Parameter Transferability against Altered Land Use Dataset on Model Predictions Using SWAT

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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 data

Alternative Land Use Data (1/2)

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- Decision made before conducting watershed modeling
  - Watershed delineation
  - Selection of model functions
    - Surface runoff, flooding routing , sediment transport equations
  - Alternative model input data
    - Various sources of input data are available
    - ***Land use***, soil type, topographic information

Alternative Land Use Data (2/2)

- Goal and objectives
  - To examine statistical model performance under different land use data
  - To cross compare statistical performance by transferring calibrated best parameter sets
  - To explore results of streamflow, sediment, and nutrients processes by temporal magnitude and percentiles in varying scenarios

Soil and Water Assessment Tool

- 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 1,800 journal articles in literature

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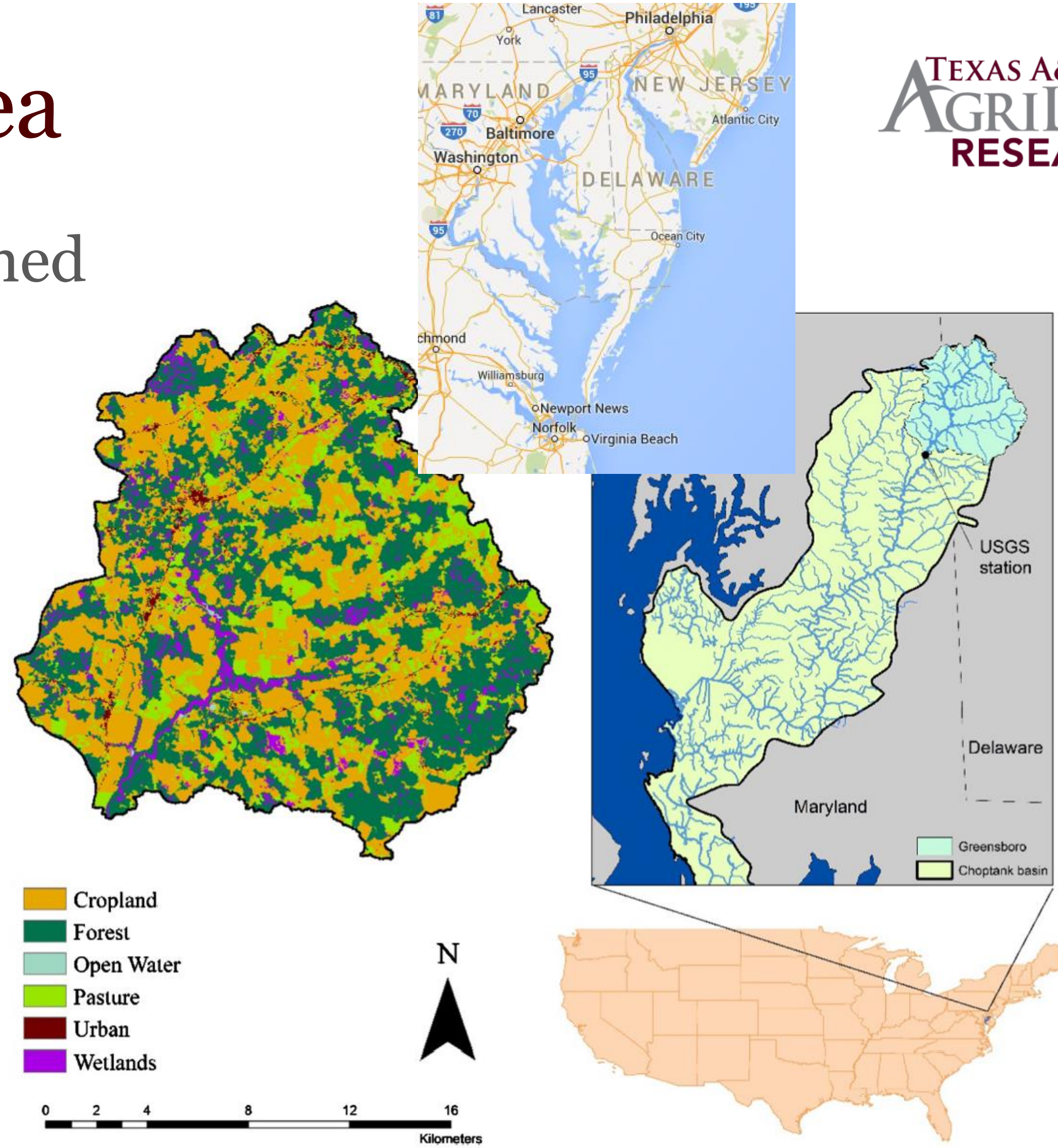
- Integrated Parameter Estimation & Uncertainty Analysis Tool (Yen et al., 2014a)
  - MATLAB based framework
  - Sources of uncertainty incorporated
    - Model parameters (last 20 years)
    - Forcing inputs (Kavetski et al., 2002)
    - Model structure (Ajami et al., 2007)
    - Measured data for calibration/validation (Harmel et al., 2006)
  - Applications
    - Input uncertainty (Yen et al., 2015b)
    - Measurement Uncertainty (Yen et al., 2015c)
    - APEX-CUTE (Wang et al., 2014)
      - **A**gricultural **P**olicy/**E**nvironmental e**X**tender auto-**C**alibration and **U**ncer**T**ainty **E**stimator (MATLAB & Python based)

