Success and challenges met during the calibration of APEX on large plots

APEX modeling of spatial and temporal flow and productivity response to management

C. Baffaut, F. Ghidey, A. Senaviratne, N. Kitchen, K. Sudduth, and R. Lerch

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USDA ars Agricultural Research Service

the in-house research arm of the U.S. Department of Agriculture

Banda Aceh, 2004 tsunami

Study site

- 30 plots 18 m x 190 m
- 4 cropping systems established in 1991
  - Corn – soybean tilled
  - Corn – soybean no till
  - Corn – soybean – wheat with a cover crop
  - Hay and perennial grasses
- Monitoring of flow and water quality from 1996 to 2002

Objectives

- Parameterize APEX to simulate crop yields, runoff, atrazine loss and nutrients loss from replicated large plots
- Evaluate the ability of the model to simulate extreme years in terms of productivity.
- Identify the challenges that we face when evaluating impacts of climate changes.

Outline

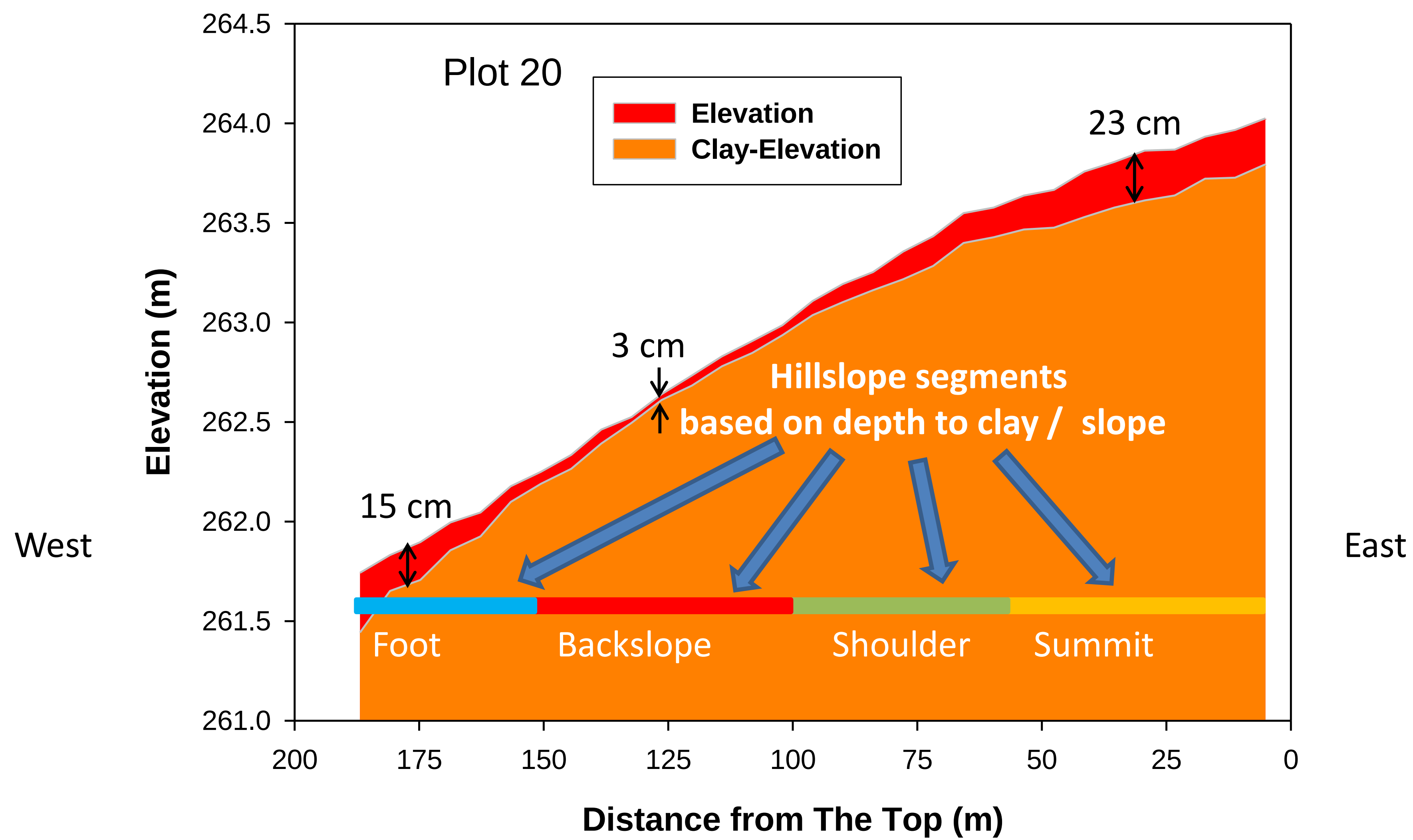
Discretization and available data

Parameterization and Calibration

- Soil properties
- Management
- Calibration

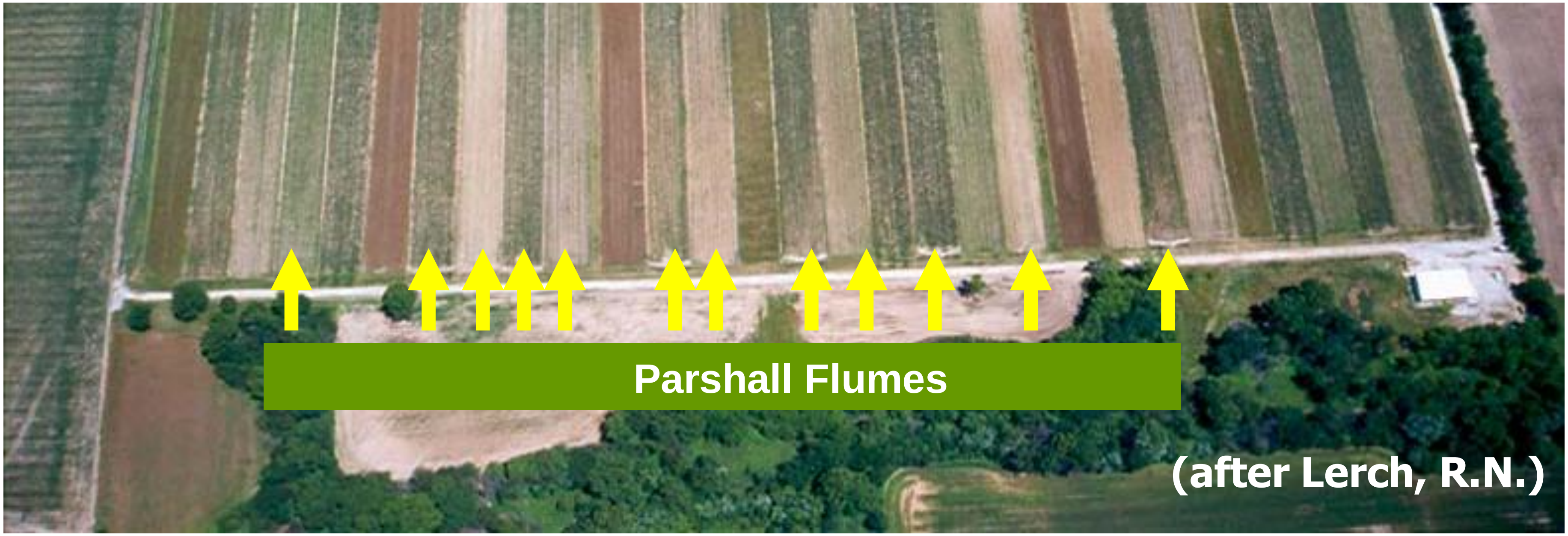
Results

Discretization



Available data

- Crop yields: 1992-2009 by plot and landscape position
- Flow and water quality: 1997-2002 during the corn phase of the rotation.



Parameterization: Soils

- Soil characterization conducted in 1991 and 1997 by landscape position
  - Texture
  - Soil profile
  - Physical properties
  - Hydraulic properties
  - Soil Test Phosphorus
  - pH
- Soil characteristics assigned according to location (for example texture) or according to management (hydraulic properties)

Parameterization: Management

- Keeping good records of management over more than 20 years is not easy!
- Some uncertainty in management;
  - Seeding rates (different understanding for different people)
  - Fertilization rates (is that rate the N rate or the product rate?)
- Good for easy years, more difficult for difficult years

Parameterization: Calibration

- Sensitivity analysis of all parameters in the parm file based on model performance
  - for crop yields (1992-2009),
  - for runoff and contaminant transport (1997-2002).
- Manual calibration followed by automated parameter optimization using PAROPT: Stepwise, multi-variable, multi-objective optimization of the Parm file parameters. (Senaviratne et al., JEQ, 2012)

Calibration / Validation

- Calibration on one plot for each cropping system
- Validation on the 3 other plots for each cropping system → provides temporal and spatial validation.
- Only global parameters were adjusted.

