Supplementary material to: *"UKESM1.1: Development and evaluation of an updated configuration of the UK Earth System Model"*

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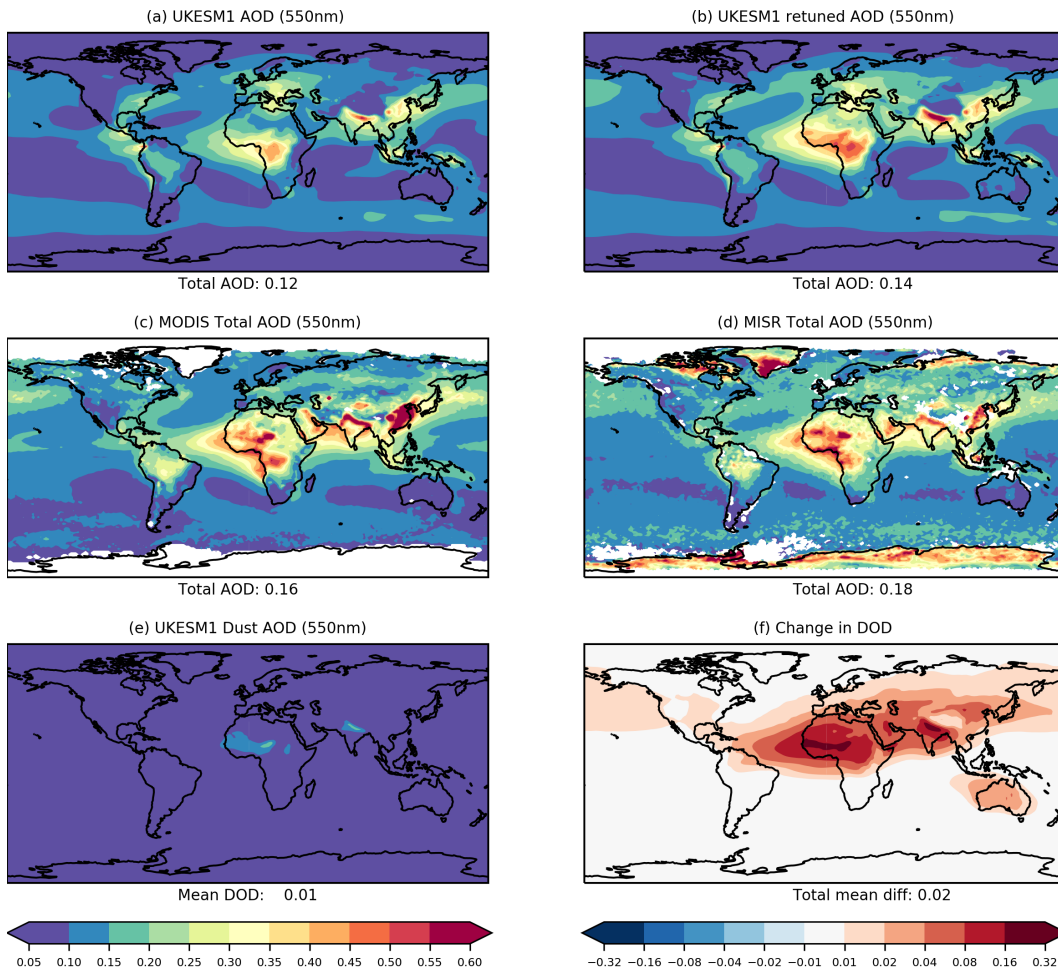
Introduction

This Supporting Information contains a number of additional, supplementary figures and table to support the findings in the main article. All figures are referenced in the main article and the reader is directed to the main text for more information.

