CLIMATE CHANGE, TROPOSPHERIC WARMING, AND STRATOSPHERIC COOLING

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ABSTRACT: Climate models predict that rising atmospheric CO2 will simultaneously warm the troposphere and cool the stratosphere. This combination of tropospheric warming and stratospheric cooling is found in the observational data over a period of rising atmospheric CO2. Although strong correlations between these time series are found in the source data, the correlations do not survive into the detrended series at annual or five-year time scales. The absence of detrended correlation implies that the correlations seen in the source data derive from shared trends and not from responsiveness at annual or five-year time scales. The results are inconsistent with the theory that rising atmospheric CO2 simultaneously warms the troposphere and cools the lower stratosphere.[1]

1. INTRODUCTION

The theory of anthropogenic global warming (AGW) is derived from the notion first expressed by Guy Steward Callendar in 1938 that man's use of fossil fuels in the industrial economy is injecting into nature's carbon cycle, large quantities of carbon that had been previously sequestered underground for millions of years. The concern is that this artificial perturbation of the carbon cycle and climate system could have catastrophic consequences in terms of an artificial, unnatural, and unprecedented human caused warming trend. The mechanism of this warming is described in terms of the absorption of long wave radiation from the earth's surface by atmospheric carbon dioxide as postulated by Svante Arrhenius and others (Arrhenius, 1896) (Callendar, 1938) (Charney, 1979) (Hansen, 1981) (Keeling, 1977) (Lacis, 2010) (Manabe, 1967).

This warming mechanism is described as a two-step process. First the carbon dioxide in fossil fuel emissions increases the CO2 concentration in the atmosphere. In turn, this change in atmospheric composition increases the ability of the atmosphere to absorb long wave radiation from the earth's surface. The re-radiated heat thus absorbed reduces re-radiated heat loss to outer space and causes warming of the troposphere. The rate of warming is described as proportional to the logarithm of atmospheric carbon dioxide concentration in accordance with a constant of proportionality that represents the sensitivity of surface temperature to the logarithm of atmospheric carbon dioxide concentration (Charney, 1979) (Manabe, 1967) (IPCC, 2013). This sensitivity is normally represented in the Jule Charney format and referred to as ECS or equilibrium climate sensitivity (Charney, 1979).

Investigation of this warming dynamic on the atmosphere as a whole has been carried out with climate models in a large number of studies[2] (Manabe, 1967) (Manabe, 1975) (Ramanathan, 1988) (Rind, 1998) (Schmidt, 2006) (Fomichev, 2007). These climate model runs show the effect of rising atmospheric carbon dioxide as a coordinated pattern of warming in the troposphere and cooling in the lower stratosphere, and describe the theory of anthropogenic global warming due to fossil fuel emissions by way of the heat trapping effect of atmospheric carbon dioxide in this way. This work is an empirical test of these relationships.

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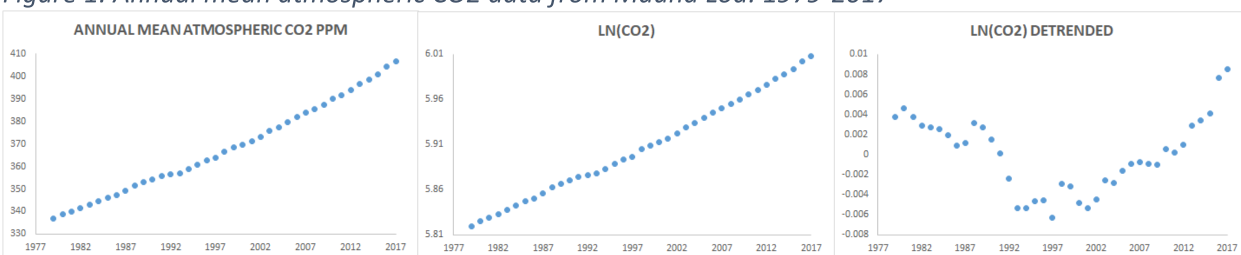
[2] Bibliography in related blog post: https://tambonthongchai.com/2018/08/22/stratospheric-cooling/

2. DATA AND METHODS

The greater precision of the Mauna Loa data for atmospheric CO2 levels as well as their availability as monthly means makes it possible to study the relationship between atmospheric CO2 and temperature estimates with greater accuracy. These data are available from 1959 to the present and they are used in conjunction with satellite data for lower troposphere temperatures available since 1979 and considered the most reliable measure of regional and global mean temperatures in the study of AGW (Reynolds, 2002) (Kawanishi, 2003) (Christy, 2007). The study period is thus constrained to 1979-2017 by the availability of both satellite regional temperatures and precise carbon dioxide measurements. Monthly mean atmospheric temperatures from satellite data at different elevations are provided by the University of Alabama Huntsville (Christy/Spencer, 2018). Data for atmospheric CO2 levels for the period 1959-2017 are provided by the Scripps Institution for Oceanography as monthly mean parts per million CO2 in the atmosphere by volume (Scripps, 2017). The annual mean CO2 time series is shown below. The data shown in the middle and right panel of Figure 1 are used in in the computation of correlation and detrended correlation with tropospheric and lower stratospheric temperatures.

