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

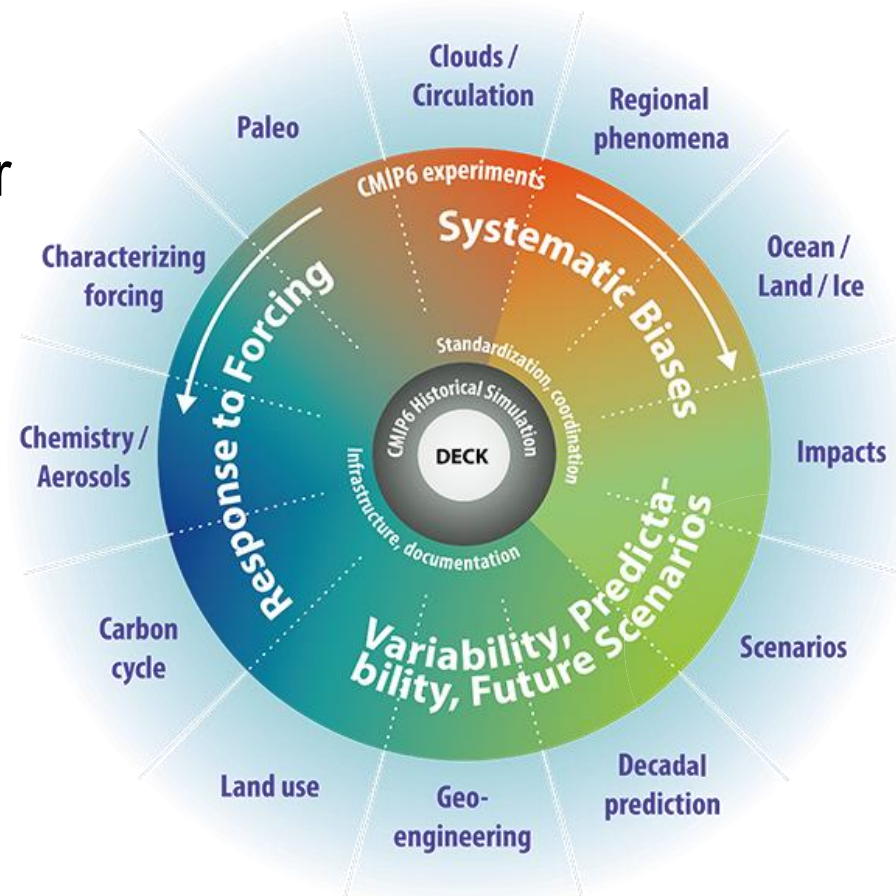3. UKESM1 projections for CMIP6: headline results

Outline

1. **CMIP6 scenarios**

2. UK Earth system model: UKESM1

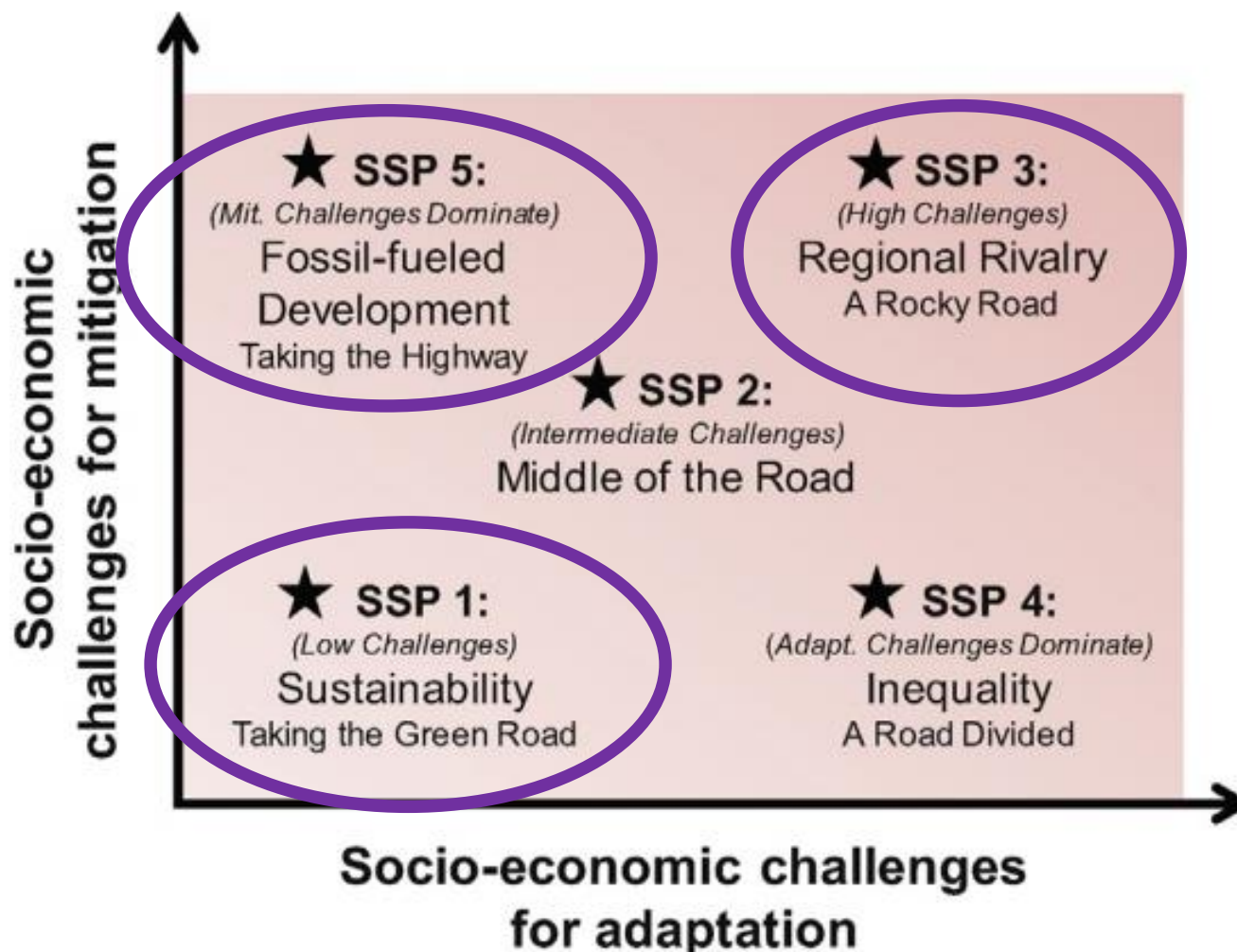3. UKESM1 projections for CMIP6: headline results

