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Skye eGuide No. 5

Broadband Radiometers V. Spectroradiometers

Contents

1. Introduction

The series of Skye eGuides have been written to help researchers choose which of the Skye Instruments range of sensors and systems could add valuable data and information to their monitoring projects, and also how to get the best results from the instruments.

This eGuide describes the difference between Broadband Radiometers and Spectroradiometers, and how each has their strengths in different applications, and also how they can be used together to expand the range of data collected.

Both types of sensors measure Light and Radiation in specific wavelength ranges and resolutions, this is explained in the following Chapters. The information gained from measuring light and radiation wavelength by wavelength in the field is described in detail in the Skye eGuide No.2 on Spectral Reflectance.

The Skye Instruments Broadband Radiometer Sensor and Systems are also described here, with their many applications.

2. Broadband Radiometers

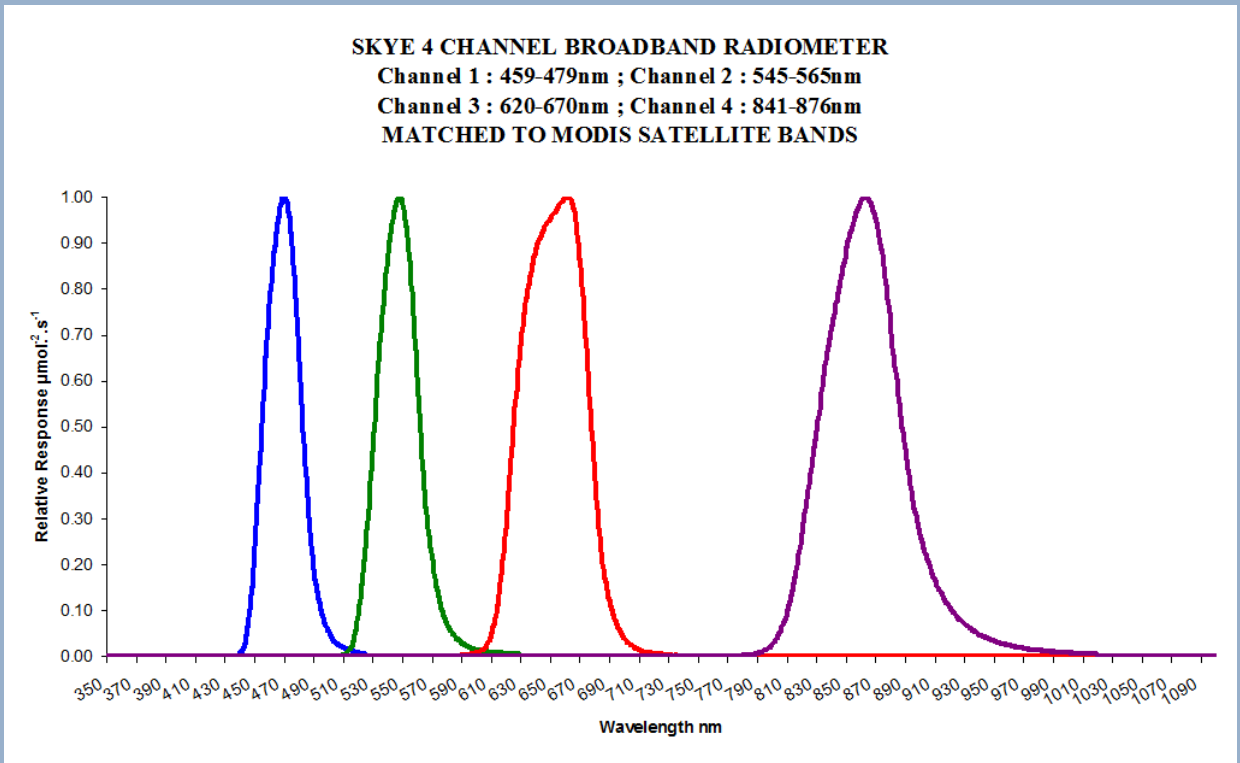
Broadband radiometers or sensors are so called because the band of wavelengths they are sensitive to are relatively broad when compared to Hyperspectral sensors.

The width of the wavelength response curve of a radiometer is often called a waveband. A waveband greater than 5nm is usually classed as Broadband, while if it is less than 5nm it is usually classed as Hyperspectral.

Broadband radiometers generally have fixed wavebands from 5nm up to several hundred nanometers and the wavelengths and bandwidth is chosen at the point of ordering. They are then built and calibrated with that specific waveband which usually cannot be changed after manufacture. Often several broadband sensors are deployed simultaneously to cover a wider spectrum of light and radiation measurements. Each broadband sensor can also be multichannel, housing up to 4 wavebands within a single radiometer. The cost of these sensors is relatively low and so a system containing a number of broadband sensors is not prohibitive.

