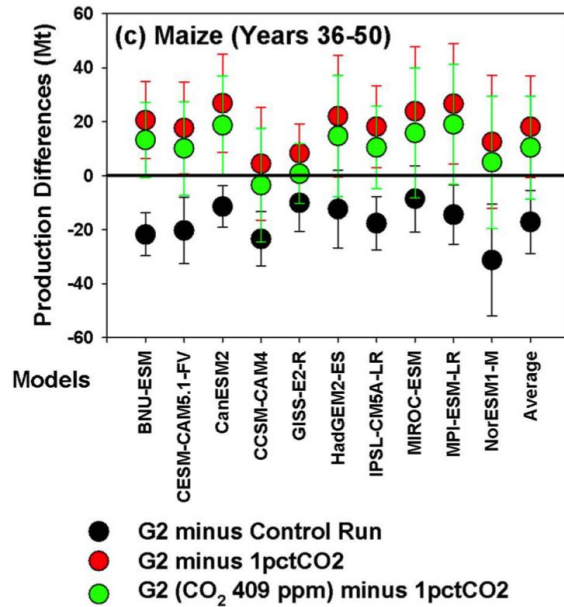# Land use change trajectories under stratospheric aerosol injection

Sam Rabin, Peter Alexander, Almut Arneth, Lili Xia, Alan Robock

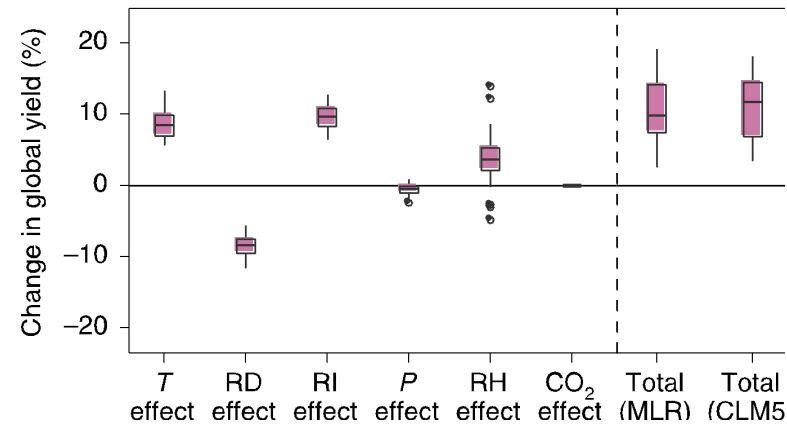# Previous work has looked at crop productivity impacts under SAI

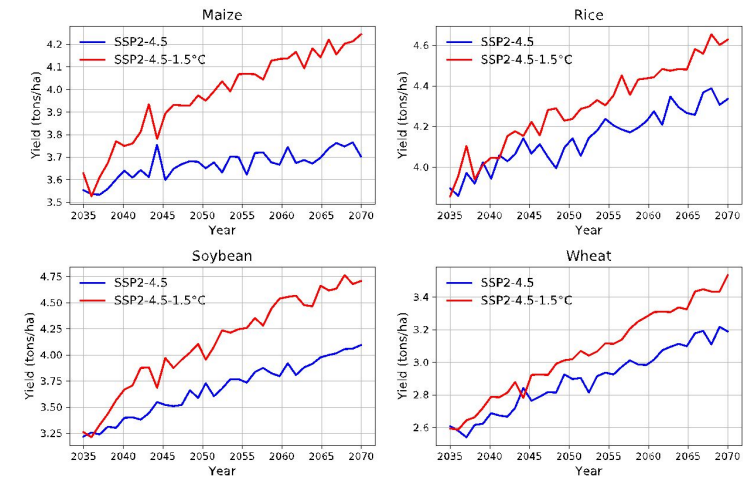**Crop production in China**
(Xia et al., 2014, *JGR: Atmos.*)

Global crop yield
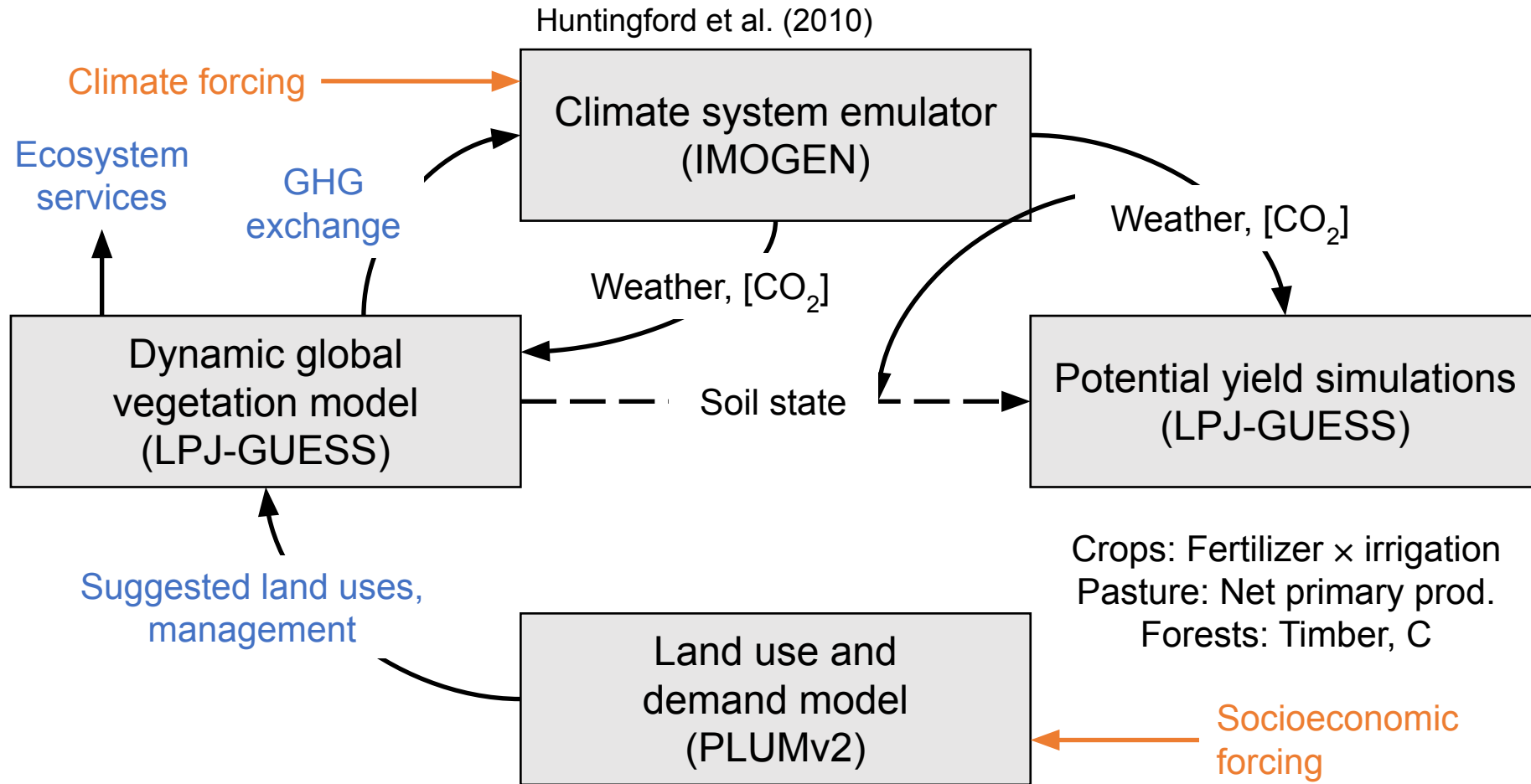(Fan et al., 2021, *Nat. Food*)

Global crop yield
(Clark et al., in rev.)

