The Greenhouse Effect: Fact and Fiction

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THE greenhouse effect is currently getting a great deal of publicity. Any unusual climatic event is widely attributed to it. Dramatic articles and documentaries frequently warn of the dire consequences for mankind of the greenhouse effect if urgent action is not taken to counteract it.

Concern about the greenhouse effect is nothing new. Arrhenius coined the term in 1896 when he warned that a doubling of the carbon dioxide content in the atmosphere would increase mean global temperatures by 5 degrees centigrade. Throughout the 20th century scientists and environmentalists have been warning about it. But only in the last few years has it become a major public issue.

Only ten years ago it was more common to read warnings that the earth was heading towards another ice age. During the 1960s and 1970s, Europe had its coldest winter in 200 years, its driest winter in 200 years, its worst drought in 250 years and hottest month in 300 years. Scientists said it was because the earth was cooling down. And they were right, for the earth was cooling down during this period after reaching a peak in temperature around 1940 following a rising temperature trend dating back to the 19th century.

However, during the 1980s mean global temperatures have risen rapidly and now exceed the 1940 level. Fears of an imminent new ice age have given way to fears of temperature increases unprecedented during the whole period of human existence on this planet. Unfortunately, as often happens in such cases, this has been accompanied by a great deal of exaggeration of the effects, of confusion of scientific facts with scientific hypotheses, and of misinformation due to lack of scientific knowledge by many who have jumped on the greenhouse bandwagon.

This article attempts to separate some of the fact and fiction that has accompanied the publicity about the greenhouse effect during the last two or three years.

The Greenhouse Effect Explained

'The greenhouse effect' is a term used to describe how the atmosphere modifies the temperatures experienced at the earth's surface arising from solar heating.

Without the greenhouse effect, the average temperature on Earth would be around minus 18 degrees centigrade instead of around 15 degrees as it is. Without it, therefore, Earth would probably be a frozen wilderness, and inhospitable to life.

The greenhouse effect arises because certain gases in the atmosphere (such as water vapour and carbon dioxide) are more transparent to solar radiation than to thermal radiation, into which solar radiation is converted when it heats up the earth's surface and the atmosphere. Consequently, heat gets trapped in the earth's atmosphere, heating it and the adjacent earth's surface to higher temperatures than would have occurred if the atmosphere was as transparent to thermal radiation as it is to solar radiation.

The greenhouse effect is not limited to Earth. Venus and Mars also experience it. Venus is indeed an extreme case: it has a dense atmosphere which is 97 per cent carbon dioxide. With no atmosphere Venus would have an average temperature of approximately 30 degrees centigrade. As it is, the greenhouse effect raises it to an average of about 500 degrees. Some writers use the example of Venus as a warning of what could happen to Earth. This is an example of misinformation. The amount of carbon dioxide in the atmosphere is thousands of times greater than that present in Earth's atmosphere.

Contrary to what some writers claim, Mars experiences a greenhouse effect of similar magnitude to that experienced by Earth. It has a much thinner atmosphere but it is 95 per cent carbon dioxide. Mars is colder than Earth because it is further from the sun, not because it experiences no greenhouse effect.

Without the greenhouse effect we could not live on Earth. The current concern is not about the greenhouse effect as such but the effect on it of changing levels of carbon dioxide and other greenhouse gases in the atmosphere, as changes in the concentration of the greenhouse gases can lead to changes in the level of the greenhouse effect.

Records of the carbon dioxide concentration in the atmosphere clearly show that it has been increasing at an accelerating rate since the beginning of the industrial revolution over 200 years ago. It has been estimated that before the industrial revolution the concentration was between 0.028 and 0.029 per cent. At present it is about 0.035 per cent and increasing by approximately 0.002 per cent each decade.

Forecasts suggest that in 40 years the concentration will be at least 0.045 per cent, with 0.06 per cent being mentioned as a possibility if rapid industrialisation occurs in developing countries. The latter would represent a doubling of carbon dioxide concentration since before the industrial revolution.

