



ČVUT
ČESKÉ VYSOKÉ
UČENÍ TECHNICKÉ
V PRAZE

AGRI-LANDSCAPE WATER RETENTION AND RUNOFF DYNAMICS

David Zumr

Desna 2023

12. 10. 2023

Typical features of Czech landscape

Large fields



Missing stabilizing elements



Low biodiversity



(ČÚZK)

Negative impacts

- Soils degradation
- Low water retention
- Accelerated runoff and soil erosion

Aims

- To understand the processes related to the water dynamics in the landscape scale
- How do the catchments react to the extreme weather



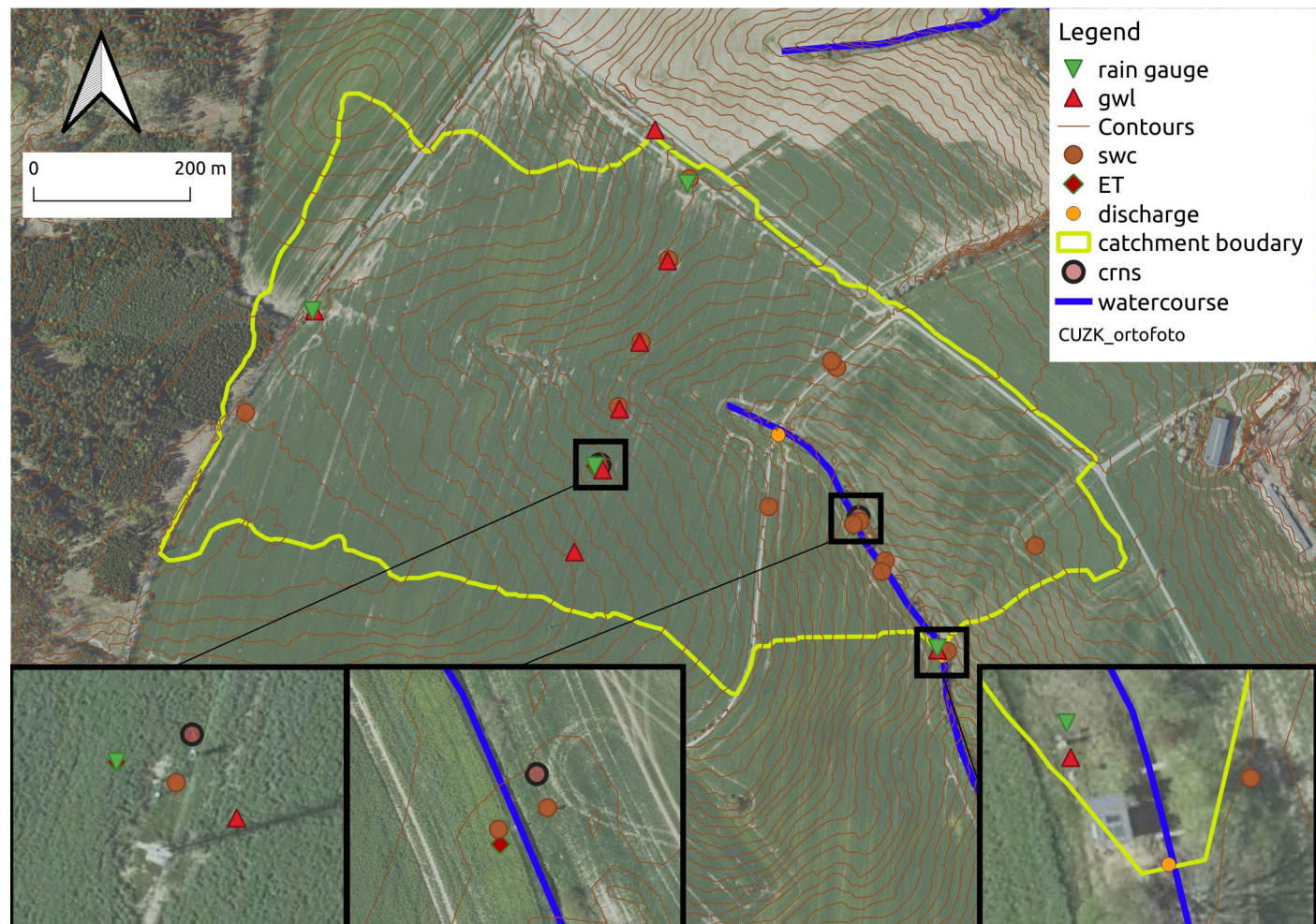
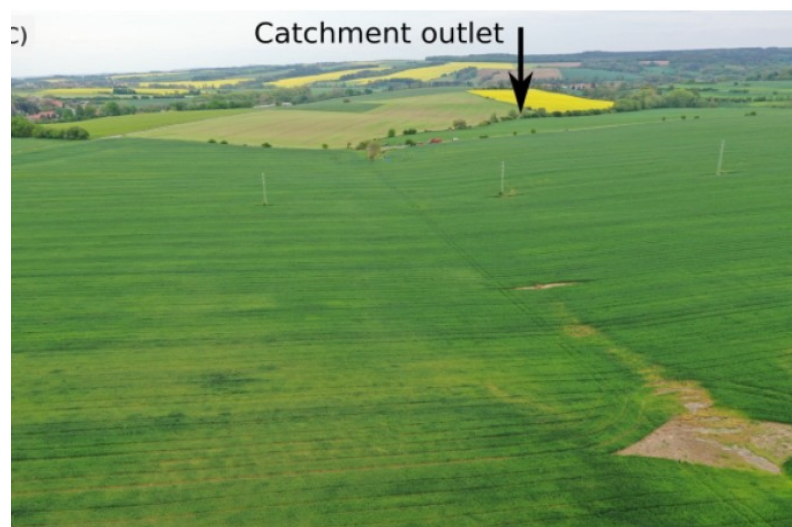
(foto: J. Krása)



(foto: D. Zumr)

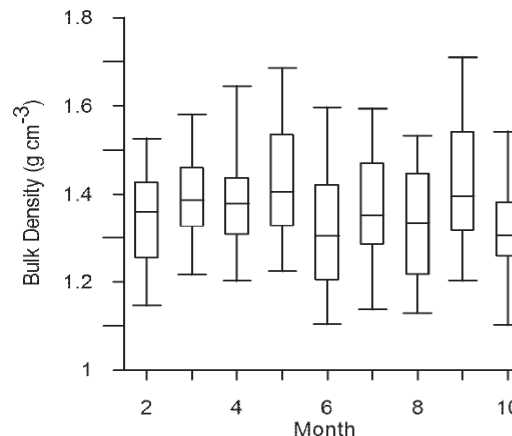
Experimental catchment Nučice (Kostelec nad Černými lesy)

- Established 2011/12
- Typical Czech agricultural landscape
- 50 ha, slopes up to 12 %, 96 % arable
- Complex instrumentation



Temporal variability of the soil properties

- Physical characteristics

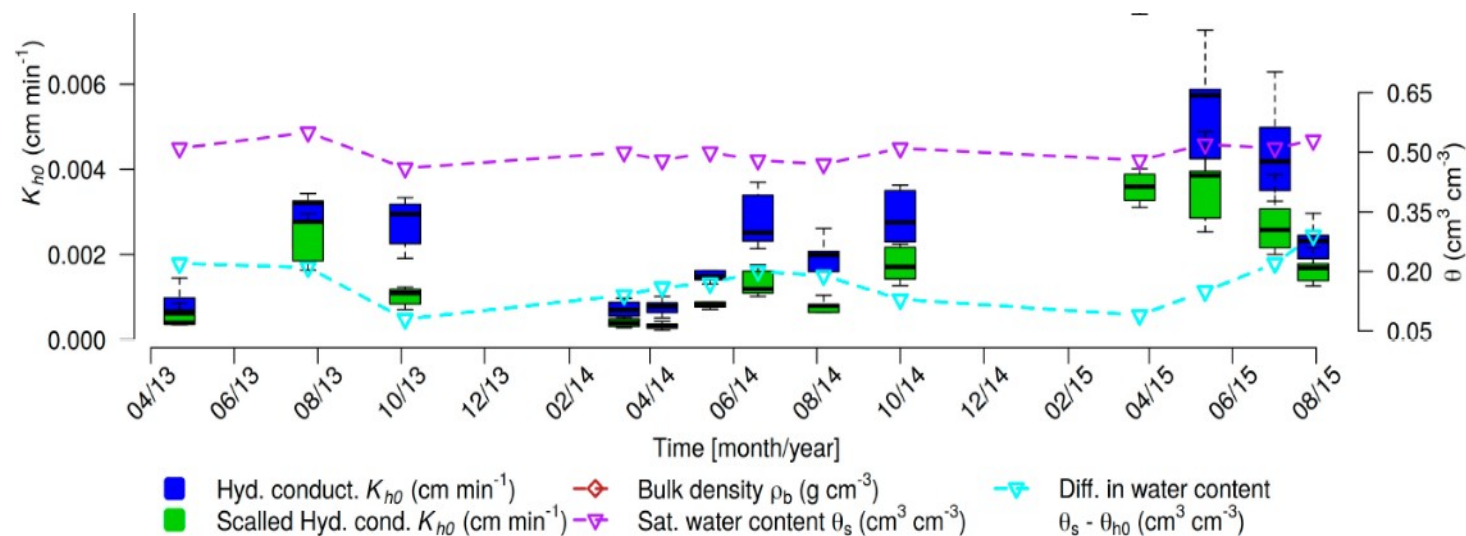


(Zumr et al., 2015)

