Variability of UV at Sites Equipped with NIWA Spectrometer Systems for 20 Years or More

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For over 20 years, ESRL/GMD has worked with New Zealand's National Institute of Water & Atmospheric Research (NIWA) to provide high-quality measurements of ultraviolet (UV) spectral irradiance at the high-altitude Mauna Loa Observatory (MLO), Hawaii (19.5°N, altitude 3.4 km) and at Boulder, CO (40°N, 1.7 km). These data sets complement the long-term measurements that have been undertaken since 1990 from NIWA's clean-air observatory at Lauder, New Zealand (45°S, 0.3km). Data from all three sites meet the exacting standards of the Network for the Detection of Atmospheric Composition Change (NDACC). The largest peak UV index (UVI) values are seen at MLO, where there is also a small seasonal variability. Despite its lower altitude and higher latitude, UVI values in summer at Lauder are similar to those at Boulder. However, winter UVI values are lower at Lauder, where in June/July they are less than 10% of those in December/January. Measurements are compared with model calculations for clear skies to determine the effects of clouds, and to compare measured and calculated trends. The model calculations agree well with measurements at Lauder. However, at MLO they are smaller than measurements, due to the effects of underlying clouds that increase the surface albedo. And at Boulder they are larger than measurements due to the effect of aerosol extinctions. After corrections are applied to the model calculations take account of these effects at MLO and Boulder, each site shows a bi-modal distribution of cloud effects, with a primary peak near cloud transmission 1.0 corresponding to clear-sky conditions, and a secondary peak (small for MLO) near cloud transmission 0.5 that corresponds to observations when the solar disk is covered. Radiative enhancements by clouds are typically less than 20%, and show only a weak wavelength dependence, with slightly larger effects at longer wavelengths. Because of the success of the Montreal Protocol on protection of the ozone layer, long term changes in ozone have been small since these UV measurements began, and any long-term changes in noon-time UVI are within the year-to-year variability due to cloud effects.

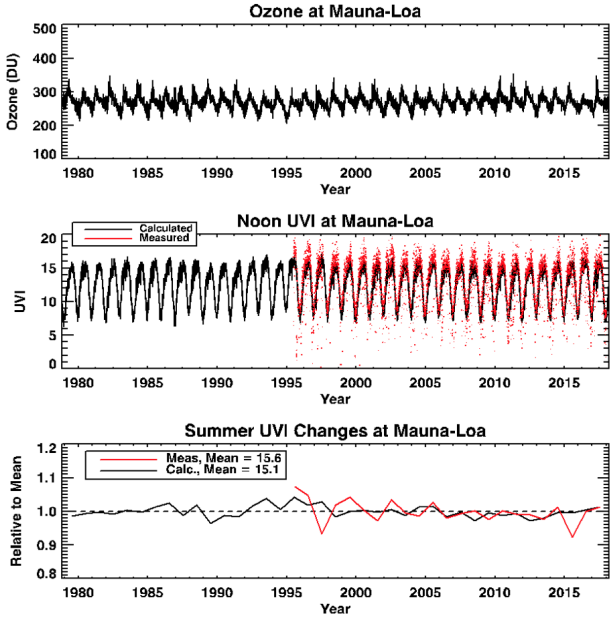

Figure 1. Time series at Mauna Loa Observatory of: ozone **(top panel)**, measured peak daily UVI near noon and calculated UVI for solar noon **(middle panel)**, and measured & calculated UVI trends in summer **(bottom panel)**.

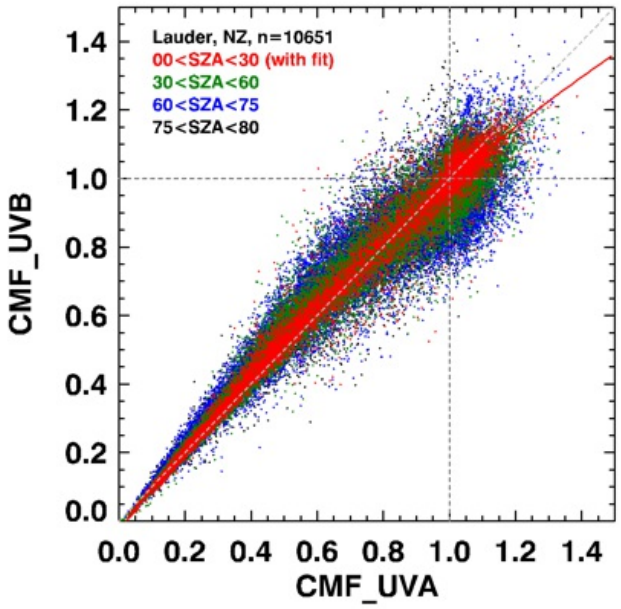

Figure 2. Cloud Effects: The **left** plot compares cloud modification factors (CMFs) in the UVB and UVA regions for Mauna Loa Observatory.