

Global Hydro Intelligence (GHI)

A Comprehensive Framework for hydrologic analysis, forecasting, and projections across time scales

Noah-MP Workshop

23 May 2023





Outline

- What is GHI?
- Motivation/Requirements
- Highlights and Vignettes
- Summary





Overview of GHI

What it is:

- 557 WW and its predecessors (i.e., AFWA, AFGWC, ETAC) have been home to the DoD's **only** operational regional and global land characterization mission (i.e., M&S of the **hydrologic cycle**) **since January 1958**
- Existing Land Information System Framework (LISF) has been enhanced from being solely a Near-Real-Time (NRT: t_{-12} hours to t_0) physics- and data assimilation- based **reanalysis system with forecast- and projection- components to enable M&S of the hydrologic cycle across all time scales**
 - Medium-Range (MR: t_0 to t_{16} days);
 - Sub-seasonal-to-Seasonal (S2S: Hindcast [$t_{2021-1991}$] & Forecast [t_0 to t_9 months]);
 - Inter-Annual or Climate (IA: Historical [$t_{1950-2014}$] & Projections [$t_{2015-2100}$] years); and
- Routing (RAPID and HyMAP) and Ground Water models to enable streamflow prediction and flood inundation modeling

What it is not:

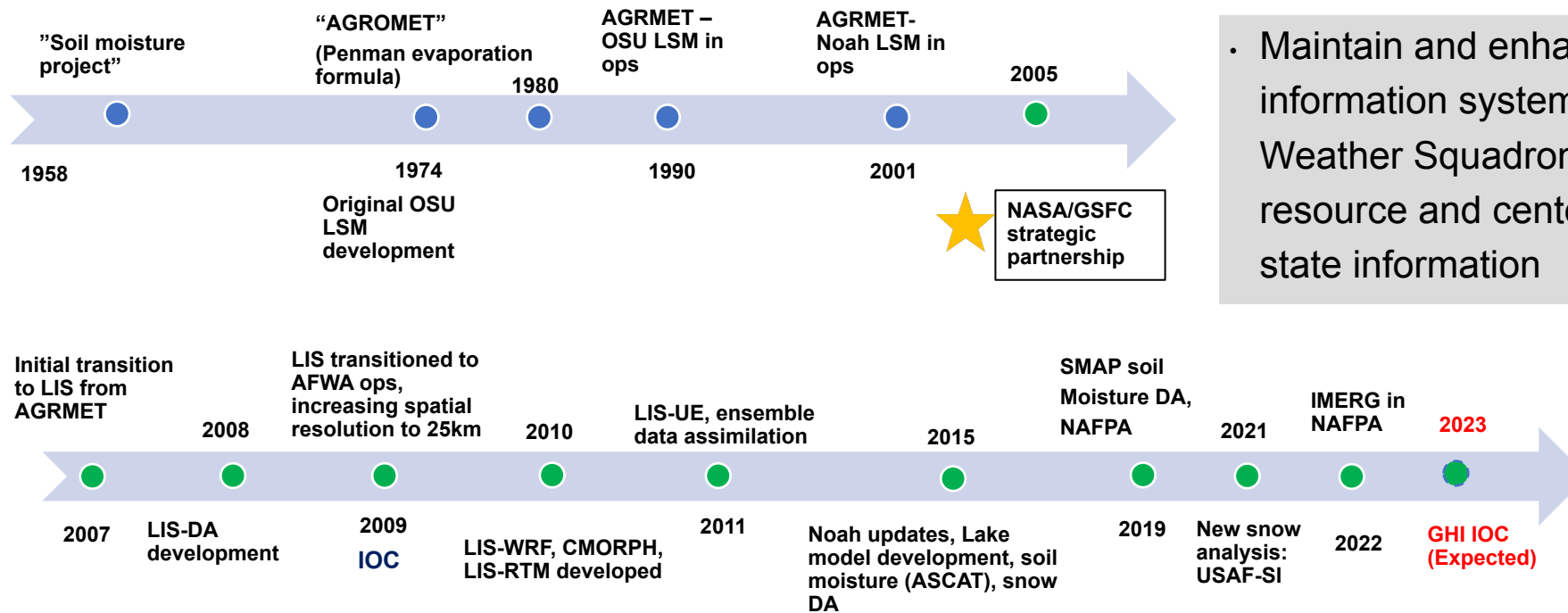
- GHI is **not** a new mission





Land characterization mission at 557 WW

- 557th Weather Wing (557 WW) provides routine geospatial intelligence information to war-fighters, planners, and decision makers at all echelons and services of the U.S. military, government and intelligence community.
- 557 WW and its predecessors (e.g. AFWA) have been home to the DoD's **only** operational regional and global land data analysis systems (GLDAS) **since January 1958**.



