Crop & Soil Module

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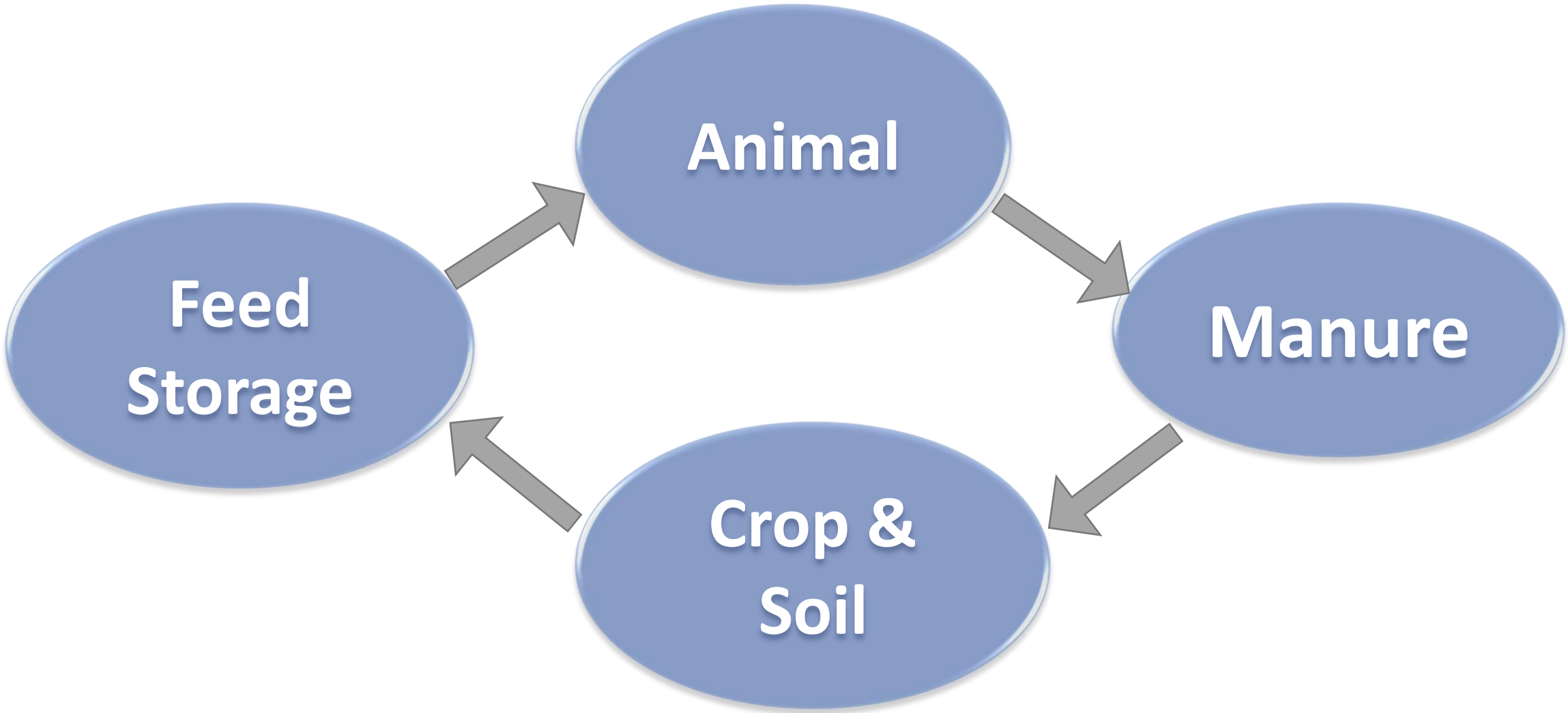
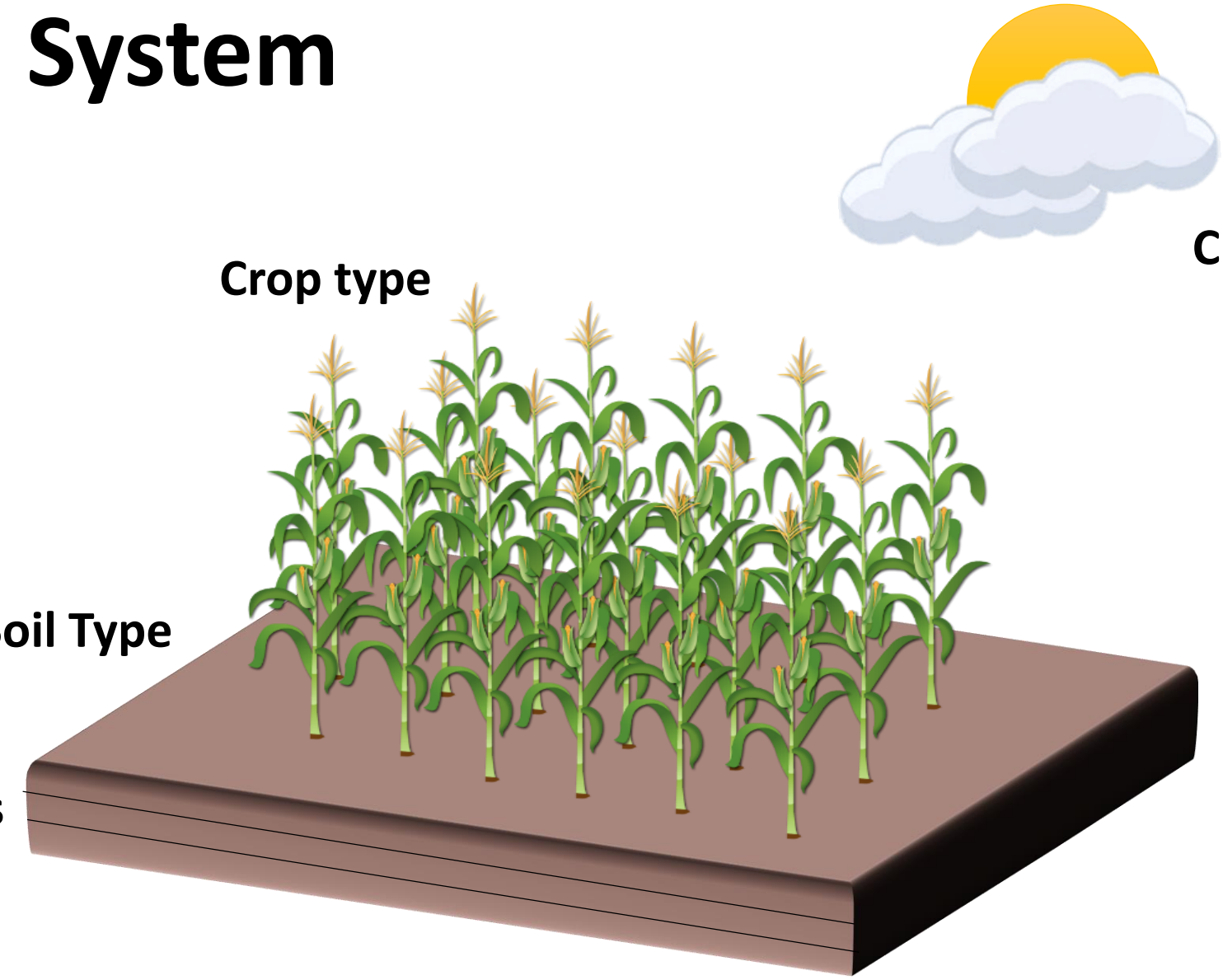
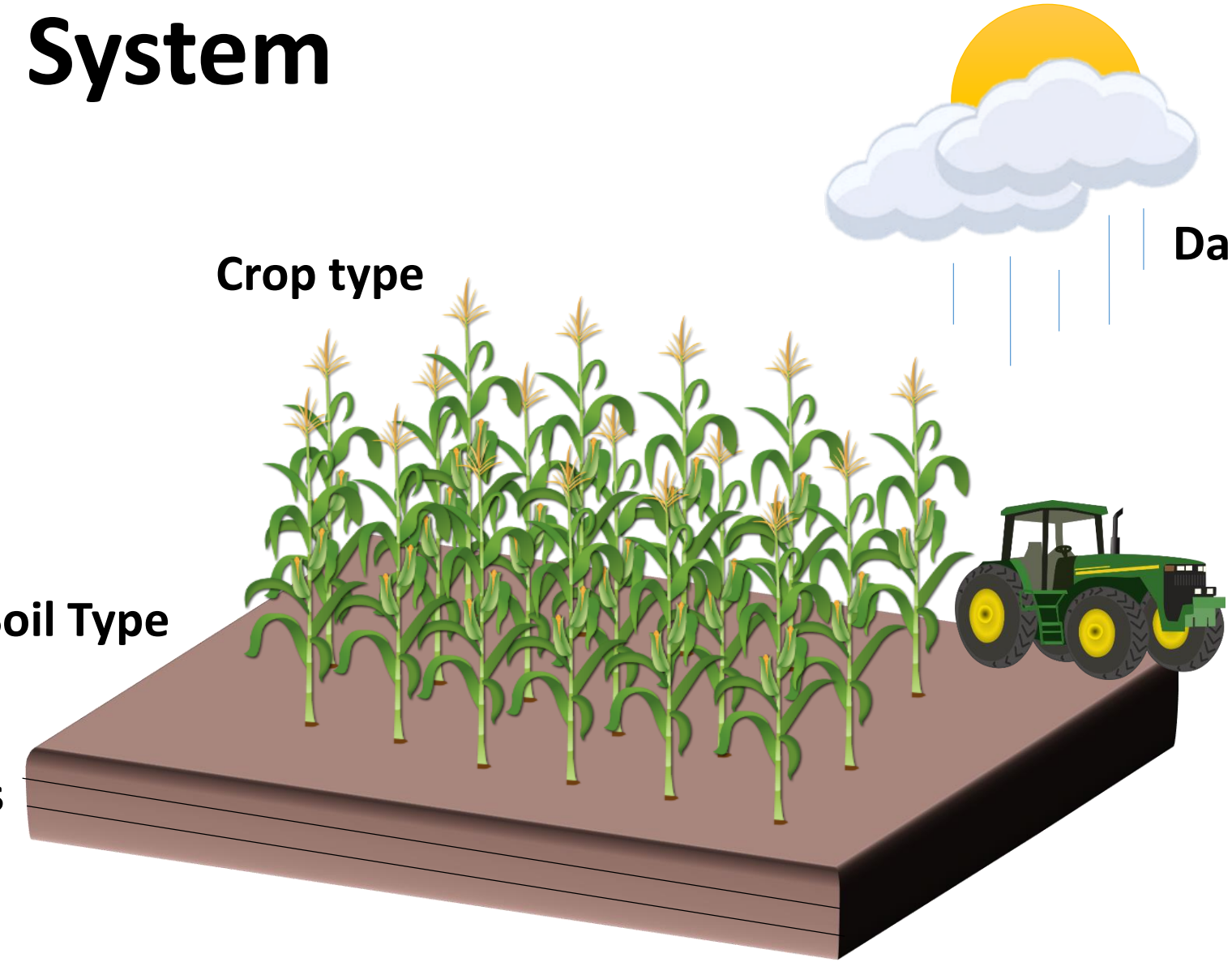
RuFaS General Structure



