CZO's-Big Data & Team Science

Towards a Cyberinfrastructure For Scaling Up and Sharing Data & Models

C. Duffy, L. Leonard, G. Bhatt, X. Yu, P. Raghavan Penn State Univ.

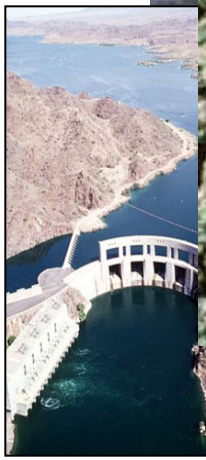
CZO Testbeds for Science and Science-Based Approach to Water & Ecosystem

Drinking

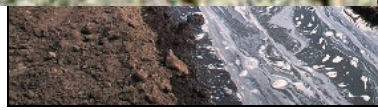
m Services

gation

Hydropo



Drought



Floods


5
39
23
29
51
46
9
62
24
49
17
42
3
41
34
31
15
20
12
37
52
61
Imagery ©2013 NASA

CZO's -> Big Data & Big Simulation

Some Issues & Questions

Scaling up CZO Simulations & Data: Framework for Earth Casting

The Essential Terrestrial Variables - National Products?

Cyberinfrastructure for Virtual Data and Models

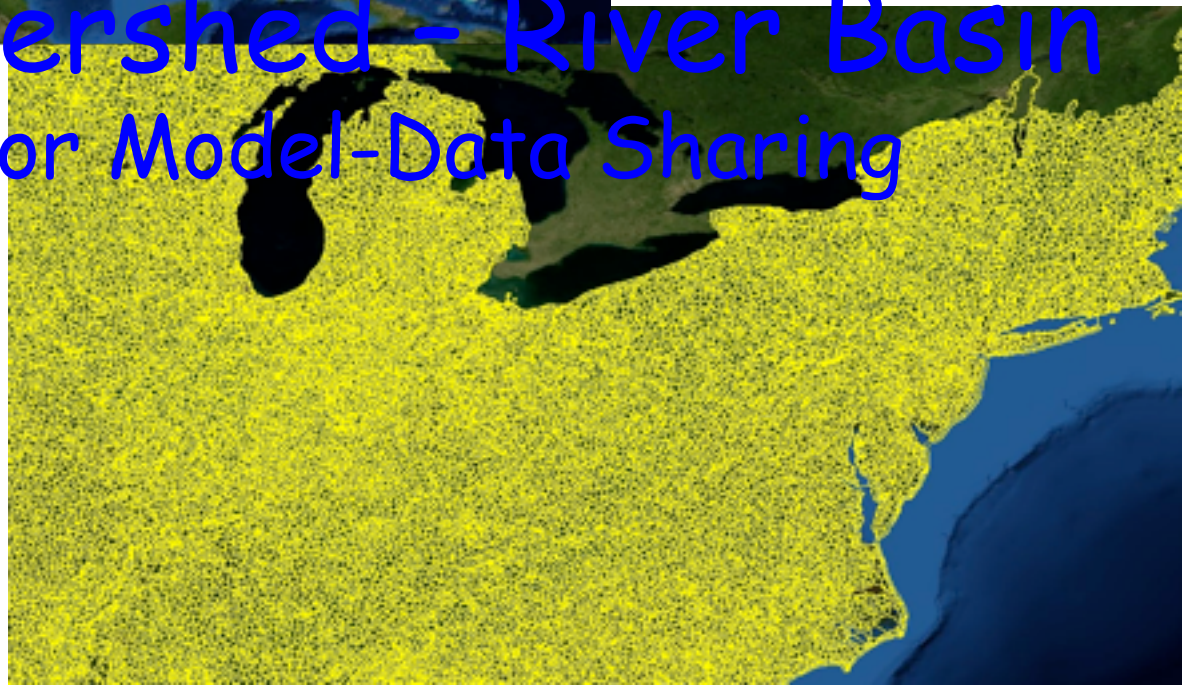
Reanalysis - Reconstruction and the Role of Environmental Observatories

Platform for communicating science and science-based decision making?

2,268 USGS
HUC 8
watersheds

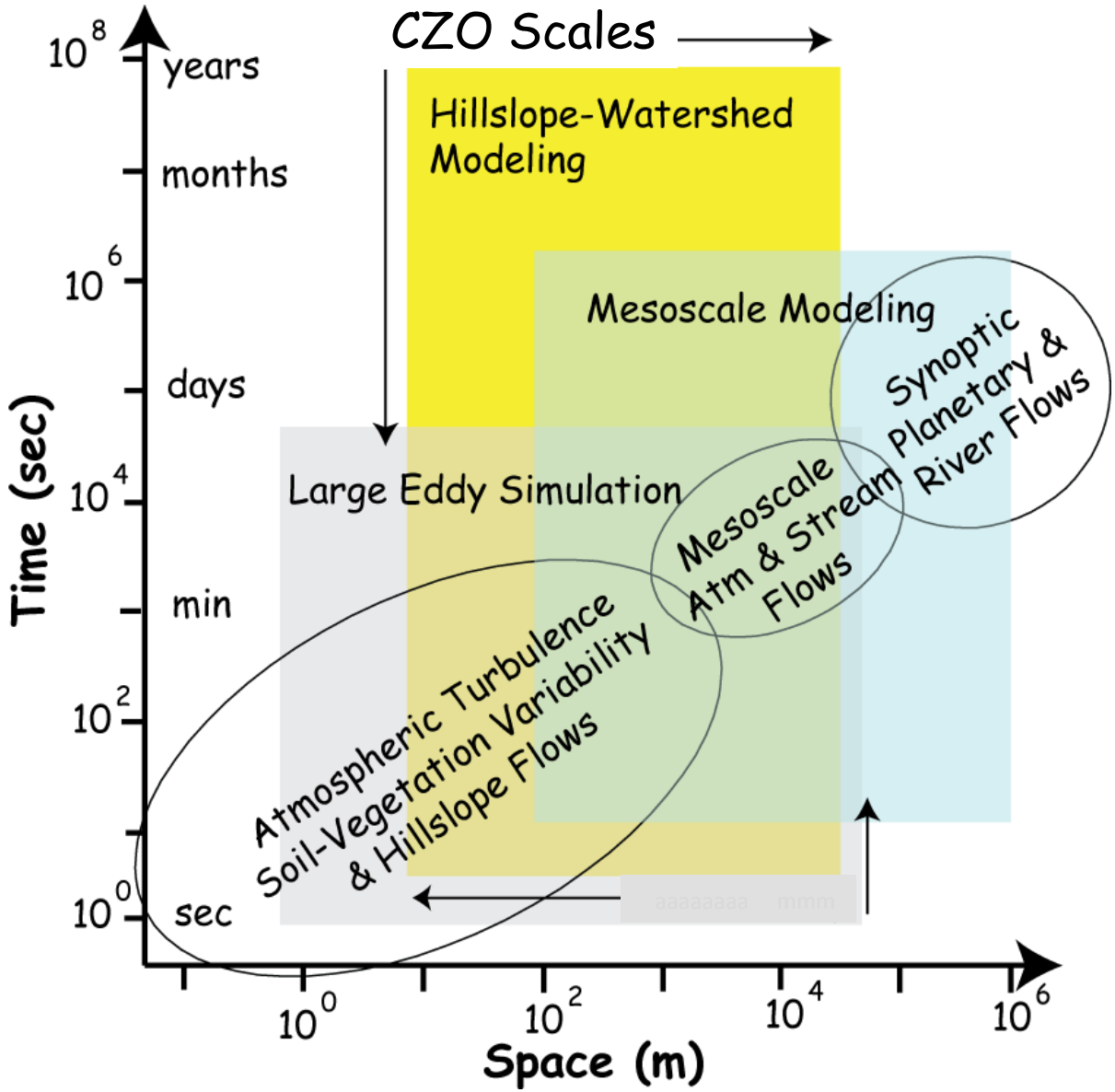
The Watershed – River Basin

Basis For Model-Data Sharing



103,444 USGS
HUC 12
watersheds

Importance of CZO's for Scaling Up Processes/Models

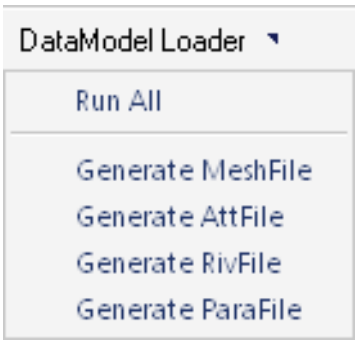


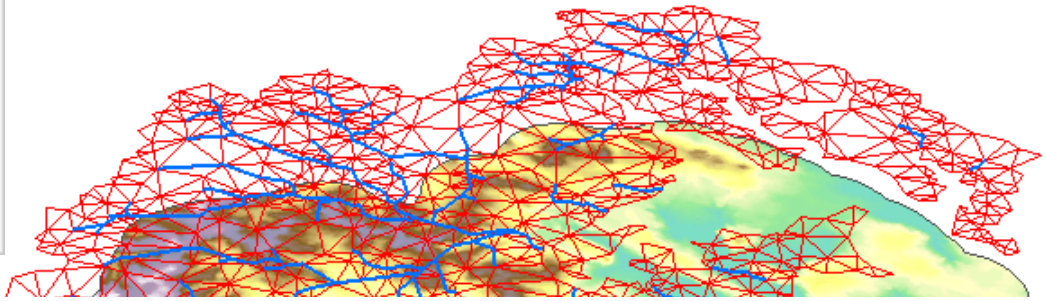
What are the Essential Terrestrial Variables?

Water-Energy-Solute-Vegetation

- Atmospheric Forcing (precipitation, snow cover, wind, relative humidity, temperature, net radiation, albedo, photosynthestic atmospheric radiation)
- Digital elevation models (30, 10, 3, 1m resolution)
- River/Stream discharge, stage, cross-section
- Soil (texture, C/N, organic, hydrologic & thermal properties)
- Groundwater (levels, extent, hydrogeologic properties)
- Land Cover (biomass/leaf area index, phenology,…….)
- Land Use (human infrastructure, demography, ecosystem disturbance, property & political boundaries)
- Environmental Tracers- stable isotopes
- Water Use and Water Transfers
- Lake/Reservoir/Diversion (levels, extent, discharge, operating rules)
- …to be cont'd……..??

Most data reside on federal servers ….many terabytes



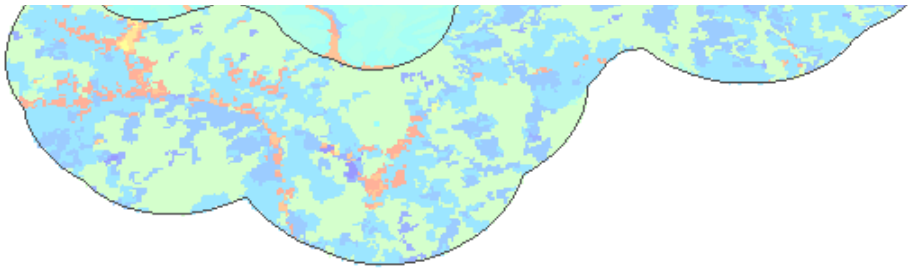


Irregular Mesh &
Stream Network

Register geospatial & geo-temporal fields

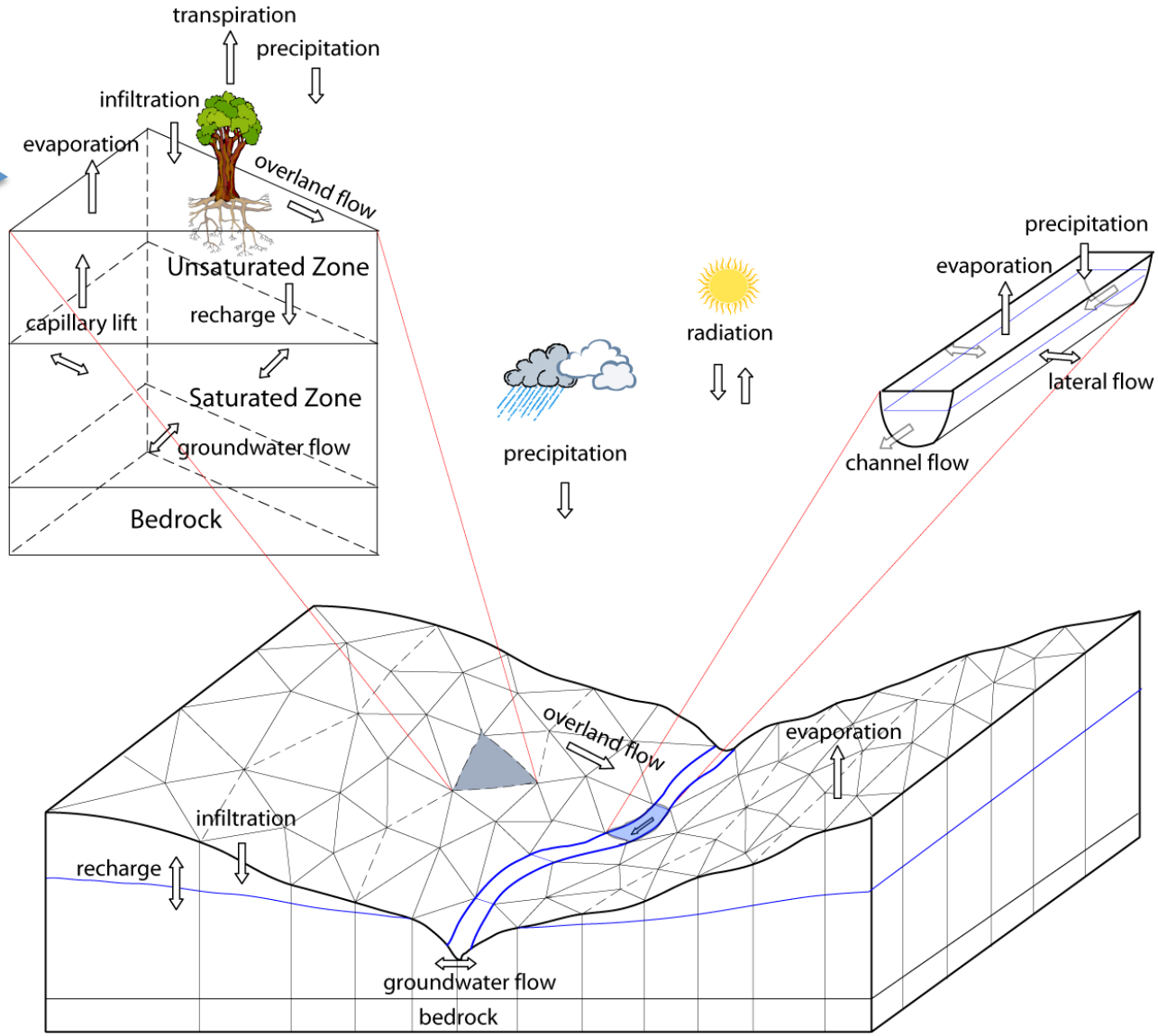
Access to ETV's

Automate CZO Modeling Workflow



Penn State Integrated Hydrologic Model (PIHM)

