INTEGRATED SWAT+ SOFT-CALIBRATION PROCEDURE FOR WATER BALANCE AND CROP YIELDS

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2023-06-28
International SWAT Conference, Aarhus, Denmark

BACKGROUND

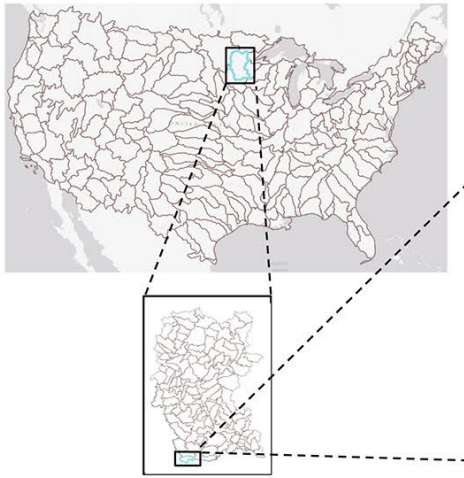
Starting a GIS MS	SWAT 2009
Starting a PhD	SWAT 2012
	Life and all that ☺
Starting a post-doc	SWAT+
Assistant Research Scientist	
	Who knows…

THE CHALLENGE

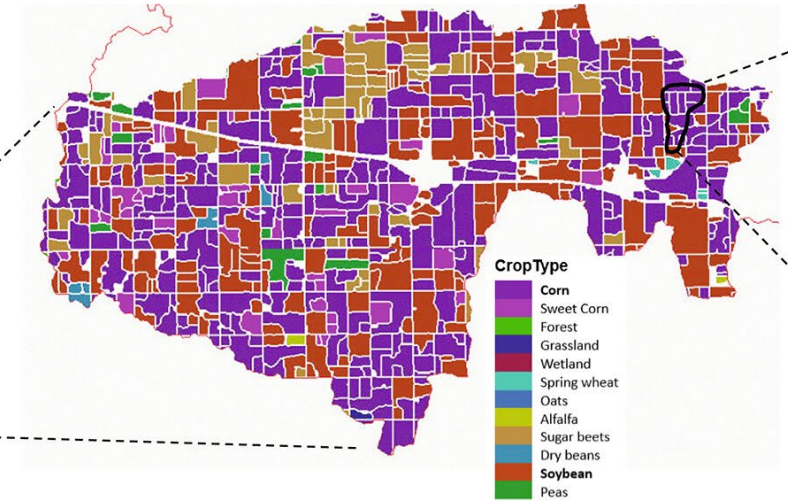
National Agroecosystems Model

DEVELOPMENT OF A FIELD SCALE SWAT+ MODELING FRAMEWORK FOR THE CONTIGUOUS U.S.

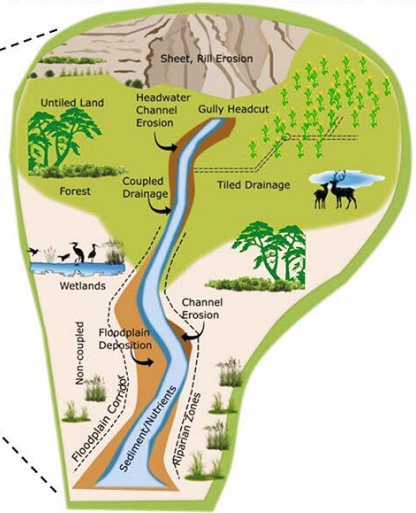
National Extent



Field Based Computational Units

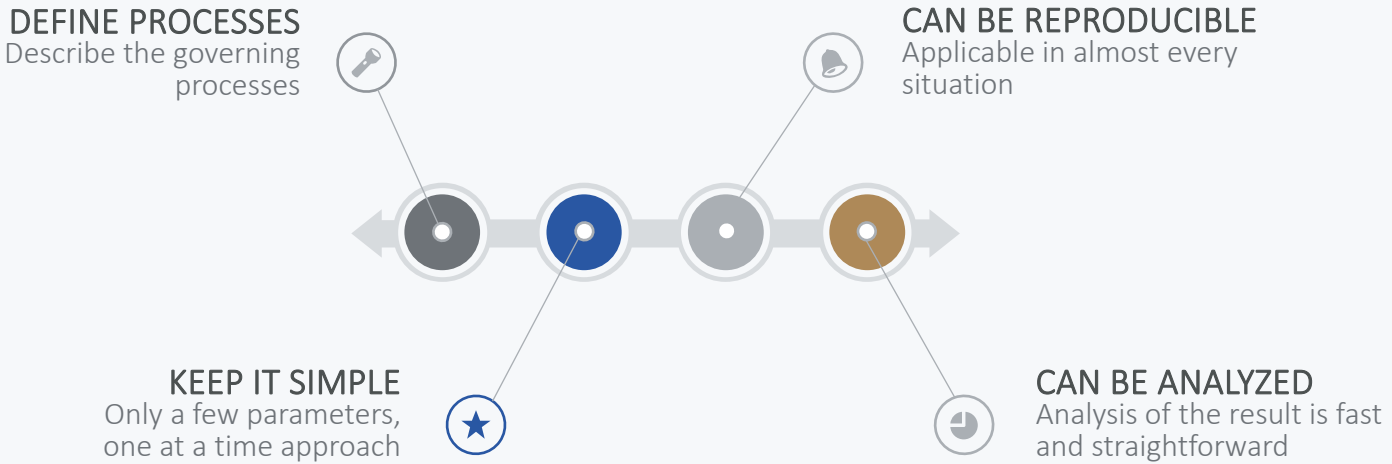


Process Based Simulation

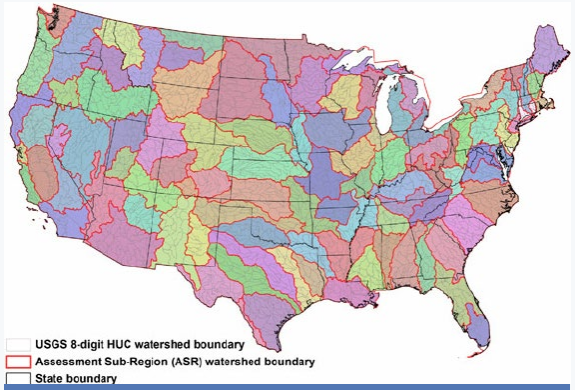


HOW TO CALIBRATE SUCH FRAMEWORKS?

