Response to Interactive Comment by Erkan Istanbulluoglu

In the following, we report the text of the Interactive Comment in blue italic, and in black our reply.

The authors investigate the contributions of spatial variability of precipitation and soil erosion parameters on the variability of suspended sediment transport using a distributed model of hydrology, hillslope erosion, and suspended sediment transport. The research is very well designed, implemented and written. The derivation and calibration of the surface erosion parameters was novel. I have no comments on the presentation of this research and the text. I have a few questions for the authors to consider in revising this manuscript.

We thank Erkan Instanbulluoglu for the interest in our work and for the constructive questions asked. The answers to the points 1 and 3 below are based on analyses that were not included in the manuscript. Given the interest, we will consider adding these figures and discussion points to the supplementary materials of the revised manuscript.

1. I was wondering how the SIMs 1, 2, 3, 4 results would look like when plotted as a suspended sediment rating curve as in Fig 3b in comparison to observations? Similarly, I would suggest adding observed sediment variability to Fig 9a as box-whisker plots.

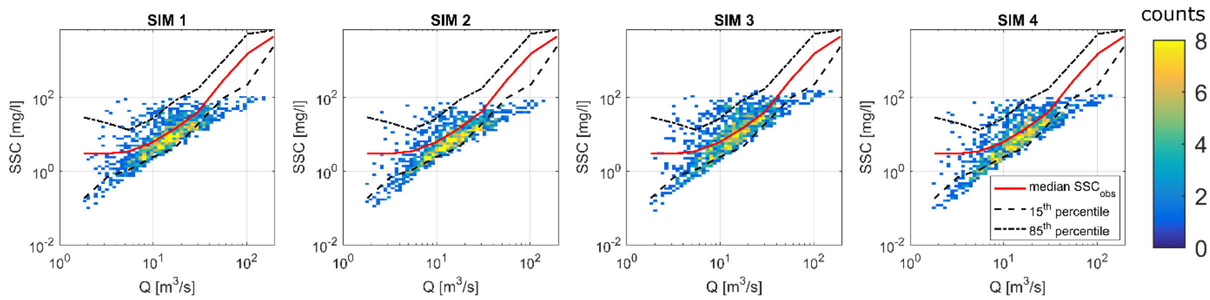

Figure 1: Density plot of simulated SSC for SIM1 to SIM4 (left to right) sampled at the time of measurements, compared with measurements (lines give median and 15-85 percentiles).

Figure 1 compares the modelled SSC (density plots) in SIM 1 to 4 with the observations (lines). The comparison of SIM 1 and 3 with SIM 2 and 4 shows the effect of the spatial distribution of precipitation in stretching the bulk of the modelled concentrations towards higher values, which reflects the increase in the annual sediment load. Analogously, the effect of spatial distribution of α is opposite (compare SIM 1 and 2 with SIM 3 and 4). The plots are in log-log scale, so we point out that the differences between the simulations are more relevant at high concentrations.

In Figure 2 (modification of Fig 9a of the manuscript) the simulated annual sediment load variability is compared with the observed variability. The observed sediment loads have been computed by fitting sediment rating curves ($SSC=aQ^b$) to the observations and by using them to estimate the SSC corresponding to each observed hourly discharge in the simulation period. Two estimates of annual observed sediment loads are proposed based on the available measurements. The loads in "OBS A" have been computed based on a single sediment rating curve fitted to the 13 years of SSC observations, while "OBS B" loads have been computed by fitting a rating curve to each year of SSC observations, with the aim of better representing the interannual variability of the sediment load. We observe that the estimated mean annual loads are lower than 2.83 10^5 t/y (line 233), proposed by Hinderer et al., (2013) and derived from BAFU (2010). The reason is that the latter is not based on sediment rating curves, but on an estimate of the mean daily load derived from the observed Q-SSC pairs of points that gives more weight to the high observed SSCs.
The figure also shows that the simulations only capture a fraction of the total observed interannual variability. The reason for this underestimation is that observed variability in SSCs also reflects the activation of local sources of sediment heterogeneously distributed across the basin, the stochasticity in mobilizing and transporting sediment on the hillslope pathways and local sediment

supply limitations, which may not be represented by the soil depth as assumed in the model (lines 306-312).

