MODELING STRATEGIES TO PROVIDE HOLISTIC PICTURE OF CLIMATE CHANGE IMPACTS IN SOUTH FLORIDA

2017 Greater Everglades Ecosystem Restoration
Coral Spring, FL

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April 20, 2017

Background

Contents

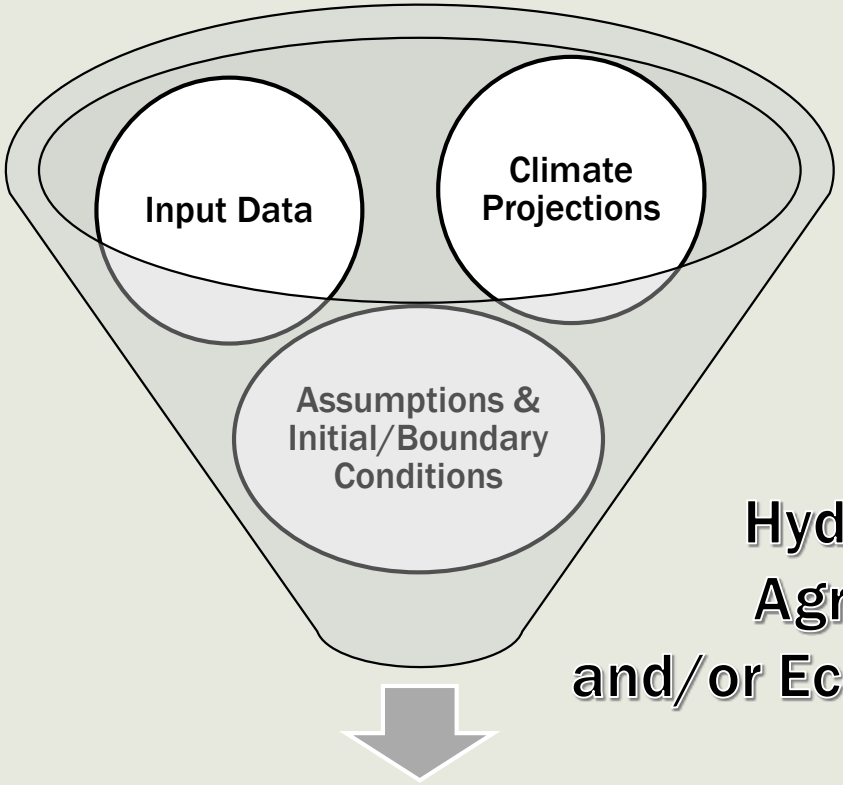
- Climate change / sea level rise
  - Coming slowly but eventually (interglacial, Holocene)
  - Accelerated by human activities (fossil fuel)

http://iloveedenvale.net/2016/04/have-we-become-blase-about-crime/

  - Simulation / modeling studies
    - Help understand the processes
    - Enables what-if scenario analyses
  - Holistic view of the hydrological/agricultural/ecological impacts of CCSLR

Current Research: Model Development

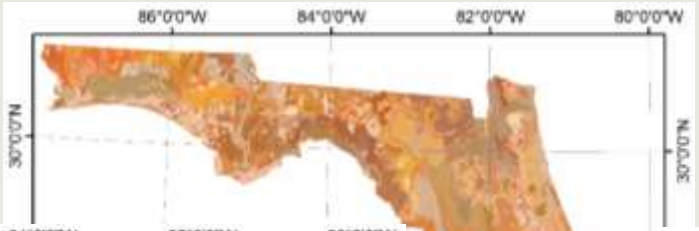
- Develop and apply
  - Based on the understanding of processes and mechanisms
  - Causal relationship between variables and processes

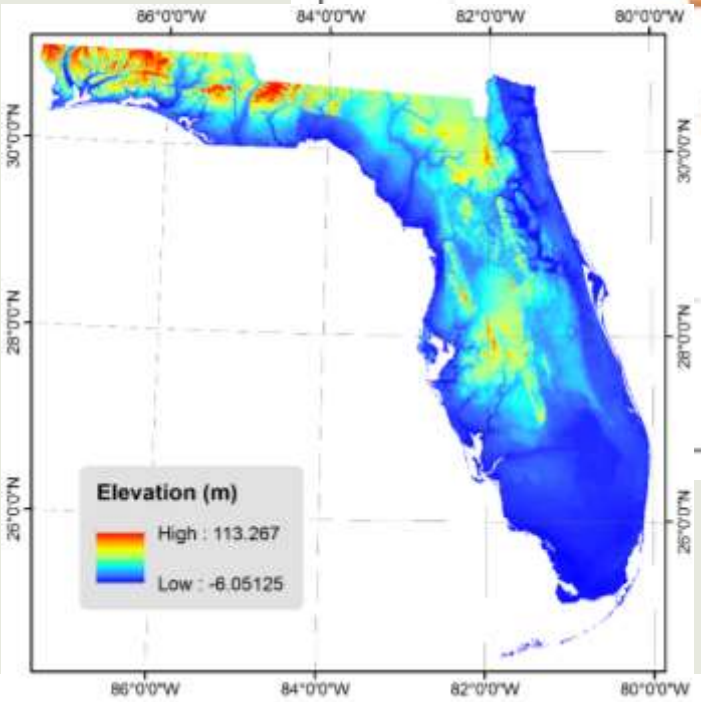


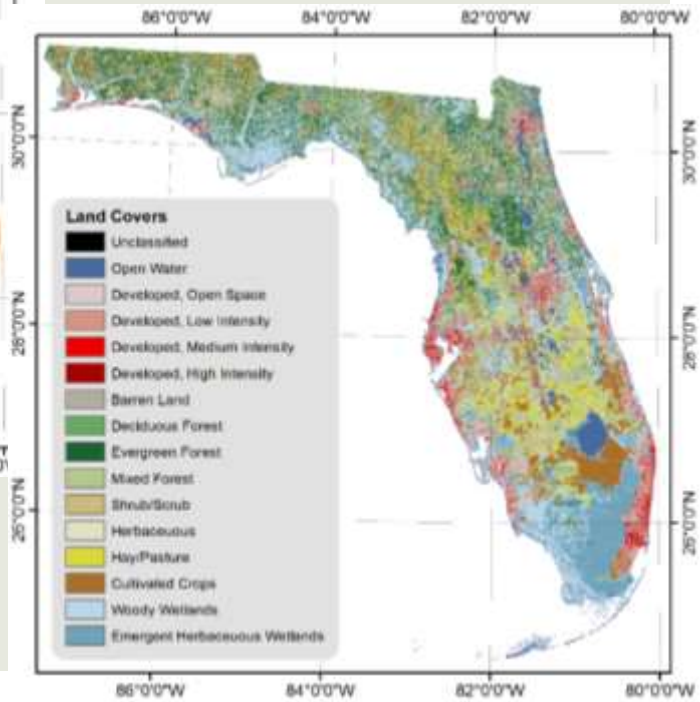
Current Research: Data Collection

Contents

- Input data
  - Describing the system of interest: landscape, weather, & human activities (agricultural practices and canal operation)







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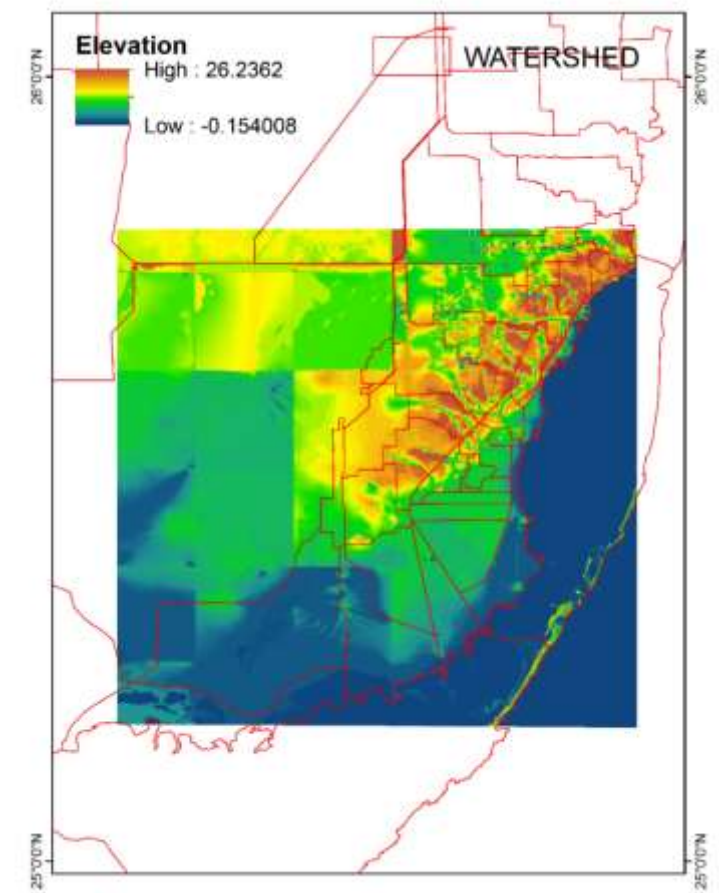