Results

Average crop yields

- By crop and management

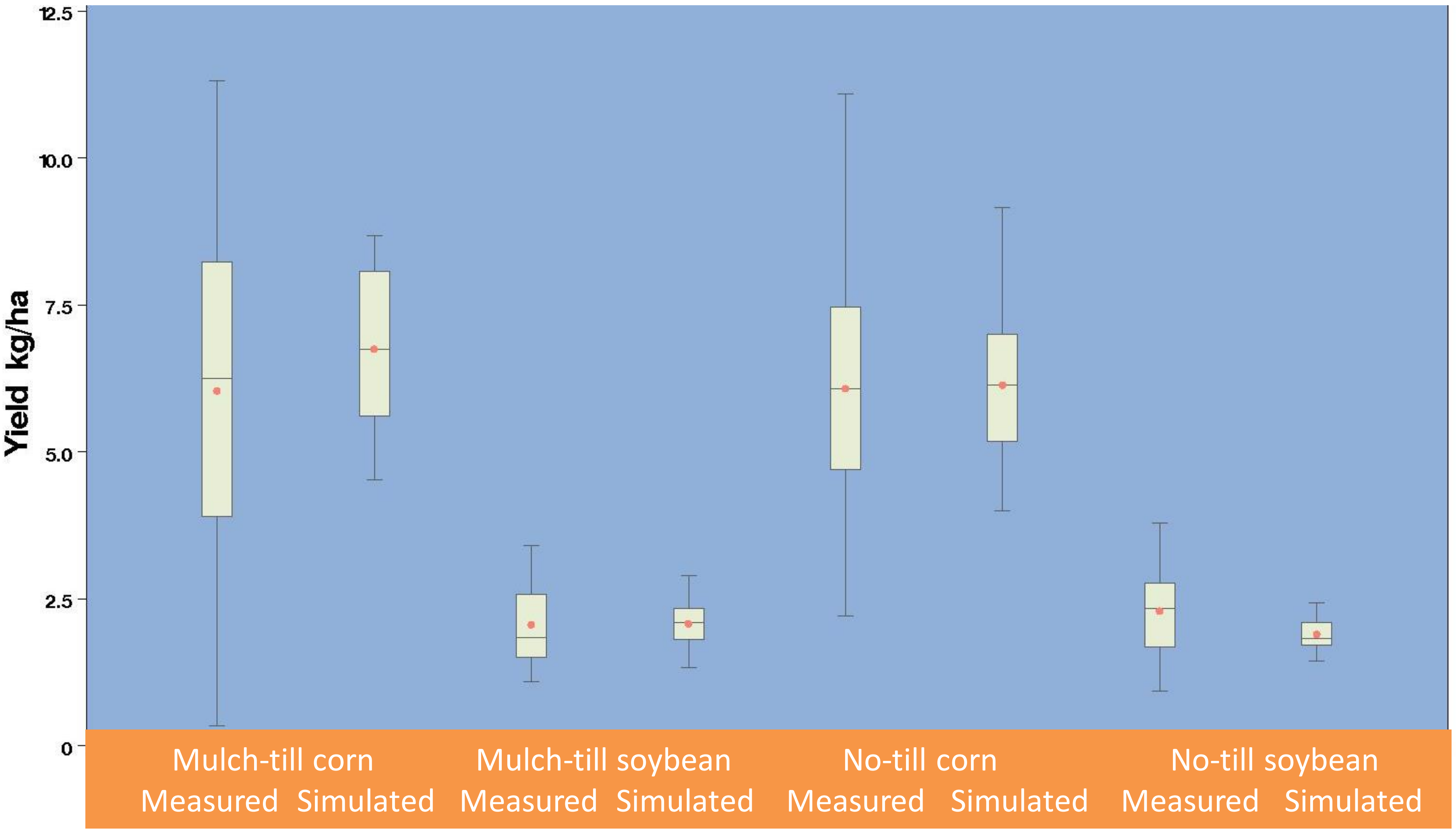
Surface runoff and contaminant transport

