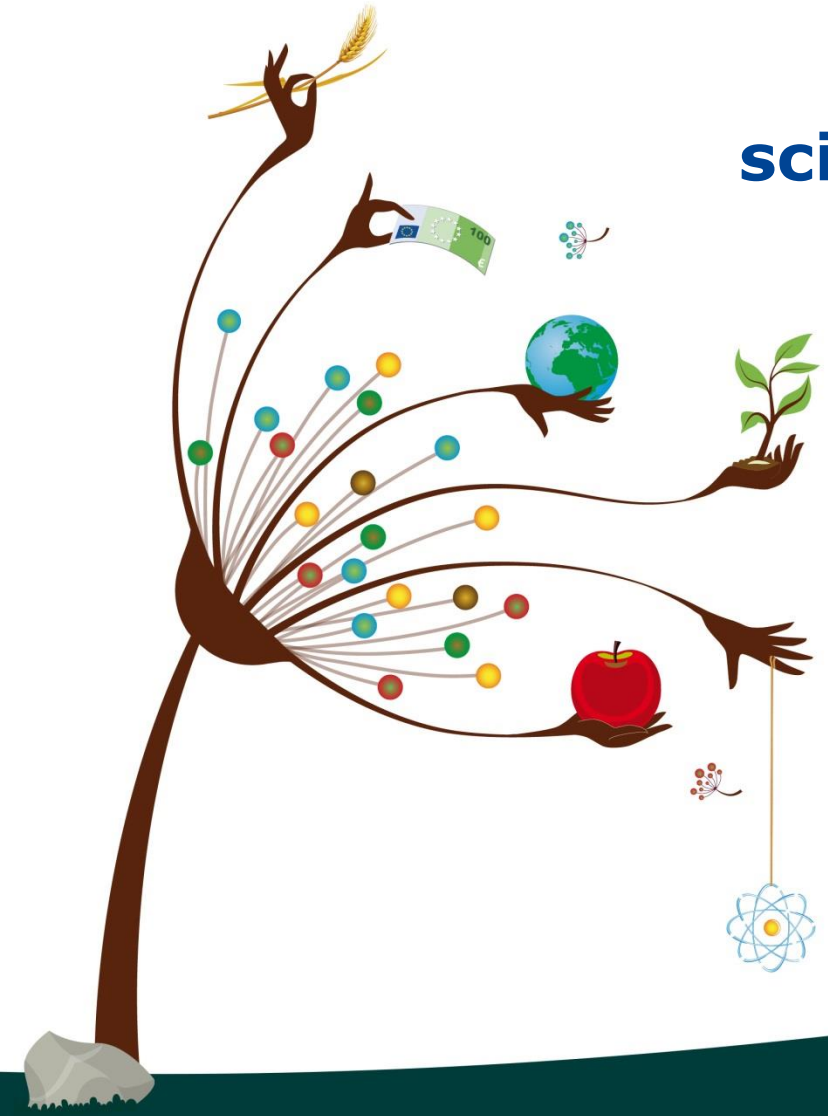

The European Commission's science and knowledge service

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Moderated discussion: Progress on European Geogenic Radon Mapping

13th GARRM, Prague, 15 September 2016

European Commission

European Basic Safety Standards (EU, 2013), Article 103 § 3:

"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"
(cf. "radon-prone areas", "high radon area", "radon affected area")

Question to be answered

How can radon priority areas be identified?

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Two main strategies for delineating radon exposure geographically

- Direct measurements of **indoor radon** concentration

- Indirect methods (concept of **geogenic radon potential**)

Geogenic Radon Potential: Concepts

European Commission

The geogenic radon potential (GRP):

measures "what earth delivers" in terms of Rn; a measure of the availability to exhalation from the ground, or for ingression into buildings. Several possible definitions.

Geogenic Rn prone area:

An area in which the probability of elevated indoor Rn concentrations is increased for geogenic reasons.

