

# LIS-Hydro: Authoritative Source for OCONUS Hydro-Intelligence

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PRESENTED AT:



## INTRODUCTION

U.S. military forces are often tasked to participate in a variety of transboundary water-related decision-making activities, including humanitarian assistance operations through Department of State tasking, support of in-country infrastructure development activities that help develop or improve diplomatic relationships, and support of transboundary water treaty negotiations or disputes to reduce risk of conflict caused by water security issues. There is limited established information available on the baseline performance of current practices in such cases, as most such operations are done in an ad-hoc manner, due to the lack of routine availability of required inputs (Intelligence Community Assessment, Office of the Director of National Intelligence, 2012<sup>[1]</sup>).

Despite what the name may infer, the USACE Reachback Operations Center (UROC; uroc.usace.army.mil) is often tasked to provide responses to flooding events, water security management and maneuver planning operations during regular business hours using research laboratory resources and staff. Existence of the UROC and the processes and procedures for requesting hydrology-related support are not universally known across the DoD or IC. As a result, the current baseline performance (turnaround times) for ad hoc requests by those situationally aware range from one to four days, depending on the complexity of the query.

And for those unaware of the UROC, their mission-related requests for hydrological support either never get satisfied or get shot-gunned out to anyone willing to listen (i.e., the charge and means to assist). This often leads senior METOC Officers (SMO), operators, analysts, and/or other stakeholders across the DoD and IC to reach out to 557th Weather Wing (557 WW; DoD's Executive Agent for Land Information) and/or AF/XOOW (the DoD Air and Space Natural Environment Modeling and Simulation Executive Agent [ASNE MSEA]) for help. This often leads to tasking one of two 557 WW entities: (1) 2nd Weather Intelligence Flight (WXI)—the only 24/7 source for tailored weather knowledge products and services to Joint Force, Defense and Intelligence Agencies at the Secret Compartmented Information level. The Weather Intel Flight provides target-specific environmental analyses and forecasts at the highest classification levels in support of US intelligence community operations worldwide; and/or (2) the 14th Weather Squadron (14WS; a 64-member unit of military and civilian personnel whose mission is to Collect, Protect, and Exploit authoritative climate data to optimize military and intelligence community operations and planning). At best, the lack of an authoritative source for global hydro-intelligence information and a corresponding CONOPS leads to mixed guidance, confusion, and delay—an inefficient and often ineffective means of supporting hydrology-related missions. At worst, the end result is mission and/or intelligence failure(s). However, even under the best of circumstances, reach-back support requests are often made ex post facto, which makes the timely planning and the responses to the events difficult.

The Summary of the 2018 National Defense Strategy of the United States of America<sup>[2]</sup> has concluded, “Interstate strategic competition, not terrorism, is now the primary concern in U.S. national security”. The US intelligence communities have identified the coordination over shared water resources as an area of significant concern to US national security<sup>[1]</sup>. Such transboundary water issues are projected to intensify in the future under increasingly complex population dynamics, political tensions due to parallel issues, and a changing climate<sup>[3]</sup>. A 2017 joint NASA, USACE/ERDC, and Air Force workshop<sup>[4]</sup> revealed a lack of sufficient decision support tools and access to timely technical and contextual information needed to assess and respond to potential water-related threats around the world. The need for an integrated operational service, with the capacity to combine and synthesize hydrological modeling, assimilation, forecasting, and visualization capabilities across the US Government (USG), was highlighted as a key recommendation. Operational deployment of the LIS-Hydro system will combine multiple models of physical processes and remote sensing data with visualization and decision support across a spectrum of time scales (i.e., Near-Real-Time, Medium-range, Sub-seasonal-to-Seasonal, and Inter-annual) to fulfill this gap/need. Finally, sustainment of the operational capability by AFW and implementation of this CONOPS will establish a national asset to help federal agencies across the USG implement government-wide strategies around water resources (US Global Water Strategy 2017<sup>[5]</sup>) while satisfying many of the strategic objectives of individual agencies and helping them bring to light transboundary water issues for the stakeholder community at-large.

At this time, an operational authoritative source of global hydro-intelligence information supporting OCONUS war-fighters, planners, and decision makers at all echelons and services of the US military, Federal government, and intelligence community **does not exist**.

