Examining the Influence of Shallow Groundwater on Net Primary Productivity and Evapotranspiration in Managed Ecosystems

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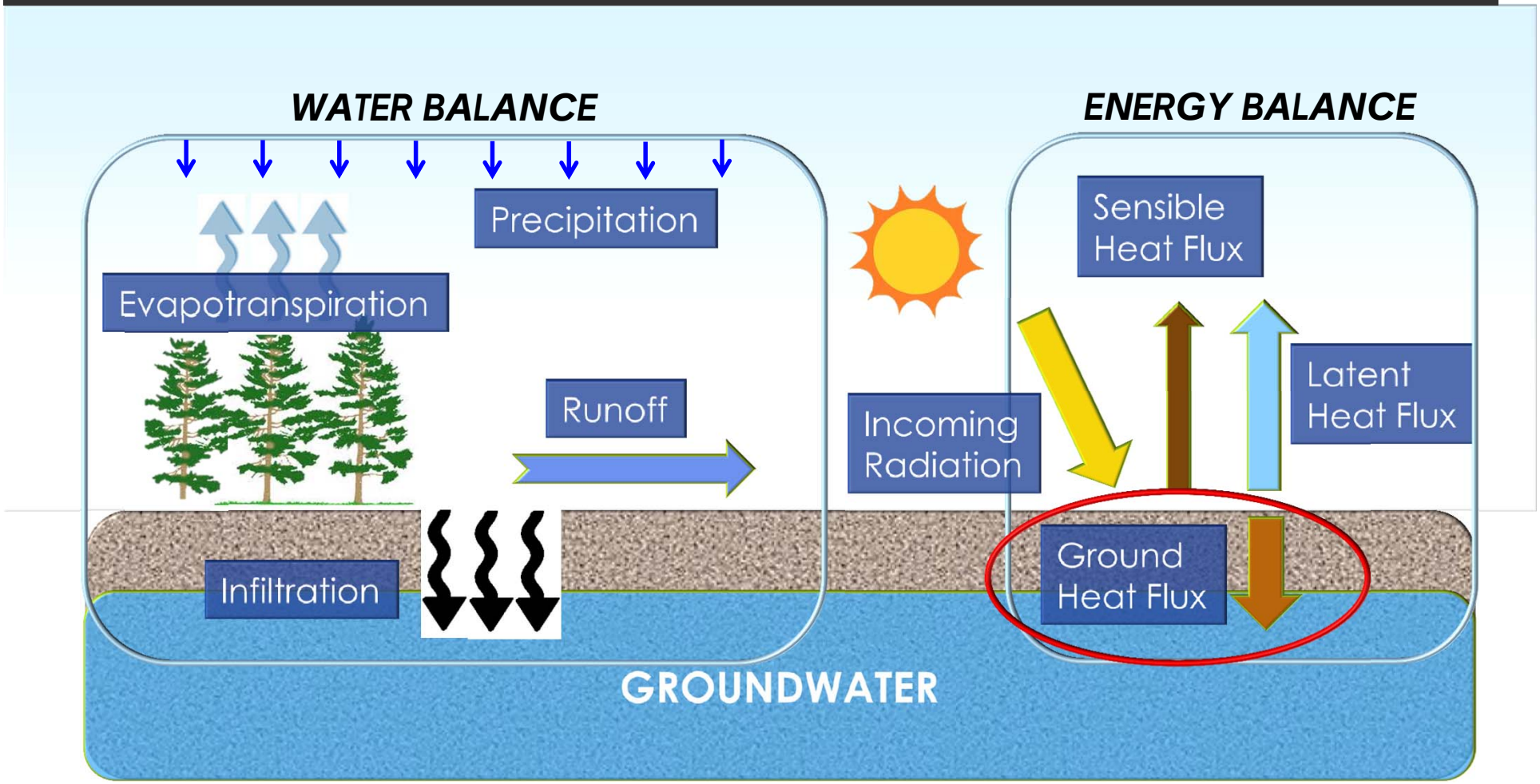
Introduction



Introduction

- Global scale observational studies showed that spring has advanced about a rate of 2.3 days per decade (*Parmesan and Yohe, 2003*).
- However, phenology of agricultural species are changing less than those in the wild (*Menzel et al., 2006*). Mainly because of
  - Farmers decisions
  - Developments in biotechnology and equipment
  - Irrigation or existence of shallow groundwater

Modeling the Impacts of GW on Plants

Land Surface Models

+ simulate water and energy fluxes among soil-vegetation-atmosphere systems in a process-based way

- lack a detailed simulation of soil water movement in the unsaturated zone, particularly when groundwater is present

