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trace Radon

EURAMET

Radon as a tracer: Application of low-level radon metrology

by

Stefan Röttger, Claudia Grossi, Ute Karstens, Giorgia Cinelli, Chris Rennick, Annette Röttger

on behalf of the traceRadon Consortium

Coordinator: Annette Röttger (PTB)

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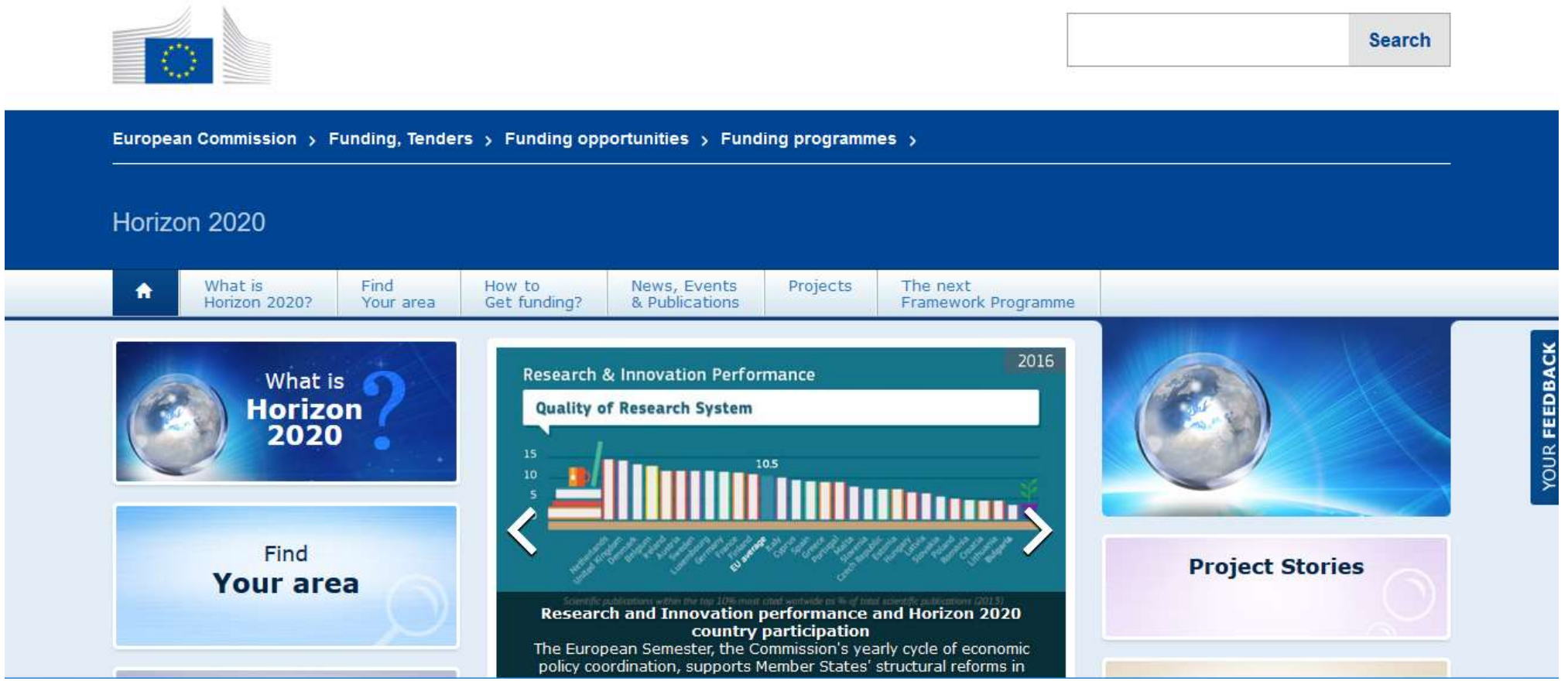
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Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020) – in addition to the private investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market.

EMPIR

EUROPEAN METROLOGY PROGRAMME FOR INNOVATION AND RESEARCH (EMPIR)

EMPIR is the main programme for European research on metrology. It coordinates research projects to address grand challenges, while supporting and developing the SI system of measurement units.

EMPIR follows on from the successful European Metrology Research Programme (EMRP), which issued its final call for projects in 2013. There is an increased focus within EMPIR on innovation activities to target the needs of industry and accelerate the uptake of research outputs.

The inclusion of capacity-building activities in EMPIR is helping to bridge the gap between countries with emerging metrology systems and those with more developed capabilities.

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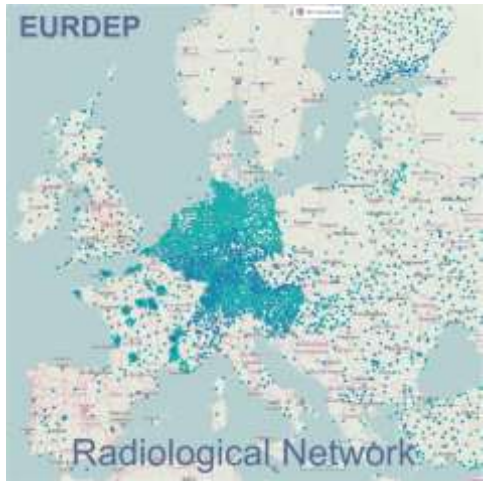
Introduction – Why ?



Climate change is one of the greatest challenges of our time.

The temperature rise of the atmosphere of our planet, due to the greenhouse effect, is caused by the increase of GHG emissions.

- ICOS: Monitoring of GHG emissions, the dispersion of GHGs and the resulting GHG concentrations in air, is of utmost importance for appropriate climate change mitigation measures.
- EURDEP: Collection and exchange of radiological monitoring data between participating countries of the radiation in the environment.

