ANNUAL PERFORMANCE REPORT ON NASA GRANT #NCC5-588

PROJECT ENTITLED:

"The Use of Remote Sensing for Monitoring, Prediction, and Management of Hydrologic, Agricultural, and Ecological Processes in the Northern Great Plains"

REPORT PERIOD:

9/1/01-8/31/02

PRINCIPAL INVESTIGATOR:

Dr. Sherry O. Farwell
Director of the SD Space Grant and NASA EPSCoR Program
South Dakota School of Mines & Technology
Rapid City, SD 57701
Telephone: 605-394-2493
Fax: 605-394-5360
E-mail: Sherry.Farwell@sdsmt.edu

NASA TECHNICAL OFFICER:

Diane DeTroye, 085.0
NASA HQs, Code FE
Washington, DC 20546-1069
Telephone: 202-358-1069

REPORT DATE:

10/7/02

BACKGROUND INFORMATION

The NASA-EPSCoR program in South Dakota is focused on the enhancement of NASA-related research in earth system science and corresponding infrastructure development to support this theme. Hence, the program has adopted a strategy that keys on research projects that a) establish quantitative links between geospatial information technologies and fundamental climatic and ecosystem processes in the Northern Great Plains (NGP) and b) develop and use coupled modeling tools, which can be initialized by data from combined satellite and surface measurements, to provide reliable predictions and management guidance for hydrologic, agricultural, and ecological systems of the NGP. Building a partnership network that includes both internal and external team members is recognized as an essential element of the SD NASA-EPSCoR program. Hence, promoting and tracking such linkages along with their relevant programmatic consequences are used as one metric to assess the program's progress and success.

This annual report first summarizes general activities and accomplishments, and then provides progress narratives for the two separate, yet related research projects that are essential components of the SD NASA-EPSCoR program

GENERAL ACTIVITIES DURING YEAR 1

Trips and Linkages. Funding in excess of $8,000 was provided from the project's core budget to support the travel of 22 EPSCoR team members to NASA Centers, NASA HQs, or NASA-related meetings. This opportunity for travel support was announced by a general e-mail to faculty members at SDSM&T, SDSU, and Augustana College. The announcement specified the required applicant information in addition to noting that a short report must be submitted at the conclusion of the travel. Authors of such reports were asked to summarize the linkages to NASA personnel and/or projects as a consequence of such sponsored trips. A listing of this travel along with the trip report summaries are given at http://www.sdsmt.edu/space/nasaepscor/trips.htm

Some specific examples of meetings and the corresponding benefits already derived from this travel support are:

- Dr. Lee Vierling (SDSM&T), Dr. Bill Capehart (SDSM&T), Dr. Changhui Peng (SDSM&T), Dr. Pat Zimmerman (SDSM&T), Dr. Dan Swets (Augustana), and Dr. Steve Matzner (Augustana) had a meeting on November 7, 2001 with Dr. Dan Deering and Dr. Alexis Conley from NASA-GSFC to discuss mutual interests in obtaining improved estimates of leaf area index via remotely sensed observations. This meeting resulted in a collaborative experimental and modeling plan that has become an integral part of the SD NASA-EPSCoR research project entitled "Leaf Area Index for Fire Chronosequences of the Black Hills and Southern Siberia: A Comparative Study."
- Dr. Dennis Helder took four of his SDSU associates to the annual three-day workshop for the Joint Agency Commercial Imagery Evaluation Team (JACIET) that was held during late March 2002. After this workshop, they spent one day at NASA-GSFC visiting colleagues in the Landsat Project Science Office. Dr. Helder briefed the GSFC group on Landsat 5 & 7 sensor

stabilities and they subsequently discussed a potential collaborative, long term project that would further investigate these stability issues.

- Dr. Chris Jenkins (SDSM&T) is currently involved with Dr. Bar-Cohen (JPL), Dr. Salama (JPL) and Dr. Vinogradov (Montana State Univ.) in a NASA-SBIR Phase I project on incorporating active control elements into gossamer spacecraft. He traveled to JPL in February 2002 to meet with his two JPL colleagues to prepare a proposal for Phase II funding. This meeting at JPL resulted in an invitation for Dr. Jenkins to present a paper at the Gossamer Aperture Technology Workshop in May 2002.
- Dr. David Clay and five of his SDSU associates attended the 6th International Conference on Precision Agriculture in July 2002. The SDSU group presented 11 papers at this conference. Dr. Clay visited with Dr. Keith Morris (NASA-Stennis) at the conference about future opportunities in the Ag 20/20 program and Dr. Morris noted his willingness to collaborate on projects using remote sensing in agriculture.
- Dr. Mikhail Foygel (SDSM&T) visited the Army Research Laboratory in March 2002 to discuss the fundamental nanotechnology research he is doing in cooperation with Dr. Robin Morris of NASA-Ames. As a result of this ARL visit, Dr. Foygel has obtained a grant from ARL and his collaborator on this new project is Dr. Morris.