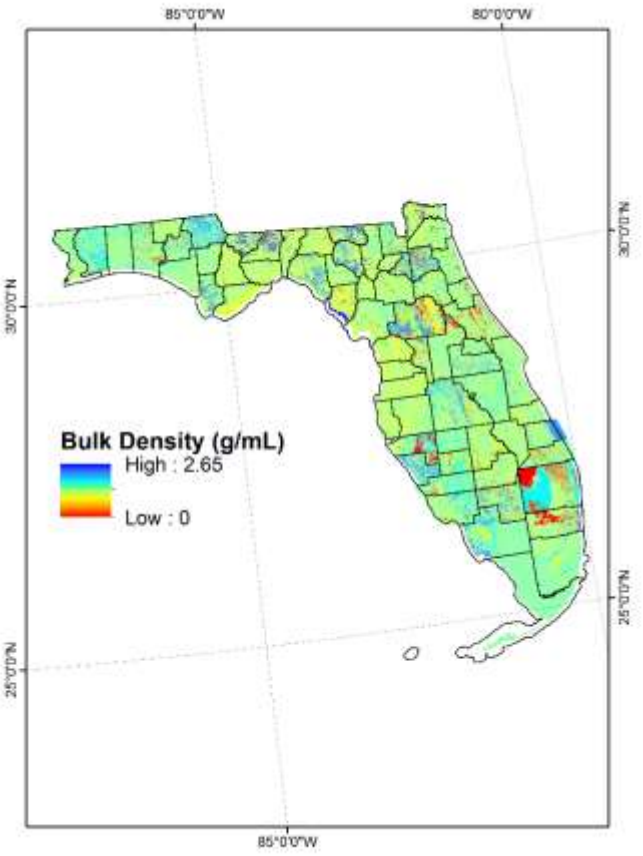

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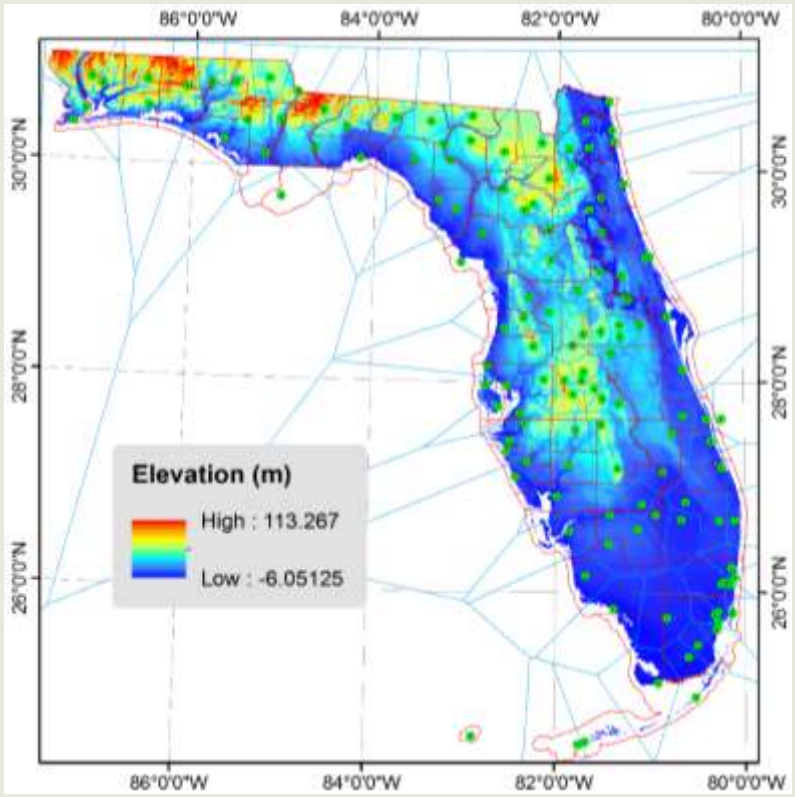
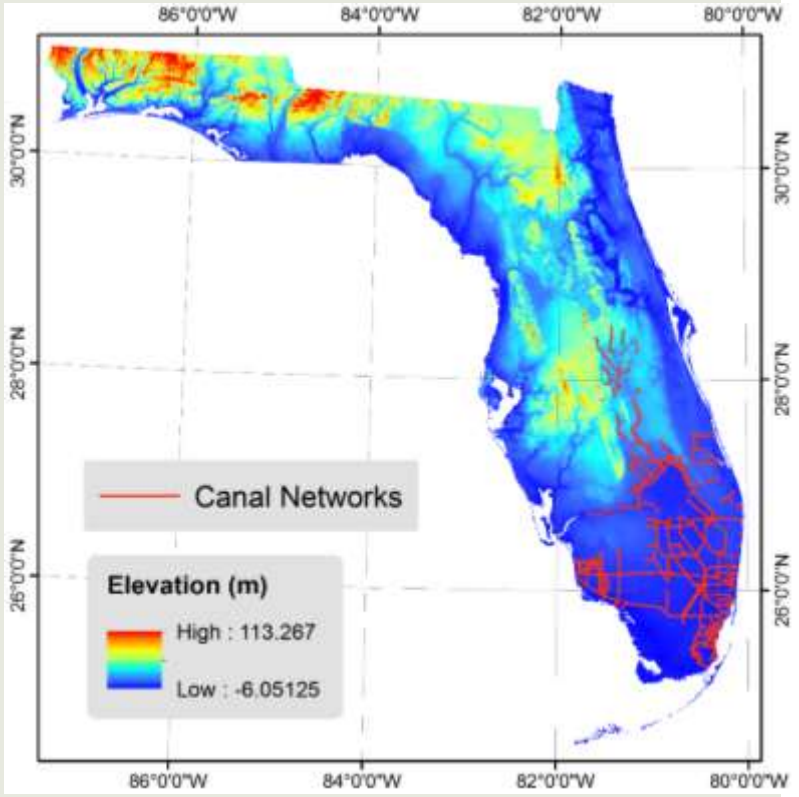
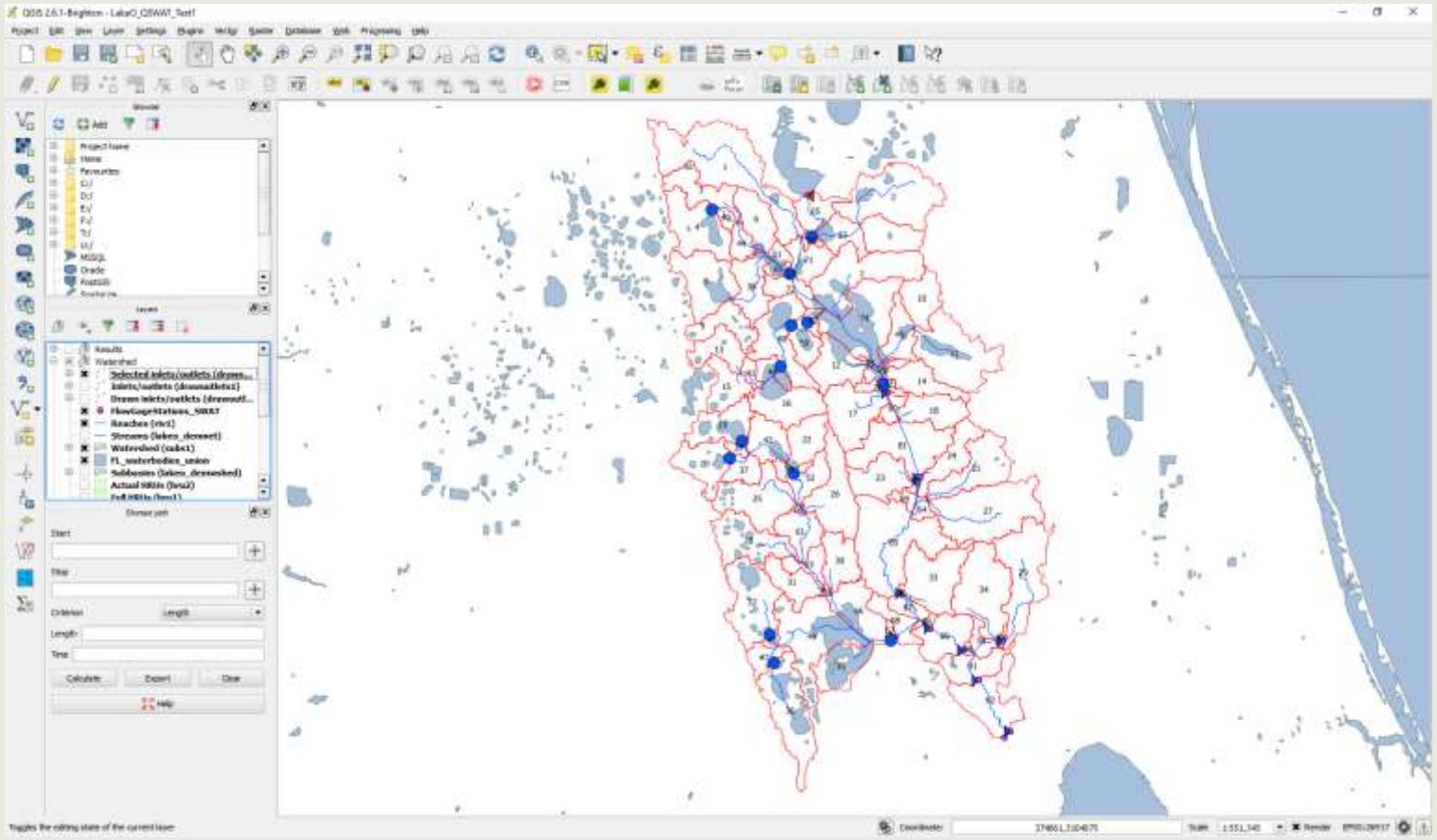




