The European Commission's science and knowledge service

Joint Research Centre

European Commission

From the digital version of the European Atlas of Natural Radiation towards its publication

Giorgia Cinelli[1], Peter Bossew[2], Valeria Gruber[3],

Tore Tollefsen[1], Marc De Cort[1]

1 European Commission, Joint Research Centre, Directorate for Nuclear Safety & Security, Ispra, Italy,
2 German Federal Office for Radiation Protection (BfS), Berlin, Germany
3 Austrian Agency for Health and Food Safety (AGES), Linz, Austria

EURATOM ARTICLE 35-36 EXPERTS' MEETING 2018, Ispra, 18-19 September 2018

European Commission

European Atlas of Natural Radiation

A tool for the public to:

- ✓ familiarize itself with natural environmental radioactivity;
- ✓ be informed about the levels of natural radioactivity caused by different sources;
- ✓ have a more balanced view of the annual dose received by the world population, to which natural radioactivity is the largest contributor;
- ✓ make direct comparisons between doses from natural sources of ionizing radiation and those from man-made (artificial), and hence to better understand the latter.

Legal background

- **Euratom Treaty**

Art.35: Each Member State shall establish the facilities necessary to carry out continuous monitoring of the level of radioactivity in the air, water and soil and to ensure compliance with the basic standards…

Art.36: The appropriate authorities shall periodically communicate information on the checks referred to in Article 35 to the Commission so that it is kept informed of the level of radioactivity to which the public is exposed.

Art. 39: The Commission shall set up within the framework of the Joint Nuclear Research Centre, as soon as the latter has been established, a health and safety documentation and study section. This section shall in particular have the task of collecting the documentation and information referred to in Articles 33, 36 and 37 and of assisting the Commission in carrying out the tasks assigned to it by this Chapter.

- **Basic Safety Standards**

Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation (BSS) http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2014:013:TOC (OJ L, 17.01.2014)

Potential support to EU Member States for the radon action plan Art. 103: "*Member States shall identify areas where the radon concentration (as annual average) in a significant number of buildings is expected to exceed the relevant national reference level*" (a.k.a. "radon-priority areas" unofficially, formerly "radon-prone areas")

Atlas, current state - overview

Exposure components already covered:

✓ **Cosmic** exposure and dose: **finished**;

✓ **Terrestrial radionuclides:**
- geochemical concentrations: **finished**

✓ **Terrestrial gamma radiation:**
- Ambient dose rate (ADER) calculated from geochemistry: **complete**
- ADER from surveys and EURDEP: some countries **complete**, many only **partly**; **to be continued** (difficult; data missing)

✓ **Indoor Rn:**
- Source: indoor concentrations: only ground floor; **34 countries (regionally incomplete)**
- Effect (exposure, dose, risk): **on going (methodology defined within the working group)**

Exposure components missing:

✓ **Rn in water**

✓ **Rn in soil**

✓ **Outdoor Rn**

✓ **Thoron,**

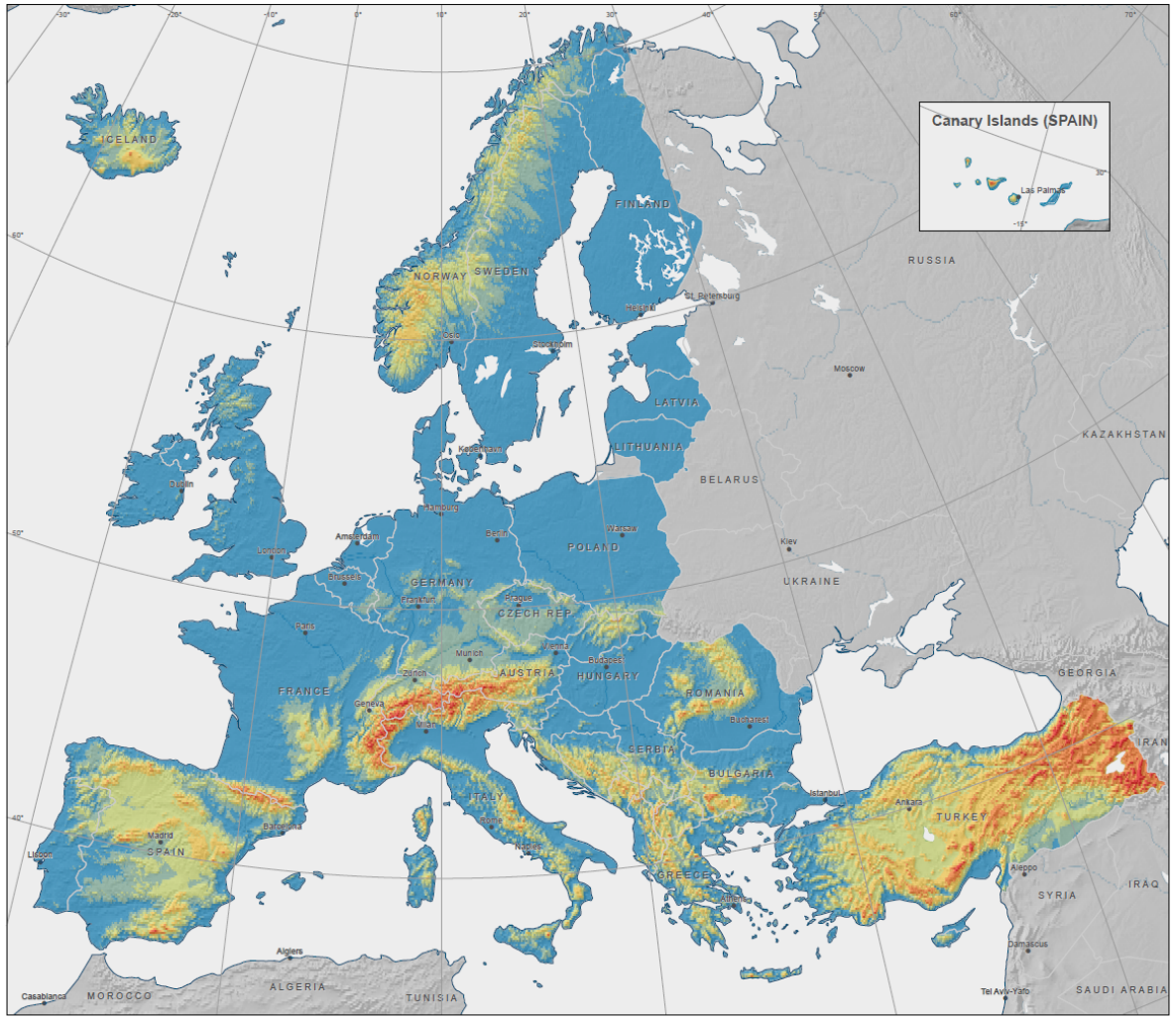
✓ **Indoor gamma (source: building materials)**

✓ **Food**

✓ **Anomalies: spatially small extremes, e.g. U mining residues, local mineralization**

European Commission

Cosmic Radiation



Annual dose cosmic-ray micro Sievert (μSv)

N

350
400
500
700
1,100

0 250 500 1,000 Km

Map projection: Lambert Azimuthal Equal Area (Datum:ETRS89)

Source data: Global digital elevation model GTOPO30 dataset

Method: The annual effective dose resulting from cosmic radiation (photons, direct ionizing and neutron components) at ground level has been calculated following a simple methodology based only on elevation data.