The project director, Dr. Sherry Farwell, attended various conferences and meetings relevant to the SD NASA-EPSCoR program. These included: a) the SD NASA-EPSCoR Steering Committee meeting in Sioux Falls on September 17, 2001, b) the National Underground Science Workshop in Lead on October 4-6, 2001, c) the Geomicrobiology Workshop in Lead on November 30-December 1, 2001, d) the Project Science Workshop at CalTech on January 18-19, 2002, e) the National Space Grant Directors Meeting in Washington, DC on March 20-23, 2002 (and attended the "First NASA-EPSCoR Caucas on March 21), f) the Annual SD Space Day in Brookings on April 5, 2002, g) visited the Washington Space Grant Consortium in Seattle on April 12, 2002, h) the American Physical Society Meeting in Albuquerque on April 21-23, 2002, i) SD asteroid plaque presentation to Governor William Janklow in Pierre on April 29, 2002, j) the Prairie Wetland Carbon Sequestration Meeting in Jamestown on May 16, 2002, k) the Earth Science Workshop in Berkeley on May 29-30, 2002, l) the DoE-EPSCoR Workshop in Richland on June 5-7, 2002, m) the NA/NRC Meeting on Underground Science in Georgetown on June 24-25, 2002, n) the DoD-EPSCoR Workshop in Laramie on August 7, 2002, o) the NSF-IGERT Workshop in Boulder on August 15, 2002, p) the National EPSCoR Conference in Anchorage on September 8-11, 2002, and q) the Neutrinos and Subterranean Science Conference in Washington, DC on September 19-21, 2002.

Steering Committee Meetings. This committee consists of Dr. Dan Swets and Dr. Steve Matzner from Augustana College, Dr. Lee Vierling and Dr. Pat Zimmerman from SDSM&T, and Dr. Dennis Helder and Dr. Dave Clay from SDSU. Dr. Dan Swets functions as the committee's chair; however, he was on sabbatical leave from December 2001 through August 2002 and Dr. Matzner acted as the interim chair during this period. Dr. Farwell usually attends these meetings upon the request of the chair, but is there to only provide

information and does not vote. To-date, the Steering Committee has met three different times, once for a face-to-face meeting and twice by teleconference. The dates and minutes from these meetings are available at http://www.sdsmt.edu/space/nasaepscor

Now that Dr. Swets has returned to his home campus after spending a sabbatical leave at the University of Mauritius, he will schedule another meeting of this committee in early November so they can address both continuing and new issues related to the evolving NASA-EPSCoR program in SD. Three important issues for the committee to address are final actions on the formation of the Technical Advisory Committee, awarding of SD NASA-EPSCoR program initiation grants, and mechanisms to further stimulate linkages to people and projects at NASA Centers and the EROS Data Center.

RESEARCH PROJECT SUMMARIES

Leaf Area Index for Fire Chronosequences of the Black Hills and Southern Siberia: A Comparative Study

This project is being carried out jointly between personnel at the South Dakota School of Mines and Technology, Augustana College, EROS Data Center, and NASA's Goddard Space Flight Center. During the first year of funding, significant progress has been made towards achieving the goals of this project. Below, we categorize the various aspects of the progress, listing the significant milestones or information under the appropriate categories:

Research Progress

1. Lee Vierling (Principal Investigator, SDSM&T) conducted initial fieldwork for this collaborative project at NASA-established research sites in Siberia during July 2001. Working with Dr. Vierling at the field sites were Alexis Conley (NASA-GSFC), Donald Deering (NASA-GSFC), and Sylvain Leblanc (Canadian Center for Remote Sensing), along with several collaborators from the Sukachev Forest Institute of Krasnoyarsk, Russia. This fieldwork completed the third year of data collection at the Siberia site and established data collection protocols for setting up comparison sites in the Black Hills of South Dakota.
2. A collaborative organizational/scientific conference of core project participants was held at SDSM&T on November 7, 2001. Presenting at this conference were Alexis Conley (NASA-GSFC), Donald Deering (NASA-GSFC), Nastia Kozhoukhovskaya (Sukachev Forest Institute), Lee Vierling (SDSM&T), Bill Capehart (SDSM&T), Pat Zimmerman (SDSM&T), Changhui Peng (SDSM&T), Dan Swets (Augustana College), and Steve Matzner (Augustana College). In addition, approximately 8 graduate students and research scientists attended the day-long conference. NASA collaborators Deering and Conley stayed in Rapid City for several days to develop a work plan for the project with the South Dakota PI's. During this visit Drs. Deering and Vierling also met with the directors of Horizon's Incorporated, a Rapid City-based photogrammetry company which owns a LIDAR (Light Detection and Ranging) instrument capable of gathering three-dimensional forest structure data that we are using to enhance our NASA-EPSCoR scientific and economic development efforts.

3. Three graduate students (Rachel Smith, Eric Rowell, and Xuexia Chen) completed remote sensing course projects relating to the goals of the NASA-EPSCoR grant during Spring, 2002. All three of these projects are being used as the foundation for further work in the students' NASA EPSCoR-related research programs. E. Rowell and X. Chen will be presenting their work at the 2002 Ecological Society of America Annual Meeting, and X. Chen's work will soon be submitted to the journal *Remote Sensing of Environment* (see below).
4. We have collaborated with Thomas DeFelice (USGS EROS Data Center) to acquire IKONOS imagery at the Black Hills Field sites via the NASA data acquisition program. This collaboration has yielded one scene so far, with two additional scenes requested for acquisition in the near future.
5. Site selection and data collection at the Black Hills sites has been under way since October 2001. This summer, a focused field effort involving four students and two PI's has been initiated. In addition, we have tested the Short Wave Aerostat Mounted Imager (SWAMI), an instrument package developed with funding from the National Science Foundation (PI: L. Vierling) that will complement our NASA-EPSCoR efforts. The SWAMI will be flown at our NASA-EPSCoR sites during the week of July 22, 2002.
6. A research-grade pneumatic boom is being transferred from Donald Deering's laboratory at NASA-GSFC to SDSM&T to support data collection at the Black Hills field sites. This boom is suitable for supporting a spectrometer at several heights above the forest floor, and will enable a new dataset to be collected that will assist with the estimation of Leaf Area Index (LAI) via satellite.

