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Characterization of soil microtopography effects on runoff and soil erosion rates under simulated rainfall

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Faculty of Bioscience Engineering

International symposium on Erosion and Landscape Evolution
Paper 11044

ASABE

Content

- Introduction and hypothesis
- Materials & methods
- Results
  - Rainfall simulations
  - Rougness indices
  - Erosion modeling
- Conclusion

"Awesome erosion!"

- Soil surface roughnes: important factor influencing soil erosion

- WEPP: interrill sediment delivery D_i

$$D_i = K_{iadj}.I_e.\sigma_{ir}.SDR_{RR}.F_{nozzle}.(R_s/w)$$

SDR_{RR}: function of random roughness

Research questions

- How does soil surface roughness influence runoff and soil erosion?
- Which indices describe soil surface roughness well?
- Possibility to improve erosion modeling

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Materials & methods

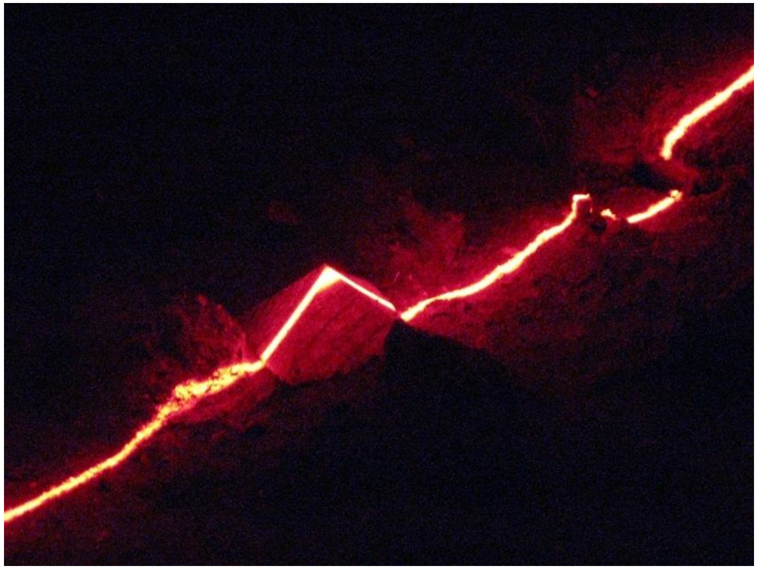
- Soil: silt loam
- Sieving to four roughness classes
  - Very smooth (0.3 – 1.2 cm)
  - Smooth (1.2 – 2.0 cm)
  - Rough (2.0 – 4.5 cm)
  - Very rough (4.5 – 10.0 cm)
- Soil trays: 0.6 x 1.2 m
- Slope set at 5%

Materials & methods

- Rainfall simulator
  - Oscillating nozzle simulator
  - Rainfall intensity: 50.2 ± 2.1 mm/h
  - Duration: 1.5 h

Materials & methods

- Soil surface roughness measurements
  - Instantaneous profile laser scanner
  - Before and after rainfall simulations



