Long-Term Hydrologic Impacts of Controlled Drainage Using DRAINMOD

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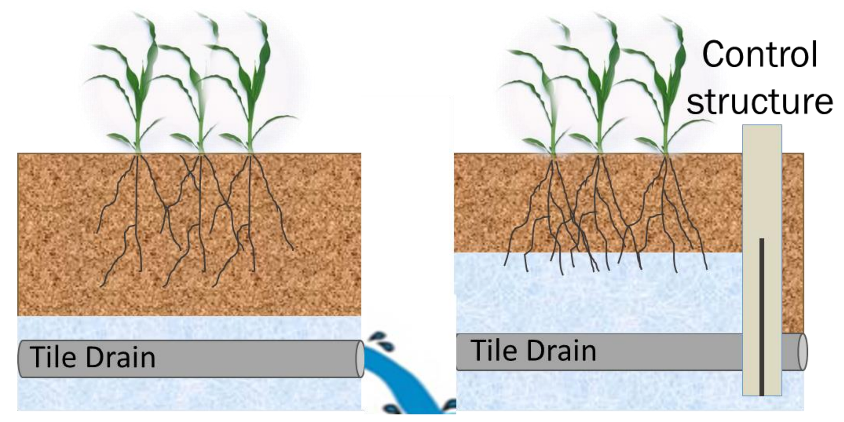
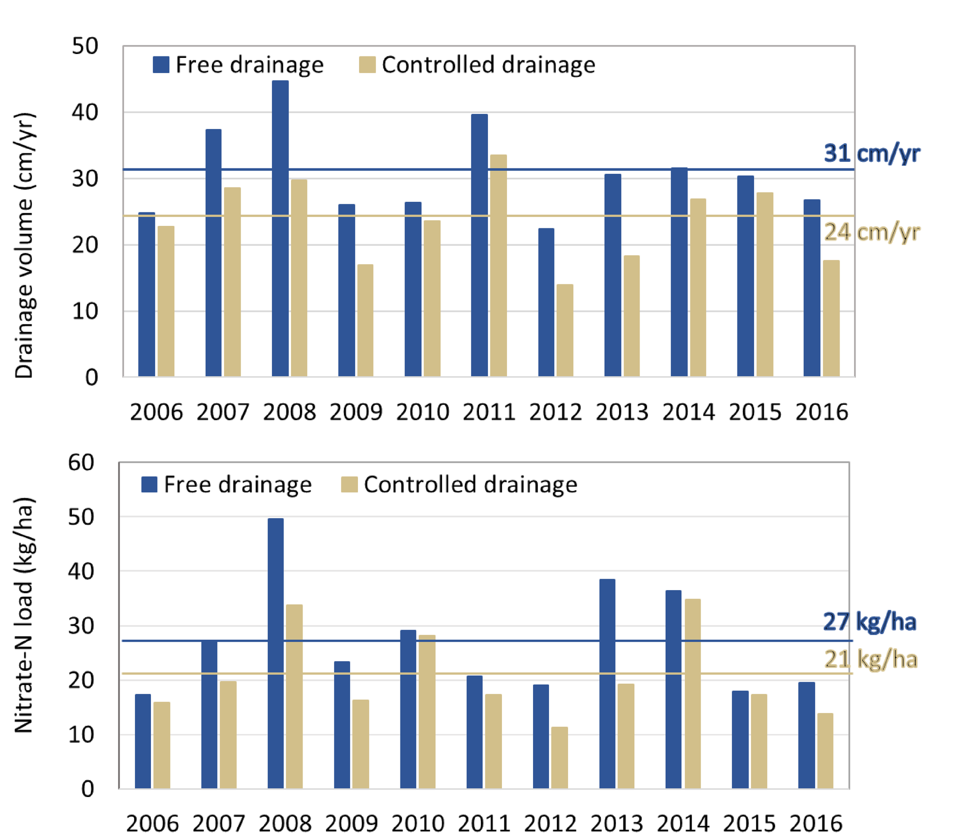
Introduction

Controlled drainage (CD) is an approach that manages the agricultural drainage system with an outlet installed at the drain in order to reduce the drainage volume and thus nutrient load to water bodies.



CD has potential as a climate change adaptation strategy because it increases water storage in the root zone, yet it may also increase surface runoff and soil erosion.

The goal of the study is to increase understanding of the environmental and hydrological effects of CD over a broader temporal and spatial scale than is possible using field-scale data, in order to develop recommendations for its use.



