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Spectral dependency of cloud enhanced UV irradiance

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Abstract

This paper addresses two questions of primary importance to the solar UV community: 1) "Are cloud induced UV enhancements always wavelength dependent?" and 2) "Are the enhancements greatest in the UVA or UVB wavebands?" The answer to the first question is a definite no, with the conclusion to the second question that most of the enhancements found at this southern hemisphere measurement site are in the UVB waveband. This research is based on the results from a scanning UV spectroradiometer and a colour, all-sky camera over a 19-month period. In both the UVB and UVA wavebands there were cases that showed increasing, decreasing and no spectral dependence towards the shorter and longer wavelengths respectively. This research has found that cases of spectral dependence that decreased with wavelength tended to correspond to cloud fraction distributed in the outer field of view of the sky camera images for relatively low solar zenith angles. It is speculated that this is most likely due to an increase of scattered UV, compared to cases of increasing trends with wavelength, which would be accounted for by an increase in reflected UV from cloud surfaces in closer proximity to the sun. It also appears that wavelength dependency trends are related to the overall cloud fraction.

Keywords: Spectral; Dependency; Enhanced; Clouds; Ultraviolet; UV

1. Introduction

It has previously been reported, and subsequently reviewed by Parisi et al. (2004), that certain configurations of cloud can cause an increase in the ultraviolet (UV) radiation reaching the earth's surface, with respect to an equivalent clear sky scenario (e.g. Bener, 1964; McCormick and Suehrcke, 1990; Mims and Frederick, 1994; Sabburg and Wong, 2000; Sabburg et al., 2001). These reports of UV enhancement due to cloud have been measured in both the UVA

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(320–400 nm) and UVB (280–320 nm) wavebands. Additionally, the spectral dependency of UV due to cloud, and to some extent cloud enhanced UV, have also been published (e.g. Bais et al., 1993; Seckmeyer et al., 1996; Schwander et al., 2002; Crawford et al., 2003). The reported extent of UV spectral dependency varies, with earlier papers concluding that the scattering of UV radiation by clouds is essentially wavelength independent. Later papers (e.g. Crawford et al., 2003) present both wavelength independent and wavelength dependent (decreasing 'trend') cases, as well as examples of UV enhancement showing an increasing trend with wavelength. The spectral data was presented mainly in the UVA waveband, with some evidence of a continuing trend in the UVB.

There are currently only three published papers specifically relating to the issues of spectral UV enhancement and their wavelength dependency due to cloud (Sabburg et al., 2003; Sabburg and Long, 2004; Lovengreen et al., 2005). The first two papers discuss preliminary data (collected from two different spectral UV instruments) and posed questions relating to the importance of quality assurance, QA, in relation to measurement methodology, which this current paper partly addresses. The third paper presents data from a multichannel radiometer, effectively a compromise between using broadband radiometers (e.g. Sabburg and Wong, 2000) and scanning spectral radiometers (e.g. Sabburg et al., 2003). There remains two questions of primary importance to be investigated in this current research: 1) "Are cloud induced UV enhancements always wavelength dependent?" and 2) "Are the enhancements greatest in the UVA or UVB wavebands?"

2. Instrumentation

The measurement site for this research was located at the campus of the University of Southern Queensland (USQ), Toowoomba, Australia (27.5°S, 151.9°E, 693 m altitude). The radiation and environmental monitoring equipment were located atop a 4-storey building with no surrounding hills or trees affecting the field of view (FOV). This site has a relatively unpolluted atmosphere (Parisi and Downs, 2004).

2.1. Spectral instrument

The solar UV spectrum was recorded from 280 to 400 nm in 0.5 nm increments with a scanning UV spectroradiometer (Bentham Instruments, Reading, UK) based on a double grating monochromator (model DTMc300F) with 2400 lines/mm gratings. This instrument is described in Parisi and Downs (2004). Briefly, it is installed in a container that is weather proof and temperature stabilised (for most of the year). On each day, the spectroradiometer automatically starts scanning at 5:00 am Australian Eastern Standard Time (EST), and thereafter every 5 min till 7:00 pm EST. Each scan takes approximately 1 min to initialise and 2 min to complete the scan.

Irradiance and wavelength calibrations were undertaken on 17 March 2003, 10 December 2003, 11 June 2004 and 17 December 2004. The irradiance calibration was against a 150 W quartz tungsten halogen (QTH) lamp calibrated to the National Physical Laboratory, UK standard and the wavelength calibration against the UV spectral lines of a mercury lamp. On a regular basis between these absolute calibrations, the wavelength calibration was checked and three sets of 150 W QTH lamps were employed to check the irradiance stability. A temporal and temperature correction was required to be applied to the data between 11 June 2004 and 17 December 2004, with no correction required between the other times of the absolute