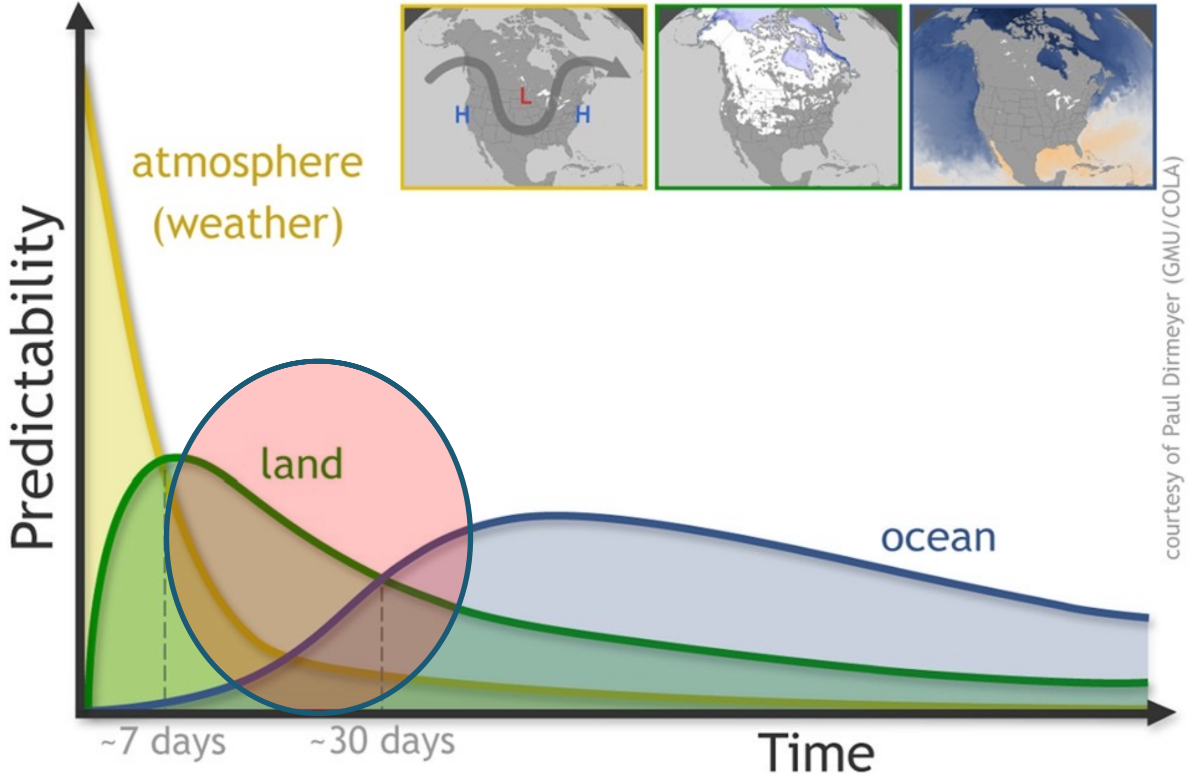
Brief History of the Noah and Noah-MP land models

Fei Chen
Hydromet Applications Program, RAL/NCAR

Noah-MP User Workshop, 23 May 2023

land-surface processes and models are crucial to improving weather and climate predictability



Land-surface model (LSM) development chronology

- Gen-0 (prior to 60s): lack of land-surface processes (prescribed diurnal cycle of surface temperature) in atmospheric models.
- Gen-1a (mid 60s): surface model with time-fixed soil moisture
- Gen-1b (late 60s): Bucket model (Manabe 1969): time- and space-varying soil moisture
- Gen-2 (70s): Big-leaf model (Deardorff 1978): explicit vegetation treatment; a major milestone
- Gen-3 (late 80s): development of more sophisticated models including hydrological, biophysical, biochemical, ecological processes (e.g., BATS, SiB, NCARLSM, Century)
- mid 90s: implement advanced LSMs at major operational numerical weather prediction centers (Noah at NCEP; ECMWF, UK Met Office, Meteo-France)
- After 2000: integrated Earth System Modeling: carbon, nitrogen, hydrology, and ecosystem processes
- Human dimension: urbanization, agriculture, forecast management, etc

