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A robust observation operator and associated background covariances to assimilate rain microwave radiances into cloud-permitting models

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To assimilate microwave radiances over clear regions as well as heavily precipitating cells, one needs an observation operator that can accurately simulate the brightness temperatures due to the emission and scattering of the condensation as well as the emission from the background, without straining the computational resources, and while minimizing the impact of poorly modeled variables such as the hydrometeor descriptors. We have developed such an operator using canonical correlation analysis and a non-linear localization/interpolation approach, to be used in conjunction with a representation of the covariances of the background model variables that exploits the empirical horizontal decorrelation of their vertical principal components. The resulting operator is indeed insensitive to the details of the microphysical variables, and it is inexpensive to use in assimilating instantaneous data that the Tropical Rainfall Measuring Mission's Microwave Imager (TMI) or the Advanced Microwave Scanning Radiometer (AMSR) typically measure over tropical cyclones. Preliminary simulations starting with synthetic window-channel microwave "measurements" that were forward-calculated from a specific time step in a hurricane simulation, along with a horizontally uniform background, show that the operator successfully localizes the condensation, water vapor, vertical motion and temperature fields, and, indeed, generates a vortex that is remarkably similar to the original simulated hurricane at that time step, from the synthetic measurements alone.

We present this method applied to the Hurricane WRF (HWRF) model and the Hurricane WRF Satellite Simulator for the representation of the TMI radiances trained on simulations of 2010's Hurricane Earl. The approach is in general applicable to any observation operator and can serve as an important tool in the data assimilation toolbox.