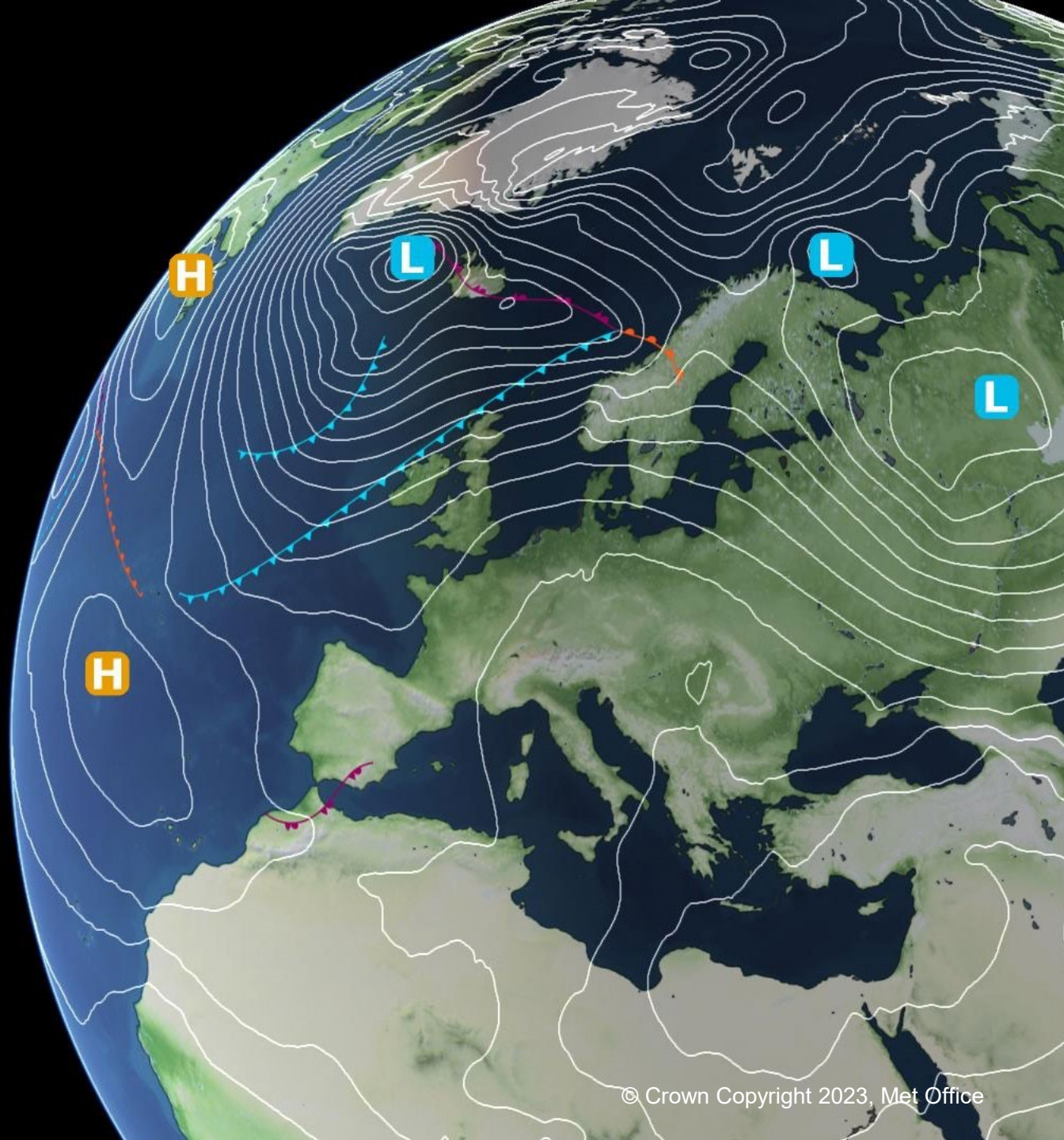
JULES-ES for Climate Impacts

Andy Hartley

JULES Annual Meeting 2025

Space Park Leicester



Outline

- How do we currently use JULES for Climate Impacts Research?
  - Biomes: how will the ecosystems on which societies depend change?
  - Fire: how will risks to people and infrastructure change? How will this affect air quality and therefore health?
  - Hydrology: what is the impact of changing biomes / vegetation on flooding events? Can adaptation / CO2 response of veg reduce the impact of droughts on water security?
  - Agriculture: can the world continue to feed itself in a warming world? How does maintaining food security impact water security?
- What are future plans and timelines?
- ISIMIP-4 plans
- Join our team!

Met Office

How do we currently use JULES?