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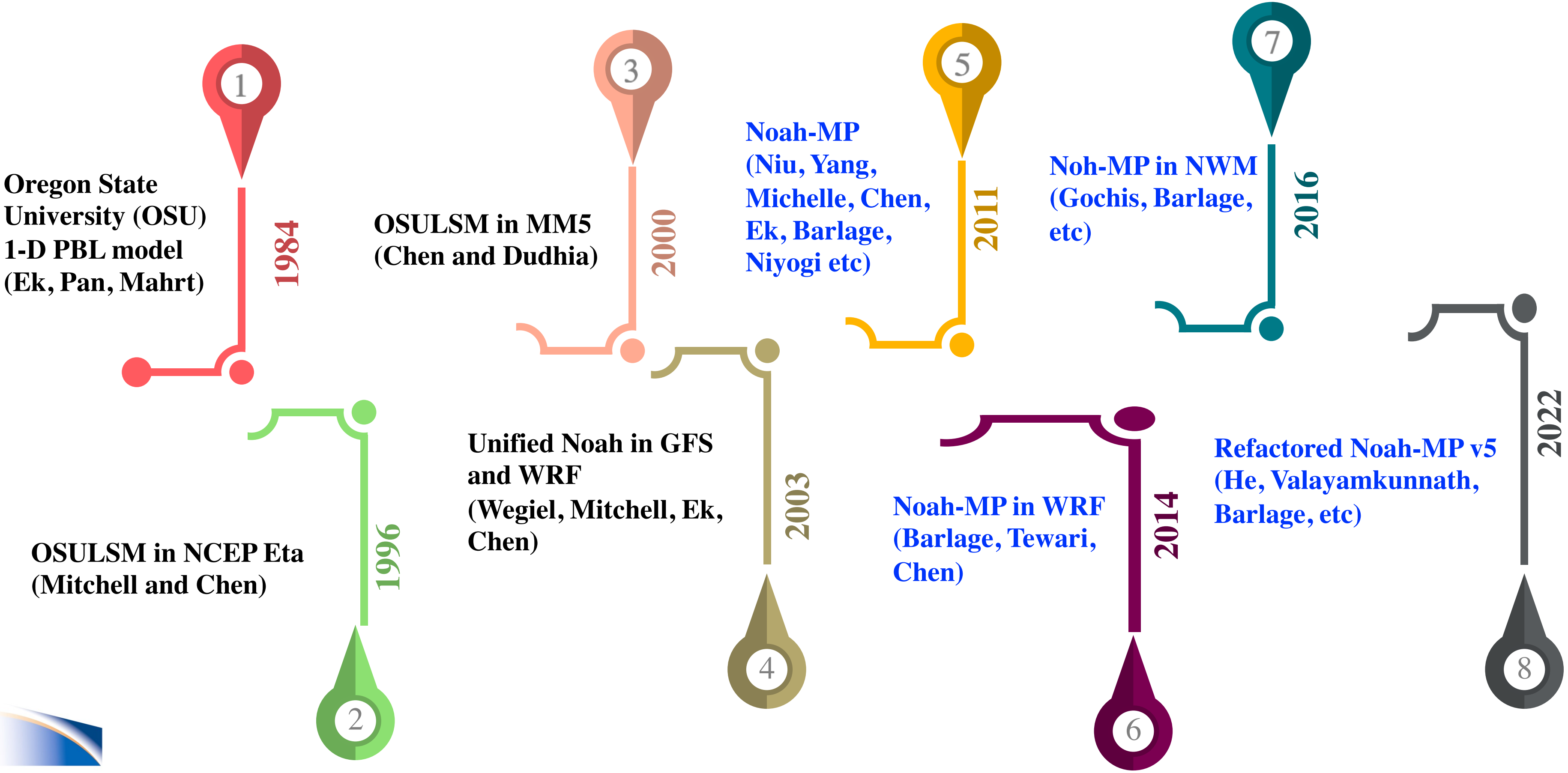
Noah and Noah-MP development milestones



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Community Noah-MP (multi-parameterization) land model

JOURNAL OF GEOPHYSICAL RESEARCH
Atmospheres
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The community Noah land surface model with multiparameterization options (Noah-MP): 1. Model description and evaluation with local-scale measurements

Guo-Yue Niu, Zong-Liang Yang, Kenneth E. Mitchell, Fei Chen, Michael B. Ek, Michael Barlage, Anil Kumar, Kevin Manning, Dev Niyogi, Enrique Rosero, Mukul Tewari, Youlong Xia

