

1 Supplementary Material for

2 **“Separating atmospheric and ocean-mediated impacts of time-evolving**
3 **industrial and biomass burning aerosols on historical boreal summer**
4 **climate”**

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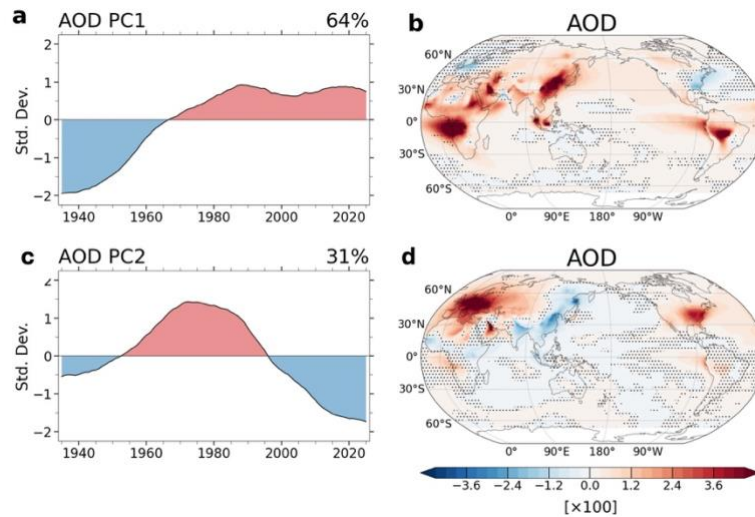
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19 This document contains 7 Figures.

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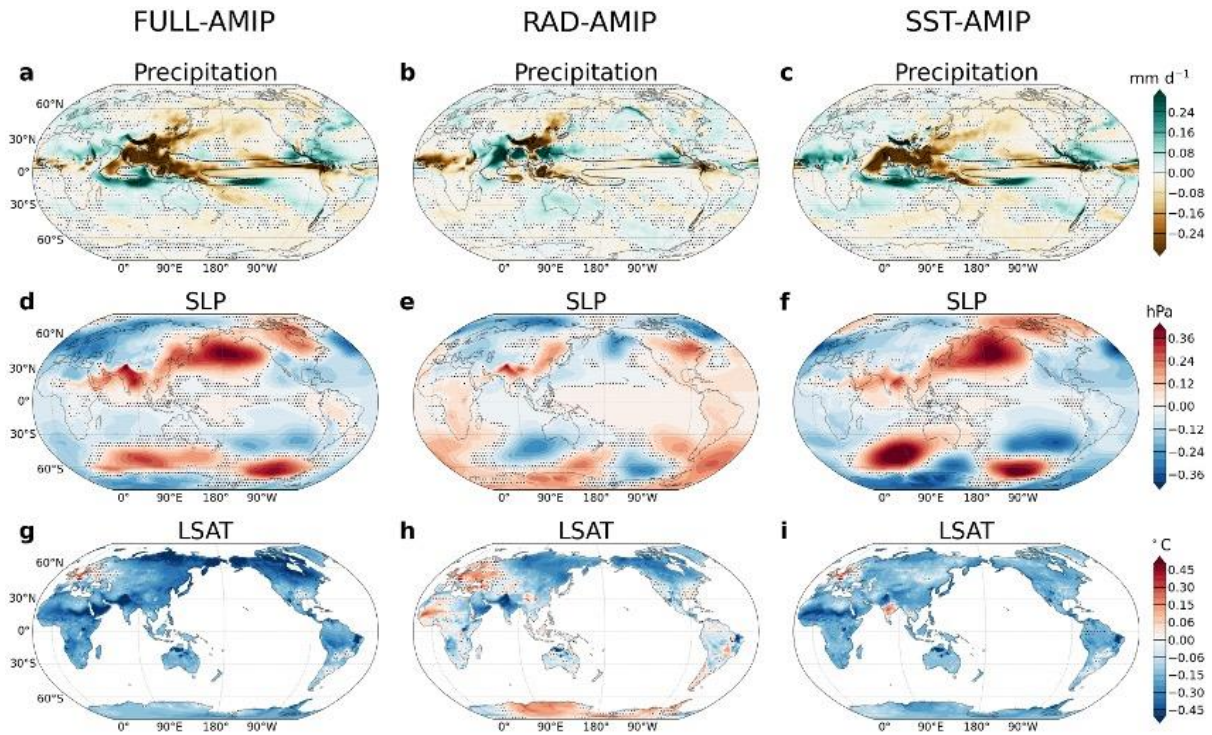
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22 **Figure S1.** (a,c) Principal Component (PC) time series of 10-year low-pass filtered Aerosol Optical Depth
 23 (AOD) in JJA based on RAD-AMIP. Percent variance explained by Modes 1 and 2 (PC1 and PC2) are given
 24 in the upper right. (b,d) Regression of JJA AOD ($\times 100$) in RAD-AMIP onto AOD PC1 and PC2. Statistical
 25 significance of all regression values is assessed using a two-tailed Student's t-test with effective degrees of
 26 freedom computed according to Bretherton et al. (1999) and applying the False Discovery Rate (FDR) with
 27 control level $\alpha_{FDR} = 0.05$ to measure the field significance of the response (Wilks 2016).

