[Earth's Future]

Supporting Information for

[Response of COVID-19 Trajectory to Compound Natural Factor]

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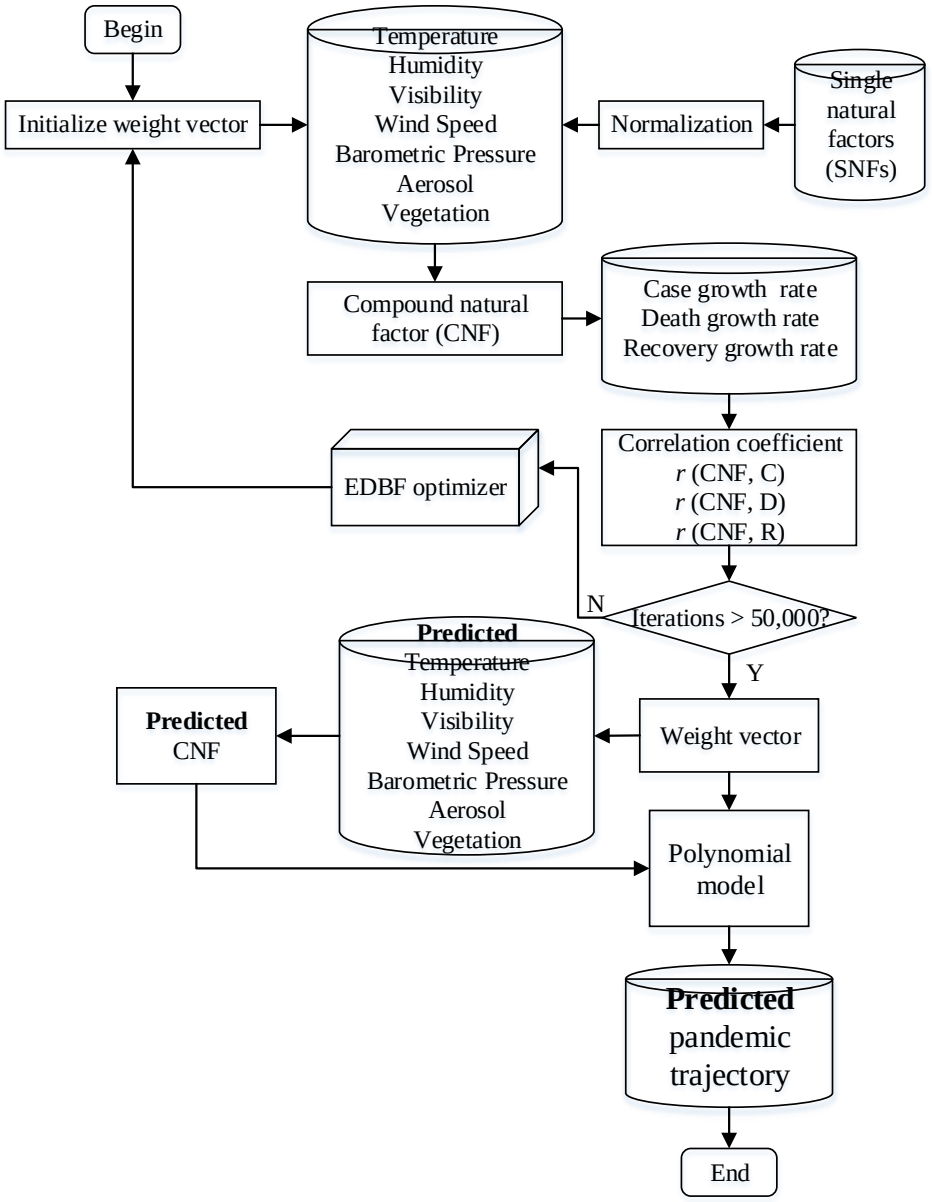


Figure S1. CNF model.

