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Interactive Comment

Interactive comment on “A space-time hybrid hourly rainfall model for derived flood frequency analysis” *by* U. Haberlandt et al.

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GENERAL REMARKS:

We are very grateful to the editor Bettina Schaefli for constructively handling the submitted manuscript and supporting the review process with valuable additional comments. We will respond to these comments in the following.

DETAILED COMMENTS:

Notations:

All mathematical equations and notations have been reviewed and revised according to the comments of the reviewers. For random variables upper case letters and for realisations lower case letters have been introduced where appropriate. The multiple letter variables like wsa, wsd, wspt have been exchanged for single letter variables.

Case study:

For calibration of the hydrological model only 7 years of continuous observed flow data with hourly resolution were available. This is a very short period considering that the hydrological model is applied for flood frequency analysis. The hydrological model was parameterised using iteratively manual and automatic calibration. The calibration was focussing on peak flows using e.g. the peak-weighted root mean square error in the objective function (USACE, 1998). Nevertheless, the results indicate an underestimation of the peak flows and an overestimation of the low flows, especially for the Selke basin. Unfortunately, this is a typical result for many hydrological models, which provide an unbiased global estimation but a smoothing of the flow time series.

We agree with the editor, that a separate validation of the rainfall and hydrological models is necessary. However, the type of precipitation input (network density, observed vs. synthetic rainfall, etc.) has a significant impact on the calibration of the model parameters (see e.g. Bárdossy and Singh, 2008). So, using a different type of precipitation input for application than for calibration of the hydrological model might lead to unexpected results. This is the case here, where using synthetic rainfall in application causes an overestimation of the observed flows compared to an underestimation in the calibration phase. One possibility to overcome this problem is to utilize stochastic rainfall already in the calibration phase of the hydrological model. This could be achieved if not the hydrograph is used for calibration but the empirical probability distribution function of the annual maximum flows. Additional advantage would be to have longer periods with observed peak flows available for model calibration (here 56 years for the Selke and 33 years for the Holtemme) compared to periods with continuous hourly flows and to focus directly on the specific objective of the application. Work is in progress to investigate these ideas for better calibration of the whole framework.

The results for the Selke catchment (left panel in the Fig. 11, former Fig. 10) also

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show typical problems with small sample sizes. The largest value from observed flows and simulated flows using observed rainfall each belongs to the same flood and is associated with the maximum possible return period according to the sample size of 56 and 12 years, respectively. Both points are located above the simulated range of flows based on synthetic rainfall. The reason for that is that these values belong to an exceptional flood event occurring in 1994 which can be associated with a much higher return period compared to the length of the observed time series (LAU, 1995). These issues are now discussed in more detail in the text referring to Fig. 5 and Fig. 10 (former Fig. 9).

Fig. 11 (former Fig. 10):

Main focus of this last analysis is to evaluate the importance of the spatial rainfall structure or more precisely the effect of the resampling procedure on the simulated flood frequencies. It has been shown, that the flood frequency curve based on spatially resampled rainfall lies appropriately between the two marginal cases "uniform rainfall" and "random rainfall". Comparing the empirical probability distributions with the observed values the random case seems to correspond best to the majority of points. However, for the more important larger return periods, the flows generated by resampled rainfall correspond better to the observed ones. Taking into account the general problem of the model to slightly overestimate the observed flows when using synthetic rainfall (cp. Fig. 10), it can be concluded that the structured rainfall produces the most plausible flood frequency curve. More discussion on the results presented in Fig. 11 has been added to the text now.

Conclusions:

The section has been renamed "Summary and conclusions" as suggested by the referees and slightly modified.

CITED REFERENCES:

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Bárdossy, A., and Singh, S. K.: Robust estimation of hydrological model parameters, Hydrol. Earth Syst. Sci. Discuss., 5, 1641-1675, 2008.

LAU: Das Frühjahrshochwasser vom April 1994 in den Flusseinzugsgebieten der Saale und Bode in Sachsen-Anhalt. Berichte des Landesamtes für Umweltschutz Sachsen-Anhalt, 1995.

USACE: HEC-1 flood hydrograph package. User's manual, US Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA, 1998.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 2459, 2008.