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Adapting soil properties of compacted tramlines into soil erosion modeling: A field-scale approach

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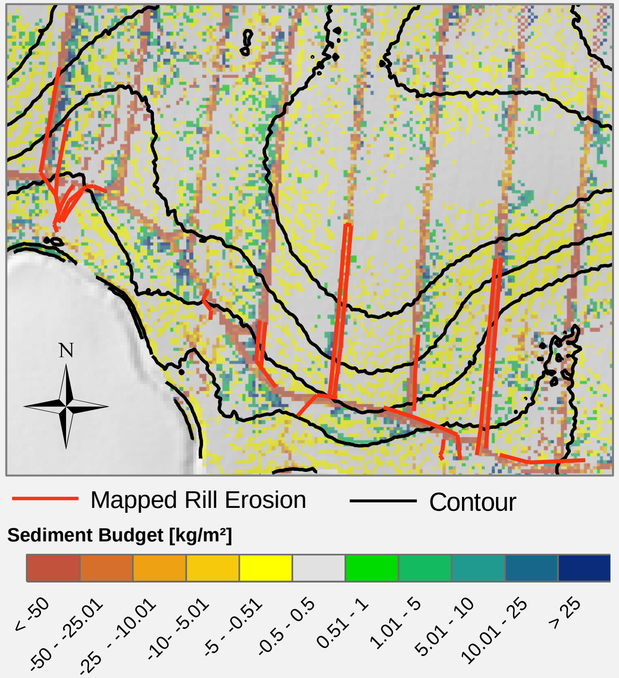
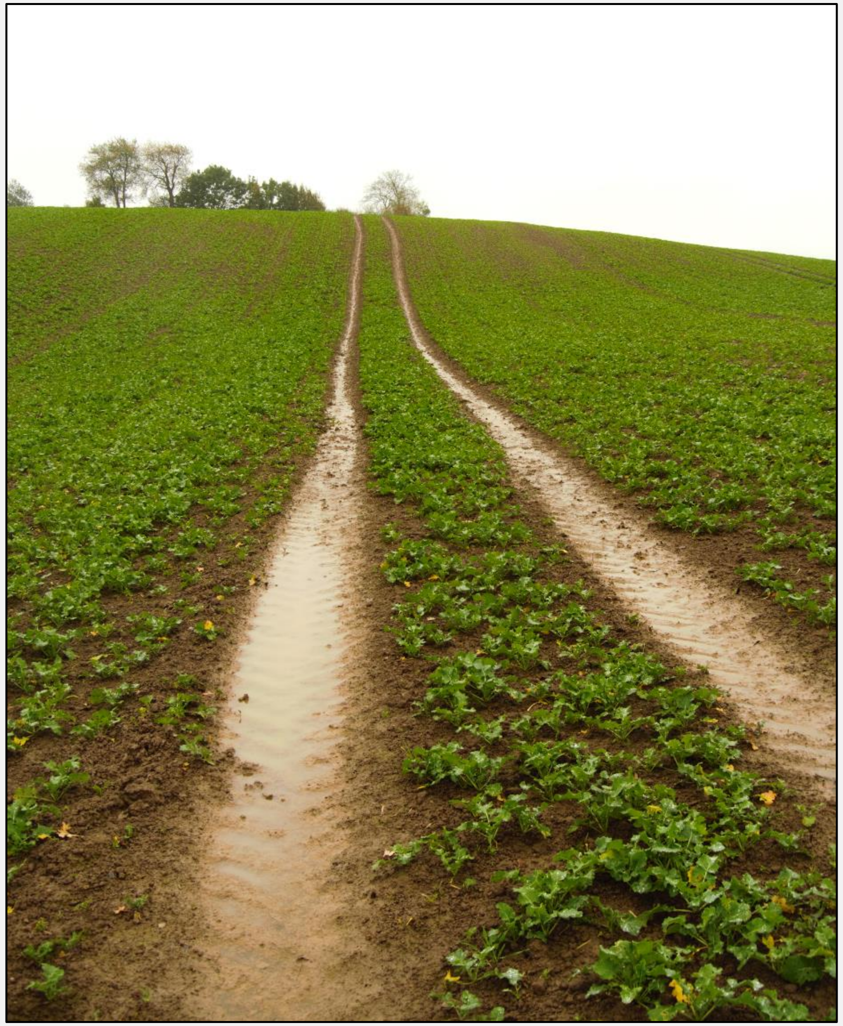