- Hydraulic characteristics

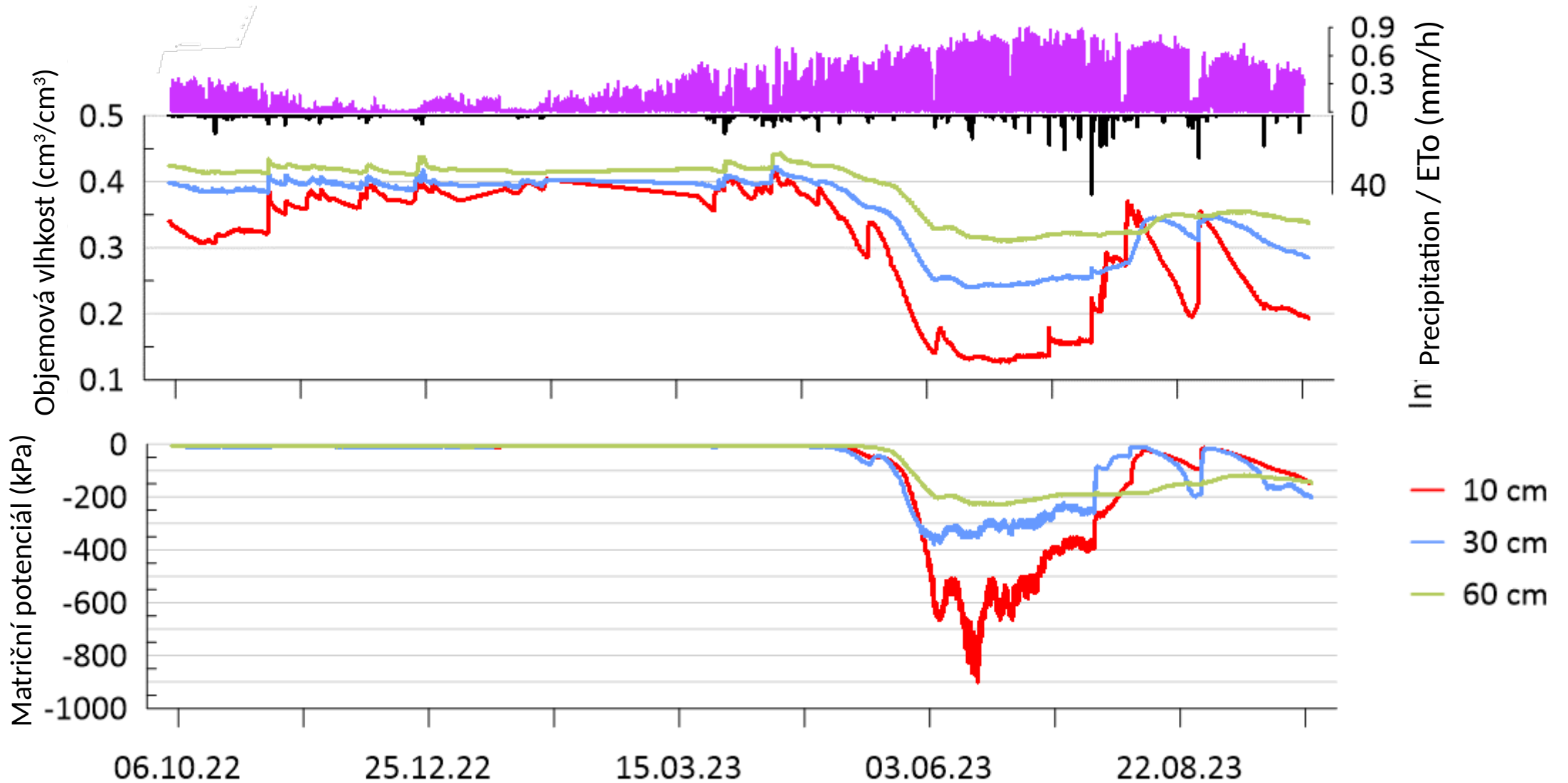


(foto: M. Císlarová)



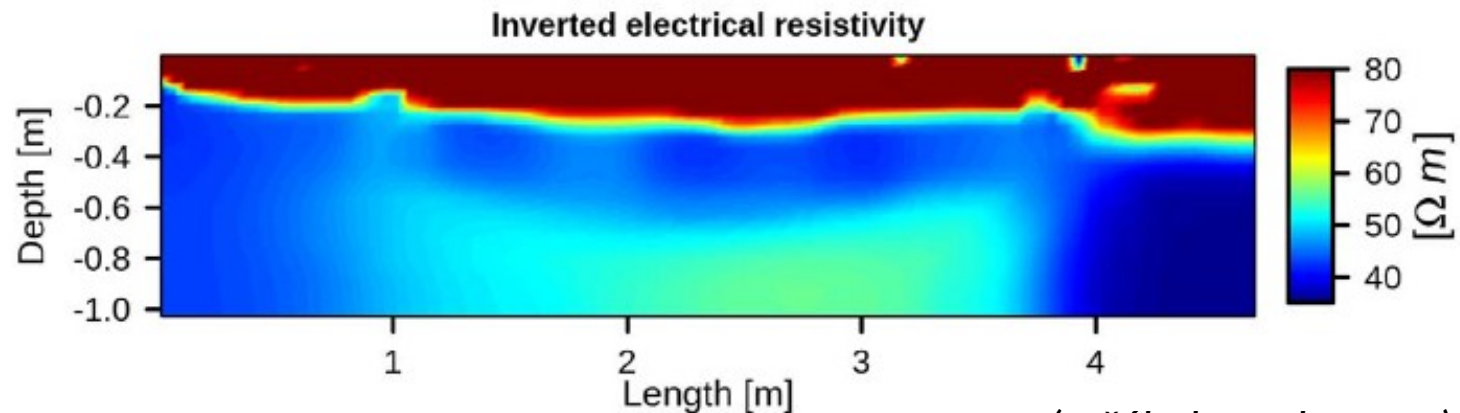
(Zumr et al., 2019)

Soil water regime monitoring



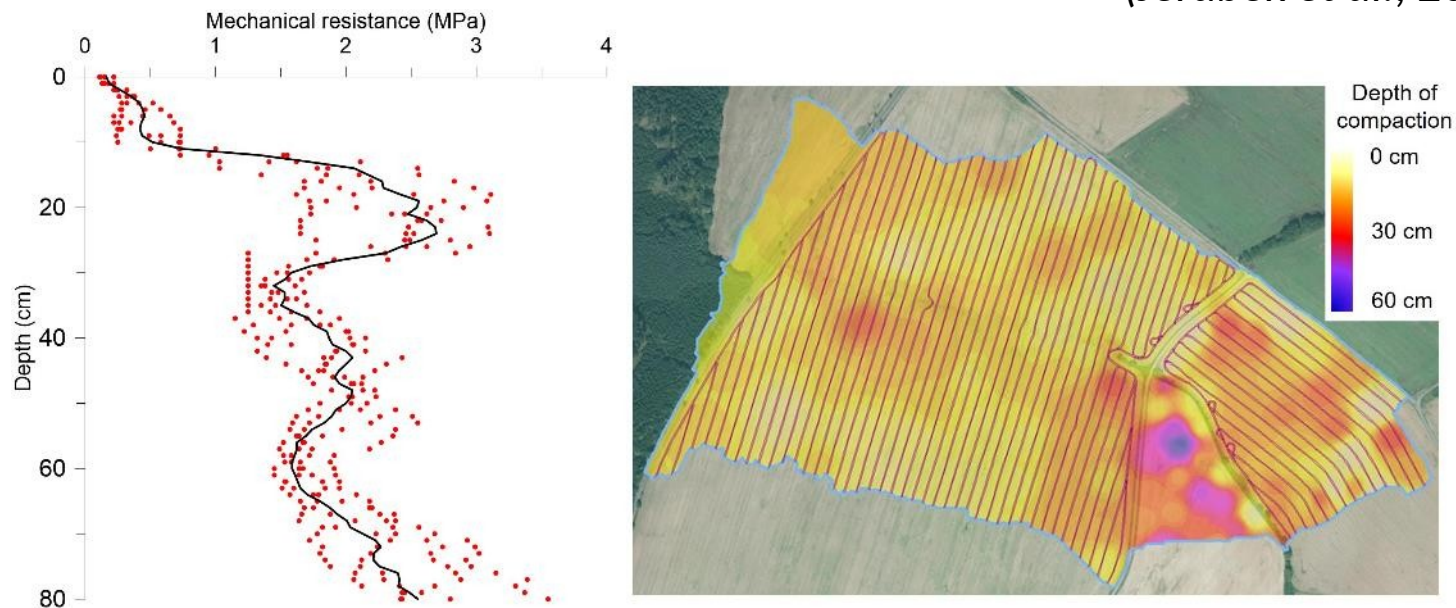
Compacted plough pan monitoring

- Electrical resistivity tomography



(Jeřábek et al., 2017)

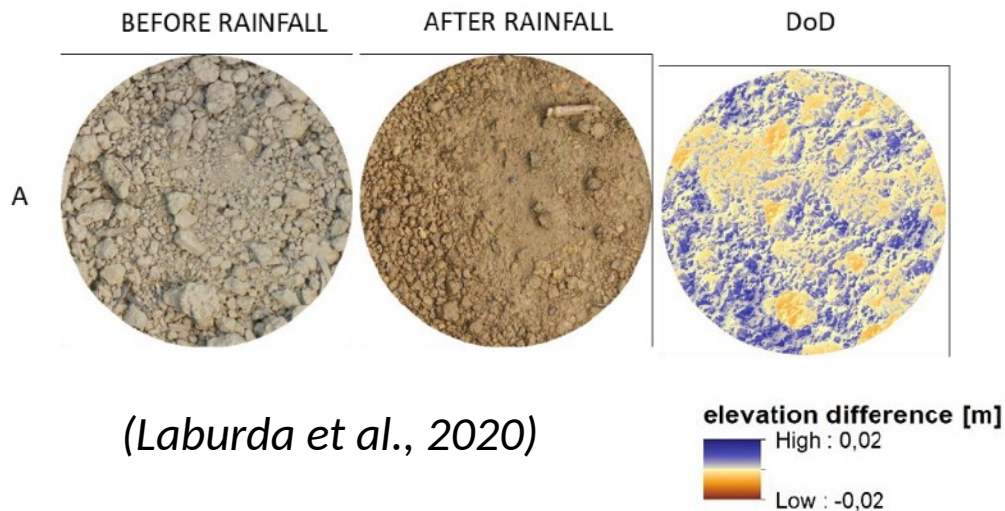
- Penetrometry



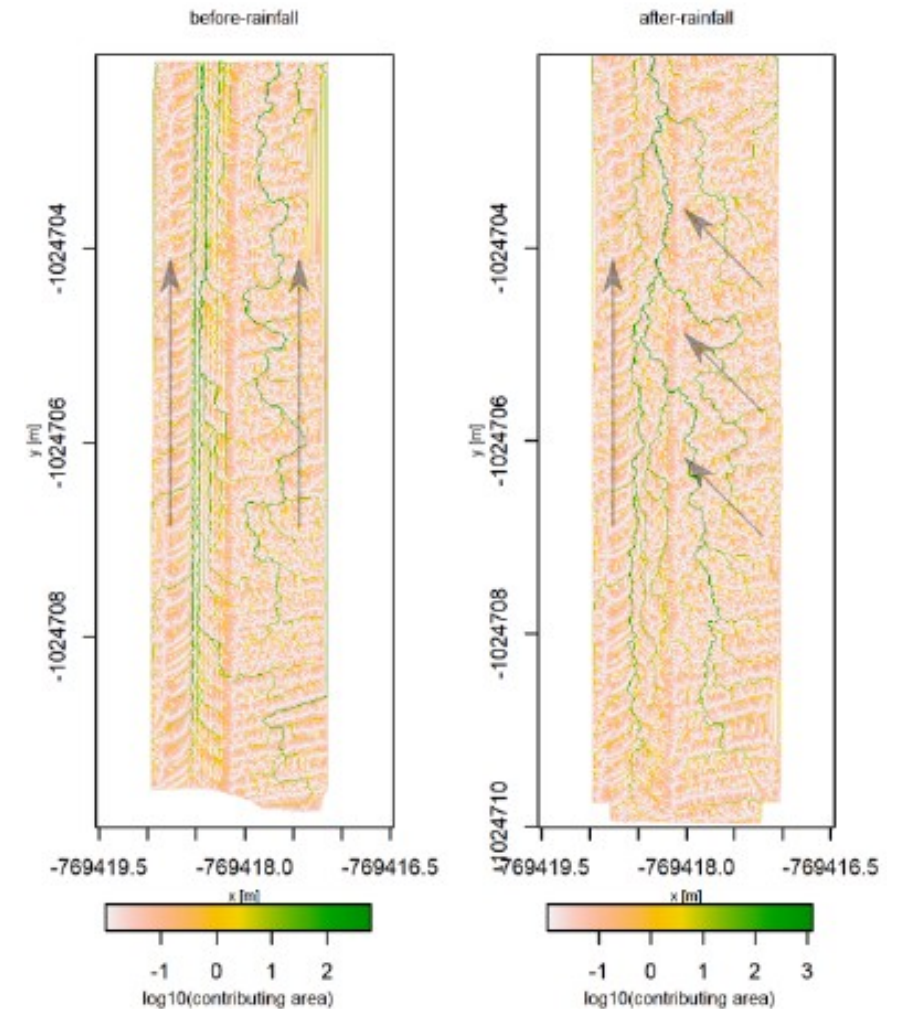
(Zumr et al., 2023)