These sensors can be configured with a cosine correcting diffuser for mounting upwards to measure the irradiance within their waveband, and also with a narrow angle field of view for mounting downwards to measure reflected radiation. A pair of sensors with identical wavebands can be used to measure incident and reflected light radiation simultaneously and together they will measure reflectance changes throughout the days, weeks and seasons as the vegetation beneath grows and develops. This arrangement is regularly used for climate change applications.

As the sensor's wavebands have been fixed at the time of manufacture, it is then fully calibrated for use in the field without any need of further in situ calibration.



This type of sensor can be easily used to take spot measurements over an area in a field study using a hand held meter and GPS mapping system. However the main advantage is long term datalogging on a meteorological station, a climate change study mast or an Eddy Covariance Flux tower.

Another important advantage of broadband sensors is their small size and light weight, making them ideal for attaching to Unmanned Aerial Vehicles (UAVs), to add measurements taken over a larger area to a combined field study campaign.

Circled above is the Skye sensor fitted to the small aircraft, while below is a photo taken from the aircraft in flight, showing its surroundings.

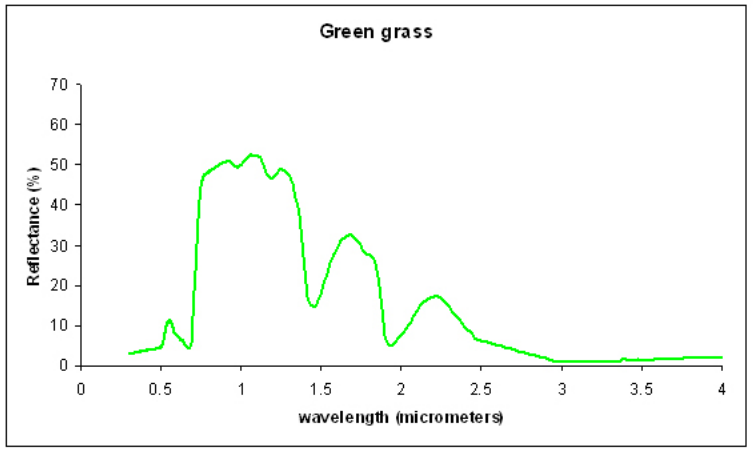
3. Spectroradiometers

Spectroradiometers are usually classed as Hyperspectral as their measurement bandwidth can be between 1-4nm.

These instruments have a very broad range, and they scan through that range taking a measurement at each hyperspectral waveband. For example a spectroradiometer with a range of 400-1100nm may take a measurement every 4nm, or a higher resolution instrument may have a range of 400-2400nm and take a measurement every 1nm.

Spectroradiometers generate a large amount of measurement data, which is very useful during initial studies of a new ecosystem. However, once the particular wavebands of interest have been identified for that ecosystem, much of the data recorded is often unused, except for the chosen wavebands.

For example one measurement "run" will give a graph similar to the one shown below. It may be decided that only the variation in the Visible Red wavelengths and Near Infra Red wavelengths may be of interest to a particular project studying vegetation



Most spectroradiometers are hand-held instruments, consisting of a single sensor attached to the wavelength scanning equipment, and often connected to a laptop. For the measurement of reflectance, first a wavelength scan of the irradiance is taken while pointing the sensor skywards, then a second scan is taken while pointing the sensor downwards. This double scan operation is limited to clear, cloudless days around midday, when the sun is directly overhead and the light intensity is unchanging, to ensure an accurate percentage of incident to reflected light to be calculated.

Before a series of reflectance measurements can take place, the system has to be calibrated in situ by taking a measurement of reflected wavelengths over a high reflectance tile, e.g. Spectralon.

Using a spectroradiometer for long term datalogging is possible but is problematical. Data storage is extremely high, and ideally two instruments should be recording incident and reflected wavelengths simultaneously and in synchronisation, to minimise errors introduced by changing light intensity levels throughout the day. Also as they are normally used as hand-held systems, they require additional waterproof enclosures and a larger power supply for permanent mounting outdoors.

The cost of spectroradiometers varies widely, from the low resolution versions with the larger wavebands of 3-4nm, to the much more expensive versions with wider ranges and 1-2nm wavebands.

