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# Hydro-sediment event types and associated conditions and processes in an alpine catchment

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## MOTIVATION AND AIM

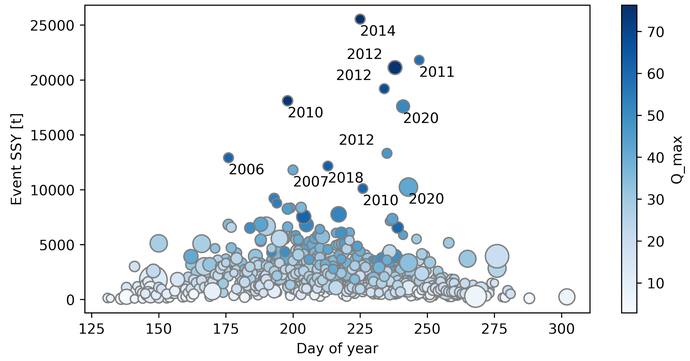
Recent changes to mountain cryosphere and climate affects sediment fluxes in high mountain areas [1]

➡ **Can we find types of hydro-sediment events that correspond to certain combinations of driving process and catchment conditions?**

## METHODS

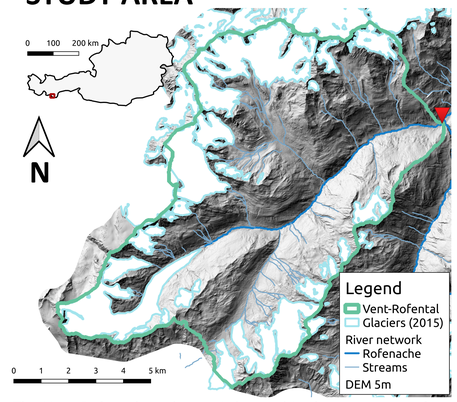
- **Event detection** from streamflow (Q) time series (2006-2020) using local minimum method [2,3], filtering out events with missing suspended sediment records or low peak suspended sediment concentration (SSC)
- **Clustering** based on Q and SSC characteristics of events
  - Calculate **hydro-sediment event metrics** from SSC and Q time series, e.g. suspended sediment yield (SSY), peak Q, hysteresis index [2], etc.
  - Pre-process **event metrics** with standard scaling and dimensionality reduction with **principal component analysis** (PCA): 16 metrics → 7 principal components
  - **Clustering** using gaussian mixture model (GMM) with spherical covariance type
- Evaluate **event types** by assessing associated catchment conditions and driving processes
  - Calculate **catchment metrics** of water and energy conditions, e.g. antecedent precipitation and temperature, and driving process, e.g. precipitation intensity

## HYDRO-SEDIMENT EVENTS



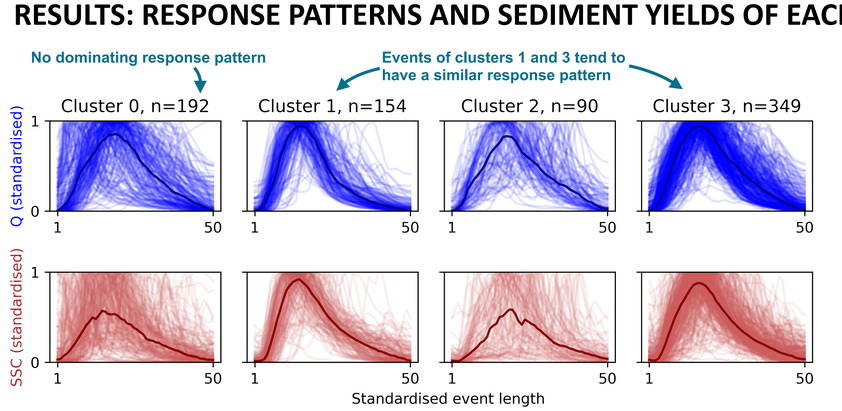

Distribution of *detected hydro-sediment events* (n=797) throughout the year. Dot size corresponds to event duration. The largest events in terms of total sediment exported (SSY) are associated with high peak streamflow.

## STUDY AREA

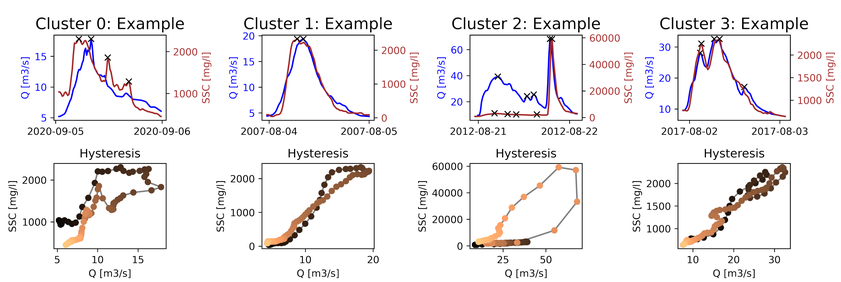



The *Vent-Rofental catchment* is located in the upper part of Ötztal valley in Tirol, Austria. The catchment area is 98 km² and spans an elevation range of 1891 to 3772 m.a.s.l. and contains several large glaciers.

