Geophysical Research Abstracts
Vol. 13, EGU2011-13286, 2011
EGU General Assembly 2011

A strategy to optimize the use of retrievals in data assimilation

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For instruments with thousands of channels, such as AIRS and IASI, for cloudy and scattering atmospheres, and in other complex or demanding circumstances, satellite instrument teams have worked hard to optimize retrievals. All their knowledge, expertise, and auxillary data sets could in principle be included in radiance data assimilation using variational or ensemble kalman filter (EnKF) techniques, but at a price in complexity and maintainance. Here we outline an approach that could overcome the currently identified drawbacks in the use of retrievals in data assimilation.

Towards this goal, we convert standard retrievals into "observations" with expected errors that are zero mean, uncorrelated, and unit variance, and define a corresponding obs-function (or H-operator) that is a weighted sum of the temperatures retrieved on the radiative transfer model vertical grid. Our approach follows some ideas from Rodgers' book, "Inverse Methods for Atmospheric Sounding: Theory and Practice". Effects of smoothing and the prior are removed from the "observation". Therefore this approach provides a path to interactive retrievals in which the prior (mean and covariance) come from the background ensemble. In fact the entire approach is consistent with the maintainability and separability virtues of EnKF data assimilation.

The obs-function weights are determined from known quantities in the retrieval process. They can be calculated within the retrieval or as post-processing step. Notably the calculation makes use of the so-called Jacobian of the retrieval, which is the matrix of sensitivity of radiance to the state vector, evaluated at the retrieval solution. In the case of large channel sets, the Jacobian will also be very large, but it can be replaced in post-processing the retrievals if the retrieval saves as output the averaging kernel and the posterior error covariance matrix of the retrieval. These are two matrices only as large as the size of the retrieved state vector. No changes to the assimilation method are needed, except to interpolate to the radiative transfer model vertical grid and to calculate the weighted sum.

The weights could also be useful in the vertical localization for data selection. In retrieval schemes that make use of EOFs as vertical basis functions in order to reduce the degrees of freedom in the retrieval, this approach can be applied in EOF space. This greatly reduces the number of "observations" but the degree of vertical localization possible also decreases. We will test this approach in our Mars Local Ensemble Transform Kalman Filter (LETKF) data assimilation system using Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) radiances and retrievals.