Radon metrology for use in climate change observation and radiation protection at the environmental level - traceRadon (19ENV01)

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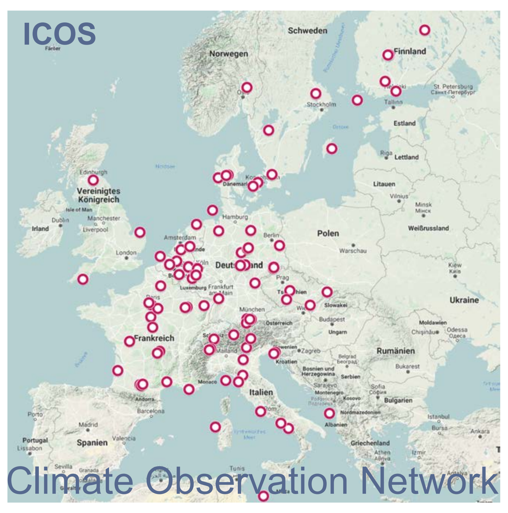
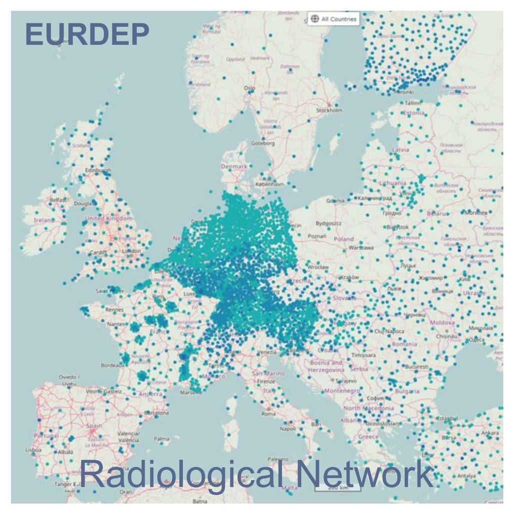
Abstract:



- Radon gas is the largest source of public exposure to naturally occurring radioactivity. Radon can also be used as a tracer to evaluate dispersal models important for supporting successful greenhouse gas (GHG) mitigation strategies. To increase the accuracy of both radiation protection measurements and those used for GHG modelling, traceability to SI units for radon exhalation rate from soil and its concentration in the atmosphere are needed.
- Atmospheric measurements of radon activity concentrations are also used for the assessment and improvement of atmospheric transport models.
- An overlapping need exists between the climate research and radiation protection communities for improved traceable low-level outdoor radon measurements, combining the challenges of collating and modelling large datasets, with setting up new radiation protection services. The EMPIR project traceRadon started to provide the necessary measurement infrastructure.
- Therefore, measurements of radon activity concentration at the environmental level (below 100 Bq·m^{-3}) need to be performed at national standard institutes as well as calibration laboratories and need to be transferred to the detectors operated at atmospheric measurements stations or within radiation protection networks.
- With this poster, an overview of possible national calibration techniques, as well as possible traceability chains for the transfer of the calibration to the detectors in field will be presented and first proof of principle will be shown, as well as their applicability.



Traceability of ^{222}Rn activity concentration to the SI:

