A drone-borne gamma-ray spectrometer for soil texture mapping

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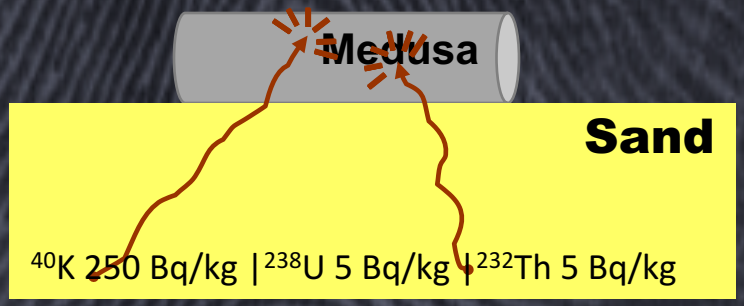
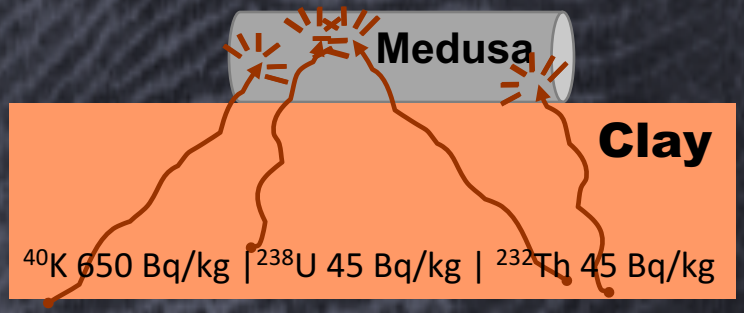
gamma-ray spectrometer for soil mapping

- Gamma-ray sensors common practice in soil mapping
- Provide spatial covering information on soil texture
- Sensor gives nuclide-specific data
  - ^{40}K (potassium)
  - ^{238}U (uranium)
  - ^{232}Th (thorium)
  - ^{137}Cs (cesium)
- Calibration to soil parameters by soil samples

Radiometric fingerprint





The idea:

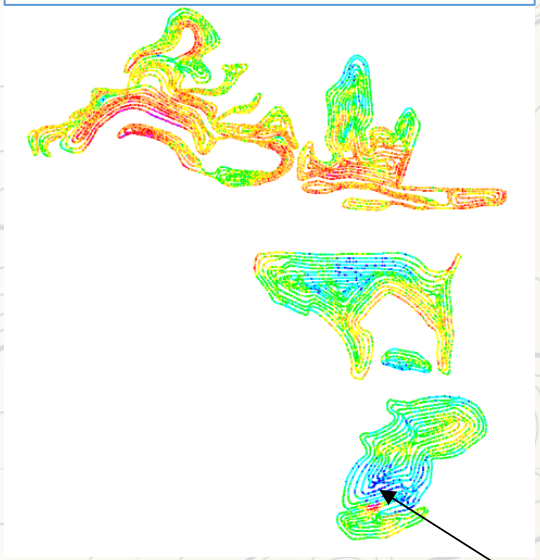
- Soil is a mixture of different minerals
- The concentrations of (radioactive) chemical elements differ in all components
- These components can be measured in the field and in the laboratory

Fingerprint:

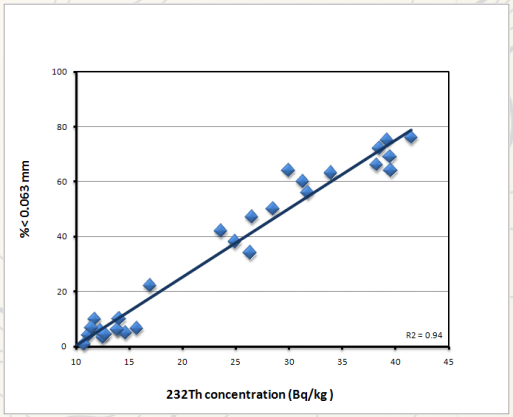
- The relation between (radioactive) chemical components and sediment composition
- Fingerprint can be used to translate field measurements to soil information

