



European Atlas of Natural Radiation

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Webinar – European Radon Association



JRC Mission

As the science and knowledge service of the European Commission, our mission is to support EU policies with independent evidence throughout the whole policy cycle.

JRC sites

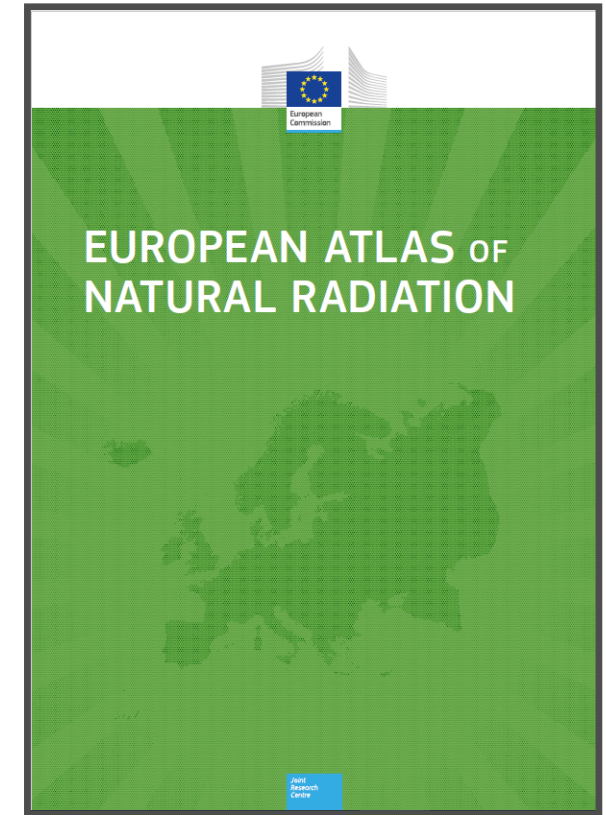
Headquarters in **Brussels**
and research facilities located
in **5 Member States:**

- Belgium (Geel)
- Germany (Karlsruhe)
- Italy (Ispra)
- The Netherlands (Petten)
- Spain (Seville)



Aims of the Atlas project

- Provide *reference values* as well as *harmonised* data for the scientific community and national competent authorities
- Address a wider public:
 - ✓ to familiarise it with natural radioactivity
 - ✓ to informed it about levels of natural radioactivity caused by different sources
 - ✓ to have a more balanced view of the annual dose received by the world's population



A bit of history

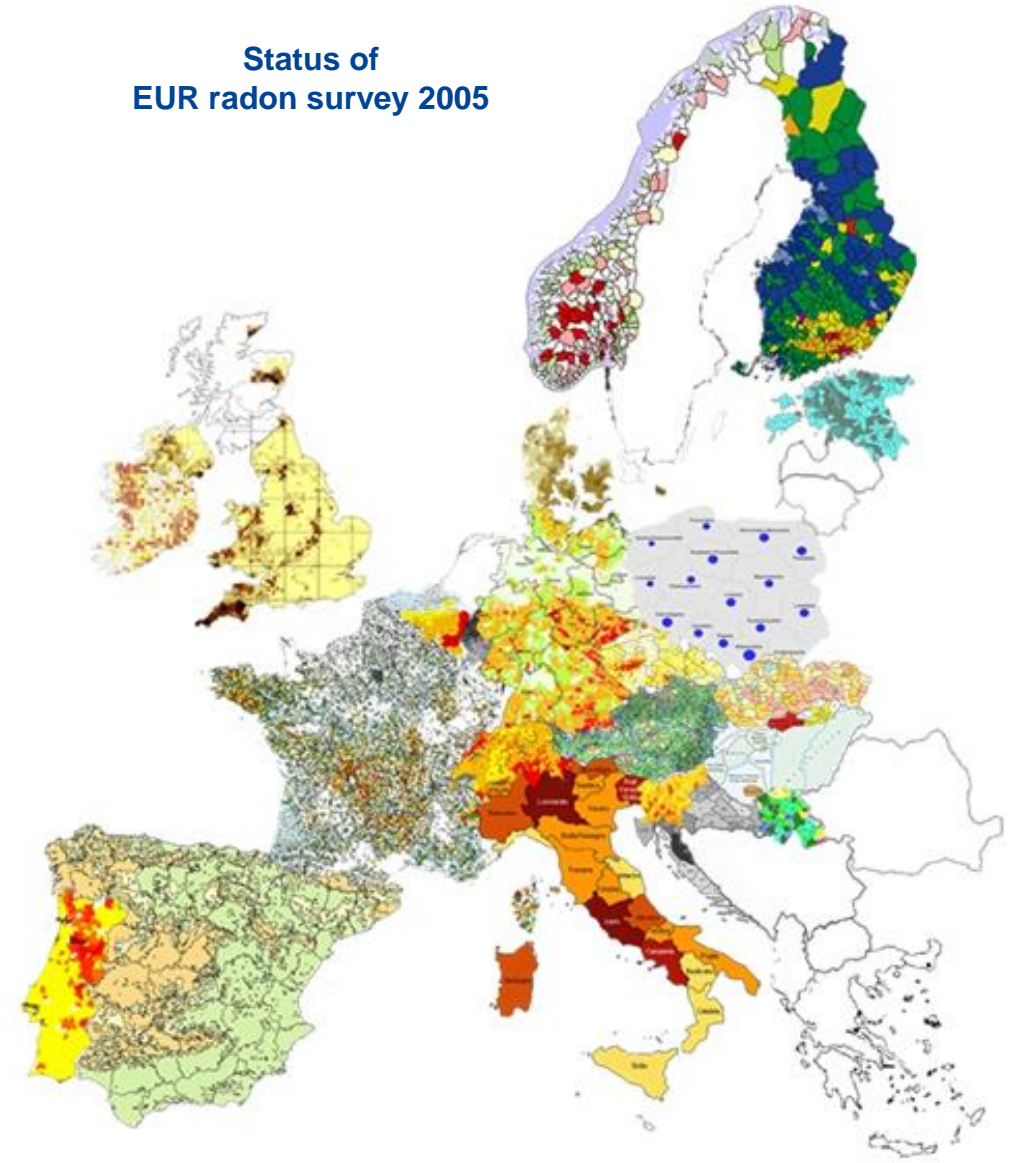
EUR radon survey 2005:

- 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

Why is radon so important?

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

Official Journal L 13
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 English edition Legislation Volume 57
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

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>

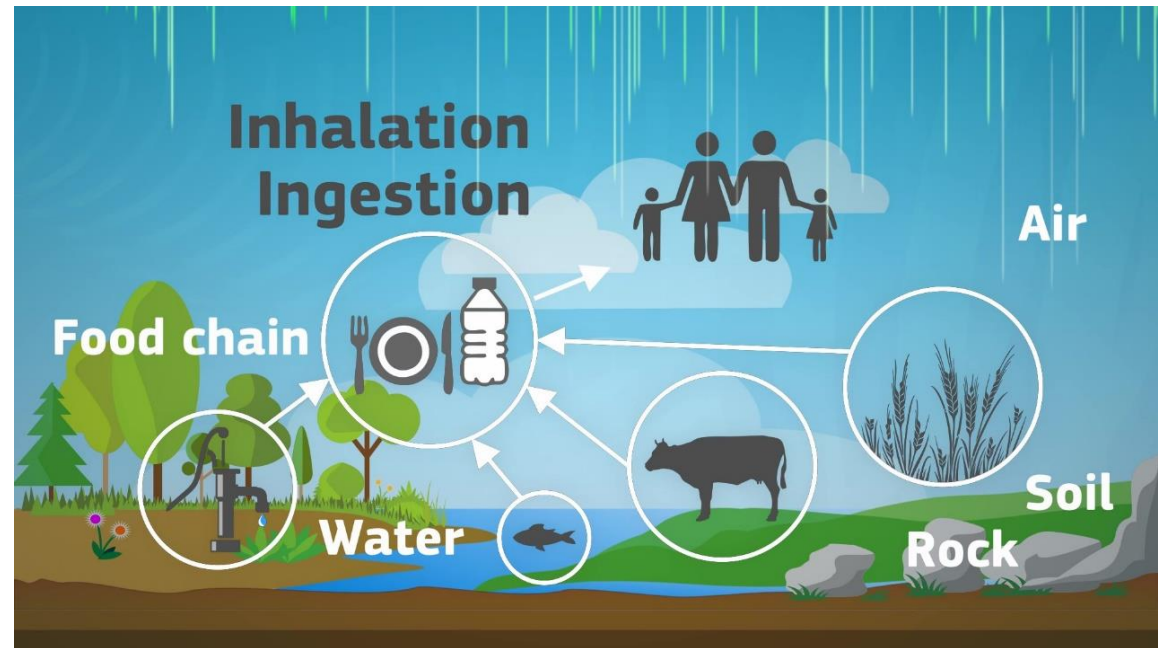
Meetings organized

- 2008 Oslo (NO): Geological Aspects of Radon Risk Mapping (GARRM) at the 33rd International Geological Congress
- 2010 GARRM (Prague): RoundTable: *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

In addition to indoor radon map...

