Subsurface drainage: how does it affect simulated soil moisture status?

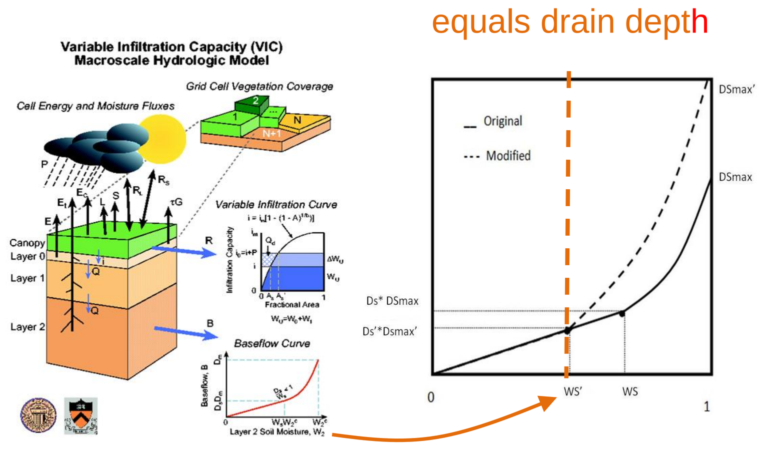
Laura Bowling, Sarah Rutkowski, Keith Cherkauer, Eileen Kladivko
Purdue University

INTRODUCTION

Soil moisture content provides a fundamental control on a range of bio-physical responses from the agricultural ecosystem. Subsurface drainage alters the mean and variability of soil moisture and temperature but many biogeochemical and crop growth models designed for use at regional scales do not represent this common management practice. The objective of this research is improved quantification of moisture and temperature dynamics in drained agricultural systems at regional scales, for improved assessment of ecosystem sustainability.

MATERIALS & METHODS

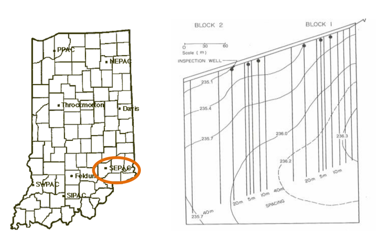
A new drainage algorithm has been developed within the Variable Infiltration Capacity (VIC) macroscale hydrology model.



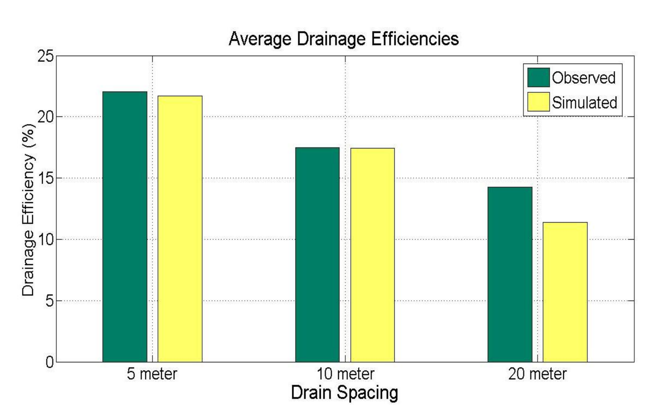
VIC baseflow curve modifications:

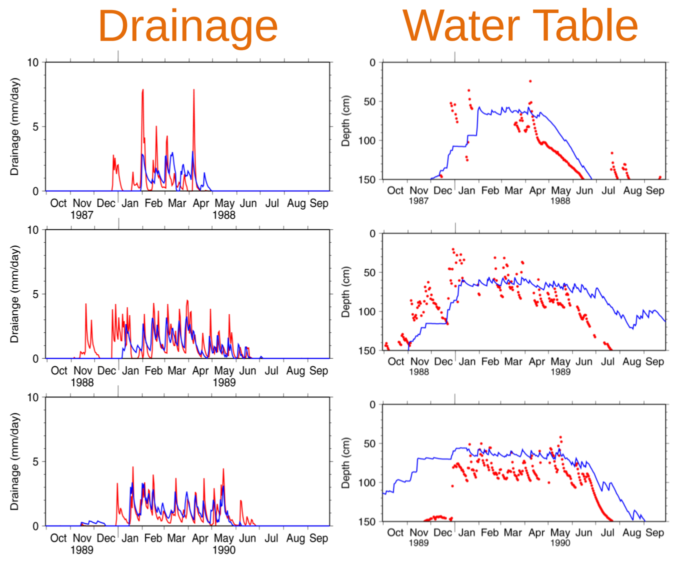
- *maximum subsurface flow rate is equal to the ellipse equation for an input drain spacing.*
- *Nonlinear subsurface flow is initiated when the water table rises above the input drain depth.*
- *Drainage water management is represented by varying the drain depth monthly.*

The new algorithm has been evaluated at the field-scale using observed drainage and water table data from the west block at the Southeast Purdue Agricultural Center (SEPAC).



