5.050 Incorporating chemical interactions and co-emissions in top-down constraints on sources of NOx, SO2 and CO .

Early Career Scientist

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Abstract:

Accurate estimates of air pollutant emissions from each human and natural activity are important for understanding atmospheric chemistry and implementing emission control strategies. Previous top-down estimates have inferred NO_x, SO_2 and CO emissions individually using observations of each species separately. With more common use of finer grid (< 10 km) air quality models and pending availability of higher resolution satellite measurements in the coming decade (e.g., TROPOMI, TEMPO, GEMS), opportunities and challenges exist for more effective usage of a broader suite of observations to better understand the sources of these pollutants. First, computationally quick approaches to constraining emissions based on the ratio of observed to modeled column densities are less accurate at the spatial scales of cutting-edge high resolution models, as column concentration are no longer governed by emissions in each grid cell. Second, the impacts of NO_x and CO emissions on OH and O_3 concentration are often overlooked in inversions using single species observations, degrading emission estimates for species oxidized by OH and O_3. Third, co-emitted pollutants and their uncertainties have correlations that should not be neglected in order to consistently invert different species emissions from the same sector and to analyze changes in activity and fuel types. Given these challenges, we develop a novel multi-species sector-based (e.g., industry) 4D-Var data assimilation framework (built on GEOS-Chem adjoint) to constrain emissions according to activities. We start with quantifying NO_x, SO_2 and CO emissions at global and regional scales using measurements from OMI and MOPITT (and TROPOMI, pending data availability). Posterior emissions from sector-based and traditional species-based inversions are compared. Simulated NO_x, CO, SO_2, $PM_{2.5}$ and O_3 concentrations are evaluated against surface and aircraft measurements. This sector-based inversion can be further applied to other species to investigate the impact of emission sources on human exposure, climate and ecosystems.