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Getting Started With Remote Sensing for Crop Production

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Introduction

There are several practical applications for using aerial and satellite imagery for crop production. Also referred to as remote sensing, information is provided in the form of a photograph or digital image. Remote sensing has several applications to identify spatial features and variability in a field through differences in color or solar energy reflectance of water, soil and vegetation. This enables us to determine crop health, plant emergence issues, insect infestations, accidental herbicide damage, uniformity of fertilizer or water application, drainage patterns, record of crop type and acres, and other crop devastation issues during the growing season. With the new technology advances and availability of acquiring images the costs are starting to get more favorable in Midwest crop production. The greatest factor that has prevented the wide-use and reliability in using this technology unfortunately is haze or cloudy conditions.

It is always good practice to verify differences found in imagery with field scouting, particularly if there is a concern from clouds creating shadows in the image. Using imagery along with other data such as soil surveys, yield data, electrical conductivity and soil sampling data can be very helpful to identifying apparent crop stresses during the growing season. In addition, rather than taking one image a series of several photographs collected over time permits one to follow the temporal changes in plant growth, soil residue cover, erosion, or other physical processes.

The decision to use remotely sensed imagery as an information technology is only valued to your operation when it leads to a management decision or validates other management practices. Whether it is from free or purchased imagery, different levels of information can help you achieve different management goals.

How Remote Sensing Works

Remote sensors record reflected solar energy in various wavelengths found in the electromagnetic spectrum. The most commonly interpreted wavelengths in the spectrum for crop management purposes are the blue, green, red and near-infrared bands. The primary colors blue, green, and red are visible energy because the human eye can read this information. Near-infrared imagery is information that the human eye is unable to see.

The near-infrared wavelength considers an average amount of light reflected back from vegetation, ground surface, or other objects. For vegetation, this amount of light is influenced by the leaf cell structure (figure 1). Healthier vegetation with denser cell structures reflect more NIR light, and stressed areas reflect less. This information obtained from the imagery can indicate better and poor producing areas in the field. It is a good idea to sample the same areas identified in the field over time and observe the relative crop response for future management decisions.

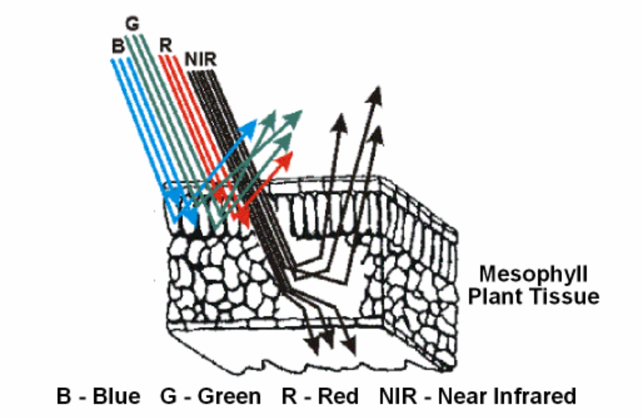


Figure 1. Absorption and reflectivity characteristics of photographic wavelengths (R,G, B, and NIR) from plant tissue.

Information obtained from remotely sensed data are based on spatial, spectral and temporal variations of these electromagnetic fields. Spatial variations tell us how much detail we can see in an image. Spectral resolution has to do with the overall size of the bandwidth. The finer the spectral resolution and the higher the sampling interval the better we are able to detect differences in the image. Temporal variations relate to the differences in the wavelength over time. The data behind a given image can also be referred to as pixel values. The differences and patterns among several pixels is used to make interpretations and explanations of surface features in the image. All of these factors need to be considered when understanding and using this data for crop management.

Obtaining Remote Sensing Data

There are a variety of options to consider when acquiring remote sensing images. Remotely sensed data can be acquired from a simple camera or sensors. These cameras or sensors can be mounted on field implements, hot air or helium balloons, ultralight and remote control aircraft, low flying and high-altitude aircraft, and by satellite. Each method has it’s own strength’s and weaknesses. The kind of service you choose largely depends on what decision you will be making from the image. Typically these considerations include costs, necessary area in land coverage, data processing and interpretation capabilities, weather patterns, availability, and turnaround of data for making decisions. Factors such as accuracy, resolution, quality, data format, and additional interpretation and analysis also need to be considered after acquiring the remotely sensed data. The two most common methods of obtaining imagery are from special sensors or cameras mounted on aircraft and satellites. No matter what service you decide to use make sure you get a sample of the company’s products and understand the process of image tasking.

