U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center – Fiscal Year 2012 Accomplishment Report

Compiled by Becky A. Foster

This report is a desk reference for internal use only.
Please do not distribute.

CONTENTS

ACRONYMS **4**

INTRODUCTION **7**

FISCAL YEAR 2012 IN REVIEW **7**

Science and Applications Activities **7**

Fire Science 8

The LANDFIRE Program Maintains Timeliness of LANDFIRE National Vegetation and Fuel Datasets by Evolving National Disturbance Mapping Processes – LANDFIRE Updating 2010 8
Remote Sensing Supports Burned Area Emergency Response Teams 11
Monitoring Trends in Burn Severity Fire Assessments Top 15,000 12
Lidar Based Canopy Fuel Mapping 15

Land Characterization and Trends 17

National Land Cover Database 2011: Designed and in Production 17
Global Land Change Monitoring 19

Landscape Dynamics and Global Change 22

Eleven Years of Cheatgrass Dynamics in the Northern Great Basin 22
Utilizing Surface and Subsurface Remote Sensing to Aid in Regional Permafrost Interpretations 24

Topographic Science, Elevation, and Lidar 26

Coastal National Elevation Database: Mobile Bay Pilot Study 26

Early Warning, Environmental Monitoring, and Hazards Management 28

USGS Science Supports the Estimation of Consumptive Use to Meet the Objectives of the WaterSMART Project 28
Understanding Recent Pacific Sea Surface Temperature Trends and Implications for the United States and Africa 31
Native American Climate Change Adaptation 35

Ecological Carbon Sequestration 38

USGS LandCarbon Project – GEMS Modeling 38

Remote Sensing Activities **40**

Landsat Program 40

40th Anniversary of Landsat 40
LandsatLook – A New Way to Look at Landsat 41
Landsat Global Archive Consolidation – A Million New Images 43

New Missions 44

Land Satellites Data System 44
International Cooperator Network: Preparing for Launch 46
USGS – NASA Landsat Science Highlighted in Special Issue of Remote Sensing of Environment 49
Landsat Data Continuity Mission's Development Progress 50
Characterizing Sensors to the "Gold Standard" of Landsat 54
Landsat 9 – Assessment of Alternatives 56

Data Management and Distribution 57

The DOI Data Access Workshop – Removing the Barriers Between Earth Scientists and their Data Systems 58
ASTER Global DEM Version 2 Validated and Released by the LP DAAC 60
Lidar Data Joins the Club – Now Through Earth Explorer 61
New High-Resolution Science Dataset – OrbView-3 62
Making Data More Accessible – Bulk Download Online 64
Full-Resolution JPGs and GIS-Ready Bundle Now Available 65
Improving Delivery Tiles 68
Consolidated Archive and Distribution Data Report: A Monthly "Consolidated Report" for All Data Managed and Distributed at EROS 68

Coordination and Collaboration 76

Emergency Operations Support to U.S. Domestic Events Increase Dramatically 76
Record Year for the International Charter 78
Committee on Earth Observation Satellites: New Directions 80

Center Support Activities 82
Rolling Out the Vision – Fiscal Year 2012 and Beyond 82
Data Center Consolidation: A Successful Partnership Between BIA and USGS 84
USGS Scientific Data Life Cycle Model 86
Sharing Science with the World 87

CONCLUSION 91

APPENDIX A. FY 2012 RESEARCH AND TECHNICAL PUBLICATIONS 92

Executive Summary of Research and Technical Publications 92

Complete Record of Research and Technical Publications 95
Journal Articles 95
Books 108
Book Chapters 108
Reports 109
Conference Papers 113
Conference Abstracts and Posters 115

Acronyms

AGEOS	Agence Gabonaise d'Etudes et d'Observations Spatiales (Gabon)
AIANCCWG	American Indian Alaska Native Climate Change Working Group
AIST	National Institute of Advanced Industrial Science and Technology (Japan)
ASRC	Arctic Slope Regional Corporation
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAER	Burned Area Emergency Response
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
C&O	Communications and Outreach
CAPE	Collection Activity Planning Element
CCRS	Canada Centre for Remote Sensing
CDI	Community for Data Integration
CEODE	Center for Earth Observation and Digital Earth
CEOS	Committee on Earth Observation Satellites
CIDR	CRSSP Imagery-Derived Requirements (CIDR) Tool
CLIRSEN	El Centro de Levantamientos Integrados de Recursos Naturales por Sensores Remotos (Ecuadorian Remote Sensing Center)
CLU	Climate and Land Use Change (CLU) Mission Area
cm	Centimeter
CMGP	Coastal Maine and Geology Program
CMIP5	Coupled Model Intercomparison Project Phase 5
CoNED	Coastal National Elevation Database
CRSSP	Commercial Remote Sensing Space Policy
CSRSR-NCU	Center for Space and Remote Sensing Research, National Central University (Taiwan)
DEIMOS	Spanish Earth-imaging satellite
DEM	Digital Elevation Model
DLR	German Aerospace Center
dNBR	differenced Normalized Burned Ratio
DOI	Department of the Interior
DPAS	Data Processing and Archive System
DV&E	Data Validation and Exchange
EE	Earth Explorer
ENVISAT	European Space Agency 'Environmental Satellite'
EROS	Earth Resources Observation and Science (EROS) Center
ERT	Earth Resources Technology, Inc.
ESA	European Space Agency
ET	Evapotranspiration
FEWS NET	Famine Early Warning Systems Network
FORE-SCE	FOREcasting SCEnarios of future land-cover (FORE-SCE) model
FOT	Flight Operations Team
FY	Fiscal Year
GA-NEO	Geoscience Australia – National Earth Observation

GDEM	Global Digital Elevation Model
GEMS	General Ensemble biogeochemical Modeling System
GEO	Group on Earth Observation
GEOSS	Global Earth Observing System of Systems
GHCN	Global Historical Climatology Network
GIS	Geographic Information System
GISS	Goddard Institute for Space Studies
GISTDA	Geo-Informatics and Space Technology Development Agency
GloVis	Global Visualization Viewer
GLS	Global Land Survey
GRT	Ground Readiness Test
HDDS	Hazards Data Distribution System
IA	Interagency Agreement
IC	International Cooperators
ICESat	NASA's Ice, Clouds, and Land Elevation Satellite (ICESat) program
IGAC	Instituto Geográfico Agustín Codazzi (Columbia)
INEGI	Instituto Nacional de Estadística y Geografía (Mexico)
INPE	Instituto Nacional de Pesquisas Espaciais (Brazilian Space Research)
IT	Information Technology
KSAT	Kongsberg Satellite Services (Norway)
km	Kilometer
LANDFIRE	Landscape Fire and Resource Management Planning Tools
LAPAN	Lembaga Penerbangan dan Antariksa Nasional (Indonesian National Institute of Aeronautics and Space)
LCLCC	Land Cover and Land Cover Change
LCMAP	Land Change Monitoring, Assessment, and Prediction
LDCM	Landsat Data Continuity Mission
LF	LANDFIRE
LGAC	Landsat Global Archive Consolidation
Lidar	Light Detection and Ranging
LP DAAC	Land Processes Distributed Active Archive Center
LRS	Land Remote Sensing
LSDS	Land Satellites Data System
LST	Land Surface Temperature
LTWG	Landsat Technical Working Group
m	Meter
mm	Millimeter
MDA	MacDonald, Dettwiler and Associates Ltd.
METI	Ministry of Economy, Trade, and Industry
MIICA	Multiple Indices Integrated Change Analysis
MOC	Mission Operations Center
MODIS	Moderate Resolution Imaging Spectroradiometer
MRLC	Multi-Resolution Land Characterization
MTBS	Monitoring Trends in Burn Severity
NASA	National Aeronautics and Space Administration
NBR	Normalized Burned Ratio

NDVI	Normalized Difference Vegetation Index
NED	National Elevation Dataset
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NRSC	National Remote Sensing Center (Zambia)
OLI	Operational Land Imager
Pleiades-1a	High-resolution satellite from SPOT
RapidEye	German geospatial information provider based on Earth observation
ResourceSat-2	Remote sensing satellite by Indian Space Research Organization
Reverb	NASA's next generation metadata and service discovery tool. Reverb searches against the ECHO metadata clearinghouse which facilitates all data discovery and order processing capabilities. To Reverberate is to "echo back or reecho."
RFI	Request for Information
ROSES	NASA's Research Opportunities in Space and Earth Sciences
RSAC	Remote Sensing Applications Center
RSLC	Remote Sensing of Landscape Change
RST	Remote Sensing Technologies
SANSA	South Africa National Space Agency
SGT	Stinger Ghaffarian Technologies
SPOT	Satellite Pour l'Observation de la Terre
SRTM	Shuttle Radar Topography Mission
SSEB	Simplified Surface Energy Balance
SSEBop	Simplified Surface Energy Balance operational model
SST	Sea Surface Temperature
SUS	System Usability Scale
tb	Terabyte
TIRS	Thermal Infrared Scanner
UK-DMC-2	British DMC (Disaster Monitoring Constellation) Earth-Imaging Satellite
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WaterSMART	Water for Sustainable Management of America's Resources for Tomorrow

U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center – Fiscal Year 2012 Accomplishment Report

Compiled by Becky A. Foster

Introduction

This desk reference is intended to provide an overview of the scientific, engineering, and operational achievements and illustrate the range and scope of the activities and accomplishments at EROS throughout fiscal year (FY) 2012. Additional information concerning the achievements can be obtained from the scientific papers and other documents published by the scientists, engineers, and information professionals affiliated with EROS. Appendix A provides both a summary and a complete list of the Center's extensive publishing records from throughout the fiscal year.

Communication with our expanding constituent, customer, and user base is vital to achieving our mission and the success of our projects and activities. To communicate with us or for more information about EROS, contact Thomas Holm holm@usgs.gov or Janice Nelson jsnelson@usgs.gov, National Policy, Communications, and Outreach Office, USGS EROS Center, 47914 252nd Street, Sioux Falls, South Dakota 57198, http://eros.usgs.gov/.

Fiscal Year 2012 in Review

Science and Applications Activities

The Center's science and applications activities include multidisciplinary Earth science research, remote sensing applications development, and generation of associated products such as oral presentations, publications, workshops, databases, and websites. Science and applications activities are aligned with the USGS strategic science goals and priorities set by the Climate and Land Use Change (CLU) Mission Area.

Disciplines and skills represented in science activities at EROS include geography, cartography, geology, soil science, hydrology, biology, forestry, ecology, geochemistry, computer science, applied physics and remote sensing, mathematics, and statistics.

Science partners and collaborators include the USGS CLU Programs and other USGS mission areas and their associated programs, other bureaus and agencies within the U.S. Department of the Interior (DOI), bureaus and agencies in other departments of the Federal Government, State agencies, tribal governments and universities, non-Government agencies, academic institutions, and international organizations.

The EROS research and applications activities take full advantage of the Center's extensive national and global archive of remotely sensed data.

Fire Science

The Fire Science Team conducts, applies, leads, and advances fire science by supporting the DOI, other land management agencies, and their fire management programs with scientifically credible, timely, reliable, and nationally consistent data, and constructive collaboration with other partners. Key accomplishments are given in the following sections.

The LANDFIRE Program Maintains Timeliness of LANDFIRE National Vegetation and Fuel Datasets by Evolving National Disturbance Mapping Processes – LANDFIRE Updating 2010

LANDFIRE (LF), the Landscape Fire and Resource Management Planning Tools project, has been a joint program between wildland fire management programs of the U.S. Department of Agriculture Forest Service and the U.S. Department of Interior with a cooperating partner of The Nature Conservancy. The USGS EROS Fire Science Team's role has been and continues to be a provider of science and innovation leadership for the mapping component of this program and has been a key component in this fire program since it was chartered in 2004. LF applies consistent methodologies and processes to attain a goal of creating comprehensive spatial data and models describing vegetation and wildland fire/fuel characteristics across the United States.

Mapped data products produced by this program are based on both Landsat satellite imagery and an extensive database of field-reference data. LF provides the first implementation of methodologies and processes to develop and combine intermediate scale spatial vegetation and fire information consistently across the entire United States. Such a suite of integrated vegetation, fuel, and fire regime data sets has not previously been created by the public or private sectors. LF data products facilitate National and regional (large landscape level) fire planning activities and the reporting of wildland fire management activities. LF products provide managers with the data needed for collaborative, landscape-scale, cross-boundary, interagency planning and implementation. LF data support land management to (1) identify fuel where fire hazards and fire risks to local communities may be located, (2) identify vegetation and fuel conditions where rehabilitation may benefit fire-dependent landscapes, (3) prioritize resources for National budget formulation and allocation, and (4) enhance management knowledge of fire behavior to improve firefighting safety. Programs within the wildland fire community that use LF data include the National Cohesive Wildland Fire Management Strategy, the Wildland Fire Decision Support System, Fire Program Analysis, and the Hazardous Fuel Prioritization and Allocation System.

LF is now focused on updates to the suite of National LF data products in order to reflect current landscape conditions. This focus is on updating landscape-level vegetation changes, such as those resulting from wildland fire, fuel and vegetation/silvicultural treatments, mortality from insects and disease, storm damage, invasive plants, and other natural or anthropogenic events where relevant data were available that occurred in the years since the initial mapping. In 2011, the USGS EROS Fire Science team completed updates to LF data products incorporating landscape changes that had occurred from the initial mapping up through 2008. Updating efforts are now focused on mapping those changes that have occurred through 2010. Landsat imagery is used to detect vegetation change and landscape disturbance. The current 2010 updating procedures build upon experiences gained from the mapping processes used in the 2008 updating effort. This includes using part of the National Land Cover Database Multi-Index Integrated Change Analysis model where multiple Landsat scenes for each year are processed to identify what LF identifies as the Remote Sensing of Landscape Change (RSLC) product. The current change analysis for the LF 2010 updating will process some 4,380 Landsat scenes. Unique to LF and is in addition to the satellite data, is how LF coordinates a yearly collection of recent natural disturbance and land management activities contributed from land managers across the country. These information are combined into a spatial LANDFIRE Events Database. This events database contained some 450,000 different event perimeters for the 2008 update. The RSLC and LF Events products are used along with mapped fire data from the Monitoring Trends in Burn Severity project to produce a yearly LF Disturbance product (fig. 1). This disturbance product is used to update existing vegetation and fuel layers and these updated vegetation and fuels layers are then used to update other LF data products (fig. 2). To view a complete list of LF products please visit the LF web site at http://www.landfire.gov/. For further information, contact Donald Ohlen, USGS EROS, ohlen@usgs.gov.

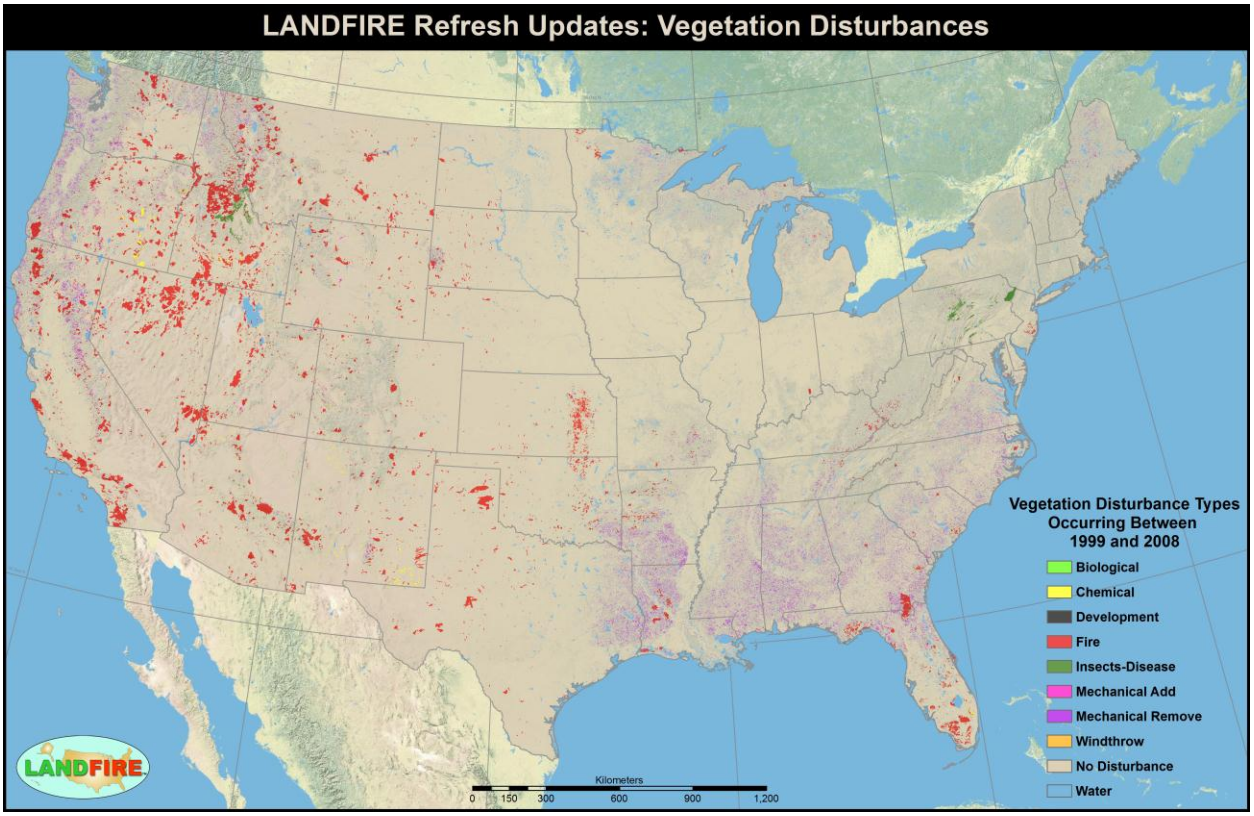


Figure 1. A map of the vegetation disturbances that were derived by LANDFIRE mapping processes for the years covering 1999 through 2008. These data provide temporal and spatial information related to landscape change. These data are attributed with the disturbance year, type, and severity.

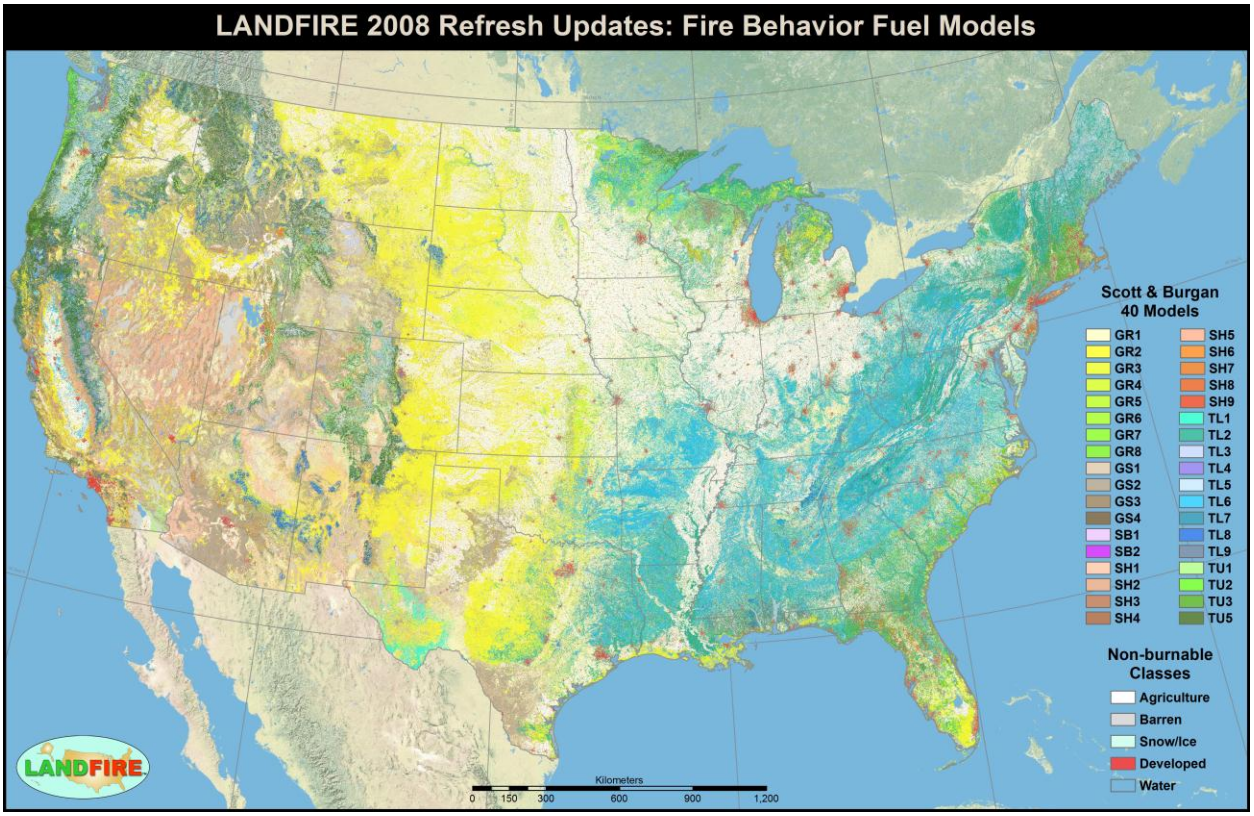


Figure 2. A map illustrating the LANDFIRE 2008 "40 Scott and Burgan Fire Behavior Fuel Models" data set. This layer represents distinct distributions of fuel loading found among surface fuel components (live and dead), size class, and fuel types. These data reflect the disturbances mapped for the years 1999 through 2008 and are derived modeled vegetation transitions from these disturbances.

Remote Sensing Supports Burned Area Emergency Response Teams

Since 2001, USGS EROS fire science staff have worked jointly with U.S. Forest Service (USFS) Remote Sensing Applications Center (RSAC) staff to map significant wildfires on DOI and USFS managed lands and to satisfy soil burn severity and other mapping requirements of Burn Area Emergency Response (BAER) Teams. EROS receives national level funding from DOI fire management programs to support this ongoing activity.

EROS rapidly processes Landsat and other satellite imagery enabling the timely delivery of both DOI and USFS map products (fig. 3), generally in less than 2 days after image acquisition. Historically, 8 to 9 years ago, BAER soil burn severity mapping was done by manually sketch mapping severity patterns on topographic maps, perhaps with the aid of a digitized fire perimeter. Today, burn severity mapping derived using satellite imagery has replaced the manual method for BAER teams, except in cases where timely high quality imagery is not available due to excessive clouds, smoke, or active fire issues.

This was a record breaking year for BAER burn mapping support. The 6 million acres mapped in 2012 exceeded all previous 1-year acreage totals including the 5.9 million acres mapped in 2007. In total, 2001 through 2012, USGS EROS and USFS RSAC have mapped over 1,187 wildfires representing almost 38 million burned acres in support of BAER and other local DOI and USFS land managers. Additionally, USGS EROS and USFS RSAC have provided support for U.S. BAER Teams deployed to international wildfire events including Chile in 2012 and Australia, Greece, and the Democratic Republic of Georgia in 2009. For further information, contact Randy McKinley, USGS EROS, rmckinley@usgs.gov.

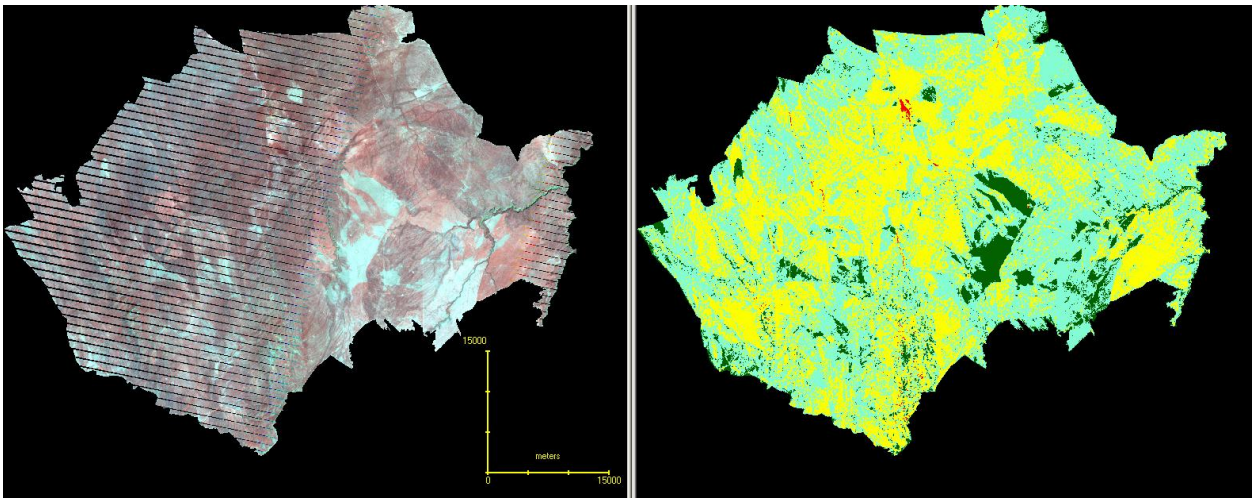


Figure 3. Burn Area Emergency Response map products, Landsat image (left) and soil burn severity map (right), for the Long Draw fire located in southeast Oregon. This was the largest fire mapped by USGS EROS in 2012 with over 582,000 burned acres. The fire was mapped two times over the course of the incident to provide local fire managers with timely burn information. Within the severity map dark green is non-burn, light blue is low severity, yellow is moderate severity, and red is high severity. Also note in the Landsat 7 post-fire image the presence of the scan line corrector-off data gap anomaly. The impact of the anomaly was minimized by using spatial filtering techniques to estimate values for the gap areas within the burn severity map resulting in a more useable product for the customer.

Monitoring Trends in Burn Severity Fire Assessments Top 15,000

Beginning in 2006, the USGS EROS and the USFS RSAC embarked on a project to map and assess the burn severity of all the large fires (greater than 1,000 acres in the west and 500 acres in the east) that have occurred in the United States between 1984 and 2010. The Monitoring Trends in Burn Severity (MTBS) effort began in response to the need for land management agencies to develop and implement consistent and comprehensive methods to assess fires and identify national trends. The data

generated by MTBS will be used to provide information necessary to monitor the effectiveness of the National Fire Plan and identify national trends in burn severity.

The Landsat archive is instrumental to map the historical and current fires. Over 10,000 Landsat scenes were used to map over 14,900 fires from 1984 to 2010. To assess burn severity for a fire, MTBS analysts evaluate Landsat imagery acquired after the fire is out. Usually, a post-fire scene is compared to a pre-fire scene to estimate the impact of the fire upon the landscape. The Normalized Burn Ratio (NBR) is derived for each image and the differenced NBR (dNBR) is computed by subtracting the post-fire NBR from the pre-fire NBR. Figure 4 illustrates this mapping assessment using the 2010 Twitchell Canyon fire in Fish Lake National Forest located in south central Utah covering 43,000 acres. The dNBR image is manually interpreted to delineate a fire perimeter and to estimate burn severity (unburned to low, low, medium, high). The resulting map, perimeter, Landsat imagery, and burn severity statistics for each fire are staged at http://mtbs.gov.

In early 2012, RSAC completed mapping the fires that occurred in 2010. In September 2012, EROS completed mapping over 1,000 additional undocumented historical fires. The combined accomplishments have mapped over 15,000 fires nationwide. Undocumented fires, mentioned above, are not uncommon especially in earlier decades. Over 2,200 undocumented fires have been found and lead to suspicion that many others exist. MTBS scientists are developing procedures to leverage other satellite resources such as MODIS (Moderate Resolution Imaging Spectroradiometer) and ENVISAT (the European's Space Agency's 'Environmental Satellite') to take advantage of active fire detections. Satellite fire detections started in the late 1990s, and this information can be used to methodically search the Landsat archive for other undocumented fires. USGS EROS was recently awarded a grant from the National Aeronautics and Space Administration (NASA) to further develop and implement these procedures. Additionally, given advances in computing power, techniques are under investigation to automatically scan Landsat scenes in order to find the spectral signature of fires and delineate a perimeter.

In 2012, several MTBS workshops and webinars were presented to bring awareness to local users of the project data and its applications such as fuels management and tactical fire suppression. With completion of the 2010 fires, research is now underway to summarize regional and national fire statistics and characterize trends. Recent developments promise increased ability to map fire disturbance and to characterize and monitor land change resulting from fire. The MTBS project will continue to produce fire assessments into the future. For further information, contact Stephen Howard, USGS EROS, smhoward@usgs.gov.

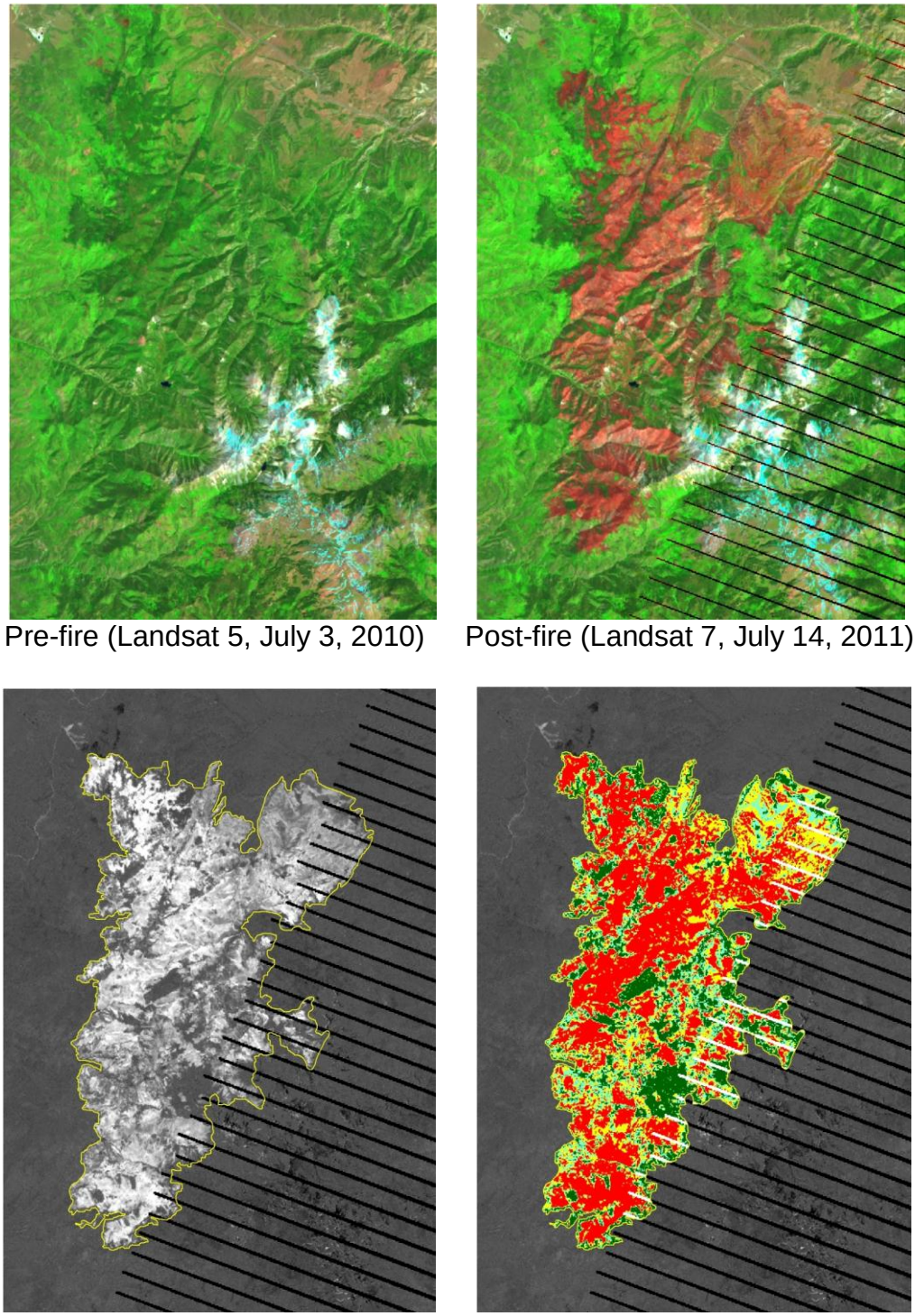


Figure 4. The Twitchell Canyon fire was the largest fire in the conterminous United States in 2010 (14 miles north to south). These images represent the suite of image products available at http://mtbs.gov for 15,000 fires that burned from 1984 to 2010.

Lidar Based Canopy Fuel Mapping

For the past 2 years, researchers at the USGS EROS Center have been working to develop more accurate methods for mapping canopy fuel metrics over large areas by integrating various remotely sensed datasets. Regional to national scale canopy fuel maps are available from the LANDFIRE program, though these canopy fuel data tend to have higher uncertainties in areas where available field observations are sparse. Accurate quantification of canopy fuel metrics is vital to fire behavior and fire effects modeling efforts. Metrics such as forest height, canopy cover, canopy base height, and canopy bulk density describe the vertical structure of a forest stand and indicate the ability for wildfire to transition from the ground surface to the canopy. Fires that propagate through the canopy are more intense and lead to increased fire effects, including fuel consumption, emissions, and altering post-fire succession.

Canopy fuel mapping over large areas is made possible by utilizing remotely sensed data. Much work has been done to map canopy fuel using optical imagery, such as Landsat. However, optical sensors lack the ability to directly capture detailed vertical structure information, given the two-dimensional overhead view of the sensor. As such, canopy fuel assessments using optical imagery alone have significant uncertainty in the mapped values. Light detection and ranging (lidar) data inherently captures vertical structure and can be very detailed, depending on the data collection parameters. Small-footprint, airborne lidar data have been used for canopy fuel assessments and typically result in much more detailed canopy fuel information with much lower uncertainty in the mapped values. Airborne lidar, though, is still relatively expensive to collect and data are not available everywhere. Therefore, assessments made with airborne lidar are restricted to the, generally small, areas covered by the lidar data. Spaceborne lidar data are also available from the NASA Ice, Clouds, and Land Elevation Satellite (ICESat) program; however, these data were collected as discontinuous samples along global transects offering detailed vertical structure information over large areas but without continuous coverage. Therefore, the data must be combined with other sources to produce large area, spatially continuous maps.

In this project, the goal is to develop regional to national level canopy fuel mapping algorithms by combining optical imagery with airborne and spaceborne lidar. This will provide much more detailed large-area fuel maps compared to existing optical based fuel maps currently available across the United States. To accomplish this, airborne lidar is used to develop very detailed canopy fuel maps for the lidar coverage area. Spaceborne lidar samples that are co-incident with the airborne lidar are used to develop statistical relationships between the spaceborne lidar parameters and the airborne lidar derived canopy fuel metrics. These relationships are applied to the spaceborne lidar samples that are not co-incident with the airborne lidar, resulting in canopy fuel metric estimates for each sample. Then, the canopy fuel values at each sample are used to develop statistical relationships with optical imagery and ancillary data layers. These relationships are applied to the image datasets to produce spatially continuous maps of canopy fuel parameters. These methods allow lidar data to be

utilized where it exists while also being extrapolated to surrounding areas to influence large-area, spatially continuous maps.

These methods were developed and tested in an area within the Yukon River Basin of interior Alaska. Canopy fuel maps were derived from the integrated airborne and spaceborne lidar and Landsat imagery. The results were compared to existing canopy fuel maps from LANDFIRE which are based on optical imagery alone. The lidar-based maps showed much greater detail and spatial patterns compared to the LANDFIRE maps. Both datasets were also used to run an idealized fire behavior modeling scenario to determine the impact of the lidar-derived fuel maps on modeling fire behavior. The results showed a more detailed and more reasonable assessment of fire behavior in that area (fig. 5), indicating that lidar-derived canopy fuel maps may lead to an increased ability to adequately represent fire behavior.

The methods developed in this project are now being tested and implemented in other parts of the country with different vegetation types. Additionally, integration with other spatially continuous datasets, such as hyperspectral and synthetic aperture radar, is being explored and tested where the data are available. This research will lead to significant increases in the ability to model fire behavior and fire effects and represent the dynamic nature of wildfire across the country. The benefits of better fire behavior model results include better pre-fire planning for communities at risk, prioritization of fuel treatments, staging of resources, fire risk determination, fire suppression support, smoke production and emissions tracking, and post-fire burn severity characterization and stabilization activities. All of these things directly impact the health and safety of firefighters, land managers, and ultimately individuals and communities across the country. For further information, contact Kurtis Nelson, USGS EROS, knelson@usgs.gov.

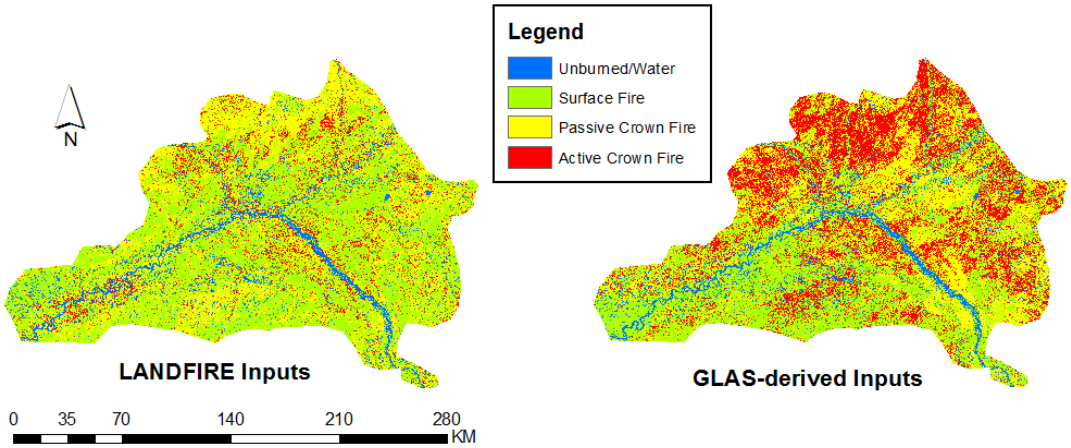


Figure 5. Results of fire behavior modeling scenario using LANDFIRE and ICESat Geoscience Laser Altimeter System-derived canopy fuel inputs. Graphics show canopy fire activity outputs across the landscape indicating areas that were unburned, burned at the surface only, burned with passive crown fire (single or group tree torching), and burned with active crown fire (crown to crown fire spread).

Land Characterization and Trends

The Land Characterization and Trends Team develops solutions for characterizing land cover at multiple temporal and spatial scales that enable subsequent analysis, monitoring, forecasting, and reporting of land cover processes. Key accomplishments are given in the following sections.

National Land Cover Database 2011: Designed and in Production

The USGS, working in partnership with the interagency Multi-Resolution Land Characteristics (MRLC) Consortium, has completed methodology design and has initiated operational production of the National Land Cover Database (NLCD) 2011. The NLCD serves as the definitive Landsat-based, 30-m pixel resolution, land cover database for the Nation. NLCD provides spatial reference and descriptive data for land surface characteristics such as thematic class (for example, urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover.

The USGS EROS Center science strategy team developed two primary advances for production of the NLCD 2011 products. This includes the development of a new change detection approach called the multiple indices integrated change analysis (MIICA), which uses two pairs of multi-temporal Landsat scenes from different seasons within the same year to characterize change more effectively than the single scene pair used for NLCD 2006. Another advance was the development of processing models for change analysis and percent imperviousness estimates that significantly automated the production process over NLCD 2006. This automation is expected to reduce the interval between data acquisition and product release, improving product relevance and timeliness. Operational production for NLCD 2011 is in progress with a target completion date of December 2013.

In addition to land cover and percent imperviousness products, NLCD 2011 will also contain a new percent canopy estimate produced in cooperation with the USFS RSAC in Salt Lake City, Utah. The new process uses the application “Random Forest” to model tree canopy cover using a highly automated process that depends on field collected Forest Inventory Analysis plot data to train models. Figure 6 provides an example where a majority of the change is from coniferous forest in 2006 to grass or shrub in 2011 – a typical land cover change in areas where forest has been harvested. Cooperation with the USFS on the tree canopy cover for NLCD 2011 is one example of many successful collaborative efforts with MRLC partners over the past two decades.

The USGS EROS Center, located in Sioux Falls, S.D., provides scientific analyses based on remote sensing, analytical modeling, and geographic information system technologies to support participating MRLC members and the NLCD user community. For further information contact Collin Homer, USGS EROS, homer@usgs.gov.

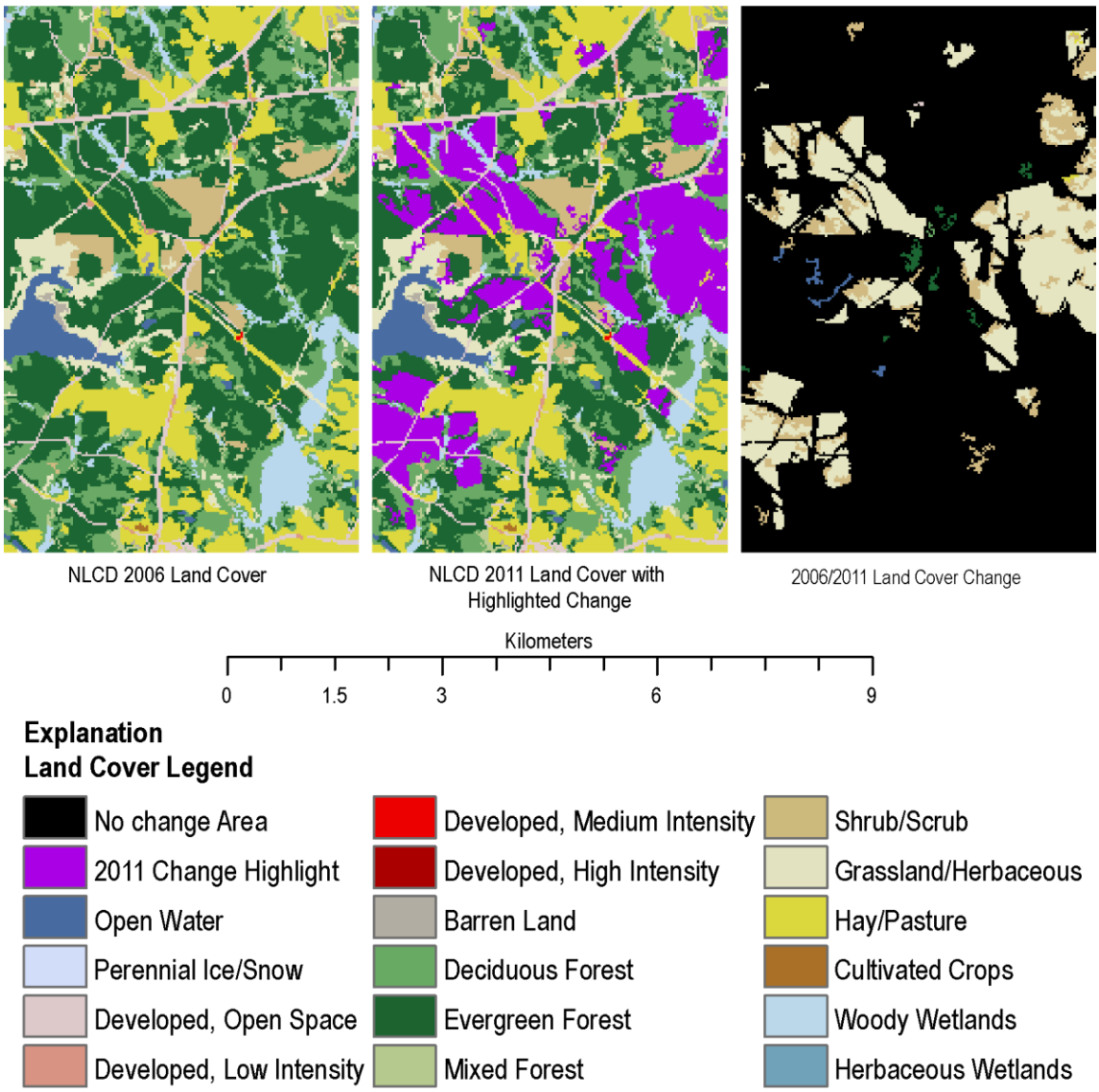


Figure 6. An example of land cover change in Pike County, Georgia (Landsat Path 19, Row 37). In the area shown, a majority of the change is from coniferous forest in 2006 to grass or shrub in 2011 – a typical land cover change in areas where forest has been harvested.

Global Land Change Monitoring

Land cover change is increasingly affecting the biophysics, biogeochemistry, and biogeography of the Earth's surface and atmosphere, with far-reaching consequences to human well-being. However, our scientific understanding of the distribution and dynamics of land cover and land cover change (LCLCC) is limited. Previous global land cover assessments performed using coarse spatial resolution (300 m – 1 km) satellite data produced a global perspective on LCLCC, but did not provide enough thematic detail or change information for local, regional or global change studies, nor for resource managers. Even though high resolution (≤30 m) global land cover data derived from the 40-year Landsat record are desirable, until recently there were a number of challenges to overcome including data cost, consistent global coverage, data volume, shortcomings in pre-processing and interpretation algorithms, availability of training and validation data, and high-computing needs.

