Hydrological response of mountain catchments during rain-on-snow events

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Motivation

- Rain-on-snow events have become more frequent and are causing substantial losses.

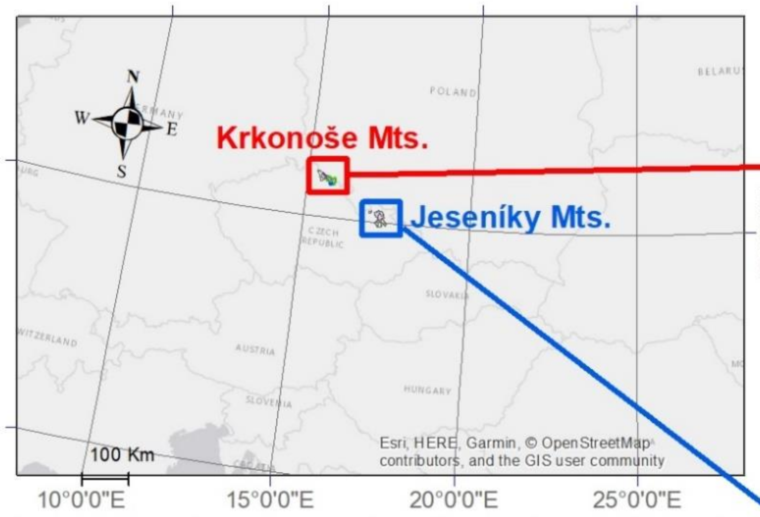
- Understanding meteorological drivers may help to improve flood forecasts of such events.

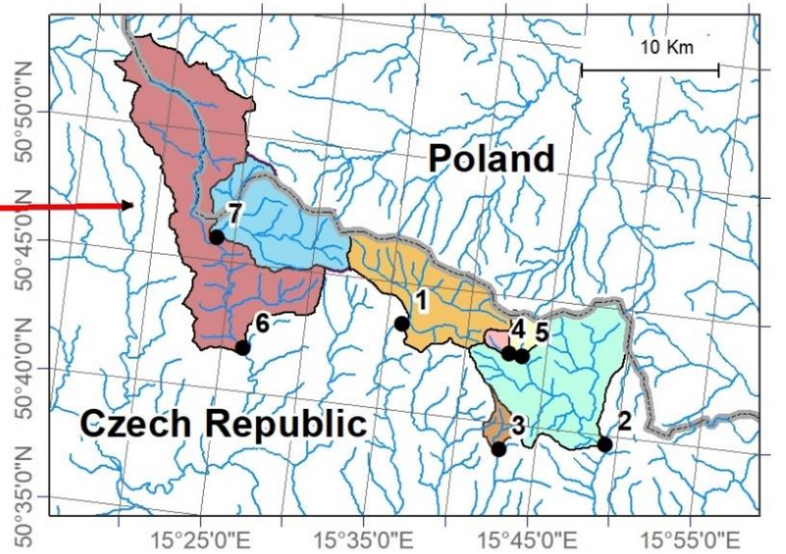
- Investigation for central Europe non-alpine regions is missing

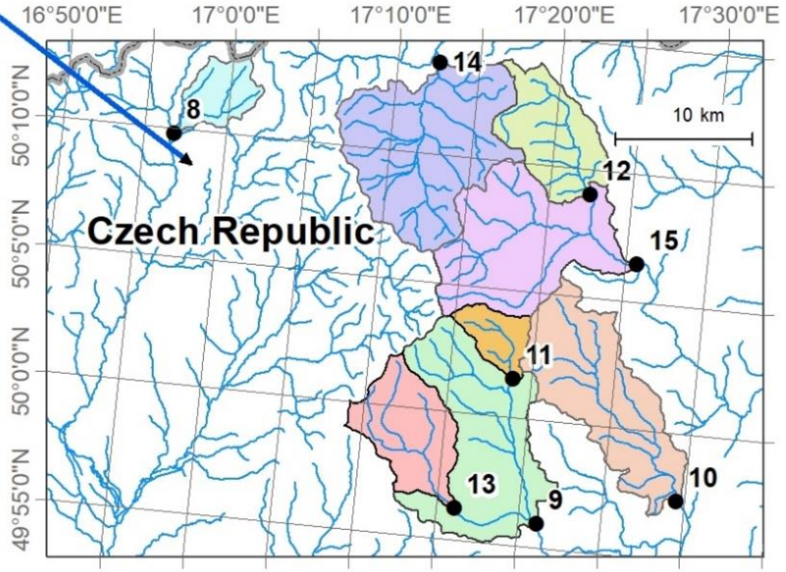
Research questions

- How fast is the runoff response after a rain-on-snow event?
- What meteorological parameters have the greatest impact on the runoff increase?
- How much does snow provide a retention potential against floods?

