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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Stochastic semi-continuous simulation for extreme flood estimation in catchments with combined rainfall-snowmelt flood regimes" *by* D. Lawrence et al.

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The authors thank the reviewer for the very positive and constructive review. We wish to prepare a full version of the paper, taking into account our responses to the minor comments listed in the review as follows:

1. We agree that a 'key message' is that the SCHADEX method allows one to drop the assumption that a design precipitation with a given return period produces a corresponding flood of the same return period. This point is highlighted in Paquet, et al.

(2013), Journal of Hydrology, which is the reference article for the SCHADEX method, and will also be mentioned in the introductory section of the revised paper. The related issue of the temporal distribution of rainfall will also be emphasized.

2. In the SCHADEX stochastic simulation process, each actual centred rainy event within a long climatological record (the so-called "simulation period") is successively replaced by a synthetic event, for which values are randomly drawn up to an extreme value. So an application to arid or semi-arid areas, having far fewer rainy events, would require a relatively longer simulation period with discharge observations to ensure that a sufficient number of pre-event catchment conditions are represented in the simulation. However, arid pre-event catchment conditions are likely to be less diversified than in a mountainous and/or Nordic climate (in which catchment saturation is conditioned by both rain and snow melt). Moreover, limited availability of rainfall data can, however, undermine the development of the weather pattern-based extreme precipitation model, independent of the climatic regime.

3. The peak-to-volume ratios of 1.04, 1.01 and for Atnasjø and Engeren, respectively, are estimated from hourly discharge data and show a good correspondence with the observed hydrographs from which they were developed and with estimates based on the regression equation developed for catchments with spring/early summer floods across Norway (e.g. Midttømme, et al., 2011 p. 26). That equation is

$Qi/Qd = 1.72 – 0.17*\log A – 0.125*Ase\^{}0.5$

where A is the catchment area and Ase is the effective lake percentage, and yields values of 1.13 and 1.07 for Atnasjø and Engeren, respectively. There are three physical factors which contribute to these relatively low values for the peak-to-volume ratios for these moderately-sized catchments, as compared with other regions in Europe. Firstly, many of the hydrographs used both in the SCHADEX peak-to-volume ratio analysis and for developing the regression equations given above represent floods in which snowmelt is important. The surface snowcover will clearly delay both incoming rainfall and percolating meltwater and contributes to these low values. This factor will be mentioned in the revised version of the paper and is an important correction. Secondly, the presence of surface water bodies in the form of marshes and bogs and small lakes will also delay runoff as compared with regions in Europe with lower annual rainfall and higher evapotranspiration. And finally, both of the catchments have an extensive cover of coniferous forest in the lower reaches, which can further attenuate the runoff response.

4. The comparison reported in this study was designed to compare the SCHADEX method, as currently implemented, with methods currently in use within the Nordic region. For this reason HBV was used, as this is the model of choice for such applications in Sweden. Both HBV and MORDOR are lumped, conceptual models and have similar internal structures, so one would expect similar behaviour, at least with respect to the initial soil moisture states and the runoff responses simulated by the models. There are some differences between the snowmelt modules for MORDOR vs. HBV with respect to the distribution of snow storage and melting with elevation in the catchment, although the physical processes are modelled using similar, temperature-based formulations. Work is in progress at the moment on incorporating HBV within the SCHADEX framework, and this will allow an investigation of the implications of the differences in the snowmelt module for the final flood estimates. However, that is further work beyond the scope of the study reported here.

5. The Q1000 values for each of the methods are illustrated and given as numerical values in Figure 11. Values for other return periods are illustrated, although the actual numerical values have not been added to the figure, as it already includes quite a lot of information. The authors think that this gives a good overview of both the magnitude and range of the values obtained and is preferable to listing the numerical values in a table.

'A comment on the difficulty and computation effort of each approach would also be valuable' – We agree very much with this suggestion and will add a short summary of

this in the Conclusions section of the final paper.

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