

Project description

Observations of atmospheric ^{222}Rn are widely used in the evaluation of climate models simulating transport, transformation and removal processes of gases and aerosols. Used in inverse mode, these models can provide information on location, extent and strength of sources and sinks of greenhouse gases based on the measurement of changes in their atmospheric concentrations. Such models are validated using ^{222}Rn as a tracer, assuming uniform flux from continents. We attempt to generate a spatially differentiated flux term. The approach is based on relating ^{222}Rn flux to a widely measured proxy (gamma dose rate; Schery et al. 1998), for which spatial data is already available for the entire region of interest.

Source function

A source function is needed to describe ^{222}Rn flux with terrestrial gamma dose rate. Simultaneous measurements of both parameters at Swiss field sites (MétéoSuisse) have been made. Additionally soil samples have been taken for a better description of outliers (e.g. soil texture, geology, radionuclides).

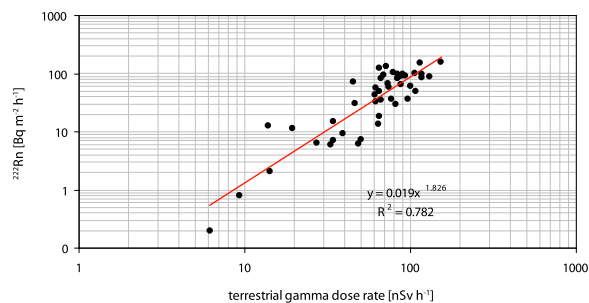


Fig.1
Correlation of terrestrial gamma dose rate and ^{222}Rn flux. Almost 80% of the variation in ^{222}Rn flux can be described by the variation of terrestrial gamma dose rate.

Gamma Ray Mapping

Gamma dose rates in Switzerland are monitored by NAZ (Swiss National Emergency Operations Center).

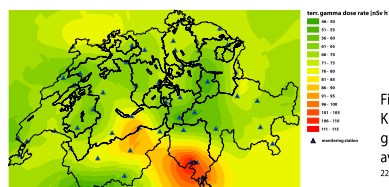


Fig.2
Kriging methods were used to establish a gamma dose rate map based on the available Swiss data as a base map for the ^{222}Rn flux map.

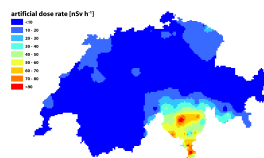
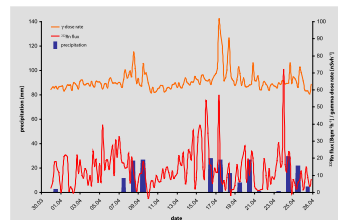


Fig.3
 ^{137}Cs map of Switzerland (Rybchak et al., 2002). Cosmic and artificial parts can be subtracted from total gamma dose rate to obtain the terrestrial component.

Soil moisture & precipitation

Fig.4
Precipitation and gamma dose rate in Rünenberg (CH) in April 2005. Heavy rainfall leads to a temporary decrease of both parameters and increases with dryer soil conditions.



Soil moisture is the most influencing parameter of temporal variations in ^{222}Rn flux.

High soil moisture decreases diffusivity and ^{222}Rn flux. It also shields part of the γ -rays. Thus, ^{222}Rn and gamma dose rate vary simultaneously. Exceptions are the few hours immediately following rainfall when gamma dose rate is enhanced by deposition of ^{222}Rn daughters. Therefore effects on soil moisture resp. rainfall events on ^{222}Rn flux can be assumed to be considered when using gamma dose data.

Soil & geological properties

The source of ^{222}Rn is ^{226}Ra , a radionuclide of the ^{238}U decay chain. ^{222}Rn diffuses through air filled pores in the soil to the surface. Air filled pore volume therefore is as important as the ^{226}Ra content. Soil texture may be used as an approximation for soil porosity. The mother nuclide ^{238}U is linearly linked to ^{226}Ra , geological parameters are possible evidences for the ^{238}U content.

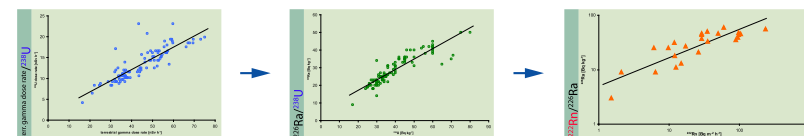


Fig.5
Left: ^{238}U dose rate is an almost constant part of the terrestrial gamma dose rate. Middle: ^{226}Ra and ^{238}U content (data from SUER). ^{226}Ra is directly linked to the ^{238}U content in soils as a part of its decay chain. Right: ^{226}Ra content and ^{222}Rn flux of soils in Switzerland and Scotland (Robertson et al. 2002).

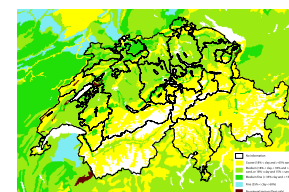


Fig.6
The soil texture map ("European Soil Database (v. 2.0), European Soil Bureau Network & European Commission"; EUR 19945 EN) gives an approximation of the soil porosity.

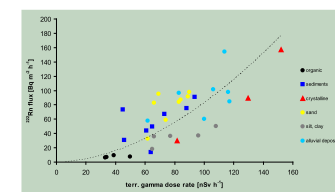


Fig.7
A correction factor is needed to improve the model (e.g. sandy soils are underestimated whereas clay soils are overestimated with the established source function (dotted line, see also Fig.1).

Swiss model for European ^{222}Rn map

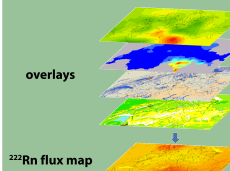


Fig.8
All informations will be adapted as overlays that leads to the ^{222}Rn flux map.

This model will then be used to establish a ^{222}Rn flux map for Europe as well as for the entire Russian Federation. The Swiss model will be validated now and improved. At regions of interest (Tall Tower Network, CHIOTTO) the ^{222}Rn flux map must be thoroughly verified. The map will be finished no later than in 2007, a draft will be available by mid 2006.