



The European Atlas of Natural Radiation: Indoor Radon Concentration and Geogenic Radon

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GARRM 2021

22 September 2021

Short Video

Other languages available

<https://audiovisual.ec.europa.eu/en/video/I-193283>

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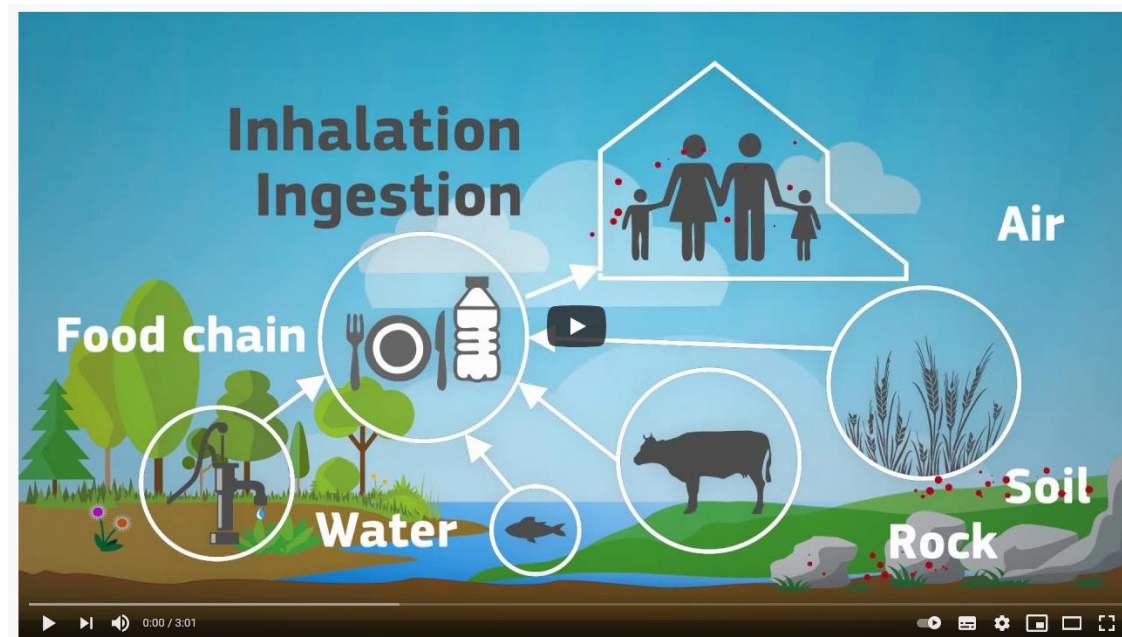
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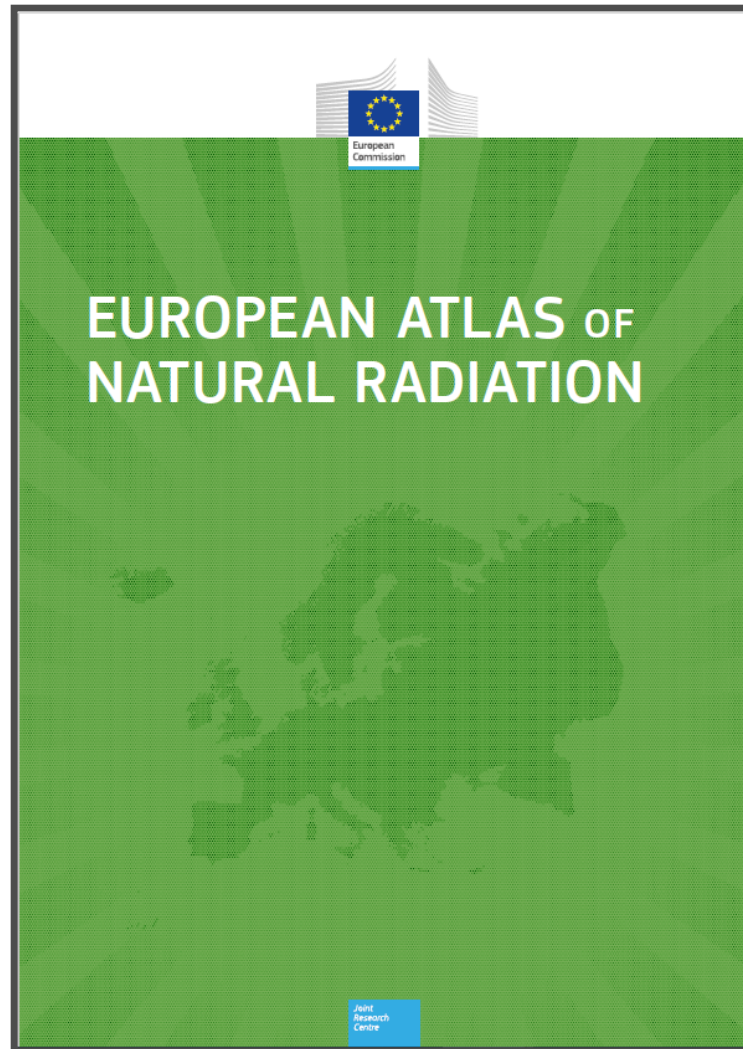
European Atlas on natural radiation – sources, data and maps

<https://www.youtube.com/watch?v=sQeWXipnw9Y>

What is the Atlas? What does it contain?

Encyclopaedia of natural radiation: it describes the different sources of this kind of radioactivity and represents the current state of knowledge on this topic.

- ✓ A3 format
- ✓ 190 pp
- ✓ Digital and paper



Collection of maps of

Europe that show the levels of natural background radiation from various sources:

- cosmic radiation,
- terrestrial radionuclides
- Terrestrial radiation,
- indoor radon

Aims

Provide reference values as well as harmonised data for the scientific community and national competent authorities

General background information

2.4 Statistics, measurement, mapping

The section intends to address some basic concepts which should be used in a uniform way in order to ensure that the data collected are comparable and can be used in a consistent manner across the different countries.

2.4.0 From sampling to mapping

Concepts such as sampling, measurement, mapping, and data analysis are essential for the development of a reliable and consistent data set. The section provides a general overview of these concepts and their application in the context of radionuclide monitoring.

2.4.1 Observed and detection process

In a practical situation, the observed data are the result of a complex process involving the detection of radionuclides in the environment and the subsequent measurement and analysis of the samples.

2.4.2 Accuracy, precision and representativeness

Quality assurance, accuracy, precision, and representativeness are key factors in ensuring the reliability of the data. The section discusses the methods used to assess and improve these aspects.

2.4.3 Scale, coverage, resolution and precision

The choice of scale, coverage, resolution, and precision is crucial for the effective monitoring of radionuclides. The section provides guidance on how to select the most appropriate parameters for a given situation.

