

DEVELOPMENT OF A TECHNOLOGICAL APPROACH FOR GETTING SATELLITE INFORMATION AND DERIVED PRODUCTS TO END USERS IN REAL TIME

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ABSTRACT

Currently the assessment of environmental conditions in New Mexico is limited to after-the-fact processing of information gathered from ground based environmental sensors and monitors and remotely sensed imagery produced by environmental satellites. Because of receiving, processing, and dissemination problems, these assessments typically occur days to weeks after the event of interest. This information is of little value to the researcher who needs to place these data in a real-time modeling framework for scientific studies or to the end user who needs to make response decisions while the event is occurring or shortly thereafter. In a rapid response situation, such as that associated with a major environmental disaster, or even in response to a bioterrorism, the lack of efficient means to access and process these data could lead to significant economic impact and could cost thousands of lives. This information could become available with the proper statewide data collection network in place, and with the proper processing and dissemination capabilities on-line.

Access to real-time environmental data is critical in developing interdisciplinary models that can be used for assessment of current conditions, scientific research, hazard response, and policy decisions. Federal and State agencies could use such data sets to rapidly assess and respond to environmental hazards and security concerns. These capabilities, when linked to predictive and diagnostic models, would be extremely useful to environmental policy makers and when coupled with advanced visualization tools and economic models could influence development of new decision-making tools across the spectrum of environmental applications.

The need for real-time data in environmental modeling, monitoring, assessment and response is well recognized by the research community. However, the ability to use environmental data within a real-time context is lacking. An effort underway at UNM would provide state-of-the-art facilities in this rapidly expanding research and applications area. The Center for Rapid Environmental Assessment and Terrain Evaluation (CREATE) to be headquartered on the UNM campus was funded under FY03 and FY04 Federal Appropriation to NASA. The Center will acquire real-time remotely sensed data from environmental satellites and integrate these data within CREATE's analytic and computational facilities to provide rapid assessment of changing environmental conditions specifically in the State of New Mexico and generally across a region ranging from central Mexico on the south to southern Canada on the north and from the Mississippi River on the east to the Pacific Ocean on the west. Full-time operational capabilities (data collection, processing, analysis, and dissemination) are scheduled to begin in July 2004 with incremental additions to the Center's capabilities and driven by the end-user community needs.

The research center will develop methods to acquire, process, analyze and deliver environmental data to end users with a goal of reducing data lag times from the current days to weeks to less than 30 min. These data sets will be used to support existing Decision Support Systems in hydrology, meteorology, ecology, and climatology, as well as providing the research framework and data sets required to generate the next generation of Decision Support Systems using NASA, NOAA, and commercially available data sets and assets. The facility will provide NM with the opportunity to take a leading role in the production, delivery, and use of real-time satellite imagery and environmental data (water, air, vegetation, soil, climate, disease occurrences) in response to rapidly changing environmental conditions.

The Center for Rapid Environmental Assessment and Terrain Evaluation (CREATE) is headquartered on the campus of the University of New Mexico and was funded under FY03 and FY04 Federal Appropriations to the University of New Mexico through NASA. The Center has acquired and installed complete satellite ground stations for the receipt of X-Band Direct Broadcast MODIS data from the Terra and Aqua satellites & L-Band Direct Broadcast data from NOAA polar orbiting satellites. The ground station provides near real-time environmental data that are integrated with ancillary data in the CREATE computational facilities to provide rapid assessment of changing environmental conditions to state and Federal agencies in New Mexico and generally across a region ranging from Central America on the south to central Canada on the north and

from the Atlantic Ocean on the east to the Pacific Ocean on the west. The research center is developing methods to acquire, process, analyze and deliver environmental data to end users with a goal of reducing data lag times from the current weeks to less than 15 minutes. The Center currently processes and outputs satellite passes and data products within 30 minutes of the completion of a satellite pass.

These data sets will be used to support existing Decision Support Systems in hydrology for a wide range of end users. Ongoing research is designed to provide the research framework and data required to generate the next generation of Decision Support Systems using NASA, NOAA, commercial and foreign data sets and satellite assets.

