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Outstanding Student & PhD candidate Presentation contest

Reconstructing 50 years of sediment yields at two high alpine gauges using non-parametric regression

Lena Katharina Schmidt[1], Till Francke[1], Peter Grosse[1], Christoph Mayer[2], Axel Bronstert[1]

contact: leschmid@uni-potsdam.de

UAV-Picture of the Vernagtferner proglacial area, August 2019, Ötztal Alps, Austria

[1] University of Potsdam
[2] Bavarian Academy of Sciences and Humanities

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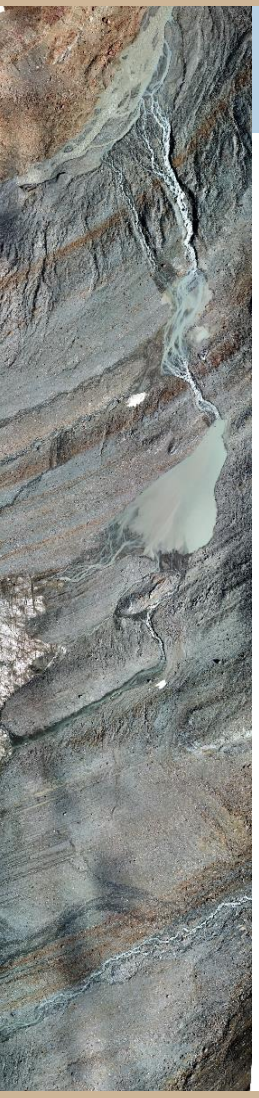
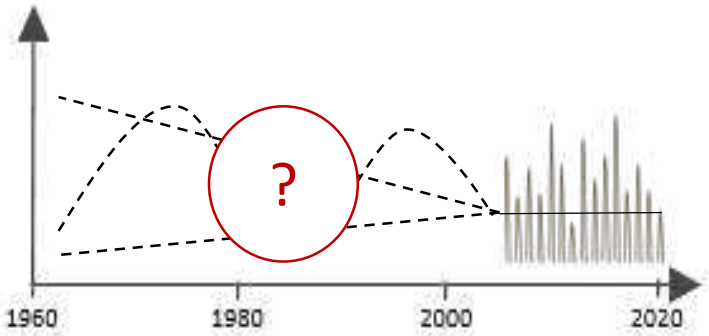


Changes in (fluvial) sediment export from high-alpine areas?

Problem: Short measurement records of SSC*



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*SSC = suspended sediment concentrations

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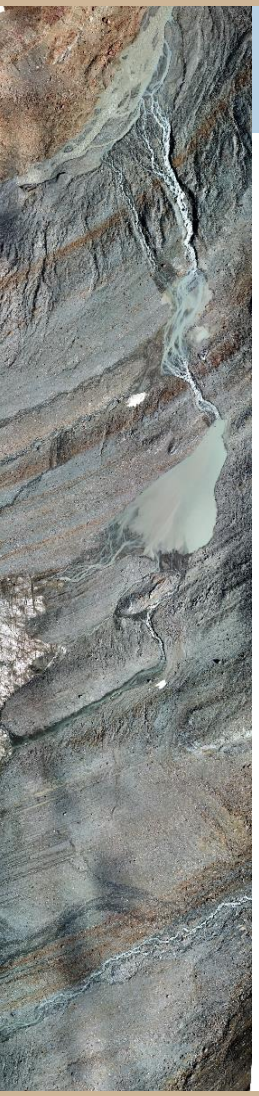
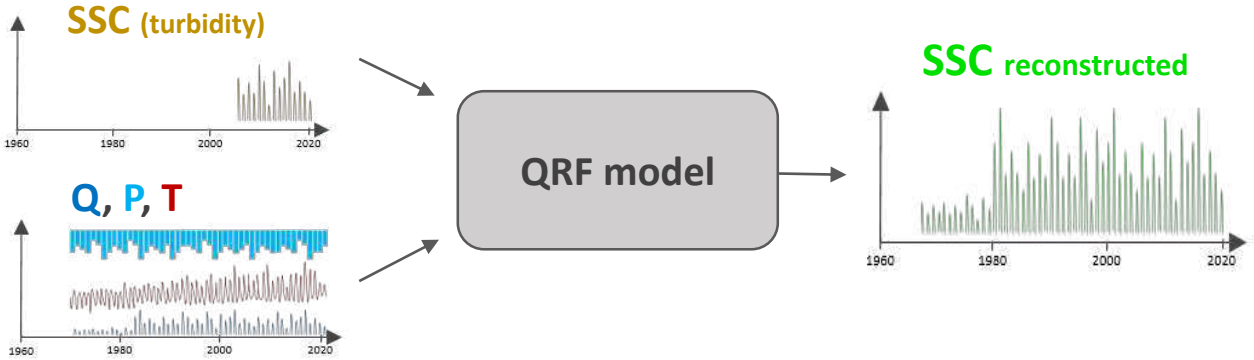


