DART Data Assimilation with CESM Models

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1. DART is ...

The Data Assimilation Research Testbed (DART) is an open source community software facility for ensemble data assimilation developed at the National Center for Atmospheric Research (NCAR). DART provides both state-of-the-art ensemble data assimilation capabilities and an interactive educational platform for researchers and students. DART works with dozens of geophysical models, ranging from the Lorenz 3-variable model to coupled climate models, and assimilates dozens of observation types from a variety of sources, including:
- temperature, winds aloft, surface winds, moisture from NCEP, MADIS, and SSEC,
- total precipitable water, radar observations, radio occultation observations from GPS satellites,
- ocean temperature and salinity from the World Ocean Database,
- land observations such as snow cover fraction, ground water depth, tower fluxes, cosmic ray neutron intensity, and microwave brightness temperature observations.
- virtually any observation can be used, if the model can generate an estimate of its value.

2. Multi-Component Assimilation – CAM-FV + POP + CLM

Separate re-analyses for different model components (atmosphere, ocean, land) are useful but may be inconsistent. A DART interface to the fully-coupled CESM is now available and has been used for ‘multi-component coupled data assimilation’ where observations of each component model directly impact only that model (e.g. atmospheric observations update only the atmospheric state) but the fully-coupled model is used for the ensemble forecasts.

3. Forecasting Hurricane Katrina with a Variable Mesh, Spectral Element CAM

The spectral element (SE) dynamical core is becoming the default for NCAR’s Community Atmosphere Model (CAM). It is implemented on a cubed sphere grid, which is irregular in latitude and longitude, but enables grid refinement. Assimilation requires interpolating the model state to the locations of the observations. Many times, efficient interpolation algorithms are essential.

4. Chemical DA – CAM-CHEM

In this study, a 30-member ensemble assimilation of meteorology plus chemistry has been performed. A spin-up of a deterministic CAM-CHEM run for 1.5 years precedes a meteorological spin-up of two months (April–May 2008). Assimilation of standard meteorological observations and the carbon monoxide (CO) measured by IASI (Infrared Atmospheric Sounding Interferometer) and MOPITT (Measurement Of Pollution In The Troposphere) was performed during June and July 2008. The ensemble spread is generated via inflation and perturbed emissions factors at the surface. IASI and MOPITT sounders are nadir sounders that measure tropospheric CO. IASI has global coverage daily, MOPITT takes 4 days to scan the globe. Figure 4 shows the difference between a control run (meteorological data assimilation only) and various CO assimilation runs. Figure 9 shows comparisons with the independent Tropospheric Emission Spectrometer (TES).

5. Model Prediction Across Scales – MPAS

Assimilation with DART+MPAS (CESM physics) can be set up through DART’s MPAS interface. Contact Sooyung Ha ( syha@ucar.edu) for details.

6. Whole Atmosphere Community Climate Model – WACCM

WACCM (Whole Atmosphere Community Climate Model) is identical to CAM, but with the model top extended to $5 \times 10^{-4}$ Pa ($145$ km) and additional chemical, dynamical, and physical processes to model the upper stratosphere, mesosphere, and lower thermosphere. The DART/WACCM interface facilitates studying of dynamical and chemical processes of specific events above the top of conventional atmospheric models and reanalysis products.

To illustrate the capabilities of WACCM+DART, a 40 member ensemble simulation was performed for January and February 2009 when a strong sudden stratosphere warming (SSW) occurred. Radiosonde and aircraft temperatures and winds, satellite drift winds, and COSMIC radio occultation observations are assimilated in the lower atmosphere. Middle and upper atmosphere temperature retrievals from TIMED/SABER and Aura MLS are also assimilated (Pedatella et al. 2013).

7. Education

DART contains a variety of instructional materials to appeal to different types of learners:
- a tutorial directory with 23 self-paced modules,
- an interactive MATLAB tutorial with point-and-click GUI examples,
- a user Application Program Interface (API),
- a web site dedicated to explaining how to use DART, and
- real live people to answer questions!


7.1 Further Information

http://www.image.ucar.edu/DAReS/DART has information about downloading DART from our subversion server, a full DART tutorial (including with the distribution), and how to contact us.

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