Large-scale, NHDPlus Resolution Watershed Modeling in the Western Lake Erie Basin Using SWAT

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TEXAS A&M AGRILIFE RESEARCH

Outline

- Overview
- Soil and Water Assessment Tool (SWAT)
- Conservation Effects Assessment Project – CEAP Wildlife
- Data Inputs & Model Setup
- Case Study & Results
- Conclusion & Future Work

Overview

- Development of complex watershed models
  - Evaluate impact from climate changing, various human activities on issues such as:
    - Availability of water resources
    - Water quality
    - Watershed management

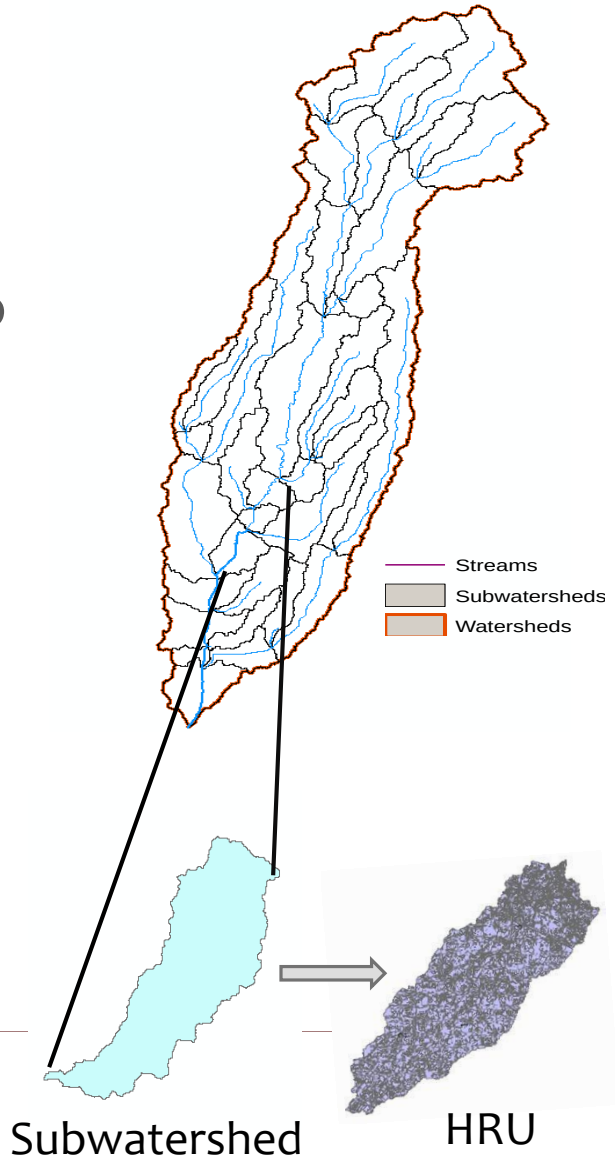
- Advanced technology in computer science
  - Complex watershed simulation models
    - Distributed in space & process-based
    - Long term simulations with large amount of input data
    - ***FINER & FINER*** resolution units for model simulation

Soil and Water Assessment Tool (1/2)

- Soil and Water Assessment Tool (SWAT)
  - Developed and maintained by USDA-ARS at Temple, Texas
    - Leading scientist – Dr. Jeffrey G. Arnold
  - GIS interface supported by Texas A&M university
    - ArcSWAT
  - Large-scale watershed management & forecast
    - Surface/subsurface runoff
    - Sediment transportation
    - Nutrients processes (nitrogen, phosphorus)
    - Pesticide losses
    - Bacteria/pathogens
  - More than 2,000 journal articles in literature

Soil and Water Assessment Tool (2/2)

- SWAT Watershed System
  - Watershed is divided into subwatersheds connected by streams
  - Subwatersheds are further divided into HRUs (Hydrologic Response Units)
    - Landuse, soil type, slope
    - Calculation of flow & nutrients is conducted at HRC level
    - HRU data summed to each subwatershed
    - Channel routing, reservoir operation to the outlets



Dr. Anthony Sasson

Texas A&M AgriLife Research

Conservation Effects Assessment Project - CEAP Wildlife

CEAP - General (1/2)

- CEAP Initiative
  - In response to the 80% increase of funds on the Farm Bills passed by the U.S. Congress in 2002

- Major Goal
  - To quantify the impact of conservation practices on actual hydrologic and water quality sponsored by government resources

CEAP - General (2/2)

