A high-resolution process-based radon flux map for Europe: development and uncertainties

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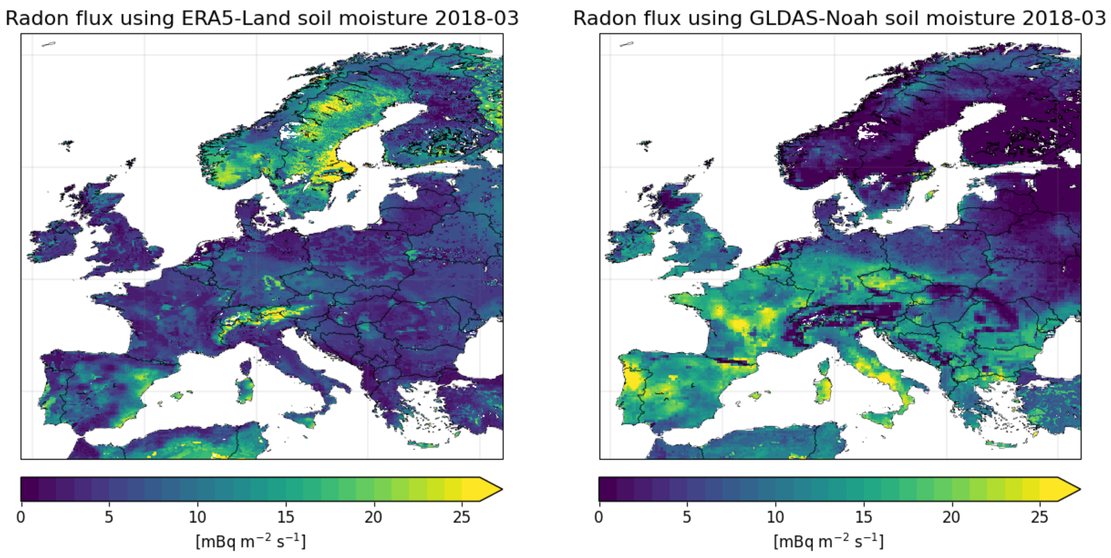
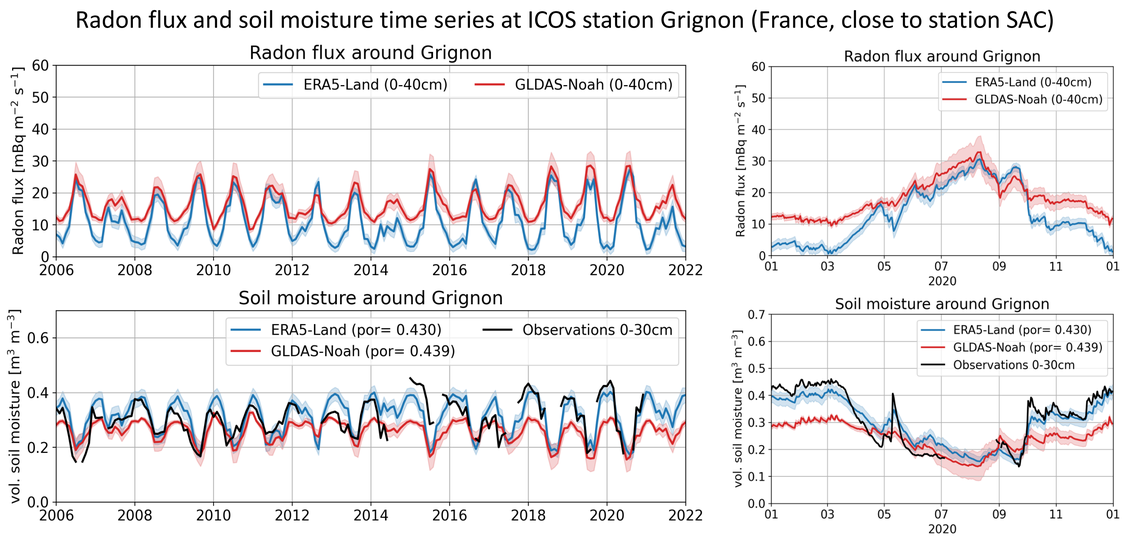
Radon flux map for Europe



