Report on the 1st EUFAR Radiation EWG meeting: spectrometer intercomparison and calibration workshop

Location: Cranfield and Cardington, Bedfordshire, United Kingdom, 11th-15th September 2006

The workshop was aimed at groups operating visible and infra-red Spectrometers on airborne platforms, and had 3 main aims:

- Share expertise among the groups.
- Exposure of spectrometers to different calibration standards.
- Direct instrument intercomparison in a field trial.

1. Participants

	Participant	Institute	Website and Email address
1	**Martin Glew**	UK Met Office (Exeter)	www.metoffice.gov.uk martin.glew@metoffice.gov.uk
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3	**Thomas Ruhtz**	Free University of Berlin	www.fu-berlin.de/iss ruhtz@zedat.fu-berlin.de
4	**Paul Zeiger**	Free University of Berlin	www.fu-berlin.de/iss paul.zieger@wew.fu-berlin.de
5	**Heike Eichler**	Institute for Tropospheric Research (Leipzig)	http://www.tropos.de eichler@tropos.de
6	Chris MacLellan	**NERC Field Spectroscopy Facility (Edinburgh)**	http://fsf.nerc.ac.uk/ chris.maclellan@ed.ac.uk

2. Spectrometers and Optics

Met Office

1. Radiance optic (SWS)
2. Irradiance optics (SHIMS)
3. 6 MMS Zeiss spectrometer modules. 3 modules sensitive in the wavelength range 300 nm – 950 nm, 3 in the wavelength range 950 nm – 1700 nm. The spectrometers can be connected to the optics in various combinations by fibre optic cables.

Free University of Berlin

1. Radiance optic attached to 2 Zeiss MMS spectrometers (FUBISS)

2. Downward and upward facing irradiance optics attached to Zeiss MMS-UV spectrometers (FUBIS – UV)
3. Direct and aureole sun photometers attached to Zeiss MMS1 spectrometers (FUBISS-ASA2

Institute for Tropospheric Research

1. Radiance optic
2. Irradiance optic
3. 2 Zeiss MMS spectrometers.

3. Calibration sources

Met Office

1. 20 inch Labsphere integrating sphere
2. 100 W bulb calibrated for irradiance

Free University of Berlin

1. 100 W bulb calibrated for irradiance

NERC Field Spectroscopy Facility

1. 12 inch Labsphere integrating sphere
2. Small Hoffman integrating sphere
3. 100 W bulb calibrated for irradiance.

4. Supporting meteorological measurements

Met Office

1. 1.2m temperature (deg C)
2. Grass IR temperature (deg C)
3. 1cm soil temperature (deg C)
4. Dew point (deg C)
5. Pressure (hPa) at ~30m a.m.s.l.
6. 50m wind speed (knots) and direction (deg)
7. 25m wind speed (knots) and direction (deg)
8. 10m wind speed (knots) and direction (deg)
9. Visibility (km)
10. Nephelometer scattering coefficient (/km)
11. Rainfall (mm)
12. Down-welling SW irradiance, global and diffuse (W/m2)
13. Down-welling LW irradiance (W/m2)
14. Radiometrics WVR-1100 Dual-frequency (23.8GHz and 31.4GHz) total power radiometer
15. Radiosonde data

These are routine measurements provided at the Cardington facility

Free University of Berlin

1. GPS system

Institute for Tropospheric Research

1. Pyrgeometer

5. Diary of Workshop

Monday 11th September 2006

Cranfield

- The participants helped set up the darkroom at Cranfield in preparation for calibration activities

Cardington

- The groups set up their field equipment. As the weather was not suitable for an intercomparison this was an occasion to check instrument operation. All groups got their field equipment working though the Met Office had significant troubles communicating with their computers.

Tuesday 12th September 2006

The groups worked at Cranfield using the NERC's small integrating sphere (Hoffmann LS658D SN/C031) for calibrations, and the following activities completed:

1. The Institute for Tropospheric Research exposed their radiance entrance optics at two different light levels
2. The Free University of Berlin exposed their sun photometer and Aureole sun photometer at two different light levels.

There was time for the groups to view the FAAM BAE-146 research aircraft and receive a short introduction to the installed instrumentation.

Wednesday 13th September 2006

The groups spent the day at Cranfield on the following activities:

1 In the morning the groups gave detailed presentations on their instruments and there was a general discussion about differences, problems and calibration issues.
2. In the afternoon: calibrations were taken from the Met Office 20 inch Labsphere radiance standard for the following instruments:
   - The Institute for Tropospheric Research's radiance optic.
   - The Free University of Berlin's radiance optics, sun photometer and Aureole sun photometer.
   - The Met Office's radiance optics (SWS).