To address this need, the U.S. Group on Earth Observations (GEO), announced during the GEO Ministerial Summit in Beijing in November 2010 that the United States is launching a new global land change monitoring initiative. Following the announcement researchers from the USGS EROS, University of Maryland, State University of New York, and other collaborators joined the force to implement the project. The aim of the project is to develop the first-ever comprehensive and up-to-date LCLCC database of the world at 30-m spatial resolution using Landsat satellite data. Specific research objectives of the project are to (1) produce global land cover estimates of percent tree (fig. 7 and fig. 8), percent bare ground, percent other vegetation, and percent water presence for 2000 and 2010 at nominal 30-m resolution; (2) develop an initial global land cover (type) baseline for the 2010 period; (3) implement an ongoing monitoring system that provides periodic (annually, biennially, and quinquennially) land cover updates and change products; (4) improve the availability and accessibility of 30-m class satellite data (whenever possible); and (5) establish the capability and capacity to develop historical land change time series (1970s to present).

The research project aims to produce the global land cover data at 30-m spatial resolution for the following reasons:

- Permits detection of land change at the scale of most human activity;
- Offers increased flexibility for environmental model parameterization;
- Provides spatial information content that is hundreds of times better than existing global land cover data sets;
- Supports many GEO tasks and activities including GEO Agriculture, Forest Carbon Tracking, the Biodiversity Observation Network, and the Land Cover Task; and
- Provides globally consistent and locally relevant information. Fulfills the requirement of resource managers and the global change research community because of higher spatial and thematic detail.

Global land cover monitoring at 30 m is possible due to the availability of Landsat or similar resolution satellite data at the global scale and at no cost to the user. Landsat is the only satellite that ensures land cover change analysis retrospectively and prospectively because of its acquisition, processing, and distribution strategies. For example, Landsat is the only satellite observation that provides the longest continuous global record of the Earth's surface dating back to the 1970s.

Without validation, global land cover datasets remains untested hypothesis and as such do not meet the requirements of the user community. The project team is validating the global land cover datasets using 500 5-km by 5-km sample frames (fig. 9). Reference data for the sample frames are produced via classification of commercial high resolution data (ranging from 0.5 – 4 m). Thematic classification are produced iteratively using a decision tree classifier performed on composite imagery comprised of sensor spectral bands and numerous vegetation and textural indices, as well as rigorous analyst interpretation and review. The validation results will be aggregated to the 30-m resolution of the vegetation continuous fields data to produce comparable estimates of percent tree cover at Landsat resolution. For further information contact Chandra Giri, USGS EROS, cgiri@usgs.gov.

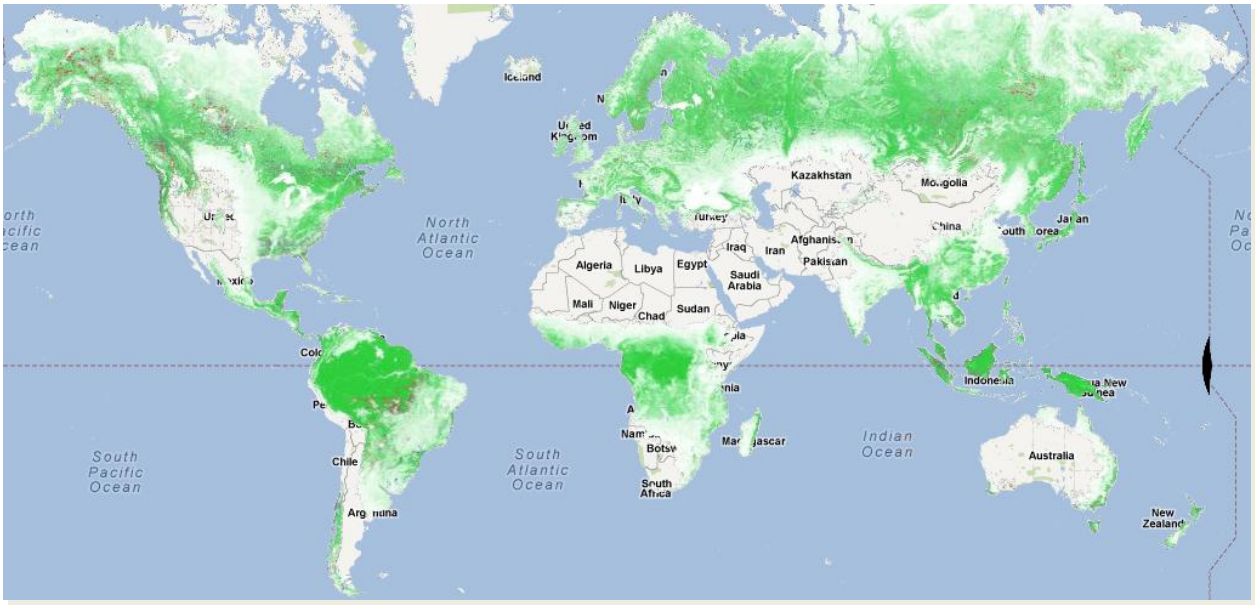


Figure 7. A 960-m test product for percent tree cover, gain and loss, 1999 to 2011, white-to-green scale: tree canopy cover (0-100 percent); red – tree cover loss; blue – tree cover gain; violet – tree cover loss followed by tree cover gain.

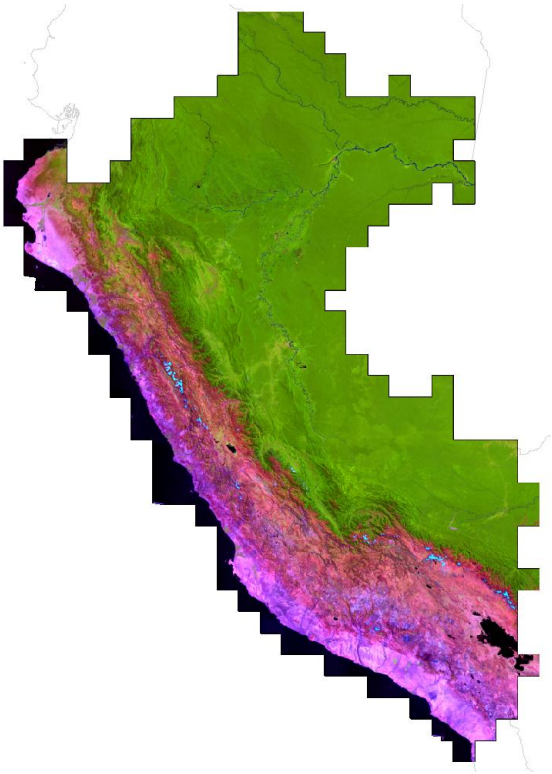


Figure 8. Example percent tree data of Peru at 30-m spatial resolution.

Figure 9. One of the 5-km by 5-km validation sites in Sao Paulo, Brazil, for 2010. Data acquired from National Geospatial Intelligence Agency's web-based access and retrieval portal https://warp.nga.mil/.

Landscape Dynamics and Global Change

The Landscape Dynamics and Global Change Team integrates remote sensing resources with simulation models of natural and managed ecosystems to understand environmental change across landscape units, ecological systems, and multitemporal/spatial scales in support of a sustainable Earth. Key accomplishments are given in the following sections.

Eleven Years of Cheatgrass Dynamics in the Northern Great Basin

USGS scientists, in partnership with U.S. Bureau of Land Management (BLM) personnel, developed cheatgrass percent cover and die-off time series (2000 – 2010) for a portion of the Northern Great Basin. These time series provide unprecedented terrestrial monitoring products that offer land managers, scientists, and policy makers a better understanding of the Great Basin ecoregion and some of its challenges (fig. 10).

The Great Basin is an imperiled ecoregion, and cheatgrass is a main driver in its continued degradation. Cheatgrass exploits post-disturbance conditions in shrub steppe environments and, during the process in many areas, alters the rich, diverse native system to one dominated by a single species. Areas dominated by cheatgrass experience significantly more fire disturbances than do native-dominated systems, causing intervals between fires to be so shortened that sagebrush, a native plant that many species need for survival, oftentimes cannot reestablish and mature before it burns again. During the very dry 2012 fire season, millions of acres burned in the Great Basin. This fire season followed one of the most productive cheatgrass growing seasons in recent history; consequently, significantly more than normal amounts of highly flammable cheatgrass from the previous year was ready to burn, and it did. Cheatgrass can be seen as a scourge on the Great Basin landscape, and its absence, or reduced production, can be seen as a positive development. However, when cheatgrass cover is absent, or reduced, several problems can emerge that collectively can rival the fire risk, including the invasion of new weed species, the acceleration of soil erosion, the reduction of spring forage for livestock and wildlife, and the development of unknown recovery pathways.

Scientists combined data from a satellite archive with elevation, soils, land cover, and weather data, and integrated it into adaptive, data-driven ecological models. This process allowed scientists to look historically at cheatgrass percent cover and die-off and to develop maps that highlight areas where, over time, cheatgrass percent cover and/or dieoffs increased, decreased, or remained relatively stable. Scientists also projected areas of future increasing and decreasing probabilities of cheatgrass die-off using future climate data. Results were validated using independent data sets, including the USGS Land Treatments Digital Library.

The time series of cheatgrass percent cover and die-off maps offer retrospective looks at changing conditions in the Northern Great Basin. The cheatgrass percent cover

datasets can be updated relatively easily and then integrated into fire models to enhance fuel-load information, potentially helping improve fire predictive capabilities. These datasets also can be compared with past fire information to better understand the relationship between cheatgrass and fire size, severity, and frequency. The cheatgrass die-off datasets highlight areas where cheatgrass is underperforming, so these maps can be used to identify where native vegetation restoration could be attempted. Additionally, the cheatgrass die-off maps can be used to help validate successful land treatments executed by land management agencies that are meant to remove cheatgrass or reduce its presence.

The Northern Great Basin climate, like climates everywhere, is changing, so perhaps what is most compelling about modeling cheatgrass dynamics in this region is our ability to use future climate data to project future cheatgrass dynamics. Because the models are adaptable and data driven, future climate data can be substituted for present-day climate data and maps can be generated that estimate cheatgrass percent cover and cheatgrass die-off probability for future years. Future projections of cheatgrass dynamics can inform land managers of potential areas of concern and allow them to develop adaptive management strategies to address, or cope with, changing conditions. The greater sage grouse is one species that can benefit from more informed land management decisions. This species is a likely candidate for inclusion on the Endangered Species list because impacts from Euro-American settlement have severely reduced their native sagebrush habitat, negatively affecting their ability to reproduce. If land managers are aware of areas that are projected to have little or no cheatgrass, they can focus management efforts in these areas. Likewise, future probability of cheatgrass die-off maps could be used to plan restoration efforts of critical native habitat.

USGS scientists partnered with BLM and received funding from the USGS Northwest Climate Science Center to expand a cheatgrass dynamics pilot study to the Northern Great Basin. EROS provided remote sensing data, ecological modeling, geographic information science technology, and scientific analysis to generate datasets, maps, and results that can be used by land managers to improve our public lands; http://lca.usgs.gov/lca/epa_cheatgrass/reports/NW%20CSC%20Final%20project%20report.pdf. For further information, contact Bruce Wylie, USGS EROS, wylie@usgs.gov. For more information on cheatgrass dieoff dynamics, see http://lca.usgs.gov/lca/epa_cheatgrass/index.php.

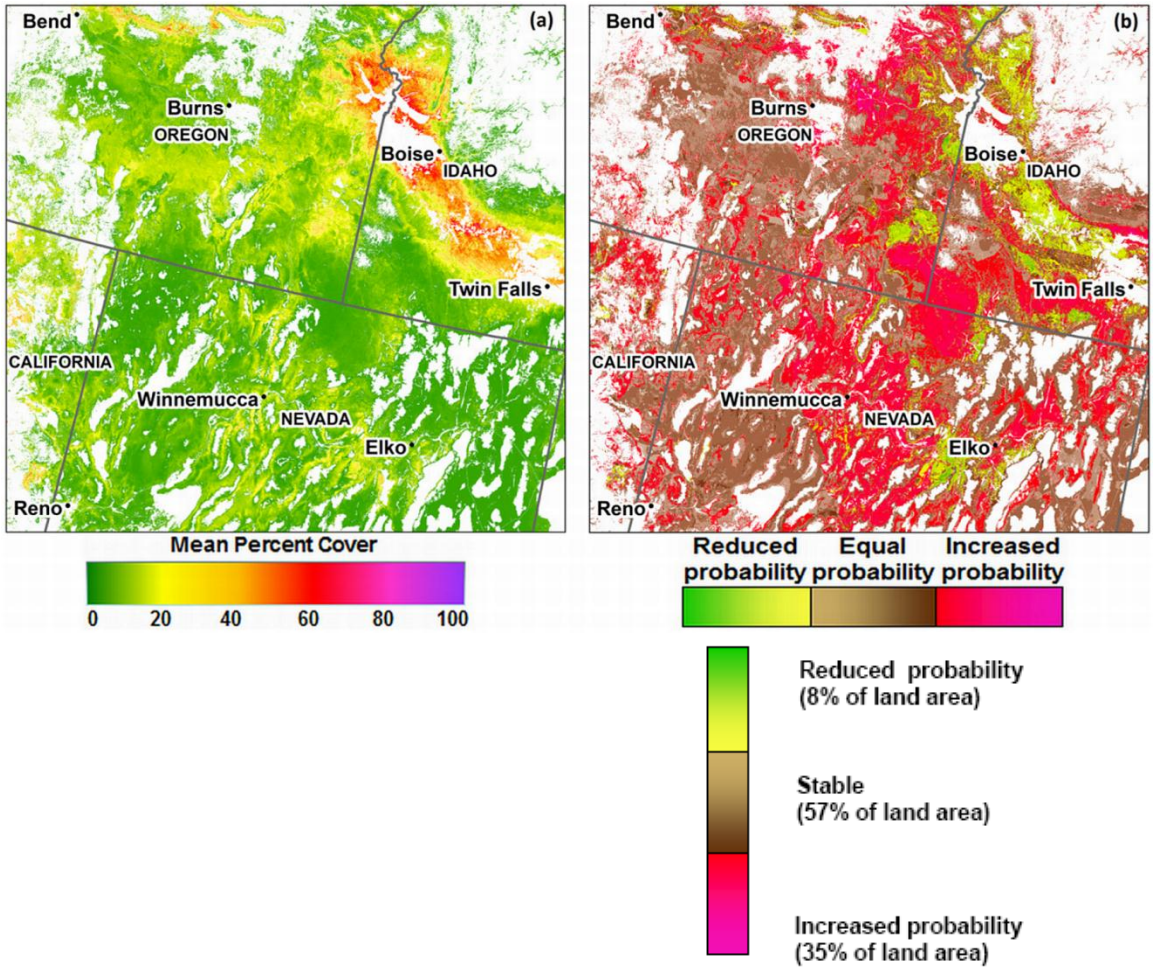


Figure 10. Maps showing (left) mean cheatgrass percent cover for 2000 – 2010 and (right) areas where cheatgrass dieoff probability was modeled to increase, decrease, or remain relatively stable in the year 2050 compared to present day.

Utilizing Surface and Subsurface Remote Sensing to Aid in Regional Permafrost Interpretations

USGS scientists, in partnership with USGS Climate Land Use Research and Development Program, Climate Effects Network Yukon River Basin Program, LandCarbon Program, and U.S. Fish and Wildlife Service, have devised a method for estimating the presence-absence of near surface permafrost and active-layer thickness, in the Yukon Flats Ecoregion, Alaska.

Permafrost, or perennially frozen ground, has a significant impact on high-latitude ecosystems and socioeconomics due to its influence on surface and subsurface hydrology, lake water levels, vegetation communities, and surface soil deformations. Permafrost degradation not only has a direct impact on high-latitude ecosystems where it is prevalent, but also poses global consequences to climate change due to remobilization of carbon pools. *"The carbon stored in permafrost soils has been*

identified as one of the more likely positive feedbacks to climate change, but the scope and magnitude of that is pretty uncertain at the moment," says Ted Schuur, an ecosystem ecologist at the University of Florida in Gainesville, and a leading expert in the field of cryospheric science. Subsequently, recent observations of abrupt increases in the extent and rate of permafrost degradation in ecosystems reinforces a need for accurately mapping spatial extents of permafrost and active-layer thickness, and for proper monitoring and management of these areas. In the past, only generalized maps have been available.

The Yukon Flats Ecoregion, a region characterized predominately by discontinuous permafrost, is one such region that is critical to monitor and map. This ecosystem is of particular importance because of its critical wetland wildlife habitat, and it is underlain by relatively warm permafrost (i.e., discontinuous permafrost), which is generally more unstable and sensitive to a warming climate than continuous permafrost in northern areas.

A combination of active (i.e., airborne electromagnetic surveys) and passive remote sensing (e.g., Landsat imagery and derivatives) data, in conjunction with field based measurements and data mining activities, allows USGS scientists to assess permafrost extents and active-layer thickness (fig. 11), as well as gain knowledge about Earth surface and subsurface processes and subsequent implications of such findings.

These assessments provide a baseline for future monitoring of this area and present a quantitative distribution of active-layer thickness. Such information is critical for evaluating and understanding active layer response and perhaps recovery to wildfire, surface water redistribution, and climate perturbations. Assessment, such as this, can serve as inputs and verification for various hydrological models, allowing for improved understanding of streamflow recession, baseflow magnitude, dissolved carbon exports, lake level dynamics, and potential future changes to these elements. These assessments may also enhance our understanding of active-layer thickness and soil organic relations, and subsequently serve as inputs into carbon cycle models by helping estimate soil organic depth and content. Current and future projections of green house gas emissions, including methane and vegetation dynamics, would be refined through better quantification of current conditions.

This research served as a pilot test study, for our current work, which involves assessing our capabilities to quantify near surface permafrost and soil organic carbon distributions throughout the Alaskan portion of the Yukon River Basin, to support USGS LandCarbon, carbon stock assessments.

The partners involved within this study include various USGS centers (i.e., USGS EROS Center, the Crustal Geophysics and Geochemistry Science Center, and the National Research Program) and U.S. Fish and Wildlife service (i.e., Yukon Flats National Wildlife Refuge).

The USGS EROS Center, located in Sioux Falls, SD, provides scientific analyses and research, based on remote sensing, environmental modeling, and geographic information system technologies to support a better understanding of a changing earth, ecosystems, and in this instance, permafrost and active-layer thickness monitoring and mapping efforts. For further information contact Bruce Wylie, USGS EROS, wylie@usgs.gov.

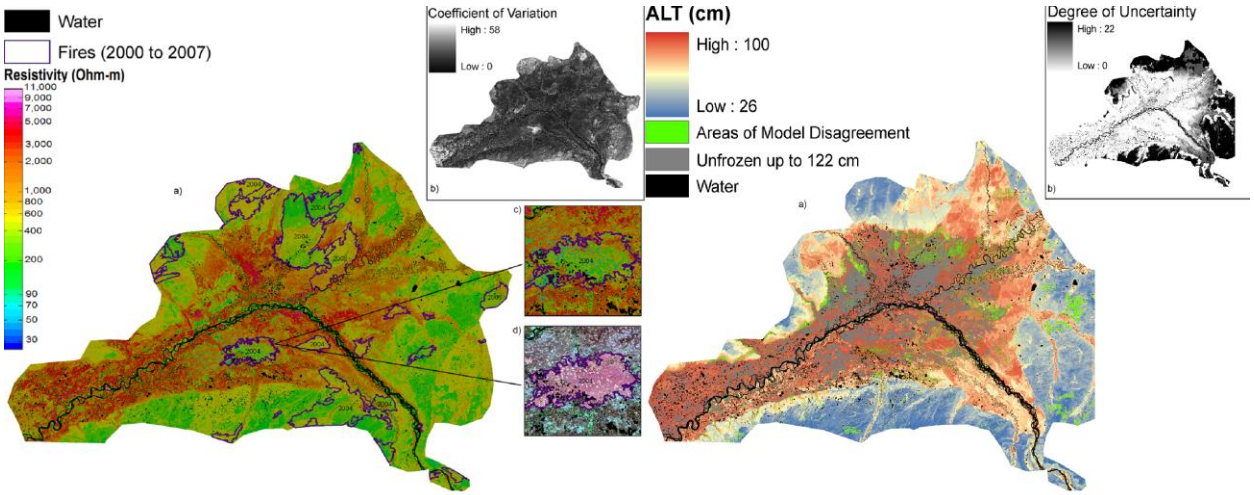


Figure 11. Extrapolated near-surface electrical resistivity (left) and estimated active-layer thickness (right) over the Yukon Flats, Alaska, using airborne electromagnetic-derived resistivity models, Landsat, and ancillary spatial data (Pastick *et al.* in revision).

Topographic Science, Elevation, and Lidar

The Topographic Science, Elevation, and Lidar Team establishes partnerships and conducts research, technique development, dataset development, and applications focused on the study of the topographic land surface. Key accomplishments are given in the following sections.

Coastal National Elevation Database: Mobile Bay Pilot Study

Many applications of geospatial data in coastal environments require detailed knowledge of near-shore topography and bathymetry as physical processes in the coastal environments are controlled by the geomorphology of both “over-the-land” topography and “underwater” bathymetry. Topobathymetric models provide a required seamless elevation product for several science application studies such as shoreline delineation, coastal inundation mapping, sediment-transport, sea-level rise, storm surge models, tsunami impact assessment, and also to analyze the impact of various climate change scenarios on coastal regions. The Coastal National Elevation Database (CoNED) is the integration of many disparate lidar and bathymetric data sources into a common database aligned both vertically and horizontally to common reference

systems. CoNED is a multi-temporal, multi-scale, and multi-resolution database that permits easy portability to geomorphological and hazard vulnerability applications but at the same time extends the framework of the National Elevation Dataset into the coastal zone. In partnership with the USGS Coastal Marine and Geology Program (CMGP) and the National Geospatial Program, integrated topobathymetric elevation models are being developed for select coastal regions along the U.S. coast.

In FY 2012, a 3-m topobathymetric elevation model was developed for Mobile Bay, Alabama (fig. 12). Mobile Bay is ecologically important as it is the fourth largest estuary in the United States. The Mobile and Tensaw Rivers drain into the bay at the northern end with the bay emptying into the Gulf of Mexico at the southern end. Dauphin Island (a barrier island) and the Fort Morgan Peninsula form the mouth of Mobile Bay. The vertical accuracy of the topographic data in the integrated model ranges from 6 to 20 cm in root mean square error. As a result of the high-vertical accuracy, a sea-level rise vulnerability assessment was also conducted using the integrated topobathymetric model (fig. 13). The region depicted in dark blue in figure 13 indicates the minimum land area extent that would be subject to a 1.18-m sea-level rise scenario.

Publications for both the integrated topobathymetric model and the sea-level rise assessment for Mobile Bay are in press. The upcoming plans in FY 2013 are to develop an integrated 3-m topobathymetric model for Southern Louisiana for the USGS CMGP and to complete a 2-m model for USGS CMGP in San Francisco Bay. For further information, contact Dean Gesch or Jeffrey Danielson, USGS EROS, gesch@usgs.gov or daniels@usgs.gov.

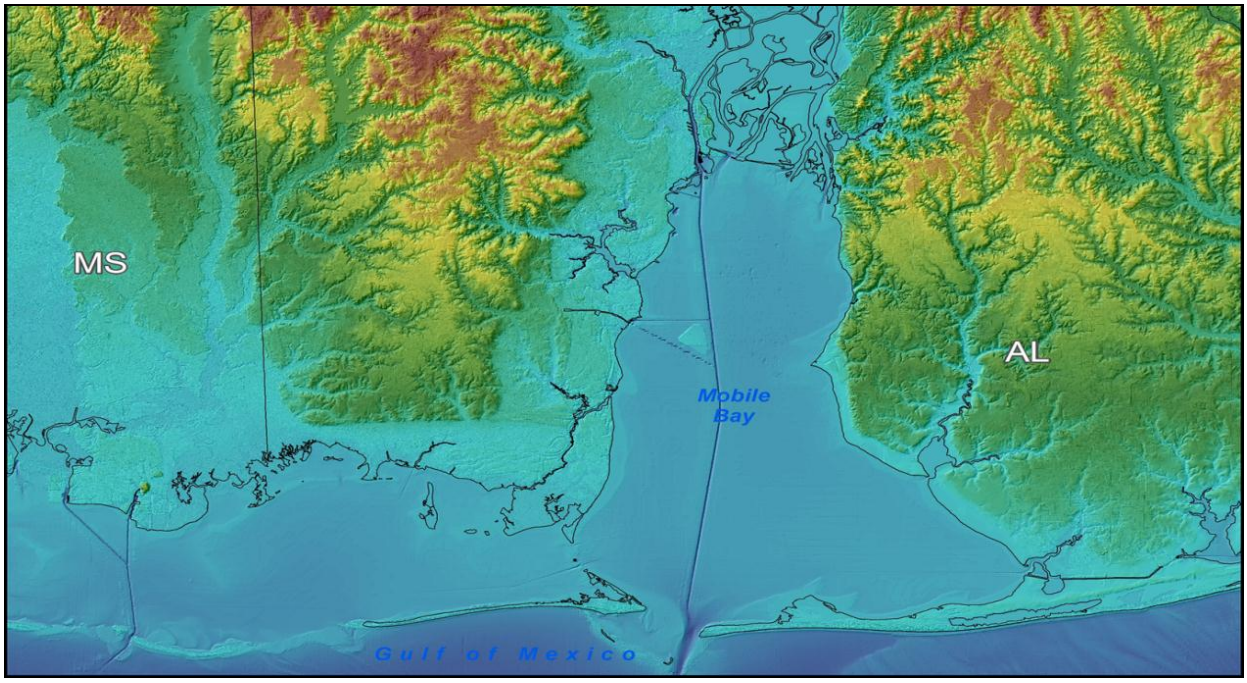


Figure 12. Topobathymetric elevation model for Mobile Bay, Alabama.

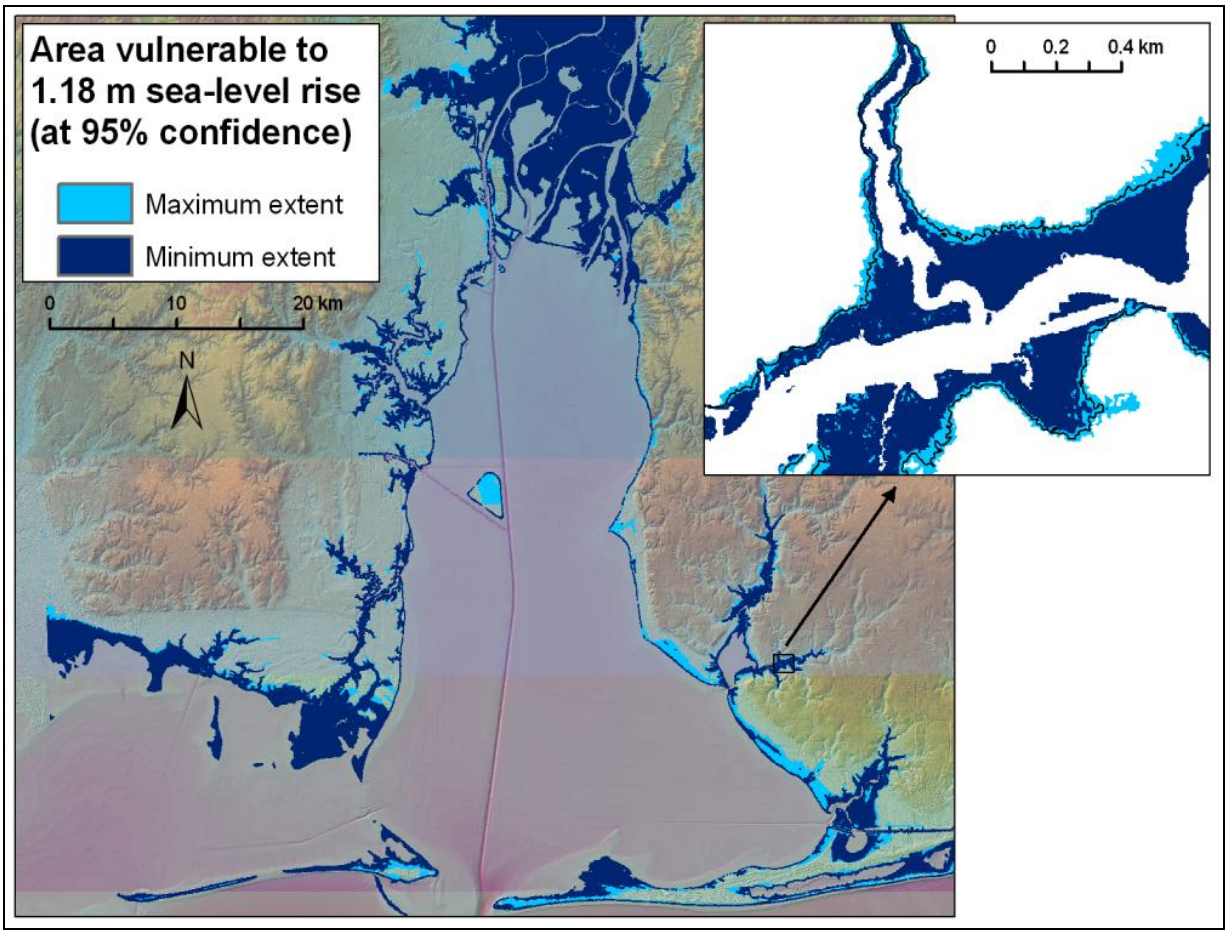


Figure 13. Sea-level rise vulnerability assessment for Mobile Bay, Alabama. The region depicted in dark blue indicates the minimum land area extent that would be subject to a 1.18-m sea-level rise scenario.

Early Warning, Environmental Monitoring, and Hazards Management

The Early Warning, Environmental Monitoring, and Hazards Mitigation Team conducts research on and implements new approaches for monitoring environmental hazards and mitigating their impact through creative applications of geographic analysis and modeling of Earth processes. Key accomplishments are given in the following sections.

USGS Science Supports the Estimation of Consumptive Use to Meet the Objectives of the WaterSMART Project

The WaterSMART (Water for Sustainable Management of America's Resources for Tomorrow) project of the DOI USGS aims to quantify the year-to-year variability of vegetation water use (consumptive use), with a focus on irrigated lands, in a cost-effective and timely manner, i.e., previous year consumptive use estimates need to be

available before the next irrigation season starts. This study presents a new parameterization approach for the Simplified Surface Energy Balance (SSEB) Model to estimate and validate evapotranspiration (ET) from irrigated lands and the general landscape. ET is directly related to consumptive use.

The WaterSMART project improved the parameterization of the SSEB ET model using important modifications so that operational ET estimation can be processed quickly and consistently. The SSEB model uses Land Surface Temperature (LST) derived from satellite sensors such as Landsat and MODIS and air temperature from local or gridded weather data sets. In the improved SSEB model “dry/hot” and “wet/cold” boundary conditions are pre-defined for a given location and time period, eliminating the manual selection of hot and cold pixels from an image. This is an innovative approach that allows the estimation of ET quickly and consistently on an operational basis, resulting in a new model, SSEBop. Using this operational model, monthly and annual ET maps were produced for the conterminous United States using MODIS data at 1-km resolution. Also, for the first time, Landsat-based ET was produced for the entire Colorado River Basin for one complete year at 100-m resolution (fig. 14 and fig. 15).

The SSEBop model will allow the quantification of ET at two important scales: (1) field and (2) hydrologic basin (fig. 16). Field-scale ET will be used for water use estimation to understand and quantify where, how much, and by whom, water is being used in the landscape. On the other hand, basin-scale ET will be important in understanding basin water balance and water availability. Quantifying water use and water availability is a critical component of the WaterSMART objectives. Irrigation water use information is used in the planning and implementation of water resources allocation and curtailment guidelines. Similarly, ET information is critical in understanding groundwater withdrawal and recharge rates. The primary users of this model/product are State water engineers and hydrologists, and USGS water scientists.

USGS EROS, in collaboration with USGS Water Science Center researchers, is advancing the application of the model in the following areas: (1) quantifying county-level crop consumptive use, (2) using ET maps for estimating groundwater recharge, and (3) understanding water balance dynamics at the lowest hydrologic unit code at the national scale. For further information, contact Gabriel Senay, USGS EROS, senay@usgs.gov.

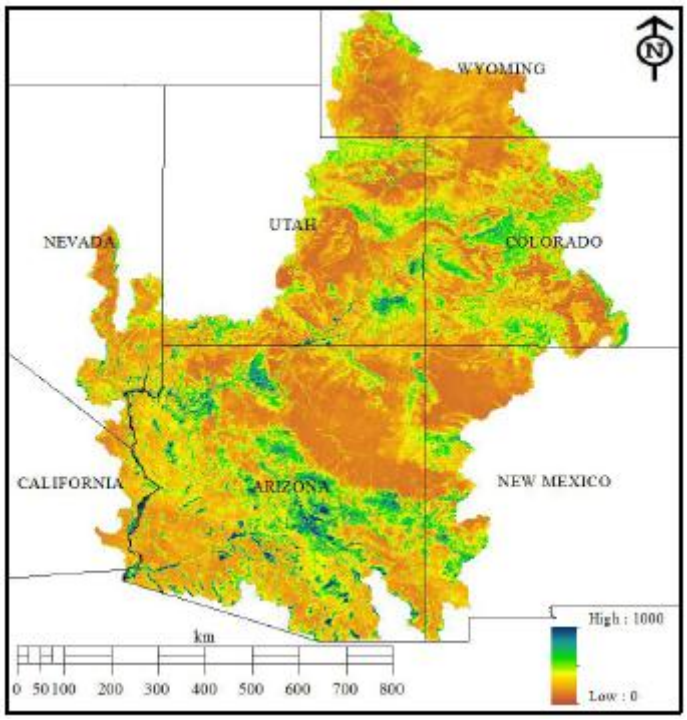


Figure 14. SSEBop model Landsat-based annual evapotranspiration in millimeters.

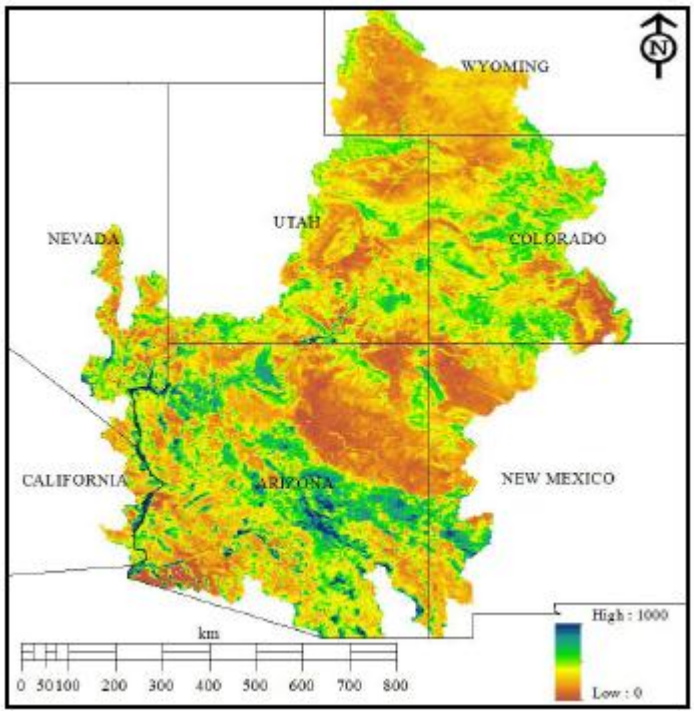


Figure 15. SSEBop model MODIS-based annual evapotranspiration in millimeters.

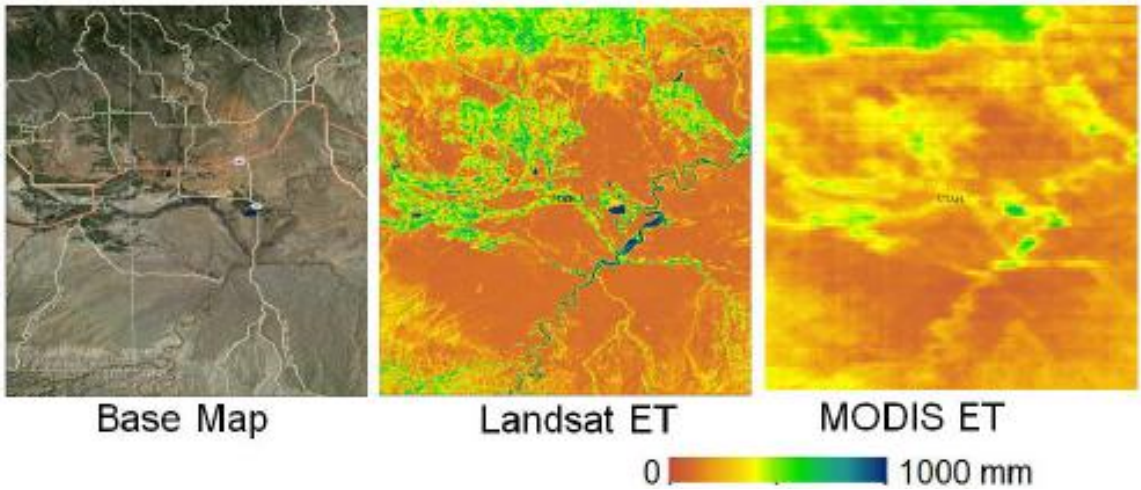


Figure 16. Comparison between MODIS- and Landsat-based annual evapotranspiration in relation to a base map using the simplified surface energy balance operational model.

Understanding Recent Pacific Sea Surface Temperature Trends and Implications for the United States and Africa

Since 2004, USGS scientists, in partnership with the University of California, Santa Barbara's Geography Department, have tracked sea surface temperature (SST) trends in tropical Pacific and Indian Oceans and examined the impacts of this warming on Africa. Project efforts in 2012, however, presented several critical breakthroughs. The cause of the rapid warming was discovered, the critical role of the tropical Pacific SST gradient was identified, and the impact of this gradient on the United States and Africa was explored. This new understanding was used to produce a forecast of East African drought that motivated an effective early humanitarian response in East Africa.

As the tropical Indo-Pacific Ocean continues to warm in concert with the globe and as predicted by climate change models (fig. 17), our analysis of the climate patterns associated with recent East African droughts revealed the important role played by the tropical Pacific SST gradient. When the western Pacific is warmer than the central Pacific, eastern Africa tends to be dry. This same SST pattern also tends to produce drought in parts of the southern United States, especially during La Niña years (fig. 18).

Careful analysis of the causes of the observed warming revealed the critical role played by water vapor. Water vapor is a very powerful greenhouse gas, and project scientists suggested that the reason the western Pacific has warmed so rapidly (fig. 17) is due to the increase in atmospheric water vapor, combined with well mixed greenhouse gasses such as carbon dioxide. This explanation also helps in understanding why the western Pacific is warming faster than the central Pacific. If this process is correct, the result could be more frequent droughts in the Middle East, East Africa, North America, and western Asia (fig. 18).

One positive aspect of the project effort is that better characterization of drought-producing SST patterns has helped improve project forecasts. In the winter of 2011, East Africa received abundant rains, and regional food security improved. In January and February of 2012, exceptionally warm temperatures helped produce a rapid decrease in vegetation greenness, as portrayed by the normalized difference vegetation index (NDVI) in figure 19, resulting in dry and perilous conditions for the region. Analysis of SSTs in March of 2012 resulted in a forecast of below normal rains for East Africa. As reported in a U.S. State Department media note[1], this forecast by the Famine Early Warning Systems Network (FEWS NET), released in early April (fig. 20), helped motivate an early humanitarian response. When poor seasonal rains did occur in April-May-June, USGS science had helped improve our ability to safeguard lives and livelihoods. For further information, contact Chris Funk, USGS EROS, funk@usgs.gov.

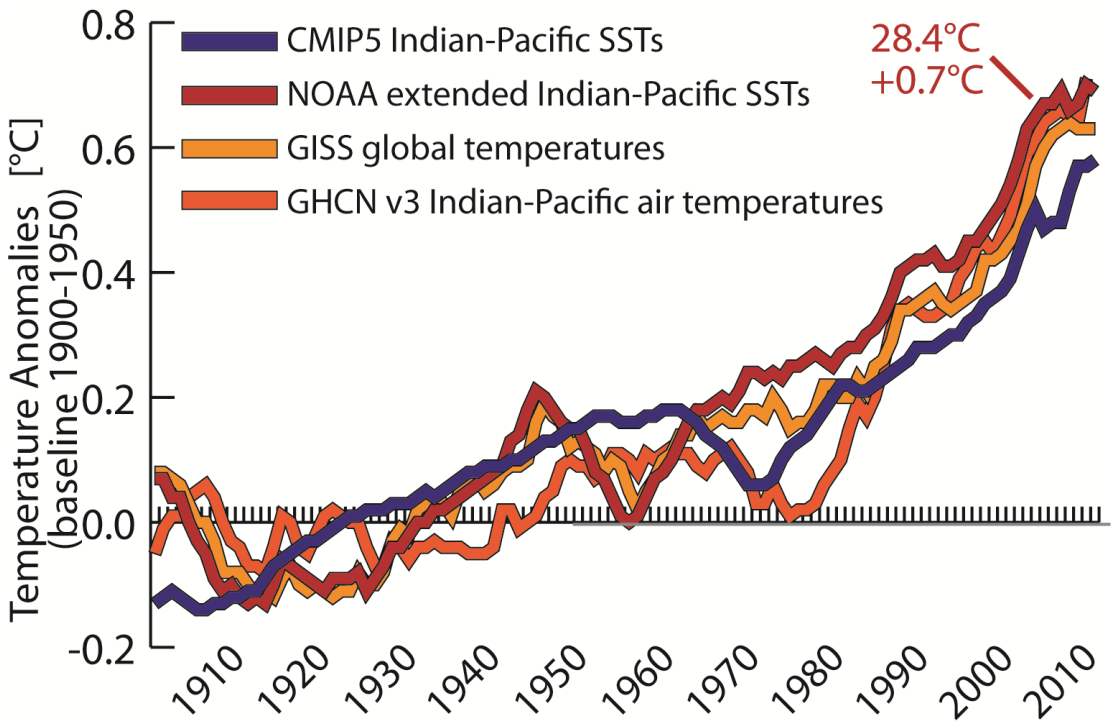


Figure 17. Long-time series of smoothed Indo-Pacific tropical sea surface temperatures from climate change simulations (CMIP5) and observations (NOAA), along with global air temperatures (GISS) and weather station observations from stations in nearby countries (GHCN). [CMIP5: Coupled Model Intercomparison Project Phase 5; NOAA: National Oceanic and Atmospheric Administration; GISS: Goddard Institute for Space Studies; GHCN: Global Historical Climatology Network].

[1] **http://www.state.gov/r/pa/prs/ps/2012/04/187456.htm**

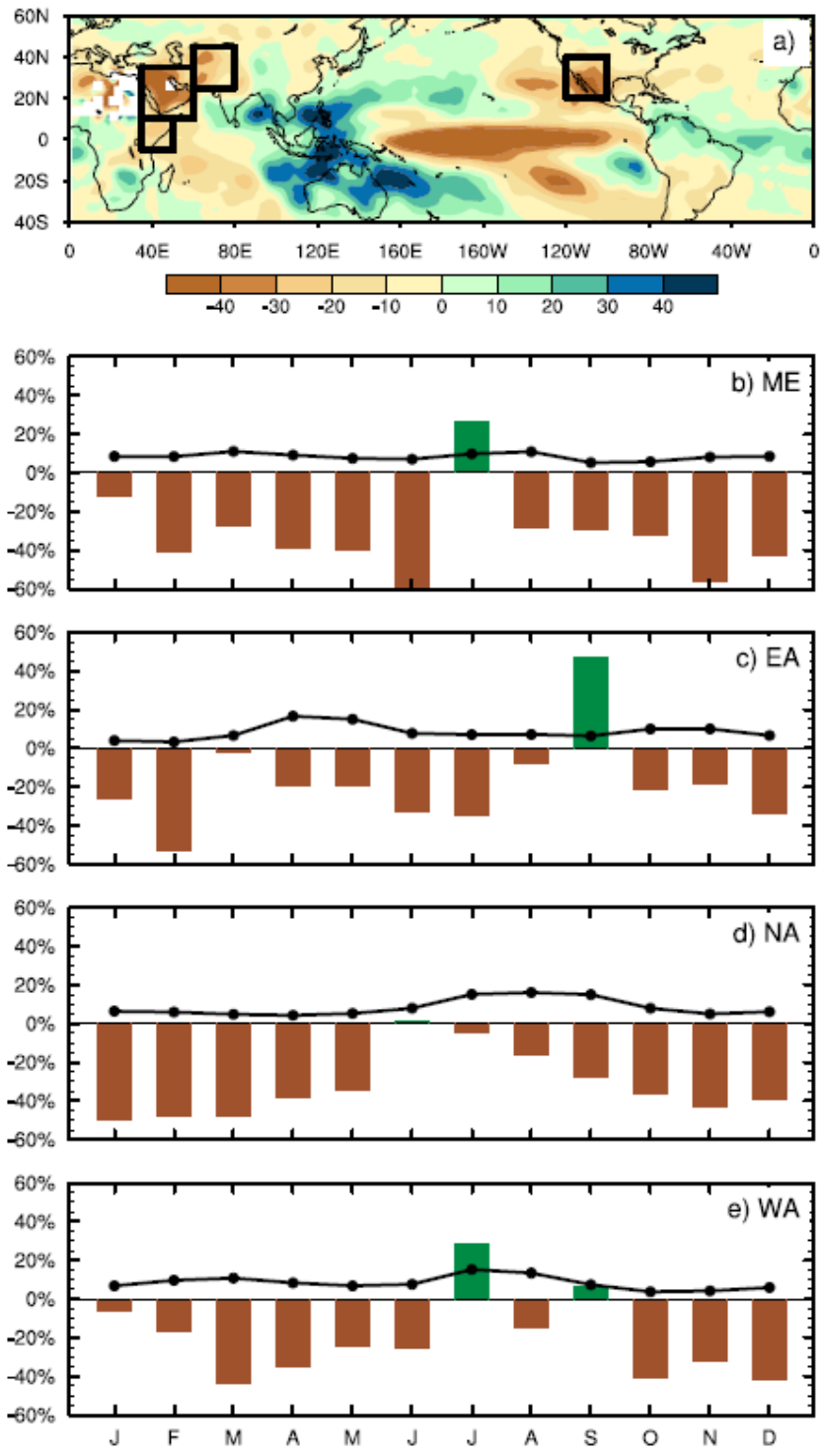


Figure 18. a) Percent rainfall anomalies during La Niña years with strong Pacific sea surface temperature gradients. b-e) Percent rainfall anomalies (bar graph) and percent contribution to annual average precipitation (line graph) by month for the Middle East (ME), East Africa (EA), North America (NA), and western Asia (WA), respectively.