NB: *Rn concentration in an actual building depends on building characteristics (presence of basement, insulation against ground) and on ventilation habits of users or inhabitants.*

Geogenic Radon Potential: Concepts

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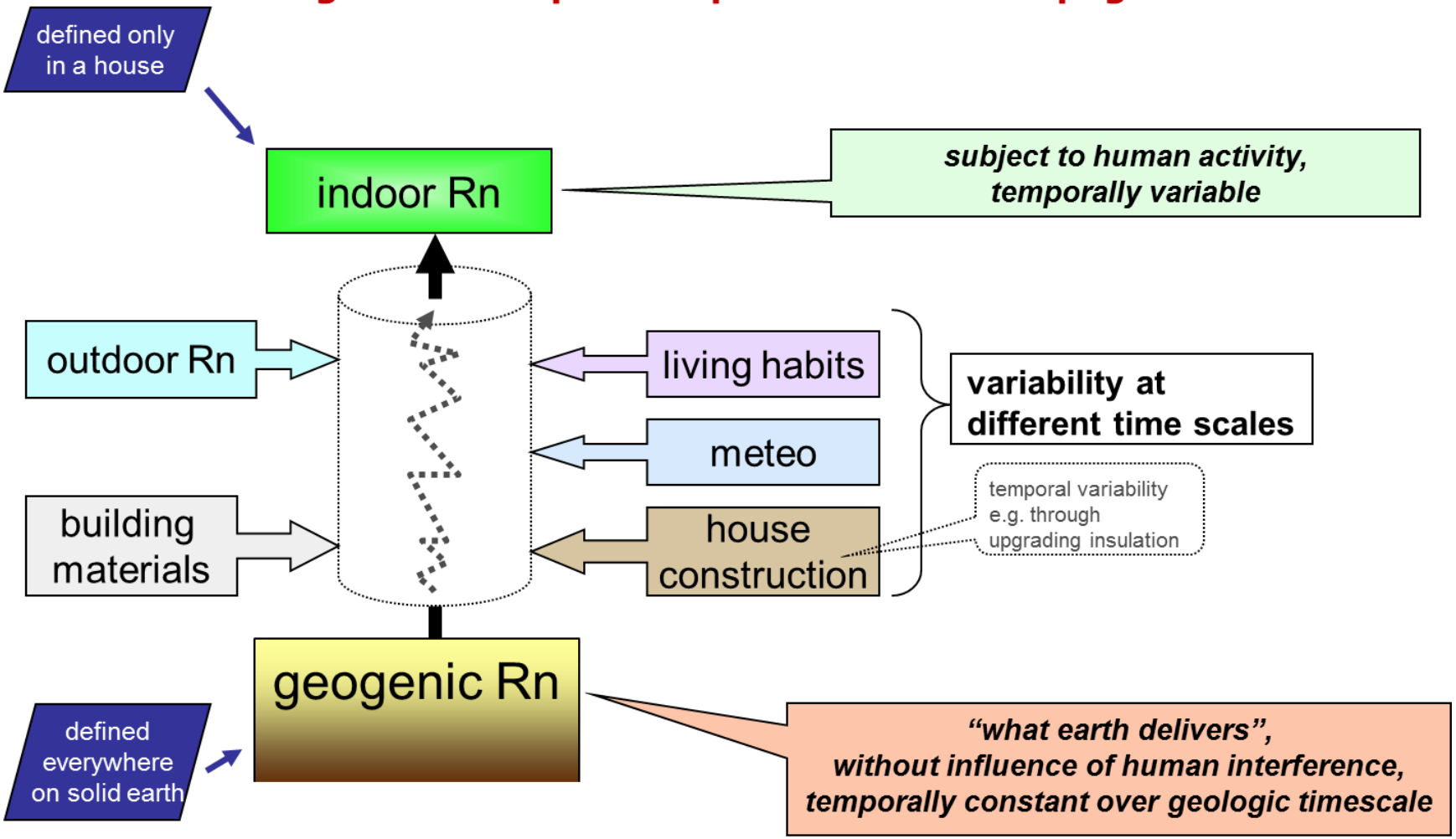
Geogenic Rn map = independent of anthropogenic factors



