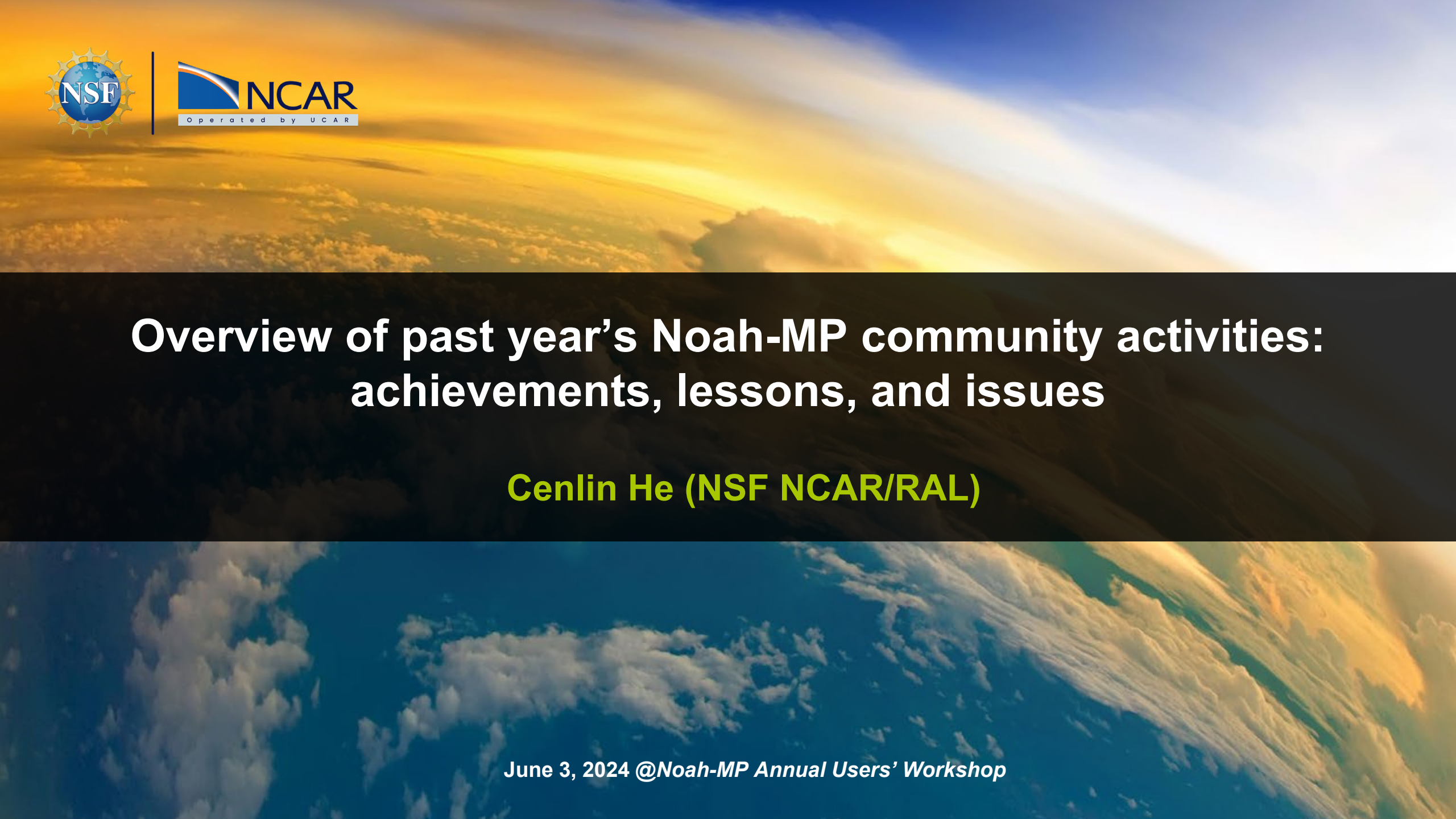


Overview of past year's Noah-MP community activities: achievements, lessons, and issues

Cenlin He (NSF NCAR/RAL)

June 3, 2024 @*Noah-MP Annual Users' Workshop*

Noah-MP name trademark and logo

United States of America
United States Patent and Trademark Office

Noah-MP

The name of **Noah-MP** (and its variants) has been officially trademarked, thanks to Tim Schneider's enormous efforts in working with the UCAR law office.

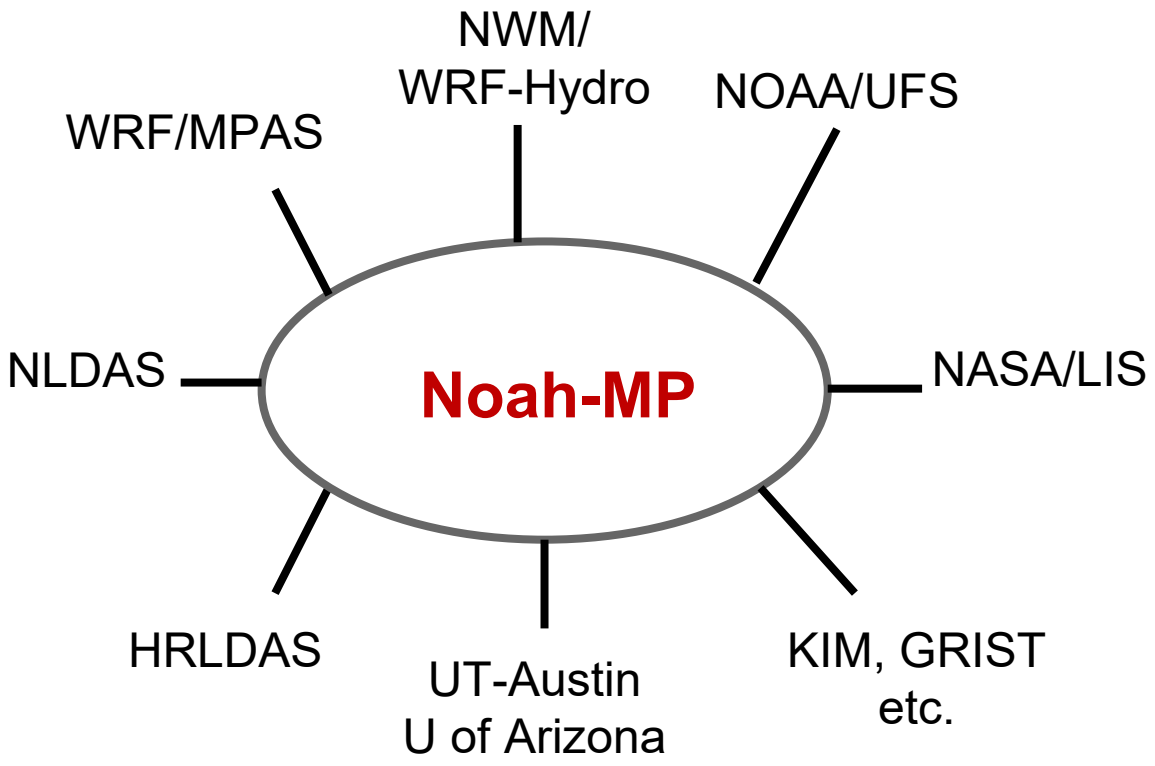
The Noah-MP logo was originally designed by Prasanth Valayamkunnath (IISERTVM, India).