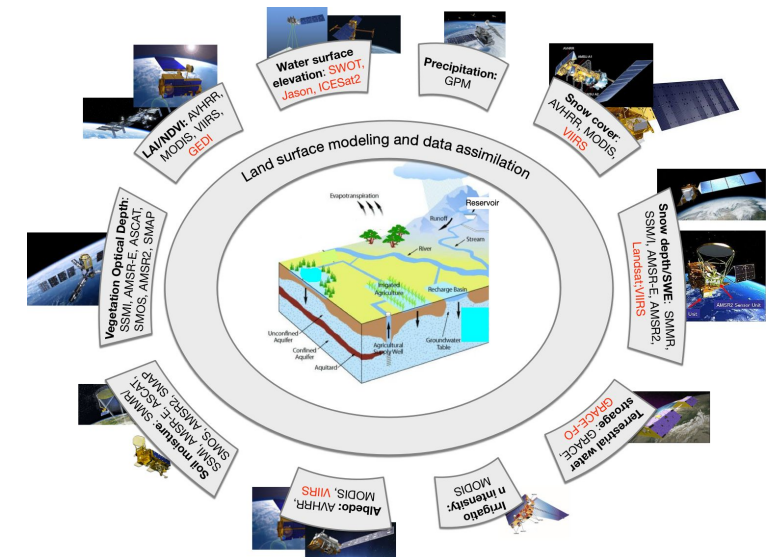
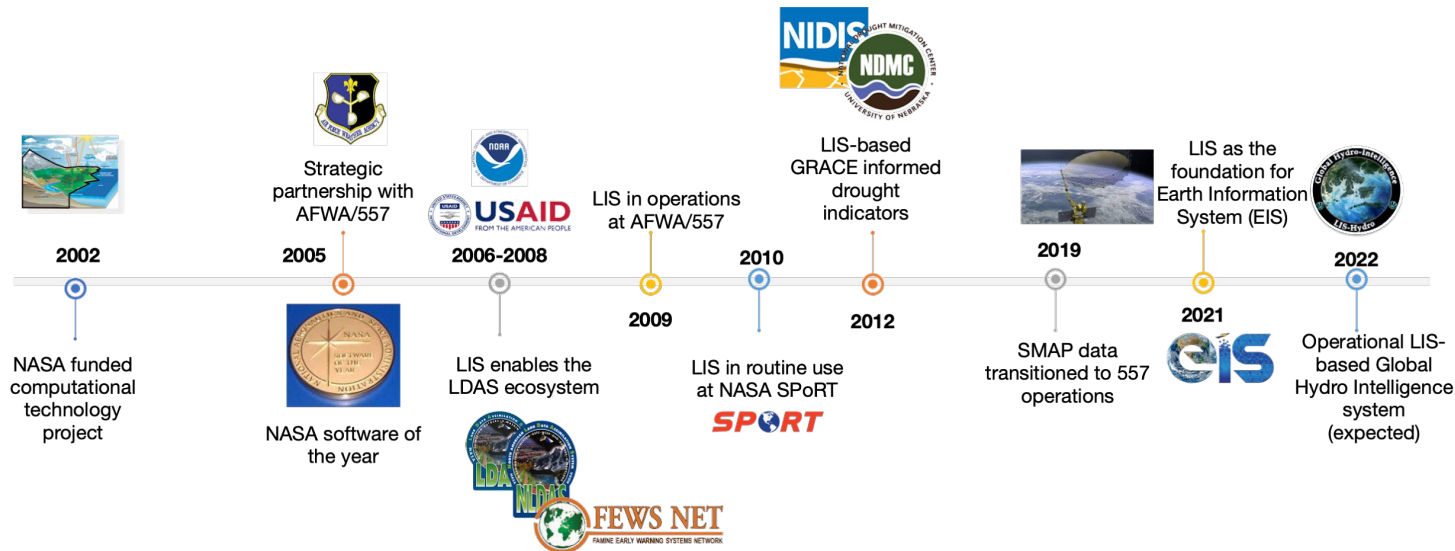
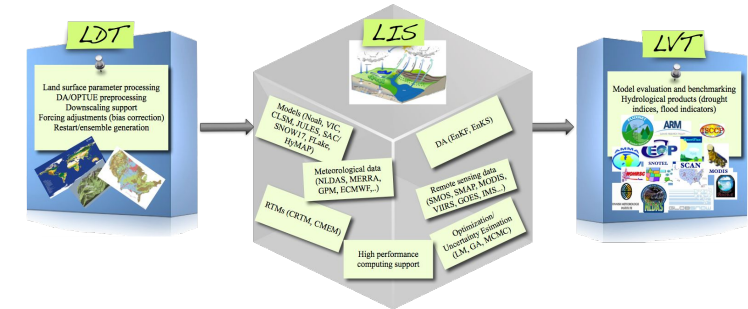
- Maintain and enhance AFW's **premier** global land information system (LIS) while preserving the 16th Weather Squadron's preeminence as a global resource and center of excellence for global land state information





