LIGHT

Application Notes
Sensors for NDVI Calculations

Skye 2 and 4 channel radiometer light sensors are ideal for making 'ground truth' observations and comparing with measurements made by Earth observing satellites, such as LANDSAT, MODIS, AHVRR etc. These satellites map the Earth's surface at various wavelengths throughout the electromagnetic spectrum.

The SKR 1800 2-channel and SKR 1850 4-channel light sensors are in effect 'multiple sensors-in-one'. They will monitor light from multiple wavebands at a single point.

The exact wavelength and width of the band in each 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 example, Channel 1 at 570-680 nm and Channel 2 at 725-1020 nm is ideal to match the broadband Red and NIR channels on the AHVRR satellite. Narrow bandwidths can also be chosen, e.g. 10, 25, 50, 75, 100 nm or larger as required.

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.

2 or 4 channel light 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.

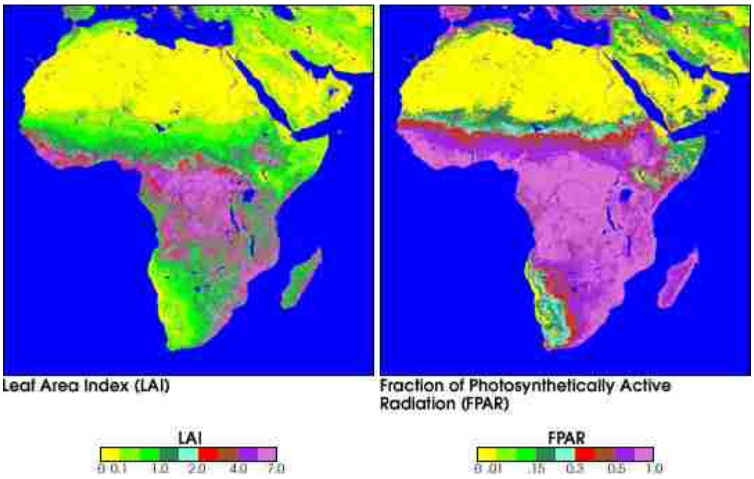
Skye

Application Notes
Sensors for NDVI Calculations (cont)

It is essentially reflected solar radiation which is being mapped by the Earth observation satellites. However errors are often introduced into these extra-terrestrial measurements by natural climatic conditions, especially scattering effects caused by cloud cover and dust particles in the atmosphere. Hence Skye 'ground truth' sensors are used to improve spatial resolution of the measurements and to correct for the climatic condition errors.

There are many useful phenomena which can be studied by the satellite maps, from geography to rates of deforestation or desert encroachment, area coverage of primary crops, flood and drought monitoring to insect breeding ground identification. Different ground types, desert, forests, crops, water etc absorb and reflect differing amounts of different wavelengths of radiation, and so are easily identified.

Vegetation Indices are produced by calculating the ratios of different wavebands of reflected radiation, and are related to the abundance and activity of radiation absorbers such as water and plant chlorophyll. These indices enable the estimation of biomass, percentage cover, absorbed PAR (Photosynthetically Active Radiation) and Leaf Area Index.

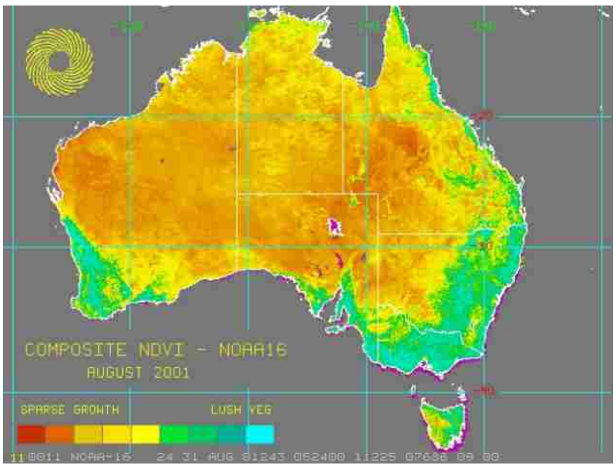


Leaf Area Index (LAI)

Fraction of Photosynthetically Active Radiation (FPAR)

NDVI or Normalised Difference Vegetation Index is calculated from the Red and NIR wavebands and is defined as:

$$\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$$



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Application Notes
Sensors for NDVI Calculations (cont)

Skye's 2 and 4 channel 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, it is possible only to give a relative calibration of one channel to another.

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

If NIR_I = NIR (incident) in μmol/m^2/s NIR_R = NIR (reflected) in nA
Red_I = Red (incident) in μmol/m^2/s Red_R = Red (reflected) in nA

Then

$$NDVI = \frac{[(NIR_R/NIR_I) - (Red_R/Red_I)]}{[(NIR_R/NIR_I) + (Red_R/Red_I)]} \quad \ldots\ldots\ldots[1]$$

$$= \frac{[(NIR_R*Red_I) - (Red_R*NIR_I)]}{(NIR_I*Red_I)} * \frac{(NIR_I*Red_I)}{[(NIR_R*Red_I) + (Red_R*NIR_I)]}$$

$$= \frac{[(NIR_R*Red_I) - (Red_R*NIR_I)]}{[(NIR_R*Red_I) + (Red_R*NIR_I)]}$$

$$= \frac{NIR_R\,[Red_I - (Red_R / NIR_R) * NIR_I]}{Red_R\,[(NIR_R / Red_R) * Red_I + NIR_I]}$$

$$NDVI = \frac{NIR_R}{Red_R} * \frac{[Red_I - (Red_R / NIR_R) * NIR_I]}{[(NIR_R / Red_R) * Red_I + NIR_I]} \quad \ldots\ldots\ldots[2]$$

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

NIR : Red = 1 : Z

For the NDVI to be correct then NIR_I, NIR_R, Red_I and Red_R must all be true values in micromoles /m^2/sec. The Skye sensor will measure NIR_I (say X μmol/m^2/sec) and Red_I (say Y μmol/m^2/sec).

For the reflected values :

$$\frac{NIR_R\ (\mu mol/m^2/sec)}{Red_R\ (\mu mol/m^2/sec)} = \frac{Z*\ NIR_R\ (nanoamps)}{Red_R\ (nanoamps)} \qquad (nanoamps = nA)$$

From [2]:

$$NDVI = \frac{\{Z*\ NIR_{R(nA)}\}}{Red_{R(nA)}} * [Y - \frac{Red_{R(nA)}}{\{Z*\ NIR_{R(nA)}\}} * X] \;/\; [\frac{\{Z*\ NIR_{R(nA)}\}}{Red_{R(nA)}} * Y + X]$$

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Hence:

$$\textbf{NDVI} = \frac{(Z * NIR_{R(nA)} * Y) - (Red_{R(nA)} * X)}{(Z * NIR_{R(nA)} * Y) + (Red_{R(nA)} * X)}$$

Where:
- X = NIR_I incident reading (in mmol/m^2/sec)
- Y = Red_I incident reading (in mmol/m^2/sec)
- Z = Ratio Sensitivity of reflected NIR : Red
- $NIR_{R(nA)}$ = reflected reading in nanoamps (or direct current output)
- $Red_{R(nA)}$ = reflected reading in nanoamps (or direct current output)

A NOTE ON EXPECTED VALUES:

NDVI values range from 1 to +1, where

-1 values are generally from snow, ice or cloud
Zero values represent no vegetation
+1 values represent the highest possible density of green leaves.

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