RE: egusphere-2023-1783 (author) - final response "Exotic tree plantations in the Chilean Coastal Range: Balancing effects of discrete disturbances, connectivity and a persistent drought on catchment erosion"

Response to Reviewers

Report # 1

Thomas Hoffmann

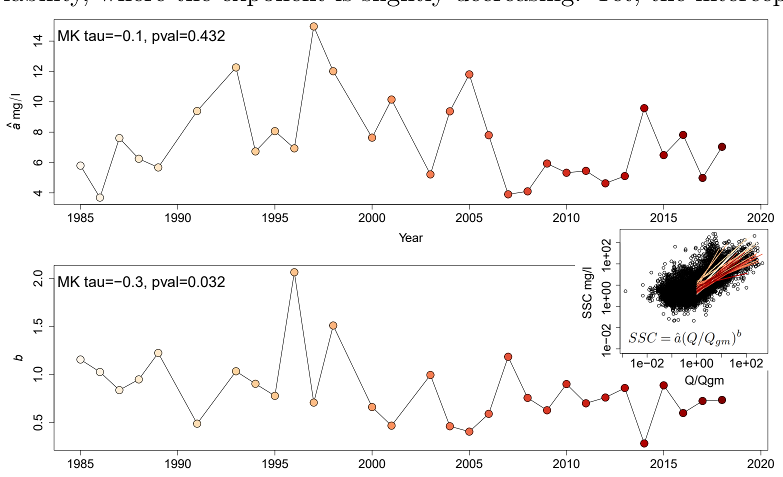
The quality of the manuscript greatly improved after the first revision and should be accepted after minor revisions. See comments below.

Kind regards Thomas Hoffmann

General comment:

The authors aim to identify the drivers of changings suspended sediment loads in the Purapel catchment, which has witnessed land use changes (tree plantations including strong clear-cuts), wild fires and superimposed climate changes (reduced rainfall which result in a reduction of discharge). The authors identify a declining trend of SSC esp during the autumn and winter months. Based on my first revision I suggested to add a sediment rating analysis to further analyze the reasons for the declining SSC. In their reply, the authors show that the rating coefficient a ($SSC = a(Q/Qgeom)^b$) shows not trend. This is e very interesting result which should be included in the manuscript because it highlights some potential explanations for changing SSC and SSL: SSC is changing but the rating coefficient "a" remains constant ("a" can be interpreted as SSC at Qgeom). This indicates that changes in SSC are not related to changes in sediment supply (which will affect "a"), but changes in discharge conditions (which affects average SSC, as SSC is related to Q). However, the authors argue not to include the rating analysis, because it does not show a significant trend. I suggest to include the analysis and to support the authors statement that SSL is reduced due to the sever drought conditions in the catchment.

Thanks for the positive feedback. We decided, however, to not include the SRC analysis. While our genuine work is out of this implicit context, we might open another completely new research thread. Results of that analysis my be interpreted in opposite behaviors, since the annual rating curves do indeed present some variability, where the exponent is slightly decreasing. Yet, the intercept does not show any trends:



In the previous plots, hydrologic years are represented only for years with >180 data points and with the pvalue of the lineal model of log transformed data <= 0.05. Interpreting these results in terms of sediment and water supply are challenging. A relatively constant $\hat{a}$ may result from a several scenarios, i.e. of changing SSD and Q alike (Fig 11 at Warrick, 2015). However, the rating curves are actually changing, and it's worth noting the trend in b. The observed decay of the exponent b may indicate a lower dependency of SSC to Q. In turn, this may favor rather the hypothesis of supply limitation, just the contrary of your interpretation.

Detailed comments:

Line 35+36: observing 2m thick soils under native forest, does not mean that this is the minimum soil thickness. It suggests that soils under natural vegetation cover might be 2m thick. However, soil thickness is strongly conditioned by topography (esp. curvature) as well. Please rephrase.

Rephrased:

`Currently, the remnants of secondary native forests (i.e. successional forests growing in areas where forest cover was removed at some point in the past) stand on soils that are up to 2 m (Soto et al., 2019), suggesting that soils under natural vegetation cover could reach an even greater thickness.`

Line 114: remove ")" after PET

Done

Line 254: "10Be denudation rater resulted in 0.024 ±0.004 mm/yr", rephrase

Done

Line 258: In addition to the limitations of the sampling for reliable load estimates, using SSD as a proxy of erosion rate is mainly limited by the sediment deliver ratio < 1.
We included that idea in the discussion section

Line 261: "Both rates do not statistically differ" $-->$ that is true, but does this assumption also hold if SDR of the catchments is <0.7 (as in many catchments of the world), which would increase the erosion rate?

Now we described that drawback in the discussion section and estimated E=SSD/0.7

Line 293: "We achieved a confusion matrix with a balanced accuracy of 0.86 and a F1 score of 0.69" $-->$ this should be explained in the methods.

