

Future Projections with the UK Earth system model

Alistair Sellar, Colin Jones, Chris Jones,
Steven Turnock, and many others

July 2019

Outline



1. CMIP6 scenarios
2. UK Earth system model: UKESM1
3. UKESM1 projections for CMIP6: headline results

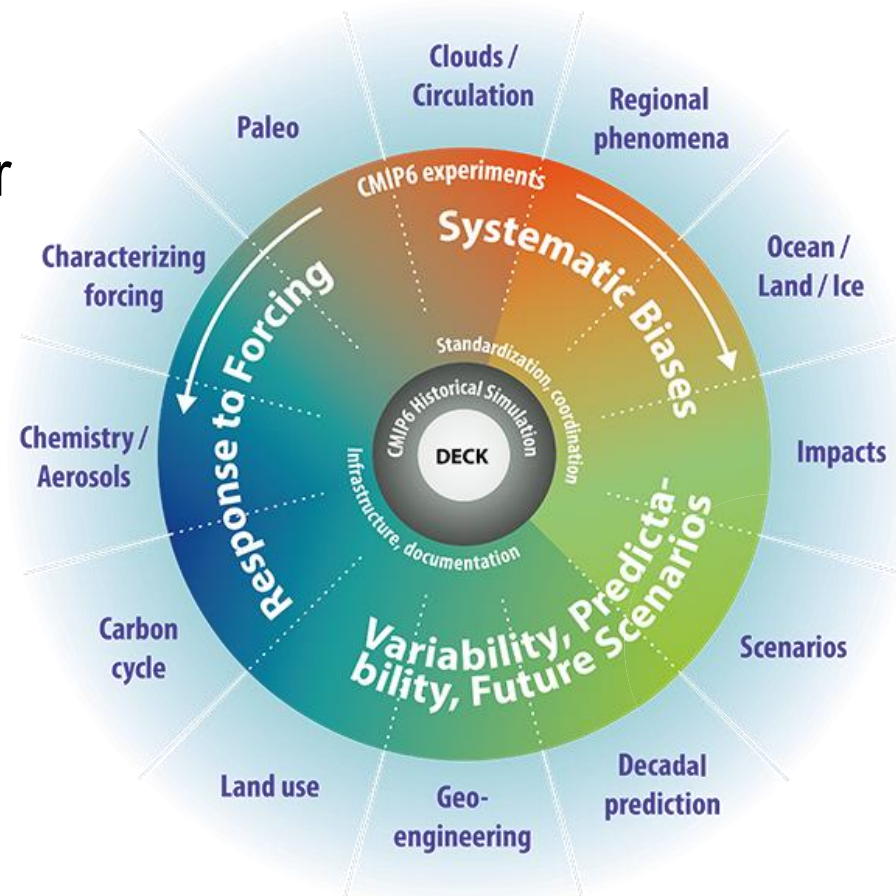
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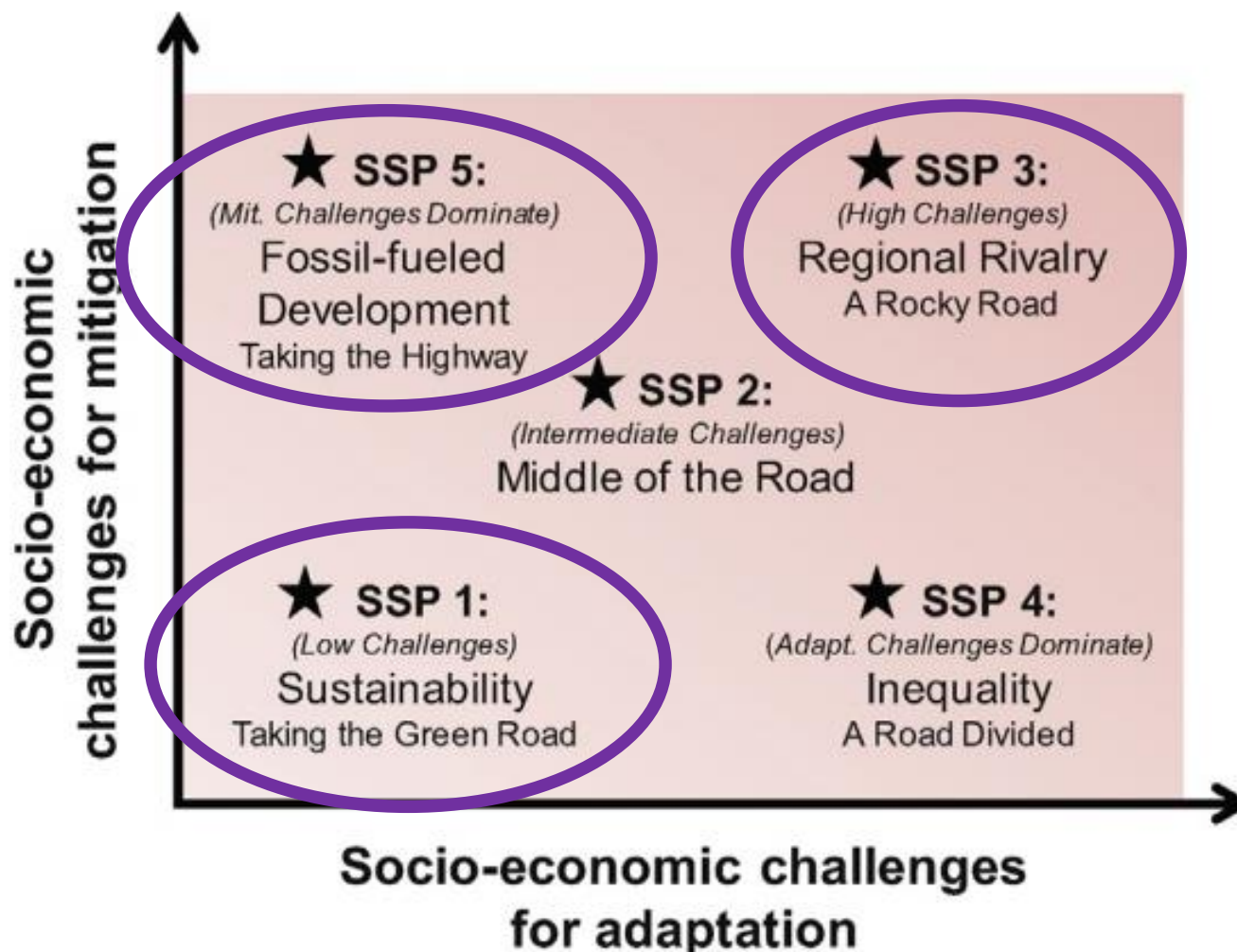
Coupled model intercomparison project phase 6 (CMIP6)

