

SUPPLEMENTARY INFORMATION

Dry and warm conditions in Australia exacerbated by aerosol reduction in China

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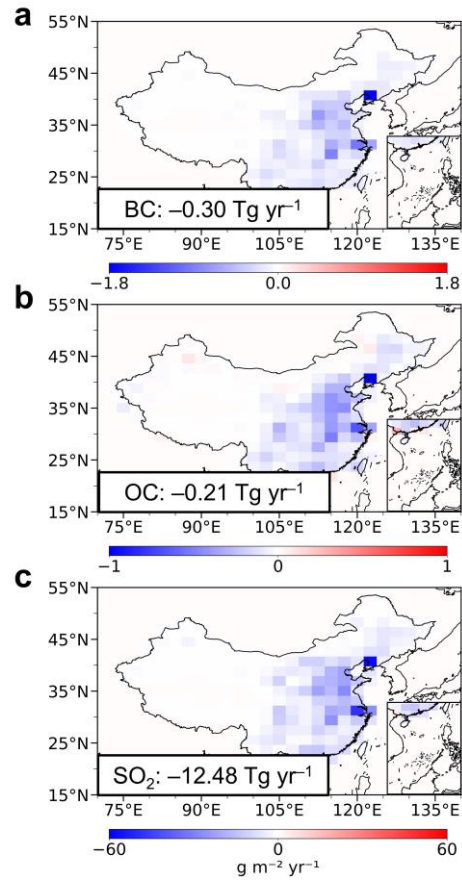
Supplementary Table S1

27 **Table S1: Experimental design.**

Experiments	Anthropogenic Emissions of Aerosols and Precursors	
	China	Other regions of the world
BASE	2013	2013
CHN	2019	2013
OTH	2013	2019
NAEU	2013	North America and Europe: 2019; Other: 2013

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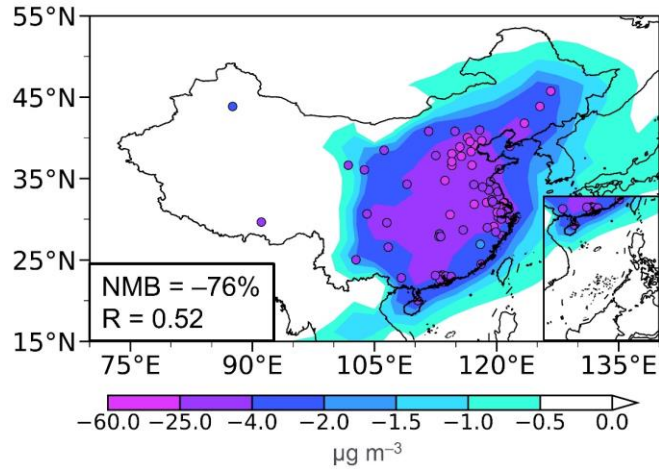
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31 **Figure S1. Differences in anthropogenic emissions of aerosols and precursors between 2013**
 32 **and 2019.** Spatial distributions of differences in anthropogenic emissions (unit: $\text{g m}^{-2} \text{yr}^{-1}$) of
 33 aerosols and precursors, including black carbon (BC, **a**), organic carbon (OC, **b**) and sulfur dioxide
 34 (SO_2 , **c**) between 2013 and 2019 (2019 minus 2013). The total changes in China are noted at the
 35 bottom-left corner of each panel.

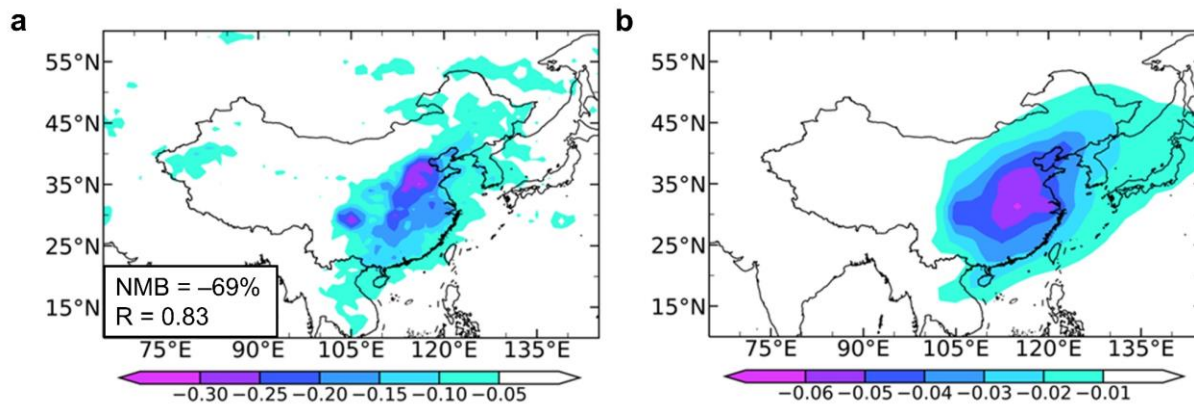
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38 **Figure S2. Comparisons of temporal changes in near-surface PM_{2.5} concentrations between**
 39 **observation and model simulation.** Spatial distributions of observed (circles) and modeled
 40 (shades) annual mean changes (2017–2019 minus 2013–2015) in near-surface PM_{2.5} concentration
 41 (unit: µg m⁻³). Normalized mean bias (NMB) and correlation coefficient (R) between observation
 42 and simulation are shown at the bottom-left corner of each panel. $NMB = 100 \% \times \sum (Model_i -$
 43 $Observation_i) / \sum Observation_i$, where $Model_i$ and $Observation_i$ are the modeled and observed
 44 values at site i , respectively.

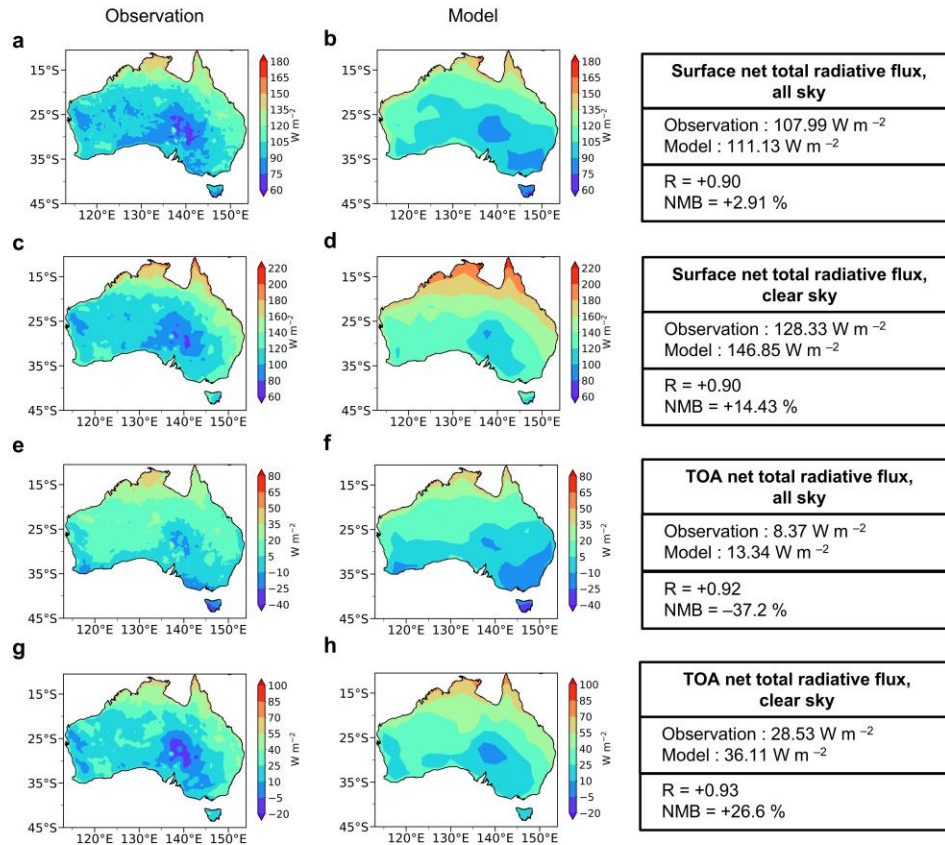
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47 **Figure S3. Comparisons of temporal changes in aerosol optical depth (AOD) between**
 48 **satellite retrieval and model simulation.** Spatial distributions of annual mean changes (2017–
 49 2019 minus 2013–2015) in Moderate Resolution Imaging Spectroradiometer (MODIS) (a) and
 50 modeled (b) AOD (unitless). Normalized mean bias (NMB) and correlation coefficient (R)
 51 between modeled AOD and MODIS AOD are shown at the bottom-left corner of panel a. NMB
 52 $= 100 \% \times \sum (AOD-model_i - AOD-MODIS_i) / \sum AOD-MODIS_i$, where $AOD-model_i$ and $AOD-$
 53 $MODIS_i$ are the modeled and MODIS AOD values at grid i , respectively.