- CEAP Framework
  - Hydrologic Unit Model for the United States (HUMUS)
    - Agricultural Policy/Environmental eXtender (APEX) – Field scale simulation
    - Soil and Water Assessment Tool (SWAT) – Watershed scale simulation according to the outputs from APEX

- CEAP Family
  - CEAP Wildlife (West Lake Erie Basin) ***Close to be done***
  - CEAP Cropland I (national scale) ***Done***
  - CEAP Cropland II (national scale) ***undergoing***

OHIO SEA GRANT

WESTERN LAKE ERIE BASIN
CEAP

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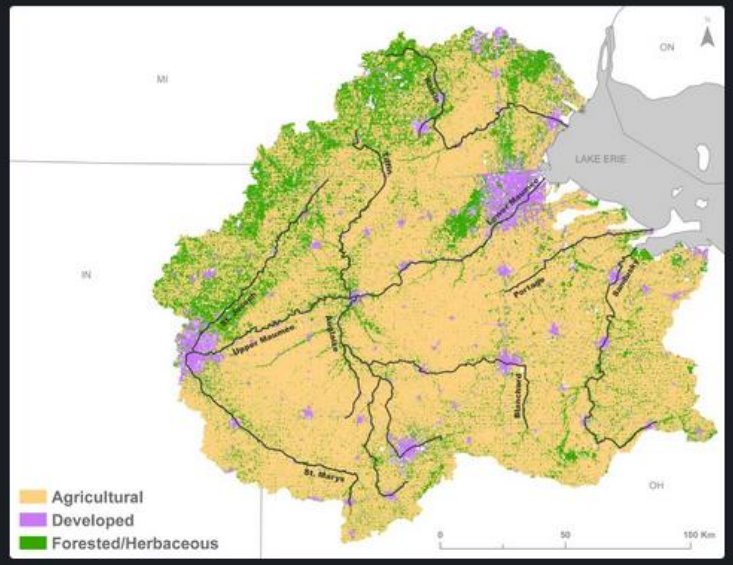
Western Lake Erie Basin Conservation Effects Assessment Project

CEAP projects assess how effective environmental conservation practices are at reducing the impacts of agriculture on the surrounding ecosystems to ensure that funding for these practices is distributed in a way that makes the most of available resources.

ABOUT US



The Western Lake Erie Basin

The landscape of northwestern Ohio, northeastern Indiana and southern Michigan is marked mostly by agriculture, with farms of all sizes stretching across the Maumee River watershed and beyond.

Agriculture impacts watersheds because runoff from farm fields – from rain or snowmelt, for example – carries with it soil particles and nutrients from fertilizers. When that runoff enters local waterways, the sediment and nutrients are carried downstream and eventually end up in places like Lake Erie, but local waterways are impacted by those contaminants as well.

http://lakeerieceap.com/

CEAP Wildlife (1/4)

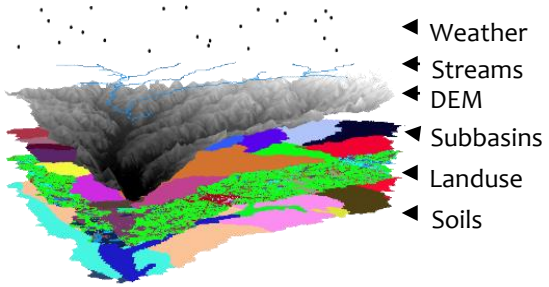
- ***Let's Play a Game ~***

HUC 12
391 subwatersheds
Area: 72 km² (range: 25 to 191)

NHDPlus
11335 subwatersheds
Area: 2.61 km² (range: 0.001 to 80)

CEAP Wildlife (2/4)

- Data Inputs & Model Setup ***all credit belongs to Dr. Daggupati***
  - Watershed characterization
    - Predefined subwatersheds and streams option in ArcSWAT used
    - HUC12: 30m DEM, 12 digit HUCs, NHD streams
    - NHDPlus:30m DEM, NHD plus watersheds, NHD plus streams
  - Landuse data
    - 2010 and 2011 Cropland Data Layers (CDLs) combined to develop 30m landuse
  - Soil data
    - STATSGO soil data at 1:250,000 scale
  - Weather data
    - Daily precipitation & temperature data from 1960 to 2010
  - Tile Drains
    - Agricultural area was given tile drainage system
  - Management
    - Fertilizer application rates: Derived from Agricultural Census Yield and Fertilizer use data
    - Tillage: Derived from USGS -Conservation Technology Information Center (CTIC) Survey Data (conventional, ridge, reduced, mulch, no-till)
  - More details in *Daggupati et al. (2015)*