Input parameters

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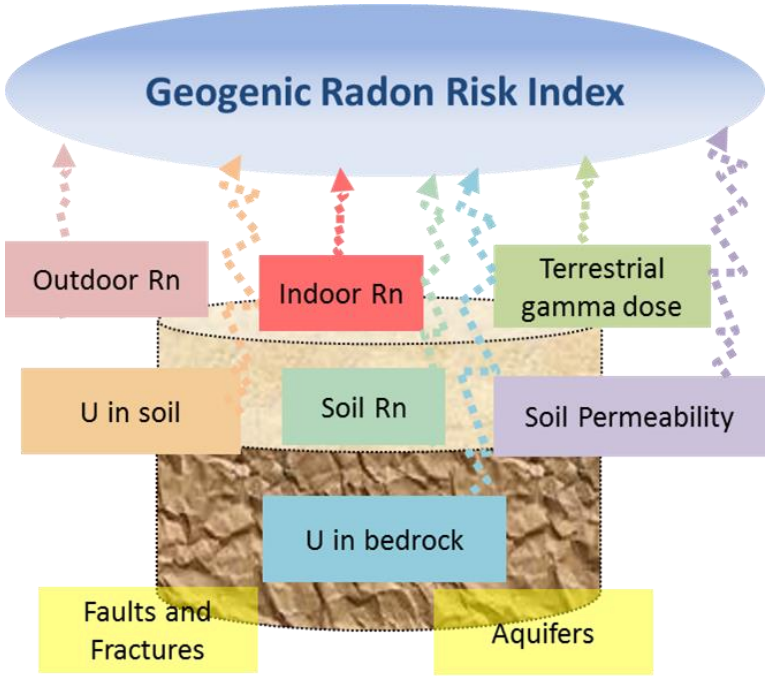
- U/Ra in soil and bedrock
- Radon concentration in soil
- Soil permeability
- (Standardized) indoor radon concentration
- Terrestrial dose rate
- Geology
- Rock fracturing, presence of fault lines, tectonic features
- Aquifers characterization
- Special natural features such as karstification, caves
- Special anthropogenic features such as mines, degree of urbanization, landscaping



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Some methods…..

- **Soil gas radon and permeability _ Neznal**

V . Gruber, P. Bossew, M. De Cort and T. Tollefsen, 2013. *"The European map of the geogenic radon potential".* J. Radiol. Prot. 33 (2013) 51–60. **European Geogenic Radon Map _Trial map**

K. Z. Szabó, G. Jordan, Á. Horváth, C. Szabó , 2014. *"Mapping the geogenic radon potential: methodology and spatial analysis for central Hungary*" . Journal of Environmental Radioactivity 129 (2014) 107–120.

- **Gamma dose assessment based on gamma-spectrometry from laboratory, field and aerial surveys**

M Garcia-Talavera, A. Garcia-Perez, C. Rey and L. Ramos, 2013. *"Mapping radon-prone areas using γ-radiation dose rate and geological information" .* J. Radiol. Prot. 33 (2013) 605–620

- **U, Ra concentration in soil and rock**

G. Ielsch, M. Cuney, F. Buscail, F. Rossi, A. Leon, M.E. Cushing, 2016. *"Estimation and mapping of uranium content of geological units in France" .* Journal of Environmental Radioactivity, available on line http://dx.doi.org/10.1016/j.jenvrad.2016.05.022

G. Ielsch, M.E. Cushing , Ph. Combes , M. Cuney, 2012. *"Mapping of the geogenic radon potential in France to improve radon risk management: methodology and first application to region Bourgogne"* . Journal of Environmental Radioactivity 101 (2010) 813-820

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Some methods…..

- **Geochemistry**

A. Ferreira, Z. Daraktchieva, D. Beamish, C. Kirkwood, T. R. Lister, M. Cave, J. Wragg, K. Lee, 2016. *Indoor radon measurements in south west England explained by topsoil and stream sediment geochemistry, airborne gamma-ray spectroscopy and geology.* J. of Environmental Radioactivity, http://dx.doi.org/10.1016/j.jenvrad.2016.05.007

- **Multivariate approach**

G. Kropat, F. Bochud, C. Murith, M. Palacios (Gruson), S. Baechler., 2016. *Modeling of geogenic radon in Switzerland based on ordered logistic regression.* J. of Environmental Radioactivity, http://dx.doi.org/10.1016/j.jenvrad.2016.06.007

H. Friedmann, A. Baumgartner, M. Bernreiter, J. Gräser, V. Gruber, F. Kabrt, H. Kaineder, F.J. Maringer, W. Ringer, C. Seidel, G. Wurm, 2016. *Indoor radon, geogenic radon surrogates and geology – Investigations on their correlation.* J. of Environmental Radioactivity, http://dx.doi.org/10.1016/j.jenvrad.2016.04.028

***Question**: Can these approaches be extended or generalized to regions/areas with different availability of datasets related to geogenic radon?*