Figure 1: Annual mean atmospheric CO2 data from Mauna Loa: 1979-2017



All temperature data are provided as temperature anomalies in Celsius units as regional and global means for each calendar month. They are combined into annual means since temperature anomalies do not contain the seasonal cycle. The regions used in this study are Global, Northern Hemisphere, and Southern Hemisphere. For each region, land surface, sea surface, and their combined temperatures are studied. For each of the nine region and surface combinations, the correlations among (1) the natural logarithm of atmospheric CO2, (2) lower troposphere temperature anomalies, and (3) lower stratosphere temperature anomalies, are studied with correlation analysis.

The theory of climate change with respect to these variables predicted in climate models implies that (1) lower troposphere temperature should be positively correlated with LN(AtmosCO2), (2) lower stratosphere temperature should be negatively correlated with LN(AtmosCO2), and (3) lower troposphere temperature should be negatively correlated with lower stratosphere temperature. The hypothesis tests for these correlations are set up accordingly as one sided tests on the appropriate side of the distribution. The time scale for all of these temperatures is taken to be annual as implied in the IPCC annual carbon cycle (IPCC, 2013). A five-year time scale is also tested. Detrended correlation analysis (Prodobnik, 2008) is used to test the existence of responsiveness at the time scale of interest. Hypothesis tests, normally made at $\alpha=0.001$ in accordance with revised standards for statistical evidence in light of an unacceptable rate of irreproducible results in published research (Johnson, 2013), are relaxed somewhat in this case to $\alpha=0.005$ minimize Type II errors.

3. DATA ANALYSIS

The results for global mean temperatures over both surfaces, land and sea, are summarized in Figure 2, Figure 3, and Figure 4. The analysis is carried out to test responsiveness at an annual time scale and also with five-year moving averages that tests a slower response dynamic among atmospheric carbon dioxide concentration, tropospheric temperature, and stratospheric temperature.

Figure 2: Global mean temperature: Responsiveness of stratospheric cooling to tropospheric warming

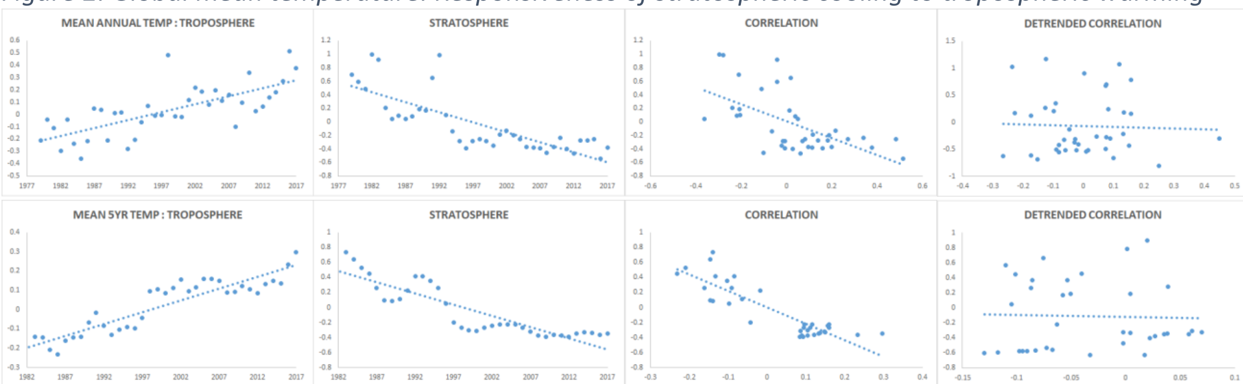


Figure 2 shows the relationship between tropospheric temperature and lower stratospheric temperature and tests the responsiveness of lower stratospheric temperature to tropospheric temperature at annual and five-year time scales. There are two panels in Figure 2, upper and lower, each with four charts referred to below from left to right as first, second, third, and fourth.