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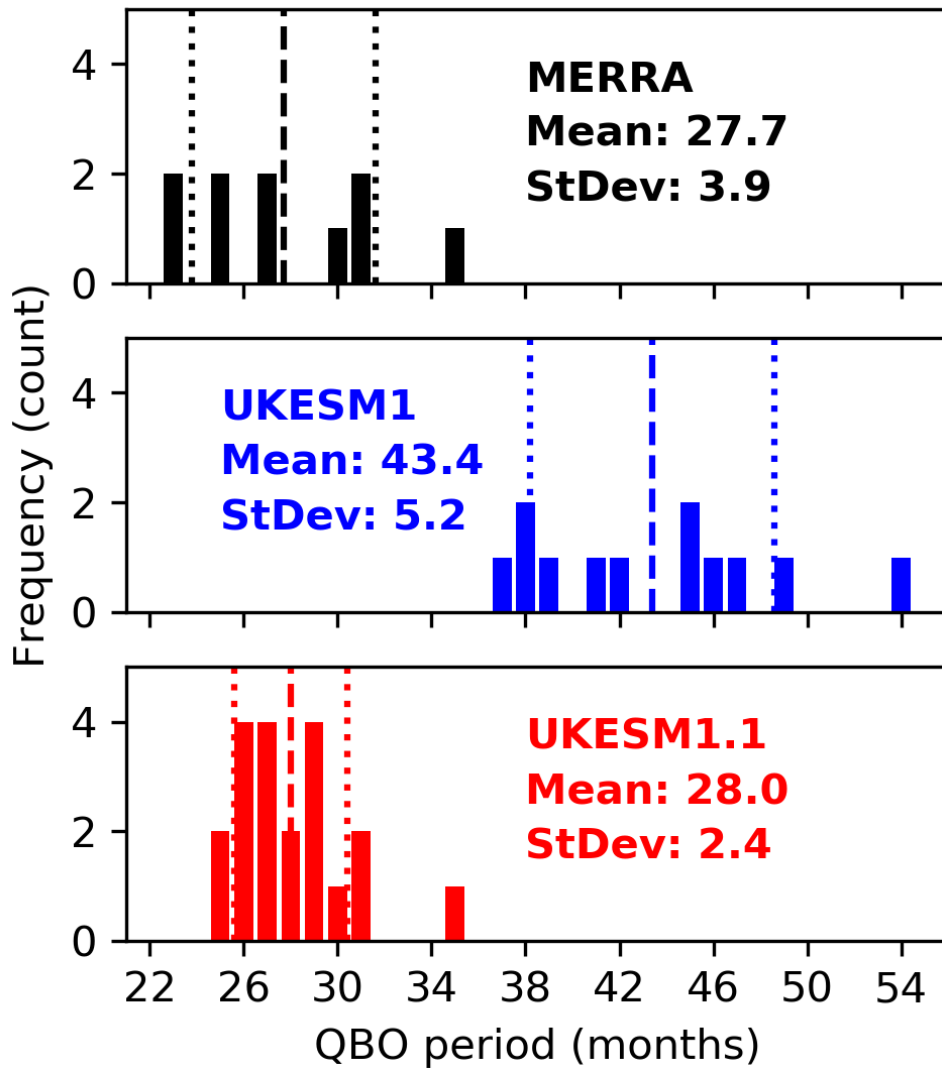
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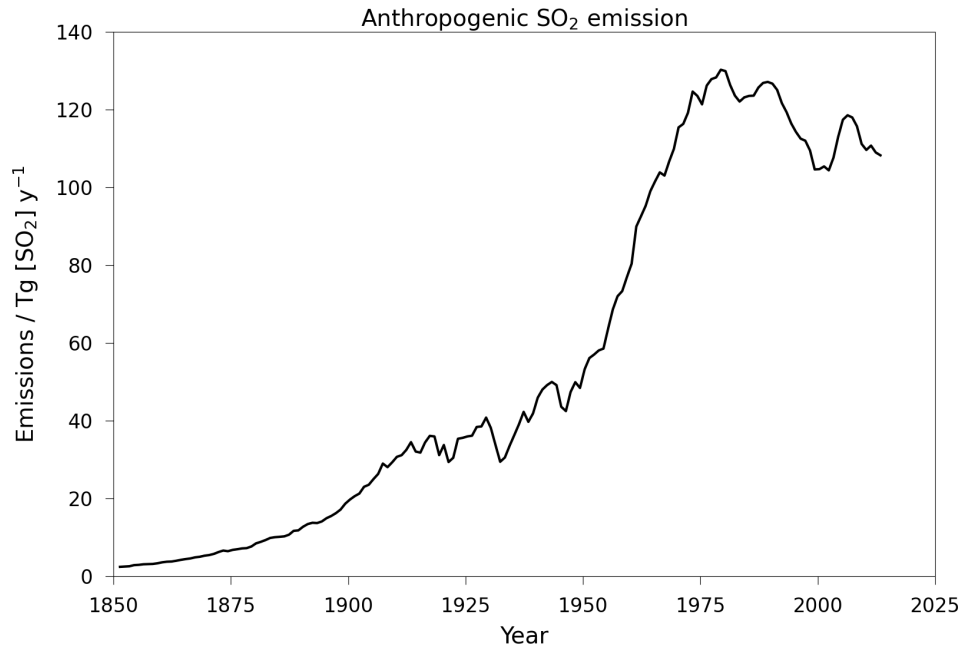


Figure S3: Historical evolution of the anthropogenic emissions of SO$_2$ in CMIP6.