Current Research: Model Application

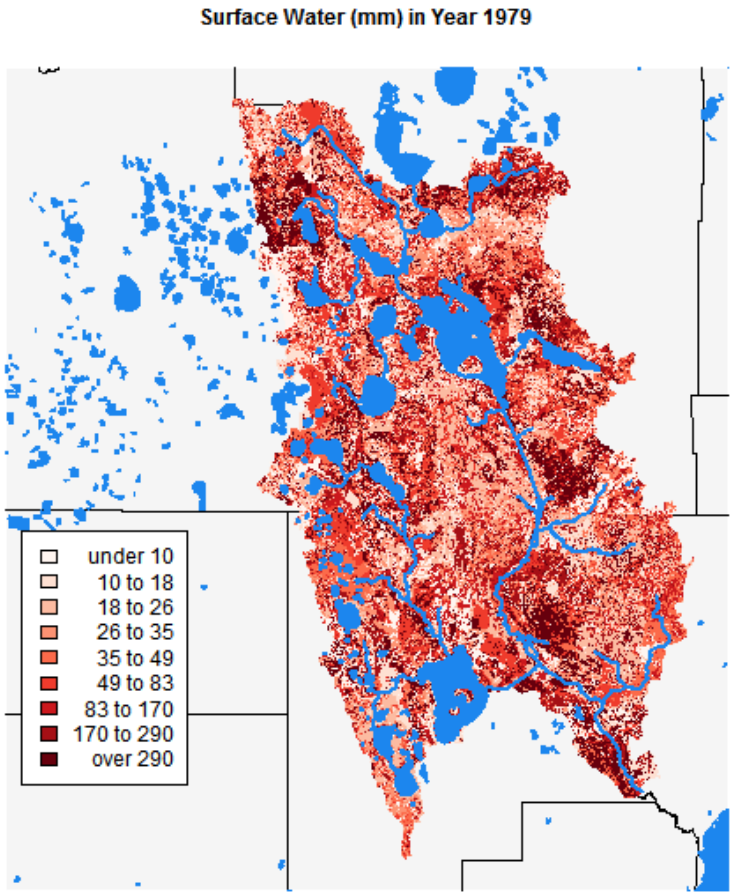
Contents

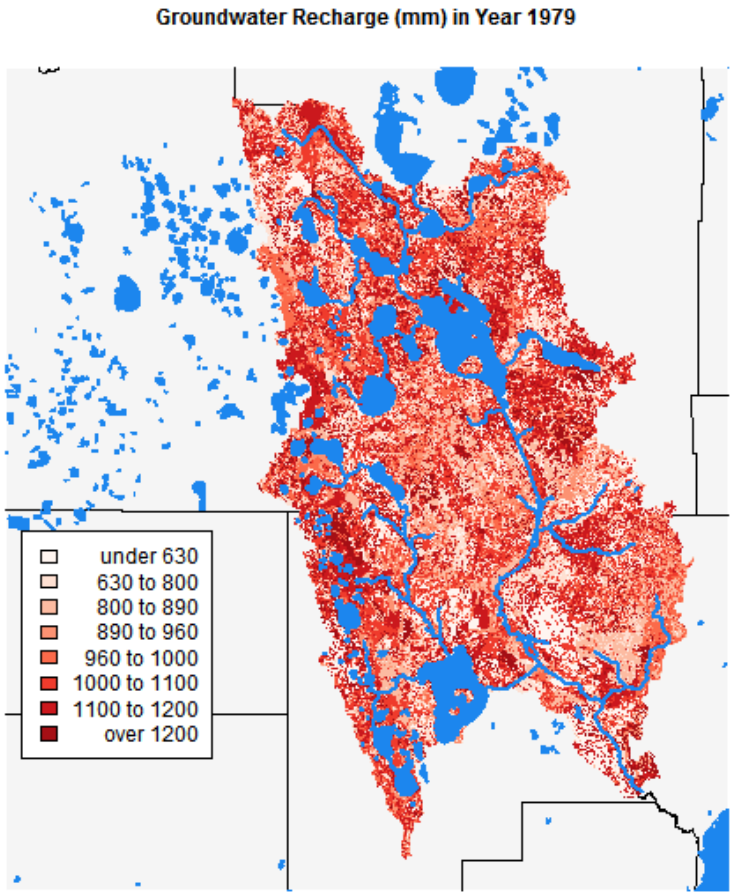
- Develop simulation models
  - Nutrient loadings from Upper/Lower Kissimmee watersheds
  - Soil and Water Assessment Tool (SWAT) – USDA-ARS



Current Research: Model Application

- Identify critical areas producing much pollutants
  - Nutrient loadings from Upper/Lower Kissimmee watersheds
  - But now simulating only hydrological processes





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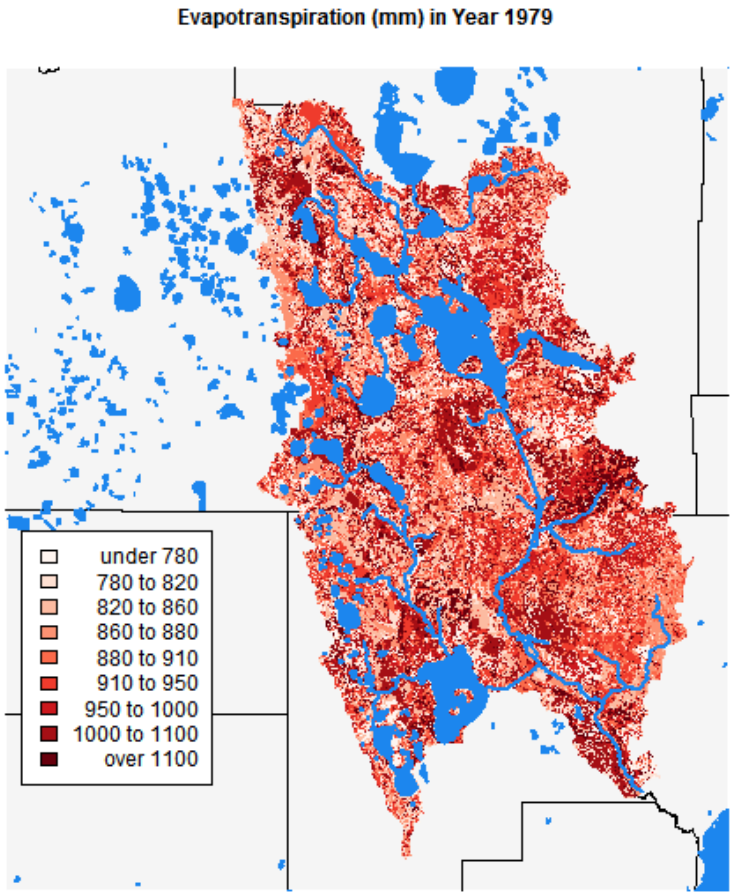