… for impacts research …

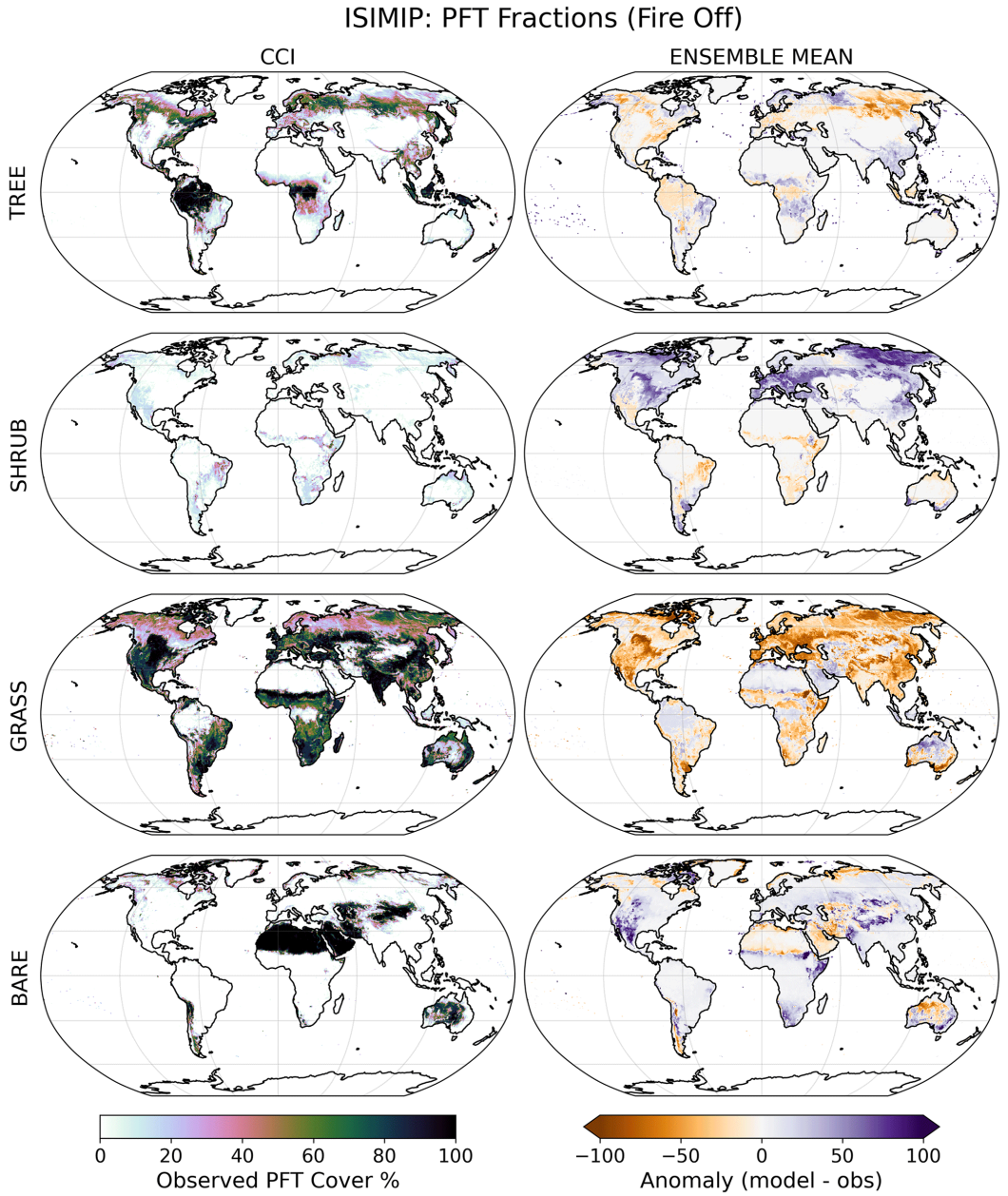
Biomes

Humans depend on the services provided by ecosystems, such as pollination, local cooling, provision of drinking water and carbon sequestration

JULES-TRIFFID

Simulates the response of major vegetation types to changes in climate, CO_2, land use and competition

- Broadleaf trees
  - Tropical
  - Temperate
  - Evergreen
  - Deciduous
- Needleleaf trees
  - Evergreen
  - Deciduous
- Shrubs
  - Evergreen
  - Deciduous
- Grasses
  - C3 Natural & Crops
  - C4 Natural & Crops
- Bare soil



Mathison, C., et al. (2023).

Description and evaluation of the JULES-ES set-up for ISIMIP2b.

Geoscientific Model Development, 16(14), 4249–4264. https://doi.org/10.5194/GMD-16-4249-2023

Dynamic Vegetation

- Amazon forest “dieback” in our climate model in 2000
  - First climate model with vegetation dynamics
- Investigated more in follow-on studies

Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model

Peter M. Cox, Richard A. Betts, Chris D. Jones, Steven A. Spall & Ian J. Totterdell

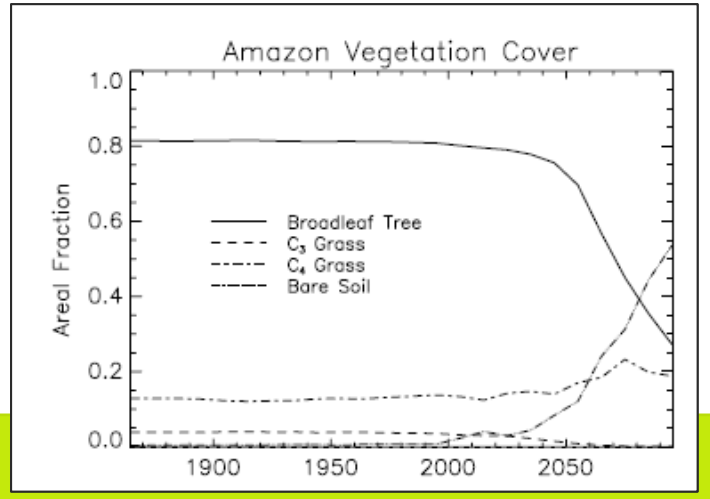
Nature **408**, 184–187 (2000) | Cite this article

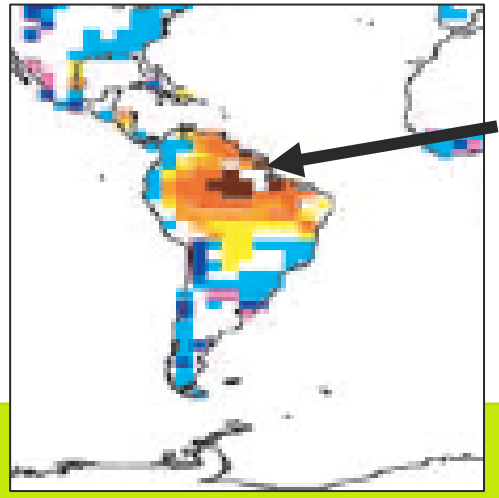
Amazonian forest dieback under climate-carbon cycle projections for the 21st century

P. M. Cox[1], R. A. Betts[1], M. Collins[2], P. P. Harris[3], C. Huntingford[3], and C. D. Jones[1]

The role of ecosystem-atmosphere interactions in simulated Amazonian precipitation decrease and forest dieback under global climate warming

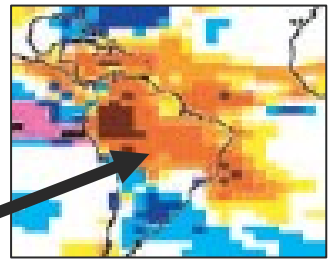
R. A. Betts[1], P. M. Cox[1], M. Collins[2], P. P. Harris[3], C. Huntingford[3], and C. D. Jones[1]