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

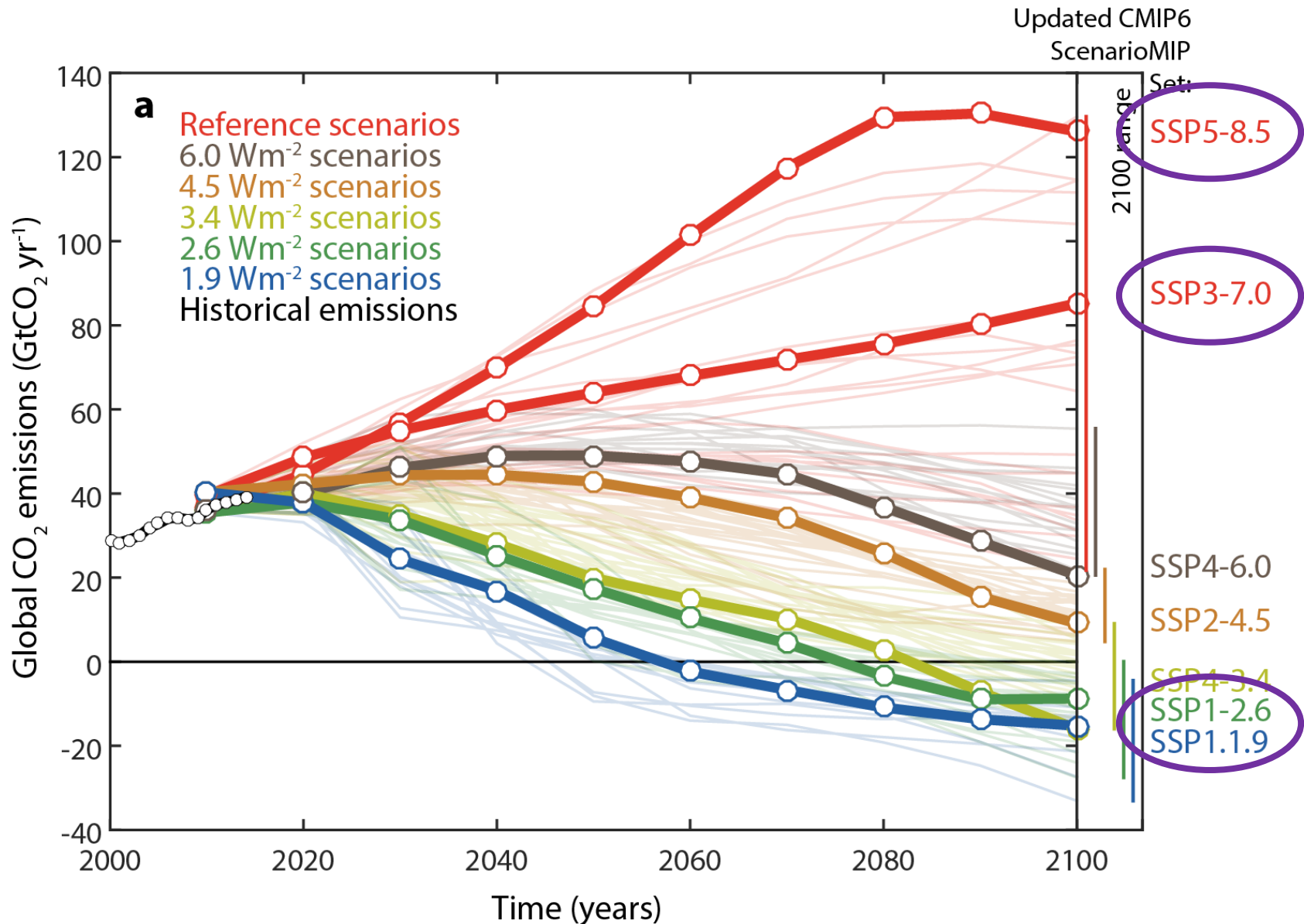# How does the socioeconomic pathway affect the Earth system?