- only a few models are available to simulate agroecosystems

Variably Saturated Soil Water Flux Models

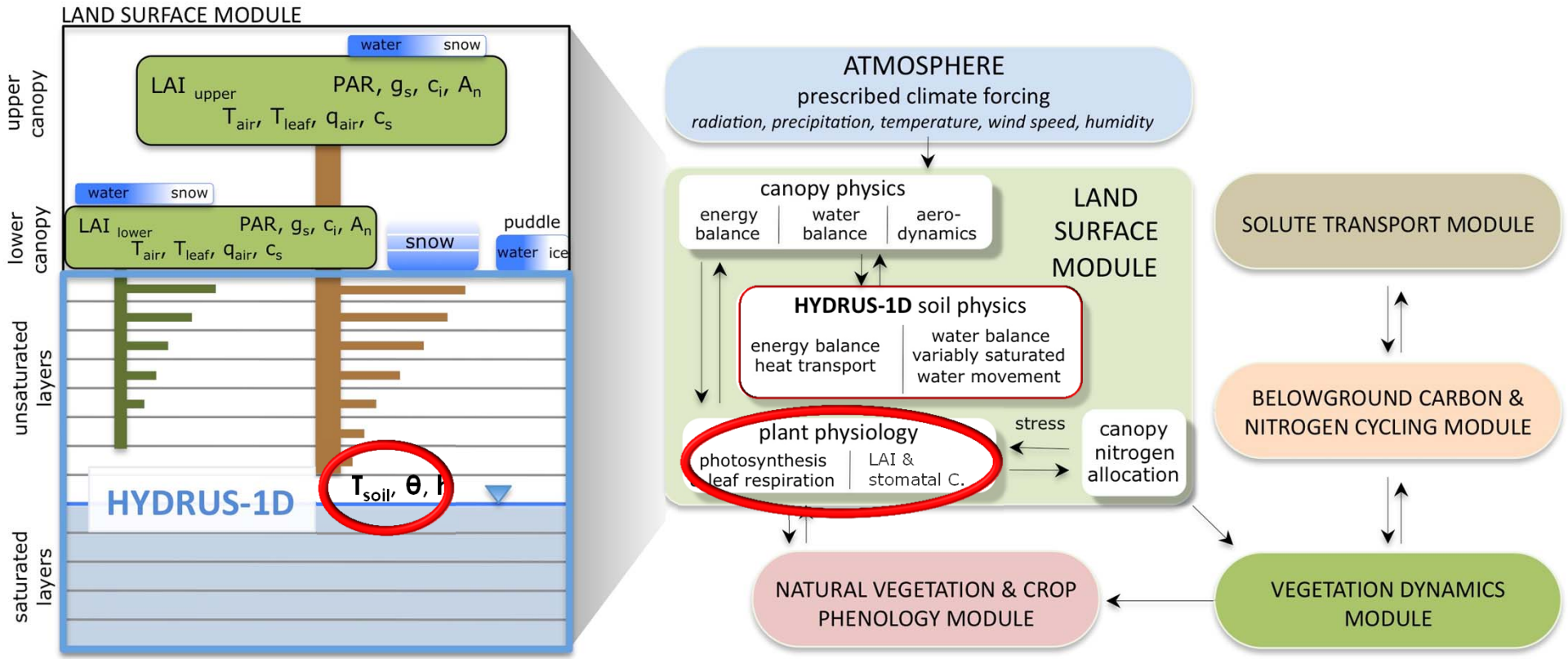
+ simulate water movement in the unsaturated zone with high accuracy

- often lack a detailed plant physiology component

Objectives

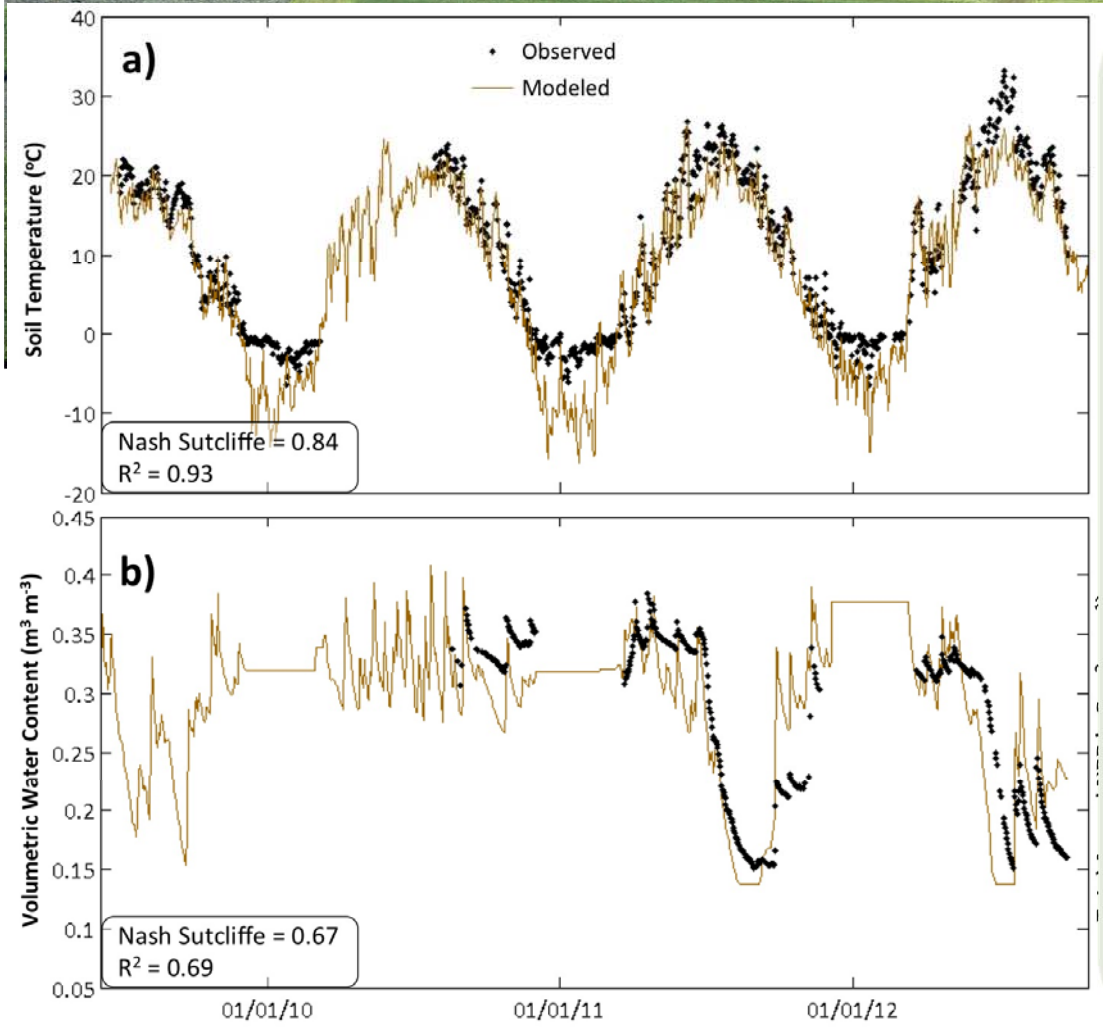
- To develop a dynamic modeling approach that is capable of simulating interactions of groundwater and plant/crop system in a fully coupled, physically-based fashion
  - How do net primary productivity, evapotranspiration and leaf level micro-scale environmental conditions respond to varying water table depths?
  - What is the influence of groundwater-induced soil temperature changes on plant phenology?

