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Supplement of

Spatiotemporal patterns and drivers of wildfire CO_2 emissions in China from 2001 to 2022

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S1 Statistical method

The Mann-Kendall trend test is a non-parametric statistical method widely used for analyzing trends in time series data. This method does not require data to follow a specific distribution, making it particularly suitable for environmental science and meteorology fields. The calculation formula for the Mann-Kendall trend test is as follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign(x_j - x_k)$$

where n is the total number of data points, x_j and x_k are numerical values in the time series, $\sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign(x_j - x_k)$ is the sign function of the difference between x_j and x_k. Based on the statistic S, the standardized statistic Z of Mann Kendall can be calculated, as follows:

$$Z(S) = \frac{S - E(S)}{\sqrt{VAR(S)}}$$

where E(S) and VAR(S) are the expected value and variance of the statistical measure S. By using the Z-value, we can determine the trend direction and significance in the time series. When the Z value is greater than the critical value, it indicates a significant upward trend; When the negative value of Z is less than the critical value, it indicates a significant downward trend. If the Z value is near zero, the time series has no significant trend. The significance of the trend is verified through a p-value, which represents the probability that the observed trend is generated by a random process. Commonly used significance levels include 90%, 95%, and 99%.

Table S1 Burned area ratios of FireCCI and GFED relative to MODIS (2001-2022)

Year	Forest		Shrub		Grassland		Cropland	
	FireCCI /MODIS	GFED /MODIS	FireCCI /MODIS	GFED /MODIS	FireCCI /MODIS	GFED /MODIS	FireCCI /MODIS	GFED /MODIS
2001	2.77	-	2.39	-	2.25	-	3.28	-
2002	1.48	1.06	1.46	1.05	1.77	1.03	1.74	1.01
2003	1.79	1.03	1.65	1.05	1.96	1.01	1.88	1.01
2004	5.27	1.09	2.80	1.05	5.00	1.06	1.54	1.01
2005	2.46	1.17	2.05	1.11	2.12	1.04	1.65	1.01
2006	3.43	1.36	2.61	1.24	2.52	1.09	1.36	1.01
2007	2.07	1.25	1.92	1.08	2.50	1.08	1.74	1.01
2008	0.85	1.07	1.46	1.07	1.26	1.02	1.90	1.02
2009	1.71	1.19	1.24	1.07	1.68	1.02	1.17	1.01
2010	2.84	1.17	1.65	1.06	2.06	1.03	1.48	1.00
2011	2.13	1.21	1.60	1.12	2.08	1.06	1.44	1.00
2012	3.24	1.31	1.86	1.15	1.21	1.13	1.67	1.01
2013	2.74	1.34	1.61	1.16	1.80	1.08	1.63	1.01
2014	1.25	1.22	1.30	1.16	1.08	1.08	0.95	1.01
2015	1.20	1.24	1.48	1.21	1.19	1.04	0.92	1.00
2016	1.34	1.26	1.28	1.17	1.43	1.06	1.55	1.01
2017	1.30	1.21	1.12	1.22	1.08	1.07	0.64	1.00
2018	0.41	1.13	0.95	1.23	1.00	1.08	0.78	1.01
2019	0.84	1.11	1.30	1.18	1.04	1.05	1.09	1.01
2020	0.89	1.14	1.05	1.15	1.41	1.06	0.89	1.00
2021	1.43	1.23	1.59	1.32	2.89	1.16	0.49	1.00
2022	1.73	1.21	1.99	1.23	2.58	1.09	0.60	1.00

Table S2 CO_2 emission factors of different vegetation cover types in China

Paper	Species	Emission factor（g/kg）
Akagi et al. (2011)	Boreal Forest	1489.00 ±121.00
Akagi et al. (2011)	Tropical Forest	1643.00 ±58.00
Akagi et al. (2011)	Temperate Forest	1573.00 ±84.50
Andreae and Merlet (2001)	Tropical Forest	1580.00±90.00