JRC decided to explore **all natural sources** of radiation and develop maps to display these sources*:

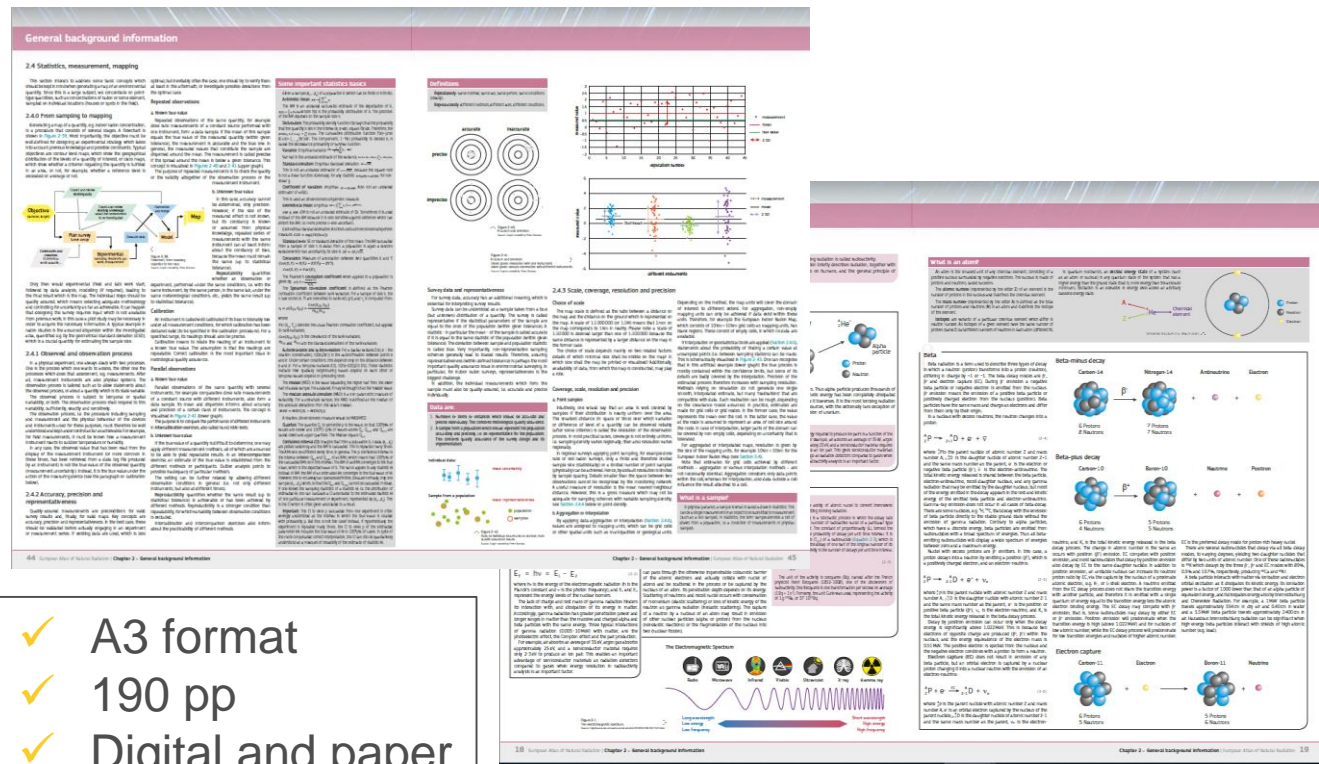
- Cosmic radiation
- U, Th and K in soil and rocks
- Terrestrial gamma dose rate



**Water and food: no maps developed but the topic and the state of art explored*

What is the Atlas? What does it contain?

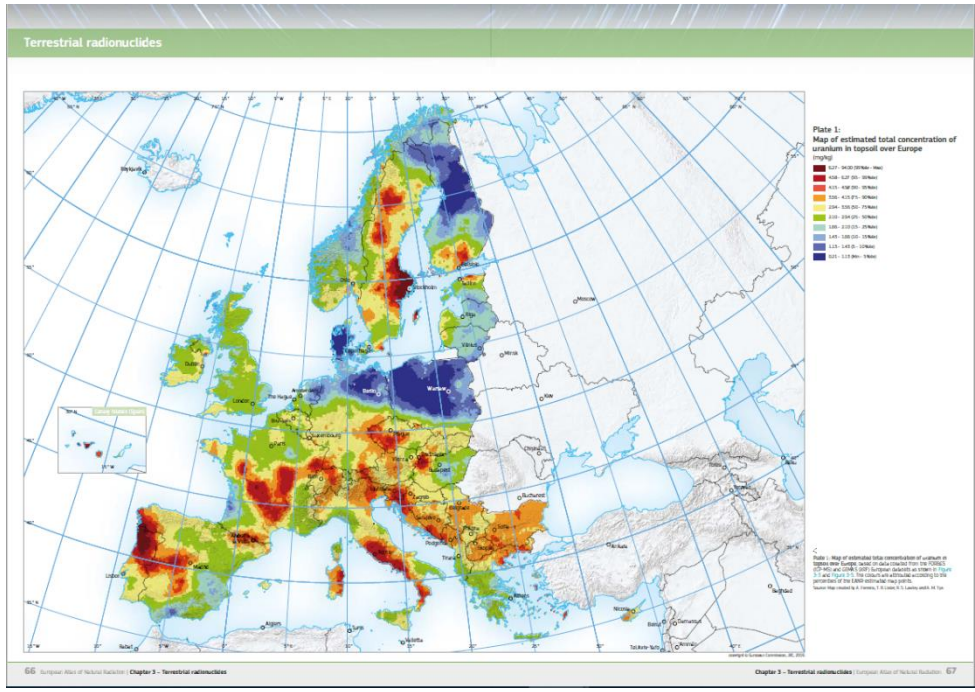
Encyclopaedia of natural radiation: it describes the different sources of this kind of radioactivity and represents the current state of knowledge on this topic.



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

Collection of maps of Europe that shows the levels of natural background radiation from various sources:

- cosmic radiation,
- terrestrial radionuclides (U, Th and K),
- terrestrial radiation,
- indoor radon



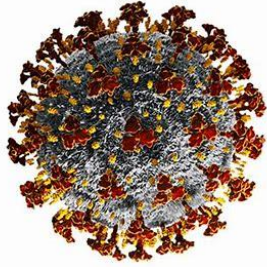
Who made the Atlas possible?

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.
©Monopoly919 - Adobe Stock.com

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

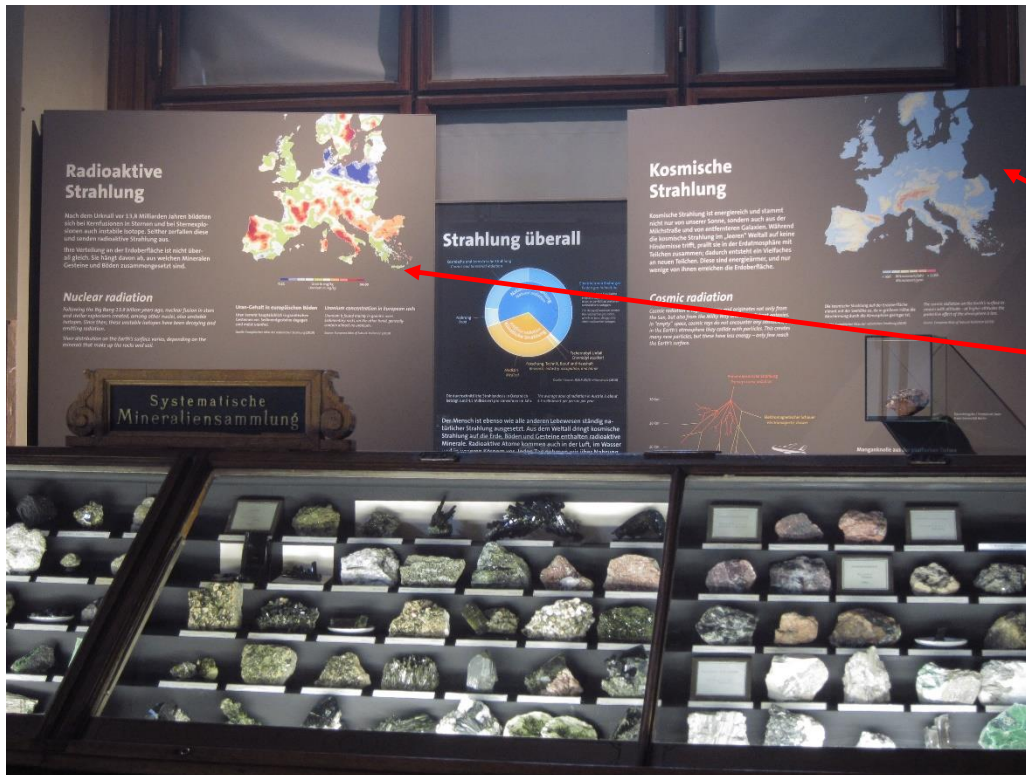


Special Exhibition

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.