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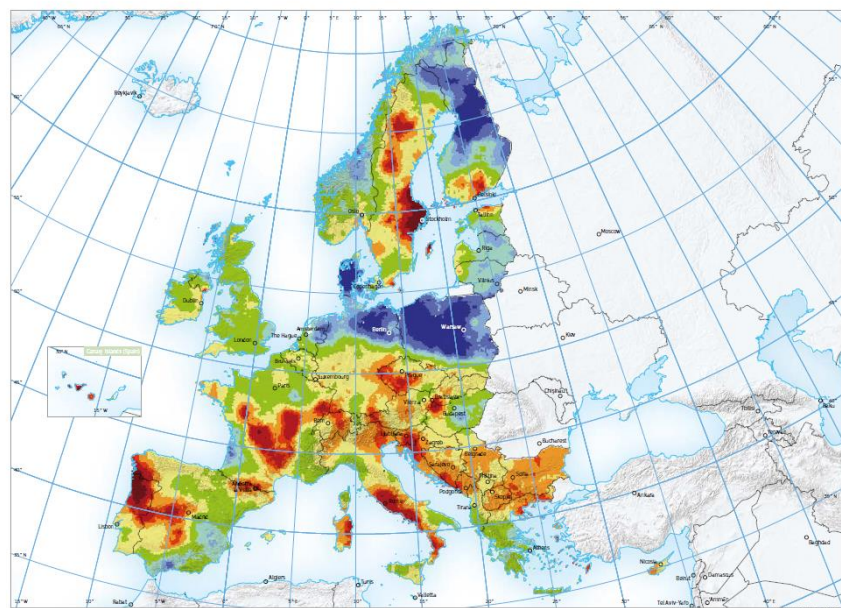
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Terrestrial radionuclides



Address a wider public:

- ✓ to familiarise itself with natural radioactivity
- ✓ to be informed about levels of natural radioactivity caused by different sources
- ✓ have a more balanced view of the annual dose received by the world's population

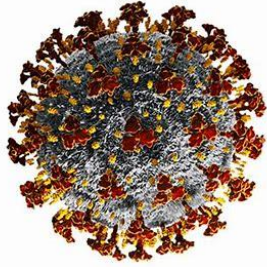
Who made the Atlas possible?

More than **100 experts**

coming from **60 different institutions:**

- universities,
- research centres,
- national and European authorities,
- International organizations





RADIACIÓN

Primer atlas de la radiación natural en Europa

El radón es el contribuyente más importante a la exposición a la radiación de la población humana

Tendencias 21

29-07-20 | 16:55



La Nueva España



EU SCIENCE HUB

The European Commission's science and knowledge service

European Atlas of Natural Radiation: new maps show levels of natural radioactivity where you live

JUL
16
2020

The European Atlas of Natural Radiation provides harmonised data on levels of natural radiation across the EU and aims to raise awareness among Europeans of living with natural radioactivity.

The human population is continuously exposed to ionising radiation from several natural sources that can be classified into two broad categories: high-energy cosmic rays and radioactive nuclides that originated in the earth's crust and are present everywhere in the environment.



The European Atlas of Natural Radiation provides reference values for natural sources of radiation across the EU.
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Energia | Inquinamenti

Radon e altre radiazioni naturali: ecco l'Atlante europeo

Le nuove mappe mostrano i livelli di radioattività naturale dove viviamo

[17 Luglio 2020]

greenreport.it

quotidiano per un'economia ecologica



Habitez-vous dans une zone exposée à la radioactivité naturelle comme le radon ?

STRAHLENSCHUTZPRAXIS 1/2021



European Atlas of
Natural Radiation

Neu erschienen

Das hat uns gerade noch gefehlt!
Das ist nun keinesfalls ironisch ge-



The Natural History Museum Vienna

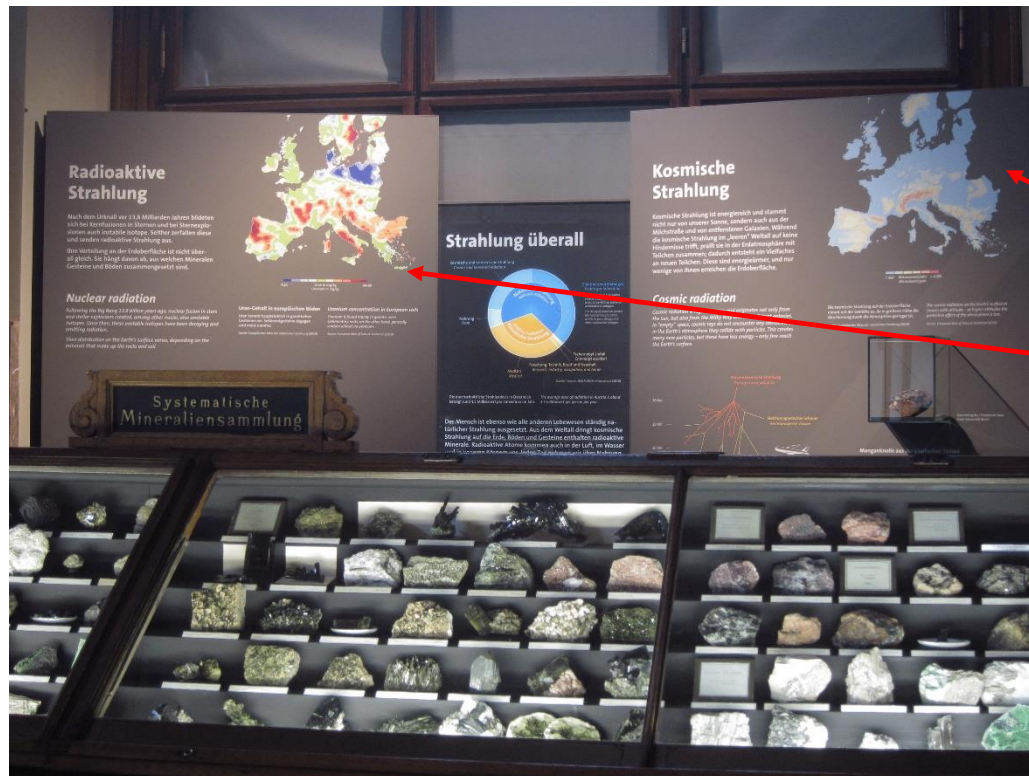


Special Exhibition

Radioactivity in the natural world

from 26. May 2020

A new part of the permanent exhibition in Hall 4 focuses on radioactivity – from natural radioactivity to geological nuclear reactors and minerals that glow in the dark.



