Ultraviolet solar radiation in tropical central Andes (12.0°S)

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1 Annual cycle of UV radiation

The annual cycle will be described in terms of the dose rate and the noon hourly average of the UV-irradiances. In general, for clear days (or total overcast), those averages represent values at the time of highest radiation. However, the effects of sporadic or standing cloudiness can cause that maximum values not necessarily occurs at noon. The observed annual cycle of the 305 and 340 nm irradiances through the complete period of measurements are shown in Figures 1a and 1b, respectively.

The difference between winter and summer, derived from the measurements in February and June, reaches 0.08 W m^{-2} nm^{-1} at 305 nm and 0.25 W m^{-2} nm^{-1} at 340 nm. In consequence, typical winter values are 42.86% at 305 nm and 66.7% nm at 340 nm of the summer values, approximately. In contrast, these seasonal differences for Valdivia, Chile (39.8°S, 14 masl) reach values of 0.07 W m^{-2} nm^{-1} at 305 nm and 0.45 W m^{-2} nm^{-1} at 340 nm (Lovengreen et al., 2005). In addition, the results recorded in Santiago, Chile (33.5°S, 550 masl) show seasonal variation of 0.09 W m^{-2} nm^{-1} and 0.70 W m^{-2} nm^{-1} for the same wavelengths due to geographical differences (Cabrera and Fuenzalida, 1999).

The lower seasonal variation of UV-irradiances in Huancayo, Perú (12.0°S, 3350 masl), in comparison with these both cities, can be mainly explained because of the lower latitude, higher altitude and lower total ozone during winter months. In all figures, it is possible to appreciate the annual cycle (blue solid line) that it is represented by the synthesis of the two Fourier components. These functions were calculated with the complete set of measurements and tend to underestimate the UV-irradiances at 305 and 340 nm, by about 15% in spring-summer and by about 8% in fall-winter, approximately.

In addition, the course of daily erythemal dose in the measurement period (2003-2005) is shown in Figure 2a. The erythemal daily dose characterises the UV energetic of the complete day and not a single moment as the UV irradiances, analysed above. The annual cycle of daily dose, represented by the sum of the

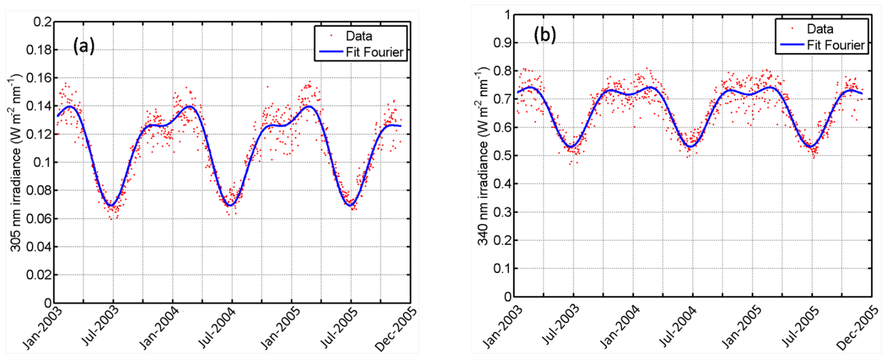

Figure 1: Observed annual cycle for the noon hourly average of: (a) UV-305 nm irradiance (red points), the solid blue line represents a Fourier synthesis with two components; (b) UV-340 nm irradiance (red points), the solid blue line represents a Fourier synthesis with two components.

