Ground based UV-B measurements at 51°N during SESAME.

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INTRODUCTION

During the three phases of the SESAME Campaign, continuous spectral UV-B monitoring has been performed at Brussels (51°N) by means of absolute spectro-radiometers, previously compared with other European instruments during the European Intercomparisons. A full database including spectral and integrated data over the UVB, UVA and visible spectral wavelength ranges cover the period ranging from January 1994 to April 1995 and is available for research purposes. Some preliminary results are illustrated and discussed in term of different atmospheric parameters.

MEASUREMENTS

Since 1991, a full automatic and self-sufficient station for the monitoring of UV-visible solar irradiance at the Earth's surface has been developed by BISA and is fully operational in Uccle, south-western part of Brussels (Lat.: 50°47'54" N, Long.: 4°21'29" E, Alt. asl : 105 m) since the end of March 1993 in an urban residential site closes to the 'Forêt de Soignes'.

Presently, this station, called SUVIM (for Solar Ultraviolet Visible Irradiance Monitoring), consists mainly of three spectroradiometers based on modified Jobin-Yvon HD-10 double monochromators which have been optically characterised in the laboratory of optics and radiometry (bandwidth, angular and azimuthal responses, slit function, linearity of detectors) and calibrated in absolute irradiance scale by means of five standards lamps provided by the 'National Institute of Standards and Technology' (NIST) in Gaithersburg, Va-USA. A general diagram of the station is given in figure 1.

Two of the instruments are included in a weatherproof (waterproof and thermal regulated) container, and are oriented in the zenith direction. They are equipped with different entrance optics allowing a field of view of 2π sr (180°), with a practically perfect cosine response for instrument # 1 and of 5° for instrument # 2. They provide absolute spectral measurements from 210 nm to 650 nm every 15 minutes for solar zenith angle smaller than 100°.

Spectral data recorded by instrument # 1 provides an absolute measurement of the total (direct + diffuse) spectral irradiance received by a Lambertian surface at the Earth's surface. Instrument # 2 give an absolute measurement of the diffuse spectral irradiance in a solid angle of 5° around the zenith direction. This last measurement is important to characterised the cloud layer and to determine the total ozone contents by differential absorption spectroscopy technique. A third instrument (instrument # 3) is fitted on a sun tracker system and is designed to measure the direct spectral irradiance (field of view : 3 solar diameters - ≅ 1.5°) synchronously with instruments # 1 and # 2.

The three spectroradiometers allow to determine the total, direct and diffuse solar irradiances and provide then a data base useful to understand the influence of atmospheric parameters (like ozone column and concentration distribution, type of cloud layer, sun position, aerosol contents,...) on the two different components (direct and diffuse) of the UV-B, UV-A and visible ranges of the solar irradiance.

SOLAR UTRAVIOLET - VISIBLE IRRADIANCE MONITORING (SUVIM)

