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Atmospheric Radon in a marine environment: a novel approach based on airborne gamma-ray spectroscopy

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^{222}Rn is a naturally occurring noble gas produced via alpha decay of ^{226}Ra and it is the only gaseous daughter product of the decay chain of ^{238}U, a radioisotope present in the majority of soils and rocks. ^{222}Rn is almost chemically inert, it exhales into the atmosphere and migrates by diffusion and convection: as it runs out mainly through radioactive decay characterized by a 3.82 days half-life, it is a widespread atmospheric tracer, particularly effective for gathering insights into air vertical mixing processes in the atmospheric boundary layer. Understanding ^{222}Rn distribution in the environment is also of great concern for investigating the health impacts of low-level radioactivity and for supporting regulation of human exposure to ionizing radiation in modern society.

Airborne Gamma-Ray Spectroscopy (AGRS) always treated ^{222}Rn as a source of background: its decay product ^{214}Bi is the main gamma-emitter in the ^{238}U decay chain and, since it binds to airborne aerosols, it is responsible for the measured radon background. For the first time we exploit the AGRS method for quantifying the presence of ^{222}Rn in the atmosphere and assessing its vertical profile. AGRS measurements have been performed in the (70 – 3000) m altitude range during a $\sim$4 hours survey over the Tyrrhenian sea. The experimental setup, made up of four 4L NaI(Tl) crystals, was mounted on the Radgyro, a prototype aircraft designed for multisensorial acquisitions in the field of proximal remote sensing. A theoretical model accounting for the presence of atmospheric ^{222}Rn has been developed in order to reconstruct experimental radiometric data over the entire altitude range: the overall count rate recorded in the ^{214}Bi photopeak is fitted as a superposition of a constant component due to the radioactivity of the aircraft and of the equipment plus a height dependent contribution due to cosmic radiation and atmospheric ^{222}Rn. Modeling the latter component requires a radon vertical profile, which is in turn directly connected with the dynamics of the atmospheric boundary layer. Thanks to the large elevation extent, it has been possible to explore the presence of radon in the atmosphere via the modeling of the count rate in the ^{214}Bi photopeak energy window according to two analytical models which respectively exclude and account for the presence of atmospheric radon. The refined statistical analysis provides not only a conclusive evidence of AGRS ^{222}Rn detection but also a (0.96 $\pm$ 0.07) Bq/m^3 ^{222}Rn concentration and a (1318 $\pm$ 22) m atmospheric layer depth fully compatible with literature data.