

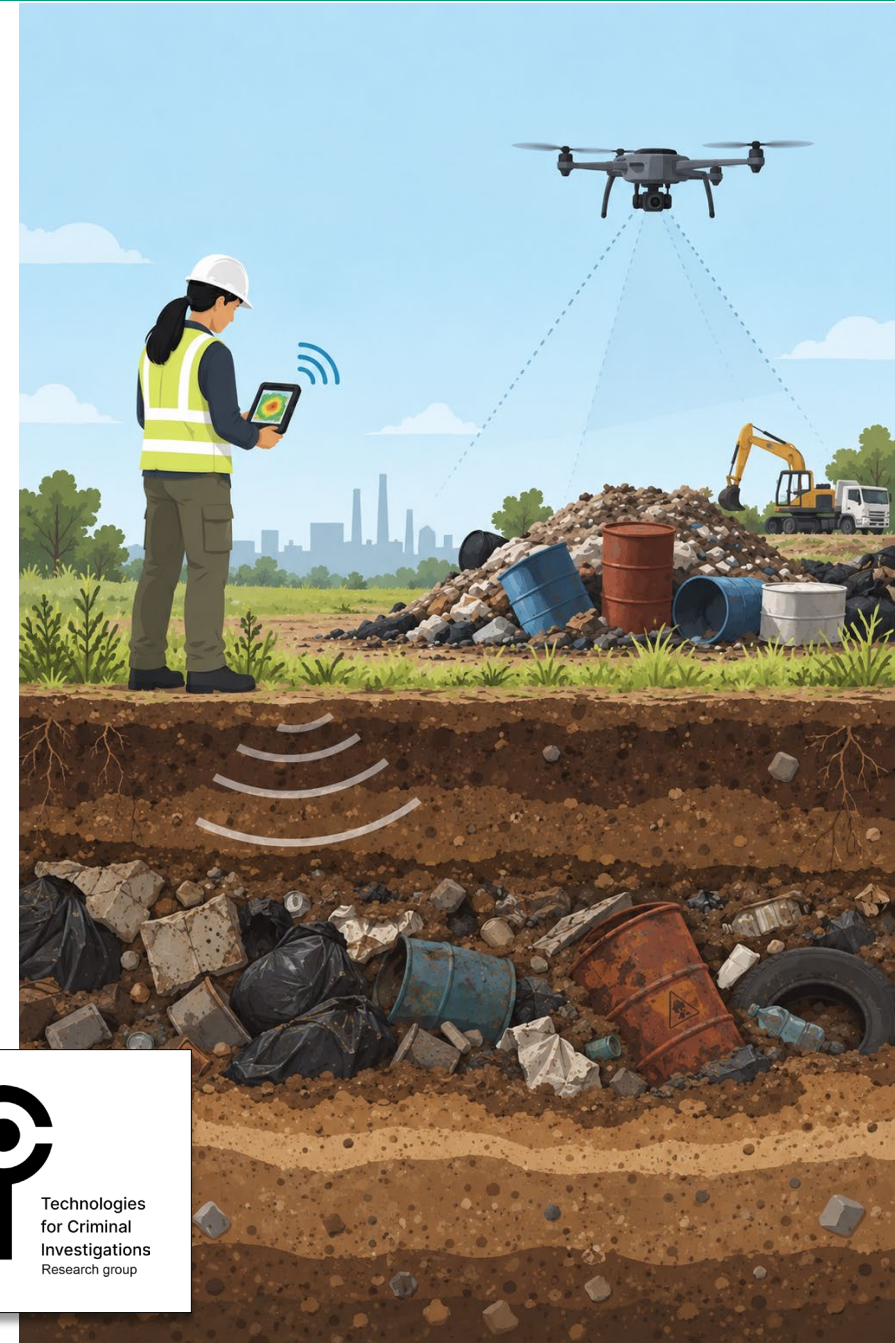
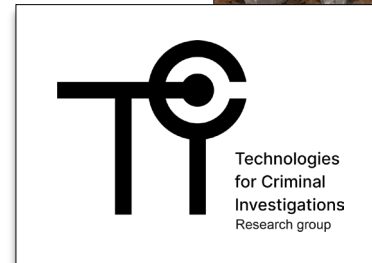
Multi-modal sensing of 'foreign' materials on top of soil and in the shallow subsurface using handheld and UAV-based Gamma-Ray and Hyperspectral sensors

Tatjana Kuznecova | Gustavo Garcia | Nilay Swarge | Alexandru Olteanu

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Data-Driven Investigations | *Research Team*



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We develop and apply science and innovation to advance the intelligence capabilities that enable better criminal investigations.

