WCRP World Climate Research Programme

CMIP6

CMIP6 Analysis Online Poster Seminar

13.00-14.00 Monday 20 April

Met Office

UKESM

UKRI Natural Environment Research Council

Satyaban Ratna

University of East Anglia

Patterns of Arctic amplification in CMIP5 and CMIP6 Projections

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In the last few decades, the Arctic has been warming faster than the rest of the globe – known as Arctic amplification. Recent studies have hypothesized that Arctic amplification may impact global weather patterns over the twenty-first century.

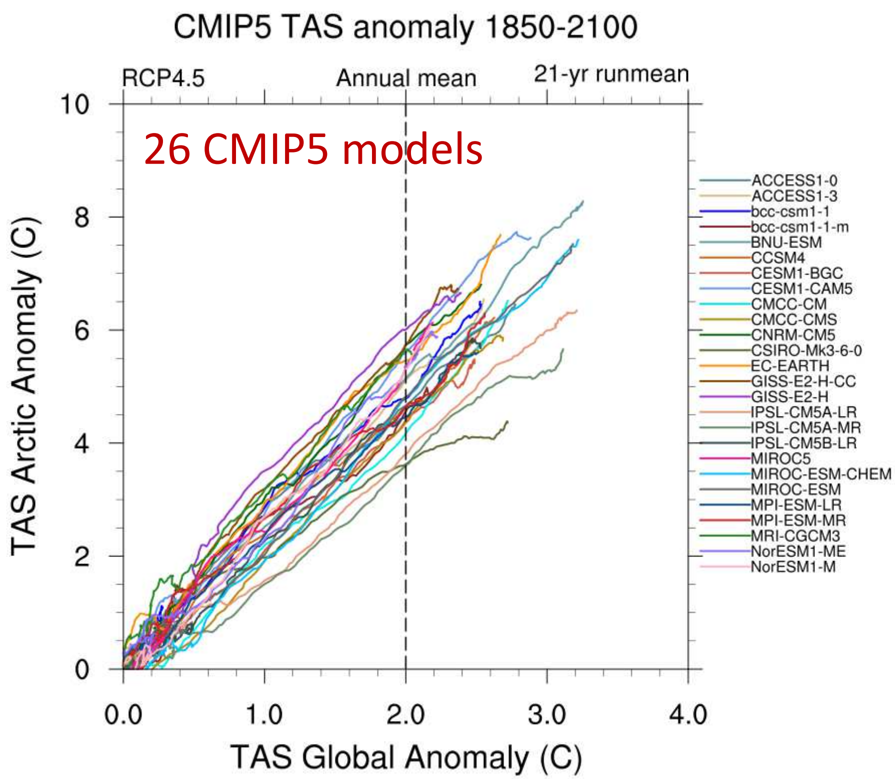
Objectives

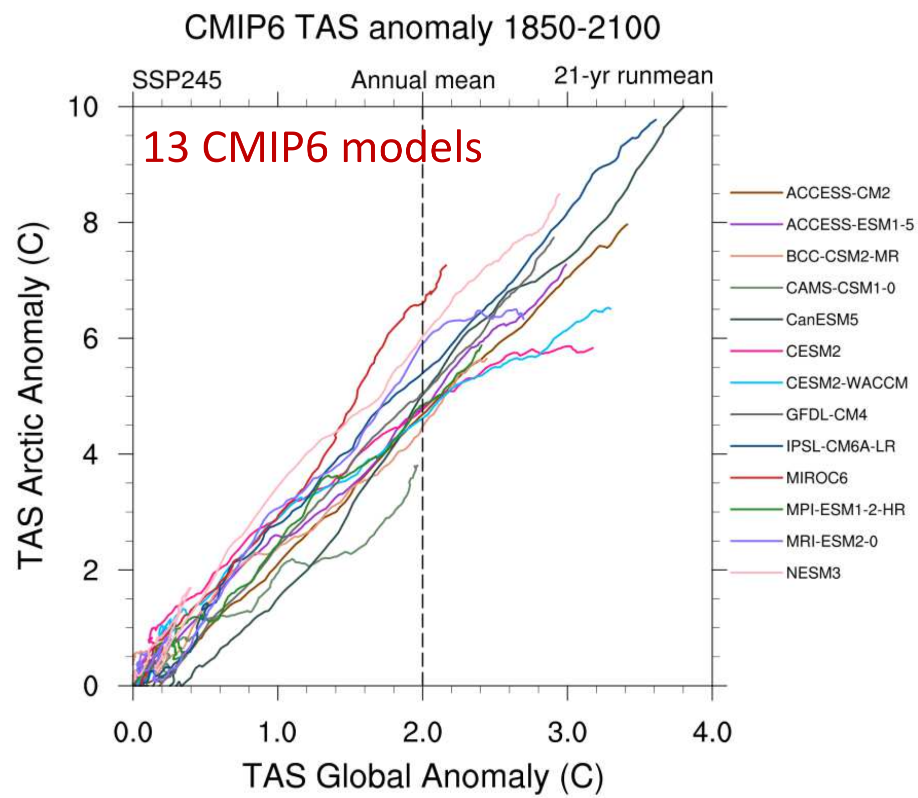
- To diagnose and compare the patterns of Arctic amplification by analysing the surface temperature anomaly from CMIP5 and CMIP6 models
- To understand the influence of Arctic amplification on lower latitude climates by forcing the Intermediate General Circulation Model version 4 (IGCM4) model with SST from CMIP5/6 projections.

Arctic Amplification

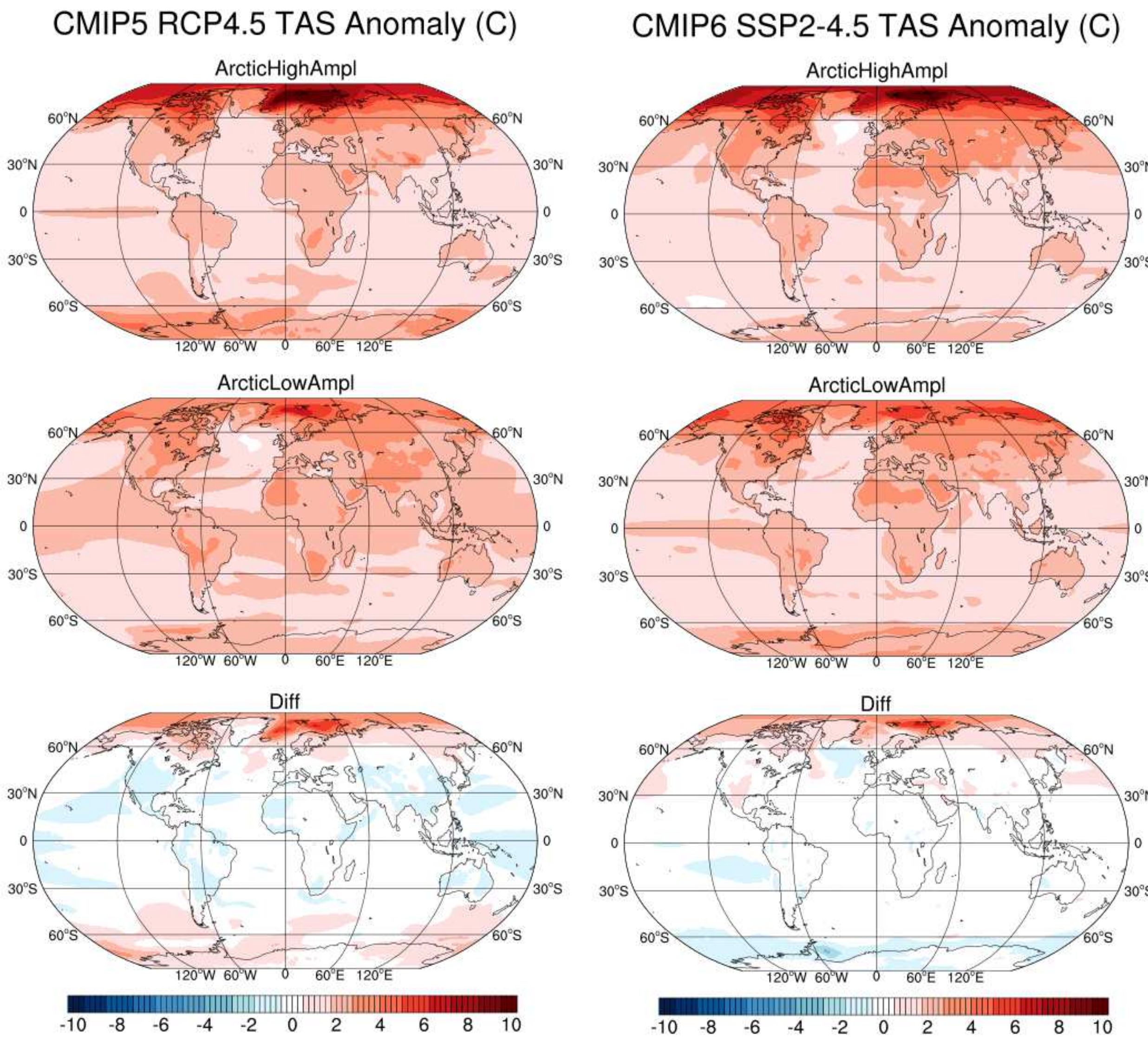
Annual means of Global mean and Arctic mean (north of 65 N) TAS anomaly time series are generated and then 21-year running means are applied

The Arctic amplification is defined for each model as the surface temperature of Arctic (north of 65 N) when the global mean surface temperature change exceeds 2 degrees Celsius above the pre-industrial mean (1851-1900).





