The MetroRADON questionnaire on geogenic radon surveys

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Content

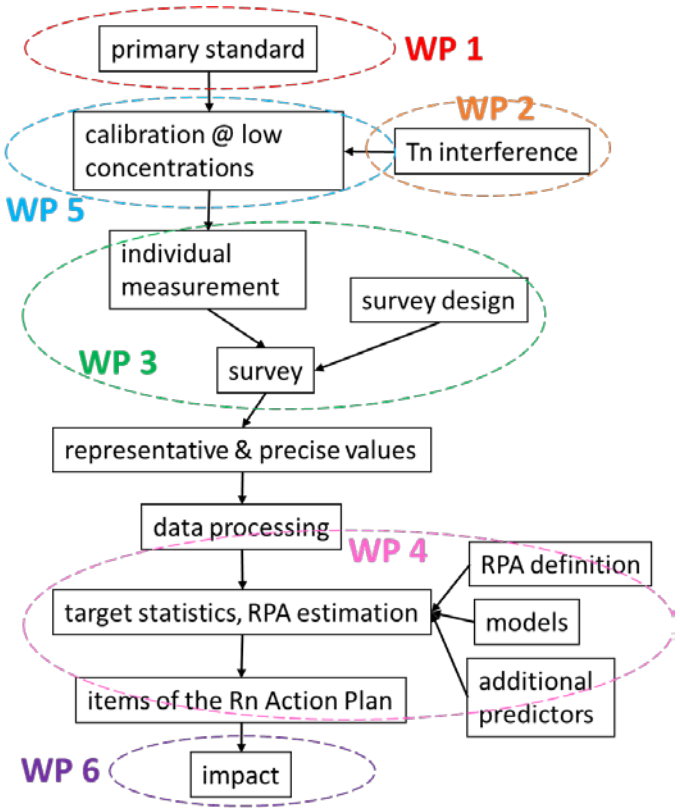
- Metro Rn ↘ WP3
  WP3 ↘ Geogenic questionnaire
- Structure, response
- Harmony ♥ disharmony
- Potential and need ? for harmonization

WP3 in Metro Rn

- "The collection of radon survey methodologies and evaluation of their comparability will provide guidance for technical and political decisions in implementing the European-Basic Safety Standards (EU-BSS) in Member States (…) as well as on a European level (e.g. European Atlas of Natural Radiation)".

⇒

- Collect & analyze meta-information on Rn surveys and surveys on Rn predictors;
- Identify possible methodical inconsistencies
- Address potential for harmonization
- Done by questionnaires to institutions engaged in surveys of ambient radioactivity.



WP3 ↘ Geogenic questionnaire

- Geogenic radon is an important predictor of indoor radon.
- Therefore, geogenic quantities are used for Rn hazard mapping.
- This implies:
  - ⋆ Assessment of geogenic quantities should be reliable and QAed;
  - ⋆ They should be harmonized or at least harmonizable between institutions that measure them and between regions and countries, so that they can be compared.
- ⇒ Questionnaire aimed to investigate state of possible "dis-harmony"