Maps of U concentration in soil and cosmic radiation from the European Atlas of Natural Radiation

How to get the Atlas

<https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation>

JOINT RESEARCH CENTRE
Radioactivity Environmental Monitoring

European Commission > EU Science Hub > REMon > About > Natural Radioactivity

REMon | About | Services | Maps

European Atlas of Natural Radiation

Do you know what natural ionising radiation is?
Where can you find natural sources of ionising radiation?
What are the levels of natural ionising radiation in Europe?
Do you know the pathways of ionising radiation?

cosmic radiation
cosmogenic radionuclides
terrestrial radiation
aquatic animals
aquatic plants
terrestrial radionuclides in soil/rock
terrestrial radionuclides in water
external radiation
INHALATION/ INGESTION natural radionuclides
building material
indoor radon
food and beverages
animals
agricultural products
root uptake
drinking water
INHALATION
INGESTION

Online version

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EUROPEAN ATLAS OF NATURAL RADIATION

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EUROPEAN ATLAS OF NATURAL RADIATION

ePUB

Foreword	
1 Rationale	Introduction; Legal basis
2 General background information	Radiation physics; Sources of radiation; Geology; Statistics, measurement, mapping; Measurement methods
3 Terrestrial radionuclides	Uranium; thorium; potassium; European maps of U, Th and K ₂ O in bedrock
4 Terrestrial radiation	Source of terrestrial natural radiation; Dose rate; Materials and methods; Terrestrial dose rate mapping
5 Radon	Radon in soil gas; Radon exhalation rate; Outdoor radon; Indoor radon
6 Radionuclides in water and river sediments	Introduction; Natural radionuclides...; Measurement methods; Activity concentration...; Applications; Challenges...
7 Radionuclides in food	Materials and methods; Applications; Discussion and conclusions
8 Cosmic radiation...	Cosmic-ray dose map; Cosmogenic radionuclides
9 Annual effective dose...	Introduction; Materials and methods; Results
10 References and appendices	References; Appendices: 1 - The International System of Units (SI), 2 - Country ISO codes 3 - List of national competent authorities 4 - Periodic Table of the Elements

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Let's focus on radon

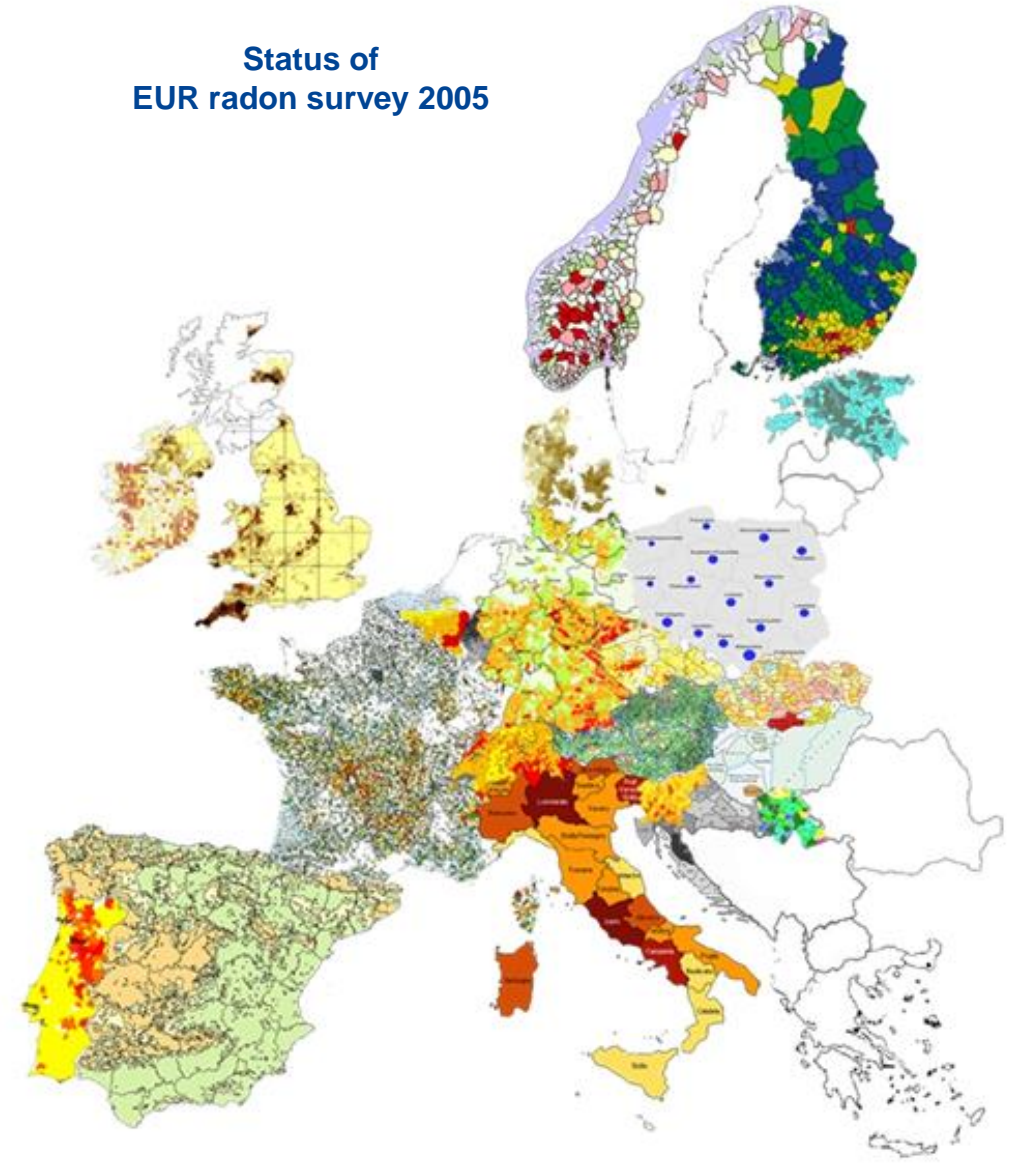
EUR radon survey 2005:

- Many countries had radon “maps” (indoor conc., radon potential etc.)
- Measurement techniques and strategies differ between countries
- Different mapping methods and visualization techniques
- => Colourful patchwork (but not very useful for analysis)

Prague Radon conference 2006:

- JRC decided to collect statistics of indoor radon data from National Authorities on 10 km x 10 km grid cells

Status of
EUR radon survey 2005



Dubois, G. (2005): An Overview of
Radon Surveys in Europe
EUR Report 21892

Meetings organized

- 2008 Oslo (NO): Geological Aspects of Radon Risk Mapping (GARRM) at the 33rd International Geological Congress
- **2010 GARRM (Prague): Round Table: *Geogenic radon potential map of Europe***
- 2011 JRC (Ispra): *European Geogenic Radon Map (EGRM) workshop*
- **2012 GARRM (Prague): Round Table: *European Geogenic Radon Map***
- **2014 GARRM (Prague): Round Table: *The European Geogenic Radon Map and the European Atlas of Natural Radiation***
- 2015 Verbania (IT): 1st International Workshop on the European Atlas of Natural Radiation
- 2017 Verbania (IT): 2nd International Workshop on the European Atlas of Natural Radiation
- **2018 GARRM (Prague): World Café: Future challenges in the field of natural radiation that could be addressed at the European level**



2021 GARRM (Prague): Round Table: Lesson learned from the European Atlas of Natural Radiation publication

Why is this so important?

