A Global PSAS

A. Rhodin[1], D. Pingel[1], O. Schmid[1], M. Tomassini[1], H. Anlauf[1], W. Wergen[1],
M. E. Gorbunov[2], M. D. Tsyroulnikov[3], L. Kornblueh[4]

[1] Deutscher Wetterdienst, Offenbach, Germany
[2] Obukhov Institute for Atmospheric Physics, Moscow, Russia
[3] Hydrometeorological Research Centre of Russia, Moscow, Russia
[4] Max-Planck-Institut für Meteorologie, Hamburg, Germany

A global PSAS (Physical Space Assimilation System) is under test at DWD and is planned to replace the OI (Optimum Interpolation) data assimilation currently operational for the Global Model (GME) at the German Weather Service.

PSAS

The PSAS is a 3-dimensional data assimilation system which minimizes the cost function as function of the control variables defined in observation space [2] [3]. Background- and observation-error covariances are represented in observation space as well. An advantage of this approach is the considerably reduced problem size (10^5 to 10^6 observations actually used compared to 10^8 degrees of freedom in model space). This allows a more flexible representation of the error covariance matrices and good pre-conditioning strategies (both background and observational error covariance matrices are accessible). The disadvantage is that the implementations of model equations, operators, and parameterizations in the forecast model cannot easily be used for observation operators and covariance modeling. Also an extension to a 4-dimensional variational assimilation is not straightforward. However, the extension to an Ensemble Kalman Filter assimilation system is an alternative.

Implementation

The assimilation system is implemented for the global model GME based on an icosahedral grid [6]. The PSAS algorithm does not depend on a particular grid and the adaption to other (regular) grids is straightforward; interpolation algorithms are implemented in a generic form. The program is coded in Fortran 95 and parallelization is based on MPI (Message Passing Interface). At the German Weather Service the operational assimilation system runs on an IBM SP2.

The underlying set of linearized equations is solved by a CG (Conjugate Gradient) algorithm. In an outer loop a Newton algorithm accounts for the nonlinearities in the observation operators and in the Variational Quality Control (VQC), which is implemented following [1].

Background Error Covariances

Background and observation error covariance matrices are represented explicitely using a sparse representation. Currently background error correlations are modeled explicitely as a function of distance for geopotential height, relative humidity and wind components closely following the approach of the operational OI [4]. However this approach does not ensure positive definite matrices because of the spatial variations of length scales of the correlation functions. (This has not been a problem in the OI because of its local formulation.) For this reason the explicit matrix representation will be replaced by an operator representation which ensures positive definiteness. Background correlations are initially estimated by the NMC method but will later be augmented by information from an ensemble system.

Observation Operators

Besides the conventional in situ observation operators (TEMP, SYNOP, AIREP, SATOB) the RTTOV [7] package is used for assimilation of satellite radiances. A 3-dimensional ray-tracing operator for the assimilation of bending angles from GPS radio occultations [5] is implemented as well.

References

[1] E. Andersson and H. Jarvinen. Variational quality control. *Q. J. R. Meteorol. Soc.*, 125(554):697–722, 1999.

[2] S. Cohn, A. Da Silva, J. Guo, M. Sienkiewicz, and D. Lamich. Assessing the effects of data selection with the DAO physical-space statistical analysis system. *Mon. Wea. Rev.*, 126:2913–2926, 1997.

[3] R. Daley and E. Barker. Navdas source book 2000. Technical report, Naval Research Laboratory, Marine Meteorology Division, Montery, CA 93943-5502, 2000.

[4] ECMWF Research Department. *Research Manual 1 - ECMWF Data Assimilation Scientific Documentation.* ECMWF, 3rd edition, 1992.

[5] M. E. Gorbunov and L. Kornblueh. Principles of variational assimilation of GNSS radio occultation data. Report 350, Max-Planck-Institut für Meteorologie, Bundesstrasse 55, D-20146 Hamburg, Dec. 2003.

[6] D. Majewski, D. Liermann, P. Prohl, B. Ritter, M. Buchhold, T. Hanisch, G. Paul, W. Wergen, and J. Baumgardner. The operational global icosahedral-hexagonal gridpoint model GME: Description and high-resolution tests. *Mon. Wea. Rev.*, 130(2):319–338, Feb. 2002.

[7] NWP-SAF. RTTOV radiative transfer model.
http://www.metoffice.com/research/interproj/nwpsaf/rtm.