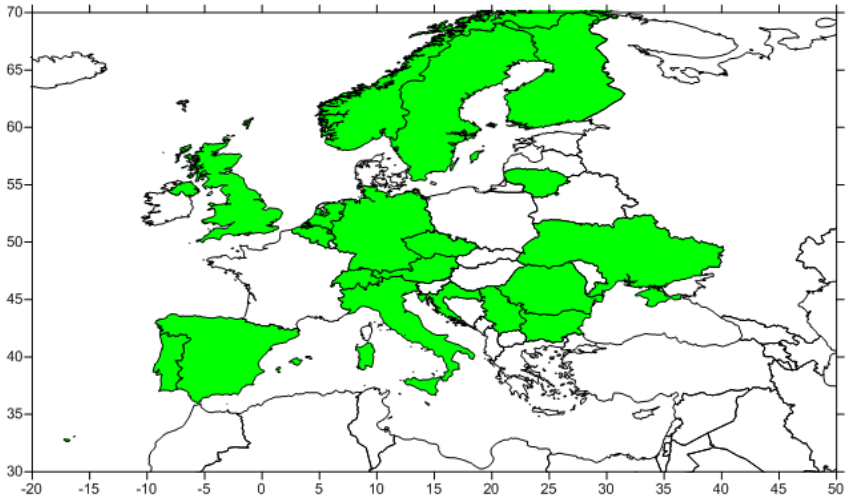
Structure

- Which quantities covered?
  - Soil Rn
  - Permeability
  - Ambient dose (equivalent) rate
  - Geochemical conc. (U, Th, K)
  - Airborne gamma spectrometry
  - Rn in water
- What has been asked?
  - Sampling design
  - Sampling and measurement methods (instruments, protocols,…)
  - Survey size and coverage
- Who has responded?

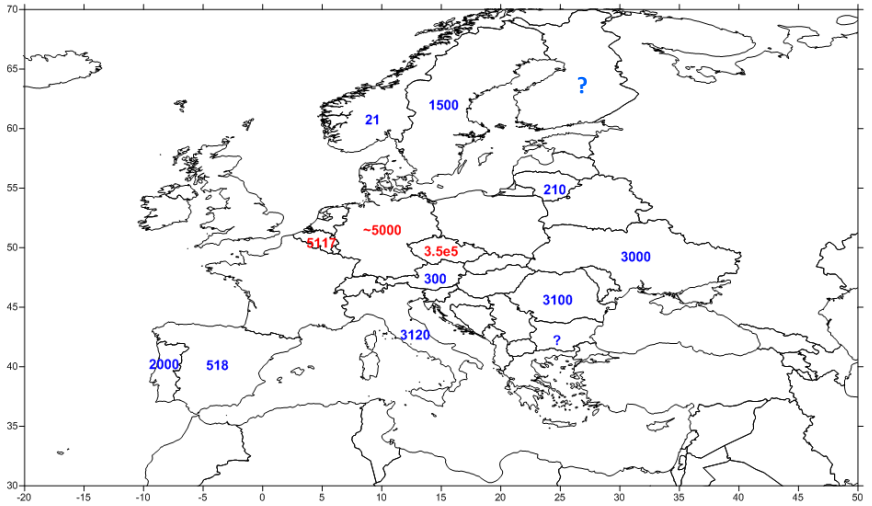
  28 institutions from 19 European countries, 15 EU (incl UK), 4 non-EU.

response, coverage

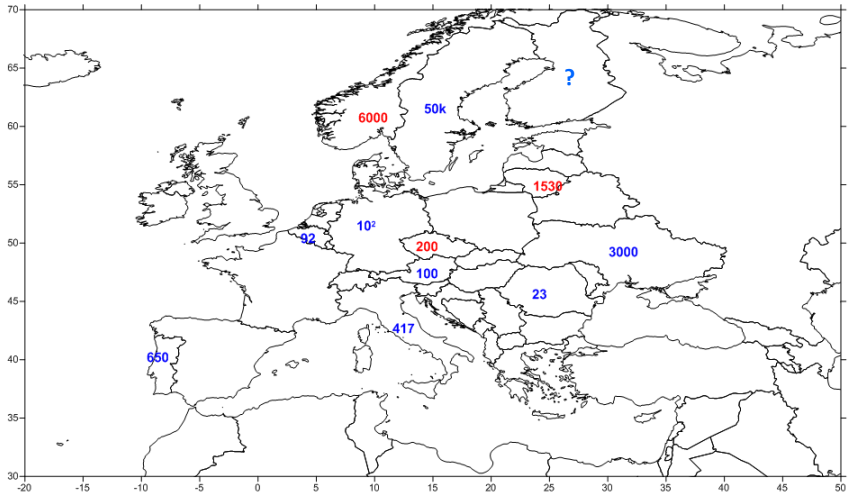
General respondents (incl. negative resp.)



