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Multiresolution analysis of high-rate radon time series from the Elat granite, Israel

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Radon (Rn-222), a naturally occurring radioactive gas with a half-life of 3.8 days, is continuously produced in uranium-bearing rocks as part of the U238 decay series. The application of stress to rocks is considered to enhance the release of radon from the solid mineral phase by emanation into the geogas, rendering radon a potential sensitive tracer of geochemical and geophysical processes in the upper crust. Hourly radon time series in the geogas from two boreholes in a granite body at Elat, southern Israel, are analysed. The time series are first segmented into consecutive intervals of 21 days. Then a wavelet-based multiresolution analysis is carried out for each segment, yielding a scale-by-scale additive decomposition of the radon time series. The decomposed signals at each specific scale are further analysed through a principal component analysis of the sub-series from the different segments. Radon time series exhibit a complex non-stationary temporal pattern with the overall variability linked to the mean radon level. Furthermore, radon signals include non-periodic low-frequency variability and periodic patterns at the annual, diurnal and semi-diurnal frequencies, superimposed to the nonlinear temporal behavior associated with the exponential decay of the radioactive element. The measurements from the two boreholes exhibit similar features, although the correlation between the values obtained near the surface and at depth is highest in the winter and lowest in the summer. The correlation between shallow and at-depth radon measurements is scale-dependent, being highest at the semi-diurnal and diurnal scales and negligible at the high-frequency scales. The statistical analysis reveals new systematic characteristics in the subsurface radon time series. Verification of such characteristics at further locations and establishing their distinctiveness opens new perspectives in the use and interpretation of radon as a proxy of geophysical processes in the upper crust.