The upper panel tests responsiveness at an annual time scale. The first and second charts display mean annual temperatures in the troposphere and lower stratosphere. They show clearly that the troposphere is warming and that the lower stratosphere is cooling over the sample period 1979-2017. The third chart shows a strong negative correlation between these two temperature series. Thus, the first three charts are indicative of the hypothesized responsiveness of stratospheric cooling to tropospheric warming, and of their inverse relationship.

The fourth chart shows the detrended correlation between the two temperature series to assess the responsiveness of stratospheric temperature to tropospheric temperature an annual time scale net of the effect of long term trends. It shows that the strong negative correlation indicated in the third chart is not found at an annual time scale. This result does not support a causal connection between the two temperature series that works at an annual time scale. It implies that stratospheric temperature is not responsive to tropospheric temperature from year to year. The lower panel shows the corresponding results for five-year moving averages in the period 1983-2017 to test a slower response system in the proposed causal dynamic of stratospheric cooling due to tropospheric warming. The results at a five-year time scale are found to be identical to those for an annual time scale. A strong correlation is seen in the source data but the correlation does not survive into the detrended series. The results do not support a causal relationship between tropospheric and stratospheric temperature anomalies that works at a five-year time scale.

A further investigation of the proposed relationship between tropospheric warming and stratospheric cooling is shown in Figure 3. Here, instead of temperature, we compare trends. The temperature trends in a moving five-year window for the troposphere and stratosphere are shown in the first two charts of Figure 3. They show no trends. The third chart shows that there is no correlation between these 5-year temperature trends but the 4^{th} chart shows something very interesting that may be relevant to the relationship between temperature trends in these two parts of the atmosphere. It appears that there is a strong *positive* detrended correlation between five-year temperature trends in the troposphere and five-year temperature trends in the stratosphere. These results are not consistent with the theory derived from climate models that cooling of the stratosphere is related to warming of the troposphere.

Figure 3: Five-year warming rates in the troposphere and lower stratosphere: 1983-2017

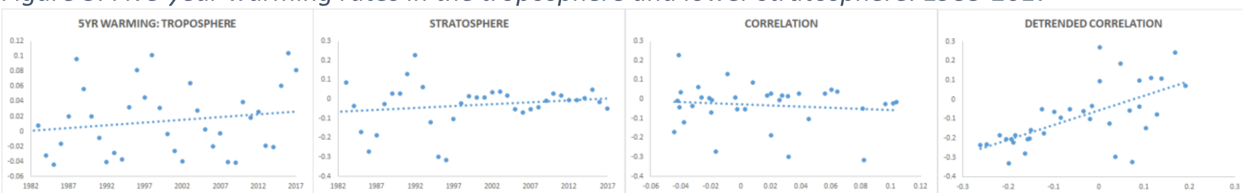
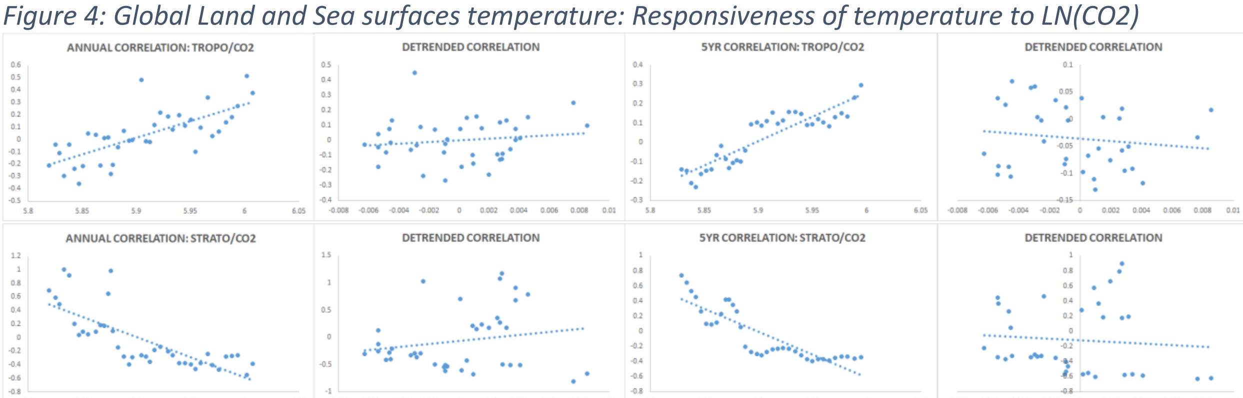


Figure 4 contains the results of a study of the "Climate Sensitivity" of tropospheric and stratospheric temperatures as predicted by the theory of the "greenhouse effect" of atmospheric CO2 concentration. The theory implies a responsiveness of temperature to atmospheric CO2 in a linear relationship between the logarithm of atmospheric CO2 concentration and temperature (Charney, 1979) (Lacis, 2010) (Manabe, 1975). This relationship is tested at annual and five-year time scales in each of the two panels of Figure 4. Troposphere temperatures are tested in the top panel and stratosphere temperatures in the bottom panel.