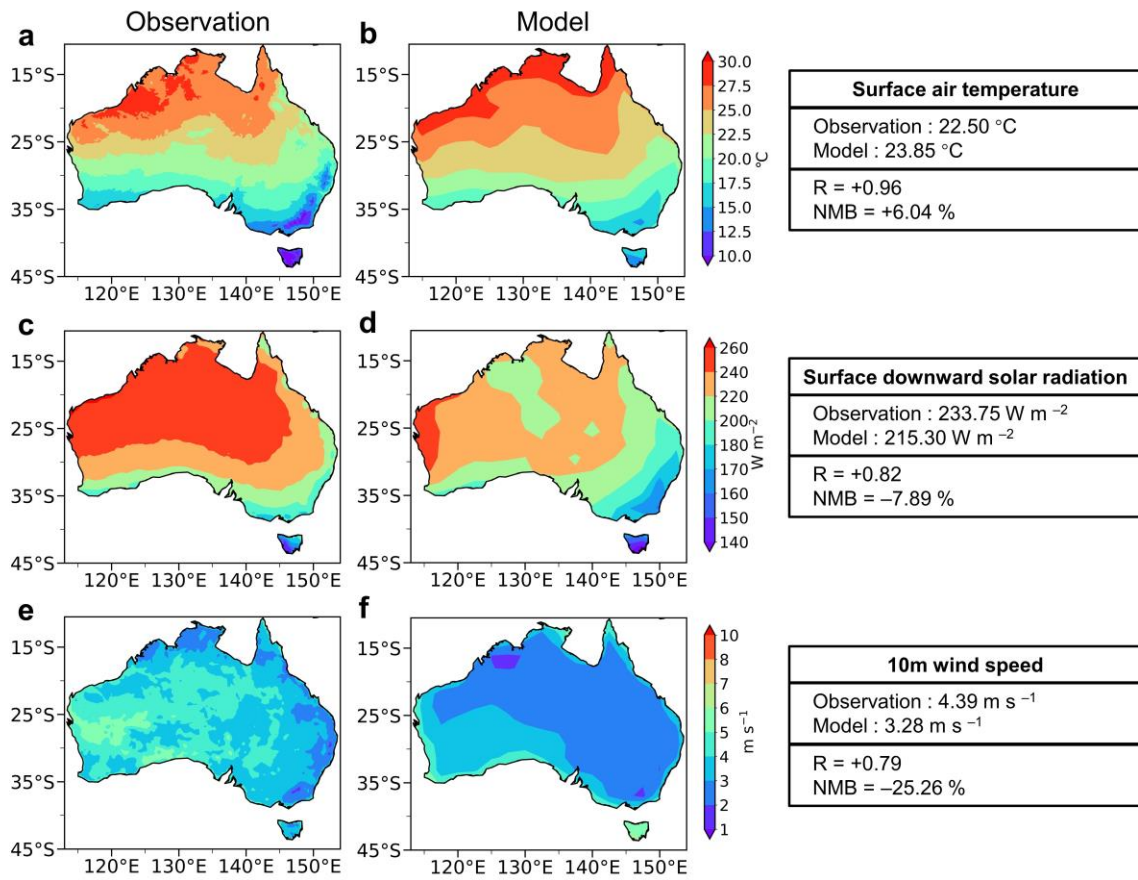
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56 **Figure S4. Comparisons of surface and TOA net total radiative flux under all sky and clear**
 57 **sky conditions between observation and model simulation.** Spatial distributions of surface (a–
 58 **d)** and TOA (e–h) net total radiative flux (unit: W m⁻²) under all sky (a, b, e, and f) and clear sky
 59 (c, d, g, and h) conditions over Australia in observation (2010–2019 annual averages from ERA5,
 60 a, c, e, and g) and model simulation (annual averages from the BASE experiment, b, d, f, and h).
 61 Regional averages over Australia in observation and model simulation and normalized mean bias
 62 (NMB) and correlation coefficient (R) between observation and model simulation are shown in
 63 the right boxes.

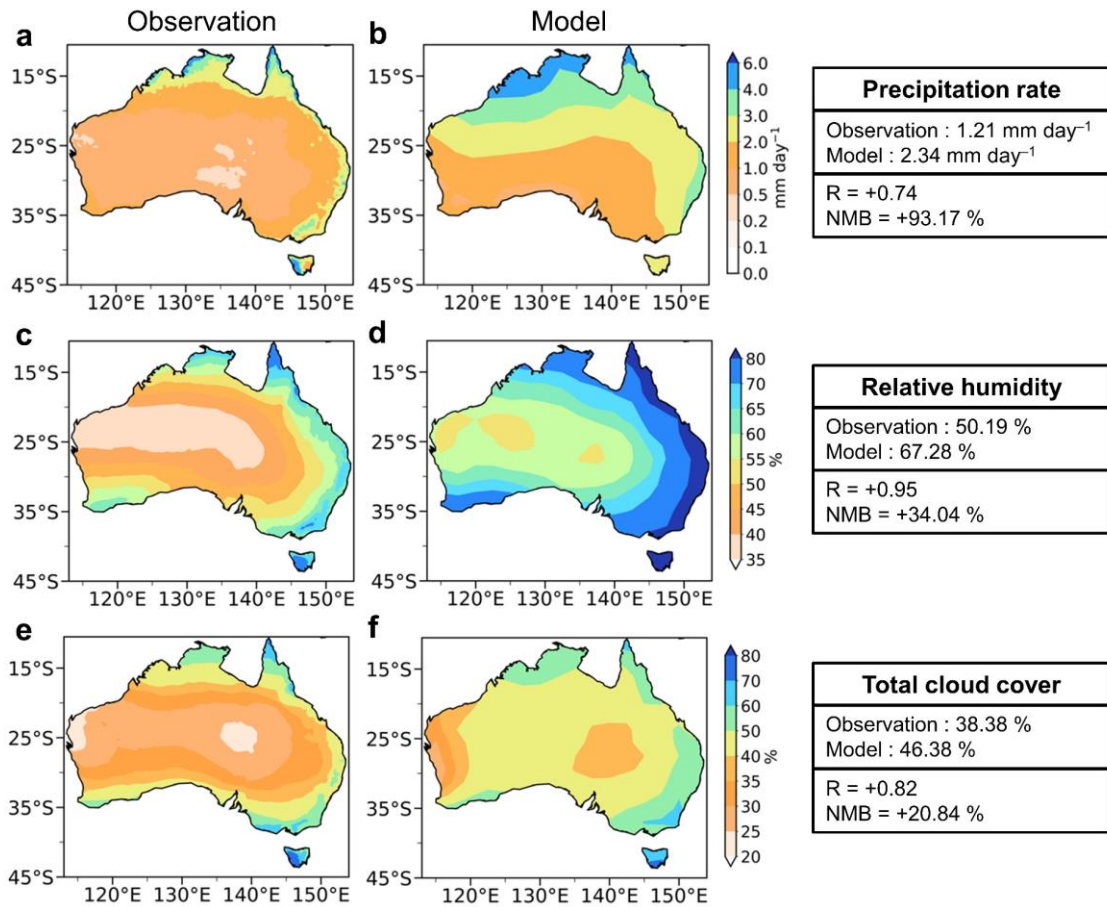
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66 **Figure S5. Comparisons of surface air temperature, surface downward solar radiation, and**
 67 **10m wind speed between observation and model simulation. Same as Figure S4, but for surface**
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 69 **10m wind speed (e and f, unit: m s⁻¹).**

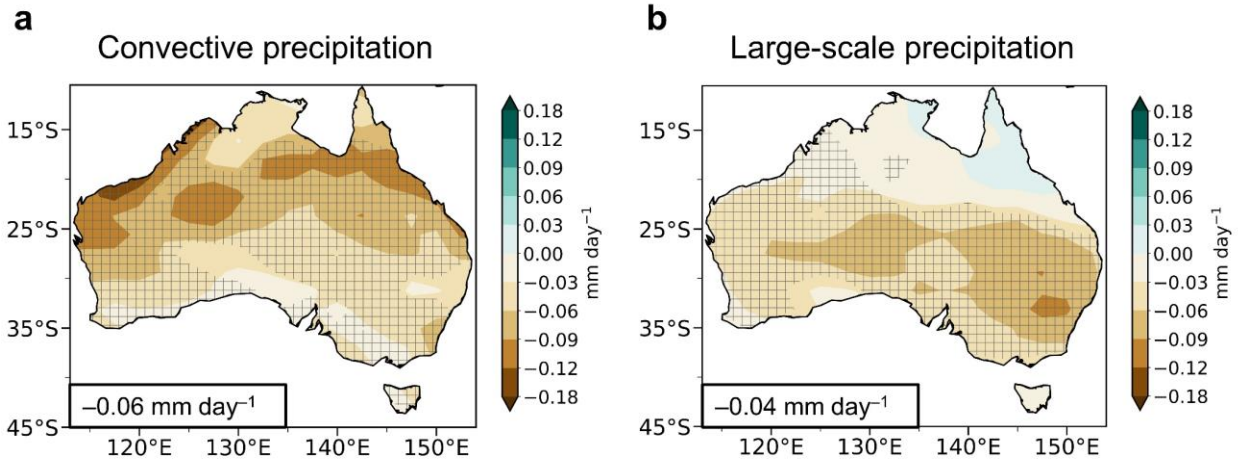
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72 **Figure S6. Comparisons of precipitation rate, relative humidity and total cloud cover**
 73 **between observation and model simulation. Same as Figure S4, but for precipitation rate (a and**
 74 **b, unit: mm day⁻¹), relative humidity (c and d, unit: %), and total cloud cover (e and f, unit: %).**