Investigated catchments







#	River	Profile	River length [km]	Min. Elev [m]	Max. Elevation [m]	Mean Elevation [m]	Area [km²]
1	Labe	Špindlerův Mlýn	25.4	699	1553	1156	53
2	Upa	Homí Maršov	48.2	574	1600	1048	82
3	Čistá	Čemý Důl	4.8	736	1350	1046	7
4	Modrý potok	Modry Důl	1.9	903	1597	1231	9
5	Úpa	Obri Důl	3.8	903	1597	1216	6
6	Jizera	Jablonec n. Jizerou	90	438	1434	862	181
7	Velká Mumlava	Harrachov	24.2	595	1434	971	51
8	Vrbenský potok	Staré Město	18.8	523	1118	810	22
9	Moravice	Velká Štáhle	90.4	542	1465	804	169
10	Černý potok	Mezina	54.3	500	1026	646	92
11	Bělokamenný potok	Malá Morávka	8.4	674	1420	940	18
12	Čemá Opava	Mnichov	23.6	568	1218	830	58
13	Podolský potok	Rýmařov	24	593	1356	866	51
14	Bělá	Jeseník	70.9	438	1417	806.2	118
15	Opava	Karlovice	67.9	484.45	1492.2	853.6	154

Projected coordinate system: S-JTSK_Krovak_East_North
Data source: Czech Hydrometeorological Institute & land.copernicus.eu

- **15 Catchments**
- **6 – 180 km²**
- **400 – 1600 m a.s.l.**

Meteo situation (Nov - May)

- **Max snow depth:** 100 – 350 cm
- **Precipitation:** 360 – 510 mm
- **Min Temperature:** -8 - + 8°C

Methods

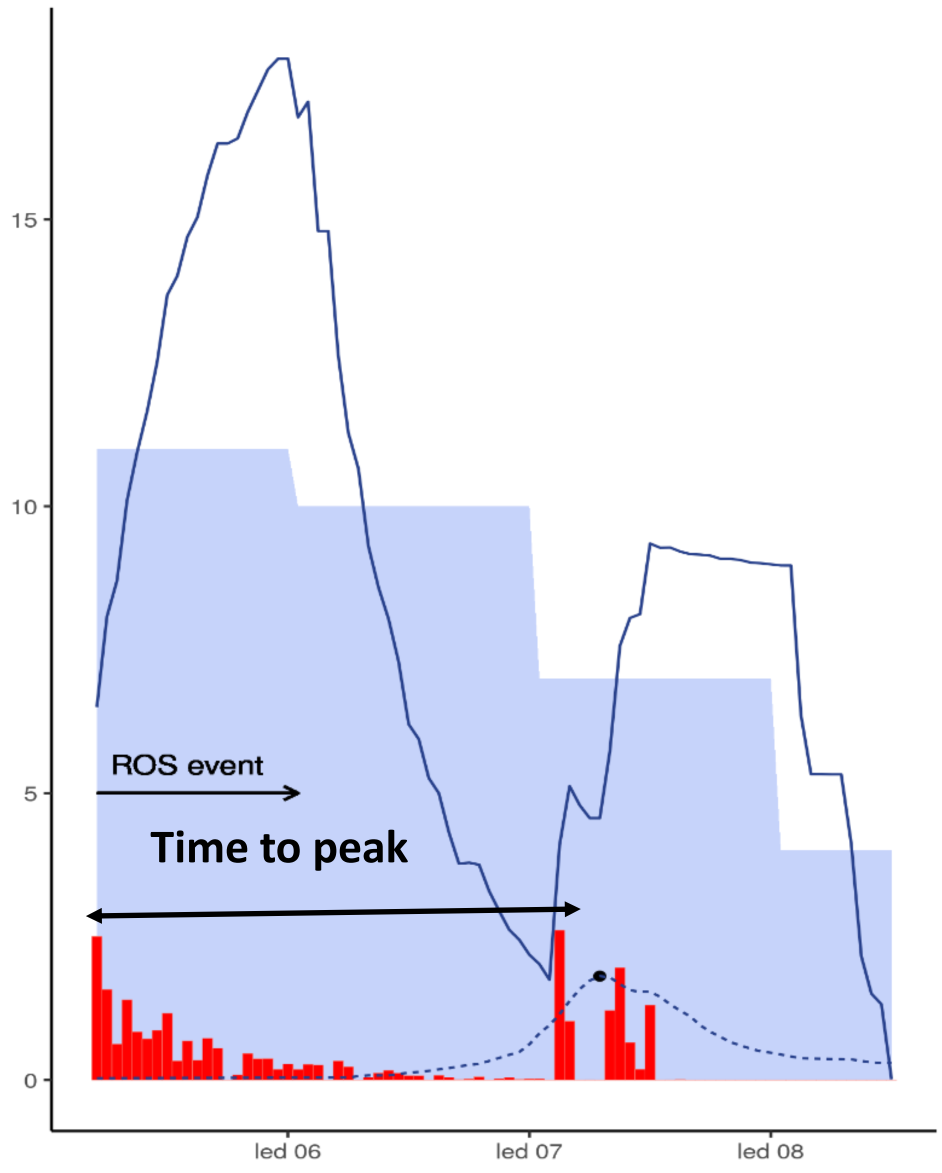
- **Rain-on-snow (ROS) definition**
  24h cumulative rain >= 5mm
  Event precipitation >= 5mm
  Snow depth >= 10 cm
  No new snow
  Temperature >= 0°C
  33% of contributing area, when ROS starts

