Princeton Activities related to ECOSTRESS

(Eric F Wood, Princeton University)

Background:

ECOSTRESS will measure land surface thermal temperature at a very high spatial and 4-day temporal resolution, which offers the opportunity to address science questions that extend beyond the immediate focus of the mission.

Our activities will provide pre-launch, model-simulated ECOSTRESS measurements based on our new hyper-resolution LSM, "HydroBlocks" that has been run at a *30m* spatial resolution at regional-to-continental scales.

Post-launch there is the opportunity to use ECOSTRESS measurements within an assimilation framework, to understand the uncertainty in the measurements and to improve LSM thermal parameterizations.

Proposed (student) activities related to ECOSTRESS science:

1. Understand the spatial and temporal scaling of LST and the derived surface radiation products, including an assessment of the uncertainty in the surface energy budget derived from current operational satellite systems that have reduced spatial and temporal coverage ET. (Science question #1, improved understanding of climate sensitivity of the biosphere.)

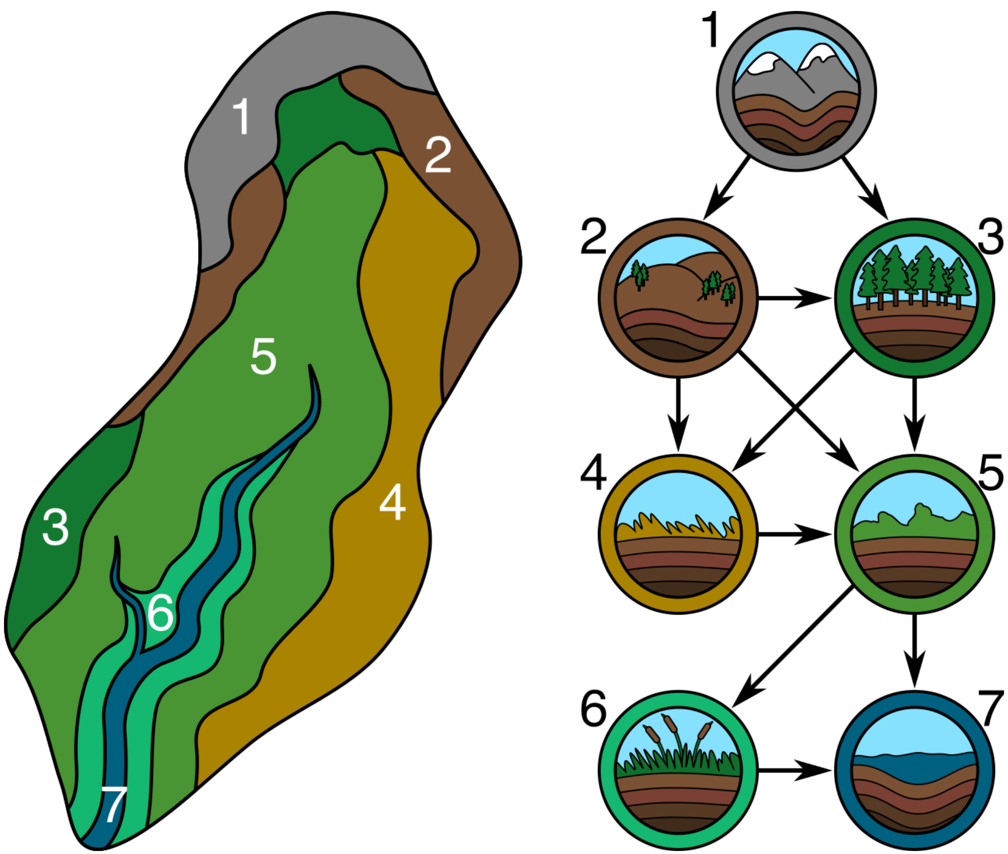
   Since land cover variability over many biomes is large and net radiation is non-linear with respect to LST, an unresolved (science) issue is to understand the scaling issues of the surface energy budget, how this affects our regional-to-continental estimates of the surface radiation budget, and how this varies over wet and dry regimes.

Proposed (student) activities related to ECOSTRESS science:

2. Develop and assess advanced monitoring needs for improved agriculture management that contributes to the ECOSTRESS science question related to improve food security (science question #3).

   Currently there is a observational gap between coarse spatial, high temporal observations based on GEO satellites and high spatial, low temporal resolution of Landsat, with MODIS in-between these end-points. The simulations can help define the spatial-temporal tradeoffs that will be useful for designing any new proposed satellite mission that has agricultural water management as a goal.