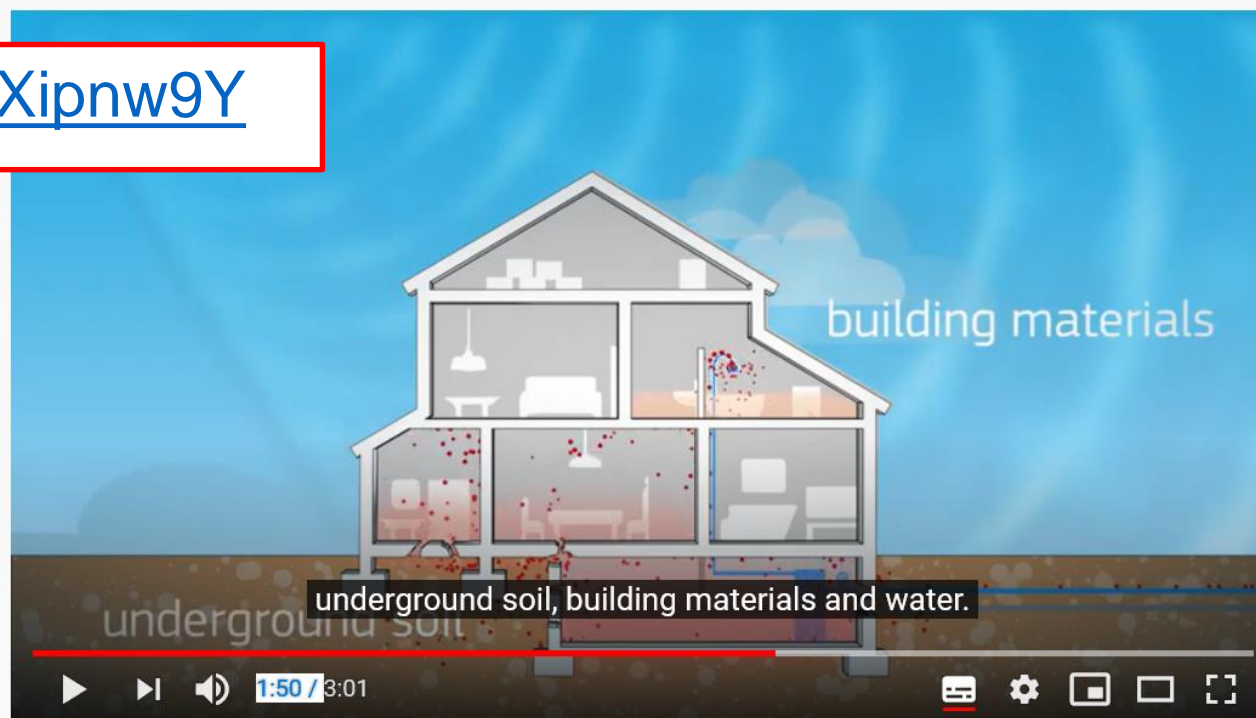


Maps of U concentration in soil and cosmic radiation from the European Atlas of Natural Radiation

Short Video
















<https://youtu.be/sQeWXipnw9Y>



European Atlas on natural radiation – sources, data and maps

Other languages available

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

16:9 Original	Download 	16:9 English	Download 
16:9 Français	Download 	16:9 Deutsch	Download 
16:9 Italiano	Download 	16:9 Espanol	Download 
16:9 Nederlands	Download 	16:9 English (English subtitle)	Download 
16:9 Français (Français subtitle)	Download 	16:9 Deutsch (Deutsch subtitle)	Download 
16:9 Italiano (Italiano subtitle)	Download 	16:9 Espanol (Espanol subtitle)	Download 
16:9 Nederlands (Nederlands subtitle)	Download 		

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

Download Publication

JOINT RESEARCH CENTRE
Radioactivity Environmental Monitoring

European Commission > EU Science Hub > REMON > Maps > Atlas of Natural Radiation

REMON About Services Maps

EUROPEAN ATLAS OF NATURAL RADIATION

PDF Adobe

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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European Indoor Radon Map

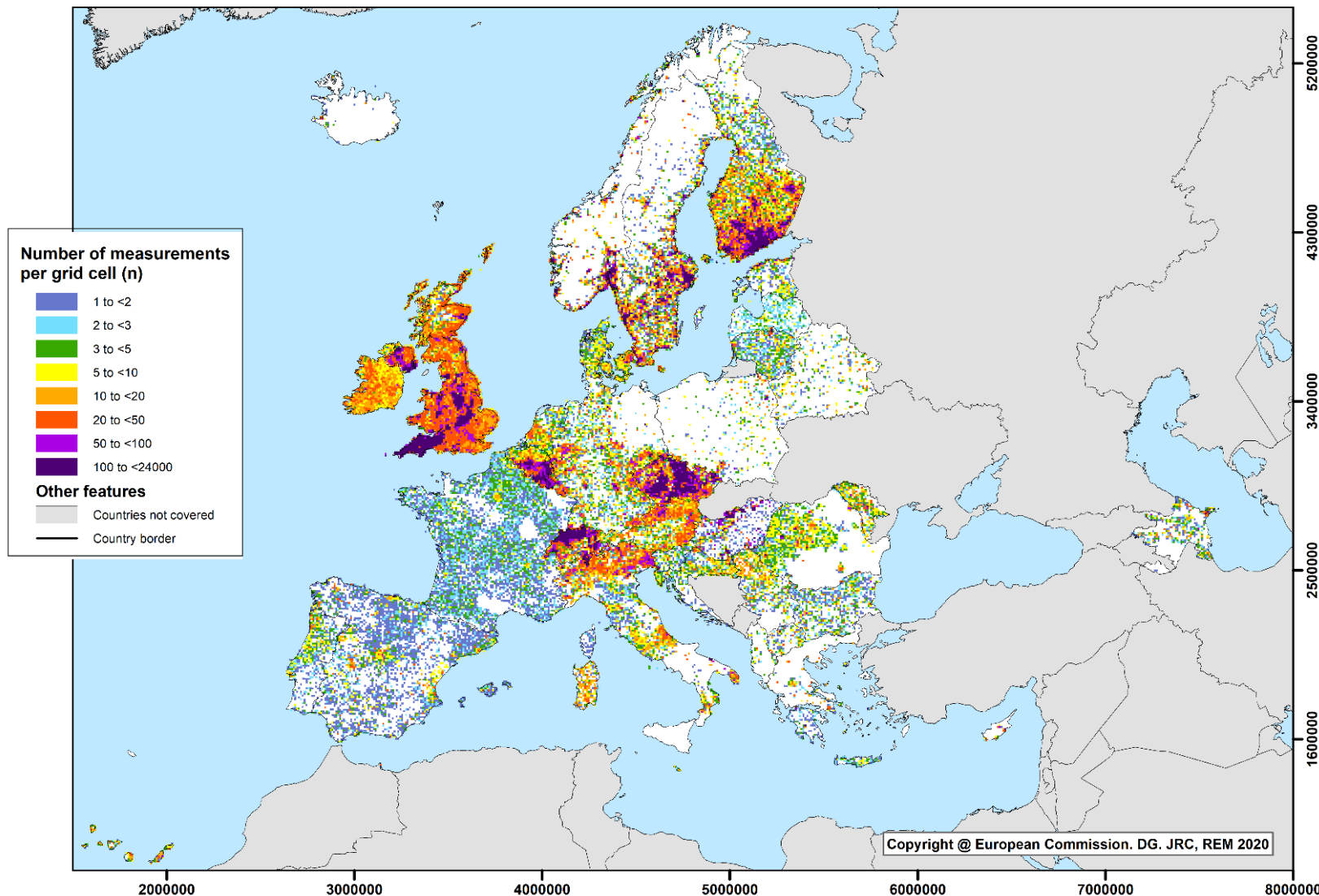
- 10 km x 10 km grid cells
- Living rooms, ground floor
- Participants send statistics:
 - ✓ Arithmetic mean (AM);
 - ✓ Standard deviation (SD);
 - ✓ AM and SD of the ln-transformed data;
 - ✓ Median (MED);
 - ✓ Minimum (Min) and maximum (Max);
 - ✓ Number of original measurements per cell (N).

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



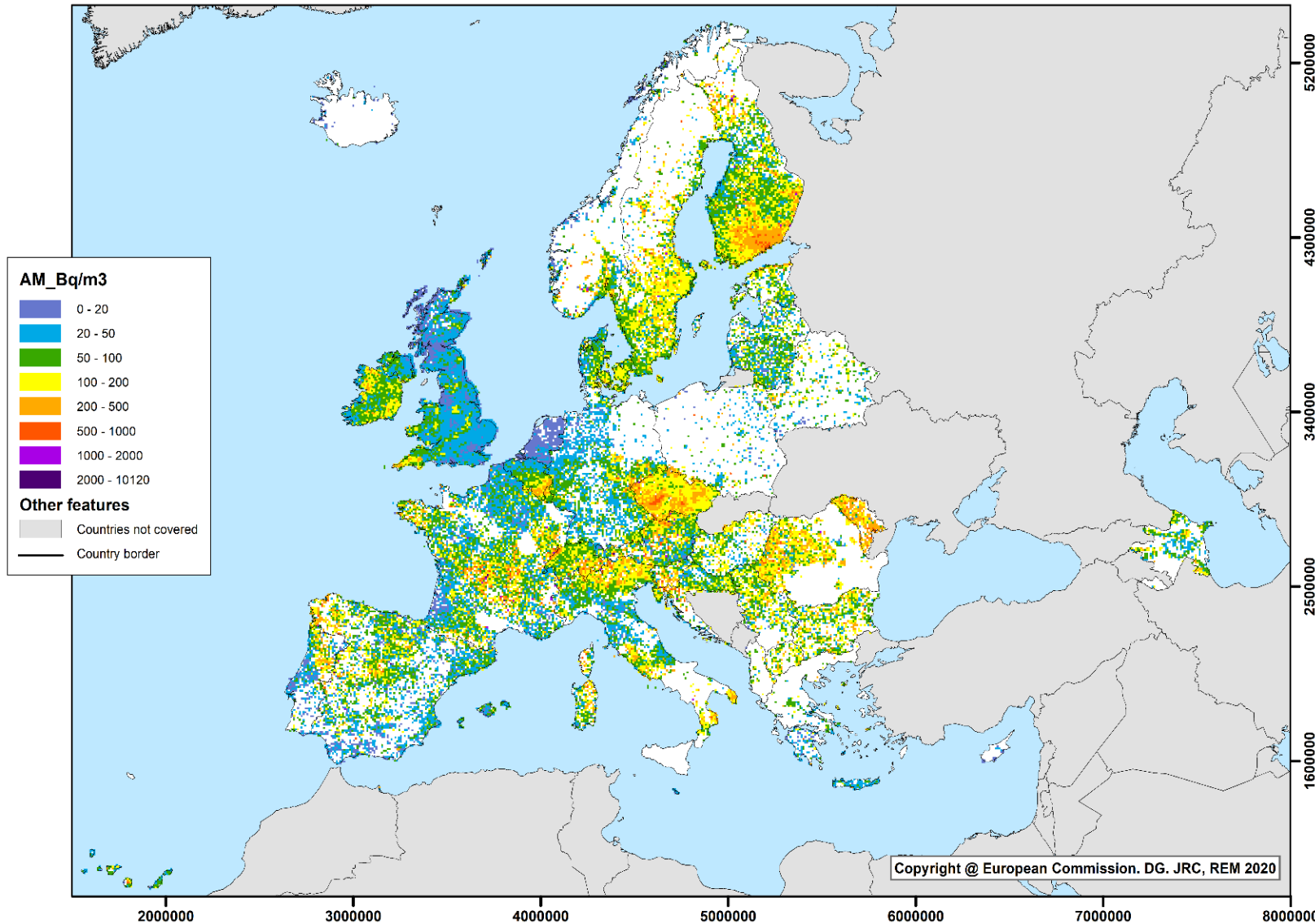
Status (Dec 2020):

