

Enhancing Accessibility and Reproducibility of Agroecosystem Modeling Research through Open-Source Web Tools



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*Reproducible research is the
foundation
on which scientific progress is
built.*

“

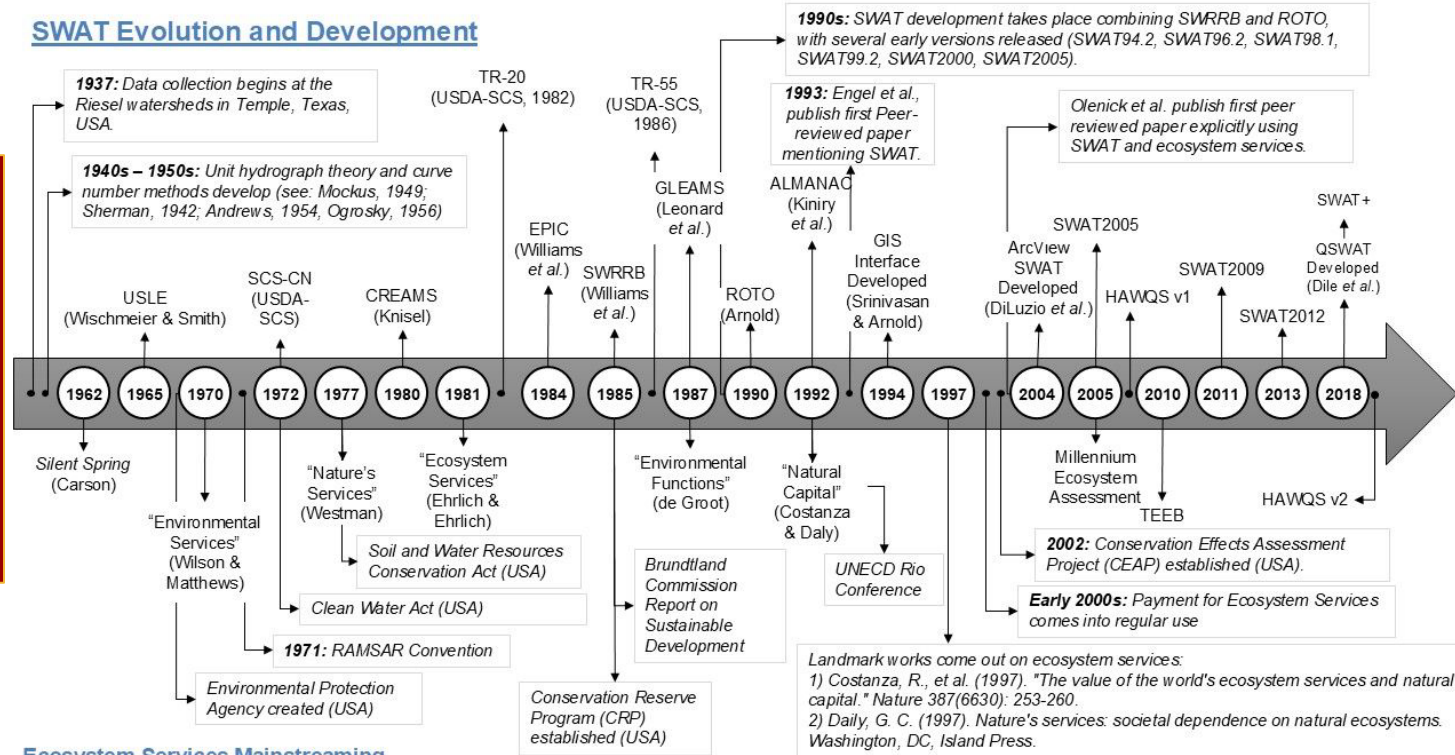
Development history

SWAT+

SOIL & WATER ASSESSMENT TOOL

Product of over
45 years of
U.S. Department of
Agriculture and
Texas A&M University
model development, with
multiple additions from
the international user-
community

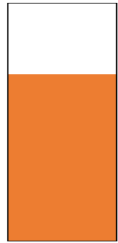
SWAT Evolution and Development



Ecosystem Services Mainstreaming

SWAT has a more than **80-year history** of rigorous hydrological research and development on experimental watersheds behind it

