Ensemble-based Assimilation of Aerosol Observations in GEOS-5

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The MERRA Aerosol Reanalysis (MERRAero) is the aerosol reanalysis produced at NASA's Global Modeling Assimilation Office (GMAO). This reanalysis is based on a version of the GEOS-5 model radiatively coupled to GOCART aerosols and includes assimilation of bias corrected Aerosol Optical Depth (AOD) from the MODIS sensor on both Terra and Aqua satellites.

The AOD analysis in GEOS-5 is performed by means of *analysis splitting*. First, a 2D analysis of AOD is performed using error covariances derived from innovation data. The 3D analysis increments of aerosol mass concentration are computed using an ensemble formulation for the background error covariance. In MERRAero, as well as in the GEOS-5 near real-time system, this calculation is performed using the Local Displacement Ensemble (LDE) methodology under the assumption that ensemble perturbations are meant to represent misplacements of the aerosol plumes. These ensemble perturbations are generated with full model resolution, without the need for multiple model runs.

Currently, the GEOS-5 meteorological data assimilation system is transitioning to a hybrid Ensemble-Variational formulation. In line with these advances, we are updating the aerosol component of our assimilation system to an Ensemble Kalman Filter (EnKF) type of scheme. Since aerosols are an integral part of the GEOS-5 forecast model, aerosol ensemble members are routinely produced by the meteorological assimilation.

In this talk we will explore several strategies for generating aerosol ensemble members by a combination of perturbed transport afforded by the meteorological EnKF and careful perturbation of emissions, chemical production and removal processes. Before a full aerosol EnKF is implemented, we will examine the impact of replacing the current LDE perturbations with the new ensemble members in the existing *analysis-splitting* scheme. We will discuss the impact of this new ensemble formulation on AOD forecast skill, as well as on aerosol vertical structure as validated by independent ground-based, airborne and space-borne LIDAR observations.