Annual Report 2013

Geosystems Research Institute and Northern Gulf Institute

MISSISSIPPI STATE UNIVERSITY

The Geosystems Research Institute (GRI) and the Northern Gulf Institute (NGI) are sister organizations. The NGI was established as a NOAA cooperative institute by GRI. The NGI Program is distinctly identifiable in its own right, but wholly embedded within the GRI framework. This allows both entities to function independently when necessary, but to capitalize as appropriate on the unique strengths of each. Both are part of the Mississippi State University (MSU) High Performance Computing Collaboratory (HPC2).

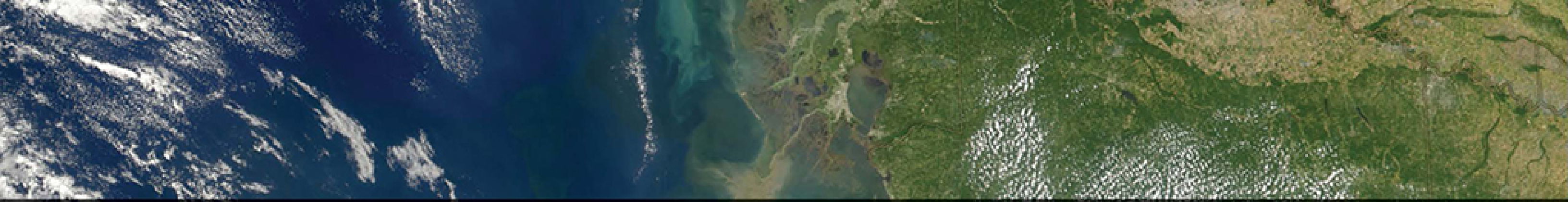
GRI supports MSU's land-grant mission of Research, Learning, and Service by acquiring and disseminating knowledge about earth and its systems, integrating geosciences and engineering, translating geospatial technologies and skills into useful tools, and transitioning science and technology into practice to support our stakeholders and improve policy and public awareness. GRI has distinctive competencies in agricultural and natural resource systems, coastal and ocean processes, sensor design, systems engineering, remotely sensed data verification and validation, large scale data and information handling, modeling, and visualization. GRI has developed nationally recognized research strengths with strong relationships and inherent respect from state, regional and national agencies and business entities.

NGI conducts research that builds an integrated, comprehensive understanding of natural and human impacts on northern Gulf of Mexico ecosystems and associated economies to improve its management. Research is conducted under four categories: ecosystem management, coastal hazards, geospatial technology and visualization, and climate change impacts. Research-driven transformations in regional ecosystem-based management enable managers and communities to improve the resilience and health of ecosystems and people and the sustainability of resources in the northern Gulf of Mexico.

GRI/NGI has excelled in interdisciplinary geospatial systems research and applications. Geospatial systems integration is an end-to-end process that takes into account the end-users' requirements and societal benefits, and integrates domain knowledge of specific scientific disciplines, observational science, and computational science to provide an optimized and integrated solution.

GRI/NGI has developed unique geosystem data streams and modeling capabilities that have responded to sponsor needs, inter-disciplinary perspectives, and systems engineering principles, using advanced geospatial knowledge, observational data, information technology, and modeling.

Application disciplines encompass typical departmental subject areas – plant pathology, biology, engineering, geosciences, wildlife conservation, etc. GIS and remote sensing include phenomenology, platforms, sensors, and remotely sensed data verification and validation, which are essential to providing unique capabilities and improve competitiveness. Research programs at GRI/NGI are substantially enhanced by utilization of high-end visualization and high performance computing.

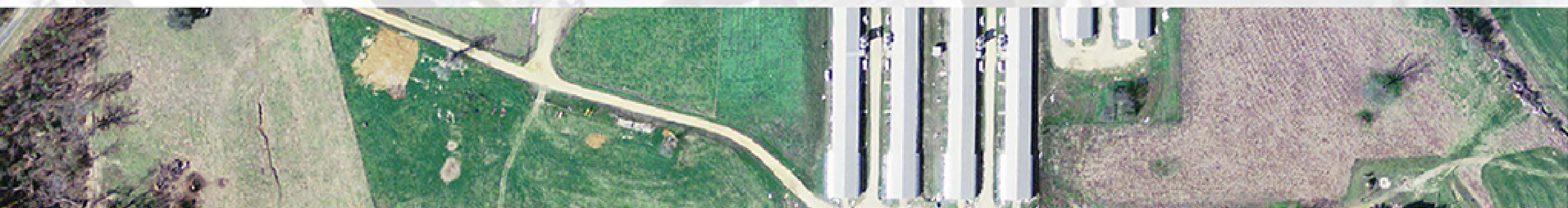


Unmanned and Remotely Piloted Vehicles

A new modality has emerged for the capture of geospatial data. Unmanned vehicles that fly in the air, cruise over the land or water, and operate under water are being used for missions that are dull, dangerous, dirty, and denied. GRI/NGI is heavily involved in the exploitation of this new means to capture data for public use. In fact, Mississippi State University holds several CoAs, including one for testing of a medium size unmanned aircraft system (UAS) at the regional commercial airport. One particular application under discussion is emergency response, a very geospatial-based operation.