Emissions

Land Use

Example: CO_2 emissions

Outline

1. CMIP6 scenarios

2. UK Earth system model: UKESM1

3. UKESM1 projections for CMIP6: headline results

UKESM1
ukesm.ac.uk

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

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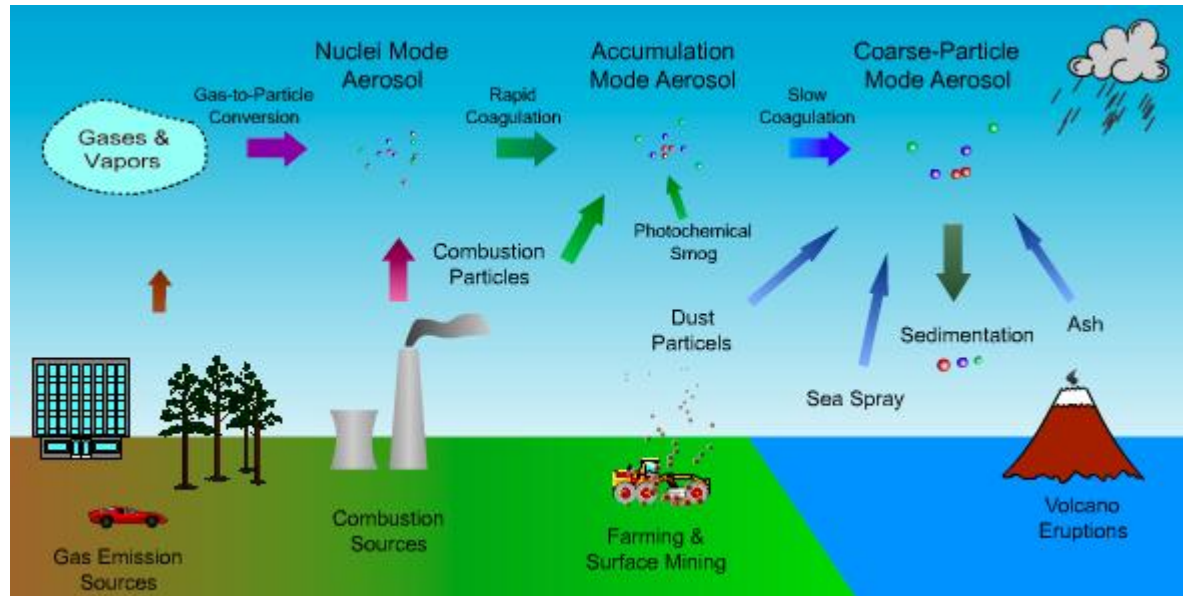
- Available for research users: contact NCAS-CMS to get started

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)
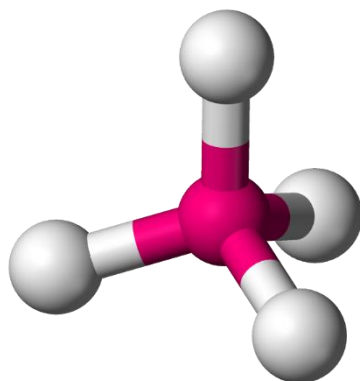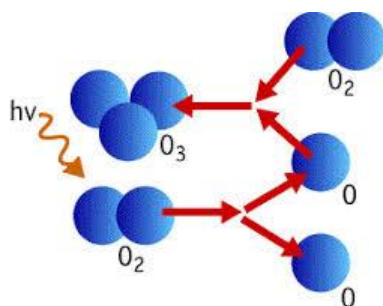
UKESM1 components…

(& 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

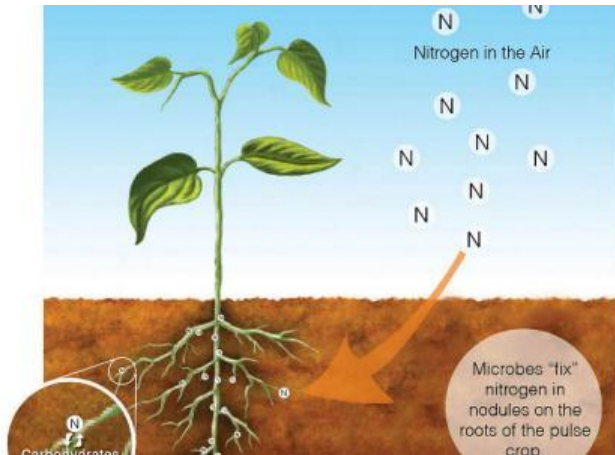(& main science developments from HadGEM2-ES)

