

Proceedings of the UK Controlled Environment Users' Group

2004 SCIENTIFIC MEETING

“UNDERSTANDING AND MEASURING LIGHT IN CONTROLLED ENVIRONMENTS”

A WORKSHOP

Volume 15

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UK CONTROLLED ENVIRONMENT USERS' GROUP**2004 WORKSHOP****UNDERSTANDING AND MEASURING LIGHT IN CONTROLLED ENVIRONMENTS****SYNOPSIS OF PROGRAMME**

The three elements of the programme were:

1. A number of Lectures on light (not necessarily one per bullet point) covering:

- Light - terminology, units and measuring instruments for energy and photons
- Light - spectral distribution in relation to plants, visible spectrum, red/far red ratio and their measurement
- Light - spectral distribution in relation to sources, natural and artificial and its measurement (manufacturer)
- Light - spatial distribution in relation to sources and sinks, leaf area index in canopies, distribution in glasshouses and controlled environment rooms and its measurement
- Light - sources for various purposes: discharge, incandescent, LED
- Light - UV: sensors, sources and safety
- Light - calibration of measuring instruments
- Light - what should a CE manager record for monitoring purposes?
- Light - what should a CE manager or user record for future publication by users?
- Light - what are the guidelines for reporting measurements of light?
- Light - in relation to animals
- Light - the future?

2. Demonstrations of light sources and measuring equipment by manufacturers and/or distributors and agents.**3. Hands-on instrument sessions** for delegates under various light sources and in various environments (e.g. cabinets and glasshouses) using their own instruments and demonstration instruments supplied by manufacturers:

- Full spectrum, PAR and UV light sensors - energy and quanta
- Spectrometers for spectral distribution of light
- Spectral ratio measurements
- Spatial distribution in CE spaces or canopies - hemispherical photography, line sensors
- Calibration of sensors (using the North American Committee on Controlled Environment Technology and Use - NCR-101's Instrument Package)

LECTURERS

There were five sessions of lectures. The lecturers were

- a) Prof. Garry Whitelam, University of Leicester
- b) Dr Lynton Incoll, University of Leeds

- c) Mr Sander Pot, Philips Lighting, Eindhoven
- d) Dr Bruce Bugbee, Utah State University, Logan
- e) Dr Nigel Paul, University of Lancaster
- f) Dr Peter O'Brien, Applied Optotech, Cork
- g) Mr John Wood, Peak Design and Development, Winstar
- h) Mrs Laura Crane, National Physical Laboratory, Teddington
- i) Dr John Jarvis, Silsoe Research Institute, Silsoe

PRACTICAL EXERCISES

There were five practical exercises involving manufacturers, lecturers and participants four of which ran concurrently in 2-hour practical sessions.

1. Measuring instruments - sensors of photons and energy

Using a) a range of sensors - quantum sensors, spherical (omnidirectional) sensors, solarimeters, pyranometers, etc.,
and b) various sources of light - natural and artificial: incandescent, discharge, fluorescent, LED, red/far red, UV, etc.,
do exercises on: c) beneath lighting rigs and in CE spaces - cabinets, rooms and glasshouses,
1. Measuring light and energy;
2. Comparing different types and makes of sensors.

2. Spectral distribution of sources and in relation to sinks (plant canopies)

Using a) a range of sources - incandescent, discharge, fluorescent, LED, red/far red,
and b) digital spectroradiometers,
do exercises on: c) beneath lighting rigs and in CE spaces - cabinets and glasshouses,
d) with and without plants,
1. Measuring spectral distribution;
2. Measuring spectral ratios;
3. Integrating light over specified wavebands.

3. Spatial distribution beneath sources and in relation to sinks (plant canopies)

Using a) a quantum sensor,
or b) hemispherical cameras and linear sensors
do exercises on: 1. Describing spatial distribution inside a CE space, vertically and horizontally;
2. Describing the quantity and distribution light penetrating a plant canopy.

4. Calibration of quantum sensors

Using a) the NCR-101 instrument package,
and b) a light source,
calibrate your own quantum sensor.

5. Synthesis of results

There was an evening sessions for analysis and synthesis of results and one concluding session for participants to report to the workshop on the results of the practical sessions.

MANUFACTURERS' TRADE DISPLAYS AND DEMONSTRATORS IN PRACTICAL SESSIONS

The companies exhibiting and their representatives are listed below. Their presence on this list does not imply endorsement of their products by the UK CEUG or the University of Leicester.

	Company	Products	Field of expertise	Name of representative
1	Apogee Instruments	Sensors	Measurement	Bruce Bugbee
2	Delta-T Devices	Sensors and hemispherical lens cameras etc	Measurement	John Wood Derek Fogg
3	LI-COR	Sensors	Measurement	Jon Welles Gerard Freeman
4	Ocean Optics	Spectroradiometers	Spectral distribution	Nick Barnett
5	Philips Lighting	Lamps (incandescent and discharge)	Sources	Brian Healy Sander Pot
6	Skye Instruments	Sensors	Measurement	Belinda Trotter Joanna Stacey
7	Astranet Systems	Spectroradiometers	Spectral distribution	Mike Mills
8	Applied Optotech	LED lamps	Sources	Kieran Cavanagh Peter O'Brien
9	Kipp & Zonen	Solarimeters	Measurement	Martin Veenstra
10	NCR-101 Instrument package	<i>Sensors:</i> Kipp & Zonen CNR-1 short-wave/long wave 4-way radiometer; two Skye Dual 660/730 radiation sensors; three LICOR quantum sensors, Apogee hand-held total UV meter, StellarNet spectroradiometer <i>Data logger:</i> Apogee	Calibration package	Bruce Bugbee

Note: NCR-101 = NCR-101 Committee on Controlled Environment Technology and Use (sponsored by the USDA)

We are grateful to Macam Instruments, who could not attend, but loaned light sensors for the practical sessions.

