MEASUREMENTS OF UV-B SPECTRAL IRRADIANCE BEGINNING OF A REGIONAL NETWORK

J.L.Bocquet, E.Pachart, C.Brogniez, J.Lenoble,
Université des Sciences et Technologies de Lille
59655 Villeneuve d'Ascq, France

D.Gillotay, D. Bolsée
Iinstitut d'Aéronomie Spatiale de Belgique
B-1180 Brussels, Belgium

ABSTRACT

The University of Lille has developed an instrument to monitor the solar UV irradiance. After many improvements, consecutive to European intercomparison campaigns, it is installed at the top of the LOA building at Lille. This spectroradiometer is planned to take part in a regional network involving, among others, France and Belgium. As validation test for such a network, comparisons of measurements performed, in different conditions, simultaneously by LOA at Lille and by IASB at Brussels have been performed and presented here.

1. INTRODUCTION

The impact of the UV-B (280-315 nm) potential trend on the biosphere is an important topic which is intensively studied since the end of the eighties. Monitoring networks have been deployed in many countries and continents. In Europe, the variability of the meteorological conditions from North to South and East to West is an important difficulty to achieve a global interpretation of the European UV climatology. Plans are therefore currently considered for regional networking including, for instance, a Dutch-Belgian-French dense network.

We present here several comparisons made with spectroradiometers operating by LOA, Lille and by IASB, Brussels, 80 km far from Lille. We compare (i) measurements obtained by both instruments located at IASB and (ii) measurements with one instrument located at Lille and the other one located at Brussels. In the first case there is an excellent consistency between the measurements. In the second case a good agreement is found only for stable meteorological conditions.

2. DESCRIPTION OF THE INSTRUMENTS

2.1 The French instrument

The instrument used at the University of Lille to monitor the solar UV irradiance, is a Jobin Yvon spectroradiometer which has undergone several modifications. It participated in two European intercomparison campaigns in Garmisch-Partenkirchen, Germany, in July 1993 (Gardiner and Kirsch, 1995) and in Ispra, Italy, in May 1995, and has been further improved after this campaign; it is presently operating regularly at the top of the physics building of Lille University at Villeneuve d'Ascq (50.65° N - 3.1° E) since February 1996. The characteristics and performances of the instrument are presented in table 1. The main improvement it has undergone is the temperature stabilization (within 0.1 degree).

2.2 The Belgian instrument

One of the Belgian instruments is also a temperature stabilized modified Jobin Yvon H10D spectroradiometer whose characteristics are reported in table 1. The instrument installed at IASB (50.8° N - 4.4° E) is performing measurements since April 1993 (Gillotay, 1996). The other one is an Optronics 754 presently under validation.

	LOA	IASB
Spectrometer type	J&Y DH10	J&Y modified DH10
Focal length (nm)	100	100
Gratings concave holographic lines/mm	two 1200	two 1200
Bandwidth FWHM (nm)	0.8	0.49
step (nm) usual finest	0.5 0.05	0.5 0.05
Usual range (nm) from to	280 450	210 680
Direction of scan	up	up
Scan duration (s)	500	400
Diffuser	Teflon	Teflon
Detector type	PM Hamamatsu R4220P	PM Hamamatsu R292
Weatherproof	yes	yes
Automatic	yes	yes

IRS '96: Current Problems in Atmospheric Radiation
Smith and Stamnes (Eds.) ISBN 0-937194-39-5

Temperature Stabilized optics	301 K	yes
Dark current removed	yes	yes
Stray light removed	yes	yes
Radiation standard	Oriel	NIST
Main Lamp (W)	1000	1000
Secondary lamp	no	4

Table 1. Specification of both instruments

3. COMPARISONS OF SIMULTANEOUS MEASUREMENTS

The two spectroradiometers have been separately calibrated, the French one with an Oriel standard lamp, the Belgian one with four NIST standard lamps (FEL 1000W). Moreover, after the July 17 comparison the USTL instrument calibration was also verified by means of the Belgian standard lamps.

Comparisons of the irradiance measurements have been conducted in two different manners:
(i) the instruments were both located at the same place, at Brussels,
(ii) the instruments were located in places separated by 80 km, one installed at Villeneuve d'Ascq, the other at IASB.

In both cases the scan step was the same for the two instruments (0.5 nm) and the measurements occurred at approximately the same time (within a few seconds in the UV-B range).

3.1 Instruments at the same location

We present first the comparison of the measurements performed at IASB on July 17, 1996.

Figure 1a shows the spectral irradiance measured by both instruments at 1215 UT from 280 to 450 nm, for a the solar zenith angle (SZA) of 30.24°. The general consistency looks good.