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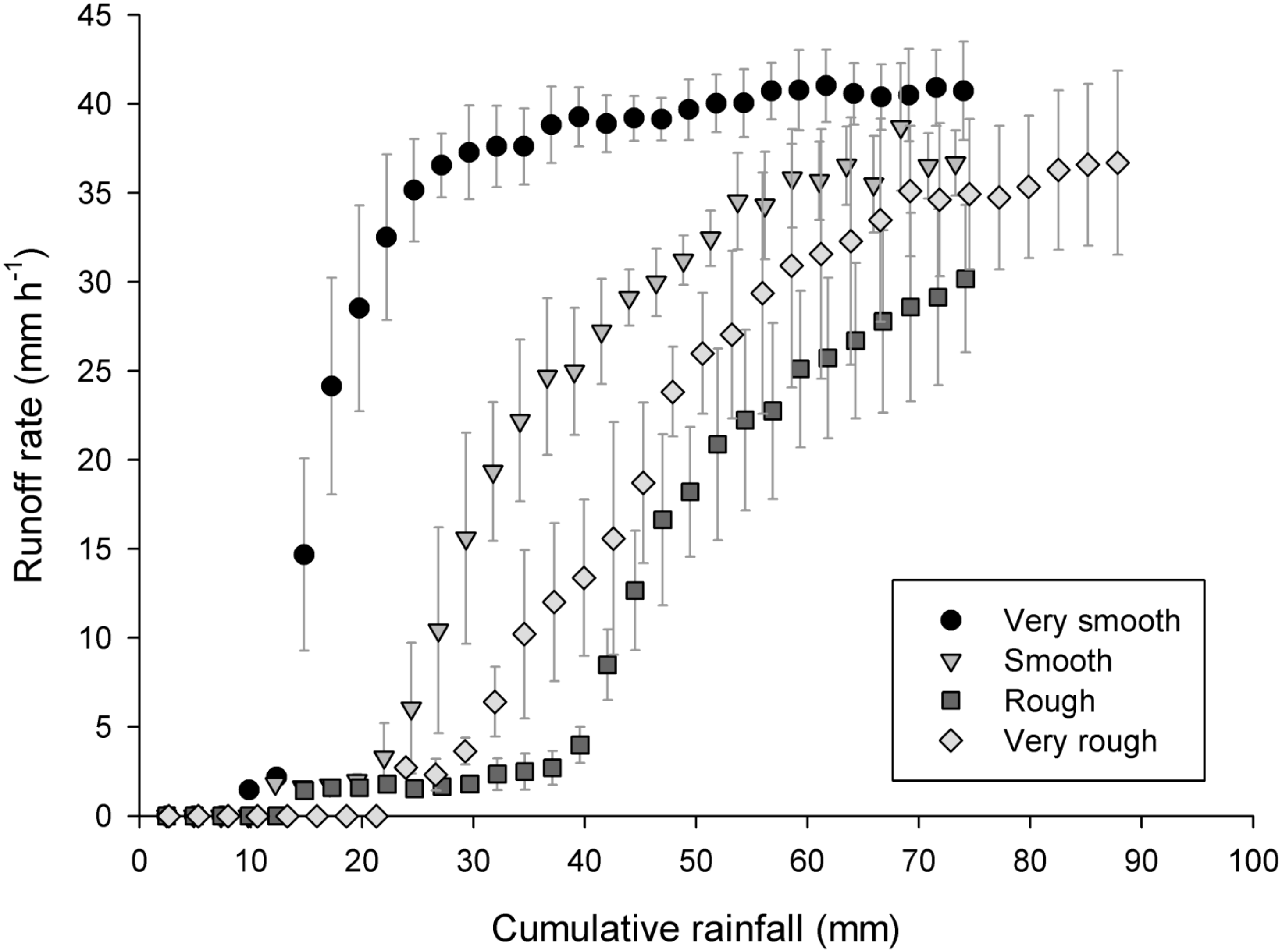
Results: Runoff



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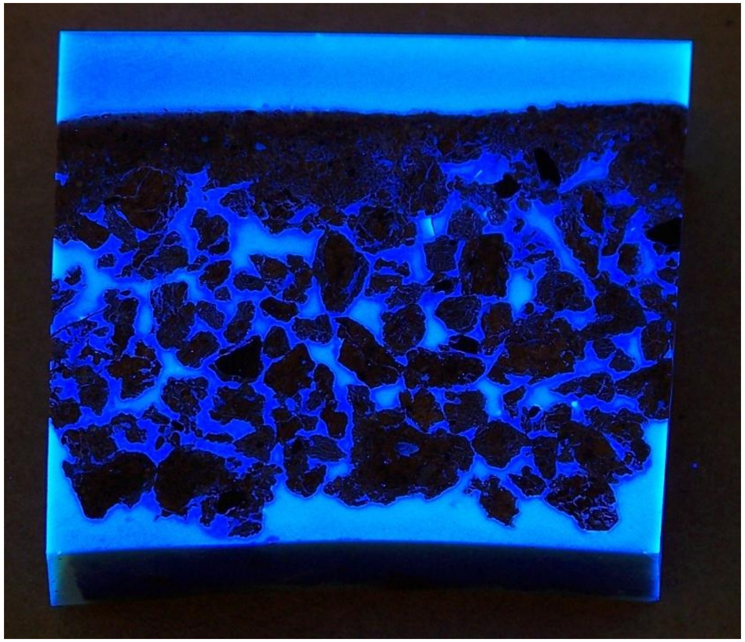
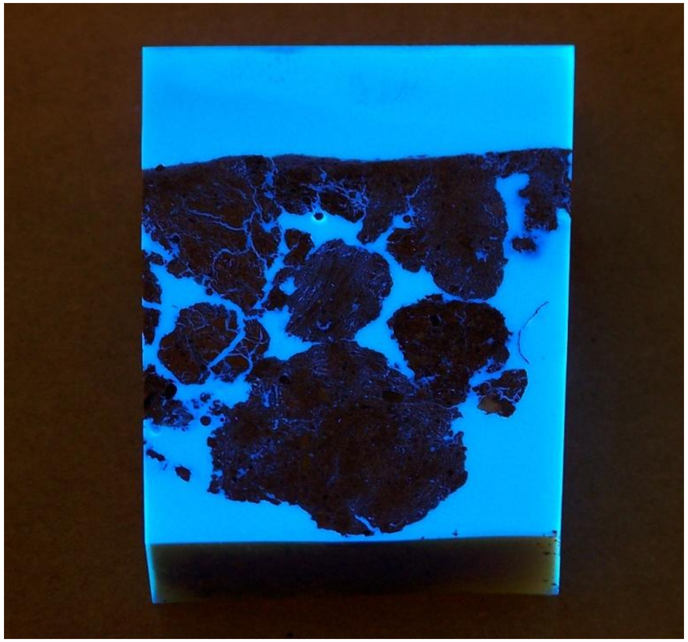
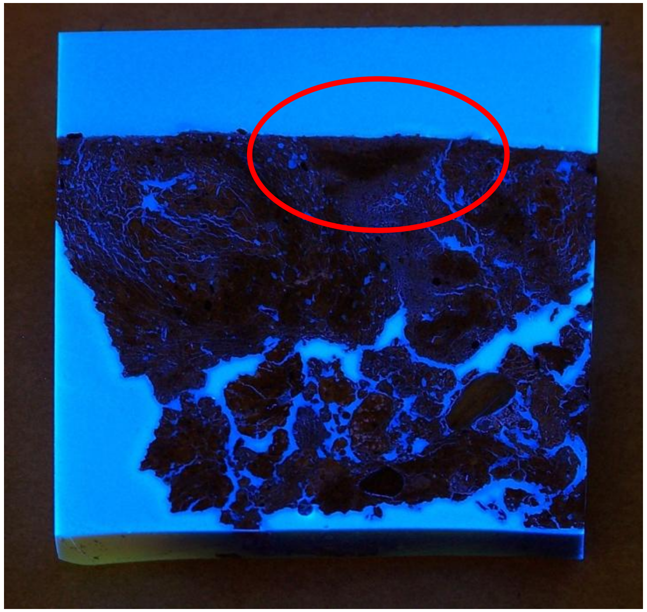
Results: Runoff