Both networks could profit from radon measurements at the outdoor level. But **traceability to the SI system** is not established yet.

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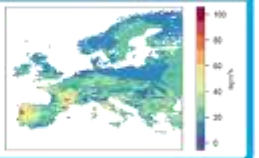
Introduction – What ?

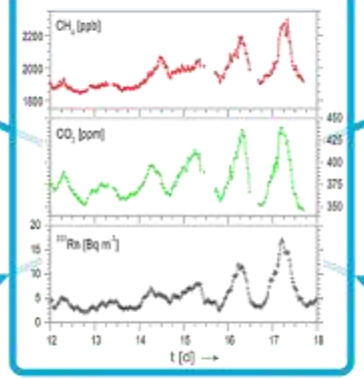
Traceability to the SI system

Radon and radon flux in maps for radiation protection issues — WP4

- Identification of RPA
- Quantifying the radon wash-out peak
- Data accessibility and public engagement



$$j_{CH_4} = j_{Rn} \cdot \frac{\Delta c_{CH_4}}{\Delta c_{Rn}}$$



Validation of radon flux models and inventories using radon flux and terrestrial data — WP3

- Radon flux maps in GHG and climate change studies
- Inclusion of data from radiological early warning systems
- Validation of radon flux maps using radon flux measurements and outdoor radon activity concentrations

Traceable measurements of outdoor radon activity concentrations — WP1

- Traceable low-level radon sources
- Development of a transfer standard
- Calibration and long-term stability

Radon flux measurements — WP2

- Development of a reference radon flux monitor
- Test under field conditions
- Measurement campaigns
- RTM application

Management and coordination — WP6

Seven leading European NMI/DI in the field of climate observation and ionising radiation. ICOS, JRC and other stakeholders directly involved as JRP-partners. Sufficient further external partners with high-level expertise to cover the broad spectrum of two scientific communities. High interest by stakeholder community, expressed by 65 letters of support and a large group of 34 potential collaborators.

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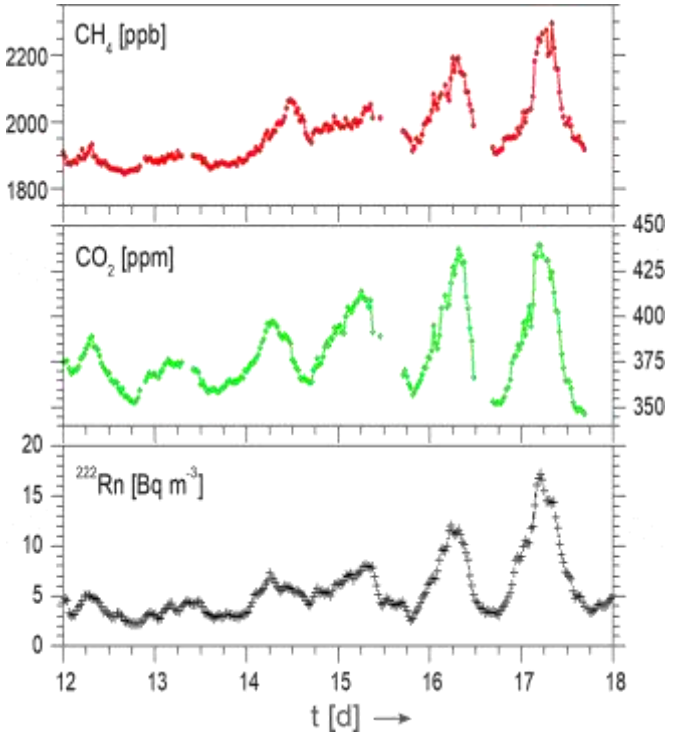
Introduction – For whom?

Why is Radon an issue in **climate observation**?

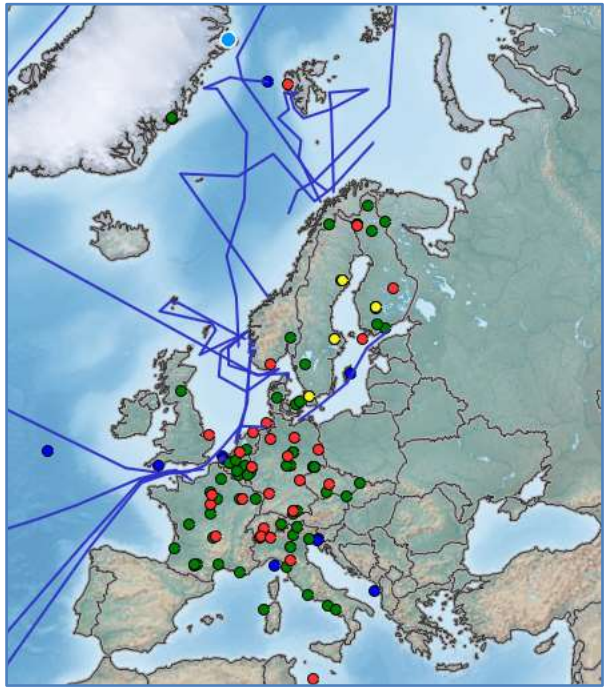
- GHG **flux measurements** are difficult though GHG concentration measurements are established.
- With radon activity concentration and radon flux measurements GHG fluxes can be **traced**!



ICOS Atmospheric Station Specifications:

Radon monitor: "At the present stage, Radon-222 measurements are not mandatory in ICOS. However, Radon-222 is recognized as a very valuable measurement, in particular for trace gas flux estimates."