Surface temperature anomaly (CMIP5 vs CMIP6)



Mean of 3 high amplification models

Mean of 3 Low amplification models

High - Low

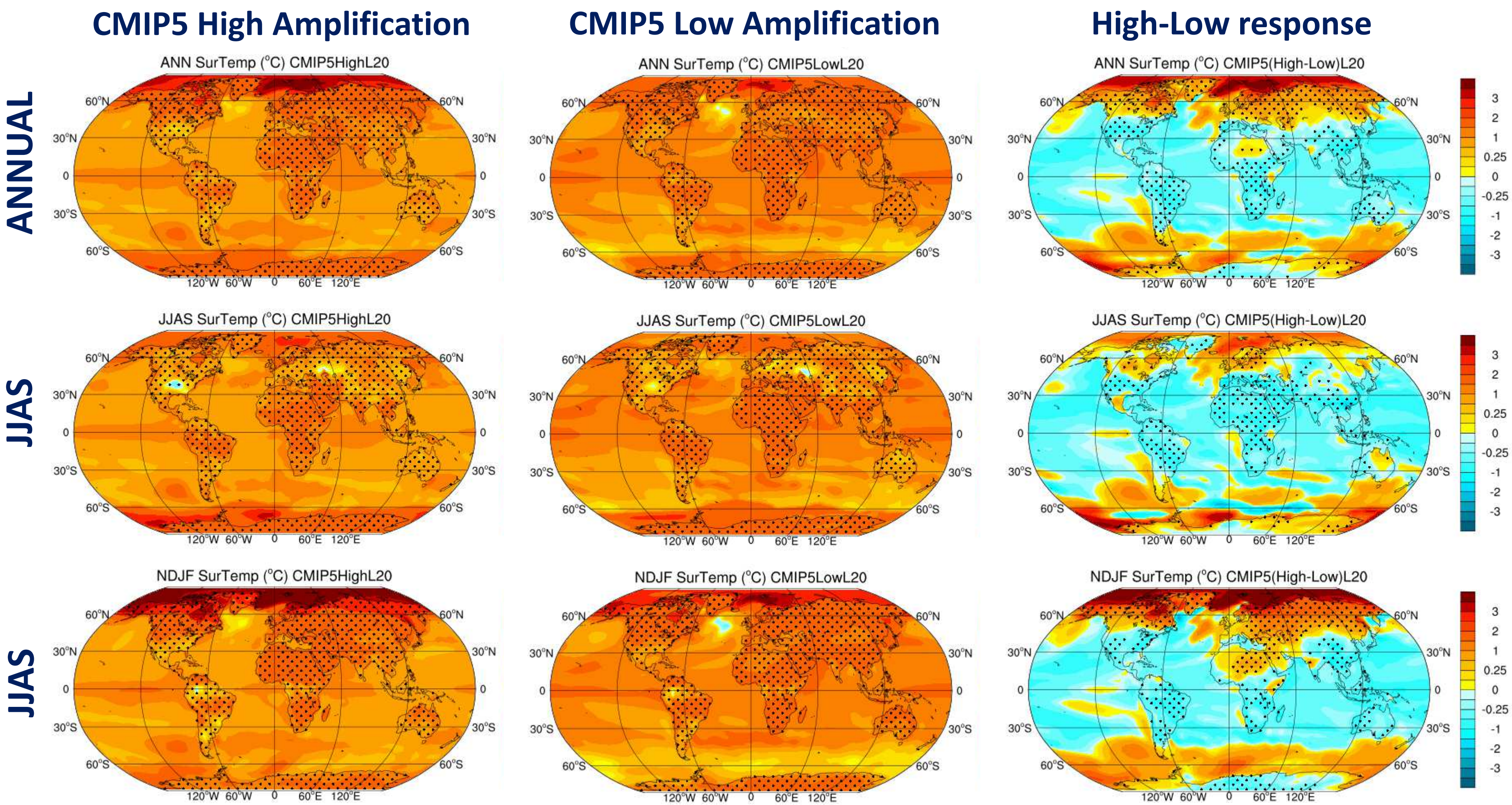
Annual mean Composites of 3 High and 3 Low amplitude models

University of East Anglia

IGCM4 Experiments

Control run: IGCM4 model (Joshi et al. 2015) run with SST from 20CR data for the 1851-1900 mean.

Two sets of perturbed experiments: Generated by adding the SST *anomaly* from the composites of 3 high and low amplification models (CMIP5).



Daniel Watters

NCEO & University of Leicester

Validation of the CMIP6 Representation of the Diurnal Cycle of Precipitation using GPM IMERG

Daniel Watters, Alessandro Battaglia and Richard Allan

Model and Observation Products

	Model **CNRM-ESM2-1 r1i1p1f2**	**Observations** **NASA GPM IMERG**
Background	DECK AMIP experiment simulation	Multi-satellite retrievals
Spatial Resolution	~1.4° x ~1.4°	0.1° x 0.1°
Temporal Resolution	1 hour	Half-hour
Period	1979-2008	2000-Present
Variable	Precipitation Flux	Surface Precipitation Rate

Novelties of analysis:

- First evaluation of CMIP6 representation of the diurnal cycle
- First analysis of interannual variability of the diurnal cycle
- First multi-decadal evaluation of the diurnal cycle

Determining the Diurnal Cycle

Methodology

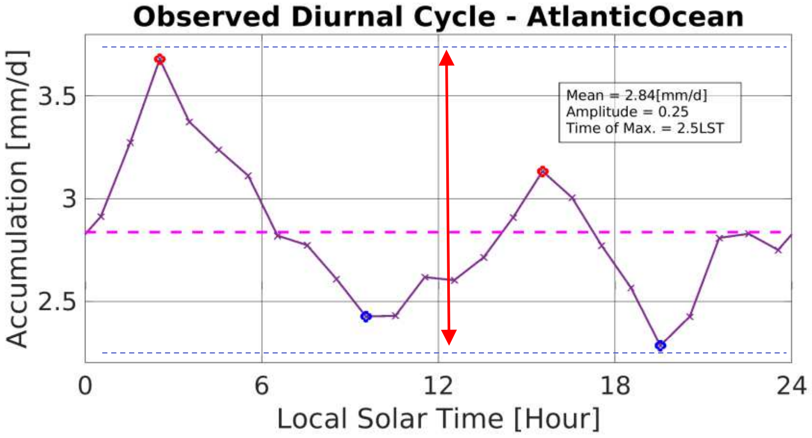
- Match spatiotemporal resolutions of products
- Produce 6D histogram
  - [lat (ϕ), lon (λ), rain rate (R), season, year, hour (t)]
- Compute accumulation for chosen season and period

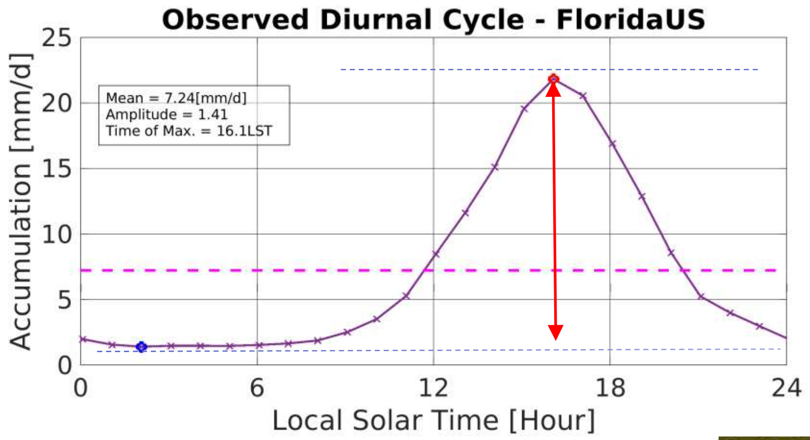
$$\text{Accumulation}(\phi, \lambda, t) = \frac{\sum_{R_i \geq 0} N_i R_i}{\sum_{R_i \geq 0} N_i}$$

Diurnal Parameters

- Mean
- Amplitude (= $\frac{Max - Min}{2\ x\ Mean}$)
- Time of Maximum & Minimum
- Number of Peaks
  - Peak identified when Prominence x Width > 0.1 x Mean x 2h

