Atmospheric horizontal gradients for slant-path assimilation of radiances in Environment Canada’s weather forecast system

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Abstract

We investigate the use of horizontal gradient information for the simulation and assimilation of slant radiances in Environment Canada’s weather forecasting system. These gradients of atmospheric variables, at each altitude layer, are used to construct slant background profiles for radiative transfer simulation. With respect to vertical background profiles, the following improvements are shown:

- forced operator performance
- a reduction in the analysis increment
- a reduction in the statistics of a prior error
- both short and long-range forecast improvements

These are particularly relevant for observations at higher slant angles, in mid to high latitudes, and for channels sensitive to temperatures in the upper troposphere and low stratosphere.

Conclusion and remarks

- We used linear horizontal gradients to estimate of the model fields’ variability and to build slant profiles for radiance observation simulation and analysis. The background field is an object that contains the vertical information of any variable required (P, T, q), and the respective horizontal level average gradients (∂P/∂x, ∂T/∂x, ∂q/∂x).
- The produced horizontal structure is effectively highly confined, with a cutoff scale of 100 km. The intent is to capture the gradients with larger scales.
- The impact is shown to be significant (e.g., 6% reduction in ATMS simulations) for the simulation of radiances at high zenith angles, upper stratosphere/lower stratosphere regions, and mid and high latitudes, particularly in respect of channels associated with respect to more sophisticated descriptions of the background state, it captures most of the potential improvement with respect to a purely vertical background.
- Since the OMI statistics are lower (atmospheric radiances were a component of background error) we have explored the assimilation with lower a priori error.

A set of four assimilation experiments (vertical/slant background and one with updated a priori error) were performed to: 1) examine the impact of slant-path radiative transfer in the assimilation cycle and 2) the effect of reduced background error. The short-range vertical forecast improvement can be attributed to the impact of the gradient-associated forward operator, whereas the long-range improvements are attributed to the modification of the observation error estimate.

- The small scale features have been filtered out using only the large-scale structures. This can be desirable as 1) if the model misrepresents or incorrectly locates features, this does not affect the quality of the results as long as the misrepresentation is smaller than the filter cutoff scale. In other words, overfitting to possible incorrect fields are avoided; 2) the analysis is performed on a lower-resolution grid, where the information from small-scale features is lost. The unnecessary additional computing time and observation misrepresentations of high-pass filtered descriptions of the background state, and the analysis of the optimal cutoff scale length.

- These results are ready for implementation. Future development will be dedicated to the study of other efficient descriptions of high-pass filtered descriptions of the background state, and the analysis of the optimal cutoff scale length.

References