WaterNet:
The NASA Water Cycle Solutions Network

CREW Center for Research on Environment and Water

GEORGE MASON UNIVERSITY

Water Cycle Research Making a Difference

WaterNet Project Team:

P. Houser(GMU/CREW), D. Belvedere(CREW), B. Imam(UCI), R. Schiffer(UMBC), C.A. Schosser(MIT), H. Gupta(UA), C. Welty(UMBC), C. Vorosmary(UNH), D. Matthews(HydroDSS), R. Lawford(UMBC)

http://crew.iges.org

What's the big deal about Water?

Water in the climate system functions on all time scales: From hours to centuries

The Energy and Water Cycles are *tightly intertwined* – Solar radiation drives and feedbacks with the water cycle, and energy is transferred through water movement and phase change.

Importance of global water and energy cycling

1.Water exists in all three phases in the climate system and the phase transitions are a significant factor in the regulation of the global and regional energy balances

2.Water vapor in the atmosphere is the principal greenhouse gas and clouds at various levels and composition in the atmosphere represent both positive and negative feedback in climate system response

3.Water is the ultimate solvent and global biogeochemical and element cycles are mediated by the dynamics of the water cycle

4.Water is the element of the Earth system that most directly impacts and constraint human society and its well-being.

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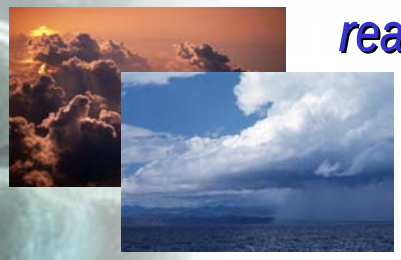
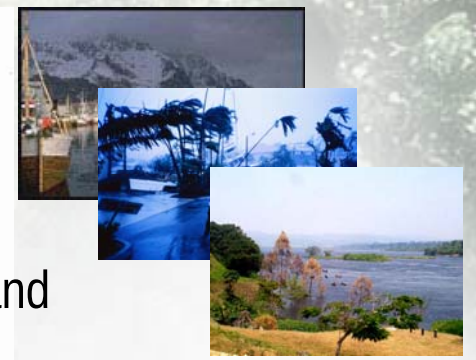
Why study the water and energy cycle?...

Variations in greenhouse gases, aerosols, and solar activity force changes in climate...

...but, consequences of climate change are realized through the water cycle.





Thus, we must *characterize*, *understand*, and *predict* variations in the global water cycle.

Water and Energy is linked to all 12 Science Application Themes.

Carbon Management

Water Management

Agricultural Competitiveness

Public Health

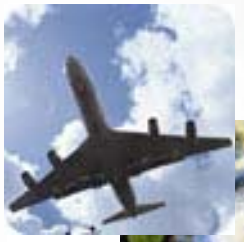
Homeland Security

Invasive Species

Energy Forecasting

Coastal Management

Ecological Forecasting



Aviation Safety

Disaster Preparedness

Air Quality

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NASA WEC Observation Capabilities

Water Cycle Missions

ICESat
- Ice elevation
- Cloud height

GRACE
- Column water-content

TRMM and GPM
- Global precipitation

Water and Energy Cycle Missions

EOS-Aura
- Atmospheric humidity
- Clouds

EOS-Terra
- Snow and ice
- Vegetation

CALIPSO
- Cloud properties

CloudSAT
- Cloud profiler

EOS-Aqua
- Atmospheric humidity
- Water storage
- Clouds
- Snow and ice

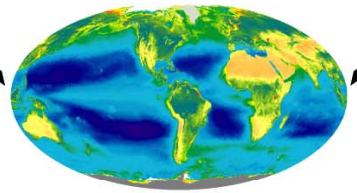
Energy Cycle Missions

TOMS
- Total column ozone

SORCE
- Total Irradiance measurements

SAGE
- Air quality
- Climate change

UARS
- Carbon management
- Air quality



Complementary Water and Energy Cycle Missions

QuikSCAT
- Sea-surface wind velocity

EO-1 LANDSAT and NMP EO-1
- Land cover

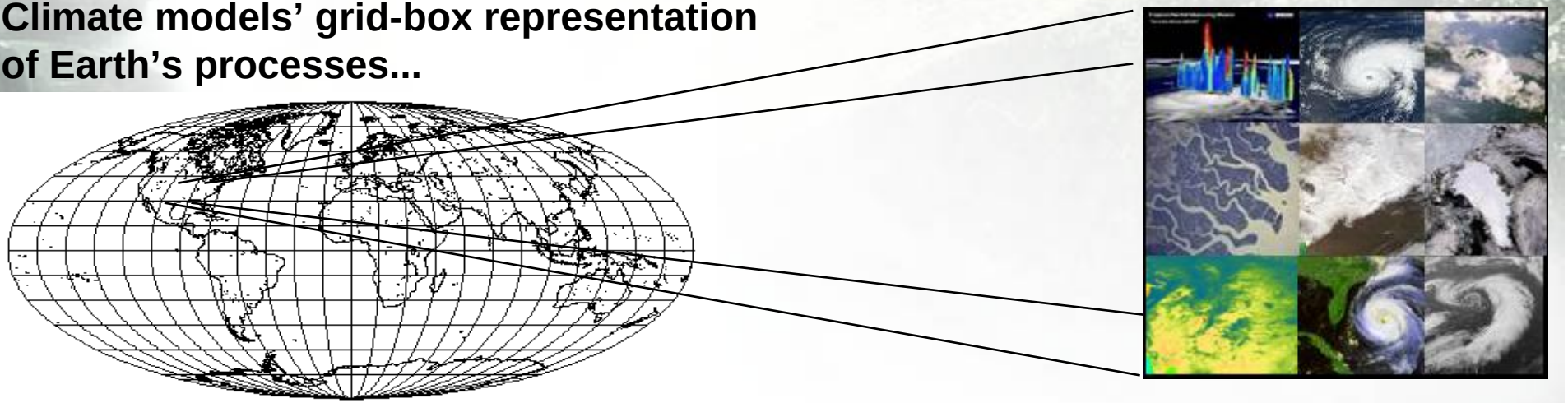
NPOESS
- Global environmental conditions

