Assessing TRIFFID-crop for agriculture impacts

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Aim: use JULES to assess climate's impacts on agriculture

Crops in JULES

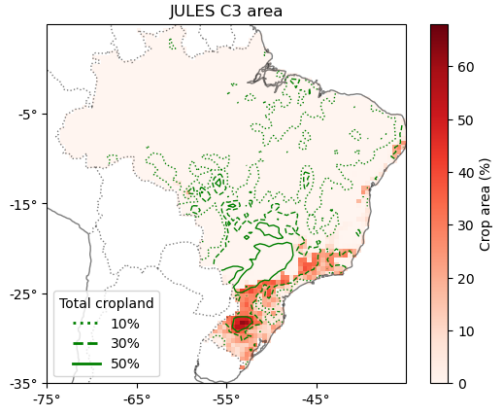
- TRIFFID-crop
  - C3- & C4-crop PFTs
  - Same properties as C3-/C4-grass but without nitrogen limitation (unlimited fertiliser)
  - Prescribed total cropland area; competition between C3- & C4-crop
- JULES-crop
  - Models the crop growth process, with separate carbon pools for different parts of plant
  - Specifies crop planting and harvesting
  - May be less flexible for ESM setups

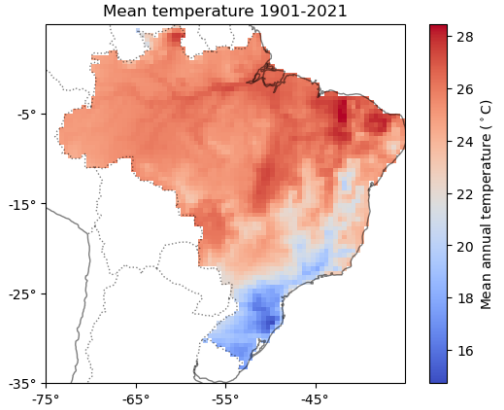
Data & setup

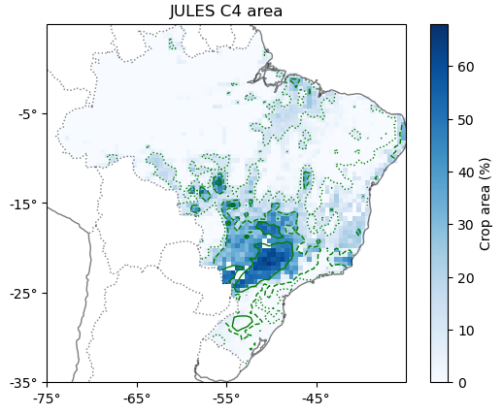
- Brazil
- ISIMIP3a
  - Driven by reanalysis (20CRv3-ERA5, GSWP3-W5E5)
  - 0.5° x 0.5°, 1901-2019/2021
  - JULES-ES (TRIFFID, no fire)
  - Other ESM land surface models: CLASSIC, ORCHIDEE-MICT
  - Crop calendar (GGCMI)
- ILAMB obs GPP
  - 0.5° x 0.5°, 1982-2008
  - FLUXNET upscaled with ML to global, with satellite and meteorological data
- FAO crop yield
  - Brazil country-level annual yields
  - 1961-2022
- CROPGRIDS crop area
  - 0.05° x 0.05°, 2020

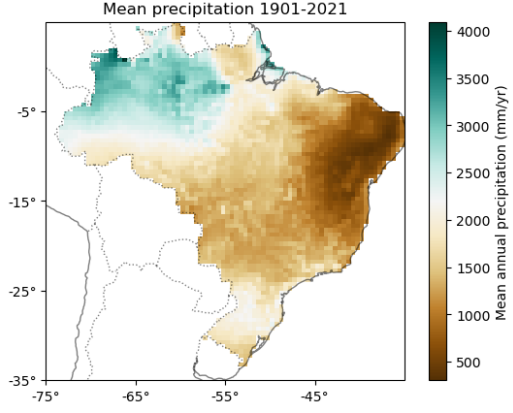
Spatial distribution

- Prescribed total cropland, competition between C3- & C4-crop









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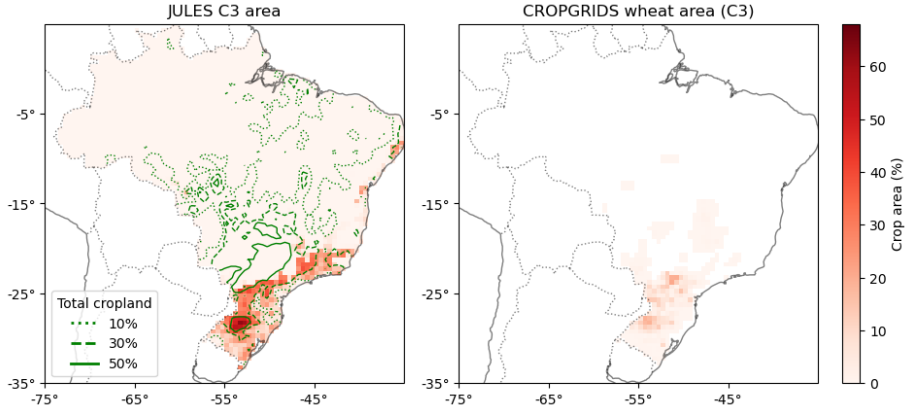

