Estimates of $PM_{2.5}$ concentration and chemical composition by application of KORUS-AQ High Spectral Resolution Lidar retrievals and CATCH algorithm

Particulate matter is one of the six criteria air pollutants that the United States Environmental Protection Agency (EPA) has established national ambient air quality standards (NAAQS) for under the Clean Air Act. Particles with aerodynamic diameter less than 2.5 μm ($PM_{2.5}$) have been found to have the most serious adverse effect on human health and the environment.

While the importance of measuring $PM_{2.5}$ has been clearly demonstrated, doing so remotely remains challenging. We have developed a methodology for using High Spectral Resolution Lidar (HSRL) retrieved information about aerosol extinction and types to derive model-independent estimates of surface $PM_{2.5}$ concentration and chemical speciation. We showed that for the DISCOVER-AQ BW campaign the results from the new methodology compared with the ground measurements better than the EPA CMAQ model predictions.

Recently we have tested the methodology using the KORUS-AQ campaign. Our preliminary data analysis shows the method did not perform as well on retrievals from Korea as it did for the aerosols from the eastern US. We hypothesize, that this is due to two main factors: (1) particularly low mixed layer heights encountered during KORUS-AQ and (2) differences in the chemical composition and optical properties for Asian aerosols versus eastern American. For shallow mixed layer heights below ~300 m, decoupling between the surface and the air aloft makes aerosol retrievals through HSRL (and subsequent characterization by our methodology) particularly intractable. It has been shown previously that the chemical composition of aerosols (e.g., more black carbon) affects their optical properties and subsequently their type-resolved characterization (e.g., for urban aerosols).

In this work, we intend to test/improve our methodology for remotely estimating $PM_{2.5}$ concentration and chemical speciation in east Asia using HSRL retrievals. This will include an introduction of a threshold for retaining the data using the HSRL derived mixed layer heights. We also plan on retraining the CATCH algorithm for east Asian aerosols using a small portion of the KORUS-AQ campaign data. Retraining will “teach” the CATCH algorithm how to treat aerosol types that may have different optical properties from the ones observed in the North American domain. Once these two steps are successfully achieved the method validation will be conducted by comparing estimated $PM_{2.5}$ concentrations and chemical speciation with data from National Institute of Environmental Research (NIER) ground sites. The successful completion of this project will mean that a new methodology has been developed and validated which can be used to estimate $PM_{2.5}$ concentration and chemical speciation in both North America and Asia with region-specific chemical speciation. Since the method developed in this study is designed for the NASA Langley HSRL sensor, this work will lay the groundwork for $PM_{2.5}$ concentrations and chemical speciation retrievals from space a part of the NASA Atmosphere Observing System (AOS).