Department of Meteorology

Improving inundation modelling using data assimilation

Elizabeth Cooper [1] | Sarah Dance[1,2] | Javier Garcia-Pintado[3] | Nancy Nichols[1,2] | Polly Smith[2]

Introduction

In a river flooding situation it is vitally important that the local community have access to accurate forecasts regarding the future behaviour of flood water.

Various numerical models e.g.[1,2] aim to describe and predict the flow of flood water via solution of the shallow water equations. However, the model equations contain uncertain parameters, making the predictions of the models uncertain.

Data assimilation (DA) is a powerful mathematical technique that combines observations of a physical system with predictions from a numerical model to improve the model forecast and simultaneously extract information about uncertain parameters. Here we use an ensemble transform Kalman filter (ETKF) to optimally combine observations with model predictions in a test domain.

Identical Twin Experiments

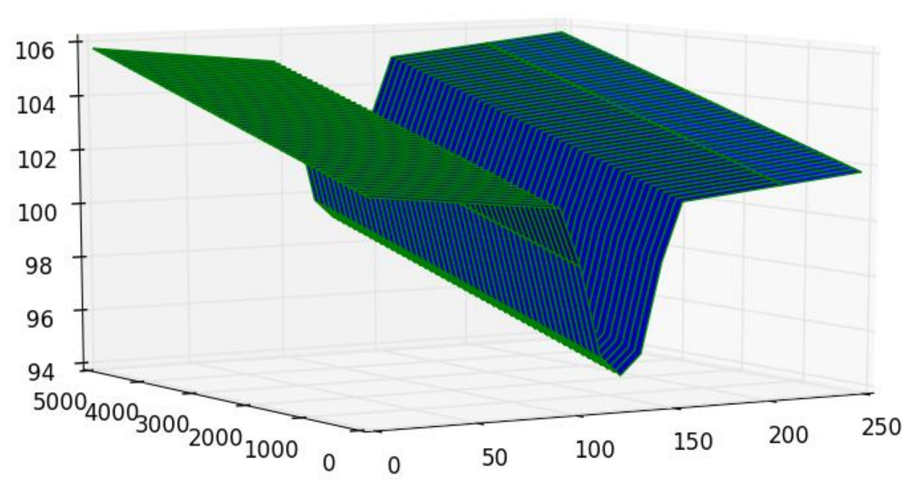

Figure 1. The test domain

We have used Clawpack [3] to simulate a 'truth' flood in an idealised river valley-like domain. The inflow used to drive the 'truth' is shown by the circles in fig. 2.

We then created an ensemble of flood simulations for the same domain, each with a perturbed time-varying inflow and a different value for the parameter describing friction between water and the channel

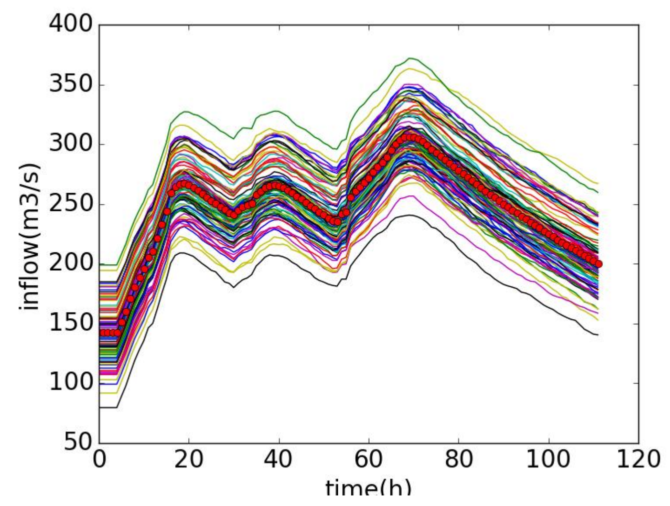

Figure 2. The inflow distribution

Distributions in inflow and friction represent uncertainty in these parameters in an operational setting. The spread in the ensemble of flood simulations then represents the resulting uncertainty in the flood forecast.

Water levels predicted by the ensemble of flood simulations can be combined to give a mean value for water depths: this is the model forecast.

Observations of water depth in the domain were taken from the truth run at 12h intervals and combined with the forecast using an ETKF. The 'synthetic' observations represent information which can be derived from SAR satellite images.

The ETKF update leads to a corrected ensemble of water levels, with a forecast which is closer to the observations.

Results and Discussion

How well can we forecast water levels?

