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Intrinsic vs. spurious long-range memory in high-frequency records of environmental radioactivity - Critical re-assessment and application to indoor ^{222}Rn concentrations from Coimbra, Portugal

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The presence or absence of long-range correlations in environmental radioactivity fluctuations has recently attracted considerable interest. Among a multiplicity of practically relevant applications, identifying and disentangling the environmental factors controlling the variable concentrations of the radioactive noble gas Radon is important for estimating its effect on human health and the efficiency of possible measures for reducing the corresponding exposition.

In this work, we present a critical re-assessment of a multiplicity of complementary methods that have been previously applied for evaluating the presence of long-range correlations and fractal scaling in environmental Radon variations with a particular focus on the specific properties of the underlying time series. As an illustrative case study, we subsequently re-analyze two high-frequency records of indoor Radon concentrations from Coimbra, Portugal, each of which spans several months of continuous measurements at a high temporal resolution of five minutes.

Our results reveal that at the study site, Radon concentrations exhibit complex multi-scale dynamics with qualitatively different properties at different time-scales: (i) essentially white noise in the high-frequency part (up to time-scales of about one hour), (ii) spurious indications of a non-stationary, apparently long-range correlated process (at time scales between hours and one day) arising from marked periodic components probably related to tidal frequencies, and (iii) low-frequency variability indicating a true long-range dependent process, which might be dominated by a response to meteorological drivers. In the presence of such multi-scale variability, common estimators of long-range memory in time series are necessarily prone to fail if applied to the raw data without previous separation of time-scales with qualitatively different dynamics. We emphasize that similar properties can be found in other types of geophysical time series (for example, tide gauge records), calling for a careful application of time series analysis tools when studying such data.