R e p o r t

from the COST-726 Short Term Scientific Mission

Calibration of broadband ultraviolet radiometers

11–17 September, 2004

Ispra, Italy.

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The Short Term Scientific Mission's reporter was hosted by the European Reference Centre for Ultraviolet Radiation Measurements (ECUV), Institute for Health and Consumer Protection (IHCP), Joint Research Centre (JRC) in Ispra, Italy, represented by Dr. Julian Gröbner. The mission aimed at:

- getting knowledge on calibration methodology of solar irradiance
- measurements of spectral response and calibration of reference SL501 instrument of IMWM UV network
- comparison of the SL501 instrument with the reference spectroradiometer of ECUV

The SL501 instrument, serial number 0935, is the reference radiometer for IMWM UV network. The IMWM UV network exists since 1994 on the 3 stations: Leba (54.75º N, 17.53ºE), Legionowo (52.4º N, 20.97º E) and Zakopane (49.3º N, 19.97º E). Last calibration of the instrument took place at the Intercomparison of Erythemal Radiometers. Campaign in Thessaloniki, Greece in 1999.

ECUV initiated solar UV irradiance measurements in 1991 at the JRC. Presently, ECUV maintains the following instrumentation:

- One Brewer spectrophotometer #066, which provides measurements of total column ozone, aerosol optical depth and global UV irradiance every day since its start in 1991.
- A number of broadband filter radiometers sensitive to the UV-B, UV-A and total solar spectrum provide continuous measurements every minute since 1995.
- A Cimel sunphotometer was deployed in 1997, which is operated within the activites of AERONET.
- In 2001, a double Brewer spectrophotometer was added to the instrumentation to provide spectral solar UV measurements with very high accuracy. Measurements were started in the summer of 2001.
- A Bentham DM-150 spectrophotometer forms the core of the travelling spectrophotometer system, which is providing QA/QC of solar UV radiation measurements to interested laboratories in Europe.

The characterisation and calibration of the spectrophotometers is obtained within a well equipped laboratory and follows the guidelines recommended by the WMO.

Laboratory characterization

On the first day of the visit in ECUV the reference SL501 instrument was calibrated in laboratory. The relative spectral response of the SL501 instrument was measured in the region 280 – 400 nm at 2 nm steps. The radiometer was irradiated by 300 W Xe lamp, using light of the same wavelenght during 3 minutes interval. The relative response is shown in Figure 1.

Relative response measured in Ispra was compared with relative response measured in Thessaloniki, Greece 1999.