Crop & Soil System

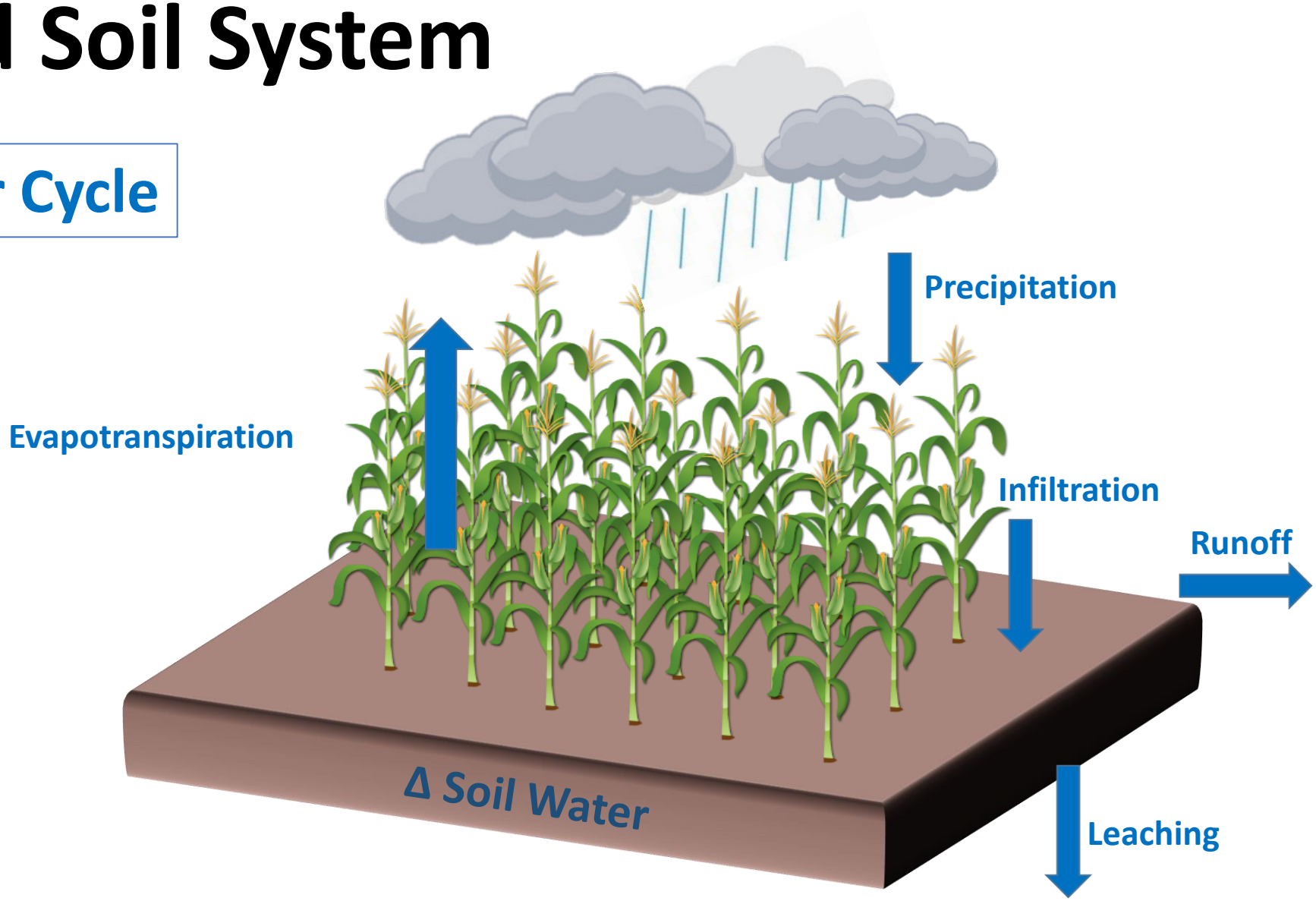


Crop & Soil System



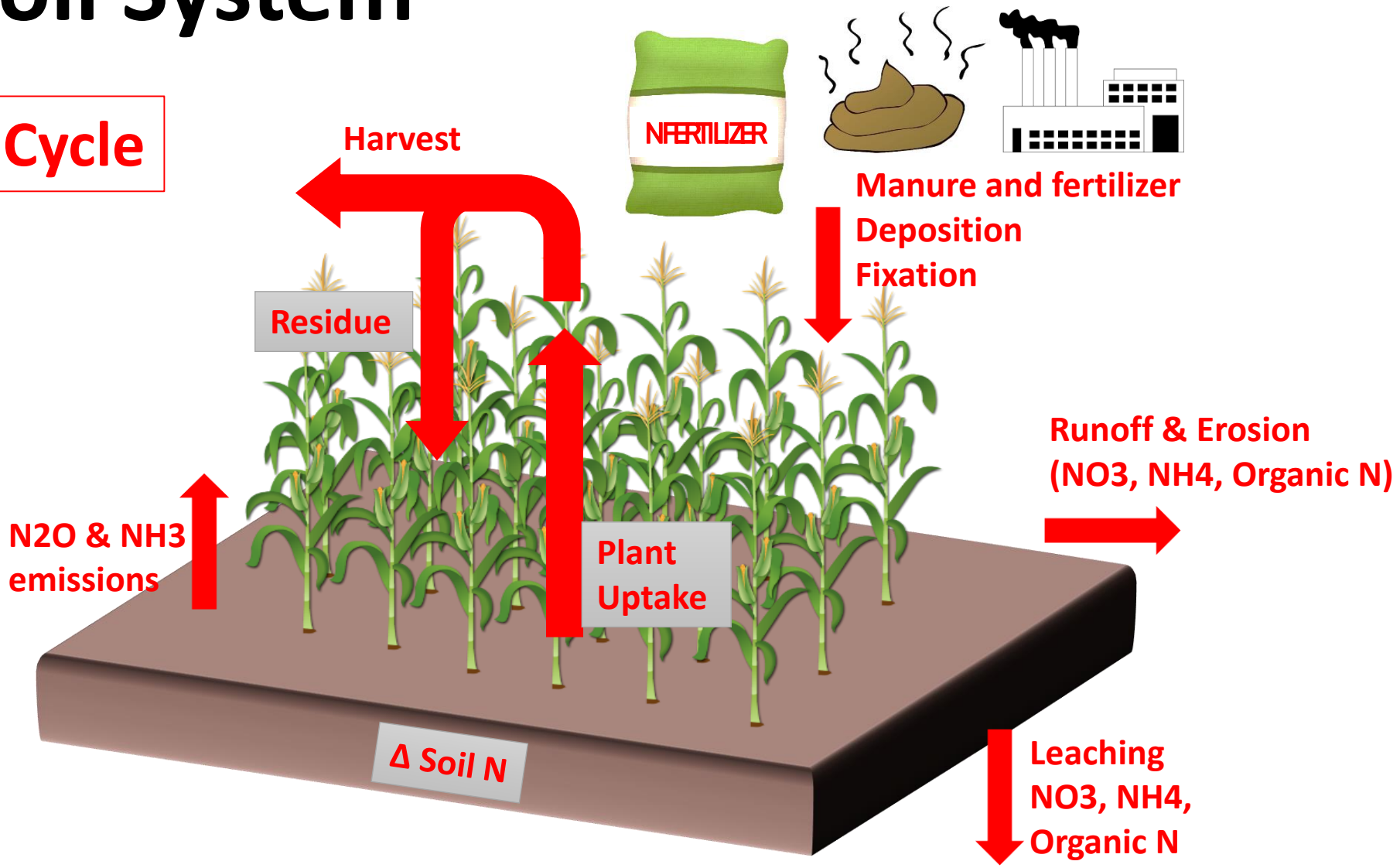
Crop and Soil System

Water Cycle



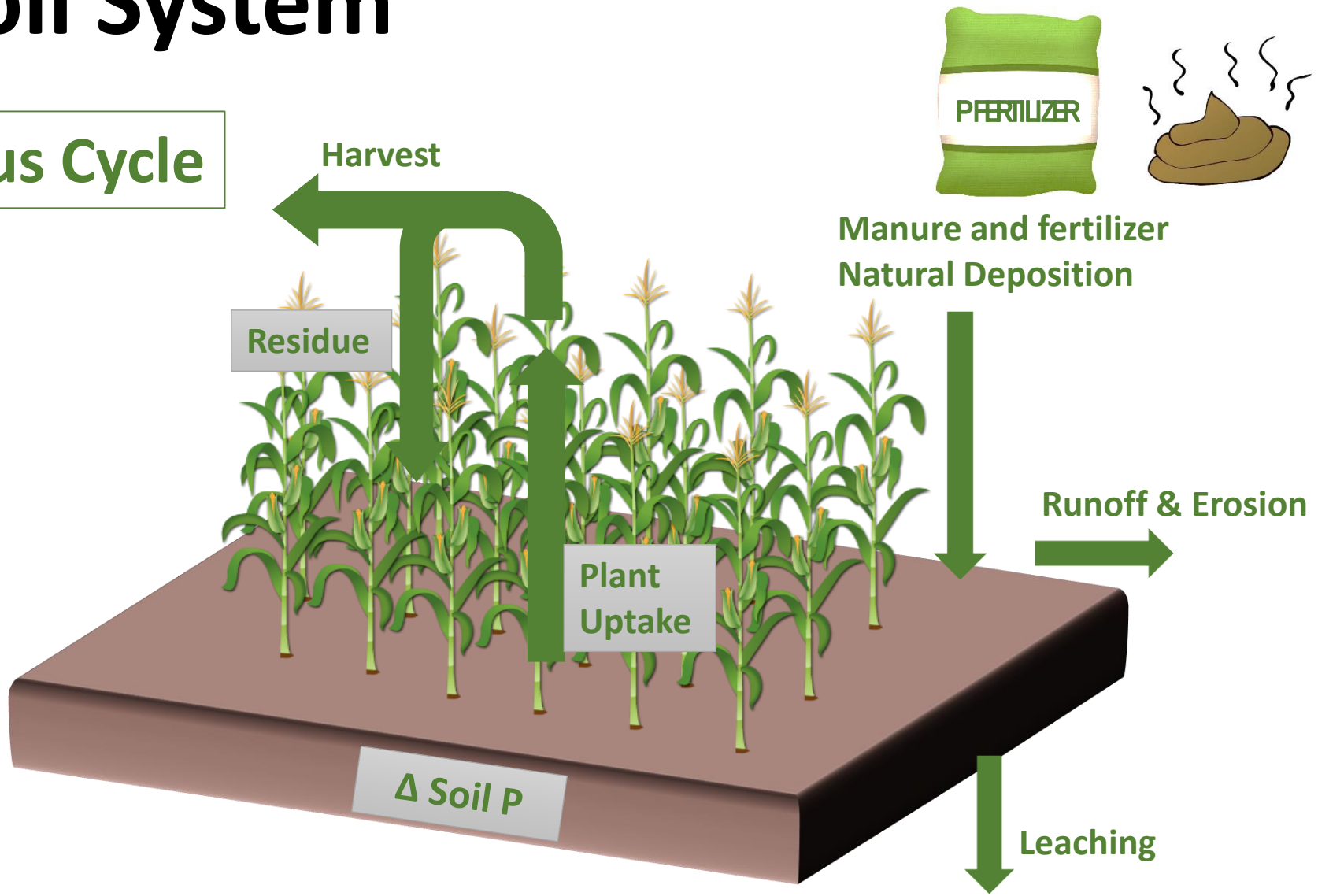
Crop and Soil System

Nitrogen Cycle

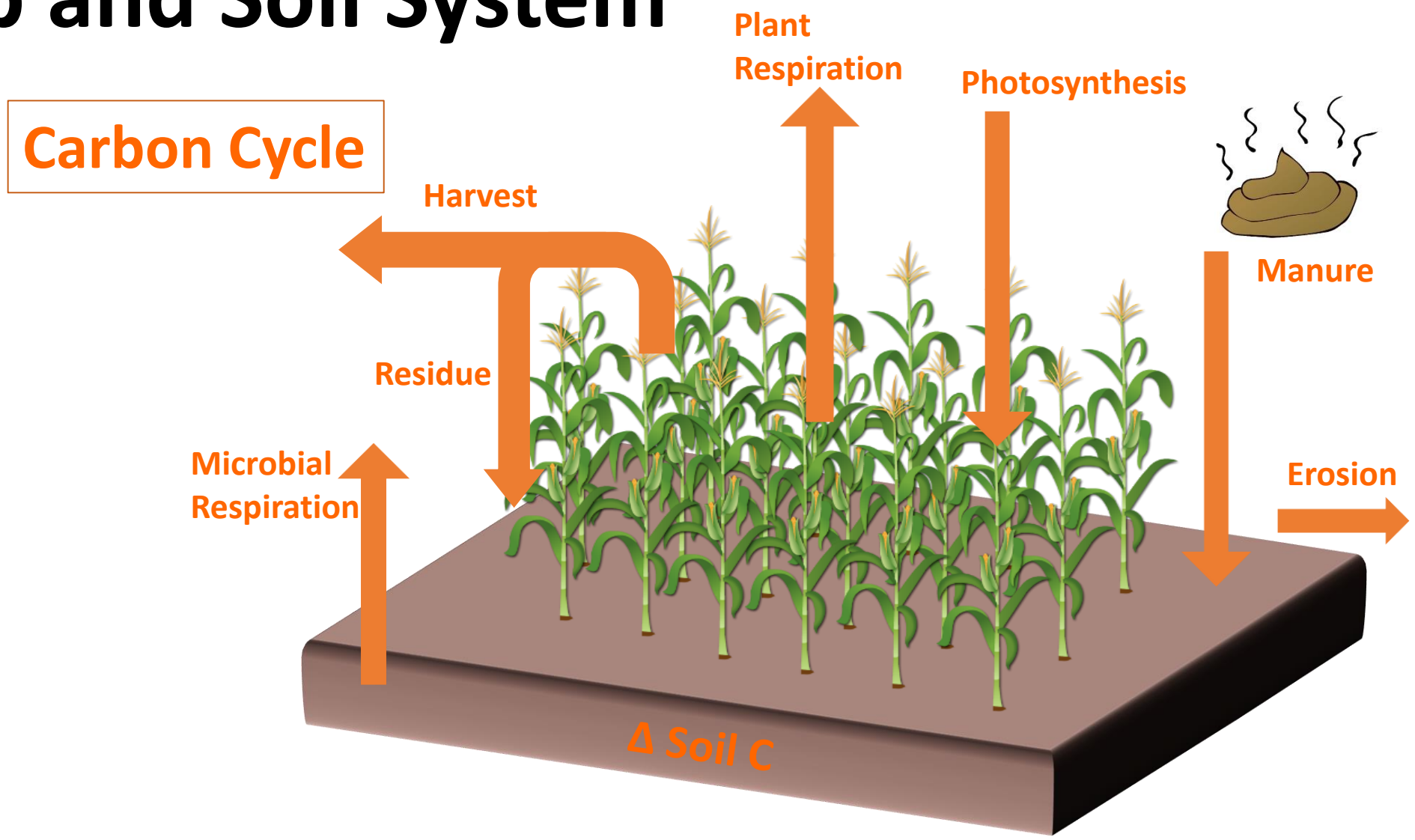


Crop and Soil System

Phosphorus Cycle



Crop and Soil System

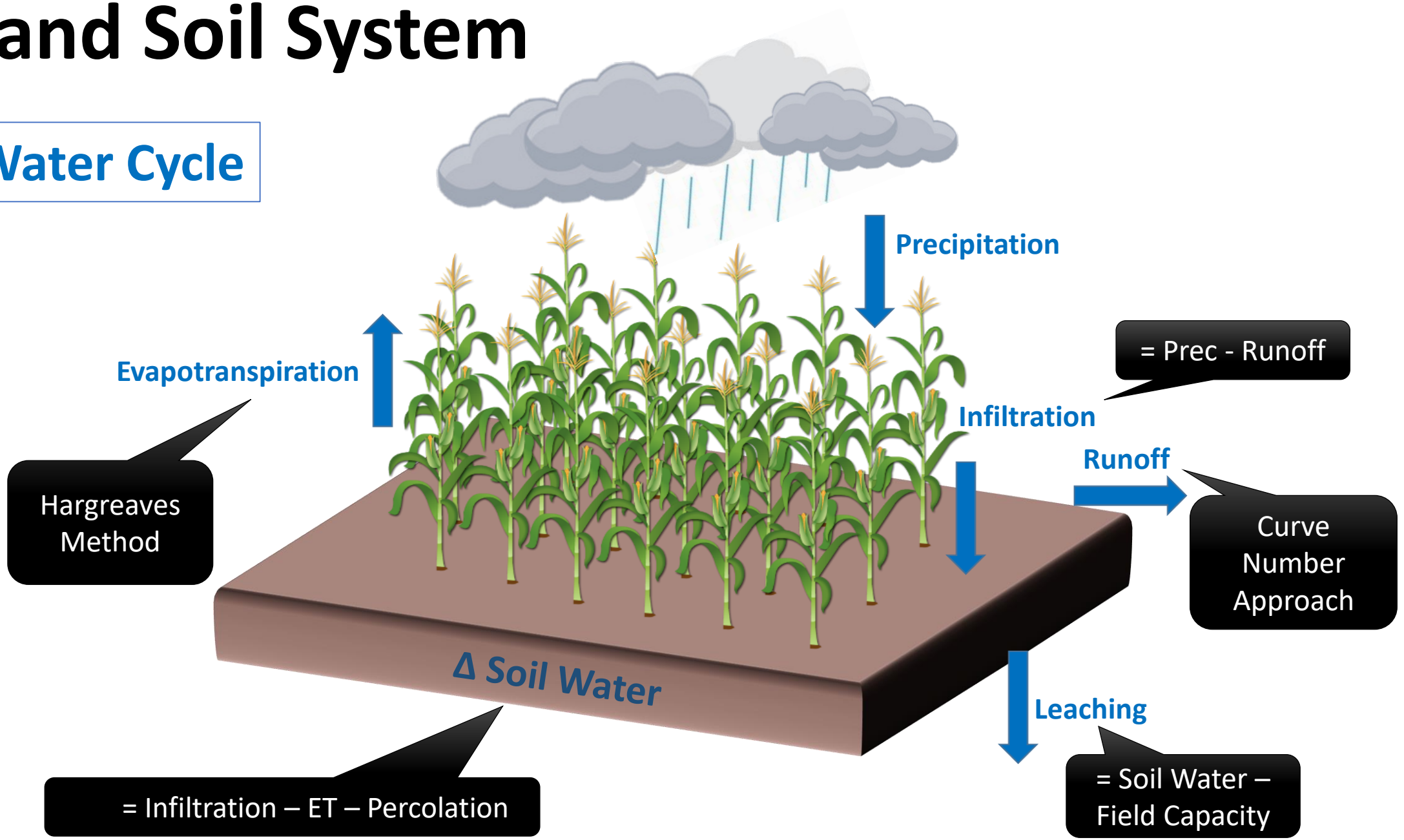


“Everything should be made as simple as possible, but no simpler.”

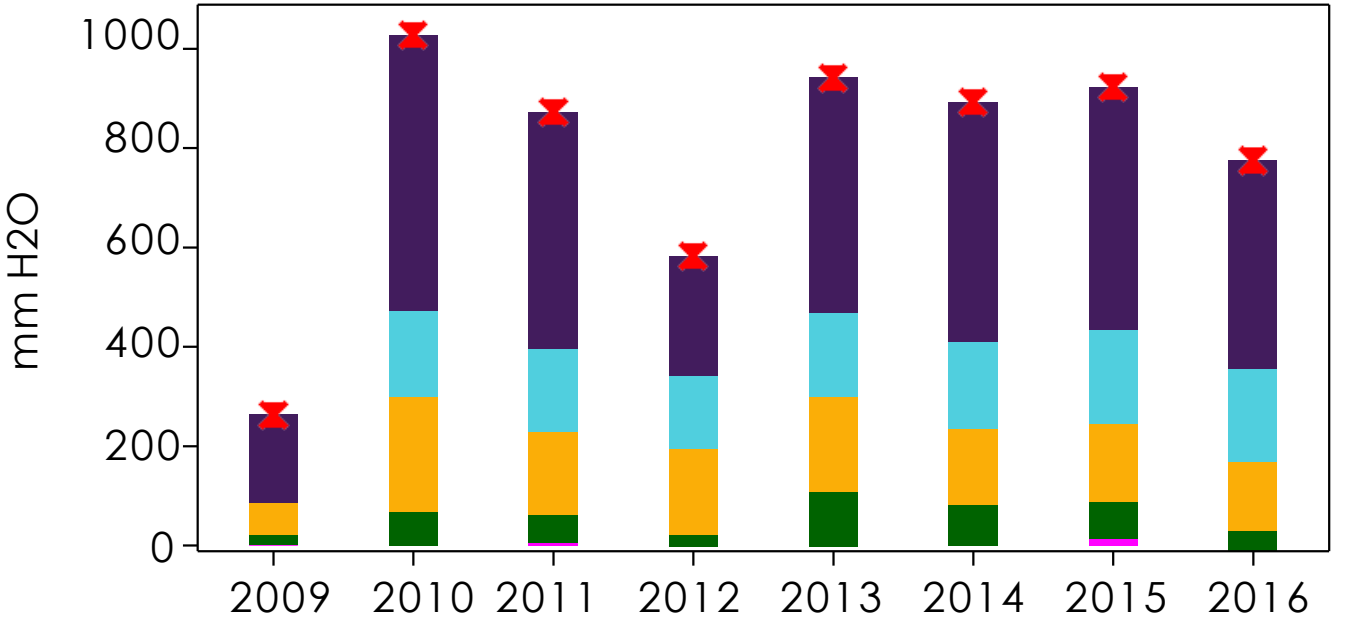
-Albert Einstein

Crop and Soil System

Water Cycle



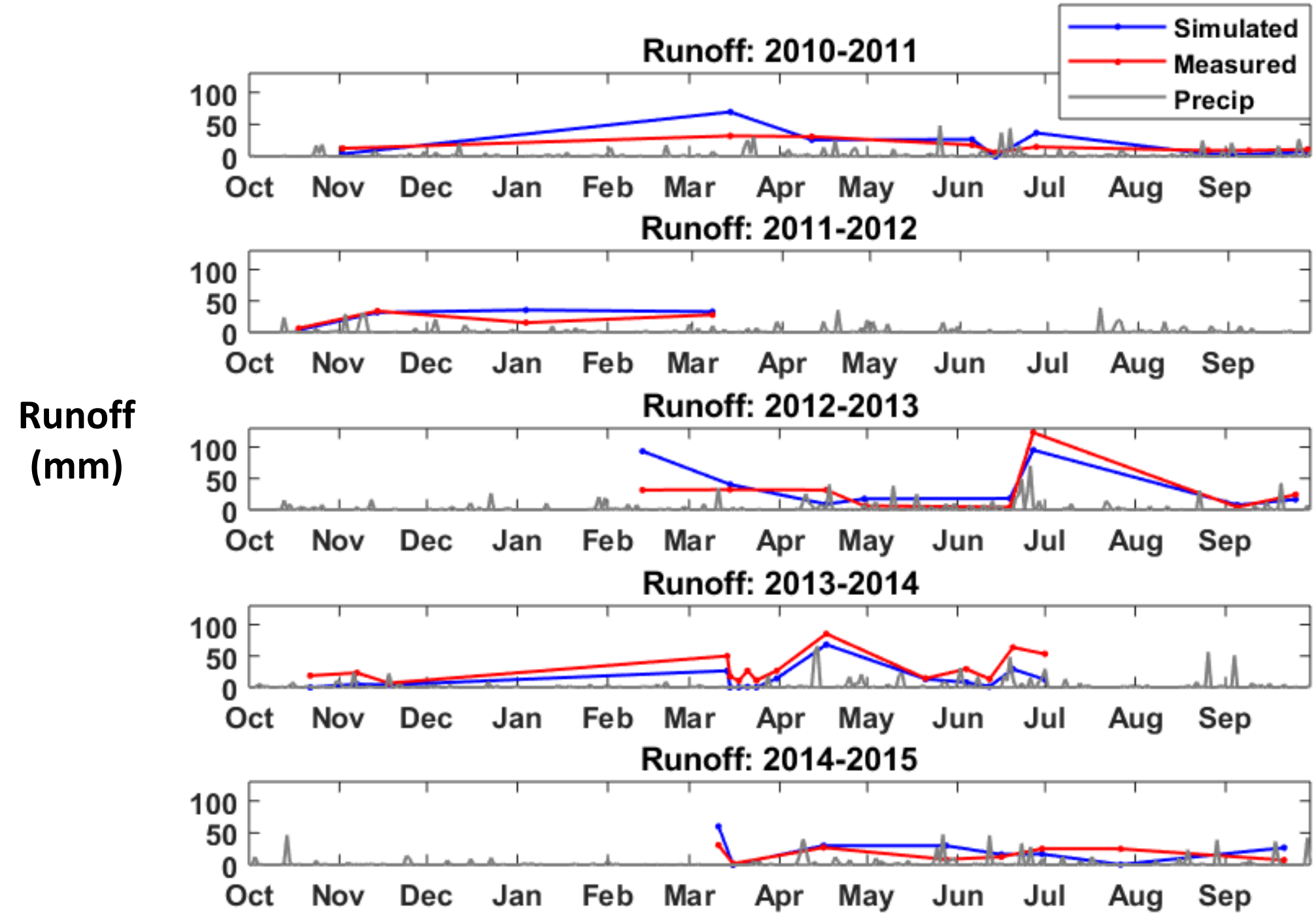
Water Balance