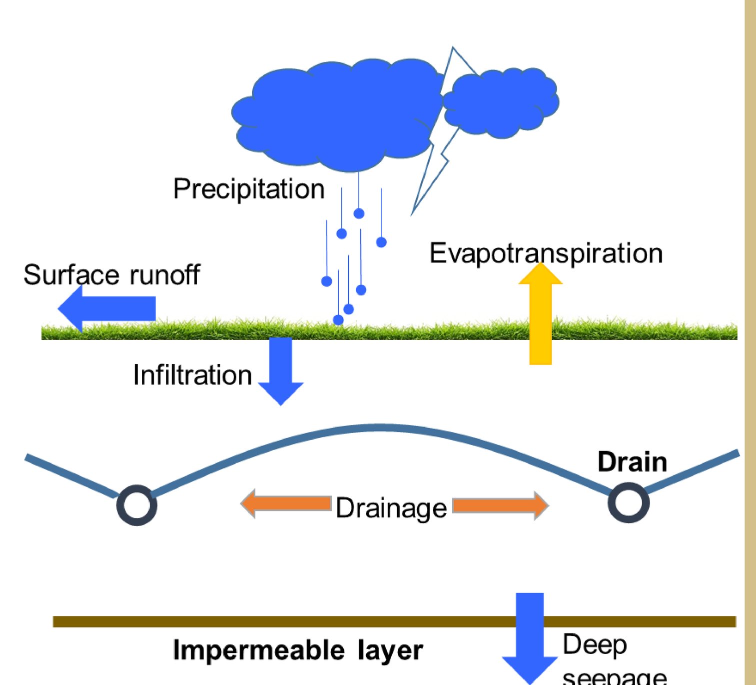
CD impacts on drainage volume and nitrate load from field measurements.

- Based on our field measurements, we know that in CD field, annual drainage was 25% and annual nitrate load was 26% lower.
- But what we don't know are the unintended consequences to **surface runoff** that is not measured in our field.

Model description

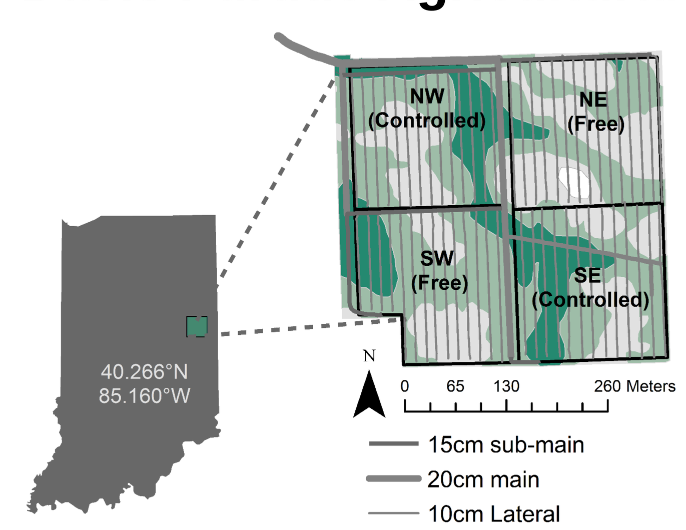
DRAINMOD is a field-scale, process-based hydrologic model which simulates the performance of agricultural drainage and related water management systems (1).

We parameterized the model for a drained field in Indiana to predict subsurface drain flow and surface runoff at this research site and to use the model for evaluating hydrologic impacts of CD.



Study location & field data

Davis Purdue Agricultural center



Hourly precipitation, wind speed, and max and min daily air temperature are recorded in the field.

Flowmeter takes drain flow measurements every hour.

