known to damage human health.

Résumé

Des affirmations alarmistes provenant d'un synopsis de l'Intergovernmental Panel on Climate Change (IPCC), destiné aux décideurs politiques, et les communiqués de presse de l'IPCC, ont mis une pression énorme sur les gouvernements, afin d'élaborer des procédures en réponse à la menace perçue du changement climatique résultant d'une augmentation des gaz à effet de serre répandus dans l'atmosphère. Le Protocole de Kyoto, proposé par les Nations Unies, fait appel aux pays de l'OCDE afin qu'ils diminuent de 5% le niveau des émissions de gaz à effet de serre relevés en 1990 d'ici l'année 2012. Compte tenu de l'énormité des conséquences économiques provenant de cette diminution, des discussions très vives ont lieu entre les gouvernements sur l'opportunité des réductions visées. Mais la raison véritable se cachant derrière l'échec d'une politique d'entente sur un traité de climat mondial, porte sur les compromis entre les risques économiques et environnementaux impliqués.

De nombreux scientifiques, qui ont soutenu initialement le réchauffement de la planète, ne sont plus si convaincus. L'une de ces raisons réside dans le fait que la température de la planète n'a pas augmenté de manière appréciable depuis les 20 dernières années, comme l'avait prédit l'IPCC. La plupart des données de températures en surface, sans être influencées par les batiments et les routes, ne révèlent aucun réchauffement. Les données provenant des satellites le confirment. Le niveau de la mer a augmenté depuis la fin de la dernière période glacière bien avant l'industrialisation, mais des rapports historiques ne montrent aucune accélération sur l'augmentation du niveau de la mer au vingtième siècle. L'IPCC et Kyoto nous ont amenés à brandir les armes. L'accroissement en dioxyde de carbone ne semble pas poser de danger immédiat pour la planète. Le gaz n'est même pas un polluant.

La compréhension du réchauffement mondial dépend des réponses à certaines questions-clés. La première repose sur le rôle que les humains jouent dans le cycle du carbone au niveau planétaire. Les questions qui demeurent, portent principalement sur ces conséquences potentielles. La planète se réchauffe-t-elle? Si tel est le cas, quelle part de ce réchauffement provient des activités humaines? Quel est le bien fondé de cette évidence? Quels sont les risques? La tâche de trouver les réponses à ces questions est entravée par la confusion de l'opinion répandue sur les aspects-clés de la science du réchauffement mondial. Cette confusion a répandu de nombreuses erreurs et de méprises. Ces mythes, ces malentendus, et les manières dont ils sont reliés aux questions ci-dessus sont expliquées. Il y a de bonnes raisons de croire qu'il n'est plus nécessaire que les scientifiques continuent à prétendre que les changements observés dans la concentration des gaz à effet de serre dans l'atmosphère, sont dangereux. Plutôt que d'essayer de réduire de manière drastique les émissions de dioxyde de carbone, nous devrions axer notre attention sur la pollution de l'air, particulièrement sur ses aspects reconnus pour être nocifs au bien être humain, tels que les matières à particules, les oxydes d'azote, les monoxydes de carbone et les hydrocarbures.

Traduit par Gabrielle Drivet

Introduction

The global warming issue is as emotionally charged as it is widely misunderstood. Calls for action have put enormous pressure on governments to formulate policies in response to the perceived threat of the human-caused climate change resulting from a build up of greenhouse gases in the atmosphere. The Kyoto Protocol proposed by the United Nations in 1997 calls for OECD countries and former USSR to cut greenhouse gas emissions by 5% from 1990 levels by the year 2012. Despite the political momentum this has generated, there is widespread reluctance to sign on to an international treaty. The main problem is that emission rates are increasing and, given current trends, would be up to 20–30% higher than 1990 levels by 2012. Thus, to meet the requirements of the Kyoto Protocol, many of the industrialized nations of the world must give up one third of their energy use, or find some other way of meeting their commitment. A decrease of this magnitude can only be achieved by severe rationing of oil, coal and natural gas. Because the economic implications — in higher prices for transportation and energy used by industry and households, and for manufacturing — would be immense, the question arises as to whether these harsh measures are justifiable.

Confusion about the global warming science is another reason why progress towards ratifying an international agreement has been slow. This is caused by uncertainty surrounding the science of global warming on the one hand, and public perception of the state of this scientific knowledge on the other. This confusion underlies problems confronting decision makers on how and when to act on greenhouse warming. The Kyoto Protocol aims to implement the United Nations Framework Convention on Climate Change set out in 1992. The global warming science has come a long way since then. The question now arises: Is it still reasonable for scientists to continue to claim that observed changes in concentration of greenhouse gases in the atmosphere are dangerous?

Public perception and factors affecting this perception

There is probably no environmental issue that is as misunderstood as that of global warming. It is now common practice to teach in schools and universities that carbon dioxide is a pollutant that is dramatically warming the Earth's climate with dire consequences such as rising sea levels and severe weather changes. We are lead to believe that the evidence is all around us. The occurrence of cold spells, heat waves, floods, droughts, and increased frequency of storms are often cited as proof of global warming. Global warming has become the scapegoat for climate variability and for prophesies of future catastrophe (de Freitas, 1991, 1994).

Why should this particular view prevail? It is likely the result of a combination of a number of things. First, it fits well with the popular concern for the environment and widespread zeal for environmentalism. The media prefer worse case scenarios, and no matter how outrageous the tale, it becomes the truth if it is told often enough. The view that global warming is both real and dangerous is now deeply entrenched in the minds of the public. Many are reluctant to challenge this, as it is politically incorrect to do so. It would be taken to imply a lack a concern for the environment. Second, politicians are drawn to the topic of global warming by the appeal of tackling something grand — a global environmental issue, as opposed to merely a local one. There is also the allure of the green vote. Believing in global warming is a litmus test for being environmentally conscientious and hence ethically and politically correct. Third, scientists are in effect reinforcing the view by alarmist speculation to propel public concern about possible dangers of man-made climate change. Heightened concern improves chances of high priority being given to climate change research and ensures an ongoing supply of research funds. Fourth, the issue is confused with the separate matter of conservation of fossil fuels and air quality. The fifth reason is perhaps the most important as it underpins all the others. It is the disproportionate influence of the reports of the United Nations Intergovernmental Panel on Climate Change (IPCC).

The role and impact of the IPCC

The IPCC was established by the World Meteorological Organisation (WMO) and the United Nations Environmental Programme (UNEP) in 1988 to: a) assess available scientific information on climate change, b) assess the environmental and socio-economic impacts of climate change, and c) formulate response strategies. The usefulness of the second and third objectives depends heavily on the conclusions from the first, which makes this the focus of the IPCC's work.

The first IPCC report (FAR) was published in 1990 (Houghton et al., 1990), the second (SAR) in 1996 (Houghton et al., 1996) and the third (TAR) in 2001 (IPCC, 2001a, 2001b). Each report consists of reviews of scientific work on climate, divided into chapters. Each chapter has several lead authors, plus a number of contributors. The TAR Scientific Report (IPCC, 2001a) has, for each chapter, Coordinating Lead Authors, Lead Authors, Contributing Authors, and sometimes Key Contributing Authors and Review Editors. There is an Executive Summary for each chapter. There is also a Policymakers Summary and a Technical Summary for the whole Report. In addition to the three major IPCC Scientific Reports there was a 1992 Supplementary Report often referred to as "Climate Change 92" (Houghton et al., 1992), and "Climate Change 1994; Radiative Forcing of Climate Change, and An Evaluation of the IPCC IS92 Emissions Scenarios" (Houghton et al., 1994).

In compiling each major IPCC Report (FAR, SAR, and TAR), three drafts were produced, which were circulated to "expert reviewers" throughout the world for comment. The TAR had 15 review editors, 124 authors and 397 expert reviewers. It is important to note, however, that comments that were not welcomed by the main authors stood little chance of being considered seriously. A commentary on this by editors of the FAR (Houghton et al., 1990) state: "Whilst every attempt was made by the lead authors to incorporate their comments, in some cases these formed a minority opinion which could not be reconciled with the larger consensus."

The dense 300–400 page IPCC Scientific Assessment Reports are generally good compilations of global warming science. But only experts read them. The UN IPCC's voice to the public, press and policy makers regarding climate science is through summaries; in particular, the brief, politically approved "Summaries for Policymakers" (SPM), which have become notorious for their bias, tendency to overstate problems and penchant for simplifying and dramatizing scientific speculation. A classic example is the claim in the 1996 IPCC SPM (Houghton et al., 1996, p. 4): "the balance of evidence suggest that there is a discernible human influence on global climate." The so called "evidence" cited in Chapter 8 of the main report was based on one paper that at the time had not been published in the refereed scientific literature. Moreover, one of the authors of this paper was also the convening lead author of the Chapter 8 that supported the "human influence" claim. A hearing in August 1998 on the subject of global warming before the U.S. House Committee on Small Business, chaired by Republican James Talent, publicized the fact that the 1996 IPCC scientific report (Houghton et al., 1996) was altered to convey the misleading impression to the public that there is a "discernible human influence on global climate" which will lead to catastrophic warming. The background to this is as follows.

The "discernible influence" statement of the IPCC's 1996 report (Houghton et al., 1996) was based on what are called "fingerprinting" studies. A fingerprint study is one in which a geographical pattern of observed climate changes are compared with the patterns of climate changes predicted by numerical simulations of global climate called general circulation models (GCMs). The idea is that by finding a pattern in the observed data that matches the predicted data, a causal connection can be claimed. Following publication of the 1996 IPCC scientific report, and in the wake of mounting criticism of the "discernible influence" claim, a paper by Santer et al. (1996) was published that endeavoured to defend the claim. Subsequently, the results of a re-analysis of the data used in this work were published in an article by Michaels and Knappenberger (1996). It showed that the research on which the IPCC "discernible influence" statement is based had used only a portion of the available atmospheric temperature data. When the full data set was used, the previously identified warming trend disappeared. In light of the widespread use of the "discernible influence" statement to imply that there is proof of global warming, the matter was of great concern (Fig. 1). Not surprisingly, this damaged the credibility of the IPCC.

Neither is the Summary for Policymakers of IPCC 2001 (IPCC, 2001b) a balanced representation of what is contained in the detailed scientific assessment report of IPCC Working Group I (WGI). General "conclusions" are highlighted in the SPM that distorts the actual climate information. For example, the SPM (IPCC, 2001b, p. 10) states: "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." It will be demonstrated later in this review that a) detailed satellite data show that no warming has been observed, b) the combined surface weather station data actually show cooling between 1940 and 1975, and c) data from good quality "de-urbanized" surface stations from around the world show no recent warming trends.

Another "conclusion" of the SPM (IPCC, 2001b, p. 10) is: "Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gases." But no evidence is presented anywhere that warming is "likely" to have been due to "greenhouse gases'. "Likely" is defined as between 66% and 90% chance, but no probability assessment has been carried out. The statement cannot, therefore, claim that there is actual evidence that the "warming over the last 50 years is likely to have been due to the increase in greenhouse gases." These and other statements made show the SPM (IPCC, 2001b) to be either slanted or misleading. It summarizes the main scientific report selectively in order to claim evidence for a human-caused climate warming.

A true conclusion of "Climate Change 2001", possibly supported by the majority of the scientists involved in the main scientific report, is in Chapter 1 of the IPCC 2001 scientific report itself (IPCC, 2001a, p.97). It reads as follows:

> The fact that the global mean temperature has increased since the late 19th Century and that other trends have been observed does not necessarily mean that an anthropogenic effect on the climate system has been identified. Climate has always varied on all time-scales, so the observed change may be natural.

From the above account it appears that the "Summary for Policymakers" is in large part a political document influenced by majority political policies.

Richard Lindzen, lead author of Chapter 7 of the main IPCC scientific report (IPCC, 2001a), has stated that the IPCC use the SPM to misrepresent what scientists say (Lindzen, 2001, p. 18).

> The full IPCC report is an admirable description of research activities in climate science, but it is not specifically directed at policy. The "Summary for Policymakers" is, but it is also a very different document. It represents a consensus of government representatives (many of whom are also their nations' Kyoto representatives), rather than of scientists. The resulting document has a strong tendency to disguise uncertainty, and conjures up some scary scenarios for which there is no evidence.

The process used for producing the SPMs has also been criticized. According to Martin Manning (2001, p.3), who until 2002 was IPCC Vice-Chair of IPCC Working Group II on Impacts, and currently is IPCC Vice-Chair of IPCC Working Group I on the Science of Climate Change:

> The process used to produce the SPM is far from ideal and may be distorting the real messages from the available science. Some government delegates influencing the SPM do not understand the methodologies being used and misinterpret or contradict the lead authors. This may need to be addressed in future through tighter rules of procedure.

By failing to convey a balanced interpretation of the science presented in the detailed reports, the SPMs, along with the IPCC press releases, have become a tool to drive public hysteria. Reinforced by the "official" status given to them, the result has been a distortion of the public's perception of scientific findings.

It may seem a paradox but the IPCC process requires that all the hundreds of participating governments' representatives agree to the text of IPCC summary reports. A statement is rejected from SPMs if only one government objects to it. This results in final reports that are not true representation of the science as a whole. Most participating governments (e.g. all Annex III countries) have pecuniary interest in supporting the United Nations Framework Convention on Climate Change (UNFCCC) objectives (i.e. The 1992 "Rio Treaty"), and the inevitable result is biased Summary reports. This does not imply dishonesty. Exclusion of information can cause more bias than adding information.

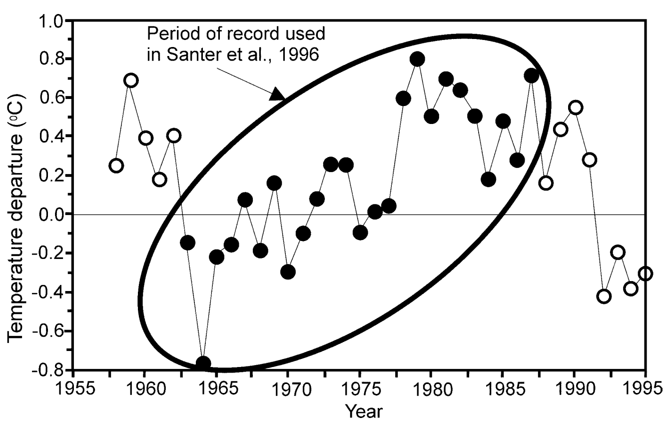

Fig. 1. A critical assessment by Michaels and Knappenburger (1996) of the work of Santer et al. (1996) that set out to provide evidence of a warming from 1963 to 1987 (circled) indicative of a global trend. Michaels and Knappenberger (1996) showed that this research, on which the IPCC "discernible human influence on global climate " statement is based, had used only a portion of the available atmospheric temperature data. When the full data set was used, the previously identified warming trend disappeared (from Michaels and Balling, 2000, p. 98).

Myths and misconceptions surrounding key questions

The scientific debate surrounding global warming hinges on the answers to certain key questions. The first centres on what role humans play in the global carbon cycle. The remaining questions focus on the possible consequences of this. Is global climate warming? If it is, what part of that warming is due to human activities? How good is the evidence? What are the risks? The task of finding answers to these questions is hindered by widespread confusion regarding key facets of global warming science. The confusion has given rise to several fallacies or misconceptions. These myths and misconceptions and the ways they relate to the above questions are the focus of this paper.

Fallacy One: Carbon dioxide in the atmosphere is increasing at alarming rates.

Each year, human activity — primarily the use of coal, oil, natural gas and production of cement — emits about 6.5 Gt of carbon into the atmosphere. Despite this, the annual rate of increase of CO_2 in the atmosphere is highly variable, falling close to zero in some years (for example, in 1992) and declining in others (for example, in 1998). In general, data show that human-caused CO_2 is levelling off, despite increased emissions (Figs. 2, 3). This is believed to be the result of natural stabilizing feedbacks. Carbon dioxide is food for plants. The more there is, the more they use. There are countless studies that show the effect of an increased concentration of CO_2 in the atmosphere is to increase the growth rates of most plants (Soon et al., 1999). This is especially so in trees but also in grasses (Daepp et al., 2001; Edwards et al., 2001; Lilley et al., 2001a, 2001b; Craine and Reich, 2001; Lee et al., 2001; Reich et al., 2001; Nowak et al., 2001). The results show that elevated CO_2 will produce enhanced growth rates with a higher photosynthesis level and greater water-use efficiency generally, and an increase in leaf longevity for grasses. An additional factor is that plants that need the boost most respond best. Not only do plants generally provide a substantial sink for atmospheric CO_2, but plants under stress from less-than-ideal conditions — a common occurrence in nature — respond more to CO_2 fertilization (Fig. 4).

The significance of all this is that as CO_2 concentration in the atmosphere rises, plants respond positively by providing an increasing sink for atmospheric CO_2. Assuming a doubling of CO_2 release as compared to current emissions, it has been estimated that atmospheric CO_2 levels will rise by about 300 ppm before leveling off (Idso, 1991a). At that level, CO_2 absorption by increased terrestrial biomass may be able to absorb about 10 Gt of carbon per year (Soon et al., 1999). This is over three times the current net annual increase in atmospheric CO_2 from world fossil fuel combustion. These studies indicate that we are anticipating larger CO_2 concentrations in future than will actually occur.

It is noteworthy that each subsequent IPCC report produces new and more numerous greenhouse gas scenarios without explaining what went wrong with the earlier ones. Hansen (2002, p. 437) has commented on this and the general decline in the growth rate of CO_2 (fossil fuel) emissions: "It is noteworthy that the current IPCC (2001) scenarios have a growth rate in the 1990s that is almost double the observed rate … but it is consistent with their failure to emphasize data."