Calibration
Drainage Statistics
Nash-Sutt. = .34
Error = 2.1%
R^2 = .34



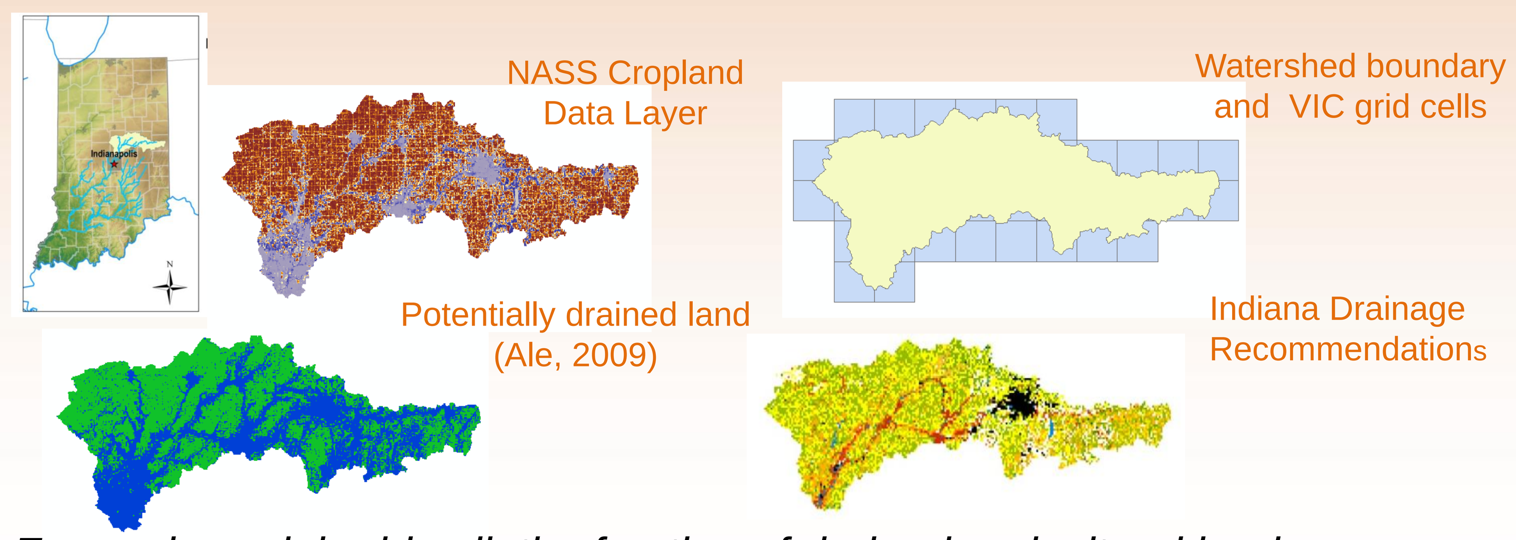


Daily drainflow and seasonal water table dynamics for the 20 m drain spacing are simulated adequately (left).

The sensitivity of drainflow to different drain spacings is well-captured (above).

