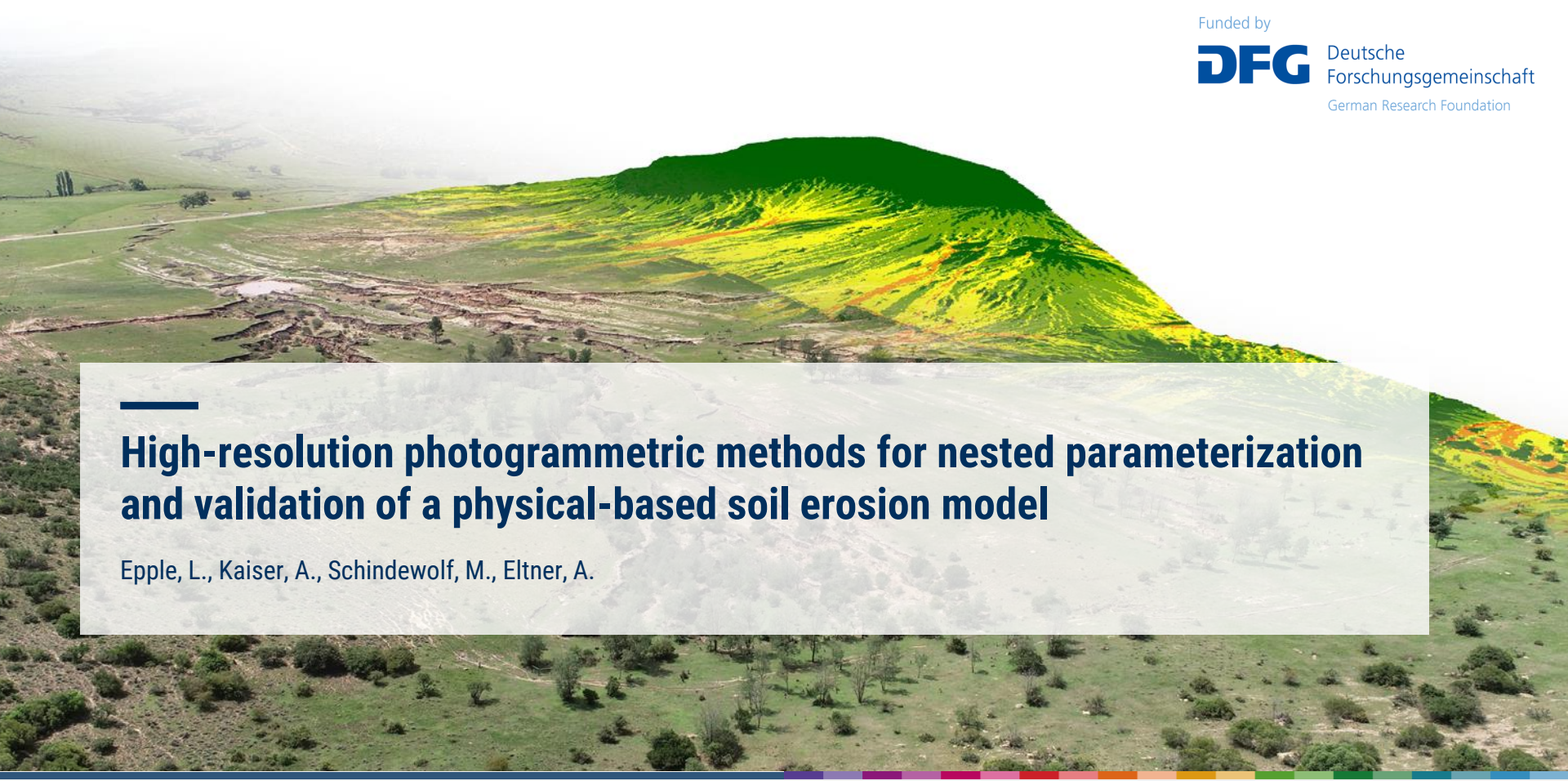
Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation



High-resolution photogrammetric methods for nested parameterization and validation of a physical-based soil erosion model

Epple, L., Kaiser, A., Schindewolf, M., Eltner, A.

