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Statistical characteristics of Radon time series in the Elat Granite, Israel

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In-depth examination of radon time series in geogas is performed using high-rate (15-minute) monitoring in three boreholes 4-53 meters deep along a 0.6 km transect located in a massive jointed granite body, in a desert environment (Elat, Israel).

The measured signal (MS) displays a compound temporal pattern, which includes – seasonal (periodic, multi-day (non-periodic), and daily (periodic) radon signals.

Statistically these time series exhibit temporal variability in variance (heteroscedasticity). The heteroscedastic features of radon time series are investigated through the analysis of the measured signal over 2 complete years from two boreholes. The variance of radon counts is computed for consecutive 7-days segments spanning the entire 2 years record. Constancy of variance is assessed through a nonparametric test of randomness, the runs test. Furthermore, the association between the variance of each segment and the overall mean radon level is investigated by linear regression. A comparative similar analysis is carried out for 6-hour time series of other geophysical variables for the Elat area. The results show that air temperature, precipitation, and long-wave radiation time series exhibit constant variance over the analyzed period, while radon time series, atmospheric pressure, short-wave radiation, ground heat flux and net solar flux exhibit temporal changes in variance. Furthermore, for radon and radiation time series the variability is associated with the overall mean radon or radiation level, while for atmospheric pressure such an association is not present. These differences in the statistical characteristics suggest that air temperature and atmospheric pressure are not driving the radon signal in the subsurface.

Time offsets occur among time series of the MS and were investigated also for the MD and DR components, using consecutive 20-day intervals spanning +900 days. The resulting time series show that systematic time offsets occur, whereby the radon signal always occurs first at the easternmost site. The MD shows a gradually varying lag of 0-12 hours, and the DR a stable 1-3 hour lag.

Spectral analysis shows that the periodic daily radon signals are characterized by diurnal (24-hour, S1) and semidiurnal (12-hour, S2) periodic constituents, while tidal (gravity) constituents (M2, O1) are clearly lacking.

The amplitudes of the S1 and S2 constituents exhibit regular temporal variation having a seasonal pattern. The ratios of co-occurring amplitudes of these constituents define a linear pattern indicating a fundamental statistical property in the frequency domain of the radon time series.

Variation of the radon signal in subsurface geogas and hydrologic systems is often suggested and investigated for significance in terms of active geodynamics. In general the frequently encountered relatively large and complex signals are difficult to interpret in term of the interactions involved. The results obtained for the Elat Granite suggest that this complexity may be due to the interaction of unrecognized dynamic processes that are driving the radon signal in the subsurface regime of the pluton.