- Standardised experiments for comparing climate models
- Model outputs are publicly available and analysed by 1000s of researchers
- CMIP is a major evidence base for IPCC assessment reports



- For links to model data see ukesm.ac.uk/cmip6
- IPCC: Intergovernmental Panel on Climate Change

Shared Socioeconomic Pathways



How does the socioeconomic pathway affect the Earth system?

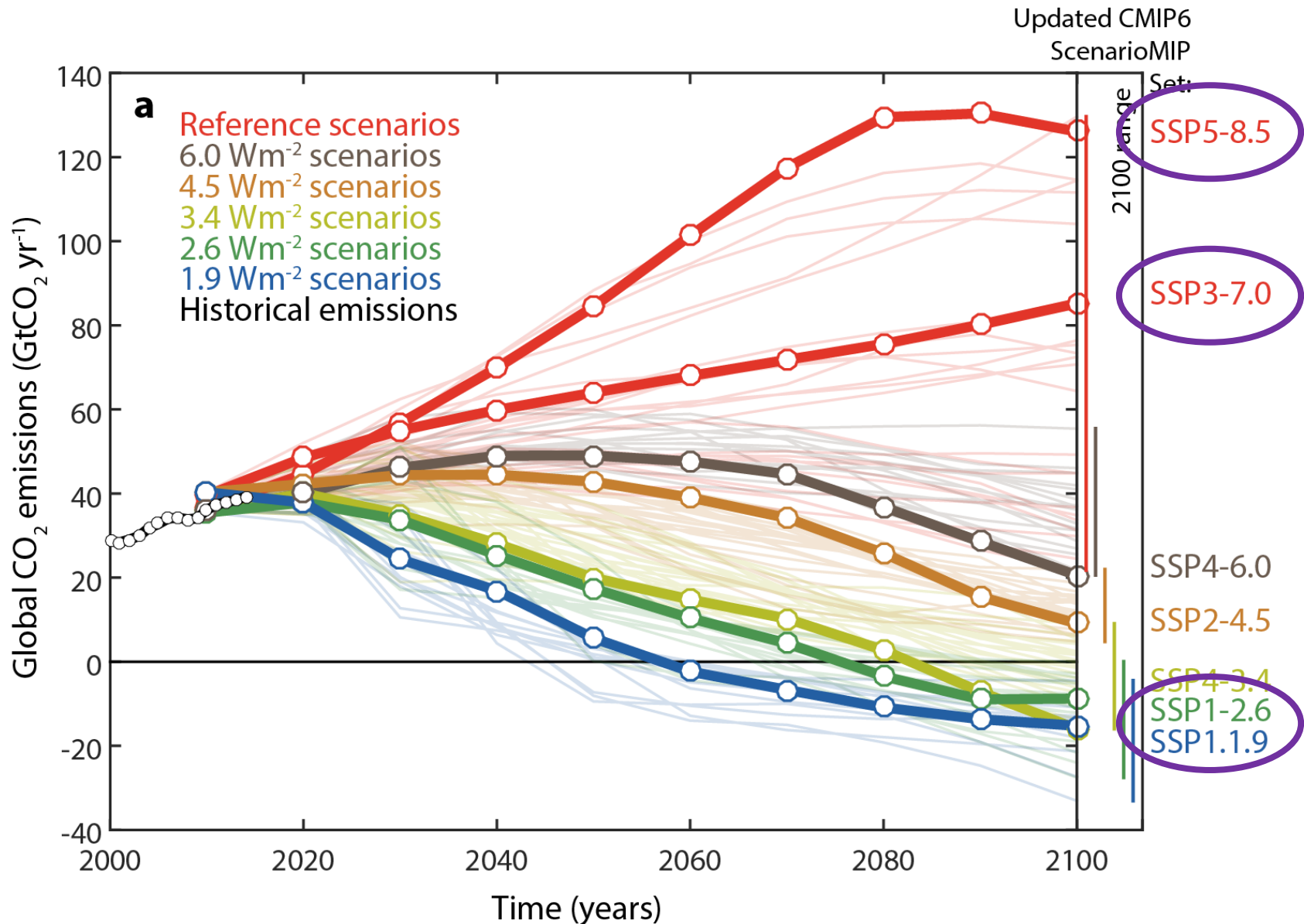
Emissions



Land Use



Example: CO₂ emissions



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UKESM1

ukesm.ac.uk



**Global Earth system model.
Jointly developed by Met Office
and NERC**

- Dedicated team of ~20 Earth system scientists & computational scientists
- Available for research users: contact NCAS-CMS to get started

