Environmental Mapping: Comparison of ground and airborne gamma spectrometry results under Alpine conditions

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Abstract

Even in a country where two thirds of the area is covered by mountains airborne gamma spectrometry should give reliable results. Ground gamma spectrometry can be the tool to test the reliability of data acquisition, calibration and data processing. The comparison of ground and airborne gamma spectrometry results showed a good correspondence in the flat part of Switzerland as well as in Alpine areas. Almost all the data points lie inside normal error ranges. This points to well working equipment, good calibration and powerful software.

Introduction

The montaineous Alps and the Folded Jura chains cover a big part of Switzerland. For that reason airborne gamma spectrometry (AGS) equipment and the appropriate software must work under Alpine conditions which is especially difficult due to problems like topography effects, strongly varying flight altitude etc. Such different conditions need good calibration and correction procedures which have to be reliable everywhere. The comparison of airborne gamma spectrometry and high resolution ground gamma spectrometry results can prove the reliability of equipment, calibration and data processing.

Equipment and data processing

The Swiss equipment consists of a package of 4 NaI crystals with a total volume of 16.7 l. The Exploranium spectrometer has 256 channels and automatic gain control based on the potassium-40 peak. The detector package is mounted underneath a Swiss army Super Puma helicopter. A PC based system is used to store the spectra with flight altitude, atmospheric pressure, temperature, GPS, co-ordinates and other data, taken at 1 sec intervals, on Memory-Cards of 4 Mbytes. This capacity is sufficient to store the data of more than 2 hours flight.
For the ground gamma spectrometry a 20 % high sensitivity pure Germanium semiconductor detector is used. The spectrometer has 4096 channels. It is cooled by liquid nitrogen. The detector 1 m above ground is connected to an analyser which is also connected to a PC. The PC controls the measurement and stores the spectra data. The processing of spectra data can be carried out by the PC in the field using software from Canberra or ORTEC. The sample time was one hour which allows to produce results with an error range of 10 to 20 %. Soil samples at different depths were also taken to provide a depth distribution of the radionuclides. During the ground gamma spectrometry measurement the dose rate 1 m above the ground was also determined by an ionization chamber. The evaluation method of ground gamma spectrometry measurements corresponds to the ICRU-report 53 (1994). The calibration of the equipment is regularly proved by international intercomparison measurements.
In the processing procedure the AGS data are corrected for the background of the aircraft, cosmic, Compton scattering as well as for radon, flight altitude and topography effects (Schwarz, 1991;

Schwarz et al., 1992). With the help of conversion factors the count rates in 100 m above ground are converted to activity per mass (Bq/kg). During the processing the errors of the measurements and corrections are calculated. The resulting signal to noise ratio gives indications about the quality of the results. Finally the processed data are graphically displayed by pixel representation on maps. In case of emergency this can already be done on a laptop computer in the aircraft.

Comparison of ground and airborne gamma spectrometry

Since 1989 several measurements were carried out for comparisons of ground and airborne gamma spectrometry to prove the reliability of the system, the appropriate data processing software and the point source calibration described in detail in Schwarz (1991). Comparisons between measurements of soil samples in the lab and airborne gamma spectrometry were also done.
Comparing ground and airborne gamma spectrometry the different field of view has to be considered (10 x 10 m in ground gamma spectrometry; 250 x 250 m in AGS). For both methods the sort of ground should be more or less the same in the field of view. As we could see ground gamma spectrometry points near river borders and edges of the forest aren't suitable because the count rates in the AGS spectra are lowered by the attenuation of the water or the forest. Those points were left out for the comparisons.

In a first step we will consider the comparisons of ground and airborne gamma spectrometry in the flatter part of Switzerland (figure 1). Those measurements were mainly carried out near the nuclear power plants. The data points mostly lie inside the error ranges of ground and airborne gamma spectrometry. In the figures 1 to 3 the dashed lines are the statistical error range of the airborne gamma spectrometry results without data processing errors. The dotted lines are the total error range including the statistical error of AGS results and a maximum error of ground gamma spectrometry of 20 %. Although the errors of the correction steps aren't included here, the correspondence between ground and airborne gamma spectrometry is reasonably well. The points for Caesium-137 are more scattered. That could point to laterally and also vertically more inhomogeneous concentrations of Caesium than of Potassium, Uranium and Thorium.

