DEVELOPMENT OF A VALUE-ADDED, REMOTELY SENSED PRODUCT FOR COMMERCIAL DISTRIBUTION*

John M. Lomas
Kevin P. Price
Edward A. Martinko
Stephen L. Egbert
Dietrich L. Kastens
Kansas Applied Remote Sensing Program
University of Kansas
2291 Irving Hill Drive, Lawrence KS 66045 USA

Alexander J. Tuyahov
Earth Science Applications Research Program
NASA Headquarters, Code YO
300 E Street, S.W.
Washington, DC 20456 USA

ABSTRACT

Applications developed from remotely sensed data can provide natural and agricultural resource managers with critical information on vegetation health and vigor. The usefulness of such applications is dependent upon the timeliness of the data delivery and the ability of users to extract meaningful information. Although remotely sensed data have been readily available for over 25 years, developing products that were both timely in delivery and useful for strategic planning was cost prohibitive due to technological limitations in the processing and delivery systems. To overcome these limitations, in 1991 the Kansas Applied Remote Sensing (KARS) Program at the University of Kansas joined with a private company to establish *TerraMetrics, Inc*., formed to develop and distribute value-added remote sensing and GIS products. The first product to be developed was The *GreenReport®*, which is a set of four maps produced each week from AVHRR composites for the conterminous United States, that illustrate vegetation/crop condition and progress. *Agrimetrix* was formed in April of 1999 to create products that combine historical and real-time remotely sensed data with historic weather data, to model and predict trends in vegetation growth and condition.

INTRODUCTION

The agricultural industry needs timely and continuous information regarding crop/vegetation progress and condition. The Kansas Applied Remote Sensing (KARS) Program at the University of Kansas, with support from NASA's Earth Science Applications Research Program have worked to

*Presented at the Second International Conference on Geospatial Information in Agriculture and Forestry Conference, Lake Buena Vista, Florida, 10-12 January, 2000. Pp. 140-147.

develop commercially viable products based on remotely sensed data. The first product that resulted from this initiative, The *GreenReport*®, is designed to complement the U.S. Department of Agriculture's weekly "Crop Weather Report." The *GreenReport*® consists of a series of four maps created from National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) remotely sensed data, generated from Normalized Difference Vegetation Index (NDVI) biweekly composite images produced at EROS Data Center, Sioux Falls, SD (Eidenshink, 1992) . The *GreenReport*® provides valuable information concerning crop progress and vegetation conditions within the conterminous United States.

In an effort to expand its technology transfer programs and to improve distribution of commercial products and services, KARS established a working relationship with a local business development company in 1991. Soon after this relationship was formalized, a new technology transfer company, *TerraMetrics, Inc*. (TMI) was formed. In 1999 the KARS Program joined *Strategic Weather Services,* (Wayne, PA), *The Farm Journal*, (Philadelphia, PA) and *TMI* to establish a joint venture company called *Agrimetrix*. Together, these three companies have the necessary expertise in digital image processing, algorithm development, computer modeling and simulation, marketing, and business management to develop and market remote sensing value-added products.

THE GREENREPORT ®

Adverse weather routinely costs U.S. businesses $34.5 billion each year, according to 1992 Department of Commerce studies. Agriculture accounts for $22.4 billion of that total, or nearly ten times the losses routinely incurred by construction, the second most affected industry. According to the Food and Agriculture Organization of the United Nations, worldwide agricultural losses due to weather exceed $100 billion annually. Weather, disease, and pest related losses in agriculture can be reduced by knowing in advance the condition of crops and yield potential. In 1996, the NASA Earth Science Applications Research Program initiated a project with the Kansas Applied Remote Sensing Program to develop a means of using remotely sensed imagery to assess vegetation conditions and monitor grain crops in the Midwestern United States. The result of this effort was the development of a commercially distributed product called the *GreenReport*®

The *GreenReport*® is a set of four maps produced each week for the conterminous United States that illustrate vegetation/crop condition, progress, and relative state of development. The *GreenReport*® maps are produced on a weekly basis using moving biweekly, Maximum Value Composite NDVI images compiled at EROS Data Center from AVHRR 1 km imagery.