Hydrologic Monitoring - Key Points

- Optimal hydrologic monitoring combines constant surveillance and the ability to rapidly analyze and respond to “events”
- Hydrologic system management requires continual updating of multiple integrated datasets
- Much of the information used for hydrology has both a spatial and temporal dimension

Management of the continually changing hydrologic resources of New Mexico requires up-to-date information on a wide range of environmental variables. This data must be provided in a timely manner so that Decision Support Systems (DSS's) for hydrology can be used to manage the water supply in a manner that represents the best use of this scarce resource. This data, which by its very nature is spatially distributed across the landscape, often needs to be updated on a daily or even finer timescale. Satellite imagery and derived products, assuming that they can be accessed and produced in near real-time, provides data for this hydrologic Decision Support need.

Remote Sensing/Geographic Information System - Tools and Products

- Remote Sensing and GIS technologies provide tools for;
 - Data capture,
 - Information display
 - Spatial analysis
- Remote Sensing and GIS technologies allow;
 - Rapid assessment and mapping
 - Informed responses when coupled with Decision Support Systems (DSS)
 - Long term inventory capabilities
 - Change detection capabilities.

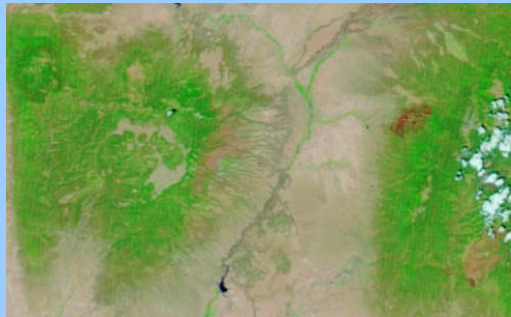
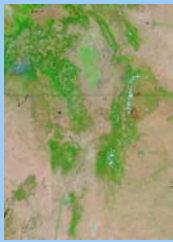
Standard image processing and analysis tools, coupled with access to satellite data in near real-time, provide the tools and products necessary for rapid assessment and monitoring, long-term inventory and change detection in response to both gradual and sudden changes in the landscape. For hydrologic use this includes the ability to monitor snow pack conditions, vegetation status and vegetative change, evapotranspiration, fire conditions and a wide range of variables that influence the hydrologic regime. Satellite data and derived products, when coupled with and processed within the spatial framework of a Geographic Information System (GIS) provides a unique data source for hydrologic management.

New Mexico- MODIS True Color Image



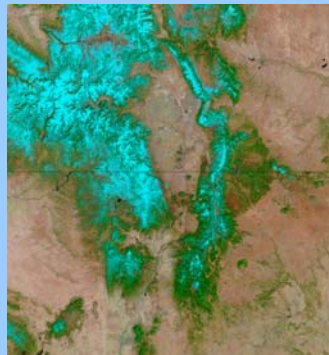
The image illustrated is a MODIS true color image of New Mexico that has been degraded from its original 0.25 kilometer resolution. Hydrologic features, vegetative cover and snow distribution are clearly visible on this degraded image. This product, and up to 20 additional derived MODIS products, are produced six to eight times per day. Satellite acquisitions from NOAA satellites are used to derive another related set of hydrologic and atmospheric products.

New Mexico/Colorado Upper Rio Grande Basin- Vegetation



An example of the power of this technology is for mapping the vegetative cover health status of New Mexico's vegetative cover. This modified false color image shows a portion of the upper Rio Grande Basin with the healthy vegetation shown in green and burn areas indicated in red. This data can be tracked through a growth season to monitor grassland conditions, responses to revegetation after fires and a host of plant/water related conditions.

Upper Rio Grande Basin- Snow Cover



Another important hydrologic application is the mapping and monitoring of snow cover. The image on the left is a true color spring image of northern New Mexico and southern Colorado in the upper Rio Grande Basin. In the image at the right the snow areas have been extracted and mapped in blue for easy visualization. The snow areas can then be reported as a percent cover by geographic region or by individual basins when analyzed within a Geographic Information System.