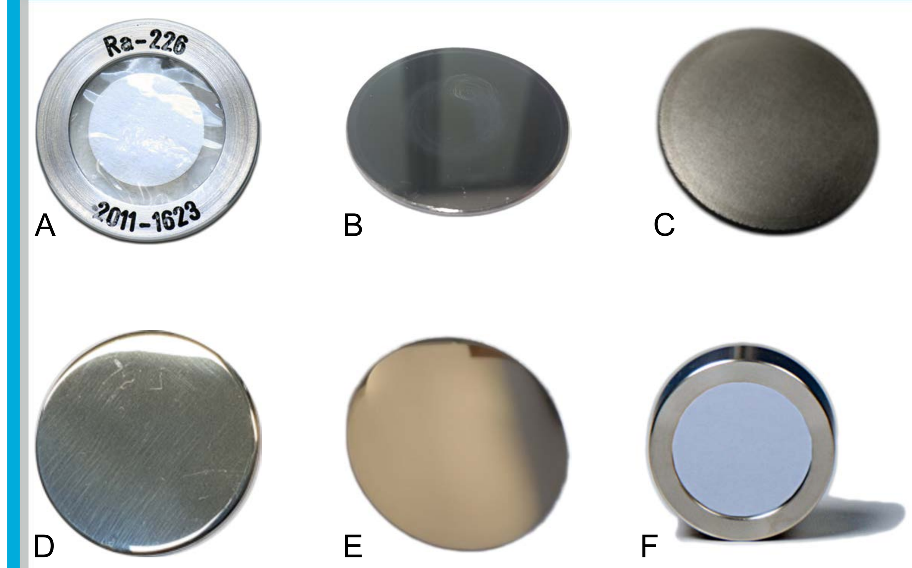


Figure 1: Overview of radon emanation sources. Historical development from upper-left to lower-right.
(A) ^{226}Ra solution drop-cast to fibre filter enclosed between polyethylene foils.
(B) ^{226}Ra solution electrodeposit to a stainless steel backing.
(C) Mass separated ion-implanted ^{226}Ra onto a tungsten backing (W or Al available).
(D) Thermal physical vapor deposition of $^{226}RaCl_2$ onto stainless steel backing.
(E) Thermal physical vapor deposition of $^{226}RaCl_2$ onto a 1" diameter silicon wafer.
(F) Thermal physical vapor deposition of $^{226}RaCl_2$ onto a 450 mm^2 ion-implanted silicon detector (PIPS), which is called the Integrated Radon Source Detector (IRSD).

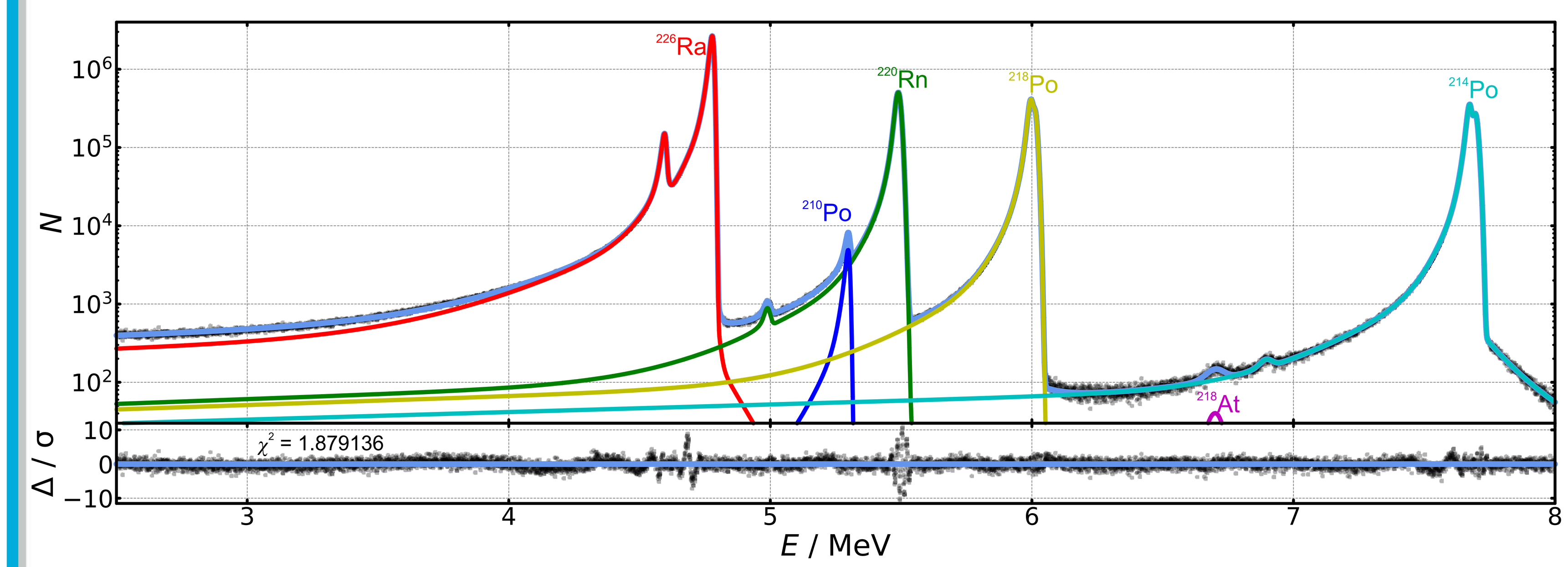


Figure 2: Absolute α-particle count rate energy spectra, recorded with the α-spectrometer of an IRSD (modified PIPS). The resolution of the IRSD is low (FWHM is larger) but the count rate is high, due to the large solid angle of detection regarding the ^{226}Ra deposit on top of the dead layer of the detector. On the other hand this allows for scattering of the a-particles in the dead layer before detection, which explains the broadening of the peaks.
The model fitted to determine the areas of the peaks is an exponentially modified gaussian with the tails of the peaks achieving a penalty for changing between isotopes.
From these areas a time series of count rates is derived to calculate the number of released ^{222}Rn atoms, see Figure 3.

