

Xiaojing Ou¹, Pu Shi², Kristof Van Oost¹

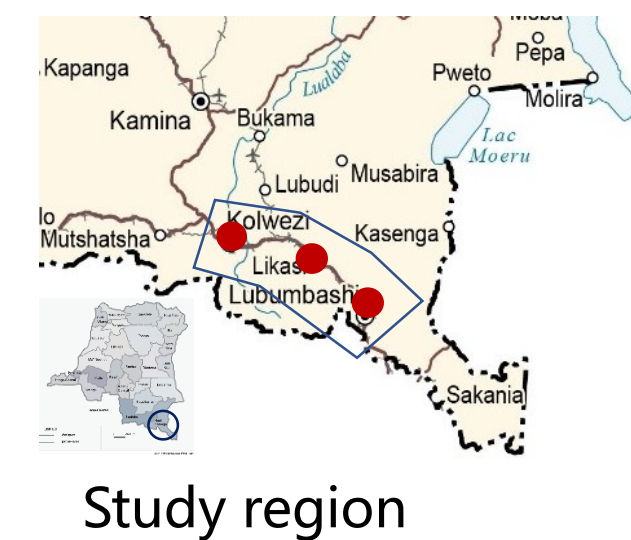
¹ Earth and Life Institute, UCLouvain, 1348 Louvain-la-Neuve, Belgium

² College of Earth Sciences, Jilin University, Changchun 130061, China

Introduction and Objectives

Cropland expansion and contrasting management by smallholders and commercial farms have altered soil organic carbon (SOC) in the Copperbelt. While commercial farms often level termite mounds and apply fertilizers, smallholders rely on low-input practices. Yet SOC changes under these conditions remain poorly understood. This study investigates how cultivation duration and farm type influence SOC dynamics to inform sustainable land management and regional carbon monitoring. Specifically, we aim to answer:

1. Within a farm type (smallholder vs. commercial farms), does SOC content change with time?
2. Does SOC content differ between smallholder and commercial farms?



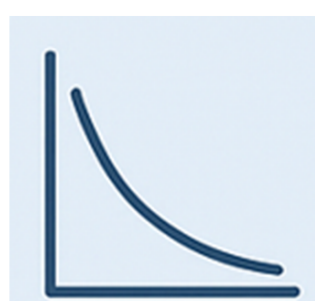
Uncertainty of spatial average



Pixel-level uncertainty (SD) from QRF
(Quantile regression forest)



Standardized prediction errors
432 samples: residual ÷ SD



Spatial autocorrelation
Fit a variogram of the standardized prediction errors -> get $\rho(d)$



Monte Carlo aggregation

- Randomly sample N pixel pairs
- Compute SD of the spatial average

$$SD_{\bar{y}} = \sqrt{\frac{1}{N} \sum_{i=1}^N \sigma(s_i) \times \sigma(u_i) \times \rho(d_{ij})}$$



Minimum detectable difference (MDD)