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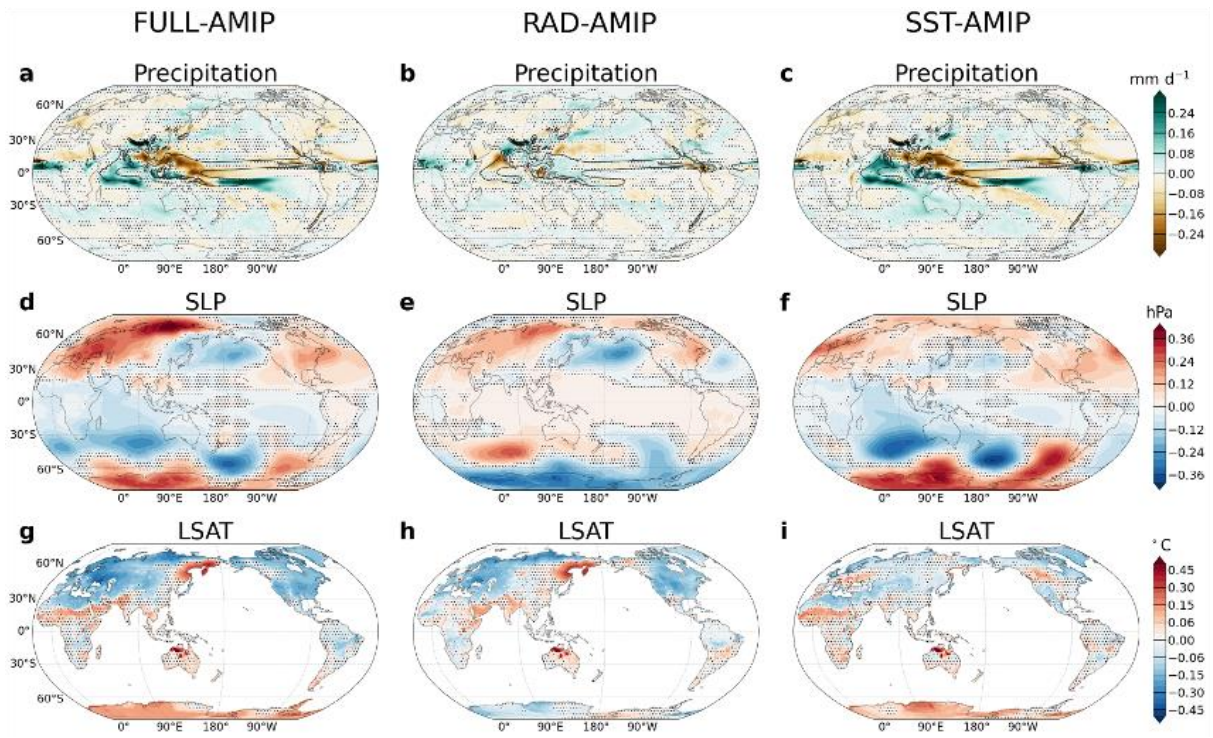


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32 **Figure S2.** Regressions onto FULL-AMIP SST PC1: (a,b,c) precipitation (mm d⁻¹), (d,e,f) sea level pressure
33 (SLP; hPa) and (g,h,i) land surface air temperature (LSAT; °C) in FULL-AMIP, RAD-AMIP and SST-AMIP.
34 Statistical significance of all regression values is assessed using a two-tailed Student's t-test with effective
35 degrees of freedom computed according to Bretherton et al. (1999) and applying the False Discovery Rate
36 (FDR) with control level $\alpha_{FDR} = 0.05$ to measure the field significance of the response (Wilks 2016).

