Site Audit at USTL, 27 – 28 November 2001

Formal Statement

This audit was the second 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 Laboratoire d'Optique Atmosphérique (LOA) at the University of Science and Technology in Lille, France, first developed a spectroradiometer in 1992 in collaboration with EUDIL (Ecole Universitaire d'Ingénieurs de Lille).

Following participation in an intercomparison of instruments during 1993 (Garmisch-Partenkirchen, Germany) a number of weaknesses in LOA spectroradiometer were identified. The instrument was then upgraded with the introduction of thermal regulation, a choice of slits, and a choice of the photo-multiplier) and well characterised (wavelength calibration, slit function, radiometric calibration, angular response of the diffuser). The new instrument performed very satisfactorily in the SUSPEN campaign in Greece, 1997.

In May 1996 a broadband UV-B instrument (YES) was purchased, which is used to perform consistency tests and ensure the quality of the spectral measurements.

Regular measurements of spectral irradiance began in May 1997, with some subsequent interruptions due to lack of man-power.

The UV group at USTL currently comprises Prof. Colette Brogniez, who oversees all operations, and M.Sc. student Mickaël Houët, who works full-time with the spectroradiometer and data analysis. Financial support is provided by the French Program of "Chimie Atmosphérique" and from the environmental ministry.

The site objectives are presently:

- To monitor (with the help of measurements and modelling studies) the impact of variations in atmospheric ozone on UVR at ground level
- To submit first-rate quality UVR data to the NDSC.

The technician responsible for the day-to-day maintenance and calibration of the spectroradiometer has more than 12 months experience and will probably leave the department in the next 18 months, following the completion of his degree.

The site is highly representative of the local environment, being surrounded by flat, urban terrain. The spectroradiometer is mounted on a rooftop platform with excellent visibility. Spectral measurements are made every 30 minutes through daylight hours.

The general day-to-day operation appears orderly and organised. All aspects of the normal calibration, measurement and data analysis procedures are carried out according to well-practiced routines. Data are stored both locally and on a centrally maintained server. The data files are held in a well-structured file system.

USTL makes good use of limited resources. Lamps and other optical equipment are shared with the UJF group in Briançon. Some technical problems have resulted in long breaks in this year's data series, but the instrument now appears to be working reliably. Calibration currently requires the manhandling of the instrument from the roof platform, down a narrow staircase to the darkroom, but a new lift should help make this operation smoother. The wavelength alignment of the spectroradiometer is a little unstable (changes of the order 0.1 nm are sometimes observed between spectra, due to temperature changes), but a routine wavelength correction is applied to all spectra.

The USTL data set would benefit from some additional analysis. In particular, the provision of a rigorous uncertainty budget would assist in assessing the absolute value of individual spectra, dose rates and daily doses, and any variation seen in these quantities. Confidence in the quality of the data set could be increased by the application of more orthodox practices in the use of calibration lamps. Ideally, the calibration procedures should involve three 1 kW lamps traceable to a national standards laboratory, with systematic procedures for checks and corrections for lamp drift. USTL plans to invest in a 1 kW lamp from NPL (calibrated against the primary radiation source!). (see USTL comment #6)

Figures

Figure 1. View from roof platform, with platform supporting spectroradiometer in background (looking North-West)

Summary

- The measuring site is highly representative of the local environment.

- The measurements made at the site are representative of the local conditions. Over the past year, there have been extended breaks in the data series for one or two weeks when the spectroradiometer was removed for maintenance.

- The standard calibration procedure is documented. Pre-printed sheets are used for the recording of routine calibration and operational parameters, and there is a clear flow-chart for the data analysis procedure.

- Procedures relating to data measurement and calibration are repeatable in principle, although changes to the instrumentation over the last 6 months make reproducibility difficult at the present time. Data collection and analysis procedures would benefit from more rigorous documentation.

