Updates to the crop model for CLM6 (and since CLM5)

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NSF NCAR CGD TSS

February, 2024

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Overview

Covering changes since CLM5.0 (Lombardozzi et al., 2020, *JGR Biogeosci.*)

JGR Biogeosciences

RESEARCH ARTICLE
10.1029/2019JG005529

Special Section:
Community Earth System Model version 2 (CESM2) Special Collection

Simulating Agriculture in the Community Land Model Version 5

Danica L. Lombardozzi[1], Yaqiong Lu[2], Peter J. Lawrence[1], David M. Lawrence[1], Sean Swenson[1], Keith W. Oleson[1], William R. Wieder[1], and Elizabeth A. Ainsworth[3]

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CTSM5.1

- Bioenergy crops

CTSM5.2 (coming soon)

- New outputs
- Crop distribution updates
- Tillage
- Residue removal
- Prescribed crop calendars *(experimental)*

CTSM6 (in progress)

- Improved crop calendars

Other

- Narender Reddy: Improved Indian wheat and rice phenology

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CTSM5.1: Bioenergy crops

- *Miscanthus* and switchgrass
- Uptake more C than maize/soy rotation, with similar evapotranspiration
- Not actually in CTSM land-use inputs at this point

JAMES Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2019MS001719

Special Section:
Community Earth System Model version 2 (CESM2) Special Collection

Parameterizing Perennial Bioenergy Crops in Version 5 of the Community Land Model Based on Site-Level Observations in the Central Midwestern United States

Yanyan Cheng[1], Maoyi Huang[1], Min Chen[2], Kaiyu Guan[3,4], Carl Bernacchi[5,6,7], Bin Peng[3,4], and Zeli Tan[1]

Key Points:

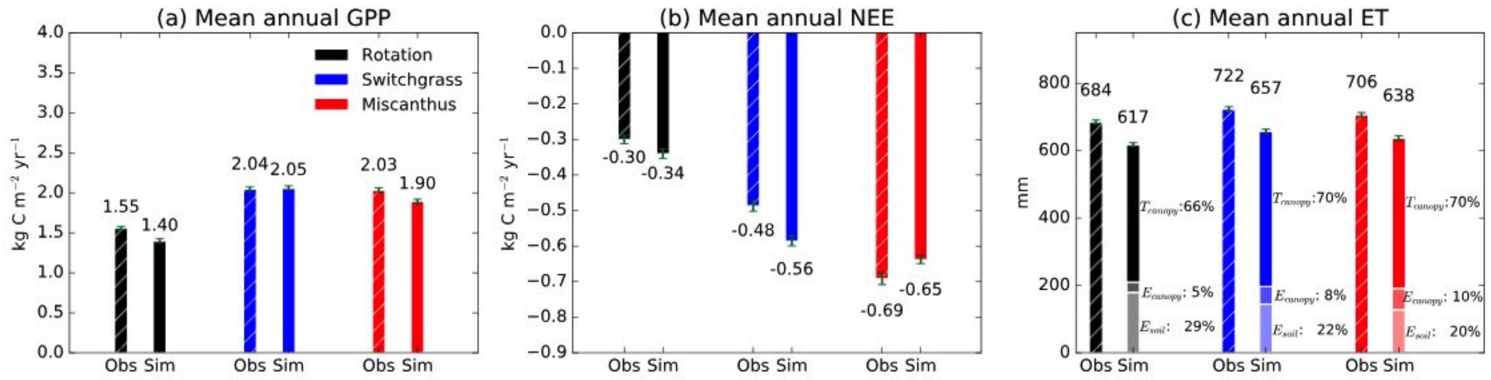

Figure 6. Five-year-average observed (hatched) and simulated annual (a) gross primary productivity (GPP), (b) net ecosystem exchange (NEE), and (c) evapotranspiration (ET) together with its component contribution for maize/soybean rotation (black bar), switchgrass (blue bar), and Miscanthus (red bar). Obs: observed; Sim: simulated; E_{soil}: soil evaporation; E_{canopy}: canopy evaporation; T_{canopy}: canopy transpiration.

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CTSM5.2: New outputs

tinyurl.com/ctsm-outputs-nofates
CTSM User's Guide Sect. 1.2.5

- **GRAINC_TO_FOOD_ANN**: You don't have to save daily GRAINC_TO_FOOD to get yield anymore!
- Sowing and harvest dates: **SDATES**, **HDATES**
- Nitrogen in harvested crop biomass: **GRAINN_TO_FOOD**, **GRAINN_TO_SEED**
- Various per-harvest (**_PERHARV**) outputs: Simplifies analyses for individual growing seasons

Docs » 1. CTSM1 User's Guide » 1.2. Setting Up and Running a Case »
1.2.5. CTSM History Fields (nofates)
View page source