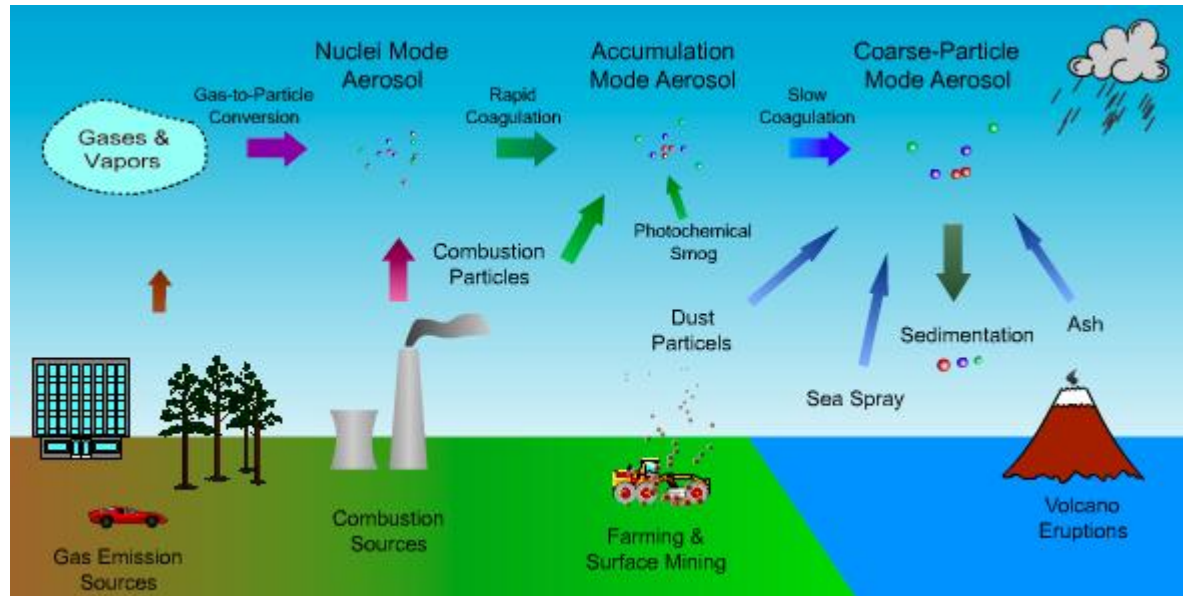
**Physical core = HadGEM3-GC3.1
(UM + NEMO + CICE + JULES)**

Resolution:

- Atmosphere: N96 (~130km) L85
- Ocean 1° L75
- Other resolutions are under development (see Marc Stringer's presentation on hybrid resolution)

UKESM1 components...

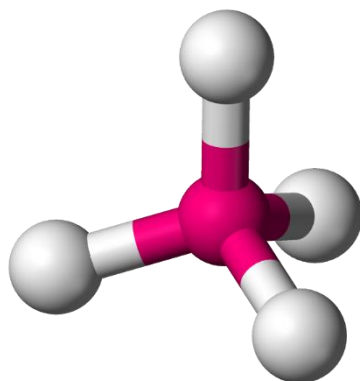
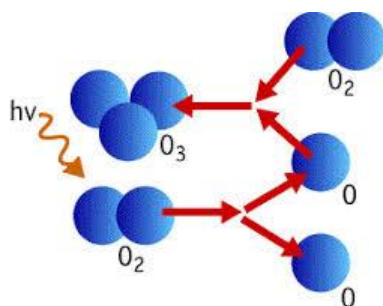
(& main science developments from HadGEM2-ES)



- **Aerosols:** UKCA-GLOMAP-mode, 2-moment (*mass and number*), 5-mode aerosol scheme (Mann 2014), enhancements to natural emissions (DMS, marine organics, BVOCs)

UKESM1

(& main science developments from HadGEM2-ES)

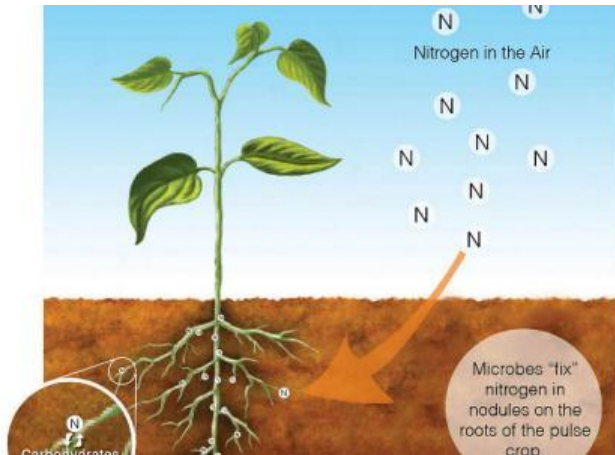


Atmospheric Chemistry:

- UKCA **stratosphere**-troposphere chemistry (Morgenstern 2009, O'Connor 2014) including:
- **isoprene chemistry**
- **interactive photolysis**

UKESM1

(& main science developments from HadGEM2-ES)



Terrestrial carbon-nitrogen cycle:

- TRIFFID prognostic vegetation (9 PFTs),
- nitrogen-limitation scheme (Wiltshire, in prep)
- interactive BVOC emissions