Soft-calibration



WHAT IS SOFT CALIBRATION IN SWAT+?



Can be used for large and small model adjustments

GROUND RULES

An algorithm that is hard-coded into SWAT+. Can be activated via input files.

Can be useful if the model is verified: all processes are working as they should be; all plants are growing as they should be; all stresses are accounted for.

Works on processes.

Uses soft data as inputs:

- Average annual values
- Average basin values
- Average aggregated values

CURRENTLY AVAILABLE SOFT-CAL OPTIONS IN SWAT+

More are in future development

WATER BALANCE SOFT-CAL (WB)

- Inputs are:

  Water Yield Ratio (WYR) =

  total water yield (surface + lateral + tile + perc) / precipitation

  Baseflow Ratio (BFR) =

  total baseflow (lateral + tile + perc) / total water yield

- The processes which are calibrated:

  surface runoff, lateral flow, percolation, ET.

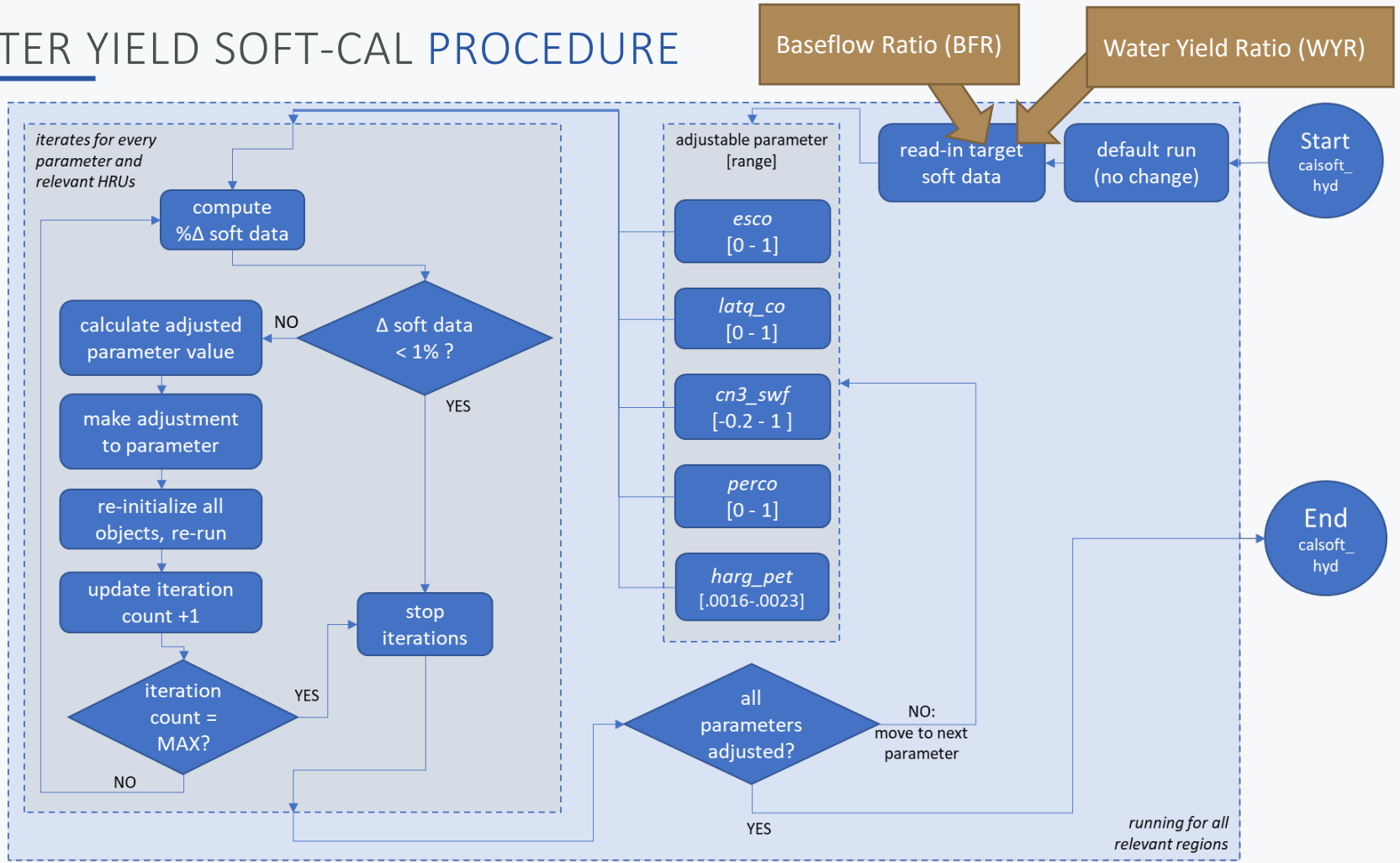
CROP YIELD SOFT-CAL (YLD)

- Inputs are:

  Average annual yield for each crop (t/ha)

- The processes which are calibrated:
  - aeration stress (no tile)
  - LAI development,
  - reduction of harvest due to unfavorable conditions,
  - plant water uptake.