- Flow
- Atrazine
- Dissolved nutrients

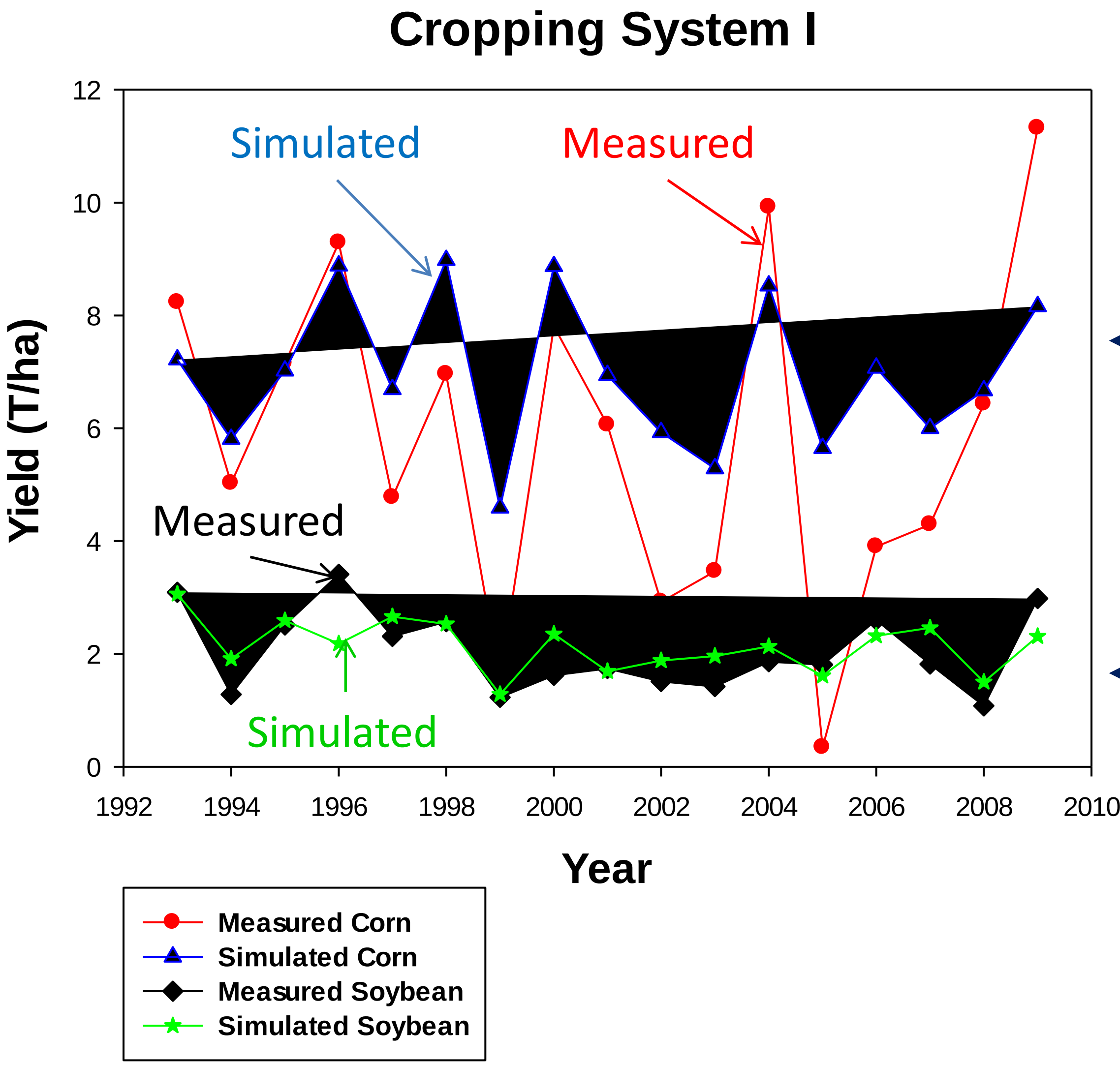
Spatial variability of crop yields

- Effect of landscape position

Average corn and soybean yields



