Universität Augsburg
Institut für Geographie

Leibniz-Zentrum für
Agrarlandschaftsforschung
(ZALF) e.V.

Kathi Öttl
lena.oettl@geo.uni-augsburg.de

What role does tillage erosion play regarding landscape evolution of an intensively used hummocky landscape?

Lena Katharina Öttl, Peter Fiener, Florian Wilken and Michael Sommer

arrows indicate Hyperlinks!

Key points:

1 In our study area – the hummocky moraine landscape of North-East Germany – **tillage erosion** is assumed to be the **main driver** of soil redistribution (Oettl et al., 2020, submitted; Wilken et al., 2020)

2 Tillage-induced soil redistribution determines the **within-field pattern of crop biomass** especially during drier spells or years (Oettl et al., 2020, submitted)

3 Can we improve long-term tillage erosion modelling to estimate its effect on crop biomass and soil organic carbon stocks more realistically by **updating the Digital Elevation Model** ("landscape evolution modelling")?

Typical topsoil pattern of eroded and colluvial soils for an example field in the study area "AgroScapeLab Quillow" (size ca. 200 km^2) located in the young moraine landscape of North-East Germany (grey area of inset map).

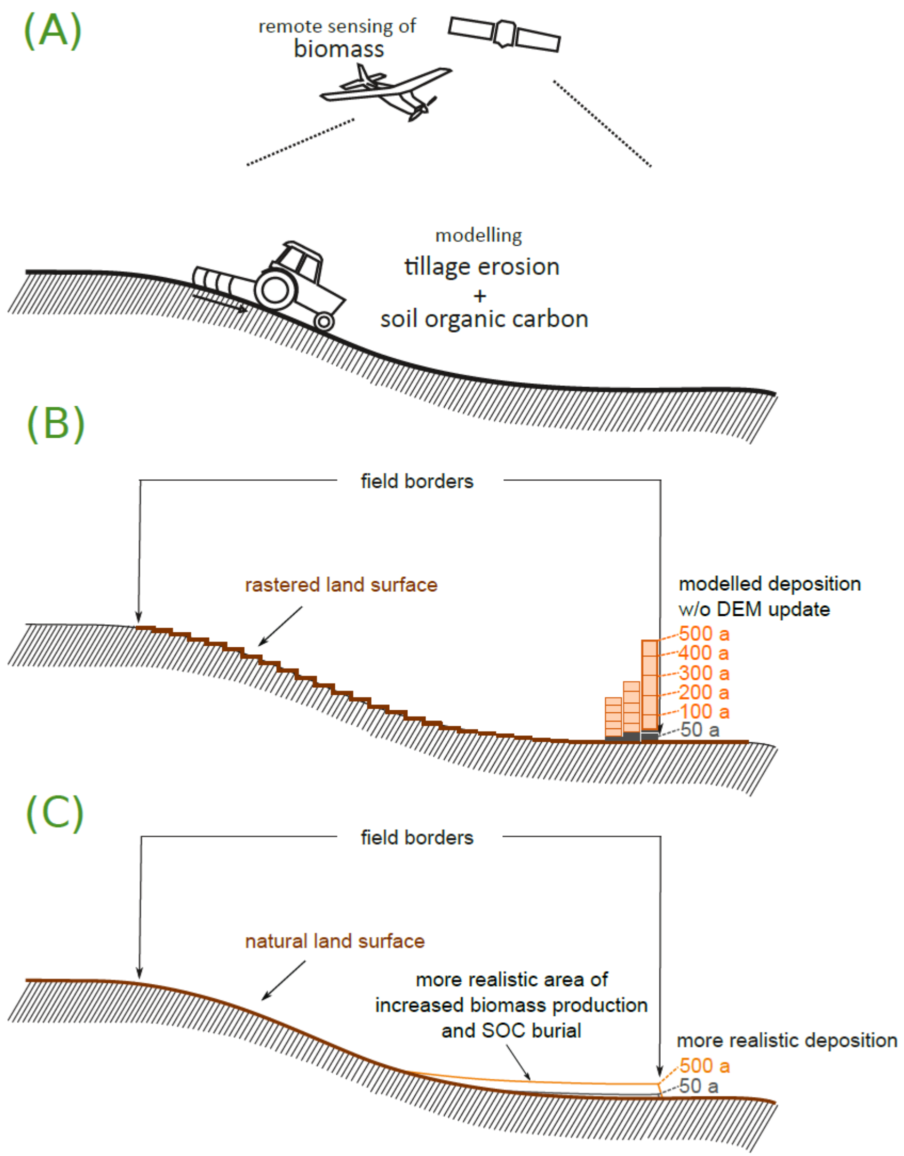
Why is landscape evolution important in long-term modelling of tillage erosion and its effects on crop biomass production and soil organic carbon stocks?