The logo meaning:

Color Represents: Soil, Water, Vegetation, and Energy

Four big circles "**C**": **C**ommunity, **C**ollaborative, **C**omprehensive, **C**utting-edge

Noah-MP widely-used in various research and operational modeling systems



Noah-MP community GitHub:

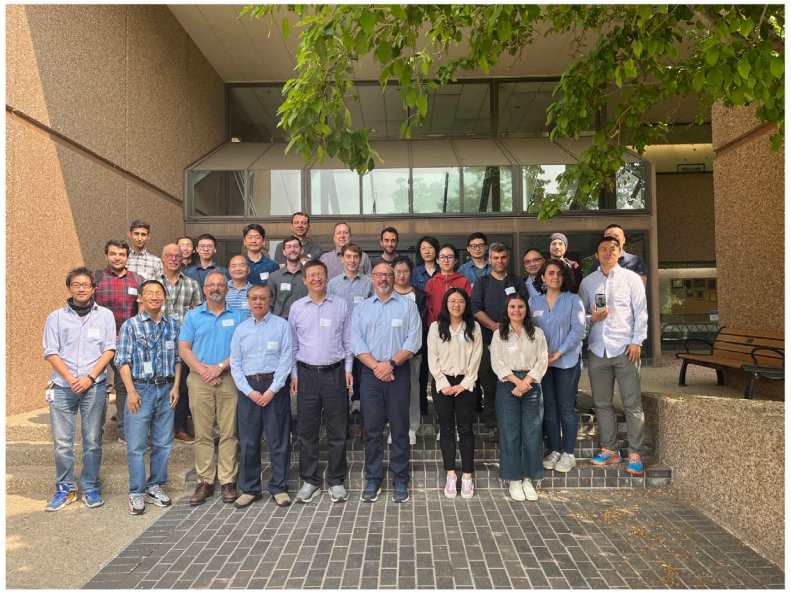
https://github.com/NCAR/noahmp

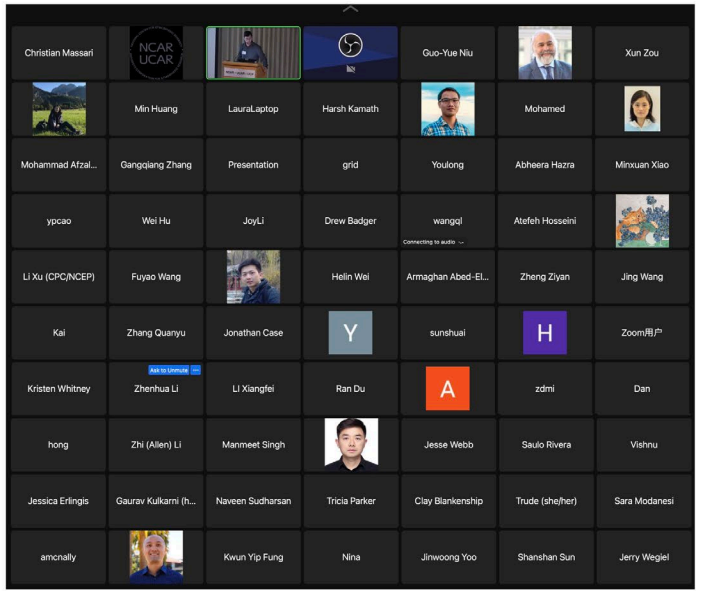
Scientific Applications

Groundwater and terrestrial water storage
Plant hydraulics/root water uptake
Prognostic vegetation growth and canopy processes
Urban
Biogeochemical cycle (e.g., carbon-nitrogen coupling, air pollution, biogenic emissions)
Climate/weather extremes (e.g, fire, drought, heatwave, flood, etc.)
Subseasonal-to-seasonal (S2S) predictions
Agriculture
Land data assimilation
Soil moisture
Snowpack and water resources
Land-atmosphere interaction and coupling
Model diagnostics and new capabilities
Land use land cover change

Recap from 2023 Noah-MP Annual Users' Workshop

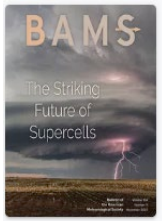
Workshop materials are available at: https://ral.ucar.edu/events/2023/noah-mp-annual-users-workshop





Noah-MP Workshop Attendee Distribution

Workshop Summary BAMS paper: https://doi.org/10.1175/BAMS-D-23-0249.1



Enhancing the Community Noah-MP Land Model Capabilities for Earth Sciences and Applications

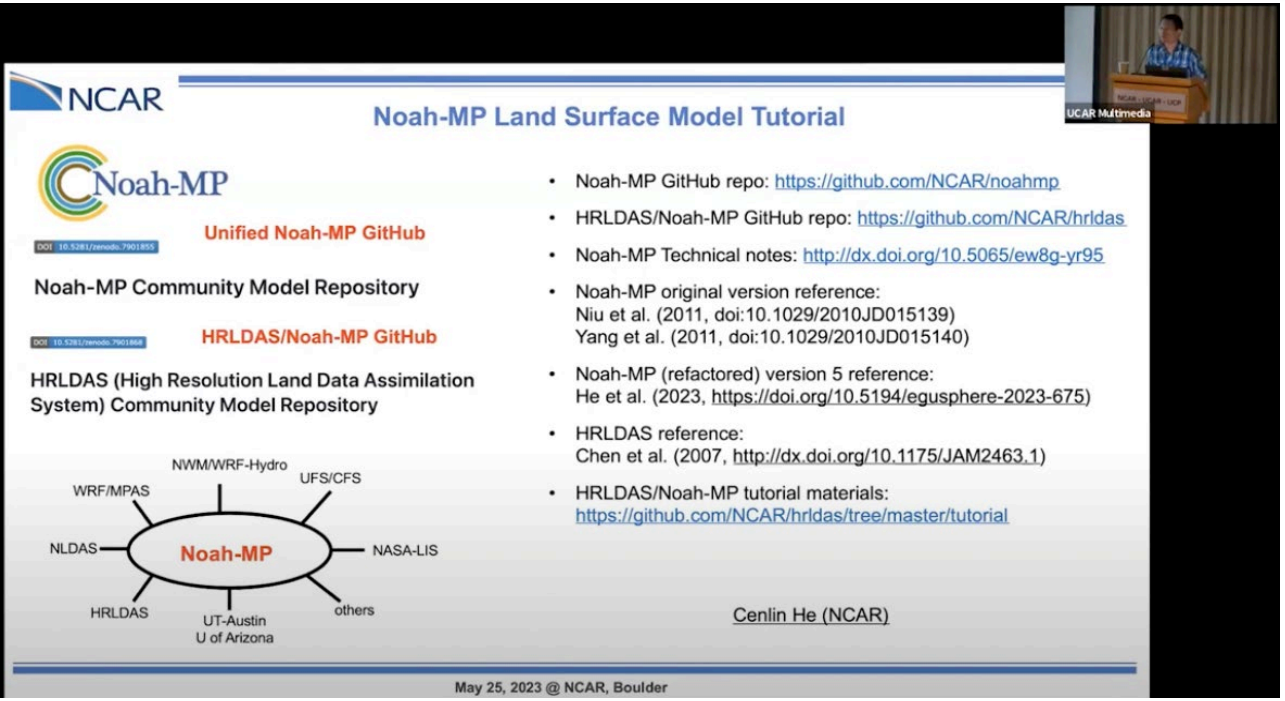
Cenlin He, Fei Chen, Michael Barlage, Zong-Liang Yang, Jerry W. Wegiel, Guo-Yue Niu, David Gochis, David M. Mocko, Ronnie Abolafia-Rosenzweig, Zhe Zhang, Tzu-Shun Lin, Prasanth Valayamkunnath, Michael Ek, and Dev Niyogi

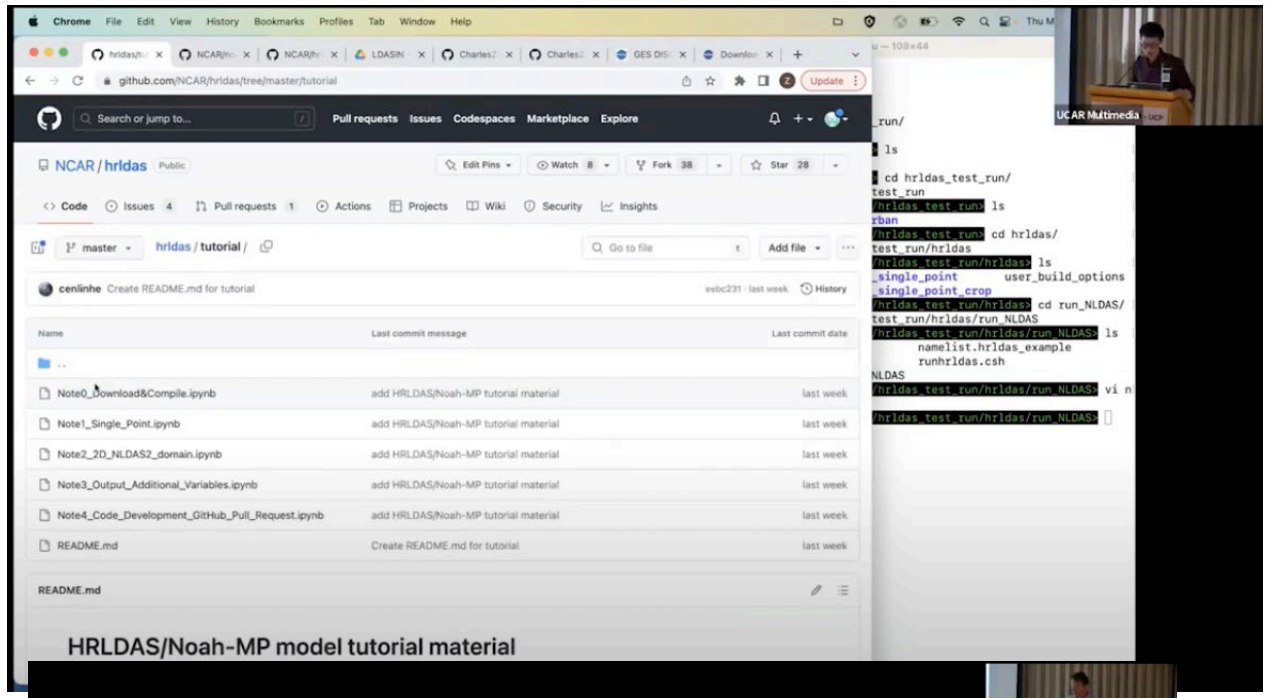
Future Priorities:

