Runoff and soil loss at cultivated soil with wheel track effect: a case study

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Workshop on soil physics and landscape hydrology

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Motivation

- Formation of runoff and soil loss at cultivated soil
- Effect of wheel tracks on runoff and soil loss formation
- Monitoring of shallow subsurface processes and their effect on runoff and soil loss

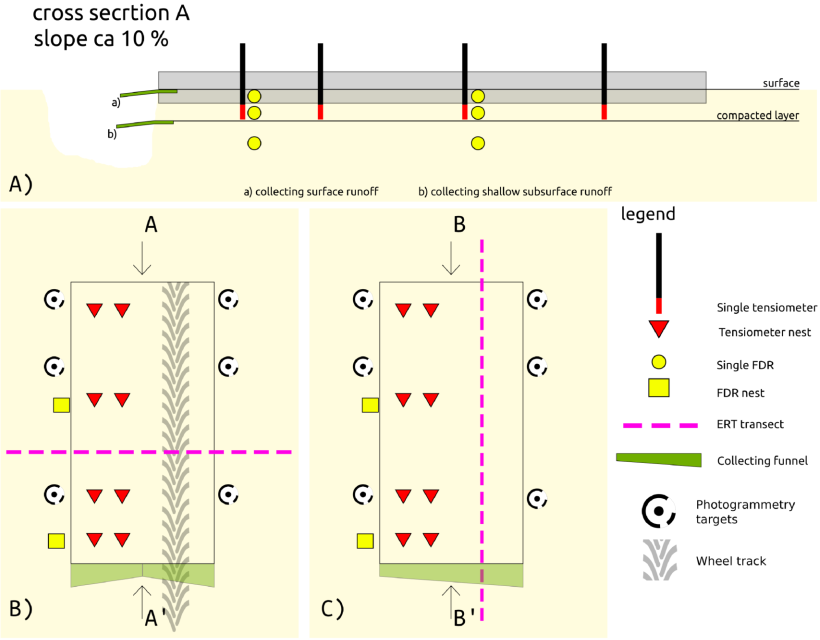
Artificial rainfall experiment on a cultivated soil

- Two 16 m^2 plots
  - without wheel track $->$ reference plot
  - with wheel track
- Rainfall of intensity of 30 mm/hour
- Measures variables
  - surface/subsurface runoff
  - soil loss
  - shallow water content and suction pressure
  - transport of tracer (deuterium)
  - soil water redistribution (ERT)
  - Surface development (photogrammetry)

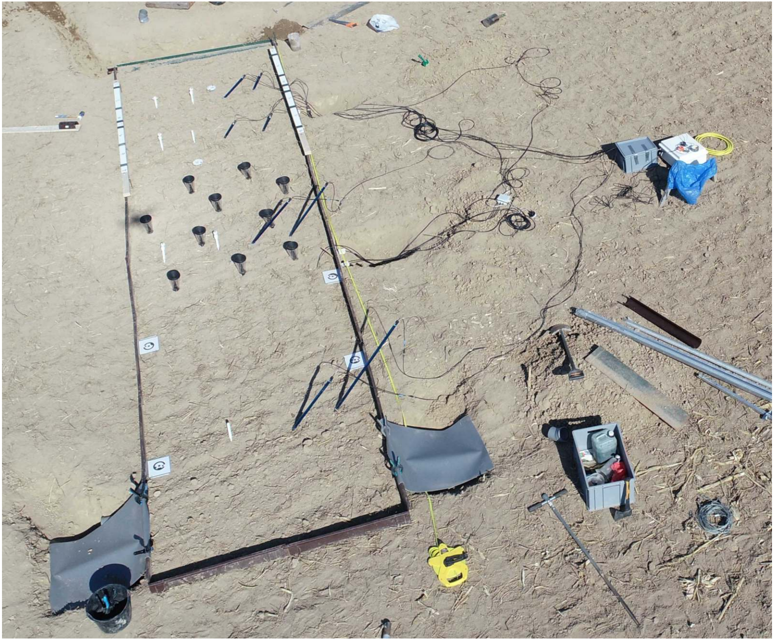
1. Overview

Seedbed and wheel track preparation

- seedbed preparation 5 days prior the experiment
- artificial wheel track created a day prior experiment
  - four passages of tractor and seedbed preparation “device”
  - very dry soil