# GOALS AND OBJECTIVES

The objective of this inter-agency scientific collaboration is to address some of the key gaps and needs identified during the initial workshop<sup>[4]</sup>, while advancing the use of NASA datasets and resources in national security decision-making. The primary goal of which is to develop a comprehensive framework that combines multiple models of physical processes and remote sensing data with visualization and decision support across a spectrum of time scales (i.e., Near-real-time [ $t_{0.12}$  hours to  $t_0$ ], Medium-range [ $t_0$  to  $t_{14}$  days], Sub-seasonal-to-Seasonal [ $t_0$  to  $t_{12}$  months], and Inter-annual [ $t_0$  to  $t_{100}$  years]).

This poster describes how AF weather will leverage an integrated software framework for high performance terrestrial hydrology modeling (GHI; a.k.a., “LIS-Hydro”) to provide a routinely available operational authoritative source of global water intelligence information supporting OCONUS war-fighters, planners, and decision makers at all echelons and services of the US military, Federal government, and intelligence community.

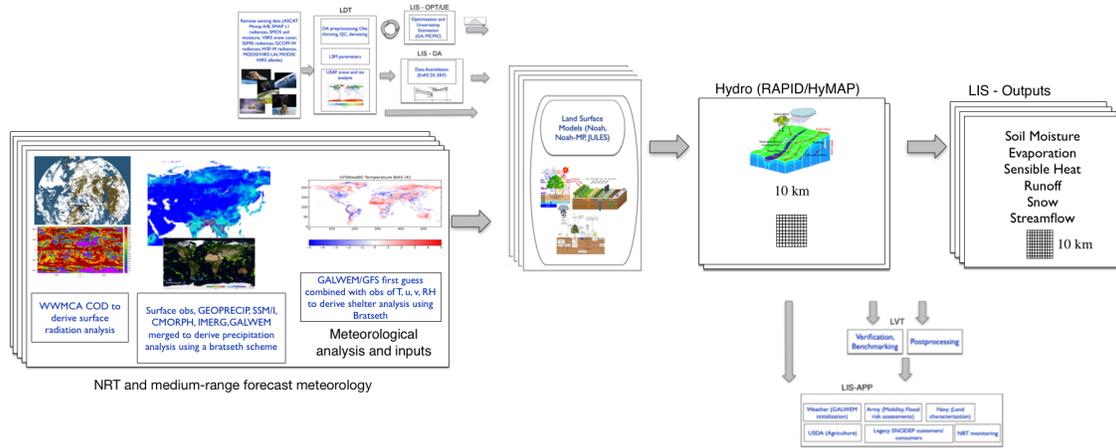


Figure 1. Global hydrology environment at 557 WW (NRT and medium-range environments).