Loss of forest

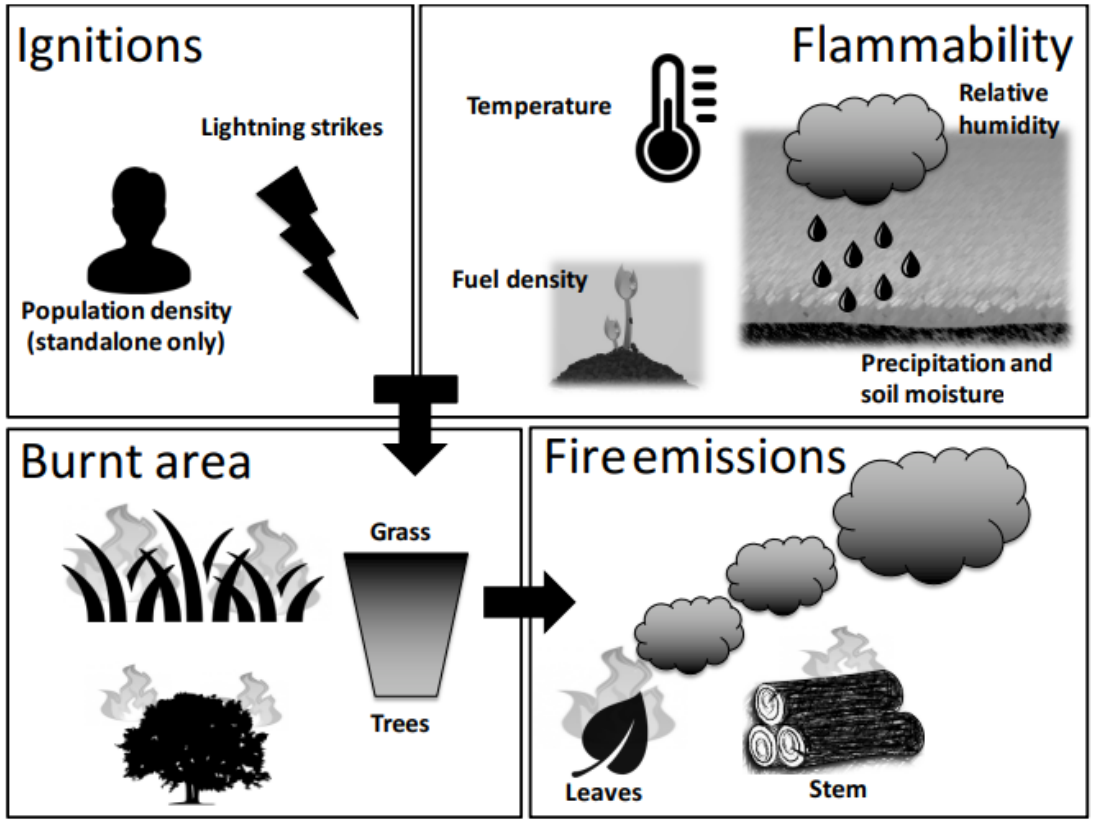
drives further drying



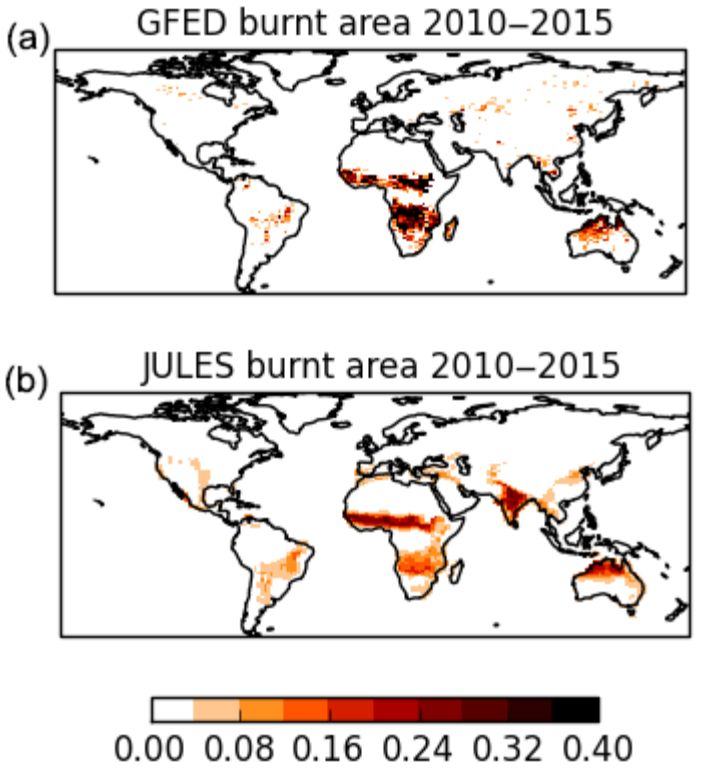
Fire

Plays a key role in shaping the natural environment, and is already increasing in prevalence and intensity due to climate change