From fielddata to maps

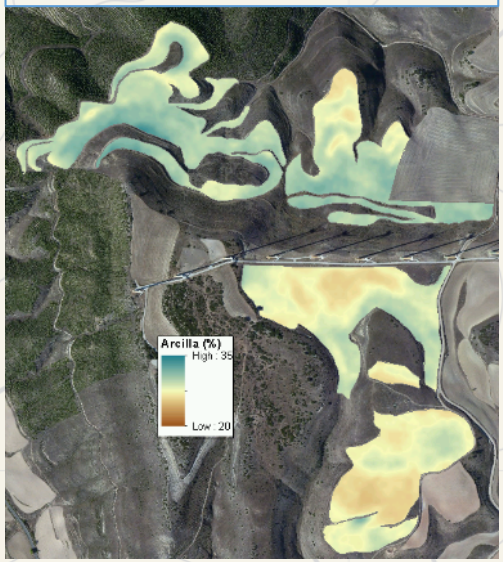
Gamma spectrometer (field)



Sample analyses (lab)



Clay content



Absolute concentrations are key!

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But what if.....

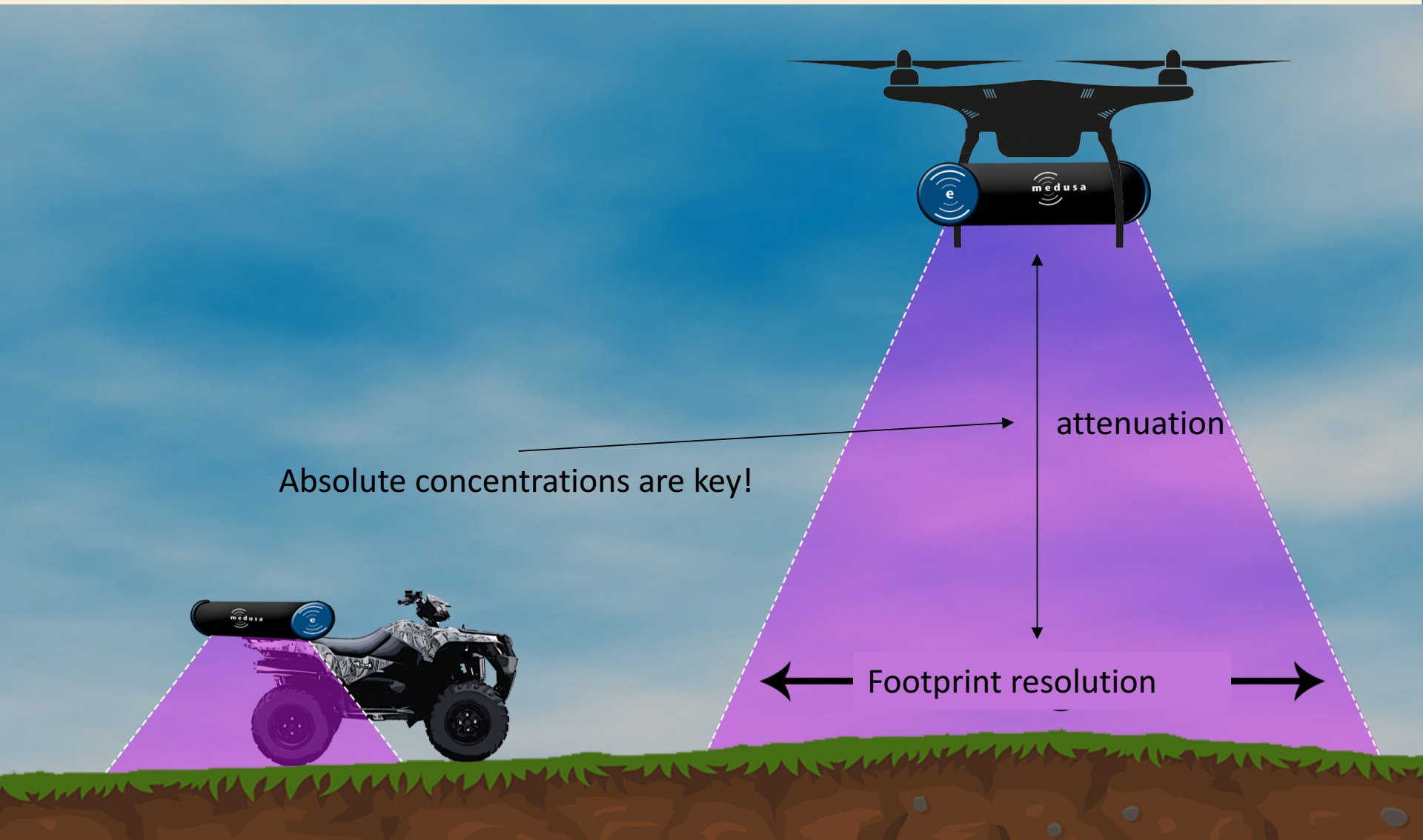
Hardware development and data modelling needed!