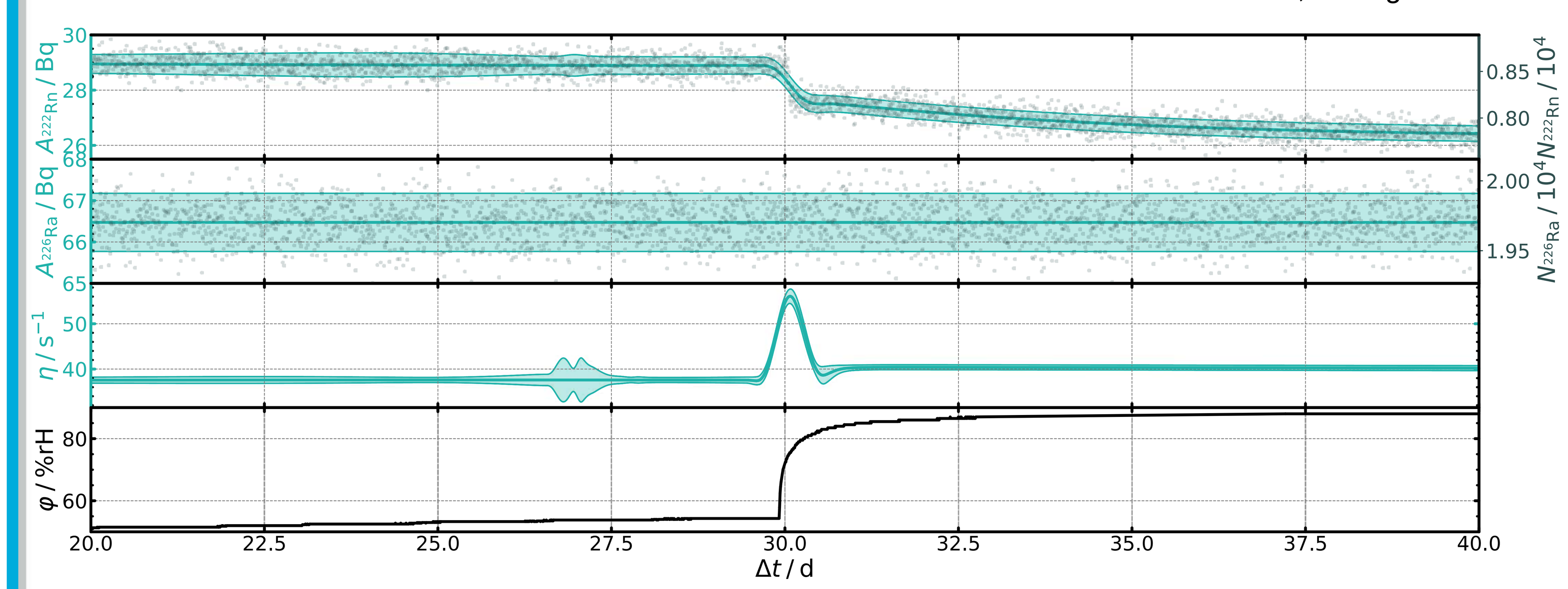


Figure 3: Quasi online calculation of the emanation of an IRSD reaction to a steep increase in humidity. η indicates the number of ^{222}Rn atoms that are released from the source per second. The shaded areas indicate the standard uncertainty intervals assigned for an expansion factors of k=1. A sudden release of ^{222}Rn at day 30 is visible in the measurement through the peak shape structure in the emanation η and the steep slope in the ^{222}Rn activity. This might be caused by condensation of water on the source surface and following solution of ^{222}Rn. The power of the procedure is shown in the stabilisation of the emanation η right after, which is represented in a slowly decreasing ^{222}Rn activity in the IRSD source.

