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Out-going Longwave Radiation and the Greenhouse Effect

Abstract

The upward surface radiation is greater than the out-going longwave radiation at the top of the atmosphere due to the greenhouse gases in the atmosphere. The strength of the greenhouse effect can be characterized by the fractional difference between the upward surface and top of atmosphere out-going longwave radiation fluxes, defined as the normalized greenhouse factor. Using radiosonde data from 1960 to date and a line-by-line radiation code, the normalized greenhouse factor was calculated to have increased by 0.19% over 49 years, which is not significant. Climate sensitivity at doubled CO_2 concentration was calculated to be 0.26 ^oC. Delaying the start date of the analysis increases the climate sensitivity to about 0.4 Celsius. This is about 13% of the 3.0 ^oC estimate by the International Panel on Climate Change (IPCC).

Introduction

The Anthropogenic Global Warming (AGW) theory postulates that greenhouse gas emissions would cause a reduction of out-going longwave radiation (OLR) from the top of the atmosphere for a given global average surface temperature. This reduction of OLR would cause an energy imbalance with the incoming solar radiation resulting in a "forcing", meaning more incoming energy than out-going energy, causing an increase in global temperatures. Increasing temperatures would cause OLR to increase until the radiation balance is restored.

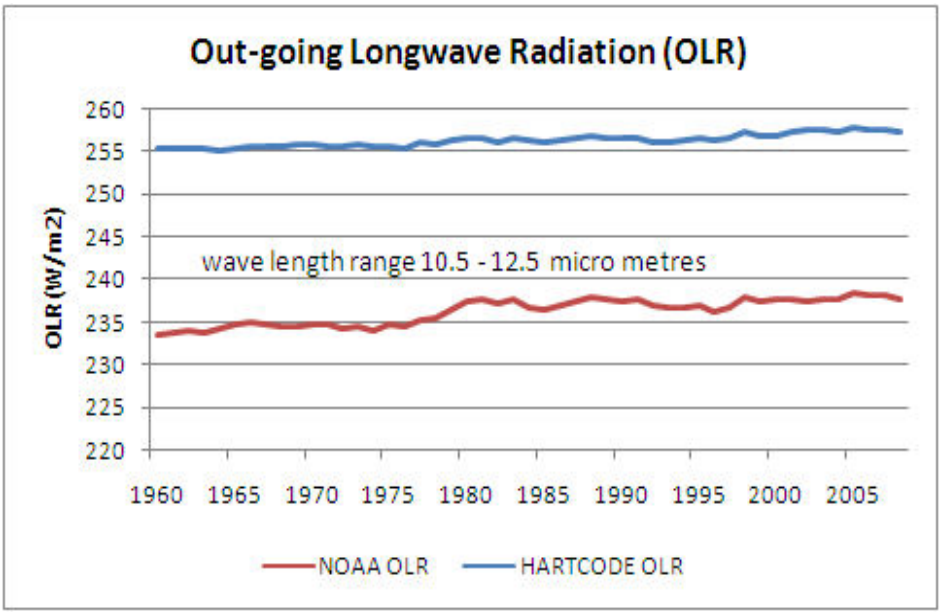
The greenhouse effect results in the upward surface radiation (Su) being greater than the OLR. The global surface temperatures are directly related to the surface radiation. As global warming may be caused by factors unrelated to greenhouse gases, the strength of the greenhouse effect is characterized by the fractional change in the radiative flux between the top and the bottom of the atmosphere, defined as the normalized greenhouse factor (NGF):

$$NGF = (Su - OLR)/Su. \quad (1)$$

If there were no greenhouse gases the temperatures at the top of the atmosphere would be the same as the surface temperatures, and the NGF would be zero. An increase in the effective amount of greenhouse gases would increase the difference between the surface and top of atmosphere longwave fluxes. AGW alarmists are demanding major changes to energy policy due to their belief that man-made CO_2 emissions are dangerously increasing the greenhouse effect.

Out-going Longwave Radiation

The trend of OLR is shown in the following graph.