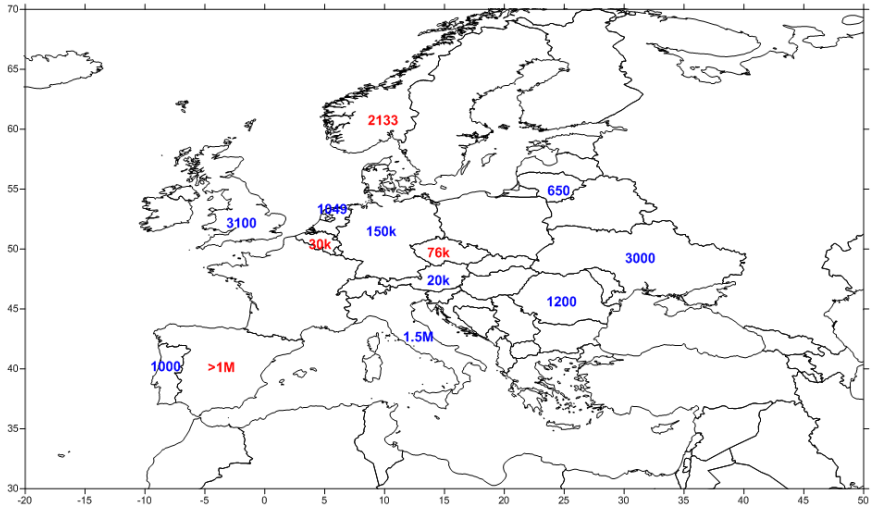
samples soil Rn; red: 100% areal coverage



