July 28, 2005

Diane D. DeTroye
Manager, Space Grant and EPSCoR Programs
Higher Education Division
Office of the Chief Education Officer
NASA Headquarters
300 E Street, SW
Suite 1800M-A
Washington, DC 20546-0001

Reference: NASA Cooperative Agreement # NCC5-588

Dear Diane,

Please find enclosed the Year Four Progress Reports and Requests for Continuation for the South Dakota NASA EPSCoR Program entitled: "The Use of Remote Sensing for Monitoring, Prediction, and Management of Hydrologic, Agricultural, and Ecological Processes in the Northern Great Plains." The South Dakota report includes a section on Core Funding for Research Infrastructure Development, and a section on each of the state's two research projects. Year five budgets (Sept. 1, 2005 – Aug. 31, 2006) are included for the Core and two Research Projects (including subawards). Also included are a summary budget (NASA form) and a summary metrics spreadsheet.

I know that this report is late; that responsibility is mine alone and should not reflect on my South Dakota NASA EPSCoR colleagues.

Please do not hesitate to contact me for clarifications or additional information.

Sincerely,

Edward F. Duke
Director
South Dakota Space Grant Consortium and NASA EPSCoR Program

cc: S. Reid, SDSM&T
T. Durkin, SDSM&T
J. Nilson, SDSM&T
B. Brown, SDSM&T

A. COVER PAGE

Name of state: South Dakota

Cooperative agreement number: NCC5-588

Effective dates: September 1, 2004 through August 31, 2005 (year four)

Project Title:

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

Director information:

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Signature and date

Edward F. Duke, Director
South Dakota Space Grant Consortium
and NASA EPSCoR Program

Date

July 27, 2005

B. PROGRESS REPORT

Components of the South Dakota Cooperative Agreement

The South Dakota NASA EPSCoR Program has the following components:

1. Core Funding for Research Infrastructure Development
2. Two Research Projects:
   "Leaf Area Index for Fire Chronosequences of the Black Hills and Southern Siberia: A Comparative Study"
   "Cross-Calibration of Landsat and IKONOS Sensors for Use in Precision Agriculture"

State Program Changes

During the past year, Dr. Edward Duke took on the official role of Director of the South Dakota Space Grant Consortium and NASA EPSCoR Program, replacing Dr. Sherry Farwell who is now Head of the National Science Foundation EPSCoR Office.

Dr. Lee Vierling, lead investigator on the "Leaf Area Index" project, accepted a position at the University of Idaho. Dr. William Capehart of SDSM&T has been designated interim PI for that project. An official request for a change of PI and a revised work plan and budget (including a new subaward to the the University of Idaho) has been submitted to the EPSCoR Office at NASA Headquarters.

Dr. Dennis Helder, lead investigator on the "Cross-Calibration" project, will be reducing his involvement in the project and has requested that Dr. David Aaron of SDSU be designated as PI. An official request for a change of PI has been submitted to the EPSCoR Office at NASA Headquarters. On the five-member NASA EPSCoR Steering Committee, Dr. Vierling and Dr. Helder have been replaced by Mr. William Arbegast, Director, Advanced Materials Processing and Joining Laboratory, SDSM&T, and Mr. Kevin Dalsted, Director, Engineering Resource Center, SDSU.

Additions to the Technical Advisory Committee include Dr. Steve Anderson, Professor of Geology and Planetary Science, Black Hills State University, and Dr. Donald T. Lauer, Scientist Emeritus, USGS National Center for Earth Resources Observation and Science (EROS).

State Program Summary

Scope of program. The South Dakota NASA EPSCoR Program was initiated in September 2001. The state program consists of the core grant and two research projects designed to enhance NASA-related research in earth system science and to develop the state's infrastructure for research and technology-based economic development. Two unifying themes underlie all components of the state program, namely: a) Establish quantitative links between geospatial information technologies and fundamental climatic and ecosystem processes in the Northern Great Plains; 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 region. In accordance with these research themes, the state program is aligned with NASA's Science Mission Directorate, and the principal NASA Centers involved have been Goddard Space Flight Center and Stennis Space Center. The U.S.Geological Survey's National Center for Earth

Resources Observation and Science (EROS), in Sioux Falls, SD, is also a key partner in the state program, because of its role as the Land Processes Distributed Active Archive Center (LP DAAC) for NASA's Earth Observing System.

Summary of progress of state program toward achieving the goals and objectives as stated in original proposal. South Dakota's EPSCoR 2000 proposal articulated six fundamental goals for the NASA EPSCoR program; these goals and the relevant accomplishments during year four are listed below (see also attached metrics spreadsheet):

1. *Establish and strengthen linkages with NASA Centers, researchers, and EROS.*

   In year four the state program provided funding for 13 trips for NASA-related planning, in addition to nine trips for SD Space Grant Consortium meetings, and three NASA scientists traveled to the state to discuss research projects. Collaborations were established with Goddard Space Flight Center, Stennis Space Center, Jet Propulsion Laboratory, Ames Research Center, Langley Research Center, Johnson Space Center, Kennedy Space Center, and NASA Headquarters. Three state researchers served on NASA panels or science teams, and state researchers are active in the Upper Midwest Aerospace Consortium (UMAC). In 2005 Ms. Cassie Soeffing, an SDSM&T graduate student, was named an Einstein Fellow and will work for a full year in the office of Dr. Ming-Ying Wei, Program Manager of NASA's Earth Science Education program at NASA Headquarters.

   Eight follow-on proposals were submitted for funding through NASA (four funded, two pending). Five graduate and undergraduate students participated in NASA internships or other research activities (at JPL, JSC, GSFC, LaRC). Ties between state researchers and EROS were strengthened through planning meetings, three student internships, Program Initiation Grants and other collaborative research projects, coauthored publications, and through representation on the NASA EPSCoR Technical Advisory Committee and the Management Team of the SD Space Grant Consortium.

2. *Promote participation of the state's major research institutions, agencies, and businesses*.

   Under the state's NASA EPSCoR program, two of the state's major research institutions, South Dakota School of Mines and Technology (SDSM&T) and South Dakota State University (SDSU), continue to develop extensive collaboration with Augustana College, Oglala Lakota College, and Sinte Gleska University, and with the State Departments of Agriculture and Environment and Natural Resources. Eleven major industrial partners interacted with the research teams, and dozens of additional contacts were facilitated through forestry and agricultural cooperatives, user workshops, guideline papers, and internet-based dissemination.

3. *Develop the state's scientific talent and infrastructure for enhanced competitiveness in research, development, and technology-based economic development*.

   SD NASA EPSCoR participants in year four included 25 faculty, 15 graduate students, and 15 undergraduates. Team members obtained over $3.2 million in new grants to support the NASA EPSCoR theme. Team members authored 20 peer-reviewed publications and 40 additional publications or presentations, and participated in a variety of economic development initiatives including SBIR grants, regional economic development alliances, assistance to user groups in the forestry and agriculture industries, and 11 industry

partnerships, some of which involve potential commercialization opportunities. A new program was initiated with the State Office of Commercialization to link NASA Space Grant and EPSCoR fellowships with the state's Science and Technology Entrepreneurship Program (STEP).

4. *Encourage greater participation by underrepresented groups, especially Native Americans*.

During year four, 25 female and seven Native Americans students were engaged in NASA EPSCoR and Space Grant programs. The SD NASA EPSCoR Program and the SD Space Grant Consortium continue to play a leading role in the state's efforts to increase the number of Native American students in STEM fields. SD Space Grant Consortium initiated two new Workforce Development programs in 2004 to continue to build on these accomplishments. Space Days 2005 will be held Oct. 7 at the Black Hills Pow Wow, an event that draws up to 14,000 attendees to Rapid City from around the region and across the U.S.

5. *Build greater public and political support for science, mathematics, engineering, and technology*.

In April 2005, two SD Space Grant undergraduate fellows from Augustana College presented their research at the "Undergraduate Posters on the Hill" meeting at the Rayburn House Office Building in Washington, D.C., sponsored by the Council on Undergraduate Research (CUR). NASA EPSCoR and other federal infrastructure programs have been a critical factor in obtaining public and political support for STEM education and research in South Dakota. These efforts contributed to the Governor's *Research 2010* initiative, which signified an unprecedented reordering of the State's priorities with respect to basic research and technology-based economic development.

6. *Communicate the benefits of current and future NASA programs to the progress and development of South Dakota, the Northern Great Plains, and the Nation*.

Through effective coordination with the SD Space Grant Consortium and its network of 35 affiliate organizations, SD NASA EPSCoR showcases NASA's contributions to science and technology by means of formal and informal science partnerships that extend across the state and the region. These include the Western Research Alliance, the Upper Midwest Aerospace Consortium, the annual South Dakota Space Days, and a variety of forestry and agriculture cooperatives and natural resource management groups. In year four there were an estimated 30 media contacts and 55 end users of geospatial data provided by the research teams.

Continuation Plan. Under the year five continuation plan outlined in Section C, the state program will maintain the same fundamental themes and will continue to support the current research projects during the final two years of the Cooperative Agreement. Increased emphasis, however, will be placed on promoting the transition to sustainability and on aligning the current projects with existing and emerging state and regional research centers, including components of the NSF EPSCoR program and the State's Research 2010 Centers. The Core Grant will also foster new research collaborations by supporting eight Program Initiation Grants and funding NASA-related travel opportunities. The SD NASA EPSCoR program will continue its close interaction with the SD Space Grant Consortium with the goal of encouraging broader

participation by all SD citizens in STEM education and communicating to the public the importance of NASA-related research to the prosperity of South Dakota and the region.

B. PROGRESS REPORT (CONTINUED)

1. Research success of individual Core Grant investigators during the period of the cooperative agreement as measured by:

a. list of articles accepted by or published in refereed journals: The following two publications involved student or faculty support from the Core Grant:

Kozak, P.K., Duke, E.F., and Roselle, G.T., 2004, Mineral distribution in contact-metamorphosed siliceous dolomite at Ubehebe Peak, California, based on airborne imaging spectrometer data: American Mineralogist, v. 89, p. 701-713.

Tan, S., Narayanan, R.M., and Helder, D.L., 2005, Polarimetric Reflectance and Depolarization Ratio from Several Tree Species using a Multiwavelength Polarimetric Lidar: Proceedings of SPIE International Symposium on Optics and Photonics (in press).

b. list of talks, presentations or abstracts at professional meetings: The following eight presentations involved student or faculty support from the Core Grant:

Duke, E.F., 2004, Hyperspectral mapping in the Gorob-Hope region, Namibia: Preliminary results from 2004 HyMap data: Invited lecture, Geological Survey of Namibia Workshop on Hyperspectral Remote Sensing, Dec. 2, 2004, Windhoek, Namibia.