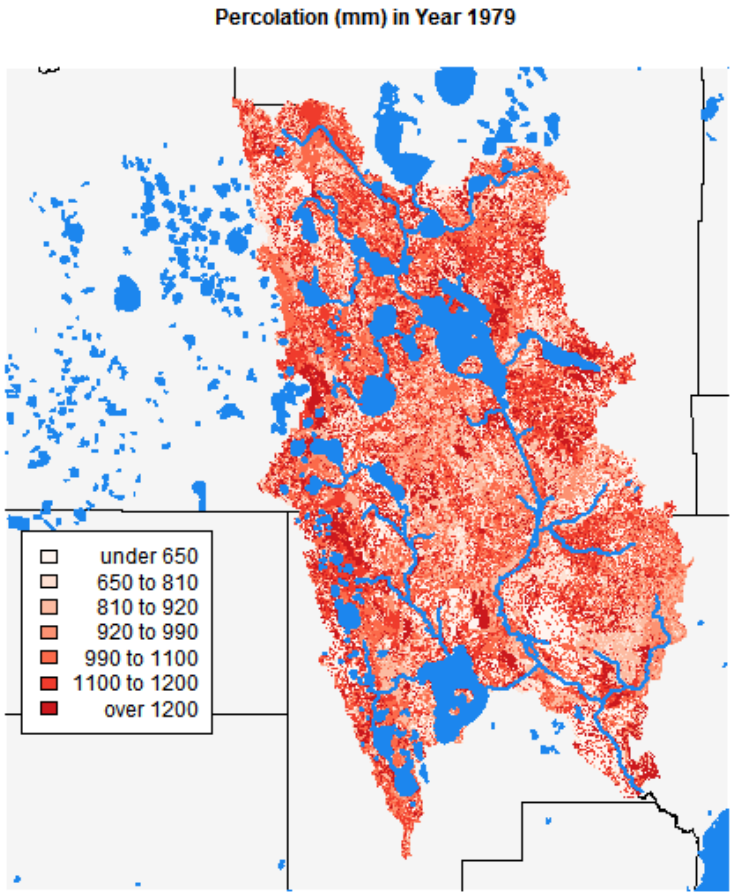

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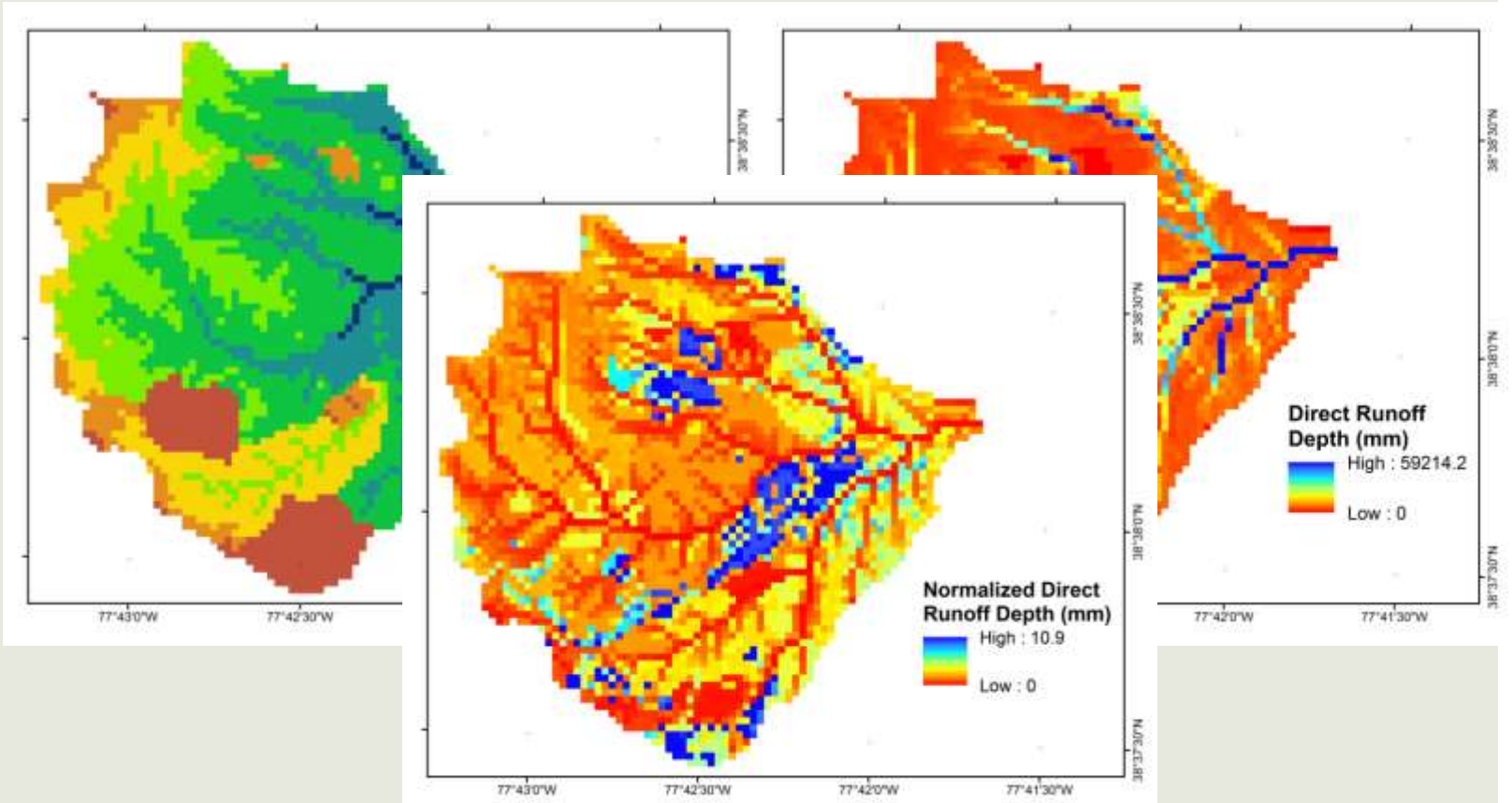

Current Research: Climate Projection

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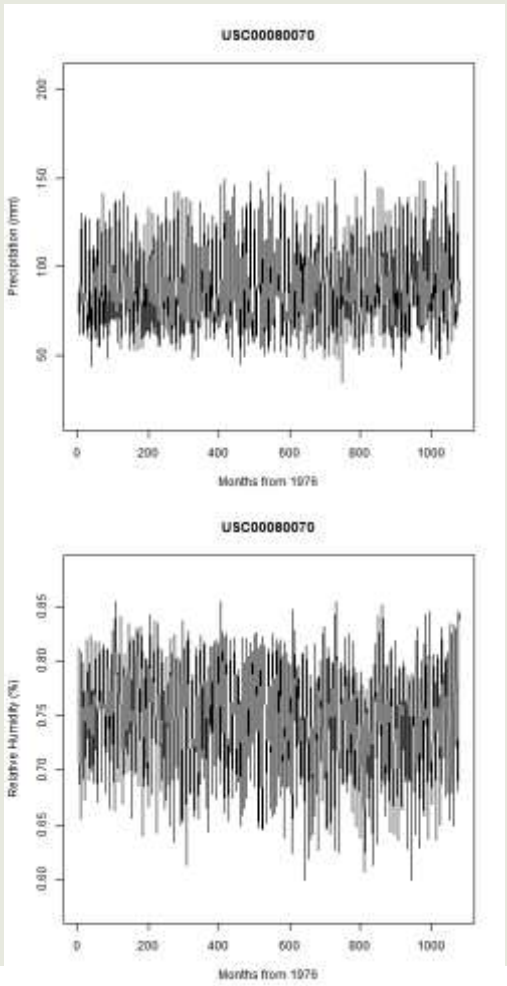
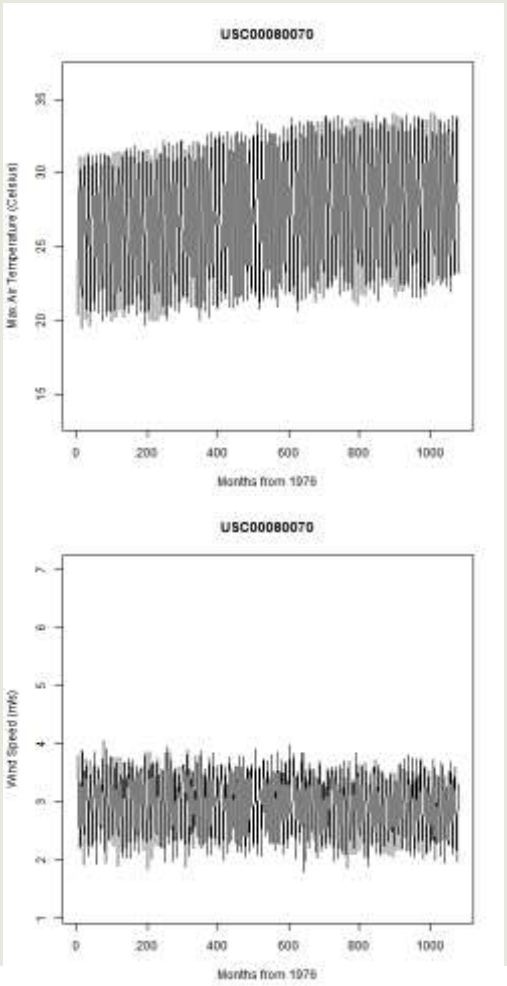
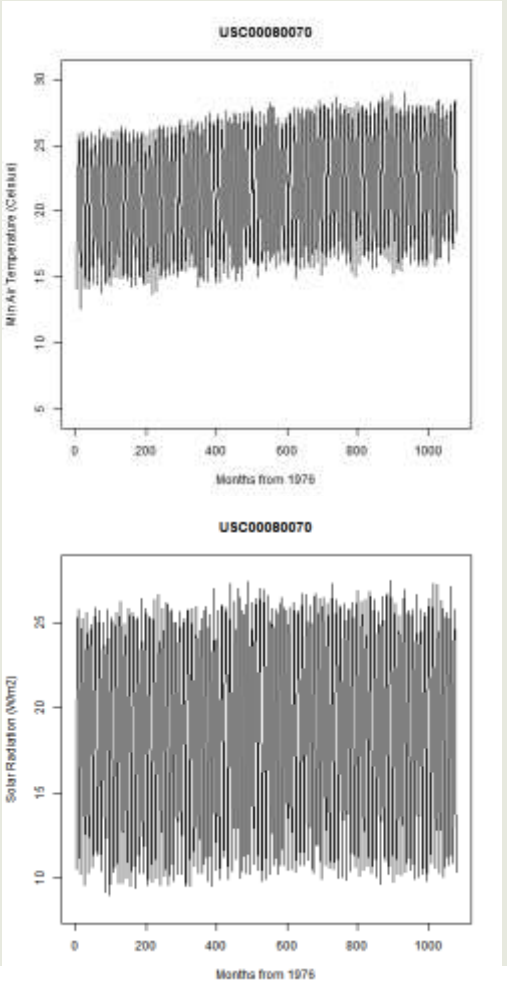
- Weather/climate projections (133 stations)
  - How does future Florida weather look like?







