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Simultaneous retrieval of aerosol variables through data-assimilation

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Detailed knowledge of the atmospheric aerosol size distribution and chemical composition is required for better understanding of the effects of aerosols on climate, air quality and health. In situ measurements provide indirect information of aerosols, such as electric mobility. Mathematical inversion techniques are successful in aerosol size distribution retrieval, but the results are limited to the parameters in the particle size range resolved by the instrument. Combining different measurement types or measurements distributed in time has proven difficult for inversion techniques. Simultaneous retrievel of chemical composition and size distribution through inversion remains a significant scientific question.

An alternative retrieval approach based on data assimilation is introduced here. A sectional evolution model of aerosol microphysics and an array of measurement data is intended to be assimilated for the retrieval of aerosol size and composition parameters. In contrast to purely mathematical inversion techniques, data assimilation enables the use of aerosol dynamics in the retrieval process, thus effectively constraining the set of possible solutions in a physically consistent way. Essentially, simultaneous use of multiple instruments, temporally distributed measurement data and an evolution model as a strong constraint for the retrieval solution provides enough information for fixing all degrees of freedom of the evolution model, even some of those not directly observed.

The modelling component of the proposed research is based on the University of Helsinki Multi-component Aerosol model. The measured variables include the particle size distribution in different particle sizes, particle mass distribution, chemical composition, light absorption, ambient vapour concentrations and meteorological parameters.

The method has been tested with synthethic size distributions and idealized conditions, with the method succesfully determining the correct initial state even when the initial estimation error was significant. Additionally, assumptions required for the application of data assimilation were found to be valid for the aerosol dynamical models and observations except for certain conditions concerning the size distribution of particles smaller than $10nm$. In these cases the evolution of the number concentration error covariance becomes problematic.

The next step of the research is to apply the method with real observations. This is currently underway.