BioEarth — Biosphere-relevant earth system model

Impact of Changes in Climate and Irrigation Management Strategies on Evapotranspiration and Agricultural Water Availability

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1- Introduction

Yakima River Basin (YRB) is located at central Washington State (Figure 1). snow storage is the dominant source of water thus hydrology and ultimately the economy of the region is sensitive to climate change (figure 2). The predominant irrigation systems used in the region have low efficiency (Figure 3)

Water use may be ameliorated by modifying irrigation practices. The dynamics of regional scale climate, geologic hydrology and agriculture is complex, requiring a comprehensive computer simulation model to study the hydrology of current and potential scenarios. Results of this study can be used for predicting intended and unintended consequences of irrigation system modification.

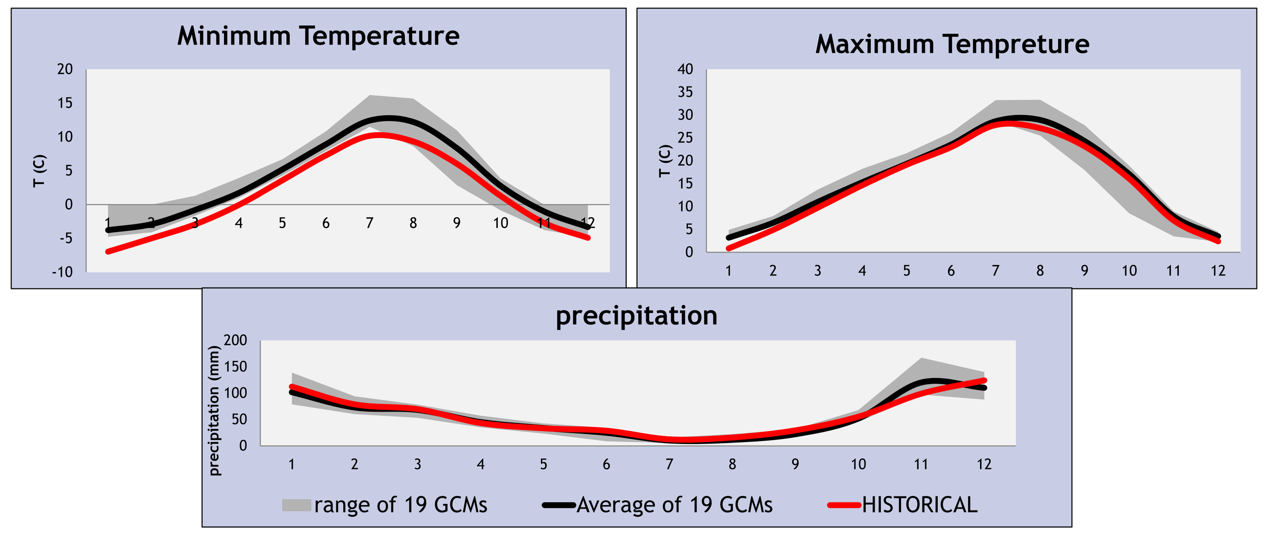


Figure 2-YRB is Sensitive to climate change

Yakima River Basin (YRB)

- Area: 16000 square km
- Average Precipitation: 686 mm / yr
- Cropping patterns are tending to higher value crops (fig 4).
- Agricultural productivity has substantial economic impact:
  - 1st county in the Washington state and 5th in nation
  - 10% of employments directly in agriculture