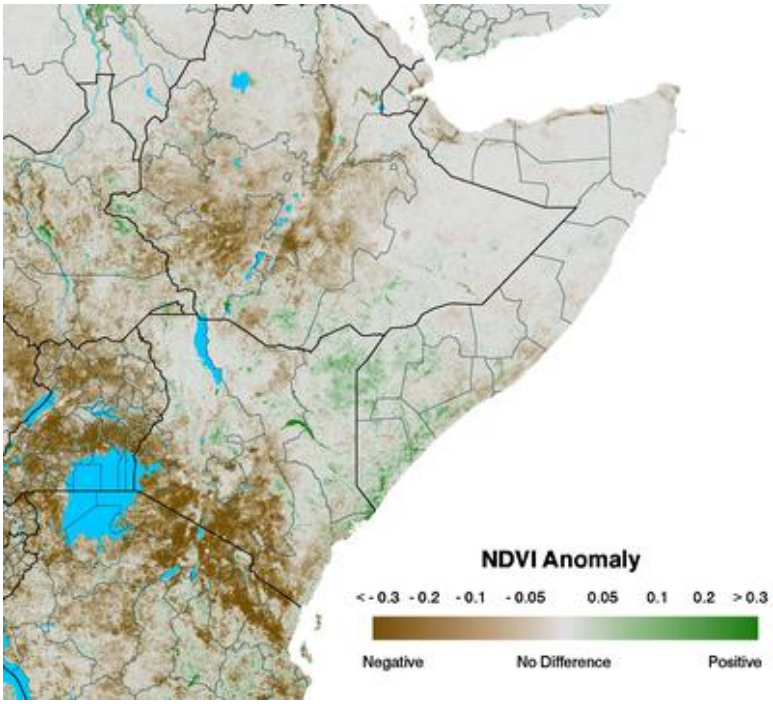


Figure 19. Normalized difference vegetation index anomalies for February 15-25, 2012.

Zoom out (Ctrl+Minus)

- Given the impacts of extreme food insecurity and famine during 2011 on human health and household livelihoods, and the likelihood of a poor March-May season, humanitarian partners should immediately implement programs to protect livelihoods and household food consumption in the eastern Horn of Africa.

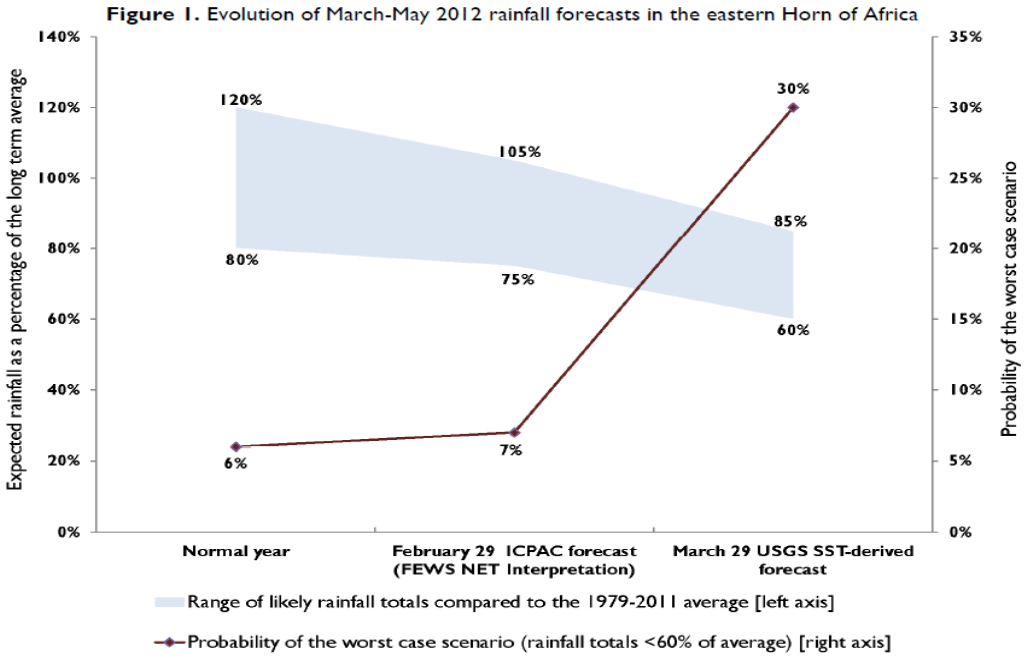


Figure 20. Famine Early Warning Systems Network forecast for eastern Africa, released on April 3, 2012.

Native American Climate Change Adaptation

USGS scientists, in partnership with other Federal agencies and tribal organizations, have been working with tribal communities in developing plans to adapt to the present and future impacts of global climate change. At the USGS EROS Center, this builds on many years of collaborating with tribal governments and educational institutions in understanding how to apply geospatial technologies in the management of natural and cultural resources.

According to the Intergovernmental Panel on Climate Change Report (2007) those communities with the fewest resources will be most vulnerable and least likely to adapt to the impacts brought on by a changing climate. The DOI understands that climate change may disproportionately affect tribes and their lands because they are heavily dependent on their natural resources for economic and cultural identity. These statements apply to many if not most tribal nations which, due to limited resources and expertise, find themselves at a distinct disadvantage in adequately preparing their communities for the changes that will likely occur.

The Secretary of Interior (Order No. 3289, Amendment No. 1, "Addressing the Impacts of Climate Change on America's Water, Land , and other Natural and Cultural Resources") has stated that:

> *"the Department will ensure consistent and in-depth government-to-government consultation with tribes and Alaska Natives on the Department's climate change initiatives. Tribal values are critical to determining what is to be protected, why, and how to protect the interests of their communities. The Department will support the use of the best available science, including traditional ecological knowledge, in formulating policy pertaining to climate change. The Department will also support substantive participation by tribes in deliberations on climate-related mechanisms, agreements, rules, and regulations."*

At EROS, and throughout the USGS, scientists are taking this DOI mandate seriously as is demonstrated by USGS efforts to work with tribes to undertake climate change adaptation planning.

Nonetheless, with over 500 federally recognized tribes, no one Federal agency can provide sufficient support to tribes for implementing climate change vulnerability assessment and adaptation planning. The strategy, therefore, is to form networks among key Federal and intertribal organizations to reach as many tribes as possible through meetings, workshops, webinars, educational materials and direct activities. Within tribal communities the activity leads usually consist of a tribe's natural resource agencies. Another option, which has been a primary focus at EROS, is to work through environmental programs at one or more of the 37 tribal colleges and universities located across the United States.

The tribal liaison for the USGS CLU Mission Area, working through the USGS Office of Tribal Relations, is located at EROS. This liaison typically serves as the interface between EROS and CLU and the various agencies that make up the informal tribal climate change network.

The result of these efforts is a wide range of activities from a growing network of agencies enabling tribal communities to begin to assess their vulnerability to climate change in hopes of developing corresponding adaptation plans. Some examples of activities in which EROS has been active include:

- Assisting the USGS National Climate Change and Wildlife Science Center in ensuring national and regional Tribal participation in the DOI funded Climate Science Centers.
- Providing operational and research support to the American Indian Alaska Native Climate Change Working Group (AIANCCWG).
- Instructor with the Institute for Tribal Environmental Professionals Climate Change Adaptation Planning courses (Environmental Protection Agency funded).
- Participation in the Climate Change Adaptation Planning Guidance Workshop for Tribal Leaders, the goal of which was to develop strategies and create a broadly-conceived written guide specifically for tribal leaders (NOAA/AIANCCWG sponsored).
- Represented the DOI at the Canadian Center for Indigenous Environmental Resources Forum on Climate Change Adaptation Planning, which focused on the relationship between climate change adaptation and food security.
- Serving on the National Oceans Policy Team to monitor collaborations among tribal, State and local governments to develop climate change vulnerability assessments.
- Participating in the NASA Tribal Colleges and Universities Project Academic and Summer Research Experience for Undergrads program by providing technical assistance to the "*Preparing Indian Country for Climate Change through Technology, Education and Research"* project. Figure 21 is an example of a regional project activity.
- In partnership with the North Dakota Association of Tribal Colleges, NASA, and the National Center for Atmospheric Research/University Corporation for Atmospheric Research, implementing the NASA ROSES (Research Opportunities in Space and Earth Sciences) Global Climate Change Education funded project *"NASA – North Dakota Association of Tribal Colleges Climate Change Education Initiative."*
- Initiated a memorandum of understanding with the National Park Service's Pipestone National Monument to address the impact of climate change on its physical and cultural resources.

This informal network, a collective effort of a number of Federal and intertribal agencies as well as specific tribal communities, is expanding and solidifying. Tribes now have a number of options for technical support in implementing climate change vulnerability assessments leading to the development of community or reservation wide adaptation

plans, and it is encouraging to note that a number of tribes have recently initiated or completed this process.

The USGS EROS Center, located in Sioux Falls, South Dakota, provides scientific analyses based on remote sensing, environmental modeling, geographic information system technologies, and climate science to support tribal activities throughout the United States. For further information, contact Eric Wood, USGS EROS, woodec@usgs.gov.

Figure 21. An example of a climate change related Research Experience for Undergrads project at one of several participating Tribal Colleges and Universities (White Earth Tribal and Community College). The USGS EROS Center is one of several partners in this NASA funded project.

Ecological Carbon Sequestration

The Ecological Carbon Sequestration Team is responsible for research, development, and application of models and information products that describe the Nation's organic carbon sinks and sources, greenhouse gas fluxes, and the natural and anthropogenic processes that affect them. At EROS, their work focuses on the development and application of the FOREcasting SCEnarios of future land-cover (FORE-SCE) model and the General Ensemble biogeochemical Modeling System (GEMS) to assess current sinks and sources and their possible future states. Key accomplishments are given in the following sections.

USGS LandCarbon Project – GEMS Modeling

The Energy Independence and Security Act of 2007 mandated the U.S. Department of the Interior to perform a nationwide assessment of the potentials for carbon sequestration and reduction of greenhouse gas emissions, including carbon dioxide , methane, and nitrous oxide, by all ecosystems under different policy, management, disturbances, and climate change scenarios. The assessment is important because it improves the understanding of the spatial and temporal dimensions, uncertainty, and the driving forces of carbon storage change in the United States.

> *"This is truly groundbreaking research that, for the first time, takes a landscape-level look at how our lands naturally store carbon and explores how we can encourage this capability in ways that enhance our stewardship of natural resources,"* said Deputy Secretary of the Interior David J. Hayes. *"Our landscapes are helping us to absorb carbon emissions that would otherwise contribute to atmospheric warming."*

USGS EROS scientists provide the necessary terrestrial biogeochemical cycle simulation capability in this assessment by developing and applying the GEMS across the country. Spatial and temporal changes of carbon stocks and greenhouse gas fluxes from 1992 to 2050 have been simulated with GEMS for the Great Plains and the Western United States at 250-m resolution. This effort effectively integrated information of carbon stocks and fluxes, land cover and land use change, disturbances, and climate change observed and projected according to the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios.

The assessment provides products that show how much carbon has been stored in the ecosystems of the Central and Western United States in recent decades and how much carbon can be stored in future years under different climate and land management scenarios (fig. 22). It also reveals how carbon storage and fluxes have been influenced by both natural and anthropogenic processes such as land use, wildland fire, and climate change. The reports for the Great Plains (Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in the Great Plains Region of the United States) and the western United States (Baseline and Projected Future Carbon Storage

and Greenhouse-Gas Fluxes in Ecosystems of the Western United States) can be found online in the USGS publications warehouse at http://pubs.usgs.gov/pp/1787/ and http://pubs.usgs.gov/pp/1797/, respectively.

> *"For the first time, we will have a comprehensive view of how carbon is cycling through our Nation's ecosystems: sources, sinks, and relative residence times in the various biological components,"* explained USGS Director Marcia McNutt. *"This study will not only result in better land-use decisions but should also advance our fundamental understanding of one of the most important chemical cycles on the planet."*

The USGS EROS Center, located in Sioux Falls, South Dakota, provides remote sensing data, geospatial data and maps, biogeochemical modeling, geographic information science technology, and scientific analysis to support this national assessment. For further information, contact Shuguang Liu, USGS EROS, sliu@usgs.gov.

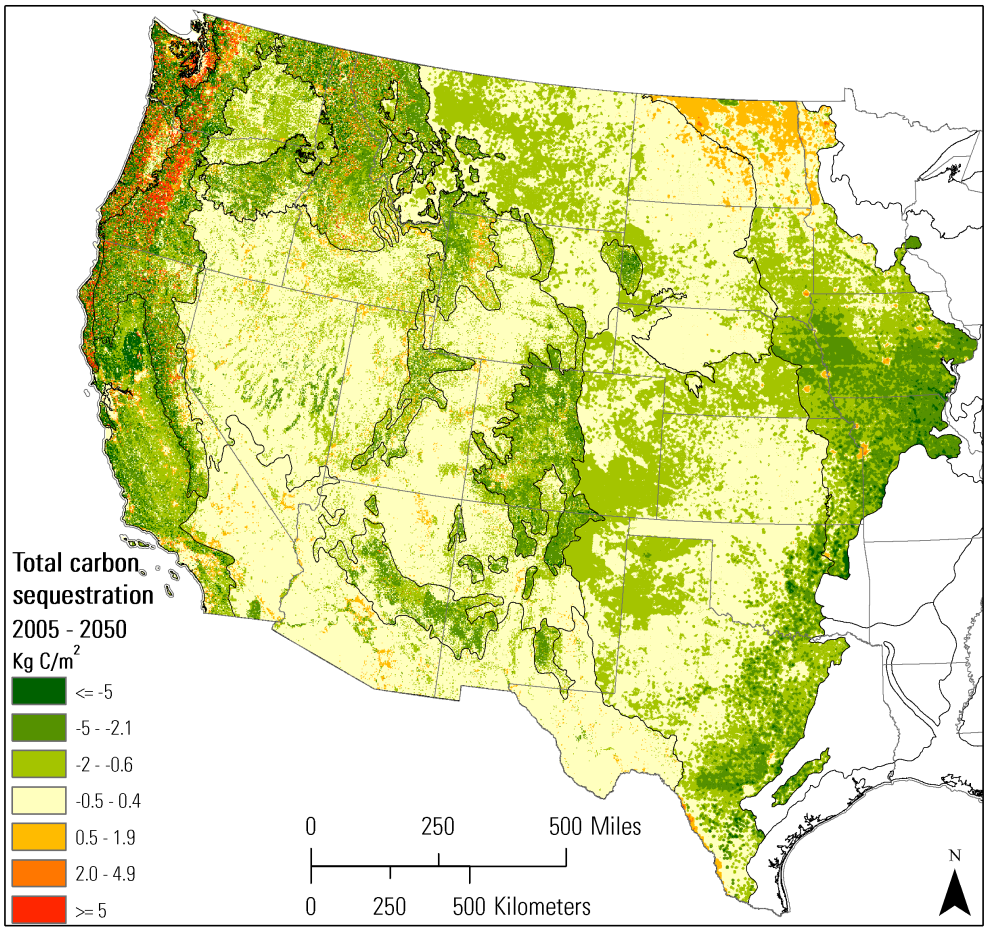


Figure 22. Total carbon sequestration from 2005 to 2050 for the Great Plains and Western States. Negative values or green colors show the magnitude and location of carbon being taken up by land, and positive values or red warm colors release of carbon into the atmosphere.

Remote Sensing Activities

The USGS EROS Center's remote sensing activities are framed around excellence in science, data management, infrastructure, and facilities devoted to evaluation and assessment of land changes and their impact on society. Core to the EROS mission is the continuity of remote sensing of the Earth's land surfaces at all scales to ensure availability of historical and current observations. Although EROS is perhaps best known as the USGS receiving station for Landsat satellite images, data from many other satellites and other remote sensing platforms also are archived and distributed by EROS. Receiving, calibrating and validating, processing, archiving, and distributing these data are primary tasks performed at EROS. In addition, EROS is defining requirements and specifications for future instruments, developing and implementing ground systems for future Earth observing missions, and developing national and international partnerships.

Landsat Program

The Landsat Program is a joint effort of the USGS and NASA to gather Earth resource data using a series of land observing satellites. Whereas NASA's role is the development and launch of Earth observing instruments and spacecrafts, the USGS is responsible for flight operations, maintenance, and management of all ground data reception, processing, archiving, product generation, and distribution. A primary objective of the Landsat Program is to ensure a collection of consistently calibrated Earth imagery. The Landsat Project at EROS manages two active satellites – Landsat 5 and Landsat 7 – and the entire historic archive of data collected since 1972. Key accomplishments are given in the following sections.

40th Anniversary of Landsat

> *"Over four decades, data from the Landsat series of satellites have become a vital reference worldwide for advancing our understanding of the science of the land. The 40-year Landsat archive forms an indelible and objective register of America's natural heritage and thus it has become part of this department's legacy to the American people."* – Ken Salazar, Interior Department Secretary

For many scientists, policymakers, researchers, and students, they have never known a time without at least one Landsat spacecraft recording the surface of the Earth. Forty years! A weighty responsibility, the USGS Landsat archive has served more images to the people of this world in the last 3.5 years than in the entire mission life combined. Landsat sensors have recorded the eruption of Mt. St. Helens and the rebound of the nearby ecosystem. A Landsat satellite was overhead the day after the meltdown at Chernobyl reactor #4. Landsat recorded the smoke plumes on the 12th and the 13th of

September 2001 over Manhattan, New York. If it happened in the last 40 years, then chances are that the Landsat archive holds an image of it.

The 40th anniversary events held in July 2012 honored the people who have supported Landsat throughout its long, and at times rocky, history. Events were held in the Washington, D.C. area where Landsat images were showcased (fig. 23). The general public had chosen their favorite Top 5 Earth as Art images, a panel of scientists had chosen the top ten most important images ever taken, and two U.S. locations were chosen for Landsat change analysis. On the west coast, the prototype LandsatLook Viewer was rolled out as a new and innovative way to gain access to the archive. Throughout the day, social media was abuzz with Landsat, getting started before the United States even awoke with news coming out of the United Kingdom. Thousands of tweets, Facebook messages, and website visits showed that the world recognized this amazing anniversary. For further information, contact Kristi Kline, USGS EROS, kkline@usgs.gov.

Figure 23. Design used for exhibit at 40th anniversary events of the Landsat missions.

LandsatLook – A New Way to Look at Landsat

From the beginning of the mission in 1972, Landsat instruments have witnessed changes on Earth. Also, since 1972, users have encountered barriers to easy use of this rich archive. A significant milestone was reached on December 8, 2008, when the entire archive became free via the internet. At this time, the products became standardized to a geoTiff format, which reduced confusion over tile type. However, large file size, expensive software, and data complexity could still make using Landsat data difficult by the novice or casual user or by experts in other fields who wanted to use Landsat.

In 2011, the Landsat project developed LandsatLook. It takes on the issues of file size, expensive software, and complexity. The LandsatLook product is a 3-band jpeg in natural color, and files are approximately 7 megabytes in size. In short, LandsatLook was designed for users that want Landsat for visual interpretation, or just to express Earth's beauty. The next step in the process was determining how to deliver these new images in the quickest and easiest way possible. To that end, a prototype LandsatLook Viewer (http://landsatlook.usgs.gov) was released on July 23, 2012, the 40th anniversary of the Landsat 1 launch.

The LandsatLook Viewer (fig. 24) is a tool by which users can conduct a place-name search or pan and zoom around the globe. When a search is initiated, the viewer reaches into a 2.5-million scene archive of LandsatLook images. In some places, there are over 1,000 images in each location. A simple jpeg of the image on the screen or a full LandsatLook image can be downloaded. The viewer is also a portal into our typical data ordering shopping basket, which allows for access and download of the full 7-band images.

In the final two months of FY 2012, more than 15,000 visitors from over 100 countries used the LandsatLook Viewer. For further information, contact Kristi Kline, USGS EROS, kkline@usgs.gov.

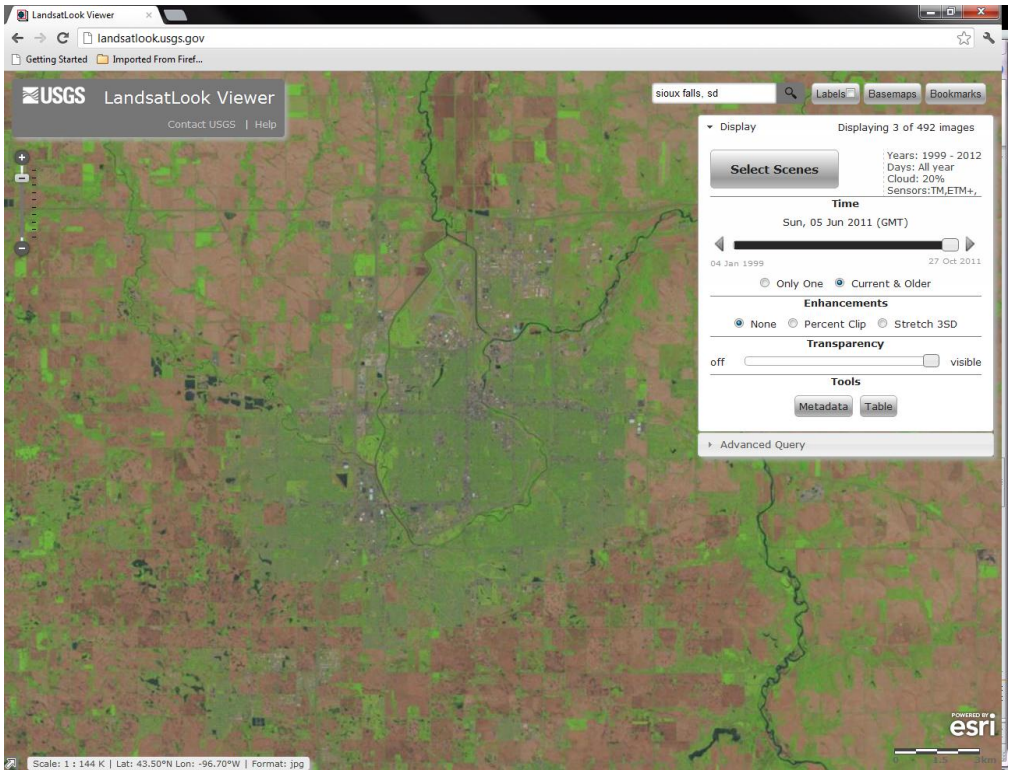


Figure 24. A screenshot of an image of Sioux Falls, South Dakota, in the LandsatLook Viewer.

Landsat Global Archive Consolidation – A Million New Images

For decades, the international Landsat community has expanded and contracted – sometimes including nearly a dozen international ground stations, at other times just a few. At each of these stations resides a unique set of Landsat data, collected only at that location. In 2010, an effort began to bring a copy of these archives back to the USGS at EROS.

The first phase of the effort was to work with all of our international partners, both past and present, and convincing them to contribute their archives. At first, progress was slow but steady. Gradually, more and more stations began sending data to the Landsat project. Today, the Landsat project has 15 stations contributing data on a continual basis (fig. 25). Thanks to this remarkable cooperation, the Landsat archive accepted its one millionth scene into the archive in the fourth quarter FY 2012.

A key goal of the Landsat Global Archive Consolidation (LGAC) is to safeguard each image taken in the more than 40 years of the Landsat missions. In the general data stewardship of the Landsat archive, the Landsat project has been saving some of its oldest data (colloquially known as orphans, due to a lack of parent metadata). By saving these orphan datasets, it has expanded our knowledge of old data and file types. Somewhat surprisingly, the Landsat project is better positioned now to accept international multispectral scanner data from throughout the mission's history than ever before. For further information, contact Kristi Line, USGS EROS, kkline@usgs.gov.

Figure 25. As of September 2012, the graphic illustrates the location of the 15 stations contributing data on a continual basis to the Landsat Global Archive Consolidation project.

New Missions

The USGS and the EROS Center continually are seeking opportunities to collaborate in the development and operations of Earth observing remote sensing missions to satisfy the needs of the Nation's land imaging data requirements. The New Missions activities facilitate the communication and definition of USGS Land Remote Sensing (LRS) program requirements to the EROS Center. These activities are focused on developing partnerships to collect, archive, process, and distribute remotely sensed data in response to the evolving needs of scientific research, operational applications, decision makers, and educators. Towards these ends, teams are established to develop project plans, define and document requirements, perform systems engineering analysis, and implement technical solutions. Key accomplishments are given in the following sections.

Land Satellites Data System

The Land Satellites Data System (LSDS) is a unique global service provider that serves a continuous 40-year record of imagery covering the Earth's entire land surface to more than 30,000 users in more than 180 countries. Customers/users include Federal, State, and local tribal governments, academia, industry, international community, and the general public requiring land surface data for applications such as global change research, emergency response, agricultural, forestry, geology, and resource management.

Figure 26 illustrates the primary high-level LSDS functions, which include long term data acquisition planning, data capture including international cooperator ground stations, archive and processing of consistently calibrated imagery of the Earth's land surface, and ensuring access and availability to users world-wide for use in monitoring global change and applications in scientific studies.

LSDS fulfills DOI/USGS requirements under the Land Remote Sensing Policy Act of 1992 for the continuity of Landsat data and the Presidential Decision Directive-4 National Space Policy that provides the Secretary responsibility for managing U.S. space capabilities to observe natural and human-induced changes to the Earth's land and land cover.

The LSDS Information Technology Security team has been performing at a high level. All identified vulnerabilities were addressed at the end of FY 2012. During FY 2012, all current and legacy Plan of Action and Milestones were addressed and closed. The USGS established a contract to perform an independent audit of our controls. No new Plan of Action and Milestones were identified as a result of the independent audit. The Office of the Inspector General performed a compliance audit of the USGS where LSDS was selected for in-depth scrutiny. No issues were identified as a result of the audit.

LSDS completed and submitted all required Capital Planning and Investment Control management products including FY 2014 Budget Request, Exhibit 300, Operational Analysis, updated Risk Management Plan, and monthly Earned Value Management reports. The DOI notified LSDS of a pending investment compliance audit. LSDS provided required products and artifacts for DOI review. LSDS began operating with an Interim Decision Board during FY 2012. Development of an LSDS Governance Plan and LSDS Program Decision Board was initiated.

LSDS continued to implement and refine practices for cost estimating and budgeting in support of current and future mission planning and operations that achieve higher confidence levels. These include practices and identification of procedures to accomplish multi-year and lifecycle planning and management across the projects within LSDS. LSDS implemented changes requiring the Technical Support Services Contractor to complete integrated monthly status reporting across LSDS projects including detailed performance reporting against the planned baseline.

LSDS implemented common risk management practices across operations and development projects. Risks were identified and managed across all projects including identification of estimated monetary value and associated liens against contingency reserve. USGS acquired a commercial risk management tool to support tracking risks, issues, and opportunities. The new tool will be implemented in FY 2013. LSDS is also currently in the process of defining common change control processes to be implemented in FY 2013.

LSDS is classified as a major investment by DOI and Office of Management and Budget. Office of Management and Budget requires that major investments be managed by program managers certified at the senior-level Federal Acquisition Certification – Program/Project Management. Dave Hair and Steve Labahn obtained senior-level certification from the DOI and Federal Acquisition Institute during FY 2012.

Planned FY 2013-2014 accomplishments are to continue operations (steady state) of Landsats 5 and 7 to capture, archive, process and distribute data to users; implement the LSDS Program Decision Board; complete Landsat Data Continuity Mission development/modernization/enhancement activities for the February 2013 scheduled launch; continue final testing and integration of the ground systems, launch rehearsals, and simulations of operations from the verification of data reception to the delivery of products; and initiate steady state phase for Landsat 8, which becomes operational 90 days after launch (May 2013). For further information, contact David Hair, USGS EROS, hair@usgs.gov.

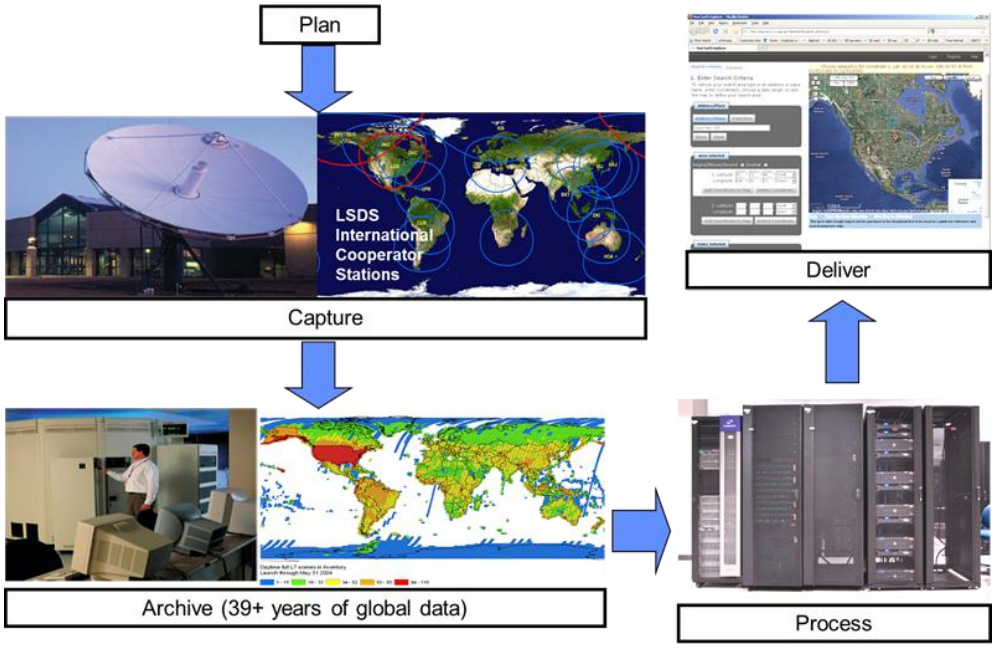


Figure 26. This is an illustration of the primary high-level Land Satellites Data System functions, which include planning, capturing, archiving, processing, and delivery.

International Cooperator Network: Preparing for Launch

The Landsat International Cooperator (IC) network is vigorously preparing for the February 2013 launch of the next Landsat mission – the Landsat Data Continuity Mission (LDCM) or Landsat 8. Figure 27 depicts the potential LDCM international ground stations, which have shown interest in participating in the LDCM/Landsat 8 mission as an IC.

The Landsat IC network has been enhanced over the years to provide not only basic data downlink services, but it also provides numerous key strategic and tactical USGS benefits, including:

- local and regional expertise to the global Landsat community,
- historical and ongoing global data collection as well as backup capabilities,
- vital International Charter and other Emergency Response support,
- critical spacecraft anomaly investigation and recovery operations, and
- an expansion of available scientific and technical resources/capabilities.

On September 24-28, 2012, the ICs participated in the Landsat Technical Working Group (LTWG#21) meeting held in Sioux Falls, South Dakota. Participants from 19 countries, including members of the USGS and NASA Landsat and LDCM Projects, represented 29 United States and international ground stations and discussed a wide range of technical topics. A photograph of the participants of the LTWG#21 is shown in figure 28. Special guest, Dr. Frank Kelly, USGS EROS Center Director and Space

Policy Advisor, welcomed the attendees, provided an overview of the EROS Center over the last 40 years and shared the Center's course for the next 40 years.

The USGS presented material on the LSDS and related future plans. Landsat Project presentations included the latest Landsat 5 and Landsat 7 mission statuses, multispectral scanner processing capability development progress, the LGAC initiative, Landsat mission planning, Landsat product evolution, operational data validation and exchange (DV&E) status, calibration/validation, and LandsatLook. NASA, USGS, and LDCM observatory contractor presentations included project and ground system status including plans and timelines for LDCM ground system processing software availability, the LDCM ground system-to-IC interface testing, DV&E, and ground station certification.

The USGS also prepared in-depth LDCM ground system technical presentations including follow-up question and answer splinter sessions for its IC attendees. The technical sessions covered LDCM ground system content such as requirements, interfaces, design, implementation, and current testing results and performance, which will prepare them for the February 2013 launch of LDCM/Landsat 8. Each IC also briefed the group on the status of their stations including LDCM ground system readiness, future satellite missions, and current status of their LGAC activities. A listing of the countries and organizations represented by the IC and United States attendees is provided in table 1. For further information, contact Steve Labahn, USGS EROS, labahn@usgs.gov.

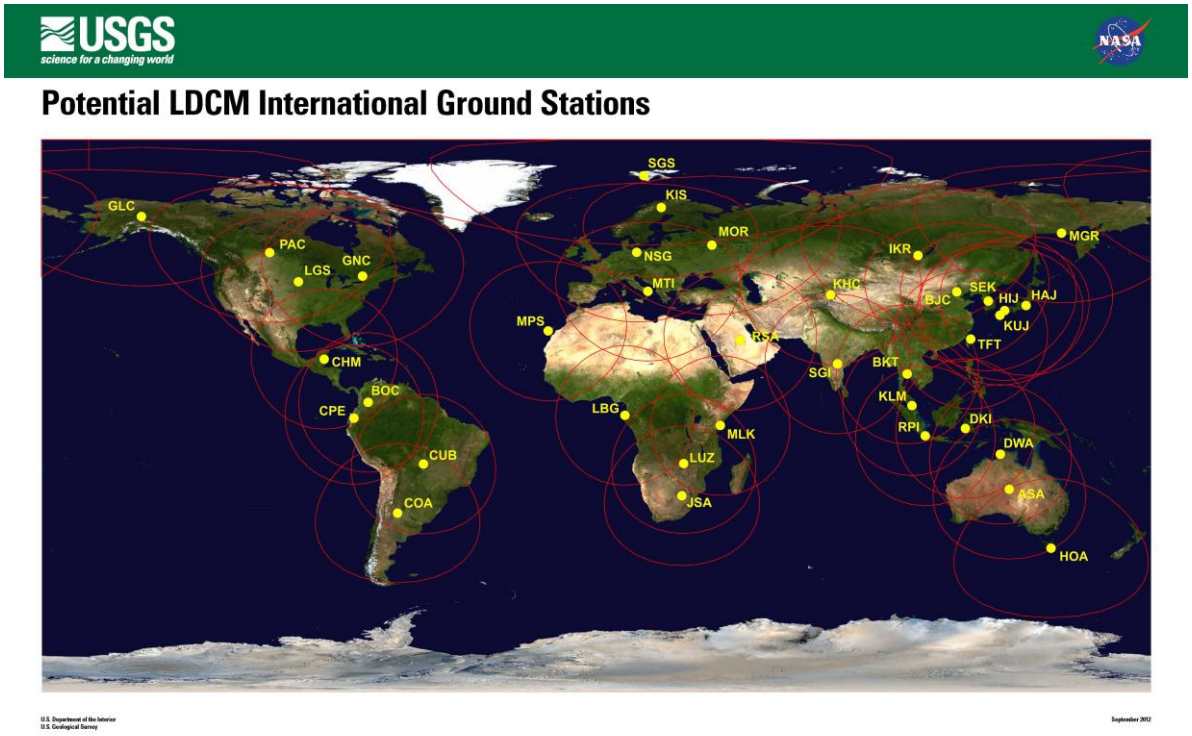


Figure 27. Potential Landsat Data Continuity Mission international ground stations.

Figure 28. Participants in 21st Landsat Technical Working Group meeting held in Sioux Falls, South Dakota, on September 24-28, 2012.

Table 1. Countries and organizations represented at the 21st Landsat Technical Working Group meeting.

Country	Organization
Australia	GA-NEO
Brazil	INPE
Canada	CCRS, MDA
China	
Colombia	IGAC
Europe	ESA
France	Zodiac Data Systems
Gabon	AGEOS
Germany	DLR
Indonesia	LAPAN
Japan	AIST, TSIC
Mexico	INEGI
Norway	KSAT
South Africa	SANSA, PinkMatter, Forest Sense
Taiwan	CSRSR-NCU
Thailand	GISTDA, Precise Steel
United Kingdom	Logica UK
Zambia	NRSC
United States	USGS, NASA, Aerospace, ASRC, Ball Aerospace & Technologies Corp, AVG-Avtec, ERT, Information Dynamics, Orbital Sciences Corporation, RT Logic, SeaSpace, SGT, Virtuoso

USGS – NASA Landsat Science Highlighted in Special Issue of Remote Sensing of Environment

The USGS has funded the Landsat Science Team to provide technical advice on new sensor, ground systems and product development, advocate the scientific and societal benefit of Landsat data to the Nation, and to conduct advanced research and applications of current and historical Landsat data for monitoring the state and condition of the Earth's terrestrial environment.

The Landsat Science Team is co-chaired by the USGS and NASA, which highlights the longstanding agency partnership responsible for the successful development and operation of the Landsat satellite missions. The awards for the next 5-year term for the Landsat Science Team have recently been completed.

The Department of the Interior revolutionized the types of research and applications that could be achieved when it changed the Landsat data policy in 2008 to provide free and open access to the archive. Innovations in science data processing complemented by decreasing costs in computing resources were also enablers.

A special issue of Remote Sensing of Environment was published with articles that highlight some of the more recent accomplishments in science research and applications resulting from the open data policy. The issue is available online at http://www.sciencedirect.com/science/journal/00344257/122. The next two paragraphs synopsize the topics covered in the articles of the special issue.

The provision of open access to the longest record of satellite observations of the Earth's land surface has enabled scientists and resource managers to address research questions that were not previously possible. Near-real time monitoring of forest resources, evapotranspiration and water resources, land cover change and land use dynamics, and studying the patterns of forest fragmentation are but a few examples. The United Nations Food and Agricultural Organization successfully completed their 2010 Forest Resource Assessment, which would not have been possible without free and open access to the Landsat archive.

Federal agencies, academic researchers, and international programs benefit directly from cost savings associated with data purchases, and commercial firms have been able to expand the types of value-added services that can be provided. The number of users and the breadth of applications continue to grow, and the derivation of geophysical and biophysical parameters from Landsat data are leading to increased spatial resolution at which process models can be prescribed and executed.

The Landsat data user community is extremely large and diverse and includes the Department of the Interior, Department of Agriculture, Department of Defense, Western States Water Association, United Nations programs, international agencies participating in the Committee on Earth Observation Satellites, and every nation that has an operational land cover mapping program.

The USGS EROS Center, located in Sioux Falls, South Dakota, provides scientific analyses based on remote sensing and geospatial data and operates the Landsat missions. For further information, contact John Dwyer, USGS EROS, dwyer@usgs.gov.

Landsat Data Continuity Mission's Development Progress

The Landsat Data Continuity Mission continues the legacy of the Landsat series of satellites. The LDCM project completed several significant development milestones during FY 2012.

The Ground Network Element completed a redesign and implementation of the Data Collection and Routing Subsystem in the fall of 2012 with a delivery planned for November 2012. The three ground stations at Sioux Falls, South Dakota; Fairbanks, Alaska; and Svalbard, Norway; (fig. 29) completed their final development milestones and are participating in end-to-end ground system testing, as well as proficiency testing with the Mission Operations Center (MOC) to prepare the station operators for normal operations.

The Data Processing and Archive System (DPAS) provides science data ingest, storage, archive, image processing, and distribution capabilities for LDCM. The DPAS completed two significant deliveries in FY 2012. The first demonstrated the DPAS's full performance capabilities to ingest, archive, process, and distribute LDCM Level 1 data products (fig. 30). The second verified all of the capabilities to interface with the LDCM International Cooperator ground stations, as well as other system enhancements to improve the usability and performance of the DPAS. The DPAS has completed the development of all capabilities needed prior to the launch of LDCM and is currently working on enhancements to the systems until data is received from the observatory on orbit.

The MOC provides the hardware, software, and personnel (including the Flight Operations Team (FOT)) to provide command and control of the LDCM observatory (fig. 31). The MOC has integrated the final pre-launch versions of the Mission Operations Element and the Collection Activity Planning Element (CAPE). The CAPE implements the Long-Term Acquisition Plan-8, which continues the Landsat image collection scheme. The CAPE completed its launch-ready release and integrated it into the MOC, verifying the CAPE's ability to schedule all image collections for LDCM. The FOT is fully staffed to support LDCM operations and has been performing extensive testing of the ground system and the spacecraft (via simulators). The FOT received spacecraft training in the spring and summer of 2012 from the spacecraft vendor.

The Ground System Systems Engineering and Integration and Test team completed a number of ground system functional and interface testing to verify ground system requirements, including:

- Network Connectivity Test – Gilmore verified the interface between the MOC and the Gilmore Creek ground station in Fairbanks, Alaska
- Ground Readiness Test (GRT) 6 – capstone test to verify the nominal operations capability of the ground system
- GRT 5a – verified the connectivity of the backup MOC with the ground stations
- GRT 4b – verified the ability of the DPAS to generate Level 1 data products
- GRT 4c – verified the performance requirements of the DPAS
- GRT 4d – verified the capability of the ground system to interface with the ICs, as well as verify remaining ground system requirements
- Algorithm Verification Test – verified the LDCM science data processing algorithms of the DPAS and Calibration/Validation Toolkit
- Mission Readiness Tests – several mission level tests of the MOC with the actual LDCM spacecraft to verify the spacecraft and ground system work as a complete system
- Mission Operations Simulations – numerous mission level tests in the MOC with the Spacecraft/Observatory Simulator – simulations for FOT training as well as tests that can't be performed with the flight hardware

The joint NASA/USGS Calibration and Validation Team continued its characterization and assessment of the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) instruments on board the LDCM spacecraft. The Calibration and Validation Team played a significant role in the assessment of instrument performance during observatory environmental testing.

The LDCM observatory made significant progress in FY 2012. The OLI instrument was shipped and integrated to the spacecraft in October 2011. The TIRS instrument was shipped and installed in February 2012. The TIRS instrument suffered a helium leak in the cryocooler during initial testing, but leak was able to be repaired by May and re-integrated to the observatory in July 2012. Both instruments have been performing extremely well throughout instrument and observatory testing. The LDCM spacecraft suffered a power short anomaly in April 2012, which damaged three spacecraft boxes. The boxes were repaired and reinstalled in July 2012. The LDCM observatory is now fully integrated and is undergoing environmental testing, scheduled to complete in November 2012 (fig. 32). The observatory is on track for a December delivery to the launch site at Vandenberg Air Force Base in California. The LDCM launch vehicle, an Atlas V, was delivered to the launch site in September 2012 and stacked on the launch pad in October.

The LDCM project has also been working collaboratively with NASA on the transition of the mission from NASA to the USGS following successful on-orbit checkout of the observatory, nominally 90 days after launch. The team has developed an interagency transition plan and met with the eventual USGS operations vendors throughout the fall of 2012. The LDCM team is preparing for the Operations Readiness Review in January of 2013, in which the project will be assessed for its readiness to proceed into normal operations.

Overall, the LDCM project is making excellent progress towards the February 2013 launch date of the LDCM observatory. For further information, contact Jim Nelson, USGS EROS, jnelson@usgs.gov.

Figure 29. Landsat Data Continuity Mission ground station coverage.