Research context

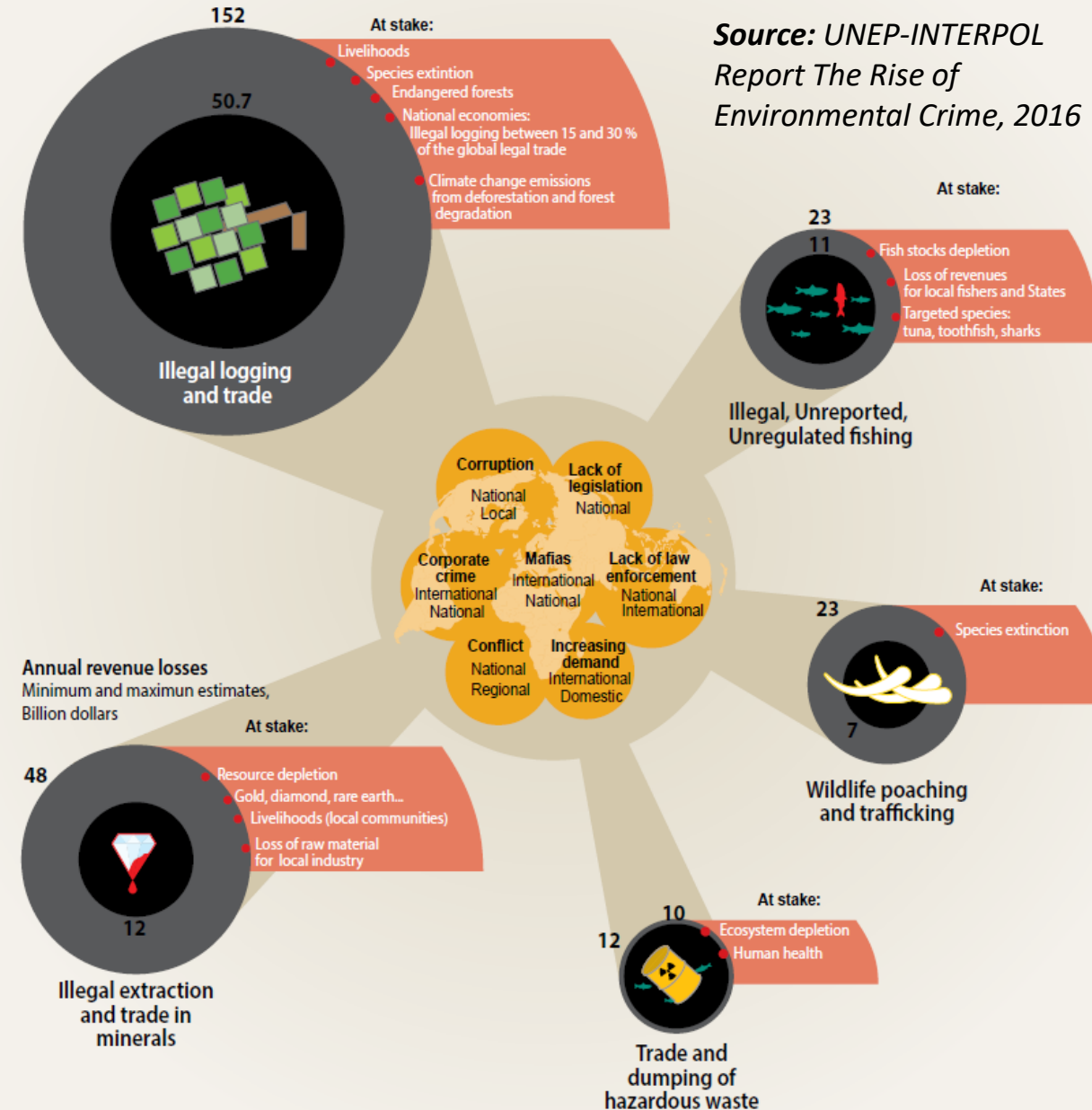


Environmental Crimes

- One of the EU's repeatedly mentioned priorities in the fight against serious and organised crime as part of EMPACT
- 4th largest organised crime activity
- 5-7% annual growth rate
- EUR 80-230 billion lost annually due to environmental-crime

