

Supplementary Materials of “Duff burning from wildfires in a moist region: different impacts on PM_{2.5} and Ozone”

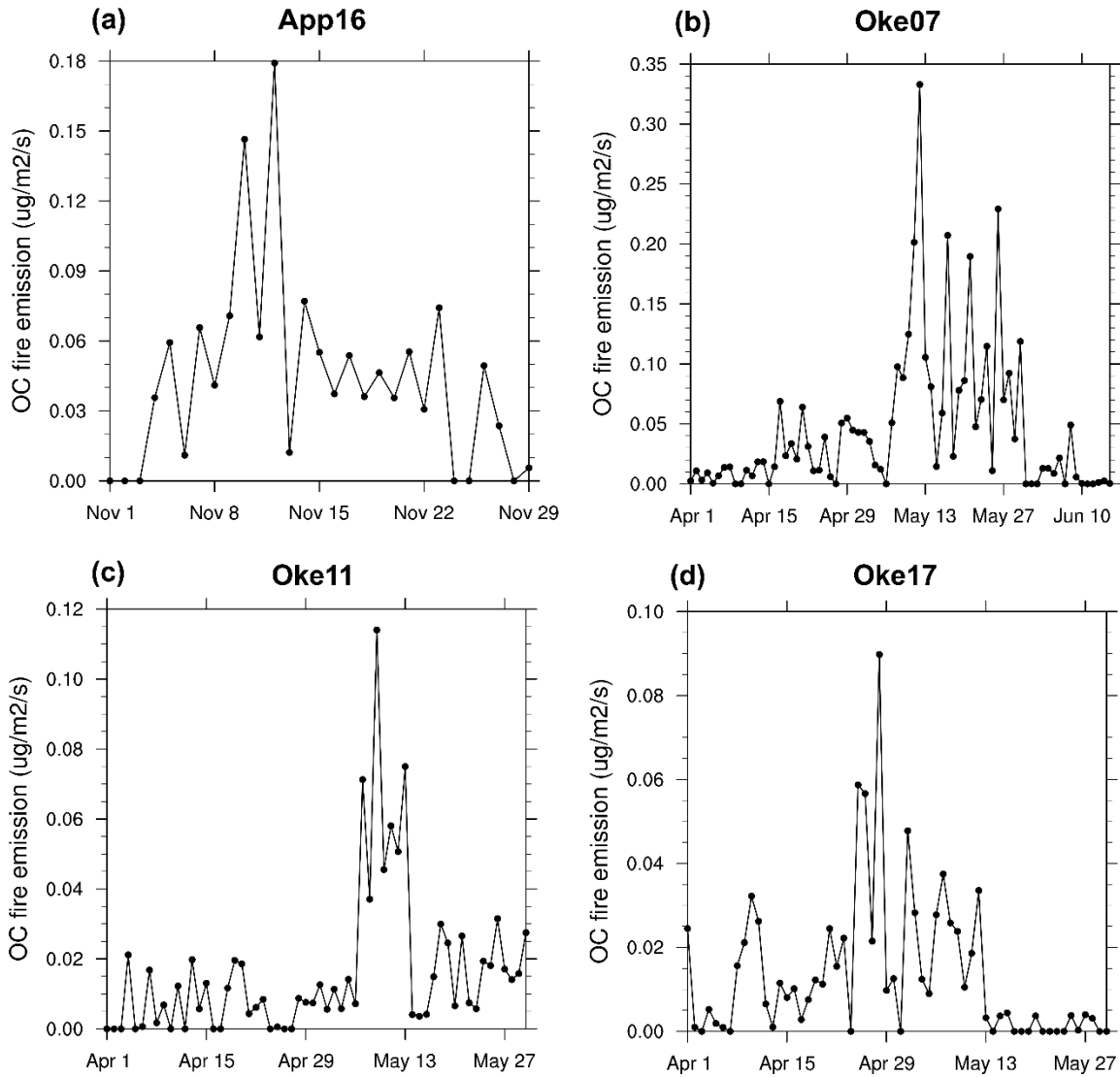


Figure S1. The daily trend of FINN fire emissions of organic carbon (OC) during the fire events. (a) the Southern Appalachian region (34.5° N to 36° N, 82° W to 84° W). (b) - (d) the Okefenokee region (30° N to 32° N, 81° W to 83° W).

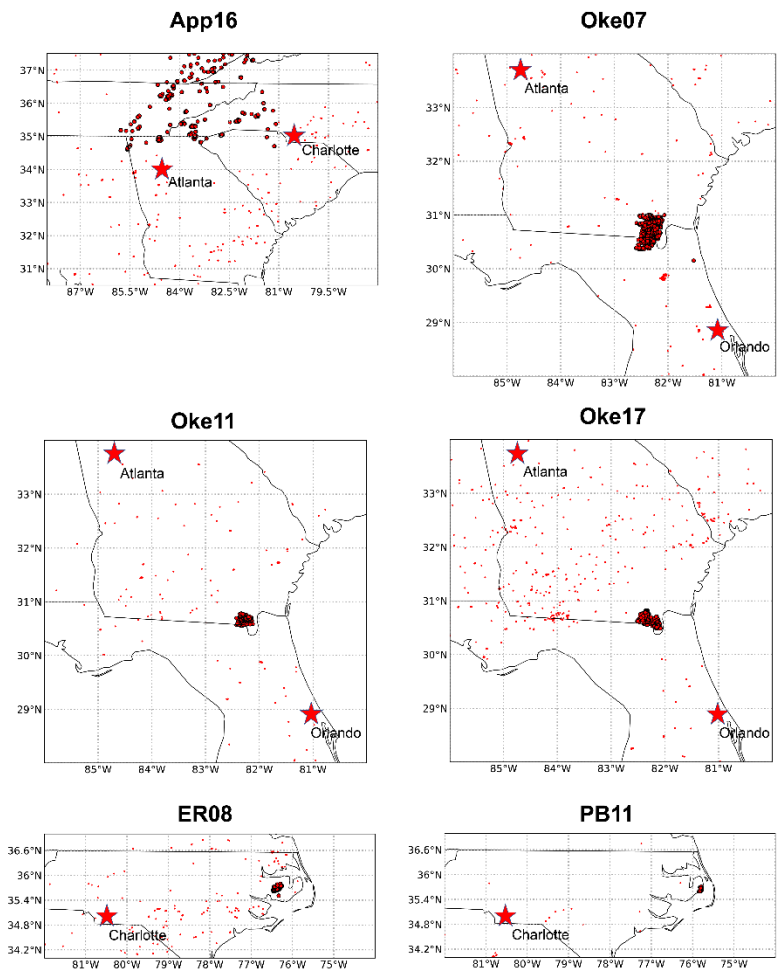


Figure S2. The burning hotspots from FINN emission inventory during the studied time periods for each case. The larger scatters represent the studied fire events with duff burning, and the smaller scatters represent the FINN hotspots with no duff burning. The nearby cities potentially affected by the studied fire cases are marked.

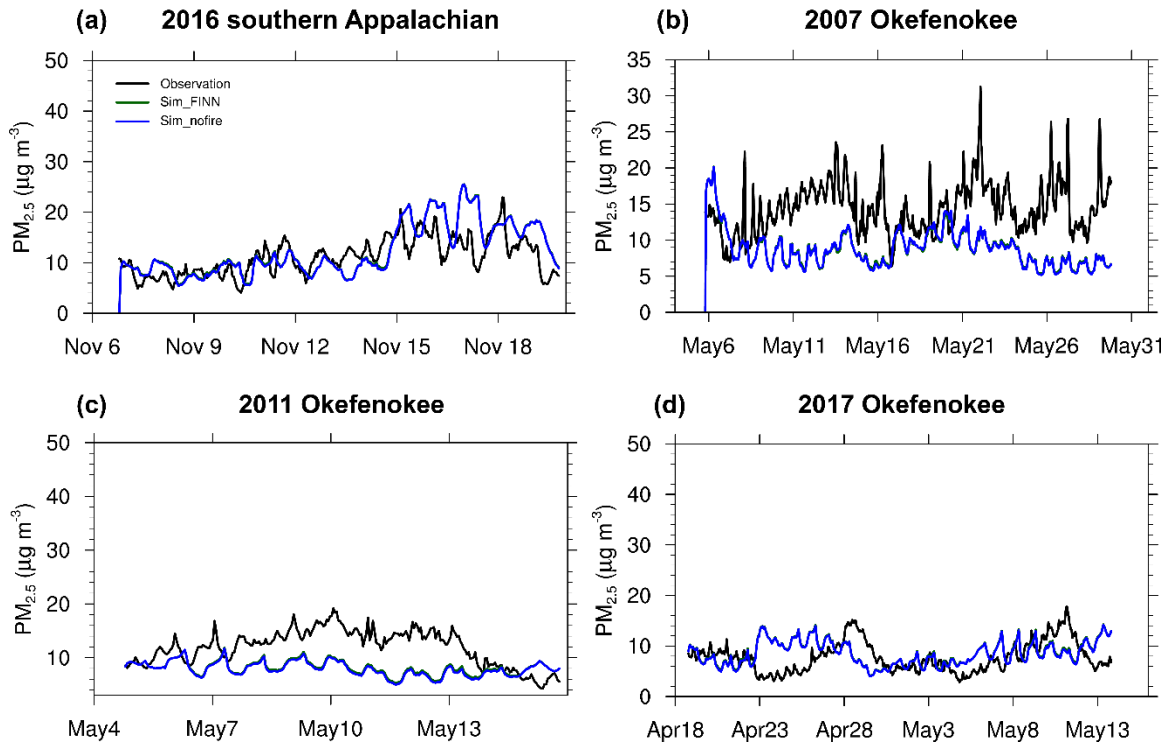


Figure S3. The time series of hourly surface PM_{2.5} concentrations averaged over the site and time that is not influenced by fire smoke (PM_{2.5} concentration difference between Sim_FINN and Sim_nofire is less than 1 $\mu\text{g m}^{-3}$). Black: Measurements averaged over observation sites that is not influenced by fire smoke within the simulation domain. Green and blue: Simulations of Sim_FINN and Sim_nofire, respectively, averaged over the observation sites that is not influenced by fire smoke.

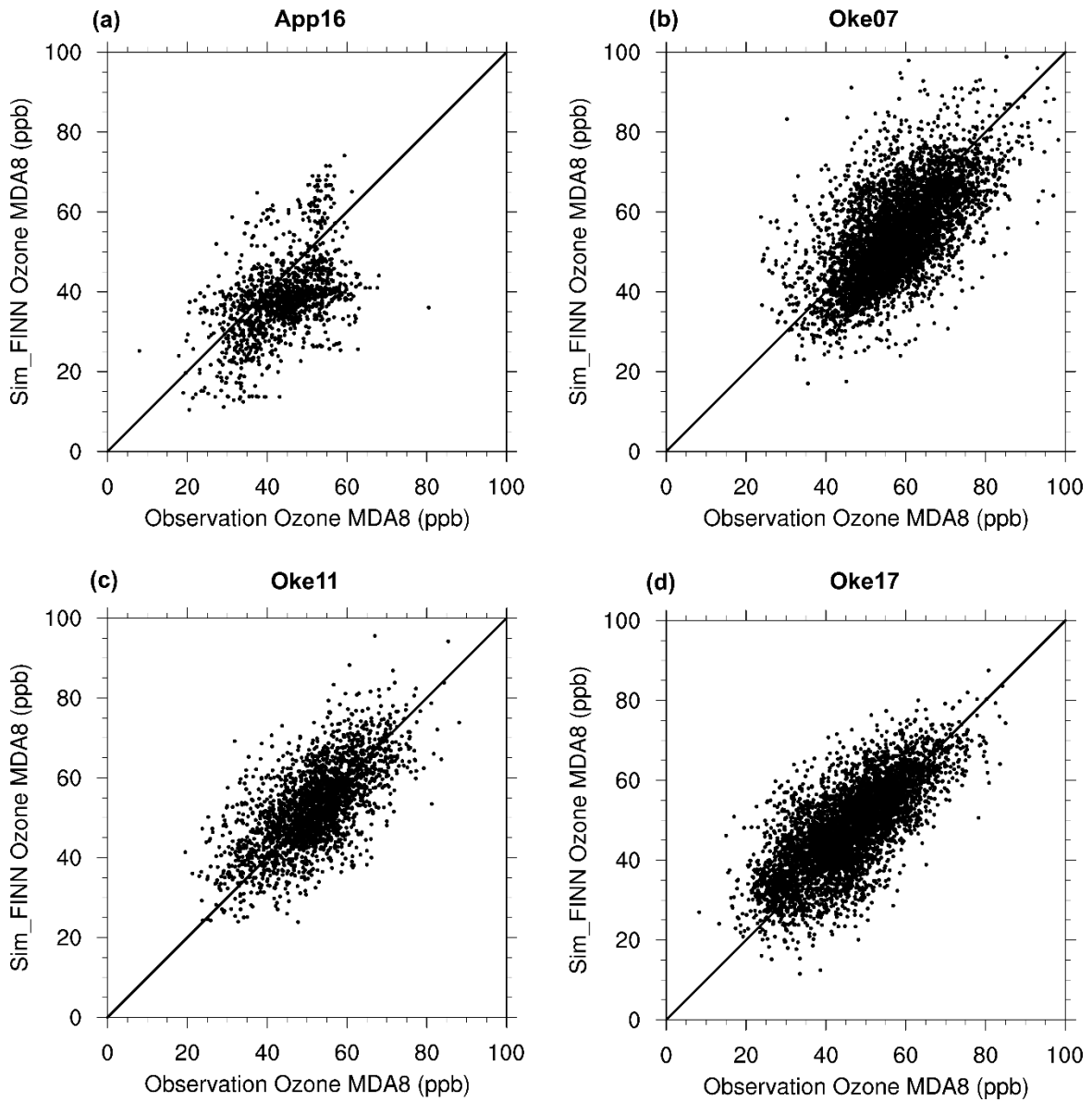


Figure S4. The comparison of MDA8 surface ozone concentrations between the observation and the baseline (sim_FINN) simulations.