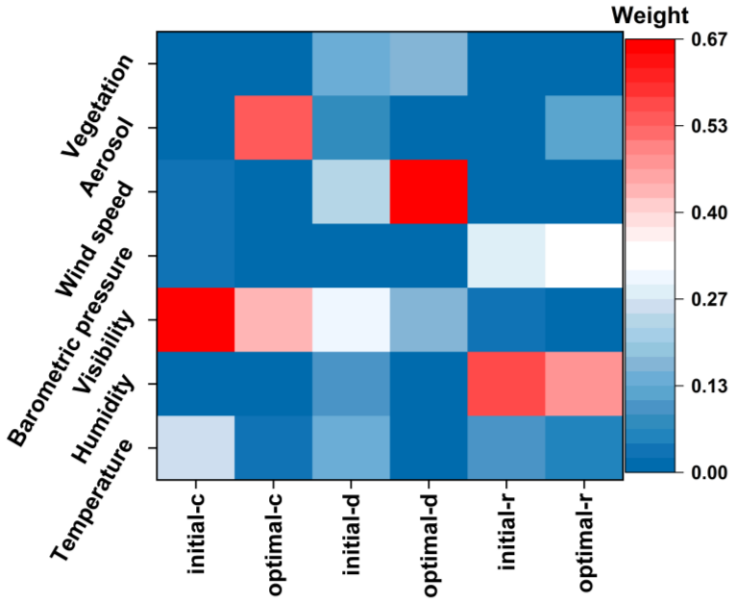
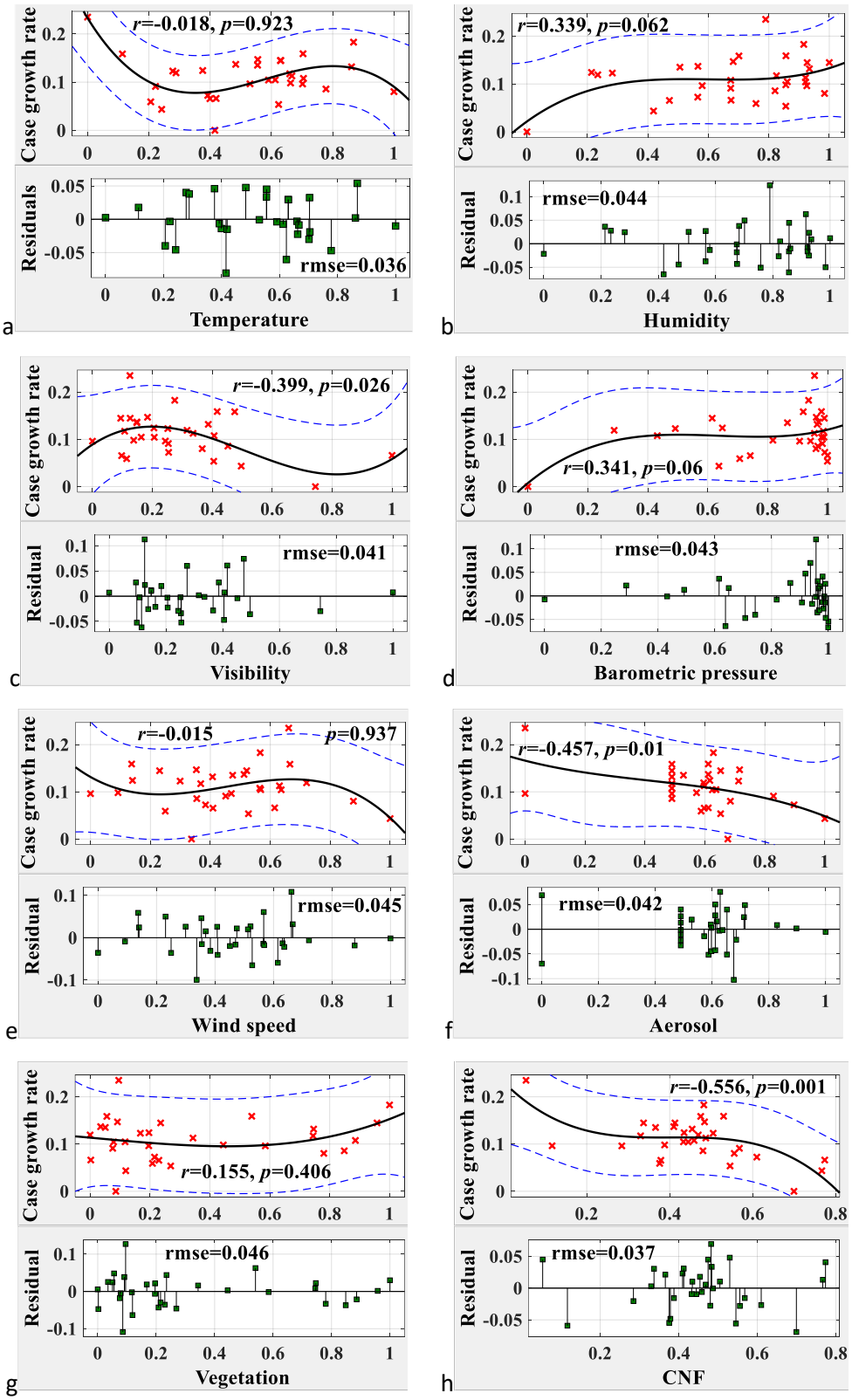
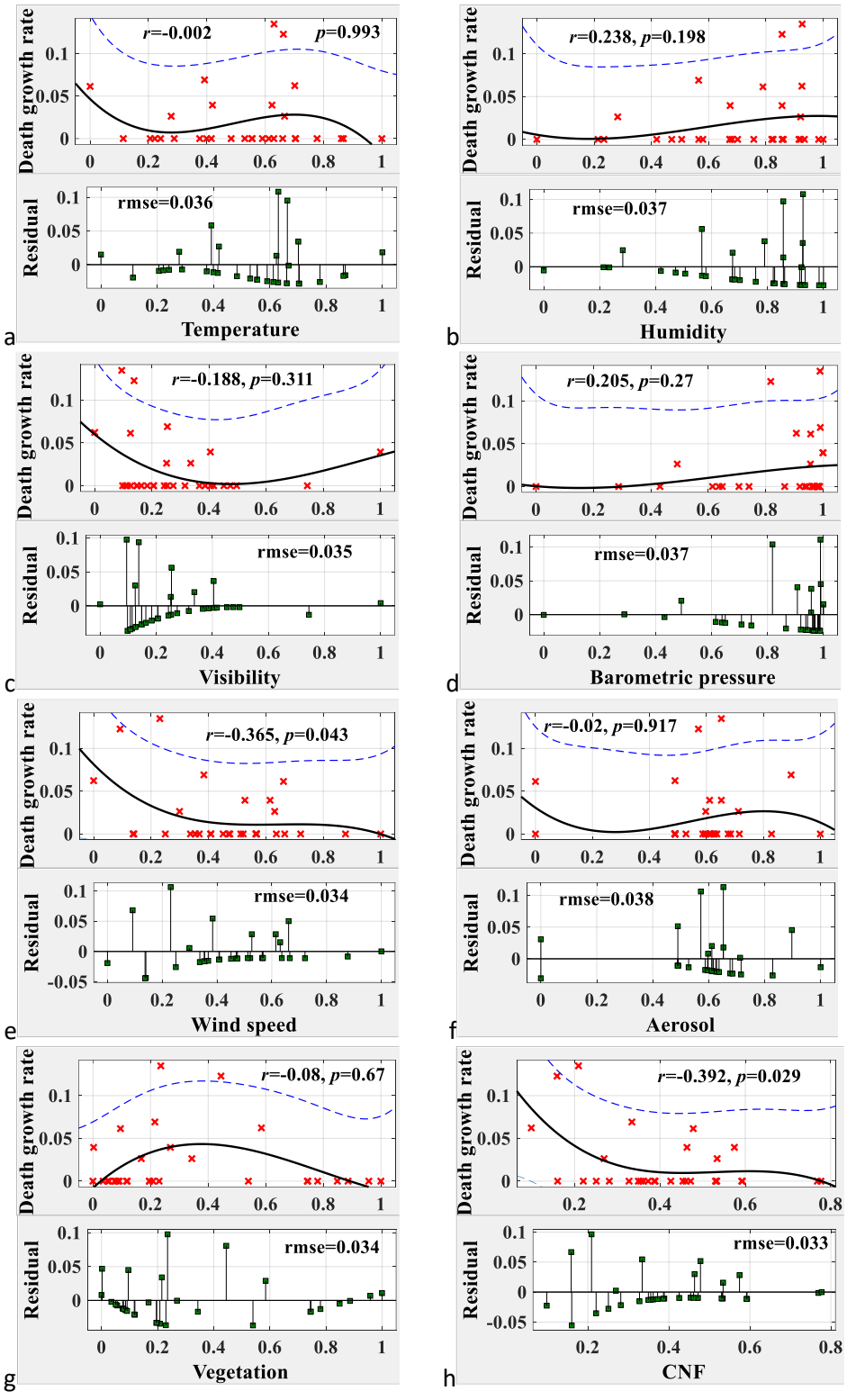