Initial Idea from GARRM 2014

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EGRM: Multivariate classification scheme

Grid 10 km x 10 km

Input Variable (i)	RP (1)	INDOOR (2)	GEO (3)	U_{soil} (4) U_{rock} (5)	TGDR (6)
Classification (PB method) 0 1 2 3	s_1	s_2	s_3	s_4 , s_5	s_6
Weight	$\omega_1(n)$	$\omega_2(n)$	ω_3	$\omega_4(n), \omega_5(n)$	$\omega_6(n)$

Geogenic Radon Risk Index

$$\sum_{i=1}^{6} \omega_i s_i \Big/ \sum_{i=1}^{6} \omega_i = \textbf{Geogenic Radon Risk Index}$$

0 | 1 | 2 | 3

Low Risk → High Risk

n – number of samples per grid cell

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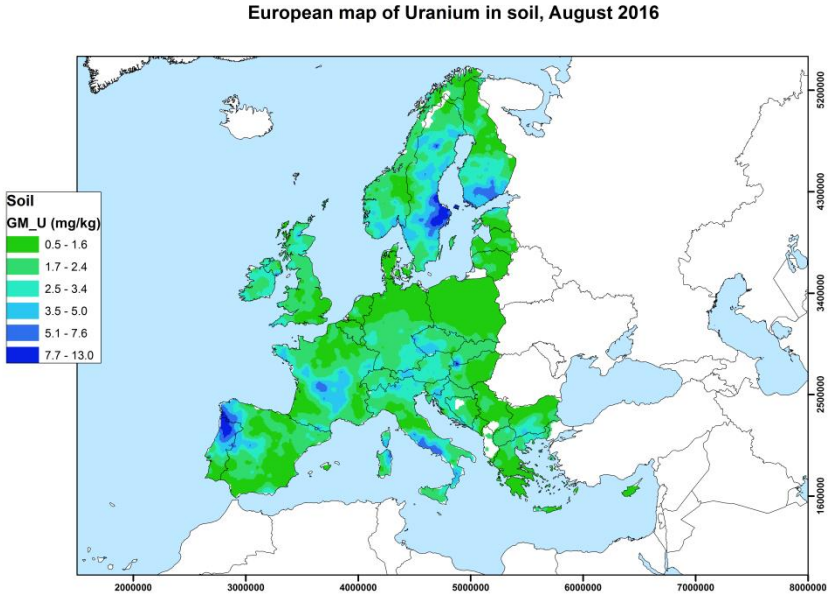
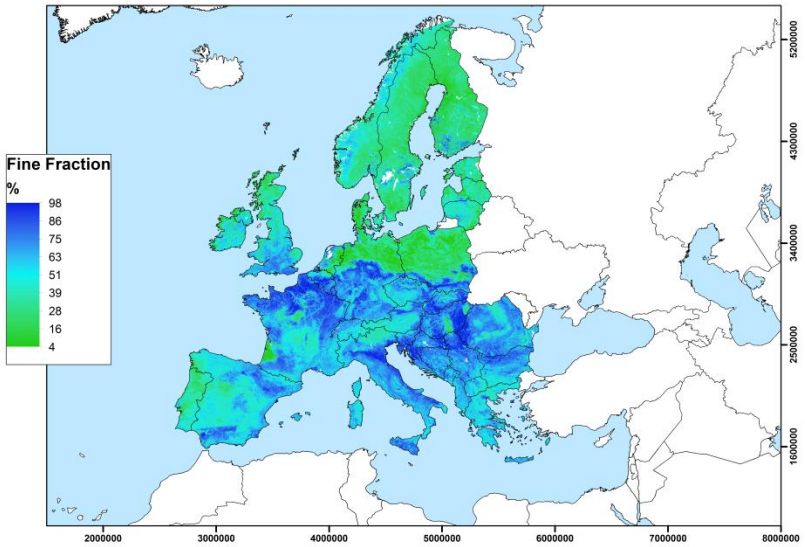
European Atlas of Natural Radiation: Data available for EGRM



Concentration of Uranium in topsoil

Input data: *FOREGS and GEMAS databases*

Resolution: *10 km X 10 km*



Percentage of topsoil fine fraction (<63 μm)

