Daily flow prediction in Ungauged watersheds: SWAT-ANN

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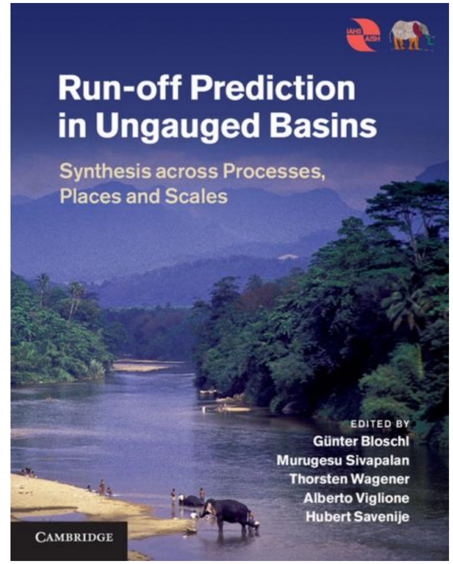
Background

- Streamflow prediction:
  - ✓ Operation and optimization of water resources
  - ✓ Flood control and water resource management
  - ✓ It is complicated: Climate, topology, topography, soil, geology, land use/cover
- Accuracy of different flow prediction models:
  - ✓ Empirical methods are simplistic and are constrained to a functional form between variables prior to the analysis.
  - ✓ Process-based models take into account various processes of the hydrological cycle via mathematical formulation.

Background

- ✓ Predictions in ungauged watersheds are more challenging
- ✓ No data for calibration
- ✓ Regionalization: *Transfer of parameters from neighboring gauged watersheds (**donor**) to an ungauged (**target**) watershed.*
  - ✓ Regression based
  - ✓ Physical similarity based
  - ✓ Proximity based



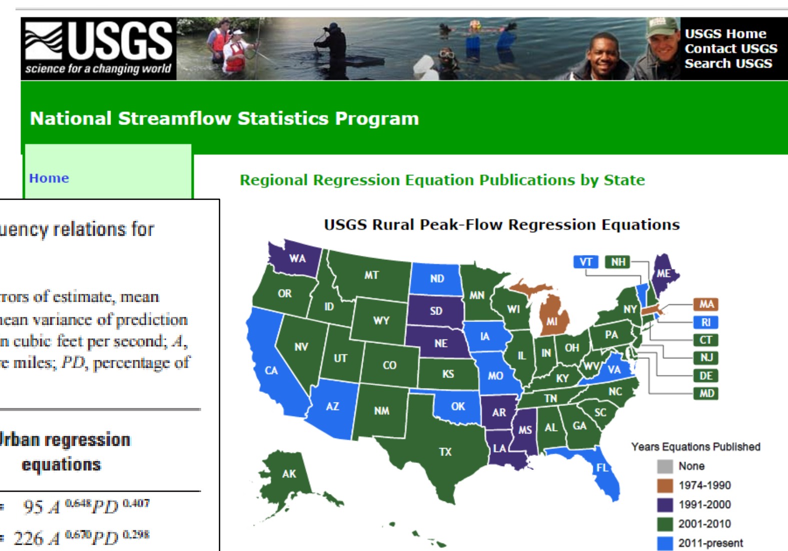
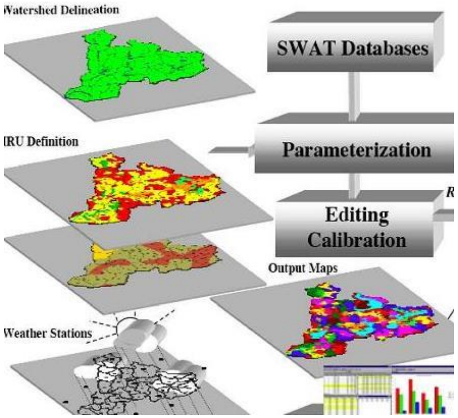


Table 3. Regional flood-frequency relations for urban streams in Alabama.

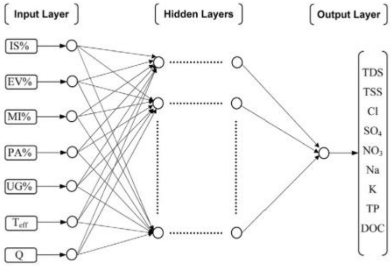
[Note: Associated mean standard errors of estimate, mean standard errors of prediction, and mean variance of prediction are listed in table 4. Q, flood flow, in cubic feet per second; *A*, contributing drainage area, in square miles; *PD*, percentage of basin developed]

Exceedance probability (percent)	Urban regression equations
50	$Q = 95\,A^{0.648} PD^{0.407}$
20	$Q = 226\,A^{0.670} PD^{0.298}$
10	$Q = 306\,A^{0.675} PD^{0.276}$
4	$Q = 417\,A^{0.670} PD^{0.253}$
2	$Q = 513\,A^{0.663} PD^{0.237}$
1	$Q = 618\,A^{0.656} PD^{0.223}$
0.5	$Q = 733\,A^{0.650} PD^{0.210}$
0.2	$Q = 897\,A^{0.642} PD^{0.196}$

