

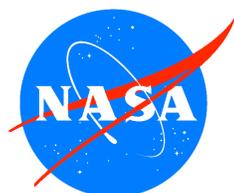
NASA SCIENCE MISSION DIRECTORATE

*Earth-Sun System Applied Sciences Program
Water Management Program Element
FY2006-2010 Plan*



Version: FINAL DRAFT

Date: 7/7/2006



*Expanding and accelerating the realization of economic and societal
benefits from Earth-Sun System science, information, and technology*

NASA Science Mission Directorate
Earth-Sun System Division
Applied Sciences Program

Applied Sciences for the Water Management Program Element:

This document contains the Water Management Program Element Plan for FY 2006-2010.

This plan derives from direction established in the NASA Strategic Plan, Earth Science Enterprise and Space Science Enterprise Strategies, Earth Science Applications Plan, and OMB/OSTP guidance on research and development. The plan aligns with and serves the commitments established in the NASA Integrated Budget and Performance Document.

The Program Manager and the Applied Sciences Program Leadership have reviewed the plan and agree that the plan appropriately reflects the goals, objectives, and activities for the Program Element to serve the Applied Sciences Program, Earth-Sun System Division, NASA, the Administration, and Society.

(Signature on file)

Jared K. Entin

Program Manager, Water Management
Applied Sciences Program
NASA Earth-Sun System Division

Date

(Signature on file)

Lawrence Friedl

Lead, National Applications
Applied Sciences Program
NASA Earth-Sun System Division

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Director, Applied Sciences Program
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Date

NASA Earth-Sun System Division: Applied Sciences Program

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NASA Science Mission Directorate – Applied Sciences Program

Water Management Program Element Plan: FY 2006 - 2010

I. Purpose and Scope

This Applied Sciences National Applications Program Element Plan is applicable for Fiscal Years 2006 through 2010. The plan documents the purpose of the program and the implementation approach to meet the program objectives using the allocated resources. The plan describes the program element approach in extending NASA Earth-Sun system science research results to meet the decision support requirements of partner agencies and organizations. The Applied Sciences Program requires this plan to function as a program management tool, describing the program structure, functional mechanisms, performance measures, and general principles that will be followed in extending NASA research results for societal benefits.

Scope within NASA and Applied Sciences Program

Each National Applications Program Element is managed in accordance with, and is guided by, the NASA Strategic Plan and Earth Science Applications Plan. The program element benefits from NASA Earth-Sun system science research results and capabilities, including the fleet of NASA research satellites, the predictive capability of models in the Earth System Modeling Framework (ESMF), Project Columbia, the Joint Center for Satellite Data Assimilation (JCSDA), and the Earth-Sun System Gateway (ESG). The Applied Sciences Program seeks to develop with its partners scientifically credible integrated system solutions in which uncertainty characterization and risk mitigation has been performed using the capability of the national Earth-Sun laboratories and others in the community of practice.

The FY06 President's Budget for the NASA Applied Sciences Program specifies between \$48 million and \$55 million annually for FY06 – FY10. There are two elements to the Applied Sciences Program: National Applications and Crosscutting Solutions. Each National Applications Program Element benefits from the performance results of Crosscutting Solutions (see Crosscutting Solutions Program Element Plan). Each National Applications Program Element leverages and extends research results from the over \$2 billion per year supporting Earth-Sun system science and development of innovative aerospace science and technology. Additional information about the NASA Applied Sciences Program can be found at <http://science.hq.nasa.gov/earth-sun/applications>.

The Water Management Program Element is one of twelve elements in the Applied Sciences Program. NASA collaborates with partner organizations to enable and enhance the application of NASA's Earth Science research results to serve national priority policy and management decision-support tools. The desired outcome is for partner organizations to use project results, such as prototypes and benchmark reports, to enable expanded use of Earth science products and enhance their decision-support capabilities. The Water Management Program Element extends products derived from Earth science information, models, technology, and other capabilities into partners' decision support tools for water management issues. NASA partners with Federal agencies and other organizations that have water management responsibilities and mandates to support water resource managers. Partnerships with the U.S. Environmental Protection Agency (EPA), Department of Interior Bureau of Reclamation (BoR), the National Oceanic and Atmospheric Administration (NOAA) and the Department of Agriculture (USDA) have been

established. The program would value additional partnerships, including those with international collaborators.

The Water Management Program Element addresses issues of concern and decision-making related to water quality, availability, and forecast. Some activities relate to the Coastal Management, Agricultural Efficiency, Disaster Management, and Energy Forecasting program Elements. The Water Management Program Element extends NASA research results to decision support tools and serves the following classes of issues related to water availability, forecasting, and quality

- Estimating water storage - snowpack, soil moisture, and aquifers.
- Modeling and predicting water fluxes - evapotranspiration, precipitation, river runoff.
- Remote sensing and modeling of water quality - direct (turbidity, eutrophication, temperature) and nonpoint source (land cover conversion, agriculture runoff, etc.).

Measurements from satellites and sensors on Earth Science missions for the Water Management Program Element include: (current) Aqua, Terra, GRACE, TRMM, EO-1, Landsat, (future) CloudSAT, Global Precipitation Measurement (GPM), NPP, and (planned) (Surface "Water {Water}, Cold Land Processes Pathfinder {CLPP}, and soil moisture mission). There are numerous land surface, mesoscale, and GCM Earth science models that provide useful, water-related assessments, including: Land Surface Models (LSMs) Community Land Model (CLM), Mosaic, Noah, and Variable Infiltration Capacity (VIC) supported by the Land Data Assimilation System (LDAS) and Land Information System (LIS); mesoscale models MM5 and RAMS; and GCMs run by GISS, GMAO, GFDL, and NCAR. In addition, we propose to explore using Observation System Simulation Experiments (OSSEs) to study capabilities provided by future and planned NASA water related missions (i.e., Global Precipitation Mission, "Surface Water" for river discharge and water level, "soil moisture mission", and Cold Land Processes for snow pack) to enhance Water Management DST applications.

The project plans associated with the Water Management Program Element designate specific sensors and models, and they state specific activities with the partners to extend Earth-Sun science measurements, and Earth science data records of geophysical parameters. This plan covers objectives, projects, and activities for Fiscal Years 2006-2010. For example, in Fiscal Year 2005 (FY05), the Program Element's priority activities focused on extending MODIS and LDAS/LIS products to four management decision support systems (DSSs): BASINS (EPA), AWARDS (BoR), RiverWare (BoR), and Eta (NOAA). In addition, NASA and the USDA Natural Resources Conservation Service (NRCS) teamed through Federal Agency Working Groups (FAWGs) to produce two project prospectuses on snow pack and soil moisture to support their Decision Support Tools: Water Supply Forecast (WSF), Automated Geospatial Watershed Assessment (AGWA), and National Integrated Drought Information System (NIDIS). Also, joint NASA collaborative activities with the US Army and Air Force Weather Agency (AFWA) in separate projects showed promising use of the NASA Land Information System to develop high spatial resolution and global precipitation applications to support their DSTs including trafficability and weapons targeting. Collaborative work between NASA and NOAA NWS National Centers for Environmental Predictions (NCEP) benchmarked the use of MODIS snow cover and NASA Land Information System (LIS) for improved weather prediction. NOAA NCEP is currently using NASA LIS in their research with plans to implement it operationally.

In FY06, work towards benchmarking of NASA products with EPA and BoR will continue. Also, exploratory work with USDA, US Army and AFWA will continue. At least three new Water Management Projects will start NOAA National Weather Service Office of Hydrology Development (NWS OHD) with MSFC and GSFC are funded to

apply NASA MODIS (cloud cover, snow pack, and soil moisture), AMSR-E (snow pack) and LIS data assimilation and integration capabilities for improving NOAA's River Forecast Systems (RFS DSTs). The University of Washington will lead a project in the Western US using NASA satellite and seasonal hydrologic and climate forecasts. USGS and JPL will work to blend NASA satellite and modeling data with the "National Drought and Monitoring System" for early warning. Also, work will continue with Bureau of Reclamation towards a Memorandum of Understanding. We will also explore the use of GRACE to derive terrestrial water storage for work with the USGS. Also in FY06, we are exploring possibilities to work with the US Army Corp of Engineers (ACE). ACE develops science and technology to support environment, water resources, disaster and military operations within the Corps missions areas and support to others. Potential DSTs include Combat Terrain Information System (CTIS), and Army Remote Moisture System (ARMS).

In FY06-FY10, the Program Element's priorities focus on evolving products for DSTs as well as expanding the variety of measurements and model products to be tested for use in these and other water management decision support tools. Also, potential products of planned satellites (e.g. GPM) and future (e.g., WatER, Soil Moisture Mission, and CLPP) need to be evaluated for their potential to augment current and future DSSs. This can be done by adapting the Observation System Simulation Experiments (OSSEs) already developed many of the specific spacecraft mission science teams. Water Management OSSEs may be evaluated for both direct use within DSTs such as hydrologic and climate/weather forecast of NOAA NWS.

