Characteristics of Analysis Error Estimated using an OSSE

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What is an 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 is under development at the NASA Global Modeling and Assimilation Office (GMAO).

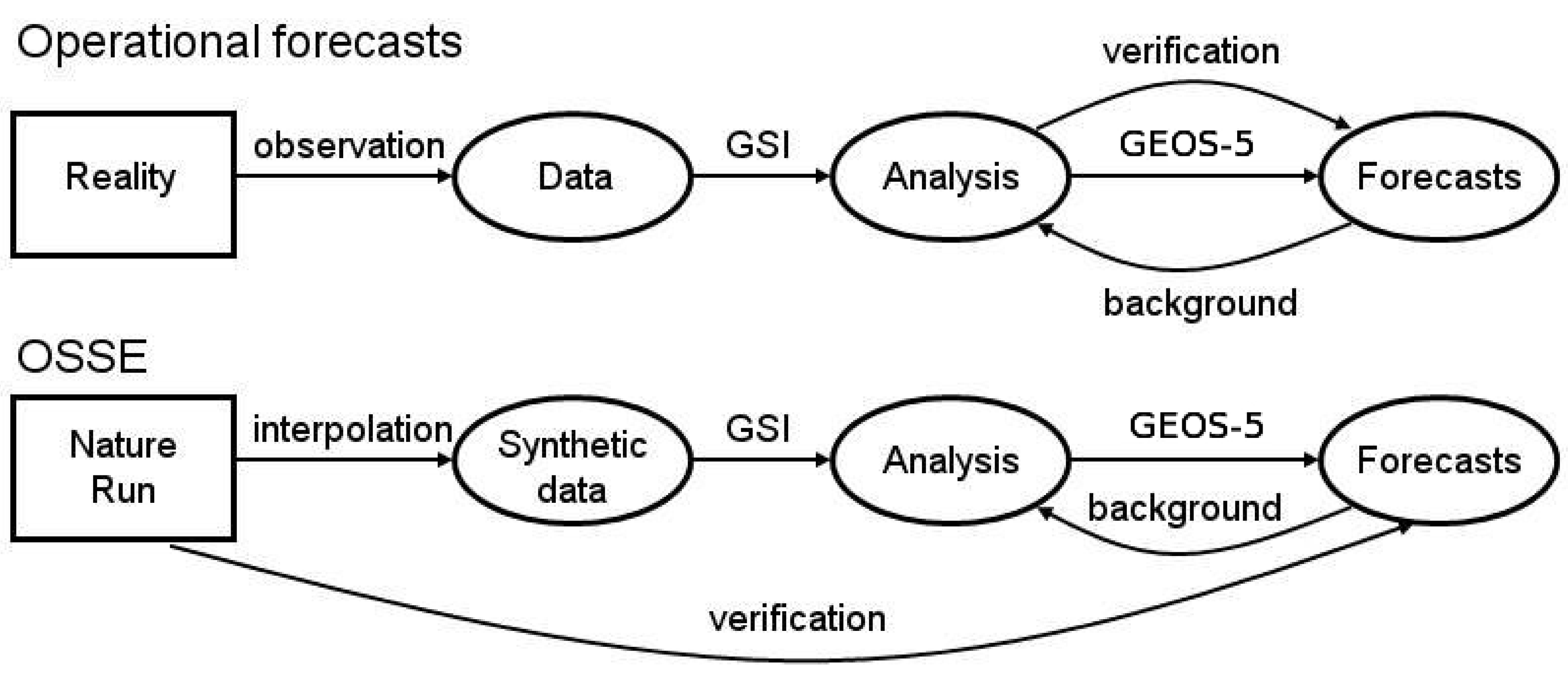

Figure 1. Schematic diagram illustrating the differences between an OSSE and operational numerical weather prediction.

Nature Run

The Nature Run acts as 'truth' in the OSSE system, and is used both for verification of forecasts and for generation of new and existing observations for ingestion into the DAS. The GMAO OSSE uses a 13-month integration of the European Centre for Medium-Range Weather Forecasts 2005 operational model at T511/L91 resolution.

Can we trust the OSSE results?

The OSSE should be thoroughly evaluated to judge the performance of the system in comparison to reality. Ideally, the observation impact, forecast skill, analysis increments, and other metrics of data assimilation behavior should be very similar in the OSSE to the real world.

The square root of the zonal mean temporal variance of analysis increments of wind and temperature is shown in Figure 2 for both the OSSE and real data control for July 2005. The magnitude and distribution of analysis increment is similar for the two datasets, although the OSSE shows slightly weaker analysis increments overall.

Synthetic Observations

Observations are generated for all current and proposed observing systems by interpolation of the Nature Run fields. For the GMAO OSSE, the locations of synthetic observations are based on real observations during the period of 01 May 2005 to 31 May 2006.