FRIEDRICH-SCHILLER-
UNIVERSITÄT
JENA

TECHNISCHE
UNIVERSITÄT
DRESDEN

The Project

- Cross-scale modelling of soil erosion processes, both on a spatial and temporal scale, using physically based modelling approaches (Erosion 2D/3D) as well as photogrammetric measurement and optimisation methods.
- Parameterization, Validation and further development of the physical-based soil erosion model Erosion 3D
- Cross-scale measurement of soil erosion as well as parameterization of the soil erosion model with photogrammetric methods

Erosion Modelling

Erosional processes are discontinuous

Modelling

Empiric (e.g. ABAG)

Low data volume
Simple parameterization

Limited transferability
Not event based

Process-based (e.g. EROSION 3D)

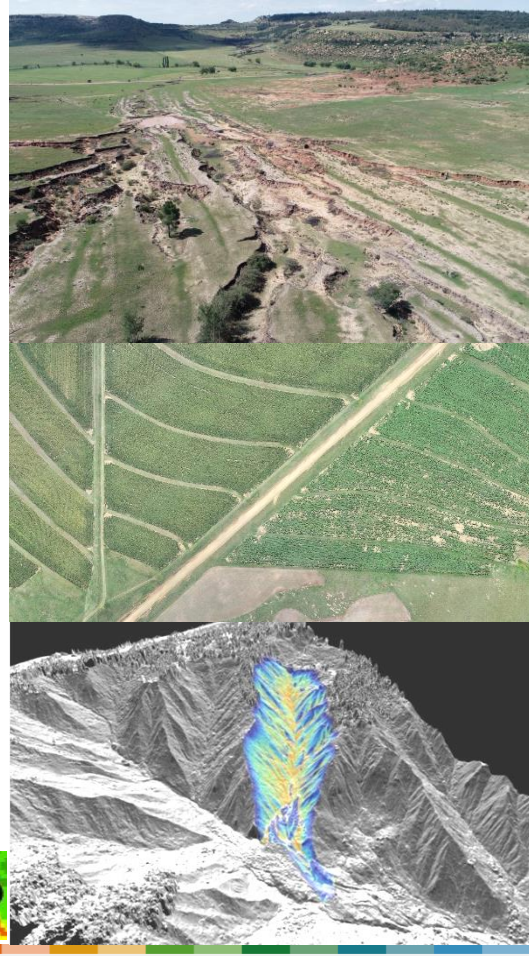
High data volume
Complex parameterization

Transferable
Event based

Other than empirical-based models, process-based models offer the advantage of transferability and the capability to display scenarios. The Event-relation enables both the (online-) linkage with measured precipitation values as well as the planning and dimensioning of protective steps.

Process Based Erosion Modelling – Erosion 3D

- Developed by **Schmidt 1991** and **von Werner 1995**
- Developed to forecast and simulate **soil detachment, transport** and **deposition** as well as **surface runoff**
- **Event-based** depiction of erosion processes
- Simulation of **conservation measures** (e.g. buffer strips, retention ponds, grassed waterways, no-till…)
- Reconstruction of **hydrographs** and thus **flood peaks**
- Modelling at **< 1m spatial** resolution in small catchments
  → **precise localisation** of erosion hot spots, flow paths and potential conflicts with infrastructure