Case Study Area

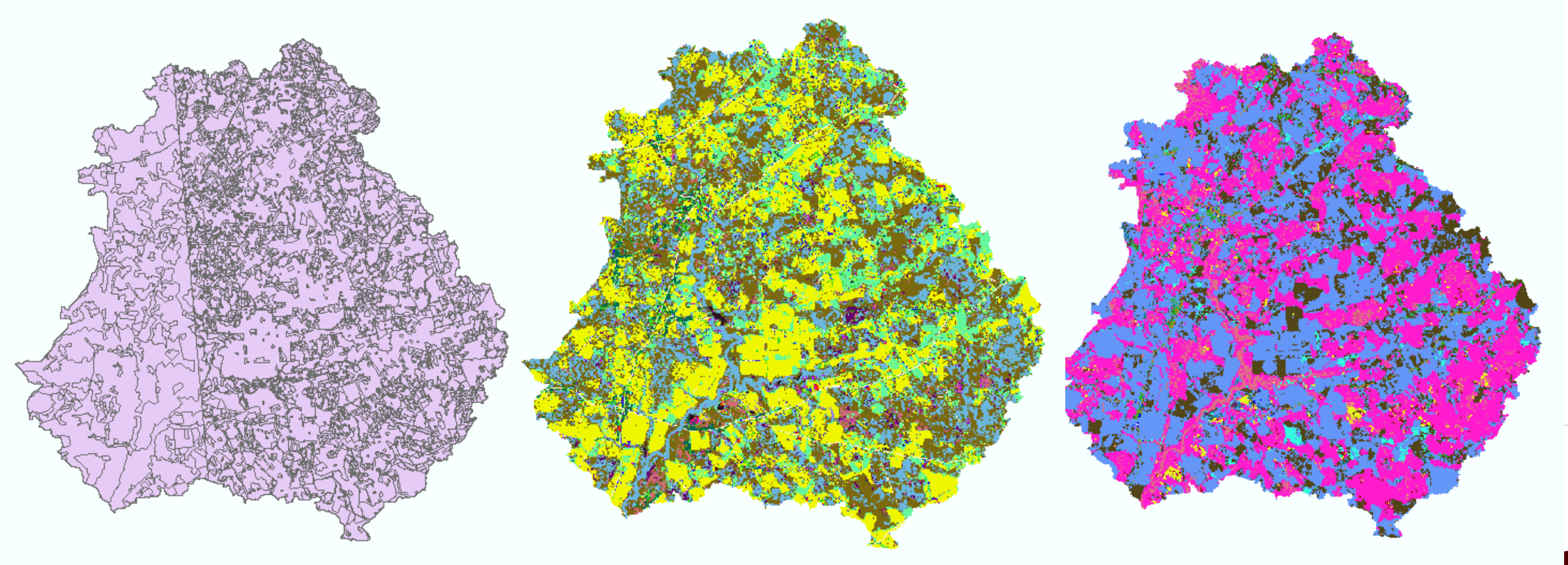
- Greensboro watershed
  - Maryland, USA
  - 294 km²
  - Available data
    - Streamflow
    - Sediment
    - TN
    - TP
  - Data length
    - 1986~1995
      - Calibration
    - 1996~2005
      - Validation



Data Source: Yen, H., A. Sharifi, L. Kalin, G. Mirhosseini, J. G. Arnold (2015) "Assessment of Model Predictions and Parameter Transferability by Alternative Land Use Data on Watershed Modeling." Journal of Hydrology, 527, pp. 458-470.
DOI: 10.1016/j.jhydrol.2015.04.076