NOAH Land Surface Model



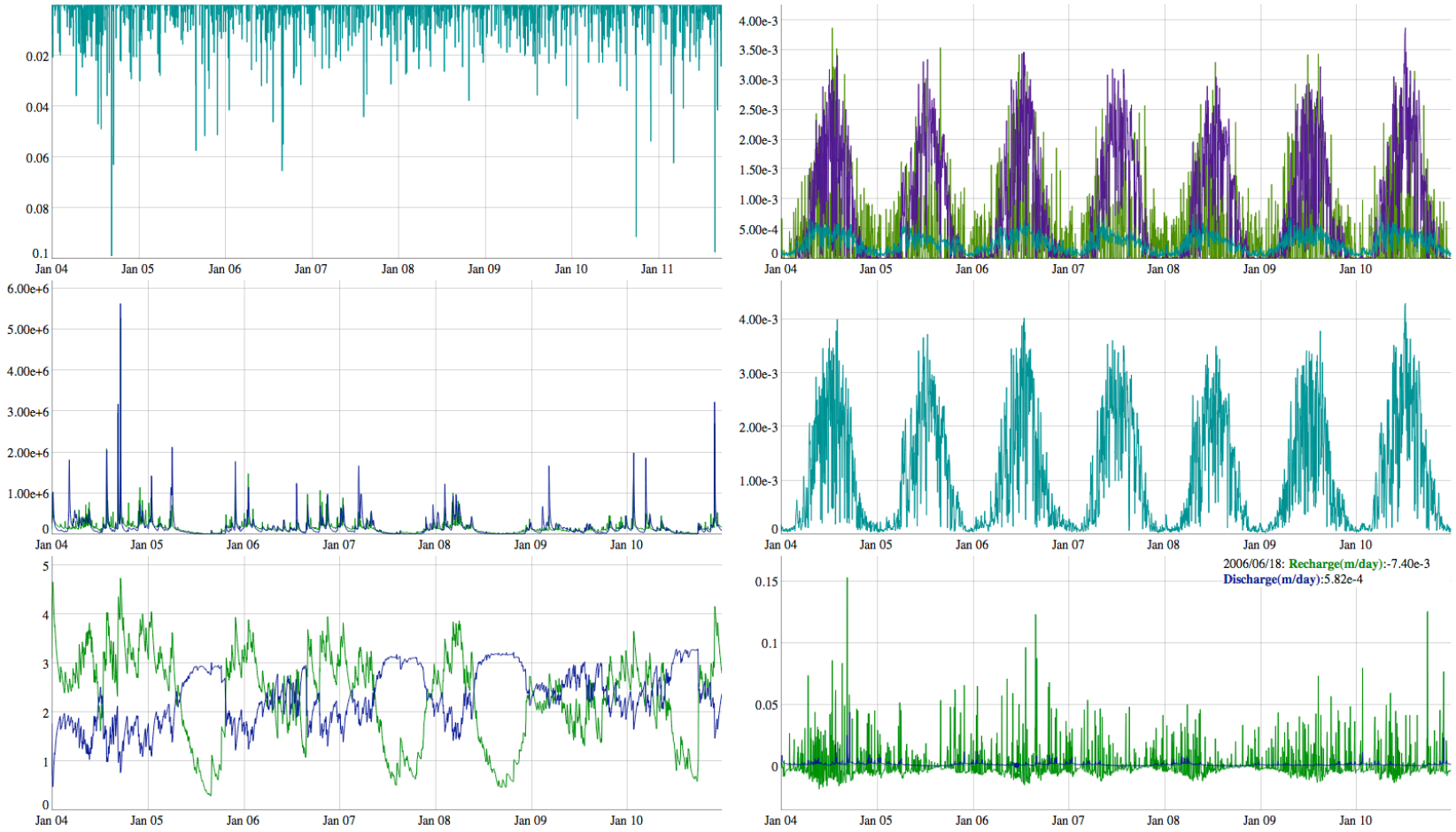
PIHM Qu and Duffy 2007. Kumar, Bhatt, Duffy 2009

HydroTerre: A Prototype for Model-Data Access

Land Parcel Data; NHD: Stream, Lake, HUC'; USDA: Soils/Crops; NLCD: LU_LC;

http://www.pihm.psu.edu/applications.html

CZO Reanalsysis time series: 1979-Present



Xuan Yu, lead

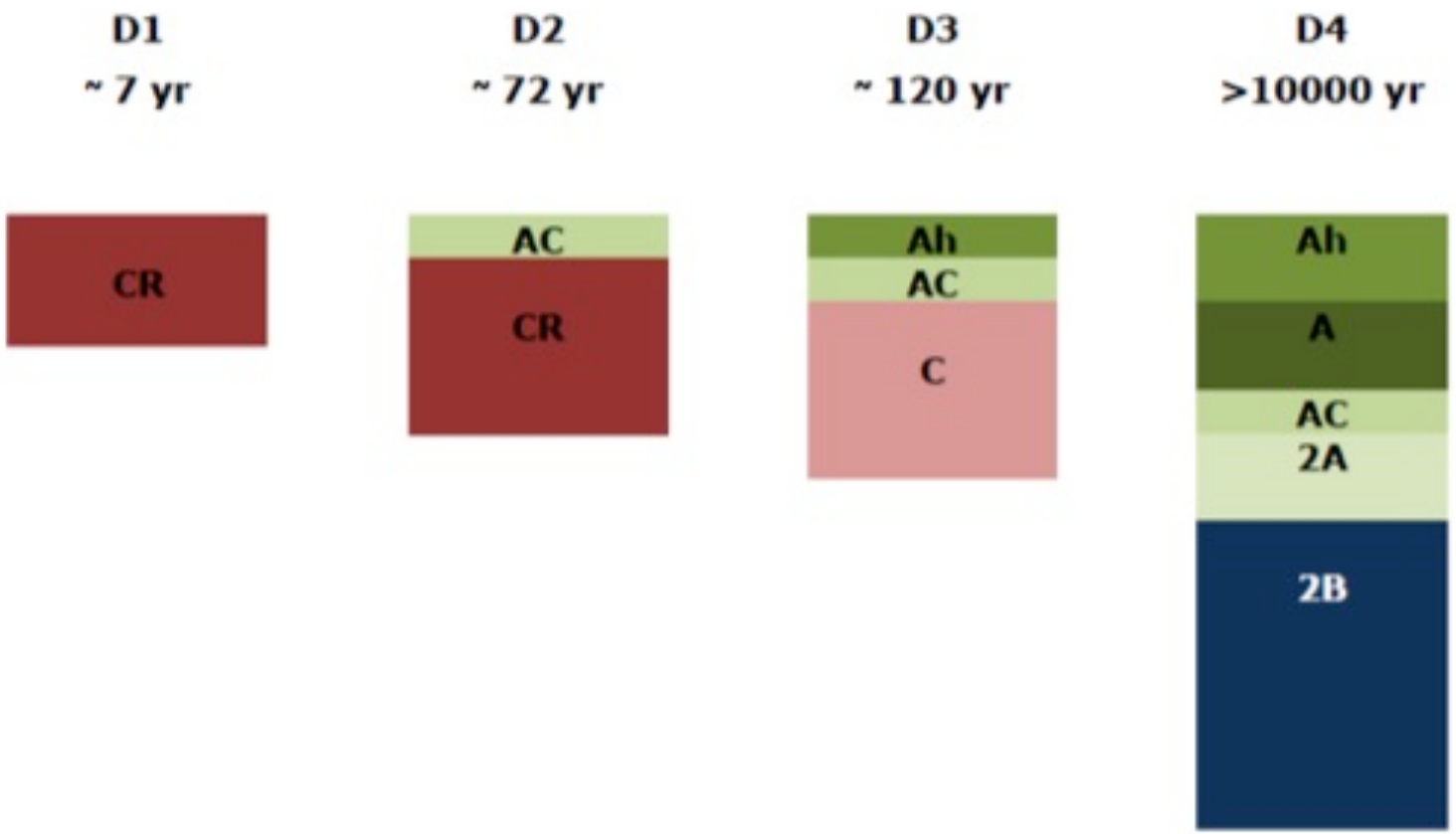
Damma glacier CZO

Stefano Bernasconi, ETHZ
Maria Andrianaki, ETHZ
Xuan Yu Penn State

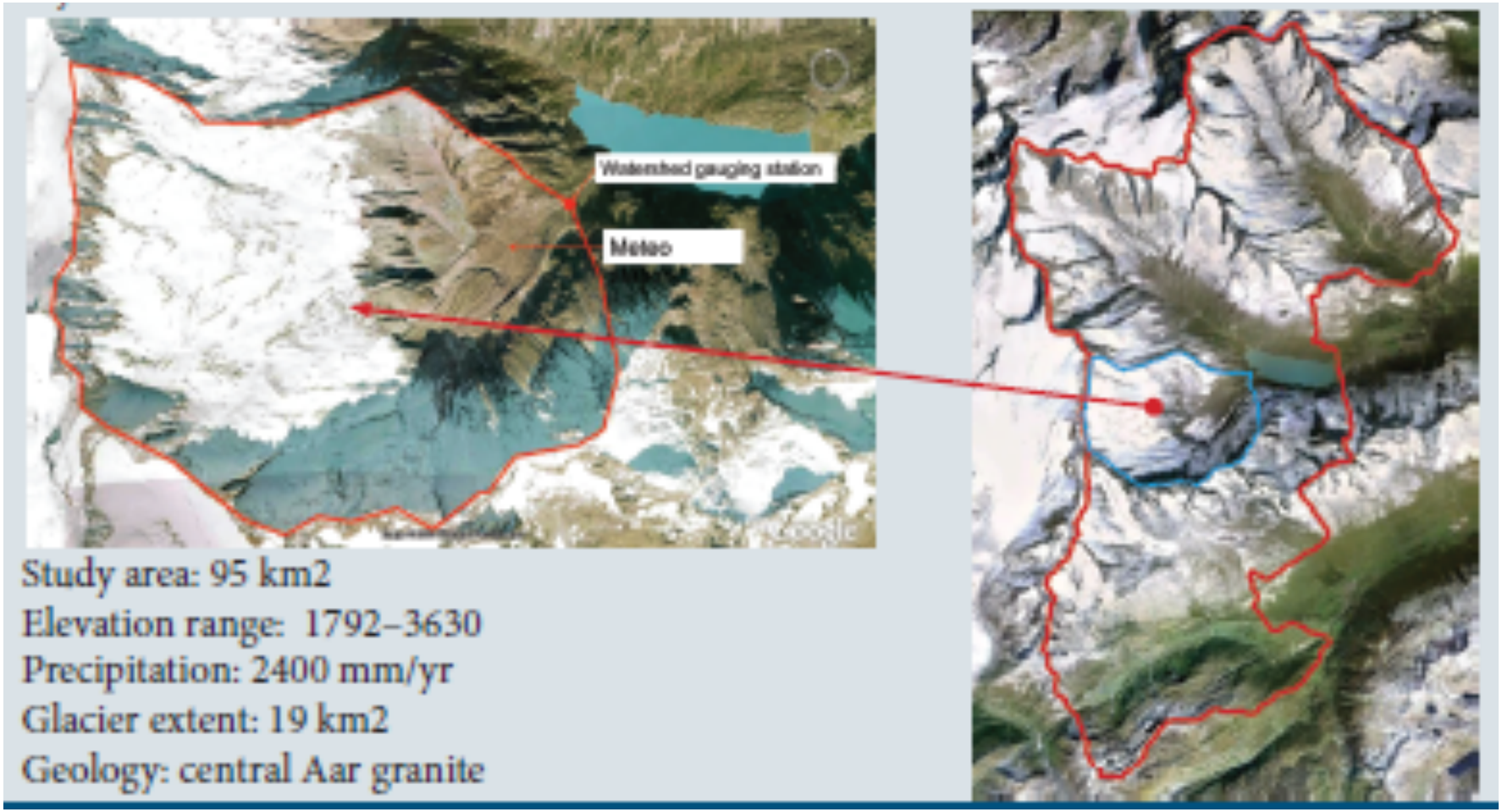
Drainage area: 10.7 km^2
Elevation range: 1800–3600
Precipitation: 2400 mm/yr
Snow depth: 2-7 m
Glacier extent: 5 km^2
Present retreat: 10 m/yr