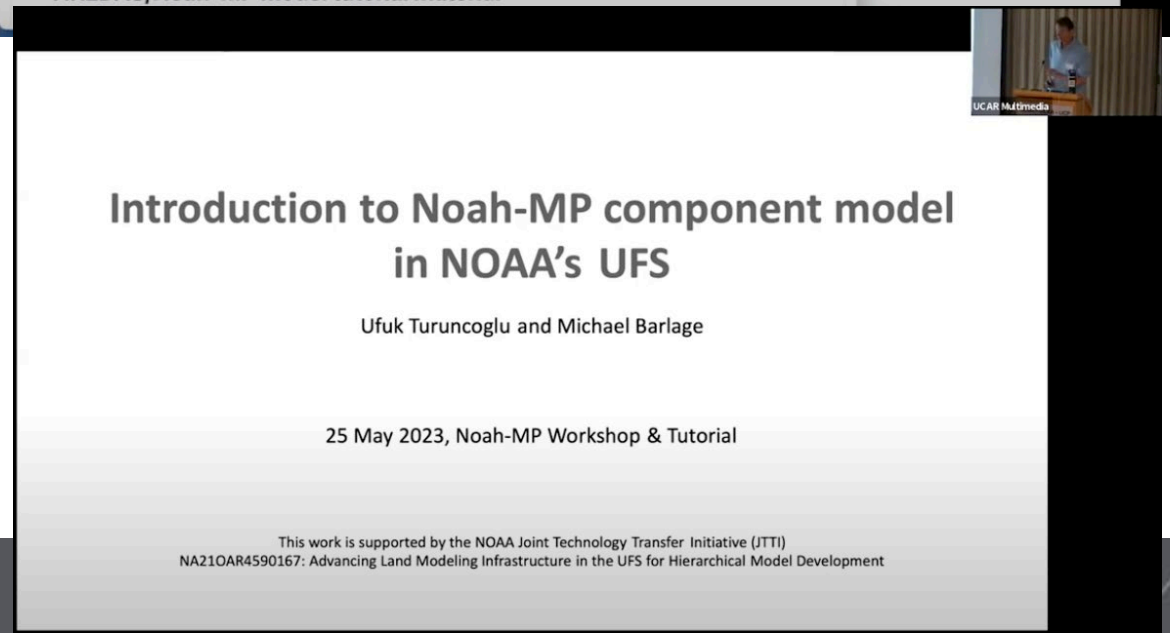
1) **Advance land DA modeling framework**
2) **Improve physics in S2S predictions particularly for hydroclimate extremes**
3) **Enhance anthropogenic processes (agriculture & LULCC) in model**
4) **Establish Noah-MP Academia Collaboratory**

Noah-MP tutorial and training

First Noah-MP Tutorial (May 25, 2023 @NSF NCAR)







Tutorial delivered by
Cenlin He, Zhe Zhang, and Ufuk Turuncoglu

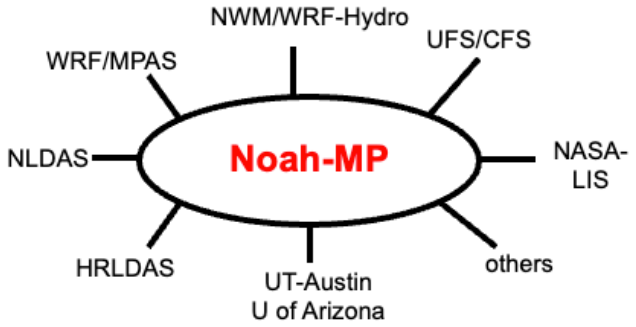
USGS Training: Noah-MP Tutorial (Sept 27, 2023)

Training delivered by Cenlin He and Fei Chen via the USGS-NCAR collaborative CONUS404 project

Noah-MP®

DOI 10.5281/zenodo.7901855

Noah-MP® Community



Refactored Noah-MP (version 5.0), released in March 2023

Geosci. Model Dev., 16, 5131–5151, 2023
https://doi.org/10.5194/gmd-16-5131-2023

Geoscientific Model Development
Open Access
EGU

Modernizing the open-source community Noah with multi-parameterization options (Noah-MP) land surface model (version 5.0) with enhanced modularity, interoperability, and applicability

Cenlin He[1], Prasanth Valayamkunnath[1,5], Michael Barlage[2], Fei Chen[1], David Gochis[1], Ryan Cabell[1], Tim Schneider[1], Roy Rasmussen[1], Guo-Yue Niu[3], Zong-Liang Yang[4], Dev Niyogi[4], and Michael Ek[1]

Technical documentation, released in 2023

The Community Noah-MP Land Surface Modeling System Technical Description Version 5.0

Cenlin He
Prasanth Valayamkunnath
Michael Barlage
Fei Chen
David Gochis
Ryan Cabell
Tim Schneider
Roy Rasmussen
Guo-Yue Niu
Zong-Liang Yang
Dev Niyogi
Michael Ek

NCAR Technical Notes
NCAR/TN-575+STR

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Boulder, Colorado
80307-3000
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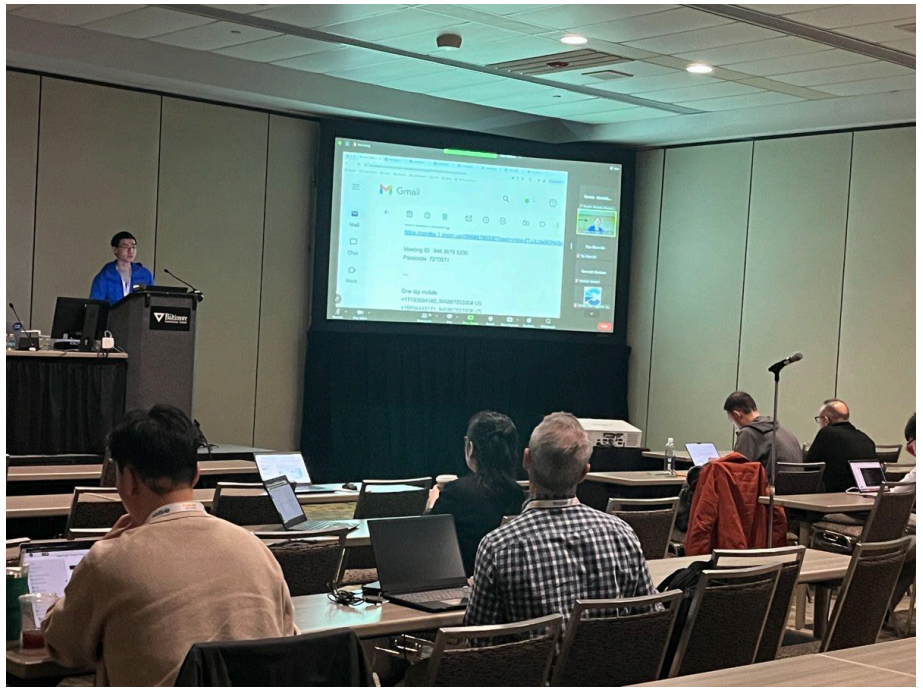
National Science Foundation