GOES
- Weather

Aquarius
- Global sea surface salinity

NASA WEC Modeling & Prediction Capacities

Climate models' grid-box representation of Earth's processes...



Each grid-box can only represent the "average" conditions of its area.

However, controlling processes of the water cycle (e.g. precipitation) vary over much smaller areas.

Developing Advanced Process-Resolving Models

- Useful prediction is critical – it is the link to stakeholders.
- We must move towards a new paradigm of climate models that produce useful weather-scale, process-scale, and application-scale prediction of local extremes (not just mean states).
- We must more fully constrain climate models with observations, to improve their realism and believability.

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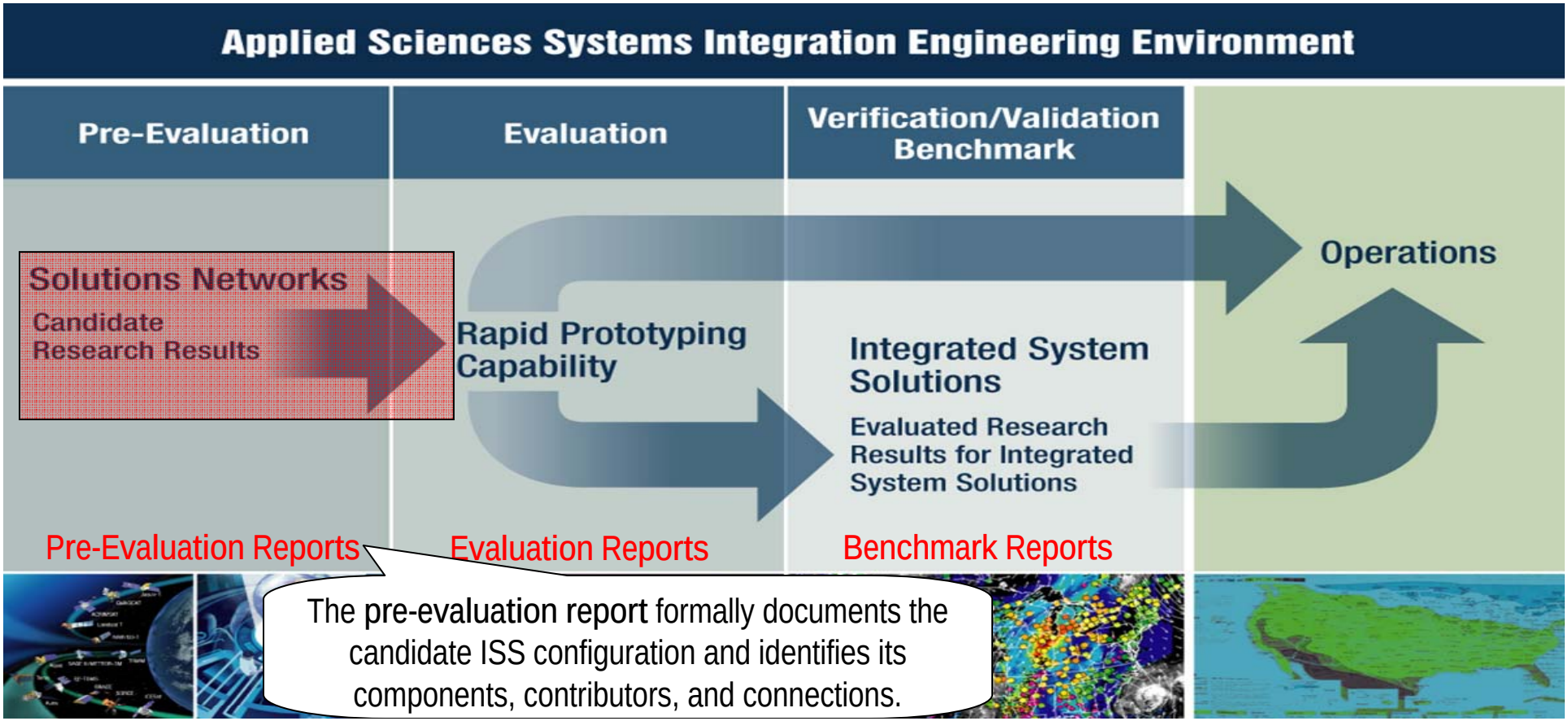
NASA Applied Science Approach