- Due to the health risk posed by indoor radon, it is attempted to regulate it.
- For Europe, this is laid down in the Basic Safety Standards (BSS). Obligatory for EU Member States.
- To this aim: Radon Action Plans, i.e. measures which should be taken to reduce or to mitigate the risk.
- One action is to find out the geographical distribution of the level of the risk (quantified by indoor Rn concentration), as one basis to decide which measure to take.
- This means performing Rn surveys, whose results may be presented as maps.

Official Journal L 13
of the European Union ISSN 1977-0677

 Volume 57
English edition Legislation 17 January 2014

Contents

II Non-legislative acts

DIRECTIVES

★ Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom 1

Price: EUR 4

EN Acts whose titles are printed in light type are those relating to day-to-day management of agricultural matters, and are generally valid for a limited period.
The titles of all other acts are printed in bold type and preceded by an asterisk.

<https://eur-lex.europa.eu/eli/dir/2013/59/oj>

European Indoor Radon Map

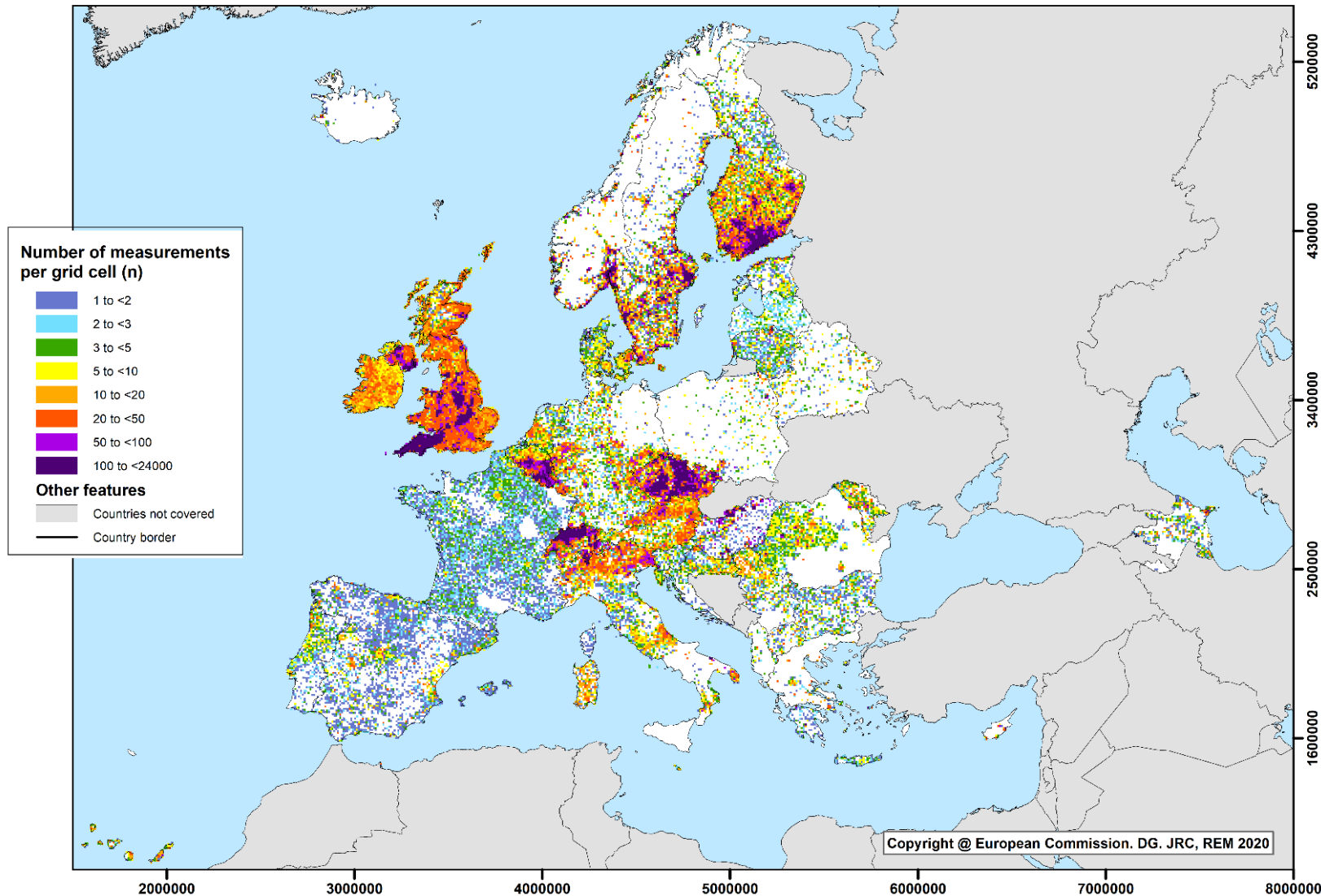
- 10 km x 10 km grid cells
- Living rooms, ground floor
- Participants send statistics:
 - ✓ Arithmetic mean (AM);
 - ✓ Standard deviation (SD);
 - ✓ AM and SD of the ln-transformed data;
 - ✓ Median (MED);
 - ✓ Minimum (Min) and maximum (Max);
 - ✓ Number of original measurements per cell (N).