There was a slight accident in the darkroom which fractured one of the Met Office optical fibres.

Thursday 14th September 2006

Further radiance and irradiance calibrations were carried out in the darkroom at Cranfield:

1. Using the 20" Labsphere source with 4,3,2 and1 lamps on – measurements were made with the following instruments:
   - Met Office radiance entrance optics.
   - IfT radiance entrance optics
   - FUB radiance entrance optics, sun photometer
2. Using the 12" Labsphere source(USS1200), the following instruments took measurements:

- Met Office radiance entrance optics
- IfT radiance entrance optics
- FUB radiance entrance optics, sun photometer

3. Using the 6“ LS-65-8D Hoffmann Electronics integrating sphere, the following instruments took measurements:
   - IfT radiance entrance optics
   - FUB radiance entrance optics, sun photometer
4. Using the NERC FEL803 irradiance calibration bulb, the following measurements were made:
   - IfT optics at calibration distances of 1m, 0.7m and 0.4 m
   - Met Office optics at calibration distances of 1m, 0.7m and 0.5m
5. Using the FUB BN-9101-322 irradiance calibration bulb, the following measurement was made:
   - Met Office’s irradiance optics (SHIMS) at 981+2 mm, 781+2mm, 581+2mm

Friday 15th September 2006

The weather finally allowed the field trial at Cardington to go ahead. It was partly cloudy with shallow cumulus, starting at 4/8 cover and decreasing to 1/8 cover. The following measurements were made:

- Met Office: Irradiance, zenith radiance VIS & NIR
- Institute for Tropospheric Research: , Irradiance, zenith radiance VIS & NIR, Pyrgeometer
- Free University of Berlin;: zenith radiance, UV irradiance, aureole Sunphotometer

6. Assessment of workshop

1. Advice to users:

- The intercomparison was open to all types of spectrometer, but only groups using Zeiss monolithic type spectrometers participated. Although very useful to the participants in allowing direct comparison of performance, operating systems, and optics, it would have been of greater benefit if other types of spectrometer had been compared.
- The Zeiss spectrometers are generally reliable and are very robust (because of the monolithic structure) which makes them extremely suitable for aircraft operations. However we were not able to make comparisons with other types of spectrometer, and would therefore welcome input from any users of other types.
- The Met Office was going through an upgrade to the in-house developed operating system for the spectrometers and therefore had some communications difficulties (which have since been resolved). Zeiss’ own ‘Aspect’ software although very robust was only capable of operating 2 spectrometers at once, which is why the Met Office and other participants chose to develop their own.
- The Met Office have used Labview to develop their own software, and believe it to be an excellent vehicle for instrument control and display software.
- It has been suggested that prior to any future such workshops, the participants should agree on units and on data formats to allow immediate comparison during the workshop.
- The participants agreed that the opportunity to meet with other users of similar spectrometer systems, and discuss aspects of design, calibration and operation, was extremely valuable to all concerned.
- A follow up meeting to discuss the data and calibrations should be organised as soon as all participants have fully processed their data.

2. Advice to aircraft/instrument operators:

- The existing technology allows measurements of spectrally resolved radiances and irradiances to a high spectral resolution (typically 3nm or better depending on the spectrometer used), and development of this instrument capability should be encouraged as it offers significant advantages in the study of aerosol and cloud microphysics.
- Large high quality laboratory integrating spheres are essential in determining the absolute calibration of these types of instruments
- The process of connecting and dis-connecting optical fibres can have a significant impact on the transmission of the fibres and hence the absolute calibration of the instruments so where possible instruments should be designed such that they can be removed from the aircraft intact.
- Due to the potential for degradation of the optics in flight, and for ease of instrument monitoring, compact transfer calibration standards should be developed that allow a direct mapping of the laboratory calibrations to the airborne installation on a day-by-day basis.

3. Advice to funding agencies:

- Calibration exercises like this are valuable for the following reasons:
  - Exchange of best practise between all parties
  - Intercomparison of evolving technologies
  - Confidence in calibration of instruments across the European fleet allowing direct comparison of results from one aircraft with another
  - Development of experts in this area and useful training for PhD students.

- For these reasons calibration exercises like these should be undertaken every 3 to 5 years and similar exercises for other radiometers should be considered.

- Because of the vagaries of the weather, it was not possible in the time allowed to have a full external field trial of the participating instruments, and therefore it would be useful in future to have funding to allow field trials to be conducted over a longer period than one week.

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