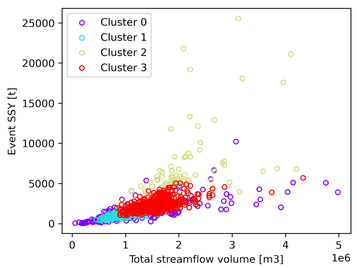
## RESULTS: RESPONSE PATTERNS AND SEDIMENT YIELDS OF EACH CLUSTER



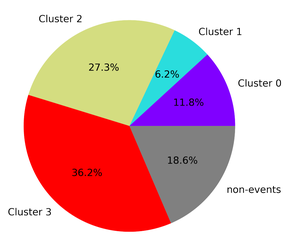

Event response and hysteresis patterns do not appear to be an important factor distinguishing the clusters. Only two of the clusters (1 and 3) appear to have a consistent Q and SSC response patterns within the cluster. Additionally, cluster 1 events tend have a rapid onset.



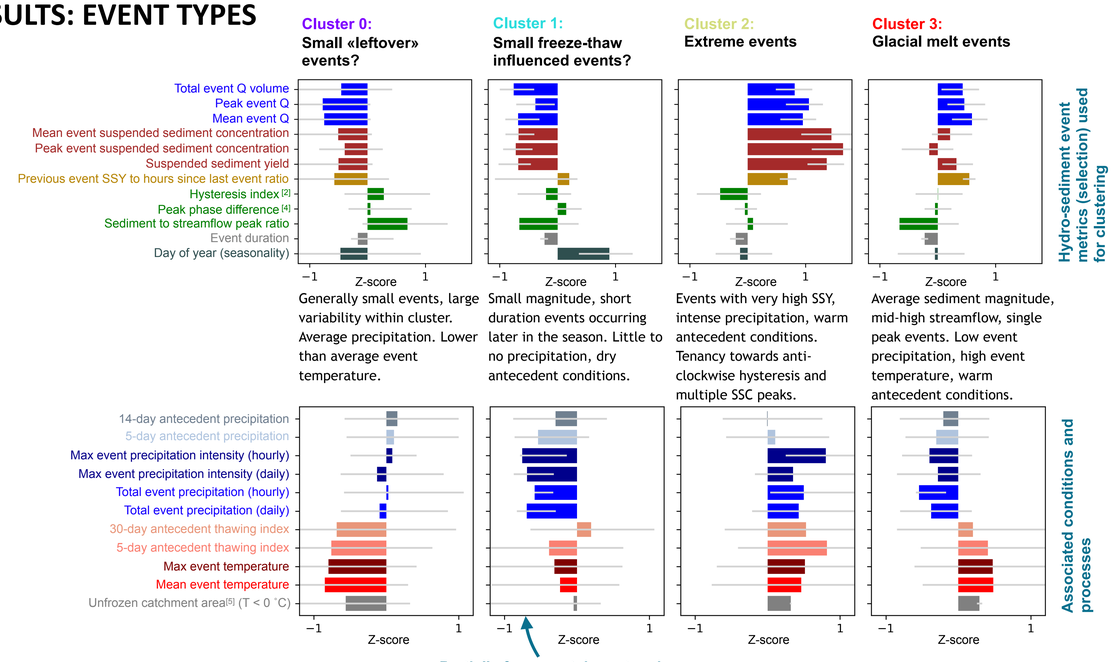

**Clusters 0 and 2 both have high streamflow volume, but cluster 0 has much higher SSY**




Events of cluster 2 and 3 are on average responsible for 27.3 % and 36.2 % of annual SSY respectively. While cluster 2 events have a much higher individual SSY, cluster 3 events, being more numerous, overall contribute more sediment.




## RESULTS: EVENT TYPES




Generally small events, large variability within cluster. Average precipitation. Lower than average event temperature.

Small magnitude, short duration events occurring later in the season. Little to no precipitation, dry antecedent conditions.

Events with very high SSY, intense precipitation, warm antecedent conditions. Tenancy towards anti-clockwise hysteresis and multiple SSC peaks.

Average sediment magnitude, mid-high streamflow, single peak events. Low event precipitation, high event temperature, warm antecedent conditions.

**Partially frozen catchment and low event temperatures indicate freeze-thaw processes?**

## CONCLUSIONS AND OUTLOOK

- Clustering events based only on streamflow- and suspended-sediment-derived metrics yields event types that correspond to certain combinations of catchment conditions and driving processes.
- The largest events are associated with high precipitation intensities and amounts combined with warm antecedent conditions.
- Events associated with glacial melt are the most numerous and are on average responsible for 36 % of annual suspended sediment yield.
- Outlook: Include further variables to assess the associated conditions and processes of event types, e.g. snow cover, global radiation.

Sharing is encouraged

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1. Zhang, et al. (2022). Warming-driven erosion and sediment transport in cold regions. Nature Reviews Earth & Environment.
2. Tsyplenkov, et al. (2020). Suspended sediment budget and intra-event sediment dynamics of a small glaciated mountainous catchment in the Northern Caucasus. Journal of Soils and Sediments, 20(8), 3266-3281.
3. Sloto, et al. (1996). HYSEP: A Computer Program for Streamflow Hydrograph Separation and Analysis. In Water-Resources Investigations Report.
4. Haddadchi & Hicks (2021). Interpreting event-based suspended sediment concentration and flow hysteresis patterns. Journal of Soils and Sediments, 21(1), 592-612.
5. Li, et al. (2021). Air Temperature Regulates Erodible Landscape, Water, and Sediment Fluxes in the Permafrost-Dominated Catchment on the Tibetan Plateau. Water Resources Research, 57(2), 1-14.