Surface runoff and soil loss regime at an agricultural catchment with developed wheel-tracks

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Overview

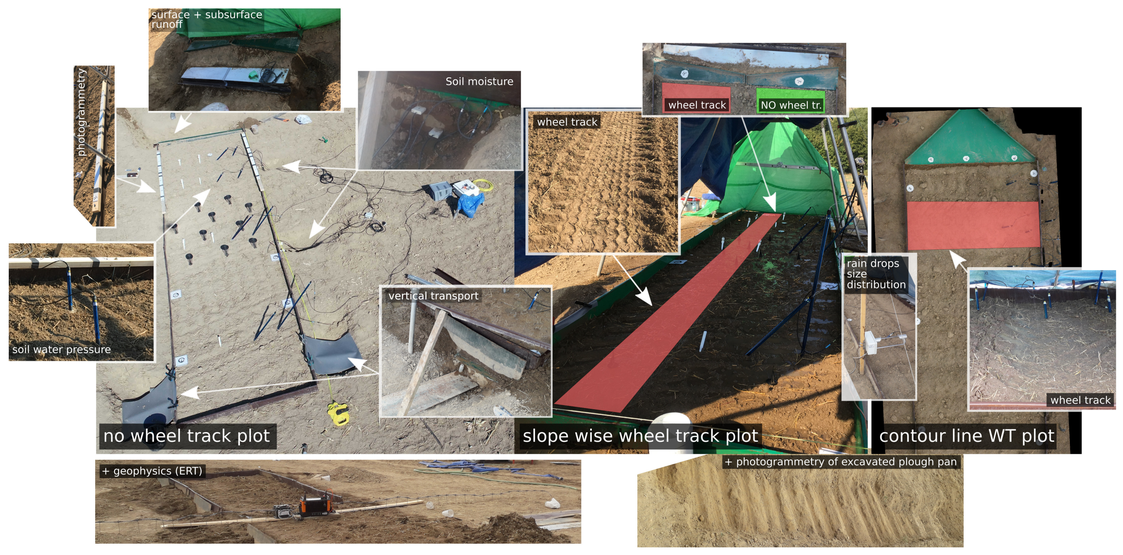
- Artificial rainfall experiments
- Wheel track and plough present
- Emphasis on subsurface processes

Objectives:

- Effect of plough pan and various arrangement of wheel tracks on surface runoff and soil loss

1 Material and Methods

- Location: Central Bohemia, Czech Republic
- Soil class: loamy (clay = 18 %; silt = 34 %; sand = 48 %)
- Slope: ca 10 %
- Soil profile: Freshly tilled topsoil, plough pan developed at depth of 12-15 cm
- Campaigns: 2018 - vol1; 2019 - vol2
- 3 setups: **noWT** - no wheel track
  slWT - slope wise wheel track
  clWT - contour line wheel track
- Rainfall intensity: 30 mm/hour
- Plot size: 16 m^2



Graphical abstract shows all plots and devices used during the experiment (only a subset presented on this poster)

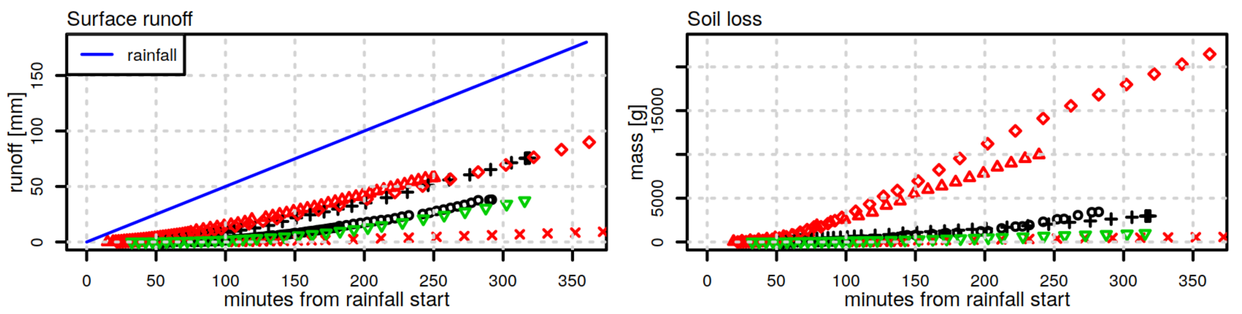
2 Results

2.1 Surface

Slope wise wheel track serves as drainage pathway. Contour line wheel track serves as a obstacle.