Surface runoff formation and connectivity (plot scale)

- Rainfall simulations
- Photogrammetry + modelling



(Laburda et al., 2020)

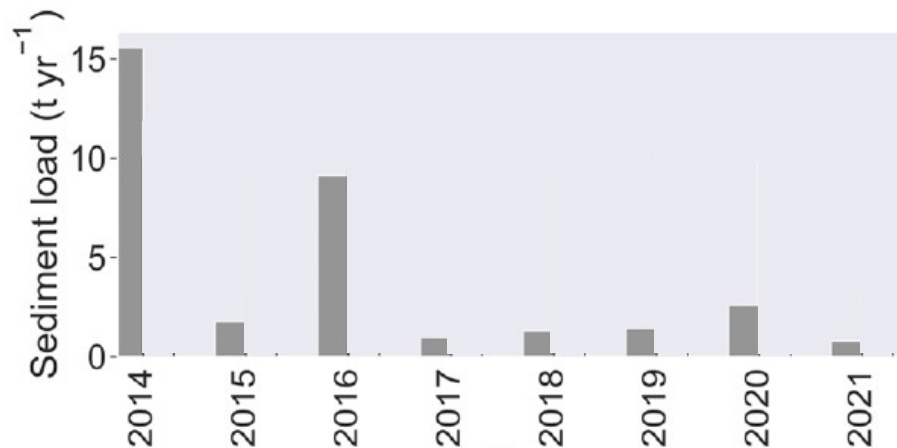


(Jeřábek et al., 2022)

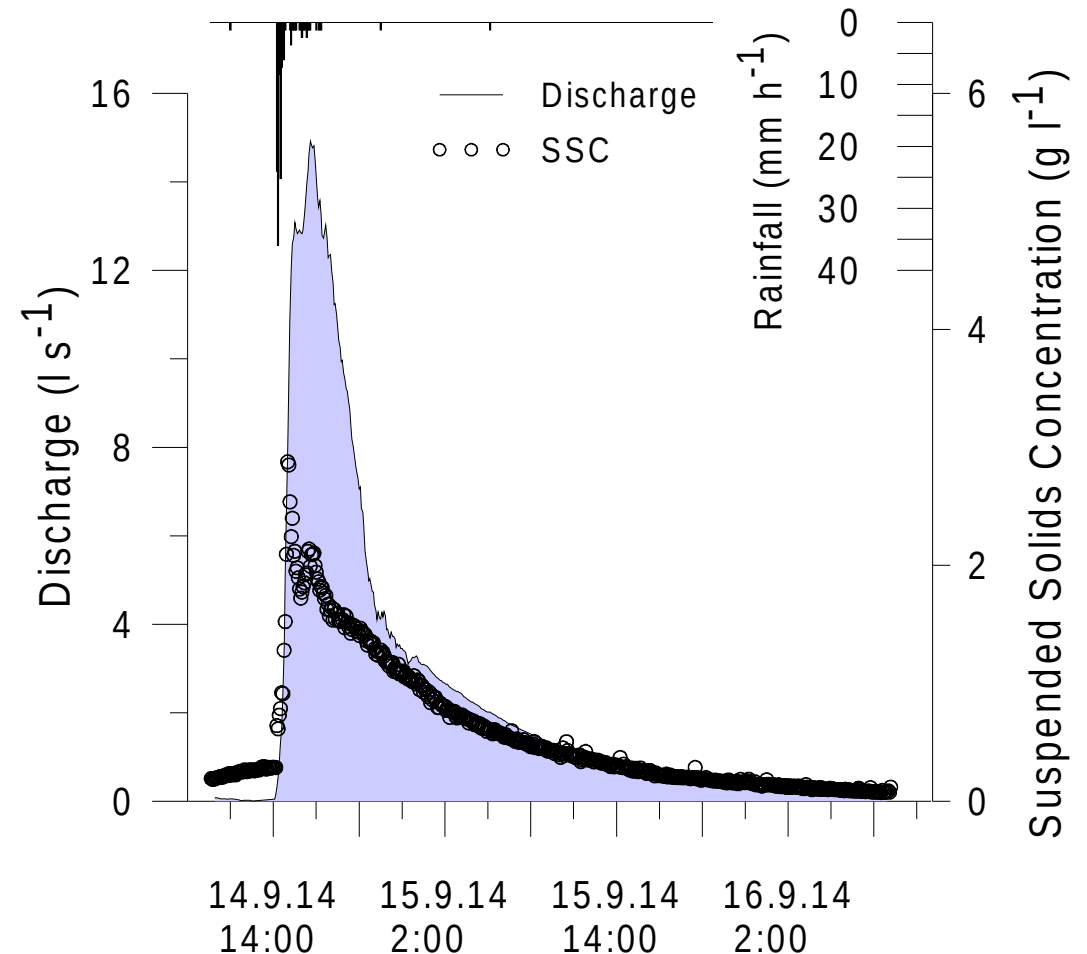
Runoff formation on a catchment scale

- Dynamic reaction (flushy)
 - Rapid runoff
 - Transport of sediment

b) Nučice, CZ



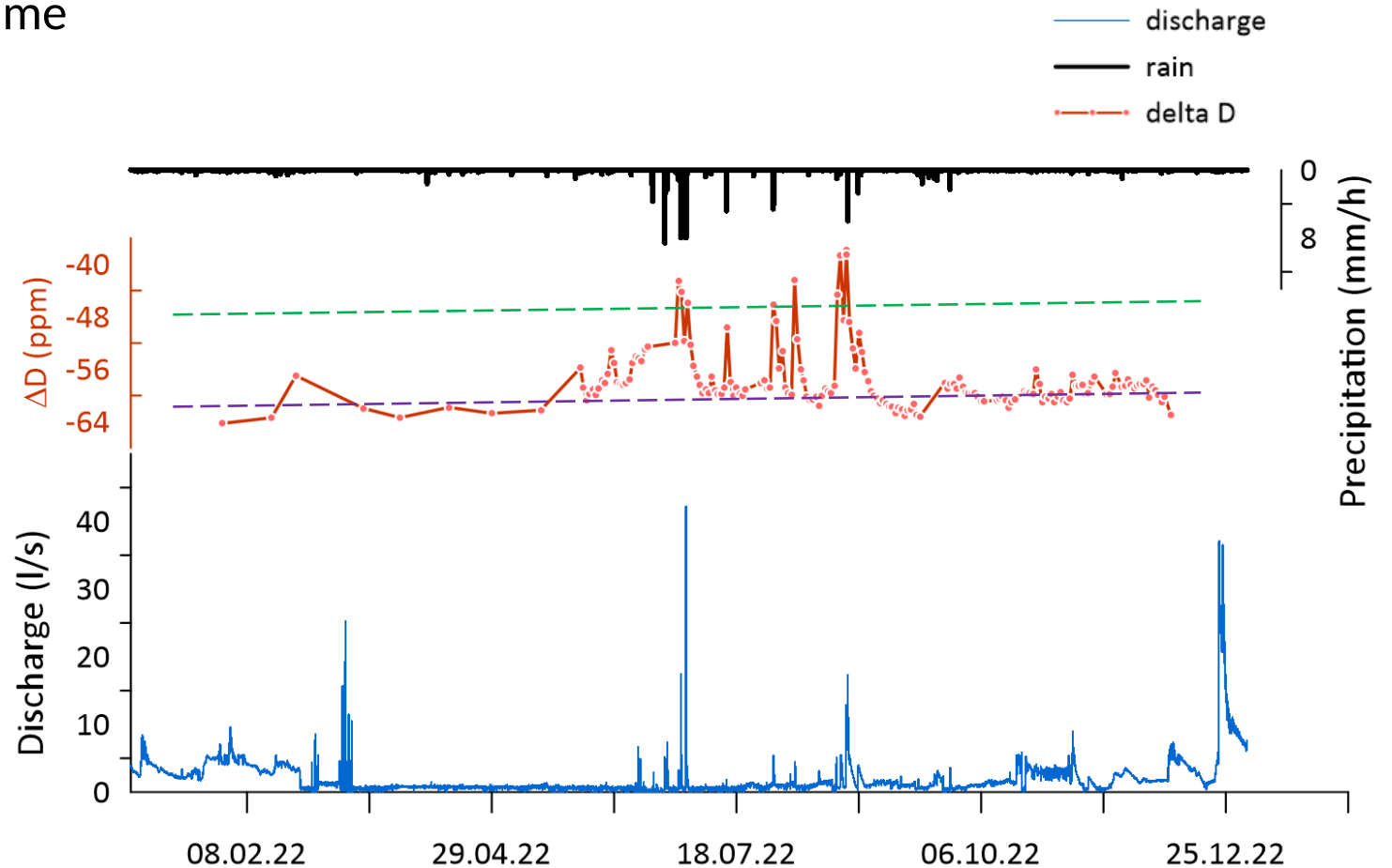
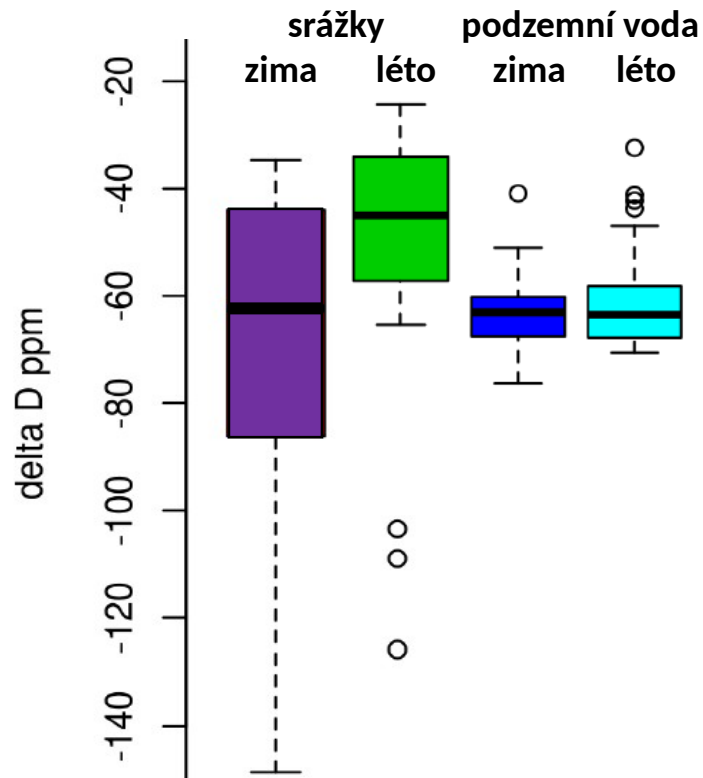
(Matthews et al., 2023)