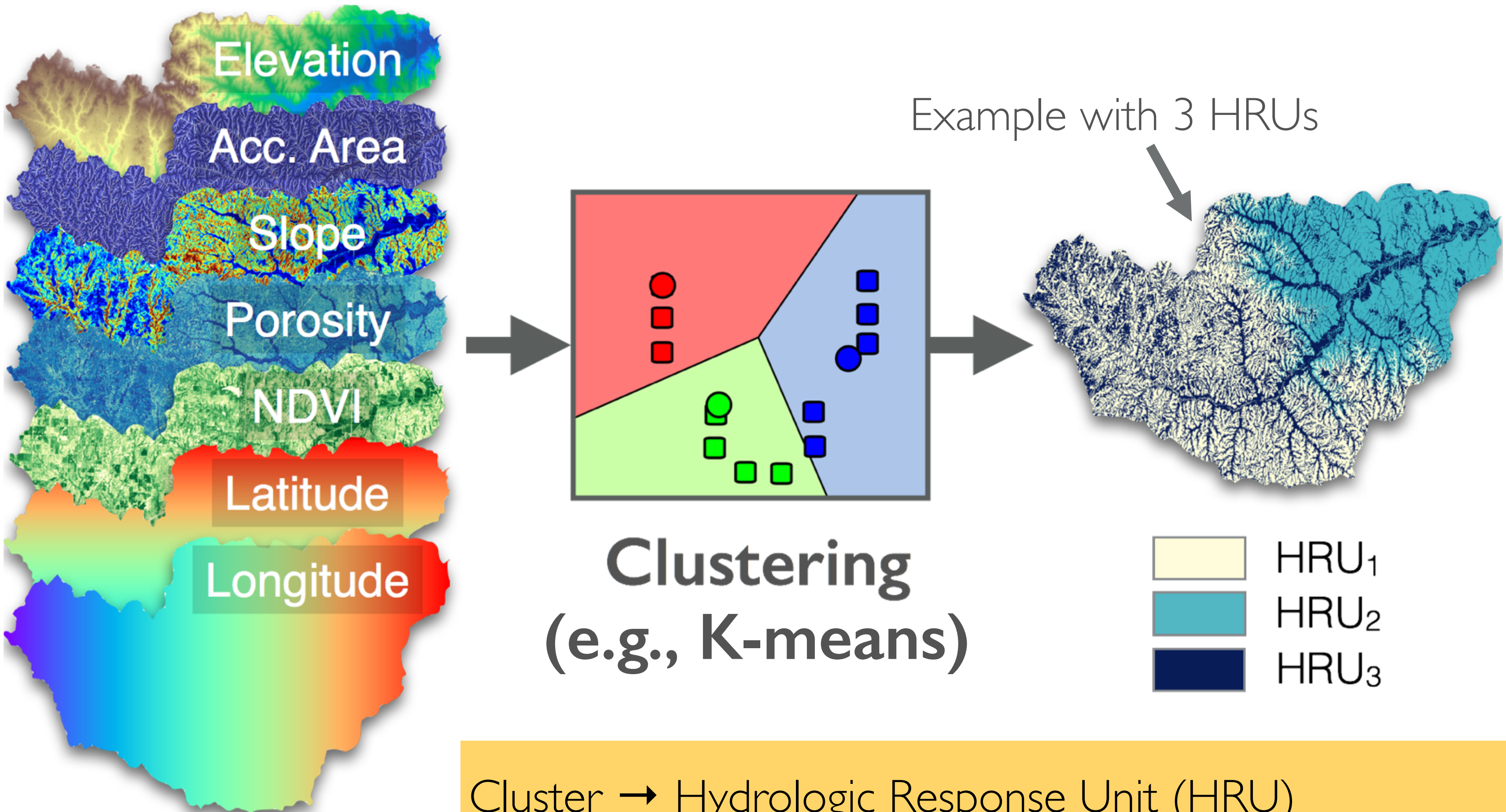
HydroBlocks



- Field-scale resolving land surface model
- Represents spatial heterogeneity through discontiguous hydrologic response units (HRUs)
- Noah-MP LSM is run on each HRU to resolve the vertical land processes
- Dynamic TOPMODEL connects the HRUs via the subsurface

Chaney, N. W., Metcalfe, P., & Wood, E. F. (2016). HydroBlocks: A Field-scale Resolving Land Surface Model for Application Over Continental Extents. *Hydrological Processes*.

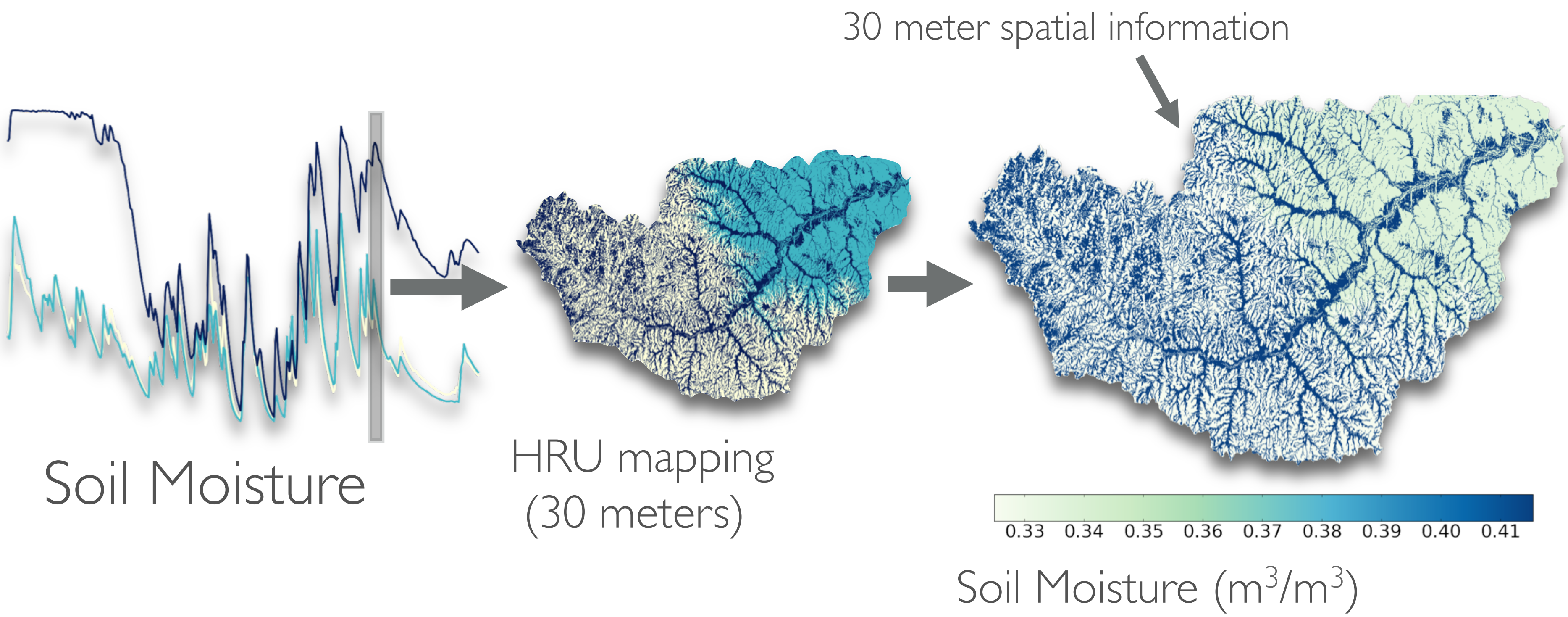
HydroBlocks: Defining the HRUs



Cluster → Hydrologic Response Unit (HRU)

