SDSU Extension

iGrow Wheat

BEST MANAGEMENT PRACTICES

Chapter 16:
Space-based Precision Farming Wheat Management Tools

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The purpose of this chapter is to discuss spaced-based precision farming tools that have been developed for producers in the Dakotas, Montana, Wyoming, eastern Minnesota, and Idaho. Numerous sources of no-cost remote sensing data and decision tools are available at http://www.umac.org/.

Introduction

Precision agriculture technologies enable producers to take into account data from multiple sources and to develop efficient management practices based on the spatial and temporal variability of crop production. Geospatial technologies include remote sensing data, other spatial data, and software tools that enable users to make effective management decisions based on spectral, temporal, and locational relationships. The tools associated with geospatial technologies can help address agricultural needs for rapid analysis (interpretation and decision-making).

Remote-sensed information can be used alone, or synthesized with information from other sources, allowing for consideration of more variables in the decision-making process. The Upper Midwest Aerospace Consortium (UMAC), which is funded by NASA, has been developing decision tools for producers and ranchers in South Dakota, North Dakota, eastern Minnesota, Montana, Wyoming, and Idaho.

UMAC has developed:

- *Digital Northern Great Plains (DNGP)*: a geospatial data archive, one of the largest collections of satellite imagery and geographic information systems (GIS) layers freely available in the UMAC region.
- *ZoneMAP*: a web-based decision-support tool to develop variable zone application maps.
- *AEROCam and ISSAC*: two sensors designed for land and agricultural management, operating on an aircraft and on-board the International Space Station (ISS), respectively.

Digital Northern Great Plain (DNGP)

http://dngp.umac.org/newdngp372/index.php

DNGP is a web-based geospatial data archive providing free access to downloadable satellite and airborne imagery and image-derived products such as NDVI (Table 16.1 and Fig. 16.1). DNGP is structured and designed based on two open source packages, GDAL (Geospatial Data Abstraction Library), which is a translator library for raster geospatial data formats, and MapServer, which is a platform for publishing spatial data and interactive mapping applications to the web (Zhang et al. 2010a).

DNGP delivers low- to medium-high and high-resolution multispectral data sets. The archive collection goes back 30 years. Current accessible images came from satellites and sensors described in Table 16.1. All accessible images are terrain corrected data, which includes atmospheric, radiometric, and geometric correction and orthorectification, and therefore, the images are compatible with other geographic maps or geo-referenced data sets such as yield, soil, soil electrical conductivity maps, etc.

Currently AEROCam data (aircraft-based) are typically only corrected radiometrically. However, geometric correction, including orthorectification, can be done on a request basis. ISSAC's first image was acquired in June 2011. Higher quality level data delivered should be terrain corrected, i.e., data delivered should be radiometrically and atmospherically corrected, as well as geo-referenced.

DNGP users have the option to download data in a raster format or in a text file format, compatible with precision farming software tools. These text files contain the latitude and longitude of the center point of each pixel and the data value for this pixel. DNGP allows users to define and save their own image sub-sets, also named Area of Interests (AOIs), to simplify recurring access to data over the same field or location, and/or facilitate the download operation even with slow Internet connection.

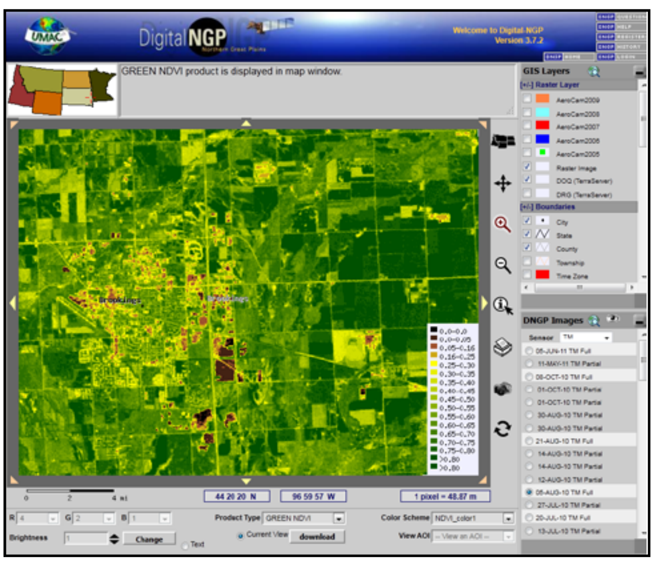

Figure 16.1. DNGP screen-shot: Displaying a Landsat TM image over Brookings, SD, acquired on June 5, 2010. Product selected is GreenNDVI. Panels list available GIS layers (upper right) and all the images covering the area (lower right). (Source: DNGP)

Table 16.1. DNGP – Satelite and sensores imagery available to users.