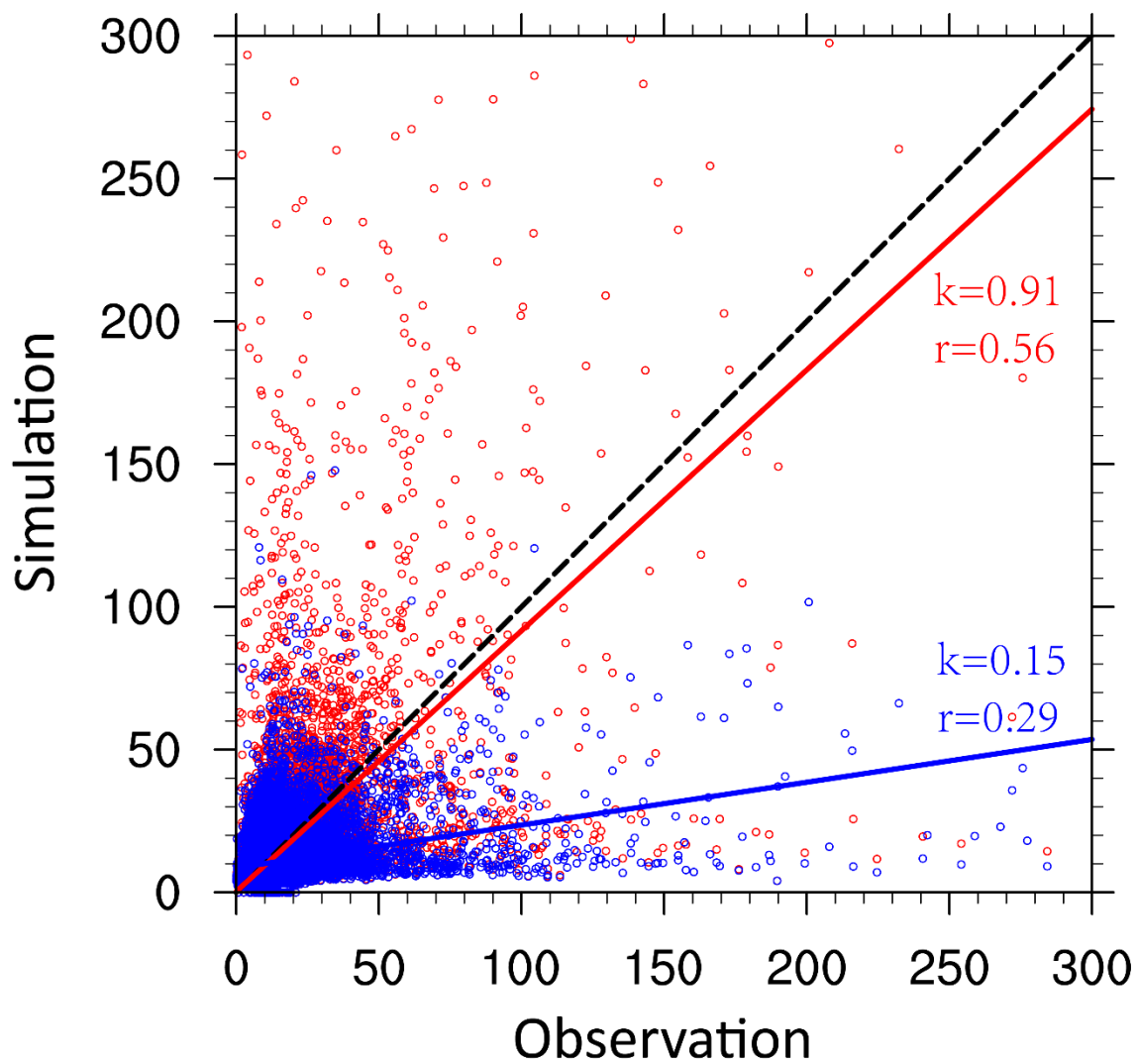


Figure S5. The comparison of Oke07 hourly surface PM_{2.5} concentrations between the observation, the baseline (sim_FINN) simulations (blue), and the best (sim_FINN+duff) simulations (red), in unit of $\mu\text{g m}^{-3}$. The corresponding correlation coefficient (r) and the regression slope (k) is enclosed.

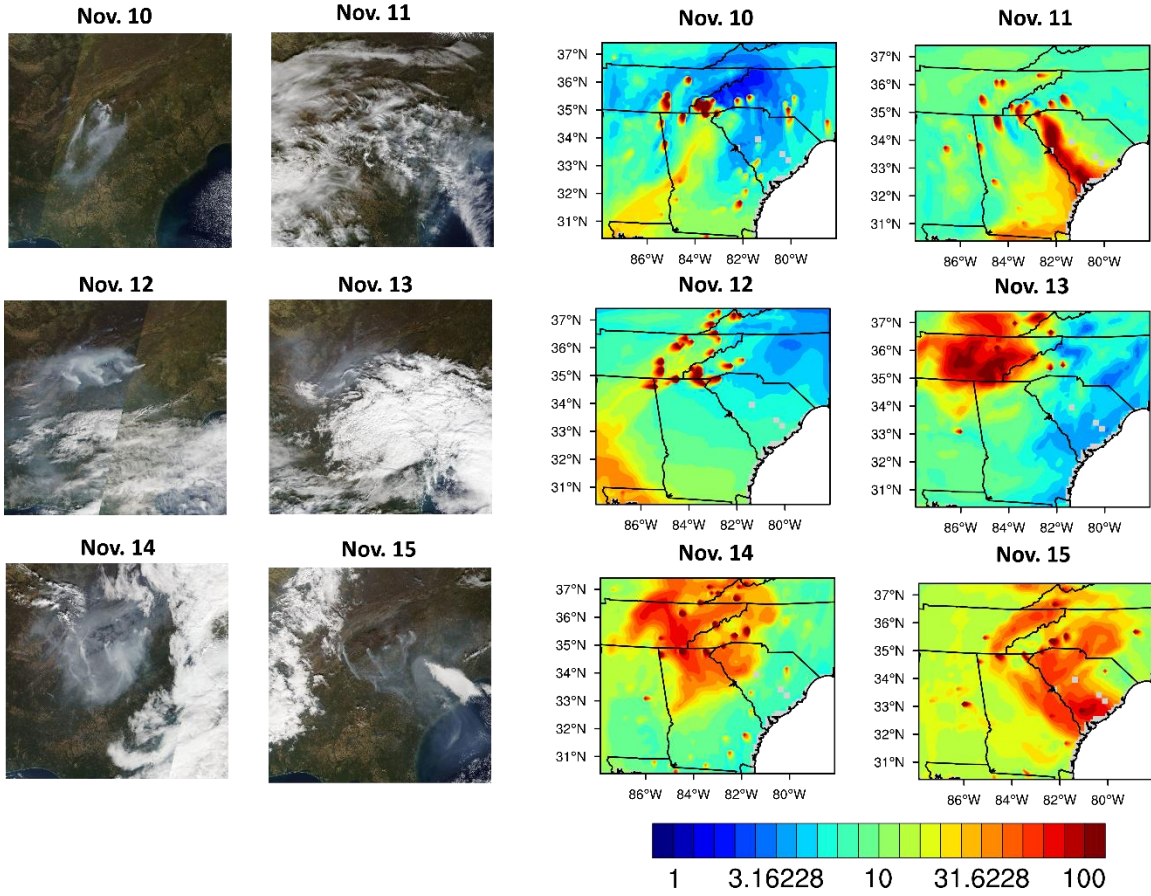


Figure S6. The MODIS Terra satellite image during November 10-15, 2016 over the APP16 fire compared with the corresponding surface PM_{2.5} concentrations ($\mu\text{g m}^{-3}$) simulated in the sim_FINN+duff run at the hour of the satellite passing.

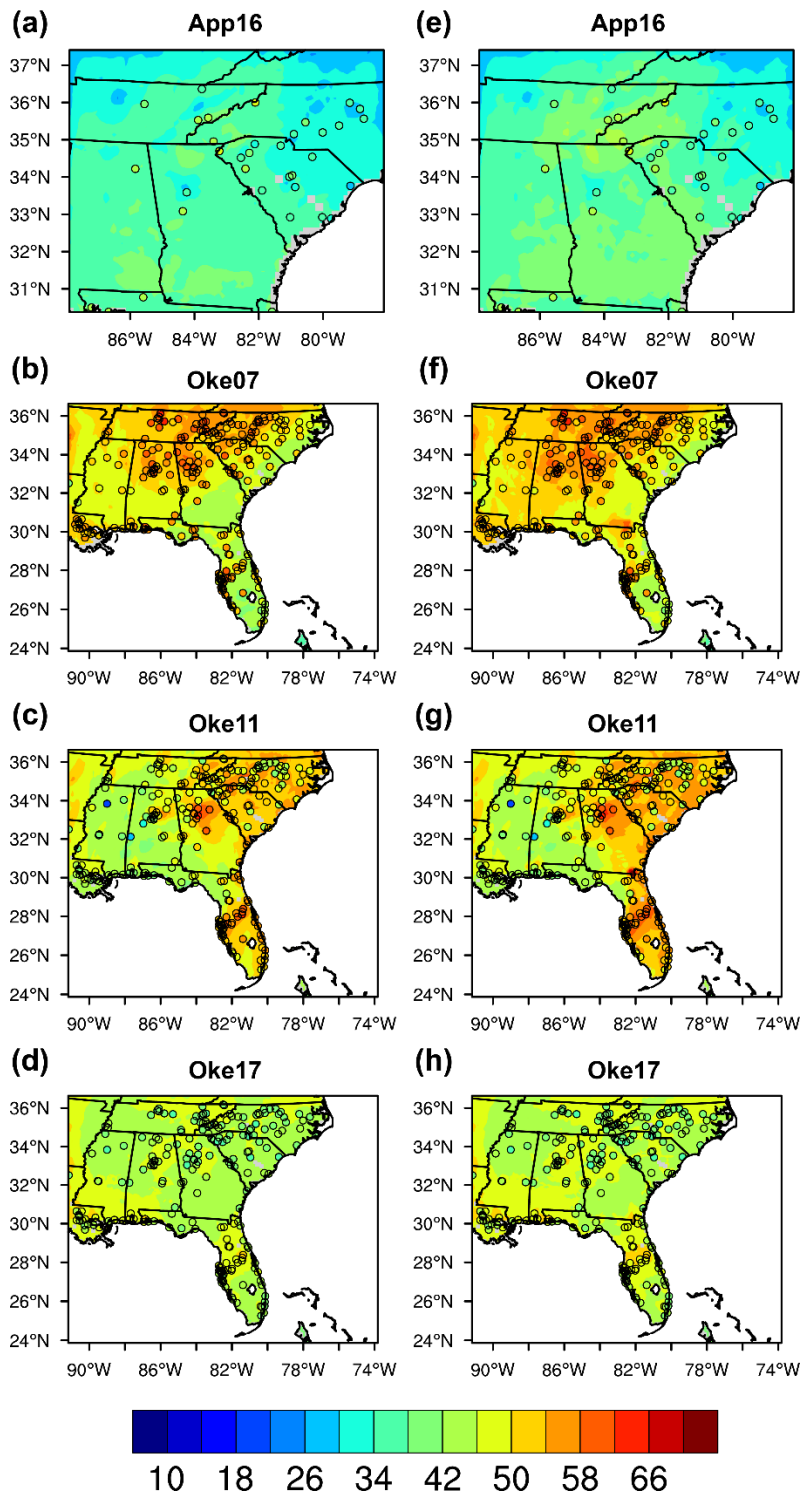


Figure S7. Mean day time (local time 10 am to 6 pm) ozone surface concentration (ppb). (a) App16 (November 7-19, 2016), (b) Oke07 (May 6-30, 2007), (c) Oke11 (May 6-15, 2011), and (d) Oke17 (April 19 to May 13, 2017) for sim_nofire. (e-h) are the corresponding fire cases for sim_FINN. The color scatters represent the observed mean day time surface ozone concentrations.