Andreae and Merlet (2001)	Temperate Forest	1569.00±131.00
Burling et al. (2011)	Conifer Forest	1668.00±72.00
Jin et al. (2022)	Forest	1392.54±248.53
Prichard et al. (2020)	Mixed Forest	1650.50±61.10
Prichard et al. (2020)	Conifer Forest	1576.04±248.04
Forest Mean	-	**1571.23±123.80**
Akagi et al. (2011)	Shrub	1710.00±39.00
Jin et al. (2022)	Shrub	1487.80±18.05
Prichard et al. (2020)	Shrub	1707.96±192.21
Shrub Mean	**-**	**1635.25±83.09**
Akagi et al. (2011)	Grassland	1686.00±38.00
Andreae and Merlet (2001)	Grassland	1613.00±95.00
Jin et al. (2022)	Grassland	1465.84±60.45
Prichard et al. (2020)	Grassland	1685.82±81.19
Grassland Mean	**-**	**1612.67±68.66**
Wang et al. (2009)	Rice	976.80±58.50
Wei et al. (2012)	Rice	1248.80±8.70
Zhang et al. (2008)	Rice	791.30±12.50
Rice Mean	**-**	**1005.63±26.57**
Wang et al. (2009)	Wheat	911.65±105.15
Wei et al. (2012)	Wheat	1454.20±12.00
Zhang et al. (2008)	Wheat	1557.90±85.80
Wheat Mean	**-**	**1307.92±67.65**
Wang et al. (2009)	Corn	1265.40±91.20
Zhang et al. (2008)	Corn	1261.50±59.90
Corn Mean	**-**	**1263.45±75.50**

Table S3 The aboveground biomass of shrubs

Pronvince/regions	Shrub (g/m^2)
Anhui	1255.15
Beijing	790.47
Chongqing	1713.15
Fujian	2150.72

Gansu	854.96
Guangdong	2110.42
Guangxi	1791.10
Guizhou	1955.83
Hainan	2131.30
Hebei	790.98
Heilongjiang	790.81
Henan	790.98
Hongkong	2110.42
Hubei	896.84
Hunan	1978.24
Jiangsu	781.61
Jiangxi	2108.69
Jilin	790.86
Liaoning	790.77
Macao	2110.42
Neimenggu	790.87
Ningxia	790.10
Qinghai	880.53
Shaanxi	821.68
Shangdong	790.61
Shanghai	781.61
Shanxi	790.84
Sichuan	1713.15
Taiwan	1377.84
Tianjin	785.53
Xinjiang	790.75
Xizang	1144.08
Yunnan	2014.15
Zhejiang	2098.60

Note: The aboveground biomass (AGB) of shrub from Hu et al. (2006) was converted from carbon storage to total biomass by dividing by 0.5, and then converted from total biomass to aboveground biomass by multiplying by 0.57.

Table S4 The straw production rates (R), dry matter fraction (D), and combustion efficiency (CE) used in this study.

Class	R[a]	D[b]	CE[b]
Corn	1.27	0.87	0.92
Rice	1.32	0.89	0.93
Wheat	1.72	0.89	0.92
other crops	1.50	0.88	0.92

Note: [a] Technical Guidelines for Compiling Emission Inventory of Air Pollutants from Biomass Combustion Sources, 2015). [b] He et al. (2015).

Table S5 Burned area ratios of GABAM, FireCCI, GFED, FINN relative to MODIS (2015)

2015 year	Forest	Shrub	Grassland	Cropland
GABAM	0.86	1.74	1.00	0.35
GFED	1.24	1.21	1.04	1.00
FIRECCI51	1.20	1.48	1.19	0.92
FINN	9.28	12.65	3.41	1.48
FINN_VIIR	11.96	17.09	4.77	2.16

