Site Audit at IM, 2 – 3 May 2002

Formal Statement

This audit was the sixth of some one dozen site visits that will be conducted within the European project EDUCE by project's Scientific Secretary. The Scientific Secretary is responsible for drafting a confidential summary (which is sent to the site operator and the EDUCE project coordinator) and this formal report (which is published at the project web pages). The wording of both the summary and the full report is agreed with the site operator. The full terms and scope of the audit are described within the audit definition, which may be retrieved from the project website at http://www.muk.uni-hannover.de/EDUCE.

Overview

The Portuguese Institute of Meteorology operates a single Brewer spectrophotometer MKII (#013). Measurements of UV spectral irradiance in Lisbon (Longitude 9.15 W, Latitude 38.77 N, Altitude 100 m) began in 1990, interspersed with monitoring of total ozone. The instrument is currently located on the roof of the IM headquarters in Lisbon, close to Lisbon international Airport.

Initially the instrument was situated on the roof of the upper air station building (Lisboa/Gago Coutinho). In June 1992 it was moved to the Azores, where it remained until June 1999. (For most of this period, however, the spectroradiometer was unable to make measurements due to difficulties with local maintenance). The instrument was eventually repaired and then, in September 1999, tested against a travelling standard (Brewer #017) at the El Arenosillo station in Spain. It was also calibrated against a certified 1000 W lamp. Since June 2000, the spectroradiometer has been installed on the roof of the IM headquarters in Lisbon, about 1 km far from the original site.

The current primary objective of the IM site is total ozone measurement (to overlap with measurements from the Dobson #13 operation). Measurements of UV irradiance are a secondary to this. For this reason, it is not possible to satisfy all requirements for UV measurements – changes to the UV measurement regime may only be made provided that the total ozone measurements are not adversely affected.

With this in mind, the present site objectives are:

- To operate as a permanent measuring station for UV spectral irradiance, providing daily estimates of the UV index.

- To develop the site to serve as a reference and calibration station for solar radiation measurements in the national Portuguese network.

The IM dataset for Lisbon begins in 2000. The primary role of the Brewer is measurements of ozone column depth, which means that the frequency of spectral measurements of UV irradiance is limited to approximately one an hour from sunrise to sunset.

There are no calibration facilities at IM. The Brewer currently carries the reference of a travelling standard (Brewer #017, September 1999).

Spectral scans are made from 280 to 550 nm using 0.5 nm steps. The bandwidth is approximately 1 nm (FWHM).

Data are used for calculating the UV index. The typical difference between measurements of the UV index made using the IM Brewer and the previous day's 24-hour forecast is typically of the order or less than 1 unit.

In addition to the spectroradiometer, two pyranometers (one measuring the diffuse and one the global component) are situated at the local meteorological station (a distance of about 1 km).

The horizon at the IM site lies entirely at 0 degrees altitude, except for a white-faced shed that stands a few metres to the North-East (elevation about 30°) and a large and equally bright satellite dish positioned a few meters to the North-West (also with a height of about 30°). The local surroundings are flat, with a mix of urban and ocean.

There is one full-time staff member, who works with the UV instruments and data. Approximately 1 day a week is dedicated to routine maintenance, data collection and data analysis.

The general operation appears organised. The routine measurement and data analysis procedures are clearly carried out according to well-practiced routines. The UV group benefits from the extensive experience of the personnel. One member of the group has nearly two decade of experience in meteorology and UV radiation measurements.

The future aim is that the IM site should serve as a national reference for the solar radiation network in Portugal. Efforts are currently being made to acquire the necessary equipment (calibration bench, sun tracker, radiometers, etc) for operational calibration procedures. It is hoped to begin continuous measurements with an RBM in the near future.

There are also plans to move the spectroradiometer to the roof of the nearby hut, which would provide an unobstructed horizon and remove potential problems with reflected light.

IM also plan to investigate the observed variability in the ratio of modelled to measured values of clear-sky spectral irradiance, and to determine the uncertainty associated with the model results.

IM do not have access to calibration facilities, so the calibration of the Brewer spectroradiometer was not assessed during the visit.

