

# Ensemble Kalman filter assimilation of near-surface observations over complex terrain: comparison with 3DVAR for short-range forecasts

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Surface observations are the main conventional observations for weather forecasts. However, in modern numerical weather prediction, the use of surface observations, especially those data over complex terrain, remains a unique challenge. There are fundamental difficulties in assimilating surface observations with three-dimensional variational data assimilation (3DVAR). In the first part of this study, a series of observing system simulation experiments is performed with the ensemble Kalman filter (EnKF), an advanced data assimilation method to compare its ability to assimilate surface observations with 3DVAR. Using the advanced research version of the Weather Research and Forecasting (WRF) model, results from the assimilation of observations at a single observation station demonstrate that the EnKF can overcome some fundamental limitations that 3DVAR has in assimilating surface observations over complex terrain. Specifically, through its flow-dependent background error term, the EnKF produces more realistic analysis increments over complex terrain in general. More comprehensive comparisons are conducted in a short-range weather forecast using a synoptic case with two severe weather systems: a frontal system over complex terrain in the western US and a low-level jet system over the Great Plains. The EnKF is better than 3DVAR for the analysis and forecast of the low-level jet system over flat terrain. However, over complex terrain, the EnKF clearly performs better than 3DVAR, because it is more capable of handling surface data in the presence of terrain misrepresentation. In addition, results also suggest that caution is needed when dealing with errors due to model terrain representation. Data rejection may cause degraded forecasts because data are sparse over complex terrain. Owing to the use of limited ensemble sizes, the EnKF analysis is sensitive to the choice of horizontal and vertical localization scales.

Then, we further examine the impact of EnKF data assimilation on the predictability of atmospheric conditions over complex terrain with the WRF model and the observations obtained from the recent field experiments of the Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program. Results are compared with these from 3DVAR and a hybrid 3DVAR/EnKF.

## References

- [1] Pu, Z., H. Zhang, and J. A. Anderson., “Ensemble Kalman filter assimilation of near-surface observations over complex terrain: Comparison with 3DVAR for short-range forecasts.” *Tellus A*, vol. 65,19620. 2013. <http://dx.doi.org/10.3402/tellusa.v65i0.19620>