



INARCH Workshop, Kananaskis, Alberta, Canada,
September 8–10, 2026

H2US: A Collaboratory for Mountain Hydroclimate Science

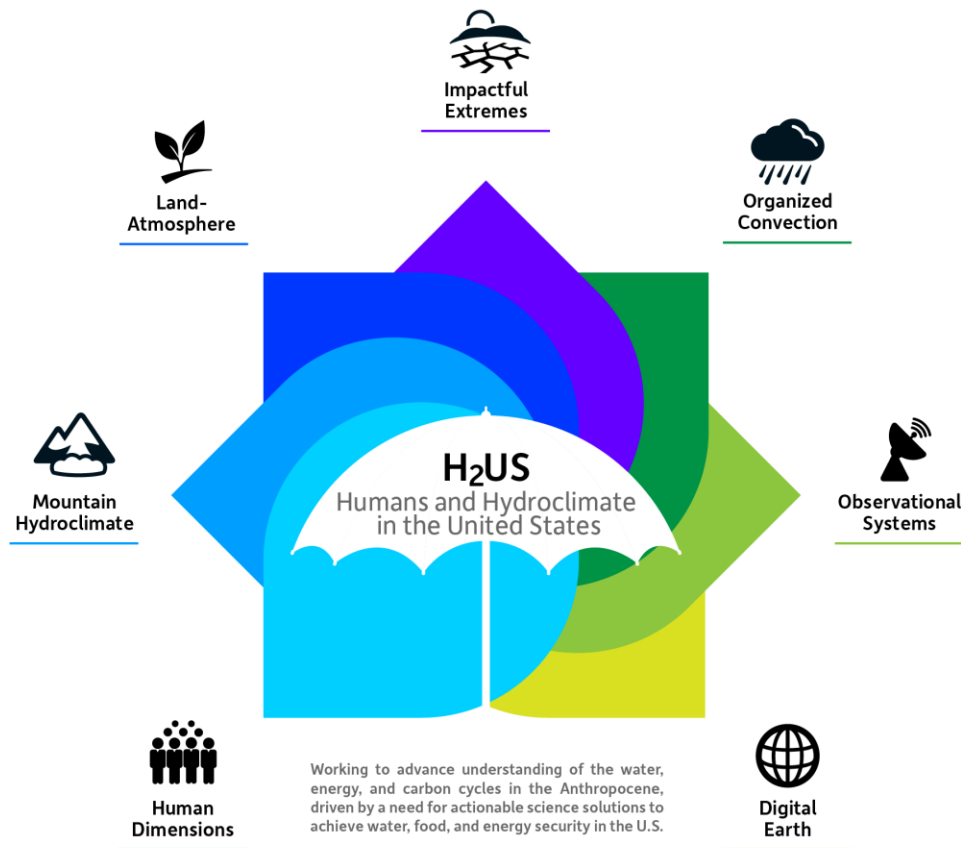
Ethan Gutmann¹, Cenlin He¹, Peter van Oevelen², **Tim Schneider**¹, Sarah
Tessendorf¹, with the H2US Affinity Group

¹Research Applications Laboratory, NSF NCAR

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Outline – H₂US

- I. Introduction: Brief Background
 - a. Humans and Hydroclimate in the U.S. – a GEWEX RHP
- II. Mountain Transects
- III. Motivation: Snow Science
- IV. Opportunities
 - a. IBOS
 - b. NASA Water Cycle Priorities
 - c. Coordination/Collaboration



Noted **Gaps**: Coastal Coupling; Modeling

I. H₂US: a Brief Introduction

A Complex, Coupled System

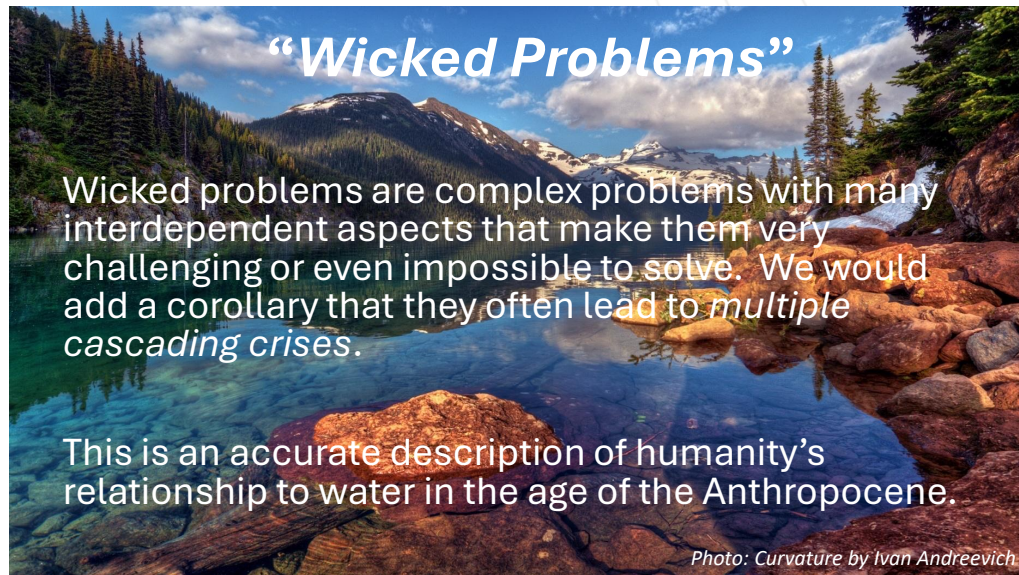
Water: $P + Q_{in} = ET + \Delta S + Q_{out}$

Energy: $R_n + G = \lambda ET + H$

Refine estimates of these terms; quantify their uncertainties; understand how will they change.