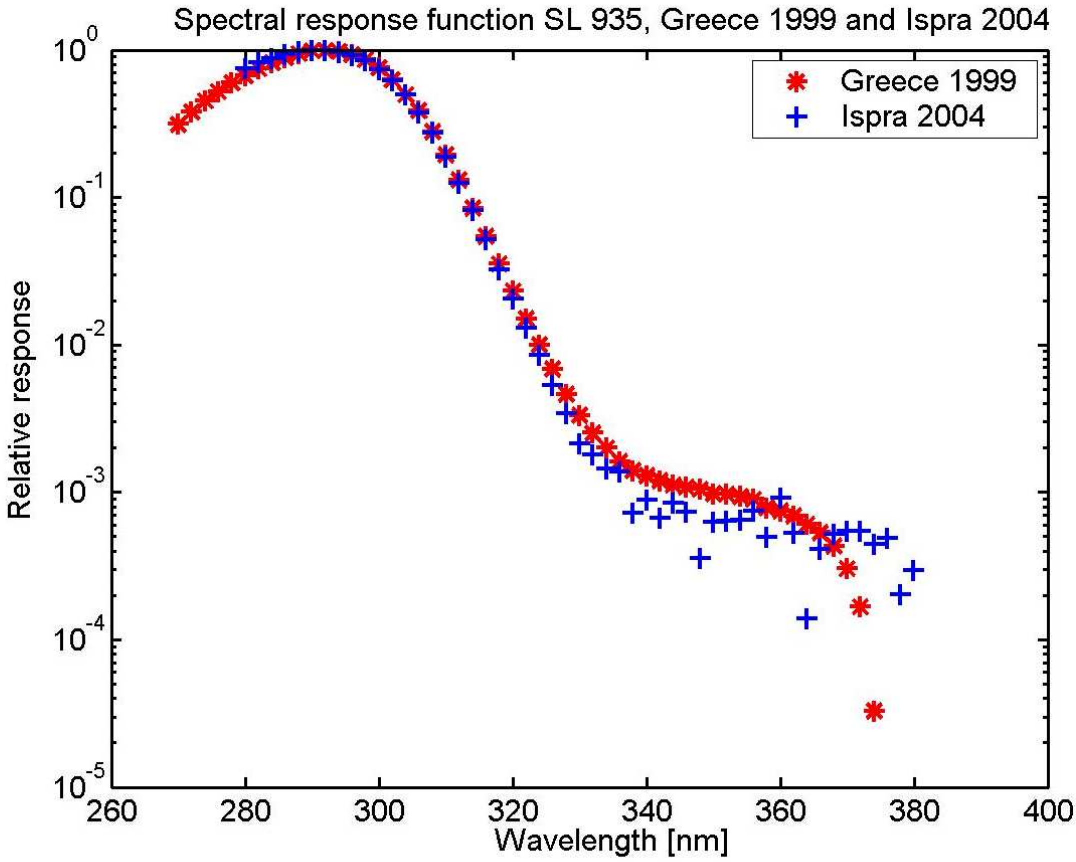

Figure 1: Comparison of the relative responses measured in Greece 1999 and Ispra 2004

Relative responses measured in Ispra and Thessaloniki are very similar for wevelenght below 330 nm. Relative responses above 330 nm differ highly due to small measurement resolution.

Outdoor measurements

During four days of the calibration (14-17.09.2004) the SL501 instrument was working on the roof together with the Brewer spectrophotometer and other radiometers. The measurement interval of the SL501 instrument was 1 minute. The diurnal cycles of UV-B erythemal irradiation are shown in Figure 2.

