GLOBAL WARMING: CORRELATION BETWEEN ATMOSPHERIC CARBON DIOXIDE CONCENTRATION AND TEMPERATURE

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ABSTRACT

The correlation between atmospheric carbon dioxide concentration and surface temperature was determined at various locations, using published data from the Goddard Institute of Space Studies and the Scripps Institute of Oceanography. Significant correlations were seen, with a lag of approximately 45 - 60 years between the rise in temperature and the rise in carbon dioxide concentration.

INTRODUCTION

The debate over the extent and causes of global warming has been acrimonious, at best.

Proponents of the hypothesis of anthopogenic global warming assert that the increase in carbon dioxide concentration in the atmosphere is the sole or at least the major contributor to the increase in surface temperature, due to the "greenhouse effect".

Others take the position that the increase in surface temperature is due to natural variation in climate, and in particular, that the globe is coming out of the "Little Ice Age", which ended in the mid to late 1800's.

In an attempt to clarify the issue, a basic question was asked: Is there a statistically significant correlation between the rise in carbon dioxide concentration in the atmosphere and the rise in temperature? A related question is: If such a correlation exists, what fraction of the rise in surface temperature can be attributed to the rise in CO_2?

If the rise in carbon dioxide concentration is causing a rise in surface temperature, then there must exist a correlation between the two. If the rise in CO_2 concentration is not causing the rise in surface temperature, then there may be a correlation (due to coincidence or to a mutual relationship with third variable). If there is no correlation, a causal relationship cannot exist.

DATA SOURCES

The surface temperature data were taken from the Goddard Institute of Space Studies website (1), and consist of monthly and yearly average temperatures for periods of up to 130 years, depending on the location. These data have an accuracy of three to four significant figures.

The atmospheric carbon dioxide concentration data were taken from the Carbon Dioxide Information Analysis Center website, and were originally developed at the Scripps Institute of Oceanography (2). These data consist of monthly and average yearly atmospheric CO_2 concentrations in ppmv, measured at Mauna Loa, Hawaii since 1959. These data have an accuracy of four to five significant figures.

Data Selection

Ten sites for these analyses were chosen at random, with the following constraints:

1.) An attempt was made to achieve a reasonably uniform coverage over the continental United States (i.e., to avoid clustering within a small area),

2.) Rural areas were chosen, so that the issues of extent and correction for the Urban Heat Island Effect could be avoided, and

3.) Sites were chosen which had continuous temperature data reaching back to aroumd 1900 or before.

Data Transfer

The data were downloaded from the respective websites as .txt files, uploaded into Microsoft EXCEL as .xls files, combined, then uploaded to SAS using ACCESS and VIEW descriptors (3). The raw yearly average data, as they appear on the respective websites, were used without transformation or modification of any kind.

An example of the code follows:

```
DATA DATA1;
  SET SASUSER.WUSS1VUE; /*VIEW
descriptor*/
  RENAME  variables;
RUN;
```

Initial Analysis

Linear regression was performed using PROC REG, with CO_2 concentration as the indicator variable and surface temperature as the response variable. The results of these analyses are summarized in the table below:

Station	R	p	R^2
Hilo, HI	0.1551	0.3268	Not sig
Colfax, CA	-0.0867	0.5900	Not sig
Needles, CA	0.2845	0.0715	Not sig
Cheyenne Wells, CO	0.4073	0.0074	0.1659
Cooperstown, NY	0.3957	0.0095	0.1566
Farmington, MA	0.4828	0.0012	0.2331
St. Leo, FL	0.4580	0.0023	0.2098

Pine River Dam, MN	0.3890	0.0109	0.1513
Greensboro, NC	0.6960	0.0001	0.4845
Waterville, WA	0.2751	0.0779	Not sig

where R is the Pearson correlation coefficient, p is the "p-value" (usually, a "p-value" of less than or equal to 0.05 is necessary to call a correlation significant), and R^2 is the coefficient of determination, that fraction of the rise in temperature which can be attributed to the rise in carbon dioxide concentration (table entries are made for only those stations where R is statistically significant).

If the rise in atmospheric carbon dioxide concentration is the sole, or even a large, factor in the rise of surface temperature, it is expected that a significant correlation between the two would be seen, and also that a large fraction of the rise in temperature would be attributed to the rise in CO_2.

It is seen, however, that the correlations between carbon dioxide concentration and surface temperature at these sites are either nonexistant or, at most, weak.

An example of the relationship between surface temperature and CO_2 concentration (at Hilo, Hawii) may be seen in Graph 1. The best fit straight line along with the 95% confidence intervals of that line are superimposed on the individual data points.

Correlation Analysis

There have been hints in the literature that temperature rise may precede carbon dioxide concentration rise. The mechanism hypothesized is that warmer temperatures allow organic material to decompose faster, thus increasing the amount of CO_2 in the atmosphere.

To check this hypothesis, the correlations between CO_2 concentration and surface temperatures were calculated, with lags from −10 years (carbon dioxide leads temperature) to 75 years (temperature leads carbon dioxide), using PROC CORR.