CEAP Wildlife (3/4)

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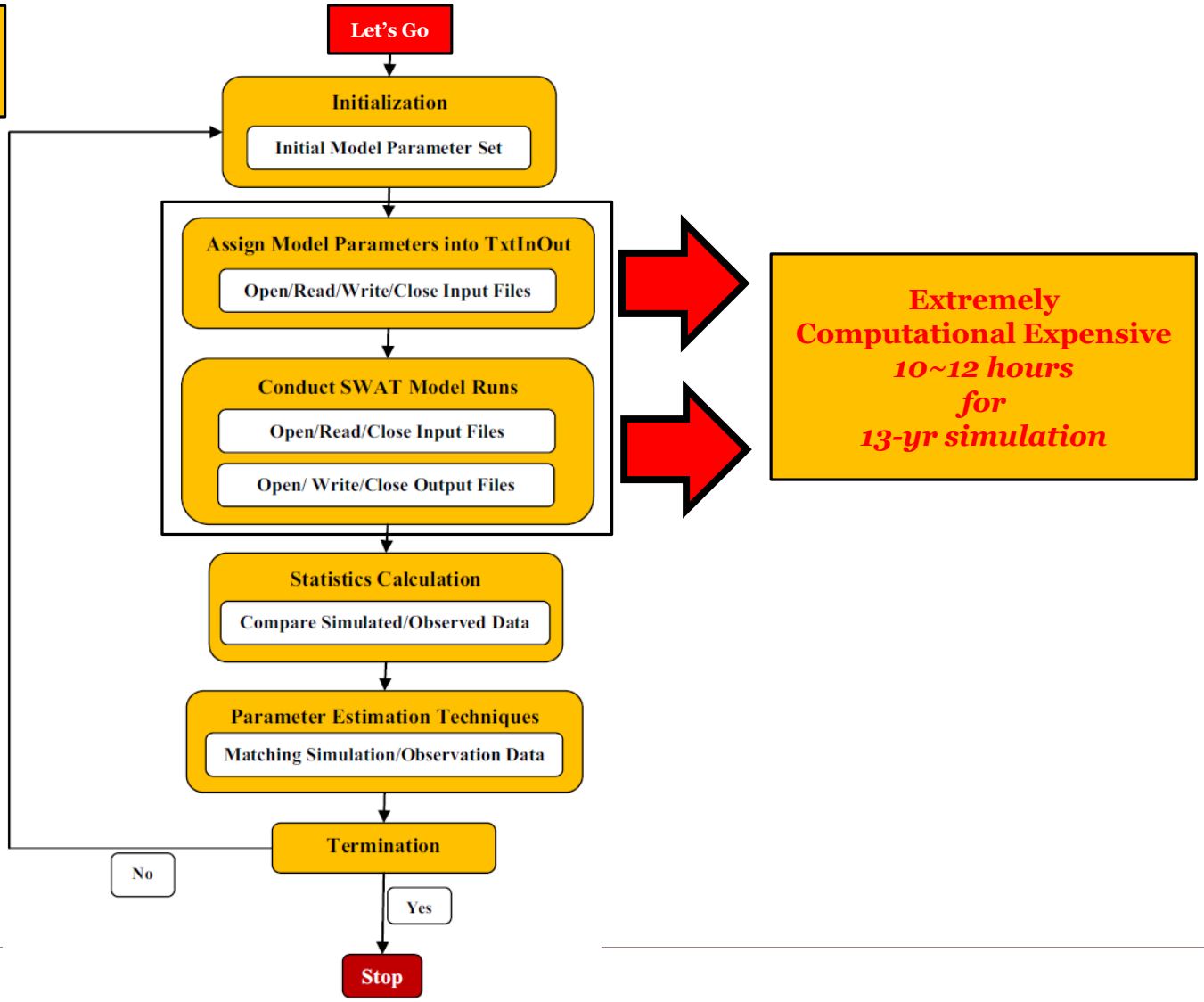
Technical Difficulties



CEAP Wildlife (4/4)