- Determine source terms of GHG



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Introduction – Radon Tracer Method

1. To develop traceable methods for the measurement of **outdoor low-level radon activity concentration** in the range of **1 Bq m^{-3} to 100 Bq m^{-3}**, with uncertainties of **10 % for k = 1**, to be used in climate monitoring (…) .
2. To develop the capability for traceable **radon flux measurements in the field**, based on the development of a radon exhalation reference system “exhalation bed” and a transfer standard (…) .

Flux ⟷ Concen-tration

$$j_{\mathrm{CH_4}} = j_{\mathrm{Rn}} \cdot \frac{\Delta c_{\mathrm{CH_4}}}{\Delta c_{\mathrm{Rn}}}$$

3. To **validate current radon flux models and inventories** by the new traceable measurements of radon activity concentration and radon flux (…).

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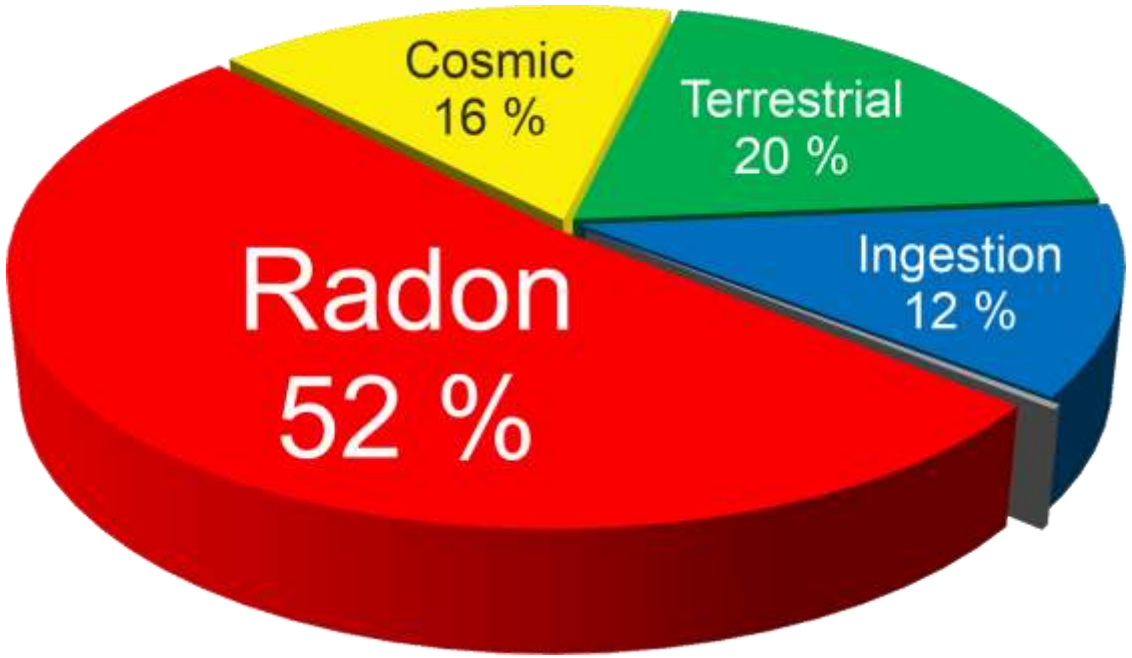
Objectives - Overview

1. To develop traceable methods for the measurement of **outdoor low-level radon activity concentration** in the range of **1 Bq m^{-3} to 100 Bq m^{-3}**, with uncertainties of **10 % for k = 1**, to be used in climate monitoring (…).
2. (…).
3. (…) To support the validation with dosimetric and spectrometric data from the **radiological early warning networks in Europe** (…).
4. To provide **easy to use dynamic radon and radon flux maps** for radiation protection in line with Council Directive 2013/59/EURATOM, including their use to identify **RPA** and **radon wash-out peaks** (…).

UNSCEAR, 2008:
Radon and its progeny contribute about half of the natural radiation dose to the public.

Public exposure to natural radiation:
Total average individual dose:
3 mSv a^{-1}



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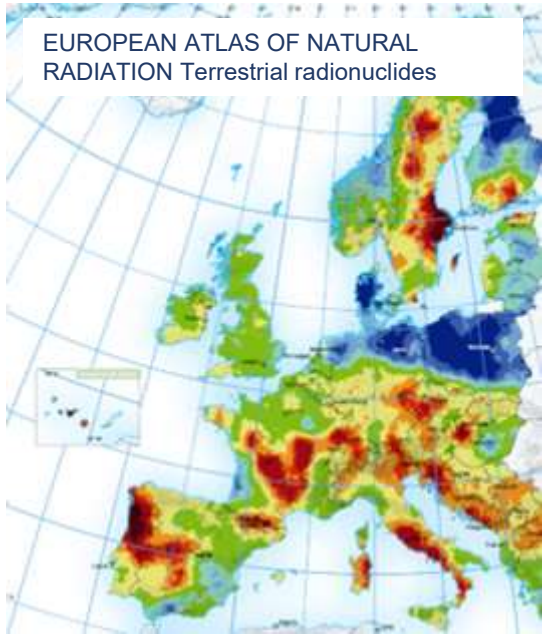
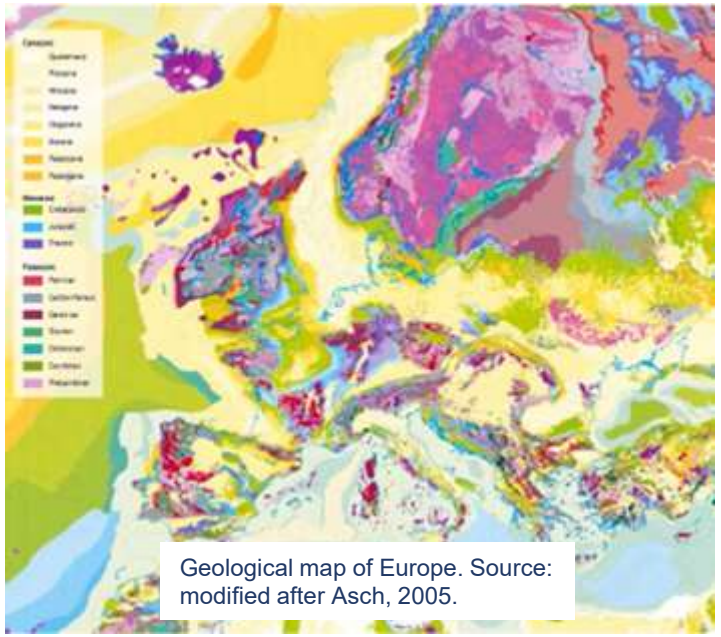
Objectives – static to dynamic