Traceability of ^{222}Rn flux and its application:

Figure 4: (A) Calibration of flux transfer standard on traceable exhalation bed, (B) intercomparison with transfer standard on exhalation bed, (C) field intercomparison exercise with transfer standard (centre) and different types of flux instruments.

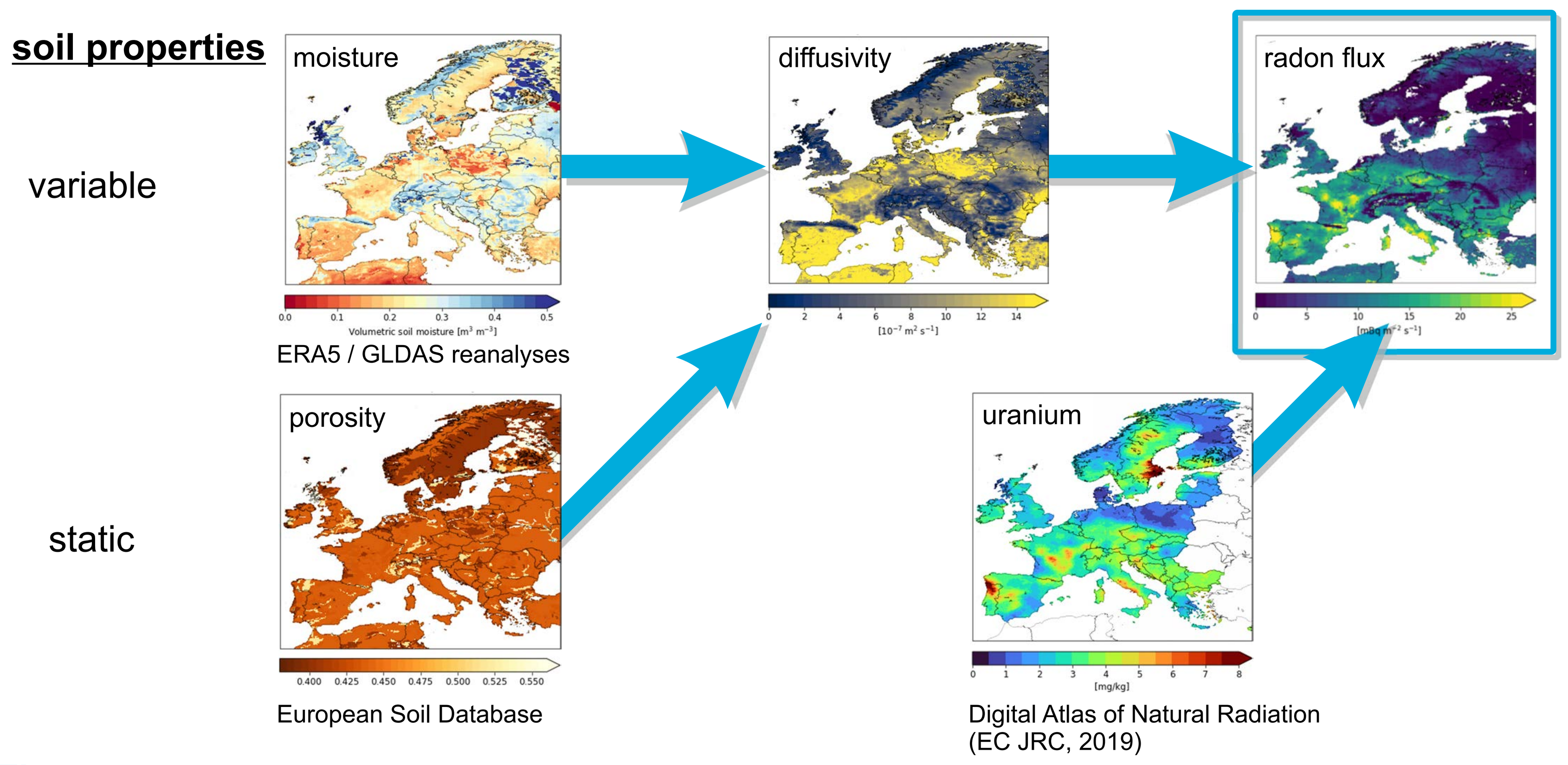


Figure 5: Radon flux model composed from different sources with its workflow of construction. The sources are already variable with time (first line, moisture) or static (second line, porosity, uranium content).