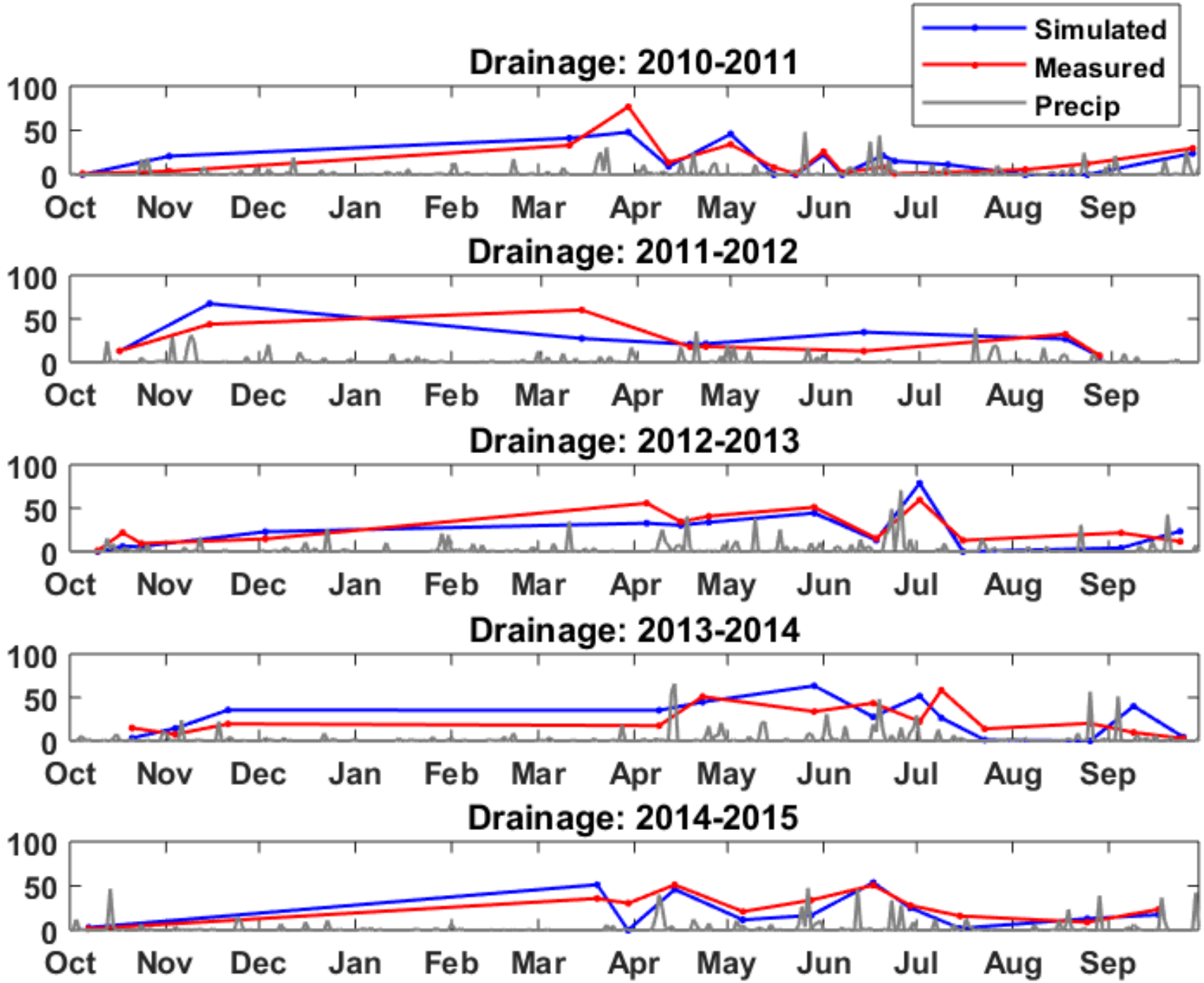
delta_sw	1.077	-1.828	5.344	-2.098	-2.449	-0.356	13.211	-11.298
runoff	19.949	70.246	57.286	23.413	110.202	81.312	74.136	40.75
evaporation	63.779	230.209	165.52	172.741	192.12	154.099	157.124	139.043
transpiration	0.0	173.575	167.396	147.308	168.047	174.957	189.091	187.151
drainage	178.085	555.228	476.944	240.804	473.151	482.036	488.966	418.546
actual precipitation	262.89	1027.43	872.49	582.168	941.07	892.048	922.528	774.192
calculated water	262.89	1027.43	872.49	582.168	941.07	892.048	922.528	774.192
difference	0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	-0.0

