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IMPACT OF THE CLOUD SPATIAL DISTRIBUTION ON SOLAR UV RADIATION TRANSFER

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1. INTRODUCTION

Due to their effects on the public health and to their relative growth linked to the ozone stratospheric depletion in some areas of the planet, atmospheric UVB radiations have been deeply studied in the past years at an experimental and theoretical level. Several studies showed a correct agreement between measurements and modelling by clear sky or homogeneous cloud cover. However under a broken clouds situation things are not so obvious.

The aim of this paper is to present a method based on the modelling the UV radiances by means of radiation transfer models including realistic correction for clouds. Experimental clouds properties are provided by instruments like 'Nephelometer' or 'Total Sky Imager'.

2. METHODOLOGIES DESCRIPTION

2.1 Introduction

Different types of radiation transfer models are in use at the Belgian Institute for Space Aeronomy (IASB-BIRA). The most widely used is the discrete ordinates radiative model.

UV experimental spectral data are provided by the different instruments of the UV-Visible Monitoring Station (SUVIM) at the IASB-BIRA [Gillotay,1996]

2.2 Description of the model

A discrete ordinates radiative model [*Stamnes et al.*., 1988] is used to simulate the experimental data

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The extraterrestrial flux is a combination of the SUSIM spectrum below 350 nm [*Van Hoosier et al.*, 1984] and the Neckel and Labs spectrum [*Neckel and Labs*, 1984] up to 600 nm.

The wavelength dependence of the aerosol optical properties follows the parametrisation of WCP [*WCP*, 1986] for typical continental mixtures. This choice is motivated by an air pollution lower in Uccle than in typical urban centres. The weak dependence of cloud extinction and asymmetry factor is parametrized following [*Slingo* , 1989].

Day 198 2001 at 12:00 U.T. (SZA 30°)

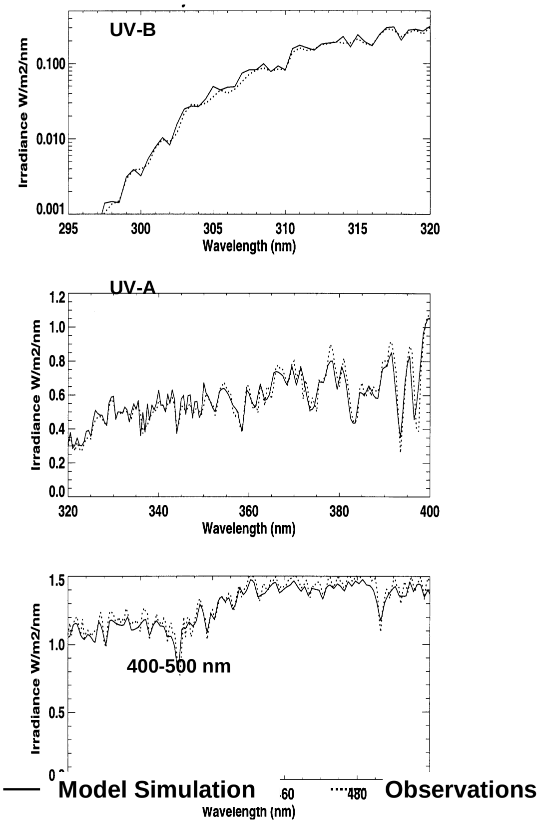

Figure 1. Comparison between experimental and modelled results for clear sky condition (Day 01-198).

A good agreement (better then 5%) between experimental data and the simulation has been established for SZA between 30° and 60° in clear sky condition. An example is shown in figure 1.

The discrepancies between modelled and experimental data increase generally with the SZA and can exceed 10% at high SZA in the visible range.

3. Preliminary study.

In order to investigate the role of clouds as a function of wavelength, average spectra for well-defined conditions (complete overcast, similar zenith angles) have been derived from the observations, and compared with a corresponding clear sky spectrum. The average cloud transmission ratios for SZA=30 ° are displayed in figure 2, and compared to a modelled transmission ratio. A 1 km low cloud with an optical depth equal to 50 has been assumed.

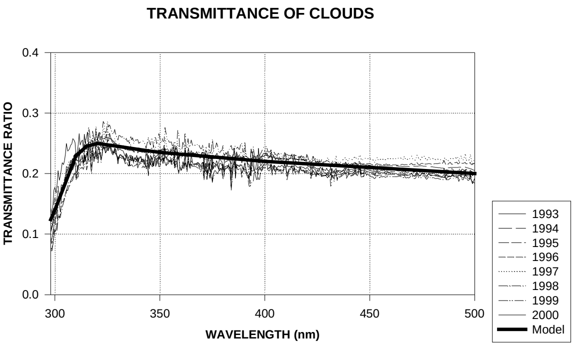

Figure 2. Ratio of cloudy (8 Octas) to clear sky irradiances.

Notice that the differences between the results from different years are not significant, the number of spectra in the averages being too low. Despite the large variability of the cloud impact, a consistent picture is found. The attenuation is lowest in the UV-A, and highest in the ozone absorption bands (UV-B) because of the increased multiple scattering and tropospheric ozone absorption caused by cloud.

