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Influence of a component of solar irradiance on radon signals at 1000 meter depth at the Gran Sasso Laboratory, Italy

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Exploratory monitoring of radon is conducted at one site at the deep underground Gran Sasso National Laboratory (LNGS; 1,000m below the surface). Monitoring is performed in a small secluded space separated by a sealed partition from the entirety of the laboratory environment in air in contact with the exposed surrounding calcareous country rock. Overall radon levels are low (0.45 kBq/m3). Utilizing both alpha and gamma-ray detectors measurements (15-minute resolution) cover a time span of ca. 600 days. Systematic and recurring radon signals are recorded consisting of two primary signal types: a) non-periodic Multi-Day (MD) signals lasting 2-10 days, and b) Daily Radon (DR) signals – which are of a periodic nature exhibiting a primary 24-hour cycle. Temperature in the closed enclosure is stable (11.5$\pm$0.3 °C) and pressure reflects above surface barometric variations. Analysis and comparison in the time and frequency domains (FFT) of local environmental data (P, T) indicates that these do not drive radon variation in air at the site. The phenomenology of the MD and DR signals is similar to situations encountered at other locations where radon is monitored with a high time resolution in geogas at upper crustal levels.

Using the Continuous Wavelet Transform analysis tool a different variation pattern is observed for time series consisting of day-time and night-time measurement of the gamma radiation from radon progeny. Applying the same analysis to the time series of local air pressure does not reveal a day-time and night-time difference. The observation of a differing day/night pattern in the gamma radiation from radon at LNGS is similar to further occurrences at other subsurface locations. Production of a day/night pattern must be related to rotation of Earth around its axis. This phenomenon is a further confirmation of the recent proposition as to the influence of a component of solar irradiance on the nuclear radiation from radon in air.
The occurrence of these radon signals in the 1 km deep low radiation underground geological environment of LNGS provides new information on the time variation of the local radiation environment. The observations and results place the LNGS facility as a high priority location for performing advanced investigations of these geophysical phenomena, due to its location and its infrastructure. New multi disciplinary prospects for the research are indicated in terms of a) the radioactive behavior of radon in above and subsurface air, b) an above surface geophysical driver for this behavior and, c) the influence of a component of solar irradiation.