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Assimilation of precipitation information using the forecast model as a weak constraint

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Precipitation assimilation in global forecast systems poses a special challenge since the forward models for rain are based on parameterized physics, which can have large systematic errors. Within a standard analysis framework such as 3D or 4D-VAR, systematic errors must be rectified in order to make effective use of precipitation information. We discuss key issues and strategies in precipitation assimilation and present results from our research.

At NASA/GSFC, we have been exploring several nontraditional approaches to assimilating precipitation information using the forecast model as a weak constraint. We describe a time-continuous variational algorithm that assimilates 6h tropical rain rates from space-borne microwave sensors (e.g., TMI, SSM/I, AMSR) using moisture tendency corrections as a control variable. Data impact studies show that this algorithm effectively acts as an online estimation and correction of forecast model biases, enabling the analysis to capture the intensity and propagation of tropical precipitation systems in NASA's global data assimilation system. The time-continuous character of this procedure allows the system's prognostic variables to directly respond, within the 6h analysis window, to improved horizontal rain/latent heating patterns, leading to improved representation of clouds and radiation in the analysis. Case studies show that the improved analysis also yields better hurricane forecasts in the tropics.

In seeking further improvements, we describe recent experimentations using a variational procedure that assimilates TMI convective/stratiform vertical latent heating structures in addition to surface rain rates by optimizing selected empirical parameters in the moist physics scheme.