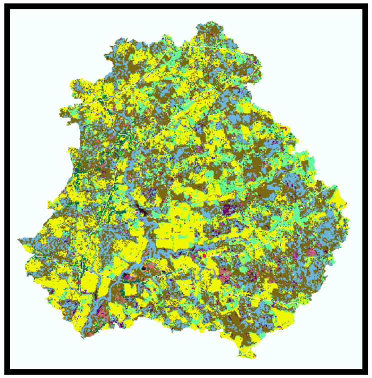
Case Study Settings (1/2)

- Land use sources and case scenarios
  - RESAC-1
    - Mid-Atlantic Regional Earth Science Application Center
  - NLCD-1
    - National Land Use Cover Dataset
  - STATE-1
    - State Land Use/Cover Maps



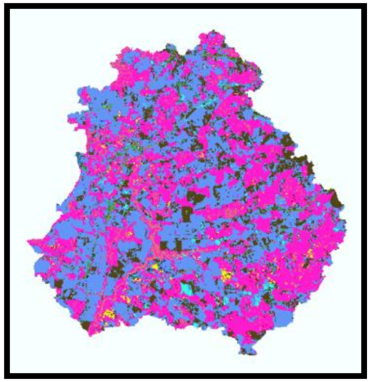
Land Use/Cover Datasets

1) NLCD 2001 (National Landcover Dataset)



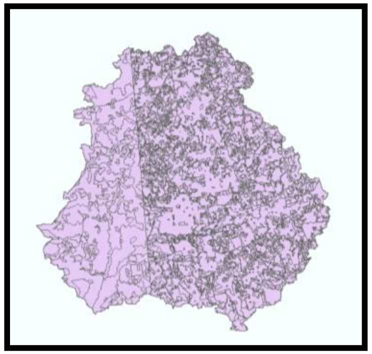
- ❑ Product of MRLC (Multi-Resolution Land Characteristics Consortium)
- ❑ 30 meter resolution
- ❑ Multitemporal Landsat 5 and 7 imagery
- ❑ Sixteen land cover classes

2) RESAC 2000 (Mid-Atlantic Regional Earth Science Applications Center)



- ❑ Product of The mid-Atlantic Regional Earth Science Applications Center (RESAC)
- ❑ 30 meter resolution
- ❑ Landsat 7 Enhanced thematic Maper imagery
- ❑ 21 classes land cover classes
- ❑ Only available for Chesapeake Bay watershed

3) STATE LULC maps (2000-2002)



- ❑ Combined Product of Maryland department of planning (2000) and Delaware Office of State Planning Coordination (2002)
- ❑ Focused on urban planning rather than environmental management
- ❑ 200 meter resolution (Maryland) Vs. 1 foot (Delaware)
- ❑ High altitude aerial photography , satellite imagery (Maryland) Vs. and false color infrared aerial digital orthophotography (Delaware)
- ❑ 24 classes land cover classes

Land Use/Cover Classifications

(after model Setup)

Land use/cover	NLCD	RESAC	STATE
Water	0.09	0.21	0.34
Residential-Low Density	1.01	2.47	9.34
Residential-Medium Density	0.48	1.12	0.17
Residential-High Density	0.1	0.28	0.04
Industrial	0.01	---	0.03
Commercial	---	0.45	0.21
Transportation	---	1.9	0
Residential	---	1.27	0.08
Institutional	---	0.03	---
Forest-Deciduous	36.83	28.21	13.97
Forest-Evergreen	1	2.58	0.9
Forest-Mixed	0.46	1.72	5.33
Wetlands-Forested	4.72	15.71	---
Wetlands-Non-Forested	1.12	1.55	---
Wetlands-Mixed	---	0.45	20.13
Agricultural Land-Row Crops	40.32	28.9	30.59
Pasture	---	12.88	0.45
Hay	13.38	---	---
Range-Grasses	0.47	0.09	1.02
Agricultural Land-Generic	---	0.18	17.4
Sum	100	100	100

Case Study Settings (2/2)

