Use of the monitoring information gathered by the UAV technologies in Decision Support Systems

Geert Olyslaegers

sck cen

NERIS

2021-09-23 – EURADOS-NERIS Webinar –
The use of unmanned aerial systems to characterize the radiological situation in the aftermath of an accident

ISC: Restricted

What's on the menu…

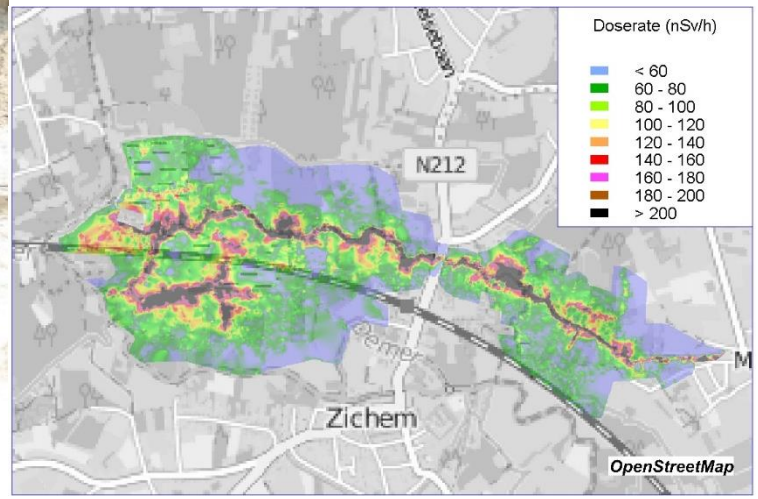
- Historical activities
- Decision Support Systems in non nuclear applications
- Some UAV monitoring case studies
- Available DSS
- Conclusions

ISC: Restricted

Scientists have always been interested in mapping contamination

- Radiological or non radiological
- Soil, air, water, …
  - E.g. Historic Ra-226 contamination from liquid releases (originating from phosphate industry)

NaI – GPS coupled



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Two four liter NaI detectors (50 kg)
Third contains electronics + battery (30 kg)
Notebook PC and a small USB GPS

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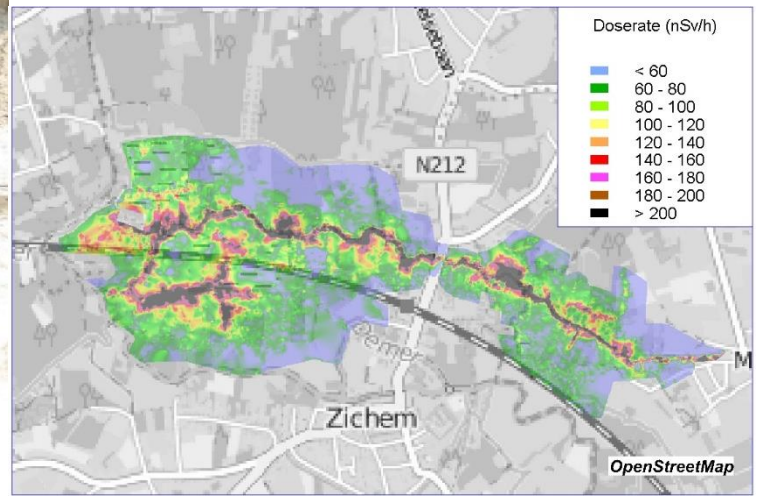

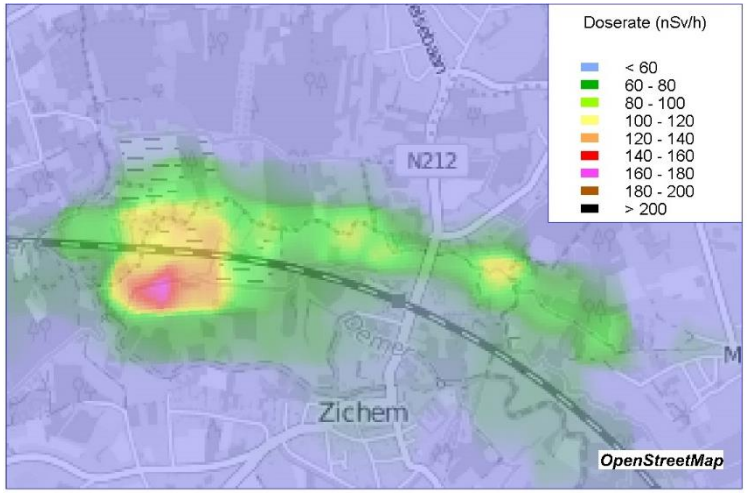

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Hostile environments →
Remote sensing techniques

RadDetecTIF with DJI M100

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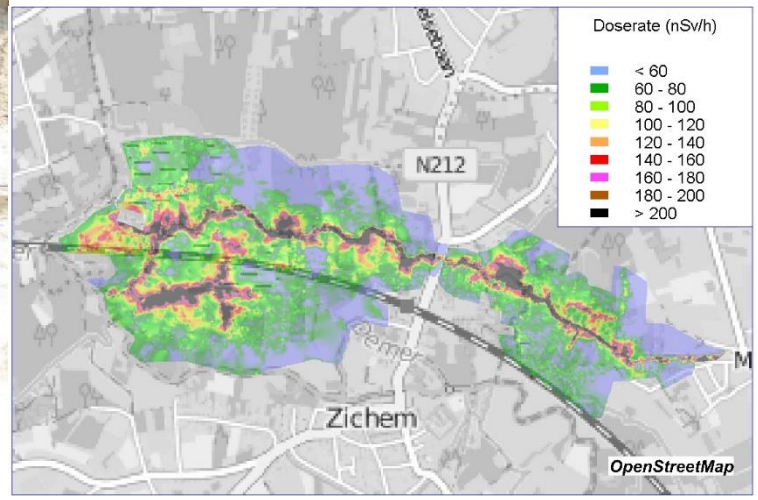
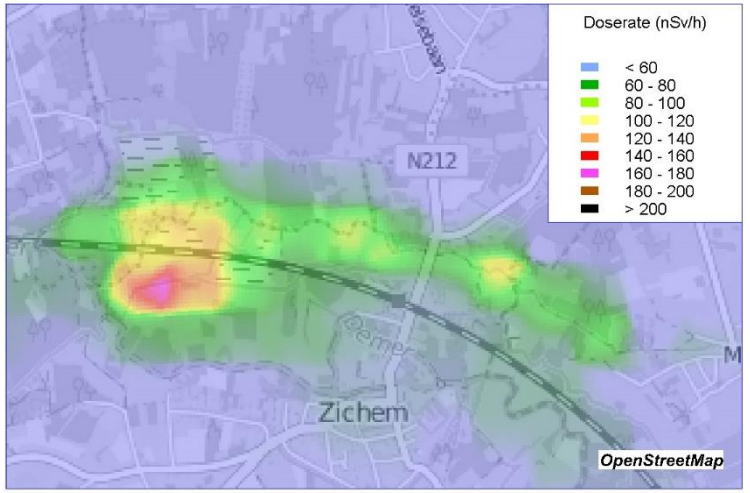


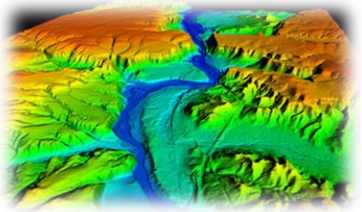


Drones have many applications

- **Daily applications**
  - Aerial photography for journalism and film
  - Express shipping and delivery, unmanned cargo transport
  - Geographic mapping of inaccessible terrain and locations
  - Building safety inspections / wind mills
  - Precision crop monitoring
  - Storm tracking and forecasting hurricanes and tornadoes
  - …











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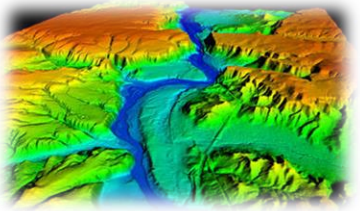
  - …
- **Emergency preparedness (by first responders)**
  - Law enforcement and border control surveillance
  - Gathering information or supplying essentials for disaster management
  - Thermal sensor drones for search and rescue operations
  - Mapping / detection of hazardous materials
  - …







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How can we use drone monitoring data in Decision Support Systems ???

'Bad news': radiation 16 times above normal after forest fire near Chernobyl

The blaze started on Saturday close to the site of the world's worst ever nuclear disaster

▲ A Geiger counter shows increased radiation level at the forest fire near Chernobyl. Photograph: Yaroslav Yemelianenko/AP

Ukrainian officials have sought calm after forest fires in the restricted zone around Chernobyl, scene of the world's worst nuclear accident, led to a rise in radiation levels.

Firefighters said they had managed to put out the smaller of two forest fires that began at the weekend, apparently after someone began a grass fire, and

The Guardian

Stopping the dirty bomb 'threat'

By Rob Broomby
BBC Radio 4

Carolyn MacKenzie goes at her job like a terrier.

High in the Caucasus Mountains of Georgia she is wielding the latest radiation detector fitted into a backpack which is flashing and beeping as we walk through the thick damp undergrowth.

Part educator, part campaigner she is what is called an Orphan Source specialist with the UN's Nuclear watchdog the International Atomic Energy Agency.

She is supporting a Georgian team hunting down missing radioactive materials - sources as they call them - once used in a range of devices from communications to health care and now lost without trace with the collapse of the Soviet Union.

The search is on for radioactive material missing since the collapse of the USSR

BBC NEWS

DSS applications are already available in agriculture…

sensors

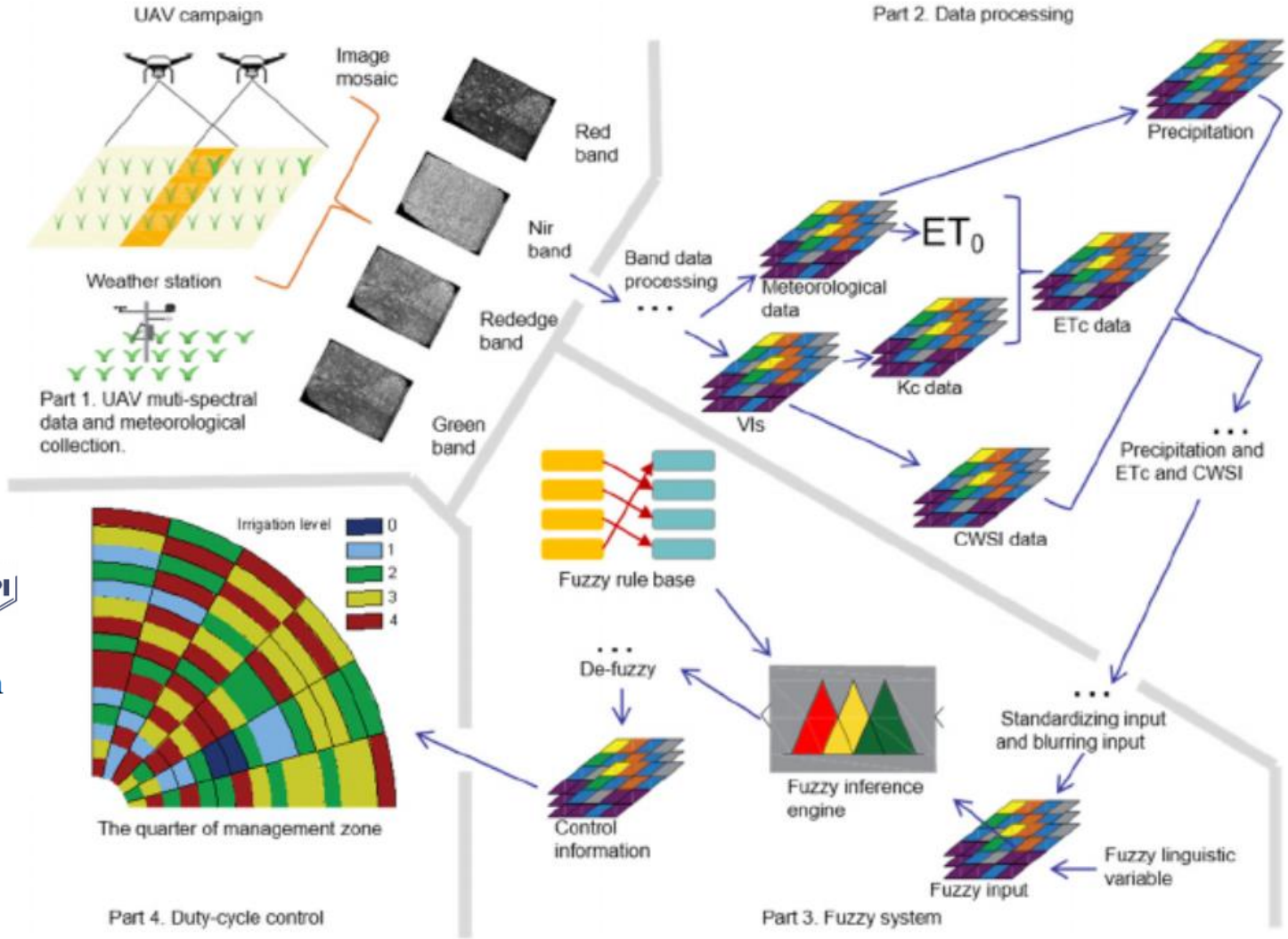
MDPI

Article

Decision Support System for Variable Rate Irrigation Based on UAV Multispectral Remote Sensing