The Carbon Cycle most directly ties in through the “ R_n ” (energy) and “ ET ” terms.

Anthropogenic influences are manifold and impact all of these cycles through GHG emissions; land use/land cover change; and water resource management.

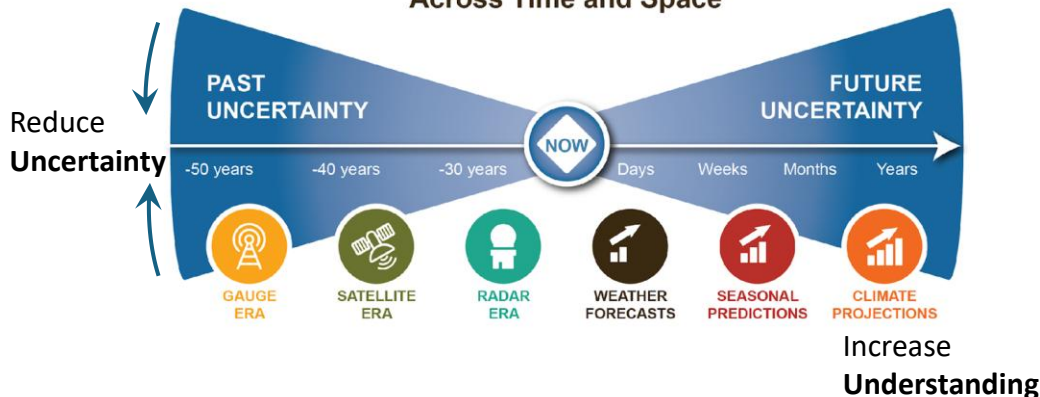


H₂US: a Brief Introduction

The Humans and Hydroclimate in the United States (H₂US) Project is envisioned as a ten-year effort to understand and characterize the physical processes of the water, energy, and carbon cycles in the Anthropocene. It is a **convergence science approach** to solving the Nation's wicked water problems. H₂US is driven by a need for actionable science solutions to achieve water, food, energy, and ecological security in the U.S.

THE BOW TIE DIAGRAM

Hydro-climate Analysis, Prediction, and Uncertainty
Across Time and Space



Traditional Ecological Knowledge (TEK)

We recognize, respect, and embrace the millennia of place-based knowledge and wisdom of those who were here first.

Rising Voices

Map Source: Traditional Native Lands (<https://native-land.ca/>)

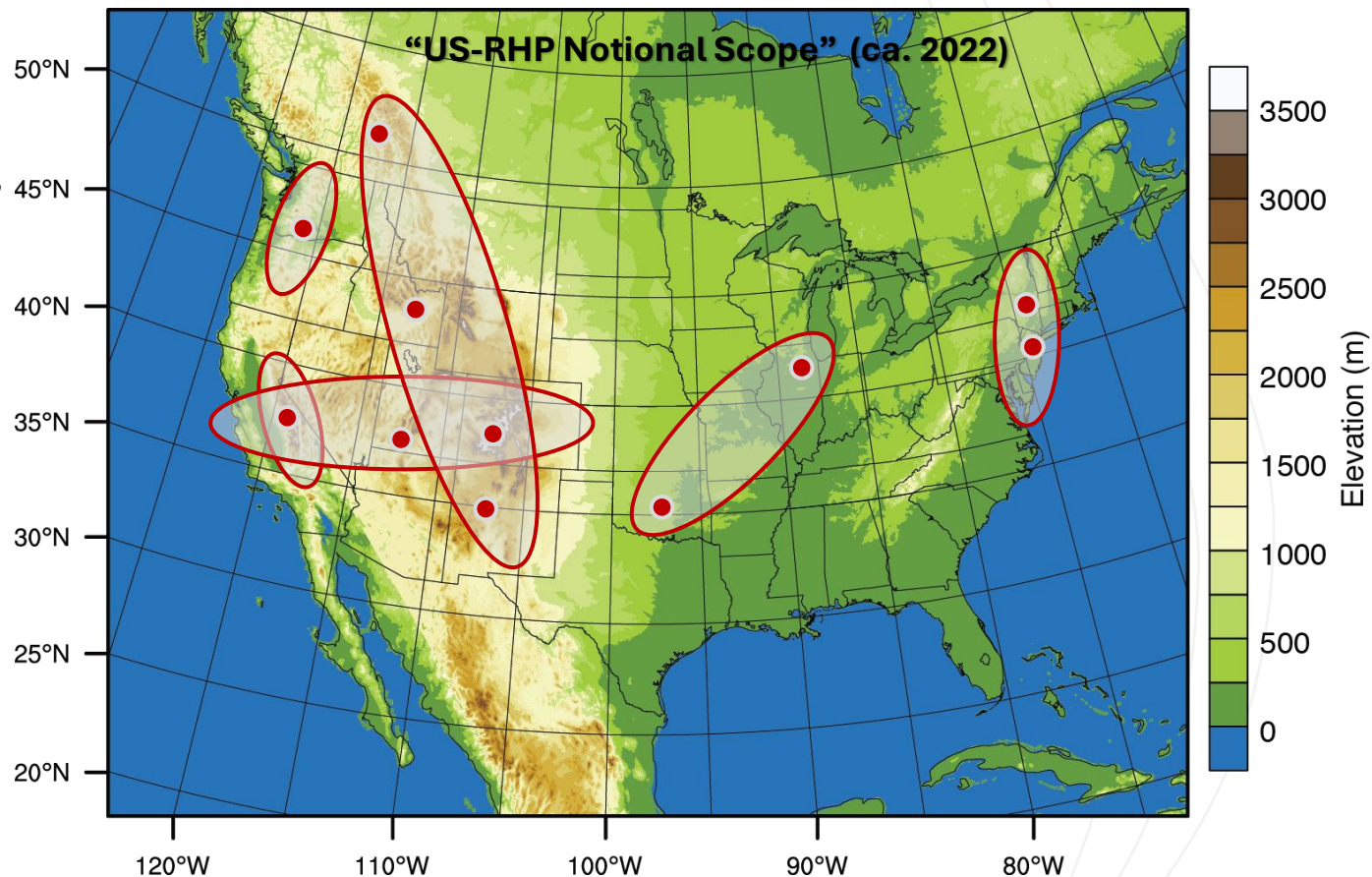
II. H₂US Transects (from the vault)

