A generalized innovation operator for the assimilation of integral measurements

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Brief Abstract:

In recent years, satellite data has become the predominant source of information for operational Numerical Weather Prediction centers and in the emerging field of chemical data assimilation. Much of the vertical profile information retrieved from satellite measurements, as well as from ground based measurements, is obtained by assimilating data provided as integral quantities. A particular challenge of assimilating integral quantities is the redistribution of increments over the integration domain. The strong dependence of these increments to background error statistics can lead to unphysical analysis in terms of vertical profiles. In this work, we provide simple examples leading to unphysical analyses, identify the current means for containing such behaviours, and present an alternative framework that can be applied to the assimilation of any vertically integrated quantity. With this framework, physical knowledge can be used in addition to, or in place of error statistics to distribute the information of integral observations in space. The key to the methodology is the introduction of a ``generalized'' innovation operator which provides the spatial structure of the analysis increments. The use of the generalized operator is illustrated with three common measurements used in atmospheric data assimilation: total column ozone, partial column ozone, and radiances from nadir temperature sounders (such as AMSU-A).