Spatial resolution: 1 x 1 km

Print scale: 1:11,000,000

Authors:
Giorgia CINELLI
Valeria GRUBER
Luca DE FELICE
Peter BOSSEW
Miguel A. HERNANDEZ-CEBALLOS
Tore TOLLEFSEN
Stefan MUNDIGL
Marc DE CORT

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

The map displays the annual effective dose that a person may receive from photons, direct ionizing and neutron components of cosmic radiation at ground level.

The dose has been assessed according to methods described in UNSCEAR (2008) and a global digital elevation model (DEM), called the GTOPO30 dataset.

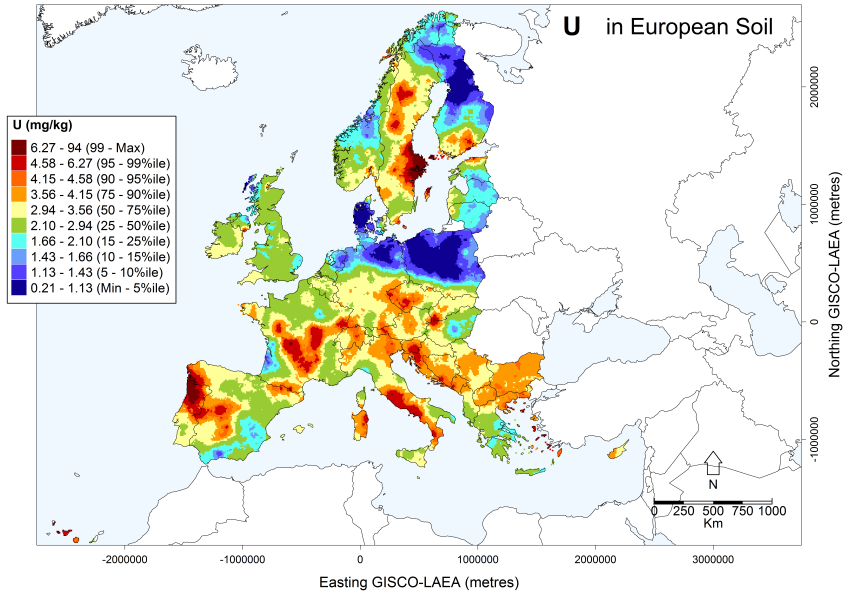
The values displayed are only linked to elevation. Latitude effect and influence of solar activity not considered.

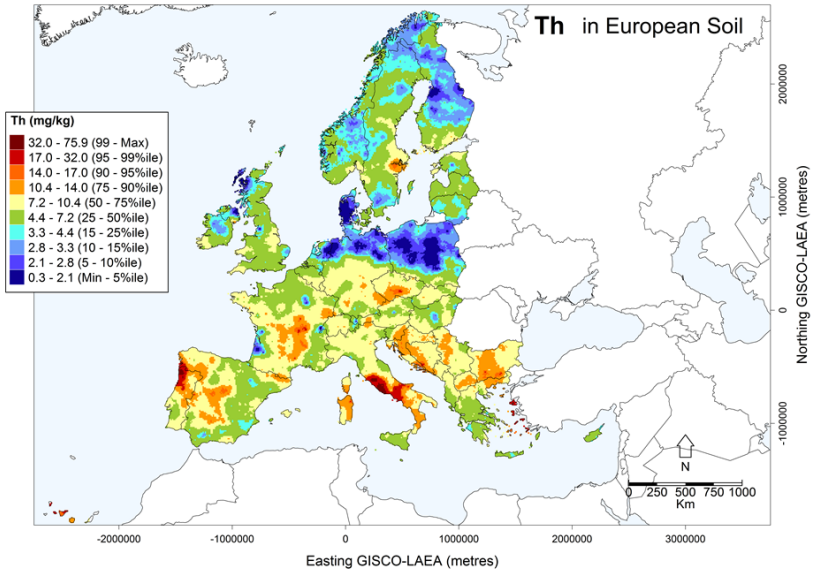
The discrepancy between our results and the ones obtained with the two models (log-lat) is below 15%, values on the same order of magnitude of the uncertainties variation due to other parameters such as solar modulation, building shielding effects, ground condition and indoor occupancy.

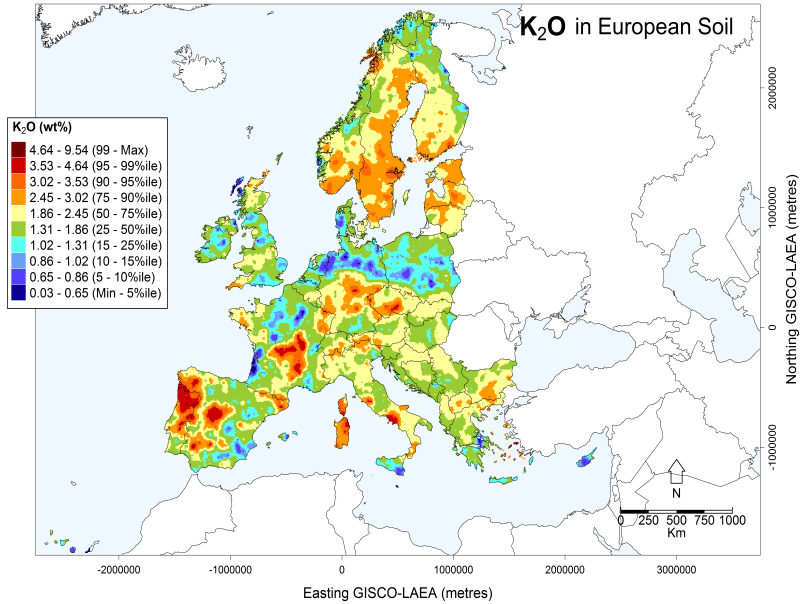
Cinelli G. *et al*., 2017. *European annual cosmic-ray dose: estimation of population exposure.* Journal of Maps, 13:2, 812-821

European Commission

U, Th and K concentration in soil Maps







Maps of estimated U, Th and K total concentrations in topsoil over Europe, based on data collated from FOREGS (ICP-MS) and GEMAS (XRF) European datasets. The colours are attributed according to the percentiles estimated map points.