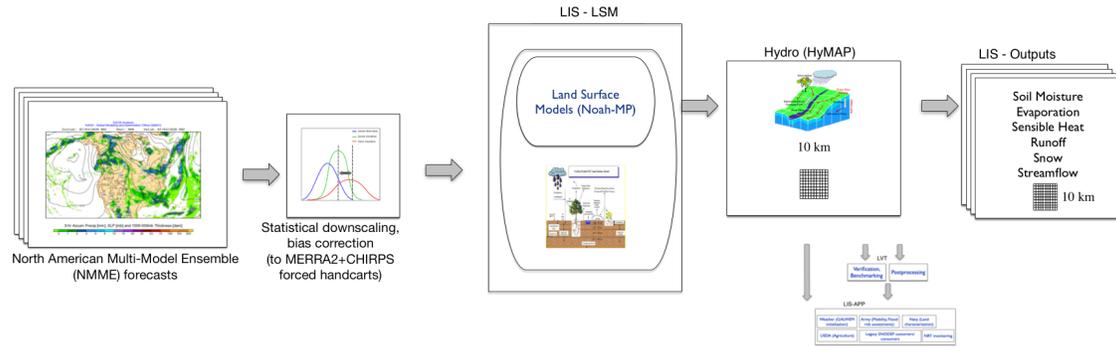
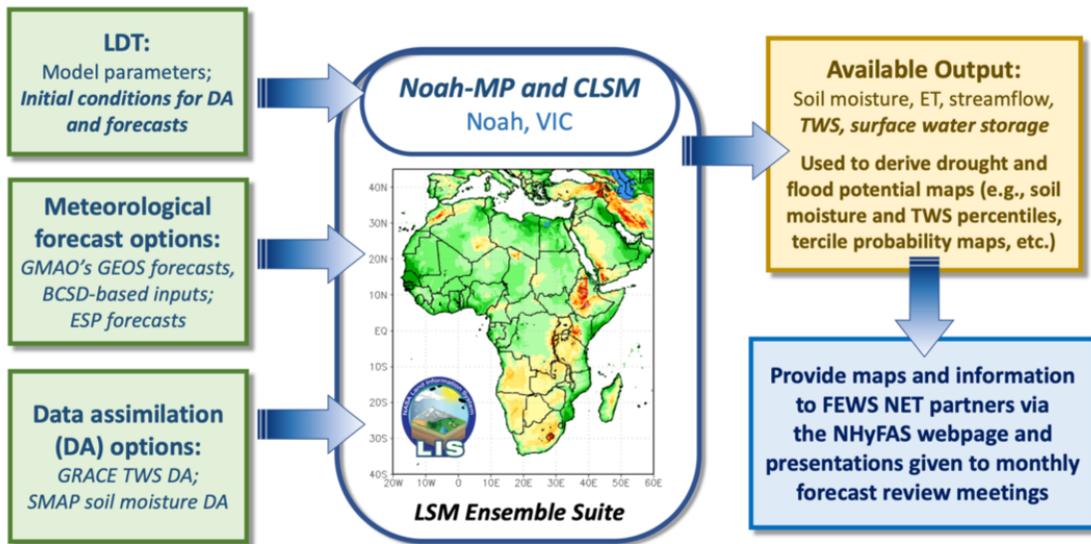


Figure 2. Global hydrology environment (S2S timescales). Based on NASA’s NHyFAS system (Arsenault et al., BAMS, 2020); initial implementation will be over USAFRICOM.



(From Arsenault et al., 2020, BAMS)<sup>[6]</sup>

<https://lis.gsfc.nasa.gov/projects/nhyfas>

Figure 3. NHyFAS (NASA's Hydrological Forecasting and Analysis System: The end-to-end hydrologic forecast system. Developed with GEOS based near real-time (NRT) monthly hydrological forecasts using LIS over Continental Africa and Middle East (originally, FAME), provided routinely since late 2018.

# METHODOLOGY

Specifically, we target the development of an integrated operational system by combining the NASA Land Information System (LIS)-based operational land data assimilation system at the US Air Force 557th Weather Wing (557 WW) with the hydrological modeling capabilities at the US Army Engineer Research and Development Center (ERDC) Coastal Hydraulics Laboratory (CHL), next-generation, hydrologically-conditioned global digital elevation model (DEM) along with additional derivative products from the National Geospatial-Intelligence Agency (NGA), and the flood inundation mapping and high-performance computing capabilities of Oak Ridge National Laboratory (ORNL). Through the NASA-developed data assimilation capabilities in LIS, information from a suite of enhanced and downscaled passive microwave, thermal, and visible/near-infrared remote sensing terrestrial hydrology observations will be incorporated into the modeling environments. This will provide the much-needed observation-based constraints on modeled estimates, particularly over data poor regions of the world.

The 557WW runs a global, 10-km operational land data assimilation system enabled by the NASA Land Information System (LIS; lis.gsfc.nasa.gov; Kumar et al. 2006<sup>[7]</sup>, Peters- Lidard et al. 2007<sup>[8]</sup>), which is a comprehensive land surface modeling and data assimilation environment. The outputs from the global system are used by a variety of applications and end-users, including the weather models at 557WW and US Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC), and agricultural decision support systems at the US Department of Agriculture (USDA) Foreign Agricultural Service, among others.

