Changes in hydrological behaviour: case studies of the Unica and Rižana karst springs

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Planinska jama, SW Slovenia, Photo: M. Blatnik

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Research questions

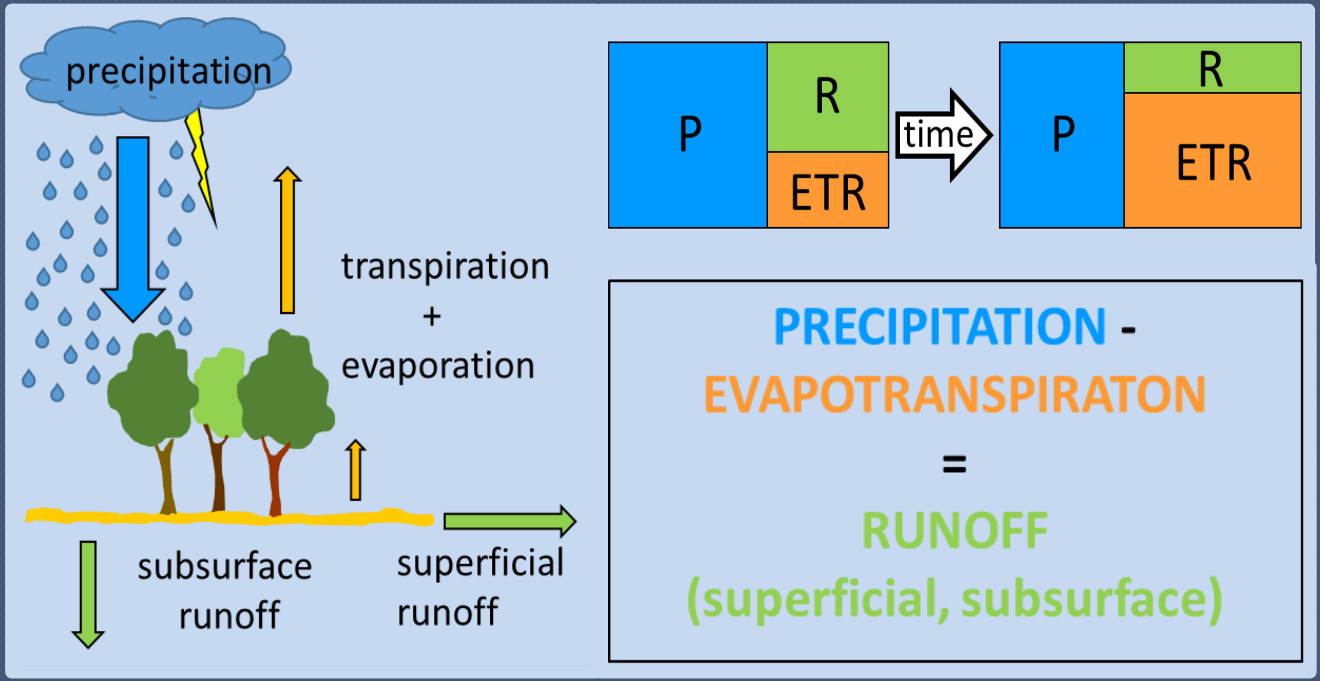
- How to assess impacts of climate and vegetation cover changes on karst water sources?
- Is it possible to evaluate and quantify individual impacts on a catchment scale / on a long- and short-term?


Postojnska jama, SW Slovenia, Photo: N. Ravbar

Background and objectives I

Climate change (increasing air temperatures and evapotranspiration, alternation of precipitation regimes) **effects water balance** by decreasing water runoff (superficial and underground).

