UFS forecast model evaluation and improvement for S2S hydrometeorological prediction in the Western United States

2024 NOAA S2S workshop

Andrew Newman[1], Andrew Bennett[2], Yifan Cheng[1], Kathryn Newman[1], Ethan Gutmann[1], Andrew Wood[1], and Arezoo RafieeiNassab[1]

[1]NSF NCAR, [2]Univ. Arizona

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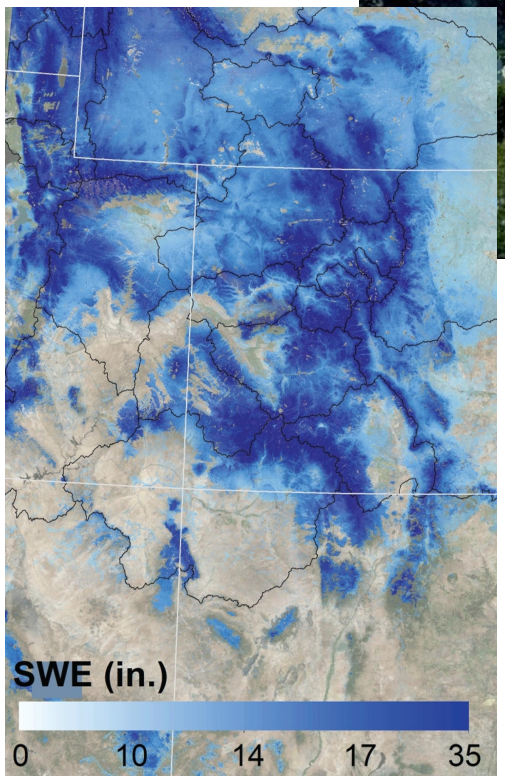
Outline

- Motivation
- Iterative Noah-MP testing
- Information theory diagnostics
- Initial progress
- Connections to other projects

Motivation

- Target - NOAA Unified Forecast System (UFS) Seasonal Forecast System (SFS) application
- Western US hydrometeorology subseasonal to seasonal (S2S) area
  - Streamflow, soil and snow states, precipitation
- S2S forecasts provide an opportunity to mitigate extreme events, improve resource allocation equity
- Intermountain west has hydrometeorological S2S predictability
  - Land initial conditions
  - Local land-atmosphere feedbacks



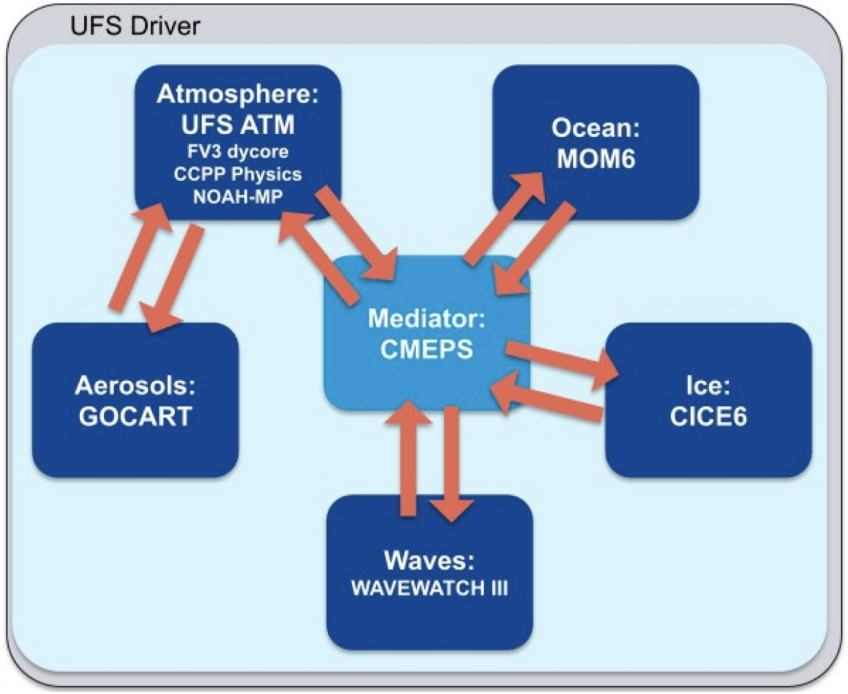
Above: Wind River Range, WY, photo from USFS, Scott Clemons

Left: Intermountain west SWE from Mountain Hydrology Group, Univ. Colorado-Boulder, Noah Molotch lead

Motivation

- Focus on Noah-MP and land-atmosphere coupling
- 2-5 week lead forecasts
- Explore formal Noah-MP optimization offline and within single column model
  - Rapid iteration of test configurations
- Novel evaluation using information theory
  - Explore causality and connectivity
- Provide potential Noah-MP updates to NCEP
- FY24-FY25 project

