Study of the UV-A/UV-B ratios retrieved from the automatically sampled solar ultraviolet irradiance spectra

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The actuality of recording the ground-level spectra of UV radiation in addition to the broadband and narrowband measurements has increased in recent years (WMO, 2007). Partly it is related to the deepened research of the health effects of UV radiation (Grant et al., 2005) as well as of its environmental effects in the atmosphere (Brönnimann et al, 2001), in plants and in microorganisms (Neale et al., 2007).

In most cases the Brewer spectrophotometers and other expensive scanning instruments are used for collecting the spectra. Recently the advancement of technology has made available the use of compact single - monochromator diode array spectrometers (Ylianttila et. al., 2005). The intrinsic stray-light problems and the restricted dynamic range of the array sensors limit the use of the CCD spectrometers in the UV-B region. The

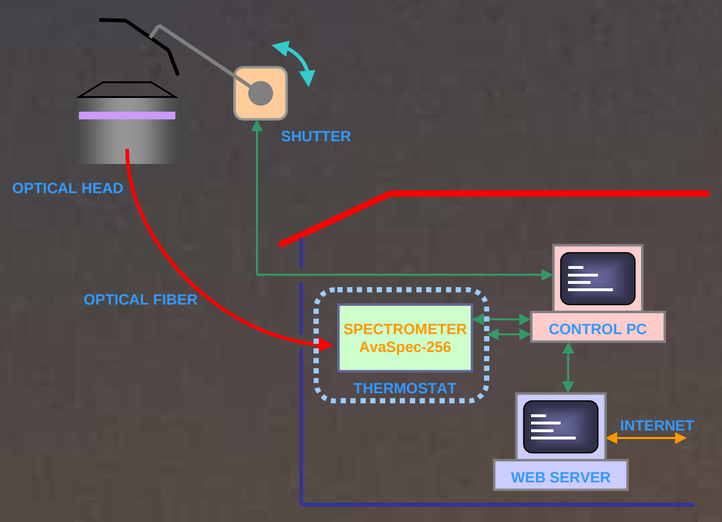


Figure 1. Schematic diagram of the spectroradiometric system

response of CCD array also decreases with time and so the instrument needs quite frequent recalibration.

At the Tartu Observatory (58°15'N, 26°28'E, 70 m a.s.l.) a minispectrometer AvaSpec-256 produced by *Avantes* company was suited for continuous field measurements adding necessary auxiliary equipment. Schematic

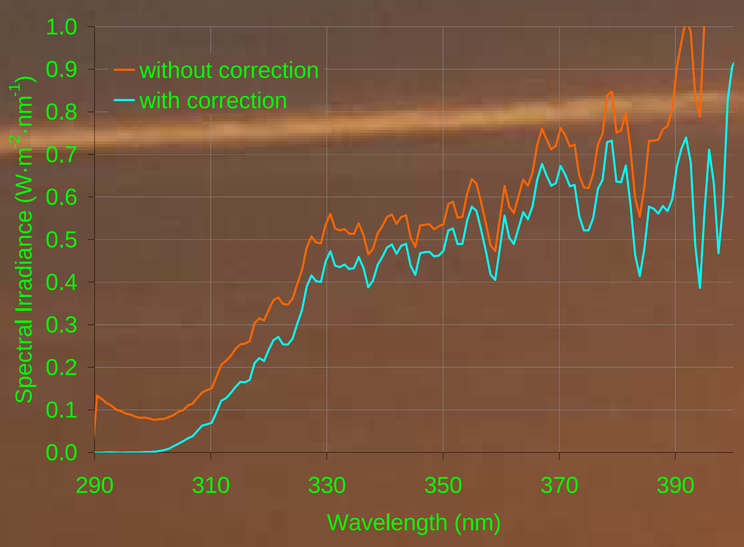
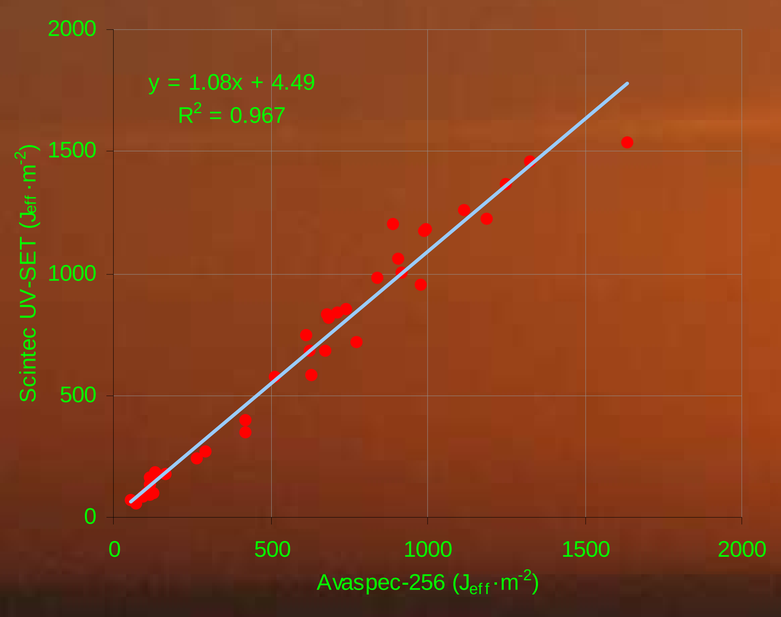