cross secrtion A
slope ca 10 %
surface
compacted layer
a)
b)
A)
a) collecting surface runoff
b) collecting shallow subsurface runoff
A
A'
B)
B
B'
C)
legend
Single tensiometer
Tensiometer nest
Single FDR
FDR nest
ERT transect
Collecting funnel
Photogrammetry targets
Wheel track

2. Setup

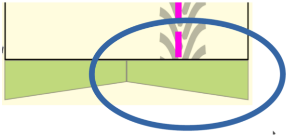



0
5
10
20 m

Runoff and soil loss

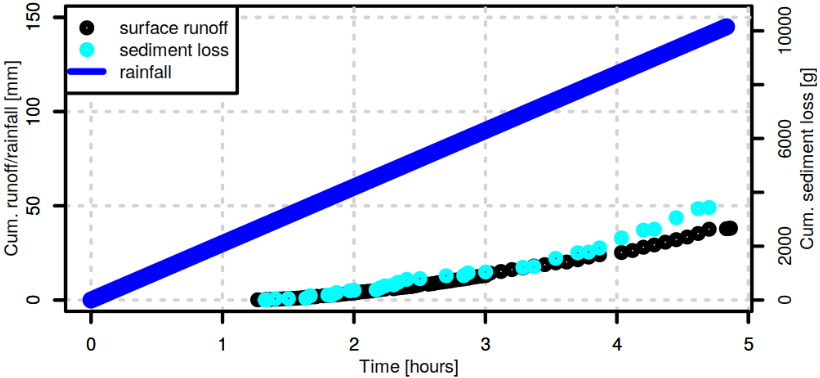
Basic runoff and soil loss parameters

- All runoff and soil loss were drained through wheel track at wheel track plot

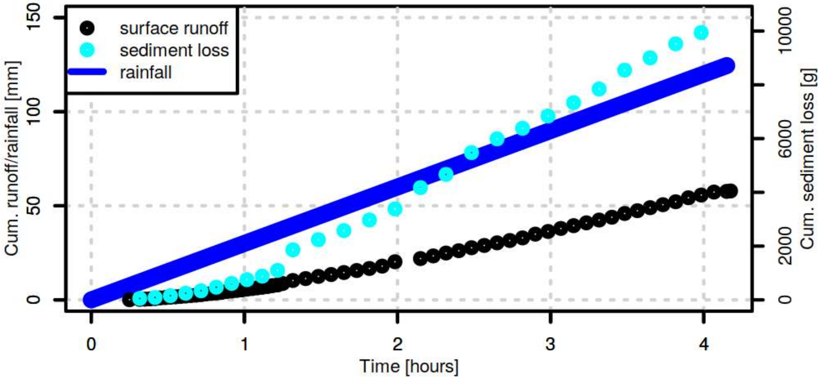


plot:	reference	wheel track
set rainfall intensity [mm/hour]	30	30
rainfall duration [min]	290	245
total rainfall height [mm]	145	124
maximal surface runoff [mm/hour]	22.7	25.5
total cumulative sur. runoff [mm]	38	57
lag time of runoff [min]	76	15
runoff coefficient [%]	26.3	46.5
total soil loss [g]	3435	9942

