# Human influence on global climate

*J. Srinivasan*

The Intergovernmental Panel on Climate Change (IPCC) has released recently its second assesment report. This has been produced by the working group I and is called 'Climate Change 1995: The Science of Climate Change'[1]. The first assessment was published in 1990 and provided an excellent overview of scientific knowledge related to climate change at that time. The most important conclusion of the second assessment is that the balance of evidence suggests a discernible human influence on global climate. This conclusion has been challenged by the fossil-fuel lobby while the environmental lobby feels that the above statement is too weak!

The major controversies in this report pertain to chapter 8 on 'Detection of Climate Change and Attribution of Causes'. In this chapter the pattern of climate change predicted by climate models (including the effect of greenhouse gases and anthropogenic sulphate aerosols) has been compared with the observed geographical, seasonal, and vertical patterns of atmospheric temperature change. There are many similarities between the patterns of observed and predicted temperature change in the northern hemisphere during the period 1963–1988 (see Figure 1). The patterns of observed and predicted temperature change are not similar in the southern hemisphere. One of the reasons for the large differences in the southern hemisphere could be the paucity of data in this region. Hence one cannot state beyond all reasonable doubt that human impact on global climate has been detected.

The most interesting aspect of the pattern analysis is the poor agreement between observations and model in the northern hemisphere if the effects of anthropogenic sulphate aerosols (from burning of fossil fuels) are excluded. Thus the most important conclusion of the second assessment of IPCC is the role of anthropogenic sulphate aerosols in cooling the atmosphere and thereby counteracting the warming by greenhouse gases. The optimists and the fossil-fuel lobby may be delighted that the effect of burning fossil fuels causes both warming and cooling of the atmosphere. They may hope that these two effects may leave the earth's climate largely unchanged. This will not happen because the emission of sulphate aerosols from thermal power plants in the industrialized countries has decreased dramatically in the last decade on account of concerns related to local atmospheric pollution. If the developing countries decide to enforce their enviromental pollution laws with regard to sulphate aerosols then there may be no cooling of the atmosphere. The residence time of sulphate aerosols is a few years while the residence time of greenhouse gas such as carbon dioxide can be hundreds of years. In addition, the cooling due to aerosols is confined to regions where it is emitted but that due to greenhouse gases emissions have a global impact. Hence one cannot hope for a neat cancellation of the impact of emission of greenhouse gases and aerosols by fossil fuels. Can we really trust the predictions of global warming made by the Climate Models? The answer to this question is not simple. The anthropogenic influence on global climate is small but cumulative. Hence the effect of anthropogenic emission of greenhouse gases will be seen unambiguously after hundred or two hundred years. The climate models can be tested by checking whether they reproduce the observed variation of global temperature after a volcanic eruption. In 1991, Mt Pinatubo volcanic eruption caused, for a short period, radiative changes in the atmosphere comparable (but of opposite sign) to the doubling of carbon dioxide in the atmosphere. The climate models were able to predict correctly the global cooling that occurred on account of the aerosols injected into the stratosphere by the Mt Pinatubo volcanic eruption. Hence one can have some confidence with regard to predictions made by climate models with regard to global temperature change. We cannot, however, have the same level of confidence with regard to predictions of regional temperature or precipitation changes by climate models.

What will be the impact of global warming on account of carbon dioxide emissions by fossil fuels? The immediate impact of global warming will be a rise in sea levels. There could, however, be a large error in the prediction of sea level rise. The large error occurs because we do not know the contribution of Greenland ice sheet and Antarctic ice sheet in the sea level rise. A warmer climate will increase the melt rates at the margins in the Greenland ice sheet and cause an increase in sea level. On the other hand, a warmer climate will increase accumulation of snow (because of higher snow fall) in the Antarctic ice sheet and hence result in a fall in sea levels! A warmer ocean will, of course, cause the water in the ocean to expand but the net effect of expansion of sea water and the change in mass balance of ice sheets cannot be predicted accurately. Hence the IPCC report predicts that in the next hundred years the rise in the sea level can be anywhere between 13 cm and 94 cm. There could, however, be unpleasant surprises on account of the instability of the West Antarctic Ice Sheet (WAIS). This ice sheet rests on a bed well below sea level. The dynamics of WAIS is dominated by fast-flowing ice streams and their influence on the stability of the WAIS is still in dispute. The IPCC report concludes, however, that the likelihood of a major sea level rise by the year 2100 due to the collapse of WAIS is low.