1.2.5. CTSM History Fields (nofates)

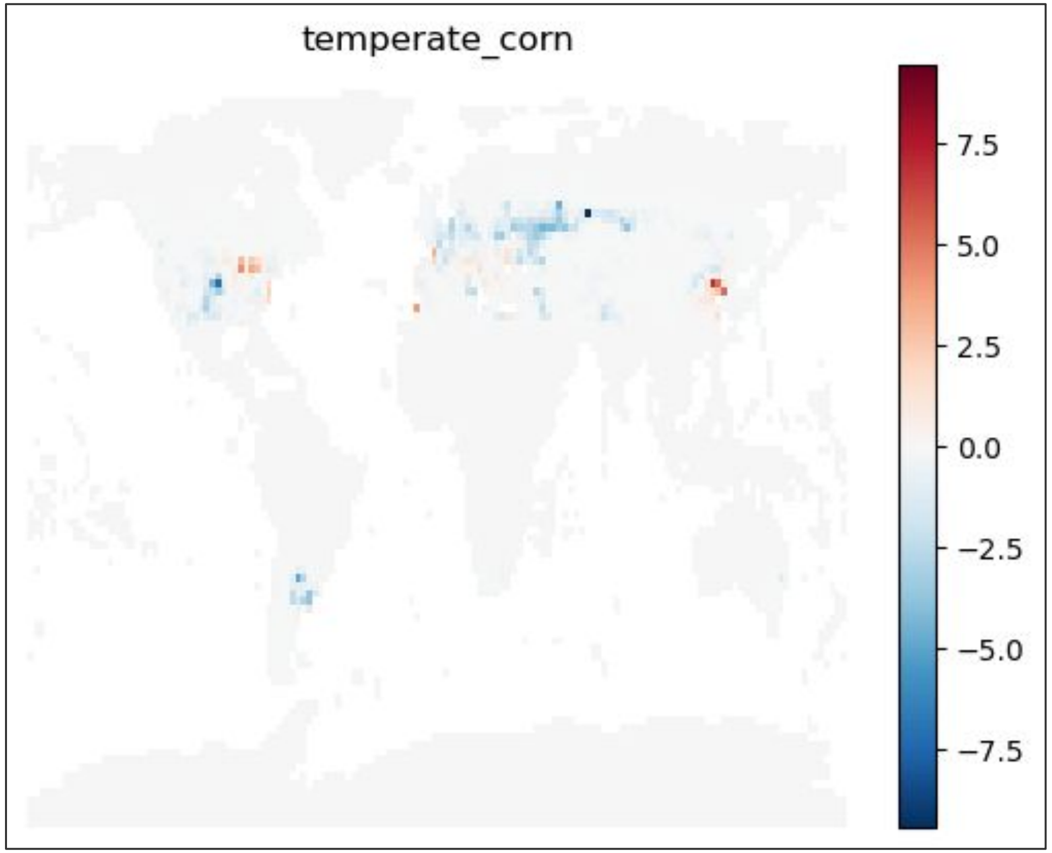
CAUTION: Not all variables are relevant / present for all CTSM cases. Key flags used in this CTSM case: use_cn = T use_crop = T use_fates = F

