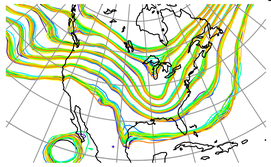
Data Assimilation for CAM - Research & Development



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1. State-of-the-art CAM Assimilation

The Data Assimilation Research Testbed (DART) provides a powerful and easy-to-use ensemble data assimilation facility for use with CAM. DART/CAM can produce global analyses and forecasts that are competitive with those from global NWP centers. DART/CAM can assimilate all conventional *in situ* observations as well as many novel observations like GPS occultation. DART can also be used with other global and regional models and includes a comprehensive tutorial and documentation. If you can run CAM, you can assimilate with DART/CAM.

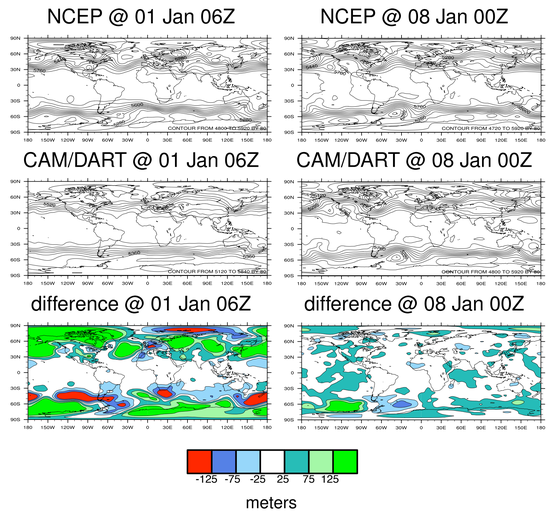

Figure 1: *500 hPa height fields from DART/CAM assimilation started from climatological ensemble at 00Z, 1 January 2003 compared to operational NCEP analyses. The 80-member CAM assimilation has equilibrated by 8 January and is indistinguishable from NCEP except over poorly observed parts of the Southern Hemisphere.*

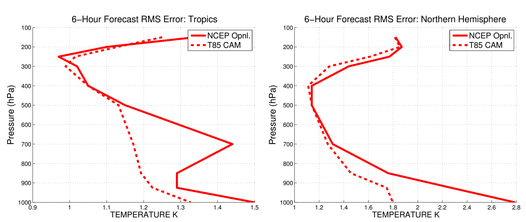

Figure 2: *Vertical profiles of 6-hour forecast RMS difference from radiosonde temperature observations averaged over January, 2003. The DART/CAM RMS is significantly better than the operational NCEP forecasts.*

2. Sensitivity Analysis

Sensitivity analysis from ensemble assimilations and forecasts is a more powerful alternative to adjoint and linear tangent analysis. Ensembles allow computation of correlations between state variables or observations at any analysis or forecast time. Computing correlations to a base point at times in the future (past) provides the same information as linear tangent (adjoint) analysis but with the addition of error estimates.

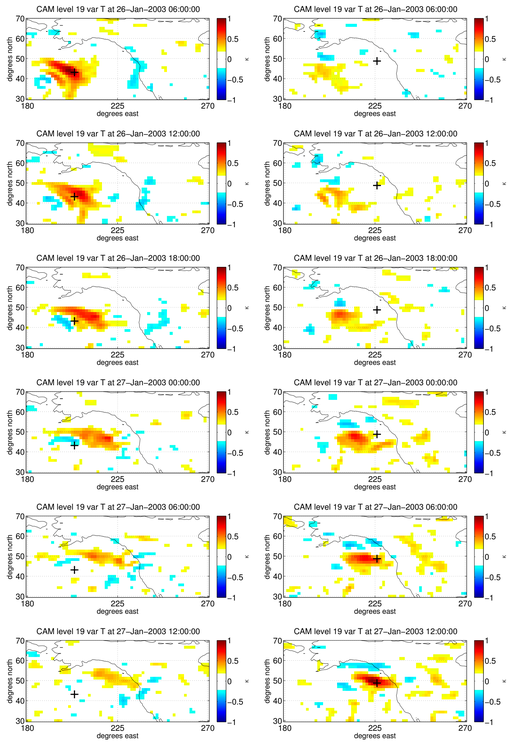

Figure 3: *Time series of forward (left) and backward (right) sensitivity from a series of CAM forecasts. Plots show ensemble correlation with base points marked by '+'.*

3. Inexpensive Model Comparison

Comparisons of assimilations produced with different versions of CAM physics or dynamics provide an inexpensive and informative complement to comparisons from long free integrations. Assimilation keeps the model state close to the real atmosphere and comparison to observations allows a direct assessment of relative model quality.