Modeling across scales:
global → **CONUS** → watershed

Coordinated intensive studies,
supported by **Regional Focal
Studies** with embedded
observational transects

New/leveraged observations:

- USGS-NGWOS
- AmeriFlux
- NEON
- DOE/ARM (SAIL)
- Global Water Futures
- Airborne missions
- Satellites
- **GLAFO**
- etc.



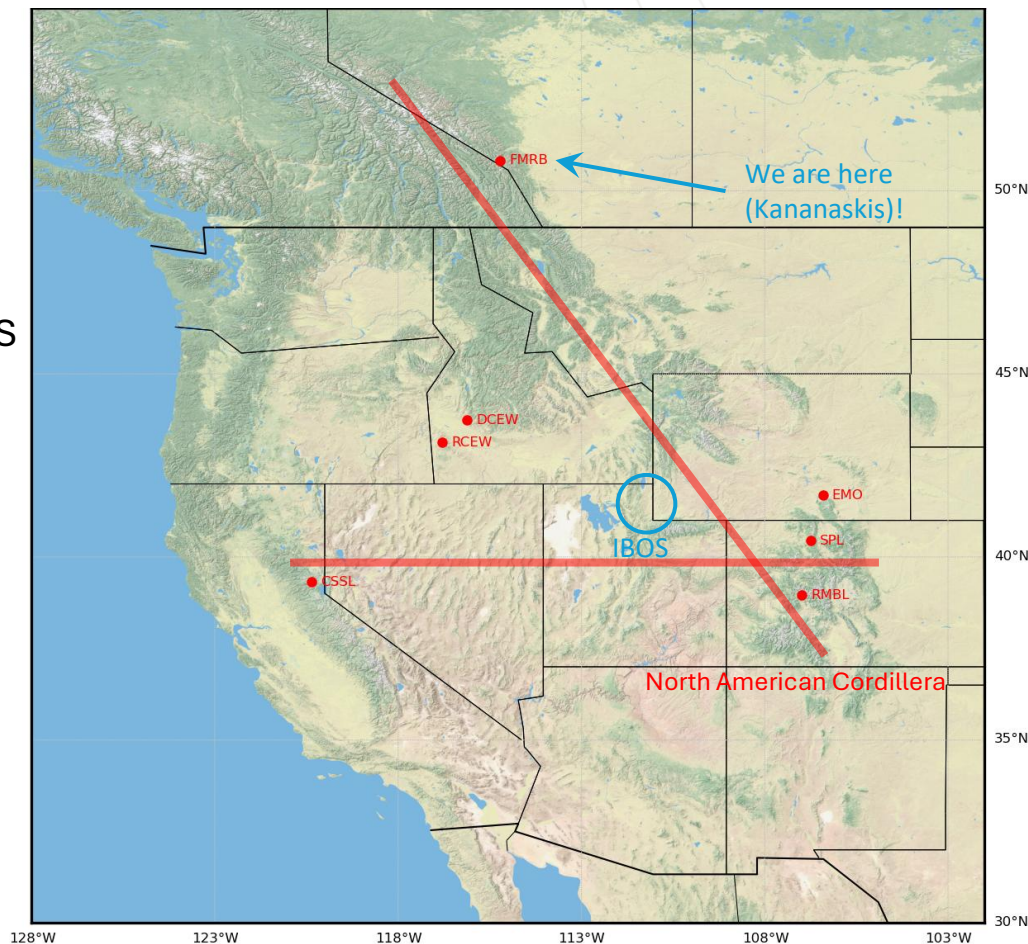
NB: Transects are not to be taken literally in this figure.

