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Hydrology and Earth System Sciences Discussions

Interactive comment on "A look at the links between drainage density and flood statistics" *by* B. Pallard et al.

G. Blöschl (Referee)

bloeschl@hydro.tuwien.ac.at

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This is a well written paper that analyses an important aspect of flood frequency hydrology. The findings on the relationship between drainage density (Dd) and flood moments are important and new. I do have a number of comments on the paper.

Most importantly, the *process basis* of the relationship between Dd and flood moments should be more strongly emphasised. I do realise that towards the end of the paper this is alluded to, but I believe the processes should be the red line throughout the paper. Knowing *why* a relationship exists is just as important - if not more important - than information on the type of relationship itself.

From my experience in Austria there are at least four mechanisms that may lead to a relationship between Dd and flood peaks which I classify into direct and indirect controls:

Direct controls

(a) Large Dd implies long stream travel paths and short hillslope travel paths. Faster flow velocities and celerities in the streams than on the hillslopes will then lead to steeper hydrographs and larger peaks.

(b) With a similar reasoning as above, large Dd implies less opportunity time for infiltration on the hillslopes, hence larger flood volumes.

Indirect controls

(c) Dd as an index of geology: Small Dd may point to the existence of Karst, to highly weathered bedrock, and to the presence of high permeability fluvial deposits in the valley floors which all may imply large storage volumes and response times and hence small flood peaks and volumes.

(d) Interaction of landform evolution, soil formation, erosion and floods (driven by climate and modulated through geology): Over time scales of centuries, large floods may shape catchments through a positive feedback loop to increase topographic gradients, increase Dd, and decrease storage volumes which in turn may increase flood peaks and volumes (Merz and Blöschl, 2008a).

The paper focuses on a subset of these mechanisms. The affdef model represents mechanisms (a) and (b) as far as I can see; the analytical model represents mechanism (a). The focus of the paper is not a problem as the analysis is very useful as it stands, but it should be clearly pointed out in the paper what processes are dealt with. In practice, controls (c) and (d) may in fact be more important than (a) and (b) but the latter are an obvious starting point that can certainly be justified.

I will now provide comments on the sections of the paper.

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Interactive Comment

1: The introduction should focus on the causes of the relationship, not on their existence.

2 and 3: In the description of the two models and in the discussion of the results the mechanisms represented should be clearly flagged out.

3.1.3: The authors equate rainfall and flood return periods. In the case of block rainfall, rectangular unit hydrograph and constant runoff coefficient, this happens to be correct (Viglione and Blöschl, 2008). I have not done the algebra but for Hortons infiltration model this is probably also correct or a good approximation. The authors should state in any case why they think the rainfall and flood return periods are equal.

3.2: A decreasing response time with drainage density reminds me of a research question that has attracted considerable attention a decade ago, i.e., how the flood moments change with catchment area (Blöschl and Sivapalan, 1997 and references therein). One of the arguments brought forward in that discussion was the increase of response time with catchment area and a number of studies have inferred the flood moments from that. Interestingly, these studies usually found a *maximum* CV at a certain threshold area, while this paper finds a *minimum* CV at a certain threshold Dd. It would be interesting to discuss this discrepancy. If response time alone would be the main control in both cases, one would expect a similar pattern.

3.2: Two lines from end of section. Please be more specific rather than stating that "it is likely that in the affdef simulation a combination of causes interact to induce what was detected for both CV and k."

4: Yes, the patterns in the flood moments can be masked by other controls, for example (c) and (d) of my enumeration above, in addition to sampling uncertainty. Also, in other regions the relationship between Dd and flood moments may look different. For example, Merz and Blöschl (2008b) found correlation coefficients of 0.19 and -0.12 for CV and skewness, respectively. The careful wording the authors have chosen about the existence of a critical Dd is hence fully appropriate.

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Interactive Comment

Recommendation

This is a very good paper but the authors are encouraged to strengthen the process interpretation of the analysis.

References

Blöschl, G. and M. Sivapalan (1997) Process controls on regional flood frequency: Coefficient of variation and basin scale. Water Resources Research, 33 (12), pp. 2967-2980.

Merz R. and G. Blöschl (2008a) Flood frequency hydrology: 1. Temporal, spatial, and causal expansion of information. Water Resources Research, 44 (8), article number W08432.

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Viglione, A. and G. Blöschl (2008) On the role of storm duration in the mapping of rainfall to flood return periods, Hydrol. Earth Syst. Sci. Discuss., 5, 3419-3447.

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