EROSION 3D

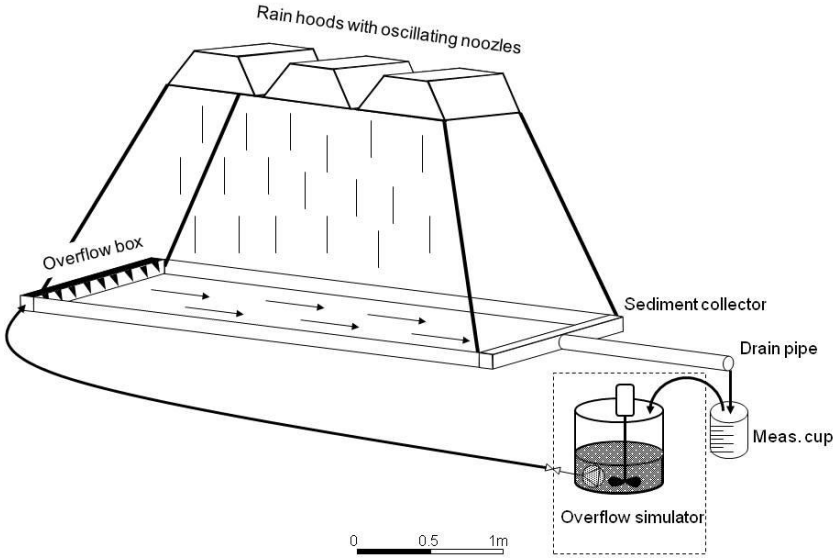
Approach

- Spatial-temporal cross-scale high-resolution land survey
- Three different scales for recording the respective effective processes and influencing factors:
    - **Microplot scale**: Observation of soil change under controlled conditions on loess soil and residual soil in Thuringia and Saxony, Germany (rainfall simulation and time-lapse SfM)
    - **Single slope scale**: Observation of laminar and linear forms of erosion under natural conditions on loess soil in Saxony, Germany (gauge at the outlet and time-lapse SfM on three different locations along the slope)
    - **Small catchment scale**: Observation of potential ephemeral gullies and local storages on loess soil in Saxony, Germany (gauge at the outlet and UAV)
- Nested parameterization and validation of process-based erosion models (Erosion 3D)

Approach – Rainfall Simulation

- Three oscillating flat-jet nozzles to simulate rainfall
- Overflow tool to simulate effects of sheet flow on longer slopes
- 3 x 1 m² plot size
- Rainfall intensity set to 40 mm/h

- 32 rainfall simulations on both loess soil and residual soil with different levels of vegetation cover



Approach – Photogrammetric Measurements

At microplot scale

- 7 triggered, overlapping cameras to perform time-lapse SfM
- RGB imagery used to map areas covered by water
- Also videos captured to measure flow velocities of runoff
- Thermal camera to estimate soil moisture

At single slope scale

- 5 rain-triggered, overlapping cameras each at lower, middle and upper slope to perform time-lapse SfM
- Videos captured during runoff to measure flow velocities at each slope position
- Thermal camera to estimate soil moisture at each slope position

At small catchment scale

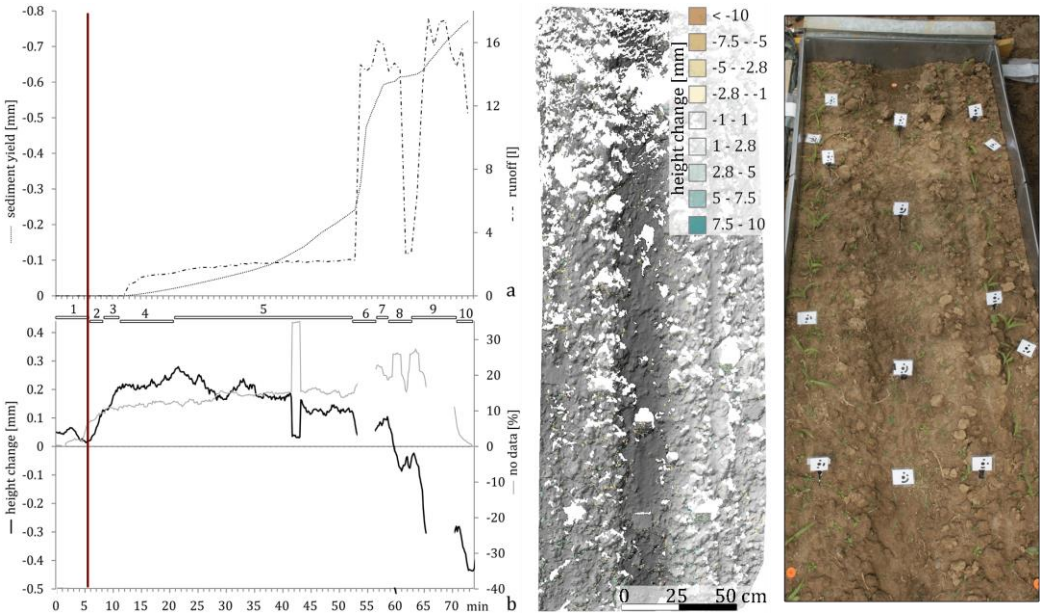
- Event based UAV missions
- Using RGB to reconstruct the soil surface
- Using NIR to map vegetation
- Using thermal sensors to estimate soil moisture

Examples of SfM time-lapse camera setup – Picture is take from Eltner et al., 2017 (Earth Surface Processes and Landforms, DOI: 10.1002/esp.4178)

Time-lapse images captured during a 20 minutes rainfall event

Erosion Model – Validation and Adaption

- Validation of the Erosion 3D model and optimization of the parameters and the process description due to highly redundant photogrammetric observations
- Comparing the data of the photogrammetric model with the actual measured soil erosion
- Possible adaption: process extension of the Erosion 3D model looking at the initial rill formation
  → in current rill erosion models initial rills can not be precisely located but are randomly distributed



With SfM measured changes during rainfall simulation compared to measurement at system outlet