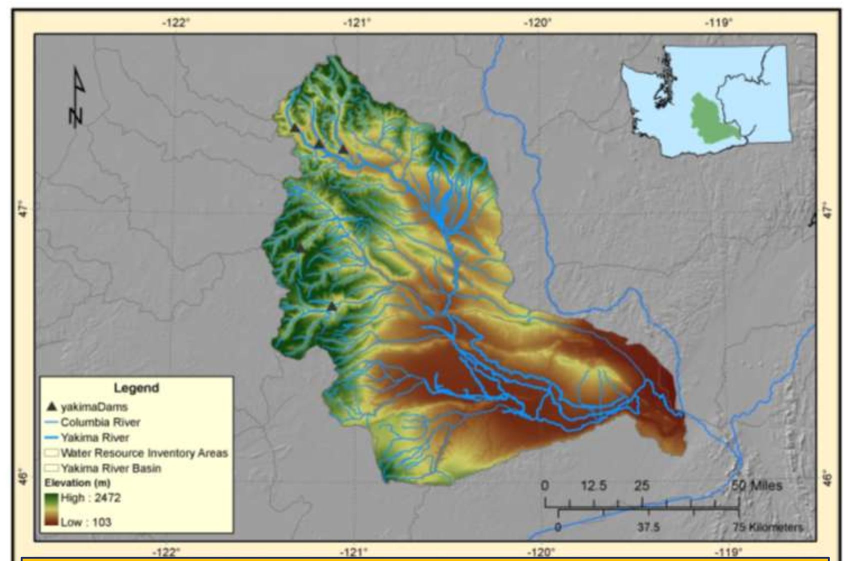


Figure 1-Yakima River Basin

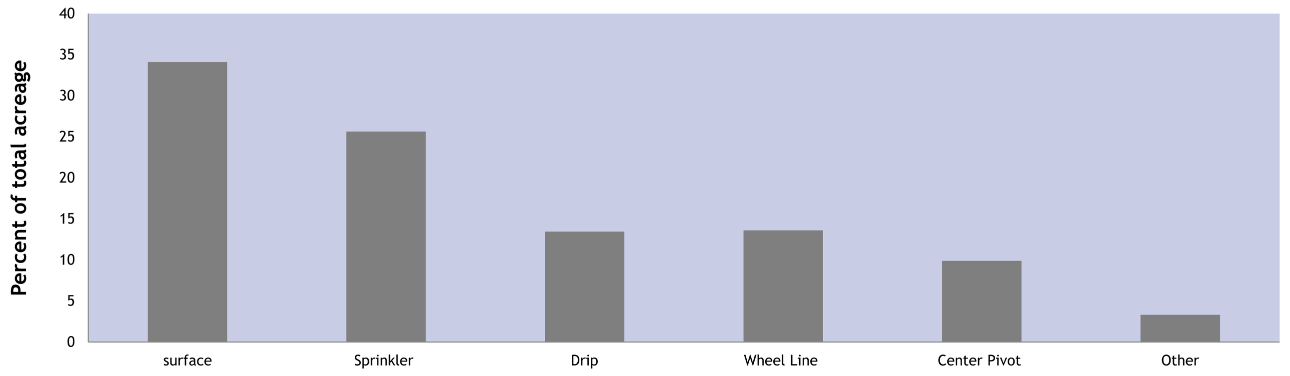


Figure 3- Current irrigation systems used in the YRB

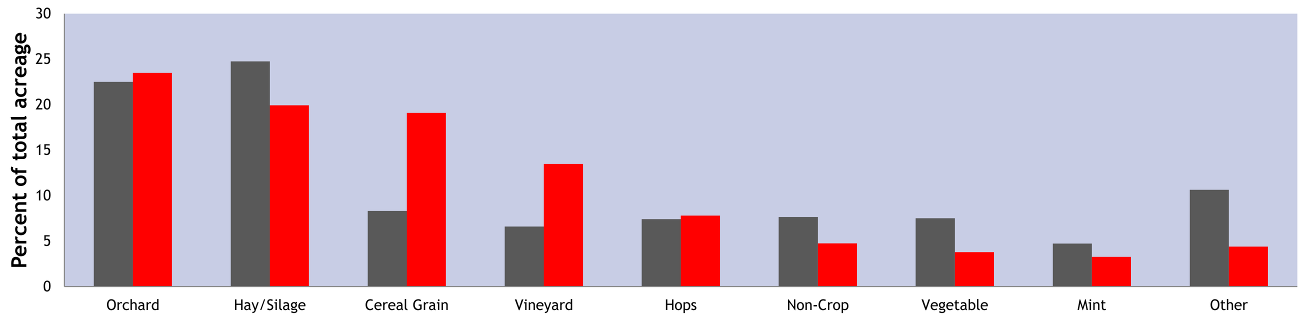


Figure 4- Cropping pattern variability in the YRB

3- Preliminary Results

Currently we are calibrating the model for YRB and following figures are our framework capabilities

