Assessing the impact of advanced satellite observations in the NASA GEOS-5 forecast system using the adjoint method

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The adjoint of a data assimilation system provides a flexible and efficient tool for estimating observation impacts on short-range weather forecasts. The impacts of any or all observations can be estimated simultaneously based on a single execution of the adjoint system. The results can be easily aggregated according to data type, location, channel, etc., making this technique especially attractive for examining the impacts of new hyper-spectral satellite instruments and for conducting regular, even near-real time, monitoring of the entire observing system.

In this talk, we present results from the adjoint-based observation impact monitoring tool in NASA's GEOS-5 global atmospheric data assimilation and forecast system. The tool has been running in various off-line configurations for some time, and is scheduled to run as a regular part of the real-time forecast suite beginning in autumn 2010. We focus on the impacts of the newest components of the satellite observing system, including AIRS, IASI and GPS. For AIRS and IASI, it is shown that the vast majority of the channels assimilated have systematic positive impacts (of varying magnitudes), although some channels degrade the forecast. Of the latter, most are moisture-sensitive or near-surface channels. The impact of GPS observations in the southern hemisphere is found to be a considerable overall benefit to the system. In addition, the spatial variability of observation impacts reveals coherent patterns of positive and negative impacts that may point to deficiencies in the use of certain observations over, for example, specific surface types. When performed in conjunction with selected observing system experiments (OSEs), the adjoint results reveal both redundancies and dependencies between observing system impacts as observations are added or removed from the assimilation system. Understanding these dependencies appears to pose a major challenge for optimizing the use of the current observational network and defining requirements for future observing systems.