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Coupling high-frequency measurement of ^{222}Rn, ^{220}Rn in soil gases with soil CO_2 efflux at Mt. Etna (Italy): a new strategy for active volcano monitoring

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Concurrent measurement of soil radon, soil thoron and soil CO_2 efflux is based on the method developed by Giammanco et al. (Geochem. Geophys. Geosys., 8(10), Q 10001, doi:10.1029/2007GC001644, 2007). An empirical relationship links the ^{222}Rn/^{220}Rn ratio to the CO_2 efflux: deep sources of gas are characterized by high ^{222}Rn activity and high CO_2 efflux, whereas shallow sources are indicated by high ^{220}Rn activity and relatively low CO_2 efflux. This relationship is more constraining on the type and depth of the gas source than using the ^{222}Rn/^{220}Rn ratio alone. We studied the temporal variation of the ratio between CO_2 efflux and (^{222}Rn/^{220}Rn), that we define as a Soil Gas Disequilibrium Index (SGDI). Since June 2006, periodical measurements of the SGDI were carried out in ten sites located on the flanks of Mt. Etna, with sampling frequency of about ten days. Remarkable variations in this parameter were recorded during the period 2006-2008 likely associated with changes in the activity level of Mt. Etna. In particular, one of the sites located in the area called Primoti (on the lower east flank of the volcano) has shown significant anomalous changes of the SGDI in time, possibly correlated with the eruptive/tectonic activity. For this reason, in this site we set up an automatic monitoring station made of a Radon/Thoron monitor (model RTM 2100, SARAD GmbH, Germany) coupled with a soil CO_2 efflux station (model ACE, ADC BioScientific Ltd., UK). The sampling frequency was set at 30 minutes, in order to allow for a sufficient decay equilibration in the radon isotopes. Air temperature and barometric pressure were recorded as well, with the same sampling rate as for the soil gases. The site chosen for testing the monitoring station is located on the east flank of Mt. Etna at an altitude of about 520 a.s.l., in an area known for widespread diffuse emissions of CO_2 and other gases of magmatic origin. The preliminary data acquired so far showed an average soil CO_2 efflux of 10 g m^{-2} d^{-1} (std dev of about 7 g m^{-2} d^{-1}) and average ^{222}Rn and ^{220}Rn activities of about 3.3 $\times$ 10^3 Bq/m^3 (std dev of about 1140 Bq/m^3) and about 2.0 $\times$ 10^3 Bq/m^3 (std dev of about 620 Bq/m^3), respectively. The corresponding values of the SGDI thus obtained varied in the range from about -1.5 to about 70.1, with an average of about 7 and standard deviation of about 6.3. The apparent baseline of the parameter is around the value of 3, and daily variations are clearly detected due to the combined influence of air temperature and barometric pressure. No clear influence from rainfall was observed. Some spikes were also detected, whose origin has to be studied by correlating the SGDI with other environmental parameters as well as with changes in the volcanic/tectonic activity of Mt. Etna.