Static maps:

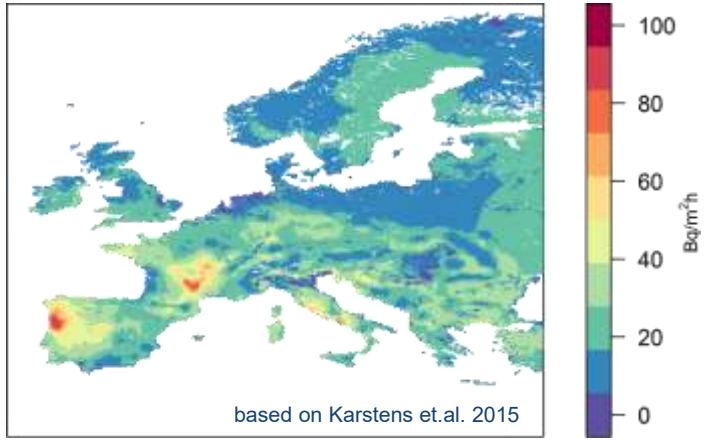




Geological map of Europe. Source: modified after Asch, 2005.

Dynamic maps:

The early warning network shows online data for the dose rate. But **outdoor radon concentration** or even better online data on **radon flux** (emission) is missing!



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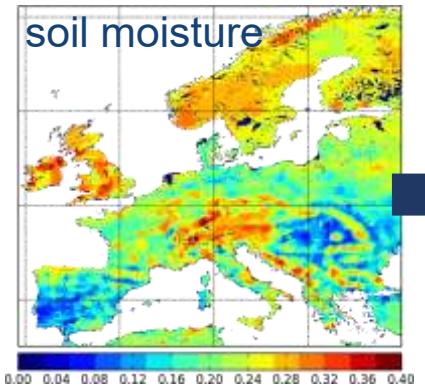
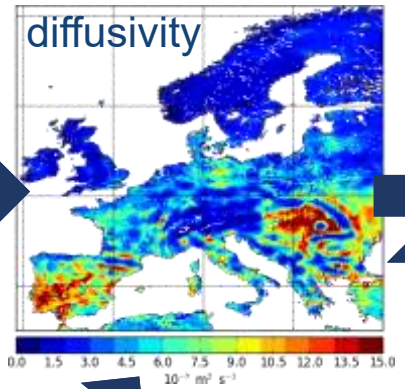
Objectives – Joining forces

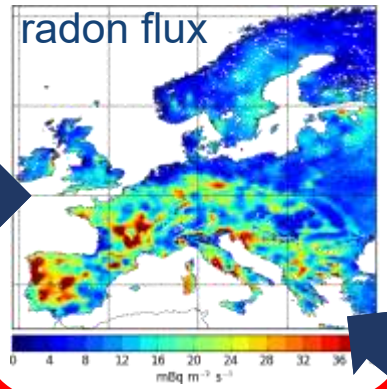
Our task: Joining forces in the field of radon

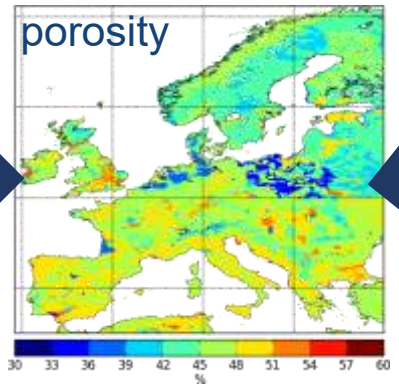
soil texture
% clay
% sand
% slit

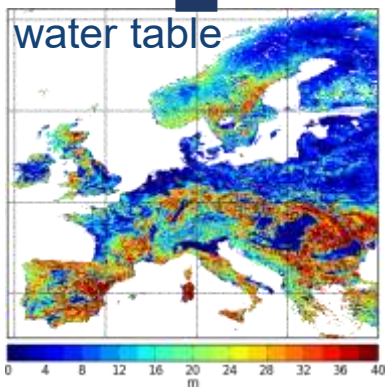
bulk density

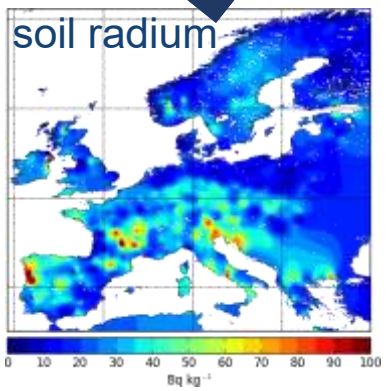












based on Karstens et.al. 2015

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Achievements – 1: New traceability

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New metrology for radon at the environmental level