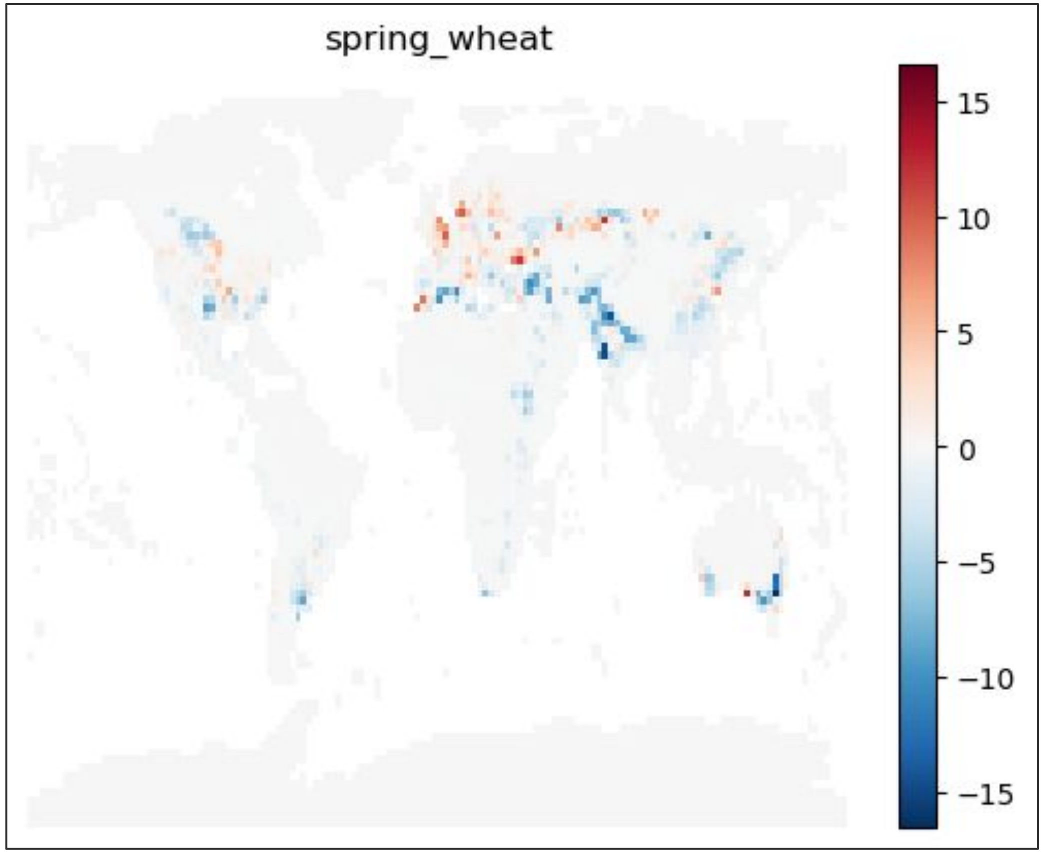
CTSM History Fields

Variable Name	Level Dim.	Long Description
A10TMIN	•	10-day running mean of mir
A5TMIN	•	5-day running mean of min :
ACTUAL_IMMOB	•	actual N immobilization
AGLB	•	Aboveground leaf biomass

CTSM5.2: Improved crop distributions

Change in % of gridcell, 2010, CTSM 5.1 to 5.2





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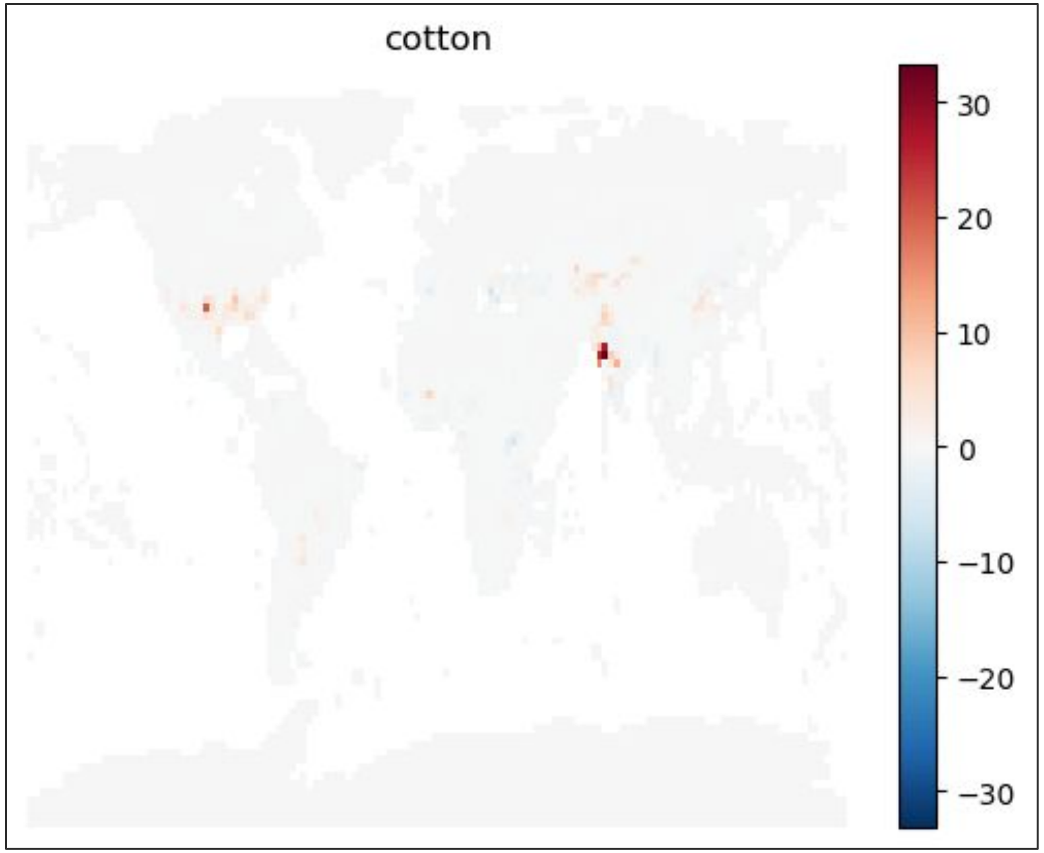