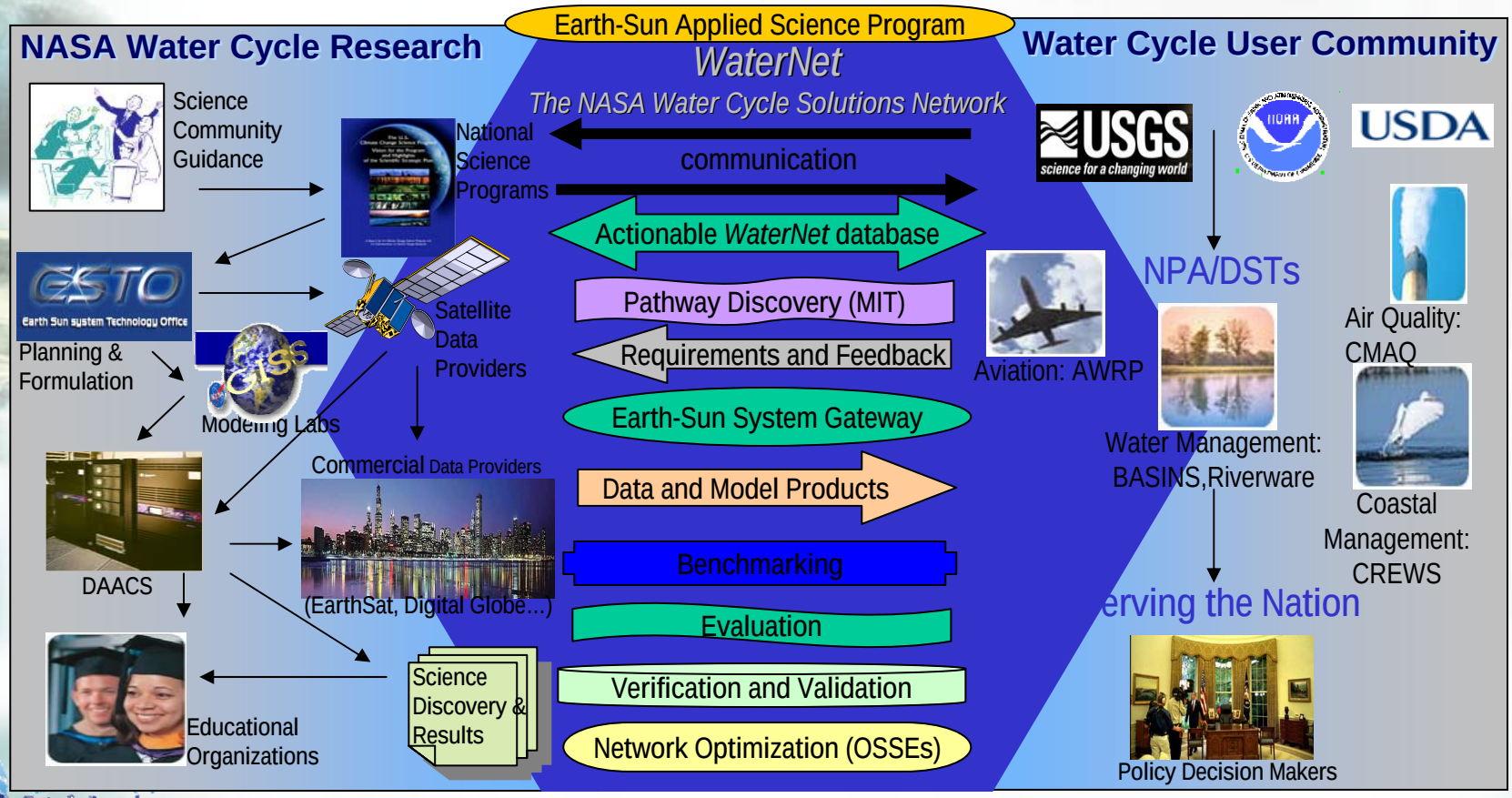
Solutions Networks harvest and explore research capabilities and support needs to identify candidate solutions. Thus, the role of *WaterNet* is to