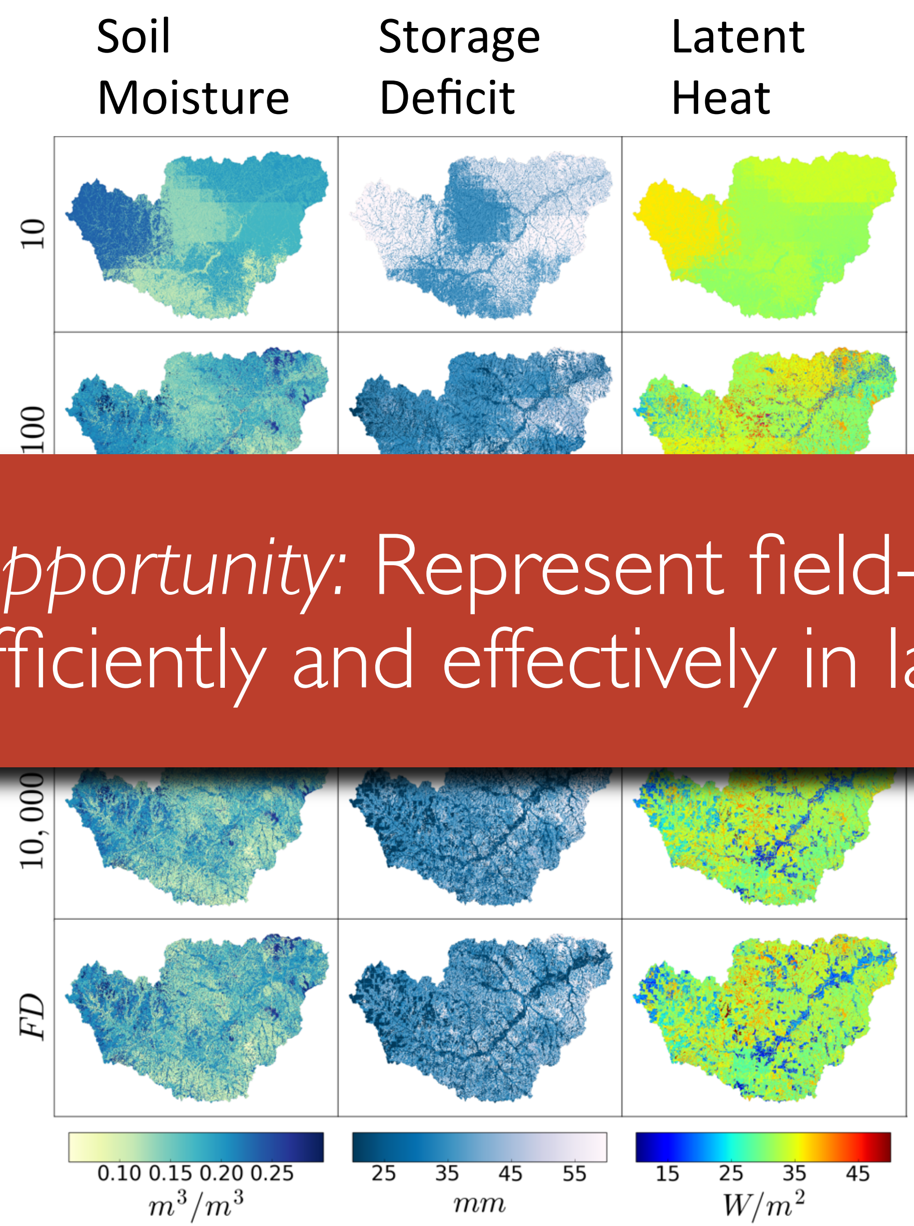
HydroBlocks models the HRUs and their spatial interactions interactions

Mapping HydroBlocks output



Map out HRU results at each time step to approximate the fully distributed model simulation at 30 meters

Converge to fully distributed simulation



- Run HydroBlocks with a different number of HRUs

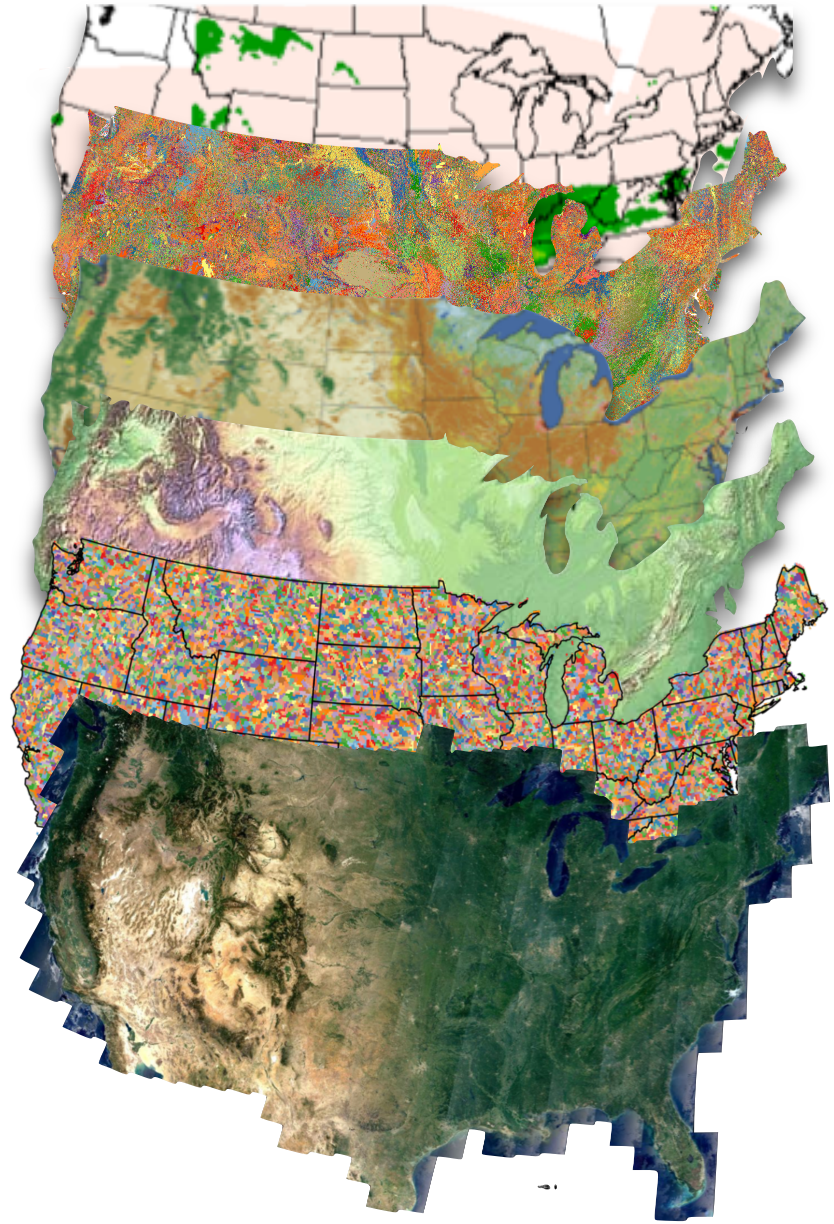
same information

Opportunity: Represent field-scale heterogeneity efficiently and effectively in land surface models

Chaney, N.W., et al., 2016: HydroBlocks: A field-scale resolving land surface model for application over continental extents, *Hydrologic Processes*.