Land Information System (LIS)

- A system to simulate land and hydrology processes by integrating a large suite of models and remote sensing data through comprehensive data assimilation capabilities
- State-of-the-art terrestrial hydrology modeling system in the world with unprecedented set of capabilities for remote sensing data infusion.





Overview of GHI

What it is:

- **Revolutionizes** CONOPS by reducing environmental RFI response times from **months/days to minutes**
- GHI output, products and services available on-line and on-demand (i.e., 24/7/365) with appropriate metadata through an interactive web service enabled geospatial platform **across all enclaves** (e.g., NIPR, SIPR, JWICS)
- Transforming to a robust **operational capability** providing **near real-time (NRT) assessments** of surface hydrology features (streamflow, flood risk, etc.) and impacts (mobility) **across all time scales**
- The routine availability of transboundary water information will address the significant hydro-intelligence gaps identified by the defense and national security communities (Intelligence Community Assessment, Office of the Director of National Intelligence, 2012).
- Most significantly, transition-to-Ops and sustainment of the operational capability by AFW **will establish a national asset** and serve as the USG's **one-stop-shop** for **authoritative global hydro intelligence across all time-scales** 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.

What it is not:

- CONOPS/CONEMP are **not** new





Current State of the (Military) Hydrology Mission

- 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 **benchmark** 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 **across all time scales** does not exist.



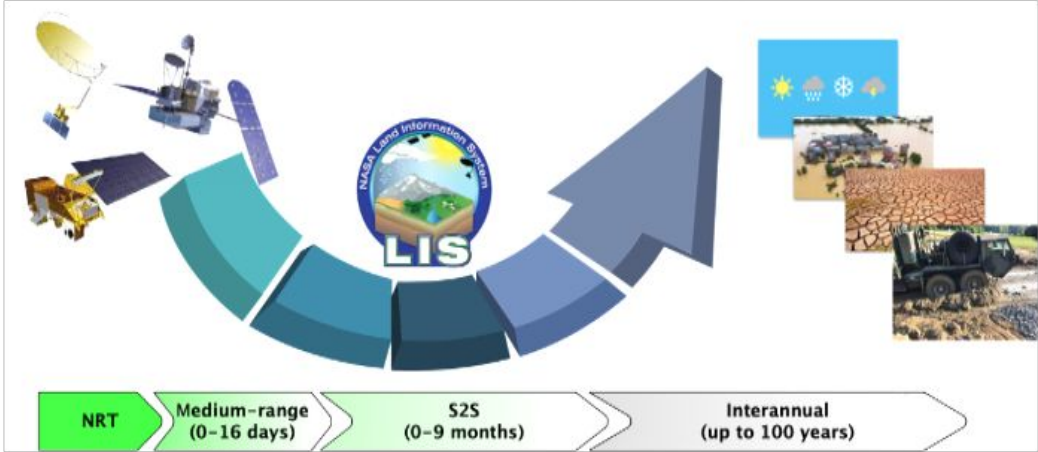
GHI vision and goals



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 community.