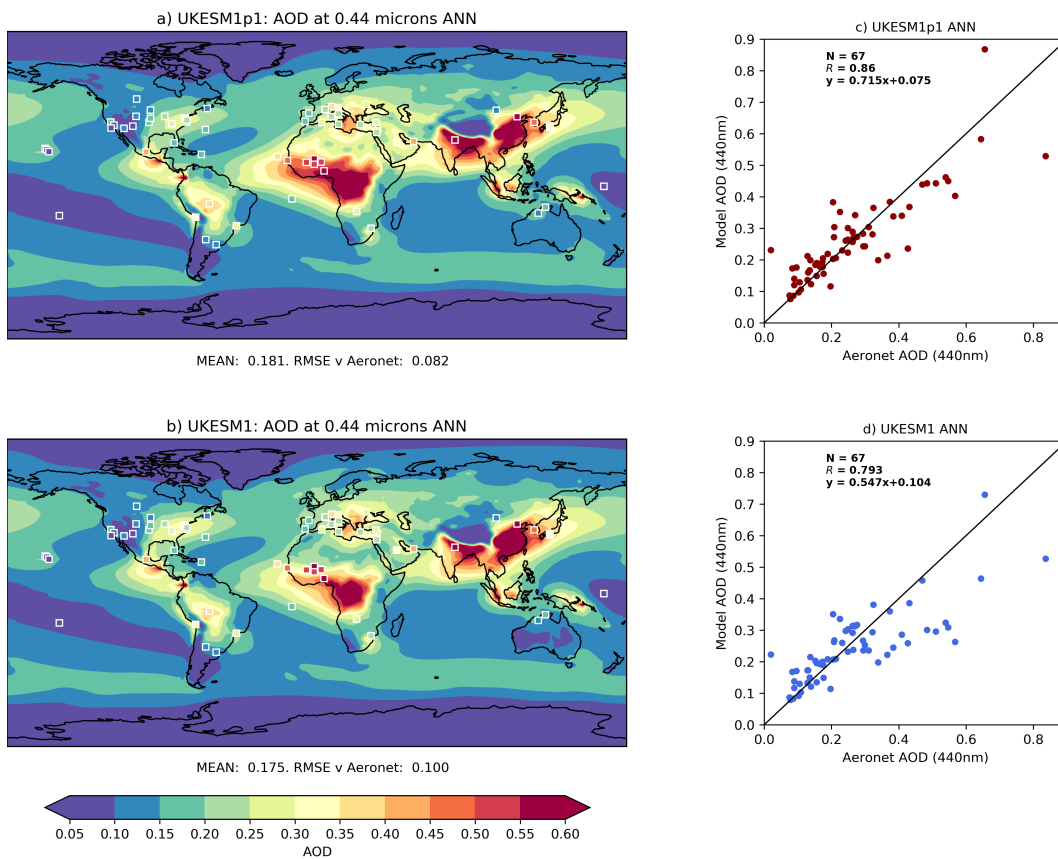
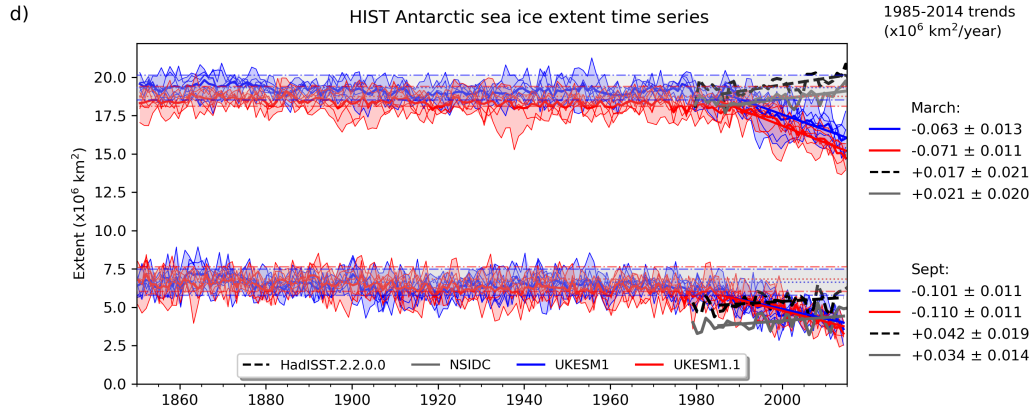



Figure S4: Annual mean AOD at 440 nm from (a) UKESM1.1 and (b) UKESM1. Ground-based AOD retrievals from the global AERONET network are overlaid at their respective locations and use the same colour