Summary of the experiment with basic characteristics

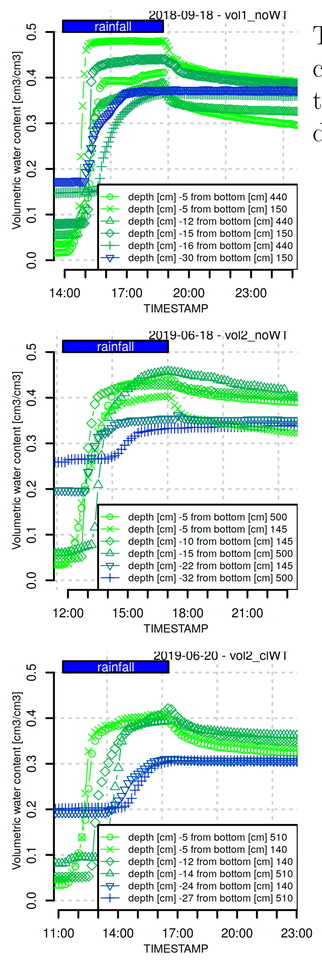
campaign	vol1		vol2			
plot	noWT	slWT	noWT	slWT	slWT	clWT
wheel track	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE
date	2018-09-18	2018-09-19	2019-06-18	2019-06-19	2019-06-19	2019-06-18
rainfall duration [min]	290	249	316	433	433	319
lag time of runoff [min]	76.0	15	51	102	22	32.5
total rainfall height [min]	145	124.5	158	216.5	216.5	159.5
maximum runoff [mm/min]	22.74	25.44	24.96	2.808	21.66	14.4
cumulative runoff [min]	38.1	57.9	75.6	12.6	94	37.2
runoff coefficient [%]	26.2	46.5	47.8	5.8	43.4	23.3
total soil loss [g]	3437	9942	2961	706	22114	972



Surface runoff (left) and soil loss (right) measured at the bottom of the plot

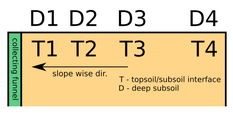
2.2 Subsurface

Volumetric water content (VWC) exhibit similar behavior at all plots. Dynamic reading in topsoil followed slow dynamics in subsoil

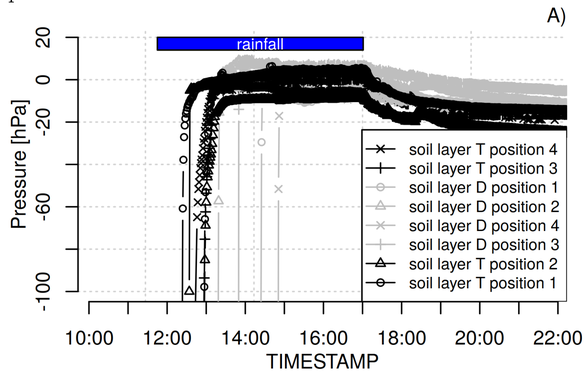


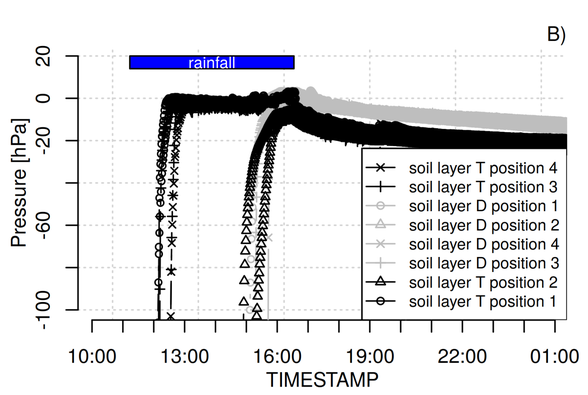
Volumetric water content during all experiments, experiment depicted by a code in top right corner of each plot.

Tensiometers at position 2 at clWT plot installed in the wheel track exhibit the same behavior as deep tens.



Positions of tensiometers.

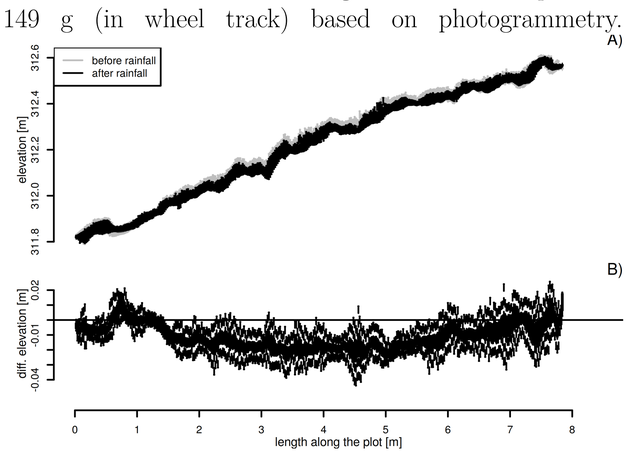




Pressure head during selected experiments: A) noWT plot in 2019, b) clWT plot in 2019