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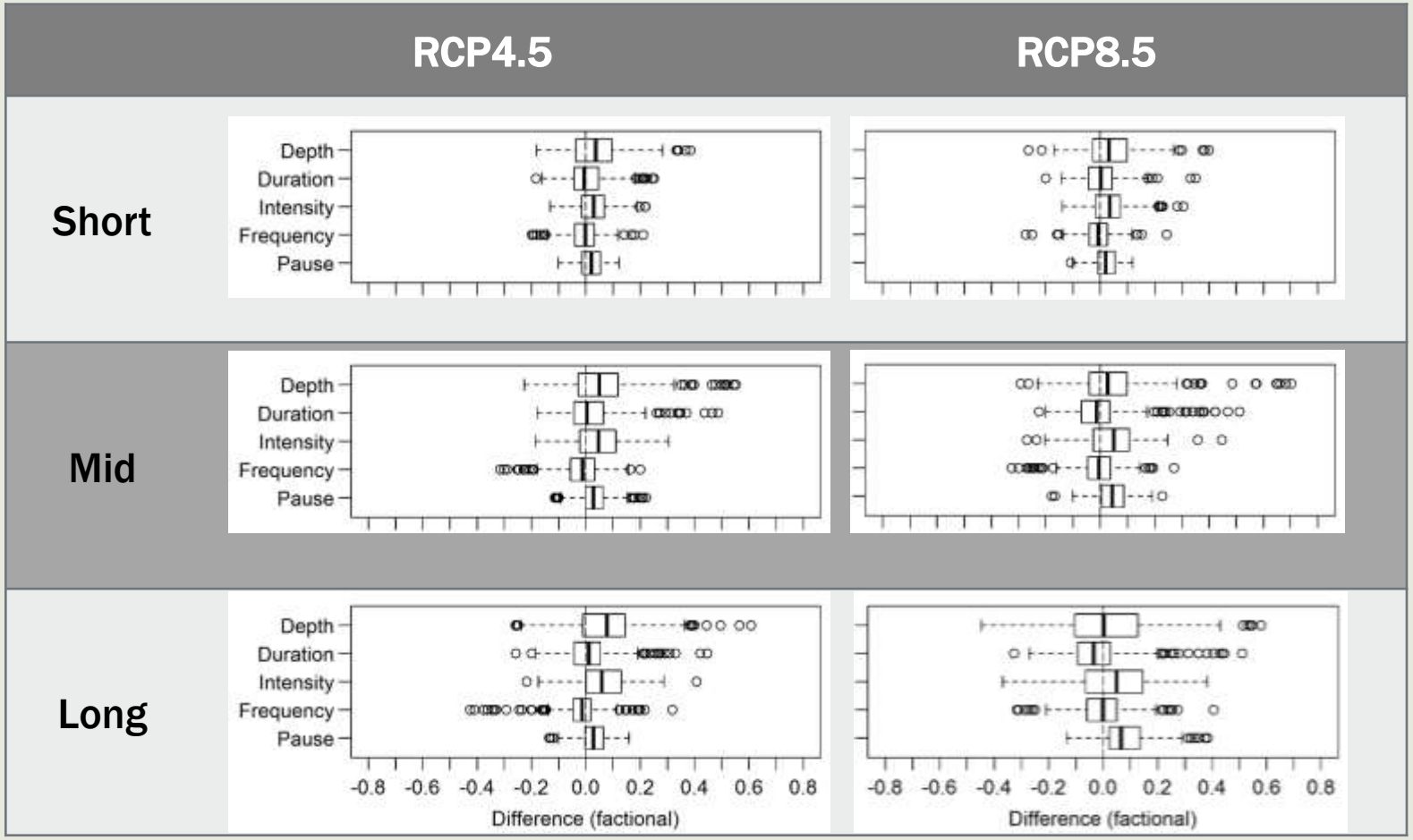

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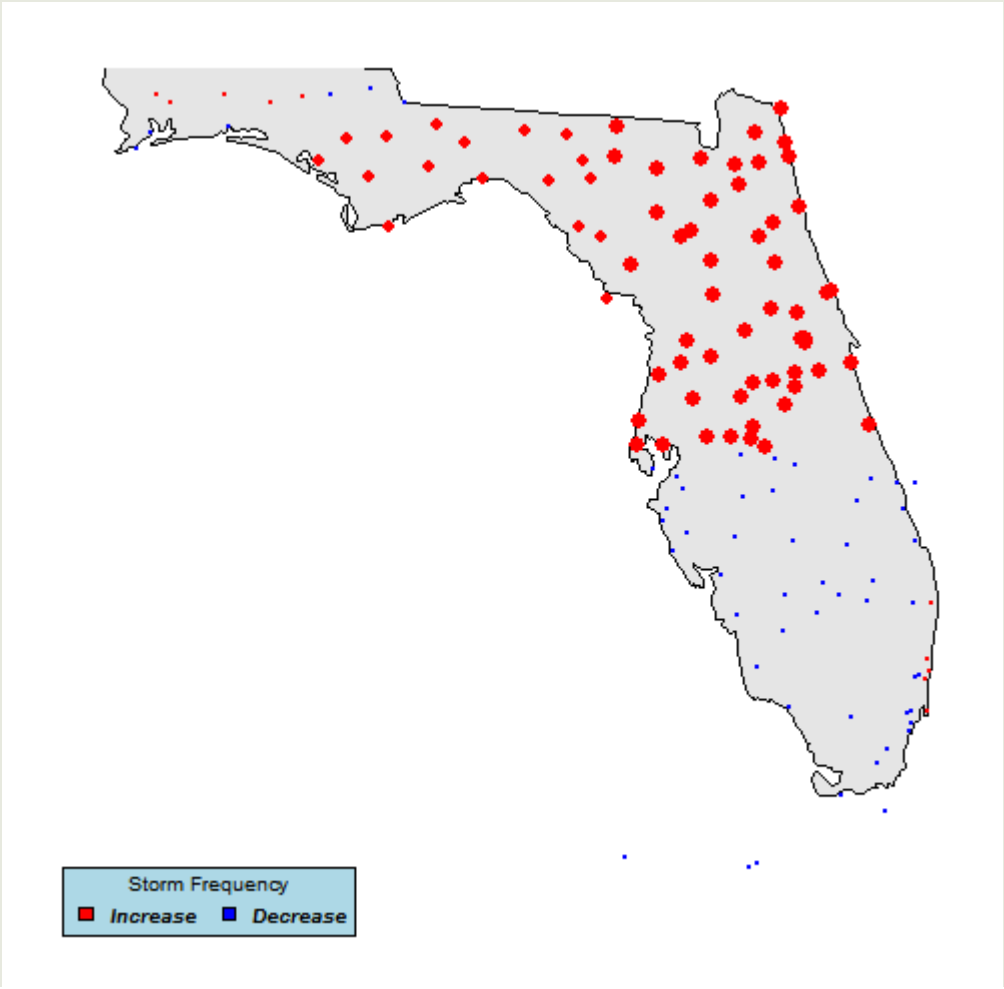
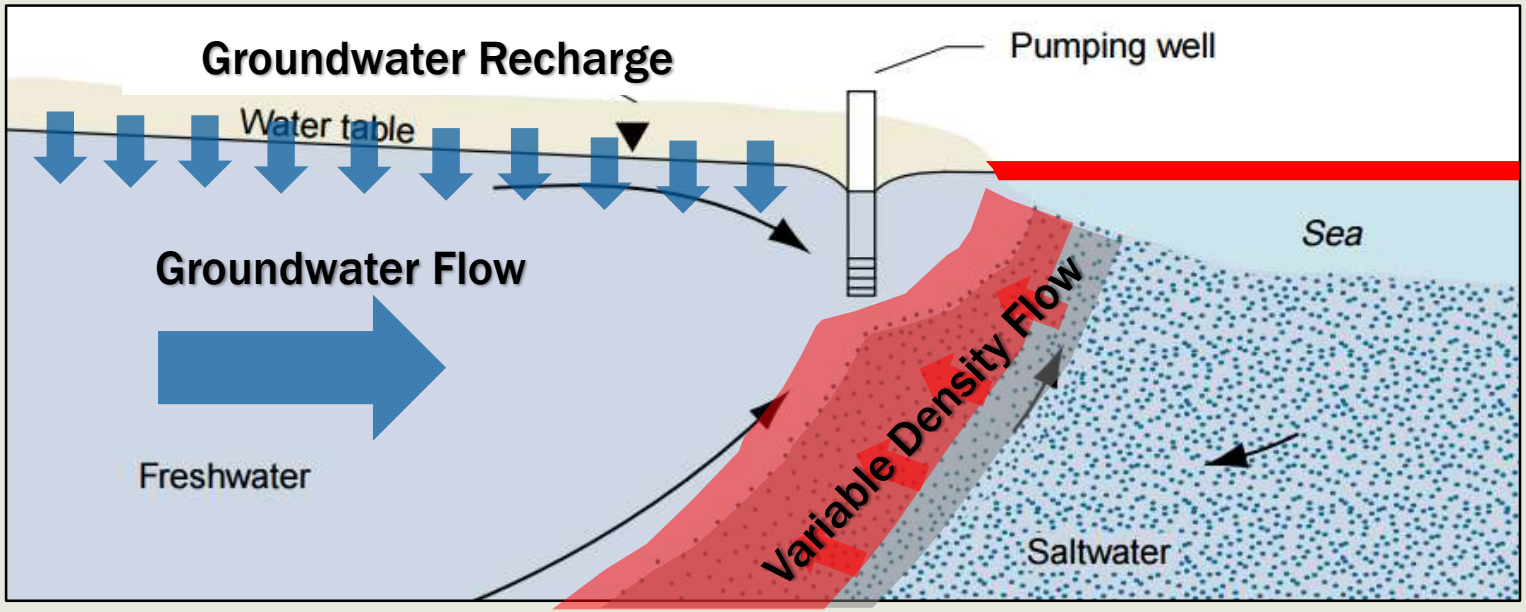


Current Research: Sea Level Rise

- Sea level rise – saltwater intrusion
  - Contaminate freshwater resources: drinking water & irrigation
  - Soil salinity: damage to crops and infrastructure
  - Unexpected/unfavorable changes in ecosystem

Current Research: Sea Level Rise

- What causes saltwater intrusion
  - Natural process, but can be a problem
  - Climate changes
    - Sea level rise, increase in ET & prolonged drought
  - Human activities
    - Pumping groundwater for irrigation & urbanization
  - Coastal (Florida) & island (the Caribbean)



Barlow, P.M., 2000. Ground-water Resources for the Future: Atlantic Coastal Zone. US Geological Survey, US Department of the Interior.