Presentations, Publications, and Proposals

This NASA-EPSCoR LAI project has spawned the following research activities:

Chen, X., Vierling, L., Dykstra, D., Rowell, E., and Capehart, W. "Assessing fractional tree coverage using IKONOS, Landsat 7, and LiDAR data in a ponderosa pine forest via sub-pixel interpretation." To be presented at the Ecological Society of America annual meeting, Tucson, AZ, August 2002.

Rowell, E., Vierling, L., Dykstra, D., and Chen, X. "Small footprint LiDAR estimates of canopy gap structure in a ponderosa pine forest." To be presented at the Ecological Society of America annual meeting, Tucson, AZ, August 2002.

Vierling, L., Rowell, E., and Dykstra, D. "LIDAR: A promising approach to estimating Western forest fire susceptibility." To be presented at the ESRI User's Conference, San Diego, CA, July 2002.

Vierling, L., Chen, X., Rowell, E., Dykstra, D., and Vierling, K. "Relationships Among Airborne Scanning LiDAR, High Resolution Multispectral Imagery, and Ground-Based Inventory Data in a Ponderosa Pine Forest." Presented at the IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Toronto, Canada, June 2002. Poster presentation. (Full 3-page paper has been published in IGARSS'02 proceedings.)

Chen, X., Vierling, L., Rowell, E., Dykstra, D., Capehart, W., and DeFelice, T. "Relationships Among IKONOS Imagery, Airborne Scanning LIDAR, and Ground-Based Tree Inventory Data in a Ponderosa Pine Forest: A Multiple Endmember

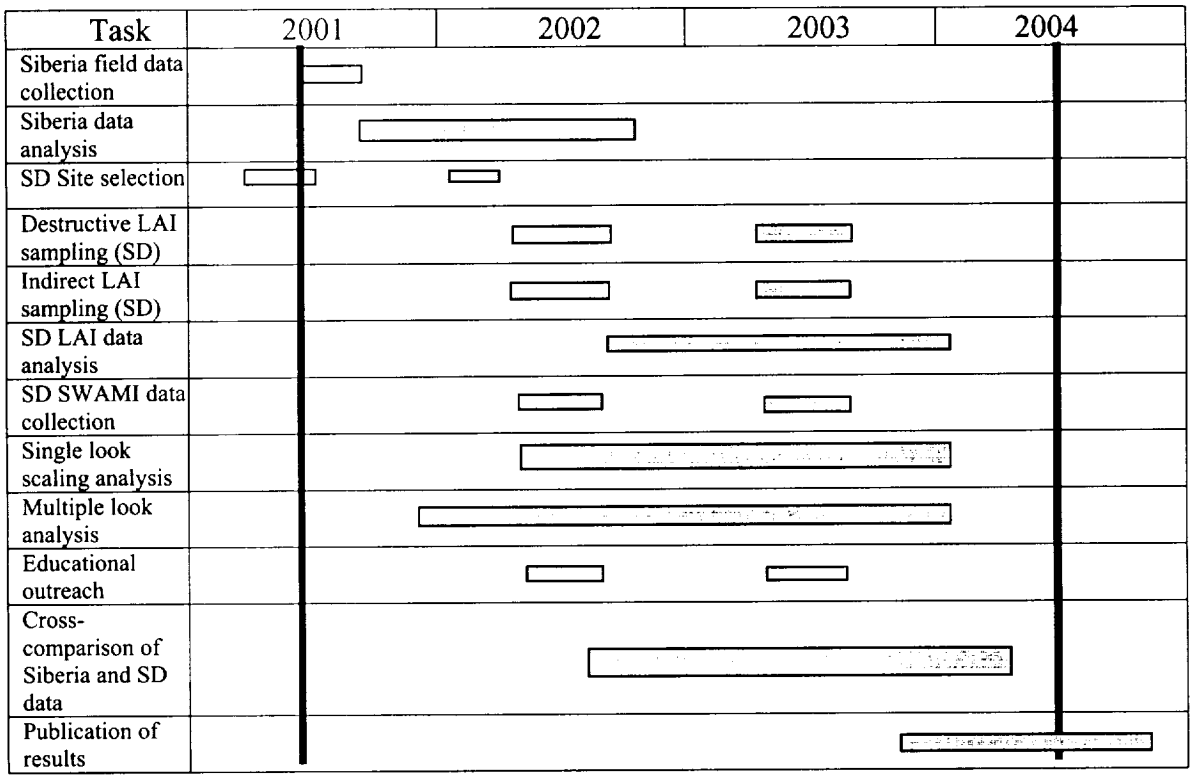
Approach." USGS/NIMA/NASA High Spatial Resolution Commercial Imagery Workshop, Reston, VA, March 2002. Oral presentation. This work is in preparation for submission to *Remote Sensing of Environment.*

