A comparison of the Austrian and Swiss airborne gamma spectroscopy systems in alpine terrain

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Abstract

In summer 1997 a common survey of the Austrian and Swiss airborne gamma ray systems was carried out in the Austrian Alps. The chosen 7 x 7 km test area is located near the Austrian - Swiss border, showing rough topography with elevations above sea levels changing for almost 1500m within a few kilometers of flight path, meaning an extreme challenge to the helicopter teams. Due to former measurements of stream sediments some spots of higher uranium concentration were expected in the area. To proof the results of the airborne measurements additional in-situ measurements at some dedicated points were carried out by a Swiss team at the same time.
While both airborne teams use NaJ - detectors, the systems differ in detector volume, spectrometer type, system mounting and calibration procedure. Despite these differences the final results show good accordance. Comparison with the ground measurements proof the correctness of calibration and processing procedures, showing the usefulness of airborne gamma ray systems even in areas of extreme topography.

1. Survey area

The chosen area is located in the Austrian Alps near the border to Switzerland and shows rather rough topography with elevations above sea varying for almost 1500 m within some kilometers of flight path. 14 parallel profiles of 7 km length were flown from WSW to ENE crossing the „Radurschtal“ - a small, deep valley, enclosed by high mountains. Line spacing was 500 m with an average flight altitude of 100 m. Due to the extreme topography both teams could not risk to keep the flight height at a constant low level in the centre of the valley.
From former geochemical sampling of stream sediments in the area some spots of higher uranium concentration with levels up to more than 70 ppm had been expected in the area. Except one anomaly in the eastern part of the area these uranium anomalies could not be found in the airborne measurements. Experience from other areas has shown that many elements tend to enrich in stream sediments, thus giving much higher concentrations than measurements in soil.

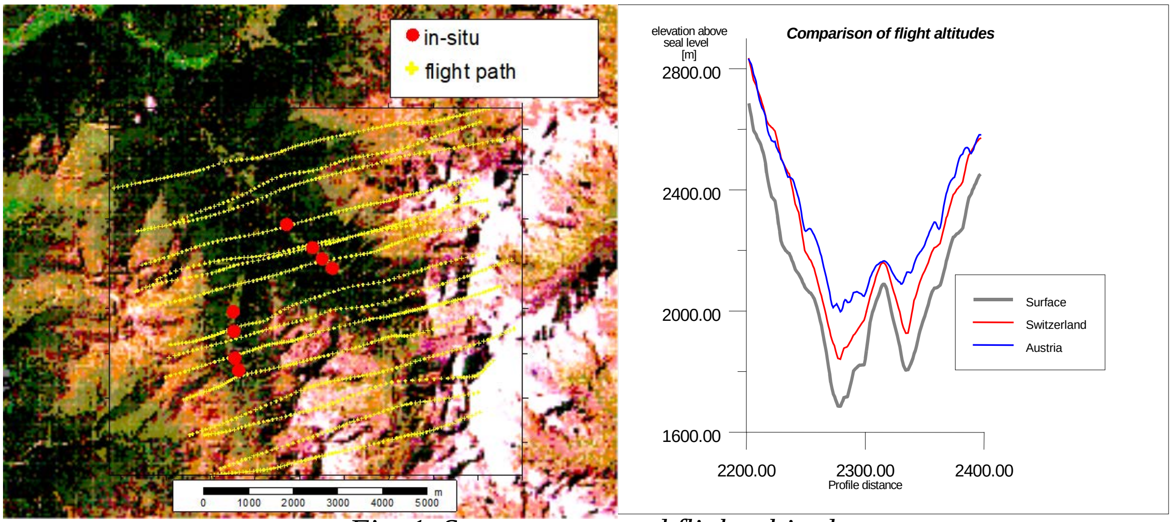

Fig. 1 Survey area and flight altitudes

2. Comparison of systems

The common survey offered a good chance for a direct comparison of systems and for exchange of experience with the equipment.
Table 1 summarises the main differences in equipment of both airborne systems.

Table 1.

Switzerland	***Austria***
detector: 16 l NaJ	33.6 l down + 4.2 l up NaJ
detector location: slot beneath floor of the passenger cabin	separated into 2 packages in the passenger cabin
Spectrometer: Exploranium GR820: gain control and spectrum calibration with K-40	Picodas PGAM 1000: Seperate ADC on each crystal, using transputers that individually manage each crystal. Gain control and spectrum calibration with Th-peaks
calibration facilities: point sources, in-situ measurements	calibration pads, test site

The meeting during the common survey was used by the system operators for a discussion on the experiences with the handling of the system. Some of the main aspects are mentioned in the following sections.