H₂US Transects

- Global Water Futures Observatories (not shown)
- INARCH Observatories ← (need to borrow your maps!)
- Integrated Basin Observing System (in development)
- A part of the North American Cordillera (a N-S Transect)
- Zonal (E-W) Transect

Considerations:

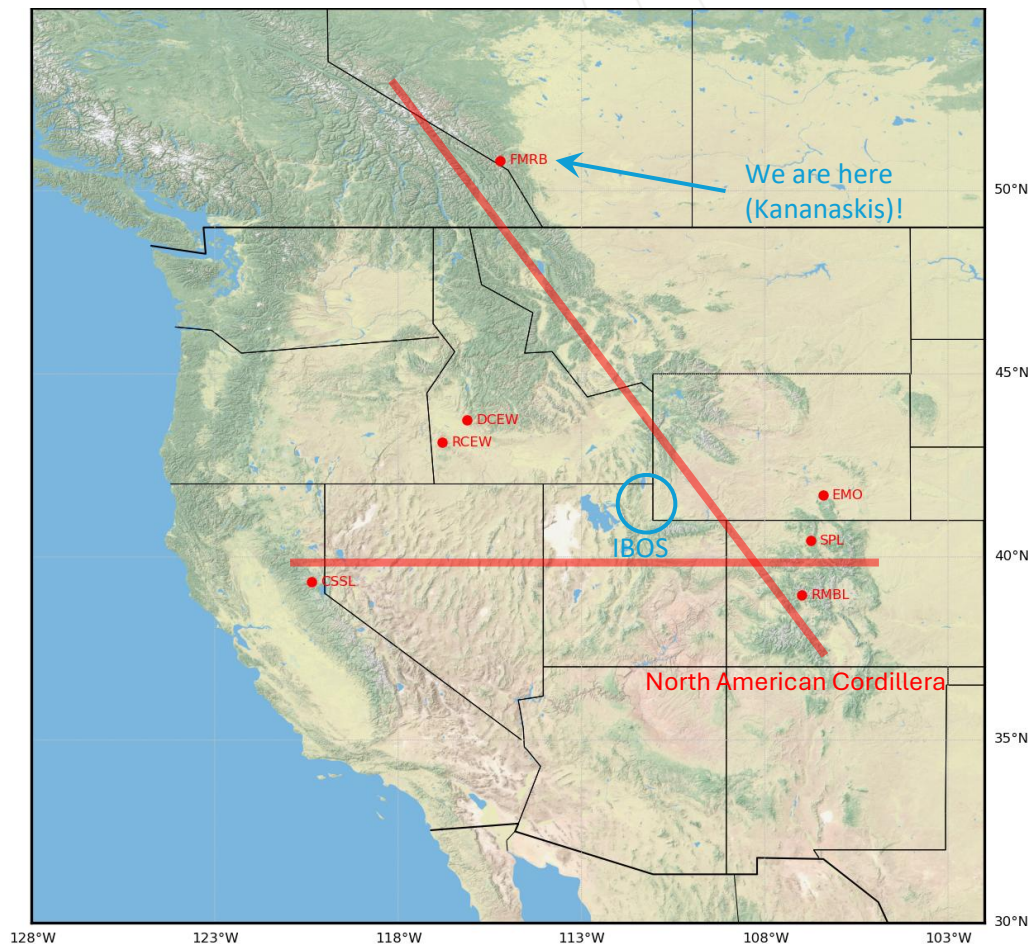
- Observatories | Laboratories | Stations -vs- Catchments | Basins | Watersheds
- Field Campaigns & Innovation (GLAFOs)
- H2US is getting organized around this effort
 - Esp. see Sarah Tessendorf, Andrew Schwartz, Kabir Rasouli



H₂US Transects

Shown on the map (not exhaustive):

- Rocky Mountain Biological Laboratory (RMBL)
- Storm Peak Laboratory (SPL)
- Elk Mountain Observatory (EMO)
- Dry Creek Experimental Watershed (DCEW)
- Reynolds Creek Experimental Watershed (RCEW)
- Fortress Mountain Research Basin (FMRB)
- Central Sierra Field Research Stations:
 - Sagehen Creek Field Station
 - Central Sierra Snow Laboratory (CSSL)
 - Onion Creek Experimental Watershed
 - North Fork Association Lands
 - Chickering American River Reserve



III. H₂US Snow Science – Example



Water Resources Research®

RESEARCH ARTICLE

10.1029/2025WR042586

[†]Deceased

Key Points:

Revisiting Snow Water Equivalent Bias in the Noah-MP Land Surface Model in the Western U.S.

Ronnie Abolafia-Rosenzweig^{1,2} , Cenlin He³ , Kyoko Ikeda^{3,†} , Changhai Liu³,
Tzu-Shun Lin³ , Michael Barlage⁴ , Lulin Xue³ , Kabir Rasouli⁵, Yongxin Zhang³ ,
Andrew Newman³ , Jimmy Dudhia³ , Timothy Schneider³ , and Roy Rasmussen³



Integrated cross-scale observations and reanalysis used for snowpack diagnosis

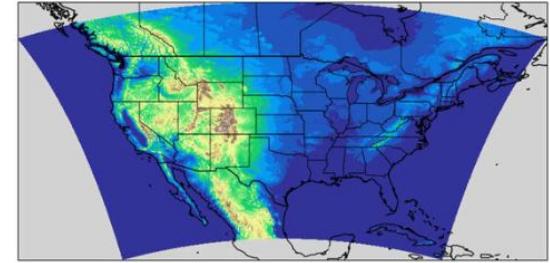
SNOTEL in-situ



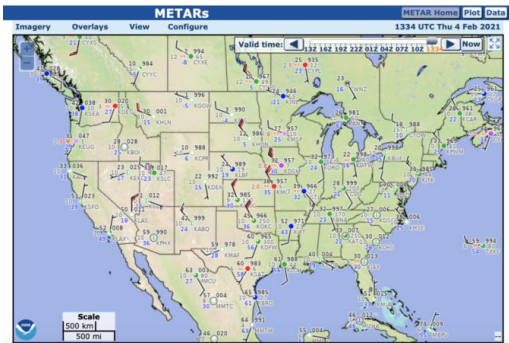
**High-res snow reanalysis
(UA, SNODAS, UCLA)**