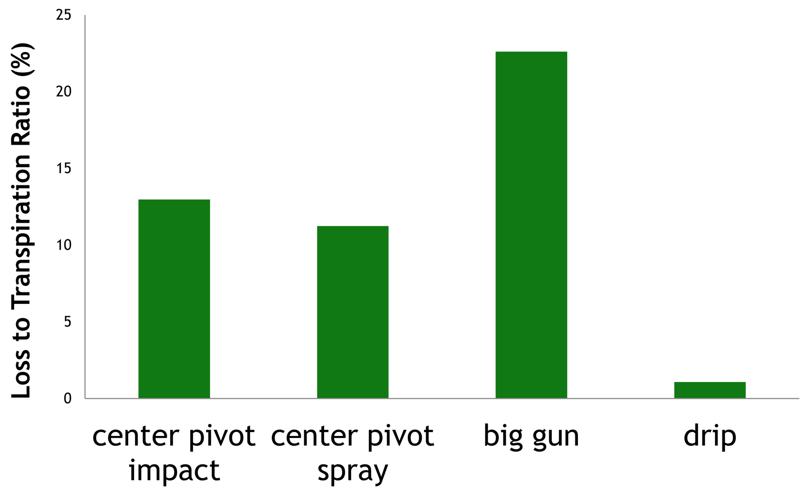


Figure 8- Impacts of change in irrigation systems on efficiency

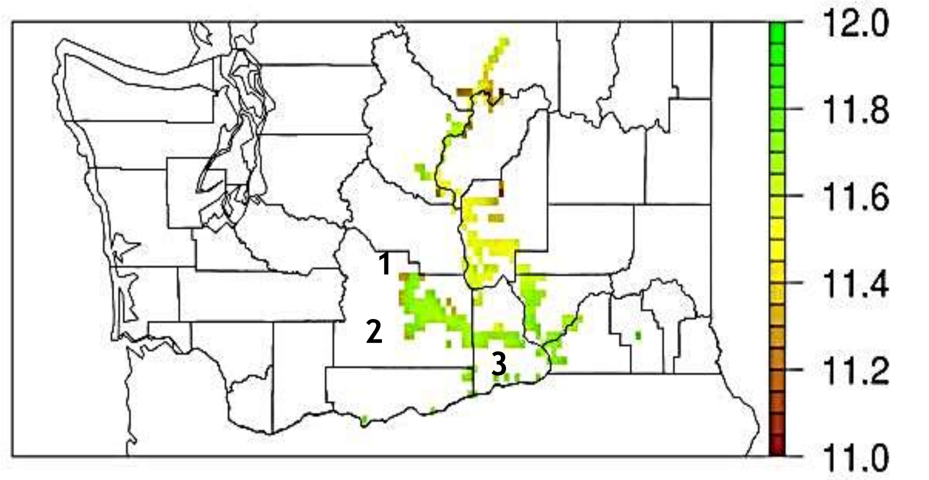


Figure 9- Spatial distribution of yield

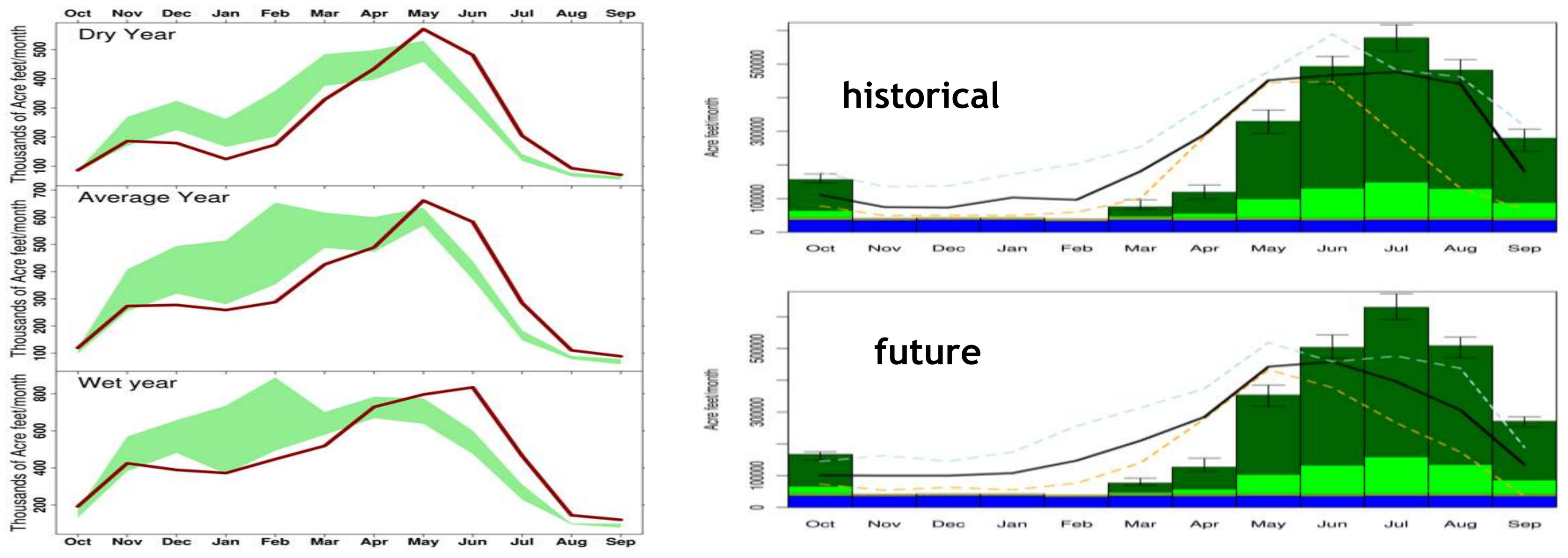


Figure 10-Impacts of climate change on agricultural water availability

2- Material and methods

Modeling Framework

The large scale physically based hydrological model (Variable Infiltration Capacity - VIC) and the processed based cropping system model (CropSyst) were coupled. The CropSyst transpiration submodel provides the agricultural water use component, an improvement over the VIC model's simple generalized estimation method. Water loss from water application using various irrigation system was also added to the model.