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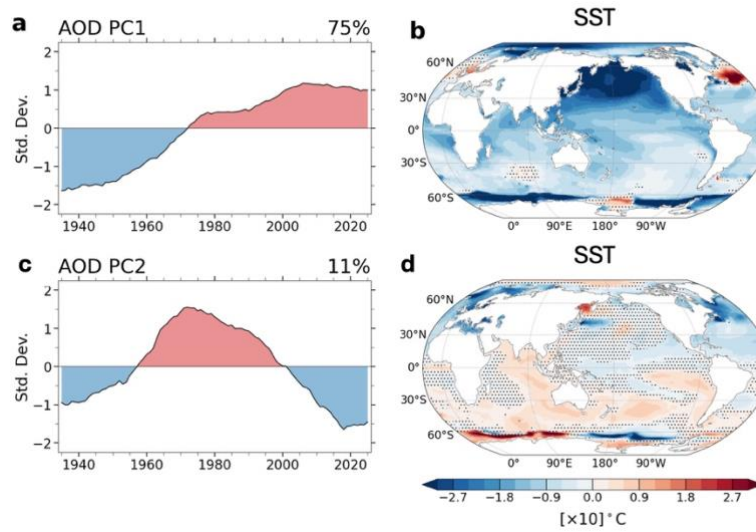


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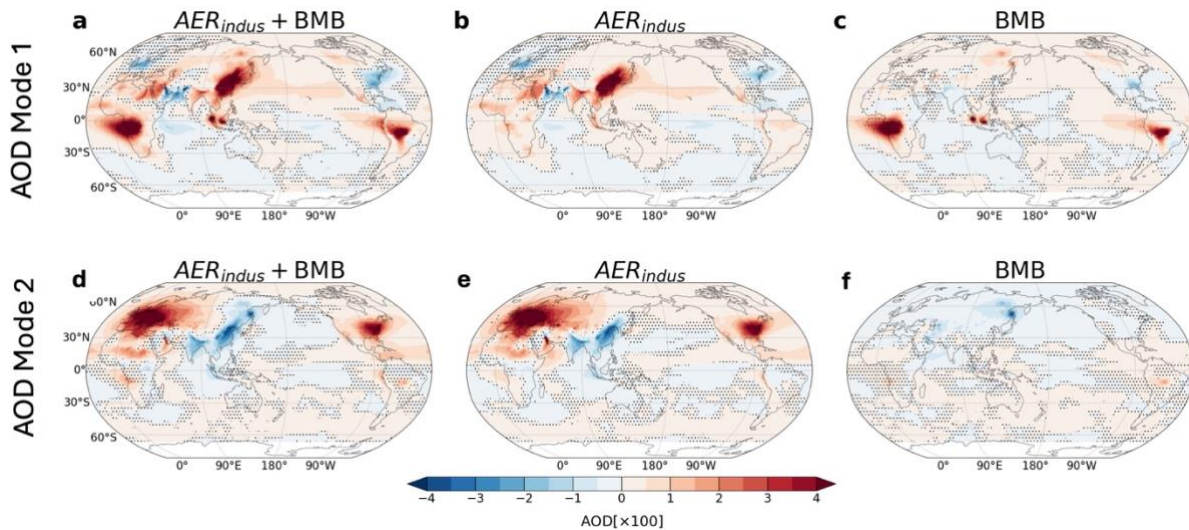
40 **Figure S3.** As in Fig. S2 but for regressions onto FULL-AMIP SST PC2.