SFS Coupled System

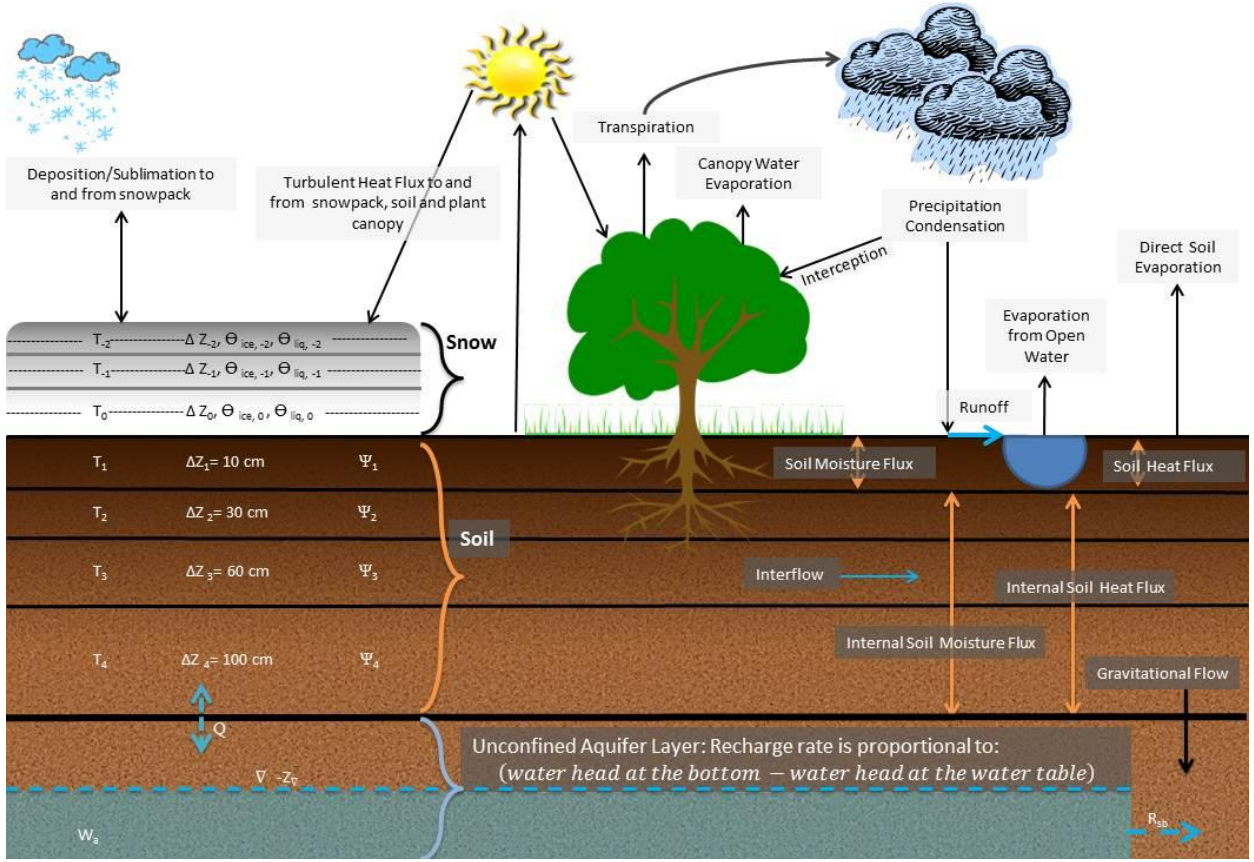


UFS
UNIFIED FORECAST SYSTEM

From UFS Website

Noah-MP Testing

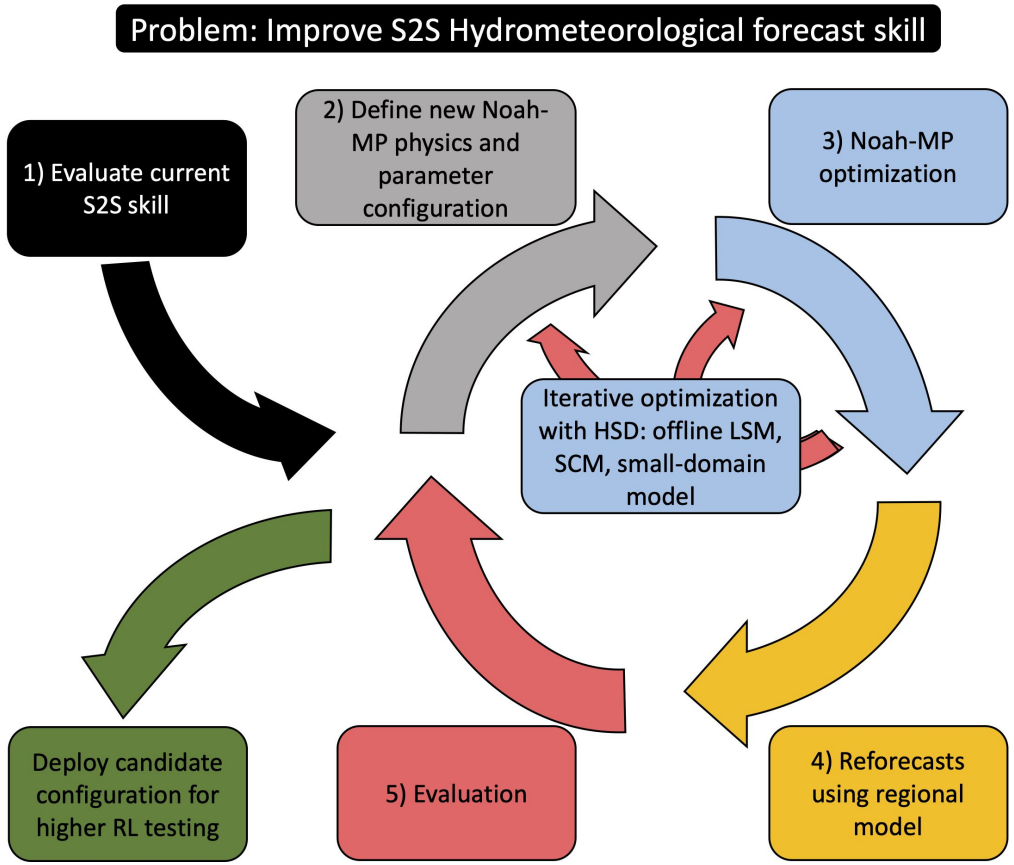
- Noah-MP is currently implemented in Global Forecast System (GFS)v17 prototypes
- Target LSM for future versions of multiple UFS applications
  - SFS for this project
- Noah-MP offers substantial process and parameterization upgrades over Noah
  - Widely utilized in the research community –> Research to Operations to Research (R2O2R) potential



