Effects of clouds and aerosols on UV radiation measured at Lauder, New Zealand

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Abstract. Nine years (2000-2008) of 1-minute resolution measurements at Lauder, New Zealand, have been analysed. Data available include global solar radiation (hereafter, GR), direct solar radiation (BR), diffuse solar radiation (DR), low wavelength downward radiation (LW) erythemally-weighted UV radiation (UV), total ozone column (TOZ), aerosol optical depth (AOD) at 412 , 500, 610, 778 and 867 nm, and cloud cover information from a TSI camera: sky fraction with opaque (OP), thin (TH) and total (CFTSI) clouds. Another estimation of the cloud fraction is available from a short wavelength based algorithm (CFSWA). A first overview of the data is shown and effects of clouds and aerosols on UV radiation are investigated.

Data overview

Monthly mean values of daily GR irradiation and UV dose are plotted in blue in Figure 1 and Figure 2, respectively. In red, only the days with mean CF<10% are included. The shaded area around the data points represents the standard deviation of the mean. The comparison between GR and UV highlights the larger summer/winter ratio for the latter than for the former. While for daily GR irradiation this ratio is around 5, for the UV it is 15.4.

Clouds also have different effects on each type of radiation. The mean reduction by clouds for GR is 27.5% (ranging from 22.3% and 31.5%), and the reduction is 22.5% (14.2-28.5%) for UV. This result is expected since the UV reaching the ground surface has a larger portion of scattered radiation compared to GR.

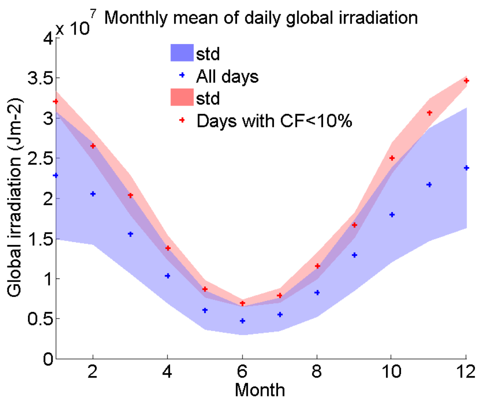

Figure 1. Monthly mean of daily global irradiation. In blue, all days are considered; in red, just days with mean CF<10% are included. Shaded bands account for the standard deviation of the mean (+/- σ).

The monthly average of the maximum daily UVI value recorded is shown in Figure 3. A large summer/winter winter contrast of 12 to 1 is also found.

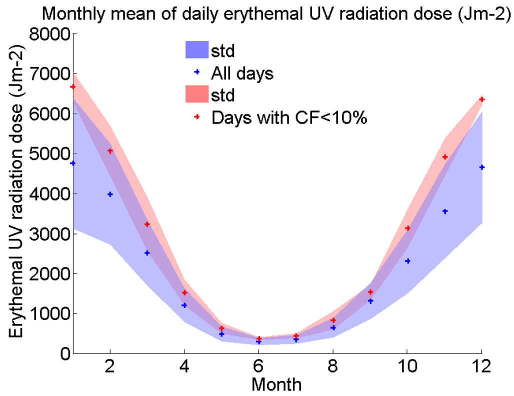

Figure 2. The same as for Figure 1 but for UV.

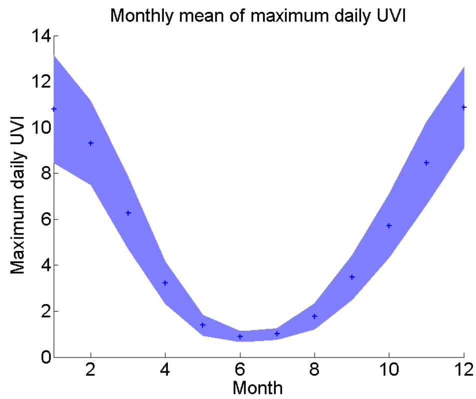

Figure 3. Monthly mean of maximum daily measured UVI.

Monthly mean values of the mean daily cloudiness (in % of sky covered by clouds) are plotted in Figure 4 for both CFTSI and CFSWA (Long et al, 2006). The overall cloudiness is about 60% in Lauder according to both methods and it has a weak annual variation.

The CFSWA method shows larger CF values especially for the winter months, when the methods can differ up to about 10%, on average.

Besides the solar zenith angle (SZA) and clouds, which in this order are the main factors affecting UV at a certain location, TOZ is the third factor. Figure 5 shows monthly means of the daily mean TOZ at Lauder, showing a clear spring/autumn seasonality. This variation in ozone (a spring maximum of 356 DU and an autumn minimum of 261 DU) leads to less UV in spring than in autumn, which can be seen in Fig 2 and Fig 3.