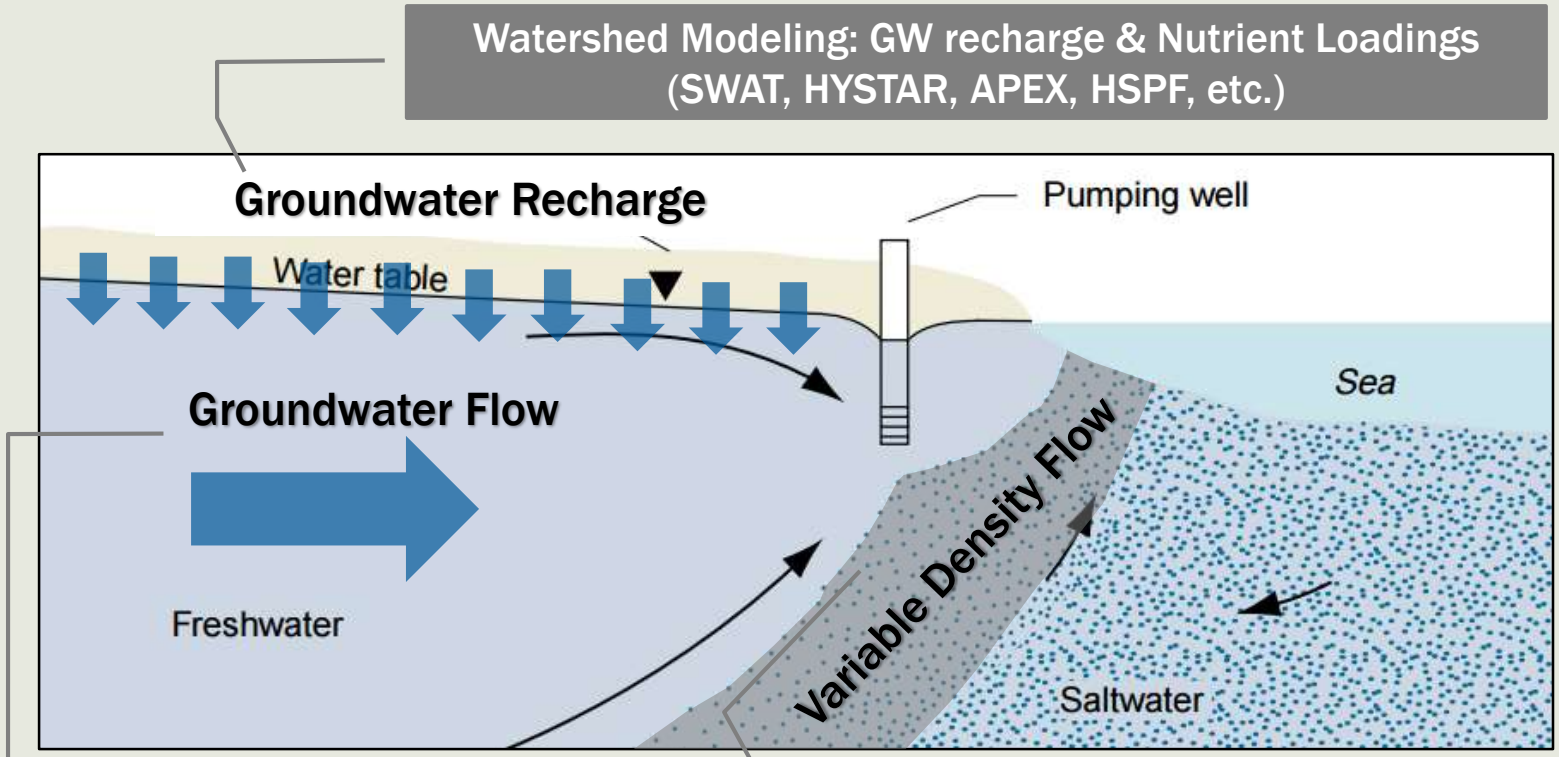
Current Research: Sea Level Rise

- Saltwater intrusion modeling
  - SWAT-MODFLOW integration: Inland watershed
    - Cho (2007, Virginia Tech: DANSAT); Cho et al. (2010)
    - Kim et al. (2008, KICT): SWAT-MODFLOW
    - Guzman et al. (2015): SWATmf
    - Bailey (2015, Colorado State University) : SWAT-MODFLOW
  - MODFLOW-MT3DMS (SEAWAT): Much simplified GW recharge
    - Guo & Bennett (1998); Guo & Langevin (2002): SEAWAT
    - Langevin (2003): Biscayne Bay & Florida Bay
    - Chang (2012, Auburn) & Chang and Clement (2012)

- *Cho, J.P., 2007. A comprehensive modeling approach for BMP impact assessment considering surface and ground water interaction. Doctoral Dissertation, Virginia Tech.*
- *Cho, J., Mostaghimi, S. & Kang, M.S., 2010. Development and application of a modeling approach for surface water and groundwater interaction. Agricultural water management, 97(1):123-130.*
- *Kim, N.W., Chung, I.M., Won, Y.S. and Arnold, J.G., 2008. Development and application of the integrated SWAT–MODFLOW model. Journal of Hydrology, 356(1):1-16.*
- *Guzman, J.A., Moriasi, D.N., Gowda, P.H., Steiner, J.L., Starks, P.J., Arnold, J.G. and Srinivasan, R., 2015. A model integration framework for linking SWAT and MODFLOW. Environmental Modelling & Software, 73:103-116.*
- *Bailey, R.T., 2015. SWAT-MODFLOW Tutorial: Documentation for preparing model simulations. Department of Civil and Environmental Engineering, Colorado State University.*
- *Guo, W. and Bennett, G.D., 1998. Simulation of saline/fresh water flows using MODFLOW. In Proceedings of MODFLOW '98 conference at the international ground water modeling center, Colorado School of Mines, Golden, Colorado (Vol. 1, pp. 267-274).*
- *Guo, W. and Langevin, C.D., 2002. User's guide to SEAWAT; a computer program for simulation of three-dimensional variable-density ground-water flow (No. 06-A7).*
- *Langevin, C.D., 2003. Simulation of submarine ground water discharge to a marine estuary: Biscayne Bay, Florida. Ground Water, 41(6):758-771.*
- *Chang, S.W., 2012. Dynamics of Saltwater Intrusion Processes in Saturated Porous Media Systems. Doctoral dissertation, Auburn University.*
- *Chang, S.W. and Clement, T.P., 2012. Experimental and numerical investigation of saltwater intrusion dynamics in flux-controlled groundwater systems. Water Resources Research, 48(9):* WR012134.

Current Research: Sea Level Rise

- Saltwater intrusion modeling



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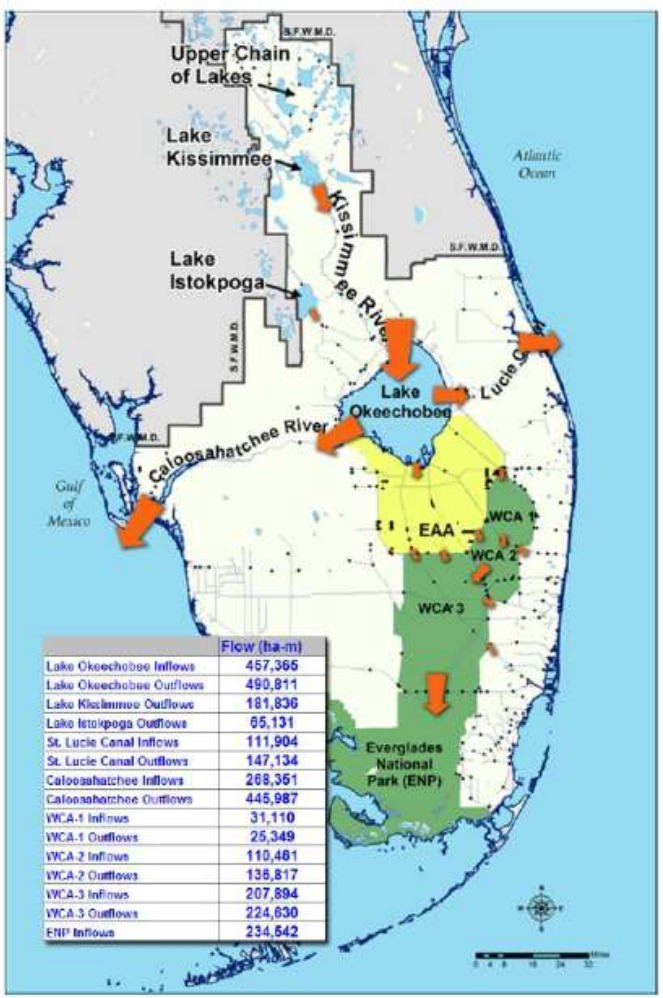
Relevance to ER

- Unique hydrological entities connected!
  - Water delivers nutrients!



