SWAT+MODFLOW

Coupling the SWAT+ and MODFLOW codes for enhanced surface / subsurface flow modeling in watersheds

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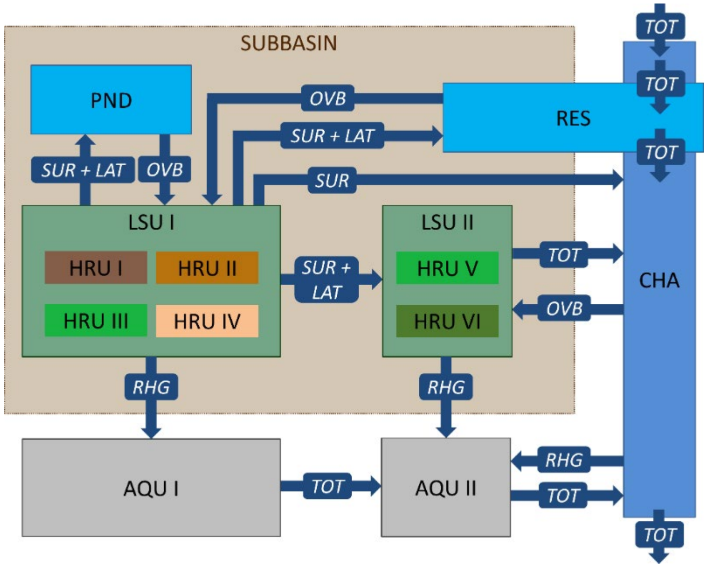
BACKGROUND AND TECHNICAL NEED

- **SWAT+** (Bieger et al., 2017)
  - Completely restructured version of SWAT
  - SWAT+ Code is restructured as Spatial Object – approach
    - New spatial objects can be defined for external models
    - SWAT+ can easily send output to and receive input from the other models.



Bieger et al.: Introduction to SWAT+, a completely restructured version of the Soil and Water Assessment Tool. Journal of the American Water Resources Association (JAWRA), 2017.

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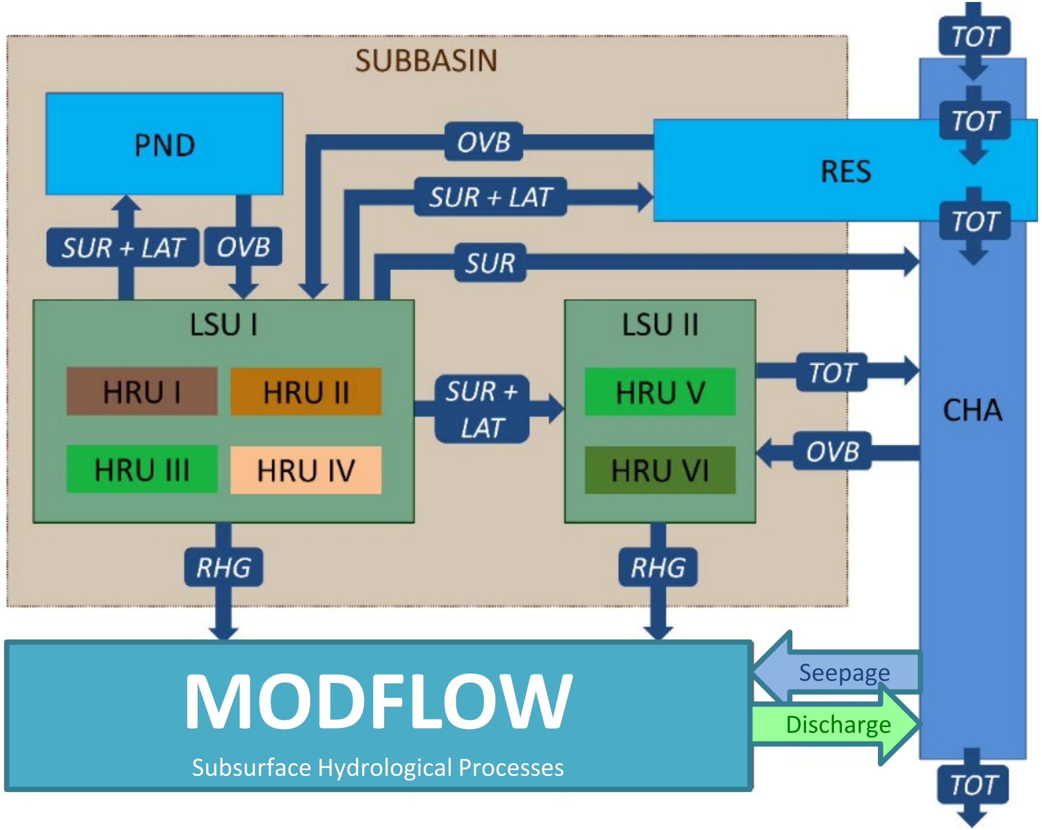