II. Goals and Objectives

Goals

The goal of the Water Management Program Element is to:

Enable partners' beneficial use of NASA Earth Science observations, models, and technology to enhance decision support capabilities serving their water management and policy responsibilities.

Major tenets of the Water Management Program Element's goal include:

- Develop and nurture partnerships with appropriate water management organizations
- Identify and assess partners' water management responsibilities, plans, and decision support tools and evaluate capacity of NASA Earth science system results to support the partners
- Validate, verify and benchmark application of NASA Earth-Sun system science results with the partners' DSSs
- With partners, assess the value of Earth system science results relative to partners' obligations and support adoption into operational use
- Communicate results and partners' achievements to appropriate water communities and stakeholders

Objectives

All National Applications Program Elements are aligned to the NASA Strategic Plan and the agency's objectives as expressed in the NASA Integrated Budget and Performance Document (IBPD) and the Performance Assessment Rating Tool (PART).

The Water Management Program Element pursues the following near-term and long-term objectives:

Objectives (FY06-FY10)

- By June 2006, verify and validate Earth Science inputs into at least three separate water decision support tools and policy/management activities;
- By September 2006, complete at least one benchmark report and conduct one results conference on Earth science inputs into a water decision support tool
- By September 2006 complete Evaluation report AirForce Agency (AFWA) using LIS
- By July 2006 complete Memorandum of Understanding with the Bureau of Reclamation
- By September 2007, establish agreements with an additional federal partner and at least one non-federal partner
- By September 2007, explore using Observaton System Simulation Experiments (OSSEs) to study capabilities provided by new and planned NASA water related mission
- By September 2007, complete an additional two benchmark reports
- By September 2008, publish at least three articles on water applications of Earth science, including at least one in a peer-reviewed journal
- By March 2009, have completed a total of six benchmark reports and conduct at least three results conferences on at least three separate decision support tools and/or water issues
- By March 2010, have completed a total of nine benchmark reports and conduct at least four results conferences on at least three separate decision support tools and/or water issues

III. Program Management and Partners

A. Program Management

Program Manager:

Lawrence Freidl,
NASA-Headquarters

Responsibilities include:

- Program development, strategy, plans and budgets
- Program representation, advocacy, and issues to Applied Sciences management and beyond
- Communication of Science Mission Directorate priorities and directives to Water Management team and network
- Implementation of interagency agreements and partnerships
- Monitor Water Management Program measures and performance evaluation

Deputy Program Manager:

David Toll,
NASA-GSFC

Responsibilities include:

- Leadership on project plans, development, performance, and partnership relationships
- Communication of project metrics, performance, status, and issues to Program Manager
- Leadership & communication to Water Management team & network
- Liaison with Science program: LDAS/LIS, Terrestrial Hydrology Program (THP), NASA Energy & Water Cycle Systems (NEWS), Global Modeling and Assimilation Office (GMAO), etc.

- Coordination between NASA centers on Water Management activities
- Management of Water Management Project tasks at GSFC

B. Water Management Network & Partners

NASA Applied Sciences Program and NASA Centers:

| | |
|---|-------------------------------------|
| Water and Energy Cycle Focus Area..... | Jared Entin, NASA HQ |
| Climate Change & Variability Focus Area | Don Anderson, NASA HQ |
| Weather Focus Area..... | Ramesh Kakar, NASA HQ |
| Atmospheric Composition | Phil DeCola, NASA HQ |
| Climate Modeling | Don Anderson, NASA HQ |
| Earth Surface and Interior..... | John Labreque, NASA HQ |
| Carbon and Ecosystems..... | Diane Wickland, NASA HQ |
| Computation..... | Tsengdar Lee, NASA HQ |
| Cryospheric Processes..... | Waleed Abdalati, NASA HQ |
| Technology..... | Parminder Ghuman,NASA ESTO |
| Business & Budget..... | Joan Haas, NASA HQ |
| Ames Research Center (ARC) | Steve Hipskind |
| Goddard Space Flight Center (GSFC) | Christa Peters-Lidard/ Shahid Habib |
| Jet Propulsion Laboratory (JPL) | Randy Friedl |
| Marshall Space Flight Center (MSFC) | William LaPenta |
| Stennis Space Center (SSC) | Robert Venezia |

Applied Science Program Partners:

| | |
|---------------------------|-----------------|
| Disaster Management | Stephen Ambrose |
| Agriculture | Ed Sheffner |
| Coastal Areas | Lawrence Friedl |
| Invasive Species | Ed Sheffner |
| Energy Management | Richard Eckman |

Federal Partners:

| | |
|--|------------------|
| US EPA Office of Water..... | Amy Neuman |
| | Ed Partington |
| US EPA Office of Research and Development | Barbara Levinson |
| Bureau of Reclamation..... | Chuck Hennig |
| US Geological Survey Water Resources | Robert Hirsch |
| | William Kirby |
| NOAA Office of Hydrologic Development | Pedro Restrepo |
| NOAA Office of Global Programs Climate Prediction Projects for the Americas | Jin Huang |
| NOAA National Operational Hydrologic Remote Sensing Center | Donald Cline |
| NOAA National Weather Service..... | Ken Mitchell |

Department of Agriculture (USDA)

| | |
|---|-----------------|
| Agricultural Research Service | Dale Bucks |
| | Tom Jackson |
| Natural Resources Conservation Program..... | Phil Pasteris |
| | Garry Schaefer |
| State Department..... | Robert Senseney |
| Army Corps of Engineers..... | Kathleen White |

International, National and Regional Organizations:

- ASCE (American Society of Civil Engineers)
- AMS (American Meteorological Society)
- AWRA (American Water Resources Association)
- GEWEX: Global Energy and Water Cycle Experiment (Rick Lawford)
- HELP: Hydrology for the Environment, Life, and Policy (Jonathan Triggs)
- IGOS: Integrated Global Observing Strategy (Rick Lawford)
- GWSP: Global Water Systems Project (Charles Vörösmarty)
- IFPRI: International Food Policy Research Institute (Mark Rosegrant)
- USGS ACWI-WICP: Advanced Committee on Water Information
– Water Information Coordination Program (Don Frevert)
- IGWCO: Integrated Global Water Cycle Office (Rick Lawford)

Distributed Active Archive Centers (DAAC) and Earth Science Modeling Centers:

- GSFC Earth Science DAAC (GES DAAC)
- Land Processes DAAC (LP DAAC)
- Langley Atmospheric Sciences DAAC (LaRC DAAC)
- SPoRT Center: Short-term Prediction Research and Transition Center
- GISS: Goddard Institute for Space Studies
- GFDL: Geophysical Fluid Dynamics Laboratories
- NCAR: National Center for Atmospheric Research
- GMAO : Goddard Modeling and Assimilation Office
- GISS: Goddard Institute for Space Studies
- Geospatial Interoperability Program

IV. Decision Support Tools and Management Issues

Priority Decision Support Tools

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS)

BASINS is a GIS-based environmental analysis system developed by EPA. The watershed simulation models require typical input data on soils, land use, topography and meteorology. EPA operates BASINS to track and assess water quality, by computing the maximum amount of pollution that a water body is allowed to hold, known as Total Maximum Daily Loads (TMDLs). These TMDLs are a standard measure in water pollution control and assessment. The primary BASINS submodel for evaluation is the Hydrologic Simulation Program-FORTRAN (HSPF). HSPF is a watershed scale model for estimating instream concentrations resulting from point and nonpoint sources. BASINS-HSPF requires multiple data inputs, and its performance could be enhanced by several NASA science data products, such as precipitation, evapotranspiration, and runoff. Primary NASA products for evaluation include land cover and surface property products from MODIS and water availability parameters from the NASA Land Information System (LIS). LIS includes inputs from a variety of NASA satellite products, primarily from MODIS, but also TRMM and AMSR.

Agricultural Water Resources Decision Support (AWARDS) and RiverWare

The Bureau of Reclamation operates AWARDS to assess the amount of water available for agriculture. These assessments are used to portion out limited water resources for various agricultural interests while retaining a portion for other uses (ecosystems, recreation, commerce, etc.). Potential NASA data products that can be used as inputs by AWARDS, include snow (liquid water equivalent), evapotranspiration, and soil moisture derived primarily from NASA MODIS and LIS data. RiverWare is a modeling system developed by CADSWES (Center for Advanced Decision Support for Water and Environmental Systems) and supported by Reclamation and the Tennessee Valley Authority. It is used to model water availability in several regions of the U.S., primarily to inform water policy decision makers and water managers on water availability and best management practices.

RiverWare

The BoR RiverWare is a reservoir regulation DSS supported by both BoR and the Tennessee Valley Authority (TVA). RiverWare simulates the routing of the river flow operations through dams and hydropower plants and maintains water delivery contracts to irrigators and to recreational, municipal, and industrial users. Even though BoR uses several hydrological modeling tools for RiverWare, spatially-distributed fields available from NASA such as soil moisture and snowpack are not fully accounted for in their operations. Including NASA fields of soil moisture, evapotranspiration, and snowpack in their operations should help increase the accuracy of Reclamation's water resource accounting.