GENERAL STRUCTURE

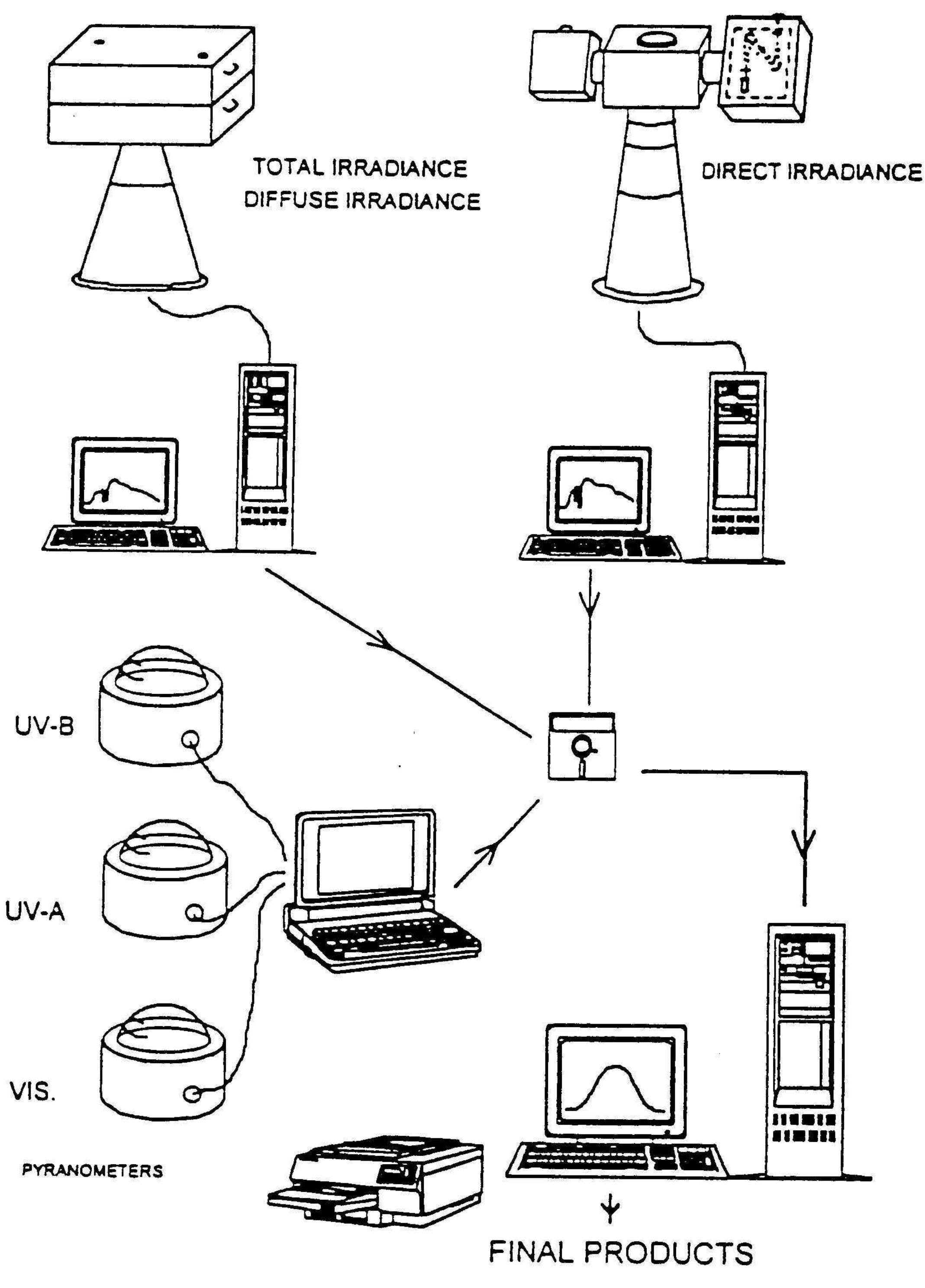

FIGURE 1. General diagram of the SUVIM monitoring station.

Three pyranometers (UV-B, UV-A and total) complete the station and provide continuous measurements of integrated irradiance (one measurement every second) in the three wavelength ranges.
Finally, ancillary measurements like total ozone contents (Dobson and Brewer), ozone concentration distribution (balloon sounding) and detailed description of the meteorological conditions (19 parameters every 3 hours for 23 stations in Belgium) are provided by the Royal Meteorological Institute of Belgium.

A special care is taken in the quality control of the provided data. Periodical absolute calibration (every 3-4 months) are performed in the dark room of the Institute with the five NIST FEL-1000 W standard lamps and the relative stability of the three spectroradiometers is verified frequently (every 2-3 weeks) by means of the Transportable Lamp System (TLS) developed in our laboratory, to be used in the field measurement configuration of the instruments. The TLS consists in a special unit including a set of five 200 w Quartz-halogen lamps and a mercury low pressure source, allowing the selection of the lamps and the perfect reproducibility of their positioning above the entrance optics of the instruments. The instability of this relative standard is lower than ± 2 % on all the wavelength range.
The combination of these two types of calibration, allow to estimate that the uncertainties on the data are lower than ± 5 %.
The results of the four European Intercomparison campaigns confirm the uncertainties of ± 5 % quoted before. (Gardiner et al., 1993)

RESULTS

For the clarity of this section, we will discuss some of the cases in terms of integrated values, each spectrum being integrated over the UV-B (280-320 nm namely the old limits of UV-B) and the UV-A (320-400 nm) ranges. The conclusions given for integrated values can be extended easily and remain valid for individual spectral values.
Figure 2 gives a diagram of the daily Effective UV dose in Brussels during the period mid-93 mid-95.
The influence of ozone is clearly shown in figure 3. by the anti correlation between UV-B integrated irradiance (daily mean value corrected for cloud attenuation) and ozone total contents (in dobson units) .
The other important atmospheric parameter regulating the UV-B penetration into the Earth's atmosphere is the cloud layer as illustrated in figures 4a & 4b. It seems that the attenuation of the UV irradiance due to the cloud layer is practically wavelength independent. Consequently this attenuation can be taken into account by using the ratio UV-B/UV-A to extract for instance the ozone influence.
Finally, some final products are available for potential users of UV measurements, as daily climatology, comparison between daily climatology and UV-meter measurements, influence of the solar zenith angle and of the variable cloud layer. Other parameters are presently under study, namely the influence of stratospheric and tropospheric ozone concentration on the direct and diffuse component of the solar irradiance, a careful determination of the attenuation due to different type of clouds as a function of wavelength, the impact of stratospheric and tropospheric aerosols on the penetration of solar UV irradiance at the Earth's level.