The attenuation increases into a lesser extent in the visible range, reflecting the lesser importance of Rayleigh diffusion at higher wavelengths. These factors are illustrated in figure 3, where the cloud attenuation has been calculated with and without ozone and Rayleigh absorption.

Another way to study the impact of clouds is illustrated in figure 4 where a drastic change in the irradiance intensity is caused by a major cloudiness variation during the day. By this way spectra for similar conditions (same day, ozone,…) except for cloudiness are directly comparable. The abrupt change seen in figure 4 around 15 TU is caused by the appearance of complete overcast by low clouds at that time.

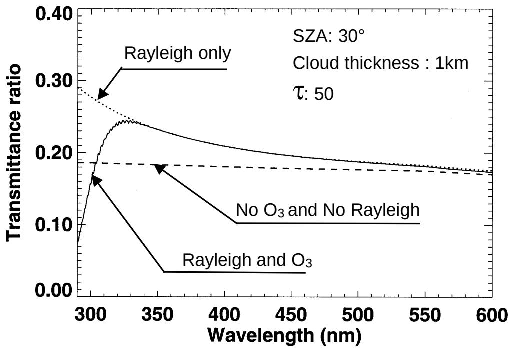

Figure 3. Simulated ratio of the mean clear sky spectrum vs. full cloud coverage.

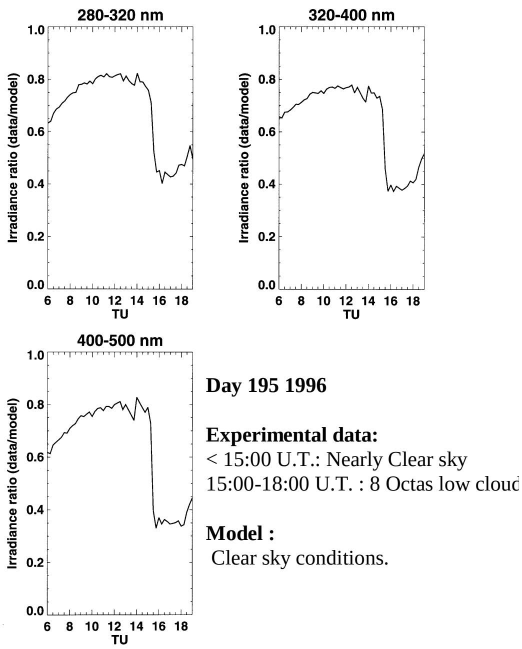

Figure 4. Ratio of measured to modelled irradiances.

Finally, the average attenuation of sunlight by different type of clouds can be also directly estimated from the pyranometers data as shown on figure 5. As expected, the attenuation by cirrus clouds (high altitude) is found to be very small. In contrast, low clouds (mainly stratocumulus) reduce solar irradiance by about a factor 5 on average.

This attenuation is found to increase monotonously with the solar zenith angle in the UV-A and UV-B ranges, but not for the total integrated irradiances (300-3000 nm). These results will be examined in more details in future modelling studies.

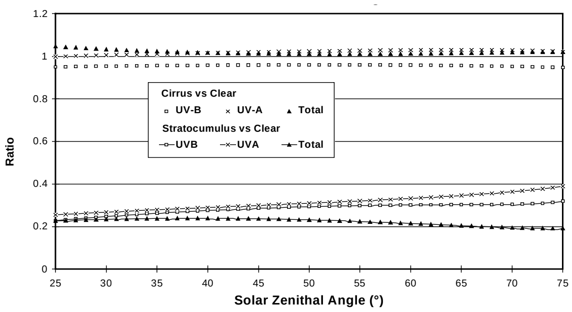

Figure 5. Irradiance ratio obtained from the pyranometers (Yearly average). Overcast sky (8 Octas) vs. clear sky.

4. Situations presented on the poster

A more sophisticated way to investigate real cloudy situations consists in modelling clouds taking into account their properties as they are established by experimental measurements with instuments like Nephelometer [Gillotay.et al., 2001]

Different real situations will be presented and discussed namely:

1) Total homogeneous cloud layer with low clouds (ceiling ≅ 1000 m)
2) Total homogeneous cloud layer with medium clouds (ceiling ≅ 4000 m)
3) Broken clouds in real number and “geographic positions”

In all these cases, the modelling has been performed by calculating radiances with solid angle of 12° in order to cover the all sky dome (2πsr). Each elementary radiance is “corrected” for the clouds properties as determined by the Nephelometer.

The total irradiance is determined by integrating the elementary radiances.

Finally, a sensitivity study has been made by moving the geographic position of one cloud and remaining the other properties of the cloud constant.

5. CONCLUSION

These results show the consistency of both our model and experimental data. They provide tools to predict UV and visible irradiances for clear and full overcast sky. They already constitute a firm basis for a more systematic treatment of observations and particularly a better understanding of the cloud effect on UV irradiances.

Necessary improvements are needed to model more specific cases such as scattered and multi-layer cloud coverage, and to increase accuracy for clear sky simulations, especially for large SZA.

6. REFERENCES

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