Ground to Drone borne

Hardware development

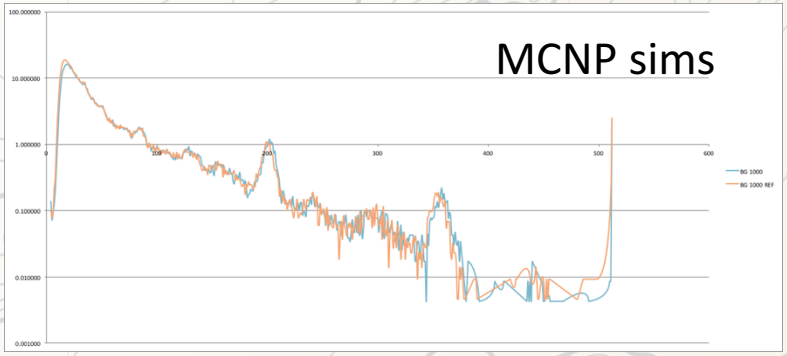
- Reduce
  - Size
  - Weight
  - Power consumption
- System should be autonomous

Ground to Drone borne

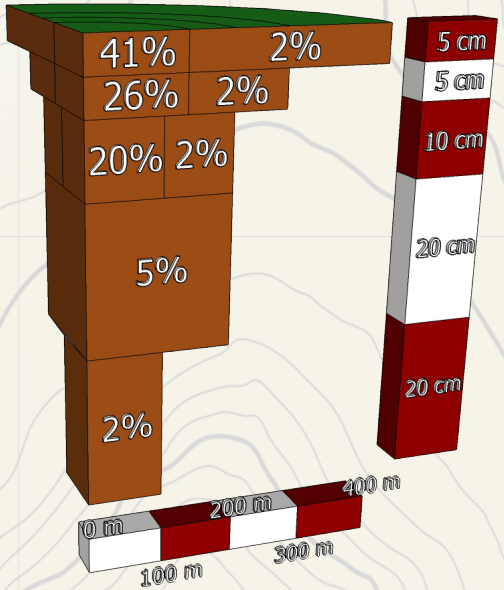


Ground to Drone borne

Data modelling attenuation



Data modelling footprint



Field trials

Ground

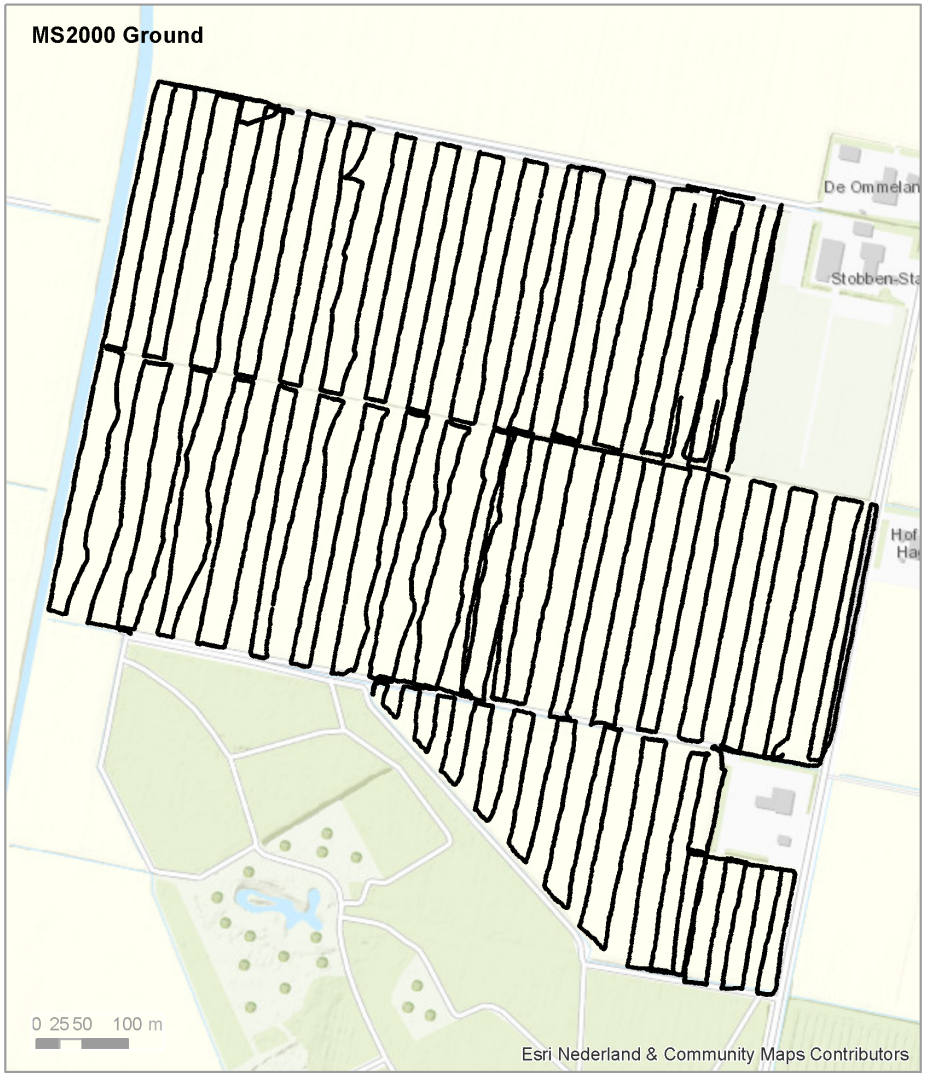
- MS-2000, 2 L crystal
- Walking survey
- Elevation 0.8 m
- Measurement frequency of 1 Hz.
- Bare soil