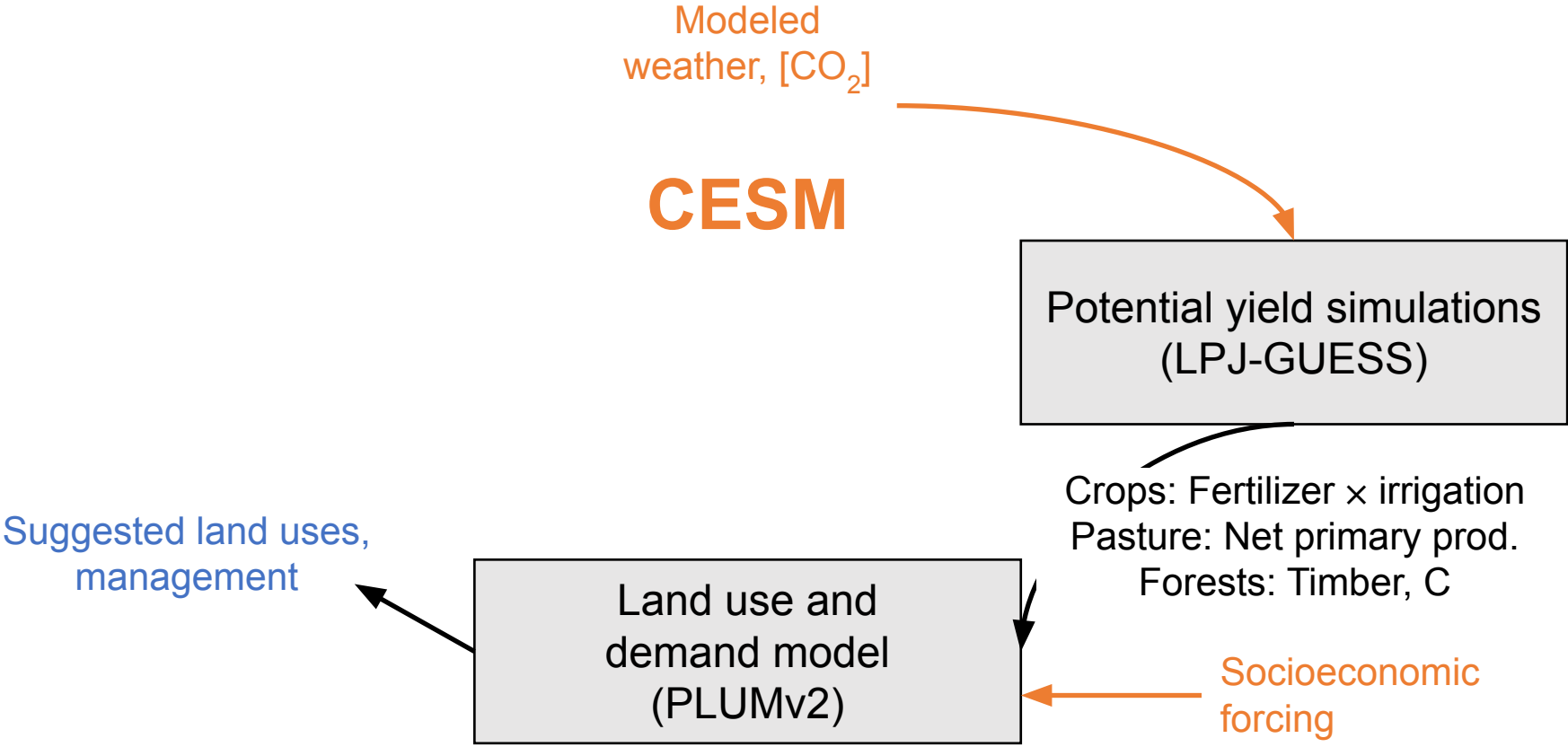But productivity changes **don't happen in a vacuum.**

How do crop (and pasture) productivity impacts of SAI affect land use patterns?
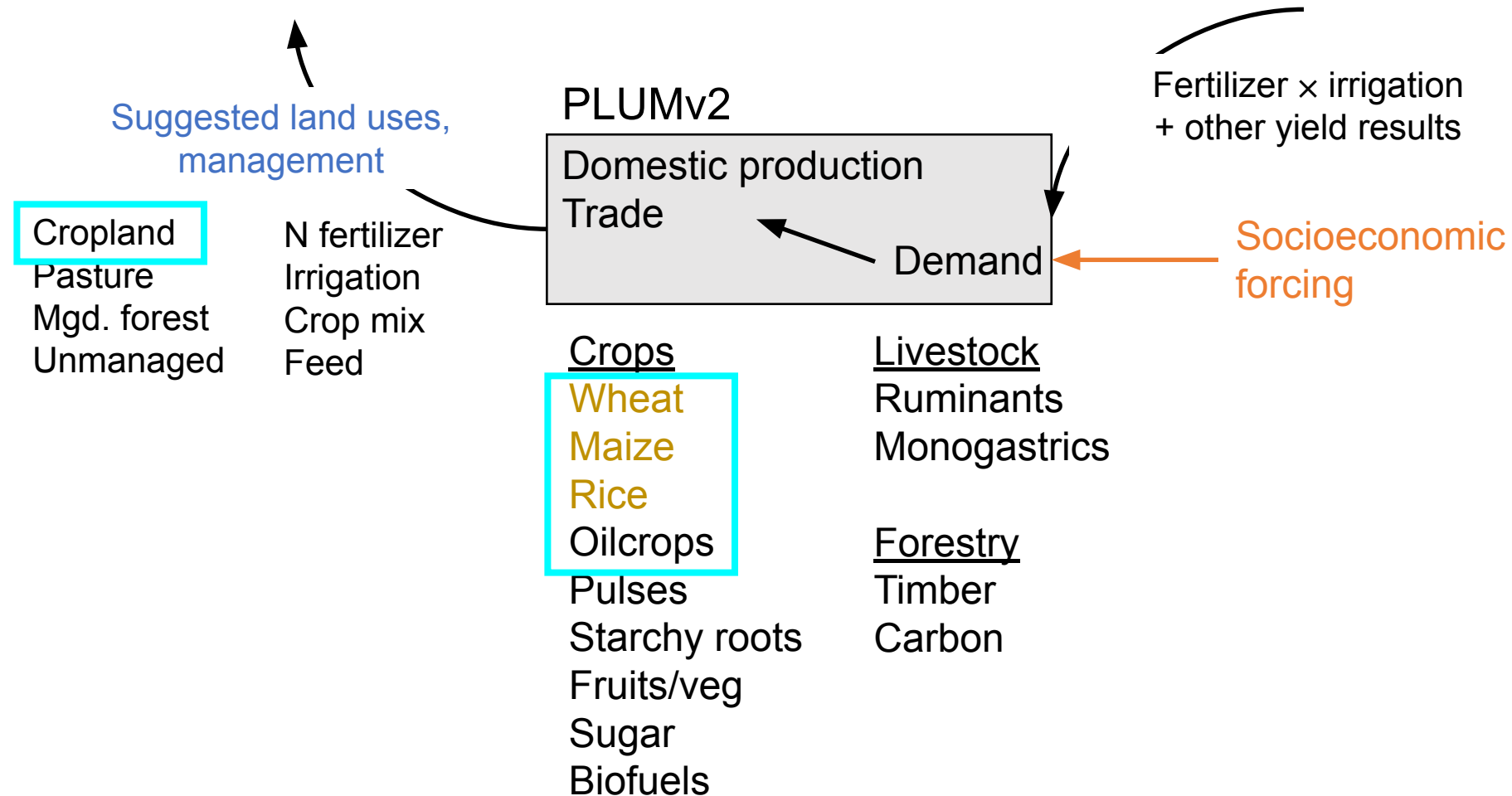
LandSyMM (Land System Modular Model)

Huntingford et al. (2010)

Climate forcing → Climate system emulator (IMOGEN)

Ecosystem services

GHG exchange

Weather, [CO$_2$]

Weather, [CO$_2$]

Dynamic global vegetation model (LPJ-GUESS)

Soil state

Potential yield simulations (LPJ-GUESS)

Crops: Fertilizer × irrigation
Pasture: Net primary prod.
Forests: Timber, C

Suggested land uses, management

Land use and demand model (PLUMv2)

Socioeconomic forcing

Alexander et al. (2018, *Glob. Chg. Biol.*)
Rabin et al. (2020, *Earth Syst. Dynam.*)

