



Supplement of

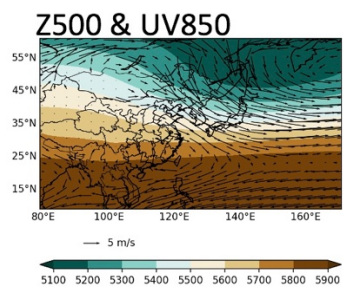
Modulation of daily PM_{2.5} concentrations over China in winter by large-scale circulation and climate change

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Supporting information



- 5 **Figure S1: UKESM1-simulated winter mean daily 500 hPa geopotential height (Z500; m, shading) and 850 hPa wind (arrows) during DJF 1999–2018.**

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Heavily polluted–winter mean

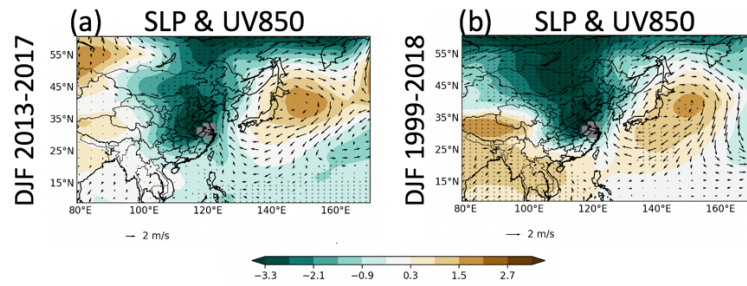


Figure S2: Anomalies (heavily polluted days minus winter mean) of SLP (hPa, shading) and 850 hPa wind (m s^{-1} , vector) during (a) DJF 2013–2017 and (b) DJF 1999–2018 over YRD. Dotted regions mark statistically significant differences at the 95 % level. Grey shading represents the YRD region.

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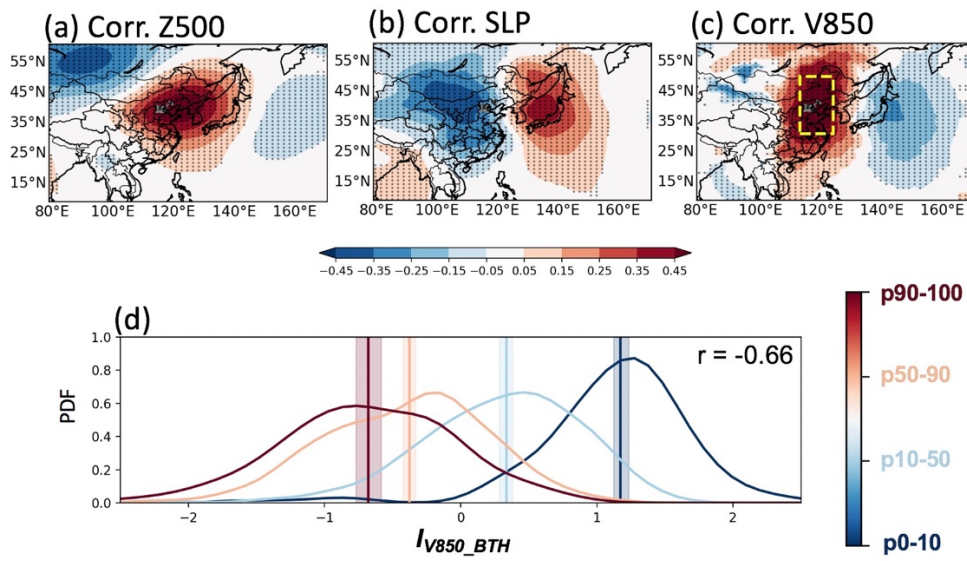
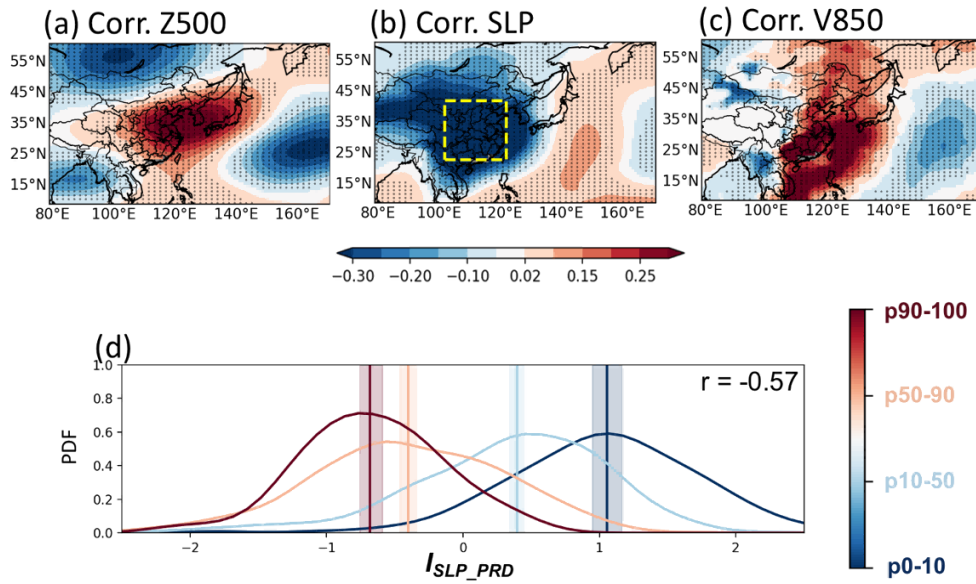