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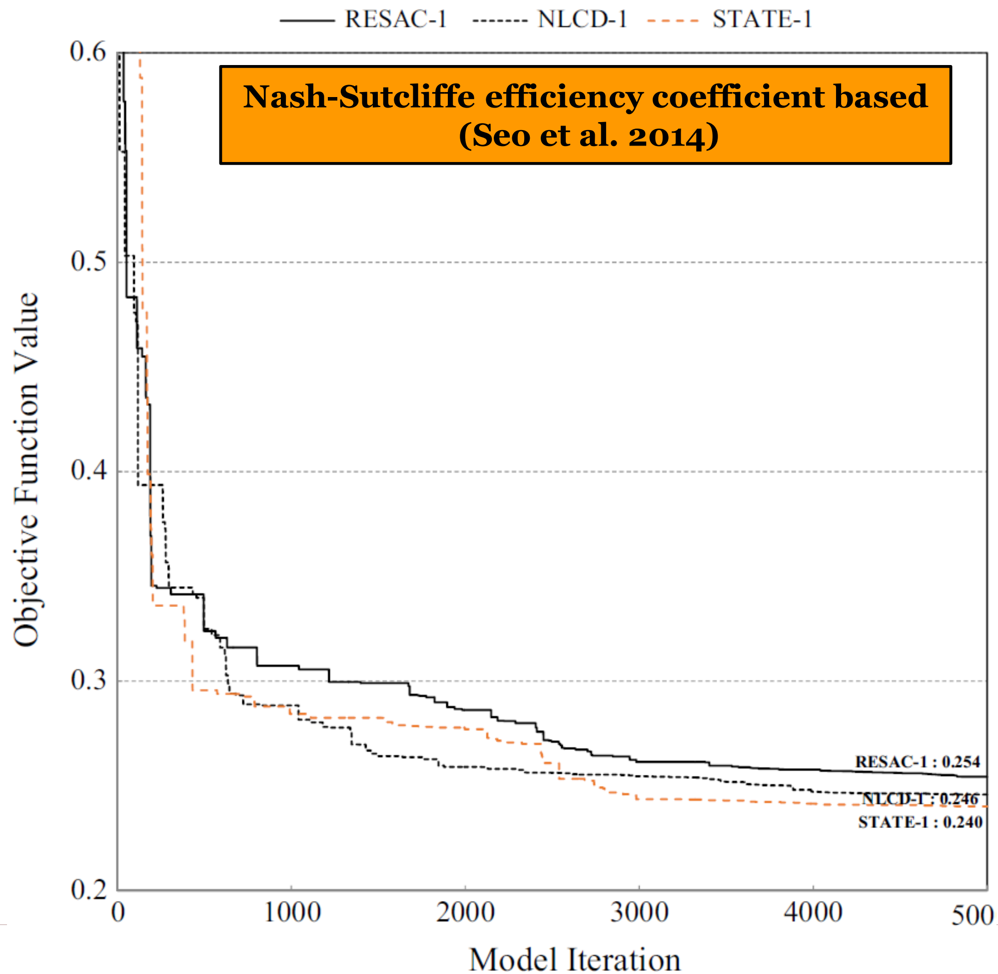
Case scenario	Description
RESAC-1	SWAT calibration/validation by RESAC dataset
RESAC-2	SWAT simulation is conducted by using best parameter set from RESAC-1 on NLCD dataset
RESAC-3	SWAT simulation is conducted by using best parameter set from RESAC-1 on STATE dataset
NLCD-1	SWAT calibration/validation by NLCD dataset
NLCD-2	SWAT simulation is conducted by using best parameter set from NLCD-1 on RESAC dataset
NLCD-3	SWAT simulation is conducted by using best parameter set from NLCD-1 on STATE dataset
STATE-1	SWAT calibration/validation by STATE dataset
STATE-2	SWAT simulation is conducted by using best parameter set from STATE-1 on NLCD dataset
STATE-3	SWAT simulation is conducted by using best parameter set from STATE-1 on RESAC dataset

Results (1/3)

- Results of objective function values



Results (2/3)

