

LIS-Hydro: A Comprehensive Framework for Flood Prediction, Analysis, and Management

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Outline



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Motivation



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- 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^[1]).
- Furthermore, *The Summary of the 2018 National Defense Strategy of the United States of America*^[2] concluded, "Interstate strategic competition, not terrorism, is now the primary concern in U.S. national security".
 - The U.S. intelligence communities have identified the coordination over shared water resources as an area of significant concern to U.S. national security.
 - 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 .





Current State



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- For domestic operations, there are a number of agencies that support water security-related efforts, including NOAA's National Weather Service, the National Water Service, River Forecast Centers, USACE offices, Bureau of Land Management, various State organizations, and others^[3].
- However, outside of the U.S., no organizations own policy or have a mandate to produce the suite of products required end-to-end to support transboundary or water security decision-making.
- And, while there are several regional and/or global frameworks for assessing elements the Food-Energy-Water (security) nexus, these frameworks^[4-8] often lack the attributes (i.e., comprehensive forcing, data assimilation systems, and high-resolution temporal and spatial resolutions) required in order to produce accurate and timely assessments of the hydrologic cycle--and the comprehensive suite of on-demand products and services.
- **Bottom Line:** 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 U.S. military, Federal government, and intelligence community does not exist.





Gaps and Deficiencies



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- In direct response, NASA and USACE hosted a transdisciplinary workshop titled, **“Transboundary Water: Improving Methodologies and Developing Integrated Tools to Support Global Water Security”**^[3] on August 15-16, 2017 in Silver Spring, MD culminating in [NASA/TM-2018-219026](https://www.nasa.gov/tm-2018-219026).
 - A key motivation for the workshop was to, *“...highlight the opportunity to advance the use of existing Earth science modeling and observational products to inform decision-making related to transboundary water.”*
 - The discussions at the workshop confirmed that, *“...barriers continue to limit the adoption of existing capabilities to the fullest extent possible.”*
 - Path Forward to address existing barriers and gaps comprised of 5 Key Findings and Recommendations, respectively.
 - The 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”*. Furthermore, *“...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**.