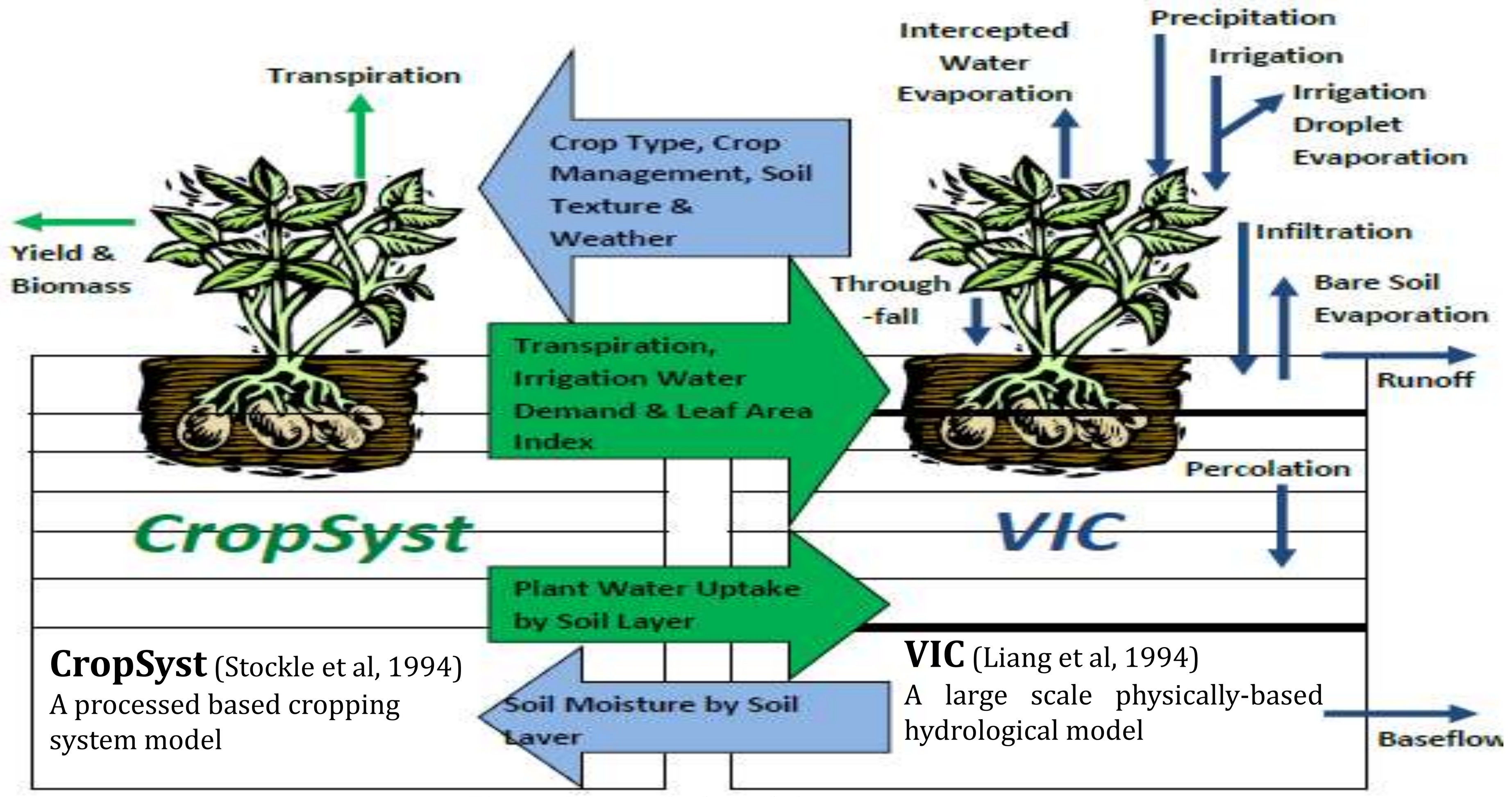