- 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

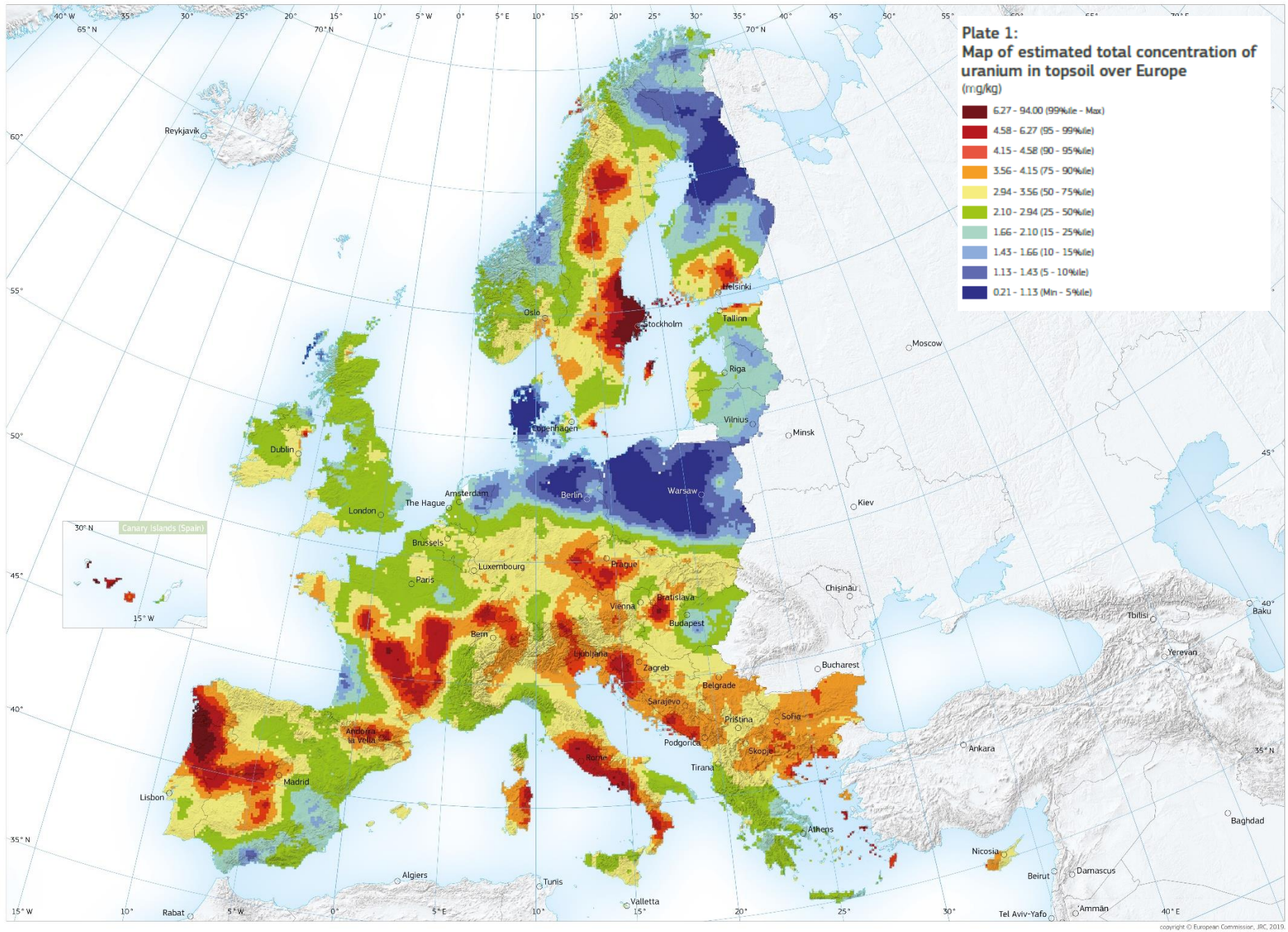


Status (Dec 2020):

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

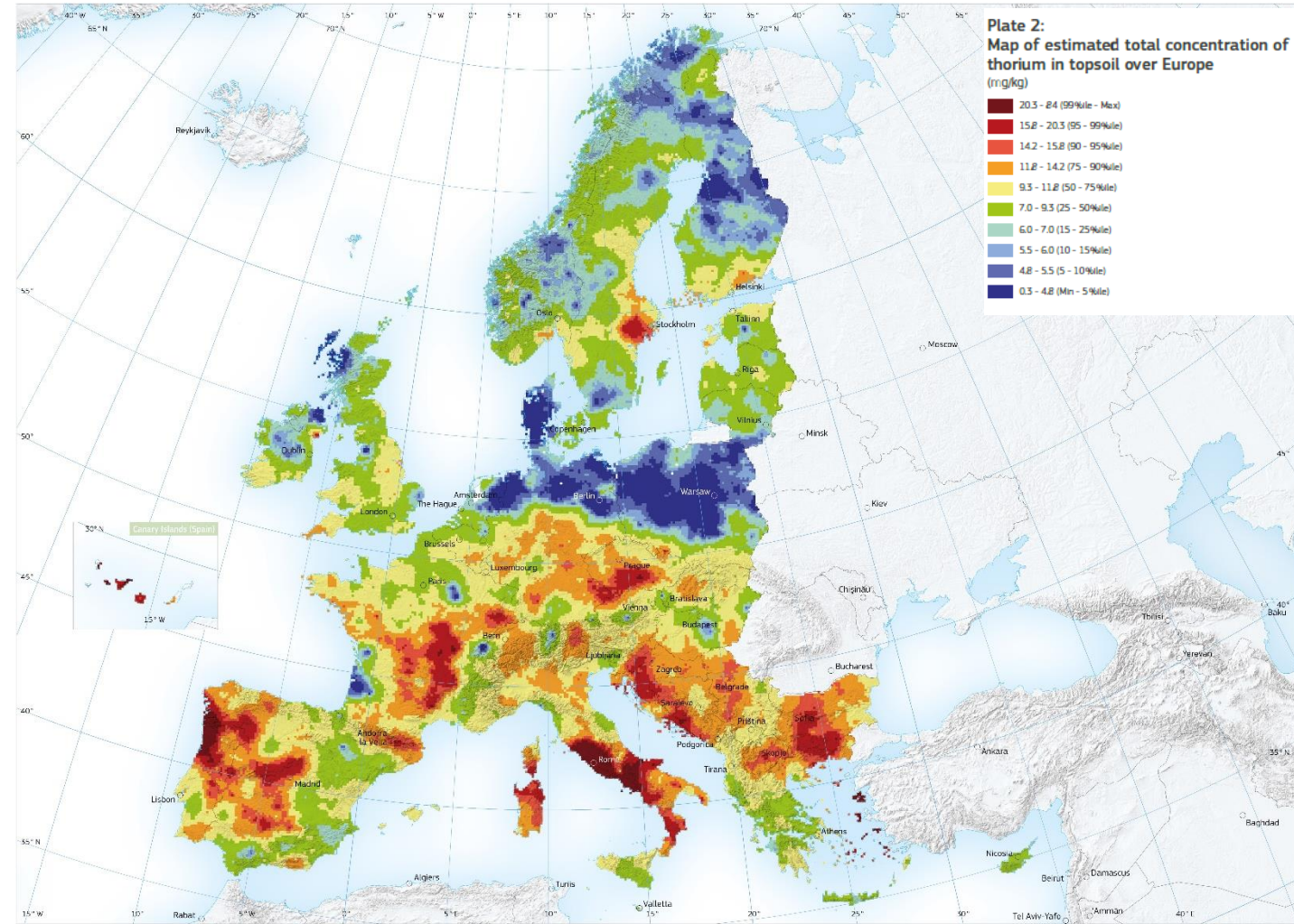
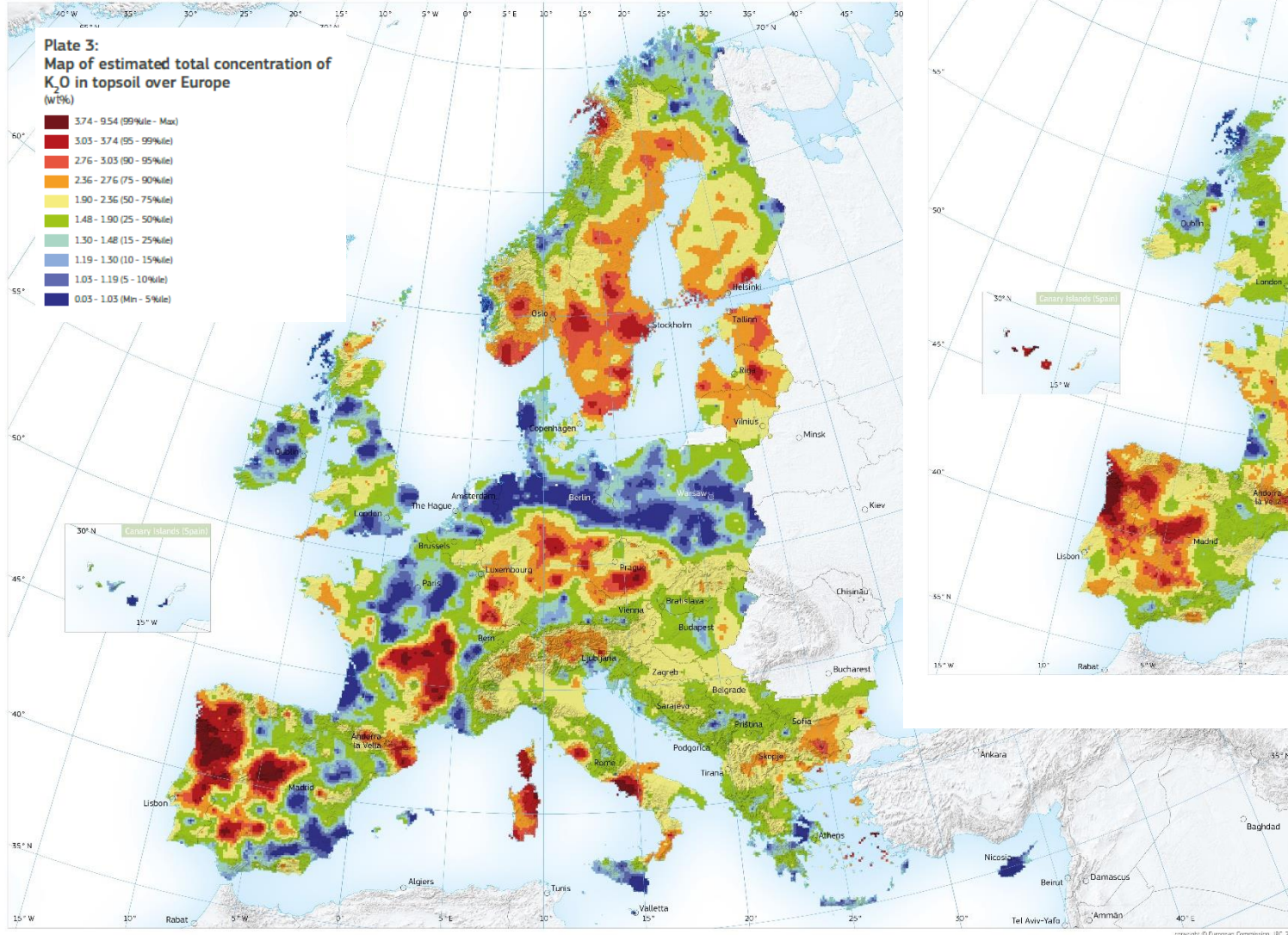
Arithmetic means over 10 km x 10 km cells of long-term radon concentration in ground-floor rooms.
(The cell mean is neither an estimate of the population exposure, nor of the risk.)