LandSyMM (Land System Modular Model)
In this work

Land use & demand model: PLUMv2
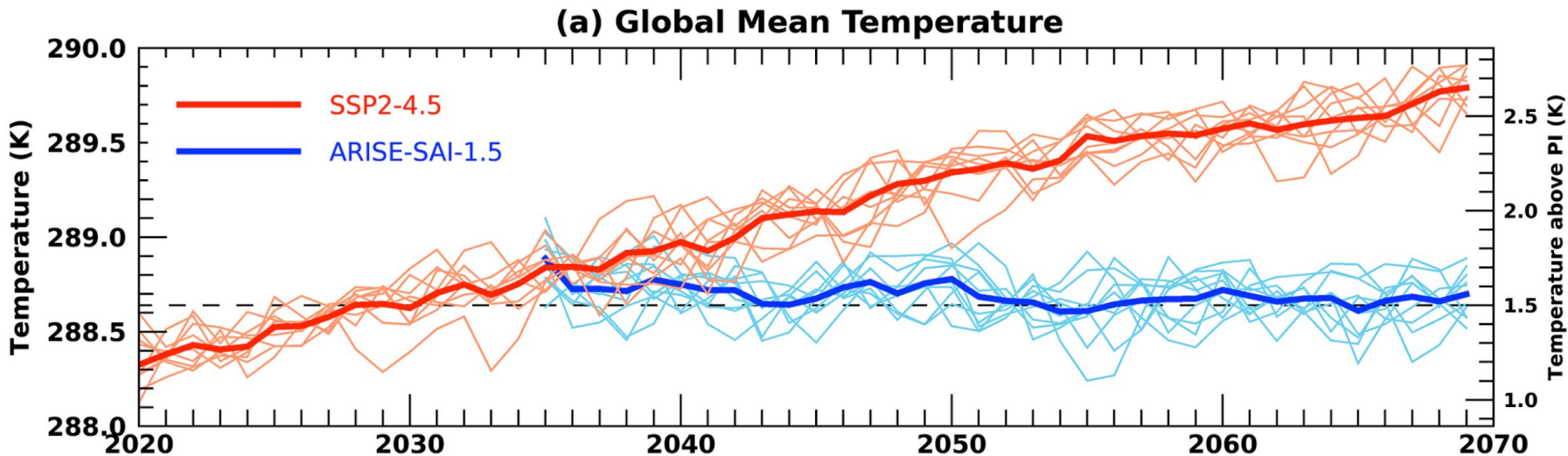

Engström et al. (2016, *Earth Syst. Dyn.*)

Scenarios and CESM climate forcing

Baseline: **SSP2-4.5**

- Moderate emissions scenario

Climate intervention: **ARISE-SAI-1.5**

- SSP2-4.5 emissions
- Stratospheric aerosol injection starting 2035
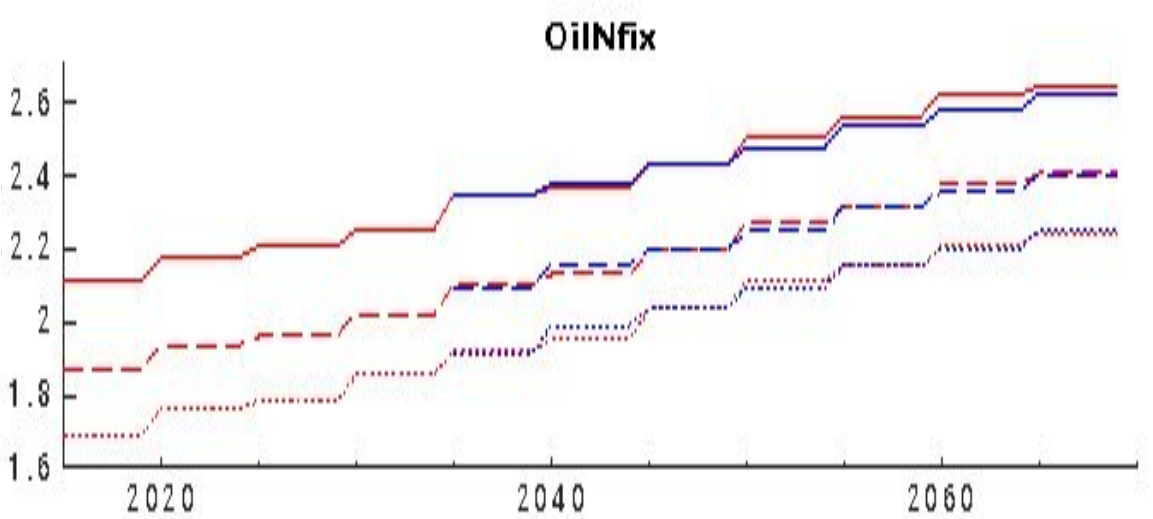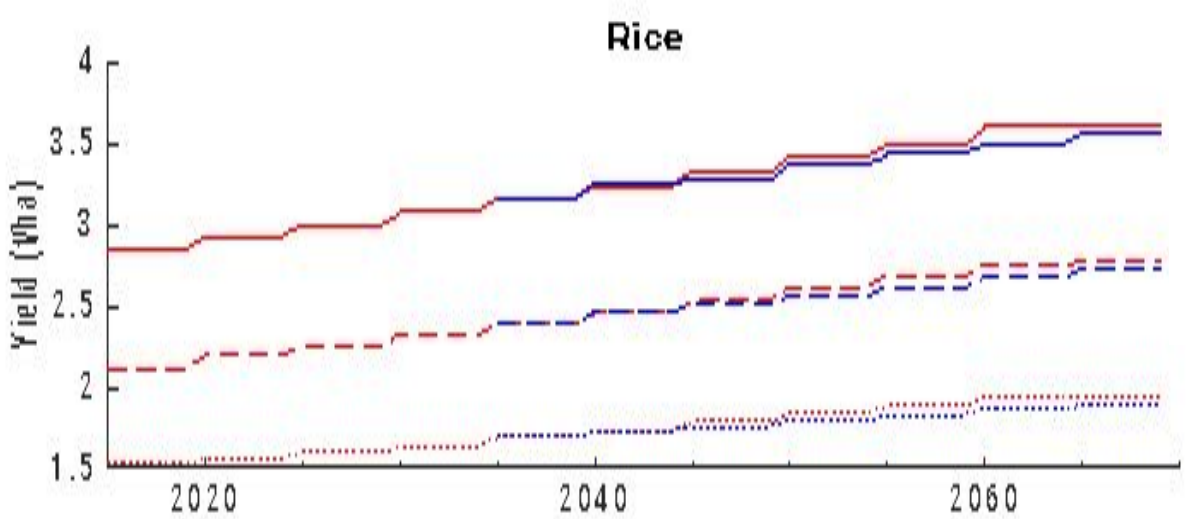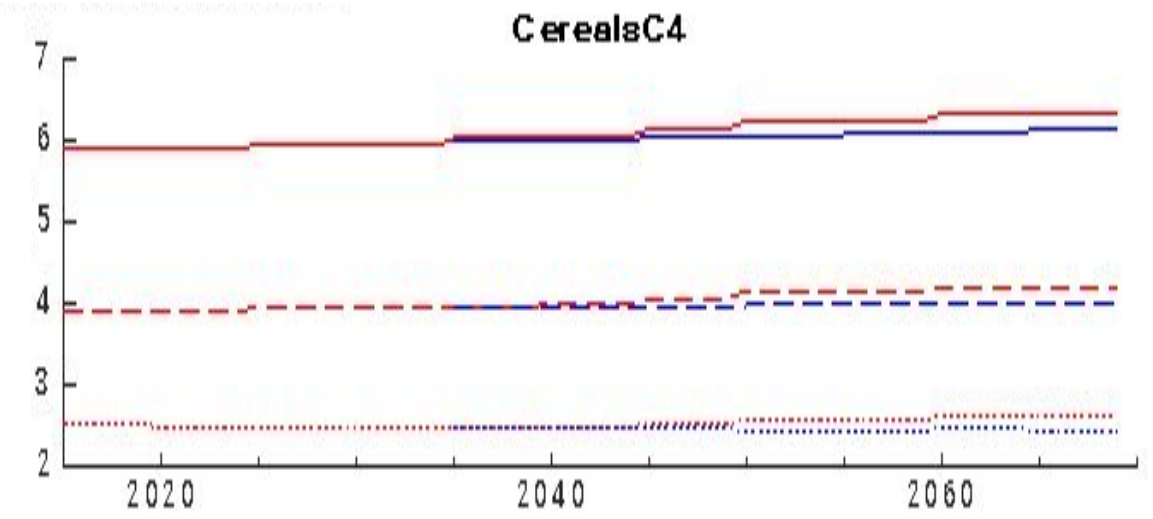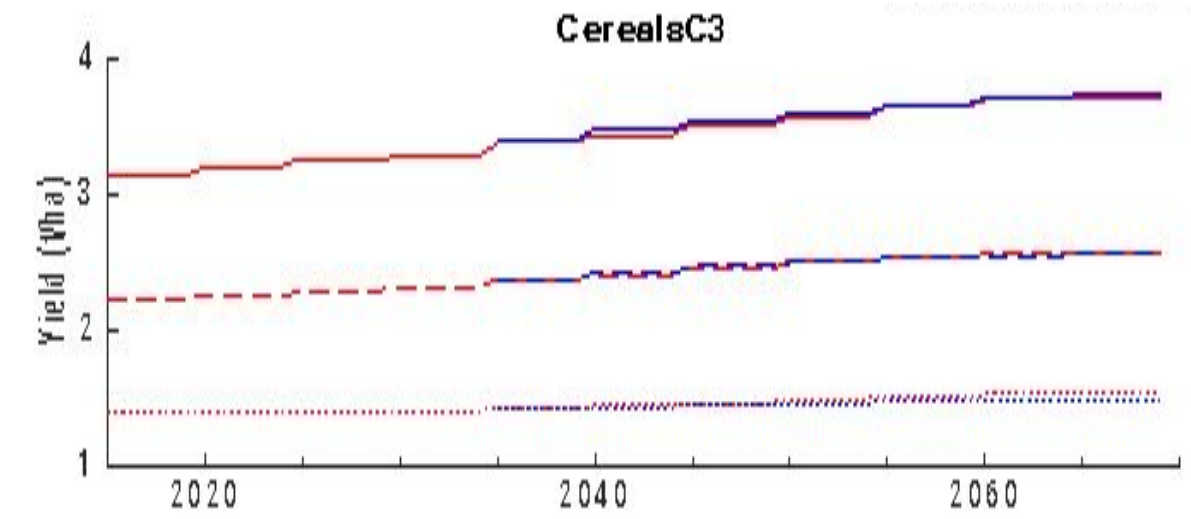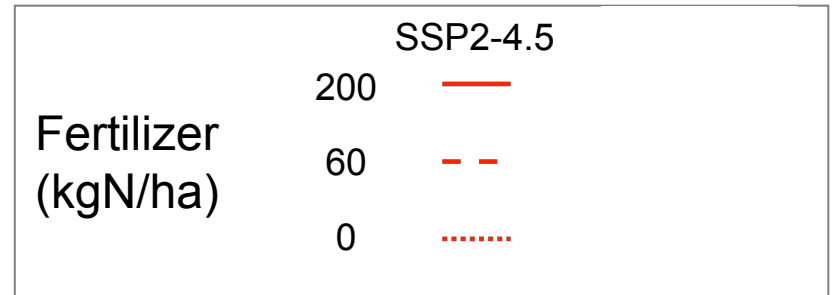- Keep global mean ΔT to 1.5° over preindustrial

