Use of Adjoint Methods for Tuning of Observation Error in the Navy Global Atmospheric Forecast System

Rolf H. Langland[a], and Dacian N. Daescu[b]

[a] *Naval Research Laboratory, Marine Meteorology Division, Monterey, California, U.S.A., rolf.langland@nrlmry.navy.mil,* [b] *Portland State University, Portland, Oregon, U.S.A.*

This talk describes a new adjoint-based method for tuning specified observation error variance (s_i^o) in atmospheric data assimilation and the results of first experimental testing. The study uses the Navy Global Environmental Forecast System (NAVGEM) and its 4d-Var data assimilation procedure (NAVDAS-AR) The practical objective of the study is to improve (through adjustment of s_i^o) the assimilation of satellite radiance observations (including AMSU-A, IASI, and AIRS) in NAVDAS-AR and thereby increase the accuracy of NAVDAS-AR atmospheric analyses (Langland et al. 2008) and NAVGEM forecasts.

Here, s_i^o is a scalar coefficient defined by assumptions of observation error. An additional scalar coefficient, s_i^b defines the assumed error of the background (in this case a 6h prior forecast) at an observation location. Together, s_i^o and s_i^b determine the weight given in NAVDAS-AR to the information from an assimilated observation (i). In our experiments the usual value of s_i^o is adjusted using sensitivity information provided by adjoint versions of the forecast model and data assimilation procedure. A sensitivity gradient vector, $\partial e/\partial s_i^o$, is defined as described in Daescu and Langland (2013). The forecast response function (e) is a scalar measure (norm) of energy-weighted 24h forecast error. Note that that unlike other methods for tuning s_i^o (for example, that of Desroziers and Ivanov 2001) in this method the adjustments to s_i^o are defined specifically to *reduce a metric of forecast error*.

The gradient $\partial e/\partial s_i^o$ provides sensitivity information for every assimilated observation. However, at present, $\partial e/\partial s_i^o$ indicates only whether the value of s_i^o should be increased or decreased and not a specific "optimal" value for s_i^o. Thus, our tuning process involves two steps: i) identification of whether s_i^o should be increased or decreased for a particular radiance channel and ii) an estimate of how much s_i^o should be changed. Note that in NAVDAS-AR, s_i^o is a constant over the entire global domain for each specific radiance channel.

First experiments using this method include a reduction (0.5) of s_i^o for AMSU-A channels 5-8, and increases (2.0) for a subset of IASI channels and AIRS observations. We are able to demonstrate that these changes to s_i^o : i) bring the NAVDAS-AR analysis closer to the ECMWF analysis, ii) reduce the 24h forecast error norm in NAVGEM, and iii) reduce root mean square error of 500hPa height forecasts.

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