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Continuous radon flux measurements: How reliable are they?

C. Grossi[1] , S. Werczynski[2], D. Rabago[3] , L. Quindos[3], V. Morosh[4], S. Röttger[4], A. Röttger[4], A. Rizzo[5], M. Capogni[6], M. Fuente[7], C. Yver[7], A. Vargas[1]

[1]Universitat Politècnica de Catalunya (UPC), Barcelona, Spain. [2] ANSTO, Lucas Heights, Australia. [3]University of Cantabria, Santander, Spain. [4]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany. [5]ENEA, Roma, Italy. [6]ENEA - Italian National Institute of Ionizing Radiation Metrology (INMRI), Roma, Italy. [7]Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif-sur-Yvette, France

Introduction

Radon gas is being used by the scientific climate and atmospheric communities as tracers for several applications such as the improvement of atmospheric transport models or the indirect estimation of GHG fluxes by the Radon Tracer Method. These previous applications will benefit from the availability of validated radon flux maps, too. Thus, reliable radon flux measurements are needed to validate and to improve present as well as future radon flux models and/or inventories. The project traceRadon (reference 19ENV01) had, between its main goals, the building of a traceability chain (Figure 1) for in situ radon flux measurements and the validation of available radon flux models (Karsten et al., 2015) and inventories (Szegvary et al., 2009) thank to four experimental radon flux campaigns (Figure 2) carried out between 2021-2022 and lasting 3-months each one (Figure 3).

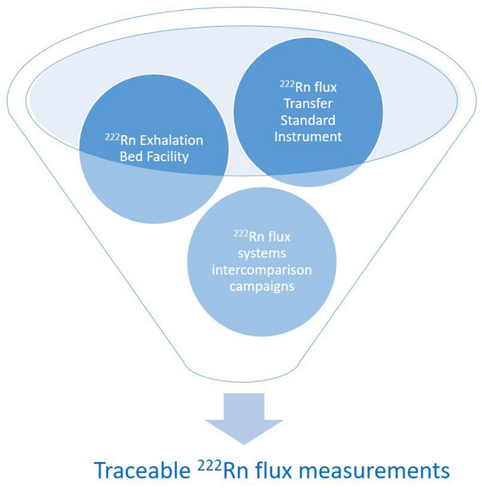

Figure 1. Elements needed to build a full metrology chain for in situ radon flux measurements.

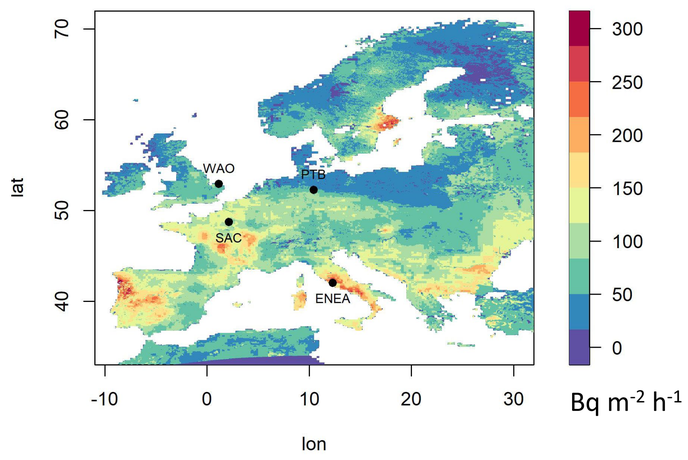

Figure 2. Four stations selected to carry out the experimental radon flux measurements campaign of the traceRadon project.

Figure 3. Installation of radon flux systems, dose and spectrometry monitors and soil sensors at the PTB site.

Traceability chain

- A literature review of existing Exhalation Bed (EB) facilities and their operational requirements was performed;
- This review informed the design, construction and characterization, both experimentally and theoretically, of an EB at the Cantabria University (UC, Figure 4);
- A literature review of available radon flux monitoring systems and their main requirements was performed. This review informed the selection and improvement of a radon flux transfer standard (TS) device including environmental sensors (Figure 5);
- The performance of the TS was characterized under controllable laboratory conditions using the EB (Figure 6);
- The combination of TS and EB were then used to calibrate a typical radon flux monitoring system (Figure 7) with a total uncertainty budget lower than 10% (k=1) and a calibration protocol was also developed;
- An intercomparison of radon flux systems was required to test and study the response of the previous monitors, between others, in situ conditions at low and high radium areas (Figure 6, Rabago et al., 2022).