The four maps (Fig. 1) include (presented for this publication in black and white) a Vegetation Greenness Map, which shows the NDVI greenness values of vegetation and crops and three "difference" maps. Greenness Difference Map1 is used to monitor vegetation/crop progress by comparing the current biweekly image to the previous biweekly period. Greenness Difference Map 2 is used to compare vegetation/crop condition and progress to the previous year. Greenness Difference Map 3, is used to compare vegetation/crop condition and progress to the ten-year NDVI

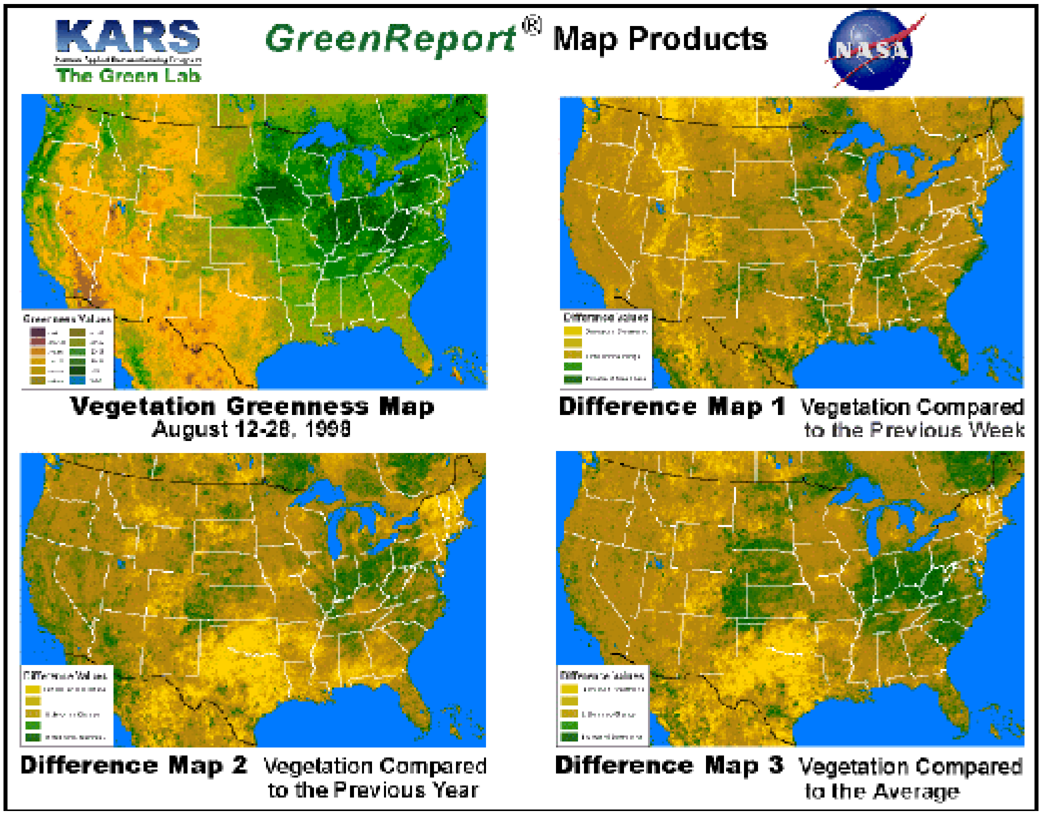


Figure 1. *GreenReport®* Map Products

average. After the basic map set is produced for the conterminous United States, areas of interest such as the cornbelt, wheatbelt, or individual states and counties can be extracted from the lager maps to present a more detailed view. In the past, attempts to market NDVI images have met with little success. One problem was that most users were unable to easily extract useful information from individual NDVI images alone. By creating "difference maps" that compare NDVI values from the present period to maps of the previous biweekly period, to the previous year, and to the average NDVI, the user can observe the current vegetation conditions relative to other time periods and to average values.

By making current NDVI values relative to other periods with the difference maps, we are doing much the same as weather forecasters who provide comparative analysis, and give high, low, and average temperature and precipitation values.