Figure 2. Example of the stray light correction of spectra

diagram of the spectroradiometric system is presented in Fig. 1. A programme for compensatory calculation of the stray light influence based on Ylianttila et al. (2005) was applied. An example of a spectrum in physical units before and after of the stray light correction is presented



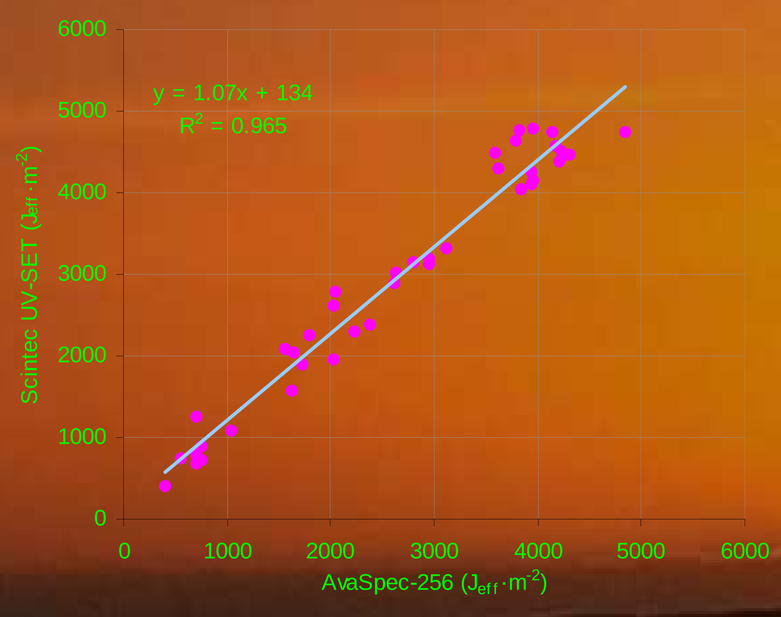


Figure 3. Erythemal doses retrieved from spectra versus Scintec UV-SET measured values in overcast (left) and fine weather (right) conditions