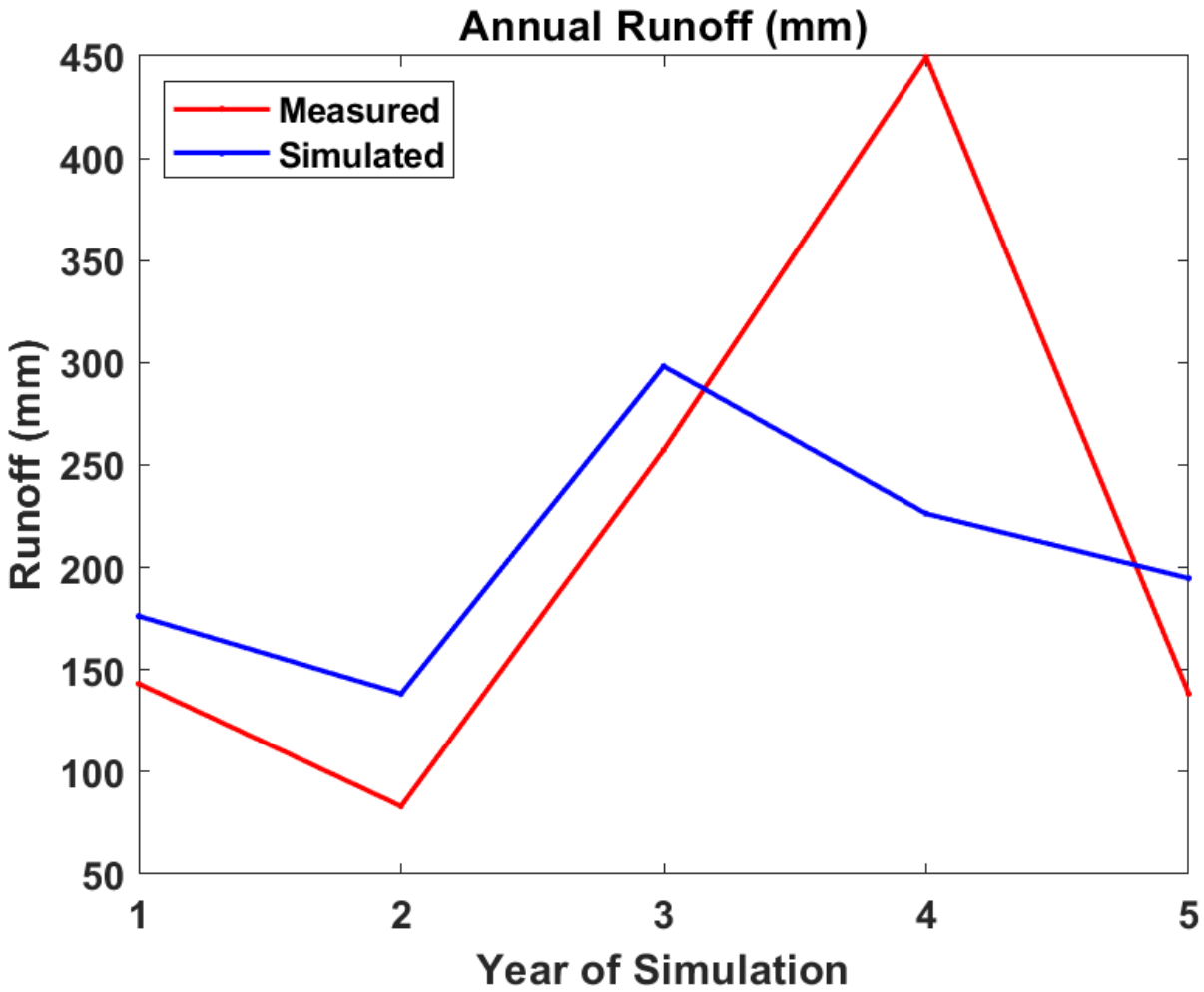
Testing: USDA-ARS Dairy Farm, Prairie du Sac, WI

