Two Decades of Spectral UV Measurements

Michael Kotkamp, Richard McKenzie, Paul Johnston, Hisako Shiona, Bruce Forgan[1]
Michael O'Neill[2], and Yutaka Kondo[3]

National Institute of Water and Atmospheric Research (NIWA), Lauder, Central Otago, New Zealand

Abstract. High-quality spectral UV measurements with NIWA UV spectroradiometer systems have been made for over 20 years in New Zealand and for extended periods at several other global sites. Any trends due to ozone depletion are small, and are insignificant compared with cloud effects, and the large seasonal changes due to changing sun angles. Summertime UV is higher in NZ than at comparable latitudes in the northern hemisphere. But peak values are less than at lower latitude sites. In NZ, the contrast between summer and winter UV is larger than at all the other sites.

Introduction

Measurements of spectral UV irradiances have been undertaken at Lauder for over twenty years, using instrumentation and data processing techniques that have been developed in house. These instruments represent the state of the art in global monitoring of UV irradiances, and are deployed at several sites within the international Network for the Detection of Atmospheric Composition Change (NDACC). Sample spectra taken at similar solar zenith angle (SZA = 90 – Solar Elevation Angle), and their ratios are shown in Figure 1 (see Table 1 for other parameters).

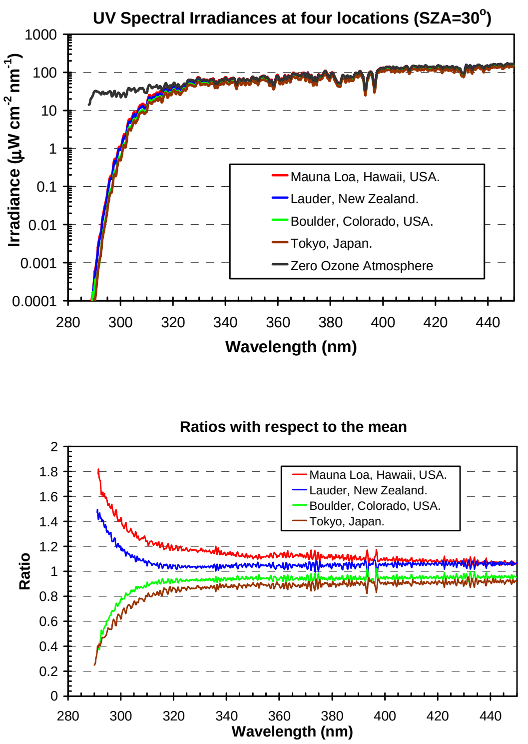

Figure 1. Sample spectra (upper panel) and their ratios (lower panel).

Site	Lat (°N)	Long (°E)	Alt (m)	Day of Year	TOZ (DU)	UV_{Ery} (Wm^{-2})
Mauna Loa	19.5	-155.6	3400	216	273	0.284
Lauder	-45.0	169.7	370	028	271	0.247
Boulder	40.0	-105.3	1650	195	306	0.196
Tokyo	35.7	-139.7	57	184	314	0.176

Table 1. Conditions for the four SZA= 30° spectra shown in Figure 1.

The spectrometer systems have also been used in shorter inter-comparison campaigns in Greece, Greenland, and Antarctica. Although more expensive to maintain than simpler broad band measurement systems, spectrometer systems such as these have several advantages. Firstly, their calibration against irradiance standards is more direct, so overall accuracy is improved. Secondly, spectral signatures can be compared with model calculations to attribute causes of differences. Thirdly, the spectral data can be weighted with any biological weighting function of interest. Here we discuss the temporal and geographic variability of erythemally-weighted UV irradiance (see Figure 2) using long term data obtained at the sites where NIWA UV spectrometers have been deployed.

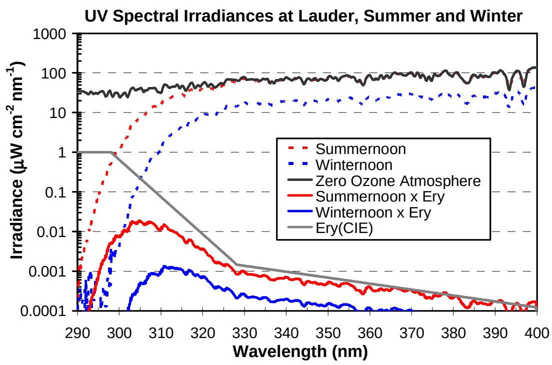

Figure 2. Sample spectra from Lauder NZ in summer and winter, compared spectra weighted by the erythemal action spectrum (heavy grey curve). The erythemally-weighted values are 0.284 and 0.0262 Wm^{-2} in summer and winter respectively.

The remainder of study will focus on erythemally weighted irradiances (i.e., sun-burning irradiances, UV_{Ery}), and derived products including the UV Index which is widely used to disseminate UV information to the public, and Standard Erythemal Dose (1 SED = 100 Jm^{-2} of erythemally-weighted UV), which is a measure of the amount of accumulated sunburning UV radiation incident over a specified time interval. For UV index of 12, one minimum erythemal dose (MED) for fair skinned

[1] Bureau of Meteorology, Melbourne, Australia
[2] NOAA, Earth Systems Research Laboratory - Global Monitoring Division, Boulder, CO, USA
[3] University of Tokyo, Japan

individual (~2 SED) is accumulated in approximately 11 minutes.