The following proposals related to our NASA-EPSCoR LAI project have been submitted during the past year:

- NASA-PARC, through the Upper Midwest Aerospace Consortium, *"Developing Forestry Applications of LIDAR"* ($30,000 - FUNDED)
- SD SBIR office, *"Phase Zero: Development of Analysis Utilities for Forestry Applications Employing Airborne Scanning LiDAR, High Resolution Hyperspectral Imaging and Ground Based Inventory Data"* ($1,500 - FUNDED)
- USFS Agenda 2020 initiative, *"Use of Lidar Remote Sensing for Precision Forest Management"* ($150,000 - PENDING)
- USFS RESAC, *"Developing Lidar Data Analysis Tools for Assessing Forest Canopy Structural Heterogeneity"* ($100,000 - PENDING)
- NCSSF, *"Identifying Core Biodiversity Indicators to Apply to Sustainable Forestry"* ($120,000 - DECLINED)

Interactions with individuals from the SD Private Sector
Degtyaryov, B., Hoon, S., Hansen, J. Quail

Task schedule for LAI project is shown below:



Cross Calibration of Landsat and IKONOS Sensors for Use in Precision Farming

The use of optical sensors is a key element to developing precision agriculture tools and techniques. The sensor platforms can be handheld ('Fieldspec and Cropscan') aircraft based or space based ('Landsats 5 & 7, Ikonos, Quickbird'). Depending on the particular sensor, results can range from 'band measurements' to hyperspectral with wavelength ranges from: UV ... visible ... near IR ...thermal IR...far IR. Particular segments of this project utilize several of these platforms and sensors. This project's overall goal is to identify and develop techniques for precision agricultural applications based on the measurements by this platform/sensor set. These diverse sensing tools give us a powerful resource to utilize in pursuit of this goal; however, any time measurements are made using multiple sensors. Therefore, it is essential that a cross calibration database exists for the individual sensors. A useable system must incorporate broad based results which can be applied across a multiplicity of sensors.

During the past year, we focused on modifying previous developed tools to this project and preparing ourselves for the 2002 growing season. Research on this project is being conducted at our 'standard' well developed site (called '3M') along with several crop sites in the Brookings vicinity (which are being routinely evaluated by the plant science group). Data taking is coordinated based on satellite overpasses. Data taking for the precision agriculture project in conjunction with other vicarious satellite calibration projects will produce a major data collect every 1-2 weeks (obviously with weather permitting).

Calibration verification is a significant issue for us. Our ASD Fieldspec spectroradiometer is one of our primary field devices. General maintenance and upgrades were performed. In 2001 Stennis Spaceflight Center temporarily loaned us a large aperture integrating sphere for routine calibration verification. General reflectance measurements are made using a spectralon white reference panel in conjunction with the ASD. Improvements were made in the carrying case and mount system. The BRF (bi-directional reflectance function) was again measured in preparation for the 2002 season. The ASR (automated solar radiometer) underwent an extensive rebuild and recalibration. The unit we use ('Unit 8') is one of the earliest models still being fielded on a regular basis and is due for replacement. Construction of a new unit is being coordinated with the University of Arizona's Remote Sensing Group (and ECE department) for the winter of 2002-2003. A handheld band type spectrometer ('Cropscan') was procured by the plant science group. Extensive work has been done in verifying calibration of this unit.

As data collections become more frequent and include more instrumentation, the shear volume of both raw and processed data has become overwhelming. Consequently, a computer was acquired with an additional RAID controller and drive. A data archive (with structure) has been developed, archive administrators identified and the system is implemented for our 'new' data. We will incorporate the 'old' data into the structure as time permits. Routines have been established to somewhat automate the first pass data analyses (especially the Langley analysis). Our atmospheric model remains MODTRAN and we are still working to identify how to best handle that aspect. Cross platform calibration models are being developed as the data is acquired to accurately compare hyperspectral data to discrete band data.

Crop Modeling: Simulation of the soil moisture dynamics

Simulation of the dynamics of soil moisture is an essential part of any agroecosystem management and modeling program. Here we describe an aggregated model of the dynamics of the moisture content of the surface 61 cm of the Vienna soil, characteristic of the top watershed positions of the Moody field. Field measurements of the moisture content of the surface 61 cm of this soil have been made during the 1999-2001 seasons, providing validation data for the soil moisture model.

Defining the average volumetric moisture content of the $\Delta z = 61$ cm layer of the Vienna soil as $\theta(t)$, conservation equation for the water content in this layer may be written as:

$$\Delta z \frac{d\theta}{dt} = Inf - ET - Q_h - Q_z , \qquad (1)$$

where $Inf = Inf(P, R_{off})$ infiltration, depending of rain intensity, P, and surface runoff, R_{off}; $ET = ET(Q_{rad}, T_{air}, \theta, LAI)$ – evapotranspiration, depending of solar radiation, Q_{rad}, air temperature, T_{air}, soil moisture content, θ, and leaf area index, LAI; $Q_h = Q_h(\theta, \eta)$ – lateral moisture flow depending of moisture content, θ, and the slope of the surface, η); and $Q_z = Q_z(\theta, K_0)$ – vertical drainage rate depending of soil moisture and saturated hydraulic conductivity, K_0. Identification of the functional form of the functions in the right-hand part of eq. (1) was based on previous work. Fig. 1 demonstrates the results of the simulation of the dynamics of soil moisture, $\theta(t)$, during a 10-year period (1992 – 2001) driven by weather data from the Brookings meteorological station. For 1999 and 2000, agreement between model and data is quite satisfactory; deviation at the beginning of the 2001 season requires additional attention.

