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Interactive comment on "Spatially dependent Intensity-Duration-Frequency curves to support the design of civil infrastructure systems" *by* Phuong Dong Le et al.

Anonymous Referee #2

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Summary: The manuscript describes a statistical framework based on an inverted max-stable process allowing to account for the spatial dependence of rainfall across durations. Application is made for a case study in New South Wales, Australia. Using the proposed framework, the author are able to compute conditional and joint return levels of rainfall. Through the use of rainfall ARFs and of an hydrological model, that authors also derive conditional and joint return levels of river flows. Finally the authors derive the failure probability of a highway section, defined as the probability that flood magnitude at any of the five river crossings exceeds a given threshold, assuming a 1-1 correspondence between flood magnitude and rainfall over a catchment.

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Main comments: The article is well written and mainly clear. The two risk applications of Section 5.1 and 5.2 are very interesting, particularly 5.2 (failure probability of a highway section) which seems to me to be more related to "real" issues than 5.1. The subject is absolutely worth publishing in HESS. However I raise below a couple of major issues to be addressed before publication:

The use of "Intensity-Duration-Frequency curves" in the title seems at the moment misleading. I would have expected from this expression to see e.g. joint or conditional IDF curves at a given station/catchment, i.e. the IF curves for several durations. Here actually only one duration is used for every catchment – basically the concentration time of the catchment. So I'd be tempted to replaced "IDF" in the title (and the text) by "return levels".

I'm puzzled about the GPD fits. If I understood correctly, GPD are fitted to 9 and 36 hr rainfall exceedances. If moving windows are considered, then there is a very strong auto-correlation for both the 9 and 36 hr rainfall values. Have you taken this into account in the fits? A declustering method should be applied. This may be the reason why the fits for 36 hr extremes are usually poorer than for 9 hr extremes (see Figs S5 and S6).

The part regarding the ARFs seems obscure to me (Section 4.5). Basically I isn't clear tome what the ARF allow for. I interpret between the lines that they allow to transform point return levels to spatial return levels over a catchment. However the way ARFs are described is very confusing to me. For example l. 346 states that "the rainfall extremal estimates need to be converted to the average spatial rainfall using an ARF". First I don't understand what are the "rainfall estimates" (rainfall return levels?). Second I guess that " average spatial rainfall" should be "spatial rainfall return levels". I recommend clarifying Section 4.5 and part of the Introduction dealing with ARFs.

Expressions such as "10-year conditional return level map given a 20-year event happen at x" are confusing to me. Wouldn't it be less confusing to say this is the levels

expected to occur on average once every 3650 times when a 20-year event happen at x. The “10-year” is misleading to me in that case due to the conditioning.

I’m confused with the reference to “annual maxima”, whereas the article considers peaks-over-threshold. For example Fig 1 illustrates the case of annual maxima (GEV), which is not the case here. L. 421-423 talks about annual maxima instead of exceedances.

I haven’t understood what is the AEP of Fig 12 and 13. I guess it would be clearer to replace AEP by return periods.

Minor comments: l. 111: Le et al → no brackets

l. 113 AFR → ARF

l. 116-117: I may be clearer to exemplify (i) in terms of evacuation route design as you do in Section 5.1.

Fig. 3: add the station numbers 1, 2, 3...

Fig. 4 estimate conditional rainfall → estimate conditional probability rainfall

l. 277: where → to be removed

l. 294-296: why don’t you estimate all parameters (beta, q, c) together?

l. 333-334 it is also noted .. 9 hrs → is it useful here?

Section 4.5: to be rewritten to clarify the ARFs as said above

l. 346: rainfall estimates: what are they?

l. 353-354: the BR process → for what duration? With which parameters?

l. 360: empirical distributions → I’m confused here. If you use empirical distributions below the threshold, how can you have rainfall at ungauged sites (maps)?

l. 373: multiple durations → Is the algorithm of Dombry still applicable in this case? I’m

not sure to see how it works for multiple durations.

l. 373 in this case... pair of locations → I don't understand it at all. What covariance matrix are you talking about?

l. 378 rainfall hyetographs → what rainfall are you talking about? Spatial rainfall over the catchments?

Fig. 6: is it useful here? It could be in the supplementary material.

l. 385 & 387: hydrological models → hydrological model layouts

l. 398: did you apply declustering before estimating the GPDs?

Fig. 7 and SM: there is a huge difference between the extremes at the different stations, e.g. station 2 vs station 6. Could you comment on this? Also what method did you use to produce the confidence bands?

l. 421-423: I'm lost here. Do you fit the BR process to annual maxima or exceedances?

Caption of Fig 8: Abbreviation TDC is useless

Fig. 9: I don't understand how you get the maps. For this you need the marginal distribution of rainfall at every pixel. How do you get this?

l. 469: average spatial rainfall: I'm confused. How can you transform return levels to averages?

Fig. 11 at the river crossing: which crossing are you talking about? There are several.

l. 495-497: Although Fig 11 . . . not part of the method → I don't understand these two sentences. What do you mean by "this is not a physical timing difference"?

Fig. 12: I don't understand the AEP. Wouldn't it be clearer with return periods instead of AEP?

l. 511: extreme rainfall intensity → over a catchment?

l. 520: and → as a function of?

Fig. 13: as for Fig. 12, would be clearer to show return periods in the x-axis?

Caption of Fig. 13: please explain what are the green segments

l. 529: 1% annual exceedance prob → 1% AEP

l. 573: 1.74 → I guess this number depends on the considered levels

l. 611: inverted max-stable → inverted max-stable process

Fig. S1: I don't understand the figure. Could you please explain what a given point represents? Given Table 1, I would have expected to have points at A=91, 294, 341, 771, 1020, which is not the case.

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