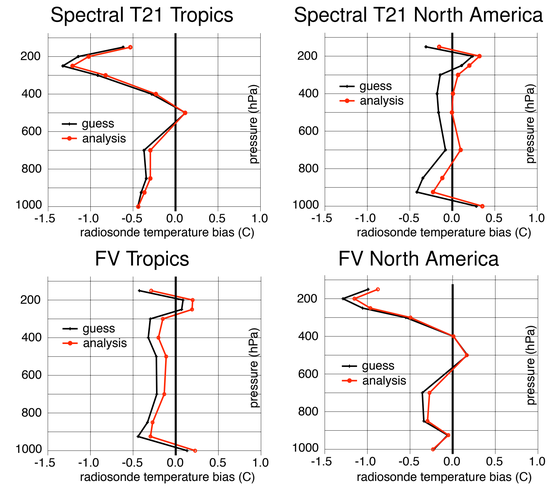

Figure 4: *Comparison of vertical profiles of temperature bias for low-resolution CAM spectral and FV cores from DART/CAM assimilation for January, 2003. Tropical bias is quite similar but the FV core is consistently too cold over North America.*

4. Process Studies

DART/CAM facilitates a wide variety of process studies that can be used to understand or improve CAM. Additional tracers can be added and an array of novel observations can be used. Assimilation experiments including tracers such as ozone, CO, CO_2, aerosols, etc., can be useful for understanding CAM and the observed climate. Assimilating some observations while others are withheld can reveal model behavior when some portions of the state are constrained to be close to reality.

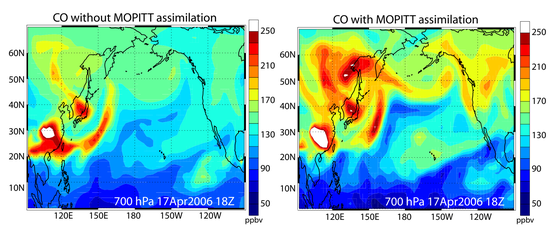

Figure 5: *700 hPa concentration of CO from CAM assimilation using standard NWP observations (left) and with addition of CO remote sensing observations from MOPITT (right). Comparison with aircraft observations shows that the MOPITT observations improve the analysis.*

5. Parameter Estimation

It is straightforward to use DART/CAM to estimate values of model parameters by adding the parameters to the CAM state vector. The assimilation output will include an ensemble of estimated values for the parameters that gives the best fit to the observations.

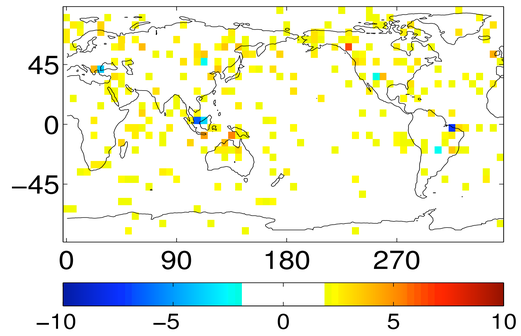

Figure 6: *Ensemble mean of GWD efficiency parameter produced by T21 CAM assimilation. Forecast error was less than with the standard GWD value, but estimated values may not be consistent with developers' a priori notions.*

6. Parallel Scaling

DART/CAM runs on a variety of NCAR supercomputers, on Linux clusters, and SGI supercomputers. The assimilation algorithm scales super-linearly on these platforms up to 64 processors and is expected to scale well on much larger processor counts.

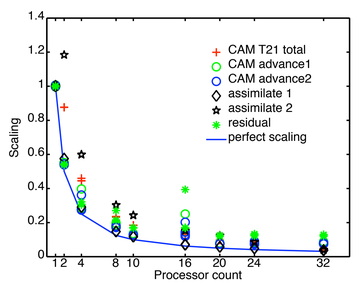

Figure 7: *Scaling on a 16-node (dual processor) Linux cluster. Times are for a 20-member CAM T21 data assimilation (state vector length ≈ 320,000) assimilating about 210,000 observations.*

7. Try this at home!

http://www.image.ucar.edu/DAReS/DART

provides information about how to download the latest version of DART, a full DART tutorial (included with the distribution), and contact information for the DART development group. There are also low-order models that can be used to learn (or teach) ensemble assimilation.