Incorporation of Hydrus-1D into Agro-IBIS

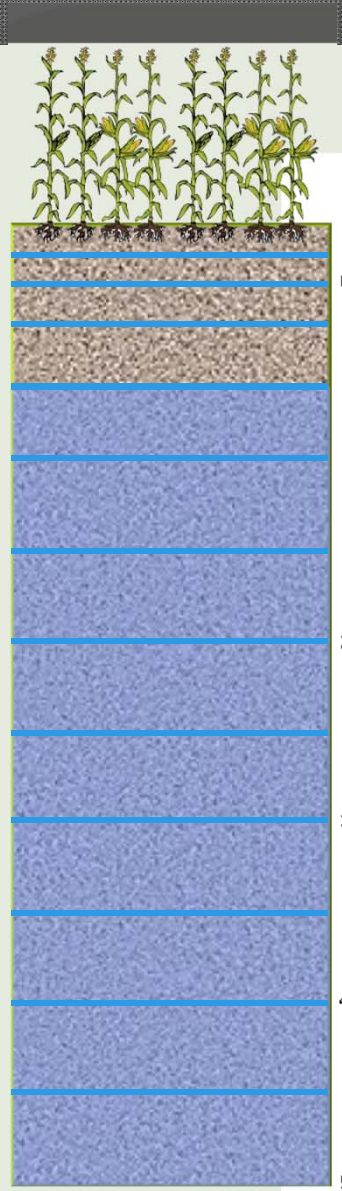


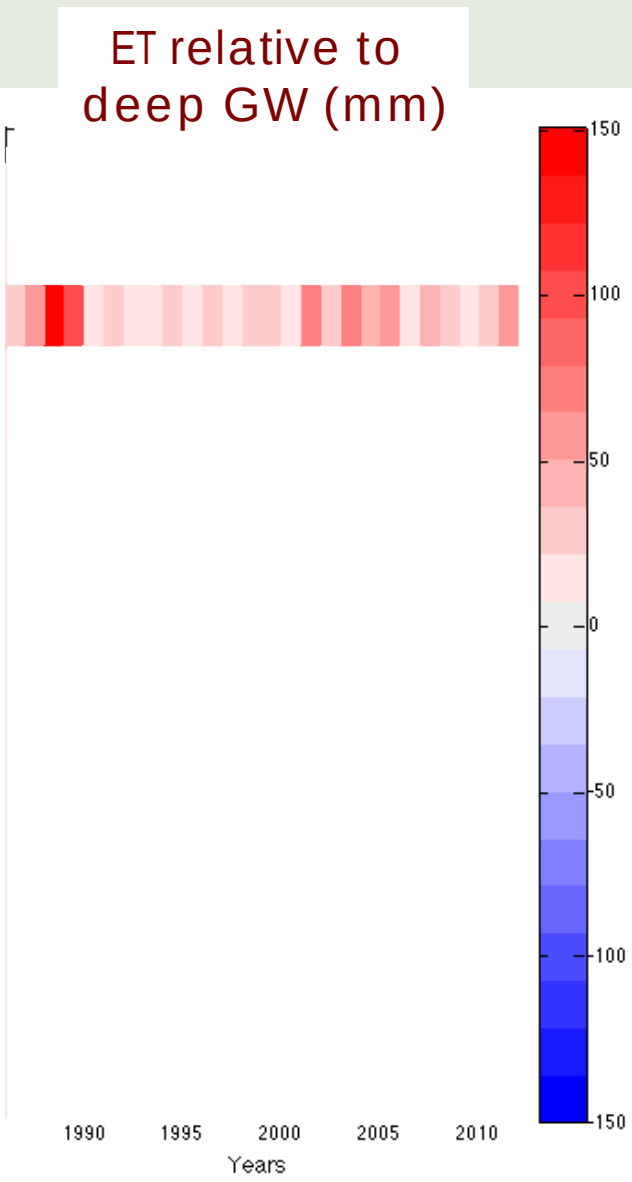
Model Evaluation

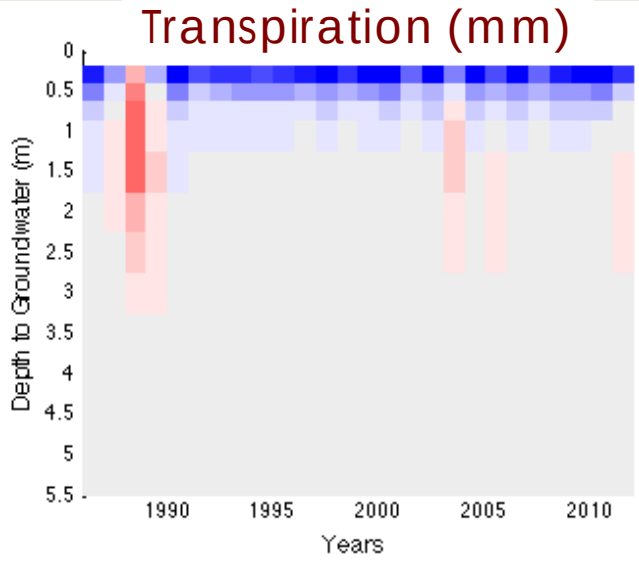
Data obtained from 3 replicated maize plots at Arlington, Wisconsin