Acknowledgment: Antonio Ferreira, Bob Lister, Andrew Tye (British Geological Survey)

European Commission

U, Th and K concentration in bedrock Maps

Bedrock geochemistry

The map displays the arithmetic mean of the concentrations of U, Th and K in bedrock over geological units

Methodology:

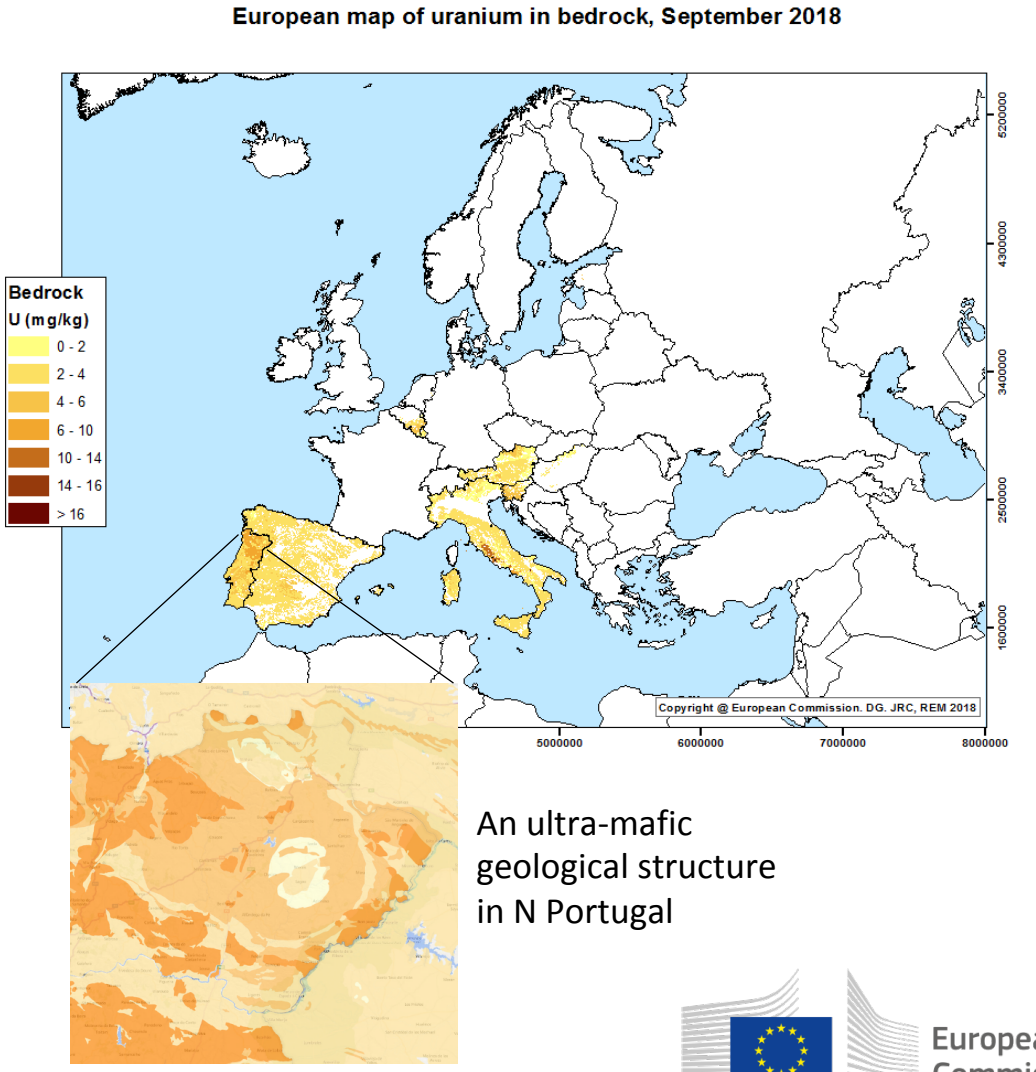
1. Identifying geological units homogenous in U, Th and K content using OneGeology-Europe data (http://www.onegeology-europe.org/).

2. Collecting data of K_2O, U and Th concentration in bedrock using scientific literature sources;

3. Checking the quality of the data

4. Assigning K_2O, U and Th concentration values in bedrock to each geological unit using the collected data

5. Mapping K_2O, U and Th concentration in bedrock



An ultra-mafic geological structure in N Portugal

European Commission

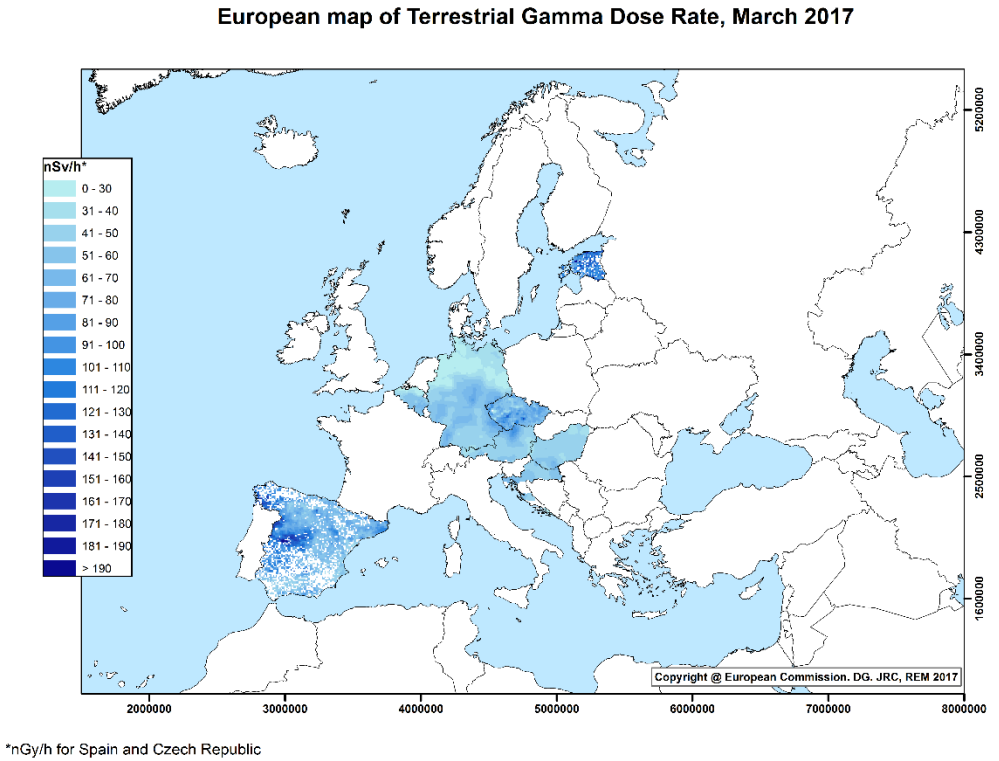
Terrestrial Gamma Dose Rate Map 1/2

Mapping options: 1. **Measurement:** national surveys, EURDEP system
2. **Calculate** ambient dose rate from terrestrial radionuclide concentrations

Option 1:

AT,DE,HR,HU: Terrestrial gamma radiation has been estimated from the total ambient dose rate data transmitted to the EURDEP system (https:// eurdep.jrc.ec.europa.eu) after subtracting:
1) cosmic,
2) Radon-washout and
3) internal background effects.

