

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/362904013>

MAPPING GAMMA DOSE RATES OF AN AREA WITH ELEVATED NATURAL RADIOACTIVITY USING A DRONE- MOUNTED SAFecast SENSOR

Conference Paper · June 2022

CITATIONS

0

READS

136

7 authors, including:



Ákos Horváth

Eötvös Loránd University

128 PUBLICATIONS 1,763 CITATIONS

SEE PROFILE



Fanni Vörös

Eötvös Loránd University

39 PUBLICATIONS 39 CITATIONS

SEE PROFILE



Márton Pál

Eötvös Loránd University

52 PUBLICATIONS 102 CITATIONS

SEE PROFILE



Tóth Szabolcs

Bányavagyon-hasznosító Nonprofit Közhasznú Kft.

1 PUBLICATION 0 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Origin of elevated radon concentrations in the Sopron Mts. [View project](#)



Developing regional and global volcanic morphometry correlations for various volcanic areas on Earth [View project](#)

MAPPING GAMMA DOSE RATES OF AN AREA WITH ELEVATED NATURAL RADIOACTIVITY USING A DRONE- MOUNTED SAFecast SENSOR

**Hédi Katreiner, Ákos Horváth, Fanni Vörös, Márton Pál, Szabolcs Tóth, András
Várhegyi, Béla Kovács**

Hédi Katreiner BSc

Institute of Cartography and Geoinformatics, Faculty of Informatics, ELTE Eötvös Loránd
University, Budapest, Hungary

address for contact: H-1117 Budapest, Pázmány Péter sétány 1/C., Hungary

e-mail: kwondi@student.elte.hu

Ákos Horváth PhD

Department of Atomic Physics, ELTE Eötvös Loránd University, Budapest, Hungary

address for contact: H-1117 Budapest, Pázmány Péter sétány 1/A., Hungary

e-mail: akos@ludens.elte.hu

Fanni Vörös MSc

Institute of Cartography and Geoinformatics, Faculty of Informatics, ELTE Eötvös Loránd
University, Budapest, Hungary

address for contact: H-1518 Budapest, Pf.32., Hungary

e-mail: vorosfanni@map.elte.hu

Márton Pál MSc

Doctoral School of Earth Sciences, Faculty of Science, ELTE Eötvös Loránd University, Budapest,
Hungary

Institute of Cartography and Geoinformatics, Faculty of Informatics, ELTE Eötvös Loránd
University, Budapest, Hungary

address for contact: H-1518 Budapest, Pf. 32., Hungary

e-mail: pal.marton@inf.elte.hu

Szabolcs Tóth MSc in chemical engineering

Mining Property Utilization Ltd.

H-1126 Budapest, Tartsay Vilmos u. 3. I emelet, Hungary

e-mail: toth.szabolcs@bvh.hu

András Várhegyi C.Sc

Mining Property Utilization Ltd.

H-1126 Budapest, Tartsay Vilmos u. 3. I emelet, Hungary

e-mail: varhegyi.andras@bvh.hu

Béla Kovács PhD

Institute of Cartography and Geoinformatics, Faculty of Informatics, ELTE Eötvös Loránd
University, Budapest, Hungary

address for contact: H-1117 Budapest, Pázmány Péter sétány 1/C., Hungary

e-mail: climbela@map.elte.hu

Abstract

Several studies are concerned with assessing radiation contamination from accidents such as Chornobyl and Fukushima. However, radioactivity can also come from natural sources, either terrestrial or cosmic. These natural sources have not been properly surveyed and documented at some locations yet. The low-cost Safecast sensor used in our research was mounted on a UAV to investigate the possibility of mapping larger anomalies this way. One of the many advantages of drones is that the survey can be carried out without endangering human life. The aim of our research is to demonstrate the mapping capabilities of a cost-effective radiation detection sensor combined with a UAV in a presumably contaminated area. We also identify the optimal flight parameters for the drone and study the variation of radiation levels with altitude.

Keywords: Safecast, gamma dose rate detection, drone, radioactivity, remote sensing, radiation

INTRODUCTION

The importance of mapping radioactivity of a larger area became important after the Fukushima accident. In 2011, when the Fukushima Dai-ichi accident occurred, a huge data blackout was established (Oshima et al., 2012). Initially, a survey was started on the contaminated area with Geiger-Müller (GM) tubes, NaI scintillation detectors and ionisation chambers mounted on cars, but this was a very hazardous and slow process (Povinec et al., 2013). The terrestrial survey was followed by several conventional aerial surveys (Terada et al., 2012; Torii et al., 2013) and further by a drone (Reavis & Hem, 2011). This small unmanned aerial vehicle (SUAS) was known as the Honeywell T-Hawk. The idea that drones could be used for radiation mapping was already a 'hot topic' before the Fukushima accident, and studies on the subject were published as early as 2009 (Pöllänen et al., 2009). The disaster highlighted the shortcomings of the technology, and since then, there have been many studies on radiation mapping with drones. In these studies, several methods have been described, some of them using a simple radiation sensor such as a GM counter or a scintillation detector attached to the drone (Gong et al., 2019; Molnar et al., 2021; Pöllänen et al., 2009) or using a Compton camera (Sato et al., 2020). Studies have also explored the use of both multi-rotor (MacFarlane et al., 2014) and fixed-wing drones (Connor et al., 2020). Detecting and mapping gamma radiation are not only crucial in the event of a nuclear accident. Some areas are important due to their geological features or their use. One such area is our research site, which is a service road within a decommissioned uranium mine used to transport uranium ore.