Major environmental crimes, drives and impacts

Source: UNEP-INTERPOL
Report *The Rise of Environmental Crime*, 2016

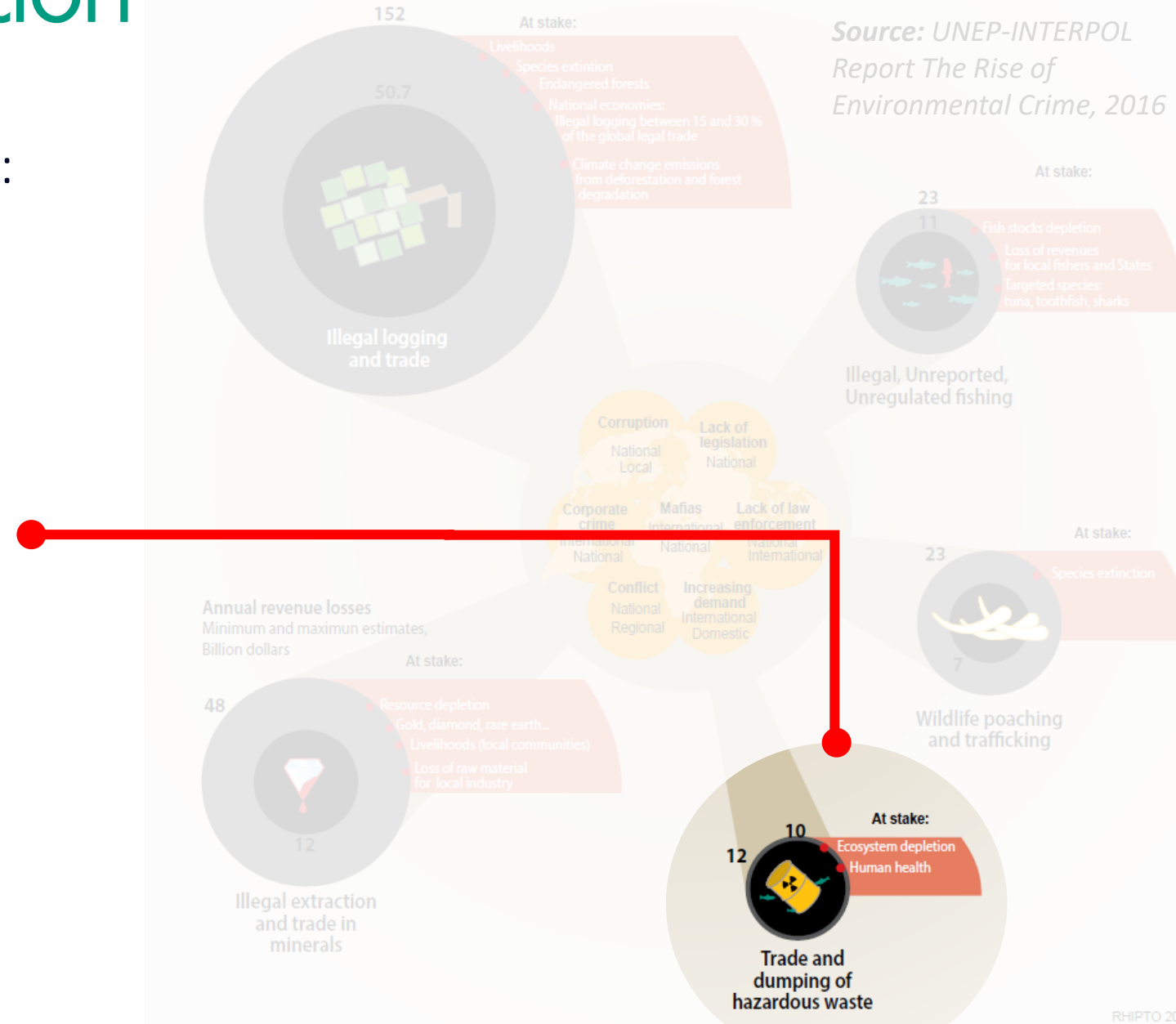


Environmental pollution

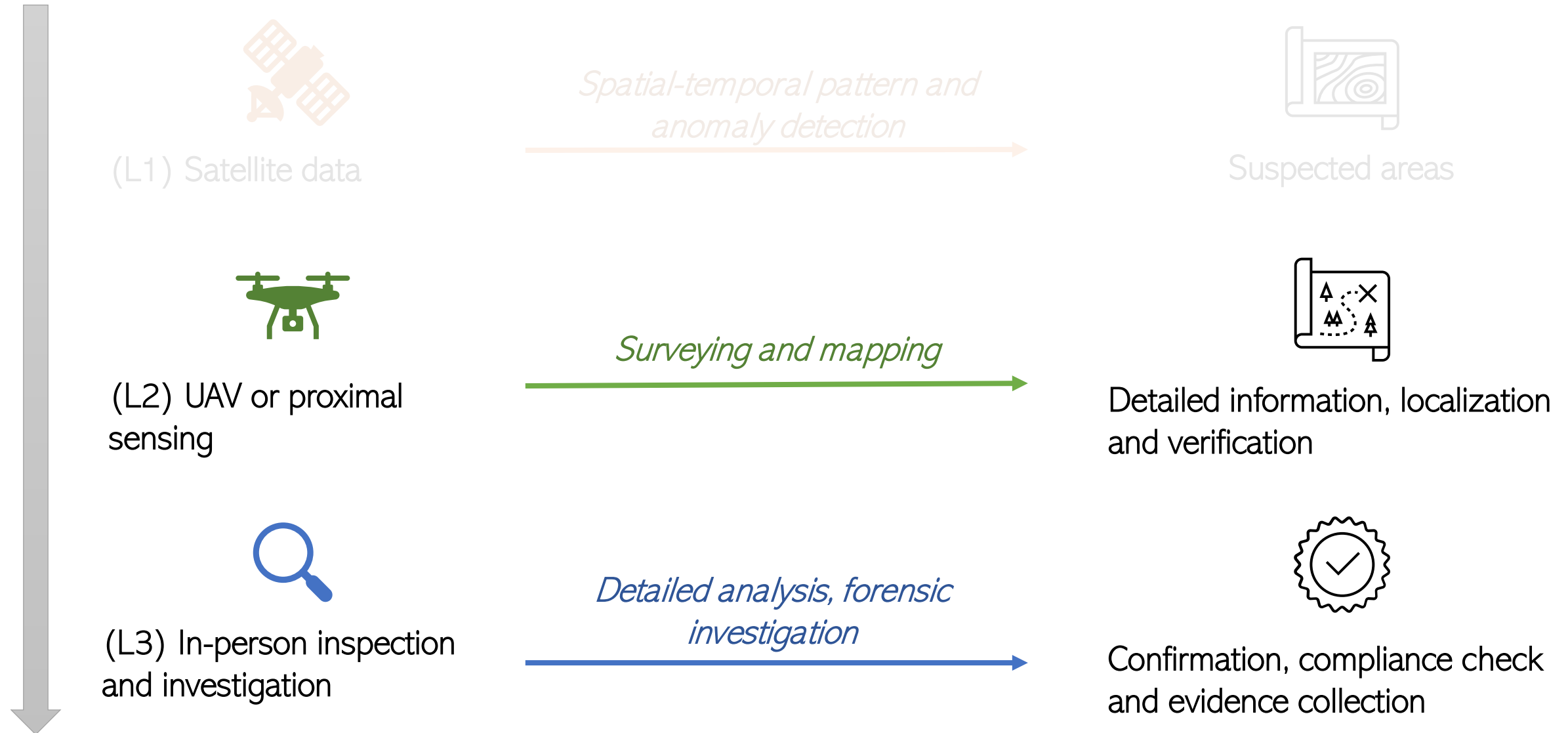
- Extent of soil pollution in Europe:
 - Number of potentially contaminated sites ~ 2.8 million
 - Lack of proper inventories
 - Emerging pollutants: PFAS, pesticides, microplastics
- Points of concern in The Netherlands
 - Groundwater: > 90% of sampled shallow groundwater sites in NL contain anthropogenic substances
 - Illegal movement and disposal of potentially polluted soils
- Human health

Major environmental crimes, drives and impacts

Source: UNEP-INTERPOL
Report The Rise of
Environmental Crime, 2016



3-level data acquisition and analysis



Instruments and testing setups



Sensors

GRS

Gamma-Ray Sensor



- **Medusa MS-350**
- Hand-held and drone-borne survey
- Mapping speed up to 15 km/h
- Radionuclide 40K, 238U, 232Th and 137Cs

[Full specification](#)

HS

Hyper Spectral Camera

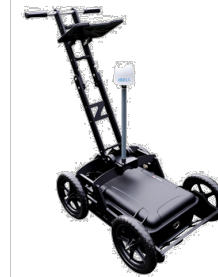


- **Cubert Ultris X20 Plus**
- Wavelength range 350 – 1000 nm
- 164 bands
- Spectral sampling 4 nm
- Max resolution 1886 x 1886 pixels

[Full specification](#)

GPR

Ground-Penetrating Radar



- **RadSys Zond Aero 500 NG**
- Cart- and drone-mounted survey
- Frequency 500 MHz
- Resolution 0.4 m - horizontal
- Depth 4 m - vertical

[Full specification](#)

Platforms

DJI Matrice 350 RTK

Multi-rotor UAV



[Full specification](#)

Shockproof cart

Four-wheeled manual platform



[Full specification](#)

Scenarios

Vegetation changes



- **Setup:** simple small-scale lab experiments
- **Sensor:** HS

Soils and contaminants



- **Setup:** Lab and UAV/handheld field measurements
- **Sensors:** HS and GRS
- **Focus:** industrial/construction contaminants

Traces of exposed and buried waste



- **Setup:** UAV/handheld field measurements
- **Sensors:** HS, GRS, and GPR
- **Focus:** Different depth

Preparing test site



Experiment description

- **Test:** detection of different waste streams
 - 3 depths: soil surface, 10 cm and 20cm below surface
- **Materials:** sand, ceramic tiles, concrete and plaster blocks, and solid household waste mix
- **Containers:**
 - Buried small containers with materials
 - On-surface medium container with sandy soil
 - On-surface large container with ceramic tiles



Data collection

- **HS (UAV-mounted)**
 - Height 5-30m in steps of 5 m
 - On 3 different dates
- **GRS (handheld and on-contact)**
 - Baseline measurements (pre-intervention)
 - 3 sets of handheld measurements
 - 1 set of on-contact measurement for comparison
 - Static point measurements
 - 4 minutes each
- **GPR (cart)**
 - 2 sweeps (vertical and horizontal directions) post-intervention