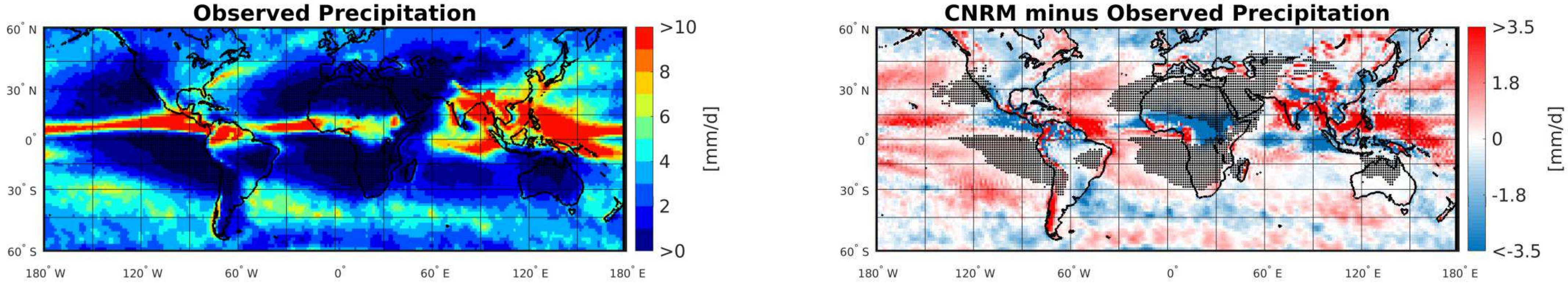
IMERG observations – JJA 2000-2018



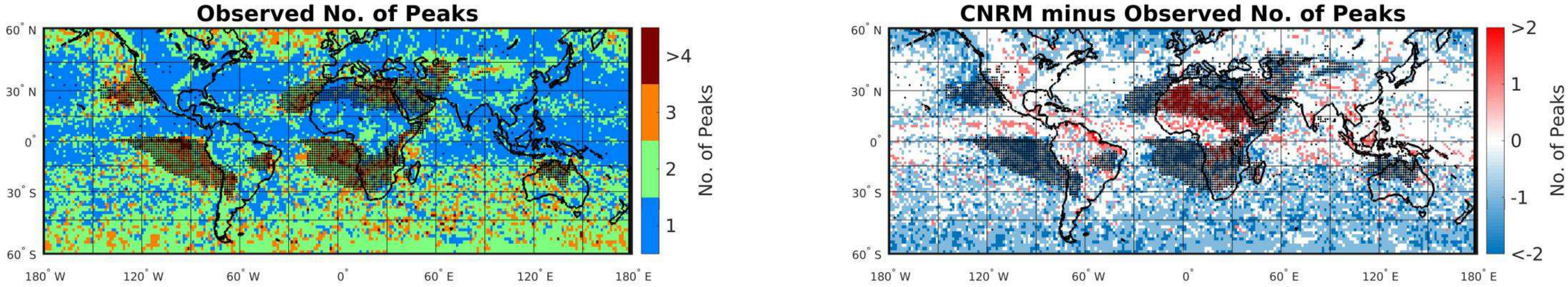


Evaluation of the Diurnal Cycle - JJA

IMERG observations 2000-2018; CNRM-ESM2-1-AMIP simulation 1979-2007



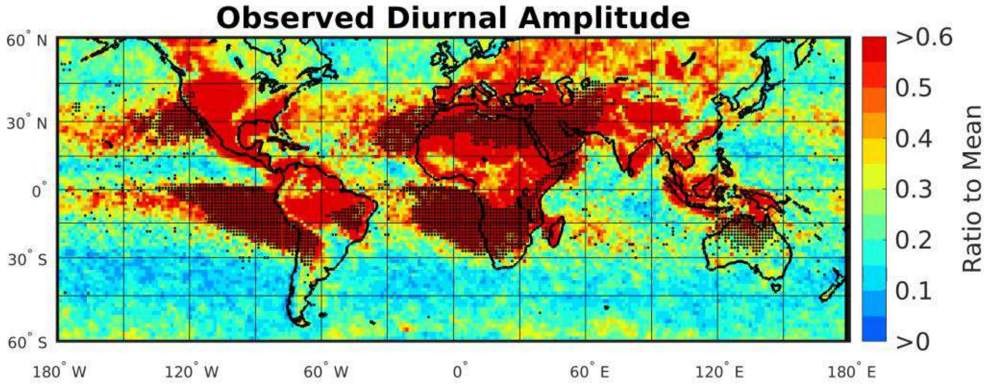
Black dots – Arid regions

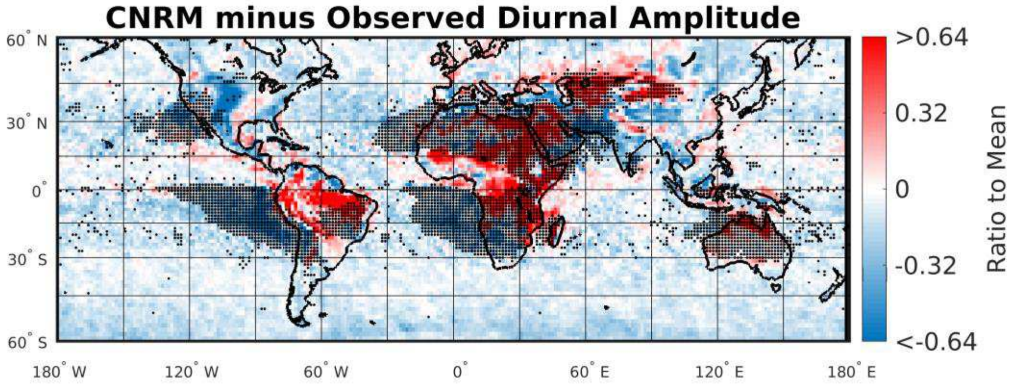


Black dots – Arid regions & interannual variability exceeding ±0.5 peaks

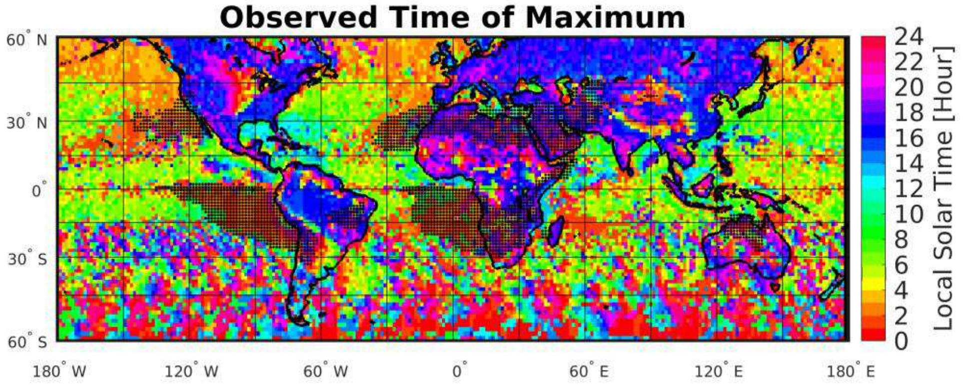
Evaluation of the Diurnal Cycle - JJA

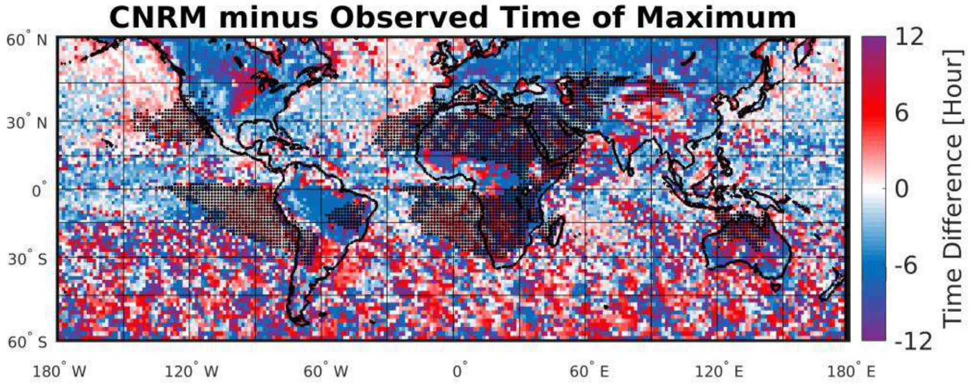
IMERG observations 2000-2018; CNRM-ESM2-1-AMIP simulation 1979-2007





Black dots – Arid regions & interannual variability exceeding ±50% of amplitude





Black dots – Arid regions

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

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NERC SCIENCE OF THE ENVIRONMENT

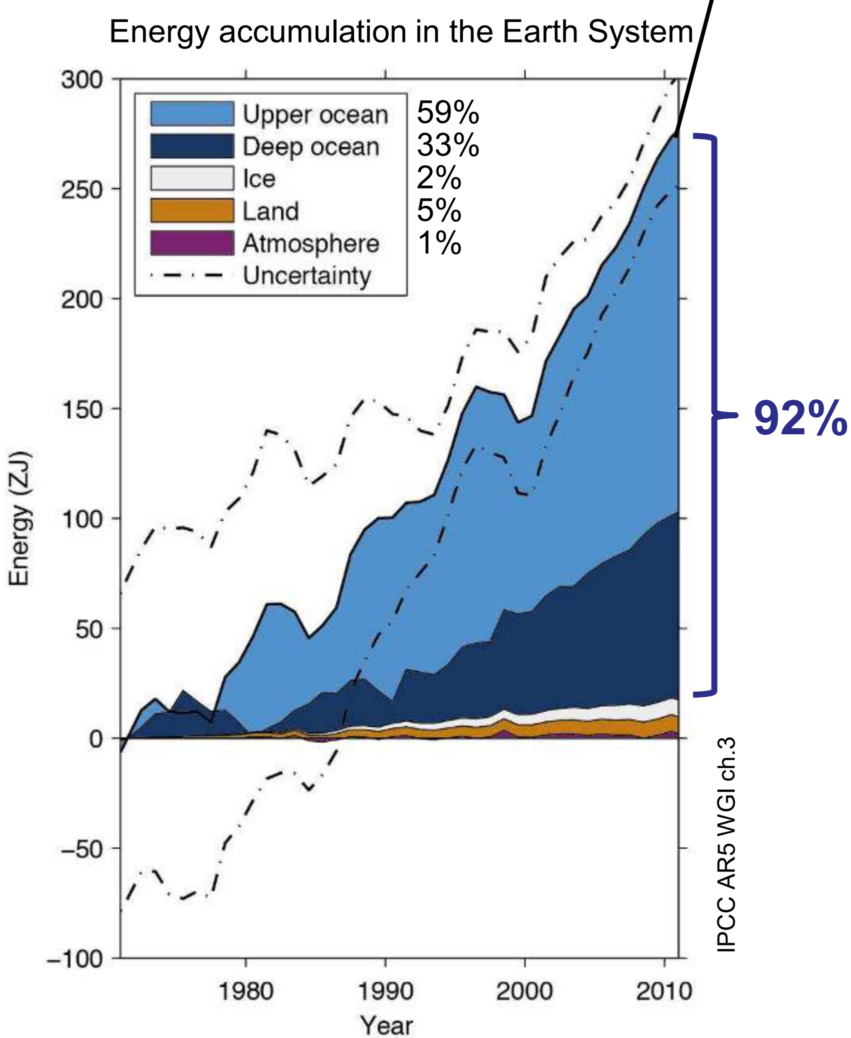
Till Kuhlbrodt

NCAS, University of Reading

Historical ocean heat uptake in CMIP6 Earth System models: global and regional perspectives