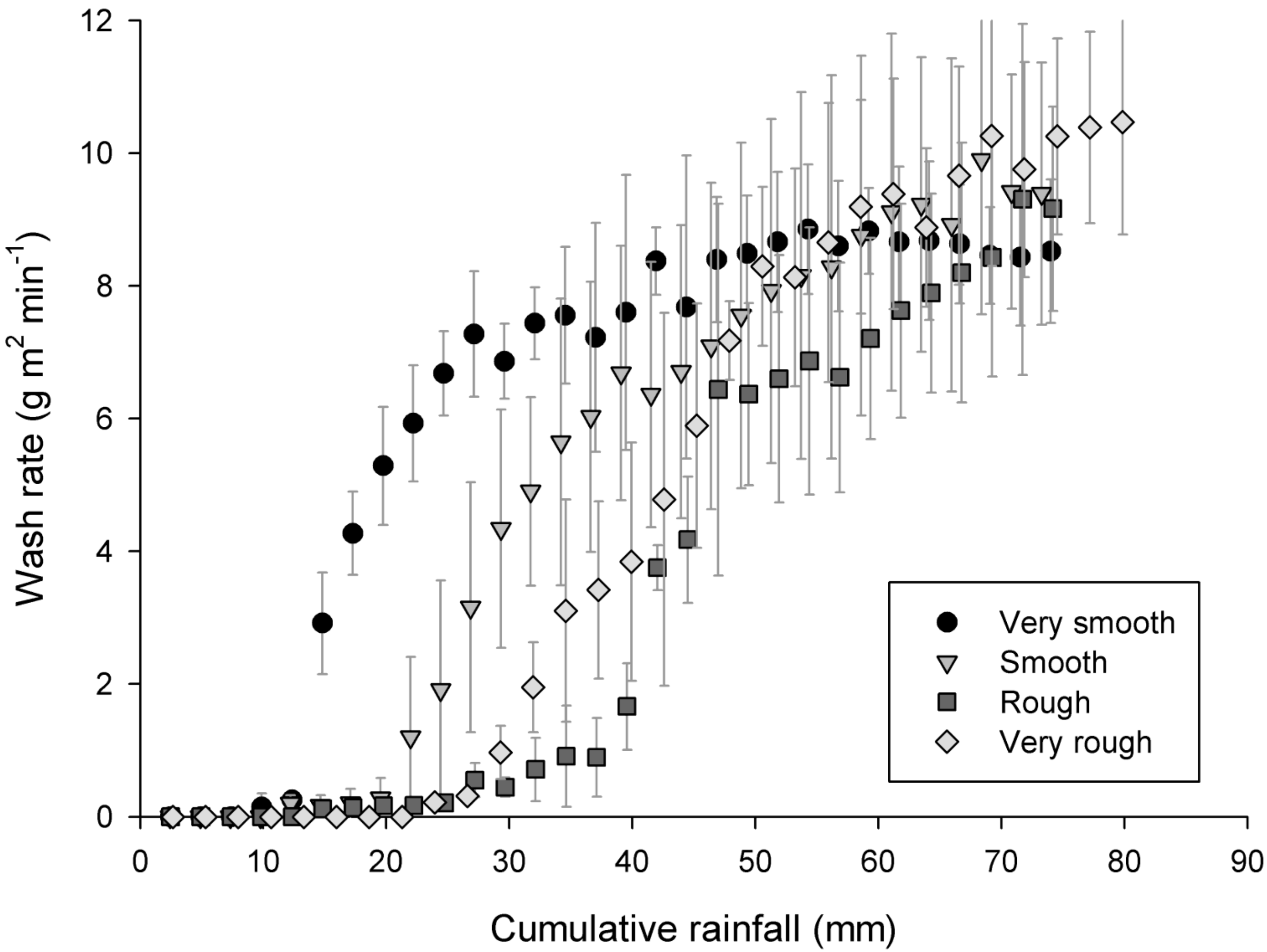




Results: Runoff

- Highest final runoff rate for very smooth surface (0.3 – 1.2 cm), lowest for rough surface (2.0 – 4.5 cm)
- Very rough surface NOT lowest final runoff rate due to
  - Formation of depositional crust
  - Topography forcing water to flow to the depressions rather than to infiltrate