The results near the Swiss NPPs point to a well working equipment and a good evaluation software for more or less flat areas. The comparison of ground and airborne gamma spectrometry under Alpine conditions should show whether the equipment is working also there. For that we used data points of a survey in the southern part of Switzerland, a survey in the Austrian Alps (together with the Austrian AGS team in area CA) and soil samples from the central Alps. Topography effects and strongly varying flight altitude can lead to problems in Alpine areas. The rough topography often is a great challenge for pilots, engine and equipment.
Nevertheless, as can be seen in figure 2, the correspondence between ground and airborne gamma spectrometry is really good. Almost all the points lie inside the error ranges. Such a good correspondence surprises because the flight altitude over the ground gamma spectrometry measurement points was usually often > 200 m.

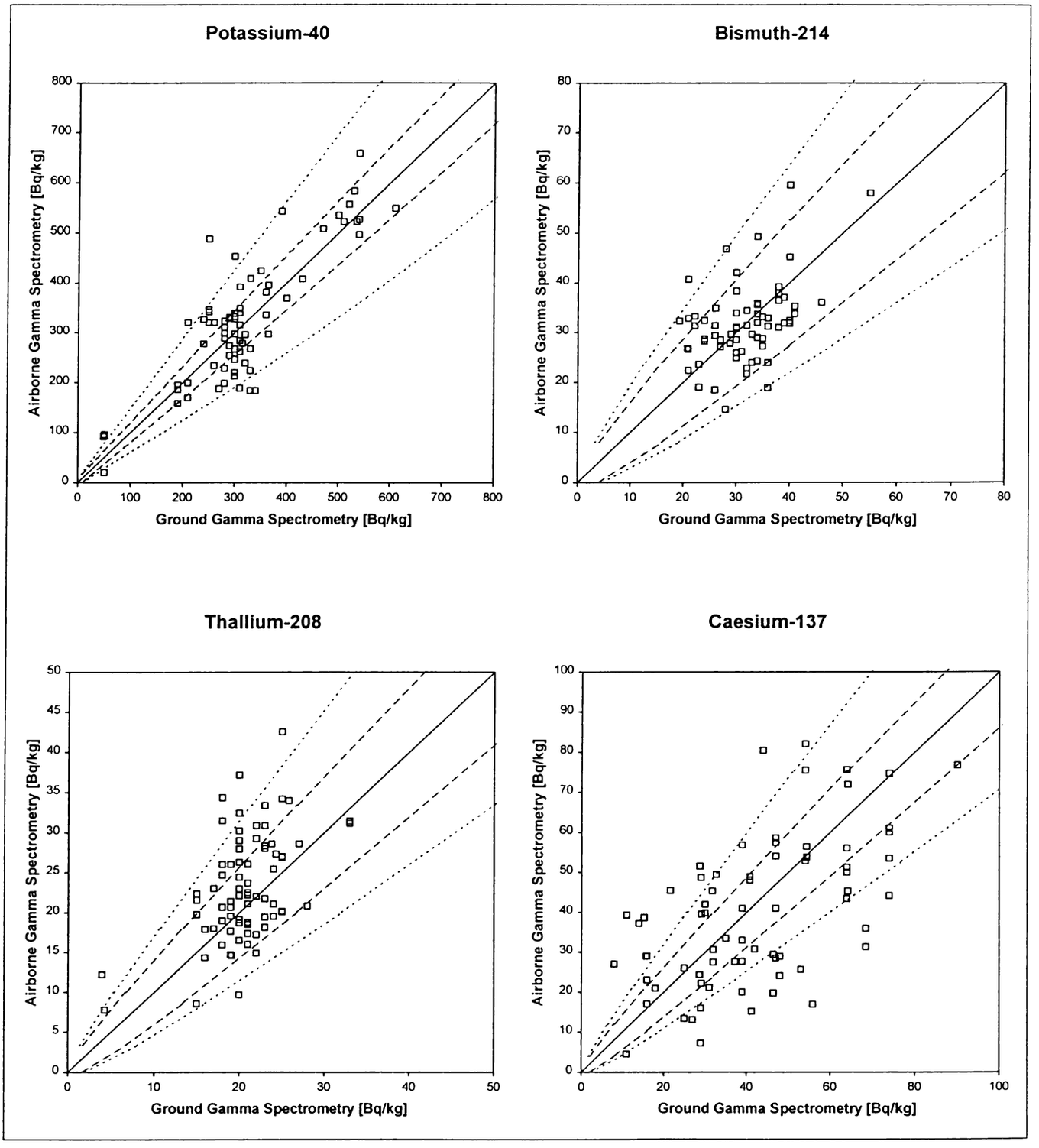

Figure 1: Comparison of ground and airborne gamma spectrometry near the Swiss NPPs with error ranges. For significance of dashed and dotted lines see text.

