Radon risk mapping

Jon Miles (UK Health Protection Agency)

Centre for Radiation, Chemical and Environmental Hazards
Radiation Protection Division
formerly the National Radiological Protection Board

Why do we want to map indoor radon?

To avoid high radiation exposures,

- We need to identify buildings with high radon concentrations, so that the concentrations can be reduced
- We need to ensure that new buildings in high radon areas do not have high concentrations, by changing building regulations

Possible sources of data for radon mapping

- Geological maps (geology determines radon potential)
- Radon in soil gas (indoor radon comes from the ground)
- Airborne surveys of gamma rays from radon decay products (gives detailed map of radon in ground surface)
- Permeability of ground (movement of soil gas into buildings depends on permeability)
- Results of measurements of radon in houses (what we want to map is radon in houses)

Use of radon house data

In fact, we have no alternative to using results of indoor measurements, because we want to map indoor radon.

Other data is supplementary data, we have to calibrate it using house radon data.

Either way, we must deal with house radon data. We must therefore understand and interpret the data.

Drawbacks of using radon house data

- Indoor radon concentrations are extremely variable, even for houses on identical geology
- We do not have as much data as we would like (especially in rural areas)
- We need to know the locations of houses accurately (may be difficult for postal surveys)

The key to radon mapping is finding solutions to these problems

Reasons for using indoor radon

- Indoor radon concentration is the parameter of interest
- Indoor radon measurements are cheap: they are carried out by post, and householders return the detectors
- Results are collected for other purposes, such as to identify high radon houses

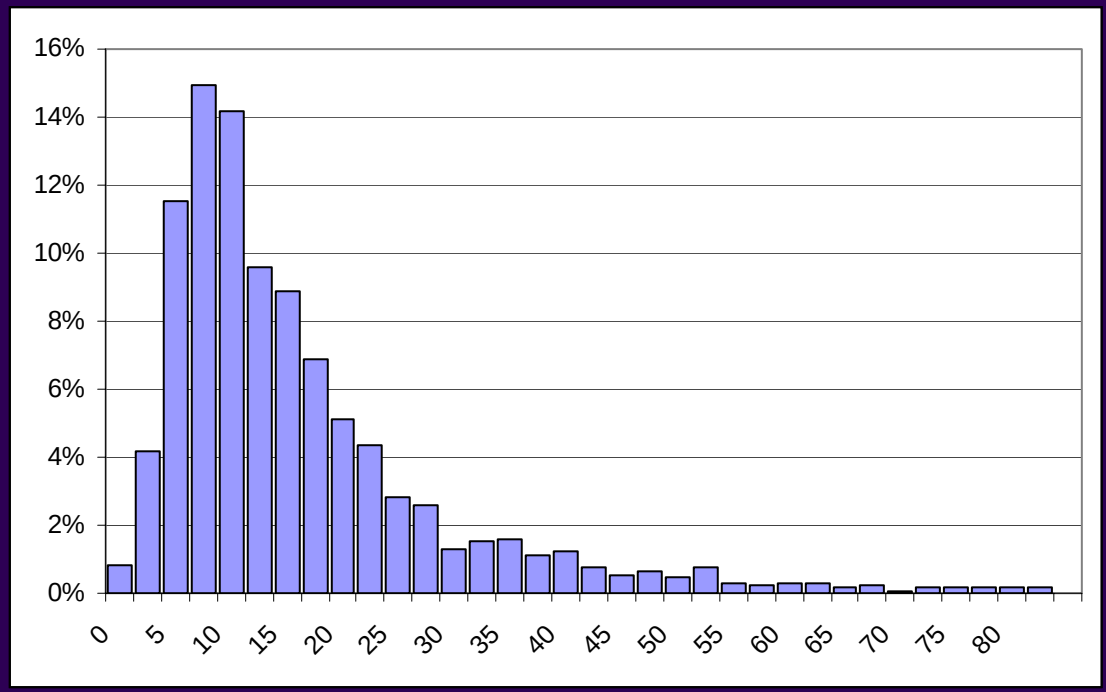
Why are indoor radon concentrations so variable?