HydroBlocks over CONUS

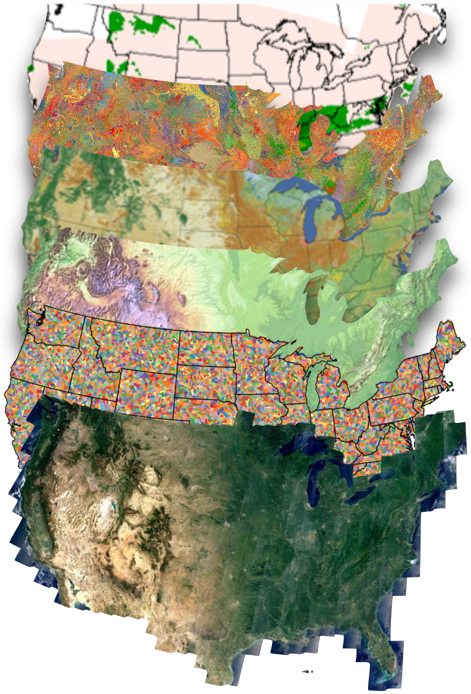
	Dataset	dx
Catchment	HUC-10	N/A
Topography	NED DEM	30 m
Land Cover	WELD	30 m
	NLCD	30 m
Soil Properties	POLARIS	30 m
Meteorology	PFD	4 km



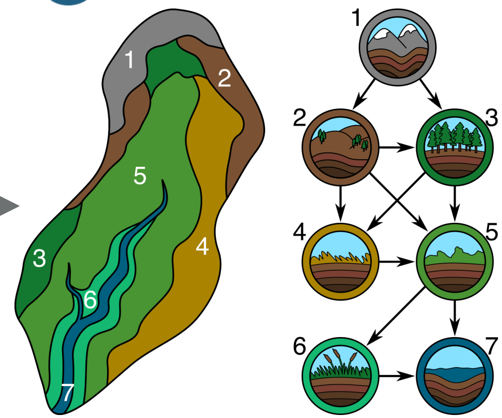
- Run model on the ~15000 HUC10 catchments
- Use available high resolution environmental data to define the HRUs for each catchment
- Hourly simulations between 2002 and 2014