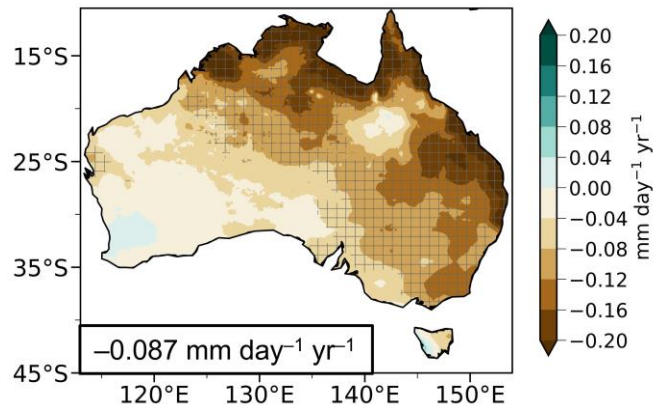
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 78 **due to aerosol changes in China between 2013 and 2019.** Spatial distributions of simulated
 79 differences in annual mean convective (a) and large-scale (b) precipitation rate (unit: mm day⁻¹)
 80 in Australia between BASE and CHN (CHN minus BASE). The shaded areas indicate results are
 81 statistically significant at the 90% confidence level. Regional averages of the responses over
 82 Australia are noted at the bottom-left corner of each panel.

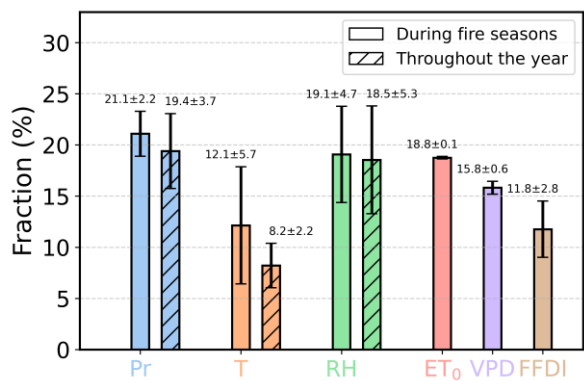
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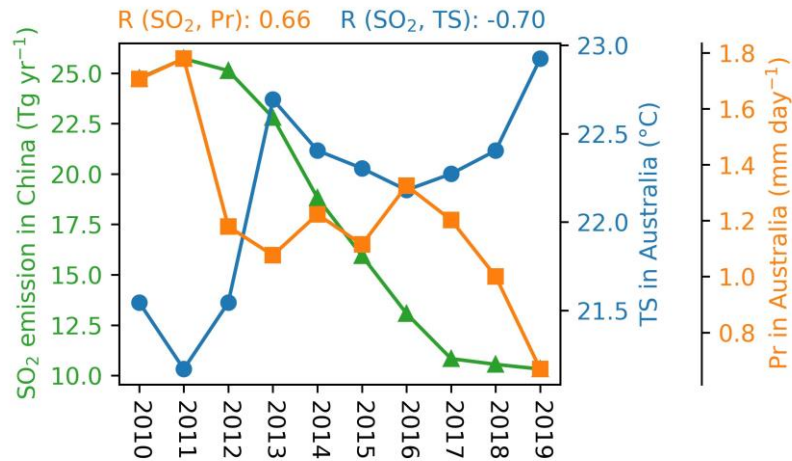
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 87 during 2010–2019 from GPM. The shaded areas indicate trends are statistically significant at the
 88 90% confidence level. Regional averages over Australia are noted at the bottom-left corner of the
 89 panel.

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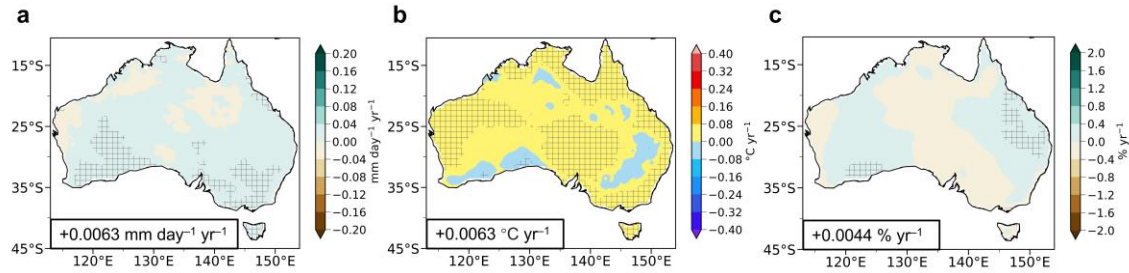
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 95 relative humidity [RH]) during fire seasons and throughout the year and wildfire risk indices
 96 (reference potential evapotranspiration [ET₀], vapor pressure deficit [VPD], and McArthur forest
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 98 represents the standard deviation of 3-ensemble members.
 99



100

101 **Figure S10. Time series of anthropogenic SO₂ emission in China alongside surface air**
 102 **temperature and precipitation rate averaged over Australia.** SO₂ emission (unit: Tg yr⁻¹) data
 103 are sourced from CEDS, while surface air temperature (unit: °C) and precipitation rate (unit: mm
 104 day⁻¹) data are derived from ERA5. Correlations between SO₂ emission in China and surface air
 105 temperature averaged over Australia, as well as between SO₂ emission in China and precipitation
 106 rate averaged over Australia, are indicated above the figure.

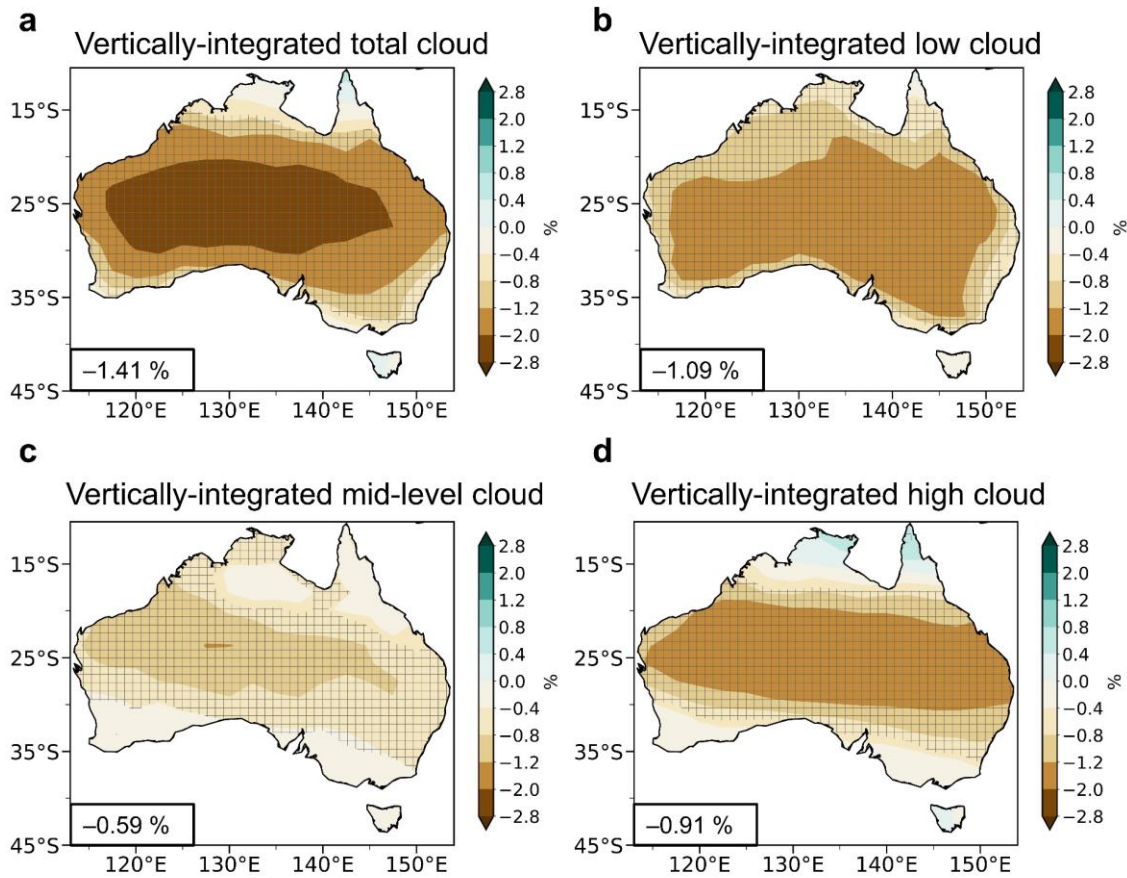
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 110 **relative humidity in Australia during 1940–2019 based on ERA5.** Spatial distributions of linear
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 113 The shaded areas indicate trends are statistically significant at the 90% confidence level. Regional
 114 averages over Australia are noted at the bottom-left corner of each panel.