Motivation:

- Raster-based soil erosion models are predominantly used on larger resolutions (cell size >= 10 m)
- Erosion monitoring and soil erosion mapping point out that wheel tracks of tramlines are most frequently affected by soil loss and target of rill erosion
- Though highly prone to soil erosion, tramlines are not yet regarded in soil erosion modeling
- Tramlines are semi-permanent pathways for field traffic (used 5-15 times a year)
- Reasons for erosion risk in tramlines
  - Higher degree of compaction (quick runoff generation)
  - No vegetation cover throughout the year
  - Reduced surface roughness (increased flow velocity)
  - Reduced mircrorelief (channeling of surface runoff)

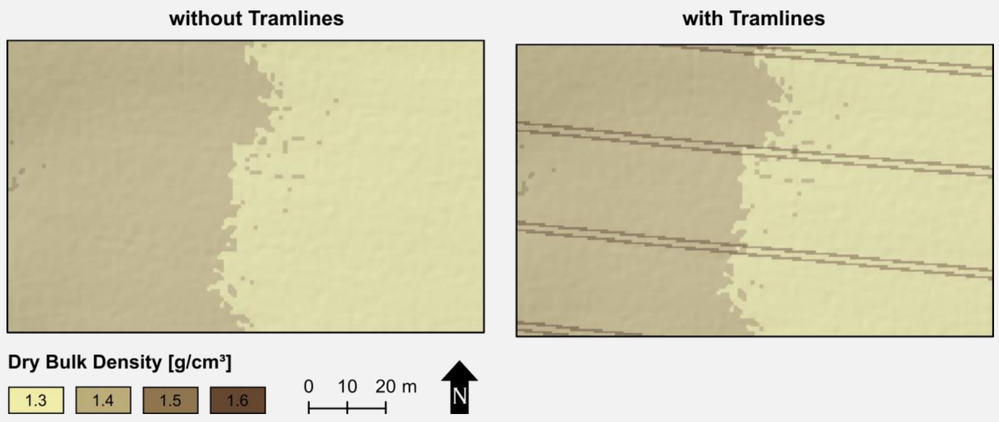


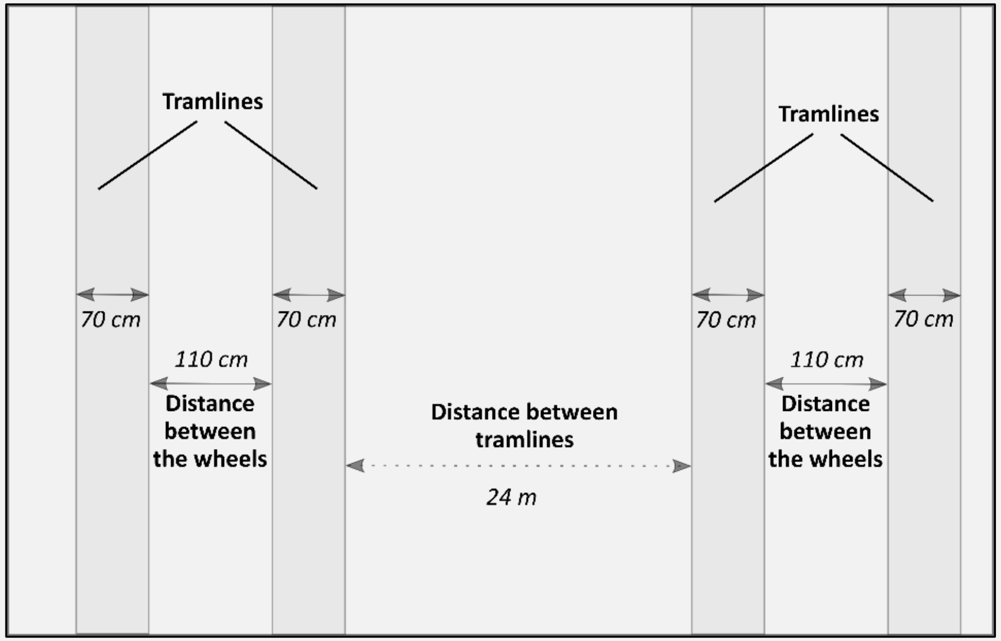
Surface runoff and soil erosion in tramlines