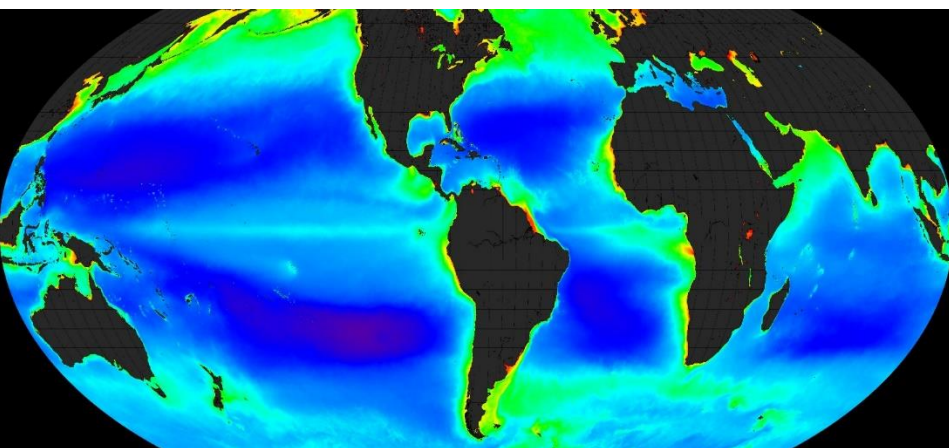


JULES

Joint UK Land
Environment Simulator

UKESM1

(& main science developments from HadGEM2-ES)

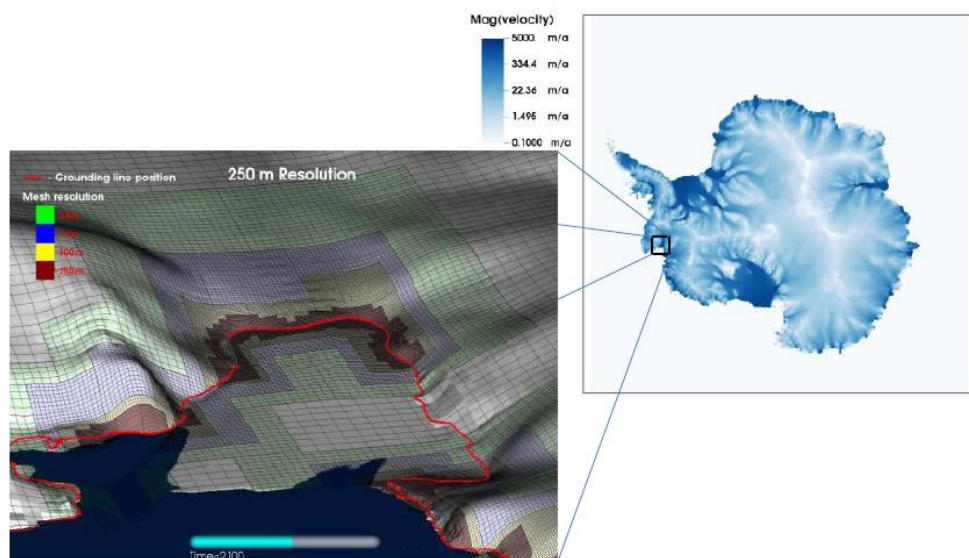


Ocean biogeochemistry:

- MEDUSA2 (Yool 2010, 2013)
intermediate complexity
plankton ecosystem model
- prognostic diatoms/non-diatoms
- variable C:N ratio

UKESM1

(& main science developments from HadGEM2-ES)



Ice sheets

- BISICLES land ice model (Cornforth 2013)
- over Antarctica and Greenland.
- *In a specific model release; UKESM1-is for ISMIP6.*

UKESM1 data is published for CMIP6



7 scenarios simulated (5-member ensemble for each)

For links to model data see ukesm.ac.uk/cmip6

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WCRP CMIP6

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MIP Era

Activity

Model Cohort

Product

Source ID

☒ UKESM1-0-LL (5)

Institution ID

Source Type

Nominal Resolution

Experiment ID

☒ ssp585 (5)

Sub-Experiment

Variant Label

WARNING: Not all models include a variant "r1i1p1f1", and across models, identical values of variant_label do not imply identical variants! To learn which forcing datasets were used in each variant, please check modeling group publications and documentation provided through ES-DOC.

Enter Text:

Display results per page [\[More Search Options \]](#)

☐ Show All Replicas ☐ Show All Versions ☐ Search Local Node Only (Including All Replicas)

Search Constraints: ☒ pr | ☒ ssp585 | ☒ UKESM1-0-LL

Total Number of Results: 5

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Please login to add search results to your Data Cart

Expert Users: you may display the search URL and return results as XML or return results as JSON

1. CMIP6.ScenarioMIP.MOHC.UKESM1-0-LL.ssp585.r1i1p1f2.Amon.pr.gn
Data Node: [esgf-data3.ceda.ac.uk](#)
Version: 20190507
Total Number of Files (for all variables): 2
Full Dataset Services: [\[Show Metadata \]](#) [\[List Files \]](#) [\[THREDDS Catalog \]](#) [\[WGET Script \]](#) [\[Show Citation \]](#) [\[PID \]](#) [\[Globus Download \]](#) [\[Further Info \]](#)
2. CMIP6.ScenarioMIP.MOHC.UKESM1-0-LL.ssp585.r2i1p1f2.Amon.pr.gn
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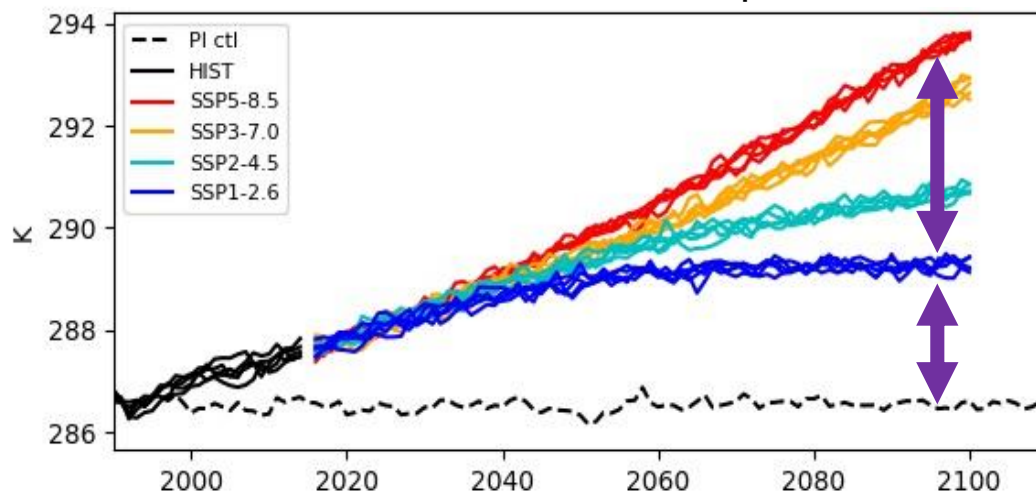
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Temperature and precipitation (Tier 1 scenarios)