GRI/NGI is applying UAS and other unmanned / remotely piloted vehicles in several areas, under 9 CoAs in 4 geographically different areas. The largest CoA is for research funded by the NOAA UAS Program Office to advance the use of UASs by the River Forecast Centers (RFCs), a part of the National Weather Service. At a workshop hosted by MSU in February 2012 in Boulder, Colorado, key needs and opportunities were identified and the foundation for an unmanned systems strategy was constructed. Attendees included representatives of the RFCs, unmanned platforms, sensors, and operators, and other government agencies invested in UAS advancement. The initial findings were presented at an ICCAGRA (Interagency Coordinating Committee for Airborne Geosciences Research and Applications) in March 2012. MSU is presently working with several federal agencies to get UASs integrated into the national air space, especially for use in detecting and measuring severe weather.

At the new MSU Science and Technology Center at Stennis Space Center, MS, an Exploration Command Center (ECC) was established in collaboration with NOAA's Office of Ocean Exploration and Research. Work is on-going with marine geologists, marine archaeologists, and other scientists who are studying live feeds from an ROV as it traverses the Gulf of Mexico seafloor.



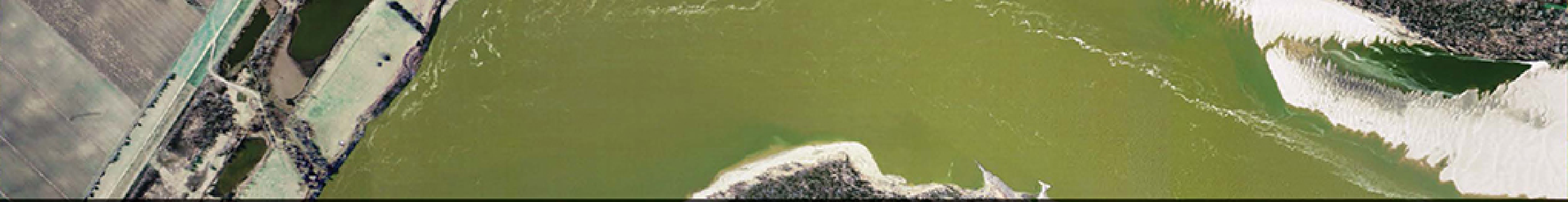
Geospatial Training and Educational Outreach

The Geospatial Education and Outreach (GEO) Project was developed in response to the limited availability of geospatial data which was needed by first responders immediately following Hurricane Katrina. An assessment was conducted of the educational needs of Mississippi's local governments, especially the localities in the southern portions of the state most susceptible to the effects of hurricanes. A series of intensive 2-, 3- and 5-day workshops were compiled that provided a strong foundation in the fundamentals and applications of GIS. Courses offered range from basic concepts of GIS to advanced, enterprise database management systems. Technical assistance is provided to local governments following classroom preparation as a means to increase the success rate of implementation of GIS in the work place. This outreach activity extends the extensive formal geospatial coursework offered through our Geosciences academic department.

The GEO Project was charged with the development and implementation of educational programs throughout local and state government agencies in Mississippi. The GEO Project has received state, regional and national recognition for the quality and diversity of training conducted in the geospatial technologies. A notable accomplishment of this project, working in conjunction with ESRI (a leader in GIS software and applications), is the development of a software "request for proposals" for rural local government agencies in Mississippi. Fifteen agencies submitted proposals and received software from ESRI. Mississippi was the first state to develop a project of this nature for rural, local governments.

The GEO Project maintains 2 portable computer labs and ancillary resources to conduct workshops at field locations. Members of the GEO Project offer 8 different workshops ranging from an introduction to GIS to multiuser database and server systems.

Over the past five years, workshop participants (over 2,400) have come from the private sector; local, state and federal government agencies; and various branches of the U.S. Department of Defense. The GEO Project can offer training where secret clearance is required. Customized workshops can be developed where targeted software and applications are identified.



