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# Opportunities for the Water Resources Community to Participate in NASA's Applied Sciences Program

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# OPPORTUNITIES FOR THE WATER RESOURES COMMUNITY TO PARTICIPATE IN NASA'S APPLIED SCIENCES PROGRAM

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NASA has long been considered to be a science organization but only within the last few years has its Earth Science Applied Science Program begun to have an impact of the solving of the nations technical, societal and economic problems. The primary goal of the Earth Science Applied Science Program is to improve future and current operational systems by infusing them with scientific knowledge of the Earth system gained through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities.

The goal of the Water Management Program Element is to encourage water management organizations to use Earth science data, models, technology and other capabilities in their decision support tools for problem solving related to water resource management Examples of the types of NASA contributions to the water management community include such possibilities as:

- Using satellite observations to estimate hydrologic variables, i.e, snow water equivalent, etc.
- Model derived products through data assimilation, i.e., precipitation, etc.
- Water quality, i.e., improved inputs to nonpoint source models, turbidity, temperature, etc.

The activities are carried out through competitive grants that are peer reviewed to insure that they are technically feasible and address high priority Program goals. This paper uses examples to describe the WMP and the potential opportunities for using NASA science products for problem solving. The paper also describes how governmental, private and academic organizations can participate and compete for NASA support to enhance their problem solving mandates

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# OPPORTUNITIES FOR THE WATER RESOURCES COMMUNITY TO PARTICIPATE IN NASA'S APPLIED SCIENCES PROGRAM

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**Abstract - This paper describes the NASA's Water Management Applications Program and opportunities for the water resources community to participate. NASA's Applied Sciences Program (ASP) has the primary responsibility to accelerate the use of NASA data and science results in applications and to help solve problems important to society and the economy. The primary goal of the ASP Program is to improve future and current operational systems by infusing them with scientific knowledge of the Earth system gained through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities.**

## 1. INTRODUCTION

Our home planet is characterized by its strong cycling and replenishing of water. However, with increasing population pressure and water usage, coupled with climate variability and change, water issues are being reported by numerous groups as the most critical environmental problems facing us in the 21st century. In recent U.S. opinion polls, water related issues are in the top 3 of 5 environmental concerns. The potential crises and conflicts arise when water is competed among multiple uses. For example, urban areas, environmental and recreational uses, agriculture, and energy production compete for scarce resources, not only in the Western U.S. but throughout much of the U.S. and in many other parts of the world.

Monitoring the surface and ground water supply is a vital societal need. Surface water includes both flowing water in streams and rivers, natural lakes, polar ice caps and man-made reservoirs. Ground water includes the large amounts of water stored beneath the Earth's surface in aquifers – vitally important to the viability of agriculture in arid climates. It is important to determine where supplies of fresh water are located, to quantify how much water is available, and to determine how fast the water supply is changing. Increased demand threatens to deplete these precious water resources and accurate information on water availability is required to meet the water resource needs of ever growing populations.

## II. NASA's MISSION

The NASA vision and mission statements include a clear focus on the Earth and life on Earth. NASA seeks to improve life on Earth by enabling people to use measurements of our home planet in valuable ways that help improve life here. NASA's Science Mission Directorate has primary responsibility for two Agency-wide, Earth oriented themes in the NASA strategic plan: Earth system science and Earth science applications. In serving these themes, the directorate works with its domestic and international partners to provide accurate, objective scientific data and analysis to advance our understanding of Earth system processes and to help policy makers and citizens achieve economic growth and effective, responsible stewardship of Earth's resources. The NASA Applied Sciences Program has the primary responsibility for

the application of Earth science data with the objective to accelerate the use of NASA science results in applications that help solve problems important to society and the economy. The primary goal of the NASA Applied Science Program is to improve future and current operational systems by infusing them with scientific knowledge of the Earth system gained through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities.

## III. NASA's WATER MANAGEMENT PROGRAM

NASA's Applied Science Program has identified twelve applications of national priority (program elements) of which water management is one. NASA collaborates with partner organizations to enable and enhance the application of NASA's Earth system science research results to serve national priority policy and management decision-support tools. The Water Management Program Element addresses issues of concern and decision-making related primarily to water quality and availability. Some cross-cutting activities also 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 that address issues related to water availability, forecasting, and quality. 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.

### A. Integrated System Solutions Architecture

Figure 1 illustrates the architecture underlying the Earth Science Applications Program. To the right, partner agencies and organizations own, develop, and operate Decision Support Tools (DSTs) to analyze scenarios, identify alternatives, assess risks, to implement their decision making process. Federal agencies use these DSTs to support their responsibilities for efficient and effective water management.

On the left side of the figure, NASA, as a research and development agency, extends its observations (data), model products and predictions, and computational techniques from its Earth science research to support its partners. Where the Earth science products have been determined to have potential value, NASA and its partners will collaborate to facilitate and streamline the flow of products to the DSTs (middle region of the figure), drawing on interoperability practices to support data system and system integration.