Large proportion of scientific research is not reproducible



> 70% failed to reproduce other scientists' work

Baker, 2016- Nature

Only 11% was reproduced successfully by peers

Begley and Ellis, 2012- Nature

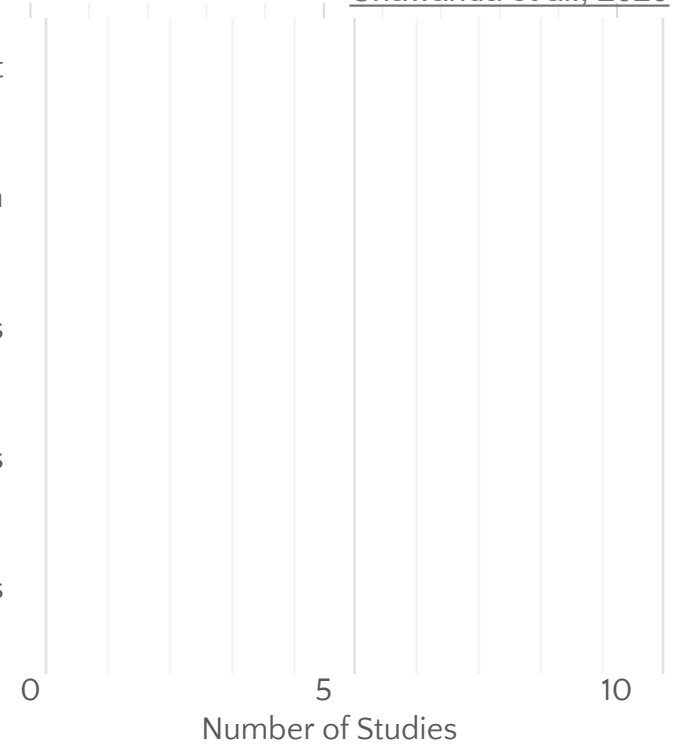


Reproducibility of SWAT+ Studies in **Blue Nile**

Issues

Chawanda et al., 2020

Management
Calibration
Process Options
Setup Settings
Data Sources





Solution

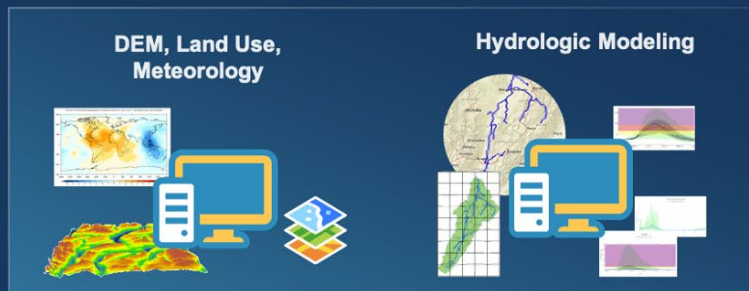
From This



Global
Data



To This



SWAT Modeling Made Simple

HAWQS

Hydrologic and Water Quality System

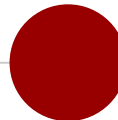


hawqs.tamu.edu



Land Use	National Land Cover Database (NLCD)	
	USDA NASS Cropland Data Layer (CDL)	2014 – 2017
	USDA NASS Fields	2006 – 2010
	U.S. Fish and Wildlife Service (FWI) National Wetlands Inventory (NWI)	2018
Soil	USDA NRCS SSURGO Database	
	USDA NRCS STATSGO Database	2018

