

Emission Source Areas of Fine Particulate Matter (PM_{2.5}) in Ho Chi Minh City, Vietnam

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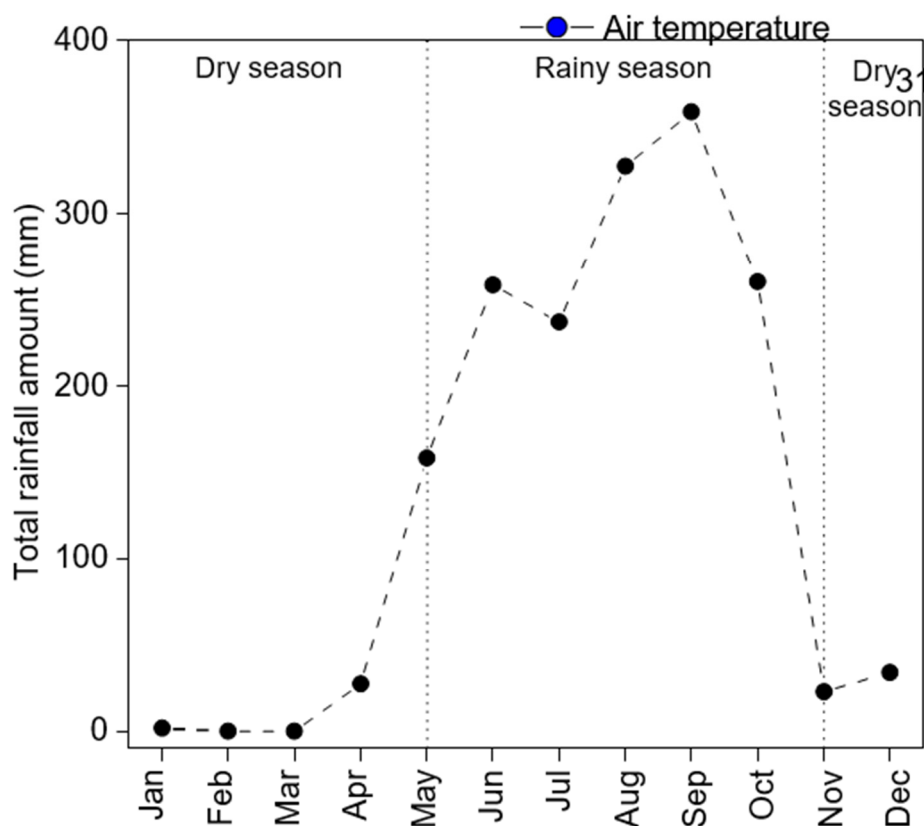


Figure S1. Monthly rainfall amount monitored at Mac Dinh Chi station in Ho Chi Minh city during the study period.

Text S1. Relationships between the PM_{2.5} mass concentrations and meteorological parameters.

The PLS approach was used to understand relationships between the PM_{2.5} mass concentrations and meteorological parameters in the dry and rainy seasons of HCM city. As shown in Figure S5, wind speed had the negative relations with the PM_{2.5} mass concentrations in both the dry and rainy seasons, meaning that strong winds could lead to the lower PM_{2.5} mass concentrations and vice versa. This is because the higher wind speeds can increase the PM_{2.5} dispersion and thus, result in a decline in the PM_{2.5} mass concentrations. The ambient air temperature and relative humidity also had a significantly negative relations with the PM_{2.5} mass concentrations in HCM city, especially in the rainy season (Figure S5b). The higher air temperature would contribute to the expansion of the air mixing layer, which facilitated the vertical mixing of PM_{2.5} and led to a decline in PM_{2.5} mass concentrations. Additionally, the greater relative humidity in the rainy season ($82.6 \pm 3.9\%$), compared to the dry season ($68.8 \pm 5.3\%$) (Figure S4), would increase the size of particulate matters.

[11] and promote their dry deposition, resulting in a decline in the PM_{2.5} mass concentrations. In addition, the PM_{2.5} mass concentrations in HCM city had the positive relationships with the air pressure in both the dry and rainy seasons (Figure S5). Indeed, under high-pressure conditions, air pollutants may be prevented from moving upward [12], resulting in an accumulation of PM_{2.5} and thus, an increase in PM_{2.5} mass concentrations. Furthermore, the positive relation between wind direction and the mass concentrations of PM_{2.5} in the dry and rainy seasons would be related to seasonal monsoon, and this issue is more thoroughly discussed in Sections 3.2 and 3.3 of the manuscript.