- Radon production in soils is determined by soil texture and radium content ➔ spatial variability
- Radon exhalation from soils is governed by diffusive transport in the soil ➔ soil moisture causes temporal variability

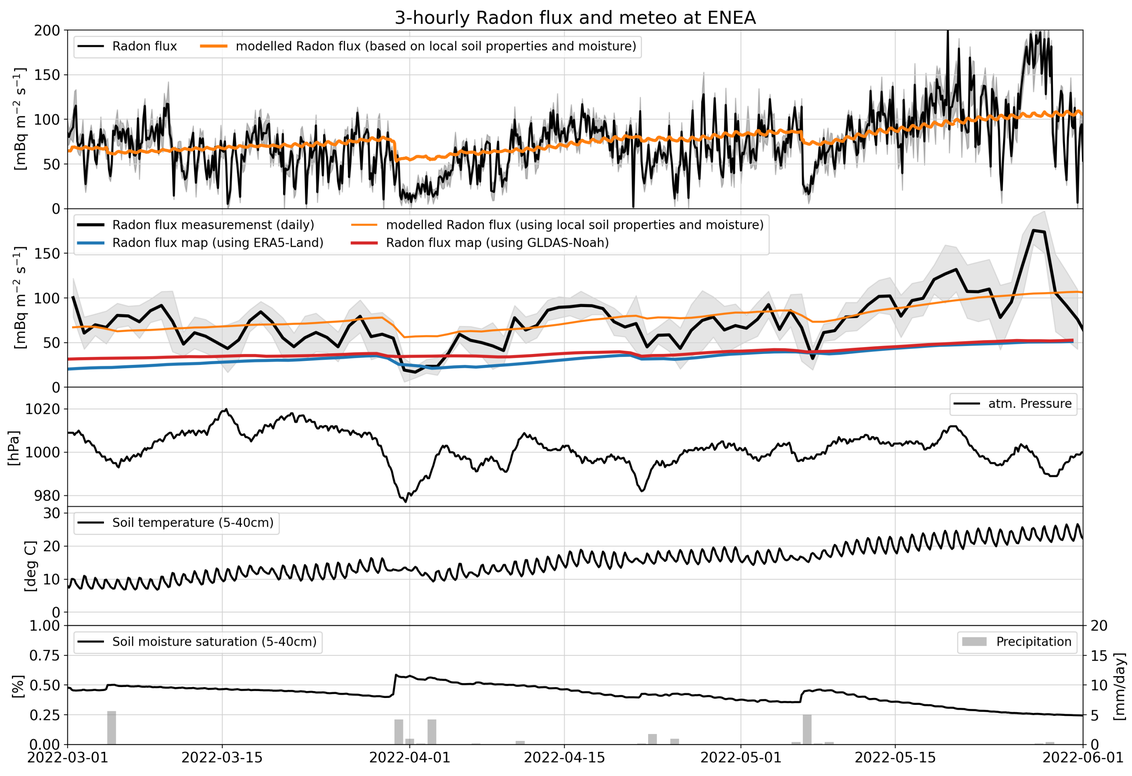


Soil moisture: Loubet, B., Buysse, P., & ICOS Ecosystem Thematic Centre. (2022). *Warm winter 2020 ecosystem eddy covariance flux product from Grignon* (Version 1.0) [Data set]. ICOS Carbon Portal. https://doi.org/10.18160/8XJC-HT7V

- Both soil moisture reanalyses show similar temporal variability but large differences in absolute values and seasonal cycle amplitudes ➔ large uncertainties in the modelled radon fluxes

Radon flux measurement campaings

- Sites: PTB, ENEA, SAC (traceRadon) & KIT (IUP Heidelberg)
- 3-hourly radon flux, soil moisture and temperature profiles, soil physical properties and radium content
- Evaluation of radon flux model using local measurements as input



- New high-resolution continuous radon flux measurements show an unexpectedly huge variability
- Correlations of radon flux and environmental parameters are inconclusive and even contradictory ➔ need to understand causalities for modelling