APPROACH

Quantile regression forest (QRF)



QUESTIONS

1. Is QRF applicable?
2. (How) Did sediment export change?
3. (How) Did predictors change?

} Trends, change points

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SSC = suspended sediment concentrations

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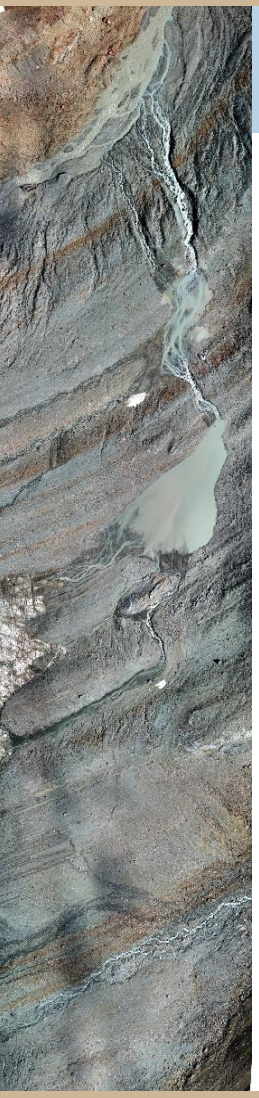
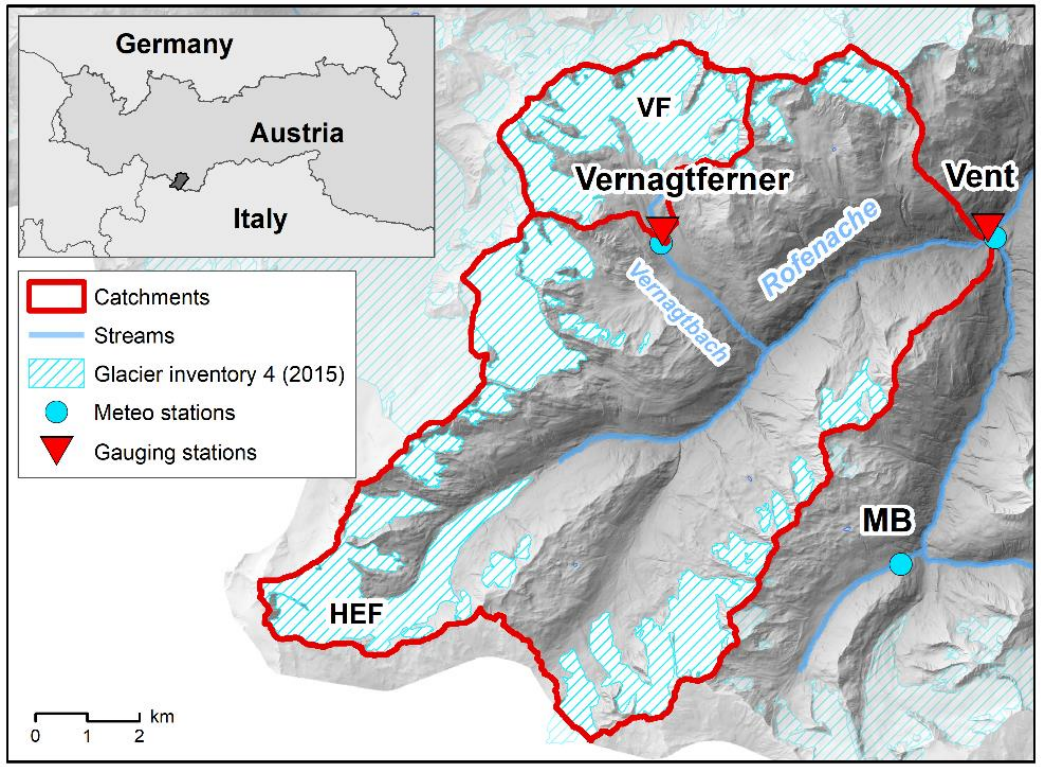


