Regional soil characterization through the integration of remote sensing, geophysics, and field data

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Objective

Determination of **clay content** in soils of **different parent materials** in Germany by **gamma-ray spectrometry** and **hyperspectral imaging**

Motivation

- **Clay content in soils** influences nutrient storage, pollutant retention, soil fertility and erosion
- **Spatial information** on **clay content** provides important information on **soil functions** and **soil degradation**

Results (1): Handheld gamma-ray spectrometry

Clay content in **soils** of **different parent materials** was derived from measurements of **radioactive isotopes of potassium** (^{40}K) and **thorium** (^{232}Th) using **handheld gamma-ray spectrometry**

Ground truthing:

<u>Soil sampling</u>

- n=195
- Depth: 0-4 cm

<u>Laboratory analyses</u>

- **Clay content**: particle-size fractionation
- **K content:** X-ray fluorescence analysis (XRD)
- **Th content:** Inductively Coupled Plasma - Mass Spectrometry (ICP-MS)

Training data set (70%: n=139)

$$Clay_{predicted} = c_1 * factor\ pm + c_2 * K + c_3 * Th/K + c_4 * Th$$

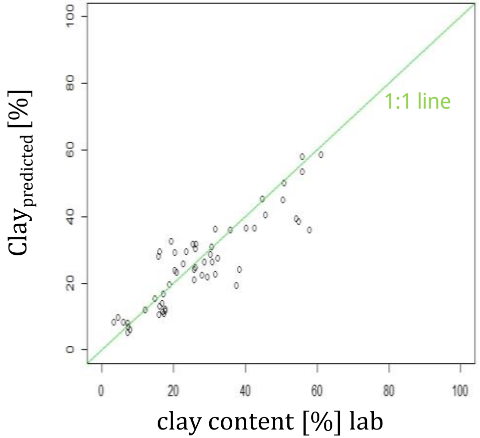
Factor_pm: Soil parent material specific factor

K: Potassium

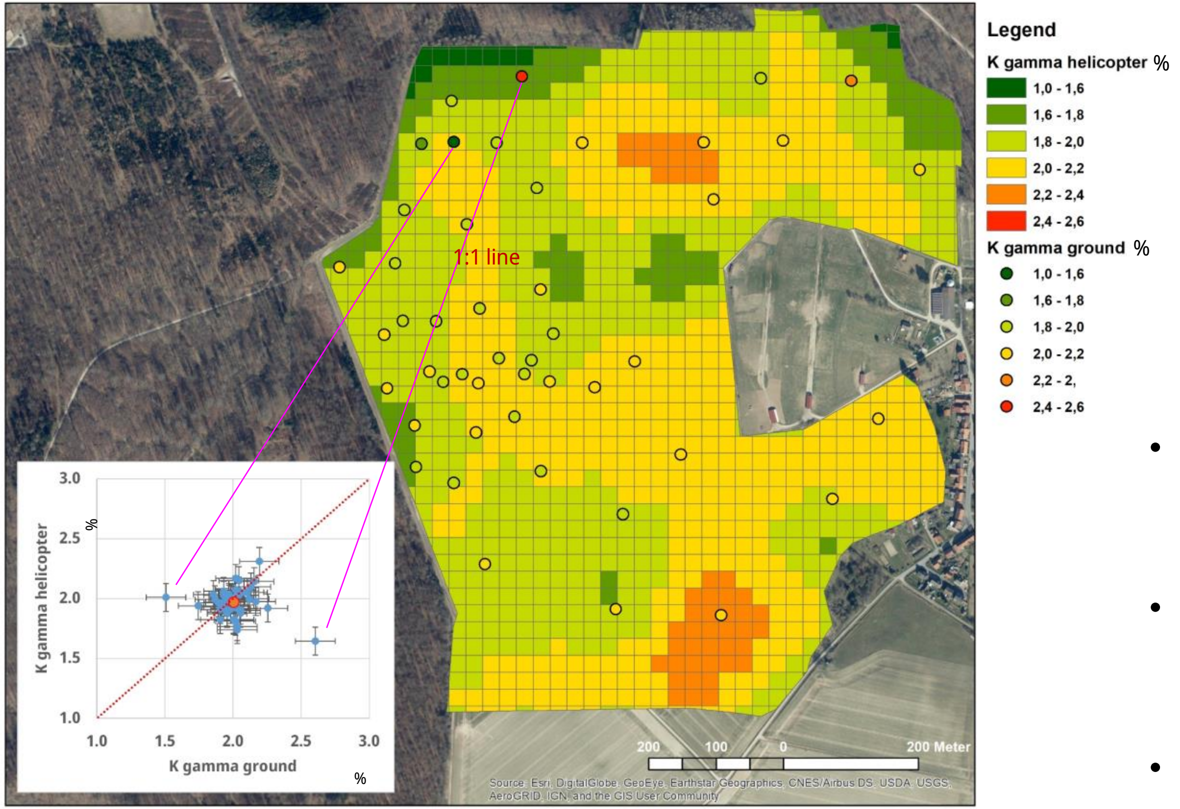
Th: Thorium

1000 iterations
Mean RMSE: 8.37 %
Mean MAE: 6.04 %

Validation data set (30%: n=56)