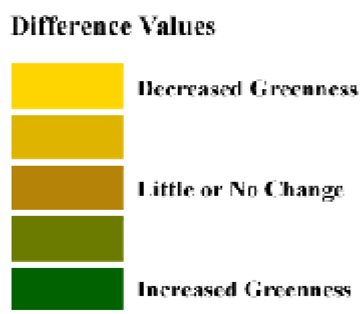


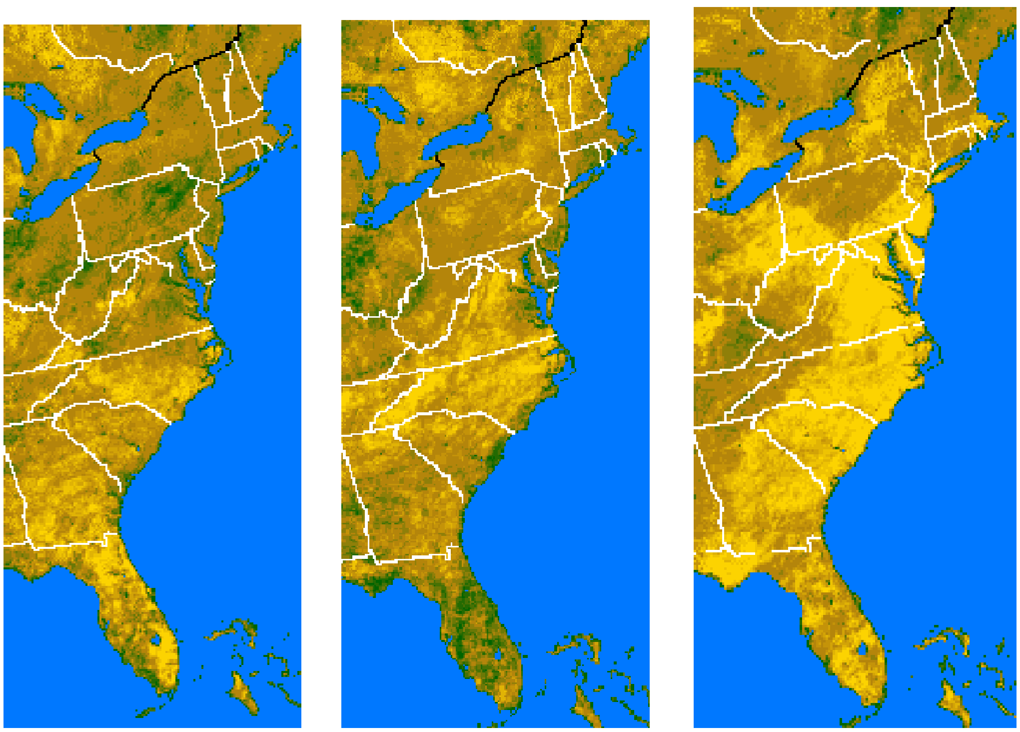
Figure 2. Difference Legend

A Difference Map legend (Fig. 2) illustrates the range of difference values represented in the maps. The basic utility of the *GreenReport®* is to provide the user with a tool for a qualitative visual analysis of crop/vegetation progress and relative condition.

APPLICATIONS

Maps produced from remotely sensed data can provide critical information on the health and vigor of vegetation, information that is important to resource managers in the agriculture industry. Satellite data can be used to illustrate vegetation/crop progress and conditions on a continuous basis, and enhance current crop reporting techniques.

The east coast of the United States suffered one of its worst droughts in recent history during the summer of 1999. The difference maps that compare the current greenness conditions with the 10-year average (Fig. 3), illustrates the spreading distribution of drought through the southeast and eastern U.S. beginning in mid-June, followed by mid-July and mid-August, 1999. Light areas on the map indicate vegetation that is less green than normal. Maps such as these are useful for monitoring drought events and determining their impacts on human populations.



June July August

Figure 3. The East Coast Drought, summer 1999. This Series of Maps Was Created by Comparing the Current NDVI Values to the 10-Year Average During the Mid-June, Mid-July, and Mid-August Periods. Light Areas on the Map Indicate Locations Where Vegetation Was Developing Behind the 10-Year Average.

The spring of 1999 brought four to six inches of rainfall to north-central Iowa between June 1 and June 12, which resulted in delayed planting and damage to emerging corn and soybean crops. Affected areas are seen in the central part of the map shown in Figure 4 which compares the current NDVI values to average values for mid-June. The map also shows that crop and vegetation greenness in adjacent areas that received less rainfall were close to normal.

