



Supplement of

Reduced surface fine dust under droughts over the southeastern United States during summertime: observations and CMIP6 model simulations

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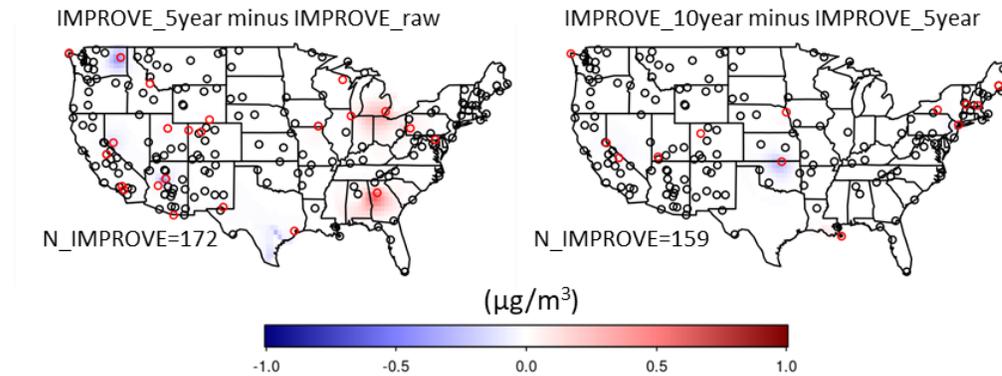
Table S1. Dataset and related variables used in this study.

Variables	Datasets	Temporal resolution	Spatial resolution (latitude x longitude)	Periods used (JJA only)	Download links
Drought indicator	USDM	Weekly	0.5°×0.5°	2000-2019	https://droughtmonitor.unl.edu/
	SPEI	Monthly	0.5°×0.5°	1973-2018	http://sac.csic.es/spei/
Fine dust	IMPROVE	Every 3 days	0.5°×0.5° or station	2000-2019	http://views.cira.colostate.edu/fed/QueryWizard/
	EPA-CSN	Every 3 or 6 days	station (comparison purpose only)	2000-2019	
Total dust	Barbados	Daily	station	1973-2014	https://doi.org/10.17604/q3vf-8m31
AOD	MODIS Terra/Aqua	Daily	1°×1°	2003-2019	https://ladsweb.modaps.eosdis.nasa.gov/
Dust extinction coefficient	CALIPSO	Monthly	2°×5°	2006-2019	https://asdc.larc.nasa.gov/project/CALIPSO
Precipitation	GPCP	Daily	1°×1°	2000-2019	https://www.ncei.noaa.gov/precipitation-gpcp
Wind, geopotential height	ERA5	Daily	0.25°×0.25°	2000-2019	https://cds.climate.copernicus.eu
NAO	CRU	Monthly	N/A	2000-2019	https://crudata.uea.ac.uk/cru/

Table S2. Information of the ten CMIP6 models selected for evaluation.

Models	Resolution (lat×lon)	Size bins (μm)	Model references
BCC-ESM1	2.81°×2.81°	4 bins: 0.1-1.0,1.0-2.5,2.5-5.0,5.0-10.0	Wu et al. (2020)
CESM2-WACCM	0.95°×1.25°	3 bins: 0.01-0.1,0.1-1.0,1.0-10	Danabasoglu et al. (2020)
CNRM-ESM2-1	1.40°×1.40°	3 bins: 0.01-1.0,1.0-2.5,2.5-20	Séférian et al. (2019)
EC-Earth3-AerChem	2.00°×3.00°	3 bins: 0.03-0.55,0.55-9,9-20	Van Noije et al. (2021)
GFDL-ESM4	1.00°×1.25°	5 bins: 0.1-1,1-2,2-3,3-6,6-10	Dunne et al. (2020)
GISS-E2-1-G	2.00°×2.50°	6 bins: <1,1-2,2-4,4-8, 8-16,16-32	Kelley et al. (2020)
MIROC6	1.40°×1.40°	6 bins: 0.1-0.22,0.22-0.46,0.46-1.0,1.0-2.15,2.15-4.64,4.64-10	Tatebe et al. (2019)
MRI-ESM2-0	1.87°×1.87°	6 bins: 0.2-2,2-4,4-6,6-8,8-10,10-12,12-20	Yukimoto et al. (2019)
NorESM2-LM	1.87°×2.50°	3 bins: 0.01-0.1,0.1-1.0,1.0-10	Seland et al. (2020)
UKESM1-0-LL	1.25°×1.87°	6 bins: 0.064-0.2,0.2-0.63,0.63-2.0,2.0-6.32,6.32-20,20-63	Senior et al. (2020)