Duke, E.F., 2004, Hyperspectral mapping for mineral exploration: Example from the Gorob-Hope region, Namibia: Invited lecture, Geological Survey of Namibia Workshop on Hyperspectral Remote Sensing, Dec. 3, 2004, Windhoek, Namibia.

Duke, E.F., and Kozak, P.K., 2004, Visible and near infrared spectra of marbles and related rocks: implications for mineral mapping using field spectroscopy and remote sensing: Geological Society of America Abstracts with Programs, v. 36, no. 5, p. 140.

Kozak, P.K., and Duke, E.F., 2004, Mineral mapping of the Ubehebe Peak contact aureole using spatially referenced visible and near infrared field spectroscopy: Geological Society of America Abstracts with Programs, v. 36, no. 5.

Pellowski, C.J., Duke, E.F., Paterson, C.J., and Badenhorst, F.P., 2004, Visible and near infrared spectral study of reduced gold skarn mineralogy from the Navachab gold deposit, Namibia, Africa: Geological Society of America Abstracts with Programs, v. 36, no. 5, p. 354.

Stock, B.J., 2004, Compilation of a Precambrian basement map and geodatabase of South Dakota: Geological Society of America Abstracts with Programs, v. 36, no. 5, p. 568.

Stock, B.J., and Pellowski, C.J., 2005, Comparison of the southern Trans-Hudson Orogen, USA, and the Damara Orogen, Namibia: implications for interpreting the crustal framework of the northern Great Plains: Geological Society of America Abstracts with Programs, v. 37, no. 6.

Tan, S., Narayanan, R.M., and Helder, D.L., 2005, Polarimetric Reflectance and Depolarization Ratio from Several Tree Species using a Multiwavelength Polarimetric Lidar: SPIE International Symposium on Optics and Photonics, Aug. 3, 2005, San Diego, CA.

c. list of patents (pending and awarded): None

d. list of follow-on grant proposals submitted and funded (including NASA awards):

SD NASA EPSCoR and Space Grant staff received three new research or education grants that support the themes of the NASA EPSCoR Program and also address broader aspects of state infrastructure development. In addition, eight researchers or teams received seed funding from the Core Grant in the form of Program Initiation Grants.

Proposals submitted by SD NASA EPSCoR Core Grant staff

Dr. Edward Duke, Director of SD NASA EPSCoR and Space Grant, is a co-investigator on the following new award, which is related to state and NASA research in nanotechnology:

> "Acquisition of a Field Emission Scanning Electron Microscope," National Science Foundation, Civil and Mechanical Systems, Major Research Instrumentation Program, 10/1/05 – 9/30/06, $554,867 (funded)

Dr. Duke and Dr. Jacquelyn Bolman, SD Space Grant Coordinator for Workforce Development received the following awards related to promoting diversity in the NASA EPSCoR and Space Grant programs:

> "Tatanka-Zitkala-Peji" (Bison-Birds-Grass), U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service 1994 Research Grant Program (Subaward -- Prime Oglala Lakota College), 10/1/04 – 9/30/06, $15,000 (funded)
>
> "He Sapa Oyate: Geoscience Community at the Heart of Everything that Is," National Science Foundation, Division of Geosciences, Opportunities for Enhancing Diversity in the Geosciences), 10/1/05 – 9/30/08, $250,000 (recommended)

Program Initiation Grants and Travel Grants funded by NASA EPSCoR Core Grant

In October 2004 the SD NASA EPSCoR office issued announcements of opportunity to state researchers for:

1. Travel Grants of up to $2000 for visits to NASA Headquarters or NASA Centers with the purpose of developing research collaborations, and
2. Program Initiation Grants of $5,000 to $20,000 to promote research projects endorsed by a collaborator at NASA Headquarters or a NASA Center.

The call was directed to all 13 institutions of higher education in the SD Space Grant Consortium (SDSM&T, SDSU, University of South Dakota, Black Hills State University, Dakota State University, Northern State University, Augustana College, Oglala Lakota College, Sinte Gleska University, Si Tanka-Huron University, Lower Brule Community College, Sisseton Wahpeton Community College, Sitting Bull College).

Eleven travel grants were awarded for planning trips to JPL, Stennis, Ames, Goddard, and a remote sensing workshop in Fort Collins, CO.

Fifteen proposals for Program Initiation Grant were received in January and reviewed by the state NASA EPSCoR Steering Committee (see section 7, below). The titles of the eight funded projects are listed in Table 1, along with the name and affiliation of the PIs, amount of the award, and information about collaborators at NASA Centers, other universities, or EROS. The new projects include written support from nine NASA collaborators (GSFC, ARC, SSC, KSC, JPL), one EROS collaborator, three external university or national laboratory collaborators, and two industry collaborators. State NASA EPSCoR funds in the amount of $71,716 were awarded, and the projects have committed $112,631 in matching funds. Most projects were funded for a two-year period (years four and five of the state grant), with the second year contingent upon receipt of year five funds from NASA. The Steering Committee determined that this approach would allow the investigators more time to develop competitive projects for potential funding as new EPSCoR 2005 major research programs. Five of these seed grant projects are currently being developed into proposals for new EPSCoR 2005 major research programs, and preproposals have been submitted to the state Steering Committee for review.

Table 1. Program Initiation Grants Awarded in Year Four.

Title, Principal Investigator(s), and Funded Amount	NASA and Other Collaborators
Vegetation and Other Natural Targets Remote Sensing Using a Multiwavelength Polarimetric Lidar, Songxin Tan (SDSU), $9,780	David J. Harding, Geodynamics Branch, Laboratory for Terrestrial Physics, NASA Goddard Donald C. Rundquist, Director, Center for Advanced Land Management Information Technologies (CALMIT), University of Nebraska – Lincoln Ram Narayanan, Department of Electrical Engineering, Pennsylvania State University
Combining Remotely Sensed Data and Process-Based Biogeochemical Modeling to Quantify the Carbon Budget and Methane Emissions in the Northern Great Plains, Qianlai Zhuang (SDSM&T), $4,475	Christopher S. Potter, Ecology Science and Technology Team, NASA Ames Jiarui Dong, Hydrological Sciences Branch, NASA Goddard
Using SEBAL to Estimate Actual Evapotranspriation Using Remotely Sensed Data, Todd Trooien (SDSU), $8,500	Rodney McKellip and Vicki M Zanoni, Earth Sciences Applications Directorate, NASA Stennis Bryan Thoreson, SEBAL North America Inc., Davis, CA
Enhanced Statistical Software for Time Series Images, Daniel Swets and Brad Reed (Augustana College and USGS National Center for Earth Resource Observation and Science), $9,104	John L. Dwyer, NASA Land Processes DAAC Project Scientist, USGS National Center for Earth Resource Observation and Science)
Hypergolic Fuel and Oxidizer Fiber Optic Leak Detector, Alfred Andrawis (SDSU), $6,000	Timothy P. Griffin, Analytical Chemist, NASA Kennedy
Intellegent and Fault Tolerant Signal Processing for Space Systems, Brian Hemmelman, Nian Zhang, and Li Chen (SDSM&T), $15,000	Umesh D. Patel and Robert Kasa, Head, Microelectronics and Signal Processing Branch, NASA Goddard Neil F. Chamberlain, Flight Communications Systems Section, NASA JPL

	Scott R. Thompson, RealTronics Corporation, Rapid City, SD
Specification and Design Defect Identification via Rapid Prototyping, Scott Overmyer (SDSU), $8,857	Michael G. Hinchey, Director, Software Engineering Laboratory, NASA Goddard
Nano-Mechanical Processing of Quantum Information in Semiconductor Systems, Andre Petukov and Mikhail Foygel (SDSM&T), $10,000	Vadim Smelyanskiy, Senior Research Scientist, NASA Ames Thomas Schenkel, Staff Physicist, E. O. Lawrence Berkeley National Laboratory

State Planning for Potential New NASA EPSCoR Competition

In May 2005 the SD NASA EPSCoR office issued a call for one-page "white papers" outlining potential major research projects for the next round of the NASA EPSCoR competition (anticipated announcement in late summer or fall 2005). The call was directed to all 13 institutions of higher education in the SD Space Grant Consortium. Thirteen white papers were received on June 30, and these are currently under review by the state NASA EPSCoR Steering Committee. Following initial recommendations by the Steering Committee, the proposed research themes will also be discussed at the next meeting of the Technical Advisory Committee (see section 7, below); that meeting will be scheduled following release of the new EPSCoR guidelines from NASA Headquarters. The 13 projects fall into three general categories: Earth Science (the current state theme) and two new research themes, one focused on Flight Support and one focused on Space Hardware/Software Engineering. The projects involve seven NASA Centers, NASA Headquarters, 49 total non-NASA collaborators, and 15 non-NASA organizations (academic, governmental, tribal, and industrial).

e. improvements in state research and development infrastructure

A continuing research infrastructure focus is the development of remote sensing training sites at several locations in the state and the cataloging and sharing of NASA earth observing satellite imagery for the sites. Extensive monitoring and calibration activities continued on targets in eastern South Dakota (Landsat 5 and 7, IKONOS, QuickBird, EO-1 ALI), and new data acquisitions have been requested for sites on the Pine Ridge and Rosebud Indian Reservations and Badlands National Park in western South Dakota. These acquisitions are being coordinated through SDView and will include data from the NASA-USGS EO-1 Hyperion and ALI imagers.

In summer 2005, an experimental Geoscience Consortium was established by members of the SD Space Grant Consortium who share special interest in regional geoscience research and education opportunities. The Black Hills – Badlands Geoscience Consortium is an informal organization dedicated to learning and teaching earth science themes with an emphasis on the unique geology of the Black Hills and Badlands region. Representatives from state universities, tribal colleges, and state and federal agencies with active interest in western South Dakota and northeastern Wyoming are participating (SDSM&T, Black Hills State University, Oglala Lakota College, Sinte Gleska University, USGS, South Dakota Geological Survey, National Park Service, EROS). A long-range goal of the group is to establish a regional, interdisciplinary geoscience center on the campus of SDSM&T, which would provide collocation for a number the collaborating organizations.

SD Space Grant and NASA EPSCoR personnel have been actively involved in SDView, one of approximately 30 state chapters of AmericaView, which is funded by in part by USGS. SDView provides access to remote sensing data and technology for research, education, workforce development, and technology transfer. This year SD Space Grant is also coordinating with EROS to make a list of the center's extensive library holdings in remote sensing available to Space Grant members and affiliates.

