Inter-replicate and duration-related systematic variability: how significant they are in predicting SOC loss?

Yaxian Hu (yaxian.hu@unibas.ch), Wolfgang Fister, Nikolaus J. Kuhn, University of Basel, Switzerland

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1. Introduction

Sediment generated by interrill erosion processes is often reported to be enriched in soil organic carbon (SOC). To assess SOC loss by erosion, the amount of eroded sediment is often multiplied with the average organic carbon content in the eroding soil and the average enrichment ratio of SOC in sediment. However, the **complex interaction between rainfall, runoff and soil crusting** renders SOC erosion to be highly variable over time. Apart from that, **conservation of mass** dictates that the enrichment ratio of SOC in sediment must be balanced over time by a decline of SOC in the source area material. The use of average enrichment values or values obtained from short erosion measurements is therefore likely to generate **a high uncertainty in estimating SOC loss** over longer events. Similar errors are also likely to occur as a consequence of applying SOC erosion data generated based on current rainfall characteristics to estimate SOC loss in the future with changing rainfall magnitudes.

2. Materials and Methods

Two silty loams from Möhlin (47°33' N, 7°50' E), Switzerland, one from the conventionally managed farm **(CS)** and one from the organically managed farm **(OS)**, were exposed to a simulated rainfall of 30 mm h^{-1} for 360 min.

Simulated rainfall tests were **repeated ten times and a two-step erosion model** was developed based on the infiltration, runoff and soil erosion data obtained from **six selected event durations** of 60, 120, 180, 240, 300 and 360 min. Random variability between tests and systematic changes due to erosion and crust formation were compared.

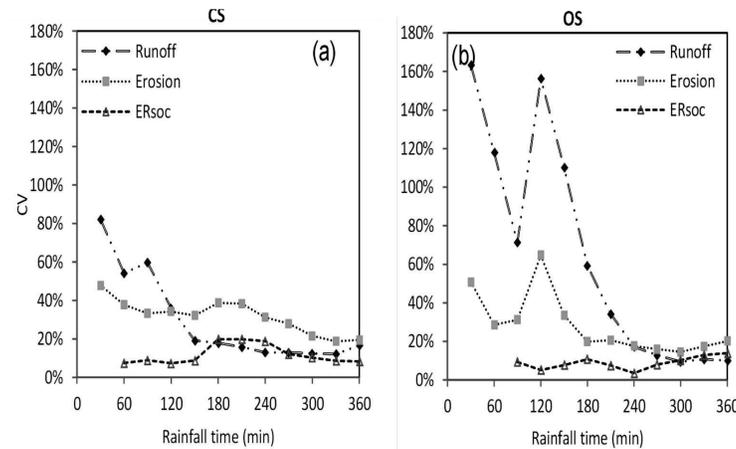## 3. Random inter-replicate variability

Figure 1. Variability (coefficient of variation, CV) of runoff rates, erosion rates and enrichment ratio of SOC (ERsoc) of CS and OS over 360 min of rainfall.

The **inter-replicate variability** of both runoff and soil erosion rates **declined over time** (Figure 1), mainly because the increasing runoff and soil erosion rates lead to a decreasing ratio between the standard deviation and the mean values.

Even after maximum runoff and erosion rates were reached (around 180 min for CS, and 240 min for OS), **the inter-replicate variability still remained between 15 and 39%** (Figure 1).
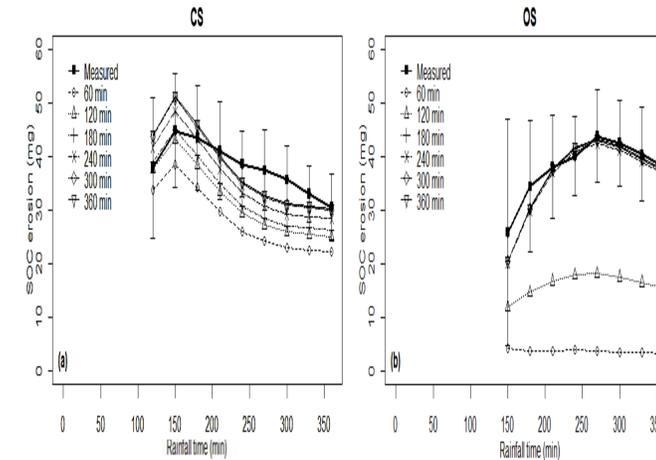
4. Sediment SOC, crusting & erosion

Figure 2. Comparison between the measured SOC loss over the entire rainfall events (360 min), and the predicted SOC loss based on six sub-events.

Enrichment of SOC dropped during prolonged erosion and crusting (Figure 2), confirming that preferential SOC erosion is limited by depletion of SOC in the eroding crust.

As a consequence, the **predicted SOC erosion rates gradually approached the measured SOC erosion rates with increasing simulated event duration** (Figure 2).

5. Conclusions

- The inherent inter-replicate variability during interrill erosion process (Figure 1) illustrates that the **complex interaction at the soil surface remains significant even under ideal laboratory conditions**, implying that predictions of **interrill erosion models remain uncertain even under ideal conditions**.

- The progressively improved predictions with extending sub-event durations (Figure 2) demonstrates the **relevance of duration-related systematic variability** in SOC erosion. **Therefore, simple linear extrapolation of the enrichment parameter values may cause significant errors in model results**.

Yaxian Hu's publications:

Hu, Y., Fister, W., Rüegg, H. R., Kinnell, P. I. A. and Kuhn, N. J.: The use of Equivalent Quartz Size and settling tube apparatus to fractionate soil aggregates by settling velocity, Geomorphol. Tech. Online Ed. Br. Soc. Geomorphol., Section 1.1.1, 2013.

Hu, Y., Fister, W. and Kuhn, N. J.: Temporal variation of SOC enrichment from interrill erosion over prolonged rainfall simulations, Agriculture, 3(4), 726–740, 2013.

Hu, Y., and Kuhn, N. J.: Aggregates reduce transport distance of soil organic carbon: are our balances correct? Biogeosciences (accepted).

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Department of Environmental Sciences
Physical Geography & Environmental Change
University of Basel

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