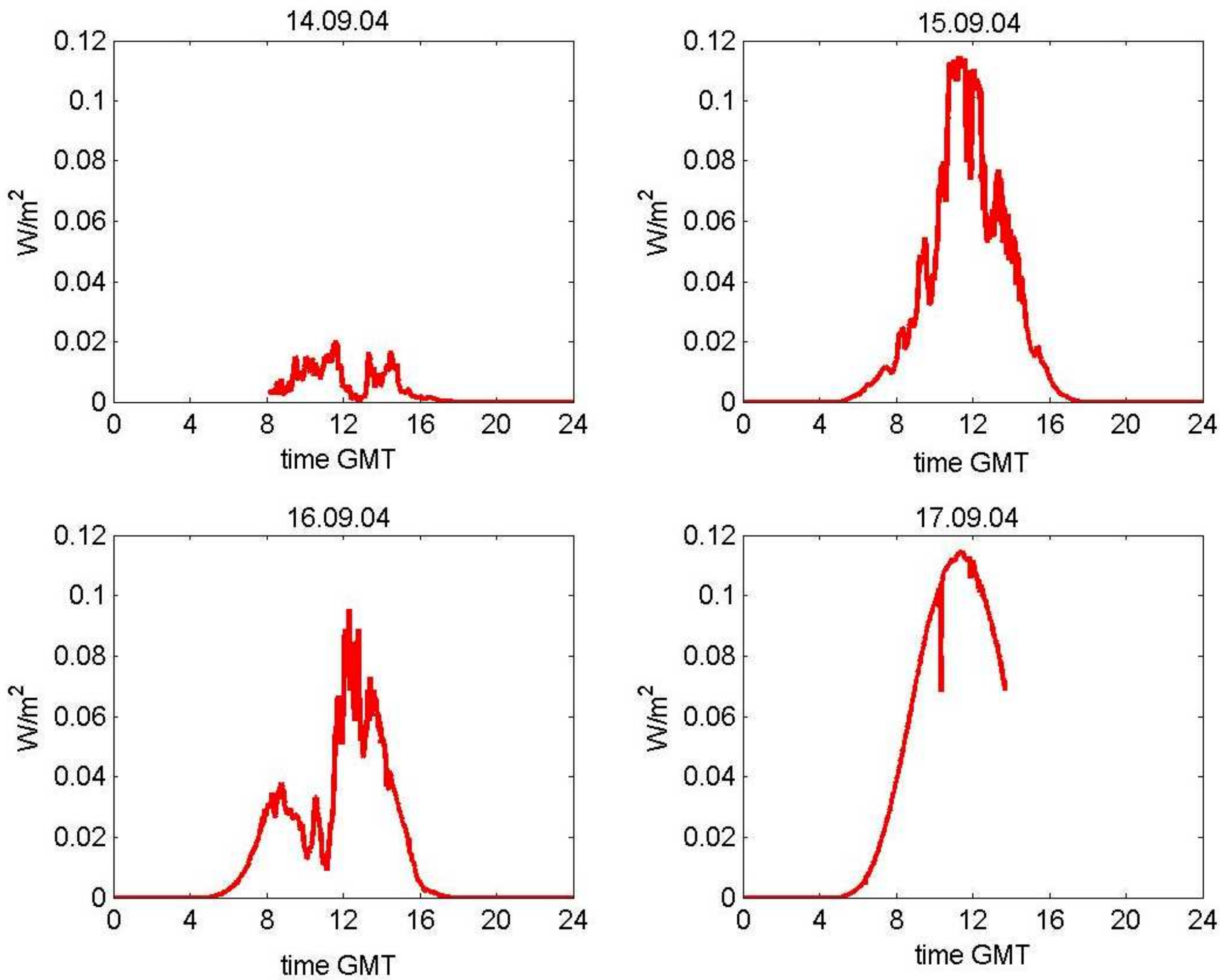

Figure 2: Diurnal UV cycles for period 14-17.09.2004

On the first day of the calibration period was cloudy and rainy, therefore only three days (15-17.09.04) were selected for the analysis. Because day 17.09.04 was the last day of the calibration, measurement was finished early afternoon. The ratio SL 0935 (raw data) to Brewer #163 (erythemal weighted spectra) as function of time, is shown in Figures 3, 4, 5 and the ratio SL 0935 (raw data) to Brewer #163 (erythemal weighted spectra) as function of solar zenith angle, is shown in Figures 6, 7, 8.

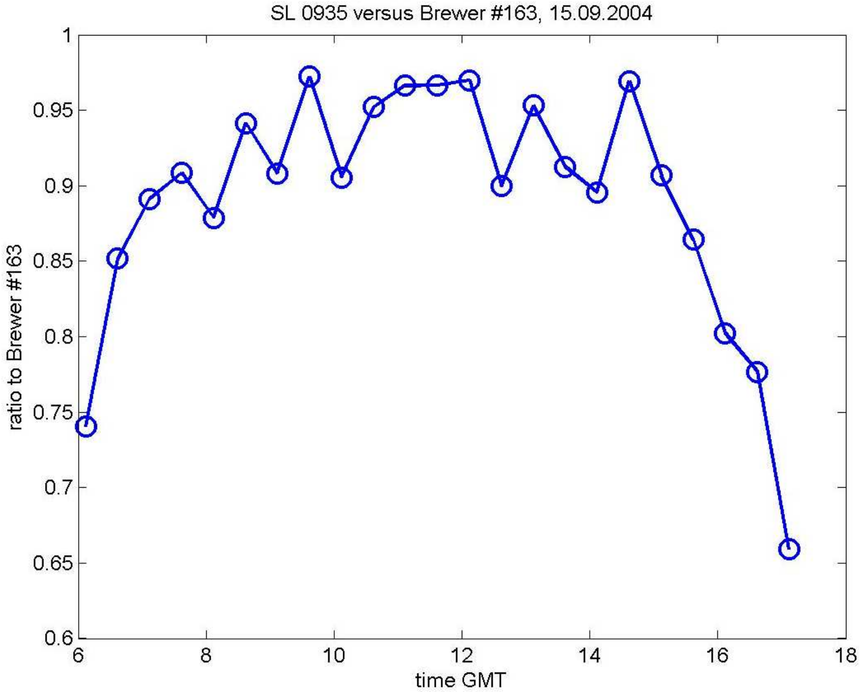

Figure3: Ratio of SL 0935 to Brewer #163 from 15.09.04 as function of time.

