# Is There Really a Greenhouse Effect?

**Roger Braddock**

*'The Greenhouse Effect' has entered the language: in scientific journals, popular media, government policy and school curricula it is assumed to be a reality. But is this assumption valid? An environmental scientist assesses the evidence and finds it wanting.*

A considerable debate has developed in the scientific and general literature on climatic change and the Greenhouse Effect. Most of the general scientific literature, including the more prestigious publications such as *Science* and *Nature*, regularly contain articles dealing with aspects of these phenomena. Such articles often start from the premise that Greenhouse is a reality and then proceed to assess the likely physical, biological and social consequences. The debate has also spilled over into the electronic media. The Prime Minister has been moved to provide funding for research in the area, to suggest that no reasonable request will be refused, and to make major policy statements with significant implications for the conduct of economic and social life.

Thus, while the Greenhouse scenarios are only predictions, they are being used for far-reaching social, planning and other decisions. There is, however, still considerable doubt as to the extent of the Greenhouse Effect, if not some questioning of its existence. The more scientific literature now carries articles which raise serious questions as to the strength and consistency of the scientific evidence of the Greenhouse Effect.[1] This in turn gives rise to questions about the accuracy and reliability of the climate predictions which are being made in the name of the Greenhouse.

A detatched review of the scientific evidence on which many of the Greenhouse assumptions and predictions are based must conclude that the case is not proven and that even a reasonable level of certainty may not be available for some time. Our doubts as to the outcomes must be taken as a moral responsibility to find out more, rather than to wait and see. And, there are in any event other sound environmental reasons to adopt recycling programs, conserve the use of resources and to control pollution emissions. But we should not at this stage rest fully the case for programs of action on possible Greenhouse scenarios.

## The 'Greenhouse' Gases

The Greenhouse Effect is generally recognized as the heating of the global atmosphere through the trapping of radiant energy in the atmosphere by the Greenhouse gases. Radiation from the sun arrives on earth as short-wave radiation, penetrates relatively easily to the surface and may re-radiate generally in the long-wave end of the spectrum. This long-wave radiation is more readily absorbed by the Greenhouse gases and may be trapped, potentially leading to a hotter atmosphere. The Greenhouse gases include carbon dioxide, methane, nitrous oxides, chlorofluorocarbons (CFCs), ozone and water vapour. The sources of these gases vary, but they are derived generally from the carbon cycle involving the burning of oil, gas and coal.

Since the industrial revolution the carbon dioxide concentration has increased by about 25 per cent.[2,3] This increase is generally attributed to our use of fossil fuels and the evidence shows a world-wide consistency. A further doubling of carbon dioxide concentration in the next 60-80 years is predicted by some experts, the predictions being based on projections of the consumption of fossil fuels[2] and population growth rates. Comparable historical trends for the other Greenhouse gases are not available as their potential significance has only been recognized in the last decade. Available evidence suggests that methane has been increasing at about one per cent p.a. since the late '70s; nitrous oxides are increasing at about 0.2 per cent p.a. and CFCs at a rate of five to seven per cent p.a.[4] All of these gases are radiatively more active than carbon dioxide in absorbing long wave radiation from the earth's surface. Generally, therefore, there is no doubt that the gaseous composition of the atmosphere has changed and that the radiatively active gases are increasing in concentration in the atmosphere.

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## Atmospheric Temperatures

How has the increase in concentration affected temperatures to date? Temperature has been recorded at various points on the earth's surface for periods of a century or more. During that time, measurement techniques have changed, as has the environment at the points of measurement.

Recently, scientists reported on a study of temperature measurements at 1,219 stations in the USA, taken over the period 1901-1984.[5] This analysis, which attempted to correct for measurement difficulties and the well-known effects of cities[6] in creating localised heat islands at particular points of measurement, could find no long-term upward trend in temperatures. This is an example of a regional study and such studies often reveal a high level of variability.

