Radiometric Calibration of MicaSense RedEdge® Multispectral UAS Imagery

November, 2017

What are multispectral imagers?

In addition to imaging red, green and blue wavelengths, multispectral cameras, such as the MicaSense RedEdge® can measure light in wavelengths that our eyes cannot see such as infrared, allowing us to better characterize our objects of interest.

Why is radiometric calibration important?

Radiometric calibration of UAS imagery allows image pixel values to accurately describe the material composing the object of interest by compensating for sensor characteristics, lighting and atmospheric conditions. The process of radiometric calibration is important for scientists, land managers and industry because it allows for the generation of accurate index and reflectance maps that can be compared over time and to datasets collected with other sensors.

When is the best time to take multispectral imagery?

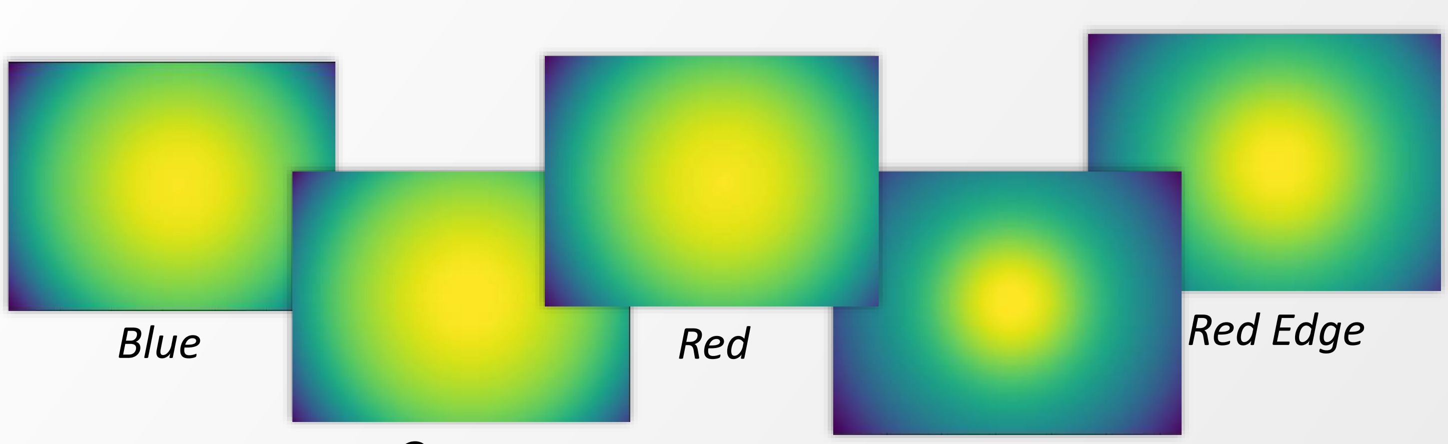
- Sunny and minimal cloud cover
- +/- 2 hours of solar noon
- Low wind conditions to avoid movement of surface features.

Converting Raw Pixel Values to Radiance

Radiance is a standard unit that describes the amount of light an instrument reads. In performing the following steps you are converting the raw image pixel values to absolute spectral radiance by compensating for the sensor characteristics.

✓ *Optical and Natural Vignette Correction*

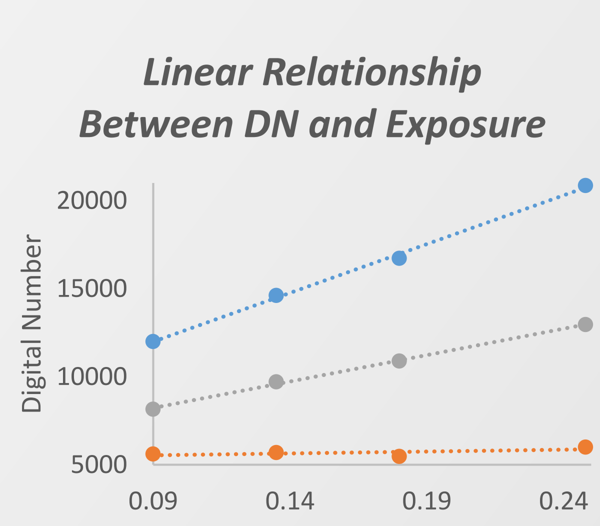
Pixels in the center of an image tend to be more sensitive to light than pixels towards the outside of an image due to intrinsic lens characteristics as well as oblique light angles near the edge of the sensor. MicaSense provides a vignette model for their sensors to correct images for this fall-off in light sensitivity. The raw images are divided by the vignette correction image. Below are examples of vignette correction images for each of the 5 RedEdge® sensors.



