Impact of climate change on predicted cotton production and water quality

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Objectives

- Conduct EPIC simulations for cotton production regions in the US

  A representative area was chosen from four regions
  Three representative soils were used for each area

- Evaluate impact of potential climate change on:

  Cotton yield
  Soil organic carbon
  Water quality

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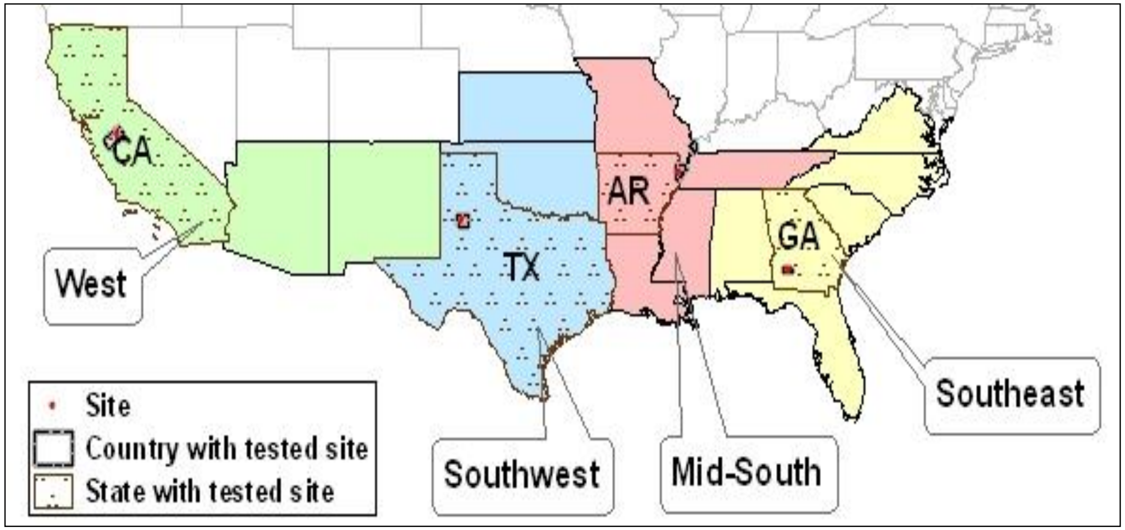
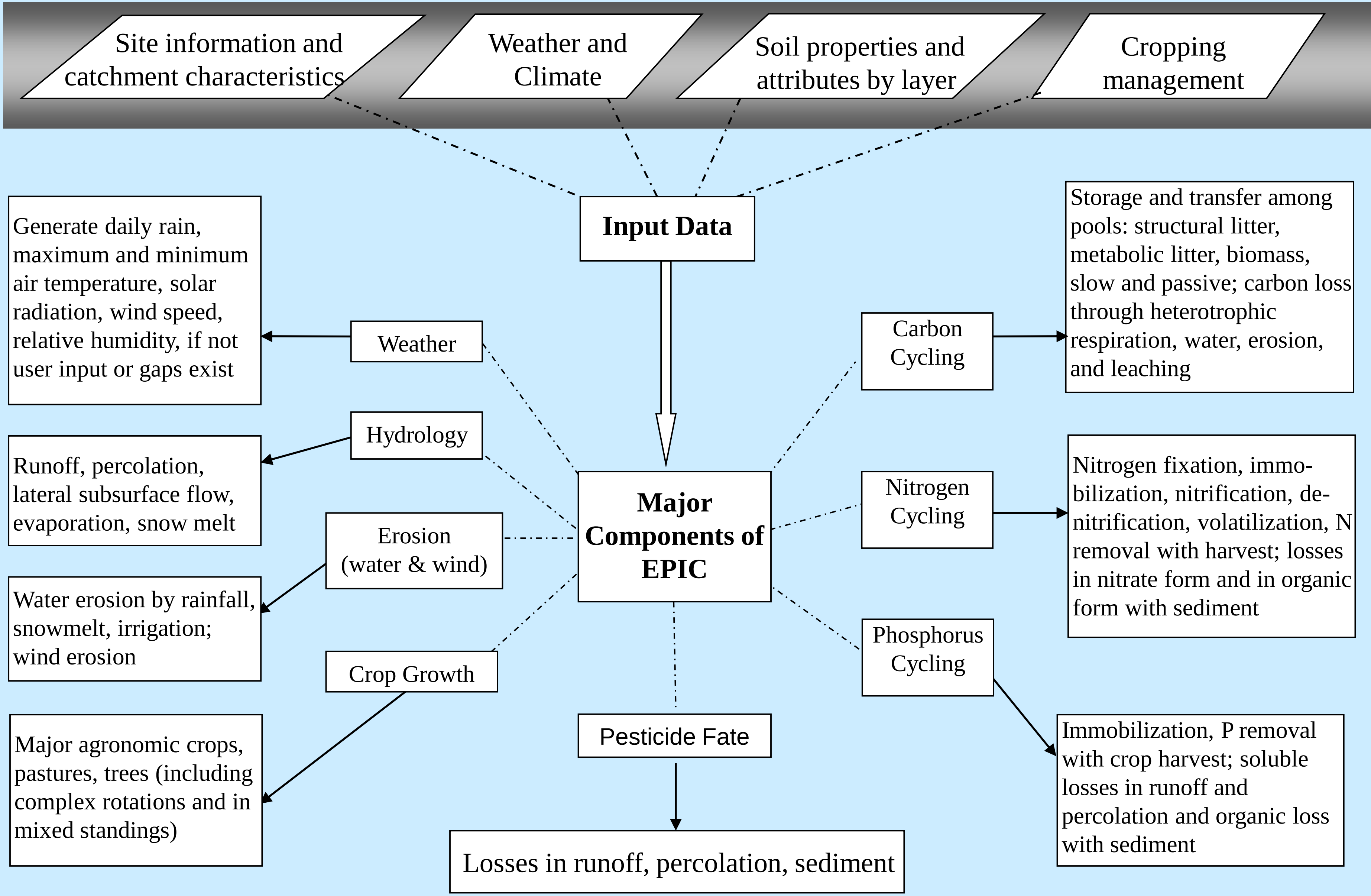
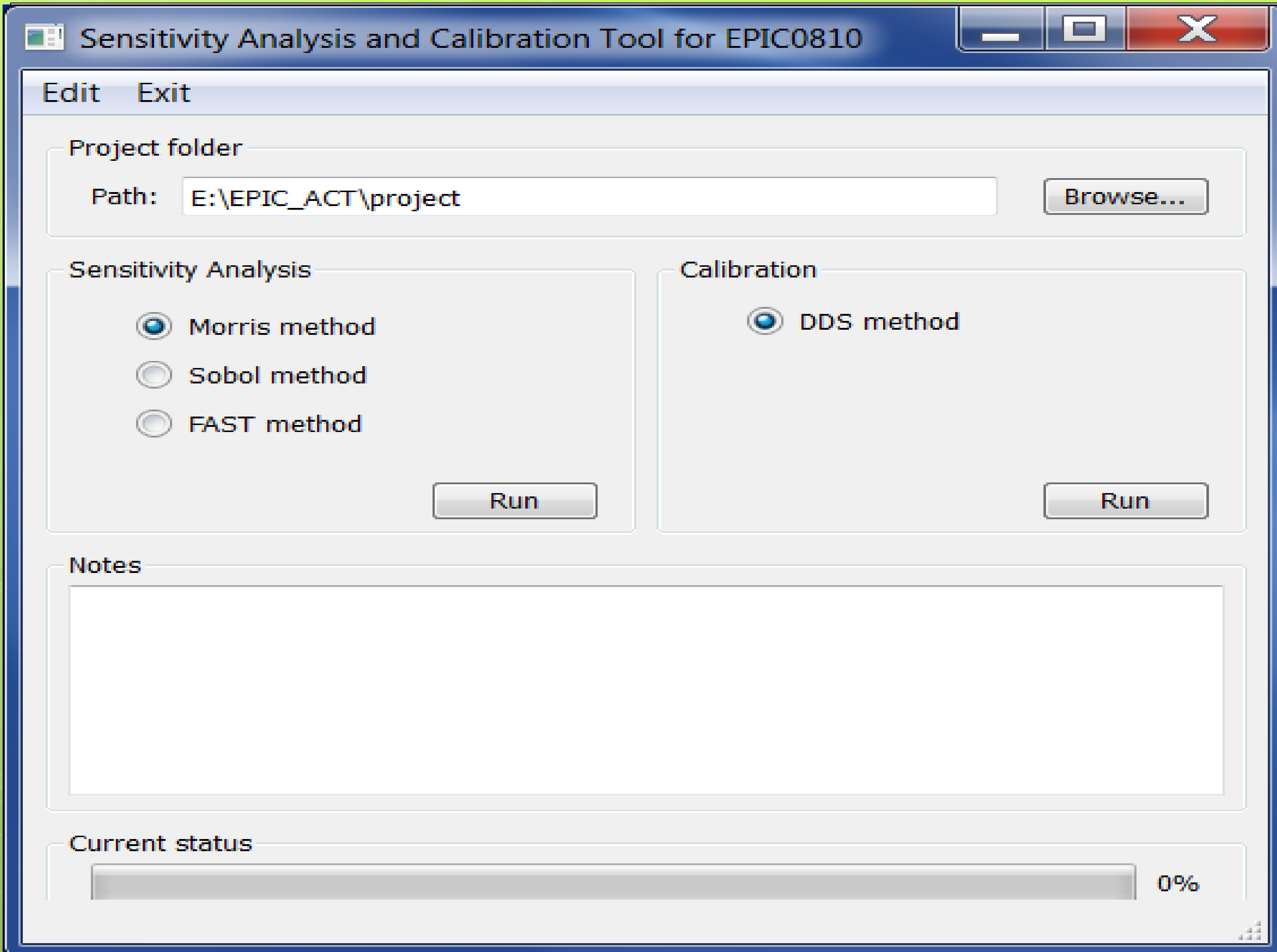
Cotton Belt