HydroBlocks CONUS simulations

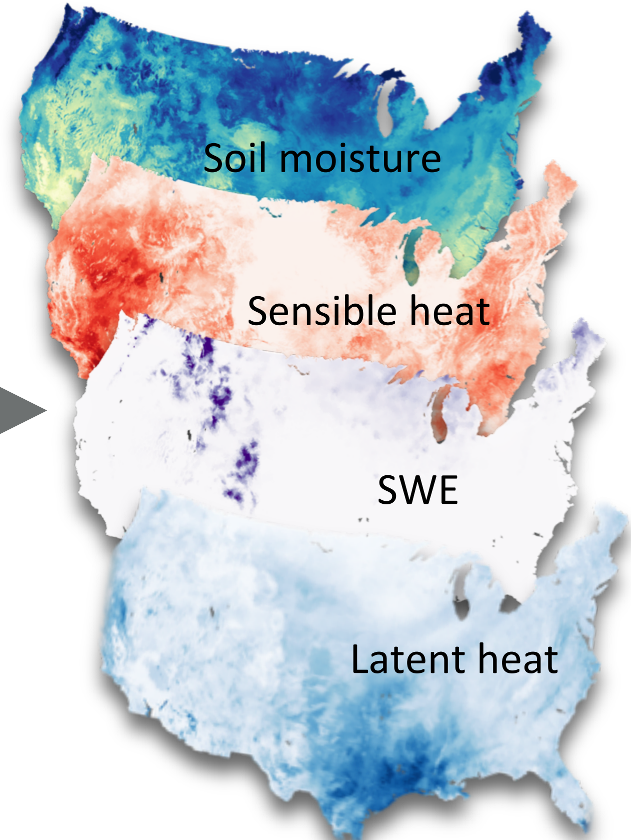
Environmental data



HydroBlocks

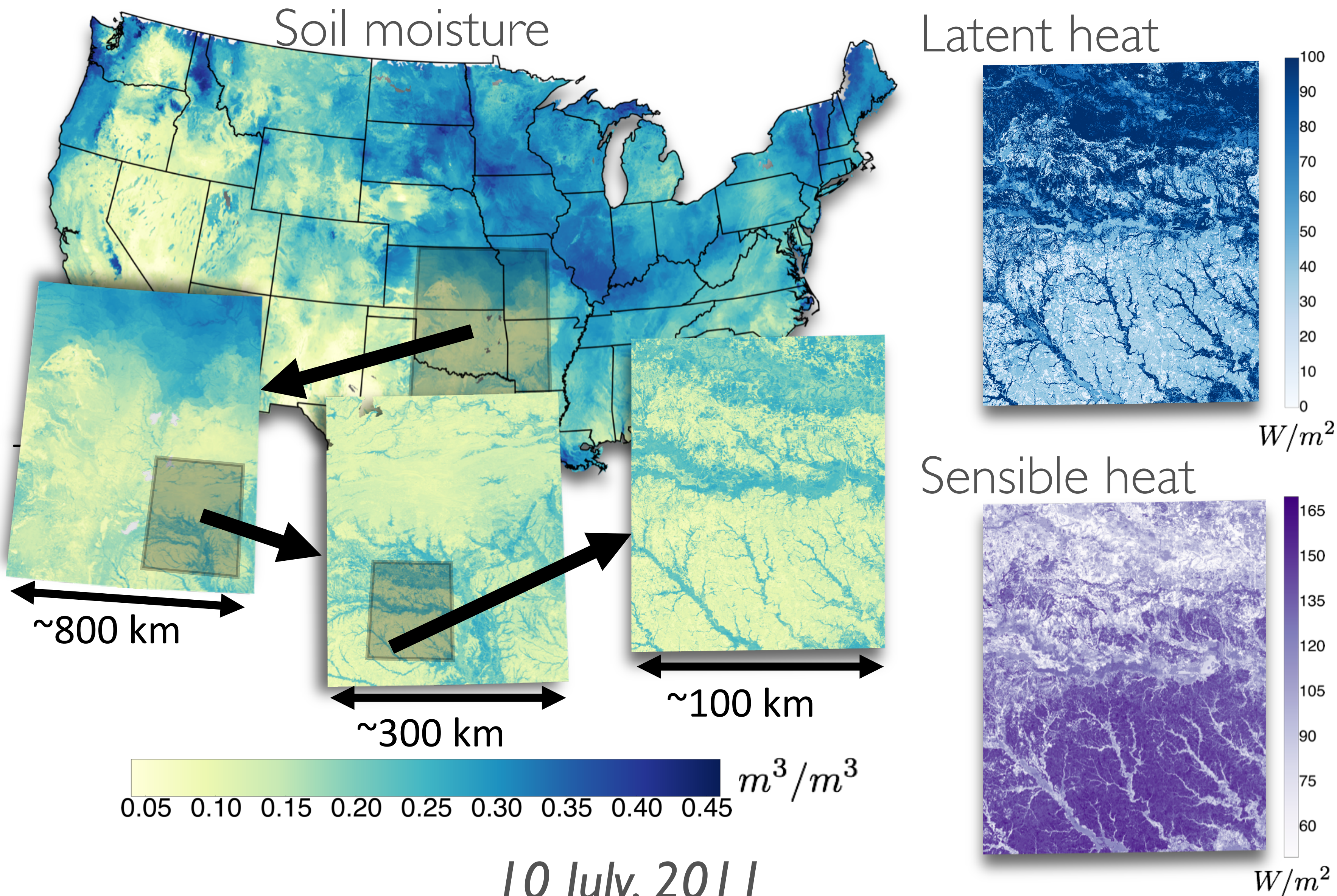


Simulations



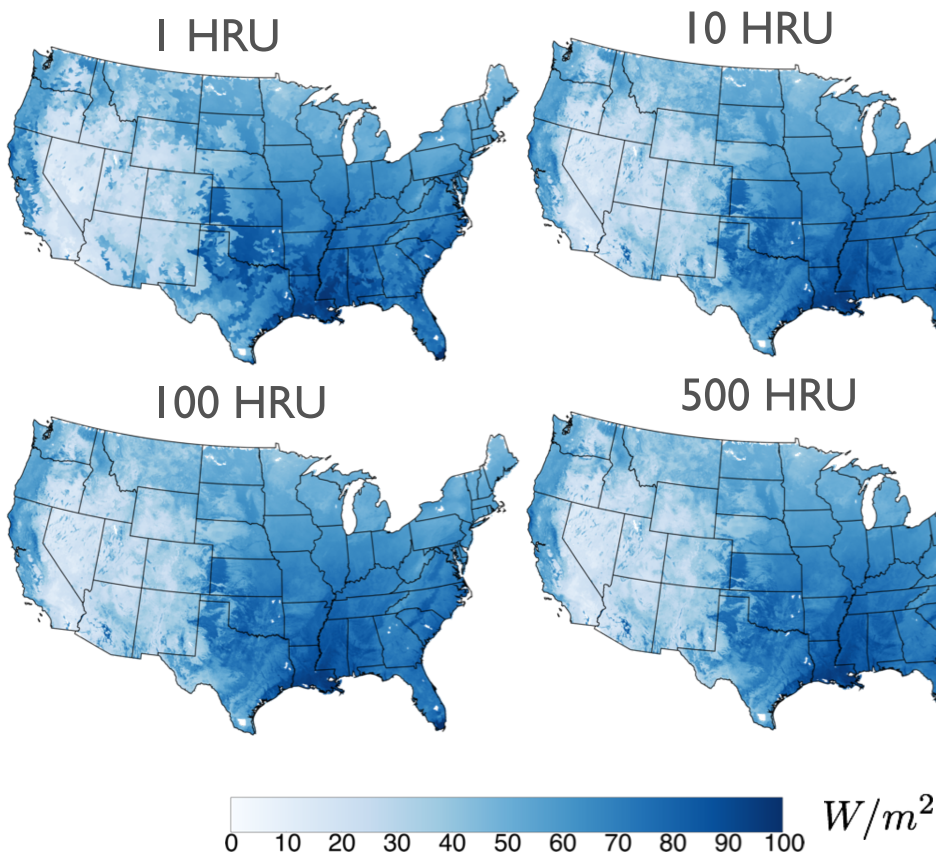
- HydroBlocks run on the ~15000 HUC10 CONUS catchments
- 500 HRUs per HUC10 catchment
  - 7.5 million different HRUs over CONUS
  - Each 30 meter grid cell belongs to a HRU
- Hourly simulations between 2002 and 2014 (~40 terabytes)