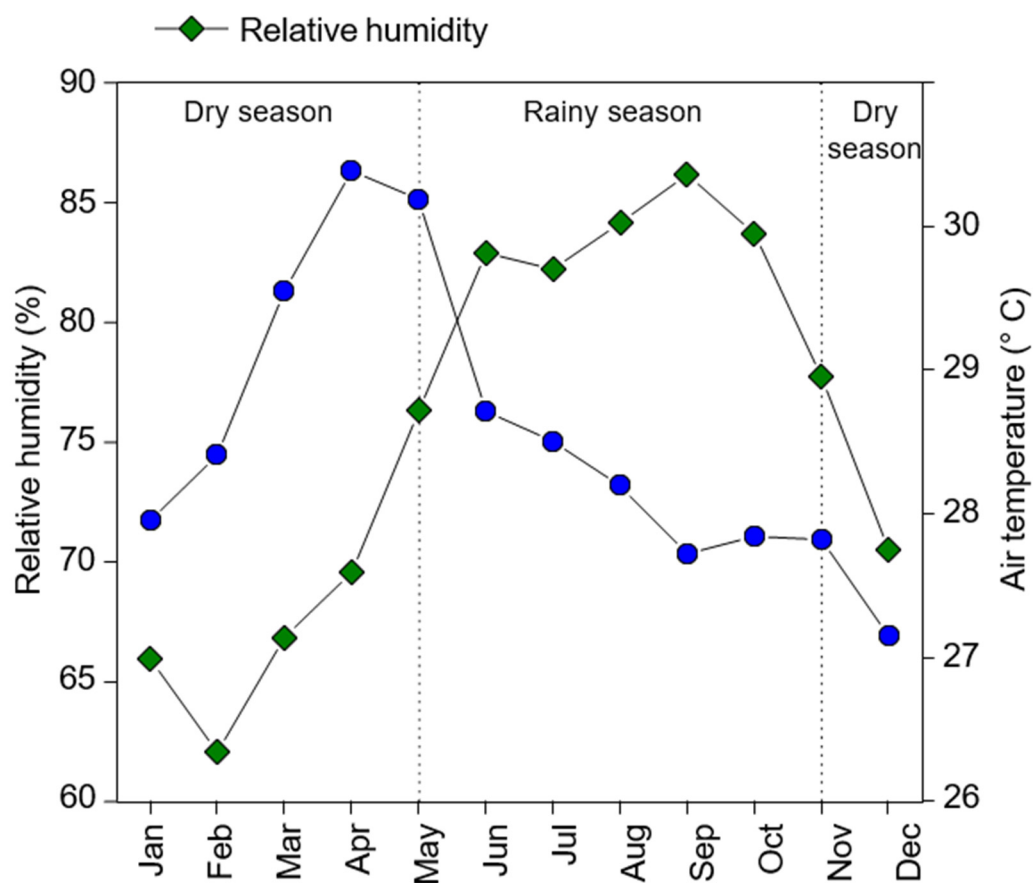


Figure S2. Monthly variations of the relative humidity and ambient air temperature in Ho Chi Minh city during the study period.

