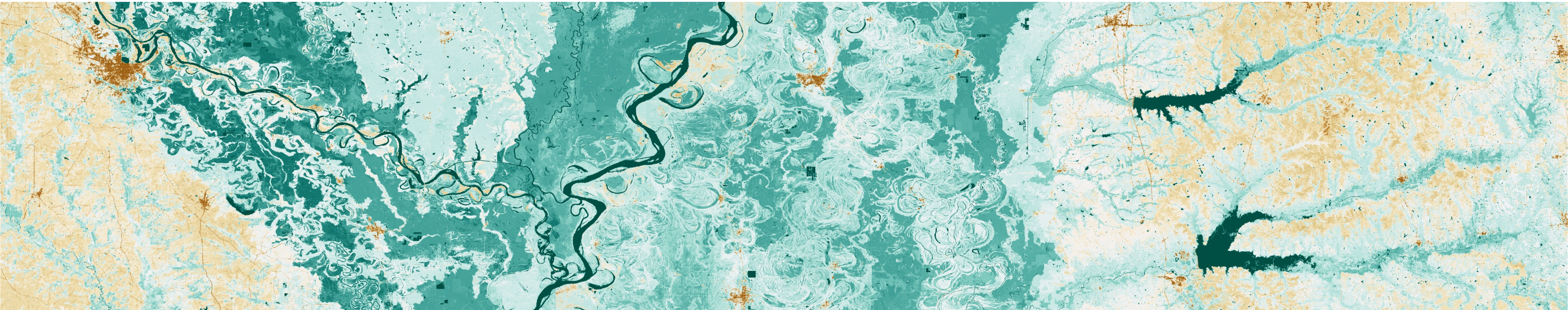
Eric Wood's contributions and recent advances on hyper-resolution land surface modeling

Noemi Vergopolan
Atmospheric and Ocean Sciences Program, Princeton University
NOAA Geophysical Fluid Dynamics Laboratory



The grand challenge of monitoring terrestrial water

Water Resources Research

Opinion | Free Access

Hyperresolution global land surface modeling: Meeting a grand challenge for monitoring Earth's terrestrial water

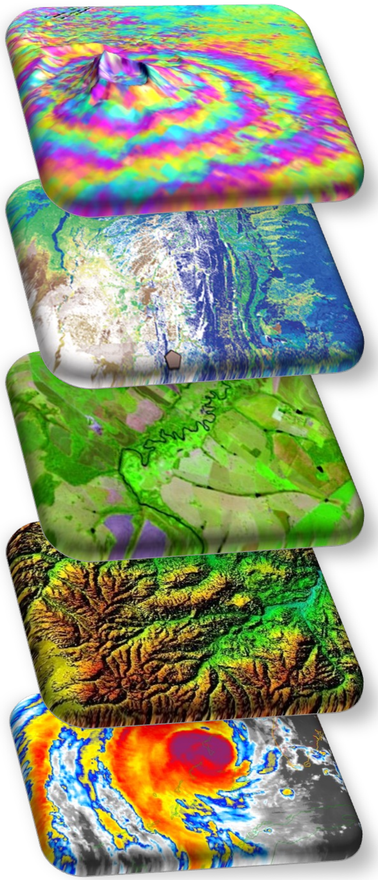
Eric F. Wood, Joshua K. Roundy, Tara J. Troy, L. P. H. van Beek, Marc F. P. Bierkens, Eleanor Blyth, Ad de Roo, Petra Döll, Mike Ek, James Famiglietti, David Gochis, Nick van de Giesen, Paul Houser, Peter R. Jaffé, Stefan Kollet, Bernhard Lehner, Dennis P. Lettenmaier, Christa Peters-Lidard, Murugesu Sivapalan, Justin Sheffield, Andrew Wade, Paul Whitehead ... See fewer authors

Challenges:

1. Representation of surface and subsurface interactions
2. Land-atmosphere interactions
3. Water quality as part of biogeochemistry
4. Human impacts on water management
5. Need for parallel and high-performance computing
6. Required in-situ & remote sensing supporting datasets

Hydrological Processes & Parameterizations

Environmental Data



Landsat & Sentinel
10-30m Derived Databases

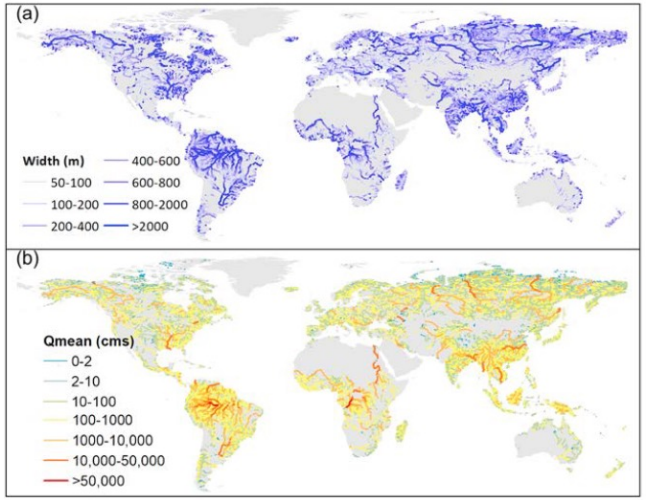
Soil Properties:
30m POLARIS
250m SoilGrids

Land Cover:
30m NLCD
30m GlobeLand

Topography:
10m USGS NED
30m FAB DEM

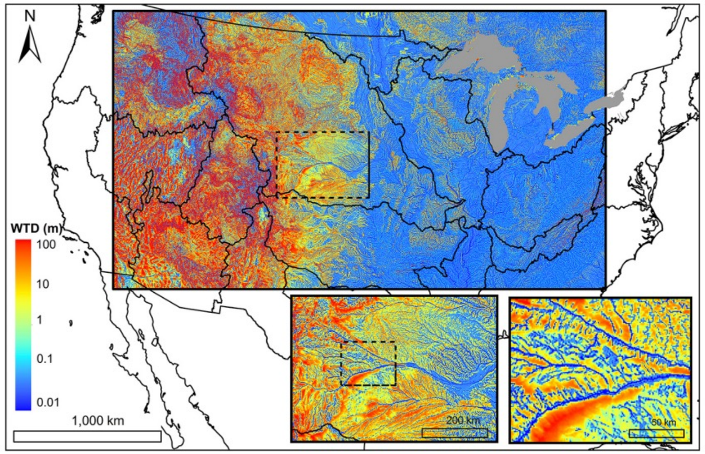
Meteorology:
1km 1h PCF
10km 1h ERA5-Land

