WaterNet

The NASA Water Cycle Solutions Network

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***Abstract*— The goal of the WaterNet project is to 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. WaterNet is being build by engaging relevant NASA water cycle research resources and community-of-practice organizations to develop what we term an "actionable database" that can be used to communicate and connect NASA Water cycle research Results (NWRs) towards the improvement of water-related Decision Support Tools (DSTs). An actionable database includes enough sufficient knowledge about its nodes and their heritage so that connections between these nodes are identifiable and robust. Recognizing the many existing highly valuable water-related science and application networks, we will focus the balance of our efforts on enabling their interoperability in a solutions network context. We initially focus on identification, collection, and analysis of the two end points, these being the NWRs and water related DSTs. We will then develop strategies to connect these two end points via innovative communication strategies, improved user access to NASA resources, improved water cycle research community appreciation for DST requirements, and improved identification of pathways for progress. Finally, we will develop relevant benchmarking and metrics, to understand the network's characteristics, to optimize its performance, and to establish sustainability. The WaterNet will deliver numerous pre-evaluation reports that will identify the pathways for improving the collective ability of the water cycle community to routinely harness NWRs that address crosscutting water cycle challenges.**

Keywords: Applied sciences, remote sensing, solution networks

I. INTRODUCTION

Earth is a unique, living planet due to the abundance and vigorous cycling of water throughout the global environment. Water is essential to life and directly impacts and constrains society's welfare, progress, and sustainable growth, and is continuously being transformed by climate change, erosion, pollution, and engineering practices. The water cycle is a critical resource for industry, agriculture, natural ecosystems, fisheries, aquaculture, hydroelectric power, recreation, and water supply, and is central to drought, flood, transportation-aviation, and disease hazards, and the need for understanding water cycle variability and its relationships with water availability and water-related natural hazards are well documented.

It is therefore a national priority to use advancements in scientific observations and knowledge to develop solutions to the water challenges faced by society. NASA's unique role is to use its view from space to improve water and energy cycle monitoring and prediction. NASA has collected substantial water cycle information and knowledge that must be transitioned to develop solutions for all twelve National Priority Application (NPA) areas. NASA cannot achieve this goal alone –it must establish collaborations and interoperability with existing networks and nodes of research organizations, operational agencies, science communities, and private industry. Therefore, WaterNet will 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.

II. SOLUTION NETWORKS

A Solutions Network must identify candidate solutions, where research results have the potential to enhance decision support. Its role is to serve as a creative, discovery process that is an entry path for a research-to-solution systems engineering framework, with an end result to ultimately improve decision support. The candidate solution(s) are documented in Candidate Solutions Reports, which are principally decision need focused; once the need is documented, then relevant research results are "discovered", and a process for evaluating, benchmarking, and implementing the candidate solution is recommended. This process is applicable for a wide range of decision needs, including partner government agencies, non-governmental organizations, international, and private sector needs.

To begin this process, it is essential to evolve a network of partners. Establishing Solution Network collaborations should be intentional and planned. It is vital that the first step in securing a partnership with the end user is a thorough understanding of what they do and what is important to them (rather than asking them for a set of requirements or decision inputs). Once a point of contact is established, continued contact is necessary to nurture trust among the participants of the partnership. Furthermore, much iteration may be required to identify a research result and implementation process that will be beneficial, as it may take the combined creativity of the researcher and the user to fully understand the solution need and available research relevance. A strong feedback mechanism is important and people-oriented connections are always essential when establishing a viable, long-lasting collaboration between end users and researchers. The end result is to define a truly useful Candidate Solution.

An end user is technically defined as the ultimate consumer of a finished product. A solutions network end-user may be a decision or policy maker or organization, a researcher, a research program or an individual in the public or private sector. Although most decisions are made at the local level, decision makers at the state, regional, national and even international levels must also be engaged.

Water managers, for example, are in many cases the conduits for additional end-users who present themselves with practical requirements for quantitative information, whether it be for flood prediction with an impending storm or identification of suitable sites for long-term hydroelectricity production. The aviation sector requires fast timely predictions of hydrometeorological conditions ranging from icing to route and terminal forecasts. They rely on remote sensing information on clouds, icing conditions, jet stream locations, turbulence and surface weather. Emergency managers require accurate predictions of extreme events that are delivered to the decision-makers at the local level in a form that they can use to warn the public and expedite relief efforts. Agricultural users – farmers and irrigation districts – need geospatial information on the crop water requirements that they can use to manage irrigation deliveries and conserve scarce water supplies. Energy producers need to know the weather conditions that impact consumption demand and affect production ranging from severe weather to heat and cold waves. These end-users have sophisticated Decision Support Tools (DSTs) that input a variety of information and transform into their specific needs for management.

A. Demonstration projects

The WaterNet team has selected several demonstration projects whose role slightly extends beyond the purely recommendation role of a Proposed Candidate Solution but does not extend as far as an Integrated System Solution (see below). Several of the water cycle projects sited below were selected based on letters of support from Partner Agencies. Additional demonstration projects may be added:

• CNRFC (NOAA National Weather Service River Forecasting System office in California and Nevada), a series of candidate solutions to modernize the River Forecasting System flood warning process.

