APPLICATION NOTES

SENSORS FOR PRI CALCULATIONS

From Wikipedia, the free encyclopedia:

"The Photochemical reflectance index or PRI is a reflectance measurement that is sensitive to changes in carotenoid pigments (e.g. xanthophyll pigments) in live foliage. Carotenoid pigments are indicative of photosynthetic light use efficiency, or the rate of carbon dioxide uptake by foliage per unit energy absorbed. As such, it is used in studies of vegetation productivity and stress. Applications include vegetation health in evergreen shrublands, forests, and agricultural crops prior to senescence."

Skye Instruments 2 radiometer light sensors are ideal for taking measurements in the 531 nm and 570 nm wavelengths, which are commonly used to calculate PRI. The SKR 1800 2-channel light sensors are in effect 'two sensors-in-one'. They will monitor light from both wavebands at a single point.

The exact wavelength and width of the band in each sensor channel can be chosen individually by the user between 280 nm (UV - Ultra Violet) and 1100 nm (NIR - Near Infra-Red). Each waveband channel within the sensor is individually calibrated to National Standards and is supplied with a response curve and calibration certificate.

For PRI, the sensor's Channel 1 is centred at 531 nm and Channel 2 at 570 nm. Skye offer two bandwidth options, 5 nm or 10 nm.

These sensors have a removable diffusing head. With the head fitted the sensors are fully cosine corrected (will accept incoming light from a hemisphere above them according to Lambert's Cosine Law), as is required for the measurement of incident solar radiation.

When the diffuser head is removed, the light acceptance of the sensor becomes a narrow angle (25°) cone shape. This makes it suitable for measuring radiation reflected up from the ground, and the geometry of the cone shape acceptance defines the exact area of the ground being monitored.

PRI sensors are generally used in pairs, one sensor measures incident solar radiation while the second simultaneously measures radiation reflected upwards. This is necessary to eliminate fluctuations in solar radiation.

The sensors can be connected to Skye DataHog2 datalogger, or loggers from other manufacturers (e.g. Campbell Scientific) for long term monitoring. The DataHog2 logger is recommended for the narrower 5 nm bandwidth option as it is specifically designed to measure the small current outputs direct from light sensor photodiodes.

PRI is calculated using the following equation

$$PRI = \frac{(p570\text{ nm} - p531\text{ nm})}{(p\ 570\text{ nm} + p531\text{ nm})}$$

where *p*531 nm and *p*570 nm are each ratios of incident to reflected light at that wavelength.

Skye's 2 light sensors are calibrated to National Standards when the diffusing cosine correction head is fitted. An exact calibration for the sensor with the diffuser head removed is not supplied, due to the light collection geometry it is possible only to have a relative calibration of one channel to another.

However, this does not hinder the PRI calculations as follows:

If 570i = 570 nm (incident) in μmol m^{-2} s^{-1}
570r = 570 nm (reflected) in nA

531i = 531 nm (incident) in μmol m^{-2} s^{-1}
531r = 531 nm (reflected) in nA

Then

$$PRI = \frac{[\ (570r/\ 570i) - (531r/\ 531i)\ ]}{[\ (570r/\ 570i) + (531r/\ 531i)\ ]} \quad \text{…….[1]}$$

$$= \frac{[(570r*531i) - (531r*570i)]}{(570i*531i)} * \frac{(570i*531i)}{[(570r*531i) + (531r*570i)]}$$

$$= \frac{[(570r*531i) - (531r*570i)]}{[(570r*531i) + (531r*570i)]}$$

$$= \frac{570r\ [531i - (531r / 570r\ ) * 570i\ ]}{531r\ [\ (570r / 531r\ ) * 531i + 570i\ ]}$$

$$PRI = \frac{570r}{531r} * \frac{[531i - (531r / 570r\ ) * 570i\ ]}{[\ (570r / 531r\ ) * 531i + 570i\ ]} \quad \text{…….[2]}$$

The Skye sensor Calibration Certificate states that Ratio Sensitivity without the diffuser head fitted (in nanoamps) is

$$570\text{ nm} : 531\text{ nm} = 1 : Z$$

For the PRI to be correct then 570i, 570r, 531i and 531r must all be true values in micromoles /m2/sec. The Skye sensor will measure 570i (say X μmol m^{-2} s^{-1}) and 531i (say Y μmol m^{-2} s^{-1}).

For the reflected values :

$$\frac{570r\ (\mu mol\ m^{-2}\ s^{-1})}{531r\ (\mu mol\ m^{-2}\ s^{-1})} = \frac{Z^*\ 570r\ (nanoamps)}{531r\ (nanoamps)} \qquad (nanoamps = nA)$$

From [2]:

$$PRI = \{\frac{Z^*\ 570r_{(nA)}}{531r_{(nA)}} * [Y - \frac{531r_{(nA)}}{\{Z^*\ 570r_{(nA)}\}} * X] / [\{\frac{Z^*\ 570r_{(nA)}}{531r_{(nA)}} * Y + X]$$

Hence:

$$\mathbf{PRI = \frac{(Z * 570r_{(nA)} * Y) - (531r_{(nA)} * X)}{(Z * 570r_{(nA)} * Y) + (531r_{(nA)} * X)}}$$

Where: X = 570i incident reading (in μmol m^{-2} s^{-1})
Y = 531i incident reading (in μmol m^{-2} s^{-1})
Z = Ratio Sensitivity of reflected 570 nm : 531 nm
$570r_{(nA)}$ = reflected reading in nanoamps (or direct current output)
$531r_{(nA)}$ = reflected reading in nanoamps (or direct current output)

A NOTE ON EXPECTED VALUES:

PRI values range from –1 to +1, where

-1 represents stressed plants
+1 represents healthy plants