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

Submitted to:

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Dr. Sherry O. Farwell, Director	**Mr. Timothy G. Henderson**
SD Space Grant & NASA-EPSCoR Programs	**Vice President of Business &**
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SD School of Mines & Technology	**SD School of Mines & Technology**

The State EPSCoR Committee Chairman has had an opportunity to review this proposal and discuss it with the NASA EPSCoR Director.

Signature:_____
State EPSCoR Committee Chair Date

Total Dollar Amount Requested $125,000, plus $575,000 for 3 Proposals for 1 Year ($2,100,000 for 3 Years)

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THE USE OF REMOTE SENSING FOR MONITORING, PREDICTION, AND MANAGEMENT OF HYDROLOGIC, AGRICULTURAL, AND ECOLOGICAL PROCESSES IN THE NORTHERN GREAT PLAINS

SECTION 1: RESEARCH AREAS

The titles of the three research projects proposed as part of this overall NASA-EPSCoR proposal submission are:

1) "**Improved Precipitation Estimation in the Northern Great Plains (NGP) by Remote Sensing Approaches**." Compendium Information: MSFC2.1, Remote Sensing of Clouds, Precipitation, and Temperature. Budget request of $187,900 per year for three years for a total of $563,700.
2) "**Cross-Calibration of Landsat and IKONOS Sensors for Use in Precision Agriculture**." Compendium Information: ESE21, Resource Management. Budget request of $223,100 per year for three years for a total of $669,300.
3) "**Leaf Area Index for Fire Chronosequences of the Black Hills and Southern Siberia: A Comparative Study**." Compendium Information: ESE12, Terrestrial Ecology. Budget request of $164,000 per year for three years for a total of $492,000.

SECTION 2: PROGRAM OVERVIEW

This collaborative proposal is the product of an ongoing set of research planning activities that have occurred as a consequence of the past two years of NASA-EPSCoR Preparation Grants. During this time a group of approximately 60 scientists, engineers, and university administrators in South Dakota have been directly involved as "theme team" members in a series of five all-day meetings to identify the research and technological priorities that are consistent both with NASA-ESE's interests and the State's expertise. Institutions represented within the group's membership include: South Dakota School of Mines & Technology, South Dakota State University, Augustana College, University of South Dakota, USGS EROS Data Center, Si Tanka College, Sinte Gleska University, Sisseton Wahpeton Community College, USGS Water Resources Division, US National Weather Service, and the SD Department of Environment & Natural Resources. Many of these organizations are also members or affiliates of the SD Space Grant Consortium. Additional information about the "theme team" members and the planning meetings is available at <http://www.sdsmt.edu/space/nasaepscor/>.

The evolving plan has been guided by the following desirable actions:

- To establish new contacts and strengthen existing linkages with NASA Centers, relevant NASA researchers, and key personnel at the USGS EROS Data Center.
- To promote participation from the State's major research institutions, State agencies, and relevant businesses in South Dakota that are interested in strengthening our scientific and technological enterprises.
- To develop the State's scientific talent and infrastructure for enhanced competitiveness in research, development, and technology-based economic development.

- To encourage greater participation by under represented groups, especially Native Americans, in scientific education and research.
- To build greater public and political support in South Dakota for the overall science, engineering, and technology enterprise.
- To communicate the benefits of current and future NASA programs to the progress and development of South Dakota, the Northern Great Plains Region, and the Nation.

The success of this comprehensive effort over the past two years is evidenced by several significant results. First, individuals located and employed at different institutions within South Dakota have now assembled themselves into a functioning "team" with shared visions for the development of earth science-based research. This "team" has agreed to pursue a research strategy that is centered on: a) the establishment of quantitative links between geospatial information technologies and fundamental climatic and ecosystem processes in the Northern Great Plains (NGP), and b) the development and use of coupled modeling tools, which can be initialized by data from a combined satellite and surface observational network, to provide reliable predictions and management guidance for hydrologic, agricultural, and ecological systems of the NGP. Whereas this "team" of earth scientists includes experimentalists, modelers, and theorists, they are all attracted by the lure of the earth science fieldwork that comprises a part of each of the three proposed research projects. Sir Walter Scott noted this characteristic of such scientists in *St. Roman's Well* in 1824: "and some rin up hill and down dale, knapping the chucky stances to pieces wi' hammers, like sase mony roadmakers un daft--they sae it is how the warld was made!"

The second indicator of the "team's" success to-date is the submission of this cooperative research proposal and the quality of the described projects. A third measure of achievement is the number of linkages the "team" members have made with external partners, including NASA personnel, during the last two years.

Summary of Trips/Linkages between SD Researchers and NASA Personnel

The SD NASA-EPSCoR Program acknowledges the importance of building and maintaining effective linkages with NASA collaborators. This is to help assure that input and output is provided at both the state and federal level and that the development of NASA-EPSCoR research infrastructure within South Dakota is in areas of strategic importance to NASA's mission. We believe that our proposals, our Technical Advisory Committee, and the agencies and organizations that are contributing matching dollars, demonstrate partnerships and cooperative arrangements that are well distributed throughout the State.

This section summarizes twenty-three (23) trips made by SD researchers to form collaborative linkages with NASA personnel during the two-year SD NASA-EPSCoR Preparation Grant period. The reader is referred to the following website for additional information on these trips including dates, locations, personnel, and institutions involved, and meeting details <http://www.sdsmt.edu/space/nasaepscor/trips.htm>. Table 1 represents a general overview of some of the linkages, followed by a summary of significant interactions that developed.

Table 1: Significant Collaborative Trips (SD Researchers and NASA Personnel)

Travel Date	SD Personnel	NASA Center/Activity/Contact
Oct. 2000	Alan Bender, SDSU	Dr. Stuart Gage, Director of CEVL, MSU
Oct. 2000	Kevin Dalsted and others, SDSU	JPL - Drs. Yunjin Kim, Mahta Moghaddam, Paul Siqueira, Paul Rosen, and Jeff Hilland
July 2000	John Helsdon, SDSM&T	Dr. Steve Goodman of GHCC at MSFC
June 2000	Pat Kozak, SDSM&T	Travel to Niobrara Valley Preserve. Worked with EROS & NASA personnel on calibration of Landsat 7 overpasses.
May 2000	Tom Durkin and Dr. Sherry Farwell, SDSM&T	Upper Great Plains SATS Symposium
May 2000	Dr. Dan Swets, Augustana	EPSCoR Expo at JSC
April 2000	Dr. Daniel Swets and Catherine Van Note, Augustana College	Council on Undergraduate Research "Posters on the Hill" session. Meeting with SD Congressional delegation.
April 2000	Dr. E. Duke & P. Kozak, SDSM&T	USGS Spectroscopy Laboratory
Mar. 2000	SDSU's Kevin Dalsted	SAR Users Working Group (SUWG) Meeting in Washington, D.C. area.
Feb. 2000	SDSM&T's Dr. Ed Duke, Pat Kozak, Dr. Maribeth Price and Dr. Lee Vierling, and SDSU's Dr. S. Burckhard	AVIRIS Earth Science and Applications Workshop at NASA's JPL
Feb. 2000	Mary O'Neill and Michelle Kelly, SDSU	Stennis Space Flight Center meeting with UAO and contractor InDyne, Inc.
Feb. 2000	Dr. Bradley Reed, EROS Data Center	Dr. Reed visited with Dr. Jim Tucker, NASA-Goddard.
Jan. 2000	Drs. D. Helder, S. Burckhard, V. Schaefer, D. Clay and S. Schiller, and S. Shin, and M. Kelly, SDSU	Goddard Space Flight Center
Jan. 2000	K. Dalsted & others, SDSU	NASA staffers and JPL scientists
Dec. 1999	Dr. Sharon Clay and Chuck Cole, SDSU	Pecora 14 LandSatellite Information III Demonstrating the Value of Satellite Imagery Conference in Denver
Nov. 1999	SDSU's Kevin Dalsted, Mary O'Neill, and Dr. David Clay SDSM&T's Drs. Pat Zimmerman and Lee Vierling	UMAC-PARC Workshop "Climate Change: Meeting the Challenge/Seizing the Opportunities" Grand Forks, ND
Nov. 1999	Michelle Kelly, NASA EPSCoR grad. Student, SDSU	Remote Sensing Applications Conference and Workshop, Auburn, AL, and meeting/tour at MSFC.
Nov. 1999	Dr. Bill Capehart, SDSM&T	1) Land Surface Hydrology Program Investigators Meeting, Columbia, MD 2) Visit to GSFC