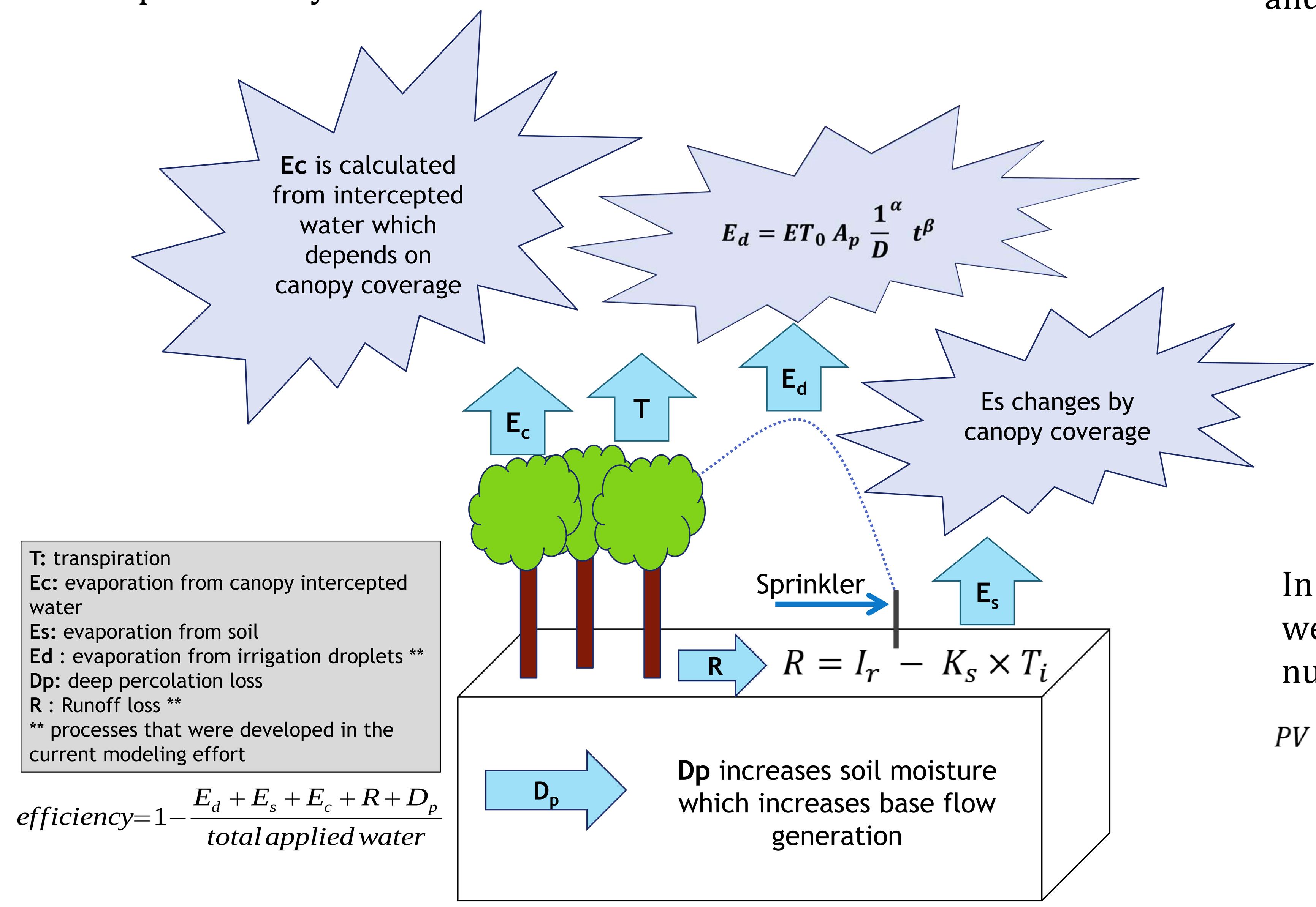