River Discharge



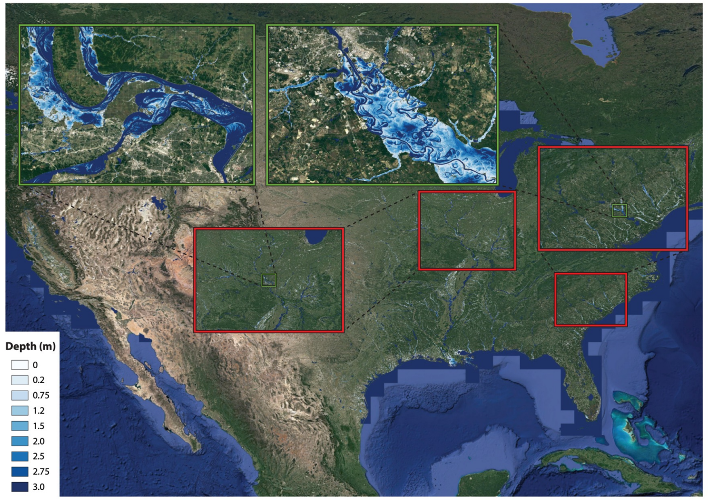
Lin et al. (2019)

Groundwater



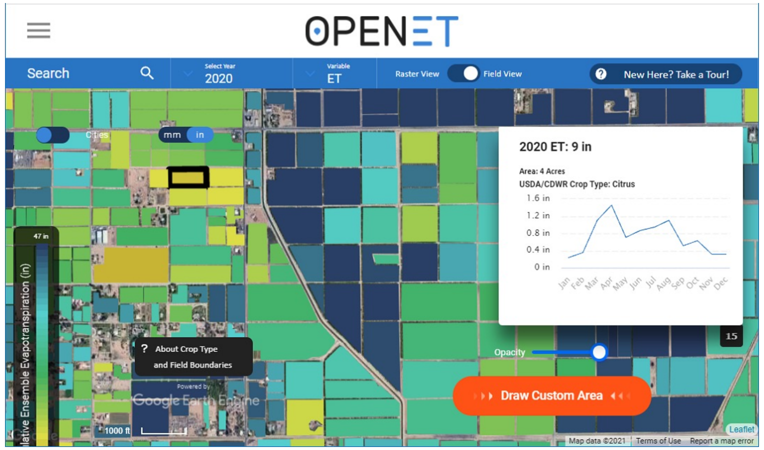
Maxwell et al. (2015)

Flooding & Inundation



Bates et al. (2021)

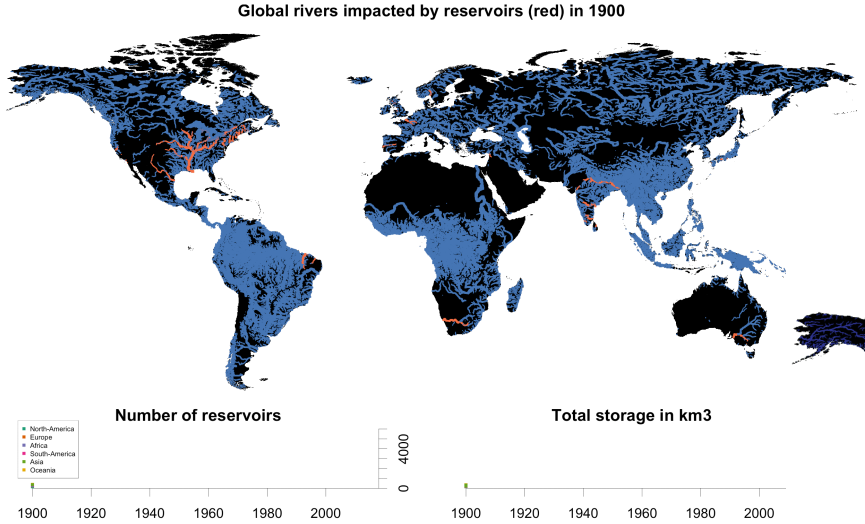
Evapotranspiration



Melton et al. (2021)

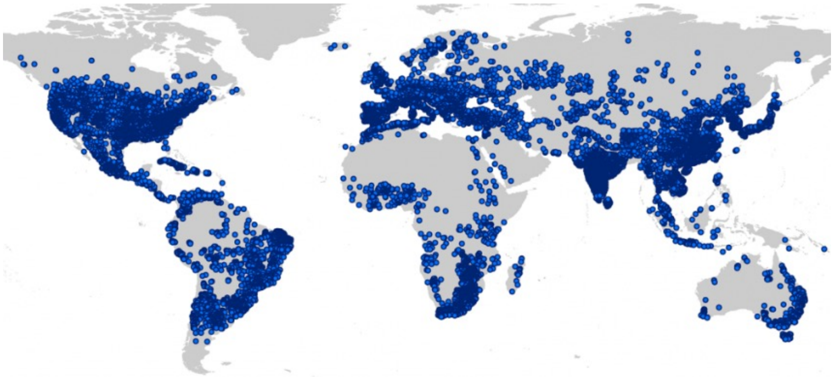
Water Management & Water Quality

Water management



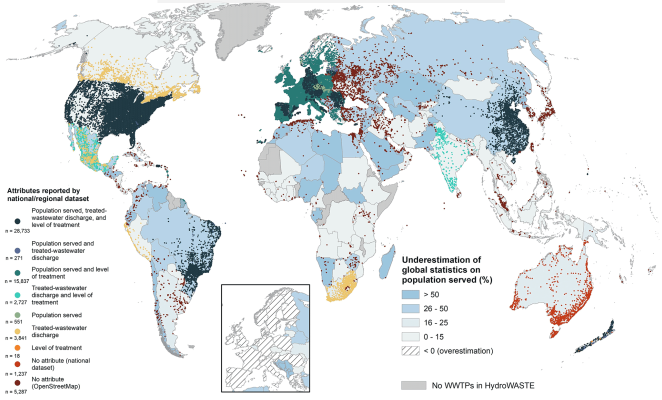
Sutanudjaja et al. (2018)

