

A SOFTWARE FOR RADON RISK MAPPING

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1.METHODOLOGY

**2.INPUT AND OUTPUT
OF THE SOFTWARE**

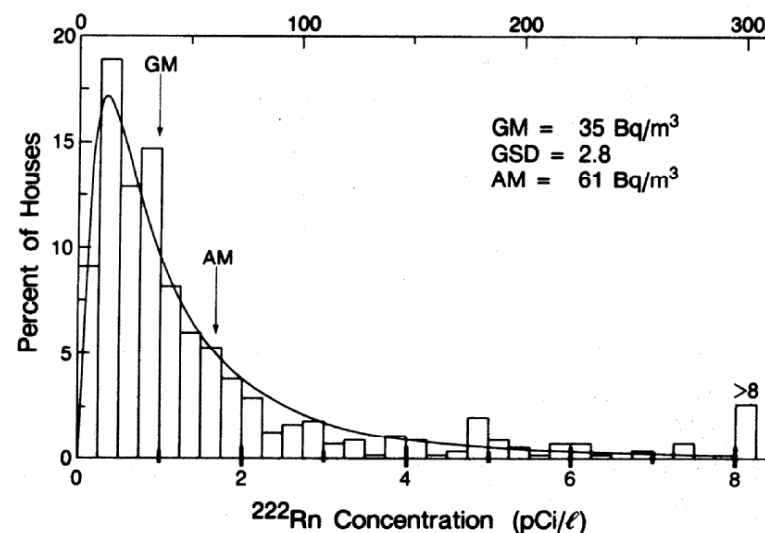
Indoor radon data in the Walloon region, Belgium

- 16844 km²
- 18718 indoor Rn data (ground floor)
- 13974 long term track-etch (~3 m)
- 4744 short term charcoal canister (~3d)
- Complementary geographical distributions
- Statistically compatible for calculating the geometrical mean (Cinelli et al., GARRM 2008)
- For geologically homogenous groups:
$$\text{LSD}^2(3d) \approx \text{LSD}^2(3m) + 0.5$$



Radon risk mapping

- Risk indicator : predicted local percentage of houses above the reference level
- = tail of the (assumed) local log-normal distribution
- Prediction sensitive to
 - deviations of data w.r. to log-normality
 - the precision of the logarithmic SD

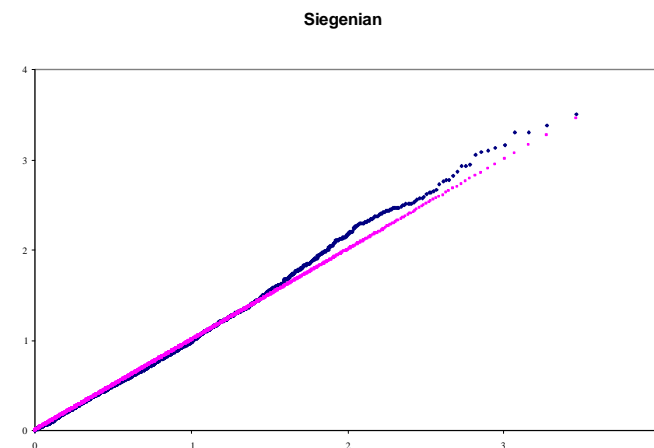
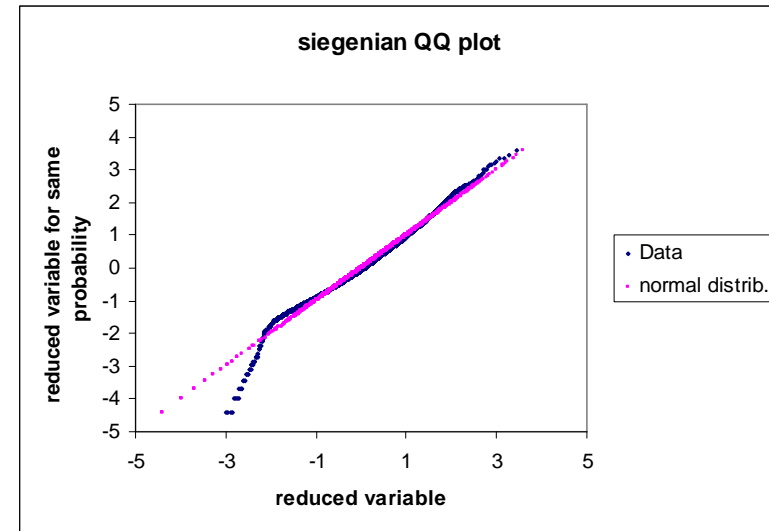


Log-normality

- normal plot (Q-Q plot)
- problems with the low-C tail

Cinelli et al., GARRM 2010

- only the high-C tail is useful for the % above the reference level
- ➔ fit LSD to the upper half only, assuming $L\text{Mean}=L\text{median}$