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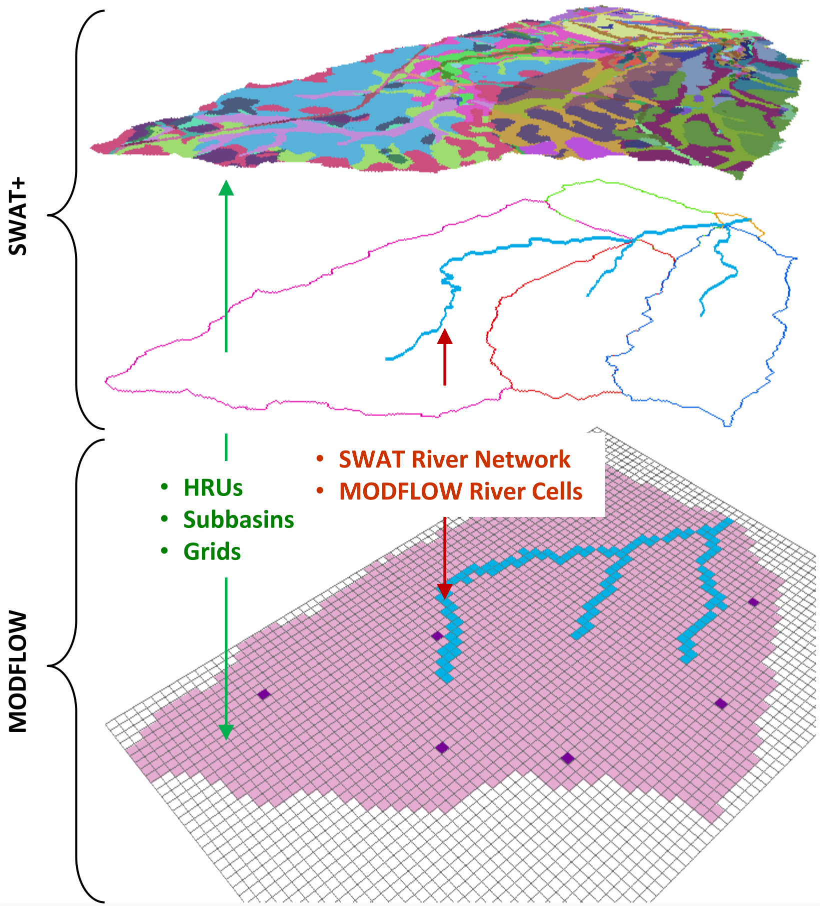
MAIN OBJECTIVE AND APPROACH

- Link SWAT+ with MODFLOW codes
- Apply the coupled SWAT+ and MODFLOW codes to the Little River Experimental Watershed (LREW)

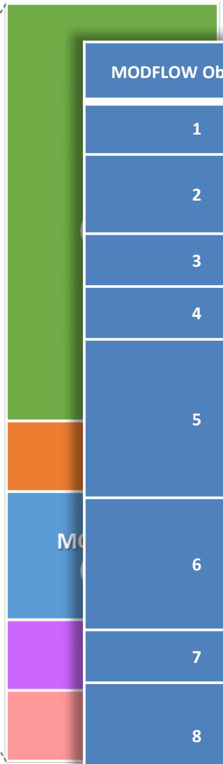
METHOD: LINKING PROCEDURE



- The basic process of passing data between the models using “mapping” subroutines that relate HRUs to MODFLOW grid cells is the same as the process of the SWAT-MODFLOW model.
- SWAT+ hydrologic response units (HRUs) and sub-basins are spatially related to MODFLOW grid cells to enable mapping of recharge, evapotranspiration, and groundwater/surface water exchange between SWAT+ and MODFLOW.
- Due to the restructuring of the SWAT+ code, the River cells of MODFLOW are included as spatial objects that receive/provide water from/to SWAT+ stream channels.
- During model construction, the user can choose whether to use SWAT+ aquifers or MODFLOW to simulate groundwater processes.

