Global Warming: A Myth?

2. Credibility of Climate Scenarios Predicted by Systems Simulations

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Part 1. Anomalous Temperature Trends Recorded from Satellites and Radiosondes, *Resonance*, Vol.6, No.6, p.43, 2001.

Much faith has been put into mathematical models for simulating future climate scenarios. The models suffer from many drawbacks, which originate due to the failure in understanding exactly how the climate behaves. But, at the same time, considerable progress has been made over the years and the present coupled ocean-atmosphere models are able to simulate the present climate quite well, lending much more creditability to future climate predictions by models.

The Intergovernmental Panel on Climate Change (IPCC), constituted by the World Meteorological Organization (WMO) and the United Nation's Environment Programme (UNEP) in 1988, concluded that the mean surface air temperature had increased by 0.3° to 0.6°C over the last 100 years, with the five warmest years being in the 1980s. The report predicted that given the usual emission of greenhouse gases, the global mean temperature would increase at a rate of 0.2°-0.5°C/decade [1]. In the IPCC 2nd Assessment, the range of projected global mean warming by 2100 is set at 1-3.5 °C [2]. Another estimate says that, if the present trend of greenhouse gases continue, atmosphere may, on an average, get warmer by 0.7-2°C by the year 2030 and more thereafter [3]. Predictions on global mean surface temperature changes estimated by general circulation models (GCM) are given in *Tables* 1 and 2.

For the Indian region, predicted temperature increase by 2030, with CO_2 doubling is around 2°-4°C in winter and 1°-2°C in summer [4]. Using the data (1901-1988) of 73 stations in India, a warming of 0.4°C per 100 years was found [5]. The warming in Indian conditions was mainly due to temperature increase up to the 1950s, after which the temperatures remained stable [6].

Global mixed layer atmosphere-ocean GCM (equilibrium 2 x CO_2 simulations)	
Global surface air temperature change (°C)	Reference(s)
4.8	Hansen J, Lacis A, Rind D, Russel G, Stone P, Fung I, Ruedy R and Lerner J *In* Climate Processes and Climate Sensitivity (eds. Hansen, J E and Takahasi T), American Geophysical Union, Washington DC, 1984.
4.0	Washington W M and Meehl G A, *J. Geophys. Res.*, 89, 9475-9503, 1984.
4.0	Manabe S and Wetherald R T, *J. Atmos. Sci.*, 44, 1211-1235, 1987.
3.2	Mitchell J F B and Warrillow D A, *Nature*, 382, 56-60, 1987.
5.2	Wilson CA and Mitchell J F B, *J. Geophys Res.*, 92, 13315-13343, 1987.
3.2	Wetherald R T and Manabe S, *J. Atmos. Sci.*, 45, 1397-1415, 1988.
3.5	Mitchell J F B, Senior C A and Ingram W J, *Nature*, 341, 132-134, 1989.
~4.3	Noda A and Tokioka T, *J. Met. Soc. Japan*, 67, 1055-1067, 1989.
2.8	Schlesinger M E and Zhao Z C, *J. Climate*, 2, 459-495, 1989.
4.0	Meehl G A and Washington W M, *Climatic Change*, 16, 283-306, 1990.
3.5	Boer G J, McFarlane N A and Lazare M, *J. Climate*, 5, 1045-1077, 1992.
4.0	Gordon H B, Whetton P H, Pittock A B, Fowler A M and Haylock M R, *Clim. Dyan.*, 8, 83-102, 1992.
3.5	McFarlane N A, Boer G J, Blanchet J P and Lazare M, *J. Climate*, 5,1013-1044, 1992.
3.5	Boer G J, *Clim. Dyan.*, 8, 225-239, 1993.
4.6	Washington W M and Meehl G A, *Clim. Dyan.*, 8, 211-223, 1993.
4.0	Gordon H B and Hunt B, *Clim.Dyan.*, 9, 195-212, 1994.
4.8	Watterson I G, Dix MR, Gordon H B and McGregor J L, *Aust .Met. Mag.*, 44, 111-125, 1995.

Table 1. Estimated changes in mean global surface air temperature by different model experiments.