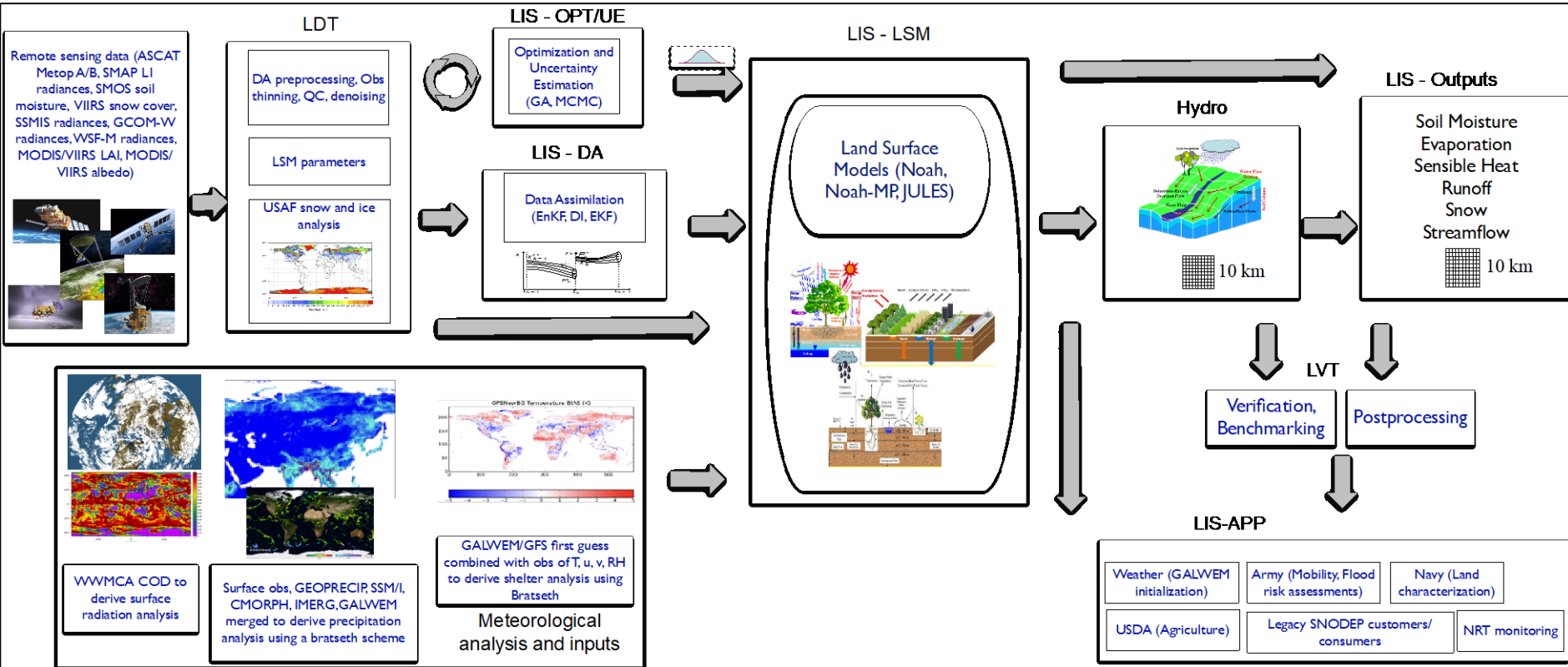


Global Hydrology Environment

Near-Real-Time and Medium-Range Timescales



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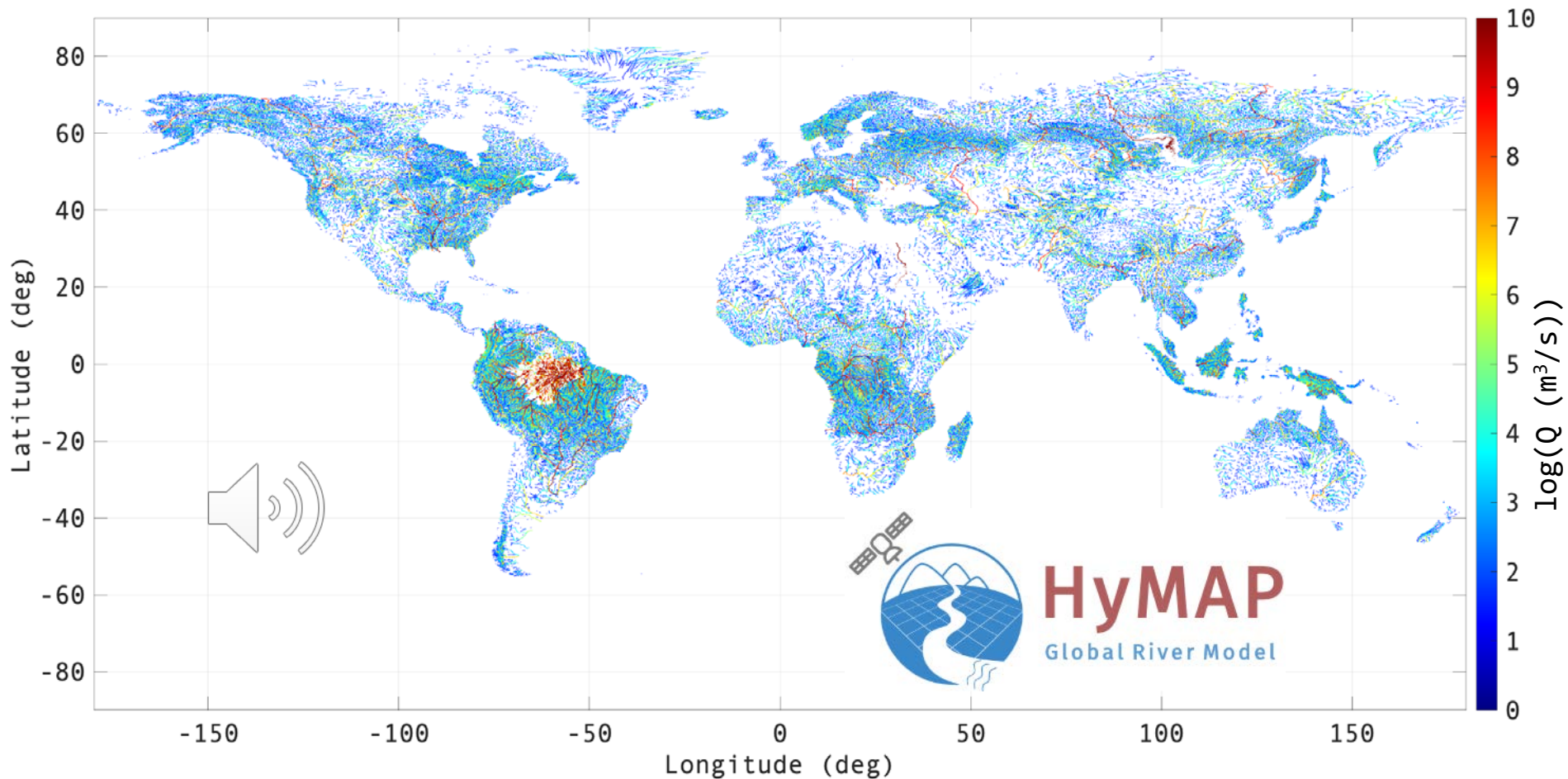