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

UKESM1

(& main science developments from HadGEM2-ES)
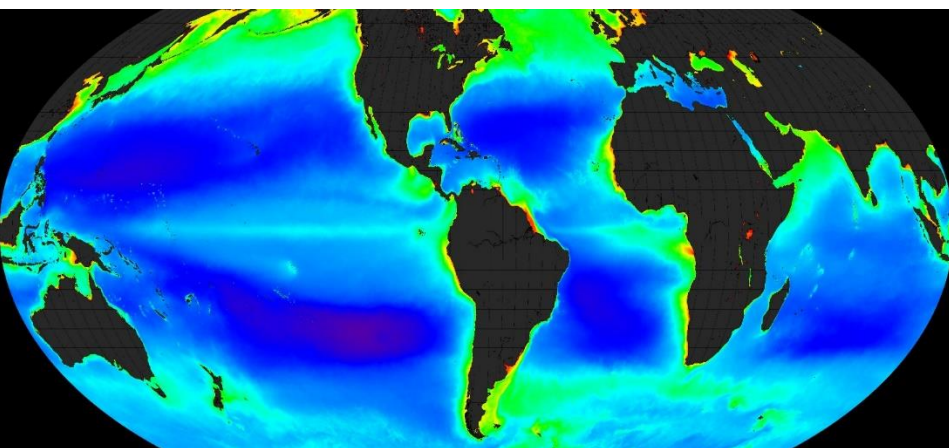
Ocean biogeochemistry:

- MEDUSA2 (Yool 2010, 2013) intermediate complexity plankton ecosystem model

- prognostic diatoms/non-diatoms

- variable C:N ratio

UKESM1
(& main science developments from HadGEM2-ES)
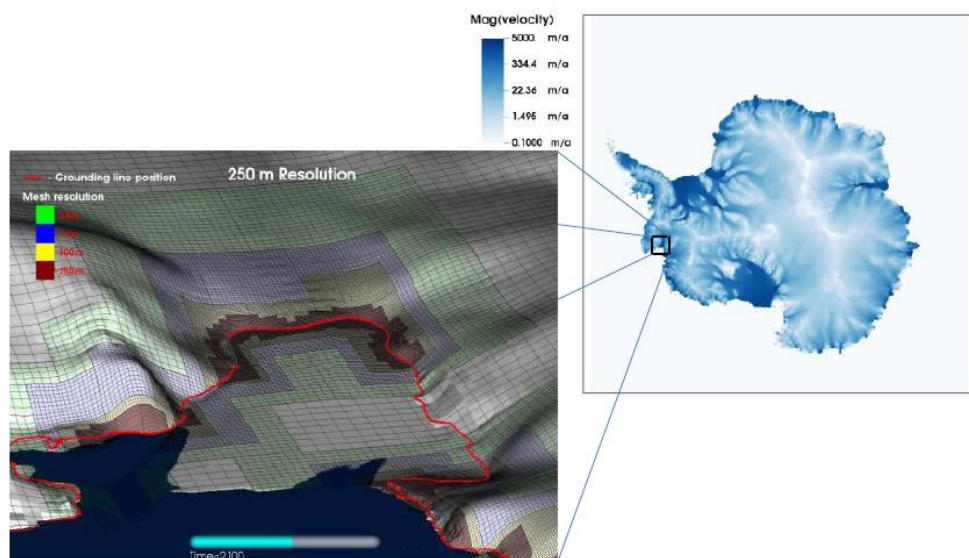
Ice sheets

- 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)

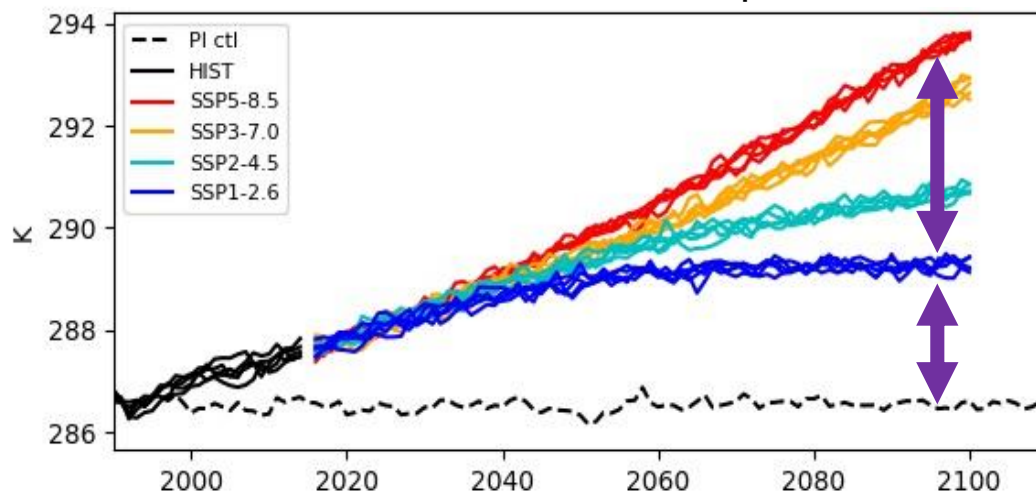For links to model data see ukesm.ac.uk/cmip6