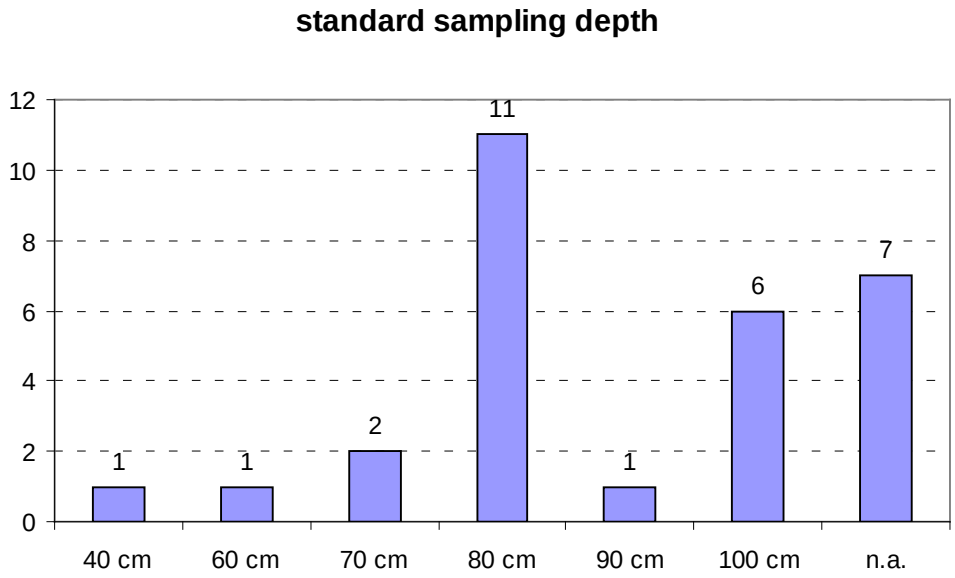
geochem; red: 100% coverage

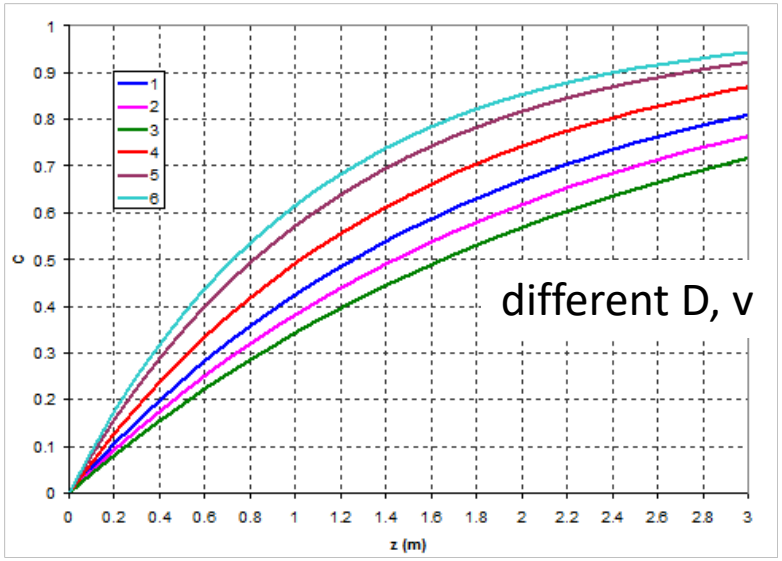


ADR; red: 100% coverage



Harmonization problems – Example 1: Soil Rn, Sampling depth





$$C(z) = C_0(1 - \exp(-\alpha z))$$

$$\alpha = -\frac{v}{2D} + \sqrt{\frac{v^2}{4D^2} + \frac{\lambda}{D}}$$

$$v = \frac{k}{\mu}\nabla p$$

Fraction of equilibrium concentration $C_0 \equiv C(\infty)$ captured by usual sampling is only 20-70% .
C(z) depends on z, D, v.
⇒ Comparability of soil Rn results??

$C_0 = C_{Ra}\, \varepsilon\, \rho / por$ (C_{Ra} – ^{226}Ra concentration assumed homogeneous, ε - emanation coefficient, ρ - bulk density, por – porosity), D = D(air)·por ; k - permeability, μ - dynamic viscosity of air, ∇p - pressure gradient (Pa/m)

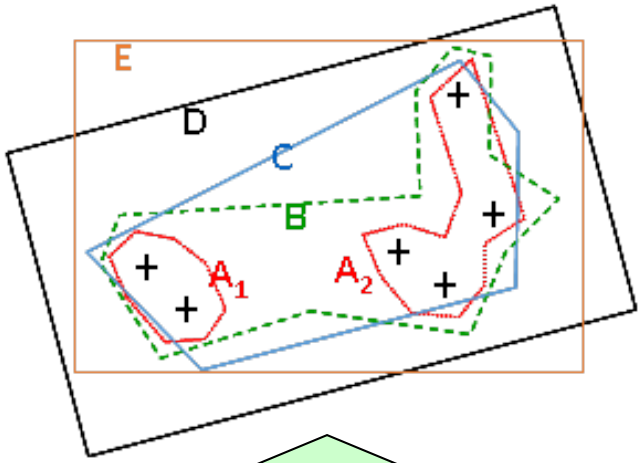
Example 2: Soil radon – what is a "sampling point"?

country	geometry	number	statistic
AT	triangle around or line across defined meas. point; size=?	3	AM,max
BE	rand at point (=?) in 1x1km² grid square	2-3	max
BG	construction site in RPA (legal); square sampling grid	10	AM, max, min
CZ	construction site, regular grid (legal)	typically 15	3.quartile
DE	triangle, 5 m side	3	max
ES	lithostrat. unit within 10x10km² grid cell	2	AM, Med
IT-1	"study area", rand. or square scheme	5	AM,GM
IT-2	triangle (size=?)	3	AM,max
LT	diagonal of 10x10m² square	3	AM
NO	Triangle (size=?) of ADR meas. points; within triangle 2 points separated 50cm	2	AM
PT	Geological outcrop or building site; acc. gamma survey or transect across faults	3 to about 1 per 4m²	Med
RO	10x10km² grid cells, rnd within	3	AM,GM,min,max,CV
SE	2 points <15m apart; rnd where possible	2	all data
UA	1 km², square scheme	30	AM,max