Geology: central: Aar granite

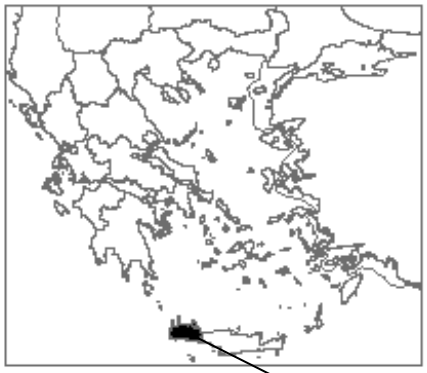
Soil profiles



Modelling for PIHM

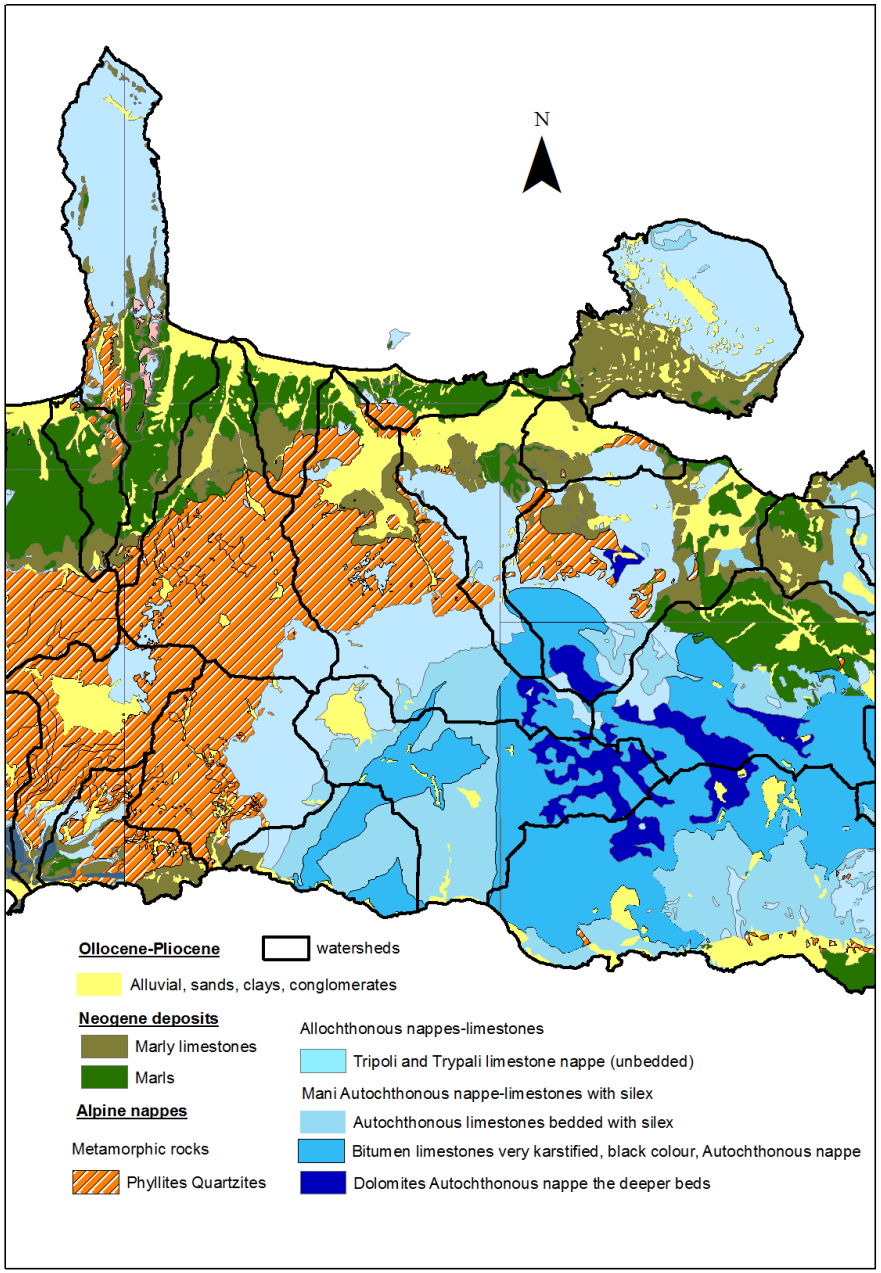


Study area: 95 km2
Elevation range: 1792–3630
Precipitation: 2400 mm/yr
Glacier extent: 19 km2
Geology: central Aar granite

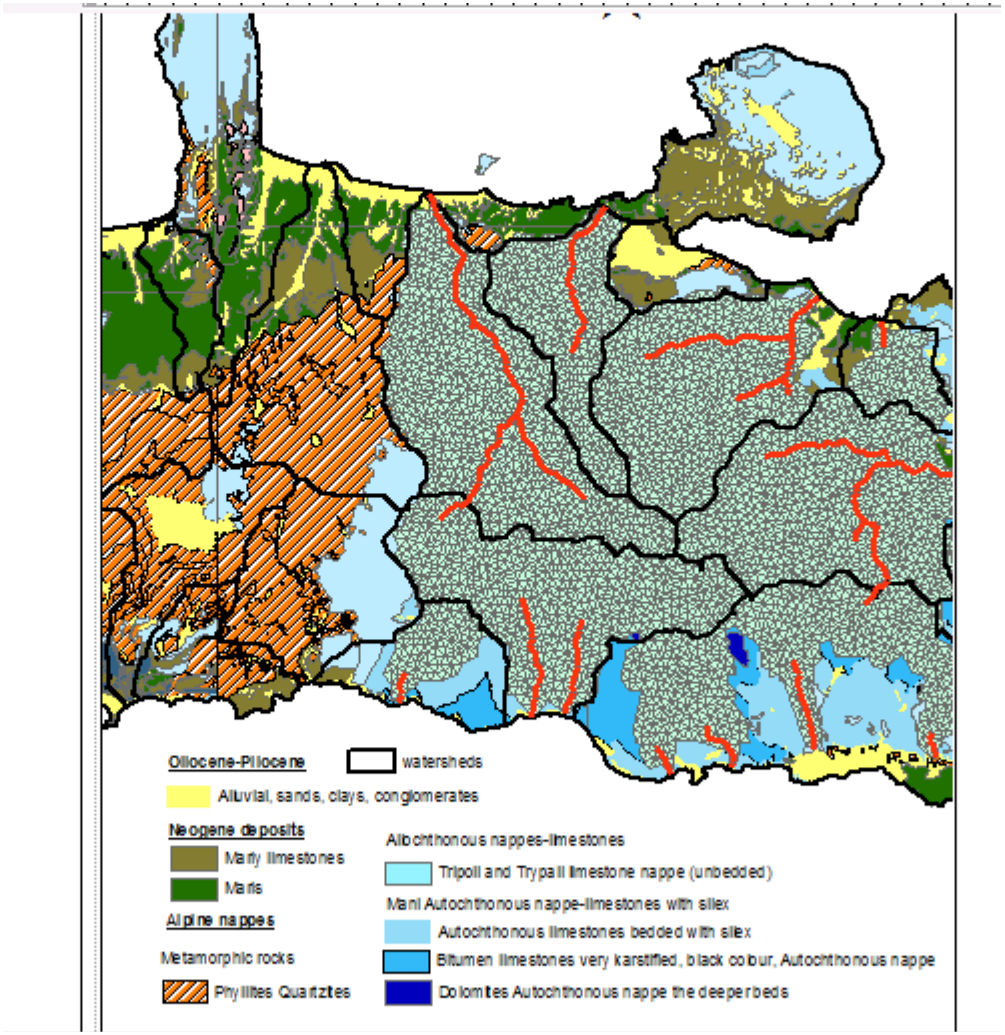


Koiliaris CZO, Crete

Nikos Nikolaidis, TUC
Daniel Moraitus, TUC
Xuan Yu Penn State
Chris Duffy, Penn State

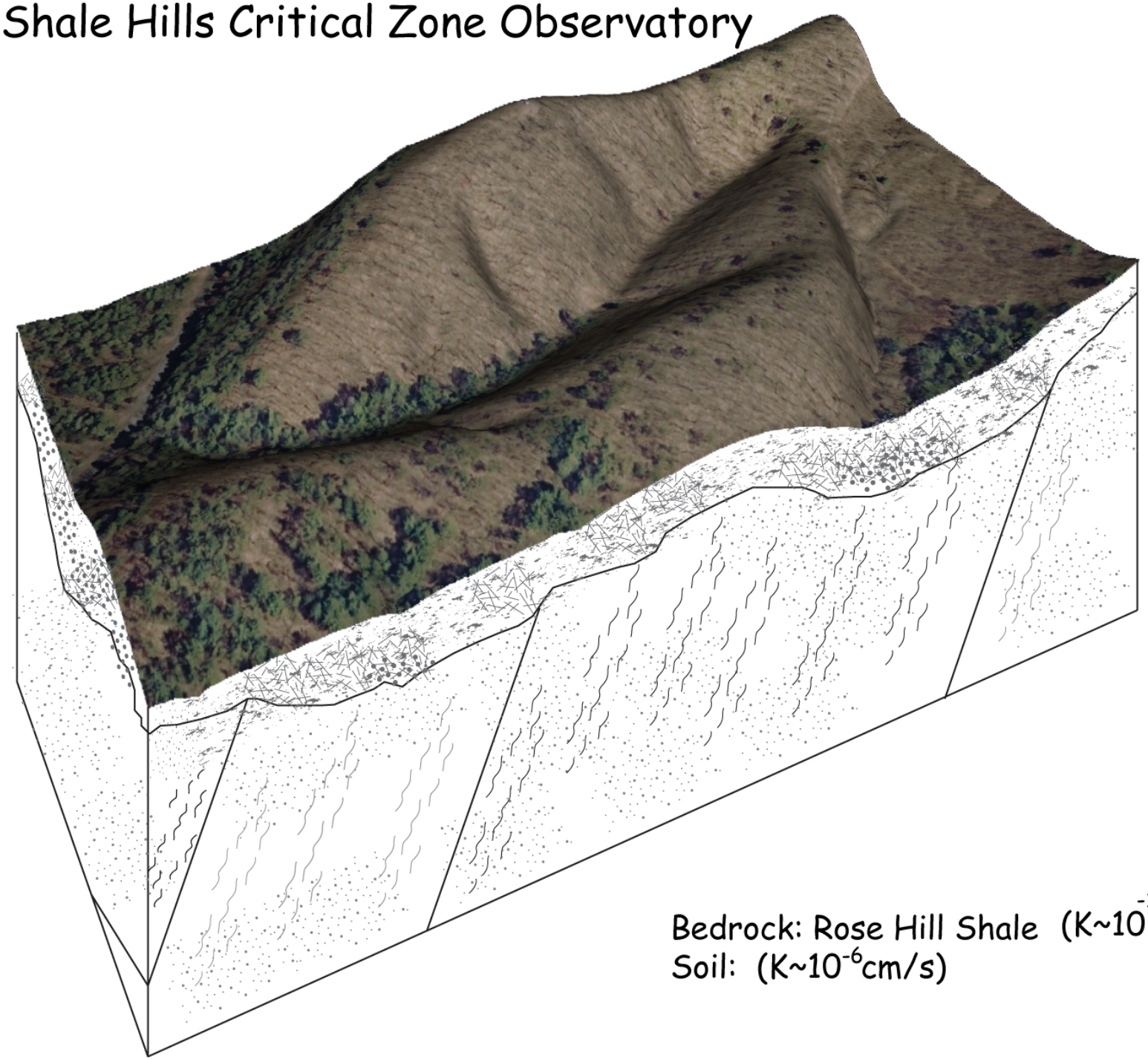


River network created with pihm



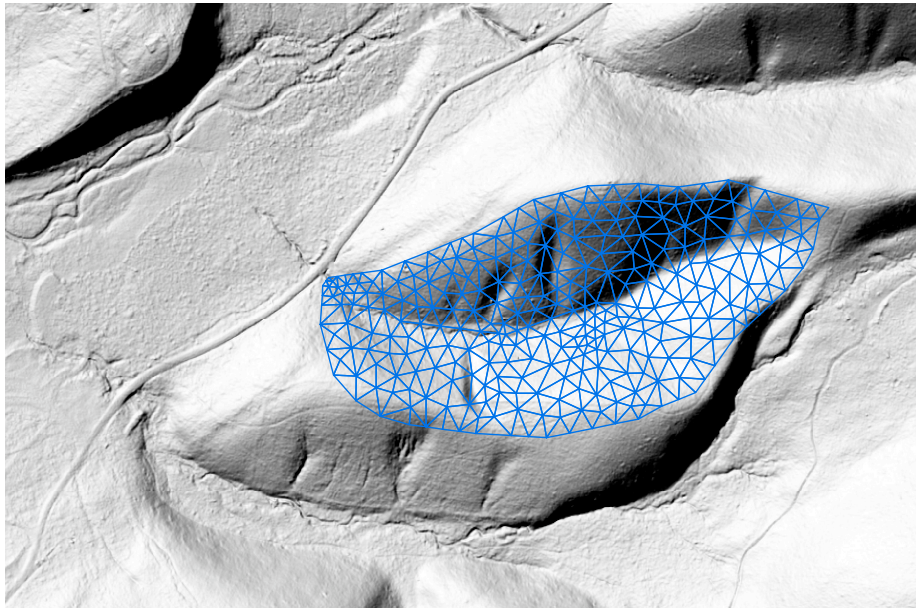
Shale Hills CZO: 1979-2010 Watershed Reanalysis

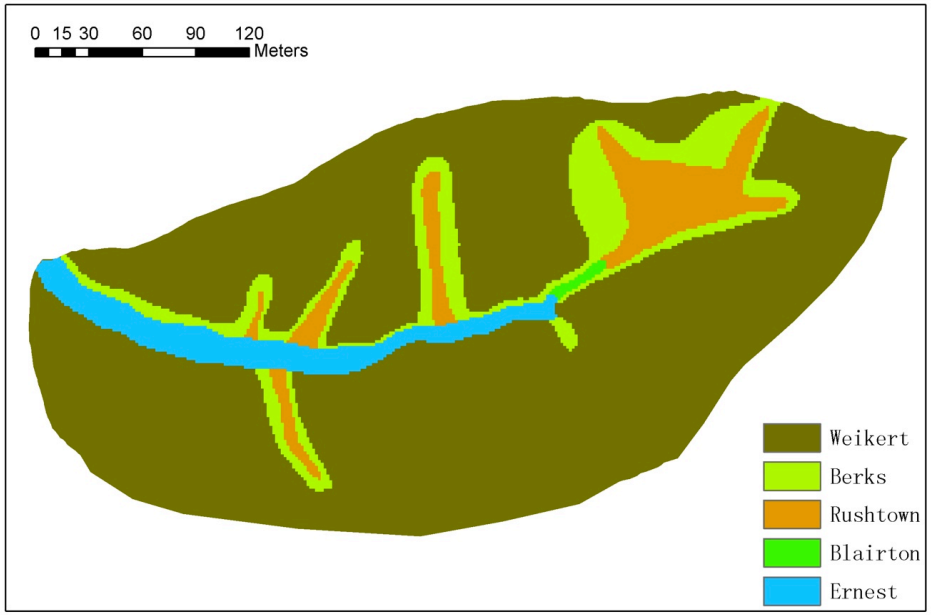
The Shale Hills Critical Zone Observatory