Figure 4. Radon Exhalation Bed designed and characterized at the Cantabria University.

Figure 5. Transfer Standard instrument calibrated and used for radon flux system calibration.

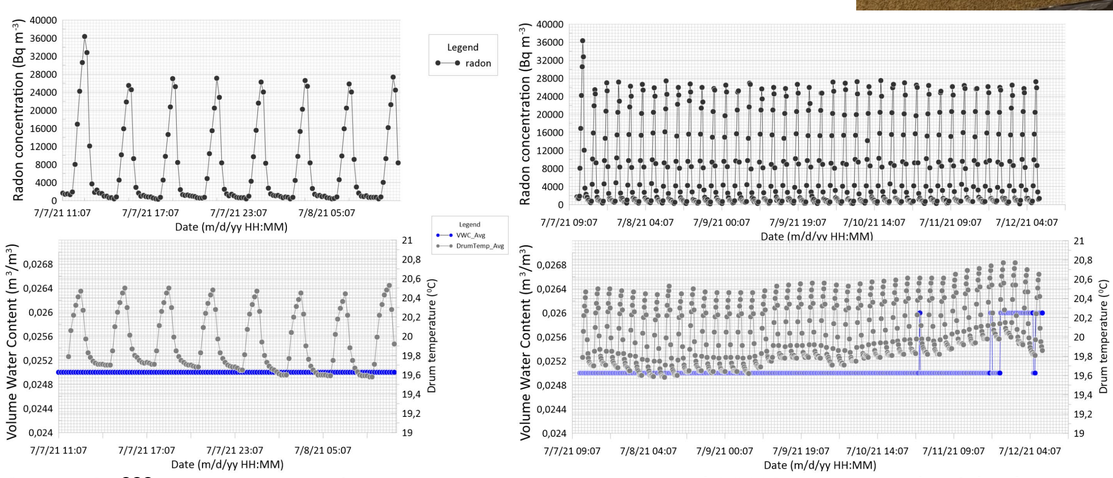

Figure 6. ^{222}Rn concentration, Drum temperature and VWC measured with the TS Autoflux system during the calibration experiments with a constant reference flux (Grossi et al., 2022 submitted).

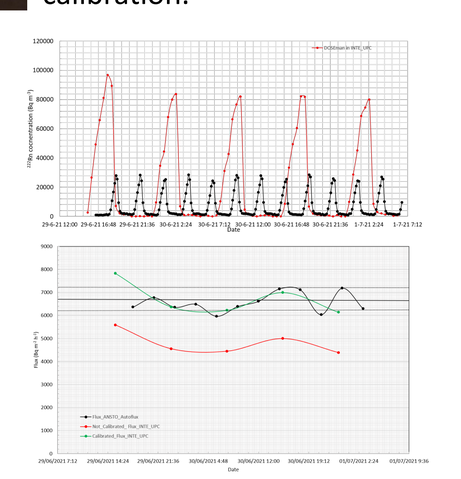

Figure 7. Calibration of the INTE-UPC system using the Autoflux ANSTO system (Grossi et al., 2022 submitted).

^{222}Rn Flux measurements campaigns

Each campaign lasted 3 months and several instruments and methods were applied to measure:

- ^{222}Rn Flux (see presentation Karstens et al., n. 23);
- Environmental conditions in the soil (Volume Water Content, Temperature, etc.), within the accumulation chamber and air;
- Gamma spectrometry at 1 m from the ground (ex. DoRayMon, see poster Vargas et al., n. 28);
- Environmental Dose Rate;
- Radionuclides activity in the soil;
- Physical characteristics of the soil (porosity, density, etc.).

Conclusions

- A full traceability chain has been designed and built to ensure the reliability of radon flux measurement in situ soil which are needed to validate radon flux models and inventories;
- Theoretical and experimental calibration of a Transfer Standard radon flux system was performed only for a constant and high reference flux (6800 Bq m^{-2} h^{-1}) and for stable environmental standard conditions when the system response was constant. No studies were performed to observe the system response under extreme climate conditions in the soil or in the ambient air.
- ^{222}Rn fluxes and environmental variables were measured at three sites during 2021-2022. Observed fluxes were compared with literature model. Experimental fluxes show high sub diurnal variability which is not yet clear if it is due to advection transport of radon in soil or to an artifact because of the accumulation chamber presence on the sampled soil.

References

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