The Data Assimilation Research Testbed (DART) is a community software environment for ensemble data assimilation research developed at NCAR. DART’s backbone is the Ensemble Adjustment Kalman Filter (EAKF) of Anderson (2001, 2003). DART also contains other forms of ensemble Kalman filters (EnKFs) as well as adaptive inflation, localization, and many other data assimilation research tools. DART works with geophysical models, ranging from the Lorenz 3-variable model to coupled climate models. DART assimilates dozens of observation types from a variety of sources. DART is a state-of-the-art ensemble data assimilation system that is well documented and contains an interactive educational platform.

WRF-Chem/DART includes the ability to assimilate the following atmospheric chemistry observation types: (i) MOPITT total and partial column CO, (ii) IASI total and partial column CO and O3, (iii) OMI total column NOx, and (iv) MODIS AOD retrievals. We are developing the ability to assimilate AIRNow in situ observations and to include emissions in forecast model state vector.

The assimilation of trace gas retrievals has been shown to improve air quality initial conditions and forecasts. Retrieval data sets contain: (i) large amounts of data with limited information content, (ii) errors in inferred missing errors, and (iii) contributions from the retrieval prior that should be removed before assimilation. Those properties present challenges to the assimilation retrievals. The use of ‘Compact Phase Space Retrievals’ (CPSRs) addresses/resolves those challenges.

CPSRs advance the work of Joiner and Da Silva (1998) and Migliorini et al. (2008) by compressing the independent information measured by the satellite into a number of observations equal to the number of non-zeros singular values in a Singular Value Decomposition (SVD) of the averaging kernel. The associated reconstruction in the number of retrieval observations is substantial and depends on the difference between the number of rows and the rank of the averaging kernel. For IASI CO and O3 it is 80%.

Figure 2 shows the vertical sensitivity of the CPSRs which resembles that of the averaging kernel. Assimilation of CPSRs should yield results similar to that for retrievals, but there differences due to inflation, localization, and observation error truncation.

3. Application to FRAPPE/Discover-AQ

During the summer of 2014, the Front Range Air Pollution and Photochemistry Experiment (FRAPPE) occurred in conjunction with NASA’s Discover-AQ project. FRAPPE measured the chemical composition and reactions associated with air pollution along the Front Range of Colorado. One aspect of FRAPPE was to study the NOx chemistry.

NOx is a highly reactive, short-lived air pollutant... Its primary sources are transportation and power production, but its emissions are uncertain. Prof. Ron Cohen and his student Xueliang Li at the University of California, Berkeley are using WRF-Chem/DART to study NOx chemistry and to better estimate its emissions.

The left panel of Fig. 8 shows their CO adjustments and transport error corrections. They also investigated the impact of adjusting the CO emissions with assimilation of MOPITT total column CO to WRF-Chem/DART and study the associated impacts. Their work showed improvement to the CO analyses and forecasts.

Figure 7: Comparison of maps showing the impact of assimilating MODIS ACD with WRF-Chem/DART.

Prof. Chen and former student Nan Miao collaborated with NCAR/ACOM to add the assimilation of MOPITT total column CO to WRF-Chem/DART and study the associated impacts. Their work showed improvement to the CO analyses and forecasts.

For more information on CPSRs, see Mizzi et al. (2015) Geosci. Model Dev. To use WRF-Chem/DART or for information on chemical data assimilation contact Arthur F. Mizzi by e-mail at mizzi@ucar.edu or by phone at 303-497-8987.

5. More Information

The method of assimilation of CPSRs into WRF-Chem/DART is similar to that used by DART in its assimilation of other data types such as adaptive inflation, localization, and many other data assimilation research tools. DART works with geophysical models, ranging from the Lorenz 3-variable model to coupled climate models. DART assimilates dozens of observation types from a variety of sources. DART is a state-of-the-art ensemble data assimilation system that is well documented and contains an interactive educational platform.