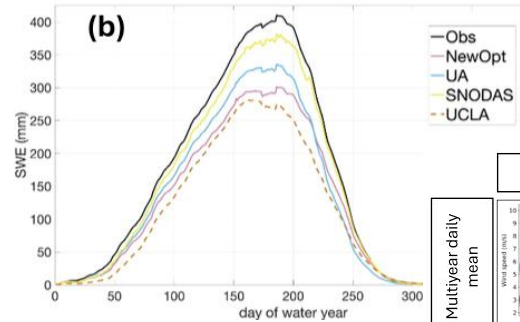
**High-res regional climate downscaling
(CONUS404)**



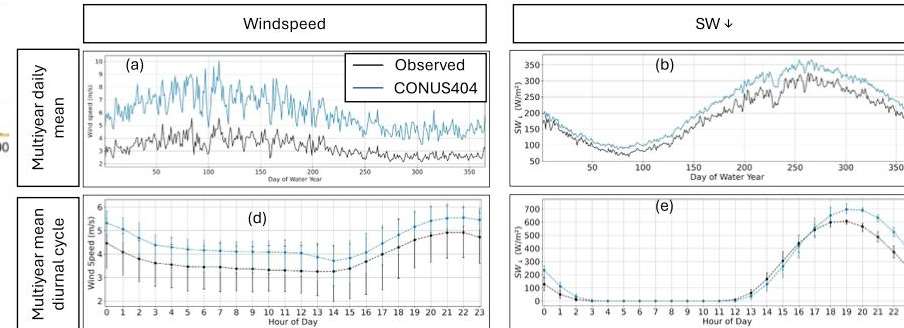
METAR in-situ



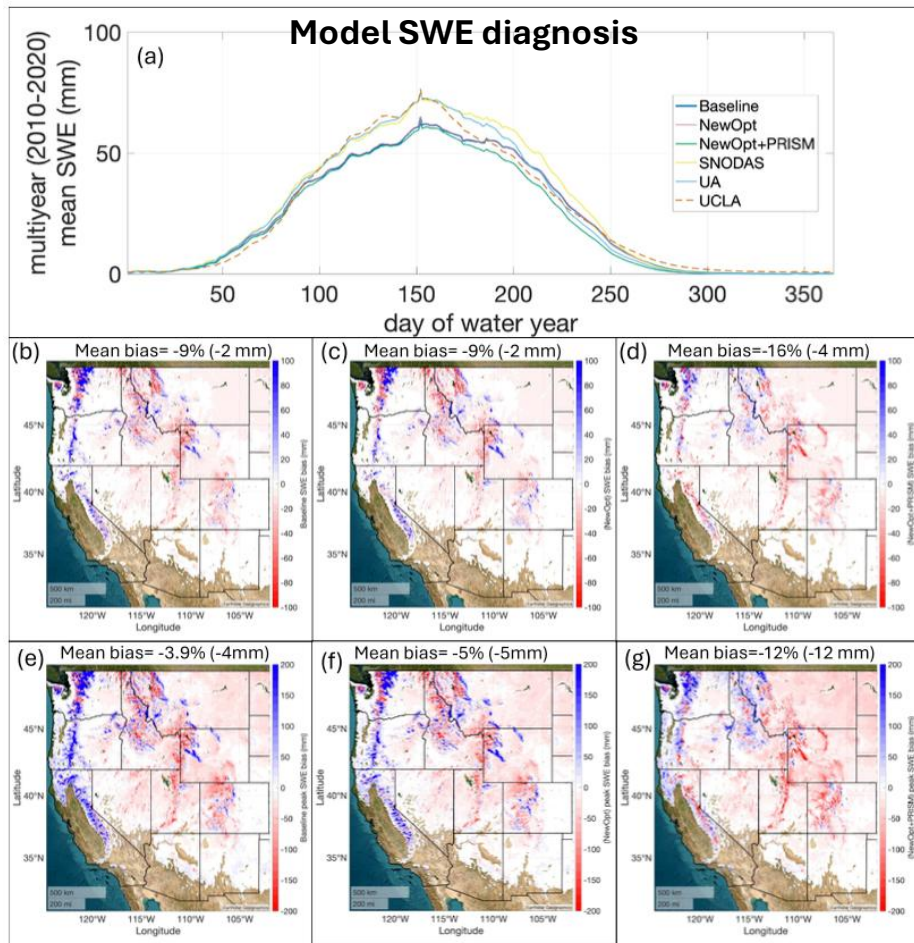
SWE across obs data and model



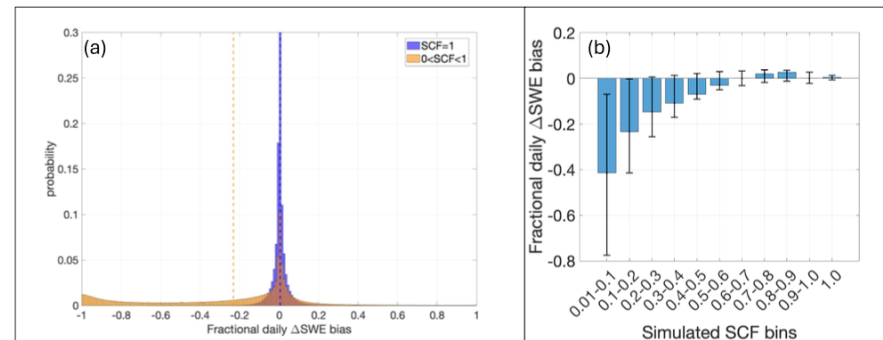
**Snow-relevant Met forcing analysis
for model and obs**