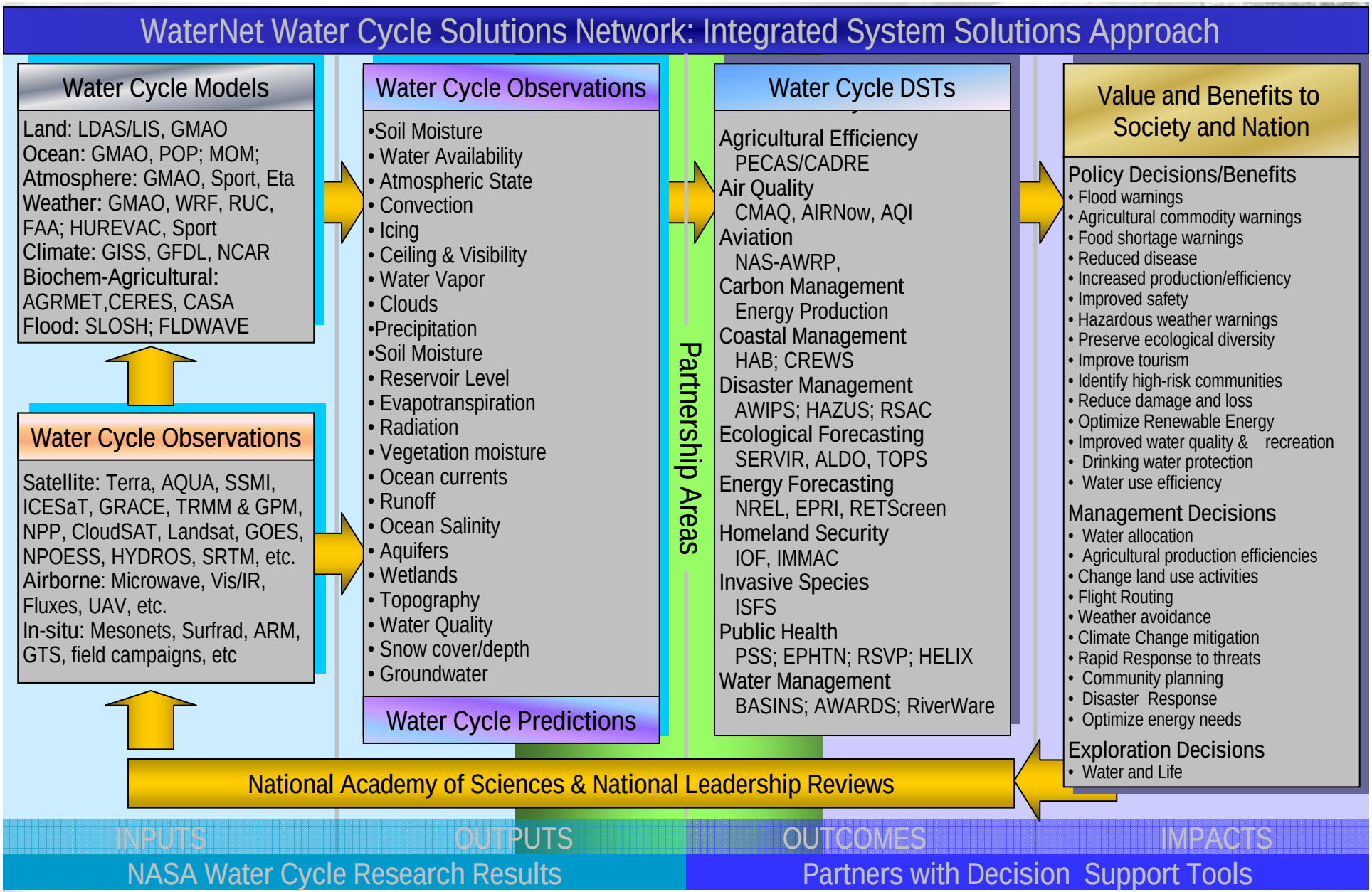
1. Harvest water-cycle ***research results*** and water-cycle relevant ***decision support needs***.
2. Analyze this information to ***identify candidate solutions***, and ***determine the configuration required to build the solution*** *(pre-evaluation report)*
3. ***Optimize the network*** to improve the fidelity of the candidate solutions.



WaterNet: Concept

WaterNet GOAL: improve and optimize the sustained ability of water cycle researchers, stakeholders, organizations and networks to interact, identify, harness, and extend NASA research results to augment decision support tools and meet national needs.





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WaterNet: Work Plan

1. *Evolve a network of water cycle partners:* identify and analyze water cycle community-of-practice organizations, DSTs and their requirements and develop well-constructed teams and partnerships to define collaboration pathways.
2. *Routinely identify, prioritize, mine and communicate relevant NASA water cycle results* that address NPAs, and develop operational information system pathways to provide timely user-community access.
3. *Optimize water cycle partner access* to NASA water cycle research, through developing prototypes, evaluation methods, verification procedures, and benchmarking standards to create an evolving and self-sustaining network.
   - Network Optimization
   - OSSEs: MIT Integrated Global System Model (IGSM)
   - PROTOTYPES: SAHRA/USBR Western Rivers Water Management; Coral Reef Early Warning System (CREWS); CUAHSI-Hydrologic Information System (HIS); State-of-the-Water-Cycle Demonstration; CNRFC-Water and Emergency Management Demonstration; NCAR's Research Applications Lab (RAL)
4. *Analyze and document* the *WaterNet* effectiveness by developing metrics, standards, resource estimates, documentation procedures, guidelines, and pre-evaluation reports to describe the steps to access and utilize NWRs
5. *Engage in education and outreach* to help society understand the water cycle and its potential application benefits.

A selection of water-cycle relevant DSTs and the potential value of NASA water cycle research