Variograms

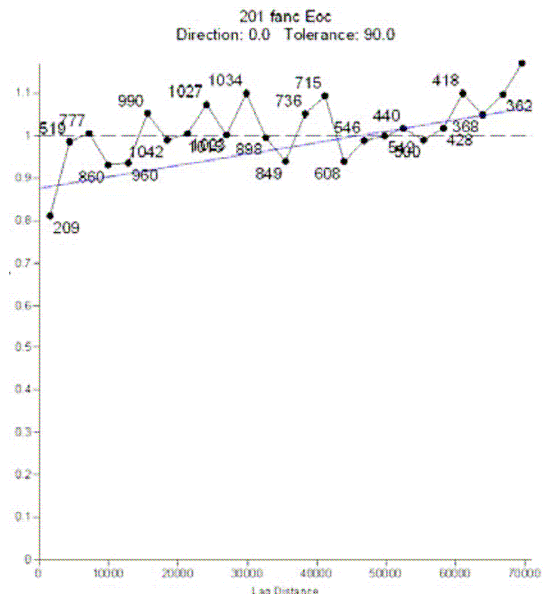
- Show the spatial correlation between data

For homogenous geological groups, Walloon data only show a small degree of spatial correlation

Cinelli et al. , GARRM 2008

Compatible with constant variogram model

➔ **MOVING AVERAGE**



Local distribution

- Local $LM(x,y)=LMed(x,y)$ from the $N=20$ nearest data in the same geological unit ($R<25$ km)
- Local LSD: not accurate with 20 data

Cinelli et al. (GARRM 2010):

local variations of $LSD(20)$ within a geological unit are almost random → constant LSD approximation (consistent with constant variogram):

local LSD = average $LSD(20)$

for the geological unit

Geological units

- In Belgium: no numerical lithological map, only the geological map can be used
- Simplified geology grouping formations of similar age and similar average indoor Rn : 19 units, compatible with OneGeology

**lower-middle Cambrian
in Brabant**

Cambrian (other)

Ordovician

Silurian

lower Devonian

middle Devonian

upper Devonian

Dinantian

Silesian

Permian

Trias

Jurassic

Cretaceous

Paleocene

Eocene

Oligocene

Neogene

Quaternary loess

Modern alluvia

Geology : example 1

- Carboniferous

	GM in Bq/m ³	% > 400 Bq/m ³	
Lower (Dinantian)			
Tournaisian	69	4.9%	limestone
Visean	75	5.6%	limestone
Upper (Silesian)			
Namurian	59	2.2%	clastic sedim.
Westphalian	50	2.1%	clastic sedim.

Geology : example 2

- Devonian

		(GM)		(*)
		Bq/m ³		
– Lower	Gedinian	144	13.4% D	(~Lokhovian)
	Siegenian	135	12.8% D	(~Praguian)
	Emsian	113	9.7% D+(C)	
– Middle	Eifelian	86	4.1% D+C	
	Givetian	73	3.5% C+D	
– Upper	Frasnian	61	1.7% C+D	
	Famennian	69	2.9% D +(C)	

(*) very approximate lithological trend:

D = clastic sedimentary rocks , C = calcareous rocks

Geology : example 3

- Cambrian
- 3 well-separated massifs

		(GM in Bq/m ³)	% > 400 Bq/m ³
Brabant	Low-Middle	57	3.3%
	Upper	112	15.9%
Stavelot	L-M	111	14.9%
	Up	133	15.6%
Rocroi	L-M	70	0<6%
(few data)	Up	79	0<4%

Software :

input file 1 : list of geological units

- Text file, to be provided by the user
 - 3-letter code for each geological unit
- CLM
CUp
Ord
Sil
DLo
DMi
DUp
Din
Hou
Per
Tri
Jur
Cre
.....

Input file 2: indoor Rn database

Text file

```
18270
10001 148620 171590      18      ST      Alm
10002 149320 172920      10      ST      Alm
10003 148890 172270      10      ST      Alm
10004 148370 170720      44      LT      Alm
10005 148240 170740      24      ST      Alm
10006 149650 171120      23      LT      Eoc
10007 149850 171140      20      ST      Eoc
```

.....

```
id#   x(m)  y(m)   C(Rn) LT/ST  geol.unit
```

Input file 3 : grid for the map

- Text file: list of coordinates where the risk indicator is calculated ($\% > \text{ref.level}$) with local geological unit

17123

45000. 156000. Alm

47000. 155000. Alm

48000. 156000. Alm

51000. 161000. Alm

.....

x(m) y(m) geol.unit

Input file 4 : options

RL
20
25000.
LS
400.
logmean.bmp percent.bmp 1000.
20. 270.
geololis.txt grid.txt database.txt
result.txt gustat.txt journal.txt
essai 8 mai

Type of distribution
Number of data for moving average
Max.radius for moving average
Long- and/or short-term
Reference concentration
Name of image files and grid scale
Colour scale (first image)
Names of data files
Names of output files
title

Output file 1: results

283000.000	145000.000	4.502	13.46	21234.809	Cam
283000.000	146000.000	4.423	12.24	21789.410	Cam
283000.000	147000.000	4.423	12.24	22440.553	Cam
284000.000	147000.000	4.423	12.24	23197.809	Cam
131000.000	149000.000	4.510	14.88	3169.479	Ord
132000.000	151000.000	4.392	13.04	2117.475	Ord
133000.000	150000.000	4.392	13.04	1104.783	Ord

.....