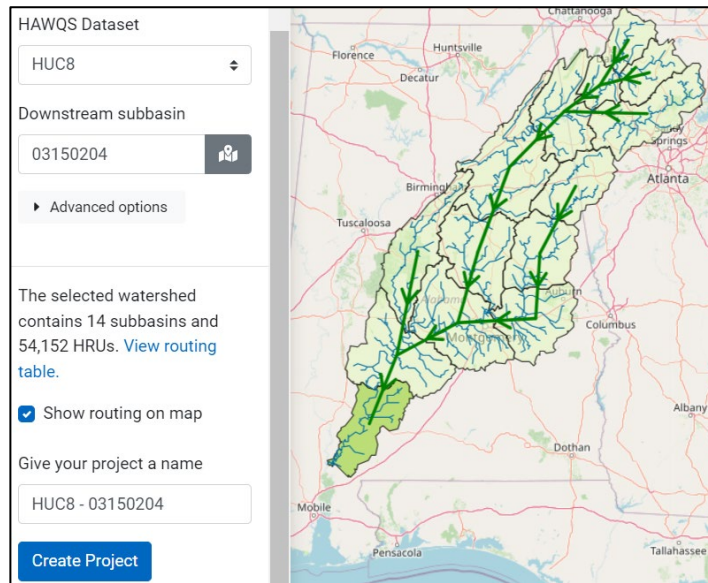
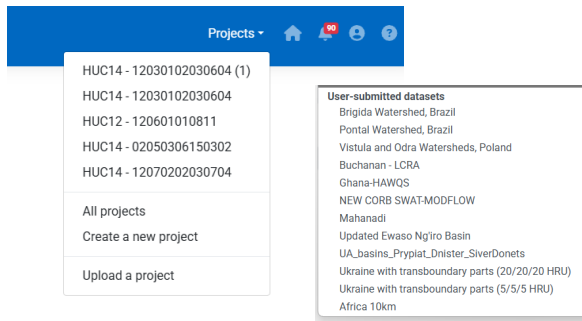
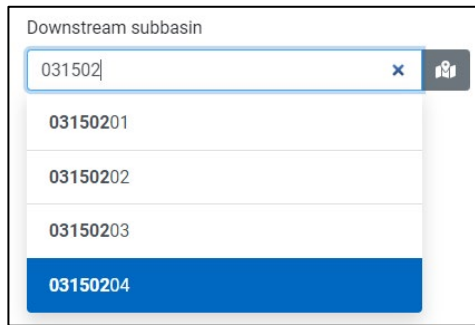
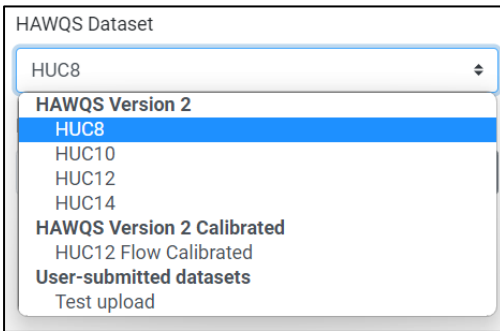
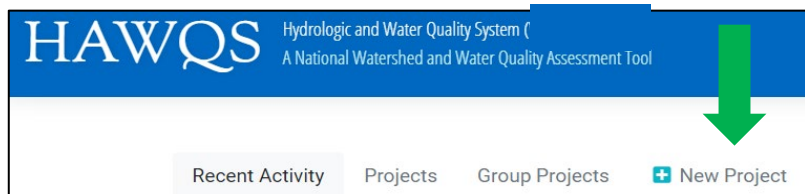
Watershed Boundaries	EPA NHDPlus v2	
Stream Networks	EPA NHDPlus v2	2019
Elevation	USGS National Elevation Dataset (NED)	2018



Federally Approved Input Datasets

Input Dataset	Source	Specifications
Weather	PRISM	1981 – 2020 (gridded)
	NEXRAD	2005 – 2020 (gridded)
Soil	USDA NRSC SSURGO Database	2018
	USDA NRCS STATSGO Database	2018
Land Use	National Land Cover Database (NLCD)	2016
	USDA NASS Cropland Data Layer (CDL)	2014 – 2017
	USDA NASS Fields	2006 – 2010
	U.S. Fish and Wildlife Service (FWI) National Wetlands Inventory (NWI)	2018
Aerial Deposition	National Atmospheric Deposition Program (NADP)	1980 – 2020 (monthly)
Watershed Boundaries	EPA NHDPlus v2	2019
Stream Networks	EPA NHDPlus v2	2019
Elevation	USGS National Elevation Dataset (NED)	2018 (10-meter DEM)
Point Sources	EPA Hypoxia Task Force (HTF)	2019
	EPA Integrated Compliance Information System National Pollutant Discharge Elimination System (ICIS-NPDES)	2019
	USDA NRCS crop management zone data	2010
Ponds, Potholes, and Reservoirs	U.S. Army Corps of Engineers (USACE) National Inventory of Dams (NID)	2018
	EPA NHDPlus v2	2019
Crop Data	USDA NASS CDL	2014 – 2017
Wetlands	FWS NWI	2018
Water Use	USGS Water Use in the United States	2015

SWAT Model setup- just a few clicks away!!



HAWQS API



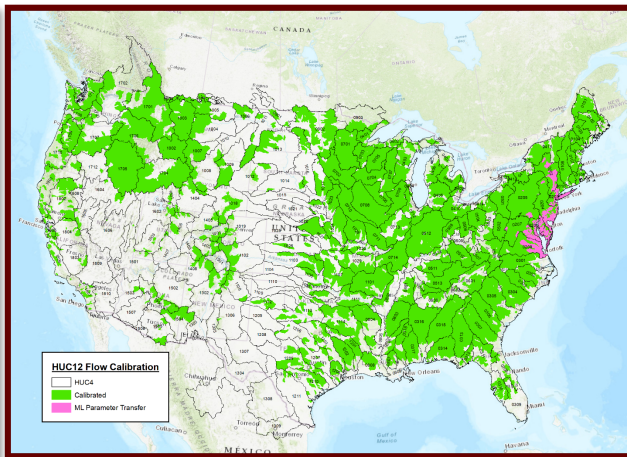
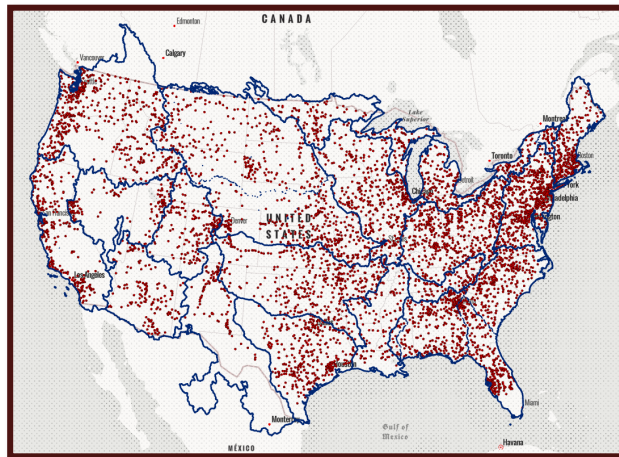
The best inventions are never finished. Great inventors don't just stand there, rub their hands together, and say 'My work is done here'. They keep working furiously to create something even better. It's part love, part n...