scale; scatterplots of simulated co-located AOD with the AERONET measurements are shown for (c) UKESM1.1 and (d) UKESM1.

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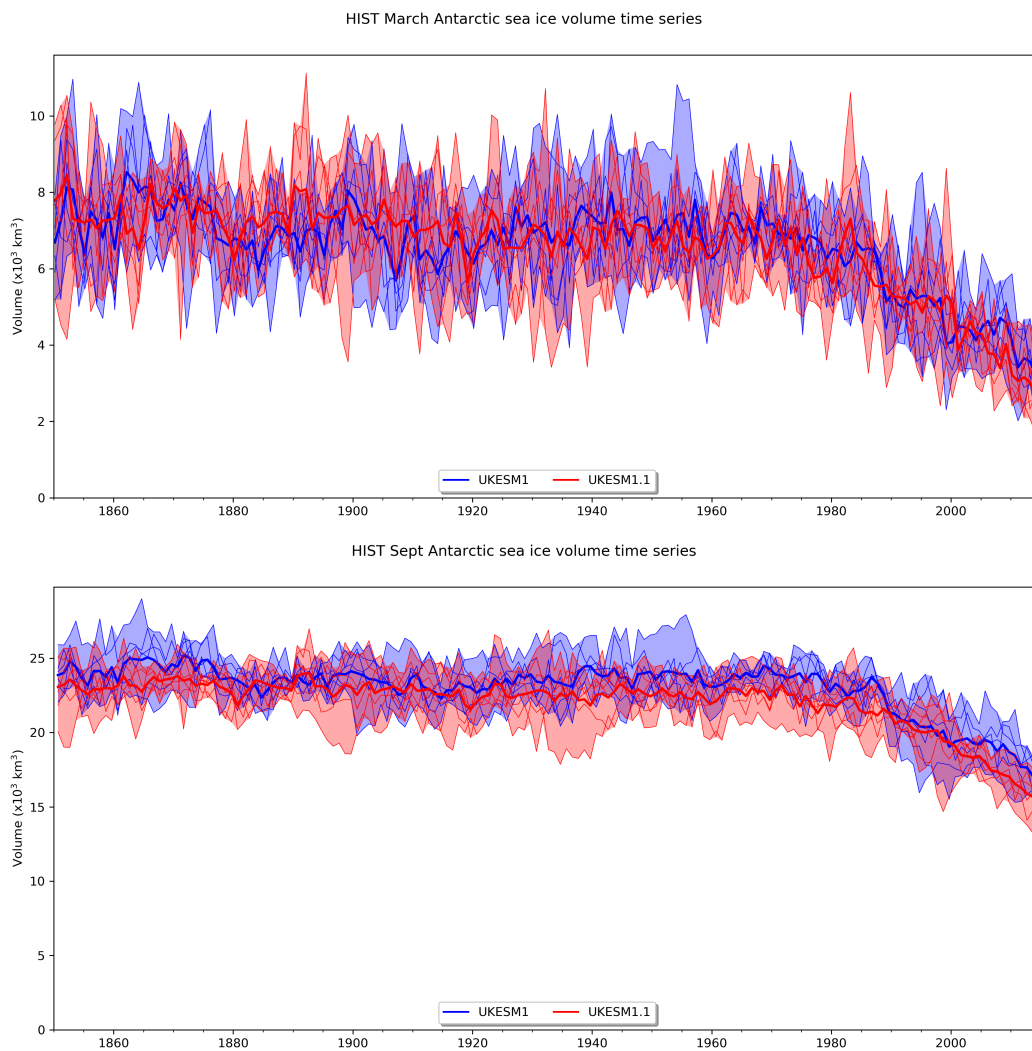


Figure S6: Timeseries of simulated (blue, UKESM1; red, UKESM1.1) sea ice volume in