Environmental Policy Impact Calculator (EPIC)




Sensitivity Analysis and Calibration Tool for EPIC0810
Edit
Exit
Project folder
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E:\EPIC_ACT\project
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Sensitivity Analysis
Morris method
Sobol method
FAST method
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Calibration
DDS method
Run
Notes
Current status
0%

Input Data Source

Data type	Source
Weather (precipitation and temperature)	Geophysical Fluid Dynamics Laboratory’s CM2 climate model under the pessimistic SRES-A2 and B1 emissions scenario
Soils	Soils_5 database, National Soil Survey Laboratory
Crop Management	USDA-Economic Research Service, Natural Resource Survey Regional Summary, USDA Ag Census, Farm and Ranch Survey, and numerous regional cotton specialists and producers.
Pesticide properties	USDA-NRCS/UMass Extension pesticide properties database

Three representative SOILS at each site

Georgia	Arkansas	Texas	California
Alviso clay loam	Alligator clay	Randall clay	Alamo clay
Izagora silt sand	Commerce silty loam	Amarillo fine sandy loam	Merced silty loam
Orangeburg loamy sand	Crevasse loamy sand	Acuff loam	Atwater sand

- **Soil albedo**
- **Hydrologic soil group**
- **Soil attributes by layer:**
  - ✓ depth
  - ✓ field capacity, wilting point, bulk density
  - ✓ % sand, % silt
  - ✓ organic carbon
  - ✓ soil pH
  - ✓ saturated conductivity

Crop Management

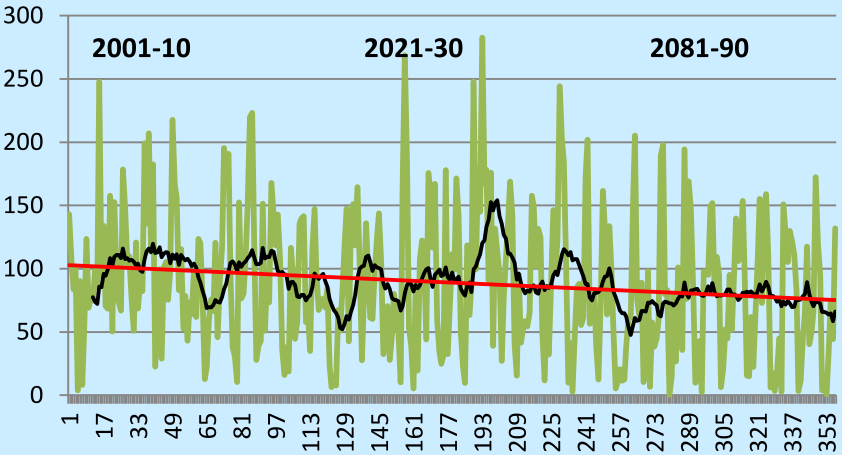
Location	Irrigation	Crop rotation	Tillage	Fertilizer
Dougherty, Georgia	Dryland	Cotton-Soybeans with Winter Wheat cover	No-till	March: 11.2 kg N/ha 21.5 kg P/ha June: 82.9 kg N/ha
Mississippi, Arkansas	Furrow irrigated	Cotton-Soybeans	Disk, Bedder	March: 11.2 kg N/ha 14.7 kg P/ha June: 106.4 kg N/ha
Merced, California	Furrow irrigated	Continuous Cotton	Five-bottom plow, Land plane, Lister, Disk bedder; Row cultivator	December: 11.2 kg N/ha 13.2 kg P/ha May: 156.8 kg N/ha
Lubbock, Texas	Sprinkler irrigated Dryland	Continuous Cotton	Disk, Bedder; Row cultivator	March: 11.8 kg N/ha 11.8 kg P/ha June: 112.6 kg N/ha (irrigated) 44.2 kg N/ha (dryland)

Influential EPIC parameters

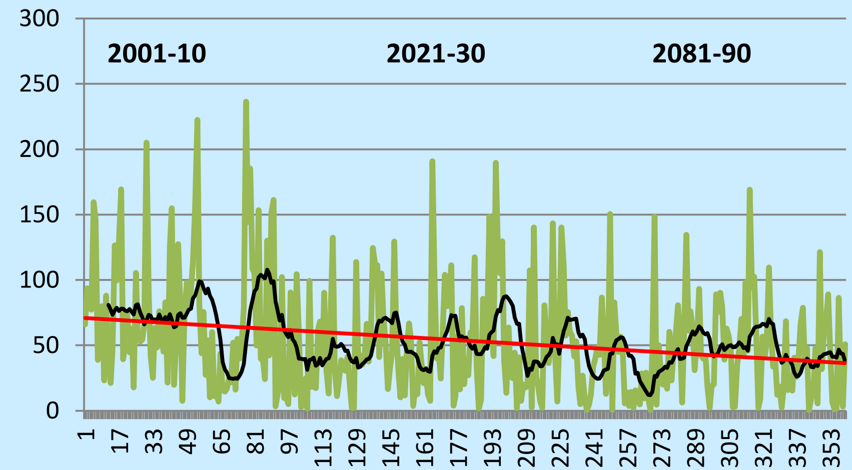
Process impacted directly	Influential parameter	Description	Range
Crop grain yield	WA	Biomass-energy ratio	± 3
	HI	Harvest index	± 0.05
	PHU	Potential heat units	± 400
	TBS	Base temperature for seed	± 2
Runoff	CN2	Initial condition II curve number (CN2) or landuse number (LUN)	± 5
	Parm42 (if NVCN=4)	Curve Number index coefficient	0.5 - 2.5
	Parm83 (if NVCN=0)	Curve number retention parameter coefficient	0.1 –2.0
Erosion/ sedimentation	Parm23	RUSLE c factor coefficient in exponential residue function in residue factor	0.5 - 1.5
	Parm26	RUSLE c factor coefficient in exponential crop height function in biomass factor	0.01 - 3.0
	PEC (having conservation)	Erosion control factor	0 - 1
	APM	Peak rate – EI_{30} adjustment factor	0 - 1.0
Phosphorus cycling	Parm8	Soluble P runoff coefficient	10 – 20
	Parm43	P upward movement by evaporation coefficient	1 – 20
Nitrogen and Carbon Cycling	Parm14	Nitrate leaching ratio	0.1 – 1.0
	Parm25	Biological mixing efficiency	0.1 – 0.5
	Parm7	N fixation coefficient	0 – 1
	Parm57	Volatilization/nitrification partitioning coefficient	0.05 – 0.5
	Parm20	Microbial decay rate coefficient	0.5 – 1.5
	FHP	Fraction of humus in passive pool	0.3 – 0.9
	FBM	Fraction of organic carbon in microbial biomass pool	0.005-0.06