USDA Drought Monitoring and Water Supply Forecasting

The USDA operates several DSSs for water management in the US. One DSS used by the Natural Resources Conservation Service (NRCS) is a water supply forecasting (WSF) tool. WSF currently uses ground-based observations to monitor snow cover and snow water equivalent. NASA data from MODIS, AMSR, and LIS will be evaluated and tested. Potentially useful NASA data products are MODIS/AVHRR snow cover and AMSR snow water equivalent. Another DSS used by USDA is SCAN/NIDIS (National Integrated Drought Information System). This system uses SCAN (Soil Climate Analysis Network) point-specific measurements of soil moisture to monitor drought conditions. NASA satellite data such as MODIS (land cover) and AMSR (soil moisture) and LIS modeling data could potentially improve spatial accuracy and representation of soil moisture.

NOAA National Centers for Environmental Prediction (NCEP) Eta Mesoscale Forecasting

The NCEP Eta model is the main operational mesoscale model used by NOAA to produce surface and upper air forecasts over North America. Eta model forecasts of precipitation, temperature, humidity, wind, and solar radiation are used by the public and by a wide range of government agencies and universities as input to DSTs. Initializations of Eta model forecasts can be improved with the use of NASA data and models, an approach being investigated by the North American Land Data Assimilation System E-grid project (NLDASE). NASA data products and models under consideration include the LIS modeling framework, MODIS snow, vegetation and temperature data, Shuttle Radar Topography Mission (SRTM) data, AMSR-E soil moisture and SWE data, and TRMM precipitation data. Better initial land surface conditions will lead to improved weather forecasts, which will benefit the public in general, and DSTs which depend on weather forecast input in particular. These DSTs include NIDIS, NASS, AWIPS, AHPS, CADRE (Crop Assessment Data Retrieval & Evaluation), ISFS (Invasive Species Forecasting System), MMS (Malaria Monitoring and Surveillance), NAS-AWRP (National Air Space - Aviation Weather Research Program), RiverWare, and AWARDS.

National Weather Service River Forecasts System (NWS RFS)

The National Weather Service River Forecast System (NWSRFS) is a robust river and hydrologic forecast system. The system includes all the necessary hydrologic and routing models as well as data handling and presentation systems. The NWSRFS has been in operation for over 20 years and is constantly refined and improved. The NWSRFS is used in the United States and in other countries throughout the world. The U.S. National Weather Service (NWS) provides river and flood forecasts and warnings in the United States for protection of life and property and by providing basic hydrologic forecast information for environmental and economic well-being. The Office of Hydrologic Development supports the NWS hydrologic mission through the design, development, testing, and implementation of a physically-based hydrologic forecasting system - the NWSRFS. Thirteen River Forecast Centers (RFCs) develop hydrologic forecasts for the U.S. The RFCs use the NWSRFS to make short-term forecasts (a day to a week in advance) of river flows and floods and long-term probabilistic river outlooks (a week to months in advance) in support of water supply management and flood mitigation.

University of Washington West-wide Seasonal Forecasting System

The University of Washington experimental west-wide seasonal hydrologic forecast system produces 6-12 month lead time hydrologic forecasts at approximately 100 forecast points in five major river basins within the western U.S. The system is an outgrowth of the North American LDAS (N-LDAS) project, and uses the N-LDAS 1/8 degree spatial grid, as well as N-LDAS vegetation, soils, and other data. The system is based on the University of Washington/Princeton University Variable Infiltration Capacity (VIC) macroscale hydrology model, driven by climate ensembles downscaled from the NCEP Seasonal Forecast Model (SFM), the NASA NSIPP1 global model, and an ensemble version of the CPC official seasonal outlooks (12 month lead time). UW also produces parallel forecasts via the Extended Streamflow Prediction (ESP) method, and a further conditioning of the ESP ensembles by ENSO and PDO state. The primary forecast products are: 1) monthly streamflow distributions and runoff volume statistics at the specified forecast points; and 2) west-wide spatial maps of monthly forecast ensemble averages for runoff, soil moisture, and snow water equivalent (SWE). UW reports results of initial real-time testing of the system with bi-monthly updates for the Pacific Northwest, and for a larger expanded domain (most of the U.S. west of the Rocky Mountains).

United States Drought Monitor (USDM)

The Drought Monitor provides a weekly overview of where in the United States drought is emerging, lingering, subsiding or forecast. The Monitor is produced jointly by the National Weather Service's Climate Prediction Center, the U.S. Department of Agriculture, and the National Drought Mitigation Center at the University of Nebraska-Lincoln. The three-way partnership is responding to the need for accurate, centralized drought information by developing a map that summarizes information from numerous drought indices and indicators on a single, easy-to-read color map known as the Drought Monitor. To create the map, the partnership blends current information from numerous sources, including the National Weather Service, National Climatic Data Center, Regional Climate Centers, USDA's Joint Agricultural Weather Facility, USDA's National Water and Climate Center, Department of Interior's U.S. Geological Survey and Bureau of Reclamation, as well as many other sources. The map uses a new classification system to show drought intensity and type, similar to the schemes currently in use for hurricanes and tornadoes. The map combines key indices of rainfall and drought to produce the final drought intensity rating. Since drought often affects various activities differently, the map indicates whether drought is affecting agriculture, fire danger, or water supplies. The latest state-of-the-art forecast tools are being used to indicate whether drought will strengthen or weaken significantly over the next two weeks.

Potential Water Management Management Issues: FY06-FY10

The Water Management Program Element authorizes activities that contribute to the overall success of the program element through studies, working groups, program reviews, and other endeavors.

Program Planning and Alignment

The purpose of this activity is to identify important water management issues, evaluate models, and evaluate associated management responsibilities and decision support tools in order to determine opportunities the program element may support in the future. This activity examines the strategies and plans of existing and potential partner organizations to identify their topics, directions, mandates, and responsibilities. The information and analysis will identify possible applications of Earth science research results to support the partners as well as help the application develop and structure partnerships. The program element will interact with the Rapid Prototyping Capacity to evaluate potential areas of collaboration between NASA and its partners. In FY06, this includes directed projects, Applied Sciences Program new start projects and exploratory efforts (e.g, Army Corp of Engineers and Air Force Weather Agency). The Water Management Program Element activities need to be performed in synergy with the evolving needs and priorities of our partner agencies. NASA is involved in various interagency working groups to facilitate these interactions. The program element will also participate in activities with USGEO, the Climate Change Science Program and the CENR subcommittee on water. Numerous other national and international groups will be supported such as HELP (Hydrology for Environment, Life, and Policy), ESIP (Earth Science Information Partners), CCSP (Climate Change Science Program), IWGEO (International Working Group on Earth Observations), WICP (Water Information Coordination Program) -ACWI (Advanced Committee on Water Information), UCOWR (Universities Council On Water Resources), AWRA (American Water Resources Association), IGWCO (Integrated Global Water Cycle Observations), AMS (American Meteorological Society), IGARSS (International Geophysical Remote Sensing Society), ASCE (American Society of Civil Engineers) etc..

Lead: David Toll

Centers: GSFC (Lead), SSC, MSFC, JPL

Timeframe: FY06-FY10

Budget: 125K (including 30K for Water Working Group)

Deliverables: Meeting reports, Evaluation reports on issues and decision support tools. Exploration of pre-evaluation of use of Earth-Sun System Science products for other national and international DSS.

Program Alignment

Cross-Application Activities

The program consists of functional elements that contribute to all of the National Applications activities. The intention is to have the performance of these functions leverage accomplishments, and therefore the apparent resource investment, to the greatest extent possible into the National Applications partnerships. These functions are: Geoscience Standards and Interoperability, Human Capital Development, Integrated Benchmark Systems, and Solutions Networks. Examples of leveraged activities are:

- The Earth-Sun System Gateway is a "portal of portals" providing an access point through an Internet interface to all web-enabled NASA research results.
- A Solutions Networks capability to discover candidate configurations of NASA research results with the potential to improve partner's decision support systems.
- A Rapid Prototyping Capability to support NASA and partners in reducing uncertainty and testing the

- validity of NASA research results in decision support tools.
- Systems integration capability, knowledge tools and skilled human capital to help conduct studies on the systematic transitioning of the results of research to operational uses and the capability of operational systems to support scientific research.
- A student-based, human capital development program for building capability in entry level participants in the community of practice while developing solutions for state and local applications.

V. Application Activities

A. Projects

All National Applications Program Elements authorize peer-reviewed projects to support each element's goal and objectives. To secure funding and authorization to undertake activities supporting NASA and the Applied Sciences Program, project teams are responsible for developing project plans and managing the activities. The project plans specify the Earth-Sun observations, models, and other research results to extend to decision support tools as well as the activities to produce appropriate deliverables. The plans integrate contributions from appropriate the partners, NASA Centers and other contributors from the community of practice. Projects are expected to extend the benefits of NASA research results to the maximum extent possible, including the use observations from sensors on: Aura, Terra, Aqua, TRMM, NPP, NPOESS, Hydros, Topex, Jason, OCO and Aquarius.