- Compare spatial means: detectable if $|SOC_i - SOC_j| > \max\{SD_i, SD_j\}$

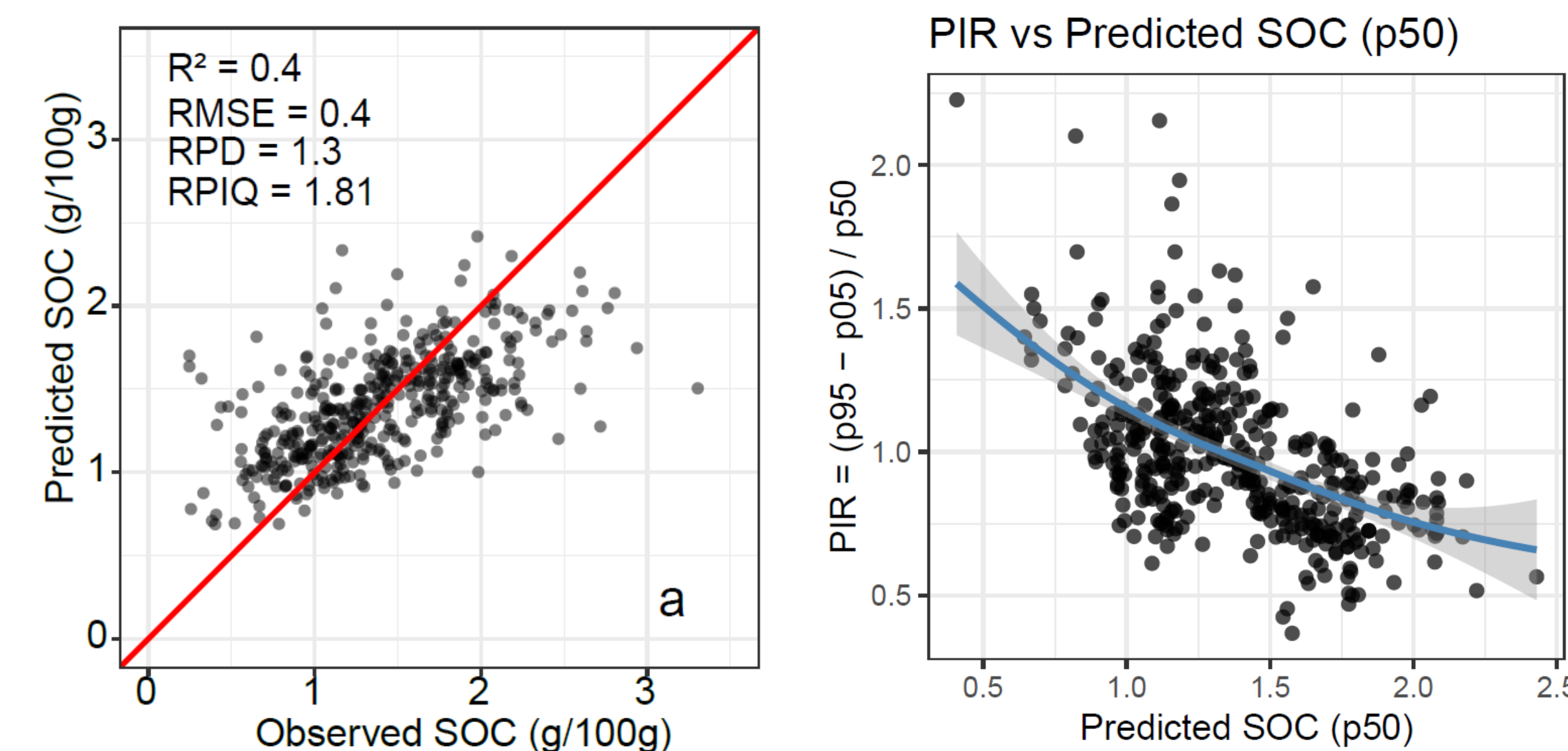
Main challenges and solutions

1. Hard to get "bare soil" images



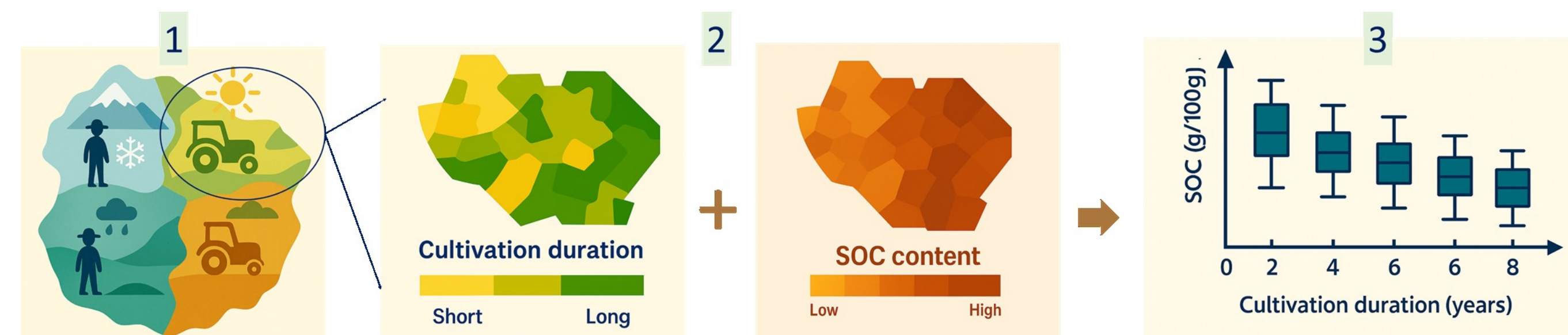
Which lead to...

