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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Exploring the interplay between state, structure and runoff behaviour of lower mesoscale catchments" *by* S. P. Seibert et al.

S. P. Seibert et al.

simon.seibert@kit.edu

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We thank the anonymous reviewer for the comments as he/she raised some important points that will help us to improve the manuscript. In the following we briefly reply to the main issues raised by the reviewer.

We regret that the structure of the manuscript hampered the reviewer to make his way to the innovative aspects of our study – we will stream line the revised manuscript and particularly the abstract as recommended by the reviewer.

We apologize for not having properly explained the terms "intensive" and "extensive" state variables, these are well known within environmental physics and thermodynam-

ics (Zehe et al., 2014). Intensive state variables such as temperature, pressure of soil water potential are continuous at interfaces but not additive – if two rooms of the same temperature are connected by opening the door, temperature of the "merged system" stays the same, while the thermal energy is the sum of both energies. Intensive state variables in hydrology are matric potential, soil water velocities, rainfall intensities, while extensive state variables such as storage volumes, rainfall totals, etc. are extensive state variables and thus additive. A full characterization of a systems state implies that conjugated pairs of (extensive and intensive) state variables are known (Zehe et al., 2013) for instance the soil water content and the matric potential.

The relevance to our objective - the search for plots of normalized response measures against normalized state measures is that proper normalization depends on the nature of the runoff process. Storage controlled runoff processes are controlled/limited by storage which performs additive and can e.g. be estimated as residual of the water balance. Intensity controlled runoff process are controlled/ limited by intensive properties such as rainfall intensity and/or infiltrability. This implies that proper normalization depends on the nature of the runoff processes, and suitable estimators for intensity controlled runoff are not straight forward to estimate at the lower mesoscale. We will revise the introduction of the manuscript accordingly and particularly reformulate the question 2 in the specified sense.

With low frequent data we mean that a daily and/or even hourly sample is to coarse to sample for instance fast convective precipitation events, which might trigger intensity controlled runoff formation. Additionally, flood routing in the river net implies dispersive smoothing of the sharp peaks, which implies dampening of the high frequent components within hydrographs.

RC: Why "particularly at the lower mesoscale."? Authors reply: The lower mesoscale refers to catchment sizes of few square kilometers to about 100 km^2, which are due to Dooge (1986) systems of organized complexity. We selected this scale because our understanding of the interplay of how catchment structure and its state jointly control runoff generation mechanisms is rather incomplete, and it is already large enough to pool 100 catchments into the sample (though only 22 were used here). Moreover, at this scale routing effects are still small, as for instance Robinson et al., (1995) pointed out that catchments up to 20 km^2 are still hillslope dominated.

RC: What is the coherence of Q1-Q3 beyond "testing dimensionless measures to discriminate differences in runoff generation"? Authors reply: We will reformulate these questions to better reflect that these normalized measures (particularly the question how to normalize) depend on a) the selected time scale (seasonal or event) and b) at the event scale on the nature of the runoff formation processes. The double mass curves we use at the seasonal scale are in fact pretty similar to common practice in soil physics to plot tracer breakthrough against cumulated irrigation (and not against time). Contrary to soil physics we have to forms of water release (evaporation and stream flow) and the proposed double mass curves are particularly suited to separate regimes where either the one or the other is dominating. Note that particularly the summer regimes are easily explained by the temperature index model proposed by Menzel et al., (2003), which explains onset of the vegetation phase. At the event scale we may use different storage estimators and check which of those explains most of the observed runoff coefficients, when assuming storage control as dominant. Or we face the problem how to detect, characterize and normalize intensity controlled runoff formation.

RC: The paper presents the findings as "generally applicable for meso-scale catchments". This is an extremely bold statement since only 22 catchments in a very small part of the world are used. Authors reply: This is a misunderstanding, we did not mean that our findings are generalizable to all catchments in the world, with respect to for instance the temperature index being a good variable to explain regime shifts. We propose that the suite of measures is applicable to mesoscale catchments of humid environments were they can applied as a starting point to learn about the interplay of structure, state and runoff response. We will clarify this in the revised manuscript.

We again sincerely thank the reviewer for the helpful comments, which are certainly helpful for improving our study and thank for the note that the reviewer is sure that we have interesting findings to share. We will restructure the manuscript in line with most suggestions and technical details recommended by the reviewer.

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