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Constraining the relationships between aerosol height, aerosol optical depth and total column trace gas measurements using Remote Sensing and Models

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Due to changes in economics, technology, population, and climate, there have been significant changes in terms of air pollution and its impacts on society. In specific, we are interested to know more about how these effects play out on the atmospheric loadings and associated impacts of aerosols. Such sources as fires and power generation both produce plumes of aerosols which are first lofted to a significant height, and then advect to impact the larger atmosphere. Therefore, the ways in which these sources have been changing is absolutely critical for our being able to better constrain the environmental and atmospheric impacts, since once advected aloft, the lifetime, radiative properties, and overall impact become considerably larger.

We combine existing measurements of NO_2 columns, AOD, and land-use, with a new dataset of global aerosol heights, as measured by OMI, MODIS, and MISR, into a single product. This product yields a spatially and temporally variable distribution of the vertical distribution of aerosols. Furthermore, we take a step further, drawing a set of relationships based on the physics and chemistry: making a connection from the emissions amounts and the heat sources to the ultimate vertical structure. The point is not only to be able to force a model to match the measurements, but to build a system through which we can mode deeply understand and constrain these relationships. This will slowly allow us to understand to the point where we can improve the model predictions analytically, as well as to perform massive uncertainty calculations.

We first draw conclusions about the relationships between the different land use types, and ratios of aerosols and NO_2, allowing us to interpret the magnitude of the pollutant emissions and the source plume heat. Next, we build relationships using plume models and WRF-CHEM to understand the basic relationships between these results and the measured height profiles. We make some initial conclusions in terms of these relationships over Africa, Southeast Asia, and the High Arctic, and show that they are different in each of these critical areas. We then try to explain a bit as to why this is the case, and build towards a more comprehensive and physically based relationship for future work.