CREATE

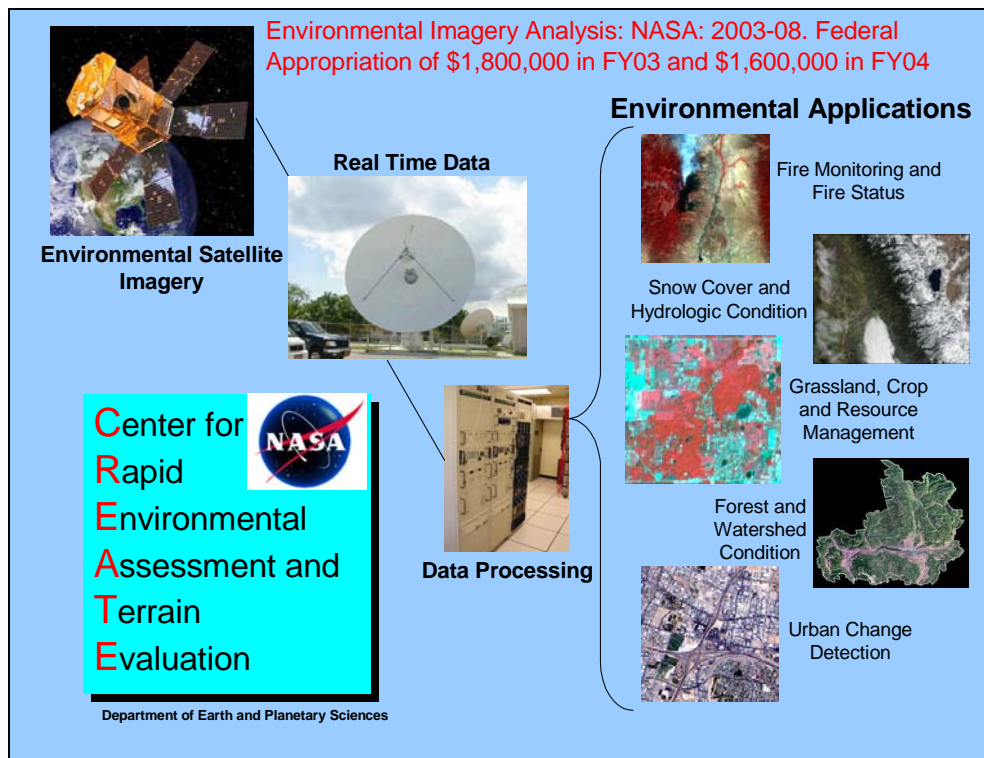
- Funded with Federal Appropriations in FY03 (\$1,800,000) and FY04 (\$1,600,000) through NASA Earth Science Enterprise (ESE) Program
- Established as a Research Center on the University of New Mexico Campus
- Associated with the Department of Earth and Planetary Sciences at UNM
- Interfaces with hydrology, climatology, geomorphology and biology/ecology programs

The Center for Rapid Environmental Assessment and Terrain Evaluation (CREATE) is funded through the NASA Earth Science Enterprise (ESE) Program at the NASA Stennis Research Center in Mississippi. It has been established as a Research Center on the University of New Mexico campus and is directly associated with the Department of Earth and Planetary Sciences. The Center interfaces with campus programs in hydrology, climatology, geomorphology and biology and ecology. Dr. Louis Scuderi of the Department of Earth and Planetary Sciences directs the Center's operations.

Project Goals

- To receive, process and distribute a wide range of remotely sensed data and analysis products within 30 minutes of data acquisition
- To support existing scientific research efforts and to aid in the development of new scientific and application efforts between researchers in New Mexico and nationwide
- To support State and Federal users with timely and appropriate data for environmental analysis and inventory of critical systems in response to user driven data requirements

The overall approach of the center is rooted in the idea that imagery from satellites sensors is of little use to the scientific and applications community if it is not readily available in near real-time. Consequently, the goals of the Center are to receive, process and distribute a wide range of remotely sensed data and analysis products within 30 minutes or less of data acquisition in support of existing research and application needs and to aid in the development of new scientific and application efforts between researchers in New Mexico and nationwide. A critical end product of this process is the support of State and Federal users with timely and appropriate data for environmental analysis and inventory of critical systems in response to user driven data requirements