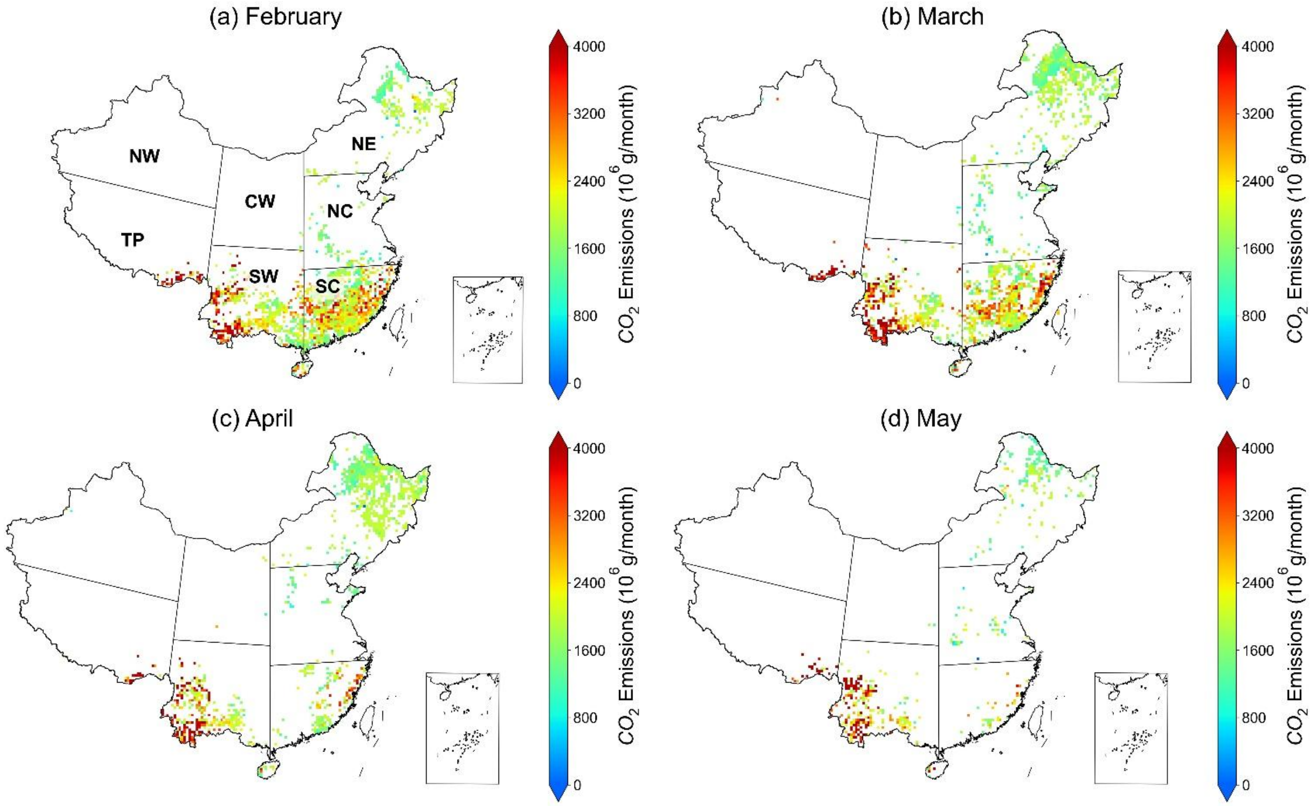

Figure S1: Spatial distribution of monthly CO_2 emissions within forest fires from 2001 to 2022 in China: (a) February, (b) March, (c) April, and (d) May.