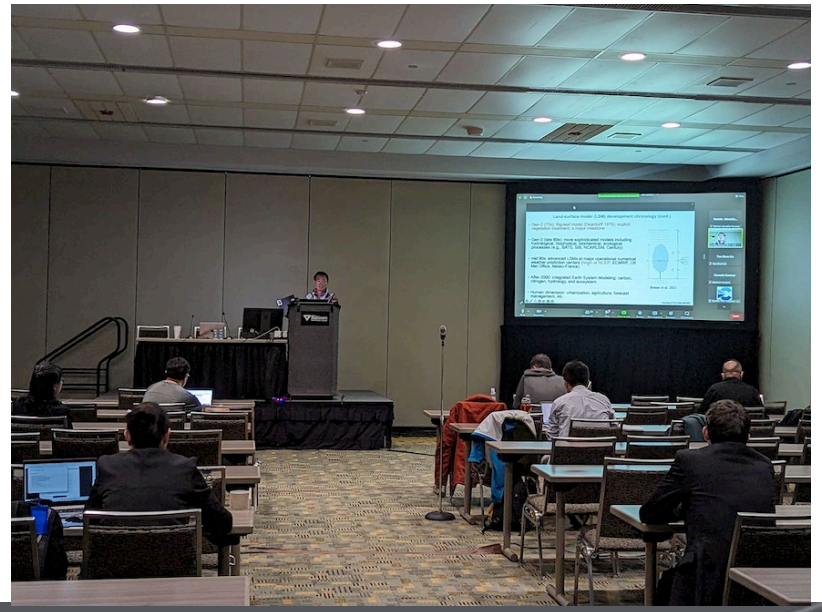
2024 AMS Noah-MP short-course (hybrid) (Jan 27, 2024)

AMERICAN METEOROLOGICAL SOCIETY
104TH ANNUAL MEETING
28 JANUARY-1 FEBRUARY 2024
BALTIMORE, MD & ONLINE

Session - Noah-MP Land Surface Model Tutorial: Model Physics, Code Structures, and Simulation Exercises (Hybrid)

Saturday, January 27, 2024
1:30 PM - 5:30 PM
316 (The Baltimore Convention Center)





Short course delivered by
Cenlin He
Zhe Zhang
Ufuk Turuncoglu

Future plans for Noah-MP training/tutorial/course

1. Make it an annual event (at least once a year)

2. Design tutorials for various difficulty levels (e.g., focused topics, specialized tools, etc.)

3. Invite more Noah-MP experts to teach at tutorials based on their specialty (volunteers are very welcome! Please email me if you are interested).

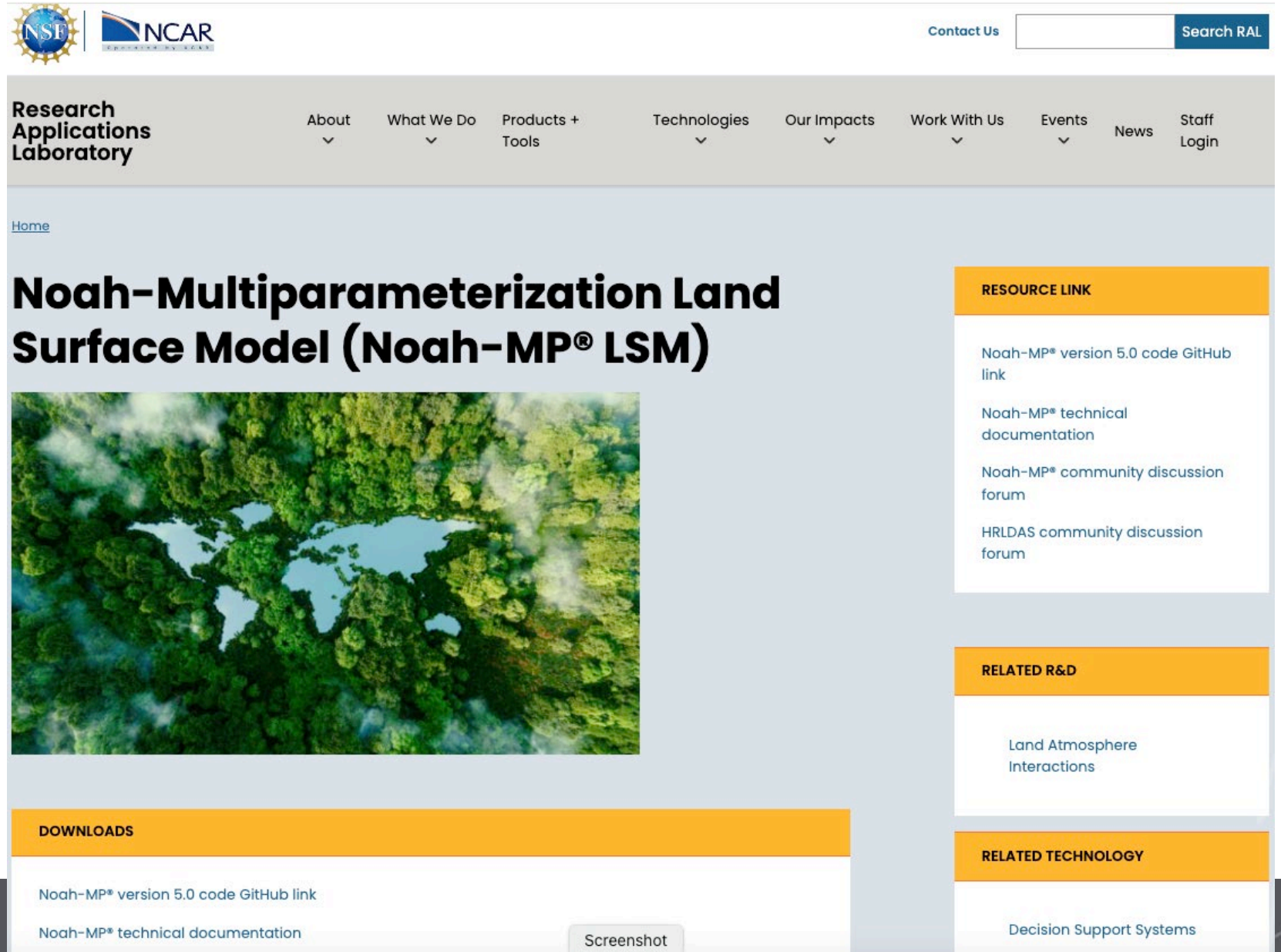
4. Different groups are welcome to organize their own training/tutorial events to expand the Noah-MP user community.

Any suggestions to improve Noah-MP tutorial are welcome!