Results: Soil loss



Results: Soil loss

- Total soil loss highest for very smooth soil surface, lowest for rough soil surface
- Final wash rates comparable for all soil surface roughnesses.

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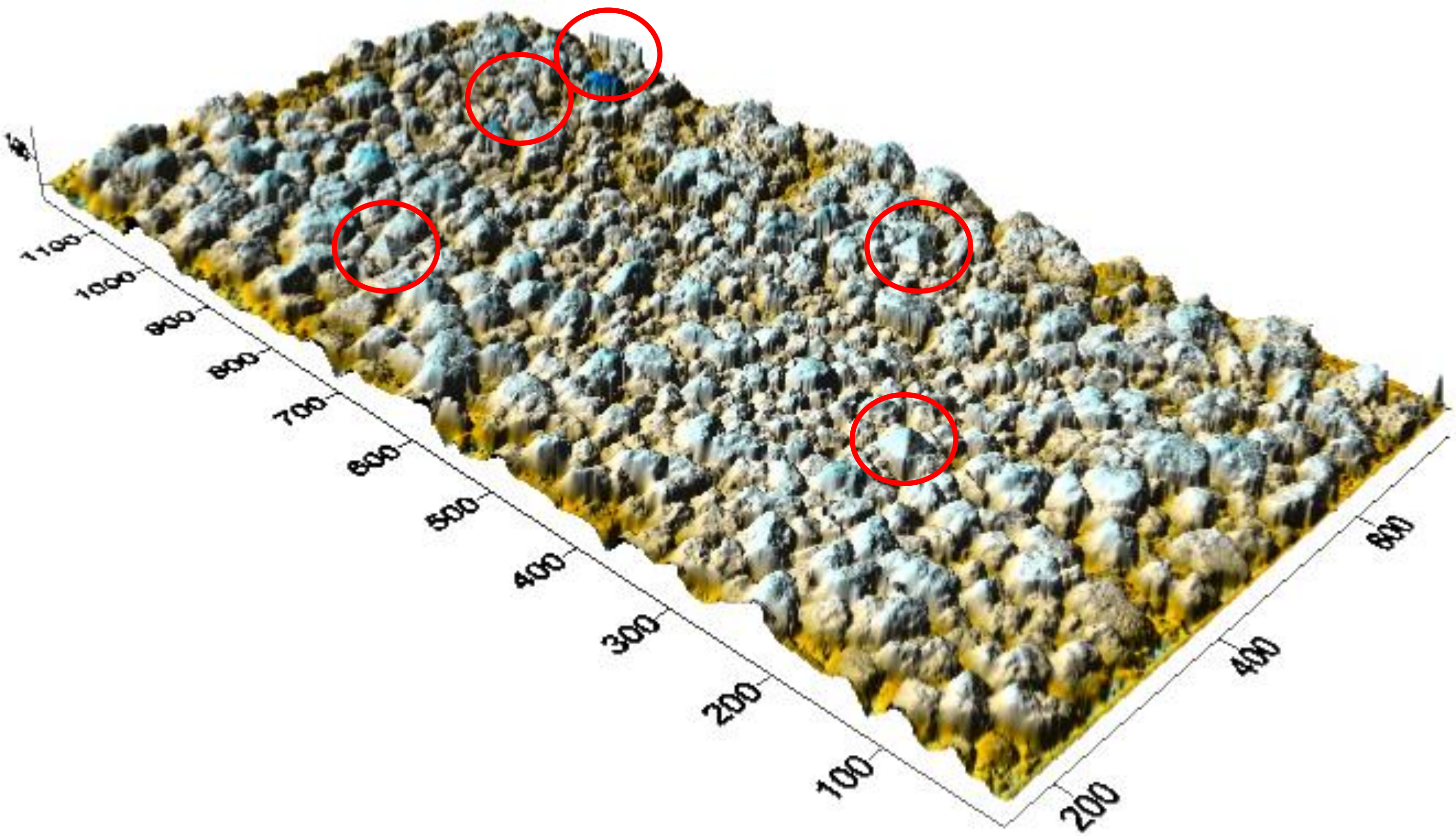
Results: Roughness indices