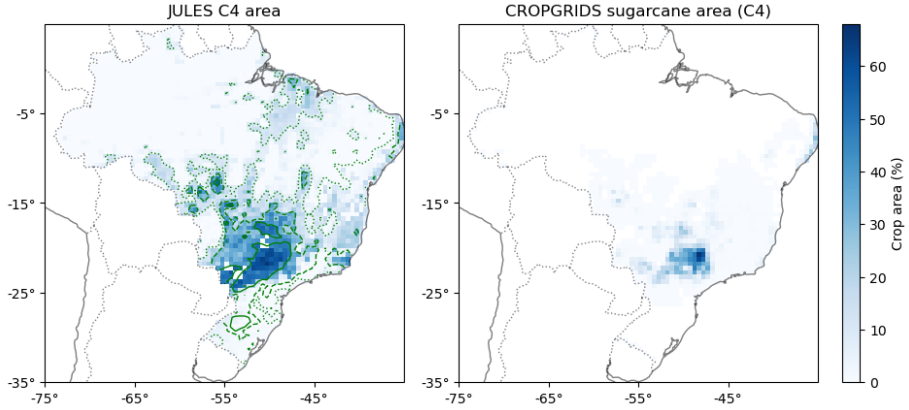

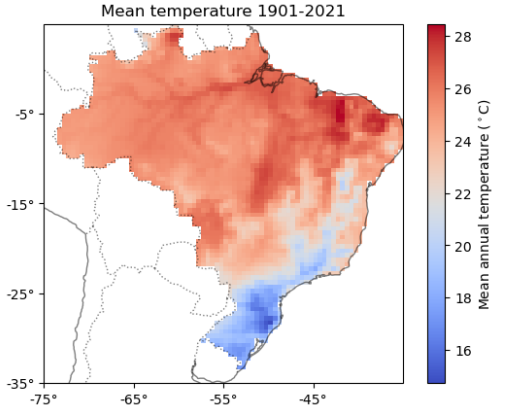

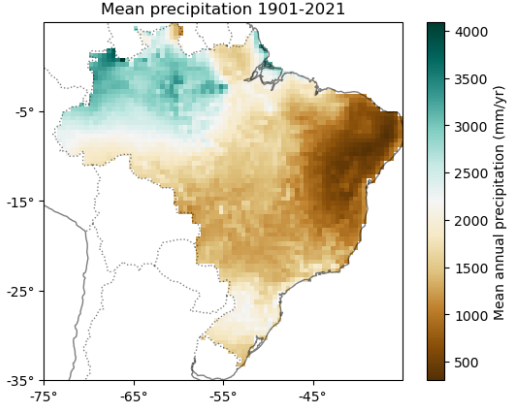

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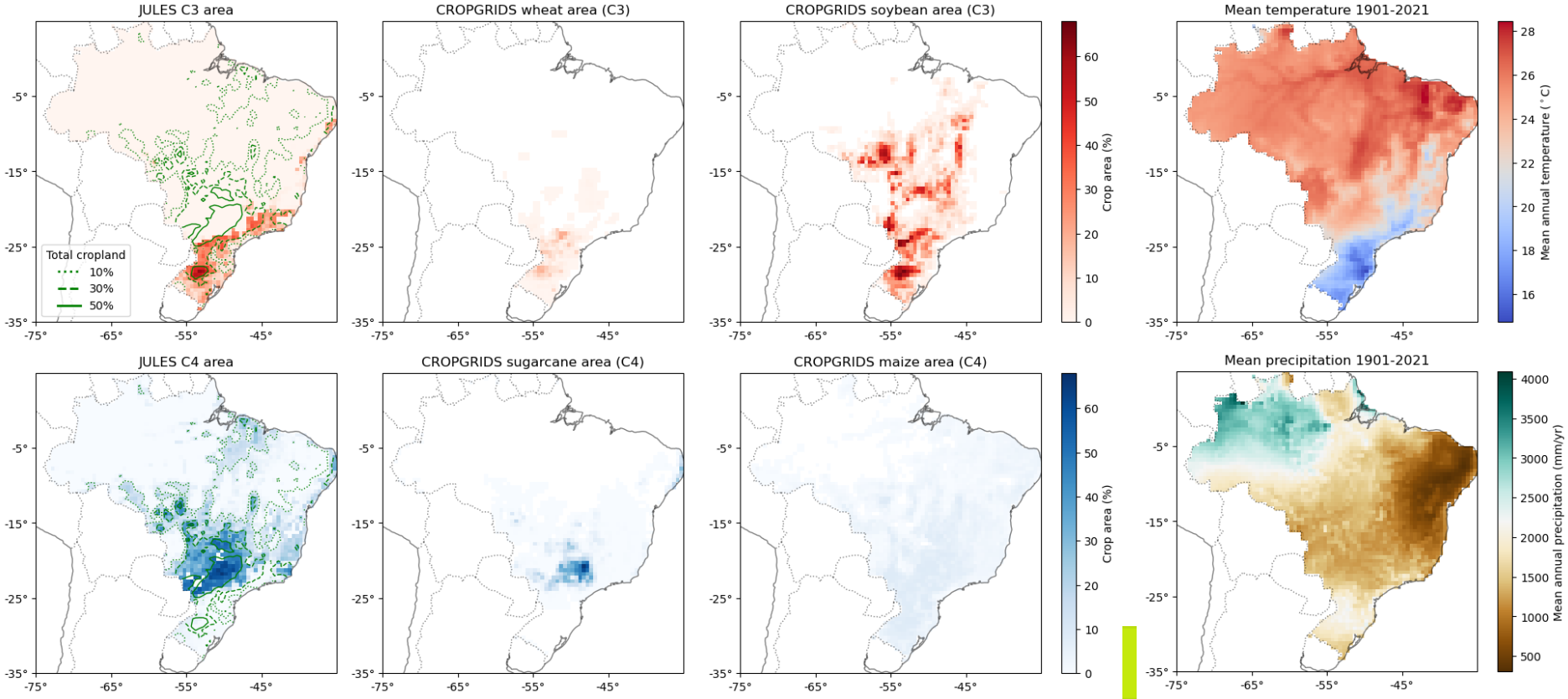
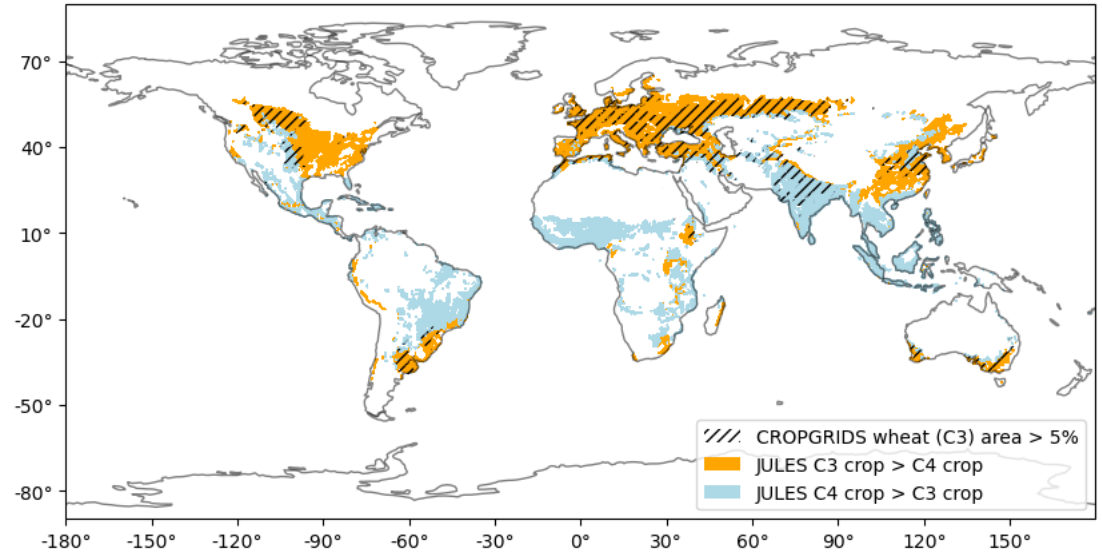
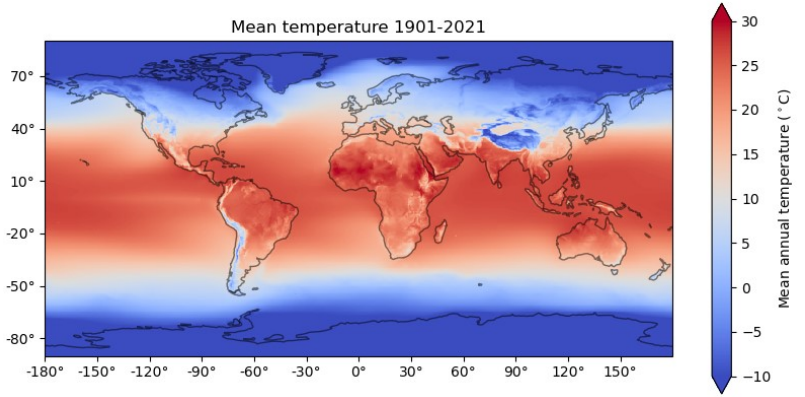
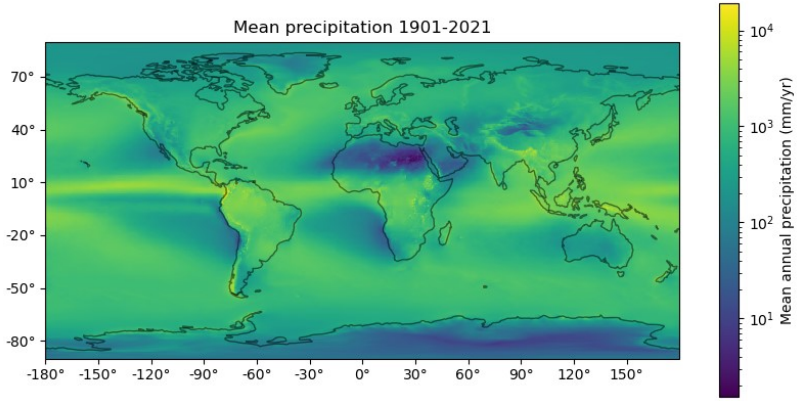


