Evaluation of JULES-ES configuration for ISIMIP

JULES Annual Meeting

September 2021

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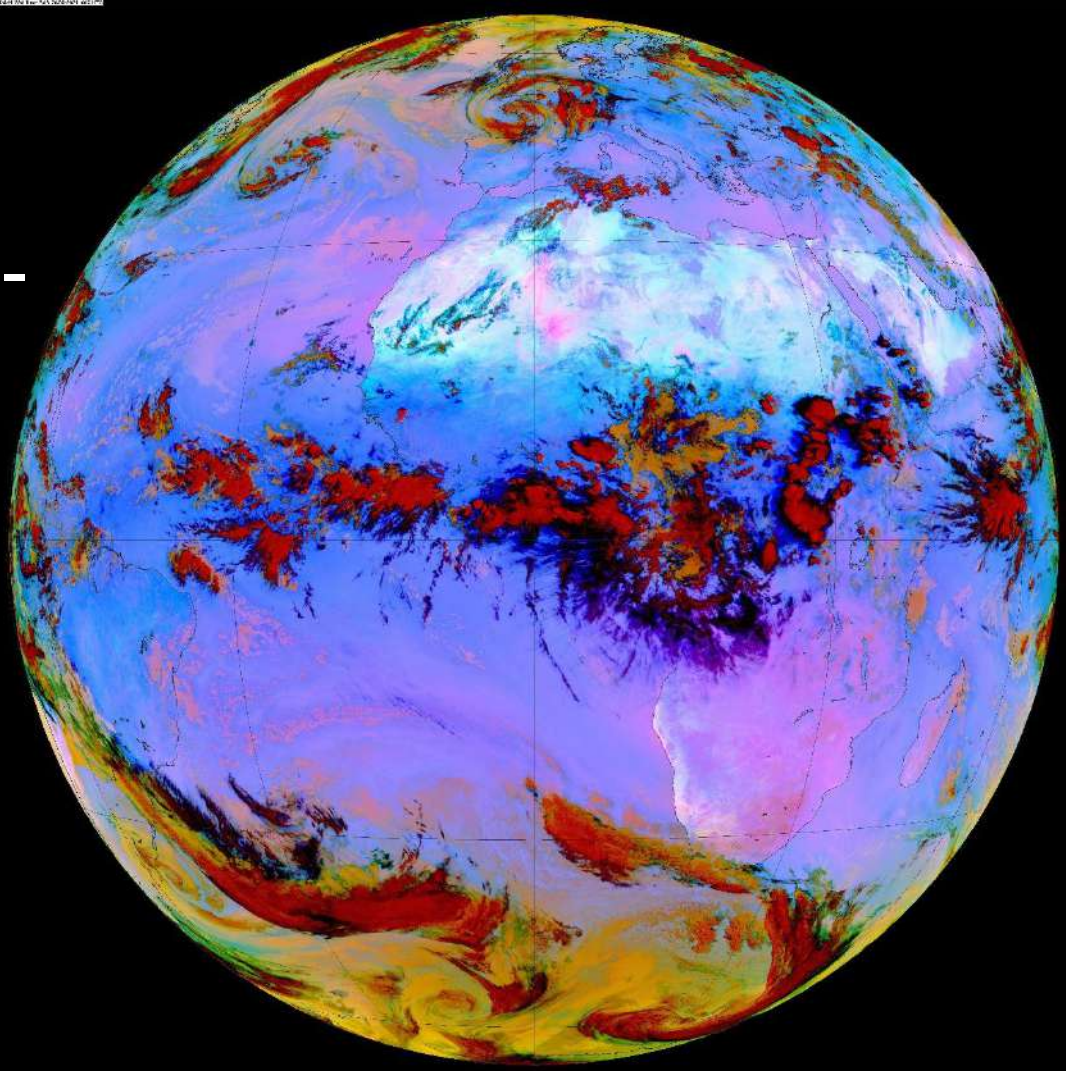


ISIMIP: Inter-Sectoral Impacts Model Inter-comparison Project

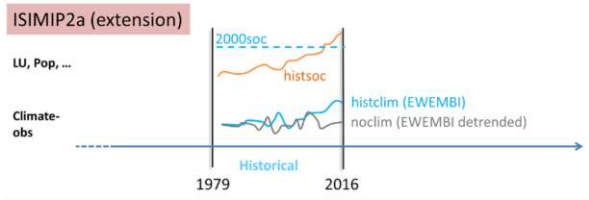
"ISIMIP provides a framework for consistently projecting the impacts of climate change across affected sectors and spatial scales"

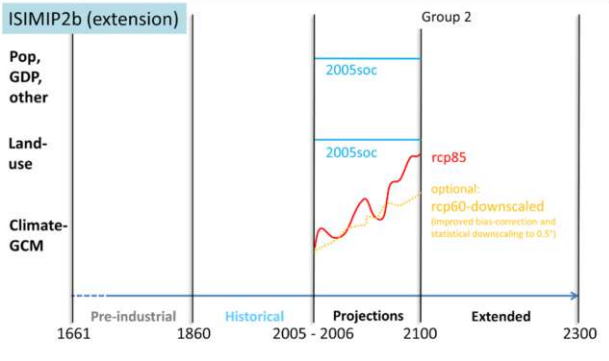
Aim: quantify the impacts of climate on multiple sectors, understand uncertainties and look at interactions between different sectors.