Satelite/sensors	Spacial resolution (Pixel size)	Bands and products downloadable	Temperal resolution
Low to Medium-high resolution			
Landsat MSS, TM, ETM+	TM-ERM+: 30m MSS: 60m	Band 1 to 7 - True and false color NDVI & Green NDVI	16 days
ASTER	15m VNIR 30m SWIR	Green, Red, NIR NDVI & Green NDVI	--
MODIS	250m	Red & NIR Natural color composite, NDVI & Green NDVI	1 week
ISSAC	20-18m	Green, Red & NIR NDVI & Green NDVI	On-request
High-resolution			
AEROCam Airborne sensor	2m to 0.5m	Blue, Green, Red or Green, Red, NIR	On-request
Shuttle Radar Topo. Mission	30m	Elevation (surface relief) data	--

Zone Mapping Application for precision farming (ZoneMAP)

http://zonemap.umac.org/

ZoneMAP is a decision support tool that captures variations in nutrient content, yields, or plant conditions using information provided by remote sensing technology and/or routine field surveys. ZoneMAP can use yield monitor or remote sensing data. It helps users design variable rate application maps. The algorithm used to create ZoneMAP clusters is the Fuzzy C-means. ZoneMap is internally linked to DNGP, the UMAC geospatial data archive.

ZoneMAP computes the optimal number of management zones and their delineation over an area based on satellite imagery, accessed directly from DNGP or provided by users, and field data provided by users (Fig. 16.2). Satellite images are cropped automatically to the area of interest (AOI) defined by users, and are re-projected and re-sampled to a common projection plan with a pixel size defined by users. Users can also input other types of data such as yield, soil or soil electrical conductivity, to be used during the cluster process. Those data must be in a classical grid text format (latitude, longitude, and parameters values) or in a raster format.

All created maps are saved in a secure online database, and every map is automatically associated with its metadata file describing the procedure and data set used for the classification. Users can input an application rate to generate a variable rate application map. Final output maps can be downloaded in raster, text, or shape file format with a wide number of possible map projections (Fig. 16.2). ZoneMAP can be accessed at http://zonemap.umac.org/.

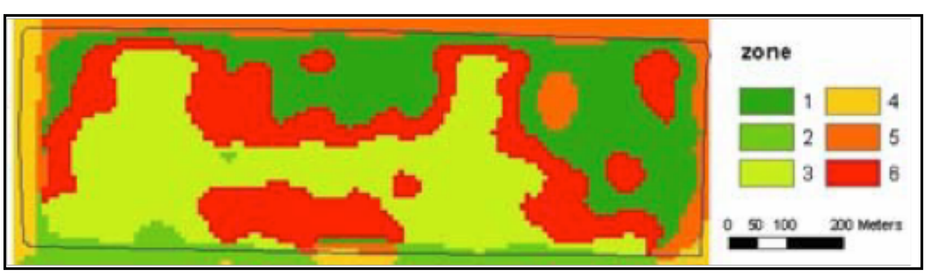

Figure 16.2. A management zone map produced using space-based information collected in the Fall of 2003. (Zhang et al. 2010b)

AEROCam

The Airborne Environmental Research Observational Camera (AEROCam) is an airborne multispectral sensor offering near real-time high resolution imagery to a variety of end-users throughout the UMAC region (Fig. 16.3). AEROCAM sensor is a Redlake MS4100 multispectral sensor, blue-green-red-near infrared, providing true color (blue, green, red) or false color (green, red, near infrared) images. Typically AEROCam images are only corrected radiometrically. Geo-rectification is not automatic but can be performed at user's request. If performed, delivery of a geo-rectified product takes several weeks or longer. AEROCam spatial resolution is typically 1 meter, but can range from 2 to 0.5 meters at user's request. AEROCAm data are acquired on demand and are accessible through DNGP.

South Dakota users can request AEROCam imagery by filling out a request form. The AEROCam request form can be accessed at http://www.umac.org/sensors/aerocam/index.html.

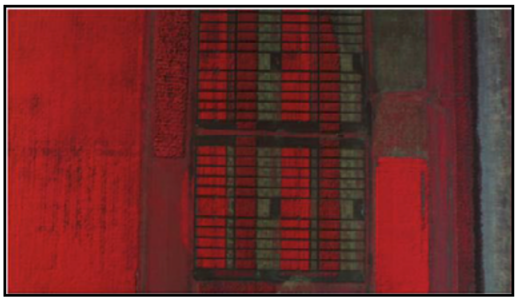

Figure 16.3. Aerocam false color imagery shows agronomy trial plots at North Dakota State University in Fargo, ND. The strength of red colors relates to plant vigor and health.