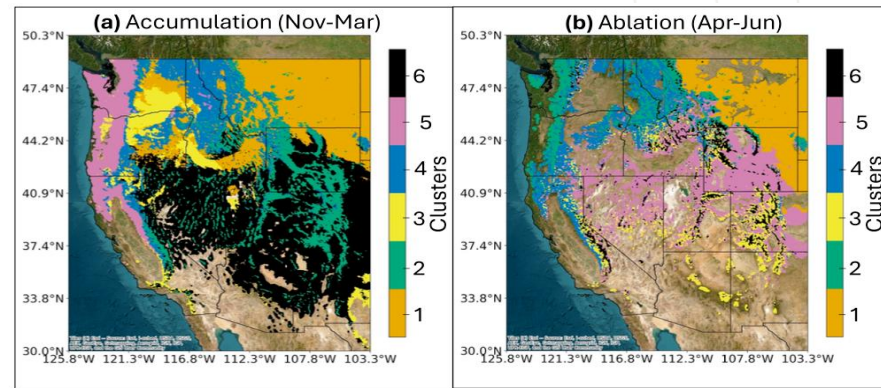
Comprehensive model SWE diagnosis via process-based and statistical analysis



SWE bias driven by model snow cover uncertainty



Regime clustering analysis for model SWE bias patterns



IV. Opportunities



1. IBOS Concept
2. NASA Water Cycle Priorities Project
3. Discussion

The Major Critical Elements of IBOS are:

1. A 'hyper-resolution' basin-wide integrated science strategy
2. Built on high density & diversity of obs (e.g. GLAFO): based on technical validity of the observational systems; "off the shelf / state-of-the-art"
3. The ability to integrate the data from the observational systems
4. Existing mature research tools (models) forming the basis for a quick path to a diverse set of operational forecast tools: **R2O2R (RAL)**

PPP



Novel aspects:

- The integrated nature: "bedrock to boundary layer+"
- The scale and scope of the effort
- *And our ability to prove the PPP approach at scale*

LAND COVER • 2025

Bear River Basin

UTAH • IDAHO • WYOMING



DATA: Annual NLCD 2025 (30 m) • USGS 3DEP • USGS WBD & NHD • U.S. Census Bureau state boundaries (2025)
Projection: Web Mercator (EPSG:3857) | Compiled August 2026