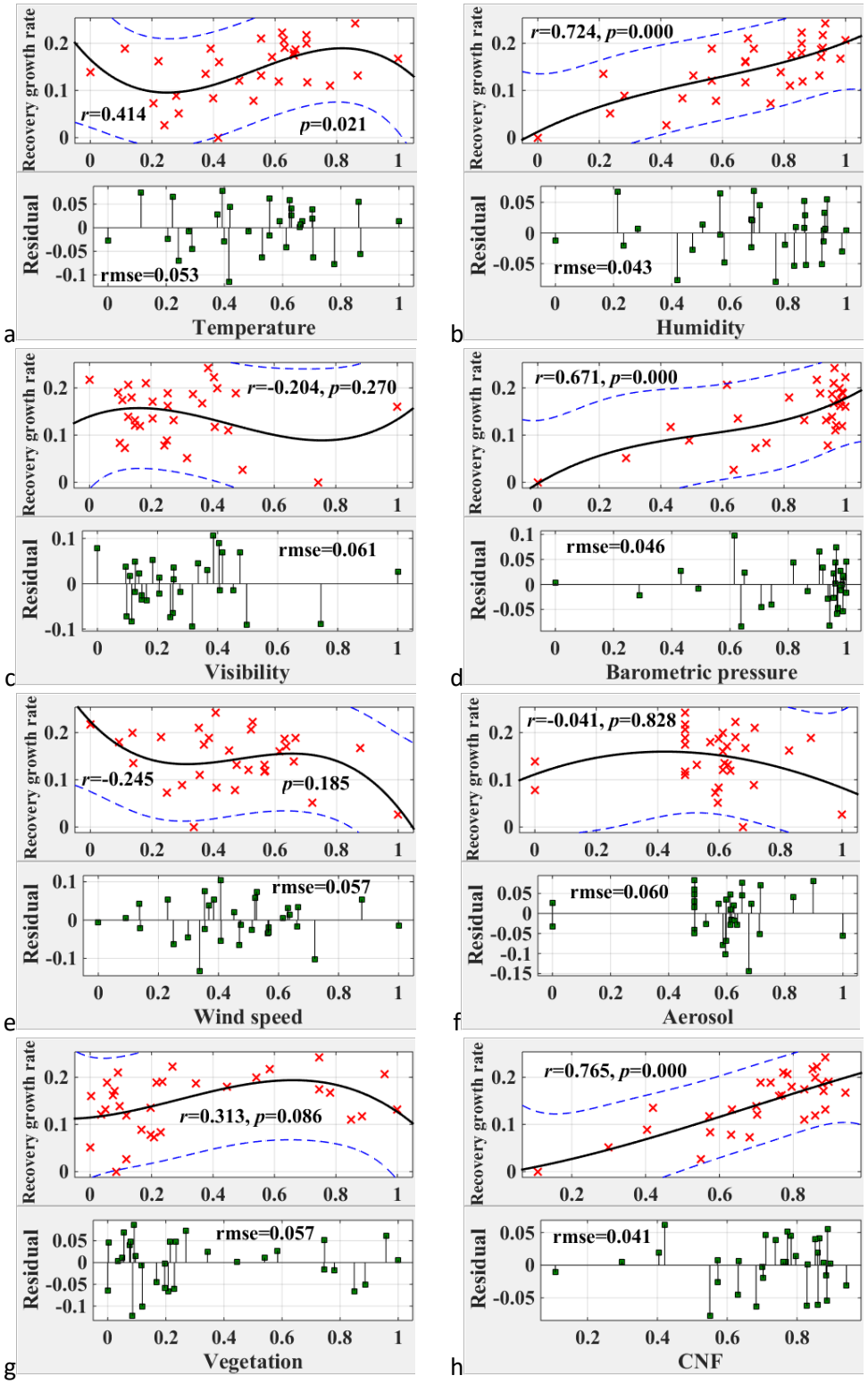
Figure S2. The initial weight values and the optimal weight values in CNF model at each pandemic variable, wherein initial-c and optimal-c correspond to case growth rate, initial-d and optimal-d (death growth rate), initial-r and optimal-r (recovery growth rate).