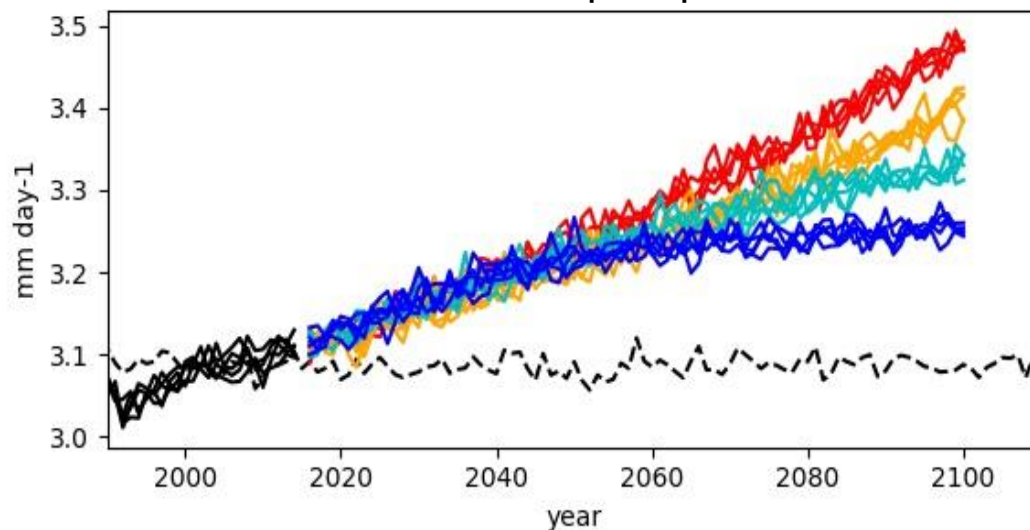
Global mean surface temperature



~4 K

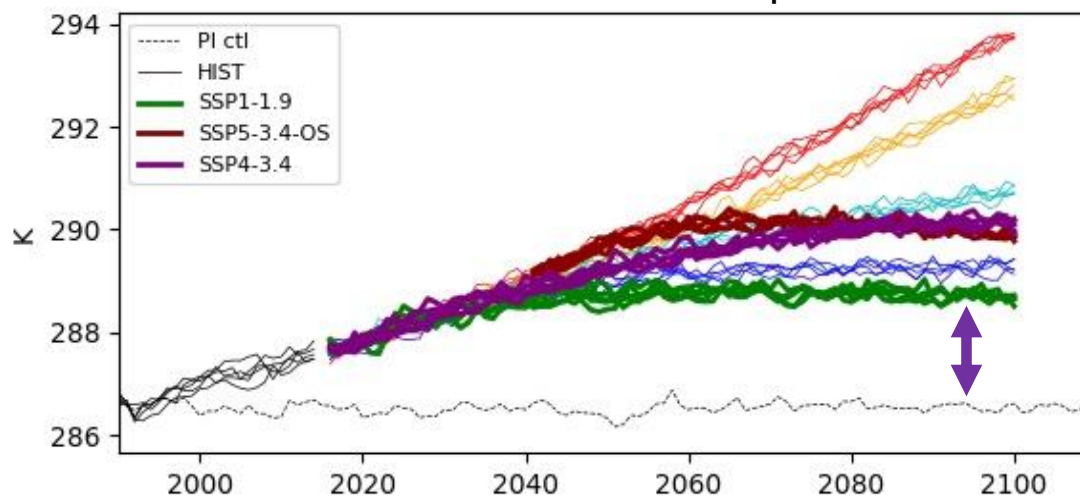
~2.5 K

Global mean precipitation



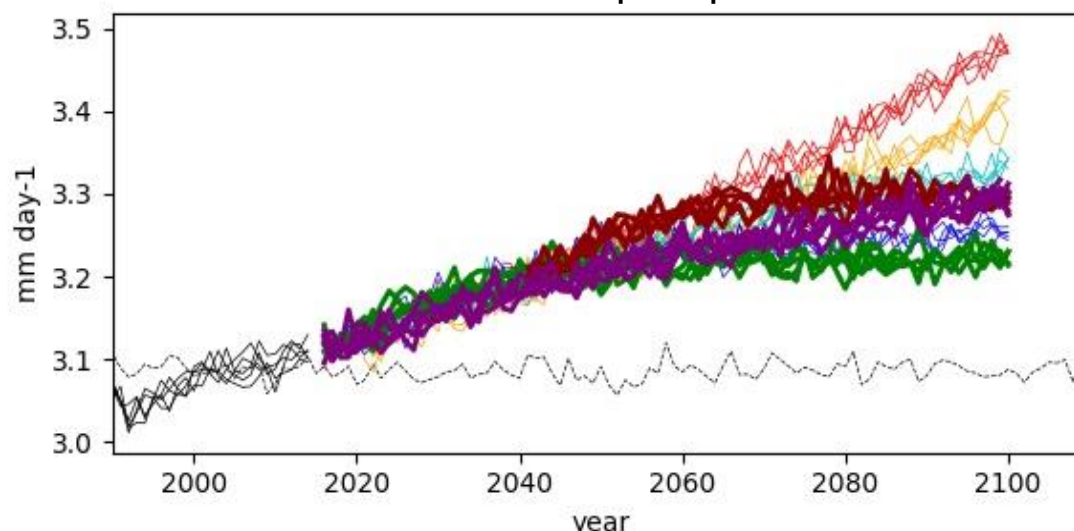
Temperature and precipitation (Tier 1+2 scenarios)

