Global Warming: A Myth?

1. Anomalous Temperature Trends Recorded from Satellites and Radiosondes

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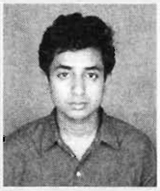

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Increase in the concentration of several greenhouse gases in the atmosphere during the last few decades has warmed up the atmosphere, a phenomena popularly known as 'global warming'. There are people who believe that 'global warming' does not exist, or will have negligible consequences on the earth and its biosphere, if at all it exists. Satellite record over the past few decades have shown a slight cooling trend in the lower troposphere, casting a doubt on the existence of 'global warming'. During the same time, atmosphere near earth's surface has shown a warming trend. Efforts are on to explain this temperature anomaly and it may take time to say conclusively whether 'global warming' exists or not.

Introduction

Global warming is one of the most important and widely discussed environmental issues of recent times. In simple terms, 'global warming' is the warming up of the atmosphere due to an increase in the concentration of several greenhouse gases e.g. CO_2, CH_4, N_2O, CFCs. Global warming is driven by the 'enhanced greenhouse effect' which is an amplification of the natural 'greenhouse effect' which has made earth a hospitable place. These gases absorb the thermal IR radiation emitted by the earth and increase atmospheric temperature. Non CO_2 gases are believed to contribute as much as CO_2 to the 'enhanced greenhouse effect'. The existence of 'global warming' is disputed, as atmospheric temperature trends measured by radiosondes and satellites separately over the past few decades are unclear (*Figure* 1).

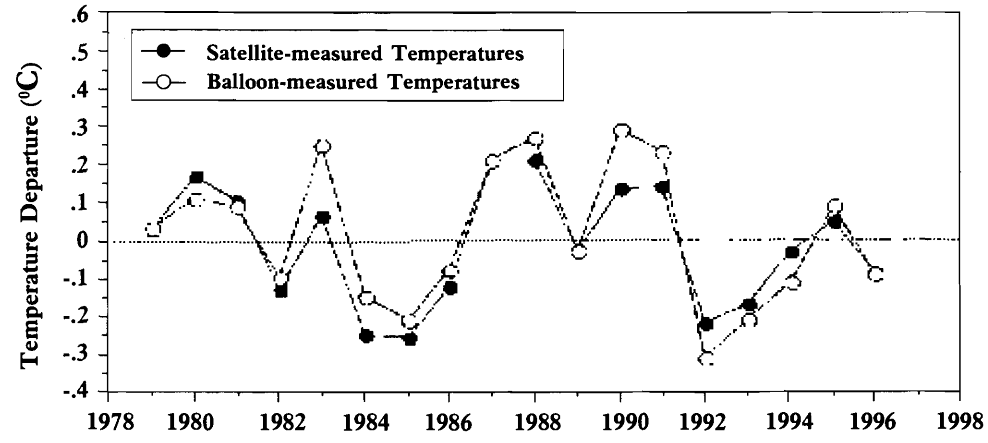

Figure 1. Satellite-measured temperature data vs. balloon-measured temperature data.

Source: John Christy and Roy W Spencer (http://www.ameritech.net/ users/storm8/Final/ Final.htm)

Global Temperature Trends from Satellites

In late 1978, a series of passive microwave radiometers was launched aboard the TIROS-N series of National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites [1]. These radiometers or microwave sounding units (MSU) measured microwave radiation emitted by oxygen molecules at around 60 GHz frequency (about 5 mm wavelength), where oxygen acts as a blackbody. Any change in the strength of this radiation can be attributed to changes in the internal energy of the oxygen molecule, which is directly related to the temperature of the troposphere [2]. Since oxygen is an abundant and well-mixed gas in the air, it acts as a better indicator than all other gases. Nearly optimum spatial coverage can be obtained from these polar orbiting satellites, although these are not capable of measuring surface air temperature. These satellite-derived temperatures have, in contrast to ground stations, shown a slight cooling of the lower troposphere and a warming in the mid troposphere (*Figure* 2). MSU middle tropospheric temperature measurements (MSU2) represent a vertically weighed air temperature centered at an altitude of ~7 km while MSU lower tropospheric temperature (MSU2R) centers around 3.5 km [3]. While the global surface temperature shows a warming of +0.13 °K/decade, lower troposphere shows a cooling of – 0.05 °K

