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Observations and multiple scales in convection permitting data assimilation

Sarah L. Dance
National Centre for Earth Observation, Reading UK

Convection-permitting (km-scale) data assimilation systems have been used in research and operational numerical weather prediction for more than fifteen years. These systems have been proven to provide improved short-term (0-36 hour) nowcasts, particularly for hazardous weather such as convective storms and fog. However, there are still many challenges to be addressed in these high-resolution systems. We will briefly review these broad challenges including multiscaling, spin-up, nonlinearity and model error.

For the main focus of the presentation, we will consider the challenge of providing detailed observation information on appropriate scales in the analysis. We will discuss the treatment of observation and background error covariances and show how they influence the scales in the analysis in idealized studies. We find that dense observations are most beneficial when they provide a more accurate estimate of the state at smaller scales than the prior estimate. In our idealized experiments, this is achieved when the length-scales of the observation-error correlations are greater than those of the prior estimate and the observations are direct measurements of the state variables. We further test these ideas in an operational system, by assimilating Doppler radar wind observations taking account of their spatially correlated observation errors. The approach taken gives results for the scales represented in the analysis increments that are consistent with the findings from the idealized studies. In particular, we find that using the correlated observation-error statistics with denser observations produces increments with shorter length-scales than the control. Furthermore, the use of dense Doppler radar wind observations with spatially correlated errors provides improvements in forecast skill, particularly for forecasts of intense convective rainfall, without increasing the wall-clock time for the assimilation.

Finally, we will discuss the potential of novel observation types such as opportunistic data and those obtained from crowdsourcing to fill some of the gaps in the observation network. We take vehicle-based temperature observations as an example. We discuss the instrument and representation uncertainties associated with vehicle-based observations and present some results from a proof-of concept trial. Despite the low precision of the trial data, our results show the potential of vehicle-based observations as a useful source of spatially-dense and temporally-frequent observations for numerical weather prediction.