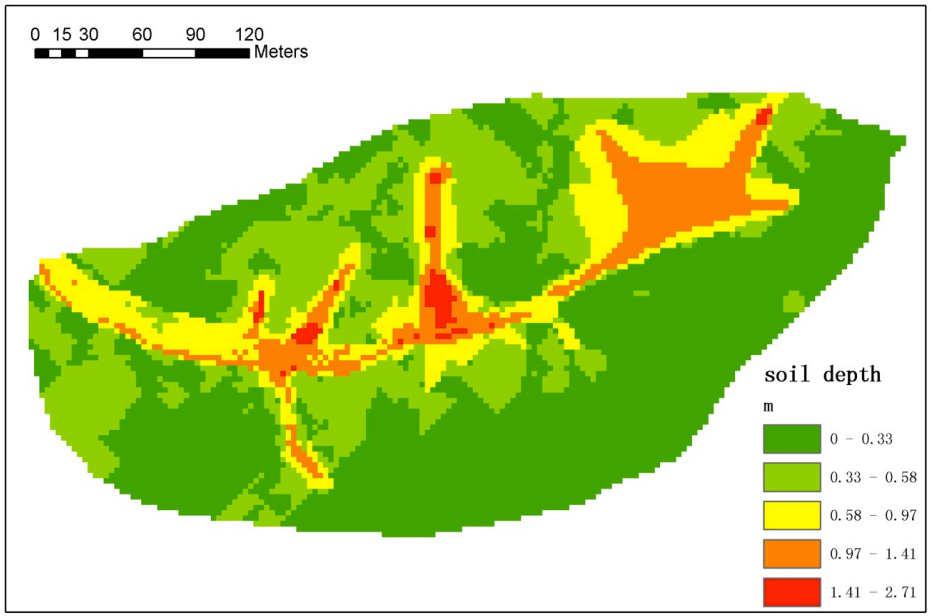


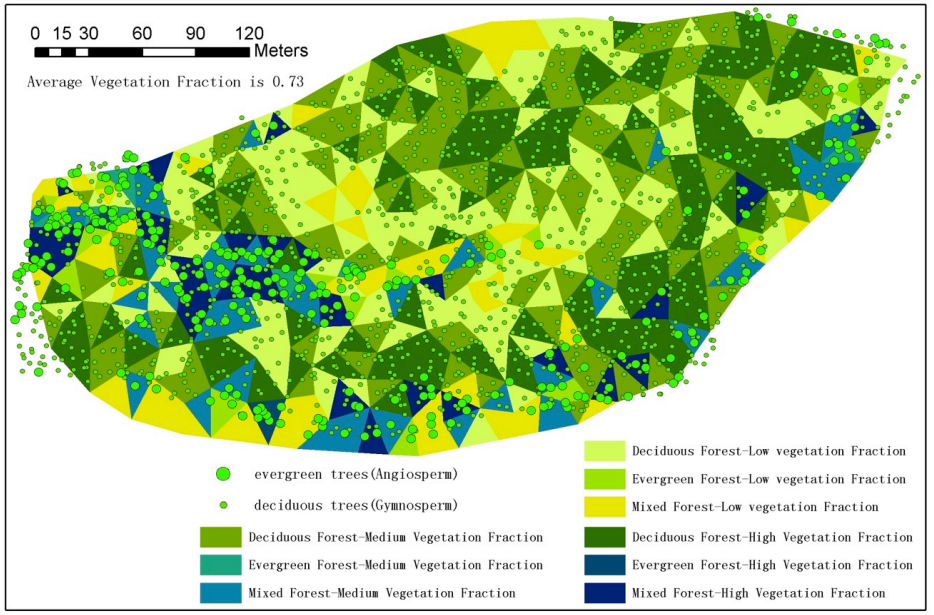
Bedrock: Rose Hill Shale ($K \sim 10^{-15}$ cm/s)
Soil: ($K \sim 10^{-6}$ cm/s)