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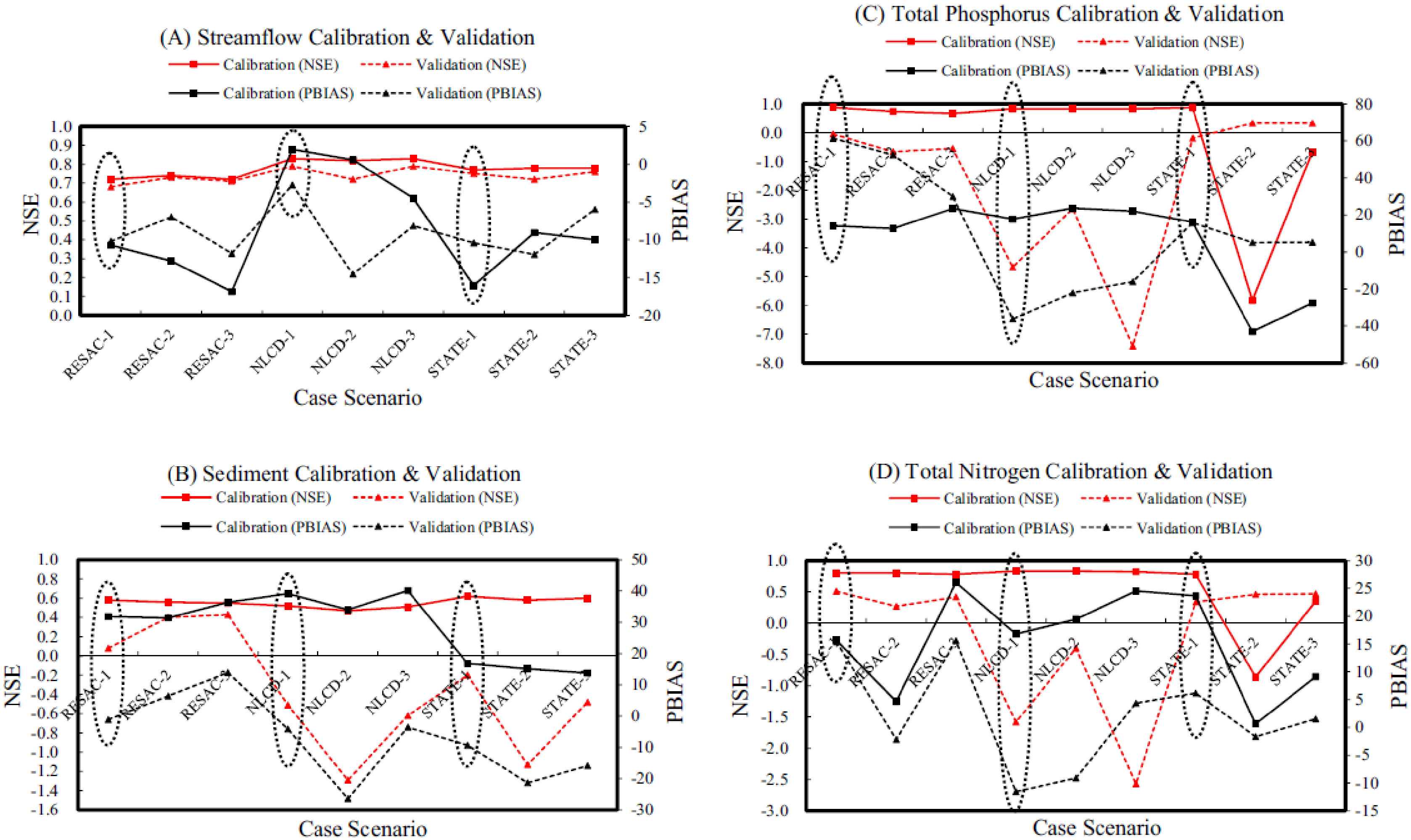
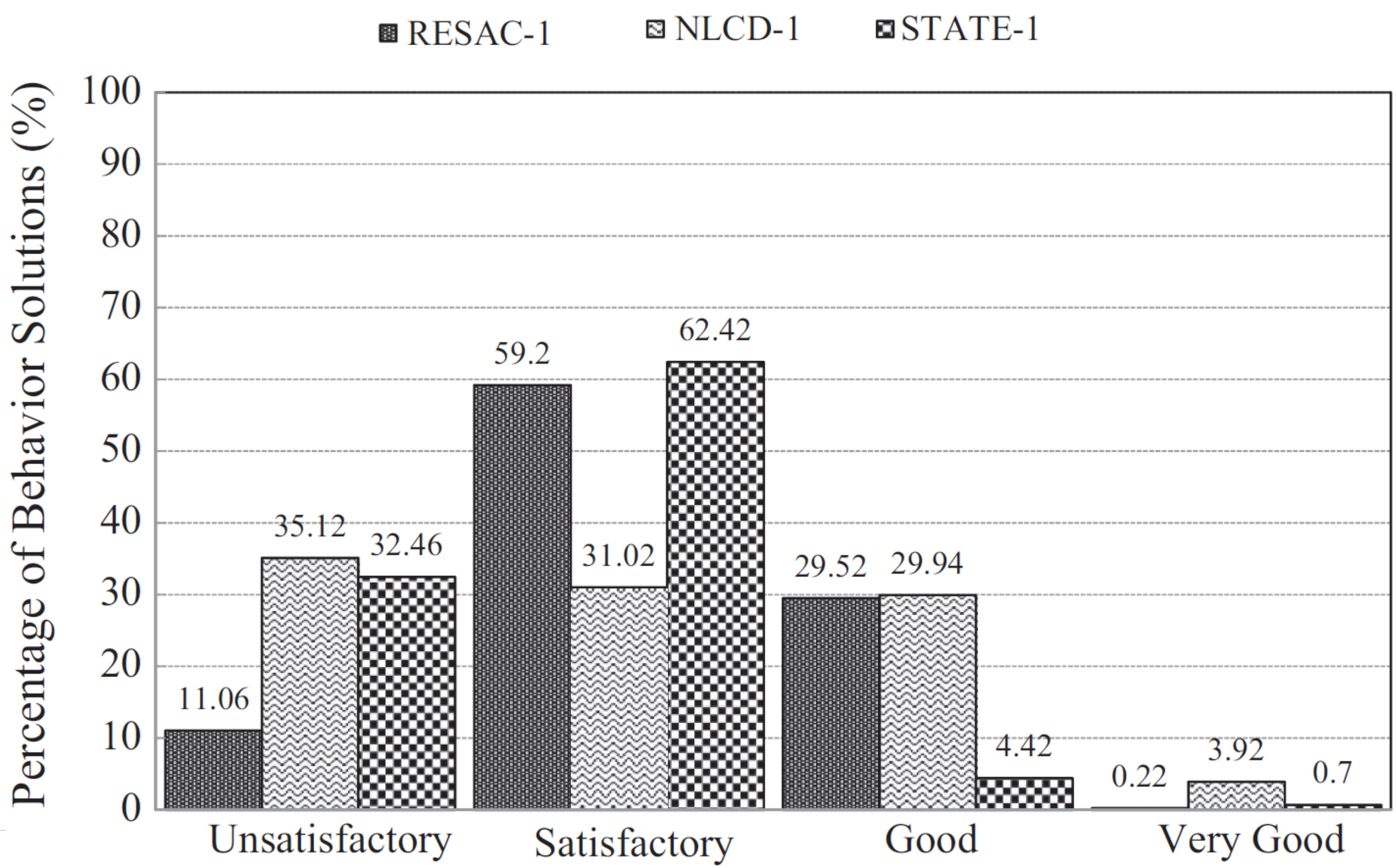
- Error statistics of the best results in each scenario



