Understanding prediction robustness of the Root Zone Water Quality Model (RZWQM)

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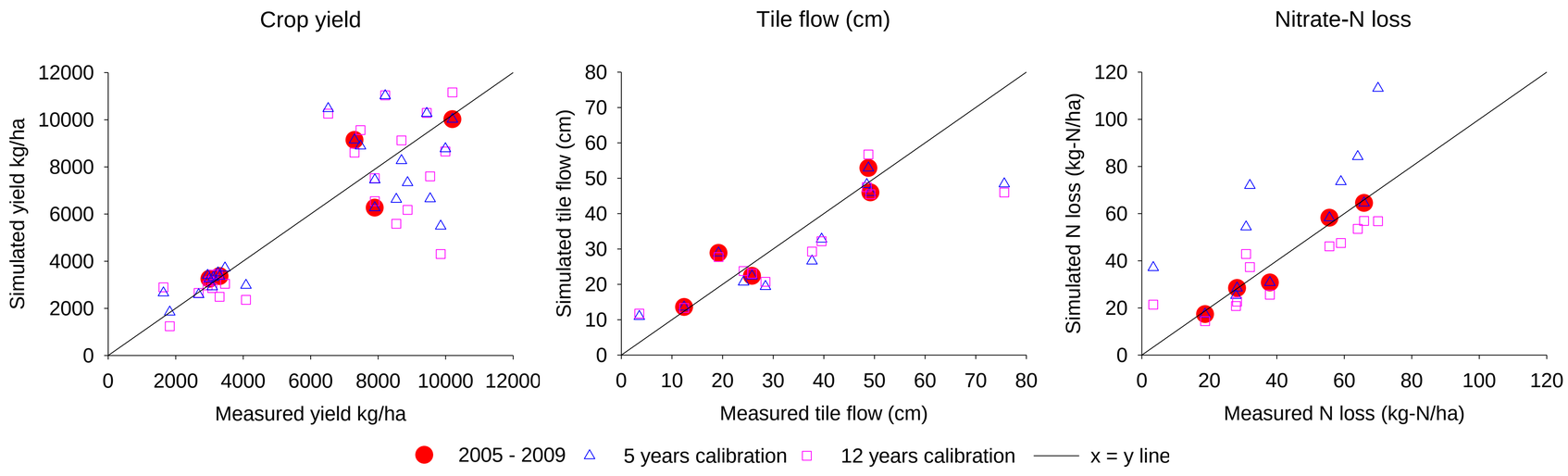
Introduction

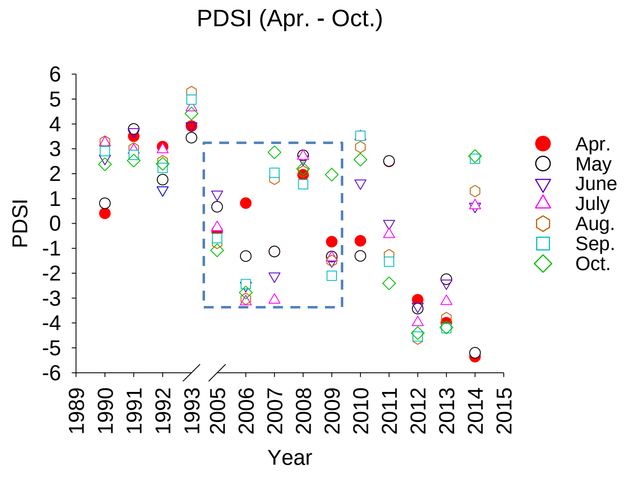
The RZWQM model is often used to make predictions of environmental behaviors such as hydrologic and chemical response, translating research to other locations and climates. Typically, a well calibrated model is believed to be able to produce reasonably good predictions under other conditions. Unfortunately, this assumption is false, as we have shown for prediction of nitrate loss from a tile-drained, corn-soybean experiment in Northern Iowa. Using experimental data over 12 years, we investigated the robustness of RZWQM predictions of crop yield, subsurface drainage flow, and nitrate-N loss for multiple model calibrations using the PEST parameter estimation software. Post-processing analyses provided insights into parameter-observation relationships. We found that prediction robustness of RZWQM model was related to the range of soil moisture conditions represented in the calibration data. We also tested the use of the Palmer Drought Severity Index (PDSI) as an indicator of the information content of calibration data related to soil moisture. We show that data representing a particular range of PDSI allow a calibration able to predict performance in years exhibiting a similar range of PDSI. For example, we show that adding to a five year calibration set a single year identified by examining the PDSI, improves the Nash-Sutcliffe model efficiency coefficient (NSE) from -0.18 to 0.7, and achieves nearly all of the improvement possible when all available observation are included in calibration. Our work shows how field observations under more variable soil moisture conditions constrain the RZWQM parameters and suggests one way of evaluating the predictive power of a calibration.