- Random Roughness (RR)
- Characterisation by the variogram:
  - Range, sill, (sill-nugget)/range
- Fractional Brownian motion (fBm)
  - Fractal dimension, crossover length
- Revised Triangular Prism surface area Method (RTPM)
  - Fractal dimension

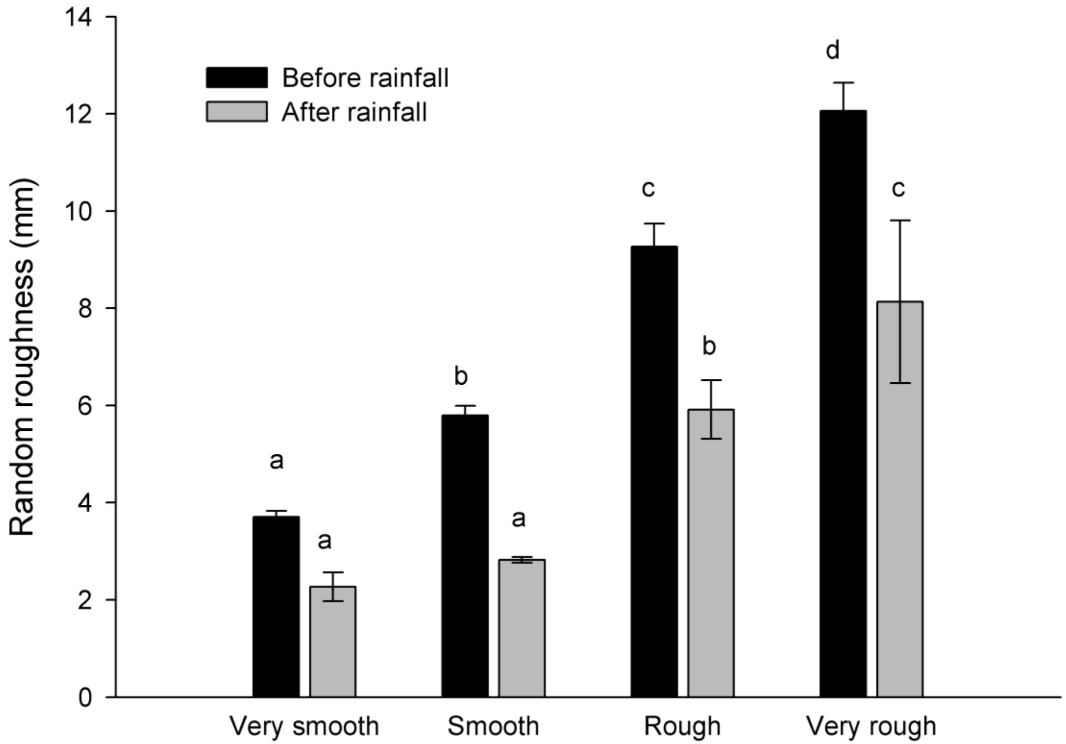
Results: Roughness indices

- DEM: correction for slope and scanning artifacts