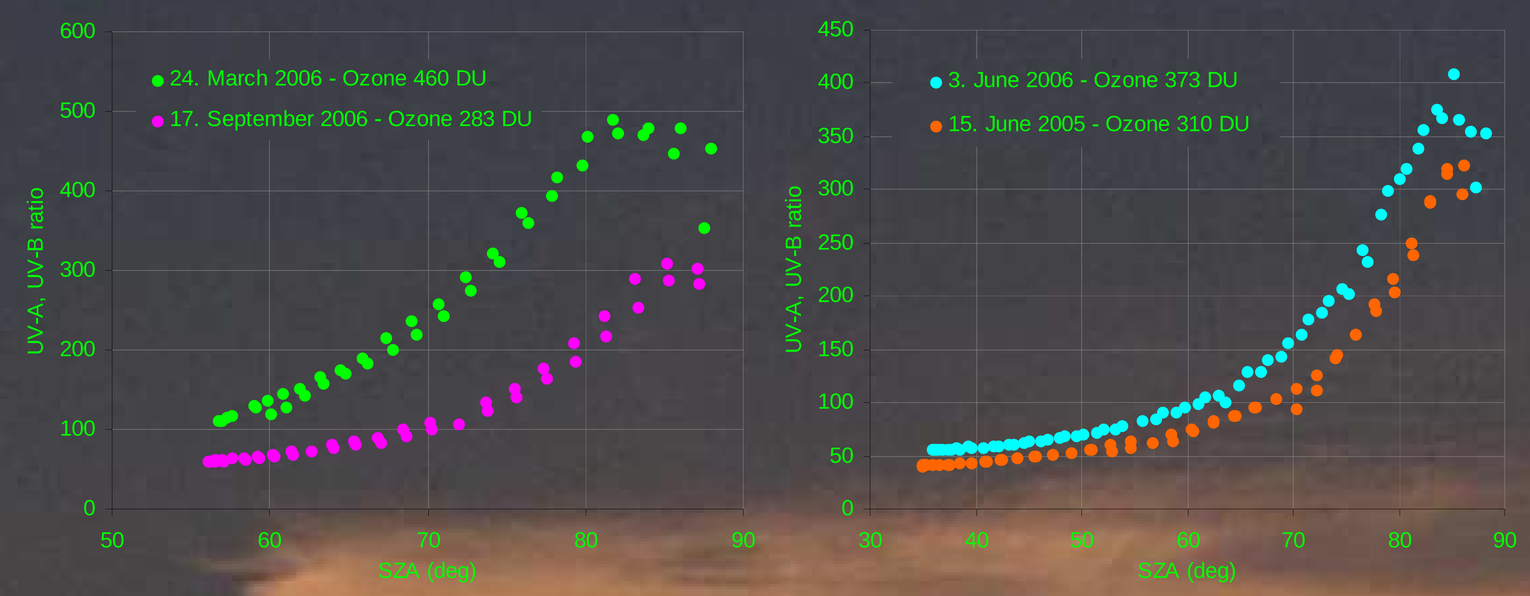


Figure 4. The ratios UV-A/UV-B versus SZA in sunshine and different total ozone conditions in spring/autumn and summer

in Fig. 2. The measurement process is fully computer-aided using a Linux programme. The control computer of the spectrometer is connected to the observatory web. The UV spectra in the wavelength range 300-400 nm are regularly sampled as the time sequences with a step 15 minutes. All the related auxiliary data have been collected at the colocated Tartu-Tõravere Meteorological Station. The distance between the locations of spectrometer and other sensors is 250 m. By now more than 40 000 UV spectra have been stored. A shortwave

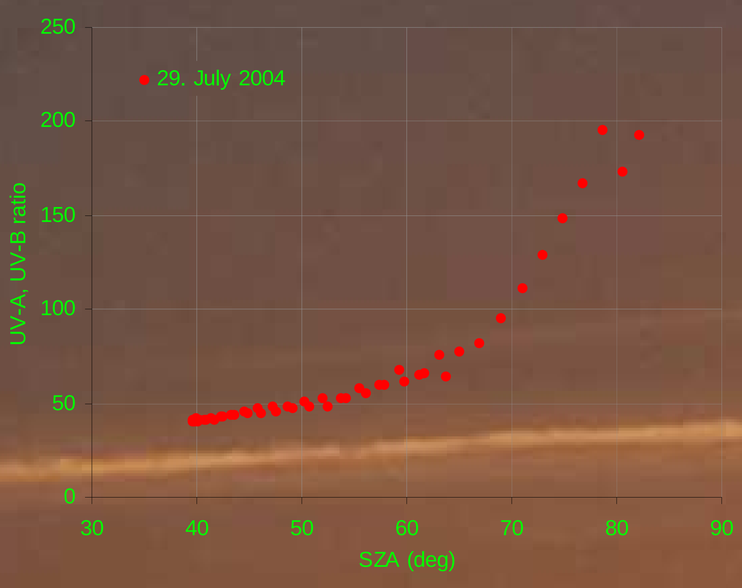


Figure 5. The ratios UV-A/UV-B versus SZA in overcast conditions

threshold of the reliably measured spectral irradiance depends on the solar zenith angle (SZA) and cloud cover. During midsummer noon hours it has reached 300 nm and dropped to 310 nm in midwinter clear days. In midwinter overcast days the mesured UV-B irradiance is very small and less reliable.

