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Multi-scale variability and long-range memory in indoor Radon concentrations from Coimbra, Portugal

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The presence or absence of long-range correlations in the variations of indoor Radon concentrations has recently attracted considerable interest. As a radioactive gas naturally emitted from the ground in certain geological settings, understanding environmental factors controlling Radon concentrations and their dynamics is important for estimating its effect on human health and the efficiency of possible measures for reducing the corresponding exposition.

In this work, we re-analyze two high-resolution records of indoor Radon concentrations from Coimbra, Portugal, each of which spans several months of continuous measurements. In order to evaluate the presence of long-range correlations and fractal scaling, we utilize a multiplicity of complementary methods, including power spectral analysis, ARFIMA modeling, classical and multi-fractal detrended fluctuation analysis, and two different estimators of the signals' fractal dimensions. Power spectra and fluctuation functions reveal some complex behavior with qualitatively different properties on different time-scales: white noise in the high-frequency part, indications of some long-range correlated process dominating time scales of several hours to days, and pronounced low-frequency variability associated with tidal and/or meteorological forcing.

In order to further decompose these different scales of variability, we apply two different approaches. On the one hand, applying multi-resolution analysis based on the discrete wavelet transform allows separately studying contributions on different time scales and characterize their specific correlation and scaling properties. On the other hand, singular system analysis (SSA) provides a reconstruction of the essential modes of variability. Specifically, by considering only the first leading SSA modes, we achieve an efficient de-noising of our environmental signals, highlighting the low-frequency variations together with some distinct scaling on sub-daily time-scales resembling the properties of a long-range correlated process.