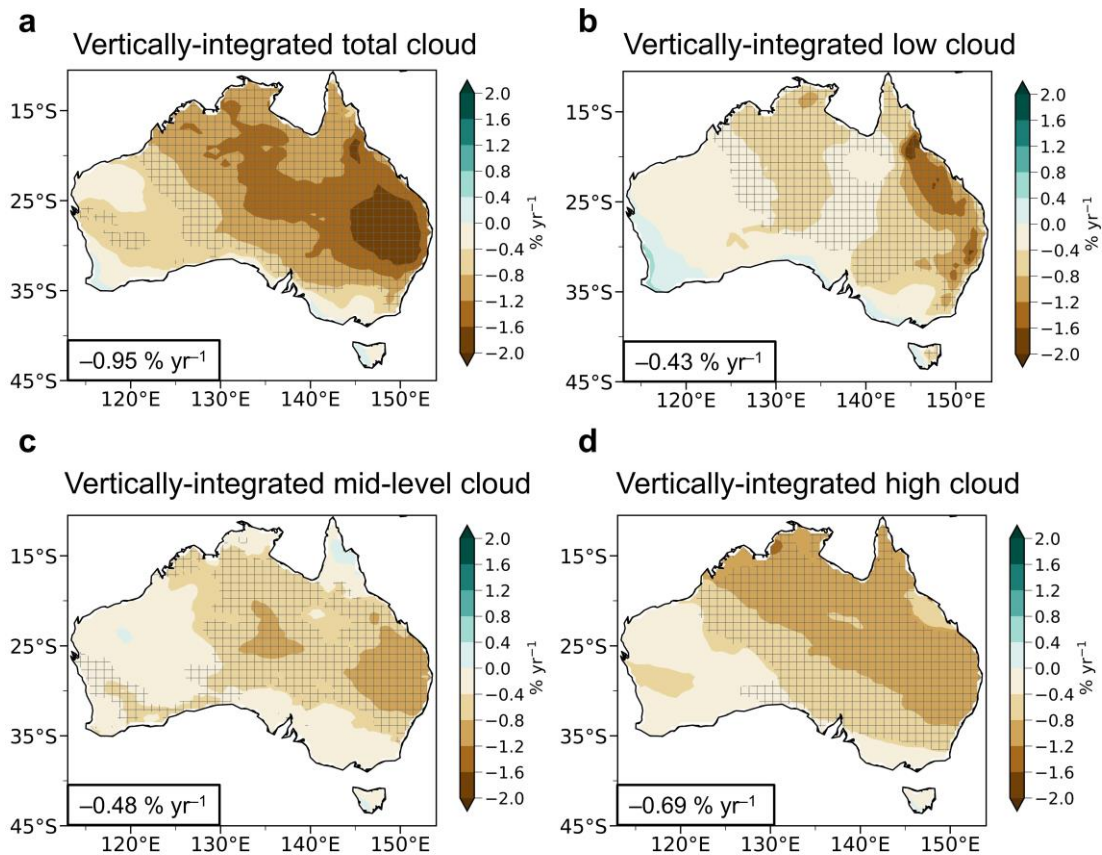
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117 **Figure S12. Changes in vertically-integrated total, low, mid-level, and high cloud cover in**
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 119 simulated differences in annual mean vertically-integrated total (a), low (b), mid-level (c), and
 120 high (d) cloud cover (unit: %) in Australia between BASE and CHN (CHN minus BASE). The
 121 shaded areas indicate results are statistically significant at the 90% confidence level. Regional
 122 averages of the responses over Australia are noted at the bottom-left corner of each panel.

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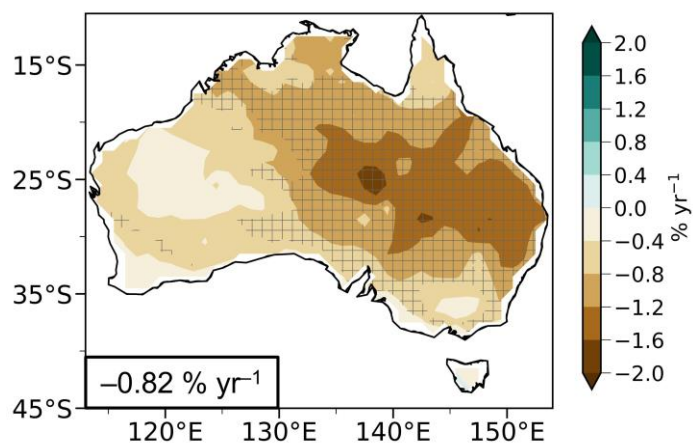


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 126 **cloud cover in Australia based on ERA5.** Spatial distributions of linear trends in annual mean
 127 vertically-integrated total (a), low (b), mid-level (c), and high (d) cloud cover (unit: % yr⁻¹) in
 128 Australia during 2010–2019 from ERA5. The shaded areas indicate trends are statistically
 129 significant at the 90% confidence level. Regional averages over Australia are noted at the bottom-
 130 left corner of each panel.

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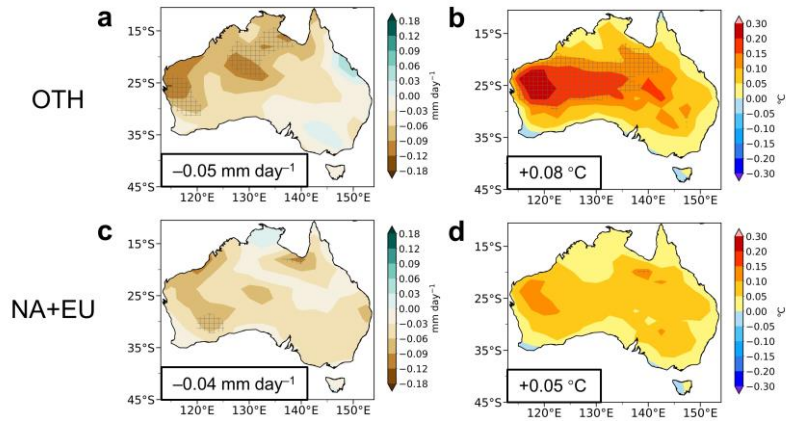


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134 **Figure S14. Linear trends of observed total cloud cover in Australia based on CERES-EBAF.**

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 136 yr⁻¹) in Australia during 2010–2019 from CERES-EBAF. The shaded areas indicate trends are
 137 statistically significant at the 90% confidence level. Regional averages over Australia are noted at
 138 the bottom-left corner of the figure.

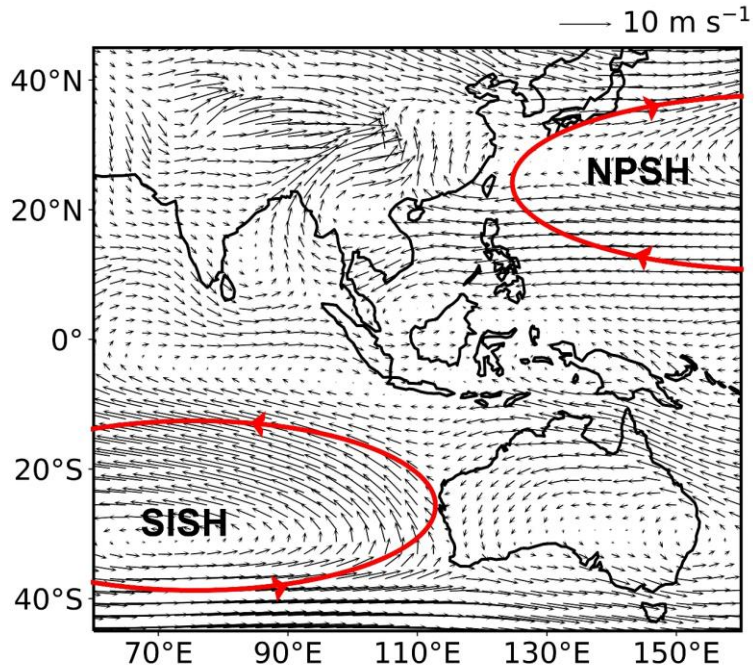
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141 **Figure S15. Simulated changes in precipitation rate and surface air temperature in Australia**
 142 **due to aerosol changes in different regions between 2013 and 2019.** Spatial distributions of
 143 simulated differences in annual mean precipitation rate (**a** and **c**, unit: mm day^{-1}) and surface air
 144 temperature (**b** and **d**, unit: $^{\circ}\text{C}$) in Australia between BASE and OTH (OTH minus BASE, **a** and
 145 **b**), and between BASE and NAEU (NAEU minus BASE, **c** and **d**). The shaded areas indicate
 146 results are statistically significant at the 90% confidence level. The regional averages over
 147 Australia is noted at the bottom-left corner of each panel.

