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Outstanding Student Poster Contest

EGU2014-3089: Uncertainty of hydrological forecasts with respect to initial conditions and meteorological forcing for two major flood events in Germany

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1. Introduction

Highly skilled hydrological forecasts can help to mitigate severe socio-economic damages caused by major flood events. Among several factors, these hydrological forecasts are strongly dependent on the initial conditions of the land surface at the beginning of the forecast period and the forecast skill of the meteorological forcing.

2. Precipitation Ensemble Generator

Two methods are applied for the generation of an ensemble of precipitation forecasts, using weights to adjust their variance (spread).

Met-RS: A *rescaling approach* [2] is used as a benchmark. It can be separated into two steps:

1. Determine historic weights w_h^y via

$$P_d^y(t) = w_h^y(t) P_w^y, \qquad (1)$$

for a given (bi-)weekly value P_w^y and the corresponding daily values P_d^y in a given year y.

2. Substitute P_w^y with a observation of another year in eq. 1 to generate a new daily time series P_d^{y*}, keeping the weights w_h^y fixed.

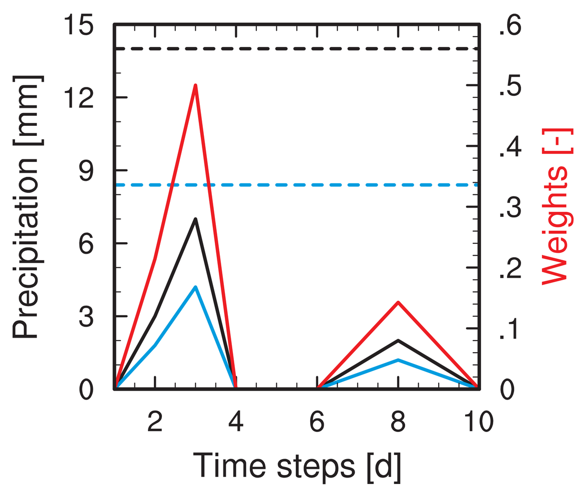

Fig. 1: Exemplary rescaling for 10 day precipitation. The weights (red line) are derived as ratios between given daily precipitation (black line) and its sum (black dashed line). Then the weights are multiplied with a new 10 day precipitation value (blue dashed line) to derive new daily precipitation (blue line).

Met-EG: An *error growth model* is proposed to combine the information from a perfect forecast P_d^y (taken from observations) and a stochastic perturbation P_d^{y*} (taken from HR method) using

$$P_d^{y**}(t) = w(t) P_d^y(t) + (1 - w(t)) P_d^{y*}(t),$$

where the weights are obtained from a logistic function with parameters k and l (Fig. 2)

$$w(t) = 1 - \frac{1}{1 + \exp(-k(t-l))}.$$

In this study, k and l are chosen as 0.5 and 7, respectively.

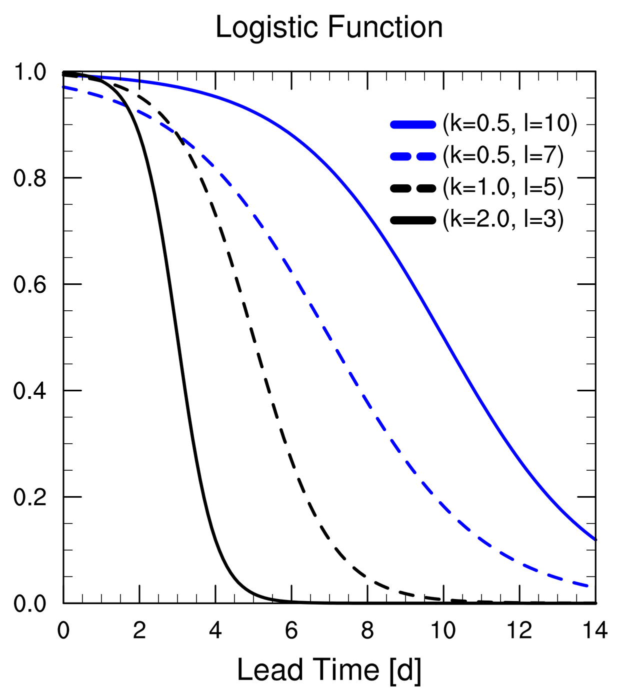

Fig. 2: logistic functions for four different parameter settings of shape parameter k and location parameter l