INFERNO

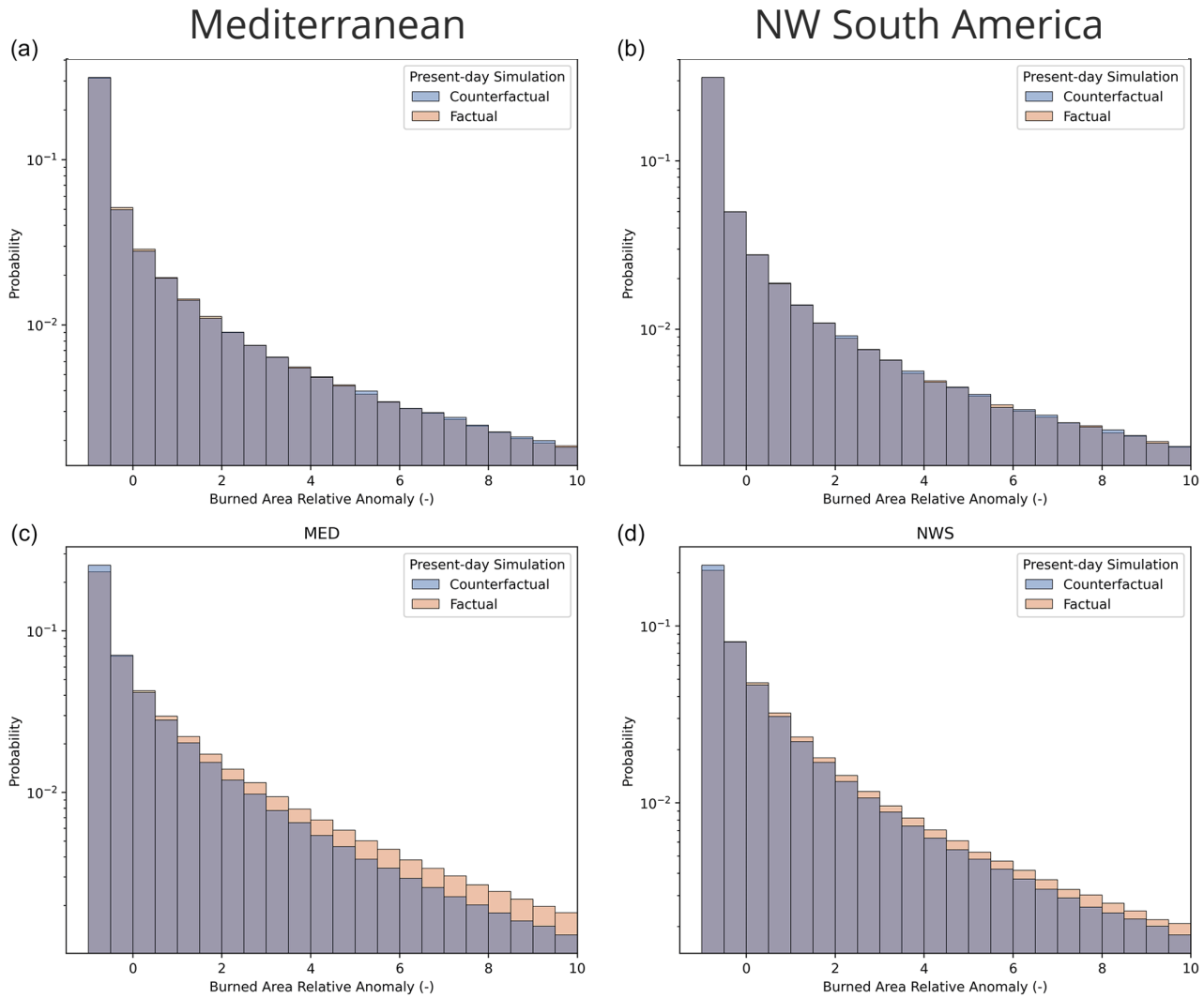


Mangeon, et al. (2016) INFERNO: a fire and emissions scheme for the UK Met Office's Unified Model, *GMD*



Burton, et al. (2019) Representation of fire, land-use change and vegetation dynamics in JULES, *GMD*

Attribution of fire events to climate change



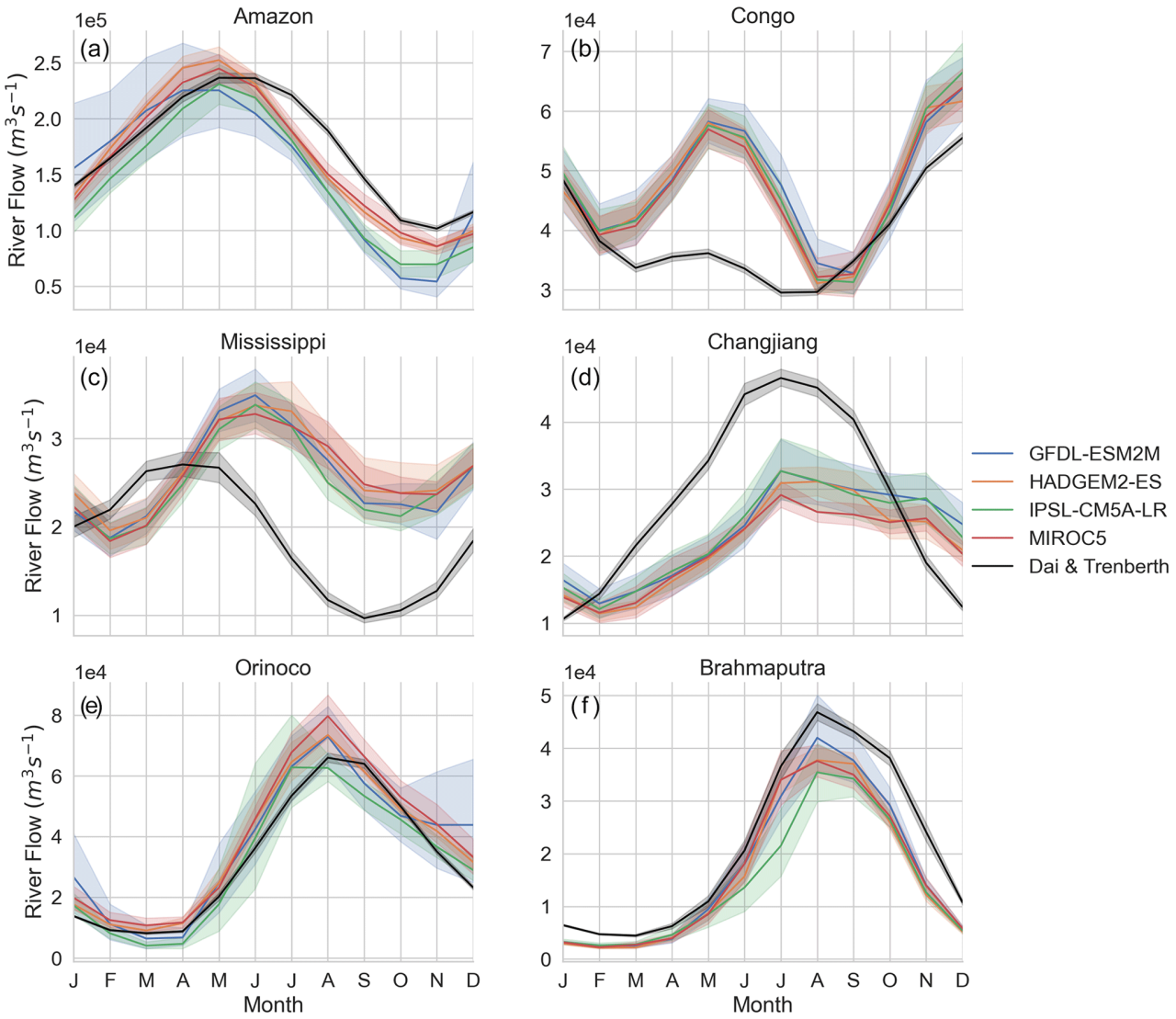
Change in median burnt area due to total climate forcing from FireMIP