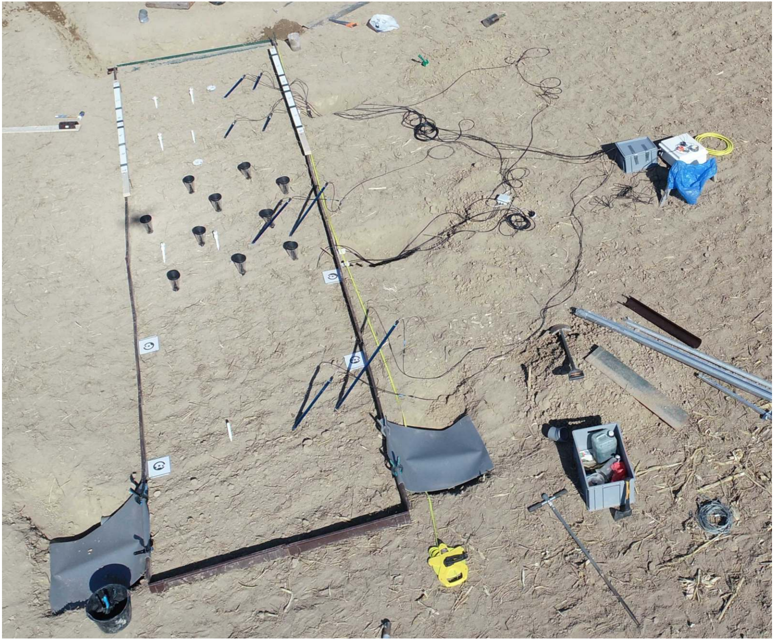
Runoff and soil loss at reference plot



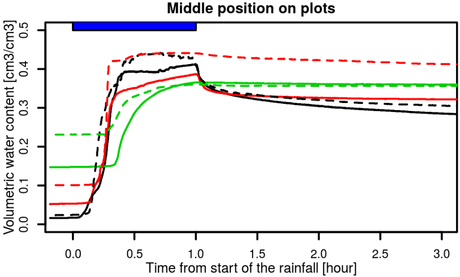
Runoff and soil loss at wheel rack plot

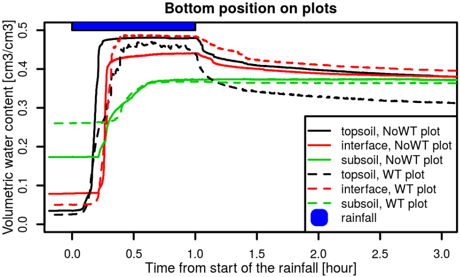


Shallow subsurface processes

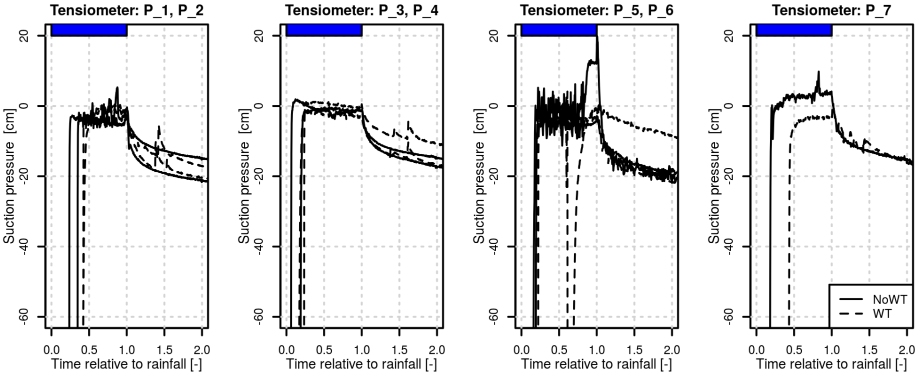


Soil water content





Runoff and soil loss at wheet rack plot



Transport of tracer (deuterium)

Deuterium as a tracer

- D_2O was added into rainfall water when runoff was steady
  - dilution ratio 1:10000