Errors are added to the synthetic observations to emulate representativeness and instrument errors. Vertically correlated errors are used for sounding observation types, channel correlated errors are used for AIRS data, and horizontally correlated errors are applied to radiance observations and satellite winds. Error magnitudes and correlations have been calibrated to match analysis statistics of real data.

Forecast Model and Data Assimilation

A second numerical weather prediction model is used for running the OSSE experiments. This model should be sufficiently different from the Nature Run model to prevent "identical twin" problems where the model behavior is too similar to the "truth". A sophisticated data assimilation system is desirable to attain the most pertinent OSSE results.

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. Forecasts are run at 0.5° latitude by 0.625° longitudinal resolution with 72 vertical levels. The DAS is cycled at 6-hour intervals, with 120 hour forecasts launched daily at 00Z.

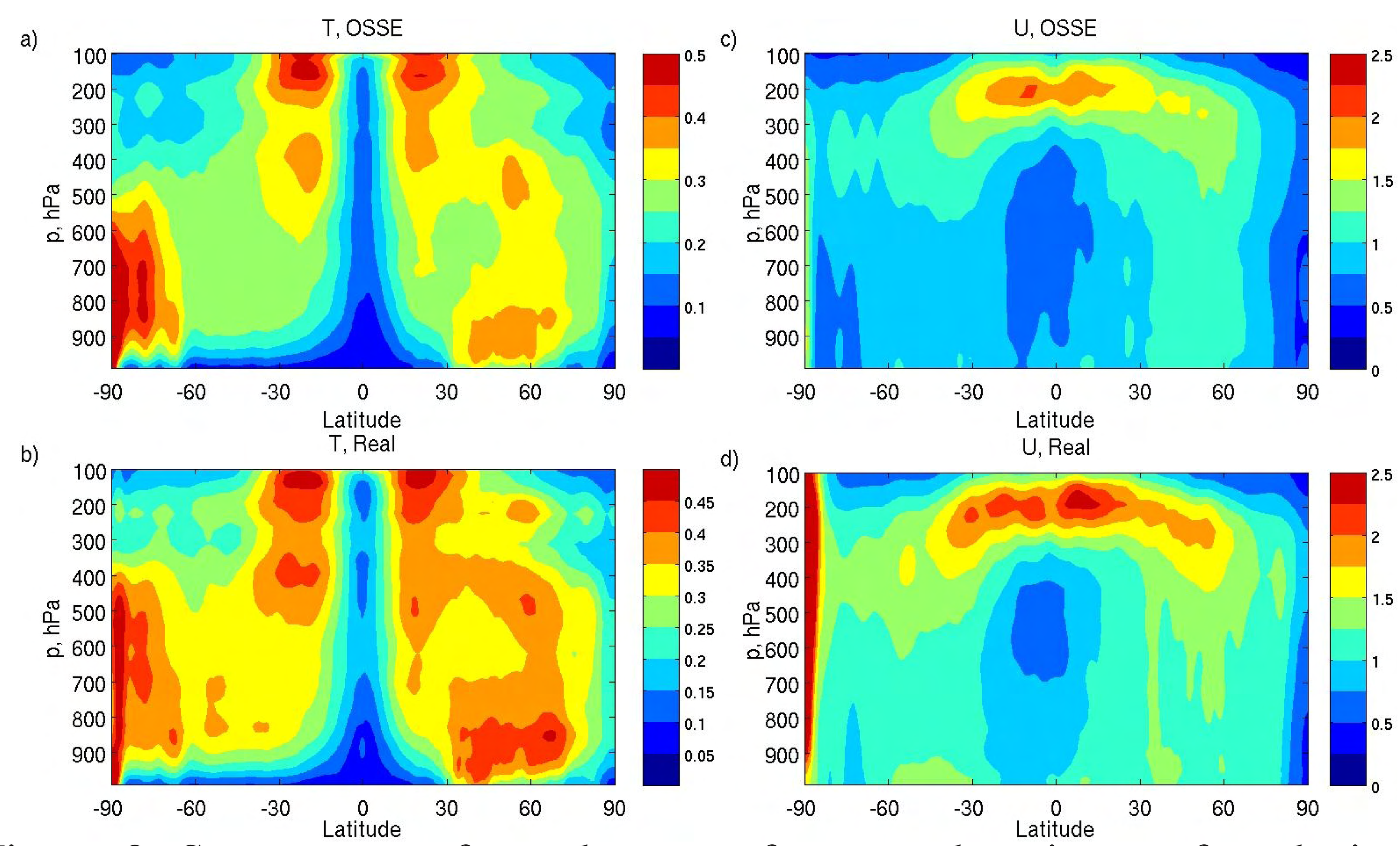

Figure 2. Square root of zonal mean of temporal variance of analysis minus background fields for July 2005. Top, OSSE; bottom, real data results. Left, temperature (K); right, zonal wind (m/s).