Outline

1. CMIP6 scenarios

2. UK Earth system model: UKESM1

3. UKESM1 projections for CMIP6: headline results
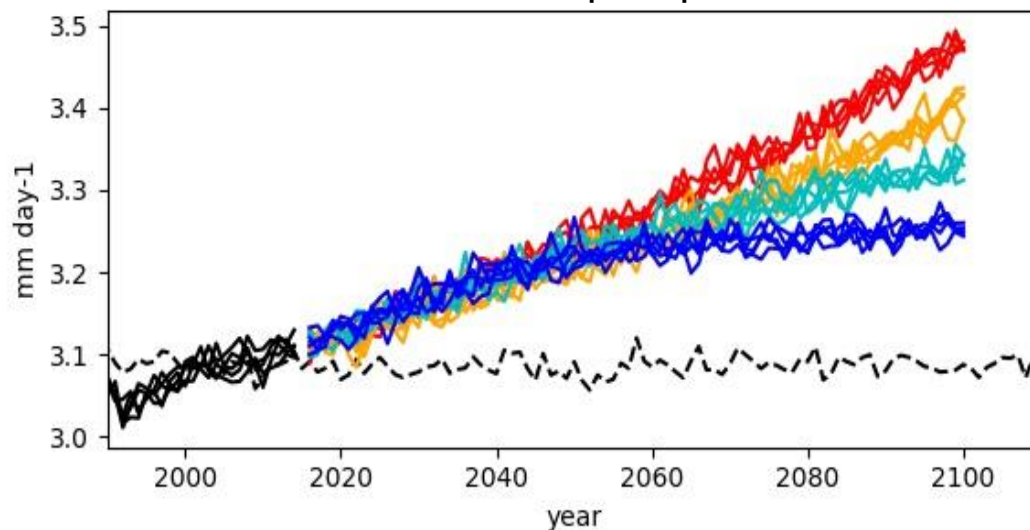
Temperature and precipitation (Tier 1 scenarios)

Global mean surface temperature
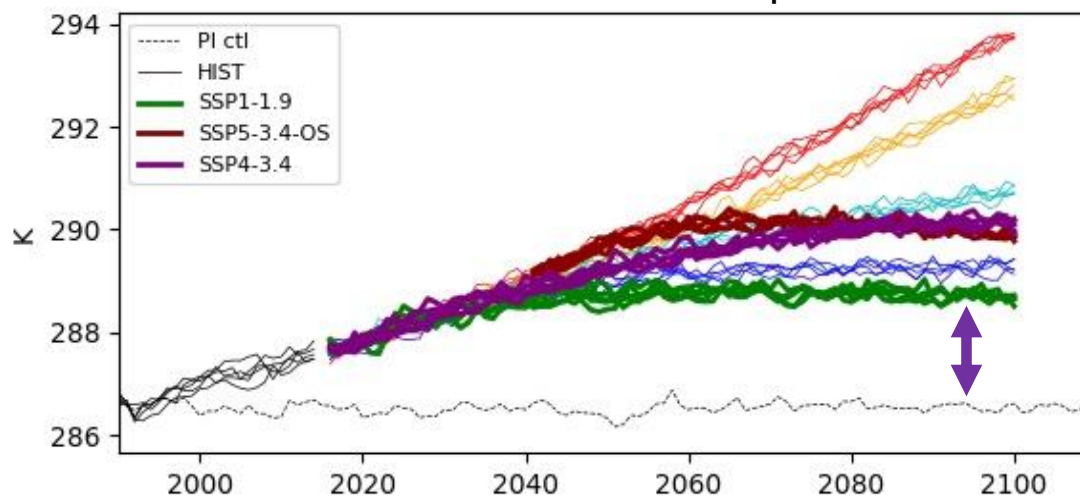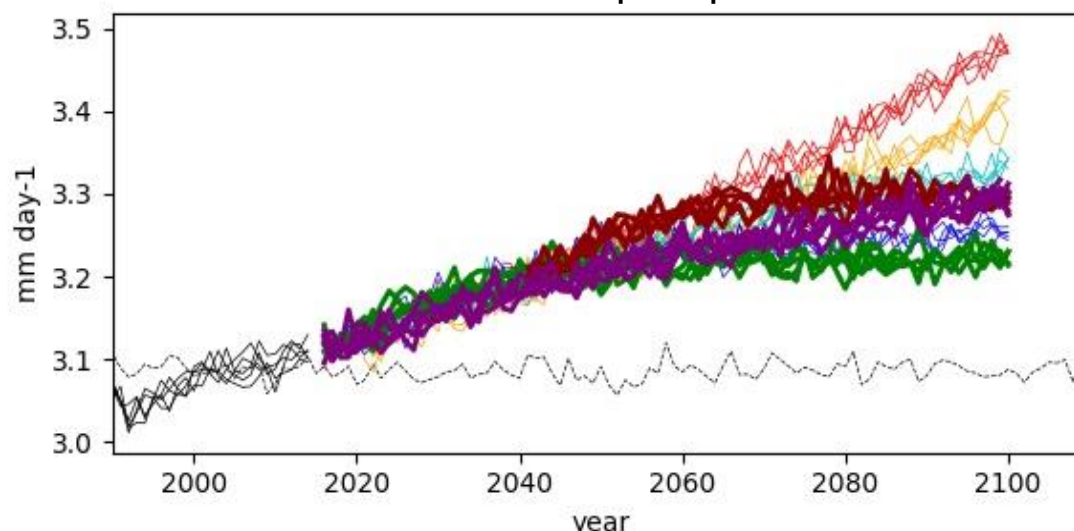
Global mean precipitation