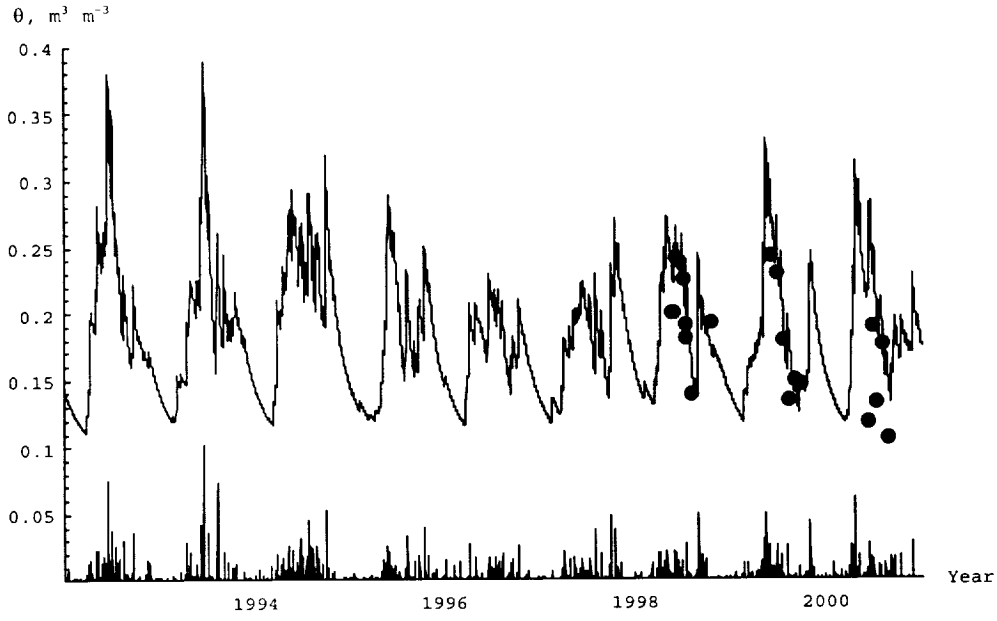


Fig. 1. Simulation modeling of the volumetric moisture dynamics of the 0-24 inch layer of the Vienna soil during 1992-2001 period. Continuous curve – solution of equation (1) driven by precipitation data for Brookings meteorological station (showed at the bottom of the graph); dots – measurement data for 1999-2001 period.

Remote sensing information has been used for estimating yield, detecting weed and disease problems, and evaluating the N status of crop plants. If producers can obtain early estimates of crop quality and quantity, this information can then be used to improve management decisions. The objective of this study was to determine the influence of remote sensing sampling date on corn (*Zea mays*) yields prediction. Research was conducted in 1999, 2000, and 2001. Data collected in 1999 and 2000 was used to develop models, which were validated on data collected in 2001. Remote sensing was collected between germination and 2nd leaf stage (1st sampling date), 6th to 8th leaf stag (2nd sampling date), and between R2 and R4 (3rd sampling date). Principal component analysis was used to develop independent variables and multiple regression was used to develop prediction models. The ability to explain yield variability was influenced by remote sensing sample collection date, and the number of sampling dates used to develop a model. Models that included information collected between R2 and R4 generally explained more yield variability than models that did not include this information. Models that used several sampling dates generally explained more yield variability than models that relied on a single sampling date. The impact of sampling date on explaining yield variability was attributed to: (i) remote sensing collected at the 1st sampling date providing information about soil moisture and organic matter; (ii) information collected at the 2nd sampling date providing information about the corn growth rates; and (iii) information collected at the 3rd sampling date providing information about crop maturity. In model validation, the models developed from two years of information explained more yield variability than models based on one year of information, and the model based on information collected at the three sampling dates explained more yield variability than models based on one or two sampling dates.

Understanding the causes of soybean yield

Diagnostic tools for measuring yield variability and assessing the cause of soybean (*Glycine max*) yield variability are needed to evaluate the impact of different management options on profitability. The objectives of this study were to determine if remote sensing and ^{13}C discrimination (Δ) can be used to evaluate soybean yield variability. Research was conducted in five eastern South Dakota fields between 1999 and 2001. At 50 sampling points in three fields (Brookings, Moody, and SDSU): (i) crop reflectance was measured; (ii) gravimetric soil water (0-60 cm) content was measured periodically during the growing season; (iii) soybean yields were measured by a combine equipped with a yield monitor and differentially corrected global positioning system (DGPS); and (iv) plant samples were collected and analyzed for total N and Δ. Elevation and sampling point locations were measured with a carrier phase DGPS. Crop reflectance was used to calculate the green normalized differential vegetation index [(GDVI=(near infrared -green)/(near infrared+Green)] and the red normalized differential vegetation index [(NDVI= (near infrared-red)/(near infrared+red)]. In four fields (Brookings, Moody, SDSU, and Lovjoy) yields were between 20 and 50% less in summit/shoulder areas than footslope areas. In these fields, soybean yield was positively correlated to GDVI, NDVI, and NIR (near infrared) reflectance measured in August. Remote sensing by itself could not be used to identify the factors responsible for yield variability. At TE80, where the coefficient of yield variability was least (CV= 0.075), water stress most likely did not limit yields. Results from this experiment suggest that remote sensing combined with ^{13}C discrimination can be used to assess the impact of water stress in soybean.