Projections from GFDL CM2 SRES-A2 Show Increasing Temperatures and Decreasing Rainfall in Cotton-Growing Regions

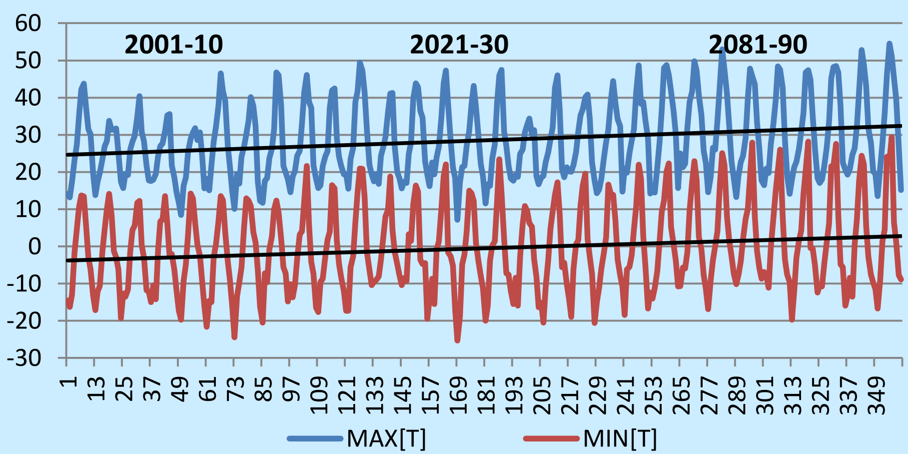
Monthly Precipitation (mm), Arkansas



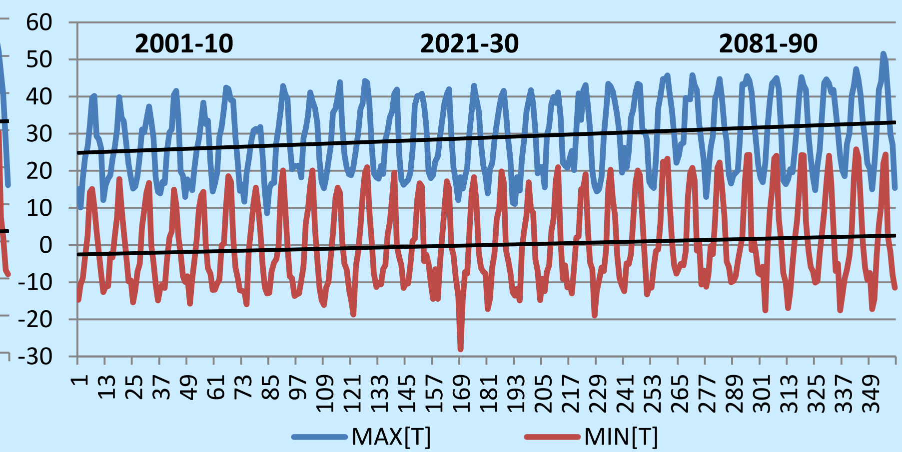
Monthly Precipitation (mm), Texas



Monthly Max & Min Temps (°C), Arkansas



Monthly Max & Min Temps (°C), Texas

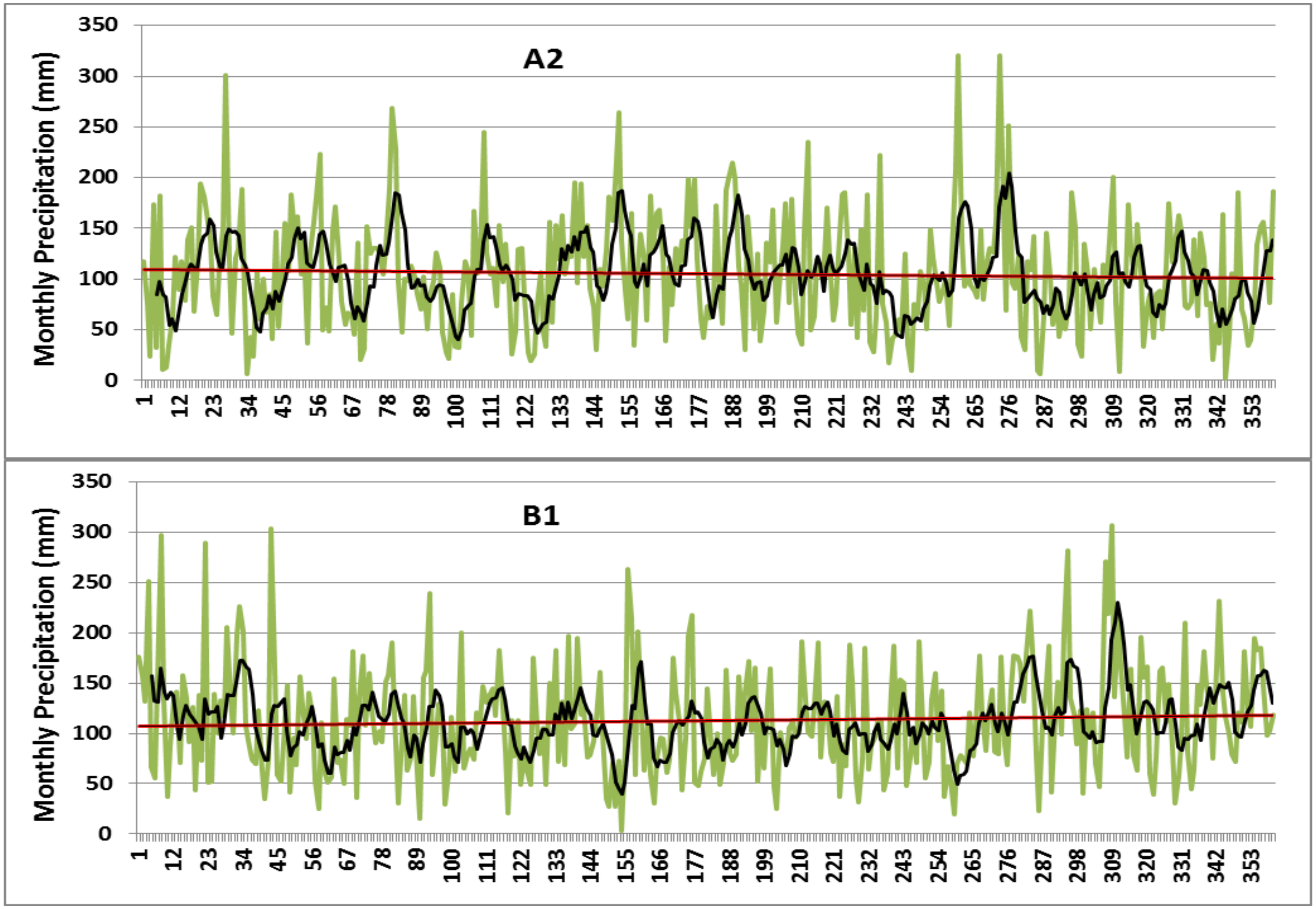


Projected Climate

GFDL CM2 SRES-A2 & B1 scenarios (2021-2050)

