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Cross-Calibration of Airborne and Ground Based Gamma Radiation Survey Techniques Under On-Site Inspection Conditions

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CTBTO PREPARATORY COMMISSION

Abstract

This poster presents two field campaigns and results obtained employing a range of on-site inspection (OSI) equipment techniques to cross-calibrate response functions and key performances of gamma radiation sensors. Airborne and ground-truth radiation survey techniques are deployed over large areas, whereas in-situ high resolution gamma spectroscopy measurements are conducted at specific locations, supported by environmental soil sampling analysis at the OSI radionuclide laboratory. The Allentsteig area includes a flight calibration line characterised for its sedimentary composition [1].

Results and lessons collected improve future field exercises aimed at periodic monitoring of performances and cross-calibrating field instruments prepared for an OSI.

The Allentsteig area also provides opportunities for practicing and training personnel under realistic field scenarios.

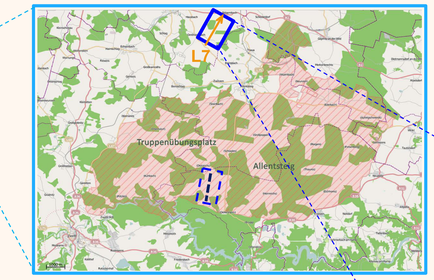
Objectives

- ❑ **Build up operational OSI capabilities**
  - ➢ Cross-calibrate ground and airborne spectrometry systems
  - ➢ Validate new developments and demonstrate progress with calibrations, data flow management, and post-processing
  - ➢ Provide regular performance monitoring of equipment
  - ➢ Improve procedures through lessons acquired
- ❑ **Provide a platform to deploy and exercise a range of OSI activities in an integrated manner**
  - ➢ Validate the design for integrated mini field exercises or training events to familiarize surrogate inspectors and representatives from state parties
  - ➢ Provide inputs for Training material for the OSI specific 3rd Training Cycle

Activities involved

A range of activities is necessary to conduct such field deployment and data analysis. This serves as a validation of procedures, and provides a good indication of our level of preparedness:

- ✓ Administrative work to organise for external participants travels and various authorisations to conduct the expected activities
- ✓ Schedule activities on sites with their points of contact Allentsteig Austrian Military; Austrian Air Force (Bundesheer), Langenlebarn airfield (LOXT); Austrian Geological Survey Prepare and communicate mission objectives and plans, including detailed characteristics of overflights and surveys
- ✓ Identify calibration requirements and any existing gaps to fill
  - ❑ sensitivities to NORM (KUT)
  - ❑ interference factors (e.g. Th-232 into K-40 and Bi-214 areas)
  - ❑ compared MDAs to Lab analysis of soil samples for in-situ high resolution
- ✓ prepare selected equipment and documentation for field tests
  - ❑ Advance preparations at the CTBTO storage area
  - ❑ Operational checks (field power supply, energy calibrations, consumables and tools)
  - ❑ Documentation: Manuals, Work instructions and check-lists
- ✓ Collect and archive all field raw data; analyses and reports
- ✓ Collect lessons learned and inform relevant Action Plan projects



Solid rectangle: Ground and Airborne Survey locations 09/2016.
Dashed line: Calibration flight area, not permitted on 7th Sept. 2016

Eisenerz Styria, Geological Survey of Austria
Ground Calibrations on "Gratsy pads" [2]

Five sensors are calibrated on 4x 750kg cement pads of known K,U,Th concentrations. The IAEA procedure described in [3] is used, and extended for Cs-137.

