GSI-based Hybrid Data Assimilation for NCEP GFS: How Is the Dual Resolution Hybrid Compared to the Single Resolution Hybrid?

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A 3DVar-based ensemble-variational (3DEnsVar) hybrid data assimilation system was recently developed based on the Gridpoint Statistical Interpolation (GSI) data assimilation system and was implemented operationally for the GFS. In the operational implementation, the hybrid was run with a dual resolution configuration where the ensemble was run at a reduced resolution as compared to the control analysis and forecast. How is the performance of the hybrid run at dual resolution compared to that run at single resolution where the ensemble was run at the same resolution of the control? Experiments were conducted over a 4-week period during the 2011 summer. As a first step of answering such question, the experiments were conducted with a lower resolution than those in operations. It was found that if the static covariance was not included, the dual resolution hybrid performed significantly worse than the single resolution hybrid. However, when the static covariance was included, the degradation of the dual resolution hybrid was much reduced and nearly negligible.

Series of diagnostics were conducted to further understand the performance of the dual resolution and single resolution hybrid DA systems. Diagnosing the spread-error relationship as a function of height using the innovation statistics revealed that the ensemble spread was under-dispersive, especially in low levels, and such under-dispersiveness was more severe for the dual resolution hybrid than the single resolution hybrid. Including the static B improved the spread-error relationship especially for the dual resolution hybrid.

Diagnostics were also conducted in the spectral space. The first guess ensemble spreads from the single resolution and dual resolution hybrid and those inferred from the static covariance were compared. For example, for meridional wind, the vertically averaged spectra of the ensemble spreads peak at about total wavenumber 20, while those derived from the static covariance peaks at a larger total wavenumber, approximately, of 30. The spread spectra derived from the static covariance are obviously higher than the ensemble spreads for most wave numbers considered. The ensemble of the dual resolution hybrid has smaller spread than the single resolution hybrid for wavenumbers greater than about 25. After the static covariance was combined with the ensemble covariance, such differences of the first guess spreads between the single and dual resolution hybrid were reduced especially for those wavenumbers close to the truncation.

The cost of the dual resolution hybrid is much cheaper compared to the single resolution hybrid. What is the tradeoff between increasing ensemble size and ensemble resolution? Would increasing the ensemble size in the dual resolution hybrid improve the performance of the hybrid? Preliminary analysis of a dual resolution experiment quadrupling the ensemble size revealed that the performance of the single resolution hybrid did not significantly improve with increasing ensemble size.