Drawbacks of Simulation Models in Climate Change Studies

Until recently, climate models were unable even to simulate the present climate adequately. To force the models to simulate the present climate right, researchers adjust the amount of heat and moisture flowing between the model's atmosphere and ocean, termed as 'flux adjustments'. These adjustments may mask the drawbacks of the models rather than rectifying their inherent deficiencies. Introduction of an error and its adjustment subse-

GHG scenario[a]	Global surface air temperature change at CO_2 doubling (°C)	Reference (s)
1% yr^{-1}	2.2	Manabe S, Stouffer R J, Spelman M J and Bryan K, *J. Climate*, 4, 785-818, 1991.
1.3% yr^{-1}	1.3	Cubasch U, Hasselmann K, Hock H, Mikolajewicz U, Santer B D and Sausen R, *Clim. Dyan.*, 8, 55-69, 1992.
1% yr^{-1}	2.2	Manabe S, Spelman M J and Stouffer R J, *J. Climate*, 5, 105-126, 1992.
1% yr^{-1}	2.3	Meehl G A, Branstator G W and Washington W M, *J. Climate*, 6, 42-63, 1993.
1% yr^{-1}	1.35	Colman R A, Power S B, McAvaney B J and Dahni R R, *Geophys. Res. Lett.*, 22, 3047-3050, 1995.
1% yr^{-1}	1.7	Murphy J M, *J.Clim.*, 8, 496-514, 1995.
1% yr^{-1}	1.7	Murphy J M and Mitchell J F B., *J.Clim.*, 8, 57-80, 1995.
1% yr^{-1}	1.7	Senior C A, *J. Climate*, 8, 2860-2880, 1995.
1% yr^{-1}	1.6	Tokioka T, Noda A, Kitoh A, Nikaidou Y, Nakagawa S, Motoi T, Ukimoto S and Takata T, *J. Met. Soc. Japan*, 74, 817-826, 1995.
1% yr^{-1}	3.8	Meehl G A, *J. Water, Air and Soil Pollution*, 92, 203-213, 1996.
1% yr^{-1} + aerosols	~2.5	Mitchell J F B. and Johns T J, *J. Climate*, 10, 245-267, 1996.
1% yr^{-1}	3.8	Washington W M and Meehl G A, *J. Geophys. Res.*, 101, 12795-12801, 1996.
1% yr^{-1}	2.6	Flato G, Boer G J, Lee W G, McFarlane N A, Ramsden D, Reader C and Weaver A, 1997.
1% yr^{-1}	2.0	Gordon H B and O'Farrel S P, *Mon.Wea.Rev.*, 125, 875-901, 1997.

[a] GHG scenario refers to the rate of increase of CO_2 used in model experiments; most experiments use 1% yr^{-1}, which gives a doubling of CO_2 after 70 years.
(Adopted from IPCC, 1998)

Table 2. Global coupled atmosphere-ocean general circulation models (transient simulations).

quently in a model results in a loss of the model's ability to predict future climates. Old simulations of atmosphere, without a component representing world oceans were able to recreate the present climate. But those models were found deficient in predicting future scenarios.

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Possible Reasons for the Failure of Models to Simulate Observed Temperature Changes

(i) Behaviour of Atmospheric Moisture: The remarkable thermodynamic properties of water can make it nature's thermostat and, perhaps, negate global warming. Moisture laden air cools while rising, forms clouds, brings rain and consequently moisture of the rising air decreases and a drier air fills up the upper troposphere. If global warming exists, this process will be quicker, so that the air will release moisture as rain more quickly and get drier. As moisture is efficient in trapping heat, its reduction will lead to reduced heat trapping by the air mass, allowing more terrestrial heat to radiate back to the space. So there will be a cooling of the troposphere. This is called 'negative feedback' and the climate models are not adequately equipped with the details of this phenomenon. If this feedback exists, doubling of CO_2 may result in only 1/8-1/14th of the warming response or even less of those attributed to equilibrium climate change models. This argument, however, has been strongly challenged. Some believe that although it is qualitatively correct, the negative feedback may not be strong. Moisture transport and distribution in the atmosphere is not fully understood and it is difficult to estimate how much of the moisture that turns into clouds ultimately comes down as rain and how much remains in the upper atmosphere. Further, increase in global surface temperature may lead to more evaporation from water bodies, which may ultimately result in a further increase in tropospheric temperature through a 'positive feedback'. And again, as the troposphere warms up, its water holding capacity also increases, amplifying chances of further warming. But satellite data indicate that free troposphere is largely cut-off from the surface and evaporated water may not moisten the free troposphere significantly. There are serious gaps in the knowledge of the water vapour in atmosphere and water vapour feedback is one of the great uncertainties of climate models. As a result, models driven by greenhouse gases alone give a warming twice as large as that observed over the last 150 years, about 1°C rather than the observed 0.5-0.6°C. The difference between the observed and the predicted warming could be because factors such as the aerosol radiative properties, clouds and cloud radiative forcing were not included.