Global mean surface temperature



~1.7 K

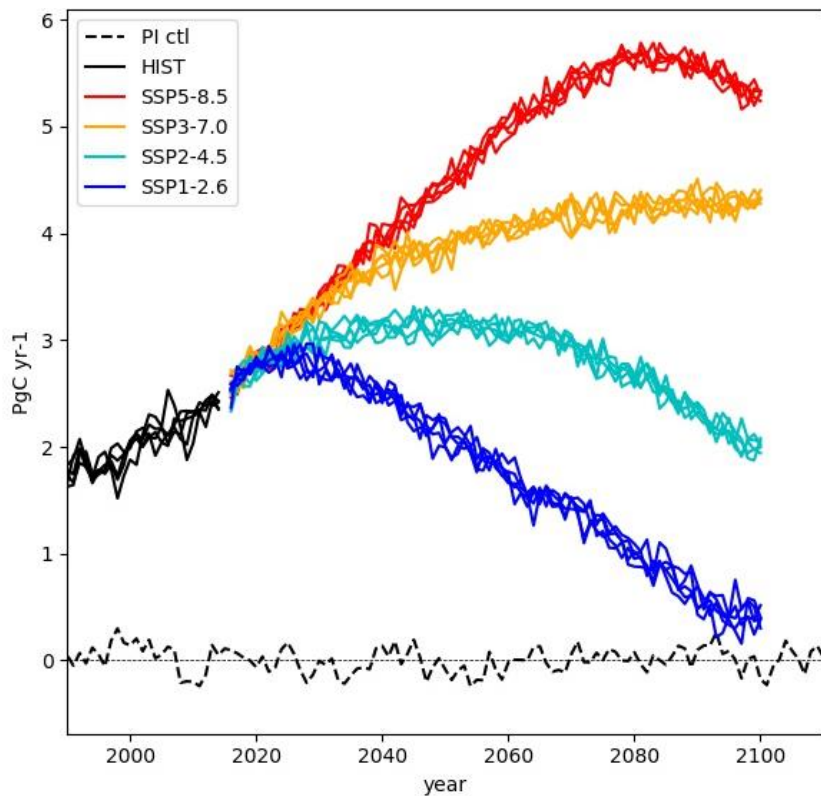
Global mean precipitation



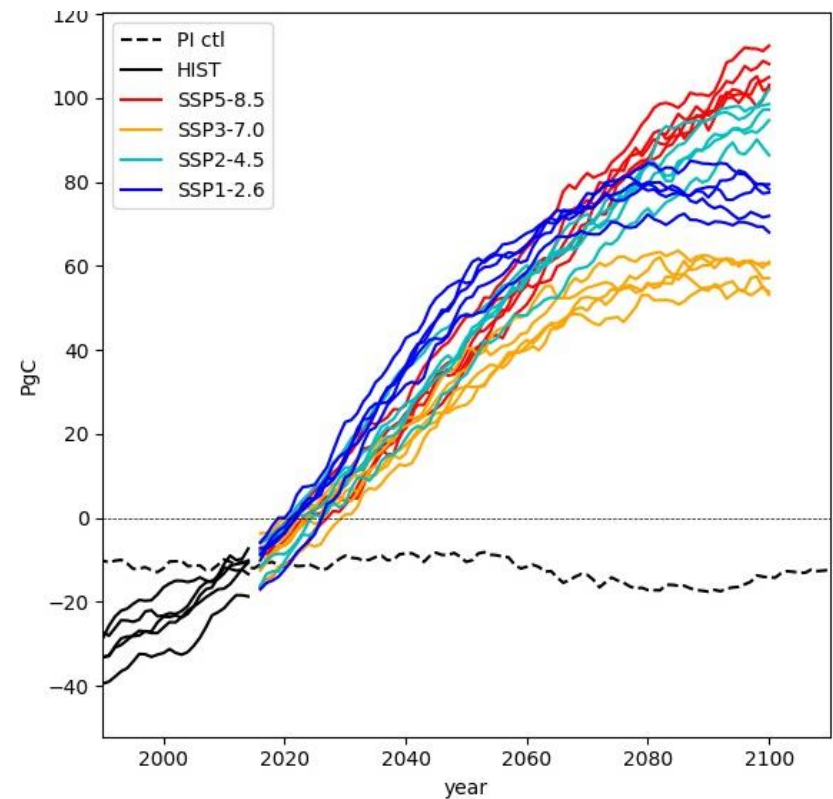
Carbon uptake

CO₂ & radiative forcing are not the whole story

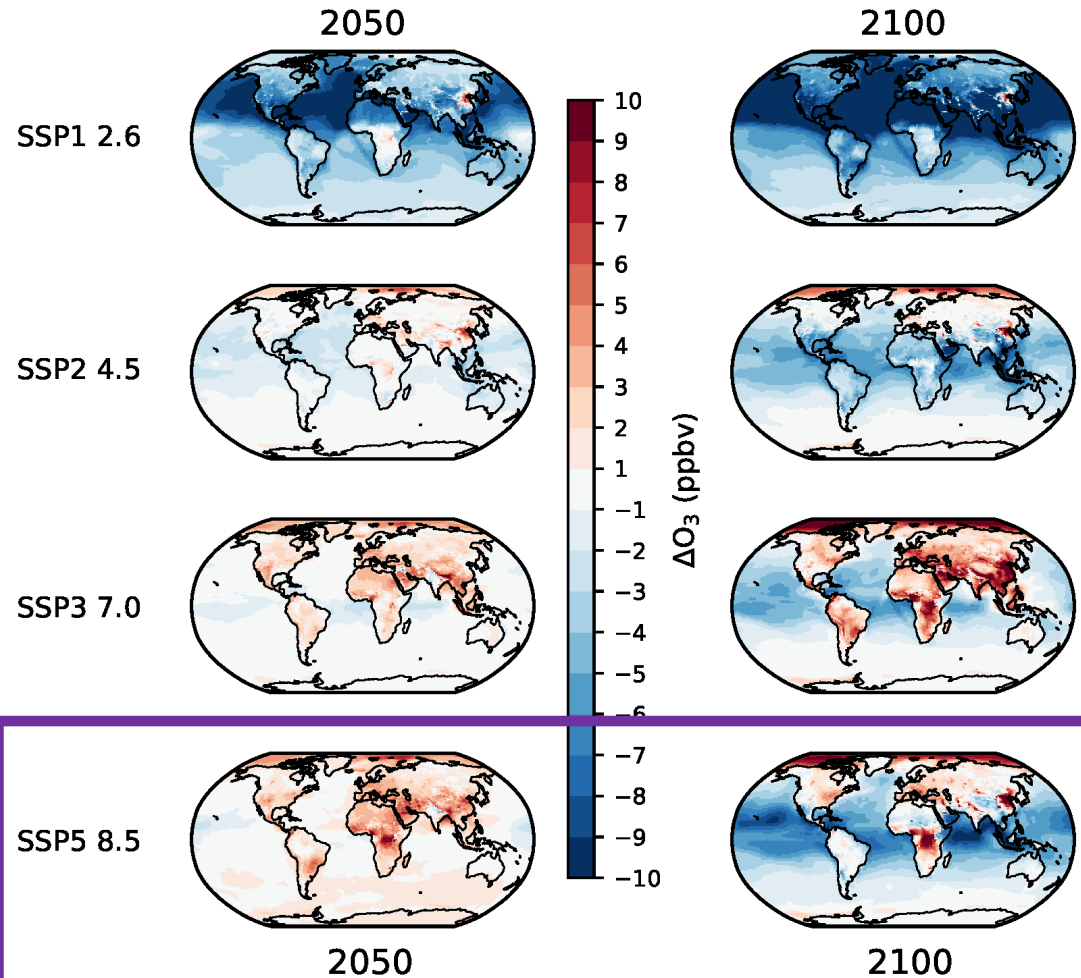
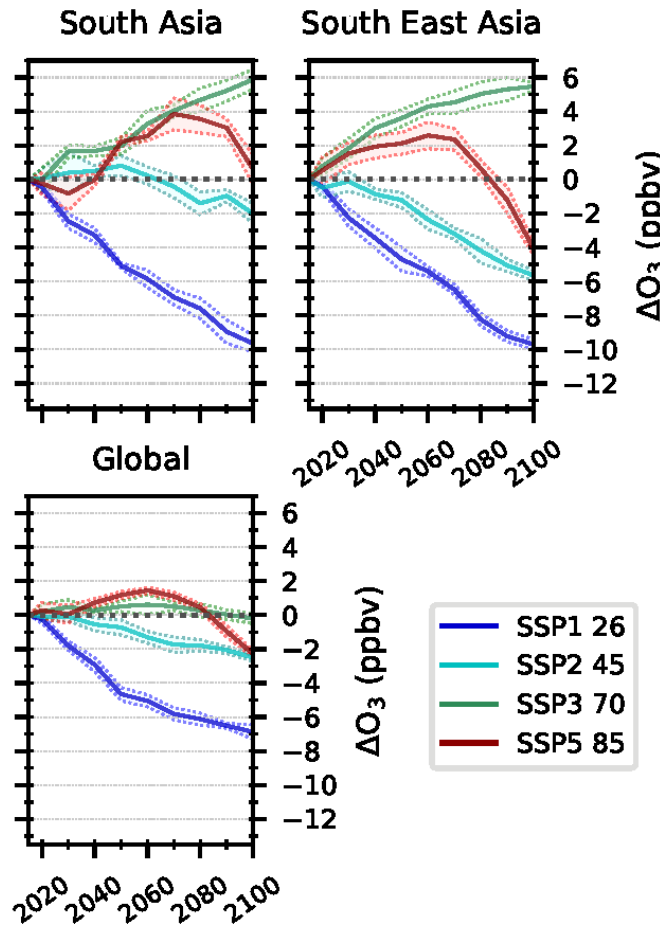
Air-to-sea CO₂ flux



Terrestrial carbon uptake



Surface ozone



Conclusions

- Scenarios cannot be characterised by radiative forcing only
- Carbon uptake depends strongly on land use – not just CO₂ and radiative forcing
- Model results are freely available:
 - see ukesm.ac.uk/cmip6