Jones et al. (2024) State of Wildfires 2023–2024, *ESSD*

Hydrology

Simulation of surface runoff and rivers help us to understand the changing nature of flooding events

River flow in major river basins



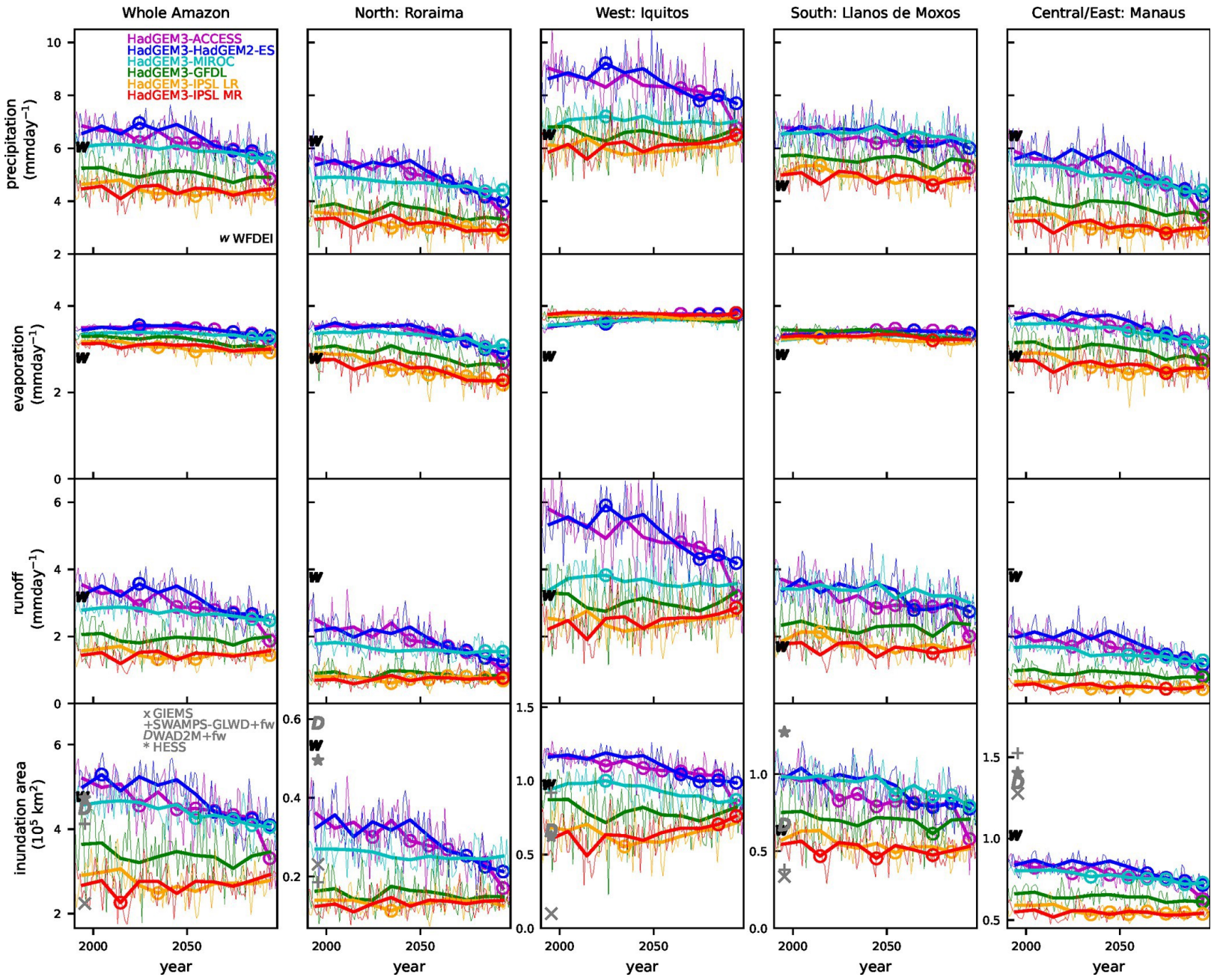
Mathison, et al. (2023). Description and evaluation of the JULES-ES set-up for ISIMIP2b. *GMD*

Wetland inundation in the Amazon

Black **W** = Observed values (1990s)
Coloured lines = decadal trend in multi-model ensemble of HadGEM3 + JULES simulations

Results show dependence of inundation on other aspects of hydrology

Gedney, N. et al (2024)