(a) Global Mean Temperature
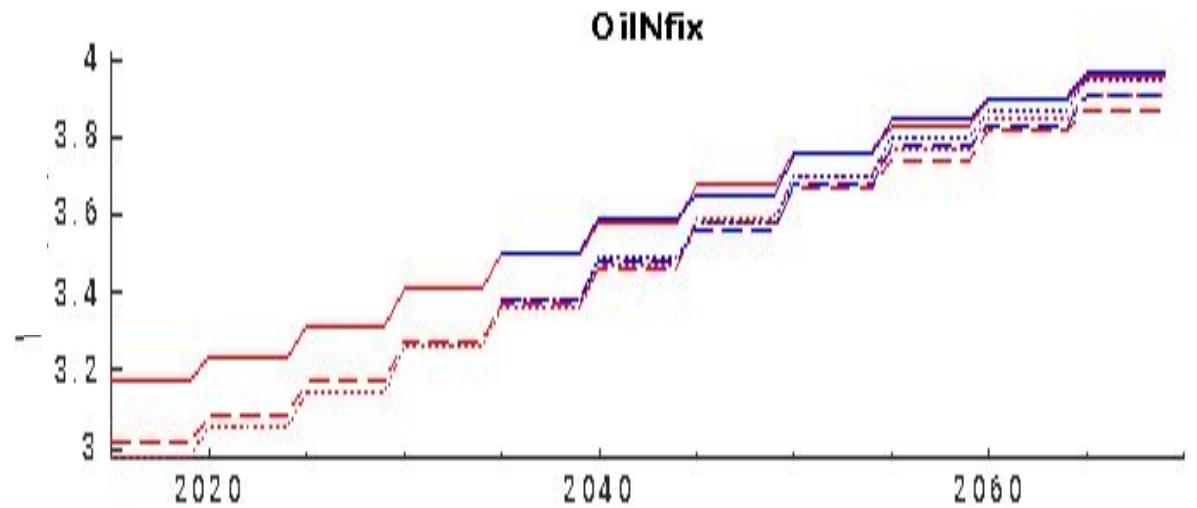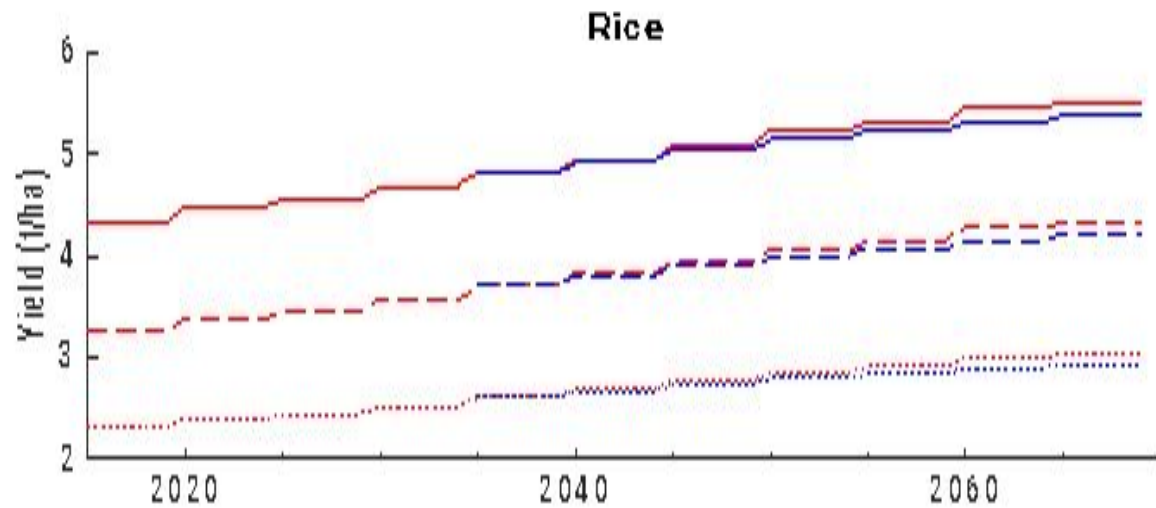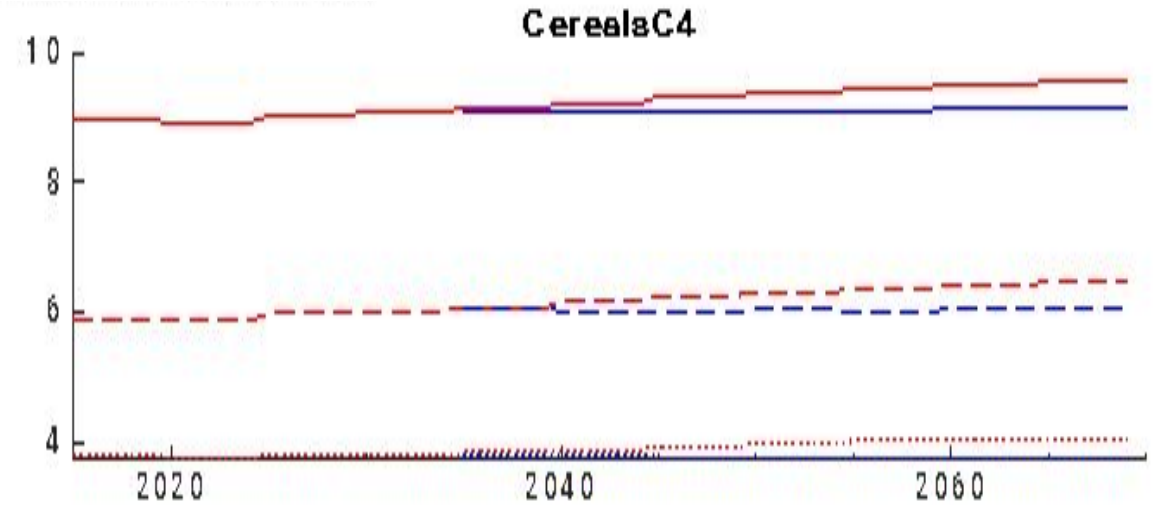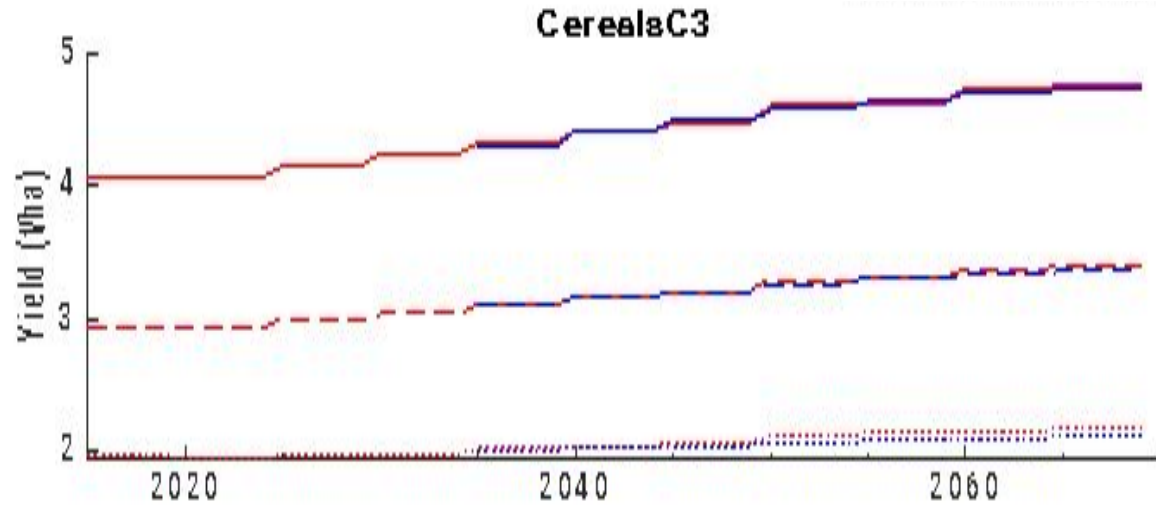
SSP2-4.5 and ARISE-1.5 in the CESM2(WACCM6) Earth system model