The primary goal is to develop a comprehensive framework comprising of four operational sub-systems, each combining multiple models of physical processes and remote sensing data with visualization and decision support across a spectrum of time scales and missions.



Sub-System	Time Scale	IOC
Near-real-time	t_{-12} to t_0 hours	June 2023
Medium-range	t_0 to 16 days	June 2023
Sub-seasonal-to-Seasonal	Hindcast ($t_{2021-1991}$) & t_0 to 9 months	June 2023
Inter-annual (Climate)	Historical ($t_{1950-2014}$) & Projections ($t_{2015-2100}$) years	June 2023





Motivation

(Policy and Requirements Driven)

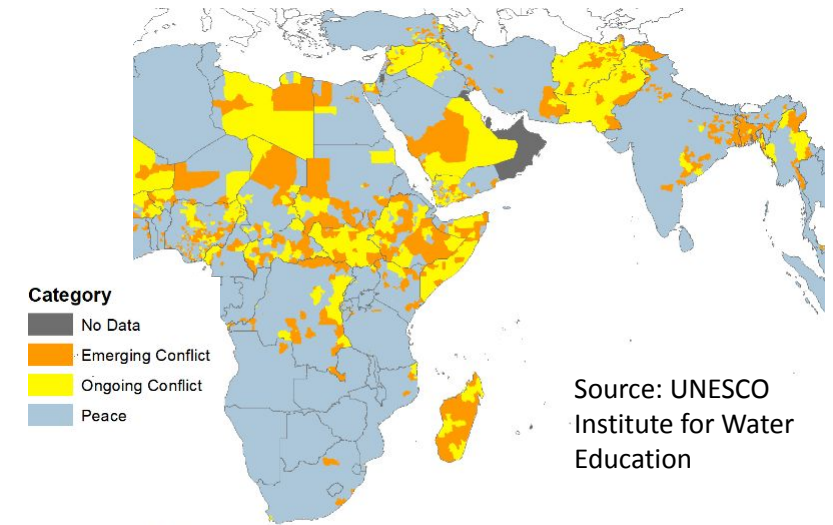
- Significant hydro-intelligence gap identified by the defense and national security communities ([Intelligence Community Assessment, Office of the Director of National Intelligence, 2012^{\[1\]}](#));
 - There is limited established information available on the baseline performance of transboundary water information
 - Most operations are done in an ad-hoc manner, due to the lack of routine availability of required inputs
- *“Water may be the most important issue we face for the next generation.”*
 - - Donald J. Trump, President of the United States ([U.S. Global Water Strategy, 2017](#))





Global Hydro Intelligence (GHI) Requirements

- The U.S. intelligence communities have identified the coordination over shared water resources as an area of significant concern to U.S. national security.
- 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.
- Many hydrology requirements formally documented to the DAF.



NASA/TM-2018-219026



Workshop Report and Recommended Path Forward

Transboundary Water: Improving Methodologies and Developing Integrated Tools to Support Water Security

Dialogue toward a future framework for Federal coordination and integrated analysis capabilities in support of global water security

A joint workshop conducted by NASA and USACE concluded that “...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)”, **is a significant need.**





Gaps and Deficiencies

- 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](#).
 - 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**.





Motivation

(Policy and Requirements Driven)

- 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.





Motivation

(Policy and Requirements Driven)

- The Biden Administration's:
 - Call for a whole-of-government approach to *Tackling the Climate Crisis at Home and Abroad* ([E.O. 14008](#); January 27, 2021);
 - Update of the [U.S. Global Water Strategy](#), 2022-2027; and
 - White House [Action Plan on Global Water Security](#) , 2022.
 - Note: The **operational GHI system** (explicitly called out on p. 111/140 of the U.S. Global Water Strategy), will enable the USAF to achieve DoD SOs 3 and 4 contained in the DoD Annex of the GWS (aligned with WHAP Pillars 2 and 3)



Strategic Objective 3: Improve Climate-Resilient Conservation and Management of Freshwater Resources and Associated Ecosystems

DoD is taking steps to improve the management of freshwater resources under a changing climate with international partner countries and on our installations around the world. Sharing water expertise between DoD and international partners can improve water resource management and contribute to water security, advancing the goals of the White House Action Plan on Global Water Security. DoD has worked with U.S. interagency partners to develop an operational Global-Hydrologic Information program, slated for roll-out in July 2023. This initiative will provide a readily accessible, authoritative source of global water information to assist in building allied and partner awareness, capacity, and resilience with which to enhance their water security.