In the source data, the results show the expected positive correlation in the troposphere and the expected negative correlation in the stratosphere in the third chart of each panel. However, these strong correlations do not survive into the detrended series as seen in the last chart of each panel. Such correlation combinations imply that the correlation in the source data is an artifact of long term trends and that they do not imply responsiveness at the time scale of interest. In this case two different time scales, annual and five-year, are investigated with detrended correlation analysis. No correlation is found.

Figure 4: Global Land and Sea surfaces temperature: Responsiveness of temperature to LN(CO2)



These results are not consistent with the assumed greenhouse effect of atmospheric CO2 that implies a climate sensitivity proportionality of temperature with the logarithm of atmospheric carbon dioxide concentration. More to the point of this study, they do not support climate model results that atmospheric carbon dioxide simultaneously warms the troposphere and cools the stratosphere in a phenomenon usually referred to as stratospheric cooling (Manabe, 1975) (Ramanathan, 1988) (Rind, 1998) (Schmidt, 2006) (Fomichev, 2007).

In addition to the analysis of global mean temperatures presented above (Figure 2 to Figure 4), Regional and surface specific temperatures are studied for land and ocean surfaces separately and for each of the two hemispheres. The complete study involves a total of nine different temperature time series. The patterns seen in the global mean temperature series (Figure 2 to Figure 4) are also found in the regional temperature series. The results for all nine temperature time series studied are summarized in Figure 5.

Figure 5: Summary of results for all nine regions

	ANNUAL		5YEAR		TROPO	ANNUAL	STRATO	ANNUAL	TROPO	5YEAR	STRATO	5YEAR
	T/S-COR	DETCOR	T/S-COR	DETCOR	CO2COR	DETCOR	CO2COR	DETCOR	CO2COR	DETCOR	CO2COR	DETCOR
GLOBAL	-0.599	-0.041	-0.876	-0.034	0.722	0.149	-0.767	0.186	0.897	-0.136	-0.859	-0.084
LAND	-0.637	-0.039	-0.868	-0.096	0.783	0.197	-0.759	0.178	0.940	0.030	-0.860	-0.066
OCEAN	-0.560	-0.046	-0.859	0.000	0.668	0.120	-0.762	0.188	0.854	-0.201	-0.856	-0.093
NH	-0.587	-0.022	-0.873	-0.030	0.746	0.187	-0.751	0.180	0.913	-0.080	-0.863	-0.062
LAND	-0.614	-0.032	-0.859	-0.058	0.779	0.217	-0.741	0.173	0.932	0.039	-0.866	-0.055
OCEAN	-0.554	-0.040	-0.866	-0.016	0.689	0.153	-0.740	0.182	0.877	-0.156	-0.855	-0.066
SH	-0.527	-0.039	-0.845	-0.019	0.664	0.093	-0.728	0.184	0.865	-0.200	-0.838	-0.108
LAND	-0.485	0.008	-0.810	-0.118	0.691	0.106	-0.699	0.177	0.940	0.017	-0.817	-0.089
OCEAN	-0.513	-0.047	-0.837	-0.002	0.632	0.084	-0.729	0.185	0.820	-0.236	-0.842	-0.113

4. SUMMARY AND CONCLUSIONS

Computer models of the greenhouse effect of atmospheric carbon dioxide show that the climate sensitivity of CO2 implies that rising atmospheric carbon dioxide concentration causes not only the warming of the troposphere as is generally known, but also a cooling of the lower stratosphere (Charney, 1979) (Manabe, 1975) (Rind, 1998). This study is a test of this hypothesis. We used nine different regional atmospheric temperature time series for the sample period 1979-2017 provided by the UAH climate research center (Christy/Spencer, 2018) to carry out detrended correlation analysis at annual and five-year time scales. Although tropospheric warming and stratospheric cooling is observed, no evidence is found to support either the greenhouse effect of atmospheric carbon dioxide, or of a coordination between tropospheric warming and stratospheric cooling. We conclude that there is no evidence to support the climate model based hypothesis that tropospheric warming and stratospheric cooling are causally related or that either of these phenomena is related to atmospheric carbon dioxide concentration. All data and computational procedures used in this work are available for download from an online data archive (Munshi, Stratospheric Cooling Archive, 2018). This paper makes use of a companion blog post available at: https://tambonthongchai.com/2018/08/22/stratospheric-cooling/ .

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