Clouds reflect a large part of the incoming solar radiation, leading to a relative cooling of the troposphere. They also absorb long-wave radiation from earth's surface, warming up the troposphere.

*(ii) **Cloud Properties:*** The behaviour of several models, in particular their sensitivity to changes in atmospheric CO_2 levels, depends on the relative properties of water-drops and ice-crystals in clouds in the atmosphere. Cloud water content depletes with precipitation, which depends on temperature, water content of the clouds and precipitation from upper layers. Transition from water to ice occurs between –15 and 0 °C. Ice particles start to fall as soon as they are formed, at $1 ms^{-1}$. As water drops fall more slowly, the water clouds remain longer in the troposphere and may lead to increased cooling of the atmosphere by reducing the amount of solar energy reaching the earth (cloud albedo effect). This effect may be alarmingly large at temperatures near 0 °C where ice crystals melt to form water drops. On replacing rela-tive humidity cloud scheme with water clouds in the models, global annual average surface temperature comes down from 5.2 °K to 2.7 °K. If cloud radiative properties are allowed to depend on the cloud water content, warming is further reduced to 1.9 °K [7].

*(iii) **Cloud Radiative Forcing:*** Clouds reflect a large part of the incoming solar radiation, leading to a relative cooling of the troposphere. They also absorb long-wave radiation from earth's surface, warming up the troposphere. These effects are called short-wave and long-wave cloud radiative forcing. The greenhouse effect of clouds may be a hundred times larger than that due to the increase in CO_2 concentration [8]. The presence of clouds puts large uncertainties in climate change simulations by influencing the effects of the greenhouse gases. This makes the handling of general circulation models (GCM) difficult and predictions become erroneous. Cloud radiative forcing has to be explicitly known to predict global temperature changes. Earth radiation budget experiment (ERBE) has showed that clouds could have cooled the earth below the temperature it would have

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without any cloud. Most of the models use positive cloud feedback, which gives a warming in presence of clouds. But until now, it has not been conclusively proved whether clouds have a net positive feedback or not.

(iv) ***Effect of Ozone Depletion:*** Presence of ozone in stratosphere is responsible for thermal heating of the stratosphere as it absorbs ultraviolet (UV), visible and infra-red (IR) radiation. It has been suggested that ozone depletion may lead to considerable changes in surface atmospheric temperature. Models show that complete removal of stratospheric ozone in the presence of a particulate layer near the surface heats up the surface. The heating is a result of combined effects of increased net solar radiation at the ground due to ozone removal and consequent increase in water vapour content in the atmosphere. If surface albedo increases, surface temperature increases because of increased reflection of visible radiation and its effective trapping by the particulate layer. Without the presence of a particulate layer, surface cooling results from complete removal of stratospheric ozone. It is generally presumed that earth surface and tropospheric temperatures change in a similar manner because of the convective coupling of these two levels. But in some special cases this may not hold good. Models have shown that ozone depletion in upper troposphere cools down that region more than it does the surface. The actual difference between the surface and the tropospheric temperatures may vary, as the profile of the ozone level fluctuations is uncertain. Computer simulation done for the period 1979-1993 has shown that, ozone change cooled the troposphere by 0.06°C/decade but the surface by only 0.03°C/decade [9].

(v) ***Variation in Solar Luminosity:*** Variation in solar radiation received by earth may affect earth's climate. There are two sources of this variability.

a) Changes in Sun-earth Orbital Parameters: Variations in earth's orbital parameters influence the latitudinal and seasonal pattern of solar radiation received by earth (called 'Milankovitch effect'). Radiative forcing due to the Milankovitch effect can be obtained for particular latitudes and months and it has been seen that the effect is small compared to radiative forcing due to 'enhanced greenhouse effect'. This comparison may be rather rough, as the Milankovitch effect results from redistribution of solar energy latitudinally and seasonally. Since, the variability in sun's orbital parameters has a periodicity of 20000, 40000 and 100000 years, these variations are unlikely to influence temperature trends recorded over the last 100 years.