2.1 System Initialisation

The Exploranium GR820 offers an easy calibration and initialisation procedure for energy calibration and spectrum stabilisation, using K-40. Some problems arise with spectrum stabilisation during surveys with very low K-40 count rates, when the K-40 peak is to low to be accurately detected. After the initialisation procedure the system needs a permanent power supply - else calibration information is lost. The problem was solved by the installation of a separate battery that can maintain continuous power supply to the spectrometer independent from the helicopters supply.

The Picodas PGAM-1000 uses a rather complex calibration procedure with a thorium source, carrying out a 2nd order energy calibration with the 4 strongest peaks of Th in the spectrum.
The procedure needs some spectrometric knowledge and leads to problems in areas with higher Cs-137 levels, which might partially overlap the 582 keV peak of Tl-208. Some inconveniences arise from the fact that coarse gain adjustment has to be done with opened detector packages. Calibration parameters are stored in each crystals transputer EPROM. Usually the system is able to automatically reset the system to proper operation even after some hours of power off.
All in all the GR-820 offers the simpler and slightly faster initialisation procedure compared to the more complicated solution offered by the PGAM-1000.

2.2 Counting statistics and detector sensitivity

The Austrian gamma ray system is part of a complex geophysical equipment dedicated to geological studies, including electromagnetic and magnetic sensors, infrared detectors and an antenna for the measurement of soil humidity. The complexity of the system causes some problems with “place management" in the rather small helicopter Bell 212. The chosen position of the NaJ detector packages in the passenger cabin is a compromise to this fact.
The humidity antenna with its large cooling body is mounted outside the helicopter beneath the pilots seat and should not influence the gamma ray system under normal flight conditions. The comparison of Austrian count rates to the results from the Swiss team showed some differences in dynamics. The only reasonable explanation was an absorption of gamma rays by the humidity antenna, depending on different horizontal angle of the helicopter. The rough topography forced strong acceleration and slowing down of the helicopters thus causing some kind of swinging. Because the helicopter has to “bend forward” during acceleration, the humidity antenna can come to a position under one of the detector packages where shielding effects start to be of importance. Additional collimation effects arise from the fuel tanks in the rear of the helicopter which shield radiation with flat angles of incidence.
A direct comparison of spectra of the two teams at same flight positions with almost similar flight altitudes showed additional differences with evidently higher Compton background of Austrian spectra and count rates smaller than expected from the two times larger detector volume. The effect was already expected from the stripping factors obtained from calibration pads and from sensitivity values derived from the calibration area. Obviously the location of detectors in the passenger cabin is not as optimal as the Swiss installation in a slot beneath the helicopter floor.

2.3 Processing

There are no main differences in processing (Schwarz, 1991), except calculation of the Compton background in the Cs-137 window, where the Swiss team uses the standard stripping process, whereas the Austrian team calculates the background directly through evaluation of the local minima of the spectrum (Oberlercher 1997). Some problems arose with topographic corrections in the areas where a constant flight altitude could not be maintained without security risks. The Swiss “Super Puma” helicopter with its stronger turbines achieved better results in keeping a constant altitude above ground - the Swiss profile sections with altitudes larger than 1000 ft over the deep valleys are usually short compared to that of Austrian profiles (see Fig. 1) .
The standard 2-D topographic correction (Schwarz et al, 1992) uses all detected values along a 700m long part of the profile to correct the value in the centre of this part of profile, using attenuation information for each value. The accuracy of the attenuation calculation decreases with high flight altitudes. This effect can add up to rather large errors at topographic corrections when a lot of the measurements have been recorded at high altitudes, leading to an overestimation of correcting factors.
Therefore the Austrian team tried successfully a rather simple topographic correction. The radiation detected at some point is associated to the nearest point at the surface of the topography instead of using the vertical position under the detector. Attenuation effects are then calculated with the distances to this positions and the corrected value is projected to the new position. The process can be considered a 3-D correction and reduced the problems along flight lines flown rather close and parallel to the crests or flanks of mountains.