two Fourier components is included in the same figure (solid blue line). The annual amplitudes ranges from 4.8 kJ m^{-2} d^{-1} in June to 8.0 kJ m^{-2} d^{-1} for February. But, the measured maximum value can reach a dose above 10.13 kJ m^{-2} d^{-1}.
These values are significant higher than the measured in Valdivia, Chile, which present annual amplitudes ranges from 0.3 kJ m^{-2} d^{-1} in winter and 5.1 kJ m^{-2} d^{-1} in January with maximum values that exceed a dose of 6.0 kJ m^{-2} d^{-1}. In contrast, these values for erythemal daily dose are more similar with the measured in La Paz, Bolivia, which oscillates between typical minima of 2.5 kJ m^{-2} d^{-1} in winter and values below 6.0 kJ m^{-2} d^{-1} in summer. The high winter values in Huancayo, Perú are due to its lower SZA and frequent clear sky days, a condition that is similar with the winter in La Paz, Bolivia (Andrade et al., 1997).
In addition, was calculated the difference between the observed value for a specific day and the one given by the annual cycle by the first two Fourier components for the same day, in order to estimate the excess or deficit of erythemal daily dose. It was chosen this approximation because of the lack of a more suitable reference for normal conditions.
The time sequence of these dose anomalies is shown in Figure 2b. Both, the relative magnitude of accumulated doses and the episodes duration can be identified. Values for excess and deficits of anomalies reach values of +3.5 μW cm^{-2} and -5.0 μW cm^{-2}, respectively. The highest anomalies are observed in spring-summer months, caused by positive and negative cloud effects over the UV-irradiances and lower anomalies are observed in dry-winter months.
From these results, high levels of UV irradiance were observed on the last week of February 2005, with values for erythemal daily dose around 10.0 kJ m^{-2} d^{-1}. For instance, high levels of UV irradiance were observed on February 26, 2005. During this day, an air mass poor in ozone reached Huancayo, leading to very

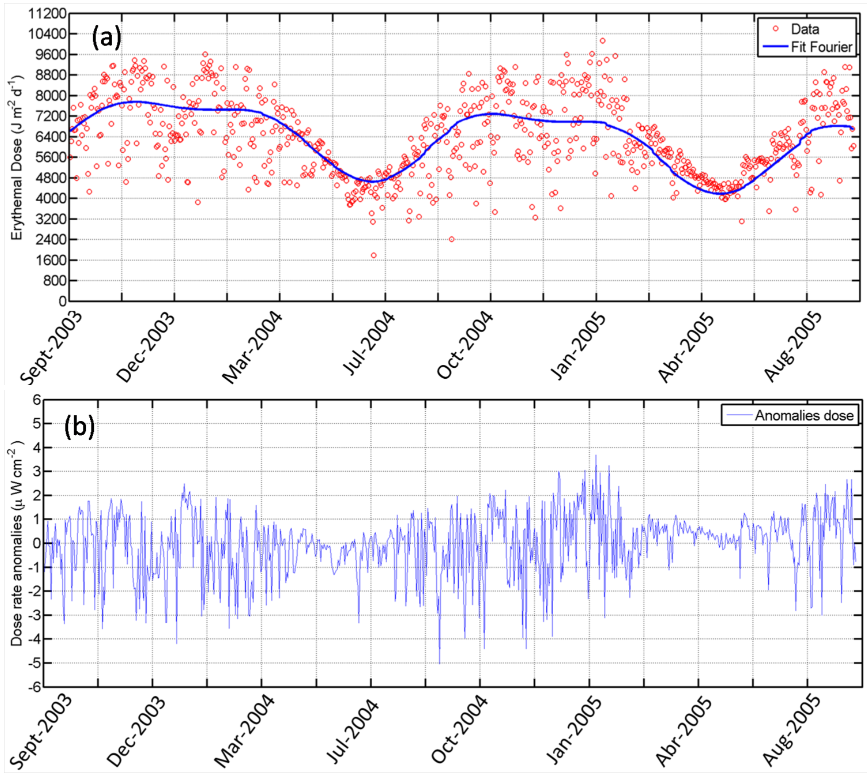

Figure 2: (a) Annual cycle of Erythemal daily dose (J m^{-2} d^{-1}) (red circles), the solid blue line represents a Fourier synthesis with two components. (b) Annual cycle of Erythemal dose anomalies (μW cm^{-2}) (observed values minus Fourier synthesis) based on noon hourly averages.

low total column ozone close to 235.80 DU estimated by OMI and also very clear sky conditions. For this anomaly, the erythemal daily dose reach values up to 10.13 kJ m^{-2} d^{-1}. This anomaly clearly stands out in Figures 1a and 1b for the UV-305 nm and UV-340 nm irradiances. The noon hourly maximum reached 0.15 W m^{-2} nm^{-1} for 305 nm and 0.33 W m^{-2} nm^{-1} for 340 nm. This high levels of UV-irradiance can increase the risk of illness for the population if they were exposed for long time intervals.

References

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