4. Broadband Radiometers V. Spectroradiometers

The main differences, advantages and disadvantages between Broadband Radiometers and Spectroradiometers is easily seen in the following table:

Feature	Broadband Radiometer	Spectroradiometer
Cost	Low cost	High cost
Accuracy	Accurate with traceable calibration	Accurate with traceable calibration
Calibration	Fully calibrated at manufacture	Requires regular field calibration
Resolution Range	Low wavelength resolution Fixed wavelength range (up to 4 fixed wavebands per sensor) Chosen by customer	High wavelength resolution Scanning wavelength range
Bandwidth	From 5nm upwards, fixed at time of ordering	Usually 1nm or less, usually fixed
Laboratory use	Ideal for monitoring lamp intensity and ageing	Ideal for measuring spectral output of lamps
Field use	Hand held or permanent operation	Best for hand held operation
Datalogging	Fully waterproof and ideal for long term datalogging	Usually non waterproof and unsuitable for long term datalogging
Data Storage	One data point of intensity per waveband	Large data storage of full wavelength range scan
Light source	Ideal for all light sources	Ideal for all light sources
Lighting Conditions	Ideal for all light conditions, constant and rapidly changing as whole waveband is constantly monitored	Best used in constant light conditions as wavelengths are scanned individually over time

Many research groups have a selection of instruments which contains both broadband radiometers and spectroradiometers. Each have their own speciality of data collection, and together they can be utilised in a variety of ways to contribute to the overall monitoring of the ecosystem under study.

4. Skye Instruments Broadband Radiometers and Systems

Skye Instruments have been specialising in Light and Radiation sensors since 1983. All are designed, manufactured and calibrated to the highest standards. Each is supplied with an individual Calibration Certificate traceable to the UK's National Physical Laboratory (NPL).

Broadband Radiometers and sensors are available with Calibrated wavelength responses from 280nm (UV), through VIS, NIR to 2400nm (SWIR). There are thirteen popular models of fixed wavelengths, plus custom models where the wavebands are built and calibrated to the user's individual requirements.

There are choices of sensor designs for the measurement of Irradiance / Incident light measurements, and also Radiance / Reflected light measurements, a matched pair of Irradiance & Reflected sensors are known as a Spectral Albedometer.

All Skye Light and Radiation sensors can be supplied as complete systems, with hand-held SpectroSense2+ logging meters and GPS mapping, or with DataHog2 dataloggers for automatic recording. The sensors are also compatible with dataloggers from other manufacturers.

Broadband Radiometers
Skye have a full range of radiometers to suit a wide array of applications, such as plant studies, environmental research, satellite ground truthing, human and animal applications, fish farming, pharmaceutical ageing tests etc.

The full range can be viewed here:
Light Measurement Overview

Broadband Radiometers are available in 1, 2, 3 or 4 channel versions, which consists of 1, 2, 3 or 4 individually calibrated wavebands within a singe sensor. The user can choose to order one or more wavebands from the standard range, or a combination of standard and or user-defined wavebands with central wavelengths between 280-2400nm, and bandwidths from 5nm to several hundred nm.

Information on these sensors and radiometers can be found here:
Custom Single Channel Light Sensor
2 & 4 Channel Light Sensors
Custom 2 Channel Sensor
Red Far Red Sensor
Spectral Albedometers

SpectroSense2 Display Meter

This Skye meter is a 4 channel display meter. It has a 4 line display for easy viewing of data from 4 different wavebands or from a pair of 2 channel sensors. It can display the individual light intensity of each waveband or the ratio of any combination of waveband pairs in simple to use menu options. It is supplied with a carry case to store the meter plus its sensors.

Information on these meters can be found here:
SpectroSense2 Display Meter

SpectroSense2+ Logging Meter

This Spectroense2+ meter version has both 4 and 8 channel options and includes automatic datalogging and GPS mapping functions. The 4 line display (with hold button and scrolling for 8 channels) also displays the individual light intensity of each waveband or the ratio of any combination of waveband pairs in simple to use menu options. It is supplied with a carry case to store the meter plus its sensors.

Information on these meters can be found here:
SpectroSense2+ Logging Meter

DataHog2 Datalogger

The Skye DataHog is a 16 channel datalogger designed specifically for light and radiation sensors. It is robust and waterproof, and can be linked to a GPRS remote communications module for automatic upload to a web site.

Up to 16 wavebands of light measurements can be recorded simultaneously, or other sensors can be combined to create an Automatic Weather Station.

Information on these dataloggers and systems can be found here:
DataHog2 datalogger
MiniMet Automatic Weather Station

Published Scientific References

Skye's sensors and systems have been used worldwide in Plant Research for many years. The research they have contributed to has been published extensively, in a variety of different scientific journals.

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