Dec. 1999	Dr. Andy Detwiler, SDSM&T	1) Visited "Center for Interdisciplinary Remotely-Piloted Vehicle Studies" (CIRPAS) with NASA's Tony Strawa 2) Visited NASA Ames
Nov. 1999	Dr. Bradley Reed, EROS Data Center	Dr. Bradley Reed met with Dr. Compton "Jim" Tucker from NASA Goddard
Sept. 1999	Dr. Maribeth Price and Dr. Lee Vierling, SDSM&T	GSFC Space Day
Aug. 1999	Dr. Dan Swets, Augustana College, Dr. Bradley Reed and Jim Rowland from EDC	Established working relationship with Dr. Jim Tucker at Goddard

Summary of significant interactions:

SDSU's State Climatologist Dr. Alan Bender visited Dr. Stuart Gage of MSU in October 2000. The meeting was productive in discussing MSU's Signature Program in Land Use and Land Cover Change, which promotes cross-disciplinary projects that will be built around a systems approach to the study of changes in land use systems.

SDSU's October 2000 visit to JPL was successful in bringing SDSU's Dr. Vernon Schaefer, Dr. Sung Shin, Dr. Suzette Burckhard, Ms. Mary O'Neill, and Mr. Kevin Dalsted together with JPL's Drs. Yunjin Kim, Mahta Moghaddam, Paul Siqueira, Paul Rosen, and Jeff Hilland. JPL's Synthetic Aperture Radar (SAR) activities were discussed and how 1 m SAR data could be used to map wind damage to crops, as well as soil moisture and biomass estimations from SAR. Drs. Kim, Moghaddam and Siqueira were interested in how Radar data might fit into South Dakota's proposed NASA EPSCoR work. Dr. Moghaddam spoke on several applications of SAR data and how she has used interferometry to infer vegetation height and Radar to estimate biomass and soil moisture. She is also interested in GIS and its role in data handling and analysis, which dovetails nicely with South Dakota's proposed projects. In discussing how they could work together, Dr. Kim indicated that, while they are interested in SD's proposed project, they have no funding to cover staff time and expenses. However, Dr. Kim indicated that they could host one or two graduate students through a SD funded activity. This would provide training for the students so that they could contribute to the overall project, particularly as it referred to Radar analyses. Dr. Kim showed interest in perhaps placing a Radar unit on a tower unit proposed in SD's project.

In June 2000, SDSM&T graduate student Patrick Kozak traveled to the Niobrara Valley Preserve to work with EROS Data Center (EDC) and NASA on calibration of Landsat 7 overpasses. Mr. Kozak worked with Dave Meyer and Bruce Wylie of EDC collecting spectra to help calibrate both the Landsat and AVIRIS calibrations and participated in an ongoing project sponsored by NASA/DOI to use remote sensing to classify distinct vegetation species. Mr. Kozak also worked with Bruce Wylie on the possible use of decision trees for classification of imagery.

Dr. Daniel Swets of Augustana College attended the EPSCoR Expo in May 2000 at JSC. JSC personnel indicated an interest in working with university researchers on EPSCoR projects.

NASA researchers involved with JSC's Regenerative Life Support project were very interested in looking at collaborative research arrangements regarding South Dakota's prairie wetlands project as a model for water/plant integration, and provided Dr. Swets with numerous contacts.

In April 2000, Dr. Dan Swets of Augustana College and Catherine Van Note, research assistant, attended the Council on Undergraduate Research's (CUR) fourth annual "Posters on the Hill" session. They met individually with Senators Tom Daschle and Tim Johnson and Representative John Thune of South Dakota, and with Senators Grams and Wellstone and Representative Sabo of Minnesota. Dr. Swets and Ms. Van Note personally met Daschle, Johnson, Thune, and Sabo, and with aids of Grams and Wellstone to extol the virtues of the NASA research programs. Ms. Van Note brilliantly told her story about how perhaps some things in NASA could change, but NASA's funding of research is invaluable, allowing her to engage in research that would otherwise have been impossible.

In April 2000, Dr. Ed Duke of SDSM&T and graduate student Patrick Kozak traveled to the USGS Spectroscopy Laboratory in Denver and met with Dr. Roger Clark, one the best-known scientists among users of NASA's AVIRIS imaging spectrometer data. While there, they successfully ran the USGS Tetracorder algorithm for mapping mineral distributions in AVIRIS images of Pat Kozak's thesis area in Death Valley. Arrangements were made to install some of the USGS spectral processing routines on Unix workstations at SDSM&T in order to continue to use the applications developed at USGS. An exchange of mineral samples and laboratory spectra is planned with the USGS in order to enhance their on-line digital spectral library. Dr. Duke and Mr. Kozak expect to make future visits to the USGS Spectroscopy Laboratory for processing imagery related to research on metamorphic processes or research on the Black Hills and Prairie Pothole regions. Several months following this meeting, Dr. Duke and Mr. Kozak presented "Delineation of Isograds and Reaction Fronts in Contact-Metamorphosed Siliceous Dolomite Using Remote Sensing and Field Spectroscopy" at the Geological Society of America's annual convention in Reno, NV on November 2000.

In March 2000, SDSU's Kevin Dalsted attended the SAR Users Working Group (SUWG) Meeting in Washington, D.C. JPL's Steven Bard invited Mr. Dalsted to become a member of the SUWG as a representative of Precision Farming Users.

SDSM&T's Dr. Ed Duke, Pat Kozak, Dr. Maribeth Price, and Dr. Lee Vierling, and SDSU's Dr. Suzette Burckhard attended the AVIRIS Earth Science and Applications Workshop at JPL on February 23-25, 2000. The following paper was presented and published in the Workshop Proceedings: Duke, E.F., and Kozak, P.K., 2000, "Imaging spectrometry and metamorphic processes." The paper was well received and numerous contacts were made that could develop into important collaborations. In addition to the AVIRIS applications for geological work, collaborative discussion focused on investigating vegetation properties and changes, especially forests and wetlands, and for swelling clays, contaminated soils, and vegetation discrimination. Valuable discussions with Drs. Lee Vierling and Suzette Burckhard were held regarding cooperation on prairie wetland research and possible studies of abandoned mine lands in Montana. The SD researchers all learned a great deal about the state-of-the-art in remote sensing applications for ecosystem classification and analysis, which will be important as SD researchers begin to apply similar approaches to SD ecosystems.