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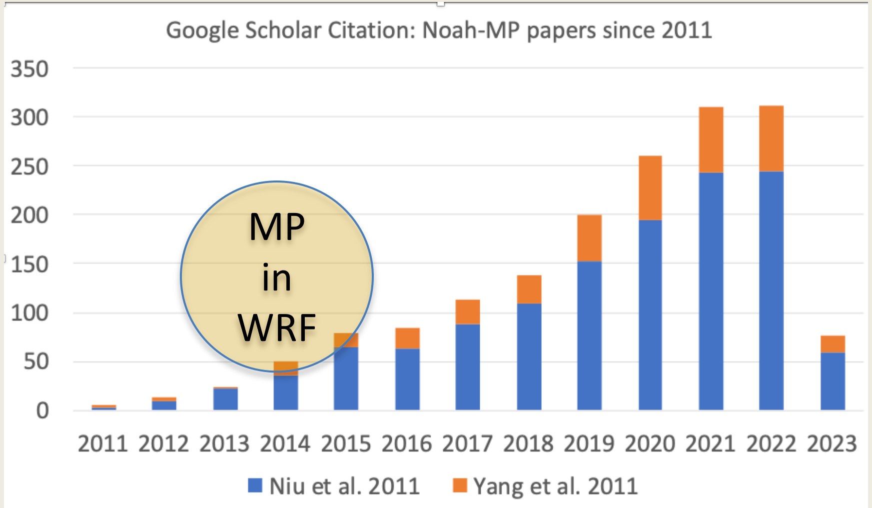
The community Noah land surface model with multiparameterization options (Noah-MP): 2. Evaluation over global river basins

Zong-Liang Yang, Guo-Yue Niu, Kenneth E. Mitchell, Fei Chen, Michael B. Ek, Michael Barlage, Laurent Longuevergne, Kevin Manning, Dev Niyogi, Mukul Tewari, Youlong Xia



Noah-MP physics options (red: options used in CONUS 404)

MP = Multi-physics
= Multi-hypothesis

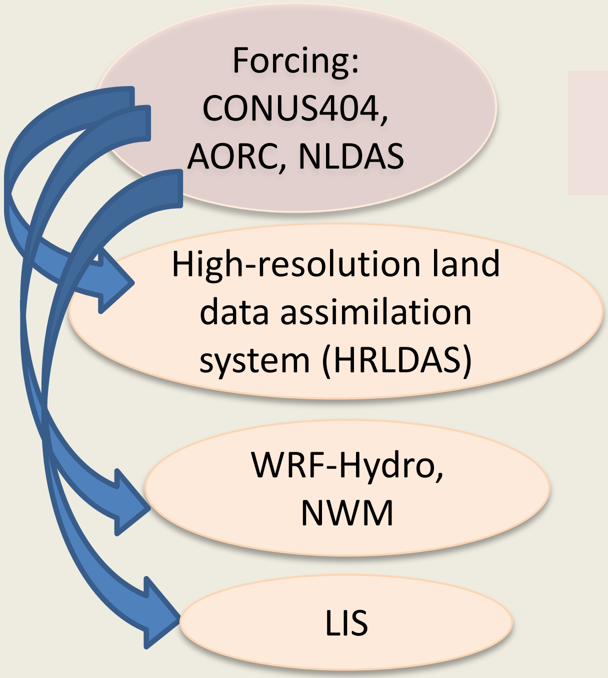
Easy to incorporate new physics parameterization and data sets

Tool for assessing land physics uncertainties and for physics ensemble prediction