Preliminary Results

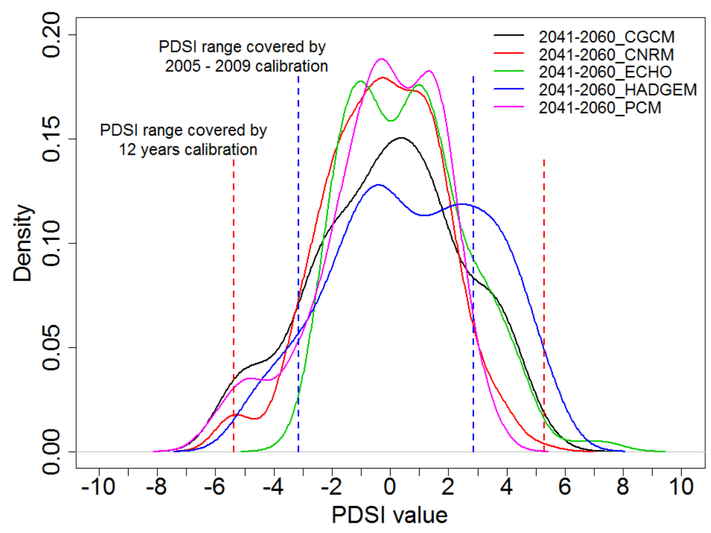
RZWQM Modeling



Soil moisture measure: PSDI

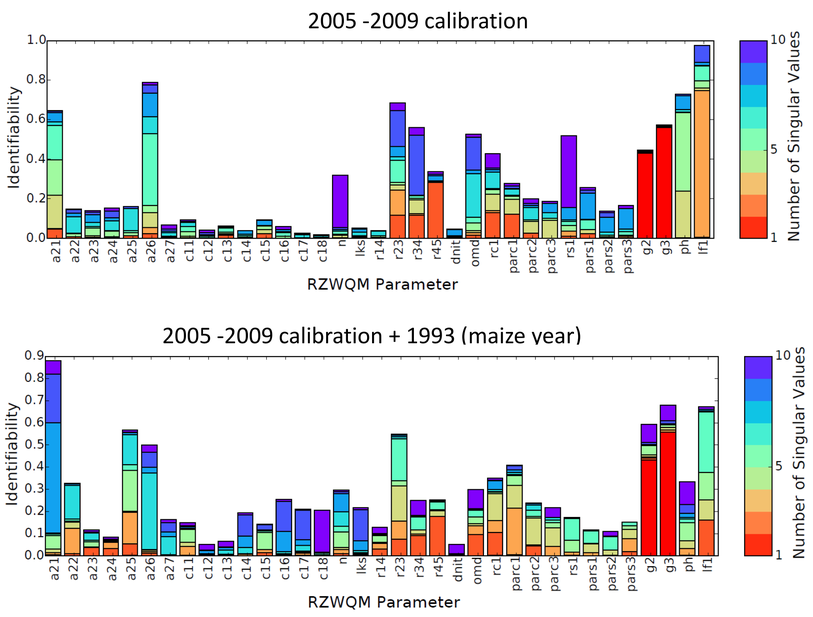


Monthly PDSI values of the 12 observation years



Probability density distribution of PDSI value for different climate scenarios

Identifiability of RZWQM parameters



Observed and RZWQM simulated crop yield, annual subsurface drainage and nitrate-N loss

	Main crop yield (kg/ha)				
		5-year calibration		12-year calibration	
	Obs	Sim	PD	Sim	PD
Corn average	8506	8553	1%	8625	1%
Soybean average	3406	3506	3%	3265	-4%

	Tile flow amount (cm)			Tile flow amount (cm)		
		5-year calibration	12-year calibration		5-year calibration	12-year calibration
Statistic	Obs	Sim	Sim	Obs	Sim	Sim
Average	34.4	30.9	29.9	41.1	54.9	37.2
NSE		0.72	0.69		-0.18	0.73
RRMSE		0.29	0.30		0.54	0.26

Notes: Obs = observed value, Sim = simulated value with RZWQM, PD = percent difference. RRMSE = relative root mean square error. NSE = Nash Sutcliffe model efficiency.

Conclusions

- This work demonstrates the use of Palmer Drought Severity Index (PDSI) as an indicator of the soil moisture related information contained in calibration and its use in evaluating the suitability of calibration data for making predictions about other climate conditions.
- Prediction robustness of a calibration is related to the range of soil moisture condition contained in the calibration data. Predictive uncertainty is only reduced when the information content of the calibration dataset is able to constrain the model parameters relevant to the processes controlling the desired prediction.
- This work provides insights into parameter-observation relationships and suggests one way of evaluating the predictive power of a calibration.

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