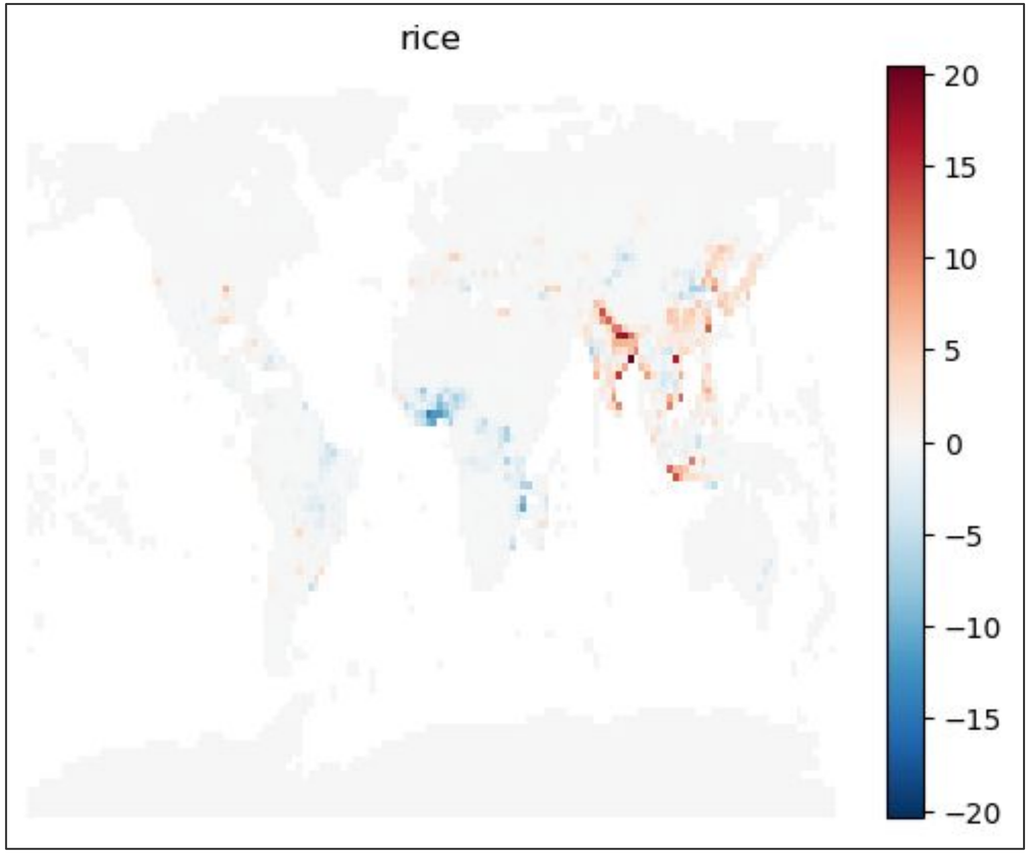

CTSM5.2: Tillage

IOP Publishing Environ. Res. Lett. 16 (2021) 054055 https://doi.org/10.1088/1748-9326/abe6c6

ENVIRONMENTAL RESEARCH
LETTERS

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LETTER

Modest capacity of no-till farming to offset emissions over 21st century

Michael W Graham[1], R Quinn Thomas[2], Danica L Lombardozzi[3] and Megan E O'Rourke[4]

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2 Department of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg 20461, VA, United States of America
3 National Center for Atmospheric Research, Boulder 80305, CO, United States of America
4 National Institute of Food and Agriculture, United States Department of Agriculture, Kansas City 64133, KS, United States of America

E-mail: graham.mic@gmail.com

Tillage as a multiplier (>1) on decomposition rate in top 26 cm of soil

Table 1. Decomposition rate multipliers for various soil carbon pools based on DayCent tillage implements for 'high' and 'low' intensive tillage treatments. DAP = days after planting; Litter2 = CLM litter pool 2; Litter3 = CLM litter pool 3; SOM1 = CLM soil organic matter pool 1; SOM2 = CLM soil organic matter pool 2; SOM3 = CLM soil organic matter pool 3.

Default "low" intensity

DAP	Litter2	Litter3	SOM1	SOM2	SOM3
		High intensity scenario			
0–15	1.8	1.8	1.2	4.8	4.8
15–45	1.5	1.5	1	3.5	3.5
45–75	1.1	1.1	1	2.5	2.5

CTSM5.2: Residue removal

Evaluating the Interactions of Crop Management, Carbon Cycling, and Climate Using Earth System Modeling and Remote Sensing

Michael William Graham

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Geospatial and Environmental Analysis

Megan E. O'Rourke, Chair
R. Quinn Thomas, Co-Chair
James B. Campbell, Member
Brian D. Strahm, Member