Figures

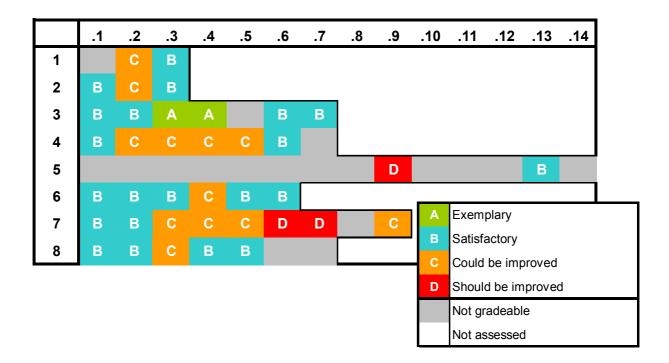**Brewer #013 on roof of IM building, looking East**

Month	Precipitation (mm)	Temperature (C)	Sunshine (h)	AOD (500 nm)	AOD (380 nm)
1	95.3	10.5	143.1	0.046	0.063
2	99.1	11.8	132.4	0.058	0.077
3	30.9	13.7	220.0	0.057	0.084
4	79.6	14.5	206.1	0.086	0.112
5	45.7	16.9	258.3	0.069	0.090
6	15.2	20.3	282.8	0.103	0.141
7	5.5	22.6	321.2	0.122	0.161
8	5.1	22.9	316.8	0.075	0.107
9	20.8	22.5	250.4	0.100	0.142
10	78.3	18.3	199.3	0.099	0.137
11	159.9	14.2	126.4	0.054	0.071
12	119.6	11.6	119.7	0.058	0.077
Year	755.0	16.7	2576.5	0.078	0.106

Local climate

Summary

-   The measuring site is representative of the local environment.

-   The measurements of the UV index made at the site are probably representative of the local conditions, but it should be demonstrated that reflection from a nearby building and satellite dish is unimportant.

-   The Brewer spectroradiometer is supplied with a comprehensive manual. The behaviour and output from the institute's parametric model are extensively documented within internal reports and various publications.

-   All procedures relating to data measurement and analysis are repeatable and reproducible.

-   The facilities and resources available are sufficient for the first of the site objectives to be fulfilled, although calibrated broadband measurements and extra person-power for data analysis would be an advantage. Before the second objective can be met, significant investment in calibration equipment will be needed.

-   A routine comparison between measurements and both forecasted UV index values and modelled erythemal dose rate give some confidence in the consistency of the measurements. An analysis of the relative uncertainty in the integrated measurements of spectral irradiance by the single Brewer would be advantageous. The importance of reflected light, cosine errors and the instrument's temperature dependence should be determined. Uncertainties should also be estimated for spectral irradiance values.

-   The measurement and collection of data are carried out in a well-practiced and systematic fashion. Some more work is needed to demonstrate beyond doubt that the agreement between measured and modelled values of the UV index is representative of the uncertainty in the absolute value of the measurements and not a fortuitous conformity. Some form of regular calibration is required in order to confirm that the instrument sensitivity is known correctly.

Graded results

	.1	.2	.3	.4	.5	.6	.7	.8	.9	.10	.11	.12	.13	.14
1		C	B											
2	B	C	B											
3	B	B	A	A		B	B							
4	B	C	C	C	C	B								
5									D				B	
6	B	B	B	C	B	B								
7	B	B	C	C	C	D	D		C					
8	B	B	C	B	B									

A	Exemplary
B	Satisfactory
C	Could be improved
D	Should be improved
	Not gradeable
	Not assessed

1. Resources and mission statement

1.1 The present site objectives are:

- To operate as a permanent measuring station for UV spectral irradiance, providing daily estimates of the UV index

- To develop the site to serve as a reference and calibration station for solar radiation measurements in the national Portuguese network.

1.2 IM operates one Brewer MKII spectroradiometer and two pyranometers (one measuring the diffuse and one the global component), which are situated at the local meteorological station (a distance of about 1 km). It would be advantageous to install an RBM or similar broadband meter alongside the spectroradiometer.

1.3 A full-time member or staff spends about 1 day a week on routine measurement and data analysis.

2. Location

2.1 Coordinates for longitude and latitude are taken from GPS readings.

2.2 No horizon map is available.

2.3 The site is representative of the local environment, surrounded by a mixture of urban and ocean surface.

3. Operational Matters

3.1 The Brewer spectroradiometer is supplied with a comprehensive manual. The behaviour and output from the institute's parametric model are extensively documented within internal reports and various publications

3.2 The equivalent of about 1 day a week is dedicated to routine instrument maintenance and data analysis

3.3 The primary staff member has been working in meteorology and UV measurement for nearly two decades

3.4 There are no staff changes

3.5 NA

3.6 The measurement schedule followed is the scan regime described within the Brewer manual

4. Instrumentation

4.1 The Brewer spectroradiometer is supplied with a comprehensive manual

4.2 The instruments available are sufficient to meet the main site objectives, although an additional RBM or similar would be highly beneficial, particularly considering the lack of calibration facilities on site.