(a) Mean difference of dust during 2000-2019 JJA



(b) Interannual correlation coefficient (R) of dust during 2000-2019 JJA

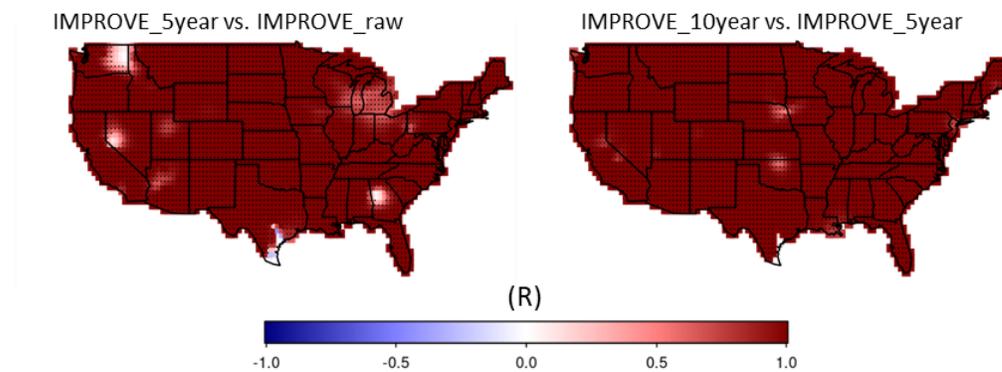


Figure S1: Dust mean differences (a) and interannual correlation coefficients (b) between the datasets interpolated from the IMPROVE sites with a data record of more than 5 years (IMPROVE_5year) and all the IMPROVE sites with data available (IMPROVE_raw) during the study period (left column), and between the IMPROVE sites with a data record of more than 10 years (IMPROVE_10year) and IMPROVE_5year (right column). N_IMPROVE in a indicates the number of sites (black circles) used for the IMPROVE_5year (left) and IMPROVE_10year (right) dataset, respectively. Red circles in a show the sites used for the IMPROVE_raw dataset but not for the IMPROVE_5year (left; 23 sites), and for the IMPROVE_5year dataset but not for the IMPROVE_10year (right; 13 sites). These red circles are included to help better understand the changes.

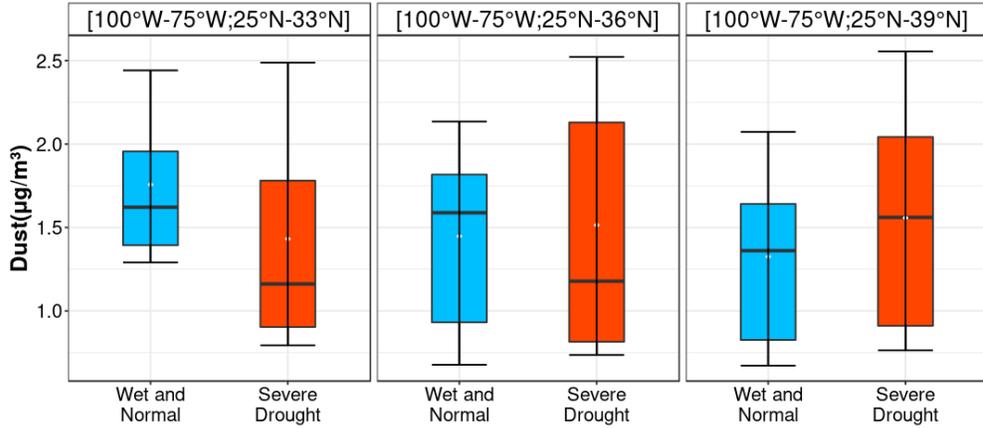
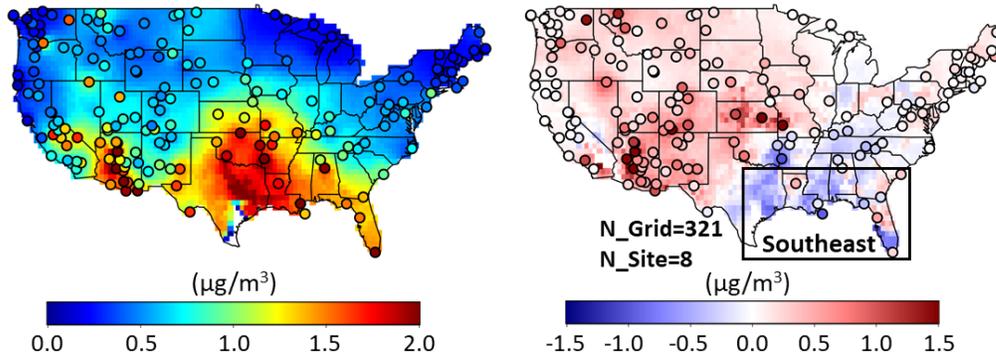


Figure S2: Boxplots of dust using three different delimitations of southeastern US (SEUS) under wet and normal (non-drought) and severe drought conditions.