WATER YIELD SOFT-CAL PROCEDURE



WATER BALANCE ADJUSTMENT

Computation steps

Variable	Initial change (guess)
esco	$(ET_{soft} - ET_{sim}) / 500.$
petco	$(ET_{soft} - ET_{sim}) / ET_{soft}$
cn3_swf	$- (SURQ_{soft} - SURQ_{sim}) / 100.$
latq_co	$(LATQ_{soft} - LATQ_{sim}) / 400.$
perco	$(PERC_{soft} - PERC_{sim}) / 1000.$

ONE VARIABLE AT A TIME:

1) esco
2) petco
3) cn3_swf
4) latq_co
5) perco
6) cn3_swf

… calibrated again to ensure surface runoff is accurate

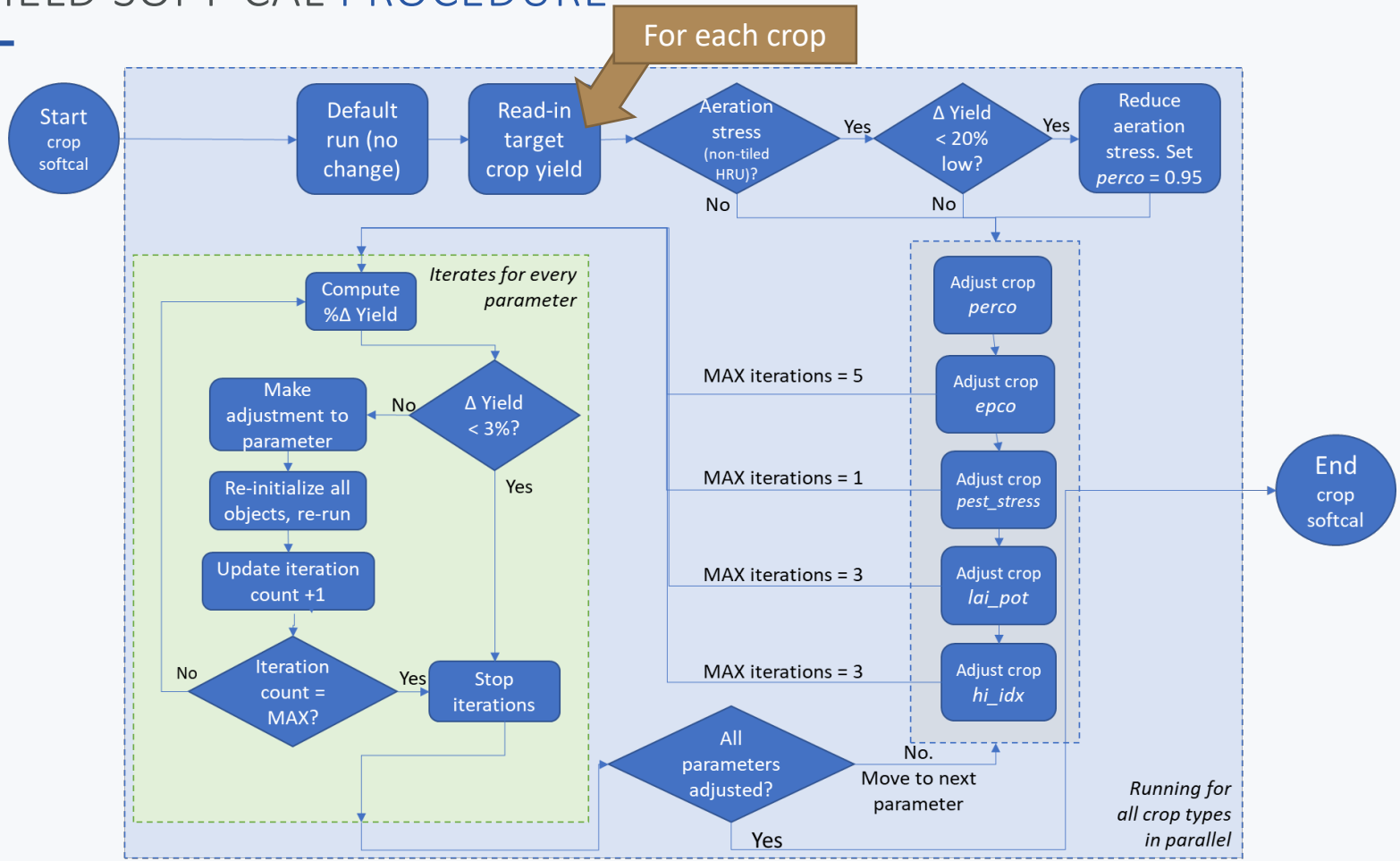
Initial change in each variable is a function of the difference (mm) in the soft ratio multiplied by precipitation minus the modeled process output.

EXAMPLE:

- The user input 0.2 surface runoff ratio;
- Simulated precipitation = 800 mm;
- Surface runoff =120 mm.
- Initial difference = 0.2*800 – 120 = 40 mm. [$(SURQ_{soft} - SURQ_{sim})$]

… the next value of cn3_swf used in the calibration would be set to (cn3_swf - 0.4) [$- (SURQ_{soft} - SURQ_{sim}) / 100$]

CROP YIELD SOFT-CAL PROCEDURE



CROP YIELD ADJUSTMENT

Computation steps

ONE VARIABLE AT A TIME:

1) perco* → if needed
2) epco
3) pest_stress
4) lai_pot
5) hi_pot

The initial change applied to each parameter is a function of the percent difference between the simulated and observed yields.

Variable	Initial change	Number of linear interpolations
epco	if ($diff_{pct}$ >= 10%) chg_init = -0.01 * $diff_{pct}$ + 0.06 if ($diff_{pct}$ < 10%) chg_init = 1.0	4
pest_stress	$diff_{pct}$	0
lai_pot	0.5 * $diff_{pct}$	2
hi_pot	0.005 * $diff_{pct}$	2

After the initial change, the algorithm uses linear interpolation in subsequent iterations

CALIBRATION SEQUENCE

Which one to do first?