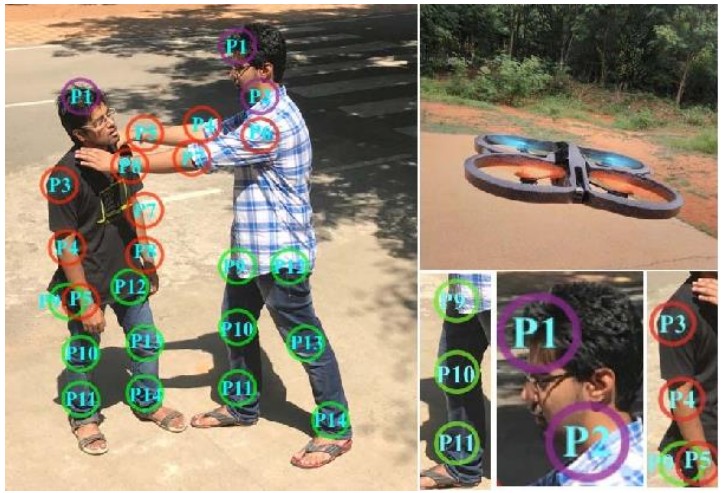
Xiang Shi [1,2], Wenting Han [1,3,*], Ting Zhao [4] and Jiandong Tang [5]

Sensors **2019**, *19*, 2880; doi:10.3390/s19132880



Other non-nuclear applications

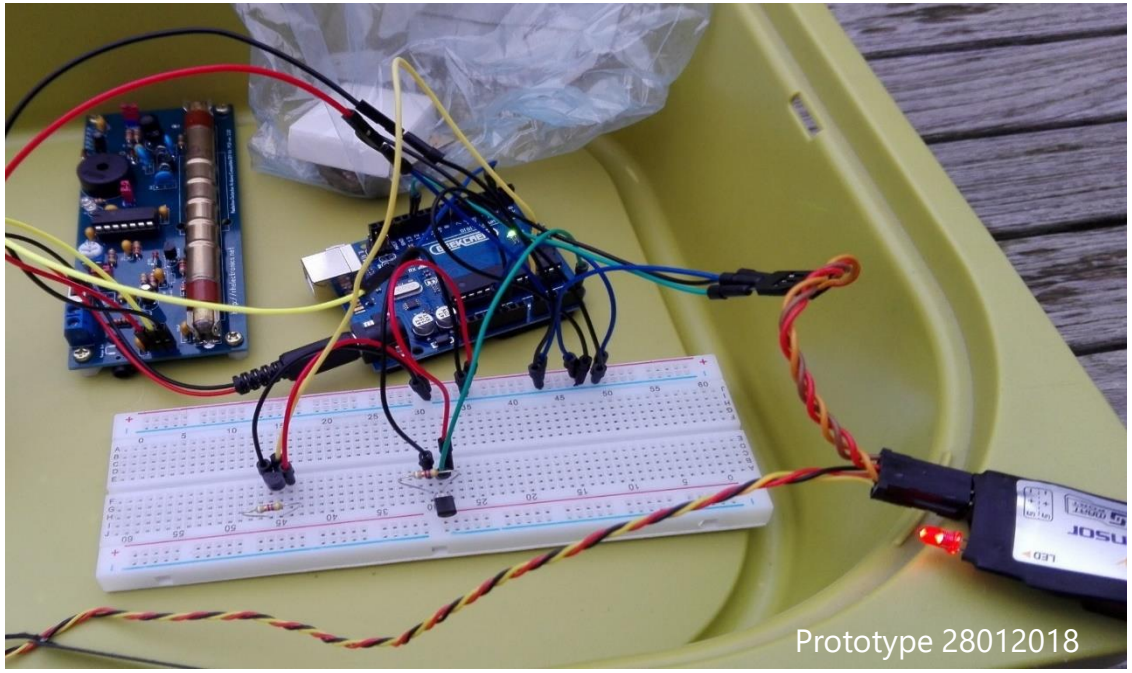
- AeroVironment Quantix™ drone & Decision Support System™ data analytics platform
  - Drone-based aerial imagery and actionable intelligence
  - Guide disaster assessment and recovery efforts
- Real-time Drone Surveillance System (DSS) for Violent Individuals Identification
  - Law enforcement agencies to monitor hostiles, spy on foreign drug cartels, conduct border control operations, etc.
  - The orientations between the limbs of the estimated pose are used to identify the violent individuals



Already in 2017 SCK CEN started to develop their own detector and build their own drone

- Goal: Construct an UAV which can detect radiation remotely by integrating a small, cheap and light detector
- Hardware:
  - RHelectronics GM
  - Arduino
  - FrSky GPS
  - FrSky X8R receiver
  - 2 temperature sensors

  - DJI F550 ARF Kit



- Over the years we extended our fleet with other drones and detectors, and we got involved in different projects

Case 1 : Finding a lost source

- Exercise in the frame of “Test and Evaluation of Airborne RN-Sensors”
- NATO project led by Dr. Stefan Potthast - Bundeswehr Research Institute for Protective Technologies – NBC-Protection (Munster, Germany)

AIM :

- Systematic (in situ) investigations and development of test procedures

Two UAV and detectors were tested

- **DJI Matrice 600**
  - Diameter : 110 cm
  - Payload : 5500 g
  - innoRIID RADEAGLE-T (ORTEC)
  - High cost system (especially detector)

- **DJI Flame Wheel 550**
  - Diameter : 60 cm
  - Payload : 1900 g
  - GM Detector DIY Kit Arduino Comp. ver. 3
  - Low cost system

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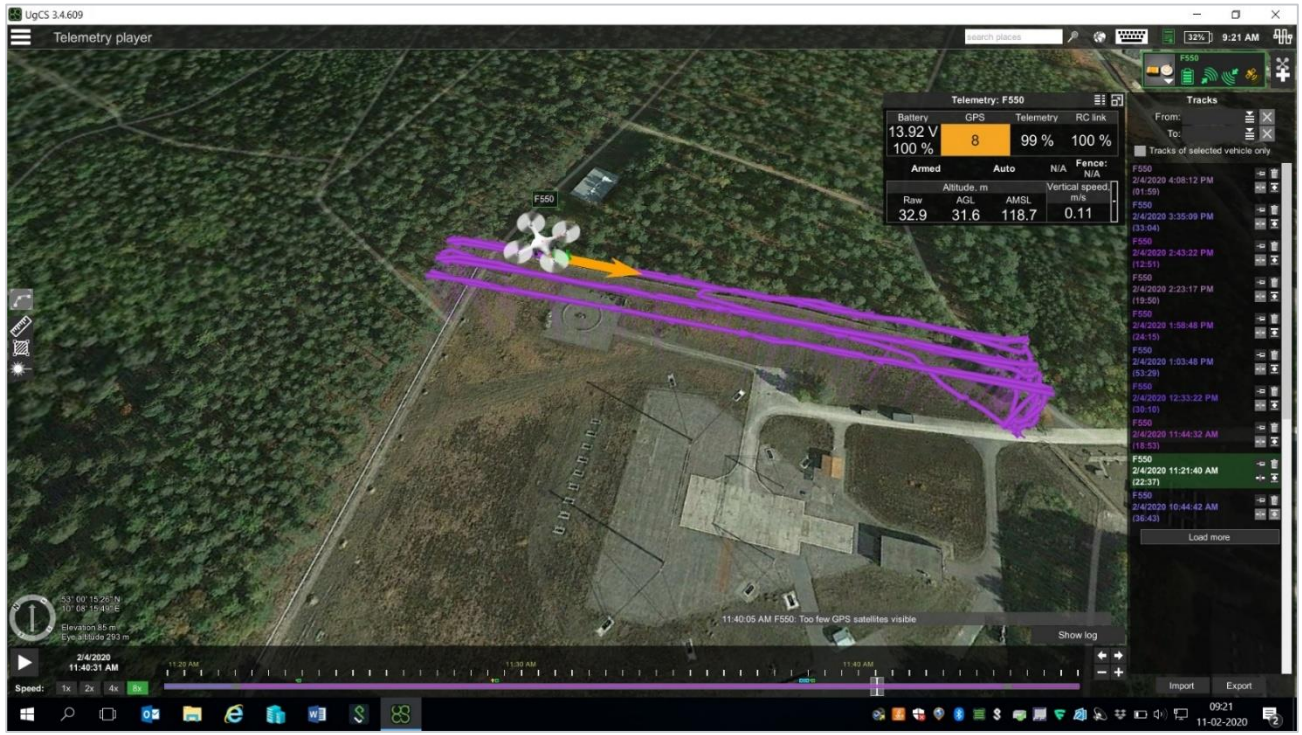
Performance of the DJI F550



Automated drone mission planning is performed with the Universal ground Control Software (UgCS)

ISC: Restricted

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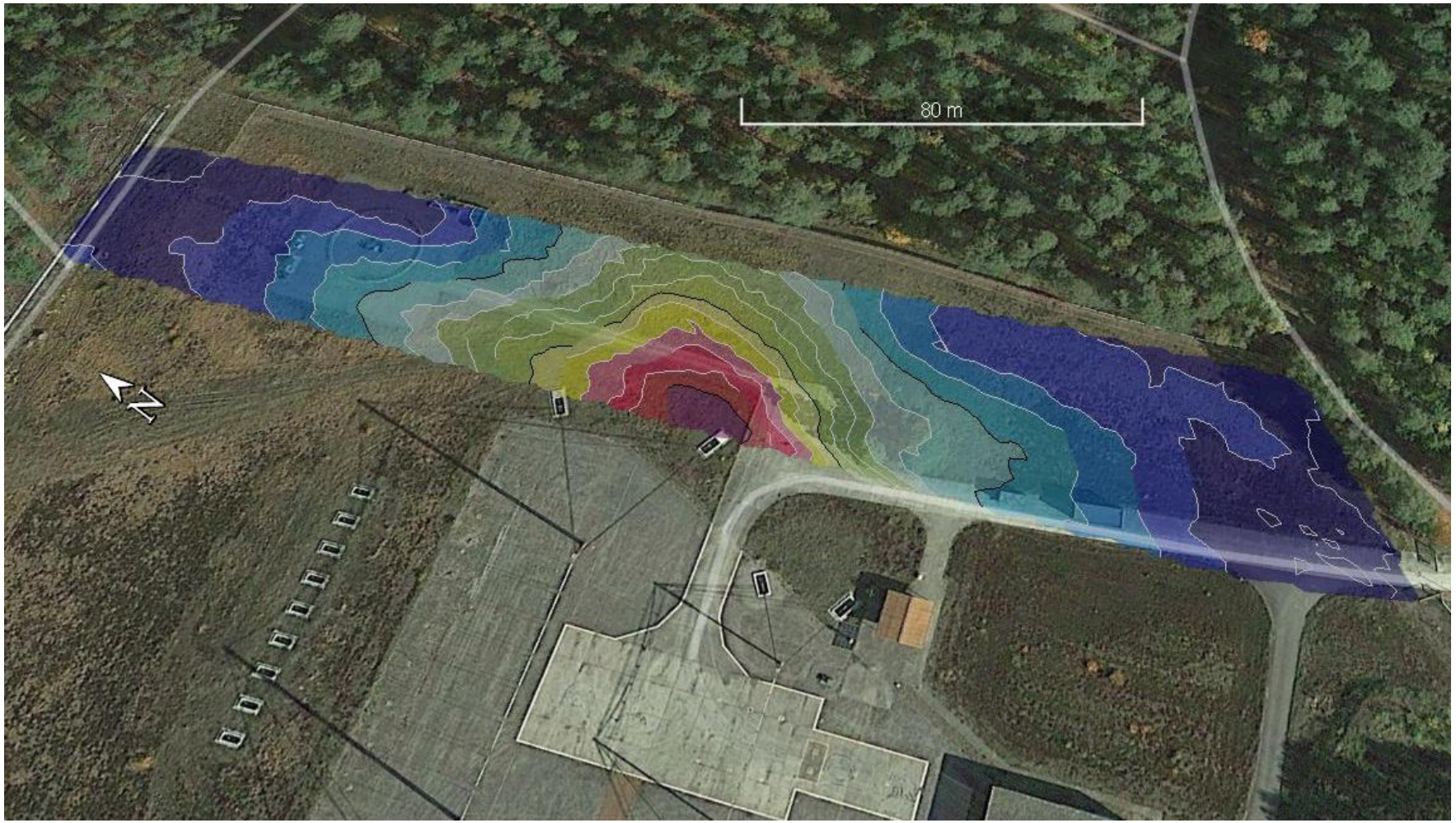

