OBSERVED RESPONSE OF THE CO_2 GROWTH RATE TO CLIMATE VARIATIONS

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BACKGROUND

The world is moving in a direction of managing the carbon cycle in order to limit the forcing of earth's climate by CO_2 as well as to limit acidification of the oceans. We may expect limitations on emissions, sequestration of carbon and enhancements of natural sinks. It would be important to be able to observe and quantify the impact of any such measures on the growth rate of CO_2. Until now it has been difficult to quantify changes of the growth rate of CO_2 with confidence due to the large year to year variations that are caused by climate variations. A statistical method has been developed to predict the growth rate of CO_2 based on observed variations of climate parameters.

METHOD

The longest directly measured record of atmospheric CO_2 at the Mauna Loa Observatory (MLO) in Hawaii is taken as representative of global CO_2. On an annual basis its representativeness is demonstrated by comparing the MLO record against a global surface average estimated from the measurement of air samples obtained through the CMDL Global Cooperative Air Sampling Network. The global record of the $^{13}C/^{12}C$ ratio of CO_2 shows that most of the observed variations of the CO_2 growth rate have terrestrial causes. It cannot be assumed that the response of the terrestrial carbon cycle to climate variability is the same on short (e.g., seasonal, annual) time scales as on longer time scales (e.g., multi-year) because quite different limiting factors are likely to come into play. After removal of the overall long-term CO_2 trend, the time derivative of the de-seasonalized “anomalies” constitutes a (noisy) record of short-term growth rate variations. This has been compared to various global climate parameters that were treated similarly in order to isolate short-term from long-term effects.

A correlation with global temperature variations clearly stands out. However, sometimes the CO_2 growth rate seems to lead the temperature, whereas at other times it seems to lag. The predictability of CO_2 growth rate variations, based on temperature, is improved considerably when not only the immediate response is considered but a lagged response is taken into account. This response has been derived directly from the CO_2 and temperature data. It is initially positive (high temperature causing a high CO_2 growth rate), but reverses sign in the following year. Expected CO_2 growth rate variations can now be calculated by taking a convolution of past temperature data with the response function. Depending on which temperature record is used, the response function explains 50-60% of the short-term CO_2 variance.

The reduced remaining variance enables a closer look at the behavior of the CO_2 growth rate on a decadal time scale, and permits earlier detection of any persistent change.