the Antarctic for the months of March and September over the full historical period (1850-2014). Model data represents the ensemble mean for UKESM1 (6 members) and UKESM1.1 (6 members) with ±1 standard deviation also shown.

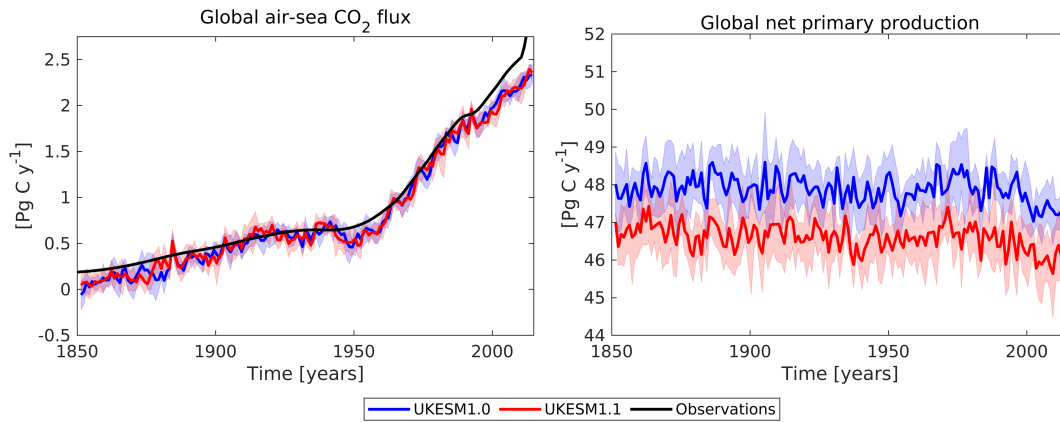
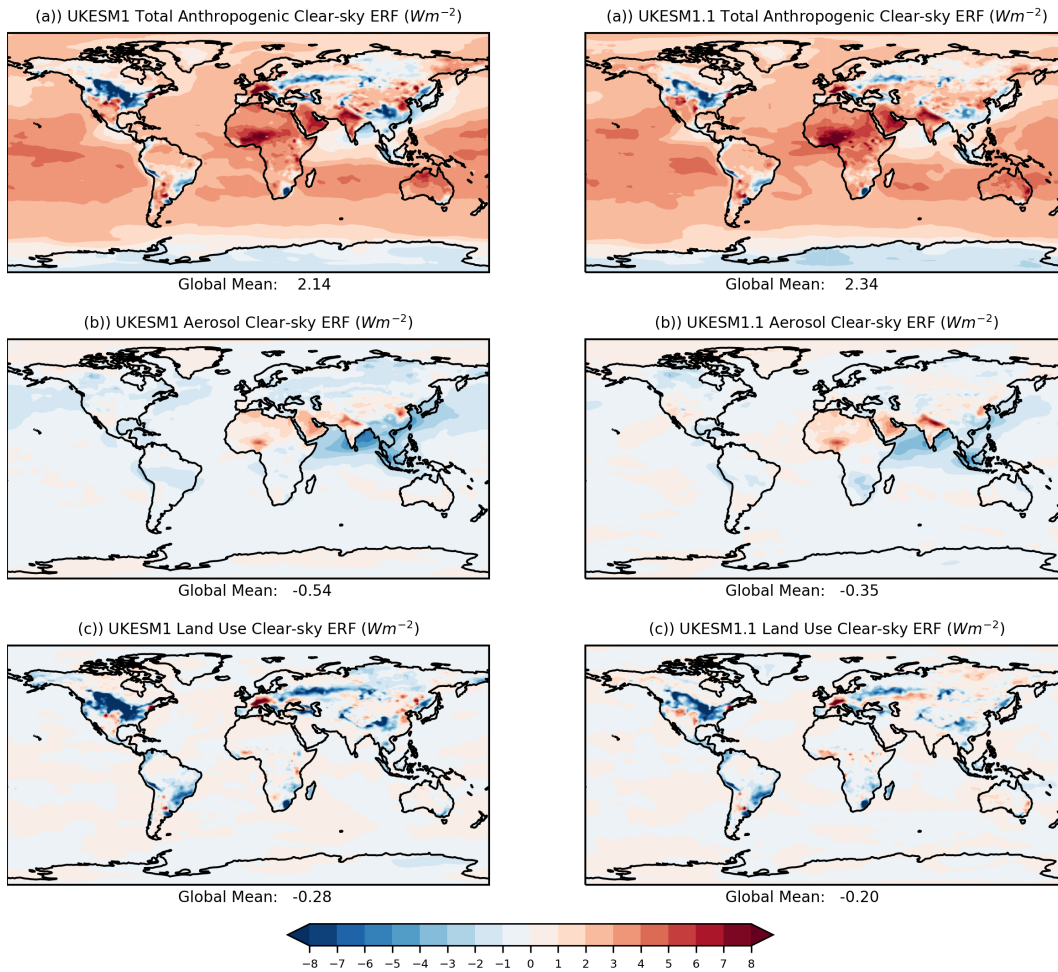



Figure S7: Global net (left) air-sea CO2 flux and (right) primary production for the UKESM1.0 (blue) and UKESM1.1 (red) ensembles. Solid lines denote the ensemble mean, with shaded areas illustrating ±1 standard deviation. Observed estimates of CO_2 flux are shown in black.

