Geophysical Research Abstracts
Vol. 20, EGU2018-17500, 2018
EGU General Assembly 2018

Cosmic radiation in the lower atmosphere with airborne gamma-ray spectroscopy

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The frontiers of Airborne Gamma-Ray Spectroscopy (AGRS) are continuously pushed forward thanks to the development of innovative instrumentation and to advances in data analysis and interpretation. The employment of new unmanned aerial vehicles, together with the need for real-time identification of anthropogenic radionuclides for homeland security purposes, are reawakening the interest in detectors efficiencies and minimum detectable activities, which can be estimated provided an adequate understanding of the background contributions. In this context, cosmic radiation is an ever-present spectral component whose characterization can supply significant insights to multiple disciplines (e.g. environmental contamination assessment, radioprotection).

For the first time a dedicated offshore AGRS survey of $\sim$5 hour has been performed in the (70 – 3000) m altitude range with the specific objective of answering the following questions: 1) how can an AGRS detector be calibrated for the cosmic background signal? 2) what is the shape of a gamma-ray cosmic spectrum in the (0.8 – 7) MeV energy range? 3) is it possible to calibrate an AGRS detector for the electromagnetic shower component of the cosmic effective dose by means of dosimetry software?

By acquiring high-statistics spectra over the sea (i.e. in the absence of signals having geological origin) and by spanning a wide spectrum of altitudes we can split the constant contribution coming from the radioactivity of the aircraft from the height dependent contributions associated with cosmic radiation and with atmospheric radon. A statistical analysis provided the parameters that linearly relate the count rates in the ^{40}K, ^{214}Bi and ^{208}Tl photopeaks with the count rate recorded in the (3 – 7) MeV energy window in which no event coming from terrestrial radioactivity is expected. By applying the obtained linear relations it is possible to calculate for every spectrum the background count rates that need to be subtracted in order to estimate the K, eU and eTh abundances in the ground. This approach also provides additional constraints in the $<$ 3 MeV energy range for the fitting of the polynomial energy dependence of the gamma cosmic spectral shape. Moreover, the AGRS detector has been calibrated for the electromagnetic shower component of the cosmic effective dose (CED^{EMS}) to human population by using as calibrating reference dose rate values obtained separately with the CARI-6P and the EXPACS (EXcel-based Program for calculating Atmospheric Cosmic Ray Spectrum) dosimetry software. The relation between the count rate in the (3 – 7) MeV energy window and the CED^{EMS} has been found to be linear. Although this approach is clearly model dependent, the results are in agreement at $\sim$10% level, similarly to accuracies obtained with traditional approaches.