NPA	Water Cycle Relevance	Example DSTs	Value & Benefit to Citizens & Society
Agricultural Efficiency	Improved production and yield prediction through water availability, and improved weather, climate, and hazard prediction	Crop Assessment Data Retrieval and Evaluation PECAD/(CADRE) POC Brad Doorn	Reduction in production costs; Better seasonal yield estimates; Early warning of food shortages
Air Quality	Quantify atmospheric nitrogen deposition to water bodies as major contaminant Provide accurate precipitation data	Community Multiscale Air Quality Modeling System (CMAQ), POC: Kenneth L. Schere Air Quality Index (AQI); POC: Doreen Neil	Reduction of the following: lung-related diseases, premature death, hospital admissions, etc Improve crop resiliency/estimates; pollution reports
Aviation	Turbulence, oceanic convective weather, and ceiling/visibility, precipitation, icing	National Air Space Aviation Weather Research Program (NAS-AWRP) POC: Gloria Kulesa	Improved Safety, Improved Efficiency, Earlier warnings of hazardous weather, Reduction in the cost of flying
Carbon Mgmt	Provide accurate precipitation SM and ET for improved carbon flux estimates	Carbon Query and Evaluation Support Tools (CQUEST) POC: Dr. Christopher Potter	Improved efficiency in crop production, Climate change mitigation
Coastal Mgmt	Providing water availability and stresses on these systems Provide accurate precipitation, salinity, and runoff data Providing water availability and stresses	Coral Reef Early Warning System (CREWS) POC: Jim Hendee General NOAA Oil Modeling Environment (GNOME) POC: Gwen Jackson	Alerting to coral bleaching conditions in the Florida Keys and the Great Barrier Reef Understand & mitigate effects of oil and hazardous materials in waters and along coasts; Improve tourism
Disaster Mgmt	Prediction, assessment, and management of drought, wildfire, hurricane, climate, flooding hazards by providing precipitation, runoff, soil moisture and snow, data.	Advanced Weather System Interactive Warning System (AWIPS) POC: TBD Hazards U.S.(HAZUS), POC: Claire Drury	Disseminate warnings including flood/forecasts in rapid, highly reliable manner Identify/ Prioritize high-risk communities, Improve disaster response, Community planning
Ecological Forecasting	Biodiversity conservation and ecological sustainability, protected area management, and marine fisheries forecasting using soil moisture, precipitation and ET	Regional Visualization & Monitoring System (SERVIR) POC: Dan Irwin Terrestrial Observation & Prediction System (TOPS), POC: Ramakrishna Nemani	Predict the impacts of changing land-use patterns & climate on ecosystem Develop ecological forecasts. Enhance management decisions related to floods, droughts, human health, and agricultural production.
Energy Mgmt	Energy production and efficiency using accurate global solar radiation, precipitation, snow, soil moisture, runoff.	Renewable Energy Technologies Screen (RETScreen) POC: Gregory J. Lend Micropower Optimization Mode (HOMER)	Optimize renewable energy systems Finds cost effective methods of energy distribution
Homeland Security	Water supply info enabling response, recovery and mitigation to threats and military mobility prediction	Interagency Modeling and Atmospheric Assessment Center (IMAAC) POC: Stephen Ambrose Integrated Operations Facility (IOF), POC: TBD	Anticipate disaster-related damage, Improve response Improve disaster response; Reduction in lives lost; Reduction in damage cost and time to recover
Invasive Species	Primary factor controlling invasive species; is accurate precipitation data	Invasive Species Forecasting System **(ISFS)** POC: Michael T. Frame	Improvement in quality of health for man, animals and plants.
Public Health	Epidemiologic surveillance systems for infectious disease, environmental health, and public health preparedness directly aided by precipitation and soil moisture	Rapid Syndrome Validation Project (RSVP) Malaria Modeling and Surveillance (MMS) POC: Richard Kiang	Provide early warnings for harmful exposures, Reduce environmental related diseases Increase warning time; Reduce pesticide/drug resistance
Water Mgmt	Provide accurate precipitation , snow, soil moisture, ET, and runoff data for water management decision support	RiverWare,POC: T. Flup, D. Frevert, D. Matthews, M. Brilly, G. Gregoric ; CALSIM: P. Fujitani, L. Peterson; HECRAS: D. Davis; WMS: J. Jorgeson Better Assessment Science Integrating Point & Nonpoint Sources(BASINS), POC: R. Kinseson	Forecasting and long-term water management planning, Water supply quantity and hydrologic runoff and floods Improved impaired surface waters, storm water management issues drinking water source protection; Improvement in monitoring of coast area water.

Selected water-cycle related science and stakeholder networks; to be engaged by the WaterNet