The current values of the erythemal UV Index (UVI) as well as the daily erythemal doses were retrieved from the measured spectra. The calculated from spectra erythemal irradiances and doses were compared with the regularly operating at the Tartu-Tõravere Meteorological Station Scintec UV-SET erythemal sensor data. The agreement of both doses in overcast and fine weather conditions is presented in Fig. 3. In both cases the Scintec UV-SET doses tend to be nearly 10 % larger of those retrieved from spectra.

The measured spectra transferred to the physical units of spectral irradiance have been weighted by the rectangular boxes of the UV-B (the wavelengths below 315 nm) and UV-A (the wavelengths 315-400 nm) ranges. Examples of daily dependence of the ratio UV-A/UV-B irradiances on SZA at different total ozone and noon SZA situations in sunshine conditions are presented in Fig. 4. At larger total ozone values the contribution of UV-B irradiance decreases and the ratio UV-A/UV-B increases. The average ratio UV-A/UV-B in the SZA range 35° (minimum available at the site) to 65-70° increases slowly from about 50 to about 100 and then the growth accelerates reaching the values 300 and more at SZA around 80°. At SZA above 80° the ratio gets unreliable due to the deviations of diffuser angular response from cosine and very small UV-B irradiances.

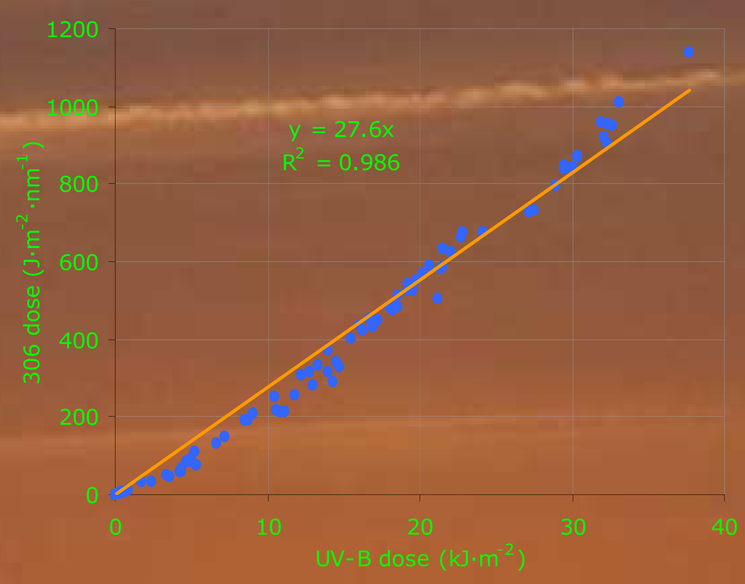


Figure 6. Covariation of the spectroradiometer integrated UV-B irradiance and narrowband 306 nm spectral irradiance daily doses

In Fig.5 an example of the ratio UV-A/UV-B versus SZA in overcast day is presented. The values of UV-A and UV-B irradiances have been 4-5 times lower of those in clear conditions. The scatterplots before and after noon in Fig. 4 and Fig. 5 do not match each other exactly due to the changing atmospheric conditions.

The daily exposures in $J \cdot m^{-2} \cdot nm^{-1}$ of the narrowband instrument CUVB1 at 306 nm measured together with other radiation data at the Tartu-Tõravere Meteorological Station with an one minute resolution have been compared with the AvaSpec-256 spectrometer retrieved UV-B daily doses in $kJ \cdot m^{-2}$. The covariance of both daily doses is presented in Fig. 6.

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