Status of the NASA GMAO Observing System Simulation Experiment

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The NASA GMAO OSSE

An Observing System Simulation Experiment (OSSE) is a pure modeling study used when actual observations are too expensive or difficult to obtain. OSSEs are valuable tools for determining the potential impact of new observing systems on numerical weather forecasts and for evaluation of data assimilation systems (DAS). An OSSE has been developed at the NASA Global Modeling and Assimilation Office (GMAO, Errico et al 2013).

The GMAO OSSE uses a 13-month integration of the European Centre for Medium-Range Weather Forecasts 2005 operational model at T511/L91 resolution for the Nature Run (NR). Synthetic observations have been updated so that they are based on real observations during the summer of 2013. The emulated observation types include AMSU-A, MHS, IASI, AIRS, and HIRS4 radiance data, GPS-RO, and conventional types including aircraft, rawinsonde, profiler, surface, and satellite winds. The synthetic satellite wind observations are colocated with the NR cloud fields, and the rawinsondes are advected during ascent using the NR wind fields. Data counts for the synthetic observations are matched as closely as possible to real data counts, as shown in Figure 2.

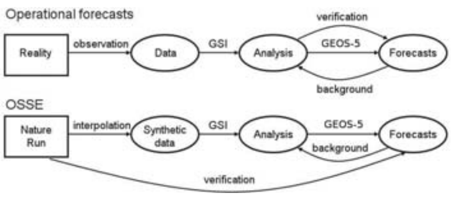

Figure 1. Schematic diagram illustrating the differences between an OSSE and operational numerical weather prediction.

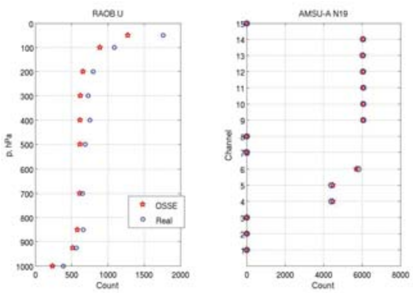

Figure 2. Comparison of data counts of select data types for the synthetic observations and real observations.

Errors are added to the synthetic observations to emulate representativeness and instrument errors. The synthetic errors are calibrated so that the statistics of observation innovation and analysis increments in the OSSE are similar to the same statistics for assimilation of real observations, in an iterative method described by Errico et al (2013). The standard deviations of observation minus forecast (x_o-H(x_b)) are compared for the OSSE and real data in Figure 3.

The synthetic errors include both random, uncorrelated errors, and an additional correlated error component for some observational types. Vertically correlated errors are included for conventional sounding data and GPS-RO, and channel correlated errors are introduced to AIRS and IASI (Figure 4). HIRS, AMSU-A, and MHS have a component of horizontally correlated error.

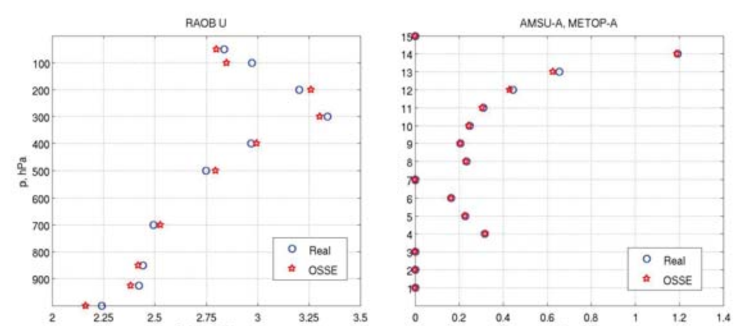

Figure 3. Standard deviation of observation innovation (x_o-H(x_b)) for the OSSE and real observations for the month of July.

The forecast model used by the GMAO OSSE is the Goddard Earth Observing System Model, Version 5 (GEOS-5) with Gridpoint Statistical Interpolation (GSI) DAS. The model version has been updated to v. 5.13.3, corresponding to the current operational model. Forecasts are run on a cube-sphere grid with 180 points along each edge of the cube (approximately 0.5 degree horizontal resolution) with 72 vertical levels. The DAS is cycled at 6-hour intervals, with 240 hour forecasts launched daily at 0000 UTC. Evaluation of the forecasting skill for July and August is currently underway. Prior versions of the GMAO OSSE have been found to have greater forecasting skill than real world forecasts. It is anticipated that similar forecast skill will be found in the updated OSSE.