Network	Description
CUAHSI	The Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) is a corporation of 100 university member institutions founded in 2001 to develop and enable a research agenda for the hydrologic science community. CUAHSI's program calls for research to be carried out at much larger spatial scales than has been done in the past, to integrate all parts of the terrestrial hydrologic cycle in addressing research questions, and to link hydrologic, chemical, and biological processes. CUAHSI's program in Hydrologic Information Systems (HIS) will create comprehensive hydrologic data models consisting of an information database coupled with tools for acquiring, analyzing, visualizing, and modeling to distribute and synthesize hydrologic data.
CBP	Columbia Basin Project is a multi-state MT, WA, ID, OR that involves a network of 175 irrigation districts, Grand Coulee Dam, and related storage facilities on the Columbia River and tributaries that produce large quantities of hydropower, agricultural products, and manage the riverine ecosystems of this region. This project is managed by Reclamation in conjunction with the Bonneville Power Administration, British Columbia Power, Canada, and state and local entities. DSTs are used in the operation and planning of water resources management in this area.
CVP	Central Valley Project of California, operated by the California Department of Water Resources, Reclamation, US Army Corps of Engineers, and a network of irrigation and power companies. The Central Valley Operations Office uses a variety of DSTs for daily and monthly operational decision-making on the 150 reservoirs and hundreds of irrigation canals and laterals through out the Central Valley.
URGOM	Upper Rio Grande Water Operations Model and network of users including the US ACE, USGS, Reclamation, and the irrigation districts and municipalities that use water from the Rio Grande Basin. This DST and user network provide water management solutions to this water scarce region which has headwaters in the San Jaun Mountains of Colorado and involves NM, TX, and Mexico, and the Colorado River Basin diversions.
GMES	GMES is a joint initiative of the European Commission and the European Space Agency , designed to establish a European capacity for the provision and use of operational information for Global Monitoring of Environment and Security (GMES).
PUB	The IAHS Decade on Predictions in Ungauged Basins (PUB) is aimed at formulating and implementing appropriate science programs to engage and energize the scientific community, in a coordinated manner, towards achieving major advances in the capacity to make predictions in ungauged basins.
GWSP	The Global Water System Project (GWSP) will undertake key cross-cutting activities such as generating an information database on global water system change, facilitating a discourse on water between the social and natural sciences, and developing scenario models for the global water system.
HELP	Hydrology for the Environment, Life and Policy (HELP) is designed to establish a global network of catchments to improve the links between hydrology and the needs of society. As a cross-cutting programme of the UNESCO International Hydrological Programme, HELP is expected to contribute to the World Water Assessment Programme (WWAP), and the Hydrology and Water Resources Programme of WMO (HWRP).
AWARE	Available Water Resource in the Mountain Environment an EU project involving Austria, Switzerland, Italy, Slovenia, and Spain, and 8 research labs and universities to establish a geo-service for tailoring models and data assimilation systems to improve forecasting and management of mountain water resources, including snowpack, floods, avalanches, and related water cycle hydrololologic processes.
EFFS	European Flood Forecast System – a consortium of EU nations studying methods to improve flood predictions and warnings in central and southern Europe, part of the EU and NATO scientific community.
UCOWR	The Universities Council on Water Resources (UCOWR) organization is comprised of about 90 universities in the United States and throughout the world. Member institutions engage in education, research, public service, international activities, and information support for policy development related to water resources. Each member university appoints four faculty members as UCOWR lead delegates. Others may join as individual members
HON	Hydrological Observatory Network-an emerging network of hydrologic observations in Europe developed to monitor global change impacts on hydrology, flood frequency and intensity, hydrologic predictions within the EU fashioned after the US CUAHSI.
ALPRESERV	Alpine reservoir sustainable management considering ecological and economical aspects within EU high alpine lakes and regions using ecological and hydrological decision-making tools and engineering management systems
GIO	A NASA Level-II Program, Geosciences Interoperability Office (GI) that is responsible for agency-wide leadership of the development, promotion and implementation of geospatial interoperability through open standards.
ESG	A NASA funded GIO project, the Earth-Sun System Gateway (ESG) is an interoperable prototype portal which enables the community to access, view, layer, and interact with dynamically updated results from NASA Earth-Sun System research, technology, education, and applied sciences programs.
DAAC	Distributed Active Archive Center (DAAC) Located at NASA/GSFC they are one of eight NASA Science Mission Directorate (SMD) DAACs that offer Earth science data, information, and services to research scientists, applications scientists, applications users, and students. Their goal is to serve users Earth science data and information needs
GLOBE	GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide hands-on, primary and secondary school-based education and science program. GLOBE is an interagency

WaterNet is an extensive "solution network of networks and nodes", encompassing and interconnecting a large number of water-relevant existing networks, research results, and decision support tools. Here we summarize the statements of commitment we have received –this is only a small sample of the potential partners.

Org.	Name
NASA	NASA Energy & Water cycle Study (NEWS); NASA's Geosciences Interoperability Office (GIO); Earth-Sun System Gateway (ESG); Geospatial Applications & Interoperability (GAI); Global Learning and Observations to Benefit the Environment (GLOBE); EOS Clearing HOuse (ECHO); Distributed Active Archive Center (DAAC)
Academic	Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) 100+ members; Universities Council on Water Resources (UCOWR) 86 Universities in US & World; Collaborative Large-Scale Engineering Analysis Network for Environment Research (CLEANER); Long-Term Ecological Research (LTER); National Ecological Observatory Network (NEON) Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA); Hydrology Web
Industry	Terrapin Asset Management, LLC; Risk Management Solutions (RMS); AMEC; AMEC Natureserve
Gov't	NOAA's National Climate Data Center (NCDC) Worlds largest archive; US Bureau of Reclamation (USBR); US Army Corps of Engineers and Development Center (USACE/ERDC); NWS/California Nevade River Forecast Center (NWCNRFC); USDA Agriculture Research Service (USDA/ARS); National Weather Service (NWS); National Water & Climate Center (NWCC); USDA Natural Resources Conservation Services/West, National Technology Support Center (NRCS); DHS Interagency Modeling & Atmospheric Assessment Center (IMAC)
DSTs	Coral Reef Early Warning System (CREWS); EPA/Community Multiscale Air Quality Model (CMAQ) RetScreen-Energy; Invasive Species Forecasting System (ISFS); Malaria Modelling & Surveillance (MMS) Terrestrial Observation & Prediction System (TOPS); Carbon Query & Evaluation Support Tools (CQUEST)
Labs	NCAR; NCAR's Research Application Laboratory (RAL)
Non-Profit	Earth Science Information Partners (ESIP) Federation Includes more than 80 member orgs; US Nat'l Academies Water Information Network (100+ peer reviewed reports)
Int'l	UN Educational, Scientific & Cultural Organization (UNESCO); World Climate Research Programme (WCRP) Global Water System Project (GWSP); Global Energy & Water Experiment cycle (GEWEX) EU AWARE (Available Water Resource); Hydrology for the Environment, Life & Policy (HELP); Environmental Agency of the Republic of Slovenia (EARS); Graz University of Technology (TUG)

Network demonstration projects

We plan several demonstrations to illustrate the development of the network and the identification of NWRs through network optimization.