As noted above (section B.1.d), the Core Grant awarded 11 travel grants for planning trips to JPL, Stennis, Ames, Goddard, and a remote sensing workshop in Fort Collins, CO.

Also, as noted above (section B.1.d), the Core Grant funded eight Program Initiation Grants for new collaborative projects linked to research at five NASA Centers and EROS. Funds of $71,716 were awarded (year 4 and 5 funds), with $112,631 committed for matching.

Furthermore, the Core Grant provided $16,000 in funding for graduate student researchers, which was matched 1:1 from non-federal sources.

2. Systemic change as evidenced by:

a. reordered State and/or institutional priorities

The 2004-05 project year included important reordering of the state's priorities with respect to basic research and technology-based economic development. The following are examples of new initiatives that should provide long-term benefits to the SD NASA EPSCoR program:

- In response to Governor M. Michael Rounds' *Research 2010 Initiative*, the South Dakota Board of Regents created the new position of System Vice President of Research.
- For the first time, the State of South Dakota is developing a Strategic Plan for Science and Technology.
- For the first time in the history of EPSCoR programs in the state, a committee of EPSCoR directors will meet with the System VPR to coordinate and improve interaction with the Board of Regents and state government. The SD NASA EPSCoR director serves on this committee along with the directors of the NSF, DOE, DoD, and NIH (BRIN/INBRE/IDeA) EPSCoR programs.
- For the first time, the legislature appropriated matching funds to support these programs. The distribution of these funds among the various EPSCoR-like programs (including Space Grant and NASA EPSCoR) has not been finalized.

These positive developments are a response to Governor Rounds' *2010 Initiative* for improving South Dakota's economic growth and quality of life, first outlined in October 2003. Goal Three of the five-goal plan asserts that South Dakota will "Become a recognized leader in research and technology development by 2010."

b. increased financial commitment from the State, industry, and participating institutions

To facilitate the establishment of the Deep Underground Science and Engineering Laboratory (DUSEL), the legislature authorized $24.3 million to create the State Science and Technology Authority and fund the Homestake Laboratory Conversion Project. In July 2005 the Homestake site proposal was selected as one of two finalists by the National Science Foundation, and the

Homestake research coalition will receive $500,000 to further develop its proposal. The state of South Dakota is one step closer to hosting a national laboratory. If selected, the Homestake DUSEL will include numerous experiments and engage international research teams in NASA-related projects including astrophysics, particle physics, microgravity, geomicrobiology, earth science, and outreach.

To implement the Governor's *2010 Initiative*, the legislature authorized $3 million to fund four interdisciplinary research centers for a period of five years. One of the 2010 Centers, the "Center for Advanced Applications at the Nanoscale" (CAAN), includes NASA EPSCoR researchers. In addition, two of the three projects funded as small grants for exploratory research by the SD NSF EPSCoR Center for Biocomplexity Studies involve NASA EPSCoR investigators; these are: "Modeling Climate-Wetland Interactions in the Northern Great Plains" and "Quantification and Scaling-up of the Coupled Biogeochemical Cycles of Carbon and Water in Grassland Ecosystems of South Dakota."

3. Examples of successful transfer of technology to the private sector

Each of the two SD NASA EPSCoR research teams is continues to pursue technology transfer opportunities. These include development of forestry applications of LiDAR technology (SBIR Phase Zero, Horizons, Inc., Lamp-Rynearson Associates); satellite and aircraft remote sensing products for precision agriculture, as well as development of unmanned aerial vehicles (UAVs) (Raven Industries, Skyhawk Sensing); radiomentric calibrations and verification of spatial resolution for QuickBird satellite (DigitalGlobe); decision support and resource management systems for precision agriculture and other markets (Resource21, a division of Boeing Company, Ag20/20, a NASA Stennis and USDA collaboration for commercialization of remote sensing, and Raytheon); numerous site-specific management guidelines and workshops for agricultural producers (Potash and Phosphate Institute, SD Soybean Research and Promotion Council, United Soybean Board, SD Corn Utilization Council); and several collaborations with SAIC Technologies at EROS.

Past state NASA EPSCoR Director, Dr. Sherry Farwell, was instrumental is establishing the Western Research Alliance (WRA), a forum for individuals and organizations dedicated to promoting technology-based economic development in western South Dakota. The WRA initiative culminated this year in the ground-breaking for a $2.2 million Business Development Center on the SDSM&T campus. The WRA was also instrumental in the development of the Center for Advanced Applications at the Nanoscale (CAAN) located at SDSM&T. CAAN was awarded $585,000 in state funds as one of four State 2010 Research Centers, and also heads up the North Central States Nanosystems Consortium. Center personnel are actively involved in planning for NASA EPSCoR 2005 and have initiated research collaborations with NASA scientists at Goddard, Johnson, and JPL. CAAN personnel have also applied for an NSF Industry/University Cooperative Research Center planning grant.

4. Extent to which collaborations with State agencies, industry, research and academic institutions, and with NASA have been developed

As noted above (section B.1.d), the Core Grant funded 11 travel grants for planning trips to JPL, Stennis, Ames, Goddard, and a remote sensing workshop in Fort Collins, CO. The Core Grant also funded eight new Program Initiation Grants, which include written support from nine

NASA collaborators (GSFC, ARC, SSC, KSC, JPL), one EROS collaborator, three external university or national laboratory collaborators, and two industry collaborators. In addition, 13 new projects are being developed for consideration in the next NASA EPSCoR competition (late 2005-early 2006). Planning for these projects has involved seven NASA Centers, NASA Headquarters, 49 total non-NASA collaborators, and 15 non-NASA organizations (academic, governmental, tribal, and industrial).

Initial meetings were held with the Director of the State Office of Commercialization and the State SBIR Coordinators to discuss collaboration in the new Science and Technology Entrepreneurship Program (STEP). SD NASA Space Grant and EPSCoR would provide co-funding for students in the STEP program who plan to combine NASA-related research and development interests with business entrepreneurship and commercialization strategies.

NASA EPSCoR participants continue to play a central role in the new Geographic Information Science Center of Excellence. The center will expand educational and research opportunities at SDSU and USGS-EROS, including a newly-approved Ph.D. in Geospatial Science and Engineering. Center personnel are actively pursuing research collaborations with NASA scientists at Goddard and Stennis.

NASA EPSCoR participants are actively collaborating with faculty and students at Oglala Lakota College on the Pine Ridge Reservation and Sinte Gleska University on the Rosebud Reservation to increase the use of geospatial technology and remote sensing. These activities involve coordination with several major programs including the NASA Earth Science REASoN program (SGU), the NSF Tribal Colleges and Universities Program (OLC), the SD Space Grant Consortium Workforce Development program, and the NASA EPSCoR multi-state Native Connections program. In June 2005, OLC dedicated the new Lakota Center for Science & Technology (LCST). The ceremony marked the openning of the NASA-funded Science, Engineering, Mathematics, and Aerospace Academy (SEMAA) and Aerospace Educational Laboratory (AEL). Dignitaries from NASA included Dr. Adena Loston (Chief Education Officer), Mr. John Hairston (NASA Glen Research Center), and Mr. John Bennett Herrington (NASA astronaut). In addition to the NASA SEMAA and AEL, the LCST includes environmental analytical laboratories funded by a $2.5 million NSF award and developed with close cooperation of Dr. Duke of SDSM&T.

5. Evidence of how EPSCoR activities have furthered State priorities

In the Governor's *2010 Initiative*, described above (Sec. 2a), Goal Four proposes to "Improve cooperative efforts with Native American Tribes." Six of the Nation's 35 Tribal Colleges are located in South Dakota and all are formally affiliated with the SD Space Grant Consortium. In addition, Mike Collins of United Tribes Technical College (ND) and James Rattling Leaf of Sinte Gleska University serve as members of the NASA EPSCoR Technical Advisory Committee, and Mr. Rattling Leaf serves on the Management Team of the SD Space Grant Consortium. SD NASA EPSCoR and the SD Space Grant Consortium also work closely with the Oglala Lakota College Summer Honors Program and the NSF Bridges to Success Program, which support programs for American Indian high school and Tribal College students. Increasing participation of American Indians in STEM fields is the focus of the SD Space Grant Consortium NASA Workforce Development Program. In summer 2005 Dr. Jacquelyn Bolman, SD Space Grant Workforce Development Coordinator, received a three-year, $250,000 NSF

award for Opportunities for Enhancing Diversity in the Geosciences. This award will allow SD Space Grant and EPSCoR personnel to engage a larger segment of the Native American community with earth and space science education and research projects.

As noted above, a new program has been initiated with the State Office of Commercialization to link NASA Space Grant and EPSCoR fellowships with the state's Science and Technology Entrepreneurship Program (STEP).

6. Discussion of interaction between and cooperation with State Space Grant program

The South Dakota Space Grant Consortium was established in March 1991 and currently includes 35 members and affiliates. The SD Space Grant Consortium and the NASA EPSCoR program work closely to promote research and education in earth system science, to expand collaboration between the universities and EROS Data Center, and to strengthen partnerships with the state's six Tribal Colleges. The NASA EPSCoR Technical Advisory Committee includes representation from all four SD Space Grant Consortium institutional members and from five of its industrial and educational affiliates. Four members of the NASA EPSCoR Steering or Technical Advisory Committees also serve on the Space Grant Management Team.

Several students who began research under SD Space Grant fellowships are transitioning into SD NASA EPSCoR research projects, and another student is participating in a summer 2005 internship at JSC.