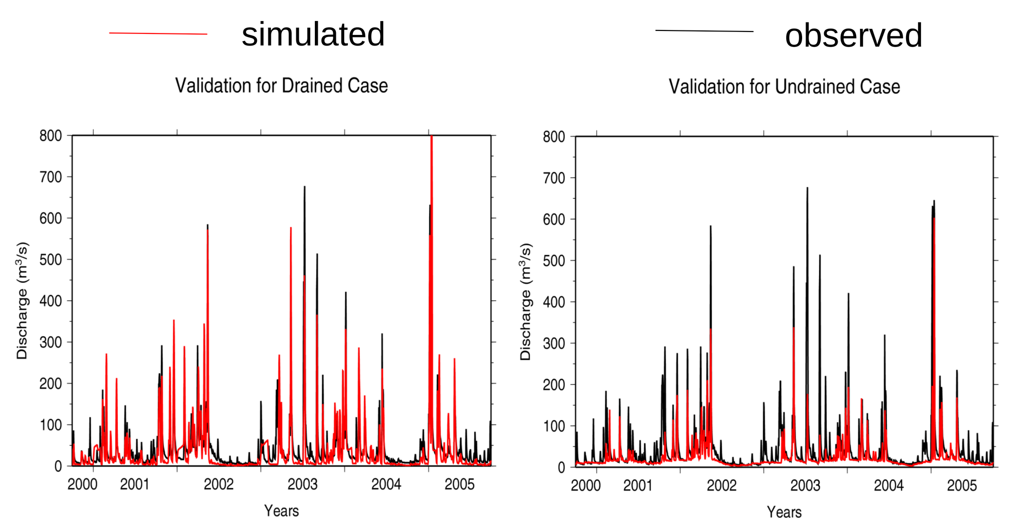
RESULTS & DISCUSSION

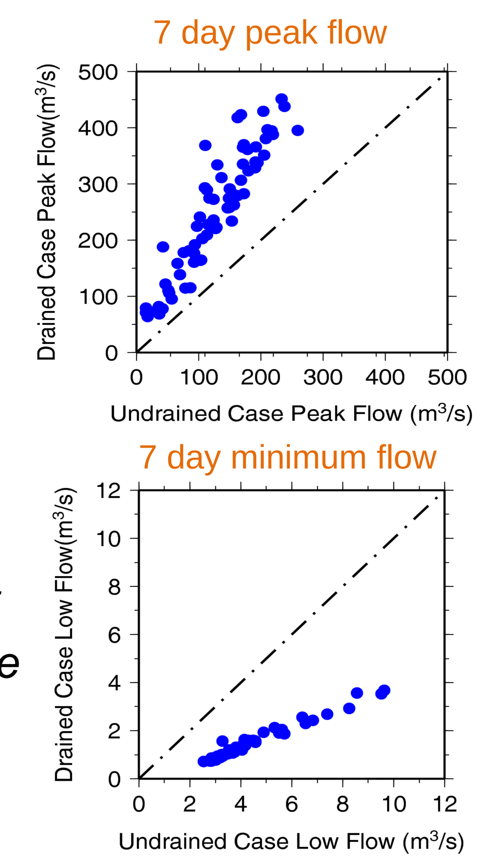
An important consideration for the case study for the Upper White River Watershed in Central Indiana is how to parameterize regional drainage.



For each model grid cell, the fraction of drained agricultural land was calculated using a soil drainage/slope classification. Drain spacing and depth were determined using extension recommendations for the majority soil series in the cell.

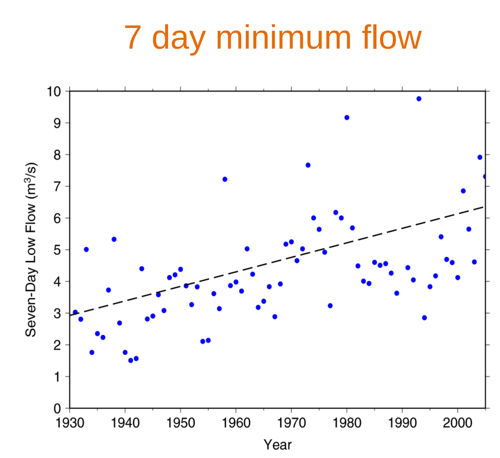
The simulations indicate that in the Upper White River watershed subsurface drainage systems have increased streamflow flashiness, peak flows and moisture variability, while decreasing low flows.

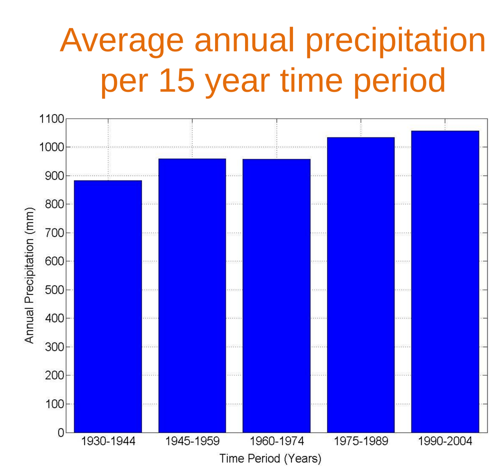




The model was calibrated for our best estimate of current conditions ("drained case", left). The same parameters are used in the undrained case (right) for illustration only.

