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Idealised forecast-assimilation experiments and their relevance for convective-scale Numerical Weather Prediction

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To aid understanding of and facilitate research into forecast–assimilation systems of Numerical Weather Prediction (NWP), 'idealised' models are utilised that embody essential characteristics of these systems. We conduct inexpensive data assimilation (DA) experiments using an idealised 'convective-scale' fluid model and justify their relevance in the context of NWP. The forecast model, introduced in Kent et al. (2017), is a modification of the rotating shallow water equations that includes some simplified dynamics of cumulus convection and associated precipitation. It is of interest owing to (i) its distinctive dynamics, including the disruption of large-scale balanced flows, highly nonlinear behaviour associated with convection and moisture, and other features of convecting and precipitating weather systems, and (ii) its computational efficiency, a crucial factor for an idealised model.

Achieving a meaningful and interesting experimental set-up is more nuanced than simply interfacing a model with an assimilation algorithm. To this end, we propose a protocol and outline the thorough process of achieving a well–tuned observing system and filter configuration using a deterministic ensemble Kalman filter. The ensemble, via a spread–error diagnostic, is shown to adequately estimate the forecast error and is assessed using the continuous ranked probability score. The forecast–assimilation system has an average observational influence similar to NWP (circa 25%) and the resulting error–doubling time statistics reflect those of convection-permitting models initialised with analysis increments from an actual cycled forecast–assimilation system (circa 4 hours), further demonstrating the model's suitability for conducting DA experiments in the presence of convection and precipitation.

An idealised forecast-assimilation framework, including the novel numerical solver for the model integration and necessary set-up instructions, is publicly available on GitHub: https://github.com/tkent198/modRSW_EnKF