Global C3-/C4-crop divide







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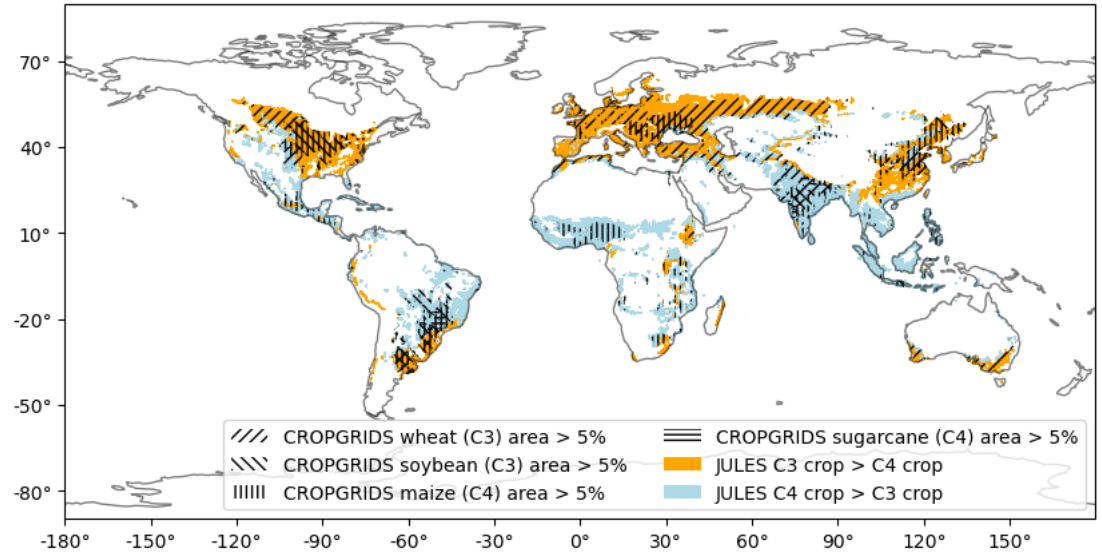
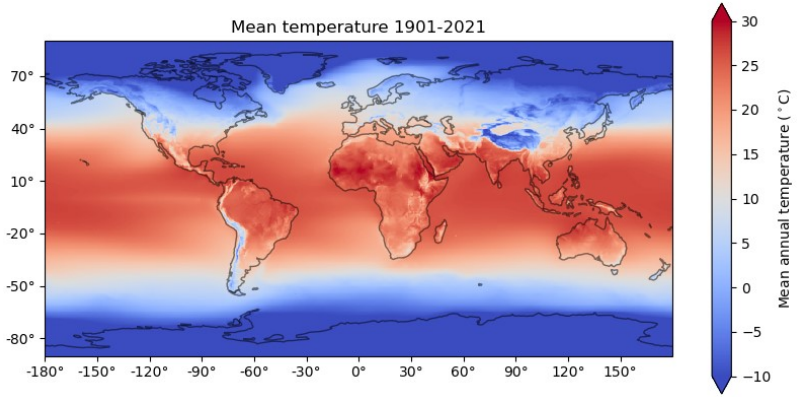
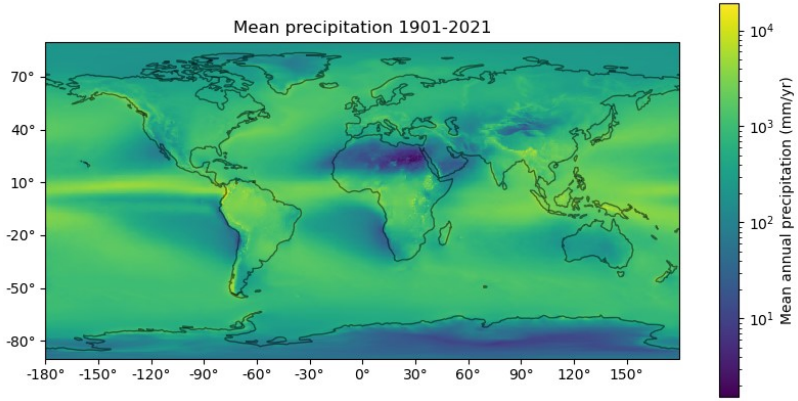