A major disadvantage with using permanent soil properties such as color, texture, organic matter, pH, EC, slope, aspect, or elevation is that for a given set of criteria these factors tend to produce fixed zone boundaries that may not correspond to pest biological processes and climatic variability. It may be possible to overcome this limitation by classifying zones based on permanent properties as well as remote sensing. The objective of this study was to determine if near infrared information collected from an aerial image could be used to identify weedy and non-weedy areas in a production field. In a field experiment, crop reflectance was measured at 8 sites in a production field. Following the reflectance measurement, the weeds were removed and reflectance was measured again. The soybeans were then removed and reflectance was measured again. Reflectance was measured with a handheld multispectral radiometer. Each treatment was replicated 4 times and the experiment was repeated several times during the growing season. At this test site, reflectance decreased at 660 and 1650 nm with increasing biomass, while at 760 and 870 nm reflectance increased with increasing biomass. Based on the observation it was determined that the largest reflectance differences between the treatments were observed at 760 and 830 nm. Findings from this project suggest that remote sensing can be used to identify weedy and non-weedy areas in production fields.

Publications

Clay, D.E., S.A. Clay and C.G. Carlson. 2002. Site specific management from a cropping system perspective. Srinivasan, A. (ed) *In* Precision Farming- A Global Perspective.

Clay, D.E., J. Chang, D.D. Malo, C.G. Carlson, C. Reese, S.A. Clay, M. Ellsbury, and B. Berg. 2001. Spatial variability of soil apparent electrical conductivity. Comm. Plant and Soil Analysis 32:1813-1827.

Johansen, D.P., D.E. Clay, C.G. Carlson, K.W. Stange, S.A. Clay, D.D. Malo, and J.A. Schumacher. 2001. Vertical accuracy of two differential corrected global positioning systems. J. Soil Water Conservation 56:198-201.

Reese, C.L., S. Christopherson, C. Fossey, J. Gray, A. Hager, R. Morman, G. Schmitt, B. Showalter, C.G. Carlson, and D.E. Clay. 2001. Trouble-shooting yield monitor systems. SSMG #32. Clay et al. (Ed) *Site Specific Management Guidelines*. Potash and Phosphate Institute. Norcross, GA.

Papers in Progress

Clay, D.E., S.A. Clay, J. Jackson, K. Dalsted, C. Reese, Z. Liu, D.D. Malo, and C.G. Carlson. 2003. C13 discrimination and remote sensing can be used to evaluate soybean yield variability. Agron. J. (In review).

Chang, J., D.E. Clay, K. Dalsted, M. O'Neill, S.A. Clay, and C.G. Carlson. 2003. Using remote sensing to predicting corn yield. Agron. J. (In review).

Chang, J., D.E. Clay, C. G. Carlson, C. L. Reese, S. A. Clay, D. D. Malo, and M. M. Ellsbury, W. Berg. 2003. Spatial and Temporal Yield Variability and Fertilizer Recommendations Using Different Yield Goals in Fields Located in Eastern South Dakota. Agron. J. (In review).

Graduate Student Theses

Chang, J. Using remote sensing and soil attributes to characterize the factors responsible for yield variability. Ph.D. Dissertation. South Dakota State University, Brookings, SD.

Kleinjan. J. Previous management impacts on soil P levels. M.S. Thesis. South Dakota State University, Brookings, SD,

Invited presentations

Carlson, C.G., S. Murrell. 2001. How to use simple statistics to determine treatment differences in on-farm trials. Minnesota Farmer Short Course.

Clay, D.E., J. Chang, C.G. Carlson, and S.A. Clay. 2001. Will variable rate N fertilizer increase profitability? Minnesota fertilizer short course. Minneapolis Dec 2001.

Clay, D.E., D. Long. 2001. Using stable isotopes to understand yield variability. ASA 2001 The State of the Art in Precision Agriculture symposium. Held at the 2001 ASA Annual Meeting Charlotte, NC.

Kitchen, N., W. Wiebold, D. Bullock, D. Clay, F. Pierce, W. Batchelor. 2001. Interactions of soil and landscape properties on corn soybean yield variability in the US Midwest. The State of the Art in Precision Agriculture. Held at the 2001 ASA Annual Meeting Charlotte, NC.

Kleinjan, J., J. Chang, C.G. Carlson, D.E. Clay. 2001. Using aerial photos that characterize previous management and P management zones. 16th Soil Plant Analysis Workshop. Nov. 13-14. West Des Moines, Iowa.

Kleinjan, J., J. Chang, C.G. Carlson, D.E. Clay. 2001. Using aerial photos characterize previous management and P management zones. 16th Soil Plant Analysis Workshop. Nov. 13-14. West Des Moines, Iowa.

Jackson, J., S.A. Clay, D.E. Clay, and Z. Lui. 2001. Weed related water stress and the impact on C-13 discrimination. At the 2001 ASA Annual Meeting Charlotte, NC.

Carlson, C.G., D.D. Malo, D.K. Lee, J.H. Lee, D.E. Clay, T.E. Schumacher, S.A. Clay, C.L. Reese. 2001. Soil Moisture, soil temperature, and soil sensor relationships in Eastern SD soils. At the 2001 ASA Annual Meeting Charlotte, NC.