From Noah-MP User's website, UT-Austin

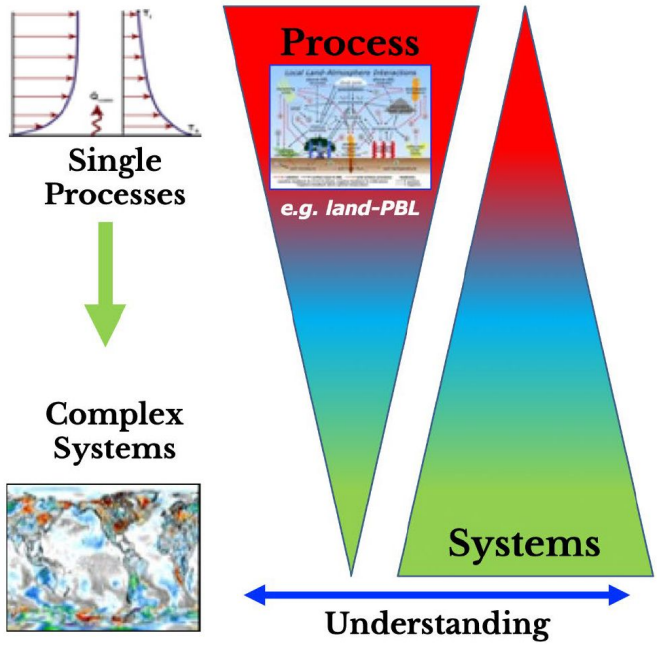
Noah-MP Testing

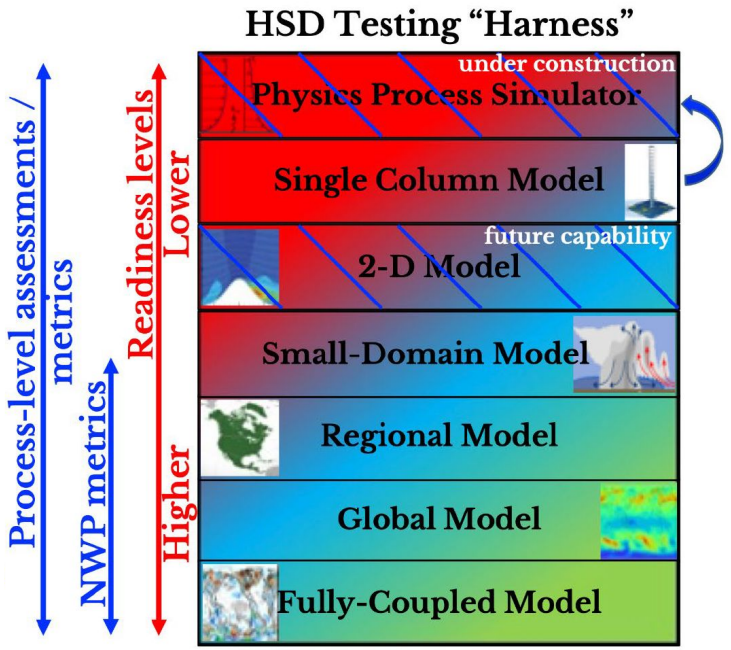
- Need to have methods and workflows to iteratively test and optimize complex component models
- Noah-MP has significantly more parameters and parameterizations than Noah
- **Outcome:** Develop community available methods and workflows for rapid hydrometeorological optimization and evaluation