Noah-MP model resources

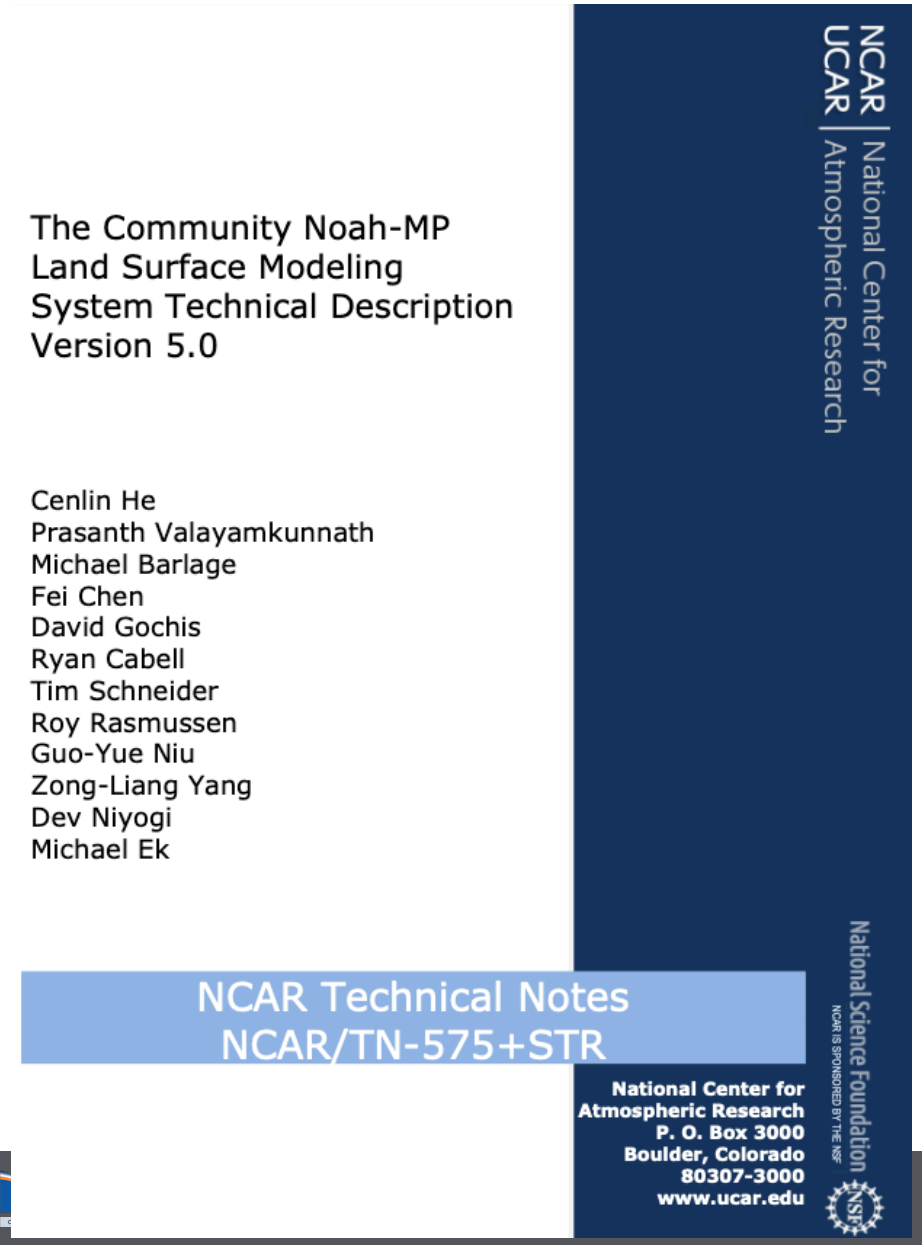
New look for Noah-MP model website

https://ral.ucar.edu/model/noah-multiparameterization-land-surface-model-noah-mp-lsm



Noah-MP Technote

http://dx.doi.org/10.5065/ew8g-yr95



The Community Noah-MP Land Surface Modeling System Technical Description Version 5.0

Cenlin He
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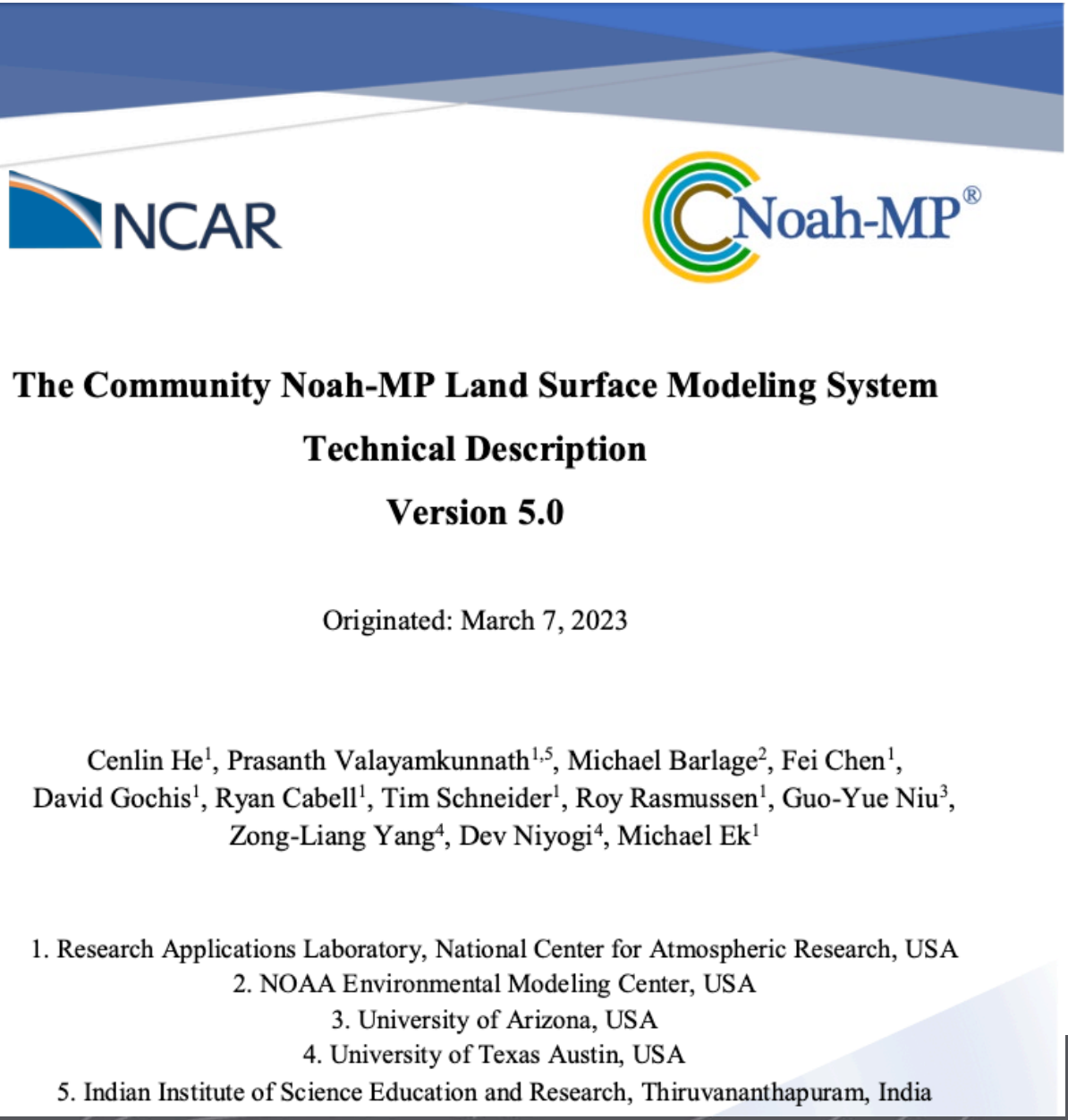