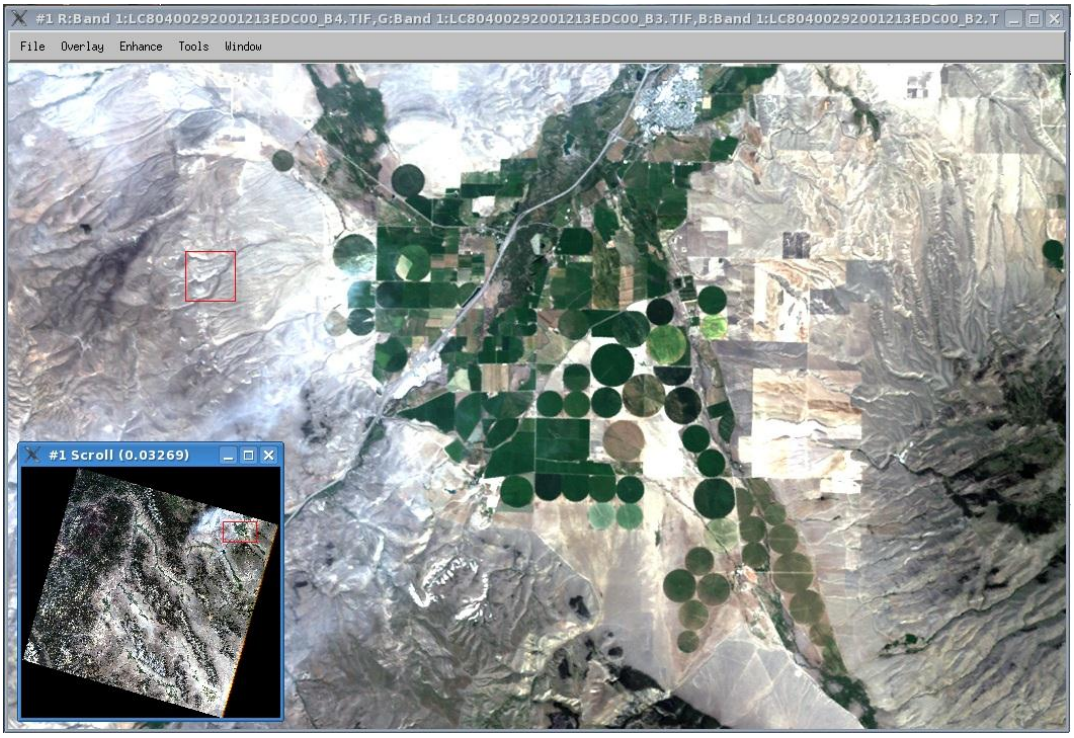


Figure 30. Simulated Landsat Data Continuity Mission Level 1T data product.

Figure 31. Landsat Data Continuity Mission's Mission Operations Center.

Figure 32. Fully integrated Landsat Data Continuity Mission observatory.

Characterizing Sensors to the "Gold Standard" of Landsat

One of the activities performed by the Remote Sensing Technologies (RST) Project at EROS is the assessment of the quality and utility of data gathered from satellites and platforms monitoring the Earth. Each year more and more satellites join the Landsat series in monitoring the Earth, but before these data can be used and compared to other data their accuracy and usability must be known.

The RST project works with satellite and sensor operators from across the nation and around the world, both Government and private, to gather data from new systems, arrange targeting of imagery over test sites, and develop accepted methods of comparison. The imagery from these systems is assessed for their geometric and radiometric accuracy against known references or "ground truth." The Landsat record, with its well-known quality and reliability, is the most commonly used reference.

During FY 2012, the RST Project worked to characterize satellite data from satellites such as UK-DMC-2, RapidEye, SPOT-5, ResourceSat-2, DEIMOS, and Pleiades-1a (fig. 33). Once their accuracy and stability have been verified these satellites may offer complementary benefits to users of Landsat 7 data in temporal coverage, spatial resolution, or geographic coverage.

An additional characterization provided this year by the RST staff, working closely with Landsat staff, was of the geometric accuracy (fig. 34) of the several Global Land Surveys (GLS). These GLS layers, from 1975, 1990, 2000, and now 2010, offer seamless cloud-free Landsat coverage of the global land mass. These EROS-produced GLS layers now provide an extremely important source of reference or control data to the production of imagery from other satellites around the world. Thus, understanding the accuracy of the GLS helps to ensure consistent accuracy and greater interoperability for users of satellite data.

While using the well-known stability and accuracy of Landsat to assess other satellite imagery and systems, the RST Project works to promote and publicize USGS data comparison methods and results through two major venues. The annual Joint Agency Commercial/Civil Imagery Evaluation Workshop is a partnership between NASA, the National Geospatial-Intelligence Agency, the U.S. Department of Agriculture, and the USGS. Annual workshops are sponsored as an independent way for Government and industry to shared sensor calibration and data quality information and present on-going characterization and application efforts. These workshops also allow the Government to learn about new systems and processes and create trust within the industry. The other major venue that the RST Project uses to share these results and promote methods of analysis and interoperability is the multi-national Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation, a cooperative gathering of experts from spacefaring nations around the world. This sharing of information and cooperation through both of these venues has shown to improve data quality worldwide and is helping to supply more useful and accurate data from all satellites and sensors for worldwide science.

The importance of sensor and data characterization and understanding is greater than it has ever been in the past. As technologies continue to advance and new systems become more prolific and exceptional amounts of data and information become available, the need for understanding the data to create and validate integrated science products will be critical in addressing societal benefit questions. For further information, contact Gregory Stensaas, USGS EROS, stensaas@usgs.gov.

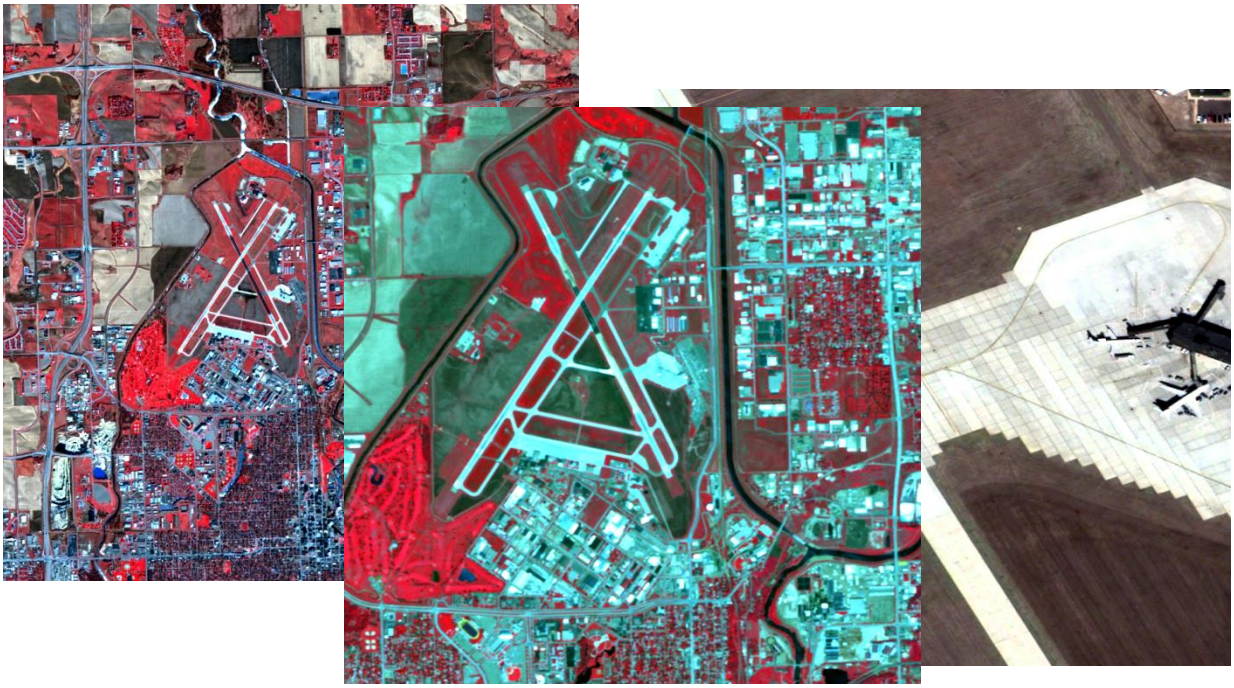


Figure 33. Examples of recent satellite imagery over Sioux Falls, South Dakota, from the UK-DMC2 22-m (upper left), RapidEye 5-m (center), and Pleaides-1a 0.5-m satellites (lower right).

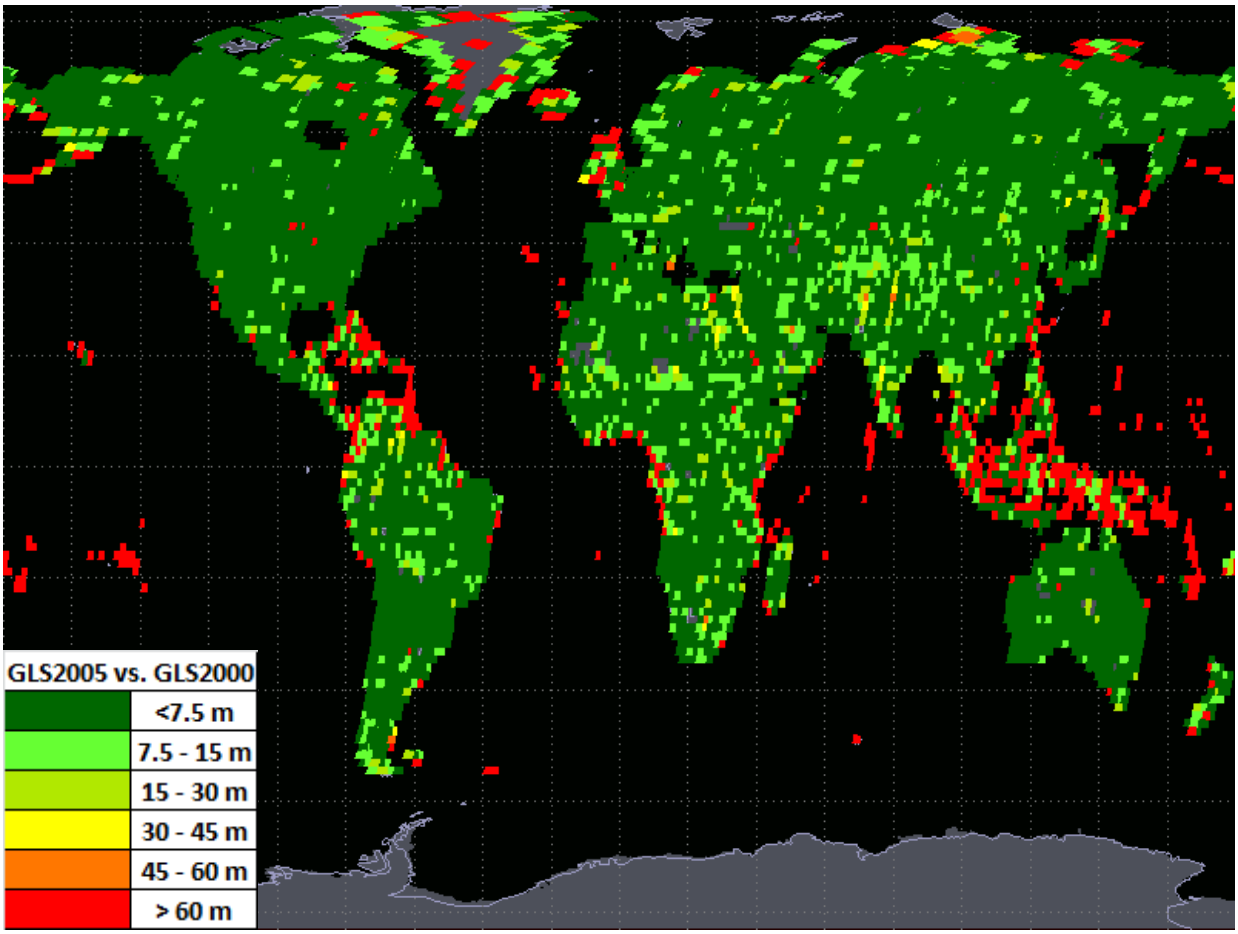


Figure 34. Illustration showing the results of geometric accuracy comparison between the Global Land Survey 2000 and Global Land Survey 2005 layers worldwide.

Landsat 9 – Assessment of Alternatives

The USGS compiled and assessed technical and programmatic options for obtaining land remote sensing data from space beyond the Landsat Data Continuity Mission (LDCM or Landsat 8), taking into account cost, schedule, relative national priorities for Earth observation, and the risk of potential Landsat data gaps. The assessment was initiated per an Office of Management and Budget directive to the USGS in 2013 budget Passback language to "…take a strategic pause to evaluate the technical and programmatic options for obtaining land remote sensing data from space following Landsat 8…" Key to this assessment was to produce, distribute, and assess the results of a Landsat Data Continuity Concepts Request for Information (RFI).

EROS worked with USGS headquarters to initiate the RFI task by assembling a multi-agency team of scientists and engineers for a two-day workshop on January 31 - February 1, 2012, to discuss, debate, and define the required set of Landsat data

parameters for a Landsat 9 mission. These parameters made up the core of the Landsat Data Continuity Concepts RFI, released on March 8, 2012.

The USGS requested information on approaches to providing a dependable, long-term source for Landsat-like data following Landsat 8. Respondents were encouraged to offer concepts for augmenting current Landsat missions and providing mitigation against a Landsat data gap occurring before the end of Landsat 8's design life in 2018. The request allowed for revolutionary "clean slate" technical approaches, as well as evolutionary "upgrade" approaches. Concepts could involve single- or multiple-satellite acquisitions, commercial data buy arrangements, hosted payloads, public/private partnerships, international collaboration, small satellites, and architectures utilizing combinations of space-based sensors. Also, concepts describing partial solutions to the full set of Landsat data parameters, as defined in the RFI, were invited.

In April 2012, the Landsat Data Continuity Concepts RFI Review Team met in Reston, Virginia, to review the RFI responses, which came from a variety of industry and Federal government sources. An assessment was done to compare the expected performance of alternatives against the RFI's set of baseline Landsat data parameters, and results were recorded in detailed worksheets. In addition to the technical evaluation, both the risk level (technical, schedule, and programmatic) and cost realism of each response were considered. The USGS and NASA will continue to assess options in 2013. For further information, contact Frank Kelly, USGS EROS, fkelly@usgs.gov.

Data Management and Distribution

The USGS EROS Center manages a variety of data collections acquired from a wide array of current and historical sources, and distributes them to a broad range of global and niche user communities in science, applications, and operations. Data sources range from active satellite missions that are operated by EROS and others, historical aerial and satellite sources, as well as information about elevation, land cover, and other aspects of the Earth's land surfaces and data that are maintained in the EROS archives. The archives include film and digital systems developed commercially, in-house, and by and with other collaborators such as NASA. Access to the data is via a number of web-enabled user interfaces tailored to the collaborators' and users' needs, from simple websites to fully featured data discovery tools. In addition to managing the data as bits, EROS maintains the data via a data calibration and validation function, as well as science-based collection appraisals, and working with NASA and academia to ensure the integrity and value of the data. EROS uses this broad range of capabilities in collaboration with a number of partners to more effectively meet USGS strategic objectives. Key accomplishments are given in the following sections.

The DOI Data Access Workshop – Removing the Barriers Between Earth Scientists and their Data Systems

The USGS EROS Center houses one the largest collections of civilian satellite-based Earth science satellite imagery products on Earth. These products can be discovered, browsed, and retrieved through a range of access channels, creating both flexibility and confusion for users. The Land Processes Distributed Active Archive Center (LP DAAC) organized a workshop to help DOI application users understand and use these access channels. The data access workshop, held at the Denver Federal Center on March 13-14, 2012, was coordinated with the Landsat and Long-Term Archive projects, and the DOI Remote Sensing Working Group. The workshop was designed to inform users of the range of products available from USGS and NASA archives housed at EROS, provide hands-on training with several access clients, and evaluate the usability of these clients.

The first day of the workshop focused on data products, including those from Landsat, MODIS, and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), and was broadcast via a webex communication. The second day included hands-on training for access clients, including Earth Explorer, GloVIS, NASA/Reverb and others. Each client's usability was evaluated using the System Usability Scale (SUS).

The workshop had six primary learning objectives. By the end of the workshop, the goal was to have attendees understand:

1. the characteristics of important NASA and USGS land remote sensing data products;
2. the policies affecting access to these products;
3. how the products are being used across multiple application areas;
4. what new products are being planned for the future;
5. which data access clients are available for getting products; and
6. how to use each client to get data.

Hands-on training modules were developed for several clients, with each module consisting of an introduction to the client, an exercise based on a use-case scenario, and SUS-based usability evaluation questions. Based on requests from the attendees, the module for a MODIS subsetting/mosaicking client was replaced by a live demonstration of the Commercial Remote Sensing Space Policy (CRSSP) Imagery-Dervied Requirements (CIDR) Tool.

The final evaluations indicated the workshop succeeded in most of its goals, with suggestions to help users better understand how the data products are being used across multiple applications. Other suggestions included hands-on access to remote users, a third day to focus on applications, and follow-on webinars to address group-derived questions. Summary discussion at the end of the workshop addressed access services to permit archive access directly from within applications such as ArcGIS.

The SUS feedback (fig. 35) helped address design issues with several of the clients. These results should not be used comparatively between clients; however, as the exercises were designed, they focused on the capabilities of each client and thus not "normalized" across clients.

User feedback suggests the workshop should evolve into a remotely accessible set of tutorials for widest possible impact. Several other DOI groups are engaged in similar efforts, so this should be coordinated through the DOI Remote Sensing Working Group into a coherent training resources for application-level users. Additionally, these efforts should be coordinated with similar NASA efforts.

The workshop gave USGS data providers useful insights into the needs of their DOI constituents, which is also of interest to NASA's data providers and Applied Science Program. Workshop materials can be found at https://lpdaac.usgs.gov/user_community/land_remote_sensing_data_access_workshop. For more information, contact David Meyer, USGS EROS, dmeyer@usgs.gov

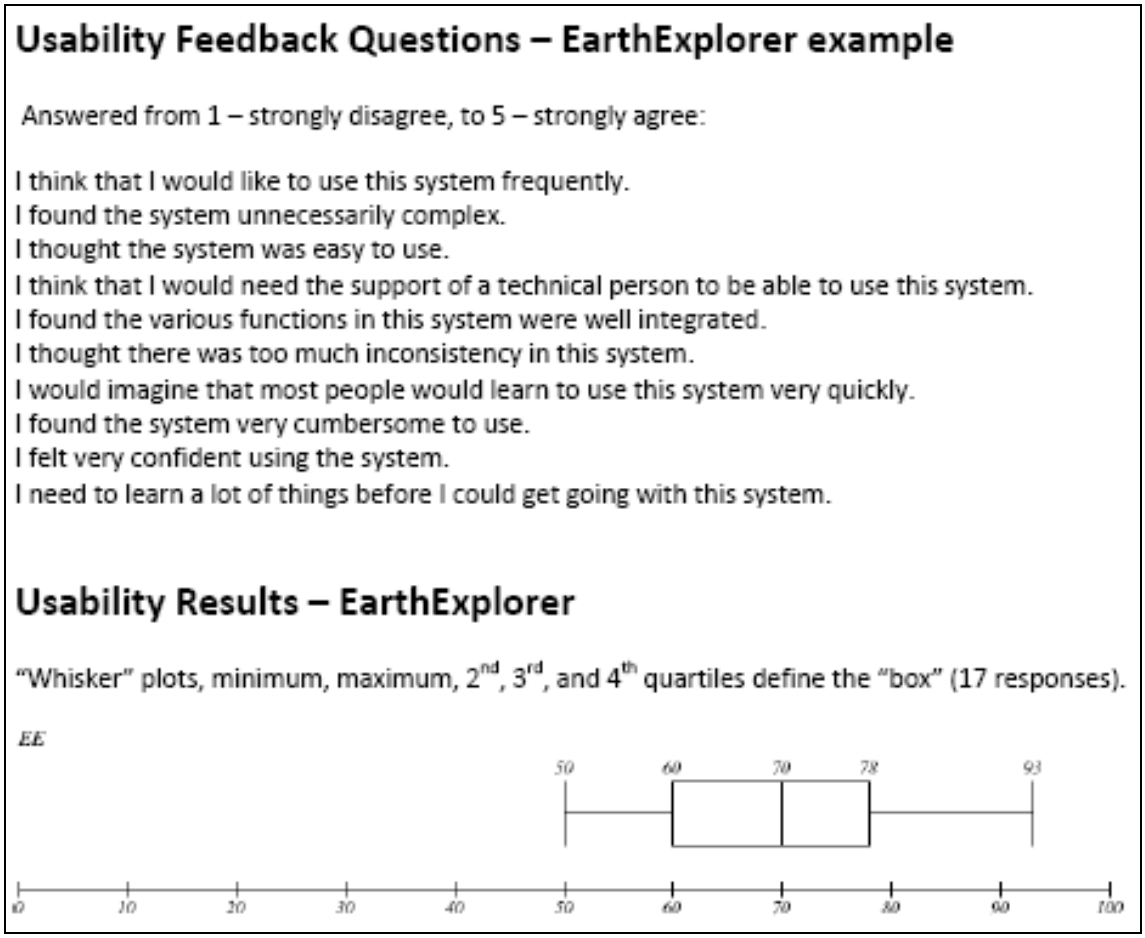


Figure 35. System usability scale questions and results for Earth Explorer. Results were also compiled for GloVIS, Global Data Explorer, the Web-Enabled Landsat Data client, and NASA's Reverb client.

ASTER Global DEM Version 2 Validated and Released by the LP DAAC

On June 29, 2009, NASA and the Ministry of Economy, Trade, and Industry (METI) of Japan released a Global Digital Elevation Model (GDEM) to users worldwide at no charge as a contribution to the Global Earth Observing System of Systems (GEOSS). This "version 1" ASTER GDEM (GDEM1) was compiled from over 1.2 million scene-based DEMs covering land surfaces between 83 degrees N and 83 degrees S.

A second version (GDEM2) was released by NASA and METI on October 17, 2011. Improvements in the GDEM2 result from acquiring 260,000 additional scenes to improve coverage, a smaller correlation kernel to yield higher spatial resolution, and improved water masking.

Vertical accuracy was measured using absolute geodetic references over the continental United States (fig. 36), against national elevation grids in the United States and Japan, using Shuttle Radar Topography Mission (SRTM) elevation globally, and using space borne laser altimeter data globally. United States and Japanese teams estimated horizontal accuracy and resolution.

The absolute vertical accuracy study found the GDEM2 to be within -0.20 m on average when compared against 18,000 geodetic control points over the continental United States, with an accuracy of 17 m at the 95 percent confidence level. The Japan study noted the GDEM2 differed from the 10-m national elevation grid by -0.7 m over bare areas, and by 7.4 m over forested areas. Similarly, the continental United States study noted the GDEM2 to be about 8 m above the 1 arc-second National Elevation Dataset (NED) over most forested areas, and more than a meter below NED over bare areas.

The global altimeter study, based on data from NASA's ICESat Geoscience Laser Altimeter System, found the GDEM2 to be on average within 3 m of altimeter-derived control, and also documented sensitivity to tree canopy height. The Japan study noted that the horizontal displacement in GDEM1 of 0.95 pixels was reduced to 0.23 pixels in GDEM2. Both teams noted improvements in horizontal resolution, between 71 and 82 m, comparable to the SRTM 1 arc-second elevation model, but at the cost of some increased noise. The number of voids and artifacts noted in GDEM1 were substantially reduced in GDEM2, and in some areas virtually eliminated.

The validation team included contributions from the Japan Space Systems (formerly the Earth Remote Sensing Data Analysis Center), the University of Tokyo, USGS EROS, California Institute of Technology's Jet Propulsion Laboratory, NASA Goddard Space Flight Center, and the National Geospatial Intelligence Agency.

The ASTER GDEM version 2 can be found both at the LP DAAC and the Japan Space Systems web sites (https://lpdaac.usgs.gov/products/aster_products_table/astgtm; http://www.jspacesystems.or.jp/ersdac/GDEM/E/index.html).

Based on these results, the joint United States and Japan ASTER validation team recommended the release of the GDEM version 2 to the public, noting substantial improvements in the quality of this product over the original GDEM. In many aspects (horizontal resolution, vertical accuracy) the GDEM2 is comparable to the SRTM Digital Terrain Elevation Data version 2, while extending to higher latitudes (83 degrees versus 60 degrees).

The validation report is found at: https://lpdaac.usgs.gov/products/aster_products_table/aster_gdem_version_2_validation. For further information, contact David Meyer, USGS EROS, dmeyer@usgs.gov.

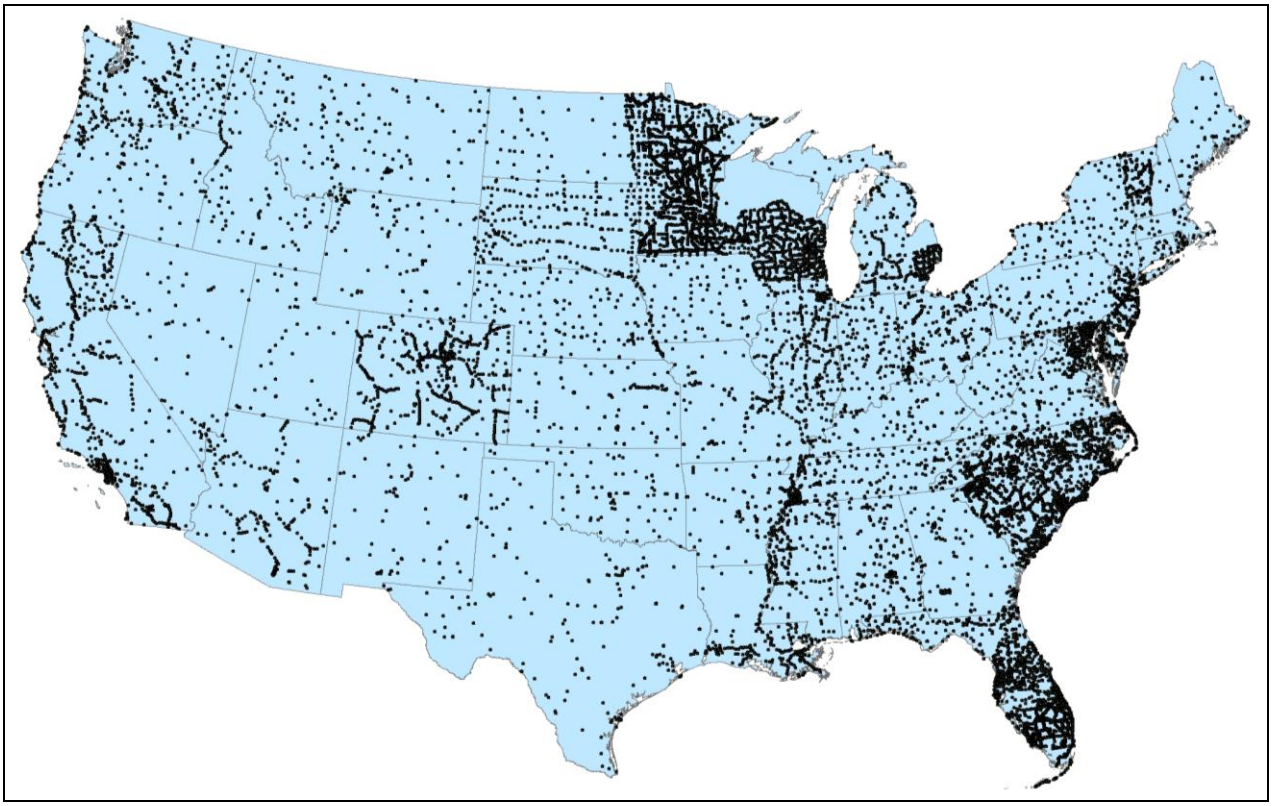


Figure 36. The map shows the 18,207 global positioning system benchmarks used for absolute accuracy determination over the continental United States.

Lidar Data Joins the Club – Now Through Earth Explorer

The USGS EROS Center provides access and distribution to over 200 datasets through the Earth Explorer user interface, which now also includes lidar point cloud data.

Lidar is a relatively new remote sensing technology that collects 3-dimensional points of the Earth's surface. This technology is being used for a wide range of applications including high-resolution topographic mapping and 3-dimensional surface modeling as well as infrastructure and biomass studies. Point cloud data represent the elevation of

landscape features including crops, forests, roads, railways, airports, bare earth, mountains, valleys, lakes, rivers, glaciers, buildings, and other urban development.

EarthExplorer (fig. 37) can be used to search, preview, and download individual lidar files. The collection is located under the lidar category within the datasets tab. Browse images are used for verifying area of interest and viewing available coverage. More information can be found at http://earthexplorer.usgs.gov or by contacting Wayne Miller, USGS EROS, wamiller@usgs.gov.

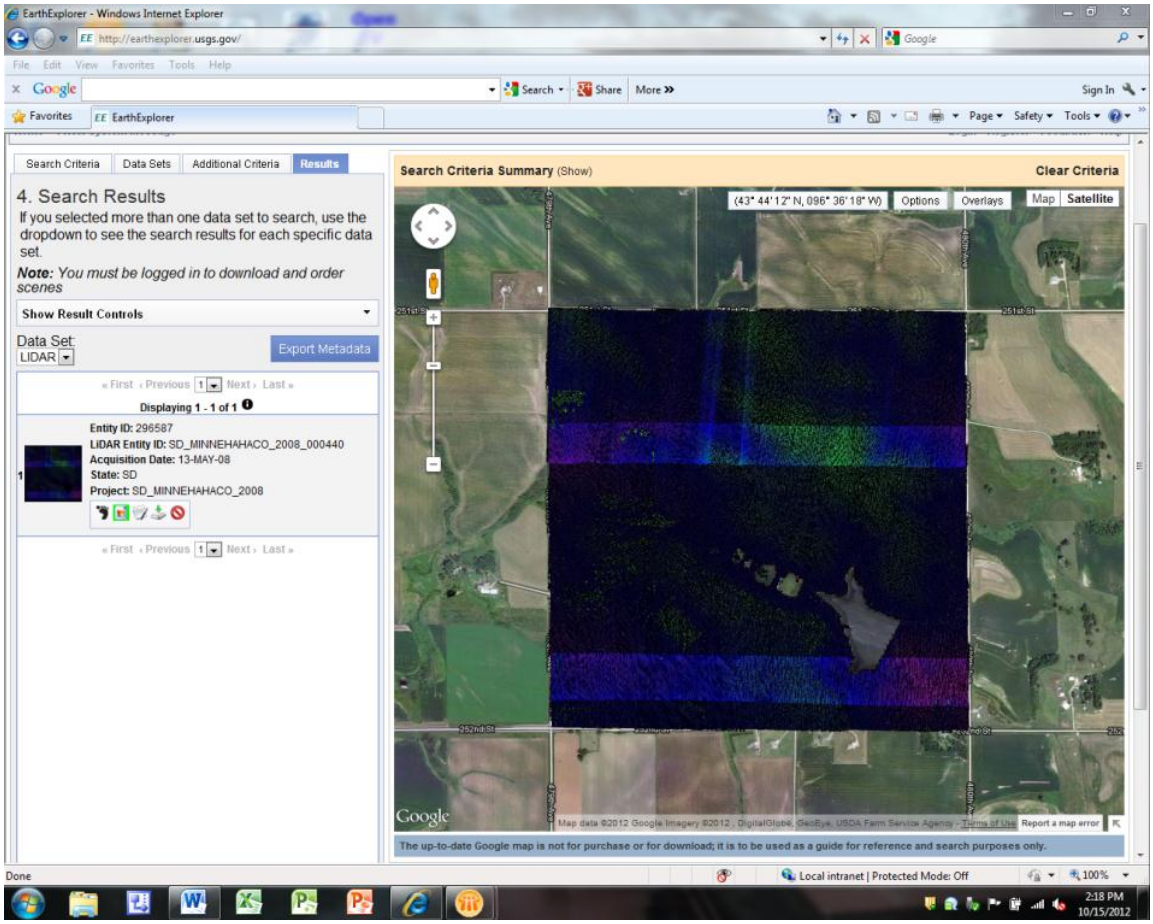


Figure 37. Light detection and ranging data in Earth Explorer.

New High-Resolution Science Dataset – OrbView-3

GeoEye's OrbView-3 satellite was among the world's first commercial satellites to provide high-resolution imagery from space. The 1-m imagery enables more accurate viewing and mapping of houses, automobiles and aircraft, and makes it possible to create precise digital products. The 4-m multispectral imagery provides color and near infrared information to further characterize cities, rural areas, and undeveloped land from space. OrbView-3 orbits 470 km above the Earth in a sun-synchronous polar orbit while collecting imagery of the Earth's surface at 1-m resolution in the panchromatic

(black and white) mode, or at 4-m resolution in the multispectral (color) mode with a 3-day repeat cycle.

The USGS EROS Center received 179,981 OrbView-3 image “segments” from GeoEye with no restrictions. The data were delivered in Basic Enhanced (Level 1B) radiometrically corrected format. The product files include satellite telemetry data, rational functions, post-processed ground sample distance at nadir data, and sufficient metadata for rigorous triangulation. The data in this collection were acquired between September 2003 and March 2007, both multispectral and panchromatic.

EarthExplorer is a web-based client tool that provides online search, browse display, data download, and exports of metadata to support scientists and users with access to Earth science data from the archives of the USGS. It can be used to search, preview, and download OrbView-3 scenes at no cost. The collection is located under the OrbView-3 data set. The data have been processed to different levels; Basic Enhanced (Level 1B), Systematic Terrain Correction (Level 1Gst), and Orthorectified (Level 1T). Figure 38 is an example of an Orthorectified image over central New York City. Full-Resolution JPGs and Geographic Information System (GIS)-Ready Bundles are also download options.

This collection provides customers with yet one more high-resolution dataset at no cost from the USGS EROS Center. The collection is a world-wide collection; however, not all areas of the Earth are covered as shown in figure 39. For further information, contact Wayne Miller, USGS EROS, wamiller@usgs.gov.

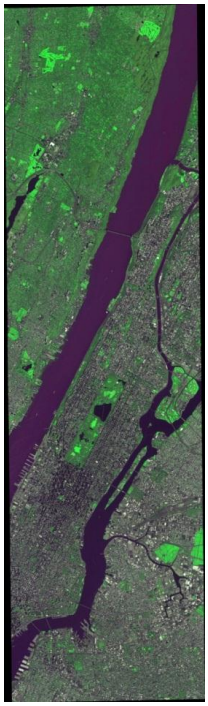


Figure 38. An OrbView-3 color scene depicting a portion of New York City with Central Park being near the center.

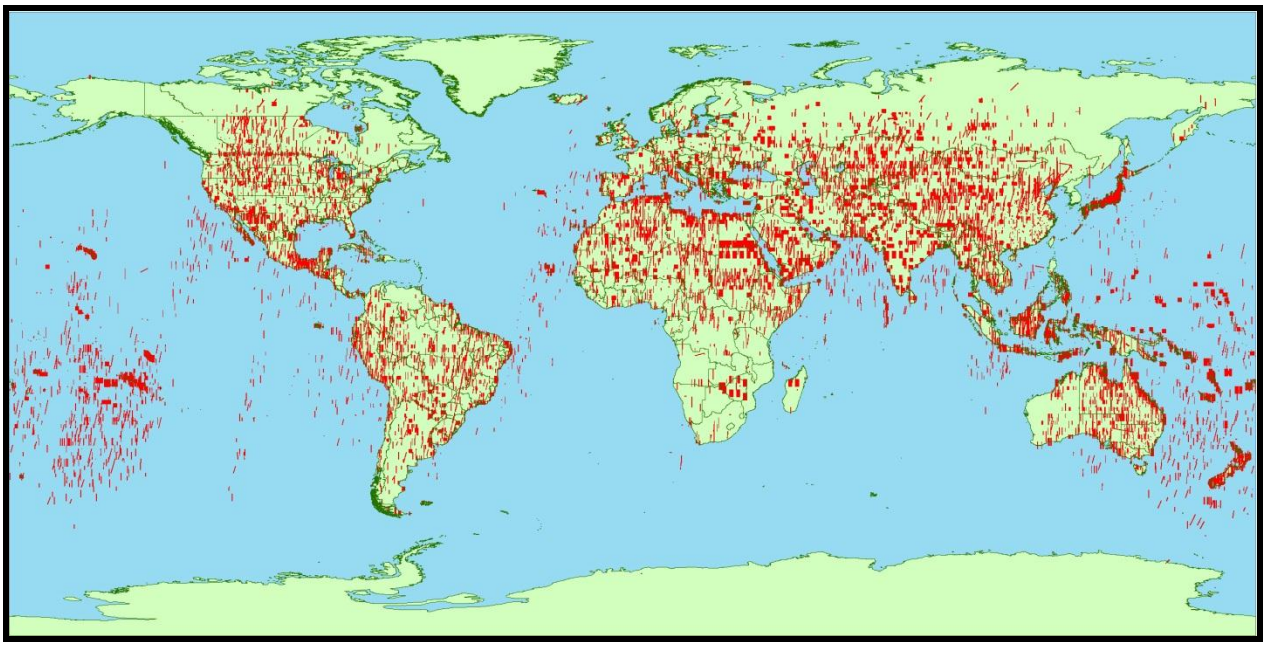


Figure 39. Coverage areas in the OrbView-3 collection are indicated in red on the map.

Making Data More Accessible – Bulk Download Online

Over the last two years, the projects at the USGS EROS Center have been directed to make more of its data holdings available to the public at no charge. Following this direction, projects began to "web-enable" data via the Earth Explorer (EE), Hazards Data Distribution Systems (HDDS), and GloVis access and distribution web portals. With the goal for making data more available, users are demanding easier ways to get access to the data. Users have requested bulk download of data to support their requirements for access to larger amounts of data. To support these requirements, the Bulk Download Application has been developed and integrated with the EE and HDDS systems to provide users with this capability.

The overall goal of the Bulk Download Application is to streamline and enhance the capability for delivering bulk data to customers, while also managing the resources that store the data. The EROS Bulk Download service requires the user to use either EE or HDDS as the front-end systems for access to the query systems for the desired data as shown in figure 40. The Bulk Download Application interfaces with the EROS Mass Storage System and other storage systems to facilitate download of data through a simple Java applet.

As a result of the Bulk Download Application, more data is being distributed to customers, downloading one scene at a time is no longer necessary, downloading is much faster since it is automated, and still no inordinate burden has been placed on the storage servers. Due to these access improvements, EROS is better able to meet the

demands of customers who require high volumes of data. For further information, contact Wayne Miller, USGS EROS, wamiller@usgs.gov.

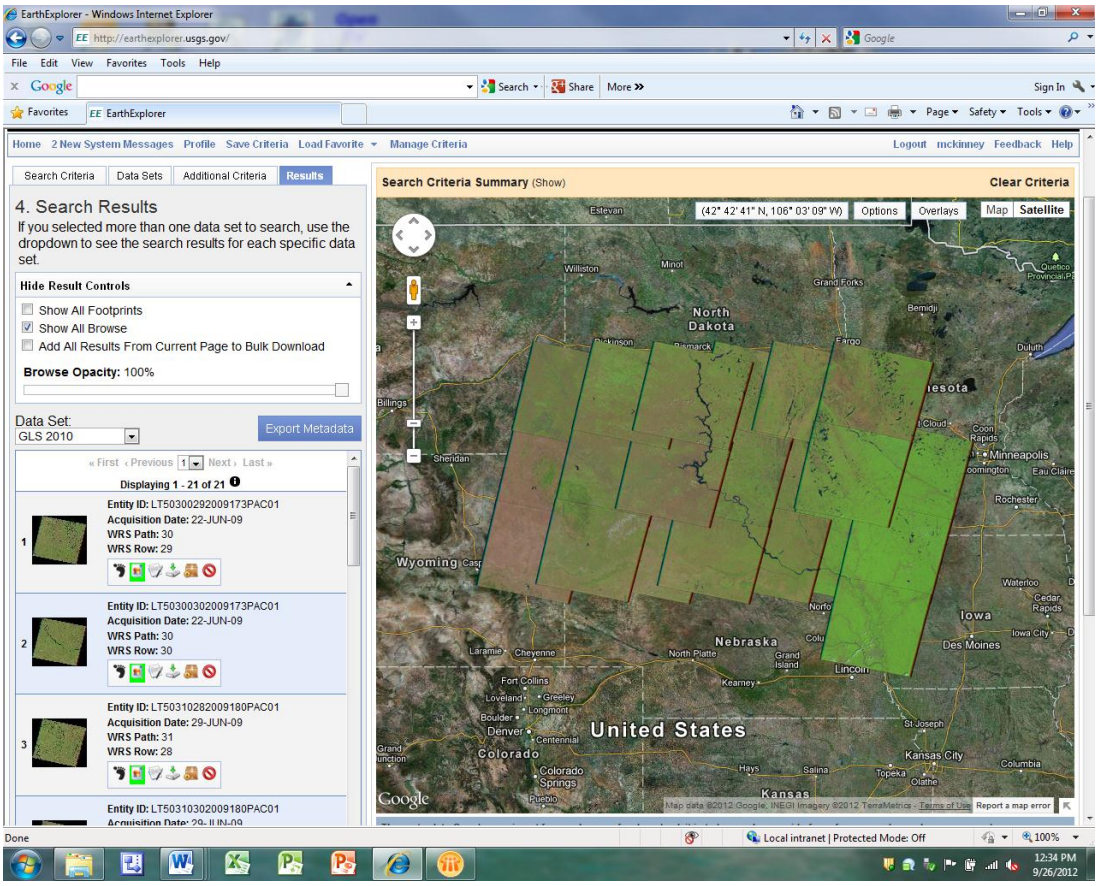


Figure 40. The state of South Dakota was selected as the area of interest with Global Land Survey 2010 as the data collection. The returned scenes are overlaid on the map and selected for bulk downloading.

Full-Resolution JPGs and GIS-Ready Bundle Now Available

Recently, users have been requesting high-resolution images but not necessarily all of the bands of specific collections nor do they want to deal with the volume of data contained in full images. They also want to overlay the image directly onto a map base with various GIS and remote sensing software packages such as Arc Info, ENVI, or Erdas. As a result, new products were created to solve this issue.

The Full-Resolution JPG product, commonly referred to as a full-resolution browse, provides a compressed full-resolution image in JPEG format. The scenes have been processed to Level 1T (Orthorectified) if possible or to Level 1Gst (Systematic Terrain Corrected) if a Level 1T can not be created. These products are either one-band or three-band color images.

The GIS-Ready Bundle includes a full resolution image in JPEG format bundled with metadata and a world file to use in GIS image processing software or web mapping applications. This option provides users with a georeferenced JPEG image and is only available for scenes that have been processed to Level 1T or Level 1Gst.

In addition to various Landsat collections, the Earth Observation-1 (Advanced Land Imager and Hyperion), Satellite Pour l'Observation de la Terre, and OrbView-3 collections have the JPG files available for customers as shown in figures 41-43, respectively. Due to the demand and success of these products, the USGS EROS Center's Long Term Archive project is planning to make JPG and GIS-ready bundles available for more collections as time permits to perform the processing. For further information, contact Wayne Miller, USGS EROS, wamiller@usgs.gov.

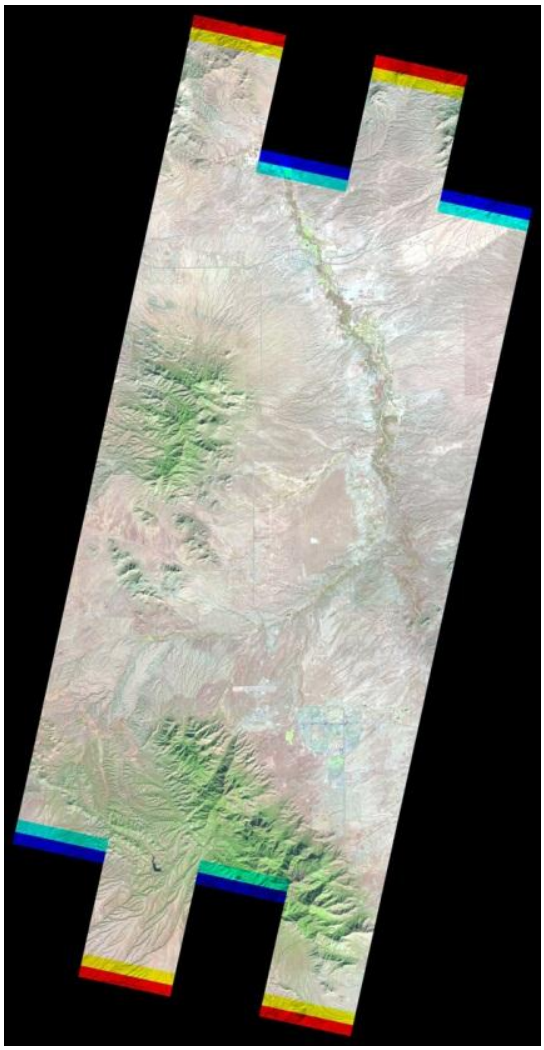


Figure 41. A full-resolution JPG image of Earth Observation-1 Advanced Land Imager data.