(Zumr et al., 2015)

Isotope hydrology

- Water pathways
- Residence time

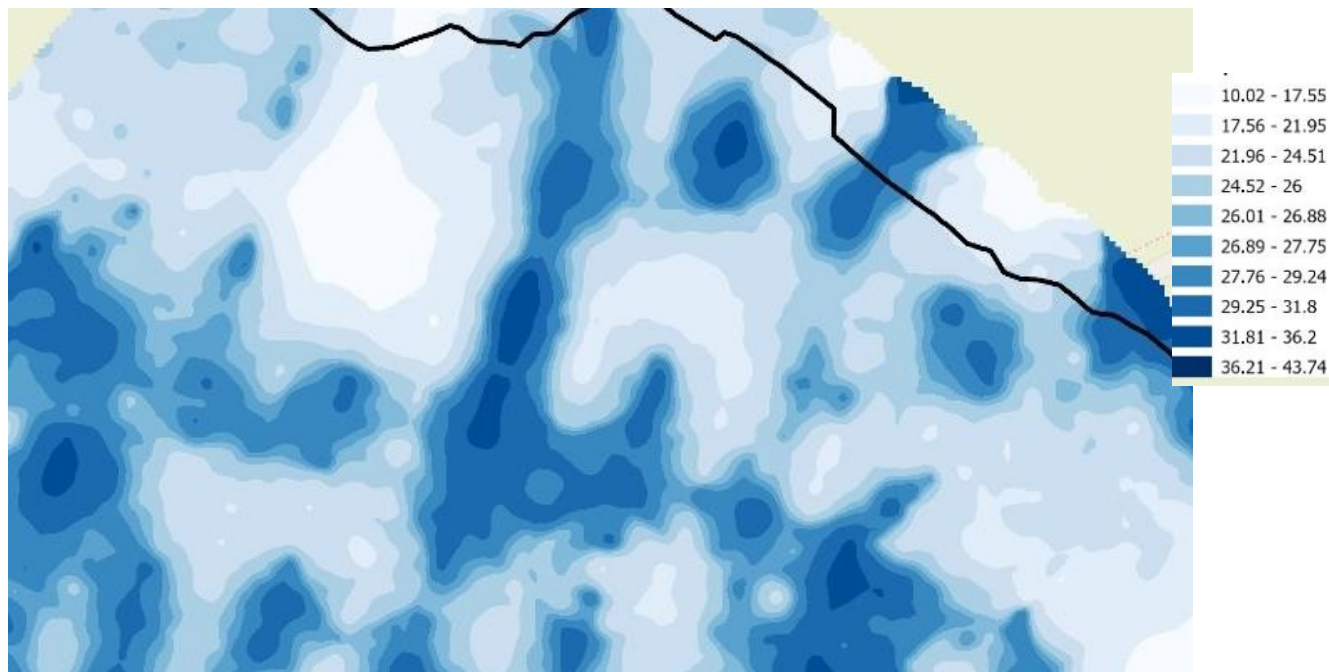


Spatial heterogeneity

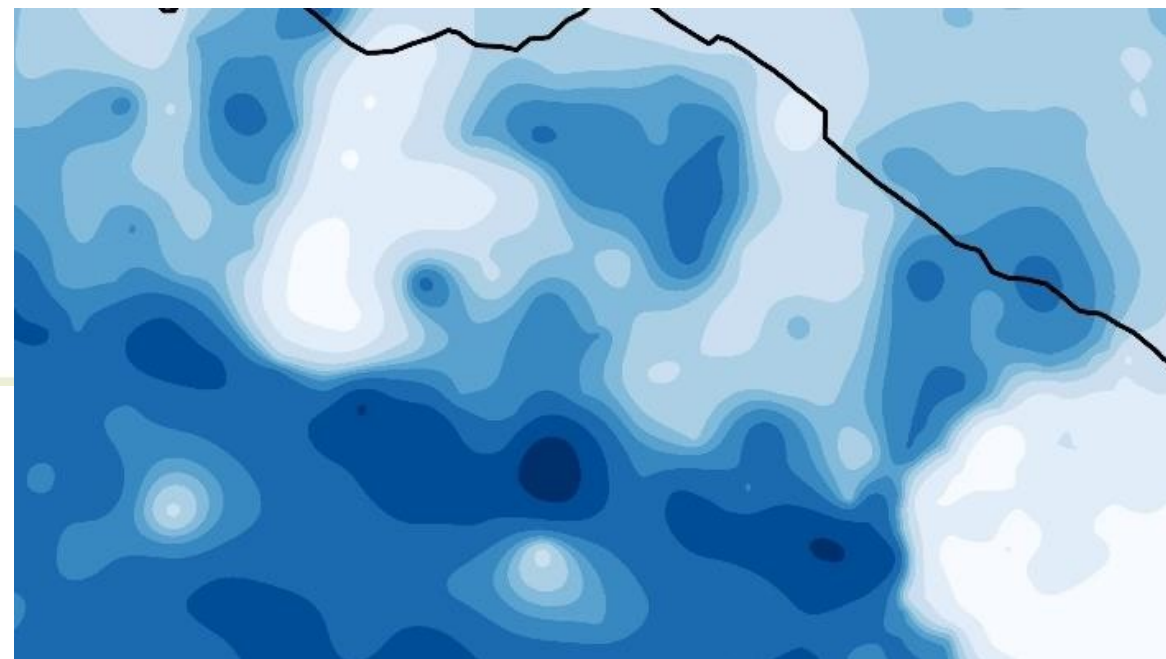


SWC spatial variability

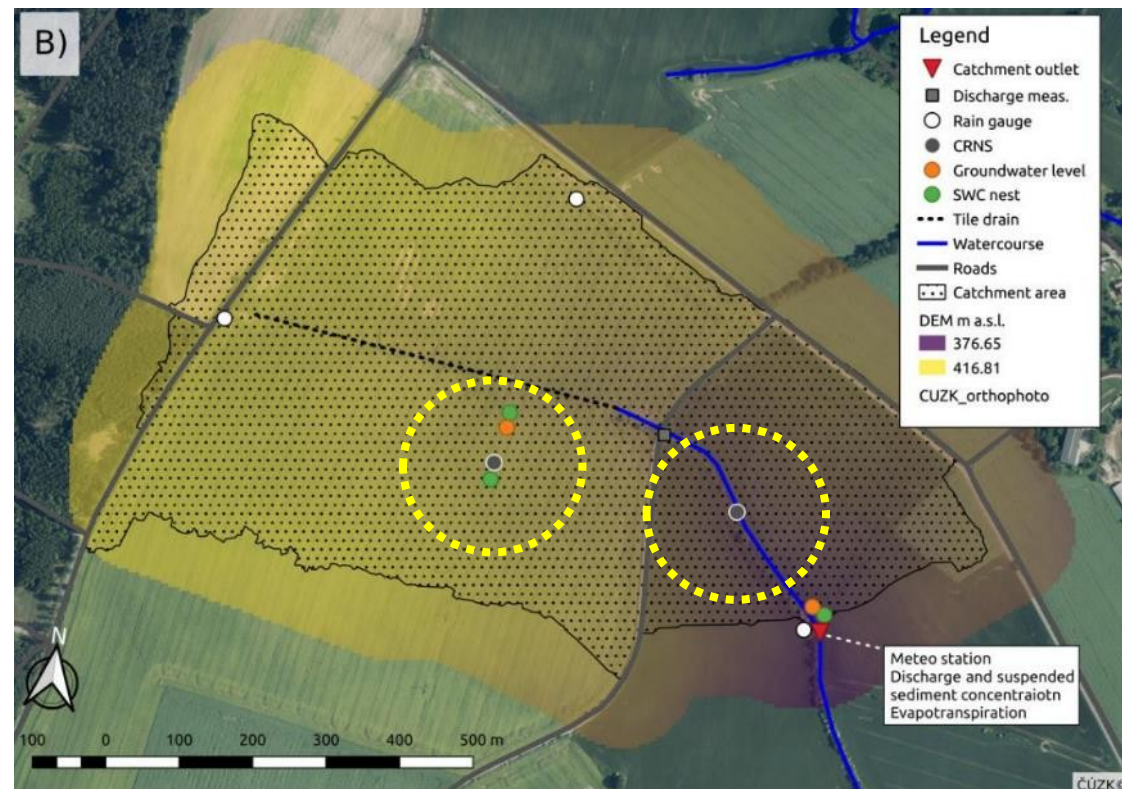
Topsoil SWC, October 2019



Topsoil SWC, March 2020

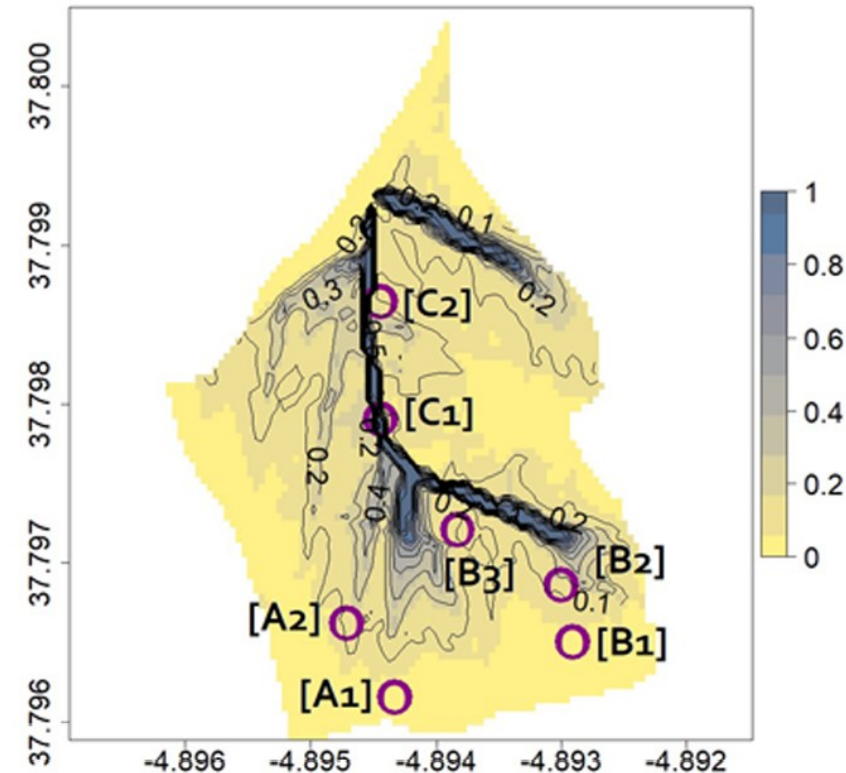


Cosmic Rays Neutron Sensing (CRNS)