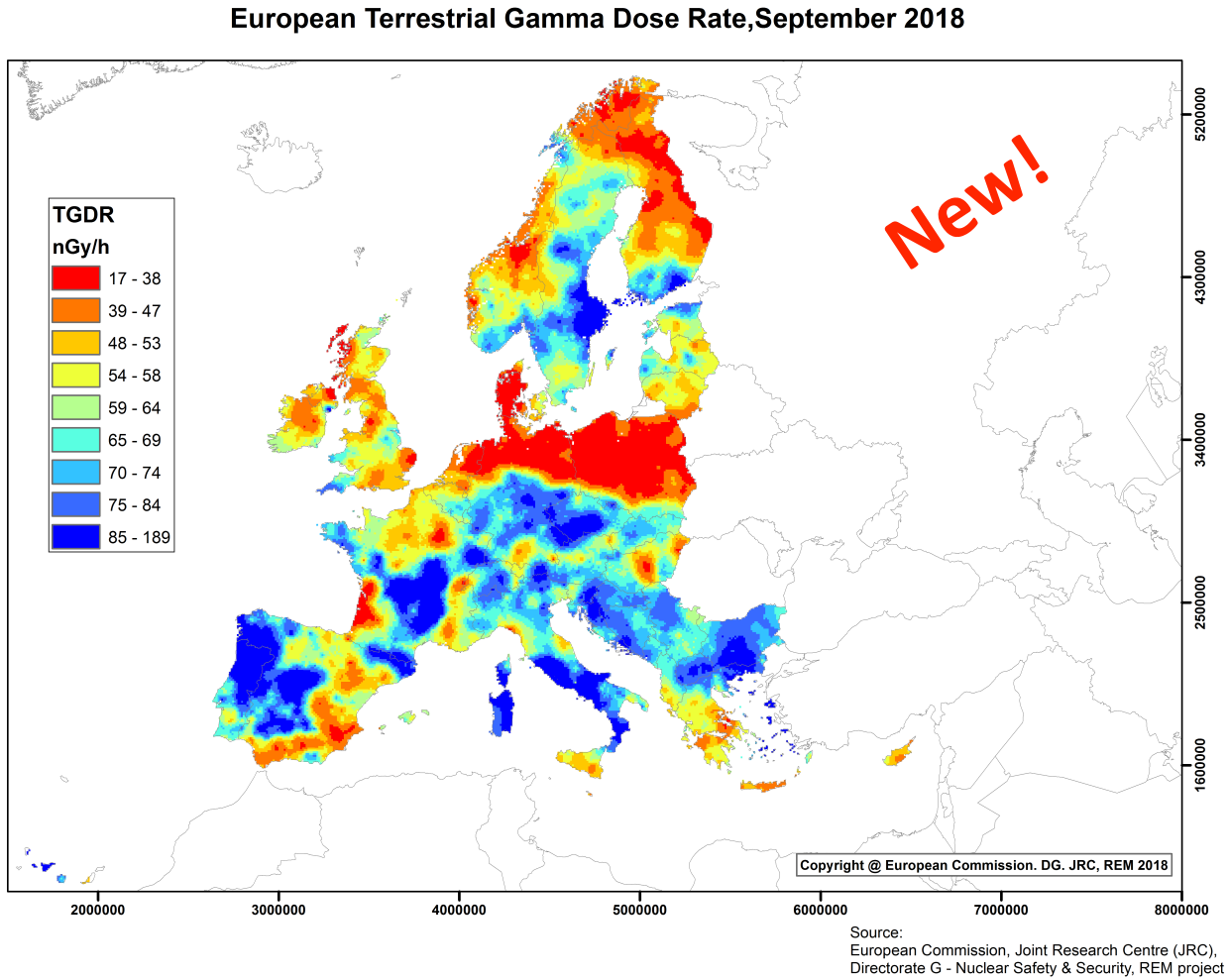
For Belgium, the Czech Republic and Spain, data from their national databases have been used.



Bossew P. *et al.*, 2017. *Estimating the terrestrial gamma dose rate by decomposition of the ambient dose equivalent rate.* Journal of Environmental Radioactivity 166 (2017) 296e308

European Commission

Terrestrial Gamma Dose Rate Map 2/2



Input data: U, Th and K concentration maps (above):

- 0.83 K%/K2O%
- 309.7 Bq/kg K / K%
- 12.35 Bq/kg U /ppm
- 4.072 Bq/kg Th /ppm

TGDR(nGy/h) (UNSCEAR, 2008)=

$0.0417 * C_K + 0.462 * C_U + 0.604 * C_{Th}$

Resolution:10 km x 10 km

Acknowledgment: Paolo Falletti, Enrico Chiaberto, Anselmo Cucchi, Mauro Magnoni (Arpa Piemonte)

European Commission

Indoor Radon - essentials

Indoor radon – most important contribution to dose!
Second most important cause of lung cancer after smoking!
In Europe estimated about 62,000 lung cancer fatalities per year attributed to Rn.
(Gaskin et al., Envir. Health Perspectives 125, 5 (2018); incl. RU, TR; missing: BiH, LV, MD, MK, MT, RS, UA)

Sources of indoor Rn:

1. Geogenic Rn (most important in most cases)
2. Building materials
3. Tap water, natural gas

Concentrations of indoor Rn controlled by

Geogenic factors:

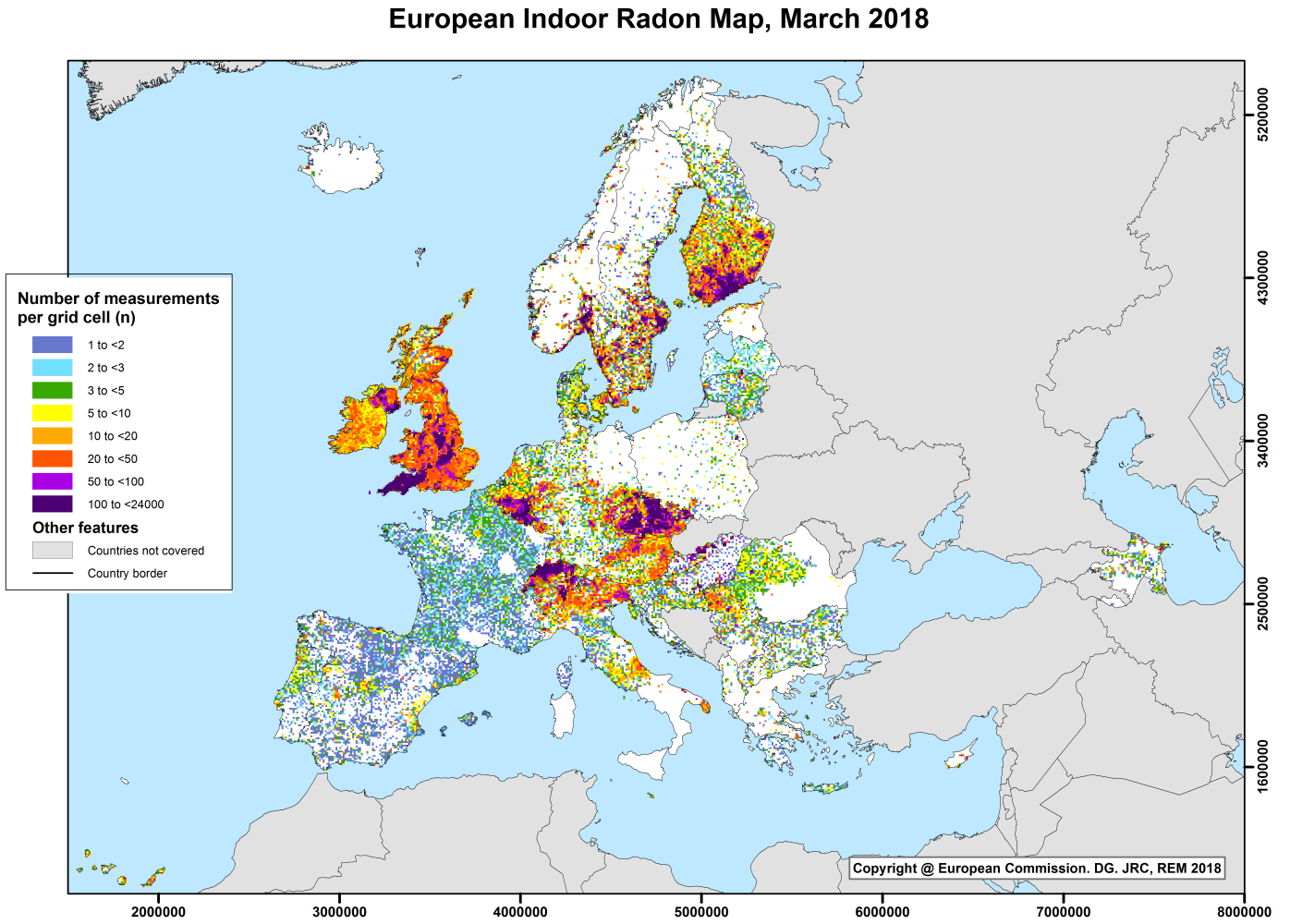
Geology, soil type, U concentration in topsoil, permeability, granulometry,…