Dashed circles are used to highlight results specifically for RESAC-1, NLCD-1, and STATE-1.

Results (3/3)

- Percentage of behavior solutions defined in Moriasi et al. 2007



Discussion and Conclusion

- No significant difference in comparing general performance
  - Objective function values
  - Convergence speed
- SWAT with RESAC dataset performed overall better than STATE and NLCD
  - Error statistics
  - Percentage of behavior solutions
- Parameter transferring
  - Model parameter may not transferable by using different sources of land use data on the same watershed
    - RESAC scenarios have shown better performance while conducting parameter transferring

Reference

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- Alternative land use data sources using SWAT

  - Yen, H., A. Sharifi, L. Kalin, G. Mirhosseini, J. G. Arnold (2015a) "Assessment of Model Predictions and Parameter Transferability by Alternative Land Use Data on Watershed Modeling." ***Journal of Hydrology***, 527, pp. 458-470.

- IPEAT Development & Applications

  - Yen, H., X. Wang, D. G. Fontane, M. Arabi, R. D. Harmel (2014) "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 (2014) "The Role of Interior Watershed Processes in Improving Parameter Estimation and Performance of Watershed Models." ***Journal of Environmental Quality***, 43(5), pp. 1601-1613.

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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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Application of Behavior Definition

- Behavior definition
  - Statistical thresholds in evaluating model performance

Performance Rating	Nash-Sutcliffe Coefficient	PBIAS (%)	
		Streamflow	NOX
Very Good	0.75 < NSE ≤ 1.00	PBIAS < ±10	PBIAS < ±25
Good	0.65 < NSE ≤ 0.75	±10 ≤ PBIAS < ±15	±25 ≤ PBIAS < ±40
Satisfactory	0.50 < NSE ≤ 0.65	±15 ≤ PBIAS < ±25	±40 ≤ PBIAS < ±70
Unsatisfactory	NSE ≤ 0.50	PBIAS ≥ ±25	PBIAS ≥ ±70

General Performance Ratings, Moriasi et al. (2007)