- Radon enters buildings not by diffusion, but with bulk airflow
- Even if houses are apparently identical, they vary in detail
- Ground conditions under houses vary, such as previous disturbance of the ground or cracks in the ground
- The habits of occupants vary, such as whether windows are opened upstairs or downstairs, the average indoor temperature, and occupancy patterns

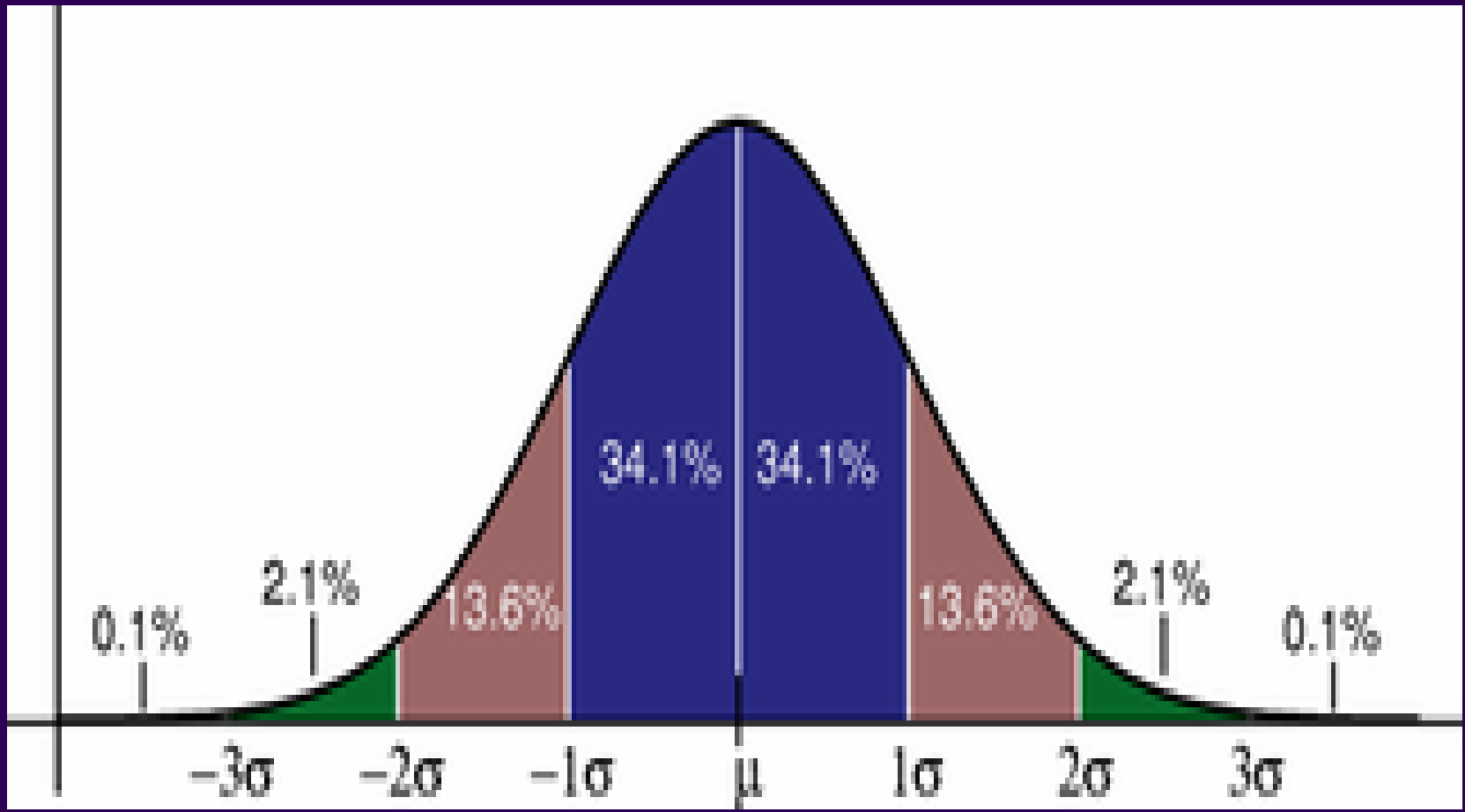
Indoor radon distribution

Indoor radon in the UK is distributed lognormally, after subtraction of outdoor radon (4 Bq m^{-3})

Applies nationally and in small areas



Distribution of logarithms of radon concentrations



Use of lognormal distribution

- We can calculate the geometric mean and geometric standard deviation of any lognormal distribution
- These parameters allow us to calculate the proportion of houses above a reference level
- This applies to a national data set, or to a local data set
- It is particularly useful for mapping, as it defines the areas where the worst problems are to be found
  1. Group data geographically
  2. Calculate percentages above reference level
  3. Colour map accordingly

How should we group the radon data?