Ms. Mary O'Neill and graduate student Michelle Kelly of SDSU traveled to Stennis Space Center in February 2000 to meet with Dr. Ramona Travis from the UAO and several people from contractor InDyne, Inc. Precision agriculture, wetlands, and transportation issues were identified as the application areas in which Stennis would have the greatest interest for SD EPSCoR collaboration.

In February 2000, Dr. Bradley Reed of EROS Data Center visited with Jim Compton Tucker of NASA-Goddard on behalf of the SD NASA-EPSCoR planning group to further refine the cooperative efforts between the Augustana College-EDC team and the NASA team on the seasonality smoothing and metrics computations, analysis, and application. The meeting and follow-up from Dr. Daniel Swets, Augustana College, further reinforced the positive aspects of the collaborative relationship between the NASA team and the SD EPSCoR team, whereby the SD team could enhance the productivity of the NASA-Goddard team by assisting with some of the work in the research projects.

In January 2000, SDSU's Dr. Dennis Helder, Dr. Suzette R. Burckhard, Dr. Vernon R. Schaefer, Dr. Dave Clay, Dr. Steve Schiller, Sung Shin, and Michelle Kelly traveled to Goddard Space Flight Center to meet with Goddard representatives on Precision Agriculture. The purpose of the meeting was to establish contact with NASA researchers at Goddard in the Earth & Space Data Computing Division, Biospheric Sciences Branch, and Hydrological Sciences Branch.

In January 2000, SDSU's Kevin Dalsted met with NASA staffers and scientists about LightSAR and potential uses of SAR in agriculture. He also attended the Jan. 19-20, 2000 workshop on NASA's plan for spaceborne SAR remote sensing.

In December 1999, SDSM&T's Dr. Andy Detwiler visited the Center for Interdisciplinary Remotely-Piloted Vehicle Studies (CIRPAS) with NASA's Tony Strawa. He then visited NASA Ames and met with Steve Weggener, Bob Chatfield, and Tony Strawa. Dr. Detwiler presented a seminar to the airborne science group on an exploratory instrument development project, the M-meter, in which he had participated with support from our armored aircraft facility operation. Discussion also included the use of Uninhabited Airborne Vehicles (UAV's) in airborne research.

In December 1999, Dr. Sharon Clay and Chuck Cole of SDSU traveled to Denver to attend Pecora 14 LandSatellite Information III Demonstrating the Value of Satellite Imagery conference. Cole presented a paper titled "Prediction of weed infestation levels through integration of landscape position, weed ecology and remote sensing" by Clay, S, Dalsted, K, Cole, C, et al.

SDSU's Kevin Dalsted, Mary O'Neill, and Dr. David Clay and SDSM&T's Dr. Pat Zimmerman and Dr. Lee Vierling attended the UMAC-PARC Workshop "Climate Change: Meeting the Challenge/Seizing the Opportunities" in Grand Forks, ND in November 1999.

In November 1999, SDSU's graduate student Michelle Kelly attended the National Remote Sensing Applications Conference and Workshop in Auburn, Alabama and later met with Jeff Luvall, Doug Rickman, Dale Quattrochi and Dr. Jim Dowdy at MSFC.

In November 1999, Dr. Bill Capehart of SDSM&T attended the Land Surface Hydrology Program Investigators Meeting, Columbia, MD and then visited GSFC. Dr. Capehart spoke with Bill Crosson and Bill Lapenta regarding possible collaborations in NASA-EPSCoR, as well as with Mike Jasinski and Charron Birkett of NASA-GSFC about potential wetland interests. While there, he also met with Marv Wesley of Argonne National Lab and Bill Gutowski and Mark Person of the University of Iowa and University of Minnesota, respectively. Similar work areas include surface-groundwater interactions and the use of Modflow. He also met with Glenn Liston. Dr. Capehart coordinated with Adam Schlosser, David Mocko, and Yogesh Sud to work on an GCIP-LSA/NW project involving subgrid snow cover representations using Glen Liston's parameterizations and related land-air-surface & groundwater interactions. Methodologies for representing subgrid snow melt processes in the Simplified Simple Biosphere model (SSiB) and its ramifications on the aggregation of surface fluxes and groundwater were discussed in detail. Preliminary discussions were made to represent a SSiB run over the Prairie Coteau during the wet up period in the early 1990's. Both Sud and Mocko were very interested in the prairie wetland problem and in interaction with SD researchers on the problem in the context of global modeling, as was the case with Marshal Space Flight Center. Dr. Capehart also met with Ted Engman, head of the Hydrology Branch to discuss details on SD's NASA-EPSCoR program.

Dr. Bradley Reed of EROS Data Center made a presentation in November 1999 to Dr. Compton "Jim" Tucker from Goddard regarding collaborative research work being done with Dr. Reed, James Rowland, and Dr. Larry Tieszen of EDC and Dr. Daniel Swets of Augustana College on the Seasonality project, involving NDVI smoothing techniques and seasonality metrics derived from the NDVI data. The software was released to the NASA group for their evaluation. The group then worked to tailor the algorithms to suit the particular needs of the NASA research group, working under the SD NASA-EPSCoR umbrella. Dr. Tucker helped identify a post doc / visiting professor that could be supported under a joint position with EDC and Augustana College to bolster the relationship between NASA, EDC, and the South Dakota NASA-EPSCoR Consortium.

Dr. Maribeth Price and Dr. Lee Vierling of SDSM&T attended Goddard Space Flight Center Space Day in September 1999. In August 1999, Dr. Dan Swets of Augustana College and Dr. Bradley Reed and Jim Rowland from EROS Data Center established a working relationship with Dr. Compton "Jim" Tucker at NASA Goddard regarding the possibility of teaming Tucker's Seasonality research projects with the South Dakota NASA-EPSCoR effort. Drs. Tucker and Swets exchanged e-mail over the potential of pooling efforts under the SD NASA-EPSCoR umbrella, which was met with a great deal of enthusiasm.

The foundation for the NASA-EPSCoR program in South Dakota is based on substantial planning, investments, and accomplishments by the State's three research universities during the past five years. Examples of these changes are: 1) A new priority on demonstrable competitiveness in scholarly activity and research is being employed to evaluate university faculty members, 2) Institutional policies and research offices have been established to promote and facilitate the procurement of external funding, 3) Competitive stipends and active recruiting programs have yielded an increase in SMET graduate student enrollment, 4) Instrumentation and facilities have been obtained with a combination of federal and state funding for state-of-the-art

research in the targeted areas of biocomplexity, biogeochemistry, earth system science, materials science, nano-science & engineering, molecular & cellular biology, and agricultural science, 5) The Governor of South Dakota by executive order recently formed the Science & Technology Council (STC), whose membership comprises selected private business people, state agency representatives, legislators, Board of Regents members, and university administrators (including the PI of this NASA-EPSCoR proposal), 6) An enhanced interest in technology transfer and SBIR programs, and 7) The development of organizations such as the Western Research Alliance in Western SD and the Sioux Falls Research Alliance in Eastern SD. These two relatively new Alliances have been designed to provide a research forum to interface the university research communities with individuals from local economic development offices, investment groups, regional entrepreneurs, relevant state and local governmental agencies, etc. One of the founding members of the Western Research Alliance is the PI of this proposal. Further information on this WRA organization and its activities is available at <http://w-research-alliance.org/>.