3. Land Surface States Generator

Hyd-CL: Climatological land surface conditions (Hyd-CL) x_h at a given day of the year (beginning of forecast period)

Hyd-BL: Blended conditions x^* are obtained by averaging the "perfect" conditions x_p with climatological conditions x_h using

$$x^* = w x_p + (1 - w) x_h,$$

with weight w. In this study, the weight was chosen as 0.5.

4. Experimental Design

The mesoscale hydrological model mHM [1] (Fig. 3) was used to evaluate the impact of different meteorological forcings and initial conditions on discharge forecasts. The Mulde catchment (7400km^2, Fig. 4) were selected for this study and the two major flood events of August 2002 and May 2013. The two following set ups were evaluated.

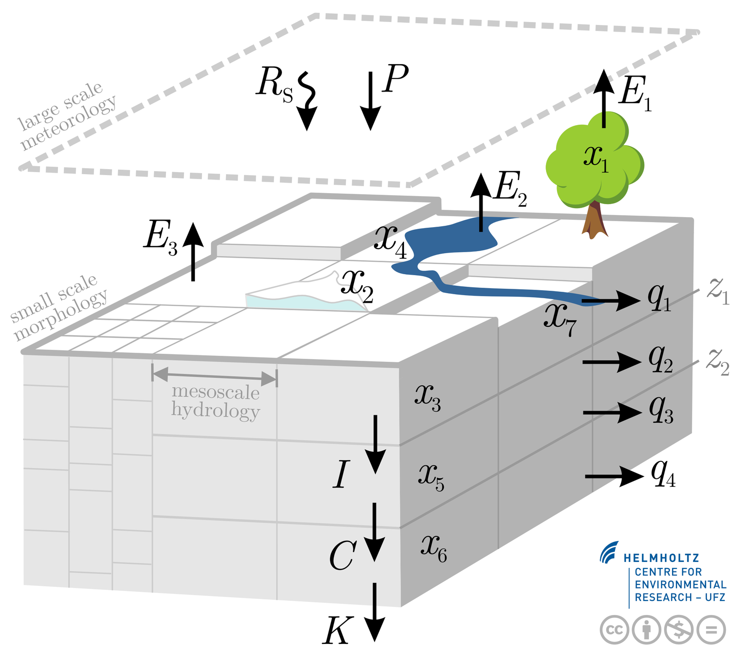

Fig. 3: mesoscale hydrologic model - mHM, State variables (x_k) and fluxes (q_k, E_k) at cell i

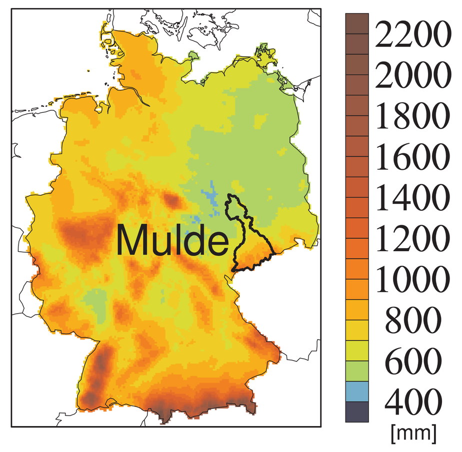

Fig. 4: Long-term annual precipitation over Germany (obtained by DWD measurements) during the period from 1960 to 2010

1. Select two ensembles of precipitation forcings for a five and 12 day lead time using accurate initial conditions. The ensembles are obtained by the Met-RS and Met-EG method (Sec. 2).
2. Select two ensembles of initial conditions x_k (Fig. 3) for a five day lead time using the observed meteorological forcing. First, initialize with historic conditions (Hyd-CL) x_h obtained from a reference run. Second, initialize with blended conditions (Hyd-BL) x^* (Sec. 3).