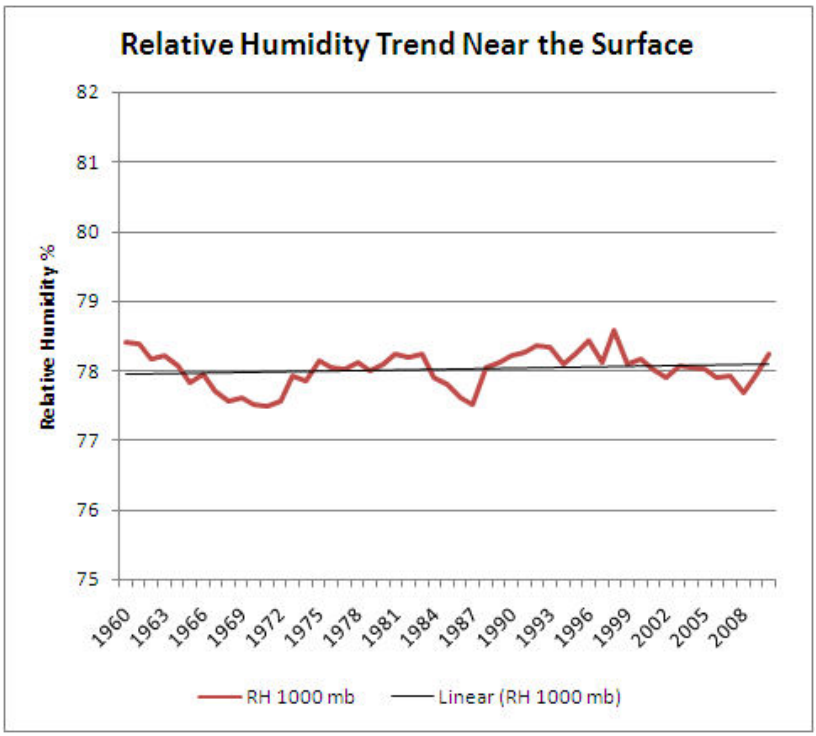


The lower curve is from the National Ocean and Atmospheric Administration's (NOAA) Earth System Research Laboratory (ESRL). It covers the range 10.5 to 12.5 µm of the longwave spectrum only, but includes most of the atmospheric window. The upper curve is calculated over the entire longwave spectrum using the NOAA, ESRL water vapour NCEP Reanalysis Dataset, CO_2 concentration data at Mauna Loa, Hawaii and the HARTCODE program. Both curves show an increasing trend, contrary to AGW theory predictions. The best fit trend of the HARTCODE OLR has increased by 2.4 W/m^2 in 49 years. Man-made CO2 emissions have not suppressed the out-going radiation to space.

Water Vapour Data Verification

The start date of 1960 of the following analysis was chosen because the water vapour relative humidity trend at the surface in the NOAA data from 1960 is zero, which is expected. Water vapour in air immediately above the ocean is in equilibrium with the water, so the air is near 100% relative humidity, regardless of the temperature. Water vapour over land is expected to vary proportionally with water vapour over the oceans, resulting in a near constant global average relative humidity near the surface with global warming. Data before 1960 is considered less reliable because the surface relative humidity is too high and would result in a declining relative humidity trend.

The graph below shows the relative humidity near the surface at 1000 mbar pressure from the NOAA database. The best fit trend line shows no trend confirming that the NOAA water vapour data from 1960 has no drying bias near the surface.