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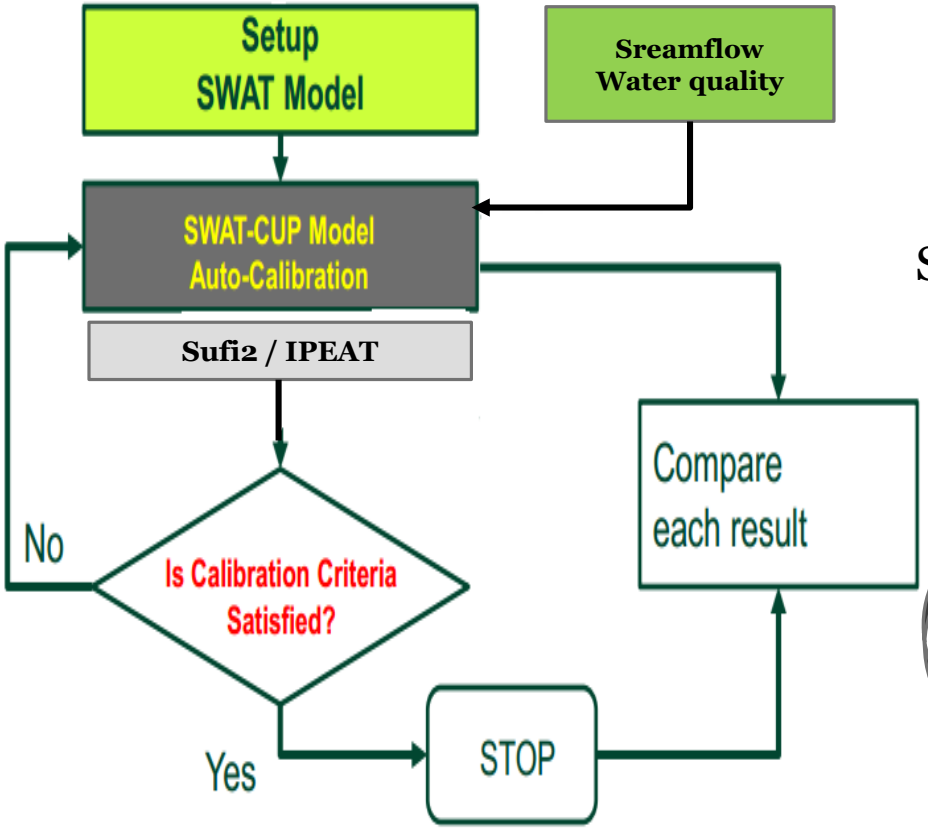
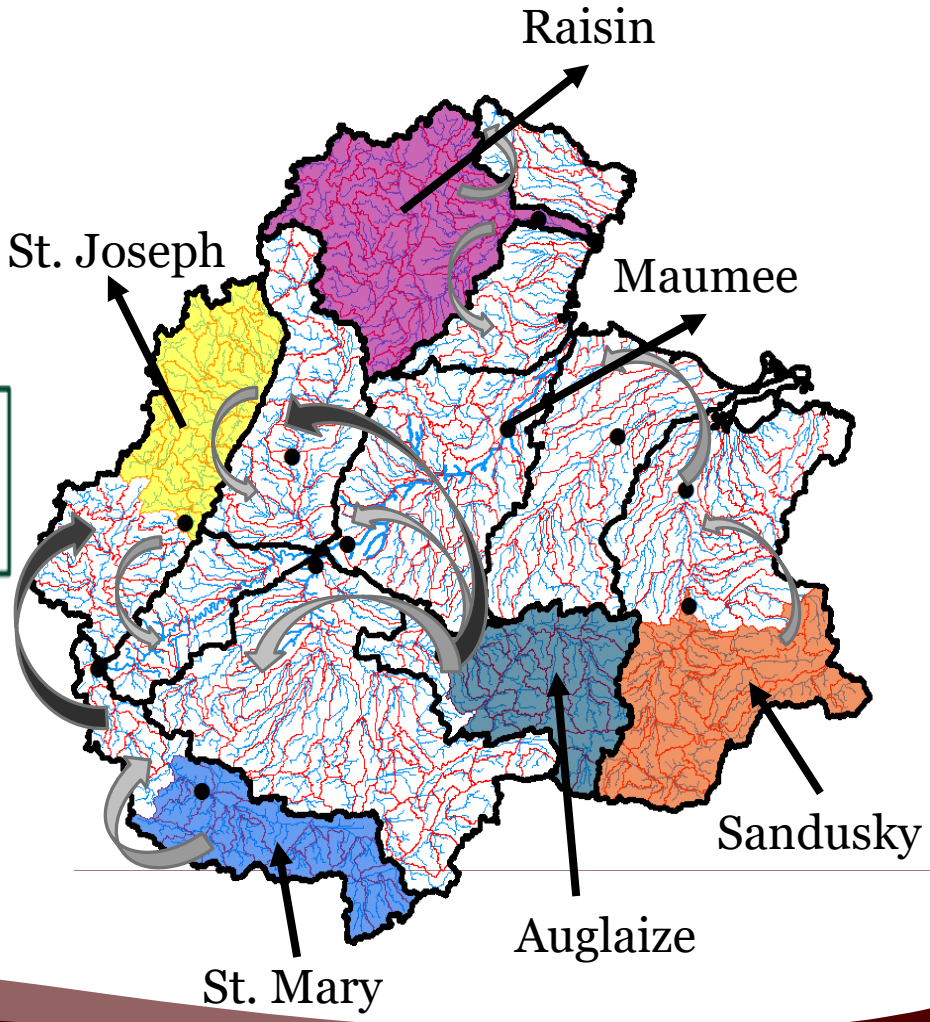
Framework of Automatic-Calibration