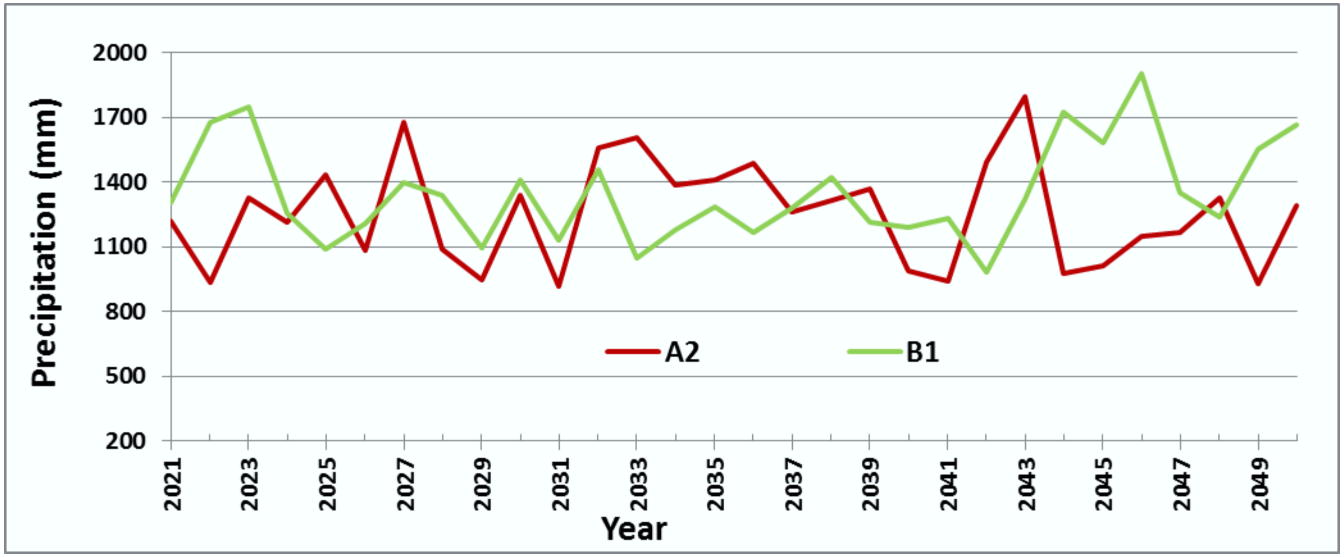
Scen-ario	Mid-South (Arkansas)			West (California)			Southeast (Georgia)			Southwest (Texas)		
	Avg-annual Rain	Avg-monthly		Avg-annual Rain	Avg-monthly		Avg-annual Rain	Avg-monthly		Avg-annual Rain	Avg-monthly	
		Tmax	Tmin		Tmax	Tmin		Tmax	Tmin		Tmax	Tmin
A2	1124	19.87	9.54	380	17.27	6.85	1265	22.13	13.18	415	21.36	8.37
B1	1304	19.28	9.10	359	16.88	6.45	1352	21.73	12.92	500	20.56	7.99
B1-A2	180	-0.59	-0.44	-21	-0.39	-0.4	87	-0.4	-0.26	85	-0.8	-0.38

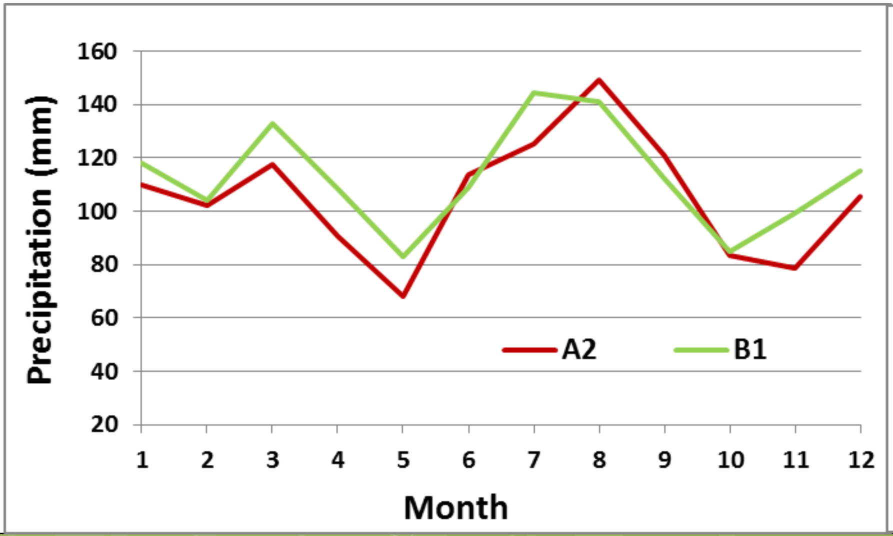
Projected rainfall from GFDL CM2 SRES-A2 and B1 (2021-2050) at Albany, Georgia

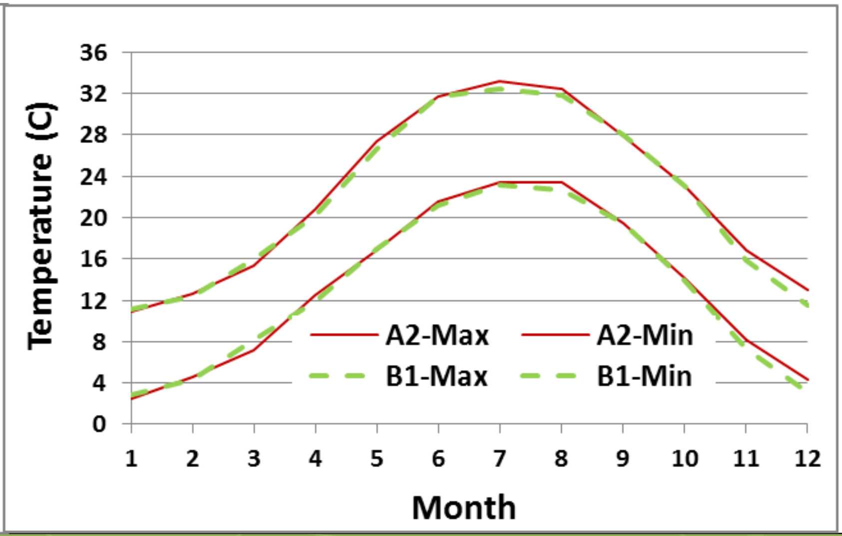


Month

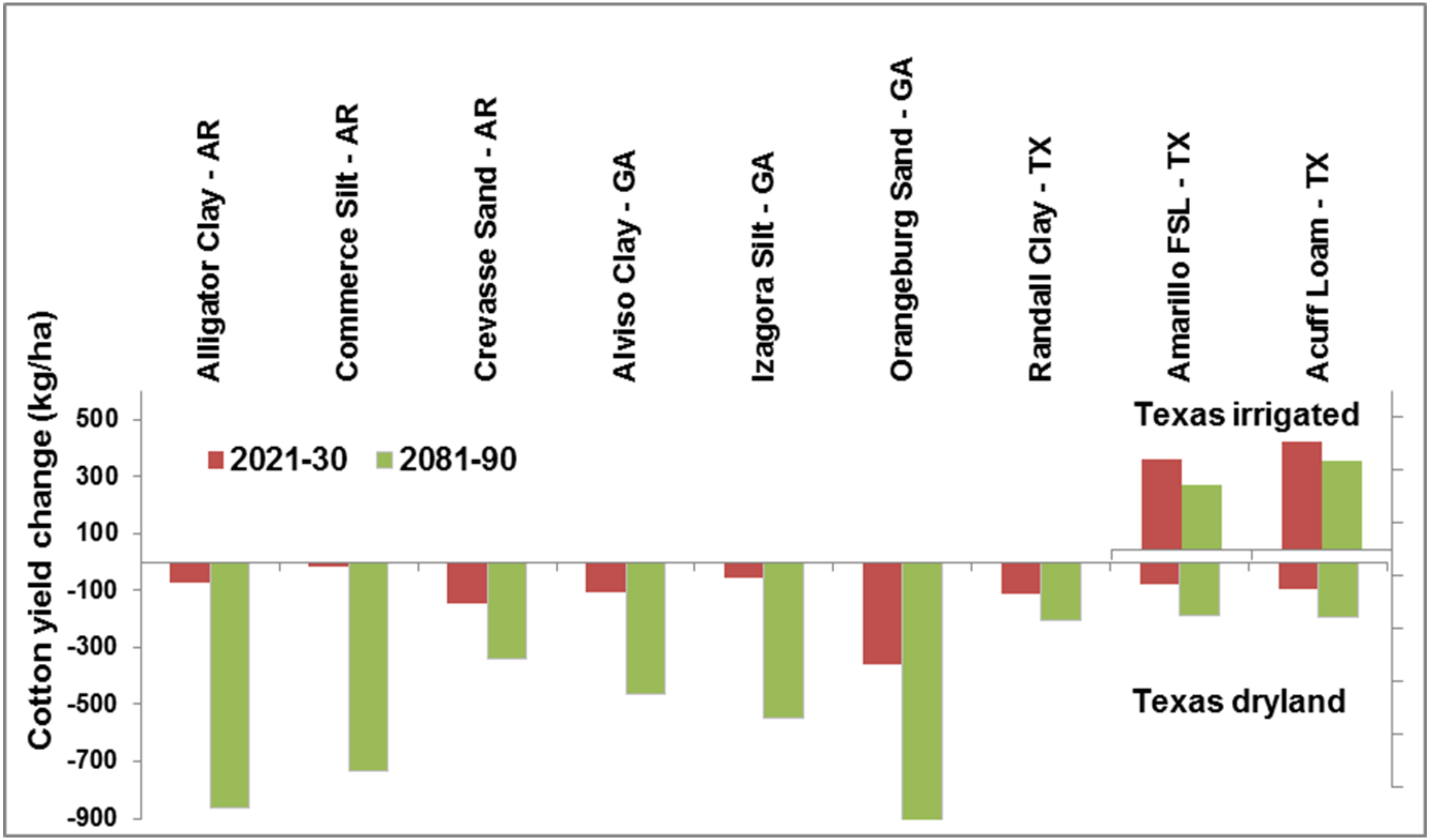
Albany, Georgia: Projected Rainfall and Max and Min Temperature (2021-2050)





