



*Supplement of*

## **Representing extreme fires and their radiative effects in a global climate model via variable scaling of emissions**

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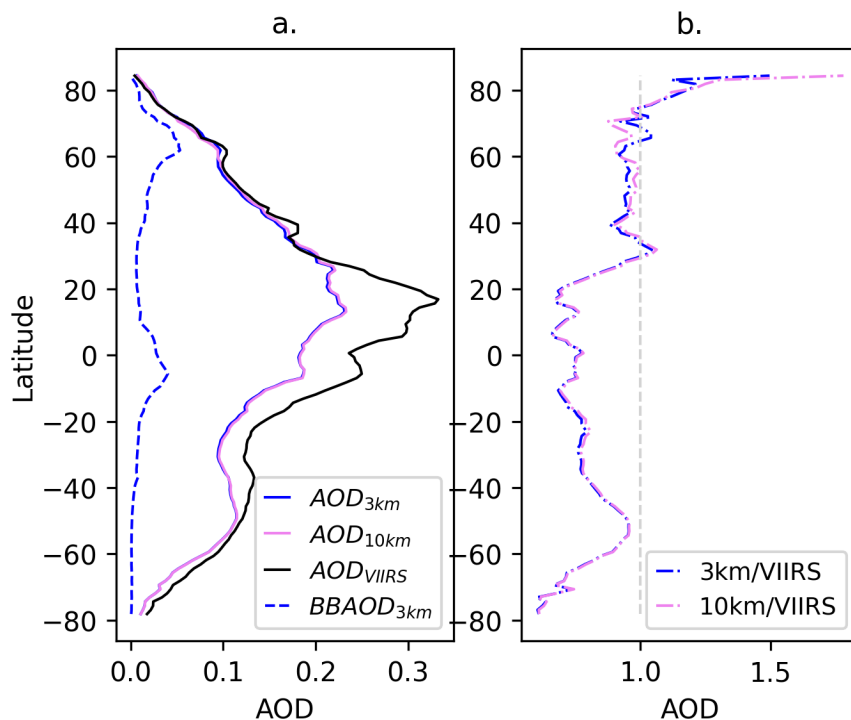


Figure S1: a. The global latitudinal AOD, comparing simulations with different emissions ejection heights. The blue line represents collocated FIRE\_3km, where unscaled GFED4.1s emissions are ejected uniformly between 0 and 3 km. The purple line represents collocated FIRE\_10km, where unscaled GFED4.1s emissions from boreal and temperate forest and deforestation fires are injected uniformly between 0 and 10 km based on lidar observations of the smoke plume, and the black line shows Suomi VIIRS Deep Blue. The dashed blue line represents the biomass burning AOD (BBAOD), from FIRE\_3km calculated by subtracting the FIRE\_0x simulation. b. the collocated latitudinal AOD as a ratio to the observations, i.e. the blue dashed line equals FIRE\_3km/VIIRS DB, and the purple dashed line equals FIRE\_10km/VIIRS DB.