Richter et al. (2022, *Geosci. Model Dev.*)

How do **crop** (and pasture) **productivity impacts** of SAI affect land use patterns?

Crop productivity changes (Rainfed) 🌏

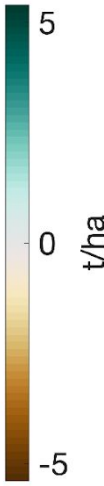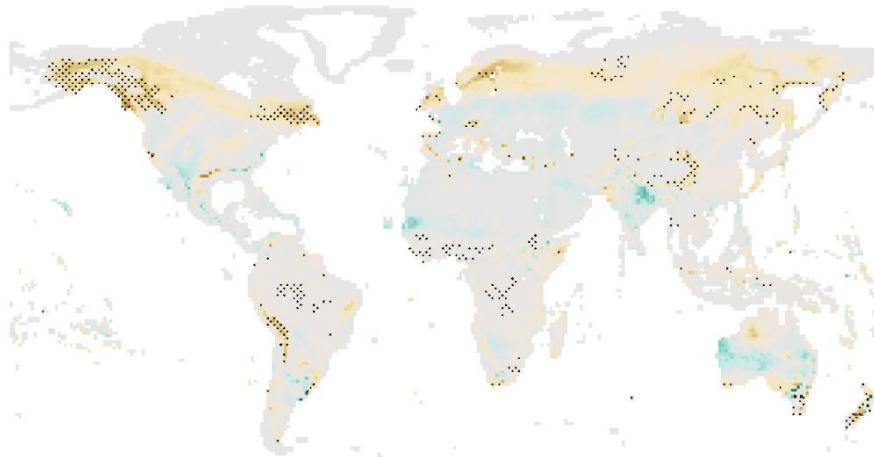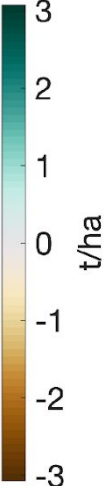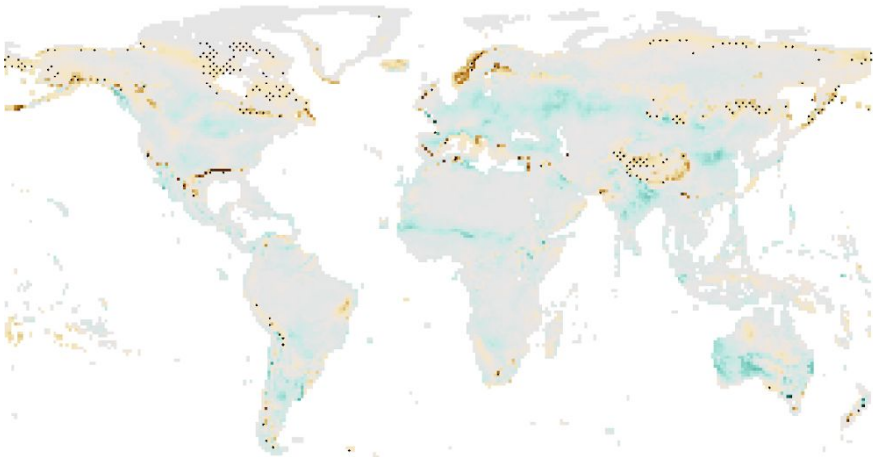# Crop productivity changes (Irrigated) 🌏

Legend: Fertilizer (kgN/ha) — SSP2-4.5 (red), ARISE-1.5 (blue); 200 (solid), 60 (dashed), 0 (dotted)
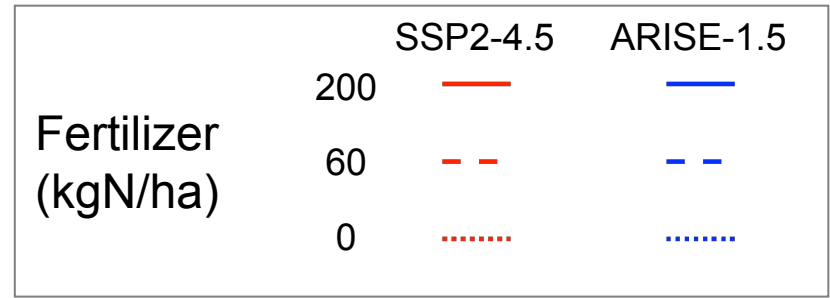
2065–2069 yield, ARISE-1.5 minus SSP2-4.5