a
Case growth rate
r=-0.018, p=0.923
Residuals
rmse=0.036
Temperature
b
Case growth rate
r=0.339, p=0.062
Residual
rmse=0.044
Humidity
c
Case growth rate
r=-0.399, p=0.026
Residual
rmse=0.041
Visibility
d
Case growth rate
r=0.341, p=0.06
Residual
rmse=0.043
Barometric pressure
e
Case growth rate
r=-0.015
p=0.937
Residual
rmse=0.045
Wind speed
f
Case growth rate
r=-0.457, p=0.01
Residual
rmse=0.042
Aerosol
g
Case growth rate
r=0.155, p=0.406
Residual
rmse=0.046
Vegetation
h
Case growth rate
r=-0.556, p=0.001
Residual
rmse=0.037
CNF

(l)


Death growth rate
r=-0.002
p=0.993
Residual
rmse=0.036
Temperature
a
r=0.238, p=0.198
rmse=0.037
Humidity
b
r=-0.188, p=0.311
rmse=0.035
Visibility
c
r=0.205, p=0.27
rmse=0.037
Barometric pressure
d
r=-0.365, p=0.043
rmse=0.034
Wind speed
e
r=-0.02, p=0.917
rmse=0.038
Aerosol
f
r=-0.08, p=0.67
rmse=0.034
Vegetation
g
r=-0.392, p=0.029
rmse=0.033
CNF
h

(II)



(III)

Figure S3. The relationship between COVID-19 pandemic variables (i.e., daily growth rate in I: case, II: death and III: recovery) and natural factors, i.e., temperature, humidity, visibility, barometric pressure, wind speed, aerosol, vegetation and compound natural factor (CNF).

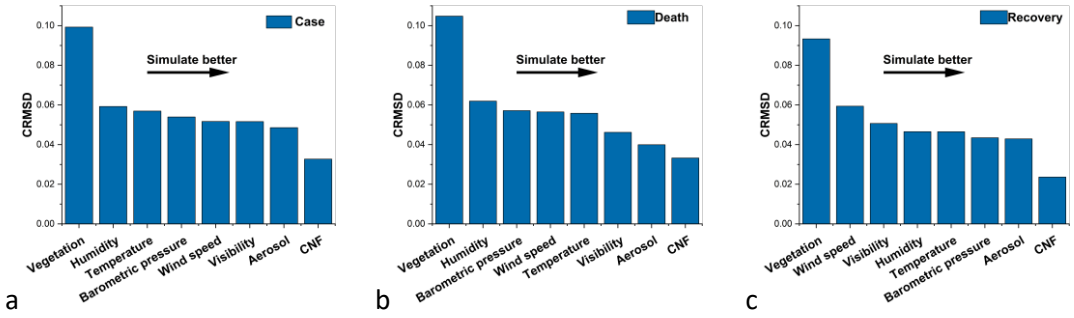


Figure S4. The centre root-mean-square difference between natural factors and COVID-19 trajectory (a) Transmission (b) Death (c) Recovery.