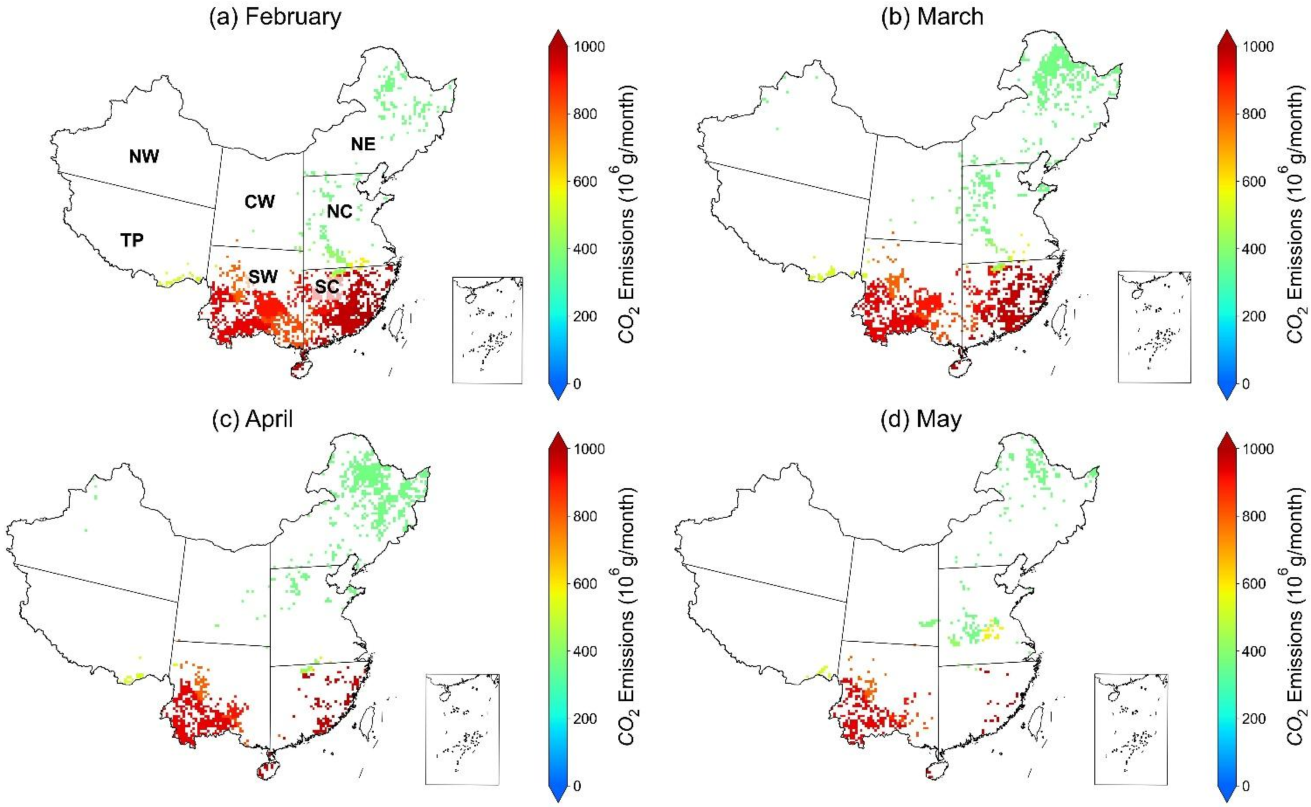

Figure S2: Spatial distribution of monthly CO_2 emissions within shrub fires from 2001 to 2022 in China: (a) February, (b) March, (c) April, and (d) May.

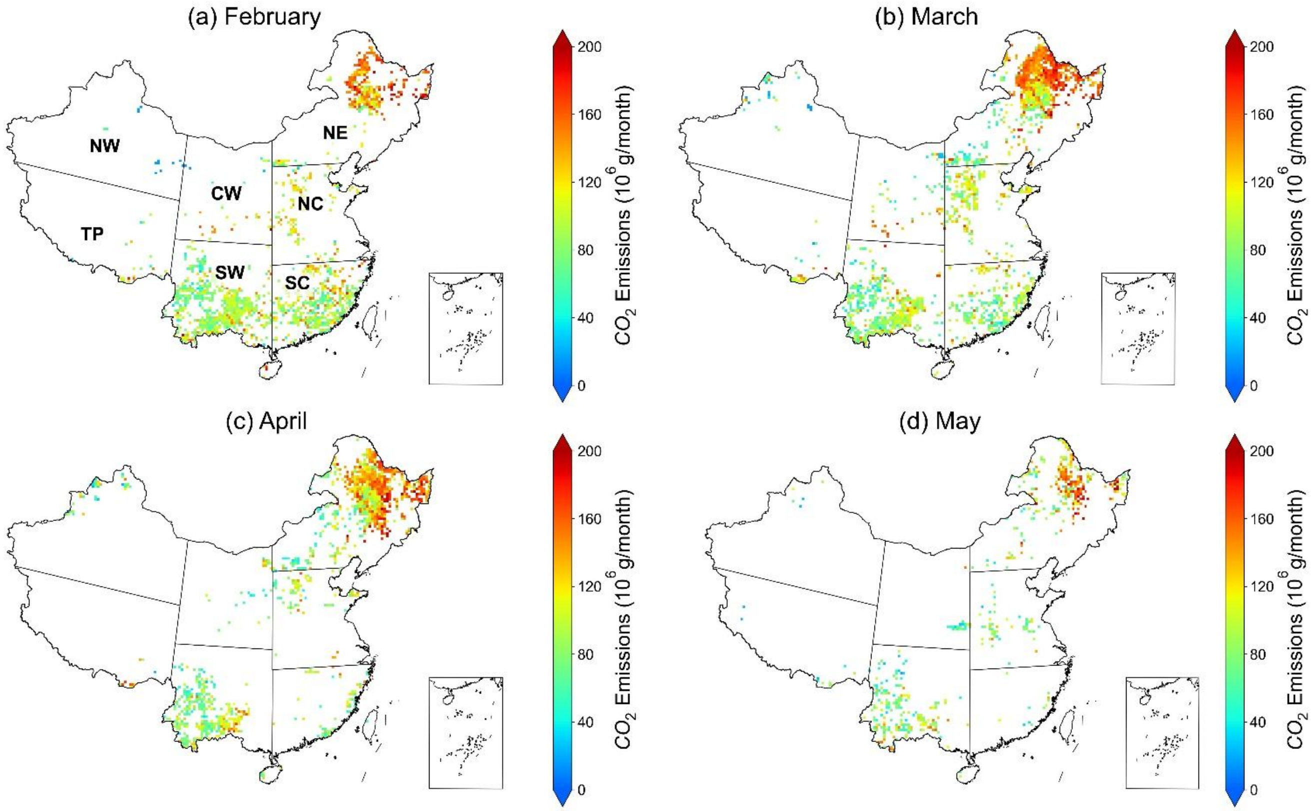

Figure S3: Spatial distribution of monthly CO_2 emissions within grassland fires from 2001 to 2022 in China: (a) February, (b) March, (c) April, and (d) May.