RADIOACTIVE RADIATION IN NATURE

Radioactive radiation occurs everywhere in nature. This background radiation can come from natural and artificial sources, but the majority come from natural ones. Natural radiation can come from cosmic or terrestrial sources. The primary cosmic radiation occurs in the upper atmosphere when heavy ions react with atmospheric gases. One isotope that is a consequence of this process is ^{14}C , which is used effectively in radiometric dating. The radiation dose from cosmic rays depends on the altitude. The 'shielding' effect of the atmosphere decreases with increasing altitude. The dose from cosmic radiation at sea level is about 0.26 mSv/year (Eisenbud & Paschoa, 1989). Radioactivity from the crust is due to three elements: Potassium (K), Thorium (Th) and Uranium (U). A study from 1965 (Heier & S Adams, 1965) shows that the crust is more radioactive than the mantle and that the continental crust has a higher U, Th and K content than the oceanic crust. Natural radioactivity in rocks increases in direct proportion to the Uranium, Thorium and Potassium content of the soil above. Acidic igneous rocks such as granite and rhyolite show higher activity than sedimentary or basic rocks (Evans & Goodman, 1941). Among the environmental radioactive radiations, gamma radiation is the most difficult to protect against, as it has high penetrating power. The natural gamma background radiation measured at the surface is due to a combination of the radiation from rocks, soil (depending on U, Th, K concentration values) and cosmic gamma radiation. The background radiation is variable, influenced by altitude, soil type, weather conditions and their variations. According to the Hungarian National Directorate General for Disaster Management, in Hungary the dose intensity of the average natural background radiation is 50-180 nSv/hour.

Instruments for radiation measurement

The most commonly used detectors for measuring ionizing radiation are semiconductor detectors, scintillation detectors, and Geiger-Müller counters. Semiconductor detectors are diodes made mainly of single crystals of semiconductors. These crystals are mostly silicon and germanium (Ahmed, 2007). Scintillation detectors consist of two main elements; a crystal and a light detector. Some crystals emit light every time they interact with a gamma-ray. If these crystals are isolated from all other light sources and connected to a sensitive light detector, the flashes can be detected as electrical pulses. Several types of scintillation crystals can be distinguished, the most commonly used being thallium-loaded sodium iodide Na (TI) (Panikkath et al., 2020). This crystal has an extremely high water-binding capacity, and its efficiency deteriorates with water binding, so these crystals must be hermetically sealed (Molnar et al., 2021). The

Geiger-Müller counter is also often referred to as a particle counter because the device associates electrical pulses with each photon it detects. The Geiger-Müller counter is an electrically charged discharge tube filled with a low-pressure gas mix, with a negatively charged wall and a positively charged metal filament in the middle. When radioactive radiation enters the tube, the incoming electron collides with molecules of the gas and knocks an electron from shells. After the collision, the electrons collide at high speed with other atoms, from which more electrons are torn off and together they move towards the positively charged metal filament (anode). These electrons are transported to an electronic counter.

SURVEY AREA

We have chosen the village of Kővágószőlős (Hungary) as the location for our research. Uranium ore mining started in 1957 and continued in this area until 1997. Due to its geological characteristics, the area is rich in uranium ore. The geological environment of the village is characterised by the Permian Sandstone (Kővágótöttös, Tótvár and Cserkút sections of the Kővágószőlős Formation), and the Triassic Jakabhegy Sandstone Formation. The Permian formations alternate conglomerate, mudstone and aleurolite (Gyalog and Síkhegyi, 2005). During the mining and transporting of uranium ore, several routes used for the transport were possibly contaminated. The investigated area was a 294 m long section of an asphalt service road and a junction (Figure 1). The road descends in a southerly direction, giving an elevation difference of 16 m between its two ends.

