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The effect of domain length and parameter estimation on observation impact in data assimilation for flood inundation forecasting.

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Timely and accurate inundation forecasting provides vital information about the behaviour of fluvial flood water, enabling mitigating actions to be taken by residents and emergency services. Data assimilation is a powerful mathematical technique for combining forecasts from hydrodynamic models with observations to produce a more accurate forecast. We discuss the effect of both domain size and channel friction parameter estimation on observation impact in data assimilation for inundation forecasting. Numerical shallow water simulations are carried out in a simple, idealized river channel topography. Data assimilation is performed using an Ensemble Transform Kalman Filter (ETKF) and synthetic observations of water depth in identical twin experiments. We show that reinitialising the numerical inundation model with corrected water levels after an assimilation can cause an initialisation shock if a hydrostatic assumption is made, leading to significant degradation of the forecast for several hours immediately following an assimilation. We demonstrate an effective and novel method for dealing with this.

We find that using data assimilation to combine observations of water depth with forecasts from a hydrodynamic model corrects the forecast very effectively at time of the observations. In agreement with other authors we find that the corrected forecast then moves quickly back to the open loop forecast which does not take the observations into account. Our investigations show that the time taken for the forecast to decay back to the open loop case depends on the length of the domain of interest when only water levels are corrected. This is because the assimilation corrects water depths in all parts of the domain, even when observations are only available in one area. Error growth in the forecast step then starts at the upstream part of the domain and propagates downstream. The impact of the observations is therefore longer-lived in a longer domain. We have found that the upstream-downstream pattern of error growth can be due to incorrect friction parameter specification, rather than errors in inflow as shown elsewhere.

Our results show that joint state-parameter estimation can recover accurate values for the parameter controlling channel friction processes in the model, even when observations of water level are only available on part of the flood plain. Correcting water levels and the channel friction parameter together leads to a large improvement in the forecast water levels at all simulation times. The impact of the observations is therefore much greater when the channel friction parameter is corrected along with water levels. We find that domain length effects disappear for joint state-parameter estimation.