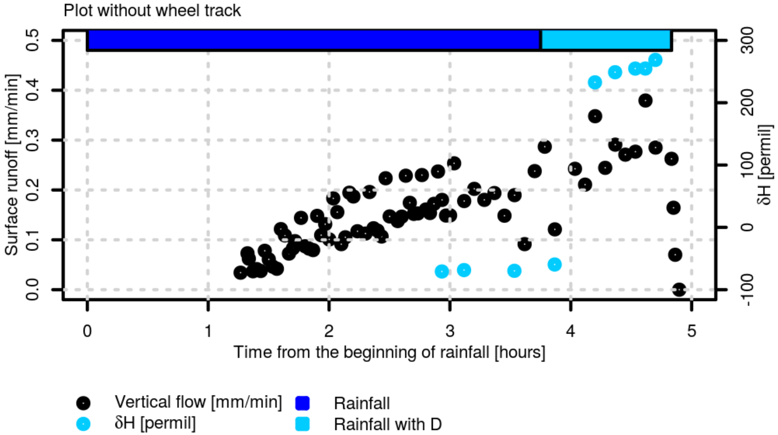
Mass balance equations

$$Q_{new}(t) + Q_{old}(t) = Q_{total}(t)$$

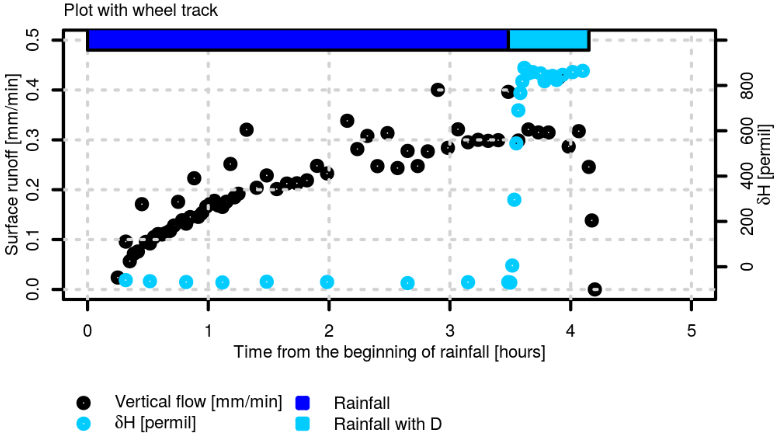
$$c_{new}(t)Q_{new}(t) + c_{old}(t)Q_{old}(t) = c_{total}(t)Q_{total}(t)$$