Input data: LUCAS texture properties

Resolution: *0.5 km X 0.5 km*

European Atlas of Natural Radiation: Data available for EGRM

TGDR

In progress

Annual effective dose rate due to terrestrial radiation

Input data: Ambient dose equivalent rate_EURDEP data

Resolution: 10 km X 10 km

U in bedrock

In progress

Concentration of Uranium in bedrock

Input data: Scientific Literature

Resolution: *simplified GU from OneGeology Europe*

Desired properties of RHI

Its value at a location must be independent on which quantities it has been estimated from.
I.e., RHI calculated from U concentration in soil should have approximately the same value as if calculated from dose rate or GRP, etc.
This follows from the requirement to be consistent across borders, or regions in which different input quantities are available.
consistency requirement

desirable: a RHI estimator which includes as much information as possible (~"sufficient estimator")

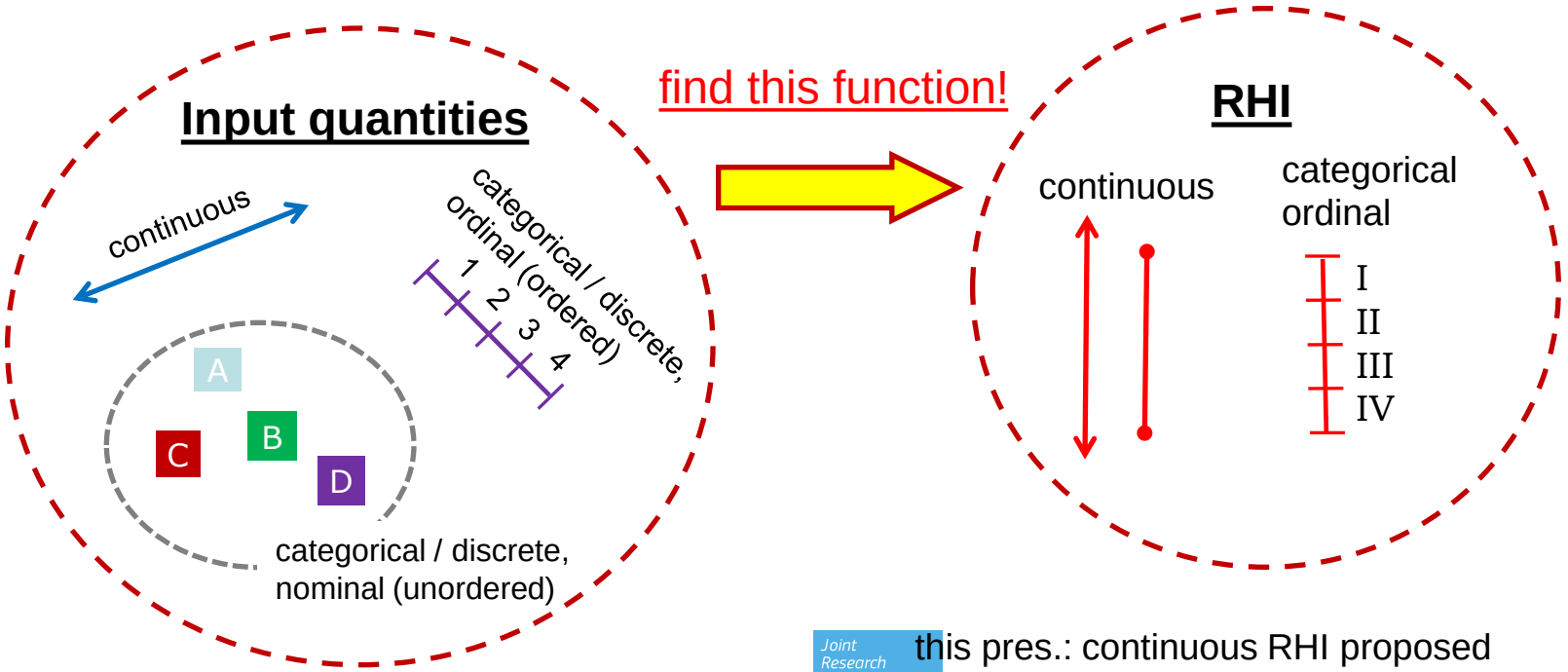
calculation shall be as simple as possible.

Different concepts

Rn hazard index RHI can be:

continuous index, e.g. ∈[0,1] or (-∞,∞) etc.

discrete index or score, e.g. ∈{I,II,III,IV}
or {low, medium, high} etc.



this pres.: continuous RHI proposed

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