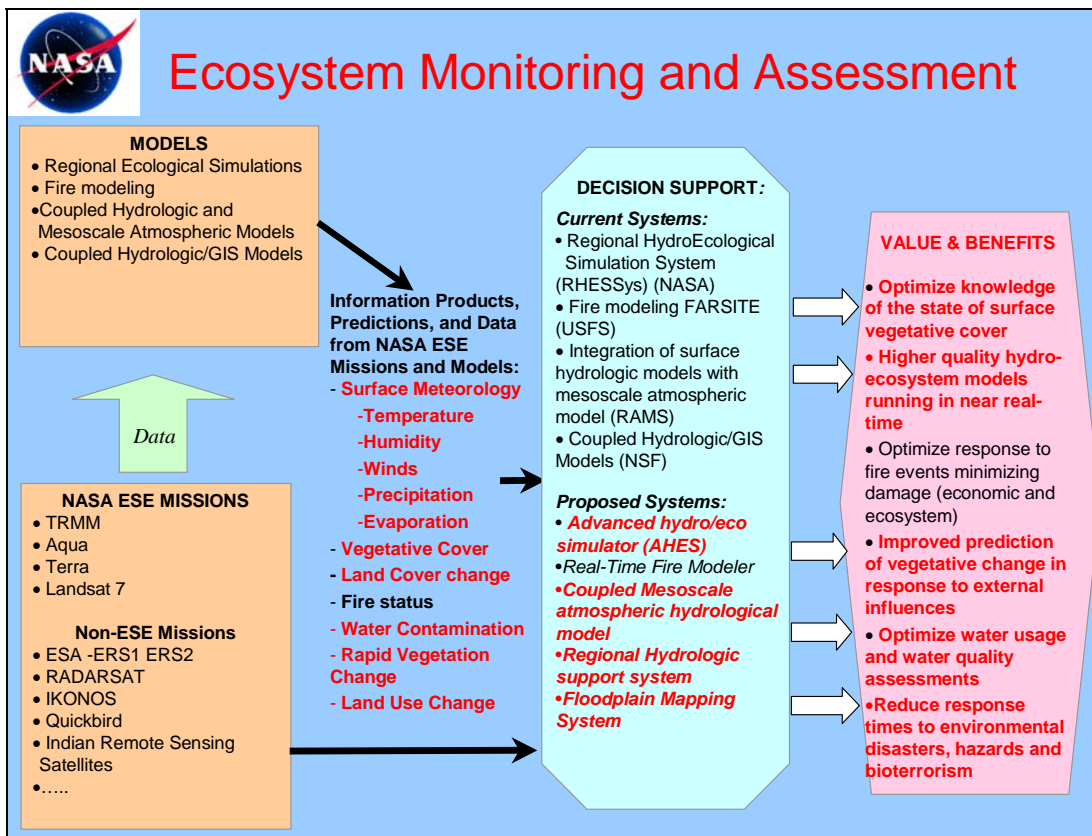


The CREATE system is actually composed of three distinct units. Environmental satellites provide a range of raw data products which can be captured by CREATE's 4.5 and 1.5 meter satellite antennas. This raw data is ingested by CREATE's multiprocessor data processing unit and output as a range of products in support of hydrologic management.