Measured in surface runoff and vertical transport with zero-tension lysimeter

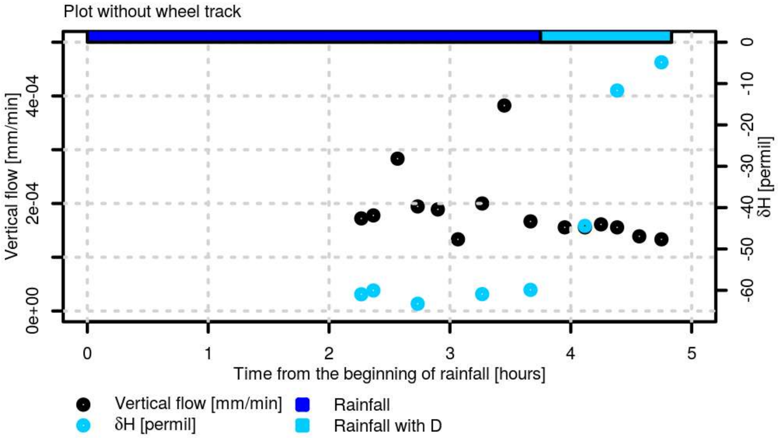
Surface runoff



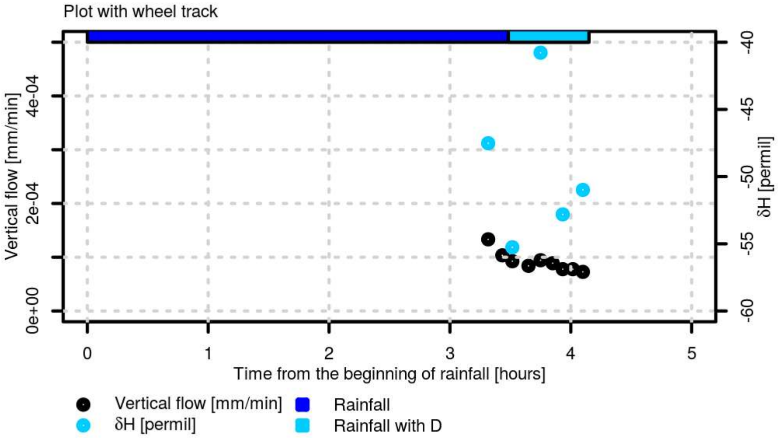
Surface runoff



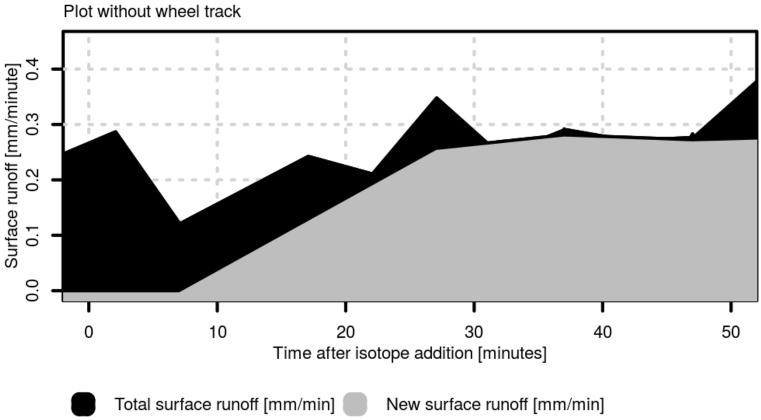
Measurement on zero-tension lysimeter



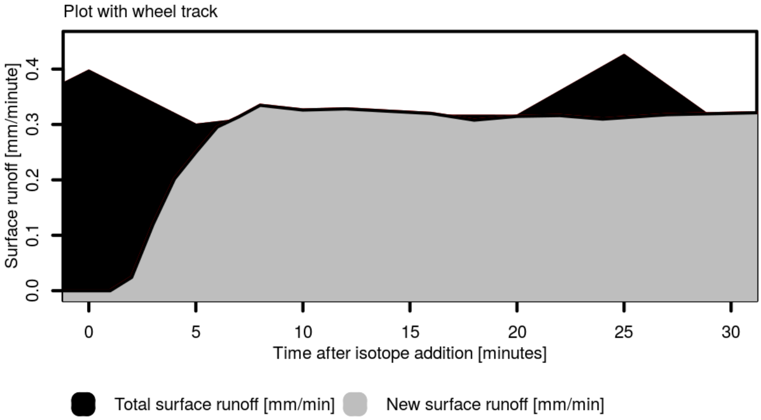
Measurement on zero-tension lysimeter



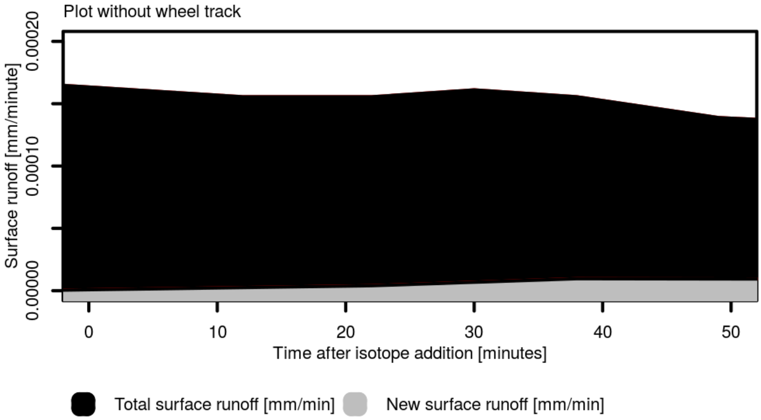
Surface runoff - mixing



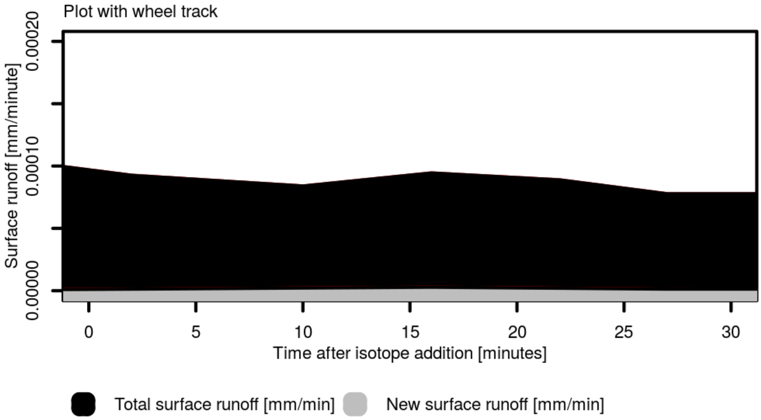
Surface runoff - mixing