Annette Röttger[1,*], Stefan Röttger[1], Claudia Grossi[2], Arturo Vargas[2], Roger Curcoll[2], Petr Otáhal[3], Miguel Ángel Hernández-Ceballos[4], Giorgia Cinelli[5], Scott Chambers[6], Susana Alexandra Barbosa[7], Mihail-Razvan Ioan[8], Ileana Radulescu[8], Dafina Kikaj[9], Edward Chung[9,10], Tim Arnold[9,10], Camille Yver-Kwok[11], Marta Fuente[11], Florian Mertes[1] and Viacheslav Morosh[1]

[1] Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany
[2] Institut de Tècniques Energètiques, Universitat Politècnica de Catalunya, 08028 Barcelona, Spain
[3] National Institute for NBC Protection, 26231 Milin, Czech Republic
[4] Department of Physics, University of Córdoba, 14071 Córdoba, Spain
[5] European Commission, Joint Research Centre, 21027 Ispra, Italy
[6] Australian Nuclear Science and Technology Organisation, 2234 Lucas Heights, Australia
[7] INESC TEC, 4200-465 Porto, Portugal
[8] Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, 077125 Magurele, Romania
[9] National Physical Laboratory, Teddington, Middlesex, United Kingdom
[10] School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom
[11] Laboratoire des Sciences du Climat et de l'Environnement, (LSCE-IPSL), CEA-CNRS-UVSQ, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

E-mail: annette.roettger@ptb.de

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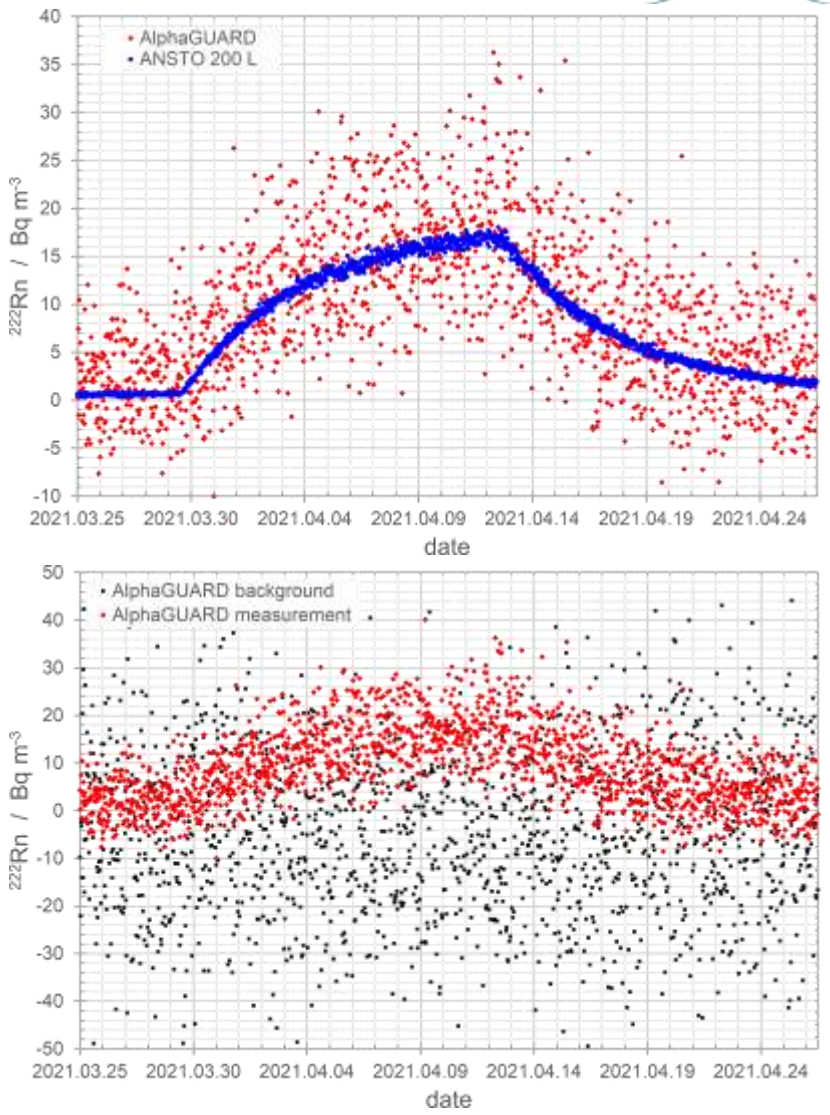

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Achievements – 2a: New sources

