Jacobian mapping between vertical coordinate systems in variational assimilation

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In atmospheric data assimilation, radiances measured by remote sensing instruments form a significant component of the observation network. Radiance assimilation involves fast radiative transfer models (RTM) which project profiles provided by forecast models onto the observation space for direct comparison with the measurements. One of the features typically characterizing fast RTMs is the use of a fixed vertical coordinate. In the absence of a fast RTM for calculating radiances directly using the levels of the forecast model, an interpolation of forecast profiles to the RTM coordinate is necessary. In data assimilation, the mapping of the Jacobians of the observations from the radiative transfer model coordinate to the forecast model coordinate is therefore also necessary. This mapping of Jacobians is accomplished through the adjoint of the forecast profile interpolator. As shown here, the nearest neighbour log-linear interpolator commonly used operationally can lead to incorrect mapping of Jacobians and can potentially lead to incorrect assimilation. This problem has been previously masked in part through the smoothing effect of forecast error vertical correlations on the analysis increments. To solve this problem, an alternative interpolator relying on piecewise log-linear weighted averaging over the layers is proposed. One of two investigated variants of this interpolator is found to satisfy design guidelines stipulated for ensuring acceptable Jacobian mappings.
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