Evaluating Modeled Haze with Measurements in US National Parks

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The Regional Haze Rule, put into place by the EPA in 1999, requires that Class I regions of the United States return to natural visibility conditions by 2064. However, it is difficult to determine what natural visibility means, and what is considered human caused visibility impairment versus naturally caused visibility impairment because haze is a complex mixture of different chemical constituents, all of which have both natural and anthropogenic sources. By looking at an updated version of the GEOS-Chem model (v12.0.2), a global 3D atmospheric composition model, we can see the impact of newer treatments of emissions and atmospheric chemistry on the particulate matter found in the atmosphere that causes haze and visibility impairment. In order to assess the accuracy of the model, we processed the GEOS-Chem model data and compared it to observed IMPROVE Network data, which is collected at National Parks and Wilderness Areas around the country. We converted the GEOS-Chem simulation data from hourly mass concentrations of haze components at the surface to daily means in units of light extinction. Then, we sampled the model grid cells containing sites in the IMPROVE Network in order to compare the model with observations. We find major improvements in two species, organic carbon and sulfate, but find that some model shortcomings evident in older versions of the model remain. The findings indicate that this version of the GEOS-Chem model is more accurate than earlier versions in many regards, but there is still progress to be made. Since we can't directly observe the natural versus anthropogenic components of haze, we use models to estimate these contributions. One approach to estimate anthropogenic impairment is very simple statistical models applied to the observations directly. Another is to use a chemical transport model like GEOS-Chem in which we can zero out US anthropogenic emissions to estimate more directly the anthropogenic impairment, or remove all anthropogenic emissions globally to estimate natural visibility. Though there are shortcomings of this updated run of the GEOS-Chem model, it is still a useful piece of information that can be used to inform the Regional Haze Rule and distinguish between anthropogenic and natural haze, and good progress has been made already to improve the model's accuracy.

Reproducing Instrumental Ozone Flux Measurements in the Harvard Forest Using A Trace Gas Method

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Tropospheric ozone (O3) is a pollutant that causes atmospheric haze, poses a threat to human health, and damages plants. The Harvard Forest research facility has a short instrumental ozone flux (FO3) record from October 1992-December 2001, and past studies have used these measurements to study diurnal and seasonal FO3 cycles. However, long term and inter-annual processes controlling patterns of flux are still uncertain. We attempted to reproduce these reliable instrumental "eddy covariance" flux measurements of ozone using the Modified Bowen Ratio, or trace gas equation, to reconstruct a 30 year record to identify long-term, inter-annual trends. Assuming all gases move together, the equation, calculates an unknown flux (FO3) from a known flux of a different gas (FCO2) and the above canopy concentrations from both gases (Δ[O3] and Δ[CO2]). All data used was collected in the Harvard Forest in Petersham, MA. This reproduced an approximation of the instrumental hourly diurnal cycle of FO3 for the growing season (July and August) as well as the seasonal cycle for the 10-year period. However, on a yearly scale, only some years matched in magnitude and pattern, with some underestimating flux, bearing noise, or large (+-100 e-6 mol/m2 s) uncertainty. The study is still in progress, and we use a method based in air dynamics to calculate fluxes for non-growing season months. Since the 1980's, the threat of tropospheric O3 from anthropogenic sources has lessened significantly (not entirely), so removal of ozone through deposition in forests is much more significant in understanding how ozone levels fluctuate now, and how they may change in the future.