Participants:

- 2007: AT, CH, FI, LT, PL, UK
- 2008: BE, CZ, DE, EE, ES, PT
- 2009: AL, DK, FR, HR, IT, NL, SI
- 2010: GR, HU, MK
- 2011: NO, RO
- 2012:
- 2013:
- 2014: IS
- 2015: AZ, BG, IE, MT, SE
- 2016:
- 2017: LU
- 2018: BY, CY, LV, RS
- 2020: MD

NEW

European Indoor Radon Map: Number of measurements



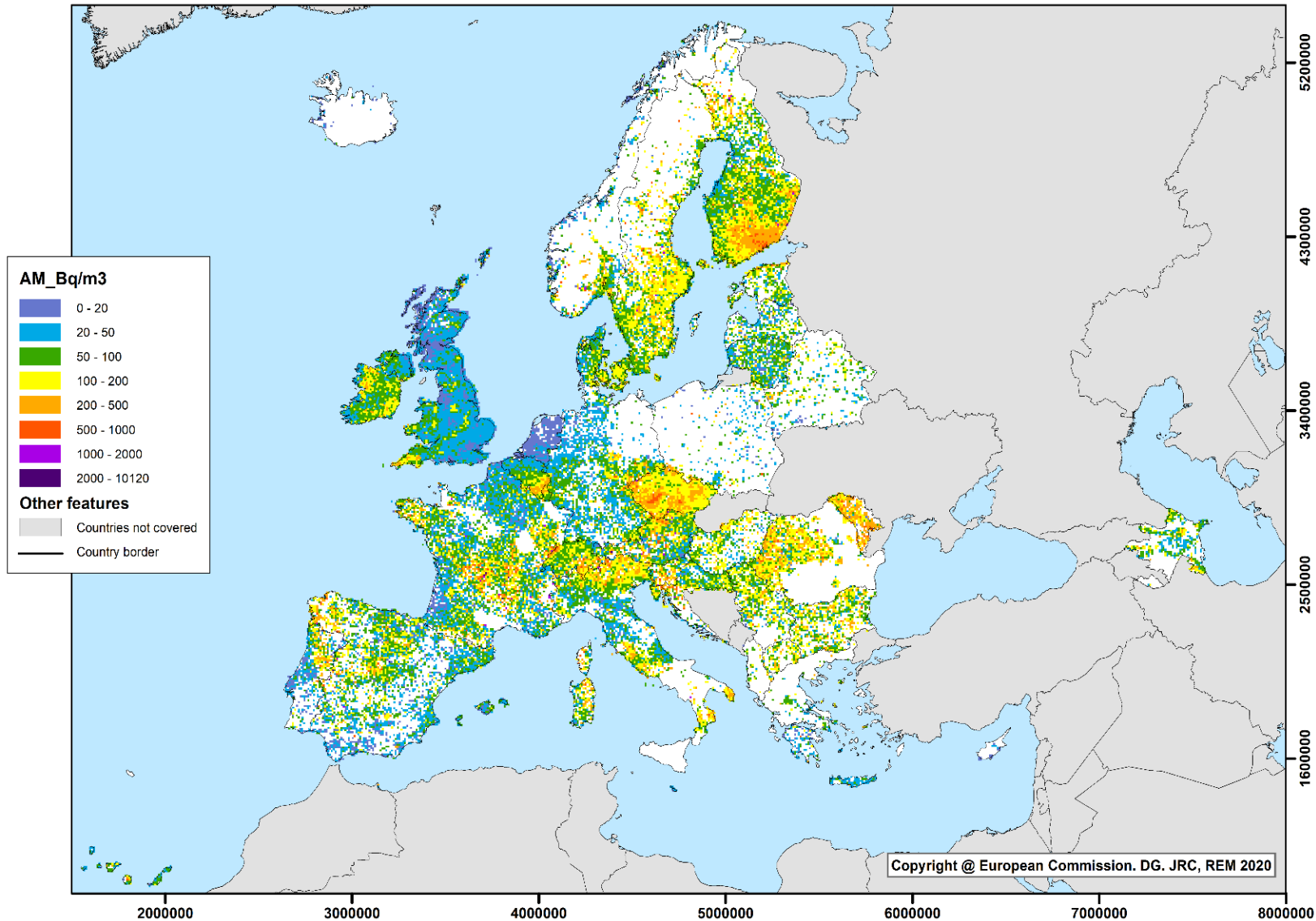
Status (Dec 2020):

- 36 countries
- ~29,000 non-empty cells
- MED: 4 measurements per cell
- Min/Max: 1/23993
- ~1,160,000 original measurements

Number of measurements per 10 km x 10 km cell of long-term radon concentration in ground-floor rooms.
(The cell mean is neither an estimate of the population exposure, nor of the risk)

Source:
European Commission, Joint Research Centre (JRC),
Directorate G - Nuclear Safety & Security, REM project

European Indoor Radon Map: Arithmetic mean in Bq/m³



Status (Dec 2020):

- AM: **104 Bq/m³**
- % of cells with AM > 300 Bq/m³: **4.53%**
- % of cells with AM > 100 Bq/m³: **34.9%**

Arithmetic means over 10 km x 10 km cells of long-term radon concentration in ground-floor rooms.
(The cell mean is neither an estimate of the population exposure, nor of the risk.)

Source:
European Commission, Joint Research Centre (JRC),
Directorate G - Nuclear Safety & Security, REM project

Examples of using Atlas' data

➤ MetroRADON

➤ TraceRadon

- ✓ EMPIR projects: European Metrology Programme for Innovation and Research
- ✓ Organized by EURAMET
- ✓ Co-funded by the European Union's Horizon 2020 programme and the EMPIR Participating States



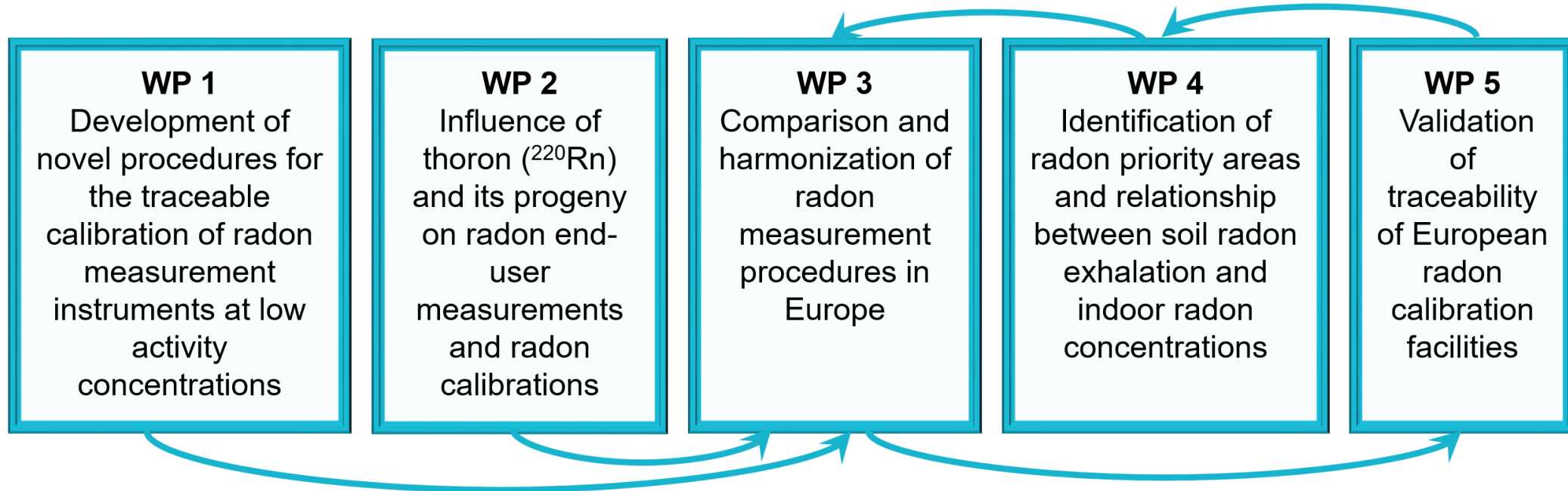
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