STUDY AREA

Ötztal, Tyrol, Austria:

- Gauges Vent & Vernagtferner (100 and 11 km²)
- 15 and 4 years of SSC measurements



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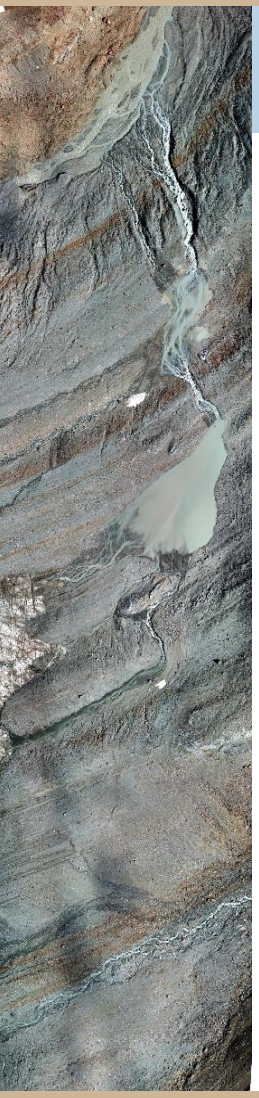
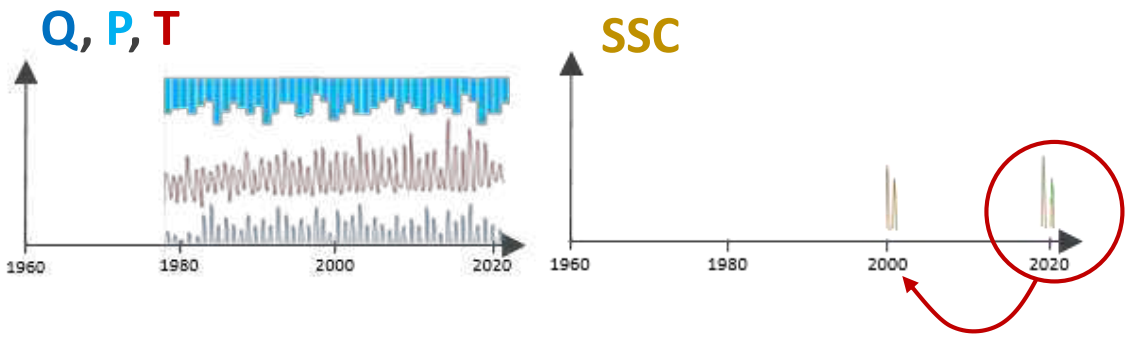


RESULTS (I) - Is QRF applicable?

Validation at gauge Vernagtferner:



→ Daily SSC : NSE* of 0.73

→ Annual yields: + 19% (2000), -4% (2001)

→ N = 212 (of 579)

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*NSE = Nash-Sutcliffe efficiency

Reconstructing 50 years of sediment yields at two high alpine gauges using non-parametric regression