Parlange[7] has reported a slight recent rise in global mean temperature, but that is still within normal statistical variations based on known temperature records. Other studies suggest a mean global heating of approximately 0.4° C in the last 100 years[8] and this has come to be a widely accepted figure. However, our temperature record for the earth's surface is very patchy, with few long-term records for the surface covered by the oceans. Confidence in the accuracy and reliability of the 0.4°C change is not high. However, the general trend of an increase in temperature has been established; the magnitude of the change is more open to question. It does lead to a questioning of the cause of the change, and the role played by carbon dioxide. This change has little to do with the model predictions (see below) but is used heavily in the politics of the Greenhouse debate.

## Global Climate Modelling

A key question that arises in assessing the potential Greenhouse Effect is the reliance that can be placed on predictions of changes in climate over, say, the next fifty years as a result of the increase in Greenhouse gases. The main source of such predictions is the output from mathematical and computer-based models of the atmosphere and its physical and chemical processes. The relationships between the movement of the atmosphere and the physical properties of pressure and temperature, and physical processes such as radiation and atmospheric mixing, can be expressed in mathematical form. Hence the models are process based and do not incorporate historical trends.

Currently, the models attempt to model the common Greenhouse gases. Frequently the effects of other gases, such as sulphur dioxide, are omitted, or modelled poorly, e.g. water vapour. As additional information becomes available, it may be incorporated in existing or new models. The effects of the various gases are incorporated in the model through the prediction of future concentration and emissions. The predicted concentrations are incorporated in the related dynamical processes and resulting equations. These equations are then translated to computer code and placed in a suitably large computer.

Such models are just that; they are models which attempt to approximate a reality which is extremely complex. Due to the finite size of even the largest computers, the models are necessarily restricted. Thus, areas as large as 100,000 square kilometres are treated as a single uniform entity or a point; and areas the size of Tasmania may not even be represented in the model. Again, some processes, such as thunderstorms, are small relative to the spatial scale of the model and are not included in the model.

The models also need large amounts of input data, including input radiation from the sun, and information about the input of gases such as carbon dioxide from the surface of the earth. The output from the models constitute spatial and temporal predictions of the weather and climate. The Australian Bureau of Meteorology argues that the three models – GISS, NCAR, and GFDL – are reputable.[4]

Although the results obtained from these models vary, they tend to predict a heating of the atmosphere generally in the range from 2°C to 5°C over the next 50-100 years. Naturally, the results depend on the input of gases being used in the model and the range of predicted temperatures relates to the concentrations of carbon dioxide used as input. The results are also heavily dependent on the region of the earth's surface which is being considered. The results all show a high variability in the distribution of the rainfall, e.g. one predicts a wet north and dry south in Australia while a second predicts the reverse.

An obvious question to ask is how good are these models and what reliance can be placed on their predictions? It should be noted that these self-same models are used in short-term weather prediction. Sceptics like myself would point out that current weather forecasts can predict weather patterns for only a few days and even then with some imprecision. But the Greenhouse scenarios are based on predictions from the models, extending 50 and 100 years into the future.

Weather models also suffer from the Butterfly Effect discovered by Lorenz in the early 1960s, which showed that even a minute change in the input data can have major effects for the global prediction from the model. Lorenz ran duplicate simulations on computers, where the input data differed only marginally, often only in terms of seemingly insignificant decimal factors. He obtained predictions which started from the same initial point. However, the output of predictions then gradually differed until, after about 30 days they bore little resemblance one to the other. The effect has been confirmed, and results from the need of the models to have precise input data on gases, and surface factors.

## Water and Water Vapour

In considering the adequacy of the modelling, attention must also be focused on one of the most common Greenhouse gases: water vapour. The high specific and latent heats of water imply that it is a major factor in determining the location and transport of energy in the atmosphere. Kerr has observed that the weakest part of the climate modelling is in the simulation of the clouds and related processes.[9] The different scale sizes of clouds, and of the numerical grid systems, present a serious problem yet to be fully addressed. Further, the generation of precipitation is not fully or properly modelled in many of the models. Increasing temperatures, if realized, would see more water vapour in the atmosphere, and would add to these uncertainties.