Global Dam Watch



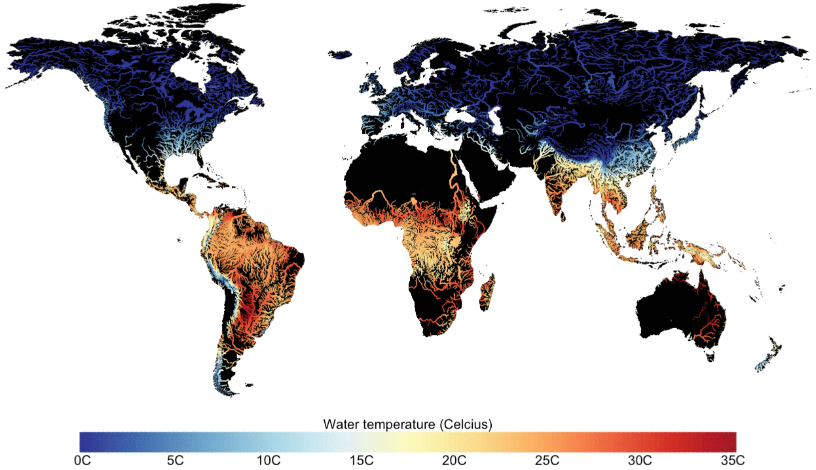
Mulligan et al. (2021)

Wastewater



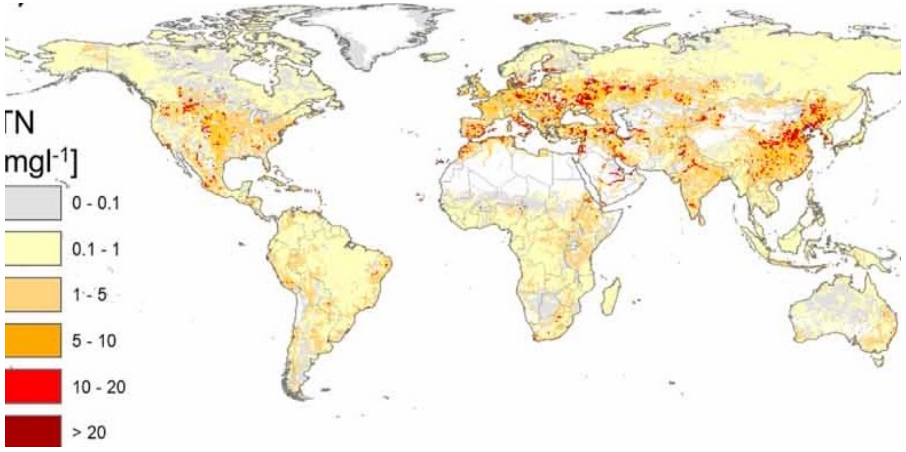
Ehalt Macedo et al. (2021)

Water Temperature



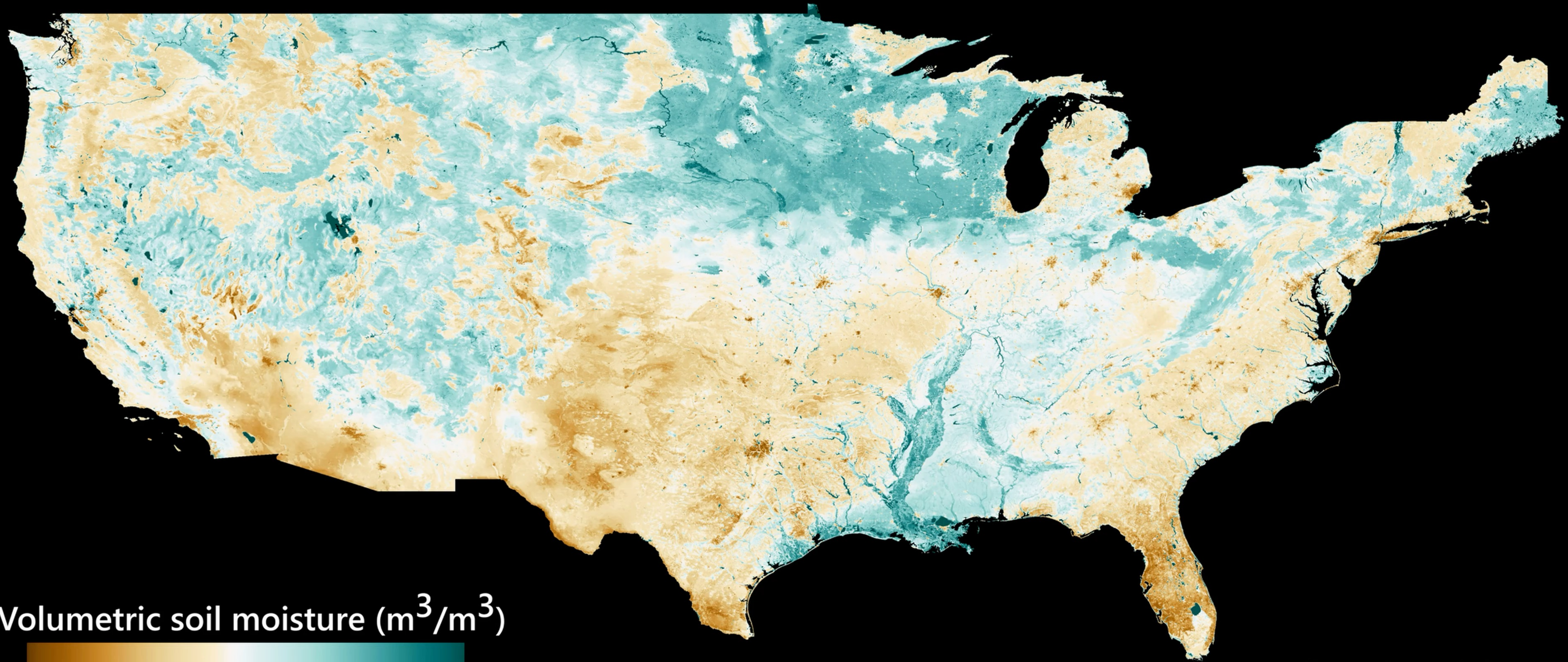
Wanders et al. (2019)

