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Evaluating the validity of the stationarity hypothesis of yearly solar irradiation data using long-term time series from the GEBA network

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The solar radiation impinging at ground level is an essential variable for climate but also for solar photovoltaic (PV) systems as it directly impacts its economic viability. As a consequence, estimating solar irradiation on a long-term time scale, up to 30 years, is a critical issue in the plan-ning of a solar system. The amount of solar irradiation expected for the future is usually computed from yearly irradiation data measured on the site of interest by pyranometers, satellite-derived data, meteorological reanalysis products or a combination of them over the past years. In other words, the amount of radiation expected for the future is computed from the amount of radiation measured on the past. Doing this, it is implicitly assumed that the temporal evolution of the solar irradiation is stationary: the yearly irradiation is assumed to be the stochastic realization of the same distribution.
However, it is well known that solar radiation reaching the ground is strongly dependent of the atmospheric constituents and their variability. Some constituent knows short term variations, as some types of clouds, when others knows long term variations, influenced for example by long term aerosols anthropic emissions. The observed dimming and brightening reported in several locations are good example of such effects. Theses variations can lead on a non-stationarity if the irradiation.
With this in mind, we have explored the temporal stationarity hypothesis for a large num-ber of in-situ measurements. The Global Energy Balance Archive (GEBA) network with more than 2500 measurement sites is considered as a reference for solar radiation data. For our study, a stringent quality check has been applied to the data. At the end, we selected 164 sites worldwide with long-term monthly time series with a high availability (more than 30 consecutive years, less than 2 consecutive month missing). The uncertainty of these stations is estimated to be lower than 5% for monthly irradiation data. We have tested the stationarity hypothesis on theses data, thanks to standard statistical methods: some of them are meant to test the stationarity hypothesis (e.g. KPSS, CUSUM, Man Kendell, Spearman-rho tests), others are meant to test the non-stationary hy-pothesis (e.g. Dickey Fuller, Phillips-Perron tests). The results of these tests as well as the use of time-frequency decomposition to analyze the stationarity of the different characteristics time-scales variability are presented, compared and discussed.