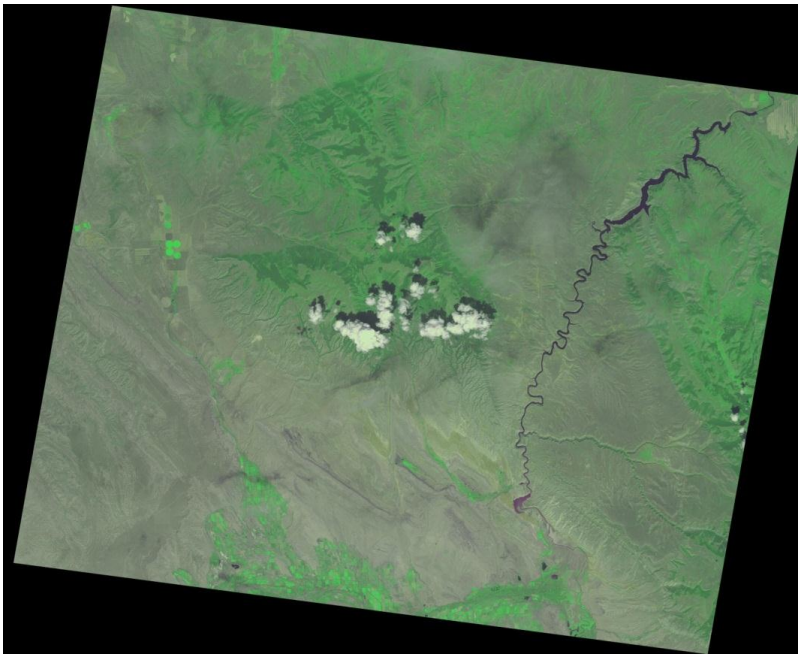


Figure 42. A full-resolution JPG image of Satellite Pour l'Observation de la Terre data.

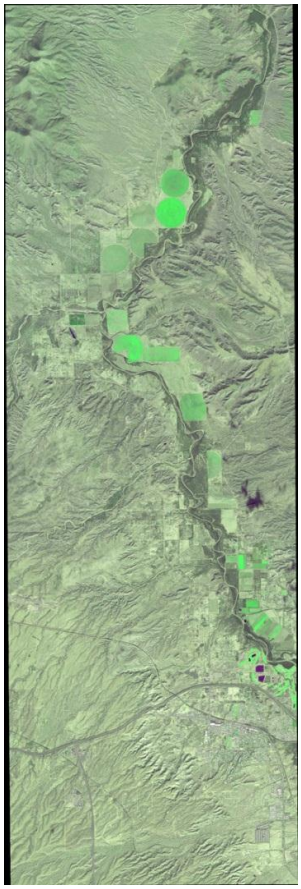


Figure 43. A full-resolution JPG image of OrbView-3 data.

Improving Delivery Tiles

The USGS EROS Center provides terrain correct digital aerial imagery called orthoimagery to the Federal agencies, State agencies and the general public. The actual Orthoimagery database at EROS, which includes 1-m National Agriculture Imagery Program and 1-foot (or higher) High Resolution Urban Areas imagery, grows at 75 tb a year. EROS distributes over 600 tb of these data yearly.

A number of workflow changes and data improvements were began in FY 2012 to reduce delivery expense and satisfy the future goals of the USGS National Geospatial Program including delivery of its data products from the public cloud in FY 2013 while maintaining a good user experience. In order to satisfy these goals economically, the delivery of data was separated from the visualization of the data.

The project is now in the process of preparing a consistently formatted, tiled product for distribution and is considering delivery of a slightly compressed (3:1-5:1 using JPEG2000) product to make it more accessible and economical when hosted on cloud resources. The separated visualization product is being considered for compression at a slightly higher 10:1-15:1 range using a Geospatial Data Abstraction Library JPEG compression algorithm to reduce the amount of disk required to host the data as well as maintain maximum refresh rates on the viewer. The separation of the delivery product and the visualization product have allowed the project to manage each separately, utilize equipment more economically, employ open source software, and provide better systems response times for our customers. For further information, contact Douglas Binnie, USGS EROS, binnie@usgs.gov.

Consolidated Archive and Distribution Data Report: A Monthly "Consolidated Report" for All Data Managed and Distributed at EROS

The USGS EROS has a prepared report template used by the EROS projects for inputting their respective data managed and distributed. The template, reviewed by the projects and the USGS LRS program, gives statistics in terabytes distributed and managed in FY 2012.

Data distributed and managed for all projects, showing both monthly and cumulative totals is shown in figures 44-47. Data distributed and managed are shown in figures 48-57 for the following groupings:

- Landsat (figures 48 and 49)
- LP DAAC (figures 50 and 51)
- Other Satellite (figures 52 and 53)
- Non-Satellite (figures 54 and 55)
- Geospatial (figures 56 and 57) including Land Cover, Orthoimagery, Elevation, and Other

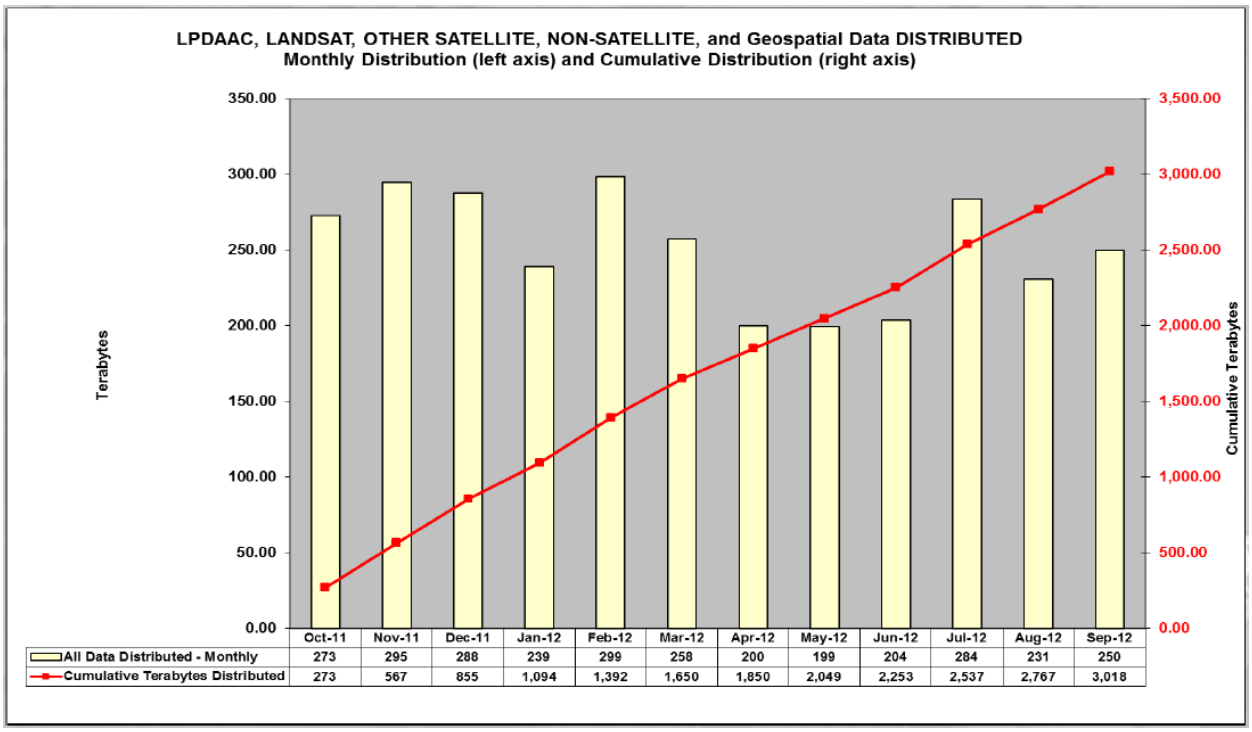


Figure 44. FY 2012 Land Processes Distributed Active Archive Center, Landsat, other satellite, non-satellite, and geospatial data distributed.

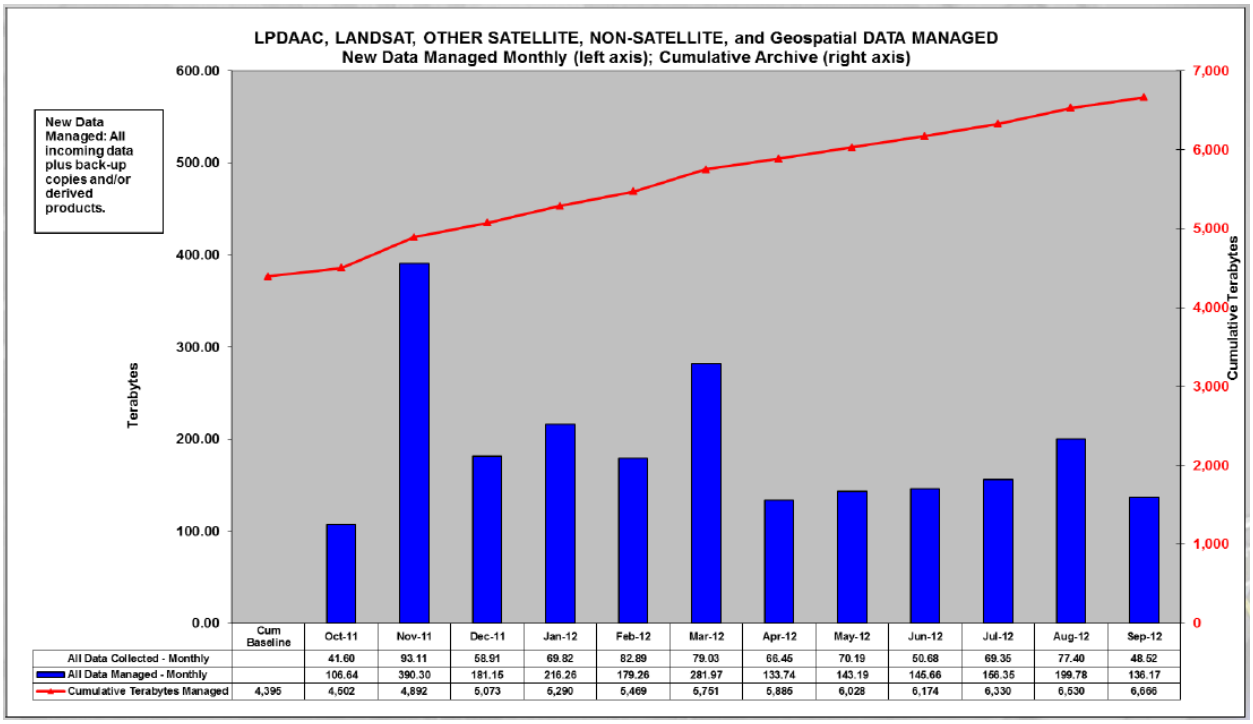
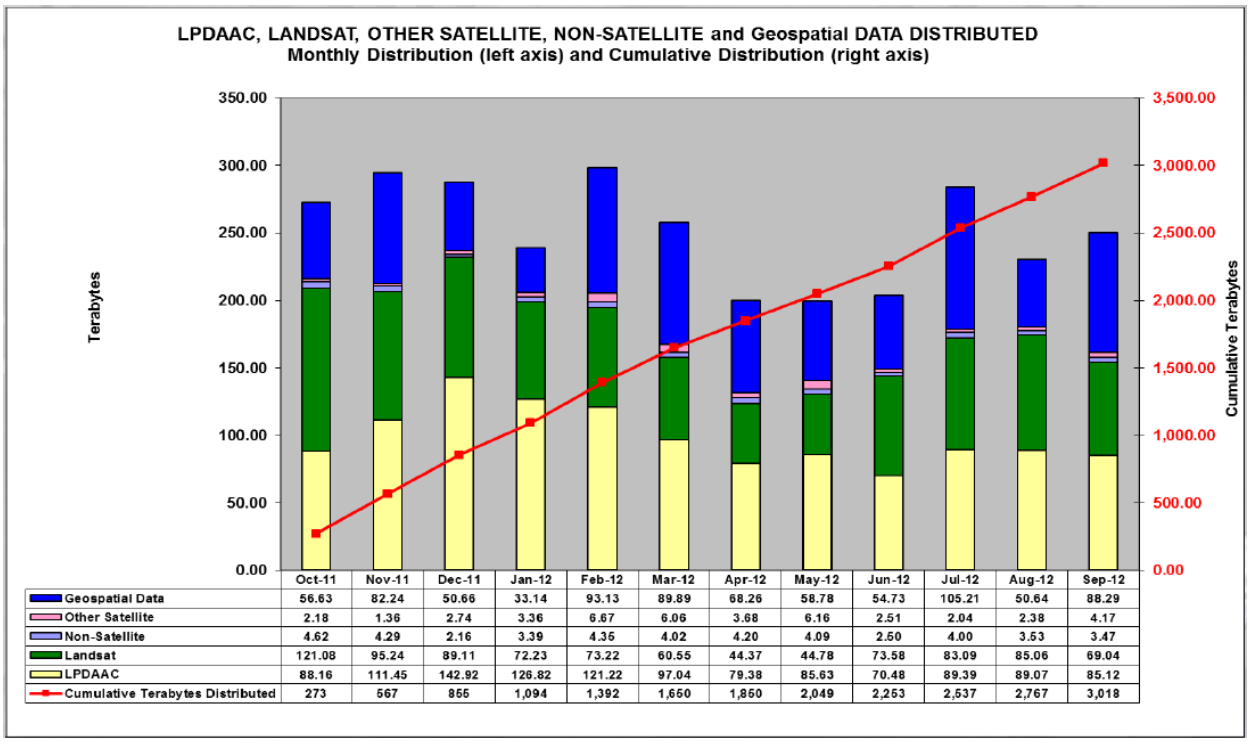
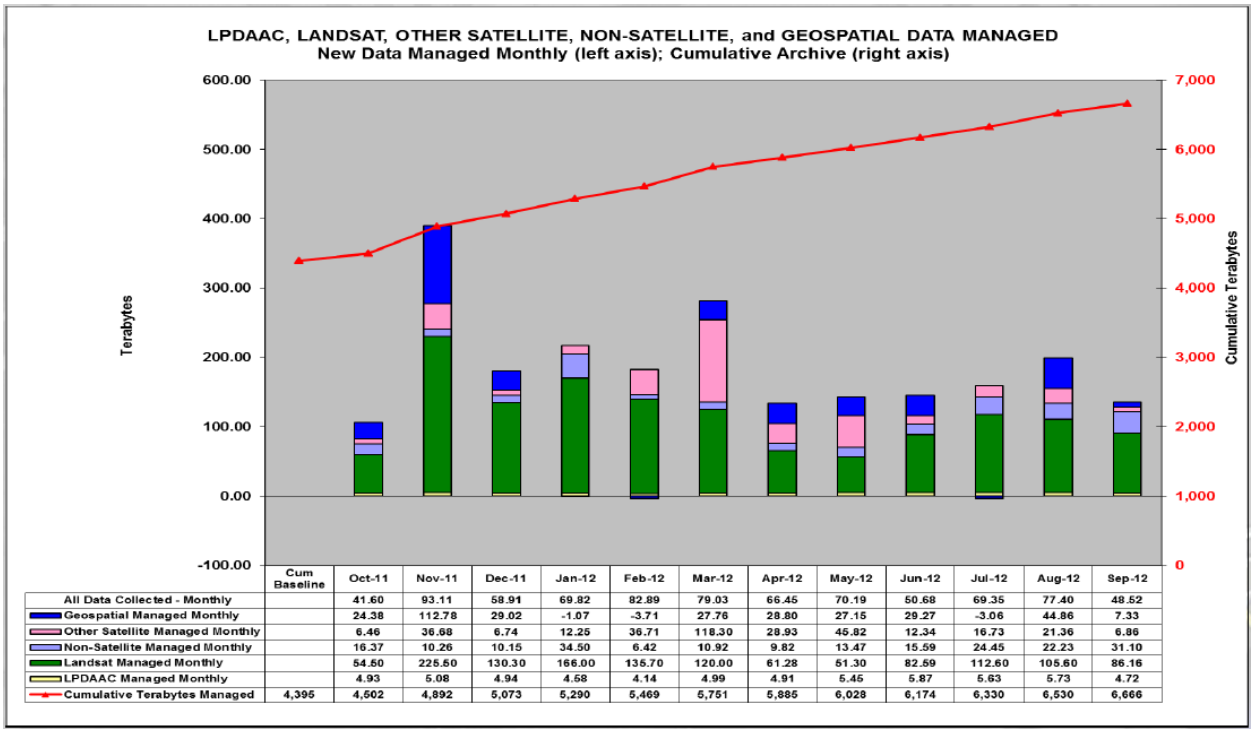


Figure 45. FY 2012 Land Processes Distributed Active Archive Center, Landsat, other satellite, non-satellite, and geospatial data managed.



	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Geospatial Data	56.63	82.24	50.66	33.14	93.13	89.89	68.26	58.78	54.73	105.21	50.64	88.29
Other Satellite	2.18	1.36	2.74	3.36	6.67	6.06	3.68	6.16	2.51	2.04	2.38	4.17
Non-Satellite	4.62	4.29	2.16	3.39	4.35	4.02	4.20	4.09	2.50	4.00	3.53	3.47
Landsat	121.08	95.24	89.11	72.23	73.22	60.55	44.37	44.78	73.58	83.09	85.06	69.04
LPDAAC	88.16	111.45	142.92	126.82	121.22	97.04	79.38	85.63	70.48	89.39	89.07	85.12
Cumulative Terabytes Distributed	273	567	855	1,094	1,392	1,660	1,850	2,049	2,253	2,537	2,767	3,018

Figure 46. FY 2012 Land Processes Distributed Active Archive Center, Landsat, other satellite, non-satellite, and geospatial data distributed.



	Cum Baseline	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
All Data Collected - Monthly		41.60	93.11	58.91	69.82	82.89	79.03	66.45	70.19	50.68	69.35	77.40	48.52
Geospatial Managed Monthly		24.38	112.78	29.02	-1.07	-3.71	27.76	28.80	27.15	29.27	-3.06	44.86	7.33
Other Satellite Managed Monthly		6.46	36.68	6.74	12.25	36.71	118.30	28.93	45.82	12.34	16.73	21.36	6.86
Non-Satellite Managed Monthly		16.37	10.26	10.15	34.50	6.42	10.92	9.82	13.47	15.59	24.45	22.23	31.10
Landsat Managed Monthly		54.50	225.50	130.30	166.00	135.70	120.00	61.28	51.30	82.59	112.60	105.60	86.16
LPDAAC Managed Monthly		4.93	5.08	4.94	4.58	4.14	4.99	4.91	5.45	5.87	5.63	5.73	4.72
Cumulative Terabytes Managed	4,395	4,502	4,892	5,073	5,290	5,469	5,751	5,885	6,028	6,174	6,330	6,530	6,666

Figure 47. FY 2012 Land Processes Distributed Active Archive Center, Landsat, other satellite, non-satellite, and geospatial data managed.

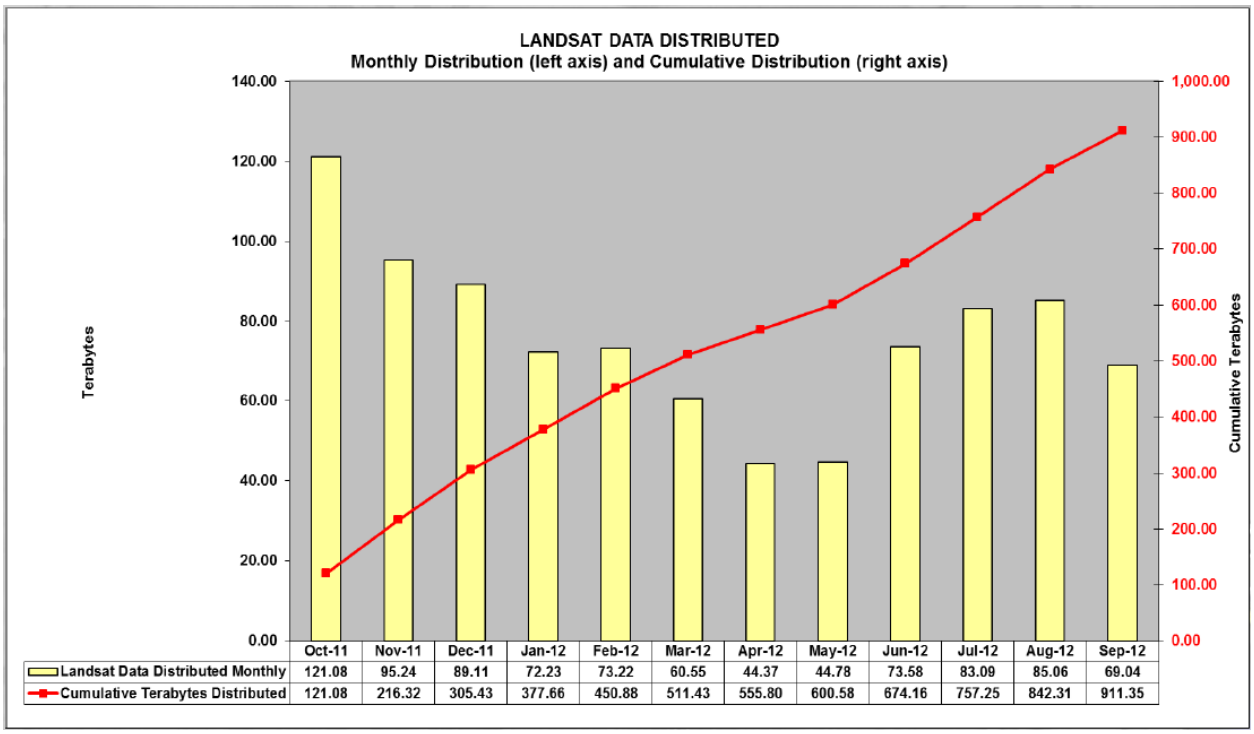


Figure 48. FY 2012 Landsat data distributed.

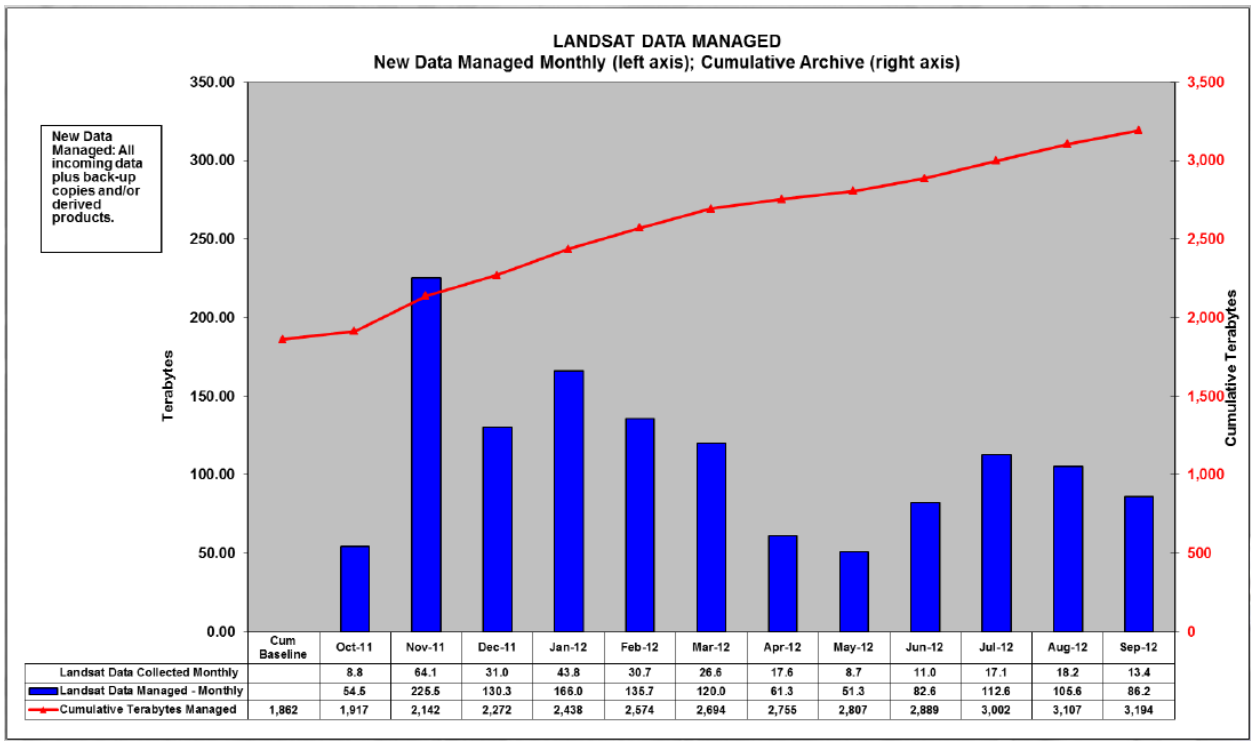
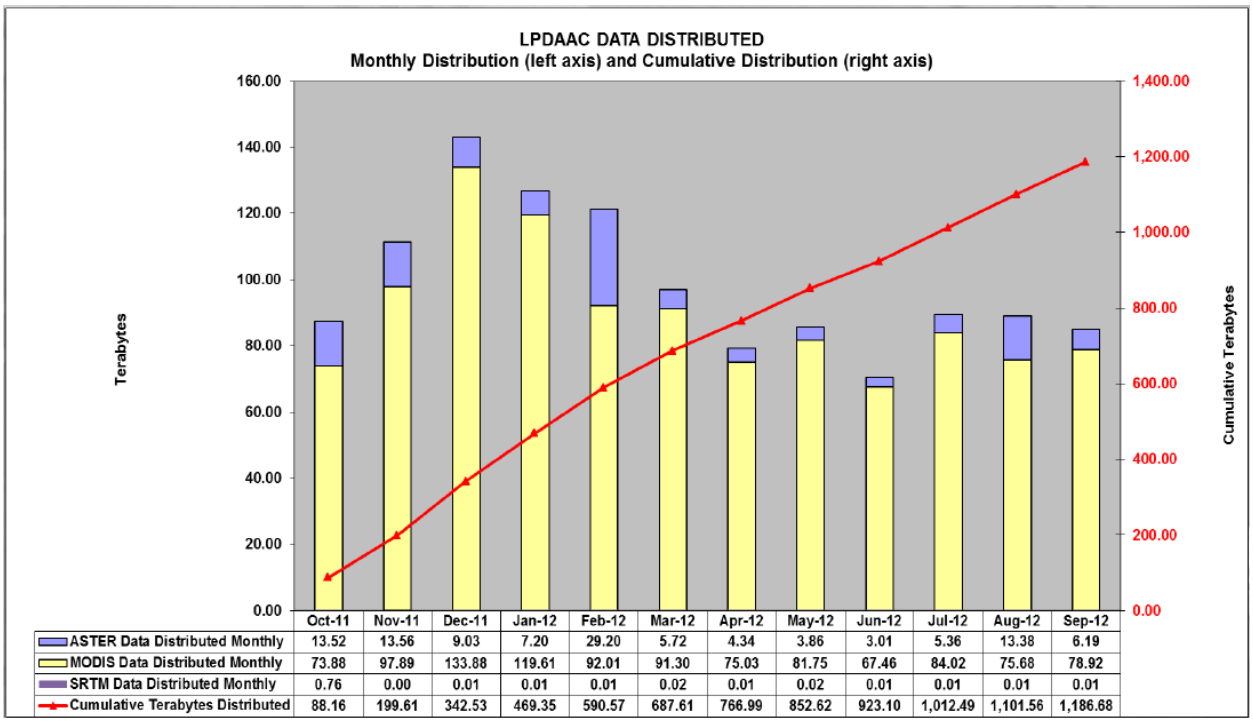
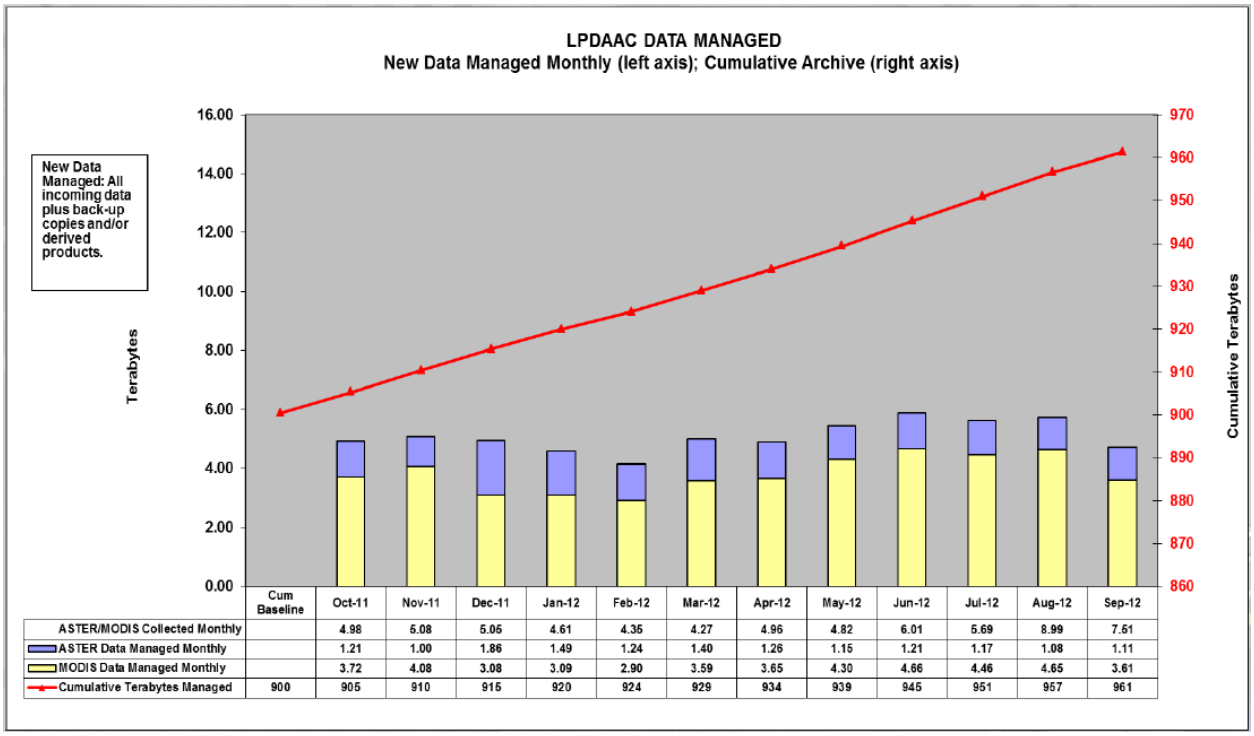


Figure 49. FY 2012 Landsat data managed.



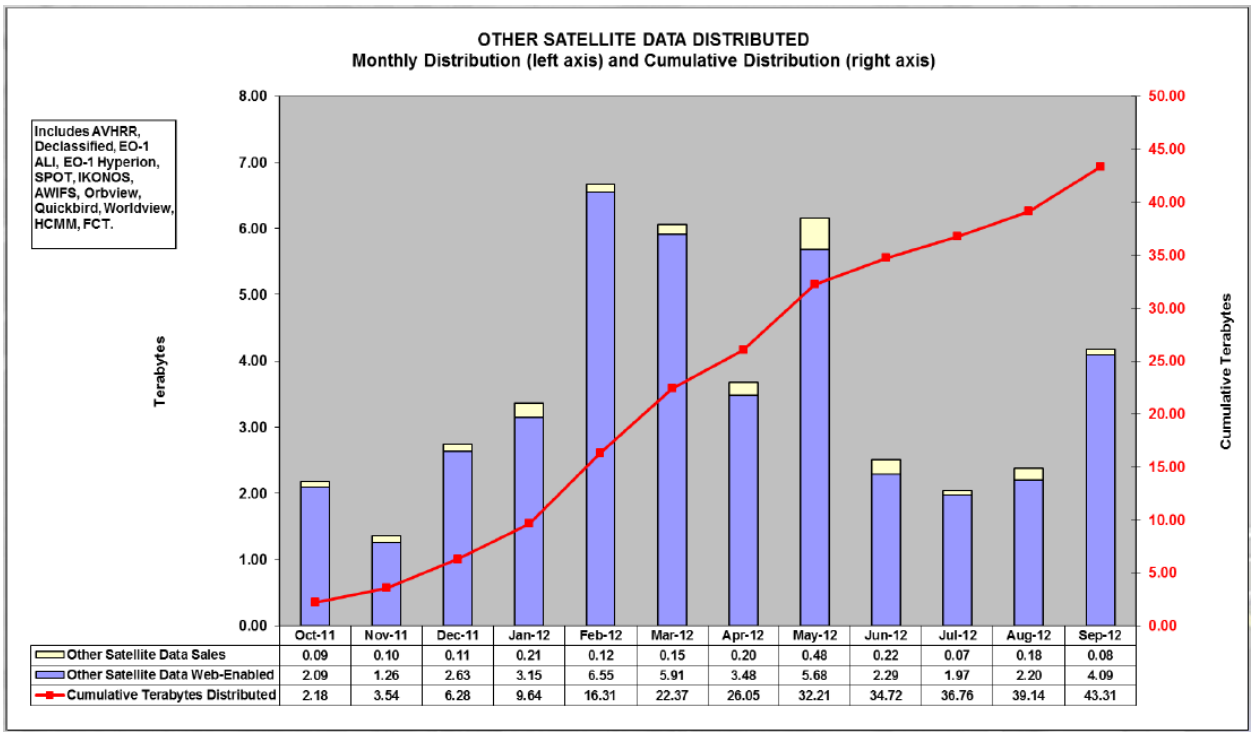
	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
ASTER Data Distributed Monthly	13.52	13.56	9.03	7.20	29.20	5.72	4.34	3.86	3.01	5.36	13.38	6.19
MODIS Data Distributed Monthly	73.88	97.89	133.88	119.61	92.01	91.30	75.03	81.75	67.46	84.02	75.68	78.92
SRTM Data Distributed Monthly	0.76	0.00	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01
Cumulative Terabytes Distributed	88.16	199.61	342.53	469.35	590.57	687.61	766.99	852.62	923.10	1,012.49	1,101.56	1,186.68

Figure 50. FY 2012 Land Processes Distributed Active Archive Center data distributed.



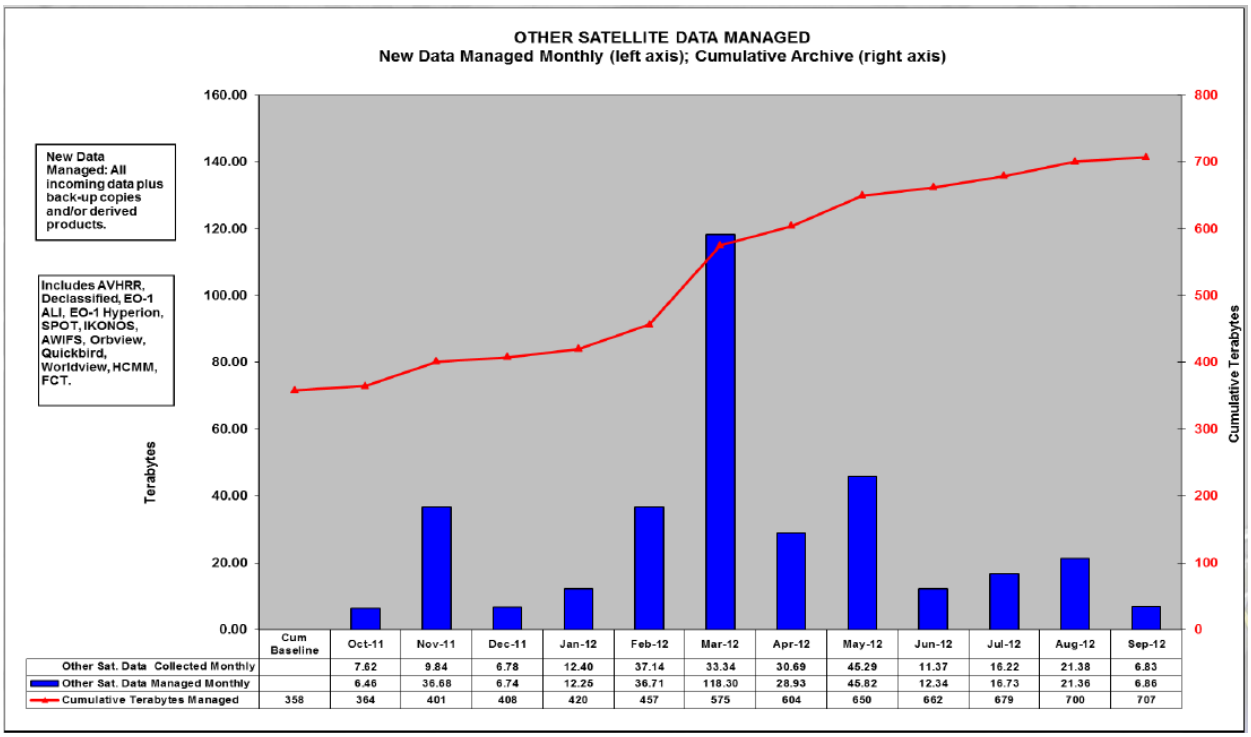
	Cum Baseline	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
ASTER/MODIS Collected Monthly		4.98	5.08	5.05	4.61	4.35	4.27	4.96	4.82	6.01	5.69	8.99	7.51
ASTER Data Managed Monthly		1.21	1.00	1.86	1.49	1.24	1.40	1.26	1.15	1.21	1.17	1.08	1.11
MODIS Data Managed Monthly		3.72	4.08	3.08	3.09	2.90	3.59	3.65	4.30	4.66	4.46	4.65	3.61
Cumulative Terabytes Managed	900	905	910	915	920	924	929	934	939	945	951	957	961

Figure 51. FY 2012 Land Processes Distributed Active Archive Center data managed.



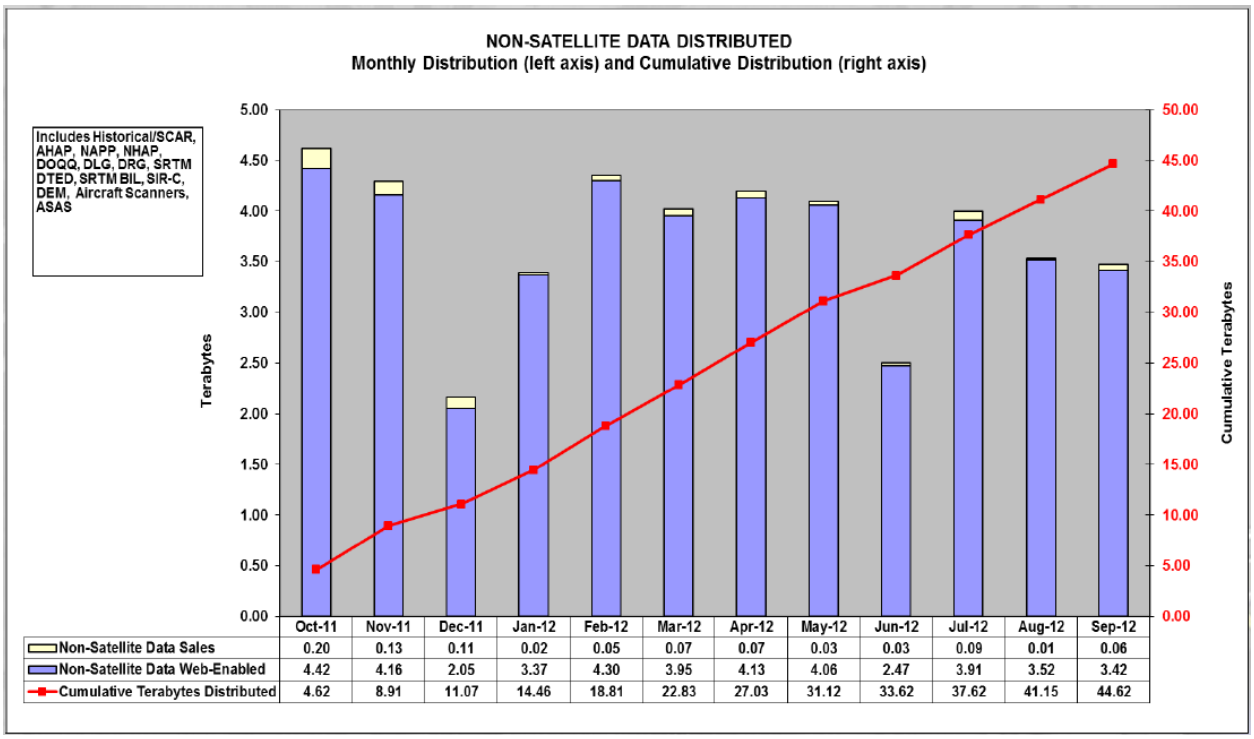
	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Other Satellite Data Sales	0.09	0.10	0.11	0.21	0.12	0.15	0.20	0.48	0.22	0.07	0.18	0.08
Other Satellite Data Web-Enabled	2.09	1.26	2.63	3.15	6.55	5.91	3.48	5.68	2.29	1.97	2.20	4.09
Cumulative Terabytes Distributed	2.18	3.54	6.28	9.64	16.31	22.37	26.05	32.21	34.72	36.76	39.14	43.31

Figure 52. FY 2012 other satellite data distributed.



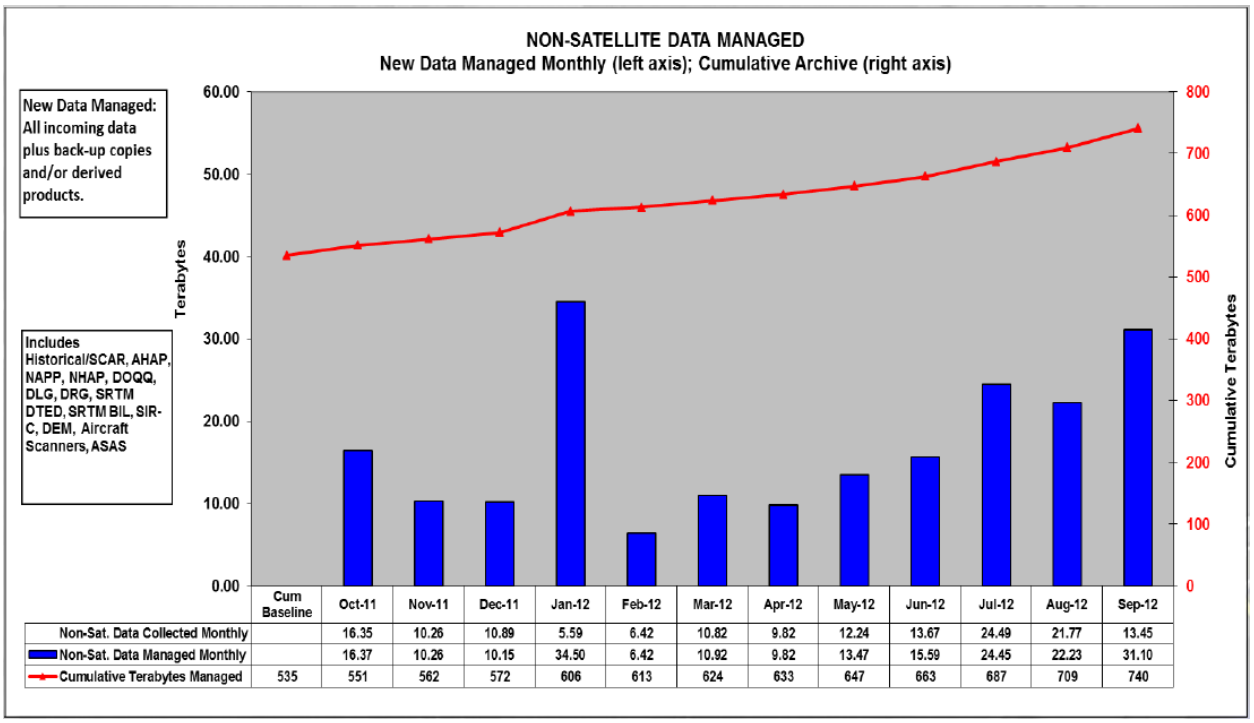
	Cum Baseline	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Other Sat. Data Collected Monthly		7.62	9.84	6.78	12.40	37.14	33.34	30.69	45.29	11.37	16.22	21.38	6.83
Other Sat. Data Managed Monthly		6.46	36.68	6.74	12.25	36.71	118.30	28.93	45.82	12.34	16.73	21.36	6.86
Cumulative Terabytes Managed	358	364	401	408	420	457	575	604	650	662	679	700	707

Figure 53. FY 2012 other satellite data managed.