According to the NSF analysis in 1985, South Dakota was deemed the "most eligible" state for inclusion in the EPSCoR program. Based on the same set of parameters, South Dakota has moved from its initial ranking of #19 in 1985 to a ranking of #14 in 2000 on this EPSCoR eligibility scale. Only one other state has improved its ranking to a greater degree than South Dakota during this fifteen-year time period. Further evidence of the change in the State's research environment comes from the National Science Foundation Data Brief of July 10, 2000. Here, South Dakota is shown to be one of only eight states with a statistically significant, real annual R&D growth rate of over 3% between 1987 and 1997. Another indicator of R&D growth is the 97% increase in externally-funded research awards obtained at the South Dakota School of Mines and Technology during the period from 1995 to 2000. It is upon this new research foundation that we propose to activate and build a successful, meritorious NASA-EPSCoR program in South Dakota!

SECTION 3: CORE FUNDING FOR RESEARCH INFRASTRUCTURE DEVELOPMENT

Some of the funding in the program plan portion of this proposal will be used for infrastructure development activities that are similar to those of the past and current NASA-EPSCoR Planning Grants. That is, a segment of the requested funds will be focused on program management costs, travel grants to State researchers who specialize in relevant earth system science, continuation of the "theme team" meetings, and ongoing development of linkages between State researchers and NASA personnel. However, a significant allocation will be used to seed meritorious Program Initiation Grants (PIGs).

As previously noted, the research landscape within South Dakota universities and colleges is now extremely fertile due to the renaissance that started here about five years ago. Consequently, properly placed research seeds to initiate new and creative projects can be expected to grow in this fertile environment and thereby provide additional impetus for the research renaissance in South Dakota. Hence, part of the NASA-EPSCoR core funding will be employed to plant and fertilize such meritorious seed projects. One of the roles for the SD Technical Advisory Committee (TAC) will be to review and recommend PIG proposals for

subsequent support from the core funding pool. Eleven examples of potential seed PIGs are summarized in the following descriptions:

- "Remote Sensing as a Monitoring Tool for Long-Term Forest Management and Decision Support Systems". The 2000 season of fires in the Western US created an acute awareness of the vulnerability of forested areas to fire. To decrease such vulnerability, regions must develop new forest management approaches. This will require research related to forest dynamics and new uses of monitoring tools such as satellite remote sensing. In addition, GIS and multi-dimensional data visualization technologies will be required to transfer data and model results efficiently from the science sector to the management sector. This pilot project will develop a "Virtual Black Hills" and employ remotely sensed data, GIS, and coupled atmospheric/surface/sub-surface hydrologic models to improve our predictions of landuse management practices and related fire vulnerabilities. The process developed to link science, policy, and disaster management plans for the Black Hills will be transferable to other forested regions of the West.

- "Use of Remotely Sensed Data for Long-Term Monitoring of Contaminated Land Sites." Currently, most environmental scientists and engineers do not utilize remote sensing as a tool to understand and solve problems. Hence, this pilot project will employ a case study that incorporates ground-based monitoring data from an existing Superfund site along with different types of remotely sensed data. The remotely sensed data will be processed to show a time series of conditions at this site and these conditions will be compared to the existing ground-based monitoring data for the same time periods. Then a decision support system (DSS) will be designed to assist the practicing environmental professional in the proper usage of remotely sensed data in the overall environmental assessment. Once the DSS is developed, it will be employed in a series of workshops to introduce environmental managers to the uses of remotely sensed data both for problem assessment and for guidance in subsequent remediation decisions.

- "Scaling Issues in the Direct Use of Satellite Remote Sensing Data in Mesoscale Models." Surface heterogeneity is one the major factors that limits the accuracy of mesoscale atmospheric models. This project will address this limitation by coupling a subgrid land-surface parameterization to a mesoscale atmospheric model. The subgrid parameterization is specifically designed to estimate surface properties (e.g., albedo and surface resistance to heat and moisture fluxes) from satellite data. The planned approach is also designed to employ remotely sensed data to estimate the subgrid influence of near-surface atmospheric properties. If successful, this project will lead to improved numerical weather prediction. In addition, many of the scale issues proposed for investigation are important to the remote estimation of land surface parameters, and hence will benefit the remote sensing community.

- "Quantification of the Carbon Flux and Storage in Soils of the Northern Great Plains." A combination of eddy flux sampling and proton-transfer-reaction/mass spectrometry will be used for measurement of volatile carbon compound fluxes in selected field environments representative of the NGP. In addition, simultaneous soil sampling and carbon analyses with a LECO Model RC-412 analyzer will be utilized to measure the different fractions of carbon stored in these soils as a function of their stability toward oxidation and their concomitant

release of carbon dioxide. The analytical sampling and measurement systems will be evaluated and optimized for such determinations in the laboratory during the first phase of this pilot project. Then, field measurements will be performed at four grassland and agricultural locations in South Dakota. Data from these initial field measurements will be compared to model predictions of carbon fluxes and carbon sequestration for these same sites.

- "Measurement of Evapotranspiration and Soil Moisture in the Black Hills for Correlation to Remotely Sensed Data and for Quantification of Aquifer Recharge." This pilot project will estimate groundwater recharge via an approach that employs satellite remote sensing coupled with a land surface process model. Relationships between direct surface measurements, remotely sensed data, and land surface model output will be calibrated using an observational experiment. The observational experiment will utilize water budget measurements made from two adjacent sites in the Black Hills that receive similar amounts of rainfall and have similar vegetation. However, one site will contain impermeable crystalline rock and the other site will be underlain with permeable sedimentary rock. The hypothesis is that differences in ET and runoff between the two sites can be used to obtain a reliable estimate of groundwater recharge. If successful, the proposed experiment will provide a rigorous test of the assumption that the recharge component of the water budget results in an ET deficit, which can be determined using a combination of remotely sensed data and a land surface process model.

- "Quantifying the Spread of Invasive Plants in SD Prairies Using Remote Sensing, Stable Isotopes, and Traditional Field Methods." This pilot project will study the spread of leafy spurge (Euphorbia esula) and big bluestem (Andropogon gerardii) in SD. A three-pronged approach will be utilized. First, the spectral signatures and seasonal growth patterns of these two invasive species will be used to map their spread. Second, stable 13C/12C isotopic signatures in soil samples from various depths will be examined for evidence of past shifts in C3 vs. C4 plant dominance. Finally, traditional field sampling methods will be used to quantify plant species composition over time in selected areas as a ground truthing validation of the first two approaches. Success in this pilot project may lead to a new methodology for documenting the rates by which invasive plants are spreading in the NGP and other areas of the US and the world.