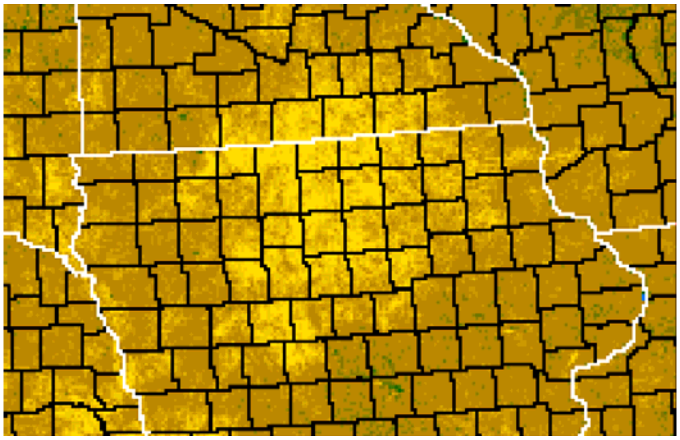
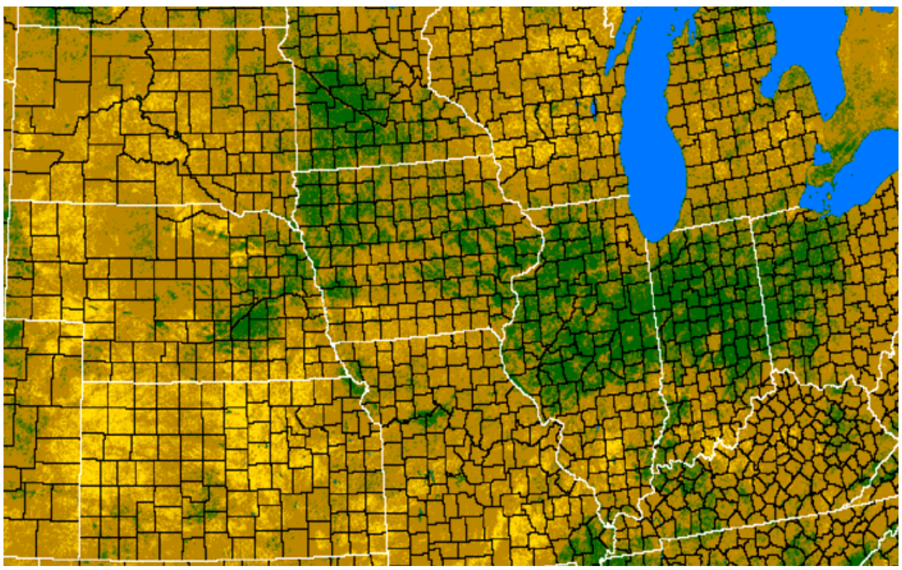


Figure 4. North-Central Iowa, June 1999. This Map Was Created by Comparing the Current NDVI Values to the 10-Year Average for Mid-June. Light Areas Indicate Vegetation that is Developing Behind the 10-Year Average

By using Difference Map 1, which compares the current NDVI values to the previous period within the same year, crop/vegetation progress can be monitored. A map of the cornbelt (Fig. 5) compares late-June greenness to early-June, 1999. Dark areas on this map represent row crops (mostly corn and soybeans) that have increased in greenness since the early June period. Such differences indicate where plants are actively growing. The dark areas on this map show the spatial distribution of the major corn and soybean growing areas (cornbelt) of the Midwest. Note, also on this same map that areas in north central Kansas and southern Illinois are light grey indicating locations where winter wheat has matured (decreased in greenness) or has been harvested. The ability to monitor crop and vegetation growth over a growing season with satellite data provides users with a means to determine relative health, vigor, and yield potential for their areas of interest.

Figure 5. Cornbelt Region in Late-June, 1999. Dark Areas on this Map Represent Row Crops (Mostly Corn and Soybeans) That Have Increased in Greenness since the Early-June Period



ADDITIONAL PRODUCTS

As a result of ongoing commercialization efforts, customized map projects, data sets, and vegetation production models are being developed by scientists at KARS utilizing the data sets that are the foundation of the *GreenReport®*   In 1998, KARS scientists used satellite imagery as input to their models to forecast yields for corn and soybeans in Iowa. The results were extremely encouraging, and now similar models are being developed for the major grain producing areas of the U.S.

Using the10-year NDVI data set for the U.S., Vegetation Phenology Metrics (VPM) were extracted from AVHRR NDVI biweekly maximum value composites using a time-series analysis approach similar to the one described by Reed *et al.* (1994). These metrics are descriptive of various vegetation phenological growth stages reached throughout the growing season. By computing the VPMs for all 10 years (1989-1998), current VPMs can be compared to the 10-year average, the previous year and the previous period. Certain metrics have proven to be useful for identifying agricultural areas dominated by particular crop types such as the wheatbelt and cornbelt. The VPM products and their associated data sets are now being integrated with meteorological data in ways that improve crop yield forecasts and condition assessment.