Measurement on zero-tension lysimeter - mixing



Measurement on zero-tension lysimeter - mixing



Soil water redistribution (ERT)

Electrical resistivity tomography

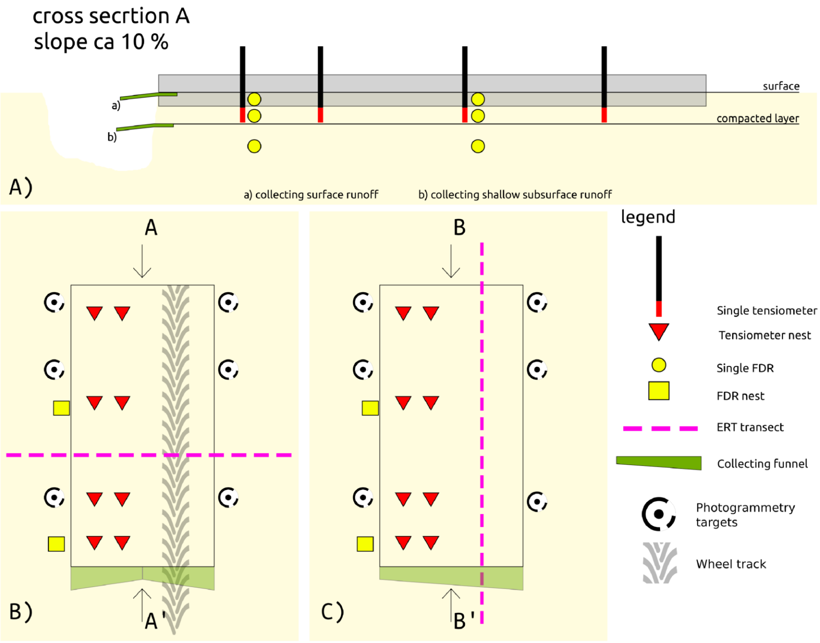
Reference plot

- 1 day after the experiment
- 2 transects oriented slope wise
- time lag between measurements 6 hours

Wheel track plot

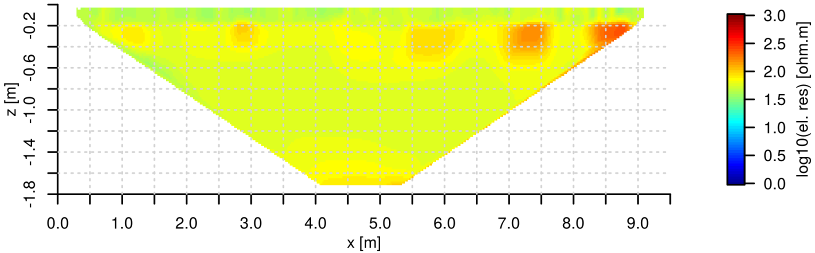
- 1 day after the experiment
- 1 cross section
- comparison with excaved soil profile