- By administrative unit (county, district, postal area, etc)
- By grid square
- By geological unit

Development of radon mapping in the UK

1. Mapping first parts, then all, of England, Wales and Northern Ireland, and parts of Scotland by 5 km grid square (1990-1999)
2. Mapping the parts of England with the highest radon concentrations by 1 km grid square (2002)
3. Mapping the variation in radon potential both between and within geological units over all of England and Wales to a typical accuracy of about 50 metres (2007)

Average accuracy of 5 km grid square mapping

Predicted percentage of homes above the Action Level	Actual percentage of homes above the Action Level
0 - 1	0.7
1 - 3	2.1
3 - 5	4.8
5 - 10	7.9
10 - 30	18
30 - 100	48

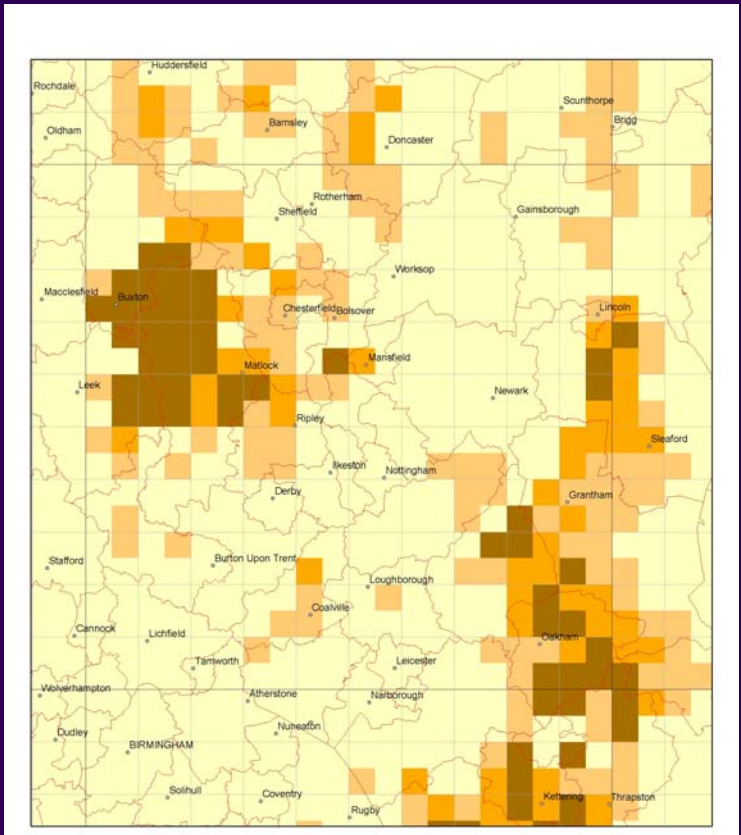
The UK is well-placed to map radon in detail

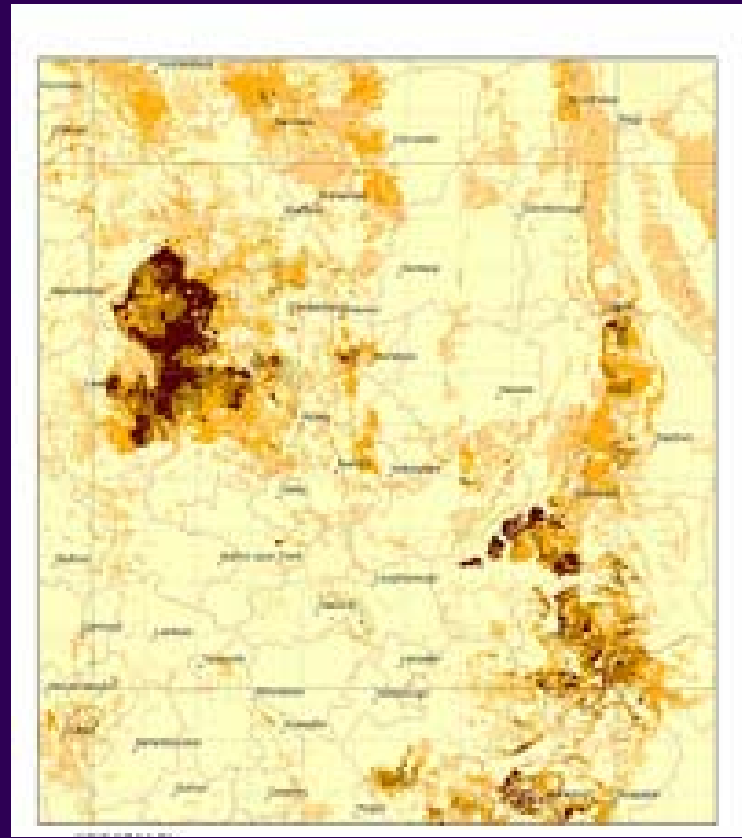
- We have about 500,000 results of measurements in homes, mostly funded by government
- Postcodes give co-ordinates of groups of 15 homes on average
- Address Point gives co-ordinates of individual homes
- Digital geological maps at 1:50,000 resolution are available