Sunspots are cold, dark spots seen on the visible face of the sun.

b) Physical Changes in the Sun: Short-wave and radio frequency outputs of the sun respond to variations in surface activity of sun which follow a phase with a 11 year sunspot cycle, which can be represented by the number of sunspots. Sunspots are cold, dark spots seen on the visible face of the sun. It has been suggested that solar luminosity increases with increasing sunspot number. Based on the observations made through the 'active cavity radiometer irradiance monitor' (ACRIM) on 'solar maximum mission', it has been discovered that sunspots on sun's visible disk block a substantial part of the solar output. Short-term observations with 'solar maximum mission satellite' have suggested an inverse relationship between sunspot numbers and solar luminosity. But, short-term observations may not clearly represent long-term situations. Short-term measurements show a decrease in sun's irradiance with increasing sunspot numbers, as they block a portion of solar flux. But the blocked solar flux has to be re-radiated at some point of time and consequently long-term measurements show an increase in solar output with increase in sunspot numbers. During the last 11 year solar cycle, the magnitude of solar irradiance variation is of the order of 0.1% of the solar constant, which is equal to a climate forcing of $\approx$0.24 W m^{-2}, taking mean solar heating of the earth as $\approx$240 W m^{-2} [10]. Although these small variations in solar output may not have significant contribution to climate change, this change has been held responsible for observed changes in atmospheric temperature. It is also suggested that irradiance variations are associated with sun's outer layer, the photosphere, specifically

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the bright areas known as 'faculae'. Increased irradiance due to 'faculae' when sunspot activity is high could overshadow the effect of decreasing output due to cooler sunspots and consequently high sunspot numbers could lead to higher solar output.

There are also suggestions that there might be variation in solar output due to changes in solar radius. Whether variations in the solar radius, as observed over the last few centuries, are connected to changes in solar output is still unclear. It is suggested that temperature may change on an 80 yr cycle, with a range of 0.2°C [11]. The physical basis for this kind of temperature change is reasonable but the statistical quality of the available data on this question is too poor for a firm conclusion. Anyhow, the possibility of temperature change due to solar radiation variations cannot be completely ruled out.

New Climate System Model: Model of the Future?

Recently, researchers at the National Center for Atmospheric Research (NCAR), Colorado [12], have come out with the 'climate system model' (CSM), a coupled ocean-atmosphere model, which is able to simulate the present climate, when run for 300 years, without any flux adjustments. The CSM has a new parameterization, which incorporates effects of ocean 'eddies', huge swirling pools of water that give birth to strong ocean currents and mix up heat through the oceans. The results from the model indicate that future greenhouse warming may be milder than predicted by other models and may take decades to take effect. Doubling of CO_2 in the model resulted in a warming of 1.25 °K and tripling of CO_2 by 2 °K. A run of the same model for 300 years, without any increase in the concentration of greenhouse gases led to a average global temperature fluctuation of 0.5°C, which is indistinguishable from the natural variation. If the climate had behaved the same way as simulated in this model, the slight temperature variation in last 130 years may be attributed to natural variation. Manabe and Stouffer [13] have also examined the multiple century response of a coupled ocean-atmospheric model to an increase in atmospheric CO_2.

Conclusion

Earth's atmosphere is a dynamic system and is driven by numerous interacting factors, which are yet to be studied with precision. Computer models, which are generally run under CO_2 doubling scenario, may have uncertainties for several reasons. At the present CO_2 emission rate, doubling may be attained only after 70-95 years (at 1% increase yr^{-1}). Global efforts to cut back on CO_2 emission, underway for quite sometime, and the stress on the use of alternative non-conventional and renewable energies may increase the doubling time considerably. Nevertheless, the considerable improvements in the capability of ocean-atmosphere models in simulating present climates show that the intricate interplay of several factors in climatic change are now better understood and there is hope for further improvement in the model performance.

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Suggested Reading

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