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Set-up and configuration of an ensemble Kalman filter for an operational flood forecasting system

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INTRODUCTION:

To forecast riverine floods, short-range forecasts are normally provided. In such cases the initial hydrological conditions highly influence the predictability of a flood event.
The study evaluates the potential of an **ensemble Kalman filter (EnKF)** for the operational flood forecasting system in the Upper Rhone River basin (Fig 1). **Observed discharge data is used to update the initial conditions of the hydrological model.** Past flood events in the Reckingen subbasin (Fig. 1) are modelled to assess the robustness of the methodology and the quality of flood predictions.

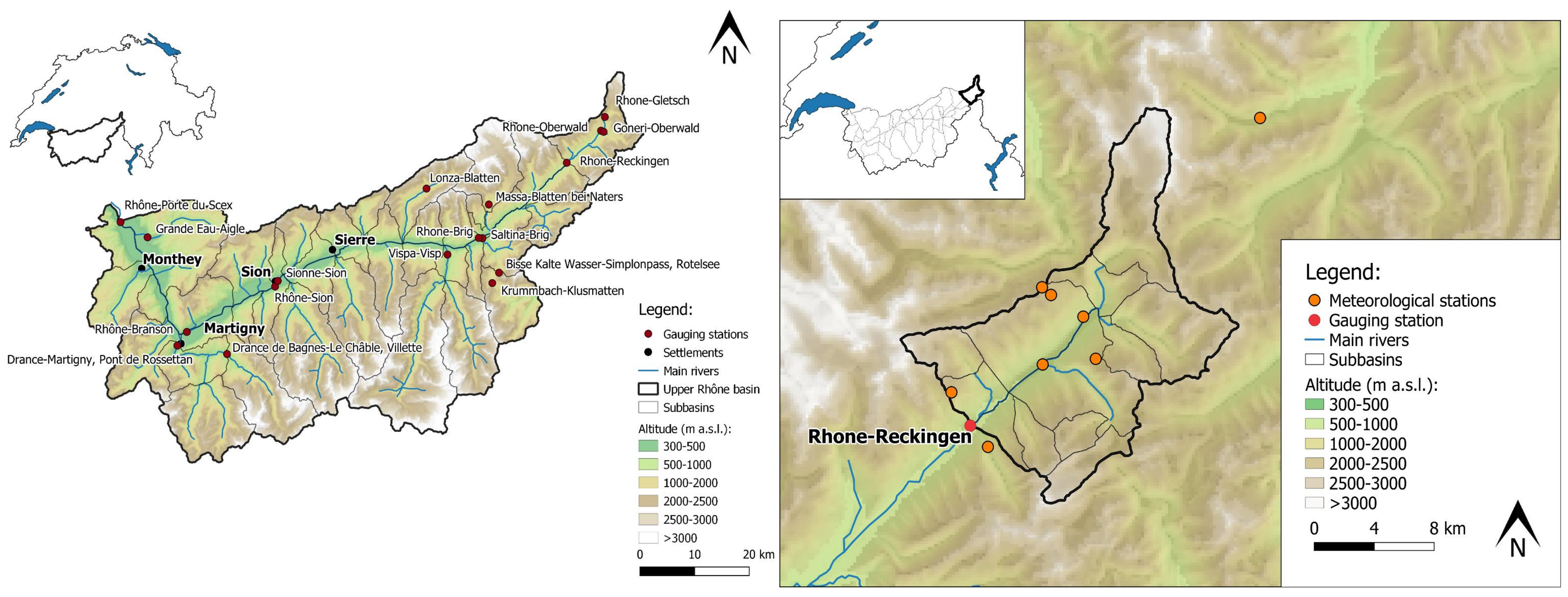

Figure 1: Maps of the Upper Rhone River basin (left) and the Reckingen subbasin (right) showing gauging stations and meteorological stations.