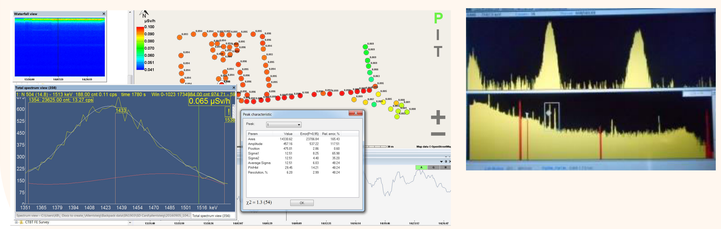
RSX-5 sn 5046	ROI Cs-137 (cps)	ROI K-40 (cps)	ROI U-238 (cps)	ROI Th-232 (cps)
Background pad (20 min)	162.93 ± 0.37	215.39 ± 0.42	26.78 ± 0.15	25.48 ± 0.15
Net Potassium 5.19%	240.05 ± 0.95	671.3 ± 1.3	-1.95 ± 0.29	-7.52 ± 0.27
Net Uranium 41.66 ppm eU	1170.6 ± 1.3	349.7 ± 1.1	463.65 ± 0.74	28.64 ± 0.34
Net Thorium 101.65 ppm eTh	1078.7 ± 1.3	305.7 ± 1.1	214.78 ± 0.58	650.87 ± 0.86

Table 1: Analyzed responses of one of three RSX-5 crystals for four regions of interest, including OSI relevant nuclide Cs-137.

Two crystals installed in a Black Hawk 32L (+ 8L up) configuration

Window	Radionuclide	Gamma Emission (keV)	Energy Window (keV)
Potassium	^{40}K	1461	1370 - 1550
Uranium	^{214}Bi	1760	1660 - 1860
Thorium	^{208}Tl	2615	2410 - 2810
Total count	-	-	400 - 2810
Cosmic	-	-	> 3000

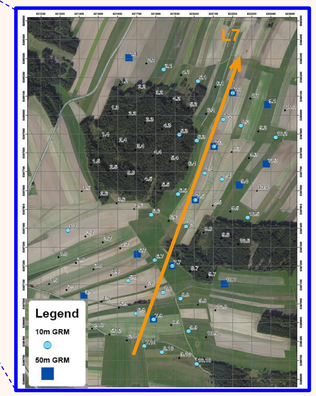
Table 2: Energy windows used to determine sensitivities of all systems.



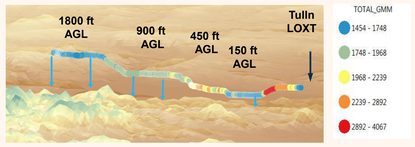
Analysis of portable scanners data (bottom left), and high resolution in situ spectra (right) supported by Laboratory analysis [4,5] are compared to airborne response over the same areas. Full set of results is still being compiled.

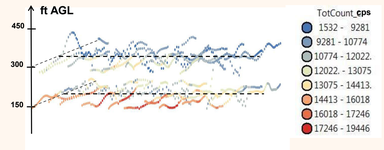
Ground Truth Measurements 2016-09-05, 1 x 2 km Area
- Portable Spectrometric Scanners: ATOMTEX AT6101C +CM [5]
- High-Resolution In-situ spectroscopy: CANBERRA FALCON
- Soil and Vegetation sampling analyzed at the OSI Laboratory

Airborne Survey 2016-09-07, Danube + Allentsteig 2 km²
- Radiations Solutions Inc. Spectrometers [6] 2x NaI 16L+4L(up)
- Survey over Danube at 4 altitudes: Radon and cosmic calibration
- Survey over cross-calibration area. Flight lines L1 to L10, spaced 100m. 8 altitudes from 150 feet (ft) to 2500 ft above ground (AGL)

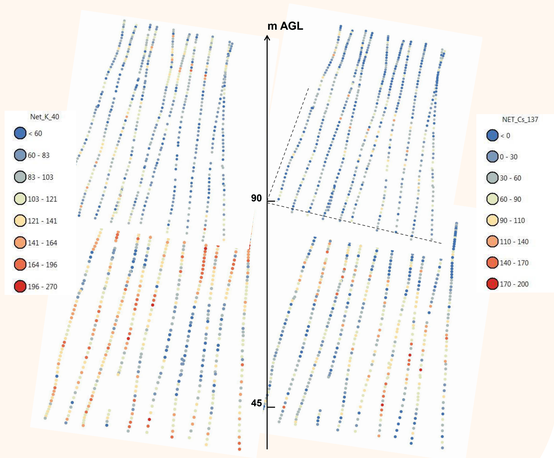


Above diagram: 2016/09/07, Mission targets for The Blue Team:
- Light blue circles: survey ca 3 minutes within 10m radius
- Dark blue squares: survey ca 10 minutes in 50m x 50m.