- "Cluster Computation of Remote Sensing Data." The advent of parallel processing has opened new frontiers in computer-based problem solving. This pilot project will study the parallel implementation of computer vision and image processing algorithms for the production of real-time, cost-effective image processing systems. Cluster analysis is one specific technique that would benefit greatly by parallel implementation. One of the member institutions of the SD Space Grant Consortium currently has a NASA contact to perform such unsupervised classification on remotely sensed data available from the USGS EROS Data Center. The work plan in this proposed pilot project would pursue additional applications of this unsupervised classification on large raster image data via parallel processing machines.

- "Sensors for Detection of Potential Landslide Hazards." Various sensors can provide different types of data that are useful in assessing the extent of slope stability, as well as the

risks associated with individual landslides. Combinations of data from various sensors may be used to predict landslide risks from different land use/management scenarios. This pilot project will review the various sensor types currently available, their specific data, and the suitability of these data for geohazard applications. The investigators of this project will collaborate with interested JPL researchers to examine the use of radar data for this purpose.

- "The Application of Multifrequency Radar in Precision Agriculture." The objective of this pilot project will be to develop statistical comparisons of AirSAR data to soil moisture, biomass production, topography, and crop height over several 65 ha fields in SD. Investigators at one of the member institutions of the SD Space Grant Consortium have already performed some preliminary work in collaboration with JPL scientists (Dr. Mahta Moghaddam and Dr. Yunjin Kim) on the soil moisture aspect of this project.

- "A Balloon-Deployable, Stationary, Multi-Spectral Instrument Palate for Soil Moisture Observations." Soil moisture has proved to be one of the most difficult parameters to derive by remotely sensed data due to its large spatial and depth variability. To further complicate matters, soil moisture often displays a high diurnal variation. The goal of this pilot project will be to explore the possibility of designing a passive microwave radiometer for soil moisture measurements that is sufficiently small to fit on a tethered balloon. This balloon measurement package will include a tensioned membrane antenna for the microwave radiometer in addition to an existing lightweight hyperspectral radiometer. If funded, this pilot project will be performed in collaboration with investigators at JPL and GSFC.

- "Development of a Miniaturized Satellite Transmitter to Track Wildlife Movements." Large-scale environmental changes such as those associated with climate, land-use changes, and species distributions can strongly influence demographic processes (e.g., survivorship and reproduction) and dispersal of organisms. Satellite telemetry is a relatively new technology that allows researchers to examine aspects of demography and movements of marine mammals, terrestrial mammals, and birds over large geographic ranges. However, a major limitation to satellite telemetry is the size of the transmitters. Most organisms must be at least 900g to carry the weight of the lightest commercially available satellite transmitter; however, most small organisms weigh less. Because the ideal weight of a transmitter is 2-3% of the body mass of the organism, miniaturization of satellite transmitters would allow for a wider variety of organisms to be studied. This pilot project would support the development of a prototype for the miniaturized satellite transmitter.

The SD NASA-EPSCoR program will continue to acknowledge the importance of maintaining and building collaborative linkages with NASA scientists and engineers. Therefore, some core funding will be designated both to promote and support trips whose goals are to construct such research partnerships. The following section illustrates the kind of collaborative activities that will be pursued during the first year of the SD NASA-EPSCoR program.

Proposed Plan to Develop and Broaden Linkages with NASA Personnel During the 3-Year Proposed NASA-EPSCoR Project and Beyond:

The SD NASA EPSCoR researchers will expand on the numerous linkages and relationships previously established with NASA scientists and other personnel. New relationships will develop as opportunities arise to interface with NASA personnel at conferences, workshops, and other meetings. To help solicit collaborative input from NASA scientists, South Dakota researchers will encourage NASA personnel to assist in joint publications and co-authored papers. This will help document collaborative scientific efforts between university researchers and NASA scientists.

To facilitate communication, in addition to routine telephone calls and face-to-face meetings with NASA personnel, each of South Dakota's funded PI's will establish an e-mail listserve consisting of university researchers, NASA personnel, and other appropriate individuals. Listserve discussions will serve to: a) update the research team members and those interested in their project with recent project advances/discoveries, b) promote idea generation, and c) generally assist in collaborative input and output.

On a project-specific level, linkages between SD researchers and NASA scientists will continue to be developed as described in Section 4.

SECTION 4: SUMMARY OF RESEARCH, AND ALIGNMENT WITH CURRENT STATE, ECONOMIC, SCIENCE, AND TECHNOLOGY GOALS AND PRIORITIES

This section will provide titles and corresponding summaries of the three research projects that comprise important parts of the overall NASA-EPSCoR proposal package from South Dakota. The specific linkages associated with each research project are also noted.

Research Proposal #1 entitled "Improved Precipitation Estimation in the Northern Great Plains (NGP) by Remote Sensing Approaches." Compendium # MSFC2.1, Remote Sensing of Clouds, Precipitation, and Temperature.

Summertime convective storms are the primary source of moisture for the Northern Great Plains (NGP). They are also the primary generator of severe weather including generalized and flash floods. The ability to measure instantaneous and accumulated precipitation is important for agricultural interests as well as for the forecasting of possible flooding events. The traditional methods of determining these precipitation parameters – radar and rain gauges – have relatively sparse coverage in the NGP. Because of this sparseness, better means of retrieving rain rates and rain volumes are necessary.

Methods involving combinations of radar data, satellite infrared and passive microwave data, and lightning data have been developed for estimating convective precipitation over areas where traditional data coverage is poor or lacking. However, such methods have been developed for more southern latitudes, where convective precipitation processes are often distinctly different than those associated with thunderstorms in the NGP. It is likely that thunderstorms with different character and precipitation processes will evidence different relationships between rainfall, radar, satellite, and lightning data than those already developed.

Our main goals will be to refine WSR-88D algorithms for estimating rainfall; test and calibrate satellite algorithms for retrieving rain rates and rain volumes; and examine, refine, and develop algorithms that combine radar, satellite, and lightning data for rainfall estimation that are appropriate to the NGP. We will use a retrospective study covering a period of up to 5 years that includes National Weather Service (NWS) archived WSR-88D radar data, surface rain gauge data, 3-hourly GOES infrared data, twice-daily DMSP SSM/I microwave data from two satellites, National Lightning Detection Network cloud-to-ground lightning data, and data on total lightning from the NASA MSFC Optical Transient Detector that operated from April 1995-April 2000. Since there are two distinct climate regimes in the NGP – crudely drier to the west of the Missouri River and wetter to the east – we will choose areas centered around several NWS NEXRAD sites distributed between the two regimes as regions for data acquisition and analysis.

Research project #1 has the following linkages.

1. Linkages to NASA Centers and Specific Research Areas from the Compendium:

The primary linkage for this proposal will be with the Global Hydrology and Climate Center at the Marshall Space Flight Center, AL. Primary contacts are Dr. Hugh Christian and Dr. Steve Goodman.

ESE1, Land Surface Hydrology: The stated goal of this program element is to develop a predictive understanding of the role of water in land-atmosphere interaction and to further the scientific basis of water resource management. One of the stated sub-goals is to develop new and improved technology and techniques for measuring hydrologic variables. The proposed effort at devising remote sensing strategies for improving estimation of precipitation directly addresses this sub-goal, since precipitation is a hydrologic variable.