METHODOLOGY:

- Simulations are computed with the semi-distributed hydrological model RS MINERVE (Crealp, 2019).
- Three different discharge predictions are computed and compared:
  - **Control simulation**: Open-loop scenario where discharge observations are not used to correct model initial conditions.
  - **Volume based update (VBU) simulation**: Iterative approach correcting the initial soil saturation in order to generate the modelled water volume which has been observed over the 24 h before the forecast.
  - **EnKF simulation**: Data assimilation (DA) method where the initial conditions of the model are updated based on the covariance matrices of the discharge observations and the model prediction (Fig. 2) (Evensen 1994).
- Forecast quality is evaluated based on the Kling-Gupta-efficiency (KGE) calculated for different lead times (Gupta et al., 2009):

$$KGE = 1 - \sqrt{(r-1)^2 + (a-1)^2 + (b-1)^2}$$

where r is the correlation coefficient, a is measure of variability and b is a measure of bias.

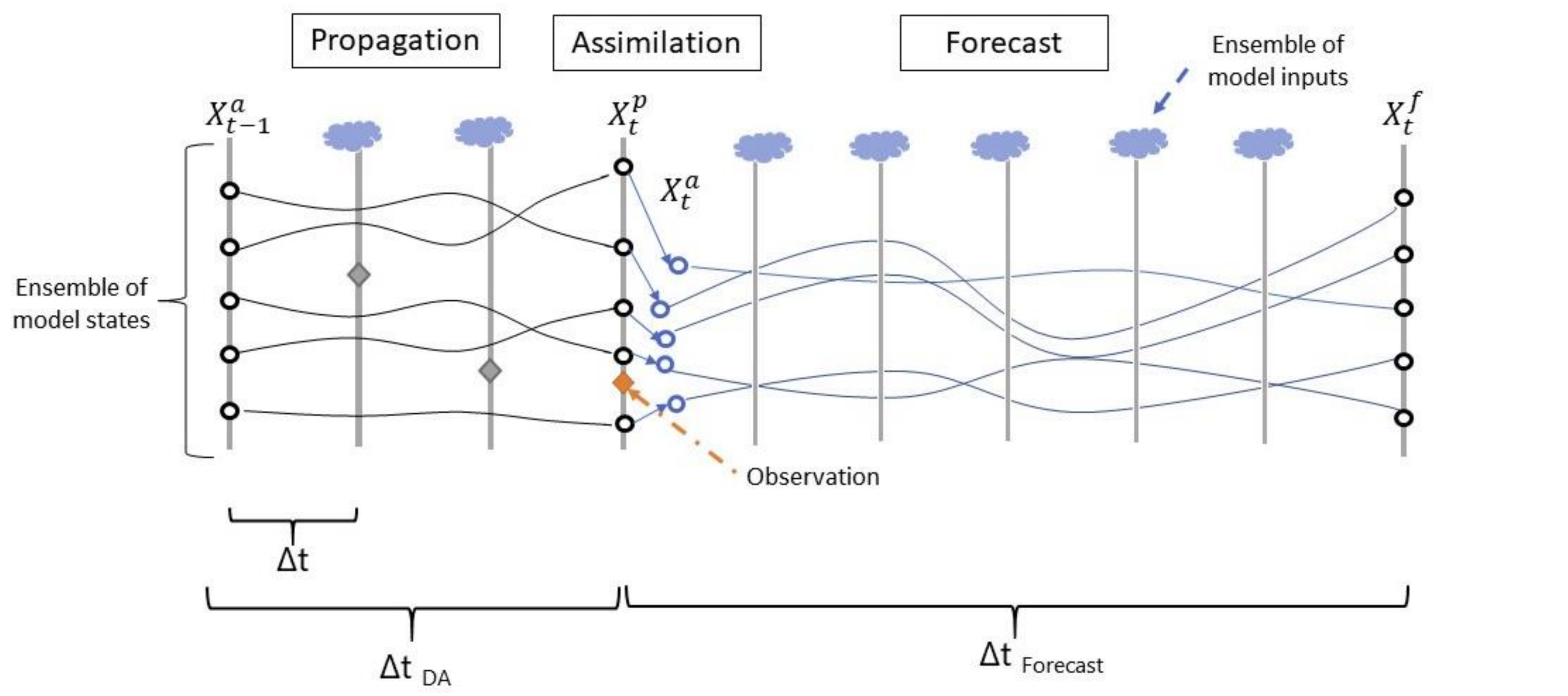

Figure 2: Schematic of the investigated EnKF where perturbed inputs are applied to an ensemble of model states (adapted Noh 2013).