METHOD: MODFLOW SPATIAL OBJECTS

- **Conceptual Spatial Objects in SWAT+**

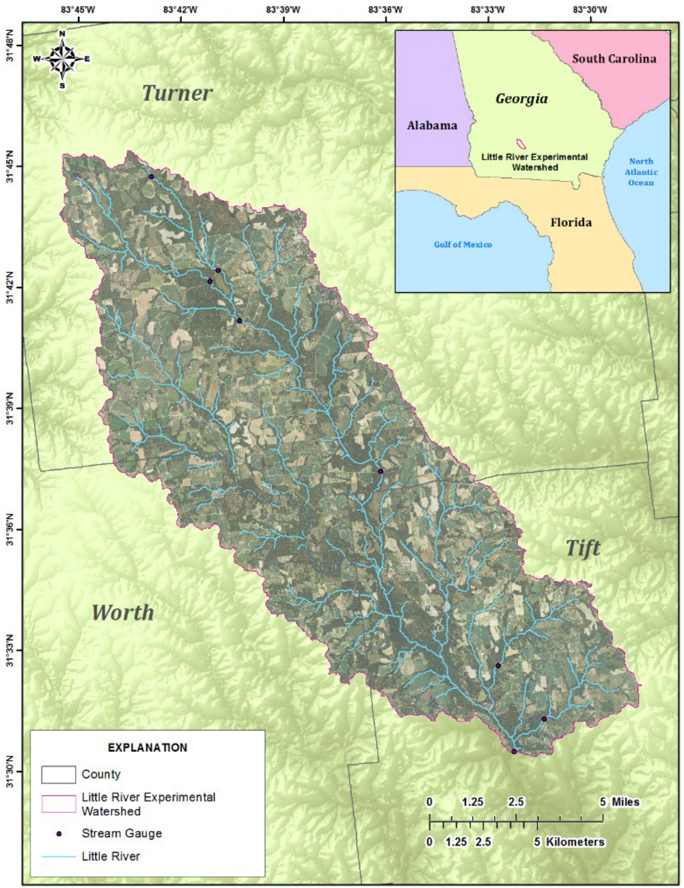


"object.cnt" file in SWAT+

Total objects: 8866

MODFLOW Object no.	MODFLOW Grid id.	Total out	Object Type	Fraction	Object id.
1	428	1	cha	1.0	3
2	429	2	cha cha	0.7 0.3	9 1
3	565	1	cha	1.0	1
4	701	1	cha	1.0	1
5	702	5	cha cha cha cha cha	0.1 0.5 0.2 0.1 0.1	2 33 65 49 18
6	820	4	cha cha cha cha	0.2 0.3 0.4 0.1	152 146 110 34
7	821	1	cha	1.0	9
8	822	3	cha cha cha	0.6 0.3 0.1	134 92 158

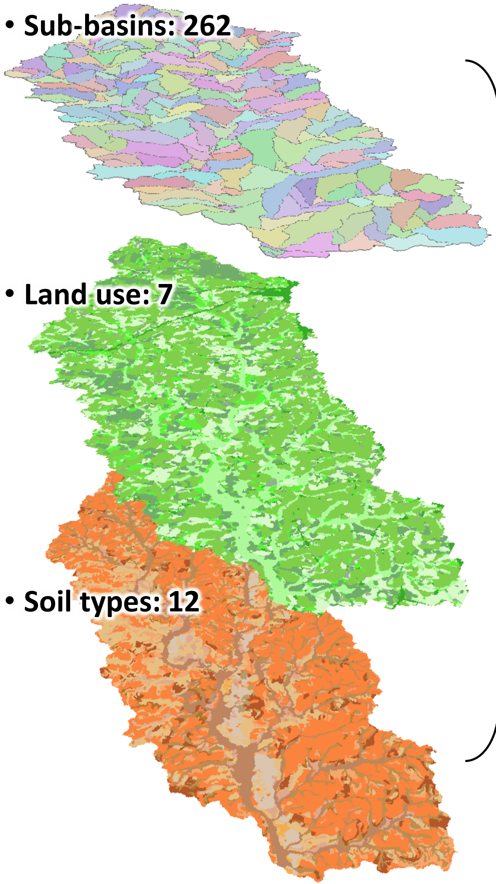
METHOD: STUDY REGION



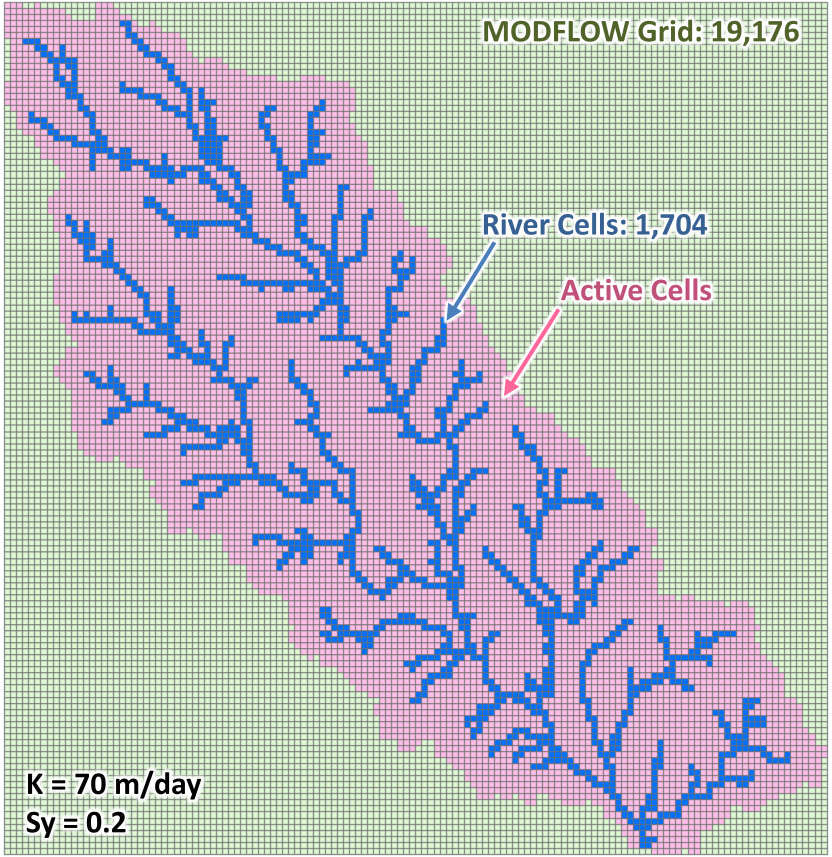
- **Little River Experimental Watershed (LREW)**
  - Located in the Upper Suwannee River Basin in South-Central Georgia (Sheridan, 1997)
  - Overlies Trinity Aquifer (unconfined aquifer) / Area: 334 km²
  - The climate in the LREW is humid subtropical with long, hot, humid summers and short, mild winters (Bosch et al., 1999).
  - Bosch et al. (2006) estimate that the percentages of forest, agricultural land, urban areas, and water are 50, 41, 7, and 2%, respectively.

