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Wavelet analysis for the study of the relations among soil radon anomalies, volcanic and seismic events: the case of Mt. Etna (Italy)

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From November 2009 to April 2011 soil radon activity was continuously monitored using a Barasol® probe located on the upper NE flank of Mt. Etna volcano, close either to the Piano Provenzana fault or to the NE-Rift. Seismic and volcanological data have been analyzed together with radon data. We also analyzed air and soil temperature, barometric pressure, snow and rain fall data. In order to find possible correlations among the above parameters, and hence to reveal possible anomalies in the radon time-series, we used different statistical methods: i) multivariate linear regression; ii) cross-correlation; iii) coherence analysis through wavelet transform. Multivariate regression indicated a modest influence on soil radon from environmental parameters (R2 = 0.31). When using 100-days time windows, the R2 values showed wide variations in time, reaching their maxima ($\sim$0.63-0.66) during summer. Cross-correlation analysis over 100-days moving averages showed that, similar to multivariate linear regression analysis, the summer period is characterised by the best correlation between radon data and environmental parameters. Lastly, the wavelet coherence analysis allowed a multi-resolution coherence analysis of the time series acquired. This approach allows to study the relations among different signals either in time or frequency domain. It confirmed the results of the previous methods, but also allowed to recognize correlations between radon and environmental parameters at different observation scales (e.g., radon activity changed during strong precipitations, but also during anomalous variations of soil temperature uncorrelated with seasonal fluctuations). Our work suggests that in order to make an accurate analysis of the relations among distinct signals it is necessary to use different techniques that give complementary analytical information. In particular, the wavelet analysis showed to be very effective in discriminating radon changes due to environmental influences from those correlated with impending seismic or volcanic events.