Figure 5- coupled model

Simulation of Irrigation System Losses

All the irrigation loss terms have been simulated mechanistically to capture the impacts of irrigation water management and climate change on hydrology and agricultural productivity of the basin.



T: transpiration
Ec: evaporation from canopy intercepted water
Es: evaporation from soil
Ed : evaporation from irrigation droplets **
Dp: deep percolation loss
R : Runoff loss **
** processes that were developed in the current modeling effort

$$efficiency = 1 - \frac{E_d + E_s + E_c + R + D_p}{total\ applied\ water}$$

Figure 6- simulation of irrigation losses

Feedbacks of climate and irrigation systems

Irrigation increases humidity (H) and changes the temperature (T) of the field therefore it changes amount of ETp.

Using the developed model, feedbacks between agricultural activities and climate can be captured.

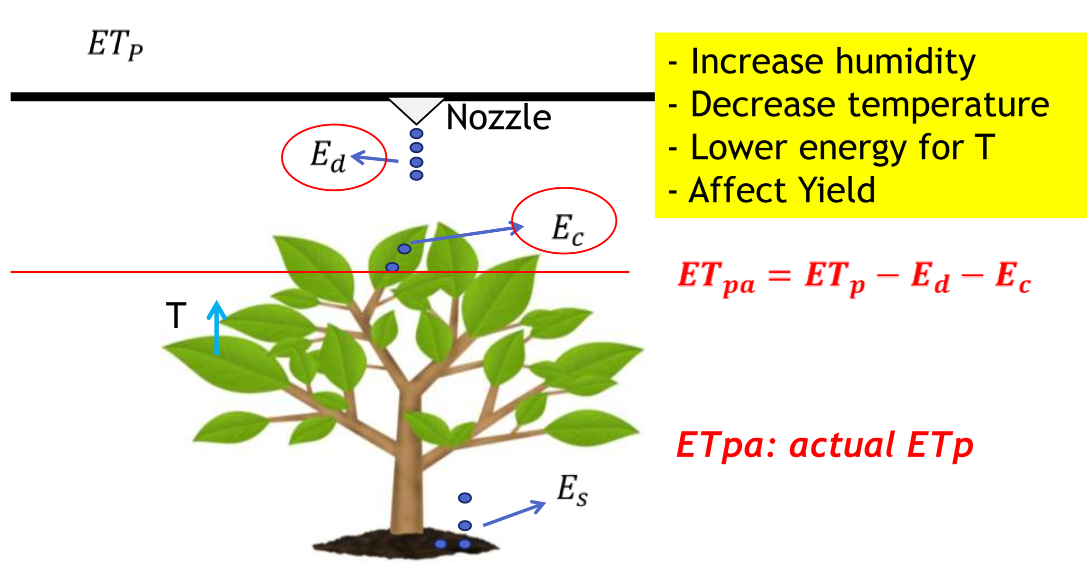


Figure 7- feedback process between irrigation systems and climate

In order to find T and H, Penman-Montheith equation and gas law were combined into a system of equations which was solved numerically in our modeling framework.

$$PV = nRT$$

$$ETpa = \frac{\left[\dfrac{\dfrac{4098[e_s(T)]}{(T+237.3^2)}(R_n - G) + \rho_a c_p \dfrac{(e_s(T) - e_a(H,T))}{r_a}}{\dfrac{4098[e_s(T)]}{(T+237.3^2)} + \dfrac{c_p\, P}{\varepsilon\,(2.501 - 0.002361T)}\left(1 + \dfrac{r_s}{r_a}\right)}\right]}{2.501 - 0.002361T}$$