- With planned improvements to instrumentation and calibration facilities completed, the facilities and resources available will be sufficient for the site objectives to be fulfilled.

- A basic estimate of measurement uncertainty has been made, but at present no thorough uncertainty budget has been prepared for measurements spectral irradiance or integrated irradiance. The uncertainty estimates would benefit from additional information on lamp drift and instrument drift between calibrations.

- The measurement and collection of data are carried out diligently and professionally. While the calibration procedure appears to be performed with care, it is clear that some improvements could be made in the area of lamp husbandry. A more rigorous determination of lamp drift should be made. This point is already being considered.

Graded results

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

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

1. Resources and mission statement

1.1. The site objectives are presently:
- To monitor (with the help of measurements and modelling studies) the impact of variations in atmospheric ozone on UVR at ground level
- To submit first-rate quality UVR data to the NDSC.

1.2. LOA maintains one spectroradiometer (double monochromator HD10 Jobin Yvon) and a broadband UVB instrument (YES). Measurements are also collected from an automatic sun photometer (AERONET).

1.3. Day-to-day measurement and analysis of UVR is dealt with by an M.Sc. student, who works full-time with instrument and data.

2. Location

2.1. The site coordinates are Lat. 50.65°, Long. 3.10°, Alt. 70 m.

2.2. There is no horizon ma

2.3. p, but the spectroradiometer sits atop a raised platform on the building roof. This ensures that the horizon is unobstructed, apart from just a few trees (at maybe 15 degrees) to the North.

2.4. The measuring site is highly representative of the local environment. Local surroundings are flat, with a mix of urban, woodland and agricultural cover at scales of 1 to 10 km and beyond.

3. Operational matters

3.1. The standard calibration procedures are documented. A full record of the daily operations (temperature reading, wavelength alignment, cleansing of domes, any problem) is kept in lab book and by completion of pre-printed forms, but there are no written protocols for normal site operation. The data analysis procedure is illustrated clearly by a flow chart, but detailed documentation on the methods applied at each stage of the analysis is not available. At present, standard procedures are carried out by one individual and are carefully followed, but for quality assurance and as a guarantee of future consistency, written protocols are recommended. (see USTL comment #1)

3.2. Sufficient manpower is available for the routine maintenance, calibration, data collection and data analysis tasks. A fixed-term full-time post is dedicated to these tasks.
3.3. Staff concerned with operation of instruments and data analysis have many years of experience.
3.4. Staff changes are infrequent. The last change occurred in 1999.
3.5. Not examined.
3.6. Several changes have been made recently, or are planned for the future, including the introduction of a new diffuser and cable, the purchase of new calibration lamps and changes to some of the data analysis software (wavelength shifts). These changes to the instrumentation and analysis have caused difficulty with ensuring the consistency of data over the past 6 months, but the outlook for the future is more positive.
3.7. The adoption of the WMO/GAW guidelines on site quality control is planned.

4. Instrumentation

4.1. User manuals are available for the JY HD10 and YES broadband meter
4.2. The spectroradiometer, sun photometer and broadband meter used for continuous monitoring are adequate for the fulfilment of the USTL objectives
4.3. The slit function and angular response have been measured in 1997 and another measurement of the slit function is planned at the end of 2001
4.4. Symmetric in 4 quadrants. Uncertainties in the measurement and specification of the angular response are not estimated.
4.5. The slit function has been measured at 336 nm using a UV laser (once in 1997, and one is planned end of 2001 with the new fibre in place). (see USTL comment #2)
4.6. There is no regular maintenance schedule, but repairs, servicing and calibration are made when required.
4.7. The broadband meter is calibrated every few years.