Sectors: Biomes, Hydrology, Fire & Agriculture

Progress: 2b runs completed, 3a&b in development.

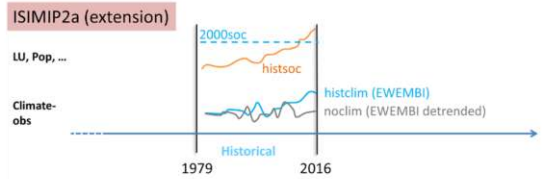
Evaluation first results, soon to begin analysis …

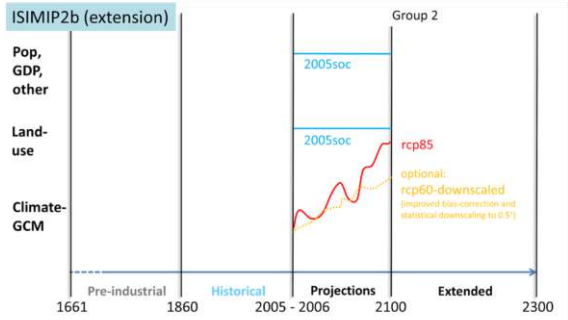




ISIMIP Modelling & Progress

- JULES land surface model configuration based on JULES-ES (used in UKESM1)
- In addition to carbon, water, energy fluxes, JULES-ES also includes:
  - Nitrogen deposition
  - Land use change
  - River routing
  - Dynamic vegetation (TRIFFID & TRIFFID-crop)
  - Fire (ISIMIP3)
- Modelling protocol:
  - 0.5° resolution, daily timestep (disaggregated)
  - Bias corrected driving data for historical, RCP2.6 and RCP6.0
  - Standardised inputs include: CO_2 concentrations, land-sea mask, land-use change, population density





NB: ISIMIP3a&b follow similar protocol, but with CMIP6

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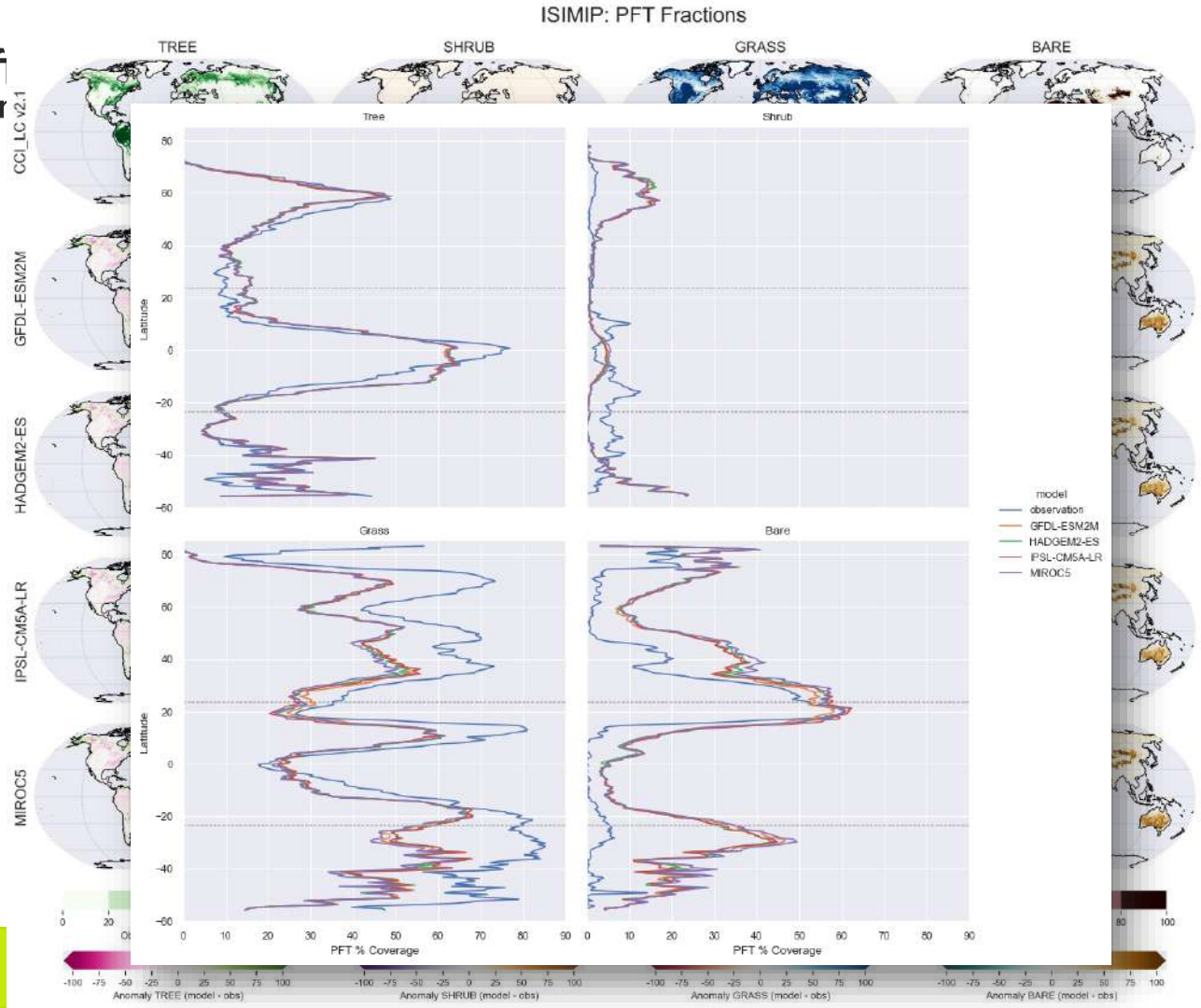
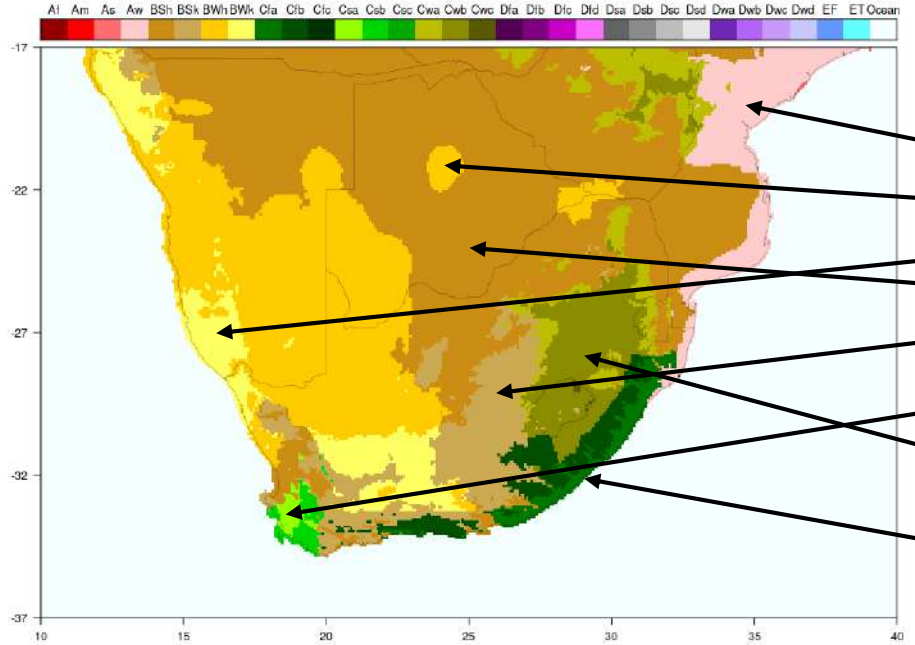