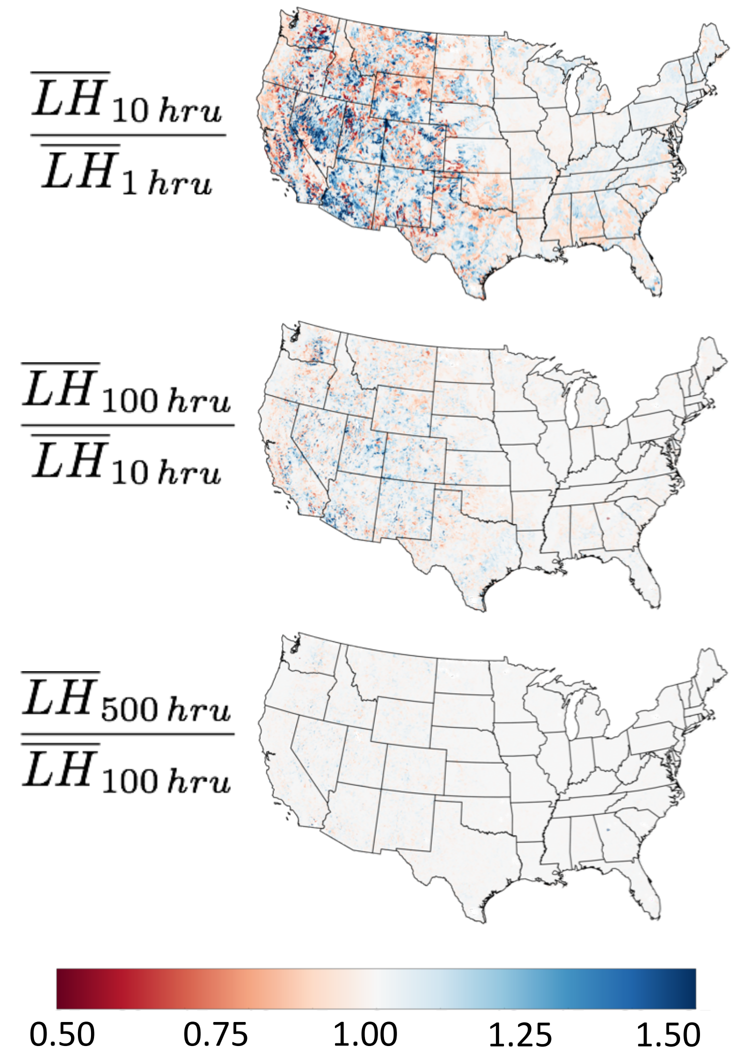
HydroBlocks CONUS: Example



Does the number of HRUs per catchment impact the macroscale?

Simulated mean latent heat (2005-2014)



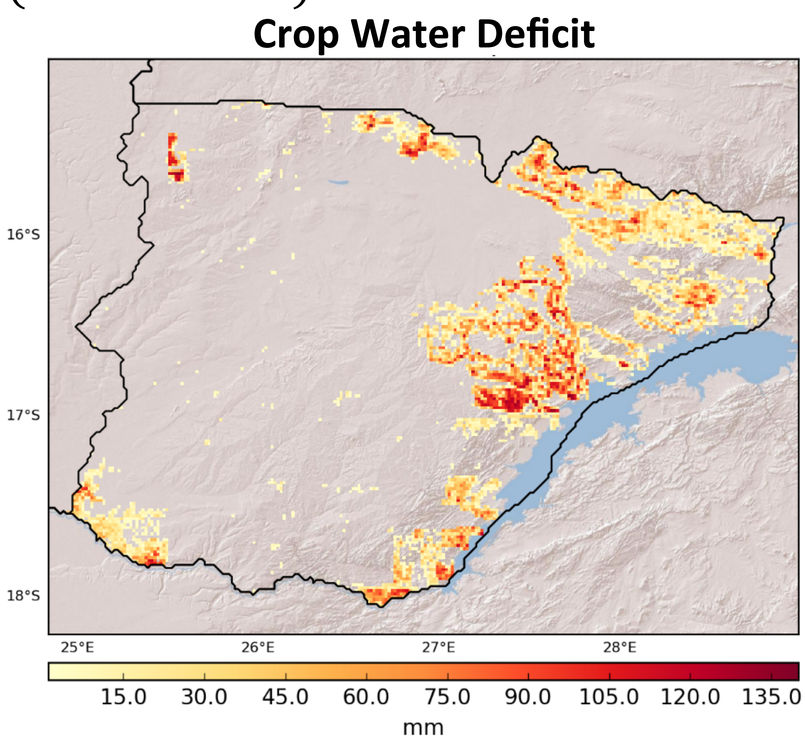


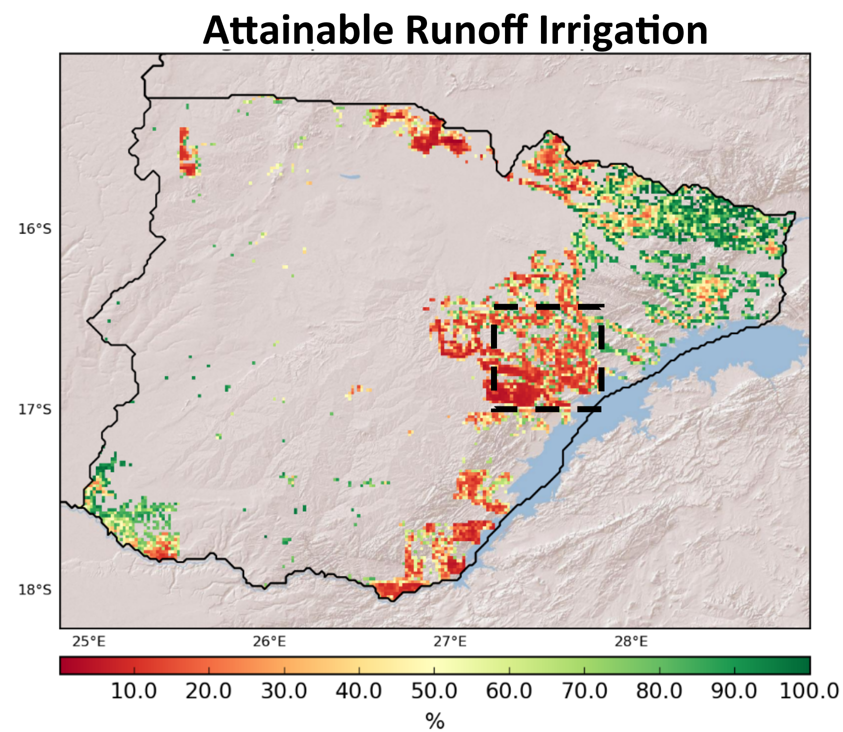
*Upscaled to 4 km grid for comparison

Current Work: Using HydroBlocks for Crop Water Deficit and Irrigation (Zambia)