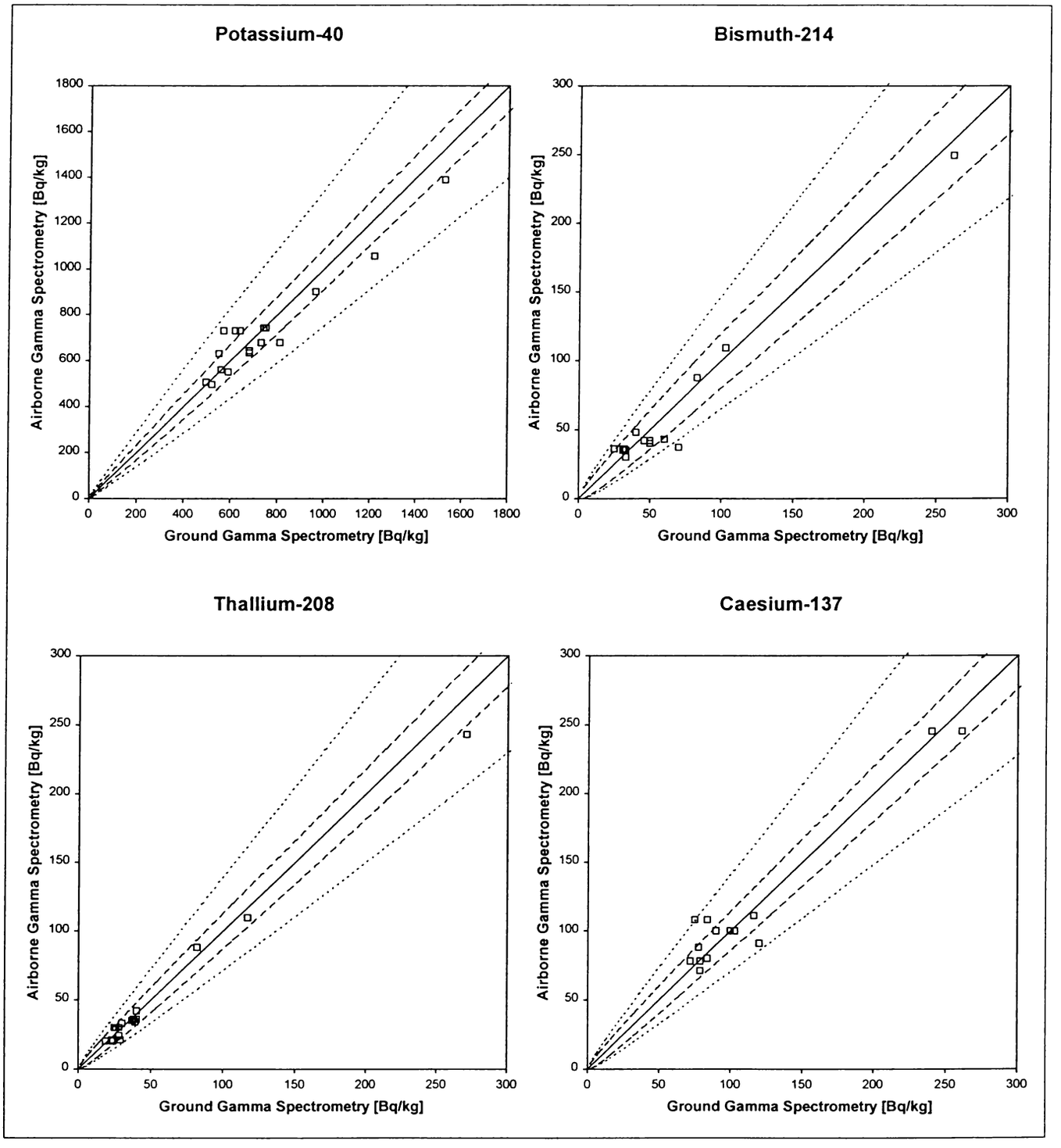

Figure 2: Comparison results of ground and airborne gamma spectrometry under Alpine conditions with error ranges. For significance of dashed and dotted lines see text.