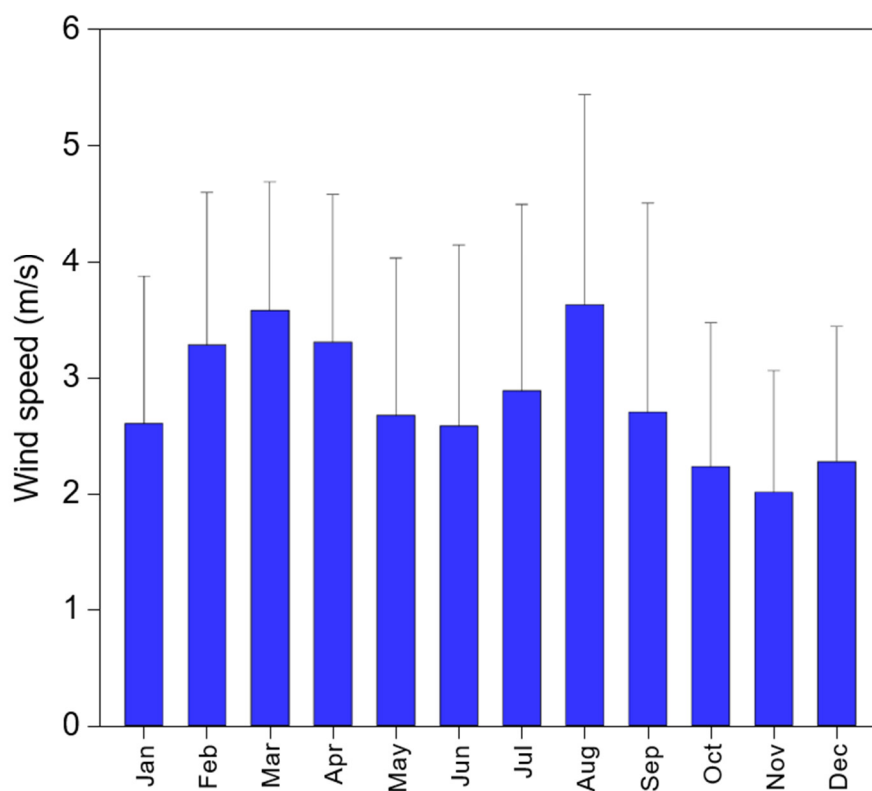


Figure S3. Monthly wind speed in Ho Chi Minh city during the study period.