Evaluating analysis error

Three experiments are performed using the GMAO OSSE: the Control case using calibrated observation error; a case with no added observation error; and a third case with observation error doubled in magnitude compared to the Control case. These three cases are integrated for the month of July 2005.

Figure 3 shows the root-mean-square analysis error for temperature and zonal wind for the three cases. Increased observation error results in increased analysis error in the midlatitudes, but there is little effect on analysis error in the tropics. The Southern Hemisphere shows somewhat greater impact of observation error on analysis quality than the Northern Hemisphere.

The relative error of the background state to the analysis state is illustrated in Figure 4. The temperature field is improved by the data assimilation for all three cases; but the zonal wind field is degraded in the tropics and Northern Hemisphere when observation errors are doubled.

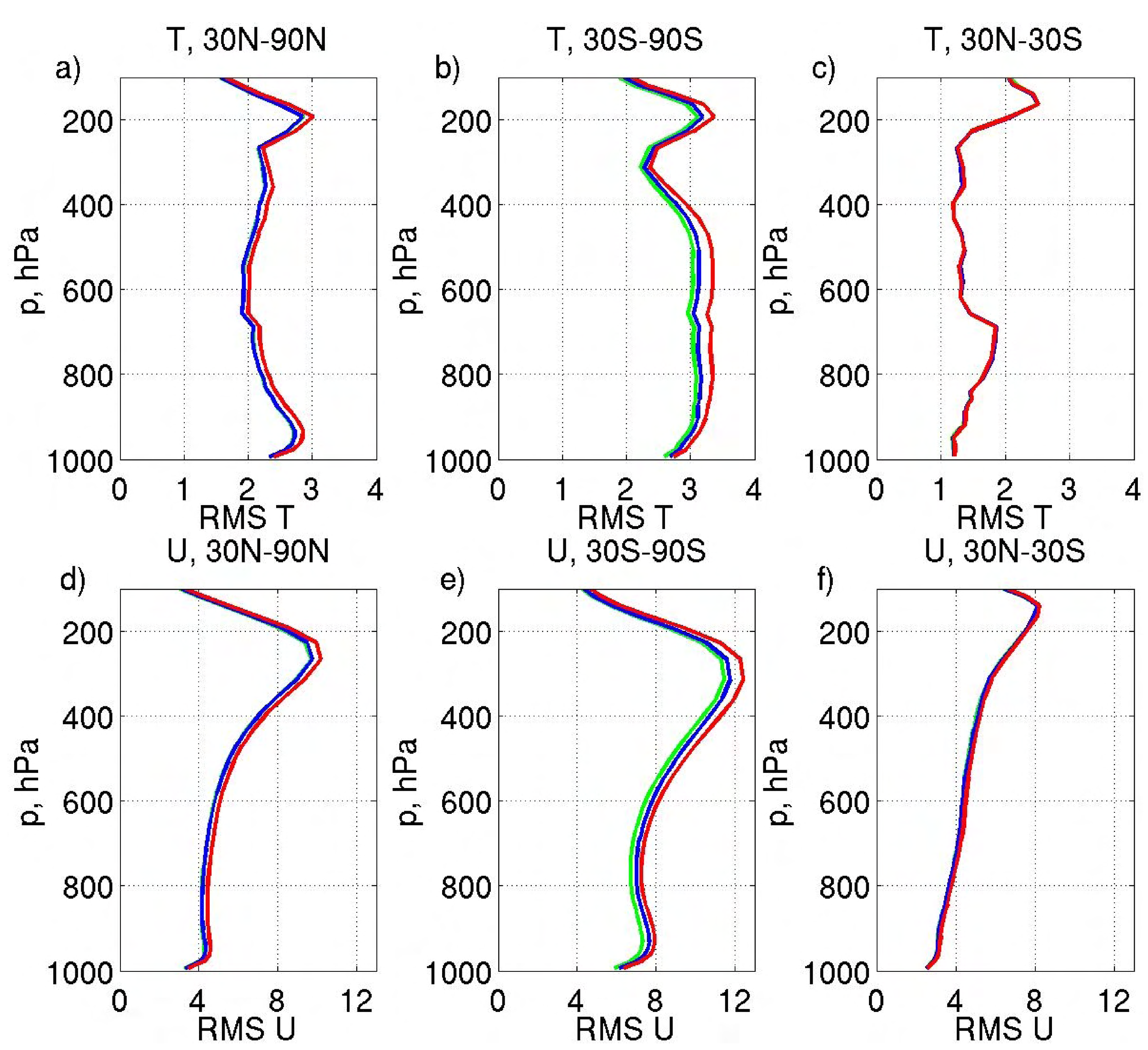

Figure 3. Root-mean-square analysis error for T (K, top) and zonal wind (m/s, bottom). No added observation error, green line; Control case, blue line; doubled observation error, red line. a,d) 30N-90N; b,e) 30S-90S; c,f) 30S-30N.