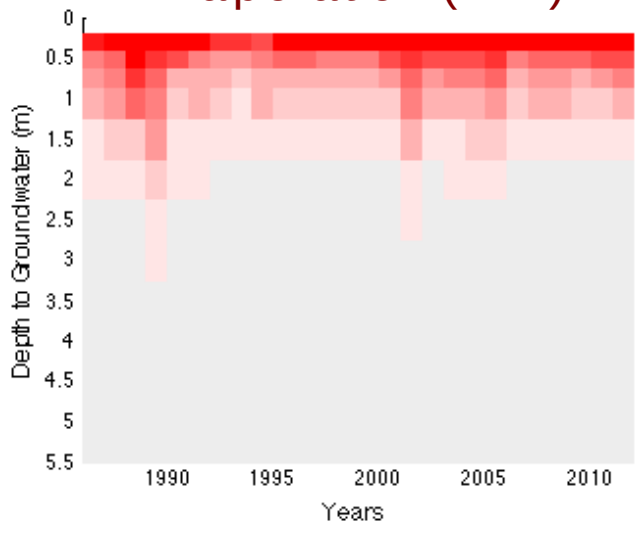


Model Sensitivity Experiments

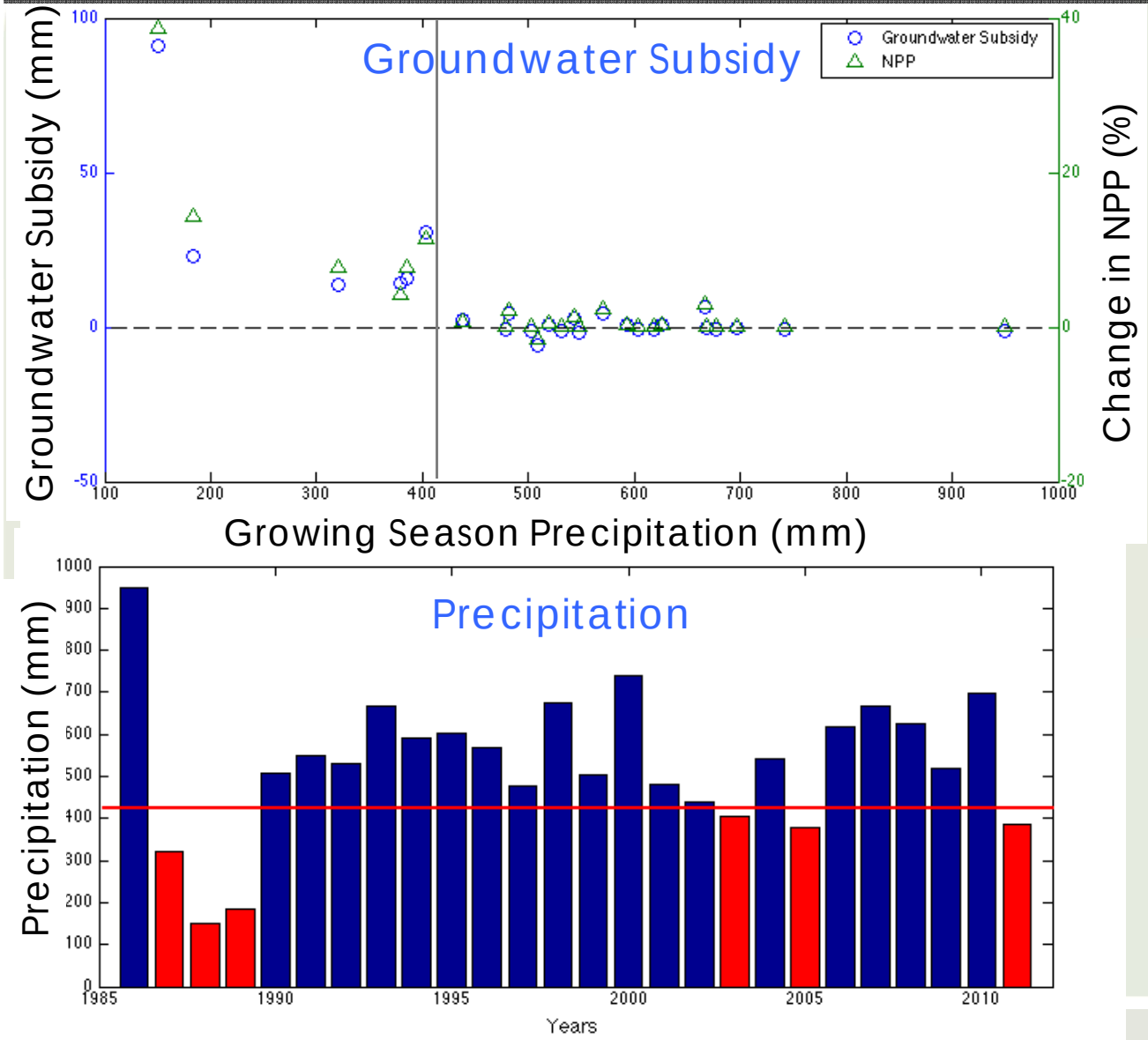








Groundwater Subsidy



Groundwater subsidy: The additional water available for transpiration resulting from shallow groundwater.