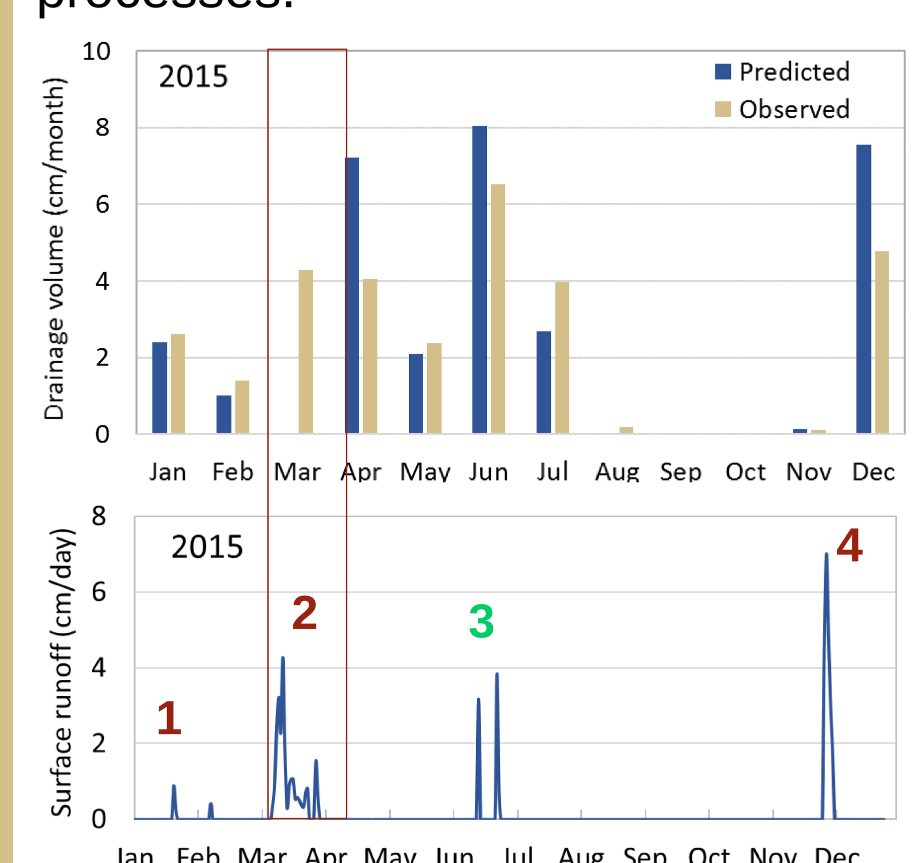
- Soil physical parameters were measured in the field.
- Lateral hydraulic conductivity was estimated using the Hooghoudt equation and the measured drain flow and water table depths (2).
- Daily potential evapotranspirations were calculated with the Penman-Monteith method using the VIC model.

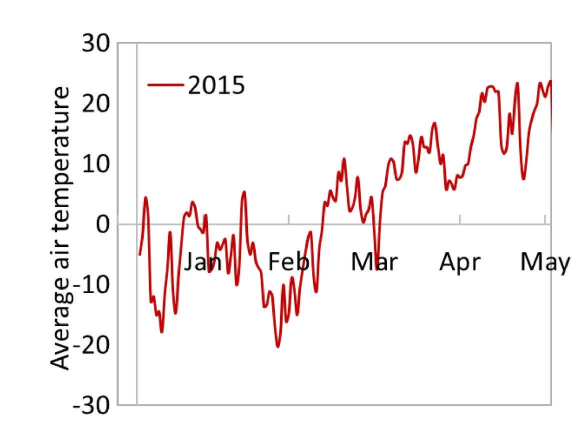
Initial model evaluation

The model is being calibrated and validated by comparing model predictions of drain flow with field observations from 2012 to 2016.

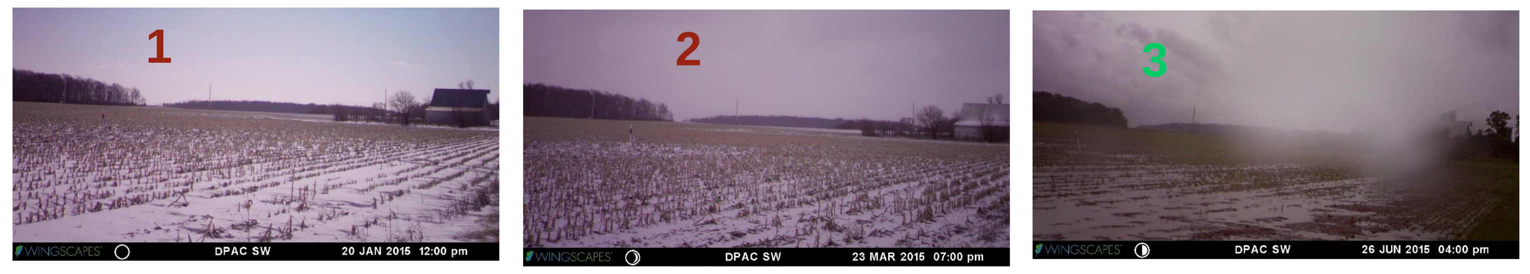
The Nash-Sutcliffe efficiency achieved so far is 0.44 for the calibration and 0.18 for the validation periods.