F550 : 30 m height – 4.2 m/s – 10 m LO

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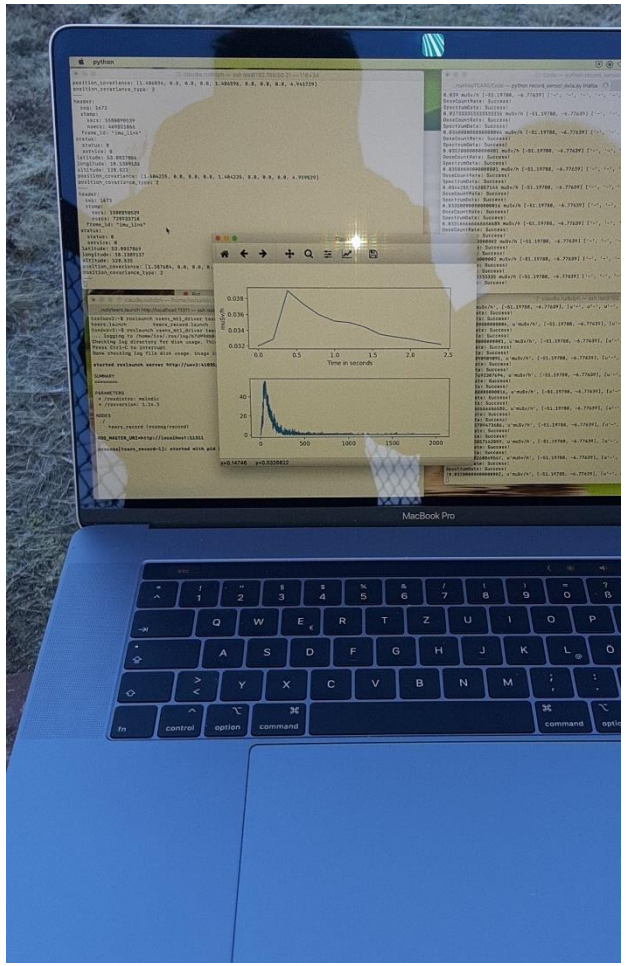
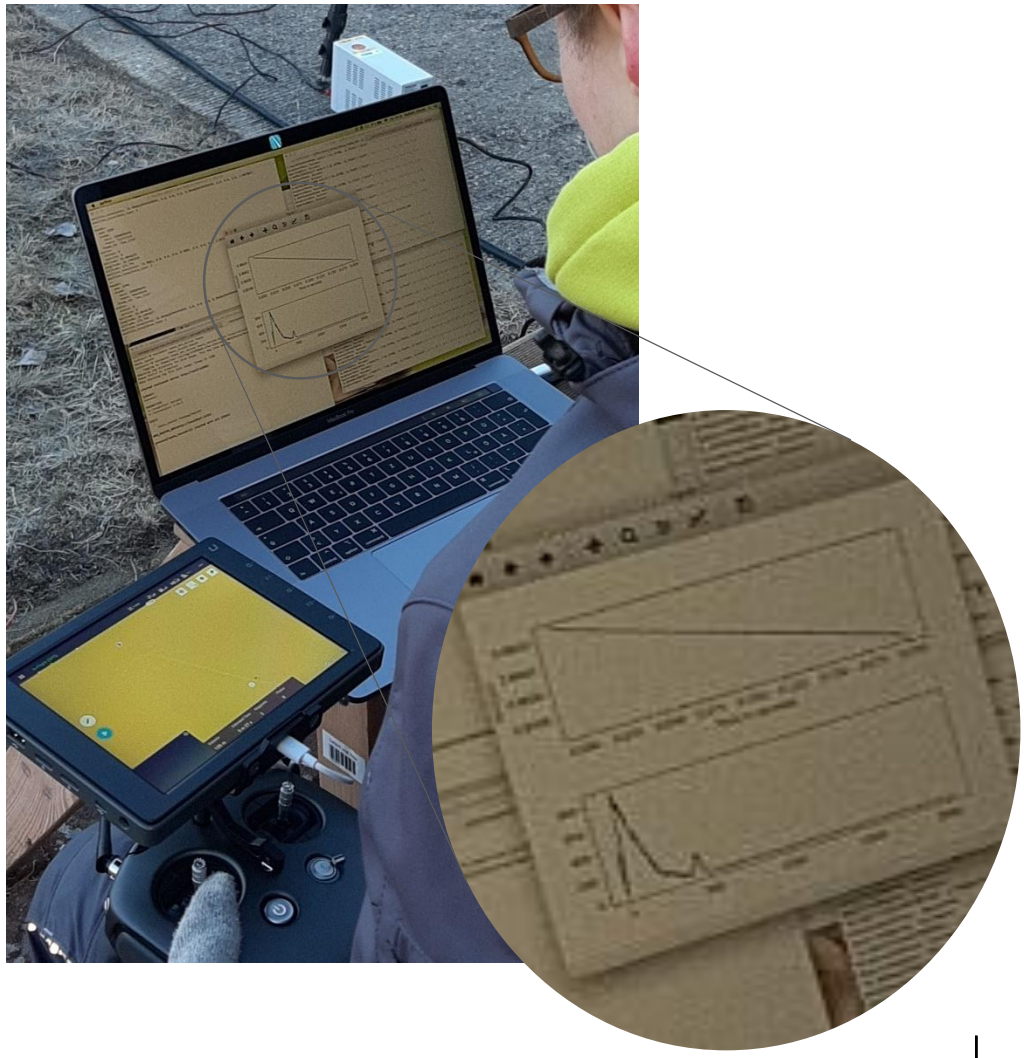
Performance of the DJI Matrice 600





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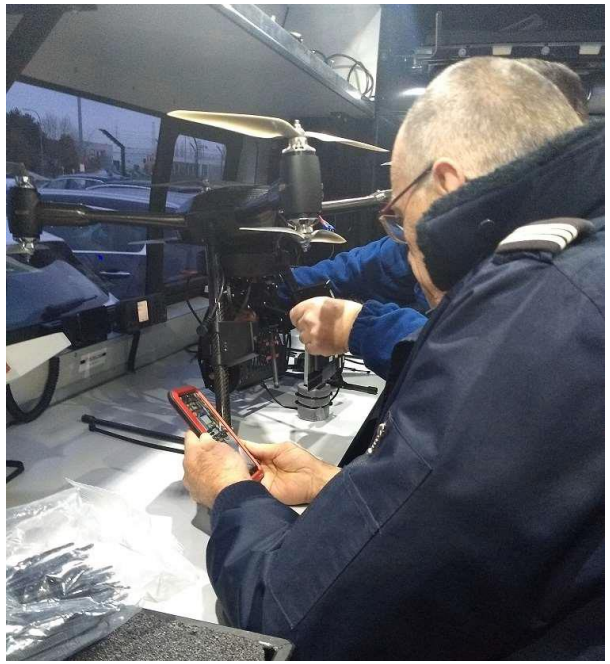
Case 2 : Measuring Xe-release from the IRE

- National Institute for Radio-elements (Fr: Institut national des Radio-Éléments) production facility for medicals isotopes in the Belgian Fleurus
- Test during a nuclear emergency plan exercise on November 20th , 2018.



Drone : Altura Zenith Aerialtronics of the civil protection

2"x1"x1" CsI detector (Kromek Sigma50) a small Windows10 PC and a device for long range radio transmission (700 grams)

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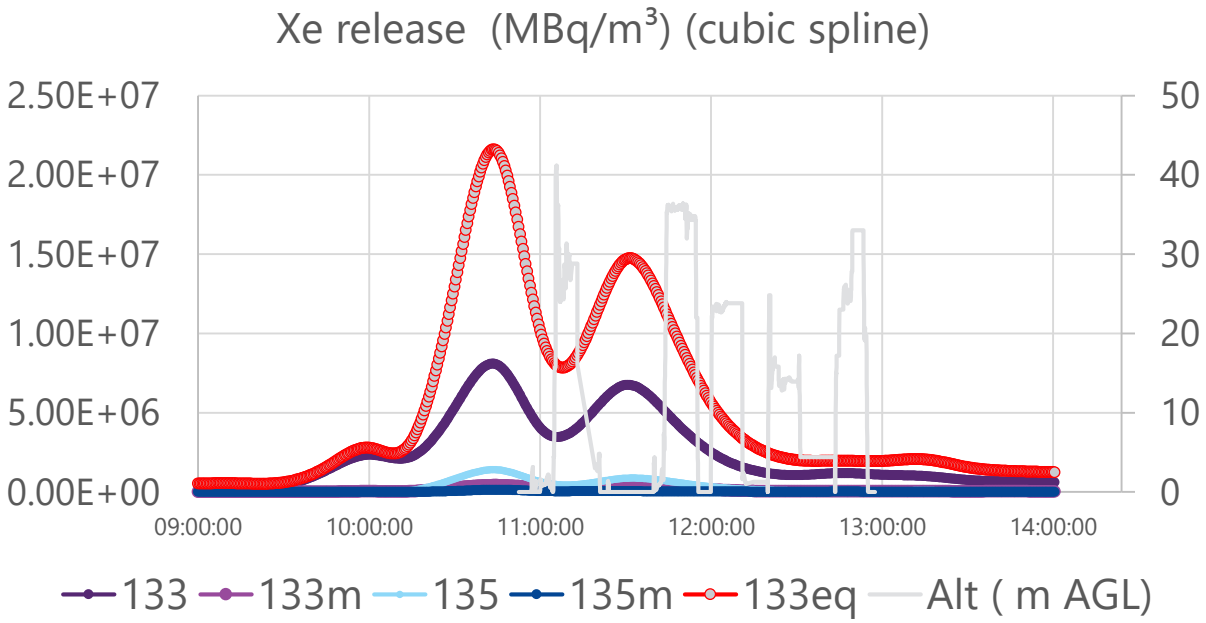
Characterization of the radioactive release

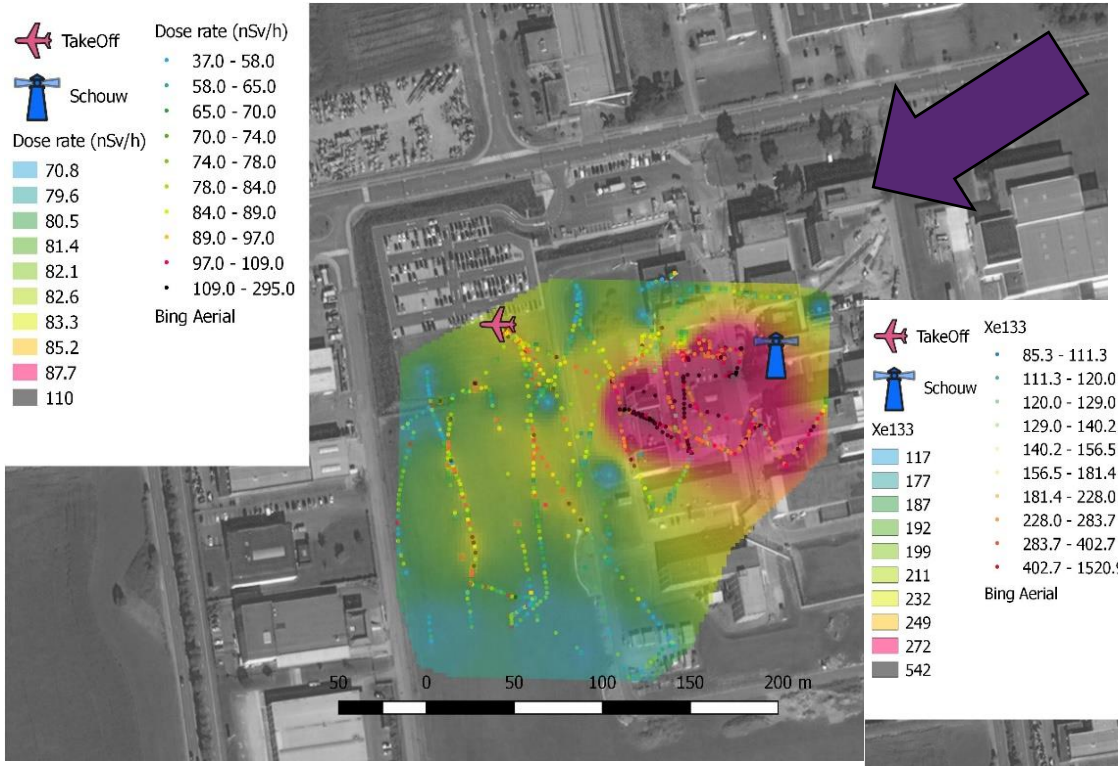
Paridaens (2018), SCK CEN-BLG-1157



Stack Release Data, IRE (HPGe stack monitoring)