Electro-deposited

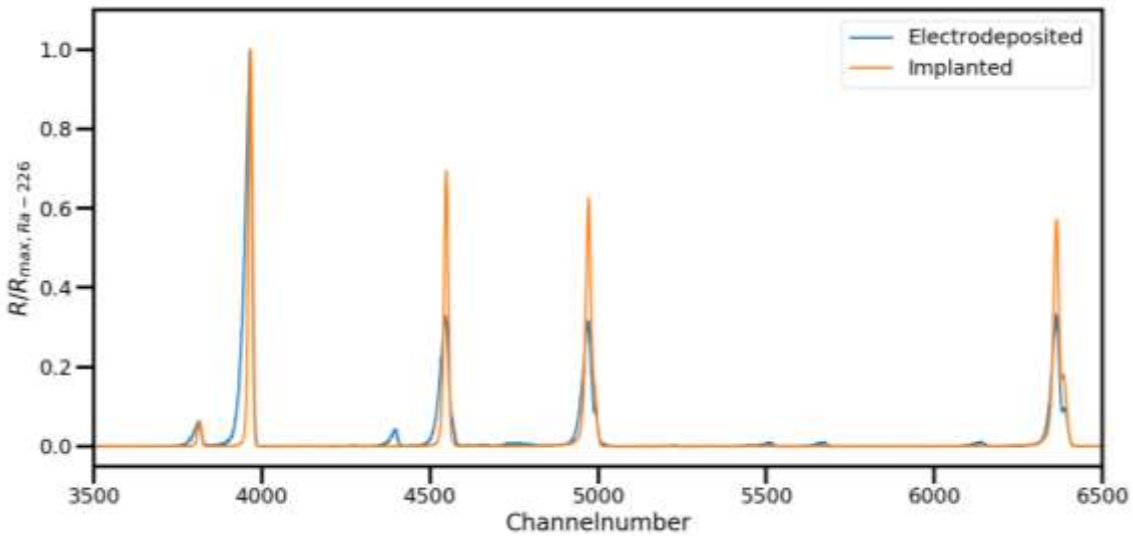
Deposition at
30 V < U < 200 V

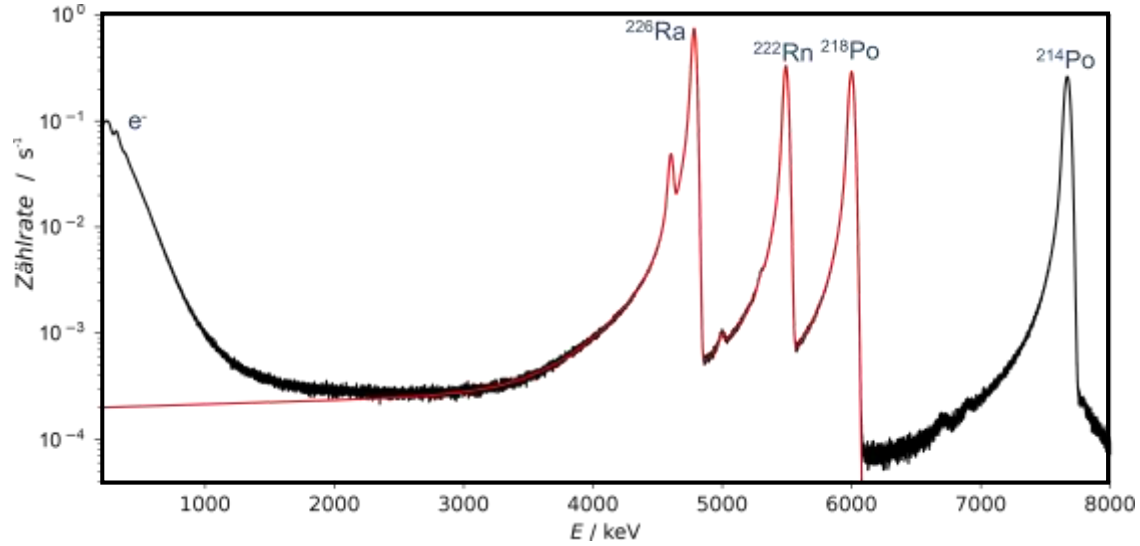
Implanted

Implantation of Ra-226 into W / Al after mass separation

PIPS

450 mm², 300 µm with 150 Bq ^{226}Ra layer





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Achievements – 2a: New sources

Electro-deposited
Deposition at
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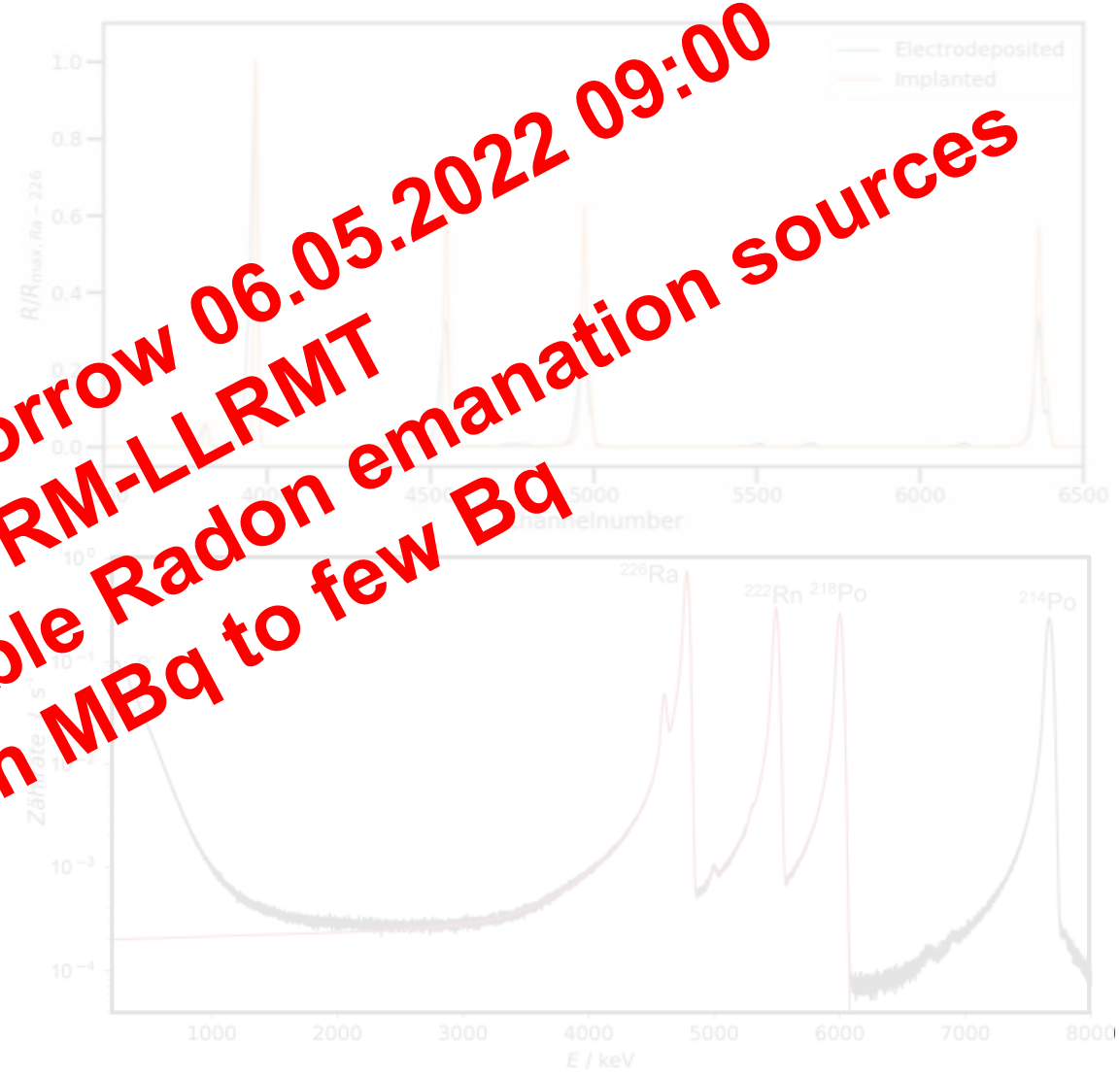
Implanted
Implantation of
Ra-226 in
after
duration