200 kgN/ha, rainfed   irrigated
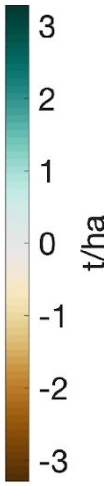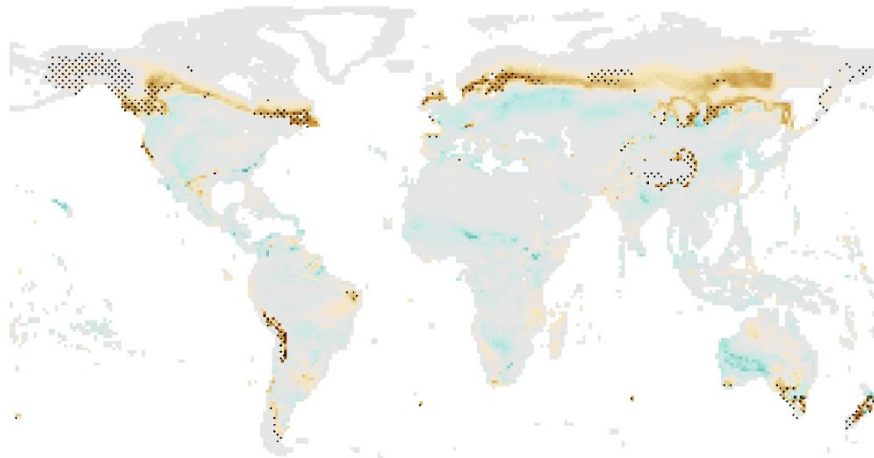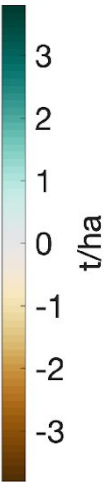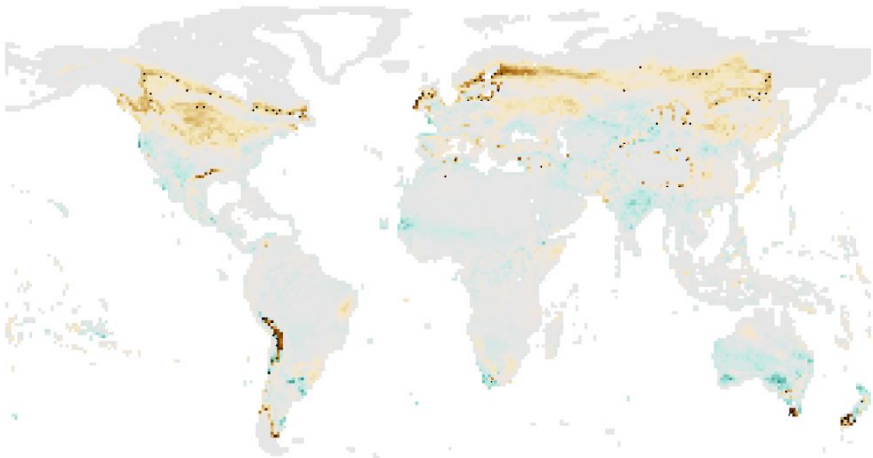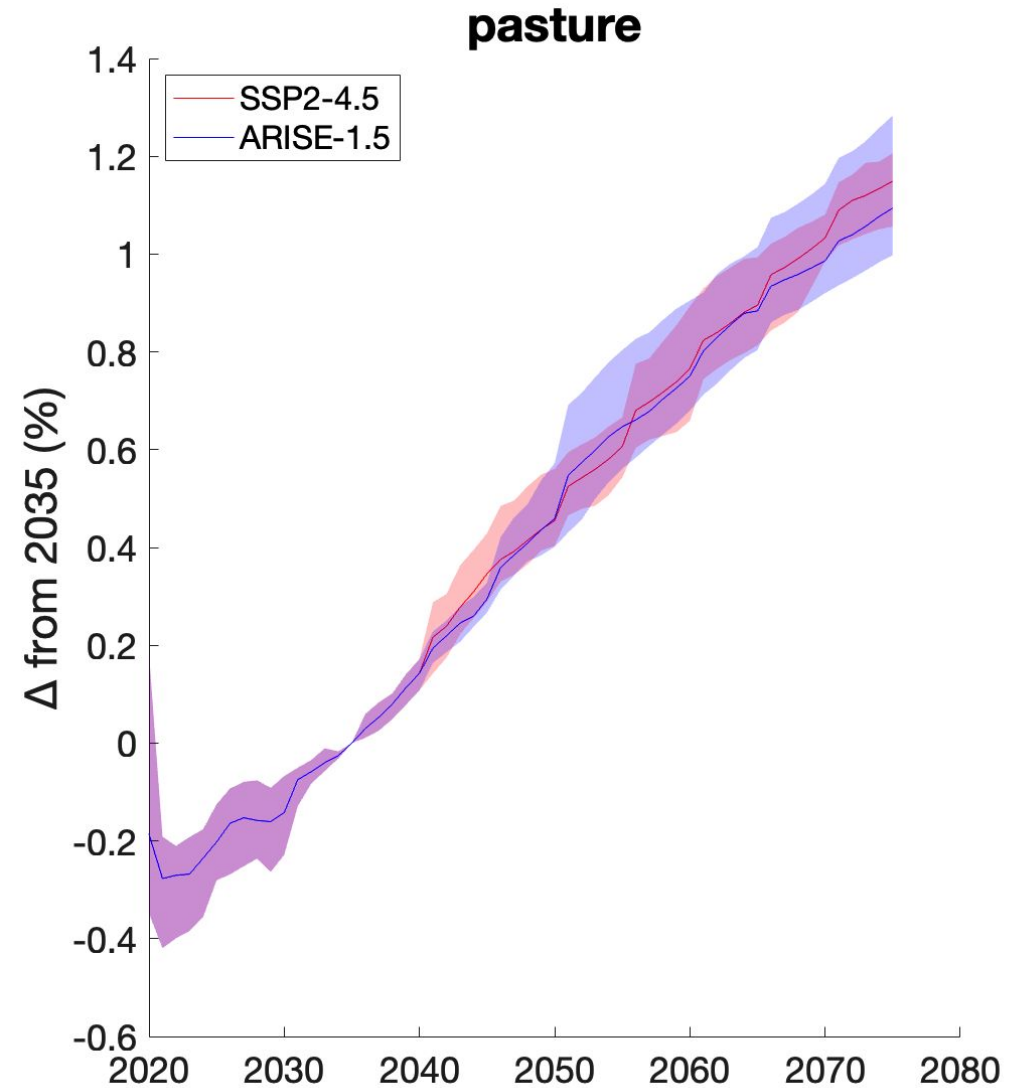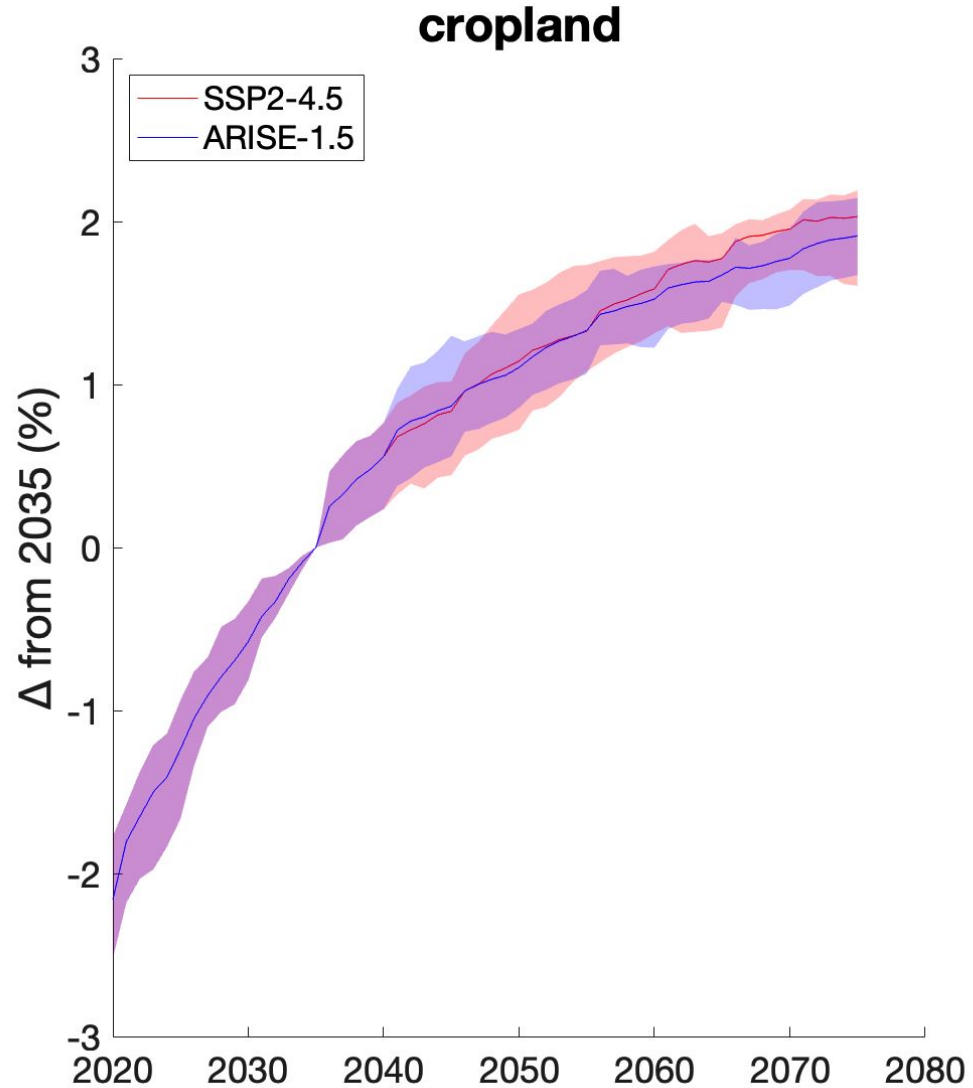
How do crop (and pasture) productivity impacts of SAI affect **land use patterns**?