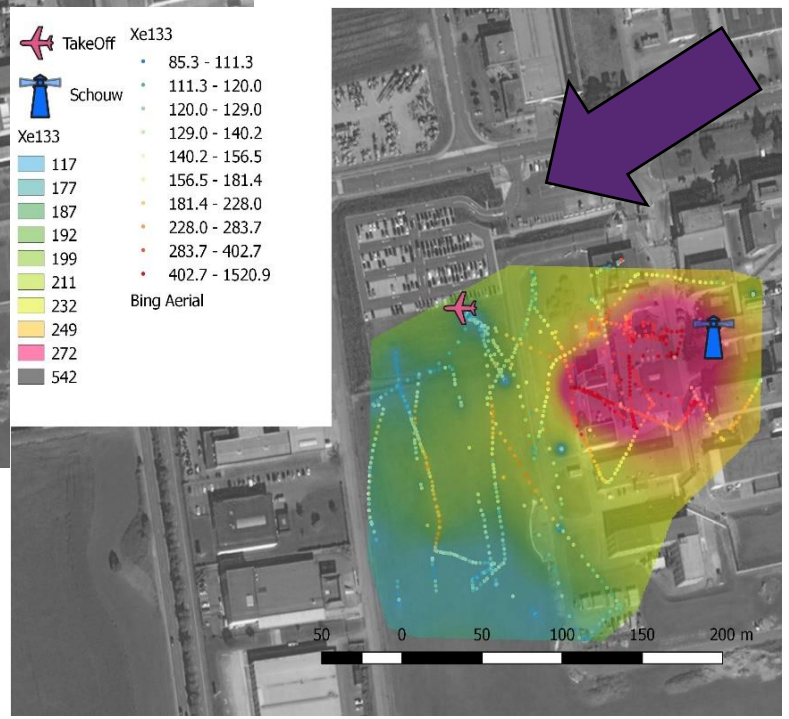
- Test flight near release stack (around 30 m high) at IRE facility during normal operation

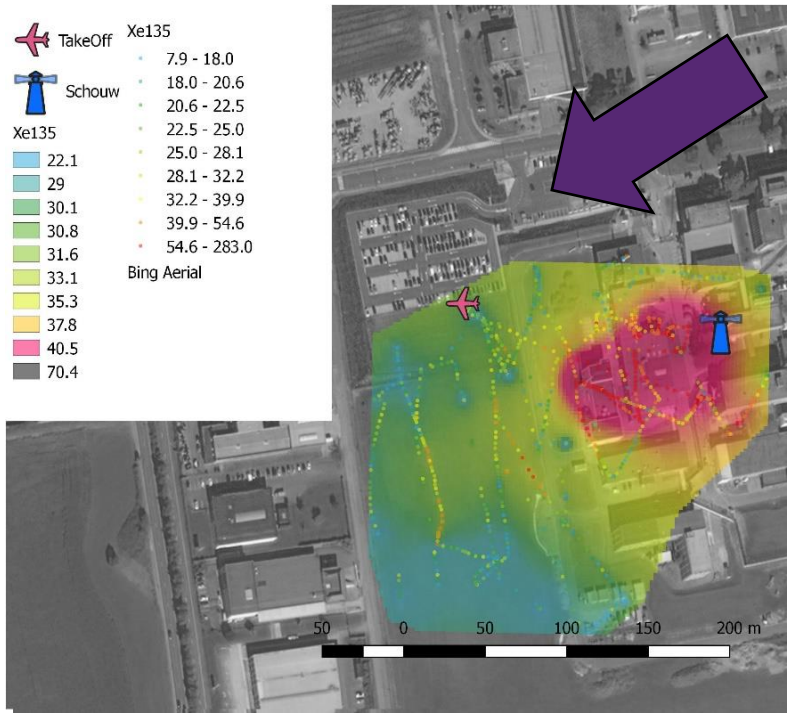
Visualisation of the dose rate, Xe-133 and Xe-135



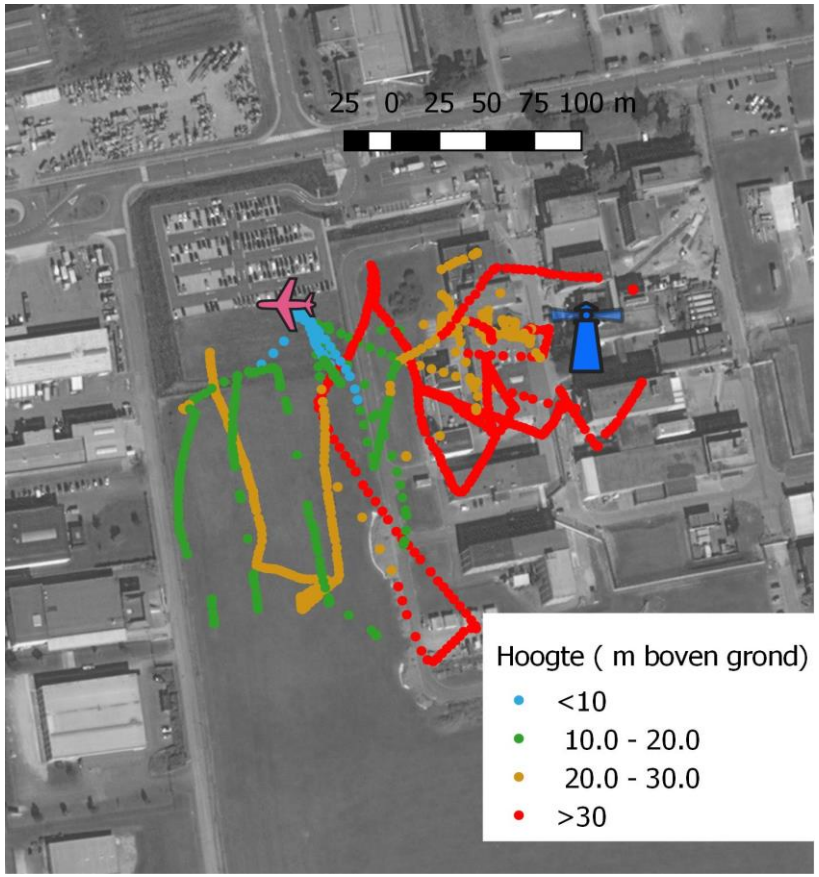
Paridaens (2018), SCK CEN-BLG-1157

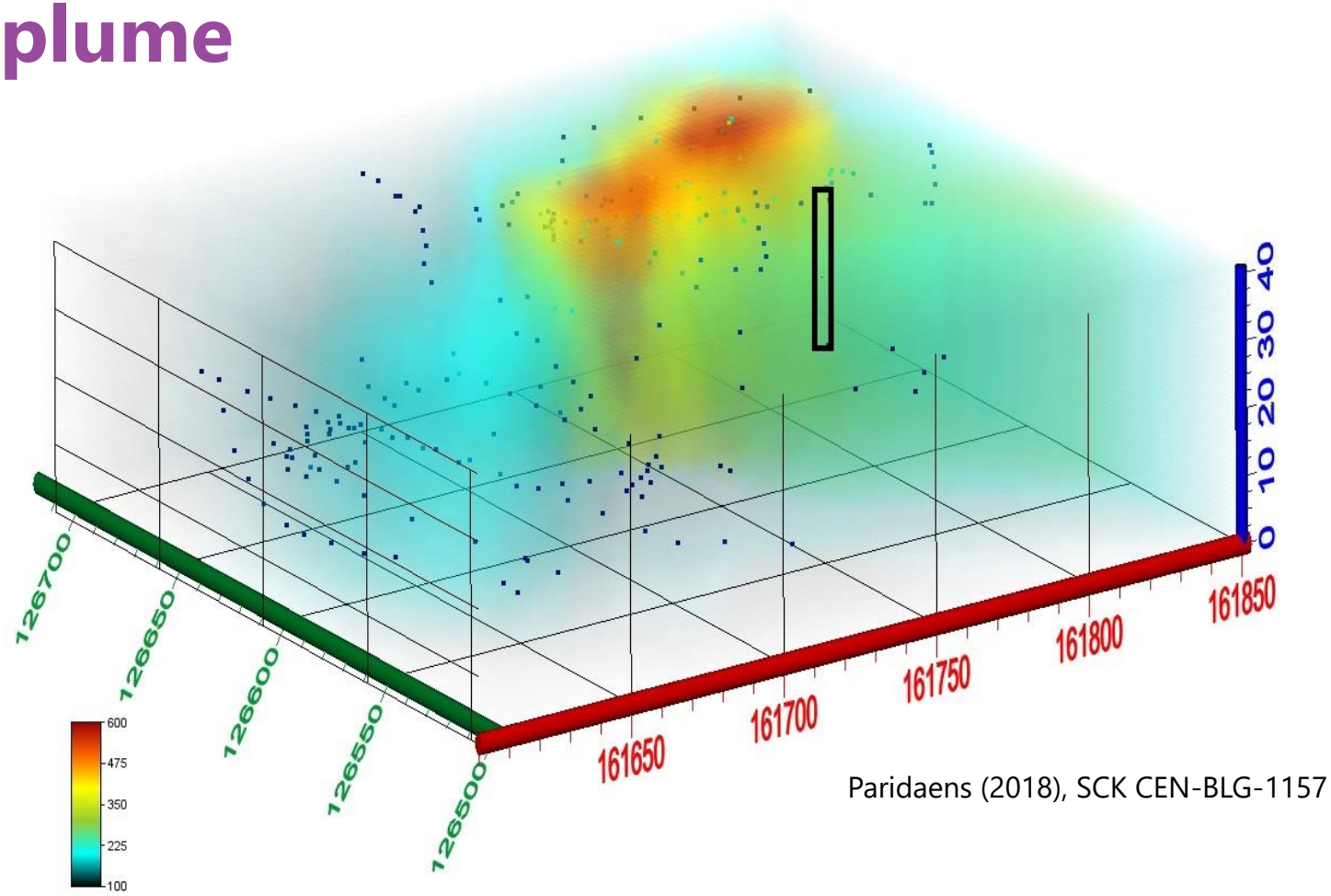
- Dose rate, Xe-133 and Xe-135 count rate during 5 short flights around release chimney
- Arrow gives on-site measured wind direction





Reconstruction of the plume

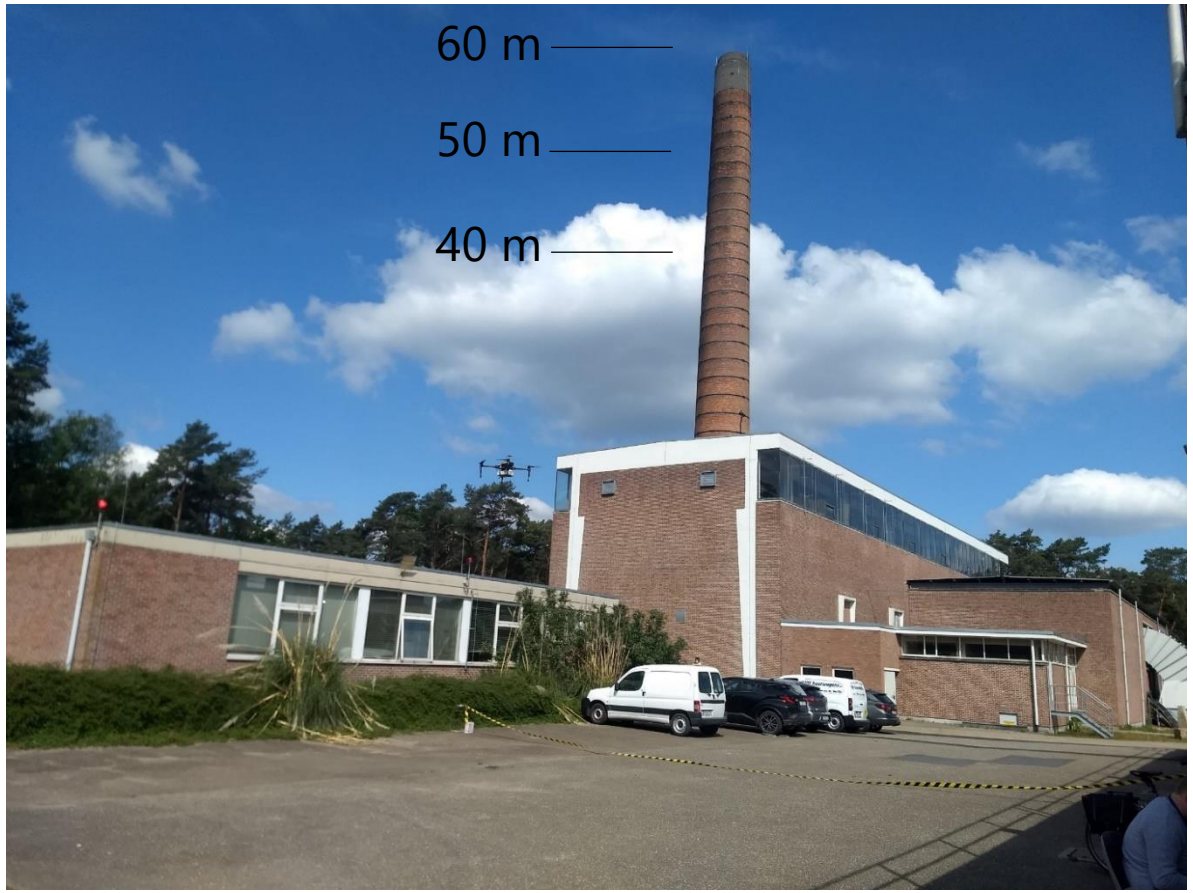




Paridaens (2018), SCK CEN-BLG-1157

- Plume reconstruction difficult due to large variation of source term during flight and limited 3-D coverage of region, however a downwash of plume seems to be present