	Flow (ha-m)
Lake Okeechobee Inflows	457,365
Lake Okeechobee Outflows	490,811
Lake Kissimmee Outflows	181,836
Lake Istokpoga Outflows	65,131
St. Lucie Canal Inflows	111,904
St. Lucie Canal Outflows	147,134
Caloosahatchee Inflows	268,351
Caloosahatchee Outflows	445,987
WCA-1 Inflows	31,110
WCA-1 Outflows	25,349
WCA-2 Inflows	110,481
WCA-2 Outflows	136,817
WCA-3 Inflows	207,894
WCA-3 Outflows	224,630
ENP Inflows	234,542

Lake O & Upstream

EAA & WCA

Everglades & Florida Bay

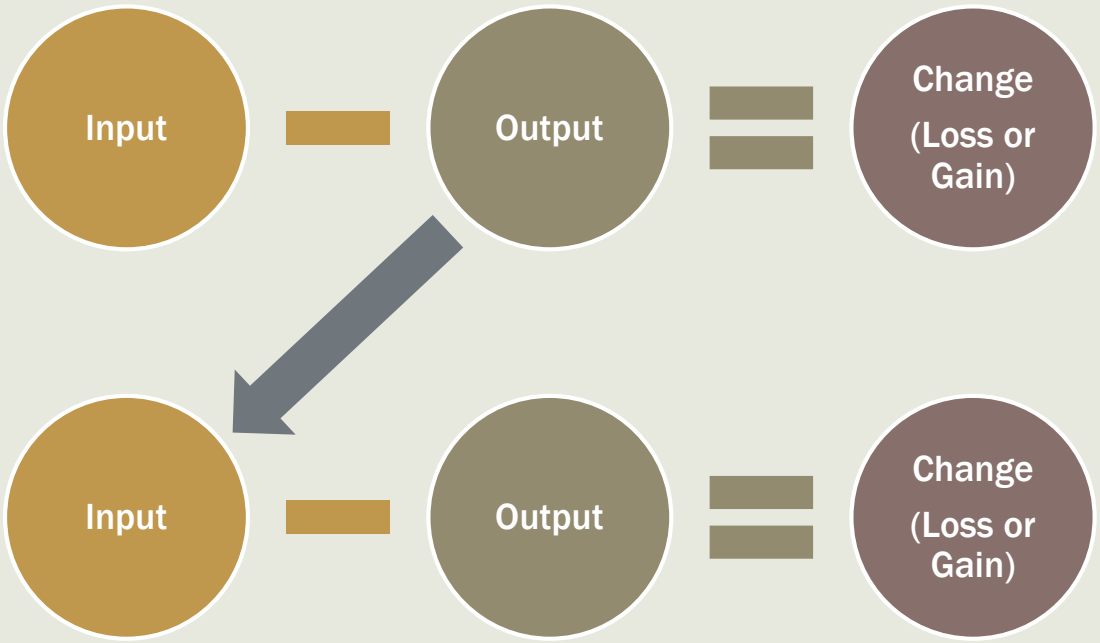
Cascade!

Connected!

Abtew, W., Huebner, R.S. and Pathak, C., 2007. Hydrology and hydraulics of South Florida. In *World Environmental and Water Resources Congress 2007: Restoring Our Natural Habitat* (pp. 1-13).

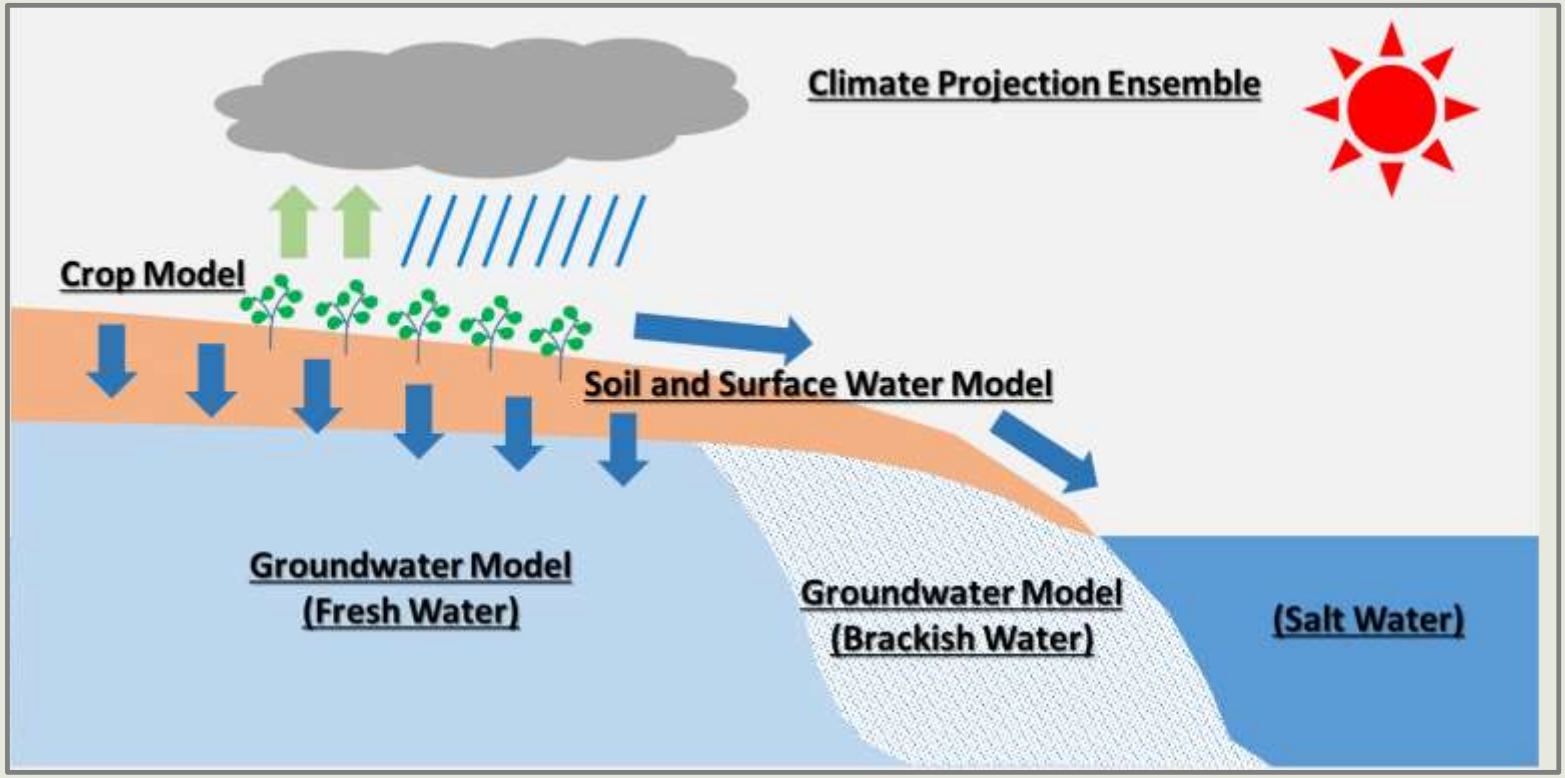
Potential Contribution to ER

- Mass balance (budget calculation)
  - Water and partitioning, sediment, and nutrient balance
  - Tracking along paths from Lake Okeechobee to Florida Bay
  - Critical area identification
  - Is the equilibrium reached?