Global Streamflow

Example 10-km LIS-Noah-MP-HyMAP^[10]



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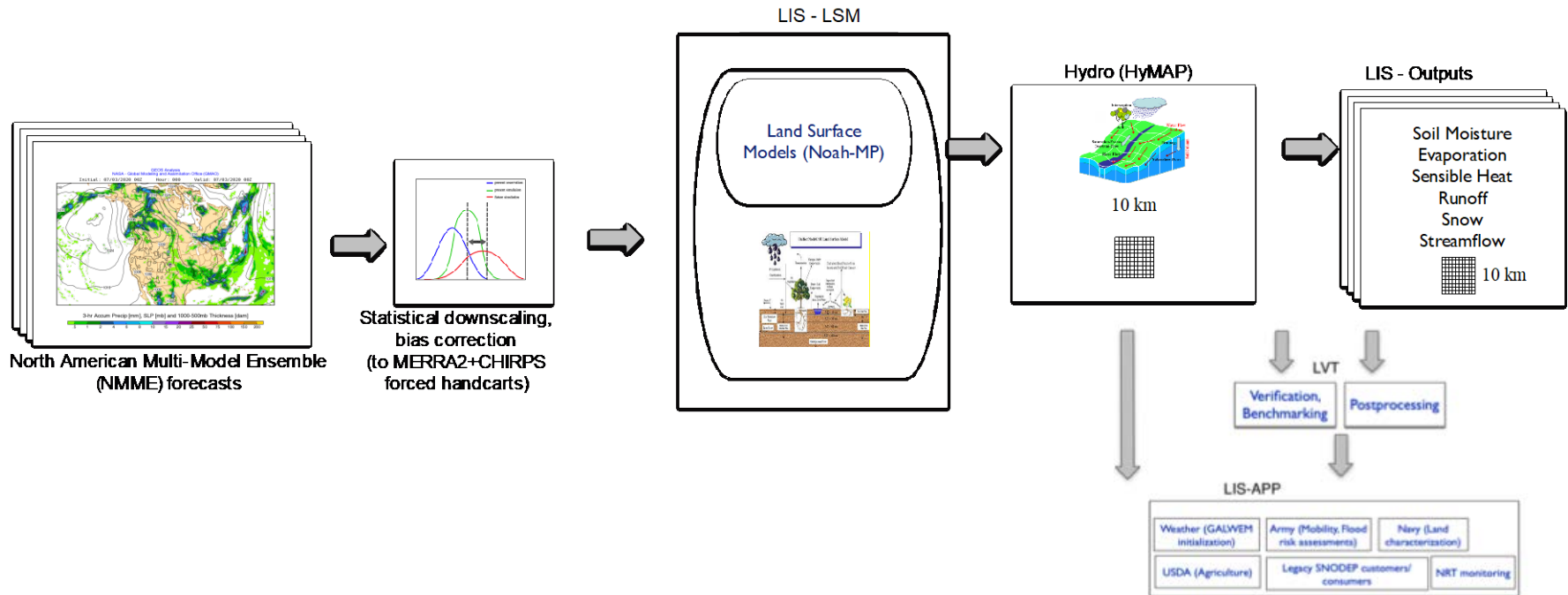


Global Hydrology Environment

Sub-seasonal-to-Seasonal (S2S) Timescales



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Based in part on NASA's NHuFAS system^[11]

<https://lis.gsfc.nasa.gov/projects/nhyf>
[as](#)





