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Reconstructing five decades of suspended sediment yields at two high alpine gauges in the Ötztal, Austria, using quantile regression forests

Lena Katharina Schmidt¹, Till Francke¹, Peter Grosse¹, Christoph Mayer², and Axel Bronstert¹

¹University of Potsdam, Germany, Institute for Environmental Sciences and Geography, Potsdam, Germany (leschmid@uni-potsdam.de)

²Geodesy and Glaciology, Bavarian Academy of Sciences and Humanities, Munich, Germany

Suspended sediment export from partly glaciated high alpine catchments is not only relevant for ecosystems, but also for infrastructure and flood hazard alterations in downstream areas. In order to estimate future changes, it is important to assess long-term developments in past sediment yields. However, existing records of suspended sediment export are mostly too short to investigate these long-term changes. For example, for the two gauges “Vent Rofenache” and “Vernagtferner” in the high alpine and partly glaciated Upper Ötztal in Tyrol, Austria, only 15 and four years of turbidity measurements exist, respectively, precluding robust explorations of longer-term developments.

To compensate for this lack of measurement data, we use a Quantile Regression Forest approach, a non-parametrical, multivariate tool based on regression trees. It allows for reconstructing continuous sedigraphs based on short-term or point-like sediment concentration data and continuous predictor variables such as discharge (Q), precipitation (P) and air temperature (T).

At gauge “Vernagtferner”, turbidity-based sediment concentration data were available only for the years 2000, 2001, 2019 and 2020. To test the ability of our model to reconstruct past sediment concentrations, we trained our model using the 2019 and 2020 data and validated against the 2000 and 2001 measurements, which showed good agreement (Nash-Sutcliffe Efficiency of 0.73). At gauge “Vent Rofenache”, the hydrographic service of Tyrol, Austria, has recorded turbidity-based sediment concentration data since 2006. Our model showed to be well able to reconstruct sediment yields based on by these data (out-of-bag Nash-Sutcliffe efficiency of 0.66).

This validation enabled us to confidently use the long-term availability of the predictor variables (Q, P, T) to reconstruct sediment yields at gauge “Vernagtferner” since 1974 and at gauge “Vent Rofenache” since 1967.

The resulting dataset allows us to

- Analyze annual sediment yields with respect to trends and change points for time series of 47 and 54 years, respectively,

- Examine changes in the predictor variables,
- and connect developments in sediment yields to mass balances of the large glaciers within the catchment.

Current results point at an almost step-like increase in annual sediment yields at the beginning of the 1980s at both gauges. This coincides with a marked increase in discharge volumes that in turn correlate with a basic change in glacier mass balances.