- **Runoff event (RE) definition**

Rain onset until the end of event runoff

$k = -\frac{dQ}{dt} \times \frac{1}{Q(t)}$, RE end when 3 hours cumulative **k = 0.01**

Blume et al. 2007



Data

- Temperature, Precipitation, Runoff (hourly)
- Snow depth (daily)
- 30m DTM

Time period: 2004 – 2014

159 ROS events

107 – Krkonoše

52 - Jeseníky

Hydrological response

- **Runoff response time**
  - No reaction (Time to peak > 96 h)
  - Slow reaction (48 h > Time to peak ≤ 96 h)
  - Medium reaction (24 h > Time to peak ≤ 48 h)
  - Fast reaction (Time to peak < 24 h)

→ **How fast?**

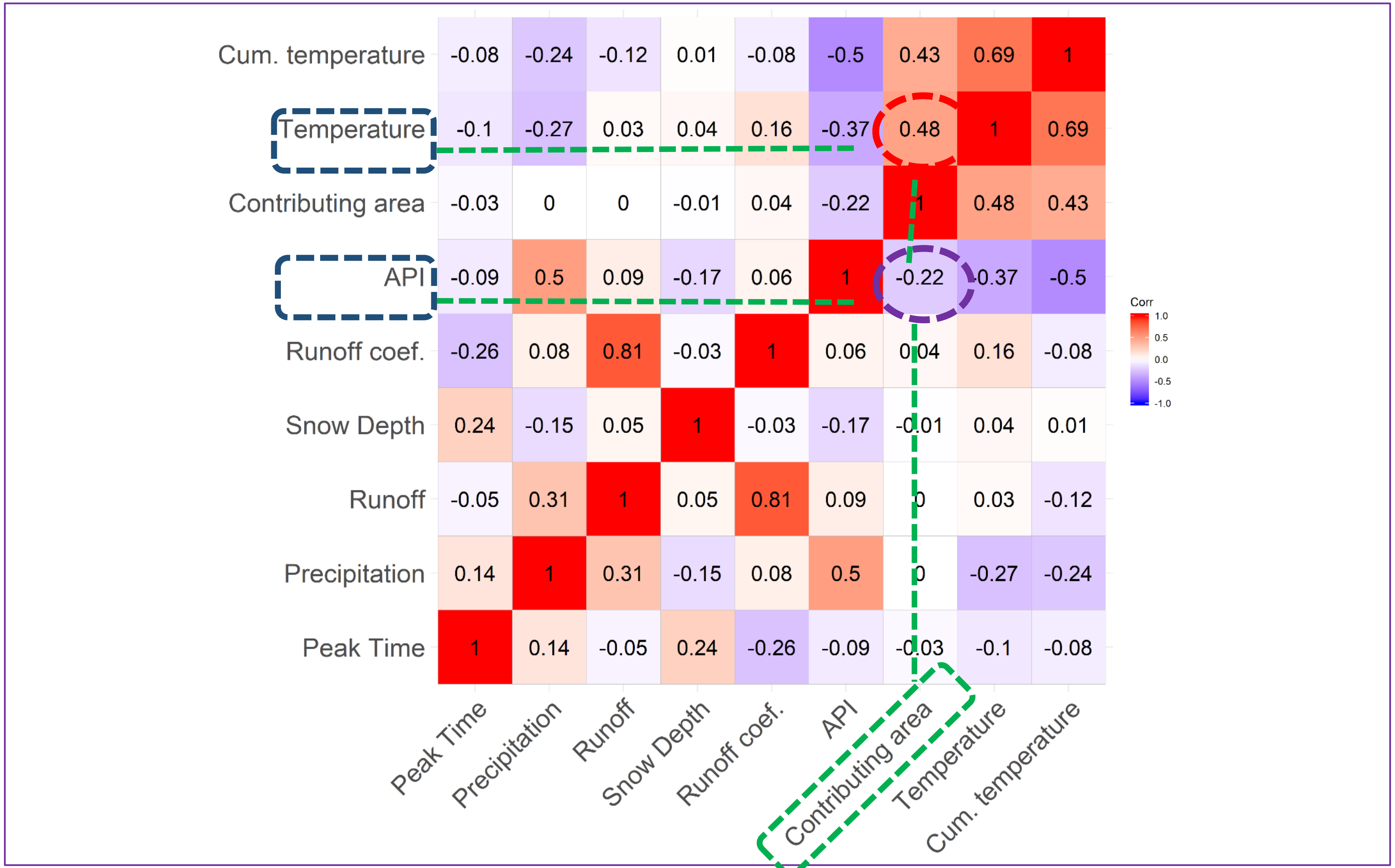
- **Runoff coefficient - CQ**
  - Little runoff (CQ < 0.1)
  - Medium runoff (0.1 > CQ ≤ 1)
  - Runoff excess (CQ > 1)