ERIC SCHMIDT



Meaningful: The Story of Ideas That Fly

SWAT Hydrological Calibration- USGS gages



Calibrated **38,295** HUC12s out of 79,837

4,113 gages calibrated across CONUS

HUC2	Total Gages	Calibration Successful	Gages Calibrated (%)
R01	258	241	93.41
R02	553	482	87.16
R03	808	696	86.14
R04	334	241	72.16
R05	528	473	89.58
R06	98	88	89.80
R07	414	352	85.02
R08	104	95	91.35
R09	88	58	65.91
R10	593	297	50.08
R11	392	247	63.01
R12	330	167	50.61
R13	91	24	26.37
R14	183	78	42.62
R15	156	42	26.92
R16	131	45	34.35
R17	515	349	67.77
R18	268	141	52.61
Total	5844*	4113	70.37

Bawa et al., 2023, Environmental Modelling & Software

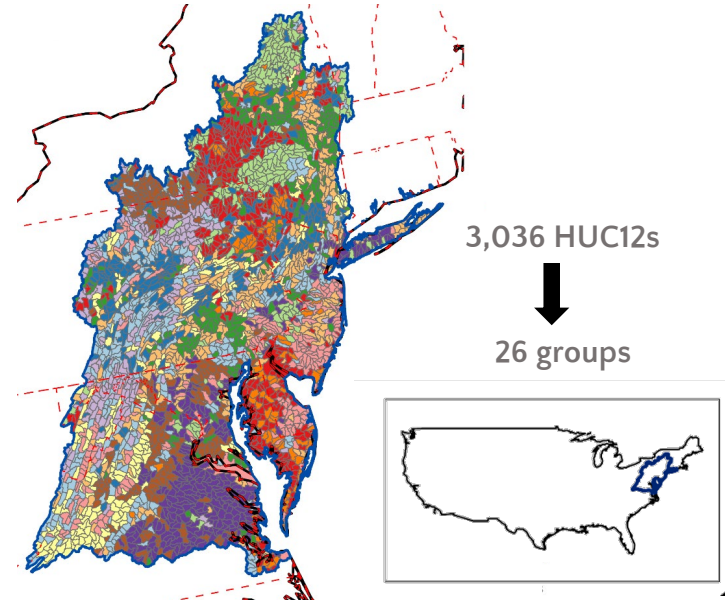
Predictions in Ungauged Basins- Parameter Regionalization

Physical similarity-based clustering of HUC12 with spatial proximity at HUC2 scale

Unsupervised clustering: Random Forest + Hierarchical clustering

Predictors

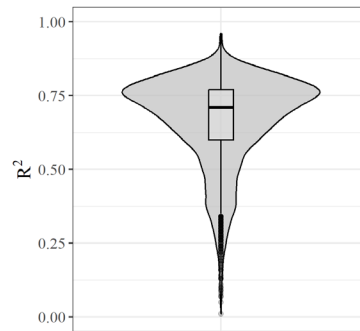
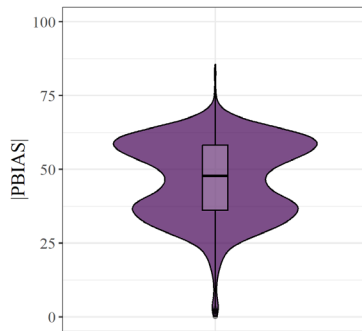
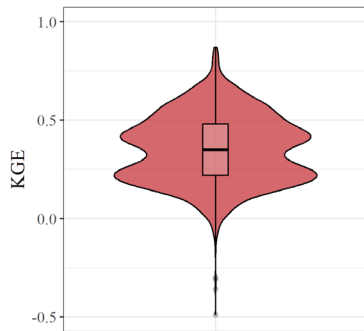
1. Surface runoff/Precipitation
2. Lateral flow/Precipitation
3. Groundwater/Precipitation
4. Evapotranspiration/Precipitation
5. Annual Average Temperature [1983-2020]
6. Average Curve Number
7. CN 35-50: % area with low runoff potential
8. CN 50-70: % area with moderate runoff potential
9. CN 70-85: % area with high runoff potential
10. CN 85-99: % area with very high runoff potential
11. Slope