DETAILED TIMETABLE FOR WORKSHOP PROGRAMME

SUNDAY 12 SEPTEMBER 2004: EVENING	
17.00 -19.00	Registration at Beaumont Hall, the University of Leicester
17.30 -19.00	<i>Buffet Supper at Beaumont Hall</i>
20.00	Welcome Reception at Beaumont Hall Exhibition by manufacturers and Bar
MONDAY 13 SEPTEMBER 2004: MORNING	
08.00 - 08.45	<i>Breakfast</i>
<u>SESSION 1</u>	<u>INTRODUCTION</u>
08.45 - 09.00	Introduction to the Workshop
09.00 -10.00	L.D. Incoll (School of Biology, University of Leeds, Leeds, UK) <i>Measurement of light: Terminology, units, recording and reporting</i>
10.00 -10.30	Organisation and preparation for practical sessions
10.30 -11.00	<i>Morning Coffee</i>
<u>SESSION 2</u>	<u>DEMONSTRATIONS AND HANDS-ON PRACTICAL SESSION 1</u>
	For participants, under various light sources and in various environments (e.g. cabinets and glasshouses) using their own instruments and demonstration instruments supplied by manufacturers: <ul style="list-style-type: none"> • Full spectrum, PAR and UV light sensors - energy and quanta • Spectrometers for spectral distribution of light • Spectral ratio measurements • Spatial distribution in CE spaces or canopies - hemispherical photography, line sensors • Calibration of sensors (using the North American Committee on Controlled Environment Technology and Use - NCR-101's Instrument Package)
11.00 -13.00	Demonstrations and Hands-0n Practical Session 1
13.00 -14.00	<i>Lunch</i>

MONDAY 13 SEPTEMBER 2004: AFTERNOON and EVENING	
<u>SESSION 3</u>	<u>SPECTRAL DISTRIBUTION</u>
14.00 -14.45	G. Whitelam (Department of Biology, University of Leicester, Leicester, UK) <i>Spectral distribution - sinks</i>
14.45 -15.30	S. Pot (Philips Lighting, Eindhoven, Netherlands) <i>The application and properties of artificial light sources for plant growth and research</i>
15.30 -16.00	<i>Afternoon Tea</i>
<u>SESSION 4</u>	<u>DEMONSTRATIONS AND HANDS-ON PRACTICAL SESSION 2</u>
16.00 -18.00	Demonstrations and Hands-on Practical Session 2
18.30	<i>Dinner</i>
20.00	Annual General Meeting of the UK CEUG and Bar
21.00	Synthesis of results of the hands-on sessions

TUESDAY 14 SEPTEMBER 2004: MORNING	
08.00 - 08.45	<i>Breakfast</i>
<u>SESSION 5</u>	<u>SPATIAL DISTRIBUTION; UV AND LEDs</u>
08.45 - 09.30	J Wood (Peak Design and Development, Winster, UK) <i>Spatial distribution of light - distribution within canopies, leaf area index in canopies, their measurement</i>
09.30 -10.00	N. Paul (Lancaster Environment Centre, University of Lancaster, Lancaster, UK) <i>UV – sources, sensors and safety</i>
10.00 -10.30	P. O'Brien (Applied Optotech, Cork, Ireland) <i>LED illumination</i>
10.30 -11.00	<i>Morning Coffee</i>
<u>SESSION 6</u>	<u>DEMONSTRATIONS AND HANDS-ON PRACTICAL SESSION 3</u>
11.00 -13.00	Demonstrations and Hands-on Practical Session 3
13.00 -14.00	<i>Lunch</i>

TUESDAY 14 SEPTEMBER 2004: AFTERNOON and EVENING	
<u>SESSION 7</u>	<u>CALIBRATION OF SENSORS; LIGHT AND ANIMALS</u>
14.00 -14.45	L. Crane (National Physical Laboratory, Teddington, UK) <i>Calibration of light measuring instruments</i>
14.45 -15.15	J. Jarvis (Silsoe Research Institute, Silsoe, UK) <i>Visual perception in animals</i>
15.15 -15.45	<i>Afternoon Tea</i>
<u>SESSION 8</u>	<u>DEMONSTRATIONS AND HANDS-ON PRACTICAL SESSION 4</u>
16.00 - 18.00	Demonstrations and Hands-on Practical Session 4
18.30	<i>Pre-dinner drinks</i>
19.00	<i>Conference dinner</i>
21.00	Discussion sessions: Synthesis of hands-on and Bar

<i>WEDNESDAY 15 SEPTEMBER 2004: MORNING</i>	
8.00 – 9.00	<i>Breakfast</i>
<u>SESSION 9</u>	<u>SYNTHESIS - GROUPS TO REPORT</u>
09.00 -10.45	Synthesis - Groups to report
10.45 -11.15	<i>Morning Coffee</i>
<u>SESSION 10</u>	<u>CONCLUDING ADDRESS: THE FUTURE?</u>
11.15 -12.15	B. Bugbee (Utah State University, Logan, Utah, USA) <i>New techniques, new instruments and new approaches</i>
12.30 -14.00	<i>Lunch before departure</i>