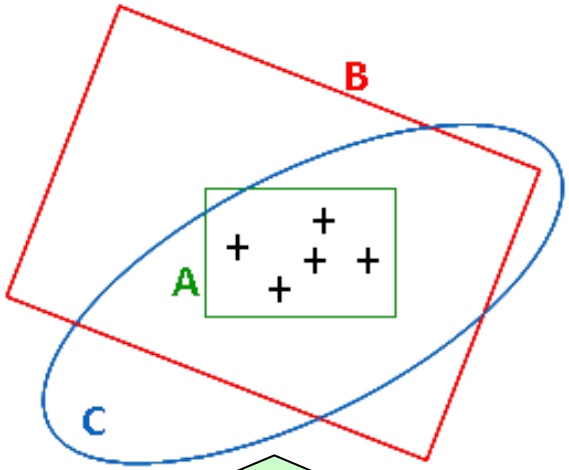
Example 3 – soil radon: for which area is a measurement result considered representative?

+ … sampling points

Usually, we are not interested in the value at the sampling point, but (unexpressed!) understand it representative for an area…. which area?



Which is the domain for which these points stand? A (broken into two parts), B, C, D and E are prima vista equally plausible.

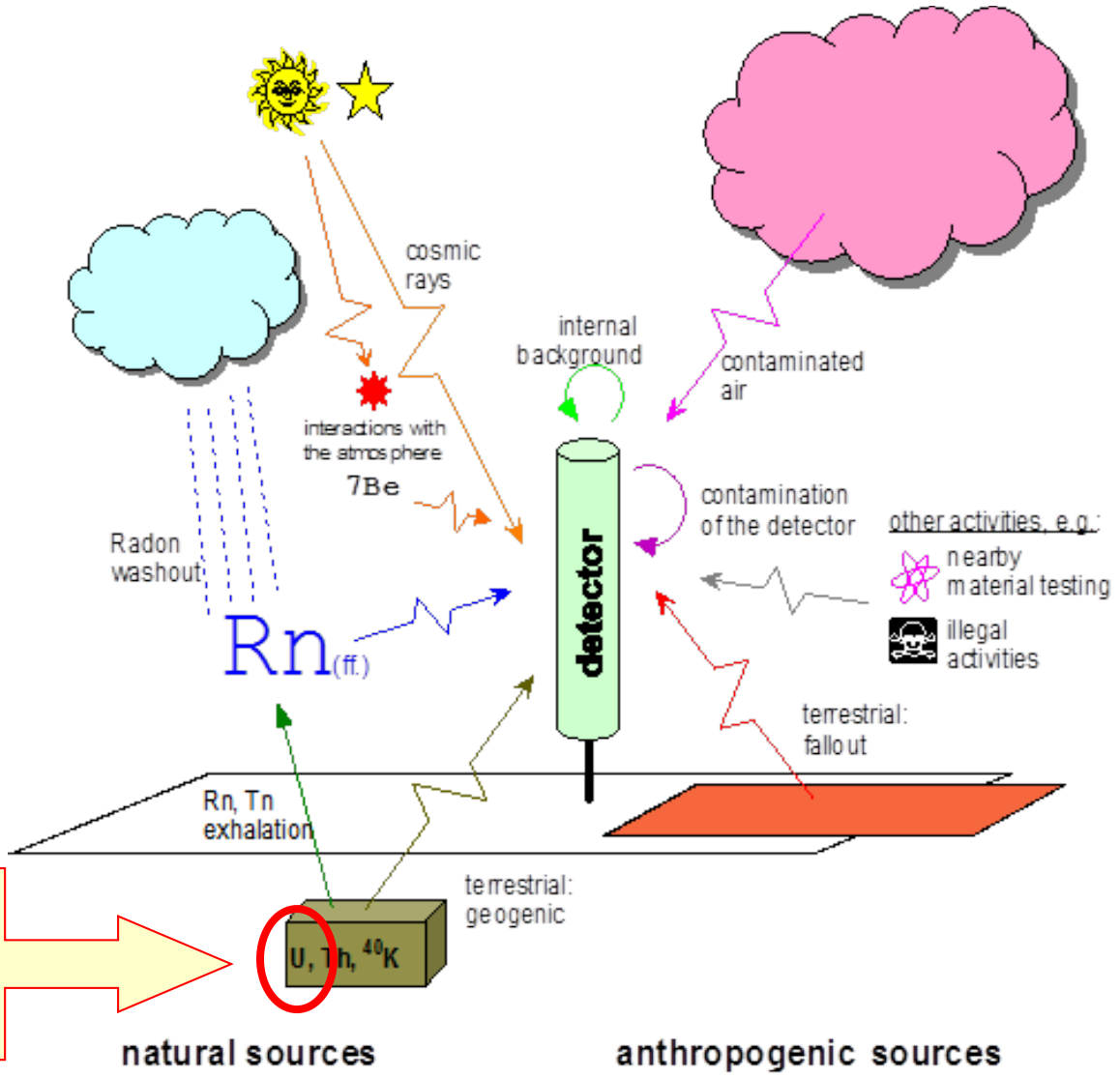


If the sample is considered representative for A – is it also for B and C? Or under which conditions?

Differences between *interpretation* approaches could not be inferred from the questionnaire!