Total cps at flight survey altitudes. a) Upper graph: above Danube, background calibration of aircraft, radon and cosmic contributions [3]. b) Lower graph: flight lines L1 to L10 over Allentsteig, 2 altitudes



Net counts (cps) in K-40 window (left) and Cs-137 window (right) in 1s spectra at altitude (not corrected) for 45m AGL (bottom) and 90m AGL (top).
Fields of view: ca 6400m² at 45m, and 25400m² at 90m.

OSI Action Plan Projects

These calibration activities provide inputs to, and contribute to validate action items from several of the OSI Action Plan projects (2016-2019) [8]:

- ➢ AP1.11 Radionuclide data interpretation
- ➢ AP2.6 New generation IIMS-FIMS
- ➢ AP3.1 Integrated airborne systems
- ➢ AP3.8 Ground-based gamma radiation monitoring
- ➢ AP3.9 Environmental sampling
- ➢ AP3.10 Radionuclide Particulates Field Laboratory
- ➢ AP4.1 Development of inspectorate

Results (extracts)

Pad	Potassium	Uranium	Thorium
Net concentration	5.19 ± 0.05 (%)	41.66 ± 0.29 (ppm)	101.65 ± 1.46 (ppm)
RSX-5 sn5046	129.3 ± 1.3	11.129 ± 0.079	6.403 ± 0.092
Sensitivities	(counts/s/%K)	(counts/s/ppm eU)	(counts/s/ppm eTh)

Position	Method	Nuclide	Energy (keV)	Surface activity (Bq/m²)	Error k=1 (Bq/m²)	Specific activity (Bq/kg)	Error k=1 (%)
L7 -7	in situ	Cs-137	662	9120	1420	114	16
	Lab.	Cs-137		-	-	128	2
						166	2
	in situ	Mo-99	141	< 1960	(MDA)	< 25	
	Lab.	Mo-99	141	-	-	< 0.65	
	Lab.	K-40	1461	-	-	394	3
	Lab.	U (Bi-214)	1764	-	-	46.6	6
	Lab.	Th (Tl-208)	583	-	-	35.5	4
L7 -2	in situ	Cs-137	662	4500	740	56.2	16
L7 -1	Lab.	Cs-137	662	-	-	71.1	2
L7 -2	in situ	Mo-99	141		(MDA)	< 24	
L7 -1	Lab.	Mo-99	141	-	-	< 0.39	
L9 -9	in situ	Cs-137	662	9900	1530	124	15
	Lab.	Cs-137	662	-	-	175.0	2
	Lab.	K-40	1461	-	-	574	3
	Lab.	U (Bi-214)	1764	-	-	40.7	8
	Lab.	Th (Tl-208)	583	-	-	37.3	5
	in situ	Mo-99	141	< 2020	(MDA)	< 25	
L7 -9	in situ	Cs-137	662	3330	670	41.6	20
	Lab.	Cs-137	662	-	-	48.0	2
	in situ	Mo-99	141	< 3580	(MDA)	< 45	
L5 -7	in situ	Cs-137	662	3760	640	47.0	17
	Lab.	Cs-137	662	-	-	66.2	3
	in situ	Mo-99	141	< 2250	(MDA)	< 28	

Lessons learned

- ➢ Access to the Allentsteig area for flight calibration purposes also provides opportunities for integrated mini-exercises and external participations.
- ➢ OIS preparedness would benefit from exercises including data analysis as a core component. Time and resource availability necessary to analyse field mission data is generally underestimated when planning for exercises.
- ➢ Preparations of equipment and personnel are key factors to allow seamless deployment on the day of field activities. Examples include:
  - ❑ Batteries including spares charged and checked operational; multiple outlets for car cigarette-lighter plugs available;
  - ❑ Equipment tested in operational conditions, with all steps for data acquisition and storage, documentation available including for troubleshooting;
  - ❑ Same reference time (UTC) checked on all computers; develop and implement a procedure for archiving and distributing users' credentials;
  - ❑ Be ready for all-weather conditions.

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