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Airborne gamma spectrometry as predictor of indoor radon concentration and radon priority areas

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Airborne gamma spectrometry has long been used as a tool for mapping radioactive elements on or in the ground. The main applications are uranium (U) exploration, fallout and mapping and geochemical surveys of gamma emitting radionuclides. A main advantage over ground-based methods is that large areas can be rapidly surveyed. Drawbacks include dependence of the signal on vertical source distribution, influence of topography and noise related to the observation process.

Indoor radon (Rn) is recognized as an important health risk, being the second cause of lung cancer after smoking. It essentially has two controls: the geogenic Rn potential (GRP) which is a measure of the natural availability of Rn, in turn depending on source (U), ease of Rn migration, and anthropogenic factors pertaining to physical properties of a building and occupancy habits.

Because of its significance to health, Rn is increasingly subjected to regulation. The latest move is the European Basic Safety Standards (BSS) Directive, which has to be transposed into national law by EU Member States. It includes obligations to define reference values for indoor Rn and Rn priority areas (RPAs). Estimation of RPAs may be based on Rn measurements directly, or predictors such as U concentration.

Airborne detected U (termed eU, or equivalent uranium, because Bi-214 is measured as a gamma emitting progeny of U) may be used as a Rn predictor. The main technical problem is to relate eU and Rn data or other Rn proxies. For airborne data, due to movement of the aircraft and a finite measurement period, the observation "footprint" or "horizon" is an oval shaped area of several hundred meters radius, depending on flight altitude. The measurement value is not uniform, but a weighted mean over the footprint, with a relatively complex weighting function. On the other hand, indoor Rn data and those of common predictors such as soil Rn concentration, GRP, U in soil samples, or terrestrial gamma dose rate have comparatively small support and can be treated as point data. The technical question therefore consists in how to "calibrate" or "gauge" eU and point data against each other.

Mathematically, different approaches may be taken depending on whether the objective is to (1) estimate a continuous quantity (e.g. indoor Rn concentration or exceedance probability), or (2) determine if a threshold value is exceeded for a given area (e.g. RPA classification). The former amounts to a regression-type, the latter to a classification-type problem, whose mathematical treatment is usually different.

We provide an overview of the physics background of the problem. We use both airborne and ground-based geochemical data from the UK, Ireland and Northern Ireland Tellus projects, and data from the Irish indoor Rn survey. Furthermore, we discuss approaches to the regression- and classification-type problems of relating observed quantities.