We suggest

1 – Water Balance

2 – Crop Yield

One will need:

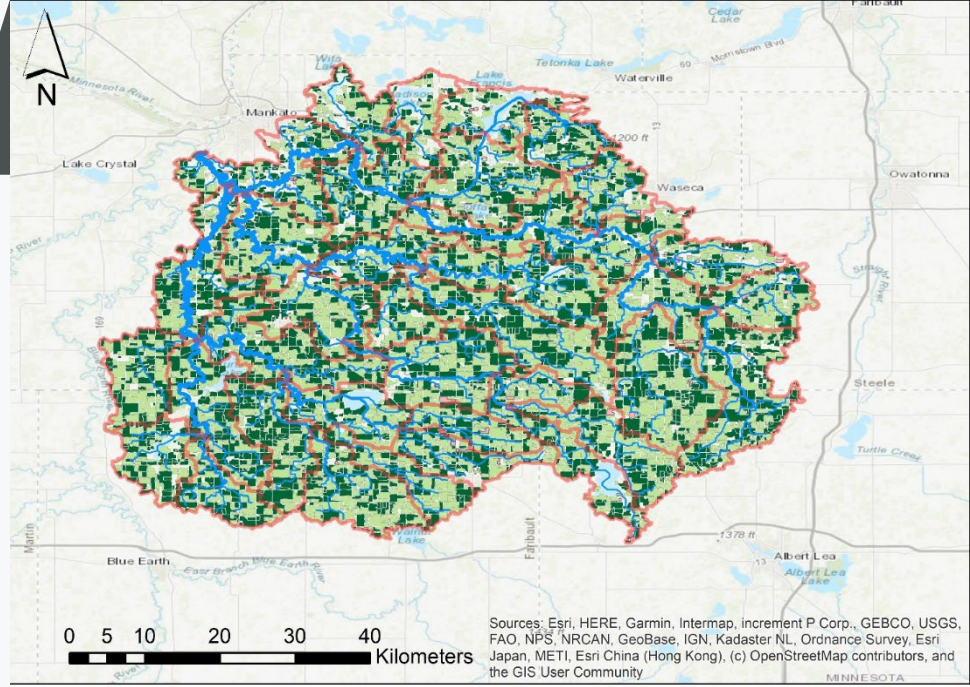
- water_balance.sft
- wb_parms.sft
- codes.sft
- plant_parms.sft
- plant_gro.sft

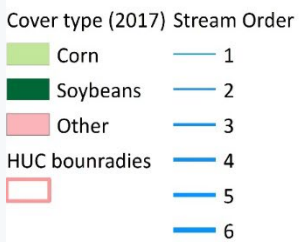
EXAMPLE WATERSHED

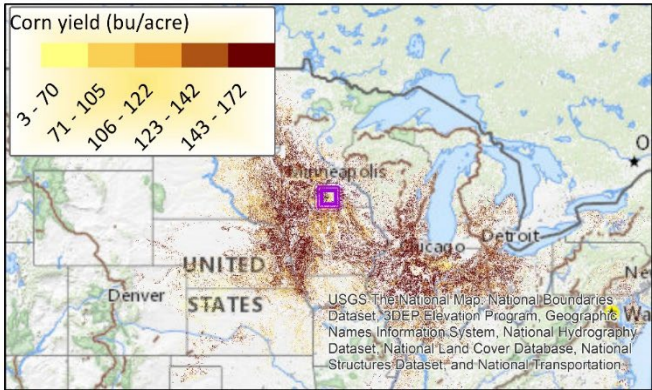
Le Sueur watershed

- Major watershed of the Minnesota River Basin.
- 2850 km^2
- Average annual mean flow ~ 21 m^3/s
- 87% - Agriculture → Corn-Soybean rotation
- Soils are poorly drained – most agriculture (~92%) is tile-drained.