6. Soil water redistribution (ERT)

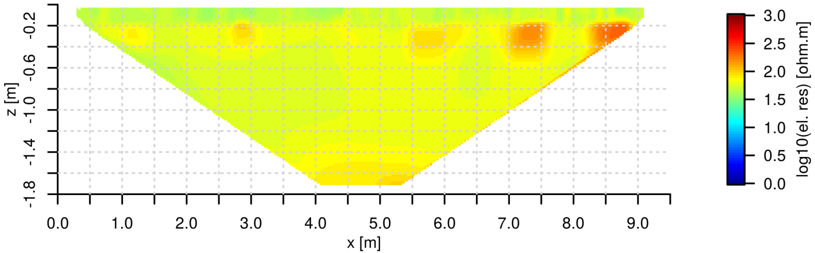


Reference plot

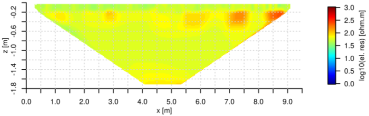
Reference plot: 19.9.2019 12:00

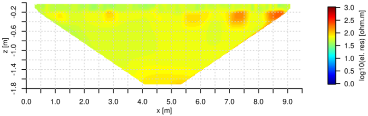


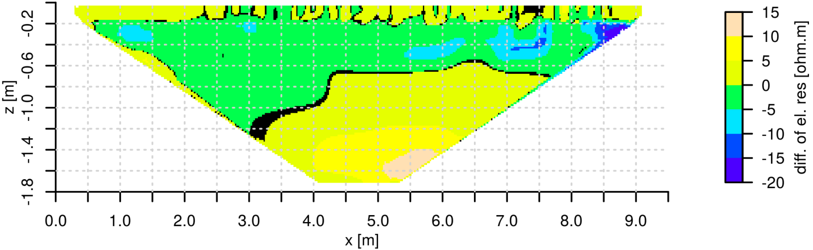
Reference plot: 19.9.2019 18:00



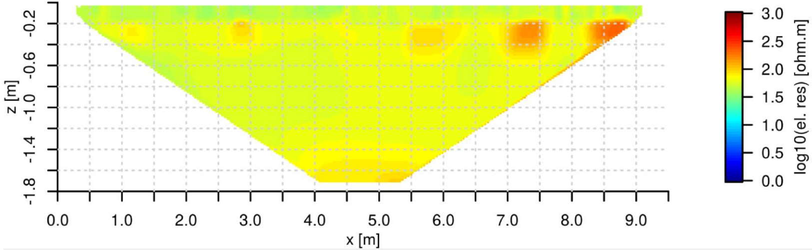
Reference plot: el. resistivity difference