In summary, interaction between sinks and sources of CO_2 are complex and not well understood. Human emissions of CO_2 are a small proportion of natural emissions. The IPCC's argument is that the relatively tiny anthropogenic emissions tip the natural balance and cause a dangerous change in global climate. This neglects the fact that anthropogenic emissions are so small that their role could also be small and get lost in the statistical discrepancy of the measurement of either the natural sources or the natural absorption of CO_2. Moreover, the ocean and biosphere sinks of CO_2 are vast and known to be influenced by a variety of factors that could easily offset anthropogenic emissions.

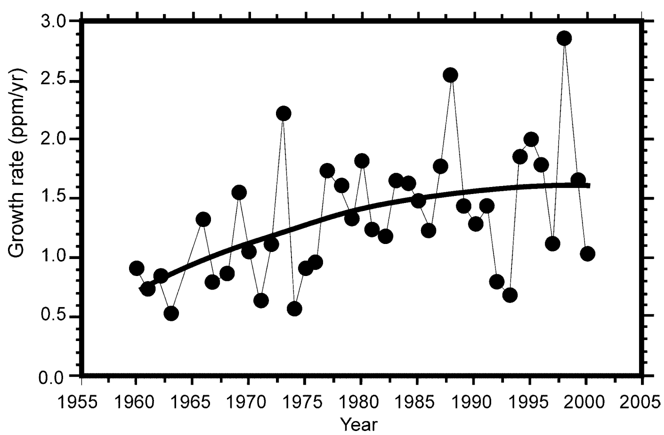

Fig. 2. Trend in growth rates of atmospheric concentrations of carbon dioxide from 1960 to 2000 showing the levelling off in recent times (from World Climate Report, 2001b).

FALLACY TWO: HUMANS ARE BIG PLAYERS IN THE GLOBAL CARBON CYCLE.

Carbon dioxide emissions caused by human use of fossil fuels are small compared to the natural carbon exchange between the atmosphere on the one hand and the terrestrial system and oceans on the other. Anthropogenic CO_2 emissions are only about 3% of the natural carbon cycle and less than 1% of the atmospheric reservoir of carbon of 750 Gt. The vast majority of CO_2 fluxes are natural. The magnitude of the natural reservoirs of carbon between ocean, atmosphere and land and the rates of exchange between them are so large that the role of

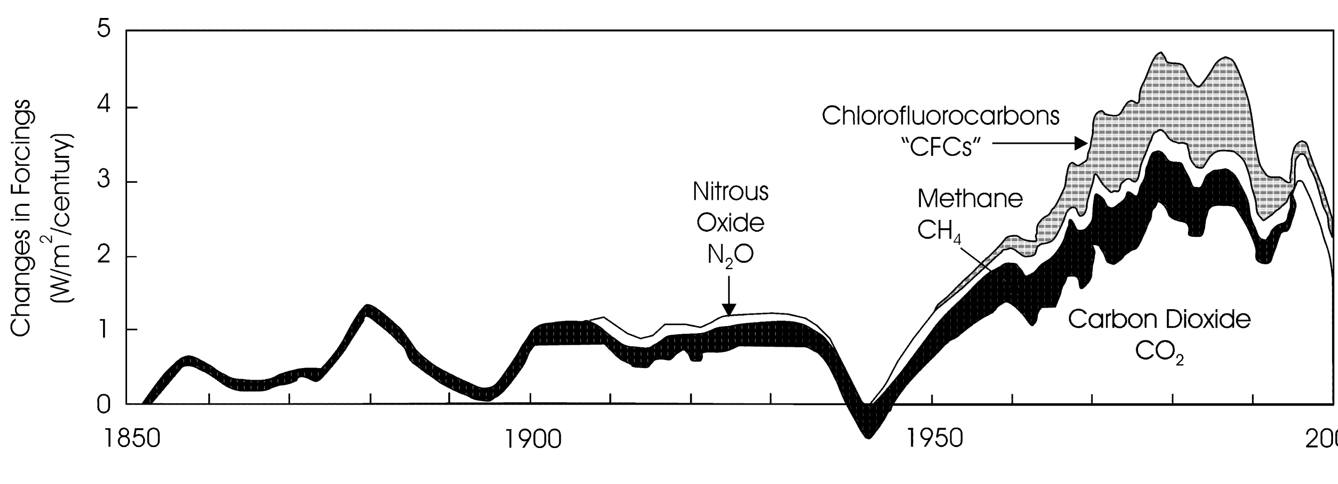

Fig. 3. Growth rates of greenhouse gas forcing showing stabilization of gases, especially carbon dioxide (CO_2) and methane (CH_4) (from Hansen and Sato, 2001).

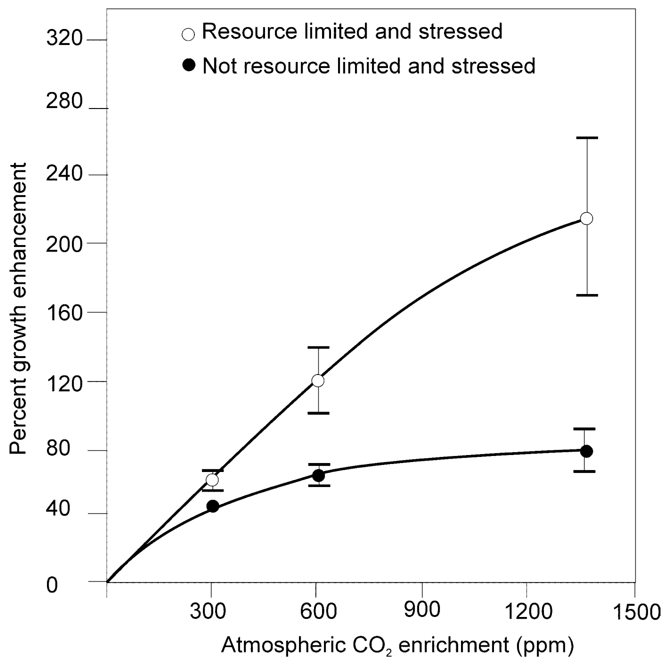

Fig. 4. Summary data from 279 published experiments in which plants of all types were grown under paired stressed and unstressed conditions (Idso & Idso, 1994). Soon et al. (1999, p. 158) explain that "the plant mixture in the 279 studies was slightly biased toward plant types that respond less to CO_2 fertilization than does the actual global mixture and therefore underestimates the expected global response. CO_2 enrichment also allows plants to grow in drier regions, further increasing the expected global response." Source: Soon et al. (1999).

humans in the natural carbon budget is unclear. So great are the difficulties quantifying the natural carbon budget and the uncertainties with which the numbers are estimated that the source of recent rise in atmospheric CO_2 has not been determined with certainty (Keeling et al., 1996; Tans et al., 1990; Adger and Brown, 1995). The fact is that there are no reliable models relating CO_2 emissions to atmospheric concentrations because it is not clear how the two are related.

Atmospheric CO_2 concentrations have varied widely over geologic time, but we are unable to fully explain why. The atmosphere is a result of outgassing of the Earth, and this outgassing was largely accomplished as volcanic activity. The rates of outgassing, however, are highly irregular. Mt. Etna, for example, has emitted well over 25 millions tons of CO_2 into the atmosphere in one year (Gerlach, 1991a; Allard et al., 1991). This equals the output of four 1,000 MW coal-fired power stations. Caldeira and Rampino (1992) have claimed that recent eruptions of Mt. Etna could affect global climate. Geothermal activity at Yellowstone National Park currently emits 10 times the CO_2 of a typical mid-sized coal-fired power plant. The mid-ocean-ridge volcanic system emits 65 million tons of CO_2 annually (Gerlach, 1991a, 1991b).

There are many other factors that influence atmospheric CO_2 concentrations that are not well understood. For example, the current increase in atmospheric CO_2 follows a 300-year warming trend, during which temperatures have been recovering from the global cool period known as the Little Ice Age (Lamb, 1982). The observed increases in CO_2 are of a magnitude that can, for example, be explained by oceans giving off gases naturally as temperatures rise (Dettinger and Ghil, 1998; Segalstad, 1998).

It is known that the equatorial oceans are the dominant oceanic source of atmospheric CO_2. The net flow per year amounts to 0.7 to 1.5 Gt of carbon — about what is emitted in the United States — of which up to 72% emanates from the equatorial Pacific Ocean. The Southern Ocean is modeled as both a source and sink of as much as 1 Gt of carbon per year. Owing to changes in sea surface temperature during the 1991 to 1994 El Niño period, the annual flow of CO_2 was 30 to 80% of normal (Feebly et al., 1999). This has a significant effect on global CO_2 concentrations in the atmosphere.

Fallacy Three: There is a close relationship between changes in atmospheric carbon dioxide and global temperature.

Recent trends in global air temperature are not well correlated with changes in CO_2 concentration in the atmosphere. According to the IPCC, air temperature measurements taken at the surface of the Earth show that the average temperature of the globe has increased by about 0.6 °C over the past century. Most of this rise occurred before 1940 (Fig. 5), but over 80% of the CO_2 entered the atmosphere after 1940. In fact, from the late 1930s to the late 1970s the Earth's atmosphere cooled despite increasing levels of CO_2.

A close association between paleo-temperatures and past CO_2 concentrations has long been used to support global warming predictions. But recent research has challenged this as, for example, in the work of Pearson and Palmer (1999, 2000) and Rothman (2002). CO_2 levels were about five times greater some 200 million years ago than present values. Pearson and Palmer (1999) show that the global cooling since the Eocene was not primarily due to decreases in CO_2 levels, but to changes of ocean circulation resulting from the tectonic opening and closing of oceanic gateways as continents move around.

Atmospheric CO_2 concentration and mean global temperature correlate and cohere such that the CO_2 follows the temperature (both up and down) by some months. This was first observed by Kuo et al. (1990) who did a frequency analysis for the period 1950 to 1990, and has been confirmed by other workers using different data sets (Priem, 1997; Dettinger and Ghil, 1998; Fischer et al., 1999, Indermühle et al., 1999). In other work, reanalysis of the famous Vostok ice core shows CO_2 increases lagging about 600 years behind the temperature increases of the three significant deglaciations (Fischer et al, 1999). Clearly, high CO_2 levels are not the primary cause of temperature rises signaling the end of an ice age. Other research on geological timescales also shows that sometimes temperatures were high when CO_2 concentrations were low, and vice versa (Indermühle et al., 1999, Panagi et al., 1999; Flower, 1999).

More recently, Monnin et al. (2001) examined a record of atmospheric CO_2 and proxy air temperature data obtained from an ice core drilled at Dome Concordia, Antarctica for the period between 22,000 and 9,000 years before the present. This period covers the transition from the glacial to interglacial climate conditions. The authors express confidence that their record "is an accurate representation of the atmospheric CO_2 concentrations." Close examination of the rise in temperature and atmospheric CO_2 concentration at the end of the last glacial maximum revealed that the increase in temperature took place 17,800 ±300 years ago, while the increase in the CO_2 took place 17,000 ± 200 years ago. The researchers conclude "the start of the CO_2 increase thus lagged the start of the [temperature] increase by 800 ±600 years." (Monnin et al., 2001, p. 113)

Veizer et al. (2000) developed a new reconstruction of tropical sea surface temperatures throughout the Phanerozoic era, which covers a little over half of the past one billion years of Earth's history. This climate reconstruction — which was derived from data obtained from the calcite and aragonite shells of tropical marine fossils using oxygen isotope (delta^{18}O) data — was found to be well correlated with climate variations inferred from other indicators of past climate. This allowed Veizer et al. (2000) to fill in gaps that had existed in the older climate data. However, when the now improved temperature history was compared with temperatures derived from a climate model driven by atmospheric CO_2 concentrations obtained from proxy indicators of CO_2, the model failed to reproduce estimated temperatures. According to Veizer et al. (2000, p. 700) "the simulations based on [the] climate model yield[ed] temperatures that are in serious disagreement with the delta^{18}O-scaled tropical temperatures." The CO_2-driven climate model over-predicted the reconstructed temperatures by as much as 7°C, which is equivalent to predicting a warm interglacial when the earth is actually in the midst of an ice age. The results of these studies do not support the notion that CO_2 is the all-important driver of climate change that some have made it out to be.

Fallacy Four: Global temperature has increased over the past two decades.

The IPCC rely on air temperatures measured at the Earth's surface to reconstruct variations in the Earth's annual mean temperature over the past century. The three authorities that have taken responsibility for the combined surface record are the Climate Research Unit (CRU) of The University of East Anglia (UEA), NASA's Goddard Institute for Space Studies (GISS) and The Global Historical Climate Network (GHCN) run by the United States National Oceanographic and Atmospheric Administration (NOAA). The data come from weather stations unevenly distributed over the Earth's surface, mainly on land, close to towns and cities (Fig. 6). These data show a warming in the range 0.3–0.6 °C over the past century (Fig. 5). The question is whether all or part of this warming can be linked to increases in greenhouse gases or to other factors linked to climate variability and change. For example, the warming may simply reflect the additional heat associated with the growth of towns and cities, or from solar variability or changes in atmospheric transmissivity from volcanic dust or other sources of atmospheric aerosols, natural or anthropogenic.

The science of climate change depends entirely on reliable data, quality controlled and homogenized rigorously, to validate numerical simulation models and to identify fluctuations and trends. Until recently, measurements of global air temperature change were based entirely on measurements taken on the ground. Modification of the surface by human activity can have a significant effect on climate near the ground. The

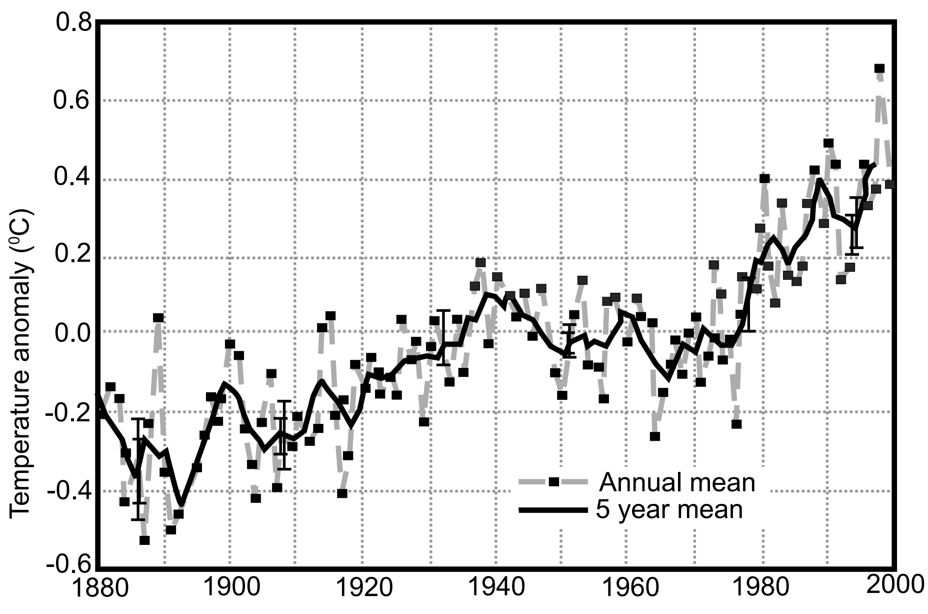

Fig. 5. GISS global annual-mean surface air temperature change derived from the meteorological station network. Uncertainty bars (95% confidence limits) shown for both the annual and 5-year mean. Average temperature of the globe has increased by about 0.6 oC over the past century and most of this rise occurred before 1940.

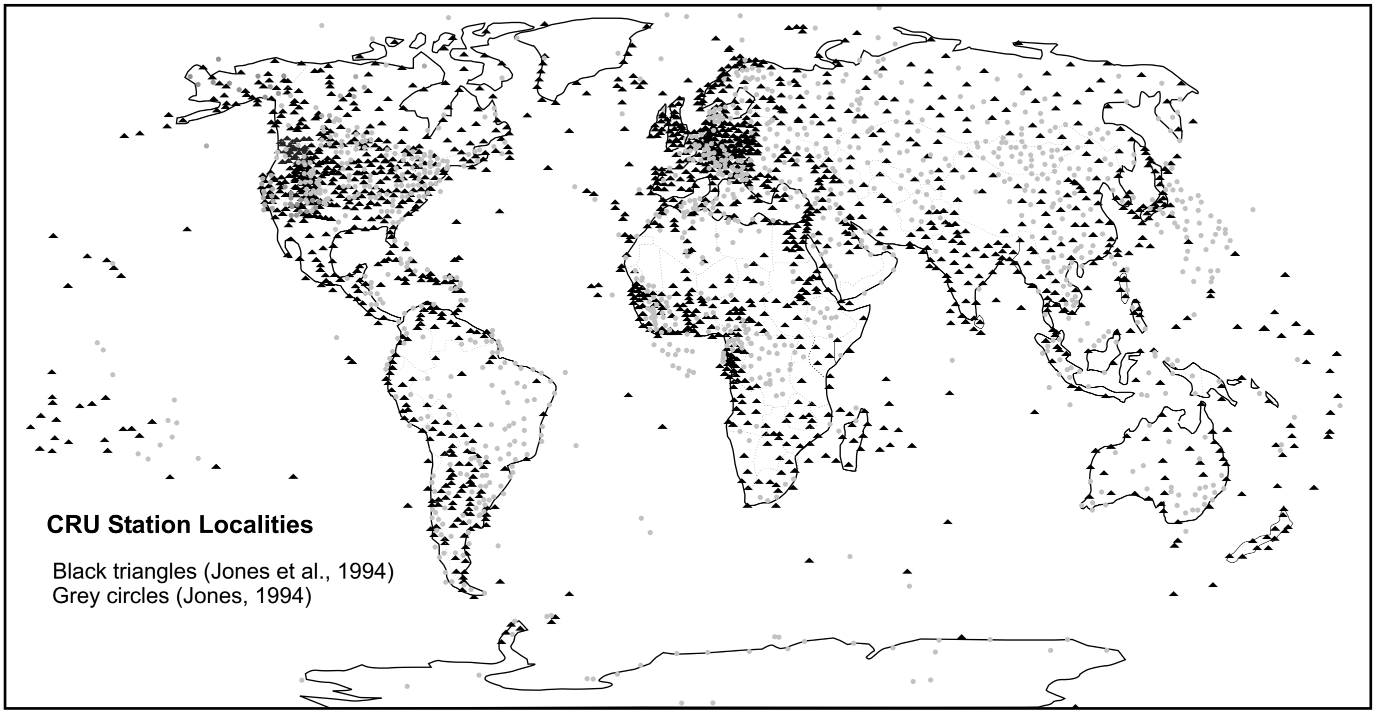

Fig. 6. Location of climate stations that make up the Jones (CRU) surface data used by IPCC.