Blue *Green* *Red* *Near Infrared* *Red Edge*

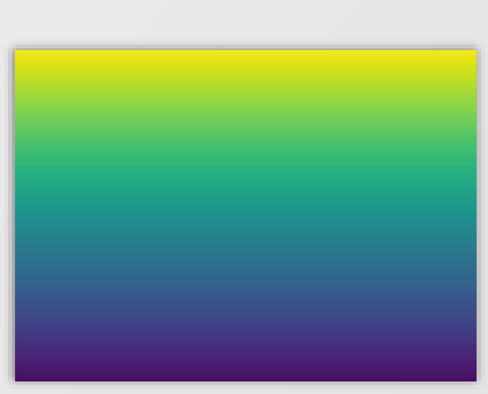
✓ *Exposure Correction*

This correction is only necessary if images were taken on an automatic exposure setting rather than a manual setting. Images taken on an automatic setting will have a different exposure for each image and therefore will have inconsistent amounts of light hitting the sensor. Because the relationship between exposure and raw image pixel value, or digital number, is linear (right), the pixel values simply need to be normalized by the ISO multiplied by the shutter speed.



✓ *Row Correction*

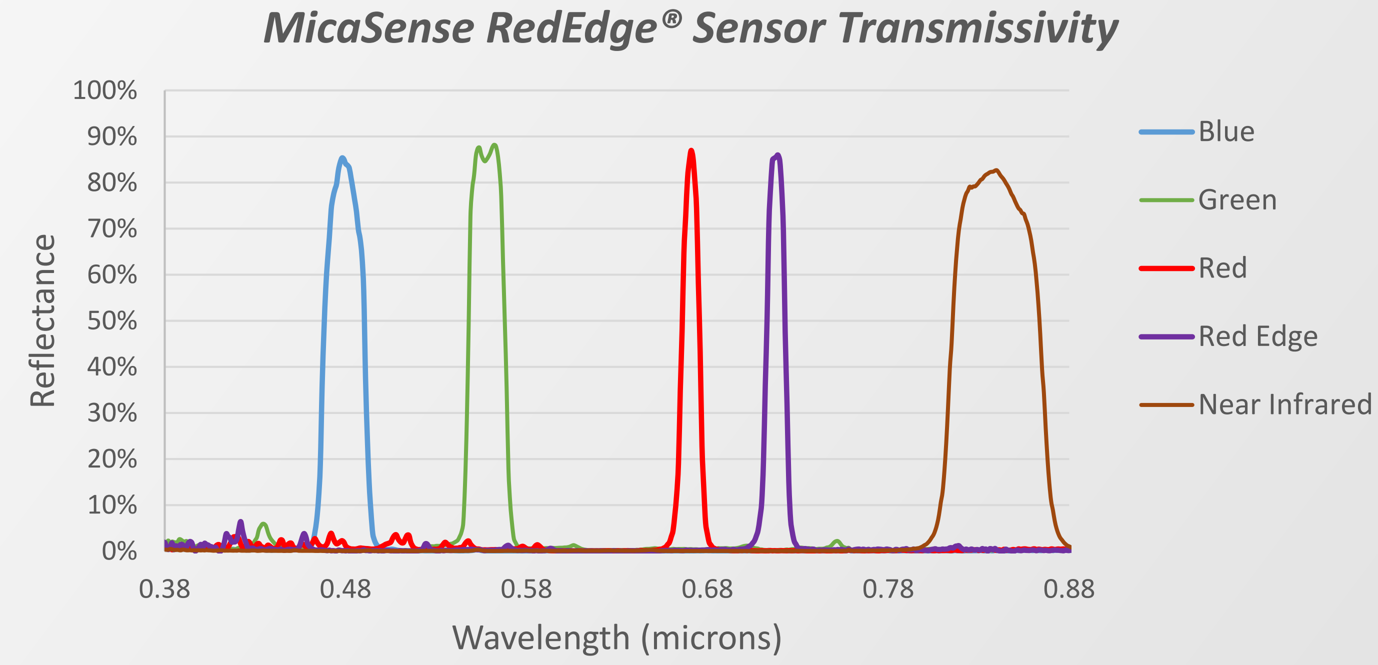
With global shutter imaging systems there are row-based changes in image pixel values due to changes in the storage pixel charge between exposure time and pixel read out (right).