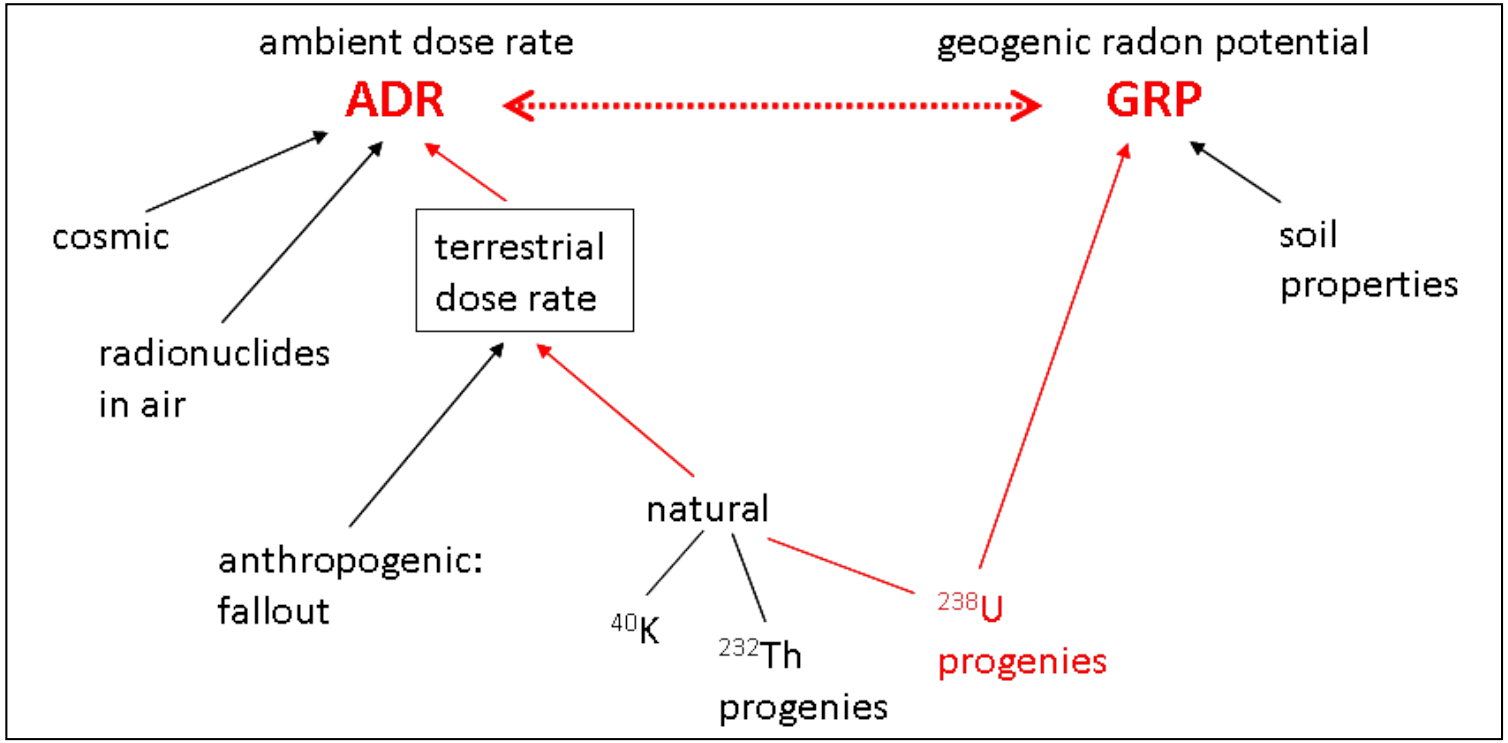
Ambient dose rate - 1

Sources of ambient dose rate



Therefore ADR is a relevant predictor or proxy of Rn !

Ambient dose rate -2



proxy relationship between ADR an GRP

Correlation is blurred by “noise factors” or “nuisance parameters”

ADR - Harmonization problems:

- Measurement geometry
  - x Height above ground
  - x Type of ground
  - x Distance to objects
- DR from secondary cosmic rays (mainly muons) included?
- Internal background (also zero-effect, intrinsic BG) subtracted?

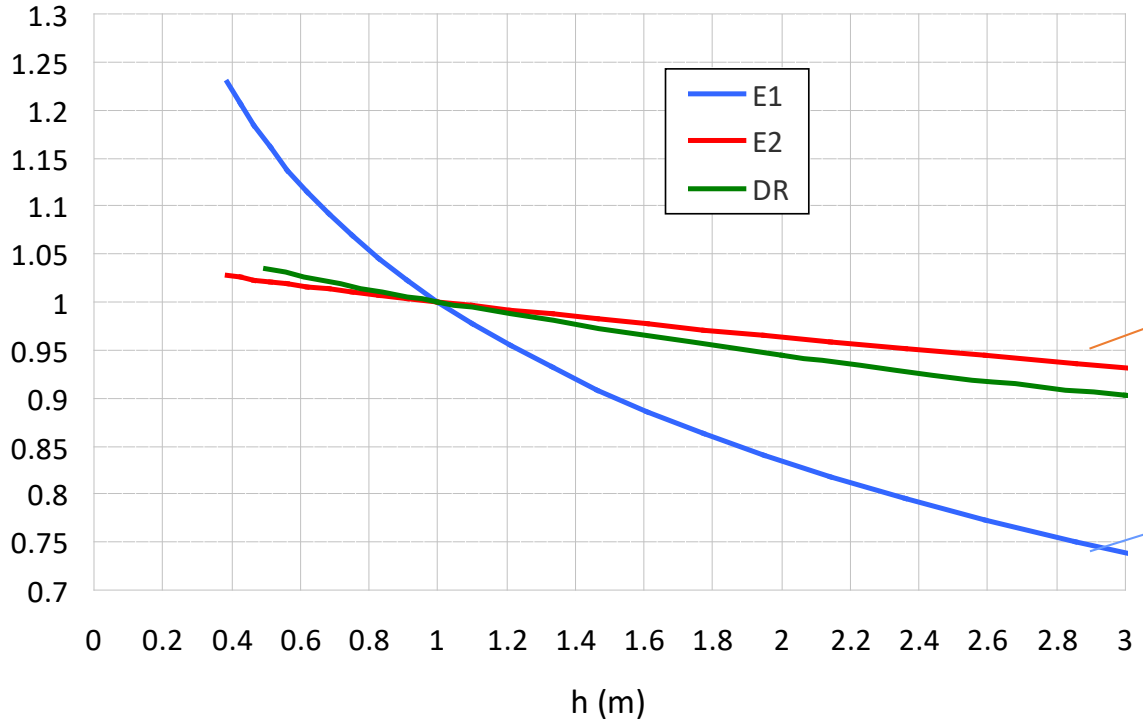
Ideal standard geometry:

