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Estimation and correction of different flavors of surface observation biases in ensemble Kalman filter

Raquel Lorente-Plazas (1,2), Josua P. Hacker (3), Nancy Collins (4), and Jared A. Lee (3)

(1) Universidad de Murcia, Physics, Murcia, Spain (lorente.plazas@gmail.com), (2) University of Washington, School of STEM, Bothell, USA, (3) NCAR, Research Applications Laboratory, Boulder, USA, (4) NCAR, Computational and Information Systems Laboratory, Boulder, USA

The impact of assimilating surface observations has been shown in several publications, for improving weather prediction inside of the boundary layer as well as the flow aloft. However, the assimilation of surface observations is often far from optimal due to the presence of both model and observation biases. The sources of these biases can be diverse: an instrumental offset, errors associated to the comparison of point-based observations and grid-cell average, etc. To overcome this challenge, a method was developed using the ensemble Kalman filter. The approach consists on representing each observation bias as a parameter. These bias parameters are added to the forward operator and they extend the state vector. As opposed to the observation bias estimation approaches most common in operational systems (e.g. for satellite radiances), the state vector and parameters are simultaneously updated by applying the Kalman filter equations to the augmented state.

The method to estimate and correct the observation bias is evaluated using observing system simulation experiments (OSSEs) with the Weather Research and Forecasting (WRF) model. OSSEs are constructed for the conventional observation network including radiosondes, aircraft observations, atmospheric motion vectors, and surface observations. Three different kinds of biases are added to 2-meter temperature for synthetic METARs. From the simplest to more sophisticated, imposed biases are: (1) a spatially invariant bias, (2) a spatially varying bias proportional to topographic height differences between the model and the observations, and (3) bias that is proportional to the temperature. The target region characterized by complex terrain is the western U.S. on a domain with 30-km grid spacing. Observations are assimilated every 3 hours using an 80-member ensemble during September 2012.

Results demonstrate that the approach is able to estimate and correct the bias when it is spatially invariant (experiment 1). More complex bias structure in experiments (2) and (3) are more difficult to estimate, but still possible. Estimated the parameter in experiments with unbiased observations results in spatial and temporal parameter variability about zero, and establishes a threshold on the accuracy of the parameter in further experiments. When the observations are biased, the mean parameter value is close to the true bias, but temporal and spatial variability in the parameter estimates is similar to the parameters used when estimating a zero bias in the observations. The distributions are related to other errors in the forecasts, indicating that the parameters are absorbing some of the forecast error from other sources. In this presentation we elucidate the reasons for the resulting parameter estimates, and their variability.