Further, clouds and water vapour also affect the radiation balance, and the effects are not fully understood. Ramanathan et al investigated the effects of clouds on the local radiative balance[10] and showed that the *cooling* effect of water vapour can be up to three times as strong as the heating effect of the current concentrations of carbon dioxide.

Clearly, therefore, water vapour has the potential to counteract the heating effects of carbon dioxide, at least at current and predicted concentrations of the latter. Future global climate modelling will need to pay greater attention to this factor.

## Testing the Models

Generally, it is not yet possible to assess fully the predictions of the computer models. The science and the resultant models are recent developments and insufficient time has elapsed to permit statistical comparison between the predicted and observed climate. However, testing and validation of these models can be carried out by simulating past and present weather conditions and by comparing the computer predictions with the historical record. Estimates of the historical atmosphere can be obtained from bore holes in ice sheets such as in Antarctica. Estimates of temperature and sea level changes have also been obtained using geomorphological techniques.[11]

When projected back over the last century, the models generally 'predict' an increase of approximately 1°C in temperature.[12] This is more than double the generally accepted value of 0.4°C obtained from observation.

In an interesting experiment, COHMAP simulated climatic change over the last 18,000 years.[13] They used historical climate data and drove the model through centuries of prehistoric weather cycles. Their general result was that solar radiation change and climate change were induced, in general, by orbital changes of the earth and associated bodies. This supports the geomorphological hypothesis of the causes of climatic change as expressed in the literature.[14] Thus the historical temperature record is intricately linked to variations in the orbit of the earth.

## Ocean Effects

Mention must also be made of the great heat engine of the earth's surface, the ocean. The high specific heat of water makes the ocean the repository of enormous energy and its interaction with the atmosphere is crucial in determining weather and climate. Yet, the air-sea interactions have generally been ignored in the current generation of global climate models.

These air-sea interactions are in fact not yet fully understood and it is only recently that coupled air-sea interaction models have been built. This involves a further level of complexity in the modelling and eventually the initial models will be seen as crude, inefficient and inaccurate. Major improvements are needed in the understanding of the physics, mathematical and numerical modelling and in computing power. However, it is very sobering to note that the more recent air-sea interaction model predicts a net *cooling* of the oceans south of Australia of about 4°C.[15]

Finally, there is the question of the projected rise in sea level associated with the assumed global warming. This projected rise involves the range of factors discussed above as well as the interactions of ice, radiation and ocean currents. This complex area is the least well understood of all of the Greenhouse scenarios. Indeed, one of the leading analysts of possible changes in the sea level, Robin, has commented that there are "so many deficiencies in our knowledge of the factors affecting sea change, that simple linear correlation from previous observations and records was the only avenue for prediction."[16] He acknowledges that the data used in his model are scattered, that the relationship should be non-linear and involve variables other than temperature, and that sea level effects would lag temperature effects. Indeed, the lag should be in the order of decades to centuries, given the relatively slow mixing of the deep ocean. It is well-known that deep ocean currents of great age can be identified e.g. North Atlantic Deep Water.[17]

Robin also points out that the method of predicting sea level changes has severe limitations in that the calculation is derived on the basis of assumed temperature ranges of approximately 0.4°C over the past century. However, the predictions involve extrapolation to much greater temperature ranges. These predictions range from an increase of 0.32M up to 1.5M in sea level, corresponding to a temperature range from 2°C to 5°C.

## Conclusions

The foregoing raises several questions for practitioners and policy makers who have to deal with estimates of climate variability and change and make decisions based on them. Conner concludes that undue attention has been given to the upper end of the range of predicted temperature and sea level change and that the advice to engineers is not sufficiently proven or detailed to provide a base for planning.[18] Indeed, the sparsity of the scientific evidence raises questions as to the legal and financial liability on engineers and planners with regard to their activities, particularly in the area of professional negligence, if they incorporate Greenhouse effects into planning and project design. Conner also traces the way in which Robin's source calculations of changes in sea levels have "been adapted and interpreted through a number of authors."