Water Quality



Van Vliet et al. (2021)

Hyper-resolution land surface modeling of
surface soil moisture



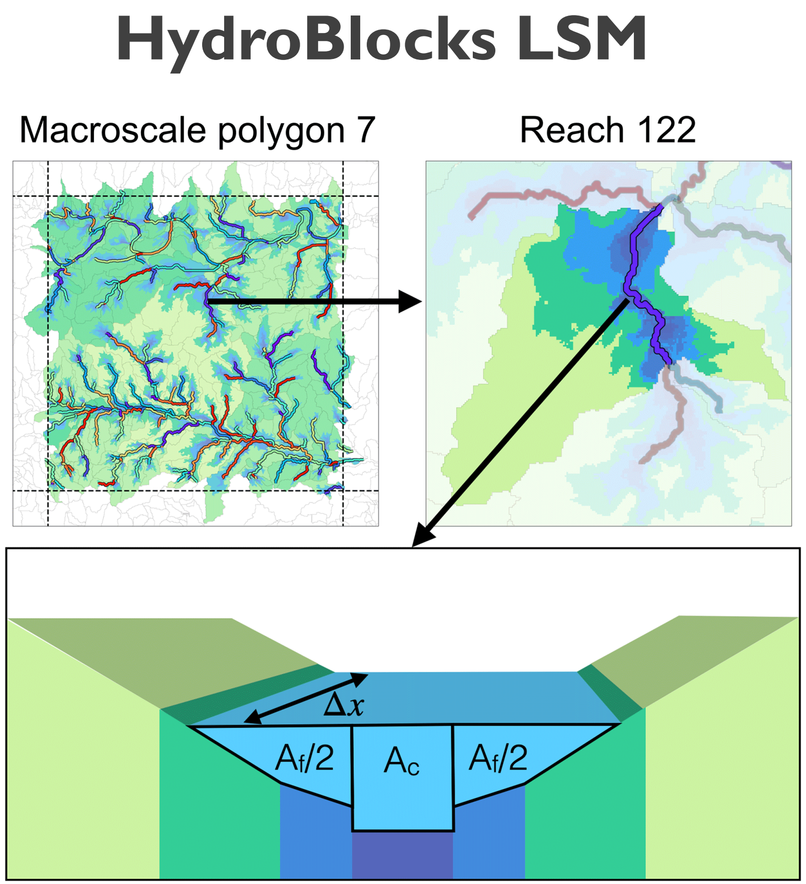
Volumetric soil moisture (m^3/m^3)