DEVELOPMENT OF A MARKETING NETWORK

The *GreenReport®* is now being distributed to over 10,000 end users and we are in the process of expanding the distribution network to over 650,000 potential users. Although satellite data has been readily available, the ability to deliver remote sensing data, information and products to end uses in a timely manner has always been a limiting factor to the commercialization process. In 1991, a remote sensing/GIS technology transfer company was established through a cooperative agreement between the KARS Program and Campbell-Becker, Inc. (Lawrence KS). The result of this agreement was the formation of *TerraMetrics, Inc.*, a new company focused on the distribution of value-added remote sensing products. Presently, there are three divisions of specialization within *TMI*: Aquatic Ecosystems, Terrestrial Ecosystems, and Remote Sensing and Geographic Information Systems (GIS), each designed to complement the other divisions. The Aquatic and Terrestrial Ecosystems divisions of *TMI* interact with scientists at the University of Kansas Biological Survey and KARS Program.

In 1995, KARS and *TMI* announced the development of the *GreenReport®* and established a commercial partnership with *WeatherExpress* (Omaha, NE), who distributed the *GreenReport®* to national data and information providers such as *Broadcast Partners* (Cedar Rapids, IA), *Market Communications Group* (Kansas City, KS), and *Data Transmission Network* (Omaha, NE).

Currently the *GreenReport®* is featured on the Chicago Board of Trade "Big Board" and is available on (Fig.6):

- KARS Internet Site http://www.kars.ukans.edu - A site featuring 1997-1999 GreenReport map sets and information about KARS and other products
- FutureSource/ProFarmer Agricultural/WeatherPackage http://futuresource.com/promo/wex/agenergy - Current data available to registered users.
- AgriBiz Internet Site http://www.agribiz.com/weather/vegative.html - A site featuring Illinois GreenReport Map sets and information.

- Data Transmission Network (DTN) Forestry Package http://dtn.com/weather/forestry - Current data available to registered users.

Figure 6. Marketing Network

AGRIMETRIX

Agrimetrix, a joint venture company (Fig.7) consisting of *TerraMetrics, Inc.* (Lawrence, KS*), Strategic Weather Services* (Wayne, PA), and *The Farm Journal* (Philadelphia, PA), was formed to provide strategic solutions to many of the problems experienced by agriculture worldwide. The company represents the convergence of satellite-based crop/soil sensing technology and reliable commercially proven long-range weather forecasts, creating an unprecedented understanding of the future impact of worldwide weather on all facets of agriculture and the businesses that support it. *Agrimetrix* will not eliminate all of the problems, inefficiencies, and financial losses caused by weather, but it will help to minimize the impact that adverse weather has on agricultural enterprises.

Figure 7. *Agrimetrix* and its Companies

TerraMetrics, Inc. is affiliated with the KARS Program and the Kansas Biological Survey, incorporating nearly 30 years of agricultural and natural resources research and product development experience. *TerraMetrics* has developed proprietary models to determine crop yields, and techniques to monitor crop condition and vegetation change using remotely sensed data.

Strategic Weather Services has been providing weather forecasting and advisory services to companies for over sixty years. Their business clients are given highly reliable, long-term forecasts for a variety of strategic, business, and event planning decisions. Strategic Weather utilizes sophisticated proprietary technology involving higher mathematics and atmospheric physics to project future weather events.

The *Farm Journal* has more than 1.1 million readers who rely on a family of publications to provide them with perspective and analysis on developments in the nation's largest industry: American Agriculture. Farm Journal was founded in Philadelphia in 1877 and boasts 660,000 subscribers nationwide, making it the largest circulation farm magazine. In addition to Farm Journal Magazine, the company also publishes “Top Producer”, a business magazine for executive farmers, and three magazines serving the livestock industry: “Hogs Today”, “Beef Today” and “Dairy Today”. *Agrimetrix* is developing and delivering custom products for agri-business based on the use of remotely sensed data, crop/vegetation modeling, and the incorporation of long and short term weather forecasting. Potential clients will be ag-chemical companies, the grain storage and transportation industries, insurance companies and commodity traders.

THE GP-RESAC AND ITS ROLE IN COMMERCIALIZATION EFFORTS

In 1999 the KARS Program was designated as a NASA Regional Earth Science Applications Center (RESAC) for the Great Plains (GP-RESAC). The overarching goal of the Great Plains RESAC is to put the results of basic and applied remote sensing research, as they relate to the Great Plains region and its agroecosystem, into the hands of end users (Fig. 8). To accomplish this goal, the following objectives for the GP-RESAC were identified:

- Expand existing partnerships to create a dynamic end-to-end consortium representing the research, service, and end-user communities of the Great Plains agroecosystem.
- Use remote sensing and related technologies to develop an understanding of the near-term productivity and long-term sustainability of the Great Plains agroecosystem.
- Use remote sensing data and technologies to create products and decision support tools for end users in the public and private sectors of the Great Plains agroecosystem.
- Distribute remote sensing-derived products and decision-support tools to end users, generating income for self-sustainability.
- Evaluate the effectiveness of value-added remote sensing products to the Great Plains end-user community through conferences, market research, and other performance metrics.