EURAMET, as the Regional Metrology Organisation (RMO) of Europe, has 37 member countries. It leads cooperation of National Metrology Institutes (NMI) with nearly 6000 metrologists in the development of the European metrology infrastructure and services. It represents Europe in the international metrology forum of the CGPM (General Conference of Weights and Measures).

www.euramet.org

EMPIR 16ENV10 MetroRADON

June 2017 - November 2020



Deliverables and Activity Reports available from:

<http://metroradon.eu/>

MetroRadon Geogenic Radon Hazard Index- GRHI



16ENV10 MetroRADON

Deliverable 6

Report on the concept and establishment of a Radon Hazard Index (RHI) including an RHI map of Europe showing areas with high geogenic radon potential and conclusions on the relationships and correlation between indoor Rn concentration and quantities related to geogenic Rn.

Lead organisation: European Commission, Joint Research Center (JRC)
Other involved organisations: JRC, BEV-PTP, BFKH, VINS, AGES, BFS, IRSN, SUBG, UC

Due date: March 2020
Submission: November 2020



The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Open Access Review

Development of a Geogenic Radon Hazard Index— Concept, History, Experiences

by Peter Bossew^{1,*}, Giorgia Cinelli^{2,*}, Giancarlo Ciotoli³, Quentin G. Crowley⁴, Marc De Cort², Javier Elio Medina⁵, Valeria Gruber⁶, Eric Petermann¹ and Tore Tollefsen²

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- ² European Commission, Joint Research Centre (JRC), 21027 Ispra, Italy
- ³ Institute of Environmental Geology and Geoengineering, National Research Council, Rome 00015, Italy
- ⁴ School of Natural Sciences, Geology, Trinity College, D02 PN40 Dublin, Ireland
- ⁵ Department of Planning, Aalborg University, 2450 Copenhagen, Denmark
- ⁶ Department for Radon and Radioecology, Austrian Agency for Health and Food Safety (AGES), 4020 Linz, Austria
- * Authors to whom correspondence should be addressed.

Int. J. Environ. Res. Public Health 2020, 17(11), 4134; <https://doi.org/10.3390/ijerph17114134>

Received: 20 April 2020 / Revised: 2 June 2020 / Accepted: 3 June 2020 / Published: 10 June 2020

(This article belongs to the Special Issue Radon Risk and Metrology)

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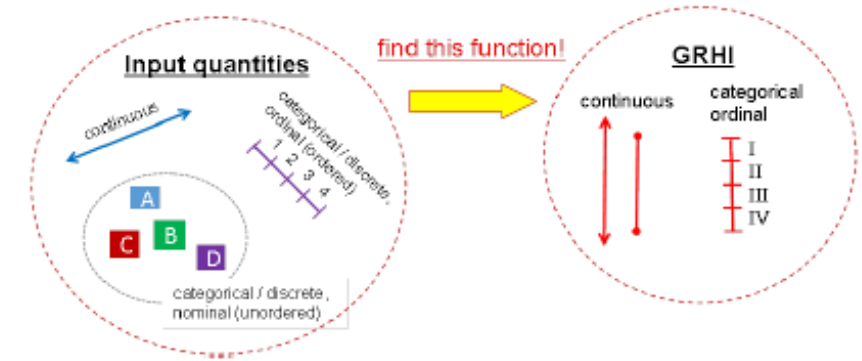
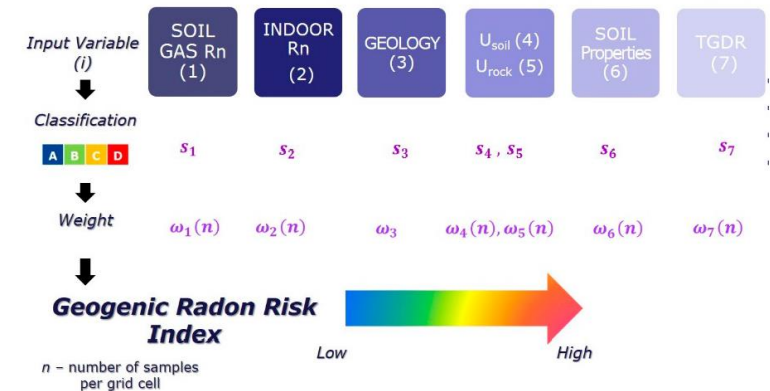


Figure 44: Construction of different types of GRHI-quantity from different types of input quantities.