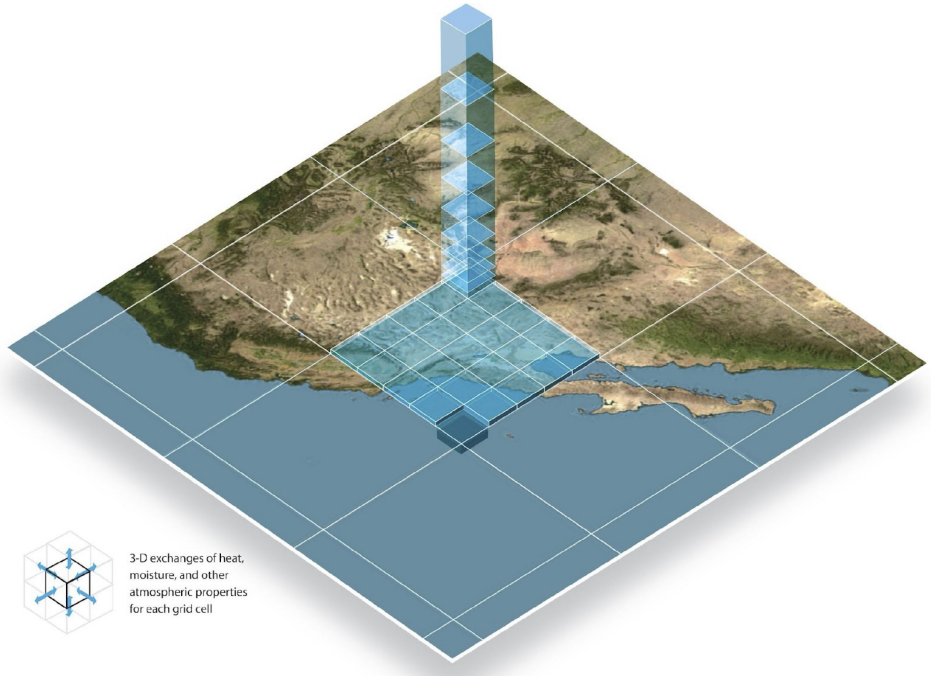


Noah-MP Testing

- Leverage concepts and capabilities within the NWP and UFS communities
  - Hierarchical System Development (lower left and center panels)
  - Offline, single column model (lower right panel), regional domain modeling
  - **Outcome:** Develop candidate Noah-MP configurations tested through regional modeling (RL 4-5)