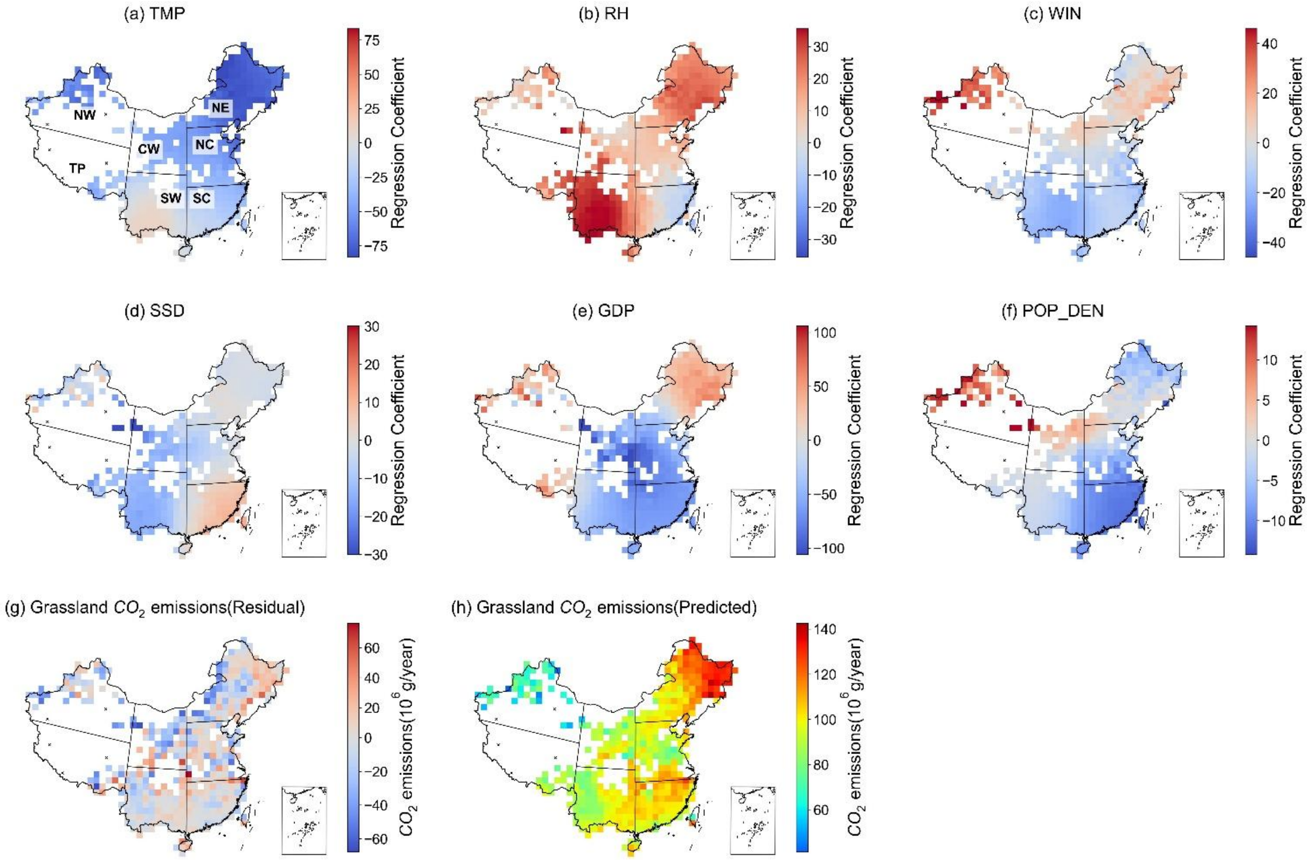

Figure S4: Spatial distribution of GTWR regression coefficients for grassland CO_2 emissions and their driving factors across China. The maps illustrate GTWR coefficients of seven environmental and socioeconomic variables: (a) temperature, (b) relative humidity, (c) wind speed, (d) daily cumulative sunshine hours, (e) gross domestic product (GDP), and (f) population density. Grey regions represent areas where the intercept was zero (i.e., no valid model fit), and black × symbols mark locations where the regression coefficients did not pass the significance test ($p \geqslant 0.05$). Figure (g) and (h) show the model residuals and predicted shrubland CO_2 emissions.

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