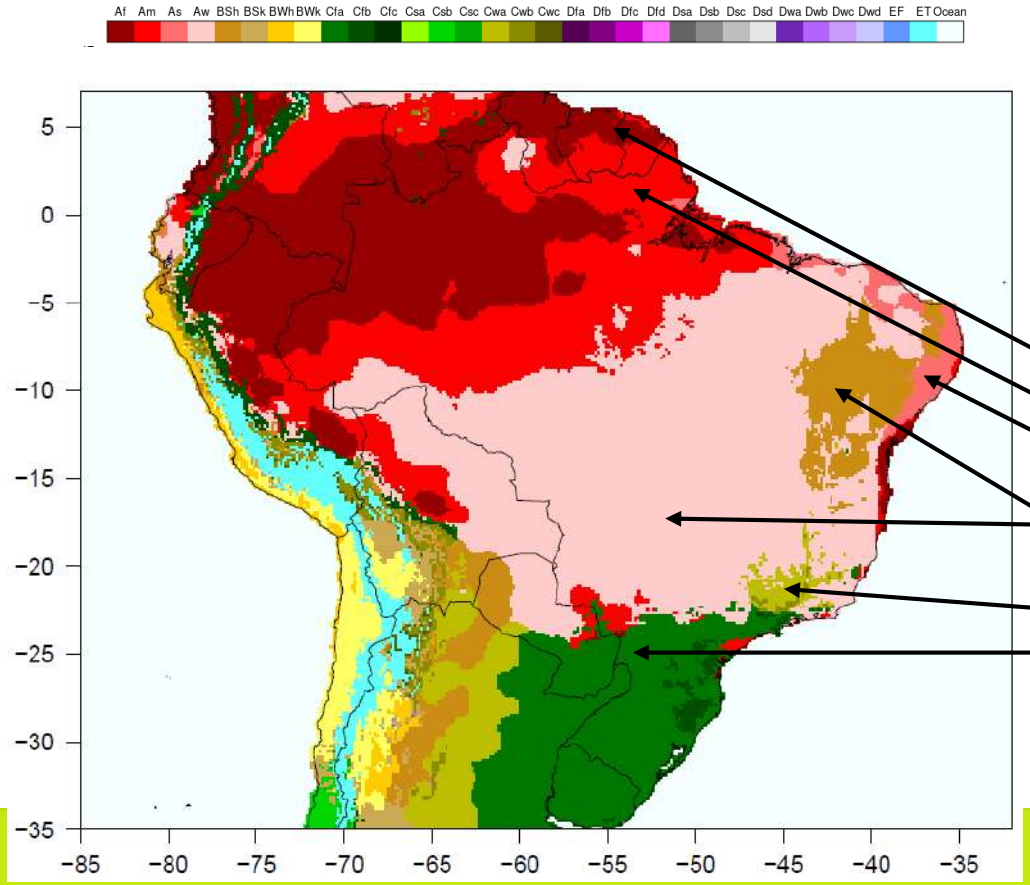
Biomes evaluation



Köppen-Geiger code	Description
Aw	Tropical, savannah
BWh	Arid, desert, hot
BWk	Arid, desert, cold
BSh	Arid, steppe, hot
BSk	Arid, steppe, cold
Csa	Temperate, dry summer, hot summer
Csb	Temperate, dry summer, warm summer
Cwa	Temperate, dry winter, hot summer
Cwb	Temperate, dry winter, warm summer
Cfa	Temperate, without dry season, hot summer
Cfb	Temperate, without dry season, warm summer