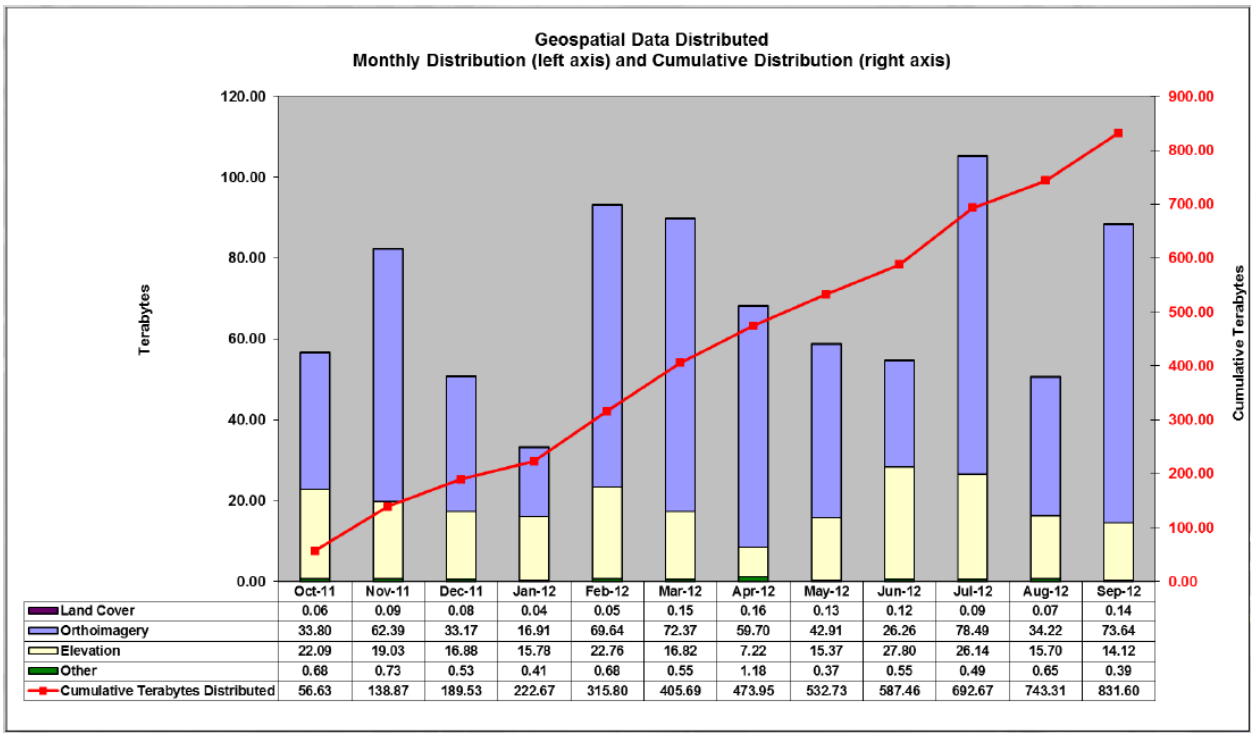
	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Non-Satellite Data Sales	0.20	0.13	0.11	0.02	0.05	0.07	0.07	0.03	0.03	0.09	0.01	0.06
Non-Satellite Data Web-Enabled	4.42	4.16	2.05	3.37	4.30	3.95	4.13	4.06	2.47	3.91	3.52	3.42
Cumulative Terabytes Distributed	4.62	8.91	11.07	14.46	18.81	22.83	27.03	31.12	33.62	37.62	41.15	44.62

Figure 54. FY 2012 non-satellite data distributed.



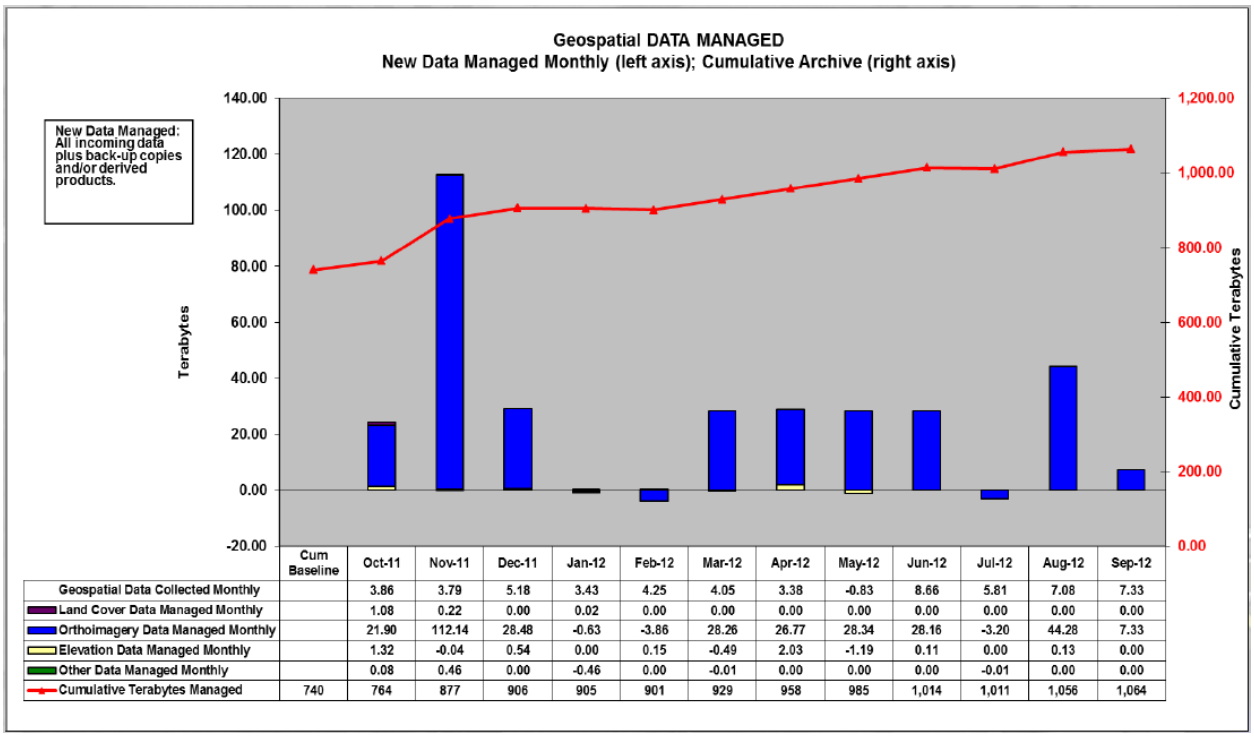
	Cum Baseline	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Non-Sat. Data Collected Monthly		16.35	10.26	10.89	5.59	6.42	10.82	9.82	12.24	13.67	24.49	21.77	13.45
Non-Sat. Data Managed Monthly		16.37	10.26	10.15	34.50	6.42	10.92	9.82	13.47	15.59	24.45	22.23	31.10
Cumulative Terabytes Managed	535	551	562	572	606	613	624	633	647	663	687	709	740

Figure 55. FY 2012 non-satellite data managed.



	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Land Cover	0.06	0.09	0.08	0.04	0.05	0.15	0.16	0.13	0.12	0.09	0.07	0.14
Orthoimagery	33.80	62.39	33.17	16.91	69.64	72.37	59.70	42.91	26.26	78.49	34.22	73.64
Elevation	22.09	19.03	16.88	15.78	22.76	16.82	7.22	15.37	27.80	26.14	15.70	14.12
Other	0.68	0.73	0.53	0.41	0.68	0.55	1.18	0.37	0.55	0.49	0.65	0.39
Cumulative Terabytes Distributed	56.63	138.87	189.53	222.67	315.80	405.69	473.95	532.73	587.46	692.67	743.31	831.60

Figure 56. FY 2012 geospatial data distributed.



	Cum Baseline	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Geospatial Data Collected Monthly		3.86	3.79	5.18	3.43	4.25	4.05	3.38	-0.83	8.66	5.81	7.08	7.33
Land Cover Data Managed Monthly		1.08	0.22	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orthoimagery Data Managed Monthly		21.90	112.14	28.48	-0.63	-3.86	28.26	26.77	28.34	28.16	-3.20	44.28	7.33
Elevation Data Managed Monthly		1.32	-0.04	0.54	0.00	0.15	-0.49	2.03	-1.19	0.11	0.00	0.13	0.00
Other Data Managed Monthly		0.08	0.46	0.00	-0.46	0.00	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00
Cumulative Terabytes Managed	740	764	877	906	905	901	929	958	985	1,014	1,011	1,056	1,064

Figure 57. FY 2012 geospatial data managed.

For further information, contact John Faundeen, USGS EROS, faundeen@usgs.gov.

Coordination and Collaboration

As the USGS endeavors to provide overall leadership for land imaging, both nationally and internationally, the USGS must continue to enhance leadership visibility, improve communications between and among the Federal and non-Federal sectors regarding remote sensing observations of the Earth, and promote excellence in remote sensing for understanding the Earth's land environment through education and training. The USGS continues to serve as the lead United States agency to the International Charter "Space and Major Disasters." EROS will continue to develop and offer a variety of ongoing education and training that together provide remotely sensed data users, and especially potential users, with opportunities to become more informed and educated about all aspects of the science and technology of land remote sensing. Key accomplishments are given in the following sections.

Emergency Operations Support to U.S. Domestic Events Increase Dramatically

This fiscal year brought a record number of Emergency Operations catastrophic events. Additional staffing was not required to support the events due in part to the enhancements that have been made along with new hardware purchases. These enhancements include new ingest functionality to ingest and archive additional datasets, additional features added to the Hazards Data Distribution System to provide users enhanced searching capabilities, and the addition of a bulk downloading feature (fig. 58). New servers have been used to provide faster ingest capabilities of data.

Table 2 shows the number and types of events that occurred over the course of FY 2012. There were approximately 66 events that included cyclones, earthquakes, fires, floods, hurricanes, oil spills, landslides, snowstorms, tornadoes, tropical storms, and volcanoes. For further information, contact Wayne Miller, USGS EROS, wamiller@usgs.gov.

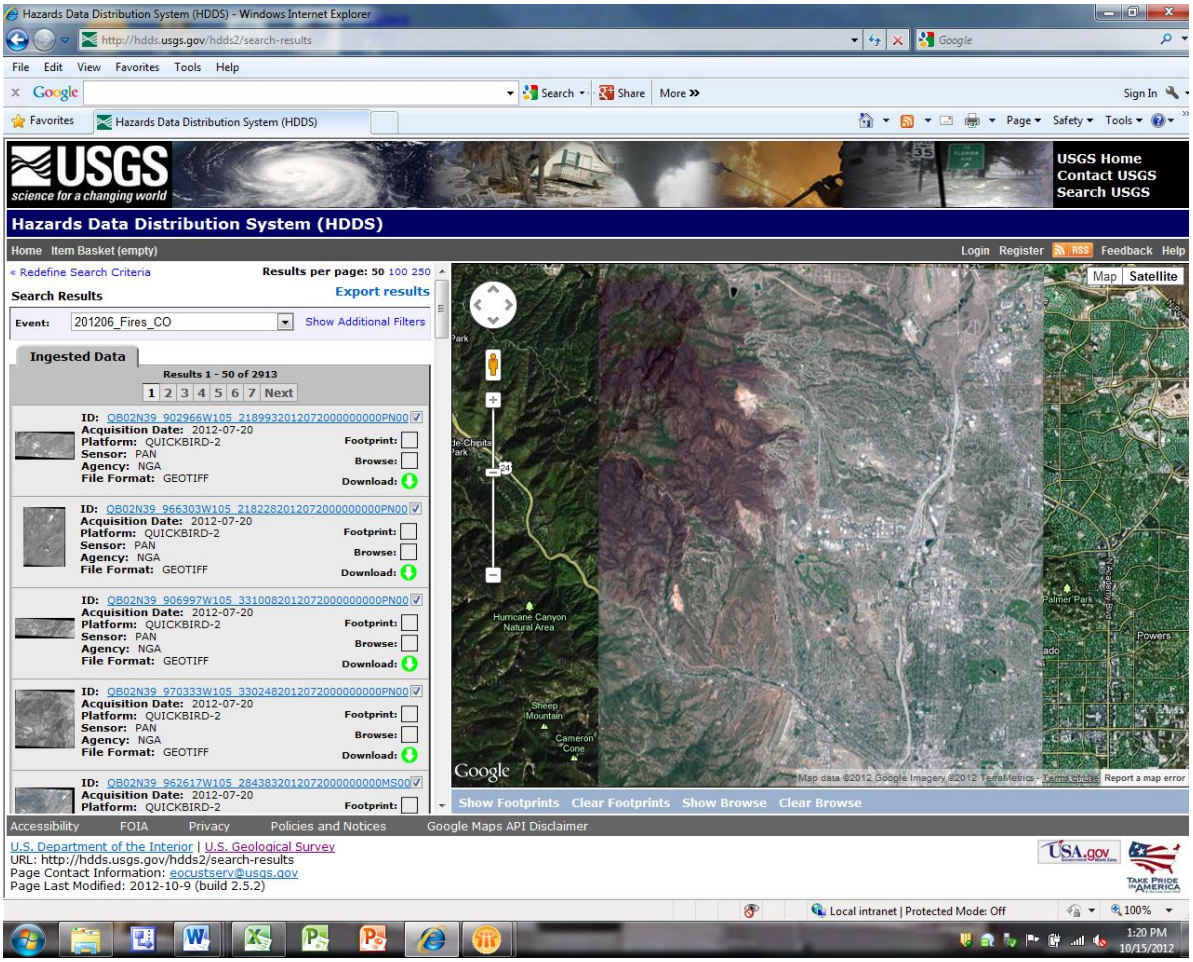


Figure 58. The Hazards Data Distribution System's graphical user interface was created in fiscal year 2010 to aid users search and obtain data over their event faster and easier. This graphical user interface provides multiple methods for obtaining ingested or ad-hoc data literally hours after it is received at EROS. The image shows the fire damage in Colorado.

Table 2. Record of FY 2012 Emergency Operations Events

Date_Type_Location	Date_Type_Location
201109_Earthquake_India	201205_Snowmelt_AK
201109_Fires_MN	201206_Fires_AZ
201110_Earthquake_Turkey	201206_Fires_CO
201110_Floods_Algeria	201206_Fires_NM
201110_Floods_Thailand	201206_Fires_WY
201110_Oilspill_New_Zealand	201206_Floods_MN
201110_Volcano_AK	201206_TropicalStorm_Debby
201111_Fires_Reno	201206_Volcano_Guatemala
201111_Storm_AK	201207_Fires_MT
201112_Fires_Chile	201207_Fires_NE
201201_Fire_NV	201207_Fires_OR
201201_Floods_Brazil	201207_Fires_SD
201202_Cyclone_Giovanna	201207_Fires_UT
201202_Floods_Algeria	201207_Floods_India
201202_Floods_Peru	201207_Floods_Russia
201202_GasExplosion_AK	201208_Fires_Algeria
201202_Landslide_AK	201208_Fires_CA
201202_NRDA (Big Bend, FL)	201208_Fires_ID
201202_Tornadoes_Central_US	201208_Fires_NV
201202_Volcano_Semeru	201208_Fires_OK
201203_Cyclone_Irina	201208_Floods_Niger
201204_Fires_CO	201208_Floods_Philippines
201204_Fires_VA	201208_Floods_Senegal
201204_NRDA (Louisiana)	201208_Hurricane_Isaac
201204_Tornadoes_Central_US	201209_Earthquake_China
201204_Tornadoes_TX	201209_Fires_Equador
201205_Fires_AZ	201209_Fires_WA
201205_Fires_CO	201209_Floods_Cameroon
201205_Fires_NM	201209_Floods_Pakistan
201205_Fires_NV	201209_Floods_South_Sudan
201205_Fires_TX	201209_Landslide_India
201205_Floods_China	201210_Floods_Chad
201205_Hurricane_LA_TX_TEST	201210_Floods_Nigeria

Record Year for the International Charter

Responding to catastrophic natural disasters requires information. When the flow of information on the ground is interrupted by crises such as earthquakes, landslides, volcanoes, hurricanes, and floods, satellite imagery and aerial photographs become invaluable tools in revealing post-disaster conditions and in aiding disaster response and recovery efforts. USGS is a global clearinghouse for remotely sensed disaster imagery. Access to the Charter suite of assets enhances the USGS' ability to respond

to global emergencies and to disasters that occur in the United States. Repeatedly, USGS and its resources have proven their worth in assisting with disaster recovery activities in the United States and abroad.

The disaster response by Charter members includes global data sources, multi-satellite data acquisition planning with priority acquisition capability, data processing at pre-determined levels and integration of multiple data sources and levels.

The USGS contribution to the Charter continues to grow on a yearly basis. In 2012 USGS provided support by providing Project Managers, images, activation requests, and participation in the Universal Access, training, data distribution and external relations sub groups.

There were 40 activations of the International Charter in FY 2012. USGS submitted 7 of the 40 requests. There was a single domestic request on behalf of the Federal Emergency Management Agency in support of Hurricane Isaac and six international activations in support of floods events in Cameroon, Russia (2), Ecuador, and Algeria, and for an oil spill in New Zealand (fig. 59). USGS also provided Project Managers who are responsible for the tasking and dissemination of imagery for these events. The USGS Project Managers were supplied by the Joint Research Center/ European Commission, Mississippi State University, USGS, CLIRSEN/Ecuador, University of Kansas, and the Pacific Disaster Center.

USGS provided over 10,000 images supporting 67 percent of the Charter activations this year. The imagery for the 27 events included 325 Landsat, 2 EO-1, 52 ASTER, 54 SPOT, 92 International Space Station, and 9,909 commercial high resolution. The commercial high resolution data includes GeoEye, IKONOS, QuickBird, and WorldView and all are provided through arrangements with the National Geospatial Intelligence Agency. The SPOT data is provided through an arrangement with the U.S. Air Force EagleVision program and the EO-1, ASTER and ISS imagery are all provided through USGS by NASA.

USGS is also very active in the Project Manager training efforts supported by the Charter Board. USGS provided the only training session in FY 2012 in Moscow, Russia. The training was funded through a State Department project.

The Charter normally responds to around 10 percent of the global major disasters. The provision of products and operational support provided by USGS are major contributing factors to the Charters success. With the implementation of Universal Access, the need for products, training, and outreach will increase as the Charter strives to provide direct access and support to all countries. For further information, contact Wayne Miller, USGS EROS, wamiller@usgs.gov.

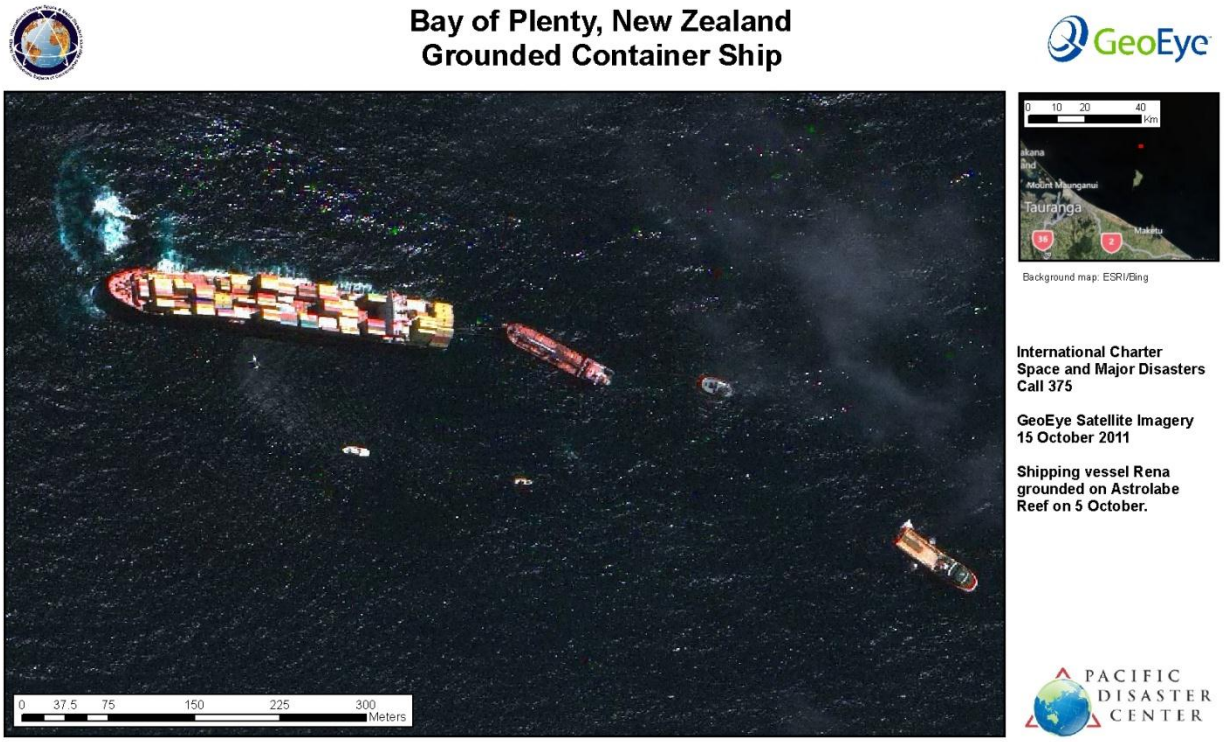


Figure 59. This map shows the grounded shipping vessel Rena near Bay of Plenty, New Zealand. The GeoEye satellite image was provided to the Charter through USGS.

Committee on Earth Observation Satellites: New Directions

The USGS has supported the CEOS for over 20 years believing that more useful information is gained than contributed. CEOS addresses coordination of the satellite Earth Observation programs of the world's civilian space agencies, along with research organizations that receive and process data acquired remotely from space.

This past year saw a number of USGS EROS staff leading multiple groups within this international cooperative. Information systems engineer, Greg Stensaas, completed his 4-year leadership role with the Working Group on Calibration and Validation where he reinforced the concept of data being fit for purpose and strengthened the network of test sites. John Dwyer, remote sensing and geospatial data applications scientist, began participation in the Working Group on Climate, which will become a focus point for both USGS and CEOS activities for many years to come. Eric Wood, geospatial technologies scientist, led the effort to produce webinar training series to educate current and future users of remotely sensed data. John Faundeen, geographic information systems specialist, led an effort within the Working Group on Information Systems and Services in developing a Data Management Statement in response to the Group on Earth Observations task. EROS also co-leads the newly formed Space Data Coordination Group and the Land Surface Imaging virtual constellation (fig. 60), both of which are working to facilitate land data products access in support of GEO forests and

agriculture initiatives. Brenda Jones, disaster response coordinator, contributed her International Charter expertise to the CEOS Disaster Risk Management efforts. Combined, EROS staff played a significant role in furthering CEOS objectives in 2012. Our next year is expected to see even greater impacts at the CEOS and GEO levels through training, disaster response, Earth Observation data access, and the release of calibrated Essential Climate Variables in support of multiple initiatives. For further information, contact John Faundeen, USGS EROS, faundeen@usgs.gov.

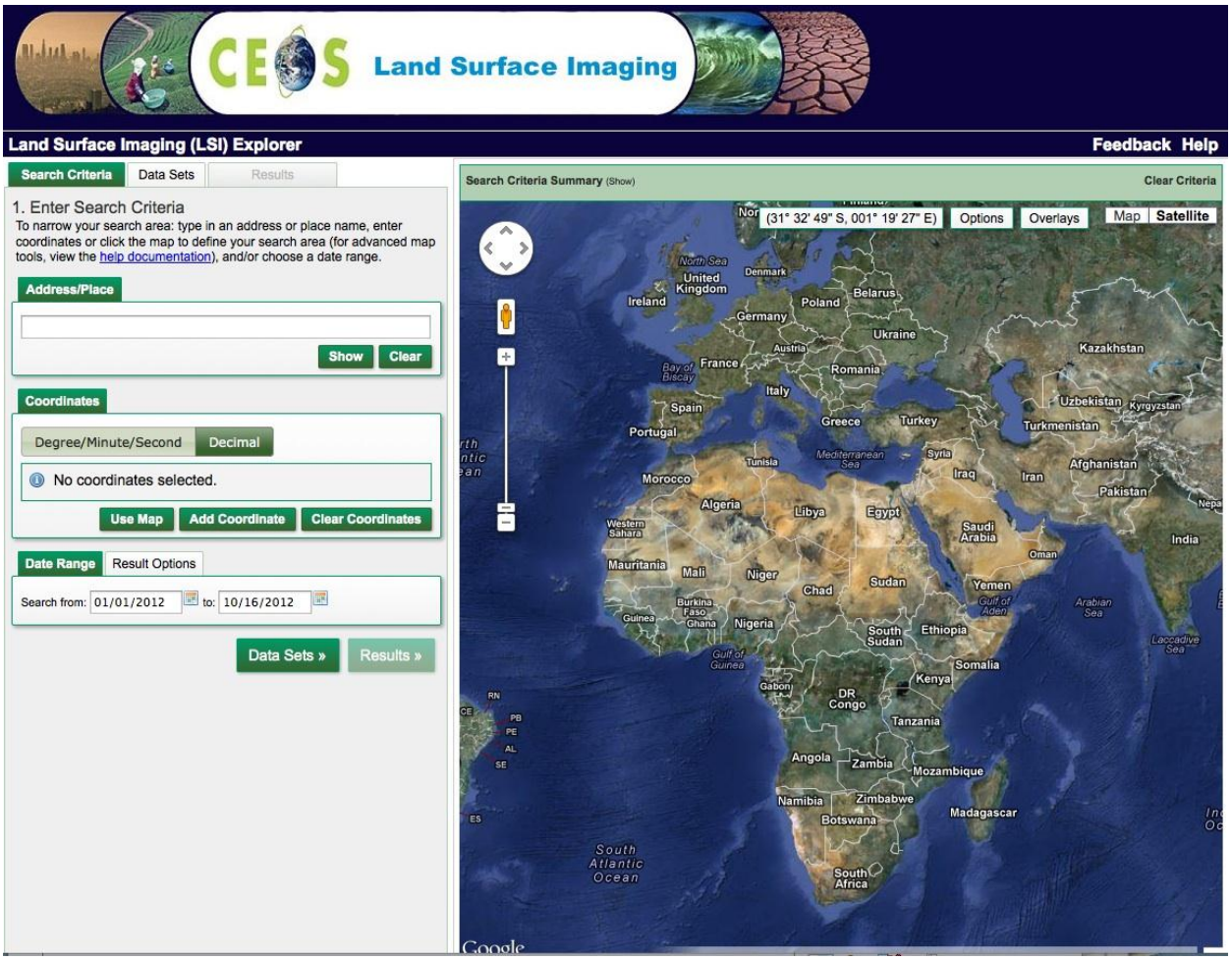


Figure 60. Land Surface Imaging cross-inventory search portal used to discover and obtain land data products in support of Group on Earth Observations' forests and agriculture initiatives.

Center Support Activities

Center support activities at the USGS EROS provides a wide range of services for numerous and highly complex science, engineering, and operational projects, diverse contracts, intricate partner and customer relationships, and national and international activities. Key accomplishments are given in the following sections.

Rolling Out the Vision – Fiscal Year 2012 and Beyond

The EROS mission, *contributing to the understanding of a changing Earth*, is accomplished through research to operations activities that include developing, implementing, and operating remote sensing based land change monitoring, assessment, and prediction capabilities needed to address science and applications objectives at all levels – within the USGS, across the Federal government, and around the world (fig. 61). Fundamental to this mission is the collection and archiving of data about the Earth's land surfaces, providing a visual and digital record of global features and environmental change, and ensuring the accessibility of these records to anyone, anywhere, anytime and at no cost to users. This record includes aerial photography dating back to the 1930s and satellite data to 1960.

Of particular note is the role of EROS as the primary provider of Landsat data – the longest most comprehensive global land record ever assembled. The Landsat archive going back to 1972 and continuing into the future, thanks to over a 40-year partnership with NASA, provides an unprecedented record of the status of the Earth's natural resources and human activity. The value of this record for understanding global change and adapting to or mitigating the impacts of a changing Earth is clearly expressed in the USGS CLU Mission Area's strategic plan:

> *"One of the great challenges is how to relate human incentives, behavior and action at particular localities to land cover change at broader (e.g., regional) geographic regions. The fine spatial resolution of Landsat images along with its global geographic extent provides the necessary data for making this linkage."*

USGS CLU and LRS Program guidance underscores the unique and significant value of Landsat and acknowledges the need to take additional steps to make the Landsat archive more valuable for a wider range of uses. Central to those uses is the need to provide application ready datasets and information products representing land cover characteristics that are consistent over the full 40-year record and suited to detecting and monitoring changes in land surface conditions and to supporting monitoring, assessment, and prediction of climate along with other related Earth system processes.

To that end, the EROS mission, *contributing to the understanding of a changing Earth*, is specifically focused on land change monitoring defined as:

> Systematic, continuous measurement, quantification, and explanation of land use, land cover, and land condition that leads to an understanding of the interactions between people and nature, i.e., describing the geography of change.

This focus is consistent with the USGS geographic research focus on land change science, and is, consistent with the USGS vision to provide "science for a changing world."

In fiscal year 2013, the EROS workforce under the guiding vision of their management teams will place added discipline on:

1. structured collection and delivery of operational, timely, accurate, and relevant land change information;
2. specific, timely, and reliable assessments of the trends and consequences of land change to support decision makers;
3. services that support the use and understanding of land change monitoring information products;
4. establishing a Land Change Monitoring, Assessment, and Prediction (LCMAP) center; and
5. investing in and maintaining a state-of-the-art land change science information system as a core action fundamental to the success of the LCMAP center.

As program planning for 2014-2015 is underway, the accomplishments of 2012 and initiating actions of 2013 are making great strides in achieving our mission goals in global land change monitoring while advancing our vision of higher levels of service to the Nation and our planet. For further information, contact Thomas Holm, USGS EROS, holm@usgs.gov.

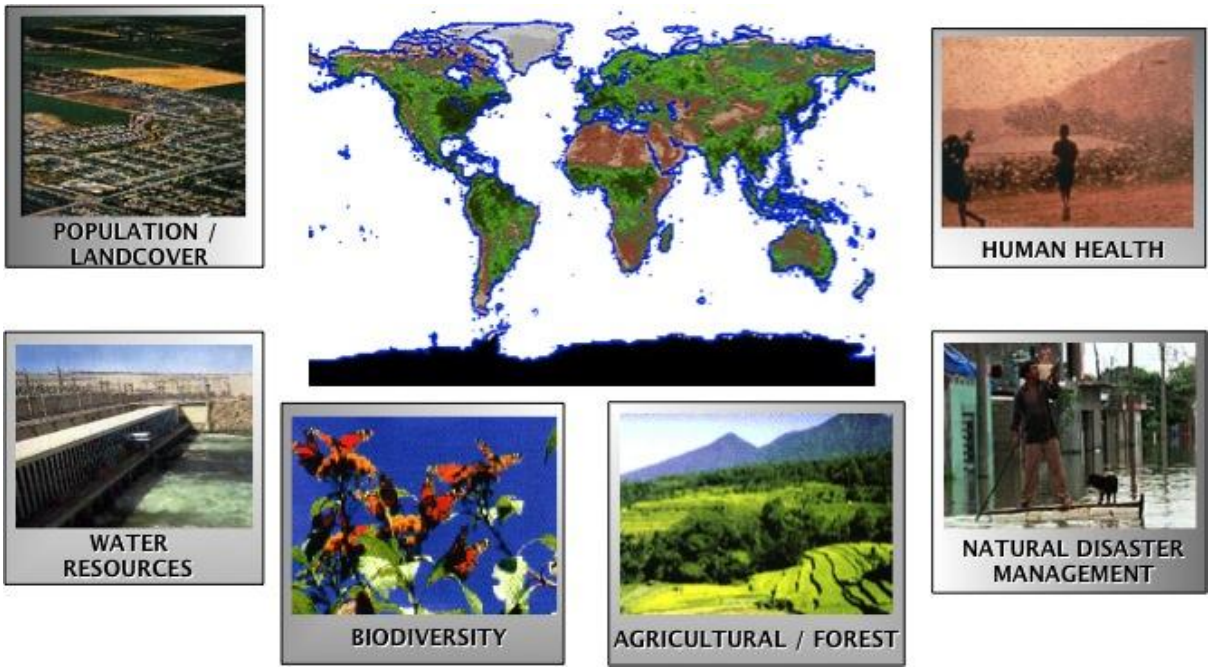


Figure 61. Illustration represents the great challenge of the EROS mission, *contributing to the understanding a changing Earth,* through patterns, processes, and consequences of land change, as it occurs, using a framework that is globally consistent and locally relevant – and that meets the needs of decision makers.

Data Center Consolidation: A Successful Partnership Between BIA and USGS

In response to a 2010 Federal Initiative, the Department of Interior has been looking at options to:

- promote the use of green information technology (IT) by reducing the overall energy and real estate footprint of DOI data centers;
- reduce the cost of data center hardware, software, and operations;
- increase the overall DOI IT security; and
- increase the use of more efficient computing platforms and technologies.

EROS is one of the largest USGS/DOI data centers. The Center has a robust and low-cost IT environment, with a widely experienced IT staff, extensive network and satellite connectivity, and inexpensive/green commercial electricity; all of which identifies EROS as a potential provider for consolidation support to other DOI activities.

The Bureau of Indian Affairs (BIA) approached the USGS regarding a need for data center space when they were planning to vacate their space in Herndon, Virginia. A delegation from the BIA came to EROS in September 2011 and met with the USGS Chief Technology Officer. It was decided that the BIA would pursue placing

approximately 15 racks of equipment at EROS as a backup site to their primary BIA Albuquerque, New Mexico, data center.

The following month, EROS staff visited the Albuquerque site to discuss tentative plans that would accommodate housing both personnel and equipment at EROS. The BIA immediately set up working groups to accomplish the transfer as did the USGS with EROS local staff as the primary contacts. A discussion requesting that formal communications occur between USGS and BIA was held with the Associate Director, Administration and Enterprise Information, in December 2011. It was proposed that USGS allow EROS to move forward on the effort as part of the DOI IT Transformation Data Center Consolidation initiative. The focus of the interaction between the BIA and USGS staff was to ensure availability of computer room power, office space, data communications, and conditioned space at the time of the BIA's arrival.

During technical discussions, accomplishments, needs, and schedules were conveyed from a local level to the greater USGS. The USGS staff tasks were to:

(1) accurately model the costs that would be incurred by installation and housing BIA staff and equipment;
(2) build contracts for support infrastructure and forward them for award;
(3) review and address logistical concerns regarding installation of the equipment; and
(4) work with the BIA on the installation of a high capacity data communications line at EROS.

The BIA established the Albuquerque Data Center as their primary data site, finalized personnel and power requirements for the EROS site, worked to install the data communications line, and refined their schedule regarding consolidation at EROS.

EROS modeled the costs that would be incurred and received final power, equipment, and rack specifications from the BIA. The communications line was brought in during Spring 2012. The BIA then installed a communications rack in one of the EROS Computer Rooms to test network connectivity. The EROS infrastructure contracts were awarded in April and the backup site went live in May 2012.

This partnership allowed EROS to develop and verify the accuracy of a custom facilities cost model that can be used both internally and for future data center consolidation activities. Additionally the BIA contract will be used as a template for other Interagency Agreements (IA) requesting infrastructure support from EROS. The effort also reduced the size of our facility footprint (the amount of space dedicated solely to EROS functions) which is a benefit in other consolidation/cost savings efforts. At the USGS level, the partnership also provides headquarters with IA and cost model templates for future cross agency consolidations. At a DOI level, it provided a successful consolidation effort and cost savings for the BIA by closure of their Herndon Data Center and subsequent movement to EROS. The BIA was very pleased with the outcome, and the USGS EROS Center was able to further reduce their costs by

movement of existing hardware. Ultimately, the real benefit in this partnership is to our customer – the U.S. Taxpayer. BIA was able to close a higher cost data center thereby reducing overall costs without sacrificing function and security. For further information, contact Bruce Potter, USGS EROS, bpotter@usgs.gov.

USGS Scientific Data Life Cycle Model

In 2011, the USGS Community for Data Integration (CDI) formed a team to develop a data life cycle model (figs. 62 and 63) that both describes how our scientific records flow from their creation to an end state as well as how those records should have an associated cycle applied. This model was identified as a foundational piece from which USGS will build data management tools and services for bureau staff to utilize.

Led by USGS EROS staff, the team utilized an extensive literature search, monthly teleconferences, a 2-day workshop, a poster session, and management reviews to formulate and end-to-end model describing how all USGS science data should proceed during its useful life. The resulting model has been approved by Kevin Gallagher and Linda Gunderson, the USGS Executive Leadership Team members and CDI sponsors.

As part of the roll out process to USGS employees, a multi-page factsheet has been created and is in formal review. The model is also a key element in the CDI Data Management website (http://www.usgs.gov/datamanagement/index.php). For further information, contact John Faundeen, USGS EROS, faundeen@usgs.gov.

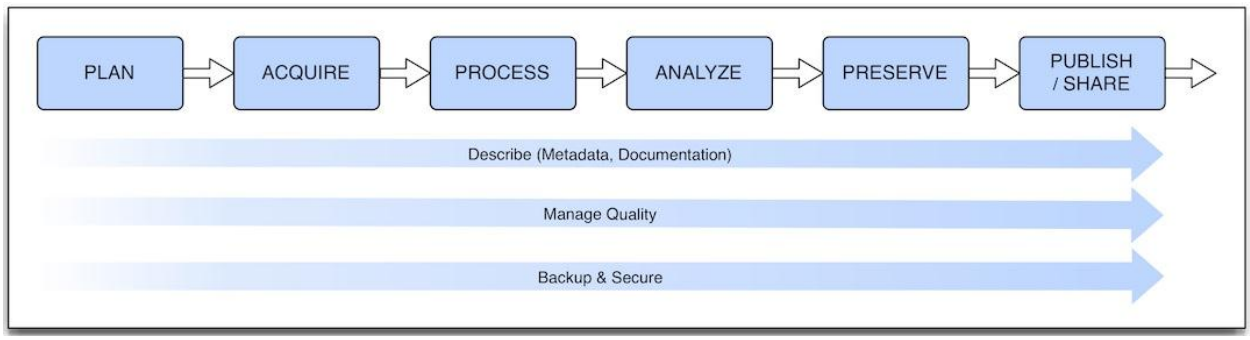


Figure 62. USGS scientific data life cycle model.

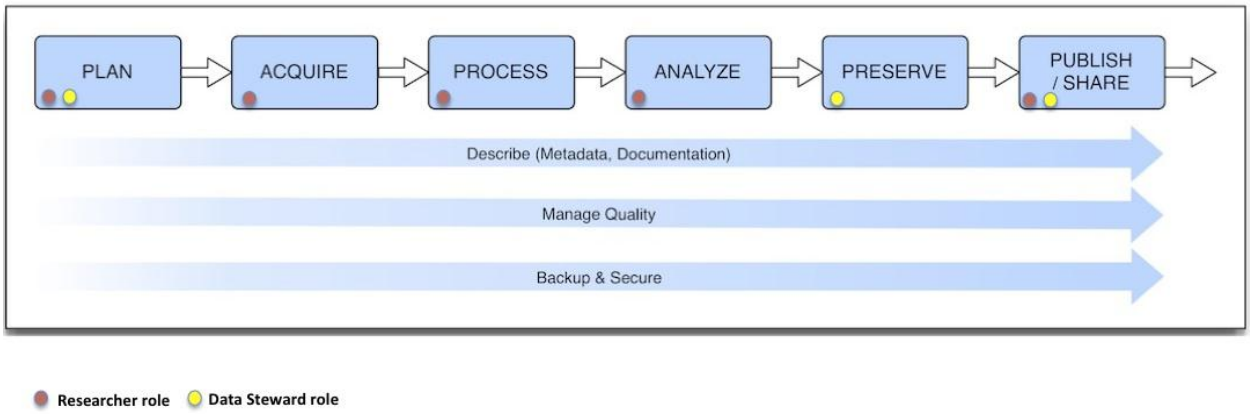


Figure 63. The U.S. Geological Survey's scientific data life cycle model with associated roles.

Sharing Science with the World

The Communications and Outreach (C&O) project at the USGS EROS Center increases awareness, understanding, and support of the Center's mission and endeavors. C&O employs community outreach and visibility strategies to cultivate increased recognition and support locally and nationwide.

A major focus of this project is the formulation and implementation of strategic communication initiatives, plans, and events that support a desired image and sets of perceptions of the USGS. An example of these efforts is the graphic displays designed to support the 40th Anniversary of the Landsat program. Working with the USGS LRS Communications Team and the NASA Public Affairs Office Communications Team, EROS staff developed a traveling exhibit of the visual history of the Landsat satellites and program. The exhibit was used at the announcement ceremony and several National conferences around the country. Staff also developed a series of pull-up display banners highlighting the Landsat satellites and examples of their imagery (figs. 64a and 64b), a website devoted to the public selection of the top five images from the Earth as Art series (fig. 65); which received over 14,000 "votes" from people worldwide, created displays for the Smithsonian National Air and Space Museum, and large wall displays that were exhibited at the Environmental Systems Research Institute's International Users Conference.

Understanding the changes to the Earth's surface is more easily comprehended using satellite imagery. To support this understanding, C&O web staff redesigned the Earthshots website (http://earthshots.usgs.gov/earthshots/). The clean, modern look and feel of the website, along with a more user-friendly flow, provides users a clearer insight into the changes captured by the satellite images over time for locations around the world.

The EROS Library strives to assist the scientists and other professionals at EROS with their research and publications. Staff provided literature and reference searches, assisted with interlibrary loans, maintained the library's digital archive, and assisted staff with the publications tracking system. To make the published work available to external users, C&O developed a publication search tool which easily withstands a large amount of simultaneous users.

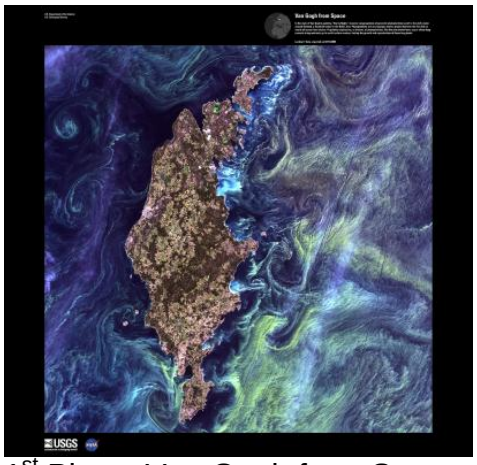
C&O staff supported media requests by providing imagery, producing a number of "Views of the News" comparison images and Image of the Week posters.

How the data gathered at EROS is used by our scientists and researchers is the main focus of our educational outreach. C&O staff supported USGS booths at national and local levels, gave presentations at community and educational events, coordinated job shadows, and developed new student hands-on activities for classroom activities.

Not to be left out, C&O welcomed 5,676 visitors, provided 334 tours, and coordinated 14 VIP tours. For further information, contact Janice Nelson, USGS EROS, jsnelson@usgs.gov.

Figure 64a. Series of pull-up display banners highlighting the Landsat satellites.

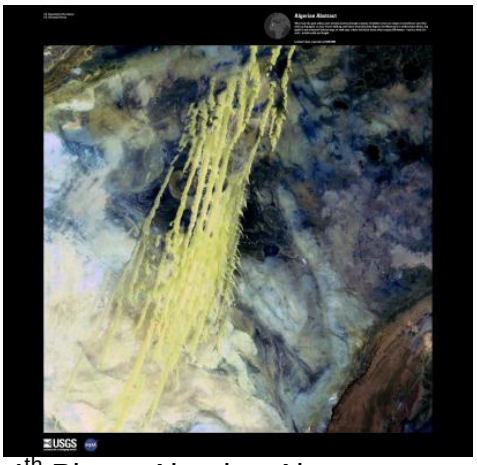
Figure 64b. Pull-up display banners highlighting the Landsat satellites' imagery.



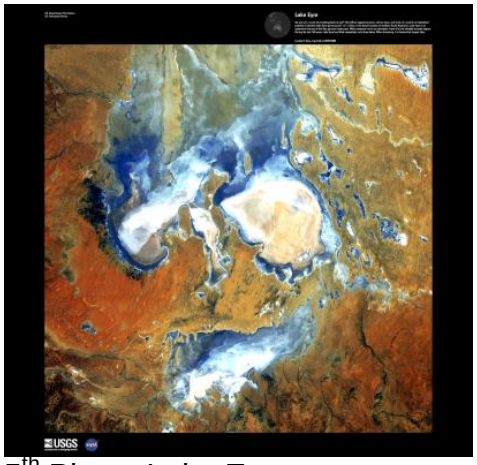
1st Place, Van Gogh from Space

2nd Place, Yukon Delta

3rd Place, Meandering Mississippi



4th Place, Algerian Abstract



5th Place, Lake Eyre

Figure 65. These are the top five images used in the Earth as Art series, which received over 14,000 “votes” from people worldwide.

Conclusion

The EROS mission, *contributing to the understanding of a changing Earth*, is specifically focused on land change monitoring. This focus is consistent with the USGS geographic research focus on land change science and with the USGS vision to provide "science for a changing world."

As program planning for 2014-2015 is underway, the accomplishments of 2012 and initiating actions of 2013 are making great strides in achieving our mission goals in global land change monitoring while advancing our vision of higher levels of service to the Nation and our planet.

Communication with our expanding constituent, customer, and user base is vital to achieving our mission and the success of our projects and activities. To communicate with us or for more information about EROS, contact Thomas Holm holm@usgs.gov or Janice Nelson jsnelson@usgs.gov, National Policy, Communications, and Outreach Office, USGS EROS Center, 47914 252nd Street, Sioux Falls, South Dakota 57198, http://eros.usgs.gov/.

Appendix A. FY 2012 Research and Technical Publications

Executive Summary of Research and Technical Publications

In FY 2012, 150 scientists, engineers, and information professionals from throughout the USGS EROS Center contributed to the Center's extensive publishing record in comparison to 119 in FY 2011. The complete record for fiscal 2012 totaled 269 publications, compared to 217 publications in the previous year. The 2012 record included:

- 104 journal articles (17 of which were published in a top-ranking journal as measured by Thomas Reuters Impact Factor: *Agriculture, Ecosystems, and Environment*, *Global Change Biology*, *Limnology and Oceanography*, and *Remote Sensing of Environment;* 7 of which were published in a Landsat Legacy Special Issue of *Remote Sensing of Environment;* 1 of which was an Invited Paper in *Proceedings of the Institute of Electrical and Electronics Engineers, Inc.)*
- 1 edited book
- 31 reports (25 of which were USGS Series reports)
- 11 book chapters
- 122 conference presentations (full papers, abstracts, posters, and slide presentations)

The following 18 bibliographic citations from FY 2012 are provided for those journal articles published in the 4 top-ranking journals and for the 1 invited paper. When looking back to 2011, there were a total of 88 journal articles (11 of which were published in 6 top-ranking journals. To search all EROS publications, see http://eros.usgs.gov/#/Publications. For further information, contact Janice Nelson, USGS EROS, jsnelson@usgs.gov.