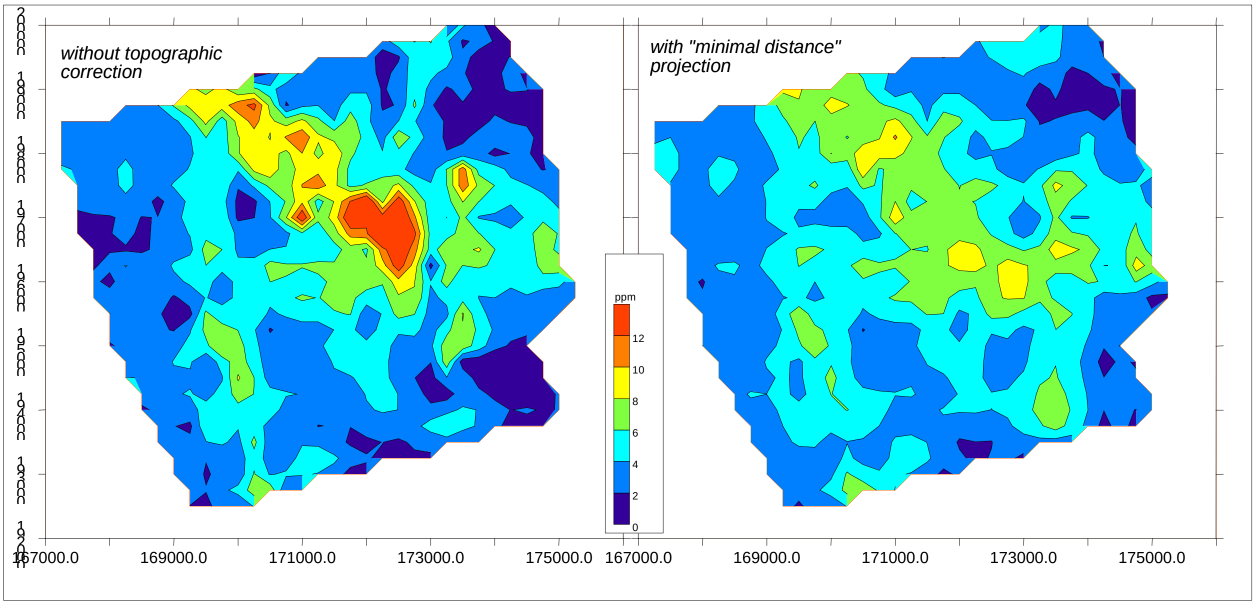

Fig. 2 uranium anomaly map with and without topographic correction. The simple “nearest distance projection” remarkable reduces overestimation of anomalies in deep gorges.

3. Results

Despite all problems and differences of the systems the comparison of anomaly maps of the processed data show very good correlation and match the results of in-situ measurements carried out additionally at some points in the valleys of the area. The agreement of results proofs the correctness of calibration and data processing of both teams, although different procedures were used for topographic correction and Compton stripping of the Cs-137 window. Fig. 3 shows the anomaly maps of all processed parameters. Data were interpolated with a minimum curvature algorithm to a 300m grid.

While most of the differences of the data are within a 20% variation some anomalies show an evidently larger variation. Most of this differences are related to parts of profiles with large flight altitudes (over 350 m) or to profiles parallel to flanks or very close to crests of mountains.

In future, additional profiles along the valleys will be included to get more information about geometric effects in rugged terrain and to reduce flight altitudes in these areas.

All in all the Austrian maps show slightly more dynamics of amplitudes than the Swiss maps.

As mentioned above shielding effects caused by the humidity antenna during strong acceleration and collimation effects due to the location of the detector in the passenger cabin could be reasonable explanations.

The higher uranium values along the northern part of the Radursch valley may be caused by overestimation of the attenuation coefficient. In this broader part of the valley the Austrian flight amplitudes are rather high .

The anomalies in the NE of the Swiss potassium map are not visible in the Austrian map – the shape of thorium anomaly might be some indication for an incomplete Compton stripping of the Swiss uranium window.

The uranium anomaly detected by the Swiss team in the east of the area was not found with the Austrian system, but the values calculated from the Austrian upward looking detector indicated a higher radon background in this area. Because the measurements of the Swiss team at this location were carried out approximately one hour after the Austrian measurements an increasing level of radon in air during the morning hours could be a reasonable explanation.

It should be mentioned that a correct radon estimation was almost impossible because many profiles were flown along the flanks of mountains, where the upward looking detector sees as much of the radiation field as the downward looking packages, because radiation is more likely to come from the side than from the terrain beneath the helicopter.