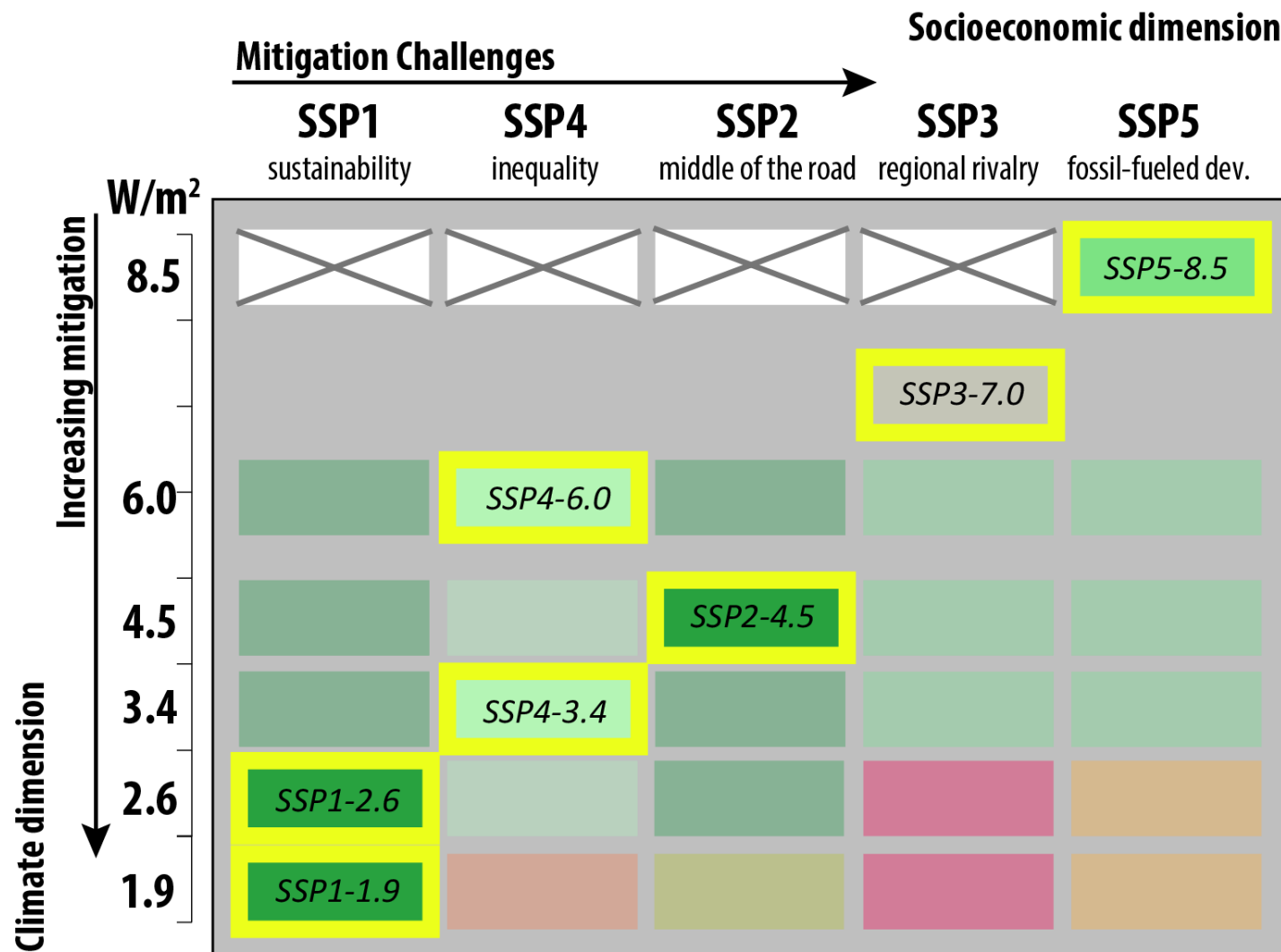
Joint Weather & Climate Research
Programme – a partnership in weather
and climate research



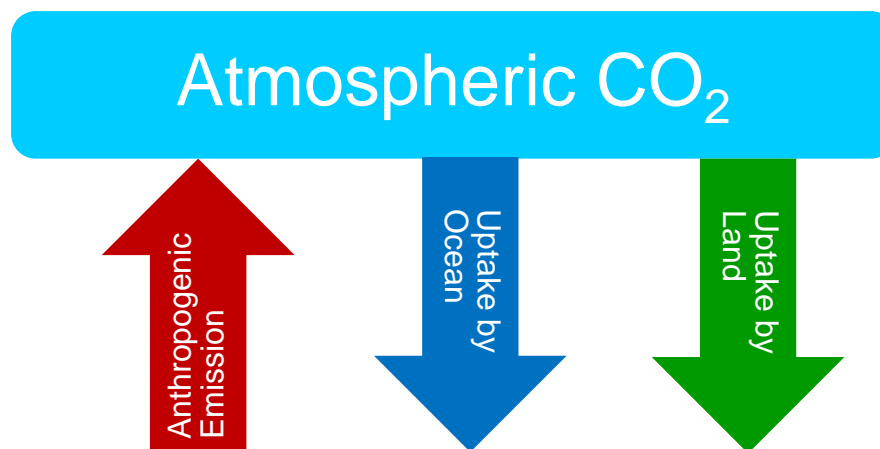
Additional slides



SSPs and radiative forcing



Carbon feedbacks and compatible emissions



- $\Delta\text{CO}_2 = \text{Emission} - \text{Uptake}(\text{land}+\text{ocean})$
 - (CO₂ emission-driven experiments)
- $\text{Emission} = \Delta\text{CO}_2 + \text{Uptake}(\text{land}+\text{ocean})$
 - (CO₂ concentration-driven experiments)