Introduction

The Global Modeling and Assimilation Offce (GMAO) is currently using an IAU-based 3D-Var data assimilation system. GMAO has been experimenting with a 3D-Var-hybrid version of its data assimilation system (DAS) for over a year now, which will soon become operational and it will rapidly progress toward a 4D-EnVar. Concurrently, the machinery to exercise traditional 4D-Var is in place and it is desirable to have a comparison of the traditional 4D approach with the other available options, and evaluate their performance in the Goddard Earth Observing System (GEOS) DAS. This work will also explore the possibility for constructing a reduced order model (ROM) to make traditional 4D-Var computationally attractive for increasing model resolutions. Part of the research on ROM will be to search for a suitably acceptable space to carry on the corresponding reduction. This poster illustrates how the IAU-based 4D-Var assimilation compares with our currently used IAU-based 3D-Var.

4D-Var Development at GMAO

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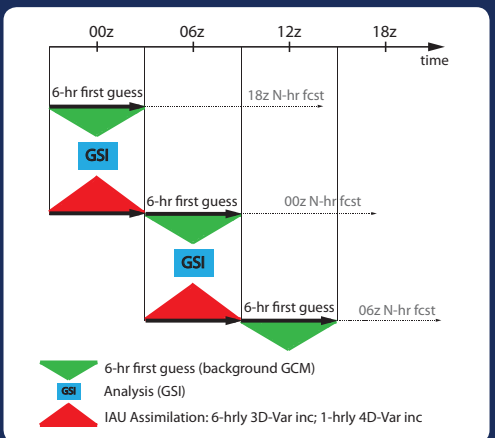
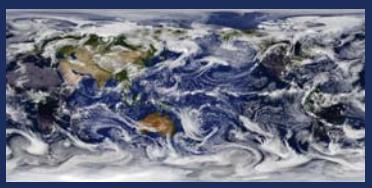
IAU Based Variational Data Assimilation

The assimilation procedure used in this work relies on the incremental analysis update (IAU) approach of Bloom et al. (1996). In its 3D-Var GEOS implementation the analysis increment is turned into a constant model tendency that forces the atmospheric model over the 6-hour assimilation window. In its 4D-Var GEOS implementation the inner loop generates an hourly time-series of increments that become hourly, time-varying, tendencies used to force the model during the 6-hour cycle.



Goddard Earth Observing System Data Assimilation System (GEOS DAS)

The Goddard Earth Observing System is an integration of models using the Earth System Modeling Framework integrations. The two main components of GEOS DAS are the atmospheric general circulation model (AGCM; Molod et al. 2012) and the Gridpoint Statistical Interpolation (GSI; e.g., Kleist et al. 2009) analysis system developed jointly with NOAA/NCEP/EMC. The GEOS DAS presently implements a number of data assimilation strategies: 3D-Var, 4D-Var, hybrid 3D-Var, hybrid 4D-Var, and hybrid 4D-ensVar.



Results

Experiments use a slighly simplified configuration of GEOS DAS. Comparions are for 3D-Var versus 4D-Var. The experiments were conducted when inner and outer loops are both at low resolution (2-degrees), and when inner-loop is at 2-degrees and outer-loop is at 1/2-degree. Experiments cover March 2014.

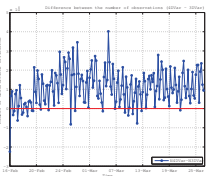
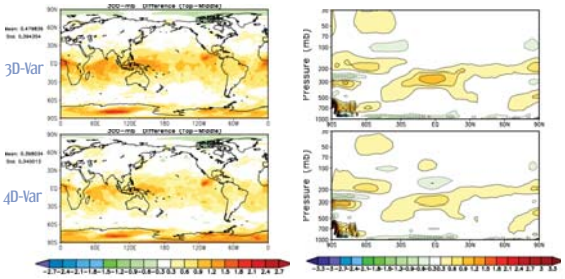
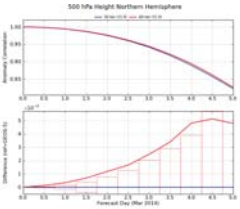
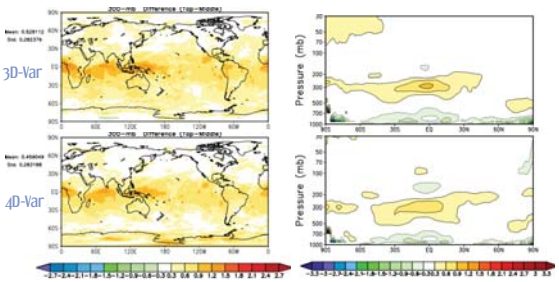


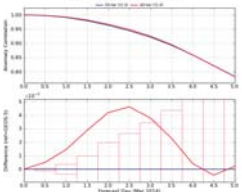
Figure above shows the difference between the number of observations admitted for assimilation in 4D-Var and 3D-Var. Values above zero indicate that more observations were accepted using the 4D-Var approach, and below zero that more observations were used in 3D-Var.



Figures display monthly mean difference of experiments with ECMWF analysis mean for March 2014. Monthly means for temperature (left panel: 300 mb, right panel: zonal means). Top panels correspond to 3D-Var, and bottom ones to results from 4D-Var. Above, low resolution experiments; below, low-high resolution experiments.







Figures above show 5 days forecast skills with their significance plots for 4D-Var and 3D-Var calculated for 500 mb height, for low resolution experiments.

Conclusions

The purpose of this work is to evaluate IAU-based 4D-Var performance in GEOS DAS in comparison with currently used IAU-based 3D-Var system. Results showed that 4D-Var is able to perform at least as well as 3D-Var, often showing slightly better results than 3D-Var. This work establishes that GEOS 4D-Var results are reliable and serve as the base for extension to 4D-hybrid and development of reduced-order model approaches.

References

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