This was accomplished with:

```
PROC CORR DATA=DATA1 OUTP=CORRVALU NOSIMPLE;
/*output to data set CORRVALU */
  WITH TEMP; /* all correlations with
temperature are calculated */
RUN;
```

The results were output to a data set, sorted by lag time and then plotted using PROC GPLOT. If the temperature is indeed leading carbon dioxide concentration, this plot should show a region of more or less random, non-significant correlations, leading to an upswing toward a maximum, then a decrease to non-significance again. This maximum would then be at the location of the lag between the temperature rise and the carbon dioxide concentration rise.

An example of such a plot (from Hilo, Hawaii) is shown as Graph 2. The data are plotted as correlation coefficent on the vertical axis, and the lag (in years) on the horizontal axis, and a spline smoothing fit to the points is superimposed, using the following:

```
SYMBOL1 I=NONE C=BLACK V=DOT;
SYMBOL2 I=SM25 C=BLACK;
AXIS1 LABEL = (J=C 'Lag Time (Years)';
AXIS2 LABEL = (J=C A=90 'Correlation
Coefficient');
PROC GPLOT DATA=DATA4;
  TITLE 'Correlation vs. Lag Time';
  PLOT CORR*LAG=1 CORR*LAG=2 / FRAME
OVERLAY HAXIS=AXIS1 VAXIS=AXIS2;
RUN;
```

This analysis was repeated for the weather stations listed above, with the results summarized in the following table:

Station	Lag(max)	p	R^2
Hilo, HI	60	0.0001	0.5063
Colfax, CA	57	0.0049	0.1813
Needles, CA	22	0.0030	0.2089
Cheyenne Wells, CO	61	0.0001	0.3077
Cooperstown, NY	45	0.0023	0.2297
Farmington, MA	45	0.0001	0.4546
St. Leo, FL	45	0.0001	0.3275
Pine River Dam, MN	12	0.0002	0.2963
Greensboro, NC	-5	0.0001	0.5472
Waterville, WA	56	0.0014	0.2279

where Lag(max) is the lag time (in years) at the maximum correlation, p is the "p-value", and R^2 is the coefficient of determination, that fraction of the rise in carbon dioxide concentration attributed to the rise in temperature.

If the rise in CO2 concentration were causing the rise in surface temperature, then the maximum correlation would be at Lag=0 (i.e., carbon dioxide concentration and surface temperature for the same year). In fact, these data show that the maximum correlation is never at Lag=0.

It is seen that significant, and sometimes highly significant, correlations exist at other lag times, with the rise in temperature preceding the rise in carbon dioxide concentration by many years.

It is also seen that these lag times tend to be clustered in about the 45 to 60 year range, indicating that temperature increase leads carbon dioxide increase by a like number of years.

An example of the relationship between carbon dioxide concentration and surface temperature at the lag time of maximum correlation (from Hilo, Hawaii) is shown as Graph 3.

CONCLUSIONS

1.) There exist no or only weak correlations between surface temperature and atmospheric CO2 concentration.These data are inconsistant with the hypothesis that carbon dioxide concentration is the sole, or even a major, contributor to the increase in surface temperature.

2.) There appears to be a lag of 45 – 60 years between the increase in surface temperature and the increase of carbon dioxide concentration, with the temperature leading the CO_2.These data are consistant with (but do not prove) the hypothesis of increased temperature driving the increase in atmospheric carbon dioxide.

REFERENCES

1. http://www.giss.nasa.gov/data/update/gistemp/ station_data /
2. http://cdiac.esd.ornl.gov/ftb/maunaloa-co2/maunaloa.co2
3. SAS/ACCESS Software for PC File Formats, Ch. 8