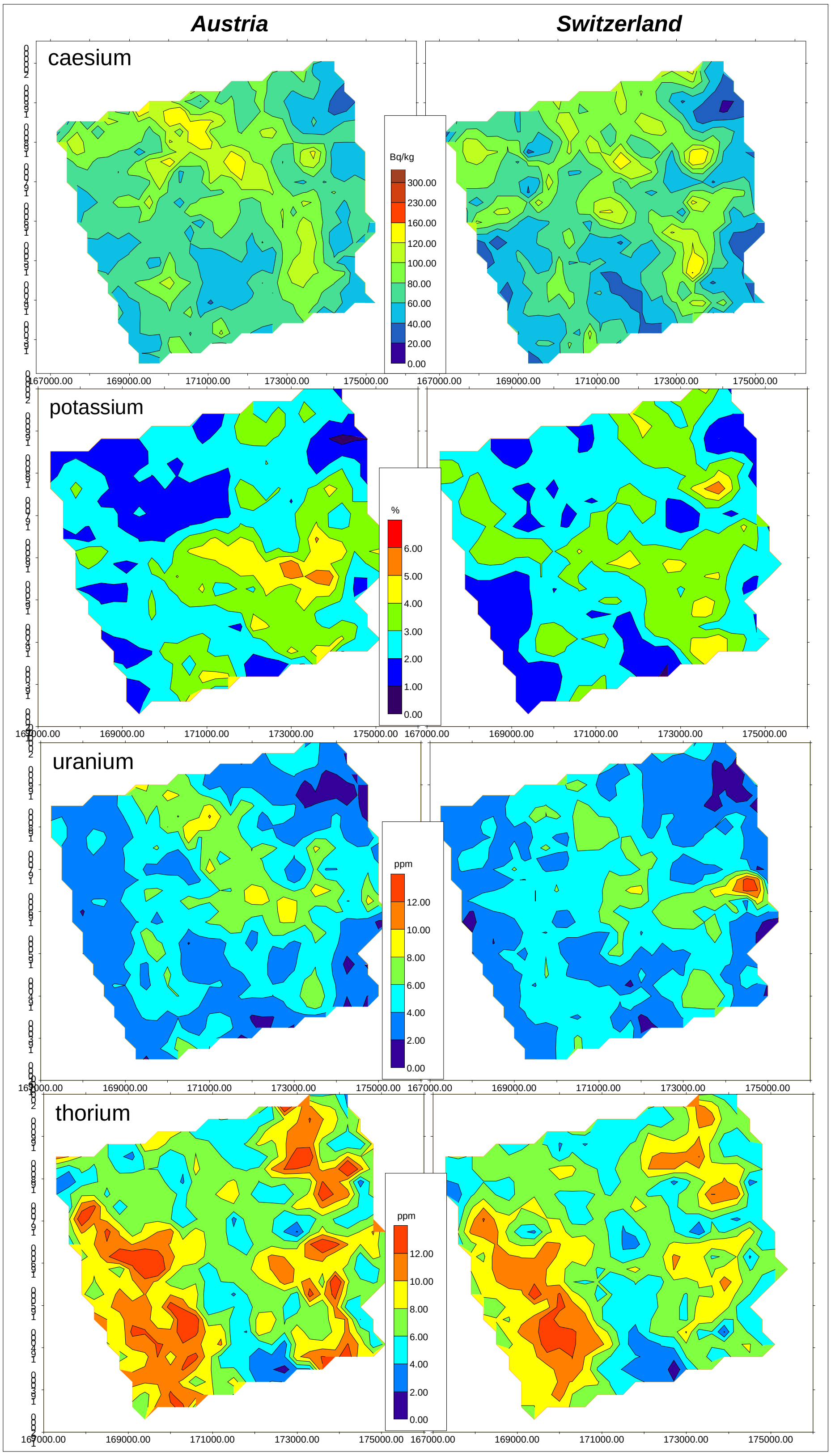

Fig.3 *Anomaly maps of processed data*

2. Conclusions

Finally the major conclusions can be summarised:

- In areas of extreme topography at least a 2D topographic correction is necessary to get comparable results.

- A simple topographic correction, based on shortest distance projection, was successfully implied – the estimation of the distance to the source of radiation is the main subject in rugged topography.

- Radon correction with an upward looking detector is impossible when large parts of the profile are flown along the flanks of mountains.

- Additional profiles along the valleys are necessary to get more information about geometric effects and to obtain reasonable flight altitudes.

- If the detector is not optimally mounted away from sources of absorption, collimation effects lead to visible variations in dynamics, depending on the deviation from a horizontal position of the helicopter during acceleration and slowing down and on the angle of incidence of radiation.

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