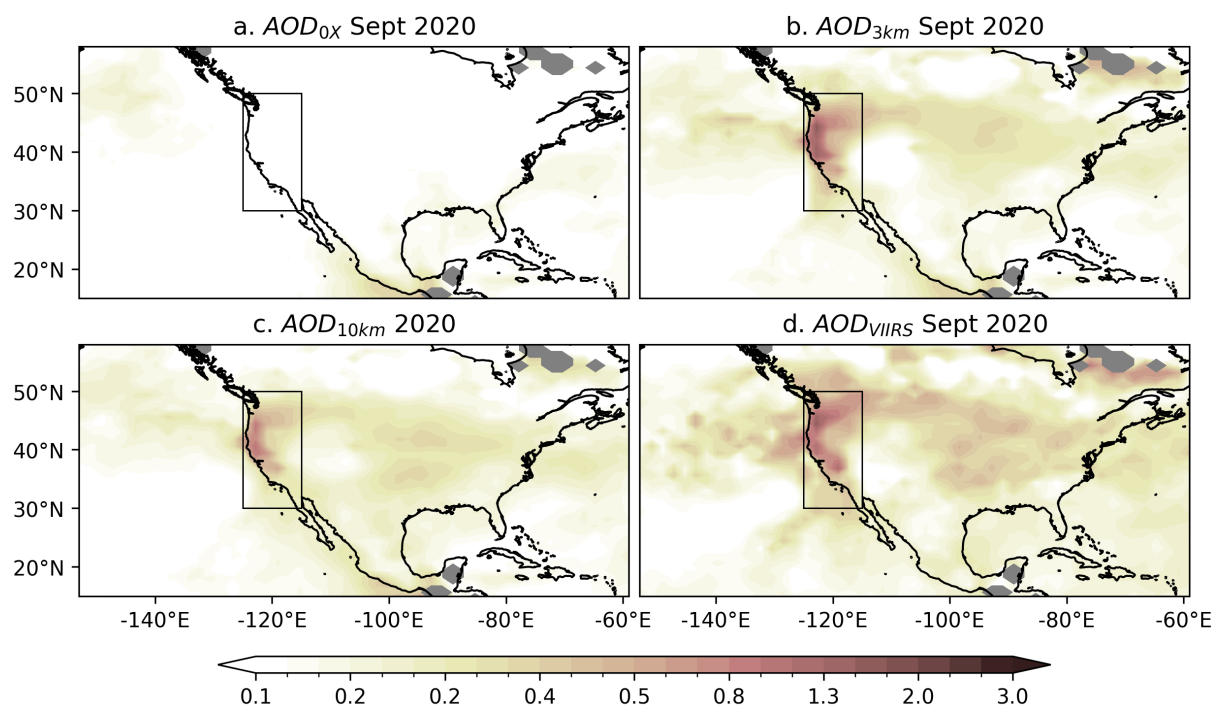


Figure S2: Mean Aerosol optical depth for September 2020. a. AOD from simulation FIRE\_0X, which has no biomass burning emissions from GFED4.1s. b. AOD from simulation FIRE\_3km, where unscaled GFED4.1s emissions are ejected uniformly between 0 and 3 km, based on a simplification of AeroCom recommendations. c. AOD from simulation FIRE\_10km, where unscaled GFED4.1s emissions from boreal and temperate forest and deforestation fires are ejected uniformly between 0 and 10 km based on lidar observations of the smoke plume, d. AOD from Suomi VIIRS

Deep Blue. The areas of grey represent missing data. Simulations FIRE\_0X, FIRE\_3km and FIRE\_10km were done in HadGEM3-GA8, an atmosphere-only configuration of UKESM1.1, therefore there are some differences between these and the UKESM1.1 simulations.