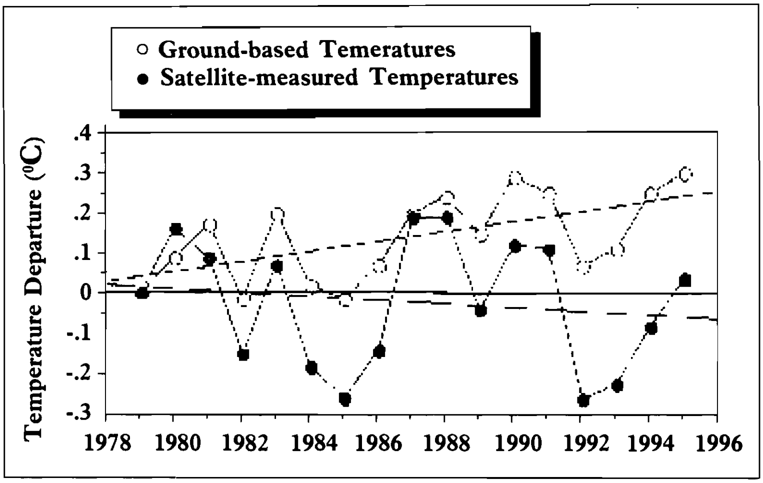

Figure 2. Ground-based temperature data vs. Satellite-measured data.

Source: John Christy and Roy W Spencer (http://www.ameritech.net/users/storm8/Final/Final.htm)

during the same period. In tropics, this difference is more pronounced, with sea surface temperature (SST) rising by +0.10 °K/decade and lower troposphere falling by 0.11 °K/decade. Within the satellite data set, lower tropospheric temperature shows a cooling of – 0.17 °K per decade relative to middle tropospheric temperature. This strong relative cooling is in disagreement with radiosonde data, which shows little relative difference in temperature trends at 1.4, 3.0 and 5.6 km altitudes [3]. Recent estimates emphasize that troposphere is cooling at – 0.046 °K/decade from 1979-1997, while near nadir measurements yield near zero (+0.003 °K/decade) trend. Different methods of analysis of the same MSU near-nadir dataset over ocean and land shows a warming of + 0.11 °K/decade during 1980-1996 [4]. These observations from satellites raised serious doubts on the existence of global warming. However, satellite temperature measurements may have their own uncertainty to some extent. There could be many unseen factors influencing temperature fluctuations in the atmosphere, or it may be that the temperature measurement systems have to be looked into for possible drawbacks.

Possible Reasons for the Observed Difference in Temperature

(i) *Physical Difference between Surface and Lower Tropo-*

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spheric Temperature Measurements: The comparison between the surface and tropospheric temperature trends, measured respectively by radiosondes and satellites, is not realistic, as there are serious physical differences between the two measurements. The reported radiosonde temperatures are virtual and are affected by the variation in humidity and cloudiness, giving an impression that they are temperature variations. Contrarily, humidity and cloudiness are almost invisible to MSU radiance [5].

(ii) ***Surface Data Quality:*** The largest record of atmospheric air temperature profiles come from radiosondes in which a balloon carries an instrument in the sky, which transmits atmospheric temperature data to the ground stations. These measurements are done once or twice daily and are confined to a narrow column of air, through which the balloon ascends. The data obtained by radiosondes may not represent the global average as the measurements cover only land regions. There is also ample scope of errors in long term temperature trends due to changes in instrumentation, station location, time of sampling, etc. Radiosondes are sparsely distributed over the globe. Although 9000 ground stations are listed in the World Meteorological Organization Report in 1978, only 1250 stations are found to have been reporting in real time over land regions during 1994. Furthermore, for their data to be of any use, data for a common period is needed, which may not be available.

Some surface temperature measuring stations suffer from urbanization effects. Also, radiosonde stations are distributed more where the population is high and many areas with low population are neglected. When located in urban areas, they may indicate more surface air warming due to man-made structures (popularly known as 'heat island effect'). The walls of man-made structures capture and store heat during the day and emit at night and consequently cities and towns are warmer than surrounding areas, particularly at night. Airports have similar heat islands with their large paved runways radiating enormous heat and keeping the surroundings warmer. Burning of large amounts of fuel also leads to localized warming in airports. A large number of surface air temperature observation stations are located near airports, which may incorporate serious errors in their data unknowingly due to these reasons.