A key feature of the LIS environment is the ability to assimilate terrestrial remote sensing observations including soil moisture, snow, water storage and vegetation. The ERDC Coastal Hydraulics Laboratory (CHL) has developed an operational Streamflow Prediction Tool (SPT) to deliver timely and efficient flood forecasting and flood inundation maps (Snow et al. 2016<sup>[9]</sup>) using the AutoRAPID (Follum et al. 2016<sup>[10]</sup>) model. The ERDC Cold Regions Research and Engineering Laboratory (CRREL) maintain a testbed to execute full weather/terrain models to generate assessment of trafficability using the operational outputs from 557WW. Finally, CHL and CRREL environments also include web-based visualization interfaces that are designed to disseminate the hydrologic analyses to the relevant end-users on-demand. Through the GHI Operating Plan, we plan to develop an integrated operational service by linking these high Application Readiness Level (ARL) systems and directly connecting them to the end-users and stakeholders involved in transboundary and global water security decision-making. A schematic of the proposed system is shown below. This will provide the much-needed observation-based constraints on modeled estimates, particularly over data poor regions of the world. All of which are pre-requisites for the Medium-range capability.

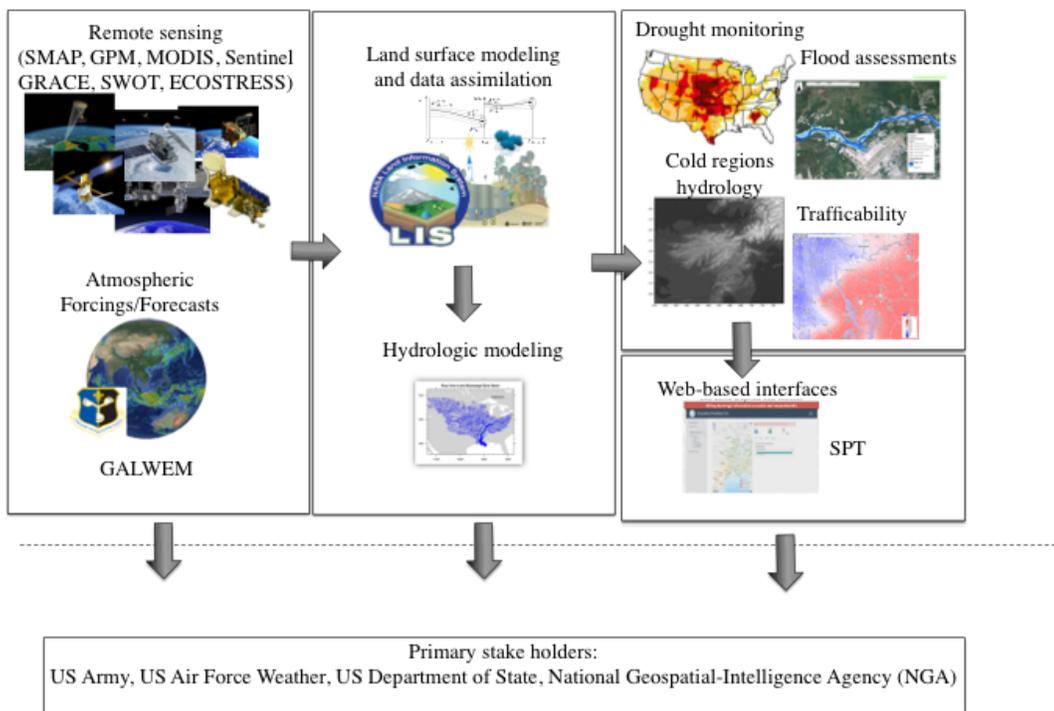


Figure 4. The LIS Framework will exploit and integrate existing capabilities to produce a series of hydrological products and services available to various strategic level stakeholders.

Transition of the integrated framework onto AFW's High Performance Computing (System)-11 at ORNL will allow for the generation of GHI output, products and services on-line and on-demand (i.e., 24/7/365) with appropriate metadata through an interactive web service-enabled geospatial platform (e.g., GeoHIP, DCSG-A, etc.) across all enclaves (e.g., NIPR, SIPR, JWICS). GHI IOC, when fully-realized, will enable the UROC program-of-record to decommission its hardware-component which is nearing end-of-life. GHI will significantly improve baseline performance by transforming and transitioning a limited

DoD ad hoc UROC R&D to a robust, and scalable operational capability providing near-real-time (NRT) assessments of surface hydrology features (e.g., streamflow, flood risk, etc.) and impacts (e.g. mobility). Additionally, GHI will be able to conduct remote, ensemble-based assessments of the surface hydrology characteristics to better support decision making including reservoir filling strategies. Finally, GHI will reduce support latency from days to minutes.