- Infinite, even, flat natural ground, regionally representative
- no buildings, trees, hills, sinks, roads, water bodies…
  (realistic: not < ca. 10 m around monitor)
- Measurement height = 1 m
- Cosmic response, int. BG: to be reported

Remember EURDEP / AIRDOS !

- Systems are quite well understood;
- But relevant parameters partly missing

ADR – height dependence of terrestrial component



DR normalized to h = 1 m

homogeneous in soil column

surface fallout

monoenergetic (E) flux, E=662 keV (^{137}Cs), $\mu_a(E)$ – linear energy absorp. coefficient

- surface fallout ~$E_1(\mu_a(E)\ h)$;
- homogeneous in the ground: ~$E_2(\mu_a(E)\ h)$
- DR: empirical, natural radionuclides about homogeneous in the ground

$$E_n(x) = \int_1^\infty \frac{e^{-xt}}{t^n}\,dt$$

ADR – disharmony

- Less than ½ of the participants care about measurement geometry
- Similar number do not know whether this factor is considered or not.
- Measurement height: most 1 m, but also 1.5, 2, 2.5 m
- Many respondents said that they do not know whether internal BG considered.
- Self-assessment about conformity to standards: most respondents indicated high degree of conformity.

Что делать ?

Approaches to harmonization

- Bottom-up: same methods everybody
  $\Rightarrow$ results consistent a priori.
  In practice impossible, because (1) data already exist and (2) changing national or institutional practice is next to impossible.
- Top-down: different methods; to make results consistent, normalize to some standard.
  Requires good knowledge of the methodical differences!

Concerning GRP predictors and proxies:

It should be investigated how their methodical variability propagates into GRP uncertainty, to decide its practical relevance.

(For example, it has been shown that the CZ and DE soil-Rn sampling protocols lead to factually same results.)

Specifically: soil radon

- Inconsistent sampling depth is a problem!
  * Normalizing difficult
  * Shallow soil?
  * More basically: what is soil Rn concentration at a location supposed to represent?
    - Rn at an actual location, given actual soil conditions?
    - Theoretical equilibrium conc.?
- How to deal with grab sampling results in presence of temporal variability?
- Radical alternative: for mapping, use "synthetic" GRP calculated from geochem., geology, soil properties etc., instead of point measurement.
  (See also WP4 session tomorrow, "Geogenic Rn hazard index")
- **To be discussed!**

Specifically: ADR

- Top-down harmonization is possible, but quite an effort as the AIRDOS project has shown.

Conclusions

- In Europe, good deal of information available on status and methodology of surveys of geogenic Rn or quantities that may be used as predictors.
- But not many countries have attempted territory-covering geogenic Rn surveys or mapping. Some do it in regional projects mainly for scientific reasons.
- Methodical inconsistency (methods being correct in themselves!) may lead to incorrect conclusions about results and communication problems.
- European coverage and generation of a European geogenic Rn map by putting together regional ones will therefore not be an option for the foreseeable future;
  However, experiences are valuable for developing bottom-up concepts of geogenic Rn mapping → see GRHI session tomorrow.

Thank you!

Bundesamt für Strahlenschutz

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