Forecasts

Forecasts about the effects of the increase in carbon dioxide concentration are based on computer simulations of complex mathematical models of the global atmospheric system. Many simplifications and assumptions have to be made, and opinions differ among those involved, resulting in a variety of models giving a variety of results. However, there appears to be overwhelming agreement that the increasing concentrations of carbon dioxide and other greenhouse gases will eventually result in significant rises in temperatures on a global scale which will in turn produce significant climatic and sea level changes. Only the rate and level of change is in question.

Most of the forecasts that have been published in the media are based on a doubling of the carbon dioxide concentration. This is often coupled with an assertion that these forecasts are likely to be realised in 40 years. This is another example of misinformation. In the next 40 years effective carbon dioxide concentrations, including allowance for other greenhouse gas increases, are more likely to increase by about 50 per cent above today's levels.

Forecasts based on a doubling of the carbon dioxide content are therefore more likely to be realised in 70 or 80 years than 40. This makes them ultimately no less serious, but it does mean that the world has more time to prepare for the changes and develop countermeasures than is often implied in the media.

Rising Global Temperatures

The primary effect of increasing concentrations of greenhouse gases is rising global temperatures. Predictions of the increase in mean global temperatures due to a doubling of the carbon dioxide content range from 1.5 degrees centigrade to 5 degrees, with around 3 degrees appearing the most likely. The models show that the temperature rises will not be uniform around the globe but will be less in the tropics and much greater at the poles.

The average rate of global temperature increase during this century is not inconsistent with these forecasts but the strongest confirmation of their validity comes from ice cores from Antarctica. These cores give a history of the climate in Antarctica over the past 160 000 years including temperature and carbon dioxide levels. They indicate a close correlation between temperature and carbon dioxide levels during this period consistent with the predictions being made from the computer models.

Rising Sea Levels

One of the major consequences of rising mean global temperatures is rising sea levels. Eventually — i.e. in several hundred years — these could be of the order of several metres as a result of the melting of the Antarctic ice cap. Rises of this order will have a dramatic effect in many countries. Within the next 100 years, however, the main cause of rising sea levels will be the expansion of sea water as it warms up.

Forecasts of the rise due to a doubling of the carbon dioxide content vary from 200 mm to 1400 mm with the most likely values being of around 800 mm to 1 metre. These changes are already occurring; some reports indicate a rise of the order of 150 mm this century as mean global temperatures have risen about 0.5 degrees centigrade. This is consistent with the above forecasts.

The records indicate that sea level changes lag behind temperature changes by 15 to 20 years, because of the time water takes to warm up. So the steep rise in temperatures that has occurred during the 1980s has not yet had a significant effect on sea levels.

Climatic Change

The other major consequence of global temperature changes is expected to be regional and local climatic change. However, a much greater level of uncertainty exists about these changes, since our knowledge about the interactions between temperature and climate on this scale is severely limited. The only reasonably reliable forecast is that the climate will get warmer in most places, with the greatest increases being in winter and in colder places. This change in itself is likely to be welcomed in many parts of the world!

Overall rainfall is generally expected to increase, but as this change will not be uniform some places will become drier while others will become wetter than they are now. But most of the rainfall forecasts seem to be based on hypothesis rather than rational analysis and are not very reliable. In Northern Australia, for example, increases of 50 per cent in summer rainfall due to a doubling of the carbon dioxide concentration have been forecast. However, forecasts have also been made that El Nino conditions may tend to increase. Anyone who has lived in Northern Australia over the past two decades can testify that these two forecasts are incompatible. Anti-El Nino conditions predominated in the 1970s, which were marked by a succession of very wet summers. The 1980s have been dominated by El Nino conditions and have been marked by a succession of dry summers. During the last year we have moved back to anti-El Nino conditions.