B. Solicitations

The Applied Sciences Program utilizes full and open competitions to fund proposals from the community to contribute the Agency's objectives. This implementation strategy will continue to be critical part of extending the benefits of NASA Earth-Sun system research results and contributing to the improvement of future operational systems. The Program has participated in providing opportunities to the community in recent solicitations, including REASoN, Decisions 2004, and Decisions under ROSES. The proposals related to this National Applications Program Element that have been funded under these solicitations are described in Section V.D. Program Element Projects.

C. Congressionally Directed Activities

As of the publication of this document, an assignment of FY06 congressionally mandated activities was not completed by the Agency.

The procurement rules and management practices of the Agency require that congressionally mandated activities follow the same principles of planning and accountability as all other funded projects. Only activities that are aligned with NASA's mission, are technically credible, and are appropriately budgeted will be approved to receive funding from the Program. The project teams of congressionally mandated activities are responsible for developing project plans and managing the activities.

D. Program Element Projects

Included below are the brief descriptions of the funded projects managed under this National Applications Program Element. Complete and detailed descriptions are documented in the Project Plans for each activity.

| Project: BASINS | | | | Directed Project | |
|---|--|--|----------------------|--|----|
| <p>The goal is to verify and validate Earth-Sun System science products, including MODIS products (land cover, LAI) and land surface model products using LIS in EPA's BASINS decision support tool. A regional test project will be initiated to connect LDAS outputs with BASINS, for use to model the Chesapeake Bay Watershed. MODIS data will either be infused into LDAS first, or directly into BASINS. Benchmark metrics are being developed and will be reported at the end of the project. Project will also conduct Rapid Prototyping to further evaluate and develop NASA capabilities.</p> | | | | <p><i>Budget (\$K)</i></p> <p><i>Procurement</i></p> | |
| | | | | FY06 | 57 |
| <i>Project Manager</i> | <i>Centers</i> | <i>Timeframe</i> | <i>Partners</i> | FY07 | 57 |
| David Toll | GSFC | FY06 - FY10 | EPA | FY08 | 10 |
| | | | | FY09 | 10 |
| | | | | FY10 | 0 |
| <i>Earth Science Products</i> | Terra - MODIS, Aqua - MODIS, Model - LDAS/LIS | | | <i>Other Apps.</i> | |
| <i>Deliverables</i> | <p><u>Description</u></p> <p>Evaluation Report</p> <p>Design & Implement</p> <p>Verification and Validation Report</p> <p>Benchmark Report</p> <p>Results Conference</p> <p>Project Plan</p> | <p><u>End Date</u></p> <p>1/30/2006</p> <p>3/31/2006</p> <p>9/30/2006</p> <p>9/30/2007</p> <p>9/30/2006</p> <p>10/1/2005</p> | <u>IBPD Metric #</u> | <p>Coastal Management, Ecological Forecasting, Public Health</p> | |
| <i>Notes:</i> | | | | | |

| Project: AWARDS and RiverWare | | | | | Directed Project | |
|--|--|------------------|----------------------|---|---------------------|----|
| <p>The goal of this project is to evaluate, verify and validate, and benchmark NASA Earth science products, especially spacecraft and land surface models, for beneficial, routine use in assessment of water availability for agriculture, hydroenergy, endangered species and public recreation based on large scale assessment (AWARDS) and for river stage condition (RiverWare). RPC will also be incorporated to improve use of NASA products.</p> | | | | | <i>Budget (\$K)</i> | |
| | | | | | <i>Procurement</i> | |
| | | | | | FY06 | 57 |
| <i>Project Manager</i> | <i>Centers</i> | <i>Timeframe</i> | <i>Partners</i> | FY07 | 57 | |
| Kristi Arsenault | GSFC | FY06 - FY10 | BoR | FY08 | 10 | |
| | | | | FY09 | 10 | |
| | | | | FY10 | 0 | |
| <i>Earth Science Products</i> | Terra - MODIS, Aqua - MODIS, AMSR-E, Model - LDAS/ LIS | | | <i>Other Apps.</i> | | |
| <i>Deliverables</i> | <u>Description</u> | <u>End Date</u> | <u>IBPD Metric #</u> | Agricultural Efficiency, Energy Management, Disaster Management | | |
| | Evaluation Report | 2/15/2006 | | | | |
| | Design & Implement | 3/31/2006 | | | | |
| | Verification and Validation Report | 9/30/2006 | | | | |
| | Benchmark Report | 9/30/2007 | | | | |
| | Results Conference(s) | 9/30/2006 | | | | |
| | International activities report | 9/30/2006 | | | | |
| | Project Plan | 10/1/2005 | | | | |
| <i>Notes:</i> | | | | | | |

| Project: Exploratory Projects. USDA-NRCS, AFWA, ACE and US Army | | | | | Directed Project | |
|---|--|---|-----------------------------|--|--|----|
| <p>The goal of this project is to establish relationships and to evaluate, verify validate and benchmark Earth science products, especially spacecraft products and land models, for improving performance of the USDA NRCS and other agency (ACE, AFWA, US Army) water supply, forecasts and drought monitoring. Staff will also provide RPC work to further explore use of NASA data.</p> | | | | | <p><i>Budget (\$K)</i></p> <p><i>Procurement</i></p> | |
| | | | | | FY06 | 57 |
| <i>Project Manager</i> | <i>Centers</i> | <i>Timeframe</i> | <i>Partners</i> | FY07 | 57 | |
| Edwin Engman | GSFC | FY06 - FY10 | USDA, ACE, AFWA, Army, USGS | FY08 | 70 | |
| | | | | FY09 | 50 | |
| | | | | FY10 | 10 | |
| <i>Earth Science Products</i> | Terra - MODIS, Aqua - MODIS, GRACE, Terra - ASTER, SRTM Model: LDAS/LIS | | | <i>Other Apps.</i> | | |
| <i>Deliverables</i> | <p><u>Description</u></p> <p>Evaluation Report Design & Implement Verification and Validation Report Benchmark Report Project Plan</p> | <p><u>End Date</u></p> <p>10/1/2010</p> | <p><u>IBPD Metric #</u></p> | Agricultural Efficiency, Disaster Management, Energy | | |
| <i>Notes:</i> | | | | | | |

| Project: Program Planning | | | | Project Management | |
|---|---|--|-----------------------------------|---------------------------|-----|
| <p>The purpose of this activity is to identify important water management issues and evaluate associated management responsibilities and decision support tools to determine opportunities the program element may support. The information and analysis will identify possible applications of Earth system science research results to support the partners as well as help the application develop and structure partnerships. This includes exploratory efforts of transferring knowledge and experience of NASA data to potentially new user groups such as the Army Corp of Engineers and Air Force Weather Agency. OSSEs will be explored to prepare for new NASA water related missions. The Program Managers will explore ways of collaborating with the Rapid Prototyping Capability. Finally, the program will interact with national and international water management related groups such as HELP, GEWEX, ESIP, CCSP, IWGEO, WICP-ACWI, AWRA, IGWECO, etc..</p> | | | | <i>Budget (\$K)</i> | |
| | | | | <i>Procurement</i> | |
| | | | | FY06 | 125 |
| <i>Project Manager</i> | <i>Centers</i> | <i>Timeframe</i> | <i>Partners</i> | FY07 | 125 |
| Lawrence Friedl | HQ (lead), GSFC, SSC, MSFC, JPL | FY06 - FY10 | NOAA, USDA, BoR, ACE, GEWEX, USGS | FY08 | 125 |
| | | | | FY09 | 125 |
| | | | | FY10 | 125 |
| <i>Earth Science Products</i> | Portfolio evaluation, Program Element Strategic Planning, Program Plan | | | <i>Other Apps.</i> | |
| <i>Deliverables</i> | <p><u>Description</u></p> <p>Evaluation Report</p> <p>Design & Implement</p> <p>Verification and Validation Report</p> <p>Benchmark Report</p> <p>Meeting Reports</p> <p>Pre-eval ESS prods for other DSSs</p> <p>Establish Working Group</p> | <p><u>End Date</u></p> <p>6/1/2006</p> | <p><u>IBPD Metric #</u></p> | | |
| <i>Notes:</i> | | | | | |

