GSI-BASED HYBRID 3DVAR DATA ASSIMILATION FOR THE BAM-CPTEC/INPE

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1. Introduction

Recent developments in atmospheric data assimilation have demonstrated that hybrid methods are advantageous in allowing the introduction of background flow dependency into the specification of error correlations. This is one of the most challenging features to attain in an operational data assimilation system. At the beginning of its operations, CPTEC has experienced with its global circulation model the Optimum Interpolation technique, the Physical-space Statistical Analysis System (PSAS) and recently, the Gridpoint Statistical Interpolation (GSI) with the CPTEC Brazilian Atmospheric Model (BAM). The application of PSAS and GSI at CPTEC is the result of long-term collaboration between the CPTEC and the Global Modeling and Assimilation Office (GMAO/NASA). At the beginning of its operational use at the center, the GSI/3DVar were run using a static background error covariance matrix. This undergoing work reports some initial results with the application of a hybrid 3DVar data assimilation system using a linear combination of a static background error covariance matrix with an Ensemble Kalman (EnKF) filter based one.

2. A Global Hybrid 3DVar System for CPTEC

The CPTEC global hybrid 3DVar system is based on coupling between the GSI system (which provides the data assimilation framework including the traditional 3DVar method, an EnKF system and the framework through which the hybrid covariances are drawn) and the Brazilian Atmospheric Model (BAM, Figueroa et al., 2016). The observations assimilated within the system come from the Global Telecommunication System (GTS), which includes surface and upper-air observations, atmospheric retrievals and radiance observations from multiple satellites and sensors. The static part of the hybrid 3DVar background error covariance is modeled with the National Meteorological Center (NMC) method using pairs of 24-hour and 48-hour forecasts from the BAM model. In experimental mode, a database of 1,460 forecast pairs has been used to calculate the background error covariance matrix in a TQ0062L028 model resolution (roughly 200 km near the Equator with 28 sigma levels). The data assimilation cycle using the hybrid system applies the hybrid background error covariance matrix during the 3DVar minimization procedure (using the same methodology as described in Wang et al., 2013).

3. Resulting Hybrid Analysis and Future Plans

The hybrid 3DVar analysis cycle was tested using 50% and 75% of ensemble (40 members) contribution to the static part of the background error covariance matrix. The experiments included a control run with the NCEP analysis (no data assimilation), another control run with a pure 3DVar analysis and two runs using the hybrid analysis (with 50% and 75% of ensemble contribution). As a result, it was found that the hybrid (deterministic) analysis allowed the BAM model to perform better when 75% of ensemble contribution were used to determine the background error covariance (experiment EnSRF75). In terms of model skill, in general, the BAM model performed better with improvements in its prediction ability. Figure 1 shows the Anomaly Correlation for specific moisture at 925 hPa and zonal wind at 850 hPa for the South America region and for the whole Globe. As can be seen, the application of the hybrid method has a great advantage over the current and pure 3DVar in use at the center. Within the steep topography of the Andes

Mountains in South America, the forecast of moist processes, especially rain, is difficult. Improving the forecast of these processes can be also beneficial for the precipitation forecasts of the BAM model. Also, improving the wind forecasts (e.g., Figure 1c) is also beneficial because of the moisture transport by the Low-Level Jet to the southeast region of the continent. Further steps with the hybrid analysis should include tests with high resolution in order to properly access the precipitation forecasts.

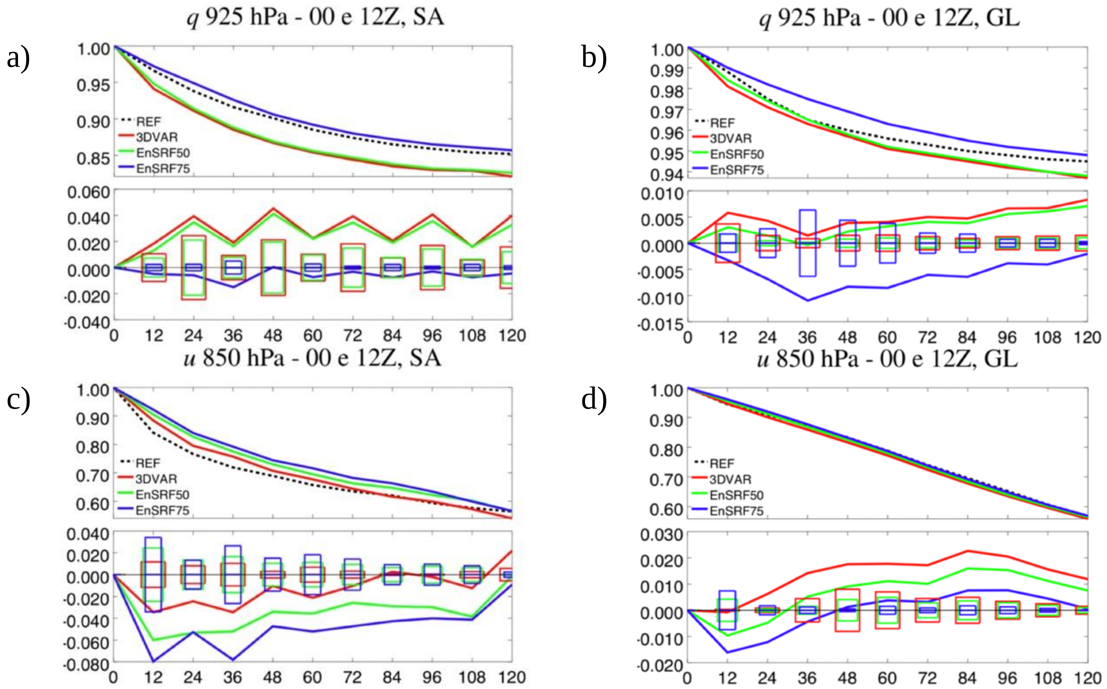

Figure 1. 5-day forecast skill for evaluated regions GL (global) and SA (South America). Dashed black lines: REF experiment (using the NCEP analyses); solid red line: pure 3DVar experiment; green line: EnSRF50 (using the 50% of the ensemble) and blue line: EnSRF75 (using 75% of ensemble). All figures are presented with their respective Student's t-test, where a 95% confidence interval is held.

CPTEC has also a global Ensemble Prediction System (EPS) which provides the center with extended range forecasts (up to 15 days). Currently, this system uses a perturbation approach based on an Empirical Orthogonal Functions methodology in order to provide the optimum perturbations to generate the ensemble members. As the tested hybrid 3DVar system makes use of an EnKF to both update the background ensemble members and to control the ensemble spread, a study is being made to access the ability of this system to provide an ensemble of analyses to serve as an upgrade to the current EPS system. Preliminary results show that at this lower analysis/model resolution, a proper configuration of the model should be defined to take in advantage the characteristics of the new system.

References

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