Done. We add to the method section:

`The accuracy assessment was performed on 35 manually drawn polygons that were randomly distributed across the catchment. Since we were dealing with imbalanced data (looking for disturbances` which we assume as anomalies in the time series), we used balanced accuracy and F1 score as the metrics to evaluate our data (Brodersen et al., 2010). Balanced accuracy was calculated as the arithmetic mean of sensitivity and specificity while F1 score was calculated as

$$F1score = 2 * [(precision * recall)/(precision + recall)] \quad (1)$$

Line 317ff: you could clarify the transient storage effect using the SDR concept and state typical SDR values.

Done:

However, we regard the suspended-sediment decennial erosion rate as a very conservative estimate for recent catchment scale erosion for three reasons.

First, we argue that this estimate does not account for possible effects of sediment storage and other transient processes that affect soils and streams. For a certain time lapse, only a fraction of sediment detached within a catchment is transported to the outlet and, thus, captured in the sediment yield due to processes such as deposition and storage (Walling, 1983). The Sediment Delivery Ratio (SDR) describes that fraction, and use to be expressed as $SDR = SY/E$, where SY is the average annual sediment yield per unit area and E is the average annual erosion over that same area. Considering empirical data (Walling, 1983; Ferro and Minacapilli, 1995; Lu et al., 2006), a SDR of 0.7 may be used as a conservative first approach for catchments larger than 100 km^2, although this value may be a couple of orders of magnitude lower. Using the mean specific SSD as SY in the previous expression, our estimation of decennial erosion at Purapel catchment increases to 67 $\pm$ 20 $tkm^{-2}yr^{-1}$ or 0.026 $\pm$ 0.007 mm/yr, which is even closer to the long-term denudation rate. The decennial catchment erosion may be much higher if the SDR is orders of magnitude lower. More reliable estimates of SDR can be done using spatially distributed models, such as the linear lumped series model of hillslope storage and channel storage of Lu et al. (2006). That model considers a theoretical relationship between sediment delivery and physical parameters such as particle size and rainfall duration.

Line 380: if you assume that tree plantations started 200 years ago, and that soils, which were 2m thick, are now removed, you would assume that average soil erosion during the last 200 years is in the order of 10mm/a, which is orders of magnitudes higher than rate presented in this study (mainly Chapter 3.2). If we assume that soil erosion adapted quickly after the introduction of tree plantations, then this erosion rate was likely much higher in the past and recent rates are now decreased due exhausted sediments (supply limitation). In this context, the similarity between long-term and recent rates can interpretd to be same erosion rate under supply limited conditions (but for different reasons) or be mere chance.

Thank you very much for this story. We added it to the discussions:

More than 200 years ago, the primary native forests probably grew on deep and carbon rich soils with surfaces probably much more enriched in fine sediments than the present topsoils. In contrast, the landscape-scale wildfire of 2017 revealed coarse saprolite widely exposed at the Earth surface (Fig. ??D). Roots of fallen trees digging up coarse sediments spread out over most hillslopes. If we assume that landscape lowering has denuded 2 m of soil in 200 years, physical erosion should present one or more stages of much higher rates in the past and after the beginning of intense deforestation. Rates of 10 mm/year are required to produce such denudation in 200 years, which exceed both our short and long term estimates by 3 orders of magnitude. While intense soil erosion occurs, the most likely evolution of grain size distribution on topsoils is a quick depletion in fine sediments and a relative enrichment in coarse and more weather resistant sediments. Together with deforestation and wildfires, this time-dependent coarsening of the inorganic component of topsoils would be described as a reduction in the supply of fine sediments from hillslopes to the streams, which may lead to a transition from transport to supply limited catchment erosion. Because vegetation and soils have been systematically disturbed, and given the high degree of coupling of those landscape elements and sediment mobilization at streams, it is unlikely that the grain size distribution on rivers remain constant. Since short-term and long-term erosion are comparable, we interpret that after a rapid response of erosion to deforestation, denudation rates decreased due to exhausted sediments. Hence, it is plausible that part of the observed decline in suspended sediment is related to changes in the grain size distribution of sediments detached from soils. In this interpretation, both the long- and the short- term erosion can be considered supply limited. The first due to the scarcity of landslides and the second due to the low speed of soil (and fine sediment) production.

Line 386: strams $-->$ streams
Corrected

Line 388: than $-->$ that ?
Corrected

Line 390 +391: this is not supported by the results from the rating analysis. Changing SSC is mainly related by decreased Q and not by decreased supply for a given discharge (i.e. Qgeom as expressed by the a-coefficient).

We can interpret just the contrary from the negative trend of the exponent. But we are aware that several different processes may produce similar results in the rating parameters. That's our main constrain to include the rating analysis.

Report # 2
Amanda Schmidt

I am satisfied that the authors adequately addressed the concerns that other reviewers and I made on the first version of the manuscript.

We appreciate the contribution you made to our manuscript. Thanks very much for your positive feedback

References

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