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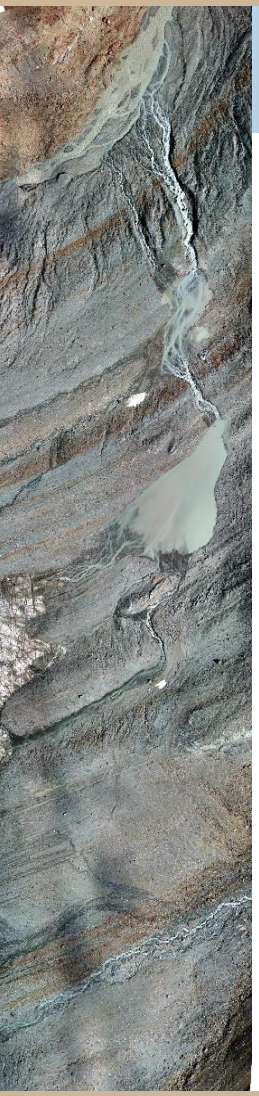
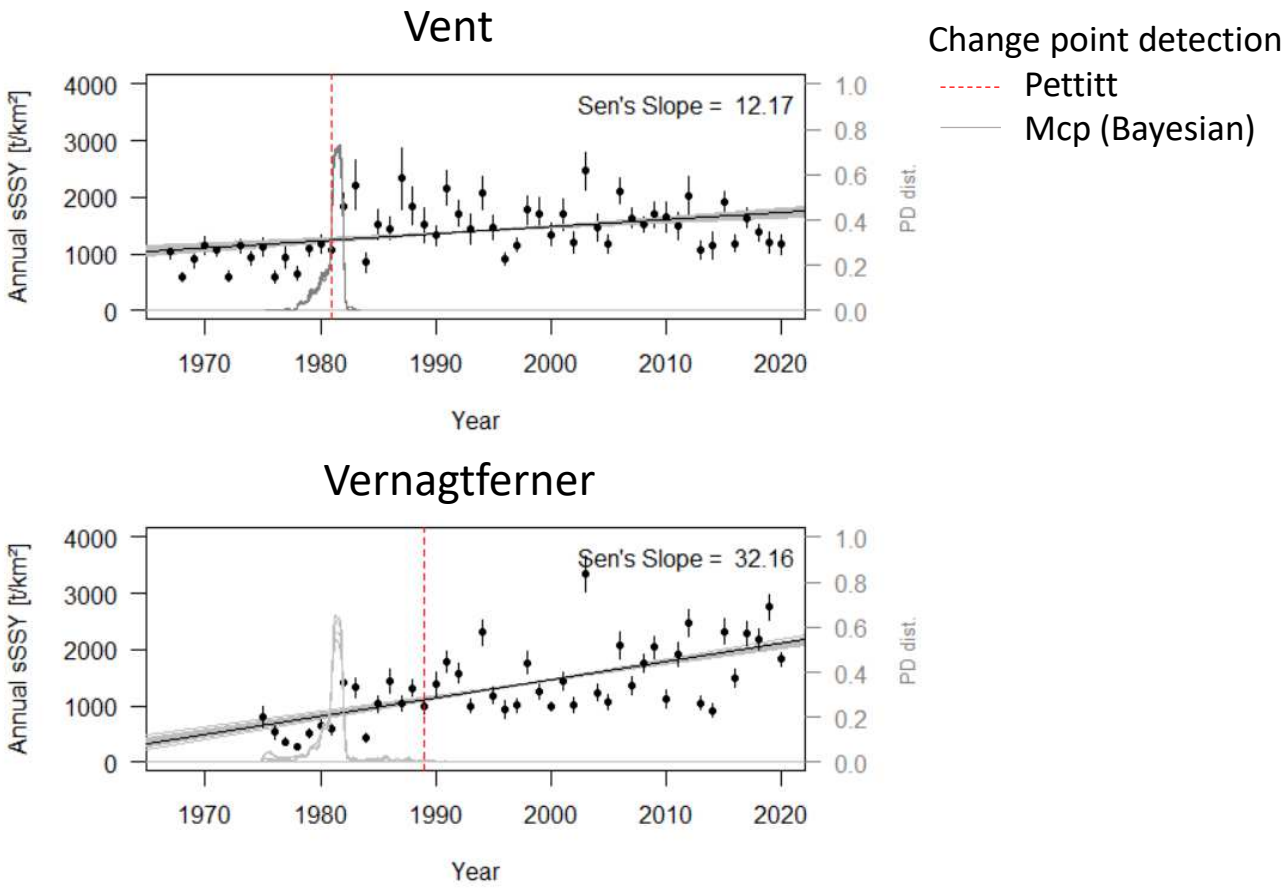


RESULTS (II) - (How) Did sediment export change?