7. Names, titles, and affiliations of Technical Advisory Committee and Steering Committee members.

James Rattling Leaf
Land and Natural Resource Developer
Director of Sicangu Policy Institute, Sinte Gleska University

Ron Woodburn
Director, Capital University Center, Pierre, SD

Larry Diedrich
SD State Senator
Diedrich Bros. Farms, Elkton, SD

Mike Collins
Environmental Science Instructor, United Tribes Technical College, Bismarck, North Dakota

Gregg Johnson
Science Department Manager, SAIC/USGS National Center for Earth Resources Observation and Science (EROS), Sioux Falls, SD

Dan Swets
Chair, Department of Computer Science, Augustana College
Associate Director South Dakota Space Grant Consortium

Kevin Dalsted
Director, Engineering Resource Center, SDSU
Associate Director South Dakota Space Grant Consortium

Don Lefevre
CEO, Cynetics Corp., Rapid City, SD

J. Foster Sawyer
Hydrology Specialist, South Dakota Department of Environment and Natural Resources

Daniel Hoyer
Hydrologist, RE/SPEC, Inc., Rapid City, SD

Steve Anderson
Professor, Geology and Planetary Science, BHSU

Donald T. Lauer
Scientist Emeritus, USGS National Center for Earth Resources Observation and Science (EROS)

Members of NASA EPSCoR Steering Committee:

Dan Swets, Chair
Chair, Department of Computer Science, Augustana College
Associate Director South Dakota Space Grant Consortium

Kevin Dalsted
Director, Engineering Resource Center, SDSU
Associate Director South Dakota Space Grant Consortium

Dave Clay
Professor, Department of Plant Science, SDSU

Patrick Zimmerman
Director, Institute of Atmospheric Sciences, SDSM&T

William Arbegast
Director, Advanced Materials Processing and Joining Laboratory, SDSM&T

8. Schedule of meetings of Technical Advisory Committee

A day-long meeting of the Technical Advisory Committee was held Sept. 10, 2004, at the USGS National Center for Earth Resources Observation and Science (EROS) in Sioux Falls, SD. The committee heard progress reports on the two major research projects and selected Program Initiation Grants. Also, the South Dakota Board of Regents Vice President for Research (new

position) briefed the committee on state research priorities and initiatives and listened to committee suggestions on ways to improve the state's research environment and the interaction between state government and the NASA EPSCoR and Space Grant programs.

A second meeting of the TAC will be held in the fall of 2005, pending release by NASA Headquarters of the announcement and guidelines for the EPSCoR 2005 competition. The goal of that meeting will be to review the 13 preproposals that have been submitted for potential EPSCoR 2005 projects and obtain recommendations regarding which projects are best aligned with the state's science and technology priorities.

C. REQUEST FOR CONTINUATION

1. Year-five program plan and budget

The plan outlined here for the final year of the SD NASA EPSCoR program maintains the unifying theme of the original proposal, namely, to support multidisciplinary, multi-institution teams that integrate remote sensing and surface measurements in order to monitor, model, manage, and predict behavior of ecosystems of Northern Great Plains. In order to address these fundamental research themes, we propose to continue the three components of the state program at the same funding levels as in the first four years. These components are:

1. Core Funding for Research Infrastructure Development (administered by E. Duke at SDSM&T), $125,000 (detailed budget attached)
2. "Leaf Area Index for Fire Chronosequences of the Black Hills and Southern Siberia: A Comparative Study" (William Capehart, PI, SDSM&T; subawards to Augustana College and the University of Idaho), $164,000 (detailed budget attached)
3. "Cross-Calibration of Landsat and IKONOS Sensors for Use in Precision Agriculture" (David Aaron and David Clay, PIs, SDSU), $223,100 (detailed budget attached)

The goals of the overall program remain the same as those outlined on pages 3-4, but, in the final year of the Cooperative Agreement, there will be added emphasis on completing the transition of currently funded research projects to self-sufficiency and on developing a new group of meritorious projects for possible NASA EPSCoR competition in late 2005 or early 2006. Within that overall framework, the role of the Core Grant will be the following:

- Provide administrative support, travel funds, and programmatic guidance to the two research teams that will assist them in accomplishing their research objectives, securing long-term funding, and completing the transition to self-sufficiency
- Identify and cultivate new research areas and teams for potential proposals to the next cycle of NASA EPSCoR (2005), for other NASA funding opportunities, or for funding through other agencies
- Continue to encourage participation of American Indian students in STEM fields and NASA-related research
- Promote alignment and integration of current and next generation SD NASA EPSCoR projects with evolving statewide programs funded by NSF EPSCoR, DOE, USDA, and the Governor's Research 2010 Centers
- Coordinate participation of SD researchers in regional NASA collaborations such as the Upper Midwest Aerospace Consortium
- Enhance public awareness of NASA research and technology development in cooperation with the SD Space Grant Consortium
- Increase interaction of SD EPSCoR participants with state and federal government agencies and with the private sector, and continually reassess long-range strategic plans under the guidance of the Technical Advisory Committee and Steering Committee

2. Metrics to be used for tracking and evaluating program progress

Metrics of progress toward the goals outline above will include the following:

- Number of SD investigators who travel to NASA Headquarters or NASA Centers or to other NASA-related events
- Number of NASA scientists, engineers, and administrators who visit SD to interact with investigators involved in the NASA EPSCoR program
- Number of follow-on proposals generated from research activities of the Core Grant, Program Initiation Grants, or the two main research projects
- Number of new research awards in SD from NASA and other federal agencies where the funded projects are related to the theme of the SD NASA EPSCoR program
- Number of SD university graduates in M.S. and Ph.D. programs whose research is related to the theme of the SD NASA EPSCoR program
- Number of publications and presentations based on research activities of the Core Grant, Program Initiation Grants, and the two main research projects
- Number of Native Americans and women who become engaged in projects supported by the SD NASA EPSCoR and SD Space Grant Consortium programs
- Number of NASA EPSCoR researchers who become funded through the new Research 2010 Centers, NSF EPSCoR projects, or other statewide programs
- Number of SD EPSCoR researchers participating in regional or national coalitions or serving on NASA review panels
- Number of media reports or informal science contacts related to SD NASA EPSCoR research
- Number of non-university individuals who become directly or indirectly involved in the SD NASA EPSCoR program as end users of geospatial data and products generated by the research
- Number of meetings of the SD NASA EPSCoR Technical Advisory Committee and Steering Committee

3. Milestones and timetables for achievement of specific objectives during the award period

Milestones for implementing the continuation plan and a proposed timetable are summarized in the chart below, which was part of the year three report and continuation request. The state program remains very close to this schedule, based on activities completed during year four and projections for year five.

a. *Technical Advisory Committee meetings*. The September 2004 meeting of the Technical Advisory Committee was held as scheduled (see section B.8); however, the May 2005 TAC meeting has been postponed until fall 2005 pending release by NASA Headquarters of the announcement and guidelines for the new EPSCoR 2005 competition.

b. *Increasing interaction with South Dakota 2010 Research Centers and the NSF Center for Biocomplexity Studies*. The Core Grant has and will continue to build alliances between NASA EPSCoR and established and emerging state programs for basic and applied research. Key opportunities for such synergy exist with the NSF EPSCoR Center for Biocomplexity Studies, the South Dakota Carbon Sequestration Project and its regional and national

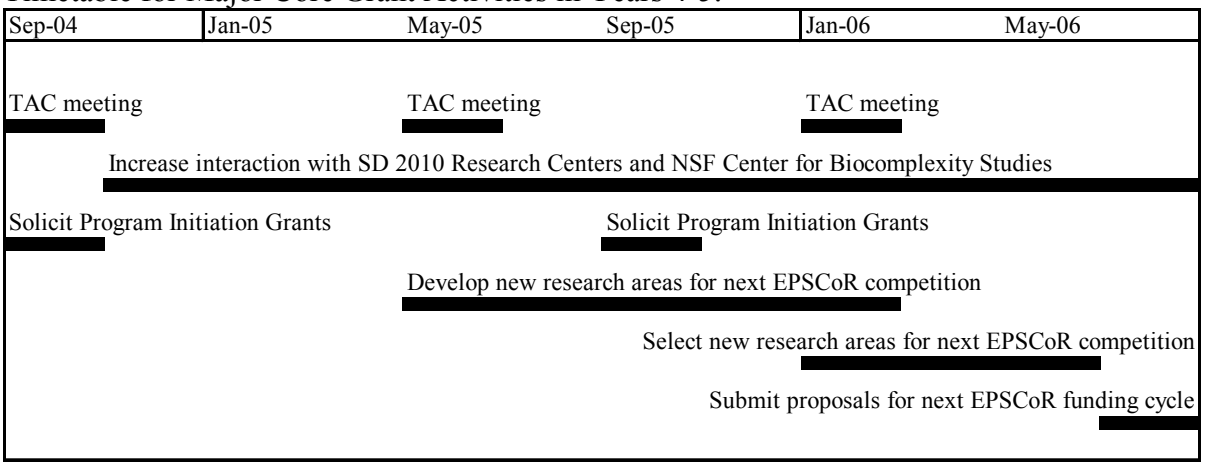
partnerships funded by DOE, and the four South Dakota 2010 Research Centers. Additional opportunities for expanding NASA EPSCoR research projects are developing through current and pending research on carbon sequestration (DOE, NASA) and a variety of USDA programs. The number of emerging state research programs with links to NASA EPSCoR research is a testimony to the success of NASA EPSCoR and its impact on state priorities. For example, six of the 13 preproposals for new EPSCoR 2005 research projects are directly linked with State 2010 Research Centers or with the NSF Center for Biocomplexity Studies. More importantly, these emerging research centers represent tangible progress toward long-term sustainability of the research initiated under NASA EPSCoR.

c. *Solicitation of Program Initiation Grants*. The solicitation for new Program Initiation Grants was issued in October 2004. Eight projects were funded, which include written support from nine NASA collaborators (GSFC, ARC, SSC, KSC, JPL), one EROS collaborator, three external university or national laboratory collaborators, and two industry collaborators (see section B.1.d, Table 1). As noted in that section, the awards were made for a two-year period; therefore the second solicitation shown on the timetable (September 2005) will not be necessary.

d. *Develop new research areas for next EPSCoR competition*. In May 2005 the SD NASA EPSCoR office issued a call for one-page "white papers" outlining potential major research projects for the next round of the NASA EPSCoR competition (anticipated announcement in late summer or fall 2005). In July 2005, the Steering Committee and Technical Advisory Committee began review of 13 prepropsals.

e. *Select new research areas for next EPSCoR competition and submit new state proposal*. Pending the final announcement and schedule for the EPSCoR 2005 competition, South Dakota researchers will refine the 13 preproposals and submit a new state proposal in late 2005. This process will be closely coordinated with the EPSCoR Office at NASA Headquarters as well as with NASA scientists at the applicable Field Centers.

Timetable for Major Core Grant Activities in Years 4-5.