NCAR

Noah-MP®

The Community Noah-MP Land Surface Modeling System

Technical Description

Version 5.0

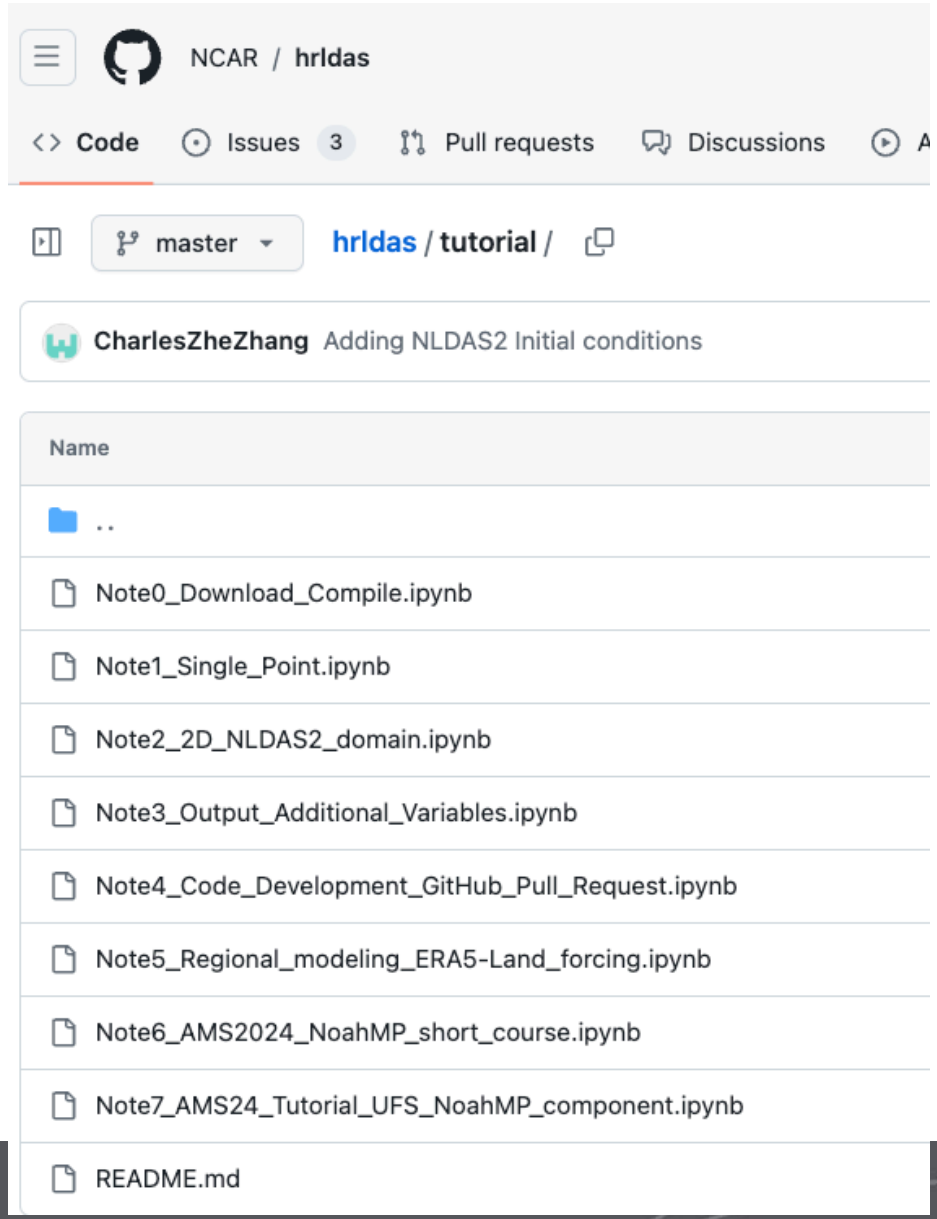
Originated: March 7, 2023

Cenlin He[1], Prasanth Valayamkunnath[1,5], Michael Barlage[2], Fei Chen[1], David Gochis[1], Ryan Cabell[1], Tim Schneider[1], Roy Rasmussen[1], Guo-Yue Niu[3], Zong-Liang Yang[4], Dev Niyogi[4], Michael Ek[1]

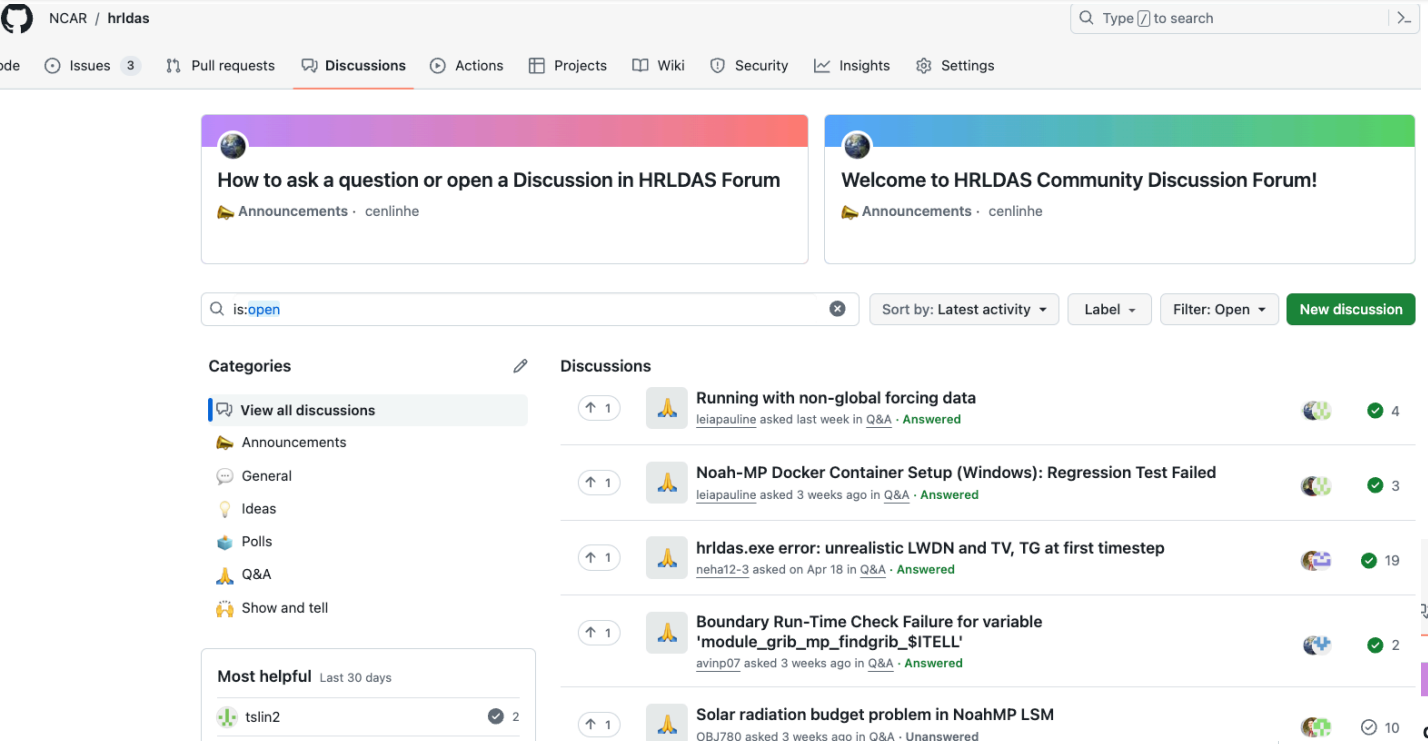
1. Research Applications Laboratory, National Center for Atmospheric Research, USA
2. NOAA Environmental Modeling Center, USA
3. University of Arizona, USA
4. University of Texas Austin, USA
5. Indian Institute of Science Education and Research, Thiruvananthapuram, India