Grid 10 km x 10 km

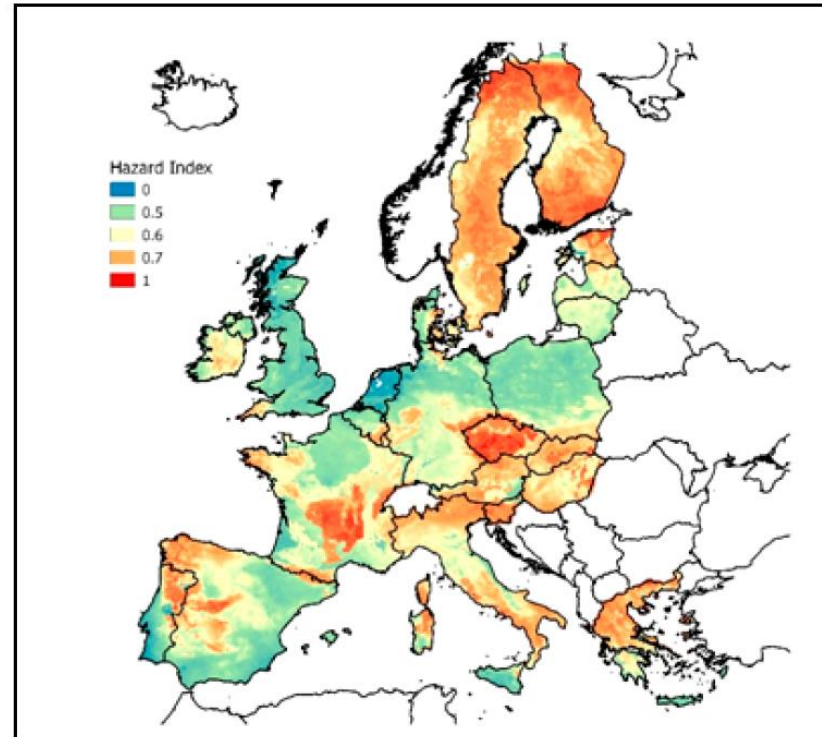
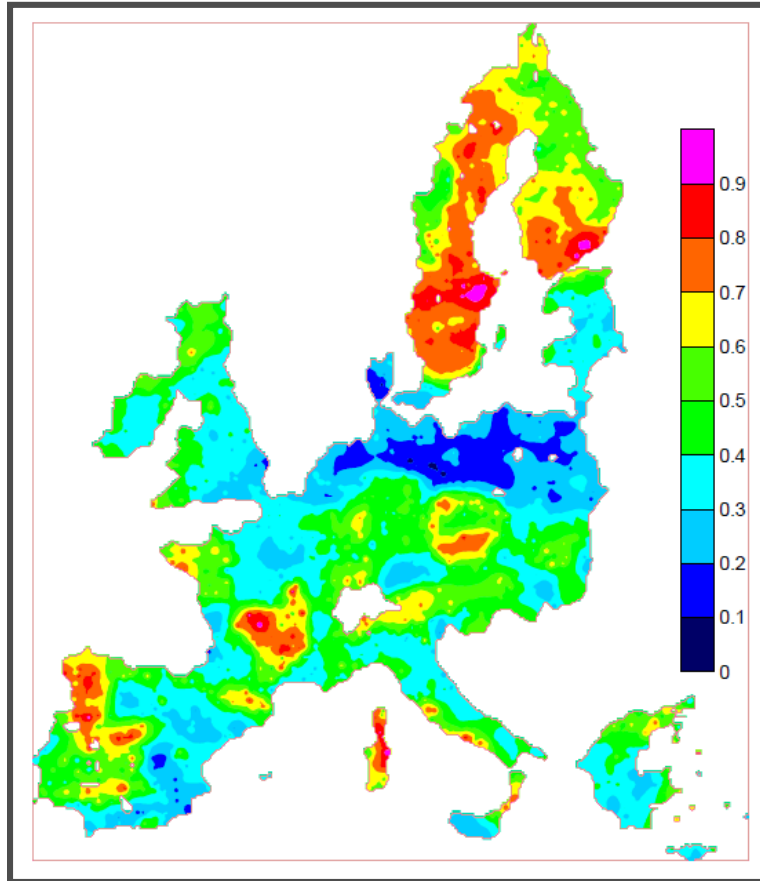


Concept: Multivariate classification (source: JRC)

Available from: <http://metroradon.eu>

Bossew, P., Cinelli, G., Ciotoli, G., Crowley, Q.G., De Cort, M., Elio Medina, J., Gruber, V., Petermann, E., Tollefsen, T., 2020: Development of a Geogenic Radon Hazard Index – concept, history, experiences, IJERPH 2020, 17(11), 4134 (2020), <https://doi.org/10.3390/ijerph17114134>

Trials of a European map of Geogenic Radon Hazard Index



The Geogenic Radon Hazard index: this quantity attempts to quantify the contribution of geogenic quantities (geochemical concentration, soil and rock types and properties etc.)

Estimated by regression of indoor Rn concentration (Atlas database) against geogenic predictors;

left: multiple regression / general linear model;

right: machine learning/ Multivariate Adaptive Regression Splines

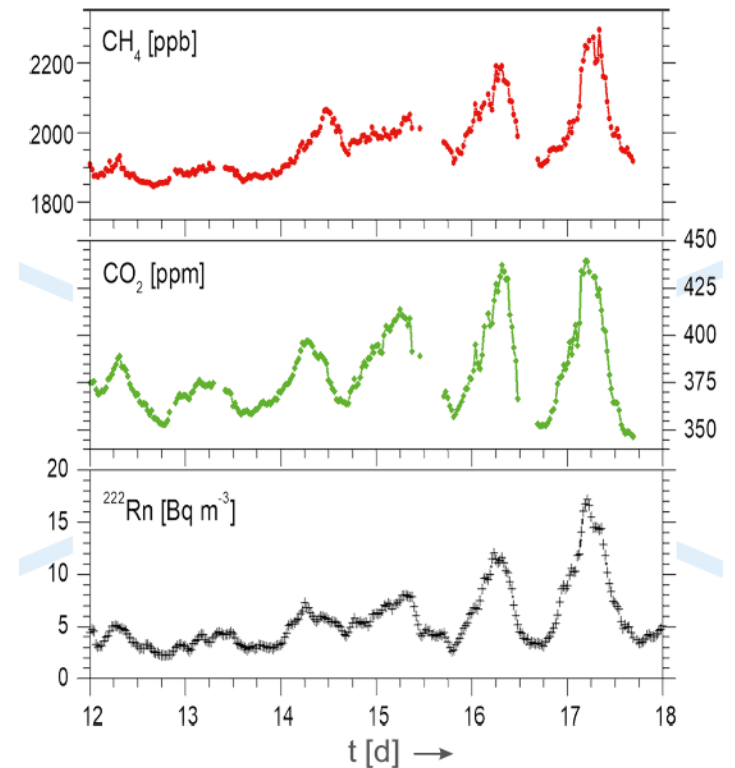
from Bossew et al. (2020). Development of a Geogenic Radon Hazard Index—Concept, History, Experiences. Int. J. Environ. Res. Public Health, 17, 4134; doi:10.3390/ijerph17114134

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

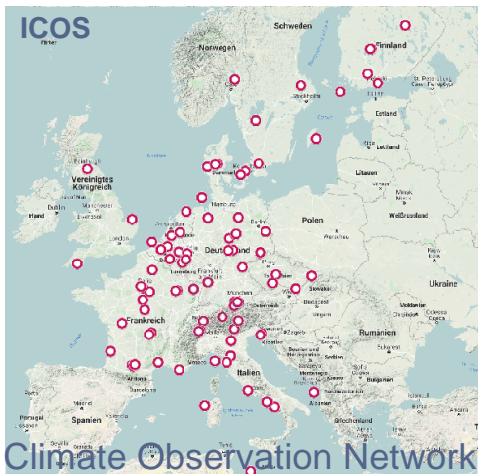
The temperature rise of the atmosphere of our planet, due to the greenhouse effect, is caused by the increase of greenhouse gases (GHGs) emissions.