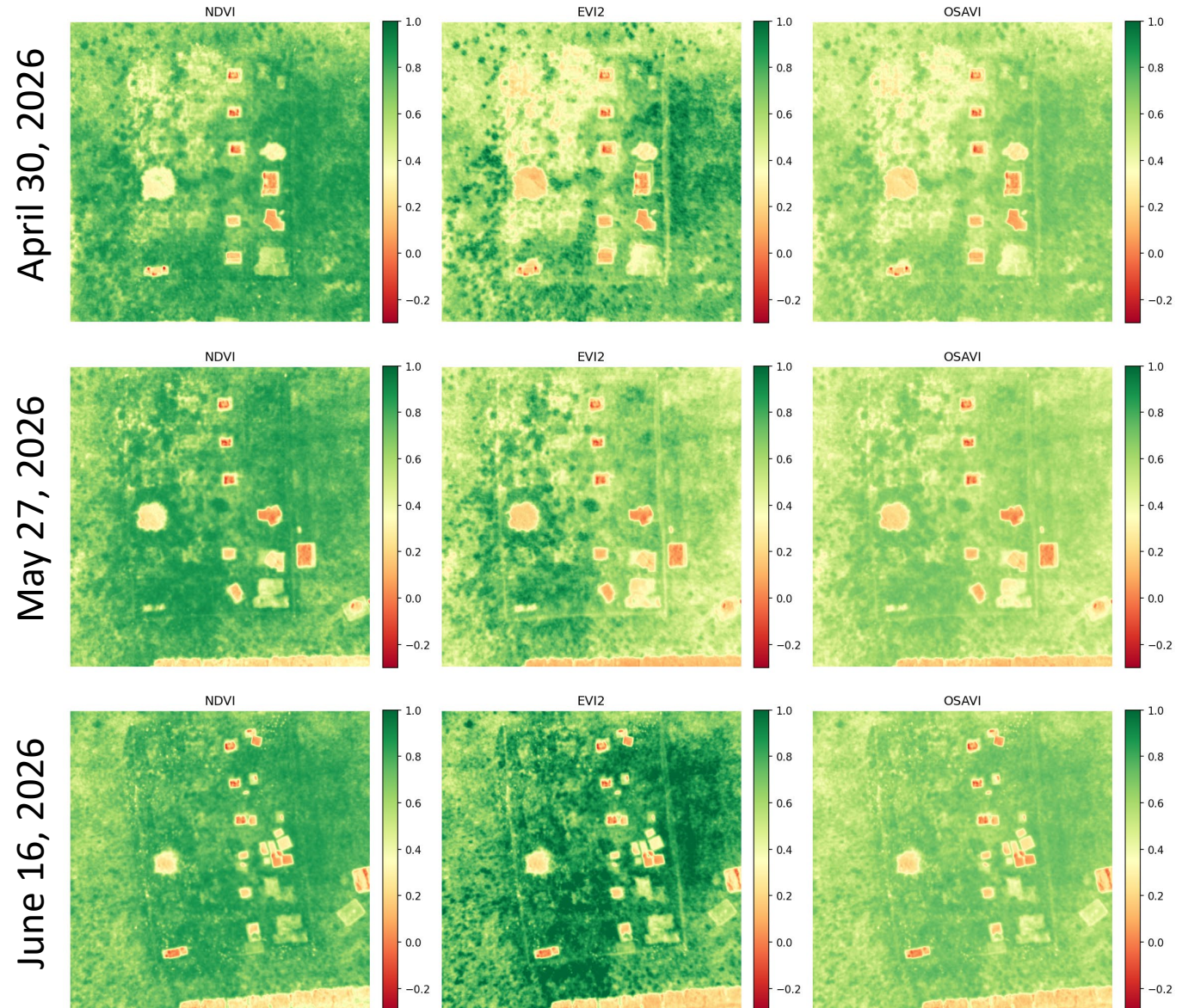


Preliminary results



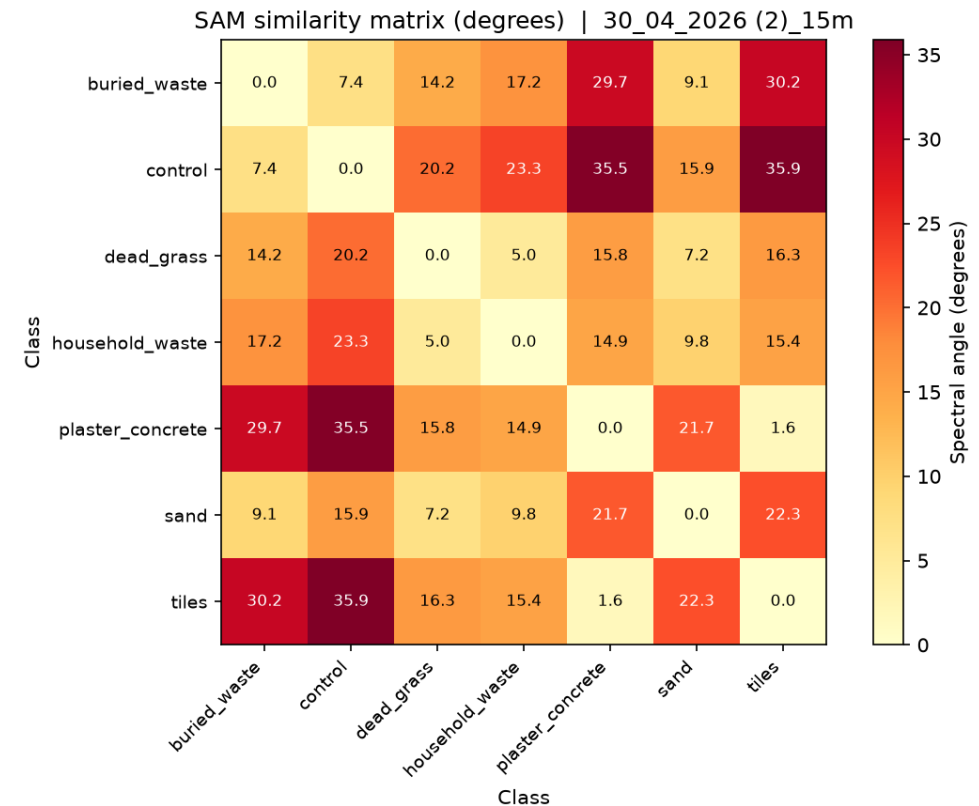
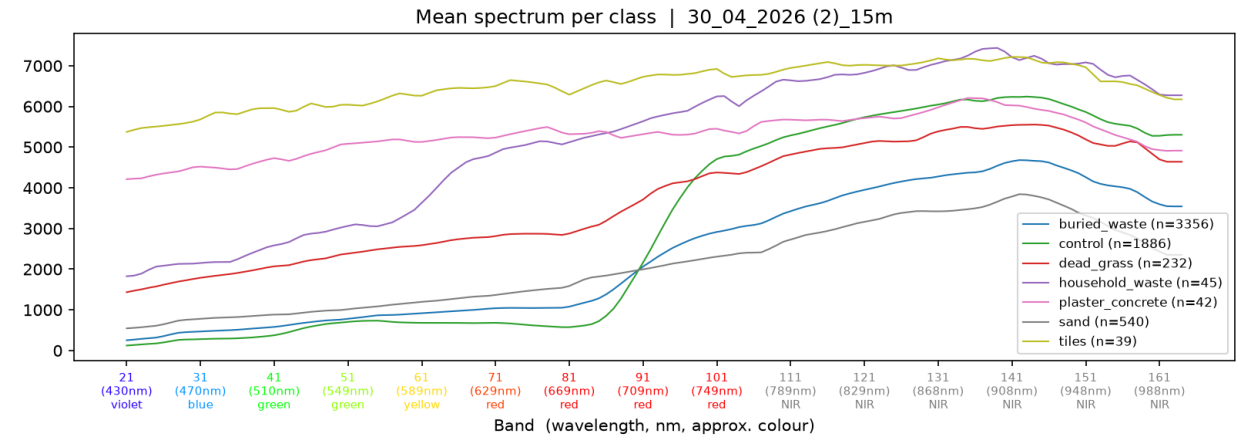
HS data analysis

- Vegetation indices:
 - NDVI
 - EVI2
 - OSAVI
- Observations:
 - Vegetation vs non-vegetated covers
 - Vegetation disturbance patterns and regrowth over time