	Water Yield Ratio (WYR)	Baseflow Ratio (BFR)
Target	0.329	0.557

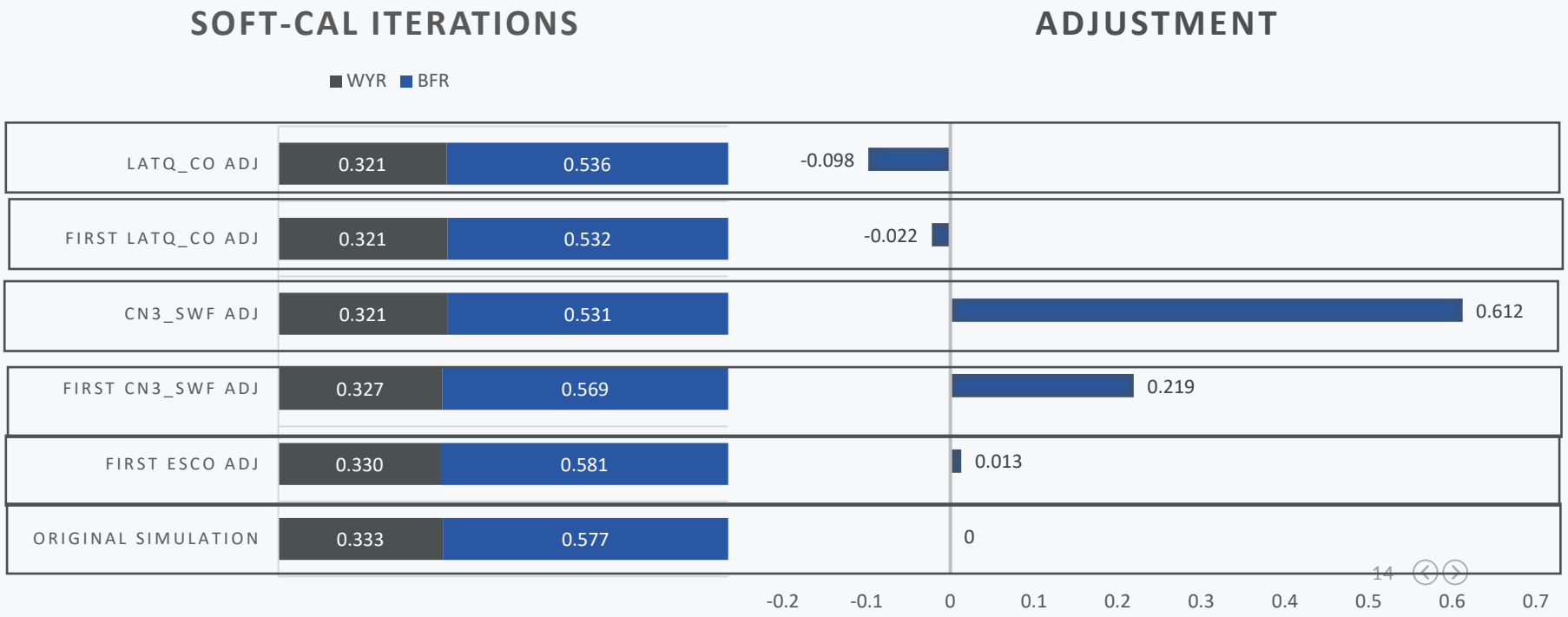






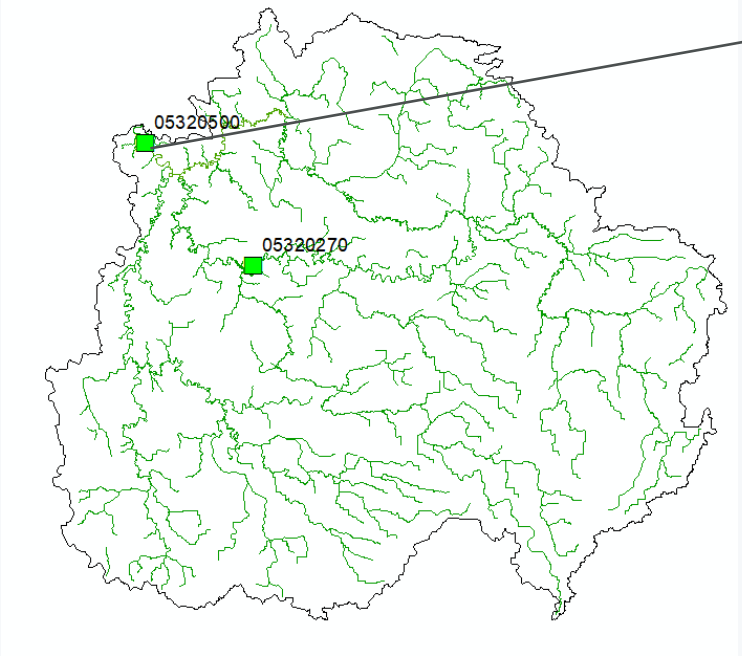
SOFT-CAL PARAMETER ADJUSTMENTS

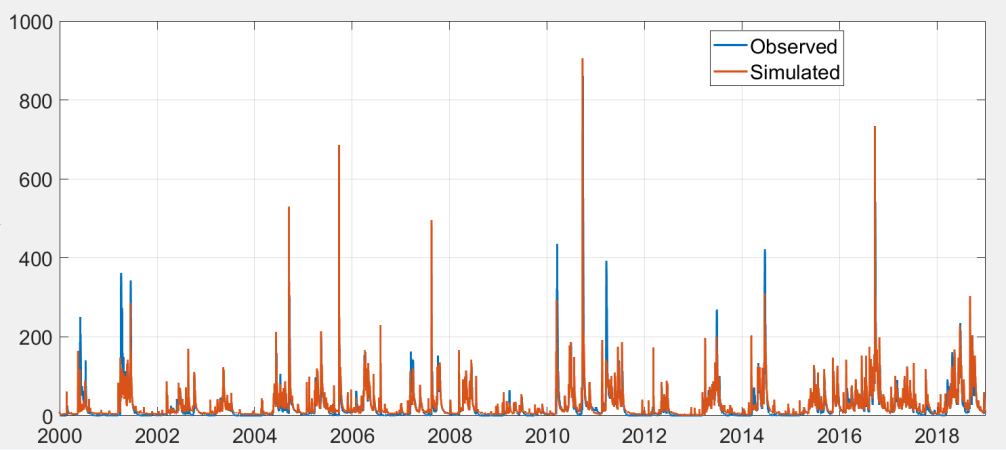
Steps



WHAT ABOUT HARD-CAL?