Aerosols in the atmosphere extinguish the overall UV reaching the surface and the most important parameter to explain this effect is AOD which depends on the wavelength. In Fig 6, monthly means of the daily mean measured AOD at 412, 500, 600, 778 and 867 nm. Larger AOD values are observed for lower wavelengths except at 500 and 610 nm, which are quite similar.

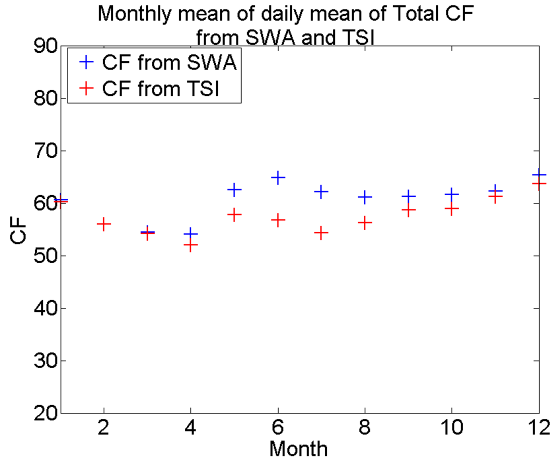

Figure 4. Monthly mean of mean daily cloud fraction according to the two considered methods

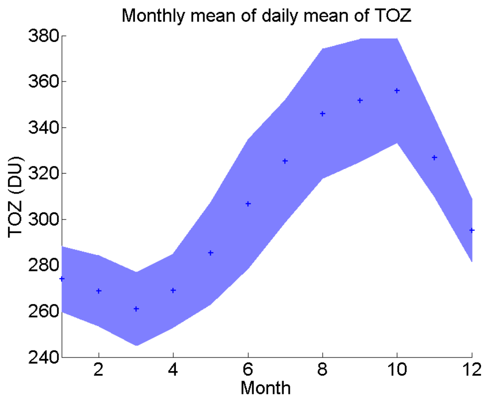

Figure 5. Monthly mean of the daily mean TOZ. The shaded band accounts for the standard deviation of the mean (+/- 1σ).

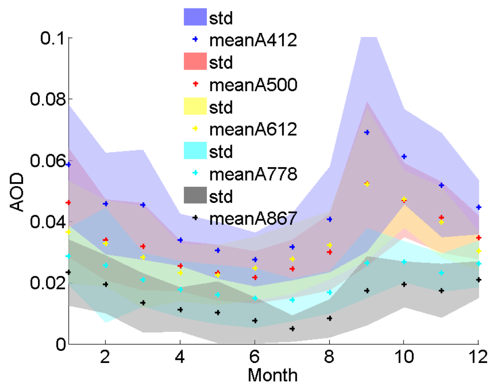

Figure 6. Monthly mean values of the daily mean AOD at several wavelengths. The shaded band accounts for the standard deviation of the mean (+/- 1σ).

Searching for cloud enhancements

The effect of clouds on UV can be investigated through cloud modification factors (CMF) defined as the ratio between the measured UV (affected by clouds) and an estimation of UV for cloudless sky conditions. To get these clear-sky calculations a simple parameterisation (referred to as PTUV) by Badosa et al (2005) was used.

Figure 7 shows the CMF vs CFTSI plots for several SZA values for minute data with sun visible (not obscured by clouds). It is seen that, as CFTSI rises, so does the CMF values and this is more important for low SZA; as SZA increases the effect gets less important. These enhancements are caused by multiple reflections caused by clouds, which increases the diffuse UV radiation reaching the surface.

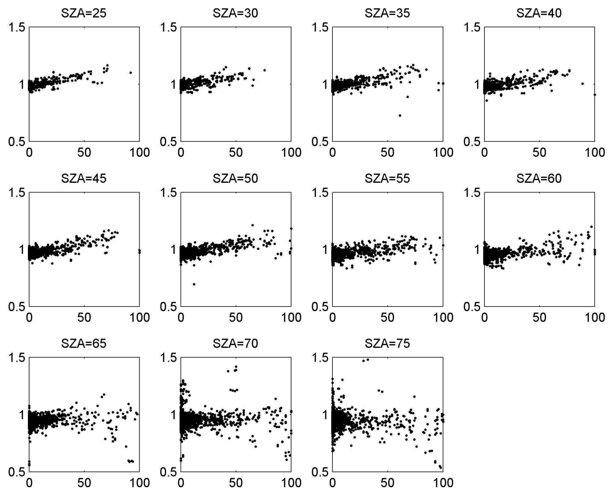

Figure 7. CMF vs CF for several SZA values. Only data points with un-obscured sun are included.

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