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

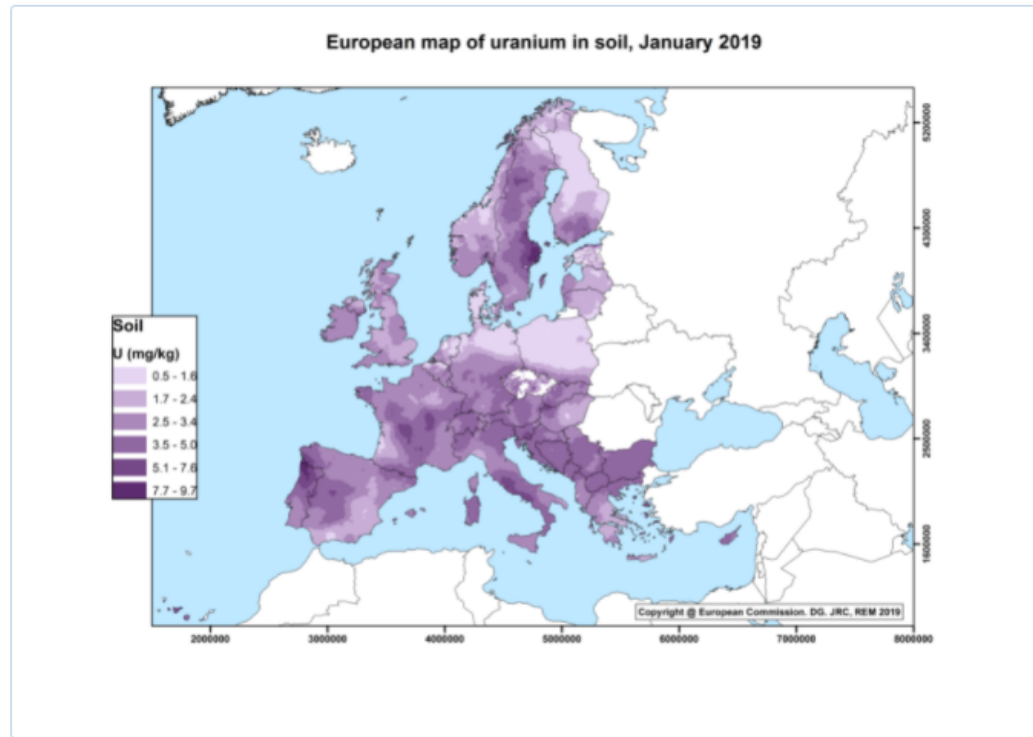


Source:
 Atlas Publication

Th and K₂O



Uranium concentration in soil

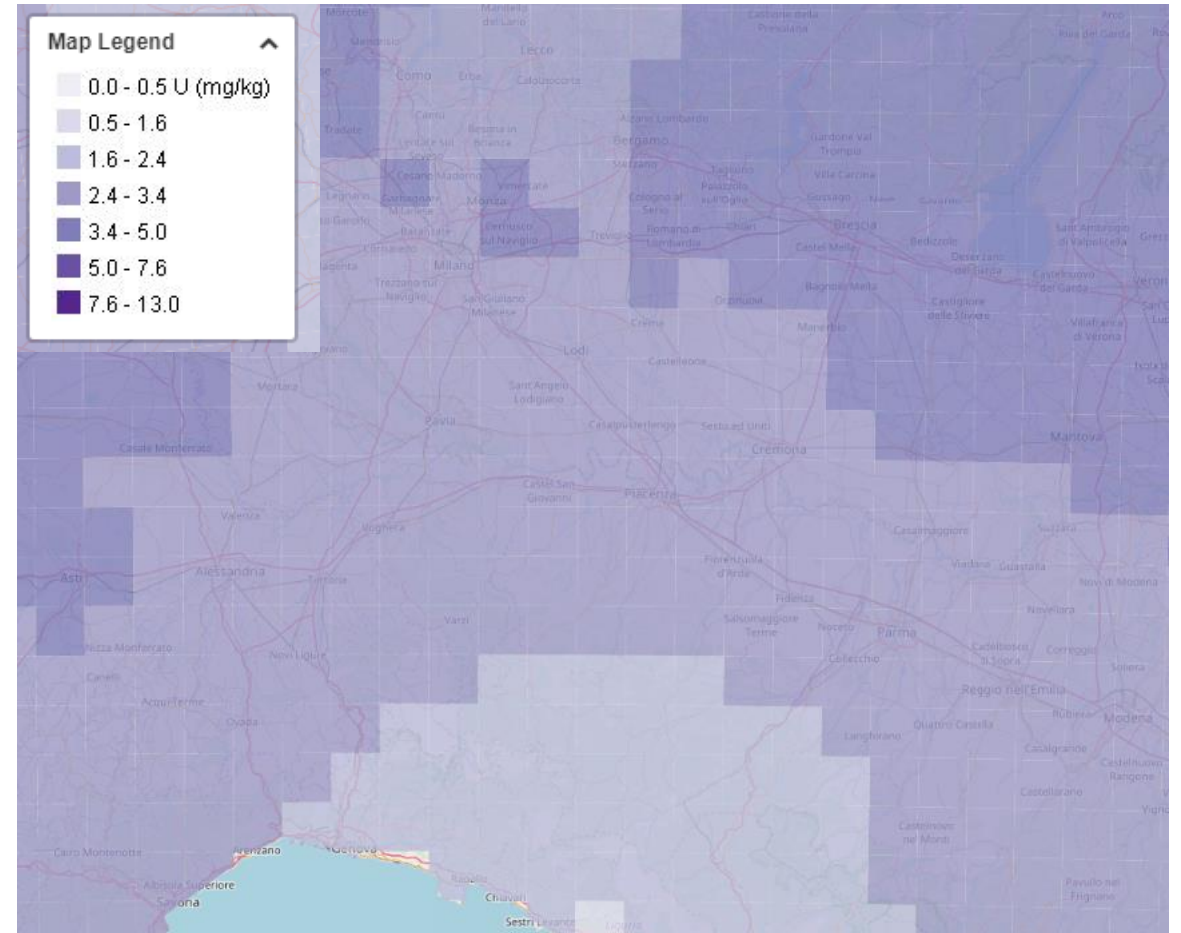


Description

The European uranium concentration in soil map displays the estimated concentration of uranium in soil over 10 km x 10 km grid cells. The map has been created using approximately 5000 data from topsoil samples belonging to two European databases: a) the Geochemical Atlas of Europe (<http://weppi.gtk.fi/publ/foregsatlas/index.php>), developed by the Forum of European Geological Surveys (FOREGS); and b) the Geochemical Mapping of Agricultural and Grazing Land soil in Europe (GEMAS; <http://gemas.geolba.ac.at/>), a project involving geochemistry experts from EuroGeoSurveys and Eurometaux organizations. The data were interpolated using ordinary kriging. For Belgium, the Czech Republic and Estonia, data from their national databases have been used.