ISSAC

The International Space Station Agricultural Camera (ISSAC) is a three-band multispectral sensor, green-red-near infrared, on board the International Space Station (Fig. 16.4). ISSAC's first image was taken on June 10, 2011. However, images still need to be tested and calibrated before they can be distributed to users. Following onboard testing and calibration, farmers, ranchers, land-use managers and researchers in the UMAC region will begin benefitting from these space images.

The sensor is expected to have a spatial resolution of 18 to 20 meters. ISSAC near real-time delivered products are planned to be the following:

- L0: raw uncorrected image (current stage)
- L1R: radiometric correction
- L1G: L1R plus geo-referenced data
- L2A: L1G plus atmospheric correction

Data will be acquired on request, and images will be accessible through DNGP, as well as the other ISSAC image-derived products such as NDVI and GreenNDVI.

ISSAC website can be accessed at http://www.umac.org/sensors/issac/index.html.

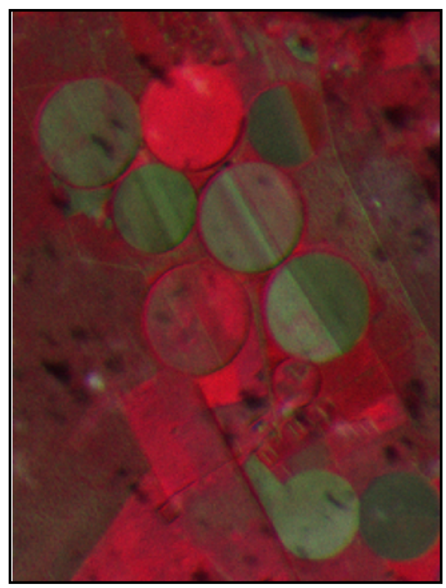

Figure 16.4. ISSAC image (06/10/2011, raw uncorrected data) taken over agricultural fields near Natal, Grande Rio do Norde, Brazil. False color composite with reds depicting growing plants.

ISSAC's purpose-built web application, Imagery Request and Information System (IRIS) can be accessed at http://www.umac.org/iris/login.html.

Glossary

Geospatial technologies

Any of a wide range of information technologies dealing with land/water, which have a locational reference (i.e., geographic or spatial coordinate systems). This includes GPS, GIS, remote sensing, land surveying, among others.

Electromagnetic spectrum

Energy that is characterized by wavelength and/or frequency, including gamma radiation, ultraviolet energy, visible light (reflected), near infrared light (reflected), thermal energy (emitted) and microwave energy.

Multispectral data

Data recorded by sensors that are sensitive to defined regions of the electromagnetic spectrum; typically land managers use data from the visible and near infrared areas.

Remote sensing

The art and science of collecting/recording data from a distance utilizing the electromagnetic spectrum. The distances can be very close or very far satellite sensors and telescopes.

Pixel

Short for picture element and represents the smallest division of a picture or image.

Raster format

A data format that relates to a row-column array of data over a geographic area. For example, a 20 m pixel represents an area on the ground that is 20 m on one side, typically with one reflectance value. One single scene of remote sensing data will be made up numerous pixels by spectral band, each of which is separate. Composite images are made by overlaying multiple bands (co-registered) to generate various color products (e.g., true color or color infrared).

Rectification

A process of eliminating various distortions in imagery/photography, and it focuses generally on eliminating scale variations to the extent possible.

Radiometric correction

A preprocessing procedure conducted in order to remove noise and/or other distorting contributions (atmospheric, sun angles, etc.) to digital numbers (DN), which is the numerical spectral value for a given pixel.

NDVI

Normalize Difference Vegetation Index, a calculation on a pixel-by-pixel basis that generally enhances the visualization of growing vegetation. It is generated by an algorithm that uses this visible and near-infrared data: near infrared value – visible (usually red) value divided by near infrared + visible values. It takes advantage of the fact that growing vegetation is very highly reflective in the near infrared region, but is not as reflective when under stress or not growing.

Additional information and references

Zhang X., S. Seelan, and G. Seielstad, 2010a. Digital Northern Great Plains: A web-based system delivering near real time remote sensing data for precision agriculture. Remote Sensing, 2(3):861-873.

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