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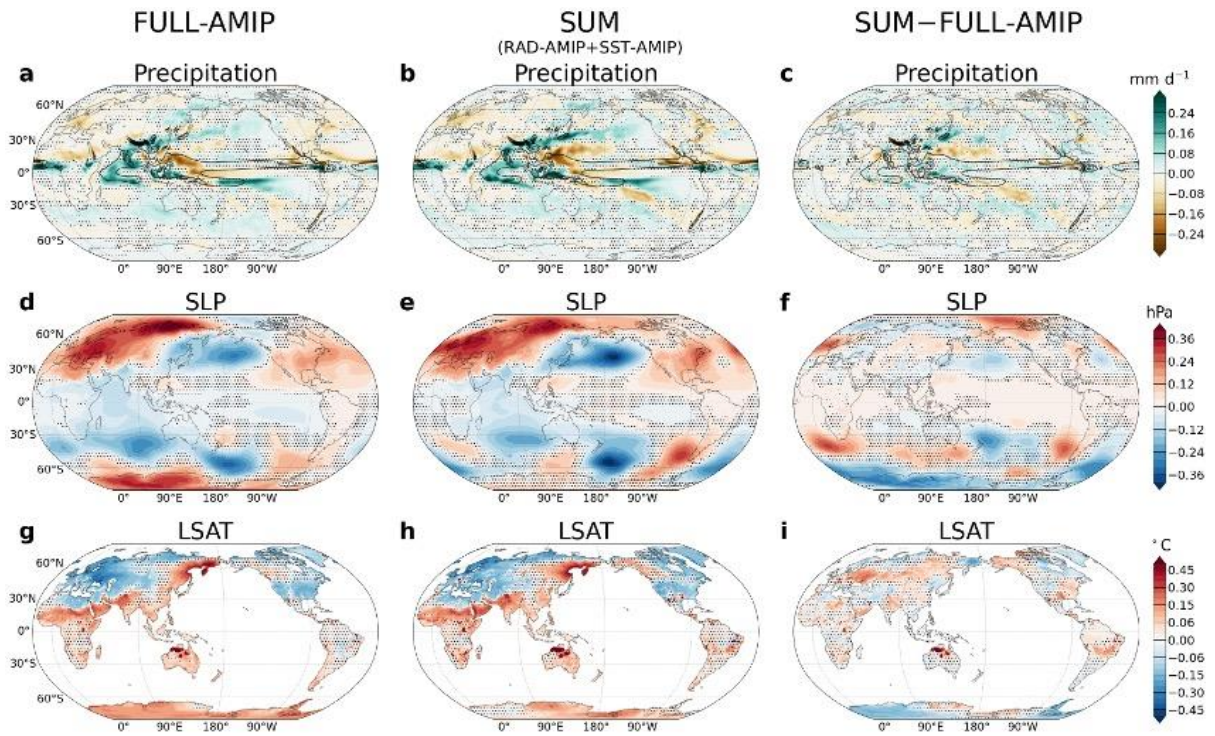
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45 **Figure S4.** (a,c) Principal Component (PC) time series of 10-year low-pass filtered SST in JJA based on
 46 SST-AMIP. Percent variance explained by Modes 1 and 2 (PC1 and PC2) are given in the upper right. (b,d)
 47 Regression of JJA SST (°C × 10) in FULL-AMIP onto SST PC1 and PC2. Statistical significance of all
 48 regression values is assessed using a two-tailed Student's t-test with effective degrees of freedom computed
 49 according to Bretherton et al. (1999) and applying the False Discovery Rate (FDR) with control level α_{FDR}
 50 = 0.05 to measure the field significance of the response (Wilks 2016).