Overall, an observed and simulated increasing trend in all streamflow metrics is largely due to climate.





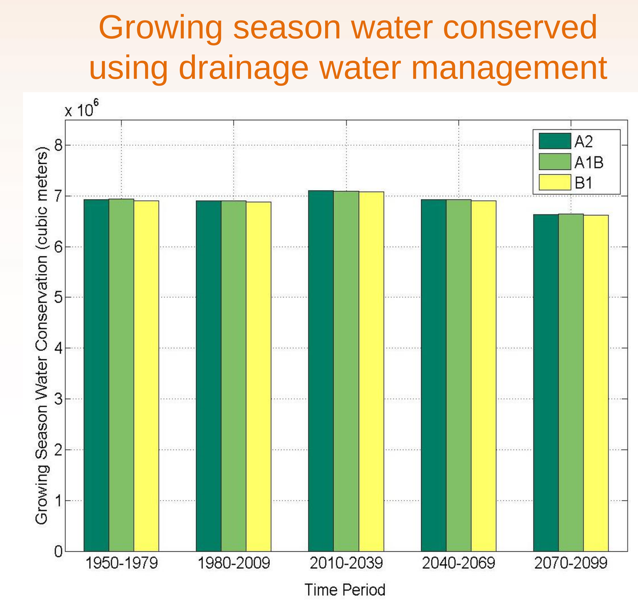
In this model run, land management did not change over time, so the simulated change must be due to climate.

This research is part of a regional collaborative project supported by the USDA-NIFA, Award No. 2011-68002-30190 "Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems"
August 2012 | sustainablecorn.org

CLIMATE PROJECTIONS

Future climate data from the GFDL model was used to force the model simulations under high (A2), moderate (A1B), and mild emissions (B1) for both conventional drainage and an assumed complete adoption of drainage water management (DWM).

Three control heights are used for DWM Case:
Winter: 0.3 meters
April and September: 0.9 meters
Summer (Growing Season): 0.6 meters



Water conserved is the difference in streamflow from the DWM and conventional drainage simulations, it represents increased soil moisture storage and/or evapotranspiration. Conserved water decreases slightly in the future, due to decreased water availability.

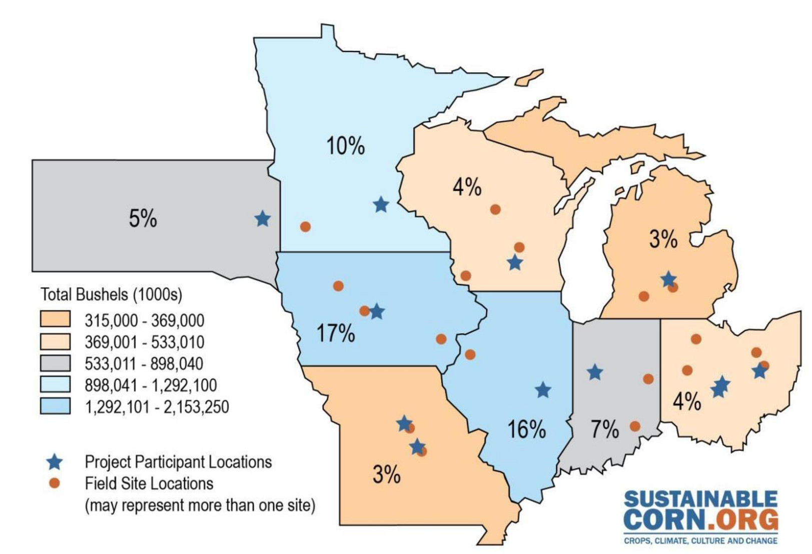
We found that DWM mitigates the effects of conventional drainage by increasing field-scale seasonal water conservation. Water conserved by DWM during the growing season will decrease in all emissions scenarios throughout the next century due to climate change effects.

CONCLUSION: WHERE DO YOU FIT IN?

Future work will involve expanding this technique to the multi-state CSCAP-domain:

- Would you like a simulated water balance of your field sites to help fill in missing data? Because I would like to do site-specific evaluation of water balance simulations!
- I would like to work with drainage experts in each state on maps of drainage extent, depth and spacing.

The end result will be a regional scale assessment of the role of drainage practices on soil hydrology for past and future climates. Potential output includes: simulated drainflow, runoff, ET, soil moisture and temperature at 1/8th degree resolution across the CSCAP domain. What should we do with them?



SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

USDA
United States Department of Agriculture
National Institute of Food and Agriculture