Joint geological / grid square radon mapping

- The new joint mapping method is based on about 500,000 results of house radon measurements
- Data are grouped first by geology, then by 1 km grid square
- Lognormal modelling of distributions of radon concentrations allows percentage above Action Level to be calculated
- Map shows variation both ***between*** geological units and ***within*** geological units
- The mapping method is based on more than 5 years of joint research by HPA and British Geological Survey

Derbyshire – East Midlands





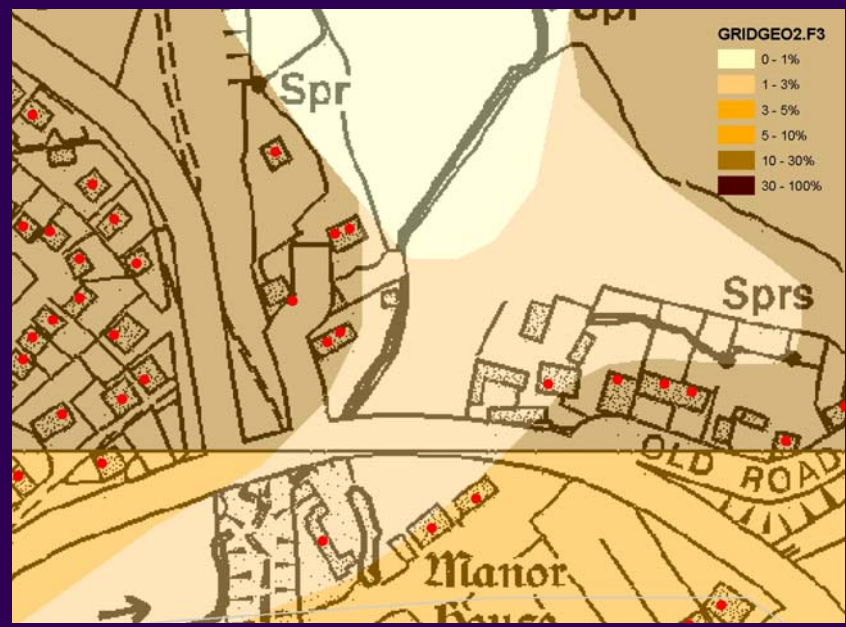
5 km grid square

Joint geological/grid square

Proposed dissemination of new radon data

HPA will publish a Radon Atlas with simplified (indicative) 1-km grid square maps classified according to the highest radon potential within each grid square

Detailed digital map database will be the definitive statement on radon potential for Radon Affected Areas and building regulations, accessible by website or licensed dataset



Use of supplementary data in radon mapping

- Geological maps (used in new UK mapping)
- Radon in soil gas (little data available, expensive)
- Permeability of ground (little data available, expensive)
- Airborne surveys of gamma rays from radon decay products (now becoming available)

Airborne survey data

- TELLUS gamma-ray data available for Northern Ireland
- HPA and BGS will use the data with house radon data and digital geological maps
- Group house radon data by geological unit
- Group gamma-ray data by geological unit
- Investigate spatial variation in radon and gamma-ray data within each geological unit
- Investigate relationship between radon and gamma-ray data within each geological unit

Present and future maps

The values of radon potential given are the best estimates that we can make on the basis of current information and mapping methods, but no map is perfect.

Maps only show probability - measurements are required to find out whether particular properties have high radon levels.