Tropical Cyclone Activity

Another forecast consequence of increased temperatures is increased tropical cyclone activity. It is quite often reported that as a result of the greenhouse effect Northern Australia can expect increases in both the intensity and the frequency of tropical cyclones and that the Southern boundary of the tropical cyclone region will move 200 to 400 kilometres further South. These forecasts are based on reasonably well-established relationships between tropical cyclone characteristics and sea surface temperatures.

However, if the forecast of increased El Nino conditions is correct, then the forecast increase in tropical cyclone activity might not be true for Australia. Another effect of El Nino conditions is that they lead to a lessening of tropical cyclone activity around Australia, but an increase further out in the Pacific. The 1980s have been an excellent example of this. While this could be good news for Australia, it will of course be bad news for many of the Pacific Islands.

All that can really be said at this time is that the greenhouse effect will probably increase the incidence and severity of tropical cyclones worldwide and may make them worse in the Australian region. But any forecast of the actual changes in risk in any particular region are pure speculation at this stage.

It must also be remembered that the driving force of the world's weather systems is the difference in temperatures between the equator and the poles. The forecast decrease in this difference as the poles warm up faster than the equator can be expected to lead to less intense weather systems generally. This concurs with climatic historians' findings that the colder the climate, the more severe the weather and the greater the fluctuations in the weather. The claim that the greenhouse effect will lead to more severe weather is therefore another piece of misinformation. If the climatic historians are correct, a warmer climate means more benign weather in general, but if the greenhouse modellers are correct local storms may become increasingly intense.

Other Factors Affecting Global Temperatures

The changing concentration of carbon dioxide in the atmosphere seems to be the major factor affecting global temperatures at the moment, but this could change. There are other factors at work, some of which exacerbate the greenhouse affect, while others mitigate it.

Of other factors **enhancing** the greenhouse effect, the most important are the other greenhouse gases that are being added to the atmosphere. Principal among these are the chlorofluorocarbons (CFCs) methane, ammonia and nitrous oxide. Other such factors are increasing quantities of water vapour in the stratosphere as a by-product of jet travel, and increasing quantities of waste heat as a by-product of energy production and use.

The principal factors **reducing** the greenhouse effect appear to be the increasing reflectivity of the earth to solar radiation (known as the earth's albedo), caused by increased cloudiness, increased bare land due to deafforestation and desertification, and increasing quantities of dust in the stratosphere. Climatic modellers attempt to include these factors in their models, but there remains considerable doubt about some of the assumptions being made, particularly in relation to the increase in cloudiness which is expected to accompany the increase in temperatures.

Another factor counteracting the greenhouse effect is the decreasing concentration of ozone in the atmosphere: an otherwise very serious problem. The release into the stratosphere of gases or dust that absorb solar energy can also reduce global temperatures. Catastrophic volcanic eruptions are believed to have this effect. Some scientists consider this to be the cause of the intermittent short-term cooling periods that mark climatic records over recent centuries. Nuclear testing in the atmosphere has also been identified by some scientists as a factor contributing to the cooling phase after the 1940s.

Some commentators have suggested that these factors may be so significant that they will almost completely counteract the greenhouse effect. However, while there is no need to embark on extreme action at this stage, this is not an argument for dismissing the forecasts relating to the greenhouse effect and doing nothing. The present evidence of significant changes due to the greenhouse effect is too strong for this. It does, however, highlight our lack of knowledge about some of the fundamental variables and the need for increased research if informed decision-making is to be possible.

The Ozone Hole

How does the hole in the ozone layer relate to the greenhouse effect? The short answer is that it doesn't. That, at least, is the opinion of most scientists who have studied it. It appears to be separate phenomenon. But because it also appears to be the result of atmospheric pollution it is often associated with the greenhouse effect.

A number of theories have been proposed to account for the hole in the ozone layer. The most common theory is that ozone is being destroyed in the stratosphere by CFCs. Other theories claim that it is a natural occurrence, that it is caused by volcanic dust, and that it is due to cooling of the stratosphere as a consequence of the greenhouse effect. But at present none of these latter theories enjoys a great deal of support.