Noah-MP GitHub Materials

https://github.com/NCAR/hrldas/tree/master/tutorial

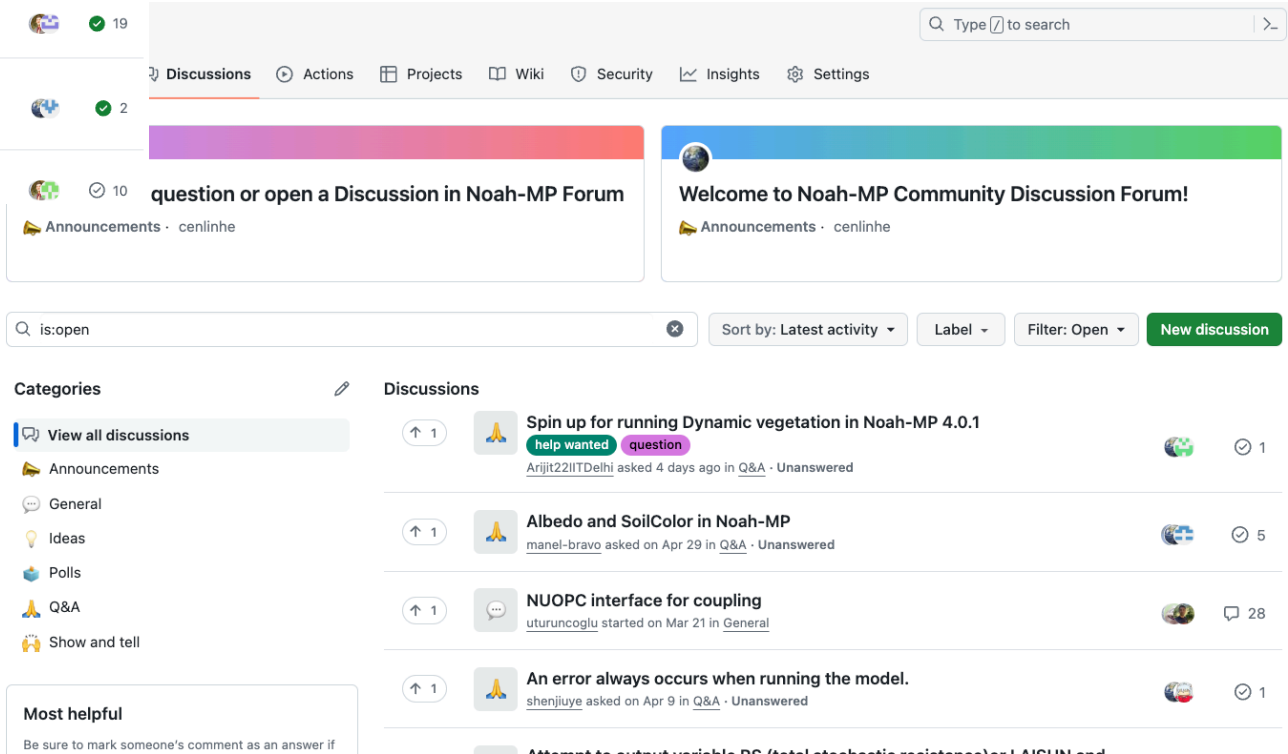


Noah-MP GitHub Discussion Forum



HRLDAS: 186 discussion threads as of June 1, 2024

https://github.com/NCAR/hrldas/discussions



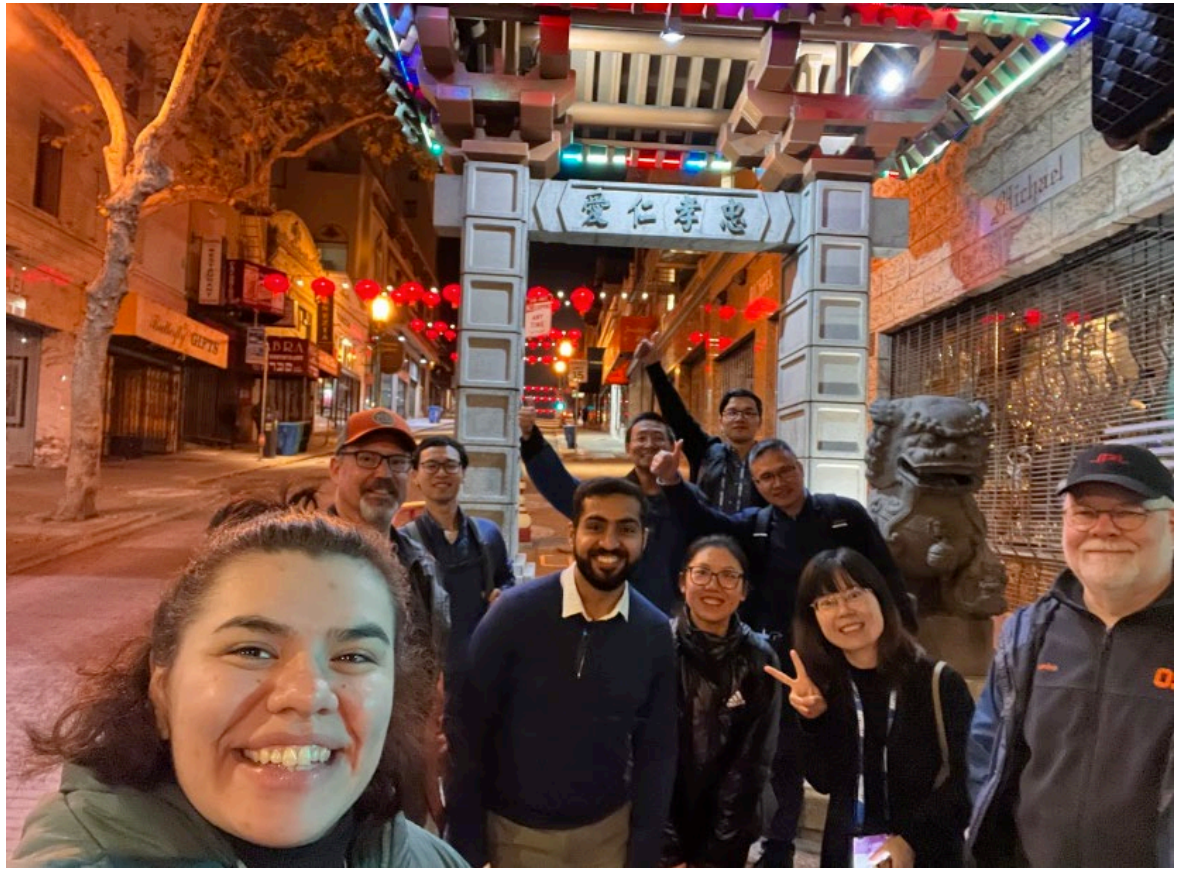
Noah-MP: 132 discussion threads as of June 1, 2024

https://github.com/NCAR/noahmp/discussions

Other Noah-MP community updates

Noah-MP community AGU get-together

Dec 2023, San Francisco, CA



Noah-MP committee formed

- **Noah-MP code review committee:**
- Role: review, approve, and answer model code issues and updates
- Current members: Cenlin He, Tzu-Shun Lin, Prasanth Valayamkunnath, Michael Barlage, David Mocko, Ronnie Abolafia-Rosenzweig, Guo-Yue Niu, Zhe Zhang, Yanjun Gan, Lingcheng Li, Zhao Yang, Ming Chang, Myung-Seo Koo, Carolina Bieri, Weizhong Zheng, Ehud Strbach, Min Huang, Huilin Huang, Van Doan, Lingbo Xue

- **Noah-MP strategic planning committee:**
- Role: guide future directions, coordinate community efforts, seek for resources, interacting with external communities
- Current members: Cenlin He, Fei Chen, Michael Barlage, Jerry Wiegel, Zong-Liang Yang, Dev Niyogi, Guo-Yue Niu, David Mocko, Myung-Seo Koo, Prasanth Valayamkunnath, Xuemei Wang, Gonzalo Miguez-Macho

We had one committee meeting in the past few months for each committee.

Noah-MP model updates

Current community Noah-MP physics capabilities

- **Canopy process**: rain/snow interception, radiative transfer, stomatal resistance, turbulence, evapo./sublime./melt/freeze, heat storage change, etc.
- **Snow process**: rain-snow partition, canopy interception, compaction, layer combination/division, melt/freeze/sublim/frost, sensible & latent heat, ground heat, radiation, temperature change, etc.
- **Soil process**: evapo/sublim/dew/frost/melt/freeze, supercooled water, infiltration, soil hydraulics, surface/subsurface runoff, radiation, sensible & latent heat, ground heat, temperature change, etc.
- Different main Noah-MP process and **soil process timesteps**
- **Groundwater process**: recharge/discharge, lateral flow, baseflow, aquifer storage change
- **Dynamic vegetation and crop growth**: key carbon processes
- **Tile drainage** schemes
- **Dynamic irrigation** processes
- Bulk urban treatment and coupling with external **urban canopy model**

Highlights: modeling anthropogenic processes (urban and agriculture)!

Other Noah-MP physics that are currently not in the community version

(1) nitrogen dynamics (Cai et al., 2016);

(2) new plant hydraulics (Li et al., 2021);

(3) dynamic root optimization (Wang et al. 2018) with an explicit representation of plant water storage (Niu et al., 2020);

(4) dynamic root growth scheme (Bieri et al., 2024);

(5) coupling with a wind erosion model (Jiang et al., 2021);

(6) a wetland representation and dynamics (Z. Zhang et al., 2022);

(7) a unified turbulence parameterization throughout the canopy and roughness sublayer (Abolafia-Rosenzweig et al., 2021);

(8) coupling with a snow radiative transfer (SNICAR) model (Tzu-Shun Lin et al., 2024);

(9) an organic soil layer representation at forest floors (Chen et al., 2016) and a microbial-explicit soil organic carbon decomposition model (MESDM; X. Zhang et al., 2022b);

(10) coupling with atmospheric dry deposition of air pollutant (Chang et al., 2022);

(11) enhanced permafrost soil representations (X. Li et al., 2020);

(12) spring wheat crop dynamics (Zhang et al., 2023);

(13) the Gecros crop model (Ingwersen et al., 2018; Warrach-Sagi et al., 2022);

(14) a 1-D dual-permeability flow model (based on the mixed-form Richards' equation) representing preferential flow through variably-saturated soil with surface ponding (University of Arizona);

(15) Mosaic subgrid treatment with urban hydrology (Alexander et al., 2024).