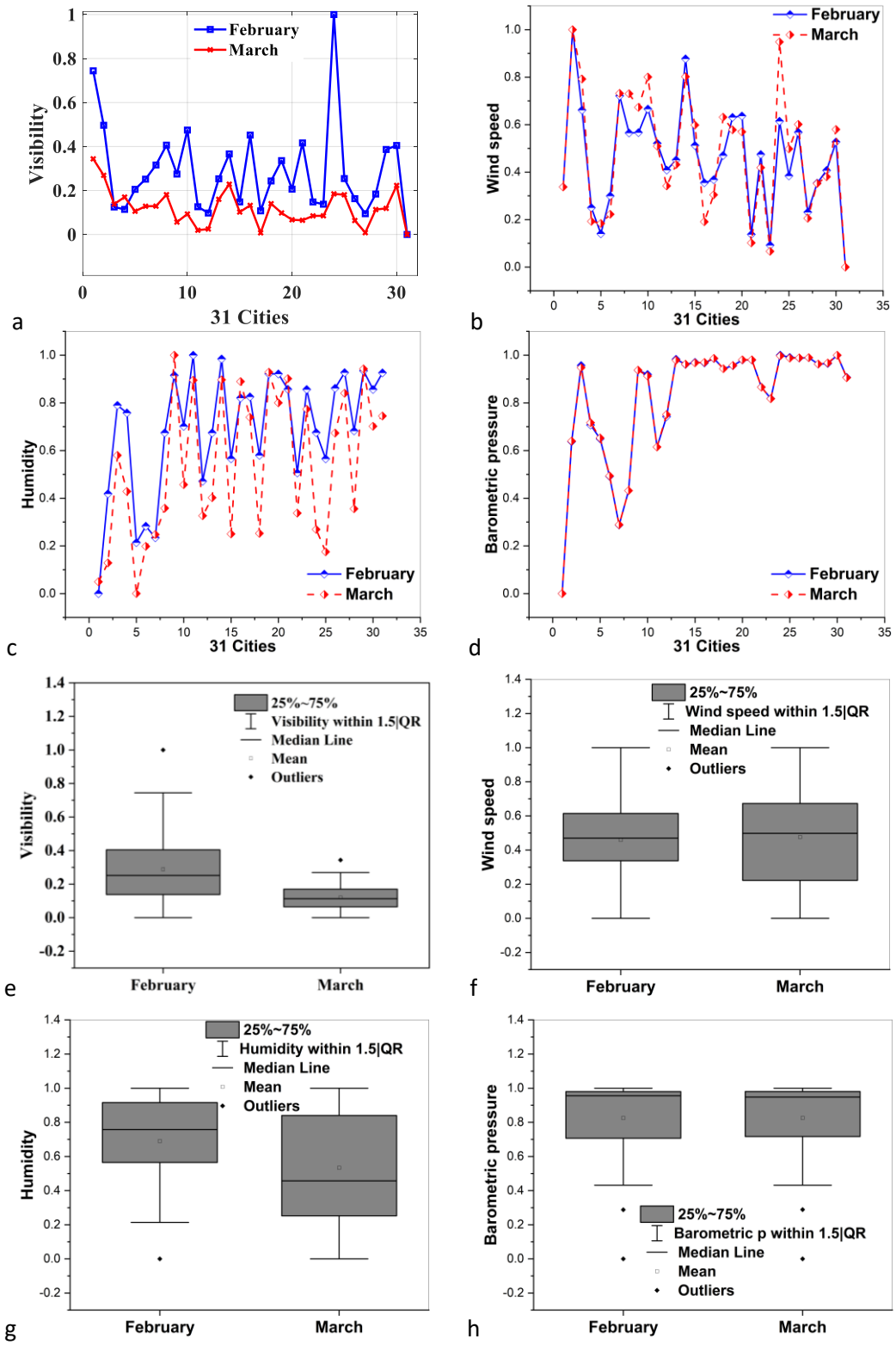


Figure S5. The shift of dominate natural factors which are respond to COVID-19 trajectory during February to March in 31 cities of China. (a, e) Visibility (b, f) Wind speed (c, g) Humidity (d, h) Barometric pressure. The blue line and red line represent city-wise natural factors in February and March, respectively.