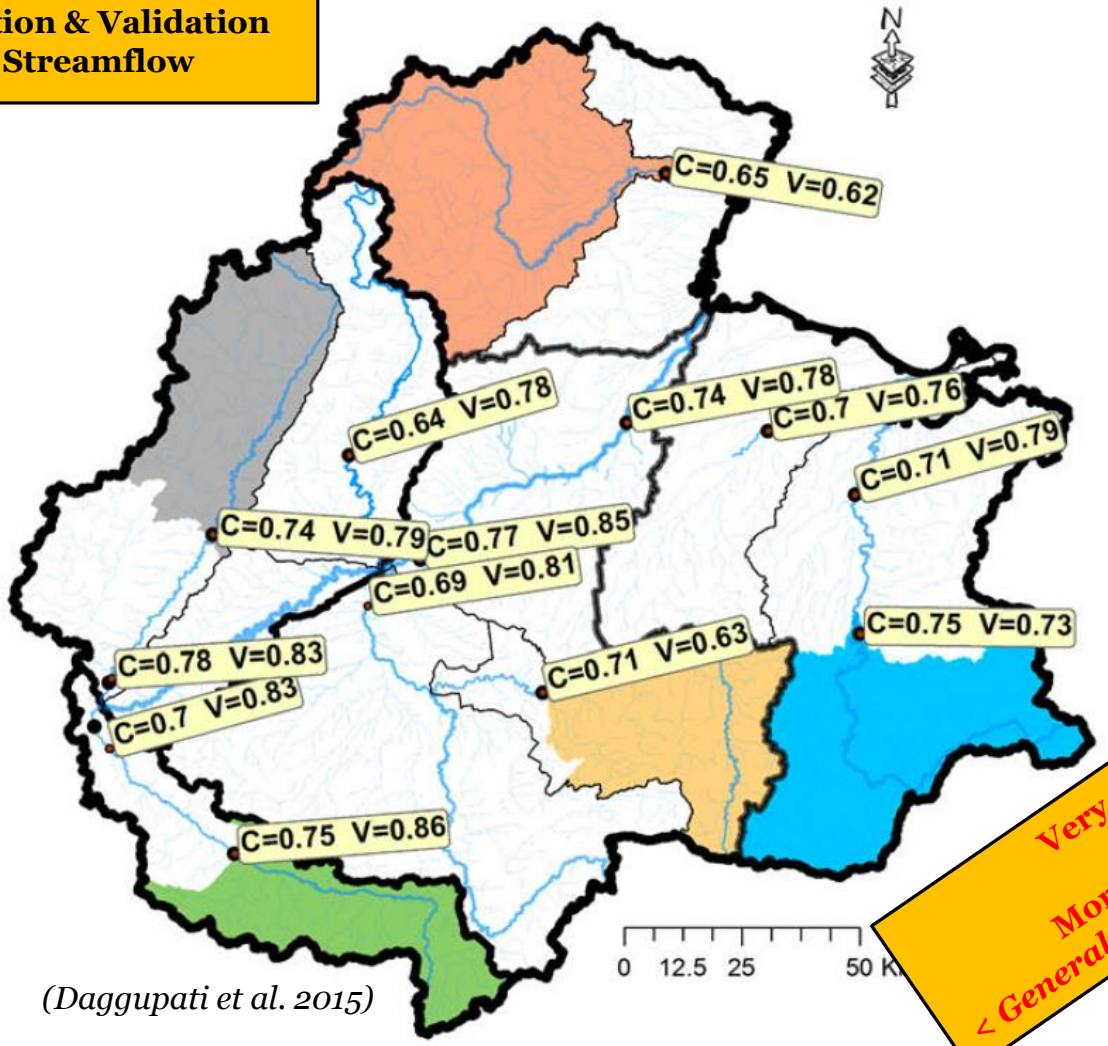
Demonstration of Flow Calibration



(Daggupati et al. 2015)