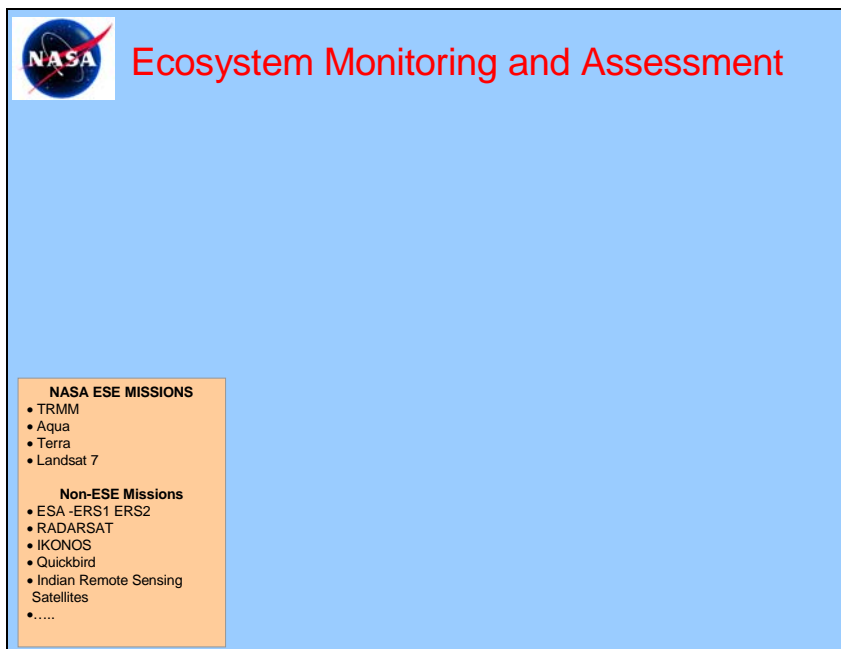
CREATE System Specifics

- 4.5 meter dish- NASA satellites, foreign and commercial
- 1.5 meter dish- NOAA meteorological satellites
- Real time data ingest and processing system
- Level 1 and 2 products produced in less than 30 minutes
- Algorithm development for specialized applications
- Ability to produce GIS referenced datasets and to integrate that output with existing GIS databases and with ground-based sensor networks
- Web-based interface to data
- 20 terabyte on-board data archiving capabilities
- Additional off-line archiving
- Operational for MODIS and NOAA data July 1, 2004 with other satellites added over the 2004 - 2006 timeframe

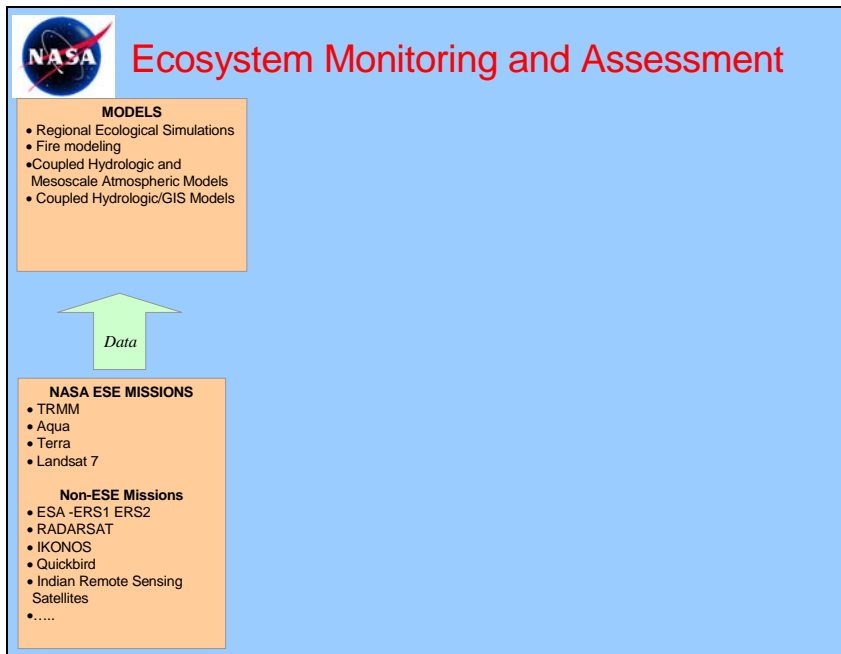
Besides data acquisition and output, a primary goal of CREATE is algorithm development for specialized applications designed to meet the specific needs of the user community in New Mexico. CREATE has the ability to produce GIS referenced datasets and to integrate satellite derived products with existing GIS databases and with ground-based sensor networks. Data from our processing unit is transferred to end users via a web-based interface to both raw data and data products. The system currently has 20 terabytes of on-board data archiving capabilities with additional off-line archiving added in the near future.



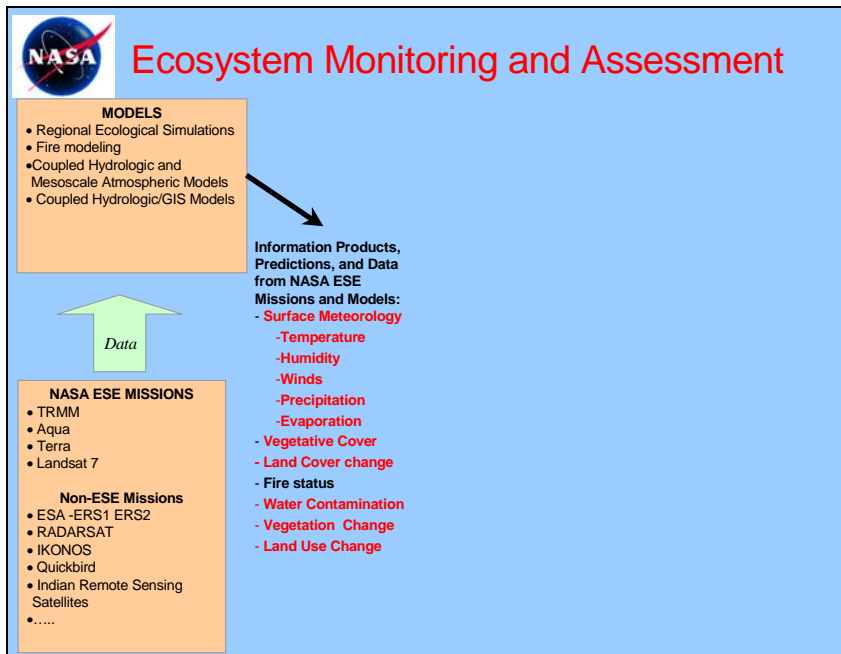
CREATE is associated with NASA via its Earth Science Enterprise (ESE) Program. This program places a high priority on the use of satellite products as input data to Decision Support Systems (DSS's) for a range of uses within 12 identified National Focus areas. Hydrology falls within the Ecosystem Monitoring and Assessment focus area and includes use of NASA assets, models and products as input into Decision Support Systems. A major focus is towards an assessment of the value and benefits derived from satellite products for improvement of current monitoring and assessment capabilities, optimization of these products and application of these products to real-world problems. The subsequent slides outline this process.