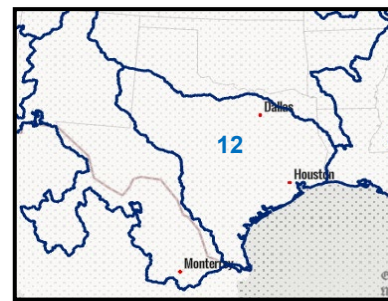
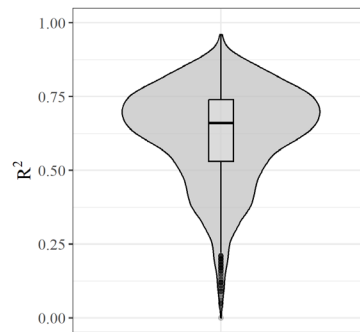
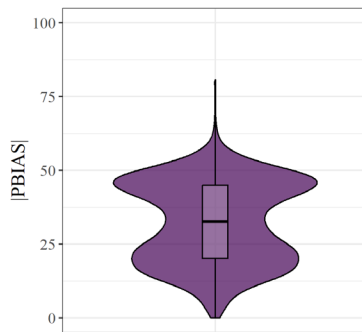
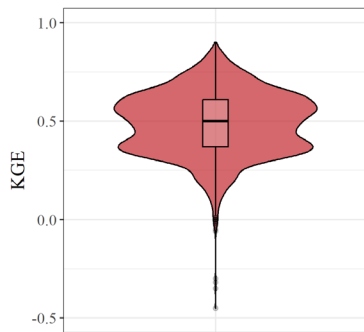
Bawa et al., 2025, Environmental Modelling & Software

SWAT Hydrological Calibration- openET

SWAT Default
Parameters



After ET
Calibration



R12: 3,871 HUC12s

KGE > 0.3

Before: 2,278 (58.9%)

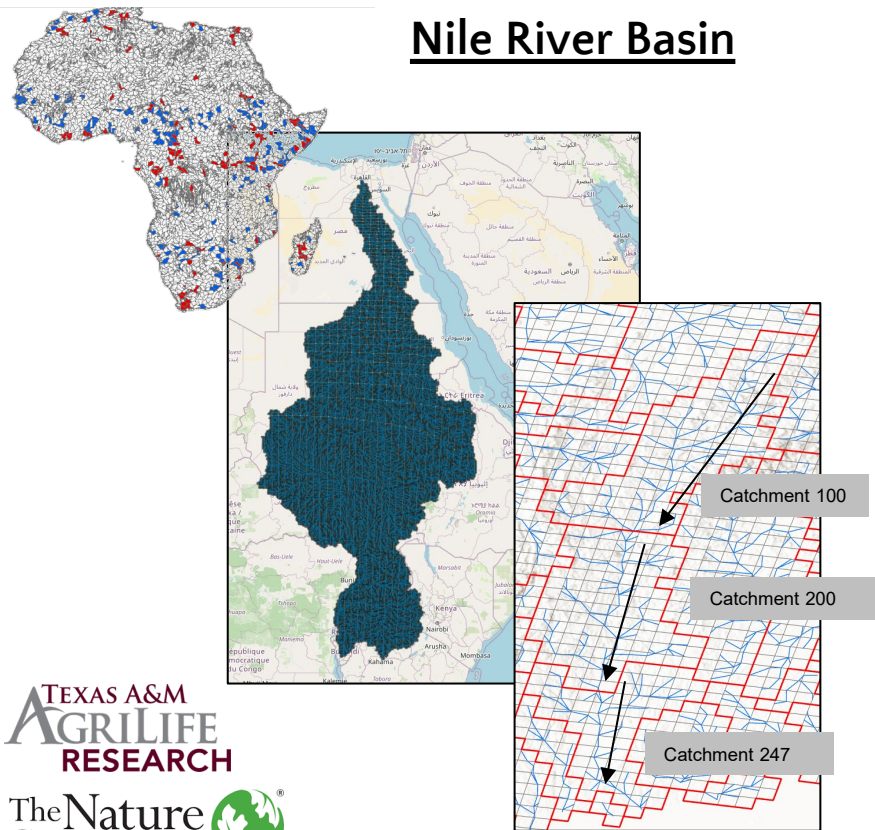
After: 3,498 (90.4%)