Till Kuhlbrodt, NCAS, University of Reading

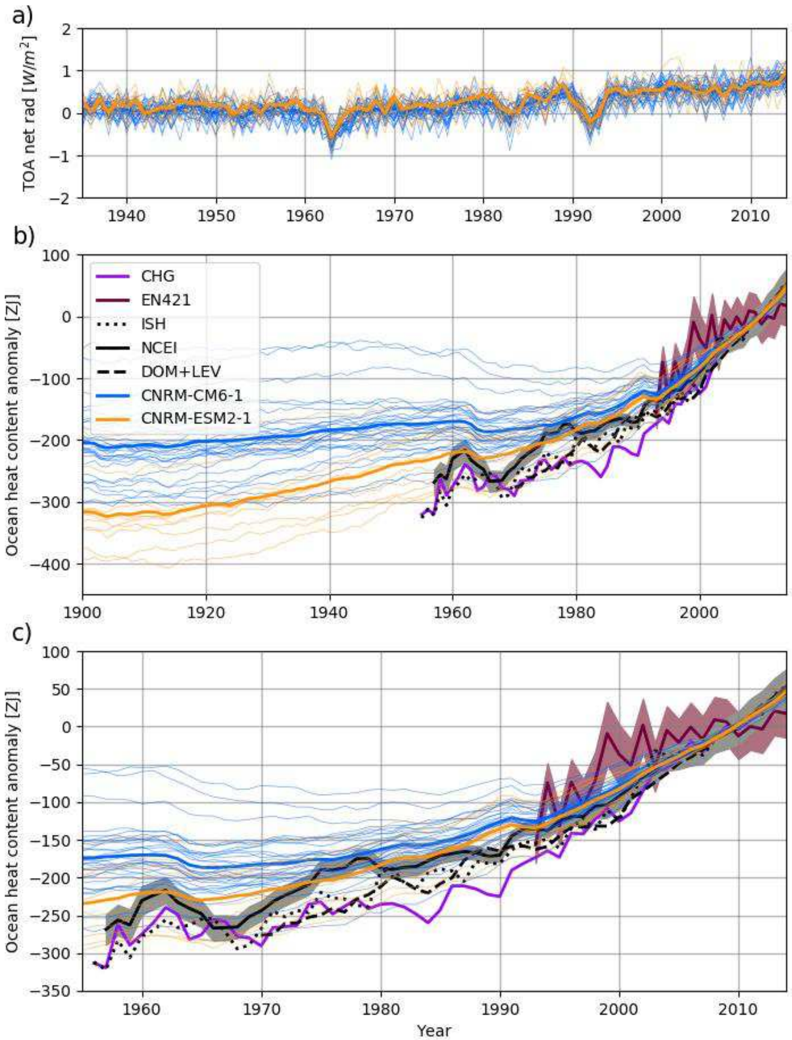
- Ocean warming (heat content change) provides by far the largest heat storage in the Earth System
- Latest estimate for total Earth System warming 1971-2018 is ~400 ZJ
- Here we analyse ocean warming and heat content change in the historical CMIP6 simulations of 4 climate and Earth System models:
  - **UKESM1.0 and HadGEM3 GC3.1-LL**
  - **CNRM-ESM2-1 and CNRM-CM6-1**
- All four models have the same ocean component: NEMO3.6 ORCA1
- CMIP5 models showed a wide range in simulating 1971-2005 ocean heat uptake (OHU), with the ensemble mean close to observations