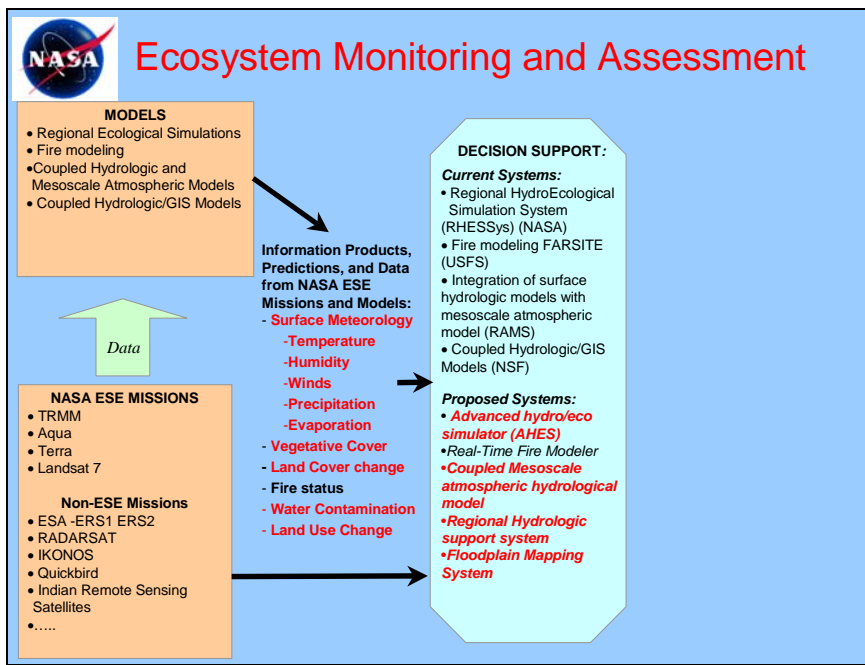
Monitoring and assessment begins with a range of raw data inputs from both NASA, NOAA, commercial and foreign satellites.