METHOD: MODEL CONSTRUCTION

- Sub-basins: 262
- Land use: 7
- Soil types: 12



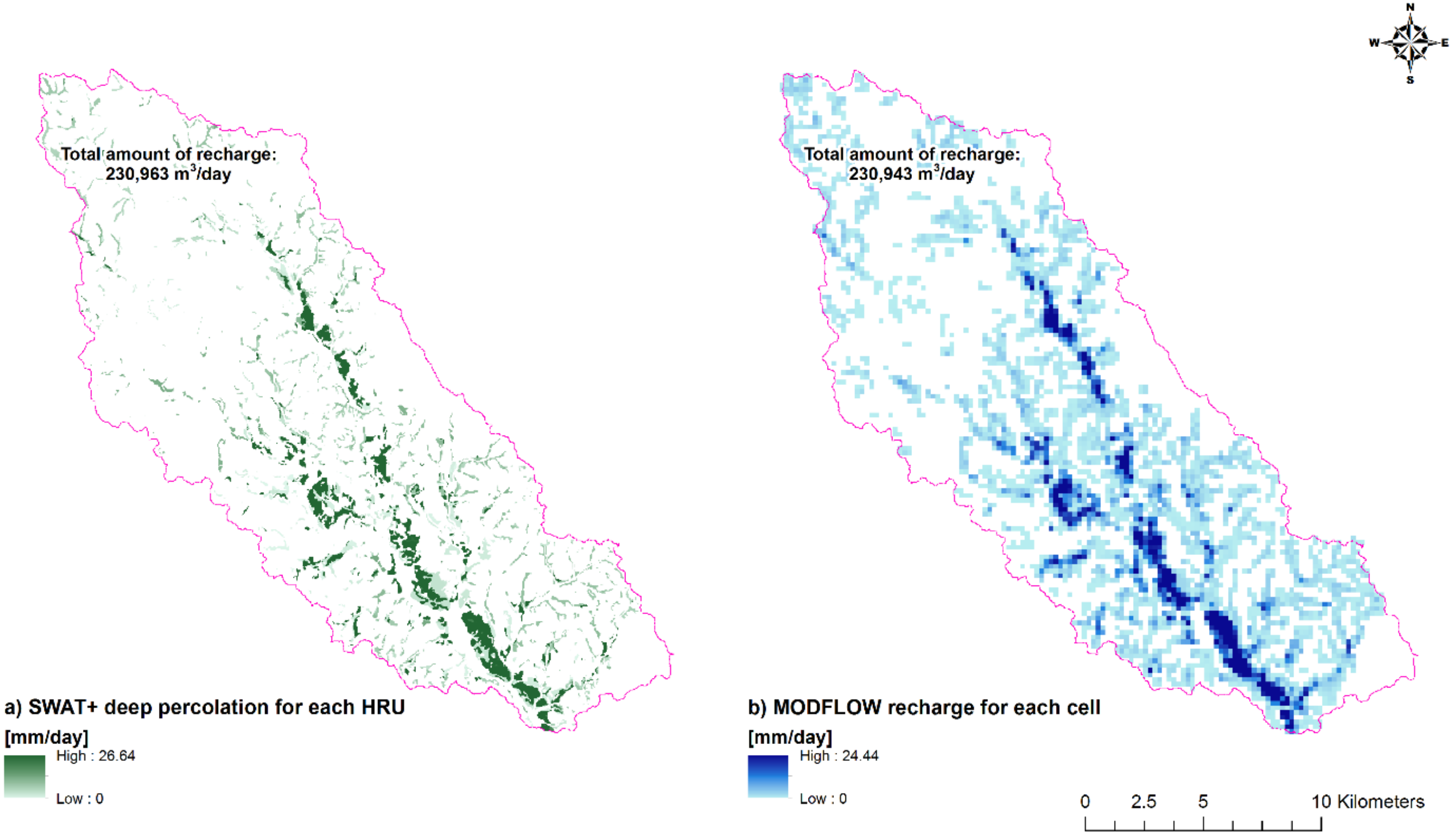
No thresholds
6,416 HRUs



Simulation period: 1/1/1988 to 12/31/2002

RESULT: VERIFICATION OF MODEL

Comparison of Spatially-varing recharges (mm/day) between a) SWAT+ HRU deep percolation and b) MODFLOW recharge