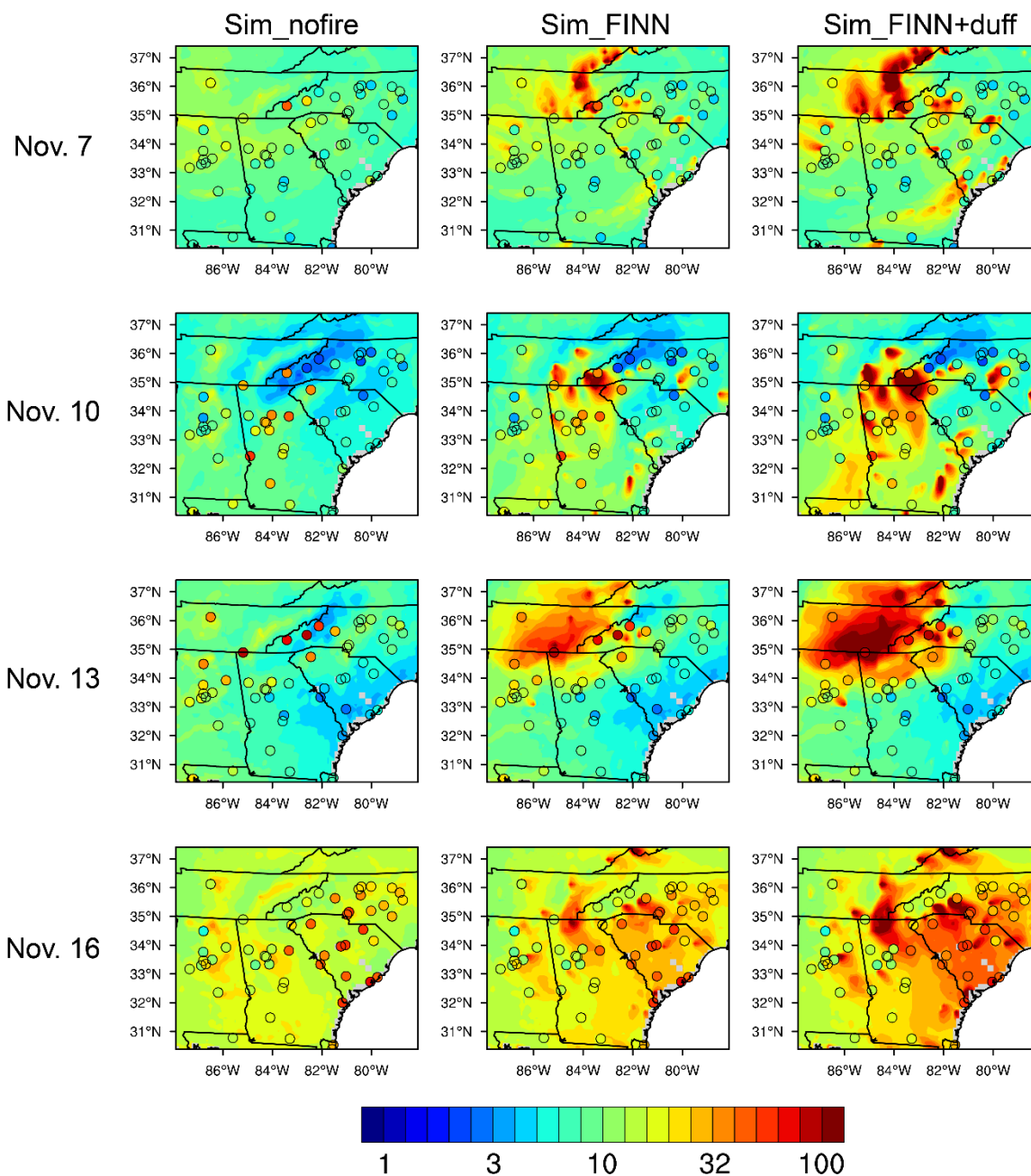


Figure S8. PM_{2.5} daily mean surface concentration (µg m⁻³) during App16 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed PM_{2.5} daily mean surface concentrations during the fire event.

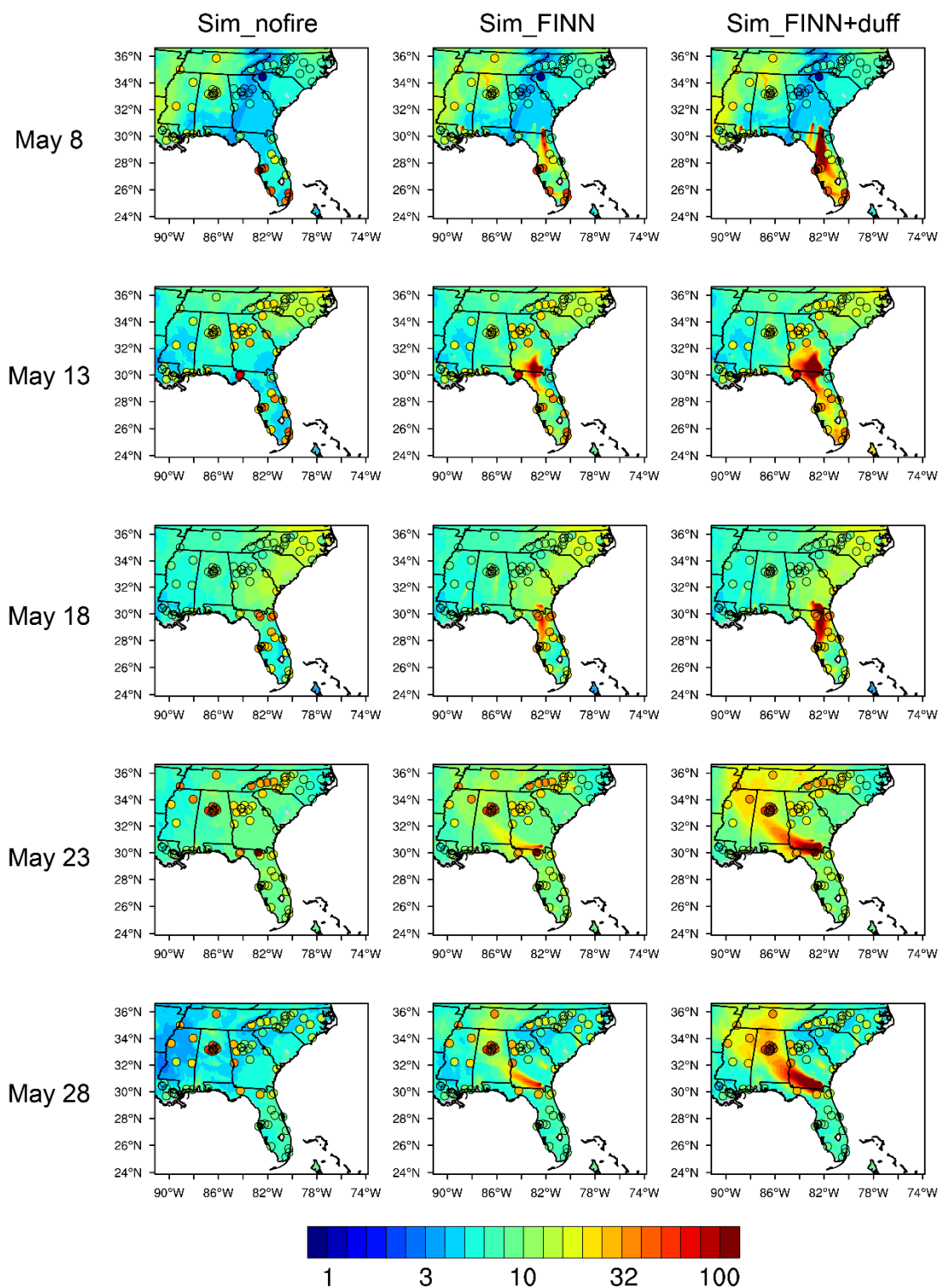


Figure S9. PM_{2.5} daily mean surface concentration (µg m⁻³) during Oke07 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed PM_{2.5} daily mean surface concentrations during the fire event.

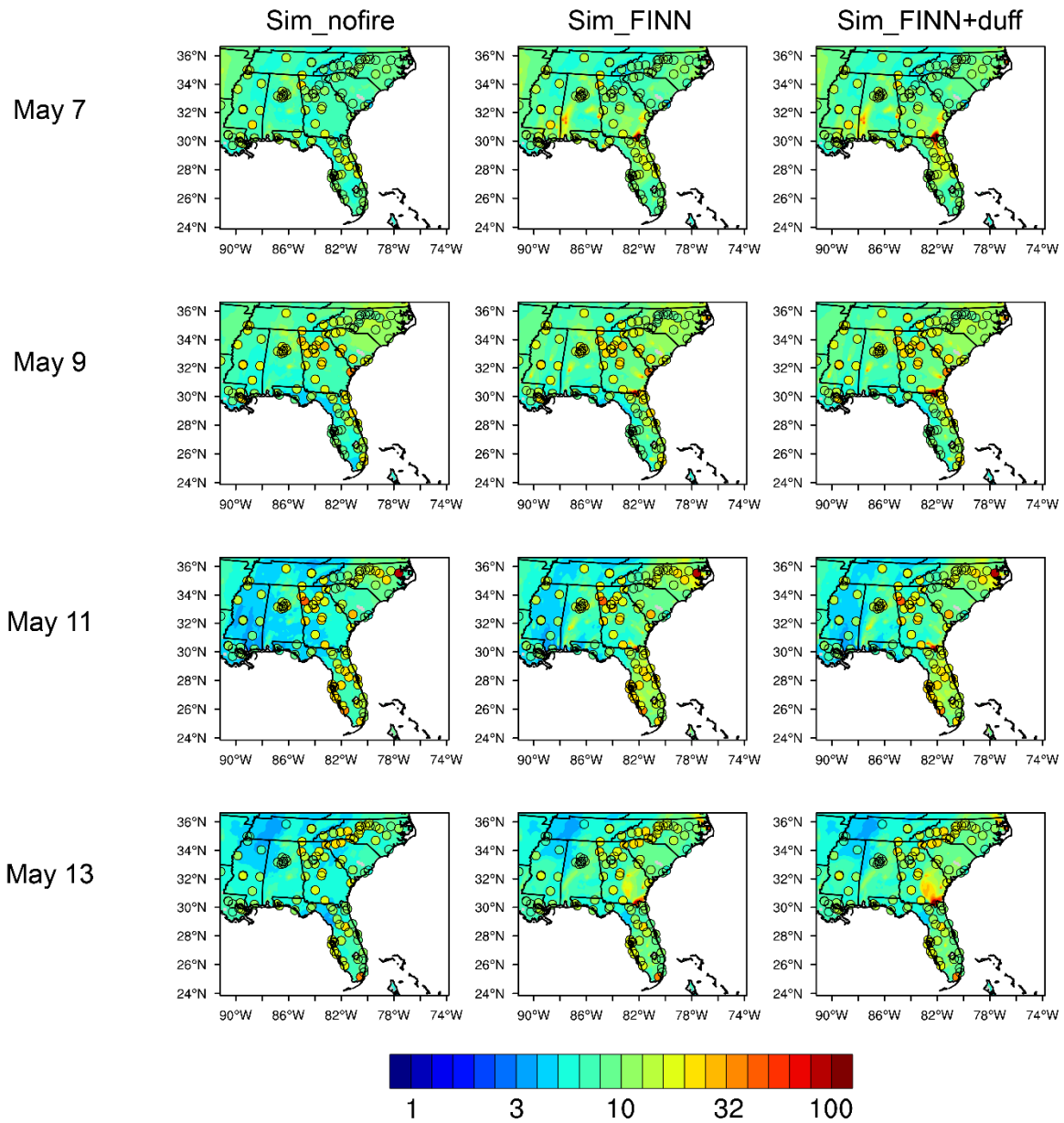


Figure S10. PM_{2.5} daily mean surface concentration (µg m⁻³) during Oke11 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed PM_{2.5} daily mean surface concentrations during the fire event.