5. Comparison of Events

The total precipitation amount is comparable for the 2002 and 2013 event (Fig. 5), but is more evenly distributed over time for the 2013 event. This lead to a substantial higher soil moisture for the 2013 event (Fig. 6).

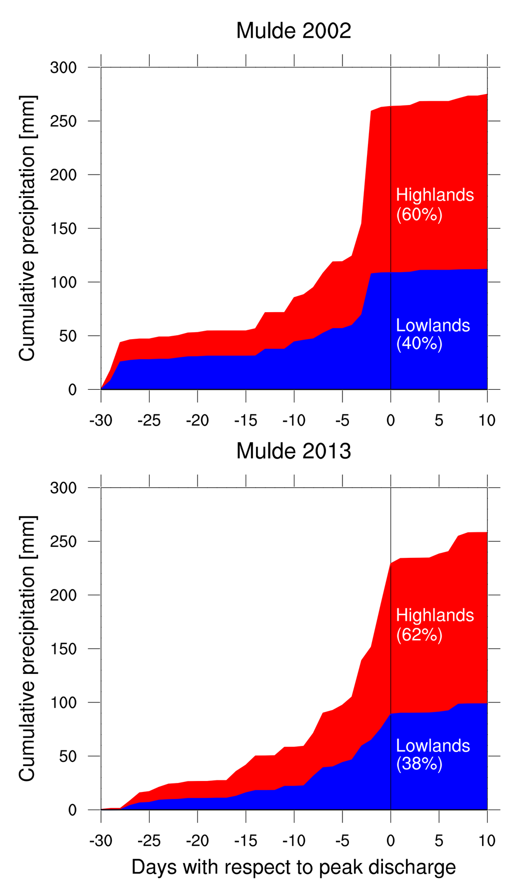

Fig. 5: Cumulative precipitation in 2002 (upper plot) and 2013 (lower plot)

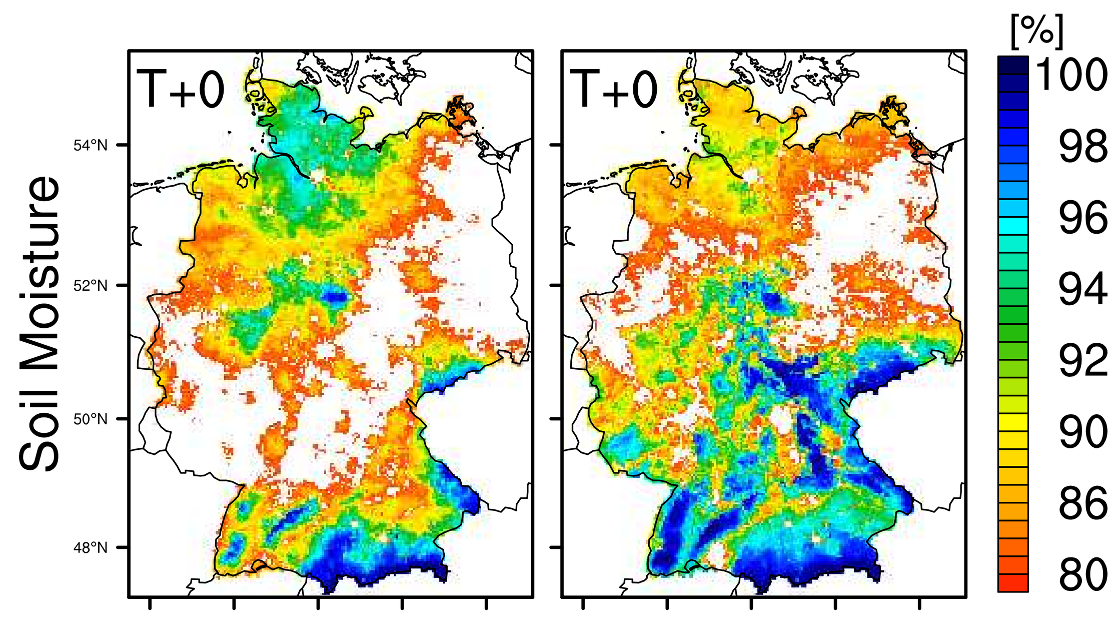

Fig. 6: Soil Moisture status at peak day for 2002 (left plot) and 2013 (right plot)