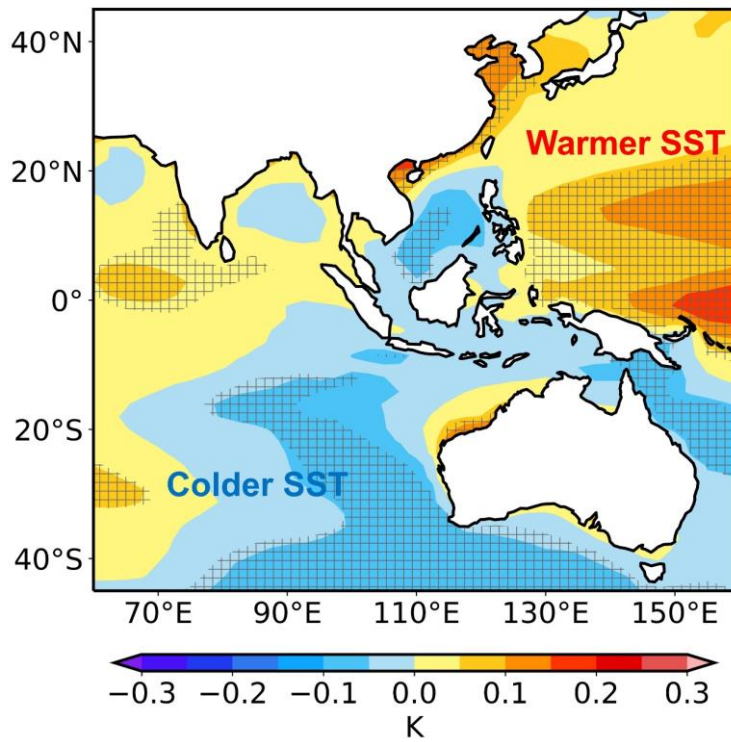
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150 **Figure S16. Climatological mean wind fields at 850 hPa.** Climatological mean wind fields (unit:
 151 m s⁻¹, vectors) at 850 hPa from the BASE experiment. NPSH and SISH shown in red circles
 152 represents North Pacific Subtropical High and Southern Indian ocean Subtropical High,
 153 respectively.

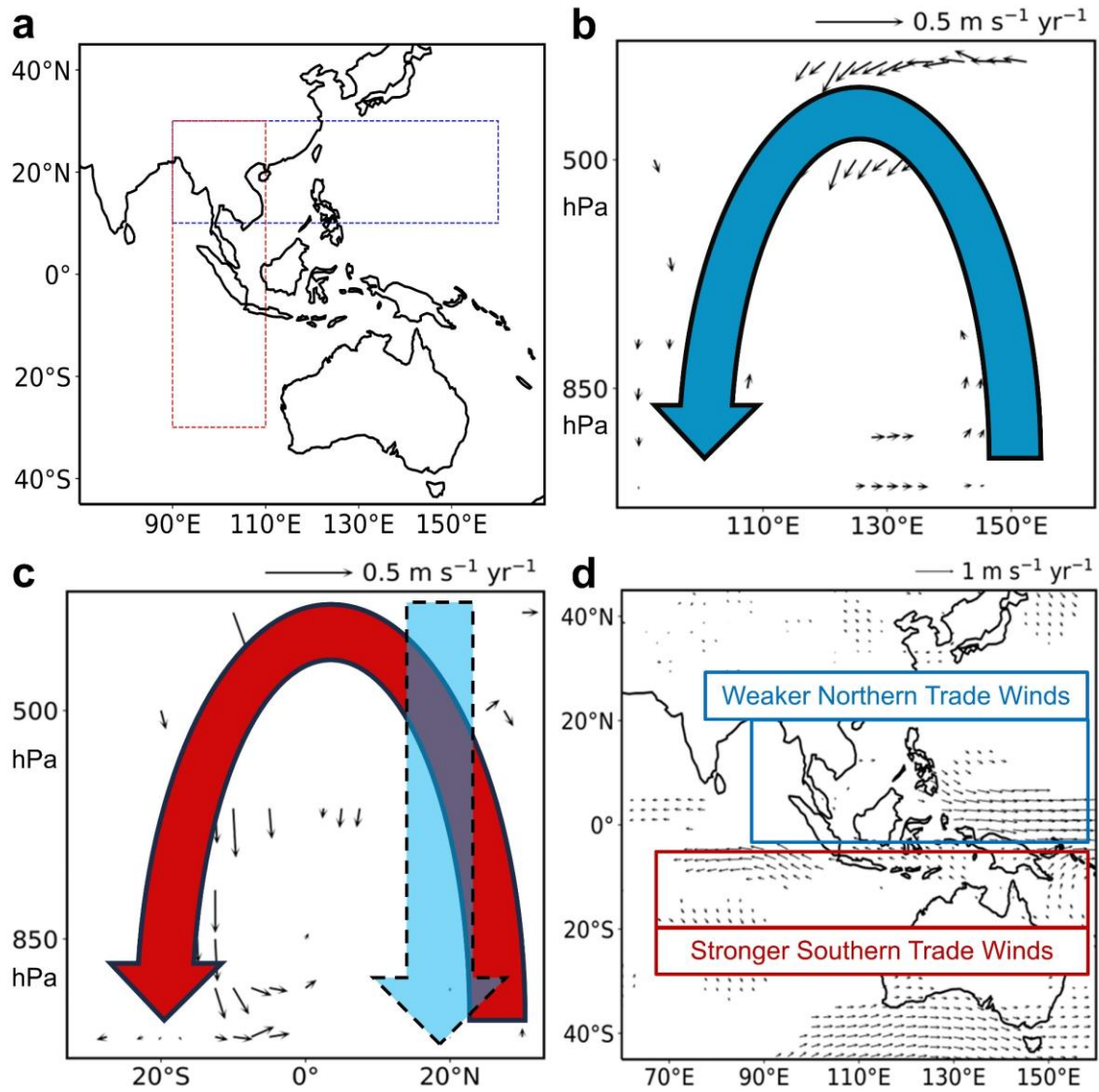
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156 **Figure S17. Simulated sea surface temperature changes due to aerosol changes in China**
 157 **between 2013 and 2019.** Spatial distributions of simulated differences in annual mean sea surface
 158 temperature (SST, unit: mm day^{-1}) in Australia between BASE and CHN (CHN minus BASE).
 159 The shaded areas indicate results are statistically significant at the 90% confidence level.

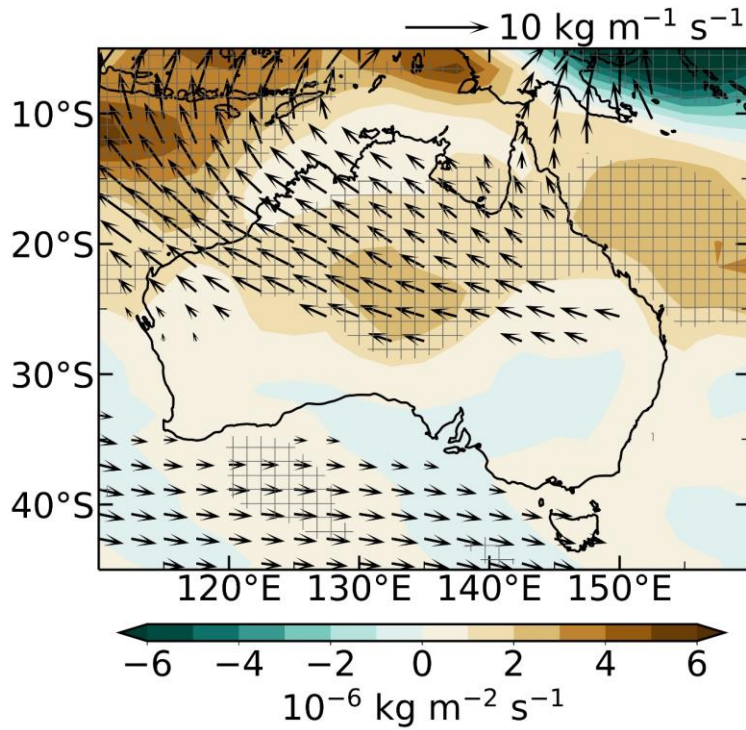
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162 **Figure S18. Linear trends in observed vertical circulations and 850 hPa wind fields in Asia-**
 163 **Pacific regions.** Panel **b** and **c** shows pressure–longitude and latitude cross-section of linear trends
 164 in annual mean atmospheric circulations (unit: m s^{-1} , vectors) over areas marked with the blue and
 165 red box in panel **a** during 2010–2019 from ERA5. Panel **d** shows linear trends of wind fields (unit:
 166 m s^{-1} , vectors) at 850 hPa in Asia-Pacific regions. Only trends of atmospheric circulations and
 167 winds which are statistically significant at the 90% confidence level are shown.