Improved stremflow

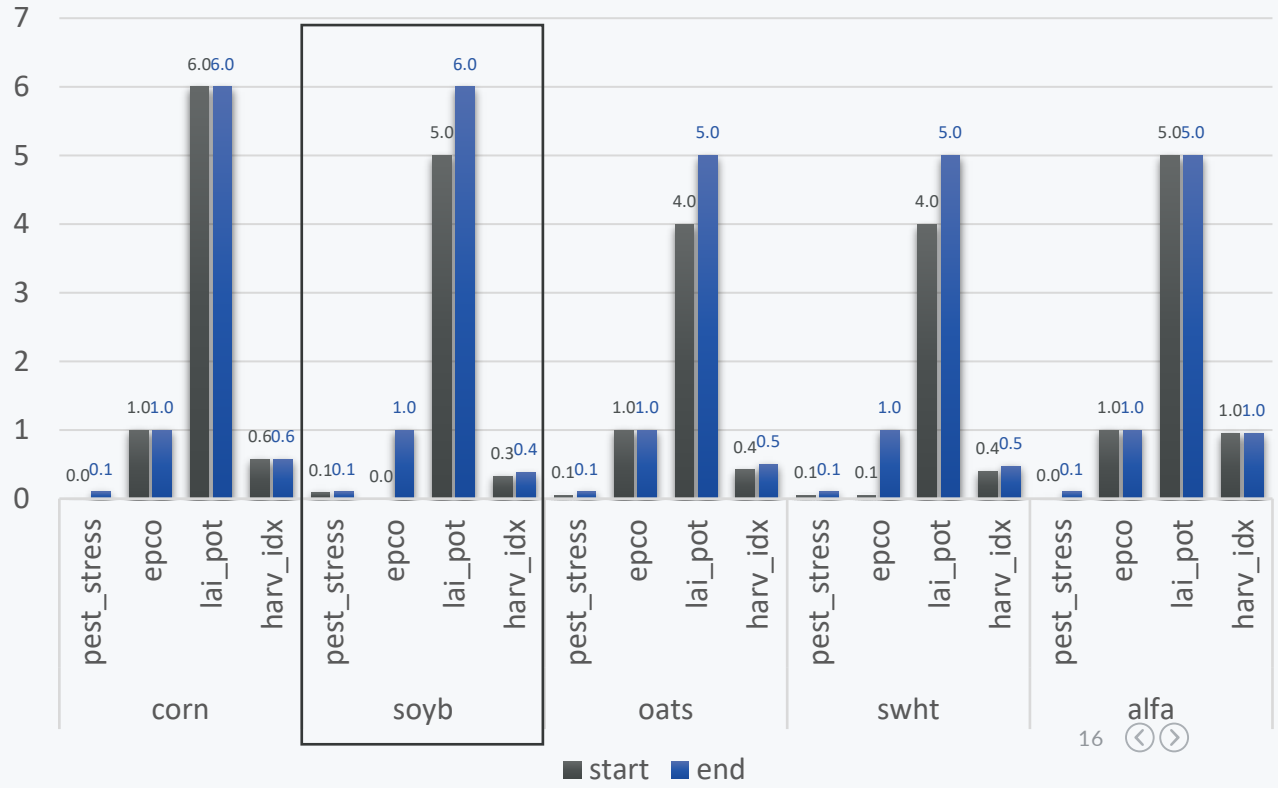




- Daily NSE for flow > 0.5

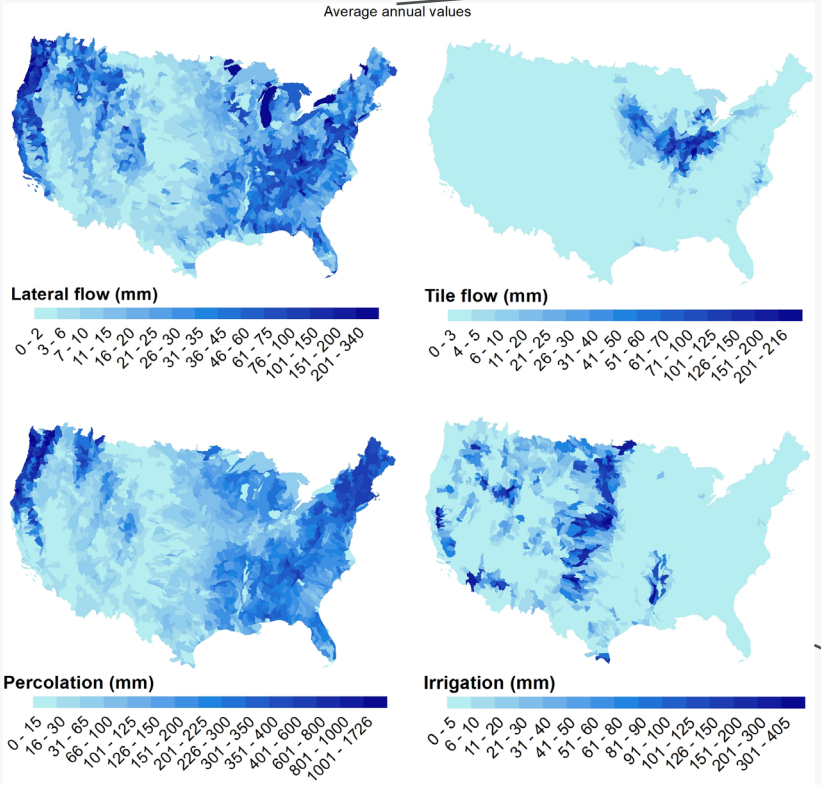
EXAMPLE CROP YIELD CALIBRATION

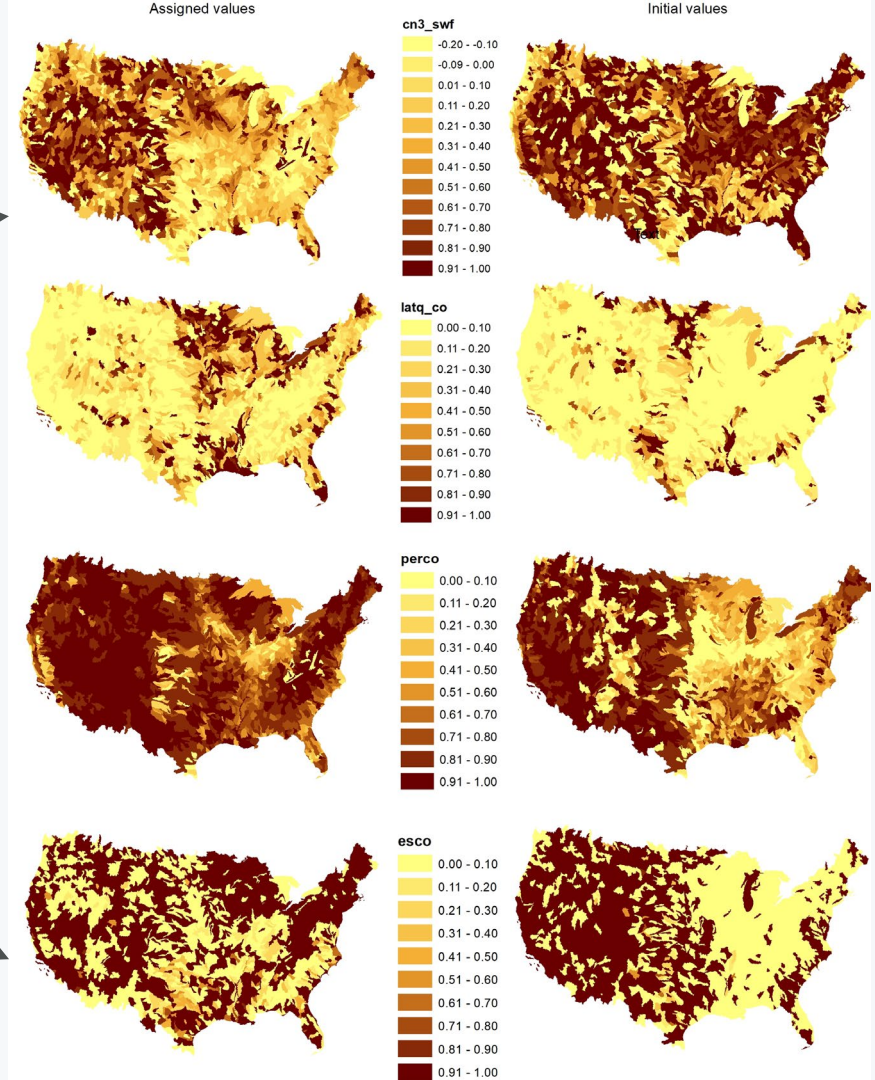
Crop	Initial yield (t/ha)	Calibrated yield (t/ha)	Target value (t/ha)
CORN	11.6	9.8	9.8
SOYB	2.3	2.3	2.3
OATS	3.2	2.0	2.1
SWHT	3.7	2.8	2.7
ALFA	4.9	3.3	4