Case 3 : Measuring Ar-41 release from the BR1



Olyslaegers et al. (2020), SCK CEN-ER-0785

RadDetecTIF:
2”x1”x1” CsI detector (Kromek Sigma50), a Rasberry Pi, Arduino mini, variometer and long range radio transmission (±1 kg incl. battery)

RadDetecTIF with DJI M100

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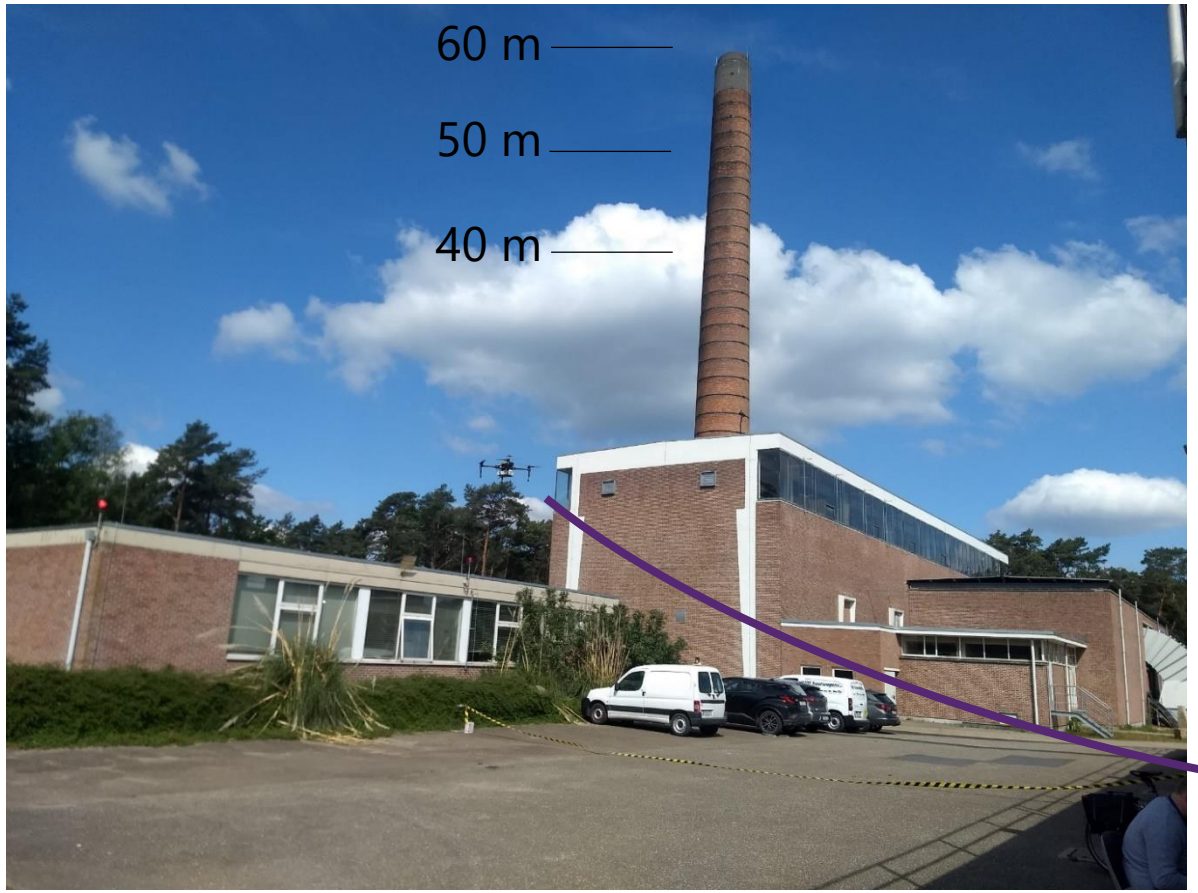

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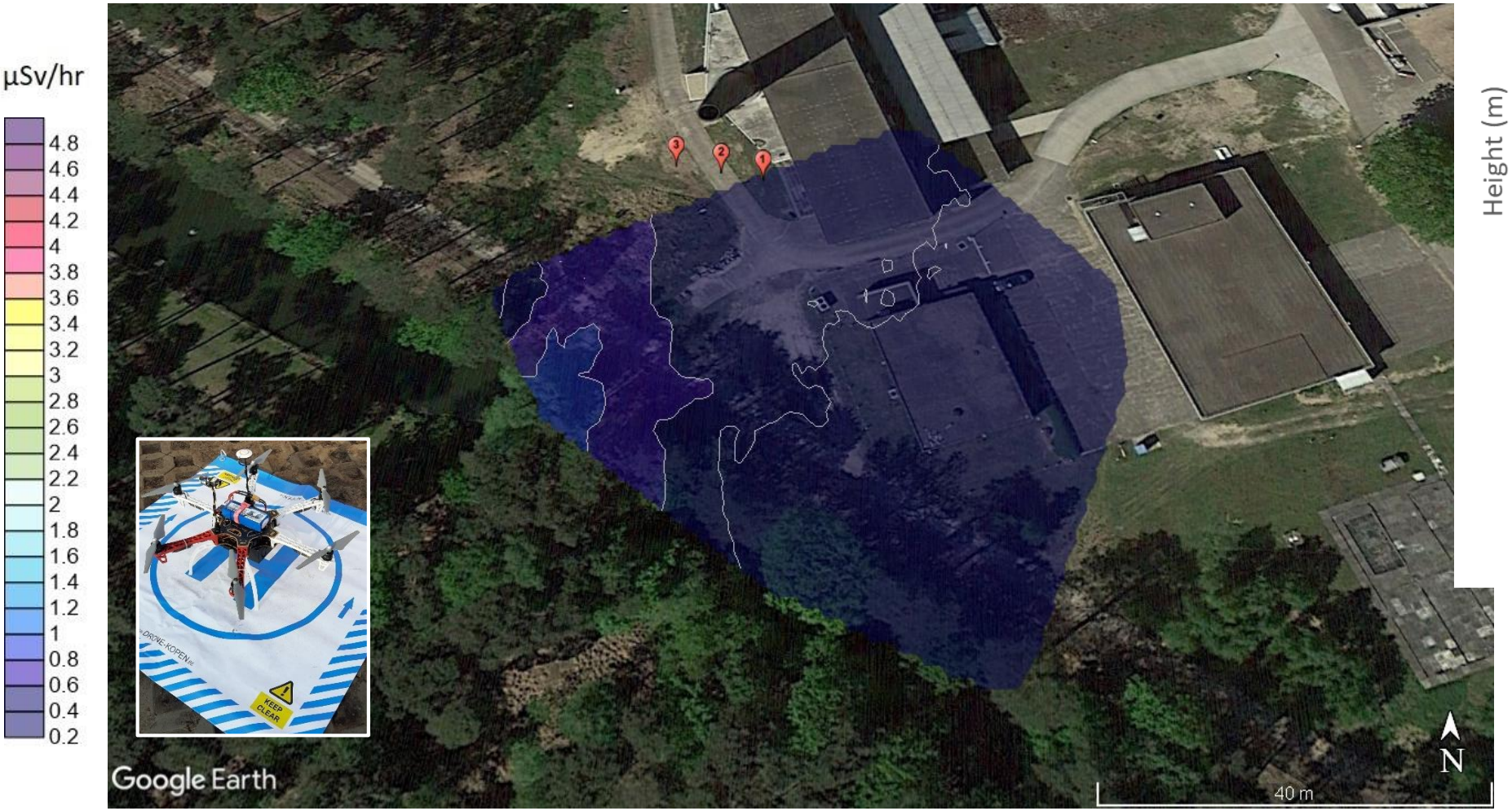
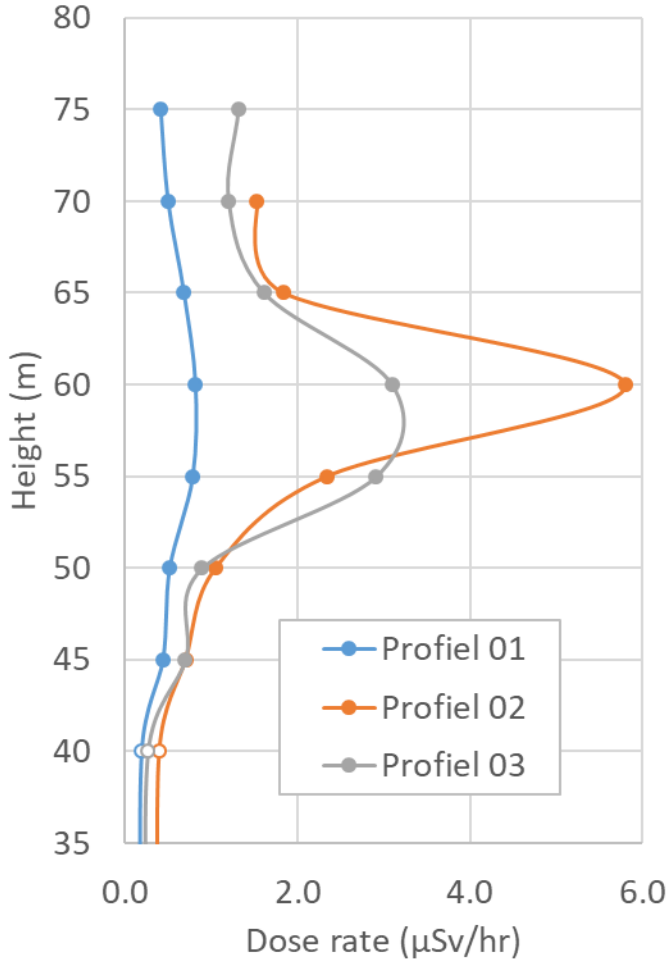
Detection of the Ar-41 plume





