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Case study - Introducing Remotely Sensed Data to Lower Costs and Increase Efficiency in Agricultural Management.

Using Remotely sensed Data for Efficient Crop Monitoring

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Leveraging precision, multi-spectral RapidEye data saves time and money while increasing crop yields.

Remote Sensing for Agricultural Crop Monitoring

If you ate today – the old saying goes – thank a farmer. While the phrase may conjure images of a bygone era, we know that many of today's commercial farms are modern technological marvels. Variables like water scarcity, soil degradation, and climate change are out of the farmers' control. Add in concerns about food safety, rising energy costs, and an increased demand for organic foods and you can see why technology is so heavily relied upon.

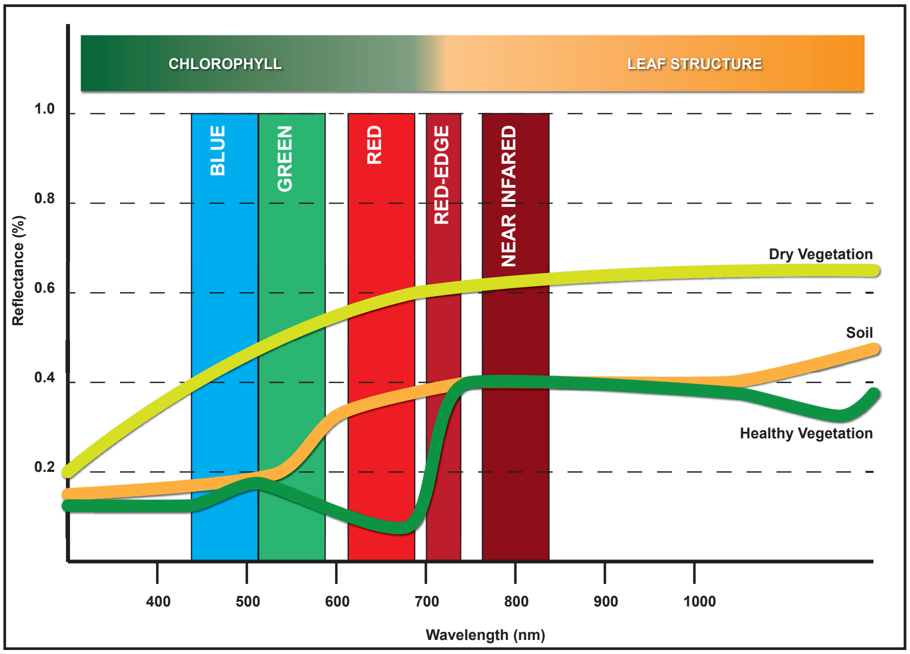
Artificial irrigation, disease resistant seeds, pesticides, and scientifically formulated fertilizers have improved crop yield significantly over the past 50 years. Today, farmers have another tool in remote sensing to improve yields even further while simultaneously reducing costs. This study will demonstrate how remotely sensed data can identify stressed areas of vegetation to allow for a precision approach to crop management.

To identify stressed vegetation in the most cost-effective way possible, high-resolution satellite data can be purchased in areas covering the fields in question. Five-meter resolution RapidEye imagery is ideal to investigate identified areas of crop stress before deploying expensive and labor-intensive specialists directly to site. The diagram below illustrates the major steps required to perform an analysis of agricultural fields for the purpose of assessing chlorophyll and leaf area (vegetation density) measurements to identify stressed vegetation.

Why RapidEye?

The RapidEye constellation consists of five satellites with an orthorectified resolution resampled to five meters. The constellation collects up to 6 million square kilometers a day, making it possible to cover large areas in a short time. Most importantly, the Rapideye sensors contain a unique spectral red-edge band, which is sensitive to detecting and measuring chlorophyll in flora.

