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Wavelet Analysis of the Bivariate Time Series of Transmittance and Reflectance of an Atmospheric Column

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In this investigation, collocated time series of narrowband 0.6μm atmospheric flux transmittance at the surface and bidirectional reflectance at the top-of-atmosphere are decomposed into distinct frequency bands, to investigate the time scale dependences of their variance and correlation. To this goal, we apply a multiresolution analysis based on the maximum overlap discrete wavelet transform and the Haar wavelet to 5 minute resolution measurements from two multifilter rotating shadowband radiometers operated at Cabauw, the Netherlands, and Heselbach, Germany, and to observations of the geostationary METEOSAT8 SEVIRI satellite imager operating in rapid scan mode.

Both time series are best correlated when the satellite data are shifted by about 1 pixel or 6 km to the North, which is likely attributable to the parallax effect caused by the location of cloud tops above the surface and the slant satellite viewing geometry. While variations in transmittance and reflectance with periods longer than an hour are found to be highly anti-correlated, the correlation breaks down for shorter periods. For periods below one hour, the transmittance time series also exhibits significantly higher variance than the reflectance. The larger extent of the satellite pixel ($6 \times 3\,km^2$) versus the point-nature of the ground measurements is proposed as an explanation. Due to the small contributions of high frequency variability to the total variance of the reflectance, aliasing effects due to the 5 minute repeat cycle of SEVIRI are expected to be small.

Our findings have important implications for the evaluation of satellite estimates of surface solar irradiance with surface measurements. Temporal averaging of the surface measurements over a period of at least 40 minutes is recommended to exclude frequencies with higher variance in transmittance than in reflectance. Estimates from geostationary satellites should be averaged over an period equal to that used for averaging the surface measurement to obtain an optimal agreement.