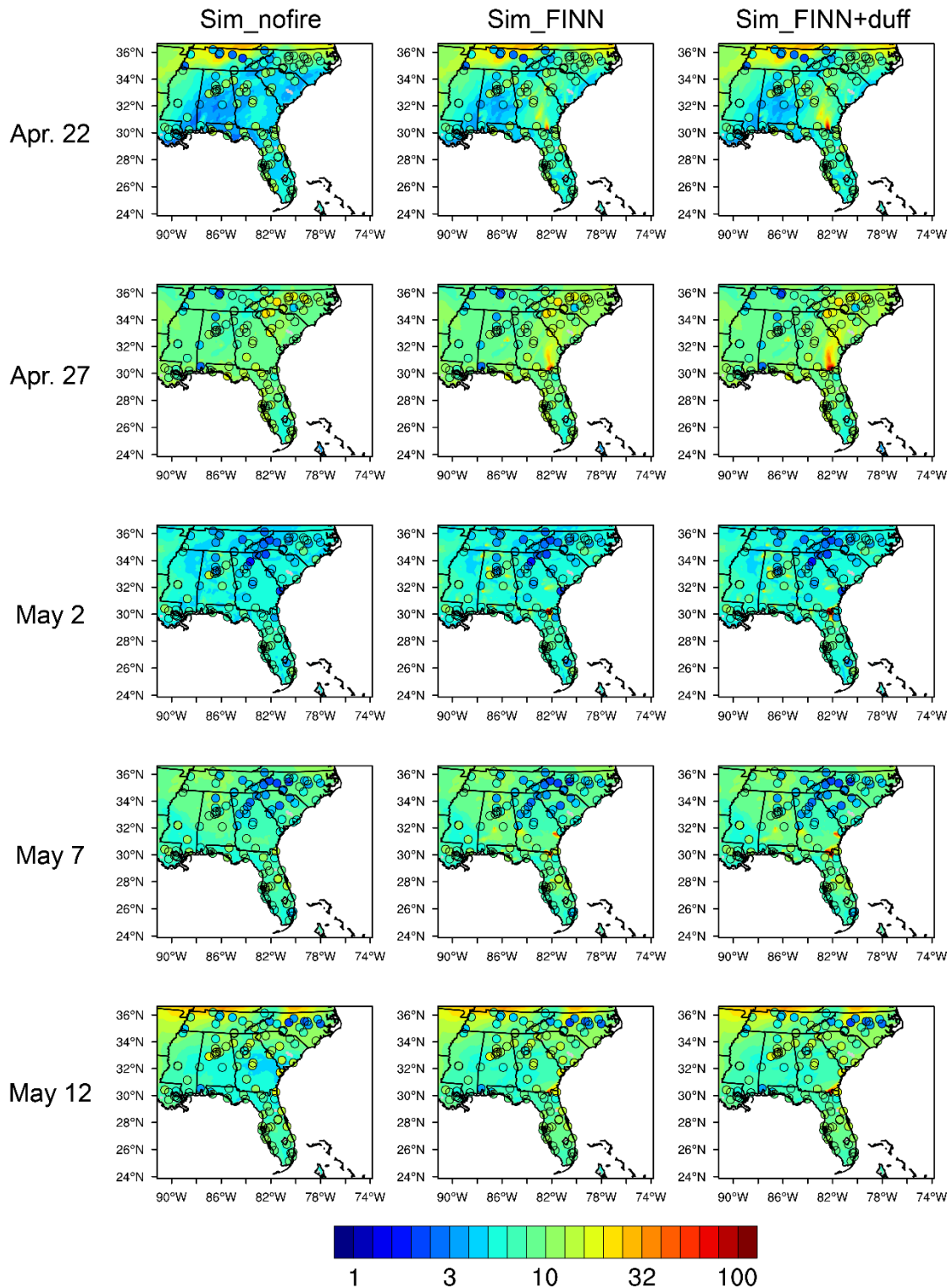


Figure S11. PM_{2.5} daily mean surface concentration (µg m⁻³) during Oke17 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed PM_{2.5} daily mean surface concentrations during the fire event.

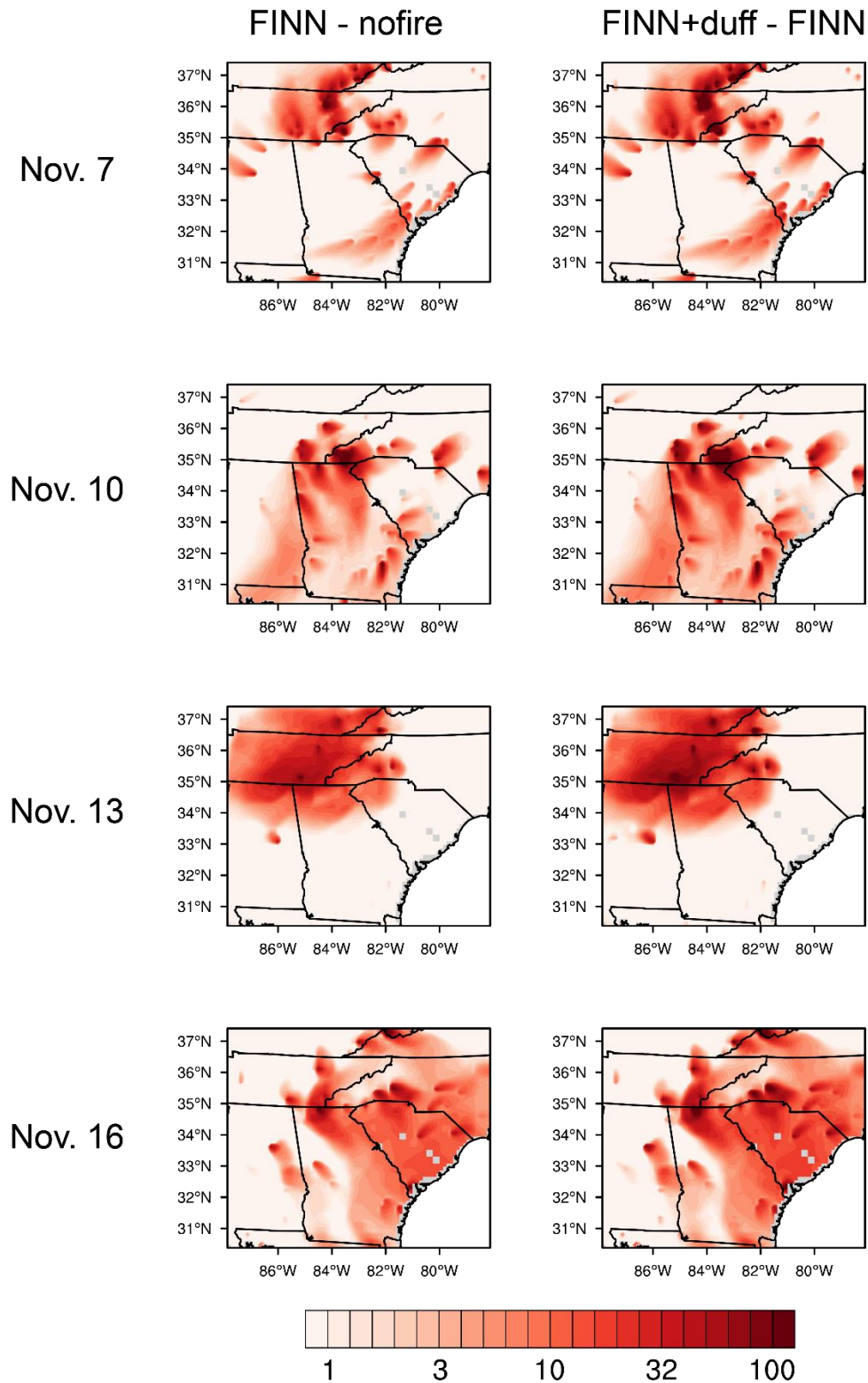


Figure S12. The PM_{2.5} daily surface concentration differences (μg m⁻³) between sim_FINN and sim_nofire and between sim_FINN+duff and sim_FINN during App16.

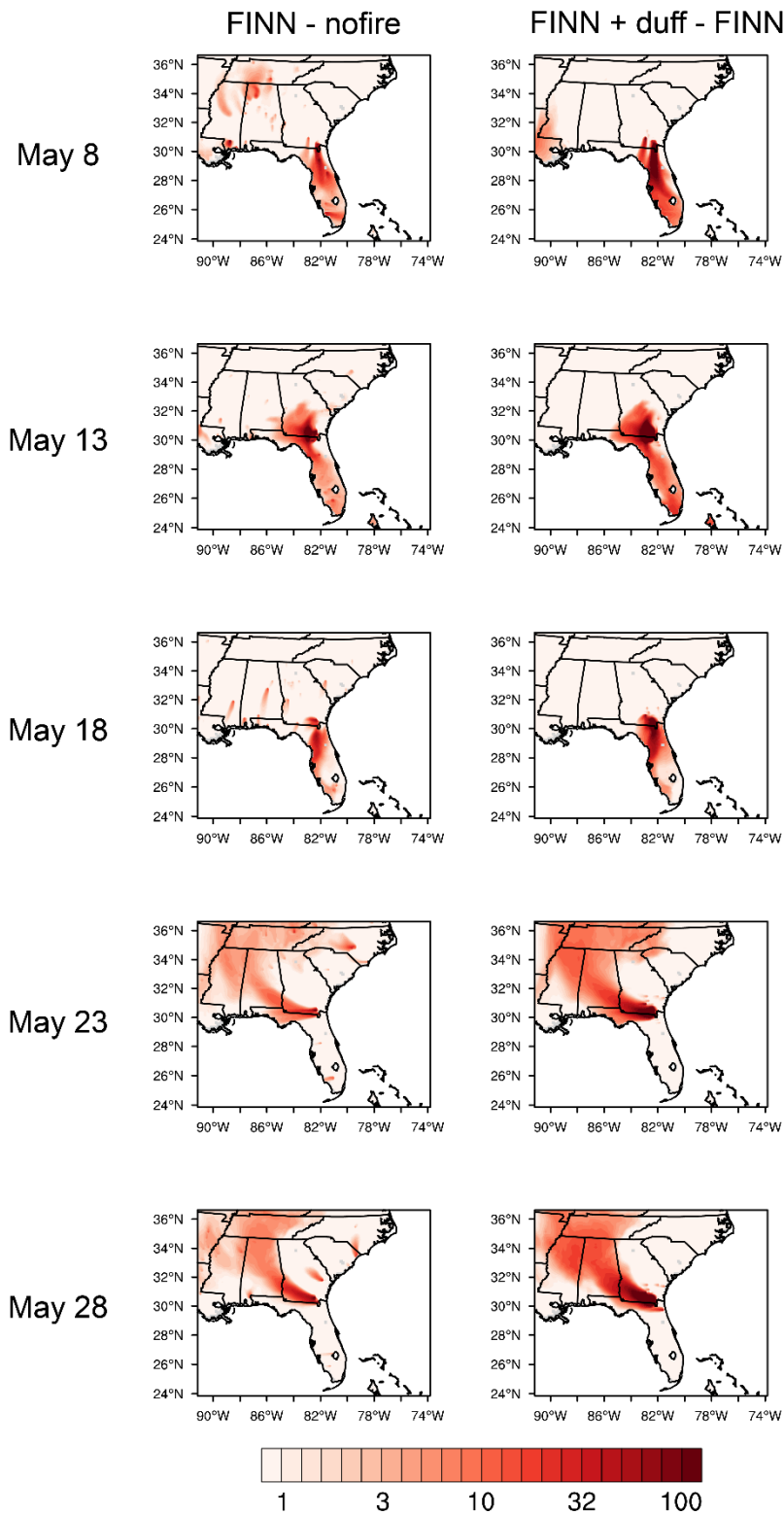


Figure S13. The PM_{2.5} daily surface concentration differences ($\mu\text{g m}^{-3}$) between sim_FINN and sim_nofire and between sim_FINN+duff and sim_FINN during Oke07.

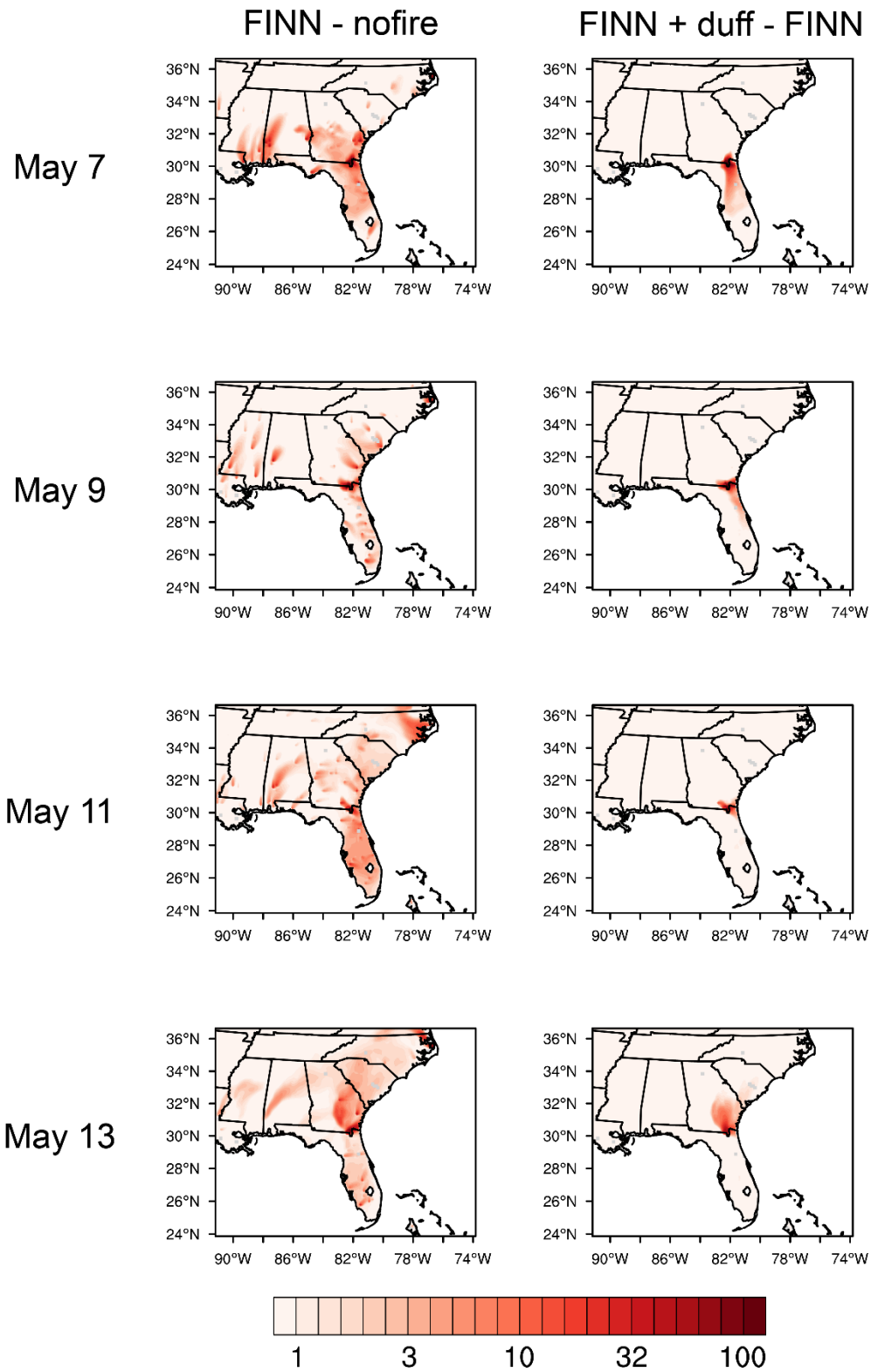


Figure S14. The PM_{2.5} daily surface concentration differences ($\mu\text{g m}^{-3}$) between sim_FINN and sim_nofire and between sim_FINN+duff and sim_FINN during Oke11.