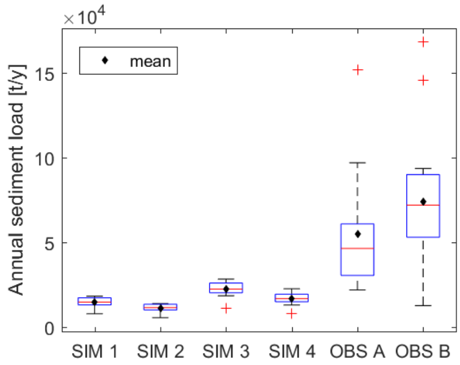

Figure 2: Boxplots of simulated and observed annual sediment loads. "OBS A" loads are computed with a unique SSC-Q rating curve fitted to the whole observation period, "OBS B" with yearly sediment rating curves.

2. I was expecting to see bigger SDR values, based on the description of the channels having bedrock exposure and the model not allowing any exchange of suspended sediment with the bed, E=0. With these low SDRs there should be deposition in the channel and if E=0 how is deposition is modeled? And even if the model allows deposition but not re-suspension how can that assumption be justified. Some clarification on this would be appreciated by readers.

The model does not allow deposition and re-suspension of fine material carried in suspension in the channels. The low SDRs are explained by the deposition of mobilized fine sediments on the hillslopes themselves, before they reach the channel. Given that hillslope sediment production (erosion) is assumed to satisfy transport capacity (equation 2 in the paper) then sediment discharge and local deposition is driven by changes in slope, overland flow discharge, or land cover. Deposition is particularly strong in the areas of low hillslope-channel connectivity, such as the area upstream of point MC1 and in tributaries T1, T3, T6 (see lines 323 to 334). For catchments of the size of the Kleine Emme, annual SDR below 10% for fine sediment are not unexpected (Julien, 1995).

3. Unless I missed this in the paper, I was wondering how do variability of precip and soil parameters contribute to the observed variability of sediment quantitatively. Could this sediment flux variability be quantified in terms of the variability of precip and soil erosion in an expression. Of course discussions of this nature can go all the way to information content, entropy and so on, but some discussion of whether more/less information in model parameters and forcing can be attributable to the changes in the variability of observed/model sediment would be interesting to see.

It is not possible to quantify the variability in sediment flux as a function of precipitation and surface erodibility variability analytically (exactly), if that is what was meant by the question. But we can provide some insights from the numerical simulations. For example, we can compare the scatter of the simulated SSC scenarios against each other and against observations.

To quantify the scatter of the SSC-Q points in Figure 1 independently of the mean simulated SSC, we binned the simulated discharges, computed the coefficients of variation (CVs) of the sediment concentrations in each discharge bin and reported them as a boxplot for all discharges in Figure 3. We observe that the distribution of the CVs shifts to lower values every time a source of variability (rainfall or α distribution) is removed, therefore, we observe a general correspondence between information content of the inputs and scatter of the predictions of SSC.
However, we also observe that the changes between simulations are very small, especially in the mean value, thus suggesting that the spatially distributed nature of the model itself plays a more relevant role than the variability of the analysed input variables (rainfall and surface erodibility).

The comparison of observed and simulated CVs, shows the amount of variability of the lower 85th percentile of observed SSCs that is captured by the model. As expected, the observed variability is much larger than the simulated one, because of the sources of variability which are not accounted for in our model (see point 1).

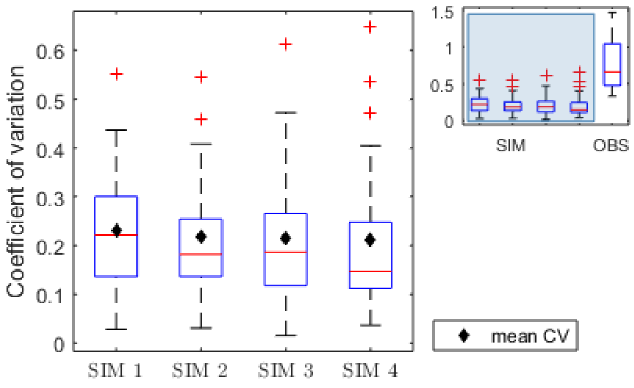

Figure 3: Boxplots of the coefficients of variation of the SSC-Q relation for the four simulations (left), and comparison with observed SSC smaller than the 85th percentile (right).

References

Hinderer, M., Kastowski, M., Kamelger, A., Bartolini, C., and Schlunegger, F.: River loads and modern denudation of the Alps - A review, Earth-Science Reviews, 118, 11–44, https://doi.org/10.1016/j.earscirev.2013.01.001, 2013.

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