Temporal fluctuations scaling, multifractality and Tweedie distributions of solar energy in insular context

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Solar energy is an intricate phenomenon, especially within tropical insular locations, where this energy source demonstrates significant fluctuations across various short-term timeframes and spatial dimensions. Research on the stochastic characteristics of solar energy is gaining momentum in the scientific literature, revealing signs of scaling properties despite its inherent complexity. This paper sequentially delves into the examination of temporal fluctuations scaling and multifractal properties of irradiance for tropical insular sites (Guadeloupe, Réunion, Hawai). By analogy with Taylor law performed on several complex process, an analysis of temporal fluctuations irradiance scaling properties is proposed. The results showed that the process of intradaily variability obeys Taylor’s power law for every short time scales and several insolation conditions. This approach elucidates the relationship between the variance of fluctuations and the mean with exponent between 1 and 2. This could confirm the relevance of Tweedie Convergence Theorem in a manner related to the central limit theorem; a mathematical basis for Taylor’s power law, 1/f noise and multifractality according to Kendal and Jørgensen [1]. Through various multifractal analysis techniques, including MF DFA, wavelet leader, structure functions, and arbitrary order Hilbert spectral analysis, on global solar radiation sequences, the intermittent and multifractal properties inherent in global solar radiation data have been brought to light across scales ranging from one second to few hours and all intensities.

The understanding the dynamics of irradiance fluctuations is essential in various fields, including atmospheric science, remote sensing, and renewable energy. The results of these properties can help improve the modeling and prediction, which is crucial to optimally integrate PV onto electrical grids.

Reference