CZO Data ->lidar, Soil, Regolith,Veg

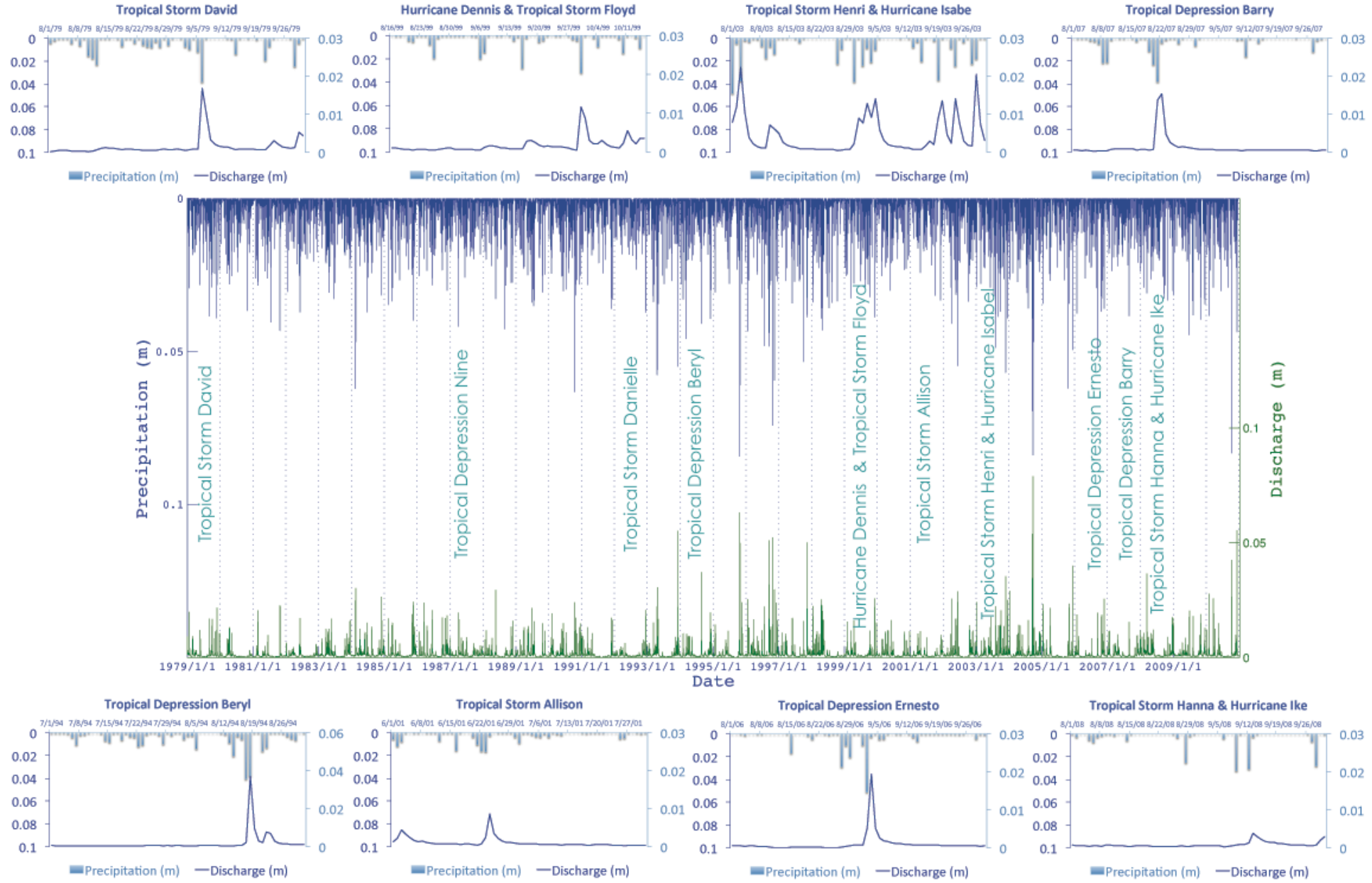




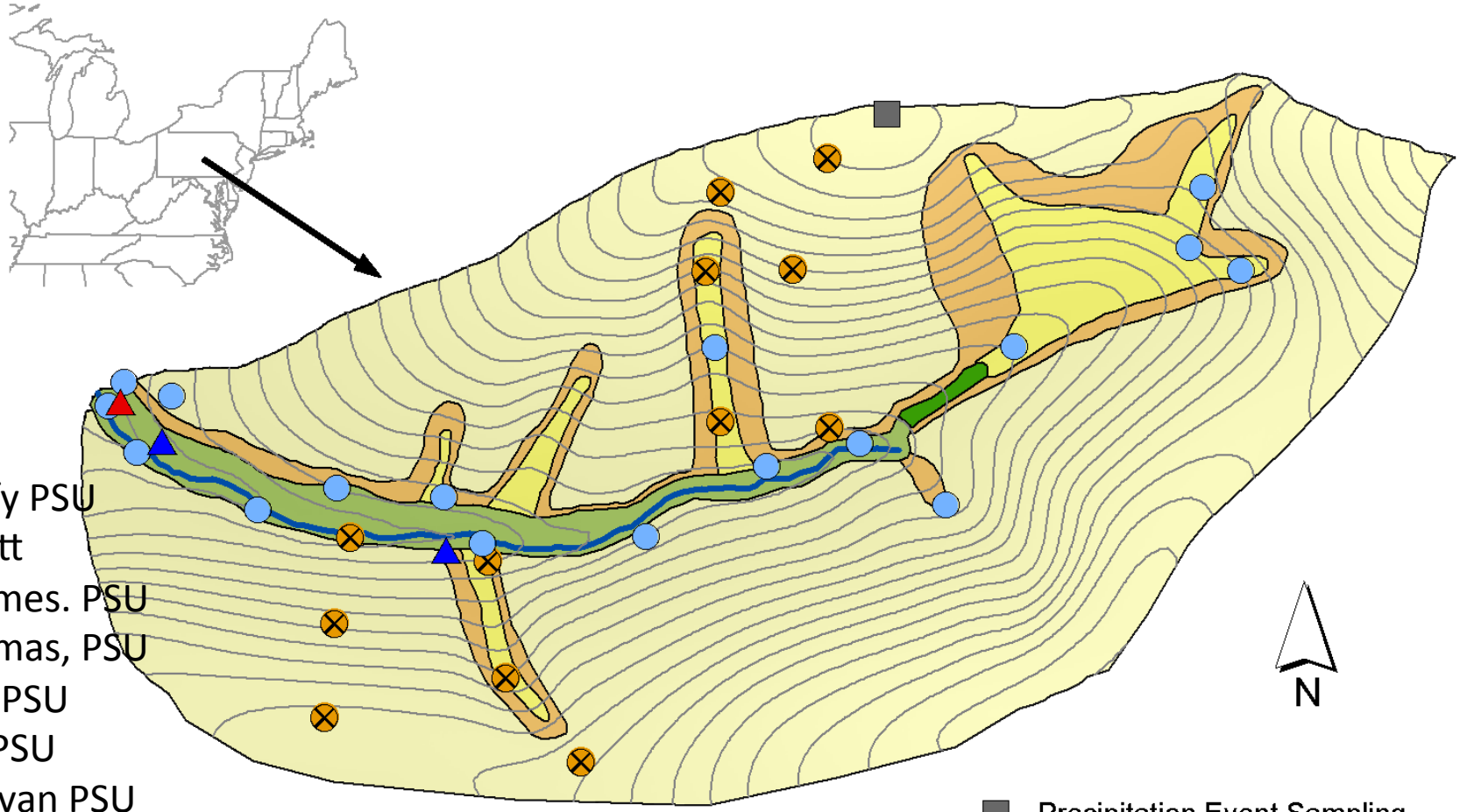




Virtual Watershed Storm Library From ”Downscaled” Reanalysis



Water Isotopes O18-D Network At Shale Hills CZO

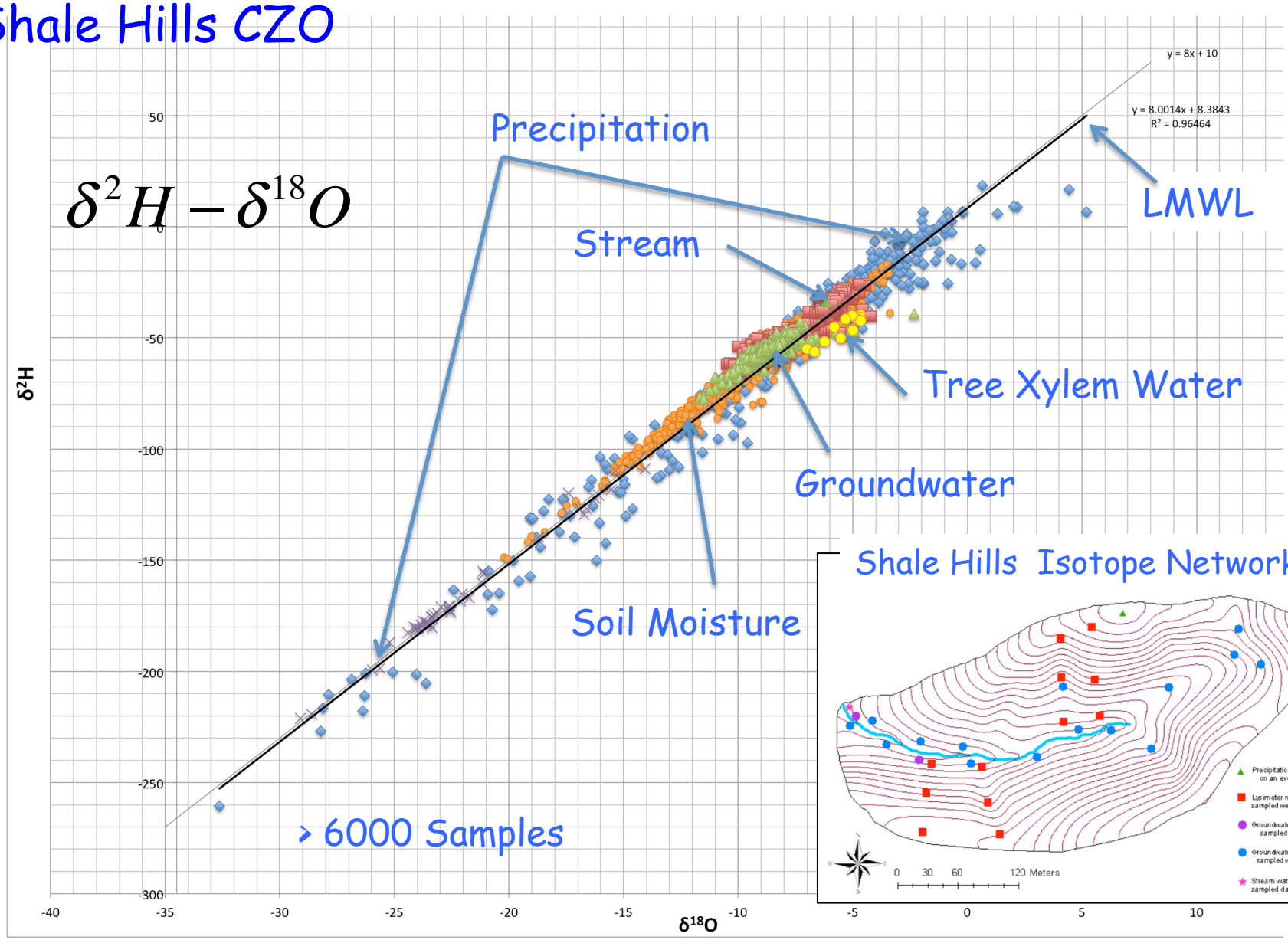


C. Duffy PSU
G. Bhatt
G. Holmes. PSU
E. Thomas, PSU
H. Lin, PSU
L. Jin, PSU
P. Sullivan PSU

Stable Isotope Experiment 2008-20012

Shale Hills CZO

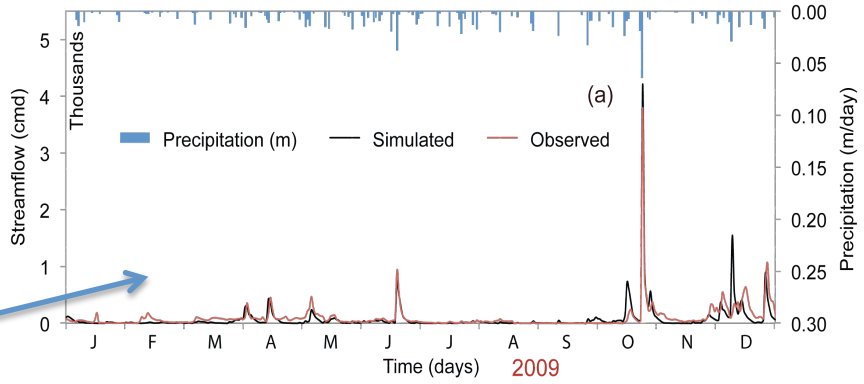
$$\delta^2 H - \delta^{18} O$$



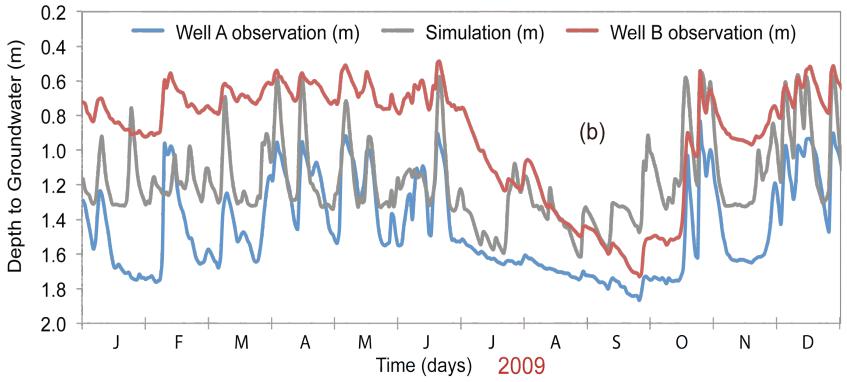
Holmes, M.S 2011, Thomas MS. 2013

Multi-State Calibration For PIHM at the Shale Hills CZO

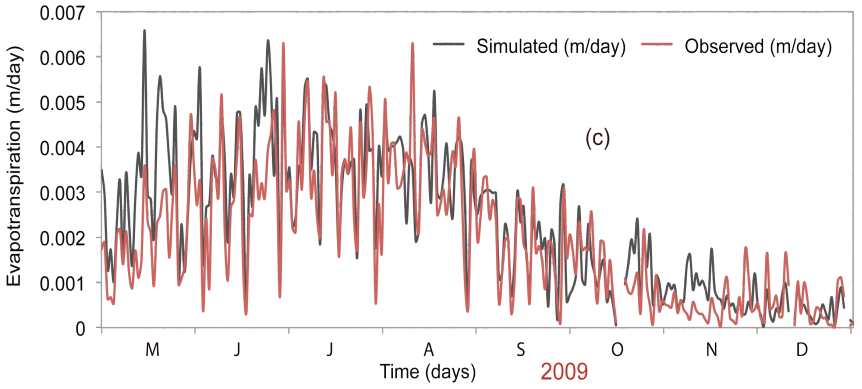
Runoff



Water Levels

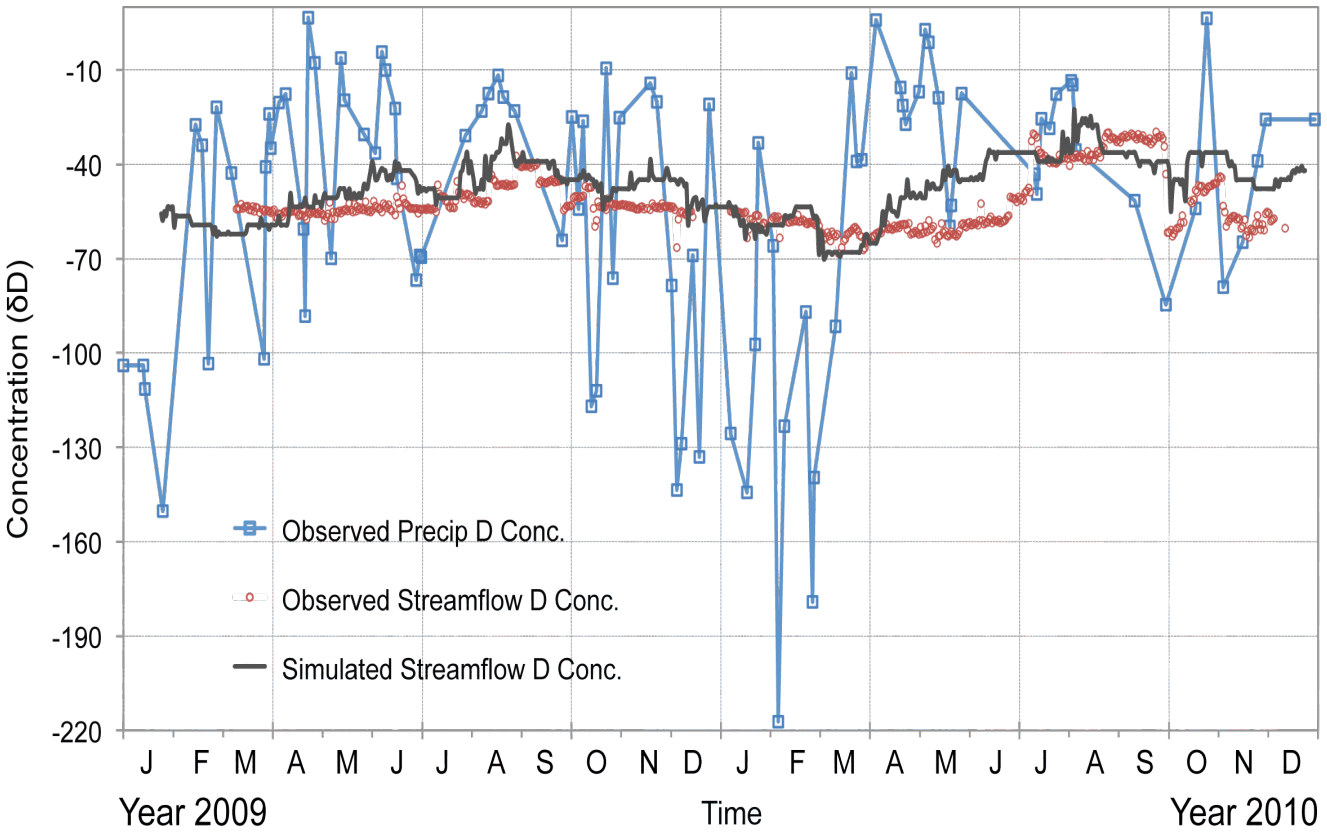


Evapotranspiration

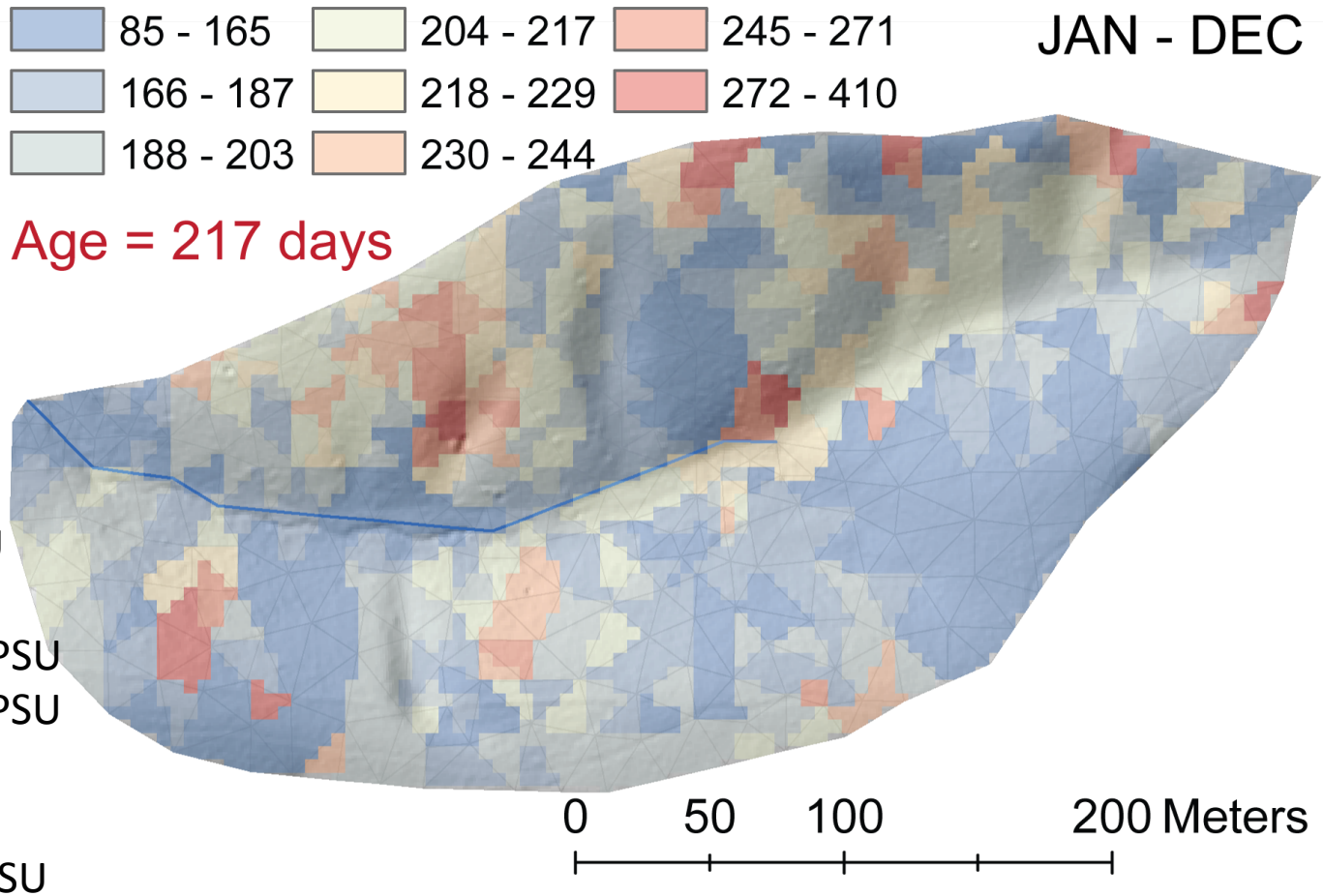


Predicted and Observed O18-D Compositions At Shale Hills CZO

G. Bhatt



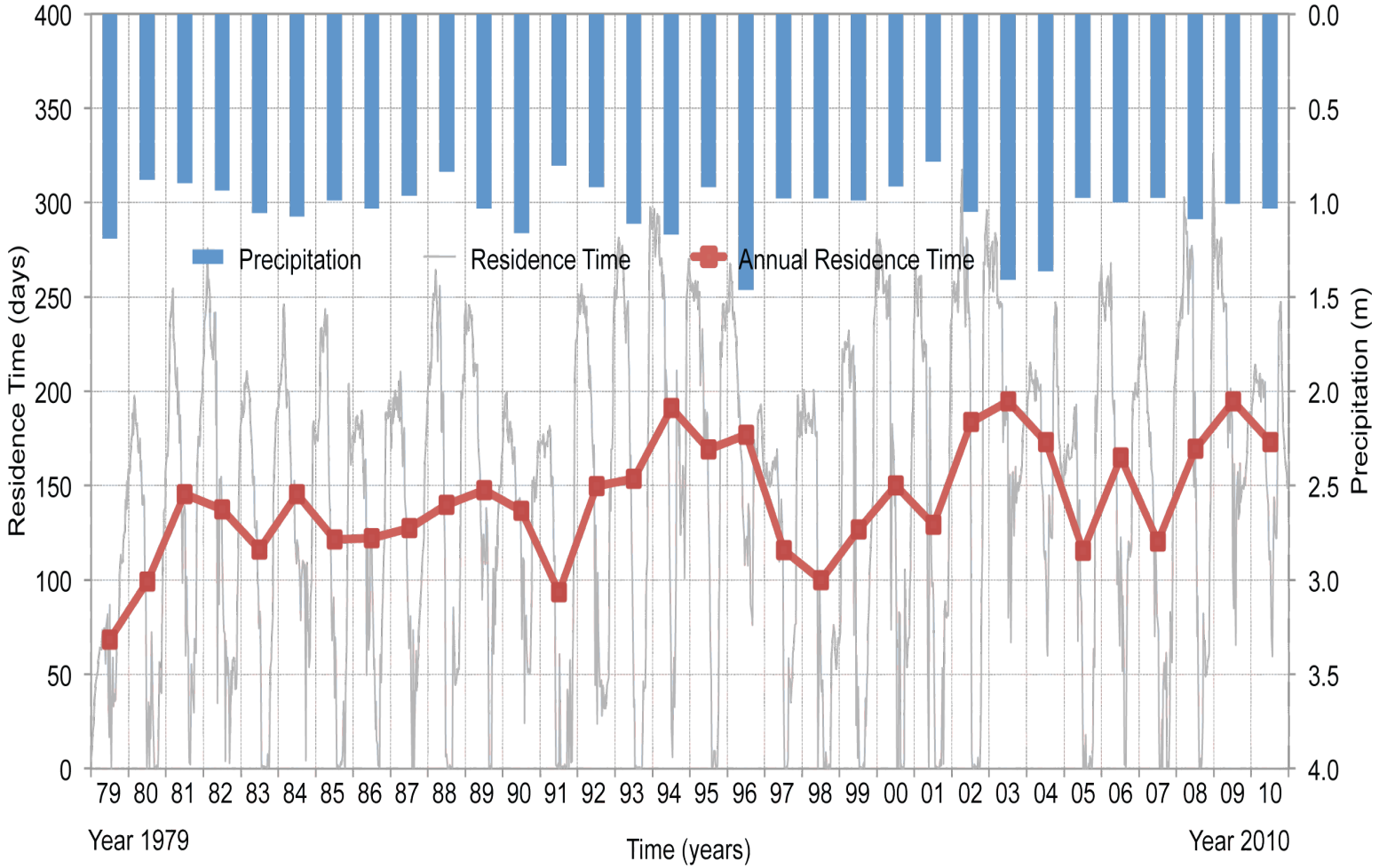
Simulated Average Age of Groundwater + Soil Water At Shale Hills CZO