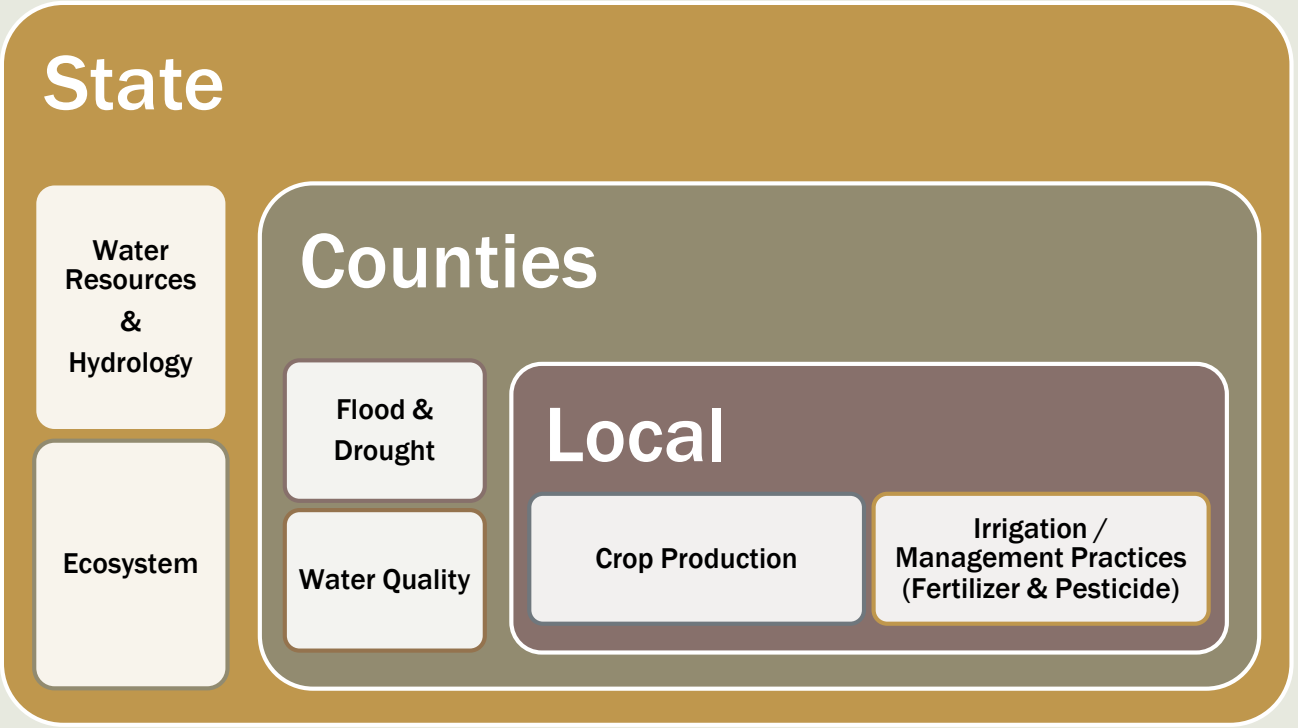
Potential Contribution to ER

- Many simulation models for individual systems
  - Not integrated yet!
  - Agricultural systems are not considered enough!
  - Regional simulation models are too complicated to use!
  - Spatially too coarse to show local details!



Potential Contribution to ER

- Unified Fine-resolution Large-scale (U.F.L.) modeling
  - Provide more consistent outputs across disciplines
    - Agricultural, hydrological, and ecological effects together
  - Promote more consistent decision making across areas
    - Efficient State-level effort (e.g. critical areas)



Future Research Direction

- Unified Fine-resolution Large-scale (U.F.L.) modeling
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Fig. 1. Runoff dynamics s

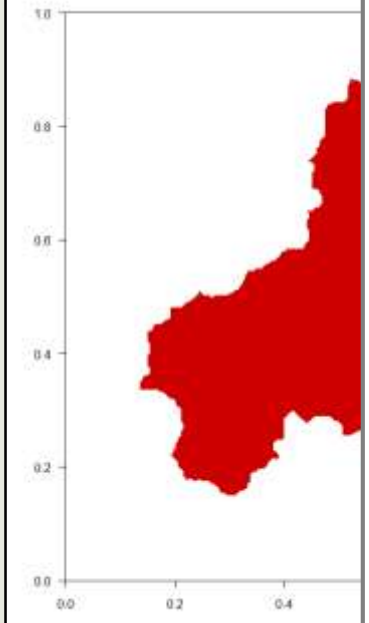
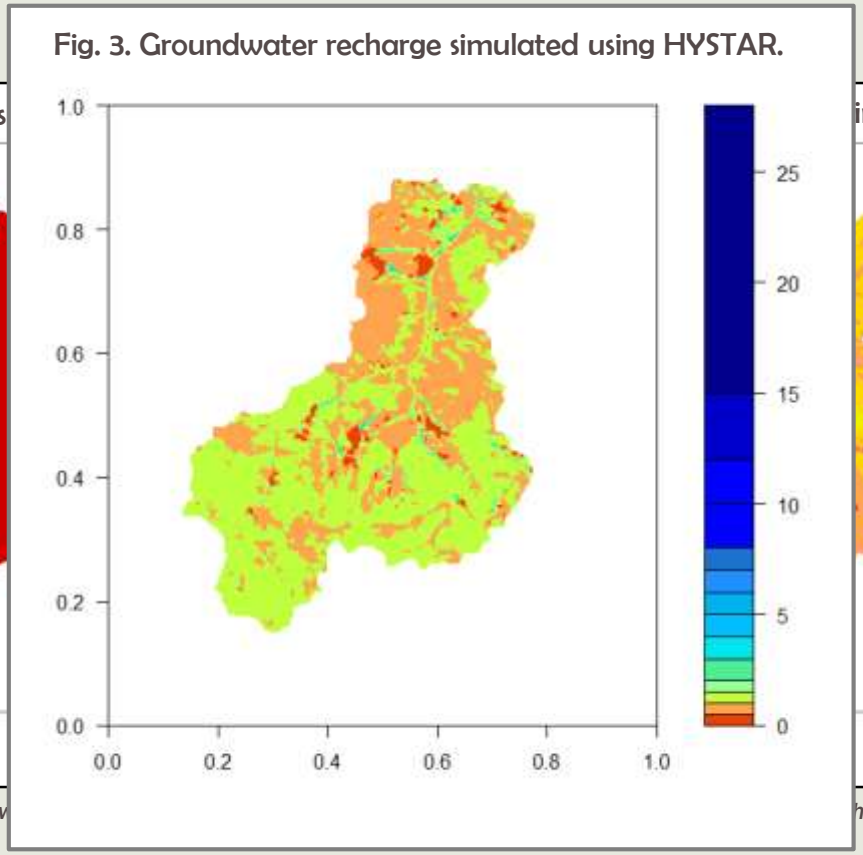


Fig. 3. Groundwater recharge simulated using HYSTAR.



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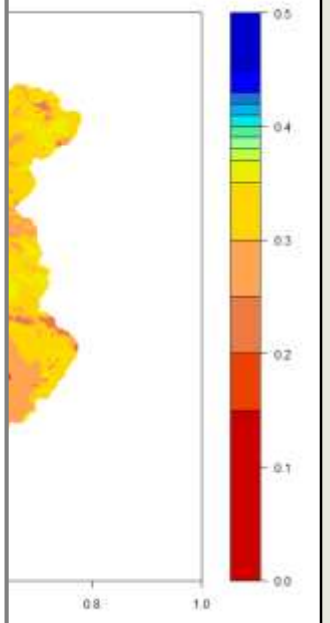
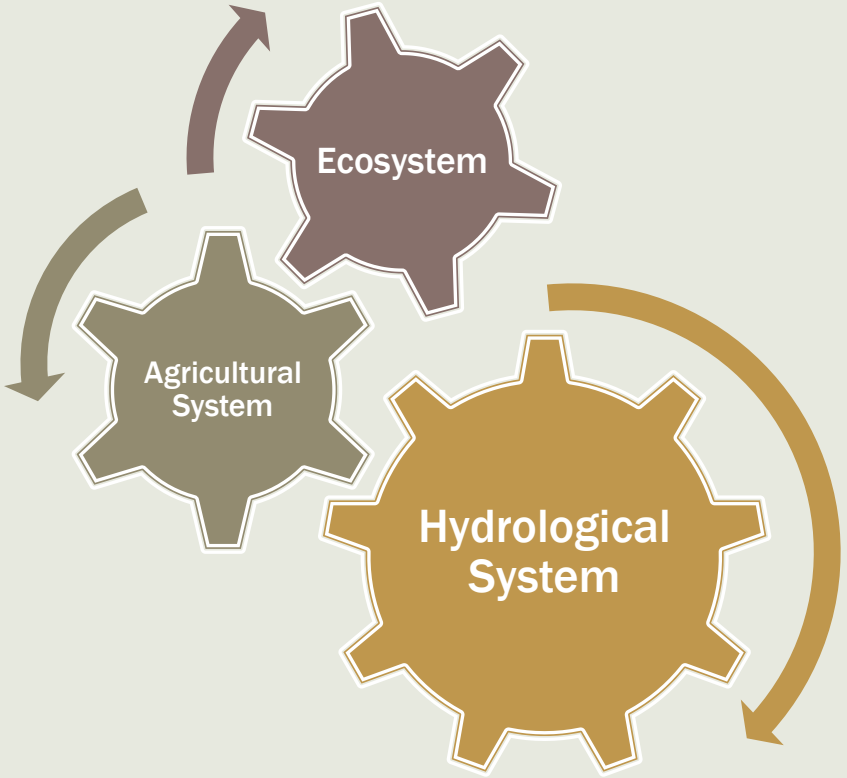


*1. **Her, Y.**, & C. Heatwole. 2015. Tw hod. Hydrological Processes, 30(5):751-770.*

*2. **Her, Y.**, & C. Heatwole. 2016. HYSTAR sediment model: Distributed two-dimensional simulation of landscape erosion and sediment transport using the time-area routing method. Journal of the American Water Resources Association, In Press.*

Future Research Direction

- Identifying the resilient hydrological equilibrium
  - What does change hydrological equilibrium?
  - How quickly can hydrological equilibrium be reached?
  - Is the equilibrium sustainable and resilient?



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