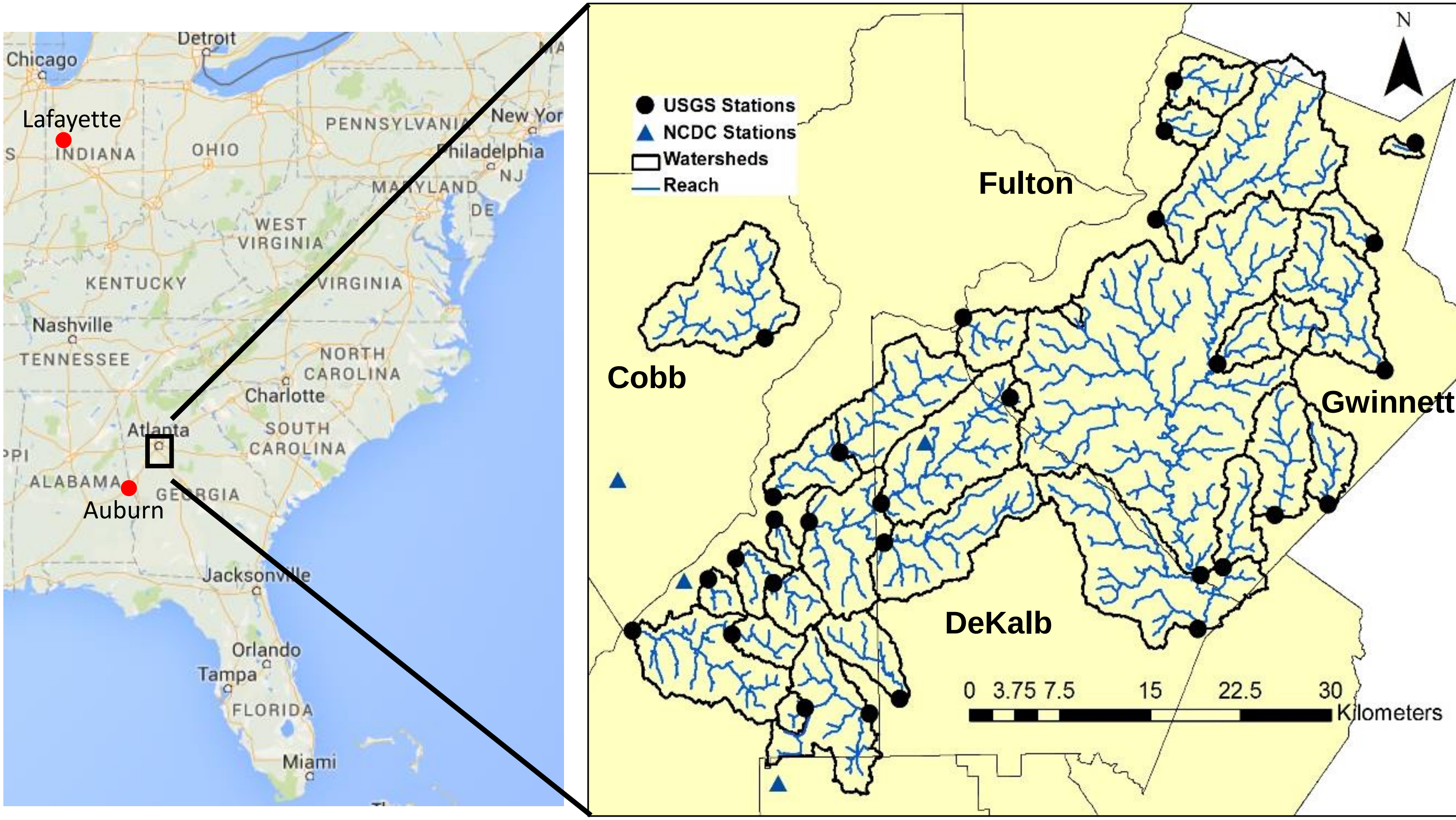
SWAT - ANN



- Soil Water Assessment Tool (SWAT)
  - ✓ a large amount of spatial and temporal data needed.
  - ✓ Calibration and validation processes are time consuming, requires good expertise and could be challenging.
- Artificial Neural Network (ANN)
  - ✓ Select the best combination of the input variables for a parsimonious model.
  - ✓ If an event is beyond their training data range, the predictive model would perform poorly with high uncertainty.