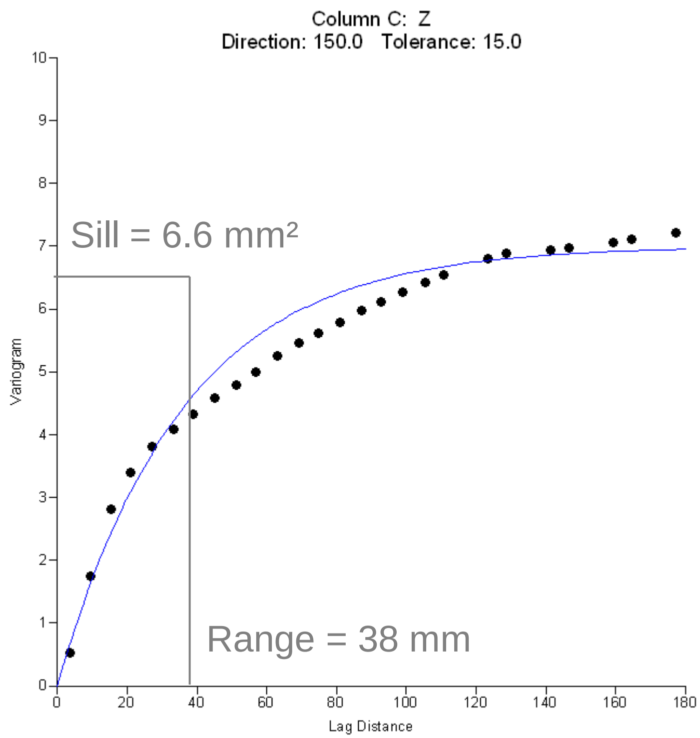
Results: Roughness indices

- Random Roughness (RR)

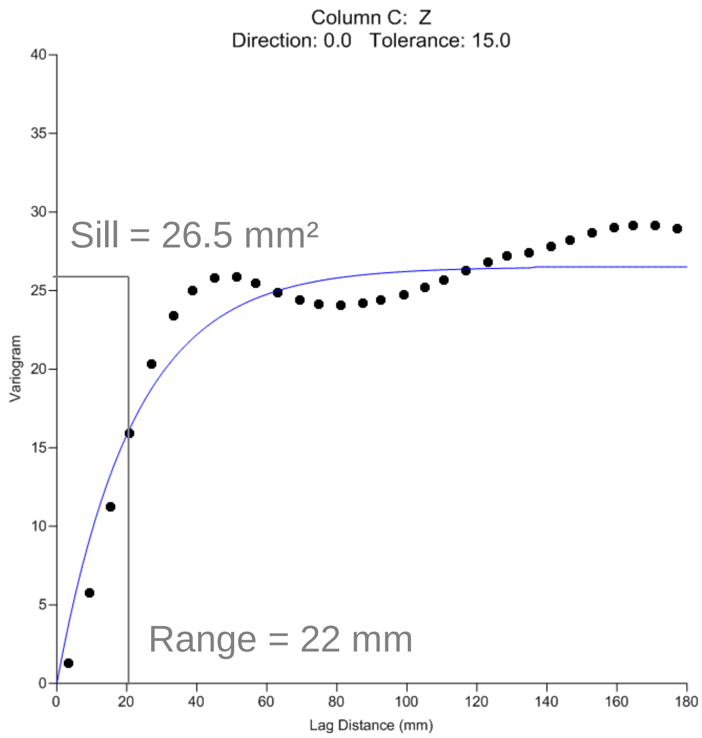


Results: Roughness indices

- Variogram:
  - Geometric anisotropy
  - Exponential model
- Rough surface: small scale periodic patterns



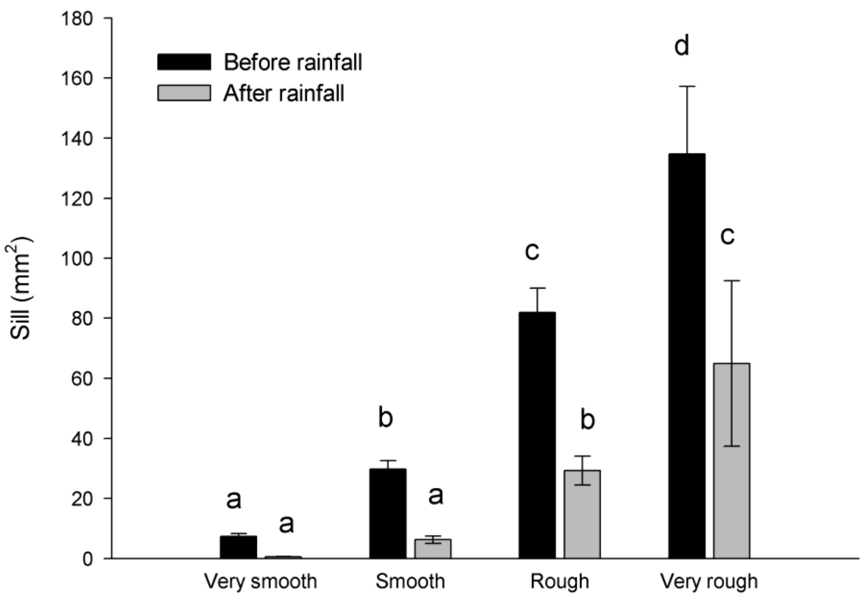
Smooth (1.2 – 2.0 cm)