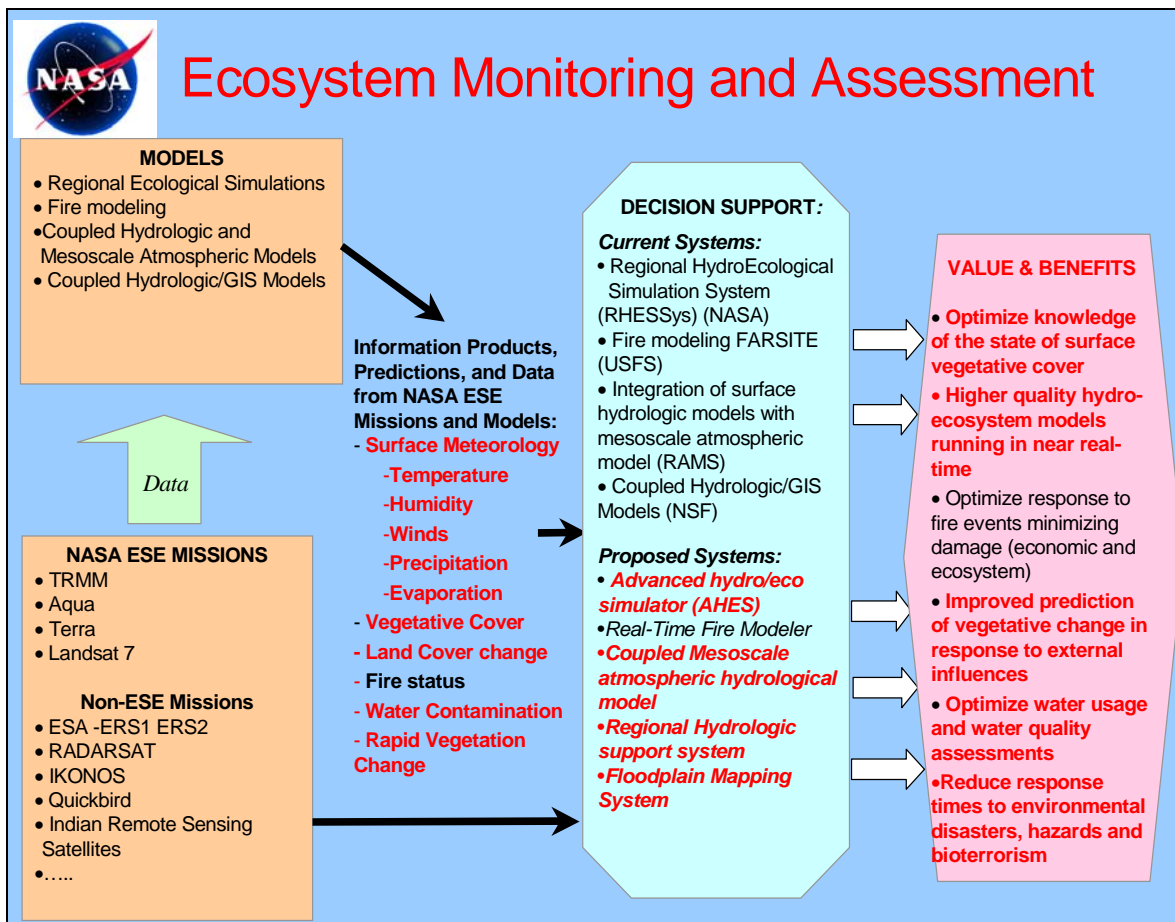
This data is then prepared for a range of existing models that may be applied to hydrologic monitoring and assessment.



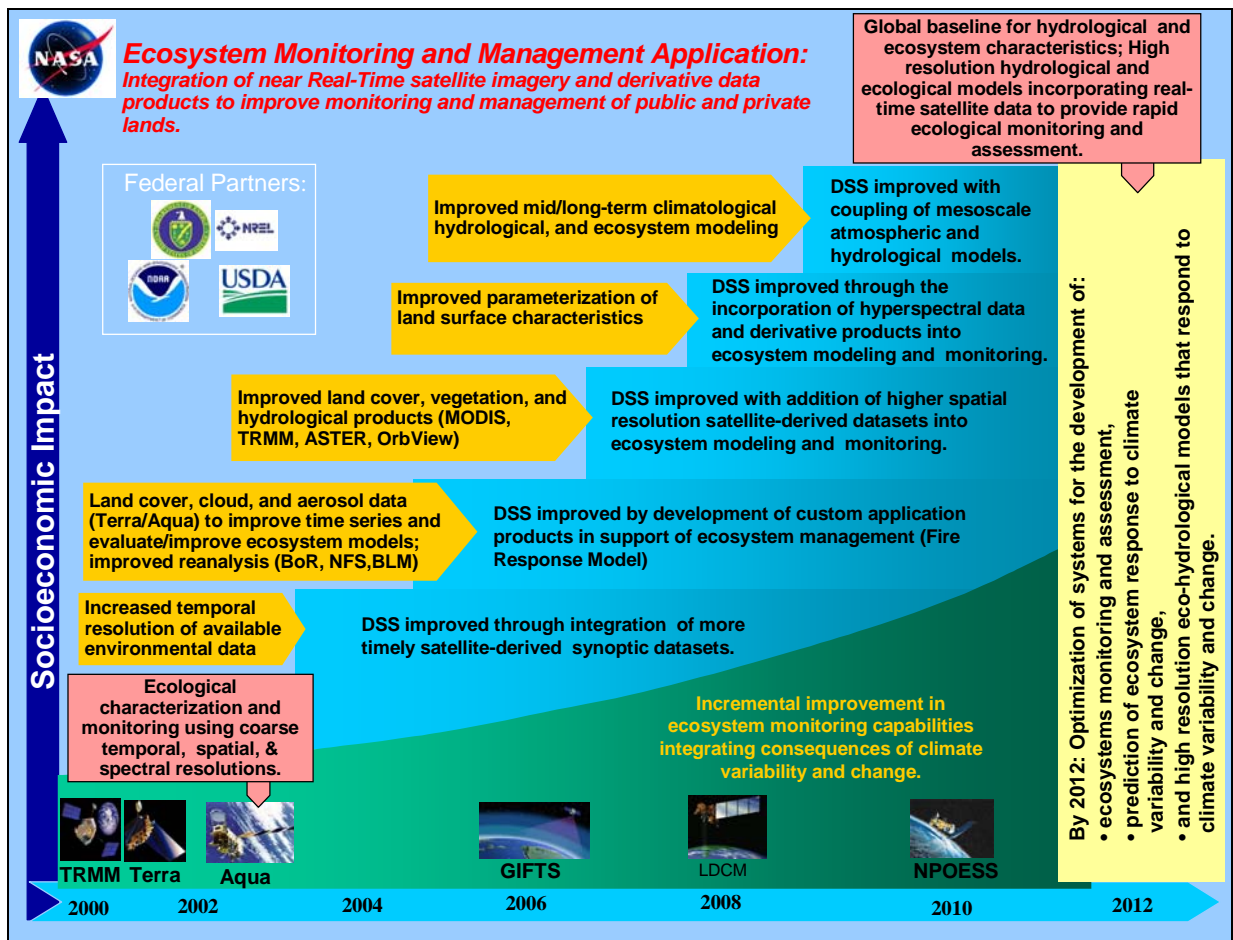
A set of data outputs necessary to run each model is produced from the raw data and is made available to Decision Support System end users.