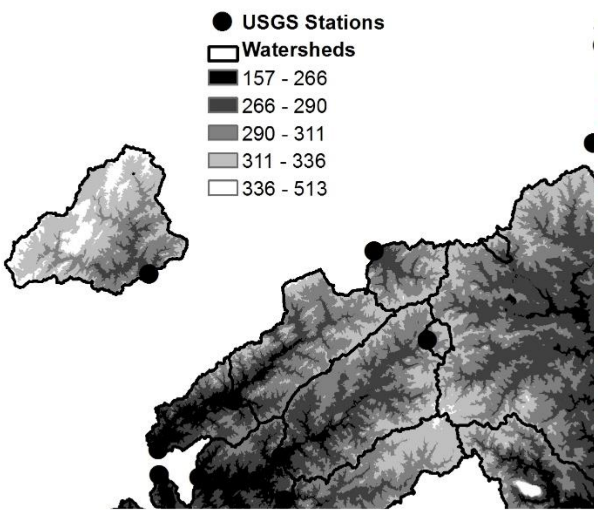


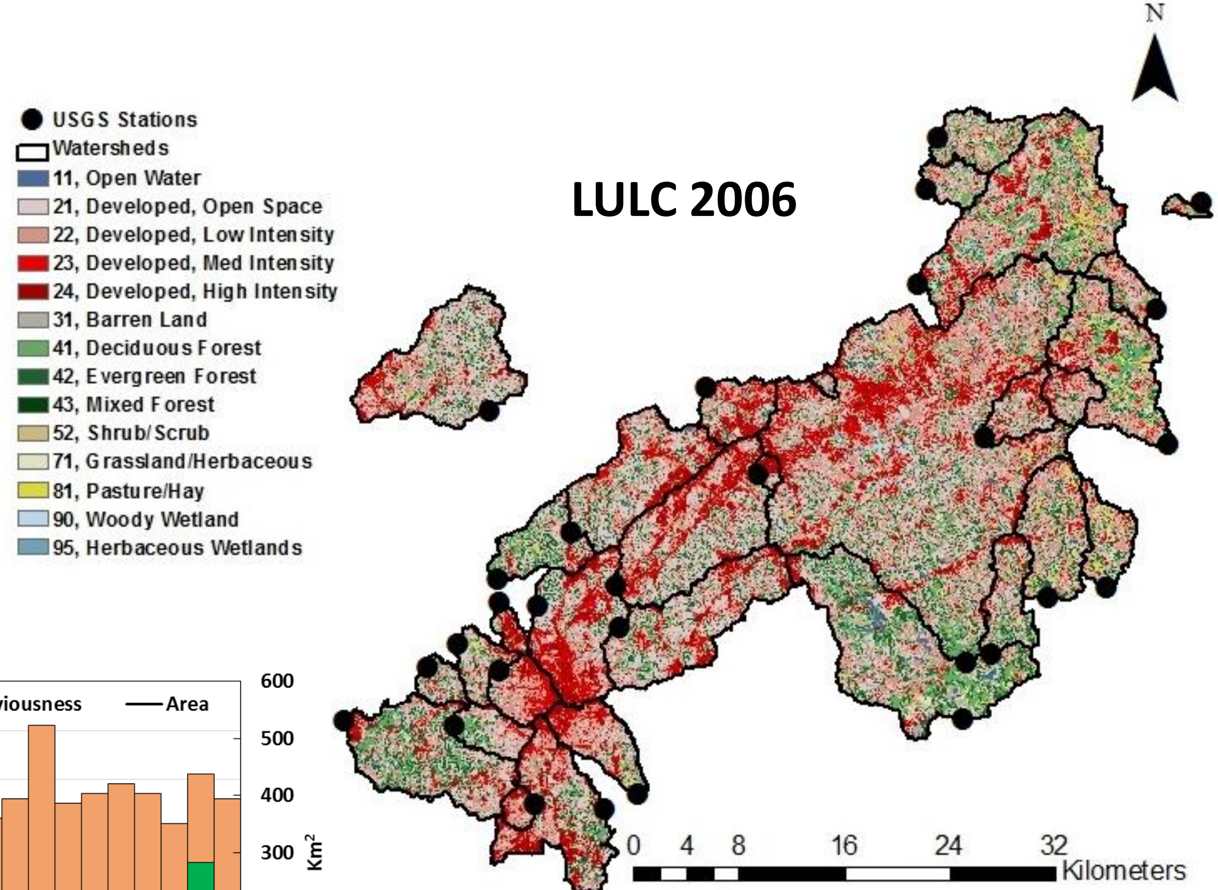
Study Area

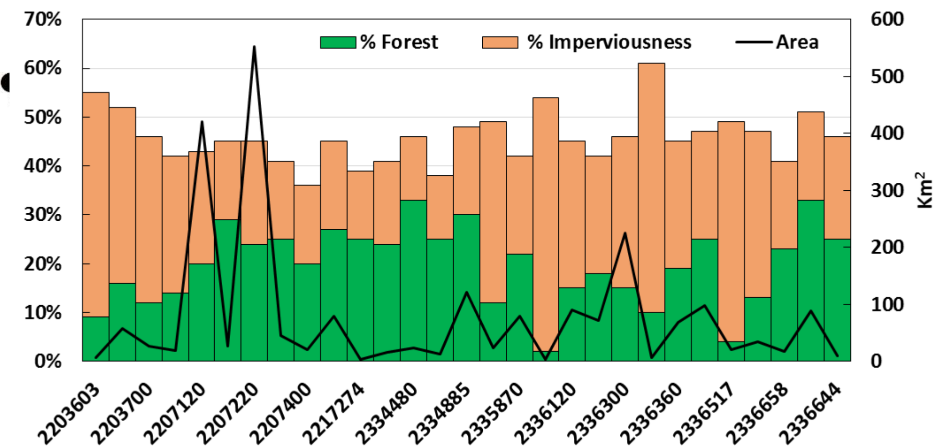


Detroit
Chicago
Lafayette
INDIANA
OHIO
Philadelphia
MARYLAND
NJ
DE
WEST VIRGINIA
KENTUCKY
VIRGINIA
Nashville
TENNESSEE
NORTH CAROLINA
Charlotte
Atlanta
SOUTH CAROLINA
ALABAMA
GEORGIA
Auburn
Jacksonville
Orlando
Tampa
FLORIDA
Miami
N
USGS Stations
NCDC Stations
Watersheds
Reach
Fulton
Cobb
Gwinnett
DeKalb
0 3.75 7.5 15 22.5 30
Kilometers