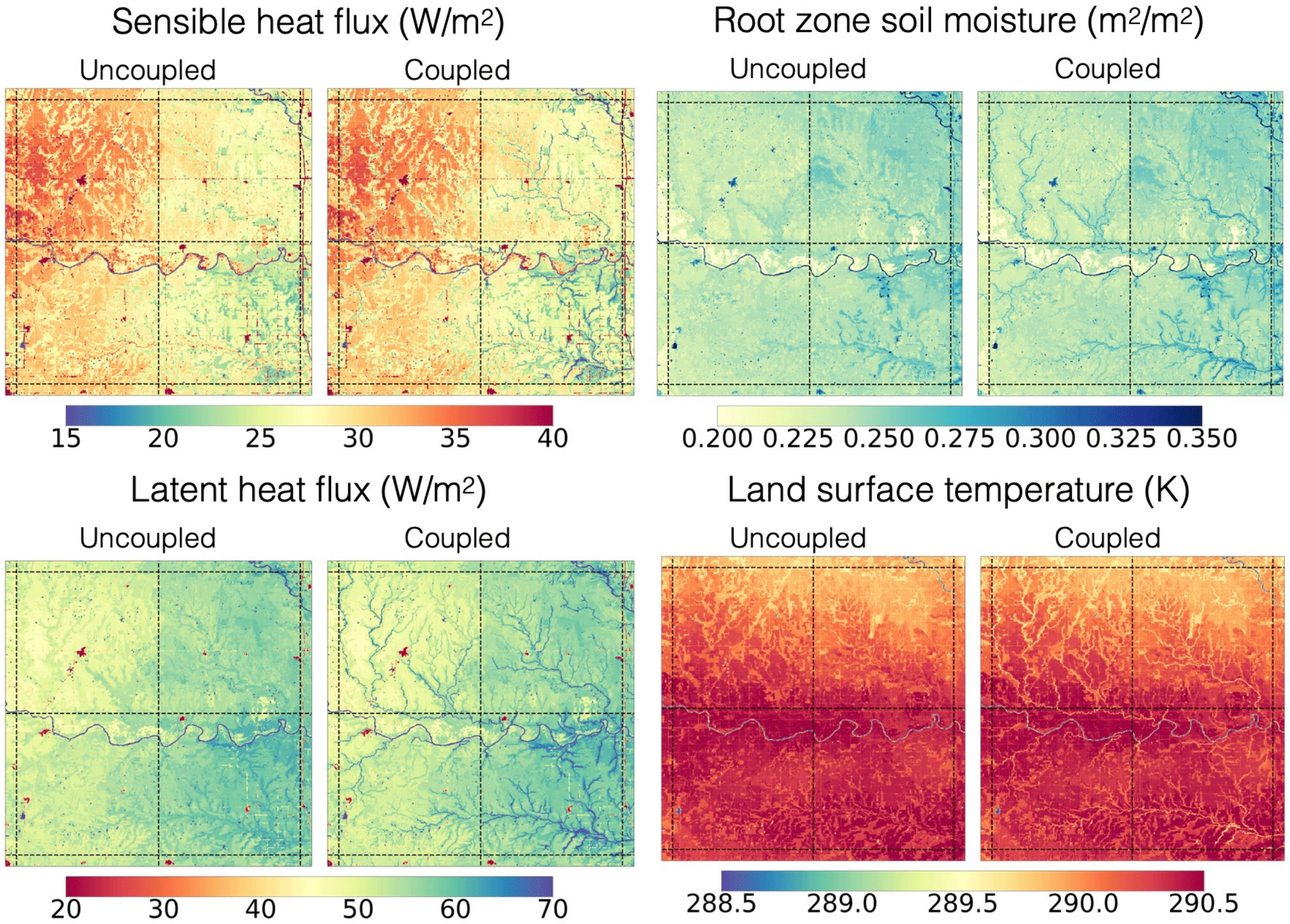
0.0 0.25 0.5

Noemi Vergopolan Princeton University

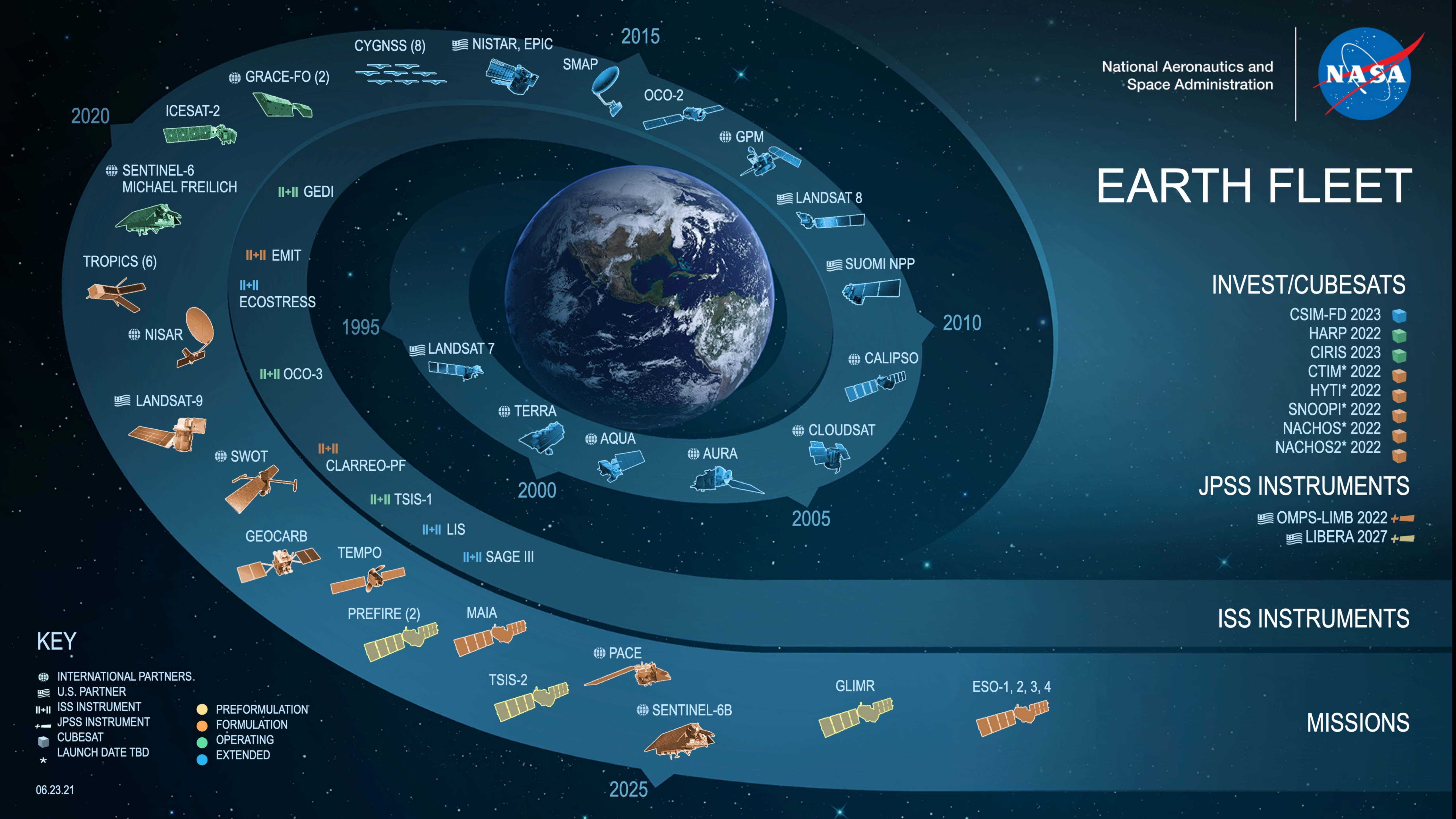
01.01.2017

Two-way coupling between land surface and the river network



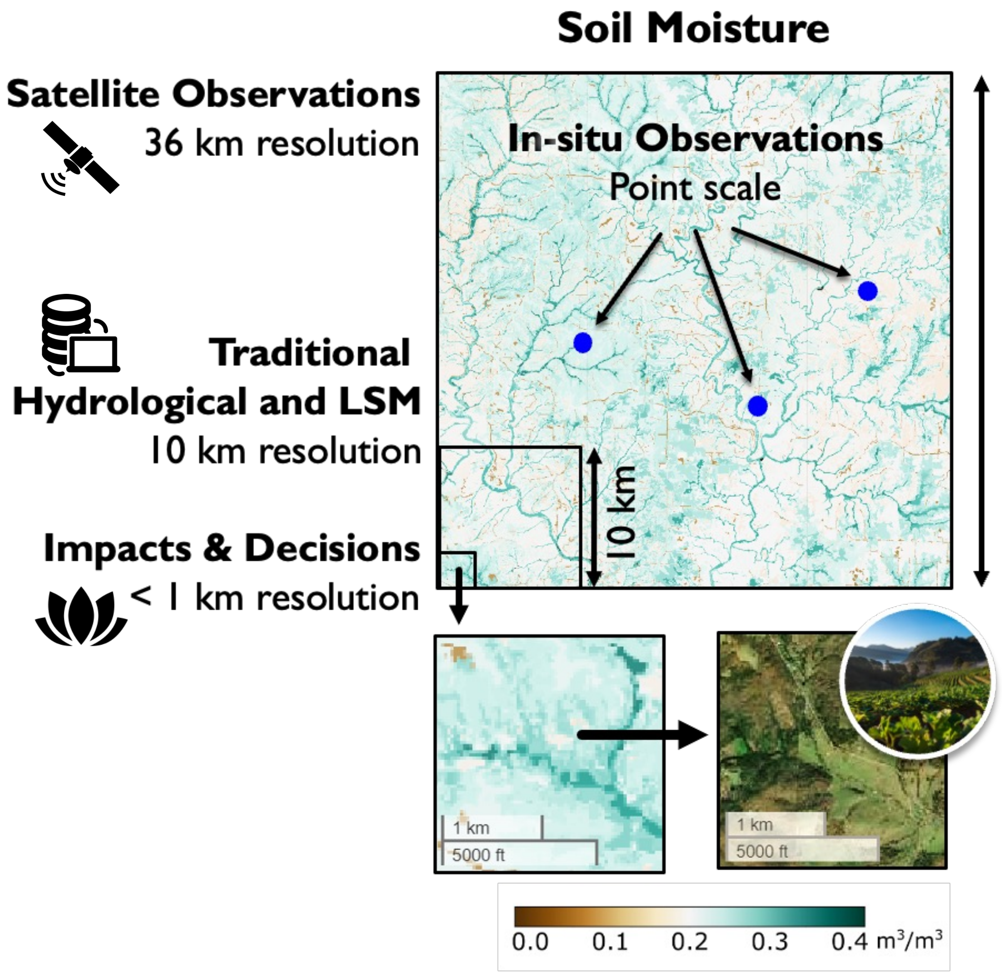


Chaney, et al. (2021). HydroBlocks v0.2: enabling a field-scale two-way coupling between the land surface and river networks in Earth system models. Geoscientific Model Development.

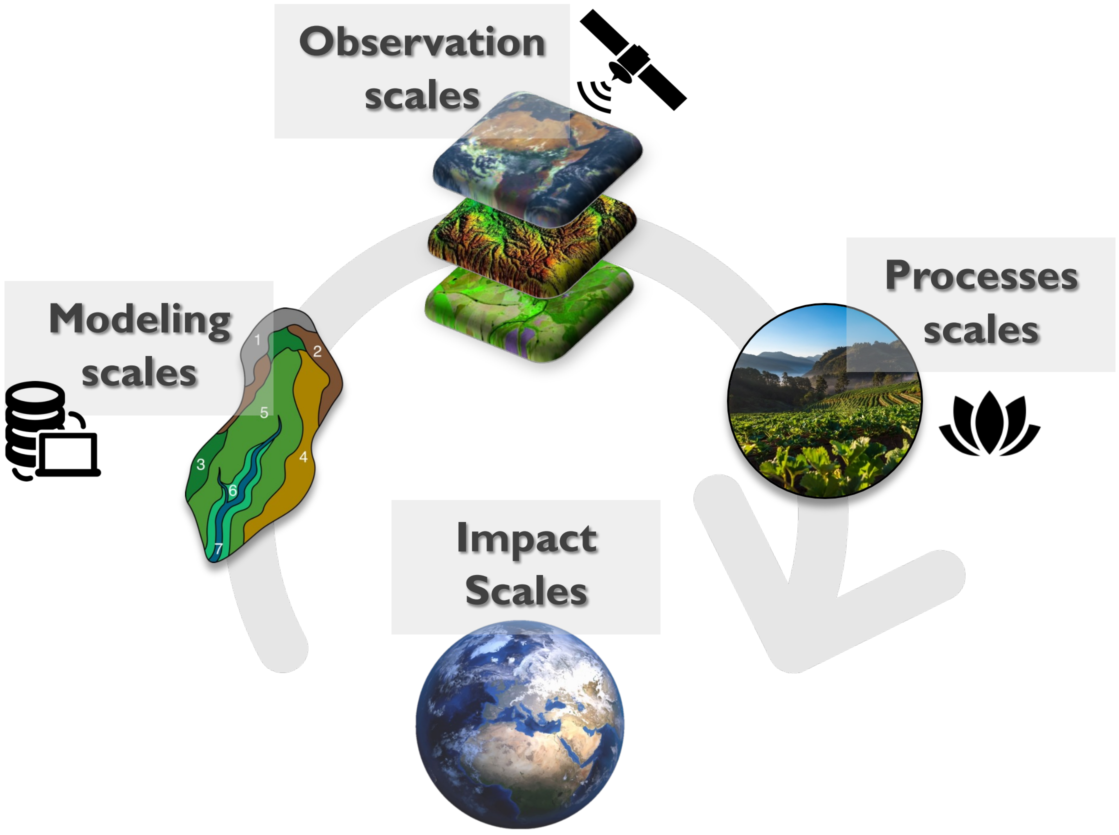


National Aeronautics and Space Administration
NASA
EARTH FLEET
1995
LANDSAT 7
TERRA
AQUA
2000
AURA
CLOUDSAT
2005
CALIPSO
2010
SUOMI NPP
LANDSAT 8
GPM
OCO-2
SMAP
2015
NISTAR, EPIC
CYGNSS (8)
GRACE-FO (2)
ICESAT-2
2020
SENTINEL-6 MICHAEL FREILICH
TROPICS (6)
NISAR
LANDSAT-9
SWOT
GEOCARB
TEMPO
PREFIRE (2)
MAIA
TSIS-2
PACE
SENTINEL-6B
2025
GLIMR
ESO-1, 2, 3, 4
GEDI
EMIT
ECOSTRESS
OCO-3
CLARREO-PF
TSIS-1
LIS
SAGE III
INVEST/CUBESATS
CSIM-FD 2023
HARP 2022
CIRIS 2023
CTIM* 2022
HYTI* 2022
SNOOPI* 2022
NACHOS* 2022
NACHOS2* 2022
JPSS INSTRUMENTS
OMPS-LIMB 2022
LIBERA 2027
ISS INSTRUMENTS
MISSIONS
KEY
INTERNATIONAL PARTNERS
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD
PREFORMULATION
FORMULATION
OPERATING
EXTENDED
06.23.21