Results

Long term changes in UVI are shown in Figure 3 for site with records longer than 10 years. At all these sites, long term changes due to changing atmospheric composition (e.g., ozone depletion) are relatively small. The dominant effects (1) are the seasonal changes due to variations in SZA, and (2) the day-to-day changes due to variations on cloud attenuation. For any given SZA, the UVI tends to be less in spring than in autumn due to seasonal changes in ozone, which has a maximum in spring and a minimum in autumn.

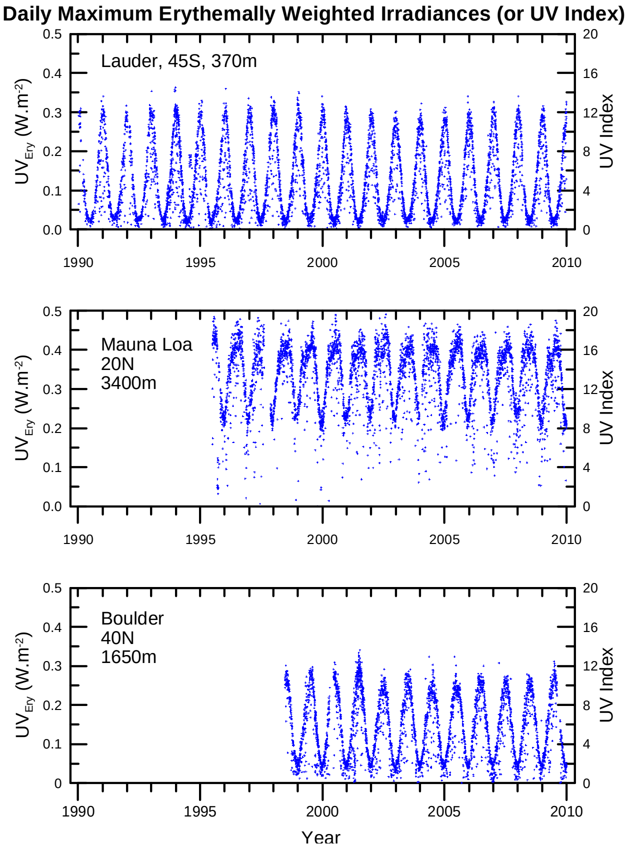

Figure 3 Long term changes in UV$_{Ery}$ (and UVI) at sites for which more than 10 years of data are available.

Peak UVI values are similar at Lauder and at Boulder, despite the latter being 5° closer to the equator, and 1300 m higher. Peak UVI values at the high-altitude equatorial Mauna Loa Observatory in Hawaii are much greater (UVI$_{max}$ = 20).

Seasonal differences in UV at the different sites can also be seen in Figure 3. The main points to note are that at higher latitudes, the winter values become very small, whereas at lower latitudes there is much less seasonal variability. As noted previously, peak summer values tend to be greater in the southern hemisphere, due to its cleaner air, its lower ozone and closer Sun-Earth separation in summer (McKenzie et al. 2006). In contrast, the winter UV amounts in the southern hemisphere tend to be less than in the northern hemisphere. Consequently, the summer/winter contrast in UV tends to be higher in the southern hemisphere than in the northern hemisphere.

Conclusions

High quality measurements of spectral UV irradiance have been undertaken by NIWA for 20 years at Lauder, New Zealand and for more than 10 years at Mauna Loa Observatory, Hawaii and at Boulder Colorado, USA.

Because of the success of the Montreal Protocol, any long term trends due to ozone depletion over these measurement periods are small compared with other variabilities. Summertime UV is higher in New Zealand than at comparable latitudes in the northern hemisphere, but peak UVI values are much less than at low latitude, high altitude sites, such as the Altiplano region, where the UVI can exceed 25 (Liley & McKenzie 2006). Of the sites tested, the New Zealand site is the highest latitude. Because of the strong dependence on SZA, this leads to lower wintertime values. The contrast between summer and winter UV shown in Figure 4 is therefore larger there than for the other sites. This large summer/winter contrast in UVI may have deleterious effects on human health.

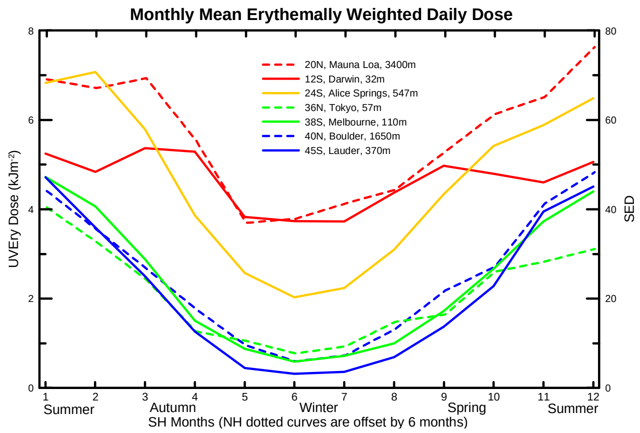

Figure 4. Seasonal Change in changes in monthly UV$_{Ery}$ dose at all sites for which more than one year of data are available.

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References

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