Introduction

Aims

- Spatial integration of tramline areas into a process-based soil erosion model with reduced resolution
- Deriving model-based soil properties of tramline areas
- Evaluating the effect of tramline properties by comparing model results with tramlines and without tramlines for an erosive rain fall event
- Comparing model results with mapped rill erosion

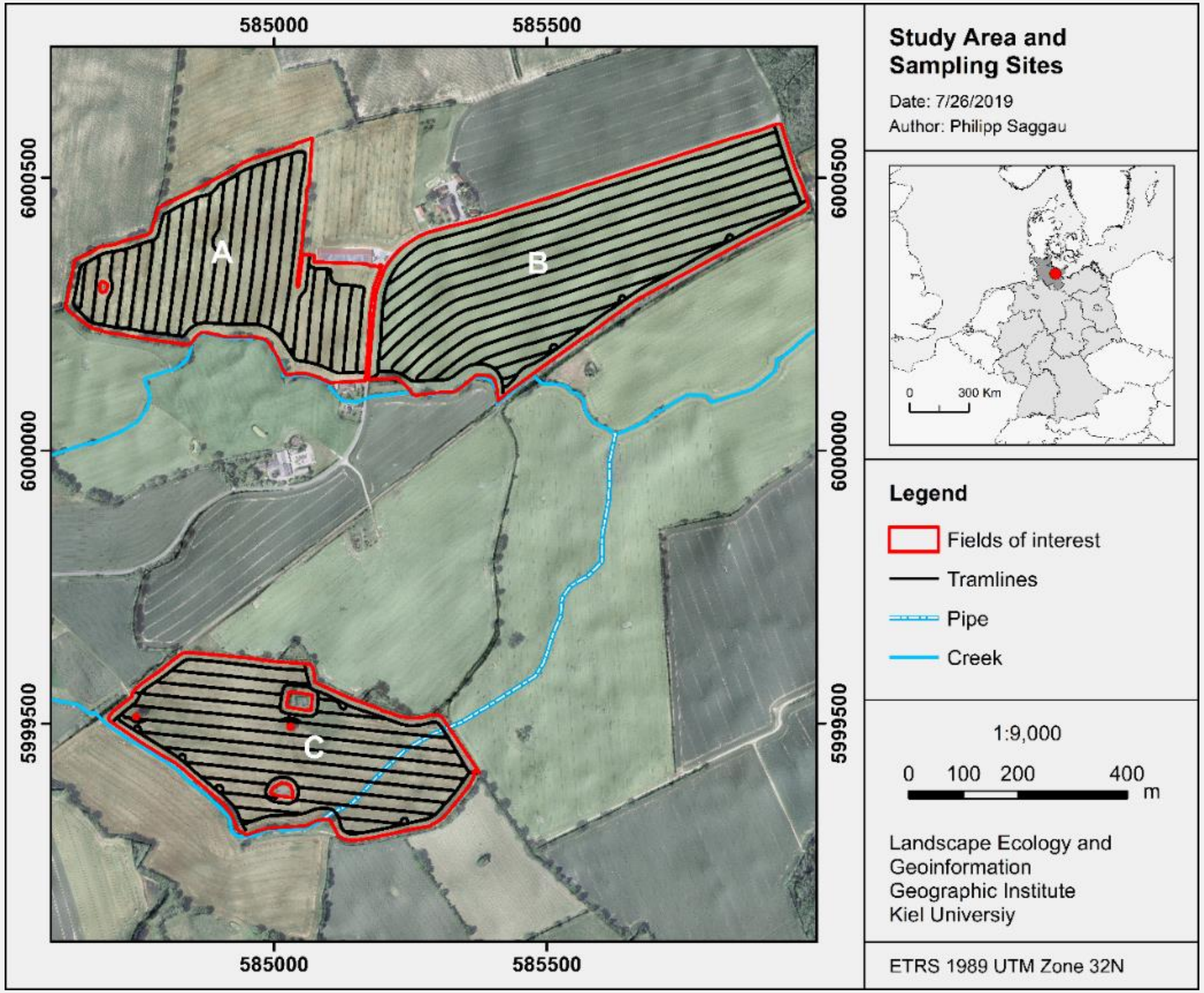




Study Area

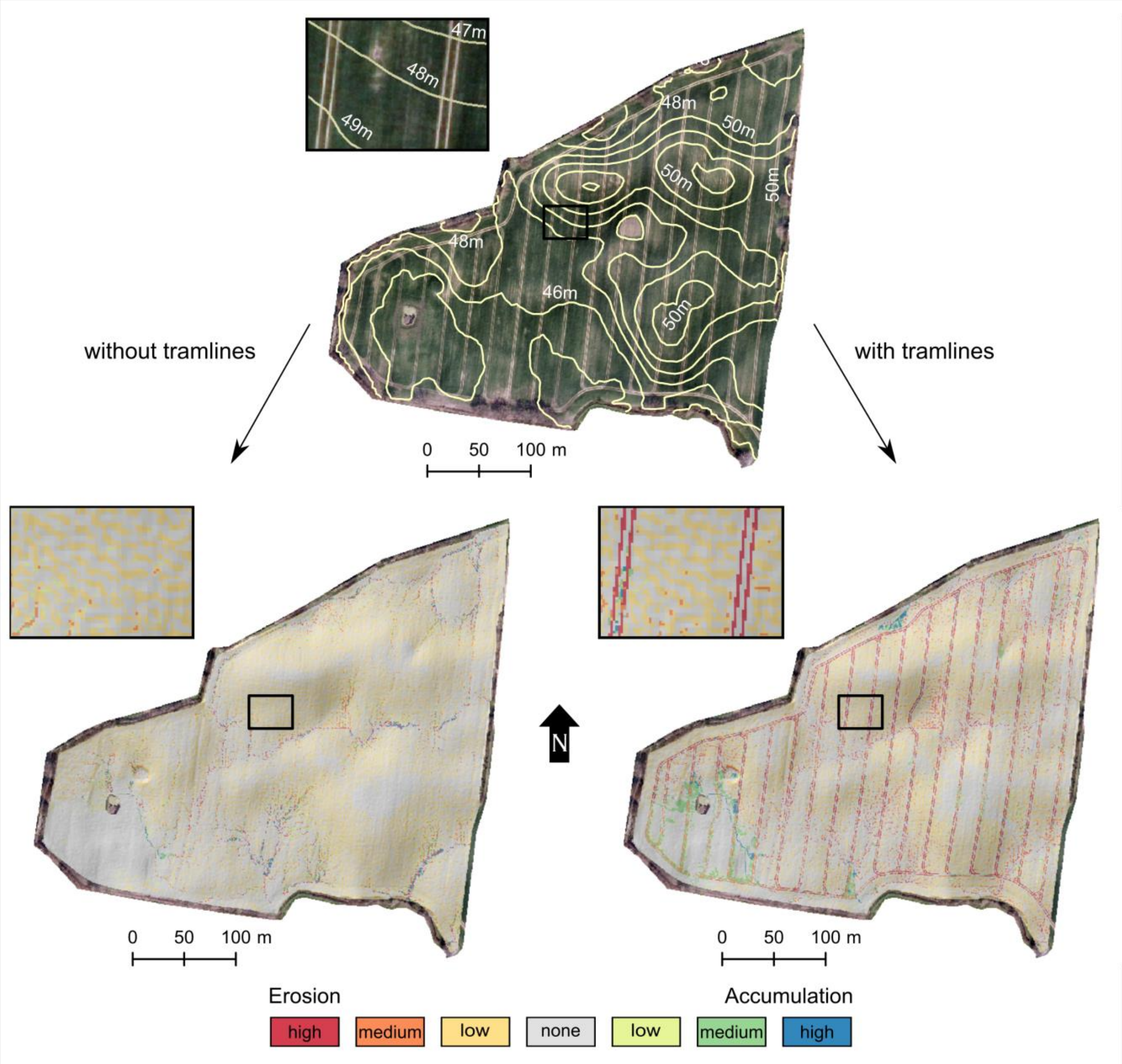
- Three fields with different properties served as study area
- Located in Northern Germany (Eastern Uplands)
- Parent material is deep Weichselian till
- Soil texture generally consists of sandy loam and loamy sand (Luvisols & stagnic Luvisols).
- Mean slope gradient of common catchment is 5.1% (range 0 to 19.6%)