The Challenge

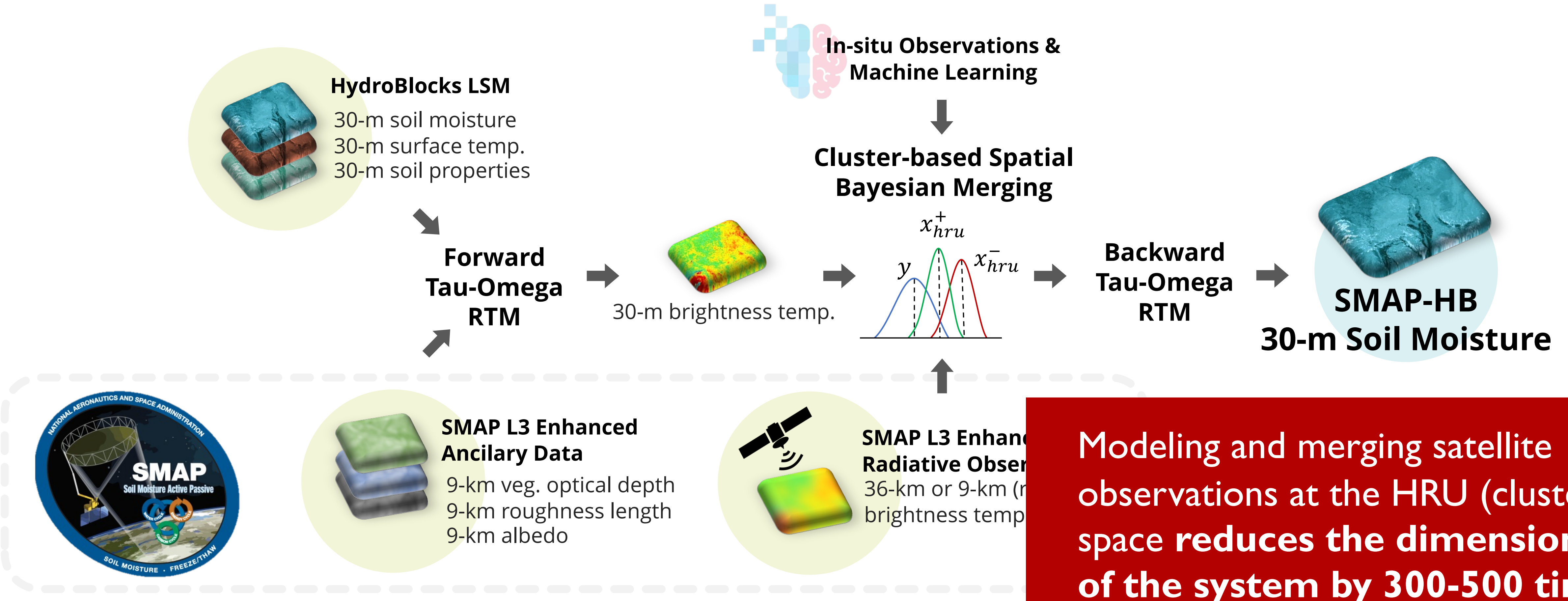


Reconcile Scales



SMAP-HydroBlocks

Combining land surface modeling, satellite remote sensing, and in-situ observations



Modeling and merging satellite observations at the HRU (cluster) space **reduces the dimension of the system by 300-500 times**

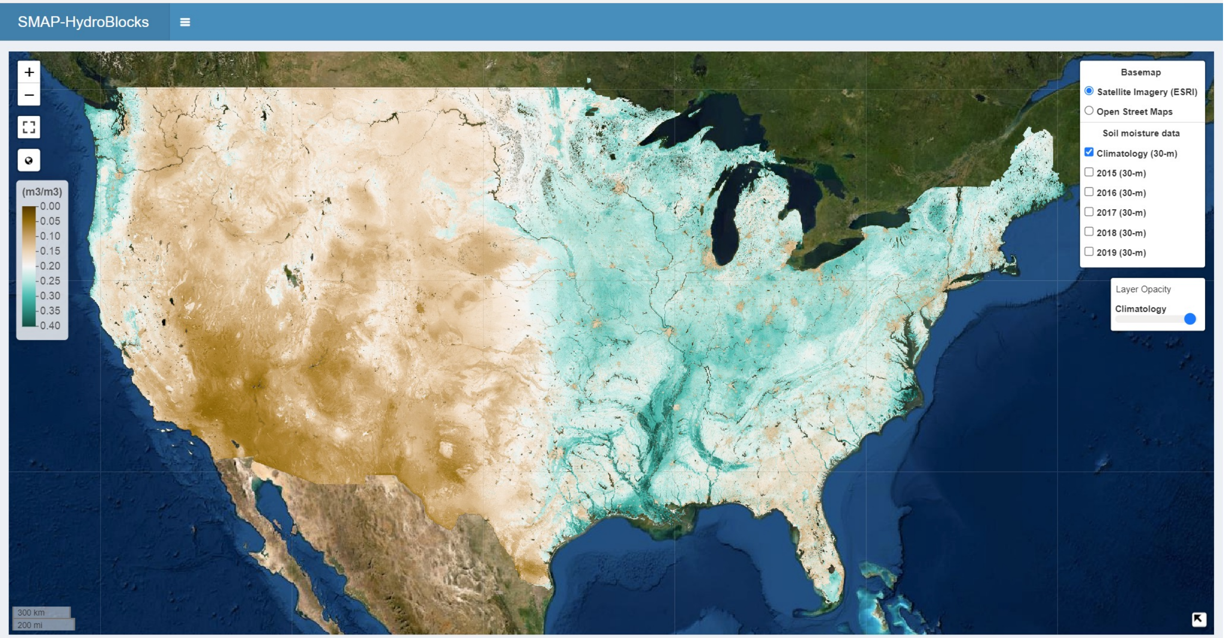
Vergopolan et al. (2020). Combining hyper-resolution land surface modeling with SMAP brightness temperatures to obtain 30-m soil moisture estimates. Remote Sensing of Environment.