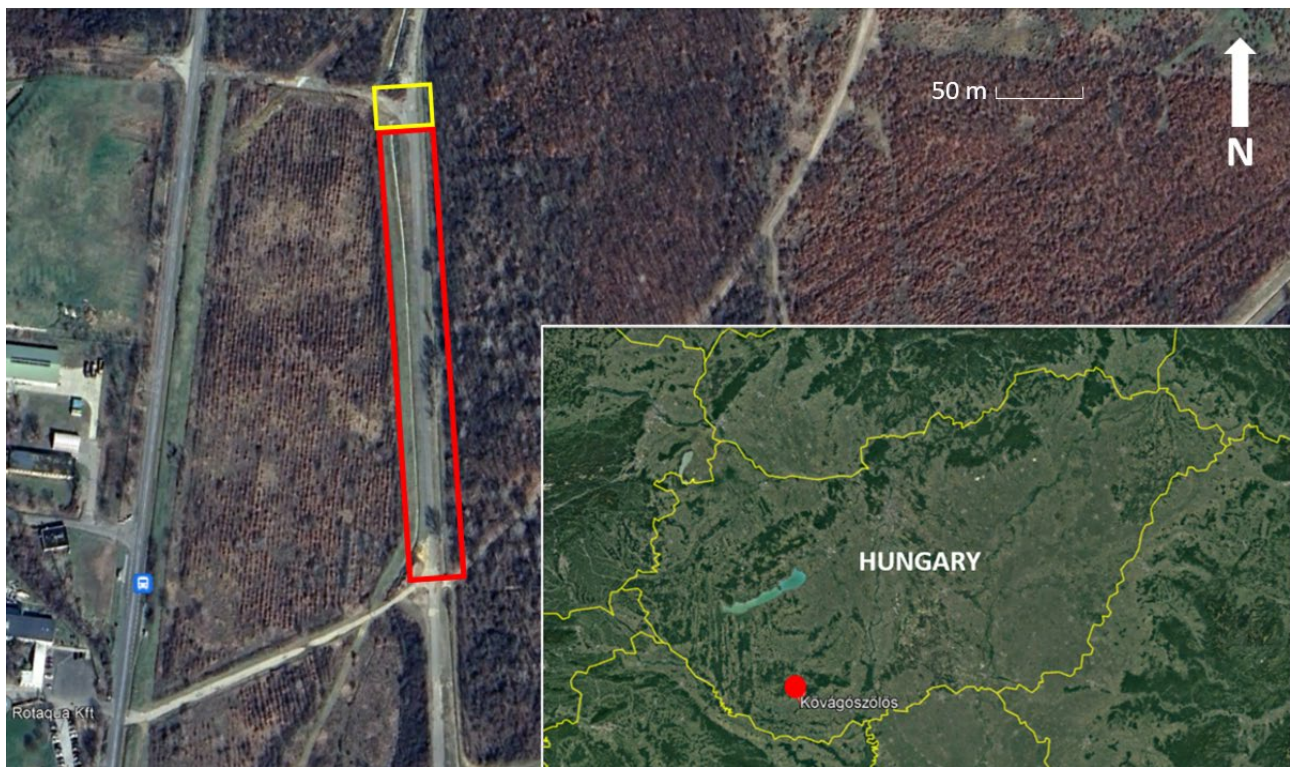


Figure 1. Survey area: asphalt road (red rectangle) with a junction (yellow rectangle)

EQUIPMENT

The drone

The drone used for the survey was a DJI Matrice 210 V2 RTK UAS quadcopter (Figure 2). The unmanned aerial vehicle system consists of several main components; in addition to the flying device, a remote controller and an external Stonex RTK (Real-Time Kinematic) GPS unit for precise positioning. This drone, with landing gear, measures 883x886x427 mm and weighs 4.91 kg with two TB55 batteries. Its maximum take-off weight is 6.14 kg, thus it can carry a payload of 1.23 kg. It has a hovering accuracy of ± 0.1 m in both the vertical and horizontal directions (when used with RTK). It can travel vertically upwards at 5 m/s and downwards at 3 m/s speed. It can fly more than 30 minutes without payload and around 25 minutes with maximum payload. The flying time depends on the weather and other conditions too. It can fly vertically up to 3000 m altitude. Its horizontal range is up to 8 km.

MAIN SENSORS AND INSTRUMENTS

- RTK antennas
- Dual IMU (Inertial Measurement Unit)
- barometer
- Flight safety sensors: AirSense
- Telemetry sensors
 - Infrared sensors
 - Downward and Forward Vision System
- TimeSync
- optional hi-res RGB sensor
- FPV (First-person-view) camera



Figure 2. DJI Matrice 210 V2 RTK UAS with the attached Safecast sensor

The Safecast sensor

The Safecast bGeige Nano Kit (Figure 3) is a lightweight, easily portable radiation monitoring device with built-in autonomous GPS and logging capability. In this logging mode, the device takes measurements with an integration time of 5 seconds, then transcribes and stores them on a microSD card with a timestamp and coordinates. The bGeige Nano uses an LND 7317 'Pancake' Geiger Müller counter. It is capable to measure the number of interactions with the gamma radiation and calculating the corresponding dose rate. This GM tube is a recessed cylinder filled with Neon and halogen gases, approx. 1 cm thick. The Safecast device can operate in three measurement modes; the first is the 'bGeige mode', which returns a CPM (counts per minute) value and a dose rate value (microSv/h) every 5 seconds and then calculates a 60 second average from these. The second measurement mode is the 'xGeige mode', which returns a dose rate in $\mu\text{Sv/h}$, but does not log. The third mode is 'iGeige', which is compatible with iPhone phones and can display the measured dose rate in real-time via an application and then transmit it in real-time to the Safecast API website. These data are also displayed on the graphical OLED display on the instrument, firstly the CPM value (a), then the calculated dose rate (b), distance travelled (c), date and time (d), followed by the time since switch-on (e) and the number of tracked satellites (f). The microcontroller timestamps the number of hits and dose rate measurements, and transfers them to a microSD card with GPS coordinates. From the microSD card, a log file containing the measurements can be retrieved by a computer. A record represents a measurement control point. The elements of the device are enclosed in a waterproof polycarbonate case, which strongly resembles Japanese lunch boxes. Thus, the 'b' in bGeige Nano stands for the Japanese word 'bento', which is the name of the Japanese lunchbox (Brown et al., 2016). The function of the

case is not only to form a waterproof layer around the sensitive segments but also to filter out alpha and beta particles. The thick polycarbonate layer allows only gamma particles to enter the GM tube (Walsh, 2019).