SAHRA/USBR Western Rivers Water Management: SAHRA will participate by developing strategies to assimilate *WaterNet* database and linkage tools into its multi-resolution integrated modeling, process study and stakeholder interaction activities for the Rio Grande, San Pedro & Northern Mexico regions.

Coral Reef Early Warning System (CREWS): A DST operated by NOAA's Office of Oceanic and Atmospheric Research as part of its Coral Reef Watch program in response to the deteriorating global state of coral reef and related benthic ecosystems.

CUAHSI-Hydrologic Information System (HIS): We will link the CUAHSI-HIS tools to the *WaterNet*, and analyze the performance with respect to generating input required for BASINS/HSPF, the existing DST for the Chesapeake Bay watershed.

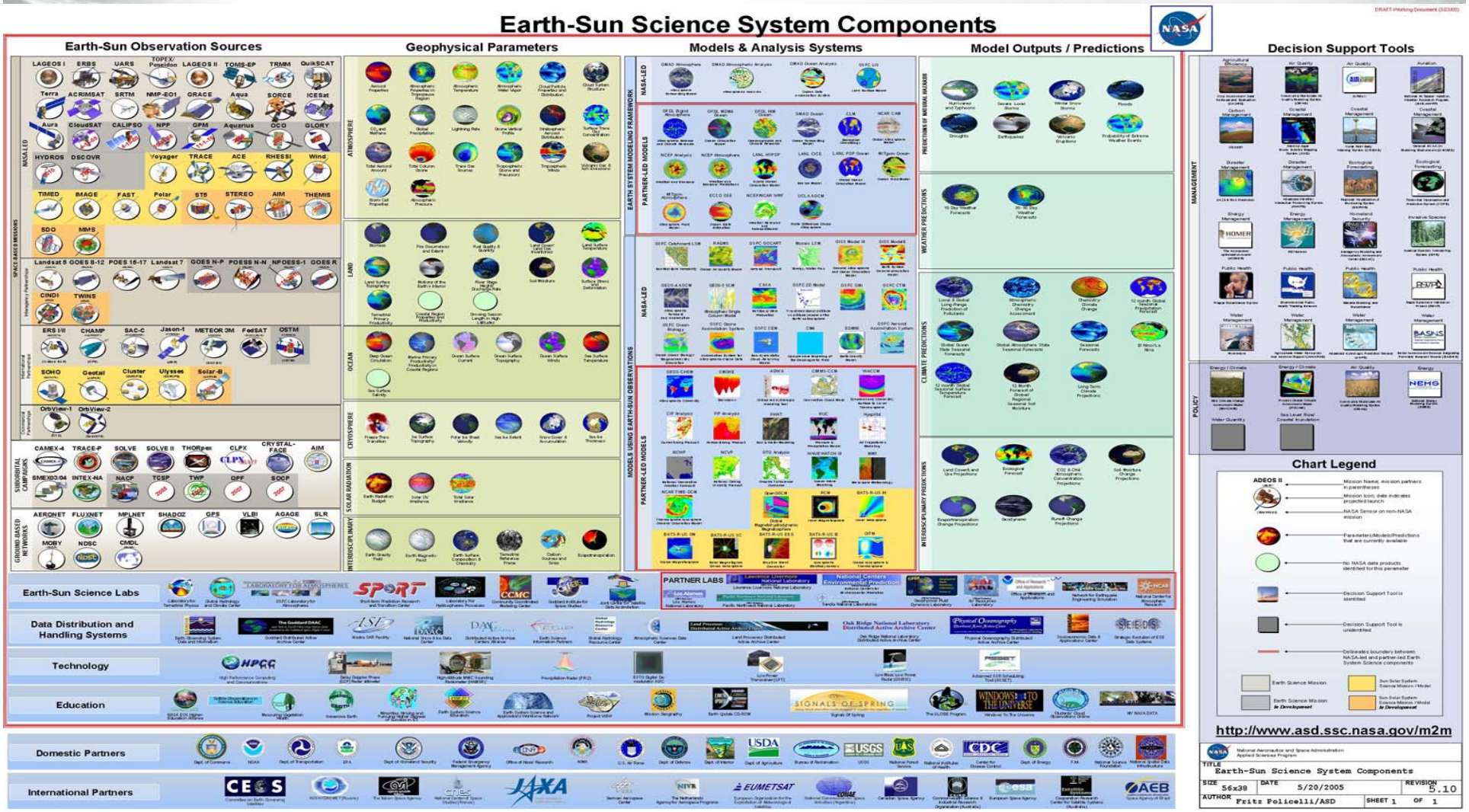
State-of-the-Water-Cycle Demonstration: The emergence of a State-of-the-Water-Cycle (SWC) initiative coordinated through the NEWS Integration Team provides a tangible focal point to exercise NASA investments in water cycle information provision in a fully global context.

CNRFC-Water and Emergency Management Demonstration: The NWS California-Nevada River Forecast Center provides an ideal demonstration of state-of-the-technology networking in human and technology dimensions.

NCAR's Research Applications Lab (RAL): The RAL has extensive knowledge of the aviation industry's needs from aircraft icing microphysical studies to microburst safety procedures at airports during landings and take-offs.