Engelbrecht, C. J., & Engelbrecht, F. A. (2016). Shifts in Köppen-Geiger climate zones over southern Africa in relation to key global temperature goals. https://doi.org/10.1007/s00704-014-1354-1

Biomes evaluation



Main climates	Precipitation	Temperature	
A: equatorial	W: desert	h: hot arid	F: polar frost
B: arid	S: steppe	k: cold arid	T: polar tundra
C: warm temperate	f: fully humid	a: hot summer	
D: snow	s: summer dry	b: warm summer	
E: polar	w: winter dry	c: cool summer	
	m: monsoonal	d: extremely continental	

Köppen-Geiger code	Description
Af	Tropical, fully humid
Am	Tropical, monsoonal
As	Tropical, summer dry
Aw	Tropical, savannah
BSh	Arid, steppe, hot
Cwa	Temperate, dry winter, hot summer
Cfa	Temperate, without dry season, hot summer

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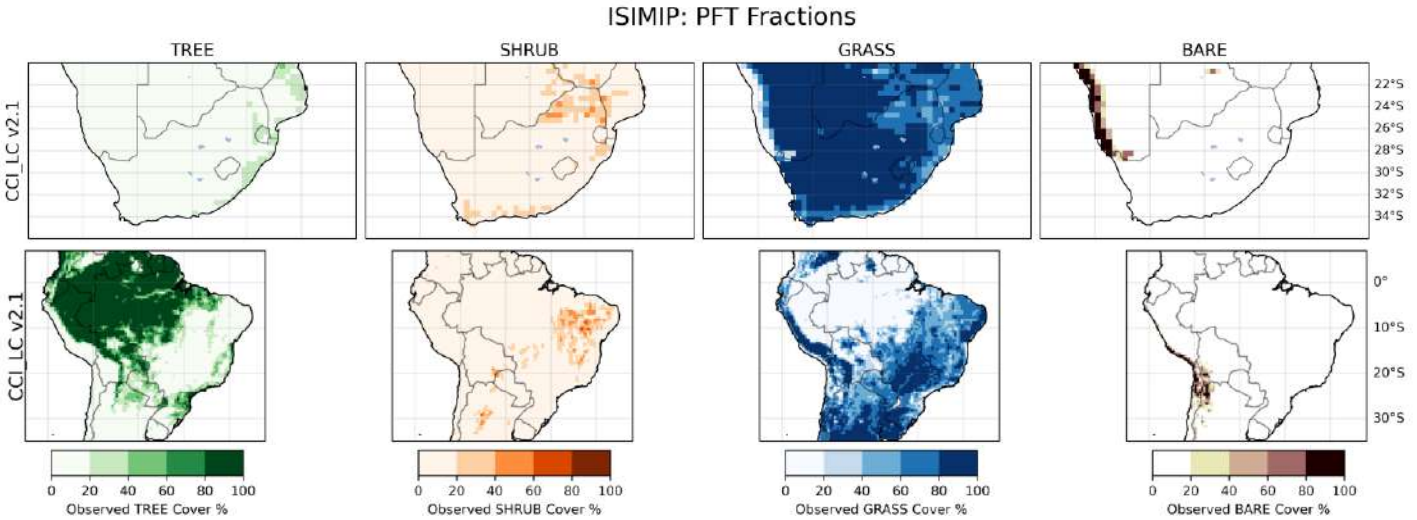
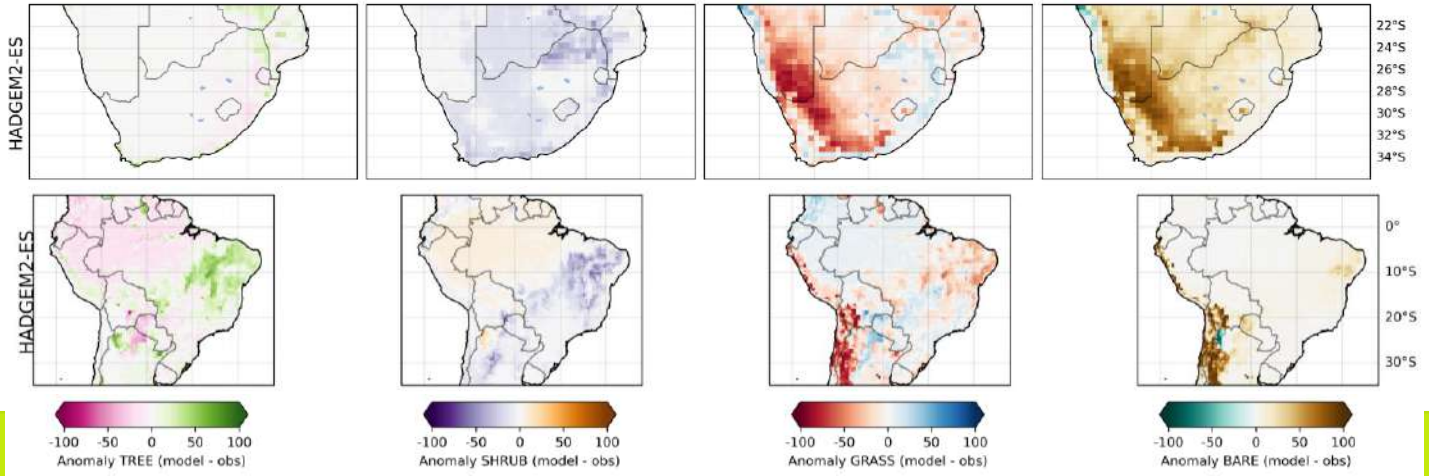
Observations (2010)