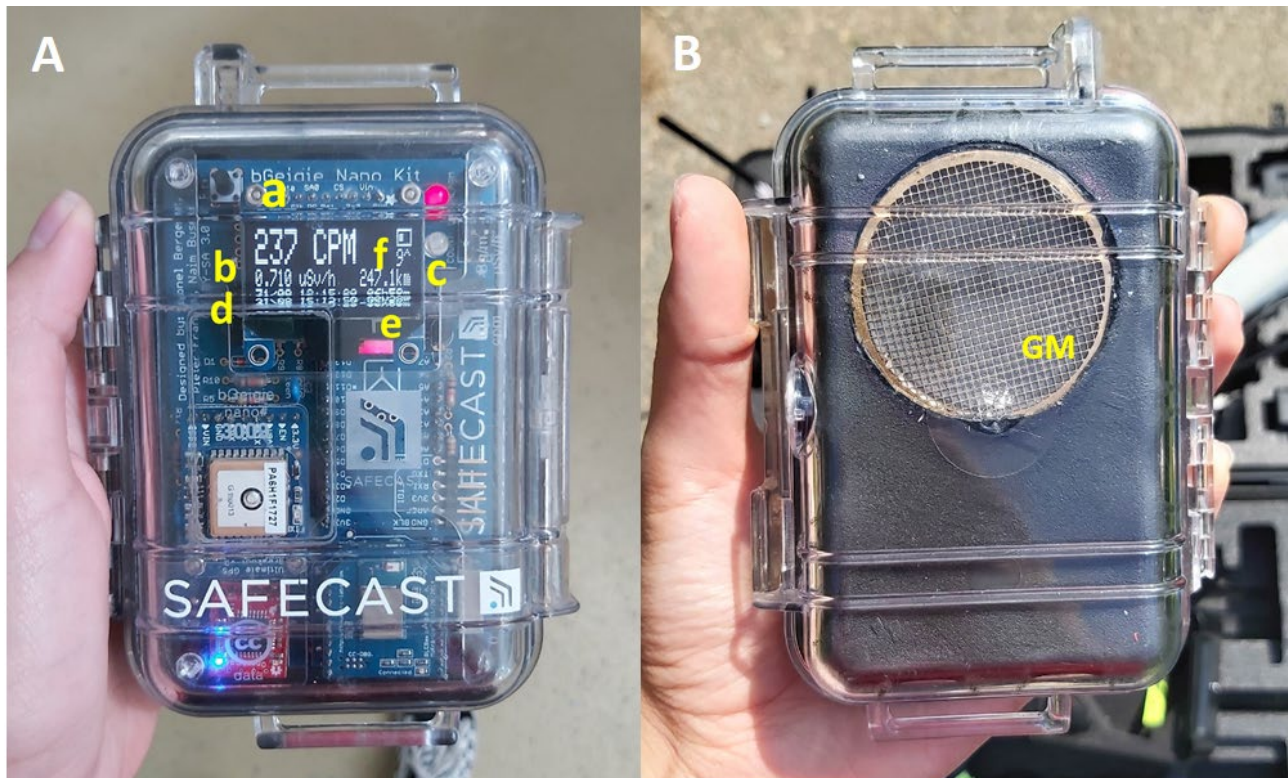


Figure 3. Safecast bGeige Nano Kit upside (A) and downside (B)

KEY COMPONENTS OF THE SAFECAST BGEIGE NANO KIT

1. „Pancake“ Geiger-Müller tube (LND-7317, 500V)
2. high voltage board (Medcom IMI iRover)
3. printed circuit board (bGeige Nano 1.1r5a)
4. Arduino Fio microcontroller
5. 8 GB microSD card with an open-source data logger (SparkFun Openlog)
6. GPS (Adafruit Ultimate)
7. graphic OLED display (Monochrome 128x64 SPI)
8. 2000mAh 3.7V 7.4W (Li-Po) lithium-polymer battery
9. polycarbonate protective case (Pelican 1010 micro-case)

It weighs about 560 g, thus not exceeding the maximum payload weight of the UAS device we have used. The purchase price of the Safecast sensor used in this research was USD 600 at the time of its purchase in 2019, plus customs duty and shipping costs, for a total of USD 750. The price varies because the device can be ordered in several forms, pre-assembled or assembled by us. Also, the price changes whether it is ordered with or without a Bluetooth unit. It also depends on the delivery place, the exchange rate and the cost of customs duty (Garamhegyi, 2019).

METHOD AND FLYING PARAMETERS

We had two radiation measuring instruments at our disposal: a scintillation detector and the Safecast sensor. The scintillation detector was used to locate the most active points in the area. The Safecast instrument was attached to the drone with the GM tube pointing downwards towards the ground. The assembled instrument is shown in Figure 2.

Flight area 1.: Junction

The aim was to create an elevation profile at the junction. Based on the ground measurement, we selected the point with the highest activity and placed the drone with the radiation sensor on it. First we moved the drone upwards at a speed of 1.1 km/s 0.5 cm/sec without moving it in x and y directions up to about 3.5 metres as it is demonstrated on figure 6., and then we moved further upwards and stopped after each eight – ten metres for around 15 seconds to allow Safecast to collect more radiation data at those heights. We continued this up to 55 meters above the surface. The drone's take-off coordinates are 46.072089° N, 18.11683° E as shown on Figure 4.