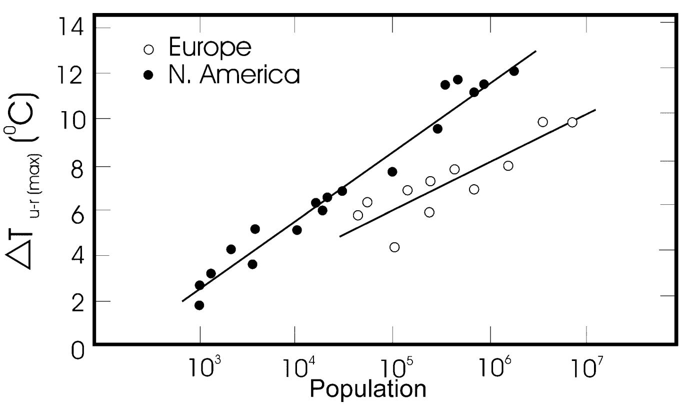

Fig. 7. Relationship between urban population size and maximum urban heating effect in North America and Europe (after Oke, 1987).

best-documented example is the "urban heat island" effect, in which data from urban stations can be influenced by localized warming due to asphalt and concrete replacing grass and trees (Fig. 7). This can account for an urban area being as much as 14 °C warmer than its rural surroundings. The trends in Figure 8 for Phoenix, Arizona, also illustrate the close correlation of city population size with urban heating influence on air temperature.

The IPCC claim that the land-based, surface temperature record it uses is a "de-urbanised" record, but it has been discovered that there is more contamination of the surface temperature record than many climatologists realised (Hansen et al., 1999; Hansen et al., 2001). Hansen et al. (2001, p. 23, 962) comment on NASA's official GISS data: "We find evidence of local human effects (urban warming) even in suburban and small town surface air temperature records." Moreover, rural stations account for only 7% of the Earth's area (Peterson et al., 1999). Balling and Idso (1989) have demonstrated that only very small changes in population are enough to induce a statistically significant local warming. Changnon (1999) used high quality data from central Illinois to evaluate the magnitude of unsuspected heat island effects that may be present in small towns that are typically assumed by the IPCC to be free of urban-induced warming. According to Changnon (1999, p. 535), "both sets of surface air temperature data for Illinois [i.e. small towns with populations less than 2,000 and 6,000, respectively] believed to have the best data quality with little or no urban effects may contain urban influences causing increases of 0.2°C from 1901 to 1950." He warns "this could be significant because the IPCC (1995) indicated that the global mean temperature increased 0.3 °C from 1890 to 1950."

Despite the questionable nature of the surface temperature record as measured by weather stations, IPCC (2001a) only occasionally refers to other methods of global temperature measurement. The fact that satellite and weather balloon measurements of the lower troposphere show little warming for the past 23 years (see Fallacy Five below) strongly suggests that the surface data are influenced by proximity to human habitation, especially concrete and asphalt, rather than by greenhouse warming. Evidence of this is reflected in the fact that many remote weather stations do not show a warming. Where warming occurs it results from a rise in the minimum temperature rather than the maximum, and in cold climates, in winter, and at night, which is consistent with so called "urbanization" effects. Many weather stations are located at airports, which originally were located in rural areas on the outskirts of urban areas. But with rapid population growth airports have made a transition from "rural" to "heat island", and the national agencies responsible for archiving climate data do not take any precautions against these influences. The problem has been made worse by the fact that two thirds of the weather stations operating in 1975, mainly rural, have been closed down.

Many scientific studies have identified urbanization effects on climate stations, but these have been underestimated, because so called rural stations are assumed to be free of such effects. Also, with time, vegetation growing around stations usually increases, but is rarely reduced. This has a pronounced warming effect. Compilers of surface temperature data sets used so far by the IPCC make inadequate corrections for these and other warming effects. An influence from emissions of greenhouse gases is yet to be established.

Christy (2002) has looked specifically at rural stations in the United States, which were thought to be more reliable than urban stations. His work confirms that data from rural stations can also have many problems and should not be treated as continuous records for climate work. There are other equally persuasive studies that show that the global surface temperature record is contaminated, such as those by Goodridge (1992, 1996) and Christy and Goodridge (1995), the results of which are summarised in Figure 9.

Uneven spatial sampling also contaminates the global surface temperature record. Most climate stations are in the northern hemisphere, in mid-latitude locations and on land (Fig. 6). The problem of the poor spatial coverage is even worse during the early part of the record, particularly in the Southern Hemisphere and Pacific Ocean generally. This further reduces the quality of the record.

Even allowing for the inadequacies of the surface temperature record, there has been no warming globally in tropical and polar regions, and southern temperate regions have cooled slightly. If there is any greenhouse effect surface warming, it appears largely confined to the very cold and very dry high-pressure cells of winter in Siberia and Alaska/Yukon (Michaels et al., 2000). In these harsh regions, winter temperatures remain far below freezing; consequently, the main impact of this regional and seasonal warming is a slightly extended growing-season.

IPCC surface data show temperature inching upwards on a global scale of about 0.005 to 0.01 °C per year, but this rate is exceeded by its standard error. In other words, it is indistinguishable from zero. Moreover, trends and temperature differences justified to one or two decimal places and significant figures are unreliable since the amounts are greater than the accuracy of the data allows, and multiple averaging of measurements do not make it more reliable.

Fallacy Five: Satellite data support IPCC claims on observed and projected global warming.

In order to validate numerical models that attempt to simulate global climate, the science of climate change depends on the availability of a reliable dataset, quality controlled and

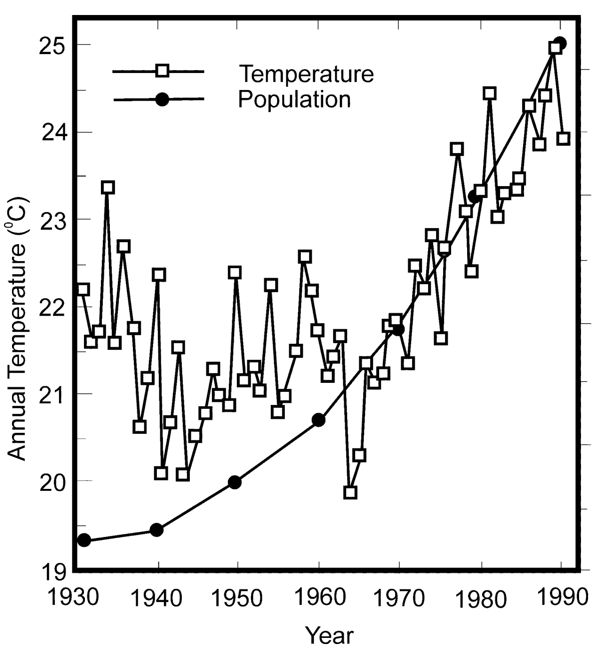

Fig. 8. Mean annual air temperature in Phoenix, Arizona, from 1931 to 1990 and population for the Phoenix metropolitan area. Source: Balling, 1992.

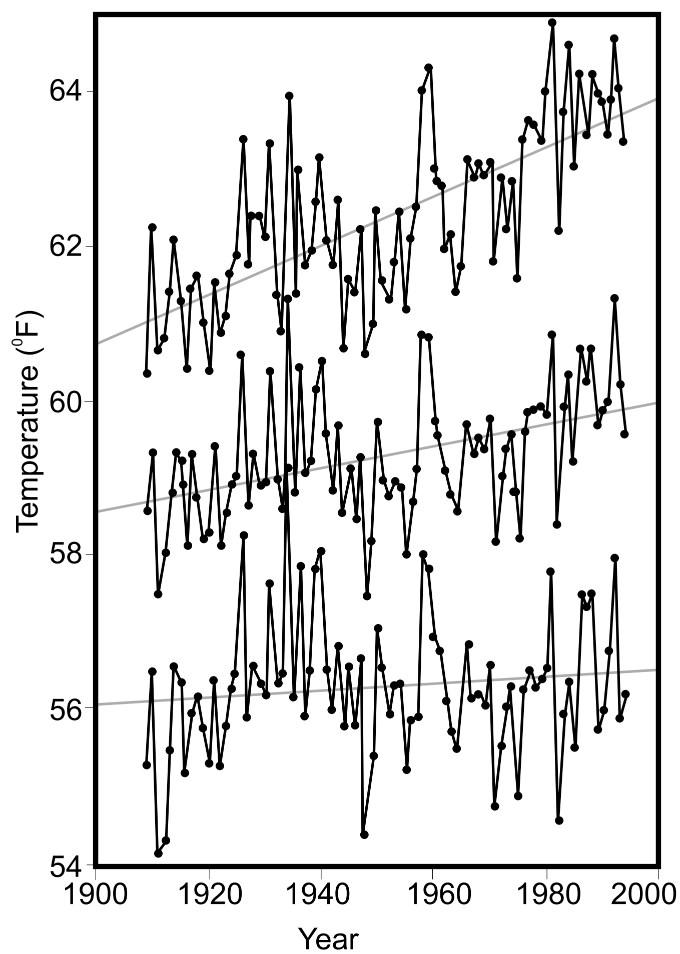

Fig. 9. Average annual air temperatures at 93 California climate stations from 1947 to 1993 stratified by 1990 county population: over 1 million (top); between 1 million and 100,000 (middle); and less than 100,000 (bottom). Source: Goodridge, 1996.

spatially representative of the globe. The IPCC temperature record for the globe is based on thermometers on the ground, usually on the land and in growing urban areas; a system which is not accurate enough to detect changes as small as 0.1 °C.

Since 1979 temperature measurements of the lower troposphere have been made by Tiros-N satellites using microwave radiometry (Microwave Sounding Units - MSU). These are the only precision measurements of global temperature available for direct comparison with temperature predictions from GCMs. The satellites cover the whole earth, measuring and averaging the temperature of the lower troposphere. This is the same region modelled by the GCMs. The accuracy of the radiometer measurements is 0.1 °C, which is considerably better than the accuracy of thermometer measurements made on the surface of the earth.

The satellite (MSU) temperature data set is the only one that is truly global, highly accurate, and uses a completely homogeneous measurement over the entire planet (Spencer and Christy, 1992; Christy and Goodridge, 1995). It also measures the part of the lower atmosphere that, according to the climate models, should be experiencing the greatest warming due to the enhanced greenhouse effect (Bengtsson et al., 1999). But satellite data since 1979 show no significant warming trend (Fig. 10). The IPCC play down the importance of these data because they do not show the recent warming trend suggested by the surface temperature record. Clearly, output from GCMs does not apply to surface temperature changes, and can only be checked by data from the troposphere. The IPCC has been testing its models on the wrong temperature record.

GCMs suffer from an inability to correctly capture the observed behaviour of the lower atmosphere and its relationship to the surface. When run with an increase in greenhouse gases, GCMs predict that the lower atmosphere can be expected to warm at about the same or slightly greater rate than the surface. However, satellite observations reveal just the opposite has happened for at least the last 23 years, which is the time of the greatest greenhouse gas build-up in the atmosphere.

The importance of the satellite data cannot be overestimated. Theory suggests that human-caused greenhouse gas emissions cause warming of the lower atmosphere, and this extra warmth is redistributed towards the Earth's surface. Greenhouse gases cannot warm the surface directly; they warm the atmosphere first. If there is no prior warming of the lower atmosphere, there can be no consequent enhanced greenhouse effect attributable to greenhouse gas emissions. Global climate models estimate temperatures in the lower layer of the atmosphere (rather than the surface itself), which is the area tracked by satellites. In fact, if climate models were correct, the satellite temperatures currently should be higher than surface temperatures. Instead, IPCC claim surface temperatures are going up and lower troposphere temperatures are roughly stable. Thus, the satellite data is direct evidence against the IPCC global warming hypothesis.

The surface temperature record is not global and has not been independently validated. The satellite data covers the entire Earth and has been independently validated by balloon radiosonde data. Moreover, the reliability of the satellite data has been thoroughly critiqued and adjusted for influences such as orbital decay of the satellite, yet the results show that the overall temperature trend is essentially zero (Spencer and Christy, 1992; Christy and Goodridge, 1995; Christy et al., 1998; Christy et al., 2000). It is noteworthy that no mention is made of the satellite data in IPCC's 1995 Summary for Policymakers. The most recent IPCC report (IPCC, 2001a) recognizes and accepts the discrepancy between satellite and the ground station records, but it still relies entirely on the spatially unrepresentative ground stations rather than on the most accurate record based on modern satellite-based instruments. For example, the Summary for Policymakers (IPCC, 2001b) highlights trends in surface temperature records and these data are used exclusively in diagrams to show recent warming.

The natural variability of the satellite record matches changes in the surface record, but no trend is obvious such as the globally averaged surface record shows (Fig. 11). These fluctuations are from 'normal' influences such as El Niño episodes and atmospheric dust from volcanic eruptions, and the temperature returns to 'normal' after each fluctuation. Prior to 1979, when satellite temperature measurements began, the surface record shows no temperature increase since 1940. This indicates that global temperatures have not increased significantly for 60 years.

Global warming is a worldwide effect, thus global rather than regional trends are indicative of its existence. However, spatially averaged hemispheric satellite records show a slight upward (warming) trend in the Northern Hemisphere (Fig. 12) and slightly downward (cooling) trend in the Southern Hemisphere (Fig. 13). The IPCC claim that sulphate aerosols from fossil fuel emissions offset greenhouse gas warming because of their cooling effect on the atmosphere. If this were the case, the hemispheric trends would be reversed as sulphate aerosol concentration is higher in the Northern Hemisphere than in the cleaner, mostly ocean-covered Southern Hemisphere.

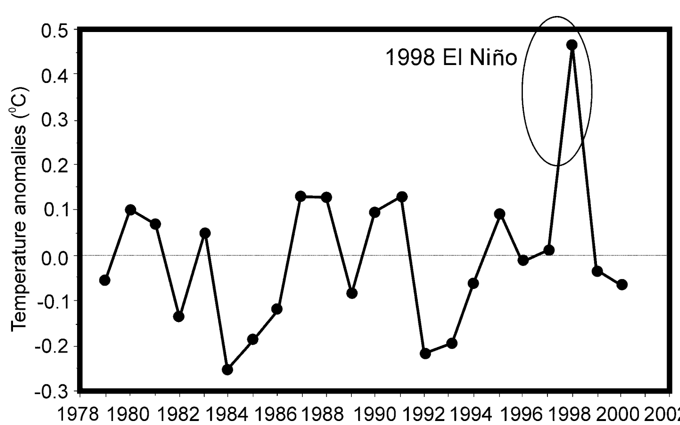

Fig. 10. Mean annual tropospheric temperatures of the globe taken by satellite (MSU) showing the conspicuous effect of the 1998 El Niño and little or no warming trend.

It is interesting that most good quality surface records show little or no warming and therefore agree with the satellite data since 1979. This is the case for the U.S. surface record (Fig. 14), mostly because there is much better coverage than anywhere else, and all of it has been under continuous quality control. Close scrutiny of the recent surface data for the globe indicate little warming, as shown in Figure 15, which is the most recent ten years of data (1991–2001) taken from the longer time series shown in Figure 5. Similarly, data for the world's oceans based on satellite measurements show no rise in sea surface temperatures (Strong et al., 2000).

Fallacy Six: Global climate trends during the past century are very unlike those of the past.

The IPCC 2001 Report has made much of one of the many reconstructions of global temperatures over the past 1000 years using proxy climate data by prominently featuring it in its Summary for Policymakers (IPCC, 2001b). The reconstruction (Fig. 16) is based on the work of Mann et al. (1998, 1999). Figure 16 shows that from about 1000 A.D. to about 1900 there is a slight 900-year cooling. Starting at around 1900 surface temperature data taken from the IPCC instrumental record are tacked on to the proxy data, which shows temperature rising abruptly. The resulting graph resembles a hockey stick. The handle of the 'hockey stick' shows a mean trend of little or no change for 900 years, disregarding the existence of the Medieval Warm Period and the Little Ice Age. The blade of the stick provides a dramatic warming in the twentieth century.