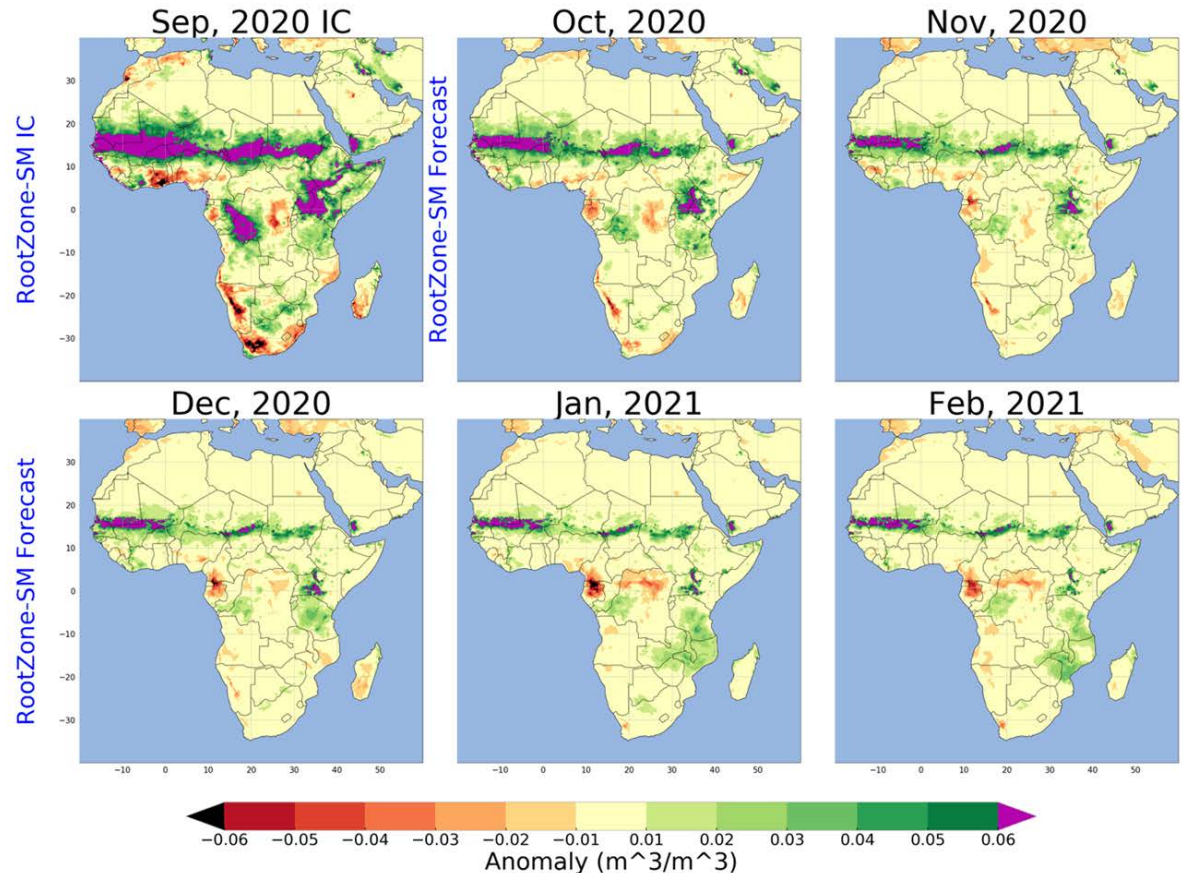
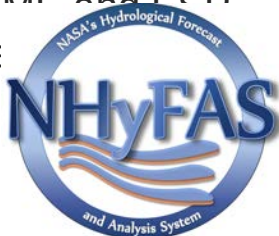
Sample NHyFAS Products



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Our webpage currently hosts forecasts of:

- Monthly forecast percentiles and anomalies of RZSM and streamflow
- 3-month aggregate forecast percentiles and anomalies of RZSM
- Monthly percent saturation forecasts of surface and RZSM
- Probabilistic RZSM terciles for monthly NMME and FSP



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

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Summary and Future Work



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- 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**[$t_{-12\text{hours}}$ to t_0], **Medium-Range**[t_0 to $t_{14\text{days}}$], **Sub-seasonal-to-Seasonal**[t_0 to $t_{12\text{months}}$], and **Inter-Annual**[t_0 to $t_{100\text{years}}$]) to fulfill this gap/need.
- Implementation of a multivariate DA scheme accounting for the simultaneous assimilation of [SWOT](#) data and terrestrial water storage (TWS) anomalies derived from the Gravity Recovery and Climate Experiment (GRACE) mission into the LIS Framework will provide the much-needed observation-based constraints on modeled estimates via the USAF's LIS-based *Global Hydro-Modeling Intelligence System*, particularly over data poor regions of the world^[12,13].
- The resultant hydrologic products and services 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 deployed LIS-Hydro framework will promote societal applications for sustainable water resource management, humanitarian assistance and disaster response, economic development, and regional stability.





Summary and Future Work



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- 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 (U.S. Global Water Strategy, 2017^[14]) 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.
- By providing a high quality, observation-driven, operational hydrologic modeling environment, the LIS-Hydro system will significantly aid in providing timely information about the transboundary water security related challenges and vulnerabilities.
 - The routine availability of such information will address the significant hydro-intelligence gap identified by the defense and national security communities (Intelligence Community Assessment, Office of the Director of National Intelligence, 2012^[15]).





Contact Information



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<https://github.com/NASA-LIS/LISF>

<https://modelingguru.nasa.gov/community/atmospheric/lis>





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