Correcting for Position Errors in Variational Data Assimilation

Thomas Nehrkorn[a], Bryan Woods[a], Thomas Auligne[b] and Ross Hoffman[a]

[a] *Atmospheric and Environmental Research, USA, tnehrkor@aer.com,*
[b] *National Center for Atmospheric Research, USA*

Forecasts used in variational data assimilation schemes for the atmosphere and ocean often exhibit significant position errors. These errors are particularly difficult to correct in data assimilation because they are usually not normally distributed. In addition, in the case of atmospheric data assimilation of cloud-related quantities, complications arise from the fact that cost function gradients are zero in cases where the first guess does not produce clouds or precipitation, making it difficult to correct cases where observed and predicted areas of clouds or precipitation do not coincide. A number of approaches have been proposed to measure and correct position or phase errors, ranging from techniques originating from image processing such as "image warping" or "morphing" [1] and "optical flow" [2], object-oriented verification measures [3], to alignment approaches aimed at data assimilation improvements [4].

We present an implementation of a displacement scheme to correct phase errors based on the feature calibration and alignment procedure described in Grassotti et al. [5]. In its original formulation, a set of two-dimensional displacement vectors is applied to forecast fields to improve the alignment of features in the forecast and observations. These displacement vectors are obtained by a nonlinear minimization of a cost function that measures the misfit to observations, along with a number of additional constraints (e.g., smoothness and non-divergence of the displacement vectors) to prevent unphysical solutions. Results from this implementation will be compared with a more recent implementation within the WRF-Var algorithm, in which the nonlinear minimization is replaced by the (linear) conjugate gradient inner-loop minimization combined with outer loop nonlinear adjustments, and the ad-hoc penalty function constraints are replaced by an error-covariance representation of the displacement vectors (analogous to the regularization proposed by Nehrkorn et al. [6]). Approaches to deal with questions of model imbalance will be described for the example of the WRF model.

Additional URLs:
http://www.mmm.ucar.edu/wrf/users/workshops/WS2012/ppts/9.4.pdf
http://www.emc.ncep.noaa.gov/GEFS/prod-review/posters/Nehrkorn_phase-errors.pdf

References

[1] Beezley, J. D. and J. Mandel. "Morphing ensemble Kalman filters". *Tellus A*, 60 (1), 131–140, 2008.

[2] Marzban, C. and S. Sandgathe. "Cluster analysis for object-oriented verification of fields: A variation". *Mon. Wea. Rev.*, 136 (3), 1013–1025, 2008.

[3] Ahijevych, D., E. Gilleland, B. G. Brown, and E. E. Ebert. "Application of spatial verification methods to idealized and NWP-gridded precipitation forecasts". *Wea. Forecasting*, 24 (6), 1485– 1497, 2009.

[4] Ravela, S., K. Emanuel, and D. McLaughlin. "Data assimilation by field alignment". *Physica D: Nonlinear Phenomena*, 230 (1-2), 127–145, 2007.

[5] Grassotti, C., H. Iskenderian, and R. N. Hoffman. "Fusion of ground-based radar and satellite-based rainfall data using feature calibration and alignment". *J. Appl. Meteor.*, 38, 665–676, 1999.

[6] Nehrkorn, T., R. N. Hoffman, C. Grassotti, and J.-F. Louis. "Feature calibration and alignment to represent model forecast errors: Empirical regularization". *Quart. J. Roy. Meteor. Soc.*, 129 (587), 195–218, 2003.