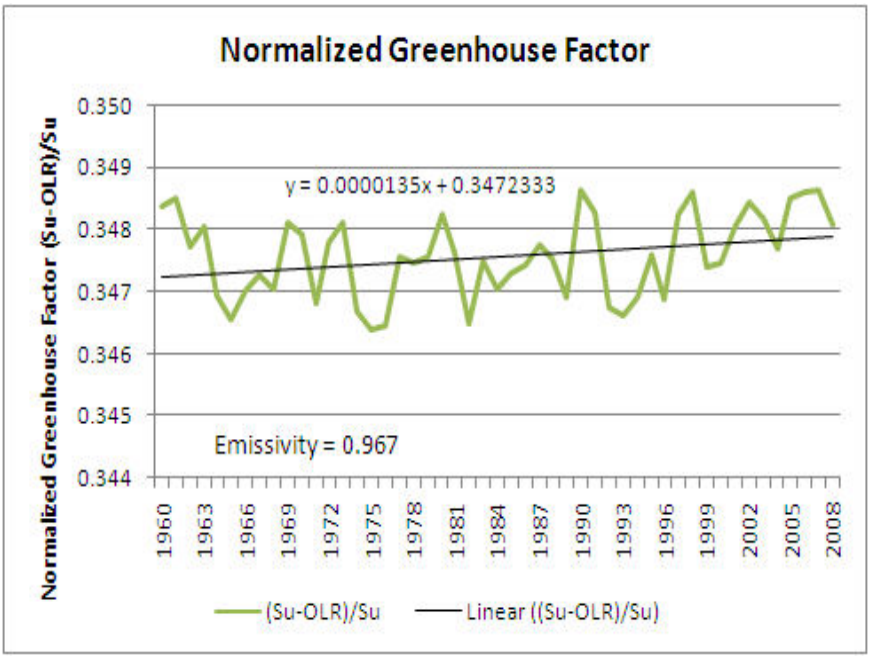


Analysis and Results

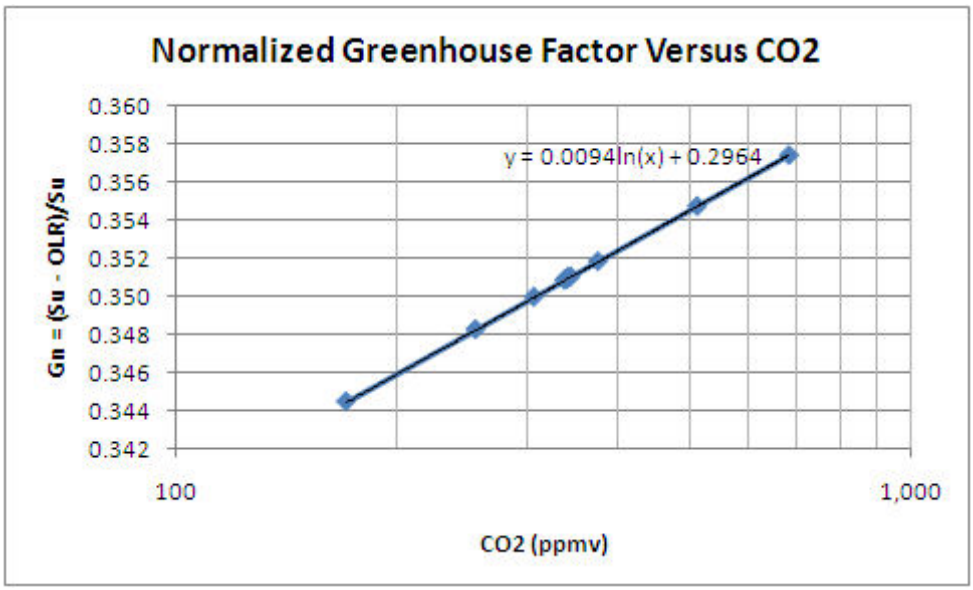
The HARTCODE program is a line-by-line code which calculates the atmospheric longwave radiation fluxes given the water vapour profiles, CO_2 concentrations and other minor greenhouse gases. It calculates the longwave absorption and radiation fluxes across the longwave spectrum utilizing 3490 spectral intervals, 150 atmosphere layers, 9 directional streams and 11 greenhouse gases. Both the surface flux and the top of atmosphere OLR flux were calculated using the NOAA data and the HARTCODE program assuming an emissivity = 1.

The radiation fluxes were adjusted using an emissivity factor of 0.967, which is the global average emissivity given in Miskolczi 2010 (page 8). The surface radiation is the upward thermal radiation due to the temperature of the surface plus the reflected portion of the atmospheric downward longwave radiation. The HARTCODE output fluxes and the emissivity adjusted fluxes are shown in an Excel spreadsheet located at the link in the References and Data section. The NGF is calculated using equation (1).

The graph below shows the NGF. The best fit line shows the NGF linear trend has increased by 0.19% over the 49 years.



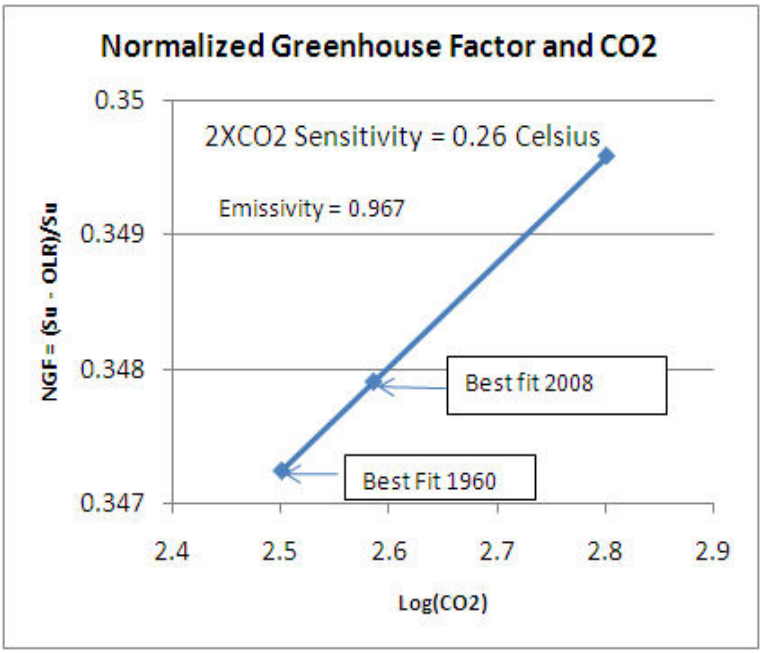
The HARTCODE program was run at various CO_2 concentrations, keeping the water vapour profile and surface temperatures constant, to investigate the effect of CO_2 concentration changes on the radiation fluxes. These simulation runs confirm that the effect of increasing CO_2 concentrations on the greenhouse effect is remarkably logarithmic as shown below. The black best fit straight line fits exactly on the calculated blue diamond data points.