ESE2, Atmospheric Dynamics and Remote Sensing: The goal is to improve understanding of the physical processes important in establishing the circulation of the atmosphere at all scales, including a complete understanding of the coupling between the dynamical and thermodynamic processes with the hydrologic and radiative processes. To accomplish this goal, the research programs pursued include the development of ground-, airborne-, and space-based remote sensing techniques. This proposal directly addresses the area of ground- and space-based remote sensing of precipitation, an important component of the hydrologic process. In addition, Alexander et al. (1999) showed that rain rates derived from satellite and lightning data helped improve model forecasts of a storm through better estimation of the latent heat forcing in the mesoscale model (advanced process modeling being another stated objective of this program effort).

GSFC2.1, Hydrological Sciences: The research opportunity includes the definition, development, execution, and interpretation of experiments designed to observe and model hydrologic processes occurring on all scales, particularly over land areas. Precipitation is one of the variables to be observed. This proposal comprises an experiment that will involve spaceborne infrared and microwave measurements in conjunction with radar and lightning data for estimating precipitation. The results of this project can easily be incorporated into hydrological models.

GSFC2.4, Remote Sensing of Lightning and its Impact on Meteorology: Although the stated focus of this program element is on VLF and other radio noise generated by lightning, the overall program design is to define new applications of remotely sensed data and to facilitate the design of new spaceborne instrumentation. The proposed use of visible lightning impulses to better refine estimates of precipitation uses a different part of the electromagnetic spectrum. The

project seeks to produce new applications of remotely sensed data and anticipates the Lightning Mapper Sensor that has been developed by NASA and is proposed to be flown on a geostationary satellite.

MSFC2.1, Remote Sensing of Clouds, Precipitation, and Temperature: The objective of this research element is to utilize space-based remote sensing instrumentation to better understand the Earth's hydrologic and energy cycles. Particular emphasis has been placed on several areas including regional hydrologic processes, lightning, and precipitation. The linkage between this research area and our proposal is direct.

2. Linkages to the Other SD NASA-EPSCoR Research Proposals:

This proposal, involving remote sensing estimations of rainfall, directly interacts with the other two proposals. Proposal #2 involves monitoring agricultural plots in the prairie potholes region. Important parameters in proposal #2 are the amount and spatial distribution of rainfall on various time scales over the agricultural test plots. The results from project #1 should provide more accurate and detailed precipitation maps than can be obtained from a single rain gauge sample for each plot. Proposal #3 involves evaluation of the Leaf Area Index both directly and by remote sensing techniques. Another aspect of the proposal is the modeling of LAI variability over a growing season. In order to accomplish such modeling, estimates of precipitation must be made for input to the model. Hence, these reliable precipitation estimates from project #1 will facilitate the accurate input of this parameter into the modeling work proposed for project #3.

3. Linkages to State Agencies and Businesses:

There are numerous state agencies that would benefit from having more accurate precipitation data including the Dept. of Transportation, Dept of Environment and Natural Resources, Dept. of Game Fish and Parks, Dept. of Agriculture, and the Dept. of Emergency Management.

Of course the prime beneficiary of better precipitation estimates will be the agricultural sector of SD, as precipitation is a prime influence both on the application of fertilizer and herbicides and on harvest activities. With better information on precipitation over their fields, SD farmers will be able to better manage their crops and increase their yields; thereby, leading to more productive farming and improved economic gains for the state.

Research Proposal #2 entitled "Cross-Calibration of Landsat and IKONOS Sensors for Use in Precision Agriculture." Compendium # ESE21, Resource Management.

Precision agriculture, or site specific farming, has changed all the old equations. In short, site specific farming uses differentially corrected global positioning systems (DGPS) and often 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 at the right time. However, accurate information is needed to develop site-specific recommendations. Remote sensing can help fill this need. For remote sensing to have value to land managers, the information must be accurate, delivered to land managers relatively quickly, and contain information that can be used directly by decision support systems. In other words, the remote sensing data must also be radiometrically corrected, cross-calibrated so that information from the different sensors or the same sensors collected at different dates can be directly compared, and represent reflectance on the ground rather than reflectance measured at the sensor.

The objectives of this study are: 1) develop and evaluate rules for identifying the "best" sensor for given agronomic applications, 2) conduct cross-calibration of Landsat TM, Landsat ETM+, and IKONOS sensors, using standard reflectance measurements, within wheat, grass and soybean fields, and 3) conduct outreach to share results with interested parties, namely agricultural producers, crop consultants, industry and service agencies.

Field research will be conducted in 2001, 2002, and 2003. In each year, cross calibrations will be conducted three times at each site (May-June, July-July, August). The sites will be fields uniformly planted to soybeans, wheat, and grass and each field site will be approximately 65 ha in size. Cross calibrations will contain three different components. In the first component, the atmospheric corrections for the different sensors will be determined. In the second component, models relating spectral characteristics to crop health will be developed. In the third component, the models (developed in component 1 and 2) will be validated. Regression analysis will be used to determine the ability of IKONOS, LANDSAT TM, and LANDSAT ETM+ to predict the yield limiting factors. Findings from this study will be used to develop precision farming guideline for selecting remote sensing information sources.

Research project #2 has the following linkages.

1. Linkages to NASA Centers and Specific Research Areas from the Compendium:

This research project has linkages primarily to the Goddard Space Flight Center and the Stennis Space Flight Center and to a lesser degree, the Jet Propulsion Lab. These linkages are based on several activities: a) ongoing research support and collaboration from both GSFC and SSFC for sensor calibration work, b) ongoing connection with the Ag20/20 activity at Stennis through precision agricultural research, c) ongoing science data buy via Stennis (Positive Systems aerial overflights) and a requested AirSAR overflight from JPL, and d) committee member on the SAR Users Working Group (SUWG), which was organized by JPL.

ESE12, Terrestrial Ecology: The research will be working to better understand the characterization of spatial and temporal variability in agricultural systems. The cross calibration of Landsat and IKONOS satellites will involve atmospheric modeling to generate spectral radiance at the surface of agricultural fields.

ESE21, Resource Management: The research has a major connection to this element. Agriculture is a major economic activity in South Dakota and the Northern Great Plains region. It is anticipated that this research will lead to adoption of remote sensing data and techniques in agricultural land management. Site specific farming may be able to use the results of this activity to better manage land resources, redirect the level of various inputs (such as fertilizer and pesticides) to the field locations where they are best needed, generate prediction of crop yields, and improve profitability while decreasing potential contamination from excessive fertilizer/pesticide applications.

ESE24, Environmental Quality: The proposed activity may be able to support the development of appropriate application guides of agricultural chemicals to farm fields. Generating improvements in this area can be seen through applying the right inputs in the right amount at the right time. This will decrease opportunities for groundwater and surface water contamination through infiltration and/or runoff.

2. Linkages to the Other SD NASA-EPSCoR Research Proposals:

The project ties to the other two South Dakota EPSCoR proposals in the following ways. Agriculture is tied directly to water and its availability during the growing season. Consequently,

improved precipitation inputs into agronomic models will generate more accurate and useful outputs, such as yield estimation and adjustment of inputs according to yield potential. In addition, this project is investigating the variables in a managed monoculture and their role in production, including biomass and seed production, while project #3 will be looking at similar variables in a managed natural system and its production.