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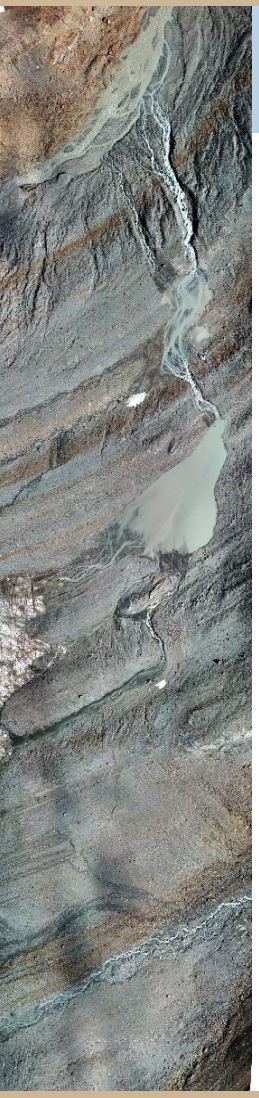

RESULTS (III) - (How) did predictors change?

Change points around 1981 in

- July temperatures
- Discharge
- Glacier mass balances (annual and summer)

No change point in precipitation.

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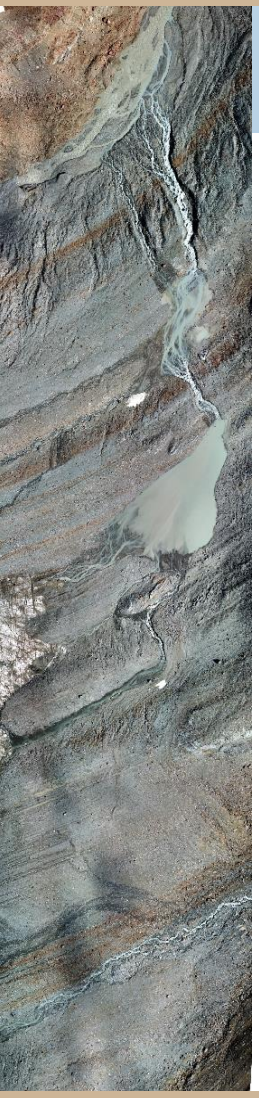

CONCLUSIONS

- Quantile regression forest is a suitable method for estimating past sediment export rates
- Step-like increase in sediment yields around 1981
- Coincides with tipping point in ice melt