HS data analysis

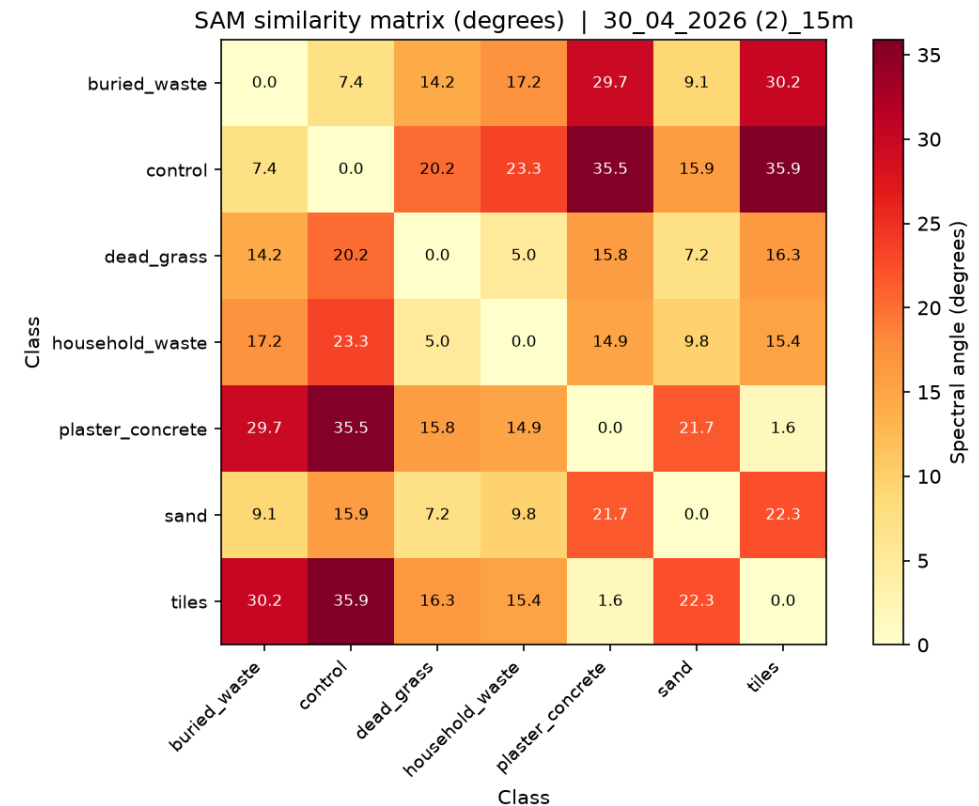
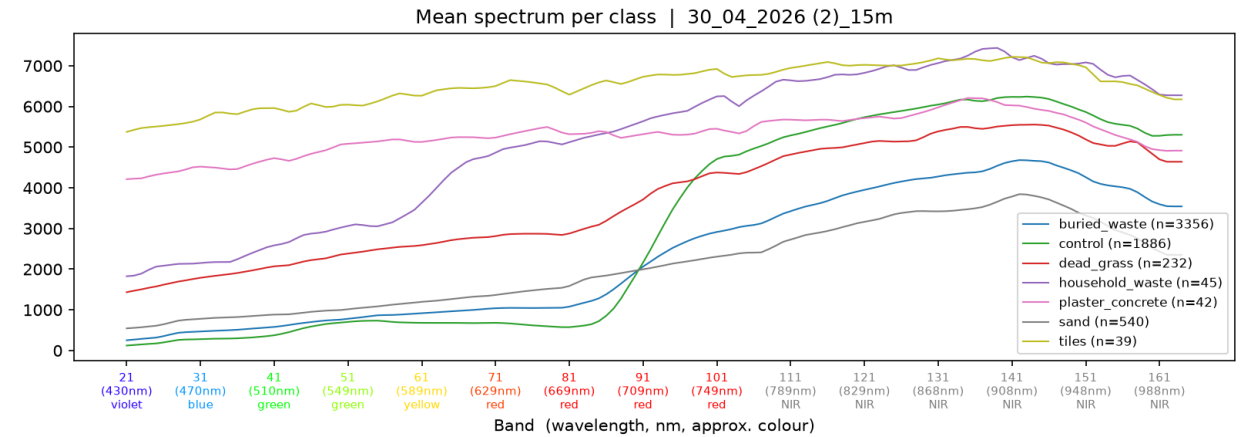
- Derivation of spectral signatures/'fingerprints'
 - Spectral signatures of vegetation under stress
 - Spectral signatures of different waste materials
- Similarity analysis – SAM method
- *Classification of materials/land covers*



HS data analysis

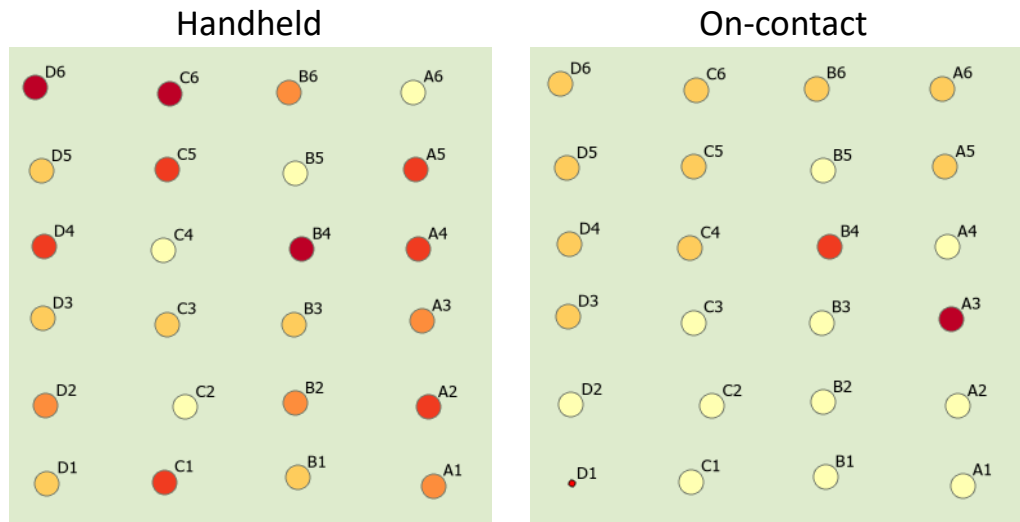
OBSERVATIONS

- Convenient and fast spectral data collection with a snapshot sensor, also in a hover mode
- Dissimilarity between materials/land covers varies
- SWIR range would be desirable
- Overexposure issues with highly reflective materials in some bands