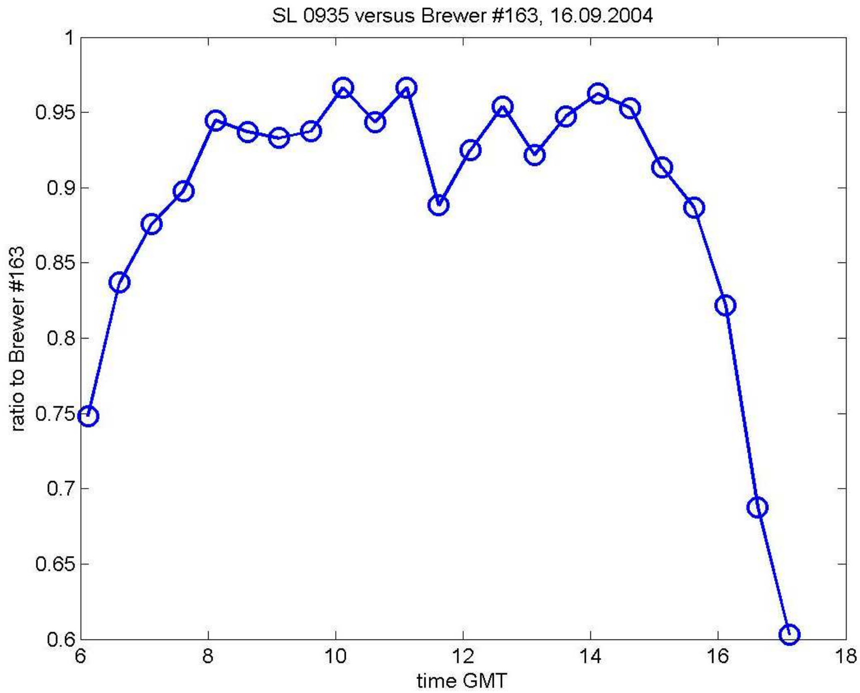

Figure 4: Ratio of SL 0935 to Brewer #163 from 16.09.04 as function of time

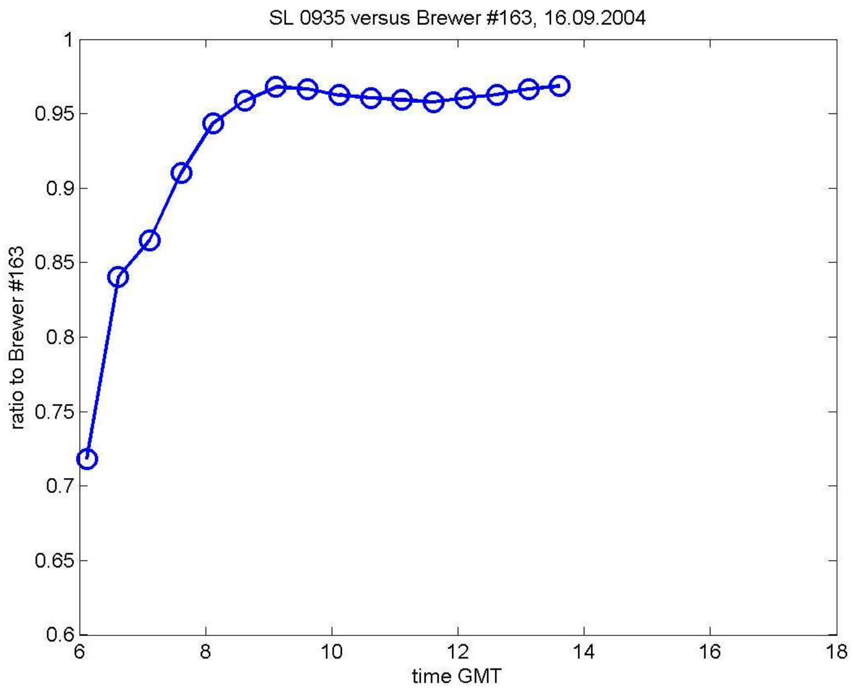

Figure5: Ratio of SL 0935 to Brewer #163 from 17.09.04 as function of time.