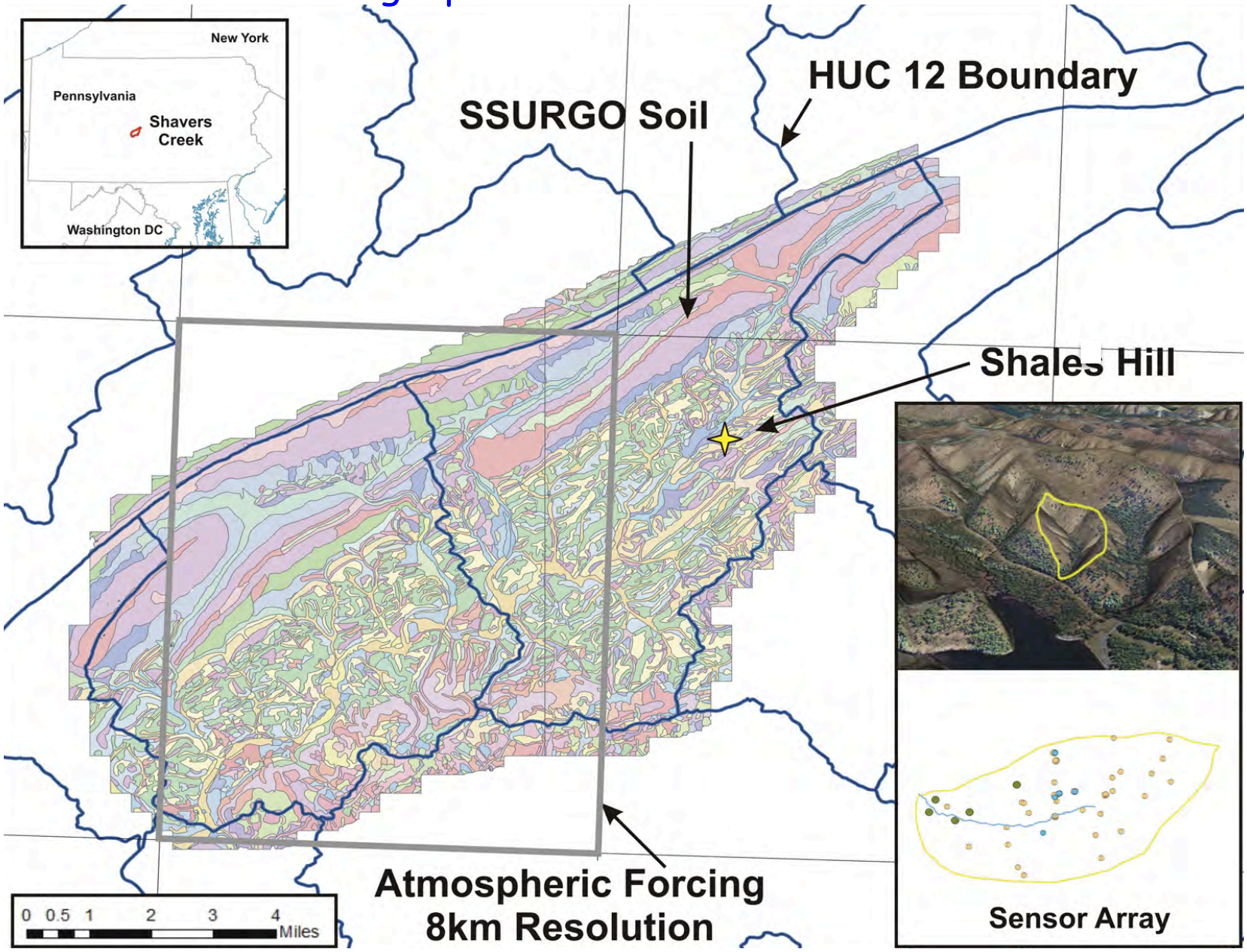
C. Duffy PSU
G. Bhatt
G. Holmes. PSU
E. Thomas, PSU
H. Lin, PSU
L. Jin, PSU
P. Sullivan PSU

Reanalysis Forced Dynamic Residence Time of Runoff from Shale Hills CZO

G. Bhatt



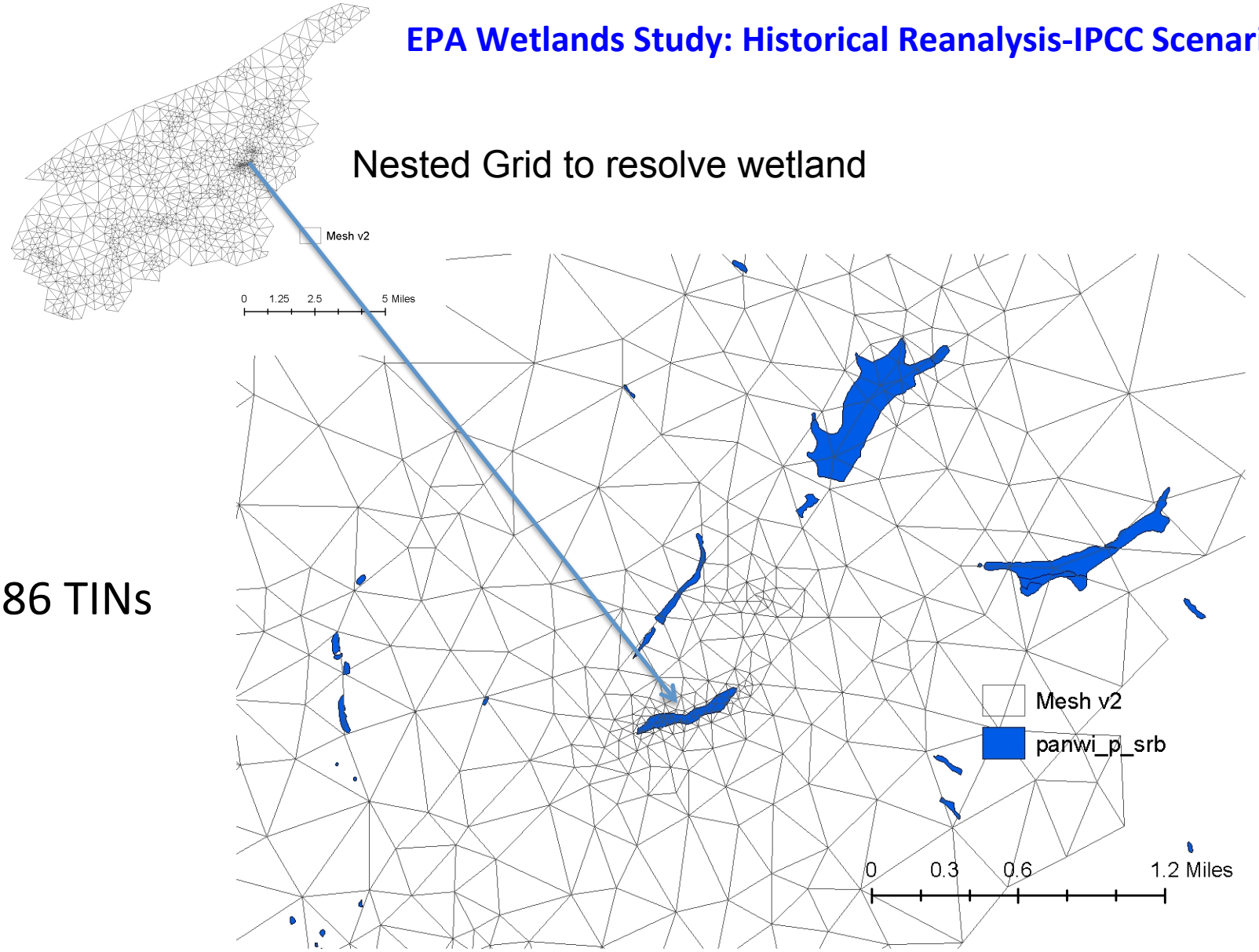
Scaling Up To HUC-12 Scale Catchment



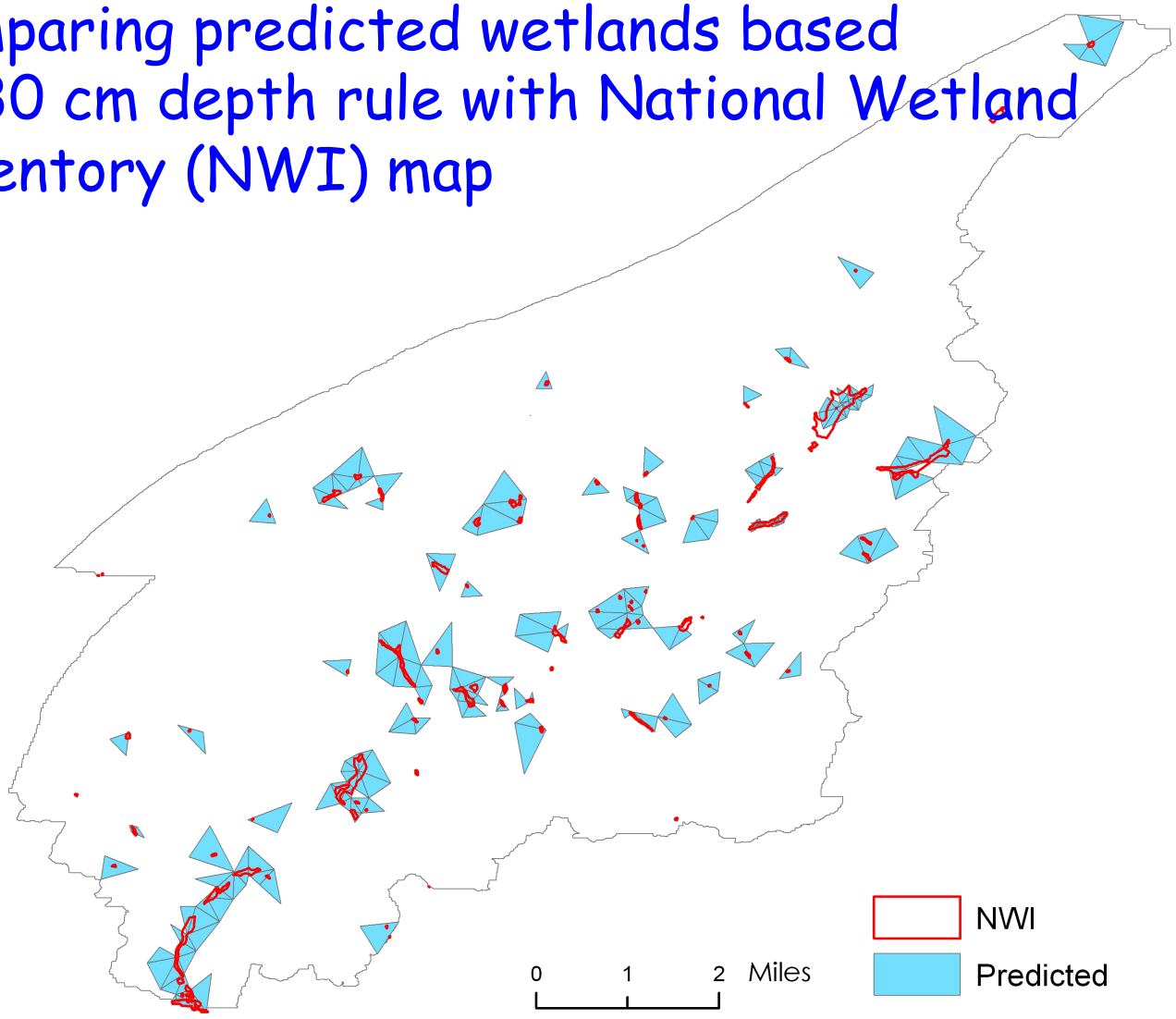
EPA Wetlands Study: Historical Reanalysis-IPCC Scenarios