Study Area

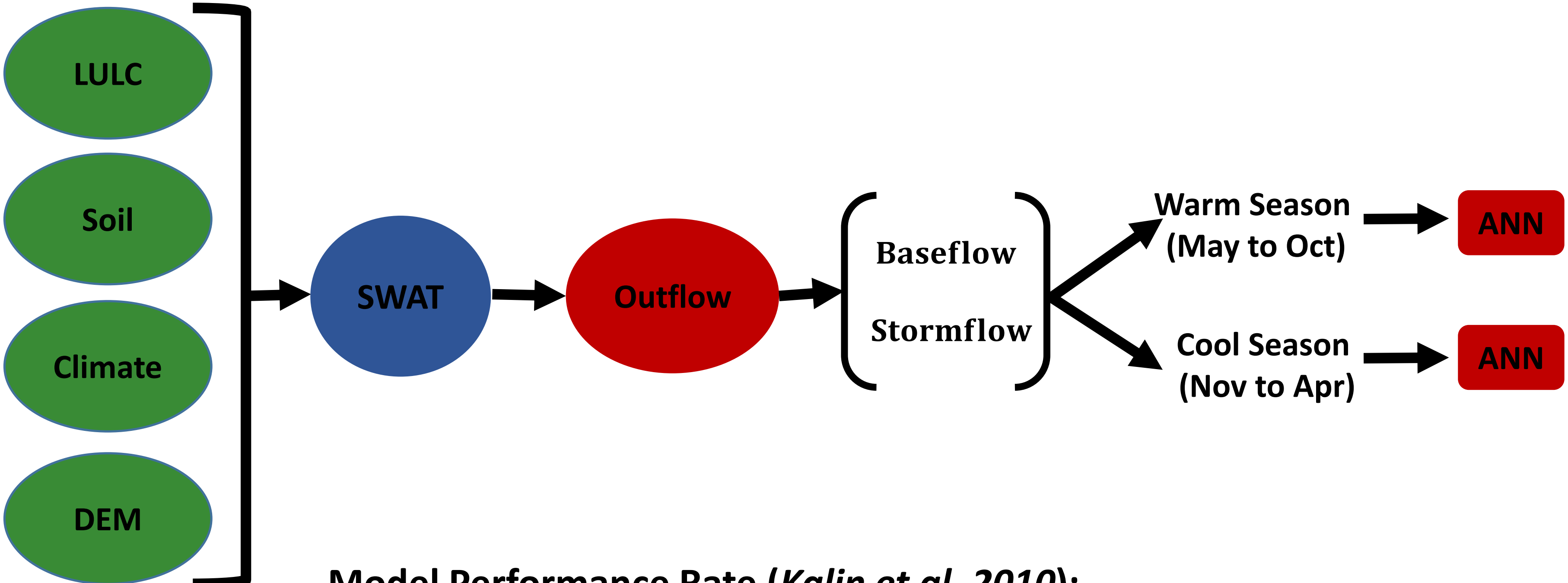






Hydrologic soil group map

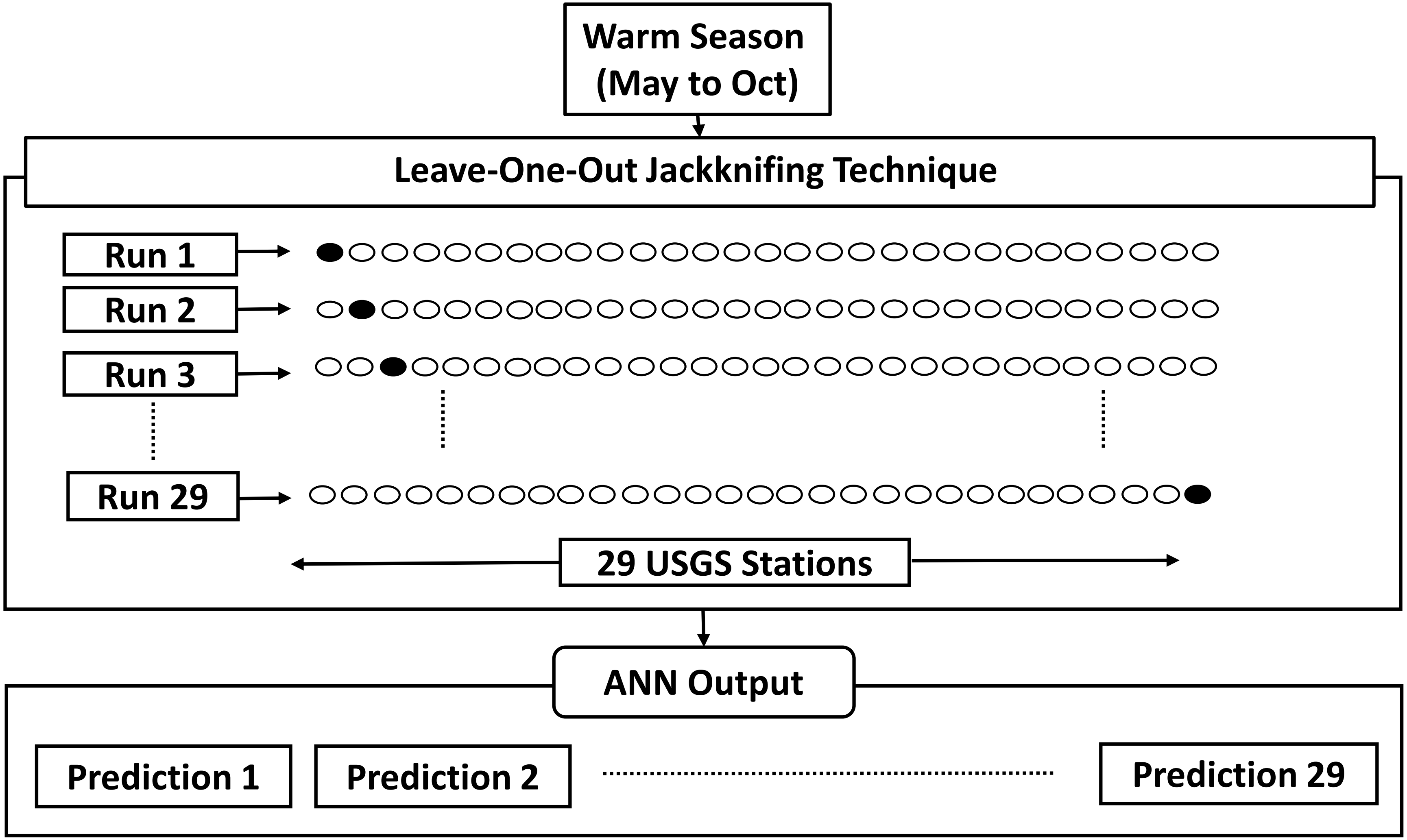
Coupling SWAT with ANN



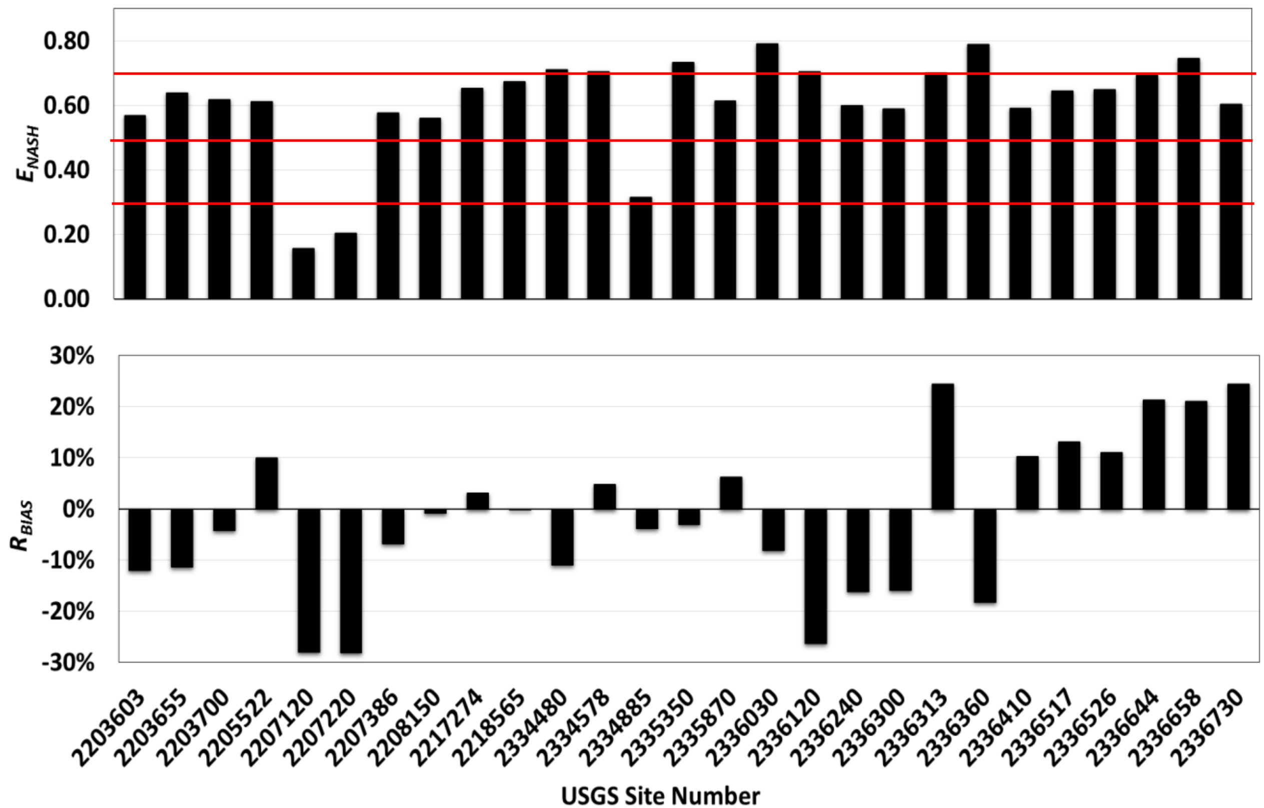
Model Performance Rate (*Kalin et al. 2010*):

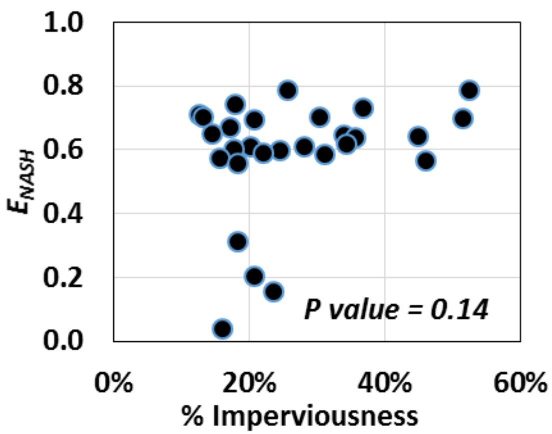
- ***Very good***: $E_{NASH} \geq 0.70$; $|R_{BIAS}| \leq 0.25$
- ***Good***: $0.50 \leq E_{NASH} < 0.70$; $0.25 < |R_{BIAS}| \leq 0.50$
- ***Satisfactory***: $0.30 \leq E_{NASH} < 0.50$; $0.50 < |R_{BIAS}| \leq 0.70$
- ***Unsatisfactory***: $E_{NASH} < 0.30$; $|R_{BIAS}| > 0.70$