Anthropogenic factors:

Construction type (tightness of structures in contact with the ground),
life or usage patterns (ventilation)

Very high local and temporal variability → makes prediction very difficult.

European Indoor Radon Map: data



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

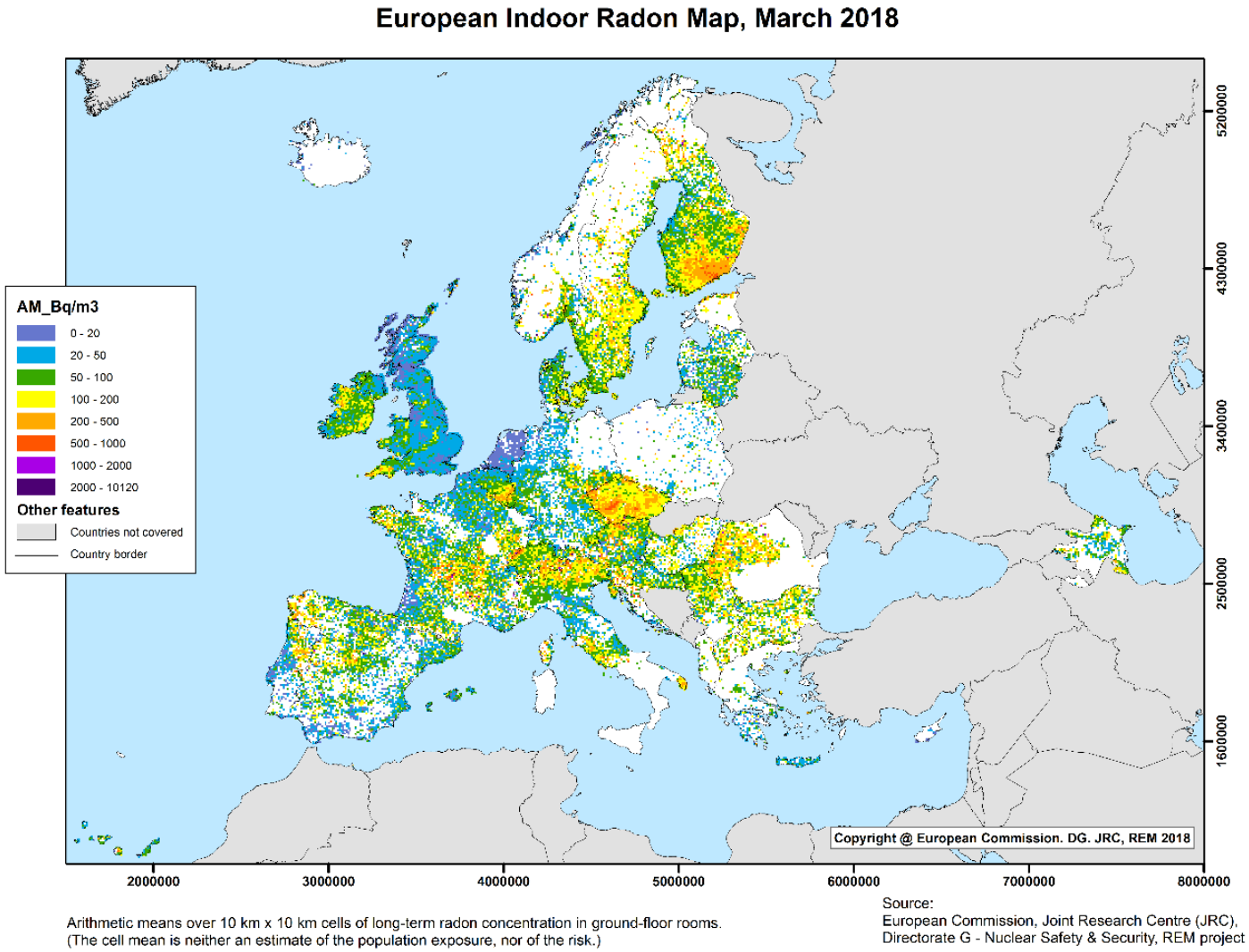
- 10 km x 10 km grid cells
- Living rooms, ground floor
- Participants send statistics:
  - number of measurements
  - arithmetic mean (AM)
  - standard deviation (SD)
  - AM(ln data)
  - SD(ln data)
  - Median
  - minimum
  - maximum

Status (March 2018):
34 countries participate
~28,000 non-empty cells
~1,150,000 original measurements

Number of measurements per cell, MED ± MAD: 4 ± 4
Min/Max number of measurements per cell: 1/23,993