6. Impact of Meteorological Forcing

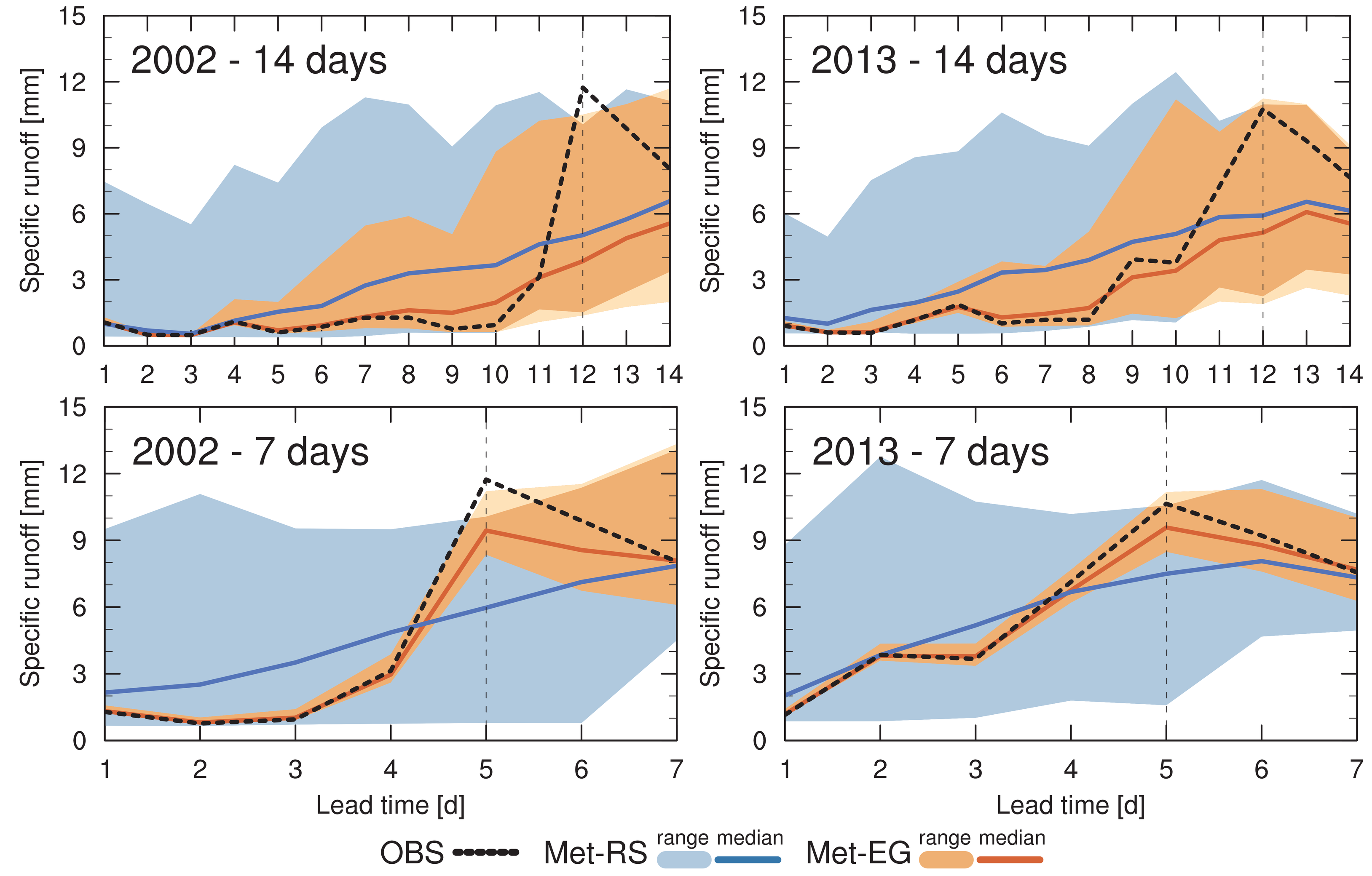

Fig. 7: Runoff for the 2002 (left plots) and 2013 (right plots) event for 14 day (upper plots) and 7 day (lower plots) lead time