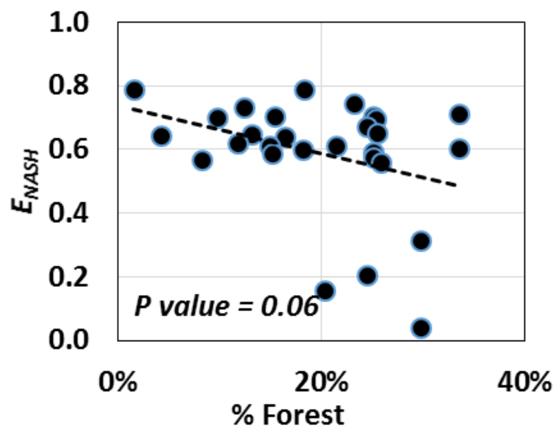
Coupling SWAT with ANN

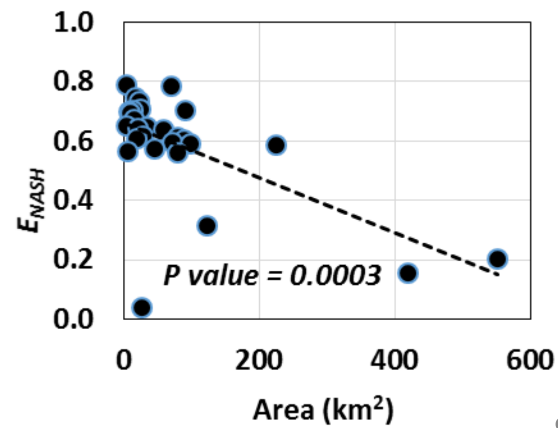


Results, Warm Season

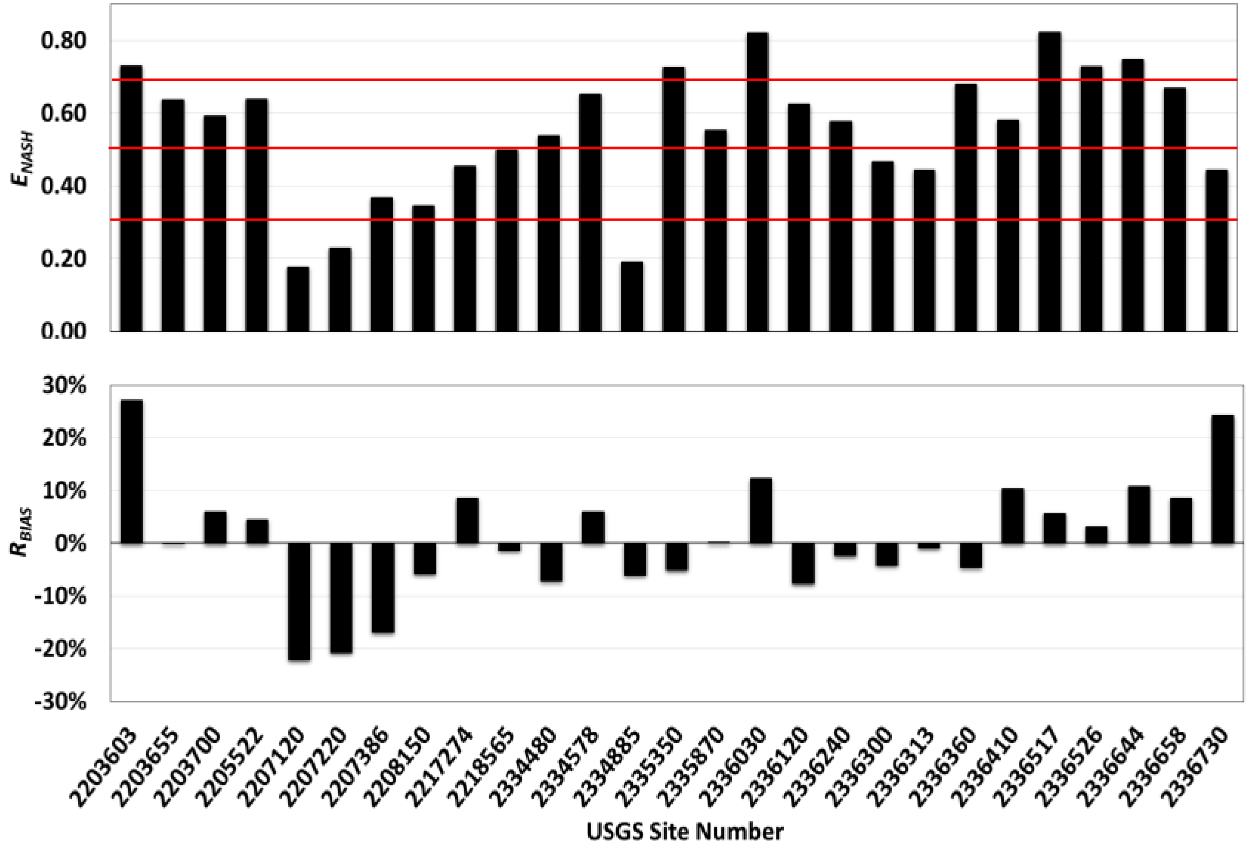


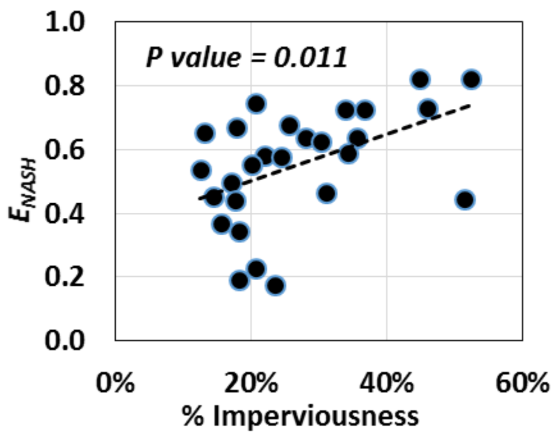


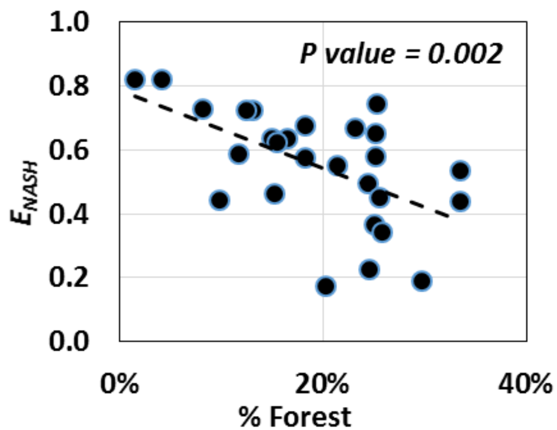


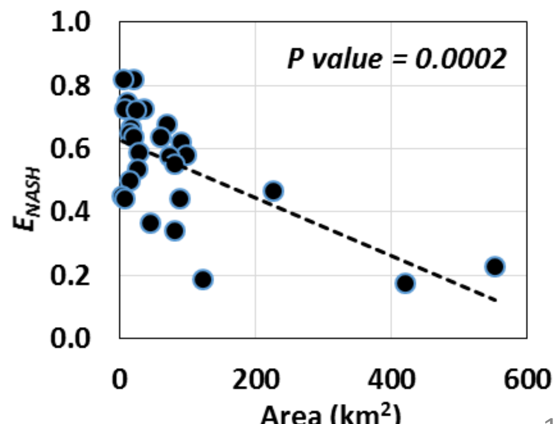


Results, Cool Season

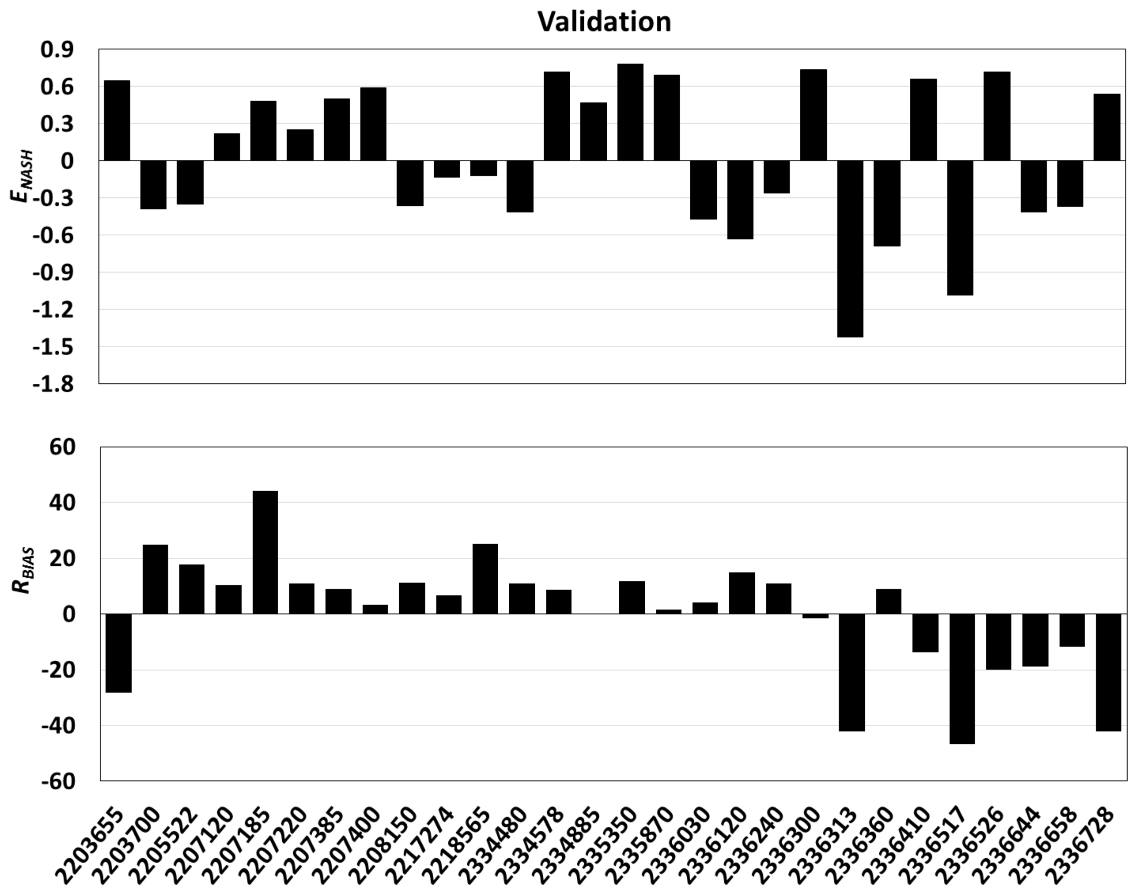








Flow Prediction Using SWAT



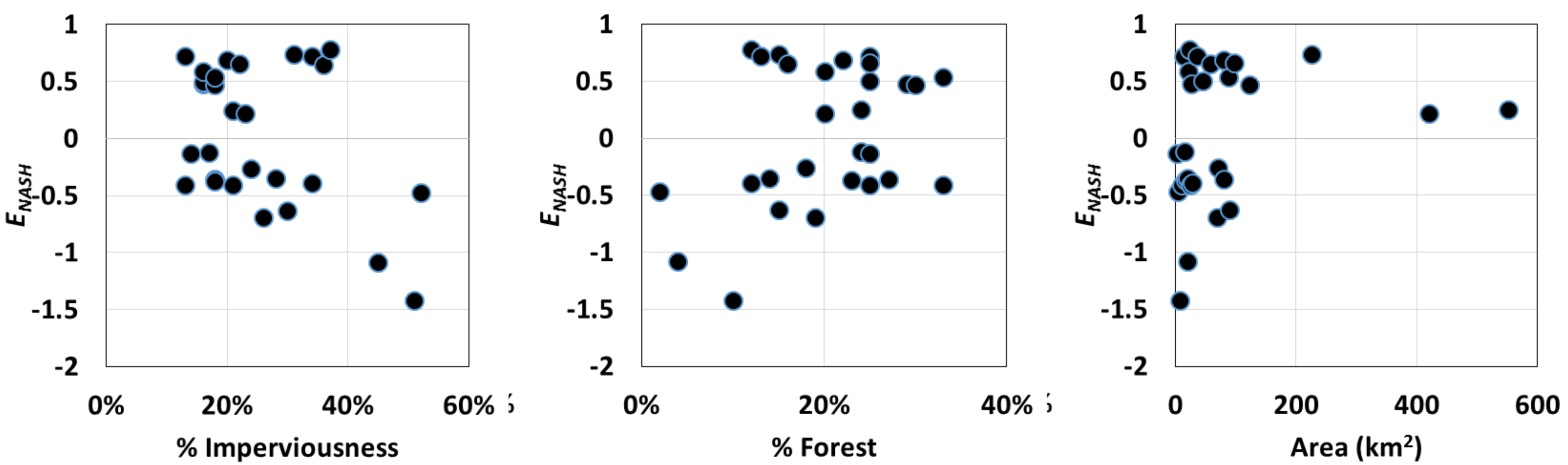
SWAT-CUP

Calibration:

- 3 iteration