| Project: Improving NOAA/NWS River Forecast Center Decision Support with NASA Satellite and Land Information System Products | | | | | Solicitation | |
|--|------------------------------------|-------------------|----------------------|--------------------|---------------------|--|
| <p>The proposed work will demonstrate improved accuracy in runoff, stream flow, and flood monitoring and simulation that result from the combination of NASA data and model infrastructure with operational National Weather Service River Forecasting System (NWS RFS) decision support tools. The goal is that the products developed by this CAN proposal will provide NOAA NWS hydrologists with a more accurate basis for decision-making and hydrologic warning product generation. The integrated NASA-NOAA system will be evaluated, verified, validated, and benchmarked in cooperation with personnel at the NOAA Office of Hydrologic Development in order to establish a beneficial, cost effective pathway for extending NASA Earth Science results to the NOAA /NWS analysis and forecast environment.</p> | | | | | <i>Budget (\$K)</i> | |
| | | | | | <i>Procurement</i> | |
| | | | | FY06 | 466 | |
| <i>Project Manager</i> | <i>Centers</i> | <i>Timeframe</i> | <i>Partners</i> | FY07 | 466 | |
| Pedro Restrepo | GSFC, MSFC | 12/1/05 - 12/1/08 | NOAA | FY08 | 466 | |
| | | | | FY09 | | |
| | | | | FY10 | | |
| <i>Earth Science Products</i> | MODIS, QuickSCAT, LDAS/LIS, AMSR-E | | | <i>Other Apps.</i> | | |
| <i>Deliverables</i> | <u>Description</u> | <u>End Date</u> | <u>IBPD Metric #</u> | | | |
| | Evaluation Report | 12/30/2006 | | | | |
| | Design & Implement | | | | | |
| | Verification and Validation Report | 6/30/2007 | | | | |
| | Benchmark Report | 12/30/2008 | | | | |
| | Revised Proposal | 10/30/2005 | | | | |
| | Pending procurement negotiations | 11/30/2005 | | | | |
| <i>Notes:</i> | | | | | | |

| Project: Improving Water Resources Management in the Western US through the Use of Remote Sensing Data and Seasonal Climate Forecasts | | | | | Solicitation | |
|--|------------------------------------|------------------|---|--|---------------------|--|
| <p>This project will incorporate NASA data into the University of Washington West-wide Seasonal Forecast System. The University of Washington experimental west-wide seasonal hydrologic forecast system produces 6-12 month lead time hydrologic forecasts at approximately 100 forecast points in five major river basins within the western U.S. The system is an outgrowth of the North American LDAS (N-LDAS) project. The system is based on the University of Washington/Princeton University Variable Infiltration Capacity (VIC) macroscale hydrology model, driven by climate ensembles downscaled from the NCEP Seasonal Forecast Model (SFM), the NASA NSIPP1 global model, and an ensemble version of the CPC official seasonal outlooks (12 month lead time). This project will incorporate EOS remote sensing data, including MODIS snow cover extent, ET, and reservoir surface temperature, and AMSR-E snow water equivalent.</p> | | | | | <i>Budget (\$K)</i> | |
| | | | | | <i>Procurement</i> | |
| | | | | FY06 | 406 | |
| <i>Project Manager</i> | <i>Centers</i> | <i>Timeframe</i> | <i>Partners</i> | FY07 | 392 | |
| Dennis Lettenmaier | | 12/05 - 12/08 | NRCS, BoR, CA Dept. of Water Resources | FY08 | 399 | |
| | | | | FY09 | | |
| | | | | FY10 | | |
| <i>Earth Science Products</i> | MODIS, AMSR-E | | | <i>Other Apps.</i> | | |
| <i>Deliverables</i> | <u>Description</u> | <u>End Date</u> | <u>IBPD Metric #</u> | Disaster Management, Energy, Ecological Forecasting, Agriculture | | |
| | Evaluation Report | 12/30/2006 | | | | |
| | Design & Implement | | | | | |
| | Verification and Validation Report | 12/30/2007 | | | | |
| | Benchmark Report | 12/30/2008 | | | | |
| | Pending procurement negotiations | 11/30/2005 | | | | |
| <i>Notes:</i> | | | | | | |

| Project: National Drought Monitoring System for Drought Early Warning using Hydrologic and Ecologic Observations from NASA Satellite Data | | | | | Solicitation | |
|--|------------------------------------|------------------|----------------------|---|---------------------|--|
| <p>The proposed work will assimilate hydrologic and ecologic observations from NASA Earth satellite sensors, including the Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E), the QuikSCAT/SeaWinds Scatterometer (QSCAT), and the Moderate Resolution Imaging Spectroradiometer (MODIS), into the United States Drought Monitor (USDM), hosted by the National Drought Mitigation Center at the University of Nebraska. The investigators will apply a systematic approach using the systems engineering process of evaluation, verification/validation, and benchmarking to achieve major improvements in national drought monitoring and early warning capabilities. NASA satellite products to be evaluated and incorporated include soil moisture, precipitation water on land surface, and vegetation state. These products have the potential to significantly enhance three of the most important indices used in USDM.</p> | | | | | <i>Budget (\$K)</i> | |
| | | | | | <i>Procurement</i> | |
| | | | | FY06 | 466 | |
| <i>Project Manager</i> | <i>Centers</i> | <i>Timeframe</i> | <i>Partners</i> | FY07 | 466 | |
| Son Nghiem | JPL | 12/200 - 12/200 | USGS | FY08 | 466 | |
| | | | | FY09 | | |
| | | | | FY10 | | |
| <i>Earth Science Products</i> | AMSR-E, MODIS, Quikscat | | | <i>Other Apps.</i> | | |
| <i>Deliverables</i> | <u>Description</u> | <u>End Date</u> | <u>IBPD Metric #</u> | Disaster Management, Ecological Forecast, Agriculture | | |
| | Evaluation Report | 12/31/2006 | | | | |
| | Design & Implement | | | | | |
| | Verification and Validation Report | 12/31/2007 | | | | |
| | Benchmark Report | 12/31/2008 | | | | |
| | Revised Proposal | 10/31/2005 | | | | |
| | Pending procurement negotiations | 11/30/2005 | | | | |
| <i>Notes:</i> | | | | | | |

E. Additional Activities & Linkages

In general, the NASA Water Management Program Element is following program direction to emphasize links such as to the following activities: National: DOI 2025, GEO, ASCE, USGS-WCIP. International: CEOS/CEOP, IGWCO, IGOS-P Water, CCSP - Water.

IBS Request

Evaluation Reports for FY06

- 1) EPA Water Quality (Toll)
- 2) BoR Water Supply and Forecast (Arsenault)
- 3) NOAA RFC Flood (Restrepo)
- 4) AFWA LIS (Peters-Lidard)
- 5) Early Drought Monitor (Verdin)
- 6) Water Supply Forecasting (Lettenmaier)

V&V Reports

- 1) EPA Water Quality (Toll)
- 2) BoR Water Supply & Demand (Arsenault)

Benchmark Report

Directed Funding Projects for FY06. One planned from BoR or EPA

Program Response to IBS Request

To be supplied by program management.

Crosscutting Request

- DEVELOP students
- Solutions Networking capabilities and prototype
- Rapid Prototyping Capability
- GIO

Program Response to Crosscutting Request

To be supplied by program management.

VI. Budget: FY06-010

The following table lists the Water Management Program budget (procurement) for FY2006:

| <u>Project</u> | FY06 Procurement Allocation (\$K) |
|--|--|
| BASINS | \$ |
| AWARDS and RiverWare | \$ 60 |
| Exploratory New ProjectsUSDA NRCS, AFWA, ACE | \$ 26 |
| Program Planning and Alignment | \$ 75 |
| Program Workshop | \$ 30 |
| NOAA NCEP Eta | \$ - |
| Improving NOAA/NWS River Forecast Center Decision Support with NASA Satellite and Land Information System Products | \$ 466 |
| Improving Water Resources Management in the Western US through the Use of Remote Sensing Data and Seasonal Climate Forecasts | \$ 406 |
| National Drought Monitoring System for Drought Early Warning using Hydrologic and Ecologic Observations from NASA Satellite Data | \$ 466 |
| Total = | \$ 1529 |

Appendix C lists program-wide budget allocations for FY2006-10.

VII. Program Management and Performance Measures

The Water Management Program team uses performance measures to track progress, identify issues, evaluate projects, make adjustments, and establish results of the program element. The program's goal and objectives (Section II) state what the program intends to achieve. These measures help the team monitor progress within and across specific activities to ensure the program meets its goal and objectives. The management team analyzes these measures retrospectively in order to make adjustments prospectively to the program approach and objectives.

The measures are in two categories (tables below): Program Management measures are internally focused to assess the activities within the program. Performance measures are externally focused to assess if the program activities are serving their intended purpose. In general, the Water Program uses these measures to evaluate the performance of activities conducted and sponsored by the program, especially the projects. In addition, the Applied Sciences Program uses this information in preparing IBPD directions and PART responses.