August 1, 2019
Blacksburg, Virginia

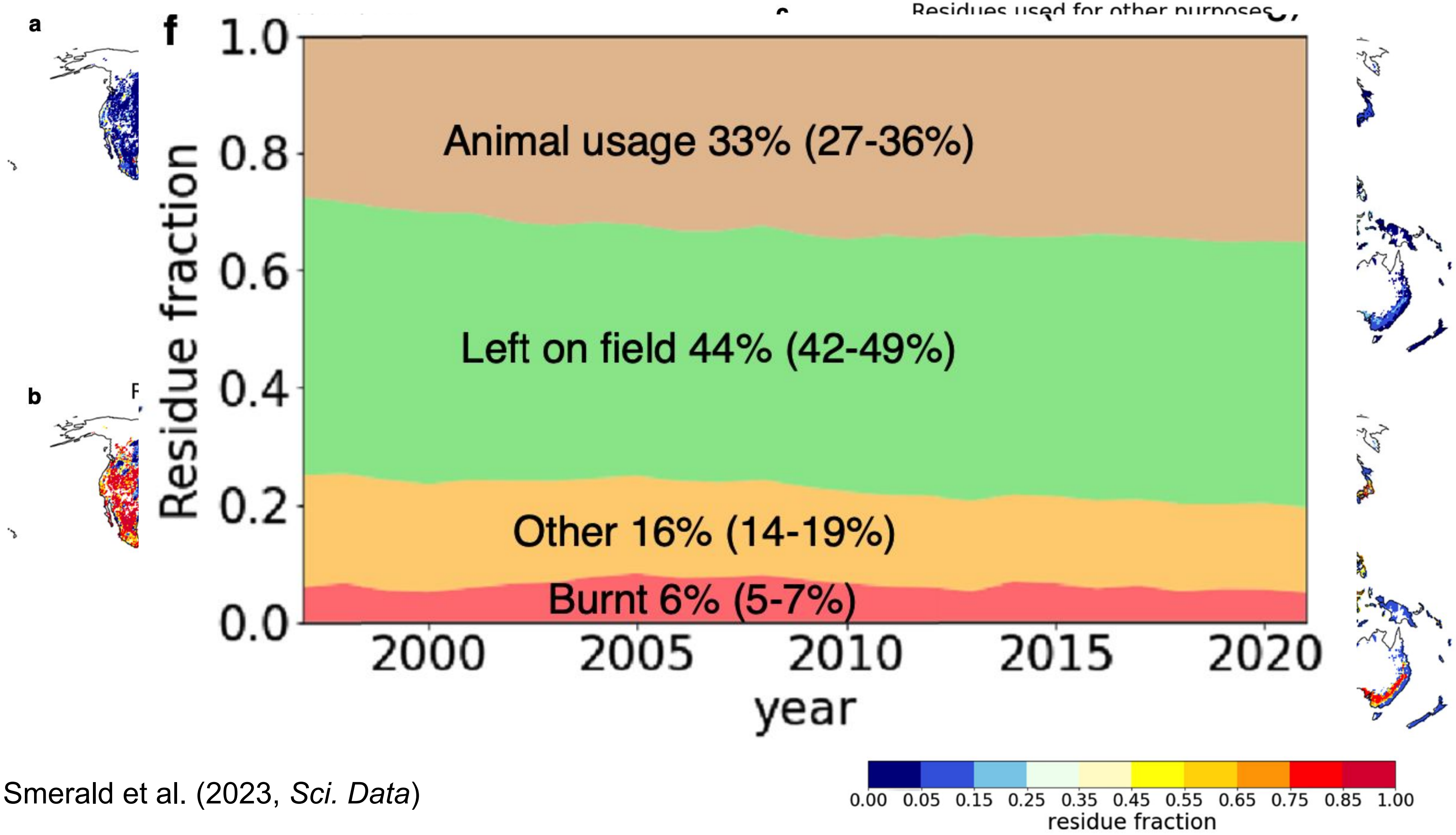
CHAPTER 4. ADDING FULL RANGE OF CROP MANAGEMENT PRACTICES INCREASES LAND USE CHANGE EMISSIONS AND REDUCES SOIL CARBON IN THE COMMUNITY LAND MODEL

Graham, M.W., R.Q. Thomas, D.L. Lombardozzi, M.E. O'Rourke

CTSM5.2: Residue removal

Leaves & stem remaining after harvest
→ "crop product" pool (1-yr res. time)