(a) Dust distribution under non-drought conditions (left) and its changes from severe drought conditions (right)



(b) Dust density plot over the CONUS (left) and the southeast region (right)

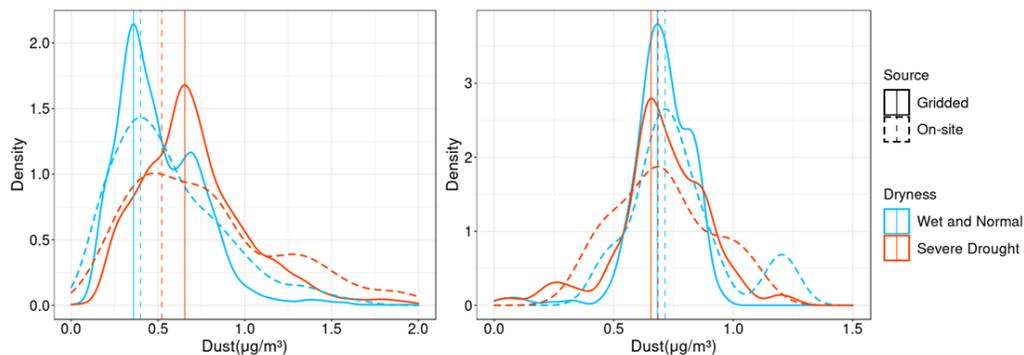
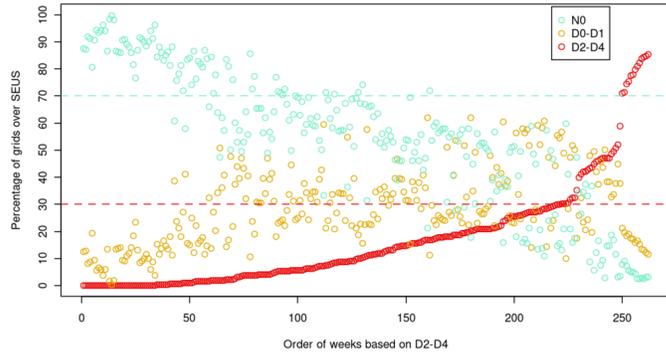
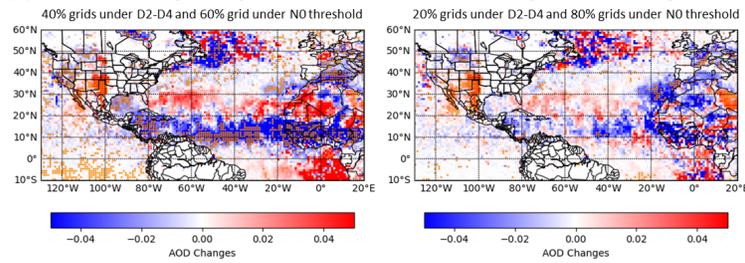


Figure S3. (a) Maps of the mean gridded and in-situ (dots) fine dust under SPEI-based non-drought (wet and normal) conditions (left) from 2000 to 2018 and its changes from severe drought conditions (right). The number of grids (sites) within the southeast region is denoted by N_Grid (N_Site). (b) Comparisons of density distributions of gridded (solid lines) and in-situ (dash lines) fine dust concentrations under drought (red lines) and non-drought (blue lines) conditions over the CONUS (left) and southeast region (right), respectively. Vertical dash and solid lines indicate the modes.

(a) Percentage of grids under D2-D4 in increasing order and the corresponding percentage of grids under N0 and D0-D1



(b) MODIS AOD changes using different thresholds of severe drought and non-drought



(c) Dust extinction coefficient changes using different thresholds of severe drought and non-drought

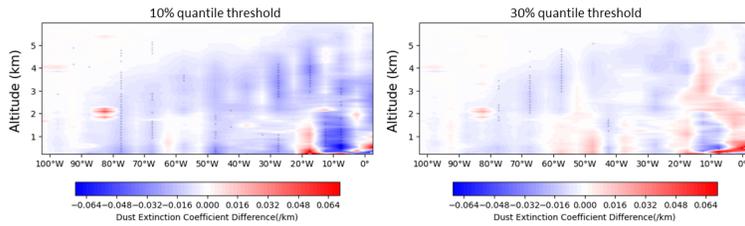


Figure S4: (a) Percentage of grids under severe drought (D2-D4; red dots) in increasing order and the corresponding percentage of grids under non-drought (N0; blue dots) and mild drought (D0-D1; orange dots). (b) MODIS AOD difference between severe drought and non-drought events if more than 40% grids are under D2-D4 (severe drought) and more than 60% grids are under N0 (non-drought; left column), or more than 20% grids are under D2-D4 (severe drought) and more than 80% grids are under N0 (non-drought; right column). (c) Dust extinction coefficient difference between severe drought and non-drought events if the regional-mean SPEI is less (severe drought) and more (non-drought) than 10% quantile (left column) or 30% quantile (right column). Black or orange dots in b and c indicate the significant difference at a 95% confidence level.

Table S3. Statistics of dust elemental ratios under wet and normal (non-drought) and severe drought conditions.

Ratios	Dryness	Mean	Median	Standard deviation	10% quantile	90% quantile
Fe:Ca	wet and normal	1.64	1.59	0.16	1.51	1.86
	severe drought	1.45	1.45	0.33	1.08	1.90
Al:Ca	wet and normal	2.53	2.59	0.47	2.04	3.13
	severe drought	2.19	2.20	0.66	1.46	2.94
K:Fe	wet and normal	1.05	1.04	0.21	0.84	1.30
	severe drought	1.45	1.27	0.44	0.99	2.03
Si:Al	wet and normal	2.71	2.47	0.68	2.18	3.58
	severe drought	2.83	2.64	0.65	2.24	3.78