Field	Crop Type	Tillage Tool	Tramline Direction	Area [ha]	Tramline-Area [%]
A	winter wheat	chisel plough	orthogonal to contour	13.6	6.9
B	winter barely	mouldboard plough	parallel to contour	19.6	6.3
C	stubble fallow	chisel plough	orthogonal to contour	14.4	6.8



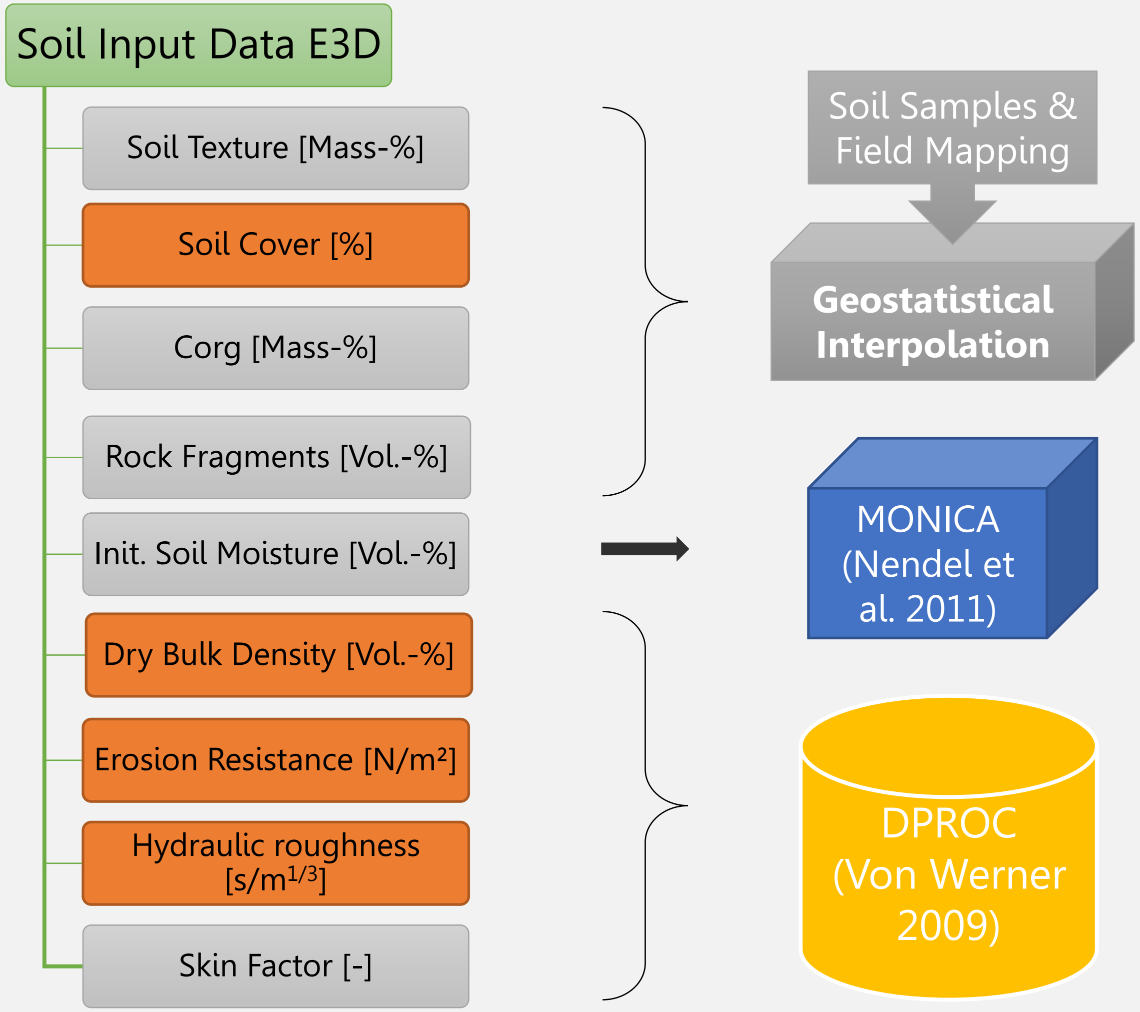
Scenario-Design

- Parameterization and modeling of two scenarios:
  a) without tramlines (Status Quo-Scenario – “SQS”)
  and b) with tramlines (Tramline-Scenario – “TLS”)
- Investigation of an erosive rainfall event with measurable rill erosion (5th October 2017 - 61 mm in 33 h)
- Application and parameterization of the process-based model EROSION 3D (E3D) for the resolution 1x1 m