Bear River Basin

IBOS Applications

Integrated Basin Observational Strategy (IBOS)
Science Matching Nature's Methods



Transportation
decision-
support tools



Hydrologic prediction
capabilities



Air quality
forecasting



Noah-MP



Wildfire Modeling:
decision-support
technology



Severe
weather
forecasting



Avalanche
forecasting

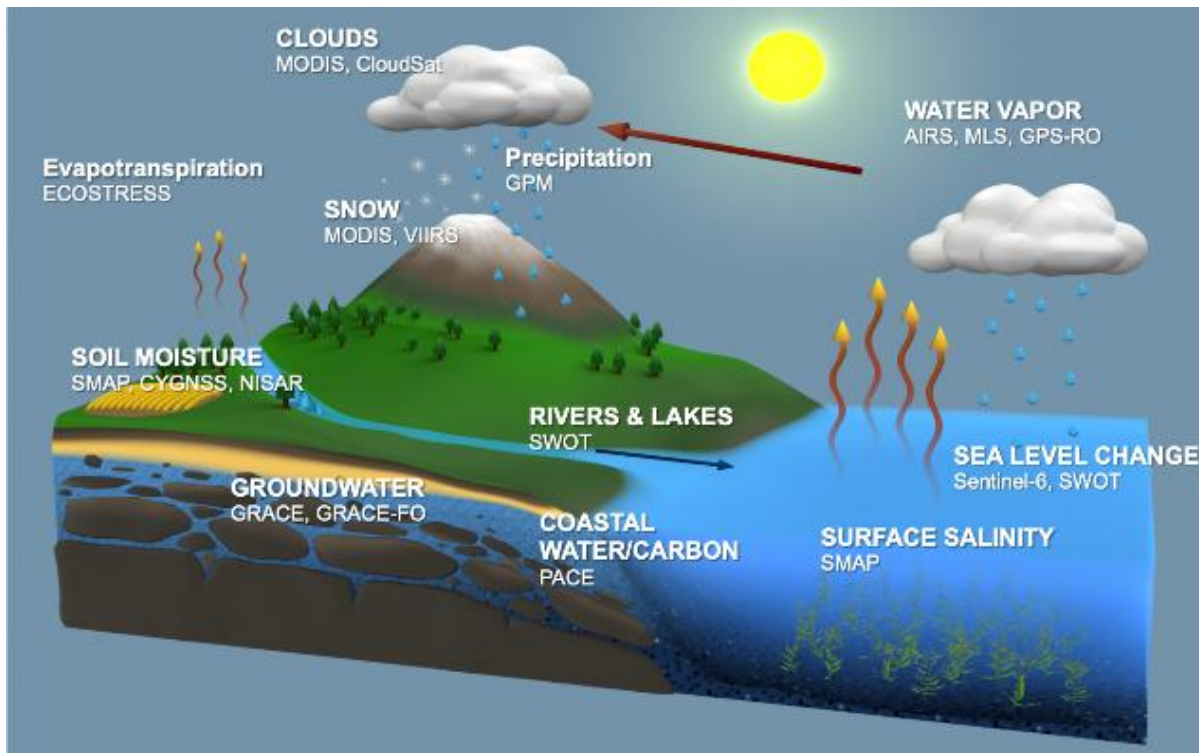


WRF-Hydro / Noah-MP

NASA Water Cycle Priorities



Community-sourced terrestrial hydrology science opportunities for NASA



A “Golden Age” of Terrestrial Water Cycle Observations

NASA has now provided at least one measurement of every major component of the water cycle. But...



NASA Water Cycle Priorities



The Aspen Global Change Institute (AGCI), along with NSF NCAR, NASA-JPL, and NASA-GSFC, led a 2-year NASA-funded effort that engaged nearly 400 contributors from across the field of Hydrology to identify community challenges, needs, and collective strategies to guide the next decade of NASA Terrestrial Hydrology research.

- **Aim of project:**

- Enhance Earth observations and terrestrial water cycle science by elevate what advances are most needed now
- Use this information to help guide ESAS 2028 Decadal Survey white papers

- **Approach:**

- Divide by topical areas (ie, droughts, floods, water quality, etc:) and expertise (ie, remote sensing, modeling, etc)
- Evaluate what we have, assess partnerships/opportunities, identify science priorities that advance space-based terrestrial water cycle monitoring
- (1) community survey, (2) topical working groups, (3) synthesis from core team: J. Vano, E. Jack-Scott, S. Kumar, JT Reager, T. Schneider

- **Outcome:**

- White papers for each topic recently submitted and published online

Crosscut (overview)



[10.69925/YEUT6918](https://doi.org/10.69925/YEUT6918)

Drought



[10.69925/XYOC6054](https://doi.org/10.69925/XYOC6054)

Floods



[10.69925/UBEA6800](https://doi.org/10.69925/UBEA6800)

Water Quality



[10.69925/WAXL4673](https://doi.org/10.69925/WAXL4673)

Water Supply



[10.69925/LCQU1962](https://doi.org/10.69925/LCQU1962)

Water Demand



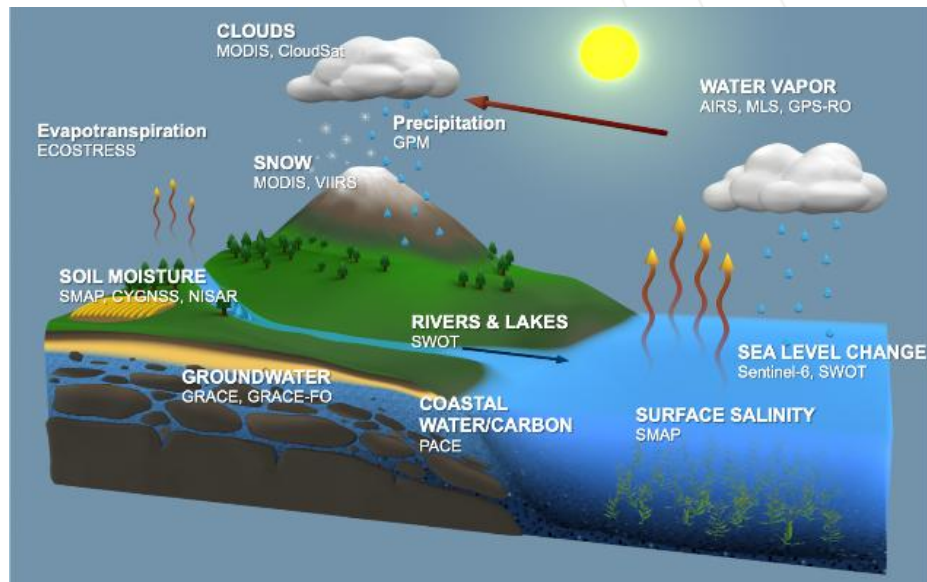
[10.69925/SJAN6565](https://doi.org/10.69925/SJAN6565)

Community-sourced terrestrial hydrology science opportunities for NASA

A “Golden Age” of Terrestrial Water Cycle Observations

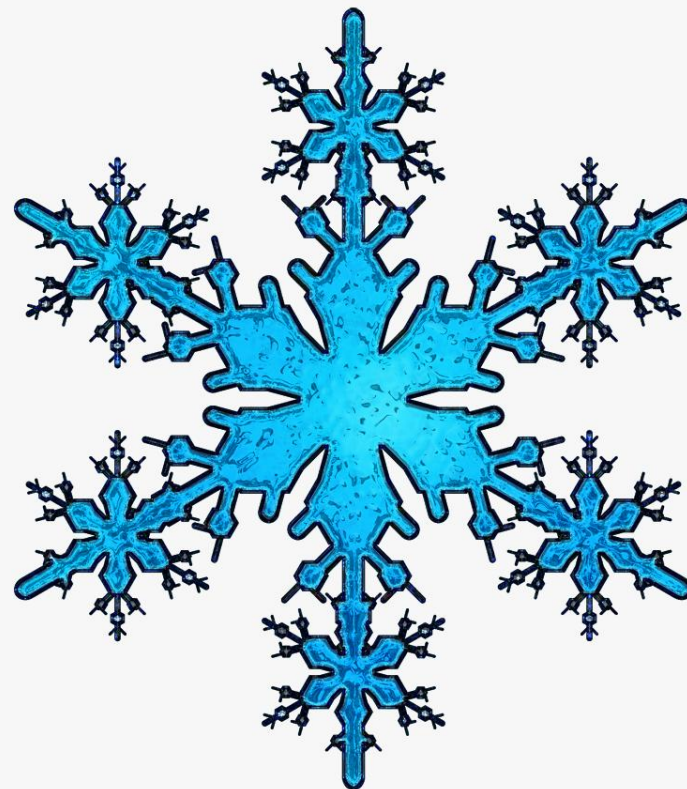
NASA has now provided at least one measurement of every major component of the water cycle. But...