Kovačič & Brečko Grubar, 2019



Background and objectives II

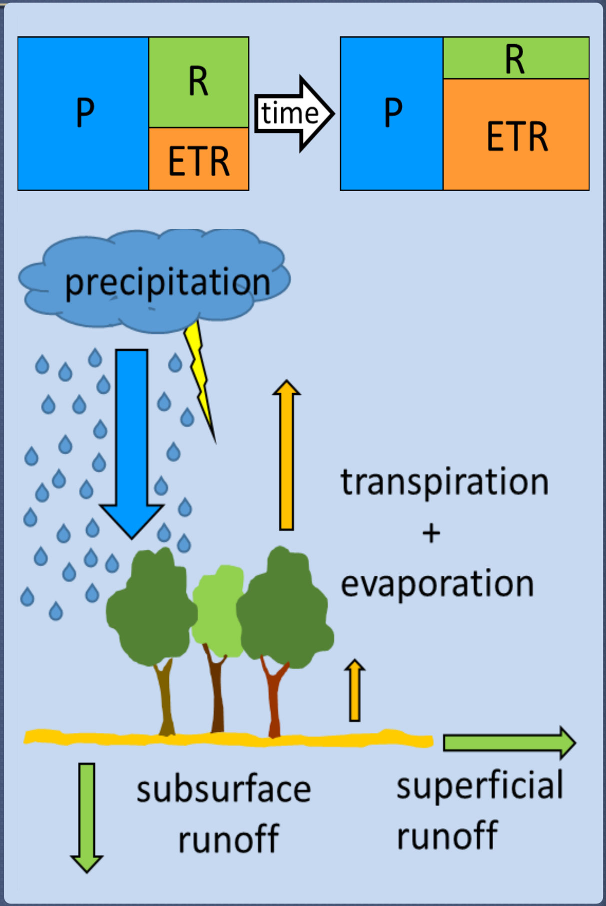
- The catchment of Unica karst spring enabled study of impacts of changes in vegetation cover due to **recent large-scale forest disturbances**.

- The catchment of Rižana karst spring has been impacted by climate and land use changes in the past six decades and enabled studies of their **long-term impacts**.

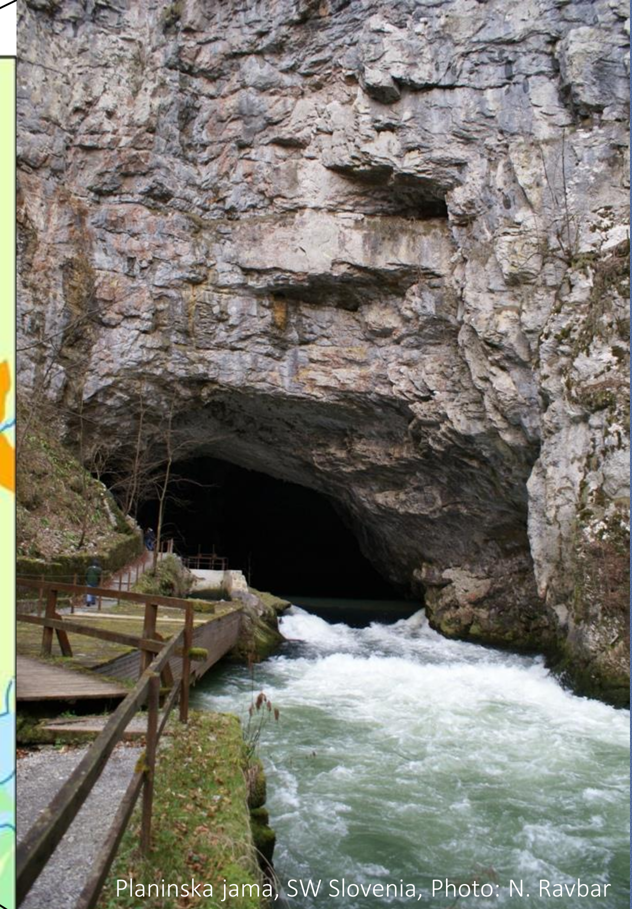
Background and objectives III

- **Hypothesis:** Vegetation cover changes alter effective precipitation and thus behavior of a karst spring.