In an eloquent article in *Nature*[2], Broecker has warned that unpleasent surprises may occur when the earth's atmopshere enters a phase space which it has not experienced during the last 160,000 years. Broecker has said: 'Earth's climate does not respond to forcing in a smooth and gradual manner. Rather it responds in sharp jumps which involve large scale reorganization of the Earth's system. If this reading of the natural record is correct, then we must consider the possibility that the main re-

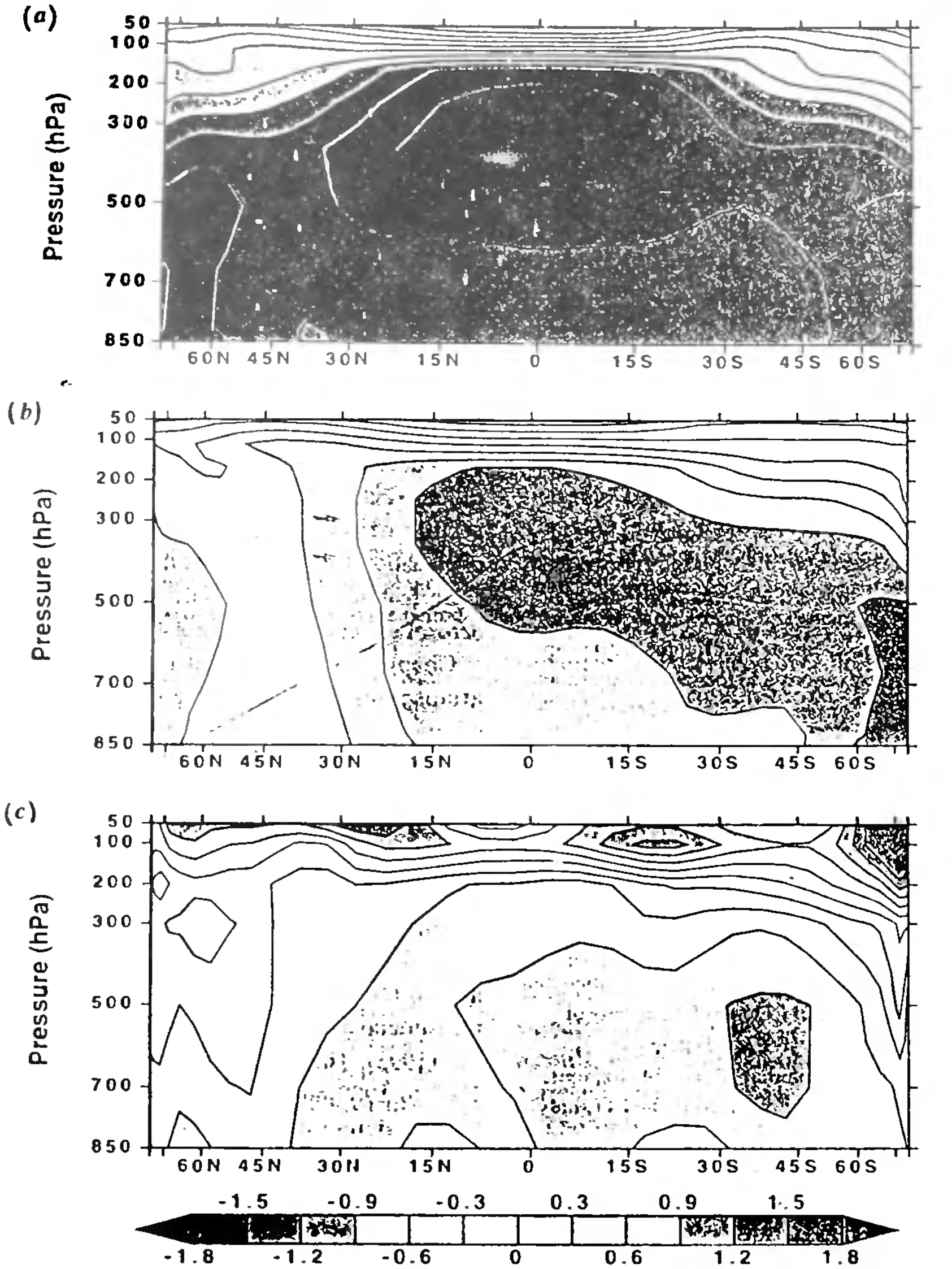


**Figure 1** *a–c*. Modelled and observed changes in the zonal mean, annual-average temperature structure of the atmosphere. Model changes are expressed relative to a control run with pre-industrial levels of $CO_2$ and no anthropogenic sulphur emissions. The results obtained with present-day atmospheric concentration of $CO_2$ are shown in (*a*) and by the combined effect of present-day $CO_2$ levels and sulphur emissions are shown in (*b*), observed changes (*c*) are radiosonde-based temperature measurements and are expressed as total least-squares linear trends over the 25-year period from May 1963 to April 1988 (i.e.°C/25 years). Figure from reference 1. For further details about the model refer to Santer, B. D. *et al.*, *Nature*, 1996, 382, 39–46.

