

Variational Data Assimilation for Multiple Aerosol Species with WRF/Chem

Zhijin Li^a, and Zengliang Zang^b

^a *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA*
Zhijin.Li@jpl.nasa.gov

^b *Joint Institute for Regional Earth System Science and Engineering,
University of California, Los Angeles, California, USA*

Aerosol data assimilation faces some fundamental difficulties that arise primarily in treating a large number of state variables. A sophisticated aerosol scheme often explicitly treats more than a dozen species, which involve not only mass concentrations but also number concentrations. The number of state variables is further multiplied for representing the wide range of aerosol size distributions, ranging from a few nanometers to around 100 μm in diameter. To circumvent these difficulties, a host of formulations are proposed and implemented in a three-dimensional variational data assimilation (3-DVAR) algorithm in a Weather Research and Forecasting (WRF) model coupled with Chemistry (WRF/Chem). The WRF/Chem model uses the MOSAIC (Model for Simulating Aerosol Interactions and Chemistry) aerosol scheme, which explicitly treats eight major species (elemental/black carbon, organic carbon, nitrate, sulfate, chloride, ammonium, sodium, and the sum of other inorganic, inert mineral and metal species) and represents size distributions using a sectional method with four size bins. To treat the large number of state variables associated with the MOSAIC scheme, this 3-DVAR algorithm first determines the analysis increments of the total mass concentrations of the eight species, defined as the sum of the mass concentrations across all size bins, and then distributes the analysis increments over four size bins according to the background error variances. The number concentrations for each size bin are adjusted based on the ratios between the mass and number concentrations of the background state. The system is evaluated using the analysis and prediction of PM_{2.5} in the Los Angeles basin, with assimilation of surface PM_{2.5}, surface speciated concentrations, and aircraft profiles.

References

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