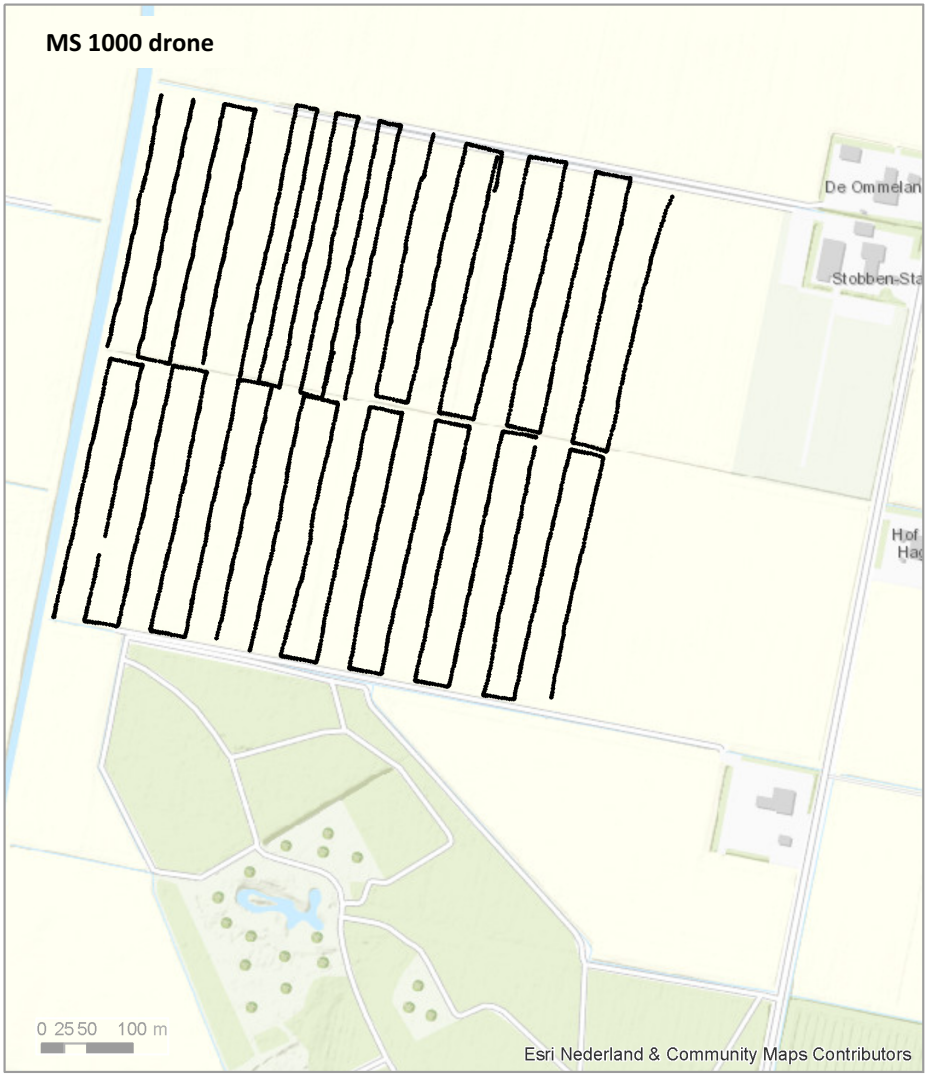
Drone

- MS-1000, 1 L crystal
- Drone survey
- Elevation 15 m
- Measurement frequency of 1 Hz.
- Vegetation started to grow