Figure 4. The drone's take-off point with coordinates (46.072089° N, 18.11683° E)

Flight area 2.: Service road

The service road is connected to one of the mines to the main road, along which the vehicles carrying uranium ore passed. Contamination from these vehicles was released into the soil and is still detectable today, mainly on the western side of the road. Furthermore, the road was built on waste rock, which also contributes to the increased radiation level. The survey of the road section started at the southern end of the road at a height of 10 metres. As the road is rising, the section was surveyed manually. This method was subject to many more errors, but it allowed us to trace the gradient of the road. The drone covered the 294-metre stretch of road in 6 minutes at a speed of 2.94 km/h. The drone track is shown on Figure 5.



Figure 5. The drone track with the attached Safecast sensor 10 m above the surface

RESULTS

Junction

At the junction, the data measured by Safecast were time-stamped to the drone. The Safecast sensor only calculates altitude above sea level, so relative altitude was calculated from this altitude. The elevation profile is shown on Figure 6.

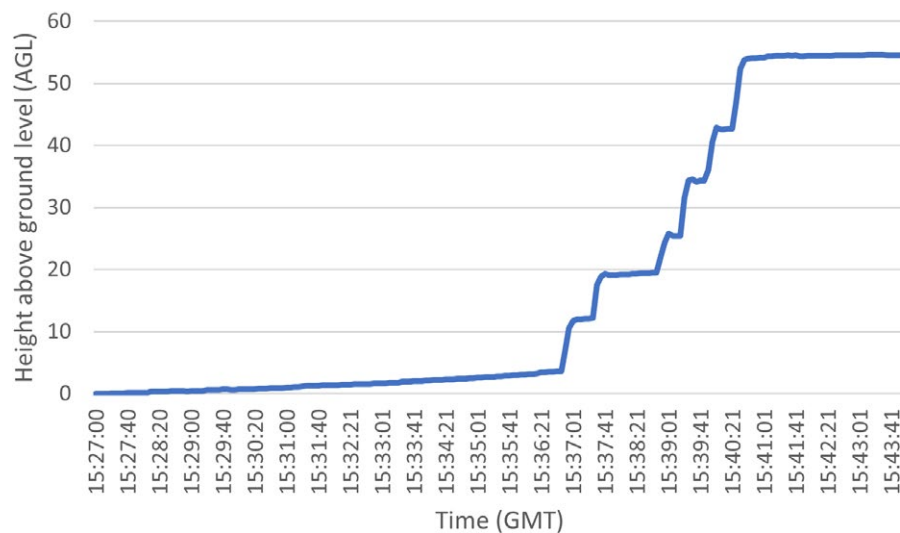


Figure 6: Elevation profile at the junction

In addition, the instrument stores radiation data in two ways. First is CPM counts summed up to the elapsed minute format and the other is a more local value corresponds to the integral of the counts over a short time of 5 seconds. The $\mu\text{Sv/h}$ (uSv/h) values then were calculated for both using factory calibration values. These two calculation methods have been compared on the altitude profile curve (Figure 7). Figure 7 and 8 show the variation of dose rate with altitude. The gamma dose intensity values show an exponential decrease at this altitude interval.

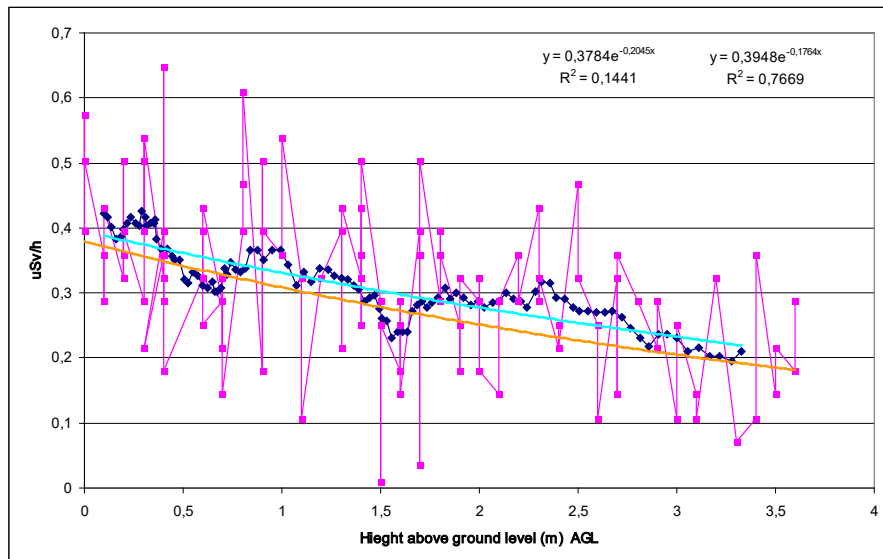


Figure 7: Comparison of 1 minute and 5-second integrated values as a function of altitude

In this steady elevation method of measuring the height profile the 5 second integrated values correspond to smaller height intervals as the drone elevated a shorter time. But on the other hand the low count situation results in much higher statistical uncertainty of the dose intensity values compared to the 1 minute integrated case. But this latter values has larger altitude intervals, therefore the other parameter has larger uncertainty. As a trend we fitted exponential functions to the altitude dependence of the dose intensity and both dataset results in about the same characteristic exponential behavior.