DJI F550 with GM Detector
2 m/s, different heights

Olyslaegers et al. (2020), SCK CEN-ER-0785

40 -50 m

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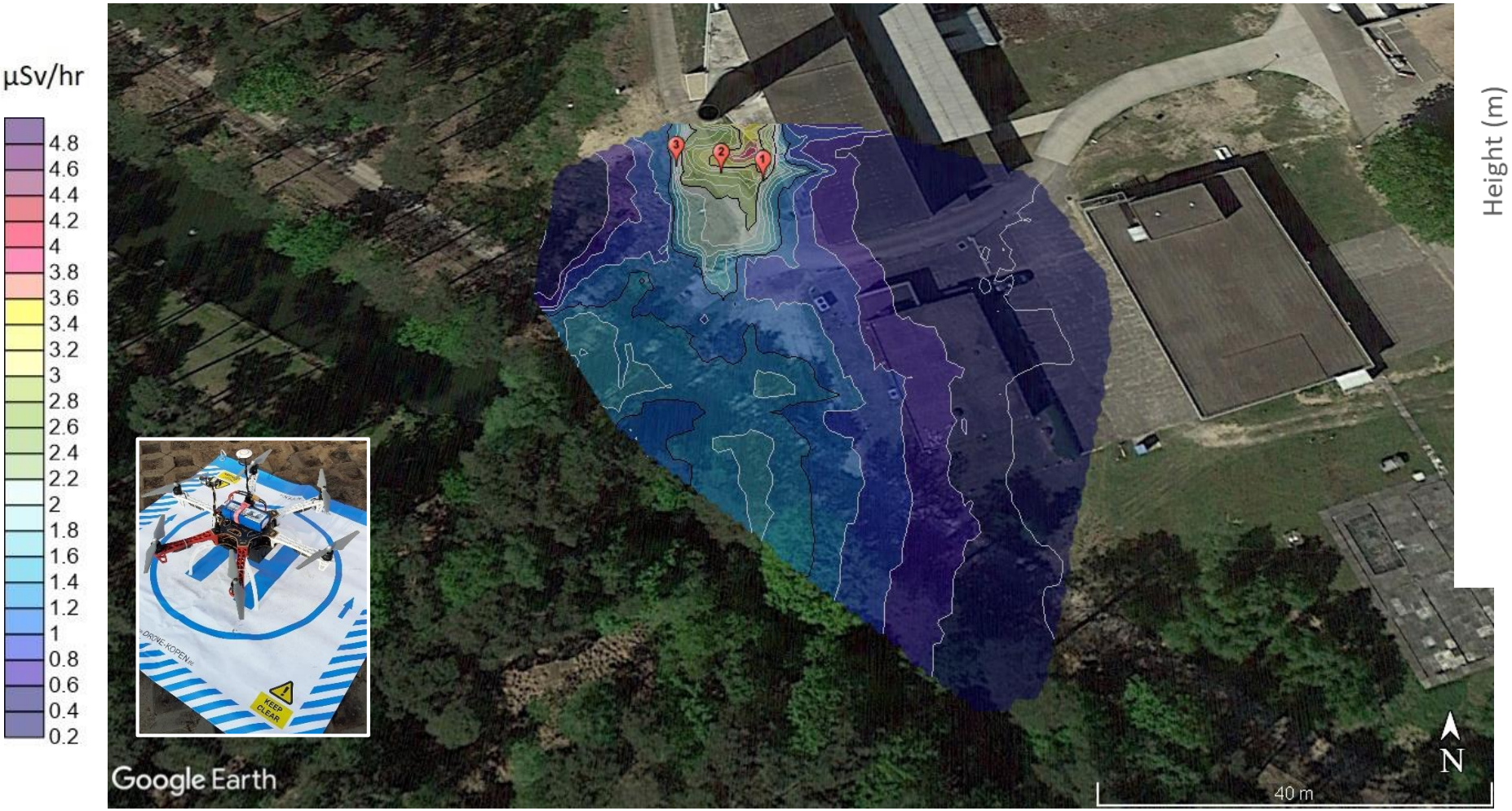
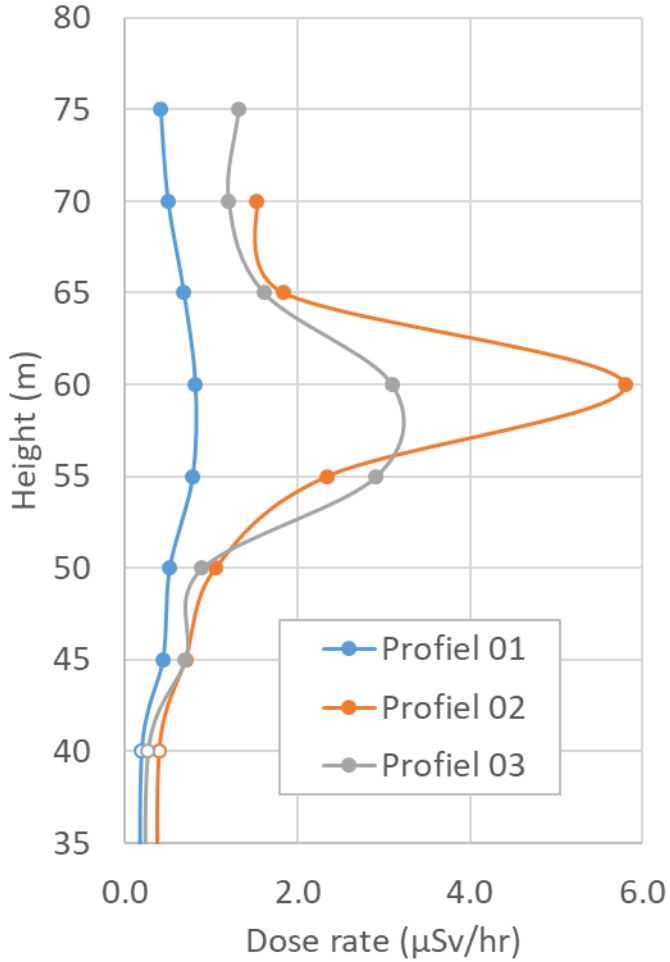
Detection of the Ar-41 plume





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Olyslaegers et al. (2020), SCK CEN-ER-0785

50 -60 m

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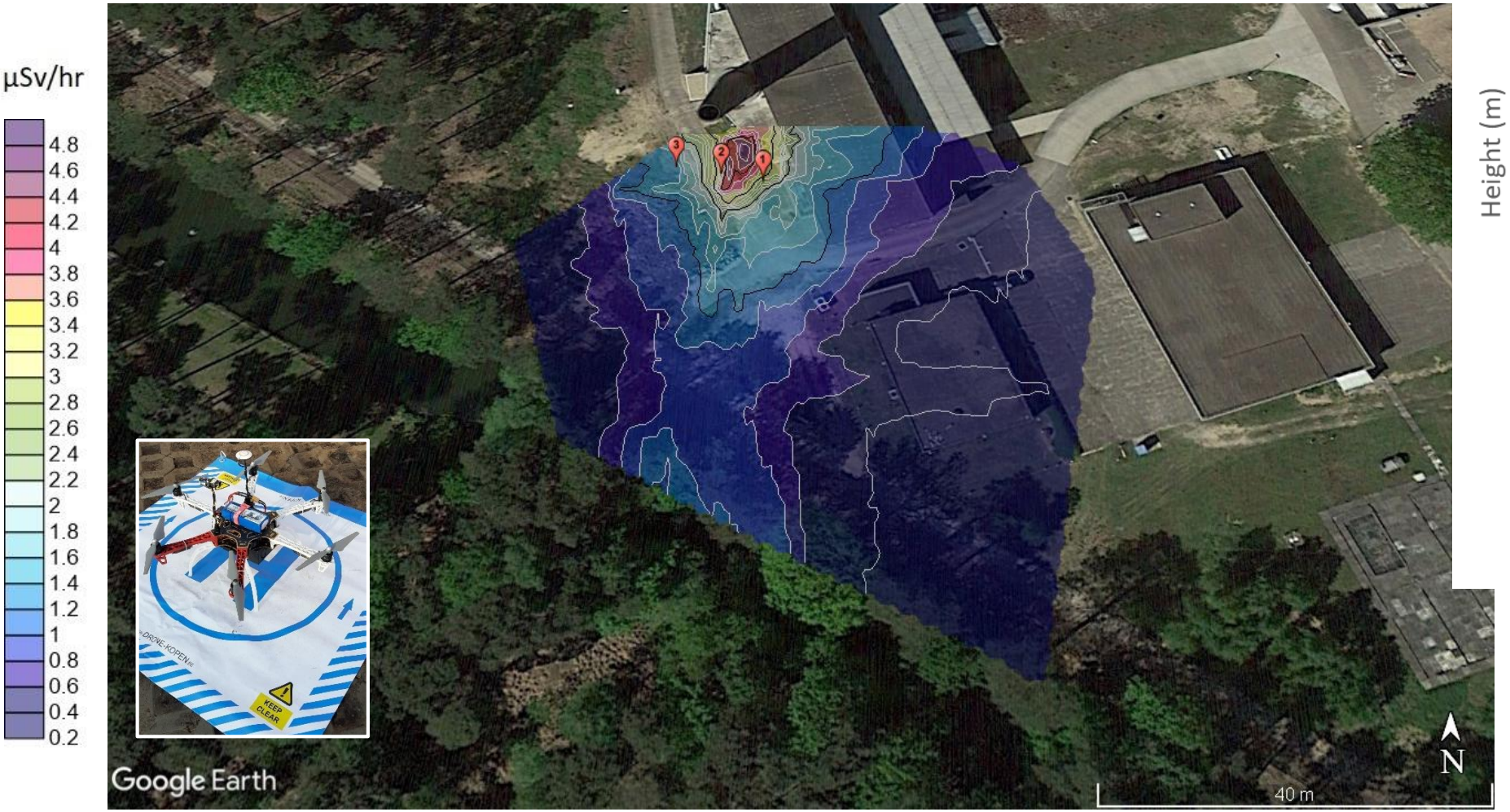

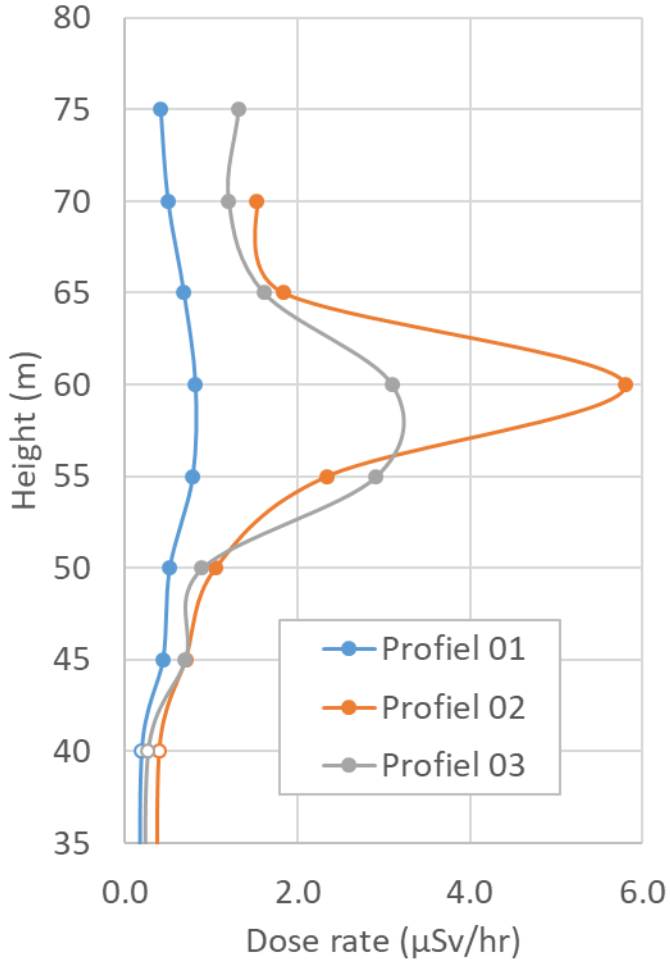

DJI F550 with GM Detector
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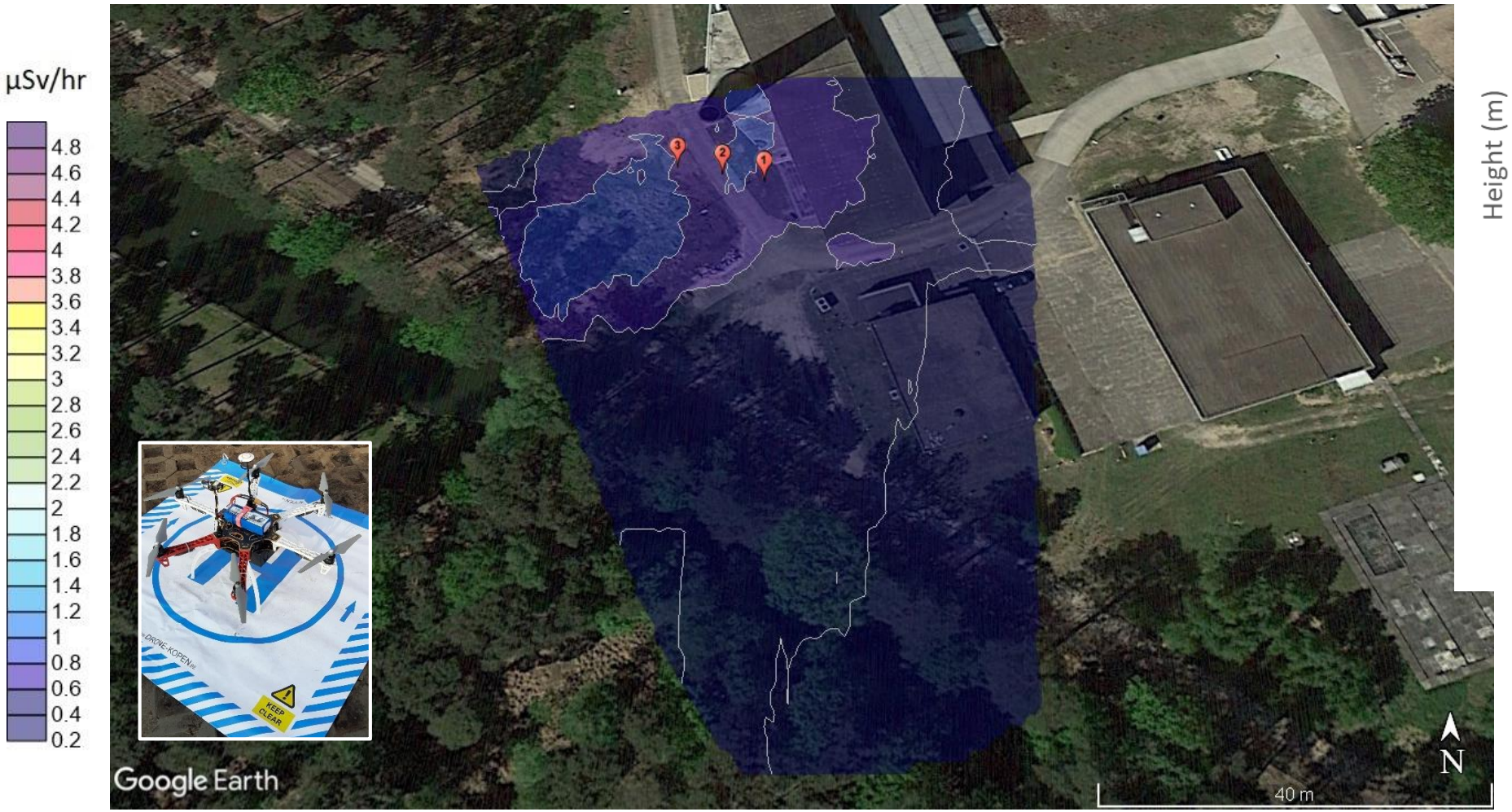
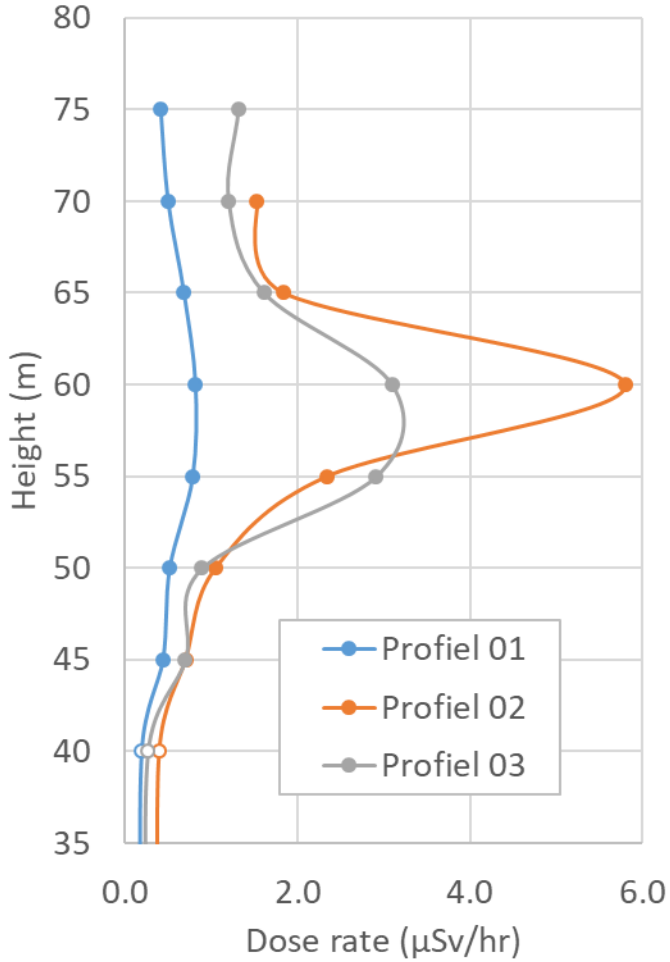
Olyslaegers et al. (2020), SCK CEN-ER-0785