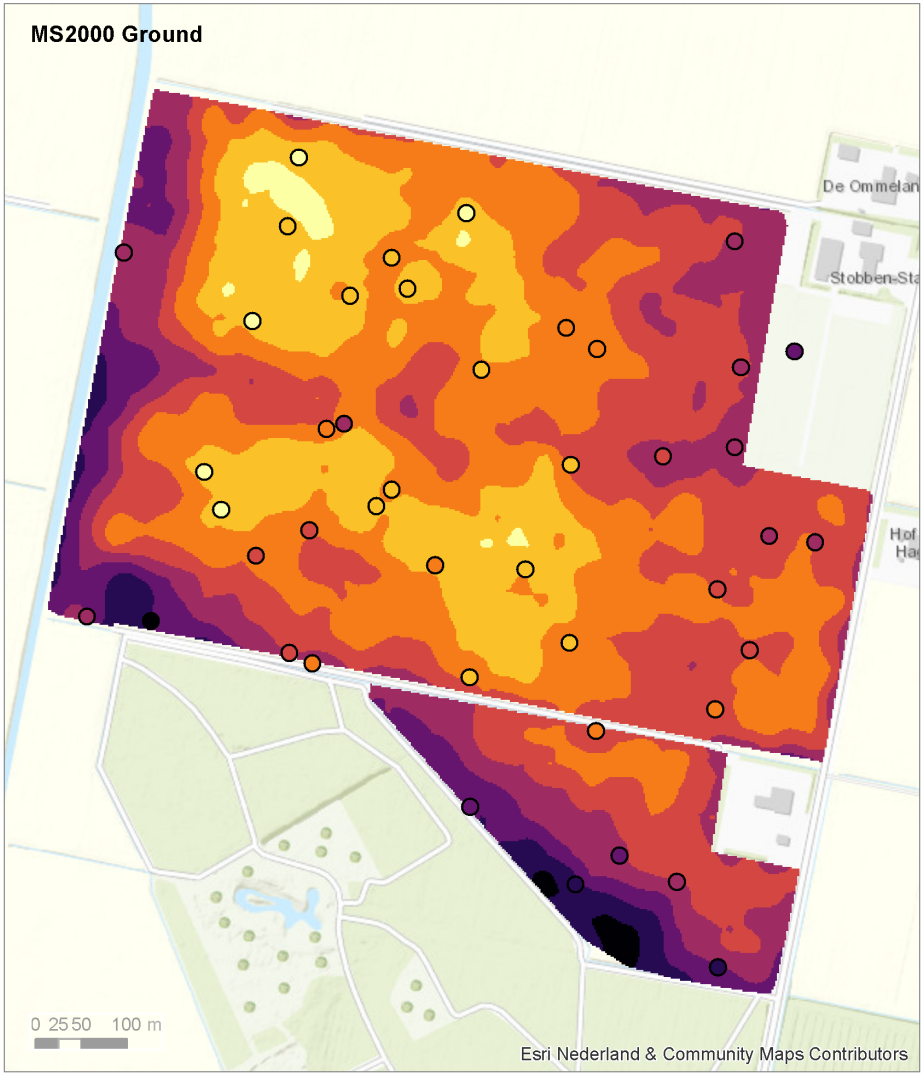
Sampling

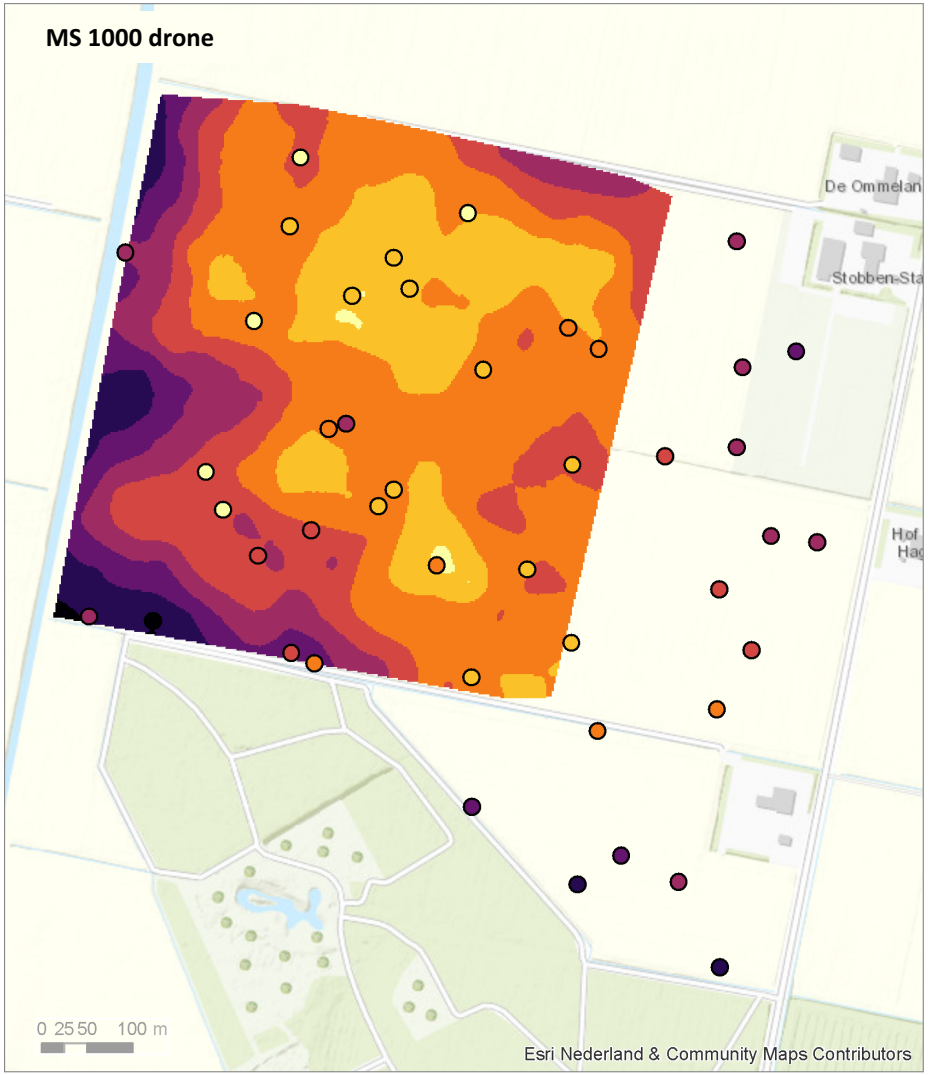
- 14 samples for calibration
- 44 samples for validation (stratified simple random sampling)
- Analysed on:
  - Radionuclides
  - Grain size
  - Clay and loam content
  - Organic matter