5. Calibrations

5.1. Standard, pre-printed forms are used to record basic details of each calibration. There is a written protocol for the standard calibration procedure.
5.2. At the time of the audit, the calibration procedures used were non-typical, in that some of the instrumentation (diffuser mounting) was under development. In the calibration observed, uncertainties were introduced into measurement of the lamp distance by the use of a flexible tape measure and the absence of a fixed mount for the diffuser. This procedure was used only for the period July 2001 to January 2002. Usually, the diffuser is well-mounted in front of the calibration lamp and could not move during the calibration. During 2001, a series of changes in the instrument configuration

(changing the gratings and the PMT, for example) prevented a reliable record of the instrument's long-term sensitivity to be constructed. A calibration is made every 8 to 10 weeks, or more frequently if something strange is observed (a large disagreement with the broadband measurement, for example). No check is made on the instrument's apparent sensitivity using a low-power lamp. While the optical bench was covered in black paper, the importance of stray light from a nearby white box was not assessed (see USTL comment #3). If possible, the lamp power should be moderated against the recorded voltage drop across shunt. (see USTL comment #4).

5.3. At the time of the audit, the multimeter and shunt certificates were expired. (see USTL comment #5). The lamps were within certificate limits.

5.4. NIST (optronic).

5.5. Each calibration is made against 2 Optronic lamps plus 1 NIST. Possible areas of improvement include introducing a method for better determination of potential lamp drift (see 5.8). Also, the Optronic lamps are shared with another lab, which requires regular transport by surface mail. This is a useful sharing of resources, but in an ideal situation the lamps would remain within a single laboratory or be transported by hand, so that the complete history of their experience is known. (see USTL comment #6).

5.6. The two Optronic lamps have c. 30 hours burn time. The NIST lamp is at about 17 hours;

5.7. The Optronic lamps agree to within 2%. The NIST lamp shows a relative discrepancy of more than 10%. Comparison with a JRC standard places doubt on the NIST lamp.

5.8. Procedures for the determination of lamp drift were not applied from July 2001 to December 2002 because of many changes that occurred. Before this period, the calibration curves as well as the sensitivity curves were compared with the previous ones for each lamp. Since January 2002 a similar analysis is also made.

5.9. Calibrations are made every 8 to 10 weeks, or more frequently if unusual behaviour is observed (disagreement with the broadband meter, for example).

5.10. At the time of the audit, typical instrument drift between calibrations was not measured because of recent changes in the spectroradiometer's optics.

5.11. The relative calibration appears reliable, but some unanswered questions at the time of the audit make it difficult to judge the absolute calibration of the spectroradiometer. For example: is there a significant effect of stray light? (see USTL comment #3). Is lamp drift important for the Optronic lamps? (see USTL comment #6). What is the instrument drift between calibrations? What is effect of step changes in PMT voltage?

5.12. The calibration is carried out according to well-practiced and pre-defined procedures.

5.13. A single check is made on the 440 nm line from fluorescent light before each calibration. A software routine is used to check the wavelength scale of each measured spectrum.

6. Measurement regime

6.1. A full record of the daily operation is kept in lab books and by the completion of pre-printed forms, but quality assurance would benefit from more detailed written procedures describing the daily operation of the instrument

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

6.3. Global spectral irradiance data are recorded continuously every day from before sunrise until after sunset. These data are supplemented with 3-minute averages from a YES broadband metre (3 sza-dependent coefficients applied).

6.4. Global spectral irradiance is recorded from 275 to 450 nm in steps of 0.5 nm (FWHM ~0.6 nm). To optimise instrument sensitivity, PMT input voltage is changed twice, and scan re-started. This results in time gaps of about 30 seconds and 50 seconds at 300 nm and 310 nm, respectively. A full scan requires about 9 minutes, so it would be possible to increase the measurement frequency from 2 to 4 or 5 scans/hour. (see USTL comment #7).

6.5. Over the past year, adaptations to the spectroradiometer have caused some data loss.

6.6. The routine measurement regime was demonstrably repeatable.

7. Data Analysis

7.1. A clear flow chart shows the application of the standard calibration and data correction routines, but there is no documentation describing in detail the nature of the corrections made.