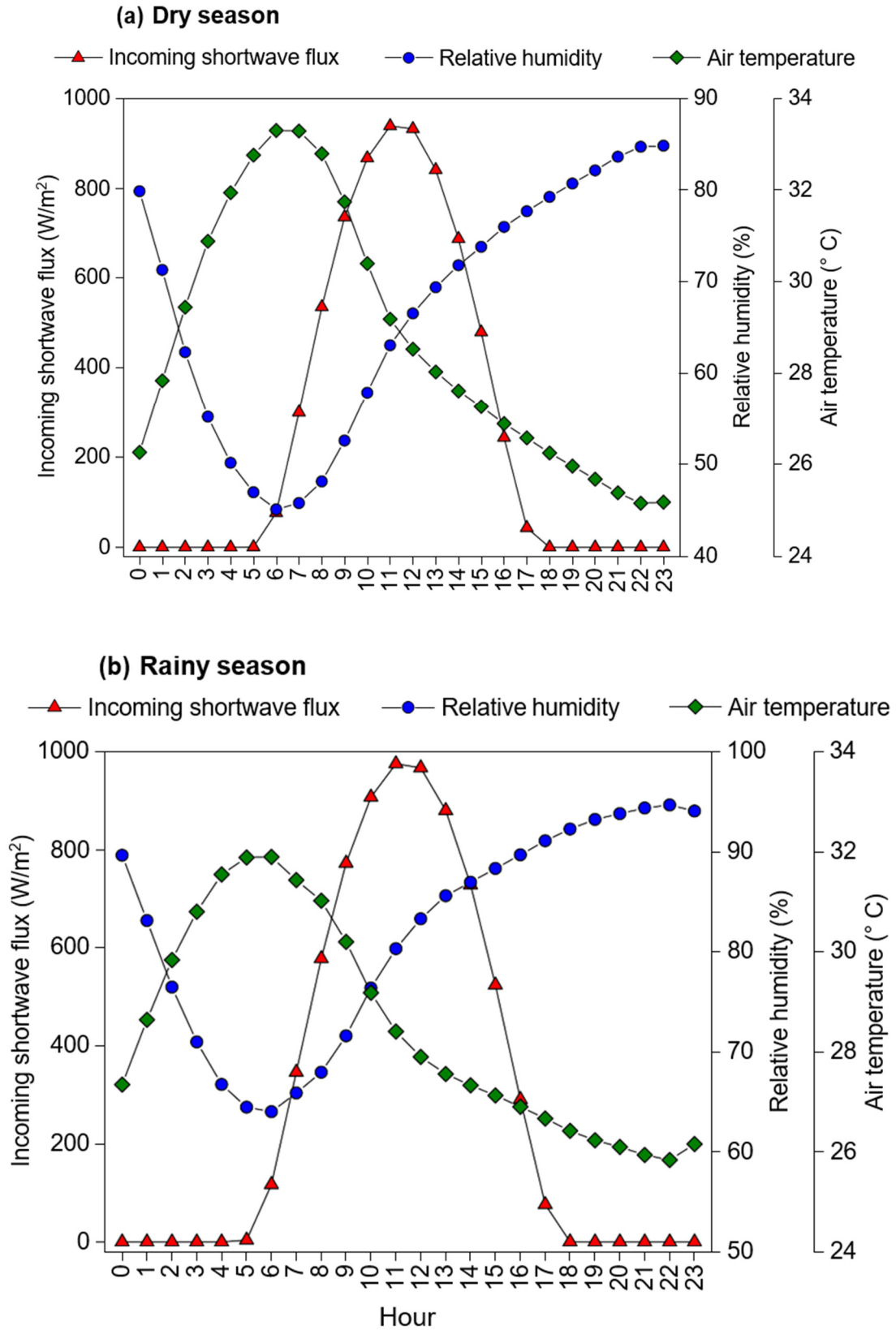


Figure S4. Hourly variations of the incoming shortwave flux, relative humidity, and ambient air temperature in the (a) dry and (b) rainy seasons of Ho Chi Minh city.

Table S1. Mass concentrations of PM_{2.5} in Ho Chi Minh (HCM) city, Vietnam, and some other cities in Asia.

No	City	City	Site/Area	Period	Mass Concentration ($\mu\text{g m}^{-3}$)	References
1	HCM City	Vietnam	Urban	2013–2017	22.7–38.9 ^(*) 28±18	[1,2]
2	HCM City	Vietnam	Roadside	12/2007–01/2008	53–151 97±31	[2]
3	Ha Noi	Vietnam	Urban	2006–2007	26–143 76±32	[3]
4	Ha Noi	Vietnam	Mixed site	2015	71±48	[4].
5	Bangkok	Thailand	Roadside	2010	57±13	[5]
6	Bangkok	Thailand	Urban	08/2017–03/2018	77±21 ^(**)	[6]
7	Kuala Lumpur	Malaysia	Semi-urban	07/2014–09/2014	6.6–68	[6.7]
8	Bandung	Indonesia	Downtown	11/2018– 01/2019	18±12 29±8.6	[8]
9	Bandung	Indonesia	Downtown	07/2019– 09/2019	39±13	[8]
10	HCM City	Vietnam	Downtown	01/2019–12/2020	17–35 ^(*) 3.5–98 25±6.3	This study

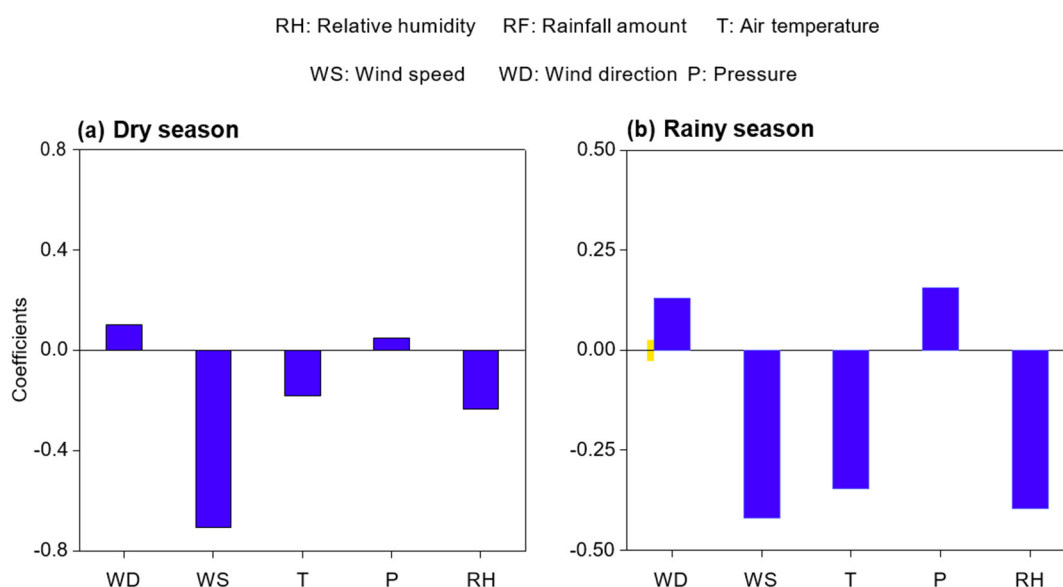


Figure S5. Results of the PLS for the (a) dry and (b) rainy seasons. The daily PM_{2.5} mass concentrations and meteorological parameters were set as the dependent and independent variables, respectively.