sponse of the system to our provocation of the atmosphere will come in jumps whose timing and magnitude are unpredictable. Coping with this kind of change is clearly a far more serious matter than coping with gradual warming.' The warning with regard to unpleasant surprises should be taken seriously since the palaeoclimate record show episodes of sudden cessation of the deep ocean circulation. There was an unpleasant surprise in 1980s when the 'Ozone hole' appeared over the Antarctic. Scientists had predicted the gradual depletion of ozone on account of the release of chloroflourocarbons (CFCs) by human beings. They were, however, unable to predict the rapid depletion of ozone that occurred in the Antarctic because the theoretical models used during that period had not incorporated the role of ice particles. The General Circulation Models (GCM) used to predict climate change are very complex and incorporate all known physical processes but one cannot rule out, for example, errors in the modelling of cloud physical processes or vegetation or uptake of carbon dioxide by the oceans.

The *Wall Street Journal* published an editorial on 12 June 1996, titled 'A Major Deception on Global Warming'. In this editorial, Fredrick Seitz (President emeritus of Rockfeller University and Chairman of the George C. Marshall Institute) has stated 'In my more than 60 years as a member of the American Scientific community, including service as president of both the National Academy of Sciences and the American Physical Society, I have never witnessed a more disturbing corruption of the peer-review process than the events that lead to this IPCC report'. He further states that nothing in the IPCC rules permit anyone to change a scientific report after it has been accepted by the panel of scientific contributors and the full IPCC. The latter statement is not true and seems to be based on the ignorance of the rules governing IPCC reports. The first statement regarding the peer review process is unfair since the IPCC scientific report has been reviewed by more than 500 reviewers from 40 countries. As a lead author of Chapter 2 of the IPCC report 'Climate Change 1995', I was impressed by the seriousness with which every objection raised by the reviewers was discussed by the lead authors. The IPCC has made every attempt to incorporate diverse viewpoints without succumbing to the pressures exerted by various lobbies. The concern of the fossil-fuel lobby is understandable since they fear that this report may prod some countries to impose legislation that may lead to the reduction in the consumption of fossil fuels.

In view of all the uncertainty regarding the consequences of global warming, should we wait for some more time till we obtain unequivocal evidence regarding the deleterious consequences of global warming? This may mean that we may have to wait for another 50 years. The politicians and the fossil-fuel lobby will be very happy because we can postpone the unpleasant decisions to the future. The fossil-fuel lobby has been advocating this view. In the 1960s the tobacco-lobby argued that link between lung cancer and smoking was not demonstrated beyond reasonable doubt. In complex systems such as the human body or the earth it may not be possible to prove some hypothesis beyond any reasonable doubt. There could, however, be serious consequences if one continues to smoke on the grounds that the relationship between smoking and cancer has not been proven beyond any reasonable doubt. Should we continue to burn fossil fuels because it provides us immediate benefits and not be concerned about the long-term consequences because there are uncertainties regarding the long-term effects ?

The answer cannot be provided by scientists, economists, or politicians alone. In the final analysis, the answer depends upon one's attitude towards the natural world and the legacy we would like to leave for future generations. If the complex natural world is held in reverence, as most ancient people did, then one would be concerned about the irreversible changes that may be brought about by human beings. On the other hand, if one considers the natural world to be a resource to be exploited for the immediate benefit of human beings then there need be no concern for the future. In the next century, we have to strike a delicate balance between the necessity to exploit nature for the benefit of human beings and the responsibility to preserve the planet for future generations.

1. Houghton, J. T., Meira, L.G., Filho, Callander, B. A., Harris, N., Kattenberg, A. and Maskell, K. (eds), *Climate Change 1995: The Science of Climate Change*, Cambridge University Press, 1996.
2. Broecker, W. S., *Nature*, 1987, **328**, 123–126.

*J. Srinivasan is in the Department of Mechanical Engineering and Center for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore 560 012, India.*