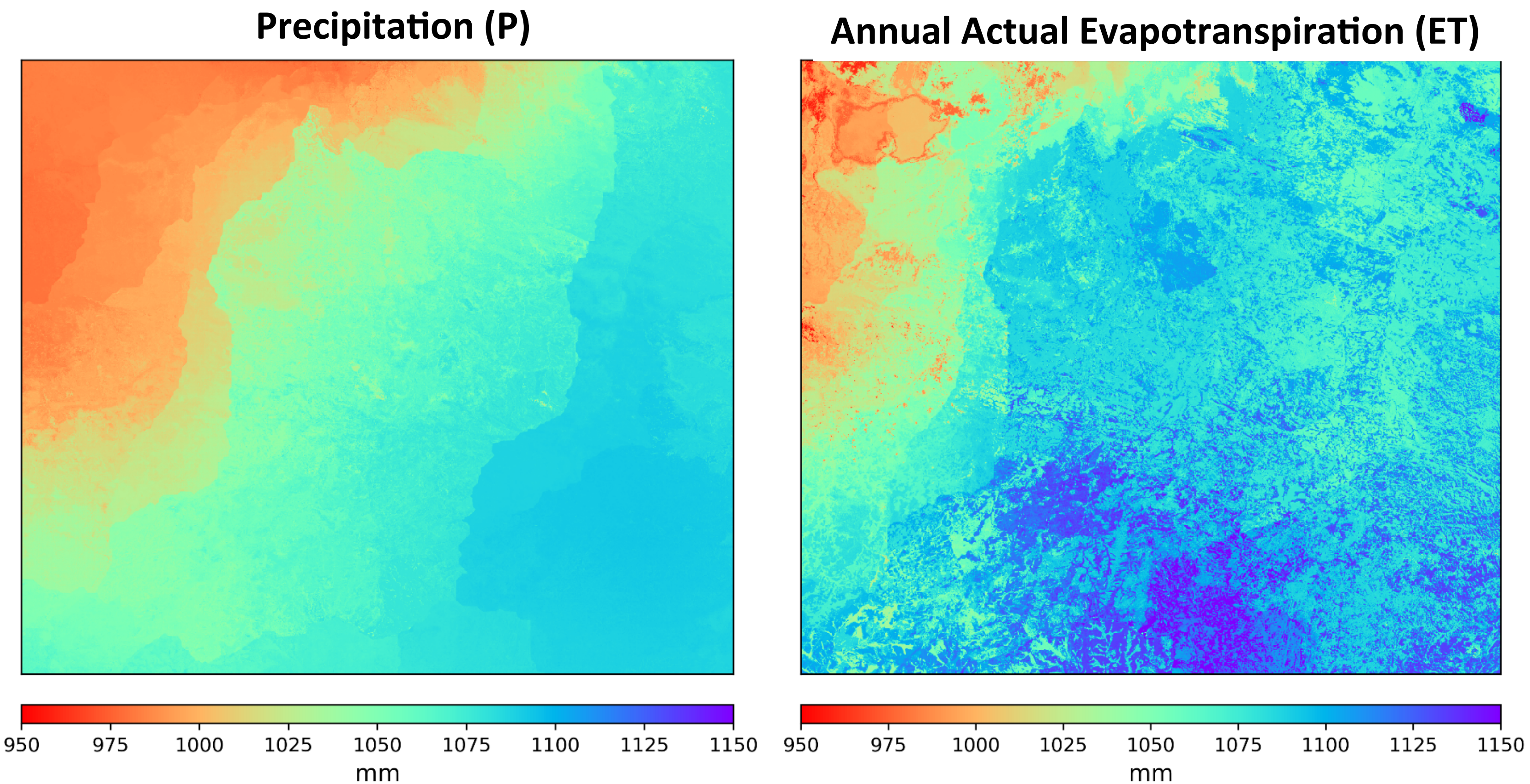
$$Crop\ Water\ Deficit = \sum_{growing\ season} C_f\,(ET_c - ET_a)$$

$$ARI = 100 * \sum_{rainy\ season} Runoff \Big/ \sum_{growing\ season} Crop\ Water\ Deficit$$