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Two-thirds of the earth's surface, namely that occupied by the oceans, is not covered by surface temperature measuring stations. This limitation can be partially removed by combining ship observations with meteorological station data but ocean data introduce several problems, which affect long term temperature change. Ship height and speed may change with time and along with the methods of measurement, often sea surface temperature is measured instead of surface air temperature changes and thus it will misinterpret surface air temperature changes. Secondly, the data quality and its documentation vary considerably among different stations.

Serious errors get into the surface temperature dataset due to temporal changes in the sample collections. If temperature data is collected at different times during the diurnal cycles, during which temperature varies significantly, the data may not be representative of the real temperature trend and so it is necessary to collect temperature data at a fixed time during diurnal cycles. In long-term data collection, another problem encountered is the changes in the instrumentation at the ground stations. Same temperature measured by different instruments may disagree due to the difference in sensitivity as well as calibration of the instruments.

(iii) ***Effects of Hydrometeors:*** Rain and ice crystals may affect the atmospheric level from which the satellite derived MSU signal for temperature arises. These hydrometeors may act as blackbodies near 60 GHz frequency apart from O_2 and may corrupt temperature datasets measured by MSUs. These water substances reach higher levels in the atmosphere with climatic warming. As temperature decreases with increasing altitude, the increase in elevation of hydrometeors will make MSUs measure lower temperature trend than that occurring at a lower

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fixed level. The altitude distribution of these hydrometeors may change when climate changes and this may change the level sampled by MSUs. So unlike the meteorological station measurements by radiosondes, which take measurements at a fixed height, MSU may end up taking samples from different levels in the atmosphere. So, temperature records may not truly represent the physical temperature of the atmosphere due to hydrometeor contamination. In contradiction, it is argued that a decrease in MSU global tropospheric temperature by even 0.01°C due to water vapour may occur under the following conditions [5]:

a) A global increase in mid level cloud by 7%
b) A global decrease in low clouds by 8%
c) A decrease in tropospheric humidity by 15% over all oceans
d) An increase in tropospheric humidity of 10% over all land.

There is no report until now about the occurrence of any of these events.

(iv) ***Effect of Aerosols:*** Aerosols are minute solid or liquid suspended particles in atmosphere, which can alter atmospheric temperature by decreasing or increasing radiation that passes into or out of the earth-atmosphere system. Particulates block IR radiation emitted by earth and reflect and scatter large part of the solar radiation back to the outer space, reducing atmospheric warming. Aerosol loading to the atmosphere increases due to volcanic eruption, deforestation, increase in desert area, and industrial and other human activities. The temperature difference between surface and troposphere has been attributed to transitory effects of volcanoes, assuming that their effect is twice as large in the troposphere as at the surface. Mean surface temperature can fall by a few tenths of a degree or more in extreme cases immediately following a major volcanic eruption and the effect may remain for a year or two. Two large volcanic eruptions, El Chichon in 1982 and Mount Pinatubo, 1991, had resulted in cooling of the atmosphere but it is argued that twice as much volcanic cooling of troposphere might not exist.

Sulphur compounds are injected into the stratosphere during large volcanic eruptions, leading to formation of sulphate aerosols in the stratosphere, which scatter incident sunlight and induce cooling in lower stratospheric layers. Sulphate aerosols are also injected into the troposphere from sulphur dioxide (SO_2) emitted from industrial activity, fossil fuel burning, and biomass burning. These tropospheric sulphate aerosols may cause substantial cooling in regions of high human activity. Moreover, stratosphere has a small quantity of residual sulphate aerosols, which originate from oxidation of carbonyl sulphide, a gas emitted by oceans. It is suggested that sulphate aerosols are much more effective than volcanic dusts in changing the radiative energy balance. The direct effect of sulphate aerosols may also be accompanied by a indirect effect, generated due to the activity of the aerosols as 'cloud condensation nuclei' (CCN). More aerosols acting as CCN can lead to smaller cloud droplets and more surface area which reflect more solar radiation and lead to more cooling. A recent experiment known as 'INDOEX' was carried out in January-March 1999, in the equatorial Indian Ocean, and the results may throw important light on aerosol radiative forcing.