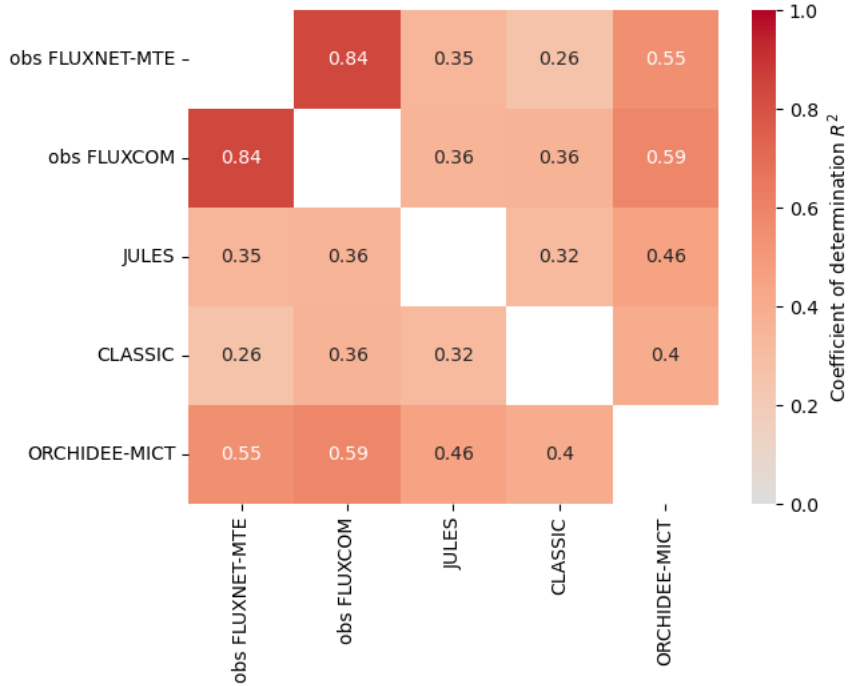




Spatial-temporal variability in GPP

- Grid-by-grid comparison
- All of Brazil
- Monthly, 1982-2008

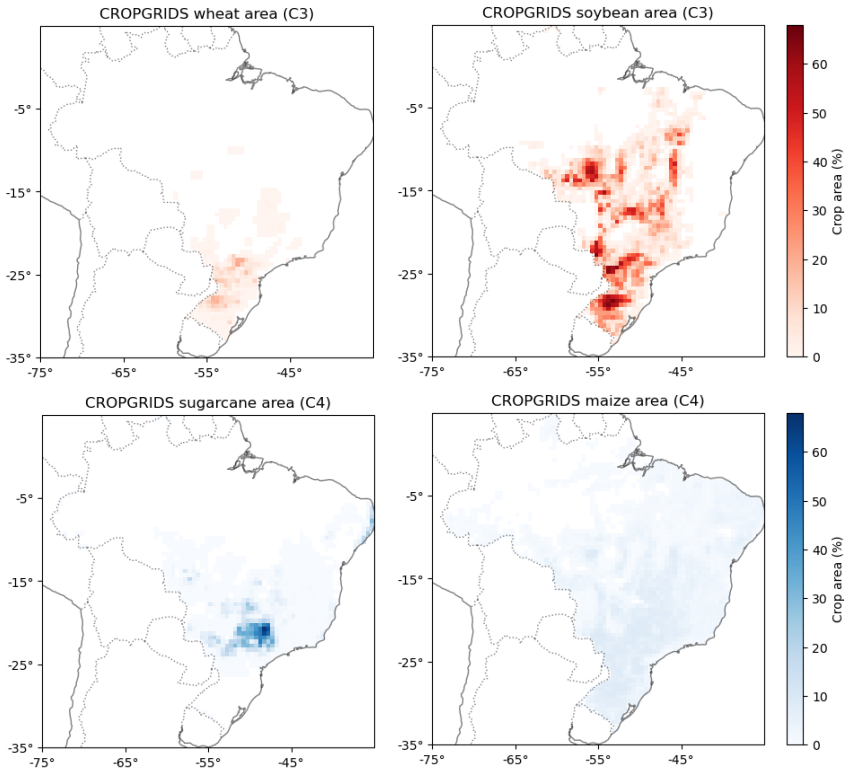
- Models have some skill in capturing observed GPP variability
  - Similarly for LAI (not shown)



