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Comment on egusphere-2022-616

Anonymous Referee #2

Referee comment on "Reconstructing five decades of sediment export from two glacierized high-alpine catchments in Tyrol, Austria, using nonparametric regression" by Lena Katharina Schmidt et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-616-RC2, 2022

I appreciate the opportunity to review the manuscript, entitled 'Reconstructing five decades of sediment export from two glaciated high-alpine catchments in Tyrol, Austria, using nonparametric regression'. The topic is study is of great importance to not only the earth and environmental science community but also the policymakers and practitioners such as hydropower companies and water resource managers. This study presents an attempt to reconstruct the long-term suspended sediment export in alpine glacierized basins based on the available shorter records and machine learning. Despite some limitations, the proposed method is capable of reconstructing the sediment yield over the past decades with satisfactory performance.

Major comment 1: Based on modelling scheme in Figure 2, the model validation should target SSC, which is very reasonable and necessary. While, in the results section, the authors only validate the performance of sediment discharge and sediment yield, which are the product of discharge and SSC. In your model (Quantile Regression Forest), discharge is also one of the model input variables and important predictors. The high validation coefficients (NSE and BE) could be only part of the story and maybe just because discharge appears in both input and output variables. Thus, I would kindly suggest the authors try to re-validate the model performance using SSC and replace both Qsed and sSSY in Figure 3-5 with SSC as shown in figure 2 if possible.

In the introduction, the authors say that "Quantile regression forests (QRF) (Meinshausen, 2006) are a multivariate non-parametric regression technique based on random forests, that have performed favorably to sediment rating curves" (paragraph 95). Although it is proven in other publications, I think this statement still needs to be tested and evaluated in this study. If possible, I would suggest the authors compare the SSC simulations by QRF model and SSC simulations by sediment rating curves and explicitly demonstrate how

much improvement can be done by the QRF model than sediment rating curves.

Major comment 2: Usually, most of the annual sediment load is contributed by several extreme sediment events and they could cause severe socio-ecological-economic impacts. However, for the daily-scale model, such episodic high Qsed events are always underestimated, especially for the smaller nested basin Vent. Apart from the insufficient observations as training data as the authors discussed already, can this be also given rise to the different erosion and sediment transport processes during the episodic high-flow events and the threshold effect in sediment transport (see ref below)? If so, is that possible to re-fine such underestimation and consider the different transport mechanisms in Quantile Regression Forest Model? Zhang, T., Li, D., East, A.E. *et al.* Warming-driven erosion and sediment transport in cold regions. *Nat Rev Earth Environ* (2022). https://doi.org/10.1038/s43017-022-00362-0

Major comment 3: As the authors introduced in Methods, Quantile Regression Forest Model is driven by discharge, temperature, and precipitation, and only a few years' sediment observations are used for training the model. The reconstructed long-term sediment yield series is highly dependent on the input hydroclimatic predictors. Thus, I guess it's not surprising that the abrupt change in sediment yield coincides with the hydroclimatic abrupt change. Is that possible for the authors to collect any other relevant erosion, sedimentation, or landscape change data to independently prove the abrupt change in sediment transport in this region?

Specific comments:

- The abstract can be substantially shortened with at most two paragraphs.
- Introduction: there is a lack of acknowledging the existing literature on multi-decadal sediment observations in other high mountain areas and cold regions such as in the Tibetan Plateau, Andes, and the Arctic.
- Line 35: Considering the distinct underestimation of high sediment yield events. I would suggest the authors to be careful about the statement and clarify the possible insufficiency: "Our findings demonstrate that QRF performs well in reconstructing past daily sediment export".
- Line 50: Impacts of sediment transport on hydropower production and reservoir sedimentation are also systematically elaborated in ref below: Li, D., Lu, X., Walling,

D.E. *et al.* High Mountain Asia hydropower systems threatened by climate-driven landscape instability. *Nat. Geosci.* **15**, 520–530 (2022). https://doi.org/10.1038/s41561-022-00953-y

- Line 60: The recent review systematically elaborates on the sediment dynamics and hydrogeomorphic processes in cold regions and discusses their complexity: Zhang, T., Li, D., East, A.E. *et al.* Warming-driven erosion and sediment transport in cold regions. *Nat Rev Earth Environ* (2022). https://doi.org/10.1038/s43017-022-00362-0

- For introduction and discussion: some of the other quantitative evaluations of the climate change impacts on sediment transport in high-mountain rivers based on decadal observations are listed below for further reading.

Zhang, T., Li, D., Kettner, A. J., Zhou, Y., & Lu, X. (2021). Constraining dynamic sediment-discharge relationships in cold environments: The sediment-availability-transport (SAT) model. Water Resources Research, 57, e2021WR030690. https://doi.org/10.1029/2021WR030690

Li, D., Lu, X., Overeem, I., Walling, D. E., Syvitski, J., Kettner, A. J., ... & Zhang, T. (2021). Exceptional increases in fluvial sediment fluxes in a warmer and wetter High Mountain Asia. Science, 374(6567), 599-603.

- Line 175: “see map” is unclear. do you mean "Fig. 1" or the other map?
- Line 165: the section numbering is quite confusing here. Please check this issue throughout the paper.
- Figure 3: the meaning of the black dash line should be explained in the caption. Besides, the actual sSSY values for the four observed years should be highlighted in Figure 3b, for evaluating the model performance.
- Line 240: the 5-fold cross-validation results are shown in any figures or tables or appendix. I would suggest the authors add at least one display item to show this result.
- Figure 2: Why there is no validation for Vent station? It seems that the extrapolation ability at this station can be tested by the cross-validation.
- Figure 7c-d: the summer discharge trends are not shown, please add the summer discharge results and be consistent with the main text.
- line 510: “satisfactory results” usually refer to the estimations with no significant overestimations and underestimations. Here, for accuracy, the authors should clarify that satisfactory results are found in annual sSSY estimations and there are underestimations for high Qsed events at the daily scale.
- Lines 580: an in-depth comparison with the world’s cold regions would greatly enhance the discussion. For the sudden, tipping-point-like shifts of sediment transport in response to climatic changes have also been observed in the headwater of the Yangtze River on the Tibetan Plateau. The relative contributions of different factors can be also disentangled. Li, D., Li, Z., Zhou, Y., & Lu, X. (2020). Substantial increases in the water

and sediment fluxes in the headwater region of the Tibetan Plateau in response to global warming. Geophysical Research Letters, 47, e2020GL087745. https://doi.org/10.1029/2020GL087745