Blue *Green* *Red* *Near Infrared* *Red Edge*

About the MicaSense RedEdge®

For multispectral UAS imaging the National UAS Project Office currently employs the MicaSense RedEdge® camera (below, courtesy of MicaSense). The RedEdge® is composed of five 3.6 MP, 12 bit sensors with discrete and narrowband filters imaging in the visible to near infrared (VNIR) between 475 and 860 nm (see example image set above, and transmissivity curves for each sensor below, courtesy of MicaSense). The MicaSense RedEdge Downwelling Light Sensor® (DLS, below, courtesy of MicaSense) sits on top of the UAS during flight and measures irradiance, or brightness for each image set and band wavelength.

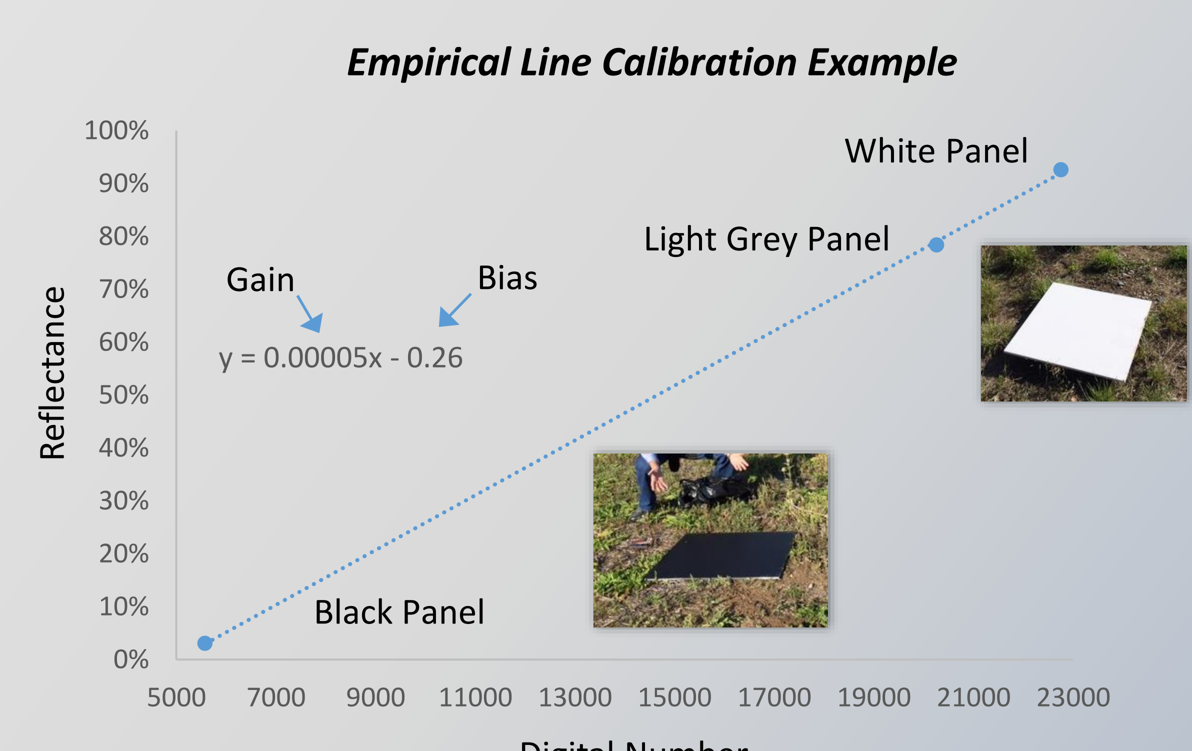


Radiance to Reflectance

Reflectance maps depict the amount of light a surface reflects in percent of total light emitted. For example, green objects such as healthy vegetation reflect the most in the green portion of the electromagnetic spectrum, or green wavelength. Converting from radiance to reflectance is done to compensate for lighting conditions at the time the images were captured. Empirical line calibration is the simplest and most common method of converting UAS radiance images to reflectance. Reflectance maps may be converted to index maps such as normalized difference vegetation index (NDVI), or used to identify and map ground features automatically in a geographic information system (GIS) environment.

Empirical Line Calibration (ELC)

ELC requires imaging Lambertian, or diffusely reflective, calibration panels from flight altitude throughout the UAS mission(s). All calibration targets were measured with a lab spectrometer to obtain absolute reflectance values for each of the 5 RedEdge® sensor wavelengths. In performing the ELC we assume a linear relationship between digital count (i.e. raw image pixel value) and reflectance. For each instance of dark and light calibration targets we can determine a linear function for converting digital numbers of all images to reflectance values. An empirical line equation is generated for each band within each set of panel images. The slope of the line is referred to as the gain, while the y-intercept is the bias. Empirical line equations may be normalized by time or irradiance values to compensate for change in lighting conditions between panel images. An example of an empirical line calibration equation is graphed below.



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