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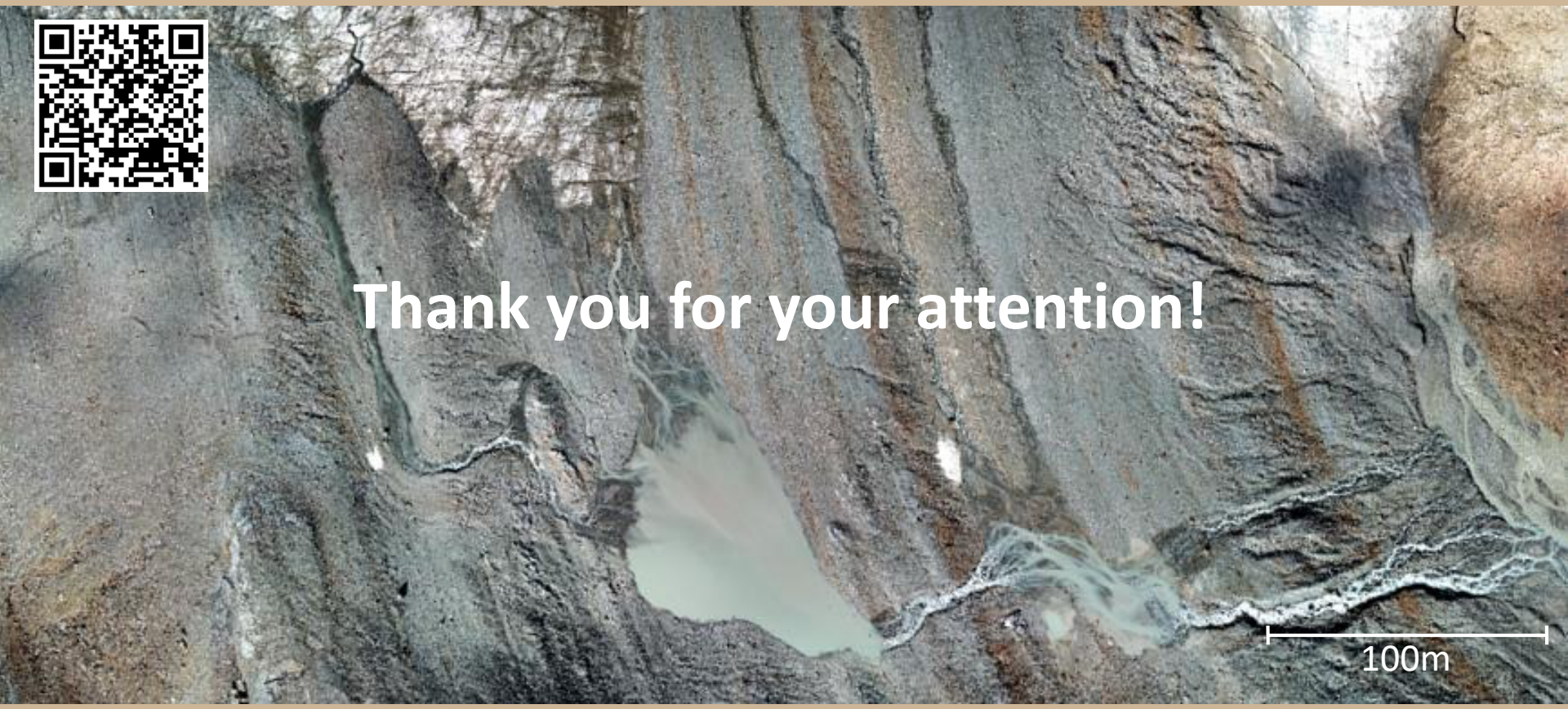

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Universität Potsdam

Natural Hazards and Risks in a Changing World

DFG

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BAdW

BAYERISCHE AKADEMIE DER WISSENSCHAFTEN

RECONSTRUCTING 50 YEARS OF SEDIMENT EXPORT FROM TWO HIGH-ALPINE CATCHMENTS USING NON-PARAMETRIC REGRESSION

LENA KATHARINA SCHMIDT[1], TILL FRANCKE[1], PETER GROSSE[1], CHRISTOPH MAYER[2], AXEL BRONSTERT[1]

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Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation
Natural Hazards and Risks in a Changing World
universität innsbruck
Universität Potsdam

* UAV-Picture of the Vernagtferner proglacial area, 2019

INTRO

PROBLEM

Records of past suspended sediment concentrations are often too short to e.g. allow for trend analyses. Yet knowing about the past is a prerequisite to understanding future changes.

AIM

Testing Quantile Regression Forests (QRF) for reconstruction of long-term sediment export