Land use change (relative to 2035)
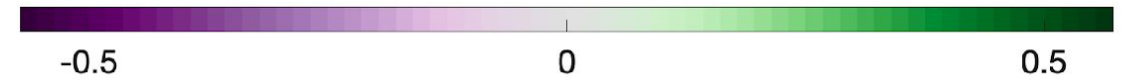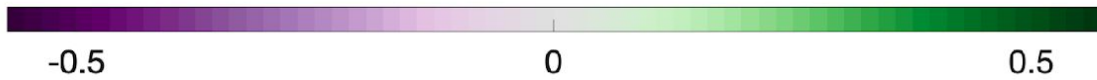
SSP2-4.5
ARISE-SAI-1.5

Cropland: 2070–2074 minus 2030–2034

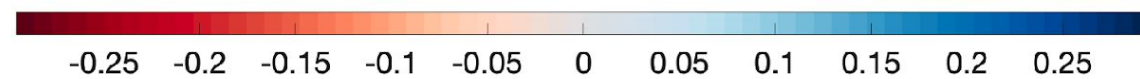Gridcell fraction

SSP2-4.5

ARISE-1.5

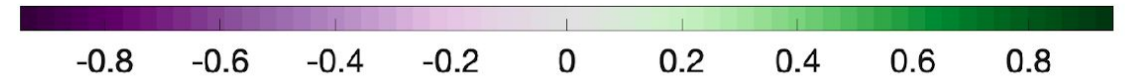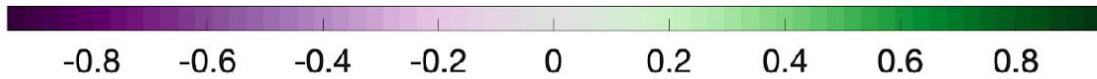2030-2034 more

2030-2034 more

SSP2-4.5 more

ARISE-SAI-1.5 more

Pasture: 2070–2074 minus 2030–2034
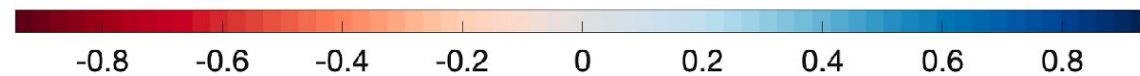
Gridcell fraction

SSP2-4.5

ARISE-1.5

2030-2034 more

2030-2034 more

SSP2-4.5 more

ARISE-SAI-1.5 more

Crop area change (relative to 2035)
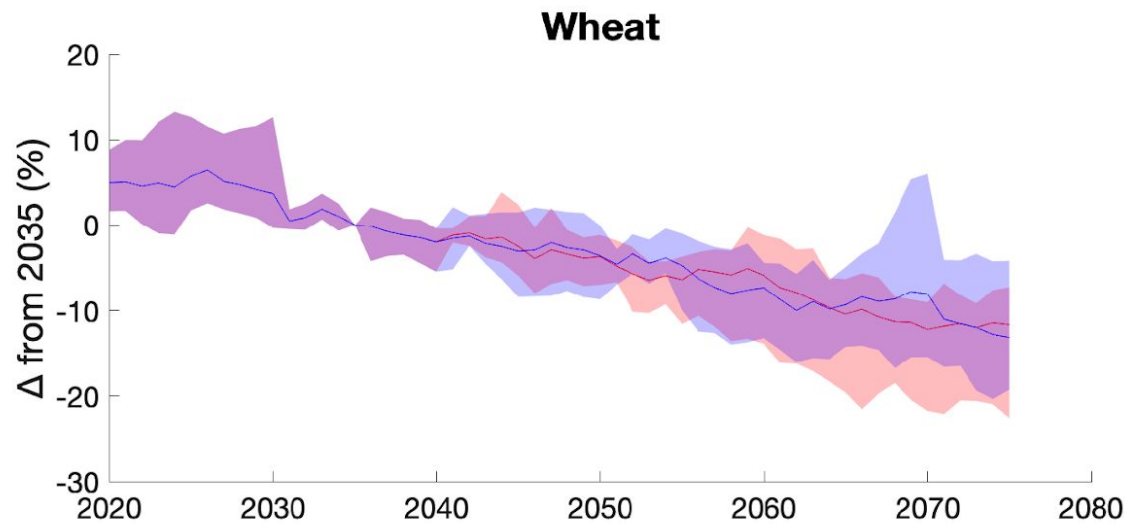
Crop area: 2070–2074 minus 2030–2034
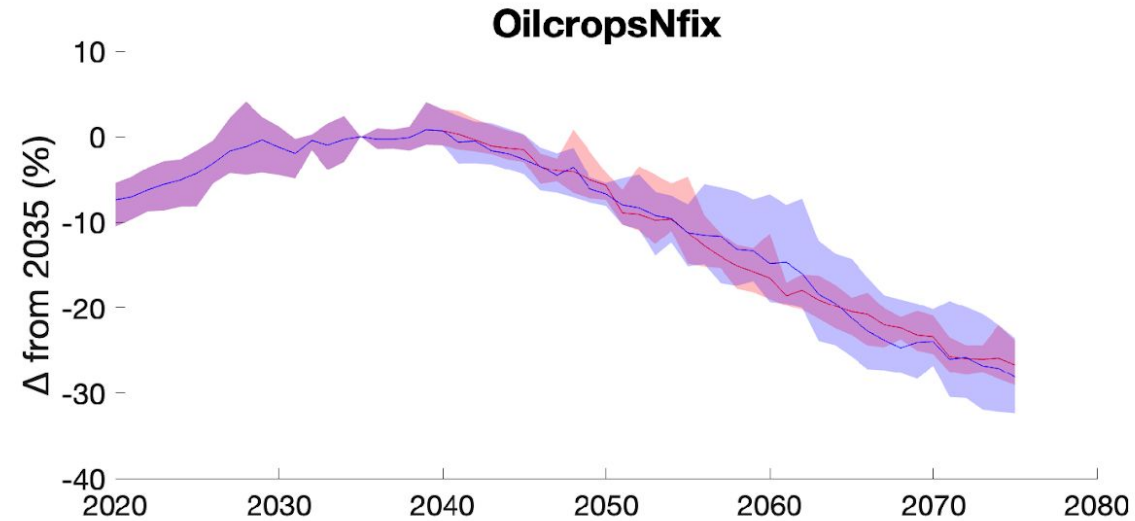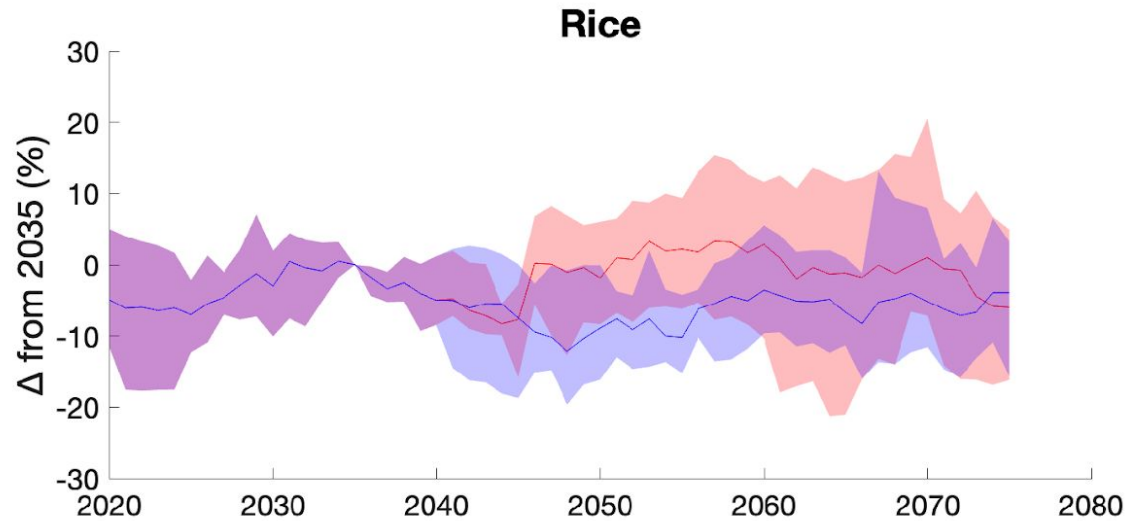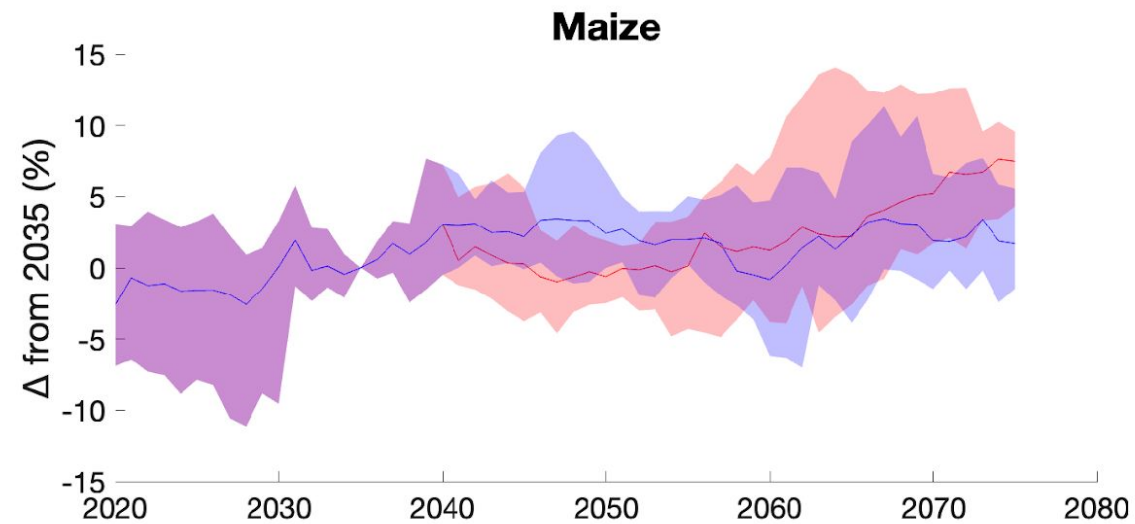
Wheat