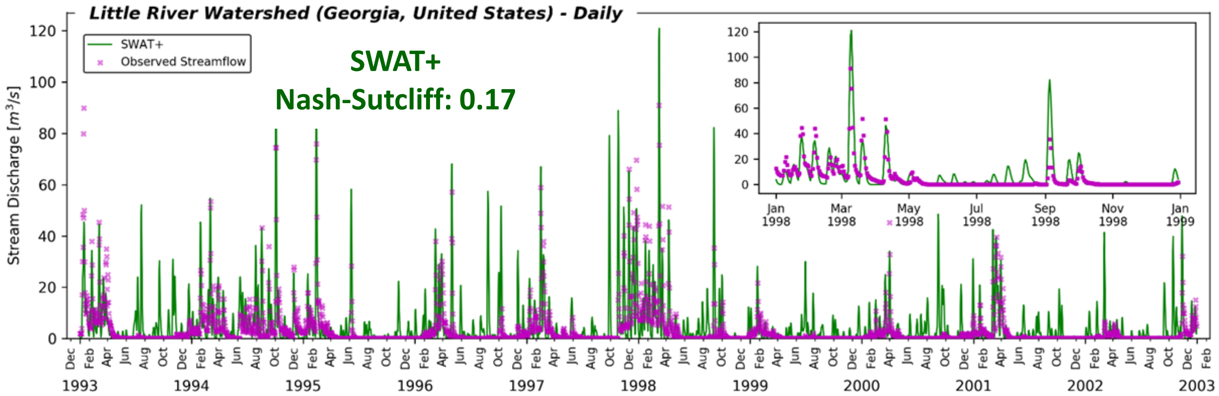


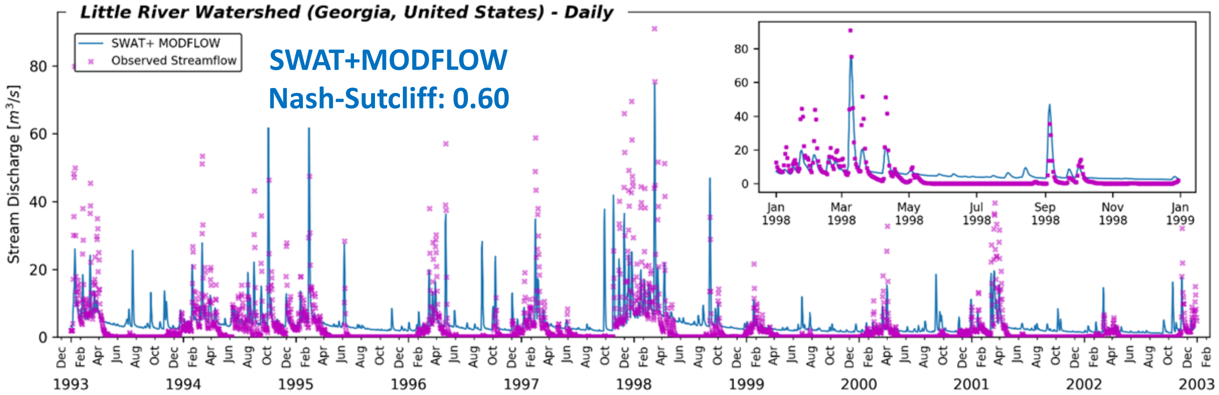
a) SWAT+ deep percolation for each HRU

b) MODFLOW recharge for each cell

RESULT : COMPARISON OF HYDROGRAPH PLOTS AND STATISTICS

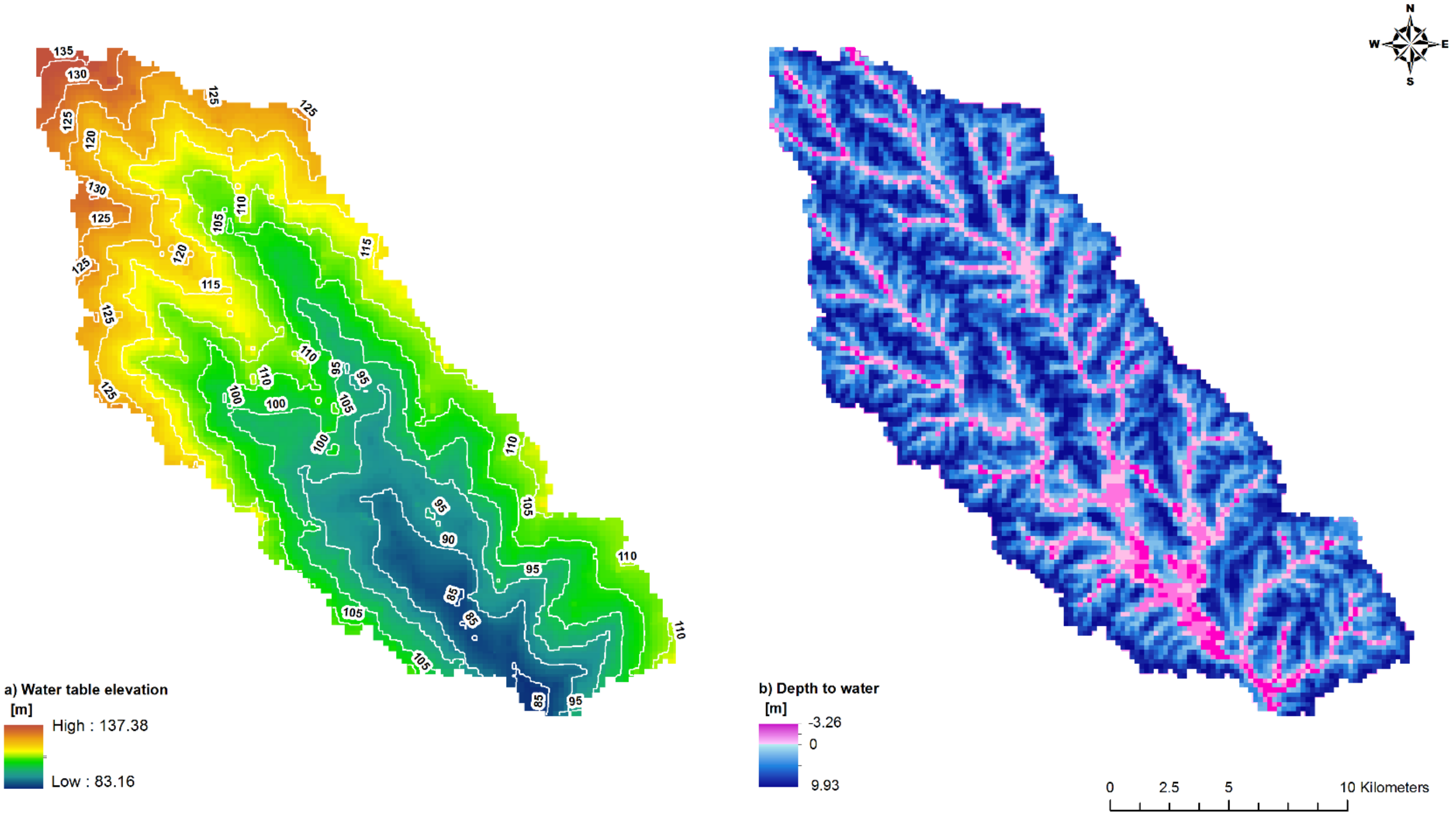
- Comparison of hydrograph plots and statistics (NS) between SWAT+ and SWAT+ MODFLOW simulations in the Little River watershed