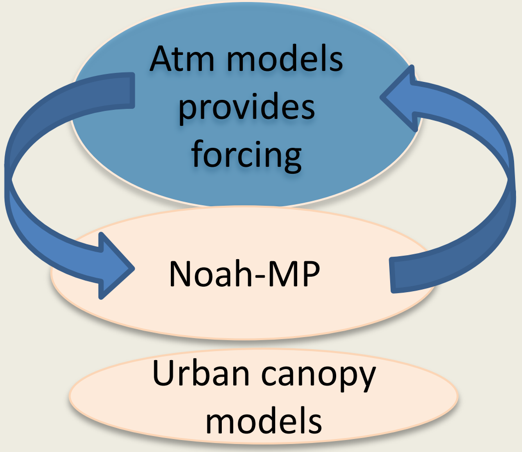
Physical Processes	Options	References
Dynamic vegetation (DVEG)	(1) Off (use table LAI; use FVEG=SHDFAC from input) (2) On (together with OPT_CRS=1) (3) Off (use table LAI; calculate FVEG) (4) Off (use table LAI; use maximum FVEG) (5) On (use maximum FVEG) (6) On (use FVEG=SHDFAC from input) (7) Off (use input LAI; use FVEG=SHDFAC from input) (8) Off (use input LAI; calculate FVEG) (9) Off (use MODIS monthly LAI; use maximum FVEG)	Dickinson et al. 1998
Canopy stomatal resistance (CRS)	(1) Ball-Berry (2) Jarvis	Ball et al. 1987 Jarvis, 1976
Soil moisture factor for stomatal resistance (BTR)	(1) Noah (soil moisture) (2) CLM (matric potential) (3) SSiB (matric potential)	Chen et al., 1996 Oleson et al., 2004 Xue et al., 1991

Typical applications of Noah-MP

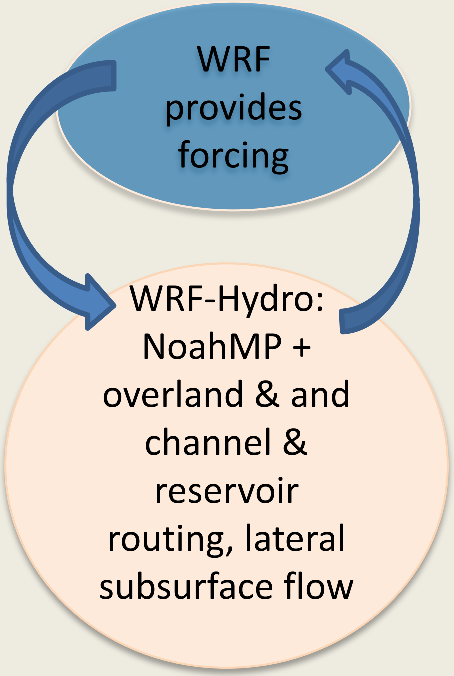
uncoupled standard-alone runs (from single point to global)