Results (1/4)

Calibration & Validation for Streamflow

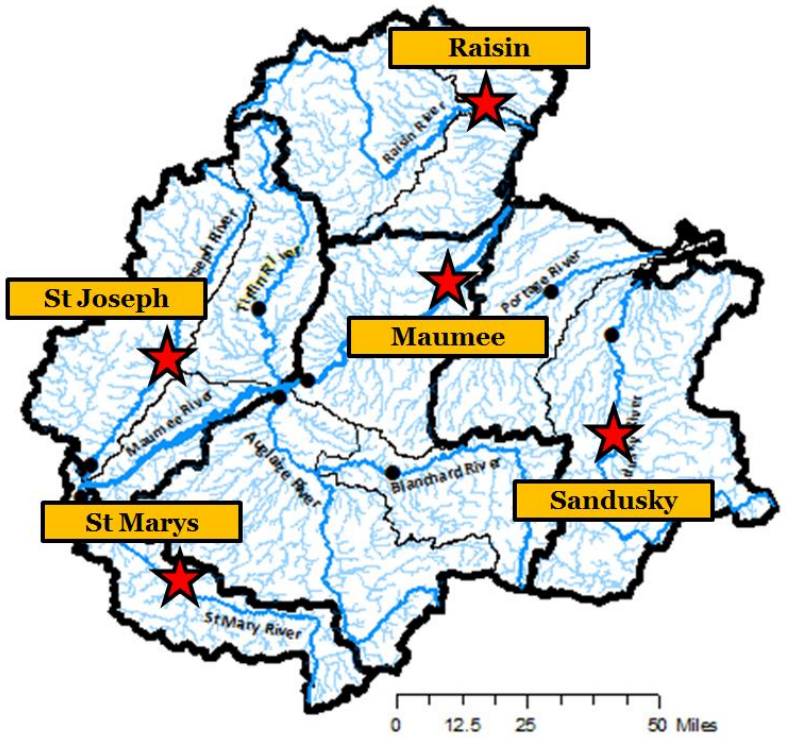


(Daggupati et al. 2015)

Very Good ! ! !
By
Moriasi et al. 2007
< General Performance Ratings >

Results (2/4)

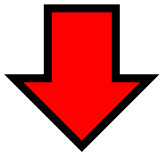
- Water Quality Calibration & Validation
  - Sediment / Total Phosphorus / Total Nitrogen
    - Model parameters are ***not*** transferable from HUC12 ⇨ NHDPlus
    - 5 selected gauge stations for each subwatershed
    - Raisin / St. Joseph / St. Marys / Maumee / Sandusky
  - Simulation periods
    - Calibration 1990 - 1999
    - Validation 2000 - 2006
  - Soft data constraints *(Yen et al. 2014a, b)*
    - Denitrification < 50 kg/ha
    - SSQ_Ratio > 60%
  - Special SWAT revision
    - Handy helper for sediment
    - SPCON can be specified in each subwatershed
    - *.rte files



Results (3/4)