(All statistically significant)

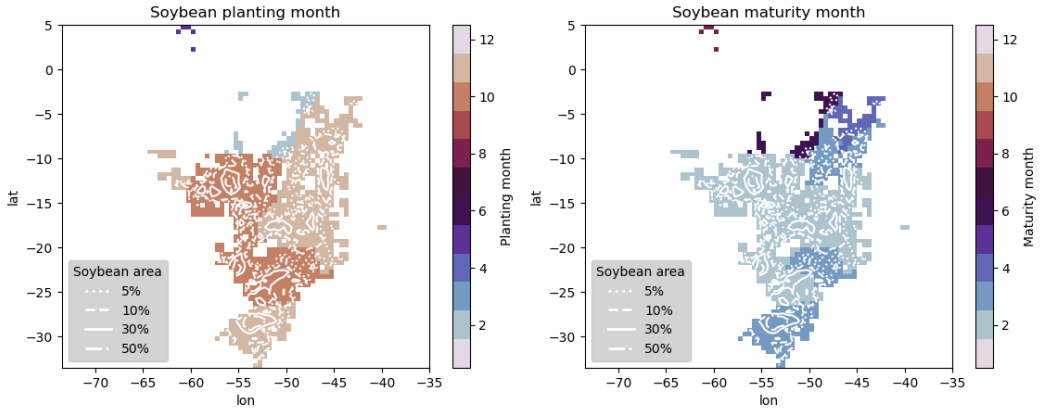
Crop subset

- Spatial subset
  - Mean weighted by observed crop cover (2020 CROPGRIDS data)



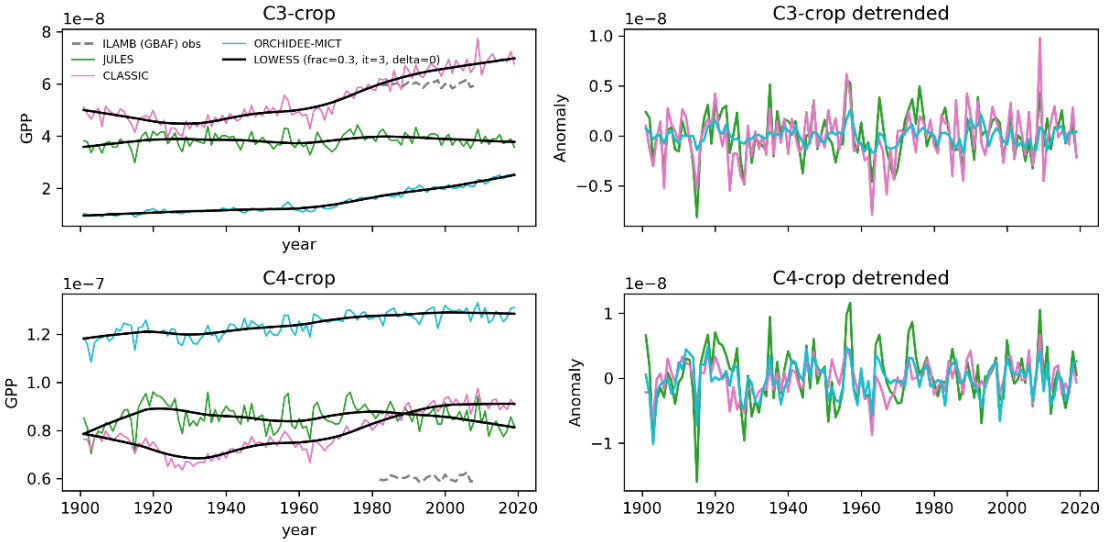
Crop subset

- Spatial subset
  - Mean weighted by observed crop cover (2020 CROPGRIDS data)
- Temporal subset
  - Growing season mean
  - Crop calendar