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(v) ***Instrument Drift in Satellites:*** Slight changes in the instrument sensitivities may lead to errors in the data collected by MSUs. MSUs do not take absolute temperature measurements but examine relative changes in temperature. So, a slight change even in instrument sensitivity may lead to an incorrect measurement of temperature trend. Instrument sensitivity can be maintained by transfer of calibration from other satellites taking temperature measurements simultaneously. But small drifts in calibration transfer may lead to errors in temperature trend analysis. These problems may be particularly important when temperature data is collected for a long time.

(vi) ***Changing Skyline Hypothesis:*** The ground-based thermometers on earth are arranged in a such fashion that the thermometer screen and adjacent regions view both earth's surface and the sky. The area of the sky viewed by the thermom-

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eters may decrease appreciably during the course of time due to the growth of trees or buildings around the stations, which block the exposure of thermometers. It has been suggested that each additional 1% blockage of sky area may lead to an increase in measured temperature to the extent of 0.2°C. The measured temperature increases because the thermometer gets embedded in a warmer cavity than before. The growth of trees and buildings will reduce the ease with which heat radiates from the earth surface upwards, which implies that warming will be greater at night, when contrast between surface temperature and sky temperature is greatest. This hypothesis is able to explain why ground stations are warming while free atmospheric observations from satellites show a cooling trend. This is a new hypothesis that needs critical examination and detailed studies to be undertaken.

(vii) ***Influence of Surface Emissivity:*** MSU2R (lower troposphere) records contain substantial noise from non-oxygen emissions through the influence of surface emissivity. MSU2R brightness temperatures receive 80% of their full signal from the atmosphere and the remaining 20% from surface emissions, over land at sea level while over oceans, 90% of the signal comes from the atmosphere. Surface emissions are strongly influenced by surface temperature, wetness, snow cover and vegetation, and any change in these parameters over time impart variations in temperature trends. MSU2 (mid troposphere) is less contaminated by noise from surface emissivity, as 90% and 10% of their full signal comes from atmosphere and surface emissions respectively, while over oceans it gets 95% of its signal from the atmosphere [6].

(viii) ***Improper Merging of Data from Different Satellites:*** The overall downward trend in MSU2R (lower troposphere) temperatures may arise from difficulties in matching records between different satellites, which is done to find out long term temperature trends. Sometimes, data collected from different satellites show different trends and contain different types of errors. Merging of data is ideal only when there are long overlaps between satellites from which data are acquired. Orbits of satellites change over time and consequently different time periods of the diurnal cycles are sampled which imparts errors in the merged data. As surface emissions also change during diurnal cycles, data collected by satellites becomes different.

Falling Satellite Effect: An answer?

A recent suggestion [3] brings to the fore a new aspect of the MSU data, which might have been responsible for the inexplicable phenomenon of the global cooling at lower troposphere. The height of a satellite's orbit decreases slightly over time because of the drag of the atmosphere over satellites, which is highest during periods of high solar activity. High solar activity increases atmospheric warming, increasing collisions of air molecules with the satellites, resulting in an higher orbital decay rate of ≈ 2 km yr^{-1} which is 0.3 km yr^{-1}during periods of low solar activity [2]. The decrease in altitude leads to a corresponding decrease in earth's incidence angle due to sphericity of the earth (*Figure* 3). With the falling satellite, incidence angle decreases by only 0.0049 °K yr^{-1} on an average for near nadir observations, while for near limb observation, incidence angle decreases by 0.0120° yr^{-1}. This leads to increases in the values of T_N and T_L by + 0.008 °K and + 0.052 °K/decade, respectively, in the following equation [3].