Model Anomalies



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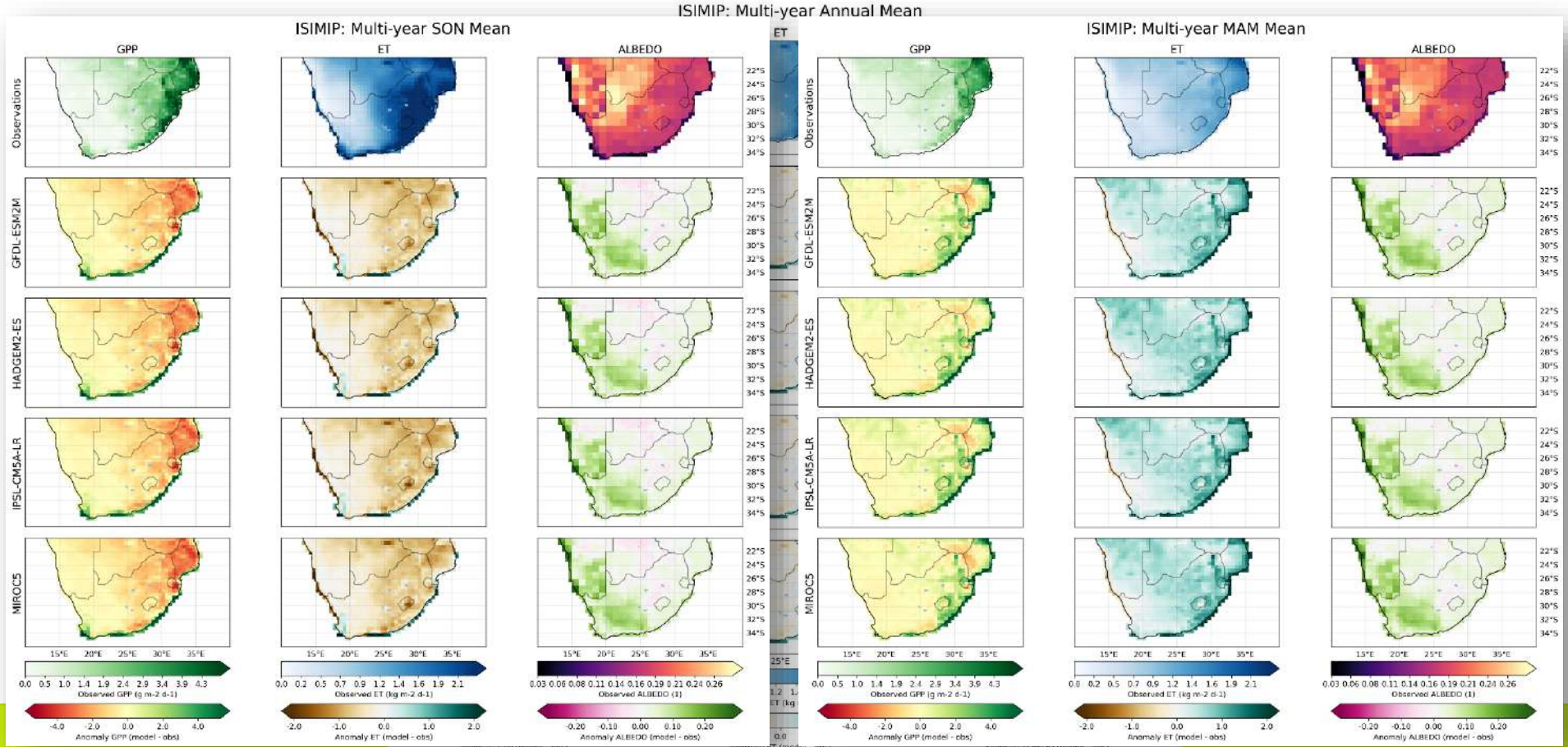
Carbon, water and energy flux evaluation