The largest inhibitor to any good image is poor climate conditions due to cloud cover, haze, and poor sunlight reflecting from the surface of the earth. Getting out to your field during a clear day is in your best interest. Images taken during mid-day versus early morning and late evening provide better reflectance of data because of minimal shadow effects within the crop canopy. Try to schedule a fly-over around noon time for a better quality image.

Aerial Imagery

Different aerial imagery services have different camera equipment and techniques for taking pictures. Pictures can be obtained with regular 35mm cameras, digital cameras, or cameras with specialized optical sensors. Also, cameras can use different lenses and film. If you wanted to take a picture of bare soil showing soil boundaries, regular color film can be just as useful as near infrared depending on the climate conditions. However, if you want a picture of vegetation differences throughout the field then you would need color or near infrared data. Cameras with digital and optical sensors collect digital data representing the different near-infrared bands collected from the reflectance of the earth’s surface. Prices for aerial photography range anywhere from a few hundred dollars to a 1,000 depending on the amount of data collected. Most services are requiring minimal order of 1,000 acres.

If you want to get a start on using and interpreting aerial imagery you should consider obtaining free archived black and white compressed digital orthophoto quadrangles (DOQ) through the OGRIP/Ohio GIS Support Center (http://www.state.oh.us/das/dcs/gis/doqq/). This imagery is one meter resolution imagery that covers the entire state of Ohio. DOQs are digital raster (pixel based) image of an aerial photograph in which displacements caused by the camera and the terrain have been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. This imagery is also different than color or near-infrared imagery that was previously explained. This information is taken at a specific time of the year for a given year. Images throughout Ohio have been acquired between 1988 to 1999. These images are generally taken in the fall/winter with no leaves on deciduous trees. To view these files you can download the MrSID GeoViewer free of charge from http://www.lizardtech.com. The Ohio GIS Support Center has also provided the images through an online browse tool at: http://metadataexplorer.gis.state.oh.us/metadataexplorer/explorer.jsp

Due to the large size of these files, downloading the files over slow Internet connections can time out or take considerable amount of time. An alternative is to purchase these data sets for a fee by CD-ROM. Contact your local GIS coordinator located at the county auditor or engineers office. You can also contact USGS customer service at 800-252-4547, http://earthexplorer.usgs.gov/.

Other locations to acquire DOQs and related geodatasets (ie., digital line graphs, digital raster graphus, etc.) include:

Microsoft Terraserver
http://terraserver-usa.com/

USGS EarthExplorer
http://earthexplorer.usgs.gov/

USDA Geospatial Data Gateway
http://lighthouse.nrcs.usda.gov/gateway/

Additional information about DOQs can be found at http://geospatial.osu.edu/resources/DOQ.pdf.

Satellite Imagery

Images taken from a satellite range in different resolutions. Typical resolutions available today for agricultural application come in 2.8m, 4m, 10m, and 30m. The higher the resolution the more expensive the image. Satellite images for crop production are typically taken of large areas from 2.5 x 2.5 miles and upwards of 7 x 7 miles depending on the type of camera used. For example, Digital Globe, www.digitalglobe.com, and SatShot, www.satshot.com make images available to agriculture producers. Digital Globe provides Quickbird imagery at 2.8 meter resolution. They provide imagery acquisition costs at around $1,500 for one image, but usually cover a much larger area. SatShot provides 10 and 30m resolution images at the township level. SatShot has software you download to manage the images.