- Water Quality Calibration & Validation

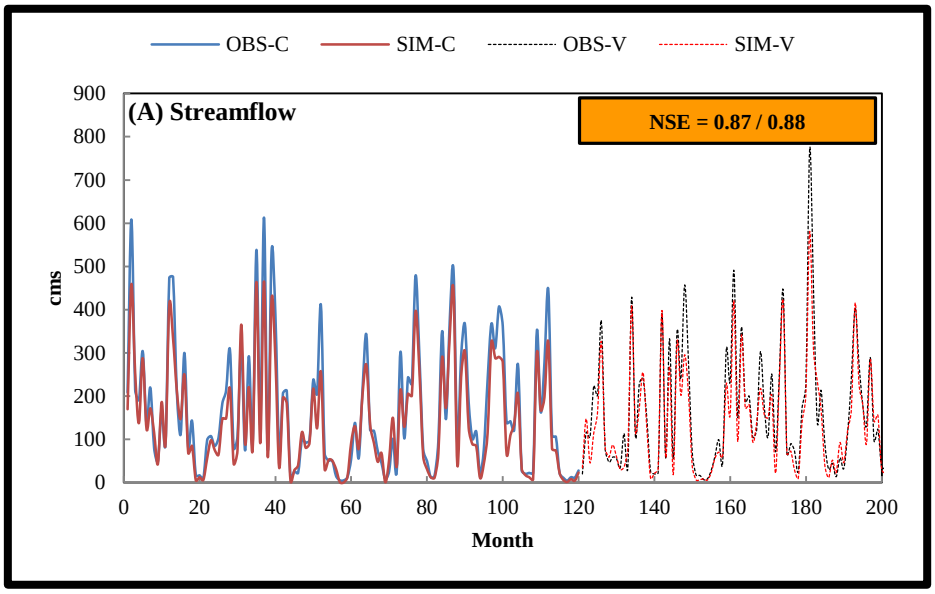
after.....
So Many Sleepless Nights

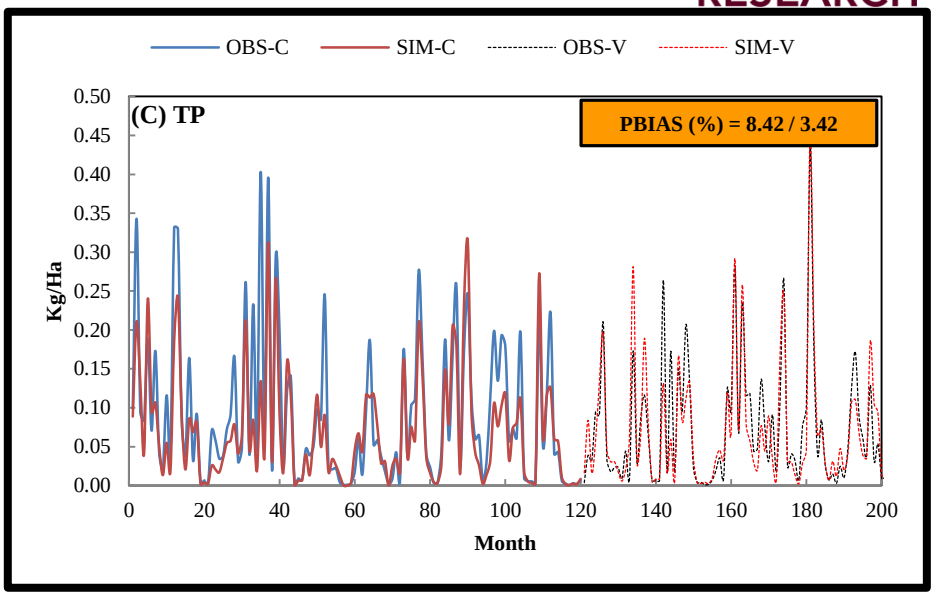


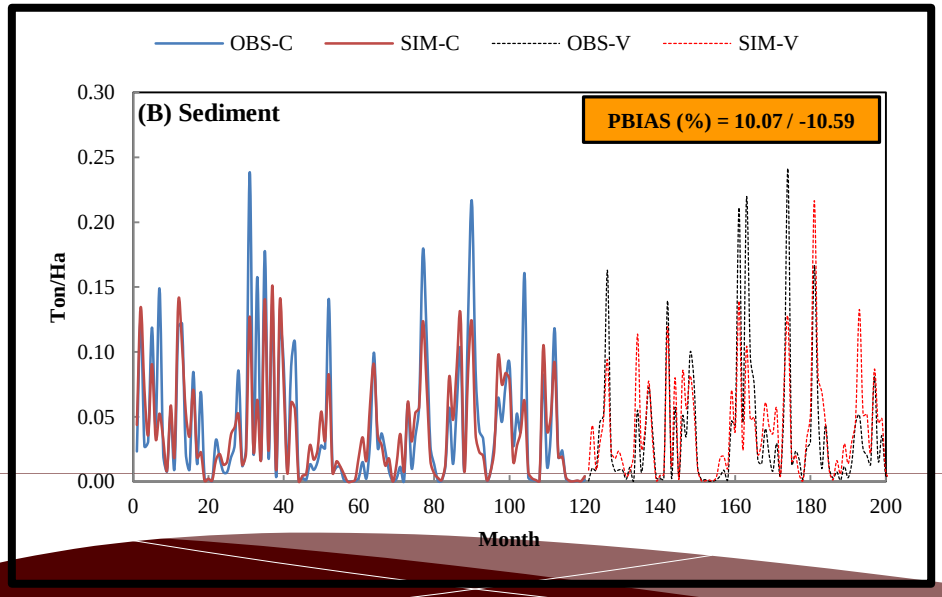
Final Statistics (NHDPlus)					
Station	Streamflow		Sediment	TP	TN
	NSE	PBIAS (%)	PBIAS (%)	PBIAS (%)	PBIAS (%)
Raisin	0.70/0.43	-11.76/-26.07	16.71/35.46	-3.55/-22.74	14.66/3.59
St. Joseph	0.73/0.74	22.70/18.66	-10.43/-20.3	5.33/4.95	-25.39/-68.71
St. Marys	0.54/0.43	17.94/25.25	17.99/19.57	6.52/9.42	8.23/21.00
Maumee	0.87/0.88	18.03/13.56	10.07/-10.59	8.42/3.42	16.87/13.27
Sandusky	0.82/0.75	18.67/7.00	18.63/-35.01	-12.78/0.61	-15.26/-12.37