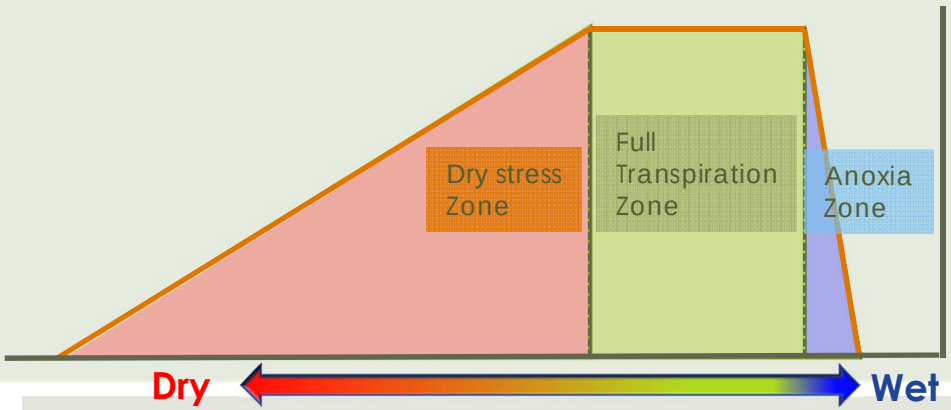
Lowry & Loheide, 2010

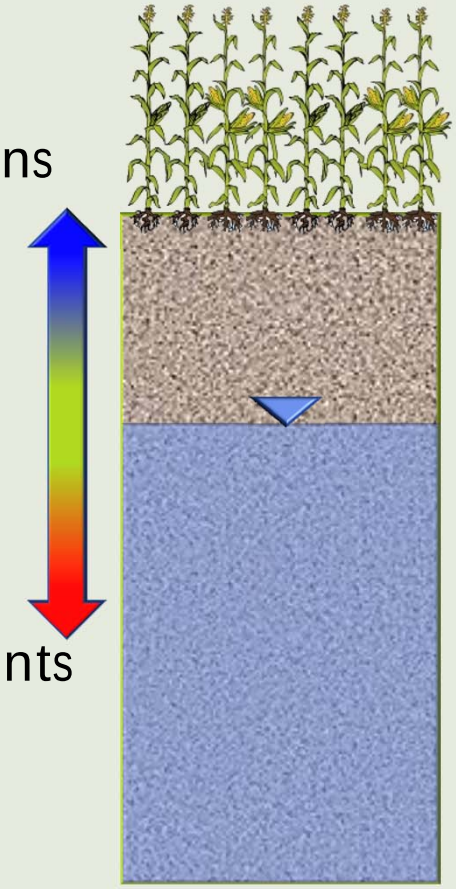
Current understanding of GW-Plant relationships

Water table is too shallow = Anoxic conditions

Water table depth is just right = GW helps plant escape water stress during dry summer

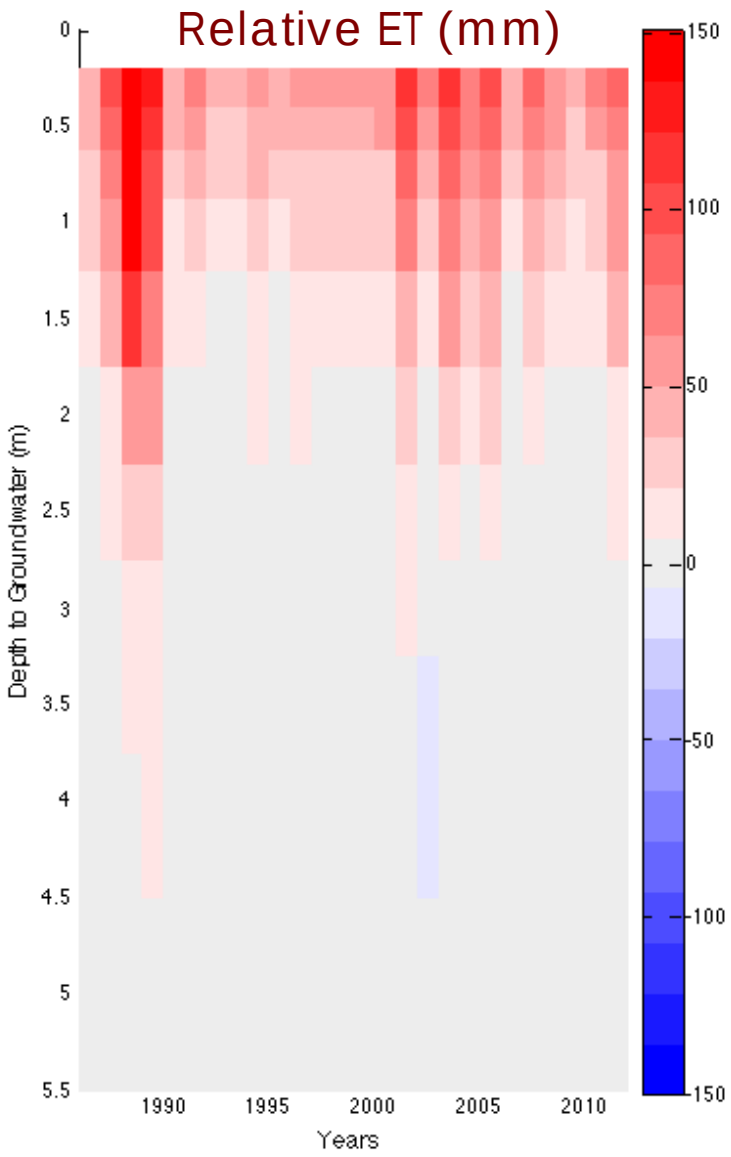
Water table is too deep = No impact on plants