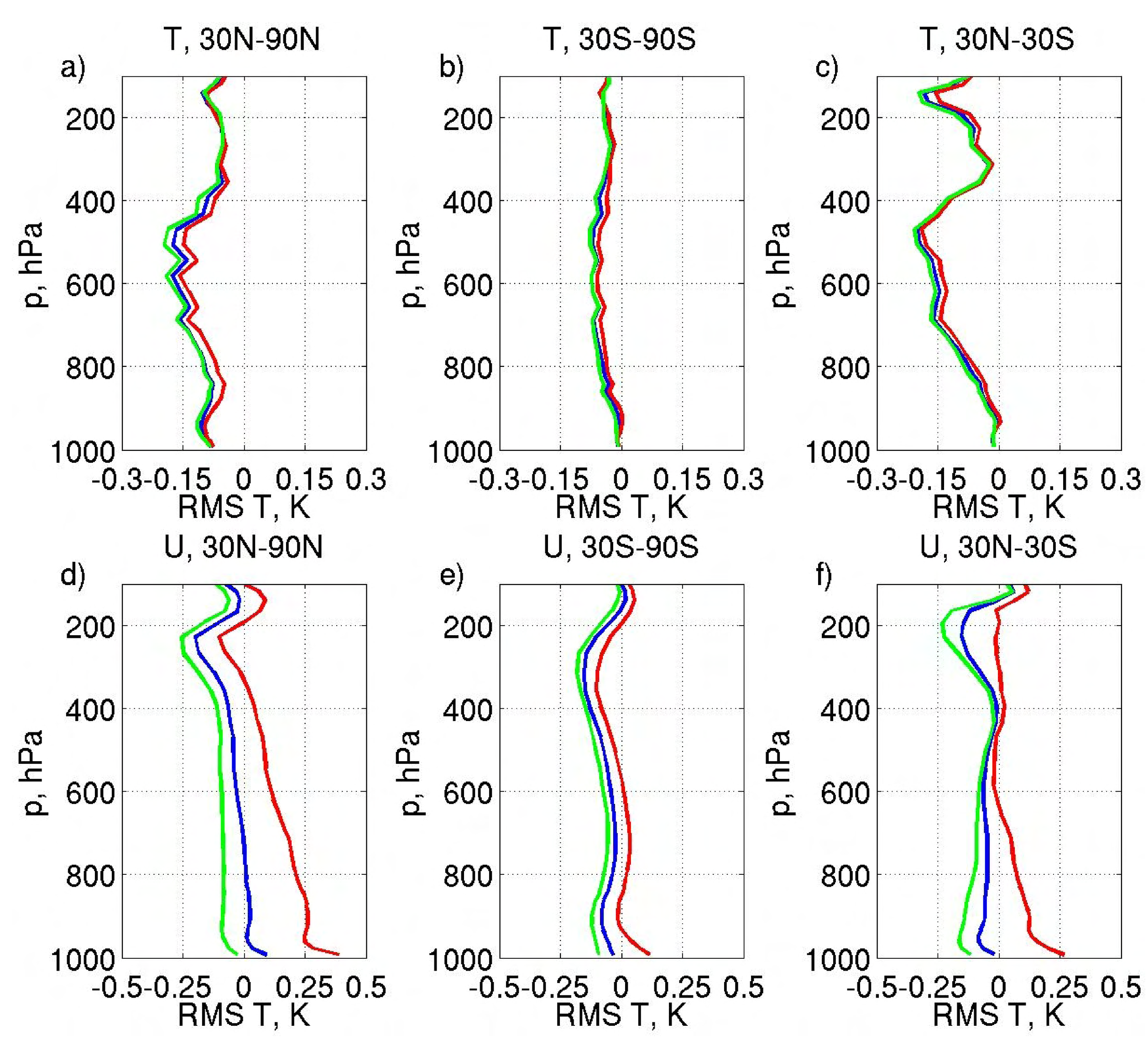

Figure 4. Root-mean-square analysis error minus root-mean-square background error for T (K, top) and zonal wind (m/s, bottom). No added observation error, green line; Control case, blue line; doubled observation error, red line. a,d) 30N-90N; b,e) 30S-90S; c,f) 30S-30N.