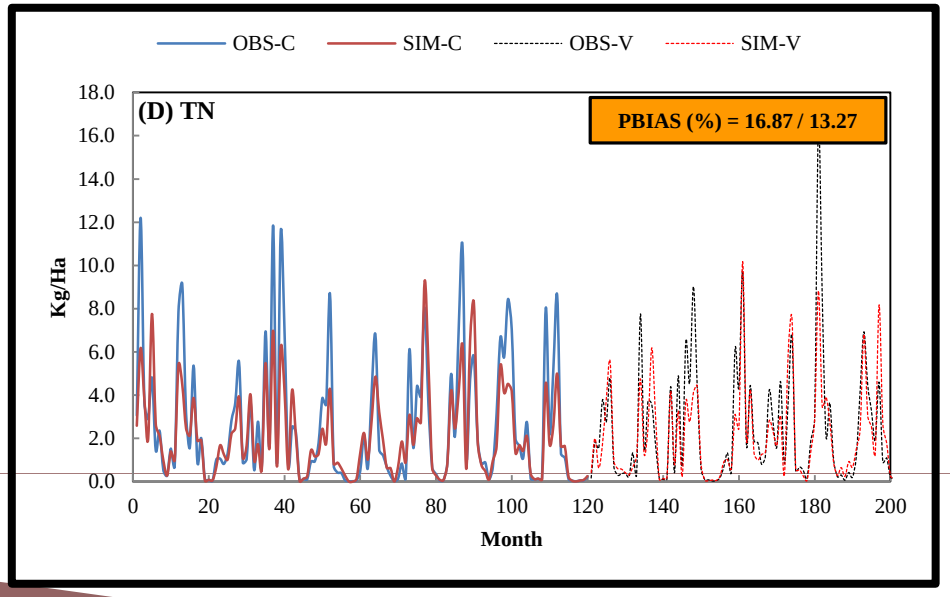
Maumee Station

Results (4/4)









Conclusion & Future Work

- WLEB NHDPlus SWAT Project
  - Baseline scenario is done
    - ***SFSG***
  - Applications of conservation scenarios with USDA-NRCS
    - Erosion control
    - Nutrient management
  - Associated biological analysis
    - Fish community health
    - Biologists from Ohio State University and Nature Conservancy
  - Additional implementations
    - Climate change scenarios
    - Uncertainty analysis

Reference

- WLEB Modeling
  - Daggupati, P., H. Yen, M. J. White, R. Srinivasan, J. G. Arnold, S. C. Keitzer, S. P. and Sowa, (2015) " Impact of model development, calibration and validation decisions on hydrological simulations in West Lake Erie Basin." ***Hydrological Processes***, doi: 10.1002/hyp.10536.

- Soft Data Implementations
  - Yen, H., X. Wang, D. G. Fontane, M. Arabi, R. D. Harmel (2014a) "A Framework for Propagation of Uncertainty Contributed by Input Data, Parameterization, Model Structure, and Calibration/Validation Data in Watershed Modeling." ***Environmental Modelling and Software***, 54, pp. 211-221.
  - Yen, H., R. T. Bailey, M. Arabi, M. Ahmadi, M. J. White, J. G. Arnold (2014b) "The Role of Interior Watershed Processes in Improving Parameter Estimation and Performance of Watershed Models." ***Journal of Environmental Quality***, 43(5), pp. 1601-1613.

Acknowledgement

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- Please do not forget that USDA is an equal opportunity employer and provider!

Thanks for your attention!

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