# RESULTS

LIS-Hydro, will deliver capabilities for three specific water security application areas (drought monitoring, assessment and forecasting of flooding potential, and monitoring of changes in snow and ice in cold regions). Products from these application areas will be synthesized into information required by decision makers (e.g., the Interagency Water Working Group) to address transboundary water security threats including potential for migration, economic losses and conflict, and disruptions to military navigation. Thus, the infrastructure will promote societal applications for sustainable water resource management, humanitarian assistance and disaster response, economic development, and regional stability.

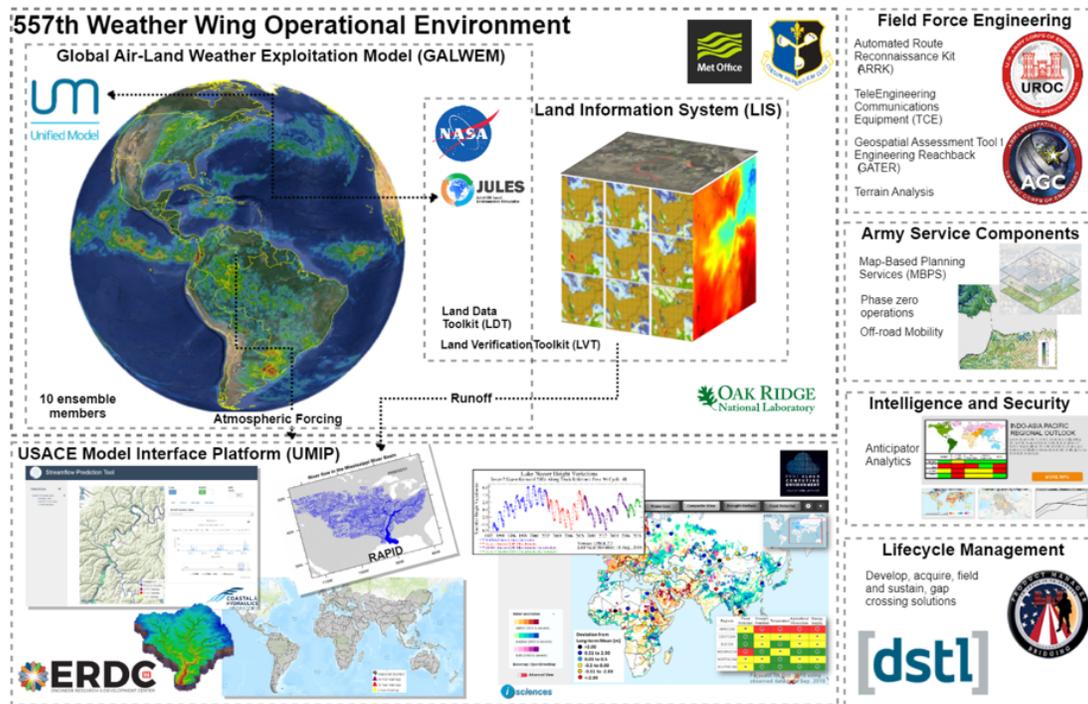


Figure 5. OV-1 High Level Operational Concept Graphic – High level graphical and textual description of operational concept (high level organizations, missions, geographic configuration, connectivity, etc).