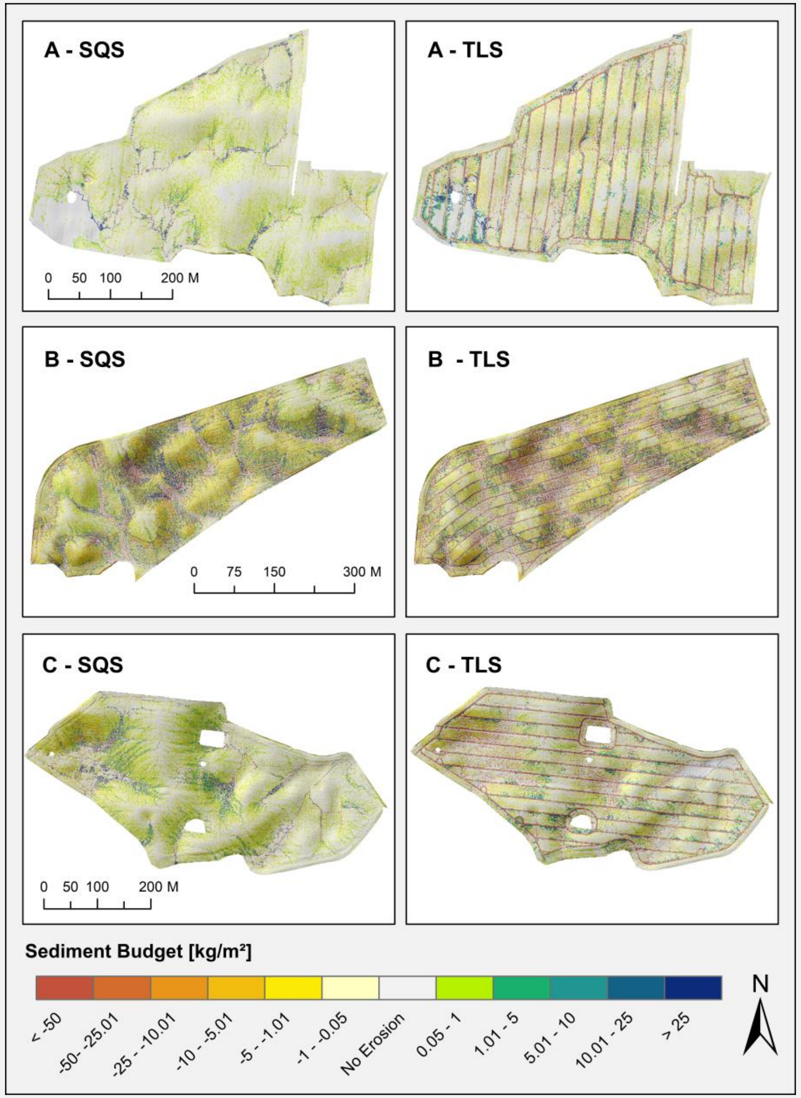
Parameterization of Scenarios for E3D

- For the Status-Quo-Szenario (SQS) the soil data set was derived according to the right figure
- For the Tramline-Szenario (TLS):
- Tramline areas were digitized and rasterized as spatial base for adapting soil properties
- Changes of soil properties for tramline areas:
- Soil Cover was reduced to the cover by rock fragments
- Dry Bulk Density was increased by 15 %, which was the result of field experiments (Fleige & Horn 2000)
- Erosion Resistance and Hydraulic Roughness were exchanged by specific values for tramlines suggested by the E3D parameter catalogue (Michael et al. 1996)