- **The aim** of the study: to **compare** long- and short-term changes in groundwater recharge and in spring discharge, and to **evaluate** impacts of climate and vegetation cover changes.



Petrič et al. 2018



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Unica

20 L/s < Q < 75 m^3/s

Qmean = 20.2 m^3/s

A > 800 km^2

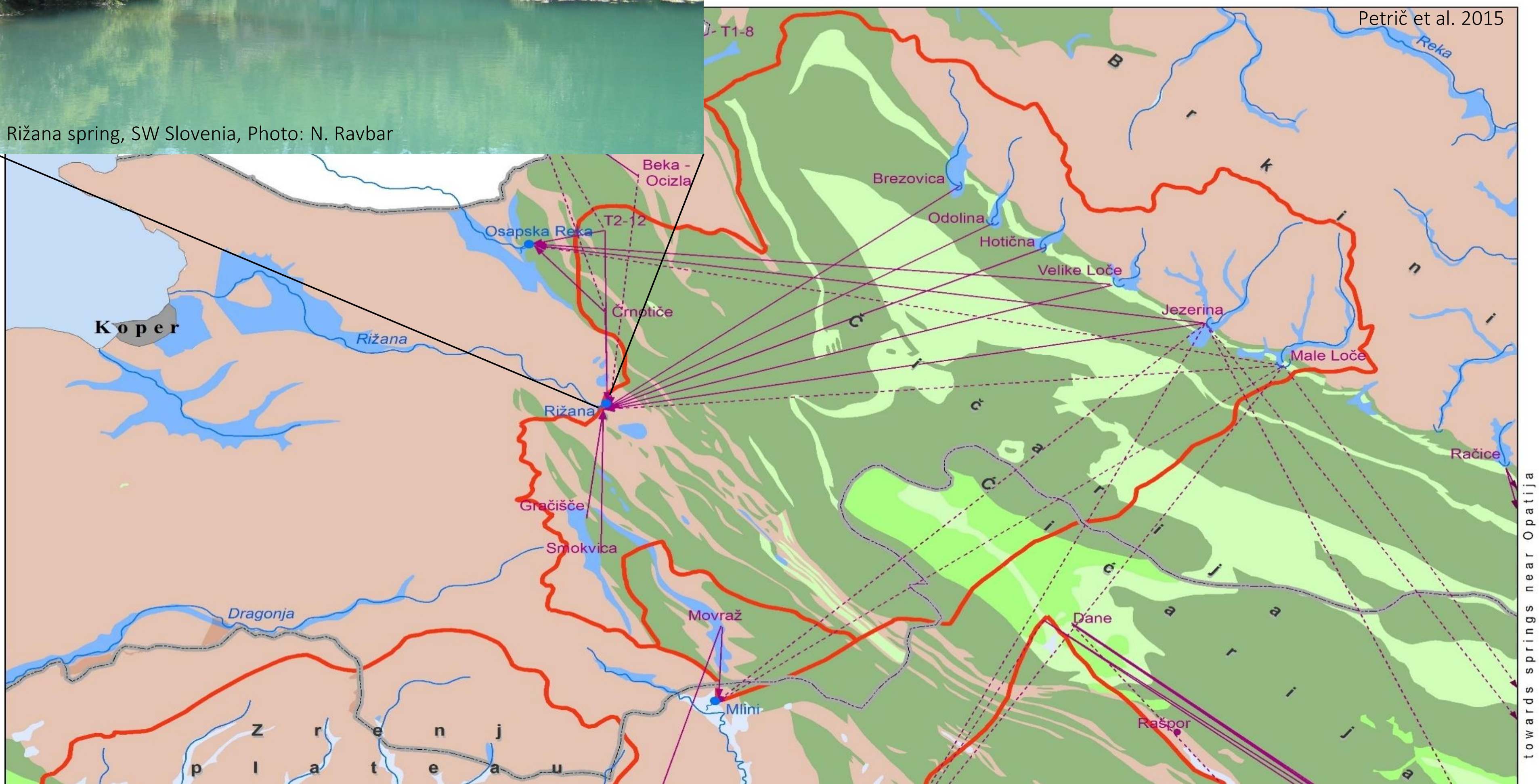
Rižana spring, SW Slovenia, Photo: N. Ravbar