The 'hockey stick' curve challenges the existence of the Medieval Warm Period and subsequent Little Ice Age, which followed the Roman Warm Period and Dark Ages Cold Period (McDermott et al., 2001), and have long been considered to be classic examples of the warm and cold phases of a millennial-scale climate oscillation that occurred throughout glacial and interglacial periods (Oppo et al., 1998; McManus et al., 1999), as well as across the early Pleistocene (Raymo et al., 1998). The interpretation by Mann et al. (1999) implies that the recent warming is anomalous and thus must be linked to increases in greenhouse gases in the atmosphere.

The 'hockey stick' is a compelling image when first seen, and the IPCC 2001 report goes to some lengths to promote it by including it among the few diagrams presented in the Summary for Policymakers (SPM). And, nowhere in the SPM will one discover warnings on interpreting the graph. The IPCC has been severely criticized for this, for four reasons. First, the 'hockey stick' adds 100 years of oranges onto 900 years of apples. The Mann et al. (1999) 900-year run of data for the handle of the 'hockey stick' is mostly tree ring proxies from high altitudes or high latitudes, and their 100-year blade is full-year thermometer measurements from climate stations. These thermometers are recording mainly Northern Hemisphere urban-influenced warming, which is mostly in winter and in early spring. Tree rings are not necessarily reliable indicators of annual mean temperature as they are primarily responses to growth in the spring and early summer, so indicate temperatures for this time of year. Tree rings are also highly dependent on soil moisture availability in the growing season and solar variability that affects photosynthesis and thus growth rates of trees. The work by Mann et al. (1999) would have been more convincing if it had contrasted 900 years of tree ring proxies with like proxies for the past 100 years — i.e. apples plus apples. But even here, it is not safe to assume tree rings will provide a homogeneous record because of recent CO_2 fertilization.

Second, error estimates for the Mann et al. (1999) data, which are shown as the shaded light grey curve in Figure 16,

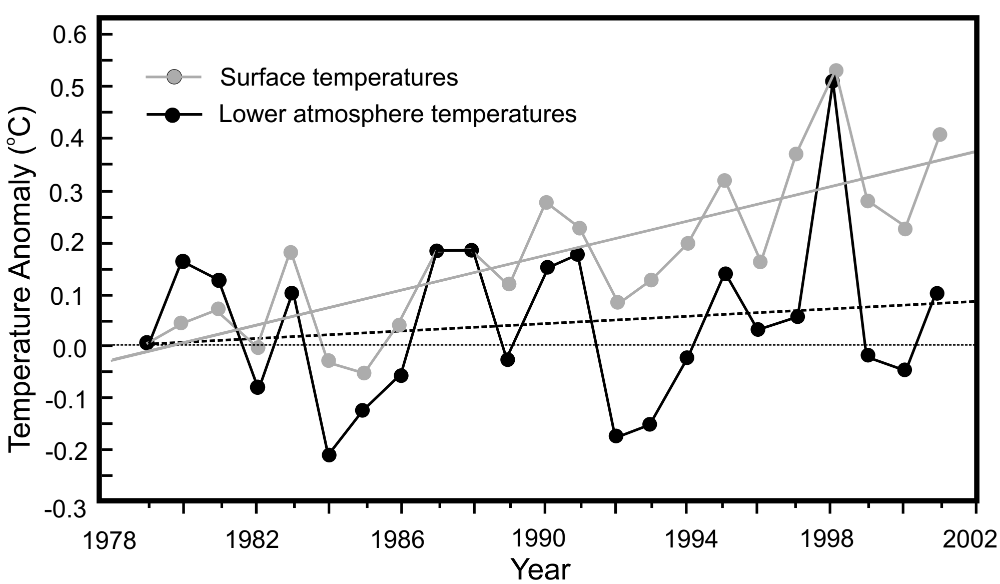

Fig. 11. Surface and lower atmosphere (satellite MSU) global temperature data for the period 1979-2001. Source: World Climate Report, 2001c.

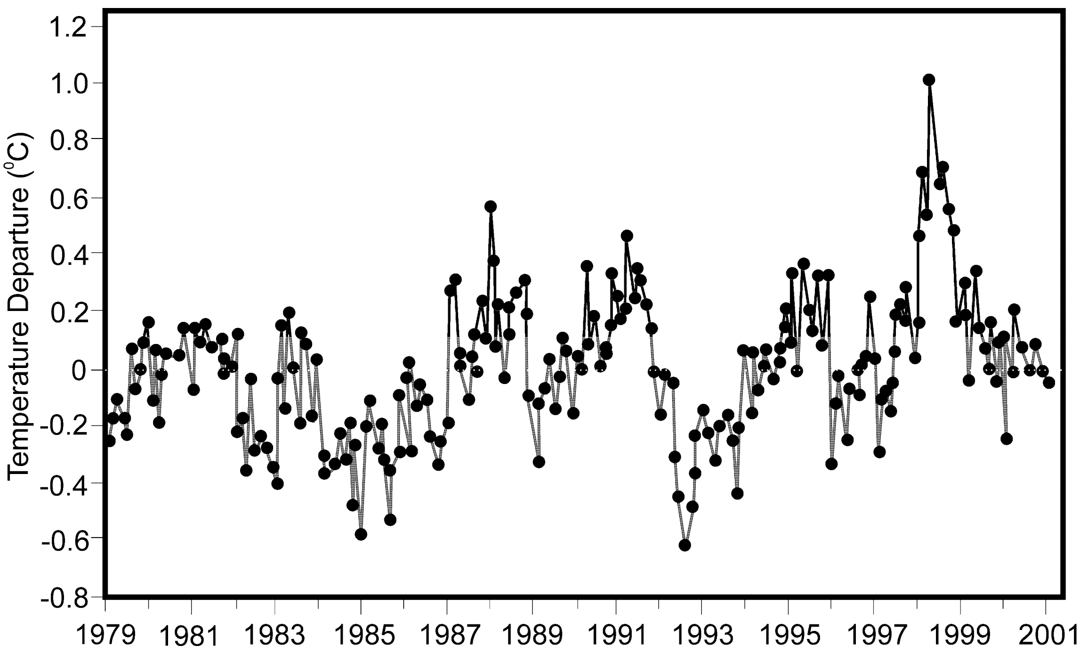

Fig. 12. Satellite (MSU) global temperature data for the period 1979-2001 for the Northern Hemisphere. Source: World Climate Report, 2001c.

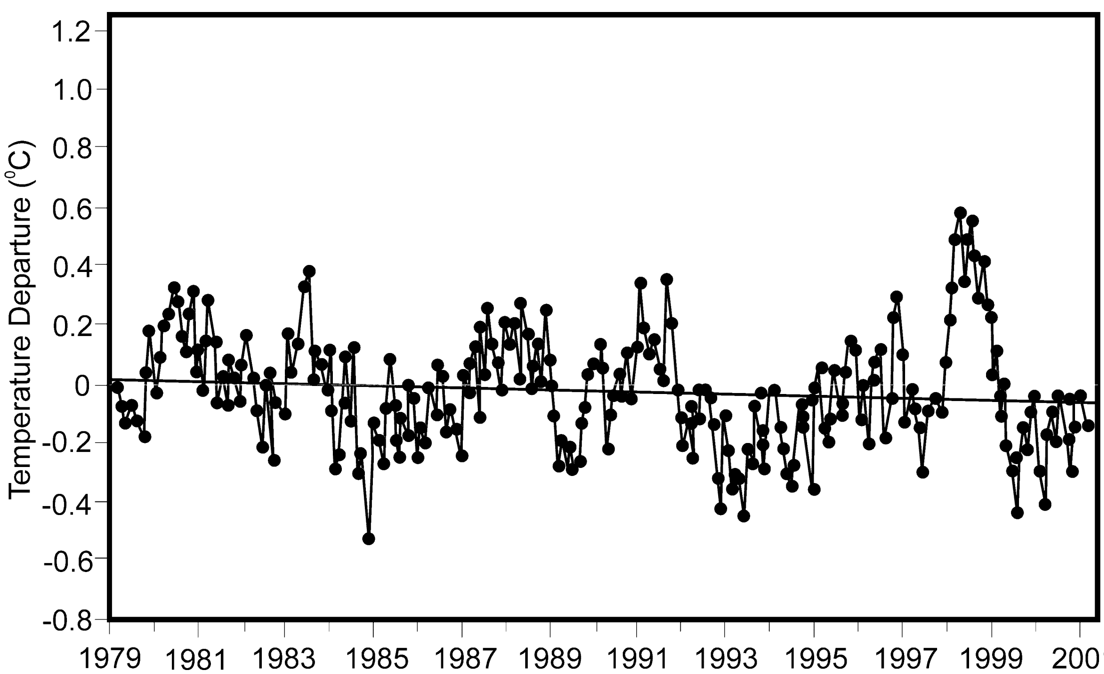

Fig. 13. Satellite (MSU) global temperature data for the period 1979-2001 for the Southern Hemisphere. Source: World Climate Report, 2001c.

are played down. The range of the error bars exceeds even the late twentieth century rise in surface temperatures. Third, tree rings and other proxies show substantial warming from about 1850 to 1940, but not since. The curve presented by Mann et al. (Fig. 16) shows proxy records only until 1980, with no temperature greater than in 1940, but does not show data since 1980, which show no warming. Fourth, the Mann curve fails to show several well-known climate events, namely, the Medieval Warm period (from about 800–1200 A.D.) followed by the Little Ice Age. Mann et al. (1999) claim that those events were not global, but rather regional temperature changes. They say this is a result of too much emphasis being placed on records from Western Europe where there is readily available historical documentation. However, the validity of this assumption has

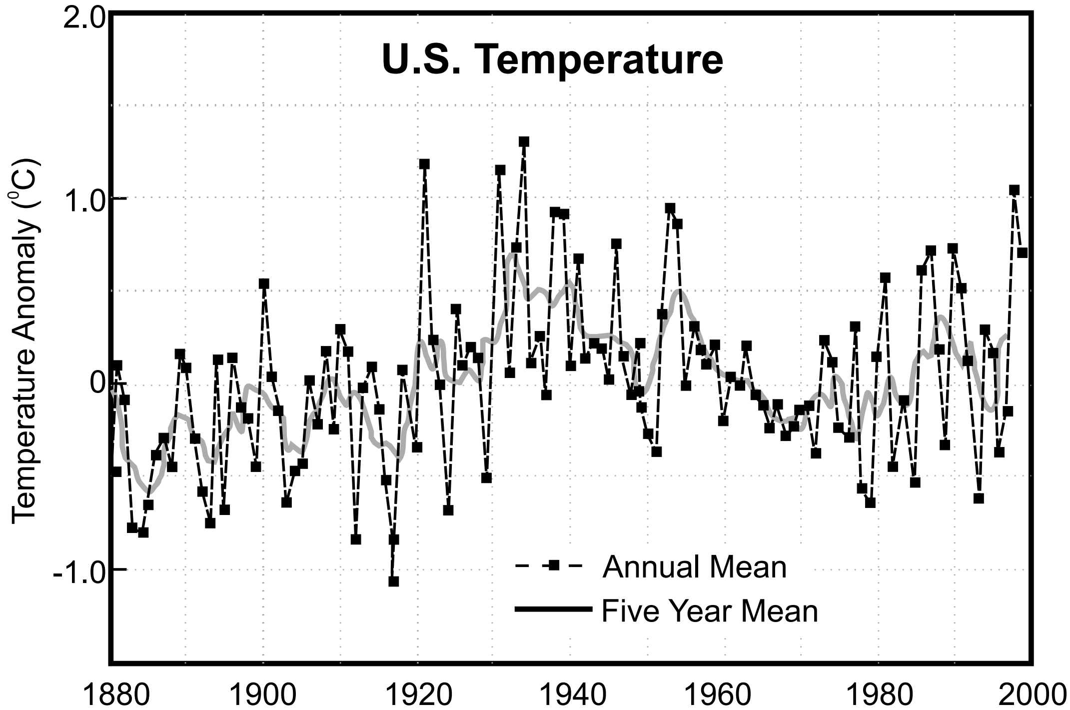

Fig. 14. GISS surface air temperature record for the United States.

been soundly challenged and sufficient evidence now exists to disprove it. A summary of this follows.

Wilson et al. (1979) provide data for far off New Zealand which, being located in the Southern Hemisphere, is meteorologically unrelated to Europe. Using $^{18}O/^{16}O$ dating profiles through a stalagmite, they found "the temperature curve for New Zealand to be broadly similar to England and such climatic fluctuations as the Medieval Warm Period and Little Ice Age are not just a local European phenomenon" (Wilson et al., 1979, p. 316). Tyson et al. (2000) gathered similar data from a stalagmite from Cold Air Cave, located 30 km southwest of Pietersburg, South Africa. Broecker (2001) cites several high-quality data sets as evidence to prove that the Medieval Warm Period and the Little Ice Age are a global phenomenon. Calkin et al. (2001) reviewed detailed research of Holocene glaciation along the northernmost Gulf of Alaska between the Kenai

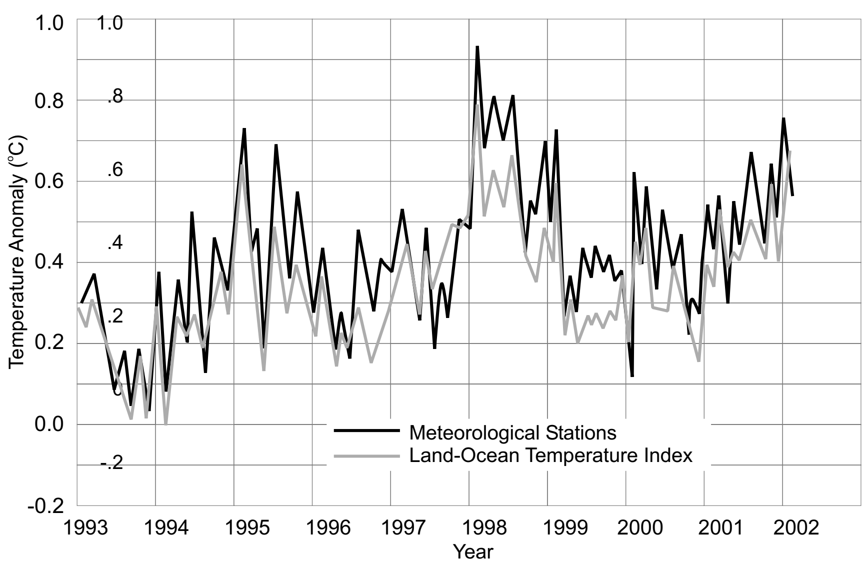

Fig. 15. GISS monthly mean global surface temperature derived from meteorological stations alone and the monthly mean land-ocean temperature index. This is the last 10 years of data shown in Fig. 5.

Peninsula and Yakutat Bay. They found that there is clear evidence of the existence of a Medieval Warm Period and a Little Ice Age in Alaska. Glaciers there reached their maximum Holocene extensions during the Little Ice Age. Given that Alaskan temperatures reached their Holocene minimum during Little Ice Age, from this time to the present, temperatures have been rising in a natural recovery from the coldest period of the Holocene.

A great deal of recent research has demonstrated that the Little Ice Age was evident even in Australia and reaffirms that it really did happen on a global scale. For example, work by Hendy et al. (2002) and Linsley et al. (2000) shows largely synchronous temperature trends of the South Pacific Ocean over the past 400 years support the view that the Little Ice Age was a truly global phenomenon and not a minor regional anomaly of lands in the vicinity of the North Atlantic Ocean. In addition, the data of Hendy et al. (2002) and Linsley et al. (2000) show temperatures in the South Pacific during the mid-18th century as being as warm as, or even warmer than, the present day. This is in contrast to the 'hockey stick' temperature history of Mann et al. (1999), which portrays the last two decades of the 20th century as the warmest of the past millennium. Other supporting evidence from around the world is provided by Le Roy Ladurie (1971), MacCracken et al. (1990), Grove and Switsur (1994), Leavitt (1994), Luckman (1994), Villalba (1994), Zhang (1994), Huffman (1996), Keigwin (1996a, 1996b), Huang et al. (1997), Dahl-Jensen et al. (1998), Cioccale (1999), de Menocal et al. (2000), Hong et al. (2000), Naurzbaev and Vaganov (2000), Winter et al. (2000), Verschuren at al. (2000), Broecker (2001), Haug et al. (2001), Holmgren et al. (2001), Johnson et al. (2001), Nicholson and Yin (2001) and Schilman et al. (2001).