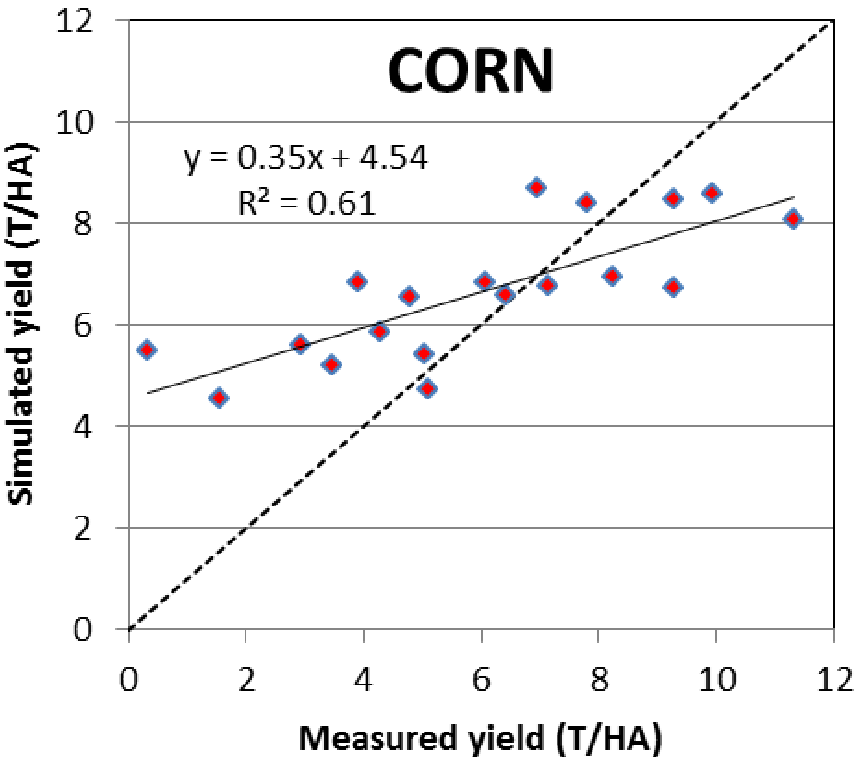
Crop yields: mulch-till corn & soybean

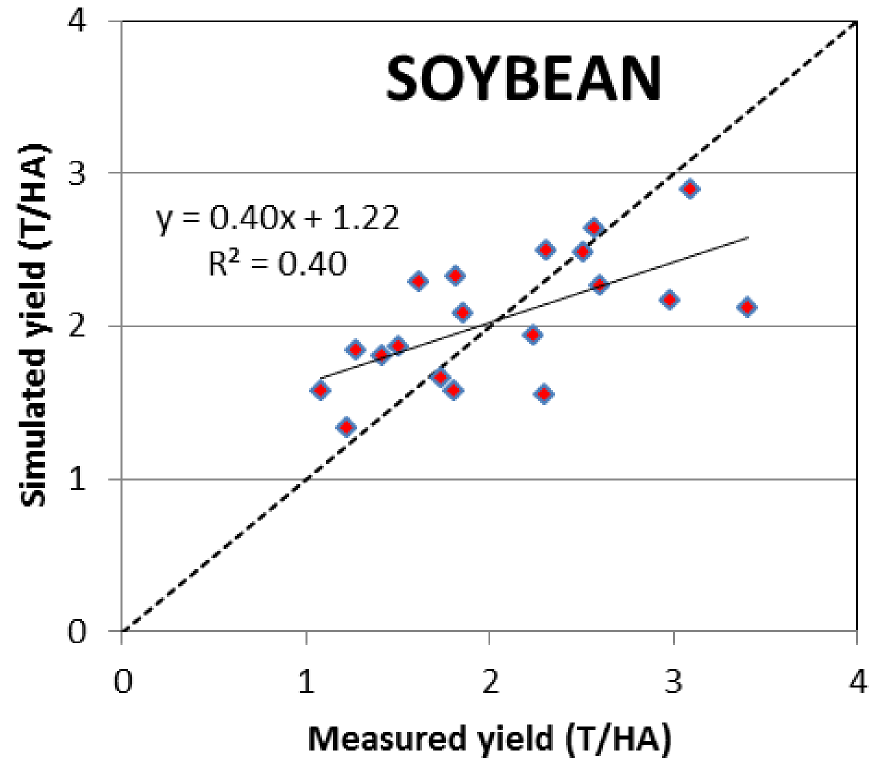


Corn
Pbias = -11%
$r^2 = 0.61$

Soybean
Pbias = 1%
$r^2 = 0.40$