Strategic Objective 4: Anticipate and Reduce Conflict and Fragility Related to Water

***Note:** SO4 shortened here for brevity (details available online).





GHI Highlights / Vignettes

- Near-Real-Time (NRT)
 - SPT GERD simulations in response to 2020 RFI submitted to UROC by Special Envoy to the Horn of Africa
- Medium Range (MR)
 - Offutt Flooding (5 ½ day lead-time; March 15-20, 2019)
 - Atmospheric River events beginning (8-day lead-time; 26 Dec 2022)
 - Southern California snowfall (8-day lead-time; 26 Feb 2023)
- Sub-seasonal-to-Seasonal (S2S)
 - Break in Sudanese and Ethiopian Drought (3 ½ month lead-time; 1 May to mid-Aug 2022)
 - Pakistan flooding (3 ½ month lead-time; 1 May to mid-August 2022)
- ***Inter-Annual (Climate)***
 - ***Projections at OCONUS installations***



GHI Climate Sub-system

Hydrological prediction at climate scales

One Foot of Sea Level Rise

Areas in red will be flooded after 12 inches of sea level rise.

Regions near all coastal NASA centers are expected to experience at least 5 inches of sea level rise between now and the 2050s.

1: Ames Research Center



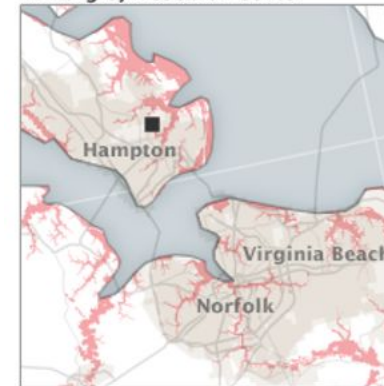
2: Johnson Space Center



3: Kennedy Space Center



4: Langley Research Center



5: Wallops Flight Facility



Locations of Selected NASA Centers



- LIS has been enhanced with capabilities for climate scale hydrologic projections
- Leveraged by the NASA Climate Adaptation Science Investigation (CASI) supported by NASA HQ
- Global configurations at 10km resolution
- Includes historical as well as future climate projections for multiple shared socio-economic pathways (SSPs)