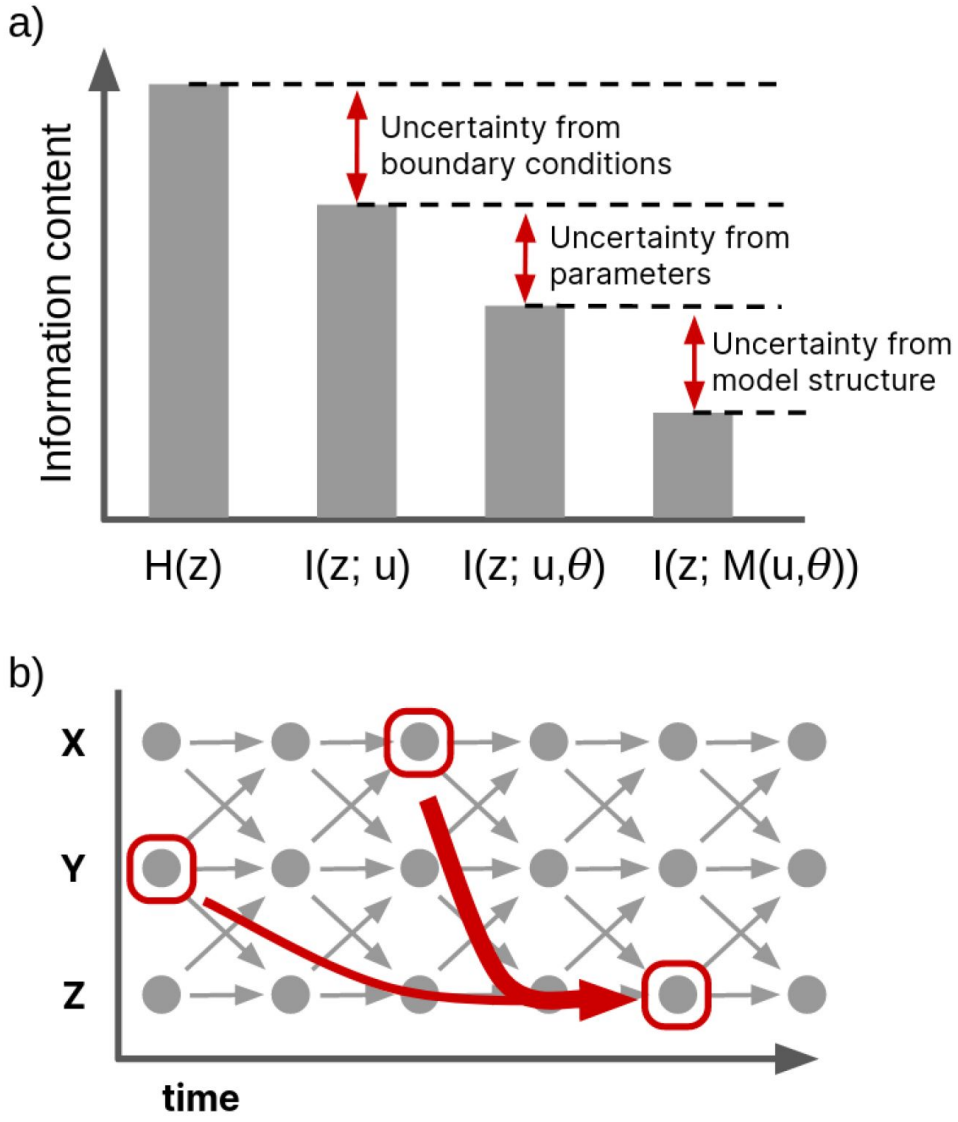




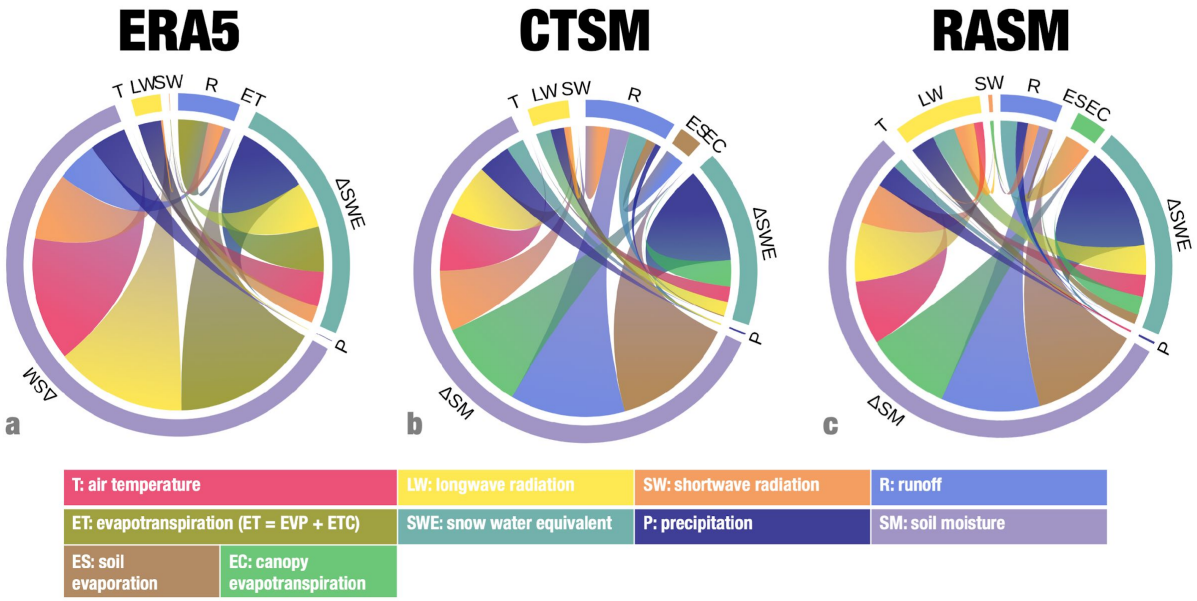
From Ek et al. (2022)

From L. Bernardet (NOAA)

Information Theory Diagnostics



- Information Theory (IT) provides statistical framework for deeper understanding of model biases and process behavior
  - Diagnose information content (left panel a)
  - Time-lagged process interactions (left panel b)
  - Flow of information (below)