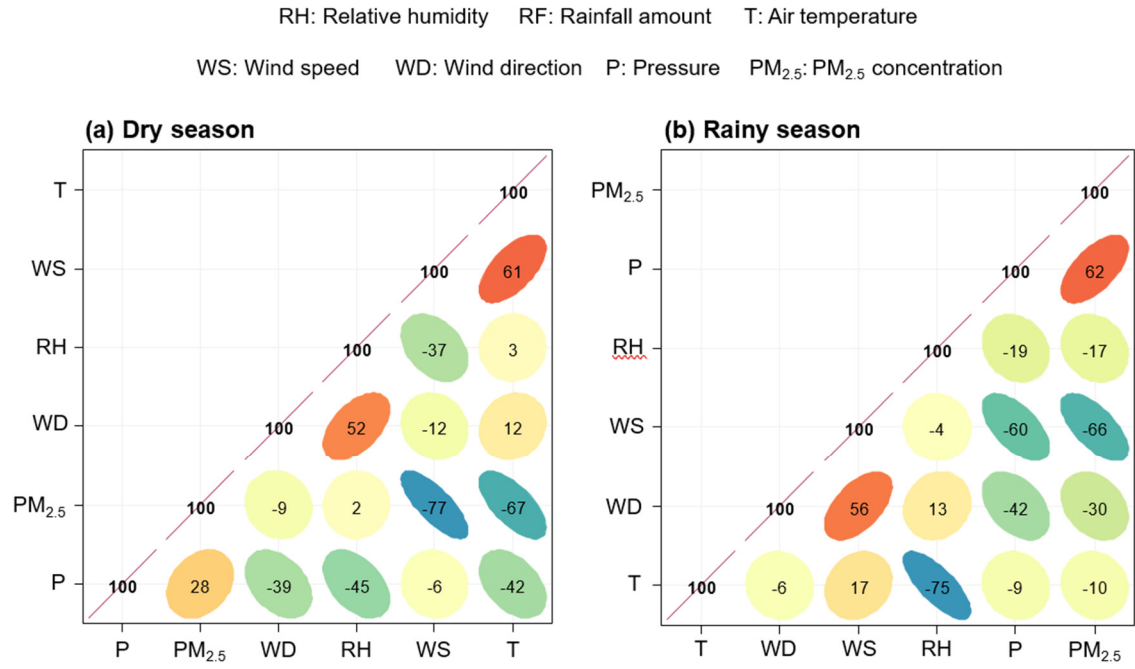


Figure S6. Spearman correlation matrix of PM_{2.5} concentrations and meteorological parameters in the (a) dry and (b) rainy seasons. The numbers indicate correlation coefficients. RStudio [9] and Openair package [10] were used to generate the correlation matrices.