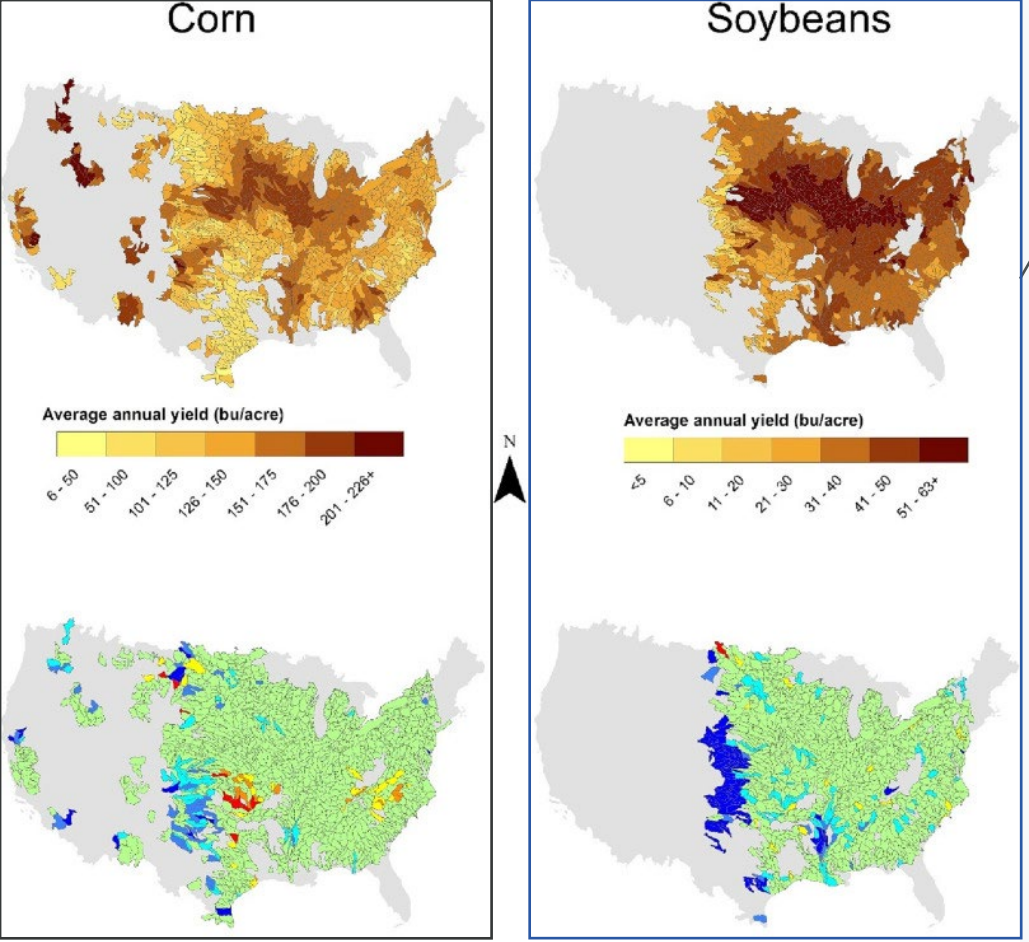


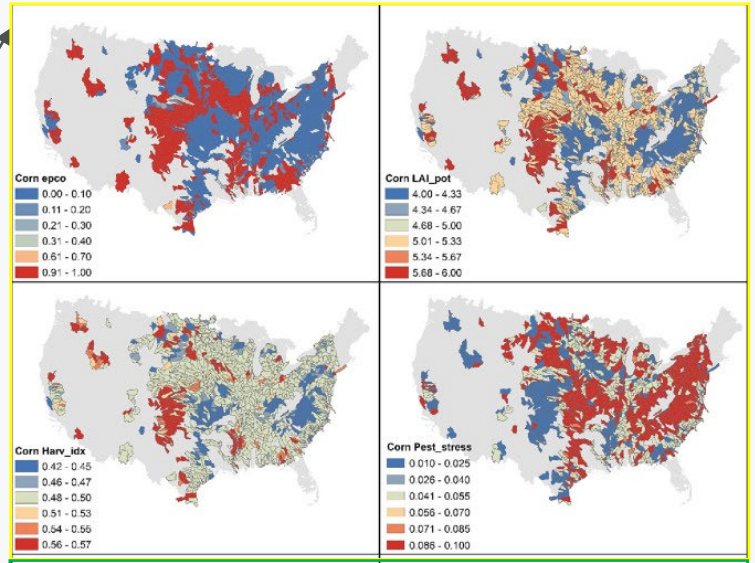
RUNNING SOFT-CAL AT LARGE SCALE

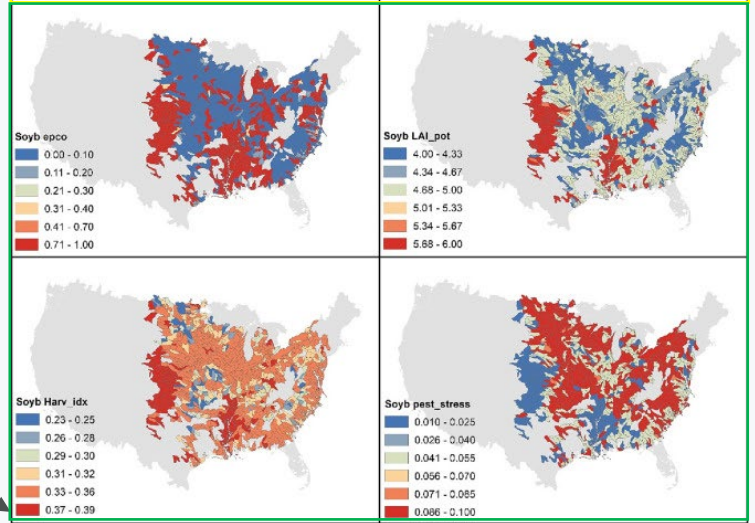
National Agroecosystems Model






Corn
Average annual yield (bu/acre)
6 - 50
51 - 100
101 - 125
126 - 150
151 - 175
176 - 200
201 - 226+
Soybeans
Average annual yield (bu/acre)
<5
6 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 63+
N
Average Annual Yield Relative Error
< -25%
-24% - -15%
-14% - -5%
-4% - 5%
6% - 15%
16% - 35%
> 38%


Corn epco
0.00 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.61 - 0.70
0.91 - 1.00
Corn LAI_pot
4.00 - 4.33
4.34 - 4.67
4.68 - 5.00
5.01 - 5.33
5.34 - 5.67
5.68 - 6.00
Corn Harv_idx
0.42 - 0.45
0.46 - 0.47
0.48 - 0.50
0.51 - 0.53
0.54 - 0.55
0.56 - 0.57
Corn Pest_stress
0.010 - 0.025
0.026 - 0.040
0.041 - 0.055
0.056 - 0.070
0.071 - 0.085
0.086 - 0.100


Soyb epco
0.00 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.70
0.71 - 1.00
Soyb LAI_pot
4.00 - 4.33
4.34 - 4.67
4.68 - 5.00
5.01 - 5.33
5.34 - 5.67
5.68 - 6.00
Soyb Harv_idx
0.23 - 0.25
0.26 - 0.28
0.29 - 0.30
0.31 - 0.32
0.33 - 0.36
0.37 - 0.39
Soyb pest_stress
0.010 - 0.025
0.026 - 0.040