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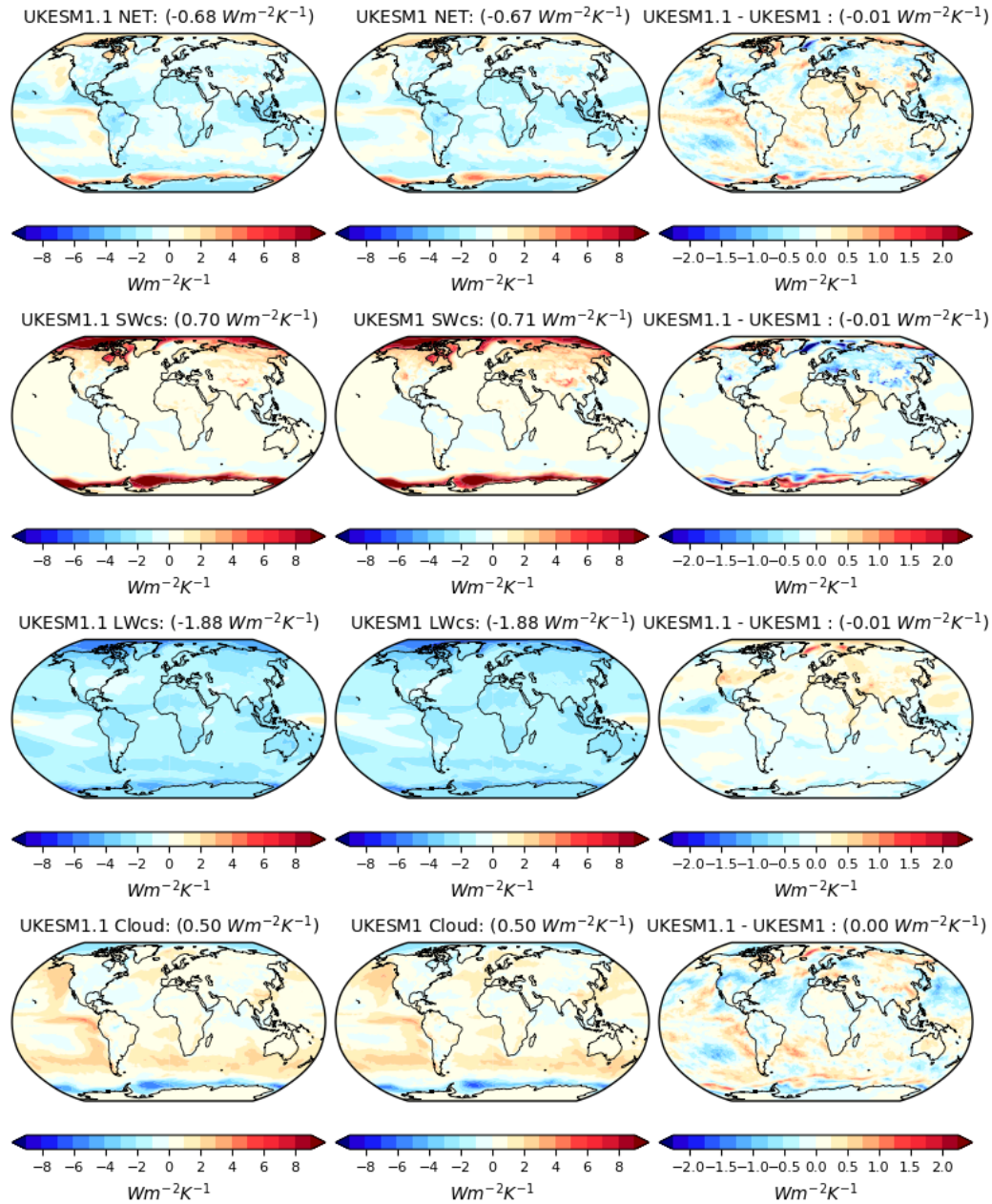
Figure S9: Regional climate feedbacks in (left) UKESM1.1, (middle) UKESM1 and (right) UKESM1.1-UKESM1 difference. The rows show (from top to bottom) the net, SW clear-sky, LW clear-sky, and cloudy-sky feedbacks.