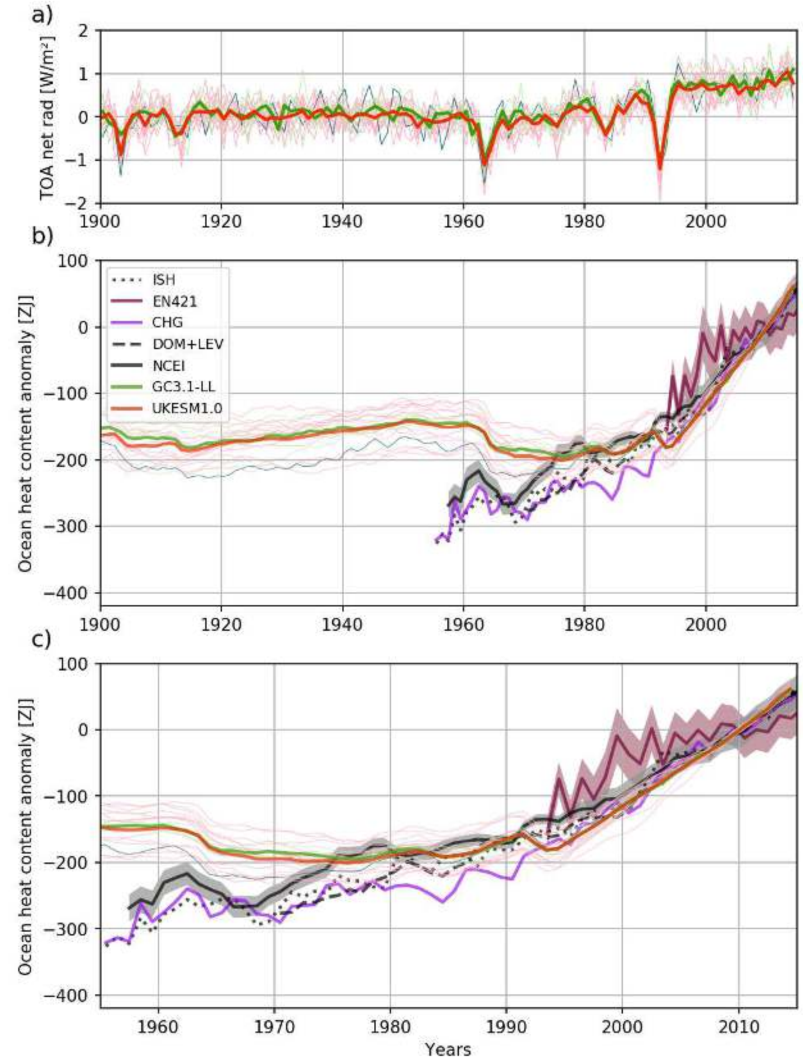
Historical OHU, globally, full depth

TOA net rad

CNRM models

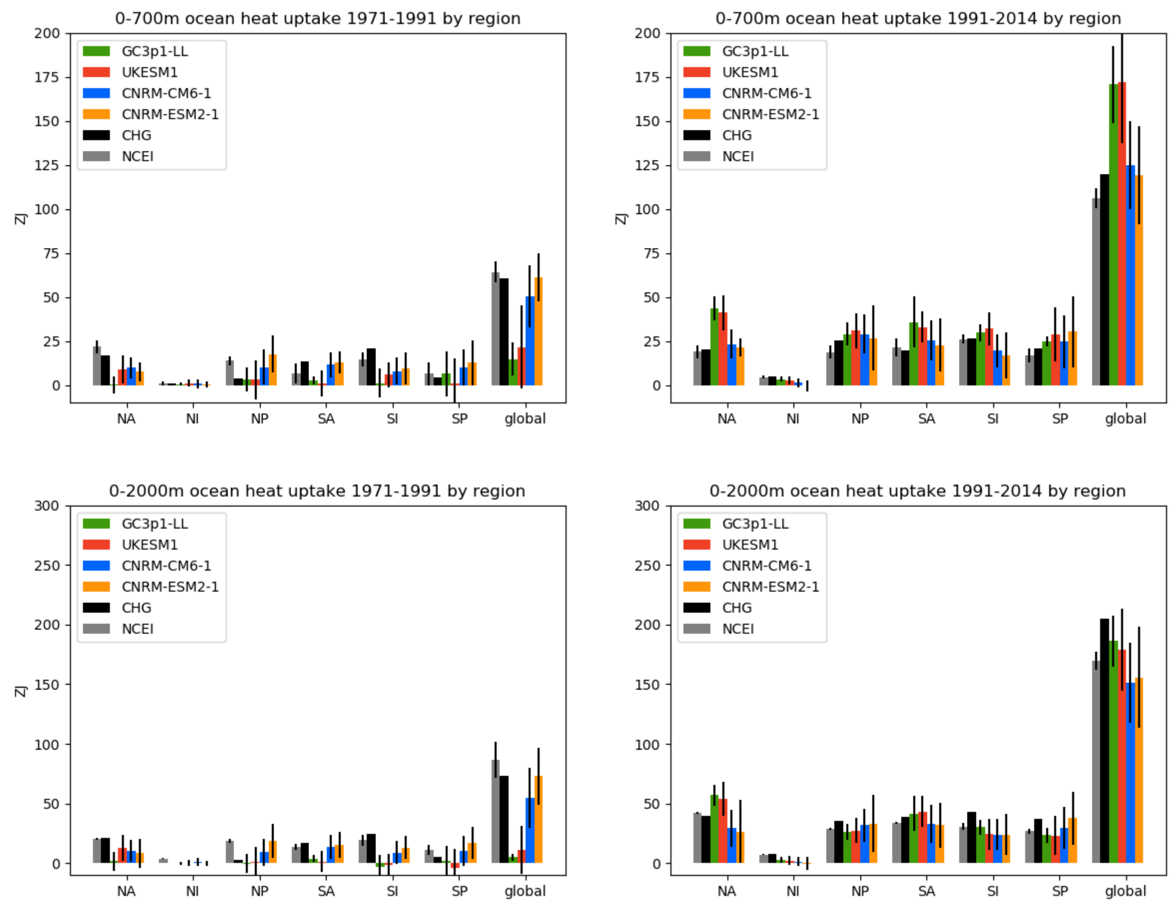


UK models



Regional ocean heat uptake 1971-1991 and 1991-2014

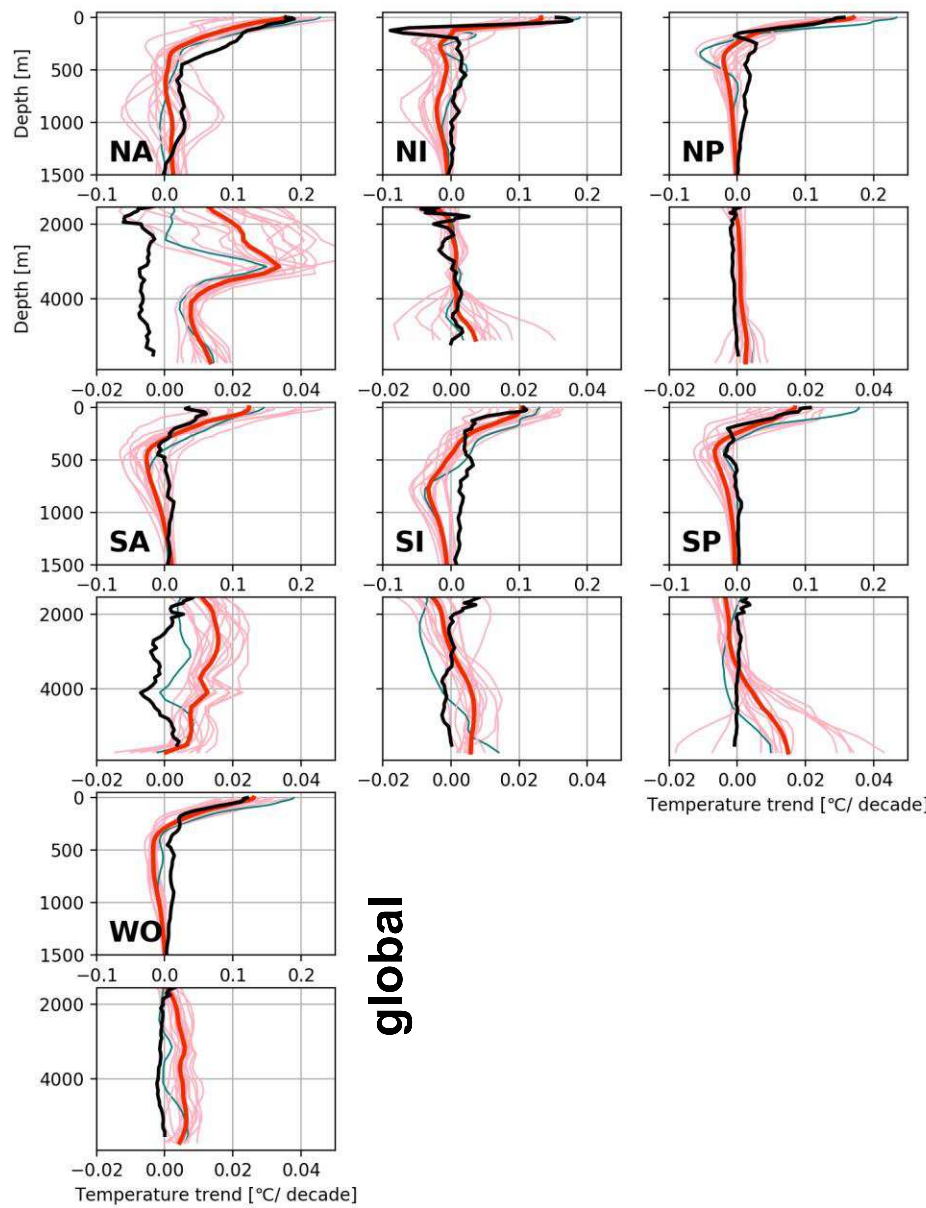
- 0-700 m layer: CNRM models mostly within observational uncertainty, slightly too warm in the Pacific
- 0-700 m layer: UK models too cold before 1991, too warm after, especially in the Atlantic
- 0-2000 m layer, CNRM models: close to observations, perhaps slightly too cold in the Atlantic
- 0-2000 m layer, UK models: far too cold before 1991, close to observations after, Atlantic slightly too warm



{**N**orth, **S**outh} {**A**tlantic, **I**ndian, **P**acific}

Depth profile of temperature change: UKESM1

- Decadal temperature trend (1965-1974) to (1995-2004) in UKESM1 (red) and WOA18 (black)
- Globally: 0-200 m UKESM1 close to observations. 300-1,300 m: model cooling, observations warming. Below 2,000 m: observations cooling, model warming
- Regionally: Huge simulated warming in deep North Atlantic. Strong warming and large variability in the abyssal South Pacific. Mid-depth cooling trend mostly in Southern Hemisphere.
- r17 (teal) stands out by showing strong surface warming in SP, and relatively weak mid-depth warming in NA



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Rebecca Varney

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UKESM

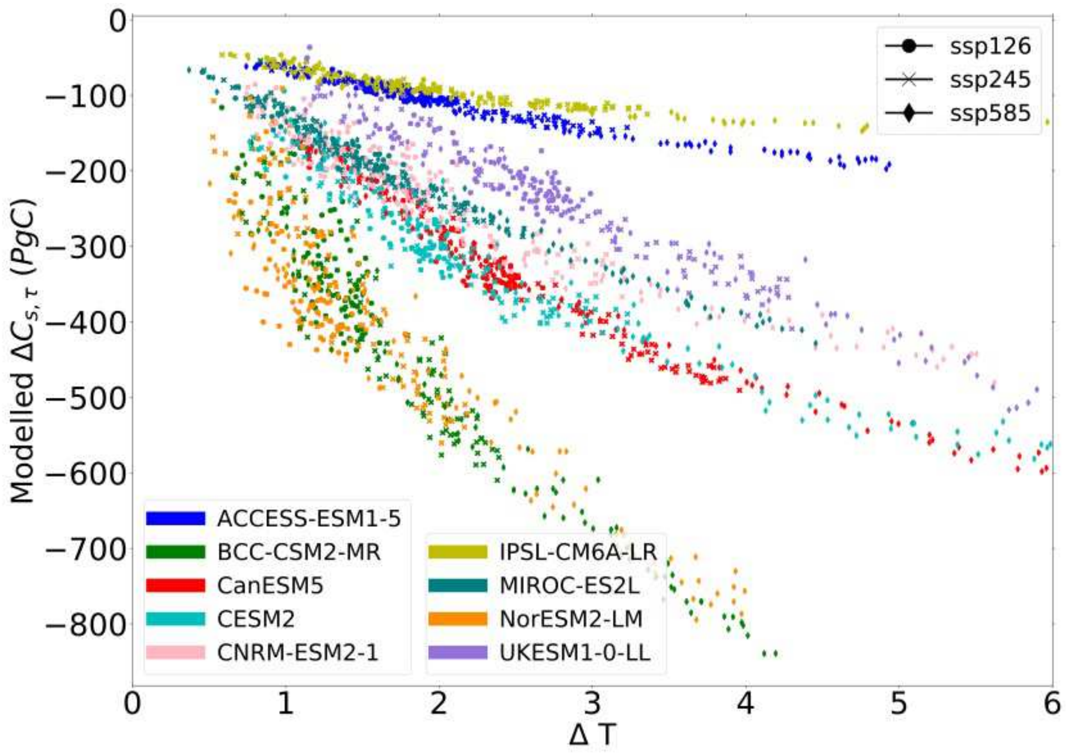
UKRI Natural Environment Research Council

Sensitivity of soil carbon turnover to global warming – a new spatial emergent constraint

Rebecca Varney, Sarah Chadburn, Pierre Friedlingstein, Eleanor Burke, Charles Koven, Gustaf Hugelius, and Peter Cox

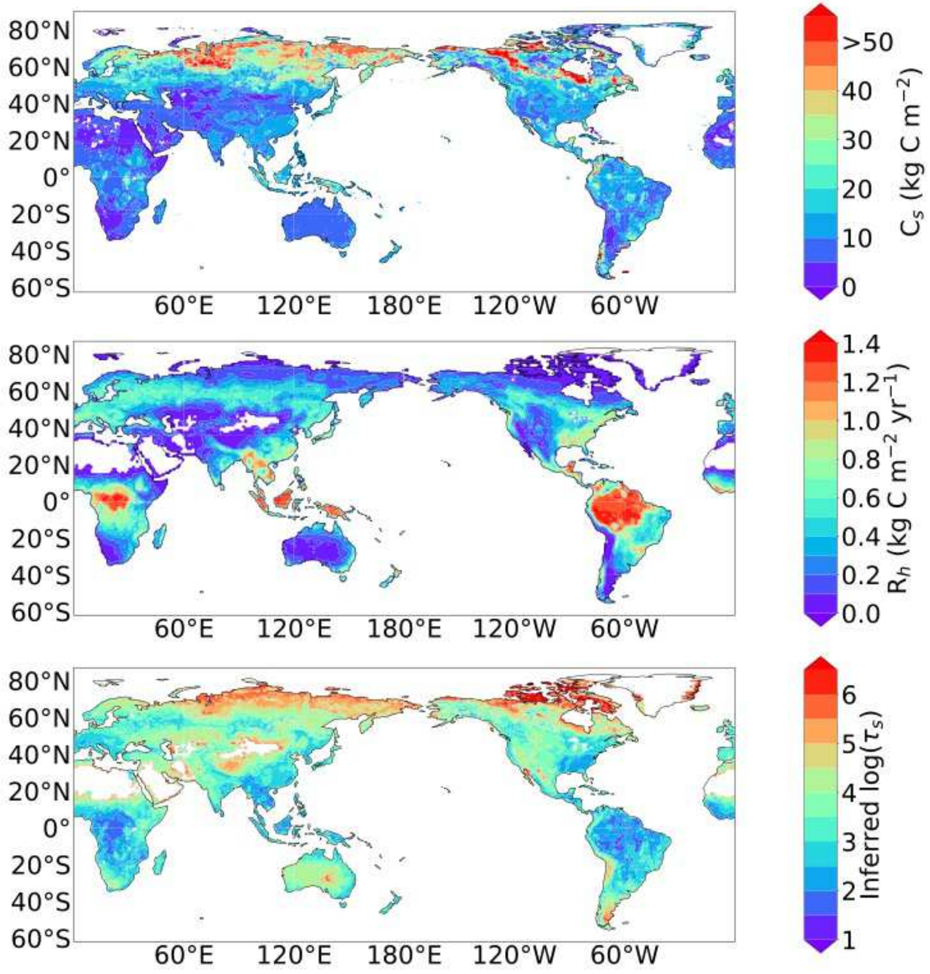
- Uncertainties in projected changes in soil carbon storage are key components of the uncertainties in the global carbon budgets for the Paris Agreement Targets.
- Uncertainty has remained across CMIP generations.
- Important as potential large positive feedback.