PIPS
mm²,
with 150 Bq ^{226}Ra
layer



Presentation tomorrow 06.05.2022 09:00 @ICRM-LLRMT
Evolution of traceable Radon emanation sources from MBq to few Bq

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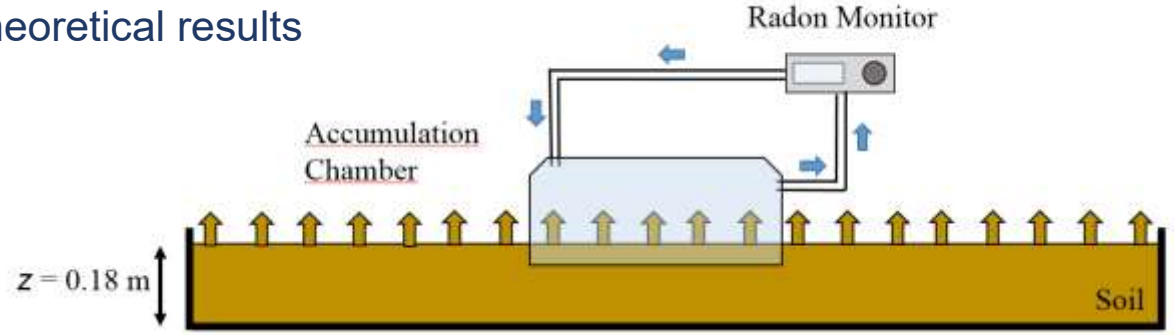
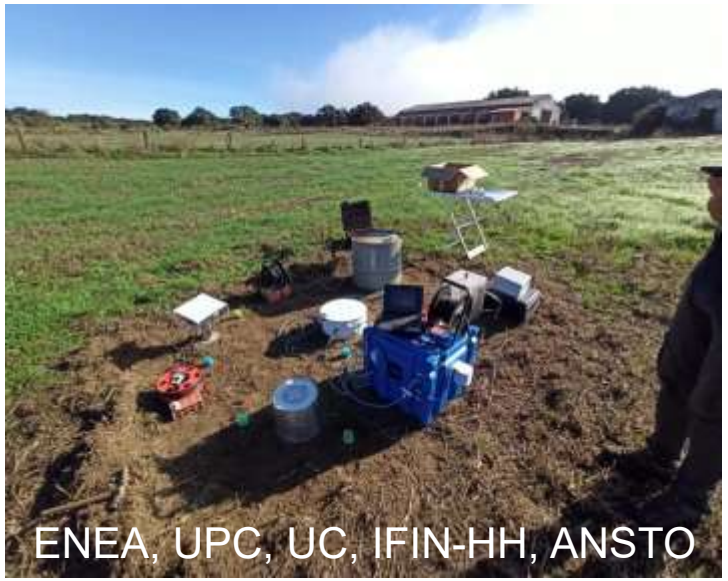
Achievements – 3: Radon flux

Calibration

Continuous radon flux systems according the experimental and theoretical results





Inter-comparison

- Good agreement between participants
- Static period is used to determine the leakages of the system and the applicability of linear assumption
- Integration time and device sensitivity are key to determine the radon flux

Next steps:

- Further data analysis (increasing period), optimize the methodology, check the time of linear assumption
- Produce the guidelines to installation and operation in field

