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Hydrology and Earth System Sciences Discussions

Interactive comment on "Mapping snow depth return levels: smooth spatial modeling versus station interpolation" *by* J. Blanchet and M. Lehning

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Page 2. Line 45. Interpolation of a physically meaningful variable, like e.g. snow depth of a continuous field of snow cover on a given day or month, is different from interpolation of a quantile, which does not represent a continuous field in space. More subtle, your method (like other methods, e.g. regional methods) implies independence of quantiles, so that interpolation makes no sense (because interpolation based upon

data in other sites can only be carried out if there is spatial correlation). Please make this clear, as the comparison seems improper here.
Response: The process of annual maxima under study do not correspond to a one-day event since annual maxima in Switzerland usually do not occur simultaneously, although neighboring stations may have it from the same event. But just because we have to assume that stations are independent, this does not mean that "annual maxima" is not a spatial process, i.e. a continuous process in space. This point has been clarified in the introduction.

Page 3. Line 60. "for the first time".. please drop this sentence, which may be questionable, and doesn't either add or subtract anything to the value of your work.
Response: Done.

Page 4 Line 98. "return levels" should be defined in the first place, as normally one deals with "return periods". Further, they are univocally linked to each other, so why is it necessary to use "return levels" ?
Response: We don't agree that one usually deals with "return periods". For example construction norms in Switzerland are based on the 100-year return level. Return levels and return periods are already defined in section 2 of the paper (equation 3).

Page 5 Line 137. What do you mean "block maxima" ?
Response: "Block maxima" is a generic term for denoting maxima of a fix quantity of observations, for example yearly or monthly maxima. Equation 1 of the paper defines for example a block maxima: Z is the maxima of a block of n (now L) variables Y_i (now Y_l). Extreme value theory focuses on the asymptotic behavior of such block maxima. The term has been introduced in section 2.

Page 6 Line 139. "dependent random.....dependence" This is circular. Dependence should be demonstrated by statistical assessment (correlation coefficient, Spearman's ro, etc.).
Response: Temporal dependence of snow depth is obvious due to snow accumulation on the ground. Furthermore, what is important here is not how much too consecutive days are independent, but how long this dependence lasts and in particular if the dependence is short enough for the D-condition to apply. Giving a correlation coefficient would not inform about this.

Page 6 Line 149. "optimization algorithms" There are plenty such algorithms, with different performances. Please be more accurate.
Response: GEV parameter estimation can directly be estimated by function "fgev" in R package "evd" or by function "gev.fit" in package "ismev" for example. Both, call function "optim" which can perform optimization based on Nelder-Mead, quasi-Newton and conjugate-gradient algorithms. In the paper, we used the Nelder-Mead procedure. This is added in section 4.

Page 7. Line 172. "little interest in practice" I don't see this point.
Response: Pointwise return levels are useful but in practice spatial information on return levels would be of much higher value. This is more clearly stated now at the end of section 4.

Page 10. Line 237. "positive correlation....as well" It seems straightforward that mean snow depth is correlated with extreme snow depth. However, if one has no measured snow depths, both are unknown. Does this make sense to use a proxy variable which is also kriged ?

Response: Comparison of tables 2 and 3 for the validation stations clearly show that yes, using the mean snow depth is useful, even if this variable is not observed but interpolated.

Page 10. Line 245. "To use.....43 winters" I do not agree here. The smoothness of mean snow depth variable in space has little to do with the amount of data you have (which instead may increase the accuracy of the point site estimation). Instead, yearly averages will be more correlated in space than single daily values.
Response: We clarified this point (see mid section 5.2).

Page 12. Line 307. " This however.....observation". I do not agree here. You are not comparing two different parameter estimation methods here. Your estimated GEV parameters are the variables you take as "real" for Kriging, so your interpolated values should fit to those.
Response: $\tilde{\mu}(s_i)$ and $\hat{\mu}_i$, for example, are both estimators, although $\hat{\mu}_i$ is taken as "real" in the interpolation. We want to validate our interpolated GEV against the original data, and not only to validate one partial step, i.e. that the -unobserved but estimated-individual GEV parameters are well fitted by the interpolation.

Page 13. Line 319. "This implies. . .. . ..shape". Did you do this in Jackknife mode (i.e. withholding the know point site parameter value and back estimating it using only the others) ? Otherwise this makes little sense.
Response: As already explained in section 3, here a fixed set of 16 validation station is used (see also Figure 2). These stations are not used for fitting the models. Tables 2 and 3 then give the errors in predicting them for the different fitted models.

Page 14. Line 346 I think you should carry out the comparison by using the confidence *bounds (as in figure 3) of the GEV distribution, to check whether the interpolated quantiles fit therein. The QQ plot seems not proper here.*

Response: As already mentioned section 6.3, it is not possible to obtain standard error with the interpolation method. More precisely, it is possible to obtain standard errors for the individual parameters. It is also possible to compute an error of interpolation when these parameters are supposed as "real". But it is not possible to combine these two errors (at least there is no theory for that). Unlike for the interpolation methods, the smooth GEV modeling allows us to compute standard errors and confident bands, as shown for example in Figure 7. Nevertheless, as anyway we cannot compute standard errors for kriging and for clarity, those errors are not shown in Figure 5. This figure is anyway already quite convincing of the better performance of the smooth GEV for these stations.

Page 15. Line 362 "Note that. . ..residuals" I can't catch this point. You mean there is no estimation error ?

Response: Here the GEV parameters are deterministic. The stochastic part of the model is simply in the fact that we fit a GEV model, i.e. a stochastic model. In the interpolations (7) and (10) unlike, the parameters are stochastic due to the presence of the residuals ϵ which are random variables.

Page 16. line 390 "As. . .correlated, " How comes so ? Why scale and position are correlated ? Please explain.

Response: The location models the center of the distribution, the scale its spread. In real data, center and spread are usually correlated. In terms of extremes, this means that we can expect the location and scale to be correlated. This is now added in section 6.1.

Page 16. Line 404. "For the sake . . .. . .independent" This may be true, but you should endeavour upon demonstrating it (e.g. by calculating correlation coefficients for annual maxima at different sites).

Response: Actually there is evidence that this approximation is wrong: annual maxima at different sites are spatially correlated. Nevertheless our results show that this approximation does not bias the results for the computation of return level map. This is also what has been noted in Smith (1990). Accounting for the spatial dependence in extremes relies on the very recent theory of spatial extremes which is clearly outside the scope of this paper and which is addressed in another paper (Blanchet and Davison 2010, under revision). This is now explained in section 6.2.

Page 20. Line 527 "Many studies. . ..theory". Bocchiola et al. (2008) studied extreme values of three day snow depth H72 within Switzerland using Mann Kendall test for stationarity, finding no evident trends, while Bocchiola and Diolaiuti (2010) studied climate change impact upon snow variables (average, snowfall days, etc. . ..) within Northern Italian Alps.

Response: Thanks for these two references which have been included in the paper (in the discussion).

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