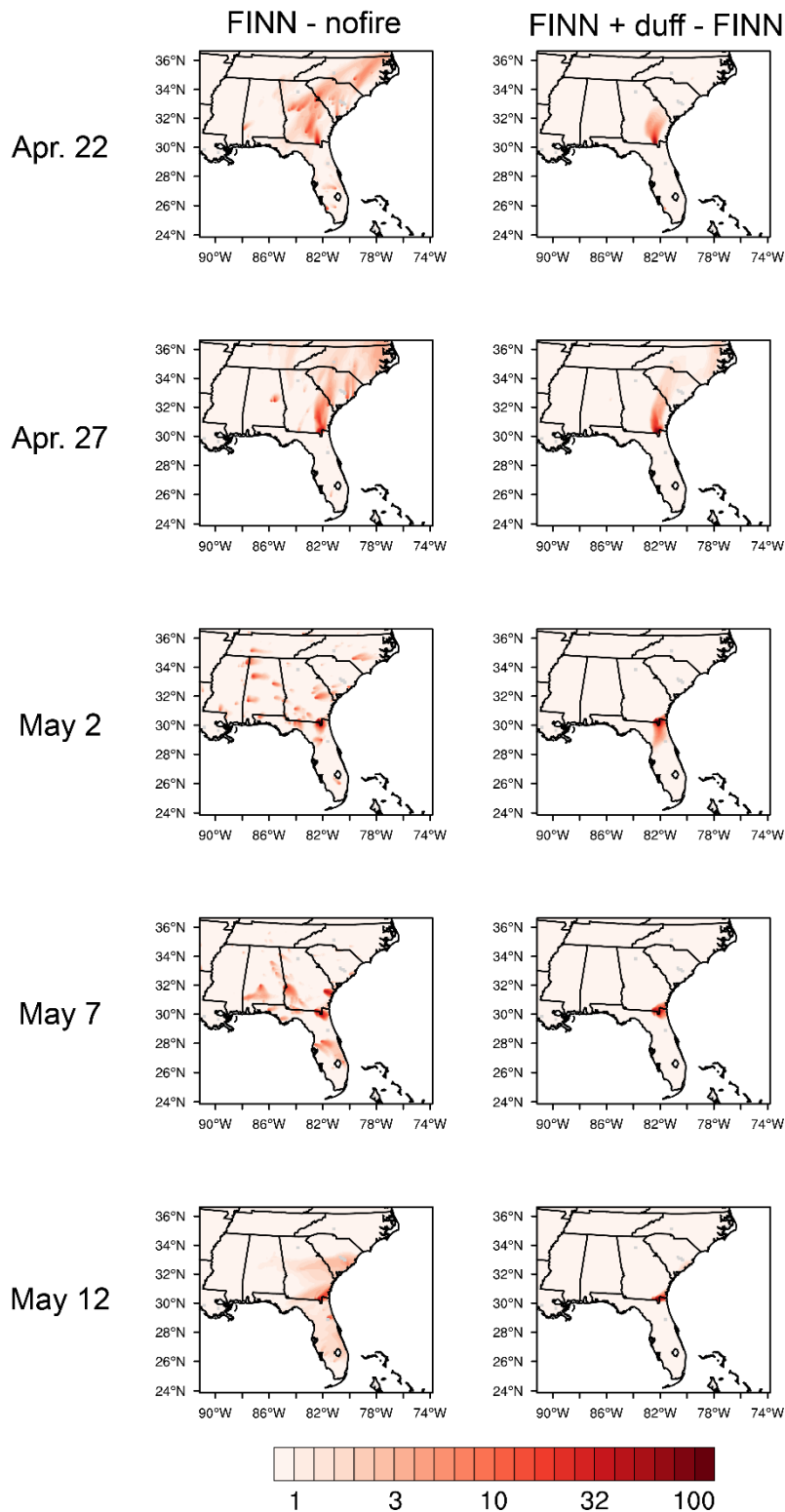


Figure S15. The PM_{2.5} daily surface concentration differences ($\mu\text{g m}^{-3}$) between sim_FINN and sim_nofire and between sim_FINN+duff and sim_FINN during Oke17.

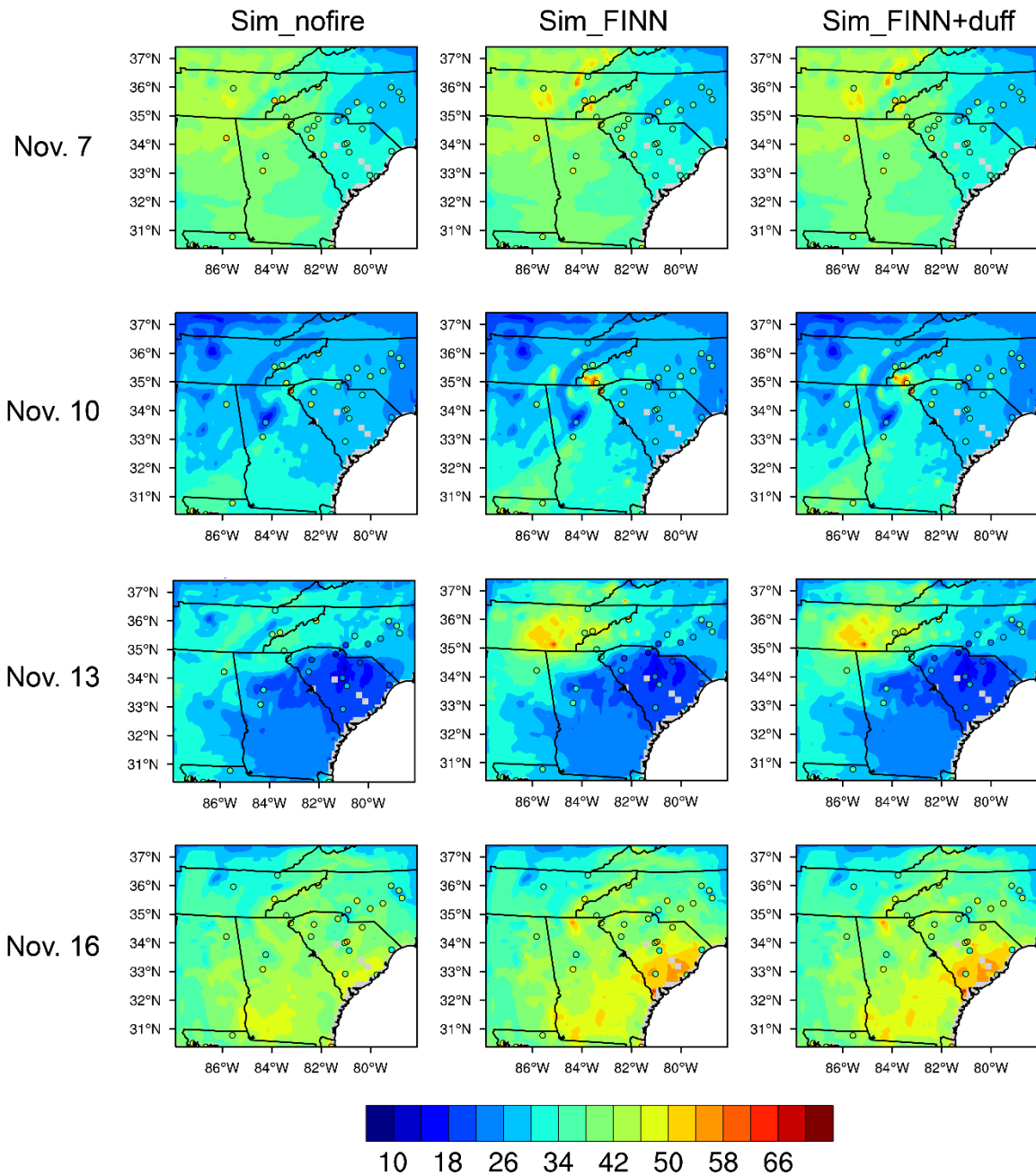


Figure S16. The ozone daytime surface concentration (averaged from local time 10 am to 6 pm; ppb.) during App16 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed Ozone daytime surface concentrations during the fire event.

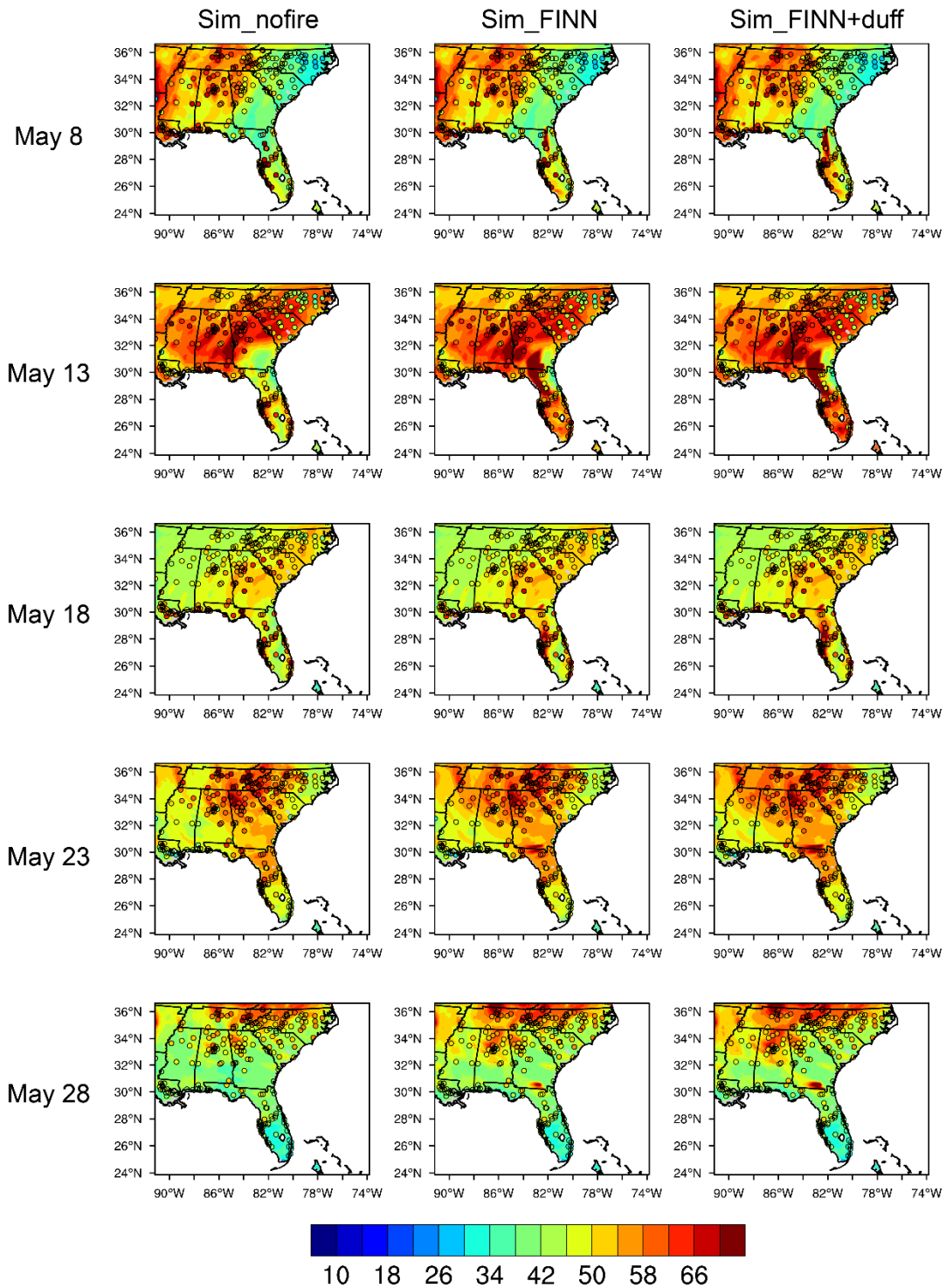


Figure S17. The ozone daytime surface concentration (averaged from local time 10 am to 6 pm; ppb.) during Oke07 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed Ozone daytime surface concentrations during the fire event.