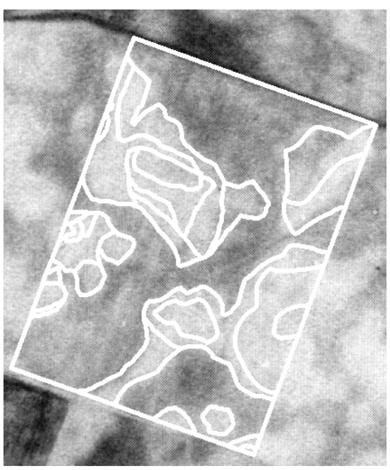
Prices for satellite imagery depend on a variety of factors. These factors include: the resolution of the image, number of images taken, or access to pictures already taken. Getting several users together to share in the cost of several square miles can be a good way to share this resource tool. Sometimes a satellite image could have already been ordered for your area. Accessing images already taken usually are stored for several years and can be offered at a discount price. Archived satellite imagery is very useful information. It can help you build a crop production story-board over time. The largest inhibitor to the quality of satellite imagery is cloud cover. All satellite companies usually have quality control measures that will retake the image if there is typically more than 20% cloud cover.

Limited imagery of Ohio since mid-year 1999 is being made available through an initiative called OhioView (www.ohioview.org). OhioView provides users access to LANDSAT 7 satellite imagery. This imagery is 30m in resolution. A recent malfunction of the camera instrumentation occurred on May 31 to September 2003. It may be difficult to acquire data in this period. However, some of the information has been recorrected. A 30m resolution image can be difficult to predict specific patterns in the field such as small weed patches, nutrient deficiencies, and other hard to see abnormalities. However, these images have been used for determining field attributes such as crop and vegetation types, field boundaries, actual crop acres planted, spray drift, hail damage, and flooding. You can inquire and download these images through the OhioLINK Digital Media Center at: http://dmc.ohiolink.edu/GEO/LS7/ free of charge. Other states typically charge a fee for this imagery. Newly acquired LANDSAT imagery for other states typically costs $600 per frame.

Applications for Crop Management

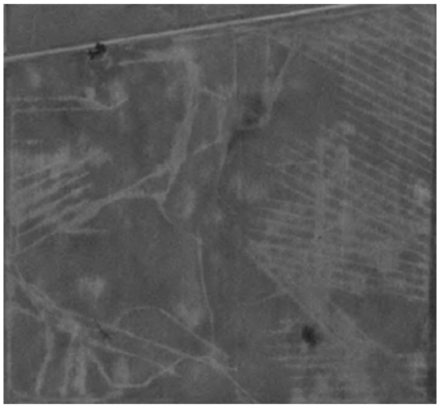
Vegetation and Land Cover Identification - For years remote sensing has been used for site planning purposes. As early as the 40's imagery was collected throughout the United States as an effort to plan the interstate highway system. The Farm Services Agency uses this practice for keeping track of what crops are planted where for government farm programs. The ability to classify different features in the landscape such as vegetation, roads, and waterways proved to be valuable in this planning process. The ability to interpret levels and changes in land cover also help us with land use planning. We can quickly identify the relationships between crops, pasture, forests, streams, roads, towns, and other features. Another important ability is to keep track of changes over time and this is where remote sensing has been valuable. Several images collected over the growing season permits one to follow the temporal changes in plant growth, soil residue cover, erosion, or other physical processes. To strengthen any conclusions on non-uniformity appearances, frequent inspections and verification need to be conducted at the ground level.

Soil Characteristics - The Natural Resources Conservation Service has used this imagery for aiding in classifying soils. Imagery for soil characterization includes evaluating the reflectance from different soil properties, influence of other surface conditions to this reflectivity value and the ability to connect soil series or patterns in the field.



Relationship of soil color patterns to a an order 1 soil survey (1:2500)

