Rain-on-snow runoff events in mountainous catchments under climate variability and change

Michal Jeníček[1], Ondřej Hotový[1], Ondřej Nedělčev[1], Jan Seibert[2]

[1] Charles University, Department of Physical Geography and Geoecology, Prague, Czechia

[2] University of Zurich, Department of Geography, Zurich, Switzerland

Motivation

Rain-on-snow (RoS) events are dynamic situations that often produce extreme runoff responses. Their frequency and intensity are expected to change in response to climate variations due to changes in precipitation, air temperature, and subsequent changes in the snow cover.

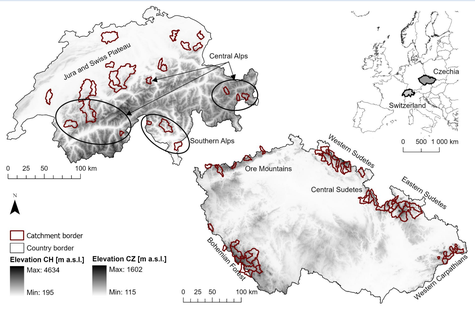
Research objectives

1) To attribute changes in selected climate variables to changes in RoS events, using a sensitivity analysis of precipitation and air temperature
2) To evaluate subsequent changes in RoS-related runoff responses

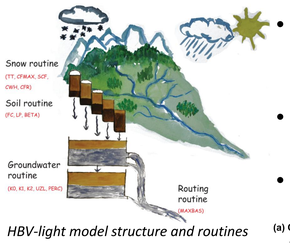
Data and methods

Study area

- 93 mountain near-natural catchments in Czechia and Switzerland investigated
- Catchments located at different elevations, not glacierized

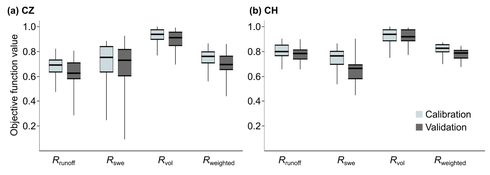


HBV model and input data



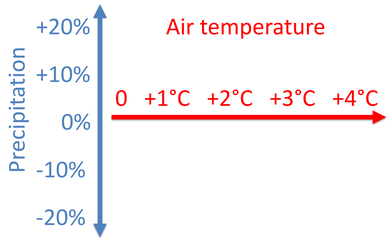
HBV-light model structure and routines

- Stational (CZ) and gridded (CH) data: daily precipitation, air temperature, snow water equivalent (SWE)
- Model calibrated against mean daily runoff and SWE using a split-sample approach
- Reference period 1980-2010



Values of individual objective functions for each catchment for calibration and validation periods.

RoS analysis in a changing climate



RoS day

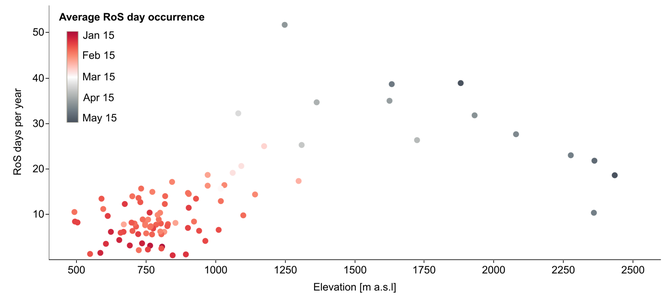
- Daily mean air temperature > 0 °C
- Snow water equivalent ≥ 10 mm
- Total daily precipitation ≥ 5 mm

RoS event

- Runoff response to RoS day(s)
- Starts at the initial RoS day, ends with the first local runoff maximum