Program Management Measures (Internal):

Inputs:

- 1) Potential issues and DST identified for Water Management – number, type, range
- 2) Eligible partners to collaborate with – number, type, range
- 3) Potential results/products identified to serve Water Management – number, type, range

Outputs:

- 1) Assessments or evaluations of DSTs – number, range
- 2) Assessments of Earth system science results/products to serve DST – number, range
- 3) Agreements with partners – presence
- 4) Reports (evaluation, validation, benchmark) – number, type

Quality and Efficiency:

- 1) Earth system science results/products – number used per DST, ratio of utilized to potential
- 2) Agreements – ratio of agreements to committed partners
- 3) Reports – partner satisfaction, timeliness, time to develop
- 4) Reports – ratio of validations to potential products, ratio of benchmarks to validations

Performance & Results Measures (External):

Outcomes:

- 1) Earth Science Division's science products adopted in DST – number, type, range; use in DST over time
- 2) Earth Science Division's science products in use – ratio of products used by partners to reports produced
- 3) Partner & DST performance – change in partner DST performance, number and type of public recognition of use and value of Earth science data in DST

Impacts:

- 1) Partner value – change in partner metrics (improvements in value of partner decisions)

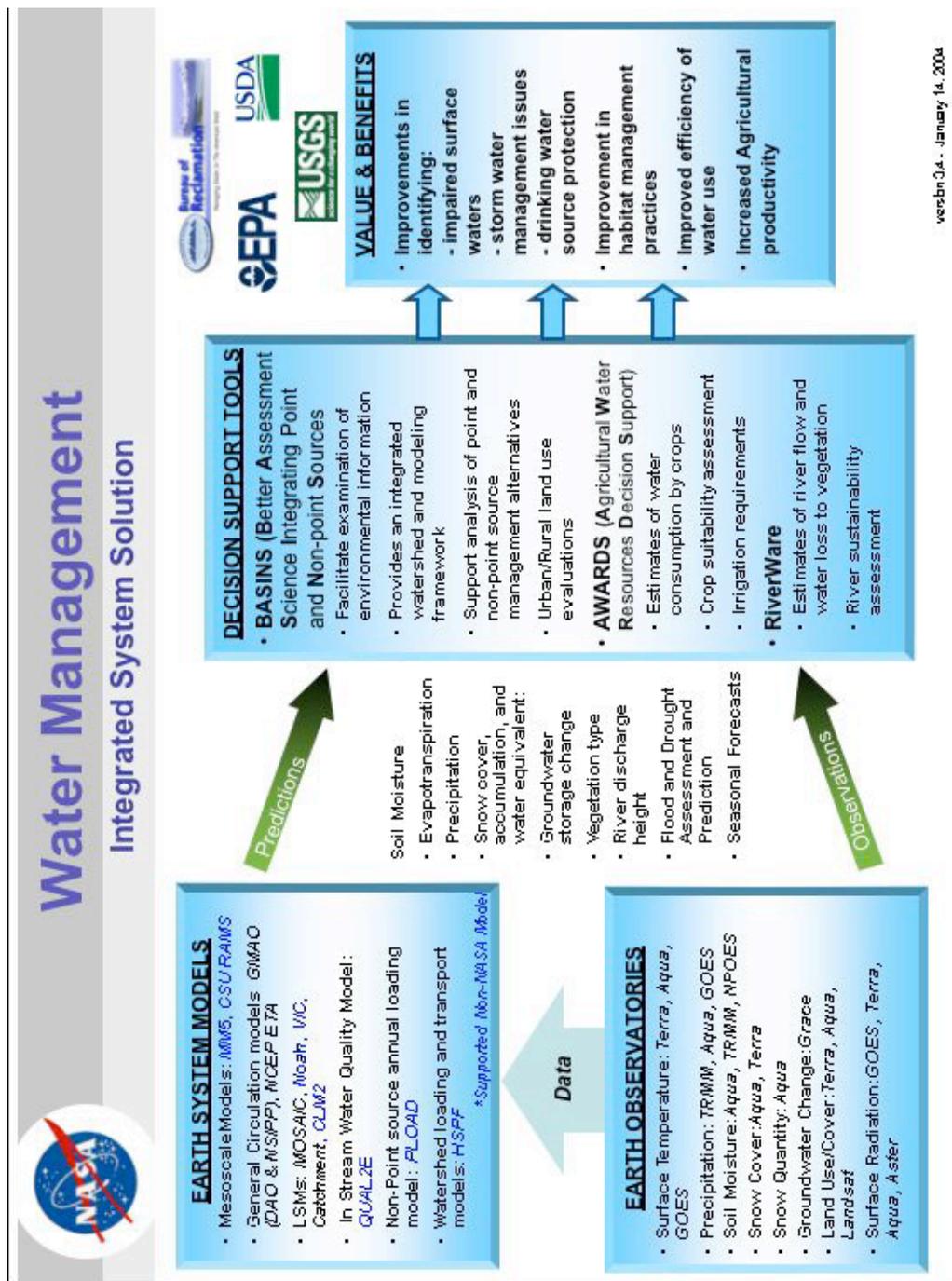
In addition to the stated measures, the Water Management Program periodically requests an assessment of its plans, goals, priorities, and activities through external review. The Water Management team uses these measures along with comparisons to programmatic benchmarks to support assessments of the Applied Sciences Program (e.g. internal NASA reviews and OMB PART). In specific, Water Management uses comparisons to similar activities in the following programs (i.e., program benchmarks) to evaluate its progress and achievements:

- Environmental and Societal Impacts Group at NCAR
- NCAR Research to Applications Group
- Global Monitoring for Environment and Security (GMES) in Europe

VIII. Appendices

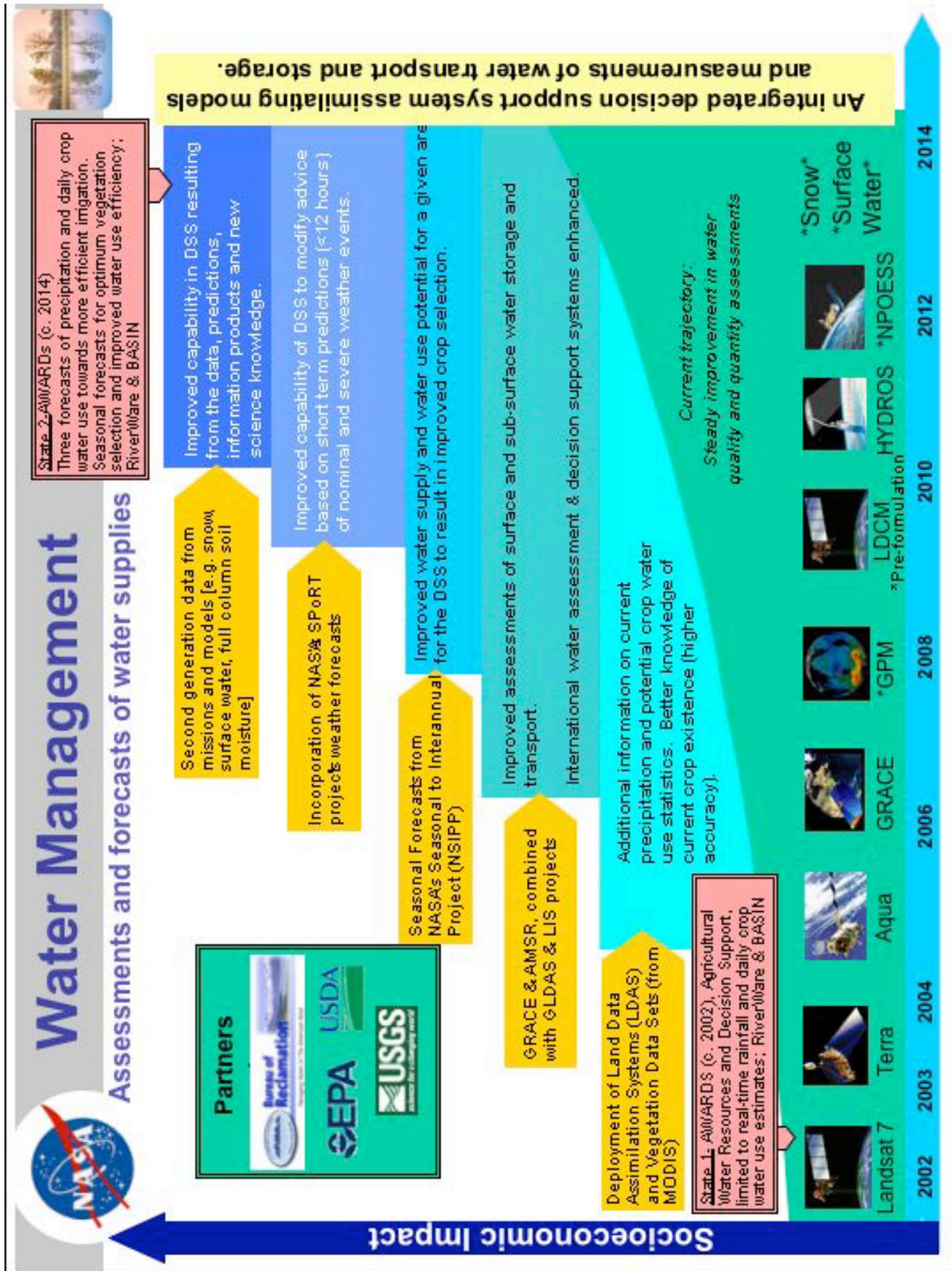
A. Integrated System Solutions Diagram

The figure below illustrates how Science measurements, model products, and data fusion techniques support the Water Management Program's partners and their decision support tools and shows the value and benefits of Science to society.