A Problem, Not a Crisis

The greenhouse effect cannot be ignored as it has been during the 100 years since it was first brought to the world's attention. That it has the potential for causing catastrophic changes in the world as we know it cannot be denied. But that is not the current issue. It is the time

scale that is in question.

Many reports in the media nowadays imply or state unequivocally that major changes will occur within the next 40 years unless positive and dramatic action is taken immediately. But this is based largely on the adoption of worst-case scenarios and misinterpretation of the forecasts of the rate of increase in greenhouse gases.

The weight of scientific evidence suggests that it is likely to be during the **following** 40 years — i.e. in 40 to 80 years time — that the greenhouse effect will start to make its presence really felt. This is still not far off but it does mean that the world has a breathing space of between ten and 20 years to invest in gaining a better

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understanding of all aspects of the greenhouse effect, including the effects on society of any policies that may eventually be adopted.

It is very important that the world is not panicked into action that it may subsequently regret having taken. We should learn from what happened in the early 1970s as a result of a similar sustained bout of publicity about the 'energy crisis'. On the basis of computer forecasts using (so we were told) complex models of the earth's resources and changing pattern of energy demand, the world became convinced that there was an energy crisis that could be solved only by urgent action. The action that was taken had little lasting effect on energy use; and we are still waiting for the crisis. Meanwhile, we have paid a heavy price for some of the precipitate action that was taken: in particular, the sudden raising of oil prices. This caused a major disruption of the world economy whose effects are with us still. Its greatest impact was on the developing countries, which built up huge foreign debts that have crippled them economically and created a still unsolved problem for the developed world. In Australia it was used as an excuse for parity pricing of petrol, which did nothing to control energy use but gave the federal government windfall tax revenues.

The most serious consequence of the over-reaction to the energy problem is, however, that the public believes the whole issue was a mistake. But this is not the case. It was, and remains, a serious problem. But it was not a crisis. And we are worse off for treating it as such. If, instead of panicking, the world had devoted the last ten or 15 years to a concentrated study of the problem and search for sustainable solutions, we would now be in a better position to cope with the greenhouse effect.

What Can Be Done About It?

The greenhouse effect is about energy use. Developing a sustainable energy use program is an essential aspect of coping with it. Other important aspects include increasing the knowledge base required to make reliable forecasts of the greenhouse effect, improving the mathematical models used to make the forecasts, and improving the monitoring of the greenhouse effect. Research also needs to be undertaken to investigate ways in which the impact of the predicted effects on society can be mitigated by changes in policy. And the possibility of counteracting the greenhouse effect by deliberate design should not be ignored.

Why temperatures dropped significantly after 1940 is not known. Some scientists have suggested that atmospheric explosions of nuclear bombs may have been a contributing factor, particularly in view of the large drop in temperature that occurred in the late 1950s and early 1960s before atmospheric nuclear tests were largely abandoned. The theory is that nuclear bombs released gases into the stratosphere that absorbed solar energy, thus reducing the amount of solar energy reaching the lower atmosphere which controls the temperature of Earth. If mankind can do this by accident it should be capable of repeating the process by design — though presumably not with nuclear bombs! Releasing such gases is the sort of solution that the world may prefer not to use, but if all else fails it may have to be considered if the consequences of the increasing concentrations of greenhouse gases do turn out to be severe.

Conclusion

The greenhouse effect poses a severe potential threat to mankind. But at this stage it is not a crisis. What is needed is a strong commitment to seeking solutions, to educating society at large about the need to develop a sustainable energy policy, and to devoting the necessary resources to researching the greenhouse effect to establish a much more reliable knowledge base on which important decisions can be made. We appear to have between ten and 20 years in which to do this. The challenge for all of us is to ensure that we make the most of this opportunity, for the sake of our grandchildren and successive generations. *Policy*