# Successful Global Food Security Inter-Agency Project Leads to High Performance Computing Model to Address Analytical Difficulties Utilizing Multiple Satellite Sensor Datasets

Dr. Shawana P. Johnson, GISP
Global Marketing Insights, Inc.
6801 Brecksville Rd. Ste. 206, Independence, OH 44131, 216-525-0600, Shawana@globalinsights.com

Alex Philp, PhD
GCS Research, Inc.
115 South 4th Street West, Missoula, Montana 59801, 406-532-3254, aphilp@gcs-research.com

**Abstract** - The successful results of a Global Food Security Project supported by the National Geospatial-Intelligence Agency (NGA), the National Aeronautics and Space Administration (NASA), the United States Department of Agriculture (USDA) and other government entities led to the development of a pilot project where these data experts are coordinating and sharing their expertise with the private sector–to perform project work which requires extremely difficult computational analytics with high volume satellite imagery such as, NOAA-TRMM, NASA-MODIS, NCEP, Air Force-AFWA, AWIFS, SPOT-Veg provided by the USDA and PET datasets which consist of raster and vector data (100's of gigabytes per country).

The data have been placed in a secure, interoperable cloud at the Rocky Mountain Supercomputing Centers, Inc. running Microsoft HPC Server 2008 and SQL Server Enterprise with the latest edition of ESRI ArcGIS. The scalable solution is being used to complete high-fidelity analytics: time series analysis, change detection, correlation analysis for geoprocessing and geostatistics.

The outcomes of the project can change earth observation monitoring forever by allowing this same processing for the entire globe, using all the data sets in an interoperable, real-time environment, whether we are looking at Global Food Security issues, Water Resource Management, Provincial Reconstruction or any other application requiring real-time management of multiple input variables these predictive models will save precious resources – time and money – and most importantly provide enormous societal benefit.

## GLOBAL FOOD SECURITY: INTER-AGENCY PROJECT HISTORY

The success of the Global Food Security Project led to the realization that inter-agency collaboration between data experts and the private sector would allow for project work requiring highly complicated analytics to be performed using different types of satellite imagery.

The early detection of the drought in Iraq in 2008 had such successful results with a pilot project conducted jointly by the National Geospatial-Intelligence Agency (NGA) and the U.S. Department of Agriculture (USDA) that the project was expanded to include more Middle Eastern countries during the 2009-2010 growing year. This pilot project (conceived in 2006) was originally developed to research new remote sensing processes for assessing crop health and predicting harvest yields in growing regions where minimal to no ground truth exists. To overcome the lack of ground information (due to the hostile environment) the projects utilized multiple sensors and engaged other U.S. government agencies, such as NASA to gain greater access to imagery and expertise. The project allowed the U.S. to provide Iraqi officials with early warning drought information 10 months before the drought effects would be felt, allowing them time to avert a famine. This success forged even stronger inter-agency and global partnerships.

The follow-on project expanded to cover more Middle Eastern countries utilizing a minimum of three-tiers of remote sensing imagery. Three different resolutions of satellite imagery to collect data, high resolution which provides detailed field-level data, moderate resolution which provides provincial and regional scale information, and coarse resolution which provides multi-annual, regional- wide views. This imagery was analyzed employing a "convergence of evidence" methodology.

The conceptual approach for the convergence of evidence in monitoring global crop conditions is an iterative process that fuses multiple data sources collected from country-specific observations. Data sources are then cross walked to identify convergence and non-convergence of information.

Reports generated from the cross walk receive feedback from analysts and local officials (if possible) and new observations are incorporated accordingly as the process is repeated.

**TYPES OF PROJECT IMAGERY**

*Image: NASA MODIS 250m Global View MODIS NDVI Anomaly, May 8, 2009, Northern Afghanistan, (courtesy of NASA Earth Observatory)*

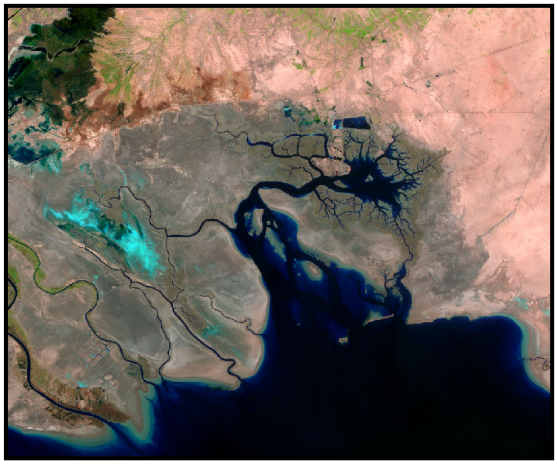

*Image: ResourceSat-1 India's AWiFS 56m Regional View– Khuzestan Providence, IRAN, March 2009 (SWIR, NIR, R False Color Composite)*