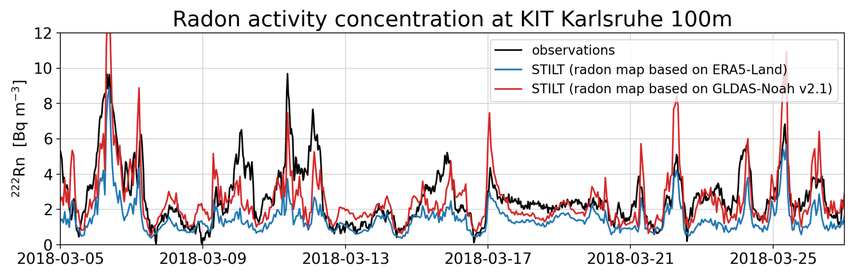
Radon as tracer for atmospheric mixing

- Radon has relatively well-defined source and sink characteristics:
  - As a decay product of uranium, it is exhaled from all natural soils
  - As a nobel gas, its only sink is radioactive decay with a half-life of 3.82 days
- Radon is applied in atmospheric mixing studies and as tracer for the evaluation of transport model performance

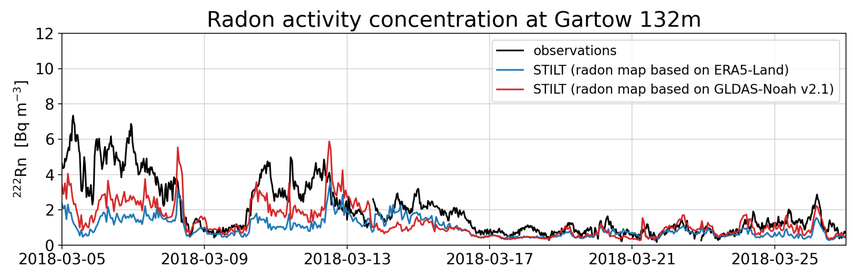
  … but this requires knowledge of the continental radon flux

Atmospheric transport simulations

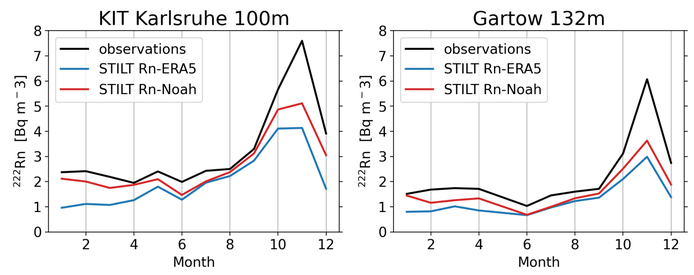
- Comparison of observed atmospheric radon activity concentration and STILT simulations based on different radon flux maps



monthly mean radon flux
4.3 mBq m⁻² s⁻¹
17.4 mBq m⁻² s⁻¹



monthly mean radon flux
1.6 mBq m⁻² s⁻¹
6.4 mBq m⁻² s⁻¹



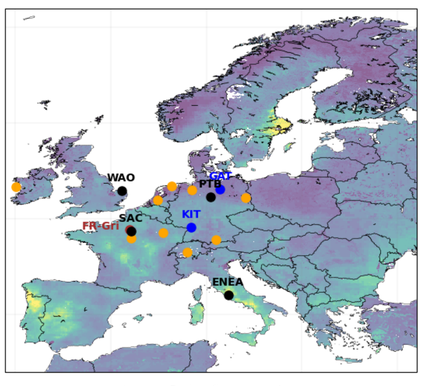
seasonal cycle 2018
daytime only

- As long as modelled radon fluxes are not fully validated, it remains difficult to disentangle deficiencies in atmospheric model transport and deficiencies in radon fluxes

Conclusions

- More dedicated and extended measurements of radon flux and environmental parameters in other soil types and climatic conditions are needed to better understand (and model) the interplay of the various processes
- High-quality, representative soil moisture measurements are needed for validation of modelled soil moisture in order to reduce the otherwise large uncertainties in the modelled radon fluxes

Get the radon flux maps at ICOS Carbon Portal



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