Downscaled CMIP6 data

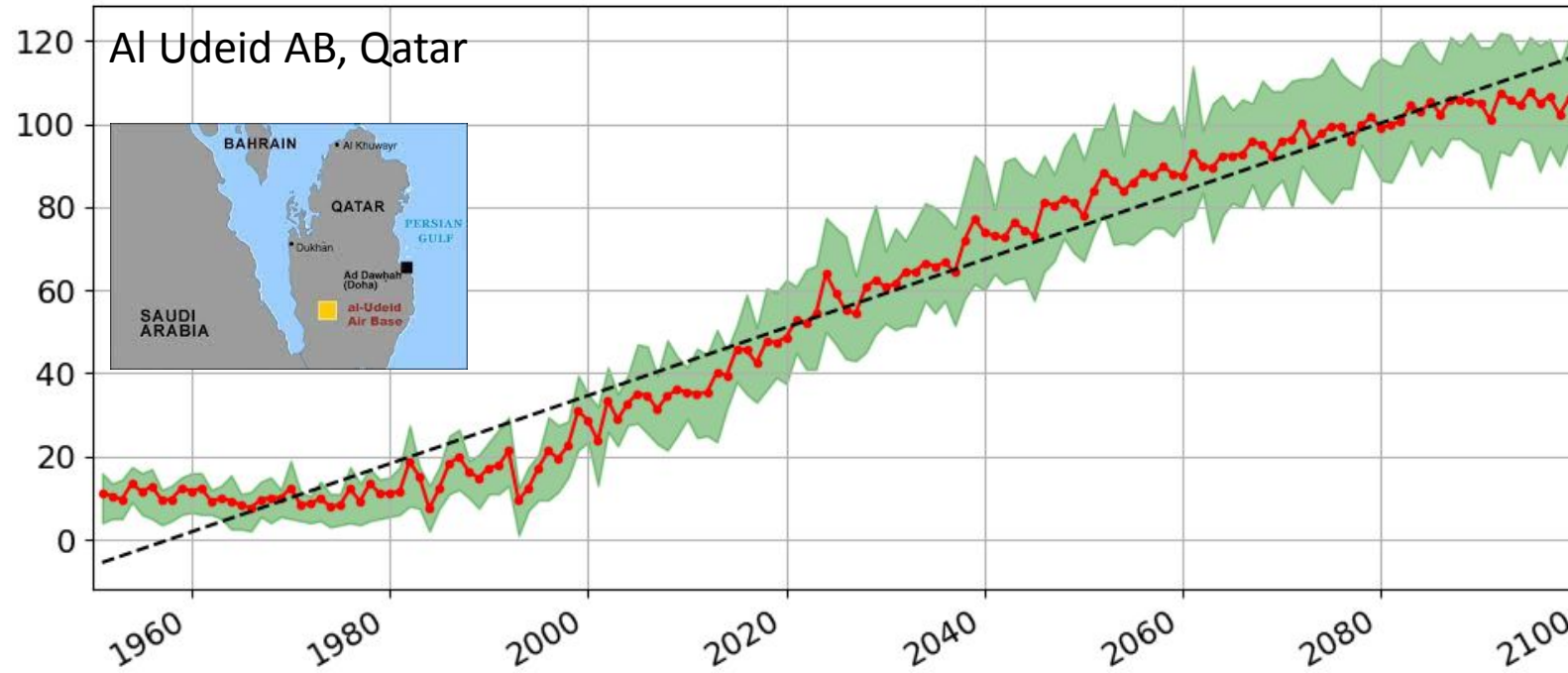
- Employs the NASA Earth Exchange (NEX) Global Daily Downscaled Projections (GDDP) dataset (NEX-GDDP-CMIP6) derived from CMIP6, developed for the IPCC Sixth assessment report ([IPCC AR6](#))
- Across four Tier-1 greenhouse gas emissions scenarios known as Shared Socio-economic Pathways (SSPs)
- 0.25 deg spatial resolution, globally with the historical data from 1950 to 2014 and future projections for 2015 to 2100
- Daily data is generated by applying the Bias-Correction Spatial Disaggregation (BCSD) method to the Princeton forcing data ([Sheffield et](#)

Table 1. CMIP6 models included in downscaled archive

[illegible]

GHI Climate Sub-System Example #1

Number of days per year when land surface temperatures are above 90th percentile (analog of extreme heat days), based on SSP2.4.5