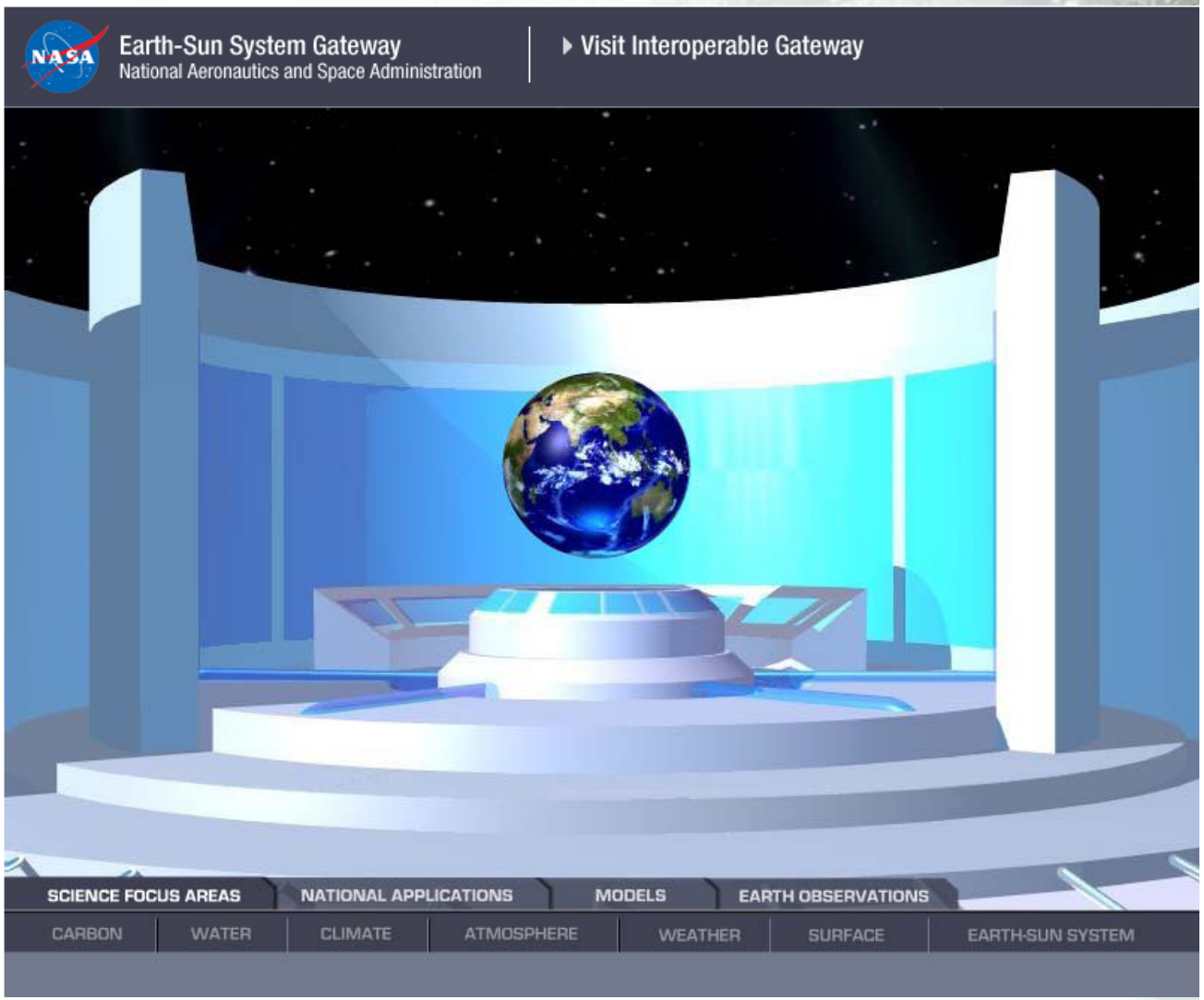
Earth-Sun Science System Components Knowledge Base

Catalogues standard NASA research products and specific partner decision support tools and makes it readily available to define potential collaborations. Includes an inventory of NASA affiliated Missions, Sensors, Data Products, Models, Model Products and partner Decision Support Systems.



Earth-Science Gateway

NASA's Earth Science Gateway (ESG) streamlines access to remote geospatial data,imagery, models, and visualizations through open, standard Web protocols. By organizing detailed metadata about online resources into a flexible, searchable registry, it lets scientists, decision-makers, and others access a wide variety of observations and predictions of natural and human phenomena related to Earth Science and the Earth-Sun System, from NASA and other sources.



Global Change Master Directory

GCMD enables users to locate and obtain access to Earth science data sets and services relevant to the global change and Earth science research. The GCMD database holds more than 16,000 descriptions of Earth science data sets and services covering all aspects of Earth and environmental sciences.

ESIP Federation

The Federation of Earth Science Information Partners brings together government agencies, universities, non-profit organizations, and businesses in an effort to make Earth Science information available to a broader community. The objective of the Federation is to evolve methods that make Earth science data easy to preserve, locate, access and use for all beneficial applications

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WaterNet Implementation – current work

Phase I:

Planning and design of solutions network has begun

- Contacts made with partner networks (ESG, ESIP, GCMD) and appropriate WaterNet team members to meet in February for portal design planning.

Demonstration projects start in manual mode

End to end approach provides opportunity for team to work completely through the solutions network process in a back of the envelope approach, to find out what works and what does not !

- One on one and group *communications with end users* have begun with goal to understand their work, DST requirements and needs

- One on one and group *communications with NASA contacts* proven highly successful in acquiring information about current water cycle research results that might improve decision support tools for end users.

NASA Water Cycle Research ⟷ *communication* ⟷ Water Cycle User Community

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