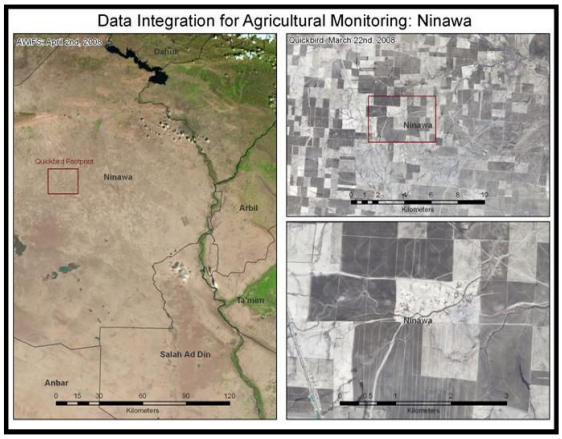


*Image: AWiFS 2005 and Digital Globe, Quickbird .61cm panchromatic; March 2008, Ninawa Province of Iraq.*

For nearly three decades the "convergence of evidence" methodology has been in utilized in research projects. Now the high level of availability of commercial data sets and free government data sets such as MODIS (provided by NASA) allow this methodology to become "operational" and provide the ability to solve "real-time problems" in hundreds of other applications where remote analysis is required. Remote sensing crop analysts can assess crop health and conditions without laborious, costly and sometimes dangerous field data collections. Advances in data sources, management, access, and distribution make timely and accurate agricultural monitoring possible.

By combining the "convergence of evidence" with the "three-tier" image analysis methodology, this Project provided the following results and benefits:

- Early warnings of drought conditions in Iraq were detected. The possible negative effects of these drought conditions on crop yields provided government and security forces with timely information that was crucial to determining the needs of the population and ensuring early imports and timely food relief before a crisis emerged.
- Crop statistics derived from the remotely sensed data sources provided an accurate forecast and quantitative measurement of crop production deficits.
- Using these two methodologies combined, the forecast of crop production at a national level in Iraq had a 1% margin of error when compared against the national crop production as reported by Iraq officials, however the key to the this project's success was the crop shortfall estimate was provided 10 months ahead of the Iraq official estimate.
- The use of remote sensing resources to obtain ground observation information as well as other imagery did not endanger ground forces or add to their work load.
- Since all of the data sets were commercial imagery sources, the information could easily be shared with the Iraq government and others in Baghdad allowing for an open and positive relationship with the Iraq officials.
- The enhancement of this remote sensing processing now provides the capability to allow more direct analysis support to the rest of the world with similar agricultural regimes in the region characterized by poor agricultural information resources or where trained ground observers are not available.
- This project methodology provides the same analysis capabilities for many other applications where similar conditions exist such as Telecom Infrastructure Observations, Energy Applications, and Water Resource Management, etc.

**HIGH PERFORMANCE COMPUTING PROJECT INTRODUCTION**

The large volume of data needed for the follow-on project led developers to research ways in which to access and manipulate even larger datasets in an on-demand, real-time, interoperable environment. These new data sets required the addition of live weather data in order to provide even greater predictive analytics. In addition to the previously discussed data sets the following weather data was determined crucial for improved accuracy.

**TRMM** (NOAA- The Tropical Rainfall Measuring Mission)-Precipitation Radar/ GOES-8/10, METEOSAT-7/5

**MODIS** ( NASA - Moderate Resolution Imaging Spectroradiometer)/ TERRA/AQUA Satellites

**NCEP** (The National Center for Environmental Prediction)-NCEP/NCAR Reanalysis 1

**AFWA-LIS** (Air Force Weather Agency-Land Information System)

**SPOT-Veg NDVI** (Satellite Pour l'Observation de la Terre, France)

**AWIFS** (Advanced Wide Field Sensor)/ IRS (RESOURCESAT-1 - India)

**PET** (Global Potential Evapotranspiration)

The addition of these types of data sets required access to a high performance computing capability. In order to maintain the operational and timely delivery for crop analysis reports the project needed a commercial computing facility. After research was conducted for computing facilities which met the project goals and objectives (and budget) RMSC was selected. The Montana-based Rocky Mountain Supercomputing Centers, Inc. (RMSC) would now carry on the next phase completing a pilot study with multiple data sets of Afghanistan. RMSC uses their high performance computing cloud (HPC Cloud) to perform project work which requires extremely difficult computational analytics necessary for hosting and managing multiple satellite sensor datasets needed for near real-time operational awareness. Typical classes of problems include Problems of Scale, Simulation and Modeling, Difficult or "Hard" Problems – Non-Deterministic (NP), and Adaptive Systems, both Artificial and Natural.