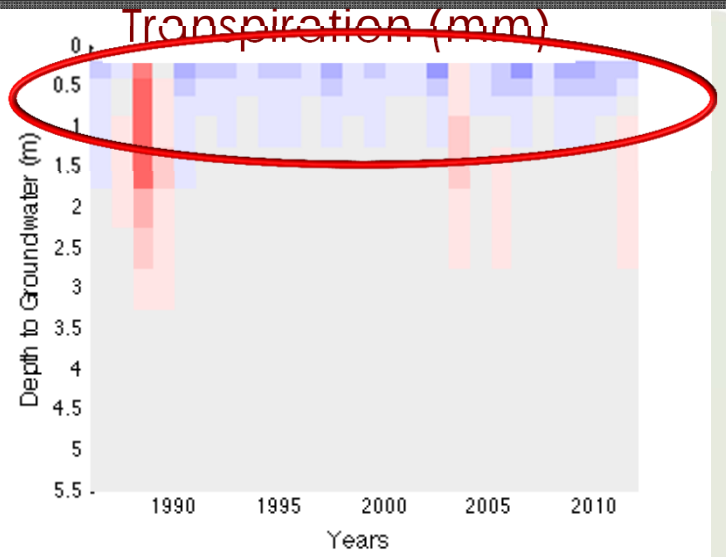


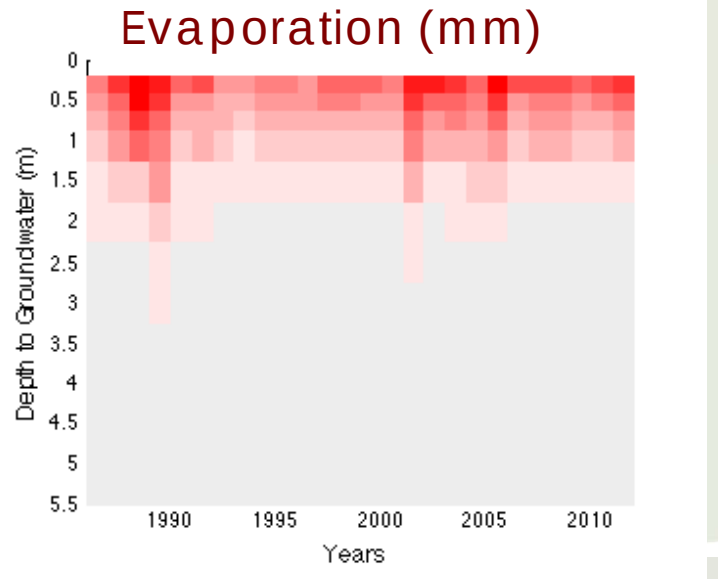


Feddes et al., 1978

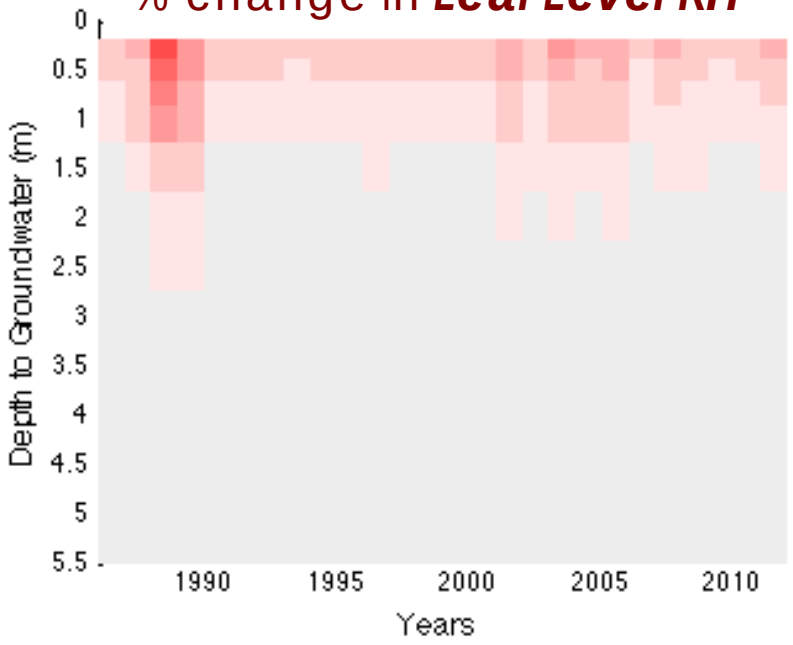
No oxygen stress experiments



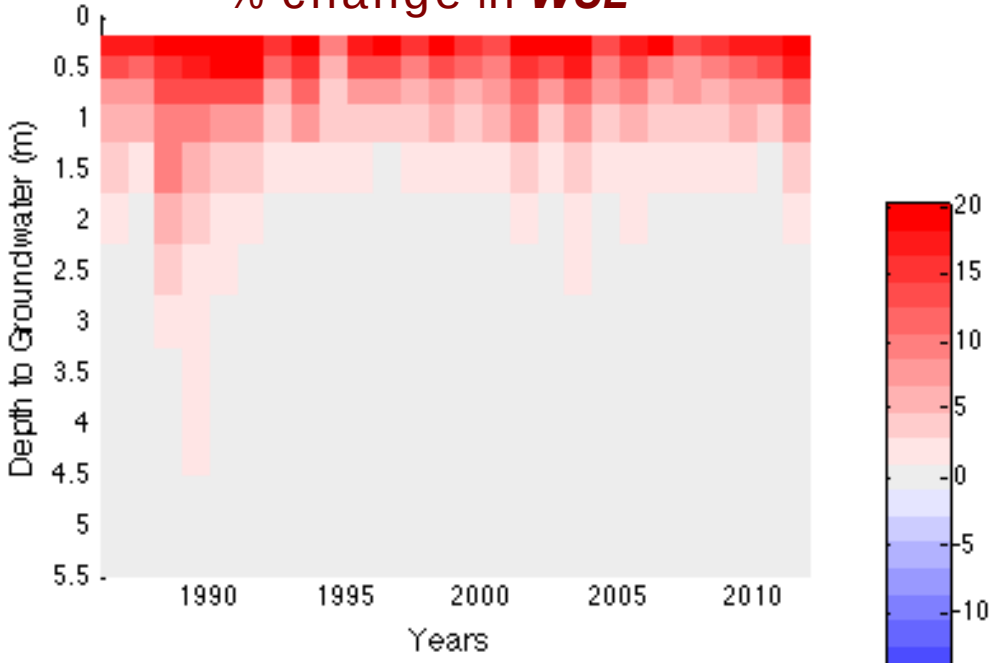




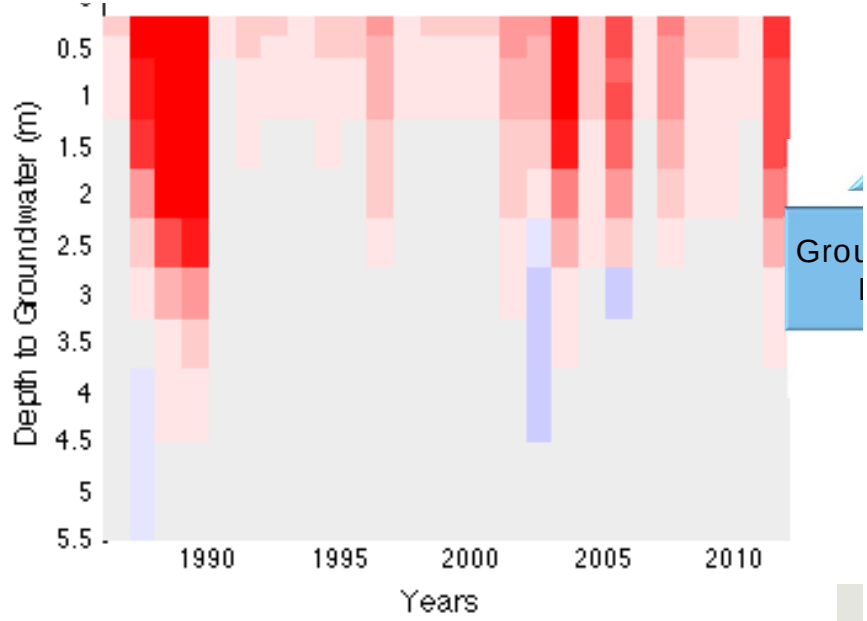
% change in ***Leaf Level RH***



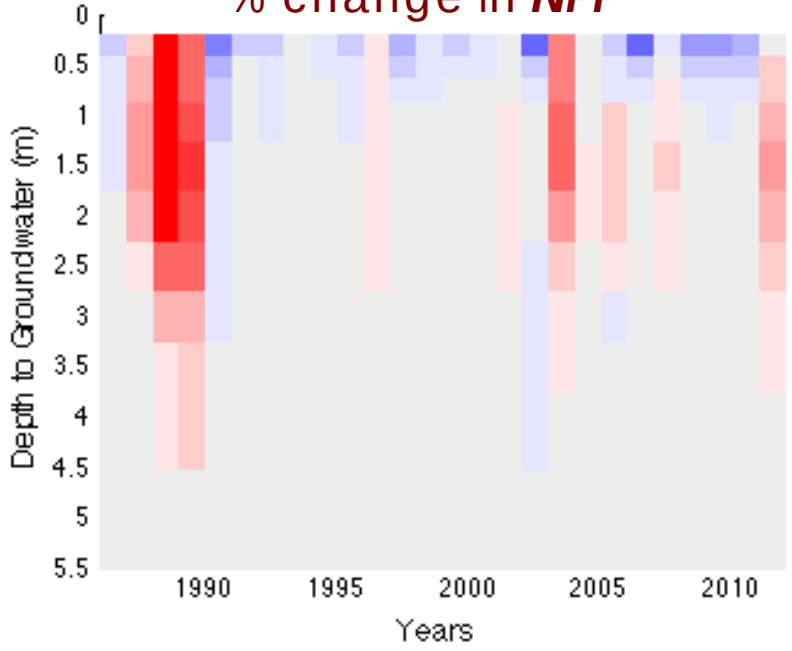
% change in ***WUE***