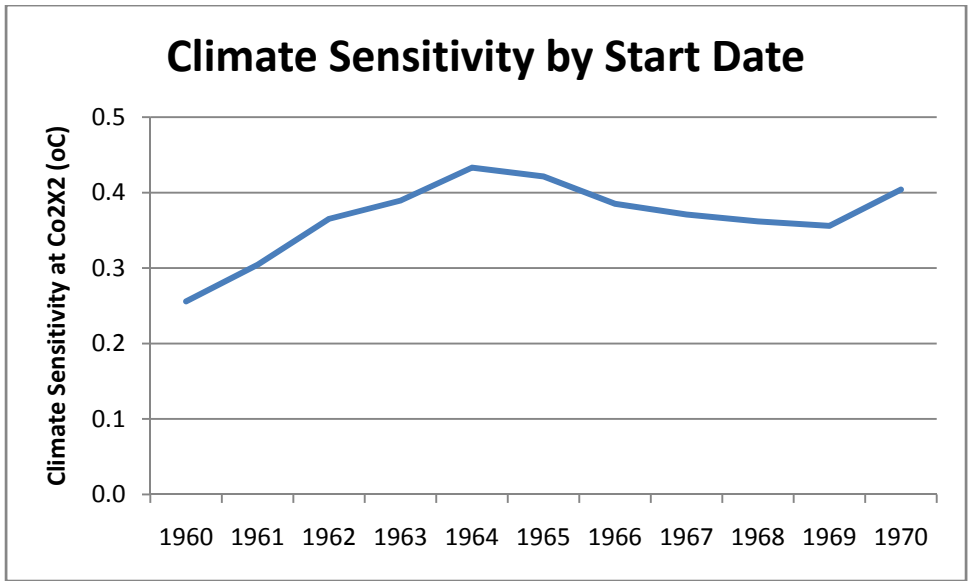
The logarithmic extrapolation to double CO_2 concentrations as shown in the table below gives a NGF of 0.66% above the 1960 value. The extrapolation assumes that the long-run OLR will be in balance with incoming radiation, so is held constant. Converting the resulting surface flux to temperature gives an estimate of climate sensitivity at double CO_2 concentration of 0.26 ^{o}C.

	CO_2 (ppmv)	Log(CO_2)	Best Fit NGF	NGF % of 1960	OLR (W/m^2)	Su (W/m^2)	Surface Temperature (^{o}C)
1960	316.91	2.501	0.34725	100.00%	257	393.72	17.94
2008	385.57	2.586	0.34789	100.19%	257	394.11	18.02
Double CO_2	633.82	2.802	0.34954	100.66%	257	395.10	18.20

The chart below shows the extrapolation.



The results depend on the start date of the analysis. Delaying the start date of the analysis to 1964 increases the calculated climate sensitivity to 0.43 Celsius, but it drops 0.36 Celsius at a 1969 start date. The climate sensitivity by start date is shown in the graph below.



Conclusion

The obvious question to the AGW advocates is "Has the greenhouse effect increased with man-made greenhouse gas emissions?"

This analysis shows that there has been **no significant increase** in the greenhouse effect since 1960. The greenhouse effect as characterized by the normalized greenhouse factor has increased by only 0.19% from 1960 to 2008. The temperature change from 1960 attributable to AGW is less than 0.1 ^{o}C. The extrapolated temperature change attributable to AGW at doubled CO_2 concentration is 0.26 ^{o}C. Delaying the start date of the analysis year by year to 1970 gives calculated climate sensitivities that vary about the 0.4 Celsius value. The data shows that the IPCC estimate of climate sensitivity at doubled CO_2 concentration of 3.0 ^{o}C is unrealistic.

References and Data

1. Miskolczi 2010, http://www.friendsofscience.org/index.php?id=503
2. NOAA, ESRL, http://www.esrl.noaa.gov/psd/cgi-bin/data/timeseries/timeseries1.pl
3. NOAA, CO_2 at Mauna Loa, ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2_annmean_mlo.txt
4. An Excel spreadsheet showing the data and calculations is at:
   http://www.friendsofscience.org/assets/documents/hartcode_61yearNOAA3.xls