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Ensemble Empirical Mode Decomposition of monthly CO_2 measurement and GEOS-Chem simulation

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With the availability of new sources of data, time series analysis has been playing an ever-increasing role in atmospheric and climate studies. Time series analysis of greenhouse gas concentrations in the atmosphere brings out different patterns of variability of these atmospheric concentrations (e.g. diurnal, synoptic, seasonal, annual, and other concealed time scales). CO_2 is the single most important climate-relevant greenhouse gas in Earth's atmosphere. In addition to the trend, different time scale oscillations have been found from long term observations which may relate to biospheric influence or the atmospheric circulation variability.

Traditional spectral analysis is generally based on certain assumptions of the data, such as its linearity and stationary nature, for example the Fourier Transform (FT), which assumes that any time series can be decomposed into a set of linear components. When decomposing a nonlinear time series, this will often produce physically meaningless harmonics. In order to accommodate the variety of data generated by nonlinear and non-stationary processes, data analysis methods need to become adaptive.

Empirical Mode Decomposition (EMD) developed by Huang can decompose a time series into time-frequency space and produces a set of independent modes called Intrinsic Mode Functions (IMFs). The application of this method provides an insight into the modes of variability hidden in the original time. The combination of EMD and Hilbert spectrum analysis is called Hilbert-Huang transform (HHT). It has become a widely used and powerful tool for the analysis of non-stationary signals in an adaptive manner. Since atmospheric and climatic phenomena are highly non-stationary and nonlinear, the adaptive methods would potentially provide more insights into their long term records.

In this study, we investigated the climate relevant surface CO_2. To determine the possible cause of the oscillation of surface CO_2, and the mismatching in model and observation, we use the chemistry transport model GEOS-Chem to simulate the surface emissions, and compare them with the IMFs decomposed by Ensemble EMD (EEMD).