7. Impact of Initial Conditions

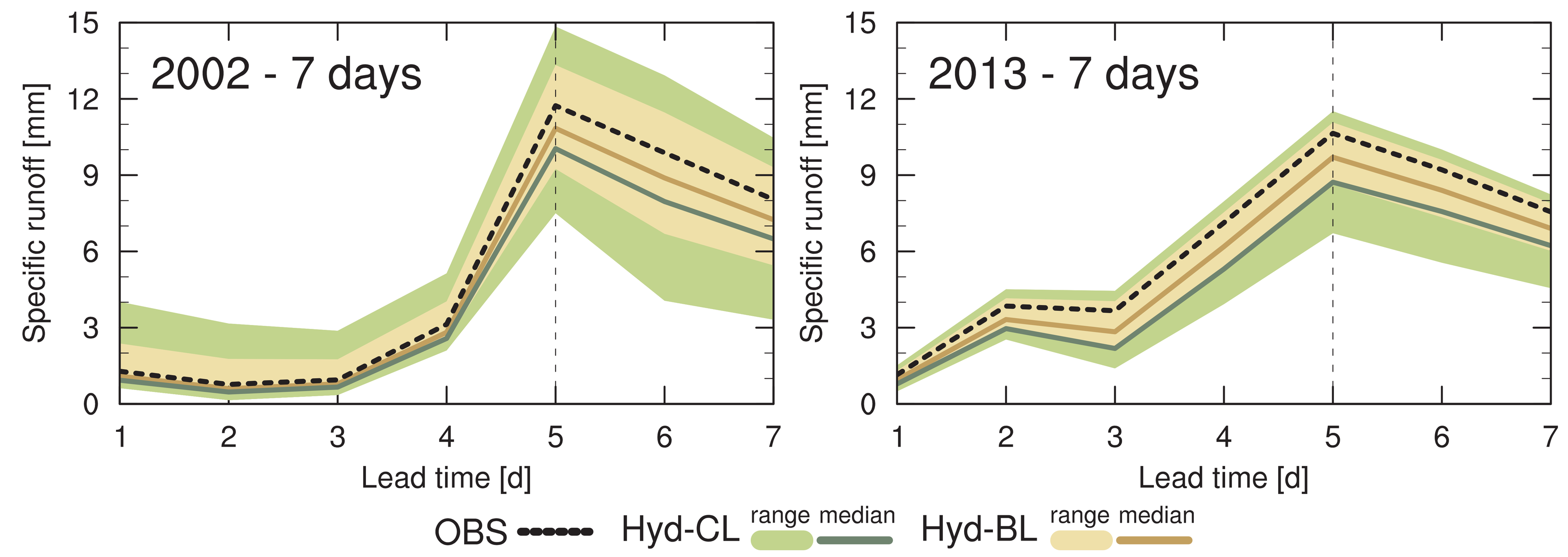

Fig. 8: Runoff for the 2002 (left plots) and 2013 (right plots) event for 7 day lead time and different initialization

8. Conclusions

1. Met-RS method provides no skill on flood forecasting whereas Met-EG method correctly times the flood peak for a five day lead time (Fig. 7)
2. Hyd-BL method leads to uncertainty bounds that are approximately a half of those obtained by Hyd-CL method (Fig. 8)
3. Uncertainty in discharge forecasts depends more on the uncertainty in meteorological forcings as compared to the one of initial conditions

References

[1] Luis Samaniego, Rohini Kumar, and Sabine Attinger. Multiscale parameter regionalization of a grid-based hydrologic model at the mesoscale. *Water Resources Research*, 46(5), 2010.

[2] Andrew W. Wood and Dennis P. Lettenmaier. An ensemble approach for attribution of hydrologic prediction uncertainty. *Geophysical Research Letters*, 35(14), 2008.

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