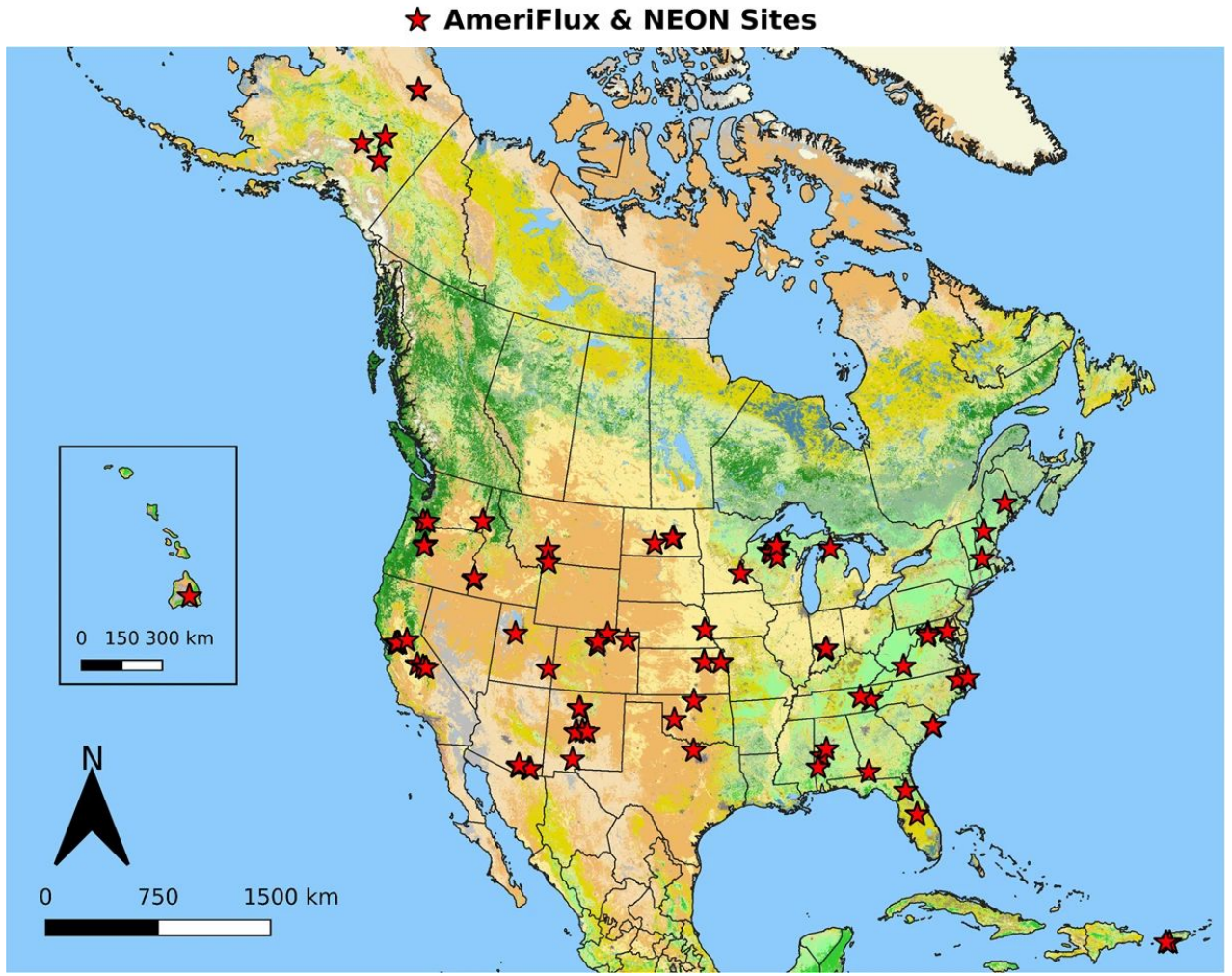


From Nearing et al. (2016)

From Cheng et al. (2024)

Initial Progress

- Compiling observational datasets for model verification, optimization, and initial IT diagnostic comparisons
- Building out computational infrastructure
- Selecting initial Noah-MP optimization sites for land-atmosphere interaction work
- Selecting initial watersheds for hydrologic optimization