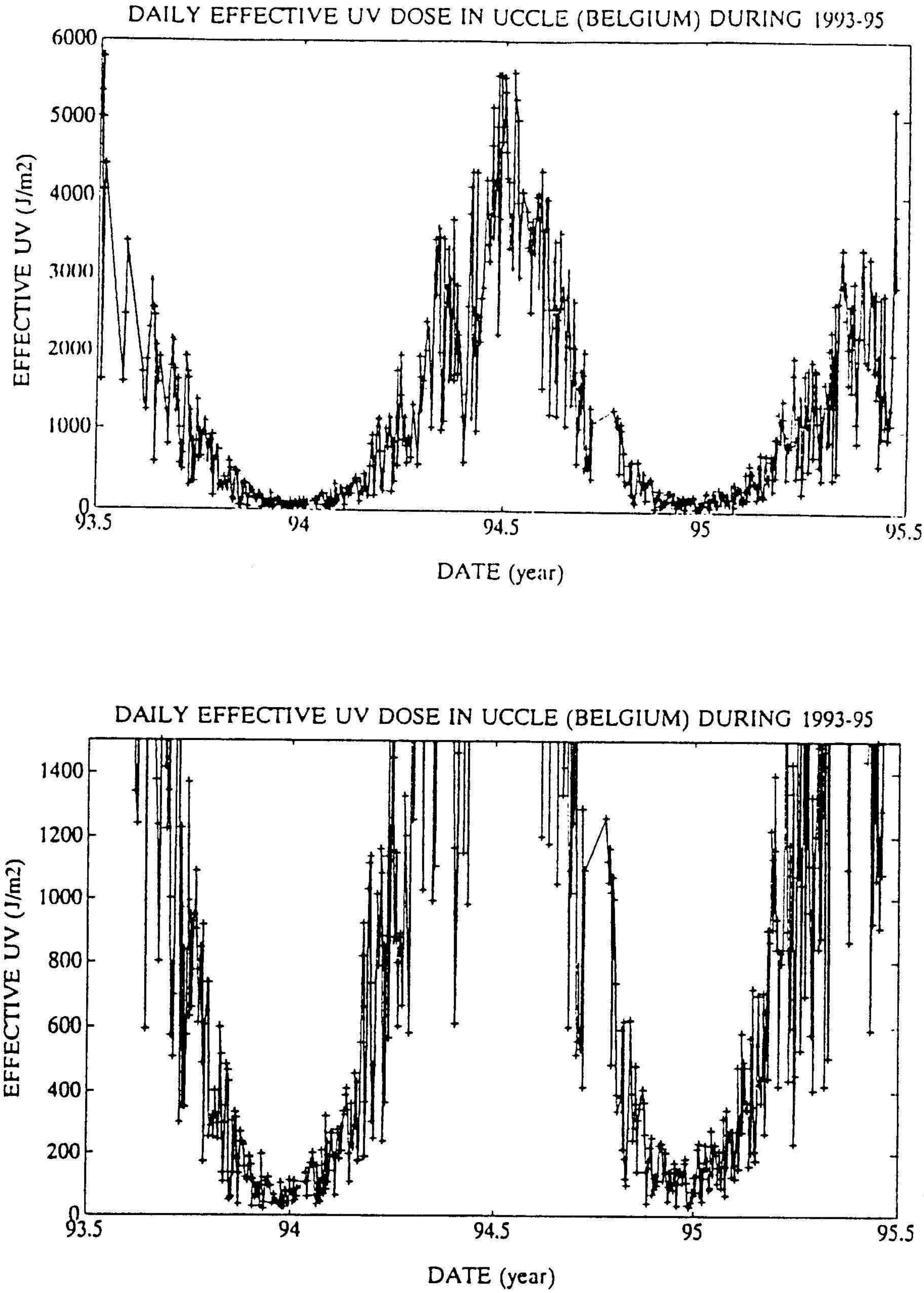

FIGURE 2. Seasonal variations of the Effective UV-B dose in Brussels (51°N) for the period mid-1993 to mid-1995.