RESULT: WATER ELEVATION AND DEPTH TO WATER

Water elevation and depth to water for MODFLOW grid in the Little River watershed at the first day of the simulation period (1/1/1988)



OVERVIEW

OBJECTIVE

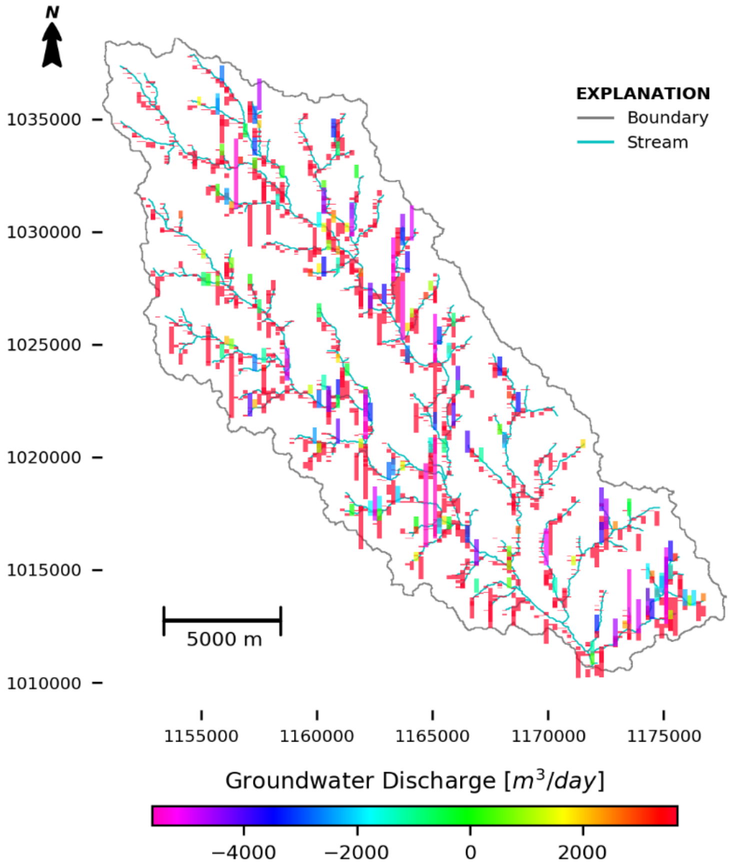
METHOD

RESULT

CONCLUSION

FUTURE WORK

RESULT: INTERACTION BETWEEN SURFACE-SUBSURFACE



- Model output includes spatially varying groundwater discharge (and stream seepage) rates along the stream network.
- Subsurface – surface interaction at the end of the simulation (12/31/2002)
- Highest groundwater discharge: 5,600 m^3/day
- Highest stream seepage: 3664 m^3/day

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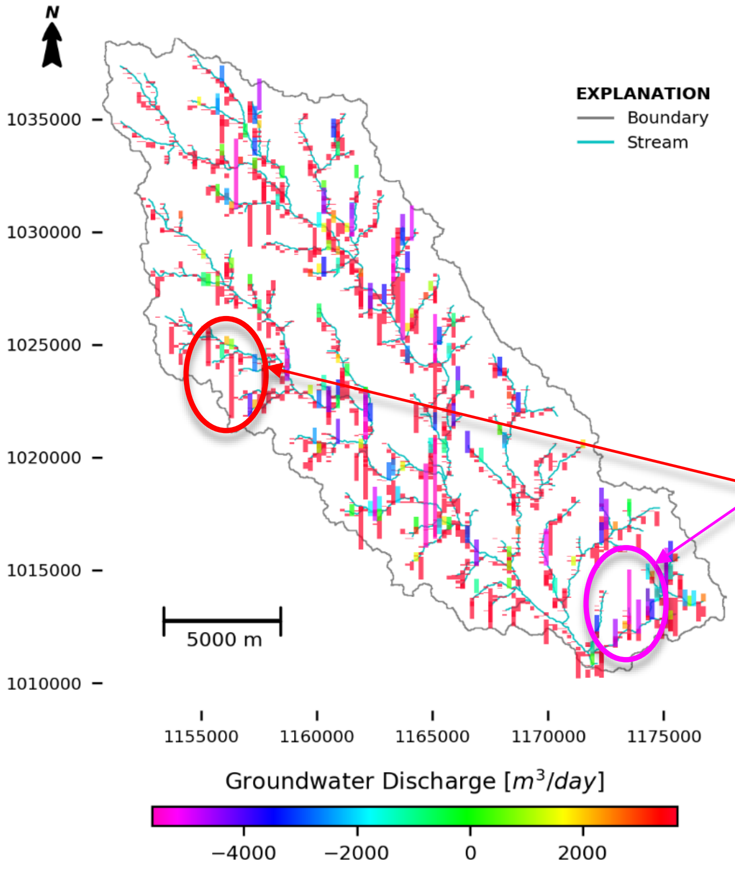