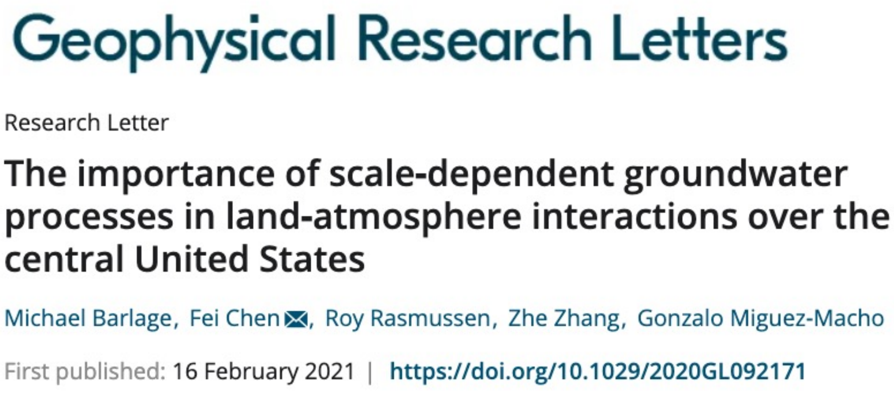


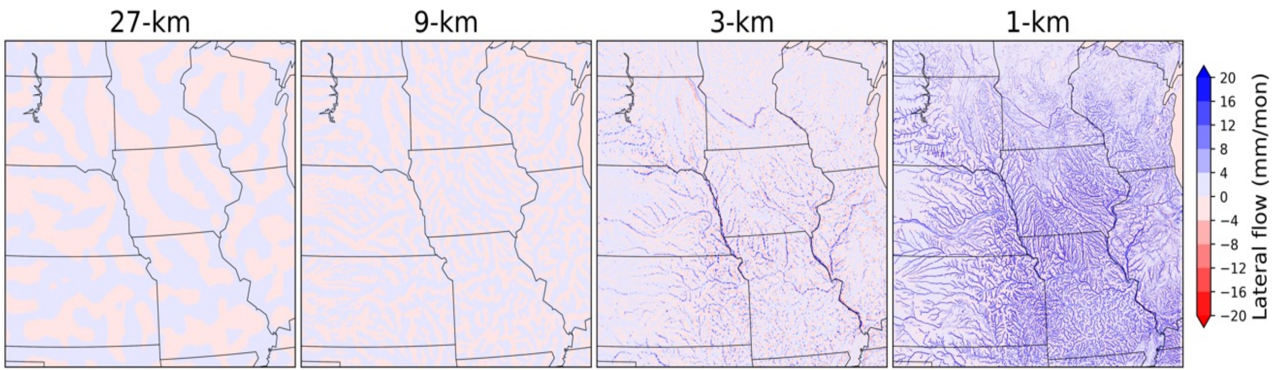
Coupled with atmospheric models (WRF, UFS, MPAS, GIST, KIM, Eta, etc)



Coupled with atmospheric models (WRF-Hydro)







Monthly accumulated groundwater lateral flow (mm/month) for 2012 July

NCAR | UCAR

Understand high-resolution climate-hydrology-agriculture impacts
Incorporating agriculture management processes

JGR Atmospheres

Research Article | Free Access

Noah-MP-Crop: Introducing dynamic crop growth in the Noah-MP land surface model

Xing Liu, Fei Chen, Michael Barlage, Guangsheng Zhou, Dev Niyogi

First published: 02 November 2016 | https://doi.org/10.1002/2016JD025597 | Citations: 48

JAMES Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2020MS002159

Joint Modeling of Crop and Irrigation in the central United States Using the Noah-MP Land Surface Model

Zhe Zhang[1,2], Michael Barlage[3], Fei Chen[3], Yanping Li[1,2], Warren Helgason[1,4], Xiaoyu Xu[5], Xing Liu[6], and Zhenhua Li[1,2]

Key Points:
- Joint modeling of crop growth and irrigation improves crop-yield simulation in irrigated regions
- Applying the state-level planting date helps improve the

JAMES Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2018MS001595

Lessons Learned From Modeling Irrigation From Field to Regional Scales

Xiaoyu Xu[1,2], Fei Chen[3], Michael Barlage[3], David Gochis[3], Shiguang Miao[2], and Shuanghe Shen[1]

Key Points:
- A dynamic irrigation scheme was incorporated into Noah-MP, using soil moisture availability and crop

Environmental Research Letters

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13 March 2018

LETTER

Memory of irrigation effects on hydroclimate and its modeling challenge

Fei Chen[1,2], Xiaoyu Xu[3,4,6], Michael Barlage[1], Roy Rasmussen[1], Shuanghe Shen[3], Shiguang Miao[4] and Guangsheng Zhou[5]

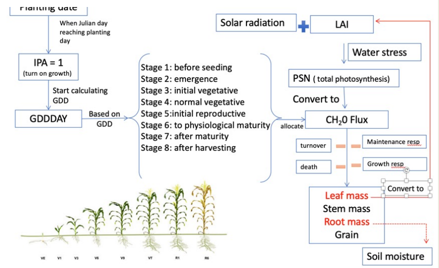
Science

NEWS | CLIMATE

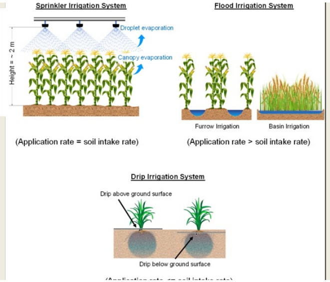
The United States's Corn Belt is making its own weather

Plentiful crops are changing rainfall and temperature trends

Noah-MP crop model



Noah-MP irrigation models



https://doi.org/10.5194/gmd-2022-311
Preprint. Discussion started: 26 January 2023
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Geoscientific Model Development Discussions

EGU

Developing Spring Wheat in the Noah-MP LSM (v4.4) for Growing Season Dynamics and Responses to Temperature Stress

Zhe Zhang[1,2], Yanping Li[1,2], Fei Chen[3], Phillip Harder[1,4], Warren Helgason[1,4], James Famiglietti[1,2], Prasanth Valayamkunnath[3], Cenlin He[3], Zhenhua Li[1,2]