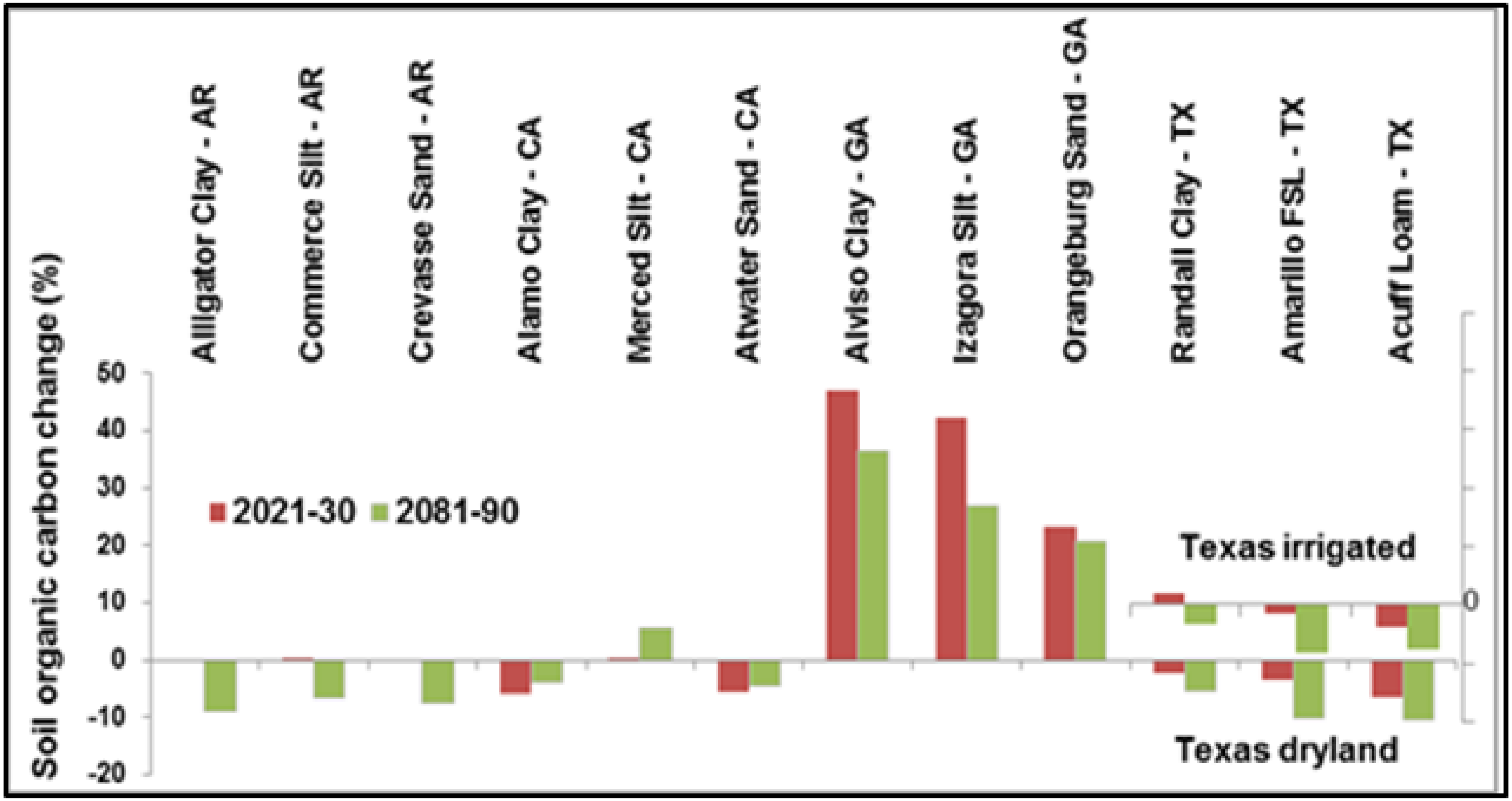


Results: Cotton Yield Change



SRES-A2 compared with 1960-2010

Soil Organic Carbon Change Across the Production Area



SRES-A2 compared with 1960-2010

Soil attributes by layer for the three soils at Georgia site

Soil layer	Depth (m)	Field capacity (m m-1)	Wilting point (m m-1)	Saturated conductivity (mm h-1)	Bulk density (t m-3)	Sand (%)	Silt (%)	Clay (%)	PH	Organic carbon (%)	
GA: Alviso Clay Loam, 0-2% slopes											26 Mg/ha
1	0.18	0.29	0.18	3	1.35	33.39	31.61	35	7.5	0.29	
2	1.14	0.3	0.18	3	1.28	7.47	55.03	37.5	7.5	0	
3	1.52	0.07	0.04	88	1.63	93.52	1.48	5	7.25	0	
GA: Izagora Silt, 0-2% slopes											28 Mg/ha
1	0.2	0.2	0.11	28	1.43	62	24	14	5.8	0.43	
2	0.38	0.2	0.11	28	1.53	62	24	14	5.7	0.43	
3	1.17	0.29	0.15	9	1.57	39	37	24	5.65	0.02	
4	2.31	0.36	0.25	1	1.66	26	28	46	4.6	0	
GA: Orangeburg Loamy Sand, 0-2% slopes											47 Mg/ha
1	0.2	0.2	0.05	28	1.45	84	9	7	5.8	0.75	
2	0.33	0.2	0.05	28	1.45	84	9	7	5.7	0.75	
3	0.41	0.23	0.07	28	1.53	68	20	12	5.65	0.25	
4	1.83	0.3	0.14	9	1.68	56	18	26	5	0.03	