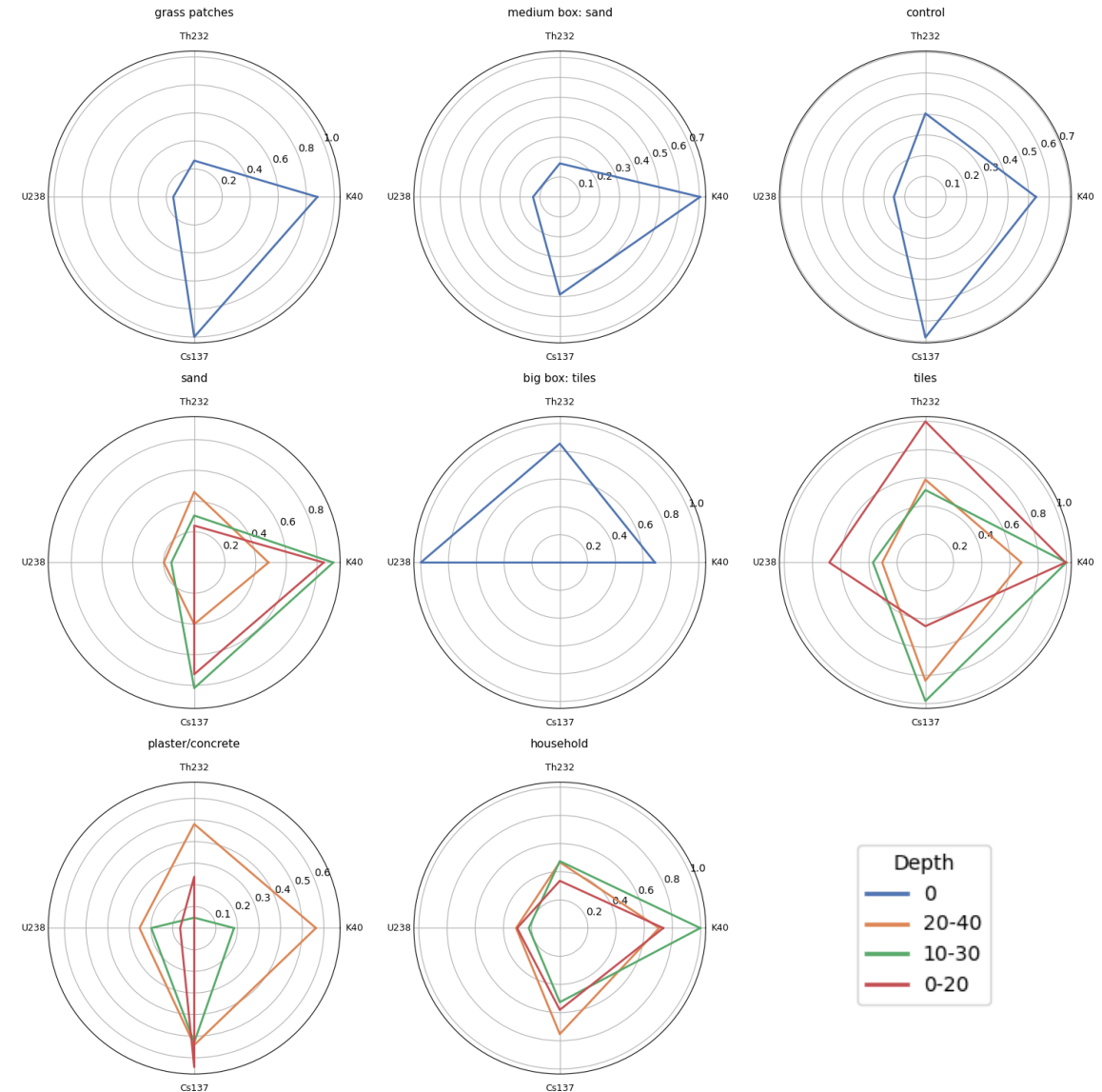


GRS data analysis

- Radionuclide 'fingerprints' and differences between materials (Bq/kg)
 - K40, Th232, U238, Cs137
- Handheld vs on-contact (height/footprint change)
- Effects of shielding/concealment



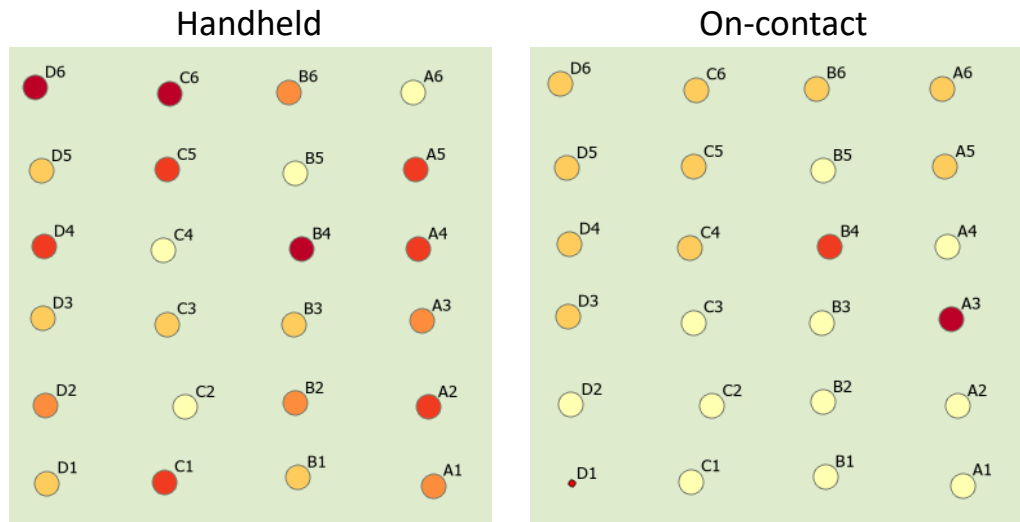
Field Samples, U238 (A3 and B4: ceramic tiles)