Temperature and precipitation
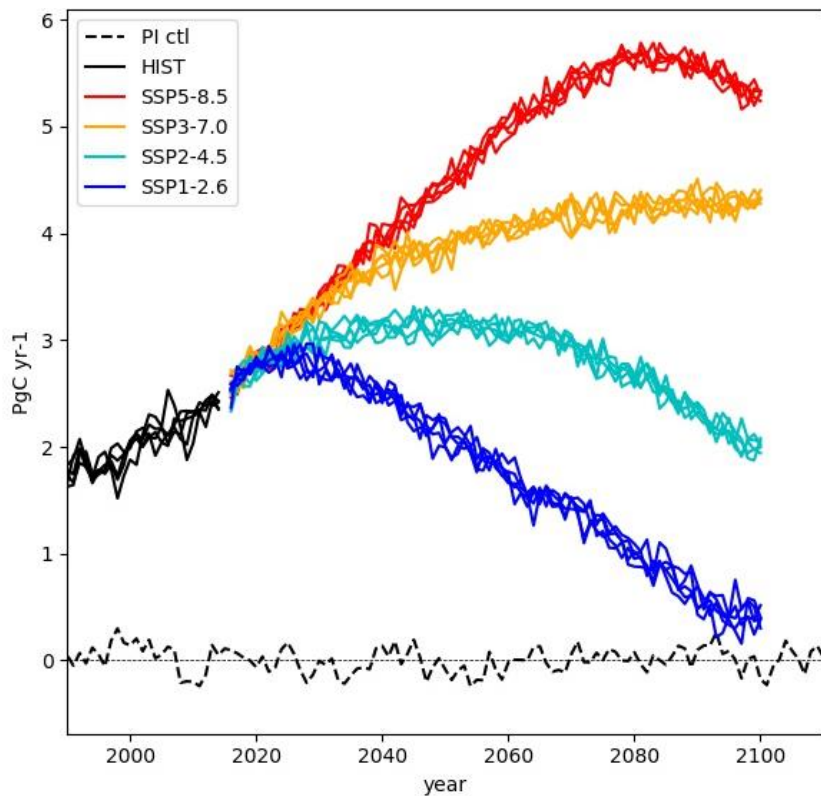## (Tier 1+2 scenarios)