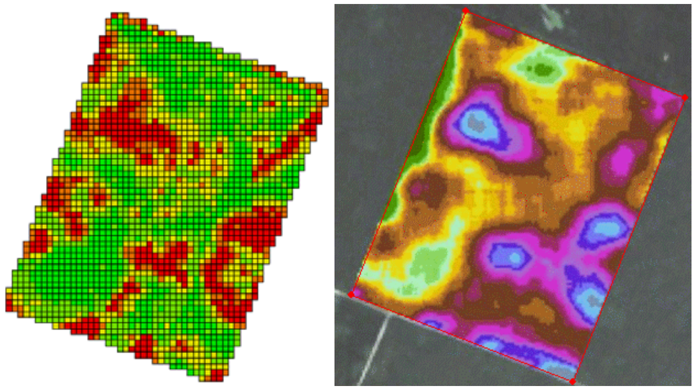
Water Management – The combination of imagery, elevation data, and other soil surface characteristic information can assist you in planning water management needs in the field. Much can be said from taking a bare soil image a day or two after a good rain. Water draining throughout a field can help you pick out tile lines, identify surface drainage issues, and determine stronger definitions between soil boundaries. You can also quickly calculate how many feet of tile may be needed for given areas of the field with today's software.



A digital orthophoto quadrangle (DOQ) 1-meter black and white image showing tile and surface drainage patterns.

Plant Health - Color or color infrared imagery has been used to evaluate the relative extent of hail damage, insect and disease infestations, weed patterns, management mistakes, accidental herbicide damage, nutrient deficiencies, or water stress. Farm appraisers and managers can use remote sensing to evaluate the relative productivity of land. Insurance agents can use the technology to assess the extent of crop damage in fields. Differentiating between low and high emission values within a color infrared image is a preferred method for evaluating crop health. These differences can be explored visually but more differences in these relationships can be explored by using computer models. No matter what technique is use it is difficult to measure actual pod, seed, or ear damages to the crop primarily because determinations are made from plant leaves and parts of the stalk. Deciphering nutrient deficiencies is difficult since there are many influences that imagery can not interpret. Leaf chlorosis from potassium deficiencies show discoloration in parts of the leaves. Purple leaves is a symptom of phosphorus deficiency in the plant. Additional ground level observations assist in the validity of any of these effects of the crop so assessments can be made within the imagery. It is very difficult to detect nitrogen deficiencies directly from an aerial or satellite image. However, research has found that ground level sensors measuring leaf chlorophyll match closely with actual corn plant nitrogen levels. Correlating ground level sensor readings with aerial or satellite images can assess nitrogen deficiencies on a broader scale.

Crop Productivity Levels – Imagery captured during the season is helpful in predicting field productivity levels. An image interpretation technique using a normalized difference vegetation index (NDVI) has been useful to measure differences in canopy cover and the relative vigor of that crop. Keep in mind that this does not tell us overall yields in the field. The readings that we get from NDVI calculations are only telling us information from the vegetation. The crop varieties that are selected can have different leaf areas and plant heights. These characteristics do not correlate with actual yield.



Similarities between crop yield (shown on left) and a NDVI calculated image in August.

Managing and Using Remotely Sensed Data

Remotely sensed data can be used stand alone, interpreted further with imagery software, and with geographic information systems (GIS) as a backdrop with other digital data sets. A low-technology approach might involve using an aerial photograph to identify a questionable landscape feature and then follow-up with ground truthing to characterize the suspected problem. The appropriateness of management practices to remediate a problem depends on the nature of problem and the producer's ability or interest in attempting a solution.

A more high-technology approach would be to further interpret the data with software. The imagery can be geo-referenced or used straight into GIS. GIS can be thought of as a way to systematically stack a series of maps representing different features (i.e., soil color, soil type, elevation, crop color, yield, etc.) and then generate new maps that integrate the desired features using some predetermined strategy or scheme (i.e., combination of factors). Boundaries can be drawn around fields to indicate acres in a field. It also serves as a reference point for conservation planning efforts in identifying locations for new waterways, buffers, drainage ditches, and other land use plans. Interpreted remote sensing images from software can immediately be used for determining crop management zones or crop vigor zones. Because relationships can be found, producers can use remote sensing to develop a "smart sampling" strategy. In practice, a photograph can be used to identify representative sampling sites and steer away from known problem areas (i.e., old fence rows, depressional areas, previous roadways, etc.). Sampling the same areas in a field over time and observing the relative crop response is a good way to assess the appropriateness of management practices.

Additional Resources

For more information about remote sensing for agriculture and natural resource applications visit http://geospatial.osu.edu/ and http://precisionag.osu.edu.

For more information, contact:

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