Water Resources Research / Volume 58, Issue 4 / e2021WR031242

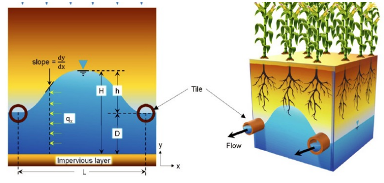
Research Article

Modeling the Hydrologic Influence of Subsurface Tile Drainage Using the National Water Model

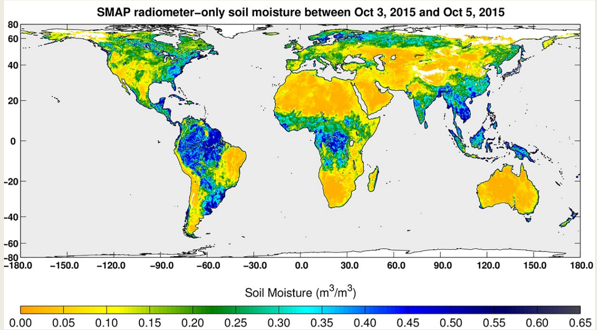
Prasanth Valayamkunnath, David J. Gochis, Fei Chen, Michael Barlage, Kristie J. Franz

First published: 08 April 2022

Noah-MP tile-drainage model



Assimilating modern-era satellite data (soil moisture, leaf area index, and solar-induced chlorophyll fluorescence) to improve land-atmosphere interactions



JAMES Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2020MS002394

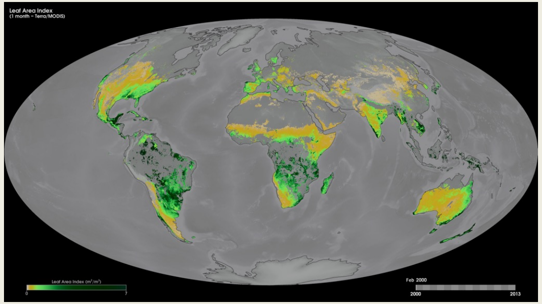
Improve the Performance of the Noah-MP-Crop Model by Jointly Assimilating Soil Moisture and Vegetation Phenology Data

Tongren Xu[1], Fei Chen[2], Xinlei He[1], Michael Barlage[2], Zhe Zhang[3], Shaomin Liu[1], and Xiangping He[1]

[1]State Key Laboratory of Earth Surface Processes and Resource Ecology, School of Natural Resource, Faculty of Geographical Science, Beijing Normal University, Beijing, China, [2]National Center for Atmospheric Research, Boulder, CO, USA, [3]School of Environment and Sustainability, University of Saskatchewan, Saskatoon, SK, Canada

Key Points:

- The Multipass Land Data Assimilation Scheme (MLDAS) is proposed based on the Noah-MP-Crop model
- Leaf area index (LAI), soil moisture (SM), and solar-induced chlorophyll fluorescence (SIF) measurements are assimilated into the MLDAS to predict sensible heat flux (*H*), latent



https://doi.org/10.5194/hess-2022-379
Preprint. Discussion started: 14 December 2022

Hydrology and Earth System Sciences
Discussions
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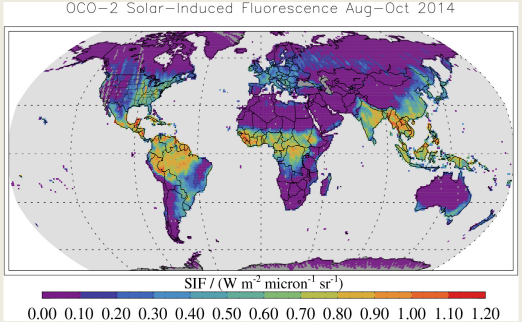
EGU

Improving predictions of land-atmosphere interactions based on a hybrid data assimilation and machine learning method

Xinlei He[1], Yanping Li[2], Shaomin Liu[1*], Tongren Xu[1], Fei Chen[3], Zhenhua Li[2], Zhe Zhang[2], Rui Liu[4], Lisheng Song[5], Ziwei Xu[1], Zhixing Peng[1], Chen Zheng[6]



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

Cenlin He
Prasanth Valayamkunnath
Michael Barlage
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David Gochis
Ryan Cabell
Tim Schneider
Roy Rasmussen
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Refactored Noah-MP (version 5.0) Released in 2022

Provide fresh avenues for developing novel physics options and active participation within the Noah-MP community.

Thank you!