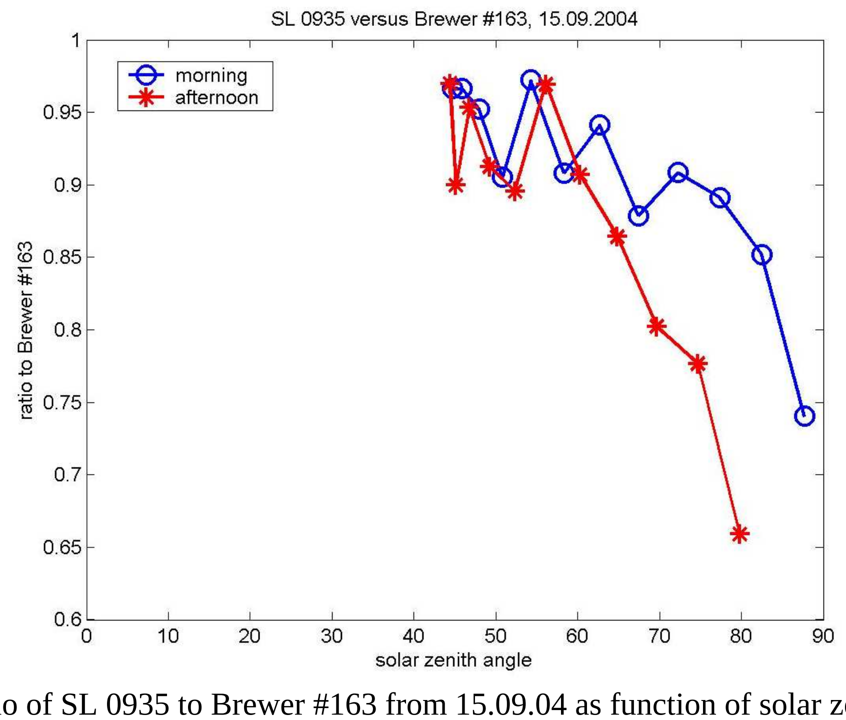

Figure 6: Ratio of SL 0935 to Brewer #163 from 15.09.04 as function of solar zenith angle.

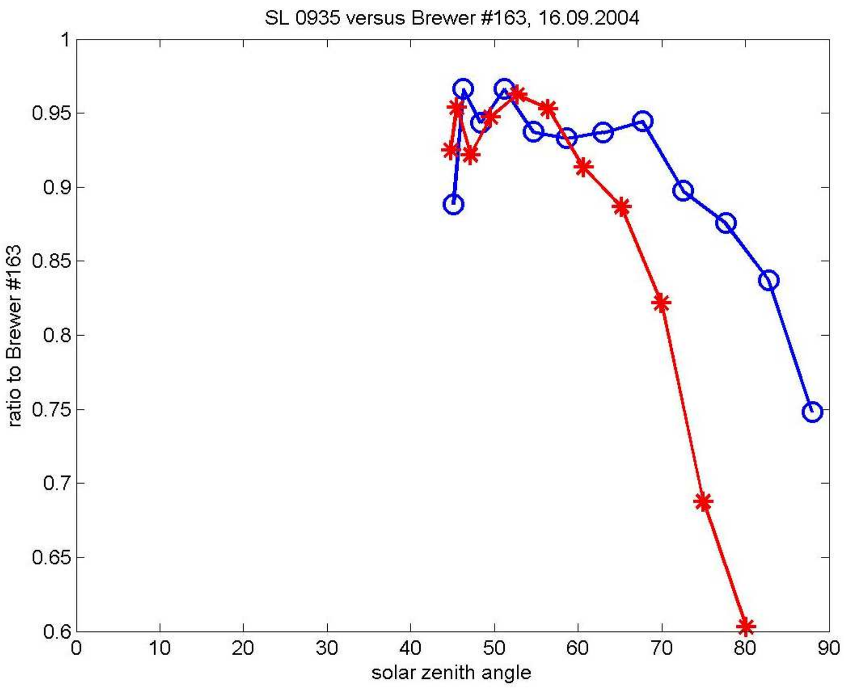

Figure 7: Ratio of SL 0935 to Brewer #163 from 16.09.04 as function of solar zenith angle.