European Commission

European Indoor Radon Map: data



AM over cell means: 103 Bq/m^3
Cell median, MED ± MAD: 60 ± 46 Bq/m^3

European Commission

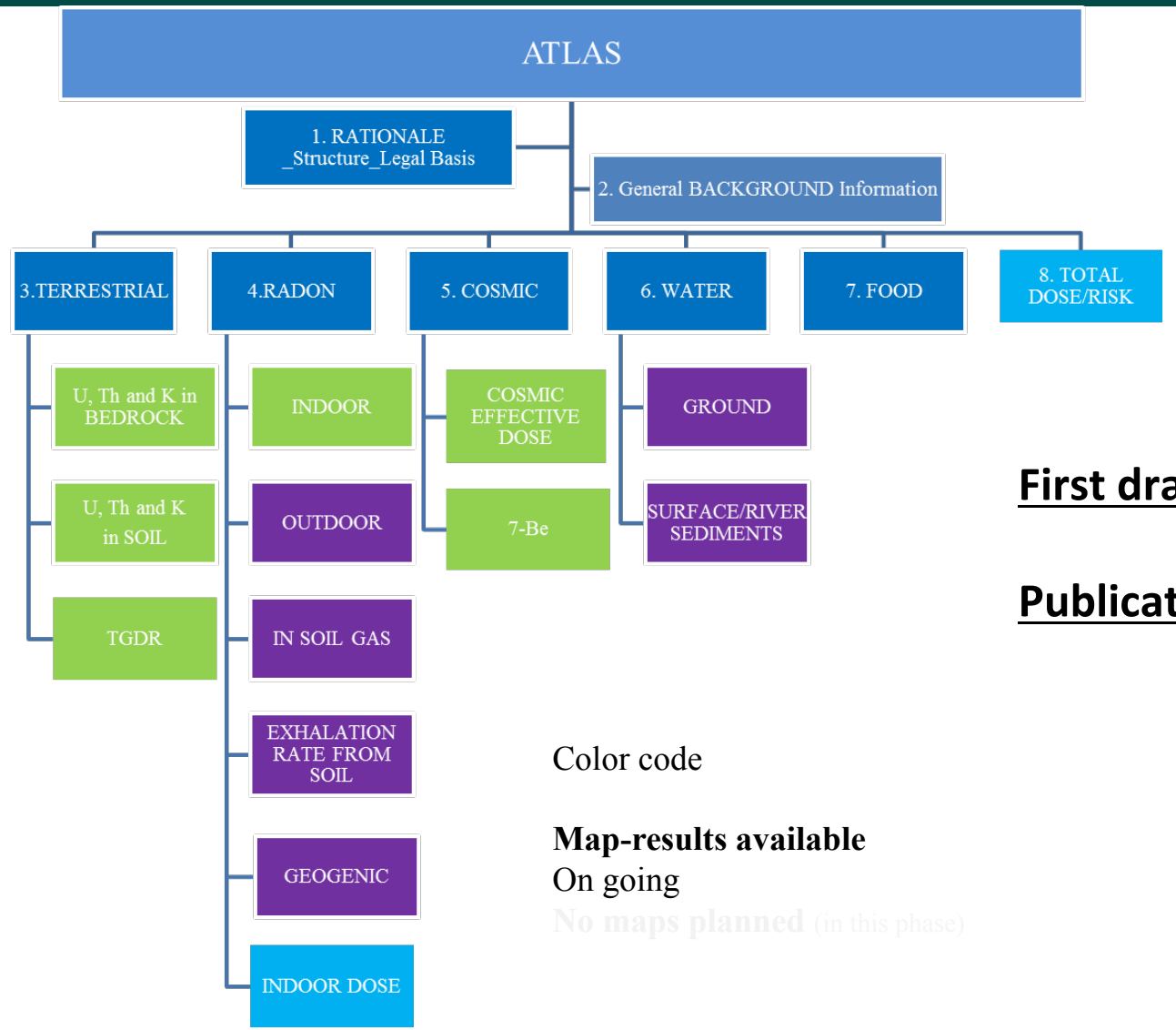
Digital version of the Atlas

https://remon.jrc.ec.europa.eu

Cinelli G. *et al.* 2018. *Digital version of the European Atlas of Natural Radiation*, Journal of Environmental Radioactivity. Article in press. https://doi.org/10.1016/j.jenvrad.2018.02.008

European Commission

Structure of the Atlas publication



First draft: December 2018

Publication: Spring 2019

Color code

Map-results available
On going
No maps planned (in this phase)

European Commission

Missing components

- Outdoor radon:
  - Typically 2 – 20 Bq/m³.
  - Surveys exist in DE, IE, SI, and scattered measurements in other countries.
  - Contribution to dose: small; mostly < 0.1 mSv/a (maybe more with new DCF)
- Cosmogenic radionuclides:
  - ^{14}C, ^{22}Na,… (^{7}Be already under development in context of rem-db)
  - pathways: external radiation (air + ground), inhalation, ingestion
  - very small contribution to dose
- Building materials:
  - "modified" natural materials.
  - Exhale Rn and Tn, produce gamma radiation.
- Water: Ground water, surface water, drinking water:
  - U, Ra, Rn contribute to dose
  - Strongly related to geology
  - Many local studies, but no European overview exists
- Foodstuff: Natural radionuclides in food.
  - Little known about regional variability.
  - Dose variability possibly mainly controlled by nutrition habits which vary regionally.
- *Anomalies: Not especial exposure components, but possibly relevant components of maps. Spatially "small" features, such as enhanced Rn along active tectonic faults, U mines etc., which contribute little to the regional mean, but are still relevant locally.*

Any questions?

Please contact us at

JRC-EANR@ec.europa.eu

giorgia.cinelli@ec.europa.eu

European Commission

JOINT RESEARCH CENTRE

Radioactivity Environmental Monitoring

European Commission > JRC > REMon > About

REMon | About | Services | Maps | Share

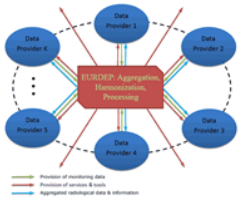
About

- Real-Time Monitoring
- Natural Radioactivity
- Who We Are
- Publications
- News

What We Do

The Radioactivity Environmental Monitoring (REM) group of the Joint Research Centre (JRC) of the European Commission provides qualified information about the level of environmental radioactivity to the public, Member States, European Commission and European Parliament.

Environmental radioactivity information are provided as a real-time monitoring data and estimated natural radioactivity levels through:



EUropean Radiological Data Exchange Platform (EURDEP) network for the exchange of radiological monitoring data between participating countries almost in REAL TIME. Monitoring information are collected from automatic surveillance systems in 39 countries. These data reflect essentially the natural radiation background, if NO radiological events occur.

About EURDEP | EURDEP Map

The **European Atlas of Natural Radiation (EANR)** is a collection of maps of Europe displaying levels of natural radioactivity caused by different sources (e.g. indoor radon, cosmic radiation, terrestrial gamma radiation, natural radionuclides in soil and bedrock).

About EANR | EANR Maps

The REM mission is based on the Euratom Treaty (download), which is to collect, validate and report information on radioactivity levels in the environment.

European Commission

About

Real-Time Monitoring

Natural Radioactivity

Who We Are

Publications

News

European Atlas of Natural Radiation

The human population is continuously exposed to ionizing radiation from several natural sources that can be classified in two categories:

- **Cosmic contribution**: high-energy cosmic rays incident on the Earth's atmosphere and releasing secondary radiation
- **Terrestrial contribution**: radioactive nuclides generated during the formation of the Earth and still present in the Earth's crust: mostly uranium and thorium radioactive families together with ^{40}K, which is a long lived radioactive isotope of the elemental potassium. In most circumstances radon, a noble gas produced in the radioactive decay of the Uranium progeny, is the major contributor to the total dose.

> The European Atlas of Natural Radiation is a collection of maps displaying the levels of radioactivity caused by different natural sources in Europe.

The Atlas is intended to familiarise the public with the radioactive environment, to give a more balanced view of the annual dose that it may receive from natural radioactivity and to provide reference material and generate harmonised data for the scientific community. The overall goal of the Atlas is to estimate the annual dose that the public may receive from natural radioactivity, combining all the information from the different maps. Indeed, natural ionizing radiation is considered the largest contributor to the collective effective dose received by the world population.

The Atlas is developed and maintained by the Joint Research Centre of the European Commission.

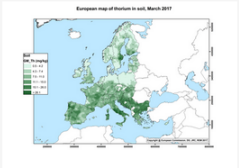
Annual cosmic-ray dose

The European Annual Cosmic-Ray Dose map reports the annual effective dose that a person may receive from photons, direct ionizing and neutron components of cosmic radiation at ground level.