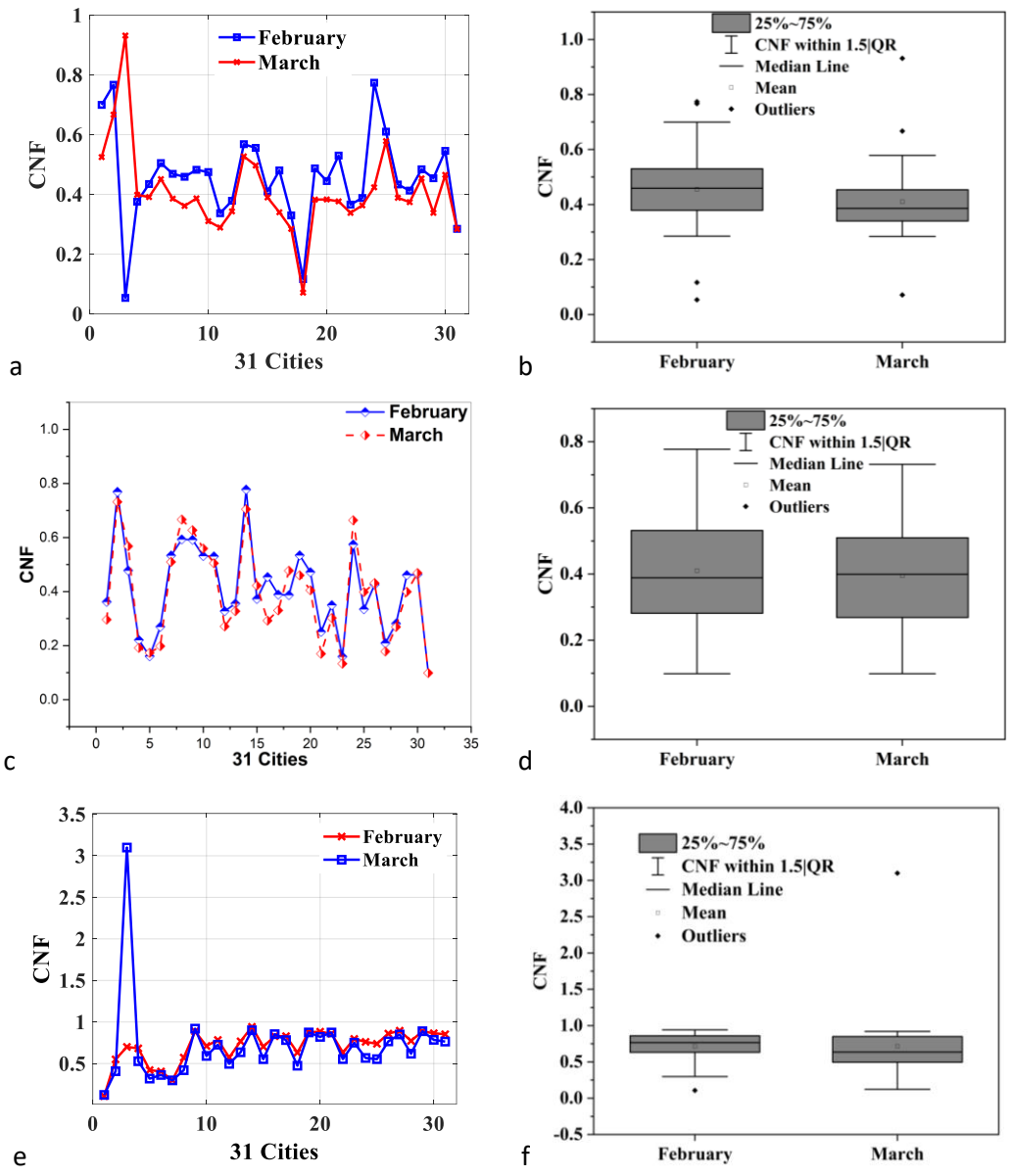
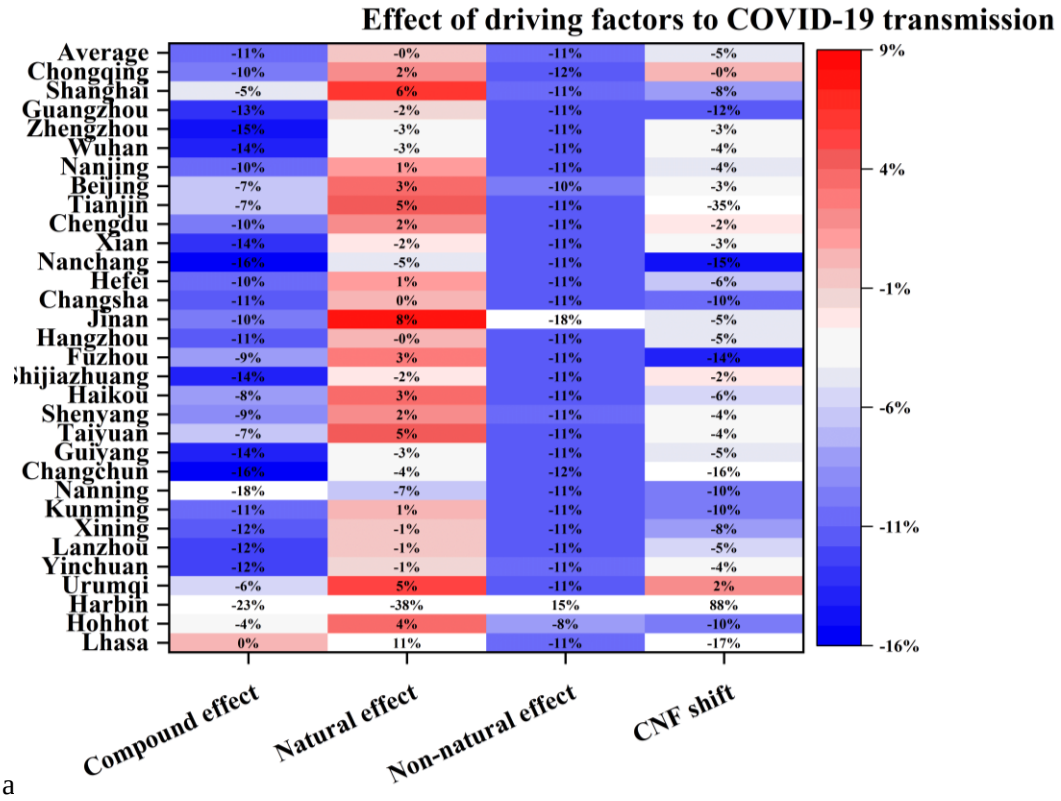
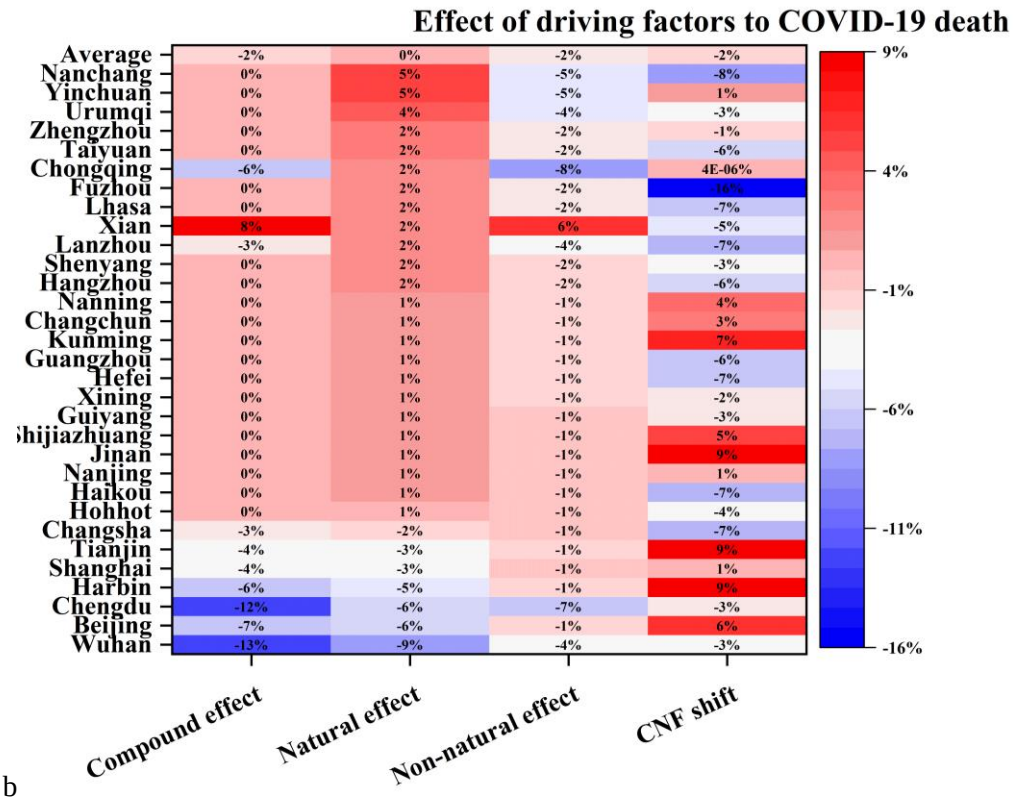