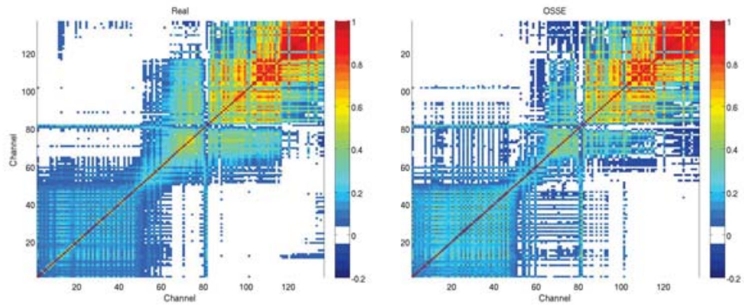

Figure 4. Channel correlations of observation innovations for IASI, real data (left) and OSSE (right).

Figure 5 shows the monthly mean, zonal mean standard deviations of analysis increments (x_a-x_b) for real observations and for the OSSE. While the standard deviations of observation innovations are similar between the OSSE and real data cases, the analysis increments are weaker in the OSSE by approximately 10-20%. This deficiency in the analysis increments is larger than observed in the previous version of the GMAO OSSE, although the most recent updates and calibration of the OSSE were performed with special care in terms of matching data counts and both spatial and channel observation innovation correlations.

The analysis increment is directly related to the observation innovations through

$$x_a - x_b = K[y_o - H(x_b)]$$

The Kalman gain matrix in the OSSE and real data contexts should be very similar since the DAS for both cases uses the same specifications for covariances of both background and observation errors, and and the two cases have very similar spaial distributions of observations. By design, the innovation variances are almost identical and the correlations among the same data types are very similar. That the variances of x_a-x_b nonetheless differ so much therefore suggests that either some subtleties of the correlation among observation errors of the same data type are very important or that the partitioning of the innovations between observation and background errors remains unrealistic in the OSSE. The latter unrealism can affect correlations between innovations of different observation types and therefore change the effect of the filter K.

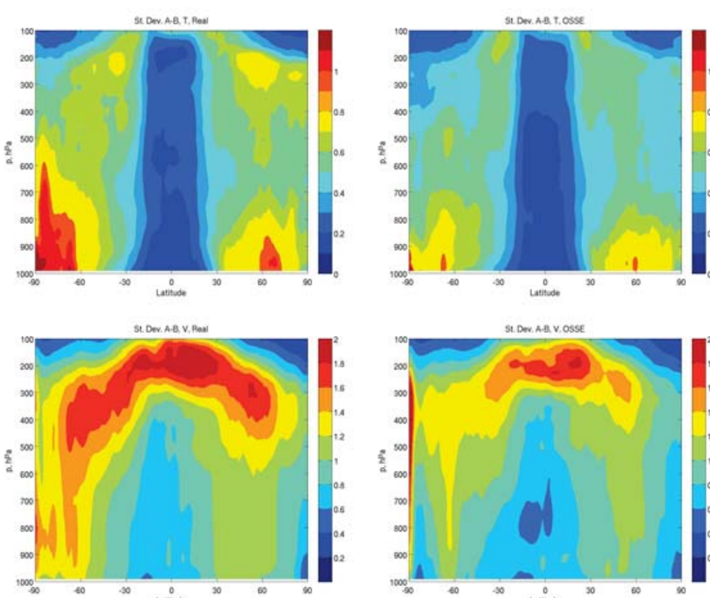

Figure 5. Zonal mean standard deviation of analysis increment (x_a-x_b) for real observations (left) and the GMAO OSSE (right) for the month of July. Top panels, temperature, K; bottom panels meridional wind, m s^{-1}.

References

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