- soil redistribution due to **tillage erosion** leads to truncated soil profiles at hilltops and slope shoulders and to deposition at footslopes and in depressions
- generally, this leads to reduced (enhanced) **crop biomass** production at erosional (depositional) areas
- so far, we modelled tillage erosion with **SPEROS-C** on basis of a static Digital Elevation Model (**DEM**; 5 m spatial resolution) and found a close relation to a vegetation index derived from satellite images (Oettl et al., 2020, submitted) (A)

The effect of a static DEM …

- … on crop biomass is rather small because of the small number of raster cells with “extreme” erosion or deposition (B)
- … on soil organic carbon (SOC) stocks is problematic because at raster cells with long-time deposition a high amount of SOC is buried → **unrealistic!** (Fiener et al., 2015)

→ with an **update of the DEM**, deposited material would be distributed **more realistically** over more raster cells (“smoothened”) (C)



Methods: Investigating the effect of tillage erosion on the EVI in a hummocky young moraine landscape in North-East Germany

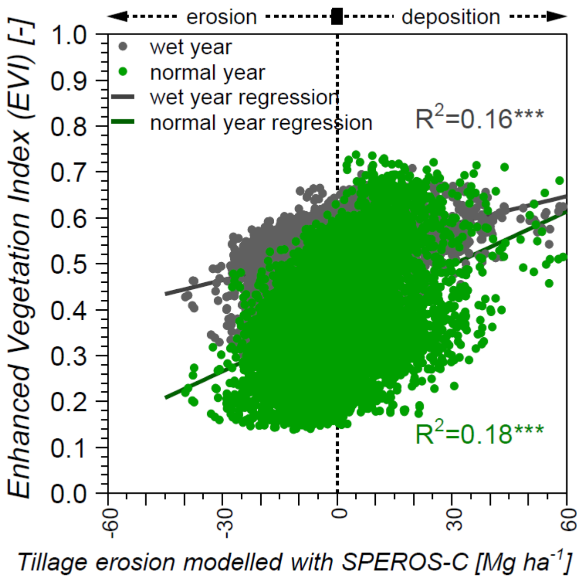
(1) Modelling tillage erosion without DEM update:

- modelling tillage & water erosion as well as SOC stocks & fluxes with **SPEROS-C** (time step: 1 year) on basis of a static DEM

→ **without update** due to soil redistribution

- Enhanced Vegetation Index (**EVI**): spatially distributed information on crop biomass from RapidEye satellite images (5 bands; 5 m spatial resolution)

EVI versus tillage erosion modelled with **SPEROS-C** for a single exemplary winter wheat field in the analysed wet and normal year (pixel-by-pixel comparison, 9230 pixels; *** = p-value < 0.001):



highly significant relation between tillage erosion and EVI values

lowest EVI values where most tillage erosion occurs (negative values) and highest EVI values in the depositional areas (positive values)

BUT: high small-scale variation in the patterns of the EVI and tillage erosion!

(2) Modelling tillage erosion with DEM update:

- modelling tillage erosion with **LAPSUS**
- **DEM update:** lowering (increase) of the DEM due to tillage erosion (deposition)
- LAPSUS is freely available and already contains a landscape evolution component (DEM update)

→ **LAPSUS** was only used for a **preliminary study!**

Preliminary results:
Effect of tillage erosion on the EVI with DEM update

(1) Comparing the original and the updated DEM

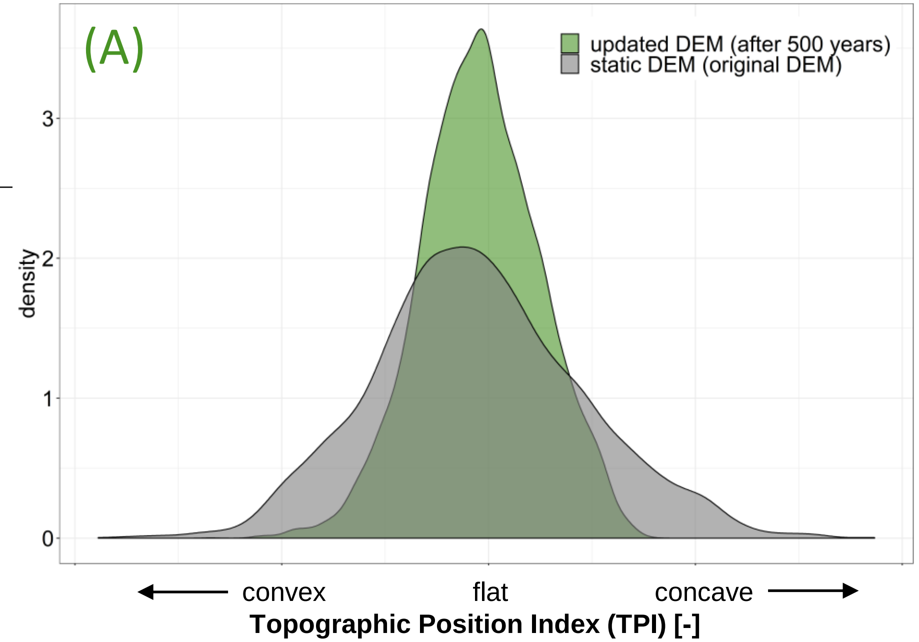
- comparing the **DEM after 500 years** of tillage erosion modelled with **LAPSUS** (with DEM update) to the **original DEM** shows that tillage erosion smoothens the landscape