Figure S6. The shift of CNF during February to March in 31 cities of China. (a, d) Case related CNF (b, e) Death related CNF (c, f) Recovery related CNF. The blue line and red line represent city-wise CNF in February and March, respectively.


Effect of driving factors to COVID-19 transmission
Average -11% -0% -11% -5%
Chongqing -10% 2% -12% -0%
Shanghai -5% 6% -11% -8%
Guangzhou -13% -2% -11% -12%
Zhengzhou -15% -3% -11% -3%
Wuhan -14% -3% -11% -4%
Nanjing -10% 1% -11% -4%
Beijing -7% 3% -10% -3%
Tianjin -7% 5% -11% -35%
Chengdu -10% 2% -11% -2%
Xian -14% -2% -11% -3%
Nanchang -16% -5% -11% -15%
Hefei -10% 1% -11% -6%
Changsha -11% 0% -11% -10%
Jinan -10% 8% -18% -5%
Hangzhou -11% -0% -11% -5%
Fuzhou -9% 3% -11% -14%
Shijiazhuang -14% -2% -11% -2%
Haikou -8% 3% -11% -6%
Shenyang -9% 2% -11% -4%
Taiyuan -7% 5% -11% -4%
Guiyang -14% -3% -11% -5%
Changchun -16% -4% -12% -16%
Nanning -18% -7% -11% -10%
Kunming -11% 1% -11% -10%
Xining -12% -1% -11% -8%
Lanzhou -12% -1% -11% -5%
Yinchuan -12% -1% -11% -4%
Urumqi -6% 5% -11% 2%
Harbin -23% -38% 15% 88%
Hohhot -4% 4% -8% -10%
Lhasa 0% 11% -11% -17%
9%
4%
-1%
-6%
-11%
-16%
Compound effect
Natural effect
Non-natural effect
CNF shift

