SUSPENDED SEDIMENT AND DISCHARGE DYNAMICS IN SPACE AND TIME IN THE GLACIATED HIGH-ALPINE ÖTZTAL, TYROL, AUSTRIA

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INTRO

Why is it important to study discharge and sediment dynamics in glaciated high alpine areas?

- Higher water and sediment fluxes than from downstream regions → influence beyond catchment boundaries
- Disproportionately affected by global warming → undergoing major changes (glacier retreat, permafrost thaw,…)

Why is this important in a natural hazards context?

- Changing water and sediment fluxes can alter flood hazard downstream
- High intensity summer rainstorms will likely occur more frequently in the future → may cause debris flows and mass movements.

→ **To range in changes in hazards in the future, we need to understand the dynamics in the present and recent past.**

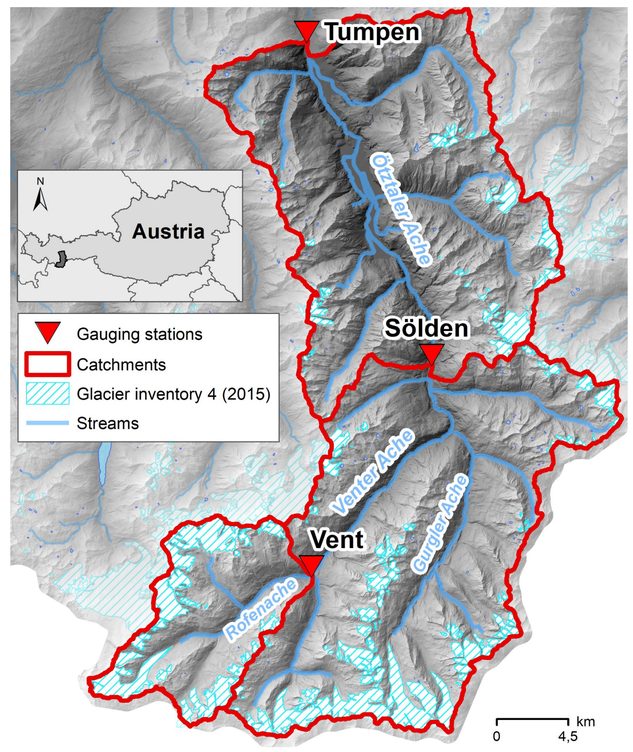
AIM

To pinpoint areas and time periods that are crucial for discharge and suspended sediment fluxes by analyzing data of the past 15 years (2006 – 2020) on several spatial and temporal scales

STUDY AREA

Ötztal in Tyrol, Austria

- **3 gauges**: Vent, Sölden and Tumpen
- 100 - 780 km² sub-catchments
- 930 - 3772 m.a.s.l.
- 10 - 30 % glacier cover



DATA

- Discharge & sediment timeseries (2006 – 2020) improved by own fieldwork
- Snowcover data based on MODIS data (Matiu et al., 2020)
- CORINE landcover and 10 m DEM of Tyrol

Right: Nested catchment areas of the three gauging stations Vent, Sölden and Tumpen.

RESULTS

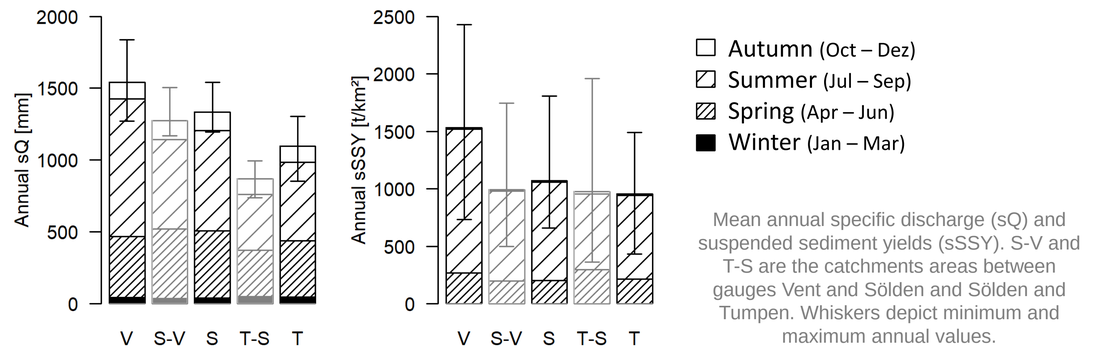
COARSE

TEMPORAL RESOLUTION

FINE

MAGNITUDES IN SPACE

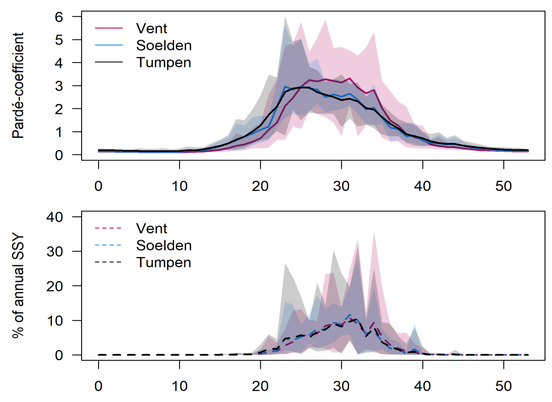
- The **highest, most glaciated catchment** (Vent) has the highest discharge (Q) and suspended sediment yields (SSY) per area
- Differences are mainly due to **differences during the glacier melt period**
- Q and SSY **correlate positively to glacier cover** and annual glacier ablation