In a particularly interesting study, Majorowicz et al. (1999) present proxy temperature records for the past 300 years. Data were extracted from borehole temperature-depth logs obtained at ten sites scattered throughout southern Saskatchewan, Canada. Data from the latter portion of the record were compared to observed surface temperature measurements over the last 100 years. The researchers found that the temperature proxies indicate the existence of a relatively cool period throughout most of the 18th and 19th centuries. Then, from about 1820 to

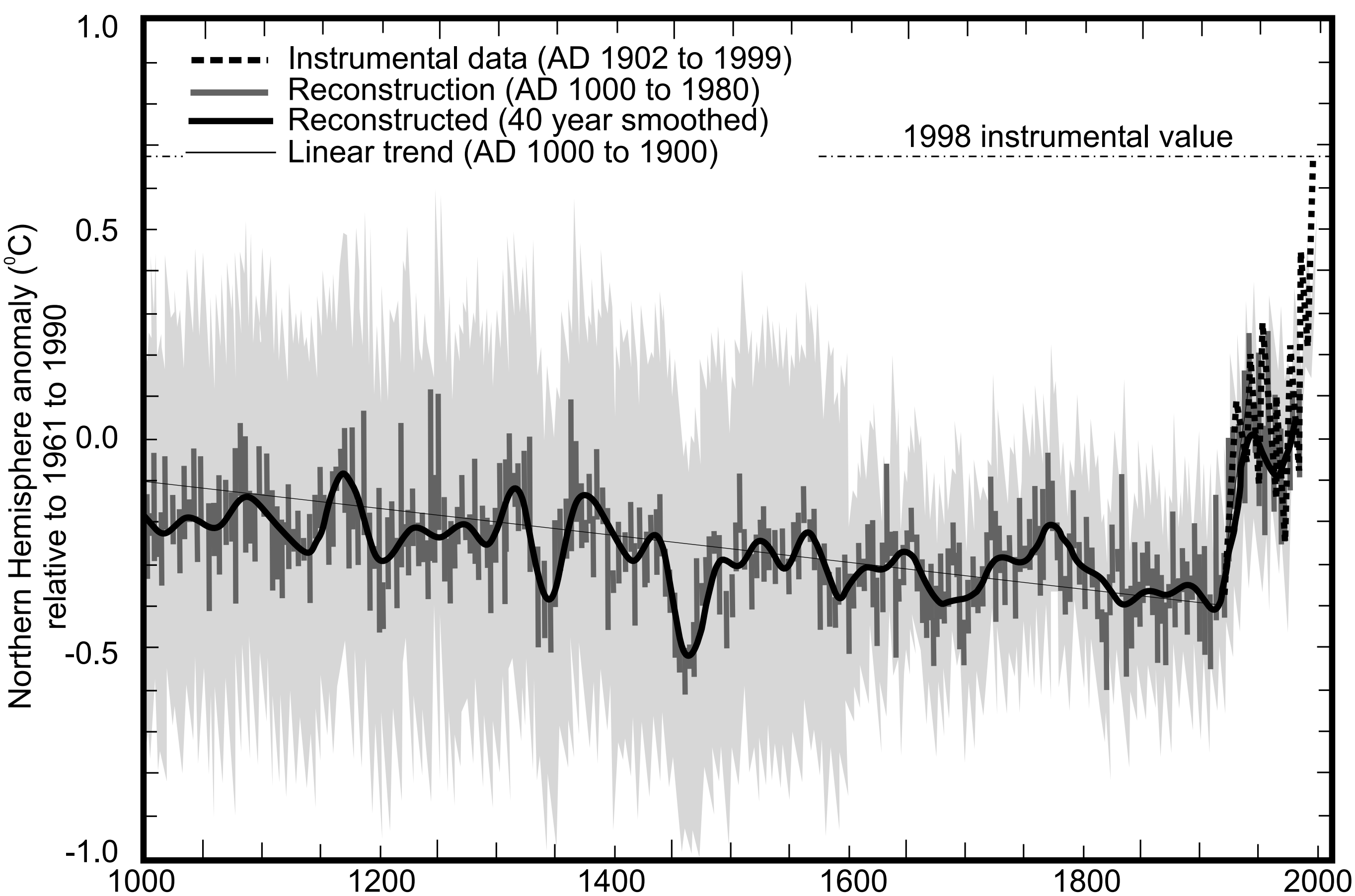

Fig. 16. Reconstruction of past Northern Hemisphere surface temperatures based on the work of Mann et al. (1999) prominently featured in IPCC (2001a). The smoothed inner curve (black line) is the 50 year average, the next curve (dark grey) is the year by year average and the outer curve (light grey) is the 95% confidence range of the annual data. The graph resembles a hockey stick. The handle of the hockey stick shows a mean trend of little change for 900 years, disregarding the existence of the Medieval Warm Period and the Little Ice Age. The blade of the stick provides a dramatic warming in the twentieth century likely linked to temperature rise from proximity of weather stations to rapid growing urban areas. Note error bars match the recent temperature peak caused by the 1998 El Niño event.

present, temperatures rose between 2.5 and 3.0°C, suggesting "the last major warming event [which is still going on] began in the 18th–19th century" (Majorowicz et al., 1999, p. 240). According to the authors, "the significance of this record is that it suggests almost half of the warming occurred prior to 1900, before the dramatic buildup of atmospheric greenhouse gases." Thus, according to a review of the article Center for the Study of Carbon Dioxide and Global Change (1999, p. 1) "if something other than greenhouse gases caused the first half of the most recent global warming event (in which we are still imbedded), something other than greenhouse gases may be responsible for the second half of the warming as well."

Recent work by Naurzbaev and Vaganov (2000) and Esper et al. (2002) appear to have finally put paid to the 'hockey stick' curve by emphasizing that most temperature reconstructions using proxy data results do not support the 'hockey stick' curve. Figure 17 from Naurzbaev and Vaganov (2000) shows tree ring data from Northern Siberia that, in contrast to the Mann et al. (1999) 'hockey stick', shows the Medieval Warm Period, 900 to 1100, and the Little Ice Age in the early 1800s, so well recognized elsewhere. The large peak in the 1940s, visible in the surface temperature data, can also be seen (Fig. 17). Esper et al. (2002) analyzed over 1200 tree-ring series derived from 14 different locations scattered over the extra tropical region of the Northern Hemisphere (Fig. 18). Their data indicate a temperature rise similar in form to most recent trends, but without any matching rise in greenhouse gases. In reviewing this and similar work, Briffa and Osborn (2002, p. 2227) note that the record of Esper et al. (2002) clearly shows that the warming of the 20th century was actually "a continuation of a trend that began at the start of the 19th century."

In conclusion, it is clear that the Mann et al. (1999) 'hockey stick' is nothing more than a mathematical construct vigorously promoted in the IPCC's 2001 report to affirm the notion that temperature changes of the twentieth century were unprecedented. The validity of this has been soundly challenged and sufficient evidence exists to disprove it.

Fallacy Seven: There are reliable forecasts of future climate.

General circulation models (GCMs) are computer simulations of global climate. The scientists that construct these models accept that they do not adequately handle key aspects of the climate system, such as the feedback effect of clouds and aspects of heat transfer in ocean circulation (Cess et al., 1995; Charlock and Alberta, 1996; Lindzen, 1997). Water vapour dominates the greenhouse effect. Because of this, half of the IPCC-predicted global warming depends on how water vapour responds to increased CO_2. But climate science is not yet capable of predicting how water vapour will respond. Earlier on, some scientists argued that better models might actually show more warming. The opposite has proved to be the case. From their inception, global climate models have been predicting spuriously high values of global temperatures. As the models have improved over the last decade, the IPCC's "best estimates" of global warming by the year 2100 are becoming smaller: 3.3 °C in 1990, 2.8 °C in 1992, and 2 °C in 1996, and perhaps even less in 2001(Fig. 19). One is led to wonder: if the climate models cannot accurately predict change a mere ten years on, what chance do they have for 100 years? Perhaps to counter this trend of decreasing warmth in "best estimates" projections, the IPCC avoided these in its most recent report (IPCC, 2001a) and introduced the concept of "storylines" instead. Storylines are constructed to depict future states, replacing 'scenarios' used in the SAR (Houghton et al., 1996), which in turn replaced 'predictions' and 'projections' used even earlier. Some see it as a means of keeping global warming

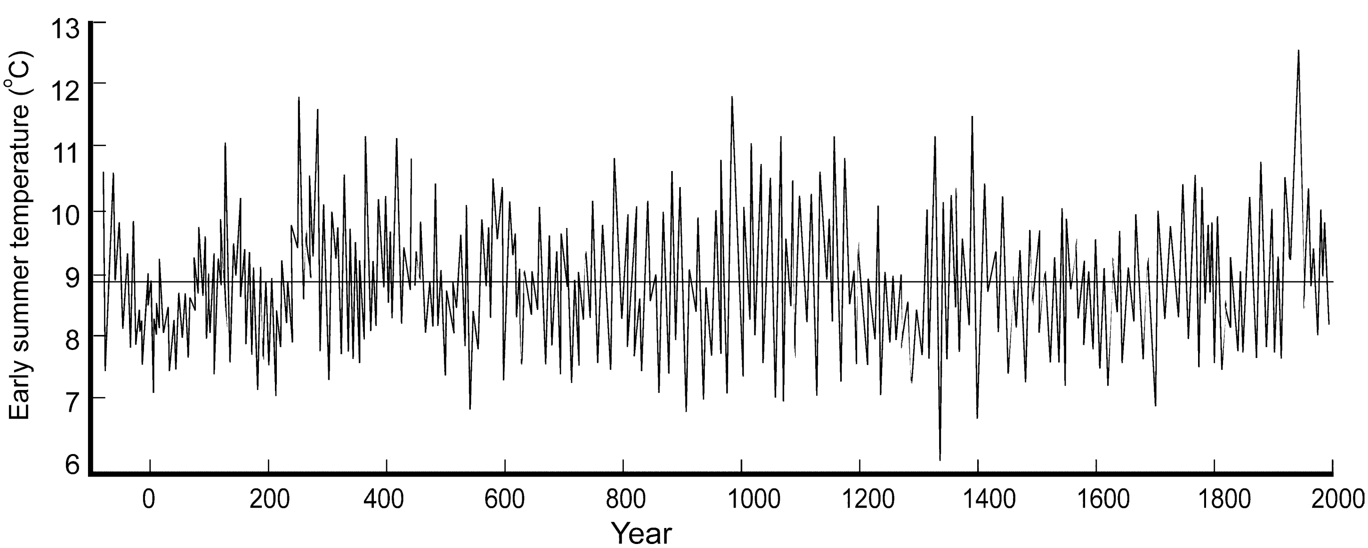

Fig. 17. Proxy early summer temperatures from tree rings in Northern Siberia (from Naurzbaev and Vaganov, 2000). In contrast to the Mann et al. (1999) Hockey Stick (Fig. 16) this shows no dramatic twentieth century warming, but it does show the Medieval Warm Period, 900 to 1100, and the Little Ice Age in the early 1800s, so well recognized elsewhere.

in the limelight and in the forefront of environmental concerns. Other approaches have also been used.

Just prior to the United States Presidential election of 7 November 2000, in which candidates Al Gore and George W. Bush were at odds on the global warming issue, a leak from the IPCC appeared in the New York Times and elsewhere, which showed the IPCC's renewed determination to promote its version of climate-change science. An editorial in *Science* of 10 November 2000 (v. 290 p. 1091) under the title "New Climate News" covered the leak as follows:

> The preface of the latest draft report from the Intergovernmental Panel on Climate Change was leaked last week and was widely reported in the press. Here are the surprises. The first is that the global warming estimate itself — at least its upper bound — has received an upward adjustment. The last IPCC estimates, in 1995, put the average global temperature increase by the end of this century at 1.5 to 4.0 °C. This newest estimate is 1.5 to 6.0 °C. The second surprise is that a firmer association between human activities and climate has emerged. Even the most sceptical climatologist in the IPCC group now concedes that warming bears an anthropogenic handprint.

And

> Even without an unpleasant surprise, the new IPCC report raises the prospect of serious risk to a new level. And it's about time: Right now, climate change has drifted off the radar screen, warranting scarcely a glance in this season of electoral politics.

The results from global climate models are of little value until the reliability of their performance can be verified. A

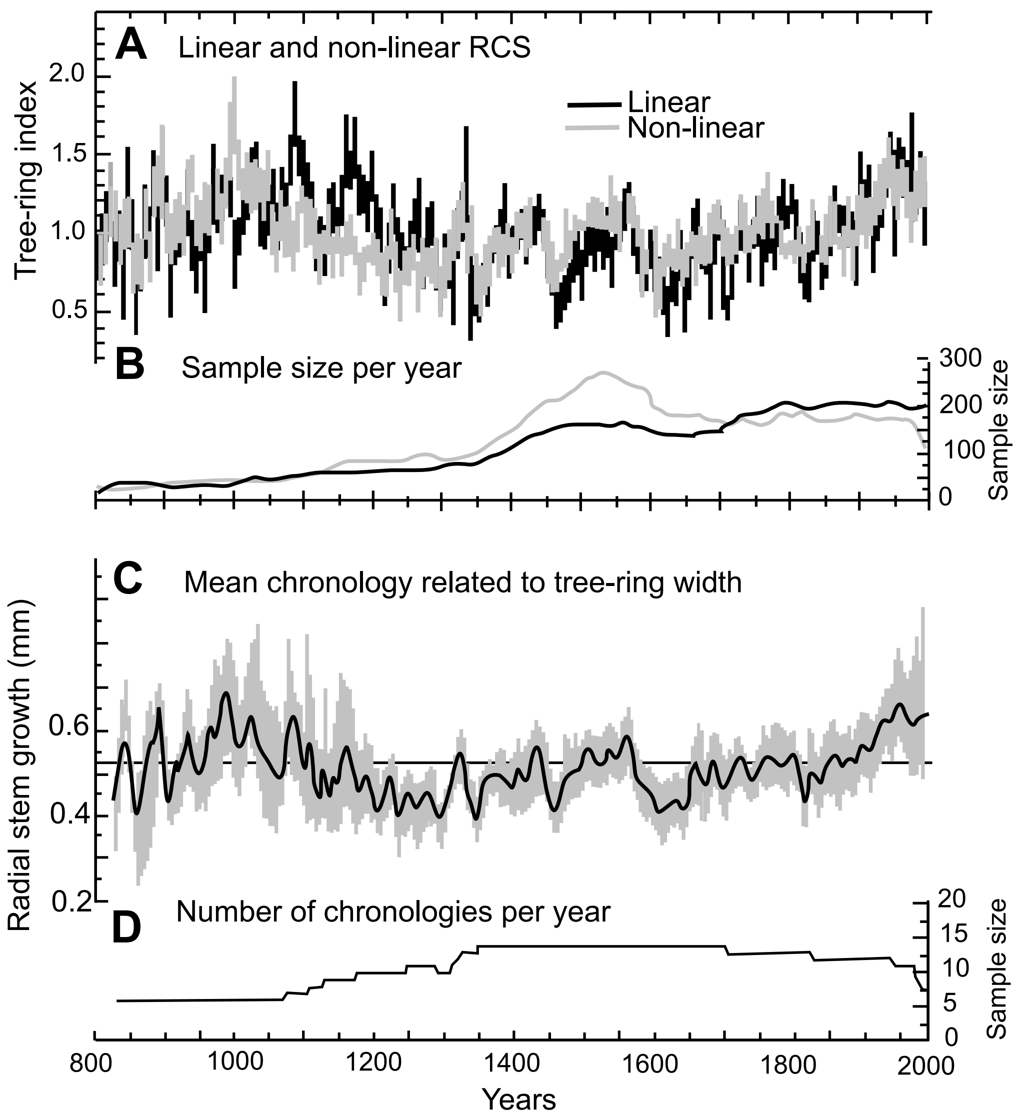

Fig. 18. Proxy summer temperatures from over 1200 tree-ring series derived from 14 different locations scattered over the extratropical region of the Northern Hemisphere (from Esper et al., 2002). In contrast to the Mann et al. (1999) Hockey Stick (Fig. 16) this shows no dramatic twentieth century warming, but it does show equally significant cycles of warming in the past.

GCM is just a hypothesis until there is supporting evidence for it. There has been widespread criticism of the use of GCMs (Soon et al., 2001). In a good deal of the literature on global warming the research content is based solely on model results that are treated as real data. This is far removed from reality.

According to Richard Lindzen (Lindzen, 1992, p.124) who is the lead author of Chapter 7 of IPCC 2001, Working Group I, The Scientific Basis: "The GCM models are just experimental tools, and now these tools are forced to make predictions that they are not able to..." and "There is nothing wrong with GCM modelers, they do the best job they are able to. The problem is, that too many people believe in the unreliable predictions. This problem is thus not scientific, it is political."

According to Singer (1996, p. 581): "The gap between the satellite observations and existing theory is so large that it throws serious doubt on all computer-modelled predictions of future warming. Yet this discrepancy is never mentioned in the IPCC report's Summary [SPM] — nor does the SPM [Houghton et al., 1996] even admit the existence of satellites."

All GCMs consistently predict greater increase in temperature with increasing distance from the equator. Thus, if IPCC models are correct, we should see the poles warming relative to the tropics. But temperatures in polar regions show no net change over the past four decades (Khal et al., 1993; Dowdeswell et al., 1997; Comiso, 2000; Przybylak, 2000; Venegas and Mysak, 2000). In fact, recent data have shown that Antarctica has cooled significantly (Doran et al., 2002).

Hanna (2001), using satellite analysis of Antarctic sea-ice cover (extent and area) based on Special Sensor Microwave/Imager data for the period October 1987 to September 1999, shows an ongoing slight but significant hemispheric increase of 3.7(±0.3)% in ice extent and 6.6(±1.5)% in area. Hanna comments that this is "entirely "consistent with cooling over Antarctica from 1979–98." Trends in Antarctic sea ice over a longer period have been examined by Yuan and Martinson (2000) using satellite data over 18 years leading up to 2000. They found that the mean Antarctic sea ice edge has expanded equatorward by 0.011 degree of latitude per year. They infer from this that it is likely that the global extent of sea ice is also on the rise. Watkins and Simmonds (2000) have analysed trends in a number of southern ocean sea ice parameters using satellite data. They found statistically significant increases in sea ice area and total sea ice extent between 1978 and 1996. In addition, the results indicate that there was an increase in the length of the sea ice season during the 1990s. The most recent measurements indicate that the movement of the glacial Ross ice streams is slowing, allowing the ice in West Antarctica to thicken, and demonstrating that the behaviour of Antarctic ice is unrelated to temperature *per se* (Joughin and Tulaczyk, 2002).