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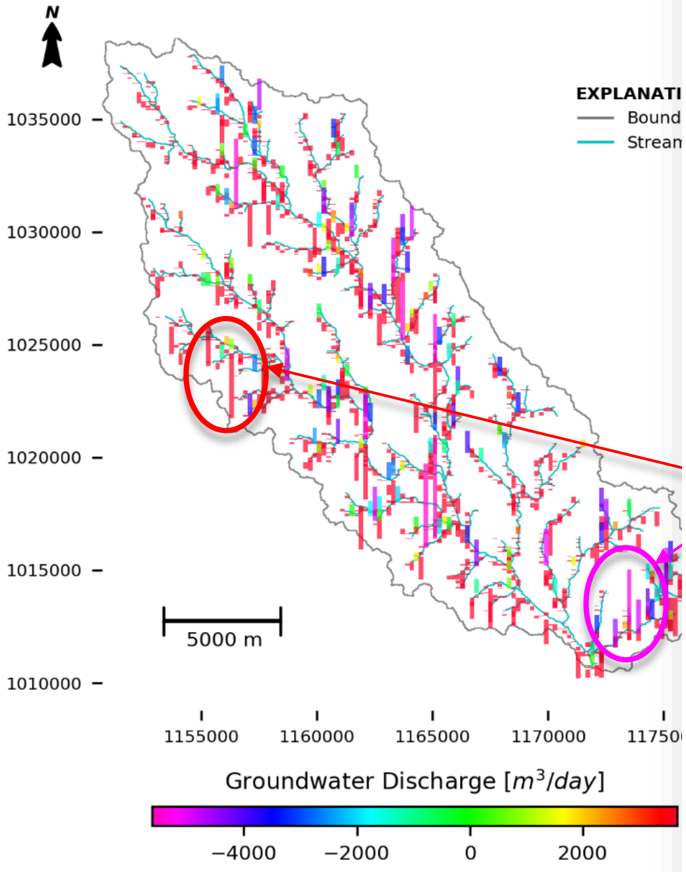