Global Gridded SWAT 2012

Africa- available on **Global HAWQS**
<https://global.hawqs.tamu.edu>

Nile River Basin

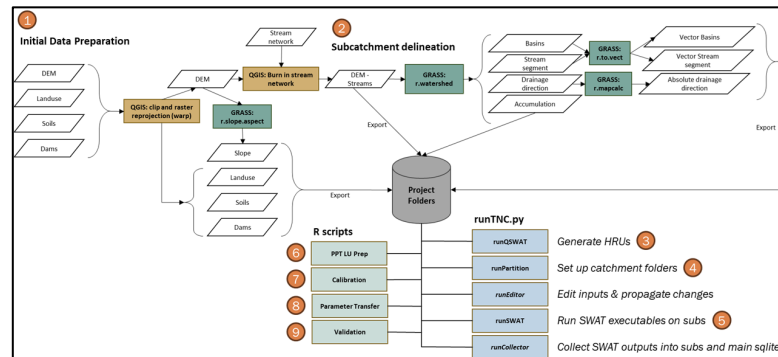


Subbasin: 10 km X 10 km
Catchment: ~10,000 km²
HRUs: 6 HRUs in each subbasin

DEM: SRTM 90m
Landcover: GlobCover 2009
Soil: FAO HWSD
Weather: CHIRPS & CHIRTS

Calibration- MODIS ET/monthly/subbasin
Validation: GRDC stream Discharge

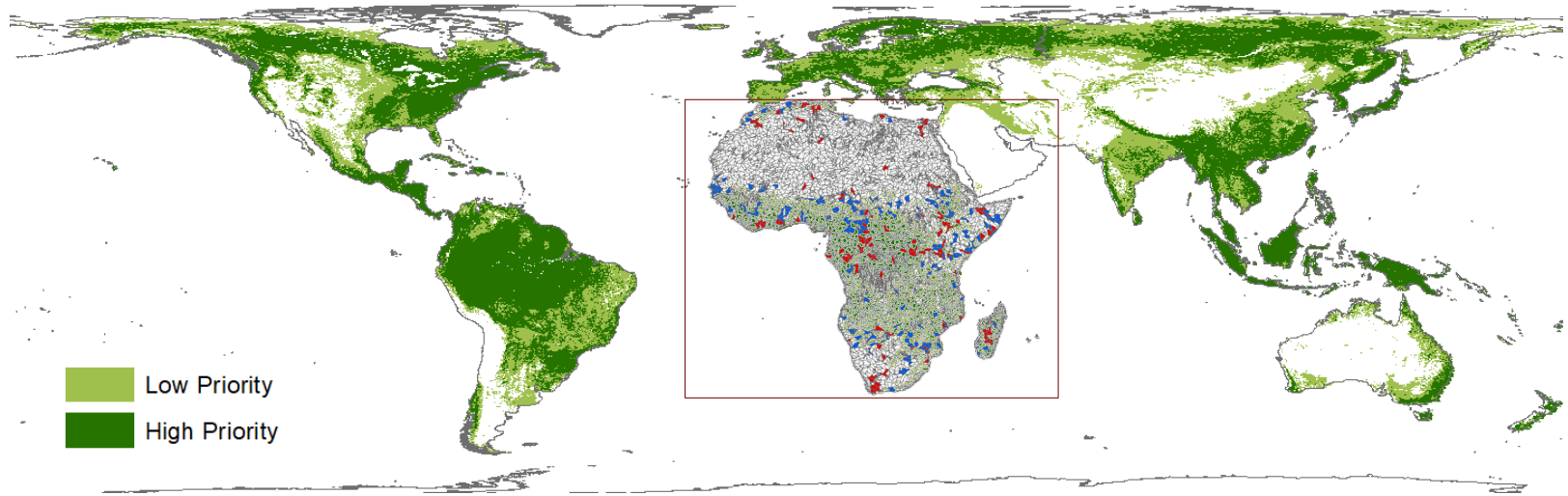
User-submitted datasets
 Brigida Watershed, Brazil
 Pontal Watershed, Brazil
 Vistula and Odra Watersheds, Poland
 Buchanan - LCRA
 Ghana-HAWQS
 NEW CORB SWAT-MODFLOW
 Mahanadi
 Updated Ewaso Ngiro Basin
 UA_basins_Pryplat_Dnister_SilverDonets
 Ukraine with transboundary parts (20/20/20 HRU)
 Ukraine with transboundary parts (5/5/5 HRU)
 Africa 10km ←





Global Ecosystem Modeling

Potential Areas for Reforestation Consideration



Map credits: TNC



Global SWAT+ CoSWAT

Subbasin:-

Catchment: 88 major basins across globe

HRUs: 2 km [1 km in process]