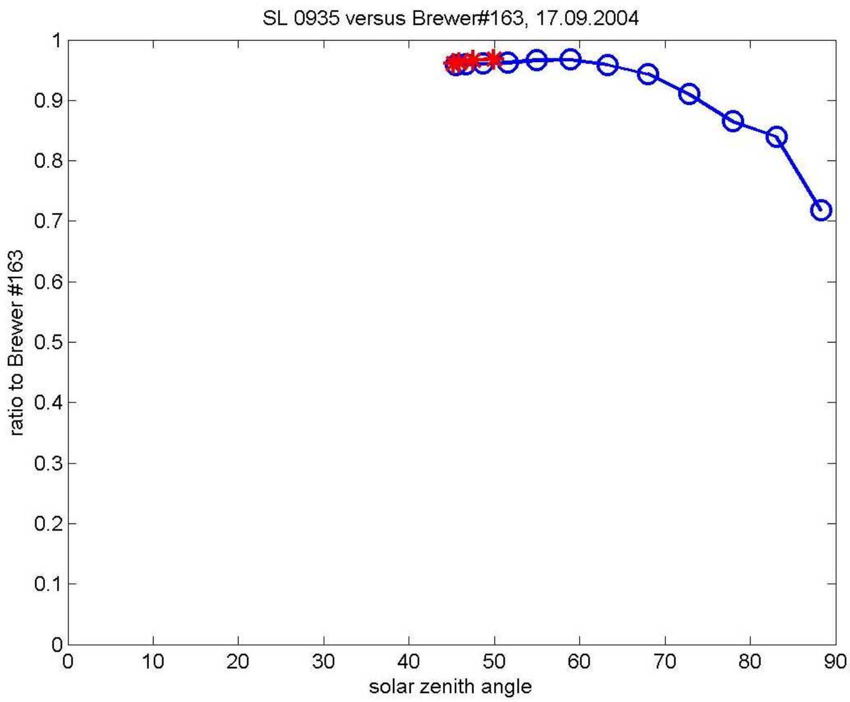

Figure 8: Ratio of SL 0935 to Brewer #163 from 17.09.04 as function of solar zenith angle.

The conversion table for SL 0935 from calibration period: 15 to 17 September 2004 is shown on the next page.

!Conversion table for sl935 using Resp. file srf_sl935_1999.dat
!Calculated on 17-Sep-2004 13:16:55 - using model disort
!First column solar zenith angle
!First row: Total column ozone [DU]
!Reference Spectroradiometer: BREWER #163
!Responsible Scientist: Dr. Julian Gröbner (julian.groebner@jrc.it)
!European Reference Centre for Ultraviolet Radiation Measurements (ECUV)
!Joint Research Centre, European Commission
!Via Enrico Fermi, TP272, I-21020 Ispra, Italy
!Calibration Period: 15 to 17 September 2004
!
!
!Calibrated output (W/m^2)=SL935_output(W/m^2) * CF(SZA,O3)
!
!

-999.000	200.0	220.0	240.0	260.0	280.0	300.0	320.0	340.0	360.0	380.0	400.0	420.0	440.0	460.0	480.0	500.0
90.000	1.625	1.642	1.663	1.685	1.709	1.733	1.758	1.783	1.808	1.833	1.857	1.881	1.905	1.929	1.951	1.974
85.000	1.399	1.420	1.440	1.463	1.486	1.509	1.532	1.555	1.578	1.601	1.623	1.645	1.666	1.686	1.706	1.726
80.000	1.240	1.252	1.267	1.283	1.300	1.318	1.336	1.355	1.373	1.391	1.410	1.428	1.445	1.463	1.480	1.497
75.000	1.156	1.161	1.169	1.178	1.189	1.201	1.214	1.228	1.241	1.255	1.270	1.284	1.299	1.313	1.327	1.341
70.000	1.118	1.116	1.118	1.121	1.127	1.134	1.142	1.151	1.160	1.171	1.181	1.192	1.204	1.215	1.226	1.238
65.000	1.108	1.100	1.096	1.095	1.096	1.098	1.102	1.107	1.113	1.120	1.128	1.135	1.144	1.152	1.161	1.170
60.000	1.114	1.101	1.093	1.087	1.084	1.083	1.083	1.085	1.088	1.092	1.097	1.102	1.108	1.114	1.121	1.128
55.000	1.128	1.112	1.100	1.090	1.084	1.080	1.077	1.076	1.076	1.078	1.080	1.083	1.087	1.091	1.095	1.101
50.000	1.145	1.125	1.110	1.098	1.088	1.081	1.076	1.073	1.071	1.070	1.071	1.072	1.074	1.076	1.079	1.082
45.000	1.159	1.136	1.118	1.104	1.092	1.083	1.076	1.071	1.067	1.064	1.063	1.062	1.062	1.063	1.065	1.067
40.000	1.179	1.154	1.134	1.118	1.104	1.093	1.084	1.077	1.072	1.068	1.065	1.063	1.062	1.061	1.062	1.063
35.000	1.197	1.171	1.149	1.131	1.116	1.103	1.093	1.085	1.078	1.072	1.068	1.065	1.063	1.061	1.061	1.061
30.000	1.214	1.186	1.163	1.143	1.127	1.113	1.101	1.092	1.084	1.078	1.072	1.068	1.065	1.063	1.061	1.060
25.000	1.228	1.199	1.175	1.154	1.137	1.122	1.109	1.099	1.090	1.083	1.077	1.072	1.068	1.065	1.062	1.061
20.000	1.240	1.210	1.185	1.163	1.145	1.129	1.116	1.105	1.095	1.087	1.080	1.075	1.070	1.067	1.064	1.062
15.000	1.249	1.218	1.193	1.170	1.152	1.135	1.121	1.110	1.100	1.091	1.084	1.078	1.073	1.069	1.066	1.063
10.000	1.255	1.225	1.198	1.176	1.156	1.140	1.125	1.113	1.103	1.094	1.086	1.080	1.075	1.070	1.067	1.064
5.000	1.259	1.228	1.202	1.179	1.159	1.142	1.128	1.115	1.105	1.096	1.088	1.081	1.076	1.071	1.068	1.065
0.000	1.260	1.229	1.203	1.180	1.160	1.143	1.129	1.116	1.105	1.096	1.089	1.082	1.076	1.072	1.068	