Nested Grid to resolve wetland

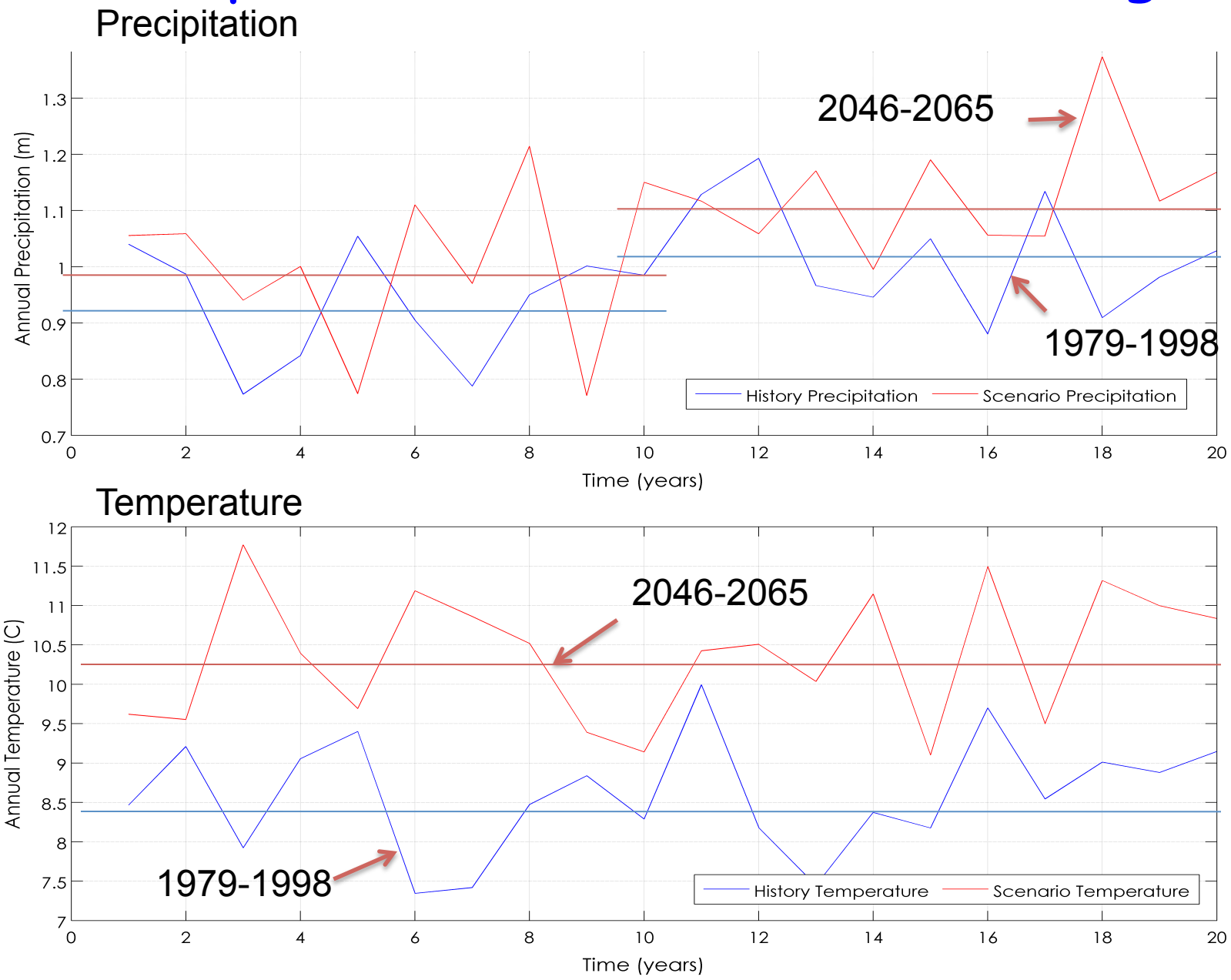
1986 TINs



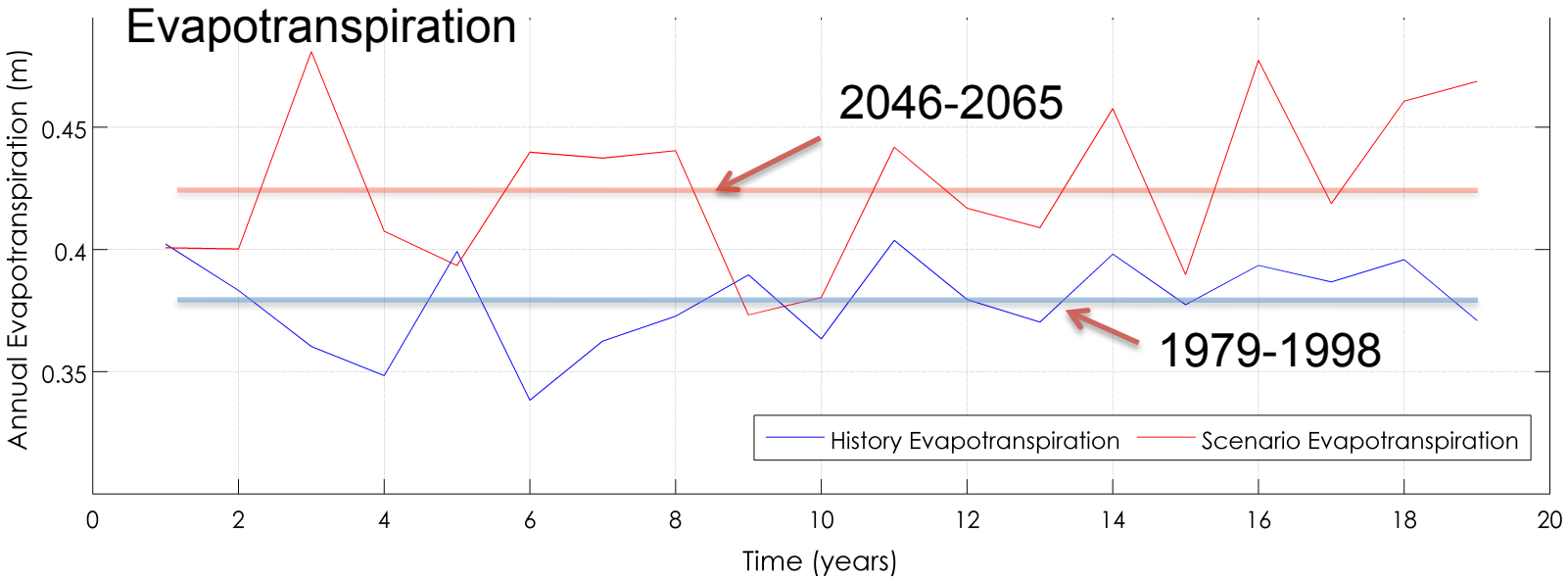
Comparing predicted wetlands based on 30 cm depth rule with National Wetland Inventory (NWI) map

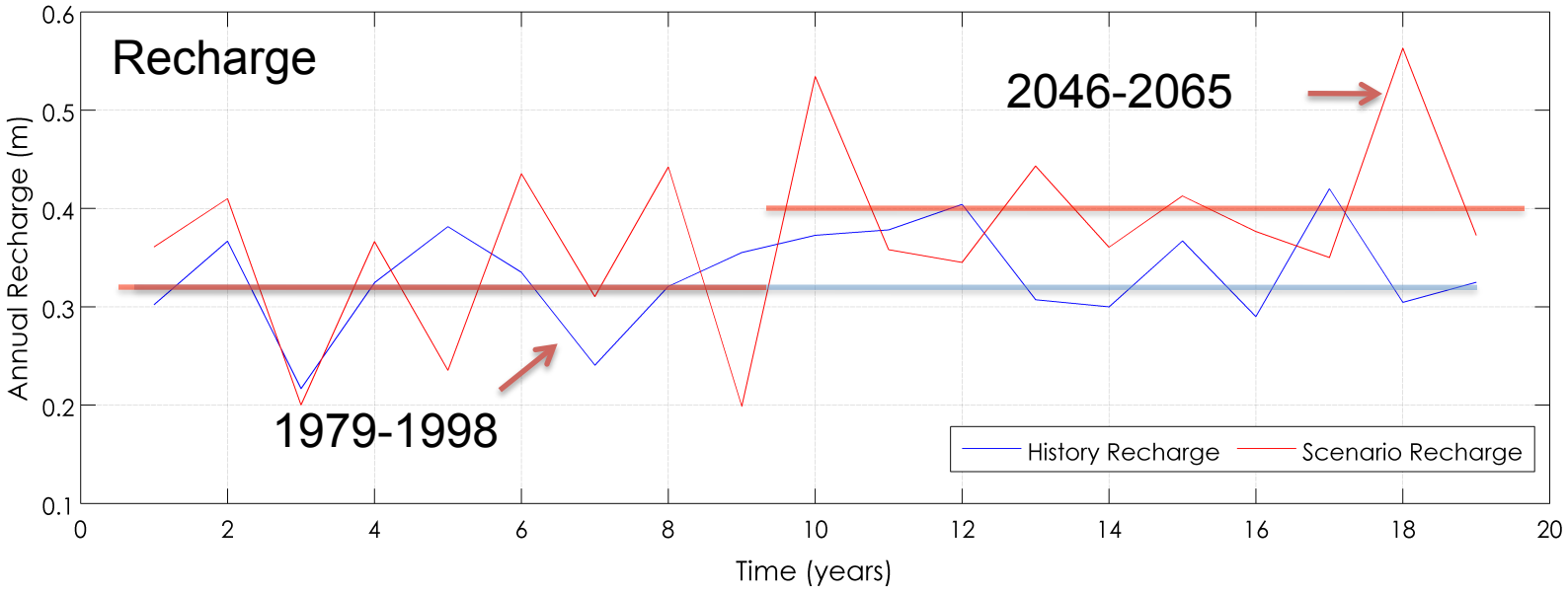


Compare Historical & IPCC Forcing

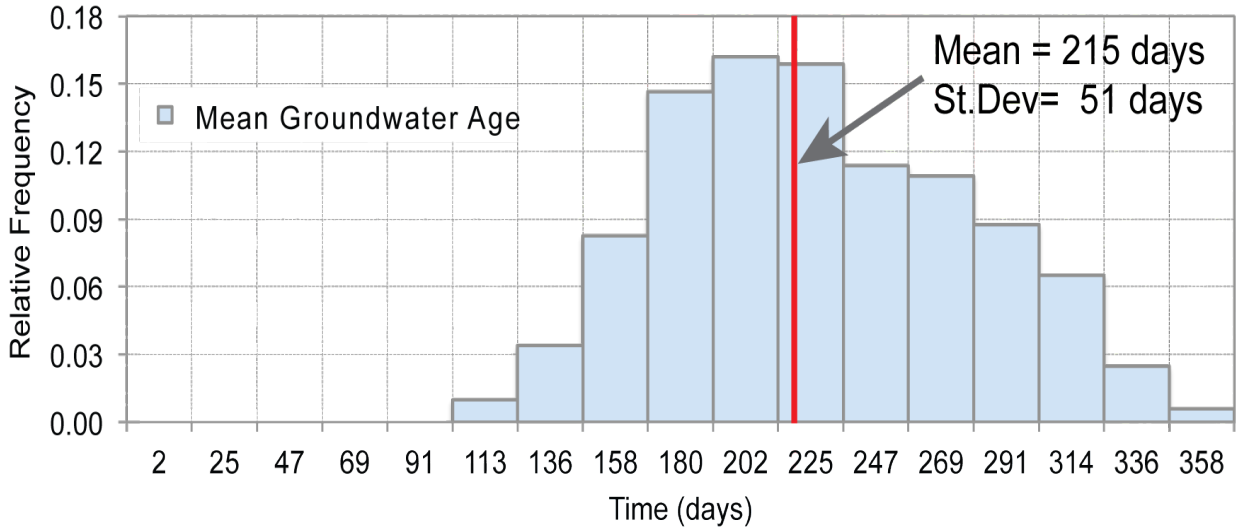


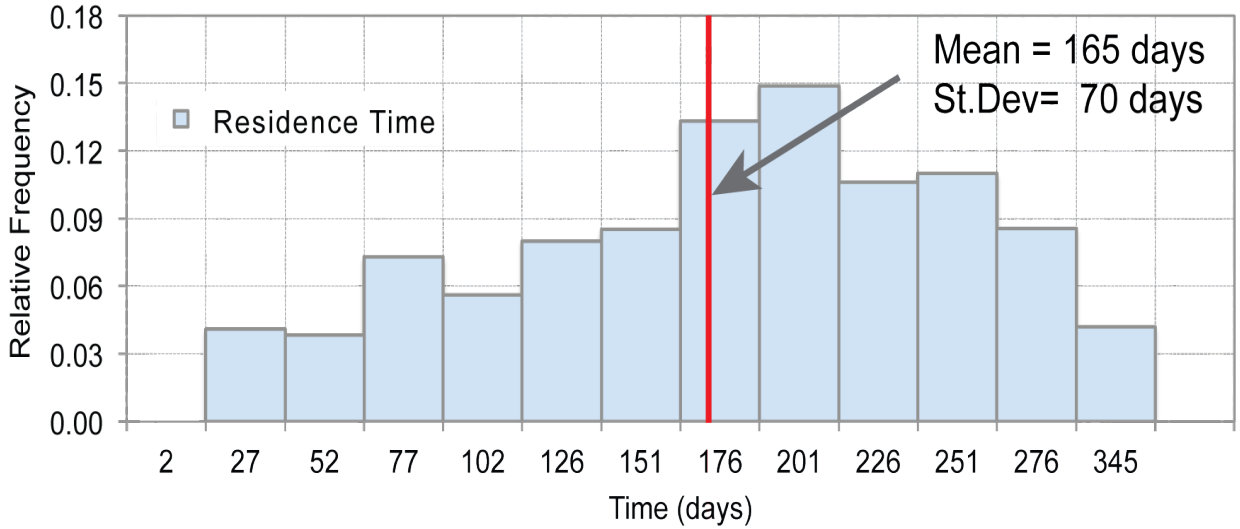
Historical vs IPCC ET-Recharge





Relative Frequency for Groundwater Age & Runoff Residence Time





Evan Thomas

Atmospheric Modeling of Stable Isotopes in Precipitation

IsoRSM experiment over Chesapeake Bay Watershed

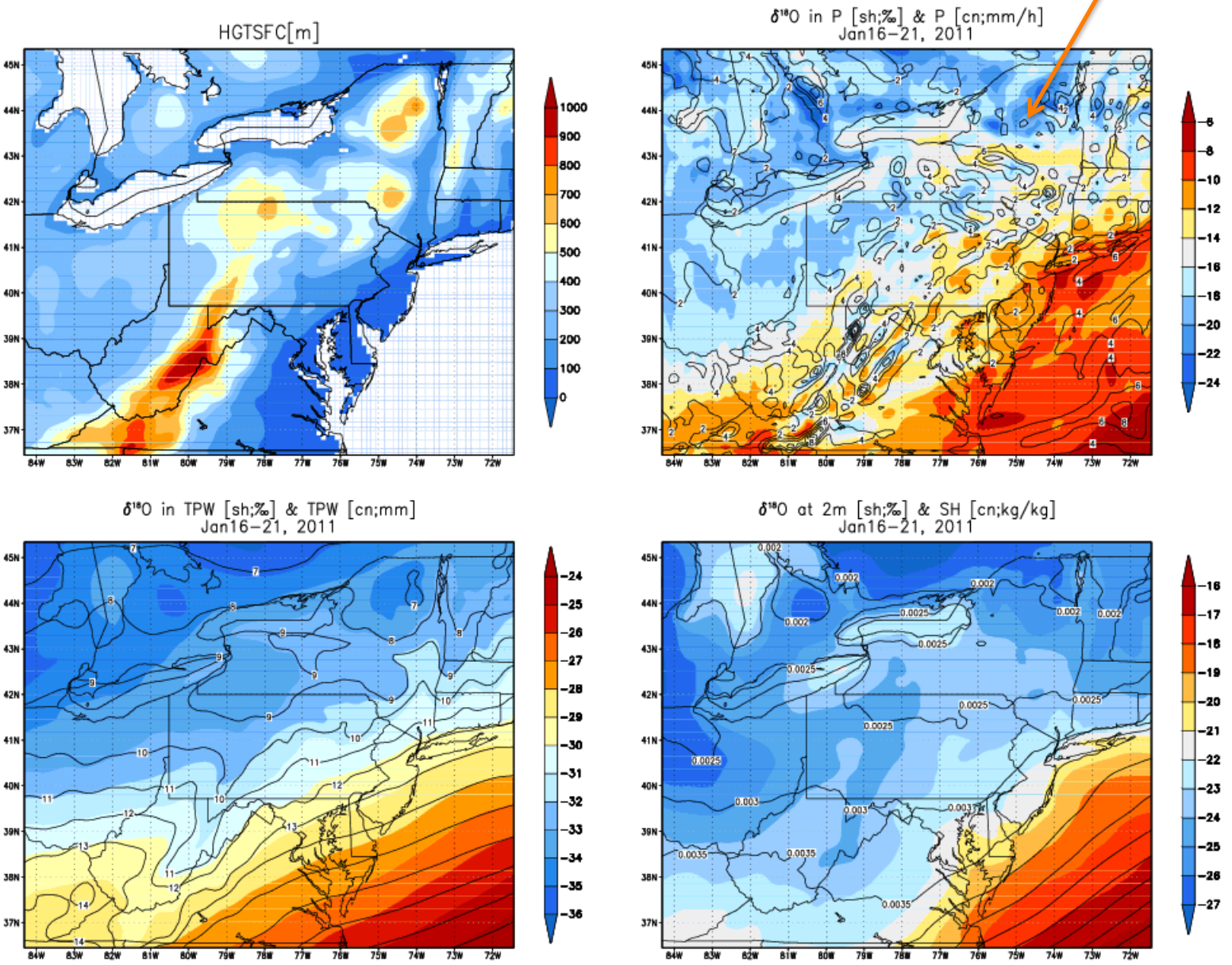
10km Simulation covering 85.5W-71.3W/35.5N-46.2N