DEM: ASTER

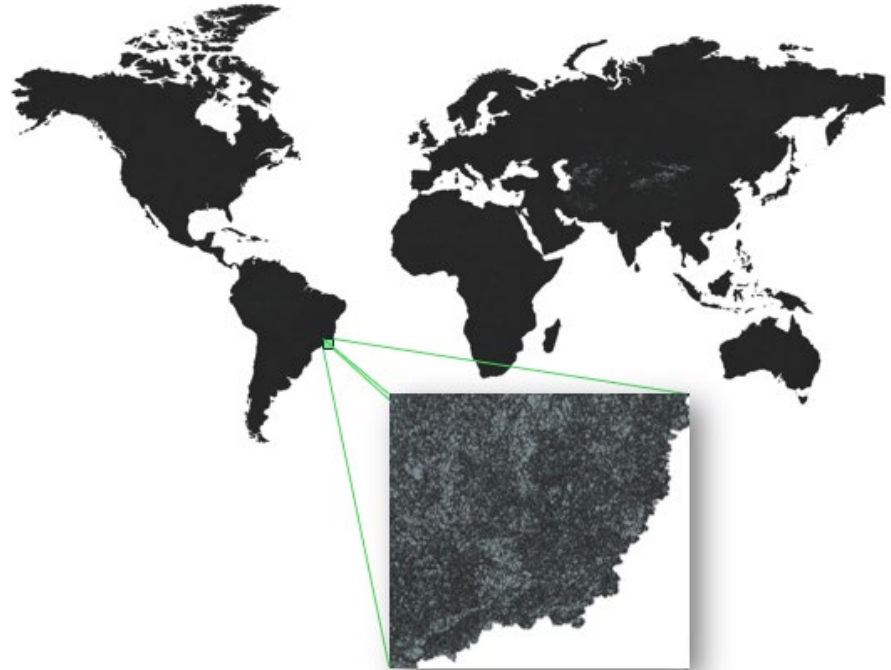
Landcover: ESA landuse

Soil: FAO

Weather: ISIMIP

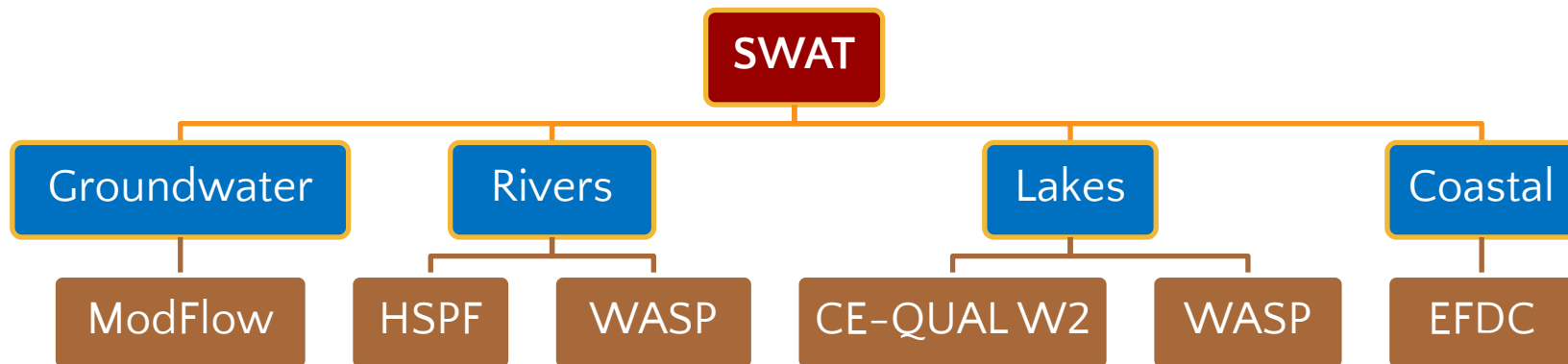
Calibration- GLEAM ET (78.54% within the range 100mm ET difference)