Figure S3: Correlation coefficients of UKESM1-simulated daily PM_{2.5} concentrations in BTH with (a) Z500, (b) SLP and (c) V850 during DJF 1999–2018 (dotted regions indicate significant correlations at the 95% level from a two-tailed Student’s t-test). Grey shading represents the BTH region. The region used for the definition of a circulation-based index for BTH is marked by a yellow rectangle in panel c. (d) As in Figure 7 of the main text, but for the circulation-based index for BTH.

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5 Figure S4: Correlation coefficients of UKESM1-simulated daily PM_{2.5} concentrations in PRD with (a) Z500, (b) SLP and (c) V850 during DJF 1999–2018 (dotted regions indicate significant correlations at the 95% level from a two-tailed Student's *t*-test). Grey shading represents the PRD region. The region used for the definition of a circulation-based index for PRD is marked by a yellow rectangle in panel b. (d) As in Figure 7 of the main text, but for the circulation-based index for PRD.

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Winter mean emission changes of fossil fuel OC from 2014 to SSP3-7.0 2058

Winter mean OM and PM_{2.5} changes due to emission reduction over YRD for DJF 2014-18

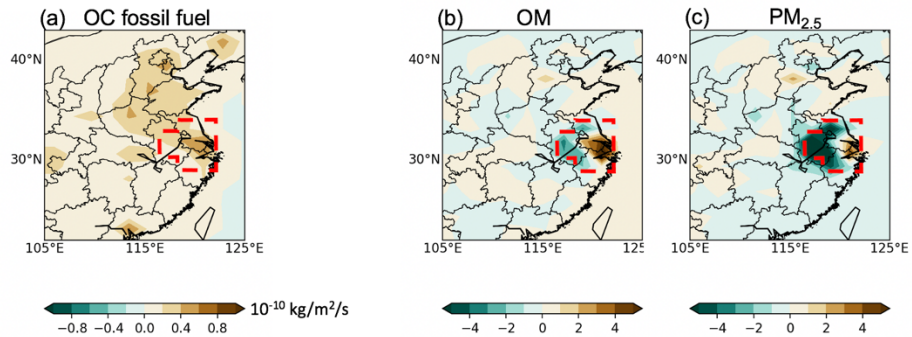


Figure S5: (a) CMIP6 emission changes of organic carbon (OC) from fossil fuel combustion from historical 2014 to SSP3-7.0 2058. Winter mean (b) organic matter (OM) changes ($\mu\text{g}/\text{m}^3$) and (c) PM_{2.5} changes ($\mu\text{g}/\text{m}^3$) during DJF 2014-2018 due to emission reductions over YRD. The red box represents the YRD region.