Maize

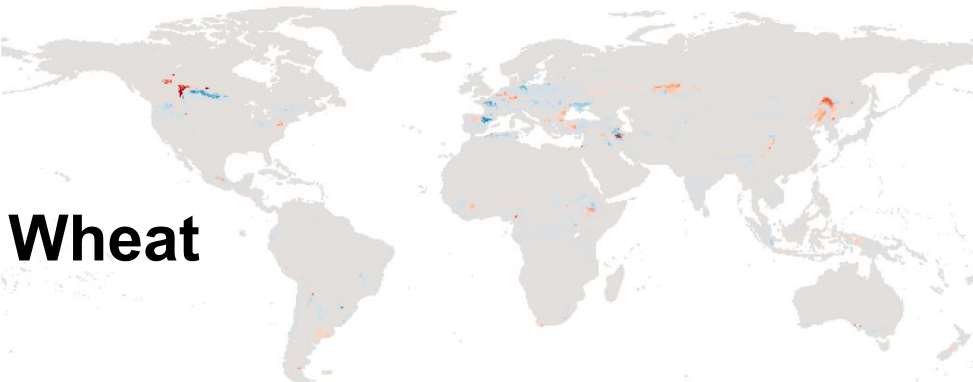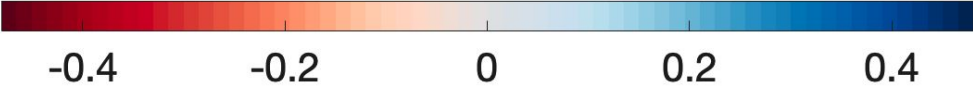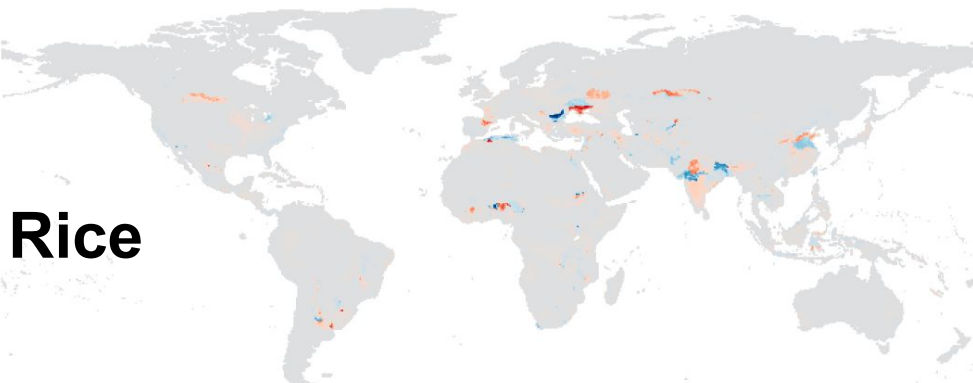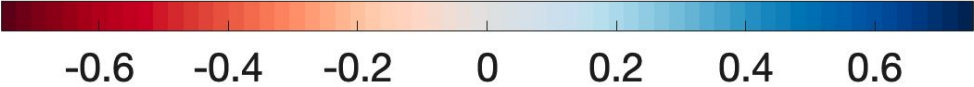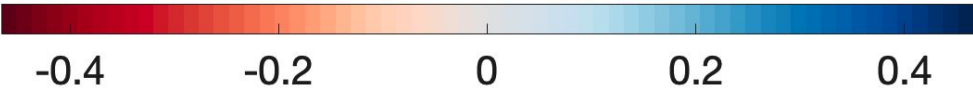**SSP2-4.5 more**

ARISE-SA -1.5 more

-0.4   -0.2   0   0.2   0.4

-0.6   -0.4   -0.2   0   0.2   0.4   0.6

Rice

Soy

-0.4   -0.2   0   0.2   0.4

-0.3   -0.2   -0.1   0   0.1   0.2   0.3
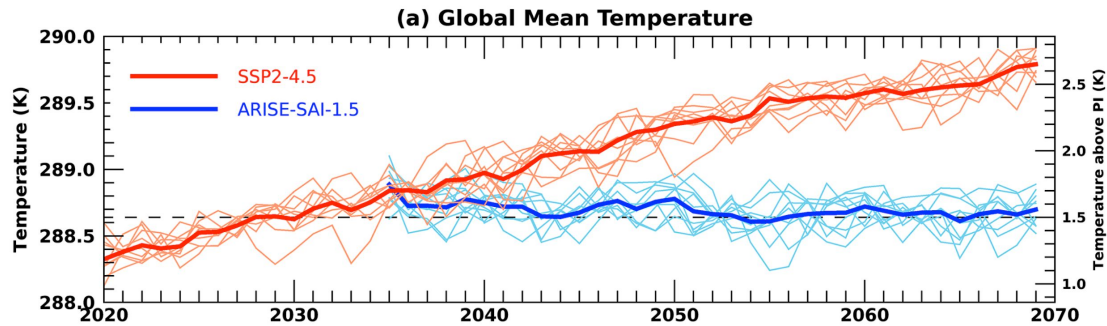
Next steps

- Double-check PLUM setup

- Run with all ensemble members

- Climate forcing attribution

- Other crop models (emulators)?

Acknowledgements

Bart Arendarczyk

Thank you!