The Characteristics of Analysis Error Estimated Using an OSSE

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As for any data, it would be useful if an analysis could be accompanied by a reasonably accurate estimate of characteristics of its uncertainty. This would include such statistics as standard deviations as functions of field types and locations as well as spatial error correlations. A major problem exists, however, because an analysis is generally the best estimate of the entire atmospheric state available at any time, and therefore it is generally impossible to estimate its accuracy directly by differencing them with any better-known truth. Indirect methods do exist that are formally defined within the formal variational or Kalman filter framework. Their problem is, however, that they depend sensitively on prior assumptions that are themselves poorly known. Comparing different analyses prepared for the same time that use many of the same observations can yield lower bounds on the uncertainty of one of the analysis, but does not by itself determine which one is the better. Thus, estimating analysis uncertainty remains elusive.

Another way to estimate analysis error that has yet to be exploited is to employ an Observing System Simulation Experiment (OSSE). Unlike traditional OSSEs that have generally been designed to estimate likely impacts of proposed future augmentations of the present observing system, this application concerns present observations only. It therefore requires fewer speculative assumptions about future observing systems and the expected error characteristics of their observation types. This application, however, depends critically on the OSSE's validation. Only if the simulated environment of the OSSE behaves similarly enough with respect to the assimilation of real observations can it be claimed that the OSSE results are informative about the latter, as intended.

During the past 4 years, a well-validated OSSE framework has been developed at the GMAO. Its behavior has been compared with the assimilation of corresponding real observations with respect to most appropriate metrics that are possible to calculate directly in both frameworks. This includes statistics such as
means and standard deviations of observation (innovation) and analysis increments, spatial and channel correlations of innovations, and forecast skill scores. For the summer period examined, almost all these statistics validate well, although there are some notable exceptions. Given this degree of validation, examination of the analysis errors in the OSSE that can be directly computed should be considered informative of real analysis error characteristics.

The present GMAO OSSE has been conducted for a June and July period in 2005. It uses most observations that were operationally assimilated during that period. The "nature run" representing truth is provided by a 13 month "forecast" produced with an early 2006 version of the ECMWF forecast model at T511L91 resolution. The assimilating system is the GMAO GEOS-5 system run at half degree resolution on 72 levels. It uses a form of GSI similar to that employed at both NASA and NCEP.

Analysis error characteristics presented will include means and standard deviations as functions of field types and locations, anisotropic horizontal and vertical correlation lengths, temporal correlations, and Kalman Gains.
The latter are actually approximated by fractional reductions of background error variances due to analyzing the observations. The correlation lengths are produced for 4 distinct regions of the globe. Also estimated are the horizontal scales at which the variances of spectral components of the analysis error are the same or larger than the corresponding variances of the analysis fields themselves. These scales are produced individually for each field type at each vertical level.

They reveal at which horizontal scales the analysis generally provides accurate information about the atmospheric state.

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