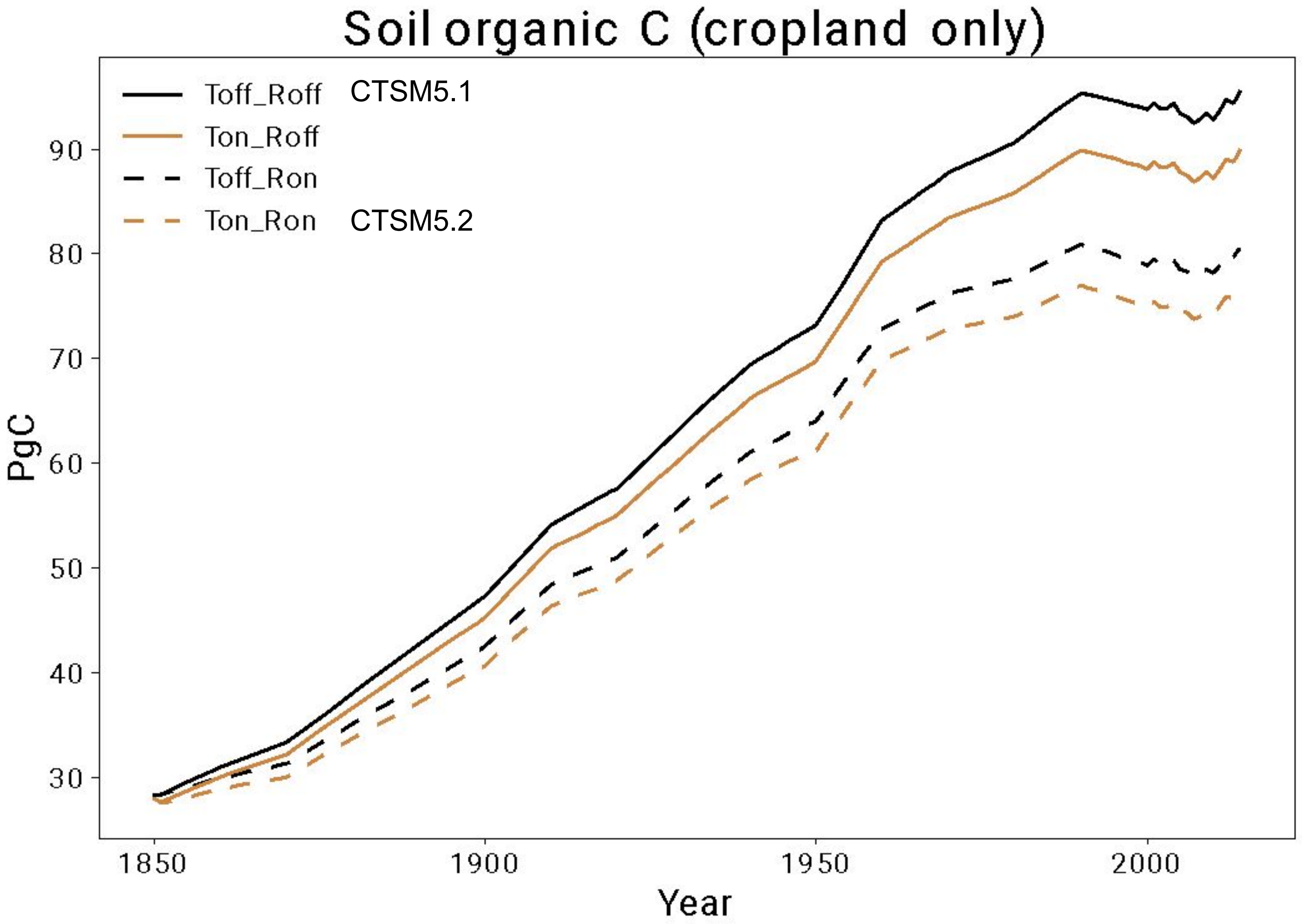
How much?