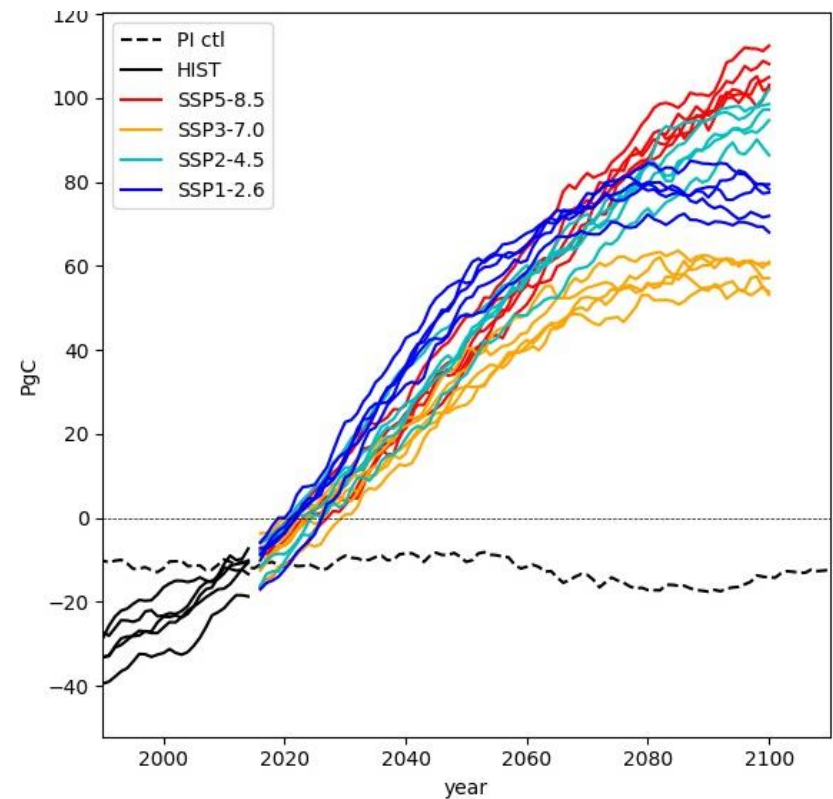Global mean surface temperature

~1.7 K

Global mean precipitation

Carbon uptake

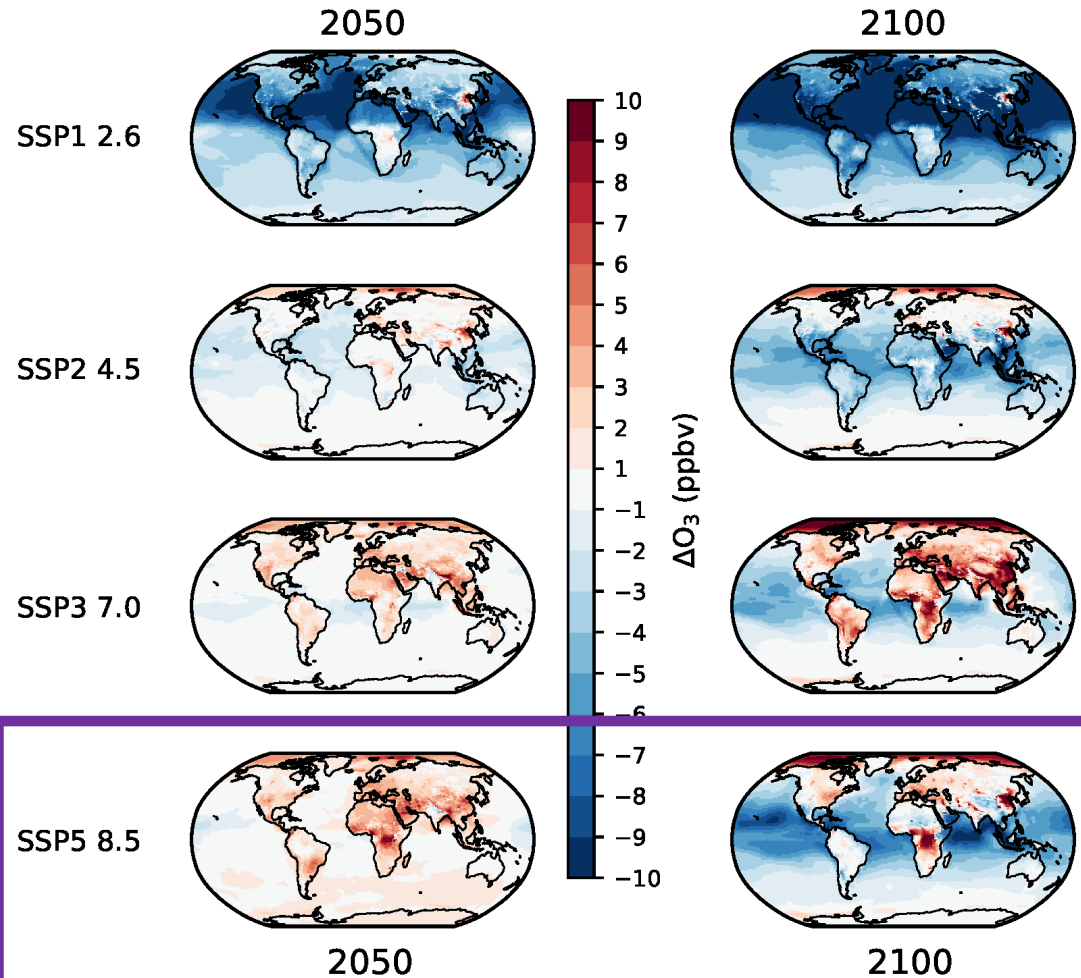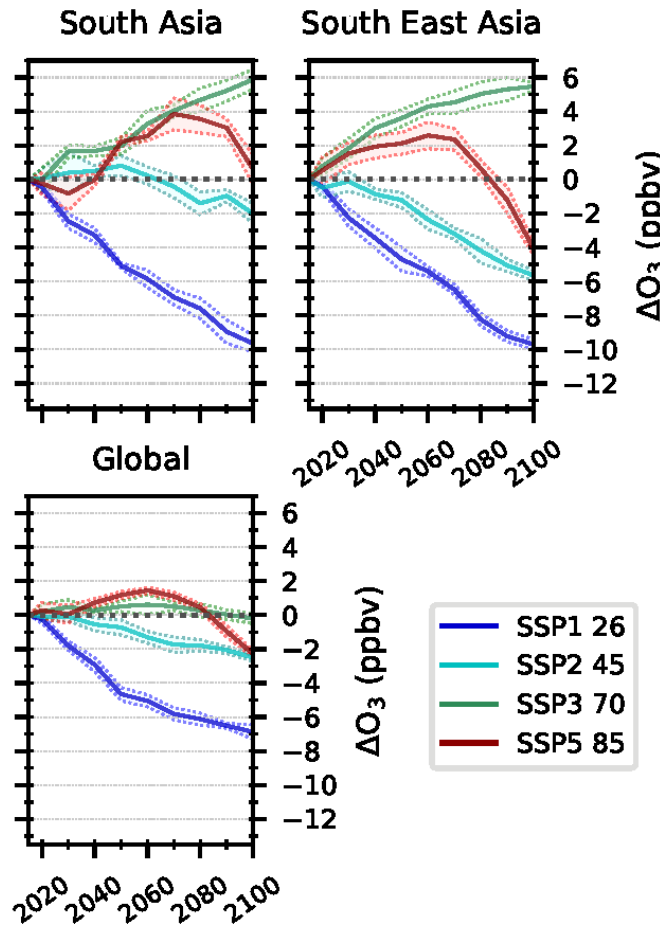CO$_2$ & radiative forcing are not the whole story

Air-to-sea CO$_2$ flux

Terrestrial carbon uptake

Surface ozone

© Crown copyright

Conclusions

- Scenarios cannot be characterised by radiative forcing only

- Carbon uptake depends strongly on land use – not just CO_2 and radiative forcing