• ICON (NOAA Atlantic Oceanographic and Marine Laboratory Integrated Coral Reef Observing Network), a series of candidate solutions to develop an interactive ocean observing system in which physical and biological oceanography are linked and utilize NASA satellite technology to provide a framework for assessing the consequences of global warming, ocean acidification, and impacts on ocean fisheries

• Western Rivers, the watershed of the Colorado River and Rio Grande and efforts to apply NASA assets to improved drought mitigation in the arid Southwest

• CUAHSI HIS, the University Consortium of Universities for the Advancement of Hydrological Science Hydrological Information System (HIS) Decision Support System, as applied to Chesapeake Bay

Projects that include the scientific user community, education, and public outreach:

• a collection of educational efforts identified through a user-friendly access portal to show how NASA information, NASA satellite efforts, and NASA research results can be of value to the educational community, at all levels.

• the development of a community that would be able to use the interactive, collaborative environment made available by portal technology to more easily utilize NASA assets in the advancement of science. This function might require more specialized search tools and/or knowledge mining capability

• the systematic conduct of sensitivity studies through Observing System Simulation Experiments (OSSEs) which focus on forecasts and attempt to identify and prioritize, within a longer time frame, a critical water-cycle issue, with major societal impacts, with sufficient lead time to enable identification and engagement at an early stage an appropriate Decision Support System

• periodic assessments of the State of the Water Cycle, identifying water cycle vulnerability and supply limits imposed by regional population distribution in different regions of the globe, pollution in those regions, ecosystem flow requirements, as humans interact with the global water cycle.

The State of the Water Cycle has links to NASA NEWS, Global Water Science Program (GWSP), and GEWEX (Global Energy Water Experiment). It develops key water indicators, in order to identify how humans are interacting with the global water cycle, on a real-world region-by-region basis. The OSSE will operationalize water stress indicators, merging near-real-time data with socio-economic information.

• studies exploiting global Earth system models such as the MIT Integrated Global System Model (coupled atmosphere-ocean-land surface model with biogeochemistry and economic model), designed for analyzing the global environmental changes that may result from anthropogenic causes, quantifying the uncertainties associated with the projected changes, and assessing the costs and environmental effectiveness of proposed policies to mitigate climate risk. The MIT Integrated Global System Model, version 2 (IGSM2) includes an economic model for analysis of greenhouse gas and aerosol precursor emissions and mitigation proposals, and the outputs of the combined anthropogenic and natural emissions model drive the coupled atmospheric chemistry and climate models. Climate model outputs then drive a terrestrial model predicting water/energy budgets, CO2, CH4, and N2O fluxes and soil composition, which feedback to the coupled climate/chemistry model. Examples of model outputs include GDP growth, energy use, policy costs, and agricultural and health impacts. Human Activity is gauged via national or regional economic development, emissions, and land use. The model also assesses sea level rise and net primary productivity, and agricultural productivity. The MIT combined system would aid in answering questions such as: to what extent does improved precipitation of hydrological inputs (via a proposed satellite system to, for example, measure precipitation at a certain scale) impact global trace gas emissions and pollutants, and what are the consequences of global trends in use of water and its impact on society?

III. Conclusion

The underlying theme of WaterNet, the NASA water-cycle Solutions Network is “end to end communication”. WaterNet members work with the Partner Agency user groups to clearly identify what is needed to improve a decision support tool and assess whether NASA has that capability, and NASA scientists to find new research results than may enhance decision support tools. It also is an end-to-end attempt to anticipate critical water-cycle issues, through its OSSEs that can make recommendations to NASA Applied Sciences Divisions via “white papers” to propose new satellite missions to meet an identified crises situation or expedite a proposed Candidate Solution.

A solution network process is built upon sharing information, research results, technology and procedures among members of other Solution Network projects, MRC/MSU, and NASA centers; such as Stennis, GSFC, MSFC, and LaRC. This is part of the discovery process. Assets can then be identified within the candidate solutions report or later utilized within an Integrated System Solution (ISS).

Finally, A Solutions Network may propose a large number of possibilities, those being projects that might take advantage of NASA technology within a multitude of US federal or governmental agencies or, alternatively, international or professional organizations that share the same statutory goals of a federal agency. NASA Headquarters may then consider some of these “proposed candidates” and then deem that they are worthy of further development. This next step is “Rapid Prototyping” or “Rapid Prototyping Capability (RPC)” which involves laboratory testing. Sometimes, there is a leapfrog from a Solutions Network to the third step, that of an Integrated Systems Solution (ISS). Again, the range of possible candidate solutions has been further narrowed to a real-life case in which an actual Decision Support System is tested against the improvement that would result from utilization of a satellite product or a NASA research result. Some metrics are defined to test the Decision Support Tool before application of the satellite technology and during utilization of the satellite technology to test whether the Decision Support System has been actually improved through use of the satellite technology. After this last stage of the Systems Engineering paradigm, implementation of the NASA technology is up to the Partner Agency. WaterNet: The NASA Water Cycle Solutions Network, however, is only involved in the first step; identification and recommendation of possible candidate solutions.

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