RESULTS:

Figure 3 shows the streamflow prediction of the EnKF in comparison with the Control and VBU simulation as well as the observed discharge during an event in Reckingen in 2012. Figure 4 shows the KGE of the different simulation methods for four flood events in the Reckingen subbasin.

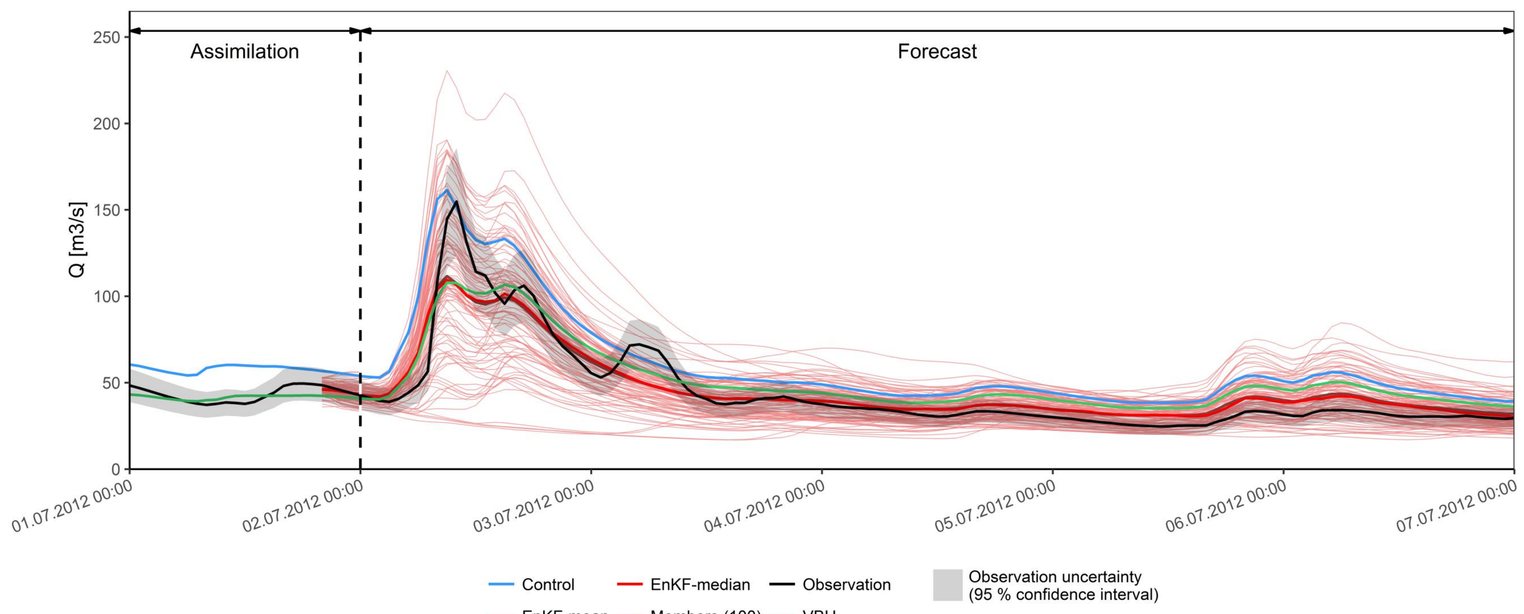

Figure 3: Example hydrograph during an event in Reckingen, July 2012.