Reports on otherwise bland scientific information on climate change often distort the facts or the intended message, presumably to shock us. An example is the news item that appears in *Nature* of 2 November 2000 (v. 408, p. 10) under the headline "Global warming happening faster than predicted":

> Global warming could be happening more rapidly than previously estimated, leading to an average temperature increase of as much as 6 °C over the next century, according to the latest assessment by the Intergovernmental Panel on Climate Change (IPCC). The Report, which was leaked in advance of its expected completion in January next year, predicts that global warming will be greater than the IPCC's earlier assessments in 1990 and 1995. The panel had previously estimated the maximum likely temperature increase at around 3 degrees C.

In reply, the World Climate Report (2000, p. 1) remarks:

> But the document the IPCC sent out for scientific peer review contained no such number. Indeed, after the scientists reviewed it, the maximum value was 4.8 degrees C… In a sad repetition of a 1995 fiasco in which the key phrase "the balance of evidence suggests a discernible human influence on global climate" was inserted after the document had circulated among scientific reviewers, the IPCC has changed its report's most crucial conclusion at the 11th hour, after the scientific peer review process had concluded.

And

> After the scientific review process, the IPCC document undergoes a 'Government Review.' It was at this stage that the 6 degrees C figure was inserted.

Rather than dramatic change, expectations of future climate are for current temperature trends to continue (Michaels and Balling, 2000). For example, Bunde et al. (2001) compared the output of several GCMs against real-world characteristics of climatic trends and persistence. They used newly-developed, sophisticated methods derived from mathematical physics called wavelet techniques and detrended fluctuation analysis. They found that "the models tend to underestimate persistence while overestimating trends", implying, in their words, "that the models exaggerate the expected global warming of the atmosphere," and that it therefore "cannot be excluded that the

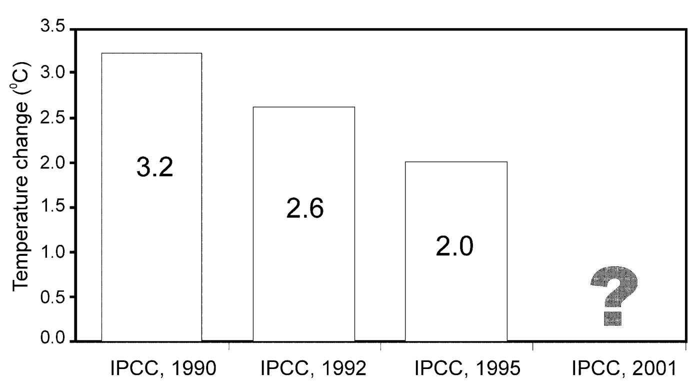

Fig. 19. Some scientists argued that better climate models might actually show more warming, but the opposite has proved to be the case. The figure shows changes in IPCC "best estimate" projections of global temperature rise to the year 2100 caused by increases in greenhouse gas concentrations in the atmosphere. IPCC 2001 breaks the tradition of giving up dated best estimate, as it did in all its previous reports. Instead, it uses "storylines" to speculate about warming as high as 5.8°C in 2100.

global warming in the next 100 yr will be less pronounced than predicted by the models." (Bunde et al., 2001, p. 264)

Because of the impossibility of testing climate models successfully on past climate sequences, the only way a climate model could achieve any sort of credibility is if it were successful in predicting future climate. Climate modelling began in earnest in the 1980s. Now we have 20 years of data to decide whether these models are capable of predicting future climate. All have failed badly. The Earth's atmosphere has warmed only about 10 per cent as much as climate models forecast, averaged over the last 30 years. The main reason for this is that there are very large uncertainties associated with most model parameters. Figure 20 from the 2001 IPCC SPM (IPCC, 2001b) graphically illustrates this. It is clear that there is only a low to very low level of scientific understanding (LSU) of the various factors that cause climate change. Amazingly, however, IPCC 2001 SPM claims a high level of confidence in projected changes in climate. Table 1 shows that estimates of confidence in projected changes in extreme weather and climate events during the twenty-first century is very high, despite a very high range of uncertainty as a result of a "low" and "very low" level of scientific understanding as to the inputs shown in Figure 19. Assuming a large warming, in spite of "very low" confidence as to its cause (LSU), has done nothing for the IPCC's credibility.

FALLACY EIGHT: SIGNIFICANT ANTHROPOGENIC GLOBAL WARMING IS UNDERWAY.

Climate is naturally variable and always changing. The notion of constant climate is misleading. Climate is always either warming or cooling. Over the past 100 years, all changes in climate have been well within the range of the climate's natural variations (Mahlman, 1997).

Climate can change as result of two categories of factors: 1) natural changes and 2) human-induced changes. The latter can be divided into two groups of causes: a) changes due to increases in greenhouse gas concentrations in the atmosphere and b) changes from other human activities, such as urbanization, change in reflectivity of the land surface due to agriculture and other forms of land use, and particulate emissions into the atmosphere. The IPCC (2001b, p. 2), however, states: "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." In this way, the IPCC lumps together all types of climate change, at the same time, readily attributing any observed change in global climate to changes in greenhouse gases concentration.

Even if twentieth century surface temperature data were taken as evidence of warming, it would indicate that forcing from greenhouse gases is lower than expected. According to

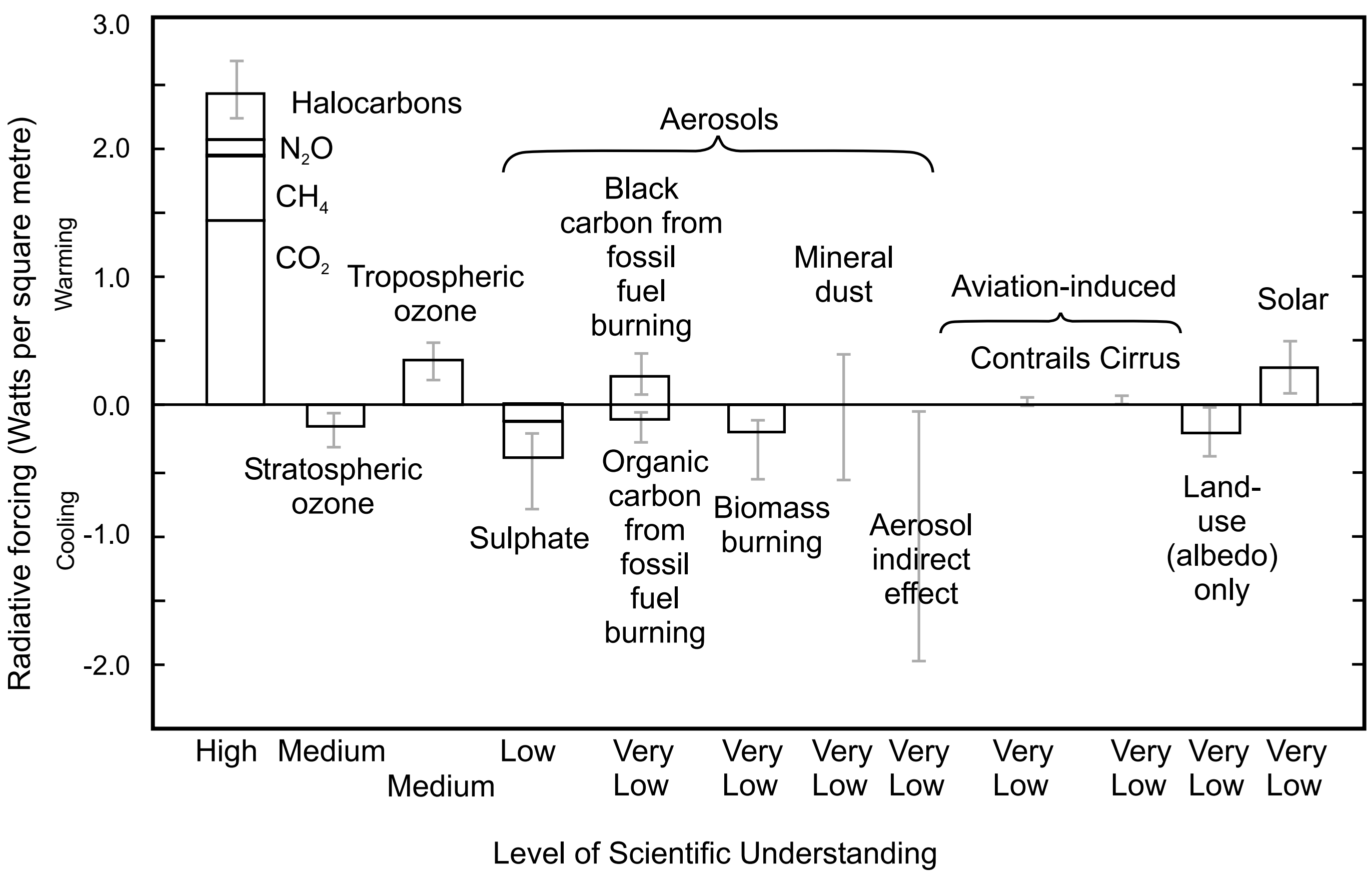

Fig. 20. Mean global radiative forcing of the climate system for the year 2000, relative to 1750. Fig. 3 in Summary for Policymakers, WG1 (IPCC, 2001b).

Table 1. Estimates of confidence in observed and projected changes in extreme weather and climate events. Table 1 in Summary for Policymakers, WG1 (IPCC, 2001b). Note that estimates of confidence in projected changes in extreme weather and climate events during the 21st century is very high, despite a very high range of uncertainty due to a low level of scientific understanding of the inputs, as shown in Fig. 20.

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 over land areas	Very likely over most areas
Likely over many Northern Hemisphere mid- to high-latitude land areas	More intense precipitation events	Very likely over many 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	Intense tropical cyclone peak wind intensities	Likely over some areas
Insufficient data for assessment	Increase in tropical cyclone mean and peak precipitation intensities	Likely over some areas

North and Wu (2001), a possible explanation for the weak CO_2 signal is global temperature is less sensitive to greenhouse gas increases than previously thought. This supports the conclusions of Michaels and Balling (2000) who have shown how the climate models have greater sensitivity to CO_2 increases than the real atmosphere, and that the likely warming by the year 2100 is significantly lower than most GCMs forecast.

Lindzen et al. (2001) have discovered further compelling evidence of reduced sensitivity. Their research showed that, over the Pacific, when the ocean is warm, there are fewer cirrus clouds than when the ocean is cold. Since cirrus clouds act like a blanket and keep longwave radiation from escaping to space, there is a negative feedback loop, which the researchers call an “adaptive infrared iris”. Lindzen et al. (2001) postulate that if this effect is common all over the Earth (rather than limited to the region in the tropical Pacific they studied), the impact of a greenhouse effect increase would be much smaller than that anticipated by the climate models. Applying the effects of this process to IPCC model runs, Lindzen et al. (2001) found that it greatly reduces output sensitivity. The net warming effect of increased greenhouse gases on global temperature was found to be 0.64 to 1.6 °C, compared to the IPCC range of 1.7 to 4.2 °C (Fig. 21). The “iris” hypothesis is yet to be confirmed (Hartman and Michelsen, 2002; Lin et al., 2002) but the seminal work of Lindzen et al. (2001) demonstrates both the role and importance of negative feedback processes.

Added to this are the results of other recent research that show there are mechanisms affecting global climate that dwarf the potential effects of CO_2 (Goode et al., 2001; Jacobson, 2001) Goode et al. (2001) developed a new technique of accurately measuring the Earth’s reflectivity using the moon. Every new moon, when the sun illuminates it from behind, light is reflected from the Earth onto the otherwise dark side of the moon. The glow that is seen on the dark part of the new moon results from earthshine, that is, sunlight reflected from the Earth and reflected back from the moon. The amount of earthshine is a measure of how much of the sun’s incoming radiation is reflected away by the Earth. Previously, the most accurate measure of the Earth’s albedo was obtained from satellites. These view only small parts of the Earth’s surface for short periods, which then must be added and averaged for global estimates of reflectivity. Using this new, highly accurate photometric technique Goode et al. (2001) show that Earth’s reflectivity varies by over 2% on the scale of nearly a decade, which is the climate equivalent of doubling atmospheric CO_2.

There is also a great deal of research on the theory relating the sun’s variability to climate change (Friis-Cristensen and Lassen, 1991; Lassen and Friis-Cristensen, 1995; Soon et al., 1996; Svensmark and Friis-Cristensen, 1997; Bjorck et al., 2001; Yu, 2002). Although the work is in its early stages, the results show a close correlation with observed global temperature trends (Fig. 22). What is most interesting is that prior to the work of Svensmark and Friis-Cristensen (1997), research to include solar variations in climate modelling had focused on variations in radiation from the sun, often referred to as total solar irradiance (TSI). But since it varied only about 0.14% over a sunspot cycle, it was dismissed as being too small a variation to contribute significantly to global temperature variations. However, Svensmark and Friss-Christensen (1997) and Yu (2002) show that global cloud cover varies in response to the solar cycle which would amplify the heating effect of the small variation in total solar irradiance. The reasoning is that changes in the sun’s magnetic field alter the amount of cosmic rays that strike Earth, which in turn affects cloud formation.

High, thin clouds typically warm the planet by trapping outgoing heat in the sky. But thick, umbrella-like low clouds have a net cooling effect. When the sun’s magnetic field, or solar wind, is stronger — as it is, for example, during high sunspot activity — it deflects more cosmic rays, preventing them from hitting air molecules. Cosmic rays collide with air molecules to produce secondary particles that seed the cloud types that act to cool the Earth. Low clouds increase and decrease as cosmic rays from deep space increase and decrease. Increased solar activity means fewer cosmic rays, fewer clouds, and more warming. The cosmic rays are modulated by the sun’s solar wind, so that when the solar wind is strong (as during a solar maximum) the cosmic rays are partially blocked out. When the solar wind is weak (as during a solar minimum) the cosmic rays increase, adding to cloudiness. Although the process is as yet unproven, many scientists are convinced that the high correlation (0.98) between global temperatures and the solar cycle length over the past 150 years is no coincidence. This and related work has been critically assessed by Soon et al. (2000).

It may be appropriate to conclude discussion of Fallacy Eight with an emphatic reminder that even the IPCC admits that recent variations in climate could be natural. In the Section headed "Detection and Attribution" IPCC (2001a, Chapter 7, p. 97) the authors state:

> The fact that the global mean [surface] temperature has increased since the late 19th century and that other trends have been observed does not necessarily mean that an anthropogenic effect on the climate system has been identified. Climate has always varied on all time-scales, so the observed change may be natural. A more detailed analysis is required to provide evidence of a human impact.

FALLACY NINE: GLOBAL WARMING WILL PRODUCE A RISE IN SEA LEVEL.

Reasonable scenarios of sea level change are based on calculations that rely on scientifically sound assumptions. Over the short term, climate warming could cause sea level to rise mainly by the thermal expansion of the oceans. Melting of polar ice caps is not involved since this is a long-term response. As only the surface water is affected, response times can be rapid but sea level changes are small, amounting to only a few millimetres (Warrick and Farmer, 1989). Other factors cause changes of sea level of far greater magnitude but sensitivity of coastal systems seems to be reasonably low. For instance, the large 1982–83 El Niño event raised sea levels 35 cm above average along parts of the west coast of the United States, as the failure of the prevailing easterly winds caused water in the west Pacific to surge back eastward across the ocean (Wyrtki, 1982; Harrison and Cane, 1984; Komar, 1986).

Supporters of worst-case scenarios of global warming point to evidence of sea level rising. But changes in sea level are often relative changes that vary from one region to another. Currently, sea level is rising in many places and is falling in many others, such as along very large areas of coastline in Western North America, Western Europe and Eastern Asia (Bryant, 1987).

Sea level measurements are subject to a number of biases, usually upwards, from removal of ground water and oil, erection of buildings, roads and airports, subsidence of the measuring equipment, surface movement due to earthquakes, or as a result of large depositional features such as river deltas.

Cabanes et al. (2001) have analyzed highly accurate global sea level observations by precise instruments carried aboard satellites. These researchers explain that the rate of sea level rise over the course of the twentieth century has likely been overestimated by a factor of two. In other words, instead of a global average sea level rise of 15 cm during the past 100 years, the true value is likely to be closer to 7 cm. The authors attribute the overestimate to the fact that historical sea level measurements have been primarily made from a rather sparse network of tide gauges located at coastal margins, which are often geologically unstable places, rather than a uniform sampling across the world's oceans. Corrected data for a large part of the globe show 1.8 mm/yr for 1900 to 1980 (Trupin and Wahr, 1990), which is roughly consistent with long-term values from corals and other proxies for the past 3000 yrs. It is noteworthy that historical records show no acceleration in sea level rise in the twentieth century (Douglas, 1992).

In light of IPCC scenarios of rapidly rising seas, the wellbeing of the populations low lying atolls in the tropical Pacific has been the subject of much speculation. As a result, it is alleged that the government of Tuvalu was ready to sue the United States and Australia because they had not signed the Kyoto Protocol. The Tuvalu government believes that most of its country, which at its highest is only five meters above sea level, will have disappeared into the ocean within 50 years. The New Zealand government too, by all accounts, believes this. It

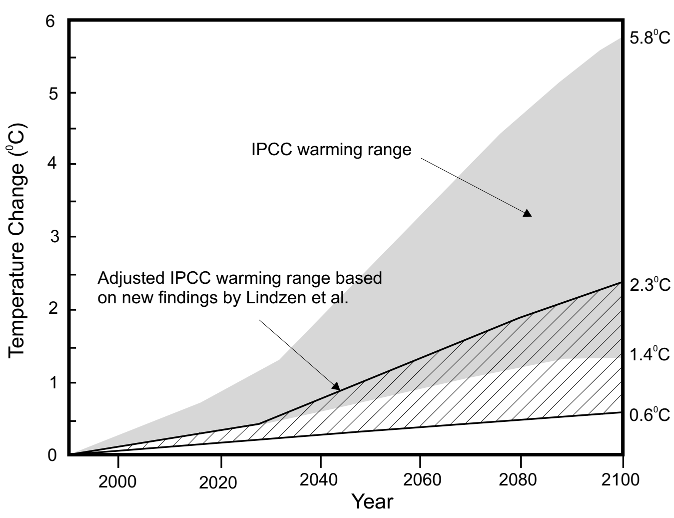

Fig. 21. Future global temperature ranges based on IPCC (2001) compared with the same models adjusted according to findings by Lindzen et al. (2001) of reduced atmospheric sensitivity from negative feedback loop caused by high level clouds (from World Climate Report, 2001a).