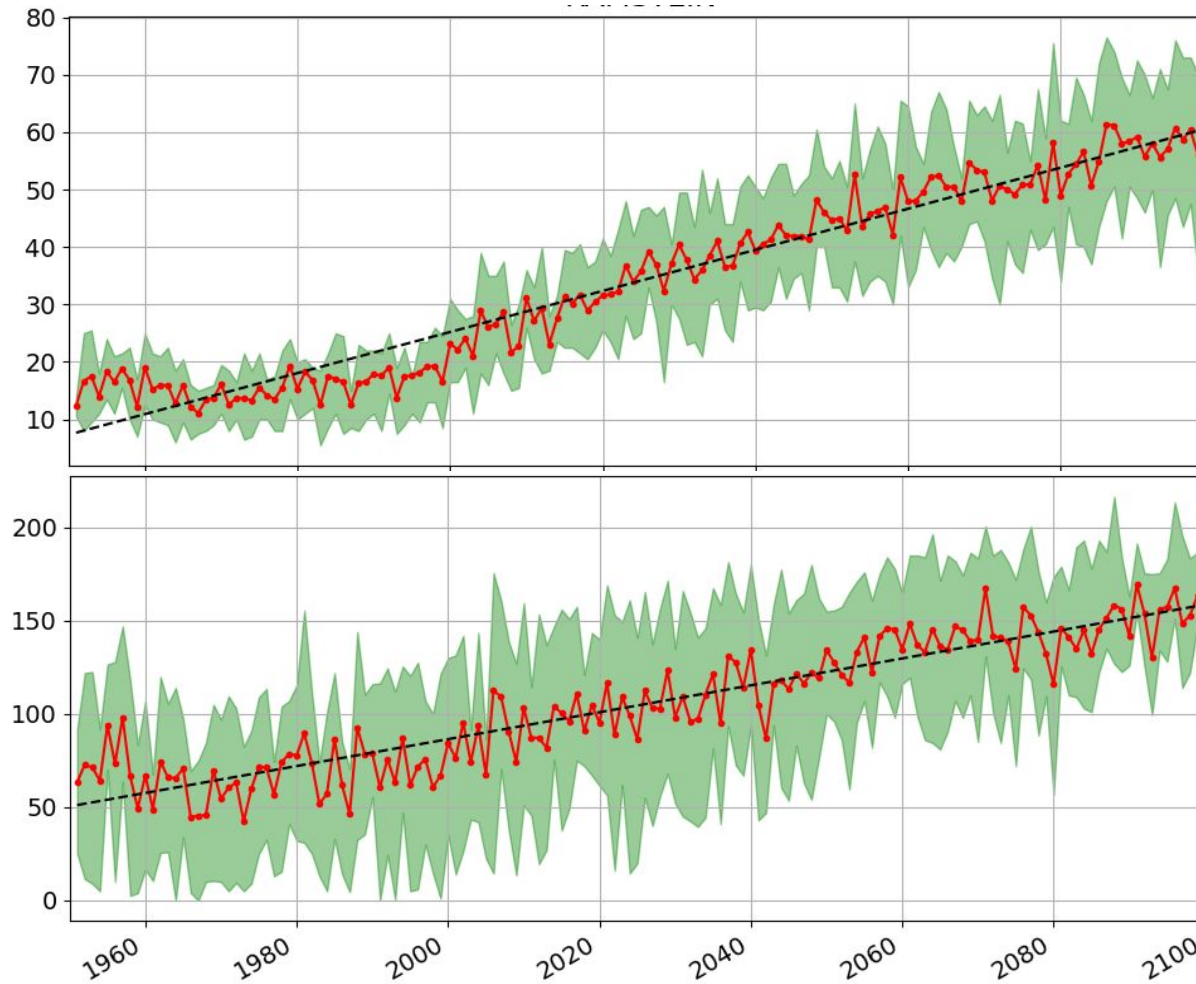


Significant increases in extreme hot days are projected at this location with more than 3 months in a year showing extreme hot days, compared to about 15 days in a year currently.

GHI Climate Sub-System Example #2

Number of days per year when land surface temperatures are above 90th percentile (analog of extreme heat days).

Number of days per year when soil moisture is below 10th percentile (analog of drought/water scarcity)



Ramstein AB, Germany



Significant increases in extreme heat and water scarcity/drought are projected at this location (More than 3 months in drought projected at the end of century)

Green shading shows the spread across 25 CMIP6 ensembles (25-75 percentiles); red line is the ensemble average; solid black line indicates that the linear trend is statistically significant





Summary

- GHI output, products and services available on-line and on-demand (i.e., 24/7/365) with appropriate metadata through an interactive web service enabled geospatial platform (i.e., GeoHIP) **across all enclaves** (e.g., NIPR, SIPR, JWICS)
- Transforming to a robust **operational capability** providing **near real-time (NRT) assessments** of surface hydrology features (streamflow, flood risk, etc.) and impacts (mobility) **across all time scales**
- **Revolutionizes CONOPS** by reducing environmental RFI response times from **months/days to minutes**
- The routine availability of transboundary water information will address the significant hydro-intelligence gaps identified by the defense and national security communities ([Intelligence Community Assessment, Office of the Director of National Intelligence, 2012](#)).
- Most significantly, transition-to-Ops 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 ([U.S. Global Water Strategy, 2022](#)) 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.





Thank you for your attention

Questions?



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