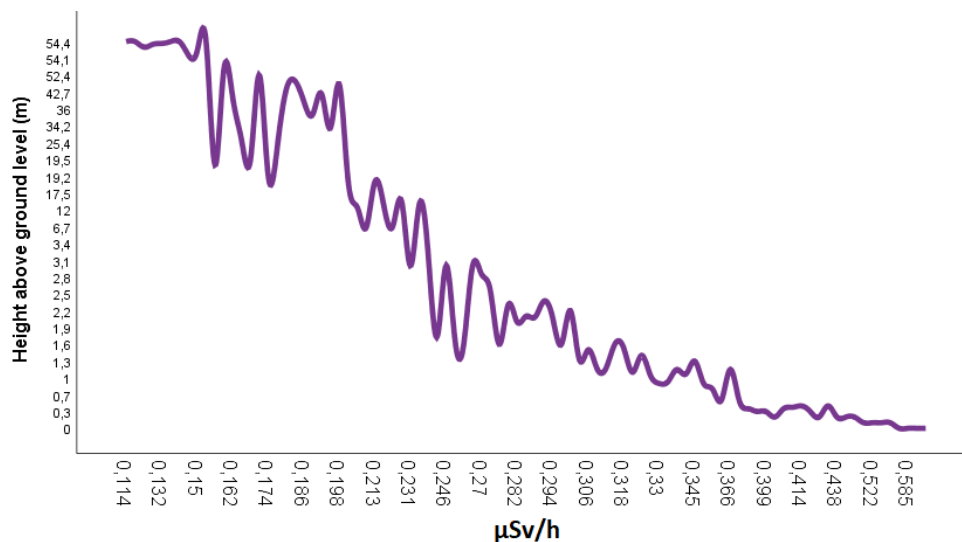


Figure 8. Variation of dose rate with changing altitude at the junction

On figure 8 we demonstrate a smoothened version of the altitude profile, Here the y axis serves as the altitude, and the data are transformed by a spline smoothing algorithm. In this way we can extend the exponential decrease trend to higher altitudes.

Service road

Data from the 10 m above ground measurement on the service road have been uploaded to safecast.org as non-public data. This safecast API page provides the possibility to display the radiation data on a map and assigns a colour scale to the radiation values. Based on this colour scale, the surveyed road section (the part framed in red) looks as shown in

Figure 9. The drone moved steadily northwards along the ascent. As the road rises, we attempted to follow the line of the road with the drone at a height of 10 metres. This trace is shown in Figure 10. From these data, a time-based diagram has been drawn, as shown in Figure 11.

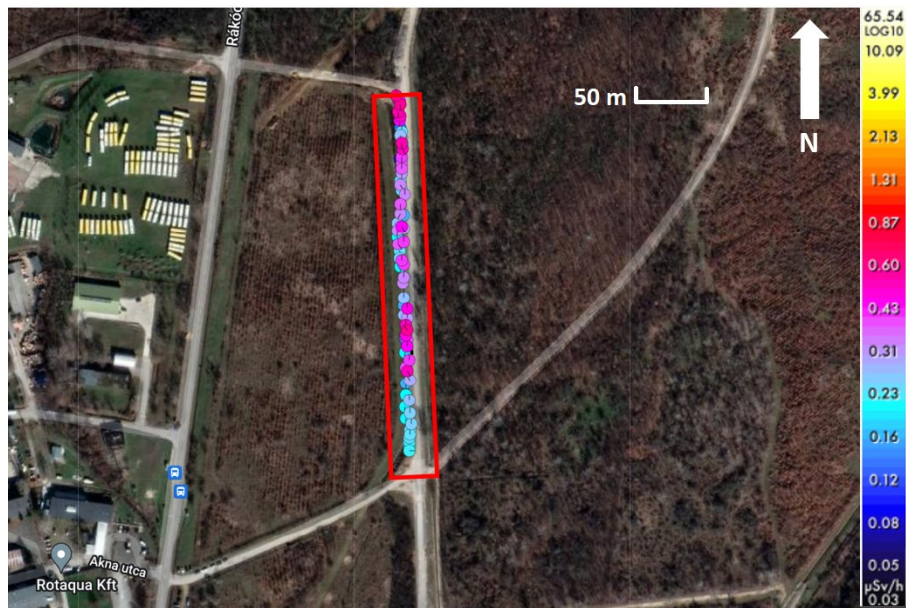


Figure 9. Surveyed service road (red framed) on the Safecast API website with map scale

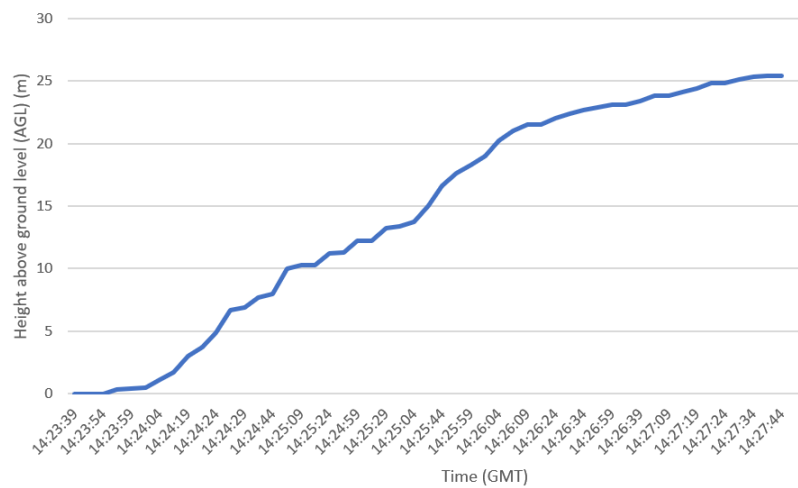


Figure 10. Trace of the drone with the radiation sensor in 10 m above ground level (AGL) in northern direction