Natural Resource Assessment Systems

Natural resource assessment systems provide users ready access to natural resources information to better understand aquascapes and their processes, to evaluate the probable consequences of management decisions and natural change, and to make informed assessments with a holistic perspective. Mississippi State University is developing a system, Sulis, in collaboration with government, industry, academia, and non-governmental organizations to address restoration and advancement in the northern Gulf of Mexico.

Sulis provides a systematic approach to holistic water, land, and ecosystem resources assessment through two major components – ecosystem models (SCEM) and tools for data assimilation and manipulation, modeling, visualization, and decision support (SIS).

Sulis Community Ecosystem Models (SCEM) are a system of models providing quantitative and qualitative predictions of how geographically determined systems of organisms (including humans) interact with the biological, chemical, physical, and social conditions that surround them. Sulis Informatics Services (SIS) applies advanced information technology to produce and share useful data, tools, and model results that enable informed decisions, scientific discovery, and integrated research and education for the benefit of technical specialists, resource managers, and the general population.

The Sulis system is one example of how a research team at GRI can pull together disparate data sources including raw data, model data products, and data analysis products into a data catalogue. Sulis showcases GRI's ability to provide data management and metadata handling. Among the management functions that can be facilitated with Sulis are: Regional Sediment Management, Ecosystem Approach to Management (EAM), and Coastal and Marine Spatial Planning. Using Sulis for data management and decision support allows management measures to be based on realistic outcome expectations.

Data catalogues like Sulis provide large amount of complex data in many usable forms. Future plans are to draw on our expertise in visualization, information processing, and programming to add an "inference engine". In this scenario, interpolations between models can be generated to make inferences about new model outputs that do not require additional model runs.

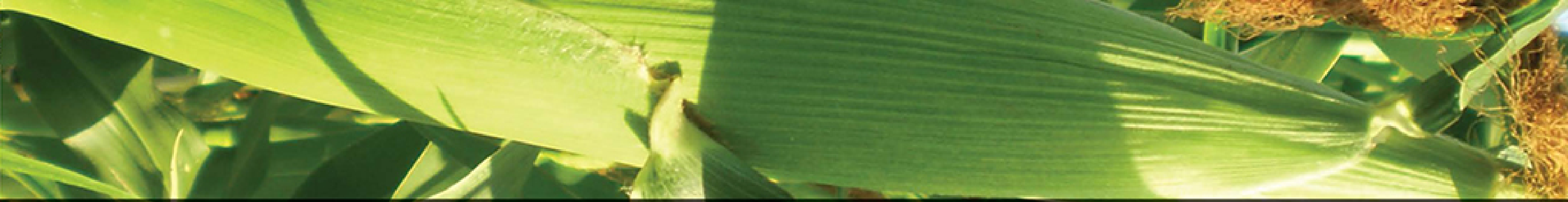
Deveopments are often part of larger watersheds that are subjected to nutrient management and land-use planning that often require decision support. A recent example is the inclusion of nutrient management strategies on military installations in the Chesapeake Bay watershed for the protection and restoration of Chesapeake Bay. Decision support systems like Sulis provide managers with a capability to evaluate management actions via simulations, to optimize implementation of management techniques.

Terrain Mobility Analysis using Synthetic Aperture Radar

Synthetic aperture radar (SAR) was used to to assess soil moisture, surface roughness, and vegetation for input to terrain mobility analyses by GRI/NGI researchers. SAR images have wide applications in remote sensing and mapping of the surfaces of both the Earth and other planets. SAR can also be implemented by observing a moving target over a substantial amount of time with a stationary antenna. Moisture estimates from SAR work best in conditions of sparse vegetation such as those found in current theaters of operation (Middle East). The SAR backscatter responds to both surface roughness and the electric dipole due to moisture and vegetation. Pattern recognition techniques applied to fully polarized SAR can be used to estimate the surface parameters needed.

Researchers at Mississippi State used this remote sensing technology to monitor and assess levee failure, whereby SAR data increased the accuracy and timeliness of reporting catastrophic changes when conventional onsite visual inspections and bore-hole sampling were prohibitively expensive. This knowledge significantly improved the allocation of both manpower and funding for levee inspection, testing, and repairs.

Additional uses of the synthetic aperture radar could include those for governments, international funding agencies, and businesses with a commercial interest in land reclamation, such as oil and gas corporations. Further development of "ground truthing" SAR could even aid those users having needs for specialist aerial surveying and mapping for minefield clearance.