Soil Carbon Turnover Time = Soil Carbon / heterotrophic respiration

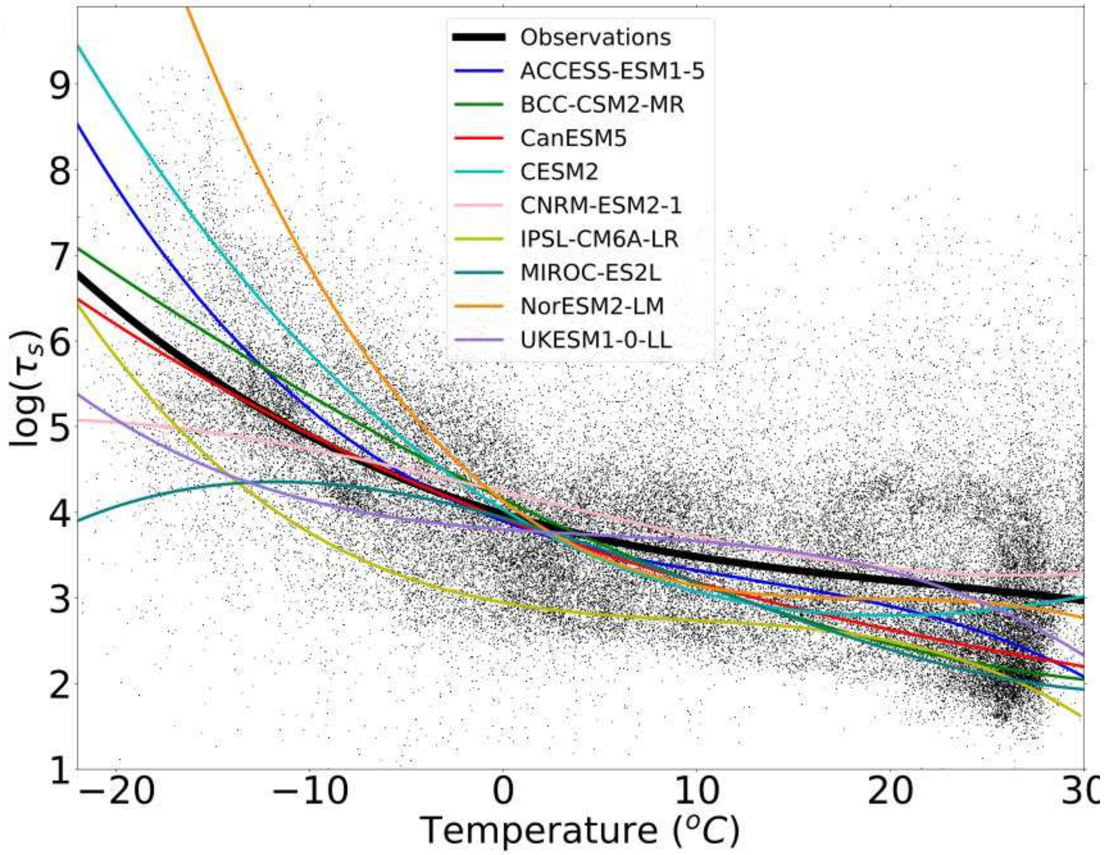


Method – Temperature sensitivity of τ_s

We use the spatial variation of soil carbon turnover, τ_s, to estimate the sensitivity of τ_s to temperature.



$$\tau_s = \frac{C_s}{R_h}$$



Soil carbon – Cs, Heterotrophic respiration – Rh, Soil carbon turnover time - τ_s

Harmonized world soil database (2012), The northern circumpolar soil carbon database: spatially distributed datasets of soil coverage and soil carbon storage in the northern permafrost regions (2013).
CARDAMOM 2001-2010 global carbon Model-Data Fusion (MDF) analysis, (2015).
The WFDEI meteorological forcing data set: WATCH Forcing Data methodology applied to ERA-Interim reanalysis data (2014).

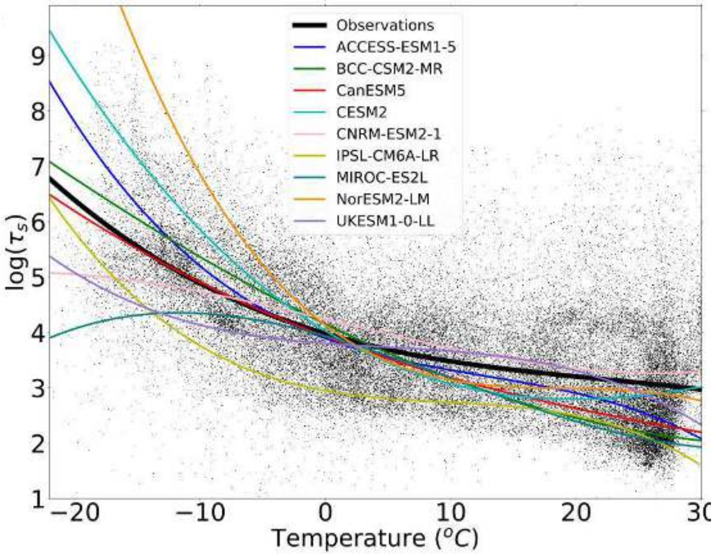
Method – testing principle

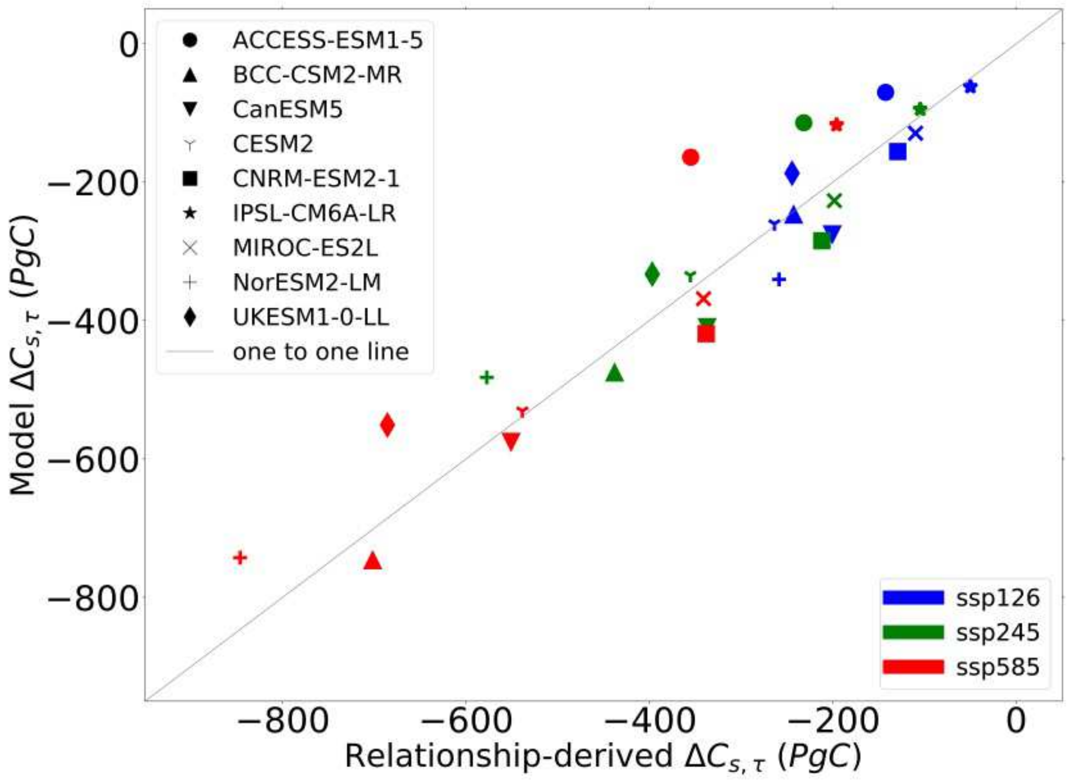
Change in Soil Carbon due to a change in Soil Carbon Turnover: $\Delta C_{s,\tau} = R_{h,0}\Delta\tau_s$

where, $\Delta\tau_s = \tau_s^{future} - \tau_s^{historical}$

Equation for Soil Carbon Turnover: $\tau_s = \frac{C_s}{R_h}$

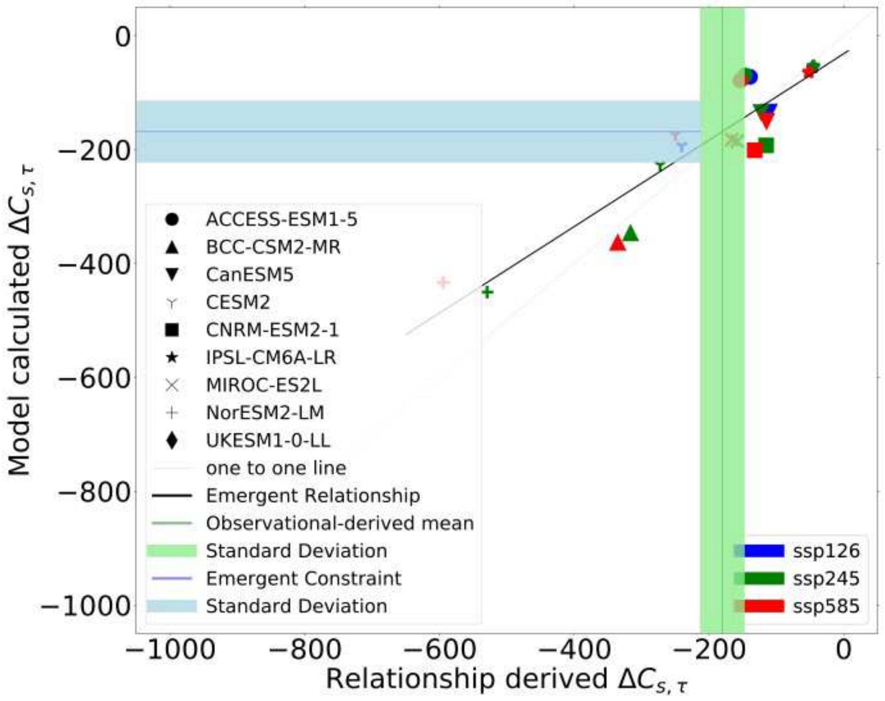
We find that the spatial variation of τ_s enables us to estimate the change in soil carbon for each model.