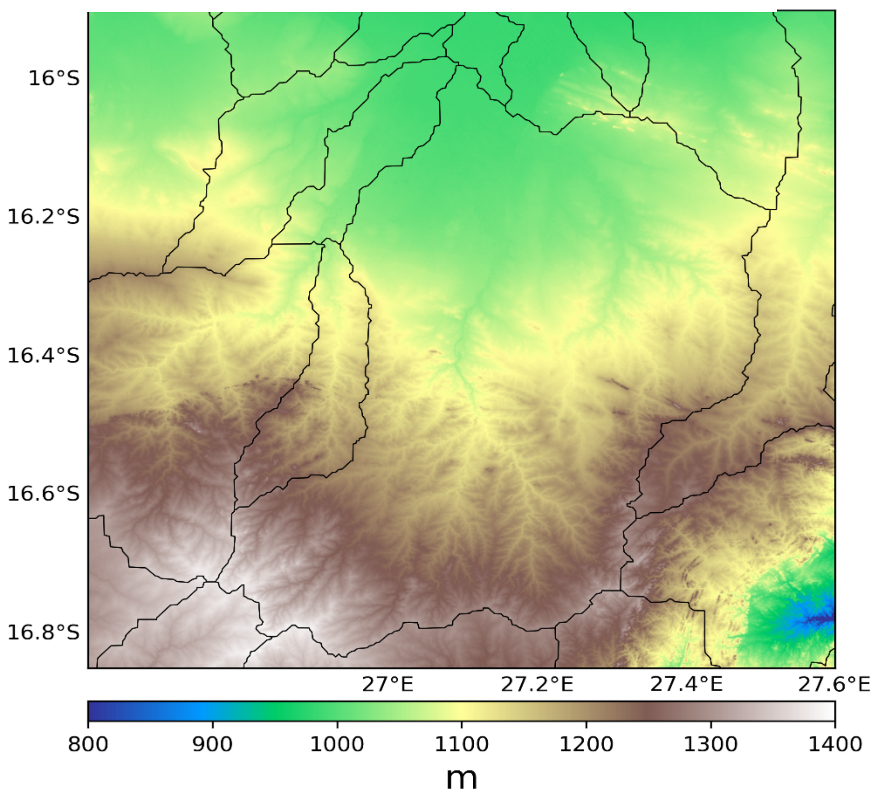


Application to Zambia: Precipitation and Evapotranspiration

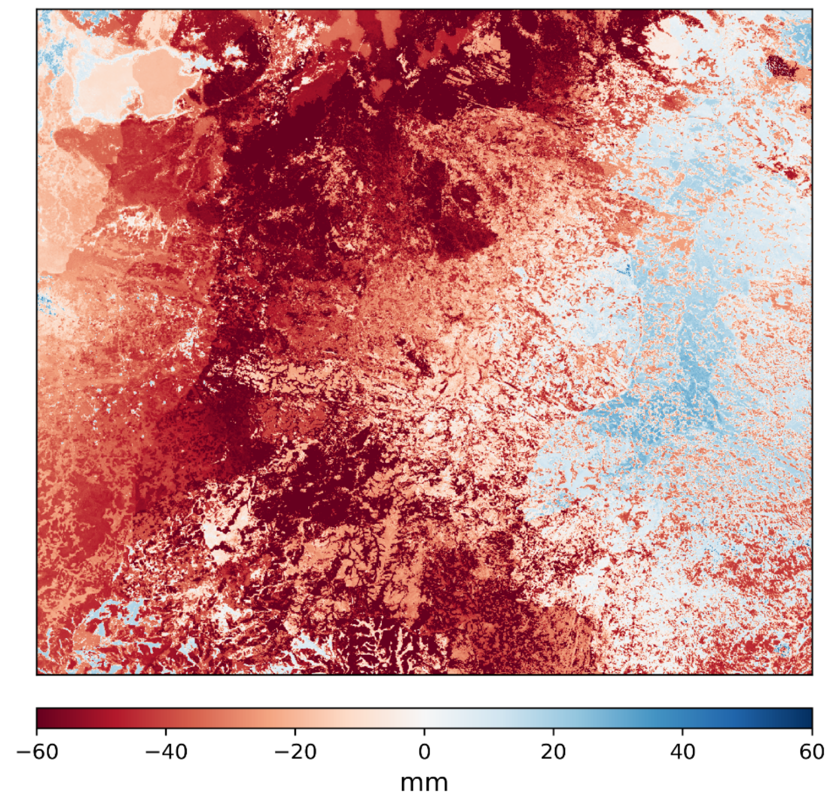


Application to Zambia: Elevation and P-ET

Elevation

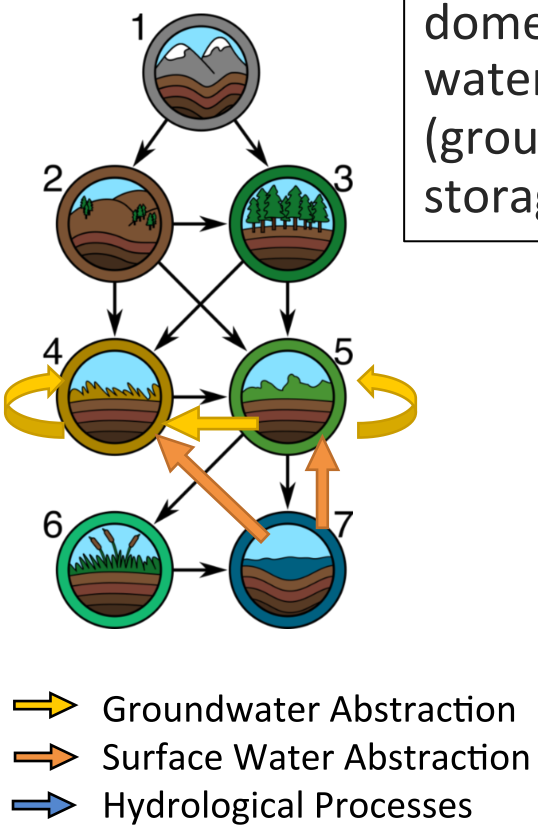


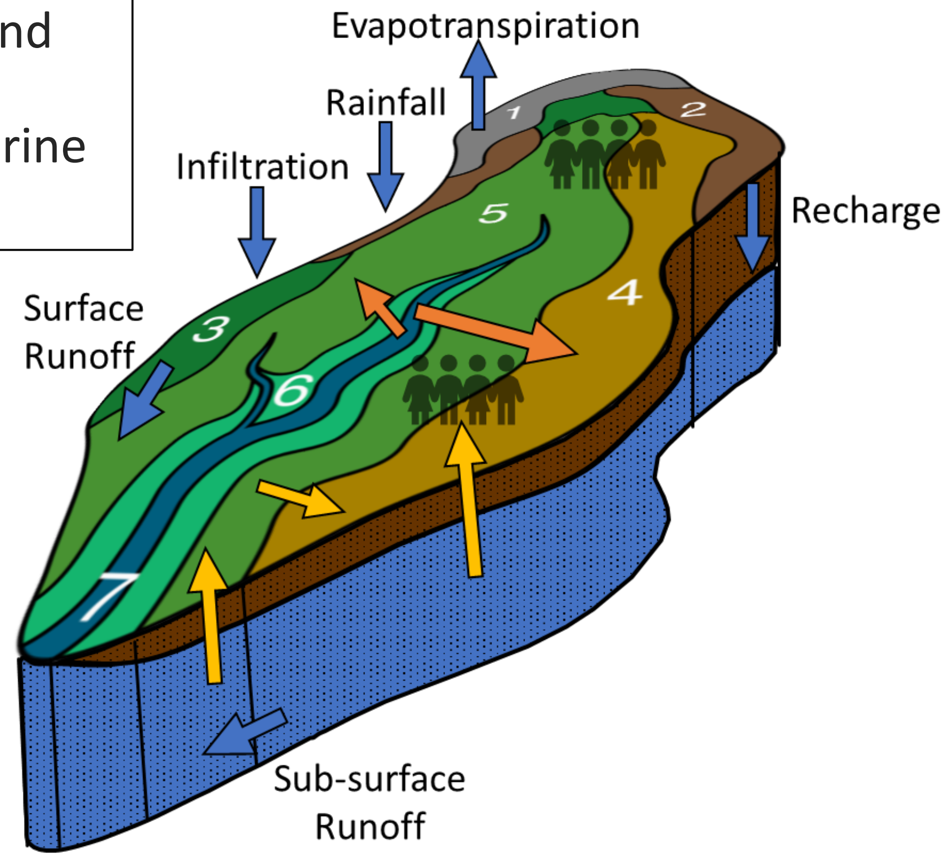
Precipitation – Actual Evapotranspiration (P-ETa)



Current Work: Modeling Human-Water Dynamics

Extend Hydroblocks to simulate **human-water dynamics**, including water demand (agriculture, domestic, industrial) and water abstractions (groundwater and riverine storage)





Application to Zambia:
Root zone soil moisture and crop water deficit