Modelling Results

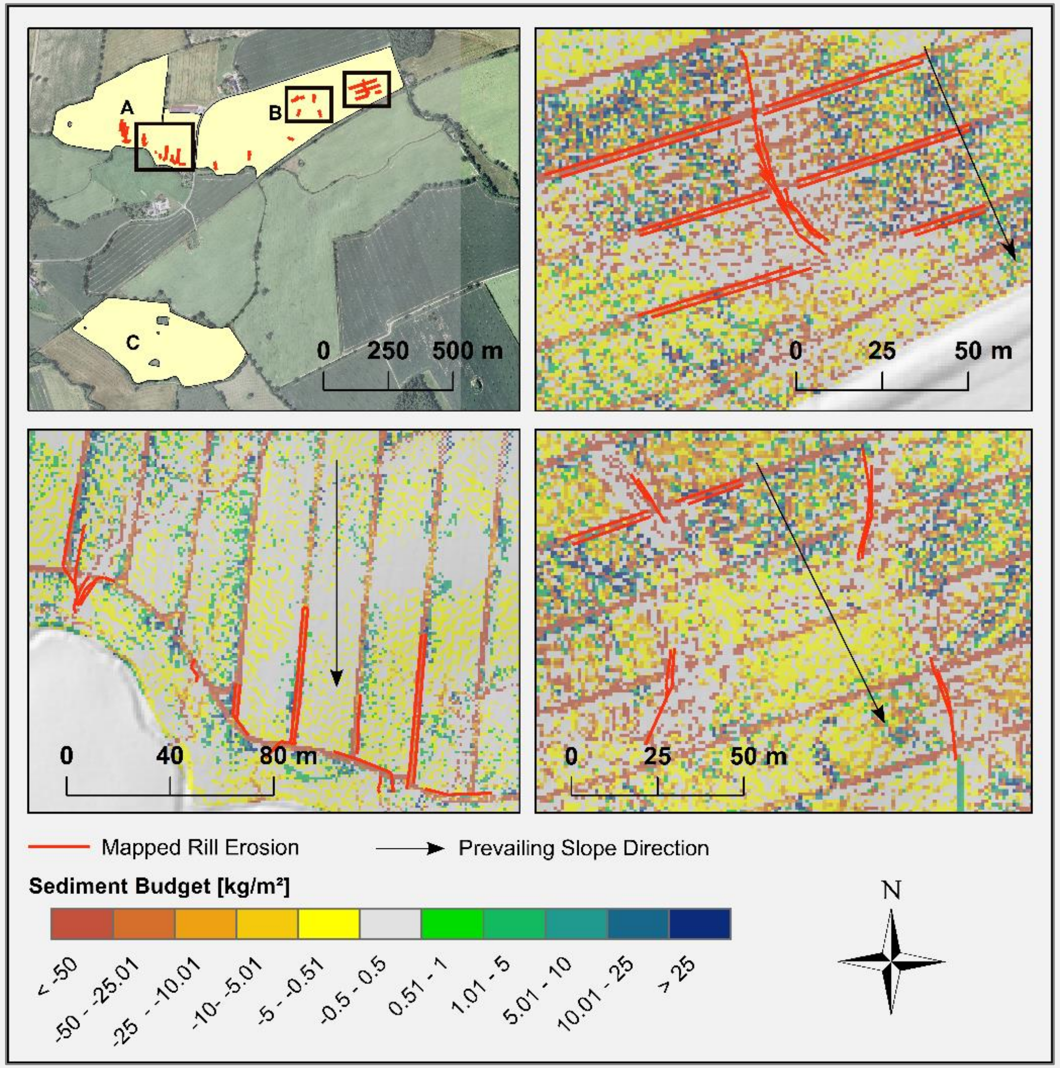
- The comparison of mapped erosion with model results showed that model outputs were plausible in terms of the areal distributions of erosion
- Results of E3D overestimate real erosion rates about two magnitudes for 1 m resolution
  - Possible reasons are the uncalibrated use of the model as well as the model base itself
- The shares of simulated erosion in tramlines compared to erosion in the field sections were well represented in the mapping results for Field A and B
  - No measurable rill erosion on Field C (only interrill erosion)