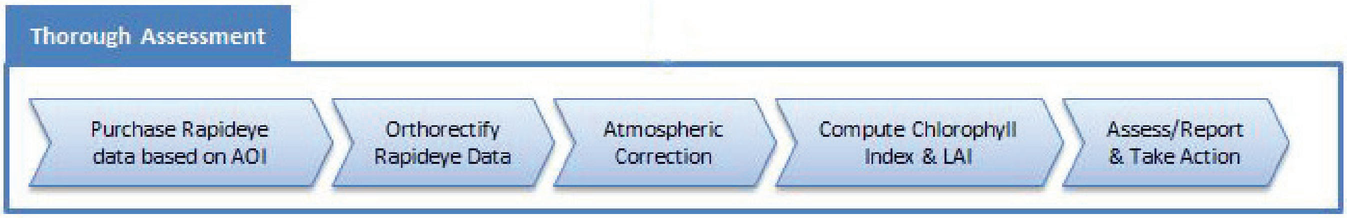
It is known that the health of any plant depends on a proper supply of nitrogen. Unfortunately, nitrogen levels cannot be measured through remote sensing and require the costly deployment of field technicians to determine. While the Red Edge band cannot detect nitrogen levels, it can detect chlorophyll levels. Oftentimes, where chlorophyll levels are low, nitrogen levels are also low, identifying these areas using the high-resolution of the RapidEye sensors can pinpoint which specific areas require extra attention on the ground.



The bands available in RapidEye sensors are specifically designed to extract the maximum information in the study of vegetation.

Remote Sensing Workflow

Monitoring the phenology of crops can be an expensive activity. The use of satellite and aerial remote sensing has helped to lower the costs by allowing analysts to perform assessments of an agricultural field prior to performing expensive in situ tests. This allows the analyst to focus their onsite samples in areas that show signs of stress in the remotely sensed images. The following diagram illustrates the major steps required to perform a cross queuing analysis of agricultural fields for the purpose of assessing chlorophyll and leaf area (vegetation density) measurements to identify stressed vegetation.



Identifying Problem Areas with Precision using RapidEye Imagery

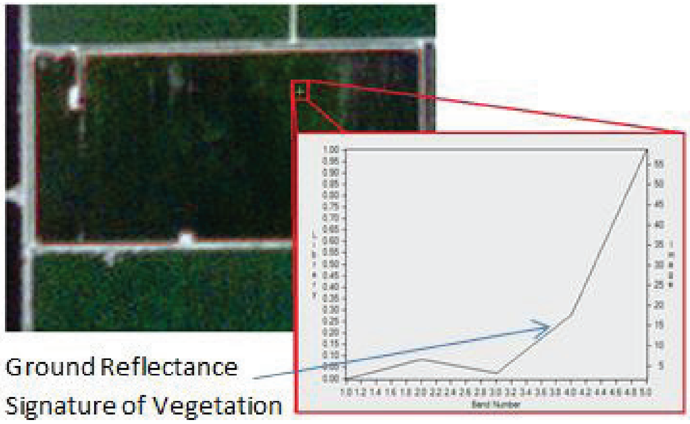
Rapideye is one of only two commercial sensors that are capable of capturing imagery in the red edge band (690nm-730nm), which is sensitive to chlorophyll variations. In addition to the red edge band, its high collection capacity, 5m resolution and competitive price structure makes it ideal for agricultural applications.

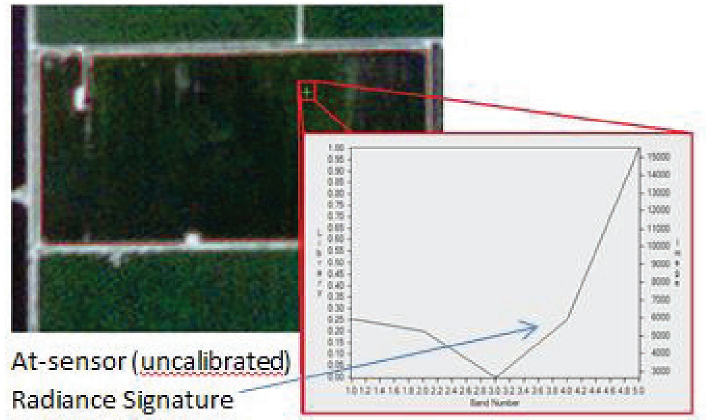
In this particular study, we exploit the information captured from the red edge band to help identify agricultural fields with areas of low relative chlorophyll measurements. Low chlorophyll measurements can be a strong indicator of inadequate nitrogen levels that ultimately affect the growth and yield of the crops. To measure relative chlorophyll levels we will compute the Modified Chlorophyll Absorption Ratio Index (MCARI) (See formula below). However, low chlorophyll measurements can also be a result of sparse vegetation cover (density). As such, we need to cross reference the results from the MCARI index with an index sensitive to vegetation density and insensitive to chlorophyll absorption. To do this, we will use the Modified Triangular Vegetation Index-1 (MTVI-1) (See formula 2). We can then compare the results by either computing a ratio of the MCARI/MTVI-1 or by performing a simple visual comparison. The comparison will help us identify areas with low relative chlorophyll levels, but consistent vegetation coverage (density). This comparison improves our confidence that the low chlorophyll levels are a result of stressed vegetation and not sparse vegetation cover (See Appendix A).