B. Roadmap

The following roadmap shows the direction of the program over the next ten years. It illustrates the current state of Water Management DSTs and the projected state of those DSTs with the infusion of NASA Earth-Sun system science research results. The Water Management program plan deals in detail with the first five years of the roadmap.



C. Applied Sciences Program Budgets FY2006-10

The following figures represent the FY06 budgets for the respective Program Elements; they do not represent the entire Applied Sciences Program budget. There is an additional \$8.95million in Congressionally-directed activities and \$5million for the Mississippi Research Consortium that these figures do not incorporate.

| Program Element | FY06 Procurement Allocation |
|--------------------------------|------------------------------------|
| National Applications | |
| Agricultural Efficiency | \$ 1,955,803 |
| Air Quality | \$ 3,116,464 |
| Aviation | \$ 3,048,878 |
| Carbon Management | \$ 1,544,831 |
| Coastal Management | \$ 1,416,233 |
| Disaster Management | \$ 2,743,760 |
| Ecological Forecasting | \$ 3,240,170 |
| Energy Management | \$ 1,875,253 |
| Homeland Security | \$ 1,987,054 |
| Invasive Species | \$ 2,241,940 |
| Public Health | \$ 3,356,124 |
| Water Management | \$ 1,714,341 |
| | |
| Crosscutting Solutions | |
| DEVELOP | \$ 1,498,000 |
| Geospatial Interoperability | \$ 2,400,000 |
| Solutions Networks | \$ 2,822,000 |
| Integrated Benchmarking System | \$ 4,500,000 |

The following figures show the five-year run-out for the entire Applied Sciences Program. The figures are based on the FY07 President's budget submitted to Congress. The lower line shows the target budget including agency corporate and institutional adjustments.

| | 2006 | 2007 | 2008 | 2009 | 2010 |
|--|-------------|-------------|-------------|-------------|-------------|
| Present Budget Summited to Congress | 53,254,855 | 51,049,000 | 50,287,000 | 48,588,000 | 48,662,000 |
| Target After Adjustments | 47,321,663 | 39,101,000 | 33,922,000 | 34,801,000 | 34,803,000 |

D. Related NASA and Partner Solicitations and Grants

Appendix D lists NASA Earth-Sun system science research projects, Earth science fellowships, GLOBE activities, and Earth science New Investigators related to Water Management activities.

Fellowships

| Earth Science Education | | | |
|--|-----------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| National Center for Atmospheric Research | Fei Chen | Atmospheric Responses to Land Surface Forcing and their Impacts on Precipitation | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|-----------------------------------|------------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| University of Wisconsin - Madison | Jonathan Chipman | Multisensor Spaceborne Monitoring of Large Lakes Worldwide: Assessment of Trends in Water Storage and Water Quality | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|-----------------------------------|-----------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| USDA Agriculture Research Service | Wade Crow | Monitoring Root-Zone Soil Moisture via Multi-Frequency Remote Sensing of Surface Soil Moisture and Evapotranspiration | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|---------------------------------------|------------------|--|-------------------------|
| <u><i>Institution</i></u> | <u><i>PI</i></u> | <u><i>Title/Subject</i></u> | <u><i>Timeframe</i></u> |
| Massachusetts Institute of Technology | Dara Entekhabi | Estimation of the Evaporation Efficiency Linking Land Water and Energy Balance Based on Remotely Sensed Measurements | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|--------------------------------|------------------|--|-------------------------|
| <u><i>Institution</i></u> | <u><i>PI</i></u> | <u><i>Title/Subject</i></u> | <u><i>Timeframe</i></u> |
| Goddard Space Flight Center | David Harding | Global Surface Water Mission Design Constraints from ICESat and Streamflow Data Analysis | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|--------------------------------|------------------|---|-------------------------|
| <u><i>Institution</i></u> | <u><i>PI</i></u> | <u><i>Title/Subject</i></u> | <u><i>Timeframe</i></u> |
| University Alaska - Fairbanks | Larry Hinzman | Current Climate Changes over Eastern Siberia and their Impact on Permafrost Landscapes, Ecosystem Dynamics, and Hydrological Regime | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|--------------------------------|--------------------|--|-------------------------|
| <u><i>Institution</i></u> | <u><i>PI</i></u> | <u><i>Title/Subject</i></u> | <u><i>Timeframe</i></u> |
| University of Washington | Dennis Lettenmaier | Estimating Continental-Scale Water Balances through Modeling and Assimilation of In-Situ and Remote Sensing Data | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|--------------------------------|---------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| JPL | Kyle McDonald | A Satellite-Based Landscape Surface Resistance Measurement for Improved Assessment of Land-Atmosphere Water and Energy Transfer | 2006-2008 |

Fellowships

| Earth Science Education | | | |
|--------------------------------|----------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA MSFC | Robert Olgesby | Evaluating the Role of Global Snow Cover on Seasonal to Interannual Predictability of Temperature and Precipitation | 2006-2008 |

New Investigators

| Earth Science Education | | | |
|--------------------------------|---------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Peggy O'Neill | A Multi-Sensor Examination of Microwave Soil Moisture Retrieval Through Tree Canopies | 2006-2008 |

New Investigators

| Earth Science Education | | | |
|--------------------------------|----------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Matthew Rodell | Assimilation of GRACE Derived Terrestrial Water Storage Variations | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|---------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ of Maryland - College Park | Peter Romanov | Continuous Fields of Snow Cover Characteristics Derived Through Coupling Satellite Data with Snowpack Model Application in the River Runoff Modeling over NEESPI Domain | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|---------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Cooperative Institute for Research in Environmental Studies | Andrew Slater | Use of NASA Technologies in the Development of the Next-Generation Streamflow Forecasting System | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|---------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ. of Cal. Santa Barbara | Jiancheng Shi | Snow Retrieval Algorithm Development for a Satellite-Based Snow Processes Mission | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|----------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ Cal - Los Angeles | Laurence Smith | Area-stage Relationships in Rivers and Wetlands: Tracking the High-Latitude Water Cycle and Provision of Core Knowledge Requirements for a Surface Water Mission | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|-------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ Washington | Leung Tsang | Retrieval Algorithms for Passive and Active Microwave Remote Sensing of Snow | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|-----------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Princeton Univ | Eric Wood | An Integrated Understanding of the Terrestrial and Energy Cycles Across the NEESPI Domain through Observations and Modeling | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| JPL | Simon Yueh | Polarimetric Passive and Active Remote Sensing of Soil Moisture | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|--------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Robert Adler | Global Precipitation and Active Remote Sensing of Soil Moisture | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Atmospheric Research | Alan Betts | Understanding and Evaluating the Coupling of Land-Surface, Boundary Layer, Cloud and Radiative Transfer Processes in the Global Water and Energy Cycle | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|-----------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Mike Bosilovich | Evaluation of NASA's Global Water Cycle Data: Interannual Variability, Inter-Decadal Changes and Trends | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|------------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Lahouari Bounoua | Development of Process Algorithms and Datasets for Urbanization and Climate Studies | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|--------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ Michigan | Daniel Brown | Changing Responses of Land Dynamics and Vulnerability to Flooding Under Policy and Environmental Change around Poyang Lake, China | 2006-2008 |

Other

| Earth System Science Research Using Data and | | | |
|---|-------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ Toledo | Jiquan Chen | Effects of Land Use Change on the Energy and Water Balance of the Semi-Arid Region of Inner Mongolia | 2006-2008 |

Other

| IDS NRA | | | |
|---------------------|---------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Colorado State Univ | Scott Denning | A Global, Multiscale Vegetation Modeling System for NEWS | 2006-2008 |

Other

| IDS NRA | | | |
|---|----------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ MD for Environmental Science - Frostburg | Keith Eshleman | Excaberation of Flooding Response Due to Land Cover/Land Use Change: A Comparative Study | 2006-2008 |

Other

| IDS NRA | | | |
|--------------------------|-------------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Univ California - Irvine | James Famiglietti | A Study of the First Global Measurements of the Water Cycle | 2006-2008 |

Other

| IDS NRA | | | |
|-----------------------|---------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Horn Point Laboratory | Thomas Fisher | Response of Coastal Waters t Terrestrial Inputs of Elemental NCP in Urbanizing Coastal Regions | 2006-2008 |

Other

| IDS NRA | | | |
|----------------------------|-------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Woods Hole Research Center | Scott Goetz | Urban Growth Impacts on Surface Hydrology in Mid-Atlantic and New England Watersheds | 2006-2008 |

Other

| IDS NRA | | | |
|----------------------------|------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| San Diego State University | Allen Hope | Regional Hydrologic Response of Semi-Arid Mediterranean Climate Watersheds to Land-Cover/Land-Use Variability | 2006-2008 |