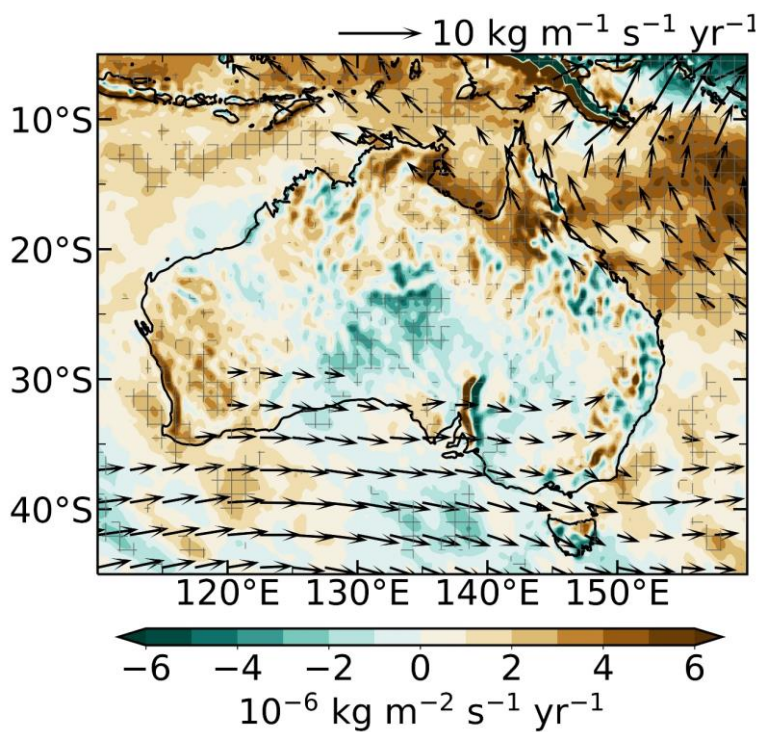
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170 **Figure S19. Simulated changes in vertically-integrated moisture flux and its divergence in**
 171 **Australia due to aerosol changes in China between 2013 and 2019.** Spatial distributions of
 172 simulated differences in annual mean vertically integrated moisture flux (unit: $\text{kg m}^{-1} \text{s}^{-1}$, vectors)
 173 and its divergence (unit: $\text{kg m}^{-2} \text{s}^{-1}$, shades) in Australia between BASE and CHN (CHN minus
 174 BASE). Only moisture fluxes which are statistically significant at the 90% confidence level are
 175 shown. The shaded areas indicate divergences are statistically significant at the 90% confidence
 176 level.

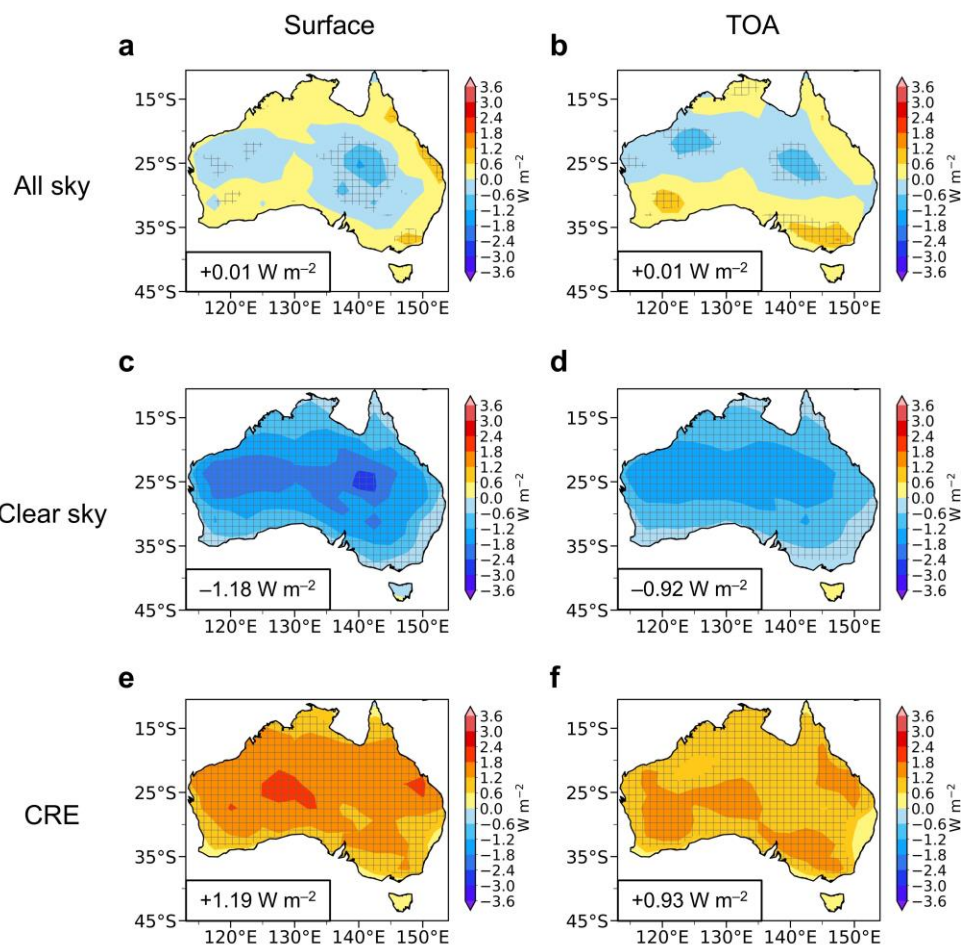
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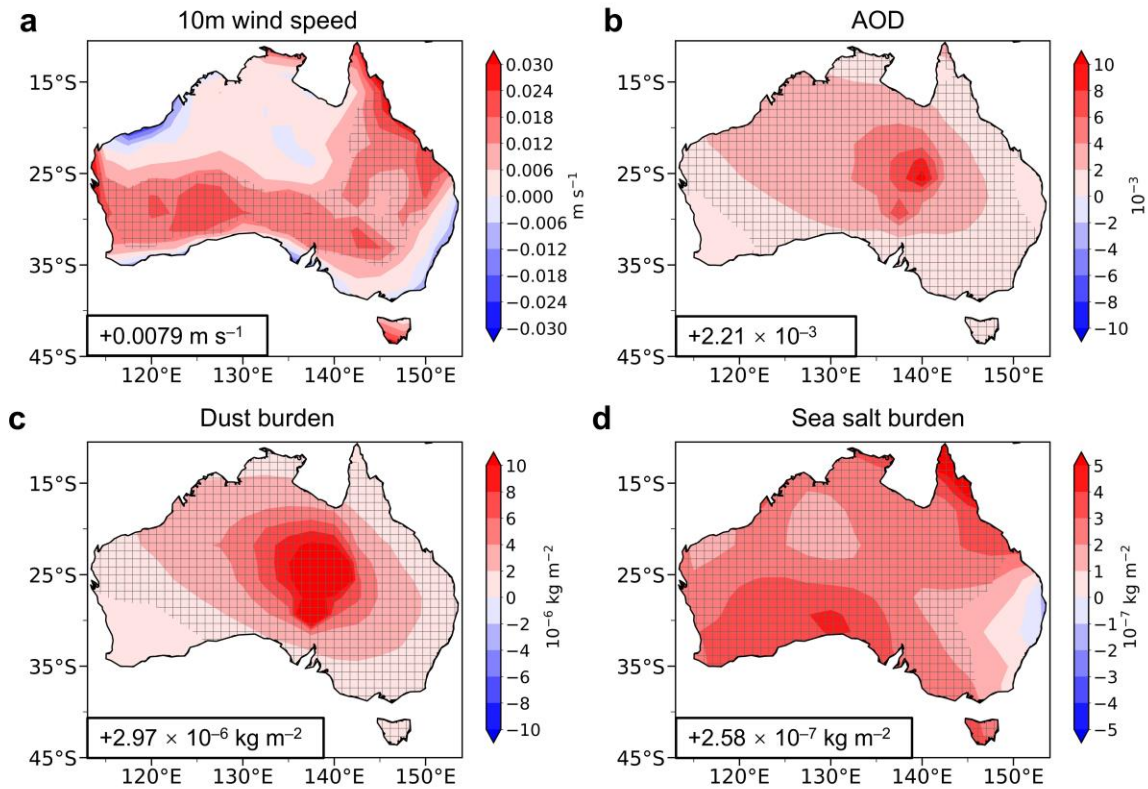
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179 **Figure S20. Linear trends in vertically integrated moisture flux and its divergence in**
 180 **Australia during 2010–2019.** Linear trends in annual mean vertically integrated moisture flux
 181 (unit: kg m⁻¹ s⁻¹ yr⁻¹, vectors) and its divergence (unit: kg m⁻² s⁻¹ yr⁻¹, shades) in Australia during
 182 2010–2019 from ERA5. Only trends of moisture fluxes which are statistically significant at the
 183 90% confidence level are shown. The shaded areas indicate trends of the divergences are
 184 statistically significant at the 90% confidence level.

