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Perspective

Gamma-ray Spectrometry Using UAVs for System Validation

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INTRODUCTION

Recent developments in autonomous flying Unscrewed Aerial Vehicles (UAVs) have made gamma ray spectrometers highly reliable instruments that are well suited for usage in tandem with these increasingly common systems. Gamma Ray Spectrometry (GRS) readings from the air offer a wide range of uses. This method is used on a former uranium mining and processing site, which necessitates the use of quite large detectors and correspondingly large size UAVs because to its relatively low specific activities and low count rates. The capacity of such UAV-based GRS systems to measure absolute specific activity of naturally occurring radionuclides, including U-238, in near-surface soil that are compatible with the findings of established and tested ground-based systems will determine whether or not they are accepted for use in radionuclide mapping in the future. The gamma radiation data from aerial detectors must be adjusted for attenuation brought on by the flight altitude above ground in order to estimate absolute particular activity on the ground. Recently, mathematical techniques for correcting height have been created that are especially suited to the several tens of metres that are usually the working range of unmanned aerial vehicles.

There is, however, very little experimental support for these theoretical strategies. A vast dataset was gathered from a low-grade uranium ore dump in Yangiabad, Uzbekistan, comprising over 3000 measurements made using unmanned aerial vehicles and 19,000 measurements made using backpacks. By upscaling backpack data to aerial data, we used several geostatistical interpolation approaches to compare the data from both survey methodologies. Because UAV-based systems have lesser spatial resolution than backpack devices, measurements average over greater areal units (or "spatial support" in geostatistical parlance). We demonstrate that the UAV-based measurements exhibit strong agreement with the upscaled backpack measurements, accounting for the shift in spatial support. Additionally, we show that UAV surveys effectively delineate contrasts of the relatively smooth U-238 specific activity distribution that is typical for former uranium mining and processing sites. We are able to demonstrate that mapping extended uranium waste facilities is possible with UAV-based techniques because of their high resolution.

DESCRIPTION

Gamma Ray Spectrometry (GRS) surveys conducted on the ground are a well-established technique for high-resolution spatial mapping of a region down to a few metres. However, because of the challenging topography, their widespread use is frequently unfeasible. This issue is absent from manned aerial surveys, which are generally terrain-independent and conducted using helicopters, for example. The high expense and intricate safety rules for aircraft, which mandate a minimum flight altitude of typically ≥ 100 m above ground, are their drawbacks, preventing helicopter based surveys from providing the high spatial resolution that land-based surveys can.

Operating at comparatively low altitudes (10 m-20 m above ground), they gather data on radionuclides with a spatial resolution similar to that of surveys conducted on the ground. When compared to backpack based systems, they benefit from being able to fly over regions that are otherwise unreachable and areas that would be hazardous to people due to the terrain's steepness, the possibility of landslides or possibly hazardous (like radioactive) contamination. On the other hand, it presents certain difficulties about the strength of the particular ground activity and its significance for the choice of an appropriate gamma ray detector. In recent years, the most popular option has been to use smaller detectors due to the relatively modest payload of many commercial UAV systems.

Compact detectors are particularly useful for surface or point sources that produce high detector count rates, such as high soil contamination from nuclear accidents or damaged sealed radioactive sources.

In this instance, they not only enable spectrometric analyses but also give a clear picture of the spatial distribution of total counts. When spectrometric examination of the data is not planned and the total count rate offers adequate information, they are also appropriate for medium to low count rates. On the other hand, it has been believed that small gamma-ray spectrometers are not very useful for mapping particular activities of naturally occurring radionuclides that are present in the ground at relatively low activities. This is valid for applications in soil science (e.g., mapping radioactive soil contamination at uranium mining and processing sites or industrial sites with naturally occurring radioactive materials; K-40 as a proxy for the potassium content of the soil, for example), exploration of radioactive ore deposits and other related fields.

In this case, the mapping targets are typically extended volume sources without discrete hot spots and the overall count rates are typically substantially lower. Therefore, the recent enormous technological breakthrough in the field of commercial heavy-lift UAV with takeoff masses (MTOM) up to 25 kg is a welcome development. According to European Union legislation, the 25 kilogramme restriction is the upper limit for using a UAV in the "open" category. Planning and carrying out UAV activities are made simpler when using a UAV in the open category.

A window has opened up for the usage of medium heavy gamma-ray spectrometers with payloads up to 10 kg. A heavy-lift UAV weighing 25 kg and carrying an 8 kg detector payload was utilized as part of the DUB-GEM research project to map the distribution of U-238 on a low-grade ore stockpile at a former uranium mining and processing site in Yangiabad, Uzbekistan. "Development of a UAV-based gamma spectrometry for the exploration and monitoring of uranium mining legacies" is what DUB-GEM stands for. The UAV was created and produced as part of the project and the flight surveys in Uzbekistan that are the subject of this discussion were a part of the project's second measuring campaign in Central Asia.

CONCLUSION

Analytical techniques must be used during the post processing of aerial UAV data in order to translate gamma-ray raw spectrum data captured at a certain altitude into absolutely specific activities on the ground. The required actions include height dependent field of view (footprint) adjustments for the detector, which account for the attenuation of gamma rays by the air layer between the ground and the detector.