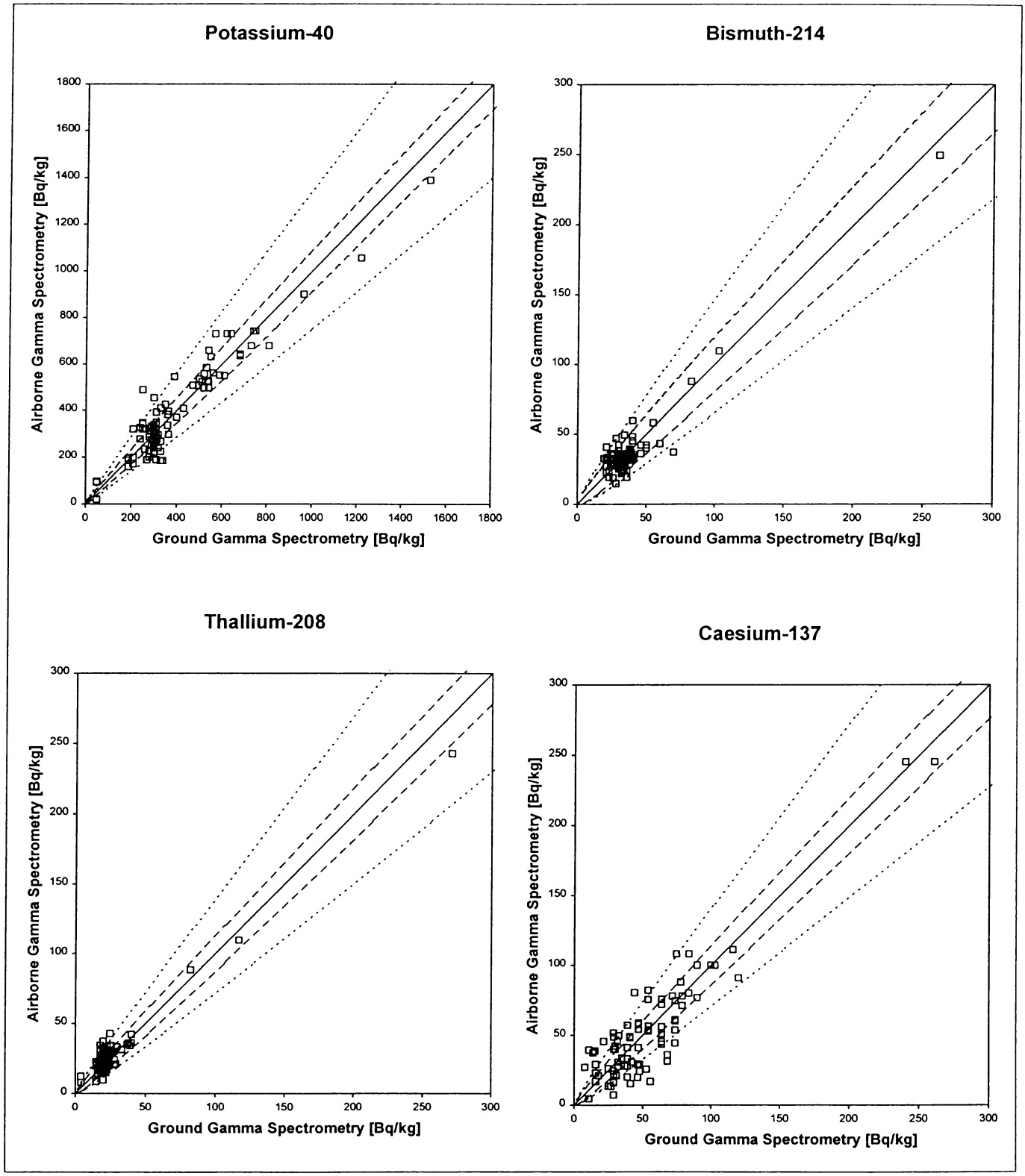

Figure 3: Comparison of all the available data points of ground and airborne gamma spectrometry. For significance of dashed and dotted lines see text.

Taking all the measurements near the nuclear facilities and in Alpine areas (after corrections) the results are depicted in figure 3. Here Caesium also shows a good trend although the points are the most scattered. In the figures for Potassium, Uranium and Thorium the measurements near the nuclear facilities look like a cloud of points. But the trend over the whole range of values shows a good correspondence.

Conclusions and Outlook

As the comparisons of ground and airborne gamma spectrometry show the equipment and the data processing software work well in flat areas as well as under Alpine conditions. That points to a good calibration of the system. The AGS equipment leads to reliable results everywhere in Switzerland. Nevertheless ground gamma spectrometry is a good tool to prove the AGS results and can be done as a quality control of AGS data.
Further work is planned with the tasks of online data processing, data transmission from the aircraft to a ground base and the building of a GIS data base with all AGS data measured in Switzerland.

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