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!**
- Determine source terms of GHG



EMPIR 19ENV01 traceRadon

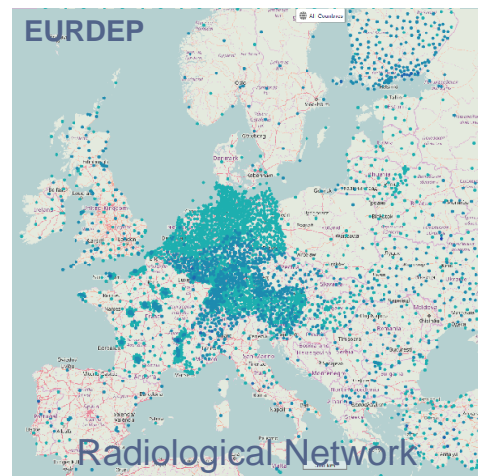


Two networks could profit from outdoor radon measurements:

- **ICOS (Integrated Carbon Observation System):** 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.

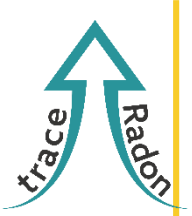
ICOS Atmospheric Station Specifications:

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."



- **EURDEP (European Radiological Data Exchange Platform):** Collection and exchange of radiological monitoring data between participating countries of the radiation in the environment.

But **traceability to the SI system** is not established yet.

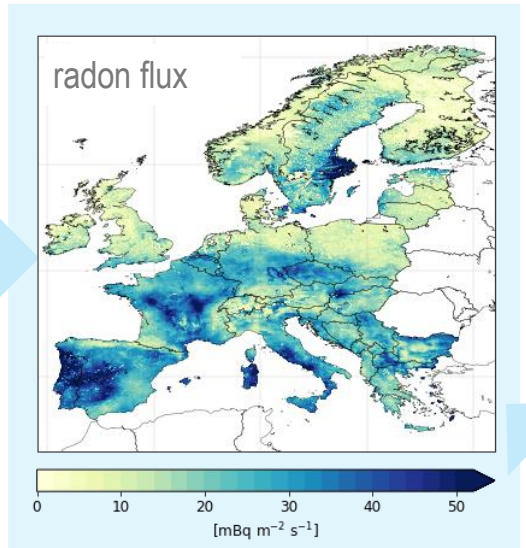
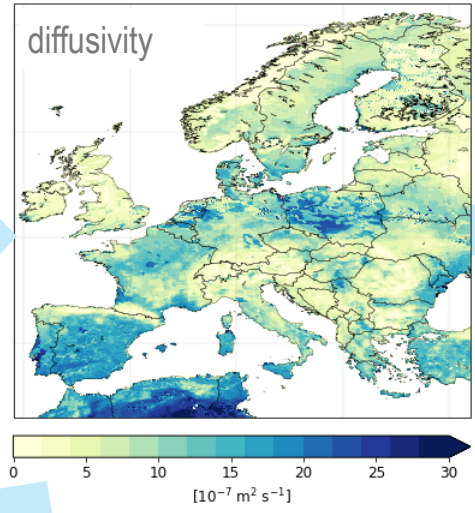
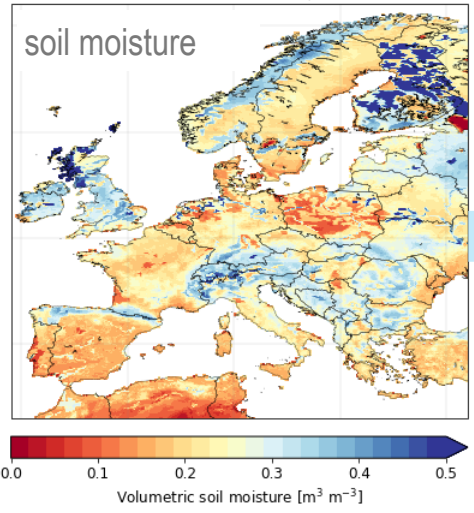


Process-based Radon flux map: components and workflow



monthly

ERA5-Land reanalysis



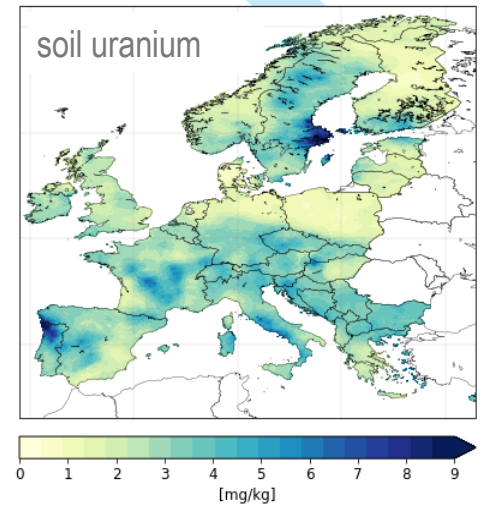
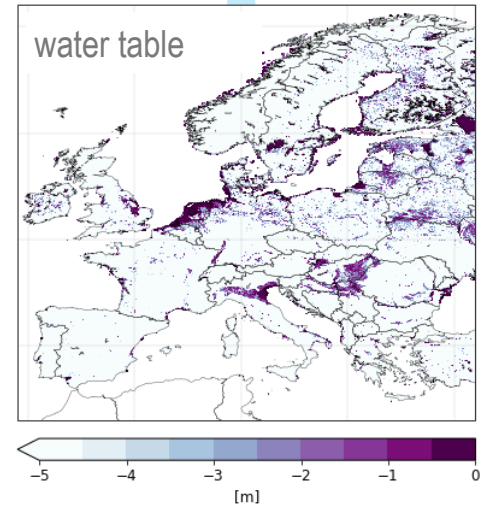
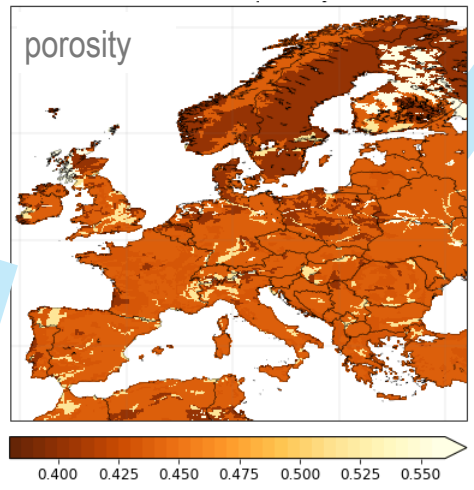
static

European Soil Database

soil texture

- % clay
- % sand
- % silt

bulk density



European Atlas of Natural Radiation



Hiederer, R. 2013. Mapping Soil Properties for Europe
doi:10.2788/94128

Keep in touch



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Thank you



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