References

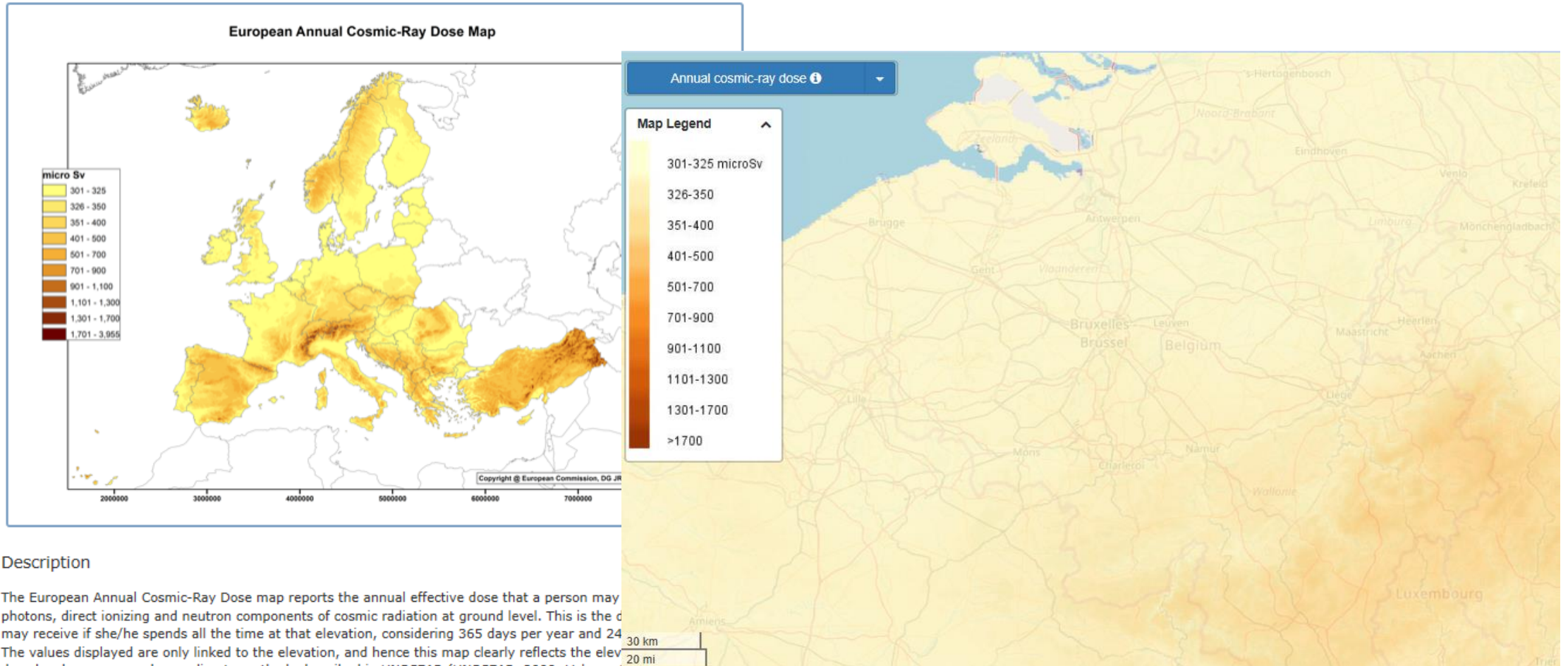
- Reimann C., Birke M., Demetriades A., Filzmoser P., O'Connor P. (2014a). Chemistry of Europe's Agricultural Soils. Part A: Methodology and Interpretation of GEMAS Data Set.-Geol.Jb.,B 102:528 pp., 358 figs, 86 Tables, 1DVD; Hannover.
- Reimann C., Birke M., Demetriades A., Filzmoser P., O'Connor P. (2014b). Chemistry of Europe's Agricultural Soils. Part B: General Background Information and Further Analysis of Gemas Data Set.-Geol.Jb.,B 103:352 pp., 121 figs, 58 Tables, 3 App; Hannover.



Source:
Digital Atlas

Annual cosmic-ray dose

[← Back to the list of maps](#)



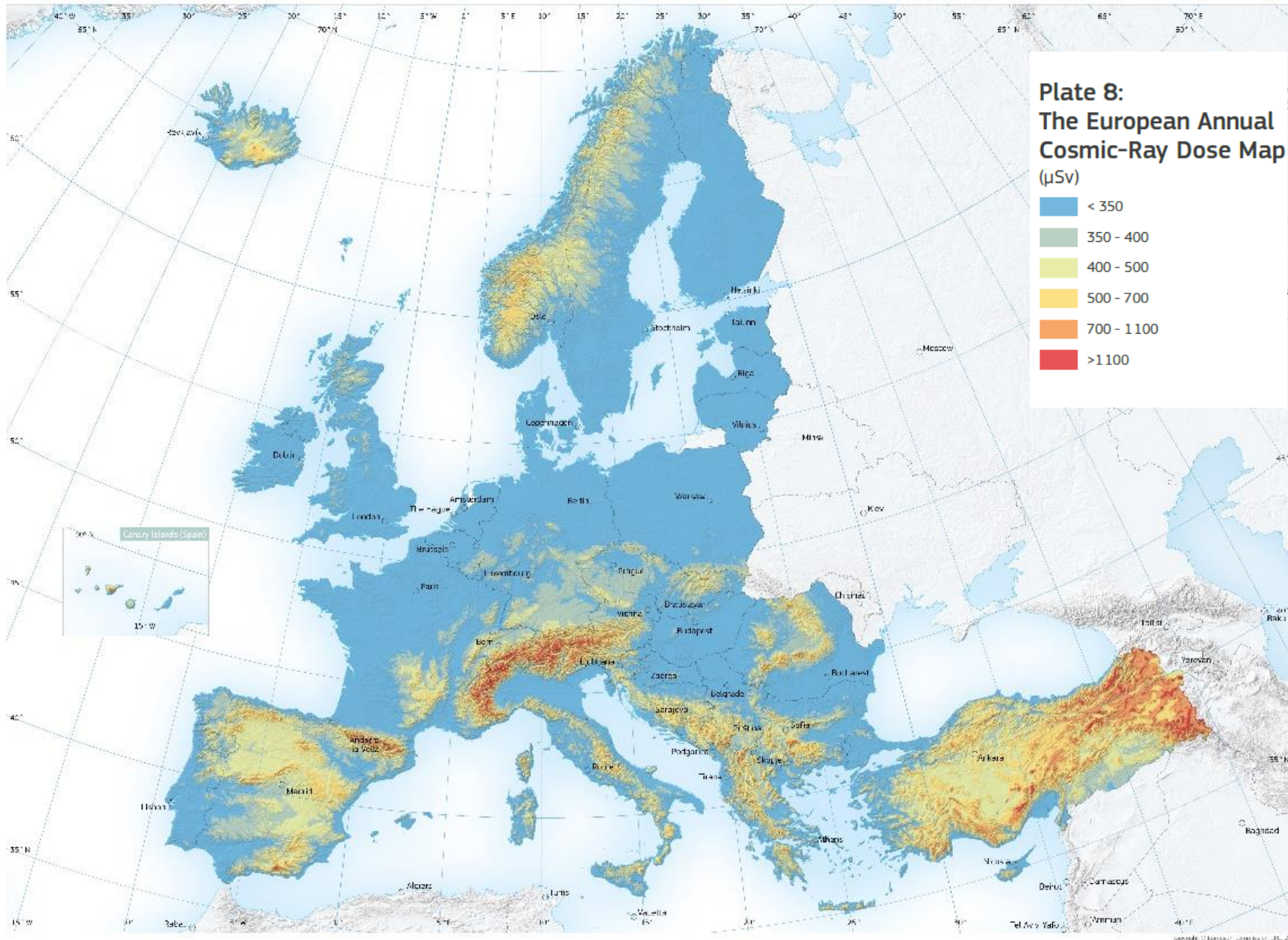
Description

The European Annual Cosmic-Ray Dose map reports the annual effective dose that a person may receive if she/he spends all the time at that elevation, considering 365 days per year and 24 hours per day. The values displayed are only linked to the elevation, and hence this map clearly reflects the elevation. The dose has been assessed according to methods described in UNSCEAR (UNSCEAR, 2008: Volume 1, Annex B, Chap.2) and a global digital elevation model (DEM), called the GTOPO30 dataset (<https://lta.cr.usgs.gov/GTOPO30>), was used. Such a dataset was derived from several raster and vector sources of topographic information and is a raster georeferenced TIFF with a horizontal grid spacing of 30 arc seconds (approximately 1 km).

References

- Giorgia Cinelli, Valeria Gruber, Luca De Felice, Peter Bossew, Miguel Angel Hernandez-Ceballos, Tore Tollefsen, Stefan Mundigl & Marc De Cort. *European annual cosmic-ray dose: estimation of population exposure*. Journal of Maps Vol. 13, Iss. 2, 2017. <http://dx.doi.org/10.1080/17445647.2017.1384934>
- UNSCEAR (United Nations Scientific Committee on the effects of Atomic Radiation) (2008). Sources and effects of ionizing radiation. Report to General Assembly, Annex B, United Nations, New York.