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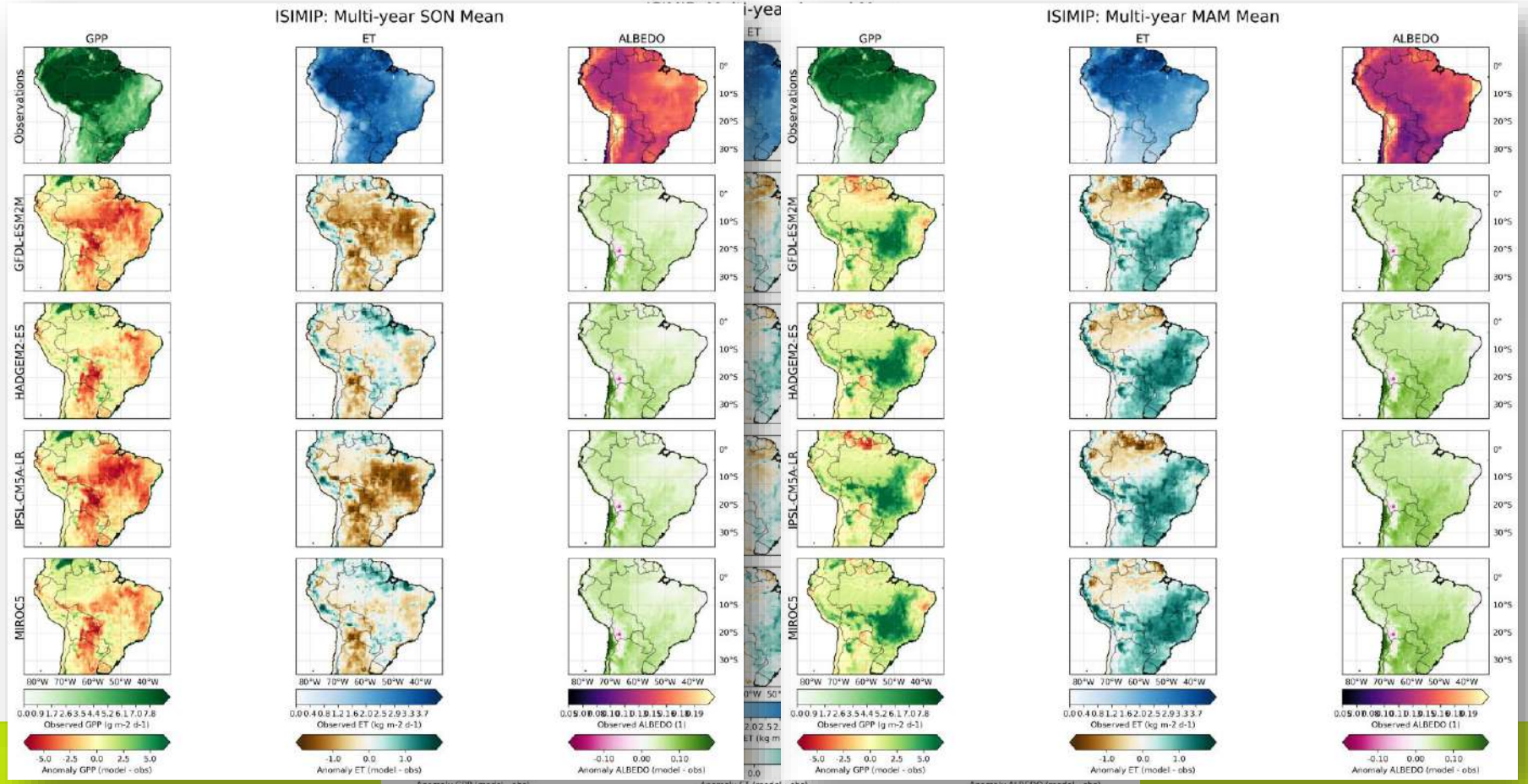

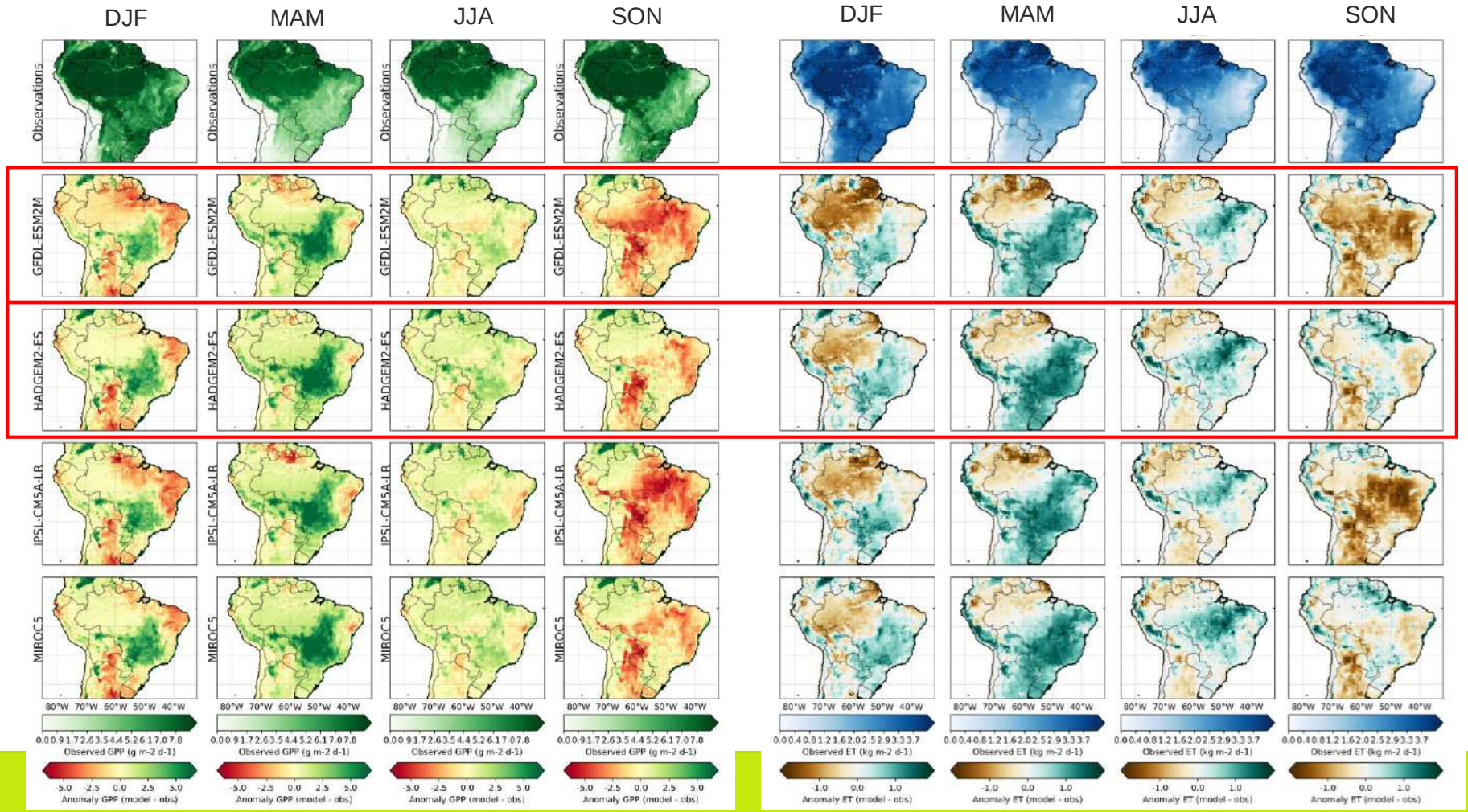
DJF
MAM
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SON
Observations
GFDL-ESM2M
HADGEM2-ES
IPSL-CM5A-LR
MIROC5
80°W 70°W 60°W 50°W 40°W
0.0 0.9 1.7 2.6 3.5 4.4 5.2 6.1 7.0 7.8
Observed GPP (g m-2 d-1)
-5.0 -2.5 0.0 2.5 5.0
Anomaly GPP (model - obs)
0.0 0.4 0.8 1.2 1.6 2.0 2.5 2.9 3.3 3.7
Observed ET (kg m-2 d-1)
-1.0 0.0 1.0
Anomaly ET (model - obs)