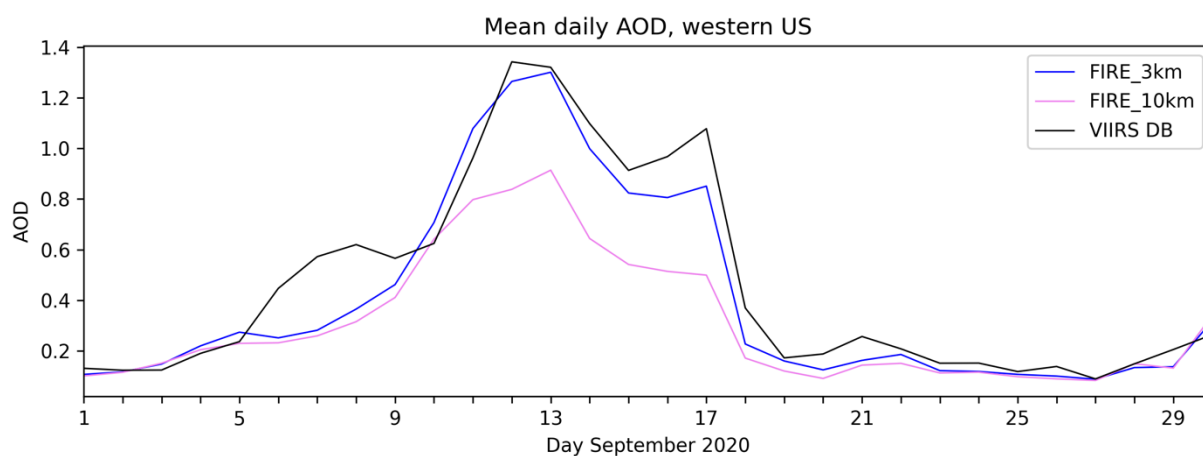


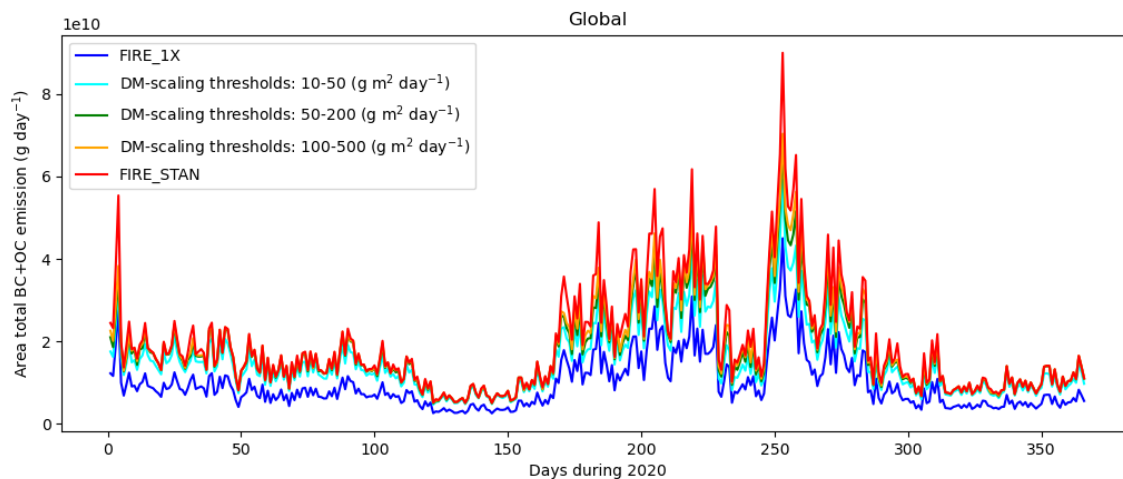
Figure S3: Area weighted daily mean AOD for region in western US, bounded by -125–115° E, 30–50° N. The black line is observational data from Suomi VIIRS Deep Blue, blue is the FIRE\_3km simulation and purple is the FIRE\_10km simulation. Simulations FIRE\_0X, FIRE\_3km and FIRE\_10km were done in HadGEM3-GA8, an atmosphere-only configuration of UKESM1.1, therefore there are some differences between these and the UKESM1.1 simulations.

DM threshold (low)	DM threshold (high)	Total BC+OC emissions during 2020 - factor of increase relative to FIRE_1X				
		Global	Western US	Northeast Siberia	Southeast Australia	Central Africa
10	50	1.59	1.07	1.11	1.09	1.76
50	200	1.80	1.22	1.33	1.26	1.97
100	500	1.87	1.41	1.51	1.44	2.00
500	1000	1.89	1.47	1.57	1.51	2.00

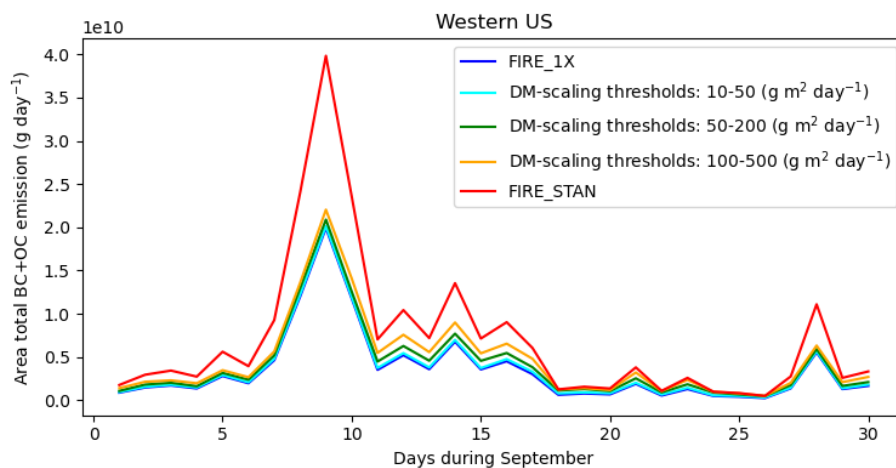
Table S1: Sensitivity tests showing the impact of applying different dry matter (DM) thresholds to the DM-scaling method. Results show the annual total emissions of organic carbon and black carbon, for the year 2020, relative to those in FIRE\_1X (i.e. the average factor of increase). Selected regions are marked in Fig. 3.

DM threshold (low)	DM threshold (high)	Total BC+OC emissions during September 2020 - factor of increase relative to FIRE_1X		
		Global	Western US	Central Africa
10	50	1.45	1.04	1.72
50	200	1.69	1.16	1.96
100	500	1.79	1.32	2.00
500	1000	1.82	1.39	2.00

Table S2: Same as Table S1, but for September 2020 and for fewer regions (where fire activity was a peak levels).



**Figure S4: Global total BBA emissions for 2020 with different scaling approaches and dry matter (DM) thresholds. Blue is no scaling (FIRE\_1X), cyan is a sensitivity test with DM thresholds of 10-50, green is with DM thresholds of 50-200 (as used in FIRE\_DM simulation), orange is a further sensitivity test with DM thresholds of 100-500, and red is the 2x scaling (FIRE\_STAN).**



**Figure S5: Same as S4, except for the Western US region and the month of September 2020.**