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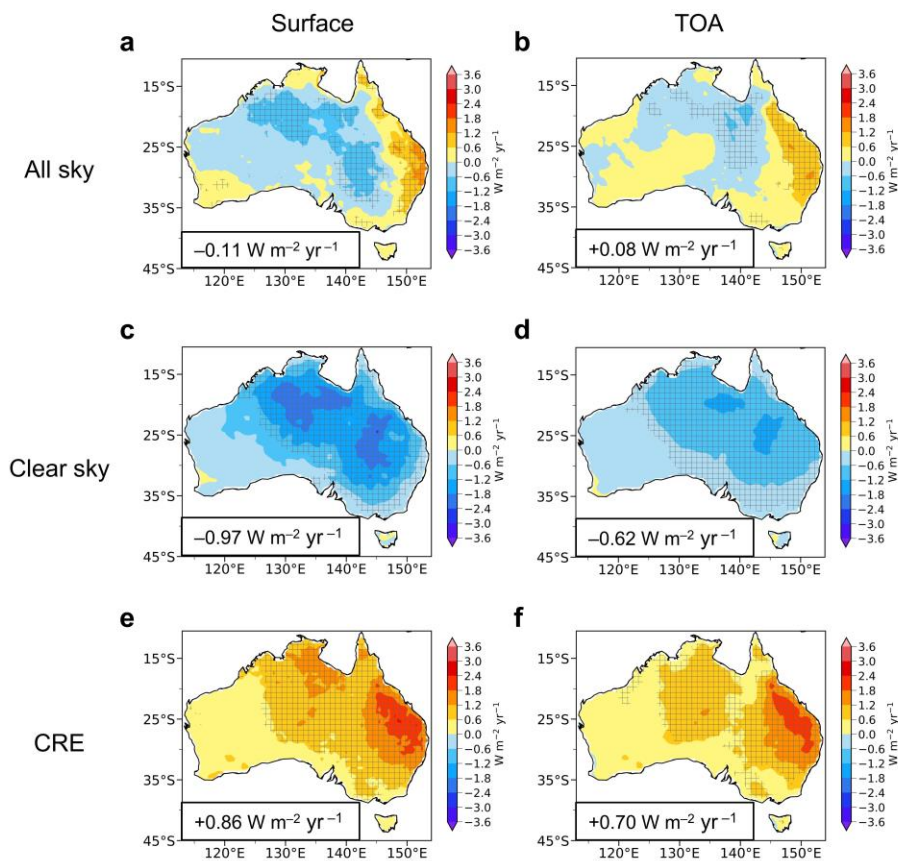
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 187 **Figure S21. Simulated changes in surface and Top of the Atmosphere (TOA) net total**
 188 **radiative flux under all sky conditions, under clear sky conditions, and from cloud radiative**
 189 **effects in Australia due to aerosol changes in China between 2013 and 2019.** Spatial
 190 distributions of simulated differences in annual mean surface (a, c, and e) and Top of the
 191 Atmosphere (TOA, b, d, and f) net total radiative flux (unit: $W m^{-2}$) under all sky conditions (a
 192 and b), under clear sky conditions (c and d), and from cloud radiative effects (CRE, e and f) in
 193 Australia between BASE and CHN (CHN minus BASE). Cloud radiative effects refer to
 194 differences under all sky and clear sky conditions (All sky minus Clear sky). The shaded areas
 195 indicate results are statistically significant at the 90% confidence level. Regional averages of the
 196 responses over Australia are noted at the bottom-left corner of each panel.
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199 **Figure S22. Simulated changes in 10m wind speed, AOD, dust burden, and sea salt burden**
 200 **in Australia due to aerosol changes in China between 2013 and 2019.** Spatial distributions of
 201 simulated differences in annual mean 10m wind speed (**a**, unit: m s^{-1}), AOD (**b**, unitless), dust
 202 burden (**c**, unit: kg m^{-2}), and sea salt burden (**d**, unit: kg m^{-2}) in Australia between BASE and CHN
 203 (CHN minus BASE). The shaded areas indicate results are statistically significant at the 90%
 204 confidence level. Regional averages of the responses over Australia are noted at the bottom-left
 205 corner of each panel.

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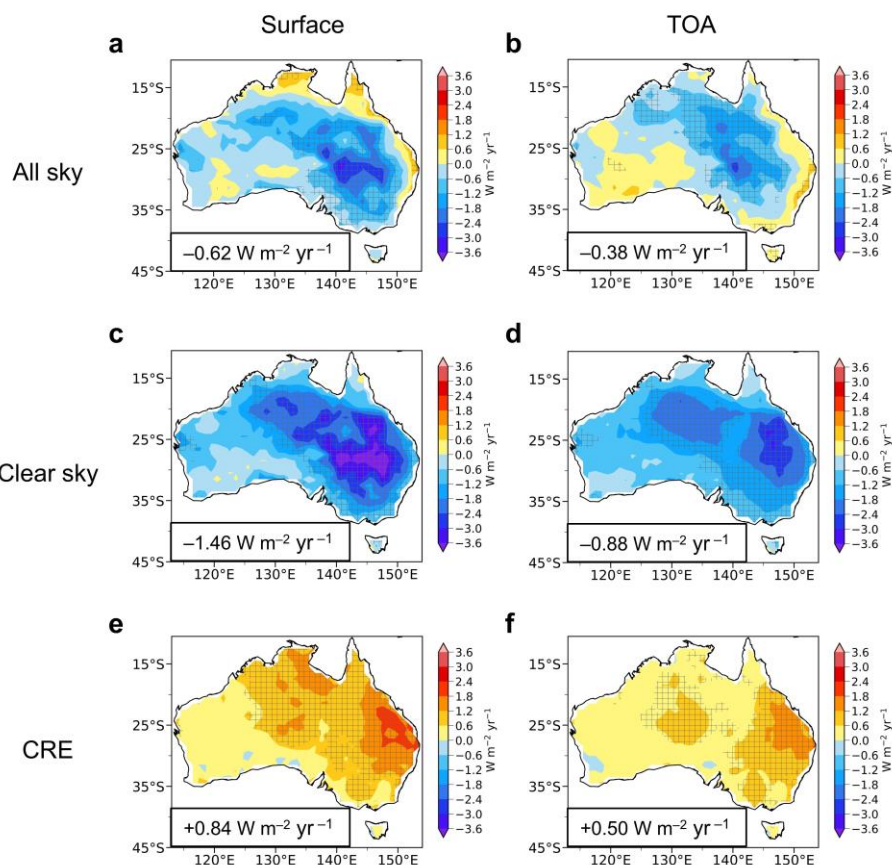


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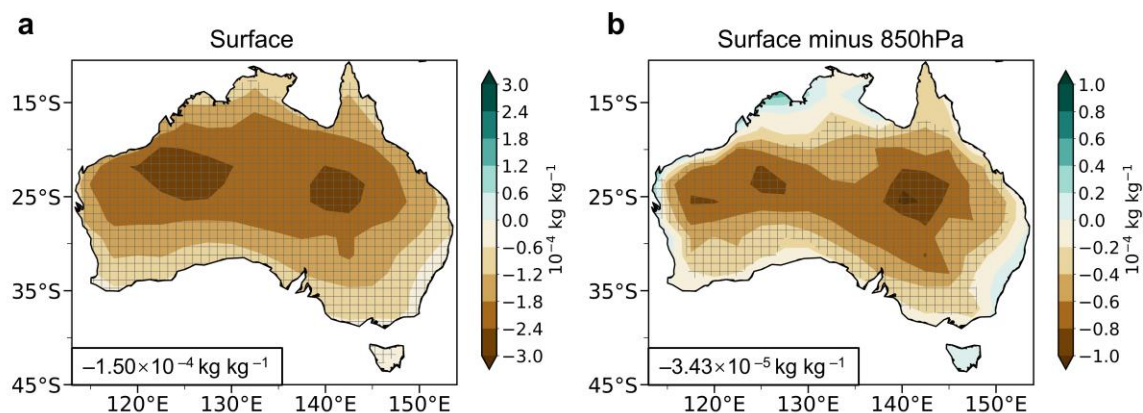
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 209 **radiative flux under all sky conditions, under clear sky conditions, and from cloud radiative**
 210 **effects in Australia based on ERA5. Spatial distributions of linear trends of annual mean surface**
 211 **(a, c, and e) and Top of the Atmosphere (TOA, b, d, and f) net total radiative flux (unit: $\text{W m}^{-2} \text{ yr}^{-1}$)**
 212 **under all sky conditions (a and b), under clear sky conditions (c and d), and from cloud radiative**
 213 **effects (CRE, e and f) in Australia during 2010–2019 from ERA5. Cloud radiative effects refer to**
 214 **differences under all sky and clear sky conditions (All sky minus Clear sky). The shaded areas**
 215 **indicate trends are statistically significant at the 90% confidence level. Regional averages over**
 216 **Australia are noted at the bottom-left corner of panels.**

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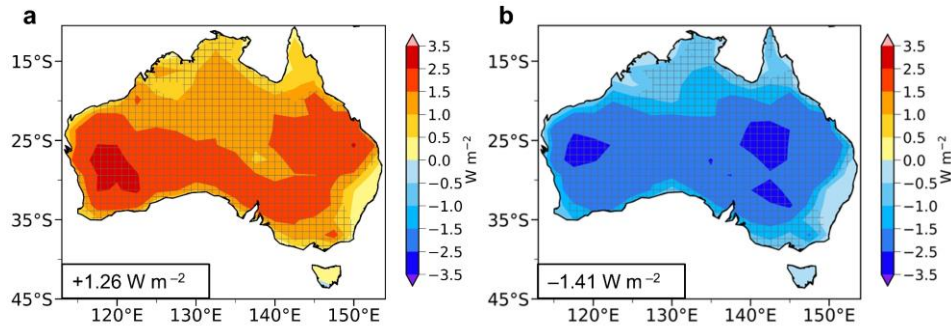