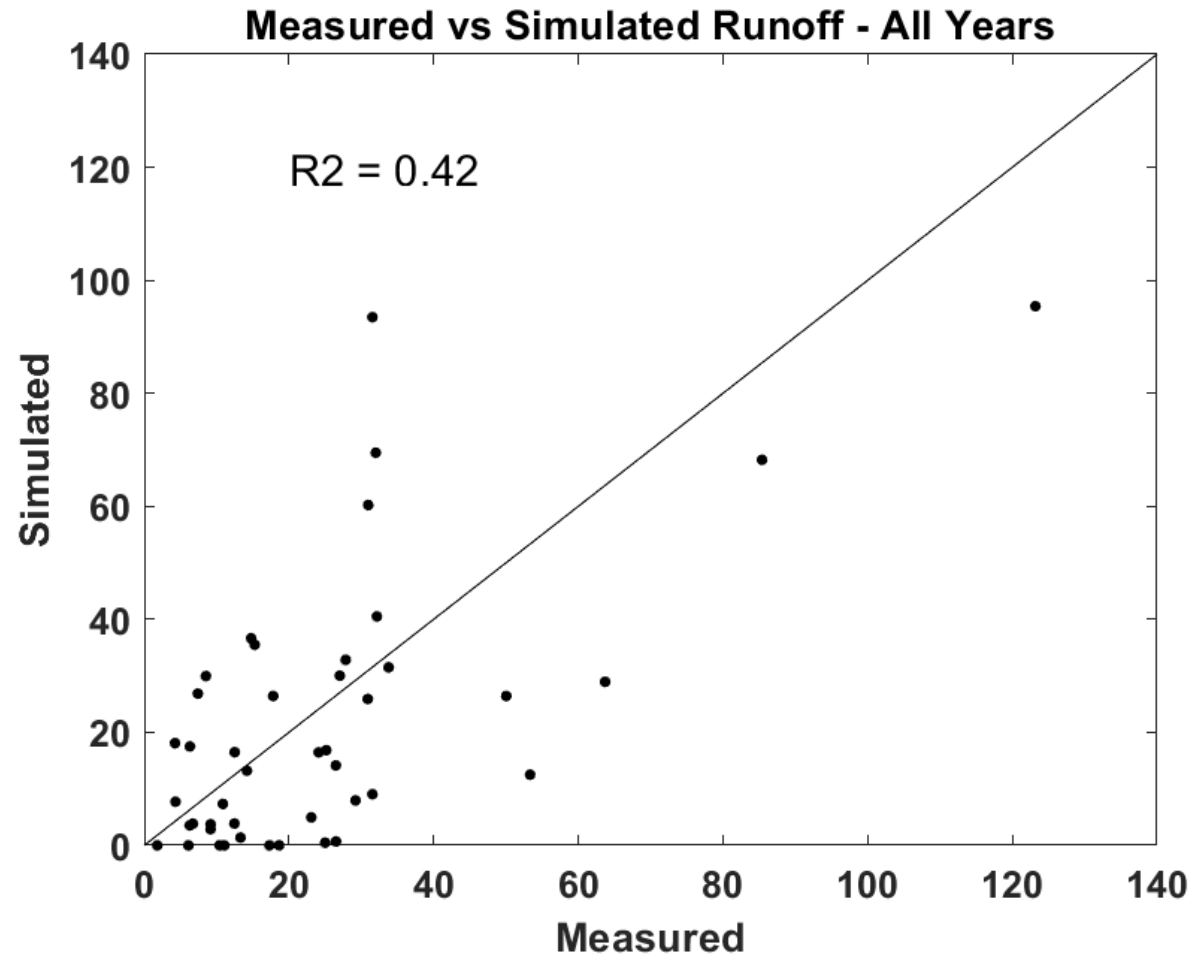
Runoff Comparison Event-Scale

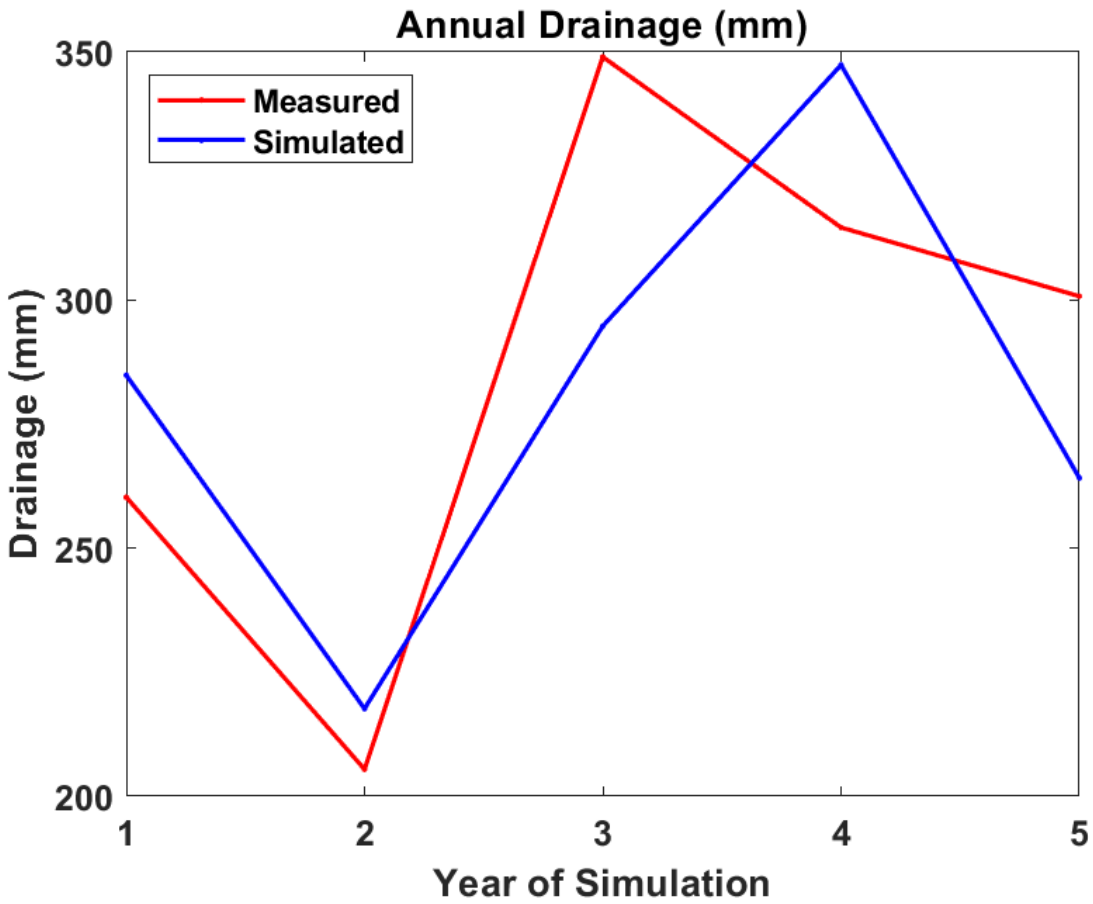


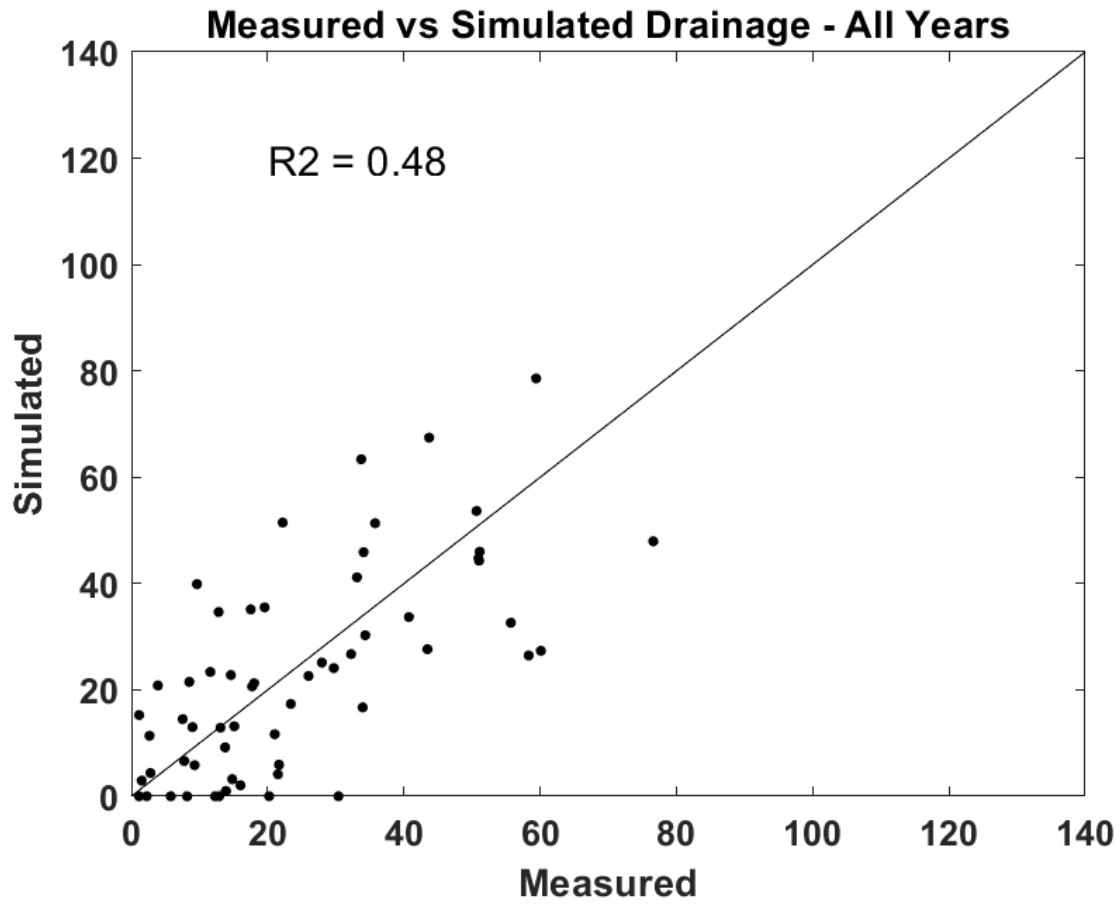
Drainage Comparison Event-Scale



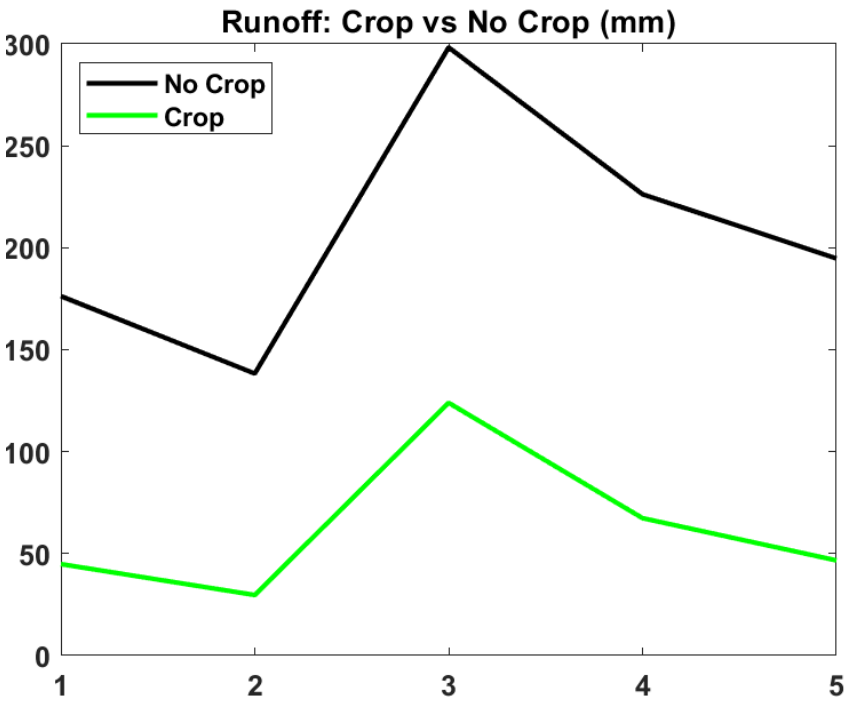

Annual Runoff (mm)
Measured
Simulated
Runoff (mm)
Year of Simulation
450
400
350
300
250
200
150
100
50
1
2
3
4
5

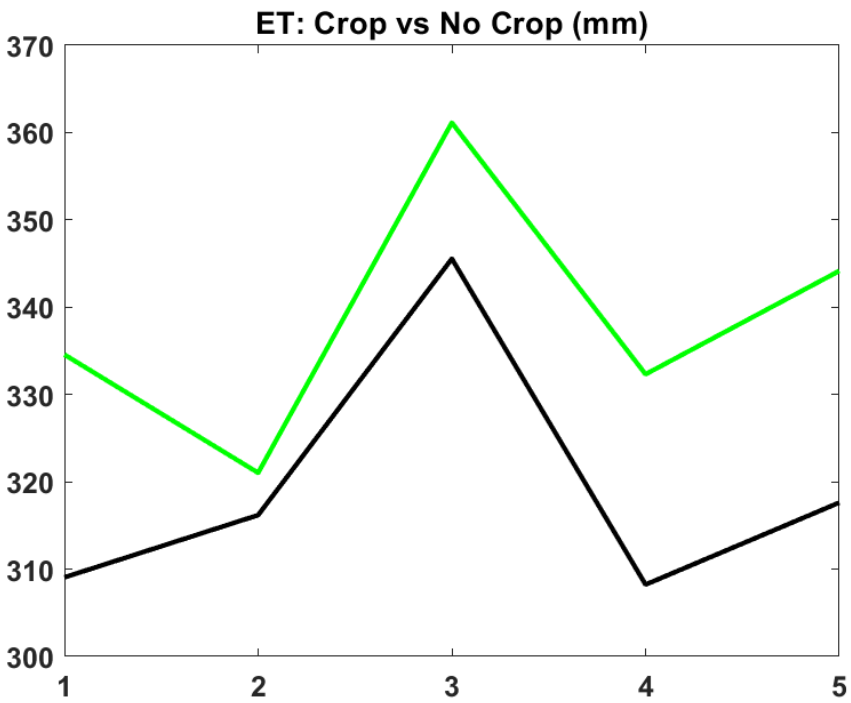

Measured vs Simulated Runoff - All Years
R2 = 0.42
Simulated
Measured
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140

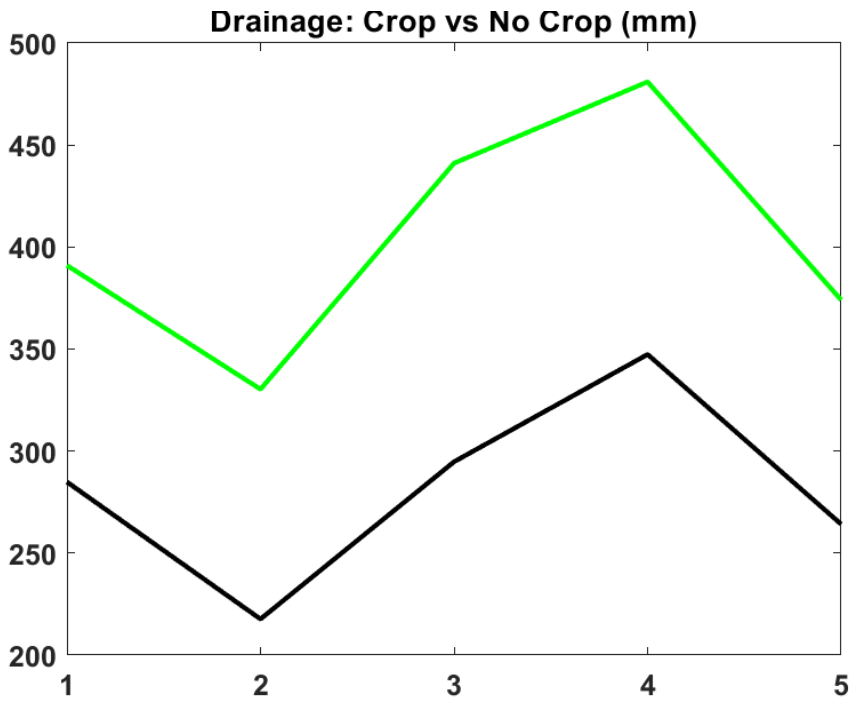

Annual Drainage (mm)
Measured
Simulated
Drainage (mm)
350
300
250
200
1
2
3
4
5
Year of Simulation


Measured vs Simulated Drainage - All Years
R2 = 0.48
Simulated
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
Measured

Hydrology: Crop vs No Crop







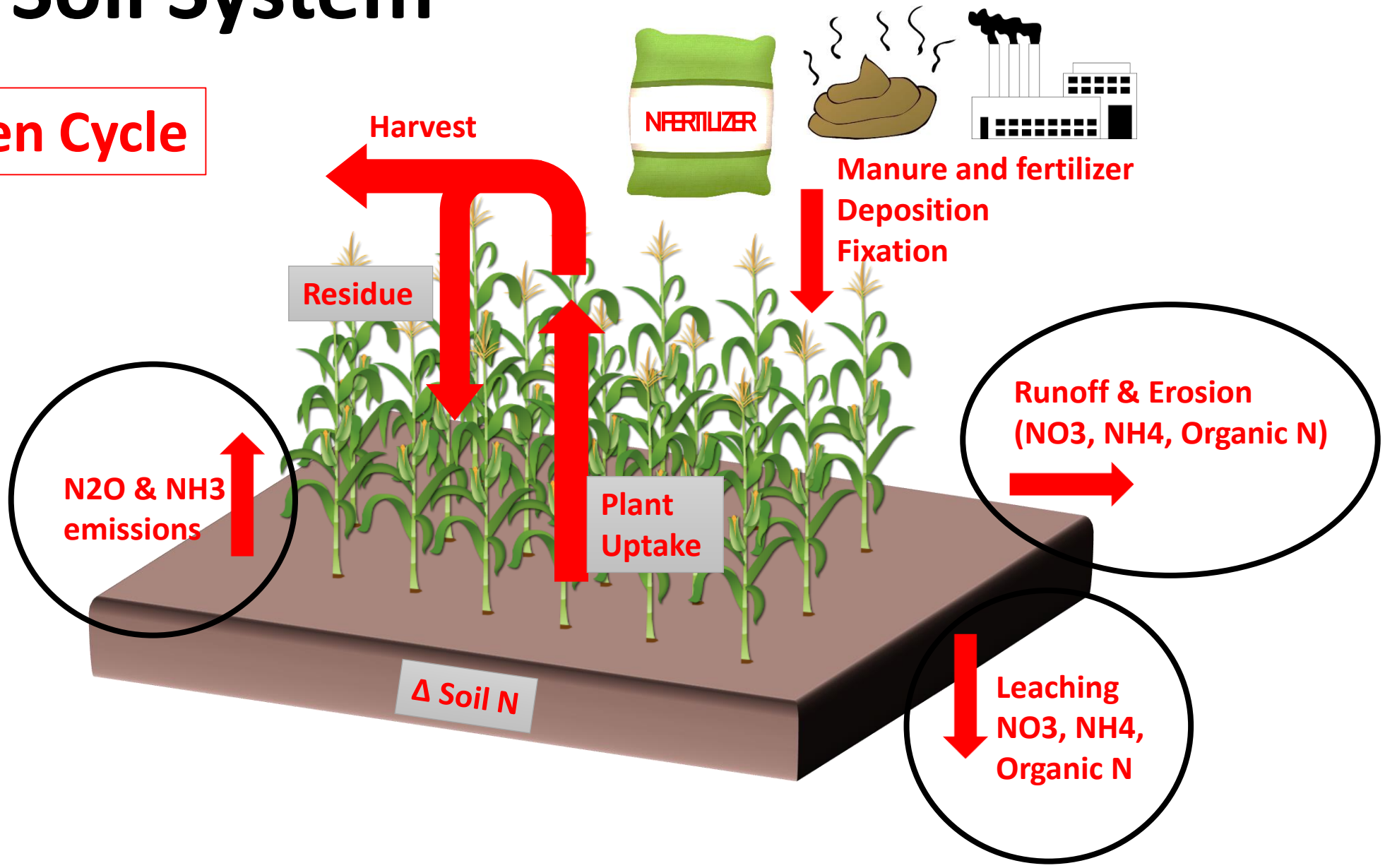
Curve Number changes → Runoff decreases ~150mm and infiltration increases