Source:
Digital Atlas



The European Annual Cosmic-Ray Dose Map (μSv)

Source:
Atlas Publication

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



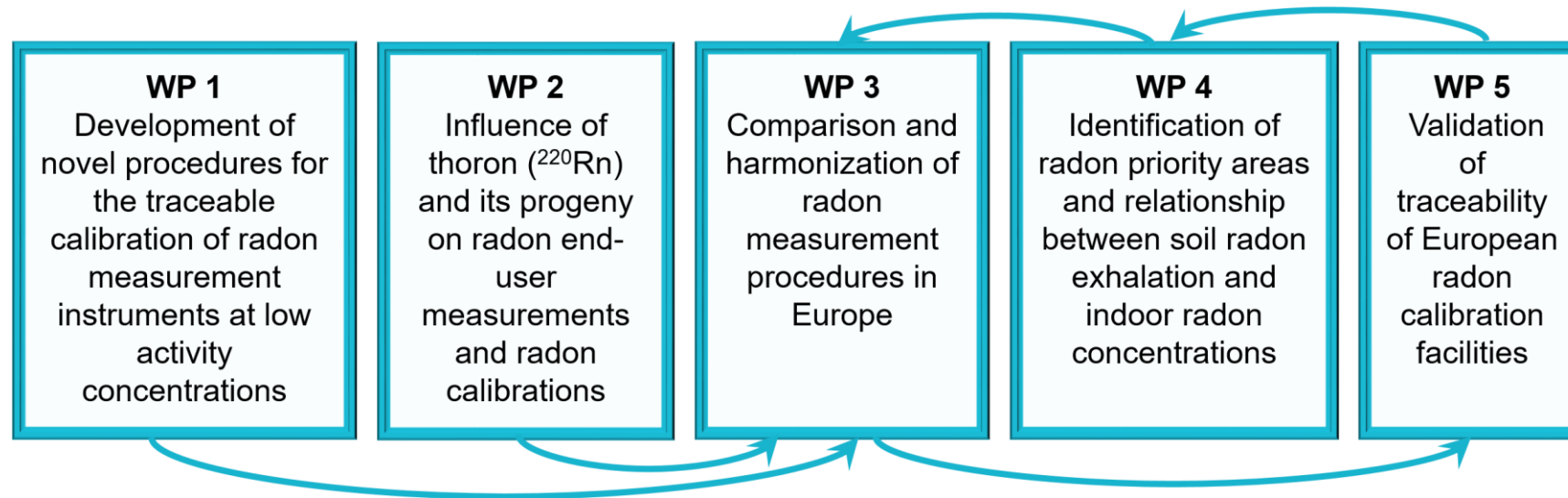
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

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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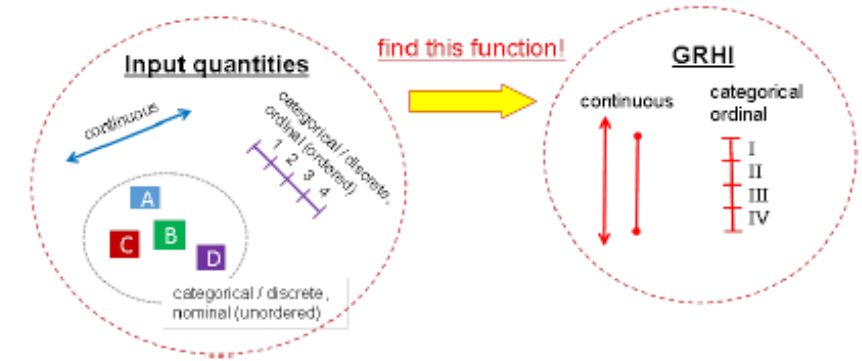
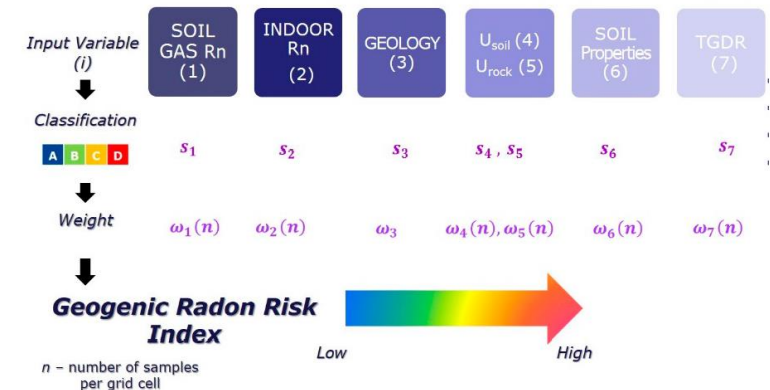


Figure 44: Construction of different types of GRHI-quantity from different types of input quantities.

Grid 10 km x 10 km

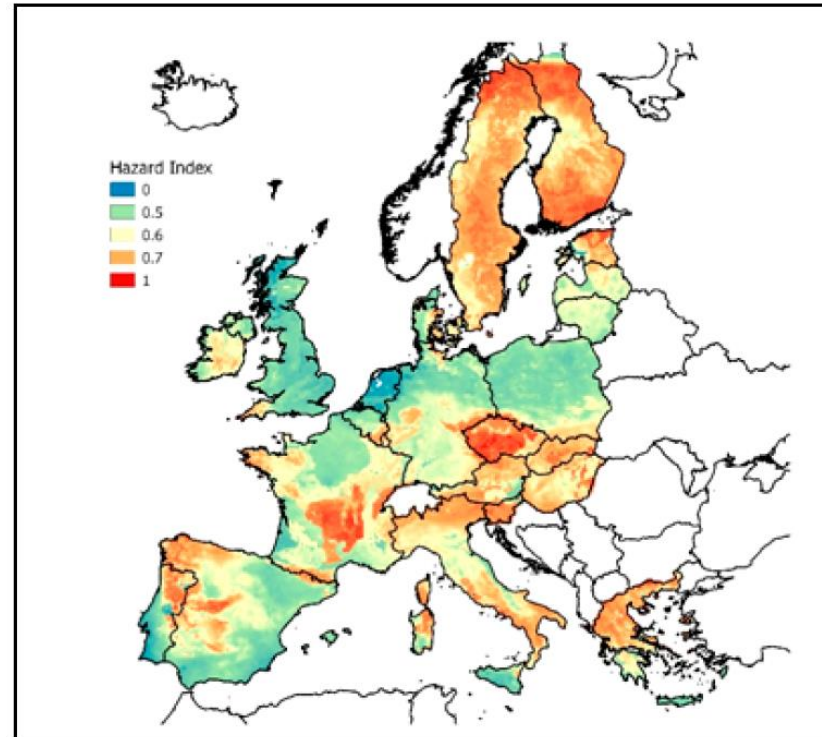
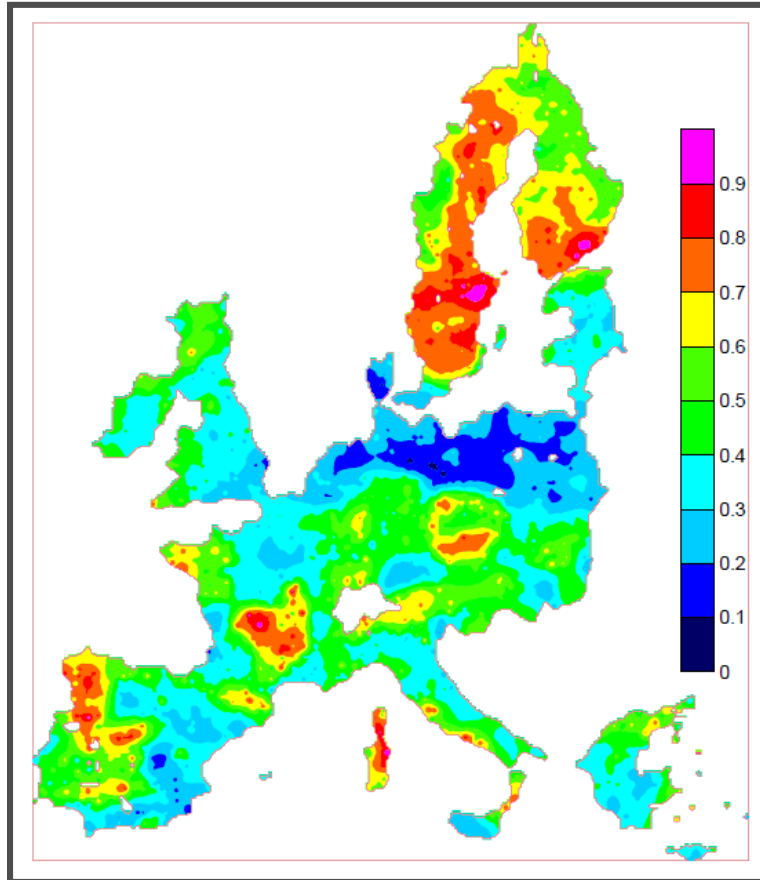


Concept: Multivariate classification (source: JRC)

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

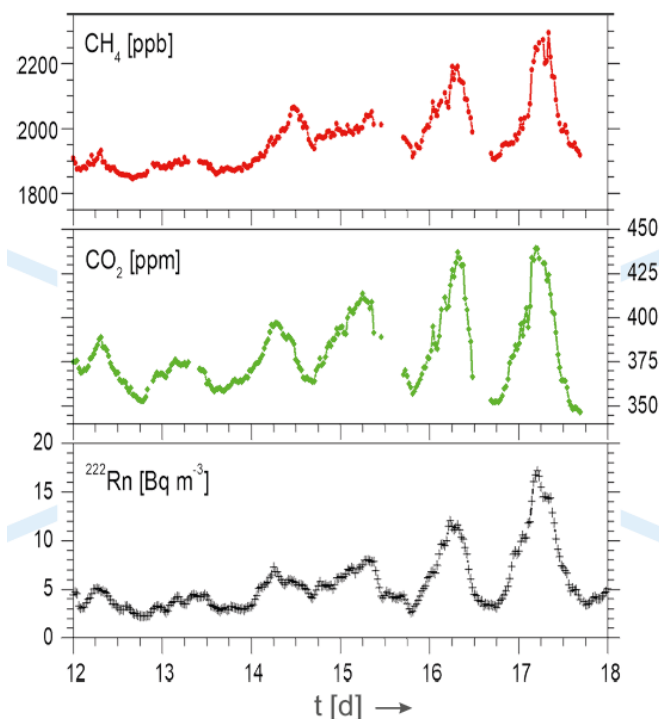
from Bossew et al. (2020). *Development of a Geogenic Radon Hazard Index—Concept, History, Experiences.* *Int. J. Environ. Res. Public Health*, 17, 4134; doi:10.3390/ijerph17114134

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 increased of greenhouse gases (GHGs) emissions.