Surface runoff is largely happening during the non-growing season (winter), so soil ice content and snow melt are important processes.





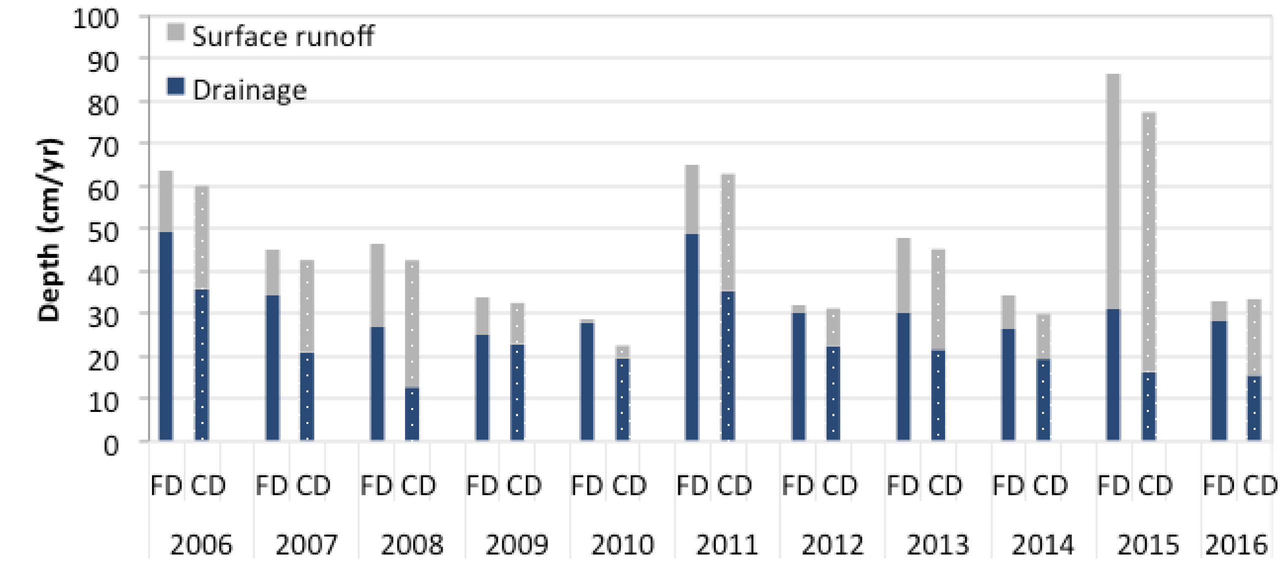
Cameras installed in the field took photos every hour for over 2 years.



Controlled drainage impact

The initially calibrated model was used for evaluating the impact of CD on subsurface drainage and surface runoff.

CD strategy:
From Nov to late Mar the outlet was set at 10 cm depth (non-growing season) and from late May to mid Aug (growing season) the outlet was set at 50 cm depth.



CD impacts on drainage volume and surface runoff from model predictions.

Controlled drainage (CD) on average:

- Decreased the annual subsurface drainage by 32% (10 cm/yr).
- Increased the annual surface runoff by 105% (7 cm/yr).
- Decreased the overall water loss through subsurface drainage and surface runoff by 7% (3 cm/yr).

Conclusions & future work

- 32% predicted reduction in drainage volume with CD was similar to the 25% reduction found from field measurements.
- Predicted results showed that CD increased surface runoff generally during the non-growing season.
- Simulated surface runoff is sensitive to soil freezing conditions; future climate projections may result in either increases or decreases in soil frost and surface runoff generation, depending on changes in snow accumulation.
- **Future work** will calibrate the model for soil freeze/thaw conditions based on the soil temperature measurements.
- Will also evaluate predictions of water table, observed ponding (using photos) and snow depth in addition to the drain flow.

Contact information

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References:
(1) Skaggs, R. W., 1978. A water management model for shallow water table soils. North Carolina. University. Water Resources Research Institute. Report (USA). no. 134.
(2) Saadat, S., L. Bowling, J. Frankenberger, E. Kladivko, 2018. Estimating drain flow from measured water table depth in layered soils under free and controlled drainage. J. Hydrology 556: 339-348.

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