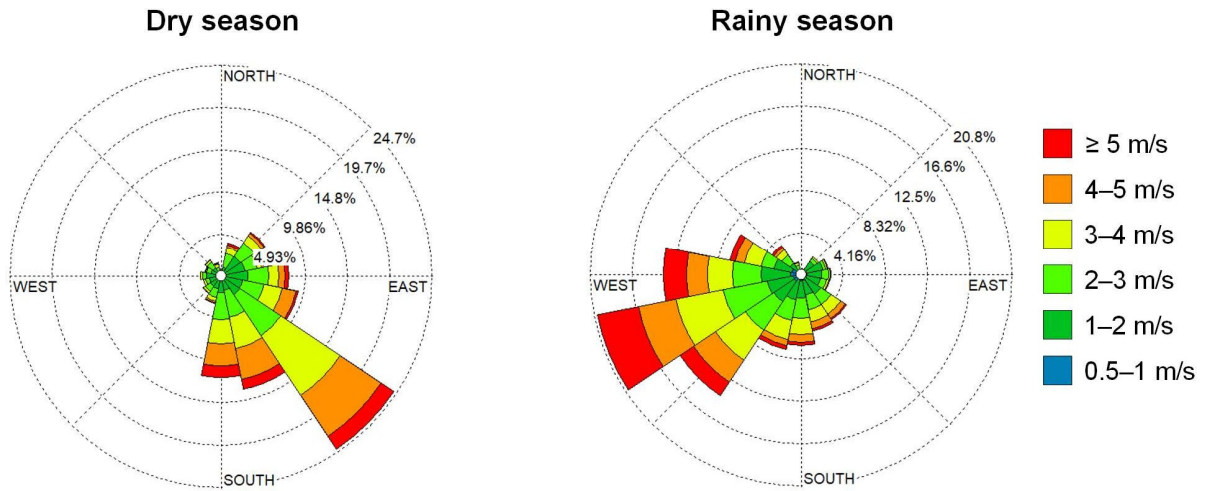


Figure S7. Wind directions of the dry and rainy seasons in HCM city during the study period.

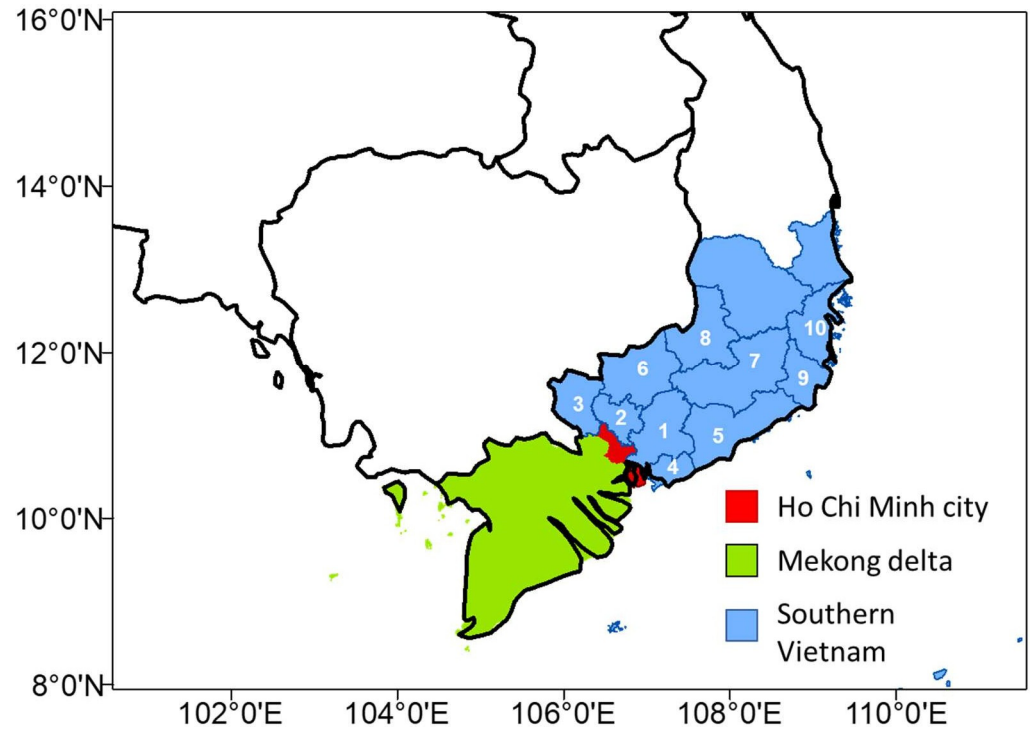


Figure S8. Locations of Ho Chi Minh city and its surrounding regions, including the Mekongdelta and several provinces of the southeastern and south-central cost Vietnam: (1) Dong Nai, (2) Binh Duong, (3) Tay Ninh, (4) Vung Tau, (5) Binh Thuan, (6) Binh Phuoc, (7) Lam Dong, (8) Dak Nong, (9) Ninh Thuan, and (10) Khanh Hoa.

Table S2. Mass concentrations of PM_{2.5} ($\mu\text{g m}^{-3}$) in each trajectory cluster. The analysis was performed using Trajstat plugin in MeteoinfoMap application.

Cluster no.	Number of trajectories	Mean	SD
<i>Dry season</i>			
1	2,086	30.0	14.6
2	2,113	16.9	10.3
3	2,755	27.9	17.5
<i>Rainy season</i>			
1	4,991	21.6	13.2
2	2,628	30.5	21.2
3	2,603	17.7	9.10

SD: standard deviation.