Numerical modelling of the soil water regime

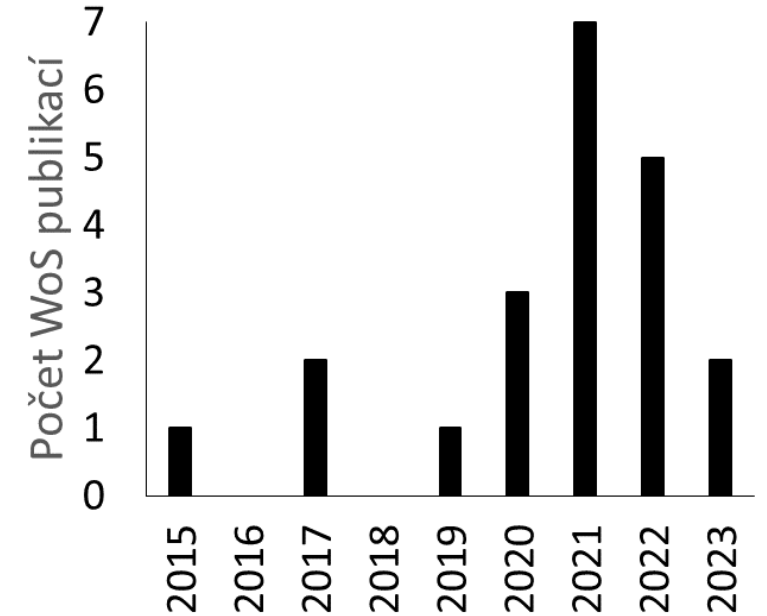
- Water balance and the runoff dynamics
 - Richards eq. (Hydrus, S1D)
 - Distributed models (MIKE SHE, HydroGeoSphere)
 - Semi-distributed model SWAT
- Scenarios simulation (climate, land/soil management, measures)



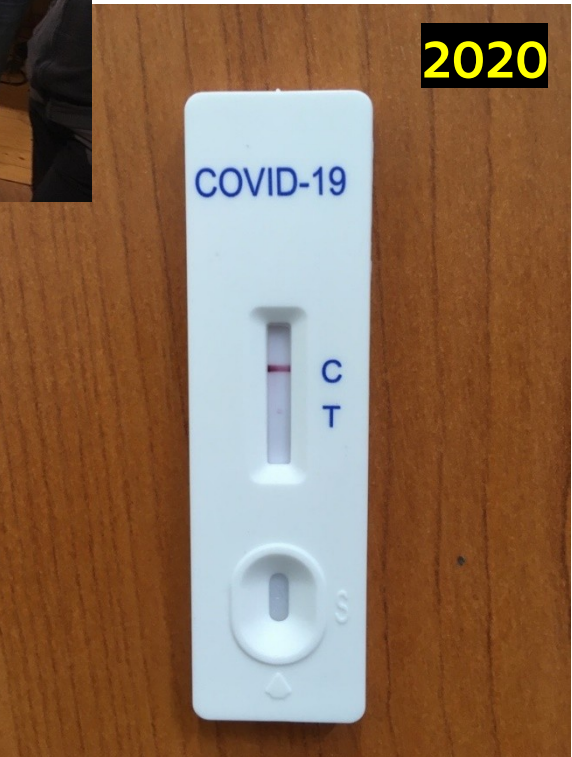
(Tenreiro et al., 2022)

Závěr – vědecké výstupy z experimentálního povodí

- součást mezinárodní sítě experimentálních povodí
- data v 5 mezinárodních databázích
- 11 financovaných projektů (+ SGS)
- 21 WoS publikací
- 2 obhájené doktorské práce (+ 1 před odevzdáním)



Thanks!





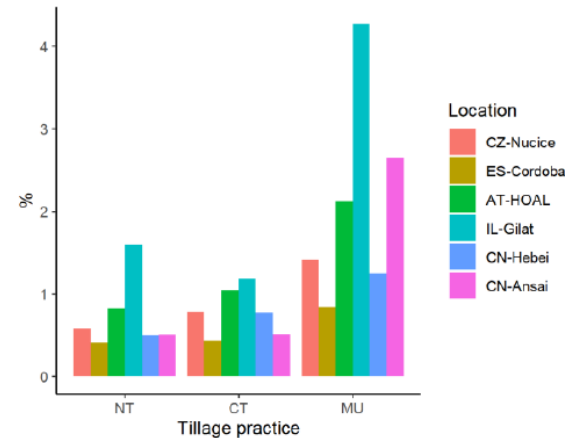
Odpovědi oponentům

Oponent: doc. Mgr. Lukáš Trakal, Ph.D.

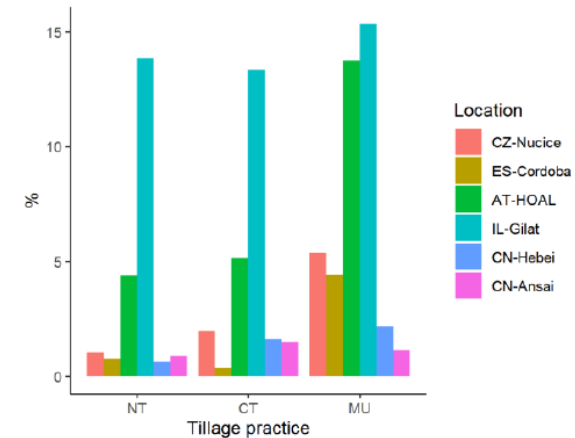
Jaký je Váš názor na "no tillage" technologii prosazovanou v rámci regenerativního zemědělství (v kontextu Vašeho tématu)?

Location	Soil type	Tillage practices	Ref.
Lower Austria	silt loam	CT*, AT, DS	[4]
Missouri, USA	silt loam	CT, DS	[3]
Prusy, Poland	silt loam	CT, AT, MU	[10]
Eastern Austria	loam	CT, AT	[6]
Upper Austria	loamy silt, silty l.	CT, DS, MU	[21]
Lower Austria	silt loam, loam	CT, AT, DS	[22]
Ohio, USA	silt loam, clay l.	CT, MU	[13]
Navarre, Spain	silt loam	CT, DS	[23]
Southern Italy	clay	CT, AT	[24]
Buenos Aires, Argen.	clay loam, clay	CT, DS	[5]
Olite, Spain	silty clay loam	CT, AT, DS	[25]
middle Germany	silty loam	CT, AT	[26]
Lttewitz, Germany	silt loam	CT, DS	[27]
Minnesota, USA	clay loam	CT, DS	[28]
New York, USA	silt loam	CT, AT	[7]
Ohio, USA	silt loam	CT, AT, DS	[29]
Belgium	sandy loam	CT, AT	[12]
Alaska	loam, sandy l.	CT, AT, DS	[30]
Alberta	loam	CT, AT, DS	[8]
Alberta	clay loam	CT, AT, DS	[31]
Colorado, USA	sandy loam	BUR., UNB.	[32]
Colorado, USA	various	BUR., UNB.	[18]
California, USA	various	BUR., UNB.	[16]
Colorado, USA	Sand	BUR., UNB.	[15]
New Mexico, USA	NA	BUR., UNB.	[19]

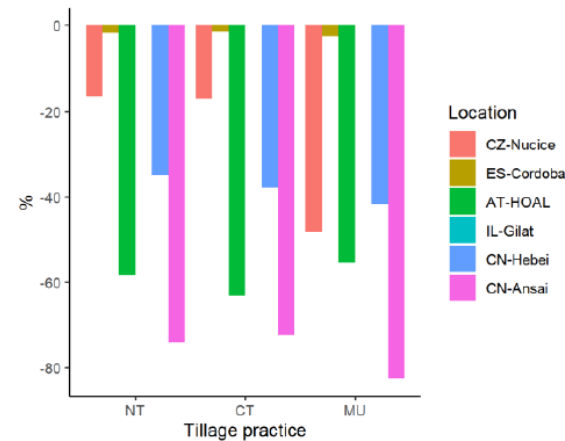
*CT - conventional tillage; DS - direct seeding; AT - alternative tillage; minimum, reduced or any kind of no soil inversion till; MU - mulch or crop residues application; BUR. - burned soil surface; UNB. - unburned soil surface.



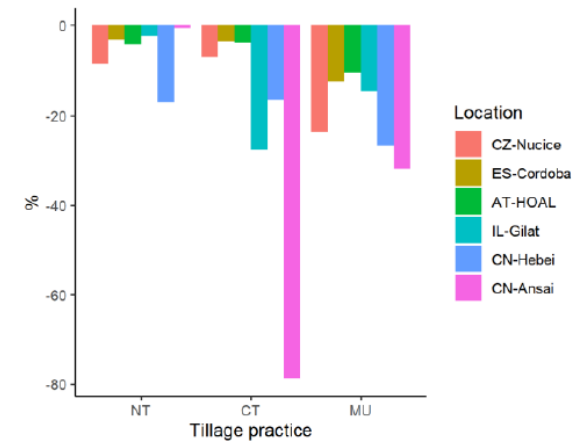
A) average increase of the soil water storage in the middle of the growing season



B) average increase of the soil water storage at the end of the growing season



C) average decrease of the cumulative surface runoff.



D) average decrease of the cumulative plant water stress.

(Jeřábek, Zumr et al., 2022. Shui project deliverable)

Oponent: doc. Mgr. Lukáš Trakal, Ph.D.

Jak velký vliv by mělo použití tzv. Konturového zemědělství (případně používání meziplodin) na výsledný odtok ppř. půdní smym v rámci pole obdělávaného konvenční orbou?