RMSC is equally focused on demonstrating sustainability improvements in modeling with the datasets all in one database, maintaining their native resolutions. This gives the analyst the ability to look at responses to all variables and see what signals the data provides in order to view entire regions of the world at one time and make quicker, more accurate land use predictions, such as global food security, while also allowing him to work with multiple data sources for rainfall, temperature, etc.

**Project Overview**

This interoperability project involves Rocky Mountain Supercomputing Center joining forces with the Federal Government in a Multiple Sensor Project.

The on-going project fully demonstrates (with RMSC's HPC Cloud) government-to-government inter-agency coordination and government-to-business collaboration. Datasets (consisting of both raster and vector with 100's of gigabytes per country) have been placed in the secure, interoperable environment located at RMSC. The scalable solution is being used to complete high-fidelity analytics on the multiple data sources. RMSC is also capturing all metrics on system performance and utilization against data volumes in order to better understand processing benchmarks, efficiency and scalability for workflow optimizations. At this point in time, scalability and flexibility are the project's strengths.

**Successful Government to Government and Government to Business Collaboration**

This pilot project is an excellent example of government entities such as NASA, USDA and other government experts (with in-depth remote sensing and weather analytical experience) coordinating and sharing their expertise with the private sector – who provides high levels of computational analytics and data. This effort exemplifies the type of public-private collaboration that RMSC was designed to foster and stimulate – solving hard problems using the investment that the State of Montana, IBM, Microsoft, ESRI, GCS Research and others have made in RMSC. IBM and Microsoft are stakeholders and collaborators in this HPC Cloud project allowing this to be an asset for Montana and the region and are supported by global partners such as ESRI. Part of the mission of RMSC is to secure sustainable growth through multiple funding mechanisms, advance competitiveness across multiple economic sectors, as well as support the expansion of Montana's economy in the global marketplace through stakeholders. The capability provided by RMSC allows the private sector with access to high levels of computing power within a reasonable budget framework. This in turn allows the analyst to make better use of their project funding.

This project effort supports the U.S. White House Cloud Computing Initiative and U.S. Chief Information Officer Vivek Kundra's announcement that multiple agencies will be the leading consumers

of cloud computing services and enjoy the benefits and cost-savings derived from the cloud's use and delivery model.

During an interview June 15th, 2009 with *Government Technology,* Kundra called cloud computing a "huge opportunity" to remake intergovernmental IT relationships. "For far too long we've been thinking very much vertically and making sure things are separated," he said. "Now we have an opportunity to lead with solutions that by nature encourage collaboration both horizontally and vertically."

**Project Future**

This project enables next-generation discoveries, advancements and solutions for commercial, academic, tribal and governmental stakeholders utilizing high performance computing applications and services. Consumers of these services can have immediate access to multiple sensors, analytics and 3D visualizations of any monitored region of the globe. For example, where we possess little or inaccurate ground information about that country's vegetative condition, this capability can provide actionable insight for any decision support process. In summary, the paradigm shifting vision of this project integrates a secure high performance cyberinfrastructure, cloud computing capabilities and an "on demand," pay-as-you-go business model that maximizes human capital and minimizes asset investments.

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**Authors and Contributors**

**Dr. Shawana P. Johnson, President, Global Marketing Insights, Inc.** GMI since 1997 has been a Ohio, USA based company. With over 20 years of experience in working directly in the remote sensing profession, with the USDA, and with agricultural and defense applications she leads GMI in being an industry leader in providing Global Geospatial Business Intelligence™ to both the public and private sectors. GMI provides Geospatial Business Intelligence Experts™ for federal government and private sector clients. Global Marketing Insights, Inc. was the project visionary and project coordinator for this on-going pilot.

**Dr. Alex Philp, President & Chair, GCS Research** located in Missoula, MT, is an award-winning, nationally-recognized leader in geospatial information technology. GCS Research works to connect people with the geospatial intelligence they require in a manner they can actually use. GCS delivers a select group of products and services that allow customers to *organize, protect, visualize, analyze, and share their geospatial information across the enterprise*.

**Angela Toth, Marketing & Research Intern, (GMI).** As an intern for the GMI marketing research and analysis team Angela is involved in collecting market research focused on geospatial forensics, satellite and aerial imagery, high powered computing cloud facilities and global remote sensing offshore services. Angela is a sophomore at Butler University, Indianapolis, IN, USA where she is a Pre-Law, Criminology/Forensics and French major, and Business Law minor.

**For More Information**

Please Contact Sherry Loy, Program Manger for GMI at +1- 216-525-0600,
sherryloy@globalinsights.com .