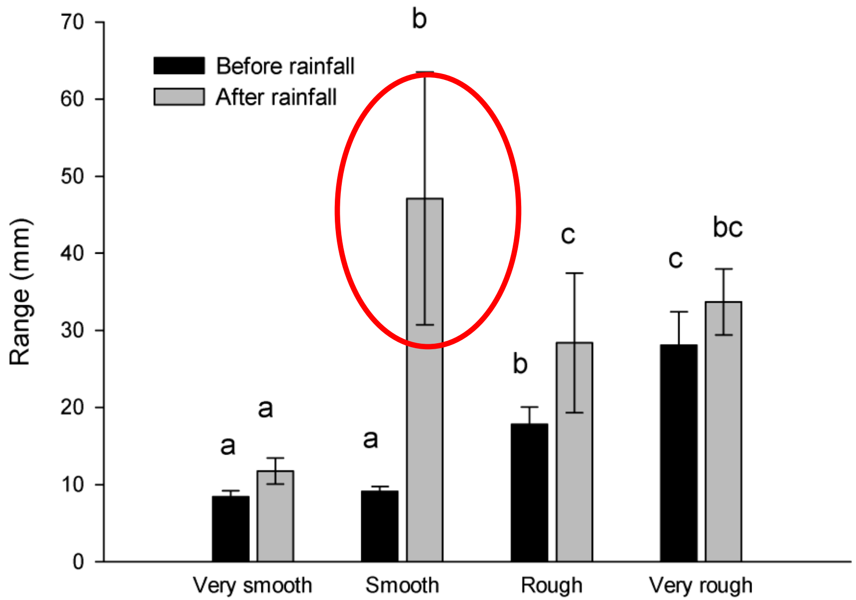


Rough (2.0 – 4.5 cm)

