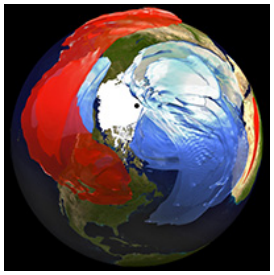

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Stratospheric data assimilation at ECMWF

Wednesday, 20 November 2019 11:30 (30 minutes)

The stratosphere presents several challenges to the assimilation system, including systematic biases in models and observations, gravity wave dynamics affecting the balance of the analysis and limited amount of humidity observations. Recent developments have made it possible to address some of these challenges more directly, leading to improvements in the stratospheric analysis.

Model errors were not included in the assimilation system in the past and in the stratosphere all of the difference between model and observations was accounted for by observation bias correction. The leading term of the model error in the stratosphere is a large scale bias, which can be modelled as geographically varying but constant in time over the length of the assimilation window. This model bias is estimated within the weak-constraint formulation of our 4D-Var system and evolves from day to day. Compared with previous versions, the key is to constrain the model error to large scales, and this leads to systematic improvement in the stratospheric analysis and forecasts.

Another key issue is the dynamic balance of the analysis. When the analysis increment is added to create a new initial state, the resulting forecast can be unbalanced and generate gravity waves during a spin-down period. More importantly, these gravity waves make it difficult for the global analysis to converge to an accurate state. The analysis increment consists of two parts, an unbalanced increment uncorrelated to other variables plus a balanced increment (derived from dynamic balances between increments) correlated with other variables. A pragmatic solution to this problem is to turn off the balanced part of the increments from the lower stratosphere to the top of the model. It has long been known however that a main cause of the lack of convergence in the analysis due to stratospheric gravity waves is the different propagation speed of gravity waves in the inner and outer loops of 4D-Var, when these use different timesteps. It has not been affordable to reduce the timesteps of the inner loops in the past due to operational constraints, but recent developments on a new configuration of 4D-Var called Continuous Data Assimilation have made it possible to use the same timesteps in the inner and outer loops. With this change, it is now possible to turn on the balanced part of the stratospheric increments without degradation of the analysis, and experiments are now evaluating this.

An analogous situation is that the humidity increments above the tropopause are turned off to prevent a drift of humidity due to lack of vertically resolved and unbiased humidity sensitive observations in the stratosphere. This, in combination with a methane oxidation source parameterization, is enough to prevent drift of humidity. Microwave limb-sounders, like MLS-AURA have not been used in the analysis due to not being available in real time. Recently, we have re-evaluated the drift of humidity in the system when humidity increments are allowed everywhere. We found they were less of an issue than before, possibly due to better bias corrections of satellite radiances, which in the past would cause ghost increments in the lower stratosphere for channels sensitive to humidity in the upper troposphere. Currently we are looking at options to better account for stratospheric humidity in the analysis.

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