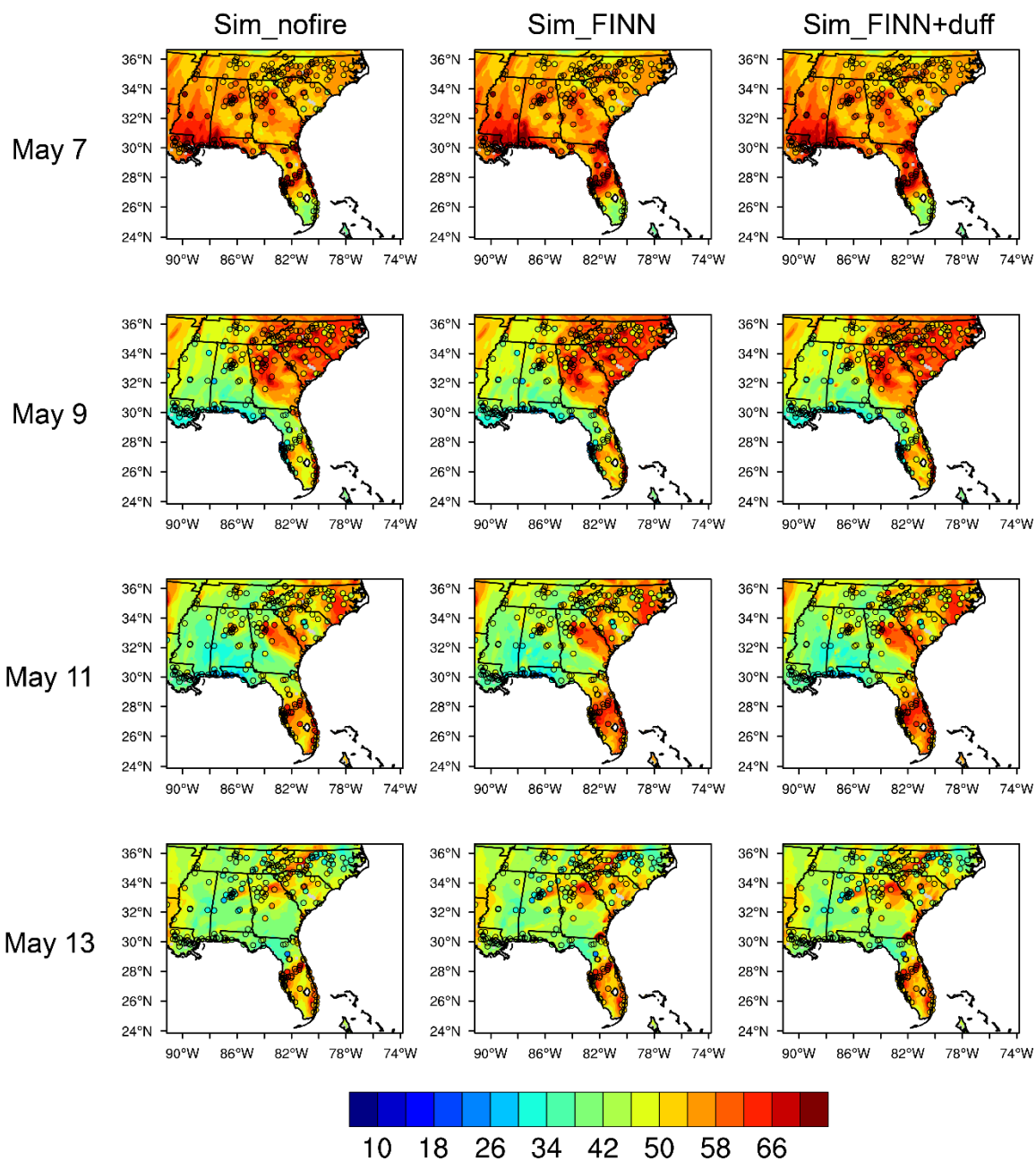


Figure S18. The ozone daytime surface concentration (averaged from local time 10 am to 6 pm; ppb.) during Oke11 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed Ozone daytime surface concentrations during the fire event.

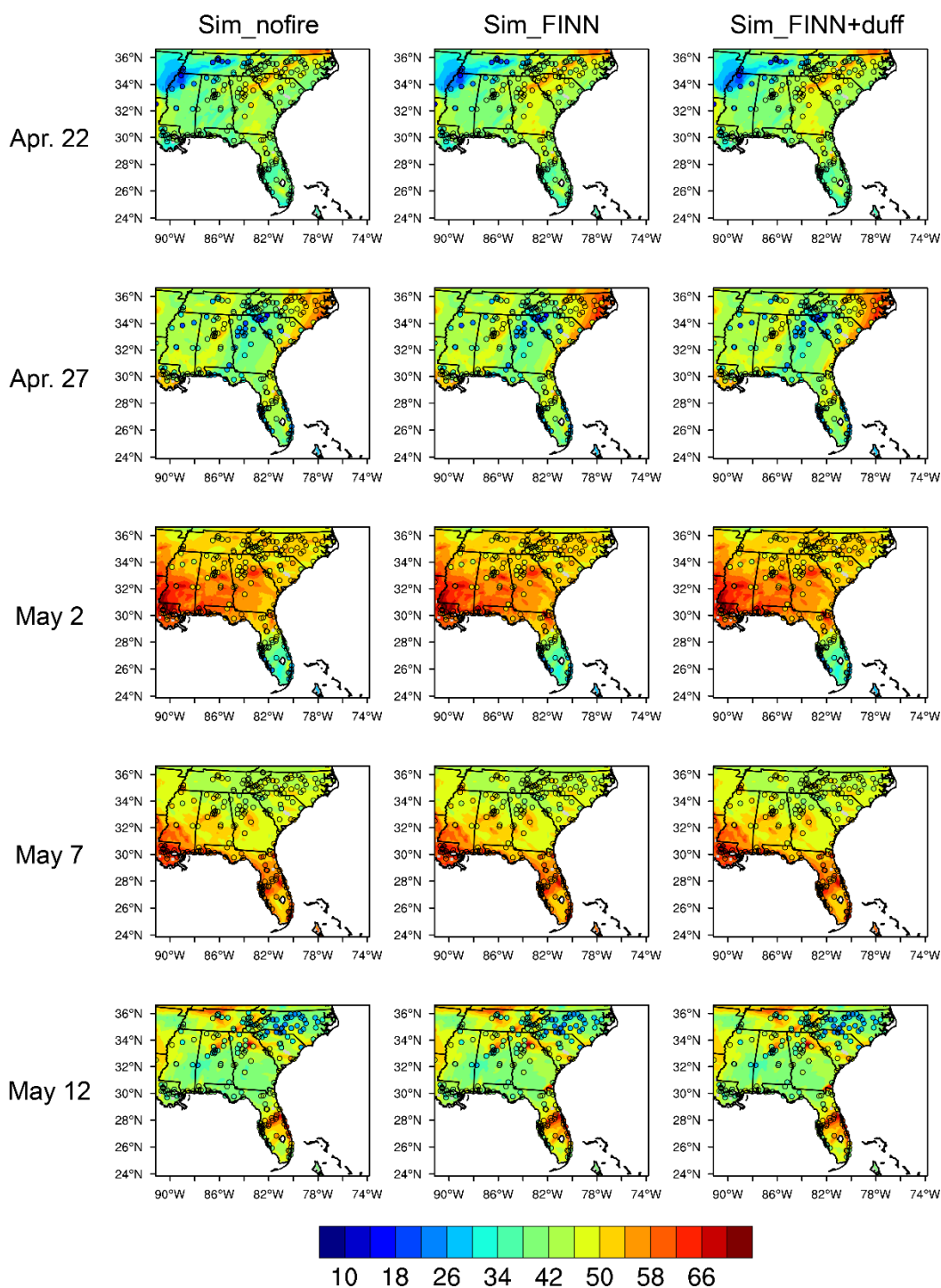


Figure S19. The ozone daytime surface concentration (averaged from local time 10 am to 6 pm; ppb.) during Oke17 simulated in sim_nofire, sim_FINN and sim_FINN+duff runs. The colored scatters represent the corresponding observed Ozone daytime surface concentrations during the fire event.

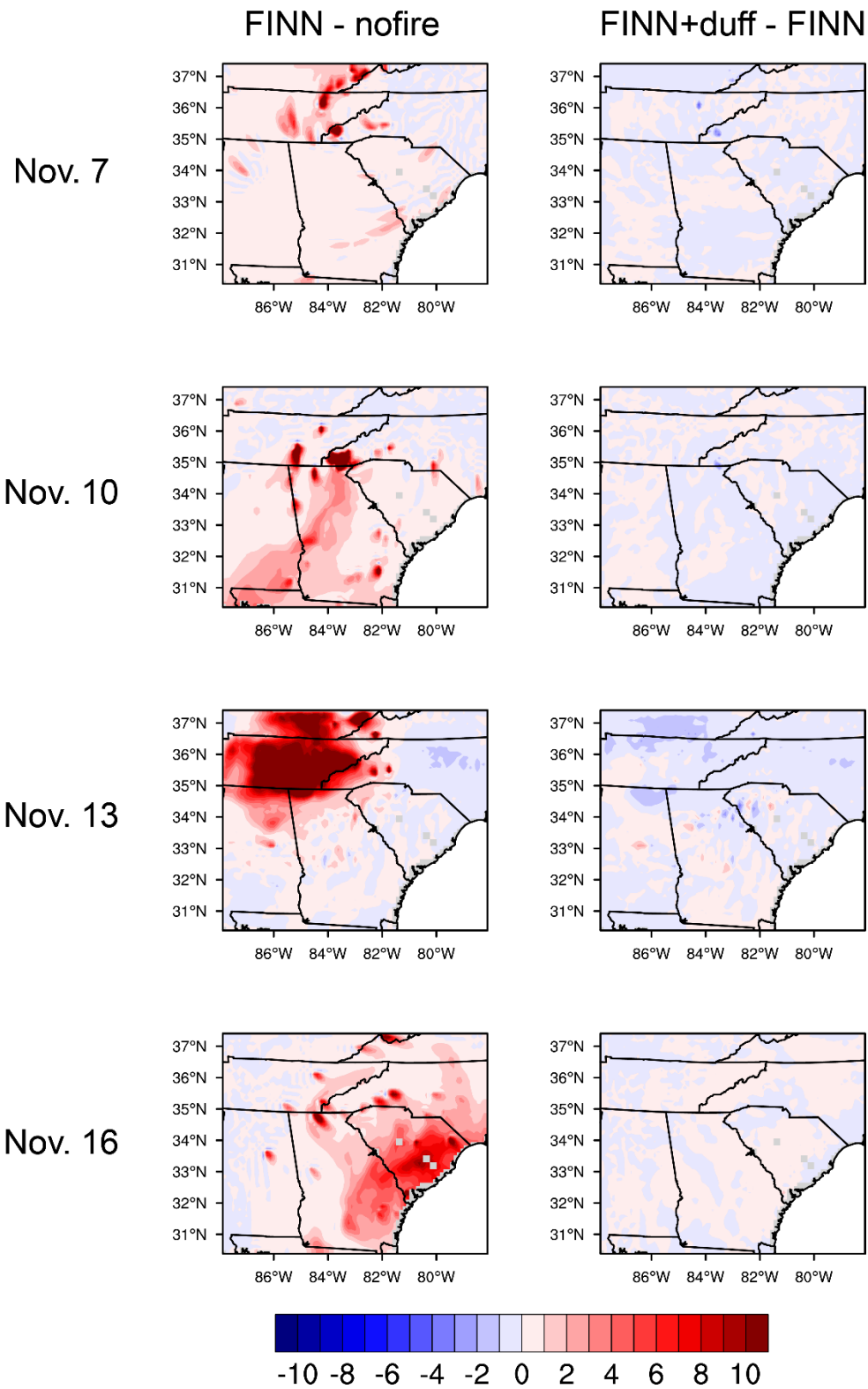


Figure S20. The ozone daytime surface concentration differences (ppb) between sim_FINN and sim_nofire and between sim_FINN+duff and sim_FINN during App16.