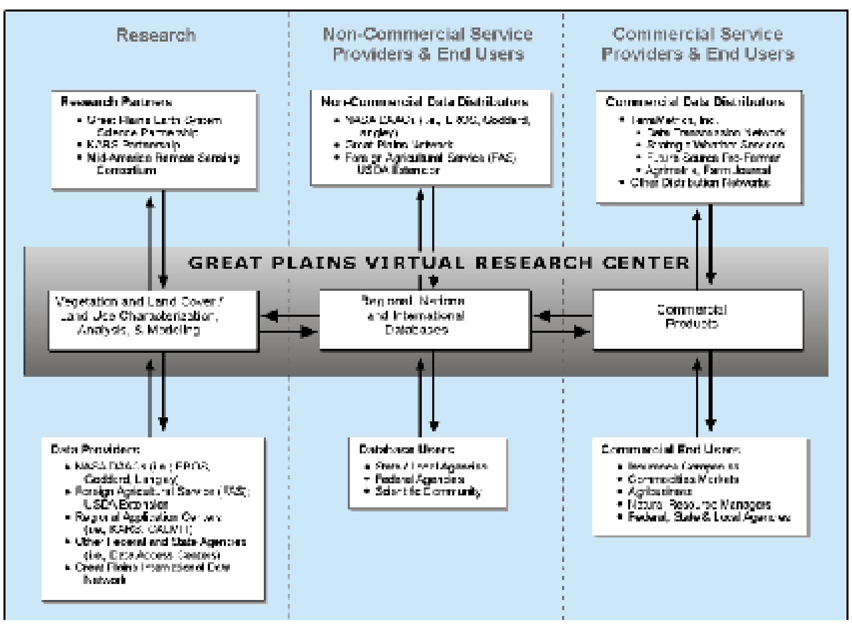


Figure 8. Great Plains RESAC Organization

CONCLUSION

At the outset of the remote sensing era, the agricultural economy was recognized as representing the largest potential end-user community for products and technologies derived from remote sensing. Value-added products from satellite imagery held the promise of major economic benefits through early detection of plant stress from disease and drought, accurate crop yield monitoring, near real-time forage condition reports, and many others. Today, despite considerable fundamental and applied research, that promise remains largely unfulfilled. There remains a dearth of cost-effective, relevant, user-friendly products that can be used by non-technical end users in their decision-making.

Through the Great Plains RESAC, we propose to put information derived from NASA Earth Science Enterprise sensors into the hands of agroeconomic end users. Through *Agrimetrix* we plan to distribute value-added remote sensing products to end-users. *Agrimetrix* is already working to integrate long-range forecasts of weather trends with remotely sensed measurements of vegetation phenology to develop products that will be of considerable value to agricultural businesses for strategic planning purposes. New methods for marketing these products are being designed and international markets are being developed. Given the new suite of satellite remote sensing systems that will soon be deployed, we are confident that many new remote sensing products will become available in the near future.

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For More Information about Agrimetrix or any of the companies and services mentioned in this article or the Kansas Applied Remote Sensing Program (KARS)

please contact:

Dr. Edward Martinko, Director,
KARS GP-RESAC
2291 Irving Hill Road
Lawrence, Kansas 66045
785-864-7720
e-martinko@ukans.edu
www.kars.ukans.edu

William S. Weaving, Director
Agrimetrix
1325 Morris Drive
Wayne,PA 19087-5521
610-640-9485
Bill_Weaving@StrategicWeather.com

William S Weaving
Strategic Weather Services
1325 Morris Drive
Wayne, PA 19087-5521
610-640-9485
Bill_Weaving@StrategicWeather.com

Sam Campbell, President
TerraMetrics, Inc.
1321 Wakarusa Drive, Suite 2102
Lawrence, KS 66049
785-841-7120
scamp@sunflower.com

Earl P. Ainsworth, Executive V.P. Publishing
Farm Journal
39 Moore Street
Princeton, NJ 08540
609-497-1795
eainsworth@aol.com