Rižana

30 L/s < Q < 63 m^3/s

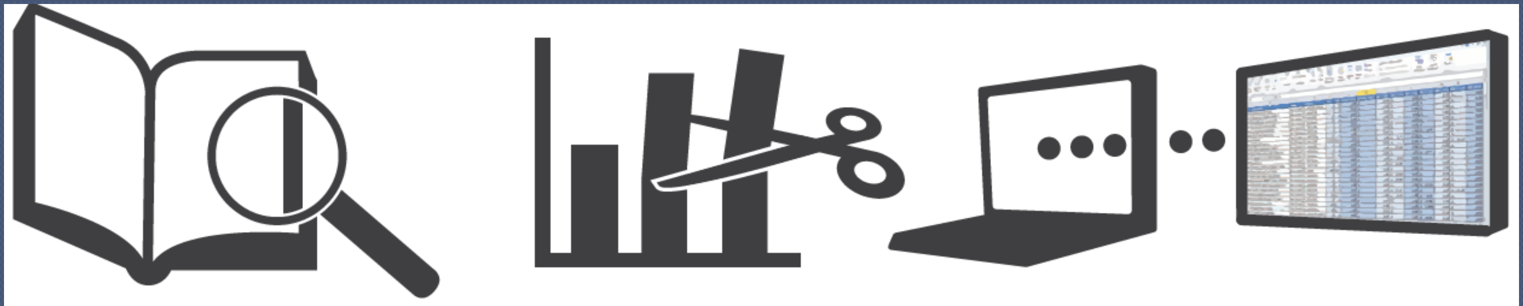
Qmean = 3.4 m^3/s

A = 247 km^2



Research methods I

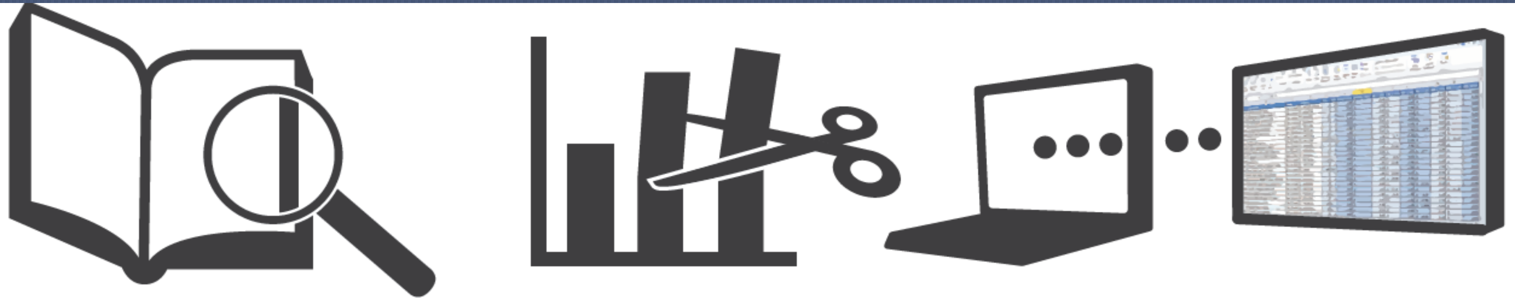
- **Vegetation cover changes:** spatial and temporal analysis
- based on digital orthophotographs, national land use and state of forests databases
- years: 1957, 2013, 2018.



Research methods II

- **Comparison** of annual values of selected hydro-meteorological parameters (since 1962 and 1965 respectively)

- basic regional **climatological parameters** (precipitation, actual evapotranspiration), groundwater **discharge values**.