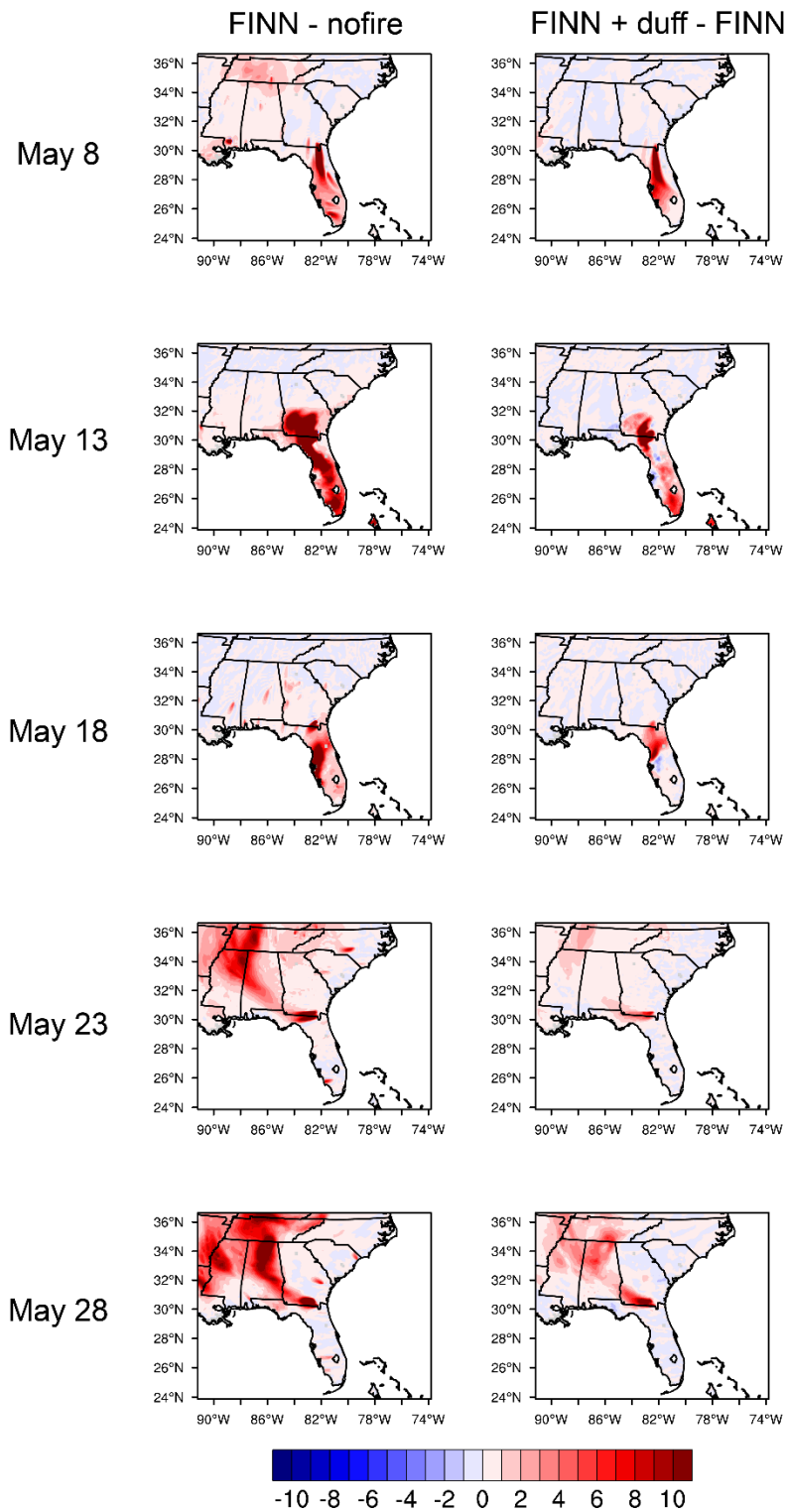


Figure S21. The ozone daytime surface concentration differences (ppb) between `sim_FINN` and `sim_nofire` and between `sim_FINN+duff` and `sim_FINN` during Oke07.

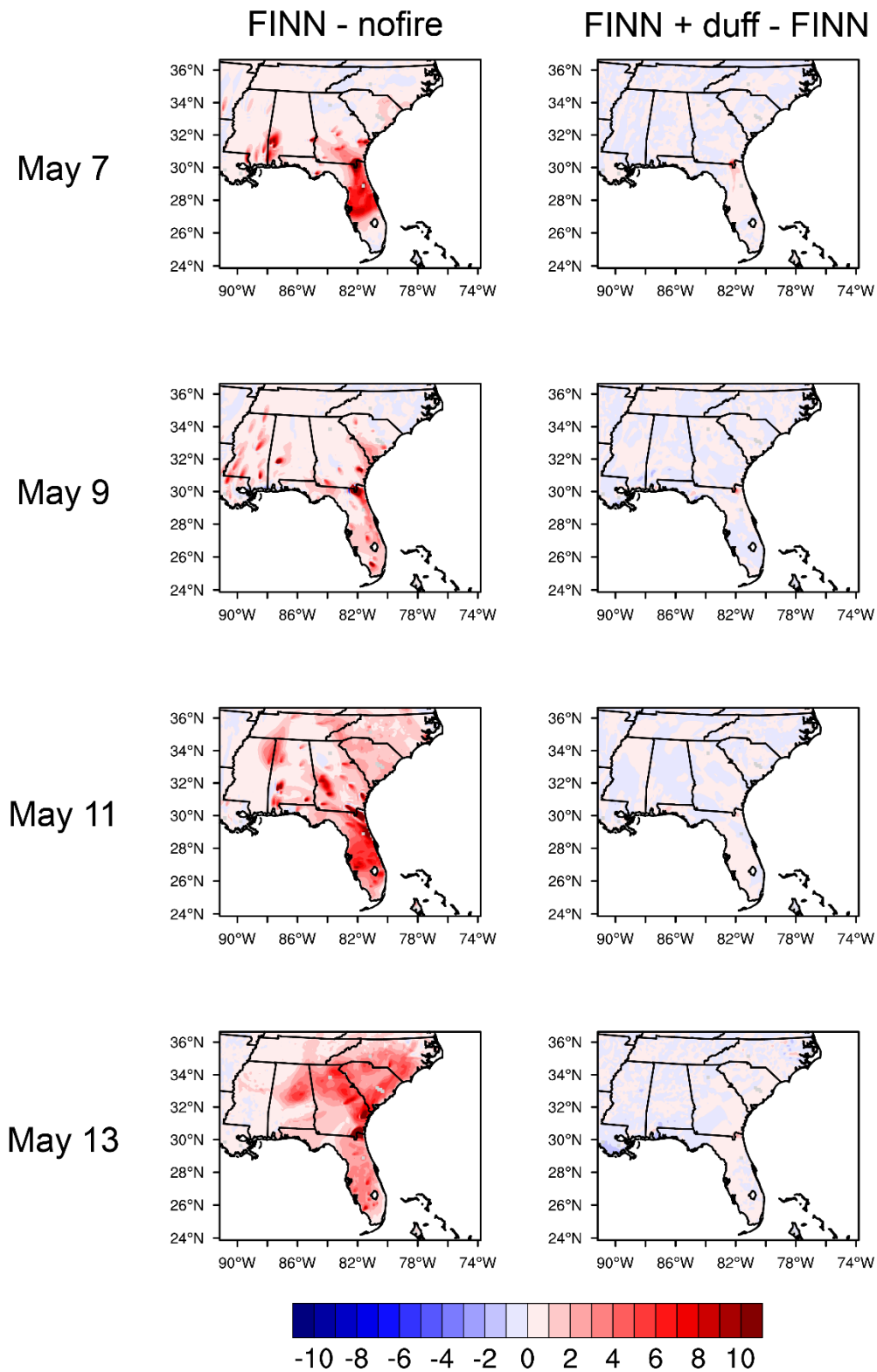


Figure S22. The ozone daytime surface concentration differences (ppb) between sim_FINN and sim_nofire and between sim_FINN+duff and sim_FINN during Oke11.

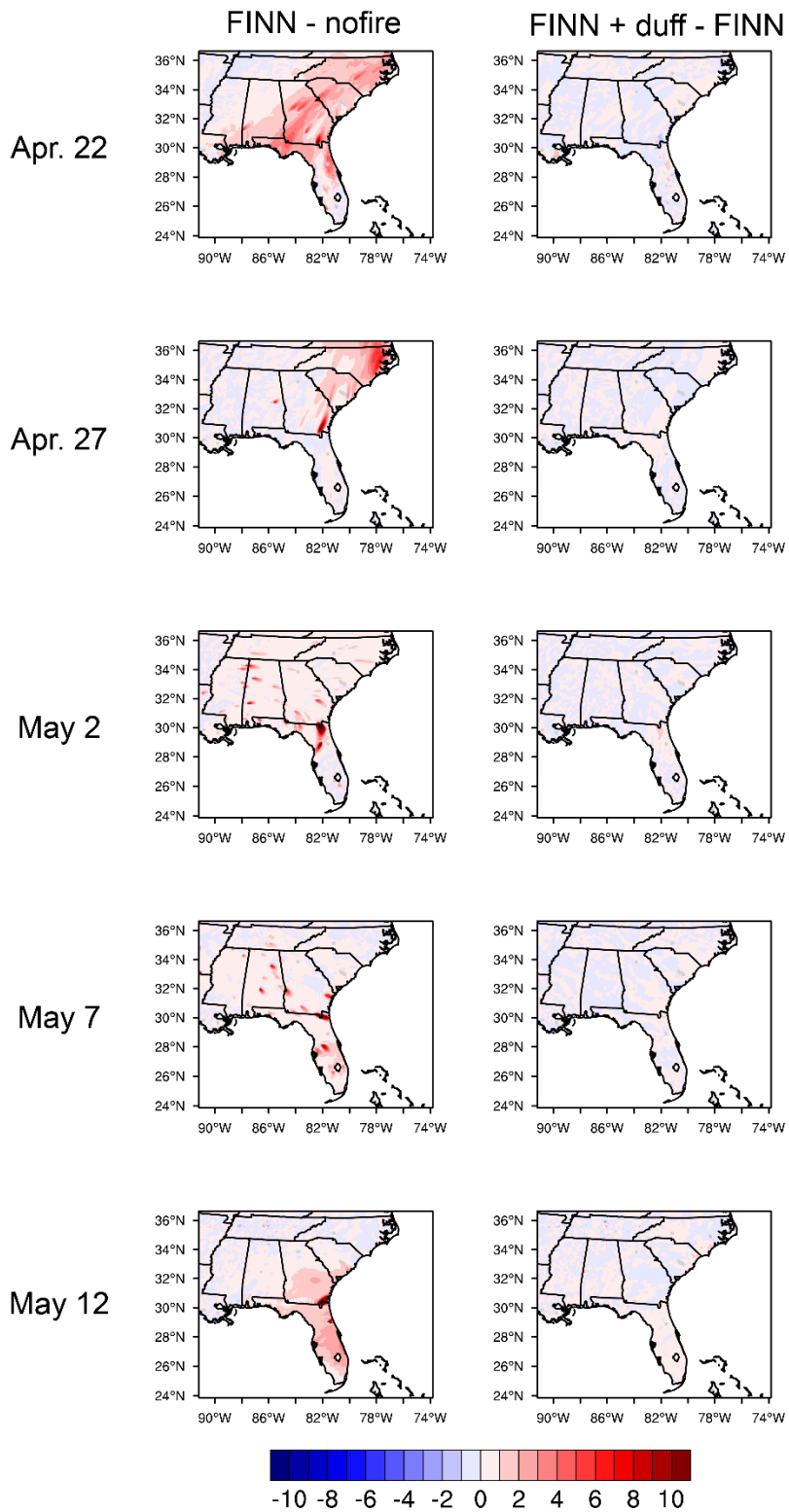


Figure S23. The ozone daytime surface concentration differences (ppb) between sim_FINN and sim_nofire and between sim_FINN+duff and sim_FINN during Oke17

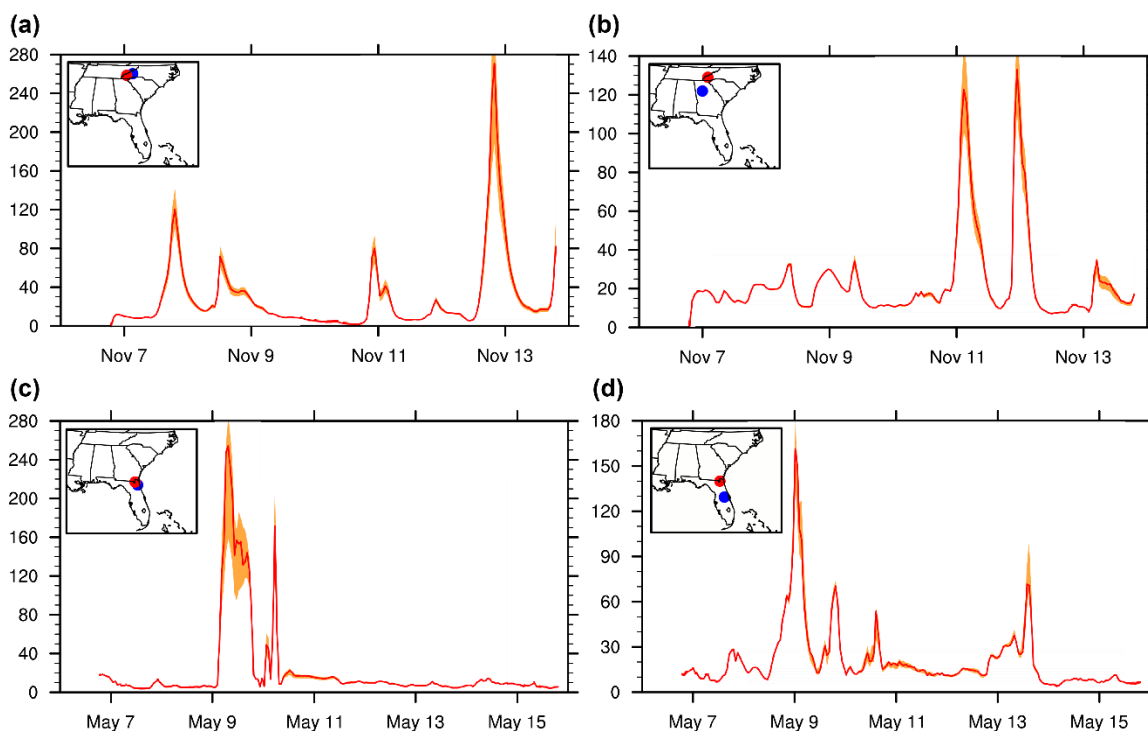


Figure S24. The time series of hourly surface PM_{2.5} ($\mu\text{g m}^{-3}$) concentrations in the sim_FINN+duff simulations. (a, b) App16. (c, d) Oke07. The shaded red represents the PM_{2.5} variation from the sensitivity runs changing the duff emission by $\pm 30\%$. The fire location (red) and site location (blue) are shown in the map attached to each panel. The studied sites are located in (a) Buncombe county, North Carolina, (b) Fulton county, Georgia, (c) Duval county, Florida and (d) Orange county, Florida.