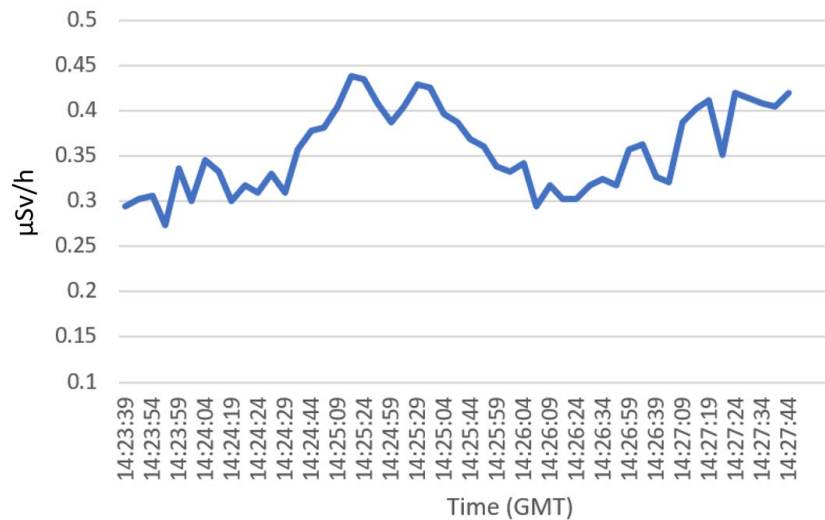


Figure 11. The detected dose rate at 10 m above ground level along the ascent in northern direction

DISCUSSION

In the case of the elevation profile at the junction, it can be seen that the measured value at 0 m above the surface was 0.585 $\mu\text{Sv/h}$. At the same geographic coordinate, at 5 meters above ground level (AGL), it was only 0.238 $\mu\text{Sv/h}$. This value decreases continuously until the last measurement point, at 55 metres, where it is only 0.114 $\mu\text{Sv/h}$. In the case of the service road, the diagram and the colour scale values show that there are two higher intensity sections on the surveyed route. This may indicate a larger anomaly. One of our further tasks will be to ground-track this section and compare these values.

CONCLUSION

Based on the presented diagrams we can conclude:

1. Even a low-cost sensor is capable to describe the terrestrial extent of environmental gamma dose anomalies.
2. Our SUAS technology was a good tool to determine the altitude dependence of the environmental gamma dose rate up to about 50 meters and showed that the rate dropped by a factor of 5 at that altitude, compared to the surface rate.

ACKNOWLEDGEMENT

The authors would like to thank for Gábor Garamhegyi and the Gábor Dénes Secondary School in Isaszeg, Hungary for lending the Safecast bGeigi Nano device to the authors for this project.

B.K., F.V., M.P., H.K. is supported by Project no. TKP2021-NVA-29 has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund, financed under the TKP2021-NVA funding scheme.

REFERENCES

- Ahmed, S. N. (2007). *Physics and Engineering of Radiation Detection*. Academic Press.
- Brown, A., Franken, P., Bonner, S., Dolezal, N., & Moross, J. (2016). Safecast: Successful citizen-science for radiation measurement and communication after Fukushima. *Journal of Radiological Protection*, 36(2), S82–S101. <https://doi.org/10.1088/0952-4746/36/2/S82>
- Connor, D. T., Wood, K., Martin, P. G., Goren, S., Megson-Smith, D., Verbelen, Y., Chyzhevskiy, I., Kirieiev, S., Smith, N. T., Richardson, T., & Scott, T. B. (2020). Radiological Mapping of Post-Disaster Nuclear Environments Using Fixed-Wing Unmanned Aerial Systems: A Study From Chornobyl. *Frontiers in Robotics and AI*, 6. <https://doi.org/10.3389/frobt.2019.00149>