26/04/2017

Cosmic

Details



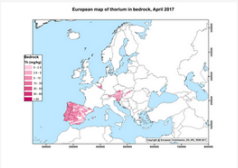
Thorium concentration in soil

The European thorium concentration in soil map displays the geometrical means (GM) of the concentration of Thorium in soil over 10 km x 10 km grid cells.

28/03/2017

Thorium in soil

Details



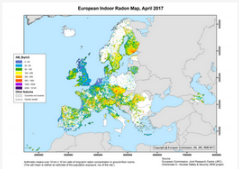
Thorium concentration in bedrock

The European thorium concentration in bedrock map displays the arithmetic mean (AM) of the concentration of Thorium in bedrock over geological units.

26/04/2017

Thorium in bedrock

Details



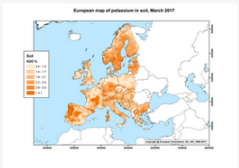
Indoor radon concentration

The European Indoor Radon Map displays arithmetic means (AM) of annual indoor radon concentration in ground-floor rooms of dwellings over 10 km x 10 km grid cells.

26/04/2017

Indoor radon AM

Details



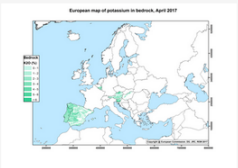
Potassium concentration in soil

The European potassium concentration in soil map displays the aithmetic mean (AM) of the concentration of potassium oxide (K2O) in soil over 10 km x 10 km grid cells.

28/03/2017

Potassium in soil

Details



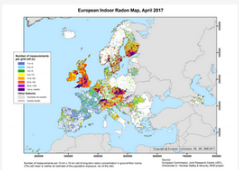
Potassium concentration in bedrock

The European potassium concentration in bedrock map displays the arithmetic mean (AM) of the concentration of Potassium oxide (K2O) in bedrock over geological units.

26/04/2017

Potassium in bedrock

Details



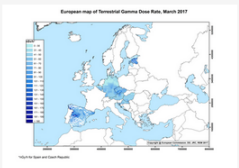
Indoor radon - Number of measurements

The European Indoor Radon Map displays the number of measurements (N) of annual indoor radon concentration in ground-floor rooms of dwellings over 10 km x 10 km grid cells.

26/04/2017

Indoor radon N

Details



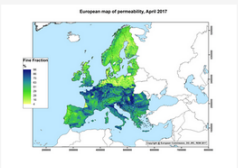
Terrestrial gamma dose

The European Terrestrial Gamma Dose Rate map displays the gamma dose rate that a person may receive from terrestrial radiation.

28/03/2017

Terrestrial gamma

Details



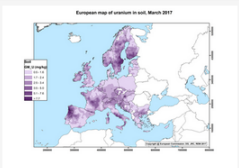
Soil permeability

The European map of soil permeability displays the percentage of topsoil fine fraction (<63 micro m). It is possible to derive a rough estimation of the permeability very easily from the weight percentage of fine fraction.

26/04/2017

Soil permeability

Details



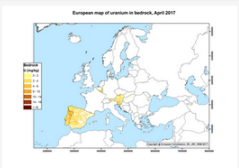
Uranium concentration in soil

The European uranium concentration in soil map displays the geometrical means (GM) of the concentration of Uranium in soil over 10 km x 10 km grid cells.

28/03/2017

Uranium in soil

Details



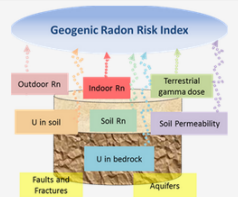
Uranium concentration in bedrock

The European uranium concentration in bedrock map displays the arithmetic mean (AM) of the concentration of Uranium in bedrock over geological units.

26/04/2017

Uranium in bedrock

Details



Geogenic radon

The Geogenic Radon Map should display a variable which measures "what earth delivers" in terms of geogenic radon potential. WORK IN PROGRESS

25/10/2016

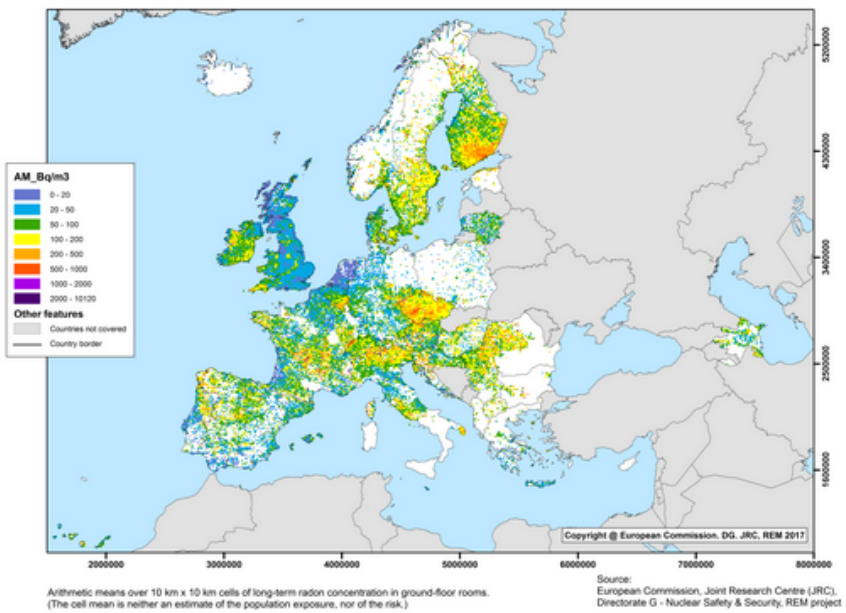
Geogenic radon

Details

European Commission

Indoor radon concentration

Back to the list of maps



Description

The European Indoor Radon Map reports the arithmetic means (AM) over 10 km x 10 km grid cells of annual indoor radon concentration in ground-floor rooms of dwellings. This grid has been defined by the JRC and uses a GISCO-Lambert azimuthal equal area projection. The input data are provided by national competent authorities (see list below), which aggregate their original data into the grid and calculate a set of statistics per cell: the AM, standard deviation (SD), AM and SD of ln-transformed data, minimum, median and maximum, as well as the number of measurements per cell. Note that this procedure guarantees data protection, since the original data and their exact locations remain at the national level. As new indoor radon data arrive at the JRC from participating countries, the map is updated at irregular intervals.

References

- M. Hoffmann, Ch. S. Aliyev, A. A. Feyzullayev, R. J. Baghirli, F. F. Veliyeva, L. Pampuri, C. Valsangiacomo, T. Tollefsen, G. Cinelli, 2016. First map of residential indoor radon measurements in Azerbaijan. Radiation Protection Dosimetry (2016). Advance access published 23.11.2016. doi: 10.1083/rpd/ncw284.
- T. Tollefsen, G. Cinelli, P. Bossew, V. Gruber, M. De Cort, 2014. From the European indoor radon map towards an atlas of natural radiation. Radiation Protection Dosimetry 162 (1-2) 129-134 (2014). doi: 10.1093/rpd/ncu244. http://rpd.oxfordjournals.org/content/162/1-2/129.full.pdf. Download
- G. Dubois, P. Bossew, T. Tollefsen, M. De Cort, 2010. First steps towards a European Atlas of natural radiation: Status of the European indoor radon map. J. Environ. Radioact., 101, 786–798 (2010). doi: 10.1016/j.jenvrad.2010.03.007.