### B. Systems Engineering Approach

In collaborating with partners to pursue integrated system solutions, the program employs system engineering steps of *evaluation, verification, validation* and *benchmarking.* The *evaluation phase* looks for an initial match between partner needs and potential NASA products that might be useful for improved DST use. *Verification* determines how the actual performance of an observation, data product or other Earth science product meets the user-defined requirements within specified tolerances. *Validation* determines if the performance of the DSTs using Earth science data or products can achieve the intended outcome. *Benchmarking* is a rigorous process to compare and quantify the performance of a DST using NASA products to a standard benchmark, or current practice to document the value added (if any) from use of the NASA products.

### C. Water Management Goal

The NASA Water Management Program Element addresses concerns and decision making related to water availability, water forecast and water quality. The goal of the Water Management Program Element is to encourage water management organizations to use NASA Earth science data, models products, technology and other capabilities in their decision support tools for problem solving. The Water Management Program Element partners with Federal agencies, academia, private firms, and may include international organizations. Examples of the types of NASA contributions to the water management community include such possibilities as:

- Satellite observations within models assist to estimate water storage, i.e., snow water equivalent, soil moisture, aquifer volumes, or reservoir storages.
- Model derived products, i.e., evapotranspiration, precipitation, runoff, ground water recharge, and other 4-dimensional data assimilation products.
- Water quality assessments by using improved inputs from NASA models, satellite observations (e.g., temperature, turbidity) and input data for nonpoint source models.
- Water (i.e., precipitation) predictions from days to decades over local, regional and global scales

D. NASA Earth Science Contributions

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. NASA partners with Federal agencies and other organizations that have water management responsibilities and mandates to support water resource managers. The program includes activities through involvement of US partner organizations. 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 values additional partnerships, including those with international collaborators, universities and private firms.

Measurements from sensors on Earth Science missions for the Water Management Program Element include: (current) Aqua, Terra, Grace, TRMM (Tropical Rainfall Measurement Mission), EO-1 (Earth Obseving-1, Landsat, (future) CloudSAT, GPM (Global Precipitation Mission), NPP (NPOESS Prepatory Project), and NPOESS (National Polar Orbiting Operational Environmental Satellite System). There are numerous land surface, mesoscale, and GCM Earth science models that provide useful, water-related assessments, including: Land Surface Models (LSMs) CLM (Community Land Model, Mosaic, "Noah", and VIC (Variable Infiltration Capacity) supported by the Land Data Assimilation System (LDAS) and Land Information System (LIS); mesoscale models MM5 and RAMS (Regional Atmospheric Modeling System); and GCMs run by GISS (Goddard Institute for Space Studies), GMAO (Global Modeling and Assimilation Office), GFDL (Geophysics Fluid Dynamics Laboratory), and NCAR (National Center for Atmospheric Research). 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, environmental data records, and geophysical parameters.

E. Examples of NASA Applications

In Fiscal Year 2005 (FY05), the Program Element's priority activities focused on extending MODIS and LDAS / LIS products to three management decision support systems (DSSs): BASINS (EPA), AWARDS (BoR), and RiverWare (BoR). In FY06, lead activities include identification of NASA resources to augment performance of the USDA Decision Support Tools (DSTs) National Agricultural Statistics Service (NASS), Automated Geospatial WAtershed Assessment (AGWA) and National Integrated Drought Information

System (NIDIS). Plans are being formulated to transfer NASA expertise and experience specifically in the fields of data assimilation to NOAA's Office of Hydrologic Development. The end intention of this transfer is the augmentation of the National Weather Service (NWS) operational DSTs. Significant potential exists to support the NWS's Advanced Hydrologic Prediction System (AHPS), the proposed Community Hydrologic Prediction System (CHPS) and the National Digital Forecast Database (NDFD). The DST targeted for improvement is the NWS River Forecast System (NWSRFS), which includes the Ensemble Streamflow Prediction (ESP) Subsystem and the Distributed Hydrologic Modeling System (DHMS). The primary data sets include MODIS land surface products (snow cover, land cover, LAI, etc.), the NASA LIS modeling of water availability, and AMSR-E soil moisture and snow water equivalent products.

## IV. FUTURE ACTIVITIES

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, Cold Land Processes, WaTER and Soil Moisture Mission) 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 by the specific spacecraft mission science teams. Potential future observational spacecraft products should be evaluated for both direct use within DSTs, and for indirect use through modeling to improve model output that is used by DSTs. In addition, the Water Management Program is working towards an integrated watershed management system approach using NASA data within the context of other Earth science data to enhance DST applications. In this integrated approach, state of the art data assimilation of observational data with land-hydrologic-atmosphere simulation modeling is optimally combined.

## V. WEB SITES

The following are useful web sites for those that want more details about the Applied Sciences Water Management Program or are interested in submitting proposals for support.

http://research.hq.nasa.gov/code_y/code_y.cfm
http://www.earth.nasa.gov/ese_missions
Http://www.earth.nasa.gov
http://science.hq.nasa.gov/earth-sun/applications/index.html
http://nspires.nasaprs.com/external/
http://aiwg.gsfc.nasa.gov

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