QUESTIONS

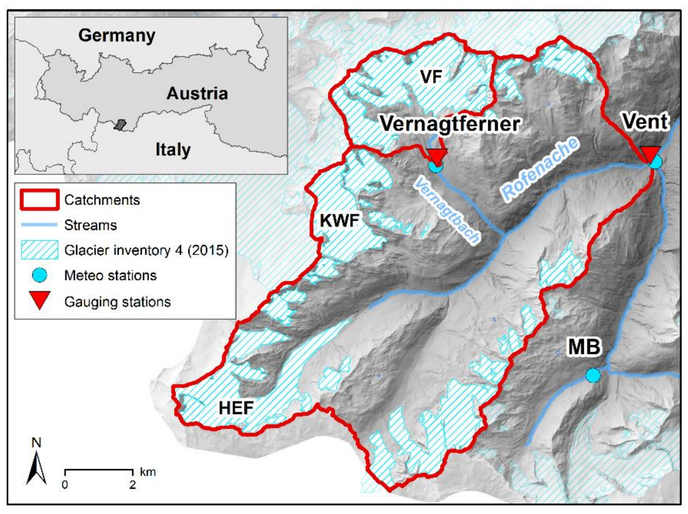
1. Is QRF applicable?
2. (How) Did sediment yields change over time?
3. (How) Did predictors change over time?

STUDY AREA

Ötztal in Tyrol, Austria

Gauges Vernagtferner (VF) and Vent

- 11 and 100 km² catchments
- 1891 to 3772 m.a.s.l.



DATA

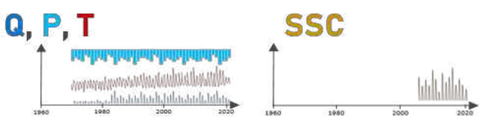
Predictors:

- **Discharge** (Q), **Precipitation** (P), and **Temperature** (T) time series,
- Derived ancillary predictors (→ antecedent conditions)
- Day of year (→ seasonality)

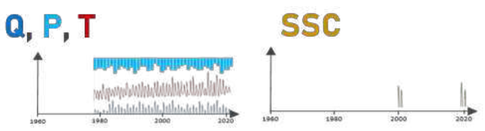
Response:

- **Suspended sediment concentration** (SSC) data (from turbidity)

Vent: Q, P, T — SSC



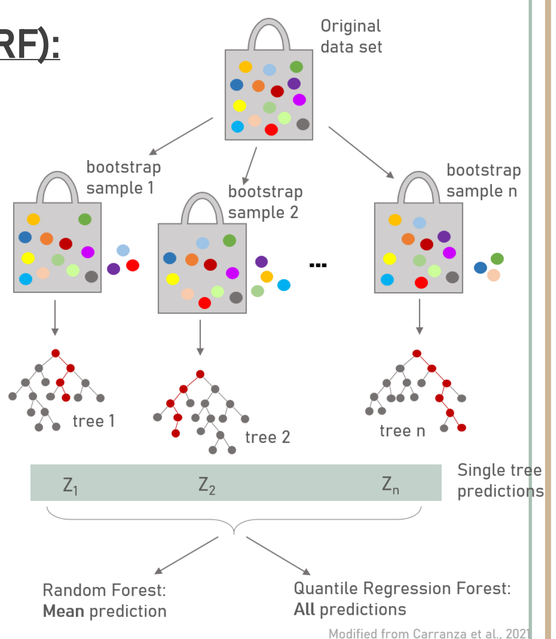
VF: Q, P, T — SSC



METHODS

STATISTICAL METHODS

- **Quantile regression forests (QRF):**
  Non-parametric regression technique based on **Random Forests**, that additionally provides **error estimates**

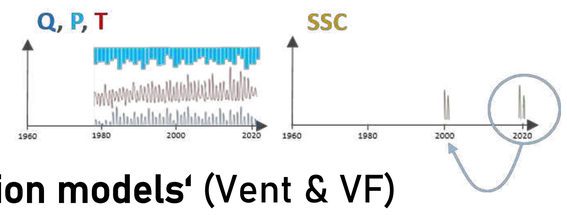


- **Trend analysis:**
  - Mann-Kendall test
  - Sen's slope estimator

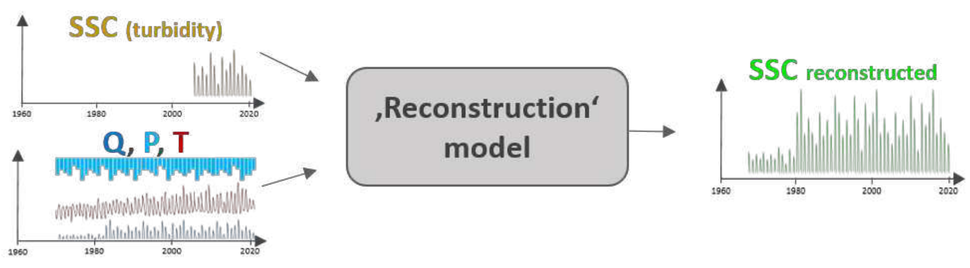
- **Change point (CP) detection:**
  - Pettitt's test
  - Bayesian change point analysis (mcp package, R)