Other

| IDS NRA | | | |
|-----------------------|------------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| Iowa State University | Brian Hornbuckle | A Prototype Remote Sensing Validation Site: Towards a Multi-Variable Approach to Validating and Scaling Remote-Sensed Obserations of the Water Cycle | 2003-2005 |

Other

| IDS NRA | | | |
|--------------------|-------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Marc Imhoff | An Earth Observation-Supported Strategy Linking Biophysics and Socio-Economics for Addressing Water Vulnerability | 2006-2008 |

Other

| IDS NRA | | | |
|--------------------|-----------------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Christa Peters-Lidard | NASA Model and Observation Products for the Study of Land Atmosphere Coupling and Its Impact on Water and Energy Cycle | 2006-2008 |

Other

| IDS NRA | | | |
|--------------------|-------------|---|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| NASA GSFC | Matt Rodell | Integration of Energy and Water Cycle Research Products in a Global Land Surface Modeling and Assimilaiton Scheme | 2006-2008 |

Research Projects

| NULL | | | |
|-----------------------------|--------------------|--|------------------|
| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
| University of New Hampshire | Charles Voorsmarty | Contributions fo Changes in Land Use, Land Cover, Water Use and Climatge to the Hydrologic Cycle Across the Central Asian States | 2006-2008 |

| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
|---------------------------------------|------------|--|------------------|
| University of California San Diego | John Roads | Global Water and Energy Budget Studies | 2006-2008 |

| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
|--------------------|--------------------|---|------------------|
| NASA GSFC | Siegfried Schubert | On the Causes and Predictability of Multi-Year North American Droughts with Applications to Drought Monitoring and Water Management | 2006-2008 |

| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
|---------------------|-------------|---|------------------|
| University of Miami | Brian Soden | The Sensitivity of the Global Water and Energy Cycles: An Assessment of Models and Observations | 2006-2008 |

| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
|--------------------------|--------------------|--|------------------|
| University of California | Soroosh Sorooshian | The Challenges of Utilizing Satellite Precipitation Data for Hydrologic Applications | 2006-2008 |

| <u>Institution</u> | <u>PI</u> | <u>Title/Subject</u> | <u>Timeframe</u> |
|-----------------------|------------|--|------------------|
| University of Arizona | Xubin Zeng | Relationship Between Land Cover/Land Use Change and Surface Hydrology over Arid and Semiarid Regions | 2006-2008 |

E. Acronyms and Websites

ACRONYMS:

| | |
|----------|---|
| ACWI | Advanced Committee on Water Information |
| ACRIM | Active Cavity Radiometer Irradiance Monitor Satellite |
| AHPS | Auxiliary Hydraulic Power supply |
| AIRS | Airborne Infrared Sounder |
| AIRS | Alliance Icing Research Study |
| ASCE | American Society of Civil Engineers |
| AMSR-E | Advanced Microwave Scanning Radiometer-EOS (Japanese) |
| AWRA | American Water Resources Association |
| Aqua | EOS Spacecraft |
| Aquarius | Mission to measure global Sea Surface Salinity |
| ARC | Ames Research Center |
| AVHRR | Advanced Very High Resolution Radiometer |
| AWARDS | Automated Weather Acquisition and Retrieval System |
| BASINS | Better Assessment Science Integrating Point and Non-point Sources |
| BOR | Bureau of Reclamation Department of Interior |
| CCSP | Climate Change Science Program |
| CLM | Center for Naval Amylases |
| CloudSAT | A NASA Earth System Science Pathfinder Mission |
| DAAC | Distributed Active Archive Center (Data Active Archive Center) |
| DOI | US Department of the Interior |
| DSS | Decision Support Systems |
| DST | Decision Support Tool |
| EO-1 | Earth Observing-1 |
| EOS | Earth Observing Systems |
| EPA | US Environmental Protection Agency |
| ESA | Earth Science Applications |
| ESIP | Earth Science Information Partners |
| ESTO | Earth-Sun System Technology Office |
| FEA | Federal Enterprise Architecture |
| FEMA | Federal Emergency Management Agency |
| FY | Fiscal Year |
| GCM | Global Climate Model |
| GES | Geospatial Extension Service |
| GEWEX | Global Energy and Water Cycle Experiment |
| GFDL | Geophysics Fluid Dynamics Laboratory |
| GIG | Global Information Grid |
| GISS | Goddard Institute for Space Studies |
| GMAO | Global Modeling and Assimilation Office |
| GMES | Global Monitoring for Environment and Security |
| GPM | Global Precipitation Measurement |
| GRACE | Gravity Recovery and Climate Experiment |

| | |
|---------|--|
| GSFC | Goddard Space Flight Center |
| GWSP | Global Water Systems Project |
| HELP | Hydrology for Environment, Life, and Policy |
| IBPD | Integrated Budget and Performance Document |
| IFPRI | International Food Policy Research Institute |
| IGARSS | International Geophysical Remote Sensing Society |
| IGOS | Integrated Global Observations Strategy |
| IGWCO | Integrated Global Water Cycle Observations |
| IMPACT | Interactive Modeling Project for Atmospheric Chemistry and Transport |
| IWGEO | Interagency Working Group on Earth Observations |
| JCSDA | Joint Center for Satellite Data Assimilation |
| JPIP | JPEG2000 Internet Protocol |
| JPL | Jet Propulsion Laboratory |
| LaRC | Langley Research Center |
| LDAS | Land Data Assimilation System |
| LIS | Lightning Imaging Sensor |
| LSM | Lightning Mapper Sensor |
| LP | Land Processes |
| MIT | Massachusetts Institute of Technology |
| MM5 | Mesoscale Model |
| MODIS | Moderate Resolution Imaging Spectroradiometer |
| MOU | Memorandum of Understanding |
| MSFC | Marshall Space Flight Center |
| NASA HQ | NASA Headquarters |
| NASA | National Aeronautics and Space Administration |
| NCAR | National Center for Atmospheric Research |
| NESDIS | National Environmental Satellite Data Information Service |
| NEWS | NASA Energy- and Water- cycle Study |
| NIP | New Investigator Program |
| NOAA | National Oceanic and Atmospheric Administration |
| NOAH | A Land Surface Model |
| NPOESS | National Polar-Orbiting Operational Environmental Satellite System |
| NPP | NPOESS Preparatory Project/Net Primary Productivity |
| NRA | NASA Research Announcement |
| NSF | National Science Foundation |
| NWS | National Weather Service |
| OAR | Office of Oceanic and Atmospheric Research |
| OMB | Office of Management and Budget |
| OSSE | Observing System Simulation Experiment |
| OSTP | Office of Science and Technology Policy |
| PART | Program Assessment Rating Tool |
| R2O | Research to Operations Network |
| RAMS | Regional Atmospheric Modeling System |
| REASoN | Research, Education, and Applications Solutions Network |
| SEA | State Enterprise Architecture |

| | |
|-------|--|
| SPoRT | Short-term Prediction Research and Transition Center |
| SSC | Stennis Space Center |
| SWAT | Soil and Water Assessment Tool |
| TERRA | Not an Acronym |
| TMDL | Total Maximum Daily Loads |
| TRMM | Tropical Rainfall Measurement Mission |
| UAV | Unmanned Aerial Vehicles |
| UCAR | University Corporation for Atmospheric Research |
| UCOWR | University Council on Water Resources |
| UMUC | University of Maryland University College |
| USDA | US Department of Agriculture |
| USGS | United States Geological Survey |
| VIC | Variable Infiltration Capacity (Macroscale Model) |
| WCIP | Water Information Coordination Program |

WEBSITES:

AIWG: <http://aiwg.gsfc.nasa.gov>
Applied Sciences Program: <http://science.hq.nasa.gov/earth-sun/applications>
DEVELOP: <http://develop.larc.nasa.gov>
Earth-Sun System Gateway (ESG): <http://esg.gsfc.nasa.gov/>
Earth-Sun Science System Components: <http://www.asd.ssc.nasa.gov/m2m>
NASA FY2005 Budget: <http://www.ifmp.nasa.gov/codeb/budget2005>
Research and Analysis Program: <http://science.hq.nasa.gov/earth-sun/science/>
Science Mission Directorate: <http://science.hq.nasa.gov>
Science Strategies: <http://science.hq.nasa.gov/strategy/>
2025 DOI Initiative: <http://www.doi.gov/water2025/>
Army Corp Engineers water site: <http://www.iwr.usace.army.mil/>
EPA Water Quality: <http://www.epa.gov/waterscience/index.html>
IGOS Water: <http://ioc.unesco.org/igospartners/Water.htm>
OSTP-SWAQ on Water Availability : http://www.ostp.gov/NSTC/html/swaqreport_2-1-05.pdf
LDAS: <http://ldas.gsfc.nasa.gov>
LIS: <http://lis.gsfc.nasa.gov>
USDA NRCS: <http://www.wcc.nrcs.usda.gov/>
University consortium on water resources: <http://www.cuahsi.org/>
NOAA NWS Office of Hyd. Development: <http://www.weather.gov/oh/>