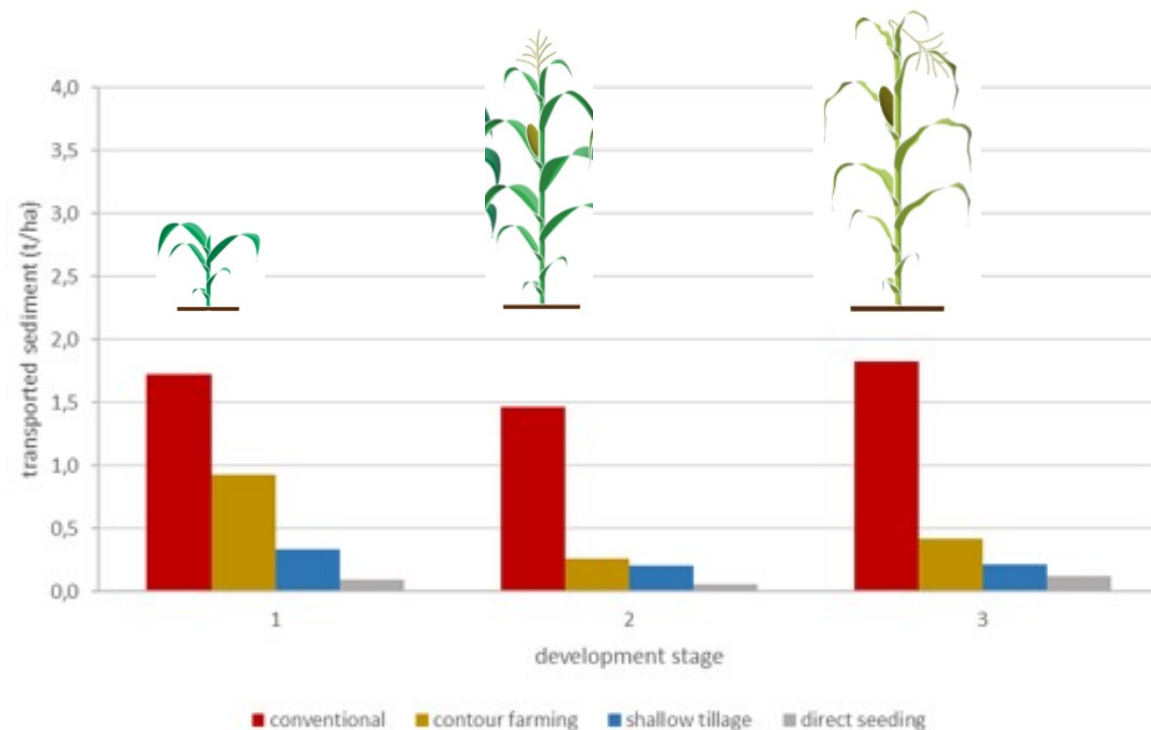
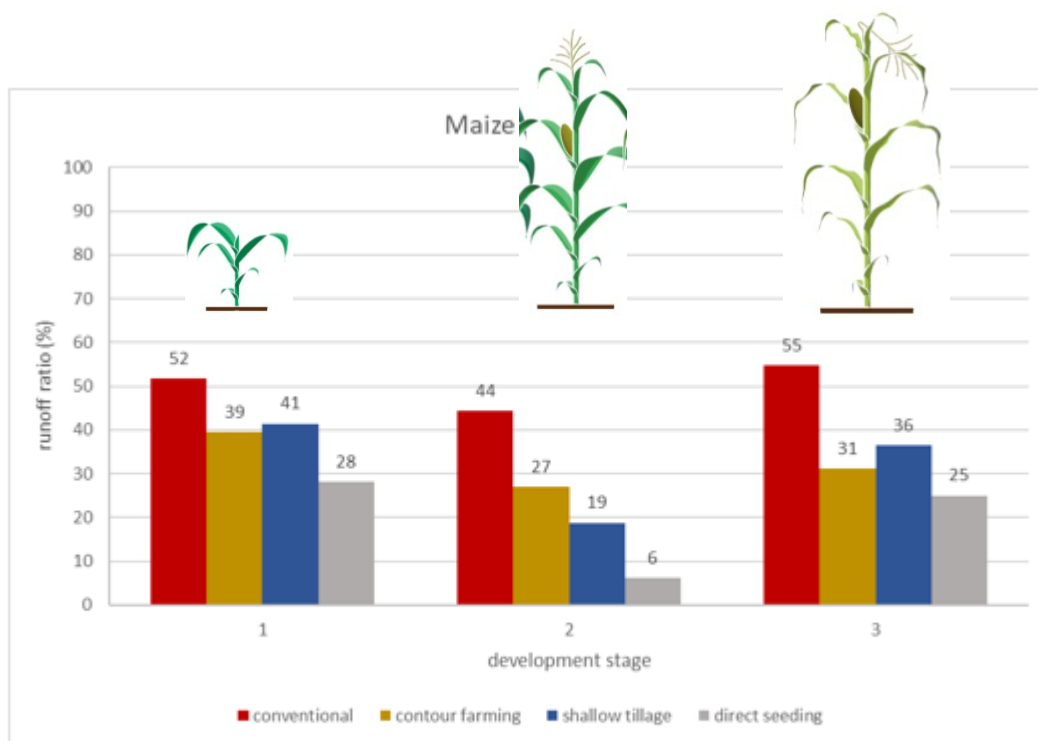


Figure 8 Runoff ratio after 30-minute intensive rainfall for maize seeded in 4 scenarios of different BMP intensity. The 3 development stages represent (1 – first month after seeding, 2 – fully developer plants, 3 – just before harvest)

(Dostál et al., 2022 Shui project deliverable)

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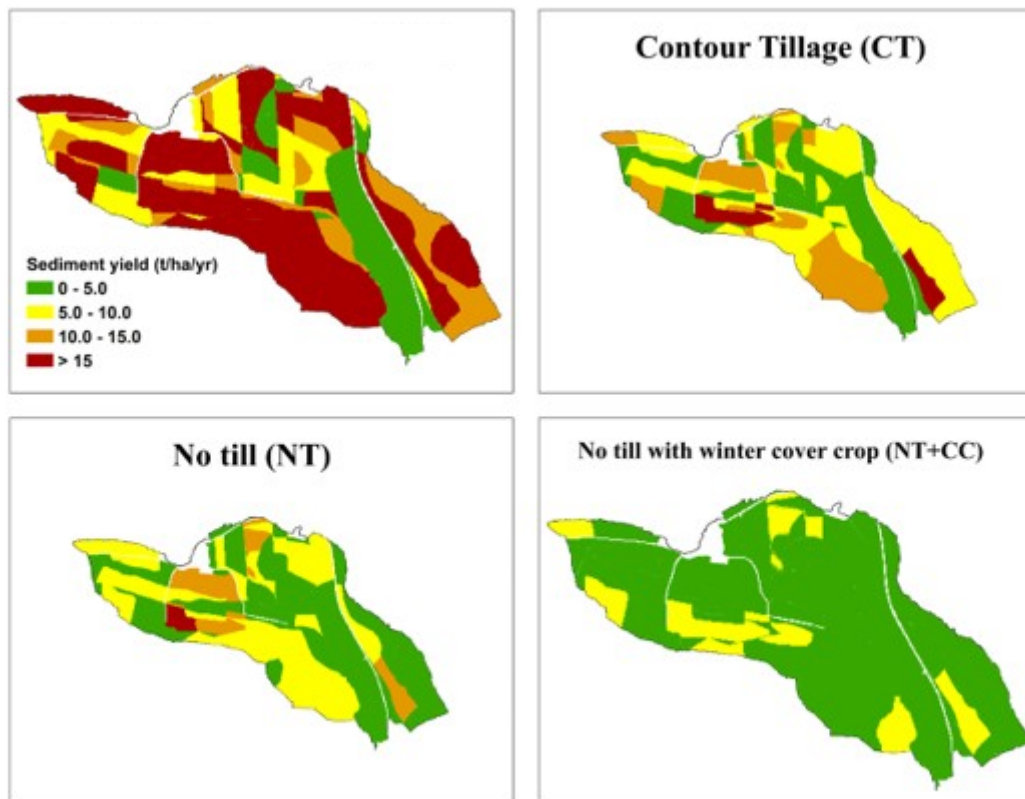
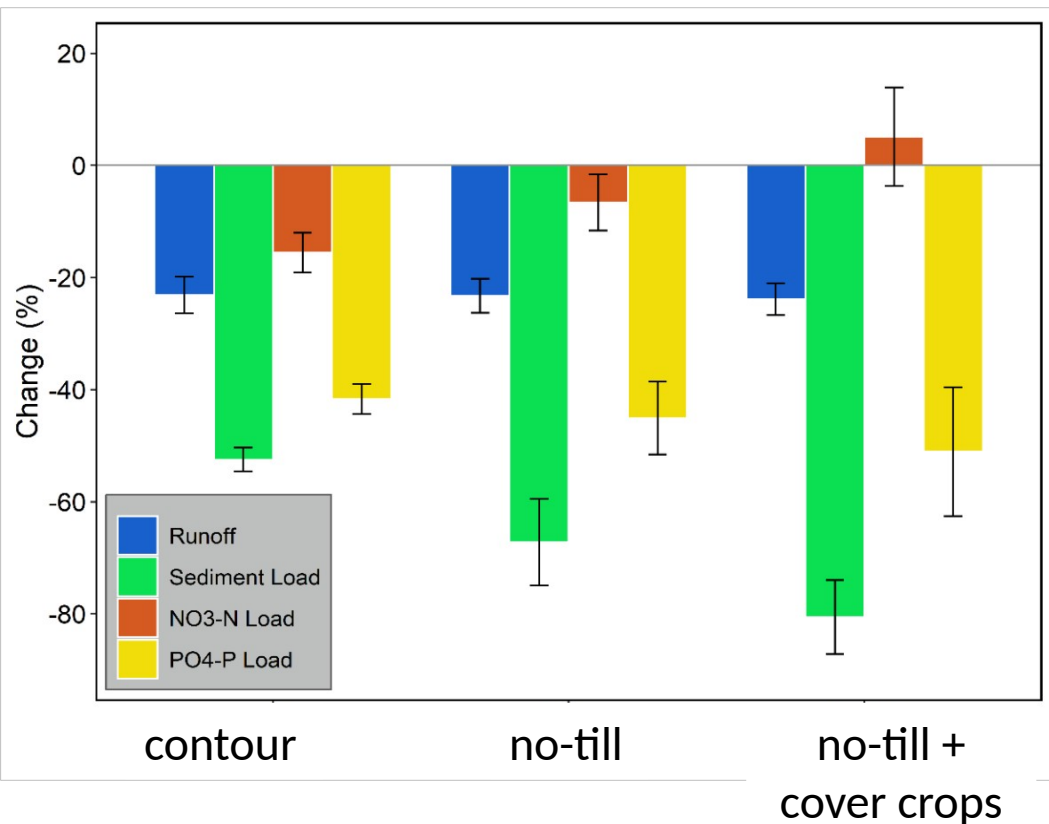


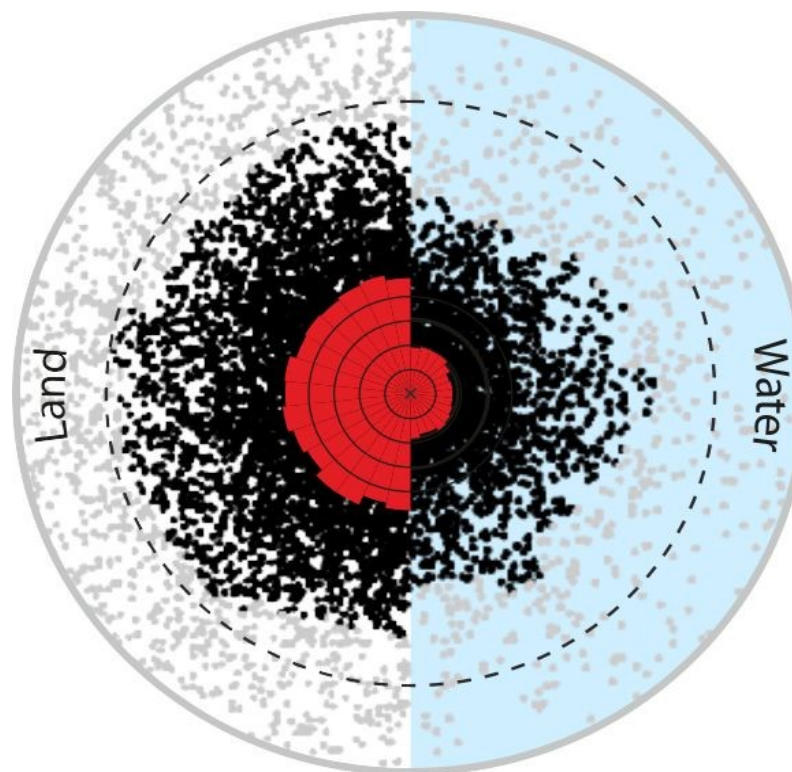
Figure 15 Annual sediment loss from agricultural fields when CT, NT, and NT+CC best management practices were implemented in the HOAL catchment

Oponentka: prof. Ing. Radka Kodešová, CSc.