Crop Management

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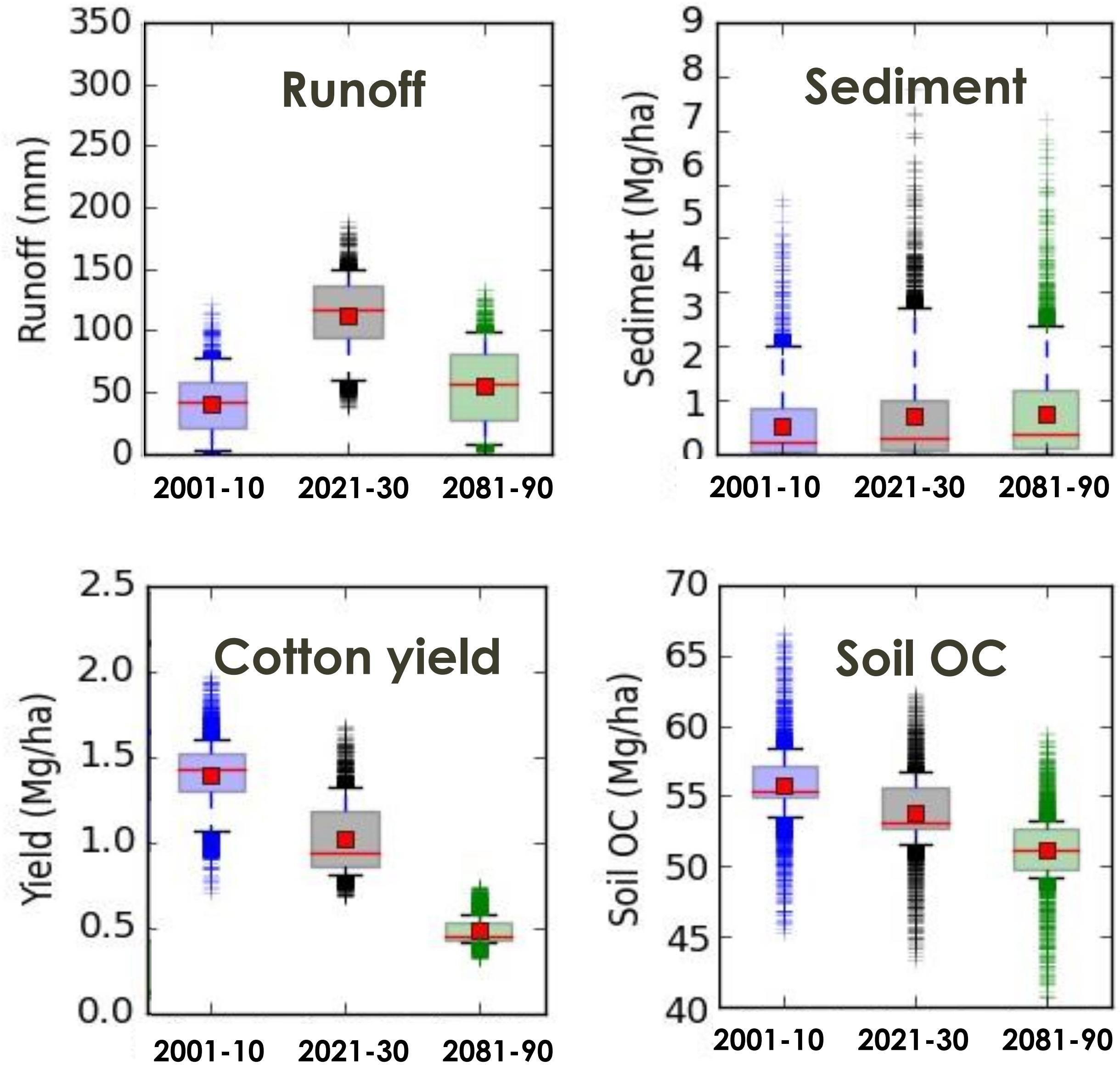
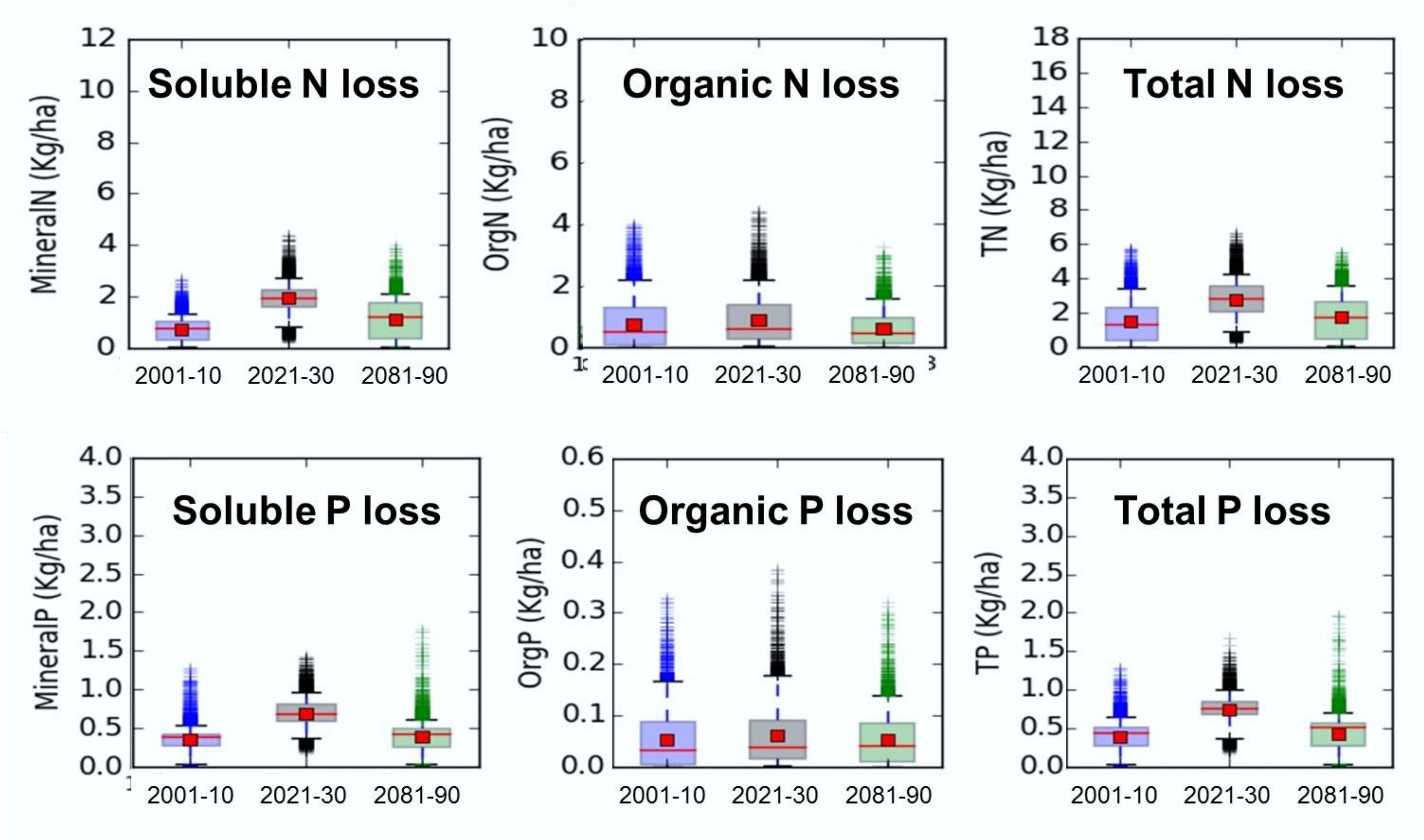
SRES-A2