In the Greenhouse debate, much of the sparse evidence is thus conflicting and inconclusive and does not provide any strong causal relationships between the variables. There is a sparsity of information with regard to the essential physics and dynamics of the atmosphere, clouds and ocean and the models are deficient in their handling of water and water vapour, particularly as cloud. Again, the interrelationships between temperature and sea level are poorly understood and the simple extrapolations leave little room for scientific confidence.

In terms of establishing whether there is a Greenhouse Effect, I find the current level of scientific evidence unconvincing. While there is no doubt that the concentration of radiatively active gases in the atmosphere has increased over the past 100 years and will go on increasing if recent rates of consumption of fossil fuels are maintained, it is by no means established that this will result in increased global temperatures. The natural tendency of the increased concentration of gases to lead to higher temperatures may be offset by other natural forces, such as the effects of water vapour and interactions between the air and the sea. Nor is it clear, even if higher temperatures do occur, what the effects would be on weather patterns or sea levels. The Greenhouse case is not proven. ■

*Notes*


1. Schneider, S., "The Greenhouse Effect: Science and Policy", *Science*, Vol. 243, p. 771, February 1989.
2. Nordhaus, W. D. and Yoke, G. W., "Future Carbon Dioxide Emissions from Fossil Fuels", *Changing Climate*, National Academy Press, Washington D.C., 1983.
3. Pittock, A.B., "The Greenhouse Effect", *Engineers Australia*, Vol. 59, pp. 40-43.
4. Bureau of Meteorology, *The Climate Issue*, Canberra, February 1989.
5. Karl, T. R., Baldwin, R. G. and Burgin, M. G., *Time Series of Regional Season Averages of Maximum, Minimum and Average Temperature Across the USA*, National Oceanographic and Atmospheric Administration,, Asheville, N. C., March 1988.
6. Abelson, P., "Climate and Water", *Science*, Vol 243, p. 461, January 1989.
7. Personal communication with Dr. M. Parlange, Princeton, 1989.
8. For example at the Climate Research Unit of the Goddard Institute for Space Studies (Schneider, op cit).
9. Kerr, R., "The Weakest Part of Climate Modelling is the Cloud Simulation", *Science*, Vol. 243, p. 11, January 1989.
10. Ramanathan, V., Cess, R., Harrison, E., Minnis, P., Barkstone, B., Akmad, E., Hartman, D., "Clouds and Radiation Balance", *Science*, Vol. 243, p. 87, January 1989.
11. Lorius, C., Merlivat, L., Duval, P., Jouzel, J. and Pourchet, M., "Evidence of climatic change in Antarctica over the last 3,000 years, from the dome C Ice Core", *Sea Level Ice and Climatic Change*, edited by I. Allison, International Association of Hydrological Sciences, publication 131, 1979.
12. Schneider, S., op. cit.
13. COHMAP, "Climate changes of the last 18,000 years; Observations and Model Simulations", *Science*, Vol. 241, p. 1,043, August 1988.
14. Budd, W. F., "The importance of ice sheets in long term changes of climate and sea level", *Sea Level Ice and Climatic Change*, edited by I. Allison, International Association of Hydrological Sciences, Publication 131, 1979.
15. Bureau of Meteorology op cit and personal communication.
16. Robin, "Changing Sea Level" in Bolin *The Greenhouse Effect*, John Wiley, 1986.
17. Kerr, R., "Linking Earth, Ocean and Air at the AGU", *Science*, Vol. 239, p. 259, January 1988.
18. Conner, T.B., *Tracing Sea Level Rise Scenarios*, Cameron McNamara and Kinhill, Brisbane, 1989.


*Other References*


Australian Academy of Science, *Climatic Change*, Report No. 21, March 1976.

Ramanathan, V., Barkstrom, B., and Harrison, E., "Climate and the Earth's Radiation Budget", *Physics Today*, p. 22, May 1986.

Somerville, R., "Clouds and Climate Regulation", *Nature*, Vol. 315, p. 713, June 1985.