“Big Data Assimilation” for 30-second-update 100-m-mesh Numerical Weather Prediction

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A typical lifetime of a single cumulonimbus is within an hour, and radar observations often show rapid changes in only a 5-minute period. For precise prediction of such rapidly-changing local severe storms, we have developed what we call a “Big Data Assimilation” (BDA) system that performs 30-second-update data assimilation cycles at 100-m grid spacing. The concept shares that of NOAA’s Warn-on-Forecast (WoF), in which rapidly-updated high-resolution NWP will play a central role in issuing severe-storm warnings even only minutes in advance. The 100-m resolution and 30-second update frequency are a leap above typical recent research settings, and it was possible by the fortunate combination of Japan’s most advanced supercomputing and sensing technologies: the 10-petaflops K computer and the Phased Array Weather Radar (PAWR). The X-band PAWR is capable of a dense three-dimensional volume scan at 100-m range resolution with 100 elevation angles and 300 azimuth angles, up to 60-km range within 30 seconds. The PAWR data show temporally-smooth evolution of convective rainstorms. This gives us a hope that we may assume the Gaussian error distribution in 30-second forecasts before strong nonlinear dynamics distort the error distribution for rapidly-changing convective storms. With this in mind, we apply the Local Ensemble Transform Kalman Filter (LETKF) that considers flow-dependent error covariance explicitly under the Gaussian-error assumption. The flow-dependence would be particularly important in rapidly-changing convective weather. Using a 100-member ensemble at 100-m resolution, we have tested the Big Data Assimilation system in real-world cases of sudden local rainstorms, and obtained promising results. However, the real-time application is a big challenge, and currently it takes 10 minutes for a cycle. We explore approaches to accelerating the computations, such as using single-precision arrays in the model computation and developing an efficient I/O middleware for passing the large data between model and data assimilation as quickly as possible. In this presentation, we will present the most up-to-date progress of our Big Data Assimilation research.