Results (2): Helicopter gamma-ray spectrometry

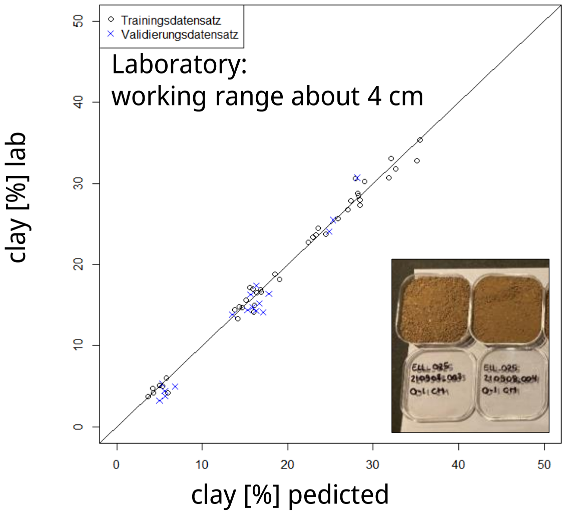


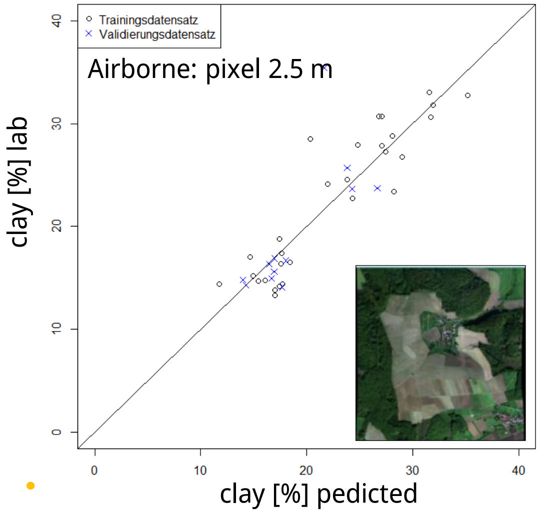
Study site: Ellierode (Harzvorland)

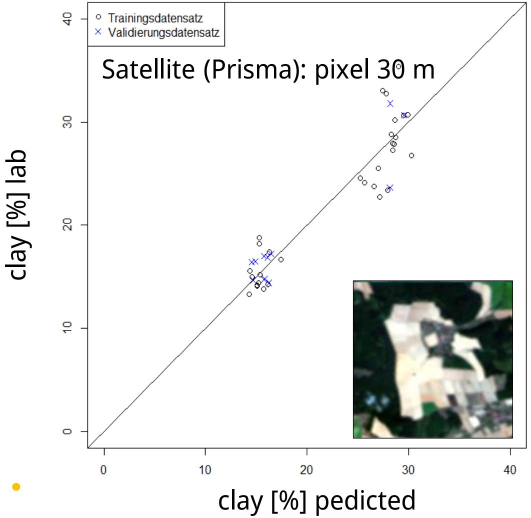
- **Helicopter gamma ray spectrometry** was validated successfully by handheld **gamma-ray spectrometry**
- **Clay content in soils** was measured successfully by **helicopter gamma-ray spectrometry**
- **Boundary effects** close to forests have to be considered

Results (3): Hyperspectral imaging

Hyperspectral imaging was successfully applied to predict **clay content in soils** from **laboratory data, airborne data** and **satellite data**







	R^2 training	R^2 validation	RMSE training	RMSE validation
Laboratory	0.98	0.97	0.94	1.52
Airborne	0.84	0.53	2.73	4.30
Satellite	0.85	0.88	2.57	2.01

Usability of results

- **Gamma-ray spectrometry** and **hyperspectral imaging** are promising for **mapping soil properties** as **clay content**
- Gamma- ray spectrometry completes hyperspectral imaging **in the top soil down to 30 cm depth**
- Combination of both methods can provide continuously updated **spatial soil data at local and regional scales**
- In particular, **satellite hyperspectral imaging** can support land use planning and soil protection at **inaccessible areas** impacted by ongoing conflicts or munition residues