Doporučuji pozornost publikaci Brunetti et al. „On the information content of cosmic-ray neutron data in the inverse estimation of soil hydraulic properties” a zajímá mne, zda by mohl podobný přístup využít pro interpretaci dat monitorovaných v Nučicích.

Princip metody CRNS

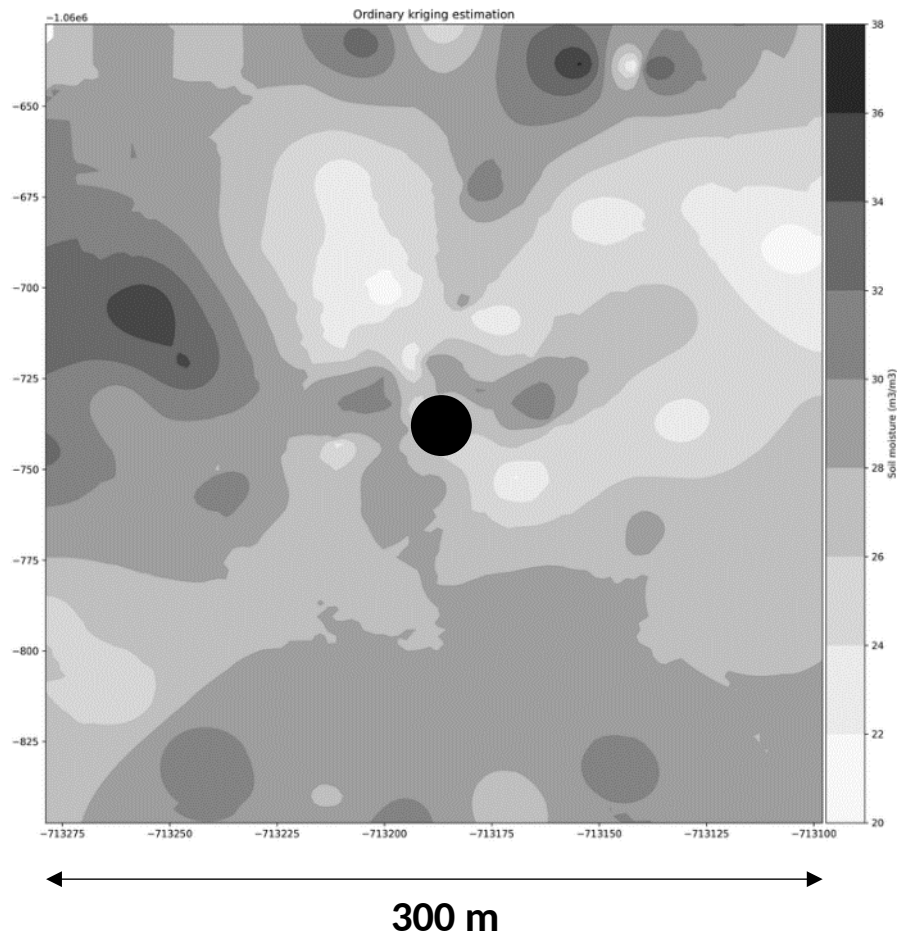
- Spršky neutronů dopadají na zemský povrch
- Neutrony interagují s atomy vodíku
 - Sucho – neutrony se odráží
 - Vlhko – neutrony jsou absorbovány



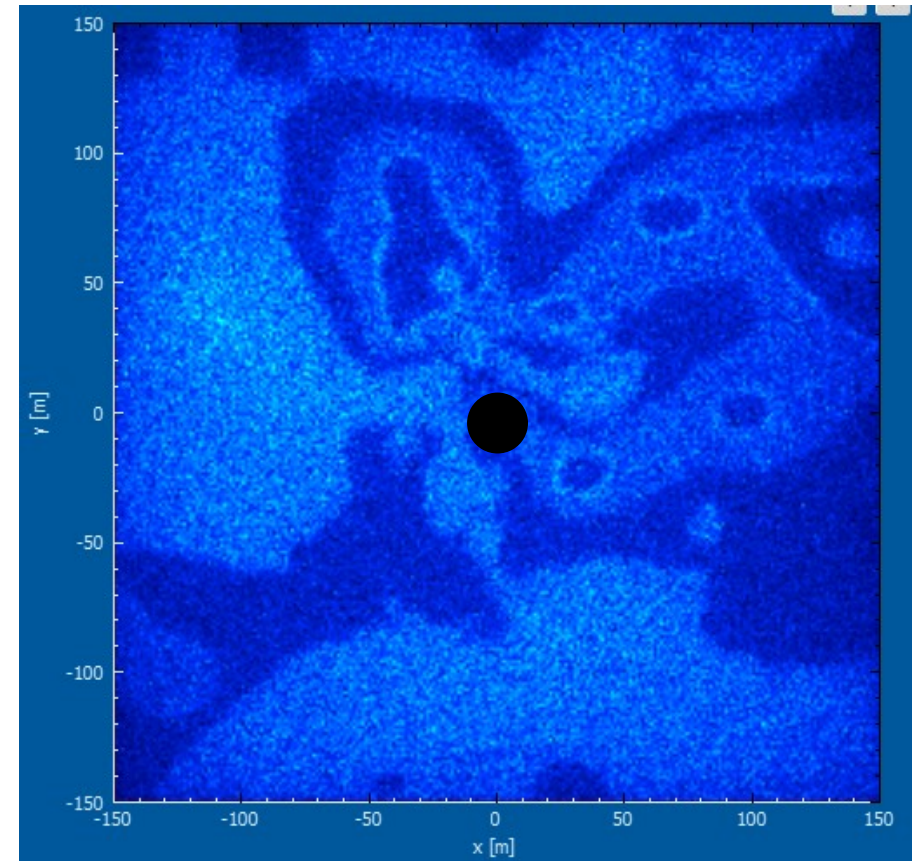
(<https://www.physi.uni-heidelberg.de/>)

Monte Carlo simulace trajektorií jednotlivých neutronů (model URANOS)

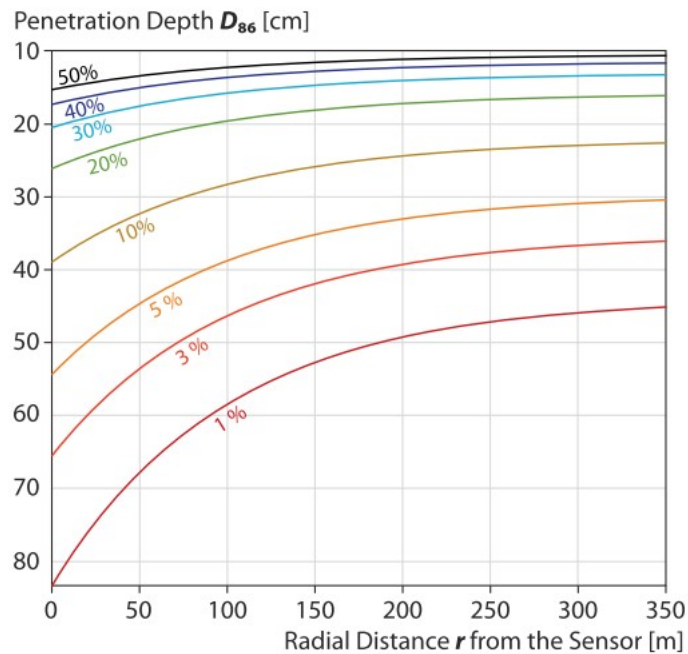
Vlhkost ornice



Zdroj detekovaných neutronů

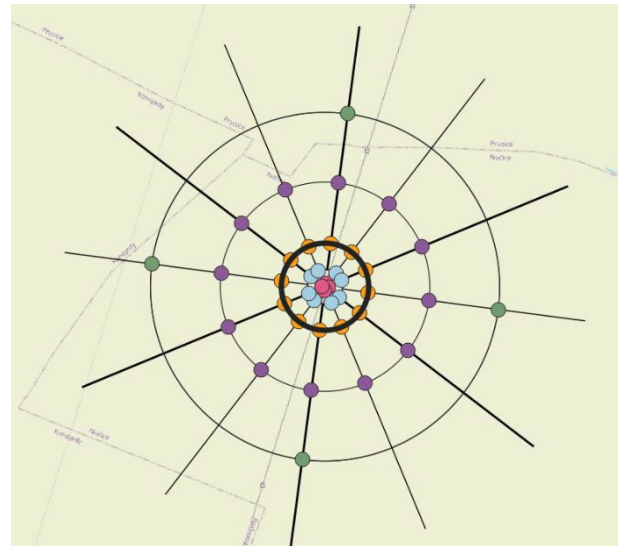


Identifikace měřené oblasti



(Koehli et al., 2015)

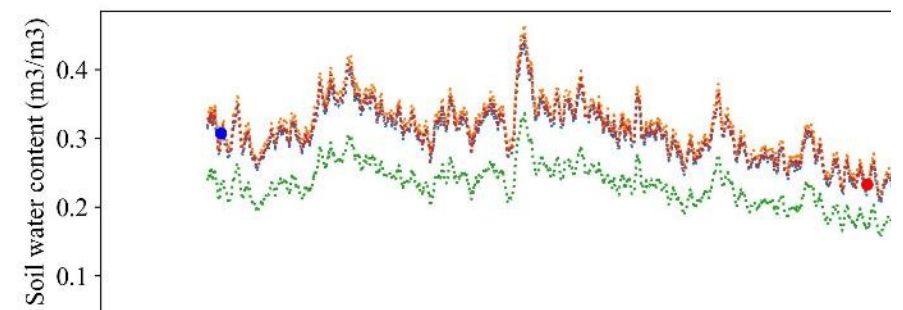
-> kalibrace přístroje



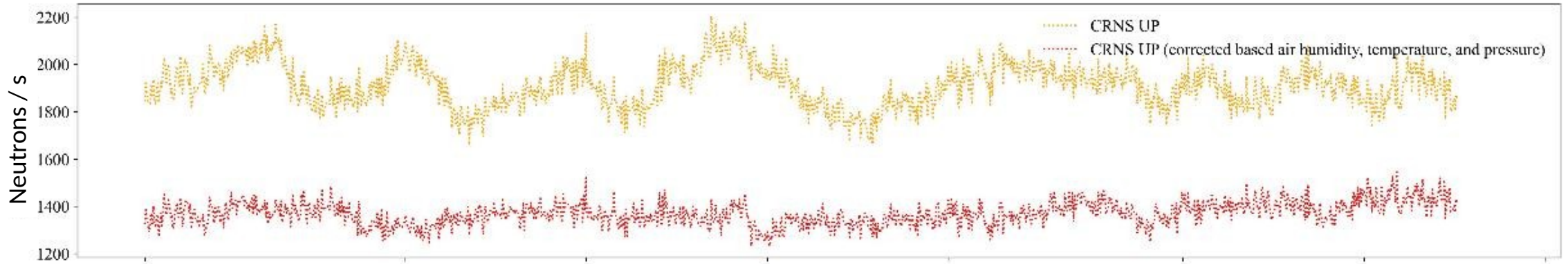
(Ferlin, 2023)

-> korekce o vodík v atmosféře nebo biomase

$$\theta_T = \theta_V + \theta_{LW} + \theta_{SOC} + \theta_B + \dots + \theta_i = \left(\frac{a_0}{F(t) \frac{N}{N_0} - a_1} - a_2 \right) \rho_b$$



Brunetti et al.