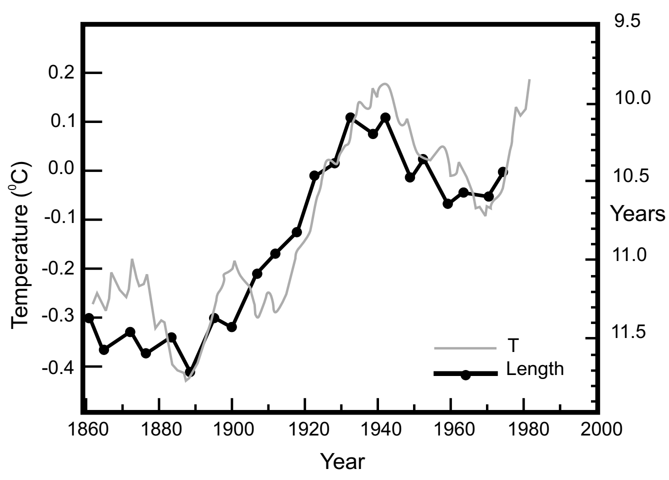

Fig. 22. Eleven-year running means of solar activity, in terms of the sunspot cycle length (years), compared with global temperature (T) based on the work of Friis-Cristensen and Lassen (1991). The global temperature is the same as that used by IPCC (Jones, 1988; Jones et al., 1986).

recently improved immigration procedures for Tuvalu residents after a false claim that the ocean level is rising, presumably to cater to "environmental refugees" wishing to re-settle in New Zealand. In fact, detailed measurements at the main Tuvalu island of Funafuti have shown no dramatic rise in ocean level over the past 30 years (Fig. 23).

It is important to keep in mind that greenhouse gas induced climate change can also act to substantially lower sea level. There is now a substantive body of research reported in the peer reviewed scientific journal literature that suggests that sea levels, which have been rising since the end of the last ice age (long before industrialization), are likely to stabilize or fall in a greenhouse-warmed world. This is because empirical evidence indicates that a modest warming of the Earth could lower sea level by increasing evaporation from the oceans. The result is increased deposition and accumulation of snow on the polar ice caps, principally in the Antarctic, thereby transferring large amounts of water from the oceans to the ice sheets (Oerlemans, 1982; Zwally, 1989; Bromwich, 1995; Thompson and Pollard, 1995; Ohmura et al., 1996; Ye and Mather, 1997; Meese et al., 1994; Hogan and Gow, 1997). The reasoning is that if the Antarctic air were to warm, it would still be below freezing, but its water holding capacity would increase as it warms. With more moisture in the atmosphere over the Antarctic, snowfall would increase and ice sheets would grow, locking up water that would otherwise be in the sea. The result would be thicker ice caps, especially in Antarctica. In this context, it is significant that during the strong warming episode of 1920-40, sea level rise did not accelerate but actually stopped (Singer, 1997). According to Singer (1997, p.19): "All these findings point to the conclusion that future warming will slow down rather than accelerate the ongoing rise in sea levels."

FALLACY TEN: GLOBAL WARMING WILL RESULT IN MORE EXTREME WEATHER EVENTS.

It is common to see media reports of how floods, droughts, or increased frequency of hurricanes are proof of global warming. The problem is that no matter how outrageous the tale, it becomes the truth if it is told often enough. According to the 1996 IPCC report (Houghton et al., 1996, p. 173): "Overall, there is no evidence that extreme weather events, or climate variability, has increased, in a global sense, through the 20th century…" The 2001 IPCC Report (IPCC, 2001b, p. 5) states that "no systematic changes in the frequency of tornadoes, thunder days, or hail are evident..." The increasing dollar cost of storm and other weather related events could be accounted for by a rise in the value of development and number of properties, especially in tropical cyclone prone areas (Changnon et al., 1997; Pielke and Lansea, 1998; Kunkel et al., 1999). In the Atlantic region, the number of intense hurricanes declined during the 1970s and 1980s, and the period 1991-1994 experienced the smallest number of hurricanes of any four years over the last half century (Idso et al., 1990; Murphy and Mitchell, 1995; Landsea et al., 1996; Bengtsson et al., 1996; Serreze et al., 1997; Zhang and Wang 1997).

There is also evidence from Europe to support these observations. For the period 1896-1995, Bielec (2001, p. 162) analyzed thunderstorm data obtained at Cracow, Poland, which is "one of the few continuous records in Europe with an intact single place of observation and duration of over 100 years." From 1930 onward the trend is negative, revealing a linear decrease of 1.1 storms per year from 1930 to 1996. Bielec (2001) also reports there has been a decrease in the annual number of thunderstorms with hail over the period of record, and there has been a decrease in the frequency of storms producing precipitation greater than 20 mm.

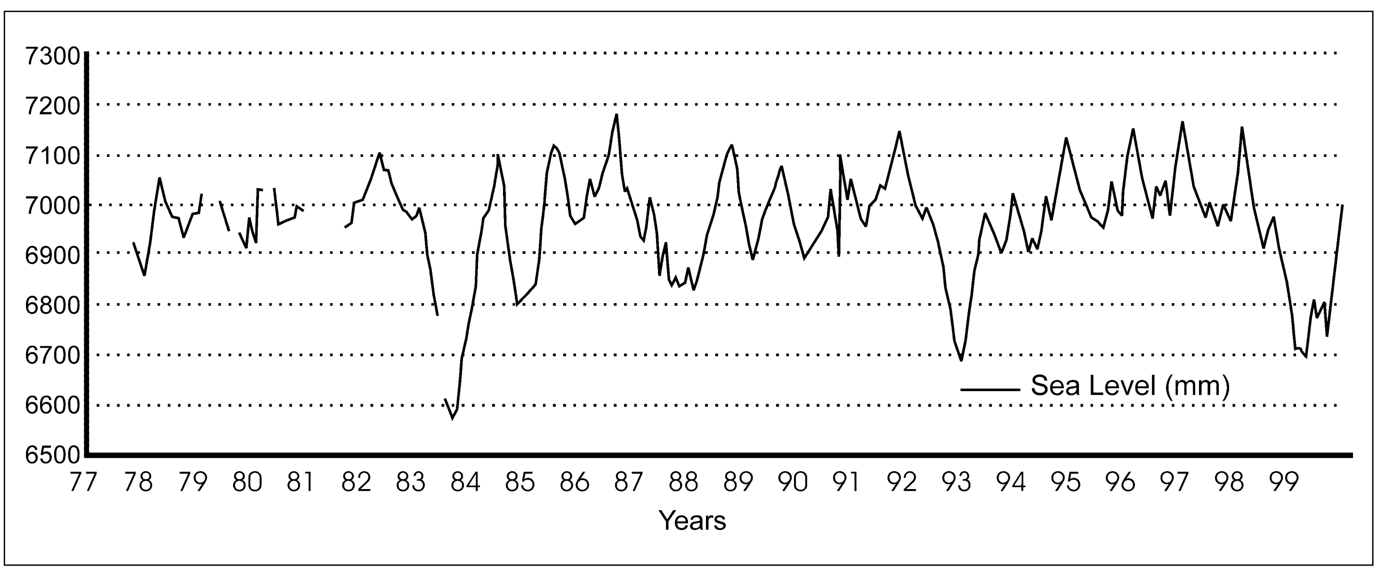

Fig. 23. Monthly mean sea level for the period 1977–1998 for Tuvalu's main atoll, Funafuti, in the tropical Pacific Data is from the Permanent Service for Mean Sea Level (PSMSL). PSMSL has been responsible for the collection, publication, analysis and interpretation of sea level data from the global network of tide gauges. It is based at the Proudman Oceanographic Laboratory (POL), Bidston Observatory that is a component of the UK Natural Environment Research Council (NERC).

Nguyen and Walsh (2001) simulated the occurrence of hurricanes in the Australia region using a GCM that assumes a tripling of CO_2. The results showed that the numbers of hurricanes declined in a greenhouse-warmed world and that the decline is statistically significant. In a study of Atlantic hurricanes, Goldenberg et al. (2001) show that they occur in distinct multidecadal cycles and are linked to sea-surface temperature anomalies in the Atlantic Ocean's main hurricane development region. Warm anomalies are associated with increased major hurricane activity; cold anomalies, with suppressed activity. Goldenberg et al. (2001) suggest that increases in the frequency of big Atlantic hurricanes are due to the natural variations in hurricane frequency and intensity rather than global warming.

The media seems to want the storms, extremes of heat and cold, floods and droughts to be caused by global warming. Unfortunately, there is no evidence that they are. In fact, there is research that more warmth means a more stable climate. Karl et al. (1995) point out that an increase in CO_2 should decrease temperature variability. Balling (1998) examined changes in the spatial variability of mean monthly and daily temperatures that have occurred during the historical climate record. His research showed that, overall, the spatial variability in temperature anomalies has declined, and that the interannual variability in temperature anomalies is negatively correlated to mean hemispheric temperatures. Balling et al. (1998) and Michaels et al. (1998) both show that as the atmosphere warms, the month-to-month variability also declines (Fig. 24). Clearly, there is little support for the popular perception that temperatures have become more variable.

There is even a case for reduced climate variability accompanying global warming. The results of a study by Andrus et al. (2002) confirm the results of several other studies that indicate the mid-Holocene was significantly warmer than the present time. Andrus et al (2002) show a situation where a considerably warmer climate than that of the present was apparently unable to sustain significant El Niño activity. This demonstrates that future global warming may lead to fewer and less intense El Niños, which contradicts the predictions of climate dismalists who claim the opposite.

Fallacy Eleven: IPCC's predictions are reasonable.

The IPCC's treatment of emission scenarios has been criticized as merely the personal opinions of their creators who seem uninterested in procedures for checking whether any of the scenarios agree with past or future trends (Gray, 1998). In particular, recent unwelcome changes in greenhouse gases are ignored. Carbon dioxide emissions from combustion of fossil fuels have fallen for the years 1997 and 1998. Over half the models listed in Chapter 9 of IPCC 2001 (IPCC, 2001a), which deals with emissions, assume that carbon dioxide in the atmosphere is increasing at the rate of about 1% a year, when the measured rate of increase, for the past 33 years, has been half this. The effect of this is to boost future projections of warming.

It is also noteworthy that the rate of increase of the only other important greenhouse trace gas, atmospheric methane, has fallen steadily for the past 17 years and, since 1998, there has been a fall in atmospheric concentration (Figs. 3, 25). Unlike CO_2, methane in the atmosphere decomposes rapidly — within about 10 years — so that the atmospheric concentration depends on a constant source of supply. Clearly, methane's importance as a greenhouse gas is decreasing, despite the emphasis placed on it by the IPCC and by Kyoto Protocol negotiators.

In any analysis of CO_2 it is important to differentiate between three quantities: 1) CO_2 emissions, 2) atmospheric CO_2 concentrations, and 3) greenhouse gas radiative forcing due to atmospheric CO_2. As for the first, between 1980 and 2000 global CO_2 emissions increased from 5.5 Gt C to about 6.5 Gt C, which amounts to an average annual increase of just over 1%. As regards the second, between 1980 and 2000 atmospheric CO_2 concentrations increased by about 0.4 per cent per year. Concerning the third, between 1980 and 2000 greenhouse gas forcing increase due to CO_2 has been about 0.25 W m^{-2} per decade (Hansen, 2000). Because of the logarithmic relationship between CO_2 concentration and greenhouse gas forcing, even an exponential increase of atmospheric CO_2 concentration translates into linear forcing and temperature increase; or, as CO_2 gets higher, a constant annual increase of say 1.5 ppm has less and less effect on radiative forcing, as shown in Figure 3. Leaving aside for the moment the satellite temperature data and using the surface data set, between 1980 and 2000 there has been this linear increase of both CO_2 greenhouse gas forcing and temperature. If one extrapolates the rate of observed atmospheric CO_2 increase into the future, the observed atmospheric CO_2 increase would only lead to a concentration of about 560 ppm in 2100, about double the concentration of the late 1800's. That assumes a continuing increase in the CO_2 emission rate of about 1% per year, and a carbon cycle leading to atmospheric concentrations observed in the past. If one assumes, in addition, that the increase of surface temperatures in the last 20 years

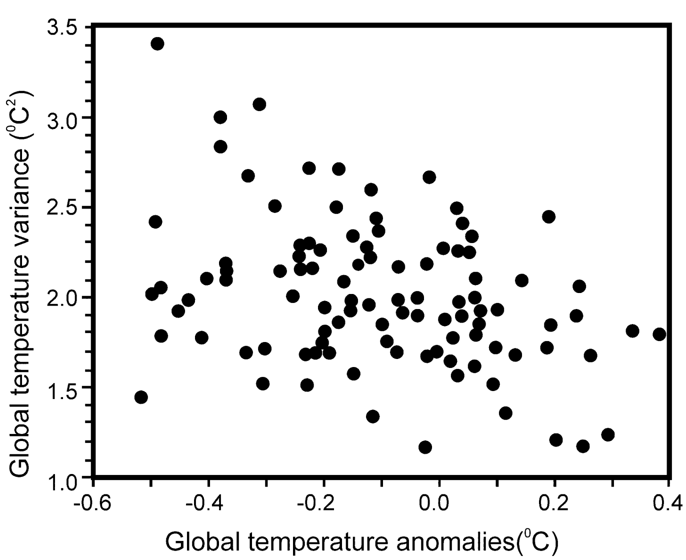

Fig. 24. Inter-annual surface temperature variability vs. global temperature anomalies for the 1897-1997 time series showing the warmer the surface temperature, the less variable climate becomes. Source: Michaels et al. (1998).

(about 0.3 °C) is entirely due to the increase in greenhouse gas forcing of all greenhouse gas, not just CO_2, that would translate into a temperature increase of about 1.5 °C (or approximately 0.15 °C per decade). Using the satellite data, the temperature increase is correspondingly lower. Based on this, the temperature increase over the next 100 years might be less than 1.5 °C, as proposed in Figure 19.

The IPCC (2001a) estimates that the direct warming contribution of a doubling of CO_2 is about 1.2 °C. Given that the 560 ppm CO_2 concentration for 2100 would be about double the concentration of the late 1800's, there would be a direct warming of 1.2 °C over late 1800's temperatures. That amounts to about 0.06 °C per decade, which is close to warming trends for the Northern Hemisphere from the satellite data. Additional warming forecast by the IPCC comes from the much higher emissions and concentration growth assumed by the IPCC SRES scenarios and amplifying feedbacks in the models that appear to be based on the assumption that the atmosphere is more sensitive to greenhouse gas induced climate change than is the case (Lindzen et al., 2001). Thus, by matching observed warming to observed forcing, anticipated warming can be more than about 0.7 °C in the next 50 years (Michaels and Balling, 2000; Allen et al., 2000; Hansen, 2002). Such a modest global temperature change would undermine the widespread concern generated so far by the exaggerated claims and hyperbole of the IPCC and the green lobby groups.

Microscopic airborne particles called aerosols can have a significant effect on global climate because they tend to cool the surface. If included in climate models, the UN IPCC 100 year prediction would include the possibility of less warming or even cooling. IPCC 2001a (p. 334) states in Chapter 5 on "Aerosols, Their Direct and Indirect Effects": "The largest estimates of negative forcing due to the warm-cloud effect may approach or even exceed the positive forcing due to long-lived greenhouse gases." But the SPM has suppressed the significance of the negative radiative forcing that can arise from an increase in some types of aerosols. Characterization of these climate forcing agents and their changes over time is required to project what climate changes could lie ahead. Figure 3 in the IPCC 2001 WG1 SPM (IPCC, 2001b) shows current estimates of the radiative forcing due to increased concentrations of atmospheric constituents and other mechanisms. Figure 3 illustrates the considerable effect of aerosols on radiative forcing and the text plainly states that an ability to predict future climate requires an understanding of the effect of these aerosols on radiative forcing. Nevertheless, the IPCC excludes them from the projections of future climate. This is a major omission.

Figure 3 in IPCC (2001b) shows estimated forcings for five classes of aerosols (Fig. 20). For four of these classes there is also a vertical error bar which the legend explains "indicates a range of estimates, guided by the spread in the published values of the forcings and physical understanding." In addition, each class is labelled with a "Level of Scientific Understanding." One class is labelled "Low" and the other four are labelled "Very Low." No explanation of these uncertainty levels is provided. Wojick (2001) points out that, in the UN IPCC's 1995 Second Assessment Report (Houghton et al., 1996, p. 117), an earlier version of this same figure appears as Figure 2.16. Here, it is explained that the levels "low" and "very low" are "our subjective confidence that the actual forcing lies within this error bar." In fact, the levels are called "levels of confidence" not "levels of understanding." Wojick (2001, p. 12) states:

> In plain language, this means that the chances that the aerosol forcings actually lie within the error bars are very low in most cases. Conversely, it is very likely that the actual forcings lie outside these error bars. What then is the likely range for these forcings? We are not told, in fact the very issue, which was at least alluded to in the IPCC SAR, has now been entirely omitted.
>
> The truth is that the possible range of forcings is very large, much larger than the error bars show. Therefore the range of aerosol forcings is much larger than the ranges for the greenhouse gases, which are shown to have a "high" level of understanding. If the correct error bars for aerosols were shown — bars that display the likely range of forcings — they would be seen to overwhelm the greenhouse gas forcings.
>
> In short we simply do not understand aerosol forcing. In fact a recent paper, Charlson et al. (2001), claims that the range of possible forcings is as much as twice the very large range that is not shown in the TAR.