Chuang, T.W., Henebry, G.M., Kimball, J.S., VanRoekel-Patton, D.L., Hildreth, M.B., and Wimberly, M.C., 2012, **Satellite microwave remote sensing for environmental modeling of mosquito population dynamics**: Remote Sensing of Environment, v. 125, p. 147-156. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.07.018.)

Colditz, R.R., Schmidt, M., Conrad, C., Hansen, M.C., and Dech, S., 2011, **Land cover classification with coarse spatial resolution data to derive continuous and discrete maps for complex regions**: Remote Sensing of Environment, v. 115, no. 12, p. 3264-3275. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.07.010.)

Duda, K.A., and Abrams, M., 2012, **ASTER satellite observations for international disaster management**: Proceedings of the IEEE, v. 100, no. 10, p. 2798-2811. (Also available online at http://dx.doi.org/10.1109/JPROC.2012.2191929.) Invited Paper

Goward, S.N., Chander, G., Pagnutti, M., Marx, A., Ryan, R., Thomas, N., and Tetrault, R., 2012, **Complementarity of ResourceSat-1 AWiFS and Landsat TM/ETM+ sensors**: Remote Sensing of Environment, v. 123, p. 41-56. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.03.002.)

Hansen, M.C., and Loveland, T.R., 2012, **A review of large area monitoring of land cover change using Landsat data**: Remote Sensing of Environment, v. 122, p. 66-74. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.024.)
Landsat Legacy Special Issue

Hicke, J.A., Allen, C.D., Desai, A.R., Dietze, M.C., Hall, R.J., Hogg, E.H., Kashian, D.M., Moore, D., Raffa, K.F., Sturrock, R.N., and Vogelmann, J.E., 2012, **Effects of biotic disturbances on forest carbon cycling in the United States and Canada**: Global Change Biology, v. 18, no. 1, p. 7-34. (Also available online at http://dx.doi.org/10.1111/j.1365-2486.2011.02543.x.)

Huang, S., Dahal, D., Young, C.J., Chander, G., and Liu, S., 2011, **Integration of Palmer Drought Severity Index and remote sensing data to simulate wetland water surface from 1910 to 2009 in Cottonwood Lake area, North Dakota**: Remote Sensing of Environment, v. 115, no. 12, p. 3377-3389. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.002.)

Irons, J.R., Dwyer, J.L., and Barsi, J.A., 2012, **The next Landsat satellite—the Landsat Data Continuity Mission**: Remote Sensing of Environment, v. 122, p. 11-21. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.026.)
Landsat Legacy Special Issue

Ju, J., Roy, D.P., Vermote, E., Masek, J., and Kovalskyy, V., 2012, **Continental-scale validation of MODIS-based and LEDAPS Landsat ETM+ atmospheric correction methods**: Remote Sensing of Environment, v. 122, p. 175-184. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.12.025.)
Landsat Legacy Special Issue

Loveland, T.R., and Dwyer, J.L., 2012, **Landsat—building a strong future**: Remote Sensing of Environment, v. 122, p. 22-29. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.09.022.)
Landsat Legacy Special Issue

McDonald, C.P., Rover, J.A., Stets, E.G., and Striegl, R.G., 2012, **The regional abundance and size distribution of lakes and reservoirs in the United States and implications for estimates of global lake extent**: Limnology and Oceanography, v. 57, no. 2, p. 597-606. (Also available online at http://dx.doi.org/10.4319/lo.2012.57.2.0597.)

Potapov, P.V., Turubanova, S.A., Hansen, M.C., Adusei, B., Broich, M., Altstatt, A., Mane, L., and Justice, C.O., 2012, **Quantifying forest cover loss in Democratic Republic of the Congo, 2000–2010, with Landsat ETM+ data**: Remote Sensing of Environment, v. 122, p. 106-116. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.027.)
Landsat Legacy Special Issue

Selkowitz, D.J., Green, G., Peterson, B.E., and Wylie, B.K., 2012, **A multi-sensor lidar, multi-spectral and multi-angular approach for mapping canopy height in boreal forest regions**: Remote Sensing of Environment, v. 121, p. 458-471. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.02.020.)

Sohl, T.L., Sleeter, B.M., Sayler, K.L., Bouchard, M.A., Reker, R.R., Bennett, S.L., Sleeter, R.R., Kanengieter, R.L., and Zhu, Z., 2012, **Spatially explicit land-use and land-cover scenarios for the Great Plains of the United States**: Agriculture, Ecosystems and Environment, v. 153, p. 1-15. (Also available online at http://dx.doi.org/10.1016/j.agee.2012.02.019.)

Tulbure, M.G., Wimberly, M.C., Boe, A., and Owens, V.N., 2012, **Climatic and genetic controls of yields of switchgrass, a model bioenergy species**: Agriculture, Ecosystems and Environment, v. 146, no. 1, p. 121-129. (Also available online at http://dx.doi.org/10.1016/j.agee.2011.10.017.)

Vogelmann, J.E., Xian, G., Homer, C.G., and Tolk, B.L., 2012, **Monitoring gradual ecosystem change using Landsat time series analyses—case studies in selected forest and rangeland ecosystems**: Remote Sensing of Environment, v. 122, p. 92-105. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.06.027.)
Landsat Legacy Special Issue

Wulder, M.A., Masek, J.G., Cohen, W.B., Loveland, T.R., and Woodcock, C.E., 2012, **Opening the archive—how free data has enabled the science and monitoring promise of Landsat**: Remote Sensing of Environment, v. 122, p. 2-10. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.01.010.)
Landsat Legacy Special Issue

Zhou, G., Wei, X., Wu, Y., Liu, S., Huang, Y., Yan, J., Zhang, D.X., Zhang, Q., Liu, J., Meng, Z., Wang, C., Chu, G., Liu, S., Tang, X., and Liu, X., 2011, **Quantifying the hydrological responses to climate change in an intact forested small watershed in southern China**: Global Change Biology, v. 17, no. 12, p. 3736-3746. (Also available online at http://dx.doi.org/10.1111/j.1365-2486.2011.02499.x.)

Complete Record of Research and Technical Publications

The work cited is the complete record of the Center's work published in FY 2012. Names in bold type are affiliated with EROS. Online addresses are provided, where available. If a problem or an error is experienced while attempting to access an address, you may need to copy and paste that address into your Web browser for access. To search all EROS publications, see http://eros.usgs.gov/#/Publications. For further information, contact Janice Nelson, USGS EROS, jsnelson@usgs.gov.

Journal Articles

Auch, R.F., Napton, D.E., Kambly, S., Moreland, T.R., and **Sayler, K.L.**, 2012, The driving forces of land change in the northern Piedmont of the United States: Geographical Review, v. 102, no. 1, p. 53-75. (Also available online at http://dx.doi.org/10.1111/j.1931-0846.2012.00130.x.)

Barber, C.P., **Cochrane, M.A.**, Souza, C., and Veríssimo, A., 2012, Dynamic performance assessment of protected areas: Biological Conservation, v. 149, no. 1, p. 6-14. (Also available online at http://dx.doi.org/10.1016/j.biocon.2011.08.024.)

Barlow, J., Parry, L., Gardner, T.A., Ferreira, J., Aragão, L.E.O.C., Carmenta, R., Berenguer, E., Vieira, I.C.G., Souza, C., and **Cochrane, M.A.**, 2012, The critical importance of considering fire in REDD+ programs: Biological Conservation, v. 154, p. 1-8. (Also available online at http://dx.doi.org/10.1016/j.biocon.2012.03.034.)

Barlow, J., Silveira, J.M., Mestre, L.A.M., Andrade, R.B., Camacho D'Andrea, G., Louzada, J., Vaz-de-Mello, F.Z., Numata, I., Lacau, S., and **Cochrane, M.A.**, 2012, Wildfires in bamboo-dominated Amazonian forest—impacts on above-ground biomass and biodiversity: PLoS ONE, v. 7, no. 3, article number e33373. (Also available online at http://dx.doi.org/10.1371/journal.pone.0033373.)

Bartelt, P.E., **Gallant, A.L., Klaver, R.W.,** Wright, C.K., Patla, D.A., and Peterson, C.R., 2011, Predicting breeding habitat for amphibians—a spatiotemporal analysis across Yellowstone National Park: Ecological Applications, v. 21, no. 7, p. 2530-2547. (Also available online at http://dx.doi.org/10.1890/10-1261.1.)

Bowman, D.M.J.S., Balch, J., Artaxo, P., Bond, W.J., **Cochrane, M.A.**, D'Antonio, C.M., Defries, R., Johnston, F.H., Keeley, J.E., Krawchuk, M.A., Kull, C.A., Mack, M., Moritz, M.A., Pyne, S., Roos, C.I., Scott, A.C., Sodhi, N.S., and Swetnam, T.W., 2011, The human dimension of fire regimes on Earth: Journal of Biogeography, v. 38, no. 12, p. 2223-2236. (Also available online at http://dx.doi.org/10.1111/j.1365-2699.2011.02595.x.)

Ceccato, P., Vancutsem, C., **Klaver, R.W., Rowland, J.D.**, and Connor, S.J., 2012, A vectorial capacity product to monitor changing malaria transmission potential in epidemic regions of Africa: Journal of Tropical Medicine, v. 2012, article ID 595948. (Also available online at http://dx.doi.org/10.1155/2012/595948.)

Chang, R., Fu, B., Liu, G., and **Liu, S.**, 2011, Soil carbon sequestration potential for "Grain for Green" Project in Loess Plateau, China: Environmental Management, v. 48, no. 6, p. 1158-1172. (Also available online at http://dx.doi.org/10.1007/s00267-011-9682-8.)

Chen, X., Vogelmann, J.E., Rollins, M.G., Ohlen, D.O., Key, C.H., **Yang, L.**, Huang, C., and Shi, H., 2011, Detecting post-fire burn severity and vegetation recovery using multitemporal remote sensing spectral indices and field-collected Composite Burn Index data in a ponderosa pine forest: International Journal of Remote Sensing, v. 32, no. 23, p. 7905-7927. (Also available online at http://www.tandfonline.com/doi/abs/10.1080/01431161.2010.524678.)

Chuang, T.W., **Henebry, G.M.**, Kimball, J.S., VanRoekel-Patton, D.L., Hildreth, M.B., and **Wimberly, M.C.**, 2012, Satellite microwave remote sensing for environmental modeling of mosquito population dynamics: Remote Sensing of Environment, v. 125, p. 147-156. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.07.018.)

Chuang, T.W., Hockett, C.W., Kightlinger, L., and **Wimberly, M.C.**, 2012, Landscape-level spatial patterns of West Nile virus risk in the northern Great Plains: American Journal of Tropical Medicine and Hygiene, v. 86, no. 4, p. 724-731. (Also available online at http://dx.doi.org/10.4269/ajtmh.2012.11-0515.)

Cochrane, M.A., Moran, C.J., Wimberly, M.C., Baer, A.D., Finney, M.A., **Beckendorf, K.L., Eidenshink, J.C.**, and Zhu, Z., 2012, Estimation of wildfire size and risk changes due to fuels treatments: International Journal of Wildland Fire, v. 21, no. 4, p. 357-367. (Also available online at http://dx.doi.org/10.1071/WF11079.)

Colditz, R.R., Schmidt, M., Conrad, C., **Hansen, M.C.**, and Dech, S., 2011, Land cover classification with coarse spatial resolution data to derive continuous and discrete maps for complex regions: Remote Sensing of Environment, v. 115, no. 12, p. 3377-3389 (Also available online at http://dx.doi.org/10.1016/j.rse.2011.07.010.)

Delamater, P.L., Messina, J.P., Qi, J.G., and **Cochrane, M.A.**, 2012, A hybrid visual estimation method for the collection of ground truth fractional coverage data in a humid tropical environment: International Journal of Applied Earth Observation and Geoinformation, v. 18, p. 504-514. (Also available online at http://dx.doi.org/10.1016/j.jag.2011.10.005.)

Dietze, M.C., Vargas, R., Richardson, A.D., Stoy, P.C., Barr, A.G., Anderson, R.S., Arain, M.A., Baker, I.T., Black, T.A., Chen, J.M., Ciais, P., Flanagan, L.B., Gough, C.M., Grant, R.F., Hollinger, D., Izaurralde, R.C., Kucharik, C.J., Lafleur, P., **Liu, S.**, Lokupitiya, E., Luo, Y., Munger, J.W., Peng, C., Poulter, B., Price, D.T., Ricciuto, D.M., Riley, W.J., Sahoo, A.K., Schaefer, K., Suyker, A.E., Tian, H., Tonitto, C., Verbeeck, H., Verma, S.B., Wang, W., and Weng, E., 2011, Characterizing the performance of ecosystem models across time scales—a spectral analysis of the North American Carbon Program site-level synthesis: Journal of Geophysical Research G—Biogeosciences, v. 116, no. G4, p. G04029. (Also available online at http://dx.doi.org/10.1029/2011jg001661.)

Dieye, A.M., Roy, D.P., Hanan, N.P., **Liu, S.**, Hansen, M.C., and Touré, A., 2012, Sensitivity analysis of the GEMS soil organic carbon model to land cover land use classification uncertainties under different climate scenarios in Senegal: Biogeosciences, v. 9, no. 2, p. 631-648, available only online at http://dx.doi.org/10.5194/bg-9-631-2012.

Drummond, M.A., **Auch, R.F., Karstensen, K.A., Sayler, K.L., Taylor, J.L.,** and **Loveland, T.R.**, 2012, Land change variability and human–environment dynamics in the United States Great Plains: Land Use Policy, v. 29, no. 3, p. 710-723. (Also available online at http://dx.doi.org/10.1016/j.landusepol.2011.11.007.)

Duda, K.A., and Abrams, M., 2012, ASTER satellite observations for international disaster management: Proceedings of the IEEE, v. 100, no. 10, p. 2798-2811. (Also available online at http://dx.doi.org/10.1109/JPROC.2012.2191929.)

Gallo, K.P., Smith, T., Jungbluth, K., and Schumacher, P., 2012, Hail swaths observed from satellite data and their relation to radar and surface-based observations—case study from Iowa in 2009: Weather and Forecasting, v. 27, no. 3, p. 796-802. (Also available online at http://dx.doi.org/10.1175/WAF-D-11-00118.1.)

Giri, C.P., Long, J.B., and **Tieszen, L.L.**, 2011, Mapping and monitoring Louisiana's mangroves in the aftermath of the 2010 Gulf of Mexico Oil spill: Journal of Coastal Research, v. 27, no. 6, p. 1059-1064. (Also available online at http://dx.doi.org/10.2112/JCOASTRES-D-11-00028.1.)

Goward, S.N., **Chander, G.**, Pagnutti, M., Marx, A., Ryan, R., Thomas, N., and Tetrault, R., 2012, Complementarity of ResourceSat-1 AWiFS and Landsat TM/ETM+ sensors: Remote Sensing of Environment, v. 123, p. 41-56. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.03.002.)

Grovenburg, T.W., **Klaver, R.W.**, and Jenks, J.A., 2012, Spatial ecology of white-tailed deer fawns in the northern Great Plains—implications of loss of Conservation Reserve Program grasslands: Journal of Wildlife Management, v. 76, no. 3, p. 632-644. (Also available online at http://dx.doi.org/10.1002/jwmg.288.)

Grovenburg, T.W., **Klaver, R.W.**, and Jenks, J.A., 2012, Survival of white-tailed deer fawns in the grasslands of the northern Great Plains: Journal of Wildlife Management, v. 76, no. 5, p. 944-956. (Also available online at http://dx.doi.org/10.1002/jwmg.339.)

Gu, Y., Boyte, S.P., Wylie, B.K., and **Tieszen, L.L.**, 2012, Identifying grasslands suitable for cellulosic feedstock crops in the Greater Platte River basin—dynamic modeling of ecosystem performance with 250 m eMODIS: Global Change Biology Bioenergy, v. 4, no. 1, p. 96-106. (Also available online at http://dx.doi.org/10.1111/j.1757-1707.2011.01113.x.)

Gu, Y., Howard, D.M., Wylie, B.K., and Zhang, L., 2012, Mapping carbon flux uncertainty and selecting optimal locations for future flux towers in the Great Plains: Landscape Ecology, v. 27, no. 3, p. 319-326. (Also available online at http://dx.doi.org/10.1007/s10980-011-9699-7.)

Gu, Y., Wylie, B.K., and **Bliss, N.B.**, 2013, Mapping grassland productivity with 250-m eMODIS NDVI and SSURGO database over the Greater Platte River basin, USA: Ecological Indicators, v. 24, p. 31-36. (Also available online at http://dx.doi.org/10.1016/j.ecolind.2012.05.024.)

Hansen, M.C., and **Loveland, T.R.**, 2012, A review of large area monitoring of land cover change using Landsat data: Remote Sensing of Environment, v. 122, p. 66-74. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.024.)

Helder, D.L., Karki, S., Bhatt, R., **Micijevic, E.**, Aaron, D., and Jasinski, B., 2012, Radiometric calibration of the Landsat MSS sensor series: IEEE Transactions on Geoscience and Remote Sensing, v. 50, no. 6, p. 2380-2399. (Also available online at http://dx.doi.org/10.1109/TGRS.2011.2171351.)

Helder, D.L., Malla, R., Mettler, C.J., Markham, B.L., and **Micijevic, E.**, 2012, Landsat 4 Thematic Mapper calibration update: IEEE Transactions on Geoscience and Remote Sensing, v. 50, no. 6, p. 2400-2408. (Also available online at http://dx.doi.org/10.1109/tgrs.2011.2171350.)

Henebry, G.M., 2011, Beyond words—effective graphics and metadata are keys to concise scientific communication: Landscape Ecology, v. 26, no. 10, p. 1355-1358. (Also available online at http://dx.doi.org/10.1007/s10980-011-9672-5.)

Hicke, J.A., Allen, C.D., Desai, A.R., Dietze, M.C., Hall, R.J., Hogg, E.H., Kashian, D.M., Moore, D., Raffa, K.F., Sturrock, R.N., and **Vogelmann, J.E.**, 2012, Effects of biotic disturbances on forest carbon cycling in the United States and Canada: Global Change Biology, v. 18, no. 1, p. 7-34. (Also available online at http://dx.doi.org/10.1111/j.1365-2486.2011.02543.x.)

Homer, C.G., Aldridge, C.L., **Meyer, D.K.**, and Schell, S.J., 2012, Multi-scale remote sensing sagebrush characterization with regression trees over Wyoming, USA—laying a foundation for monitoring: International Journal of Applied Earth Observation and Geoinformation, v. 14, no. 1, p. 233-244. (Also available online at http://dx.doi.org/10.1016/j.jag.2011.09.012.)

Howard, D.M., Wylie, B.K., and **Tieszen, L.L.**, 2012, Crop classification modelling using remote sensing and environmental data in the Greater Platte River basin, USA: International Journal of Remote Sensing, v. 33, no. 19, p. 6094-6108. (Also available online at http://dx.doi.org/10.1080/01431161.2012.680617.)

Huang, S., Dahal, D., Young, C.J., Chander, G., and **Liu, S.**, 2011, Integration of Palmer Drought Severity Index and remote sensing data to simulate wetland water surface from 1910 to 2009 in Cottonwood Lake area, North Dakota: Remote Sensing of Environment, v. 115, no. 12, p. 3377-3389. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.002.)

Huntzinger, D.N., Post, W.M., Wei, Y., Michalak, A.M., West, T.O., Jacobson, A.R., Baker, I.T., Chen, J.M., Davis, K.J., Hayes, D.J., Hoffman, F.M., Jain, A.K., **Liu, S.**, McGuire, A.D., Neilson, R.P., Potter, C., Poulter, B., Price, D.T., Raczka, B.M., Tian, H.Q., Thornton, P., Tomelleri, E., Viovy, N., Xiao, J., Yuan, W., Zeng, N., Zhao, M., and Cook, R., 2012, North American Carbon Program (NACP) regional interim synthesis—terrestrial biospheric model intercomparison: Ecological Modelling, v. 232, p. 144-157. (Also available online at http://dx.doi.org/10.1016/j.ecolmodel.2012.02.004.)

Irons, J.R., **Dwyer, J.L.**, and Barsi, J.A., 2012, The next Landsat satellite—the Landsat Data Continuity Mission: Remote Sensing of Environment, v. 122, p. 11-21. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.026.)

Ji, L., Wylie, B.K., Nossov, D.R., **Peterson, B.E.**, Waldrop, M.P., McFarland, J.W., **Rover, J.A.**, and Hollingsworth, T.N., 2012, Estimating aboveground biomass in interior Alaska with Landsat data and field measurements: International Journal of Applied Earth Observation and Geoinformation, v. 18, p. 451-461. (Also available online at http://dx.doi.org/10.1016/j.jag.2012.03.019.)

Ji, L., Zhang, L., **Wylie, B.K.**, and **Rover, J.A.**, 2011, On the terminology of the spectral vegetation index (NIR – SWIR)/(NIR + SWIR)—Technical Note: International Journal of Remote Sensing, v. 32, no. 21, p. 6901-6909. (Also available online at http://dx.doi.org/10.1080/01431161.2010.510811.)

Johnson, K.D., Harden, J.A., McGuire, A.D., **Bliss, N.B.**, Bockheim, J.G., Clark, M., Nettleton-Hollingsworth, T., Jorgenson, M.T., Kane, E.S., Mack, M., O'Donnell, J., Ping, C.-L., Schuur, E.A.G., Turetsky, M.R., and Valentine, D.W., 2011, Soil carbon distribution in Alaska in relation to soil-forming factors: Geoderma, v. 167-168, p. 71-84. (Also available online at http://dx.doi.org/10.1016/j.geoderma.2011.10.006.)

Ju, J., **Roy, D.P.**, Vermote, E., Masek, J., and Kovalskyy, V., 2012, Continental-scale validation of MODIS-based and LEDAPS Landsat ETM+ atmospheric correction methods: Remote Sensing of Environment, v. 122, p. 175-184. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.12.025.)

Klaver, R.W., Backlund, D., Bartelt, P.E., Erickson, M.G., Knowles, C.J., Knowles, P.R., and **Wimberly, M.C.**, 2012, Spatial analysis of Northern Goshawk territories in the Black Hills, South Dakota: Condor, v. 114, no. 3, p. 532-543. (Also available online at http://dx.doi.org/10.1525/cond.2012.110080.)

Koh, L.P., Gibbs, H.K., Potapov, P.V., and **Hansen, M.C.**, 2012, REDDcalculator.com—a web-based decision-support tool for implementing Indonesia's forest moratorium: Methods in Ecology and Evolution, v. 3, no. 2, p. 310-316. (Also available online at http://dx.doi.org/10.1111/j.2041-210X.2011.00147.x.)

Kovalskyy, V., and **Henebry, G.M.**, 2012, Alternative methods to predict actual evapotranspiration illustrate the importance of accounting for phenology - Part 2—The event driven phenology model: Biogeosciences, v. 9, no. 1, p. 161-177, available only online at http://dx.doi.org/10.5194/bg-9-161-2012.

Kovalskyy, V., and **Henebry, G.M.**, 2012, A new concept for simulation of vegetated land surface dynamics - Part 1—The event driven phenology model: Biogeosciences, v. 9, no. 1, p. 141-159, available only online at http://dx.doi.org/10.5194/bg-9-141-2012.

Kovalskyy, V., **Roy, D.P.**, Zhang, X.Y., and Ju, J., 2012, The suitability of multi-temporal Web-Enabled Landsat Data (WELD) NDVI for phenological monitoring—a comparison with flux tower and MODIS NDVI: Remote Sensing Letters, v. 3, no. 4, p. 325-334. (Also available online at http://www.tandfonline.com/doi/abs/10.1080/01431161.2011.593581.)

Kumar, S.S., **Roy, D.P.**, Boschetti, L., and Kremens, R., 2011, Exploiting the power law distribution properties of satellite fire radiative power retrievals—a method to estimate fire radiative energy and biomass burned from sparse satellite observations: Journal of Geophysical Research D—Atmospheres, v. 116, no. D19, citation number D19303. (Also available online at http://dx.doi.org/10.1029/2011jd015676.)

Lee, C.-W., Lu, Z., and Jung, H.-S., 2012, Simulation of time-series surface deformation to validate a multi-interferogram InSAR processing technique: International Journal of Remote Sensing, v. 33, no. 22, p. 7075-7087. (Also available online at http://dx.doi.org/10.1080/01431161.2012.700137.)

Li, D., Wang, C., Hu, Y., and **Liu, S.**, 2012, General review on remote sensing-based biomass estimation: Geomatics and Information Science of Wuhan University, v. 37, no. 6, p. 631-635. (Also available online at http://www.oriprobe.com/journals/whchkjdxxb/2012_6.html.)

Liebmann, B., Blad, I., Kiladis, G.N., Carvalho, L.M.V., **Senay, G.B.**, Allured, D., Leroux, S., and **Funk, C.C.**, 2012, Seasonality of African precipitation from 1996 to 2009: Journal of Climate, v. 25, no. 12, p. 4304-4322. (Also available online at http://dx.doi.org/10.1175/JCLI-D-11-00157.1.)

Lioubimtseva, E., and **Henebry, G.M.**, 2012, Grain production trends in Russia, Ukraine and Kazakhstan—new opportunities in an increasingly unstable world?: Frontiers of Earth Science, v. 6, no. 2, p. 157-166. (Also available online at http://dx.doi.org/10.1007/s11707-012-0318-y.)

Liu, S., Bond-Lamberty, B., Hicke, J.A., Vargas, R., Zhao, S., Chen, J., Edburg, S.L., Liu, J., McGuire, A.D., Xiao, J., Keane, R., Yuan, W., Tang, J., Luo, Y., Potter, C., and **Oeding, J.**, 2011, Simulating the impacts of disturbances on forest carbon cycling in North America—processes, data, models, and challenges: Journal of Geophysical Research G—Biogeosciences, v. 116, citation number G00K08. (Also available online at http://dx.doi.org/10.1029/2010JG001585.)

Loveland, T.R., and **Dwyer, J.L.**, 2012, Landsat—building a strong future: Remote Sensing of Environment, v. 122, p. 22-29. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.09.022.)

Lü, Y., **Liu, S.**, and Fu, B., 2012, Ecosystem service—from virtual reality to ground truth: Environmental Science and Technology, v. 46, no. 5, p. 2492-2493. (Also available online at http://dx.doi.org/10.1021/es300475w.)

Markham, B.L., **Haque, M.O.**, Barsi, J.A., **Micijevic, E., Helder, D.L.**, Thome, K.J., Aaron, D., and Czapla-Myers, J.S., 2012, Landsat-7 ETM+—12 years on-orbit reflective-band radiometric performance: IEEE Transactions on Geoscience and Remote Sensing, v. 50, no. 5, pt. 2, p. 2056-2062. (Also available online at http://dx.doi.org/10.1109/tgrs.2011.2169803.)

Marshall, M., **Funk, C.C.**, and Michaelsen, J., 2012, Examining evapotranspiration trends in Africa: Climate Dynamics, v. 38, no. 9-10, p. 1849-1865. (Also available online at http://dx.doi.org/10.1007/s00382-012-1299-y.)

McDonald, C.P., **Rover, J.A.**, Stets, E.G., and Striegl, R.G., 2012, The regional abundance and size distribution of lakes and reservoirs in the United States and implications for estimates of global lake extent: Limnology and Oceanography, v. 57, no. 2, p. 597-606. (Also available online at http://dx.doi.org/10.4319/lo.2012.57.2.0597.)

Minsley, B.J., Abraham, J.D., Smith, B.D., Cannia, J.C., Voss, C.I., Jorgenson, M.T., Walvoord, M.A., **Wylie, B.K.**, Anderson, L., Ball, L.B., Deszcz-Pan, M., Wellman, T.P., and Ager, T.A., 2012, Airborne electromagnetic imaging of discontinuous permafrost: Geophysical Research Letters, v. 39, no. L02503, citation number L02503. (Also available online at http://dx.doi.org/10.1029/2011GL050079.)

Moran, C.J., and **Cochrane, M.A.**, 2012, Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? Comment: Ecology, v. 93, no. 4, p. 939-941. (Also available online at http://dx.doi.org/10.1890/11-1035.1.)

Narayanaraj, G., and **Wimberly, M.C.**, 2012, Influences of forest roads on the spatial patterns of human- and lightning-caused wildfire ignitions: Applied Geography, v. 32, no. 2, p. 878-888. (Also available online at http://dx.doi.org/10.1016/j.apgeog.2011.09.004.)

Numata, I., **Cochrane, M.A.**, Souza, C.M., and Sales, M.H., 2011, Carbon emissions from deforestation and forest fragmentation in the Brazilian Amazon, Environmental Research Letters, v. 6, no. 4, p. 1-7, available only online at http://dx.doi.org/10.1088/1748-9326/6/4/044003.

Potapov, P.V., Turubanova, S.A., **Hansen, M.C.**, Adusei, B., Broich, M., Altstatt, A., Mane, L., and Justice, C.O., 2012, Quantifying forest cover loss in Democratic Republic of the Congo, 2000–2010, with Landsat ETM+ data: Remote Sensing of Environment, v. 122, p. 106-116. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.08.027.)

Ramsey III, E., Werle, D., Suzuoki, Y., Rangoonwala, A., and **Lu, Z.**, 2012, Limitations and potential of satellite imagery to monitor environmental response to coastal flooding: Journal of Coastal Research, v. 28, no. 2, p. 457-476. (Also available online at http://dx.doi.org/10.2112/jcoastres-d-11-00052.1.)

Rebelo, L.M., **Senay, G.B.**, and McCartney, M.P., 2012, Flood pulsing in the Sudd wetland—analysis of seasonal variations in inundation and evaporation in south Sudan: Earth Interactions, v. 16, no. 1, p. 1-19. (Also available online at http://dx.doi.org/10.1175/2011EI382.1.)

Rover, J.A., Ji, L., Wylie, B.K., and **Tieszen, L.L.**, 2012, Establishing water body areal extent trends in interior Alaska from multi-temporal Landsat data: Remote Sensing Letters, v. 3, no. 4, p. 595-604. (Also available online at http://dx.doi.org/10.1080/01431161.2011.643507.)

Scaramuzza, P.L., Bouchard, M.A., and **Dwyer, J.L**., 2012, Development of the Landsat Data Continuity Mission cloud-cover assessment algorithms: IEEE Transactions on Geoscience and Remote Sensing, v. 50, no. 4, p. 1140 - 1154 (Also available online at http://dx.doi.org/10.1109/TGRS.2011.2164087.)

Schaefer, K., Schwalm, C.R., Williams, C., Arain, M.A., Barr, A., Chen, J.M., Davis, K.J., Dimitrov, D., Hilton, T.W., Hollinger, D.Y., Humphreys, E., Poulter, B., Raczka, B.M., Richardson, A.D., Sahoo, A., Thornton, P., Vargas, R., Verbeeck, H., Anderson, R., Baker, I., Black, T.A., Bolstad, P., Chen, J., Curtis, P.S., Desai, A.R., Dietze, M., Dragoni, D., Gough, C., Grant, R.F., Gu, L., Jain, A., Kucharik, C., Law, B., **Liu, S.**, Lokipitiya, E., Margolis, H.A., Matamala, R., McCaughey, J.H., Monson, R., Munger, J.W., Oechel, W., Peng, C., Price, D.T., Ricciuto, D., Riley, W.J., Roulet, N., Tian, H., Tonitto, C., Torn, M., Weng, E., and Zhou, X., 2012, A model-data comparison of gross primary productivity—results from the North American Carbon Program site synthesis: Journal of Geophysical Research G—Biogeosciences, v. 117, citation number G03010. (Also available online at http://dx.doi.org/10.1029/2012JG001960.)

Selkowitz, D.J., Green, G., **Peterson, B.E.**, and **Wylie, B.K.**, 2012, A multi-sensor lidar, multi-spectral and multi-angular approach for mapping canopy height in boreal forest regions: Remote Sensing of Environment, v. 121, p. 458-471. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.02.020.)

Senay, G.B., Leake, S., Nagler, P.L., **Artan, G.A.**, Dickinson, J., Cordova, J.T., and Glenn, E.P., 2011, Estimating basin scale evapotranspiration (ET) by water balance and remote sensing methods: Hydrological Processes, v. 25, no. 26, p. 4037-4049. (Also available online at http://dx.doi.org/10.1002/hyp.8379.)

Senay, G.B., Verdin, J.P., and **Rowland, J.D.**, 2011, Developing an operational rangeland water requirement satisfaction index: International Journal of Remote Sensing, v. 32, no. 21, p. 6047-6053. (Also available online at http://dx.doi.org/10.1080/01431161.2010.516028.)

Shen, D., Liu, Y., and **Huang, S.**, 2012, Annual accumulation over the Greenland ice sheet interpolated from historical and newly compiled observation data: Geografiska Annaler Series A—Physical Geography, v. 94, no. 3, p. 377-393. (Also available online at http://dx.doi.org/10.1111/j.1468-0459.2012.00458.x.)

Shrestha, M.S., **Artan, G.A.**, Bajracharya, S.R., Gautam, D.K., and Tokar, S.A., 2011, Bias-adjusted satellite-based rainfall estimates for predicting floods—Narayani basin: Journal of Flood Risk Management, v. 4, no. 4, p. 360-373. (Also available online at http://dx.doi.org/10.1111/j.1753-318X.2011.01121.x.)

Silva, L.C.R., Giorgis, M.A., Anand, M., Enrico, L., Pérez-Harguindeguy, N., Falczuk, V., **Tieszen, L.L.**, and Cabido, M., 2011, Evidence of shift in C_4 species range in central Argentina during the late Holocene: Plant and Soil, v. 349, no. 1-2, p. 261-279. (Also available online at http://dx.doi.org/10.1007/s11104-011-0868-x.)

Singh, R.K., Liu, S., Tieszen, L.L., Suyker, A.E., and Verma, S.B., 2012, Estimating seasonal evapotranspiration from temporal satellite images: Irrigation Science, v. 30, no. 4, p. 303-313. (Also available online at http://dx.doi.org/10.1007/s00271-011-0287-z.)

Singh, R.K., Liu, S., Tieszen, L.L., Suyker, A.E., and Verma, S.B., 2012, Novel approach for computing photosynthetically active radiation for productivity modeling using remotely sensed images in the Great Plains, United States: Journal of Applied Remote Sensing, v. 6, citation identifier 063522. (Also available online at http://dx.doi.org/10.1117/1.JRS.6.063522.)

Sleeter, B.M., **Sohl, T.L., Bouchard, M.A., Reker, R.R.**, Soulard, C.E., **Acevedo, W.**, Griffith, G.E., Sleeter, R.R., **Auch, R.F., Sayler, K.L.**, Prisley, S., and Zhu, Z., 2012, Scenarios of land use and land cover change in the conterminous United States—utilizing the special report on emission scenarios at ecoregional scales: Global Environmental Change, v. 22, no. 4, p. 896-914. (Also available online at http://dx.doi.org/10.1016/j.gloenvcha.2012.03.008.)

Sohl, T.L., Sleeter, B.M., **Sayler, K.L., Bouchard, M.A., Reker, R.R., Bennett, S.L.**, Sleeter, R.R., **Kanengieter, R.L.**, and Zhu, Z., 2012, Spatially explicit land-use and land-cover scenarios for the Great Plains of the United States: Agriculture, Ecosystems and Environment, v. 153, p. 1-15. (Also available online at http://dx.doi.org/10.1016/j.agee.2012.02.019.)

Sohl, T.L., Sleeter, B.M., Zhu, Z., **Sayler, K.L., Bennett, S.L., Bouchard, M.A., Reker**, **R.**, Hawbaker, T., Wein, A., **Liu, S., Kanengieter, R.**, and **Acevedo, W.**, 2012, A land-use and land-cover modeling strategy to support a national assessment of carbon stocks and fluxes: Applied Geography, v. 34, no. 0, p. 111-124. (Also available online at http://dx.doi.org/10.1016/j.apgeog.2011.10.019.)

Sohl, T.L., and Sohl, L.B., 2012, Land-use change in the Atlantic coastal pine barrens ecoregion: Geographical Review, v. 102, no. 2, p. 180-201. (Also available online at http://dx.doi.org/10.1111/j.1931-0846.2012.00142.x.)

Spindler, B.D., Chipps, S.R., Klumb, R.A., Graeb, B.D.S., and **Wimberly, M.C.**, 2012, Habitat and prey availability attributes associated with juvenile and early adult pallid sturgeon occurrence in the Missouri River, USA: Endangered Species Research, v. 16, no. 3, p. 225-234, available only online at http://dx.doi.org/10.3354/esr00408.

Thenkabail, P.S., Knox, J.W., Ozdogan, M., Gumma, M.K., Congalton, R.G., Wu, Z., Milesi, C., Finkral, A., Marshall, M., Mariotto, I., You, S., **Giri, C.P.**, and Nagler, P.L., 2012, Assessing future risks to agricultural productivity, water resources and food security—how can remote sensing help?: Photogrammetric Engineering and Remote Sensing, v. 78, no. 8, p. 773-782. (Also available online at http://www.asprs.org/Photogrammetric-Engineering-and-Remote-Sensing/PE-RS-Journals.html.)

Tulbure, M.G., **Wimberly, M.C.**, Boe, A., and Owens, V.N., 2012, Climatic and genetic controls of yields of switchgrass, a model bioenergy species: Agriculture, Ecosystems and Environment, v. 146, no. 1, p. 121-129. (Also available online at http://dx.doi.org/10.1016/j.agee.2011.10.017.)

Velpuri, N.M., **Senay, G.B.**, and Asante, K.O., 2012, A multi-source satellite data approach for modelling Lake Turkana water level—calibration and validation using satellite altimetry data: Hydrology and Earth System Sciences, v. 16, no. 1, p. 1-18, available only online at http://dx.doi.org/10.5194/hess-16-1-2012.

Vogelmann, J.E., Xian, G., Homer, C.G., and **Tolk, B.L.**, 2012, Monitoring gradual ecosystem change using Landsat time series analyses—case studies in selected forest and rangeland ecosystems: Remote Sensing of Environment, v. 122, p. 92-105. (Also available online at http://dx.doi.org/10.1016/j.rse.2011.06.027.)

Whiting, J.C., Olson, D.D., Shannon, J.M., Bowyer, R.T., **Klaver, R.W.**, and Flinders, J.T., 2012, Timing and synchrony of births in bighorn sheep—implications for reintroduction and conservation: Wildlife Research, v. 39, no. 7, p. 565-572. (Also available online at http://dx.doi.org/10.1071/WR12059.)

Wilson, R.T., Giroux, J., Kasicky, K.R., Fatupaito, B.H., **Wood, E.C.**, Crichlow, R., Rhodes, N.A.S., Tingueley, J., Walling, A., Langwell, K., and Cobb, N., 2011, Breast and cervical cancer screening patterns among American Indian women at IHS clinics in Montana and Wyoming: Public Health Reports, v. 126, no. 6, p. 806-815. (Also available online at http://www.publichealthreports.org/Issues.cfm.)

Wimberly, M.C., Midekisa, A., Semuniguse, P., Teka, H., **Henebry, G.M.**, Chuang, T.-W., and **Senay, G.B.**, 2012, Spatial synchrony of malaria outbreaks in a highland region of Ethiopia: Tropical Medicine & International Health, v. 17, no. 10, p. 1192-1201. (Also available online at http://dx.doi.org/10.1111/j.1365-3156.2012.03058.x.)

Wright, C.K., de Beurs, K.M., and **Henebry, G.M.**, 2012, Combined analysis of land cover change and NDVI trends in the northern Eurasian grain belt: Frontiers of Earth Science, v. 6, no. 2, p. 177-187. (Also available online at http://dx.doi.org/10.1007/s11707-012-0327-x.)

Wu, Y., and **Liu, S.**, 2012, Automating calibration, sensitivity and uncertainty analysis of complex models using the R package Flexible Modeling Environment (FME)—SWAT as an example: Environmental Modelling and Software, v. 31, p. 99-109. (Also available online at http://dx.doi.org/10.1016/j.envsoft.2011.11.013.)

Wu, Y., and **Liu, S.**, 2012, Impacts of biofuels production alternatives on water quantity and quality in the Iowa River basin: Biomass & Bioenergy, v. 36, p. 182-191. (Also available online at http://dx.doi.org/10.1016/j.biombioe.2011.10.030.)

Wu, Y., and **Liu, S.**, 2012, Modeling of land use and reservoir effects on nonpoint source pollution in a highly agricultural basin: Journal of Environmental Monitoring, v. 14, no. 9, p. 2350-2361. (Also available online at http://dx.doi.org/10.1039/c2em30278k.)

Wu, Y., Liu, S., and **Abdul-Aziz, O.I.**, 2012, Hydrological effects of the increased CO_2 and climate change in the Upper Mississippi River basin using a modified SWAT: Climatic Change, v. 110, no. 3-4, p. 977-1003. (Also available online at http://dx.doi.org/10.1007/s10584-011-0087-8.)

Wu, Y., Liu, S., and **Gallant, A.L.**, 2012, Predicting impacts of increased CO_2 and climate change on the water cycle and water quality in the semiarid James River Basin of the Midwestern USA: Science of the Total Environment, v. 430, p. 150-160. (Also available online at http://dx.doi.org/10.1016/j.scitotenv.2012.04.058.)

Wulder, M.A., Masek, J.G., Cohen, W.B., **Loveland, T.R.**, and Woodcock, C.E., 2012, Opening the archive—how free data has enabled the science and monitoring promise of Landsat: Remote Sensing of Environment, v. 122, p. 2-10. (Also available online at http://dx.doi.org/10.1016/j.rse.2012.01.010.)

Wylie, B.K., Boyte, S.P., and Major, D.J., 2012, Ecosystem performance monitoring of rangelands by integrating modeling and remote sensing: Rangeland Ecology and Management, v. 65, no. 4, p. 241-252. (Also available online at http://dx.doi.org/10.2111/REM-D-11-00058.1.)

Xian, G., Homer, C.G., and Aldridge, C.L., 2012, Assessing long-term variations in sagebrush habitat—characterization of spatial extents and distribution patterns using multi-temporal satellite remote-sensing data: International Journal of Remote Sensing, v. 33, no. 7, p. 2034-2058. (Also available online at http://dx.doi.org/10.1080/01431161.2011.605085.)

Xian, G., Homer, C.G., and Aldridge, C.L., 2012, Effects of land cover and regional climate variations on long-term spatiotemporal changes in sagebrush ecosystems: GIScience and Remote Sensing, v. 49, no. 3, p. 378-396. (Also available online at http://dx.doi.org/10.2747/1548-1603.49.3.378.)

Xian, G., Homer, C.G., Bunde, B., **Danielson, P., Dewitz, J.A., Fry, J.A.**, and Pu, R., 2012, Quantifying urban land cover change between 2001 and 2006 in the Gulf of Mexico region: Geocarto International, v. 27, no. 6, p. 479-497. (Also available online at http://dx.doi.org/10.1080/10106049.2011.652675.)

Xu, Y., Zhang, J., and **Yang, L.**, 2012, Detecting major phenological stages of rice using MODIS-EVI data and Symlet11 wavelet in Northeast China: Acta Ecologica Sinica, v. 32, no. 7, p. 2091-2098. (Also available online at http://dx.doi.org/10.5846/stxb201108131186.)

Yuan, W., Liang, S., **Liu, S.**, Weng, E., Luo, Y., Hollinger, D., and Zhang, H., 2012, Improving model parameter estimation using coupling relationships between vegetation production and ecosystem respiration: Ecological Modelling, v. 240, p. 29-40. (Also available online at http://dx.doi.org/10.1016/j.ecolmodel.2012.04.027.)

Yuan, W., **Liu, S.**, Liang, S., **Tan, Z.**, Liu, H., and **Young, C.J.**, 2012, Estimations of evapotranspiration and water balance with uncertainty over the Yukon River basin: Water Resources Management, v. 26, no. 8, p. 2147-2157. (Also available online at http://dx.doi.org/10.1007/s11269-012-0007-3.)

Yuan, W., Luo, Y., Li, X., **Liu, S.**, Yu, G., Zhou, T., Bahn, M., Black, A., Desai, A.R., Cescatti, A., Marcolla, B., Jacobs, C., Chen, J., Aurela, M., Bernhofer, C., Gielen, B., Bohrer, G., Cook, D.R., Dragoni, D., Dunn, A.L., Gianelle, D., Grünwald, T., Ibrom, A., Leclerc, M.Y., Lindroth, A., Liu, H.P., Marchesini, L.B., Montagnani, L., Pita, G., Rodeghiero, M., Rodrigues, A., Starr, G., and Stoy, P.C., 2011, Redefinition and global estimation of basal ecosystem respiration rate: Global Biogeochemical Cycles, v. 25, no. 4, citation number GB4002. (Also available online at http://dx.doi.org/10.1029/2011gb004150.)