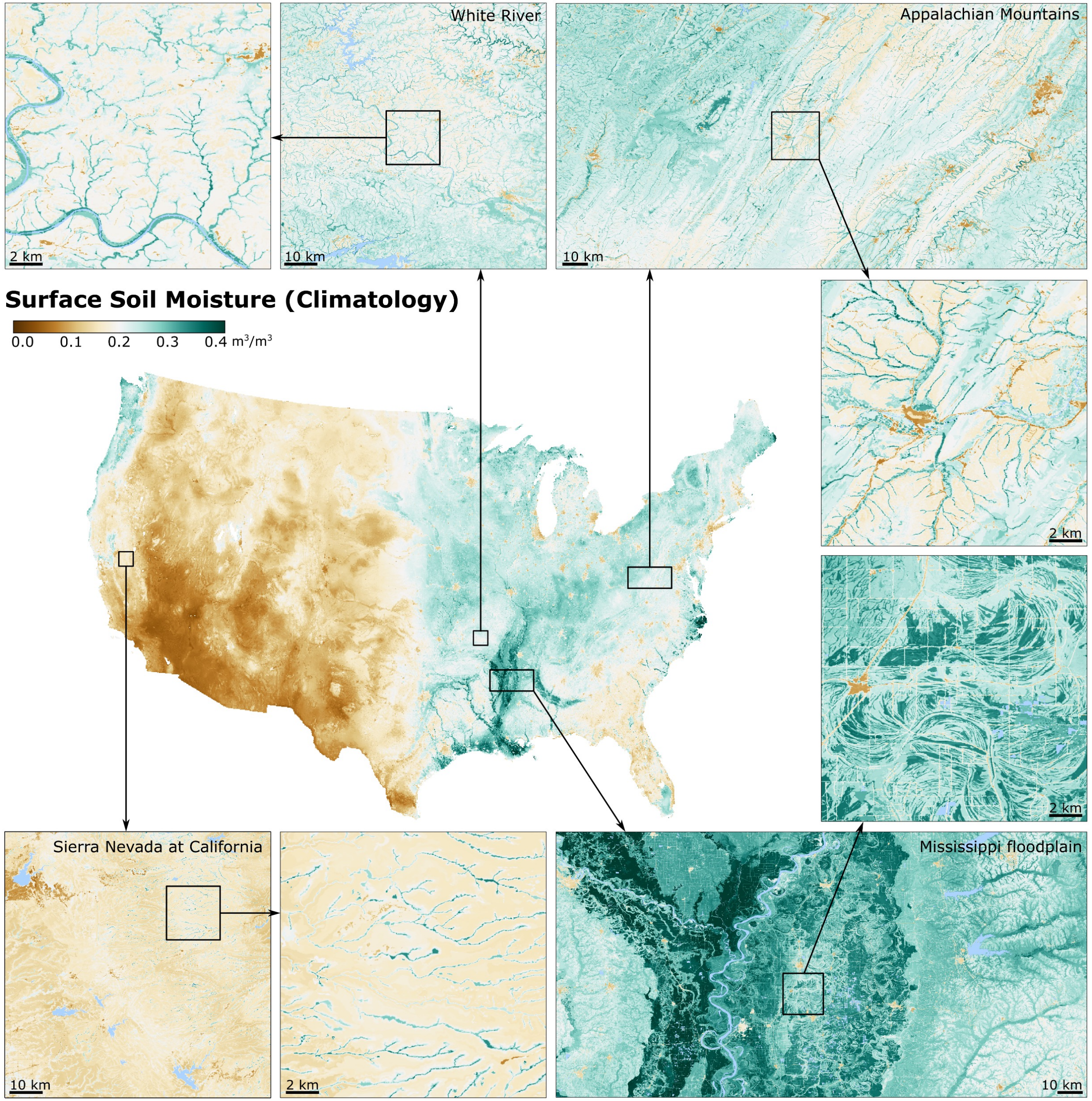
SMAP-HydroBlocks

The first satellite-based hyper-resolution surface soil moisture dataset for the US

- Open Access
- 2015-2019
- 30-m spatial resolution
- 2-3 days revisit time
- 62 TB

http://waterai.earth/SMAPHB



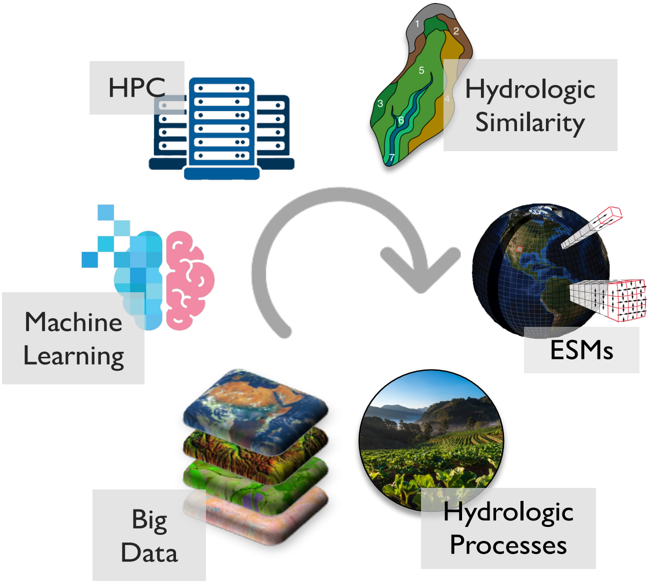


Vergopolan et al. ***SMAP-HydroBlocks, a 30-m satellite-based soil moisture dataset for the conterminous US.*** *Scientific Data. 2021*

Persistent challenges ahead

Move beyond grid resolution

- Realism and representativeness
- Data assimilation
- Supporting data on water management and water quality
- Land-atmosphere coupled simulations



Rethink uncertainties and ethics in land surface modeling

- Quantify uncertainties and limitations due to model parameterization and datasets
- How choice of parameterization and datasets used impact stakeholders?

Towards sustainable computing

- Difficult to scale globally (e.g., ensemble simulations)
- Environmental footprint of energy-intensive HPC systems
- Beyond parallel computing (e.g., sub-grid tiling schemes, ML emulators)
- Modular, reusable, and open-access development

What does it take?

It takes courage.
Courage to be creative,
courage to think in ways others aren't,
courage to persist but also
courage to sit down and listen …
I try to have courage.

Eric Wood

AGU Honors Award 2017