The IPCC deals with this lack of understanding of aerosols forcing in a curious fashion. It states (IPCC, 2001b, p. 13 and Footnote 11): "The globally averaged surface temperature is projected to increase by 1.4 to 5.8°C over the period 1990 to

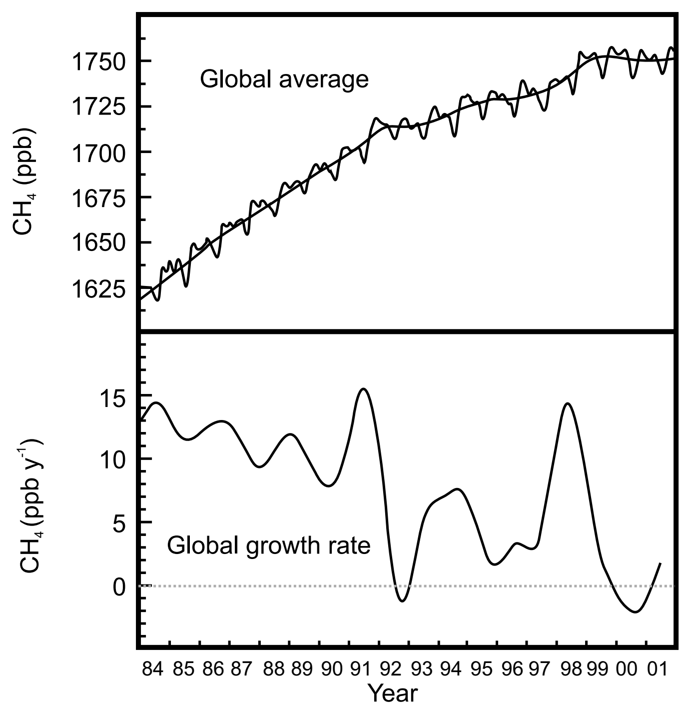

Fig. 25. Global average atmospheric methane (top) and global average growth rate (bottom). Source: The National Oceanic and Atmospheric Administration (NOAA), Climate Monitoring and Diagnostics Laboratory (CMDL).

2100. These results are for the full range of 35 SRES scenarios, based on a number of climate models." And, Footnote 11 states: "This range does not include uncertainties in the modelling of radiative forcing, e.g. aerosol forcing uncertainties." Thus, the IPCC has simply ignored the large aerosol uncertainties, and no reason is given. Clearly, if they were included, predicted warming rates might be considerably lower, or non existent. According to Wojick (2001, p. 13): "It is hard not to see this as scientific fraud."

In summary, CO_2 is increasing in concentration linearly at the rate of 0.4% a year, and as a result, agricultural and forestry yields are increasing. There are no established harmful effects of this increase. The rate of increase of the only other important greenhouse gas, methane, has fallen steadily for the past 17 years and the concentration is currently falling. Computer climate models are based on the incorrect belief that changes in the greenhouse effect are the only influences on the climate, and the role of aerosols has been omitted. There are huge uncertainties in the model outputs which are unrecognized and unmeasured. They are so large that adjustment of model parameters can give model results which fit any climate, including one with no warming, and one that cools. No model has ever successfully predicted any future climate sequence. Despite this, future "projections" for as far ahead as several hundred years have been presented by the IPCC as plausible future trends, based on hypothetical and, some say, largely distorted "storylines", combined with untested models. The IPCC has provided a wealth of scientific information on the climate, but has not established a case that increases in CO_2 are causing any harmful effects. Model uncertainties are so great that the models are quite unsuitable for any form of future projection.

Fallacy Twelve: Observed temperature trends are those predicted by climate models.

The inadequacies of the climate models were recognized early on (Houghton et al., 1990, p. 321): "If the atmosphere and the upper-ocean alone were responding to the increase in greenhouse heating and the cloud-radiation feedbacks operated according to current knowledge, then the surface of the earth would already be 1 to 2 degrees C warmer than the temperatures of the nineteenth century." So far, the climate models are, in effect, unproven hypotheses, since observations of the past 100 years are not consistent with model's calculations. The shortcomings of the models call attention to the need for research into discrepancies between observations and GCM theories: to explain why increased radiative forcing by CO_2 has not produced the expected global temperature rise, and in particular, why the highly accurate satellite data show no global warming.

The most likely explanations lie in negative feedback processes that counteract warming from increase concentrations of greenhouse gases, or solar effects that offset or are mistaken for an enhanced greenhouse effect. The most obvious negative feedback would come from increased cloudiness.

Orthodox greenhouse theory says CO_2 warms the oceans, which causes more evaporation, which puts more water vapour (the dominant greenhouse gas) into the atmosphere, and this leads to more warming and so on until the final warming becomes several times larger than the initial CO_2 warming which triggered it. Without this positive feedback built into most climate models, the calculated temperature increase due to, say a doubling of CO_2, would be only in the vicinity of 1 °C. Initially the IPCC dismissed this and any research that suggested anything to the contrary, as illustrated by this statement in IPCC 1990 (Houghton et al., 1990, p. 78): "The best understood feedback mechanism is water vapour feedback, and this is intuitively easy to understand." With time, views slowly changed, and this is reflected in the 1996 IPCC report: "Feedback from the redistribution of water vapour remains a substantial uncertainty in climate models…" (Houghton et al., 1996, p. 201). Recent work (Chen et al., 2002; Wielicki et al., 2002) supports the scale and significance of the negative feedback mechanism advocated in 1984 by Ellsaesser (1984), and later by Lindzen (1990), that has been used to explain why observed global warming is so much less than predicted by conventional climate models. Both show that the process starts with increased convective activity in the tropics leading to an intensification of the Hadley circulation. This in turn leads to increased subsidence in the return flows in the extra-tropical zones. Drying of the upper troposphere leads to increased longwave emission into space from the water vapour in the warm boundary layer. This produces negative feedback, reducing the warming effects of increased CO_2 and therefore the sensitivity of global climate to changes in CO_2 (Singer, 1997, p. 52; see also Hartmann, 2002). The resulting sensitivity is considerably lower than that suggested by the IPCC (Fig. 21). Thus, there is now persuasive evidence that errors inherent in the climate models cause over-prediction of the rate of future global warming.

Fallacy Thirteen: There is a consensus that greenhouse induced climate change is a major threat.

Scientific issues are not decided by ballot. They are resolved by observations that support a theory or hypothesis. In 1990, the IPCC claimed their report represented the "consensus" view of science, and this was used by some as an excuse for discouraging debate. Consensus, however, is like models. Neither are evidence, or proof, of global warming claims. The views of scientists who objected to the IPCC stand were dismissed as those of a "fringe group". However, the increasingly large number of critics and the presence of their opposing views in the peer reviewed scientific literature led the IPCC and environmental groups to abandon the "consensus" claim.

The study of climate change is a relatively new science. It is both complex and inter-disciplinary and its methods are still crude. Most important, its analyses suffer from a paucity of long-running observational data. Despite this, the work published by the IPCC has never displayed signs of the contention and debate on which the advancement of scientific understanding necessarily depends. Scientists are a well-educated, diverse and ill-disciplined assortment of freethinkers. And yet, consensus has been paramount in the workings of the IPCC. One wonders where the dissidents are among the IPCC scientists, especially those who contribute to the SPMs.

Fallacy Fourteen: The threat of human-caused climate change justifies taking the action proposed in the UNFCCC and Kyoto Protocol.

The United Nations Framework Convention on Climate Change (UNFCCC) is a product of the 1980s, following the First World Climate Conference in Villach, Austria. But research, science, our knowledge and understanding is increasing and improving constantly and at an accelerated pace. According to recent findings, human-caused CO_2 growth rates are levelling off (Table 2, Figs. 2, 3), despite increased emissions (Hansen and Sato, 2001). Human influence on global climate is less than previously thought, probably because climate is not so sensitive to greenhouse gases as earlier believed. Most important, there is no evidence of catastrophic man-made global warming, thus throwing doubt on the IPCC predictions.

The Kyoto Protocol, although economically costly, would be ineffective in reducing the calculated temperature increase. Wigley (1998) shows that the 1997 Kyoto Protocol (calling for an average cut in greenhouse gas emissions of 5.2% from 1990 levels by industrialized nations by the year 2010) is not sufficient to significantly reduce the growth of greenhouse gases in the atmosphere; therefore, its effect on temperature would be imperceptible (Fig. 26). The required emission cuts by OECD countries would, according to the climate models, reduce warming by as little as 0.07°C by 2050. Reductions of this size would be lost in the noise of natural climate variability. So, in addition to being ineffective, costly, and unfair to industrialized nations, the Kyoto Protocol is also unnecessary.

Table 2.
Emissions of CO_2, atmospheric increase of CO_2 and percentage CO_2 uptake compared for the periods 1980-1989 and 1990-1999. According to IPCC SPM (IPPC, 2001b, p. 12): "As the CO_2 concentration of the atmosphere increases, ocean and land will take up a decreasing fraction of anthropogenic emissions". But information from Table 3.1 on page 190 of the WG1, IPCC 2001 main report (IPCC 2001a) shows an increase in CO_2 uptake. The net effect is less CO_2 in the atmosphere despite increasing emissions (see Fig. 2).

	1980-1989	1990-1999
Emissions (Gt/yr)	5.4	6.3
Atmospheric increase (Gt/yr)	3.3	3.2
CO_2 uptake (%)	39	49

Conclusion

Climate change science is a relatively new area of study. Over the past two decades progress has been rapid, but the findings are uncertain and are likely to remain so into the foreseeable future because of the complexity of climate and the inadequacy of scientific understanding. The controversy surrounding global warming comes not from the uncertainty of scientific findings, but from attempts by ideologues and interests to promote their own viewpoint or advantage. Scientists, like any one, can be biased, politically motivated and ideologically driven. There is a difference between scientific findings and speculation by scientists. Often the public is not told which is which.

The concepts of scientific 'proof', 'evidence' and 'truth' are also open to manipulation. Consider the issue of temperature record (i.e. use of measurements from thermometers a few feet above the ground versus those from satellites), which has been discussed here in some detail. The IPCC chose to use the surface temperature record rather than the more accurate satellite record. Sceptics wonder why. Taking into account the error limits on the surface record, the two records show a high degree of correlation, and although the trends differ slightly, the IPCC opted for the more dramatic one. To take one record as the 'truth' and ignore the other is non-scientific. Clearly, it is necessary to resist the temptation to select only data that support a hypothesis and ignore other available data.

Global warming involves a scientifically realistic mechanism that links climate change to the concentration of greenhouse gases in the atmosphere. Beyond this, scientists must be careful what they say in 'summary' statements to the public. It is extremely important to make it clear that there is debate rather than a consensus of opinion on the subject. Criticism for the failure to emphasize this is being directed at reports by governmental climate panels and some environmental groups claiming to speak on behalf of scientists. The content of the IPPC's Summaries for Policymakers epitomizes this. The SPMs are cleverly biased reports on climate change science. A SPM clearly based of scientific knowledge would be more credible, and more useful for ideologues of all persuasions.

A balanced summary would include the following statement. Although the future state of global climate is uncertain, there is no reason to believe that catastrophic change is underway. The Earth's surface has warmed slightly, but floods, droughts, hurricanes and tornadoes have not changed for the worse. The atmosphere may warm because of human activity, but if it does, the expected change is unlikely to be much more than 1 °C, and probably less, in the next 100 years.

A lot of very complex work has been done on general circulation models (GCMs) over the past 20 years; of which none has been verified by evidence. Satellites provide the best evidence and this does not show the warming trend predicted by the GCMs. Even the climate models promoted by the IPCC do not suggest that catastrophic change is underway. They suggest that increases in greenhouse gases are likely to give rise to a warmer and wetter climate in most places, in particular, warmer nights and warmer winters. Generally higher latitudes would warm more than lower (equatorial) latitudes. This means milder arctic winters and, coupled with increased atmospheric CO_2, it also means a more robust biosphere with more forest, crops and ground cover for more animals and people. This is

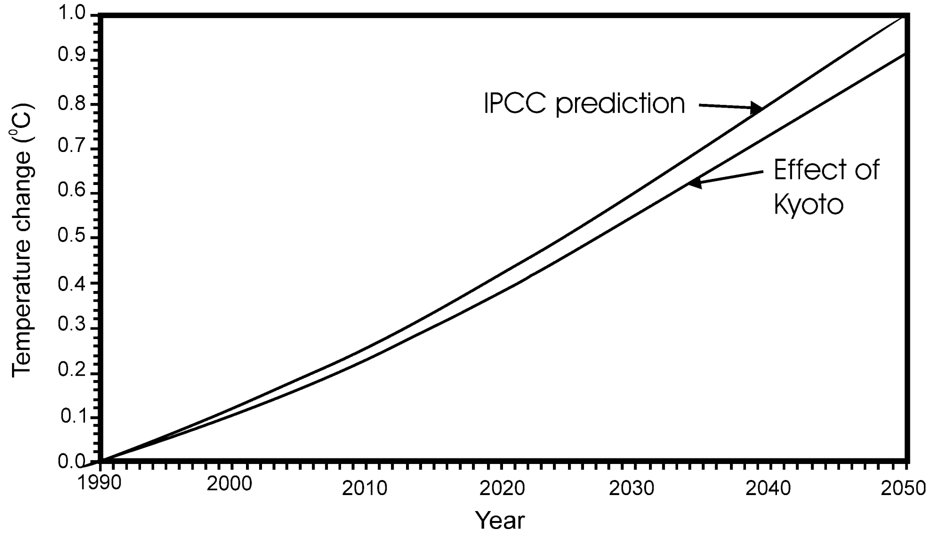

Fig. 26. The effect on global temperature rise of cuts in greenhouse gas emissions proposed by the Kyoto Protocol (Wigley, 1998). Upper line is the projected temperature rise based on IPCC projections of what would occur if greenhouse gases were to continue to increase into the next century; labelled the "IS92e" scenario. The lower line is the temperature rise that would occur if emissions were stabilized at 1990 levels, as proposed by the Kyoto Protocol; labelled the "IS92d" scenario. The figure shows that by 2050 the Kyoto stabilization emission policy would have reduced temperature rises by less than 0.1 °C, and would be even less under the modified "New Kyoto" proposal shown in Fig. 27.

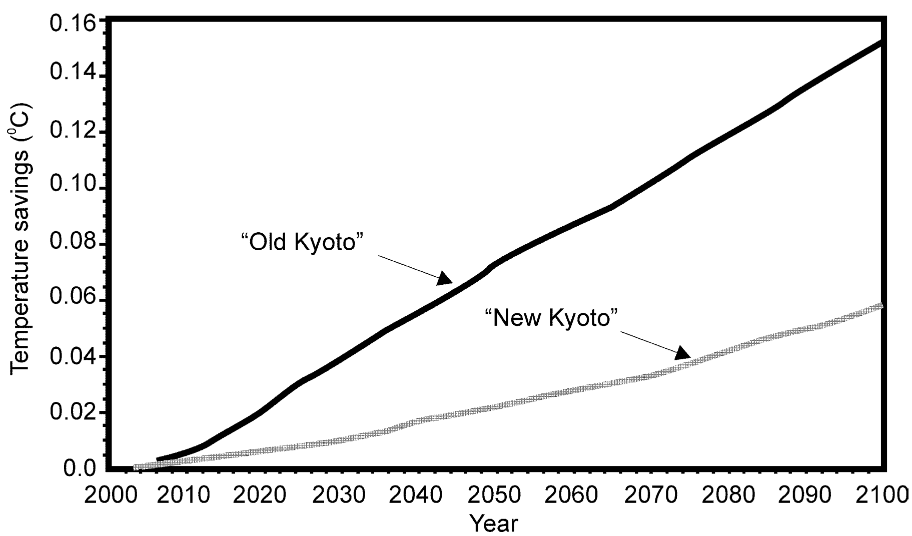

Fig. 27. The effect on global temperature rise of cuts in greenhouse gas emissions proposed by the "Old" Kyoto Protocol drafted in 1997 and the "New" Kyoto agreement drafted in July 2001. The Old Kyoto required that the major industrialized nations reduce their emissions of carbon dioxide to 5.2% below 1990 levels beginning in 2008. The New Kyoto requires 1.8% below 1990 levels at the same time. Assuming global temperature rises by 2.5 °C for a doubling of atmospheric carbon dioxide, which is the standard IPCC assumption, the Old Kyoto produces a world, in 2100, whose surface temperature is 0.15°C lower than it would be if no one did anything; the New Kyoto, a temperature that is 0.06°C lower. The effect on global climate change of either one would be imperceptible. Expressed in another way, the New Kyoto delays the 2.5°C warming by 288 days. Source: World Climate Report, 2001c.

hardly a major threat. Warming, from whatever cause, is more likely to produce economic benefits than economic losses. A more likely threat is policies that endanger economic progress. For many countries, the negative impact of such policies would be far greater than any change caused by global warming.

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