Chang, J., D.E. Clay, C.G. Carson, C.L. Reese, S.A. Clay, D.D. Malo, M.M. Ellsbury. 2001. Spatial and temporal yield variability in fields located in eastern South Dakota. At the 2001 ASA Annual Meeting Charlotte, NC.

Carlson, C.G., D.D. Malo, D.K. Lee, J.H. Lee, D.E. Clay, T.E. Schumacher, S.A. Clay, C.L. Reese. 2001. Soil Moisture, soil temperature, and soil sensor relationships in Eastern SD soils. At the 2001 ASA Annual Meeting Charlotte, NC.

Helder, D., and Choi. 2002 Calibration of Landsat data. At the High Spatial Resolution Commercial Imagery Workshop (March 25-27, 2002).

Workshops and Camps

Integrating Emerging Technologies Into Ag Production Systems. August 28th, 2001. SDSU Brookings, SD. 105 farmers and crop consultants attended. Goal: provide producers with an update on research activities and have hands on training sessions on integrating emerging technologies into their production system.

Info Ag, August 7-9, 2001. Indianapolis, Indiana. Coordinated five 2-hour, hands-on workshops at the Info Ag conference. 150 participants.

Dakota Fest, August 2001, Poster presentation on why different DGPS systems have different levels of accuracy. Contacted over 100 different people at the meeting.

Soil Moisture Clinic. Representatives from the conservation districts attend the meeting. January 27-29 2002, Brookings, SD (110 participants).

Youth Engineering Adventure (YEA), June 17, 2002: Two groups of high school freshmen through juniors, 7 students in each group, used new Leica survey-grade GPS unit to survey small watershed on campus (just east of HPER bldg), then generated topo map and drainage pathway map and discussed watershed connection and uses of map/watershed knowledge. Each student took home maps of the watershed. Summary of activity available at http://www.engineering.sdstate.edu/yea/index.htm

Aerospace Career Education (ACE) Camp will take place this July and over 20 high school students will spend 5 days learning about various aspects of careers in aerospace and related fields, including image processing.

Beginner ArcView training for producers held March 14th and 21st. Eleven people attended the training sessions. Topics discussed were: how to import yield data into GIS, how to view yield data as an Event Theme; how to convert the Event Theme into a shapefile, the importance of projections, how to load imagery and view in ArcView, and how to create a layout to view imagery beside other field data.

Intermediate ArcView training for producers. Supplemented training provided in Beginner training. Held June 13th and 21st 2002 at Britton, SD, (3 producers attended).

Conducted summer workshops at the EROS Data Center and Rapid City on GIS/remote sensing, 31 K-12 teachers attended the week-long training (impact is estimated at 750 students/year).

Showcase of Outstanding GIS Classroom Projects held October 8-10, 2001 in Bozeman, MT, in which three SD student projects were on display through the teacher training activity.

Earth Science Tools for Educators, workshops for K-12 teachers, December 13, 2001 in Pierre, SD (60 attendees).

Dakota Fest, August 2002. Poster presentation on why different DGPS systems have different levels of accuracy.

Presentations to community groups

Jackson, J. and S.A. Clay, Site Specific Weed Management. September 6, 2001, SE Research Farm Field Days, Beresford, SD, 150 participants.

Carlson, C.G., December 2001, Ag Horizons, 200 participants, 1 hour emerging technology presentation.

Carlson, C.G., December 2001, Davison County Precision Farming Meeting, 200 participants, 2 hour emerging technology presentation.

Reese, C., C.G. Carlson, D.E. Clay. 2002 Introduction to Precision Agriculture at the SD North Central Precision Farming Conference. January 16, 2002, Aberdeen, SD (150 farmers present).

Carlson, C.G., Integrating emerging technologies in farm management, December 2001, Ag Horizons, 200 participants.

Carlson, C.G., Integrating emerging technologies in farm management, December 2001, Davidson County Precision Farming Meeting, (200 participants).

Reese, C., C.G. Carlson, D.E. Clay. 2002. Precision farming the basics. At the SD North Central Precision Farming Conference January 16, 2002, Aberdeen, SD (30 farmers present).

Carlson, C.G. coordinator and 30+ SDSU faculty, January 27-29, 2002, Clinic for soil and moisture conserving farmers and ranchers, 110 participants, 19 hours. Soil and water conservation issues.

Carlson, C.G., Carbon and precision farming, January 2002, Central South Dakota Precision farmers, 15 participants.
Carlson, C.G., Emerging technology, January 2002, South Dakota Outstanding Young Farmer Seminar, 30 participants.
Carlson, C.G., Emerging technology, January 2002, Sioux Falls Regional Ag Farmer Seminar, 70 participants.
Carlson. C.G. Emerging technology. February 2002, North Central SD Farmers. Precision farming meeting, 20 participants.
Kleinjan, J. 2002. The basics of precision farming. February 15, 2002, Dakota Lakes Research Farm Annual Meeting, Pierre, SD (30 people present).
Carlson, C.G. February 2002, Hands on computer training, 5 participants, 3 hours in computer lab.
Carlson, C.G. 2002. Profit center analysis. March 13, 2002. Brookings, SD (5 producers attended).
Carlson, C.G., Emerging technology. March 2002, Minnehaha County Precision Farming Meeting, 25 participants.
Carlson, C.G. Emerging technology. April 2002, 15 participants.
Carlson, C.G. May 2002, South Dakota Water Festival, 1200 participants, 6 hours environmental education.
Carlson, C.G., Emerging technologies June 2002, South Dakota Farm Managers and Rural Appraisers, (45 participants).
Carlson, C.G., Dakota Fest, August 2002.