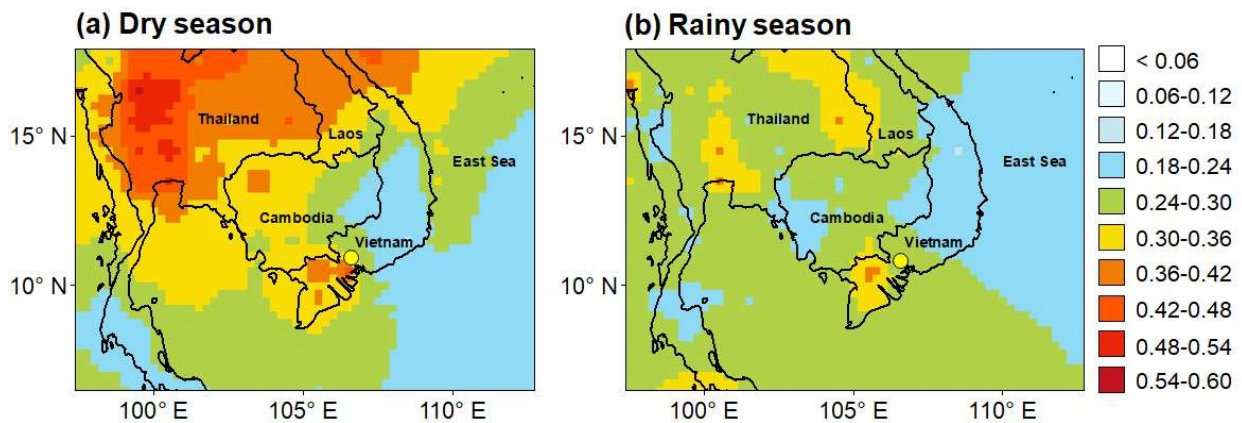


Figure S9. Aerosol optical depth (AOD) observed in Vietnam in the (a) dry and (b) rainy seasons of the study period. Data were obtained from the Terra Moderate Resolution Imaging Spectroradiometer (MODIS). The yellow dots represent the monitoring site in HCM city.

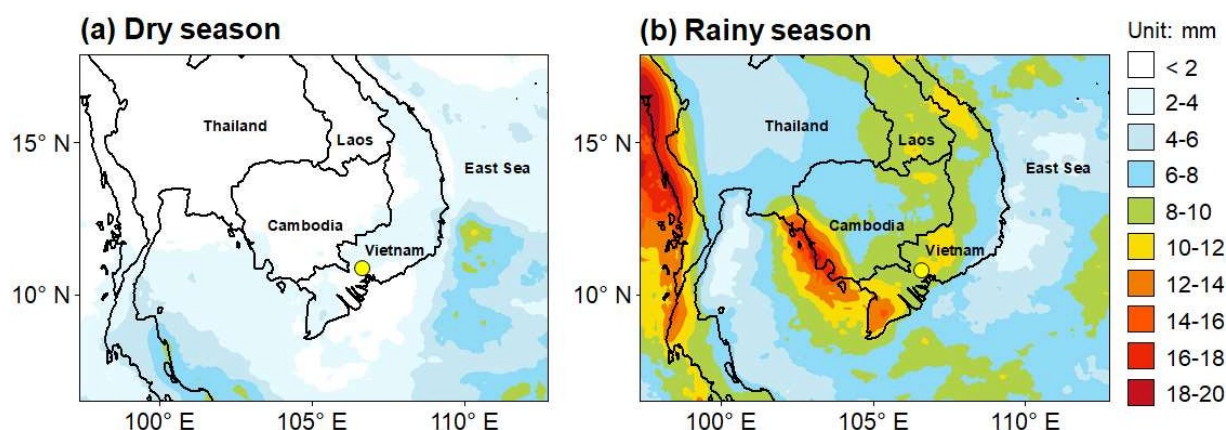


Figure S10. Daily accumulated precipitation observed in Vietnam in the (a) dry and (b) rainy seasons of the study period. Data were obtained from the Integrated Multi-satellite Retrievals for Global Precipitation Measurement (GPM IMERG) final product [13]. The yellow dots represent the monitoring site in HCM city.

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