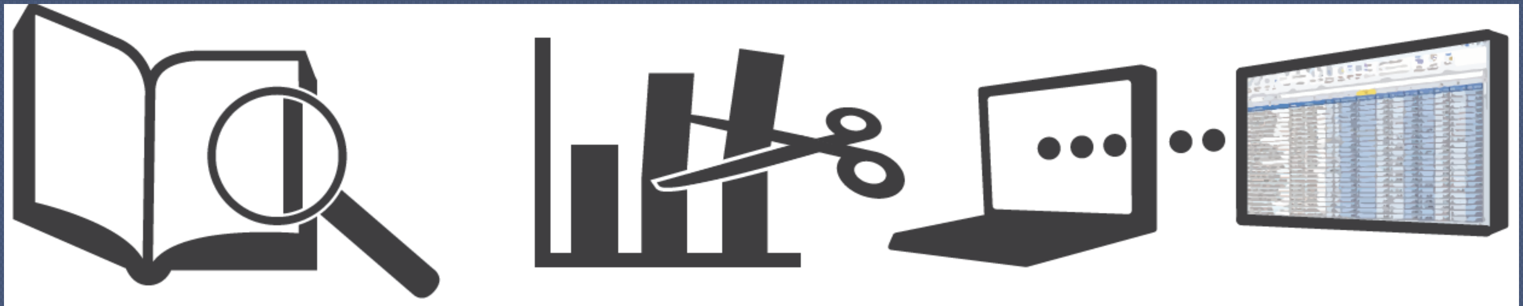
Research methods III

- Modelling based on **Soil water balance model**
- take into account the influences of vegetation interception, evapotranspiration, snow melt, and water storage in soil
- calibrate to measured Qmean in the same period
- estimate daily values of **effective precipitation (Pef)** based on daily values of precipitation, thickness of snow cover and new snow, air temperature, wind speed, relative humidity, and sunshine hours.

Research methods IV

- calculation, where vegetation cover change has been taken into account

- **compared** to the calculation, in which it has been assumed that there would be no such changes.



Results: Unica I

In the period 2014-2018 compared to the period 1962-2013, there was:

- P increase: 2.7%
- significant ETP increase: 14.8%
- outflow (P-ETP) decrease: -6.9%
- Qmean decrease: -0,4%

Assumption: Vegetation cover change mitigated the effects of climate change: if there were no large-scale forest disturbance, the Qmean would have been significantly lower …

Results: Unica II

… Instead, Qmean decreased by only 0.4% !!!

- In the period 2014-18 large-scale disturbance in the forest – gradual decrease of forest from 77.1% to 64.2%; decrease of growing stock for -16.77%

- Modelling: **increase of effective precipitation** by 5%, **increase of spring Qmean** by 1.0 m^3/s.

- Due to the vegetation cover change the amounts of effective precipitation increased (i.e., less canopy interception and evapotranspiration) and caused smaller decrease of Qmean than expected.

Results: Rižana I

In the period 2014-2018 compared to the period 1965-2018, there was:

- P increase: 6.43%
- Qmean increase: 4.85%

- Share of forest in 1957: 37.4%
- Share of forest in period 2014–2018: 67.6%

Assumption: If there is no vegetation cover change bigger increase of Qmean would have been expected.

Results: Rižana II

Modelling:

- without increase in share of forests the effective precipitation in 2014–2018 would be 20% higher – Qmean would increase from 4.12 to 4.95 m^3/s.
- Even more significant would this impact be in summer months (Jun–Aug) when effective precipitation would be 49% higher.

Conclusions

The study proved:

- the vegetation cover can have a significant impact on the spring hydrology over short and long time span.
- the applied methodology enabled the quantification of impacts of vegetation cover change on karst water sources.

Further modelling is needed for better understanding of long-term impacts of climate and land-use changes on water balance of karst springs with special focus on the quantification and evaluation of both factors.

Thank you!

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