2. Low mapping accuracy and high mapping uncertainty



So we have to...

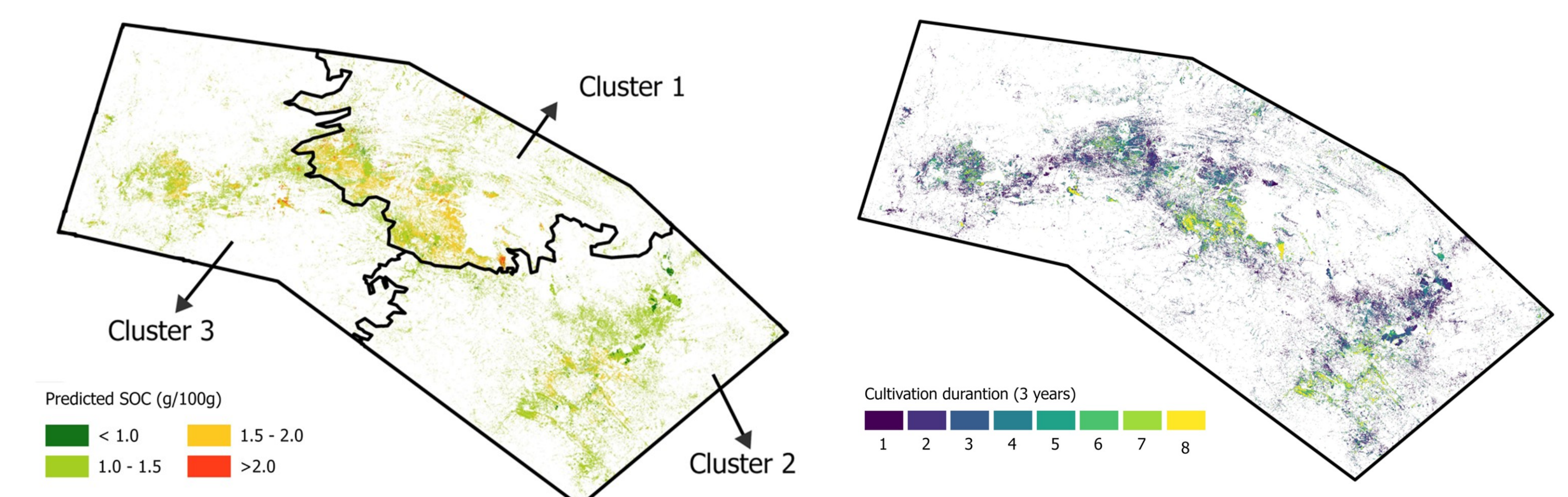
3. Spatial average to reduce uncertainty