- Each iteration was 500 run

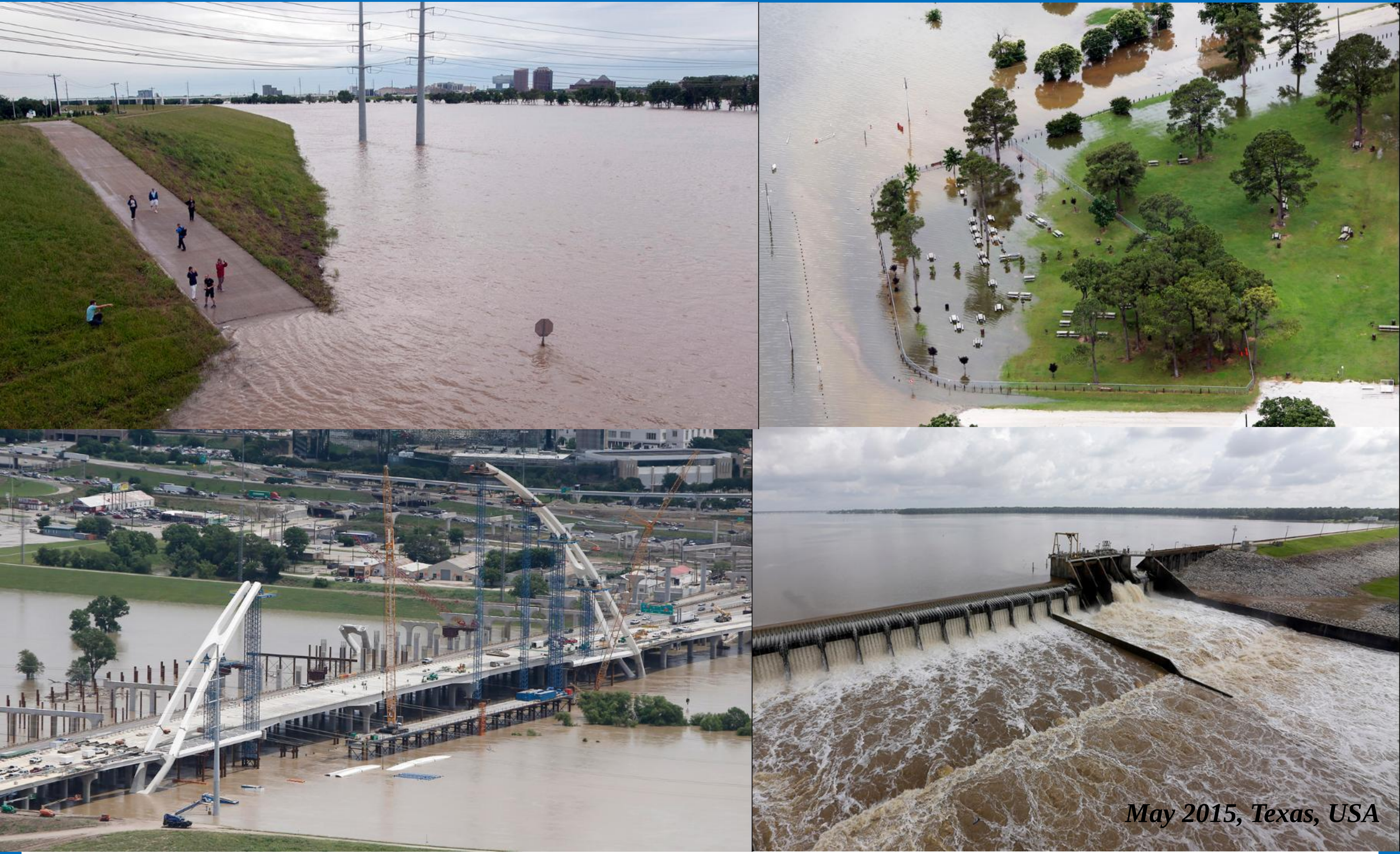
Validation:

- Parameters transferred from nearest donor with E_{NASH}>0.5 to a target watersh.



Conclusions

- Performance rates of coupled models:
  - ✓ 62% of the runs for the cool season → Good to Very good
  - ✓ 83% of the runs for the warm season → Good to Very good
- Performance rate of SWAT models:
  - ✓ 34% of the runs → Good to Very good
- As the percent forest cover or the size of test watershed increased, the coupled model performances gradually decreased during both cool and warm.
- Coupled models work better in urbanized watersheds with size <200 km^2.
- Combining ANN and SWAT could enrich the modeling environment by:
  - ✓ Excluding the calibration and sensitivity analysis to adjust the SWAT model parameters
  - ✓ Narrowing down the number of inputs to ANN.



Thank you for your attention!

For more information please contact: ***Latif Kalin, Latif@auburn.edu***