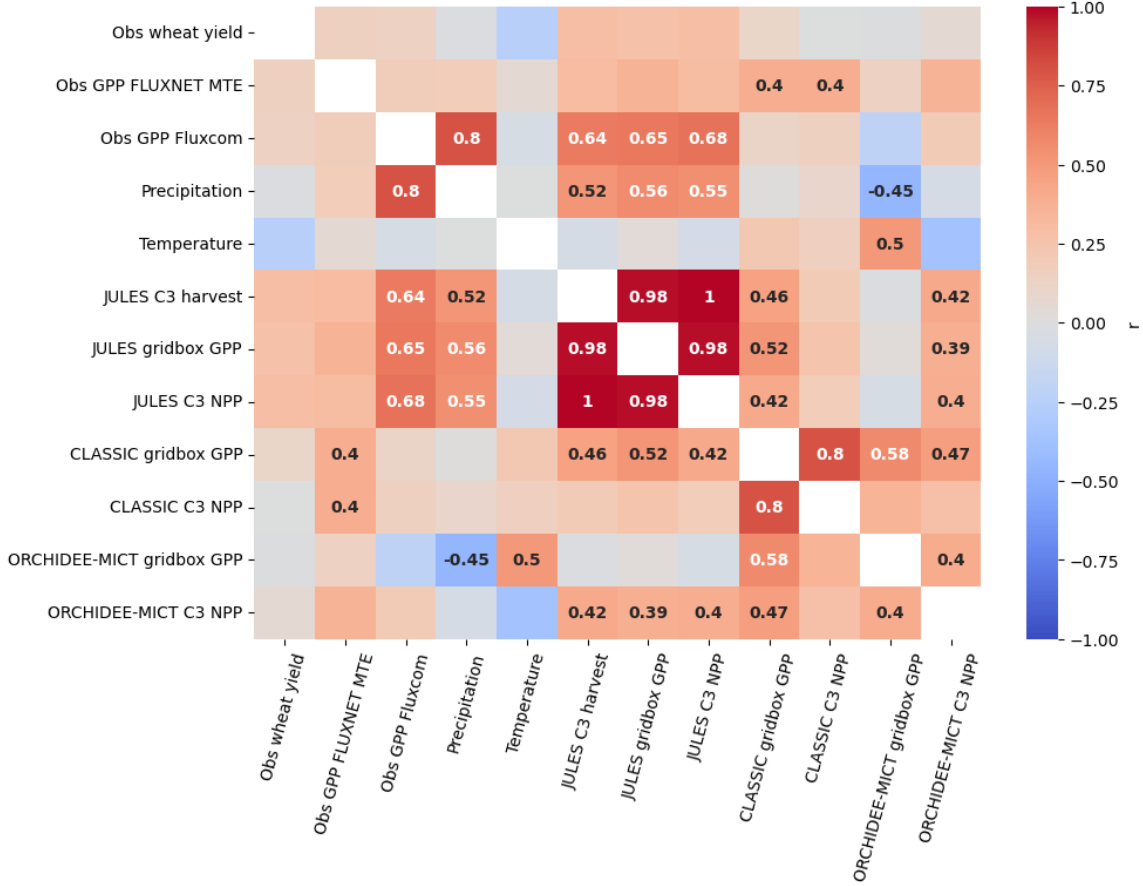


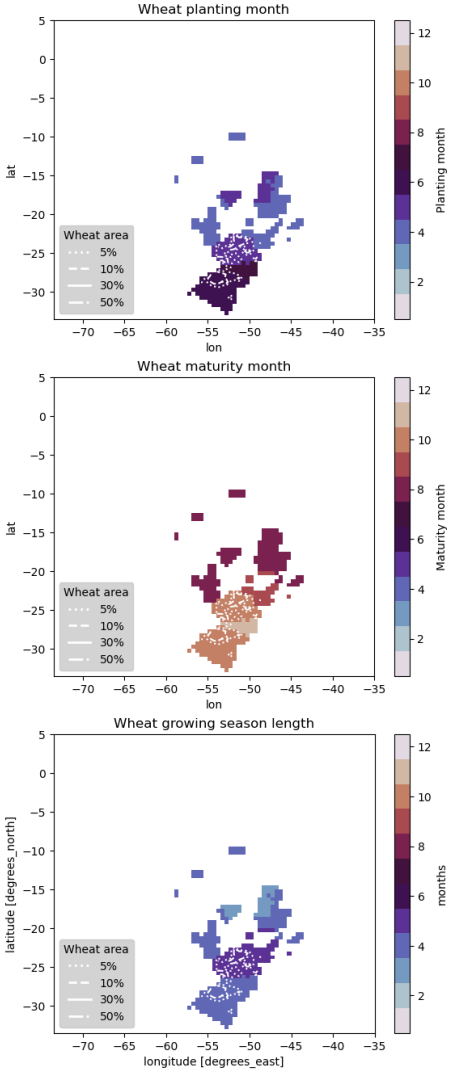
Crop subset

- Spatial subset
  - Mean weighted by observed crop cover (2020 CROPGRIDS data)
- Temporal subset
  - Growing season mean
  - Crop calendar
- Detrend
  - Remove long term trends to focus on interannual variability (response to meteorological conditions)
  - Both GPP/NPP and obs