The Space Grant Consortium research at SDSU has focused on precision agriculture and remote sensing for the past several years. Project #2 is an outgrowth of this research emphasis. SDSU has been collaborating with Sinte Gleske University (SGU) through the SDSGC and the Upper Midwest Aerospace Consortium. We have been working with the Sicangu Policy Institute at SGU to aid in the land management applications of remote sensing and GIS.

SDSU and SDSM&T have also been collaborating on several fronts including a NASA-supported RESAC project. In this latter collaborative project, a tower has been placed in an agricultural field to collect various data in support of both an agronomic modeling study and a state-funded Carbon sequestration project (CQuest).

3. Linkages to State Agencies and Businesses:

Several state agencies are involved with the proposal team dealing with precision agriculture and remote sensing/GIS: Bureau of Information Technology, Department of Agriculture and the Department of Environment and Natural Resources.
The USGS EROS Data Center is a collaborator with the SDSU team on Landsat calibration studies and land cover/use studies. Several individuals from the EROS Data Center are also Ph.D. students in the joint SDSM&T/SDSU AEWR graduate program. The USGS Water Resources Division is also a minor partner on a SDSU laser swath-mapping project, which has primary collaboration with the S.D. Dept. of Transportation and U.S. Corps of Engineers. We anticipate that the NASA-EPSCoR project will propel additional collaborative opportunities with the state government, the COE, and the USGS.

SDSU is currently working with Raven Industries in Sioux Falls to adapt remote sensing and GIS technology into their existing lines of equipment for site specific application of various chemicals and other inputs. The incorporation of remote sensing into decision support systems (a direction in which the state is definitely interested in moving) will directly benefit Horizons, Inc. and other GIS and remote sensing based companies in South Dakota. Additionally, SDSU is working with numerous trade organizations that deal with agricultural commodities and have an interest in site specific farming; e.g., the Soybean Research Board, the Corn Utilization Council, and the Potash and Phosphate Institute.

<u>Research Proposal #3</u> entitled "Leaf Area Index for Fire Chronosequences of the Black Hills and Southern Siberia: A Comparative Study." Compendium # ESE21, Terrestrial Ecology.

Leaf area index (LAI, the number of leaf layers occurring above a given ground area) is a fundamental biophysical parameter through which vegetation canopy functioning can be related to remotely sensed observations. Although LAI can play a large role in the fraction of absorbed photosynthetically active radiation (fAPAR) and, ultimately, net primary productivity and biosphere-atmosphere exchange of many important trace gases, quantifying LAI presents numerous challenges. Existing methods of quantifying LAI include destructive sampling on the ground (accurate but prohibitively labor-intensive) as well as ground-, aircraft-, and satellite-based remote observations (rapid and appropriate for large-scale measurements, but often

inaccurate due to complex canopy geometry and signal attenuation). The need for comprehensive ground-based data sets still exists to allow validation and improvement of LAI derivations from a number of satellite platforms operating at various spatial scales.

The project investigators propose to work with D. Deering and A. Conley of the Goddard Space Flight Center Biospheric Sciences Branch to collect fundamental LAI ground validation data sets. In addition, the collaborative team will establish the relationship between spectral data (collected at and off nadir) and LAI along fire and thinning chronosequences in two conifer-dominated ecosystems: the boreal forest of southern Siberia, and the Black Hills ponderosa pine forest of western South Dakota. This project will build upon and assist in the analysis of two years of ground LAI measures already completed near Krasnoyarsk, Russia and provide comparison measurements in the Black Hills region to determine the broad scale applicability of satellite-based LAI derivations for coniferous forests. Field measurements will include destructive sampling to establish allometric LAI relationships and non-destructive optical sampling using established techniques (e.g. hemispheric photography and Li-Cor LAI-2000 measurements). In addition to these within-canopy measurements, above-canopy remote sensing data at several scales will be collected to establish scaling rules for LAI. Remote sensing imagery will include multispectral IKONOS, Landsat 7, MODIS, and MISR data. At the Black Hills sites, additional spectral measurements will be made with the South Dakota School of Mines and Technology Short Wave Aerostat-Mounted Imager (SWAMI), a pointable hyperspectral instrument with a ground instantaneous field of view (GIFOV) adjustable between approximately 1-250m.

Research project #3 has the following linkages.

1. Linkages to NASA Centers and Specific Research Areas from the Compendium:

This project closely relates to several ongoing NASA research activities and priorities within the Earth Science Enterprise. Relevant NASA-ESE program elements include Land-Cover and Land-Use Change (ESE3) and Terrestrial Ecology (ESE12). Within these program elements, this proposed work aligns with work being done in several programs at various NASA Centers, most specifically GSFC2.36: Vegetation and Soil Science and KSC2.1: Ecology. Many of the ideas that formed the basis of this project arose out of conversations between Drs. Lee Vierling (SDSMT) and Don Deering (GSFC). For the past two years Dr. Deering has been directing a NASA-funded effort to quantify and scale Leaf Area Index (LAI) using ground and satellite remote sensing techniques near Krasnoyarsk, Russia in order to produce LAI validation data sets for EOS objectives. Dr. Deering anticipates that at least one more year of fieldwork and data analysis will need to be completed for the Russian site and has invited Dr. Vierling and his colleagues to participate in this activity. The fact that this ongoing NASA field study is based on an ecosystem, which has several parallels with the ponderosa pine forest of the Black Hills, makes the South Dakota study site a natural extension and comparison site for this work.

2. Linkages to other SD NASA-EPSCoR research proposals:

The work proposed in proposal #3 relates to proposal #1 in that leaves form the main conduit for the transfer of water from the terrestrial biosphere to the atmosphere. Because a substantial fraction of the annual precipitation that falls on South Dakota is derived from summertime convective storm activity, it is important to improve estimates of leaf area index (LAI) at the regional scale in order to better constrain the convective flux of water vapor via evapotranspiration. We expect that improvements made in LAI mapping in the Black Hills

region will greatly assist modeling and prediction of regional rainfall events, two goals of the work proposed by Helsdon et al. in project #1. Conversely, precipitation maps created through the workplan of project #1 may help to understand seasonal development and magnitude of LAI. Work proposed by Vierling et al. in project #3 will also link directly with the proposed effort in SD NASA-EPSCoR project #2. Because the researchers in project #2 will develop improved atmospheric correction algorithms for LANDSAT7 and IKONOS imagery, the results from their work will potentially improve the quality of LANDSAT7 and IKONOS imagery with which Vierling et al. will derive LAI using nadir-viewing remote sensing.

3. Linkages to State Agencies and Businesses:

By improving remotely derived estimates of forest biophysical parameters such as LAI, the work proposed for project #3 will assist agencies and businesses with management and financial interests in the Black Hills National Forest. These entities include the South Dakota Department of Game, Fish, and Parks, the South Dakota Department of Environment and National Resources, and Custer State Park. In addition, this information will be helpful to the local timber industry to assess areas of potential harvest. One of the graduate students who will be involved with this project is an employee of Raytheon Corp. (EROS Data Center) and is stationed on the SDSM&T campus. In addition, this project will provide baseline data that can be used by Horizon's Inc., a Rapid City-based remote sensing and photogrammetry firm which acquires, processes, and sells airborne remote sensing imagery for a variety of applications. Horizon's has recently acquired an aircraft-mounted LIDAR system and their management has indicated a strong interest in using LIDAR to provide quantitative information about forest biophysical parameters. We fully intend to collaborate with Horizon's as this project progresses in order to strengthen the local capacity for acquiring and interpreting remotely sensed imagery of forest systems.