7.2. The standard data calibration and correction of raw data is made using home-grown programs, including correction for cosine errors and wavelength shifts. There is flagging for wavelength error, variations in cloudiness, spikes and deviations from broadband measurements. Any adaptations to the standard data analysis are applied retrospectively to the entire data set.

7.3. Cosine correction assumes isotropy in global radiance. The horizon is almost unobstructed, so no estimate of the influence of the local horizon on measurements is required. The wavelength correction shows sometimes strong diurnal change (e.g., 0.1 nm in 1 hour due to temperature changes). Stray-light is estimated at 25% of the dark current.

7.4. The cosine correction assumes isotropic distribution of sky radiance. No account is currently taken of the direct beam (there are plans to change this). The typical correction is 3 to 4% (the diffusers have good cosine response). Wavelengths are shifted to a uniform grid, using an extraterrestrial spectrum (atlas 3). There is no systematic correction for lamp-drift errors. Future plans include the ~~measurement~~ thorough consideration of lamp-drift. Dark current (& stray light) are measured at beginning of each spectrum and subtracted.

7.5. Broadband measurement used as gross check on spectroradiometer stability (flagging at 8% and 15%).

7.6. Estimates are made of lower-limit on uncertainty for typical wavelength in typical spectrum (+/- 5 to 6%). At the time of the audit, no detailed uncertainty analysis was available for the measurements of spectral UV irradiance or daily doses. Plans are afoot to estimate the uncertainty according to the procedure described in the WMO/GAW guidelines for site quality control or to prepare a more detailed uncertainty budget along the lines of that described in Bernhard and Seckmeyer (1999).

7.7. Any changes to the irradiance scale or to data processing routines are applied retrospectively to the entire data set. It would be beneficial if the data version number, date of creation and details of all changes made to the dataset were all included in the data header.

7.8. Previous versions of data are deleted, but previous processing programs are retained, and these can be used to re-create intermediate data versions.

7.9. Data are stored on a central server, with full automatic backup. The directory structure is clear and unambiguous. All spectral and broadband data are available on-line.

8. Quality management

8.1. There is documentation giving an overview of flagging algorithm (philosophy, methodology, examples).

8.2. The standard procedures include flagging for wavelength errors, variations in cloudiness, spikes and deviations from broadband measurements. There are presently no investigation for any trends or correlations in these flags. Flags for each day are examined by eye.

8.3. Available QC tools include the home-written flagging routine and wavelength correction algorithm.

8.4. The WMO/GAW guidelines on site quality control of UV monitoring are not yet applied. Plans are afoot to estimate the uncertainty according to the procedure described in these guidelines.

8.5. Comparison of the 2 Optronic and 1 NIST lamp have been made with the JRC travelling standard. The spectroradiometer participated in international intercomparisons in Germany (1993) and Greece (SUSPEN, 1997)

8.6. Any changes to the irradiance scale or any of the standard data-processing routines are applied retrospectively to the entire data set. The data version number is not included in the header information of each data file. Earlier versions of the data correction routines are kept, so that old versions of data may be recreated if necessary.

8.7. None.

USTL comments

#1- The full documentation is planned to be included in the student-PhD's report.

#2- The slit function measured in January 2002 is 0.7 nm.

#3- Since October 2002 the stray light is measured and substracted.

#4- Since January 2002 the lamp power is moderated against the recorded voltage drop across shunt.

#5- The multimeter has been calibrated in December 2001, the shunt in January 2002.

#6- A lamp from NPL has been purchased in March 2002, and is kept carefully in lab to avoid transportation and allow a better monitoring of the other lamps.

#7- Since January 2002 the scan is from 280 to 450 nm and the PMT input voltage is change only once (at 320 nm) during a record and the scan restarted, resulting in a gap of 33 seconds at 320.5 nm, a full scan requires now about 6 mn. 2 additional scans/hour are planned for diffuse irradiance measurements with a shadow disc.