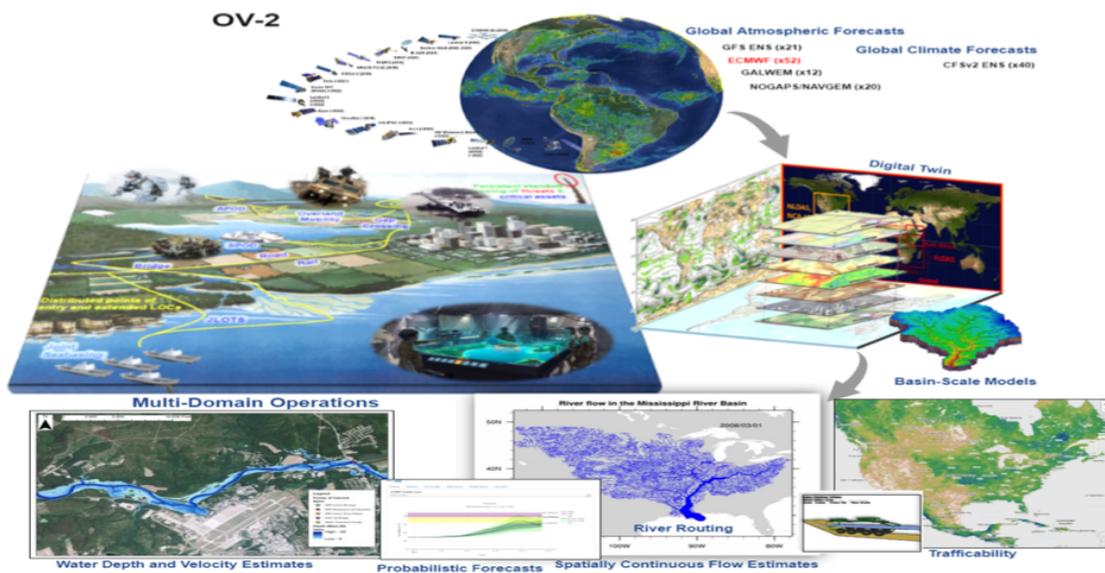


Figure 6. OV-2 Operational Node Connectivity Description – Operational nodes, activities performed at each node, and connectivities and information flow between nodes.

In terms of quantifiable expected performance improvements, the services at the core of the envisioned integrated framework will reduce turnaround times for most queries from units of days down to minutes. Most significantly, completion of this project and sustainment of the operational capability by AFW will establish a ***national asset*** which can then be used to help federal agencies across the USG implement government wide strategies around water resources (US Global Water Strategy 2017<sup>[5]</sup>), while satisfying many of the strategic objectives of individual agencies and helping them bring to light transboundary water issues for the stakeholder community at-large. The hydrological products and services produced by the integrated system will, ***for the very first time***, provide a routinely available authoritative source of global water intelligence information supporting war-fighters, planners, and decision makers at all echelons and services of the US military, Federal government, and intelligence community.

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## ABSTRACT

U.S. military forces are often tasked to participate in a variety of transboundary water-related decision-making activities, including humanitarian assistance operations through Department of State tasking, support of in-country infrastructure development activities that help develop or improve diplomatic relationships, and support of transboundary water treaty negotiations or disputes to reduce risk of conflict caused by water security issues. The U.S. intelligence communities have identified the coordination over shared water resources as an area of significant concern to U.S. national security (U.S. National Defense Strategy, 2018). Such transboundary water issues are projected to intensify in the future under increasingly complex population dynamics, political tensions due to parallel issues, and a changing climate.

A 2017 joint NASA, USACE/RDC, and U.S. Air Force co-sponsored workshop revealed a lack of sufficient decision support tools and access to timely technical and contextual information needed to assess and respond to potential water-related threats around the world. The need for an integrated operational service, with the capacity to combine and synthesize hydrological modeling, assimilation, forecasting, and visualization capabilities across the U.S. Government, was highlighted as a key recommendation.

In direct response, a subset of the U.S. Department of Defense, National Intelligence Community, and Oak Ridge National Laboratory are collaborating on the development of a fully integrated hydro-modeling and streamflow prediction system (i.e., LIS-Hydro). Completion of the project and sustainment of the operational capability by Air Force Weather will establish a national asset to assist federal agencies implement government-wide strategies around water resources (U.S. Global Water Strategy, 2017). The hydrological products and services will, for the very first time, establish a routinely available authoritative source of global water intelligence information supporting war-fighters, planners, and decision makers at all echelons and services of the U.S. military, Federal government, and intelligence community. A summary of the interagency scientific collaboration in addressing some of the key gaps and needs identified during the 2017 workshop will be presented.