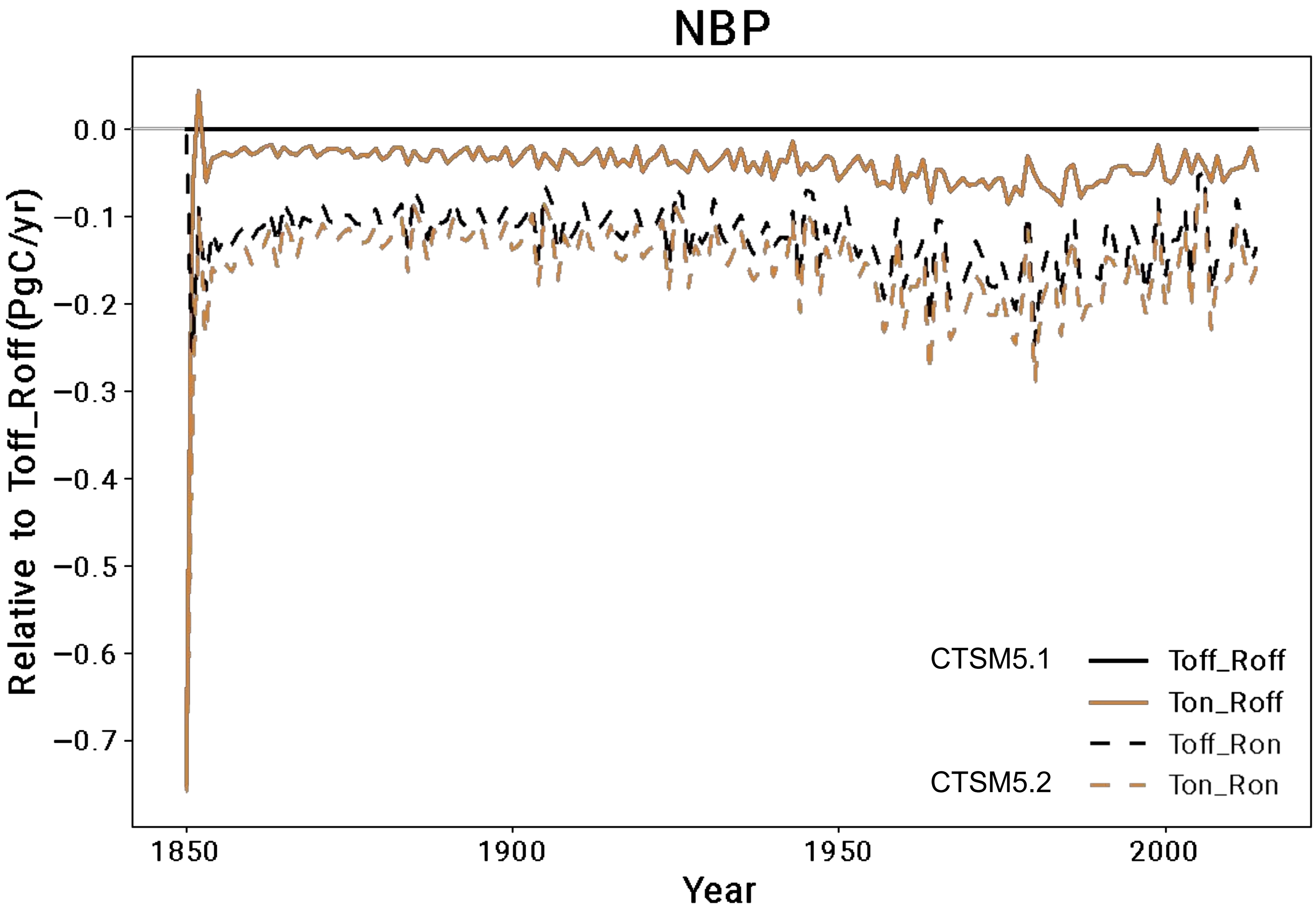
50%

Smerald et al. (2023, *Sci. Data*)

CTSM5.2: Tillage & residue removal



CTSM5.2: Tillage & residue removal



CTSM5.2: Prescribed crop calendars *(experimental)*

- Derived from GGCMI mean sowing and harvest dates:
  - Sowing date
  - Maturity requirements

Geosci. Model Dev., 16, 7253–7273, 2023
https://doi.org/10.5194/gmd-16-7253-2023

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Observation-based sowing dates and cultivars significantly affect yield and irrigation for some crops in the Community Land Model (CLM5)

Sam S. Rabin[1,2], William J. Sacks[2], Danica L. Lombardozzi[2], Lili Xia[1], and Alan Robock[1]

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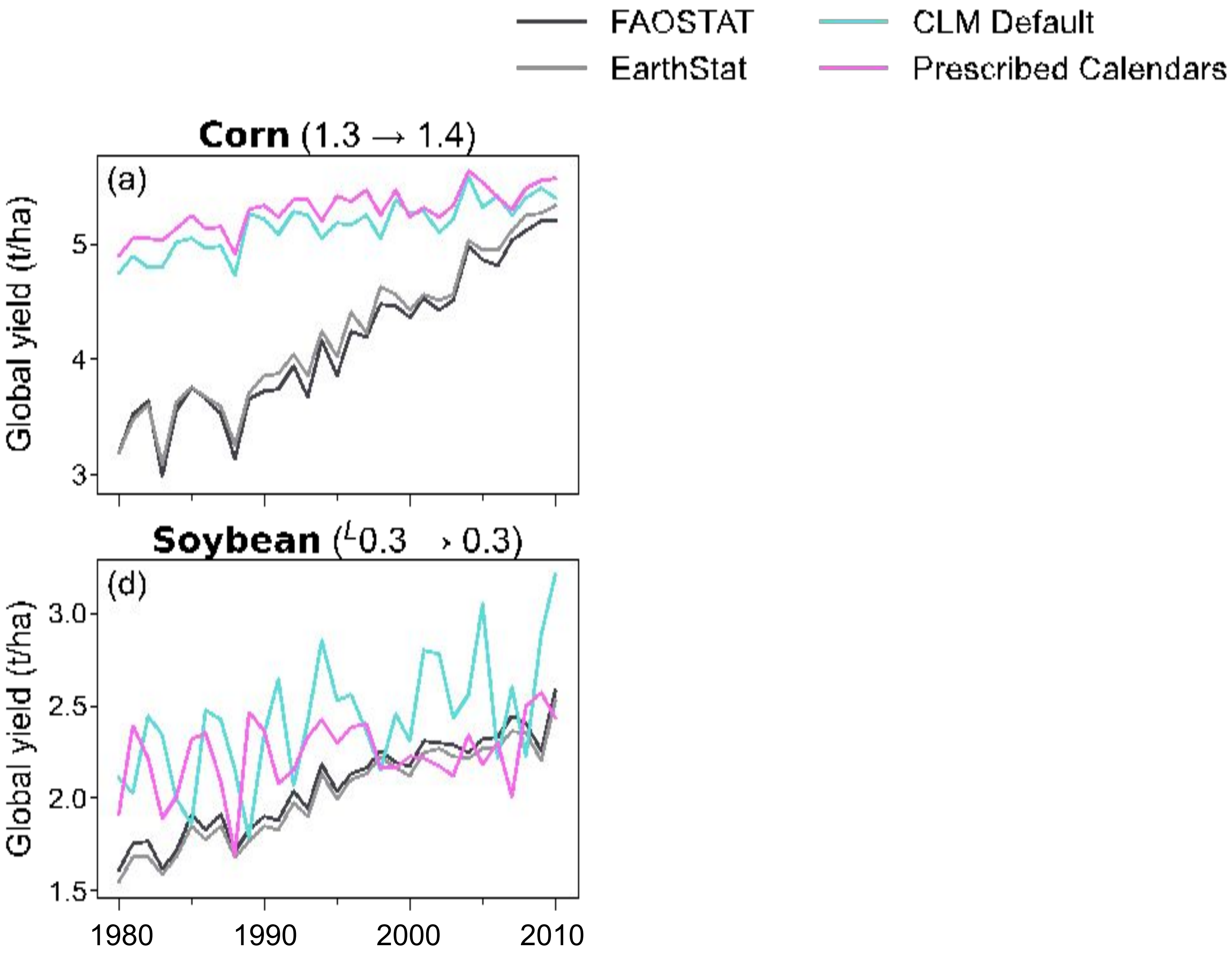