South Dakota NASA EPSCoR

		Patents and Publications				New Grants		Participants				Collaborations		
State	Universities Involved	Peer Reviewed Pubs.	Other Pubs.	Present.	Patents	New Grants	New Grants Value	Undergrad Students (cum)	Graduate Students (cum)	Post-Doctoral	Faculty	Collabs. w/ NASA Centers	Collabs. w/ Industry	Collabs. w/ Others
NASA EPSCoR years 1-3 (Sept. 1, 2001 through Aug. 31, 2004)														
SD	Core Grant	0	0	0	0	2	$73,000	6	11	0	10	0	2	7
SD	SDSU	17	37	106	0	13	$1,100,000	14	8	1	7	2	5	100
SD	SDSMT, Augustana	10	16	19	0	11	$329,131	8	5	0	6	1	5	30
State totals (years 1-3)		27	53	125	0	26	$1,502,131	28	24	1	23	3	12	137
update for year 4 (Sept. 1, 2004-Aug. 31, 2005)														
SD	Core Grant	2	0	8	0	3	$819,867	0	5	0	12	3	0	5
SD	SDSU	17	3	17	0	5	$700,000	6	3	0	7	2	5	30
SD	SDSMT, Augustana, U Idaho	1	6	6	0	3	$695,044	9	7	0	6	2	6	40
SD	Augustana					1	$1,020,596							
State totals (year 4)		20	9	31	0	12	$3,235,507	15	15	0	25	7	11	75

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

Year 4 Annual Report

Lead investigators:

Dr. Lee A. Vierling
College of Natural Resources
University of Idaho
Moscow, ID 83844

Drs. William Capehart and Patrick Zimmerman
South Dakota School of Mines and Technology
Rapid City, SD

Drs. Steven Matzner and Daniel Swets
Augustana College
Sioux Falls, SD

Publication Activity

The following publications have been completed as a direct result of this project. All publications listed cite NASA EPSCoR support in their acknowledgments.

Manuscripts submitted, published, or in press

Toomey, M., and Vierling, L. A comparison of Landsat and ASTER for equivalent water thickness derivation*, Canadian Journal of Remote Sensing,* in review.

Chen, X., Vierling, L.A., Deering, D.W., and Conley, A.H. Monitoring boreal forest LAI across a Siberian burn chronosequence: a MODIS validation study. *International Journal of Remote Sensing*, provisionally accepted pending revision.

Chen, X., Vierling, L.A., and Deering, D.W. A simple and effective image normalization method to improve landscape change detection across sensors and across time. *Remote Sensing of Environment*, in press.

Derr, K.D., Vierling, L.A., and Matzner, S.L. 2005. Effects of different fire intensities on understory vegetation diversity in the Jasper Burn area of the Black Hills. *Proceedings of the South Dakota Academy of Sciences* 83, 189-195.

Toomey, M. and Vierling, L. 2005. Multispectral remote sensing of landscape level foliar moisture: techniques and applications for forest ecosystem monitoring. *Canadian Journal of Forest Research*, 35(5): 1087-1097.

Chen, X., Vierling, L., Rowell, E., and DeFelice, T. 2004. Using lidar and effective LAI data to evaluate IKONOS and Landsat 7 ETM+ vegetation cover estimates in a ponderosa pine forest. *Remote Sensing of Environment,* 91(1): 14-26.

M.S. Theses

Fersdahl, M. Seasonal variations of MODIS vegetation index products in a coniferous forest canopy. South Dakota School of Mines and Technology. Successfully defended in Fall, 2004.

Nelson, K. Evaluating the Effects of Spatial Scale on Remotely Sensed Mapping of Burn Severity: A Comparison of Landsat and MODIS Data. South Dakota School of Mines and Technology. Successfully defended in April, 2005. (Note: this M.S. thesis was conducted as a direct result of this NASA EPSCoR project, but received student funding through another source.)

Rowell, E.M. Estimating forest biophysical variables from airborne laser altimetry in a ponderosa pine forest. South Dakota School of Mines and Technology. Successfully defended in Spring, 2005.

Toomey, M. Remote sensing of arboreal leaf area index and foliar moisture using empirically- and physically-based methods. South Dakota School of Mines and Technology. Successfully defended in August, 2004.

Ph.D. Dissertation

Chen, X. Improvements in quantifying and monitoring terrestrial land cover across scales using remote sensing techniques. South Dakota School of Mines and Technology. Successfully defended in August, 2004.

Invited talks and presentations at professional meetings

Vierling, L. "A Global Change Sampler Plate: Observations, Challenges, and Opportunities." University of Wyoming, Laramie, WY. June, 2005.

Vierling, L., Chen, X., Rowell, E., and DeFelice, T. "The Use of Lidar to Validate Sub-Pixel Forest Cover Estimates from IKONOS and Landsat." Lidar Concepts and Resource Applications Workshop, USFS/RSAC, Salt Lake City, UT. May, 2005.

Seielstad, C., Rowell, E., Queen, L., Hardy, C., McCaughey, W., and Vierling, L. "Assessing Forest Fuels with Airborne Laser Altimetry." Lidar Concepts and Resource Applications Workshop, USFS/RSAC, Salt Lake City, UT. May, 2005.

Chen, X., Vierling, L., and Deering, D. "A Simple and Effective Image Normalization Method to Monitor Boreal Forest Change in a Siberian Burn Chronosequence across Sensors and across Time." American Geophysical Union Fall Meeting, San Francisco, CA. December, 2004.

Toomey, M. and Vierling, L. "A Comparison of Landsat TM and ASTER for Equivalent Water Thickness Derivation in a Ponderosa Pine Ecosystem." American Geophysical Union Fall Meeting, San Francisco, CA. December, 2004.

Vierling, L. "From the Leaf to the Landscape: Using Advanced Remote Sensing Techniques to Identify Plant Canopy Structure." Idaho National Environmental and Energy Laboratory (INEEL), Idaho Falls, ID. October, 2004.

Follow-on grant proposals submitted/funded

"An Airborne Laser Monitoring System for Certification and Monitoring of Terrestrial Vegetation Carbon Stocks." Submitted to DOE STTR Phase 1 Program. Collaborators: L. Vierling, P. Gessler, A.M.S. Smith, P. Zimmerman, R. Nelson. PI: Chuck Eubank (AquilaVision, Inc.). $100,000. Declined.

"Hyperspectral Imaging for Range Monitoring and Management." Submitted to Little Endowment Grant Competition. PI: Lee Vierling. $10,000. Funded.

"Integrating applied spatial analysis into an undergraduate curriculum to solve interdisciplinary natural resource problems." Submitted to NSF. PI: Paul Gessler co-PI: L.Vierling, P. Morgan, L. Waits. $200,000. Declined.

"Identifying sources of smoke aerosols and combustion gases using stable isotope signatures." Submitted to USFS-Joint Fire Sciences. Collaborators outside UI: USFS/RMRS Moscow, ID. PI: John Marshall. Collaborator: L. Vierling. Declined.

"Evaluating the effects of institutional change on regional hydrometeorology: Assessing the vulnerability of the Eurasian semi-arid grain belt." Henebry, G.M., A. Gitelson, E. Lioubimtseva, and W.J. Capehart, co-PIs. NASA NEWS/04-02-0000-0165, $599,719, Funded at $569,693.

"Quantification and Scaling-Up of the Coupled Biogeochemical Cycles of Carbon and Water in Grassland Ecosystems of South Dakota: Synthesis of flux Tower measurements, Modeling, GIS, and Remote Sensing." T. Gilmanov, L. Vierling, S. Matzner, A. Smart, co-PIs. Project dates 4-1-04 through 10-31-05, South Dakota EPSCoR Biocomplexity Small Grants for Exploratory Research, under NSF #EPS-0091948. $115,351. Funded.

"ForestPARC - The Forestry Remote Sensing Outreach Program." Submitted to NASA via the Upper Midwest Aerospace Consortium (UMAC), University of North Dakota (Prime). L. Vierling and P. Gessler, Co-PIs. $109,870. Pending.

Enhancement of the U.S. Drought Monitor by Integrating NASA Earth Science Data, , Jim Verdin (EROS), PI, and Jess Brown (EROS), Steve Goddard and Don Wihite (both from UNL), Michael Hayes and Mark Svoboda (both from National Drought Mitigation Center), Daniel Swets (Augustana). Total 3-year budget: $1,020,596.00, cost share $156,550.00.

Examples of collaboration that have arisen from this project:

Note: Items # 1, 2, and 4 were listed last year in the 3rd year report, and are re-listed here in edited form due to continued fruitful collaboration. Other items are new.

1. Locally, we have partnered with Horizons, Incorporated, a Rapid City-based photogrammetry and lidar remote sensing firm, and entered into a formal agreement whereby Horizons provided three lidar data flights over our Black Hills field sites for incorporation into our research and development program. In addition, Horizons paid for one year of salary for a graduate student (Eric Rowell) to develop his MS thesis, which includes elements of LAI algorithm development. This collaboration has continued to establish Horizons, Inc. as an industry player in providing discrete-return lidar data for forestry purposes. In total, this collaboration and related activities represent more than $75,000 in industry investment.
2. As a result of discussions with Don Deering (NASA GSFC) to suggest video-controlled stabilization of the Short Wave Aerostat-Mounted Imager (SWAMI), we have established a cooperative agreement with Pyramid Vision Technologies (a division of Sarnoff Corp., Princeton, NJ) and have been granted a no-cost use of approximately $45,000 of computer vision hardware and software from that company. This collaboration is continuing, with current exploration as to how other technologies developed by Sarnoff Corp. (originally designed for DOD usage) can be used for forest measurement and monitoring.
3. We are now collaborating with the Oglala Lakota College, Kyle, SD which has acquired their own high resolution tripod-mounted laser scanner and has allowed its use in this project. We have made scans of larch trees in north Idaho pre- and post-needle drop (during Fall and Winter, 2004) in order to investigate the utility of such an instrument in deriving parameters essential for calculating LAI for conifer forests. Previously, these parameters could only have been measured by cutting down trees. This work is the cornerstone of the MS research being conducted by Rick Clawges, SDSM&T.
4. Our work has attracted the attention of scientists at the Science Applications International Corporation (SAIC) directing the LANDFIRE project at the USGS EROS Data Center, Sioux Falls, SD. The SAIC employed one SDSM&T graduate student (Kurtis Nelson) full time in order that he could complete work relating to pre/post-fire vegetation health in this project. As a result of this collaboration, three recent SDSM&T graduates (Kurtis Nelson, MS, Zhengpeng Li, MS, and Xuexia Chen, Ph.D.) now hold scientist positions at EROS, keeping this research expertise within the state of South Dakota.
5. We have begun to partner with Aquilavision Inc., a remote sensing applications company based in Missoula, MT and Moscow, ID, to develop advanced lidar techniques for biomass assessment. In Winter 2004 we submitted an SBIR grant proposal representing a collaboration between R. Nelson, NASA/GSFC, SDSM&T, UI, and Aquilavision. Although this proposal was declined, we continue this collaboration and plan to submit future proposals as a research team.
6. In relation to this work we have established the Forest Public Access Resource Center (ForestPARC), led by scientists at SDSM&T, the University of Idaho, the University of Montana, and Montana State University in collaboration with the Upper Midwest Aerospace Consortium. As a result of the work started with this EPSCoR grant, ForestPARC co-sponsored a "Lidar Concepts and Resource

Applications" conference with the USDA Forest Service Remote Sensing Applications Center in Salt Lake City, UT, May, 2005.