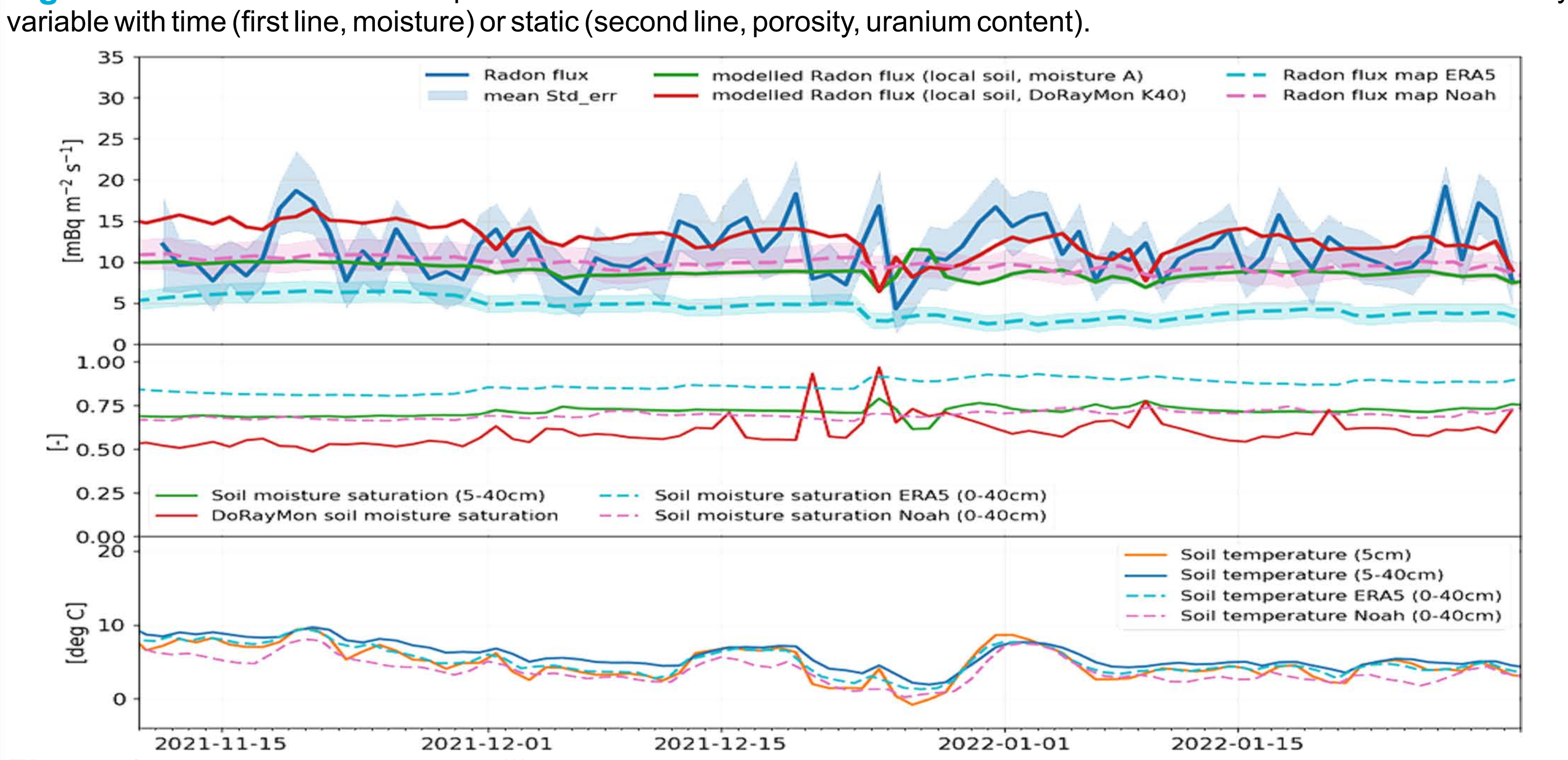


Figure 6: Comparison exercise for ^{222}Rn flux at the PTB reference field site ERADOS. Upper diagram compares the measured radon flux (ANSTO, AutoFlux) with models feeded from different soil moisture measurements and different radon flux maps (ERA5, Noah) already existing. For comparison/correlation the middle graph shows the soil moisture variation and the lower graph the soil temperature measured in different depth compared with maps.

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Funding:
This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.