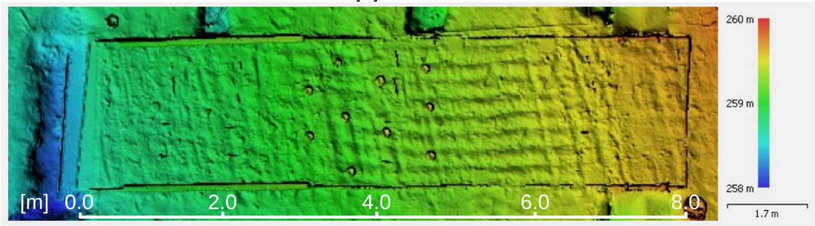




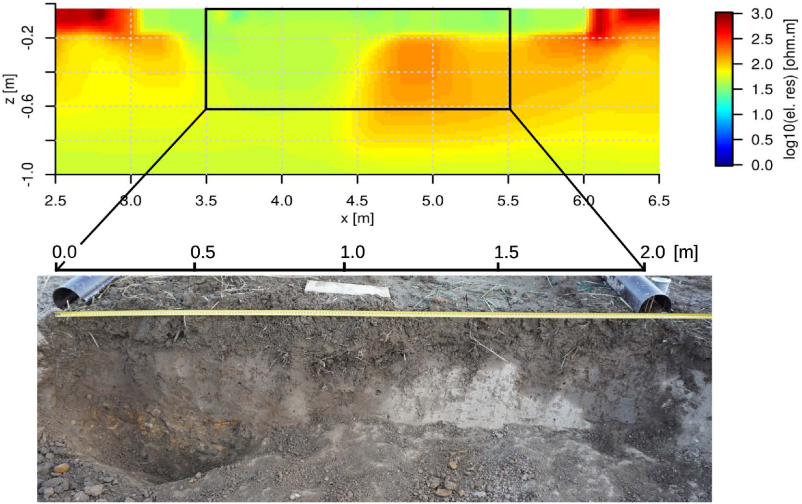


Reference plot: Comparison to DTM



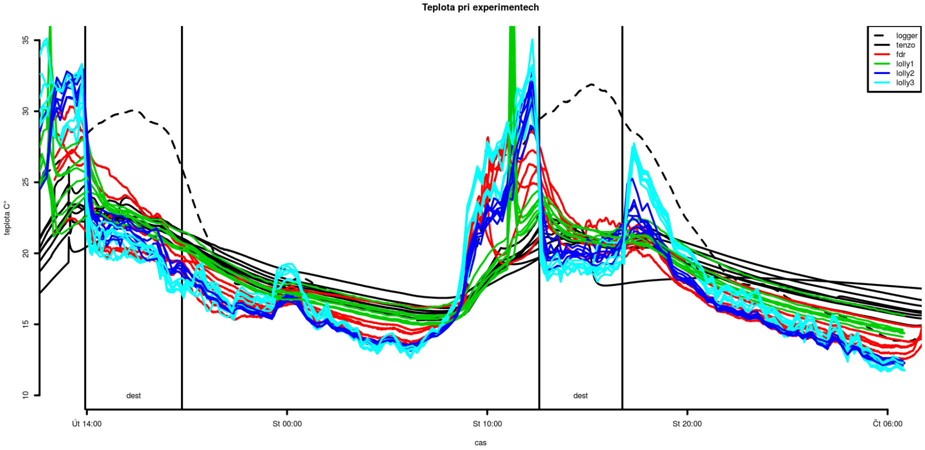


Wheel track plot: comparison to excaved soil profile



- Use model to identify processes affecting the runoff formation
  - measuring soil hydraulic properties: in progress
- Link surface roughness to flow regime
- Analyze travel time and mixing in the flow pathways
  - analysis of stable isotopes: in progress

- Presence of wheel track affects the surface runoff and soil loss and vertical water transport
- Vertical transport is heterogeneous even in homogeneous soil
- ERT may be used to wheel track artifacts identification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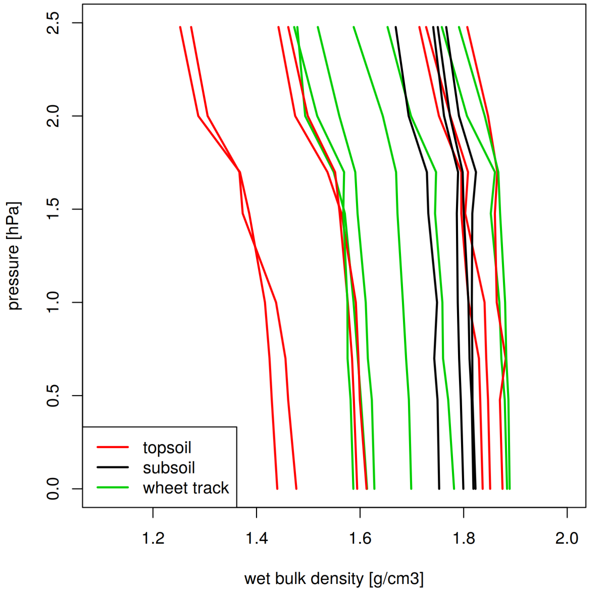
8. Conclusions



8. Conclusions