Data providers

The following national competent authorities have provided input data:

- Albania: Institute of Applied Nuclear Physics
- Austria: University of Vienna
- Azerbaijan: Azerbaijan National Academy of Science
- Belgium: Agence fédérale de contrôle nucléaire
- Bulgaria: National Centre of Radiobiology and Radiation Protection
- Croatia: University of Osijek
- Czech Republic: Czech Geological Survey
- Denmark: Danish Health Authority
- Estonia: Environmental Board
- Finland: Radiation and Nuclear Safety Authority
- France: Institut de radioprotection et de sûreté nucléaire
- Germany: Bundesamt für Strahlenschutz
- Greece: Greek Atomic Energy Commission
- Hungary: Szent Istvan University
- Iceland: Icelandic Radiation Safety Authority
- Ireland: Environmental Protection Agency
- Italy: Istituto Superiore per la Protezione e la Ricerca Ambientale
- Lithuania: Radiation Protection Centre
- Macedonia, FYRO: Institute of Public Health
- Malta: Ministry for Energy and Health
- Netherlands: National Institute for Public Health and the Environment
- Norway: Norwegian Radiation Protection Authority
- Poland: Wrocław University of Science and Technology
- Portugal: Instituto Tecnológico e Nuclear
- Romania: Babeş-Bolyai University
- Serbia: Serbian Radiation Protection and Nuclear Safety Agency
- Slovenia: Jožef Stefan Institute
- Spain: Consejo de Seguridad Nuclear
- Sweden: National Board of Housing, Building and Planning
- Switzerland: Bundesamt für Gesundheit
- United Kingdom: Public Health England

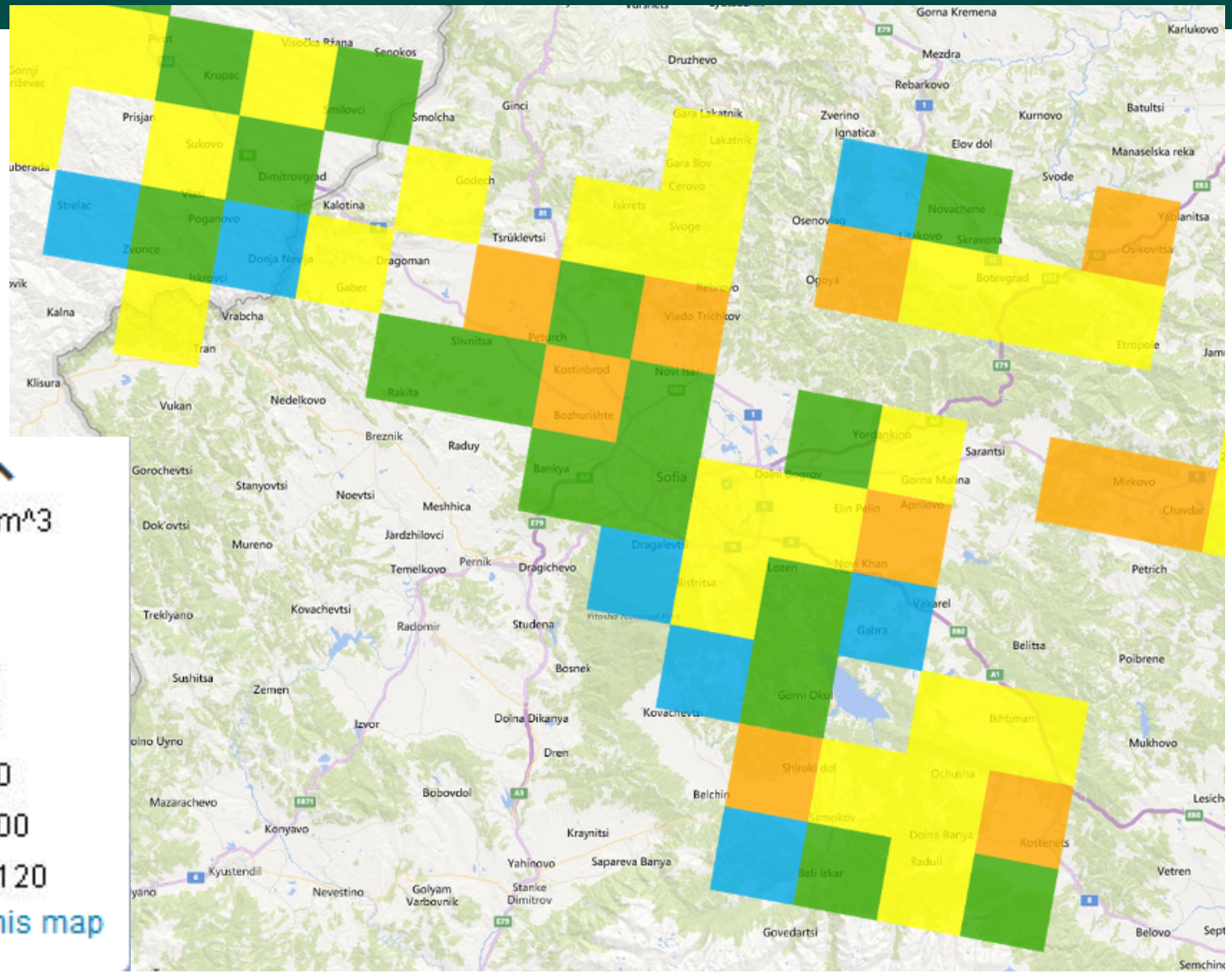
Additional information

Resolution: 10000 m

Last Modified: 26/04/2017

Update frequency: Irregular

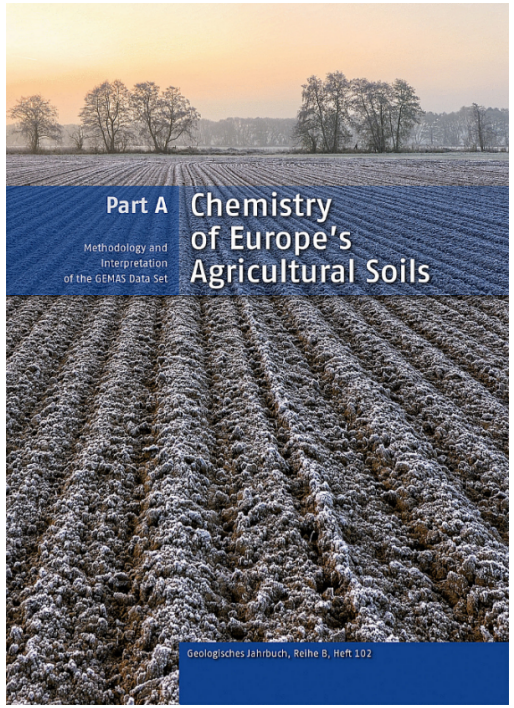
European Commission



European Commission

FOREGS
(Forum of the European Geological Surveys)

www.gtk.fi/publ/foregsatlas/



GEMAS
(geochemical mapping of agricultural and grazing land soil)

http://gemas.geolba.ac.at/

European Commission