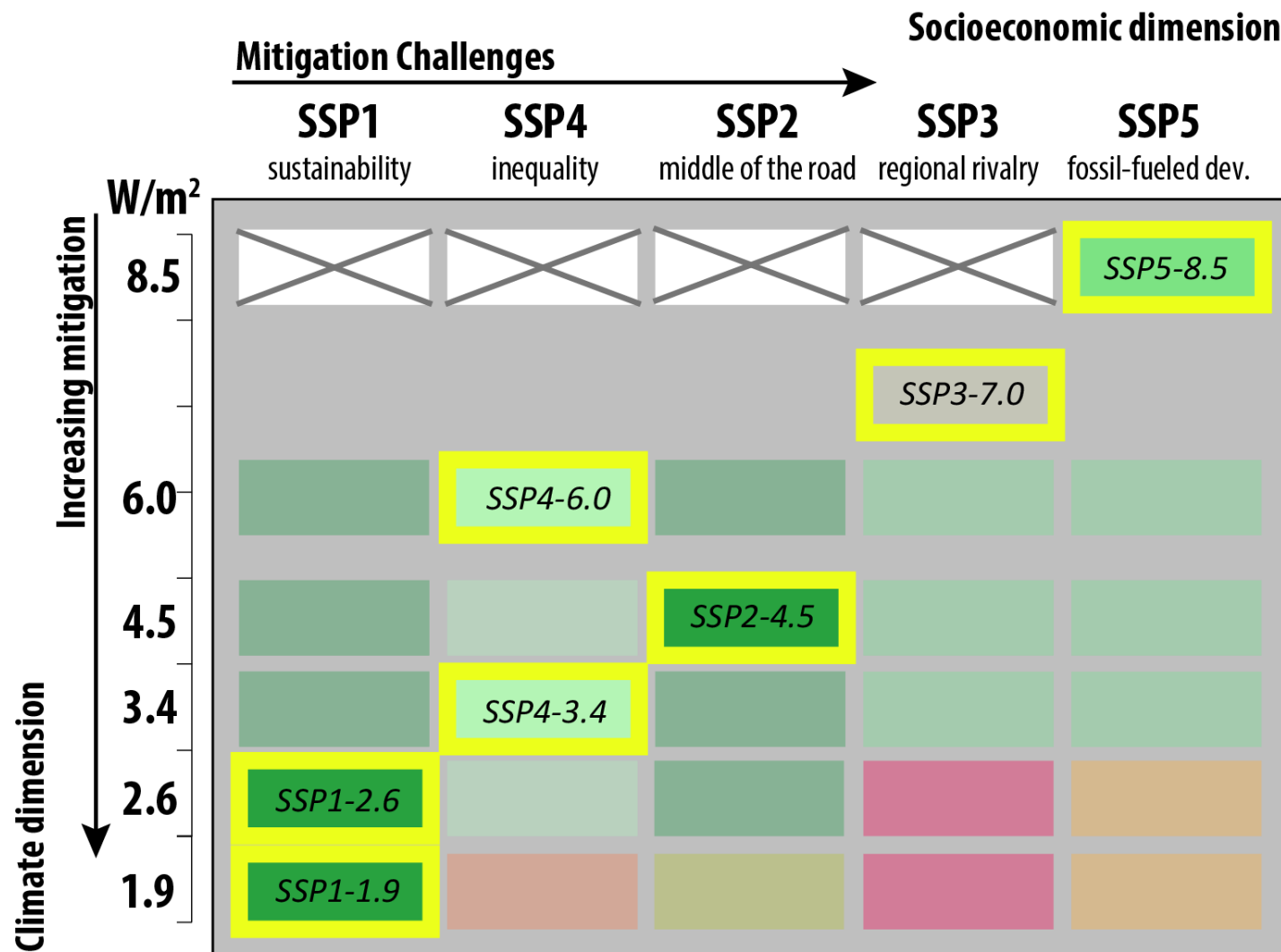- Model results are freely available:
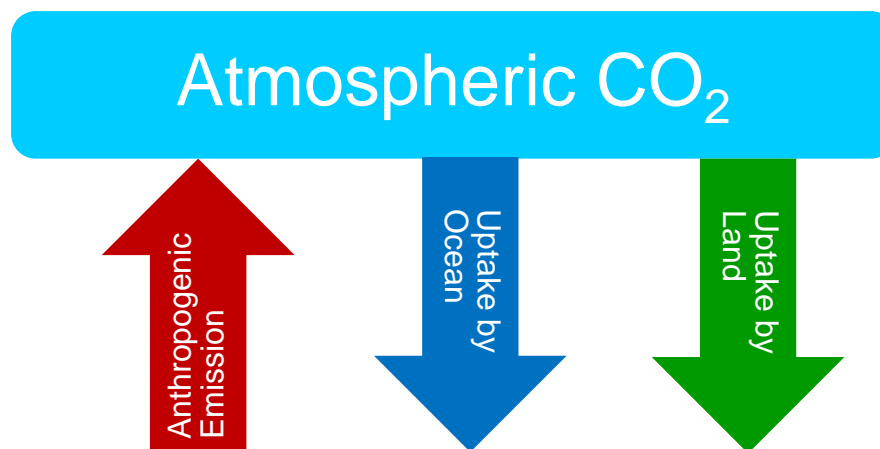
  - see ukesm.ac.uk/cmip6

Additional slides

SSPs and radiative forcing

Carbon feedbacks and compatible emissions

- ΔCO_2 = Emission - Uptake(land+ocean)
  - (CO_2 emission-driven experiments)

- Emission = ΔCO_2 + Uptake(land+ocean)
  - (CO_2 concentration-driven experiments)