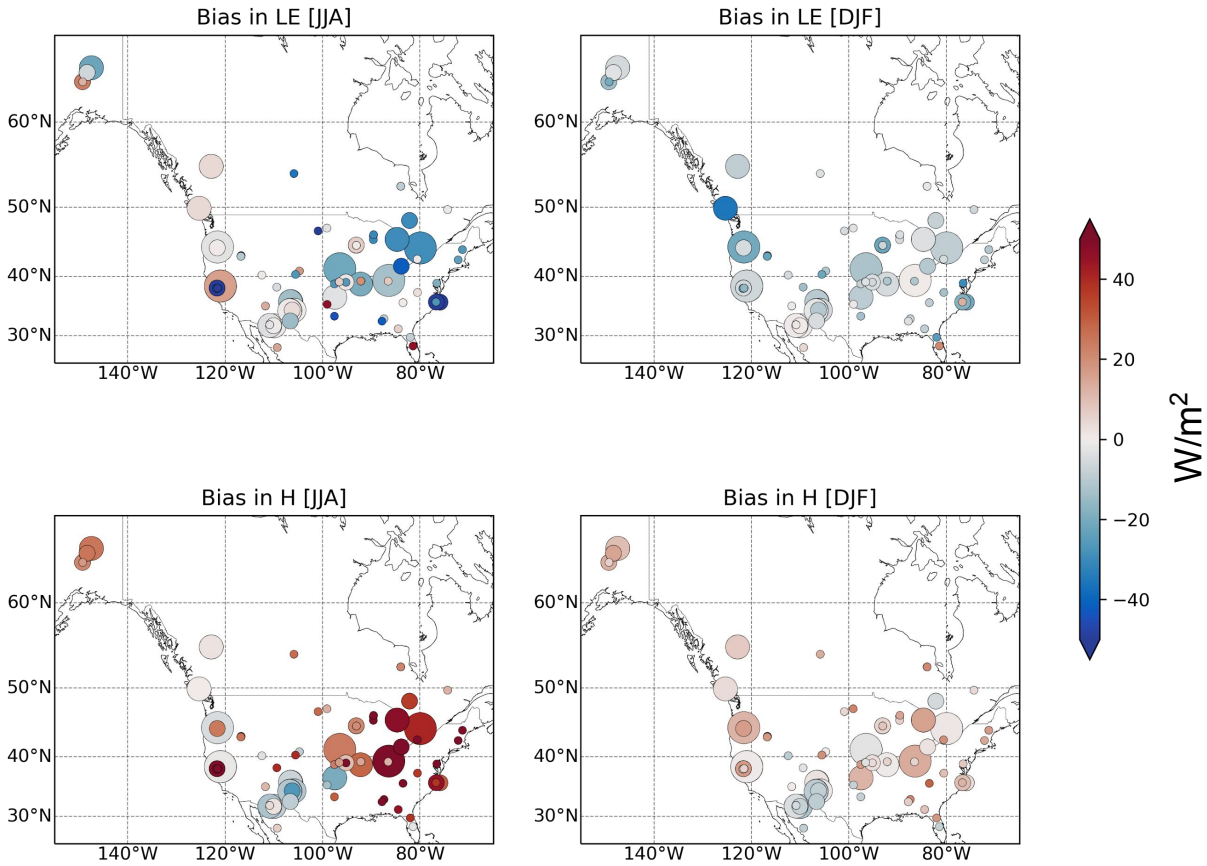


From Moon et al. 2022

Initial Progress

Point-scale experiments for Ameriflux sites

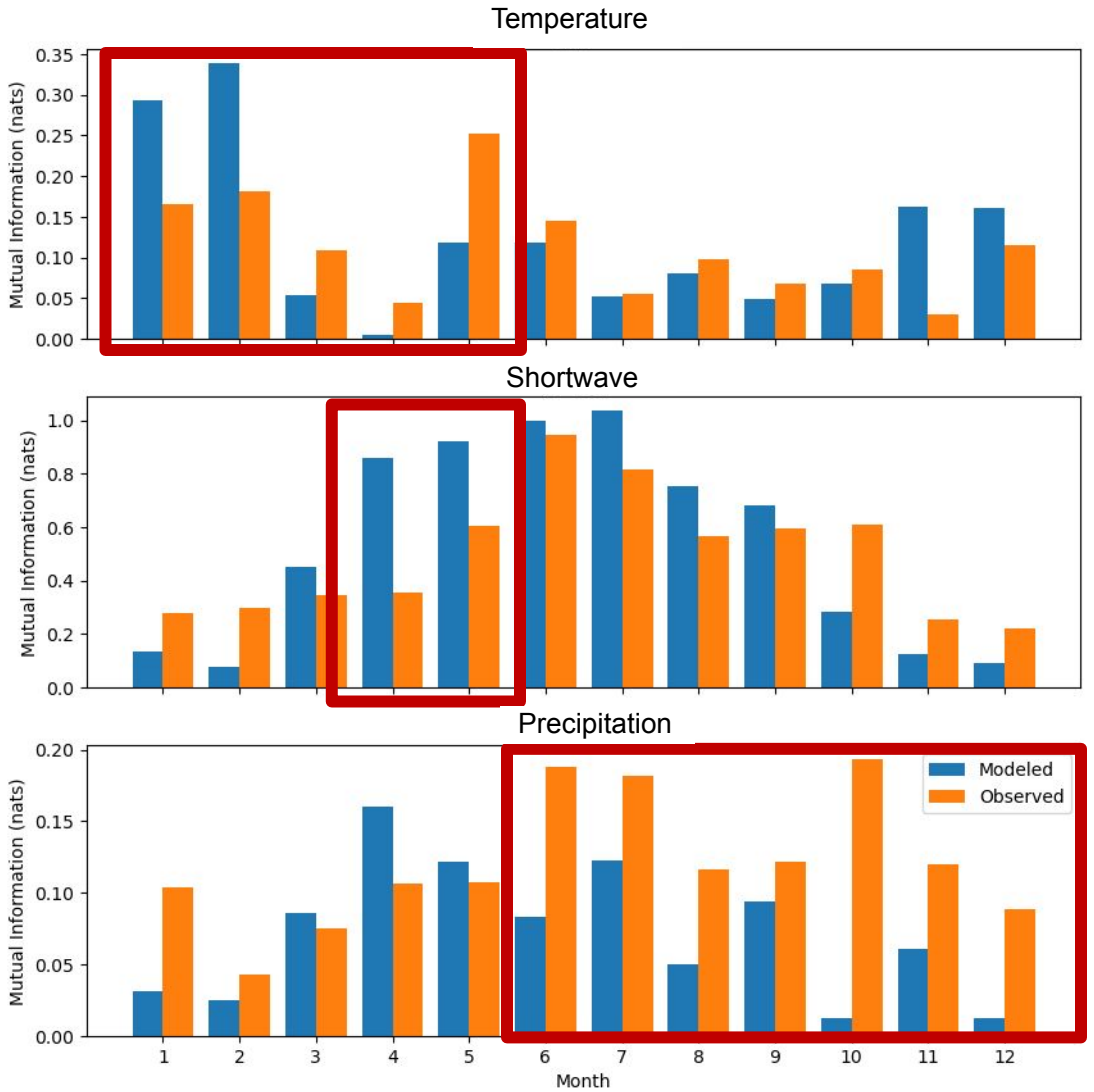
- 88 Ameriflux sites were selected
- Set up workflow for model spin-up for UFS-land-driver
- Conduct model runs for all selected sites
- Right plots show seasonal biases in latent heat fluxes (LE) and sensible heat fluxes (H)
- Developing community tools to easily modify Noah-MP parameters for parameter tuning work