ET increases ~20 mm with crop present

Drainage increases ~125 mm with crop present

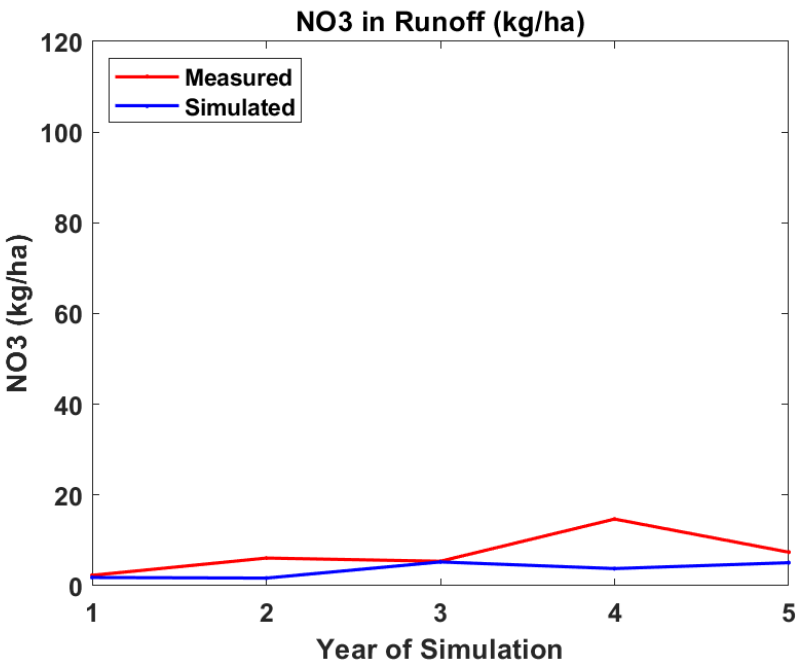
Crop and Soil System

Nitrogen Cycle

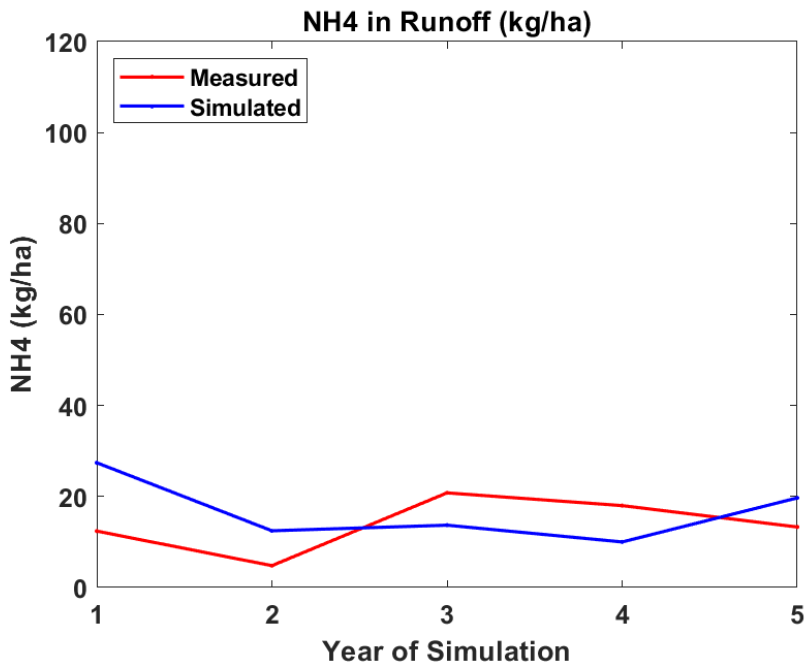


Annual Time Series Comparisons – Runoff N

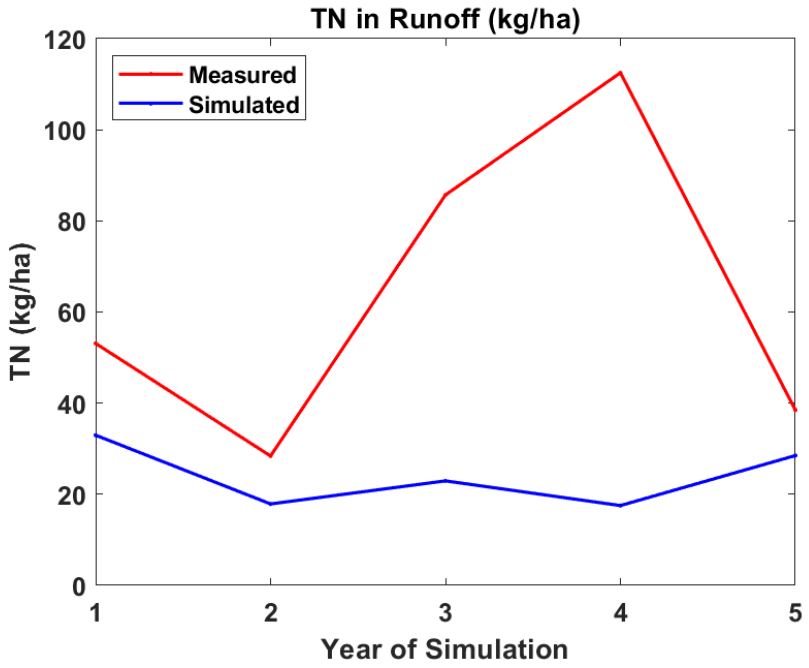
NO_3



NH_4



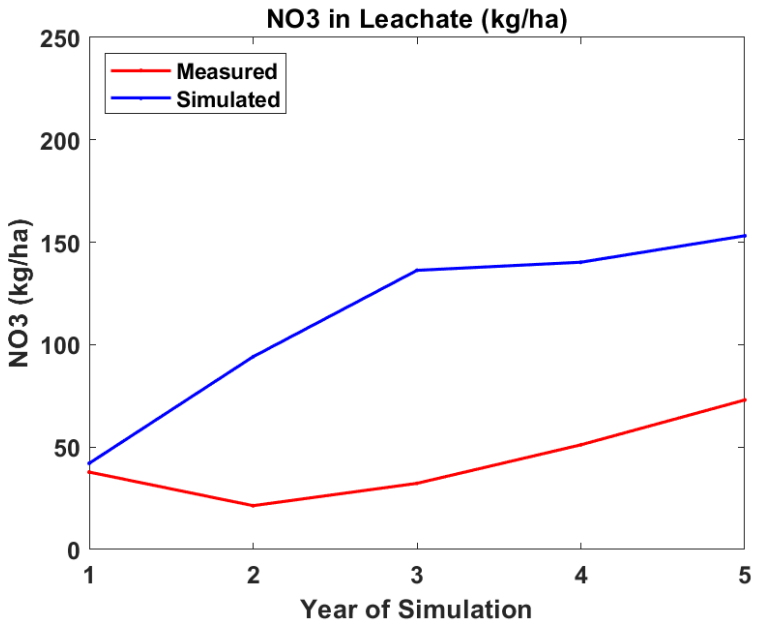
Total N



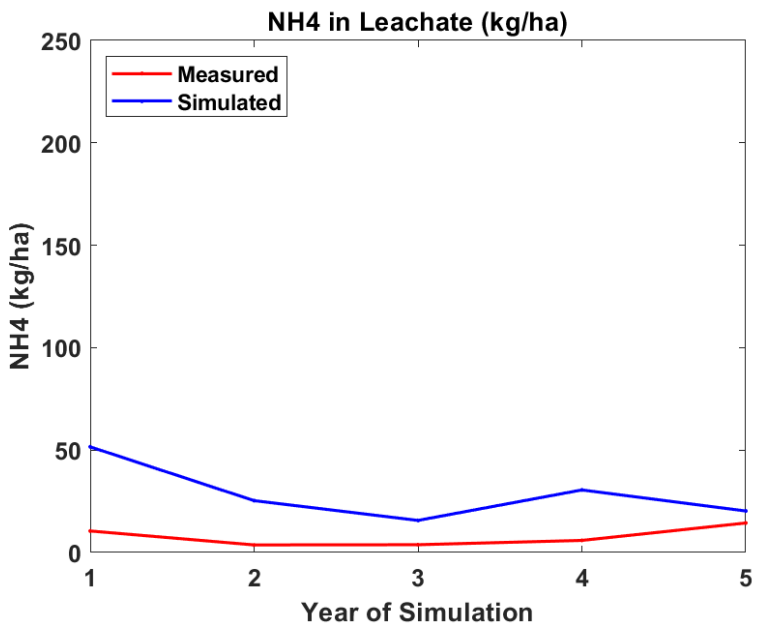
Year

Leachate N

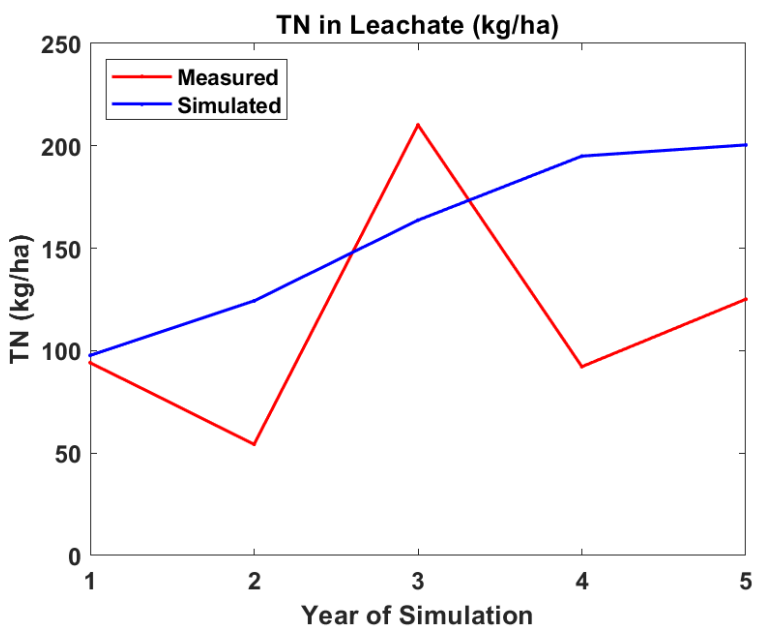
NO_3



NH_4



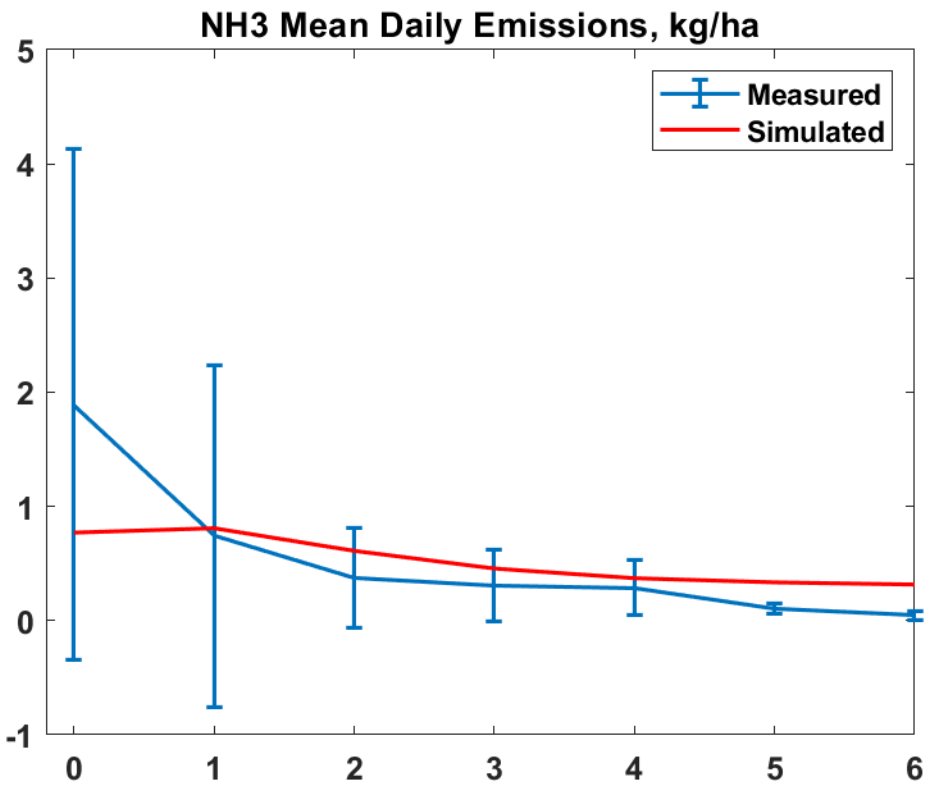
Total N



Year

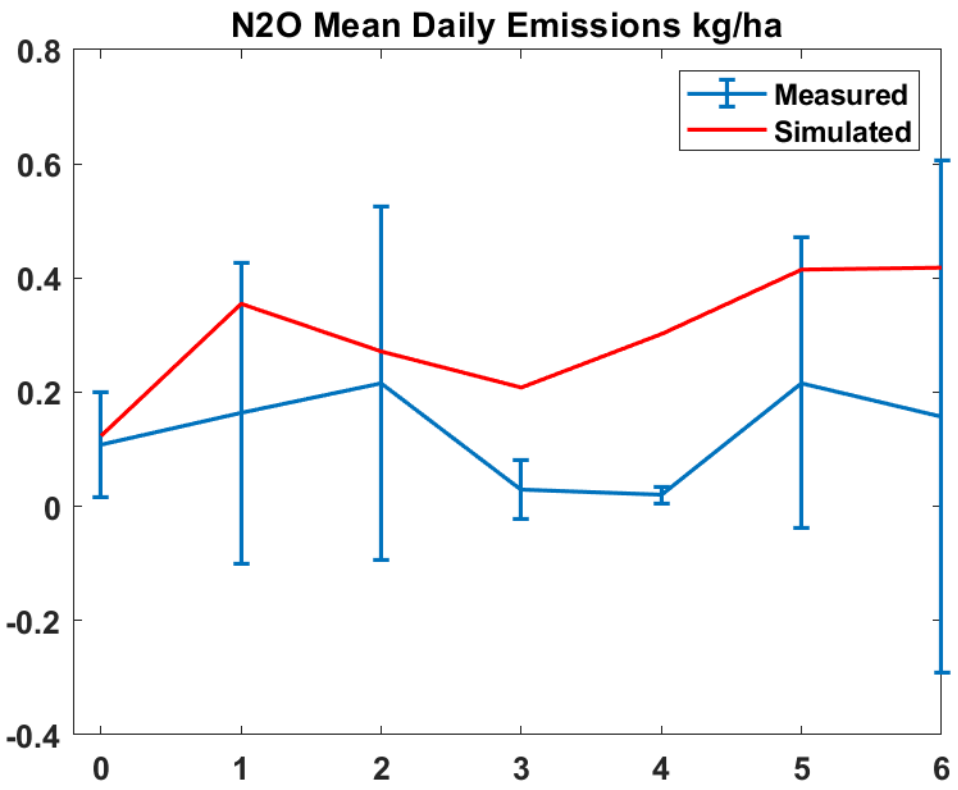
Gas N

NH_3



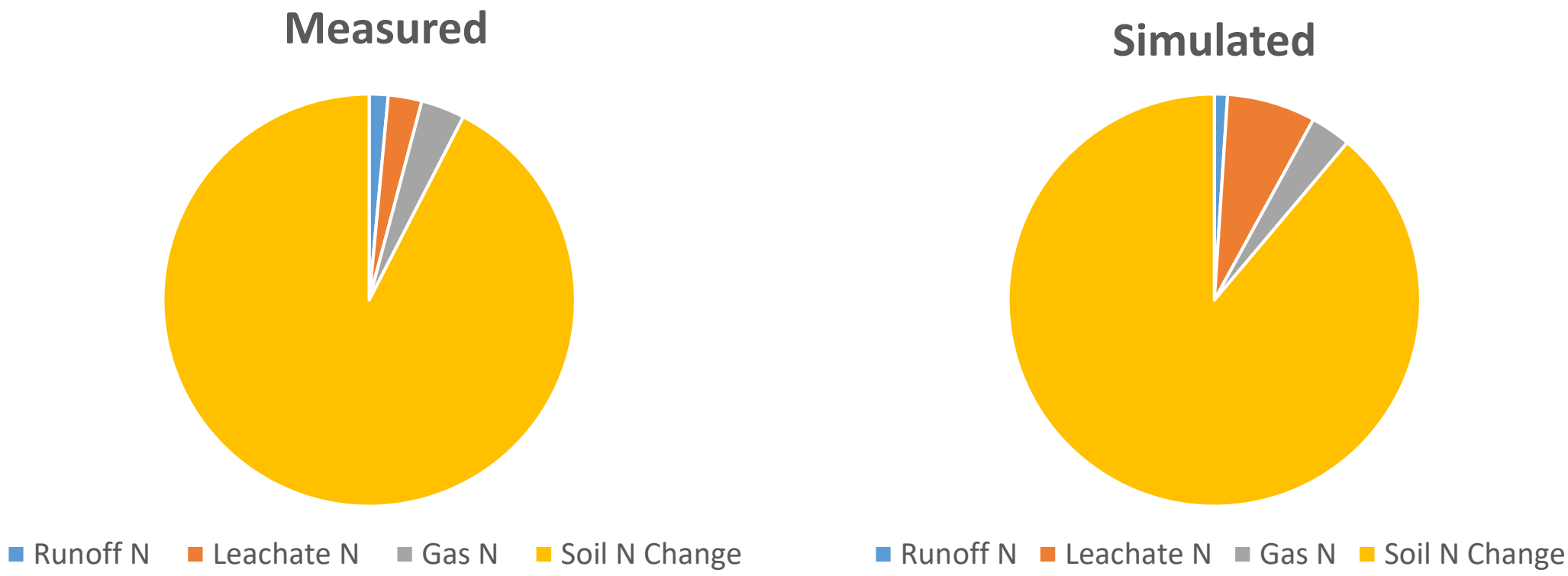
Days after heifers leave

N_2O

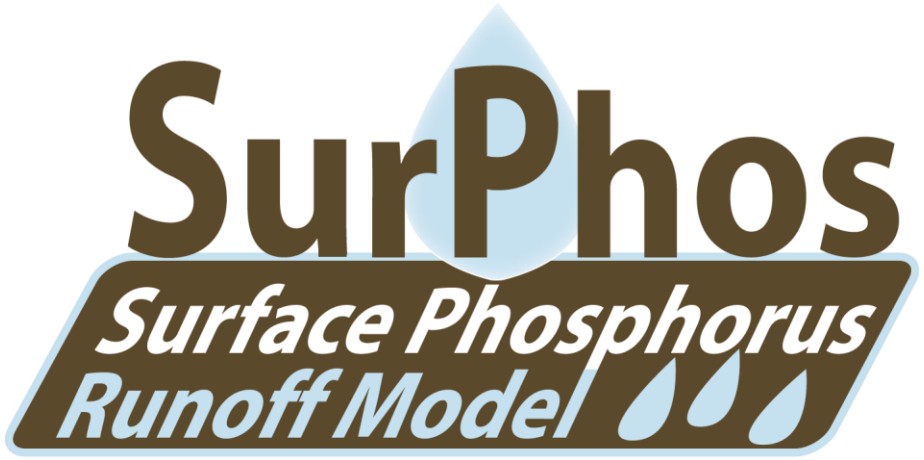


Days after heifers leave

Total N Budget



Phosphorus



Modified Universal Soil Loss Equation