60 -70 m

Detection of the Ar-41 plume





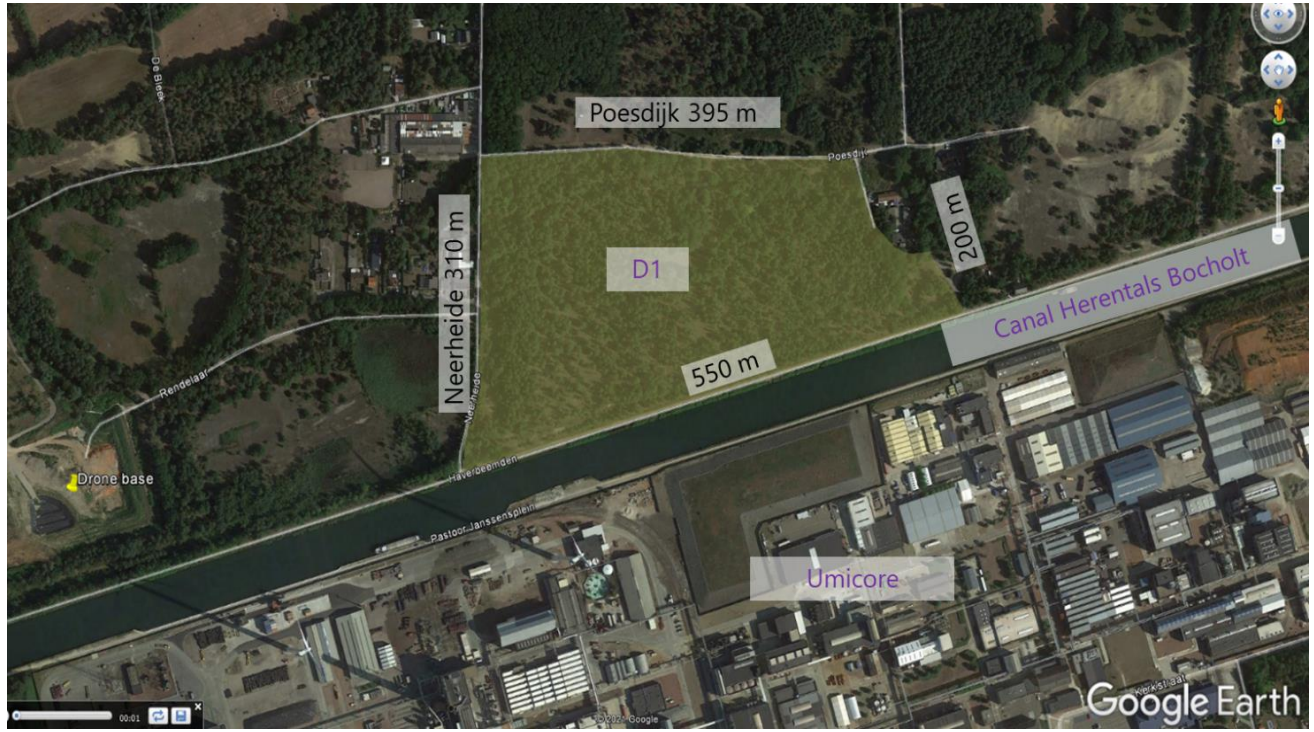
DJI F550 with GM Detector
2 m/s, different heights

Olyslaegers et al. (2020), SCK CEN-ER-0785

70 -80 m

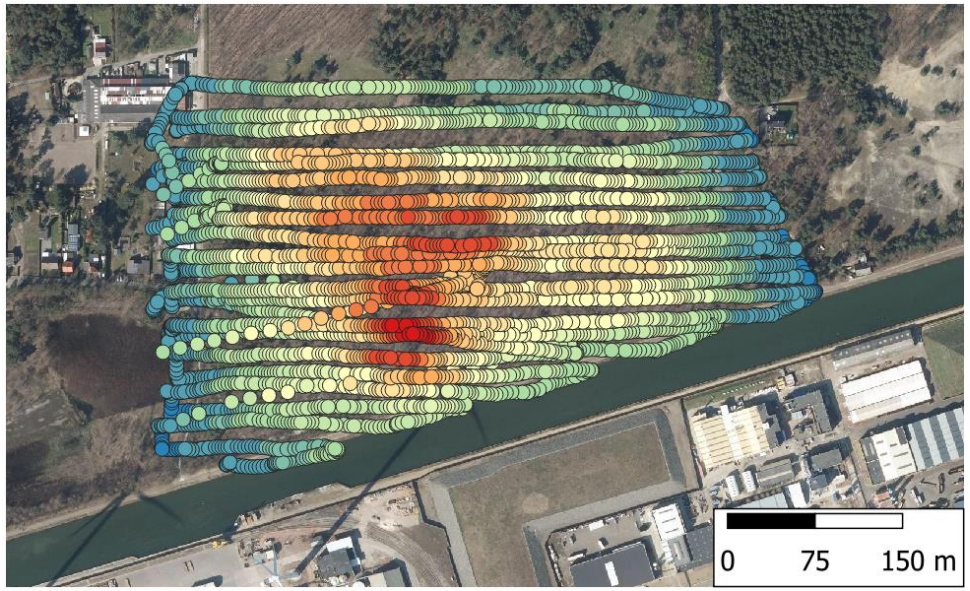
Case 4 : Characterisation of D1 repository

- D1 repository of Umicore (Olen, Belgium)
- DJI M600 from civil protection with ADb and RadDetecTIF
- DJI F550 with GM-detector

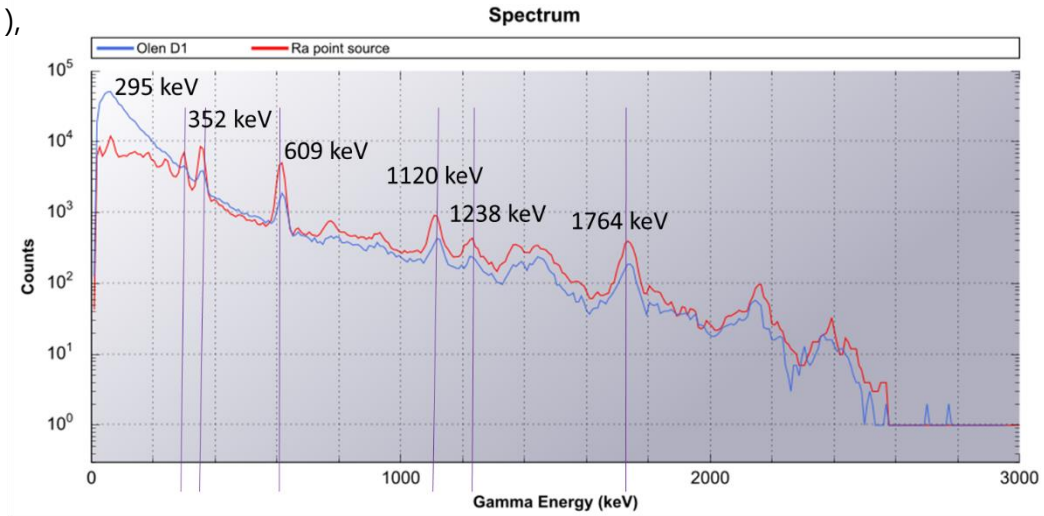


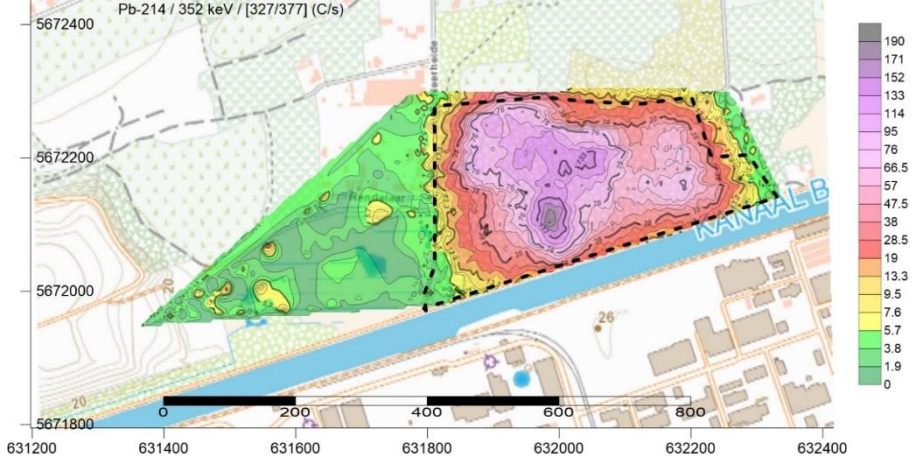
Olyslaegers et al. (2021), SCK CEN-BLG-2933