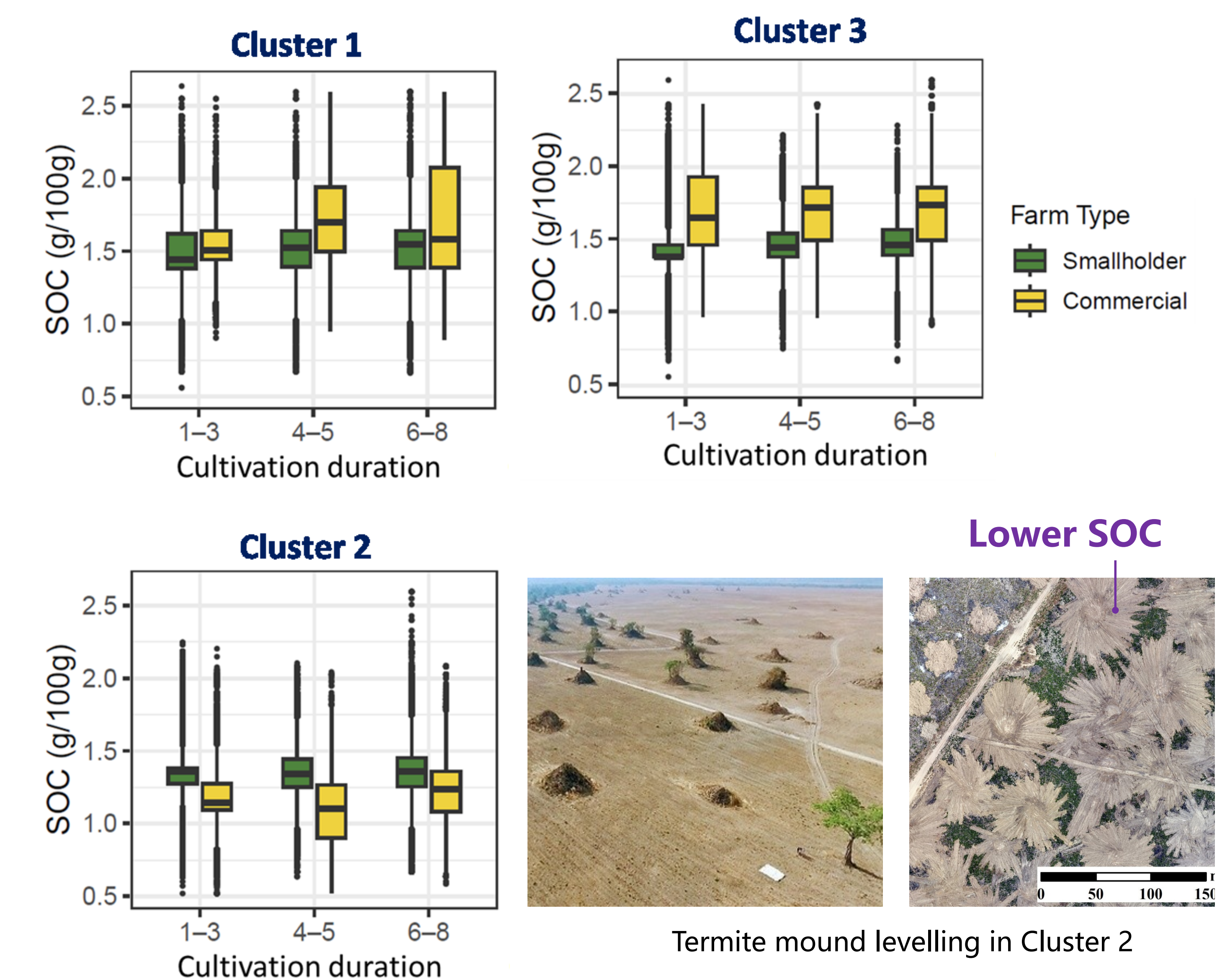
- 1) Group the region into clusters with similar environments: climate, topography, and farm type (smallholder vs. commercial).
- 2) Within each cluster, overlay the two maps: cultivation duration and SOC content.
- 3) Compare mean SOC under different cultivation durations.

Results

1. Predicted SOC map and cultivation duration map



2. SOC content vs. cultivation duration



Conclusions

1. As cultivation duration increased, SOC changes were small and not detectable.
2. SOC differences between smallholder and commercial farm were larger, but the directions and magnitude were environment-specific.

The way forward

1. Process-based SOC mapping? Then we need more in-situ data on field-scale management (fertilization, irrigation, cropping-fallow cycles...).
2. Why SOC differences between smallholder and commercial farms are environment-specific? Management? Mound levelling?
3. We need repeat sampling on fixed plots to track real SOC changes through time.