Orangeburg loamy sand

Albany, Georgia

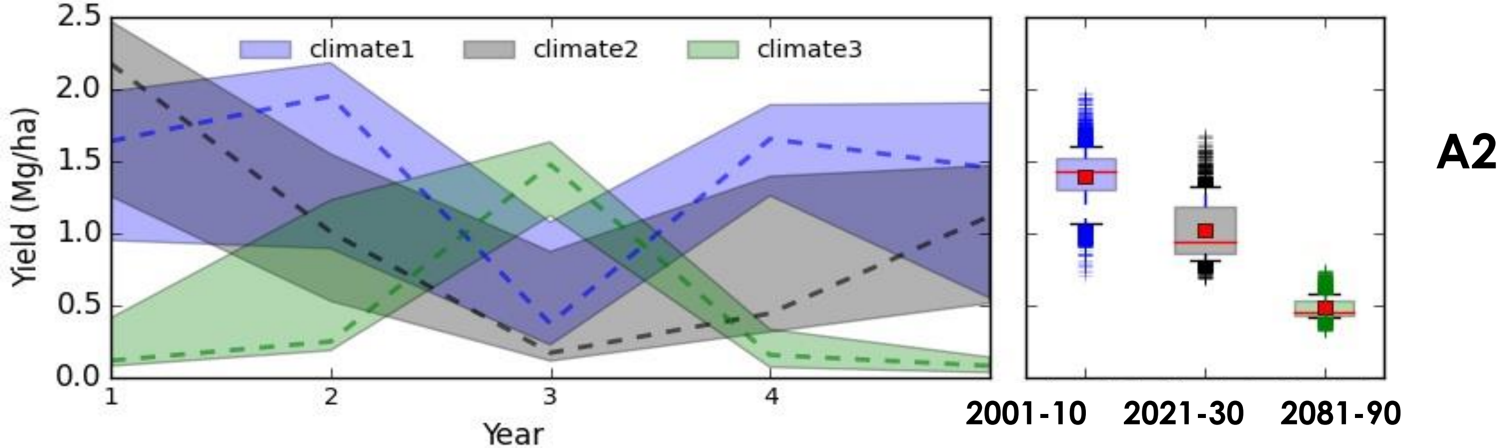


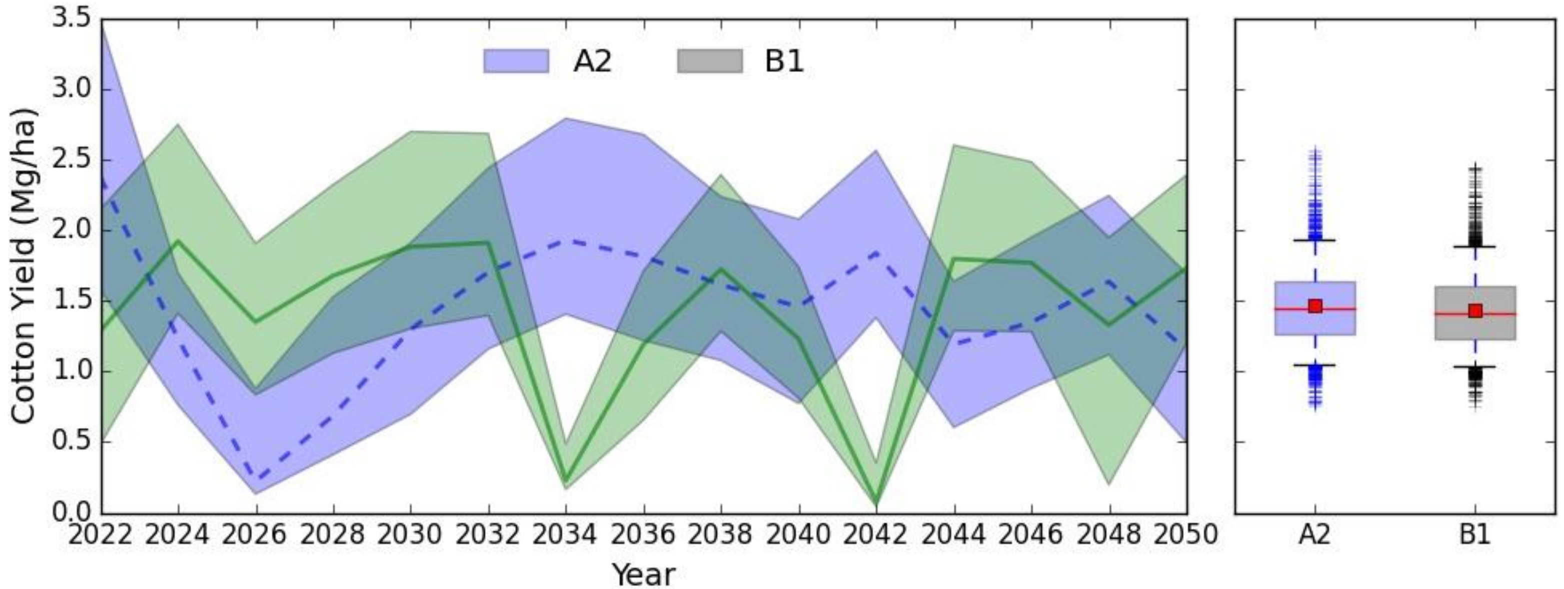
Nitrogen & Phosphorus Loss (SRES-A2)