Results

Rain-on-snow occurrence at different elevations



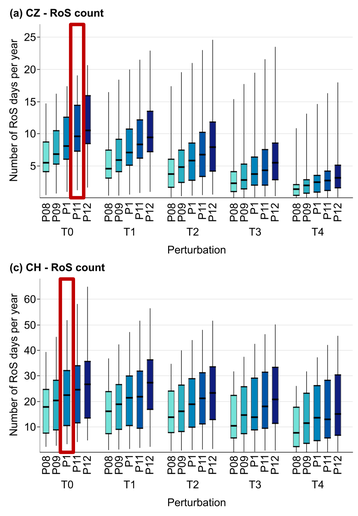
Czechia

- RoS days increase with elevation

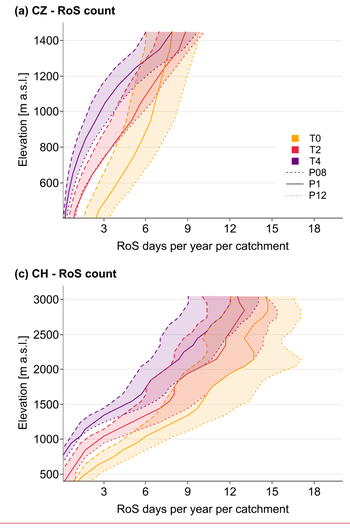
Switzerland

- RoS days increase with elevation up to about 2000 m a.s.l., then decrease

Potential future change in RoS days



- Only four projections for the Czech dataset and five projections for the Swiss dataset will lead to an increase in the number of RoS days
- Joint effect of air temperature and precipitation
- +4 °C projections suggested a decrease of RoS days by about 75% for the Czech catchments and about 50% for Swiss catchments.



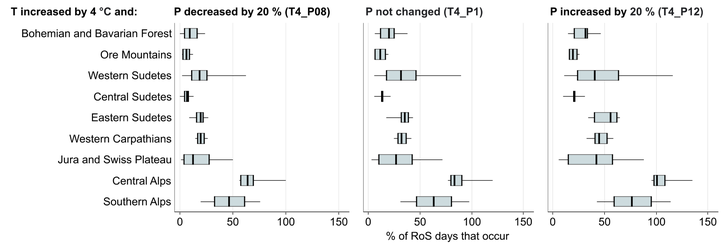
RoS changes across elevation zones

Largest decrease in RoS events below 1000 m a.s.l. for CZ and below 1500 m a.s.l for CH catchments

Czechia: Increase in RoS for wet scenarios above 1300 m a.s.l

Switzerland: Decrease in RoS at all elevations except wet and less warm scenarios

Regional differences in the future RoS occurrence

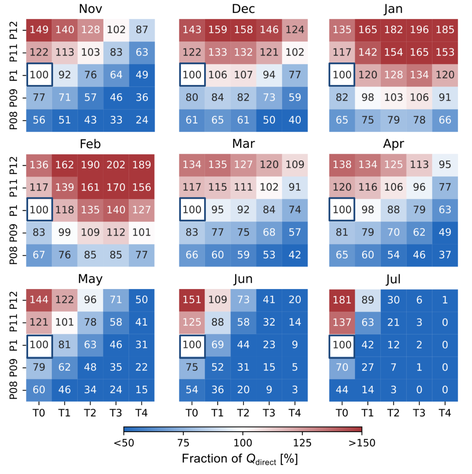


Decreasing RoS events with **increasing** air temperature and/or decreasing precipitation

Czechia: Larger decrease for southern and western regions

Switzerland: Larger decrease for Jura, Swiss Plateau and Southern Alps, smaller decrease for the Central Alps

Runoff response to RoS in Switzerland



- RoS **increase in winter and early spring** and increased precipitation; **decrease for spring** period and decreased precipitation
- **For T +4°C**, decrease in RoS events except January and February
- **Compensating effect** of increased precipitation => RoS increase for scenarios with a moderate increase in air temperature

Conclusions

- Number of RoS days per season varies **from one to 50**, with the most frequent occurrence in **1000–2000 m a.s.l**. March is the month with the highest RoS occurrence.
- **RoS events are expected to decrease** at low and middle elevations. Swiss catchments respond less sensitively than Czech catchments.
- **RoS contribution** to annual runoff will **likely be reduced**.
- However, the RoS contribution to **runoff may increase in winter in Switzerland**, which may be further **enhanced by increased precipitation**.
- The **winter runoff increase in Czechia** is expected only for **wet projections** with a relatively small air temperature increase

FACULTY OF SCIENCE
Charles University

Contact to authors:
Charles University, Department of Physical Geography and Geoecology
Albertov 6, Prague, 128 43 Czechia
michal.jenicek@natur.cuni.cz , https://natur.cuni.cz/en/

Acknowledgements:
Support from the GAČR and SNSF, project No. 23-06859K „Mountain snowmelt and its importance for catchment storage and runoff (MountSnow)“, and the Johannes Amos Comenius Programme, project No. CZ.02.01.01/00/22_008/0004605 „Natural and anthropogenic georisks“ are gratefully acknowledged.

EGU25-4433 | HS2.4.2

Poster:

HESS preprint:

Photography encouraged