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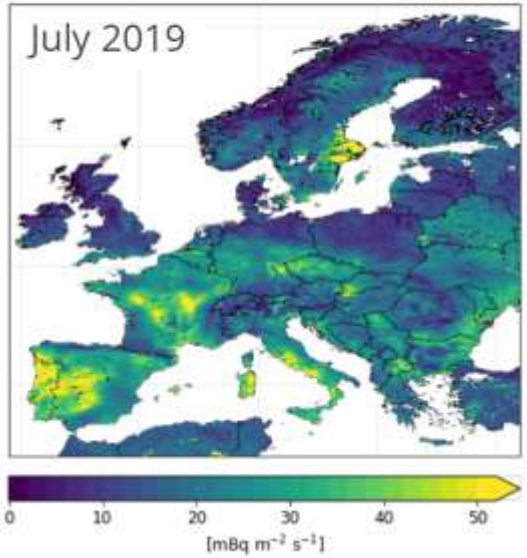
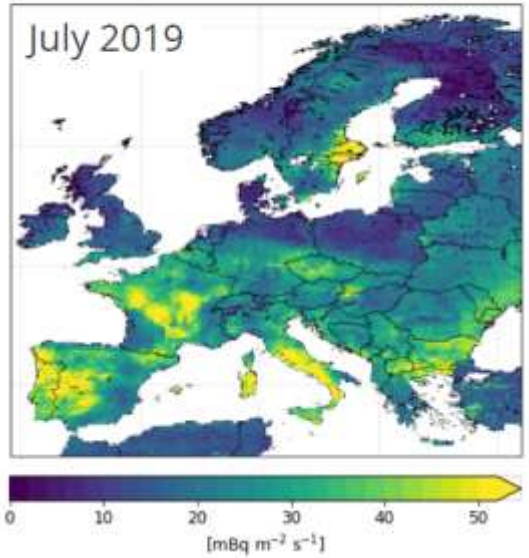
Achievements – 4: Data reanalysis

Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

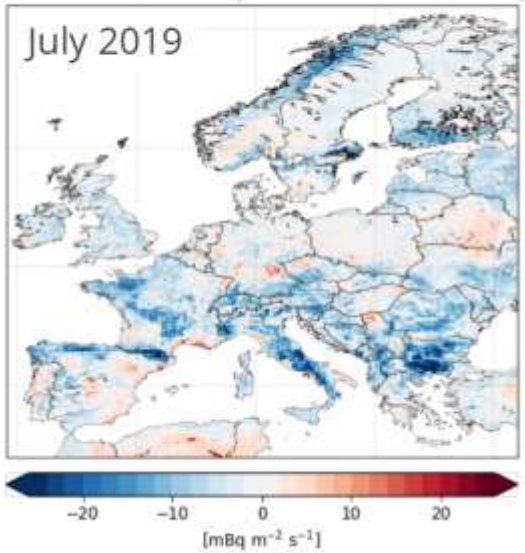
Radon flux based on GLDAS-Noah v2.1 soil moisture

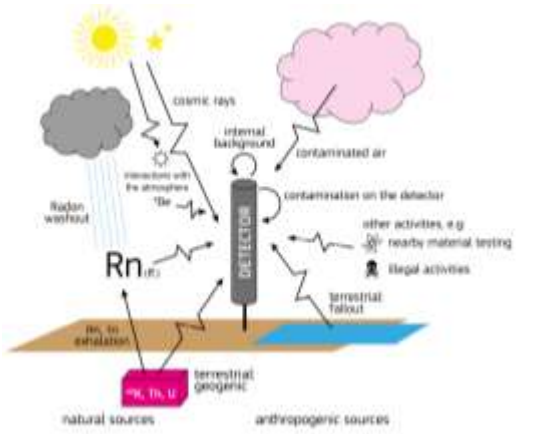


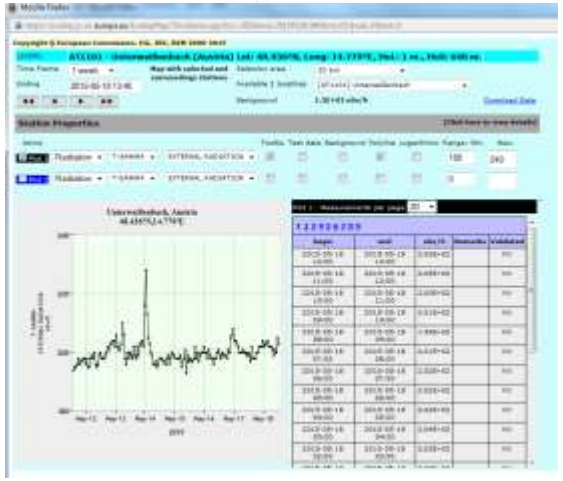
Radon flux based on ERA5-Land soil moisture



Radon flux difference ERA5-Land – GLDAS-Noah







The identification of the right origin of Ambient Dose Equivalent Rate (ADER) peaks is a crucial issue to prevent the impact of false alarm in the population.

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Summary

The key targets to be reached by the end of this project (and to be exploited in the 5 years that follow the end of the project) are as follows:

- **New SI traceability** for measurement quantities used in climate observation and radiation protection;
- **New customer calibration services** for new types of measurement and new types of device. To develop a **first standard protocol for the application of the radon tracer method** (RTM) to enable retrieval of greenhouse gas fluxes at atmospheric climate gas monitoring stations and to use radon flux data for the identification of **Radon Priority Areas** (RPA);
- To **validate current radon flux models and inventories** by the new traceable measurements of radon activity concentration and radon flux. To **support the validation with dosimetric and spectrometric data from the radiological early warning networks** in Europe;
- To provide easy to use **dynamic radon activity concentration and radon flux maps** for climate change research and radiation protection in line with Council Directive 2013/59/EURATOM, including their use to identify RPA and radon wash-out peaks;
- To facilitate the **take up of the technology and measurement infrastructure**.

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Aim: presentation on all continents

Last continent reached: Antarctica!

Thanks…

… to the 18 traceRadon-project partners:

… to the 12 traceRadon-project collaborators:

… to the traceRadon-project Stakeholder Committee, Stakeholders, MSU, EURAMET,

… and for your attention!

Thanks…

… to the 18 traceRadon-project partners:

… to the ~~12~~ traceRadon-project collaborators:
13 since last week

… to the traceRadon-project Stakeholder Committee, Stakeholders, MSU, EURAMET,

… and for your attention!