Latest Noah-MP version5 coupling in weather and climate models

- Coupling with **NASA/LIS** (completed, to be released soon; led by Cenlin He and LIS team)
- Coupling with **MPAS** (completed, to be released soon; led by Laura Fowler w/ help from Cenlin He)
- Coupling with **UFS** (on-going as a component model; led by Ufuk Turuncoglu w/ help from Cenlin He)
- Coupling with **WRF-Hydro** (on-going; led by Soren Rasmussen and WRF-Hydro team)
- Coupling with **WRF** (planned; led by Cenlin He and WRF team)
- Coupling with **Korean Integrated Model** (KIM) (completed; led by Myung-Seo Koo)
- Coupling with **FastEddy®** (GPU-based LES) (started; led by FastEddy® team w/ help from Cenlin He)

HRLDAS/Noah-MP preprocessor update for ERA5-Land data

- HRLDAS/Noah-MP ERA5-Land Pre-processor (HRLDAS_forcing) updated with tutorial: https://github.com/NCAR/hrldas/blob/master/tutorial/Note5_Regional_modeling_ERA5-Land_forcing.ipynb
- The new preprocessor is much more computational efficient.
- A great example of community collaboration and contribution:

master | hrldas / hrldas / docs / README.ERA5 | Go to file

CharlesZheZhang Update documentation regarding soil thickness 51f34fa · 8 mont

Code | Blame | 241 lines (159 loc) · 12.1 KB | Raw

```
1
2   Steps for running a HRLDAS simulation using ERA5-Land for forcing.
3
4   UPDATES in 2023-10-23, with contribution from Dr. Stefano Serafin (University of Vienna);
5   Dr. Allesandro Anav (alessandro.anav@enea.it) from Italian National Agency for New Technologies, Energy and Sustainable Economic Development;
6   Dr. Ehsan Jalilvand (ehsanj@msu.edu) from Michigan State University;
7   Dr. Tzu-Shun Lin (tslin2@ucar.edu) and Dr. Zhe Zhang (zhezhang@ucar.edu) from NCAR.
```

HRLDAS/Noah-MP Docker Container

- **Allow running Noah-MP in local machine with all environments setup included in the docker container**

  https://hub.docker.com/r/cenlinhe/noahmp_container/tags

- **How to set up Noah-MP docker container:**

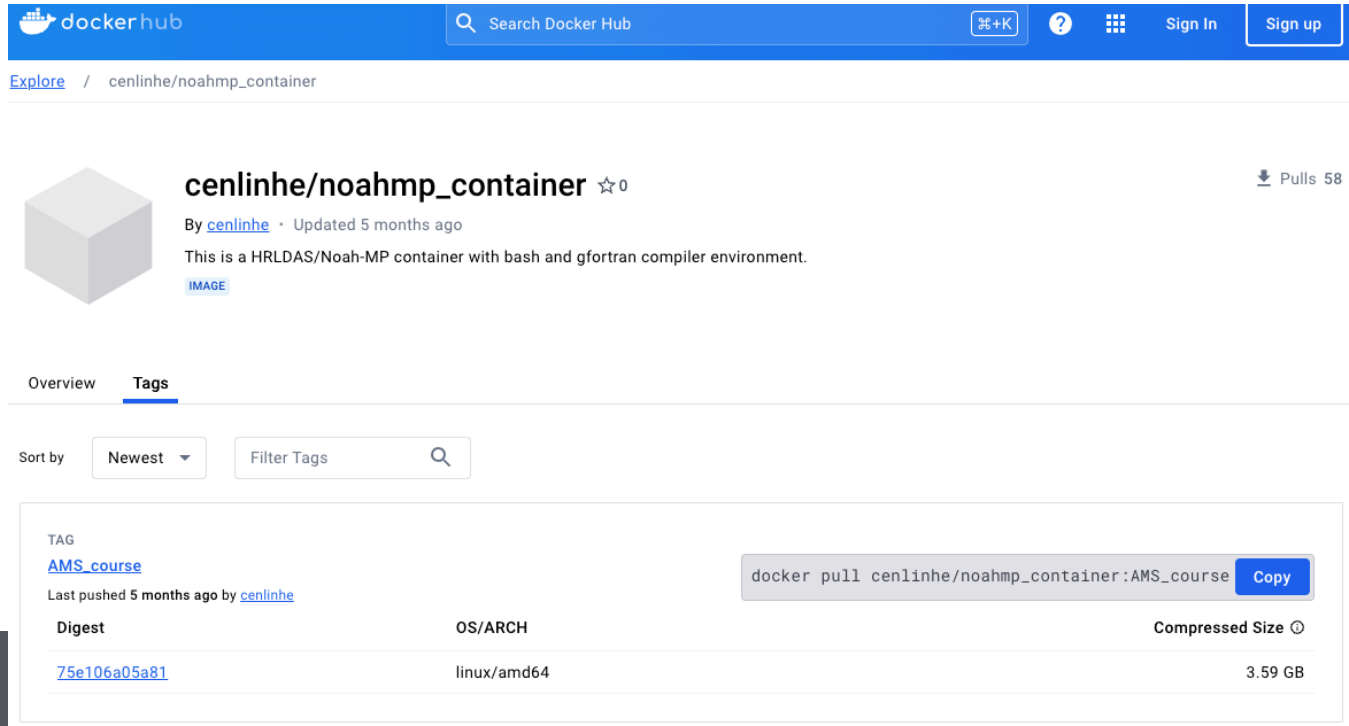
  https://github.com/NCAR/hrldas/blob/develop/tutorial/NoahMP_docker_container_setup.pdf

- **How to run HRLDAS/Noah-MP and UFS/Noah-MP component model in docker container:**

  https://github.com/NCAR/hrldas/blob/develop/tutorial/Note6_AMS2024_NoahMP_short_course.ipynb

- **How to run UFS/Noah-MP component model in docker container:**

  https://github.com/NCAR/hrldas/blob/develop/tutorial/Note7_AMS24_Tutorial_UFS_NoahMP_component.ipynb



Noah-MP key bug fixes since the release of version 5.0

- **bug fix for LECH SURFACE FUNCTIONS in Chen97 scheme:** https://github.com/NCAR/noahmp/commit/ca2219246cebdcd9157f327c4527c9294ad6852c
- **bug fix for leaf mass initialization for urban pixel:** https://github.com/NCAR/noahmp/commit/843a742c6019a613450f0002e7ec65f44e49b523
- **bug fix for FVEG scaling in canopy interception and stomatal resistance:** https://github.com/NCAR/noahmp/commit/a7dd399972fca4d477c43654d384287ad62114a2
- **bug fix for snow layer combine:** https://github.com/NCAR/noahmp/commit/e0d20644c4532064669359f931ef0a621d503314
- **bug fix for initialization to work with BEP,BEM urban physics:** https://github.com/NCAR/noahmp/commit/45f65210cebe1bb4f821bfbde42723c6215acfcd
- **bug fix for FVEG scaling of canopy heat storage:** https://github.com/NCAR/noahmp/commit/dfb99b670d2c0dc998c03644dbd21db9670688e0
- **bug fix for LW calculation in SLUCM:** https://github.com/NCAR/hrldas/commit/b4f73d664094927be585a17acf2b53516ab41687
- **bug fix for restart frequency setup for gfortran compiler:** https://github.com/NCAR/hrldas/commit/c9aa8ce0f7b26f6e9ba2efb759fb2b56f1c81630
- **bug fix for SLUCM saturated humidity calculation:** https://github.com/NCAR/hrldas/commit/922a66f1c89963b5841952ca75e92bcbaf7f0193
- **bug fix for ground heat flux sign in urban model:** https://github.com/NCAR/hrldas/commit/a3ce25e36733fddb277691db80225eabb33aa29e
- **bug fix for ERA5 longitude and soil vert interpolation:** https://github.com/NCAR/hrldas/commit/ba09bf052c22f1e0fcbb93065998f3903ce2c033
- **bug fix for detecting LCZ and update URBPARM_LCZ.TBL:** https://github.com/NCAR/hrldas/commit/9b3002238fe9bcf68a3ad41a31e2ce066175d91e
- **bug fix for GLDAS forcing preprocessor**: https://github.com/NCAR/hrldas/commit/fe3f2adf23fc84809e7f3ea0deecd383ebe41574

Noah-MP Emergent Model Issues/Deficiencies

- Cold bias in daily max 2-m air temperature over snow-covered regions
- Warm bias in daily min 2-m air temperature throughout the year
- Too large soil temperature diurnal cycle (e.g., soil heat diffusion; coupled canopy-ground flux solver)

- **More to discuss during our discussion session (Tuesday afternoon, June 4)**