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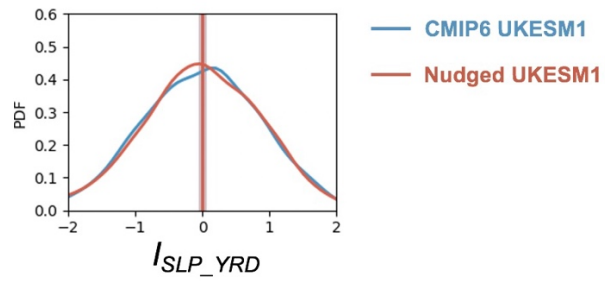


Figure S6: Frequency distributions of daily mean I_{SLP_YRD} during DJF 1999-2014 from nudged UKESM1 and from the UKESM1 historical run in the CMIP6 archive. The vertical lines and shading represent the mean values and the associated 95% confidence intervals, respectively.

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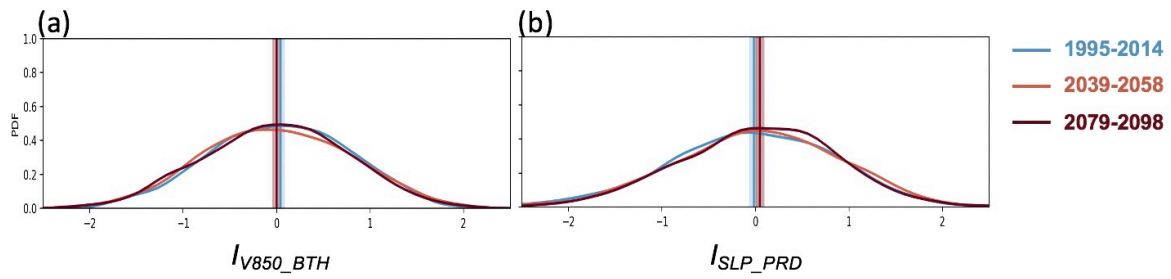


Figure S7: Frequency distributions of daily mean circulation-based indices for (a) BTH and (b) PRD during winter for present day (1995-2014), mid-century (2039-2058) and the end of century (2079-2098).

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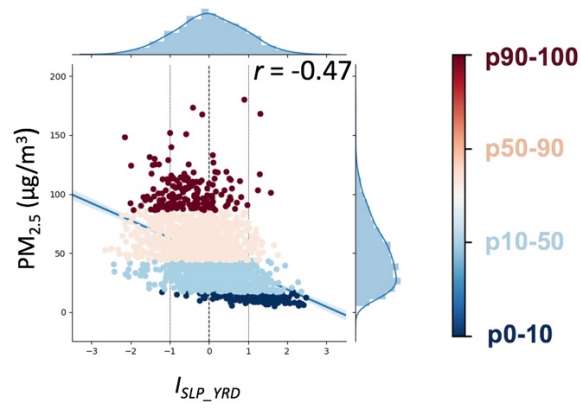


Figure S8: Joint distributions of daily I_{SLP_YRD} against $PM_{2.5}$ concentrations over YRD for different percentile thresholds (colour coded), including the corresponding linear fits with 95 % prediction intervals, during DJF 1999–2018.

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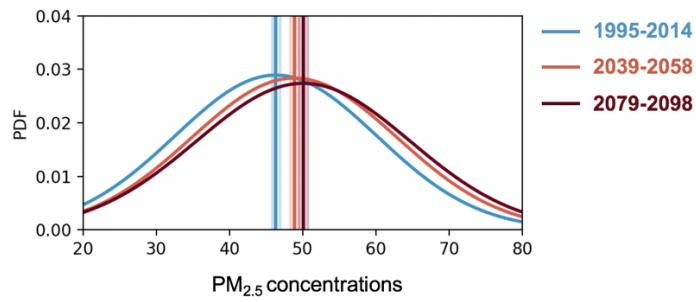


Figure S9: Normal frequency distributions of daily mean climate-driven PM_{2.5} concentrations (µg/m³) over YRD during winter over present day (1995-2014), mid-century (2039-2058) and the end of century (2079-2098). The vertical lines and shading represent the mean values and the associated 95% confidence intervals, respectively.