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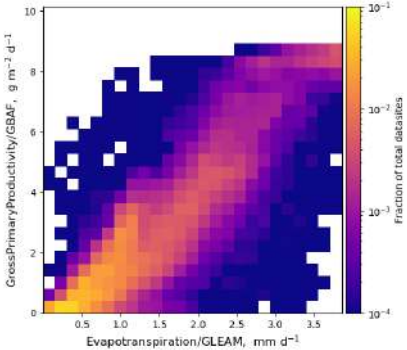
Relationships

Initial look at drivers relevant to carbon & hydrological cycles

GPP vs ET

Why do different driving data lead to different ET distributions in Amazon at the end of the dry season?

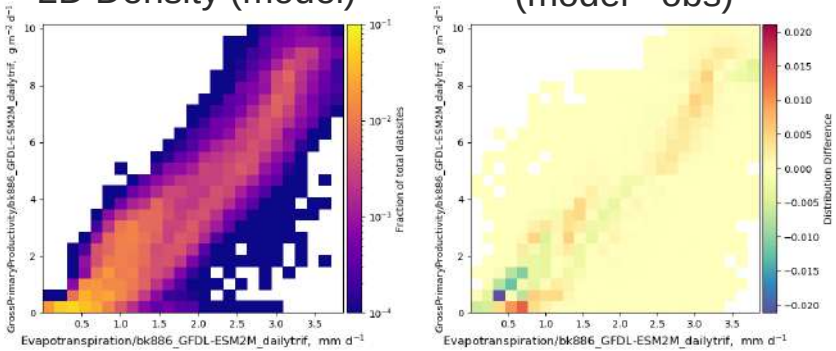
2D density (Observations)



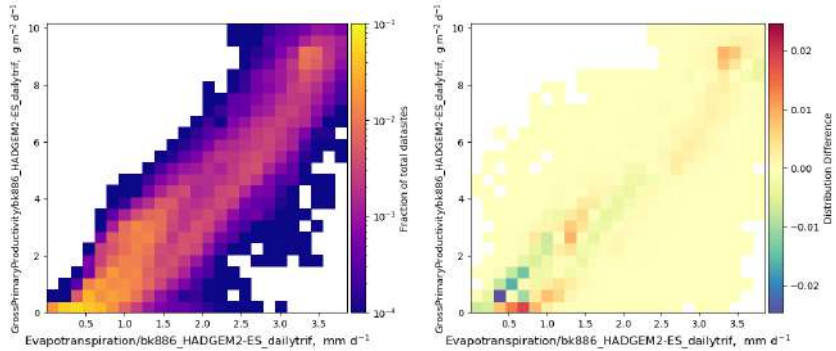
2D Density (model)

2D Density (model - obs)