The calibration factor for three days as function of solar zenith angle is shown in Figure 9.

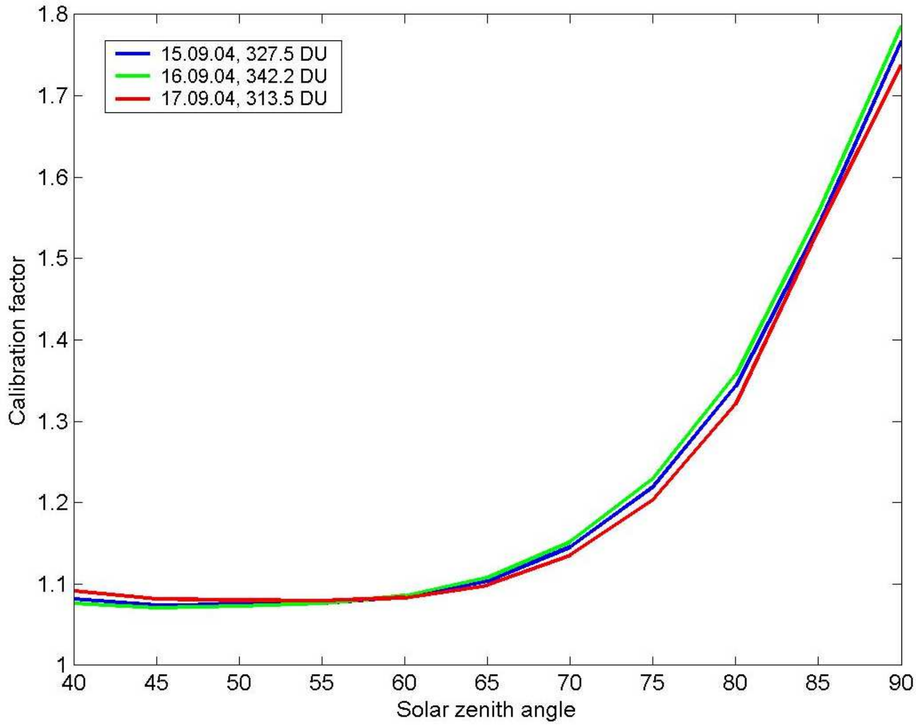

Figure 9: Calibration factor for three days (15-17.09.04) as function solar zenith angle.

The calibration factor obtained in Thessaloniki, Greece 1999 for 30º solar zenith angle and 327 DU total ozone was 0.952. The calibration factor from the conversion table for the same solar zenith angle and total ozone is 1.10. Therefore the calibration factors are within 15%.

Conclusions

- The mission allowed the scientist to get practical knowledge on calibration of broadband ultraviolet radiometers
- The scientist increased her experience in UV data analysis
- The reference SL501 instrument will be used for calibration of other instruments of IMWM stations
- The scientific and infrastructure quality of the host was very good for mission's objectives

Date: Legionowo 18th October, 2004 Julita Biszczuk