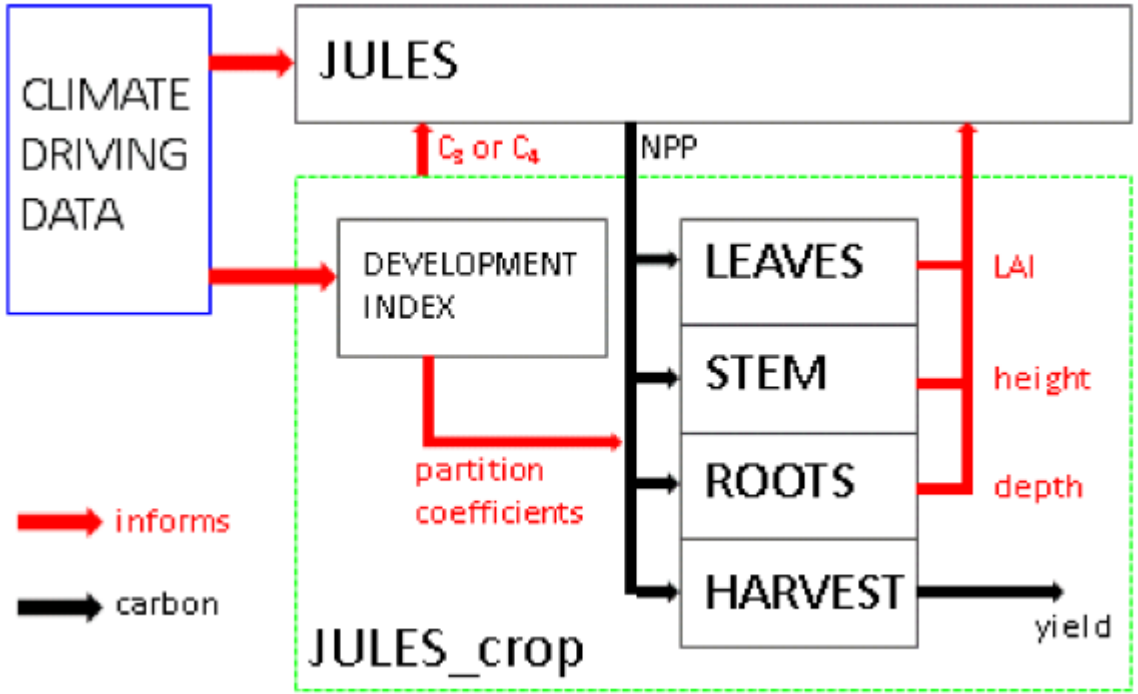


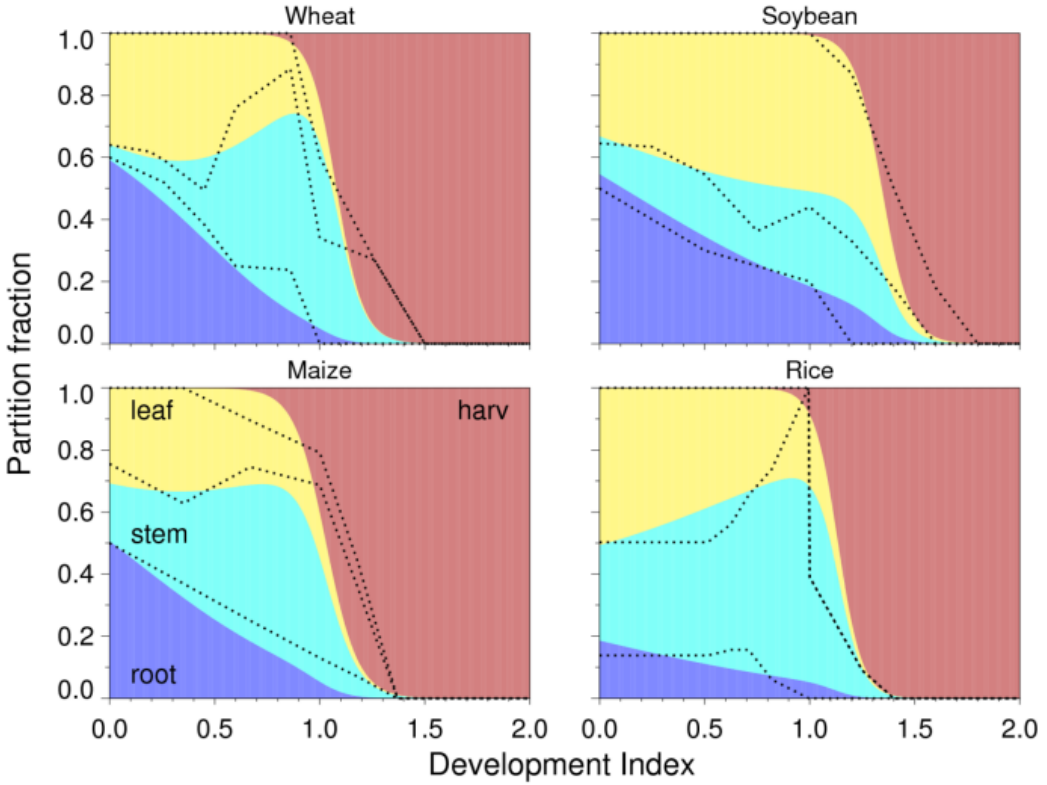
Agriculture

Particularly as the climate changes, JULES can help us to understand the changing niche of key crops, and their potential response to climate extremes