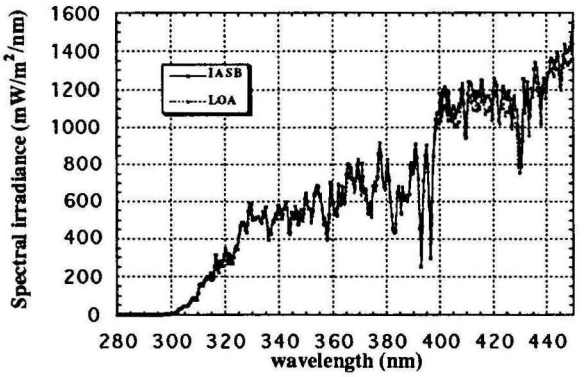

Fig. 1a. Spectral irradiance measurement comparison. Brussels: July, 17th 1996. 12h15 UT SZA: 30.24°

The small differences appear more clearly on the ratio of the IASB to USTL measured irradiance shown in Figure 1b (light line). It exhibits oscillations due to different bandwidth of the instruments (see Table 1) and to the wavelength calibration. The thick line represents the ratio after smoothing. The measurements agree within 5 % for wavelengths larger than 295 nm. For shorter wavelengths the discrepancies maybe related to large uncertainties due to the very low signal level.

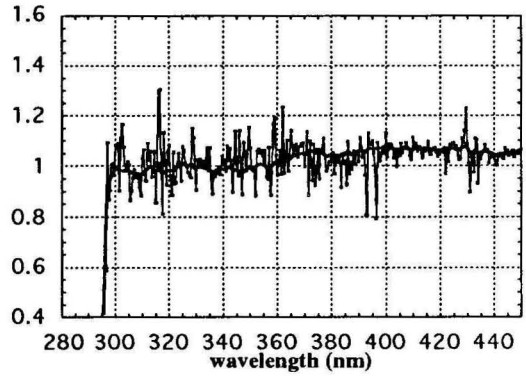

Fig. 1b. July, 17th 1996 12h15 UT SZA: 30.24° ratio (IASB/LOA)

Figure 2 presents the ratio obtained later on the same day at 1630 UT, with SZA = 61.6°. The consistency between the measurements is again quite good, the ratio remaining close to unity, within 5 %.

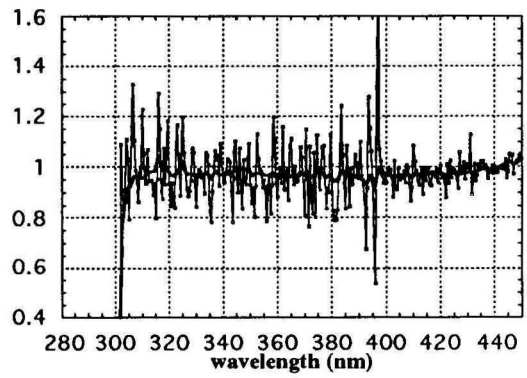

Fig. 2. July, 17th 1996 16h30 UT SZA: 61.6° ratio (IASB/LOA)

These error limits are in close agreement with those observed during the previous European Intercomparison Campaigns (Gardiner et al., 1993, Gardiner and Kirsch, 1995).

The irradiances integrated over the UV-B spectral range are drawn in Figure 3a versus time, two wavelength intervals are considered: 280-315 nm and 280-320 nm. The erythemal dose, which is defined as the integral over 280-400 nm spectral range of the measured spectral irradiance weighted by the erythemal action spectrum integral (McKinlay and Diffey, 1987) is also shown in Figure 3a. In the three cases the IASB and USTL measurements are in very good agreement. Figure 3b shows the IASB/USTL ratios obtained for the three cases. The ratios are very close to unity up to 70°. SZA for the UV-B irradiances. Above 70°, we have a disagreement which increases more and more, probably due, on the one hand to the unperfected synchronization and, on the other hand, to the difference in the cosine responses of both instruments. For the doses the ratio is close to unity up to 80° SZA.

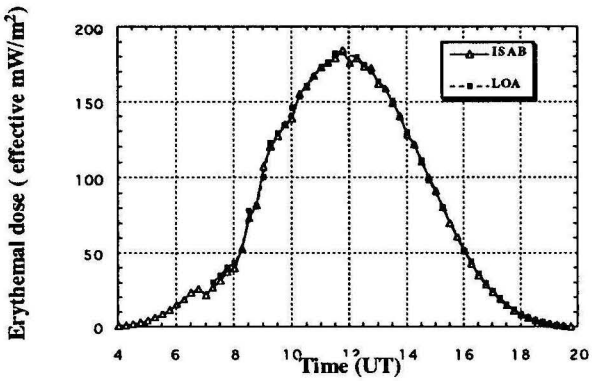

Fig. 3a. Erythemal dose measurement comparison. Brussels: July, 17th 1996

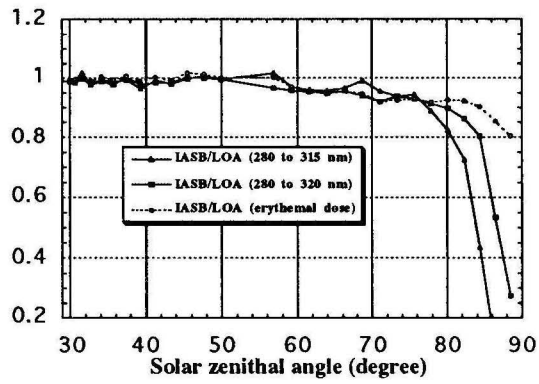

Fig. 3b. UV-B irradiance and erythemal dose measurement ratio (IASB/LOA)