Mean annual specific discharge (sQ) and suspended sediment yields (sSSY). S-V and T-S are the catchments areas between gauges Vent and Sölden and Sölden and Tumpen. Whiskers depict minimum and maximum annual values.

SEASONALITY

- Q and SSY: **strong seasonalities at all gauges**
- Sediment fluxes limited to shorter period of time

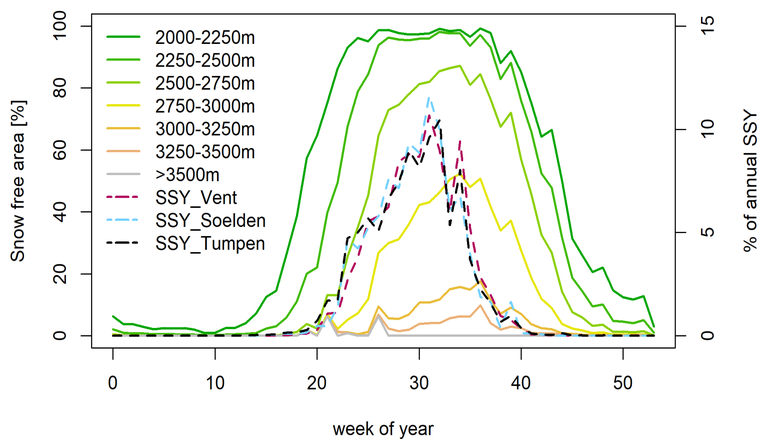


Weekly Pardé-coefficients and percentages of annual SSY in weekly resolution. Lightly colored areas show minimum and maximum values of individual years.

SEASONALITY IN SPACE

Synopsis with **snowcover evolution**:

- Q seasonality changes in space – but **SSY seasonality does not**!
- Sediment flux onset coincides with snow melt above 2500 m a.s.l.
- These areas contain glacier tongues, bare rock and recently deglaciated areas



The spring increase in SSY at all gauges coincides with the increase in snow-free areas above 2500 m a.s.l. within the Tumpen catchment

EVENTS

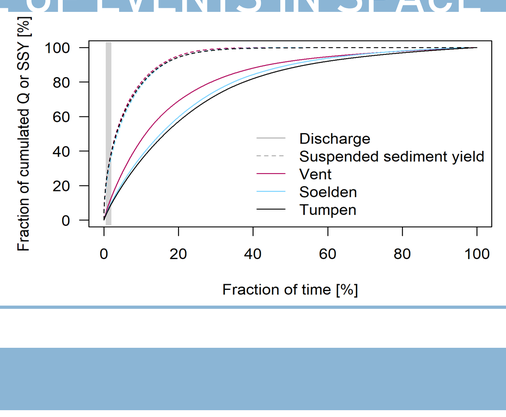
Analysis of **sediment flux events** in Vent & Tumpen:

- More important for sediment than for discharge: **25% of annual SSY but only 6% of Q** transported during events
- 84% of events in Vent are associated with precipitation

IMPORTANCE OF EVENTS IN SPACE

Similar importance in Vent and Tumpen:

- 25 % of SSY and 6 – 7 % of Q fluxes during 0.5 – 2 % of the time



Duration curves of Q and SSY. The grey area indicate 0.5 – 2 % of the time, i.e. the time classified as events

SEVERAL SPATIAL SCALES

CONCLUSIONS

Magnitudes: Q change with elevation & glacier cover due to non-equilibrium glacier melt, precipitation gradient (5 % / 100 m), lower evapotranspiration
SSY increase with glacier cover: **glaciers act as important sediment sources**

Seasonality: **Discharge seasonality is scale dependent**: more pronounced at higher elevations due to later onset of snowmelt
Sediment fluxes are altitude-dependent: areas above 2500 m crucial for sediment fluxes → Sediment fluxes in spring is limited as long as these areas are frozen

Events: **Highest sediment yields associated with events**, most of them due to precipitation. Yet bulk of fluxes due to glacier or snow melt (~75%)
Single events involving mass movements transported up to 25% of the annual yield within 24 hours.

But: future increase of high-intensity summer rainstorms + longer snow-free period and accelerating permafrost
→ Precipitation events might gain in importance drastically; reconstruction and trend analysis of past development in progress.

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* Picture of the recently deglaciated (i.e. proglacial) area of the Vernagtferner, Tyrol, Austria, taken by UAV in 2019