Zjednodušený model



Inverzní úloha H1D

Repräsentativní hydraulické charakteristiky

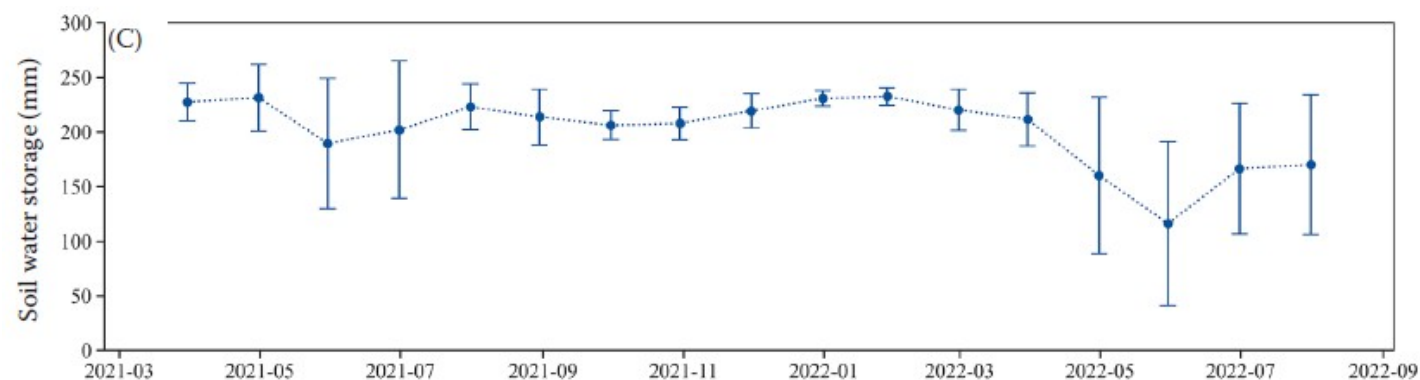
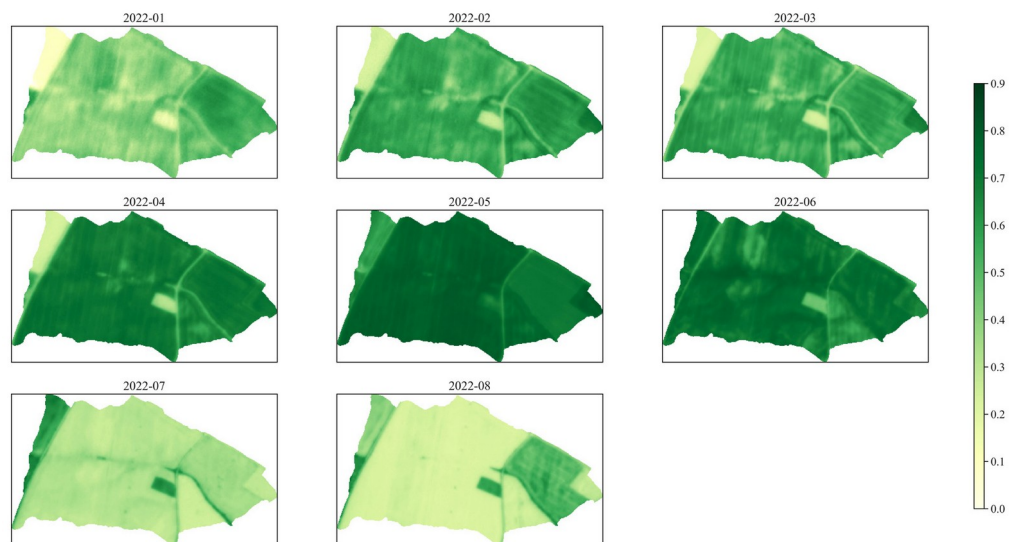
Oponentka: prof. Ing. Radka Kodešová, CSc.

... má v plánu využít satelitní dálkový průzkum pro monitorování půdních vlhkostí. Jaký přístup by chtěl využít, a to jak po stránce technické a metodické?

- Propojení dat z bodových čidel, CRNS a dálkového průzkumu (Sentinel)

Prostorová variabilita na základě vegetačních indexů

- CubeSats (PlanetScope): denní / 3 m rozlišení

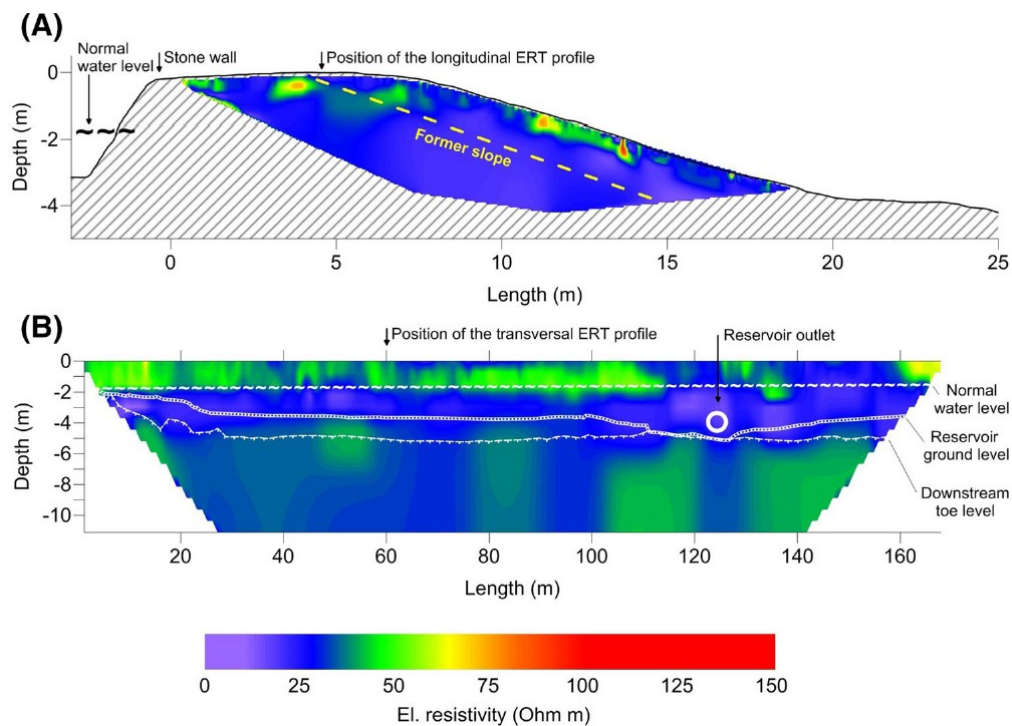


(Li et al., 2023)

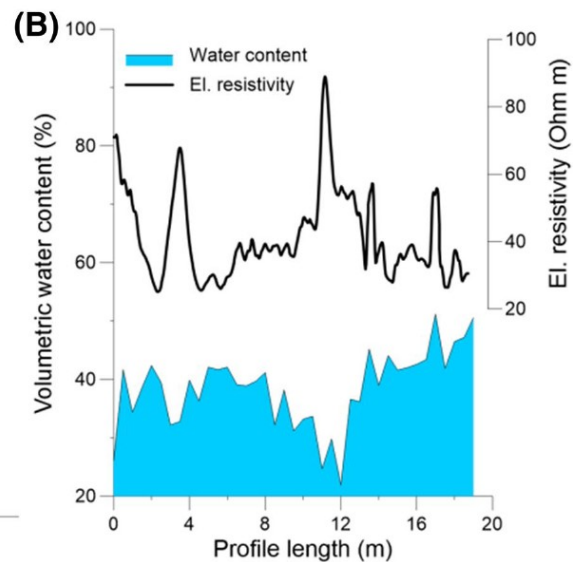
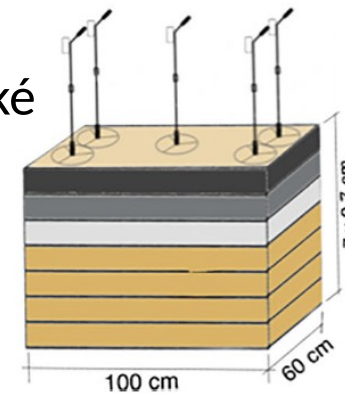
Oponentka: prof. Ing. Radka Kodešová, CSc.

Jaké další geofyzikální metody je v plánu v budoucnosti využít pro popis stratifikace vadózní zóny? Jaké jsou možnosti geofyzikálních metod (včetně elektrické odporové tomografie) pro plošné mapování půdních vlastností včetně půdní vlhkosti.

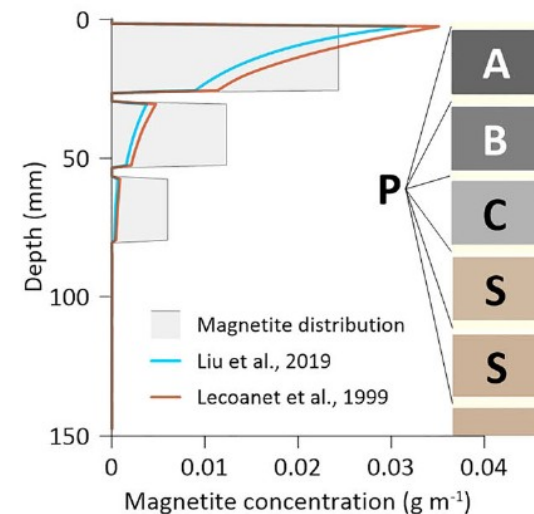
Elektrická rezistivní tomografie



Měření magnetické susceptibility



(Zumr et al., 2020)



(Zumr et al., 2023)