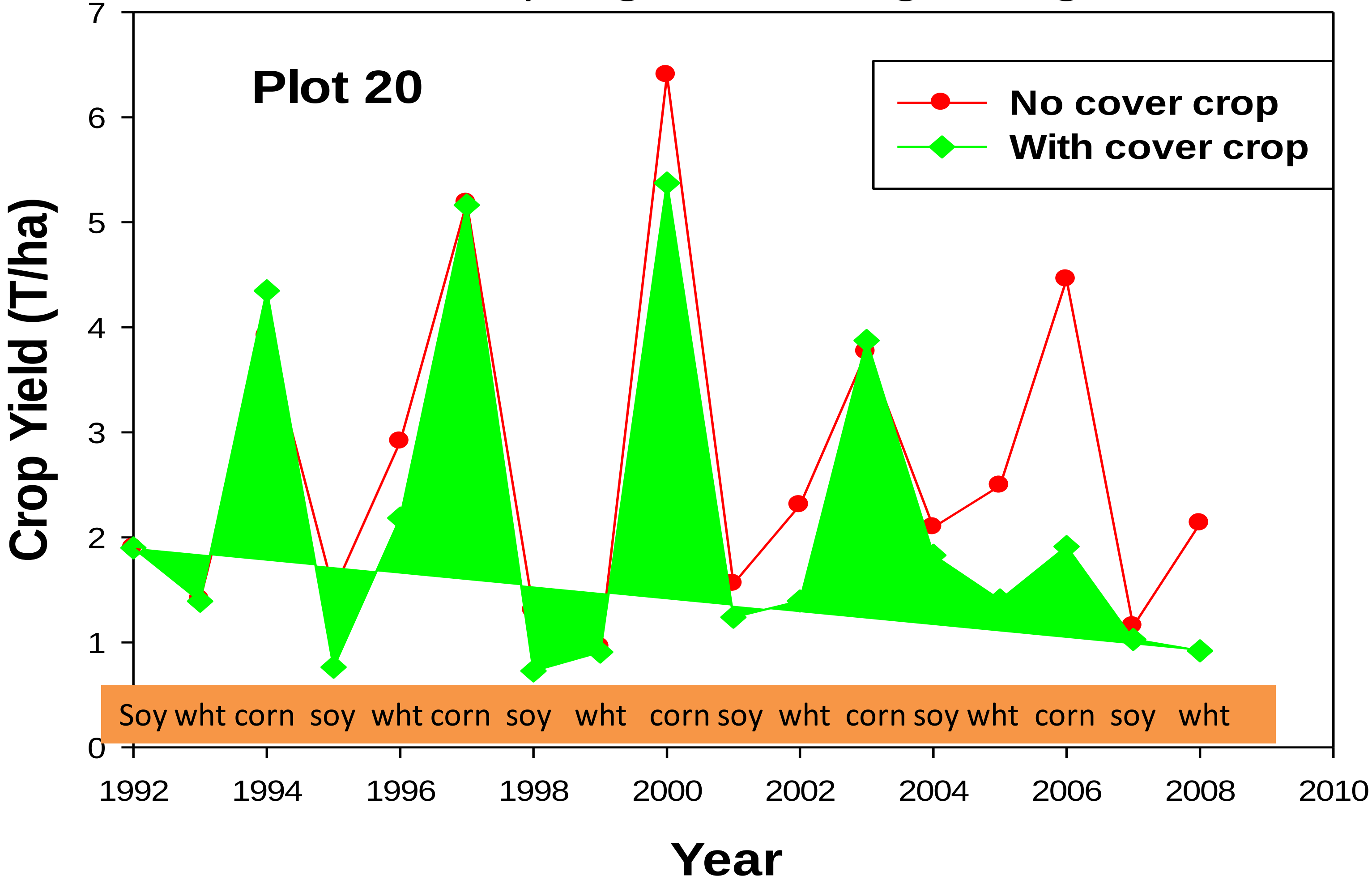
Crop yields: mulch-till corn & soybean





Effect of cover crop

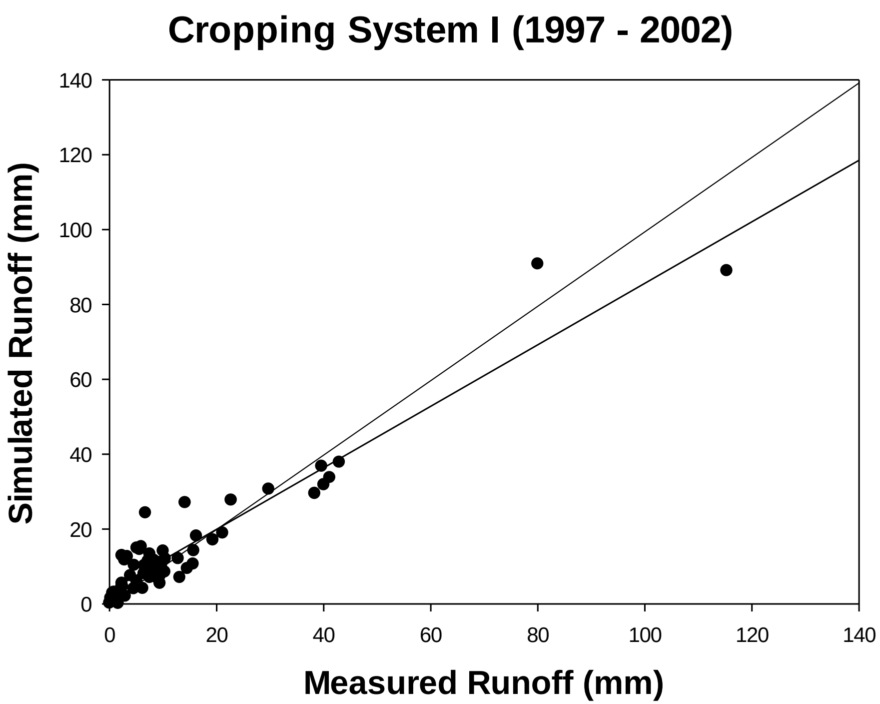
Red clover spring seeded in growing wheat