CONCLUSIONS

Despite the fact that the UV-B monitoring from Brussels was no initially included in the SESAME programme, a full data base of experimental spectral and integrated values of UVB, UVA and visible irradiances measured at mid-latitude is available for potential user. A careful interpretation of these data is under progress to highlight the influence of the different atmospheric parameters.

REFERENCES

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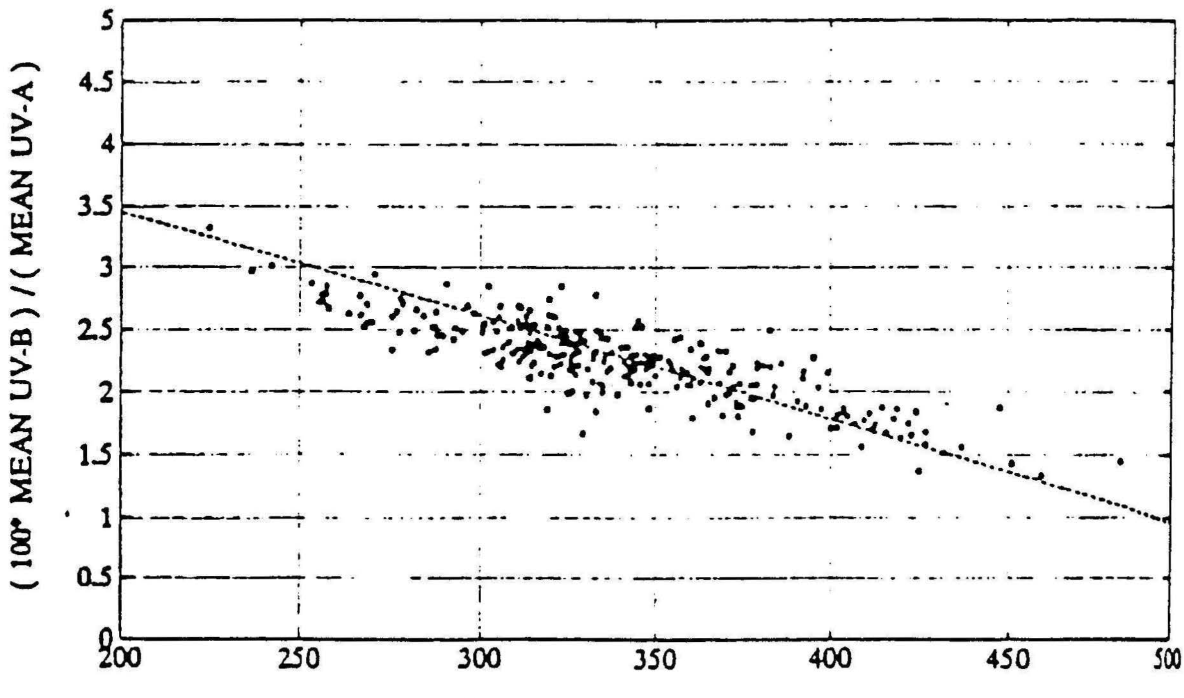
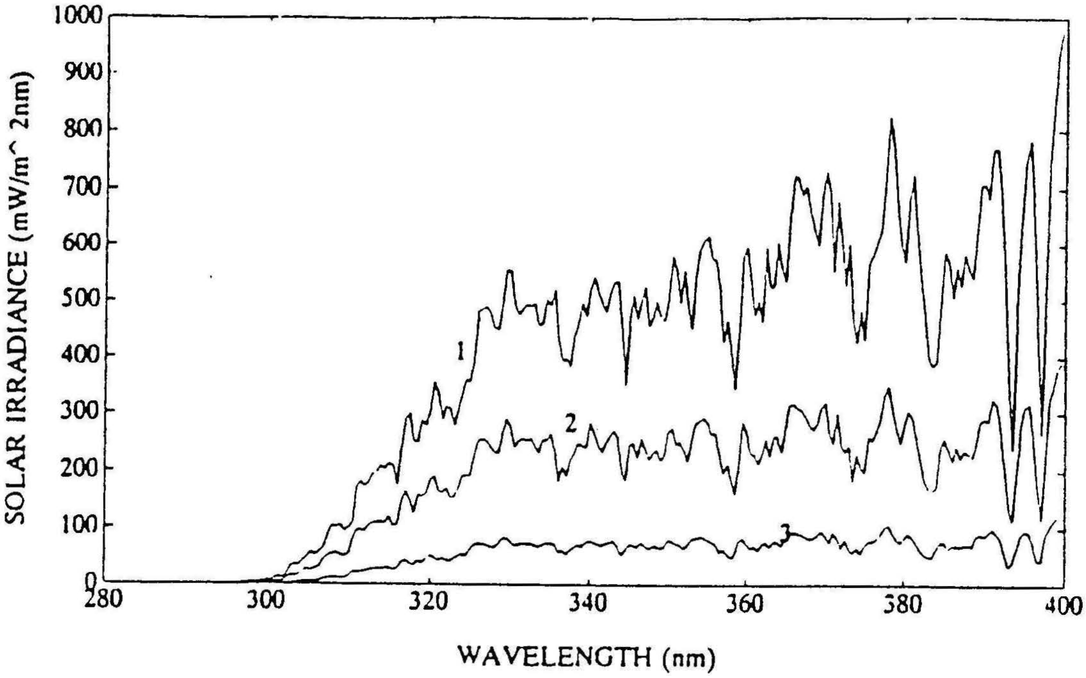