Results: Roughness indices

- Variogram parameters

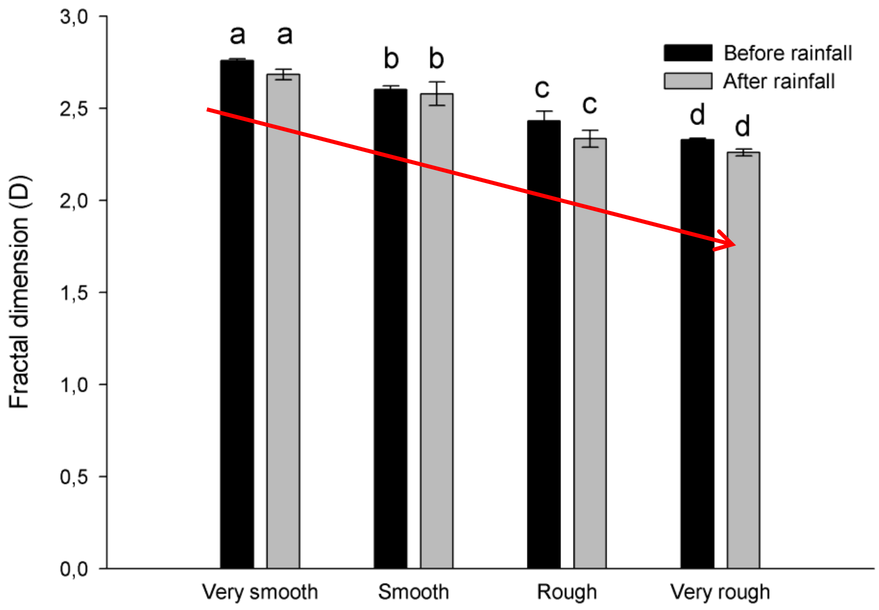


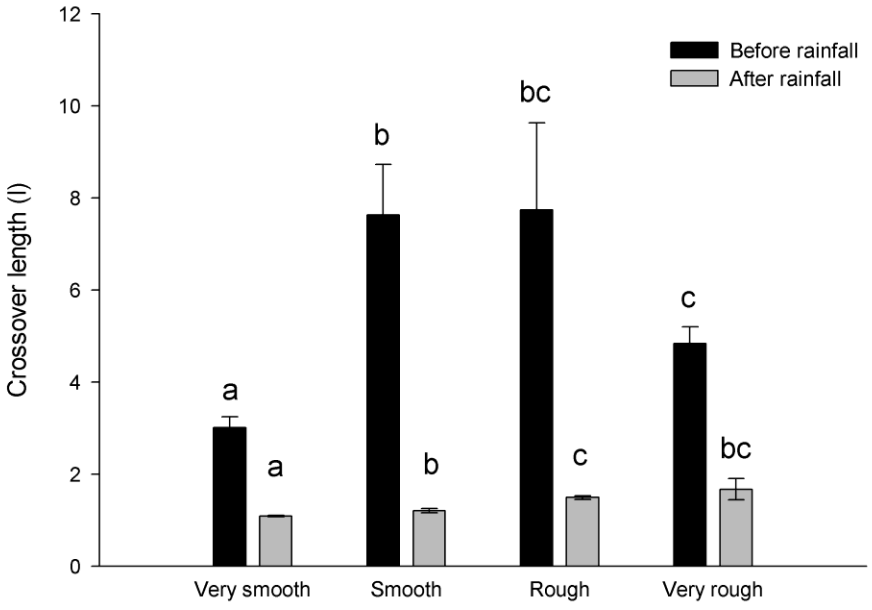


- Sill: good predictor
- Range: Smooth surface not in line

Results: Roughness indices

- Fractional Brownian motion

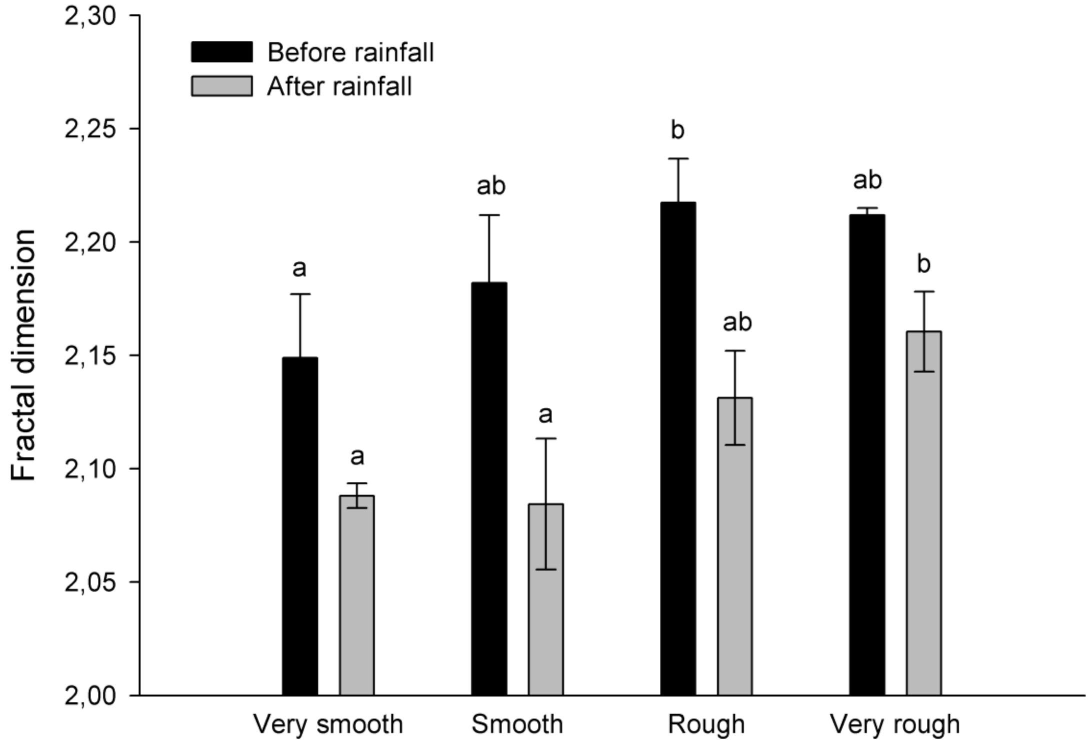


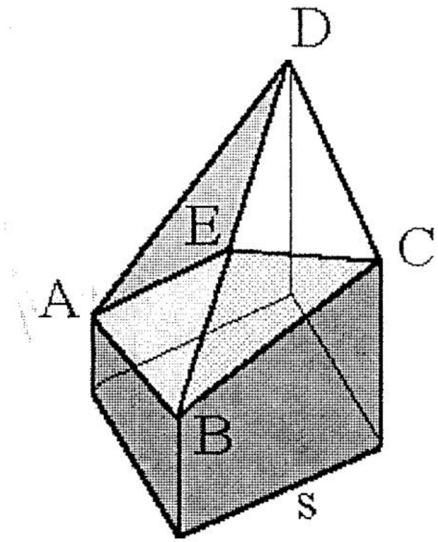


- Fractal dimension (D): decreasing trend
- Crossover length (l): no constant trend

Results: Roughness indices

- Revised Triangular Prism method





  - Better predictor than fBm
  - Little significant differences

Results: erosion modeling & WEPP

- Expectations for use in erosion models:
  - RR differentiates good between roughness classes
  - Improvements can be expected with real measured values of RR
  - Use of Sill or RTPM:
    - + spatial correlation
    - − lower significant differences
  - Best option: use of DEM by depression filling models

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Conclusion

- Effect on runoff & soil loss
  - delay in runoff rather than the decrease of soil erosion amount.
- Roughness indices
  - Random roughness performs well
  - Spatial correlation taken into account:
    - Variogram sill and RTPM fractal dimension perform best


Thank you for your attention!
Denali NP, 10/11/2011

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