- Eisenbud, M., & Paschoa, A. S. (1989). ENVIRONMENTAL RADIOACTIVITY *. In *470 Nuclear Instruments and Methods in Physics Research* (Vol. 280).
- Evans, R. D., & Goodman, C. (1941). Radioactivity of Rocks. *BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA*, 52, 459–490.
- Garamhegyi, G. (2019). *SAFECast-PROJEKT MEGVALÓSÍTÁSA AZ ISASZEGI GÁBOR DÉNES GIMNÁZIUM ÉS SZAKGIMNÁZIUMBAN*. <https://safecast.org/tilemap>
- Gong, P., Tang, X. Bin, Huang, X., Wang, P., Wen, L. S., Zhu, X. X., & Zhou, C. (2019). Locating lost radioactive sources using a UAV radiation monitoring system. *Applied Radiation and Isotopes*, 150, 1–13. <https://doi.org/10.1016/j.apradiso.2019.04.037>
- Gyalog, L., Sikhegyi, F. (2005). *Magyarország földtani térképe*. Magyar Állami Földtani Intézet, Budapest
- Heier, K. S., & S Adams, J. A. (1965). *Concentration of radioactive elements in deep crustal material* (Vol. 29). Pergamon Press Ltd.
- MacFarlane, J. W., Payton, O. D., Keatley, A. C., Scott, G. P. T., Pullin, H., Crane, R. A., Smilion, M., Popescu, I., Curlea, V., & Scott, T. B. (2014). Lightweight aerial vehicles for monitoring, assessment and mapping of radiation anomalies. *Journal of Environmental Radioactivity*, 136, 127–130. <https://doi.org/10.1016/j.jenvrad.2014.05.008>
- Molnar, A., Domozi, Z., & Lovas, I. (2021). Drone-based gamma radiation dose distribution survey with a discrete measurement point procedure. *Sensors*, 21(14). <https://doi.org/10.3390/s21144930>
- Oshima, K., Tanaka, K., Hachisuka, R., Yokoyama, Y., Saito, M., Sugimoto, J., Nakajima, I., Matsuoka, T., & Anjo, T. (2012). *The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission*.
- Panikkath, P., Udupi, A., Sarkar, P. K., & Sankaranarayanan, K. (2020). Estimation of neutron energy distributions from measured prompt gamma intensities: Experimental validation. *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, 969. <https://doi.org/10.1016/j.nima.2020.164101>
- Pöllänen, R., Toivonen, H., Peräjärvi, K., Karhunen, T., Ilander, T., Lehtinen, J., Rintala, K., Katajainen, T., Niemelä, J., & Juusela, M. (2009). Radiation surveillance using an unmanned aerial vehicle. *Applied Radiation and Isotopes*, 67(2), 340–344. <https://doi.org/10.1016/j.apradiso.2008.10.008>
- Povinec, P., Hirose, K., & Aoyama, M. (2013). *Fukushima Accident: Radioactivity Impact on the Environment*.
- Reavis, B., & Hem, B. (2011). Honeywell T-Hawk Aids Fukushima Daiichi Disaster Recovery: Unmanned Micro Air Vehicle Provides Video Feed to Remote Monitors. *Honeywell Aerospace Media Center*.
- Sato, Y., Ozawa, S., Terasaka, Y., Minemoto, K., Tamura, S., Shingu, K., Nemoto, M., & Torii, T. (2020). Remote detection of radioactive hotspot using a Compton camera mounted on a moving multi-copter drone above a contaminated area in Fukushima. *Journal of Nuclear Science and Technology*, 57(6), 734–744. <https://doi.org/10.1080/00223131.2020.1720845>
- Terada, H., Katata, G., Chino, M., & Nagai, H. (2012). Atmospheric discharge and dispersion of radionuclides during the Fukushima Dai-ichi Nuclear Power Plant accident. Part II: Verification of the source term and analysis of regional-scale atmospheric dispersion. *Journal of Environmental Radioactivity*, 112, 141–154. <https://doi.org/10.1016/j.jenvrad.2012.05.023>
- Torii, T., Sugita, T., Okada, C. E., Reed, M. S., & Blumenthal, D. J. (2013). Enhanced analysis methods to derive the spatial distribution of ¹³¹I deposition on the ground by airborne surveys at an early stage after the Fukushima Daiichi nuclear power plant accident. *Health Physics*, 105(2), 192–200. <https://doi.org/10.1097/HP.0b013e318294444e>
- Walsh, J. (2019). Assessment of Safecast bGeige Nano Monitor. In *Radiation Environment and Medicine* (Vol. 8, Issue 1). <http://safecast.org/tilemap/?y=38.7&x=135.1&z=5&l=0&m=0>

BIOGRAPHY

Hédi Katreiner is a senior BSc student at ELTE Eötvös Loránd University, Department of Earth Sciences, at Cartography and Geoinformatics specialization. Besides her studies she is doing research on radiation detection and mapping.

Ákos Horváth is an associate professor at Department of Physics at ELTE. He received his PhD in 1996 in nuclear physics. His research topics cover the measurements of the exotic nuclei, development of neutron detector systems. On the other hand he is involved in the investigation of natural radioactivity from several aspects, like radon concentration of subsurface water, uranium content of rocks, accumulation of radium.

Fanni Vörös is from ELTE Eötvös Loránd University, Department of Cartography and Geoinformatics. She received her MSc degree in Cartography in 2019, now she is doing PhD in GIS and volcano morphometry. She takes part in a project about UAV technologies. Paralell to her studies she acts as a teaching assistant in GPS and cartography.

Márton Pál is a cartographer and PhD student in Earth Sciences. He currently works at the ELTE Eötvös Loránd University as a system administrator and gives lectures on numeric methods in geoscientific mapping and fieldwork. His research topics are the GIS connections of geodiversity and geoheritage, webcartography and UAV-based remote sensing.

Szabolcs Tóth graduated in 2019 from the Faculty of Chemical Engineering of the University of Pannonia. During his master studies he got acquainted with the recultivation activities and water treatment technologies in the uranium industry. He is currently acting as technology leader at Mecsek Environmental Protection Base. His current research interests are focused on the ion exchange purification potentials of high conductivity, high uranium mine waters.

András Várhegyi C.Sc. Head of environmental Department of Mining Property Utilization Ltd., the legal successor of former uranium mines in Hungary. Main activities: mining remediation, radioprotection, operation of environmental, radiometrical monitoring system at former uranium mines area. Professor at Pécs University, specialization: radiometry, radioprotection, radiological monitoring, mine remediation.

Béla Kovács, assistant professor at Eötvös University, Faculty of Informatics, Institute of Cartography and Geoinformatics. He received his Phd degree in 2010, in topic: GNSS and connection of former triangulation on Balkan peninsula. Present research and teaching activities: autonomous navigation/driving systems, GNSS, connections between old maps and modern technologies, mobile mapping, multimedia and map visualization, field measurements and data collection, UAV/UAS technologies.