MODELLING PROCEDURE

1. **‚Validation model'** (VF)
   training model on 2019/20 data at VF, validation on 2000/01 data



2. **‚Reconstruction models'** (Vent & VF)



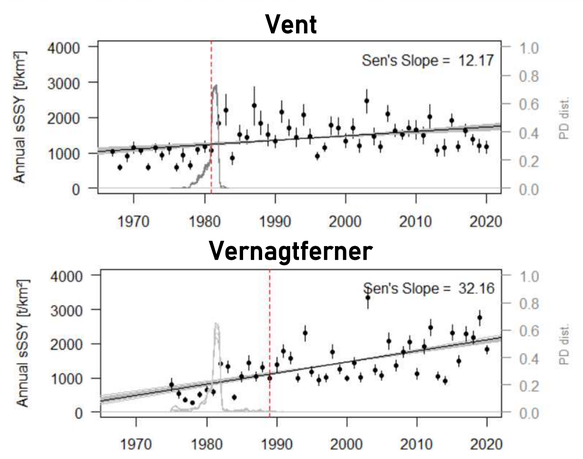
RESULTS

QRF APPLICABILITY

- Annual yields: + 19% (2000), -4% (2001)
- Nash-Sutcliffe-efficiency of daily SSC: 0.73
- Rigorous test: n = 212 days (of 579)

RECONSTRUCTED ANNUAL SEDIMENT YIELDS

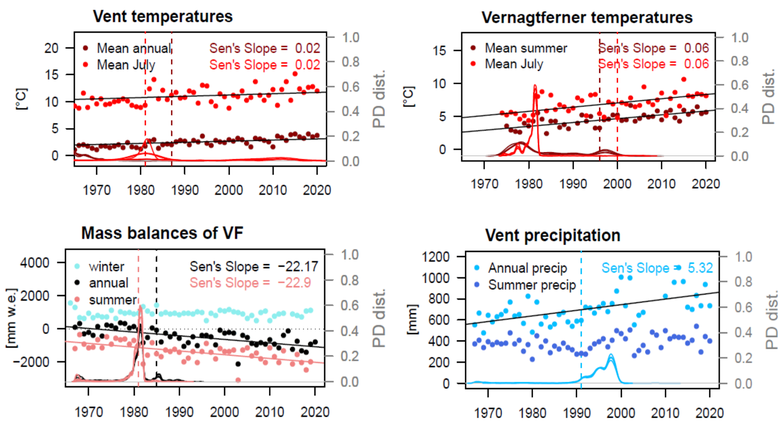
- **Significant positive trends** in annual suspended sediment yields in Vent and at VF
- **Change points** (CP) indicated around 1981 → step-like increase



PREDICTORS

Change points around 1981 in July temperatures, discharge and glacier mass balances

Precipitation:
no clear CP



CONCLUSIONS & OUTLOOK

- QRF is suitable, but tends to underestimate large events / high concentrations. Uncertainty estimates only capture model uncertainty.
- Results suggest increase in SSY over last 5 decades, with change points around 1981.
- Coincides with change points in July temperatures (crucial month for firn and ice melt), discharge and mass balances → step-like increase in SSY due to enhanced glacier melt. → Tipping point in high alpine system!

OUTLOOK

→ Using QRF to estimate future changes in sediment dynamics (using climate projections & modelled Q of AMUNDSEN, Hanzer, 2018)?

→ OR to detect extreme events (e.g. mass movements) and assess changes in their occurrence?

ACKNOWLEDGEMENTS AND AFFILIATIONS

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