Survey lines





Grain size 0 - 50 µm (%)

27 - 30 | 30 - 35 | 35 - 40 | 40 - 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 67

Validation

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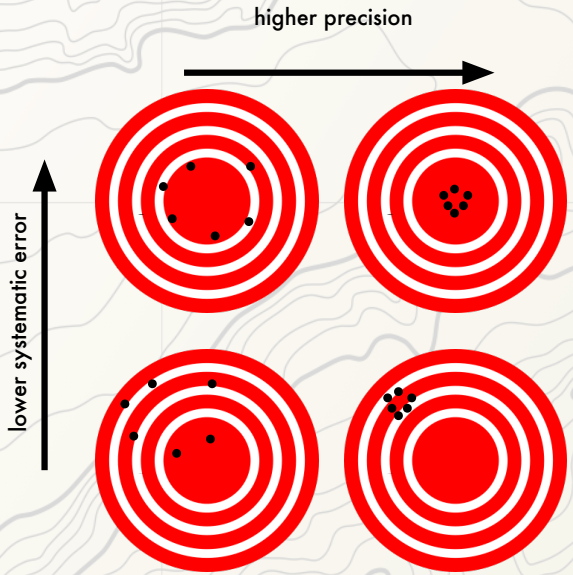
44 validation samples

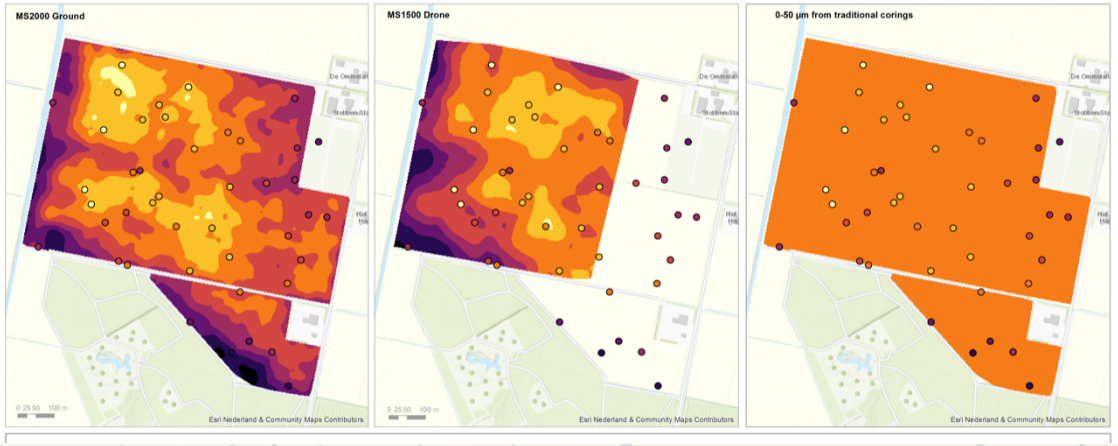
Map	Ground	Drone	Averaged
Range (0-50 µm)	27%-66%	27%-66%	27%-66%
Systematic error	not significant	4.0% (1.2)	4 % (1)
Precision	6%	9.3%	9.9 %
Median absolute error	3.8%	6%	5.9%



SE: still some work needed to understand effects of elevation

P: probably effect of lower resolution due to elevation, smaller detector

What if.. Benefits?

Map	Ground	Drone	Averaged
Median absolute error	4%	6%	6%
Cost/ha*	€120	€130	€80
Resolution			

*costs based on pilot project, with 15 samples calibration, 12m line spacing

Conclusions & outlook

- Hardware
  - A gamma-ray spectrometer with reduced size, weight, power consumption was developed.
  - This system is self-supporting
  - Succesfull test flights have been conducted
- Data modelling
  - First MCNP modelling and test measurement give promising results, will be improved.
- Initial results field validation trials
  - Good correspondence with predicted values and validation samples
  - A cost-benefit overview shows the trade off between statistical accuracy, costs, resolution
- Outlook
  - PhD traject started on improving data modelling, hardware development