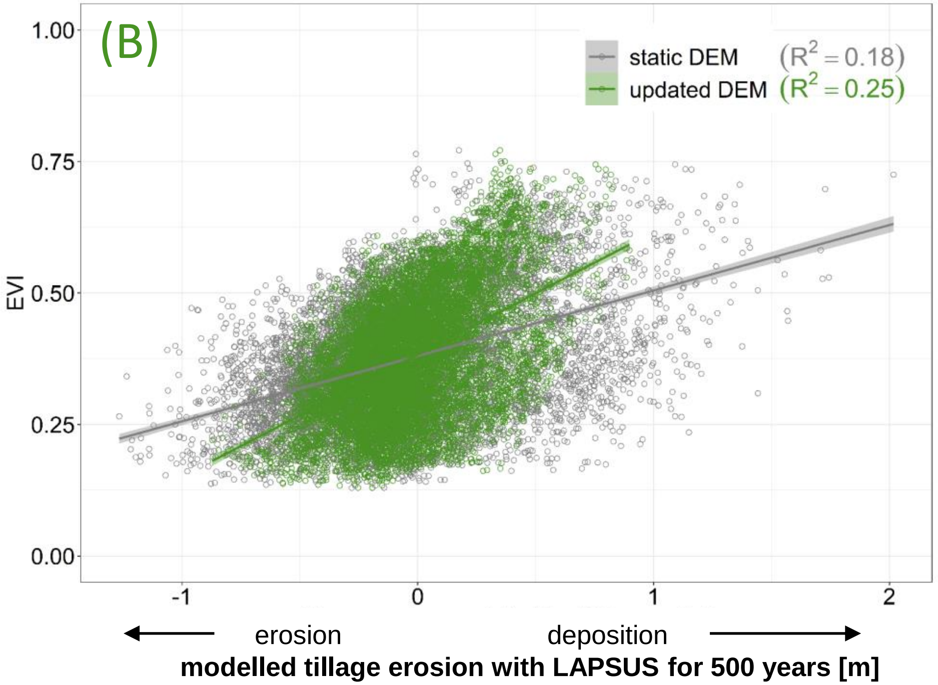
→ this is indicated by a change of the Topographic Position Index (TPI) * calculated for the two DEMs (A)

→ on a longer time-scale, erosion and deposition take place at **different landscape positions** which is not considered when using a static DEM

(2) Tillage erosion vs. EVI with update of the DEM

- updating the DEM leads to a **closer relationship** between tillage erosion modelled with LAPSUS for 500 years and the EVI and **less scattering** towards deposition compared to using a static DEM (B)





* explanation of the Topographic Position Index (TPI):
positive TPI values represent areas that are higher than the average of their surrounding grid cells (convex landscape positions → hilltops) and negative TPI values represent locations that are lower than their given neighbourhood cells (concave landscape positions → depressions)

Universität Augsburg
Institut für Geographie

Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.

Summary & outlook

- the annual **update of the DEM** shows the potential to better represent the effect of **long-term tillage erosion** on the EVI as a proxy for crop biomass
- implementing a **landscape evolution component** into SPEROS-C could enable modelling the effect of tillage erosion on crop biomass and SOC stocks **more realistically** for longer time-scales

Kathi Öttl
PhD student
Water & Soil Resource Research
Institute of Geography
University of Augsburg
lena.oettl@geo.uni-augsburg.de

Next step:

- previous studies have shown the problems of **equifinality** (different paleo-landscapes may result in one present landscape) and **polygenesis** (different processes may be responsible for the formation of a landscape) by modelling backwards in time
- Should a **new model component** be implemented in SPEROS-C to „**internally**" update the DEM (that may face the known difficulties of landscape evolution modelling) **or** can an existing LEM (e.g. LAPSUS) be coupled with SPEROS-C to update the DEM „**externally**" and use the newly generated DEMs as input?

→ questions and suggestions are welcome!

follow us on ResearchGate

References:

Fiener, P., Dlugoß, V., Van Oost, K., 2015. Erosion-induced carbon redistribution, burial and mineralisation. Is the episodic nature of erosion processes important? Catena, 133, 282-292.

Oettl, L.K., Sommer, M., Wehrhan, M., Wilken, F., Fiener, P., 2020, submitted. Tillage erosion as main driver of in-field biomass patterns in an intensively used hummocky landscape.

Wilken, F., Ketterer, M., Koszinski, S., Sommer, M., Fiener, P., in review, 2020. Understanding the role of water and tillage erosion from $^{239+240}Pu$ tracer measurements using inverse modelling. SOIL Discussions.