→ **How much?**

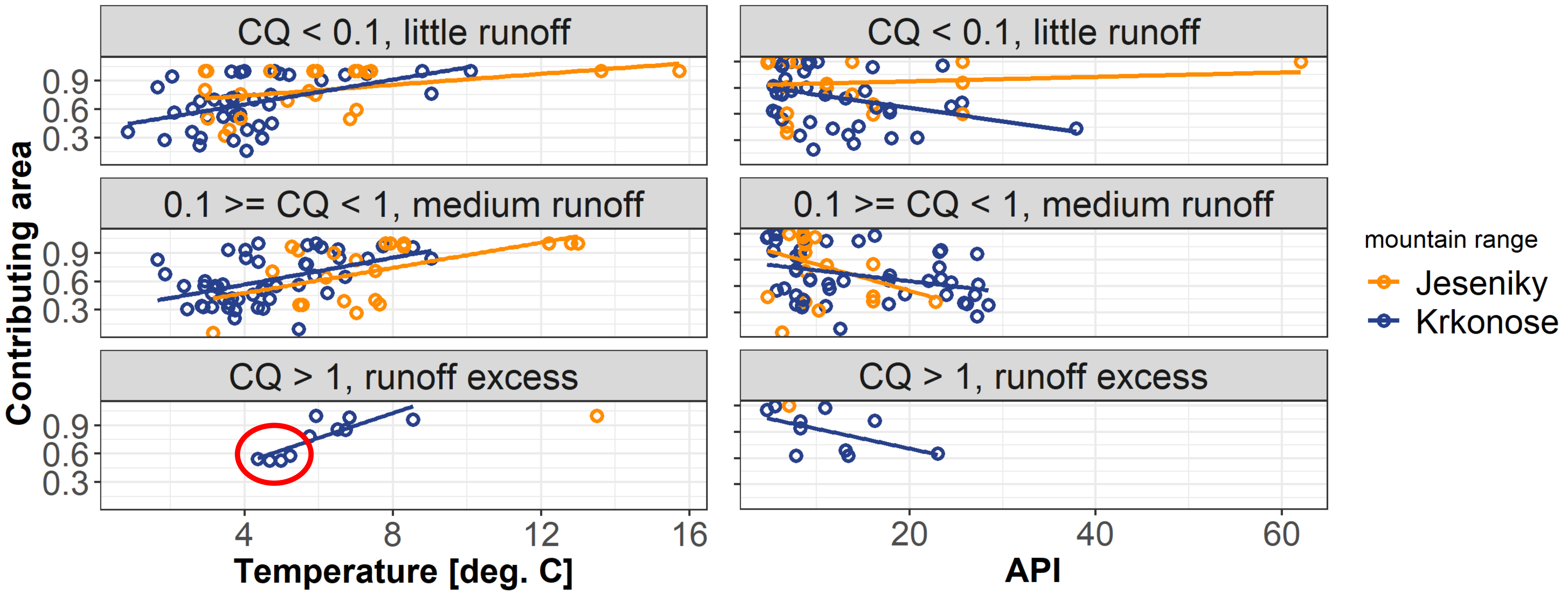
Hydrological response

	Event numbers			Temperature [°C]			Snow Depth [cm]		
	little runoff	medium runoff	runoff excess	little runoff	medium runoff	runoff excess	little runoff	medium runoff	runoff excess
fast	36	60	6	5.0	5.4	6.7	40.1	50.4	74.8
medium	7	7	4	4.1	4.3	5.6	51.6	72.4	93.5
slow	8	6	1	5.2	6.2	8.5	61.4	72.3	18.0
very slow	14	2	2	4.5	4.7	6.2	75.8	77.5	89.5