This data is both used to run current DSS's and as inputs to proposed DSS's which are currently in the research/development phase.



After use each data output is assessed for relevance and the value and benefit of these data streams is quantified. This provides input back to NASA for the development of new sensors for applications which need additional capabilities and as justification for sustaining current satellite systems.



This approach is designed to lead to satellite systems with advanced capabilities. Output data and products from these systems will lead to significant improvements in DSS's capabilities and applicability. NASA's goal by 2012 is to optimize ecosystem monitoring and assessment, prediction of ecosystem response to climate variability and change, and to produce high resolution eco-hydrological models that respond to climate variability and change.

Remote Sensing and GIS technologies as part of a hydrologic management toolbox

SOME KEY SYSTEMS and USES

All Sensors

- Surface change detection
- Multispectral Scanner, or Hyperspectral Scanner
 - Analysis of imagery spectral signatures for mapping and surface delineation
- LIDAR and RADAR
 - Surface elevation measurements
 - Surface elevation change
 - Water surface determination

At CREATE we view Remote Sensing and GIS technologies as part of a hydrologic management toolbox which includes both satellite and surface based data acquisition systems. Our integrated approach will allow New Mexico to better manage the scarce hydrologic resource and improve our response to seasonal to decadal length drought events.

Some Concluding Points

- To plan effectively, managers need current and cost-effective information
- Remote sensing of snow cover, hydrologic characteristics, topography, land cover, evapotranspiration and soil moisture distribution can provide valuable information for hydrologic management
- New techniques and products are being developed to exploit the capabilities of remote sensing and to provide the required high resolution data sets
- The goal of CREATE is to the expand the utility of these remotely-sensed products for improving the predictive reliability of hydrological models and management tools in a real time framework
- The CREATE project has the ability to provide information for these models and tools in near real time to a wide range of users throughout New Mexico

In summary, remote sensing of snow cover, hydrologic characteristics, topography, land cover, evapotranspiration and soil moisture distribution can provide valuable information for hydrologic management. However, to plan effectively and to respond to changing conditions, water managers need current and cost-effective information.

The goal of CREATE is to the expand the utility of these remotely-sensed products for improving the predictive reliability of hydrological models and management tools in a real-time framework. The CREATE project has the ability to provide information for these models and tools in near real-time to a wide range of users throughout New Mexico. We look forward to application of our capabilities and products to more effectively utilize one of New Mexico's most valuable and critical resources.