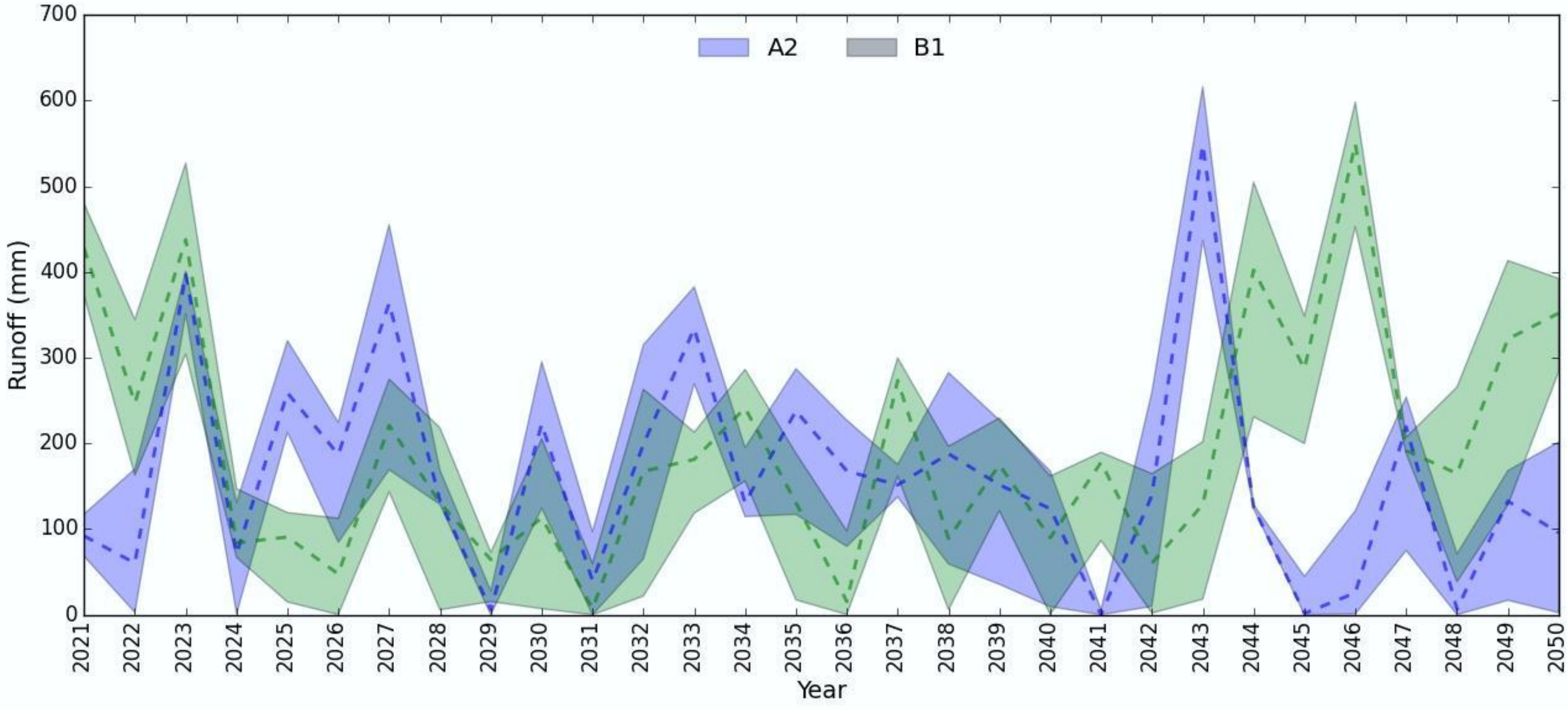
Orangeburg loamy sand, Albany, Georgia

Cotton Yield: SRES-A2 and B1, Albany, Georgia



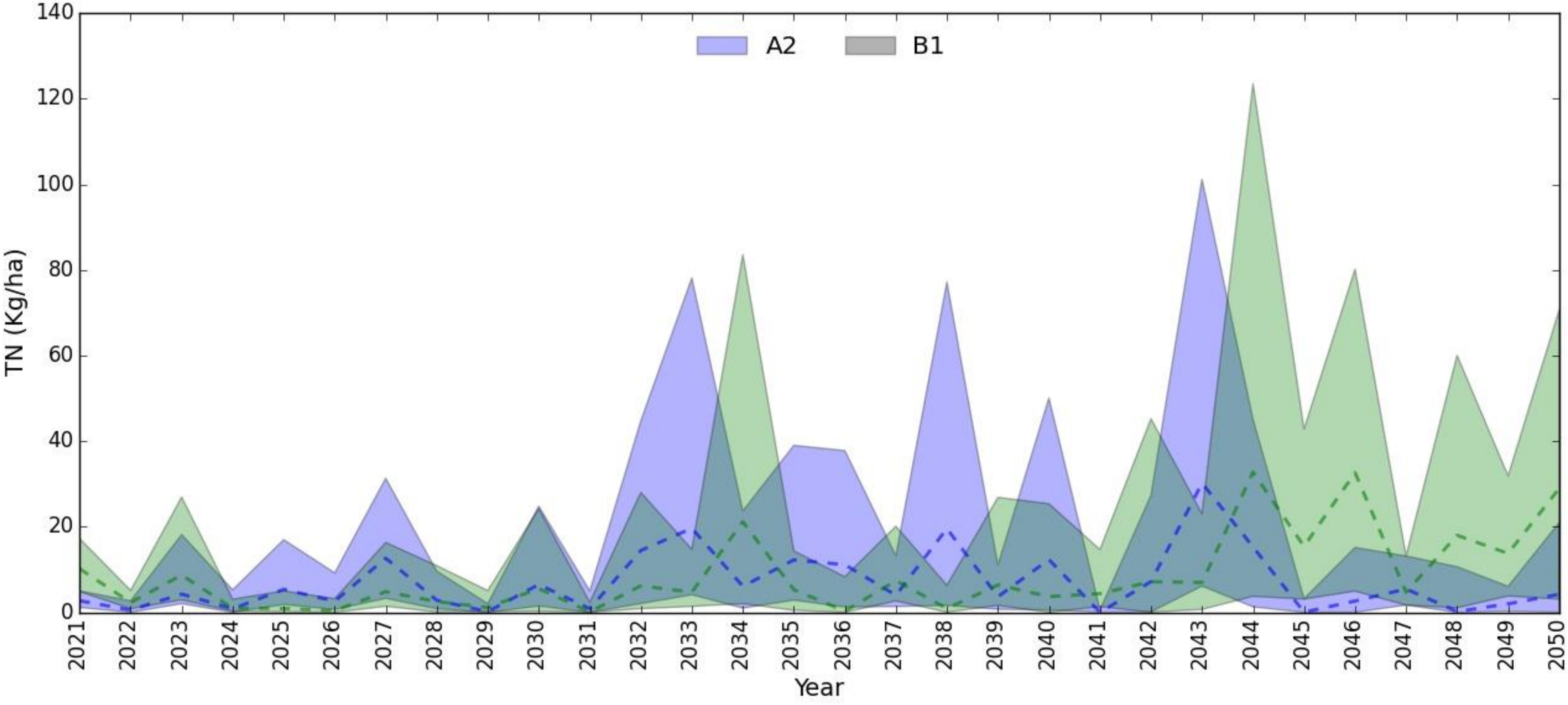


Runoff: SRES-A2 and B1 (2021-2050)



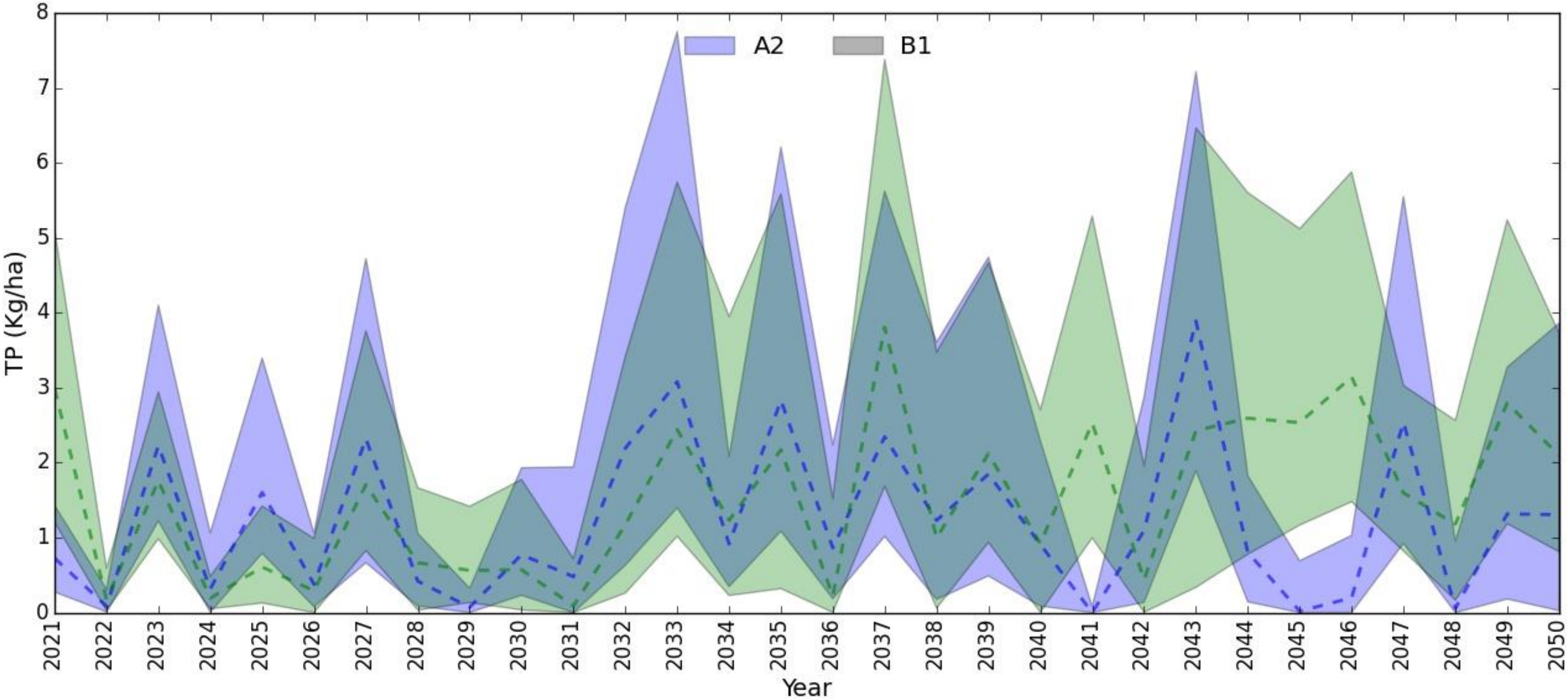
Orangeburg loamy sand, Albany, Georgia

Total N Loss: SRES-A2 and B1 (2021-2050)



SRES-A2 & B1, Orangeburg loamy sand, Albany, Georgia

Total P Loss: SRES-A2 and B1 (2021-2050)



SRES-A2 & B1, Orangeburg loamy sand, Albany, Georgia

Conclusions

- Projected higher temperature and reduced precipitation are likely to decrease cotton yield.
- If there is sufficient water for irrigation, we could see an increase in cotton yield in West Texas, for example.
- Soil organic carbon content decreased with climate warming which is correlated with decreased yield.
- Sediment, organic N and P losses are expected to increase in the later decades.
- Although climate scenarios of SRES-A2 and B1 in the Southeast US show yearly variations, the average annual predicted cotton yield and water quality show similar distribution in the mid-century.

Questions?

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Thanks