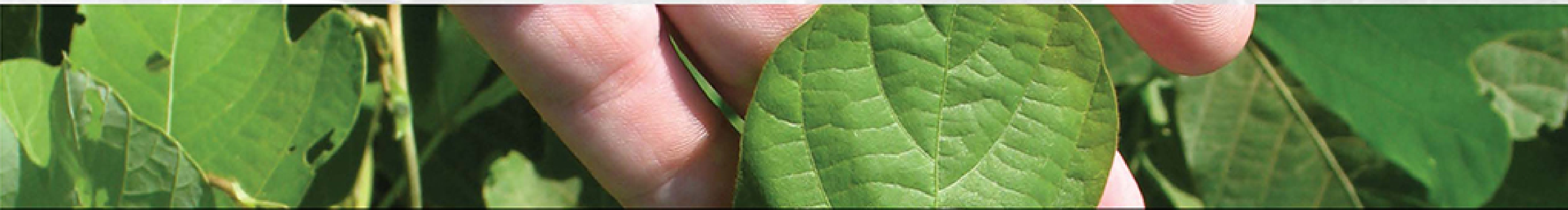


Hyperspectral Imaging to Detect Toxins in Food and Feed Crops

Hyperspectral imaging technologies are an innovative non-invasive approach toward screening for toxigenic fungi and the presence of toxins in our country's food and feed crops. Contaminated grain is toxic to domestic animals when ingested in feed and is a known carcinogen associated with liver and lung cancer in humans. Hyperspectral imagery is used to detect biological or chemical contamination of vegetation. A system such as the Automated Target Recognition - ATR - system is applied to the problem of bio-security, i.e. the detection of crop contamination via biological or chemical agents.

GRI researchers are using remote sensing technologies, especially hyperspectral imaging, as an innovative rapid and non-invasive approach for agricultural, food safety, and environmental protection. One of the main efforts involves screening for toxigenic fungi and the presence of toxins in our country's food and feed crops.

GRI researchers have developed a hyperspectral imaging system that can be used either in airborne or land based applications. This system uses push-broom line scanning for spectral data generation. In its current capacity both reflectance and fluorescence hyperspectral images can be acquired. GRI has also developed multispectral imaging systems based on liquid crystal tunable filtering. These systems can be used for grain inspection and other food crop applications. For hyperspectral image analysis, image processing techniques and multivariate statistical analysis, as well as artificial intelligence, are exploited. A hybrid feature selection and feature extraction approach for hyperspectral data reduction has also been developed and applied in current research. This represents an innovative approach that utilizes genetic algorithms and multivariate statistical analysis for high dimensional data processing.



Habitat Suitability Modeling

Invasive plants, such as cogongrass, benghal dayflower, and hydrilla, significantly reduce the productivity of agro-ecosystems and degrade ecosystem services of wildland and water resources. Early detection and rapid response to manage new or spreading invasive plant populations is greatly assisted by models that predict likely areas for introduction, establishment, and success of these nonnative species in a landscape context. Appropriate predictive models narrow the search area required for detection of new nonnative species, or likely avenues for the spread of existing plant populations.

GRI has developed the field monitoring protocols, spatially-explicit biological databases, and landscape parameter databases for use in landscape modeling. GRI has also developed models as both ArcGIS tools and external modeling logarithms to develop landscape-explicit models for predicting the establishment and success of invasive plant species.

GRI scientists have a wide range of field tools for the collection of spatially explicit data to survey invasive aquatic and terrestrial plants. This expertise is directed at initial survey and discovery, monitoring of population dynamics, and assessment of management success. Data of GRI scientists and a wide range of volunteers have been entered into an occurrence database of almost 12,000 records, housed in the Invasive Plant Atlas of the MidSouth (http://www.gri.msstate.edu/ipams).

These data are modeled using a variety of algorithms in both statistical platforms and in ArcGIS model builder. Environmental data are collected from a variety of public sources including U.S. soils maps, the National Land Cover Dataset, and U.S. Geological Survey stream gauge data. Using these data and GIS tools developed from logistic regression of occurrence data with environmental data, predictive models can be developed on likely areas for success of species such as hydrilla and giant salvinia. Similar approaches have been used to examine factors in the spread of cogongrass and other invasive terrestrial species.

Using data from our Cactus Moth Detection and Monitoring Network (http://www.gri.msstate.edu/cactus_moth), GRI has also developed models predicting the occurrence of pricklypear cactus species, the host of the invasive cactus moth. Knowing the range of host plans for cactus moth narrows the search area of this species, and aids in locating monitoring traps. Similar approaches may be used with other invasive plant and animal species.

Research Expenditures for GRI and NGI totalled $10, 291,939 for Fiscal Year 2013.
Following is a list of publications from our researchers:

Publications

Books or Book Chapters

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