Evidence of Causality Between the Atmospheric Concentration Levels of Carbon Dioxide and Temperature

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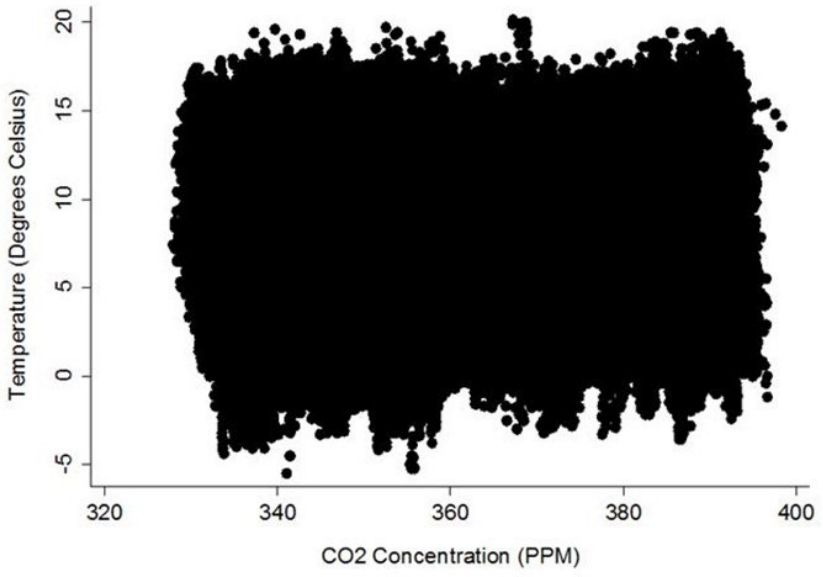
This paper explores the relationship between the atmospheric concentration of Carbon Dioxide (CO_2) and the dry-bulb temperature using hourly CO_2 atmospheric concentration data from the Mauna Loa Observatory (MLO) in Hawaii. The starting point is that traditional correlation analysis does not yield evidence in support of a causal relationship between the CO_2 concentration level and temperature. This is readily apparent if one inspects a simple scatter diagram of the hourly CO_2 and temperatures levels at the MLO in Hawaii over the period 1 Jan 1977 through 31 Dec 2010 (Figure 1). More fundamentally, traditional correlation analysis is not capable of addressing whether there is a causal relationship between CO_2 and temperature because statistical methods alone cannot render results that establish or reject causality between two variables that are contemporaneously correlated. Nevertheless, advanced statistical methods can address the issue of causality.

The approach adopted in this paper addresses the issue of causality between CO_2 and temperature by following *Granger* [1969], who defined causality in terms of whether lagged values of a variable lead to more accurate predictions of some other variable. This study embraces this view of causality by examining whether lagged values of CO_2 lead to more accurate forecasts of temperature. The analysis makes use of lagged hourly CO_2 atmospheric concentration data from MLO, data on the hourly temperature at the nearby Hilo International Airport, and day-ahead hourly forecast data for the Hilo location. The estimated equation is used to make hourly out-of-sample forecasts. Consistent with the existence of a causal relationship, the inclusion of the CO_2 level as an explanatory variable improves the accuracy of the forecast. The improved forecast is also more accurate than conventional temperature forecasts for the same location.



Source: http://www.esrl.noaa.gov/gmd/dv/data/ and ftp://aftp.cmdl.noaa.gov/data/meteorology/in-situ/

Figure 1. A Scatter Diagram of Hourly CO_2 and Temperature Levels at the Mauna Loa Observatory in Hawaii, 1 Jan 1977 through 31 Dec 2010.