Zhang, Y., Zhang, J., Wu, H.A., **Lu, Z.**, and Guangtong, S., 2011, Monitoring of urban subsidence with SAR interferometric point target analysis—a case study in Suzhou, China: International Journal of Applied Earth Observation and Geoinformation, v. 13, no. 5, p. 812-818. (Also available online at http://dx.doi.org/10.1016/j.jag.2011.05.003.)

Zhou, G., Wei, X., **Wu, Y., Liu, S.**, Huang, Y., Yan, J., Zhang, D.X., Zhang, Q., Liu, J., Meng, Z., Wang, C., Chu, G., Liu, S., Tang, X., and Liu, X., 2011, Quantifying the hydrological responses to climate change in an intact forested small watershed in southern China: Global Change Biology, v. 17, no. 12, p. 3736-3746. (Also available online at http://dx.doi.org/10.1111/j.1365-2486.2011.02499.x.)

Zhu, Q., Jiang, H., Peng, C., **Liu, J.**, Fang, X., Wei, X., Liu, S., and Zhou, G., 2012, Effects of future climate change, CO2 enrichment, and vegetation structure variation on hydrological processes in China: Global and Planetary Change, v. 80-81, p. 123-135. (Also available online at http://dx.doi.org/10.1016/j.gloplacha.2011.10.010.)

Books

Giri, C.P., ed., 2012, Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press, 477 p.

Book Chapters

Auch, R.F., Drummond, M.A., **Sayler, K.L., Gallant, A.L.**, and **Acevedo, W.**, 2012, An approach to assess land-cover trends in the conterminous United States (1973-2000), chap. 23 *of* **Giri, C.P.**, ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-27.)

Chander, G., 2012, Preprocessing, chap. 8 *of* Giri, C.P., ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-11.)

Chen, X., Giri, C.P., and **Vogelmann, J.E.**, 2012, Land-cover change detection, chap. 11 *of* **Giri, C.P.**, ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-14.)

Gesch, D.B., 2012, Elevation uncertainty in coastal inundation hazard assessments, chap. 6 *of* Cheval, S., ed., Natural disasters: Vukovar, Croatia, InTech, p. 121-140. (Also available online at http://www.intechopen.com/books/natural-disasters/elevation-uncertainty-in-coastal-inundation-hazard-assessments.)

Giri, C.P., 2012, Brief overview of remote sensing of land cover, chap. 1 *of* **Giri, C.P.**, ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-3.)

Latifovic, R., **Homer, C.G.**, Ressl, R., Pouliot, D., Hossain, N., Colditz, R.R., Olthof, I., **Giri, C.P.**, and Victoria, A., 2012, North American land-change monitoring system, chap. 30 *of* **Giri, C.P.**, ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-24.)

Liu, S., Tan, Z., Chen, M., Liu, J., Wein, A., **Li, Z.**, Huang, J., **Oeding, J., Young, C.J.**, Verma, S.B., Suyker, A.E., Faulkner, S., and McCarty, G.W., 2012, The General Ensemble Biogeochemical Modeling System (GEMS) and its applications to agricultural systems in the United States, chap. 18 *of* Liebig, M.A., Franzluebbers, A.J., and Follett, R.F., eds., Managing agricultural greenhouse gases—coordinated agricultural research through GRACEnet to address our changing climate: San Diego, Calif., Academic Press. (Also available online at http://dx.doi.org/10.1016/B978-0-12-386897-8.00018-8.)

Loveland, T.R., 2012, History of land-cover mapping, chap. 2 *of* **Giri, C.P.**, ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-4.)

Sohl, T.L., and Sleeter, B., 2012, Role of remote sensing for land-use and land-cover change modeling, chap. 15 *of* **Giri, C.P.**, ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-18.)

Stibig, H.-J., and **Giri, C.P.**, 2012, Land-cover mapping in tropical Asia, chap. 18 *of* **Giri, C.P.**, ed., Remote sensing of land use and land cover—principles and applications: Boca Raton, Fla., CRC Press. (Also available online at http://dx.doi.org/10.1201/b11964-22.)

Varanka, D.E., **Deering, C.A.**, and Caro, H., 2012, The use of U.S. Geological Survey digital geospatial data products for science research, chap. 8 *of* Liebenberg, E., and Demhardt, I.J., eds., History of Cartography, Lecture Notes in Geoinformation and Cartography, v. 6, pt. 3: Berlin, Germany, Springer. (Also available online at http://dx.doi.org/10.1007/978-3-642-19088-9_8.)

Reports

Barr, J., and **Chander, A.**, 2012, Africa without ice and snow: United Nations Environment Programme, Global Environmental Alert Service (GEAS), August, 9 p., available only online at http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=90.

Bristol, R.S., Euliss Jr., N.H., Booth, N.L., Burkardt, N., Diffendorfer, J.E., **Gesch, D.B.**, McCallum, B.E., Miller, D.M., Morman, S.A., Poore, B.S., Signell, R.P., and Viger, R.J., 2012, Science strategy for Core Science Systems in the U.S. Geological Survey, 2013-2023: U.S. Geological Survey Open-File Report, 2012-1093, 29 p., available only online at http://pubs.er.usgs.gov/publication/ofr20121093.

Evenson, E.J., Orndorff, R.C., Blome, C.D., Bohlke, J.K., Herschberger, P.K., Langenheim, V.E., McCabe, G.J., Morlock, S.E., Reeves, H.W., **Verdin, J.P.**, Weyers, H.S., and Wood, T.M., 2012, Strategic directions for U.S. Geological Survey water science, 2012–2022—observing, understanding, predicting, and delivering water science to the Nation: U.S. Geological Survey Open-File Report, 2012-1066, 42 p., available only online at http://pubs.er.usgs.gov/publication/ofr20121066.

Funk, C.C., Rowland, J.D., Adoum, A., Eilerts, G., and White, L., 2012, A climate trend analysis of Chad: U.S. Geological Survey Fact Sheet, 2012-3070, 4 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20123070.)

Funk, C.C., Rowland, J.D., Adoum, A., Eilerts, G., and White, L., 2012, A climate trend analysis of Mali: U.S. Geological Survey Fact Sheet, 2012-3105, 4 p., available only online at http://pubs.er.usgs.gov/publication/fs20123105.

Funk, C.C., Rowland, J.D., Eilerts, G., Adoum, A., and White, L., 2012, A climate trend analysis of Niger: U.S. Geological Survey Fact Sheet, 2012-3080, 4 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20123080.)

Funk, C.C., Rowland, J.D., Eilerts, G., Adoum, A., and White, L., 2012, A climate trend analysis of Burkina Faso: U.S. Geological Survey Fact Sheet, 2012-3084, 4 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20123084.)

Funk, C.C., Rowland, J.D., Eilerts, G., Kebebe, E., Biru, N., White, L., and Galu, G., 2012, A climate trend analysis of Ethiopia: U.S. Geological Survey Fact Sheet, 2012-3053, 6 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20123053.)

Funk, C.C., Rowland, J.D., Eilerts, G., and White, L., 2012, A climate trend analysis of Uganda: U.S. Geological Survey Fact Sheet, 2012-3062, 4 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20123062.)

Gallant, A.L., and Sadinski, W., 2012, Integrated monitoring of ecological conditions in wetland-upland landscapes: U.S. Geological Survey Fact Sheet, 2012-3103, 2 p., available only online at http://pubs.er.usgs.gov/publication/fs20123103.

Haynes, J.V., and **Senay, G.B.**, 2012, Evaluation of the relation between evapotranspiration and normalized difference vegetation index for downscaling the simplified surface energy balance model: U.S. Geological Survey Scientific Investigations Report, 2012-5197, 8 p., available only online at http://pubs.er.usgs.gov/publication/sir20125197.

Heidemann, H.K., 2012, Lidar base specification version 1.0: U.S. Geological Survey Techniques and Methods, book 11, chap. B4, 63 p., available only online at http://pubs.er.usgs.gov/publication/tm11B3.

Holmes Jr., R.R., Jones, L.M., **Eidenshink, J.C.**, Godt, J.W., Kirby, S.H., Love, J.J., Neal, C.A., Plant, N.G., Plunkett, M.L., Weaver, C.S., Wein, A., and Perry, S.C., 2012, Natural hazards science strategy: U.S. Geological Survey Open-File Report, 2012-1088, 54 p., available only online at http://pubs.er.usgs.gov/publication/ofr20121088.

Homer, C.G., Fry, J.A., and **Barnes, C.A.**, 2012, The National Land Cover Database: U.S. Geological Survey Fact Sheet, 2012-3020, 4 p., available only online at http://pubs.er.usgs.gov/publication/fs20123020.

Houska, T.R., 2012, EarthExplorer: U.S. Geological Survey General Information Product, 136, 2 p., available only online at http://pubs.er.usgs.gov/publication/gip136.

Houska, T.R., and **Johnson, P.A.**, 2012, GloVis: U.S. Geological Survey General Information Product, 137, 2 p., available only online at http://pubs.er.usgs.gov/publication/gip137.

Jonescheit, L., 2011, LandsatLook images: U.S. Geological Survey Fact Sheet, 2011-3153, 1 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20113153.)

Jonescheit, L., 2012, Monitoring floods and fires during the summer of 2011—the value of the Landsat satellite 40-year archives: U.S. Geological Survey Fact Sheet, 2012-3006, 2, available only online at http://pubs.er.usgs.gov/publication/fs20123006.

Maupin, M.A., **Senay, G.B.**, Kenny, J.F., and Savoca, M.E., 2012, A comparison of consumptive-use estimates derived from the simplified surface energy balance approach and indirect reporting methods: U.S. Geological Survey Scientific Investigations Report, 2012-5005, 8 p. (Also available online at http://pubs.er.usgs.gov/publication/sir20125005.)

Pengra, B.W., 2012, One planet, how many people? A review of Earth's carrying capacity: United Nations Environment Programme, Global Environmental Alert Service (GEAS), June, 17 p. (Also available online at http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=88.)

Pengra, B.W., 2012, A glass half empty—regions at risk due to groundwater depletion—why is this issue important?: United Nations Environment Programme, Global Environmental Alert Service (GEAS), January, 15 p. (Also available online at http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=76.)

Pengra, B.W., 2012, The drying of Iran's Lake Urmia and its environmental consequences: United Nations Environment Programme, Global Environmental Alert Service (GEAS), February, 15 p. (Also available online at http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=79.)

Schmidt, G.L., Liu, S., and **Oeding, J.**, 2011, Derived crop management data for the LandCarbon Project: U.S. Geological Survey Open-File Report, 2011-1303, 15 p. (Also available online at http://pubs.er.usgs.gov/publication/ofr20111303.)

Sohl, T.L., and Sleeter, B.M., 2012, Land-use and land-cover scenarios and spatial modeling at the regional scale: U.S. Geological Survey Fact Sheet, 2012-3091, 4 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20123091.)

Tyler, D.J., and **Greenlee, S.K.**, 2012, Creation of digital contours that approach the characteristics of cartographic contours: U.S. Geological Survey Scientific Investigations Report, 2012–5167, 31 p., 2 appendixes, available only online at http://pubs.er.usgs.gov/publication/sir20125167.

United Nations Environment Programme (UNEP), 2012, Early warning systems—a state of the art analysis and future directions: United Nations Environment Programme, Global Environmental Alert Service (GEAS), July, 70 p. (Also available online at http://na.unep.net/siouxfalls/publications/Early_Warning.pdf.)

United Nations Environment Programme (UNEP), 2011, Keeping track of our changing environment—from Rio to Rio+20: Division of Early Warning and Assessment (DEWA), UNEP, 111 p. (Also available online at http://na.unep.net/.)

U.S. Geological Survey, 2012, Landsat—a global land-imaging mission: U.S. Geological Survey Fact Sheet, 2012-3072, 4 p. (Also available online at http://pubs.er.usgs.gov/publication/fs20123072.)

U.S. Geological Survey, 2012, Landsat Data Continuity Mission: U.S. Geological Survey Fact Sheet, 2012-3066, 4 p., available only online at http://pubs.er.usgs.gov/publication/fs20123066.

Wu, Y., and **Liu, S.**, 2012, R-SWAT-FEM user's guide: U.S. Geological Survey Open-File Report, 2012-1071, 5 p., available only online at http://pubs.er.usgs.gov/publication/ofr20121071.

Zhu, Z., ed., **Bouchard, M.A.**, Butman, D., Hawbaker, T., **Li, Z., Liu, J., Liu, S.**, McDonald, C., **Reker, R., Sayler, K.L.**, Sleeter, B., Sohl, T.L., Stackpoole, S., Wein, A., and Zhu, Z., 2011, Baseline and projected future carbon storage and greenhouse-gas fluxes in the Great Plains region of the United States: U.S. Geological Survey Professional Paper, 1787, 28 p. (Also available online at http://pubs.er.usgs.gov/publication/pp1787.)

Conference Papers

Carabajal, C.C., Harding, D.J., Boy, J.P., **Danielson, J.J., Gesch, D.B.**, and Suchdeo, V.P., 2011, Evaluation of the Global Multi-Resolution Terrain Elevation Data 2010 (GMTED2010) using ICESat geodetic control, *in* Li, J., International Symposium on Lidar and Radar Mapping 2011—Technologies and Applications Nanjing, China, 26-29 May 2011, Proceedings of SPIE Vol. 8286: Bellingham, Wash., Society of Photo-Optical Instrumentation Engineers (SPIE), paper number 82861Y. (Also available online at http://dx.doi.org/10.1117/12.912776.)

Gesch, D.B., Oimoen, M.J., Zhang, Z., **Meyer, D.J.**, and **Danielson, J.J.**, 2012, Validation of the ASTER Global Digital Elevation Model Version 2 over the conterminous United States, *in* Shortis, M., and El-Sheimy, N., eds., Imaging a sustainable future, Congress, 22nd, Melbourne, Australia, 25 August-1 September 2012, The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, XXXIX, pt. B4: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, p. 281-286. (Also available online at http://dx.doi.org/10.5194/isprsarchives-XXXIX-B4-281-2012.)

Gurbuz, S.Z., Ozen, H., and **Chander, G.**, 2012, A survey of LANDNET sites focusing on Tuz Golu Salt Lake, Turkey, *in* Shortis, M., and El-Sheimy, N., eds., Imaging a sustainable future, Congress, 22nd, Melbourne, Australia, 25 August-1 September 2012, The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, XXXIX, pt. B1: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, p. 115-120. (Also available online at http://dx.doi.org/10.5194/isprsarchives-XXXIX-B1-115-2012.)

Lu, X., Jiang, H., **Liu, J.**, Zhou, G., Zhu, Q., Peng, C., Wei, X., Chang, J., Liu, S.R., **Liu, S.**, Zhang, Z., Wang, K., Zhang, X., and Solomon, A., 2012, Spatial and temporal variability of nitrogen deposition and its impacts on the carbon budget of China, *in* Biennial ISEM Conference on Ecological Modelling for Global Change and Coupled Human and Natural System, 18th, Beijing, China, 20-23 September 2011, Procedia Environmental Sciences, v. 13: Amsterdam, Netherlands, Elsevier, p. 1997-2030. (Also available online at http://dx.doi.org/10.1016/j.proenv.2012.01.193.)

McKinley, R.A., Clark, J., and Lecker, J., 2012, Burn severity mapping in Australia 2009, *in* Shortis, M., and El-Sheimy, N., eds., Imaging a sustainable future, Congress, 22nd, Melbourne, Australia, 25 August-1 September 2012, The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, XXXIX, pt. B8: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, p. 51-54. (Also available online at http://dx.doi.org/10.5194/isprsarchives-XXXIX-B8-51-2012.)

Meyer, D.J., Tachikawa, T., Abrams, M., Crippen, R.E., Krieger, T., **Gesch, D.B.**, and Carabajal, C.C., 2012, Summary of the validation of the second version of the ASTER GDEM, *in* Shortis, M., and El-Sheimy, N., eds., Imaging a sustainable future, Congress, 22nd, Melbourne, Australia, 25 August-1 September 2012, The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, XXXIX, pt. B4: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, p. 291-293. (Also available online at http://dx.doi.org/10.5194/isprsarchives-XXXIX-B4-291-2012.)

Nelson, J., Ames, A., **Williams, J.**, Patschke, R., Mott, C., Joseph, J., Garon, H., and **Mah, G.R.**, 2012, Landsat Data Continuity Mission (LDCM) space to ground mission data architecture, *in* Aerospace Conference, Big Sky, Mont., 3-10 March 2012: Piscataway, N.J., Institute of Electrical and Electronics Engineers (IEEE), article number 6187391. (Also available online at http://dx.doi.org/10.1109/AERO.2012.6187391.)

Poppenga, S.K., Worstell, B.B., Stoker, J.M., and **Greenlee, S.K.**, 2012, Using selective drainage methods to hydrologically-condition and hydrologically-enforce lidar-derived surface flow, *in* Neale, C.M.U., and Cosh, M.H., eds., Remote sensing and hydrology 2010, Jackson Hole, Wyo., 27-30 September 2010, IAHS Publication 352: Wallingford, UK, International Association of Hydrological Sciences, p. 329-331.

Sampath, A., Moe, D., and **Christopherson, J.B.**, 2012, Two methods for self calibration of digital camera, *in* Shortis, M., and El-Sheimy, N., eds, Imaging a sustainable future, Congress, 22nd, Melbourne, Australia, 25 August-1 September 2012, The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, XXXIX, pt. B1: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, p. 261-266. (Also available online at http://dx.doi.org/10.5194/isprsarchives-XXXIX-B1-261-2012.)

Singh, R.K., Liu, S., and **Tieszen, L.L.**, 2011, Sustainability of water resources in the Central Great Plains of the United States under changing land use and climate change, Impacts of climate change on water resources in arid and semi-arid regions, International Symposium, Xi'an, China, 21–23 October 2011, International Association of Hydrological Sciences.

Wu, H., Zhang, Y., Zhang, J., **Lu, Z.**, and Zhong, W., 2012, Monitoring of glacial change in the head of the Yangtze River from 1997 to 2007 using InSAR technique, *in* Shortis, M., and El-Sheimy, N., eds., Imaging a sustainable future, Congress, 22nd, Melbourne, Australia, 25 August-1 September 2012, The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, XXXIX, pt. B7: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, p. 411-415. (Also available online at http://dx.doi.org/10.5194/isprsarchives-XXXIX-B7-411-2012.)

Zhang, Z., Jiang, H., **Liu, J.**, Zhou, G.M., Liu, S.R., and Zhang, X.Y., 2012, Assessment on water use efficiency under climate change and heterogeneous carbon dioxide in China terrestrial ecosystems, *in* Biennial ISEM Conference on Ecological Modelling for Global Change and Coupled Human and Natural System, 18th, Beijing, China, 20-23 September 2011, Procedia Environmental Sciences, v. 13: Amsterdam, Netherlands, Elsevier, p. 2031-2044. (Also available online at http://dx.doi.org/10.1016/j.proenv.2012.01.194.)

Conference Abstracts and Posters

Abraham, J.D., Minsley, B.J., Cannia, J.C., Smith, B.D., Walvoord, M.A., Voss, C.I., Jorgenson, T.T., **Wylie, B.K.**, and Anderson, L., 2011, Airborne electromagnetic mapping of subsurface permafrost (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number C51B-02. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Abrams, M., Tsu, H., Fujisada, H., and **Meyer, D.J.**, 2012, ASTER global DEM—the Kaizen approach [abs.], *in* Imaging a sustainable future, Congress of the International Society for Photogrammetry and Remote Sensing, 22nd, Melbourne, Australia, 25 August-1 September 2012, Abstracts: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, unpaged, available only online at http://www.isprs2012.org/abstractsByAuthor.asp.

Acevedo, W., 2011, National assessment of land cover change using the NLCD 1992-2006 database [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Alemu, H., Velpuri, N., **Senay, G.B.**, and Angerer, J., 2011, A multi-index approach to delineate surface water bodies in the pastoral regions of Mali using ASTER imagery [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number H21F-1196. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Anderson, L., Finney, B.P., Guldager, N., **Rover, J.A.**, Shapley, M.D., and Van Sistine, D.R., 2012, Hydroclimate of northeast Alaska—oxygen isotope tracers of recent hydrologic change and late Holocene variability, *presentation at* International Paleolimnology Symposium, 12th, Glasgow, Scotland, 21-24 August 2012: United Kingdom, International Paleolimnology Association.

Anderson, M.T., and Driscoll, D.G., 2011, Lake levels in northeastern South Dakota reach historical maximum elevations in 2011 [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number H51K-1355. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Barnes, C.A., and **Roy, D.P.**, 2011, Radiative forcing over the conterminous United States due to 1973 to 2000 land cover albedo change [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number GC21B-0887. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Barnes, C.A., and **Roy, D.P.**, 2011, Radiative forcing over the conterminous United States due to contemporary land cover land use change, and sensitivity to snow and inter-annual albedo variability [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Bohms, S., Senay, G.B., Lietzow, R.W., and **Verdin, J.P.**, 2011, Evaluating two global air temperature datasets [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number GC23B-0951. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Bouchard, M.A., Sohl, T.L., Reker, R.R., Sayler, K.L., and Sleeter, B.M., 2012, Backcasting land cover/land use change in the Great Plains [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 13. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Bouchard, M.A., Sohl, T.L., Sleeter, B.M., **Sayler, K.L., Reker, R.**, and Zhu, Z., 2011, Forecasting land-use and land-cover in the Great Plains using scenario-based modeling [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number GC43B-0898. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Boyte, S.P., Wylie, B.K., Major, D.J., and Burton, R., 2012, Identifying cheatgrass dieoff in the Great Basin by integrating eMODIS NDVI data with ecological models [abs.], *presentation at* Lessons from the past, strategies for the future, Annual Meeting, 65th, Spokane, Wash., 29 January-3 February 2012, Abstracts: Wheat Ridge, Colo., Society for Range Management, abstract number 0066. (Also available online at http://www.rangelands.org/spokane2012/pdf/SRM%202012%20-%20title%20index%20with%20links.pdf.)

Broich, M., **Hansen, M.C.**, Potapov, P., and Wimberly, M.C., 2012, Patterns of forest cover loss along the Indonesia-Malaysia border on Borneo [abs.], *in* Imaging a sustainable future, Congress of the International Society for Photogrammetry and Remote Sensing, 22nd, Melbourne, Australia, 25 August-1 September 2012, Abstracts: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, unpaged, available only online at http://www.isprs2012.org/abstractsByAuthor.asp.

Brown, J.F., Howard, D.M., Stricherz, B., Wardlow, B., Callahan, K., and Paulsen, C., 2011, Tracking recent drought effects across the upper Colorado River basin using the Vegetation Drought Response Index [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Brown, M.E., Racoviteanu, A., Tarboton, D.G., Bajracharya, S., **Artan, G.A.**, Shrestha, M., Policelli, F., Habib, S., and Ouyang, H., 2011, Understanding the contribution of glacier and snowmelt in the Himalaya using a spatially-distributed energy balance model and remotely sensed data—implications for water security in the Himalayas (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number GC21D-04. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Budde, M.E., Rowland, J.D., Senay, G.B., Funk, C.C., Pedreros, D.H., Husak, G.J., and **Bohms, S.**, 2011, New and improved remotely sensed products and tools for agricultural monitoring applications in support of famine early warning [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B13B-0558. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Chen, M., Liu, S., Young, C.J., and **Tieszen, L.L.**, 2011, An improved analysis on trends and uncertainties of carbon stocks and fluxes in the Piedmont ecoregion of the United States using data assimilation [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B33B-0430. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Culbert, P.D., Radeloff, V.C., Coops, N.C., Kellndorfer, J.K., **Loveland, T.R.**, and Pidgeon, A.M., 2012, A nationwide predictive map of avian biodiversity [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 25-26. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Danielson, J.J., 2012, The Global Multi-resolution Terrain Elevation Data (GMTED2010)—final products and accuracy assessment [abs.], *in* Annual Meeting, New York, N.Y., 24-28 February 2012, Proceedings: Washington, D.C., Association of American Geographers, abstract ID 44667. (Also available online at http://meridian.aag.org/callforpapers/program/index.cfm?mtgID=57.)

Danielson, J.J., 2012, Topobathymetric elevation model for Mobile Bay, Alabama [abs.], *in* Alabama Water Resources Conference, 26th, Orange Beach, Ala., 5-7 September 2012, Session Four: Auburn, Ala., Auburn University Environmental Institute, abstract #29, available only online at http://www.auei.auburn.edu/conference/session4.php.

Danielson, J.J., Gesch, D.B., Meyer, D.J., and Carabajal, C.C., 2012, GMTED2010—source evaluations between the ASTER GDEM Version 2 and comparable higher resolution data sources [abs.], *in* Imaging a sustainable future, Congress of the International Society for Photogrammetry and Remote Sensing, 22nd, Melbourne, Australia, 25 August-1 September 2012, Abstracts: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, unpaged, available only online at http://www.isprs2012.org/abstractsByAuthor.asp.

Dettinger, M.D., Earman, S., and **Funk, C.C.**, 2011, Climate change and groundwater—implications for global food and water security (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number GC21D-01. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Duda, K.A., 2011, Near real-time satellite data delivery for natural disasters [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN11B-1292. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Dwyer, J.L., 2011, The evolution of Landsat data systems and science products (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN43C-06. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Dwyer, J.L., and **Loveland, T.R.**, 2011, Science data products from the Landsat Data Continuity Mission and the historical Landsat archive [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Eidenshink, J.C., 2011, A project for monitoring trends in burn severity [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Engebretson, C., 2011, LDCM data processing and archive system (DPAS) overview [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Faundeen, J.L., and **Holm, T.M.**, 2011, William Pecora's vision—a historical review of past Pecora symposiums [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Fosnight, E.A., 2011, LandsatLook imagery for conservation, education and an open society [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Fosnight, E.A., Gasch, J., and Arvidson, T., 2011, Landsat's long-term acquisition plan [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Franks, S., Arvidson, T., Masek, J., **Headley, R.M.**, and Gasch, J., 2011, Global scene selection for Landsat data [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Fry, J.A., 2011, Land cover change analysis results between 2001 and 2006 for the conterminous United States [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Funk, C.C., Mishra, V., and Davenport, F., 2011, Hydrologic and undernourishment trends in food insecurity hotspots (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number GC11C-04. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Funk, C.C., Williams, A.P., Mishra, V., Barlow, M.A., Hoerling, M.P., and Hoell, A., 2011, Potential change in the Indian monsoon circulation (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number A31F-0158. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Gallo, K.P., and Meyers, T., 2011, Comparison of Landsat surface reflectance-based NDVI with *in situ* data for potential validation of the GOES-R NDVI [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Gesch, D.B., 2012, Consideration of elevation uncertainty in coastal inundation and sea-level rise assessments [abs.], *in* Annual Meeting, New York, N.Y., 24-28 February 2012, Proceedings: Washington, D.C., Association of American Geographers, abstract ID 44846. (Also available online at http://meridian.aag.org/callforpapers/program/index.cfm?mtgID=57.)

Gesch, D.B., 2012, Vertical uncertainty in elevation-based sea-level rise assessments—Mobile Bay, Alabama case study [abs.], *in* Alabama Water Resources Conference, 26th, Orange Beach, Ala., 5-7 September 2012, Session Two: Auburn, Ala., Auburn University Environmental Institute, abstract #27, available only online at http://www.auei.auburn.edu/conference/session2.php.

Giri, C.P., 2011, Status and distribution of mangrove forest of the world using earth observation [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Gu, Y., Wylie, B.K., and Zhang, L., 2011, Evaluation of net ecosystem production (2000-2008) for potential grassland biofuel feedstock sites in the Greater Platte River basin [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B51N-0607. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Hansen, M.C., Potapov, P.V., Egorov, A., Roy, D.P., and **Loveland, T.R.**, 2011, Mapping national scale land cover disturbance for the continental United States, 2006 to 2010 (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B53D-02. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Headley, R.M., LaBahn, S.T., Sauer, B., Van Batavia, C., Holter, J., Shaw, J.L., Marthaler, S.A., Etrheim, D.L., Beck, J., and **Engelbrecht, A.G.**, 2011, Landsat global archive consolidation [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Healey, S., Schwind, B., Brewer, C.K., **Eidenshink, J.C.**, and **Rollins, M.G.**, 2011, National landscape change monitoring—a coordinated, remote sensing-based system for mapping and monitoring land cover and land use change in the United States [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Heinrichs, T., Ledlow, L., and **Mah, G.R.**, 2011, Landsat 5 partnership in Alaska—low-cost academic-government joint program [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Hill, D.V., and **Werpy, J.**, 2011, Satellite imagery production and processing using Apache Hadoop [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN42A-06. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Homer, C.G., 2011, Landscape change monitoring with the National Land Cover Database [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Homer, C.G., Fry, J.A., Acevedo, W., and **Yang, L.**, 2011, National Land Cover Database [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Howard, D.M., Gu, Y., Wylie, B.K., and Zhang, L., 2011, Uncertainty mapping of upscaled net ecosystem production in grasslands of the Great Plains [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B51N-0608. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Huang, S., Dahal, D., Singh, R.K., Young, C.J., Tieszen, L.L., and **Liu, S.**, 2011, Partitioning energy flux using climate record and remote sensing data across the Yukon River basin, Alaska [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B33B-0434. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Jenkerson, C.B., Meyer, D.J., Evenson, K., and **Merritt, M.**, 2011, USAID expands eMODIS coverage for famine early warning [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN14A-01. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Jepsen, S.M., Walvoord, M.A., Voss, C.I., Minsley, B.J., and **Rover, J.A.**, 2012, Linkages between changes in lake surface area and the distribution of permafrost, Yukon Flats basin, interior Alaska, USA [abs.], *in* Congress of the International Association of Hydrogeologists, 38th, Niagara Falls, Canada, 16-21 September 2012, Abstracts: Kenilworth, United Kingdom, International Association of Hydrogeologists, abstract number 763, available only online at http://www.xcdtech.com/iah2012/iah2012/authors.html.

Ji, L., Wylie, B.K., Nossov, D., **Peterson, B.E.**, Waldrop, M.P., McFarland, J.W., Alexander, H.D., Mack, M.C., **Rover, J.A.**, and **Chen, X.**, 2011, Estimating aboveground biomass in the boreal forests of the Yukon River basin, Alaska [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B51C-0406. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Jin, S., Yang, L., Vogelmann, J.E., and **Homer, C.G.**, 2011, Applicability of Landsat ETM+ SLC-off imagery filled using the neighborhood similar pixel interpolator for change detection [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B51M-0582. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Jones, B.K., and **Lamb, R.M.**, 2011, Emergency response and the international charter space and major disasters [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number NH51C-08. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Kim, J., Calmant, S., Lee, H., **Lu, Z.**, and Shum, C., 2011, Seasonal inundation monitoring of northern Pantanal wetland, Brazil using ALOS SAR/InSAR and Envisat altimetry [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN23A-1443. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Kovalskyy, V., Henebry, G.M., Roy, D.P., and **Senay, G.B.**, 2011, Evaluation of the event driven phenology model coupled to the VegET evapotranspiration model using spatially explicitly comparisons with independent reference data [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B13A-0529. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Li, Z., Liu, S., Tan, Z., and **Young, C.J.**, 2011, Simulating grazing impacts on ecosystem carbon dynamics in the Green River basin, Wyoming [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B23C-0448. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Liu, S., 2011, USGS General Ensemble Biogeochemical Modeling System (GEMS) [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Liu, S., Li, Z., Chen, M., Gleason, R., Grangaard, L., **Young, C.J., Schmidt, G.L., Oeding, J., Davis, B.N.**, Zhu, Z., **Dahal, D., Abdul-Aziz, O.I., Sohl, T.L.**, Hawbaker, T.J., and Sleeter, B.M., 2011, Impacts of disturbances, management and climate change on carbon dynamics and N_2O and CH_4 emissions from1992 to 2050 in the US Great Plains [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B21J-06. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Longhenry, R., Sohre, T., McKinney, R., and **Mentele, T.**, 2011, USGS Earth Explorer client for co-discovery of aerial and satellite data [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN51B-1584. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Loveland, T.R., 2011, Landsat—the backbone for mapping and monitoring global ecological trends (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B53D-01. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Loveland, T.R., and **Dwyer, J.L.**, 2011, Landsat—building a strong future [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Maiersperger, T.K., Meyer, D.J., and **Werpy, J.**, 2011, Gauging user data access needs—the Land Processes Distributed Active Archive Center perspective [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN41B-1416. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Markham, B.L., **Morfitt, R.**, Canova, B., and Kvaran, G., 2011, Operational land imager radiometric calibration [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

McDonald, C.P., **Rover, J.A.**, Stets, E.G., and Striegl, R.G., 2012, Size and distribution of lakes and reservoirs in the contiguous United States, their potential for greenhouse gas emissions, and implications on a global scale [abs.], *in* Annual Meeting, New York, N.Y., 24-28 February 2012, Proceedings: Washington, D.C., Association of American Geographers, abstract ID 46266. (Also available online at http://meridian.aag.org/callforpapers/program/index.cfm?mtgID=57.)

Meyer, D.J., 2011, The ASTER Global Digital Elevation Model—case study for the Group of Earth Observations Data Sharing Task Force [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Meyer, D.J., Tachikawa, T., Abrams, M., Tsu, H., Hato, M., Gesch, D.B., and Crippen, R.E., 2011, The ASTER Global Digital Elevation Model version 2.0—early validation results [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN43B-1442. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html)

Micijevic, E., Barsi, J.A., and **Haque, M.O.**, 2011, Continued radiometric characterization of the Landsat thematic mappers [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Nelson, J., Williams, J., and **Engebretson, C.**, 2011, LDCM ground system overview [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Pastick, N.J., Wylie, B.K., Minsley, B.J., Jorgenson, T.T., Ji, L., Walvoord, M.A., Smith, B.D., Abraham, J.D., and Rose, J., 2011, Using remote sensing and ancillary data to extend airborne electromagnetic resistivity surveys for regional permafrost interpretation [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number C41B-0390. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Pedreros, D.H., Funk, C.C., Michaelsen, J., Peterson, P., Verdin, A., Magadzire, T., Husak, G.J., **Rowland, J.D., Verdin, J.P.**, Aguilar, L., and Rodriguez, M., 2011, Validation of the FEWS NET satellite estimated rainfall enhancement process [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number A31C-0098. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Pervez, M.S., and **Brown, J.F.**, 2011, Understanding the spatial dynamics of irrigated areas across the conterminous United States [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B11E-07. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Poppenga, S.K., Thompson, R.F., and Driscoll, D.G., 2012, High-resolution hydrographic mapping using lidar-derived digital elevation models [abs.], *in* Western South Dakota Hydrology Conference, 10th, Rapid City, S. Dak., 19 April 2012, Program and Abstracts: Rapid City, S. Dak., U.S. Geological Survey, South Dakota Water Science Center, p. 58. (Also available online at http://sd.water.usgs.gov/WSDconf/2012conference.pdf.)

Reker, R.R., Sohl, T.L., Bouchard, M.A., Sayler, K.L., and Sleeter, B.M., 2012, The potential impacts of a biofuels industry on land-use modeling [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 82-83. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Rengarajan, R., Steinwand, D.R., Mann, J., **Choate, M.J., Johnson, L.D., Micijevic, E., Haque, M.O.**, Karki, S., and **Fosnight, E.A.**, 2011, Re-discovering the Landsat multispectral scanner [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Rigge, M.B., Smart, A., and **Wylie, B.K.**, 2012, Remotely detecting the influence of off-stream water sources on the riparian vegetation of ephemeral streams [abs.], *in* Western South Dakota Hydrology Conference, 10th, Rapid City, S. Dak., 19 April 2012, Program and Abstracts: Rapid City, S. Dak., U.S. Geological Survey, South Dakota Water Science Center, p. 41. (Also available online at http://sd.water.usgs.gov/WSDconf/2012conference.pdf.)

Rover, J.A., Ji, L., Wylie, B.K., Tieszen, L.L., and **Rodriguez, J.L.**, 2011, Surface water trends derived from Landsat MSS, TM, and ETM+ [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Rowland, J.D., 2011, Famine Early Warning—data delivery and data analyses tools [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Sayler, K.L., 2011, Trends in land use and land cover change for the conterminous United States—1973-2000 [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Sayler, K.L., Sohl, T.L., Sleeter, B., and **Acevedo, W.**, 2012, Current and historical USGS land-cover databases [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 85. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Senay, G.B., Bohms, S., Verdin, J.P., and **Rowland, J.D.**, 2012, MODIS-based evapotranspiration for crop performance monitoring and drought early warning applications [abs.], *in* Imaging a sustainable future, Congress of the International Society for Photogrammetry and Remote Sensing, 22nd, Melbourne, Australia, 25 August-1 September 2012, Abstracts: Lemmer, Netherlands, International Society for Photogrammetry and Remote Sensing, unpaged, available only online at http://www.isprs2012.org/abstractsByAuthor.asp.

Singh, R.K., Senay, G.B., Verdin, J.P., Liu, S., and **Tieszen, L.L.**, 2011, Status of water use and availability in the lower Colorado River basin based on satellite remote sensing and ground observations [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number H21F-1189. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Sleeter, B.M., Sleeter, R.R., **Sohl, T.L., Sayler, K.L.**, and **Bouchard, M.A.**, 2012, Ecoregion-based projections of land-use and land-cover change in the United States—downscaling the IPCC Special Report on Emission Scenarios [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 93. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Sleeter, B.M., **Sohl, T.L., Sayler, K.L., Bouchard, M.A., Reker, R.**, Sleeter, R.R., Zhu, Z., **Auch, R.F., Acevedo, W.**, Soulard, C.E., and Griffith, G., 2011, The future of land use in the United States—downscaling SRES emission scenarios to ecoregions and pixels [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number GC43B-0897. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Smith, B.D., Walvoord, M.A., **Wylie, B.K.**, Voss, C.I., **Pastick, N.J.**, Minsley, B.J., Jepsen, S.M., Jorgenson, T.T., Cannia, J.C., Abraham, J.D., and Anderson, L., 2011, New perspectives of permafrost distribution and its influence on groundwater flow and ecosystem performance for the Yukon Flats area, northern Alaska [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number C41B-0389. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Sohl, T.L., Sayler, K.L., Bouchard, M.A., Reker, R.R., and Sleeter, B.M., 2012, Spatially explicit land-use projections for the United States—The LandCarbon Project [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 94-95. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Sohl, T.L., Sleeter, B.M., **Sayler, K.L., Bouchard, M.A.**, and **Reker, R.R.**, 2012, The USGS LandCarbon Project—project summary [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 94-95. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Sohre, T., and **Maiersperger, T.K.**, 2011, Enhancing access to land remote sensing data through mainstream social media channels [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN41B-1419. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Stensaas, G.L., 2011, CEOS quality assurance processes [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Stoker, J.M., 2011, A national-scale assessment of lidar and Landsat TM fusion for improved vegetation characterization [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Storey, J.C., Lee, K., and **Choate, M.J.**, 2011, Operational land imager geometric calibration [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Tagestad, J., Downs, J., Brooks, M., Klilnger, R., and **McKinley, R.A.**, 2012, Using MODIS NDVI time series data to assess distribution and abundance of nonnative annual grasses in the Mojave [abs.], *presentation at* Lessons from the past, strategies for the future, Annual Meeting, 65th, Spokane, Wash., 29 January-3 February 2012, Abstracts: Wheat Ridge, Colo., Society for Range Management, citation number 0297. (Also available online at http://www.rangelands.org/spokane2012/pdf/SRM%202012%20-%20title%20index%20with%20links.pdf.)

Velpuri, N., and **Senay, G.B.**, 2011, Semi-empirical lake level (SELL) model for mapping lake water depths from partially clouded satellite data [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number H14C-06. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Verdin, J.P., and **Funk, C.C.**, 2011, Application of LIS to drought monitoring [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Vermote, E., Justice, C., Csiszar, I.A., **Meyer, D.J.**, Myneni, R.B., Baret, F., Masuoka, E., and Wolfe, R.E., 2011, A terrestrial surface climate data record for global change studies [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN21A-1414. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Vogelmann, J.E., 2011, Monitoring gradual ecosystem change using Landsat time series data [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Vogelmann, J.E., Tolk, B.L., Xian, G., and **Homer, C.G.**, 2011, Monitoring forest and rangeland change in the United States using Landsat time series data [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B54C-05. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Voss, C.I., Abraham, J.D., Day-Lewis, F.D., Jepsen, S.M., McKenzie, J.M., Minsley, B.J., Nolan, J., **Rover, J.A.**, Smith, B.D., Walvoord, M.A., Wellman, T.P., and **Wylie, B.K.**, 2012, Geophysical permafrost mapping and permafrost-hydrology interaction—U.S. Geological Survey studies in Yukon Flats, Alaska (Invited) [abs.], *in* Alaska's waters—challenges and opportunities, American Water Resources Association (AWRA) Alaska Section Annual Conference, Juneau, Alaska, 5-7 March 2012, Final Program: Middleburg, Va., AWRA, p. 10, available only online at http://state.awra.org/alaska/ameetings/2012am/index.shtml.

Voss, C.I., Abraham, J.D., Day-Lewis, F.D., Jepsen, S.M., Minsley, B.J., **Pastick, N.J., Rover, J.A.**, Smith, B.D., Walvoord, M.A., Wellman, T.P., **Wylie, B.K.**, McKenzie, J.M., and Nolan, J., 2012, Geophysical permafrost mapping and permafrost-hydrology interaction—U.S. Geological Survey studies in Yukon Flats, Alaska, USA [abs.], *in* Congress of the International Association of Hydrogeologists, 38th, Niagara Falls, Canada, 16-21 September 2012, Abstracts: Kenilworth, United Kingdom, International Association of Hydrogeologists, abstract number 547, available only online at http://www.xcdtech.com/iah2012/iah2012/authors.html.

Wacker, S.D., **Wimberly, M.C.**, and Butler, J.L., 2012, Understory vegetation changes following logging on the Black Hills National Forest, South Dakota [abs.], *in* Informing decisions in a changing world, Annual Landscape Ecology Symposium, 27th, Newport, R.I., 8-12 April 2012: International Association for Landscape Ecology, p. 104-105. (Also available online at http://www.usiale.org/newport2012/printed-program-and-abstract-book.)

Wang, L., Shum, C., Kim, J., **Lu, Z.**, Simons, F.J., and Kuo, C., 2011, 2011 Mw 9.0 Tohoku earthquake coseismic deformation observed and constrained by space geodetic sensors [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number G51A-0855. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Werpy, J., and Wolfe, R.E., 2011, Metrics measurement for data services [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number IN41B-1417. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Wood, E.C., 2011, The role of USGS in the CEOS effort to promote data democracy [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Wu, Y., and **Liu, S.**, 2012, Application of SWAT in quantifying impacts of land use and climate change on water resources in the midwestern United States [abs.], *in* Western South Dakota Hydrology Conference, 10th, Rapid City, S. Dak., 19 April 2012, Program and Abstracts: Rapid City, S. Dak., U.S. Geological Survey, South Dakota Water Science Center, p. 61. (Also available online at http://sd.water.usgs.gov/WSDconf/2012conference.pdf.)

Wu, Y., and **Liu, S.**, 2011, Hydrological responses to projected land cover change—a case study of the Iowa River basin in the midwestern United States [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number H13E-1254. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Wylie, B.K., Gu, Y., Phuyal, K.P., and **Howard, D.M.**, 2011, Dynamic monitoring of cropland using remotely sensed data and ecosystem performance models (Invited) [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B11E-02. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Xian, G., Homer, C.G., Meyer, D.K., Granneman, B.J., and **Dewitz, J.A.**, 2011, Developing a shrub canopy cover product for NLCD across the conterminous United States—prototype design and implementation [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Yang, L., Jin, S., Homer, C.G., Danielson, P., Fry, J.A., and **Xian, G.**, 2011, NLCD 2011—a new generation of land cover characterization and monitoring [abs.], *presentation at* Forty years of Earth observations... understanding a changing world, William T. Pecora Memorial Symposium on Remote Sensing, 18th, Herndon, Va., 14-17 November 2011: American Society for Photogrammetry and Remote Sensing.

Young, C.J., Liu, S., Oeding, J., Liu, J., Schmidt, G.L., Sohl, T.L., and **Bliss, N.B.**, 2011, Estimating soil erosion and deposition under historical and projected climate and land cover change scenarios in the Temperate Prairies ecoregion of the United States [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Zhang, L., **Wylie, B.K.**, Yuan, W., Ji, L., Xiao, J., **Howard, D.M.**, and Gilmanov, T.G., 2011, Upscaling carbon fluxes over grasslands of the U.S. Great Plains and northern China—a comparative study [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B22C-04. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)

Zhu, Z., **Liu, S.**, Sleeter, B.M., **Sohl, T.L.**, Hawbaker, T.J., and Stackpoole, S.M., 2011, Assessing and monitoring spatial and temporal distributions of ecosystem carbon storage and changes in the United States [abs.], *in* Fall Meeting, San Francisco, Calif., 5-9 December 2011, Fall Meeting Abstracts: Washington, D.C., American Geophysical Union, abstract number B51C-0413. (Also available online at http://www.agu.org/meetings/fm11/waisfm11adv.html.)