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SHORT NOTE

On the 1/f noise in the UV solar spectral irradiance

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A major shortcoming of many climate studies on long-range dependence is the inference of long-term memory from climate data without considering that the power-law scaling needs to be established and a simple exponential decay of the autocorrelation function has to be rejected (Efstathiou and Varotsos 2010; Maraun et al. 2004; Varotsos 2005a; Varotsos and Kirk-Davidoff 2006; Varotsos et al. 2003a, b, 2005, 2006, 2007, 2008, 2009, 2013).

Very recently, Varotsos et al. (2013), studying the high-resolution observations of the spectral solar incident flux (SIF) reaching the ground and the top of the atmosphere, concluded that SIF versus ultraviolet wavelengths (WL) exhibit 1/f-type power-law correlations. This result was based on the slope (i.e., 1.02±0.02) of the log–log plot of the root mean square fluctuation function $F_d(\tau)$ of SIF versus the WL segment size τ, after the application of the detrended fluctuation analysis (DFA).

However, the reader of the paper by Varotsos et al. (2013) may argue that the afore-mentioned power-law scaling should be established by employing the two criteria suggested by Maraun et al. (2004), notably the rejection of the exponential decay of the autocorrelation function and the constancy of “local slopes” in a certain range towards the low frequencies.

In this respect, we herewith plot the profile of the power spectral density (i.e., the distribution of the variance over frequency) versus $\log\tau$ for the detrended SIF-WL data set (depicted in Fig. 1a). This plot shows that in a WL scale range from $\log\tau\approx0.3$ (given that the measurement step is 0.05, the value of $\tau\approx10^{0.3}\times0.05\approx0.1$ nm) to maximally $\log\tau\approx1.46$ ($\tau\approx10^{1.46}\times0.05\approx1.4$ nm), the power spectral density is better fitted exponentially, while for larger scales, it turns into an algebraically (power-law) fit (i.e., satisfying thus the first criterion of Maraun et al. (2004) for the rejection of the exponential fit). On the other hand, we apply the method of local slopes, suggested by Maraun et al. (2004), in order to examine the establishment of the 1/f noise in the UV solar spectral irradiance. Since the single straight line of the DFA plot for the detrended SIF-WL data set that established in the whole range of scales may be biased, we evaluate the local slopes of $\log F_d(\tau)$ versus $\log\tau$ detecting for constancy in a sufficient range. Along these lines, we first fit a straight line to $\log F_d(\tau)$ versus $\log\tau$ within a specific window of WL scale range. This window is then shifted successively over all calculated scales τ. At this point, it should be noted that Maraun et al. (2004) state verbatim: “Choosing the optimal window size, one has to trade bias for variance: For small windows, the bias is small, but the variability renders the interpretation difficult, whereas for large windows, the variance is reduced at the cost of a biased estimate of a.” Figure 1b illustrates the local slope a versus $\log\tau$ for two different window sizes. In addition, we compute the standard deviations, s_a, of each estimated local slope over all the scales, along with the error bounds of each local slope a, defined as $a\pm1.96\cdot s_a$. Inspection of Fig. 1b shows that for small scales, the variance of the local slopes is low, while for large scales, the variance is increased with a values reaching to a constant threshold ($a\approx0.92$) at a range that coincides with that in Fig. 1a, where the power-law behavior prevails (establishing thus the long-range dependence). Similar results were obtained by considering other windows.

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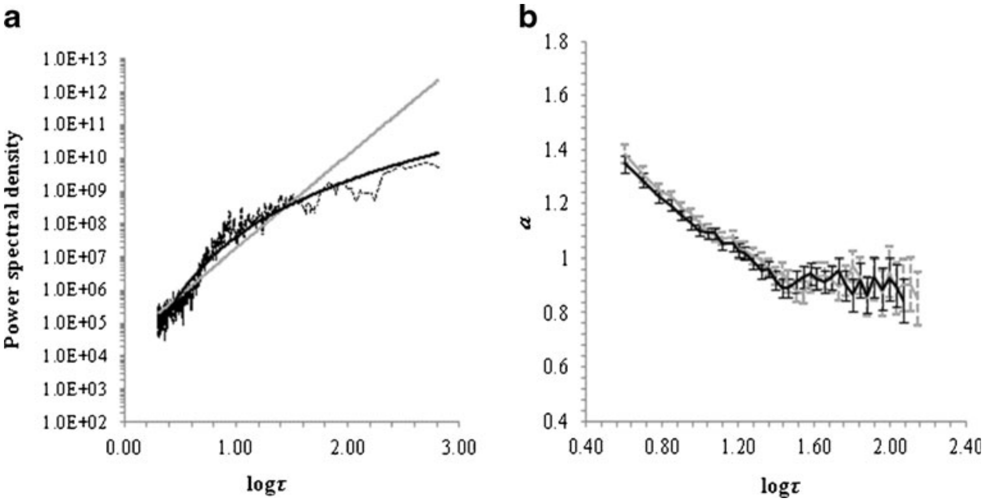

Fig. 1 **a** Power spectral density of the detrended SIF-WL (in milliwatt per square meter per nanometer) versus logτ, with the power-law (*black line*) and the exponential (*gray line*) fit (y=40524482$x^{5.65}$ with R^2= 0.93 and y=28924e$^{6.475x}$ with R^2=0.82, respectively). **b** Local slopes of the log$F_d(\tau)$ versus logτ calculated within a window of 18 points (*dashed gray line*) and 20 points (*solid black line*) for the detrended SIF-WL data set. The *error bars* indicate the corresponding 1.96·s_a—intervals of the slopes over all the considered scales

The fulfillment of the two criteria of Maraum et al. (2004) shown above ensures the 1/f-type power-law correlations in SIF versus WL suggested by Varotsos et al. (2013). Interestingly, the WL range found in Fig. 1b is of the same order of magnitude (i.e., WL lags between about 0.2 and 30 nm) with that suggested by Varotsos et al. (2012), fitting better to the WL separation of the major Fraunhofer lines in the UV (299.4, 302.1, 336.1, 358.1, 382.0, 393.4, 396.8, and 410.2 nm). These separations range from 2.7 to 34.0 nm and are of the same order of the wavelength interval of the 1/f behavior mentioned above. The latter is of crucial importance for the UV impacts to the atmosphere and biosphere (Alexandris et al. 1999; Efstathiou et al. 1998; Kondratyev et al. 1995; Kondratyev and Varotsos 1995, 1996; Feretis et al. 2002; Varotsos et al. 1998; Varotsos 2005b; Cracknell and Varotsos 2007; Tzanis et al. 2008; Ziemke et al. 2000).

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