$$\mathrm{MCARI} = [((R_{690\text{-}730} - R_{630\text{-}685}) - 0.2) * (R_{690\text{-}730} - R_{520\text{-}590})] * (R_{690\text{-}730} / R_{630\text{-}685}) \quad (1)$$

$$\mathrm{MTVI\text{-}1} = 1.2\text{^}1.2(R_{760\text{-}850} - R_{520\text{-}590}) - 2.5(R_{630\text{-}685} - R_{520\text{-}590}) \quad (2)$$

In order to correctly compute the MCARI and MTVI-1 indices, the Rapideye imagery must first be orthorectified if it was purchased at level 1B and atmospherically corrected. The orthorectification process was performed with Geomatica's OrthoEngine and was highly automated. The orthorectified Rapideye imagery was then processed through Geomatica's Atmospheric Correction wizard, which uses the ATCOR3 model. The advantage of using Geomatica's atmospheric correction wizard is that most of the parameters are automatically computed and setup from image metadata. This makes a previously complicated and time consuming process into a simple and quick operation. The atmospheric correction is required so that atmospheric noise is removed from the pixel values, illumination effects are minimized and the data is normalized to a value between 0% and 100%, which is the ratio of the reflected direct (path) energy over incoming direct (path) energy (see figure following).

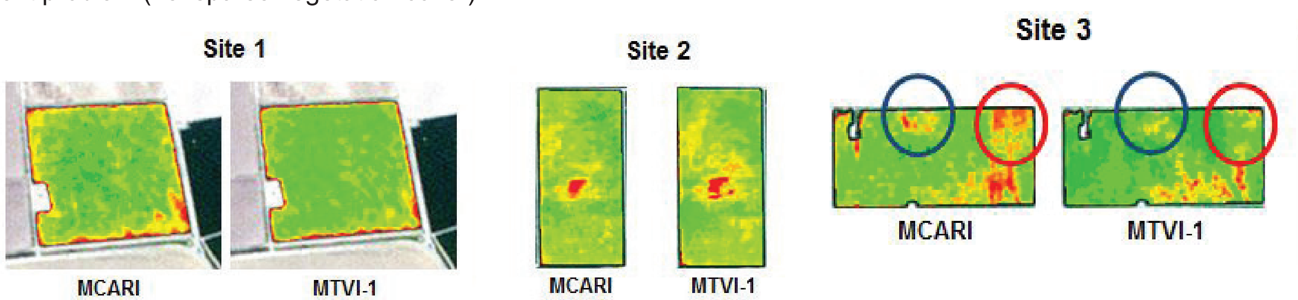




After computing the atmospheric correction and MCARI/MTVI-1 indices we can compare the results and look for patterns that indicate low chlorophyll measurements that are not a result of sparse vegetation.

Results

Our assessment identified three agricultural fields that displayed symptoms of vegetation stress due to low relative VI values. These three fields were analyzed using Geomatica software to identify whether the low VI values were, in fact, a cause of stress or a result of a different problem (I.e. sparse vegetation cover).



The similarities in the spatial distribution of the MCARI and MTVI-1 values indicate that the potential problem areas in both site 1 and 2 are a result of sparse vegetation cover and not due to stress (nitrogen deprivation).

The results of the MCARI and MTVI-1 calculations from site 3 display a stark contrast from the results of sites 1 and 2. There are two obvious areas in site 3 that experience low MCARI values and high MTVI-1 values

After comparing the results of the MCARI and MTVI-1 calculation for site 3, it is evident that there is a high likelihood of stressed vegetation in parts of this field. Furthermore, the low relative chlorophyll measurements suggest that the vegetation may be stressed due to low nitrogen levels.

Only you can determine if a remote sensing workflow is the right approach to cost savings for your crop management, but studies like this show how easily one can be implemented while showing instant results. To find out more about how to do this and more, contact PCI Geomatics at info@pcigeomatics.com.

About PCI Geomatics

PCI Geomatics is a world-leading developer of software and systems for remote sensing, imagery processing, and photogrammetry. With more than 30 years of experience in the geospatial industry, PCI is recognized globally for its excellence in providing software for accurately and rapidly processing satellite and aerial imagery. There are more than 30,000 PCI licenses, in over 150 countries worldwide. Find out more about PCI Geomatics at www.pcigeomatics.com.

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