Hydrometeorological parameters affecting hydrological response

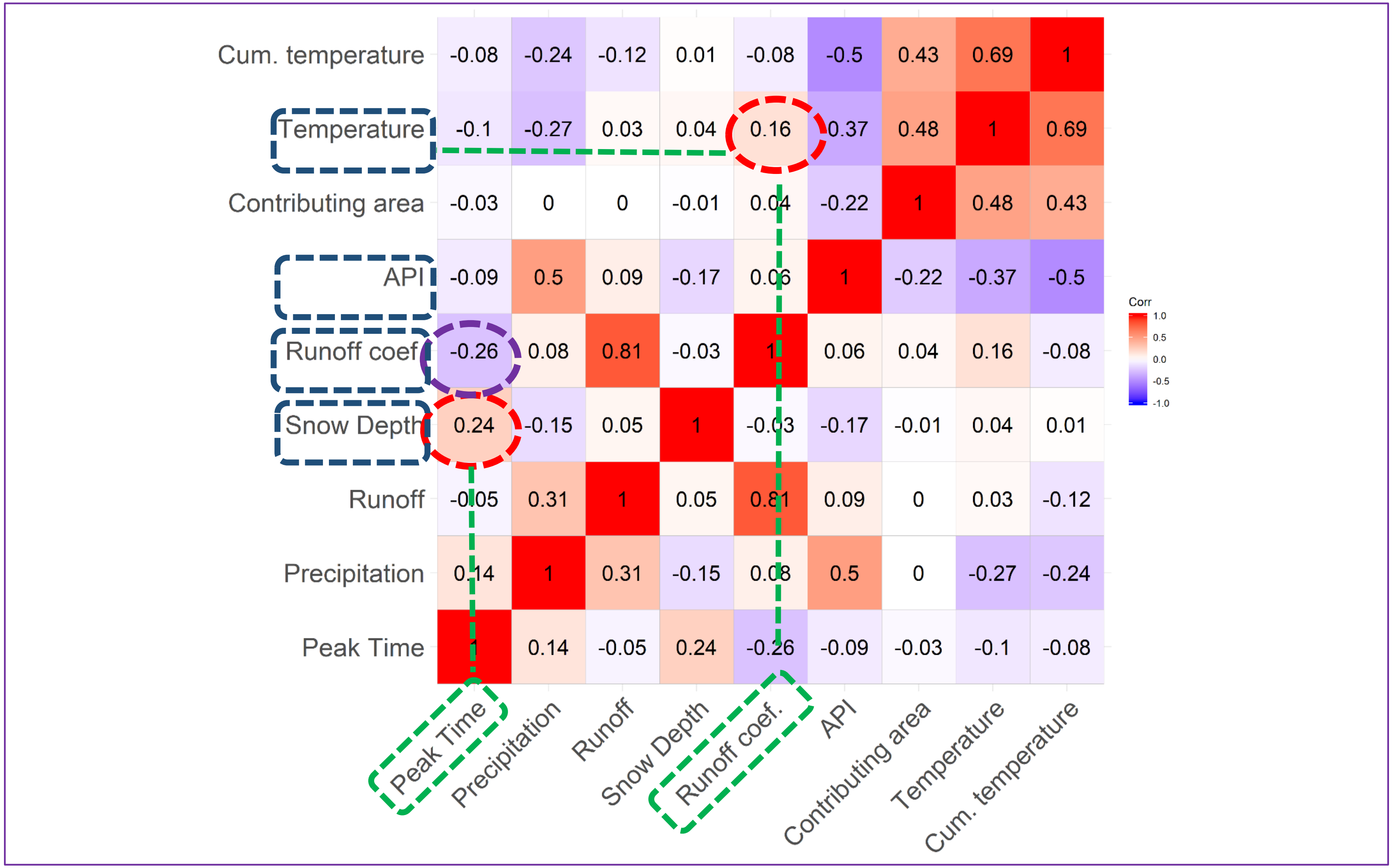


Contributing area to the runoff

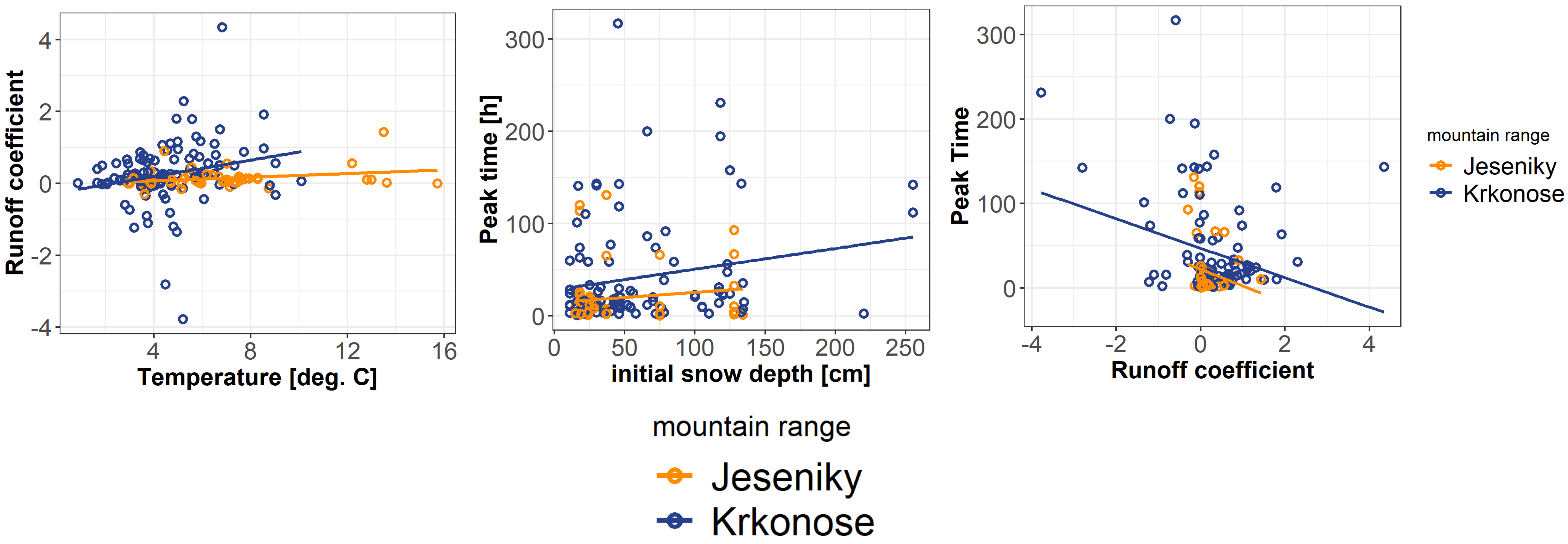


API = antecedent precipitation index

Hydrometeorological parameters affecting hydrological response



Closer look



Runoff coefficient
4
2
0
-2
-4
4
8
12
16
Temperature [deg. C]
Peak time [h]
300
200
100
0
0
50
100
150
200
250
initial snow depth [cm]
Peak Time
300
200
100
0
-4
-2
0
2
4
Runoff coefficient
mountain range
Jeseniky
Krkonose
mountain range
Jeseniky
Krkonose

Conclusion

- Meteorological parameters do not fully explain the hydrological response on ROS events
- Most of the ROS events with high precipitation responded with little runoff
- We assume that internal processes in snow play an important role
- Snowpack properties are also important for liquid water behaviour (**Visit our poster at Hall A, A.27**)

Ackowledgement

We would like thank to Czech Hydrometeorological Institute for proding us data.

We will be very gratefull for any comments or questinons.
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