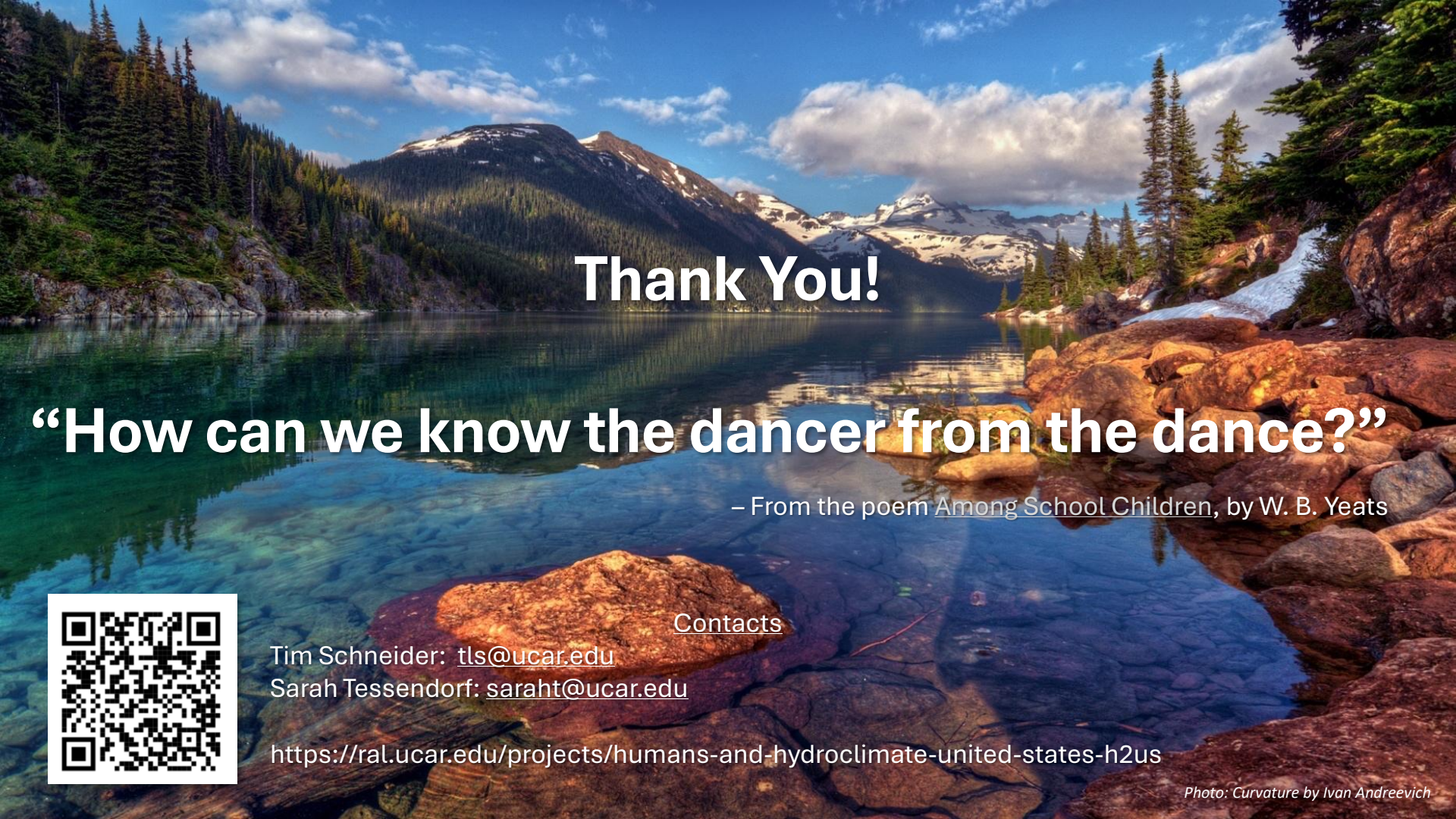
A community-led activity with 300+ responses, 5 white papers, and shared priority variables: SWE and higher spatio-temporal terrestrial water storage. Ensure user usability at beginning and not just as an afterthought.



Let's Discuss...

- What has worked well in INARCH?
- How do we coordinate?
 - Transboundary issues
 - North American Cordillera
 - Field Campaigns
 - Joint Workshops
- Common measurements & instrumentation
- Other...





Thank You!

“How can we know the dancer from the dance?”

– From the poem Among School Children, by W. B. Yeats

Contacts

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<https://ral.ucar.edu/projects/humans-and-hydroclimate-united-states-h2us>



Photo: Curvature by Ivan Andreevich