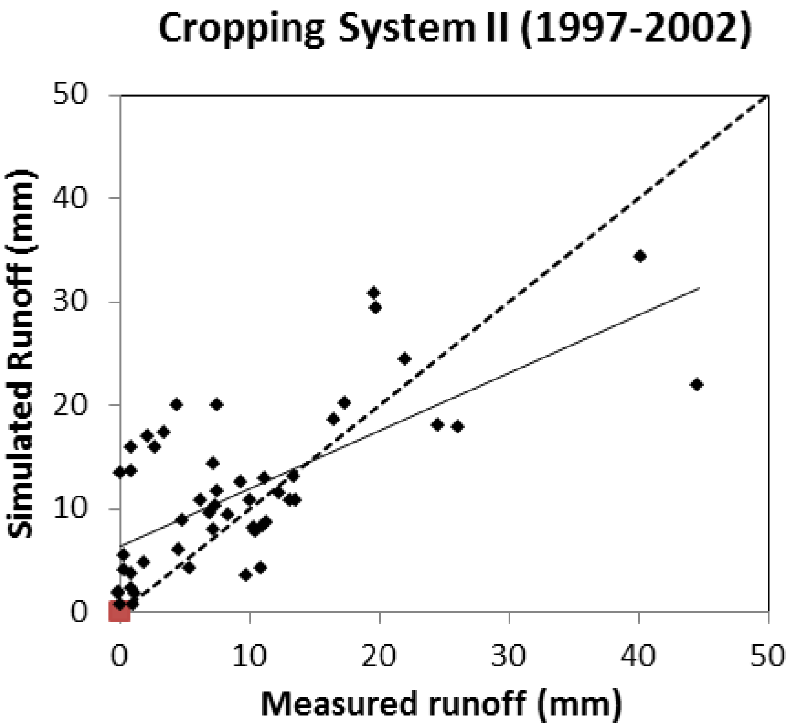


Individual Plot Model Performance

	Runoff				Atrazine			
Cropping System 1	r2	slope	NSC	Pbias	r2	slope	NSC	Pbias
Plot 11 calibration	0.97	0.74	0.91	7.7	0.96	0.91	0.96	4.5
Plot 19	0.81	0.70	0.79	0.8	0.92	1.02	0.90	13.2
Plot 22	0.88	0.73	0.85	6.5	0.96	0.64	0.83	29.7
Plot 23	0.95	0.96	0.94	-14.8	0.70	0.88	0.64	15.7
Cropping System 2								
Plot 18 calibration	0.94	0.91	0.94	-10.3	0.88	0.45	0.58	57.7
Plot 13	0.73	0.64	0.65	-24.8	0.46	0.40	0.38	40.6
Plot 21:	0.96	0.89	0.93	-36.9	0.74	0.91	0.70	5.4
Plot 24	0.50	0.34	0.33	29.1	0.27	0.19	0.02	63.9