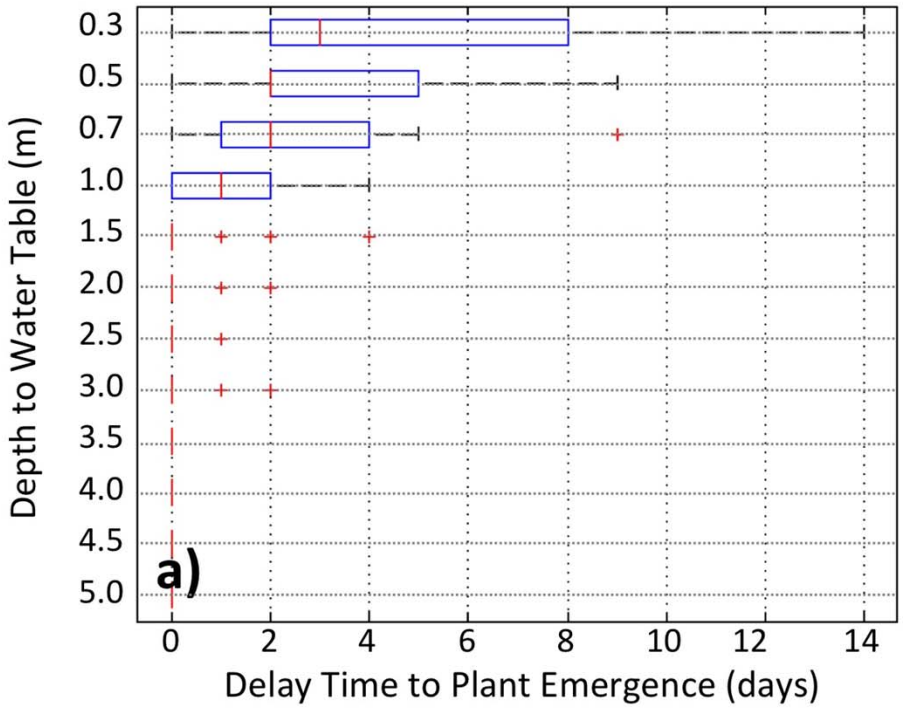


% change in ***Stomatal Conductance***



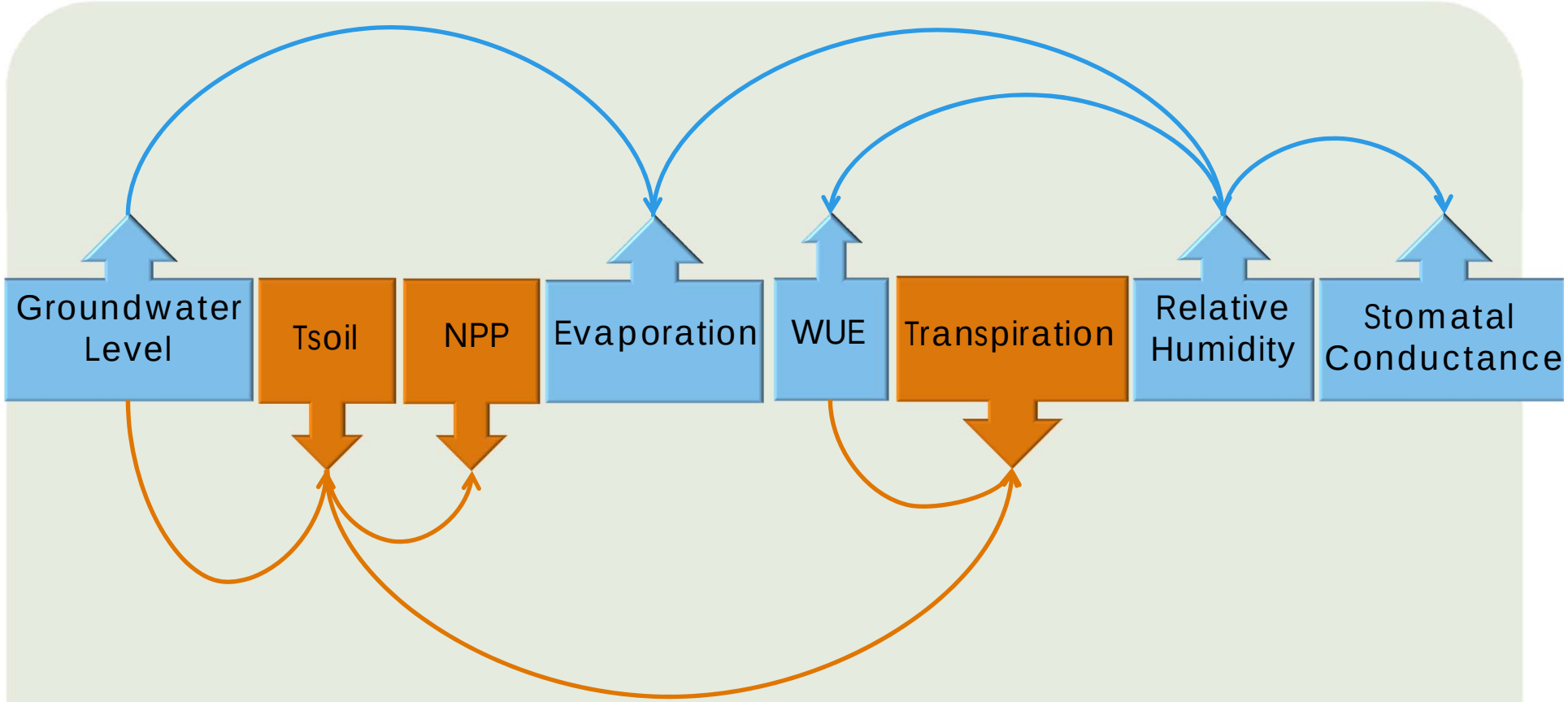
% change in ***NPP***





- Cooler early season soil temperatures delays leaf emergence
- The delay impacts both annual carbon uptake and transpiration

Summary



- Groundwater could play a critical role in plant phenology, which might be necessary to take it into account in agricultural management decisions in a changing climate

For non-drought years

Questions

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Water Sustainability and Climate

In the Yahara River Watershed

http://wsc.limnology.wisc.edu/

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