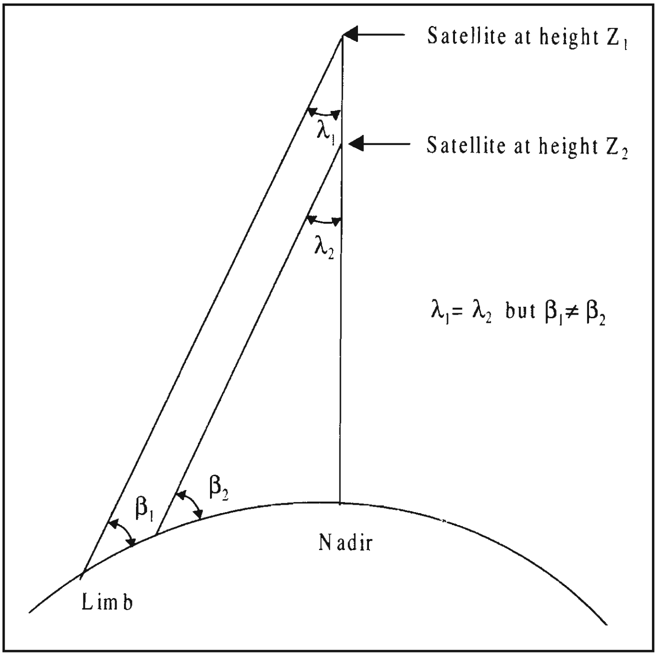
$$T_{2R} = 4\,T_N - 3\,T_L,$$

where T_{2R} = lower tropospheric temperature
T_N = Near nadir temperature
T_L = Near limb temperature

The warming of T_L relative to T_N at a rate of 0.044 °K/decade results in a negative value of T_{2R}, which means a cooling of the lower troposphere.

Figure 3. A change in the height (z) of polar orbiting satellites has little influence on near-nadir measurements of temperature. But, as instruments scan away from a nadir, the interpretation of near-limb measurements(at angle λ) requires knowledge of the angle β. Incorporating changes in z (and thus in β) in data from MSUs, Wentz and Schabel have derived new estimates of temperature trends in the lower troposphere which indicate warming rather than cooling.

Source: Gaffen, 1998



This cooling was in good agreement with the anomalous temperature trends. Removal of the effect of orbital decay of satellites shows T_L and T_N warming nearly at the same rate. Substitution of the correct values of T_N and T_L results in a warming of 0.12 °K/decade of the lower troposphere. Adding this correction to the previously reported trends (– 0.11°K/decade in the tropics and – 0.05 °K/decade globally) results in new trends of +0.01 °K/decade in tropics and +0.07 °K decade globally.

Conclusion

There has been a substantial increase in temperature from 1880 to 1940. But from 1940 to 1960, temperature dropped alarmingly giving rise to speculation about the arrival of an ice age. Since 1970s, there is again an increasing trend in surface air temperature on a global average basis. The year 1998 has been considered as the warmest year in the present century, indicating that global warming cannot be dismissed outright, at least on shorter time scales. Our discussion has shown that the present situation witness conflicting reports about the global warming. This stresses for the need to look for the possible errors in the measurements of temperature trends and understand precisely the way climate behaves. It may not be easily possible to totally neglect the effect of anthropogenically introduced greenhouse warming, as the present trend is within the range of natural variability. Effective monitoring will more precisely determine the amount of global warming, if any, if and where the signal goes above the natural variability range during the next two decades.

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Suggested Reading

[1] R W Spencer and J R Christy, Precise monitoring of global temperature from satellites, *Science*, Vol. 247, pp.1558-1562, 1990.

[2] D J Gaffen, Falling satellites, rising temperatures?, *Nature*, Vol.393, pp.615-616, 1998.

[3] F J Wentz and M Schabel, Effects of orbital decay on satellite derived lower tropospheric temperature trends *Nature*, Vol.394, pp.661-664, 1998.

[4] C Prabhakara, R Iacovazzi Jr., J M Yoo and G Dalu, Global warming deduced from MSU, *Geophys. Res. Let.*, Vol.25, pp.1927-1930, 1998.

[5] J R Christy and R W Spencer, Assessment of precision in temperatures from the microwave sounding units, *Climatic Change*, Vol.30, pp. 97-102, 1995.

[6] J W Hurrell and K E Trenberth, Spurious trends in satellite MSU temperatures from merging different satellite records, *Nature*, Vol.386, pp.164-167, 1997.