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 221 **radiative flux under all sky conditions, under clear sky conditions, and from radiative**
 222 **effects in Australia based on CERES-EBAF.** Spatial distributions of linear trends of annual
 223 mean surface (a, c, and e) and Top of the Atmosphere (TOA, b, d, and f) net total radiative flux
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 225 from cloud radiative effects (CRE, e and f) in Australia during 2010–2019 from CERES-EBAF.
 226 Cloud radiative effects refer to differences under all sky and clear sky conditions (All sky minus
 227 Clear sky). The shaded areas indicate trends are statistically significant at the 90% confidence level.
 228 Regional averages over Australia are noted at the bottom-left corner of panels.
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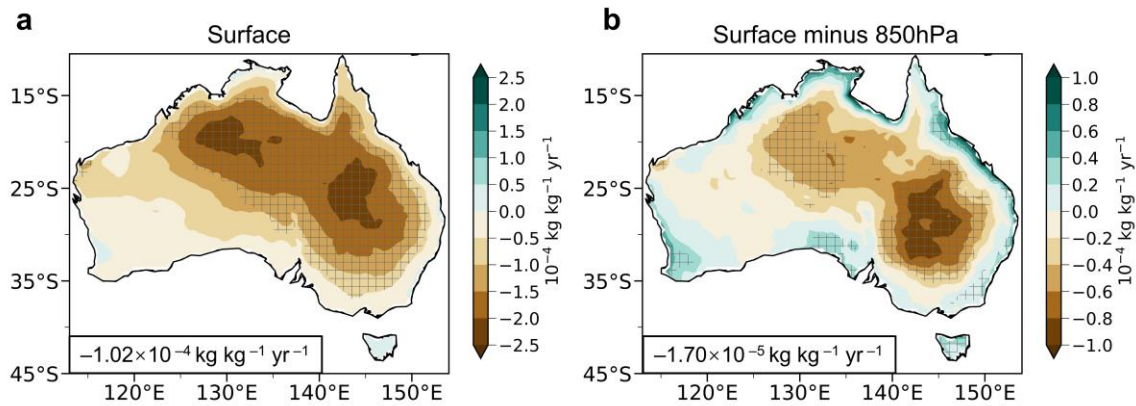
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 235 850 hPa, unit: kg kg^{-1}) in Australia between BASE and CHN (CHN minus BASE). The shaded
 236 areas indicate results are statistically significant at the 90% confidence level. Regional averages
 237 over Australia are noted at the bottom-left corner of each panel.
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239

240 **Figure S26. Simulated changes in surface upward sensible and latent heat flux in Australia**
 241 **due to aerosol changes in China between 2013 and 2019.** Spatial distributions of simulated
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 243 Australia between BASE and CHN (CHN minus BASE). The shaded areas indicate results are
 244 statistically significant at the 90% confidence level. Regional averages over Australia are noted at
 245 the bottom-left corner of each panel.

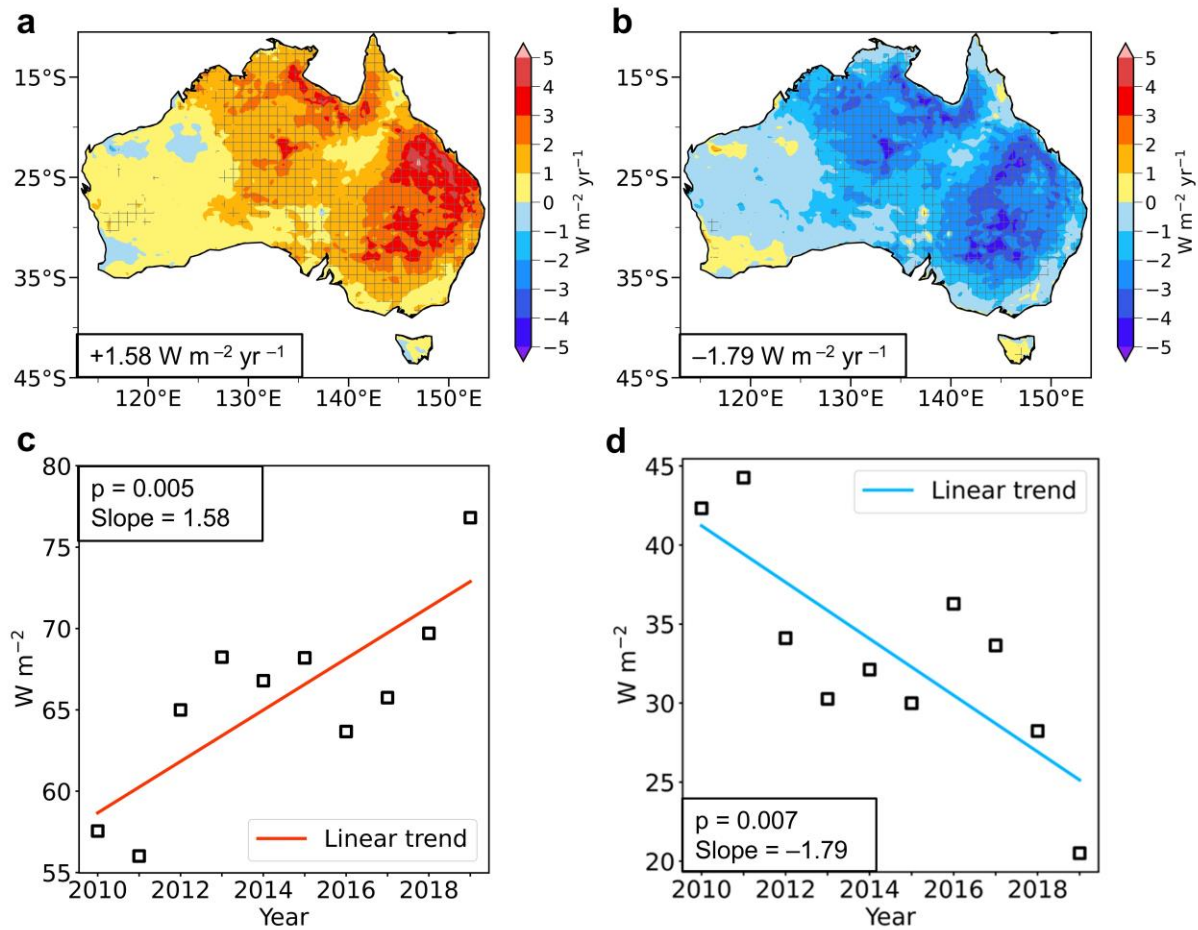
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248 **Figure S27. Linear trends of observed surface specific humidity and specific humidity**
 249 **differences between surface and near-surface air in Australia.** Spatial distributions of linear
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 252 Australia during 2010–2019 from ERA5. The shaded areas indicate trends are statistically
 253 significant at the 90% confidence level. Regional averages over Australia are noted at the bottom-
 254 left corner of each panel.

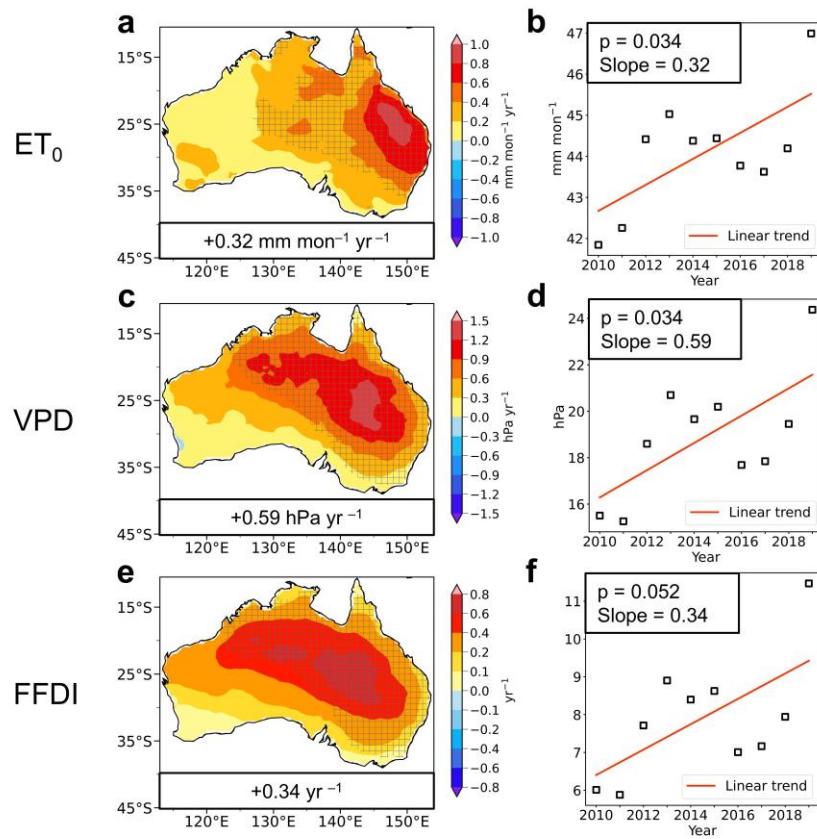
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 258 **during 2010–2019.** Spatial distributions of linear trends (a and b) and time series (c and d) of
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 261 significant at the 90% confidence level. Regional averages over Australia are noted at the bottom-
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 263 and d.

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266 **Figure S29. Linear trends of reference potential evapotranspiration, vapor pressure deficit,**
 267 **and McArthur forest fire danger index during fire seasons in Australia.** Spatial distributions
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 271 the February of the next year) in Australia during 2010–2019 from ERA5. The shaded areas
 272 indicate trends are statistically significant at the 90% confidence level. Regional averages over
 273 Australia are noted at the bottom of panels a, c, and e. The p values and slopes of these linear
 274 trends are noted in panels b, d, and f.