Modelling Results

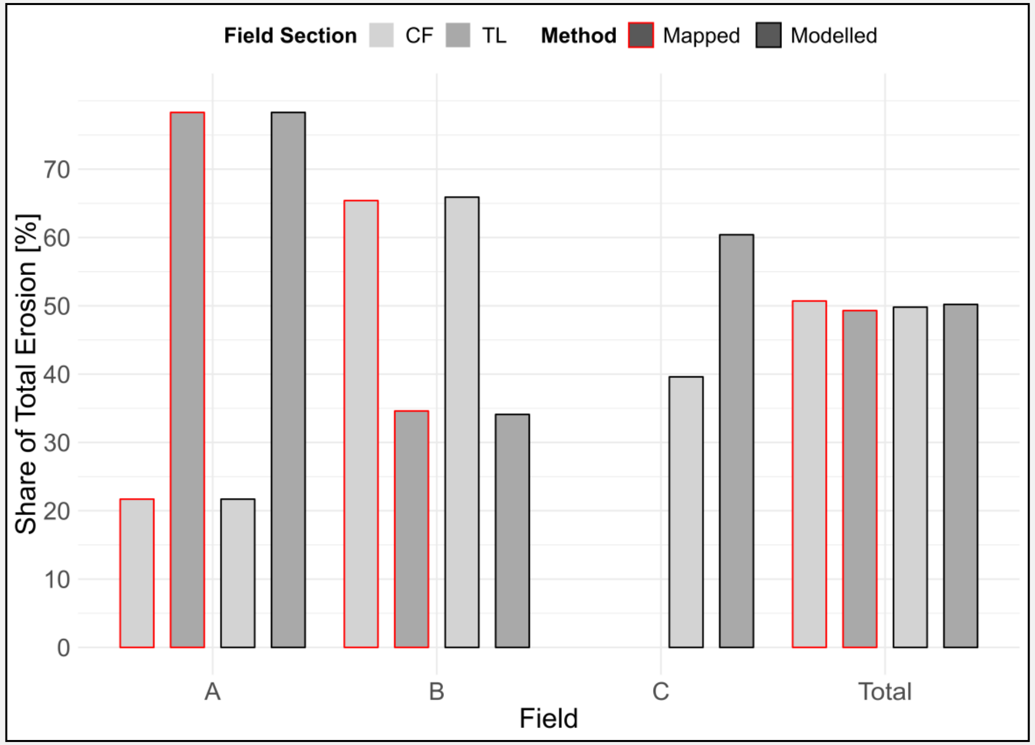
- Model results show similar relative increase of soil loss for the tramline sections compared to field experiments on similar soils conducted by Fleige and Horn (2000)
- Model results show that the increase in soil loss for tramline sections is higher at fields were the prevailing slope direction is parallel to the slope

Field	Soil Loss - SQS [t]	Increase of Soil Loss for TLS [%]	Measured rill erosion [t]	Tramline direction to contour
A	1,962.2	80.6	11.3	orthogonal
B	6,415.5	15.0	29.2	parallel
C	4,689.1	31.2	-	orthogonal
Total	13,066.7	-	40.5	-



Conclusion

- Grid–based erosion models like E3D are able to regard the effect of compacted tramlines on soil erosion.
- The results reveal that integrating soil properties of tramlines into soil erosion modeling improves model outcomes on field-level and therefore the assessment and identification of erosion hot spots
  - ➢ The share of measured soil loss between tramlines and cultivated areas is well accounted for on grid sizes of 1x1 m
  - ➢ The integration of tramlines showed a high dependency to the angle of slope. Therefore, the increase in estimated soil loss was higher for fields where tramlines were in the direction of the major slope (confirmed by mapped soil loss)
- High computer power and workload necessary for parameterization on such high resolutions



Outlook

Future Work(?)

- Calibration and validation still necessary for such fine resolutions (Catchment Scale?)
- We showed the impact of compacted tramlines on modeling results. How do other highly compacted areas (e.g. Turn-Around-Points) affect model outcomes?
- Taking into account tramline properties in soil erosion modeling might help to evaluate the effect of conservation measures (e.g. contour farming, intermittent or total planting of tramlines, etc.)
- Our results show the influence on modeling results for one erosive rainfall event. Soil erosion risk in tramlines persists throughout the vegetation period. Can continuous models help to evaluate this effect?

Intermittent planting of tramlines

Thanks for your attention!

See the following article for more detailed information:

https://doi.org/10.3390/soilsystems3030051

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