Met Office

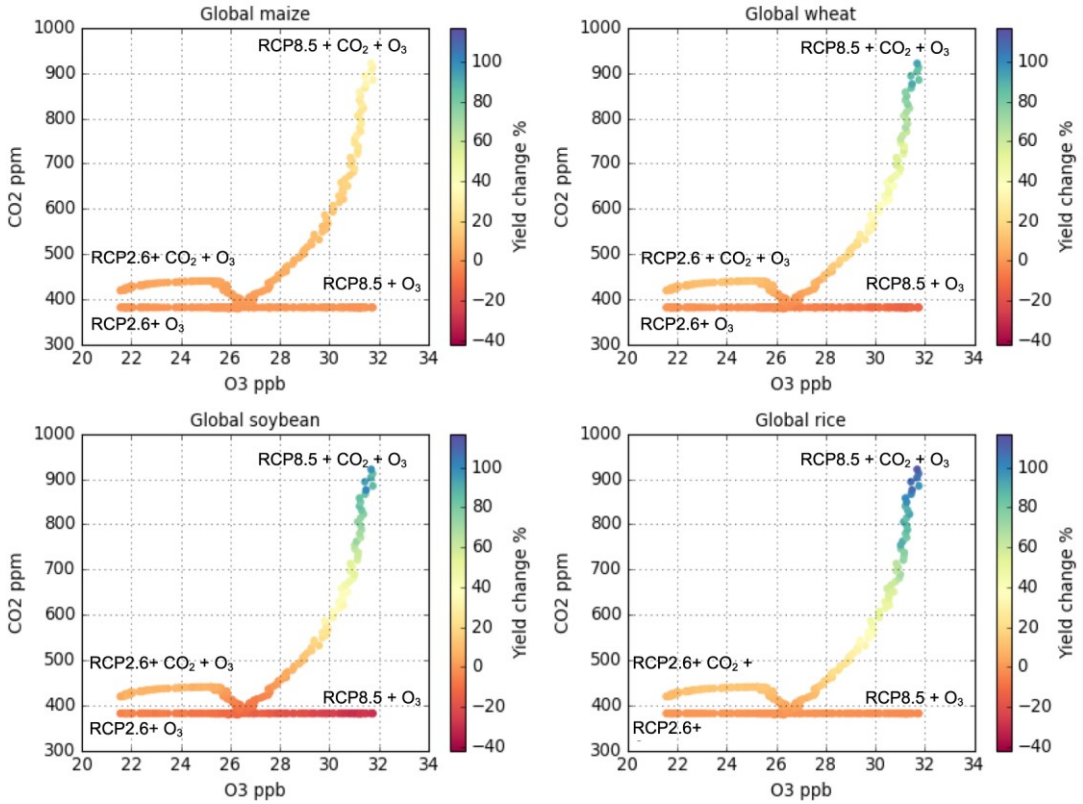
JULES-Crop





Osborne et al. (2015), JULES-crop: a parametrisation of crops …, *GMD*

Ozone and CO2 affect on crops



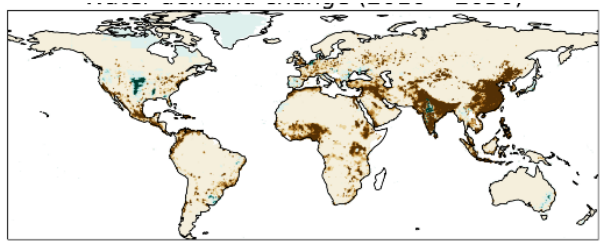
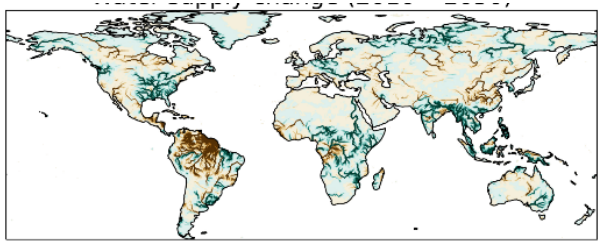
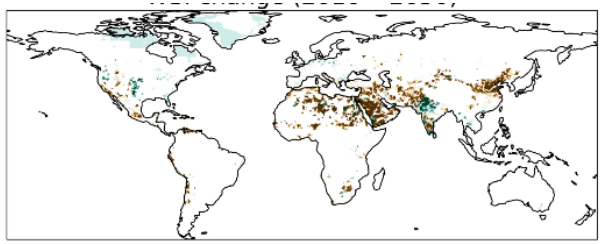
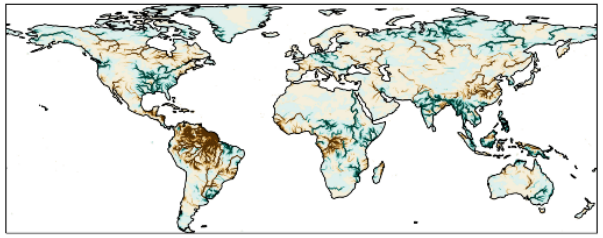
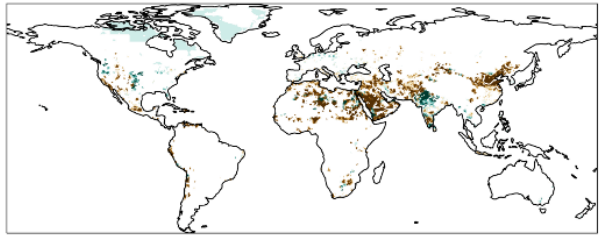
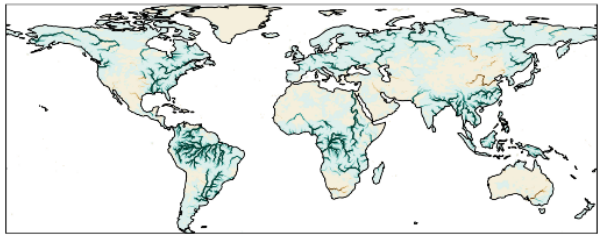
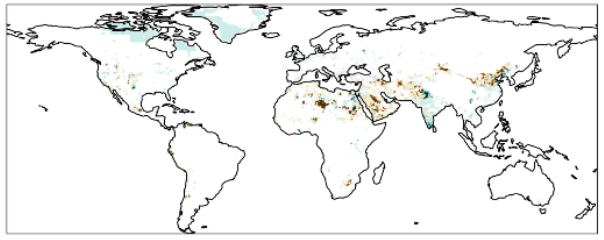
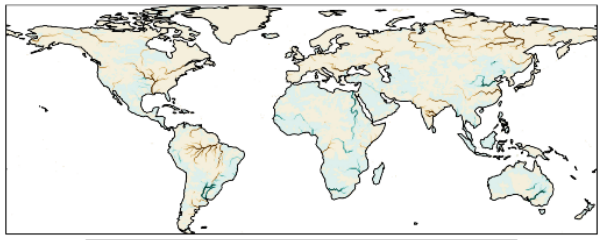
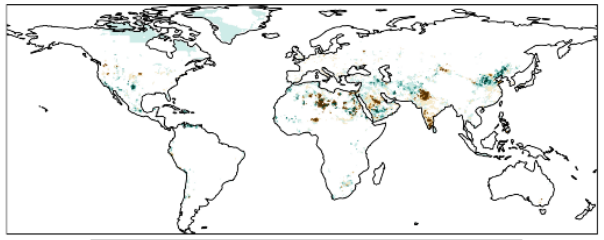
O_3 has been shown to damage photosynthesis, reduce gas exchange, induce early leaf senescence, and inhibit growth in both natural vegetation and crops

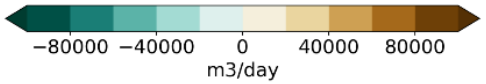
Leung et al. (2022), CO_2 fertilization of crops offsets yield losses due to future surface ozone damage and climate change, *ERL*

