Atmospheric carbon and the statistical science of measuring, mapping, and uncertainty quantification

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Abstract

My presentation is divided into two parts. The first part is about how spatio-temporal statistical models can be motivated by physical models arising from partial differential equations, where the approach is illustrated in the one-dimensional case. This leads on to a problem I have been working on for several years, namely the evolution in Earth's atmosphere of the greenhouse gas, carbon dioxide (CO2), which has increased to levels not seen since the middle Pliocene (approximately 3.6 million years ago). One of the National Aeronautics and Space Administration's (NASA) remote-sensing missions is the Orbiting Carbon Observatory-2, whose principal science objective is to estimate the global geographic distribution of the CO2 sources and sinks at Earth's surface through time. From a mathematical point of view, this is an ill-posed inverse problem for which regularisation is needed, and part of that regularisation involves a model of atmospheric transport. Uncertainty quantification using hierarchical statistical models is key; then an application of Bayes' Theorem allows CO2 fluxes to be estimated (in principle). The second part goes into the research needed to make the Bayesian approach work in practice, and it illustrates the importance of using global simulations of the hierarchical model to assess the validity and efficiency of the flux estimates.