(Dissolved P)

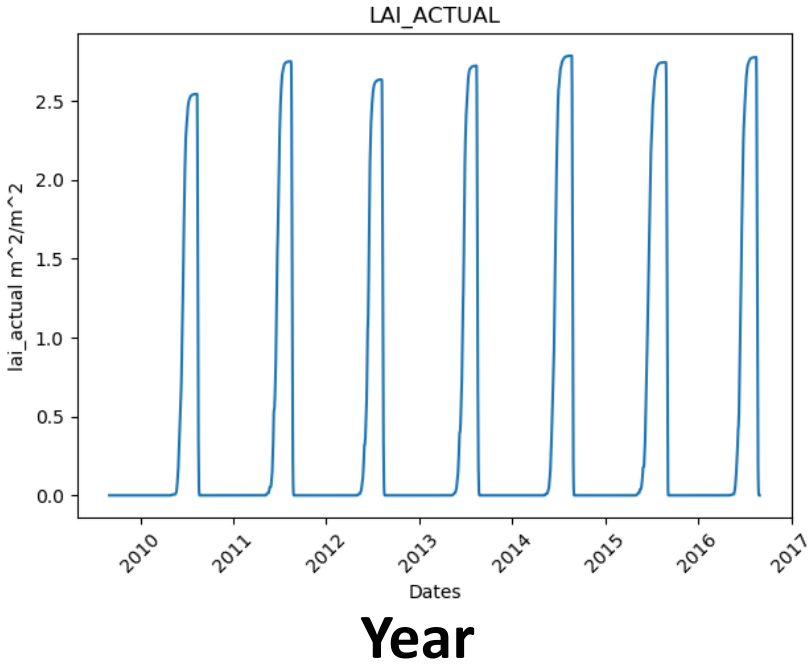
(Sediment P)

Crops

- In development
- Based on SWAT:
  - LAI → potential heat units
  - Biomass → radiation use efficiency and LAI
  - Water uptake → PET & available soil water
  - Growth limited by water, temp, N & P.
- 3 crops implemented: corn, soy, alfalfa, with variable rotations
- Testing underway
- Pass on harvested tonnage and C, N, & P to Feed Storage

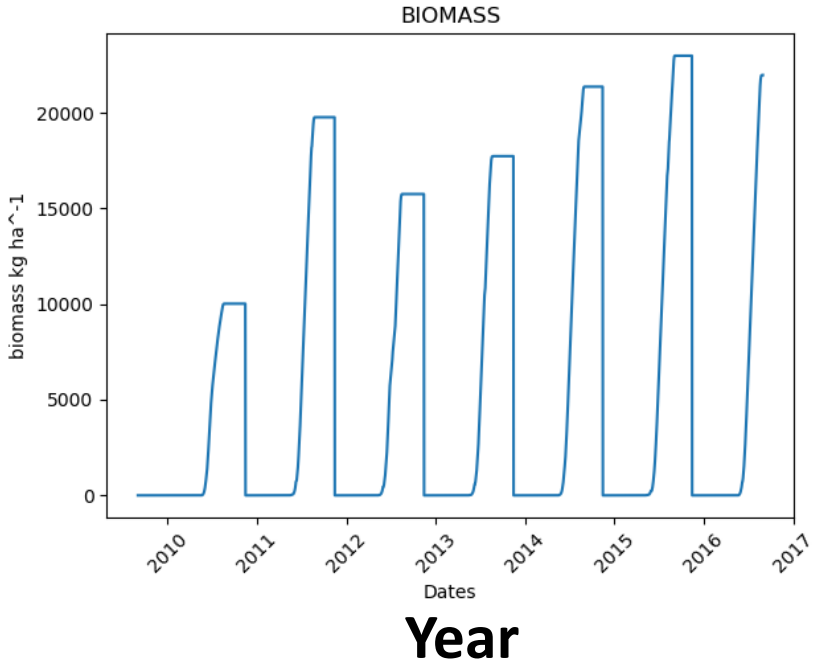
Corn

Leaf Area Index



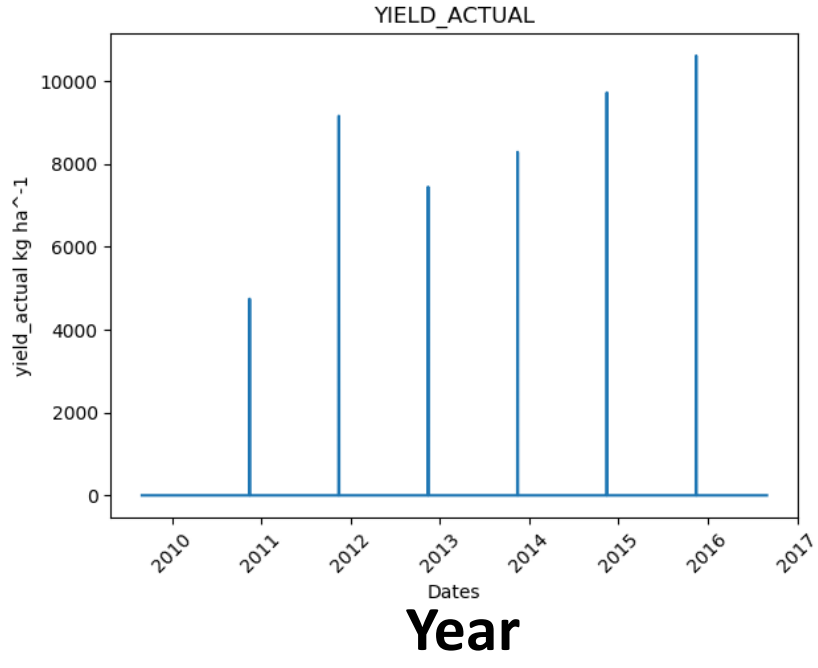
Year

Biomass (kg ha^{-1})



Year

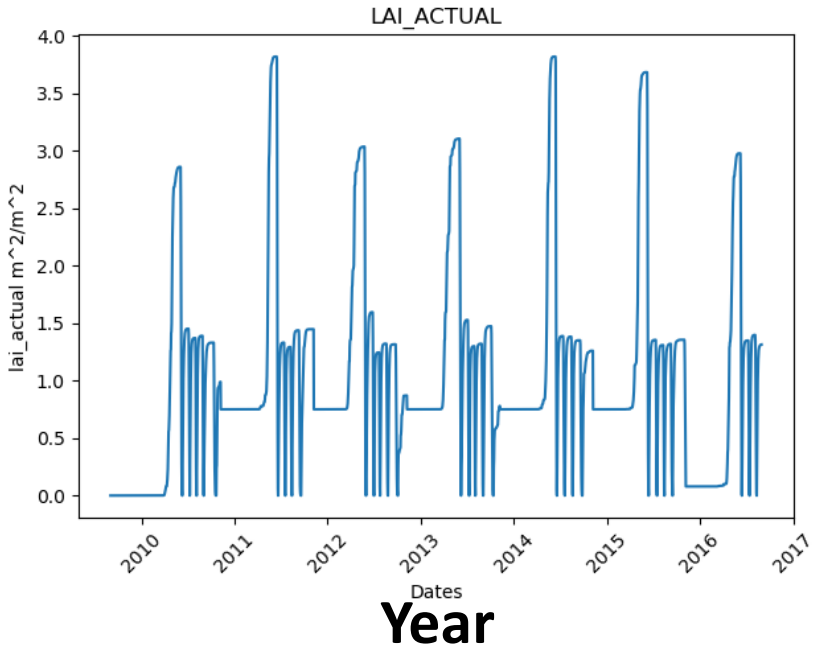
Yield (kg ha^{-1})



Year

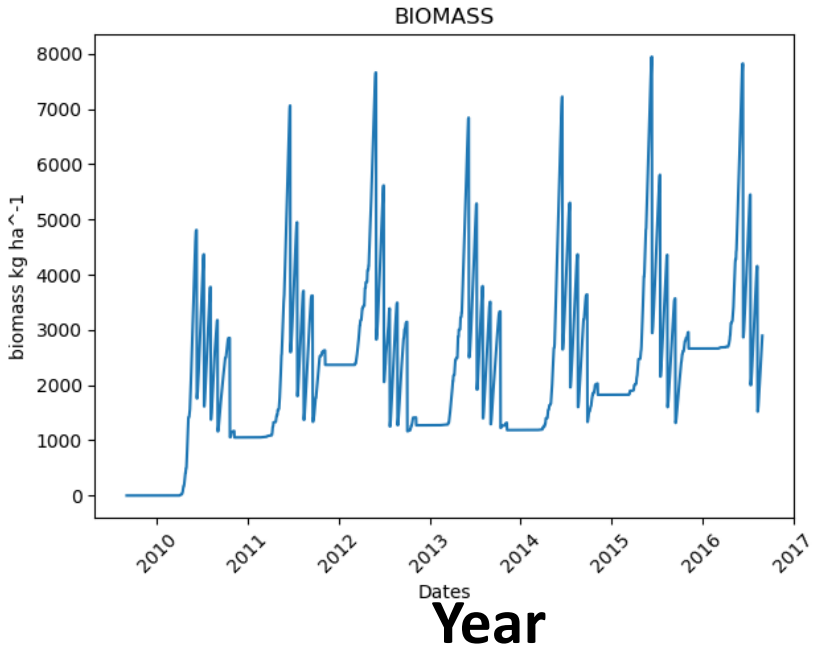
Alfalfa

Leaf Area Index



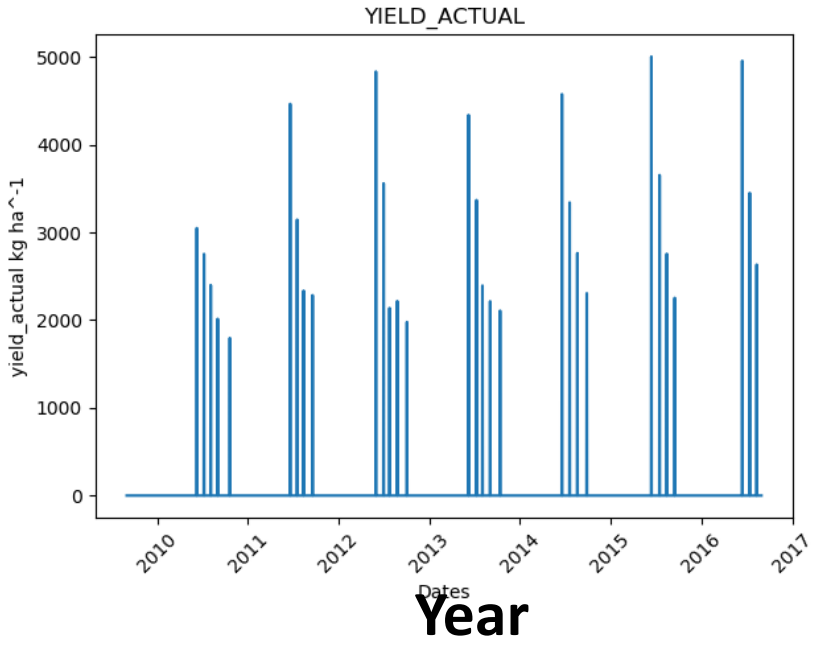
Year

Biomass (kg ha^{-1})