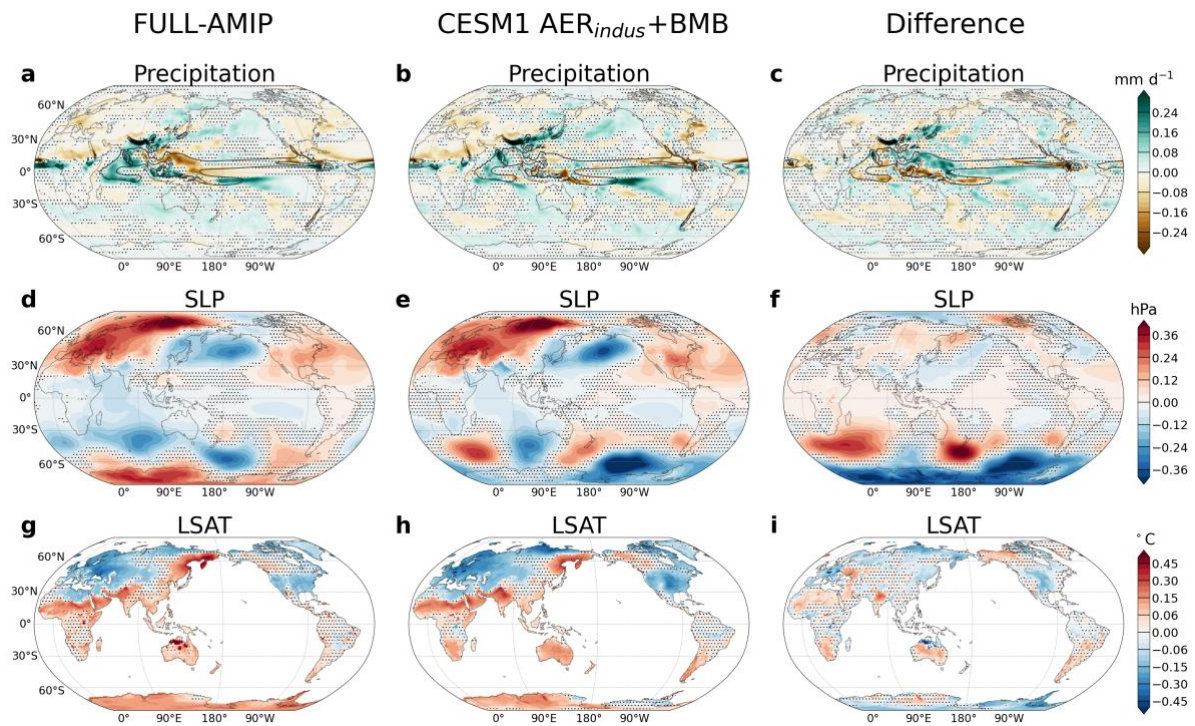
53 **Figure S5.** Industrial and biomass burning contributions to AOD Modes 1 and 2. AOD regressions onto
 54 FULL-AMIP AOD PC1 and PC2: (a,d) CESM1 AER_{indus}+BMB, (b,e) CESM1 AER_{indus} and (c,f) CESM1
 55 BMB. Statistical significance of all regression values is assessed using a two-tailed Student's t-test with
 56 effective degrees of freedom computed according to Bretherton et al. (1999) and applying the False
 57 Discovery Rate (FDR) with control level $\alpha_{FDR} = 0.05$ to measure the field significance of the response
 58 (Wilks 2016).



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60 **Figure S6.** Additivity analysis based on AOD Mode 2. (a,d,g) FULL-AMIP, (b,e,h) the sum of RAD-AMIP
 61 and SST-AMIP (SUM), and (c,f,i) the difference of SUM and FULL-AMIP. Statistical significance of all
 62 regression values is assessed using a two-tailed Student's *t*-test with effective degrees of freedom computed
 63 according to Bretherton et al. (1999) and applying the False Discovery Rate (FDR) with control level α_{FDR}
 64 = 0.05 to measure the field significance of the response (Wilks 2016). Black contours on precipitation panels
 65 show the climatological 6 mm d⁻¹ isopleth.

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69 **Figure S7.** Regressions of Precipitation, SLP and LSAT in FULL-AMIP (left column) and CESM1-
70 AERindus+BMB (middle column) and their difference (right column) based on AOD PC2 from FULL-
71 AMIP. Statistical significance of all regression values is assessed using a two-tailed Student's t-test with
72 effective degrees of freedom computed according to Bretherton et al. (1999) and applying the False
73 Discovery Rate (FDR) with control level $\alpha_{FDR} = 0.05$ to measure the field significance of the response
74 (Wilks 2016).