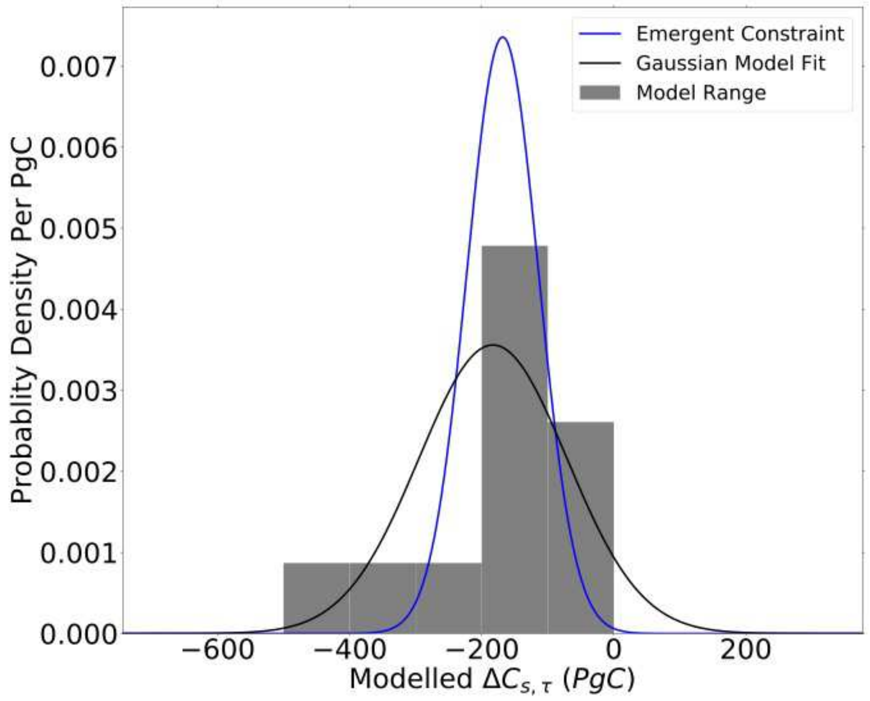




Soil carbon – Cs, Heterotrophic respiration – Rh, Soil carbon turnover time - τ_s

Result – Spatial Emergent Constraint





A spatial emergent constraint on the change of global soil carbon due to the temperature sensitivity of soil carbon turnover for the 2K global mean warming on CMIP6.

Uncertainty in projections reduced from -183 ± 112 PgC to -180 ± 33 PgC.

World Climate Research Programme

CMIP6

Paul Ritchie

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Met Office

UKESM

Natural
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Research Council

Identifying potential abrupt shifts of Amazon rainforest dieback in the CMIP6 dataset

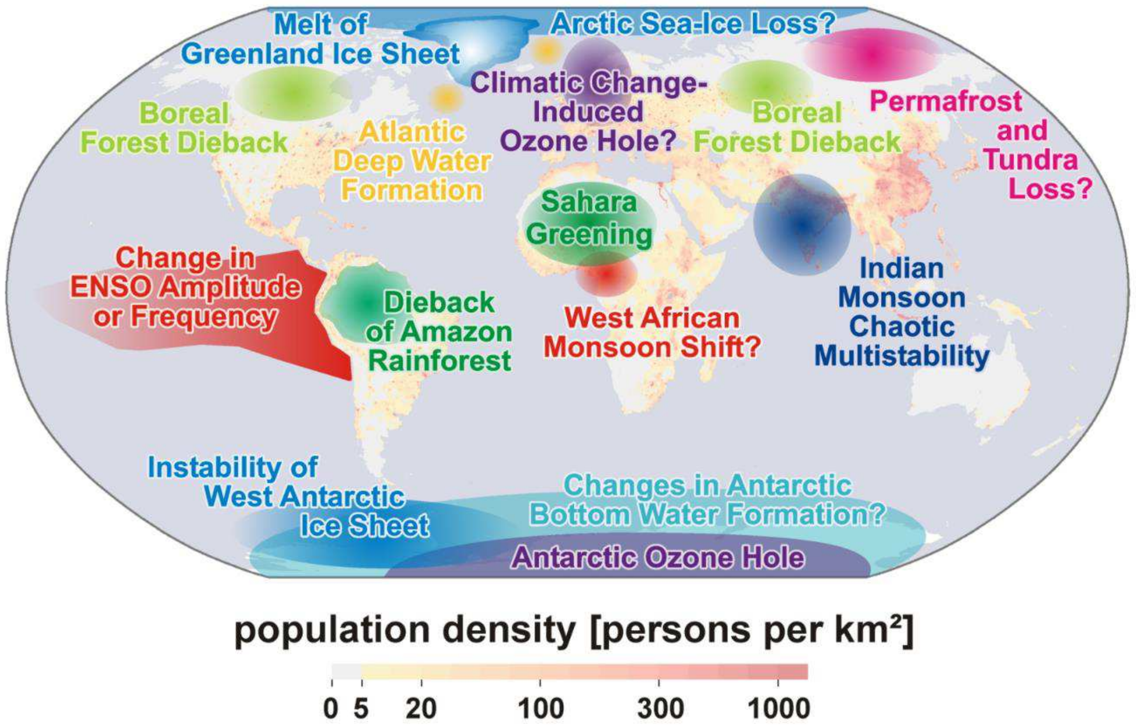
Paul Ritchie, Peter Cox and Joe Clarke

- Amazon dieback one of the recognised policy-relevant tipping points in the climate system

- A tipping event is where a small change in input leads to a large, qualitative change in the output of a system

- Use 1% per year CO_2 increase experiment runs to search for potential abrupt shifts in tree cover in the Amazon

Tipping elements of the climate system



Lenton et al., 2008

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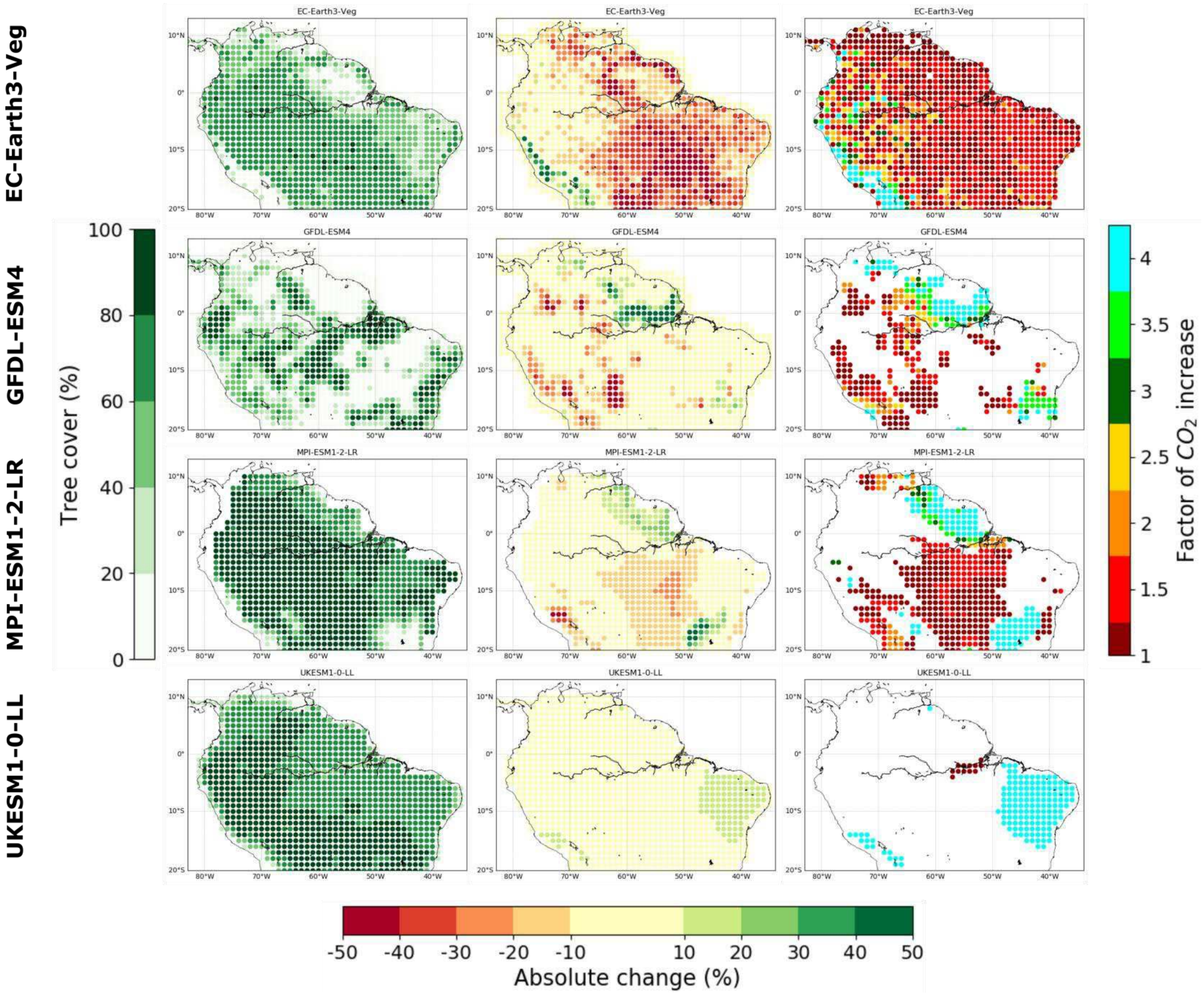
Models give varying levels of accuracy for initial tree cover