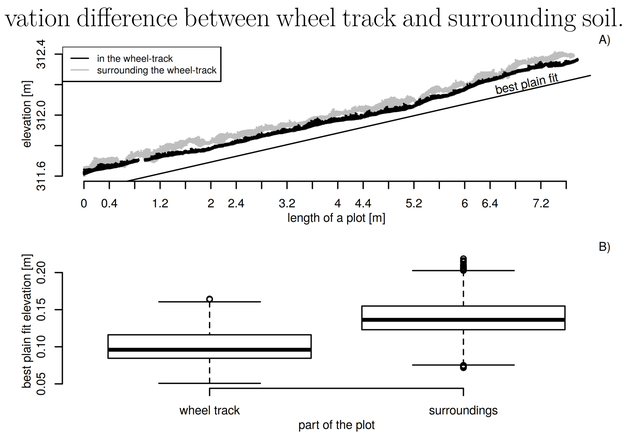
2.3 Photogrammetry

Total soil loss was 2214 g and total deposition 149 g (in wheel track) based on photogrammetry.



Elevation difference between the soil conditions before and after the artificial rainfall. A) shows side view to the plot profile with maximum and minimum elevation in each contour line. B) shows subtracted soil surface states. Positive difference indicates soil reposition

A plain was subtracted from DTM to analyze the mean elevation difference between wheel track and surrounding soil.



Elevation difference between wheel track and the surrounding soil. A) shows side view to the plot profile with maximum and minimum elevation in each contour line. B) shows the elevation difference after best plain fir substracted.

Wheel track preparation

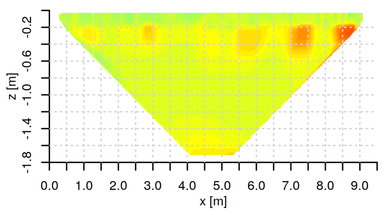
Experimental plots

During the rainfall

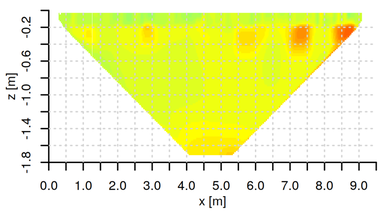
2.3 Electrical resistivity tomography ERT

ERT shows redistribution of water in 2 time snapshots.

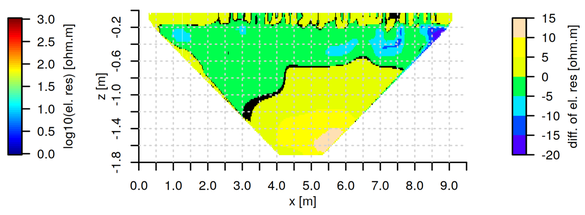
noWT plot measured in slope wise direction during campaign vol1



18 hours after the experiment

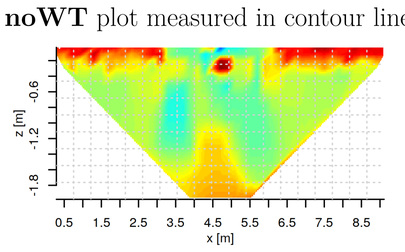


23 hours after the experiment

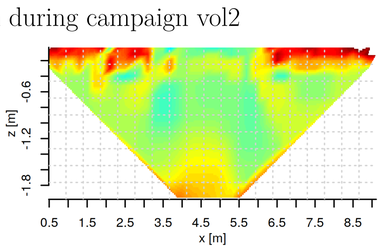


difference in el. resistivity

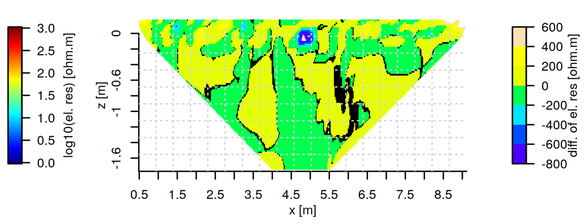
noWT plot measured in contour line direction during campaign vol2



2.5 hours after the experiment



26 hours after the experiment



difference in el. resistivity

3 Conclusions

- Wheel track served as a preferential pathway for both surface water and soil particles
  - Soil loss increased 3 times in 2018 and more than 7 times in 2019 at slWT plot compared to noWT plot
  - Maximum discharge was similar at noWT and slWT plot (slWT plot was drained almost exclusively by the wheel track).
  - Soil deposition was observed in the wheel track at clWT plot. NoWT plot exhibit lowest runoff and soil loss.
- Sharp infiltration front was detectes.
  - Wheel track compaction decreased the soil permeability, the sharp infiltration front was preserved.
- Wheel track artefacts were observed with electrical resistivity.

4 Acknowledgement

Experiments were carried out within the LTC18030 - “The effect of land-use changes on soil erosion, sediment transport, water quality and rainfall-runoff balance” project and were further supported by the TJ01000270 - “Atlas HYDROLOGIE – modern tool for soil loss and runoff estimation, and design of water and soil protection measures” project and internal CTU student graphs SGS17/173/OHK1/3T/11 and SGS18/122/OHK1/2T/11.