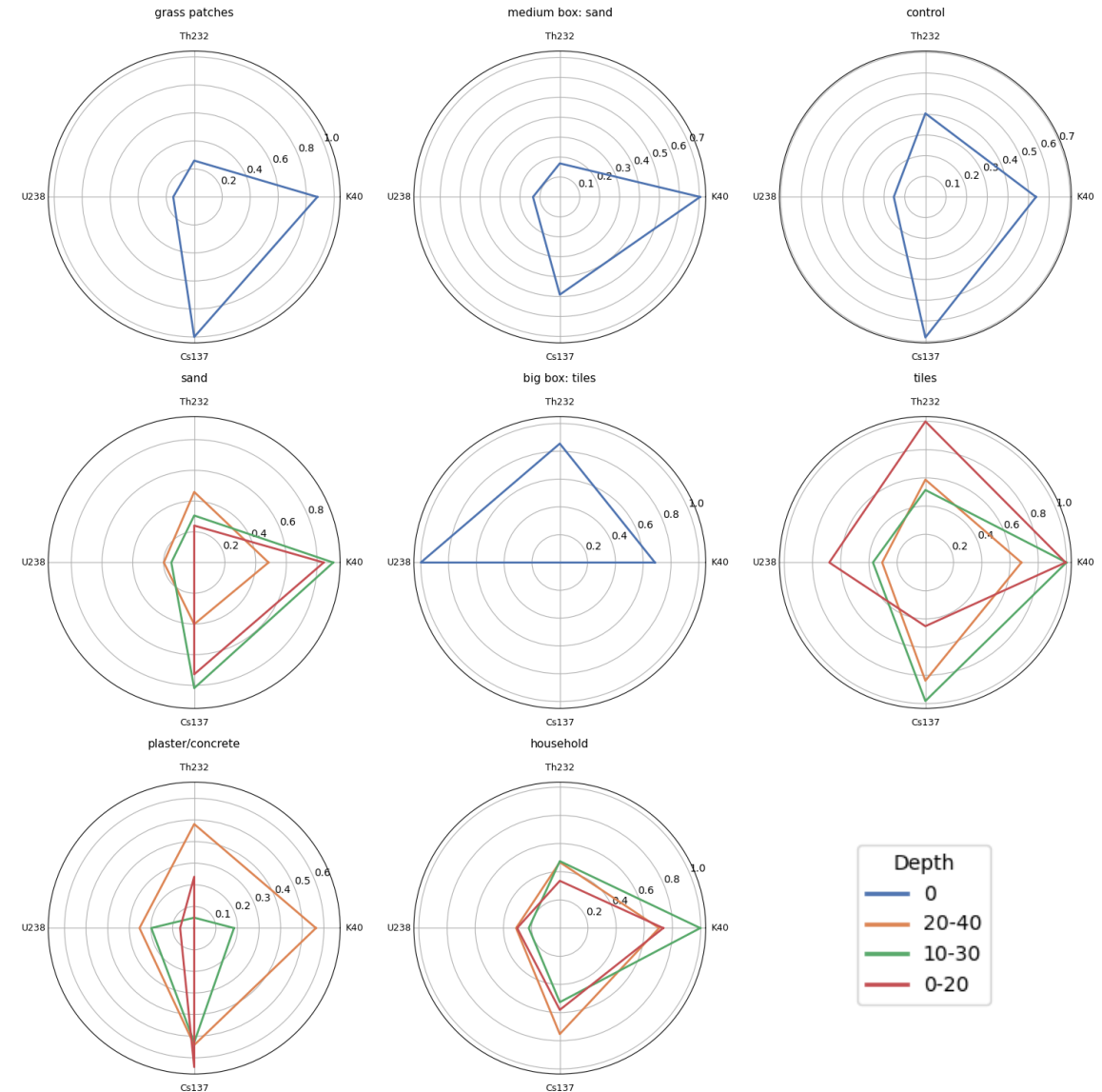
GRS data analysis

OBSERVATIONS

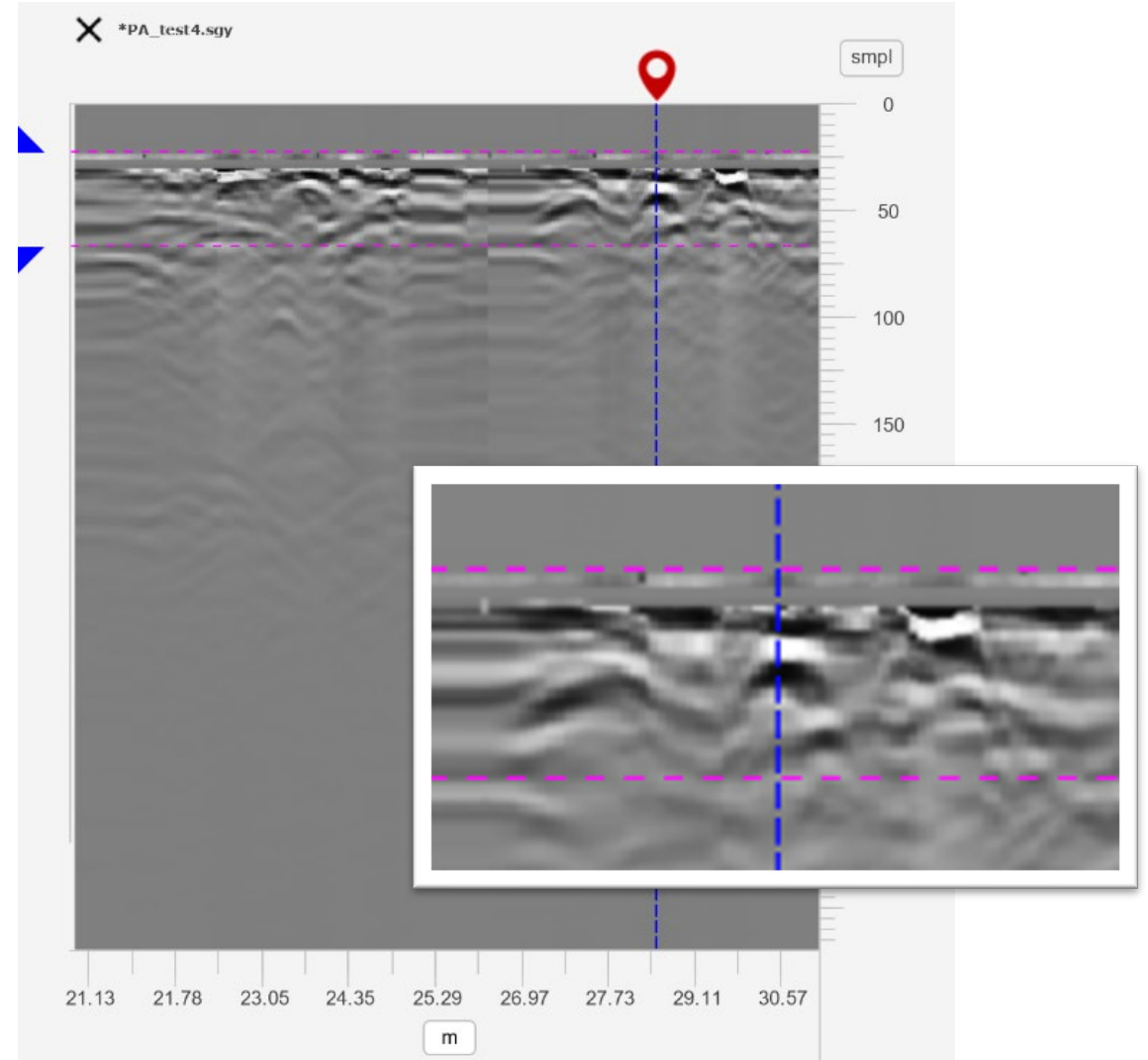
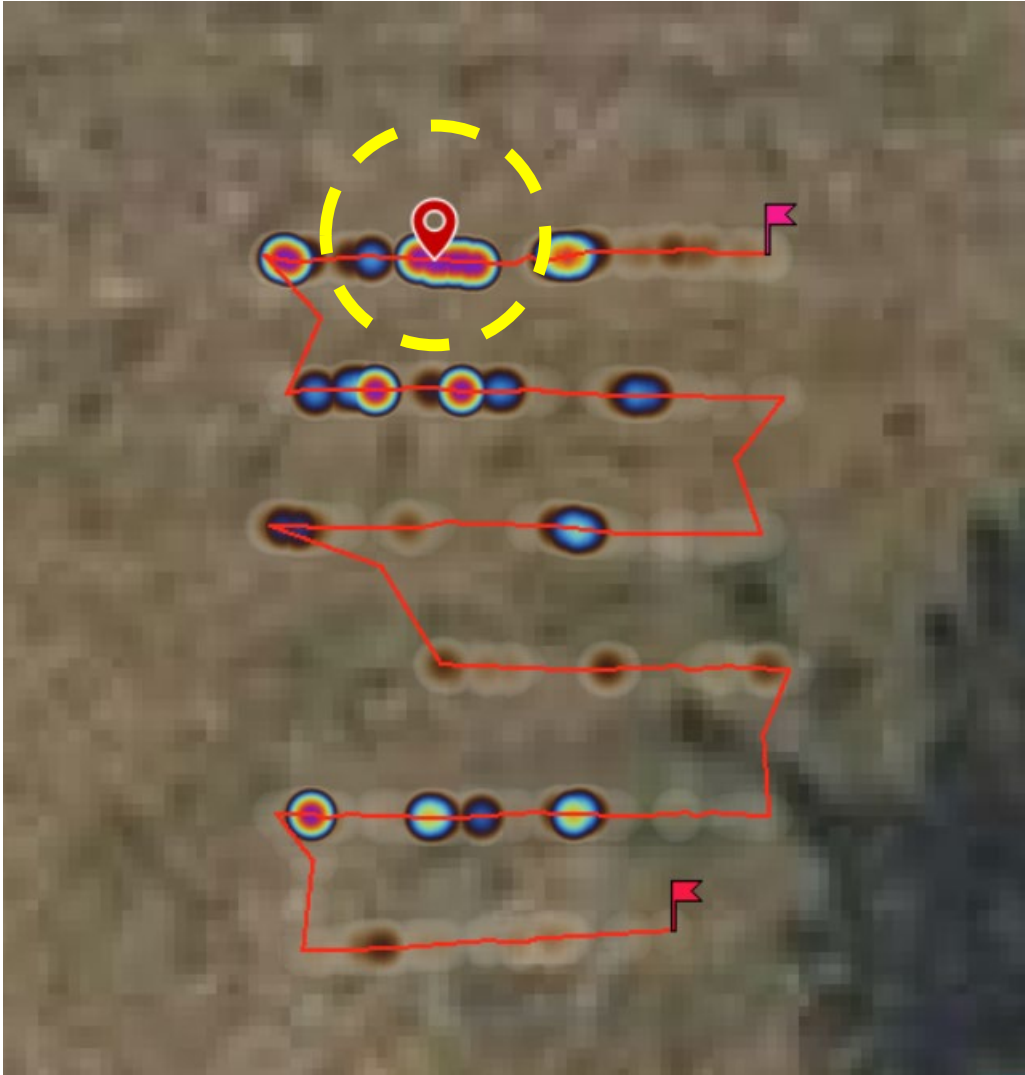
- Low contrast between background and samples in our test location
- Sample size too small for elevated measurements
- Soil 'shields' most of differences even in on-contact mode
- UAV mode only for large-scale anomalies