Synopsis of Program Activities for the remainder of the grant period:

The original PI of this project, Dr. Lee Vierling, moved from the South Dakota School of Mines and Technology (SDSM&T) to the University of Idaho in September, 2004. Due to Dr. Vierling's central role in completing this grant project, a budget revision (including a subcontract to the University of Idaho) has been requested under separate cover. Dr. William Capehart will become the project's new PI within South Dakota, and will coordinate closely with Dr. Vierling to achieve the desired grant outcomes.

The following table spells out the breakdown of work tasks that will be fulfilled by researchers at SDSM&T, Augustana College, and the University of Idaho during the remainder of the grant period. These work tasks are each directly relevant to the research goals outlined in the original EPSCoR proposal as well as in the request for follow-on funding. The numbers shown in the table indicate the level of responsibility of each institution in fulfilling the various tasks, with a "1" indicating primary responsibility, and a "2" indicating secondary responsibility. Tasks with equally shared responsibility are so indicated using equal numbers. *In addition, those tasks representing focal areas during the final stages of the grant are shown in **bold** typeface, while the tasks representing areas of synthesis from previous stages of the grant are shown in normal typeface.*

Task	SDSM&T	Augustana College	U. of Idaho
Collect field data sets with which to validate/evaluate remote sensing measures of LAI, with the goal of improving the accuracy of remotely derived leaf area estimates across fire chronosequences in the Black Hills and Siberia.	2	2	1
Determine the spatial scale at which conifer forest LAI can be most accurately derived using remote sensing.	1		1
Determine the extent to which bidirectional measurements using the Multi-Angle Imaging Spectroradiometer (MISR) can be used to improve LAI (and FPAR) estimates using remote sensing.	**1**		**2**
Establish relationships between spectral vegetation indices and LAI for the Black Hills and Siberia across fire chronosequences.	2		1
Use LAI datasets to gain further insights to vegetation structure and function in forested ecosystems using satellite remote sensing.	2	2	1
Conduct analyses of ground lidar data to derive biophysical parameters in needleleaf systems.	**1**	**2**	**1**
Utilize airborne lidar data to improve delineation of LAI and biomass among vegetation functional groups for landscape-level assessment of biogeochemical pools and wildlife habitat.	**1**	**2**	**1**
Strengthen collaboration between SD and NASA scientists.	**1**	**2**	
Establish/strengthen collaboration between SD scientists and industry partners at the local, regional, and national scales.	**1**	**2**	
Strengthen collaboration among SD university scientists and scientists at other institutions in the area of terrestrial remote sensing.	**1**	**2**	**1**

Provide research and educational opportunities for students interested in remote sensing-related careers.	**1**	**2**	**1**
Organize outreach activities to educate K-12 students and the general public about remote sensing and earth system science.	**2**	**2**	**1**

A. Cover Page

Name of state: South Dakota

Cooperative agreement number: NCC5-588

Effective dates: September 1, 2004 through August 31, 2005 (year four)

Research project title:

Cross-Calibration of Landsat and IKONOS Sensors for Use in Precision Agriculture.

Lead investigator information:

D. Helder[1], D.E. Clay[2], and D. Aaron[3]

[1]Department of Electrical Engineering and Computer Science

[2]Department of Plant Science

[3]Department of Physics

South Dakota State University, Brookings, SD, 57007

Date: July 12, 2005

B. Progress Report for Year 4

1. Abstract

Precision agriculture, or site specific farming, has revolutionized modern agriculture. Site specific farming uses differentially corrected global positioning systems (DGPS) and geographic information management systems (GIS) to vary management within fields to optimize returns. Site specific farming is based on the idea that the right inputs can be applied at the right place an at the right time. However, to develop site-specific recommendations, accurate information is needed. Remote sensing can help fill this need. For remote sensing to have value to land managers, the information must be accurate and contain information that can be used directly by decision support systems. For example, the remote sensing data must be radiometrically corrected, cross-calibrated to other sensors being used by the grower, available in a timely manner, and corrected for atmospheric distortions. The research conducted under this NASA EPSCoR project has shown that one of the largest errors associated with using remote sensing information is incorrect calibration of atmospheric effects. Accordingly, the objectives of this study are to: (i) conduct cross-calibration of Landsat TM, Landsat ETM+, and IKONOS sensors using standard reflectance measurements within wheat, grass, and soybean fields, and (ii) develop and evaluate rules to identify the "best" sensor for given agronomic applications, including applying various levels of atmospheric correction to the sensor data.

Research conducted in the first four years of the study showed that remote sensing can be used to improve agricultural management and band-specific radiometric correction improves the usefulness of remote sensing data. Research during the last year of this study will concentrate on expanding plot and whole-field specific findings to the watershed scale, continue research on radiometric corrections, analyze data, and prepare a final report. Findings from this study are being published in scientific journals, being used to develop precision farming guidelines, integrated in proposals for additional funding, and shared with end-users at conferences and workshops.

2. Accomplishments

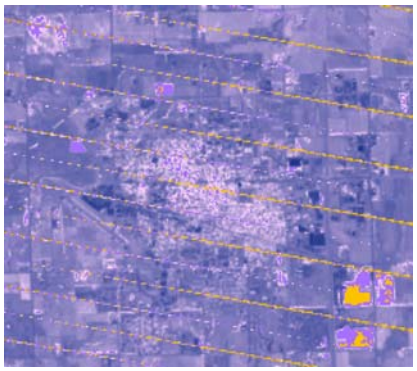
a. Research activities

Cross calibration and atmospheric correction

The goals of the this part of the project include cross calibration, atmospheric modeling, and replacing top of atmosphere surface reflectance with atmospherically corrected to ground level reflectance. The calibration group has developed and verified the equipment base and data tools used to both cross calibrate and routinely parameterize the atmosphere. Specific goals for years 4 and 5 were to 'productionize' the parameterization of atmosphere corrections. Specific goals are to: (i) reduce the atmospheric analysis time to less than 48 hours after an overpass, (ii) to produce atmospherically correctly reflectance images in less than one week after receipt of the image, and (iii) develop an accurate assessment of the error bounds for the processed data (i.e. the reflectance product).

Complete Modtran based atmospheric analysis is now routinely performed at SDSU by the satellite calibration team. All 'good' days were analyzed and select 'marginal' days had attempted analyses. These results were applied to image correction and used to verify instrument calibration factors (results were reported to the Landsat Science and JACIE teams). Two process capability experiments were run to verify turn-around time for the analyses. In both cases the atmospheric analysis was performed in less than 30 hours which was well within our goal of 48 hours. Since successful data collection did not occur until within the university's academic year verification of the time required to produce an atmospherically corrected reflectance was postponed until the 2005 data collection season. Typical results that illustrate correcting imagery for atmospheric effects are shown below (Fig. 1).

a. Landsat 7 image from Sept 29, 2004.



b. weighted change in reflectance due to atmospheric effects.

Fig. 1. A typical Landsat scene of the Brookings, SD, area. Part a. shows the base image, however, atmospheric effects produce errors in ground reflectance that range from 0.4% for band 7 (near IR) to 28.6 % for band 1 (blue). Part b illustrates the net change due to atmospheric effects for different spatial areas.

Comparison of corrected data with measured values

To validate the atmospheric correction procedure, atmospherically corrected and Landsat 1G data were compared to reflectance values measured at six targets (parking lots and fields) with a range of spectral reflectance at three dates in 2004. (Note: this work is continuing in 2005.) At each target that was at least 80 by 80 m in size, reflectance was measured with a calibrated Cropscan on at least a 10 by 10 m grid. These sites were selected based on their uniformity. The Cropscan measures incoming and reflectance values simultaneously. Known reflectance values for the Landsat pixel were determined by averaging the values with the pixel.

Data in 2004 were collected on three dates in 2004 (June 25, July 11, and September 29). A root mean square error was used to compare measured, corrected, and reflectance converted 1G data (uncorrected). The corrected data were based on the approach developed by the Physics Team described above. The three dates had different atmospheric conditions (Table 1). On June 25 and July 11 the atmospheric conditions were hazy, while on September 29, atmospheric conditions were clear. These results show that for the blue, green, red, NIR, and MIR bands the radiometrically corrected data are better than the 1G data. The largest improvement for the corrected data, relative to 1G data, occurred on hazy days. On the clear day, the RMSE for the standard Landsat product were lower than hazy days. The corrected data did equally well on all days.

Table 1. The influence of sampling data and atmospheric conditions on root mean square errors for corrected and reflectance converted Landsat 1G data (uncorrected).

Landsat	Band	25July		11 July		29 Sept.	
Band	centers	Corrected	Uncorrec.	Corrected	Uncorrec.	Corrected	Uncorrec.
	nm			RMSE			
Blue	485	5.01	33	3.43	30.7	1.83	3
Green	510	5.24	23.8	4.65	27.3	1.88	3.98
Red	660	4.7	21.2	2.57	17.1	3.54	7.13
NIR	830	8.49	19.9	2.35	14.5	5.75	13.59
MIR	1650	8.23	24.7	3.89	19.7	5.73	14.22
All	bands	6.34	24.5	3.37	21.8	3.74	8.38
atmospheric conditions		Hazy		Hazy		Clear	

Test the feasibility of using remote sensing to assess regional yield variability

The goal of this part of the project is to determine if Landsat TM data can be used to develop an evapotranspiration (ET) map for production fields located in the Great Plains. If successful, findings from this project could be used to develop a regional yield assessment based on local information. This information can be used for within field and watershed planning. Two fields of 65 ha, located near Brookings and Moody in east-central South Dakota were used for this study. Soybean and corn were planted in Moody and Brookings, respectively. The crop yield data were collected using the yield monitor. The METRIC^{tm} model was used for calculating ET values on data collected on August 4, 2001. In this model the ET flux is calculated for each pixel of the cropped area as a residual of the surface energy budget equation and it is expressed as the energy consumed

by the evaporation process. If water is the limiting factor, then there should be a strong correlation between ET and measured yields. In the Brookings field, soybean yields and ET had a correlation coefficient of 0.78**, whereas in the Moody field, corn yields and ET had a correlation coefficient of 0.72**. Water limitations in corn and soybean yields were confirmed by field experiments. For comparative purposes, yield and ET maps for Brookings field are provided below.