4.3 The spectroradiometer could be better characterised. The slit function is not measured, but is taken from the Brew user's guide. The angular response of the instrument is not known. The wavelength-dependence of the wavelength error is not known. The importance of the stray light correction is not known. The temperature dependence of the instrument is not known (although the temperature is recorded, so a retrospective correction might be possible)

4.4 Facilities for the measurement of the angular response of the instrument are currently not available.

4.5 The slit function has not been measured. The Brewer manual suggests a value of 1 nm (FWHM).

4.6 The spectroradiometer has undergone periodic maintenance. (1990, 1996, 1999).

4.7 The local pyranometers are calibrated every 2 years.

5. Calibration

There are currently no calibration facilities at IM. The Brewer currently carries the reference of a travelling standard (Brewer #017, transferred in September 1999). It is important to make a more frequent calibration of the instrument. A mercury lamp is scanned before each spectral scan, which fixes the wavelength scale at 303 nm, but the wavelength dependence of any wavelength error is not known.

6. Measurement regime

6.1 The Brewer spectroradiometer is supplied with a comprehensive manual

6.2 The standard operating procedures ensure sufficient data are collected in a reliable and repeatable manner.

6.3 Global spectral irradiance data are recorded continuously every day from sunrise until sunset. These data are supplemented with pyranometer data from the nearby met site. Information on ozone column depth and aerosol optical depth is also available from direct-beam measurements

6.4 Spectral scans are made approximately once an hour, with 2 scans made in the hour about noon. The wavelength range is 280 to 550 nm with a step size of 0.5 nm. The primary role of the Brewer is measurements of the ozone column. This means that a compromise must be made between ozone observations and spectral scans of UV irradiance. Increasing the frequency of spectral scans would probably increase the accuracy of estimates of the daily UV index, but this is not possible at the moment. On the other hand, the UV index is most important on cloudless days, when it is not so important to make frequent measurements of the UV irradiance. In any case, the influence of low-frequency measurements on uncertainties in the UV index should be investigated.

6.5 Routine data backups and cleaning do not interrupt measurements.

6.6 All aspects of the routine measurement regime are demonstrably repeatable.

7. Data analysis

7.1 The behaviour and output from the institute's parametric model are extensively documented within internal reports and various publications

7.2 The routine data processing is applied automatically according to computer algorithms. The UV index is calculated and compared with the previous day's forecast. Spectral data are compared with a clear-sky model.

7.3 No analysis is made of cosine errors, the influence of the horizon and reflected light, wavelength error, stray-light or temperature dependence.

7.4 No corrections are made for cosine errors, the influence of the horizon and reflected light, wavelength error, stray-light or temperature dependence. Summer temperatures inside the spectroradiometer can exceed 50°.

7.5 No auxiliary data are used for monitoring the stability of the spectral data. As a minimum, the installation of an RBM alongside the spectroradiometer is recommended.

7.6 No estimate is made of the relative or absolute uncertainty in spectral measurements. Comparison with a clear-sky model show differences typically of about 10%.

7.7 No estimate is made of the relative or absolute uncertainty in integrated spectral measurements. As a minimum, it would be most advantageous to make some quantitative estimate of the uncertainties associated with calculations of the UV index. For example, it would be sensible to determine the importance of the instrument's angular response, the effects of reflected light, and the relatively low number of daily spectra. The typical difference between measurements of the UV index made using the IM Brewer and the previous day's 24-hour forecast is typically of the order or less than 1 unit, which gives some confidence in the consistency of the data.

7.8 At the time of the audit, no retrospective corrections were made.

7.9 Data are stored on pc, with a six-monthly backup to CDROM. More frequent backups are advisable.

8. Quality management

8.1 Standard data products, such as erythemal daily dose and UV index, and also comparisons of integrated spectral with broadband measurements are regularly plotted.

8.2 Data are compared daily with UV index forecasts and clear-sky models.

8.3 Regular application of a tool such as shicRIVM for checking the accuracy of the wavelength is recommended.

8.4 WMO recommendations on site quality control have been adopted.

8.5 The last intercomparison was the Iberian campaign of 1999. There are plans for another intercomparison in Spain in late 2002 (these are generally organised every 2 years).

8.6 There have been no retrospective corrections to the data, or changes in the data analysis.

IM comments