Tree cover in UKESM1-0-LL appears resilient to rising CO_2

Starting tree cover | **Absolute change to starting tree cover at quadrupled CO_2** | **Factor of CO_2 increase at maximum tree cover**



Models generally show dieback across central and southern Amazonia

Localised regions have an optimal level of CO2

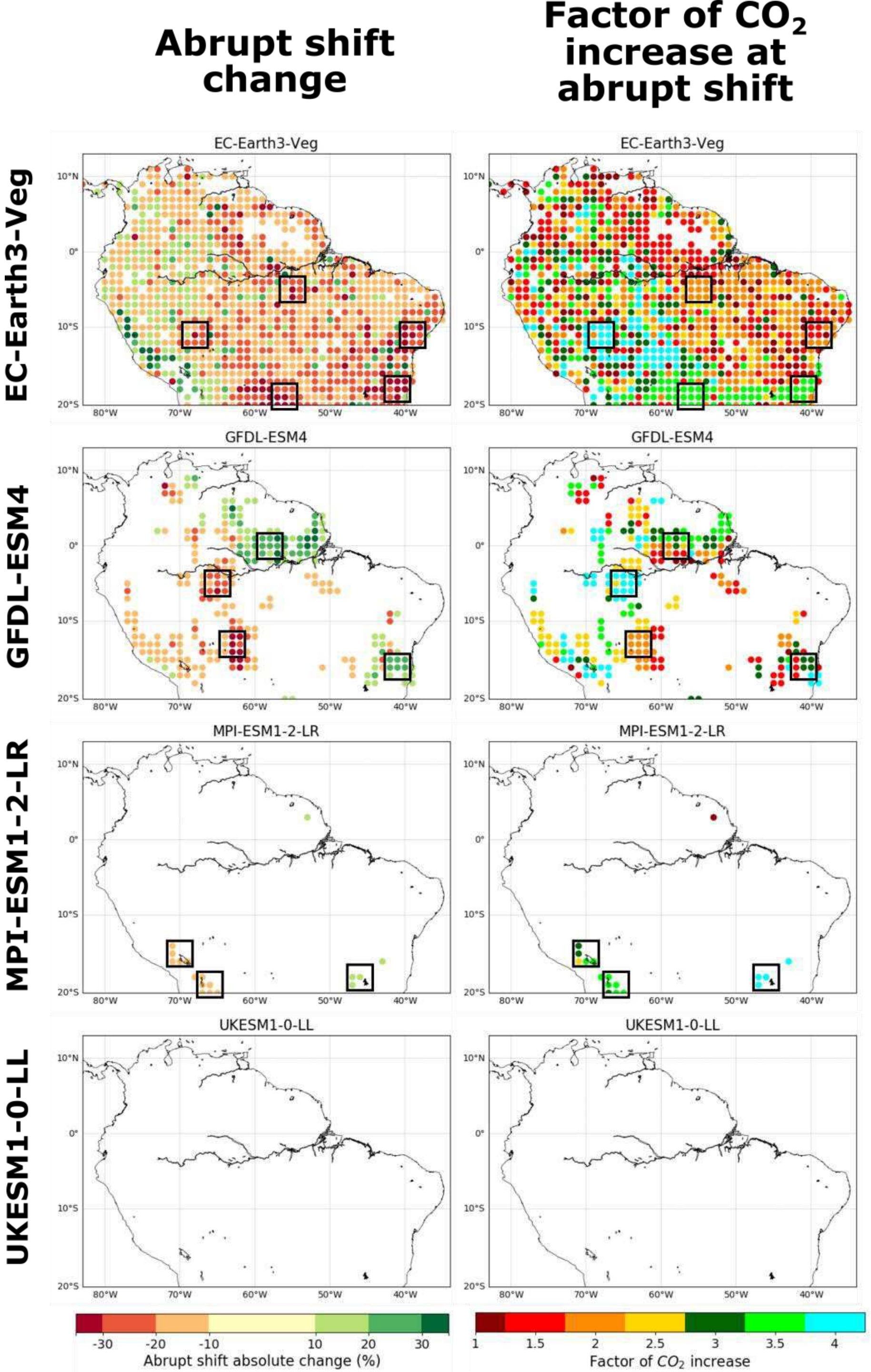
Some abrupt shifts detected in EC-Earth3-Veg are a result of high variability

Abrupt shift criteria

Tree cover changes by at least 10% over 15 year period

Abrupt shift contributes to at least 25% of overall change

UKESM1-0-LL no abrupt shifts detected



Boxes indicate domains of consistent abrupt shifts

No coherent structure amongst models

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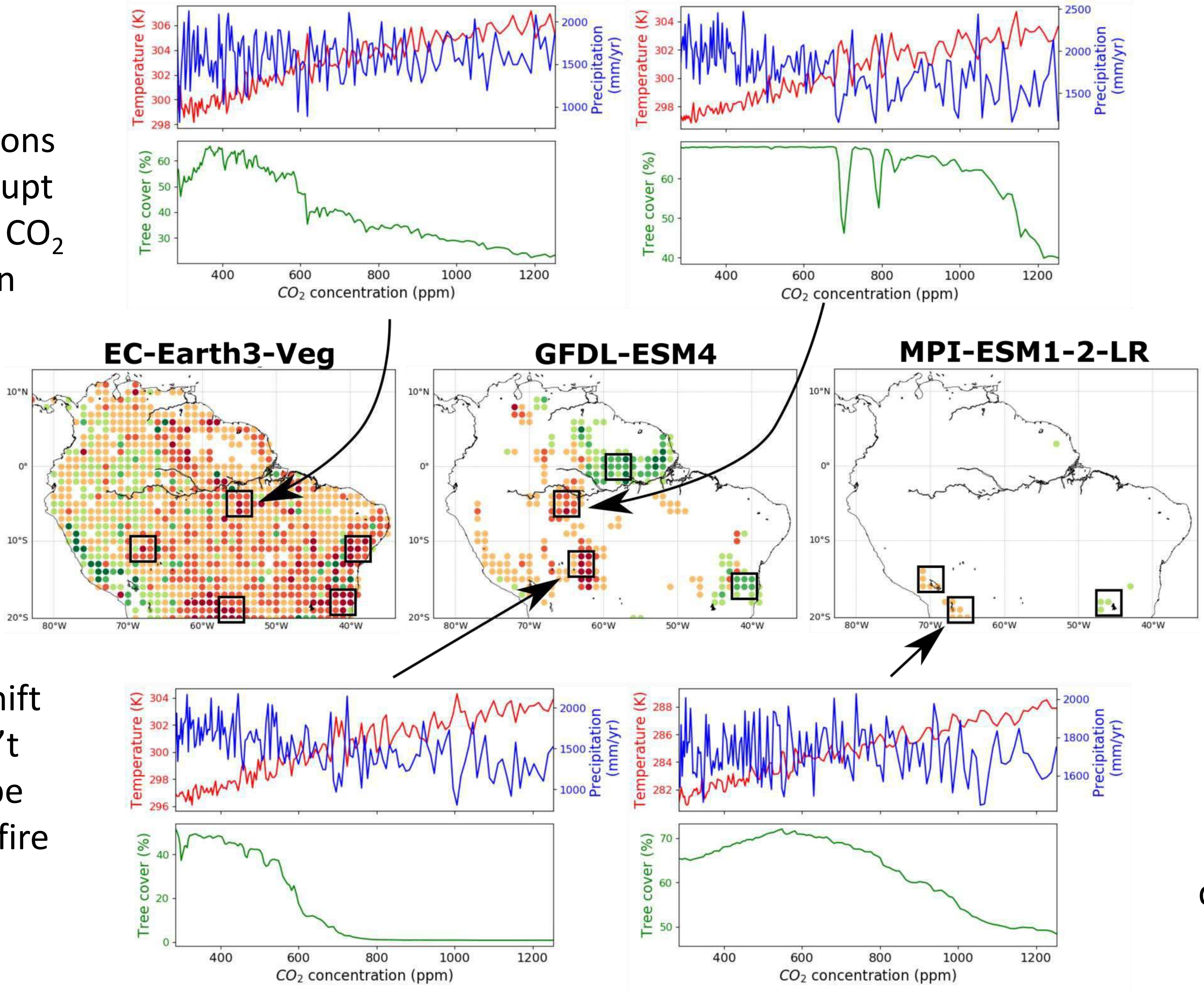
Optimal conditions now before abrupt shift at 600ppm CO_2 concentration

Fire events triggered by sudden warming and drying, before dieback at high CO_2



An abrupt shift that doesn't appear to be triggered by fire

Optimal CO_2 600ppm, smooth domain average despite individual abrupt shifts

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