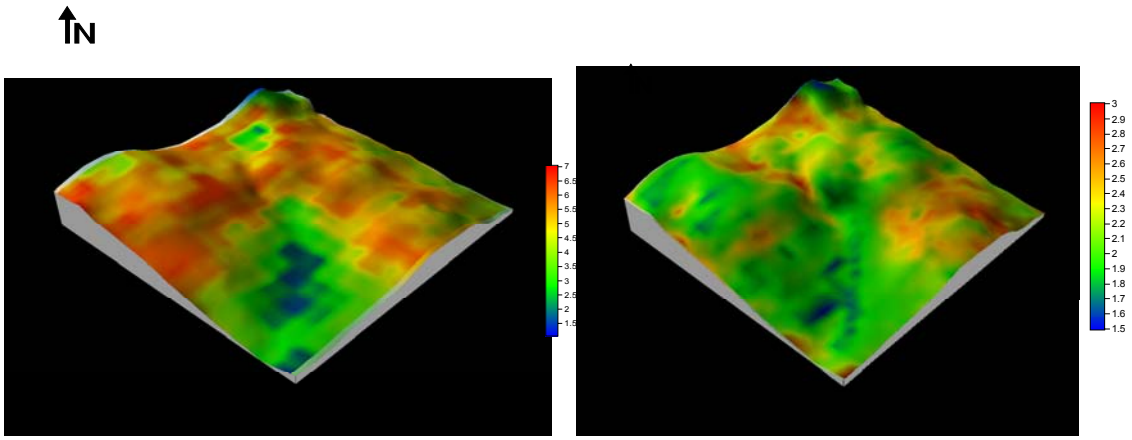


Fig.2. ET (left) and soybean yield (right) map from the Brookings field. The METRIC^{tm} model was used to calculate ET values for August 4, 2001. Yields were measured with a calibrated yield monitor.

Remote sensing for improved nutrient and water management

Remote sensing has been proposed as a tool to assessing a variety of stress in production fields. To develop quantitative models, relationships between remote sensing and specific stresses must be understood. The objectives of this study are to determine the influence of water and N stress on reflectance from a corn (*Zea mays* L.) crop and the ability to detect N and water stress with different indices. A replicated N and water treatment factorial experiment was conducted in 2002, 2003, and 2004. Yield losses due to water (YLWS) and N (YLNS) were determined using the ^{13}C discrimination (Δ) approach. Reflectance data (400 to 1800 nm) collected at three growth stages (V8-V9, V11-VT, and R1-R2) were used to calculate seven different remote sensing indices. At the vegetative (V8-VT) growth stages, YLNS was negatively correlated to all indices. YLWS was not correlated to any indices except the normalized difference water index [NDWI= (NIR-MIR)/(NIR+MIR)] at V11-VT (r = -0.28**) and the normalized difference vegetation index [NDVI = (NIR-Red)/(NIR+red)] at the R1-R2 (r = -0.61**). Findings from the study show that at the V8-V9 growth stage, N stress impacted reflectance and water stress did not influence reflectance, while at the R1-R2 growth stage both N and water stress impacted reflectance. A remote sensing model based on YLNS was more accurate at predicting N requirements than models based on yield or yield plus YLWS. These results were attributed to N and water having an additive effect on yield and similar optimum N rates (between 100 and 120 kg N ha^{-1}) for both moisture regimes.

b. Findings will be shared with local communities through workshop and teacher training

During this project numerous training opportunities have been provided to teachers, producers, and crop consultants. These training opportunities have provided hand-on training on using GIS and remote sensing data. One unique program supported by this project is the Adopt-a-Farm website. The goal of the website is to document how remote sensing and spatial information is used to improve management decisions. The website contains detailed a geospatial technology curriculum. The curriculum was prepared by agricultural education majors in collaboration with South Dakota agriculture teachers.

c. Continue collaboration with NASA scientists

Collaborations with NASA scientists were continued and expanded during the project. In June of 2003 a Landsat Team conference was hosted at SDSU. At this conference representatives from several NASA Centers were present. In Washington D.C., at an NASA EPSCoR conference, SDSU researchers met with Jack Xiaong and Bill Barnes of NASA MODIS at Goddard, James Dodge of EOS at NASA Headquarters, Brian Markham, John Barker, Jim Butler, and others Landsat Goddard personnel. On May 20, 2004, a group of SDSU Scientists (D.E.Clay, S.A. Clay, C.G. Carlson, and K. Dalsted) traveled to Stennis Space Center to present research findings and discuss current and future activities with Rodney McKellip, Project Manager, Applications Research Division, Earth Science Applications Directorate, and Vick Zanoni, Technical advisor for the Cross Calibration Project, NASA Earth Science Applications Directorate. Research activities and a proposal were prepared with NASA collaborators (McKellips and Zanoni) was submitted to NASA for funding. Although not funded, relationships were strengthened.

3. Publications (year four)

Clay, S.A., J. Kleinjan, D.E. Clay, F. Forcella, and W. Batchelor. 2005. Growth and fecundity of weed in species in corn and soybean. Agron. Journal. 97:294-302.

Clay, D.E., C.G. Carlson, S.A. Clay, C. Reese, Z. Liu, and M.M. Ellsbury. 2005. Calculating soil organic C turnover for elevation zones using the C-13 natural abundance approach. Agronomy Journal (in review)

Clay, D.E., C.G. Carlson, S.A. Clay, J. Chang,a nd D.D. Malo. 2005. Soil organic C maintenance in a corn (*Zea mays* L.) and soybean (*Glycine max* L.) as influenced by elevation zone. Journal of Soil Water and Conservation. (in review)

Clay, D.E., J. Chang, Ki-In Kim, and S.A. Clay. 2005. Characterizing water and N stress in corn using remote sensing. Agron. Journal. (In review).

Clay, S.A., J. Chang, D.E. Clay, C. Reese, and K. Dalsted. 2004. SSMG-41. Using Remote Sensing to Develop Weed Management Zones in Soybeans. Clay et al. (Ed) *Site Specific Management Guidelines*. Potash and Phosphate Institute. Norcross, GA.

Kleinjan, J, D.E. Clay, C.G. Carlson, and S.A. Clay. 2004. Developing productivity

zones from multiple years of yield monitor data. GIS in Agriculture ESRI (In review).
Clay, D.E. N. Kitchen, J. Kleinjan, and C.G. Carlson. 2004. Using historical management areas to reduce soil nutrient sampling error. GIS in Agriculture, ESRI (In review).
Clay, D.E., P. Danielson, C. Reese, K. Dalsted, and S.A. Clay. 2004. Whole Field Corn Yield Estimates Using Remotely Sensed Data. Comm Soil Sci Plant Anal. (In review).
Clay, D.E., C.G. Carlson, and J. Chang. 2004. Identifying the "Best" Approach to Identify Nutrient Management Zones: A South Dakota Example SSMG 41. Clay et al. (Ed) *Site Specific Management Guidelines*. Potash and Phosphate Institute. Norcross, GA.
Chang, J. D. E. Clay, C. G. Carlson, C. L. Reese, S. A. Clay, and M.M. Ellsbury. 2004. The Influence of different approaches to define yield goals and management zones on N and P fertilizer recommendations errors. Agron. J. 96:825-831.
Chang, J. S.A. Clay, D.E. Clay, D.Aaron, and D. Helder. 2004. Comparing spectral reflectance data collected from two different spectroradiometers for ground reflectance measurements. Com. Soil and Plant Anal. (In press).
Clay, D.E., S.A. Clay, D.J. Lyon, and J.M. Blumenthal. 2005. Can ^{13}C discrimination in corn (*Zea mays)* grain be used to characterize intra-plant competition for water and nitrogen? Weed Sci. 53:23-29.
Chang, J., S.A. Clay, and D.E. Clay. 2004. Detecting weed free and weed infested areas of a soybean (Glycine max) field using NIR reflectance data. Weed Sci. 52:642-648.
Helder, D., and T. Ruggles. 2004. Landsat Thematic Mapper Reflective Band Artifacts. IEEE Transactions on Geoscience and Remote Sensing, 42: 2704-2716.
Helder, D. and E. Micjevic. 2004. Landsat Thematic Mapper Outgassing Effects. IEEE Transactions on Geoscience and Remote Sensing, 42:2717-2729.
Helder, D., T. Ruggles, J. Dewald, and S. Madhavan. 2004. Landsat Thematic Mapper Reflective Band Artifacts. IEEE Transactions on Geoscience and Remote Sensing, 42:2730-2746.
Helder, D., T. Ruggles, and J. Dewald. 2004. Landsat 5 TM Reflective-Band Absolute Radiometric Calibration," IEEE Transactions on Geoscience and Remote Sensing, 42:2747-2760.
Helder, D. 2004. In-Flight Validation and Recovery of Water Surface Temperature With Landsat 5 Thermal Infrared Data using an Automated High-Altitude Lake Validation Site at Lake Tahoe. IEEE Transactions on Geoscience and Remote Sensing, 42:2767-2776.
Helder, D., J. Dewald, K. Thome, and D. Aaron. 2004. Landsat 5 TM and Landsat 7 ETM + Absolute Radiometric Calibration Using Reflectance Based Method. IEEE Transactions on Geoscience and Remote Sensing. 42:2777-2785.
Helder D. 2004. Landsat 7 ETM + On Orbit Reflective-Band Radiometric Stability and Absolute calibration. IEEE Transactions on Geoscience and Remote Sensing, 42:2810-2820.
Helder, D. 2004. Cross Calibration of the Landsat -7 ETM+ and EO-1 ALI Sensor. IEEE Transactions on Geoscience and Remote Sensing. 42:2821-2830.

Helder, D., T. Choi, and M. Rangaswamy. 2004. In-Flight Characterization of Spatial Quality using Point Spread Functions. International Society for Photogrammetry and Remote Sensing, 2:149-170.