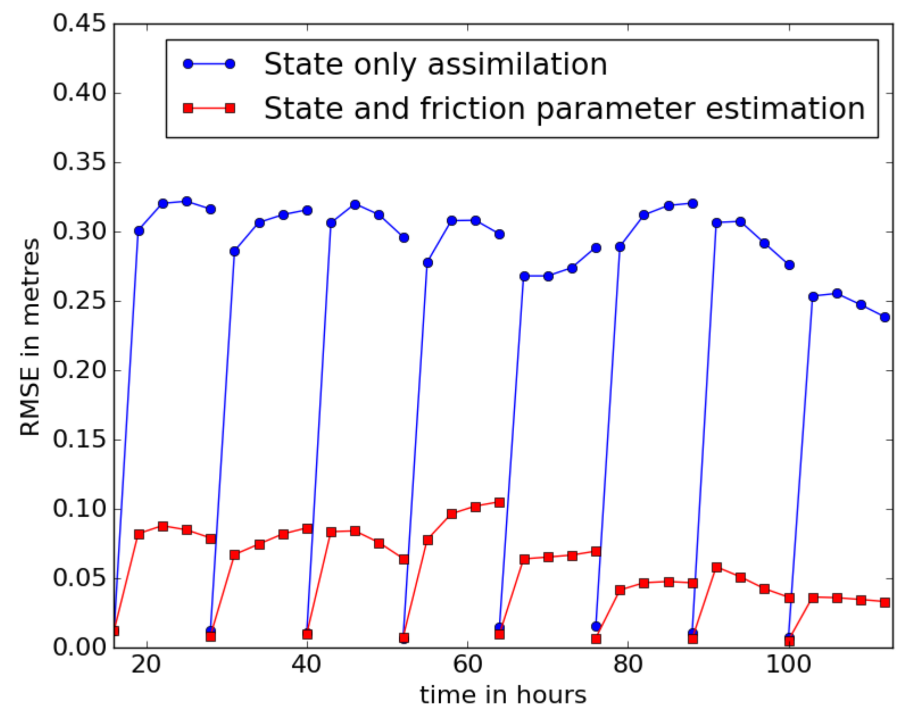

Figure 3. Difference between the forecast and truth

- In this domain, state-only estimation corrects the water levels very well at the time of the observations
- The forecast skill quickly disappears with time due to the relatively fast flow of water out of the domain
- Simultaneously correcting the channel friction parameters leads to a far better forecast skill with time, allowing the same observations to influence the forecast for a greater time

How well can we retrieve the friction parameter?

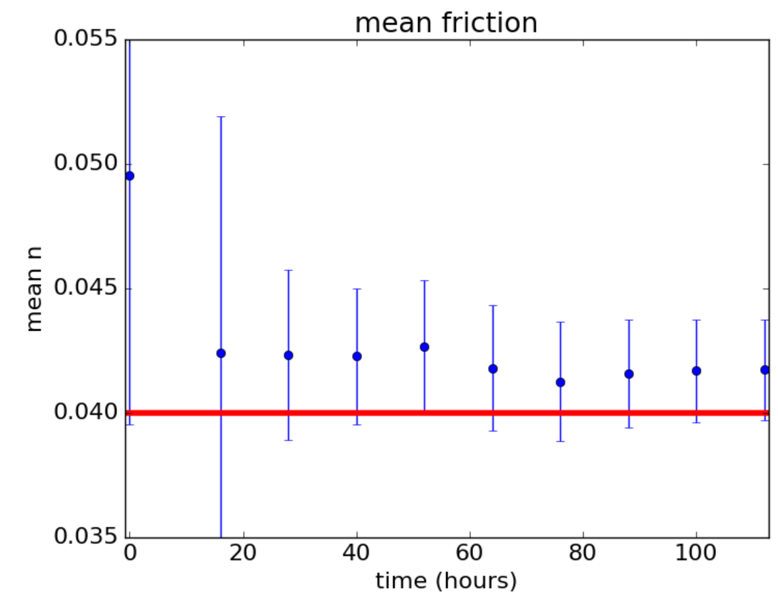

Figure 4. friction parameter with time

Figure 4 shows the true friction value with a red line.

Calculated values are shown as blue circles with error bars showing one standard deviation.

Observations of water depth quickly move the friction parameter towards the true value

Conclusion

Simultaneously estimating channel friction parameter along with correcting the water levels increases the effective time of the observations in our test domain and leads to better forecast ability.

References

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3. Clawpack software, Clawpack development Team, http://www.clawpack.org, version 5.2.2

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Contact information

1 Department of Meteorology, University of Reading, Whiteknights, RG6 6AH

2 Department of Mathematics and Statistics, University of Reading, Whiteknights, RG6 6AH

3 MARUM, Department of Geosciences, Bremen, D-28334 Bremen, Germany