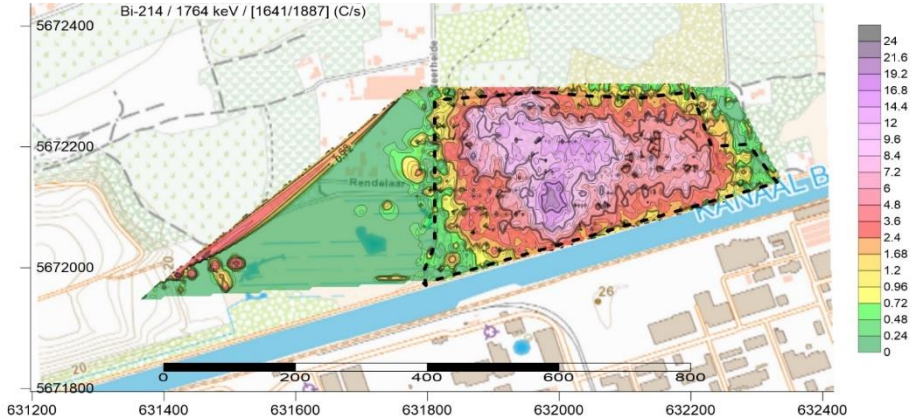
Characterisation of the site

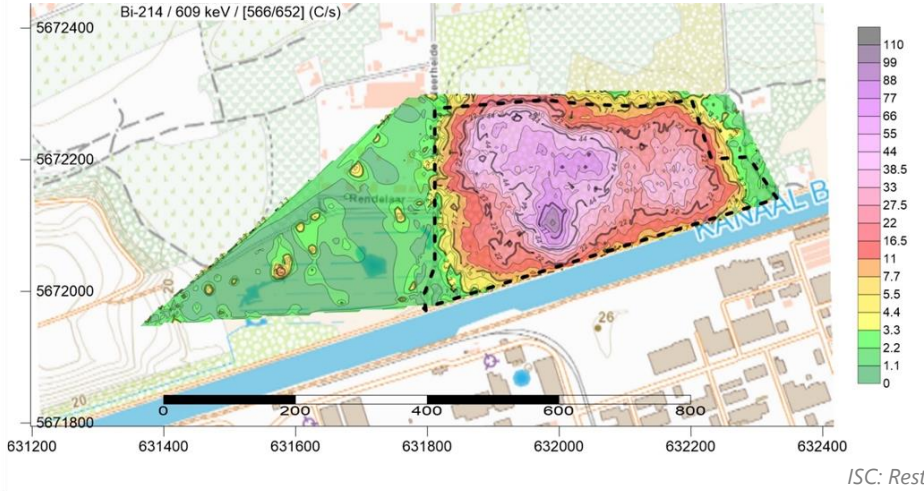


Olyslaegers et al. (2021), SCK CEN-BLG-2933







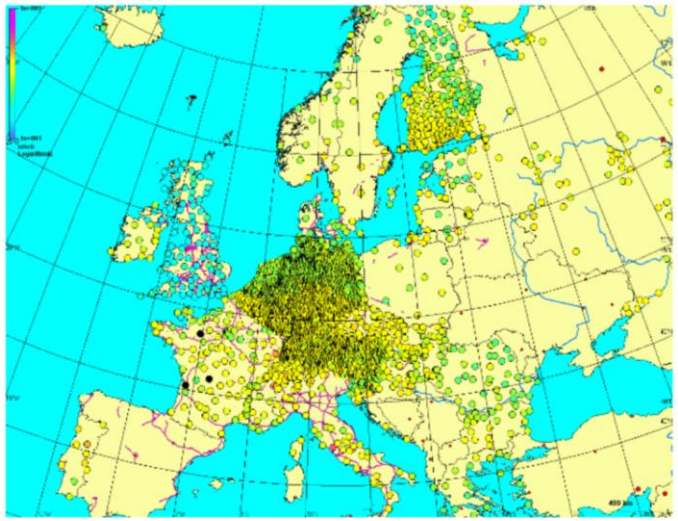


Current decision support systems can cope with different kind of data

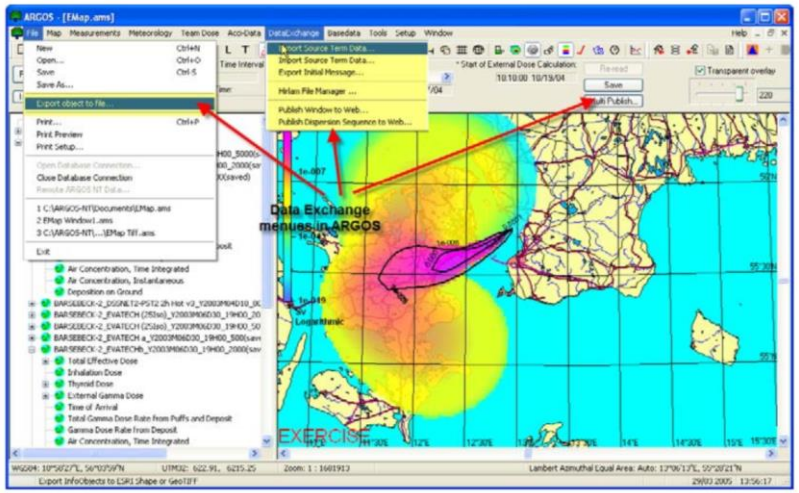
- Meteorological:
  - Real time readings from a meteorological tower at or near an nuclear power plant
- Source term:
  - Real time readings from stack monitors during normal operation or planned or accidental release via such route
- Radiological:
  - Real time readings from gamma dose rate meters such as the European Monitoring Stations (EURDEP-protocol) (dose rate and even spectra)
  - Deposition maps (Bq/m^2 per nuclide)
  - Air Sample Stations (Bq/m^3 per nuclide)

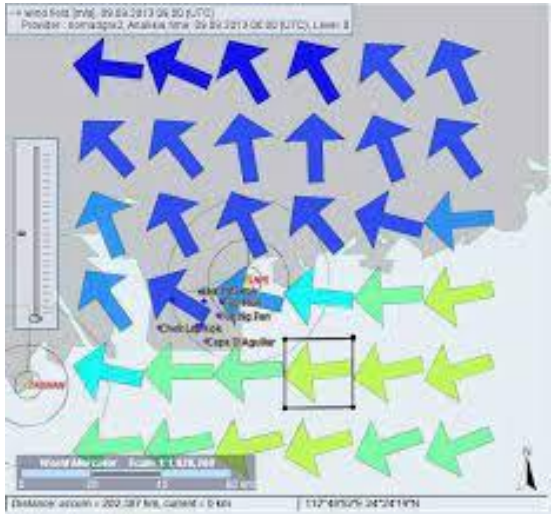
Different decision support systems have been developed in an European context

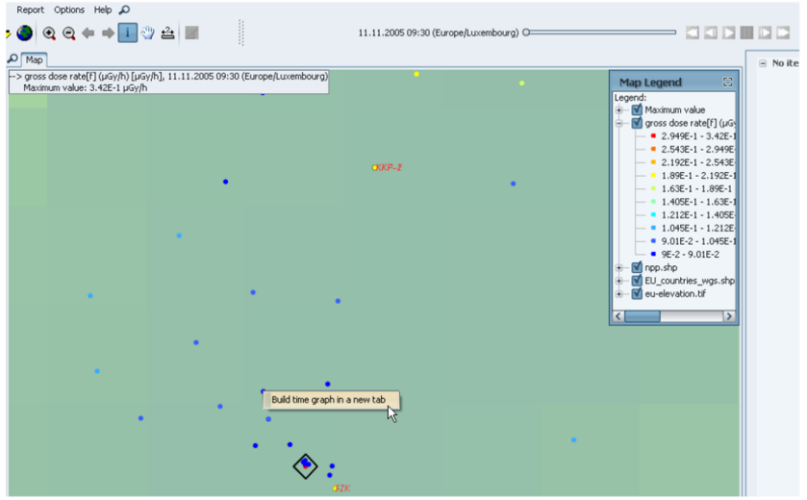
- JRODOS – (KIT, Germany)
- ARGOS (PDC-ARGOS, Denmark)



European Monitoring Stations

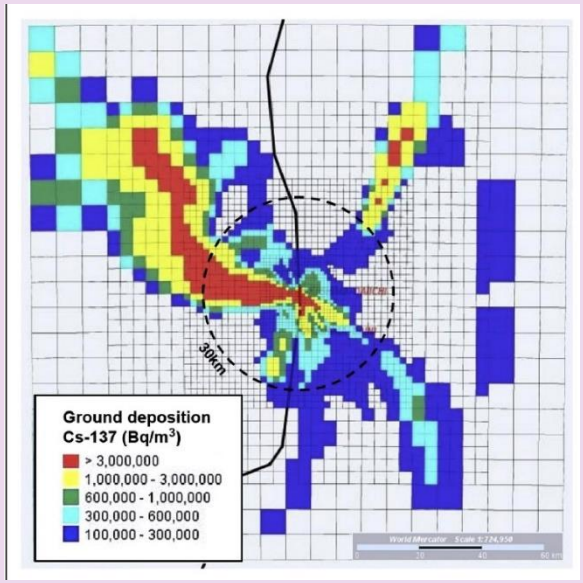




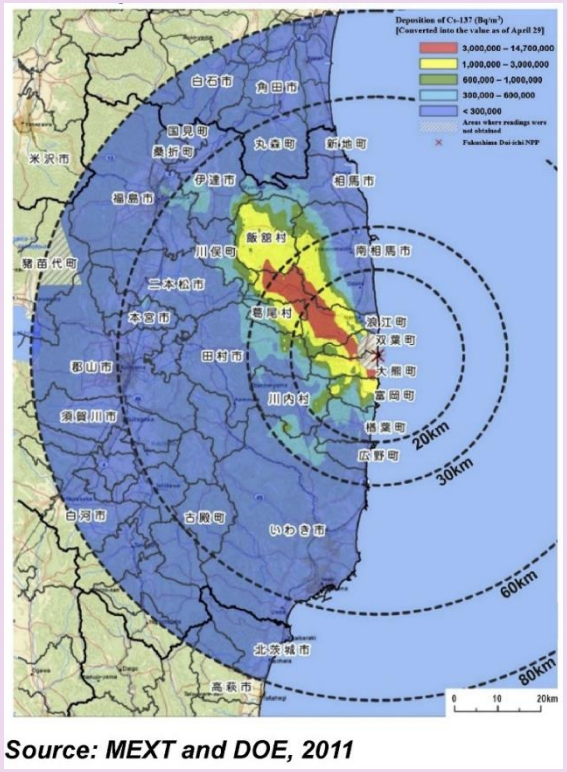


- https://resy5.iket.kit.edu/JRODOS/
- https://pdc-argos.com/nuclear.html

Real integration with drone measurements is currently missing but not impossible



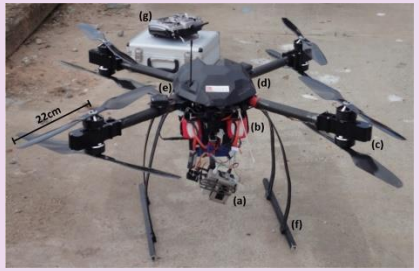
Leung et al. (2018)
J. Env. Rad 183 pp 27-36

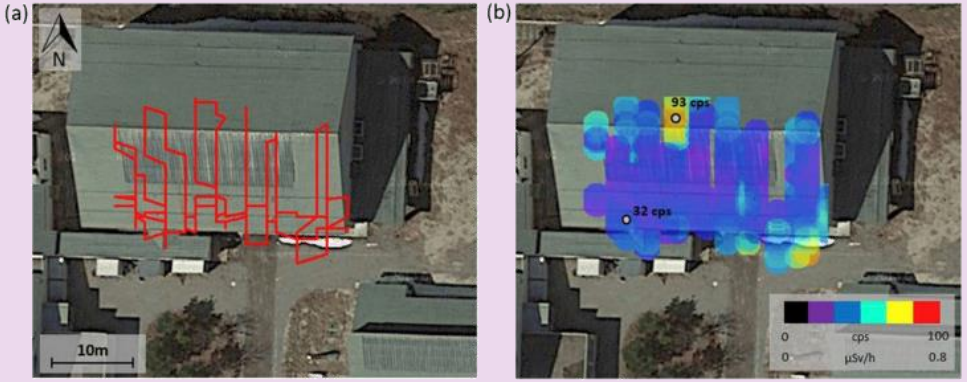


Source: MEXT and DOE, 2011

Current DSS

Martin et al. (2016)
J. Env. Rad 151(1)
pp 58-63





- Observe the effect of remediation
- Sub-meter resolution mapping
- ....

UAV measurements

So…how can we use drones monitoring data in Decision Support Systems ???

'Bad news': radiation 16 times above normal after forest fire near Chernobyl

The blaze started on Saturday close to the site of the world's worst ever nuclear disaster

▲ A Geiger counter shows increased radiation level at the forest fire near Chernobyl. Photograph: Yaroslav Yemelianenko/AP

Ukrainian officials have sought calm after forest fires in the restricted zone around Chernobyl, scene of the world's worst nuclear accident, led to a rise in radiation levels.

Firefighters said they had managed to put out the smaller of two forest fires that began at the weekend, apparently after someone began a grass fire, and

The Guardian

Stopping the dirty bomb 'threat'

By Rob Broomby
BBC Radio 4

Carolyn MacKenzie goes at her job like a terrier.

High in the Caucasus Mountains of Georgia she is wielding the latest radiation detector fitted into a backpack which is flashing and beeping as we walk through the thick damp undergrowth.

The search is on for radioactive material missing since the collapse of the USSR

Part educator, part campaigner she is what is called an Orphan Source specialist with the UN's Nuclear watchdog the International Atomic Energy Agency.

She is supporting a Georgian team hunting down missing radioactive materials - sources as they call them - once used in a range of devices from communications to health care and now lost without trace with the collapse of the Soviet Union.

BBC NEWS

Conclusion

- UAVs represent a culmination of cutting edge avionics and remote sensing technology.
  - They are lightweight, highly deployable, and relatively inexpensive systems
  - Have the ability to quickly provide data from inaccessible areas, while alleviating humans from hazardous operations.
  - Dose rates and radionuclide specific concentration can easily be mapped
- Technological which can directly links drone monitoring information with decision support systems exists.
- There is still room to integrate drone measurements into DSS
  - Corrected drone measurements (cps) to deposition map (Bq/m^2)
  - Extrapolations dose rate measurements to ground level (1 m)
  - …

ISC: Restricted

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ISC: Restricted

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