Initial Progress – Process diagnostics

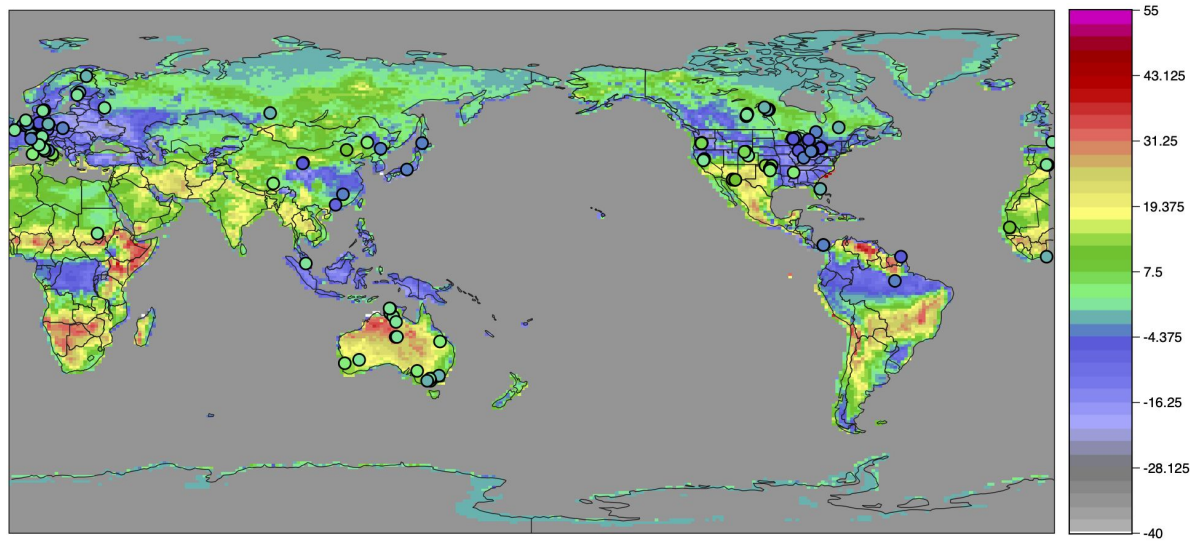
Initial workflows for process diagnostics underway

- Arid site test case: Walnut Gulch in Arizona
- IT analysis suggests errors driven by
  - energy balance in late winter/spring
  - Water balance in fall/early winter



Connections to other NOAA Land Oriented Projects

- A critical mass of NOAA projects examining Noah-MP and land-atmosphere coupling
- Connected to METplus land and land-atmosphere diagnostic development
- Other WPO S2S projects optimizing aspects of Noah-MP
  - Snow physics
  - Dynamic vegetation



METplus Land Projects — Add status update

List View | Table View | + New view

Filter by keyword or by field — Discard | Save

	Title	Repository	Milestone	Assignees	Status	Linked pull requ
	Ready 5 This item is ready but hasn't been started					
1	Enhance Terrestrial Coupling Index (TCI) METplus Use Case #2388	dtcenter/METplus	METplus-6.0.0	anewman89, ...	Ready	
2	Convective Triggering Potential - Humidity Index #2390	dtcenter/METplus	METplus-6.0.0	anewman89, ...	Ready	
3	Enhance ASCII2NC wrapper as needed to support the development of an ISMN use case #2447	dtcenter/METplus	METplus-6.0.0	anewman89 a...	Ready	
4	Document the recommend used of ISMN data in the Verification Datasets Guide #2448	dtcenter/METplus	METplus-6.0.0	anewman89	Ready	
5	Add new Python functionality to convert MET netcdf observation data to a Pandas DataF... #2781	dtcenter/MET	MET 12.0.0	DanielAdriaan...	Ready	
+	Add item					
	Done 2 This item has been completed					
6	Enhance ASCII2NC to read ISMN point observations of soil moisture and temperature #2701	dtcenter/MET	MET 12.0.0	anewman89 a...	Done	#2758
7	Feature #2701 ismn #2758	dtcenter/MET	MET 12.0.0		Done	
+	Add item					

Summary

- Develop community available methods and workflows for rapid hydrometeorological optimization and evaluation
- Develop candidate Noah-MP configurations tested from offline land model through regional land-atmosphere coupled model (~RL 4-5)
- Develop improved process and model behavioral understanding using IT
- Connect to METplus land and land-atmosphere diagnostic developments
- Connect to other NOAA land efforts across applications where relevant