3.2 Instruments at different locations

The first two following comparisons were achieved on March 27th, 1996 at 1045 UT, and on April 16, 1996, 1430 UT, by clear sky conditions. The SZAs were slightly different for the two instruments: 49.68° at Villeneuve d'Ascq, 49.52° at Brussels in the first case, and 52.13°, 52.89° respectively in the second case.

Figures 4a,b show the ratio of the IASB to USTL measurements on the two dates. We still have a good agreement between the measurements, within 10 % for wavelengths larger than 320 nm and within 20 % for the shorter wavelength range, 305-320 nm.

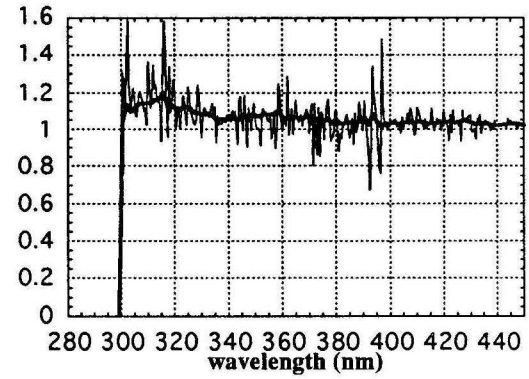

Fig. 4a. Spectral irradiance measurement comparison between Villeneuve d'Ascq and Brussels. March, 27th 1996 10h45 UT. Villeneuve d'Ascq: SZA 49.68°. Brussels: SZA 49.52° ratio (IASB/LOA)

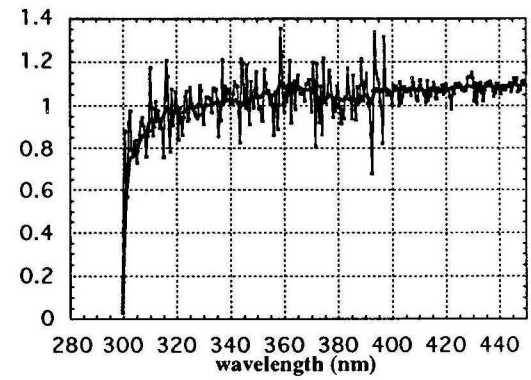

Fig. 4b. Spectral irradiance measurement comparison between Brussels and Villeneuve d'Ascq. April, 16th 1996 14h30 UT. Villeneuve d'Ascq SZA: 52.13°. Brussels SZA: 52.89°. ratio (IASB/LOA).

The agreement is poorer for the last comparison conducted during a variable cloudy day. The example of ratio, drawn in Figure 5, exhibits large

variations, with values reaching 1.4 at the end of the scan period, corresponding to more cloudy sky at Villeneuve d'Ascq. The apparent discrepancies are therefore quite justified.

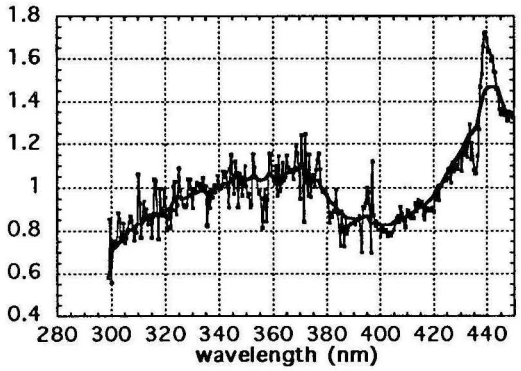

Fig. 5. Spectral irradiance measurement comparison between Brussels and Villeneuve d'Ascq. June, 11th 1996 15h30 UT. Villeneuve d'Ascq SZA: 50.74°. Brussels SZA: 51.88°. ratio (IASB/LOA)

4. CONCLUSION

We have compared in this paper the spectral irradiance measurements obtained with two instruments located first at the same place, and then separated by 80 km.

The excellent agreement found in the first case and in the second case by clear and stable meteorological conditions demonstrates the ability of both instruments to measure the UV spectral irradiance. The differences observed by unstable weather conditions confirm the UV spatial variability and demonstrate the difficulties to give a global representation of the UV-B climatology even for a small geographic area.

The Belgian and French spectroradiometers are currently involved in a Dutch-Belgian-French network covering a relative small area of N.W. Europe with stations distant of no more than 200 km. A looser network covering the French territory with three stations (Lille, Briançon and maybe Toulouse), distant by about 500-800 km is planned.

ACKNOWLEDGMENTS

This study was partially supported by European Union (contract #EVSV-CT93-0353).

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