CTSM5.2: Prescribed crop calendars *(experimental)*

- Derived from GGCMI mean sowing and harvest dates:
  - Sowing date
  - Maturity requirements

- ***Not prognostic***
- ***Often worse than default behavior***
- ***You probably shouldn't use these!***

- Use cases?
  - Use arbitrary calendar algorithms without needing to code them into CLM
  - Participate in model intercomparisons like GGCMI
  - Force CLM with observed seasons to understand and improve crop PFTs

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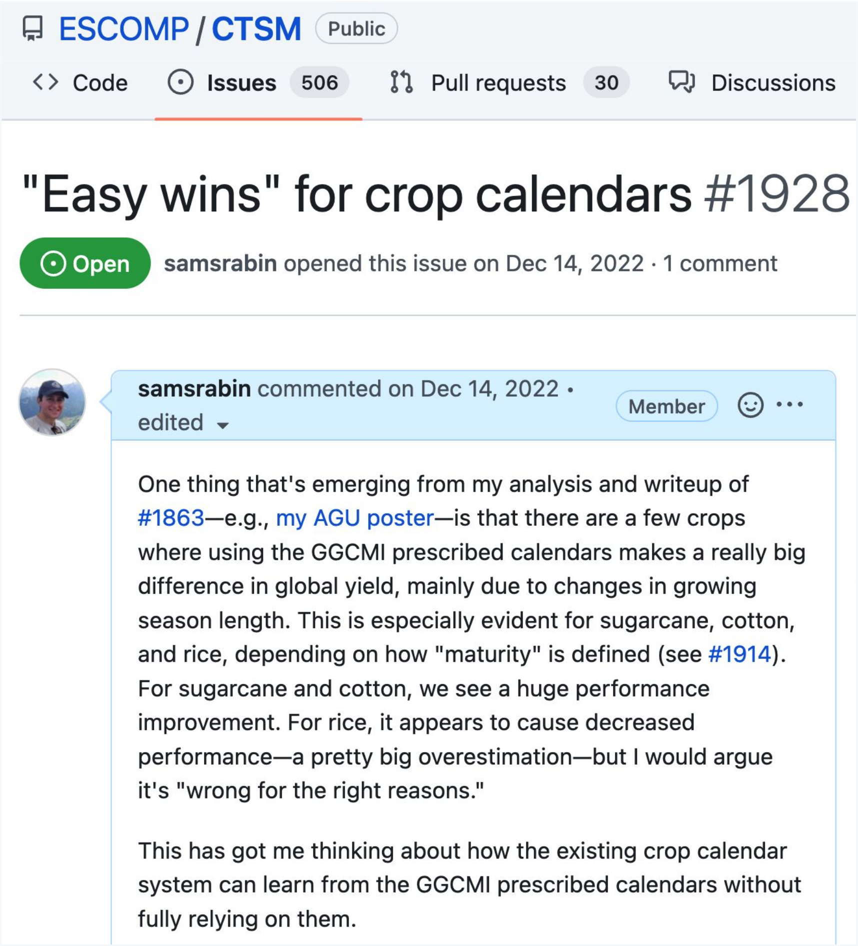
CTSM6 (in progress): Improved crop calendars

- ✅ Sowing windows:
  - Gridcell-specific
  - Derived from GGCMI dataset
- Maturity requirements:
  - Gridcell-specific
  - Derived from GGCMI dataset (present-day)
  - Allow shifting based on recent climate
- Rework max growing season length
- Reparameterize crop parameters, esp. phenology


ESCOMP / CTSM Public

Code | Issues 506 | Pull requests 30 | Discussions

"Easy wins" for crop calendars #1928

Open samsrabin opened this issue on Dec 14, 2022 · 1 comment

samsrabin commented on Dec 14, 2022 · edited Member

One thing that's emerging from my analysis and writeup of #1863—e.g., my AGU poster—is that there are a few crops where using the GGCMI prescribed calendars makes a really big difference in global yield, mainly due to changes in growing season length. This is especially evident for sugarcane, cotton, and rice, depending on how "maturity" is defined (see #1914). For sugarcane and cotton, we see a huge performance improvement. For rice, it appears to cause decreased performance—a pretty big overestimation—but I would argue it's "wrong for the right reasons."

This has got me thinking about how the existing crop calendar system can learn from the GGCMI prescribed calendars without fully relying on them.

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Thanks!

samrabin@ucar.edu