GFDL-ESM2M

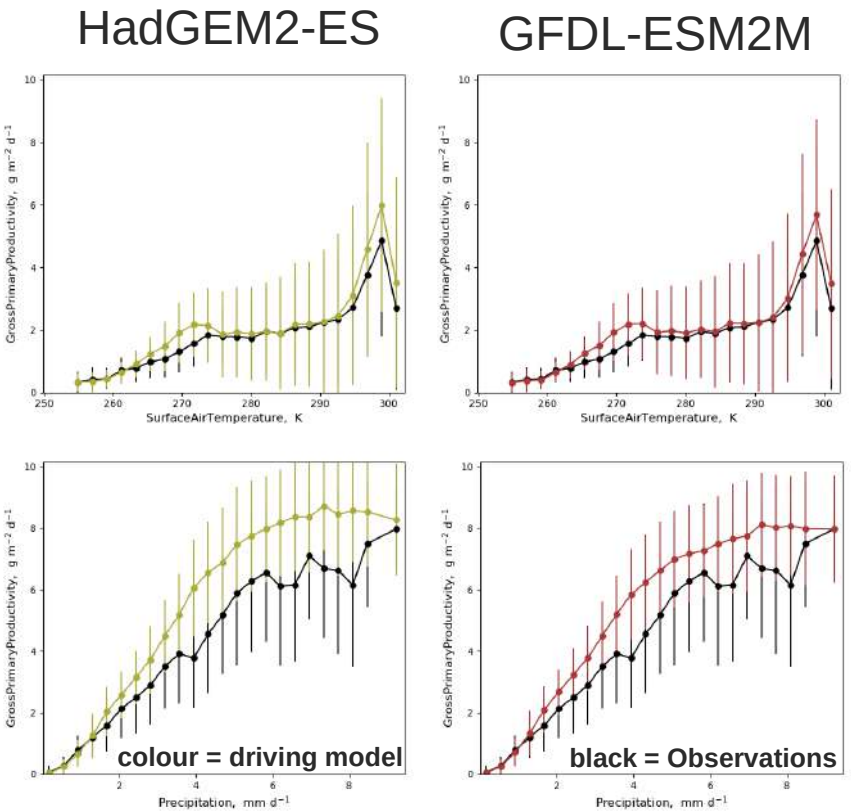


HadGEM2-ES



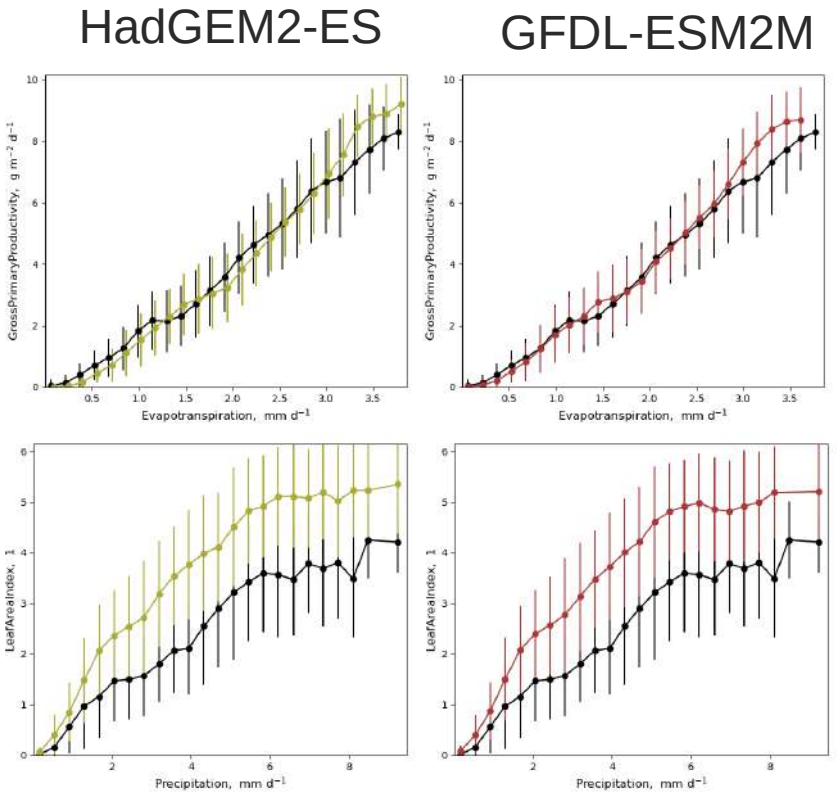
GPP vs Precipitation & Temperature

- Generally, GPP in JULES-ES is responding the same to different driving data
- Reduction in positive bias of GPP, at higher precip rates in GFDL-ESM2M. Why?
- Too much GPP @ 273K and >290K



GPP, ET and LAI

- GPP – ET relationship seems pretty good on first glance
- However, LAI far too high relative to precip



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Initial conclusions

- JULES captures well the major vegetation types
- Possibly over-estimates bare soil fractions
- Over-estimation of albedo
- GPP and ET annual means appear to evaluate well
  - However, seasonal cycles appear shifted, with delayed onset and retreat of the growing season
  - Needs further investigation to determine causes of these biases, and indeed whether they affect climate impacts results (e.g. river flooding, crop productivity)
- Addition of fire will likely improve seasonal cycle of vegetation

Future work

- Analysis of future trends in:
  - biomes, and change in suitability for key habitats
  - suitability of C3 and C4 croplands
  - water availability (run off, soil moisture)
  - fire weather and fire occurrence
- Sensitivity of impacts to meteorological drivers and extremes
- Combined impacts
- Development of weather or climate services?
- Other impacts?

Paper plan:

1. JULES-ES for ISIMIP config paper: Camilla
2. Multiple climate impacts paper: AndyH
3. Fire impacts on the C cycle: Chantelle
4. CONFIRE vs ISIMIP (no fire): Doug
5. Multiple impacts models: TBC
6. Regional analysis for Brazil / South Africa: TBC

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Thank you!

Any questions?

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