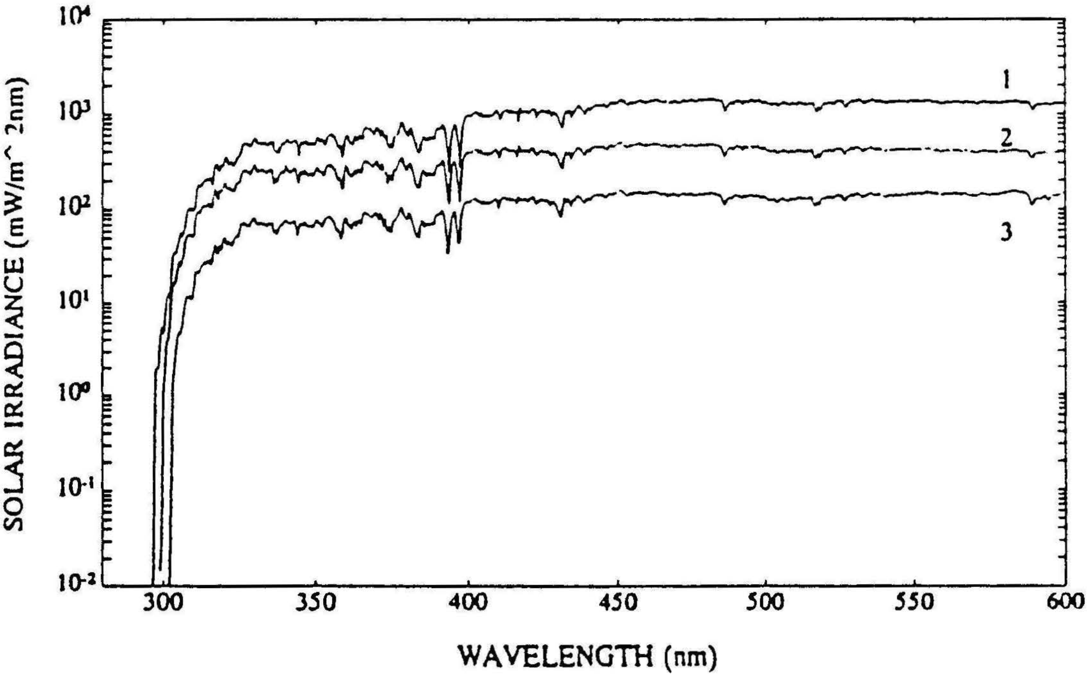


FIGURE 3. Anticorrelation between UV-B irradiances corrected for the effect of the cloud layer (UV-B/UV-A) and total ozone contents in 1994 for SZA = 65°.



(a)



(b)

FIGURE 4. Influence of the cloud layer on the UV-B spectral irradiances at 10:00 for ozone contents of 320 dobson units, in linear scale (a) and logarthmic scale (b).

1. DAY 175 (24/06/1994) -> CLEAR SKY CONDITIONS
2. DAY 174 (23/06/1994) -> 5 OCTAS STRATOCUMULUS -> ALTOCUMULUS
3. DAY 176 (25/06/1994) -> 8 OCTAS ALTOCUMULUS