Validation: GRDC stream Discharge





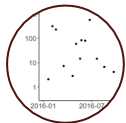
HAWQS integration



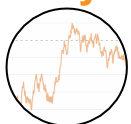
Methodology

Results

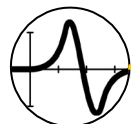
WQ observed data



Dynamic

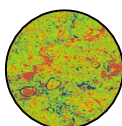


Flow

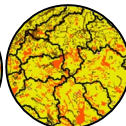


Seasonality

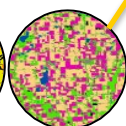
Static



Topographical

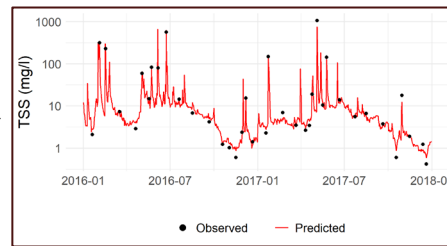


Soil

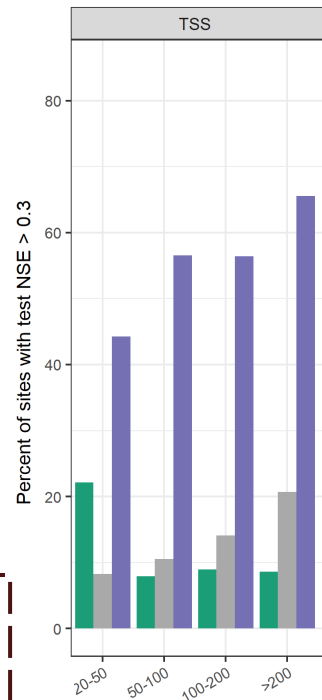


Landcover

XGBest



**LOADEST
WRTDS**



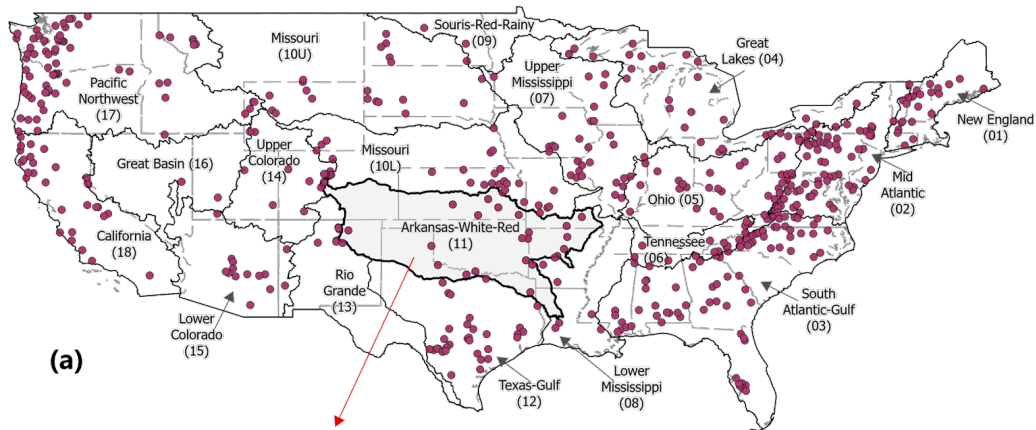
Number of samples per site

LOADEST WRTDS XGB



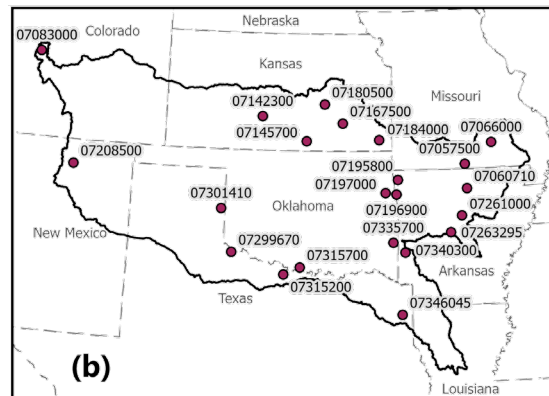
HAWQS-SWAT-LSTM

Training: 509 watersheds



(a)

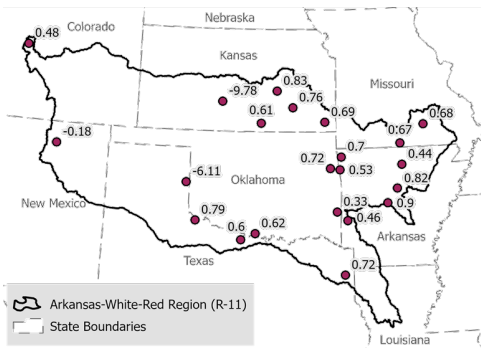
Test: 22 watersheds



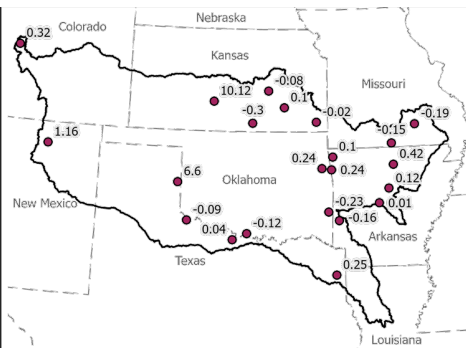
(b)

- USGS Hydrologic Regions
- Arkansas-White-Red Region
- Study Watersheds
- US State Boundaries

KGE



PBIAS





Thanks!

questions ?



hawqs.tamu.edu

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