Boundary Conditions: IsoGSM simulation based on NOAA Climate Reanalysis

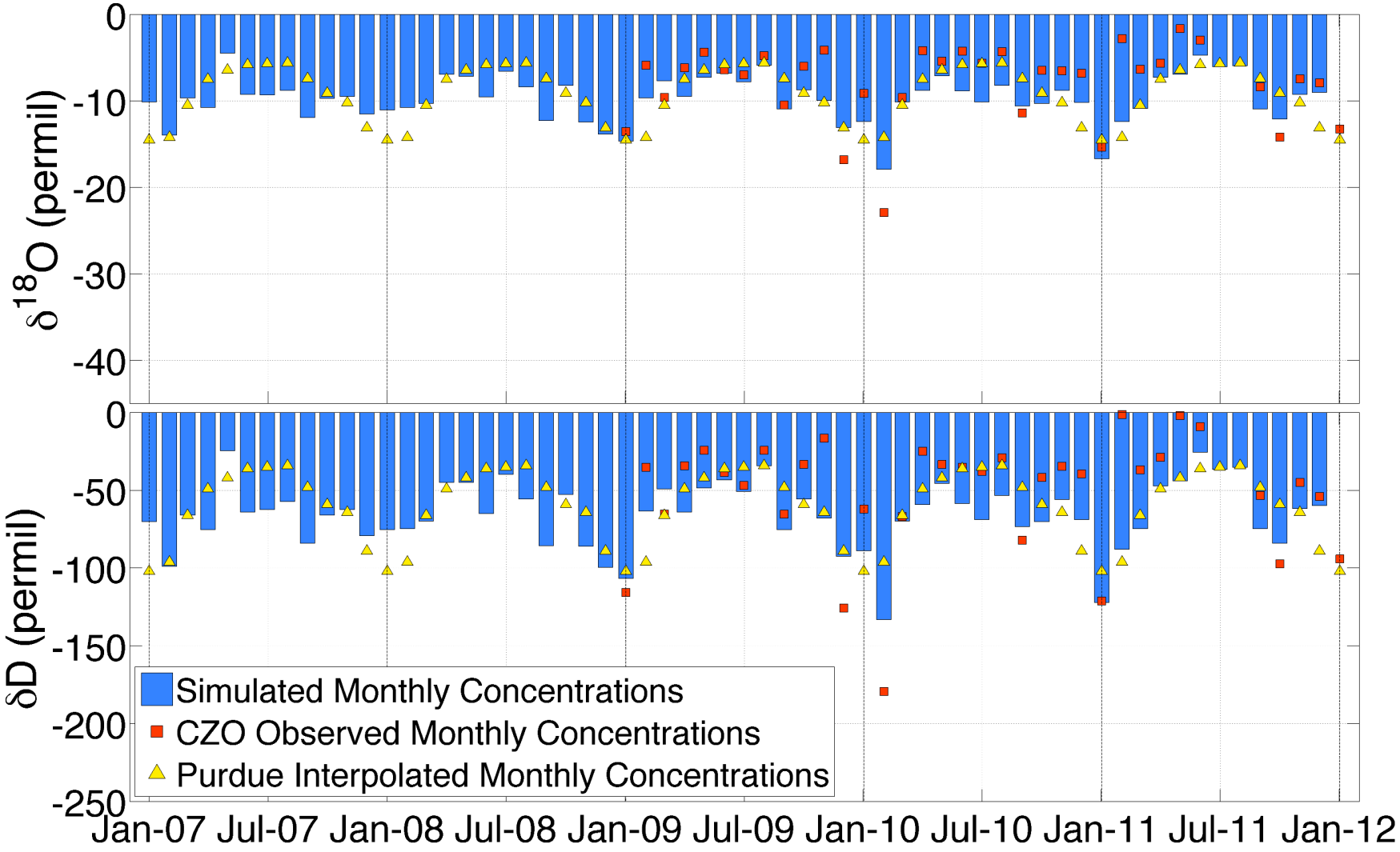
Kei Yoshimura, University of Tokyo, Japan
(Yoshimura et al., 2010)

Regional 10 km res.

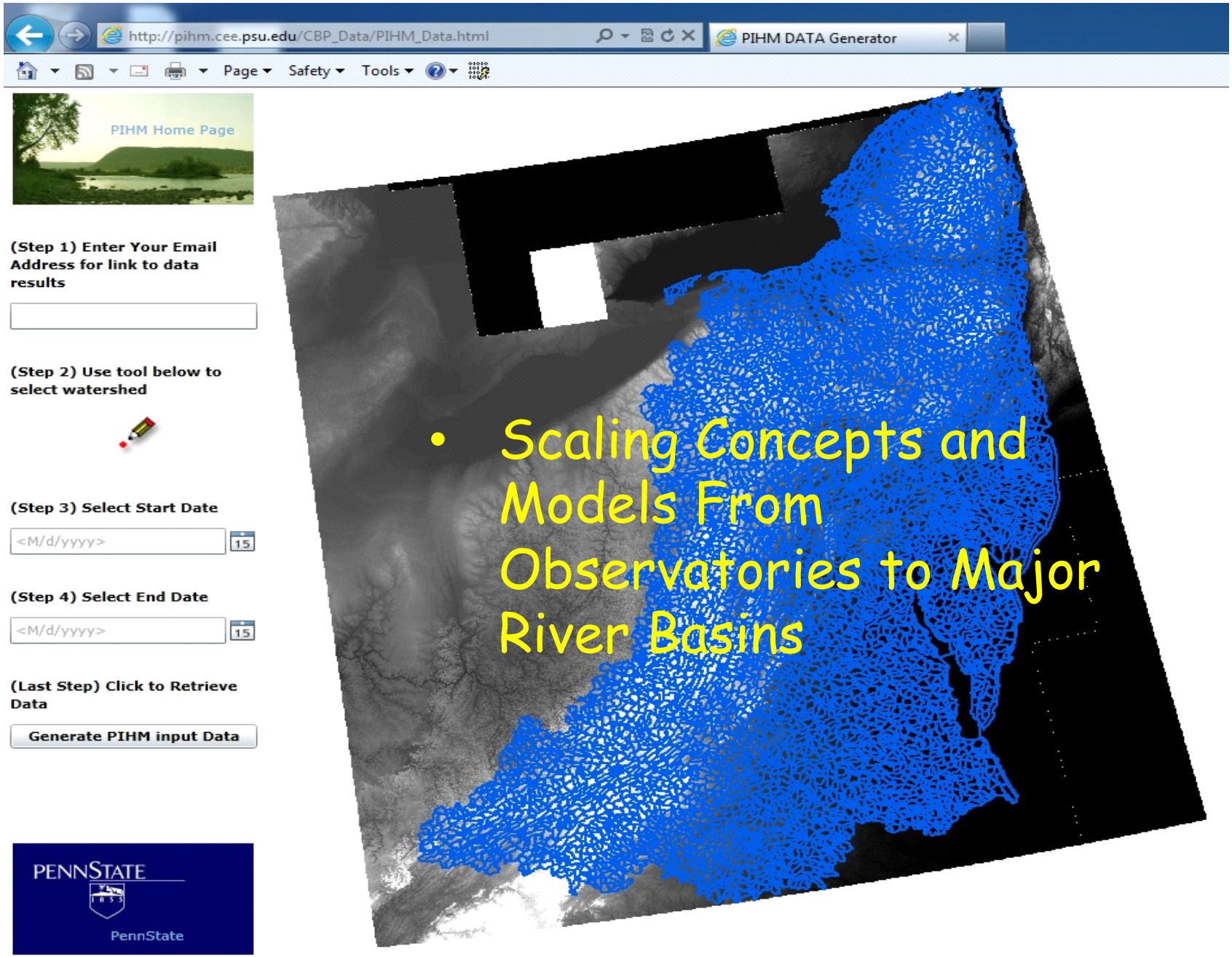
$\delta^{18}O$ in precipitation



Simulated-Observed Seasonal Isotopes in Precip.



HPC Model-Data Access & Scalability



CZO's -> Big Data & Big Simulation

Some Issues & Questions

Multi-Model Simulation Framework for Earth Casting

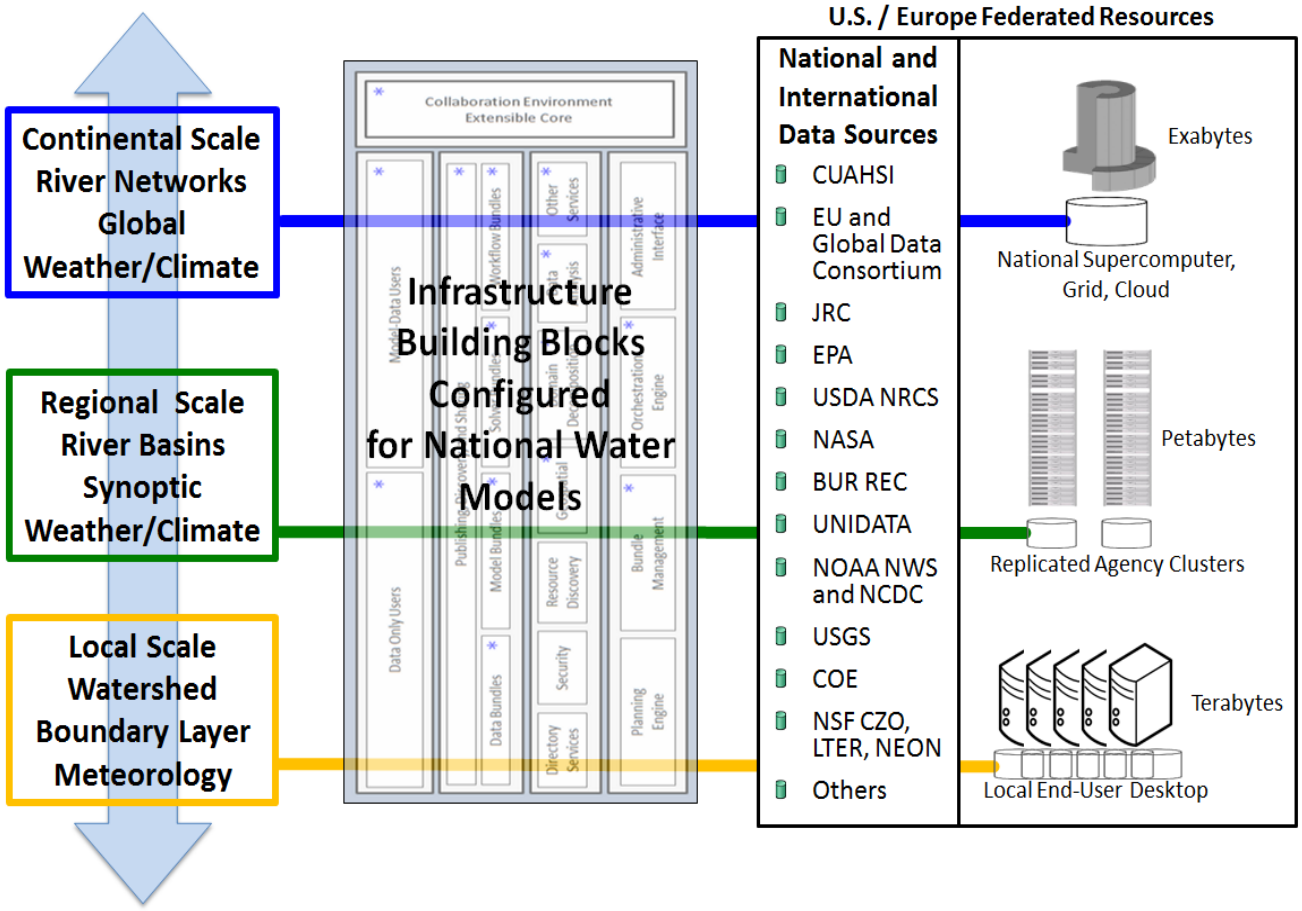
The Essential Terrestrial Variables - National Products?

Cyberinfrastructure for Virtual Data and Models

Reanalysis - Reconstruction and the Role of Environmental Observatories

Platform for communicating science and science-based decision making?

Collaborations: RENCI UNC, HYDROSHARE/HIS USU , CUAHSI, CyberScience Institute PSU



Stan Ahalt, David Tarboton, Rick Hooper, Lorne Leonard, Padma Ragavan