Year

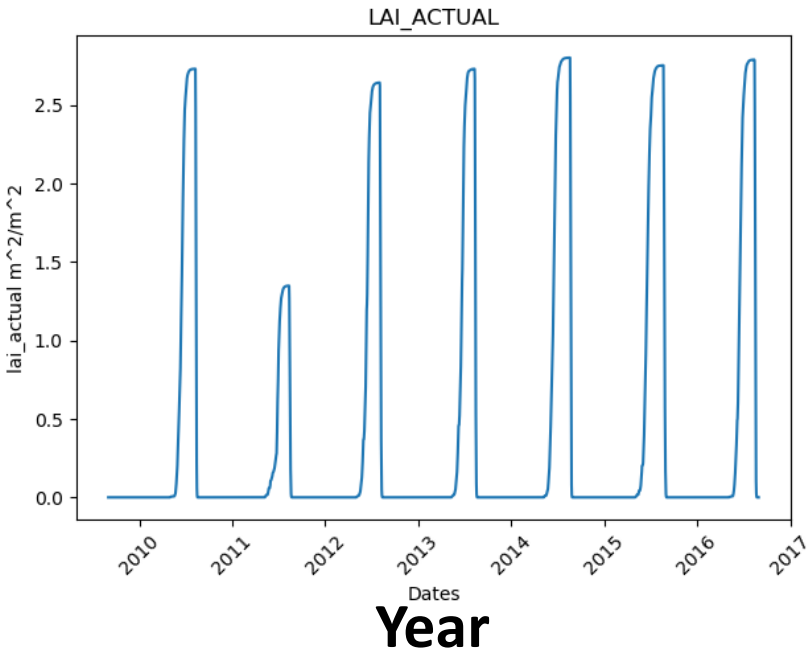
Yield (kg ha^{-1})



Year

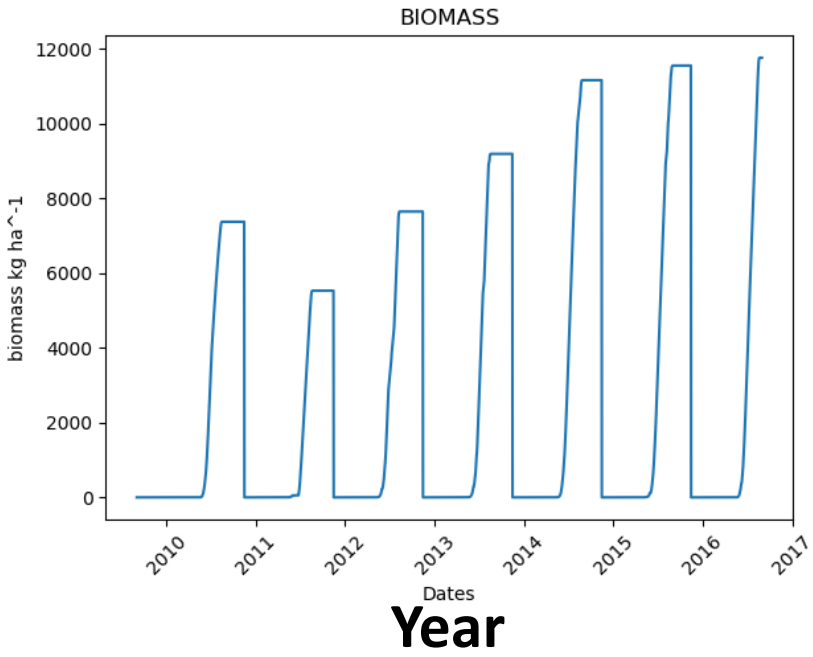
Soybean

Leaf Area Index



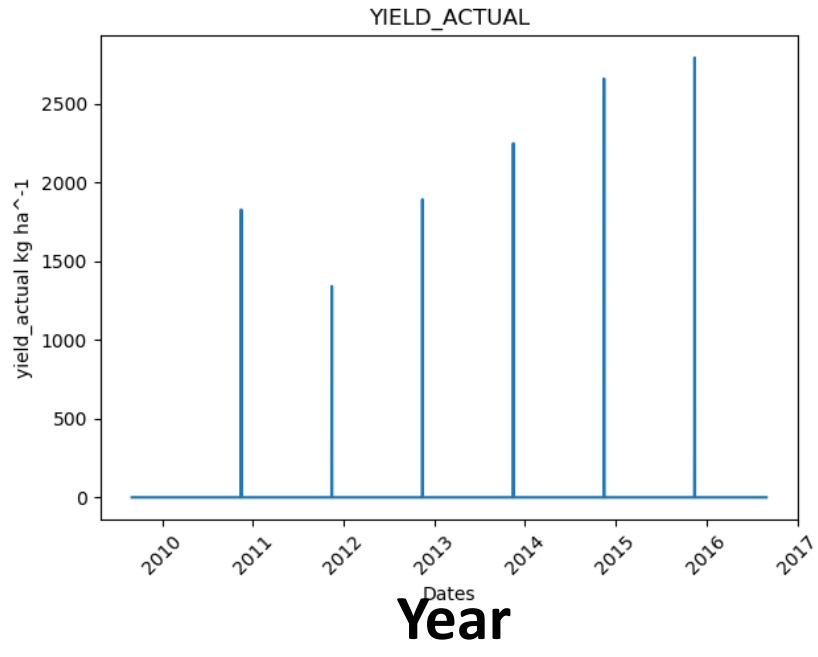
Year

Biomass (kg ha^{-1})



Year

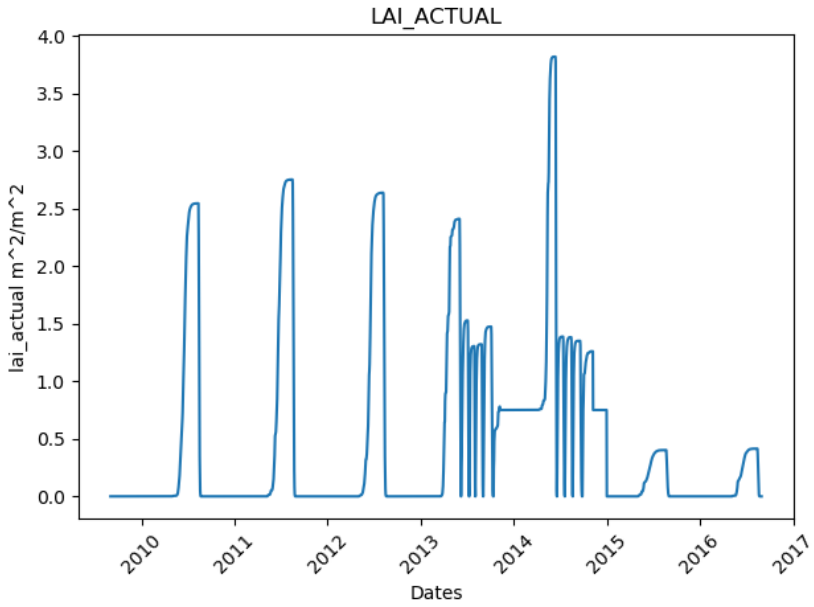
Yield (kg ha^{-1})



Year

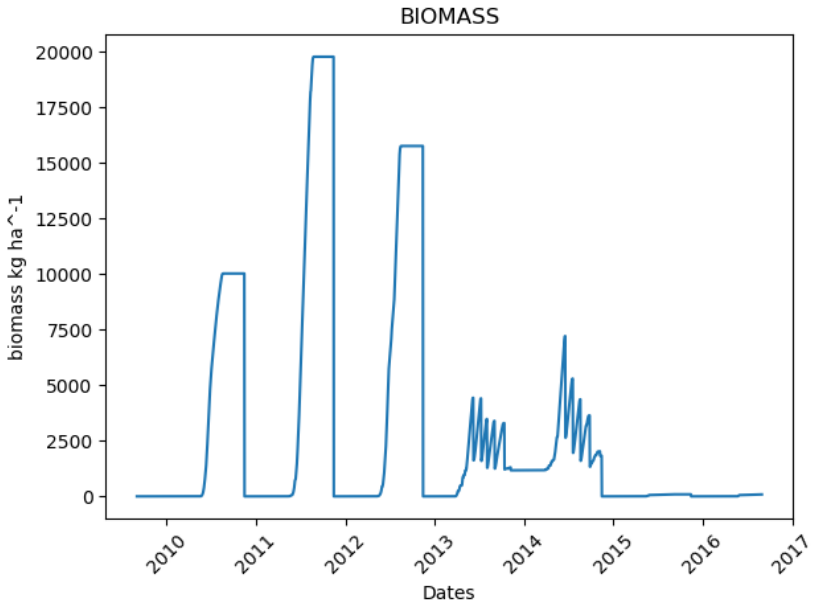
Rotation: CCCAASS

Leaf Area Index



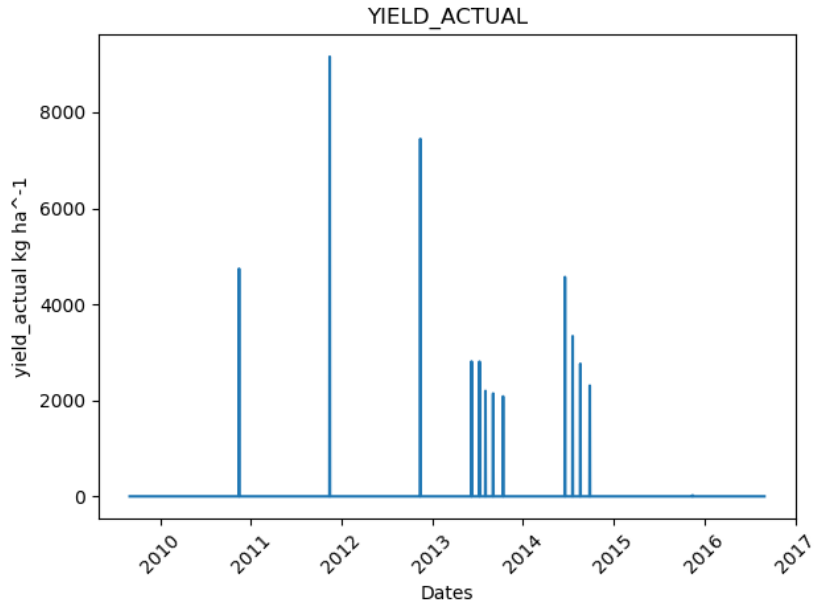
Year

Biomass (kg ha^{-1})



Year

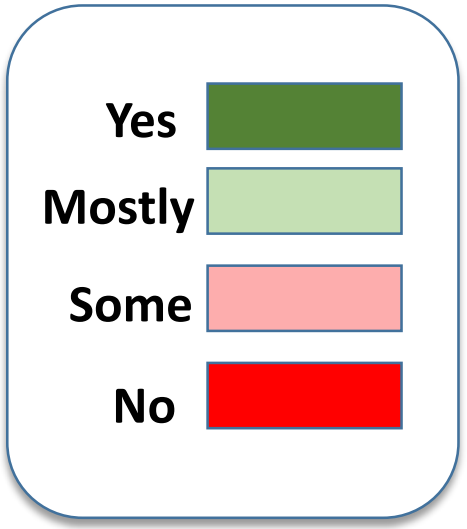
Yield (kg ha^{-1})



Year

Progress

Component	Implemented?	Tested?
H_2O		
N		
P		
Crops / Carbon		



Management

On Deck:

- **-Grazing**
- **-Irrigation**
- **-Tillage (affecting hydrology & erosion)?**
- **-Tile drainage?**

What are we missing?

Datasets Needed

Cropping System	Measurements
Forage crops (corn silage, alfalfa, soy, pasture, clover, small grains)	Runoff volume, N, P Leachate volume, N, P Forage crop C, N, P content
Field sites w/ manure & fertilizer at agronomic rates	N emissions (N2O, NH3) Daily meteorology (Prec, Tmax, Tmin, Radiation)
Climates outside Midwest	Soil C, N, P
Soils outside Midwest	
Irrigated	
Pasture	
Tiled	

Required model inputs are daily meteorology + application amounts & timing

Thanks!

Questions?

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N Mass Balance Comparison

5-year totals (from Table 5, Vadas and Powell 2019)
Estimated N Inputs = 20,087 kg ha^{-1}
Model N Inputs = 20,762

	N Runoff *kg ha^{-1} (% of input N)*	N Leachate *kg ha^{-1}*	N2O Gas *kg ha^{-1}*	NH3 Gas *kg ha^{-1}*	N Gas *kg ha^{-1}*	Change in Soil N (0-45cm) *kg ha^{-1}*	Total Measured N *kg ha^{-1}*	Budget Closure
Measured	318 (2)	576 (3)	274 (1)	463 (2)	737 (4)	19,849 (92)	21,480	+7%
Simulated	221 (1)	1490 (7)	300 (1)	380 (2)	680 (3)	19,055 (89)	21,446	+3%