CONTACT INFORMATION

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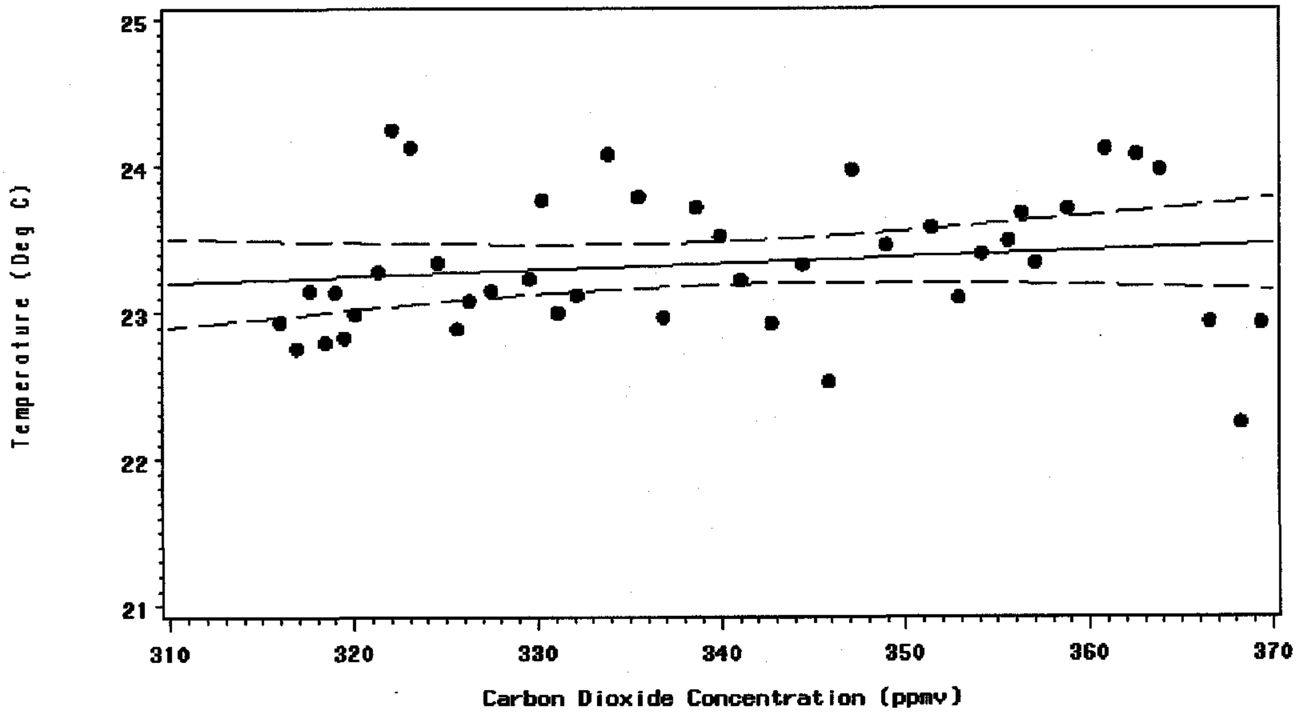
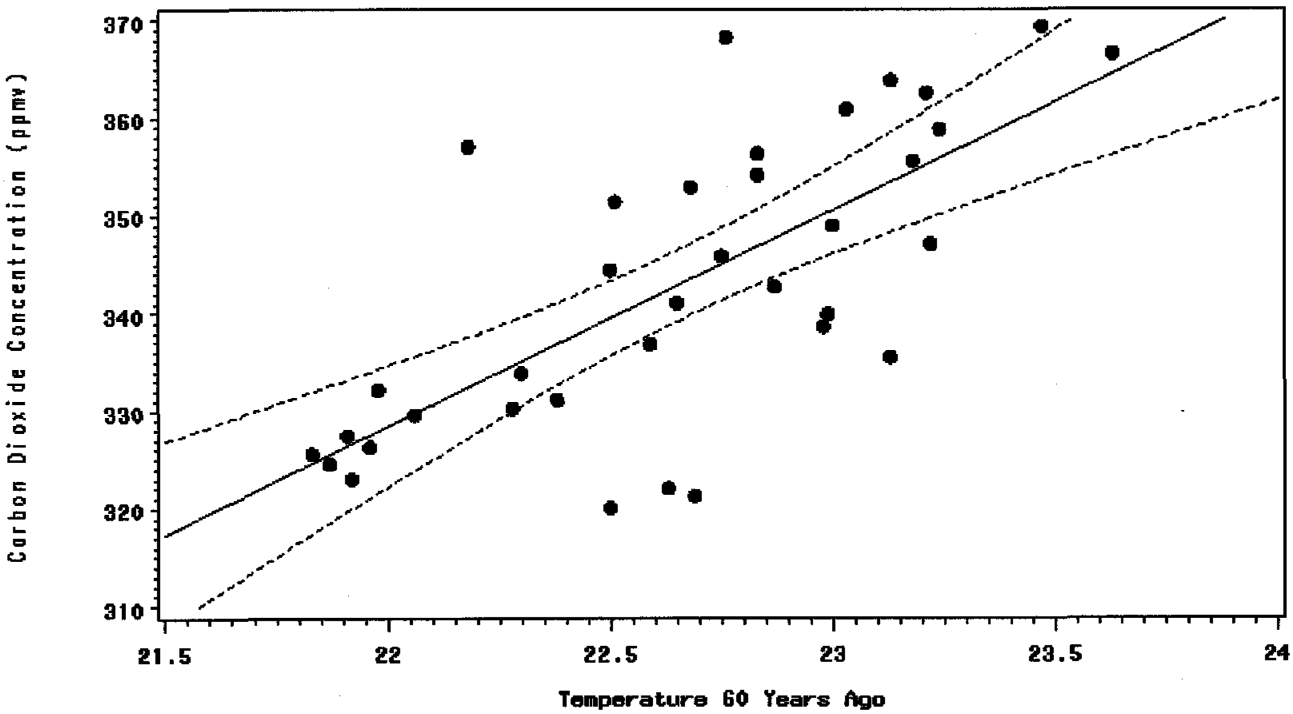
Graph 1 – Temperature vs Carbon Dioxide

Station: Hilo (19.7 N 155.1 W)



Graph 2 – Carbon Dioxide vs Temperature 60 Years Ago

Station: Hilo (19.7 N 155.1 W)



Graph 3 – Correlation vs. Lag Time

Station: Hilo (19.7 N 155.1 W)