X	Y	logmean	%	Radius	Geol.unit
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Output file 2: statistics

102 LT data in GU Sil
53 ST data in GU Sil
6044 LT data in GU DLo
443 ST data in GU DLo
614 LT data in GU DMi
155 ST data in GU DMi
.....other

Output file 3 : journal

Title

List of options

List of files

“error” messages and comments

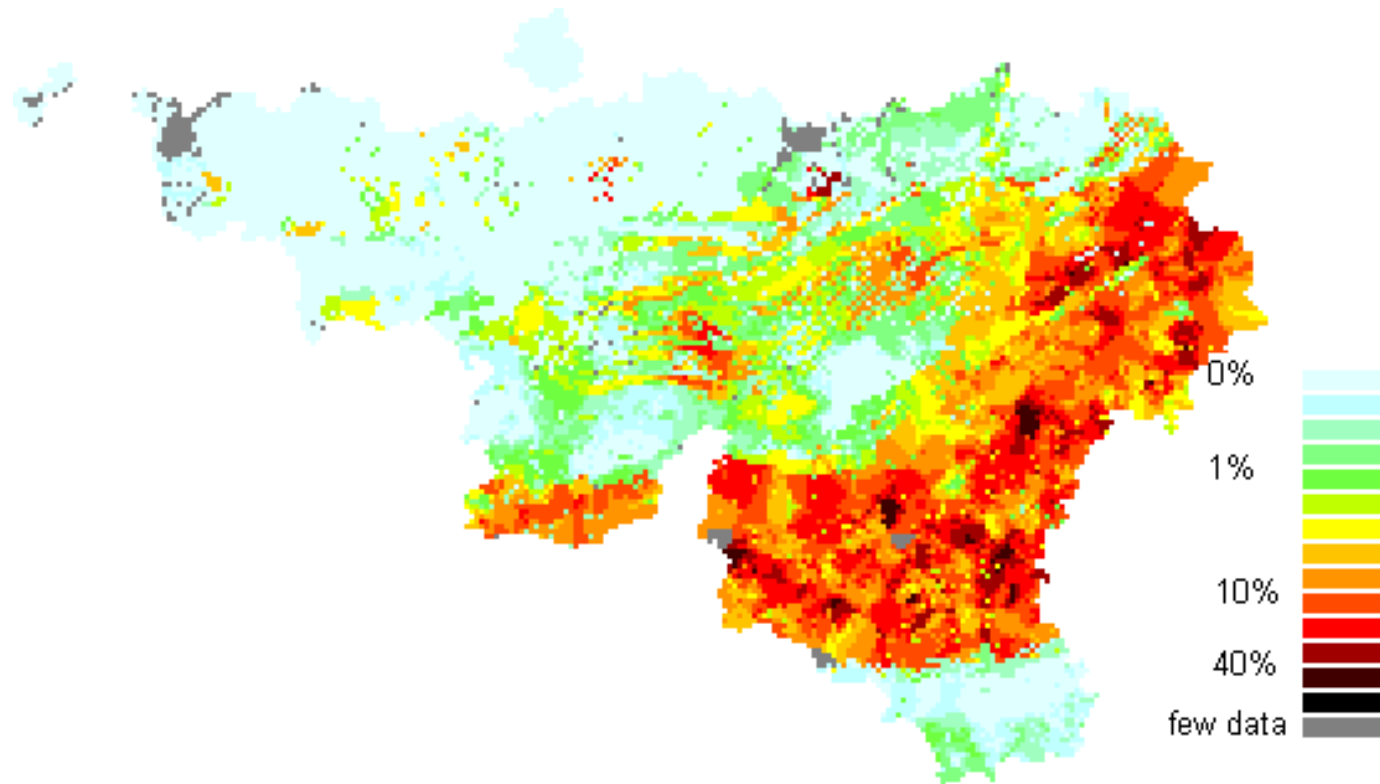
187000.000	71000.0000	Cam	11	too few LT+ST data for this node
187000.000	72000.0000	Cam	11	too few LT+ST data for this node

too few nodes in GU for ST variance Tri 0

GU data not recognised # 10108 zzz

Result file: map

- 1km grid



Call for collaboration

- Presently : A bit old-fashioned:
DOS executable
source in FORTRAN
- We seek help for a conversion to modern style : C++, windows-type ...
- β -testers welcome

Thank you