4. Presentations (year four)

Helder,D., and Jason Choi. 2004. On-orbit Modulation Transfer Function (MTF) measurement of QuickBird. Nov 8, 2004 High Spatial Resolution Commercial Imagery Workshop
Reston, Virginia, USA

Helder D., and Kenton Ross. 2004. QuickBird and OrbView-3 Geopositional Accuracy Assessment. High Spatial Resolution Commercial Imagery Workshop. Reston, Virginia, USA. November 8, 2004

Mettler C., and D. Helder. 2005. Cross-Calibration of the Landsat 4 and Landsat 5 Thematic Mappers., Brookings, SD 57006 SPIE Conference, August 2005

Songxin Tan, Ram Narayanan, and Dennis Helder 2005. Polarimetric reflectance and depolarization ratio from several tree species using a multiwave polarimetric lidar. Brookings, SD SPIE Conference, August 2005

Clay, D.E. and C.G. Carlson. 2004. Precision conservation on spatial variability of C sequestering, N cycling, and water infiltration in two Northern Great Plains no-tillage production fields. Presented at the Precision Conservation in North American Symposium held at the ASA 2004 annual meetings, Seattle October 31- Nov. 4, 2004.

Reese, C, D.E. Clay, C.G. Carlson, and J. Chang. 2004. Intergrading soil and crop information in the development of management zones. Presented at the SDSU Soil Moisture, Brookings SD 12 January, 2004.

Reese, C. J. Kleinjan, D. Beck, D.E. Clay, S.A. Clay, and C.G. Carlson. 2004. Nitrogen and Water Stress effects on Wheat Yield and Quality. Presented at the Dakota Lakes Research Farm Field Days, on 24 June, 2004.

Reese, C., D. Beck, C.G. Carlson, D.E. Clay, and S.A. Clay. 2004. Nitrogen and Water Stress effects on Wheat Yield and Quality. Presented at the Dakota Lakes Research Farm Tours: North Dakota-Manitoba Farm Group. 22, July, 2004.

Clay, D.E., C. Reese, C. Ullery, and S.A. Clay. 2004. An overview of SD USDA 406 water quality activities. January 11-12, Clearwater Florida.

Clay, D.E., C. Reese, and C.G. Carlson. 2004. Evaluating techniques for identifying management zones. South Dakota precision farming workshop on identifying management zones. February 25, Brookings SD.

Reese, C. and D.E. Clay. 2005. Identifying management zones. February 3-5, 2005, Grand Forks Annual UMAC meeting.

Clay, D.E., S.A. Clay, C.G. Carlson. 2005. Is precision farming a BMP. National 406 water quality meeting. San Diego California, February 7-10, 2005

Kim, K., D.E. Clay, S.A. Clay, and C.G. Carlson. 2004. Using stable isotopes to understand N and water stress in corn production fields. ASA annual meeting, Seattle Washington, November 2004

Chang, J., D.E. Clay, S.A. Clay, and K. Kim. 2004. Predicting N and water stress in corn using remote sensing. ASA annual meeting, Seattle Washington, November 2004

Brunner, R., K. Lane, C. Reese, D.E. Clay, S.A. Clay, and C.G. Carlson. 2004. How to use GPS/GIS and Introduction to Adopt A Farm website. Presented at the Sinte Gleska GPS/GIS training, in Rosebud, SD on 21 June, 2004.

D.E. Clay, C.G. Carlson, S.A. Clay, C. Reese, Z. Liu, and M.M. Ellsbury. 2005. Landscape position influences soil organic C maintenance rates in the northern Great Plains. Presented at the 1st SD Regional Biocomplexity conference August, 2004, Sioux Fall, SD.

Clay, S.A., D. E. Clay, J. Change, and Z. Liu. 2004. Quantifying N and water stress in plants. Presented at the 1st SD Regional Biocomplexity conference August, 2004, Sioux Fall, SD.

Brunner, R., C. Reese, D.E. Clay, M. O'Niell. 2004. Introducing the Adopt-A-Farm Website. Presented a the SD Association for Career and Technical Education meeting, Pierre, SD, August 2, 2004.

Reese, C., D.E. Clay, and C.G. Carlson. 2004. Identifying soil nutrient management zones. UMAC annual meeting, Grand Forks, ND, March 4-March 5.

5. Outreach

- Conducted summer workshops at the EROS Data Center on GIS/Remote Sensing. 31 K-12 teachers attended the week-long training (impact is estimated at 750 students/year).
- 30 presentations at farmer groups and field days.
- Profit CenterAanalysis Workshop, February 18, 2004, SDSU
- Identifying Management Zones Workshop, February 25, 2004, SDSU (31 participants).
- Semi Annual Soil and Moisture Conference, January 11-14, 2004, SDSU (90 producers).
- Integrating Emerging Technologies into Ag Production Systems Conference held at the Sioux Fall Farm show on January 26, 2005. (100 producers attended)
- Aberdeen Precision Farming Conference, March 8 2005. (250 producers attended)

6. List of follow-on grants funded (year four)

Clay, D.E., C.G. Carlson, and S.A. Clay. 2005. USDA-CSREES Challenge grant program. $141,096, Information Age Technology for Integrated Agricultural Systems Analysis Curricula, 2005-2007.

Dwayne Beck, David Clay, C. Greg Carlson, and Cheryl Reese. SD Wheat Commission $43,310, Optimizing wheat management. 2004-2006.

Clay, D.E. and C.G. Carlson. SD Corn Utilization Council 2002-2006. $136,000 requested, Using deep tillage to improve corn profitability.

O'Neill, M,, D.E. Clay, S. Shin, and K. Dalsted. USGS, SDView, 2002-2006, $360,000.

Helder, D., and Aaron, D. Continuation of assessment of high resolution satellite imagery. NASA Stennis Space Center. $140,000/year, IKONOS 5 NAG13-03023.

Waskom, R., B. Seelig, D. Clay, J. Bauder, N. Mesner, Q. Skinner 2004-2009. $260,000 SD component only. Coordinated agriculture water quality programming for the Northern Plains and Mountain Regions. USDA-CSREES-406 program.

7. Grants submitted and not funded: Will be provided if requested

8. Name and frequency of contact with technical monitor

This project technical monitor has been Vicky Zanoni of the NASA Earth Science Applications Directorate, John C. Stennis Space Center, MS. Currently she is on temporary assignment at NASA Headquarters. During this assignment this project has coordinated activities with Rodney McKellips located at Stennis. During the past year we have communicated through E-mail, phone conversations, and have visited Stennis. The monitoring on this project has both formal and informal components.

9. Advisory and technical monitors board members

Advisory/planning Board
David Diedrich, Diedrich Bros. Farms, Elkton, SD
Ryan Patterson, Patterson Farms, Britton, SD
Ron Alverson, President of the SD Lake Area Corn Processors Cooperative, Chester SD.
Lannie Mielke, Mellette, SD
Scott Carlson, Lake Preston, SD
S. Murrel, , Northcentral Director Potash and phosphate Institute, Woodbury, MN
M. Ellsbury (USDA-ARS), Northern Grain Insect Research Laboratory, Brookings, SD.
D. Long (USDA-ARS), Columbia Plateau Conservation Research Center, Pendleton, OR
K. Reitsma, SD Department of Agriculture, Pierre, SD
D. Clarke, SD Department of Water and Natural Resources, Pierre, SD

10. Metrics for tracking

Metrics for continued tracking of the accomplishments of the project will record impacts in both the outreach and scientific aspects of the work. For outreach purposes the project will record: (i) the number of invited and volunteered presentations made to both scientists and to the general public, (ii) the number of fact sheets and guideline papers prepared, and (iii) an index as to the acceptance of producers integrating remote sensing into their management process and their general knowledge. At workshops and symposiums participants will be asked to fill out surveys. By tracking survey responses over time, we will be able to assess changes in end-user perceptions.

For scientific activities, the metrics that will be used for evaluation will include the number and quality of peer review papers prepared and published, the number and quality of invited and volunteered presentations, and the ability to meet the timetable.

11. Improvements in state research and development infrastructure

- SDSU College of Engineering received a hardware server from the USGS for Landsat Thematic Mapper Assessment System.
- Development of a New Geographic Information Sciences Center at SDSU (see below)

12. Systemic changes

Reordered state and/or institutional priorities: A significant new research entity has been established at SDSU (the Geographic Information Sciences Center of Excellence, or GISc) and at EROS through state funding. Five new research faculty are in the process of being hired for the GISc, and most of them will be working on NASA related research priorities.

Increased financial commitment from the state, industry, and participating institutions: The College of Engineering received a partially funded position to work with Raven Industries on remote sensing applications with an Unmanned Aerial Vehicle and multispectral sensor.

13. Examples of successful transfer of technology to the private sector

The College of Engineering received a partially funded position to work with Raven Industries on remote sensing applications with an Unmanned Aerial Vehicle and multispectral sensor

14. Extent to which collaborations with State agencies, industry, research and academic institutions, and with NASA have evolved.

Two College of Engineering staff members were awarded Research 2010 follow-on research projects from the state: Songxin Tan for work on Lidar, and Alfred Andrawis for work on fiber optics sensor development (50% faculty release time for one year).

Collaborative projects between NASA and SDSU scientists have been developed and proposed to various funding opportunities.

15. Evidence of how EPSCoR activities have furthered State priorities.

Technology programs are now seen as a key to South Dakota's economic development future. A significant new research entity has been established at SDSU (the Geographic Information Sciences Center of Excellence, or GISc) and at EROS through state funding. Five new research faculty are in the process of being hired for the GISc, and most of them will be working on NASA related research priorities.

16. Discussion of interaction between and cooperation with State Space Grant program.

Space Grant staff are actively involved in the research funded by EPSCoR and serve on both the Steering Committee and the Technical Advisory Committee. Similarly, Mr. Kevin Dalsted is involved with the SDSU EPSCoR research project and serves on the Management Team of the SD Space Grant Consortium. Space Grant is beginning to more actively involve its industrial and other affiliates in its programs, and is also looking for potential collaborations.

17. Milestones and timetable (year five)

During year five of the project, the SDSU research team will:

- Conduct radiometric calibration field experiments during the summer of 2005. In these field experiments the reflectance values on calibrated tarps located in South Dakota will be measured for targeted overpasses of both Landsat and Quickbird satellites.
- Measure atmospheric characteristics during satellite overpasses.
- Develop, test, and modify reflectance models that account for atmospheric characteristics following field campaigns.
- Test and validate these models during the summers of 2005 and 2006
- Conduct field experiments during the summers of 2005 that are designed to determine the simultaneous effects of water, N, and weeds on crop reflectance. These experiments will test and validate models that were developed during the first three years of the project. Validation of the models will include testing of radiometric calibrated space-based remote sensing in producers fields.
- Annual planning and technical review meeting will be convened in January or February each year.
- Prepare and submit proposals for sustained funding from various sources.
- Prepare and submit manuscripts for publication.
- Prepare annual and final reports.