Wheat





- Labelled values have p-value < 0.05

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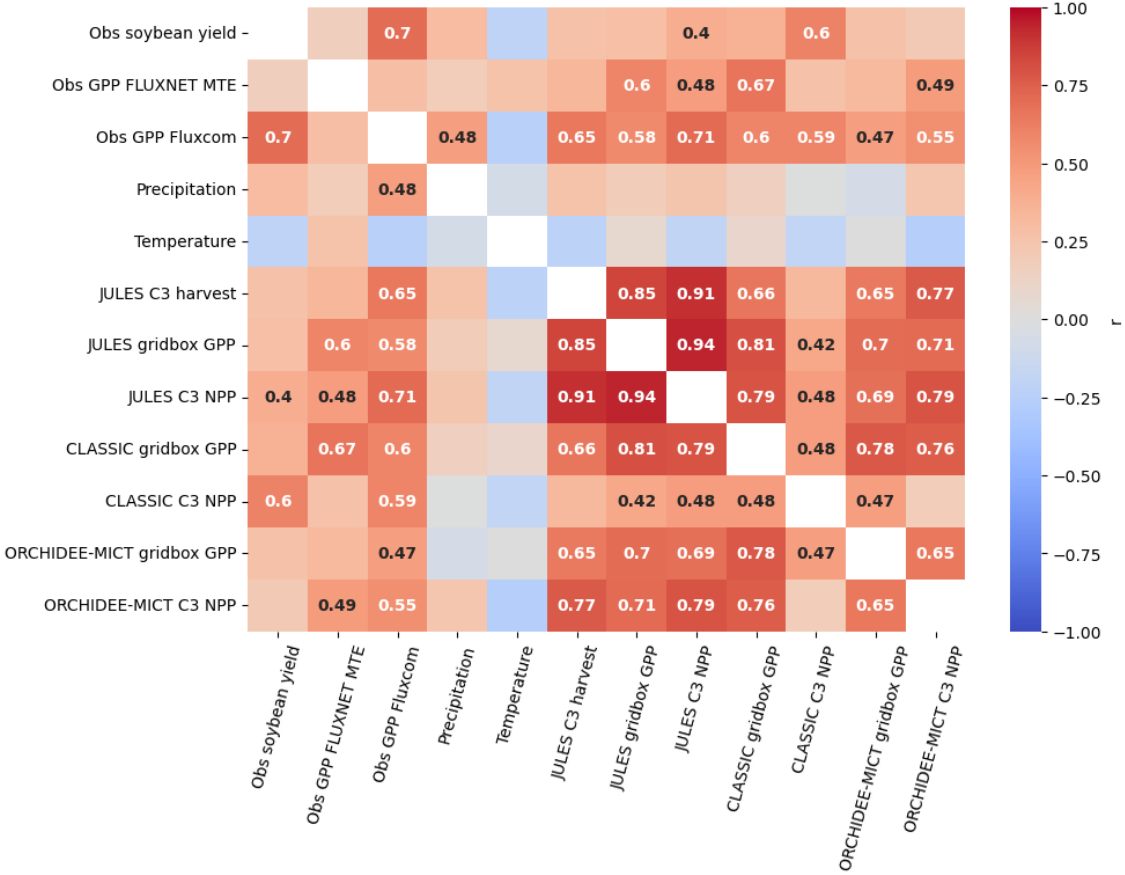
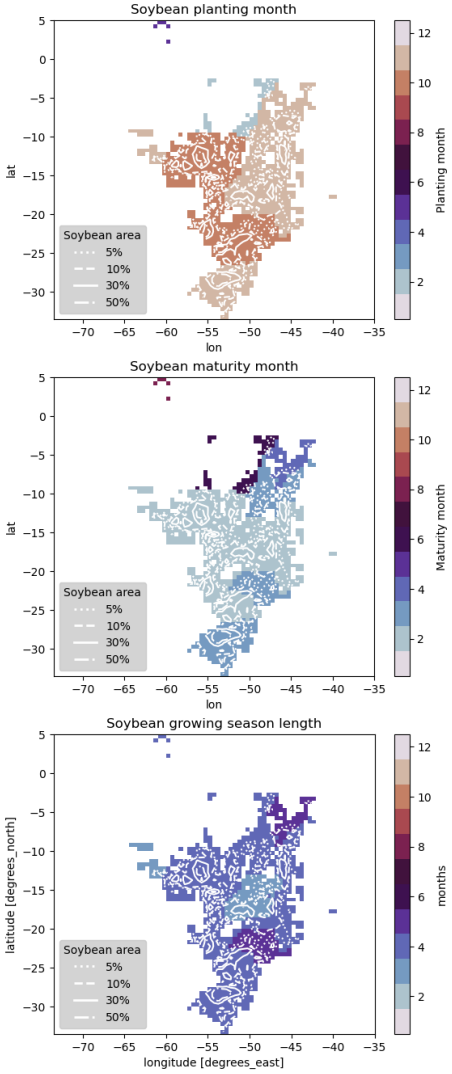
Soybean





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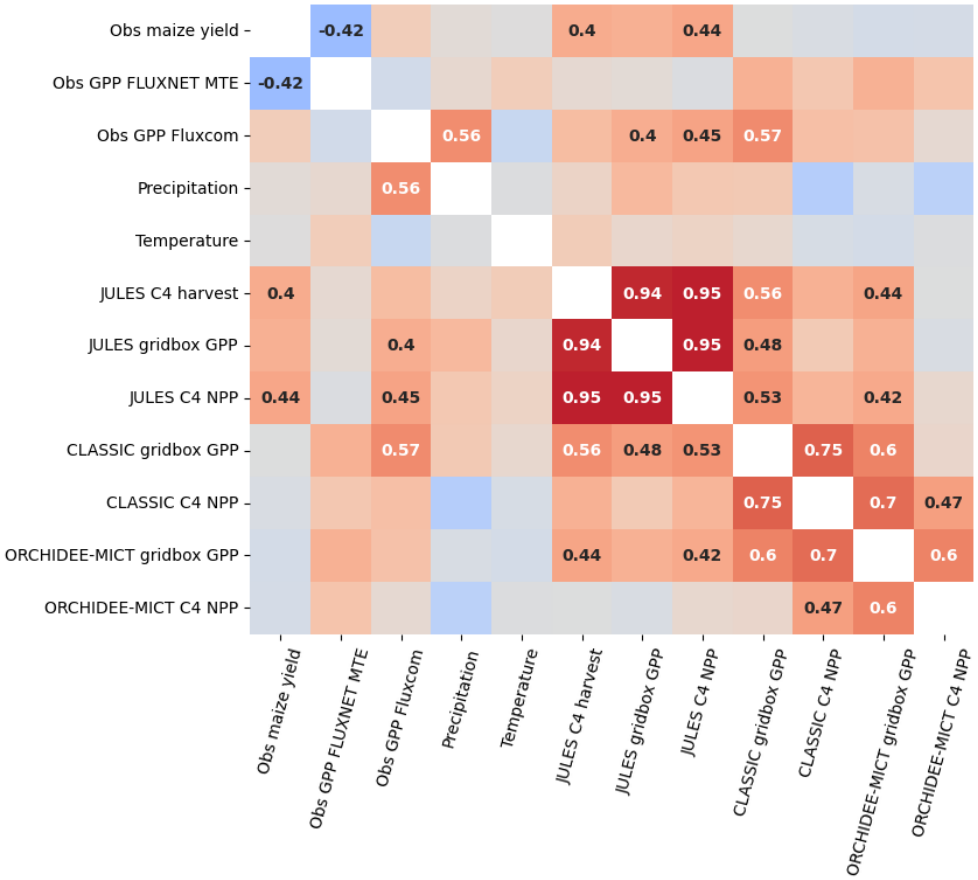
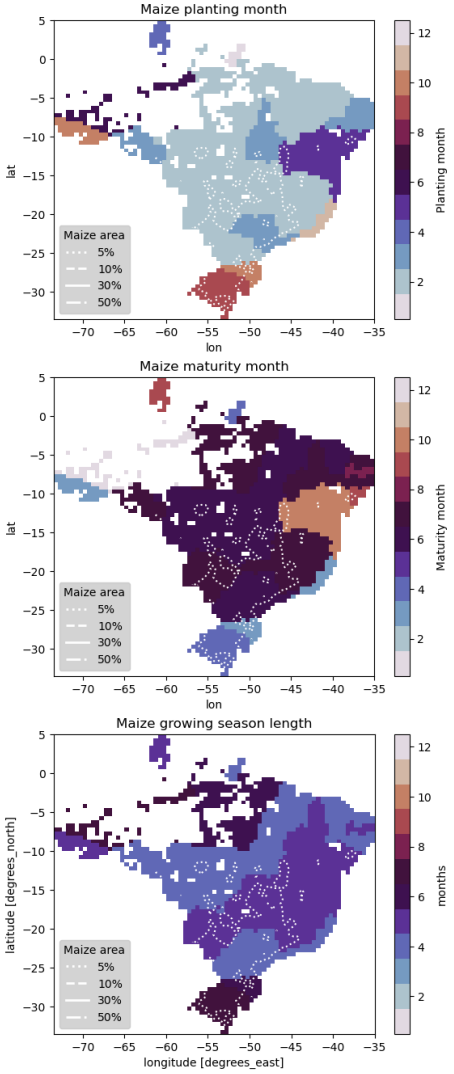
Maize