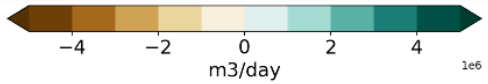
Water Security

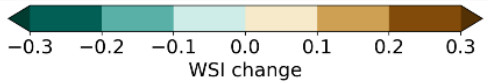
The availability of drinking water is a critical concern especially in arid and semi-arid regions in a changing climate

Met Office

	Water demand (SSP3)	Water supply change	WSI change
ALL			
CLIMATE	Climate changes (e.g., precipitation/temperature) are contributing to worsening water scarcity		
PLANT PHYS	Physiological forcing further worsens water scarcity in areas; the stomatal effect shows limited positive contribution		
VEGETATION	Vegetation distribution changes contribute to negative and positive WSI changes		







Non water-scarce areas (WSI < 0.05) masked out

Competing elements of the earth system may affect water supply in vulnerable locations

Plant physiological response to increasing atmospheric CO_2 may result in more available water

However, climate change and vegetation response may counteract

Jess Stacey et al., *in review*

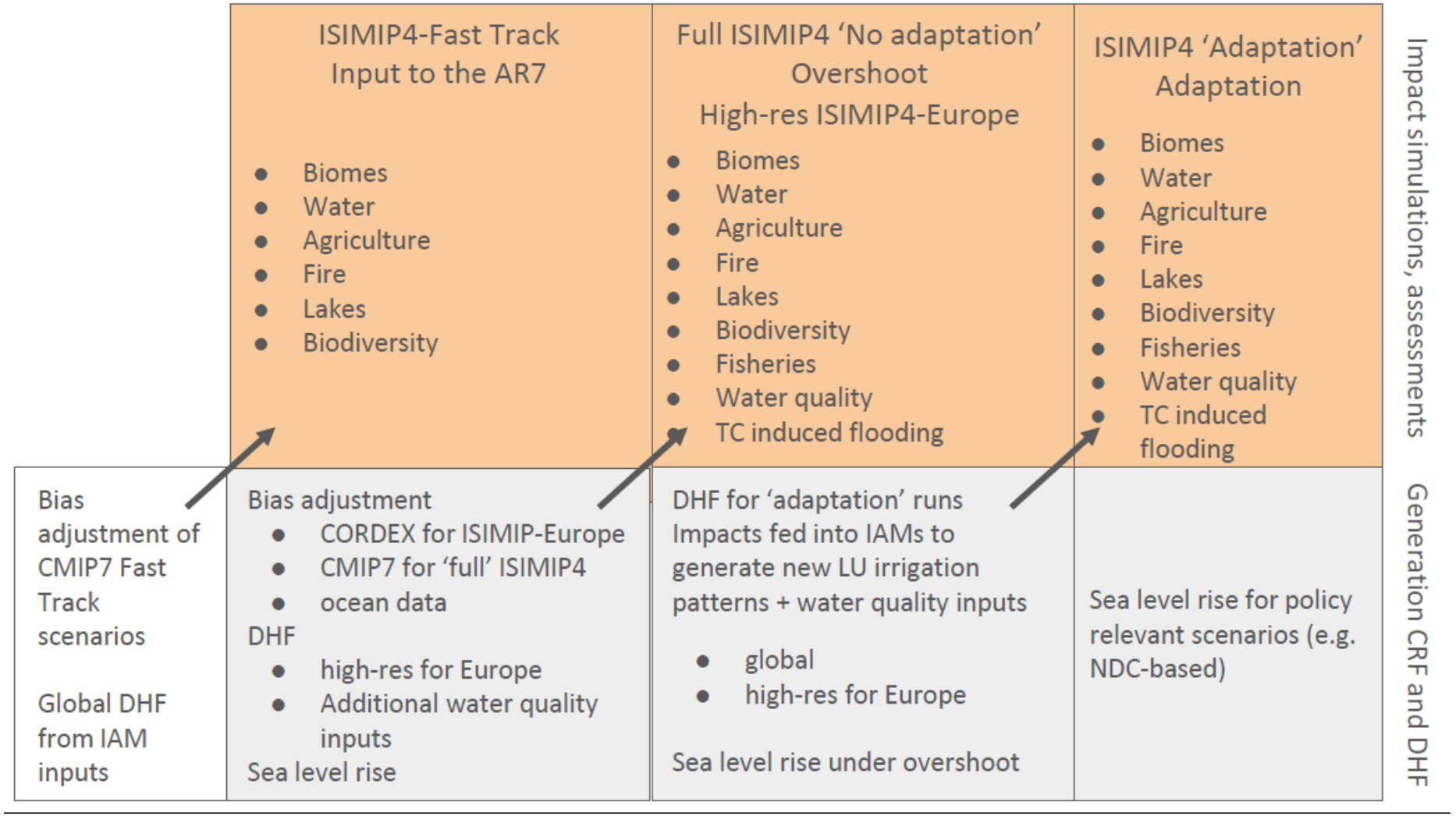
Future plans and timelines

ISIMIP-4 approximate dates

- Focus on JULES-ES (v3) configuration
- Dev time whilst ESMs run, and bias corrected driving data created
- Modelling protocol TBC, but likely to include overshoot and recovery scenarios

	FY25/26		FY26/27				FY27/28				FY28/29	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Development time												
Suite setup and running												
Analysis & paper writing												

ISIMIP-4 Fast Track



Met Office

Ongoing work for ISIMIP-4

- Biomes: RED (Arthur)
- Fire: reduced sensitivity to driving meteorology (Ol Perkins)
- Irrigation with water conservation (Nic Gedney)
- Crops: investigation of post-processing of TRIFFID-Crop (Katty Huang)
- Crops: JULES-Crop with irrigation
- Water: storage in dams & water management
- Permafrost & fire (Eleanor & friends)
- Peat & fire (Eleanor & friends)

Join our team!

We welcome collaboration across the JULES community!

Novel chance to see your JULES development & process research being used for high profile papers on impacts

New opportunity to work at the Met Office!

https://careers.metoffice.gov.uk/