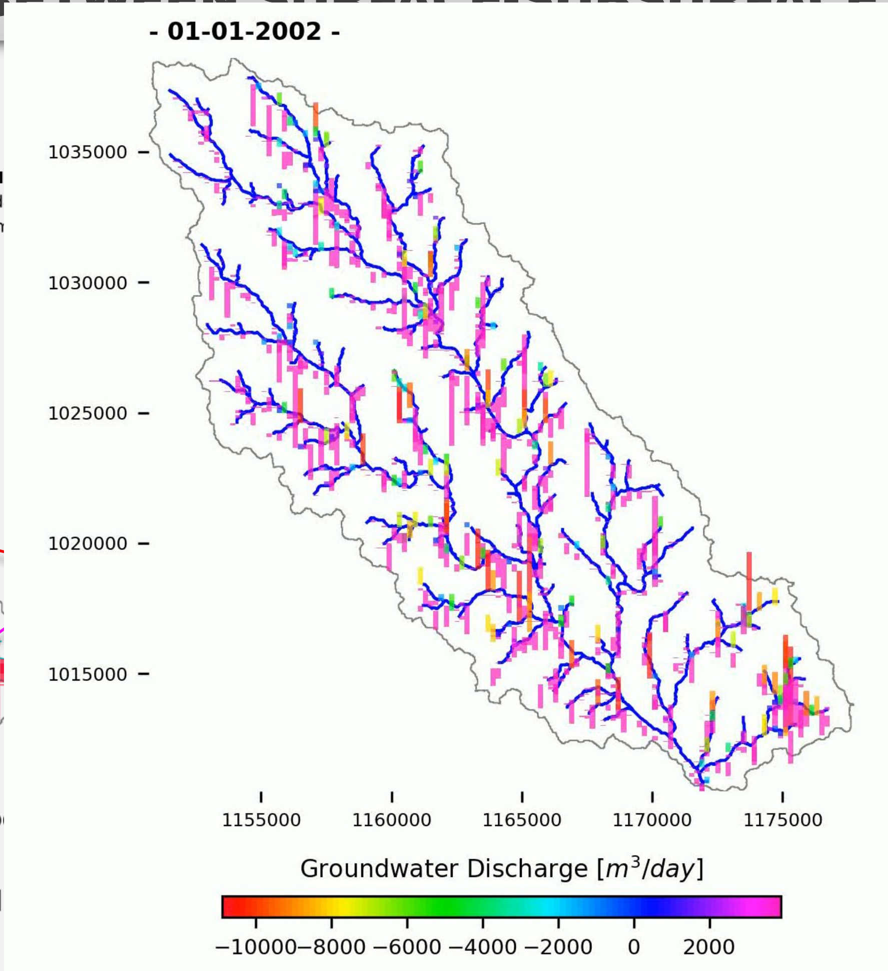

OVERVIEW

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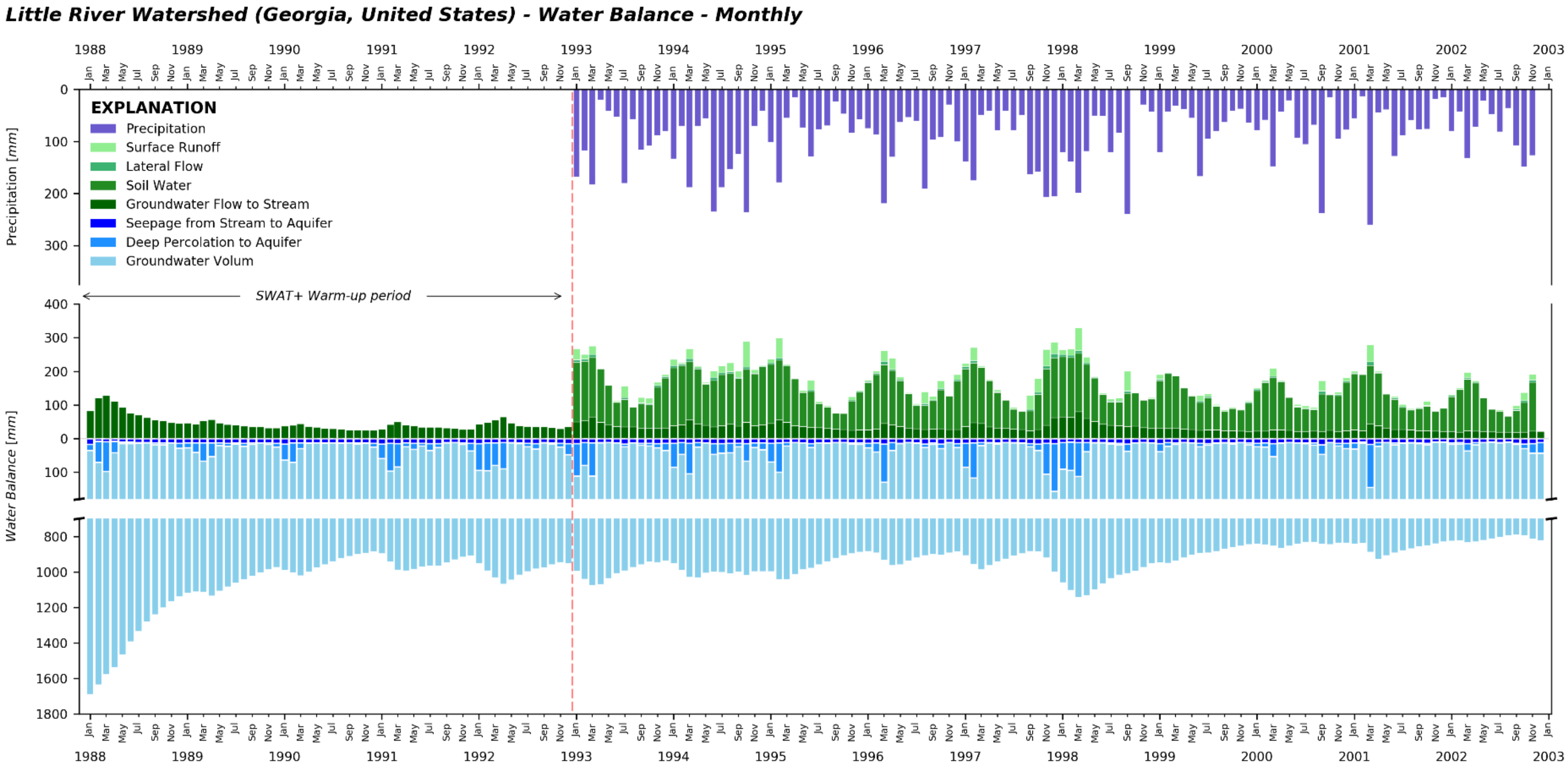
RESULT : MONTHLY WATER RESOURCE AVAILIABILTY

- Monthly water resource availability in the Little River watershed



CONCLUSION

- Linking SWAT+ with MODFLOW codes has been properly completed.
- Improvement of spatial representation of elements and processes
- More flexibility in defining spatial interactions of hydrologic objects
- Interaction between the two models more efficient than the previous SWAT-MODFLOW code
- Ease in its future code development
- Result from the coupled model has been improved.

FUTURE WORK

I. Implement RT3D to simulate subsurface solute transport

II. Implement Shallow water tables

III. Implement irrigation-pumping interactions

IV. Implement subsurface drains

V. Apply the coupled SWAT+ and MODFLOW codes to watersheds

Thank you for your attention!