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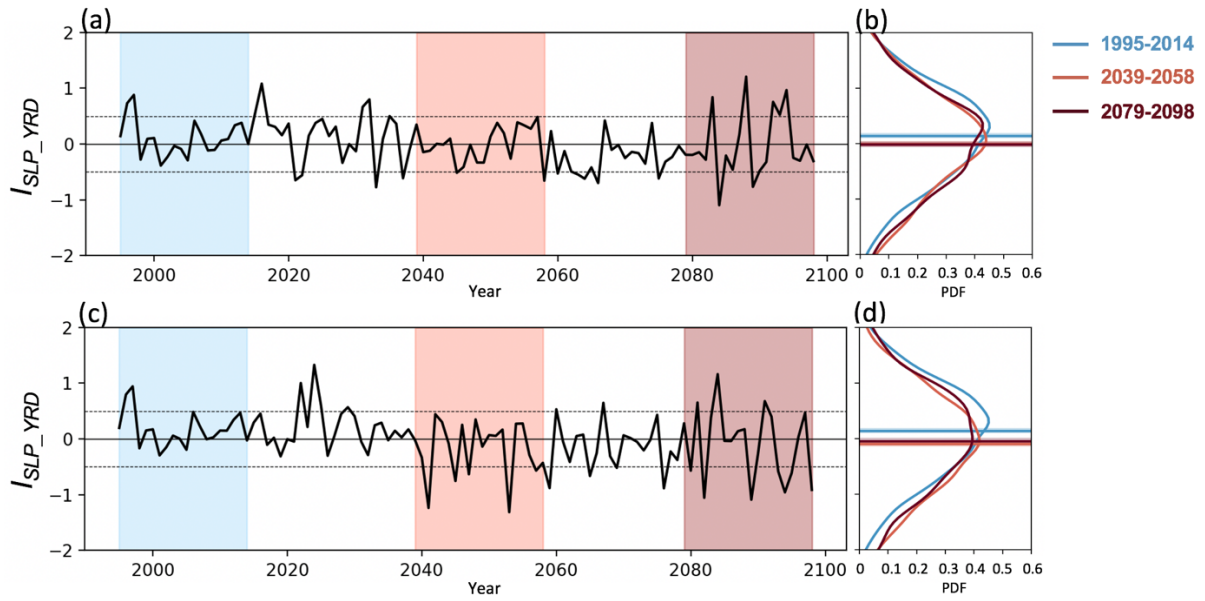


Figure S10: Time series of winter mean I_{SLP_YRD} from historical (1995–2014) and (a) future (2015–2098, SSP1-2.6) simulations, (c) future (2015–2098, SSP2-4.5) simulations of UKESM1 in the CMIP6 archive. Blue, orange and red areas represent present day (1995-2014), mid-century (2039-2058) and the end of century (2079-2098), respectively. (b) (d) Frequency distributions of daily mean I_{SLP_YRD} during winter over each period. The horizontal lines and shading represent the mean values and the associated 95% confidence intervals, respectively.

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Table S1: Winter mean anthropogenic emissions of sulphur dioxide (SO₂), organic carbon (OC) and black carbon (BC) in 2014 (CMIP6 historical) and 2058 (CMIP6, scenario SSP3-7.0) over YRD, north China and south China. The three regions are displayed on Figure 8.

Emissions (Unit: 10 ⁻¹⁰ kg/m ² /s)	YRD		north China		south China	
	2014	2058	2014	2058	2014	2058
SO ₂	6.17	3.18	5.74	2.98	3.13	1.60
OC	0.73	0.77	0.86	0.83	0.37	0.40
BC	0.39	0.35	0.44	0.37	0.18	0.17
Total	7.29	4.30	7.04	4.18	3.68	2.17