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

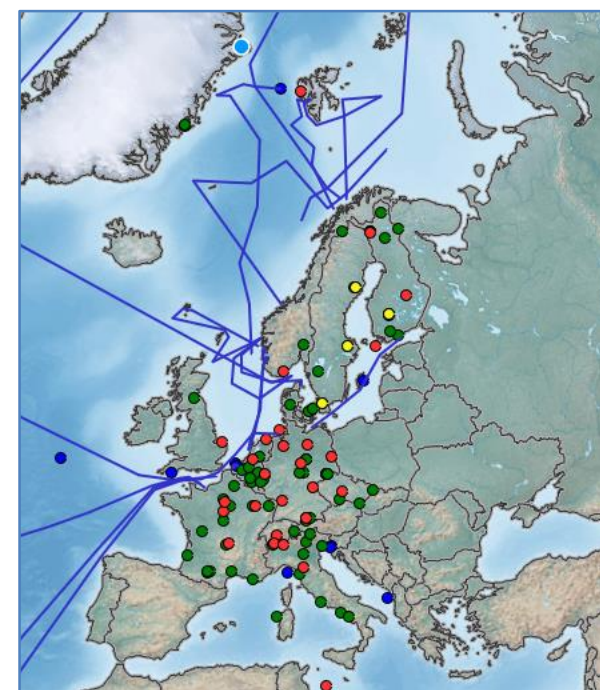
- **GHG flux measurements** are difficult though GHG concentration measure-ments are established.
- With radon activity concentration and radon flux measurements GHG fluxes can be **traced!**



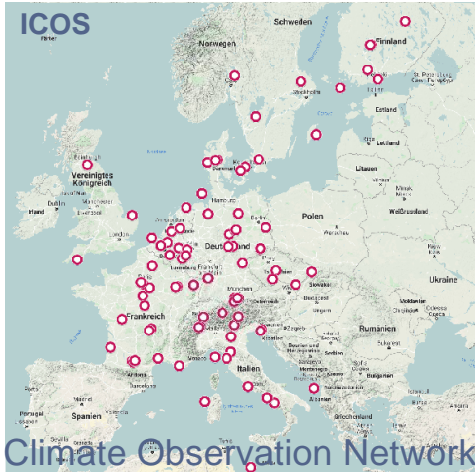
ICOS Atmospheric Station Specifications:

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.”

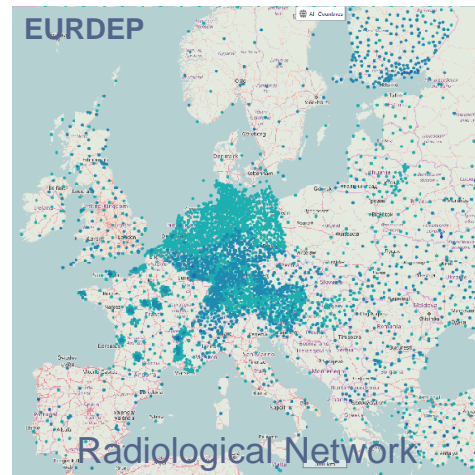
- Determine source terms of GHG



EMPIR 19ENV01 traceRadon



- 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.

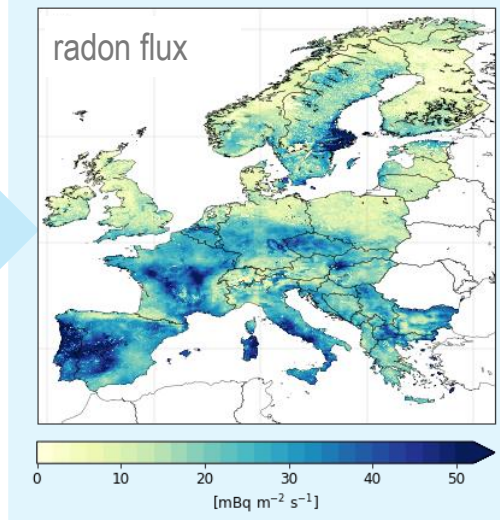
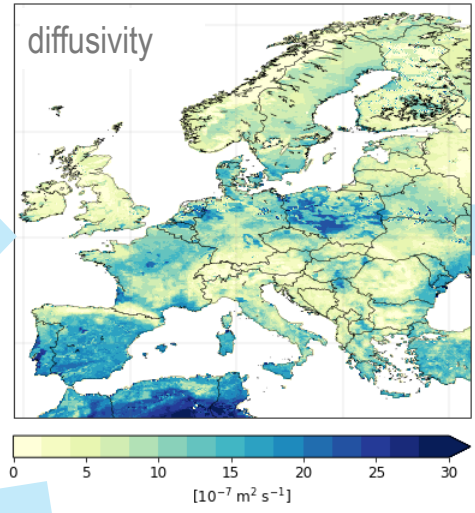
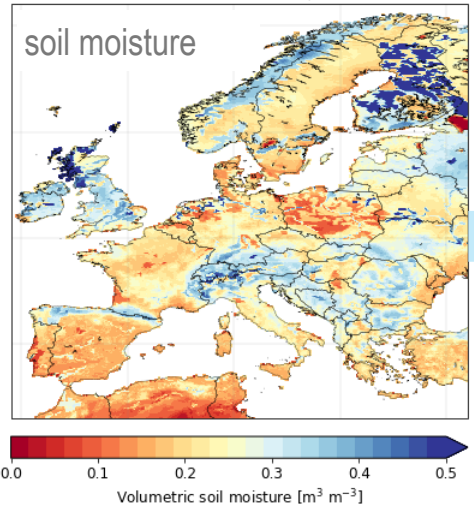


Both networks could profit from outdoor radon measurements. But **traceability to the SI system** is not established yet.

Process-based Radon flux map: components and workflow

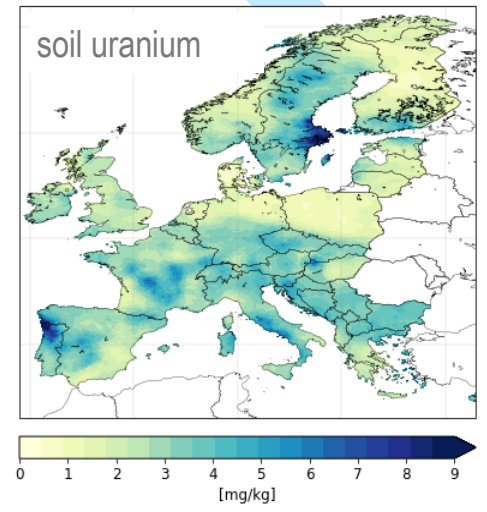
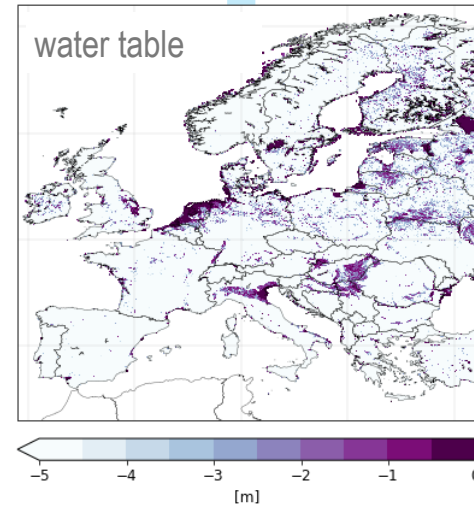
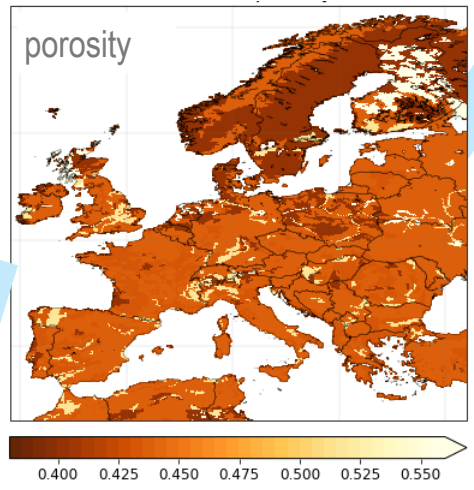
monthly

ERA5-Land reanalysis



static

European Soil Database
soil texture
% clay
% sand
% silt
bulk density



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

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EU Science Hub – Joint Research Centre



EU Science, Research and Innovation



Eu Science Hub

Thank you



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