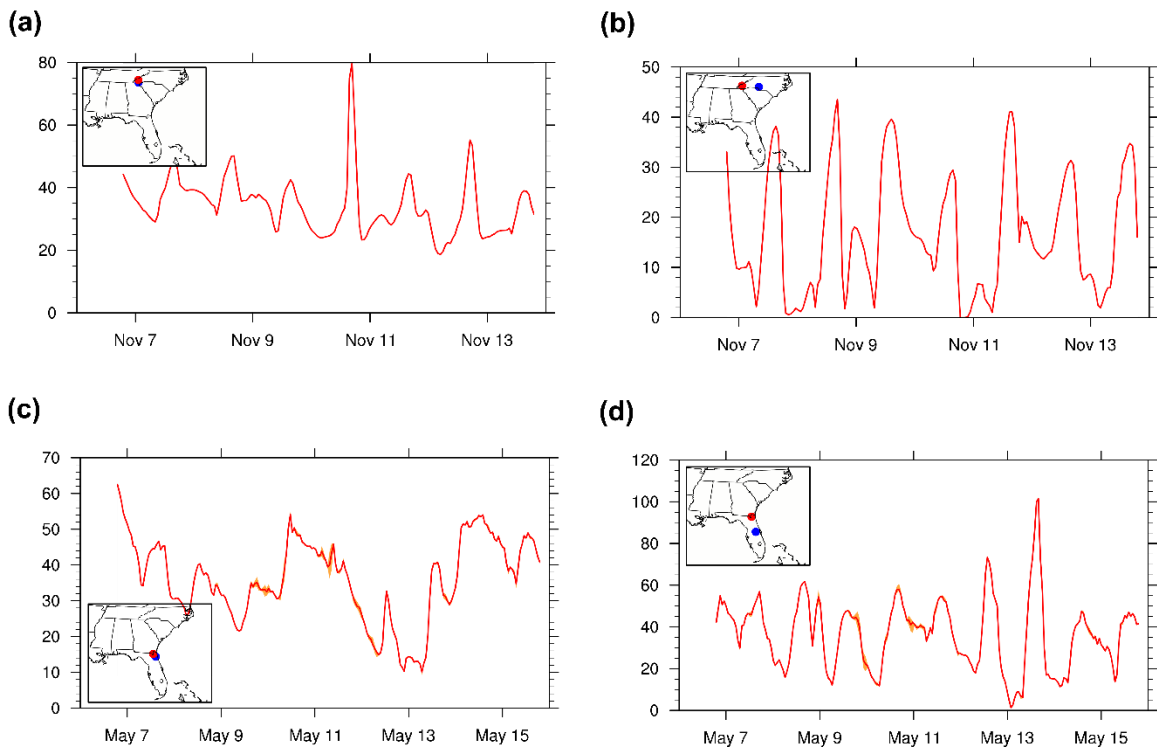


Figure S25. The time series of hourly surface ozone (ppb) concentrations in the sim_FINN+duff simulations. (a, b) App16. (c, d) Oke07. The shaded red represents the PM_{2.5} variation from the sensitivity runs changing the duff emission by $\pm 30\%$. The fire location (red) and site location (blue) are shown in the map attached to each panel. The studied sites are located in (a) Macon county, North Carolina, (b) Fulton county, Georgia, (c) Duval county, Florida and (d) Orange county, Florida.

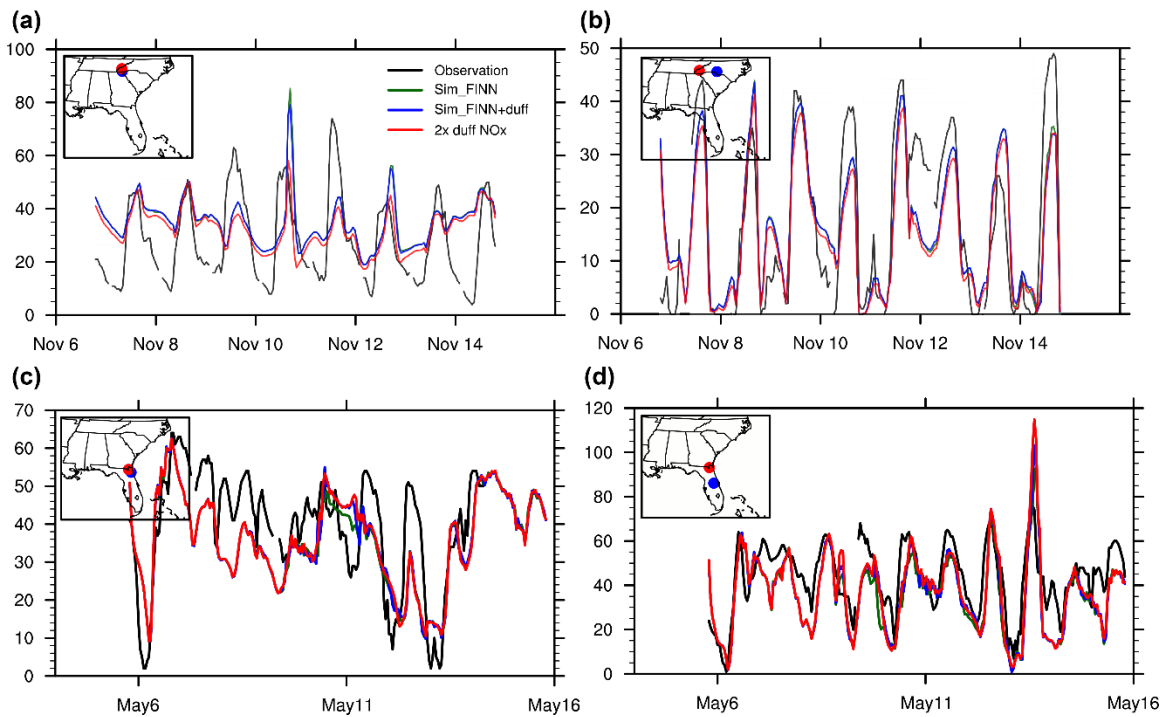


Figure S26. Comparisons of in-situ hourly surface ozone concentrations (ppb) among the observation (black), sim_FINN (green), sim_FINN+duff (blue) and 2x duff NOx simulations. (a, b) App16. (c, d) Oke07. The fire location (red) and site location (blue) are shown in the map attached to each panel. The studied sites are located in (a) Macon county, North Carolina, (b) Fulton county, Georgia, (c) Duval county, Florida and (d) Orange county, Florida.

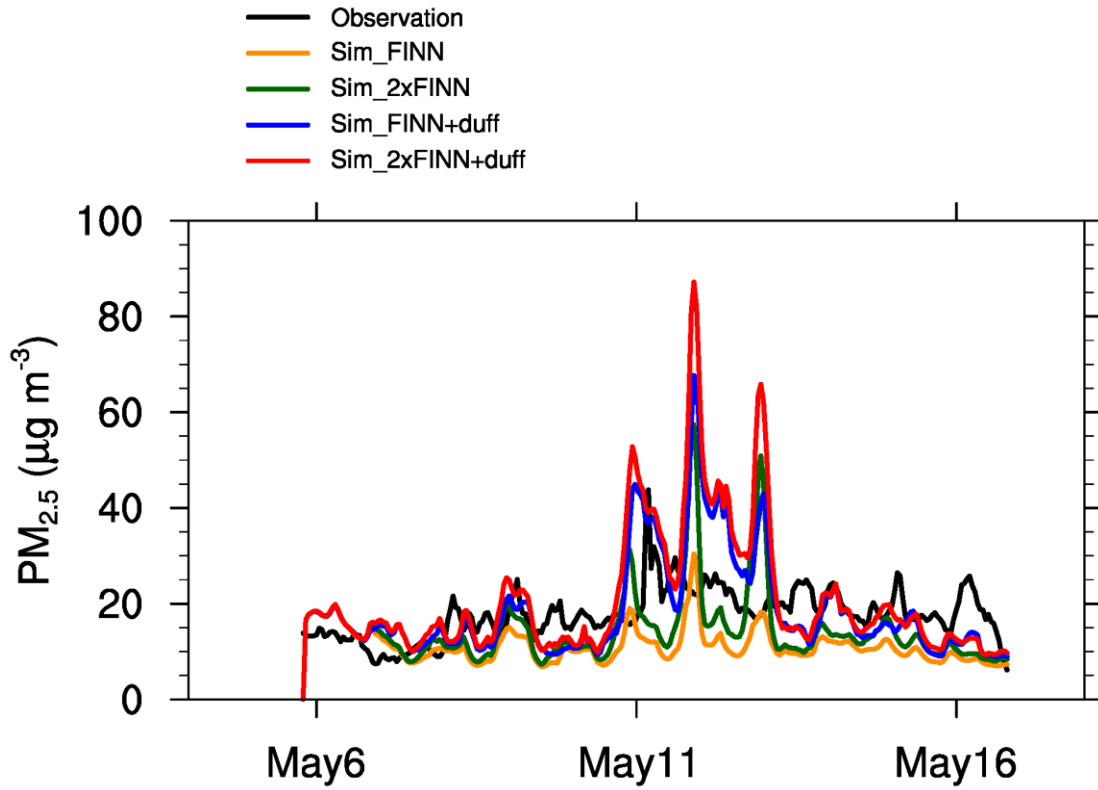


Figure S27. The time series of hourly surface PM_{2.5} concentrations from May 6 – 16, 2017 in the observations, sim_FINN, sim_FINN+duff, and corresponding simulations with FINN emission doubled (sim_2xFINN and sim_2xFINN+duff) in the simulated region.

Table S1. Summary of previous studies of the PM emission factors of duff/peat/organic soil burnings.

Source	Region	Fuel type	Emission Factor (g/kg)	Note
Geron and Hays (2013)	Southeastern US	Peat/Organic soil	34 - 79	34-79 g/kg for ground fire; 9-16 g/kg for prescribed fire
Black et al. (2016)	Southeastern US	Peat	7.1 and 5.9	
Benner (1977)	Southeastern US	Peat/Organic soil	44 ± 9	Total suspended particulate (TSP) is measured.
McMahon et al. (1980)	Southeastern US	Peat	30 ± 20	
Urbanski (2014)	US	Duff/Organic soil	50 ± 16	Average of ground fire values by Geron and Hays (2013)
Yokelson et al. (2013)	US	Organic soil	20	prescribed burning
Kiely et al. (2020)	Equatorial Asia	Peat	22.3	Summarized from previous studies, used in model simulations
Roulston et al. (2018)	Southeast Asia	Peat	8 - 58	Average 24 g/kg; newly ignited fire has higher emission factor.
Jayarathne et al. (2018)	Indonesia	Peat	17	
Stockwell et al. (2016)	Indonesia	Peat	15.7-29.6	
May et al. (2014)	Indonesia	Peat	34.9	PM1 emission factor from lab burns
Bertschi et al. (2003)	Africa	Duff	6 - 16	
Andreae (2019)	Global	Peat	18.9 ± 2.3	Summarized from previous studies
Akagi et al. (2011)	Global	Peat	9.92	Summarized from previous studies
Giglio et al. (2013)	Global	Peat	9.1	Used in GFED4

Table S2. Summary of the duff burning emission factors of the gas phase species used in this study, based on Yokelson et al. (2013)

Species	Emission factor (g/kg)	Species	Emission factor (g/kg)
CO	271	CH ₃ OH	3.24
NO	0.559	MEK	0.422
SO ₂	1.76	Toluene	2.5965
NMOC	68.67	NH ₃	2.67
Bigalk	0.658	NO ₂	0.176
Bigene	1.4332	Open	1.1998
C ₂ H ₄	1.43	C ₁₀ H ₁₆	1.1102
C ₂ H ₅ OH	0.495	CH ₃ COOH	7.47
C ₂ H ₆	1.339	MGLY	0.153
C ₃ H ₈	0.797	Acetol	0.277
C ₃ H ₆	1.22	Isoprene	0.0786
CH ₂ O	1.88	MACK	0.102
CH ₃ CHO	2.7	MVK	0.421
CH ₃ COCH ₃	1.39	CH ₄	7.47

Table S3. Summary of previous studies of the NO_x emission factors of duff burnings.

Source	NO emission factor (g/kg)		NO ₂ emission factor (g/kg)	
	duff	above-ground fuel	duff	above-ground fuel
Burling et al. (2010)	0.738	1.720 ± 0.454	0.232	1.023 ± 0.286
Selimovic et al. (2018)	0.56-0.93	1.78(0.44-3.53)	0.77-1.30	1.26(0.44-7.04)
McMeeking et al. (2009)	2.0 ± 0.7	1.7-4.6	1.0 ± 0.5	0.3-1.6
Clements and McMahon (1980)	11.58	0.23-16.50	2.7	0.06-7.32
Yokelson et al. (2013)	0.559*	0.77-1.74	0.176*	1.01-2.68

* The number is used in this study.

Table S4 Summary of duff flaming rate and the corresponding fuel loading for the studied fire cases.

Fire case	mean duff flaming depth and rate (cm/day)	duff fuel loading (kg/m ²)
App16	4.6	3.15
Oke07	4.6	3.15
Oke11	0.95	0.65
Oke17	1.68	1.15
ER08	4.6	3.15
PB11	4.6	3.15

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