The Relationship between Hourly CO2 Concentrations and Hourly Temperature: Evidence from Alaska

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Brief Description

One gap in current climate change research is that the statistical relationship between hourly CO2 concentrations and the hourly temperature has not been rigorously investigated.

Addressing this issue is challenging because the hourly temperature data are noisy, which makes it difficult to extract the CO2 signal.

Yet, this challenge needs to be resolved to advance climate science and public policy.

This paper addresses this issue using ARCH/ARMAX time series methods and over 200,000 hourly data observations from the Barrow Atmospheric Observatory in Alaska, USA.

Abstract

According to the IPCC and other leading scientific organizations, “it is extremely likely that human influence has been the dominant cause of the observed increase in global temperatures since the mid-20th century.” One gap in the research underlying this assessment is that the statistical relationship between hourly CO2 concentrations and the hourly temperature has not been rigorously investigated. Addressing this gap in the research is challenging because the hourly temperature data are noisy, which makes it difficult to extract the CO2 signal. Yet, this challenge needs to be resolved to advance climate science (including the emerging science of climate attribution), and public policy. The latter issue is especially important given that a significant percentage of the population does not fully embrace the scientific consensus on climate change.

This paper examines the relationship between hourly CO2 concentrations and hourly temperature issues using hourly data from the Barrow Atmospheric Observatory in Alaska, USA. It is first noted that the average annual temperature at Barrow over the 2015-2020 period was about 3.37 C higher than in the 1985-1990 period. The analysis employs hourly solar irradiance (a key driver of the weather and climate system), CO2, and temperature data. Possible non-anthropomorphic drivers of annual temperature are also considered. The data are analyzed using an ARCH/ARMAX (Autoregressive Conditional Heteroskedasticity/ Autoregressive–Moving-Average with Exogenous Inputs) approach. This statistical method captures the data’s heteroskedastic and autoregressive nature, which would otherwise “mask” CO2’s “signal” in the noisy data. The model is estimated using hourly data from 1985 through 2015. The results are consistent with the hypothesis that increases in CO2 concentration levels have nontrivial consequences for hourly temperature. The model is evaluated using data over the period January 1, 2016, through December 31, 2021. The model’s out-of-sample hourly temperature predictions are highly accurate, but this accuracy is significantly degraded if preindustrial levels of CO2 are assumed. The implications for selected global locations such as Ottawa Canada are assessed using Vector Autoregressive temperature models coupled with Granger causality tests