Field Samples, U238 (A3 and B4: ceramic tiles)

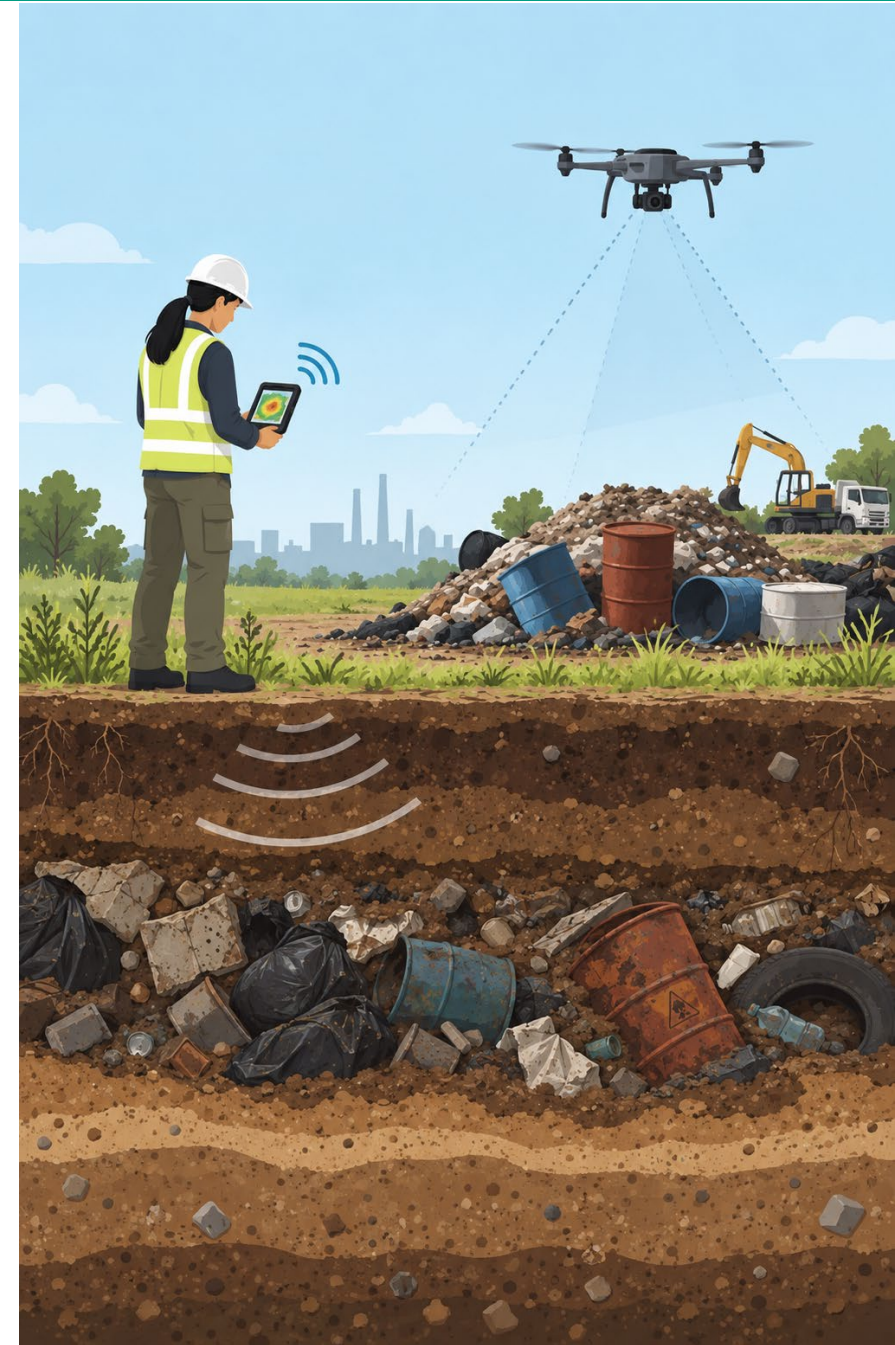


GPR data analysis



Outlook

- Scaling up experiments and tests on real cases
 - Collaborations are wanted!
- Full UAV mode testing for all sensors
- Exploring fusion potential
- Development of a visual-analytical dashboard for working with multi-modal sensor data



Q&A session

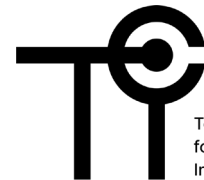
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