Related Research Awards and Proposals

North Central Soybean Board, Clay, D.E. S.A. Clay, J. Smolik, M. Catangui, and K. Dalsted. 2002-2003, $61,000. Using remote sensing to identify management problems.
USDA-CSREES-NRI. Clay, D.E. and S.A. Clay. Linking ecological and soil property information to improve site specific management. 2001-2003, $150,000.
United Soybean Board through Potash and Phosphate Institute, Clay, D.E. and G.E. Carlson. Measuring and predicting the causes of yield variability. 2002-2003, $15,000.
SD Soybean Research and Promotion Council. Carlson, C.G., D.E. Clay, and S.A. Clay. SD Precision Agriculture Project. 2001-2002. $13,300.
AmericaView - Preparing a proposal to be submitted to AmericaView (USGS) in July 2002.

Project-related Travel

- November 1, 2001, Dalsted traveled to Washington to discuss NASA request to fund the Geospatial Extension Specialists. Representatives from NASA headquarters for the GES meetings included Ed Scheffner, Julius Dasch, and J-M Wersinger (on-loan from Auburn).
- March 25-27, 2002 at the High Spatial Resolution Commercial Imagery Workshop. Helder, Dewald, Aaron, Ruggles & Choi had formal and informal with Mary Pagnutti, Bob Ryan, Vicki Zanoni of Stennis Space Flight Center, Kurt Thome of University of Arizona, representative of DigitalGlobe (Quickbird) and Space Imaging (Ikonos), and many others from NASA, USGS, and NIMA.
    - March 28 Helder, Dewald, Aaron, Rggules, and Choi had a meeting with GSFC in Greenbelt, MD. Several key NASA personnel were met. Dr. Helder

of SDSU briefed the group regarding research work to characterize the long term Landsat changes that have been detected.

- January 2002, Kurt Thome from the University of Arizona traveled to SDSU to assist in data analysis.
- At Goddard on March 28, Helder and Aaron met with John Barker, Jen Sun, and Jeff Miller of Landsat to discuss Landsat calibration results generated by SDSU and develop further investigations.
    - Member of the research team also met with Jim Butler of their instrument calibration group. Began planning to set up an ASD spectrometer 'shoot off' in conjunction with other investigators and NIST. It will occur at Stennis sometime in the fall of 2002.
- May 21, 2002, Dalsted traveled to Storrs CT to discuss NASA request to fund the Geospatial Extension Specialists. Representatives from NASA headquarters for the GES meetings included Ed Scheffner and J-M Wersinger (on-loan from Auburn).
- April, 25, 2002, Dalsted attended a meeting between SDSU and the USGS EROS Data Center to discuss ongoing and potential collaborative research and outreach activities.
- Dalsted attended at meeting (1/16/02) on imaging Radar at Greenbelt, MD with representatives from Goddard Space Flight Center, NASA Headquarters and JPL in attendance.
- June 8-14, Aaron traveled to Primm NV (IvanPah Playa) for a joint data collect with U of A Remote Sensing Group and Chander Gyanesh of Eros Data Center. Then traveled to Tucson to work on calibration of ASR unit 8 and 18inch panel BRF with Stu Biggar and Rob Kingston.
- March 23-28, Dewald traveled to Reston, VA and Greenbelt, MD.
- O'Neill attended AmericaView meetings at Ohio Aerospace Institute with NASA Glenn Research Center staff in attendance (1/25-26/02)
- Received Science Data Purchase project from Stennis Space Center for IKONOS data for 4 field sites times 4 coverages (April, May, June and August), Dr. Lauren Underwood is Stennis contact.

Work plan for next project year

- Continue cross calibration of Landsat TM and IKONOS sensors using standard reflectance measurements;
- Continue the development of rules to identify the "best" sensor for agronomic applications;
- Continue the development of models relating spectral characteristics to crop health.
- In terms of calibration activities, we are in excellent shape. We have a good equipment set-up, facilities for data reduction and analysis, and our new personnel have had an opportunity to familiarize themselves with the activities and procedures involved in previous data collects and to move onto using and improving. Also a great deal of intercommunication with other individuals in the satellite calibration community has been established.
- Our near term goals are focused around data collects. Our collect season here is reasonably short and intense. Primarily during the summer, the data is collected, a

check is made to insure proper instrument operation, but the real analysis won't be until the fall/winter.

- Upgrades and additional calibrations are being planned (but generally again will wait until the 'slow' season).
- To develop a prototype WEB-Based GIS/remote sensing project. This project will develop web-based tools that land managers can use to improve field management.
- Continue the development of the Site-Specific Management Guideline Manual. During the past several years over 35 guideline papers have been published. During the next year we anticipate publishing several more.
- To provide technical support for farmers, county agents, and precision farming clubs who are using remote sensing in on-farm-research trials.
- To organize South Dakota 4th biannual Precision Farming and Remote Sensing Workshop and Symposium.
- Organize Dakota Fest.