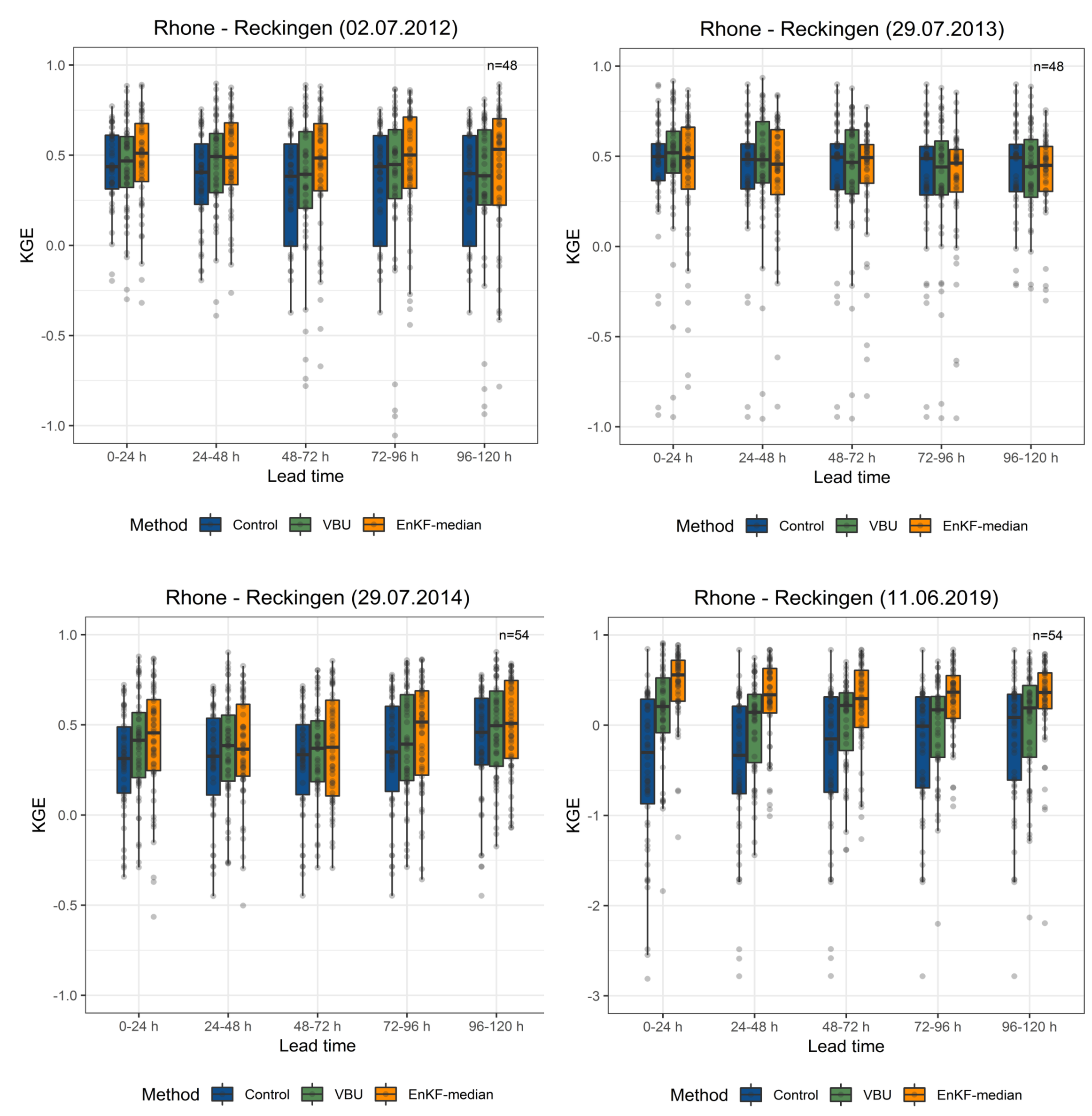

Figure 4: KGE of the three simulation methods for flood events in Reckingen in 2012, 2013, 2014 and 2019.

DISCUSSION AND CONCLUSION:

- **For short lead times, the EnKF simulation outperforms the other two simulations.** With an increased lead time the results depend on the event and the model calibration.
- To achieve good results with the EnKF, **an appropriate model calibration and high-quality input data is needed.**
- A DA method which specifically **accounts for the time lag needed for streamflow routing could increase the robustness** of the framework.

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