0.041 - 0.055
0.056 - 0.070
0.071 - 0.085
0.086 - 0.100

PUBLISHED RESULTS

Full text available at

https://doi.org/10.1016/j.agsy.2023.103695

Agricultural Systems 210 (2023) 103695

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Field scale SWAT+ modeling of corn and soybean yields for the contiguous United States: National Agroecosystem Model Development

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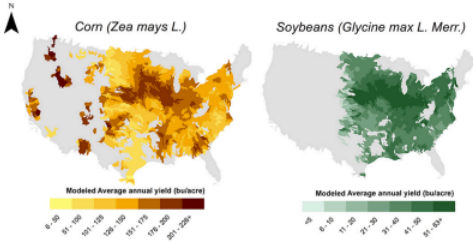
HIGHLIGHTS

- SWAT+: a high-resolution national-scale model for crop growth and yield estimation
- National scale model with over 2.5 M individual corn and soybeans fields simulated.
- Crop yield calibration procedure incorporated into the new SWAT+ model.

GRAPHICAL ABSTRACT

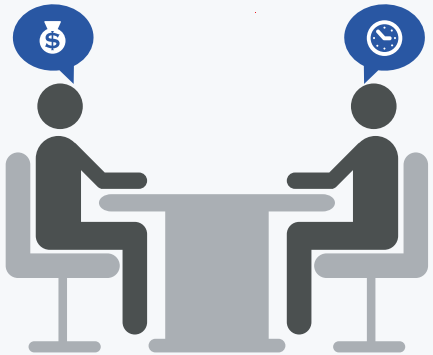


TO SUM-UP

Soft-cal

TEXAS A&M UNIVERSITY | TEXAS A&M AGRILIFE RESEARCH | USDA ARS Agricultural Research Service

THANK YOU!



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01 **IN-BUILD**
Does not require additional software

02 **FAST**
Runs in just a handful simulations

03 **MINIMAL INPUT**
Only several sof-cal values required as input

04 **REPEATABLE**
Can be reproducible with ease