Alignment of Proposed Research Projects with the South Dakota NASA-EPSCoR and Space Grant Consortium Plans

The Executive Summary of the proposal that led to the establishment of the SDSGC in 1991 contained the following description "The scientific theme of the Consortium will focus on earth system science. The Earth Observing System (EOS) program is a major NASA initiative and South Dakota scientists are already playing active roles in this program. We therefore believe South Dakota is in a strong position to make a major thrust in this scientific area." NASA funding of the research projects in this EPSCoR proposal will promote realization of this thematic proposition. The strategic long-term plan for a NASA-EPSCOR program in South Dakota has two general themes. The first broad goal is to develop the methodology and infrastructure required for establishment of quantitative links between remotely sensed data and fundamental processes in the NGP that affect agriculture, ecology, and other natural resources. The second comprehensive goal is to develop and validate coupled process models that can readily incorporate satellite and surface observational data for subsequent model-based predictions within stated uncertainly limits. We recognize that it is vital for our scientists in South Dakota to establish external partnerships with NASA personnel as they develop and implement projects that are designed to address these two goals. The three research projects contained herein are focused on topics relevant to agriculture, forestry, and the ecology/hydrology of the NGP. Thus, the results expected from the three separate, yet related

research projects will contribute to areas of importance both to the citizens of South Dakota and to the basic goals of the SD NASA-EPSCoR program.

The NASA-EPSCoR research program in South Dakota will be intimately connected to the State's Space Grant educational program. Each program shares the same foci on earth system science, capability enhancement activities, competitive projects, effective partnerships, and technological-based economic development. Furthermore, each emphasizes strong interactions with the members/affiliates of the SDSGC, including the various Tribal Colleges in SD. As shown at the SDSGC's website <http://www.sdsmt.edu/space>, the Consortium currently has four institutional members plus twenty-one affiliates. Our objective is to engage an increasing number of the members/affiliates from the SDSGC in future research activities performed through the new NASA-EPSCoR program.

SECTION 5: MANAGEMENT, COORDINATION, AND EVALUATION

The Director of the NASA-EPSCoR program in South Dakota will be Dr. Sherry Farwell. Mr. Tom Durkin will function as the Deputy Director and he will assist Dr. Farwell in the areas of project coordination, project communications, budget monitoring, diversity enhancement, public and K-12 outreach, report preparation, and overall program evaluation. A five-person NASA-EPSCoR Steering Committee will provide recommendations to Dr. Farwell in regard to research priorities, partnership building, NASA linkages, and overall programmatic strategies. This committee will be composed of the following individuals: 1) Dr. Pat Zimmerman from SDSM&T, 2) Dr. Lee Vierling from SDSM&T, 3) Dr. Dan Swets from Augustana College, 4) Mr. Kevin Dalsted from SDSU, and 5) Dr. Suzette Burckhard from SDSU.

As noted earlier in this proposal, Dr. Farwell also serves as the Co-Director of the NSF-EPSCoR program in SD, as a member of the State EPSCoR REACH Committee, and as a member of the new SD Science and Technology Committee. Consequently, he will serve as the active interface between the NASA-EPSCoR program and these other research-building endeavors within the State.

A new Technical Advisory Committee (TAC) for the NASA-EPSCoR program will be formed in the first year of the project. The ten-person membership of TAC will likely consist of: 1) Dr. Sherry Farwell, the Director of both the NASA-EPSCoR program and the SDSGC; 2) Dr. David Hilderbrand, Dean of Graduate Education at SDSU and a member of the State EPSCoR REACH Committee; 3) Mr. Mark Rath from the Water Rights Program of the SD Department of Environment and Natural Resources, 4) Mr. Jack Dozzi, Vice President of Horizons Inc. (Horizons Inc. is an industrial affiliate of the SDSGC); 5) Dr. Randy McKinley, the coordinator of the SDSGC from the EROS Data Center (EDC is an institutional member of the SDSGC); 6) Dr. Pat Zimmerman, Director of the Institute of Atmospheric Sciences at the SDSM&T (SDSM&T is the headquarters for the SDSGC); 7) Mr. Tom Durkin, the Deputy Director of the SDSGC; 8) Mr. Kevin Dalsted, Associate Director of the SDSGC and a faculty member at SDSU (SDSU is an institutional member of the SDSGC); 9) Mr. Mike Collins, science faculty member at Oglala Lakota College (OLC is an educational affiliate of the SDSGC), and 10) Mr. James Rattling Leaf, an administrator at Sinte Gleska University (SGU is an educational affiliate of the SDSGC). The general charge for TAC will be to provide advise on research priorities, to

assist in planning and pursuing research topics that align with State and regional priorities, to provide political guidance to the NASA-EPSCoR program, and to review program progress and accomplishments. More specific charges for TAC will be developed over time. The TAC will meet two times per year. During the initial meeting of each project year, TAC will review the results from the preceding year and then provide guidance on next year's workplan. During the second meeting of each project year, TAC will review the progress to-date and recommend any changes that may be necessary to achieve that year's stated objectives for the NASA-EPSCoR program in SD.

The success of the SD NASA-EPSCoR program will be evaluated by a set of key metrics. These metrics will include:

- Number of research projects in SD with NASA and/or EDC collaborators.
- Number of new research proposals submitted from SD to NASA programs.
- Number of new research awards received in SD from NASA along with corresponding total NASA obligations for R&D in SD.
- Number of new research awards in SD from other Federal agencies where the funded projects are related to the State's strategic plan for earth system science.
- Number of publications and presentations by SD personnel that describe research supported by NASA-EPSCoR and other NASA programs.
- Number of reports in area newspapers, radio, and TV that describe SD projects supported by NASA-EPSCoR and other NASA programs.
- Number of SD investigators who travel to NASA Headquarters, Centers, and other NASA-related events.
- Number of NASA scientists/engineers who visit SD to interact with investigators involved with the NASA-EPSCoR program.
- Number of Native Americans and women who become engaged in projects supported by the SD NASA-EPSCoR and Space Grant programs.
- Number of SD university graduate students in M.S. and Ph.D. programs whose research is focused on earth system science and the use of remote sensing.
- Acquisition of equipment and facilities that contributes to the State's competitiveness for externally funded research projects in earth system science.
- Number of SD NASA-EPSCoR investigators who participate in economic development organizations such as the Western Research Alliance and the Sioux Falls Research Alliance.
- Number of non-university individuals who become either direct participants in the SD-NASA-EPSCoR program or end-users of the results from the corresponding projects.
- An ability of investigators to meet the specific objectives of the SD NASA-EPSCoR research projects in timely manners that correspond to the proposed schedules.
- Timely preparation of required project reports and other documentation specified by the NASA-EPSCoR grant requirements and the NASA-EPSCoR Program Manager.