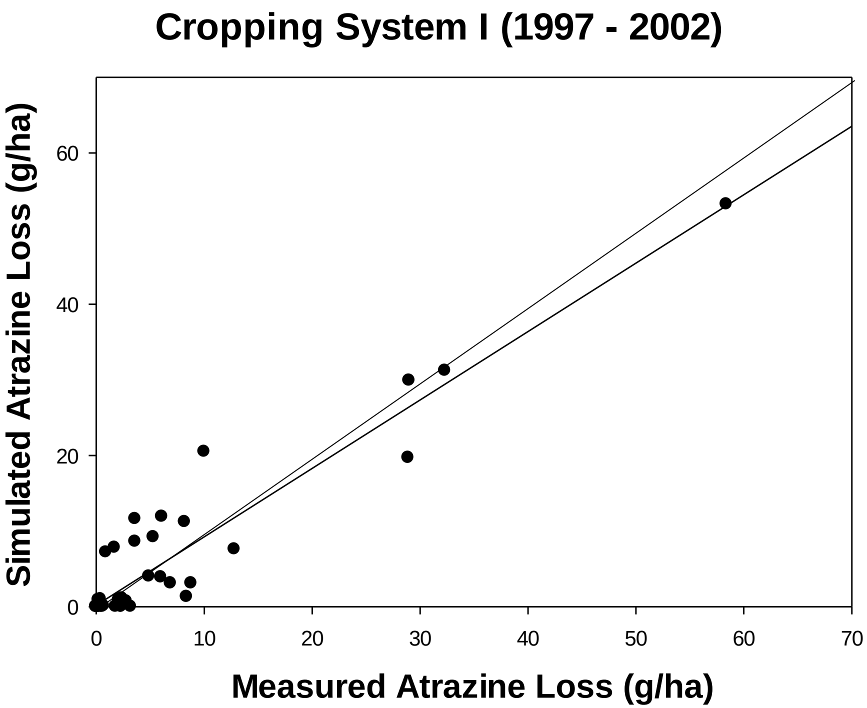
Runoff

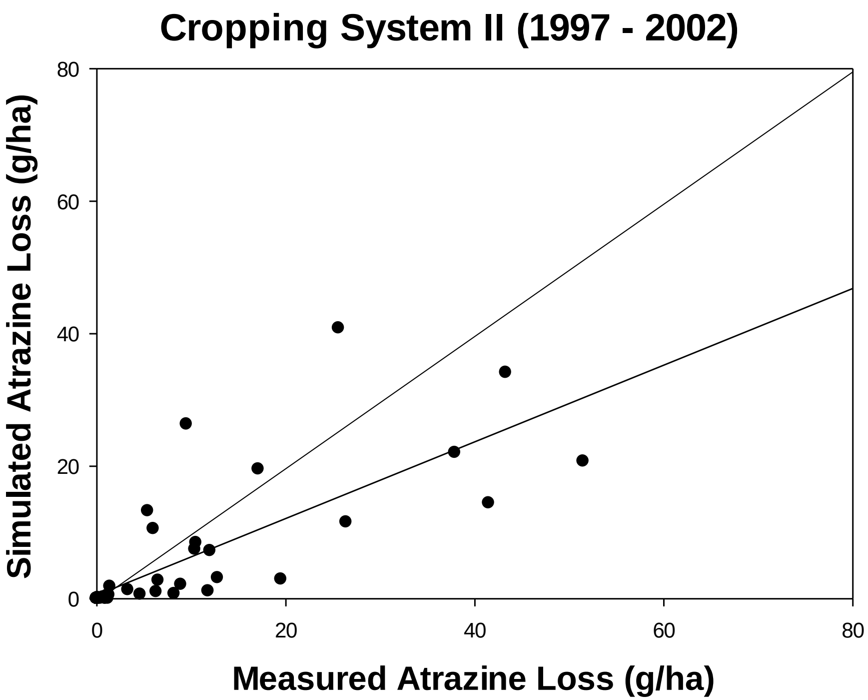




r^2	0.77	0.47
slope	0.75	0.56
br^2	0.57	0.26
NSC	0.75	0.40
Pbias	-12%	-22%

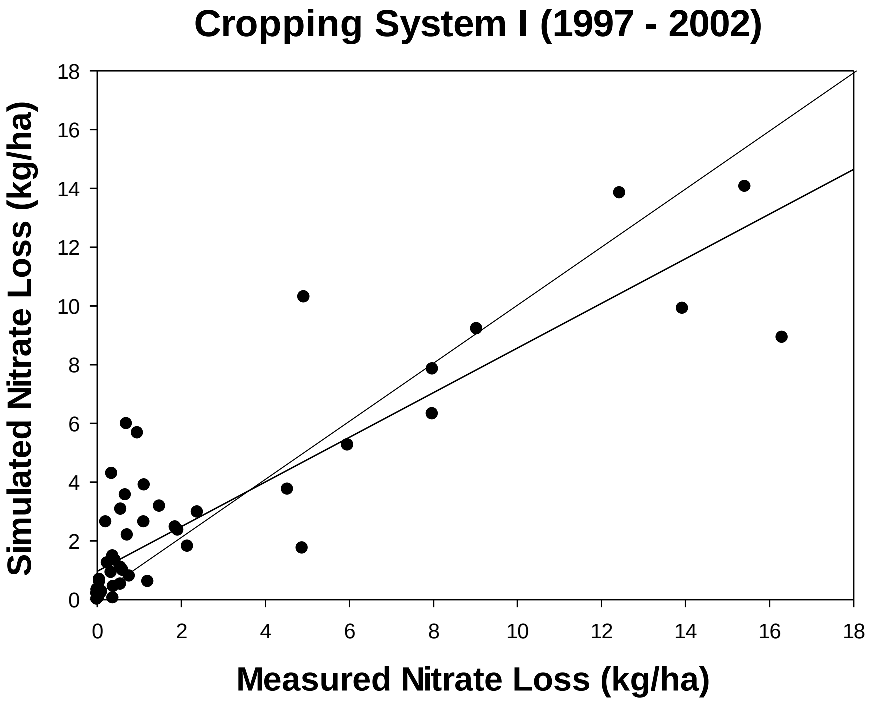
Atrazine

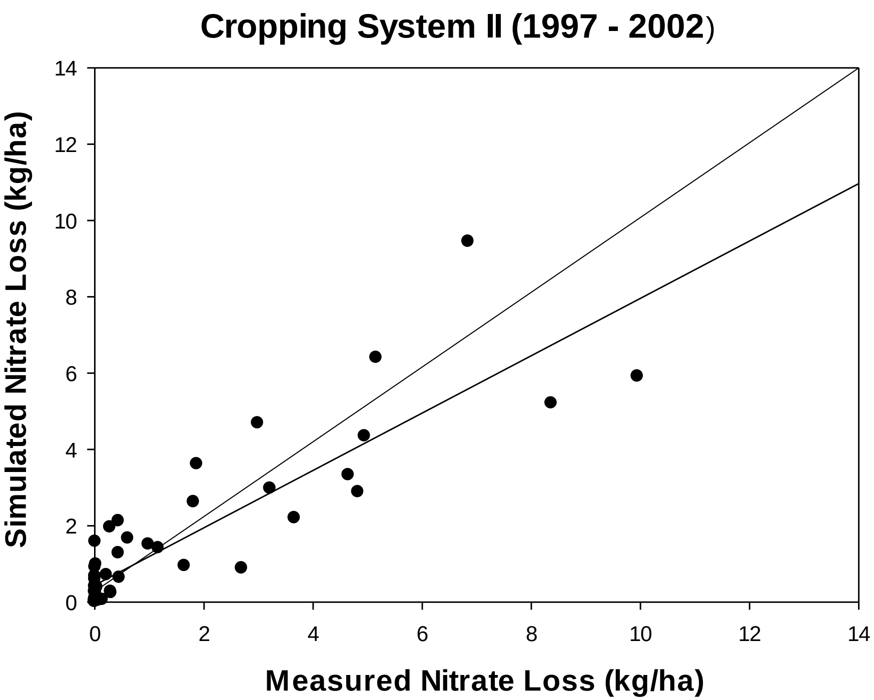




r^2	0.92	0.51
slope	0.92	0.42
br^2	0.85	0.21
NSC	0.92	0.43
Pbias	9%	44%

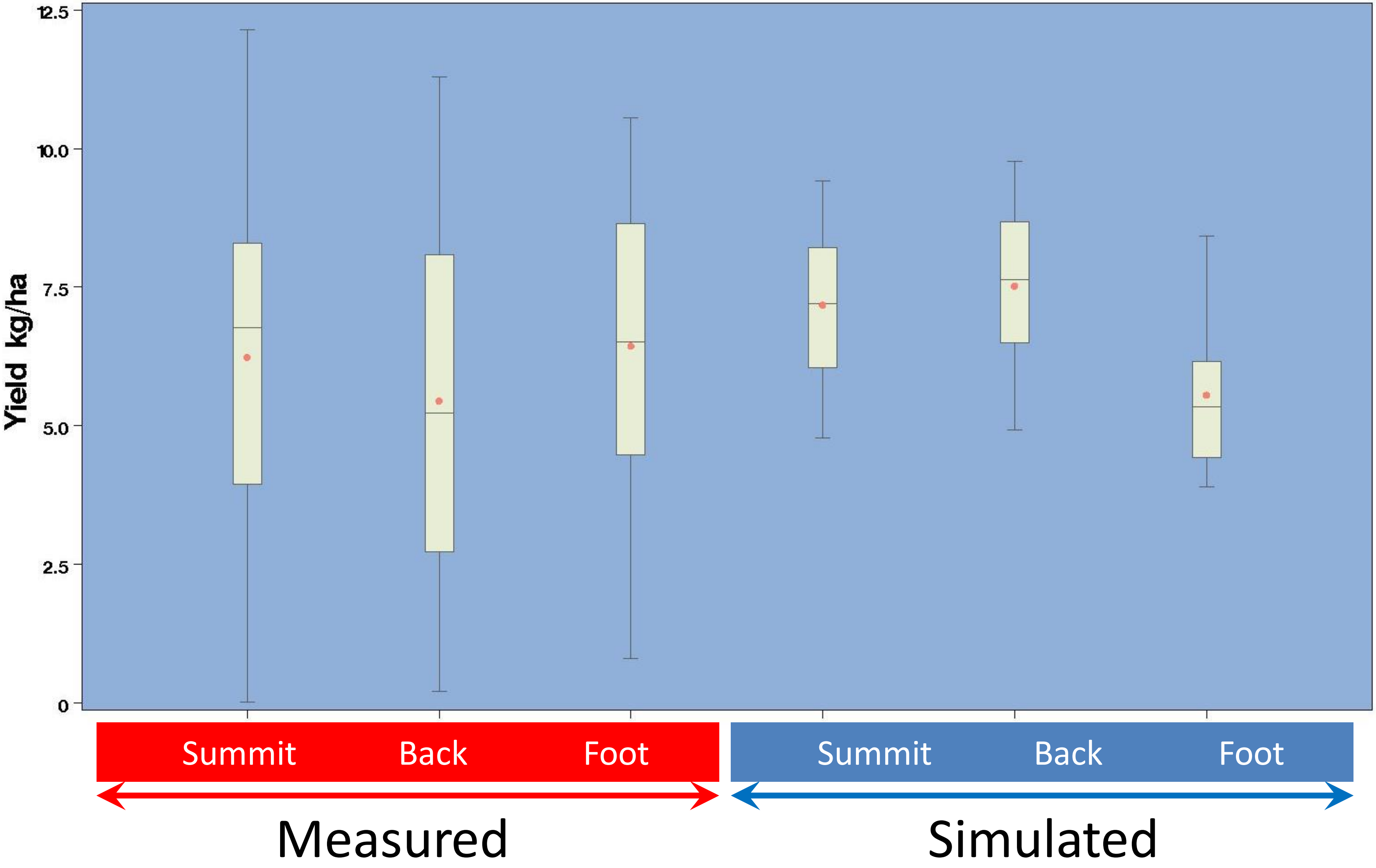
Dissolved Nitrogen





r^2	0.78	0.71
slope	0.77	0.70
br^2	0.60	0.49
NSC	0.76	0.68
Pbias	-23%	-23%

Corn yields spatial variability



Conclusions

- On average, we can simulate the yields and the effects of tillage.
- Challenges with over-seeding a cover crop that provides cover and nitrogen.
- Extreme yields not well reproduced yet.
- Spatial variability not matching observations.