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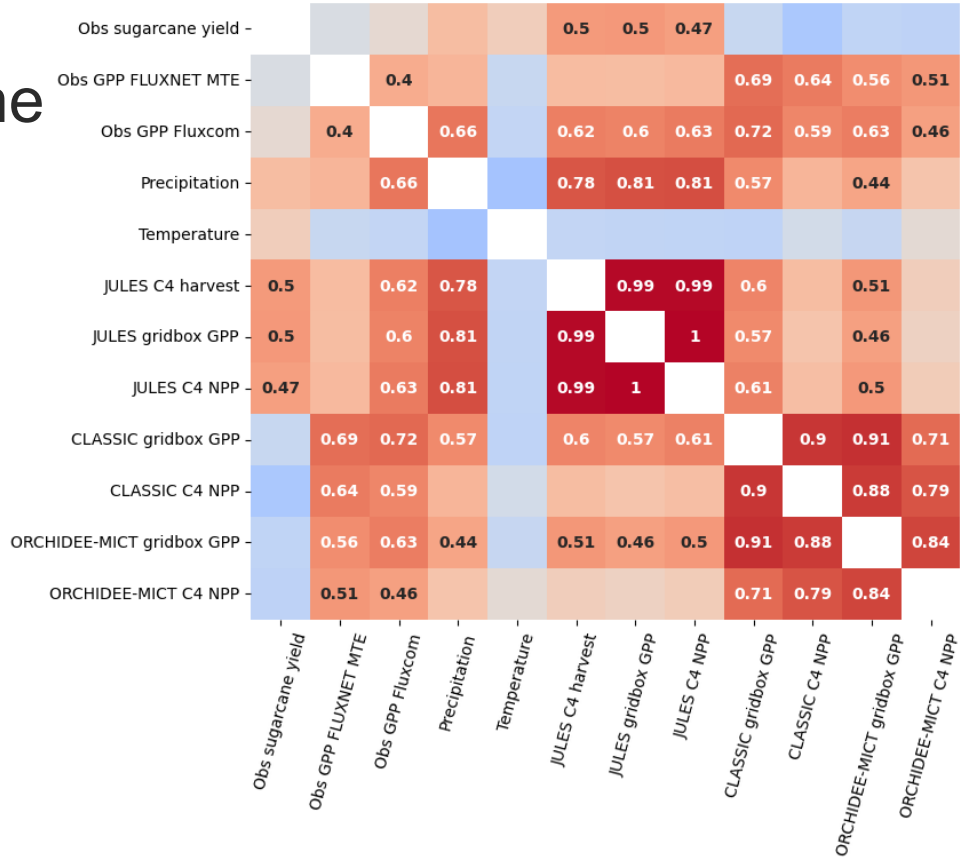
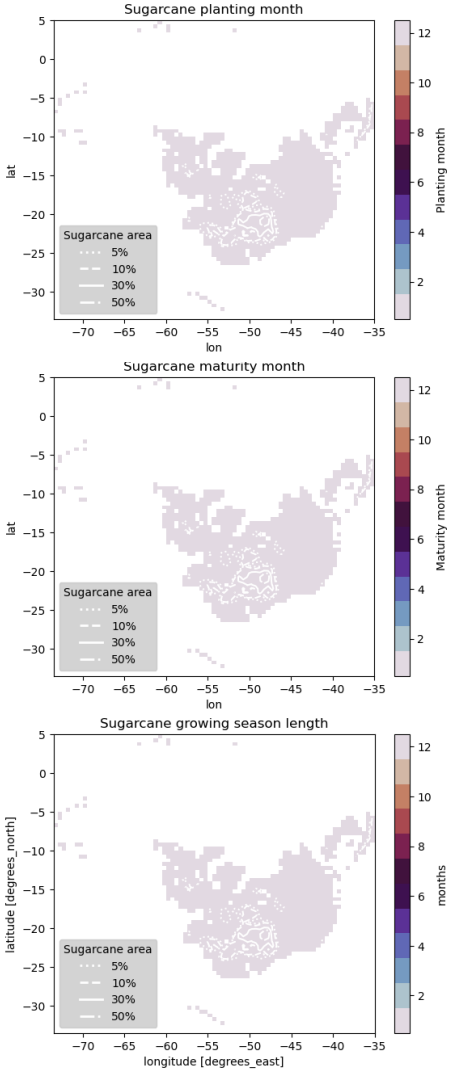
Sugarcane





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Conclusions

- JULES-ES can be useful as first order indicators of crop growth potential
  - C3/C4 spatial preference
  - Response to interannual variability in meteorology
- Crop yield is difficult to model
  - Crop specific characteristics/response
  - Human influences affecting agricultural yield
- Model performance is crop-dependent

Possible ways forward:

- Test globally
- Look at PFT outputs even where they don't outcompete other PFTs
- Specify crop specific PFTs instead of generic C3-/C4-crop
- JULES-crop