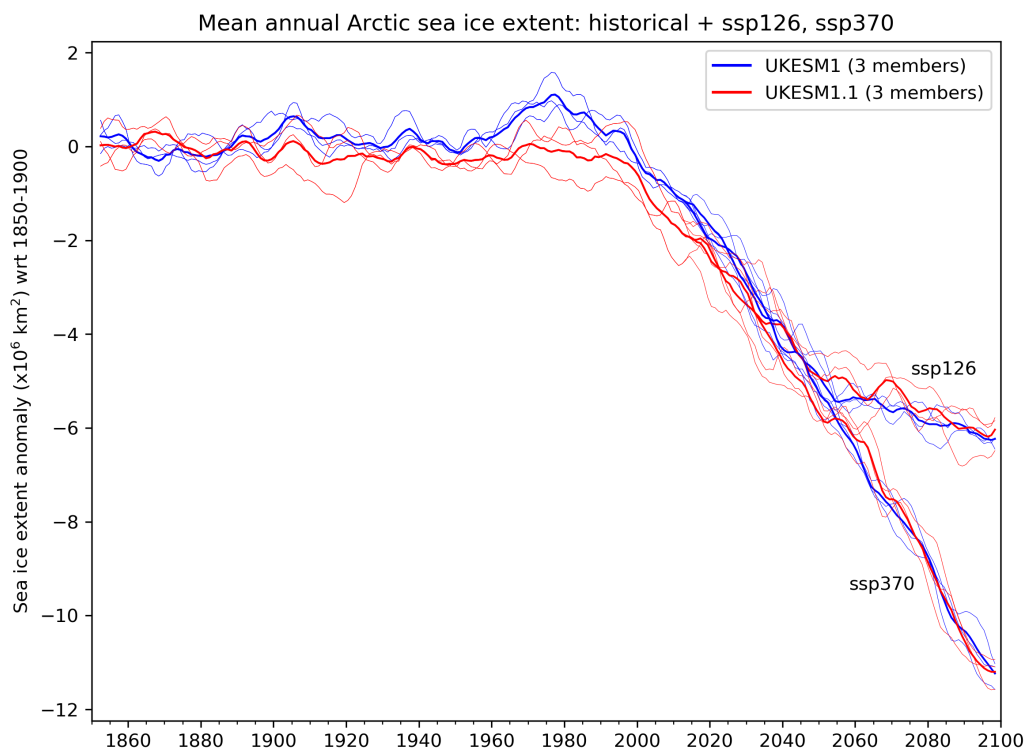
Figure S10: Global mean sea ice extent anomalies 2070-2100 mean minus 1850-1900 mean for SSP126 and SSP370. UKESM1.0 is in blue and UKESM1.1 in red. Thick lines are the respective three member ensemble means and the thin lines are the individual ensemble members. 5-year running means have been applied in all cases.
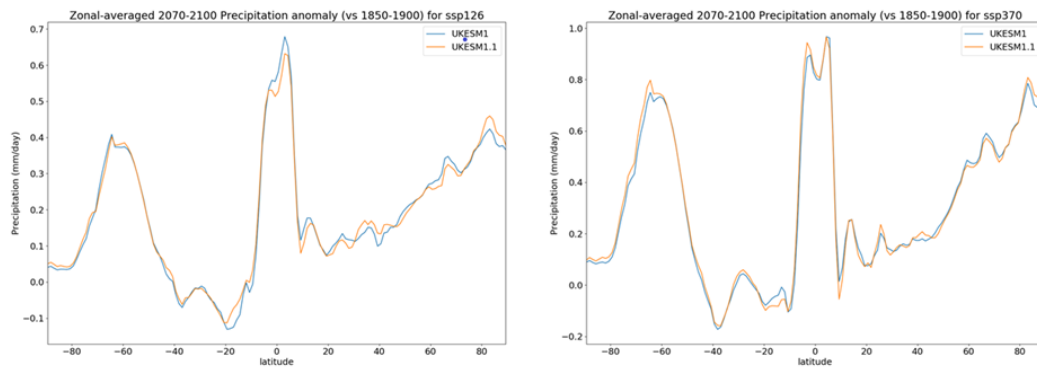
Figure S11: Zonal mean precipitation anomalies (2070 to 2100 mean) minus (1850 to 1900 mean) for SSP126 (left) and SSP370 (right). UKESM1.0 is in blue and UKESM1.1 in red.

Table S1: Values for the short-wave snow metric[a] used in the tuning of the snow burial of vegetation parameter, *n_lai_exposed*. The metric is calculated for both atmosphere-only (AMIP) and coupled historical simulations.

Model	AMIP (W m^{-2})	Historical (W m^{-2})
UKESM1	53.1	54.3
UKESM1.1	48.1	47.9
Observed range		50.5-53.6

[a] Defined as the DJF mean clear-sky outgoing SW radiation at TOA over land between 30° N-60° N.