a


Effect of driving factors to COVID-19 death
Average -2% 0% -2% -2%
Nanchang 0% 5% -5% -8%
Yinchuan 0% 5% -5% 1%
Urumqi 0% 4% -4% -3%
Zhengzhou 0% 2% -2% -1%
Taiyuan 0% 2% -2% -6%
Chongqing -6% 2% -8% 4E-06%
Fuzhou 0% 2% -2% -16%
Lhasa 0% 2% -2% -7%
Xian 8% 2% 6% -5%
Lanzhou -3% 2% -4% -7%
Shenyang 0% 2% -2% -3%
Hangzhou 0% 2% -2% -6%
Nanning 0% 1% -1% 4%
Changchun 0% 1% -1% 3%
Kunming 0% 1% -1% 7%
Guangzhou 0% 1% -1% -6%
Hefei 0% 1% -1% -7%
Xining 0% 1% -1% -2%
Guiyang 0% 1% -1% -3%
Shijiazhuang 0% 1% -1% 5%
Jinan 0% 1% -1% 9%
Nanjing 0% 1% -1% 1%
Haikou 0% 1% -1% -7%
Hohhot 0% 1% -1% -4%
Changsha -3% -2% -1% -7%
Tianjin -4% -3% -1% 9%
Shanghai -4% -3% -1% 1%
Harbin -6% -5% -1% 9%
Chengdu -12% -6% -7% -3%
Beijing -7% -6% -1% 6%
Wuhan -13% -9% -4% -3%
9%
4%
-1%
-6%
-11%
-16%
Compound effect
Natural effect
Non-natural effect
CNF shift

b

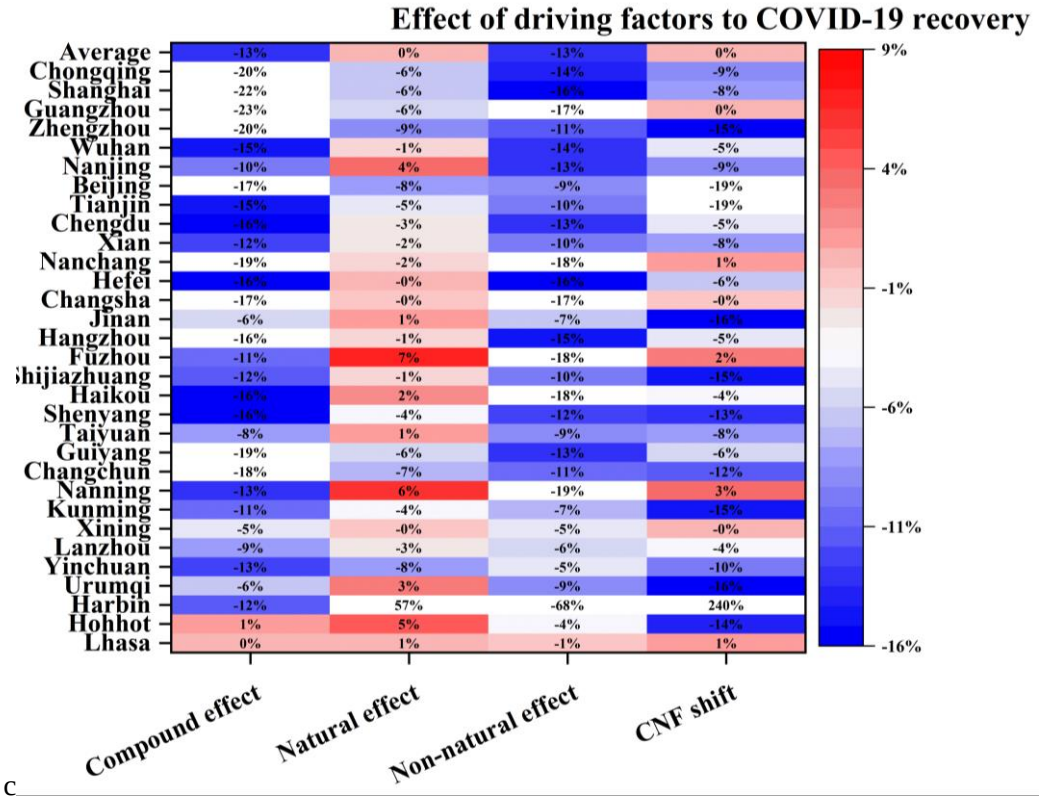


Figure S7. Effect of driving factors to COVID-19 trajectory concerning (a) infection (b) death (c) recovery. The first three columns of each figure exhibited the compound effect of natural and non-natural factors, the separated effect of natural factors, and the separated effect of non-natural (human) factors to the COVID-19 trajectory, respectively. It is noteworthy to mention that labels with positive and negative values respectively reveal the positive and negative effects of driving factors to the trajectory.

City name	Data source
Lhasa	http://wjw.xizang.gov.cn/
Hohhot	http://wjw.nmg.gov.cn/
Harbin	http://wsjkw.hlj.gov.cn/
Urumqi	http://wjw.xinjiang.gov.cn/
Yinchuan	http://wsjkw.nx.gov.cn/
Lanzhou	http://wsjk.gansu.gov.cn/
Xining	https://wsjkw.qinghai.gov.cn/
Kunming	http://ynswsjkw.yn.gov.cn/
Nanning	http://wsjkw.gxzf.gov.cn/
Changchun	http://wsjkw.jl.gov.cn/
Guiyang	http://www.gzhfpc.gov.cn/
Taiyuan	http://wjw.shanxi.gov.cn/
Shenyang	http://wsjk.ln.gov.cn/
Haikou	http://wst.hainan.gov.cn/swjw/index.html
Shijiazhuang	http://www.hebwst.gov.cn/
Fuzhou	http://wjw.fujian.gov.cn/
Hangzhou	https://wsjkw.zj.gov.cn/
Jinan	http://wsjkw.shandong.gov.cn/
Changsha	http://wjw.hunan.gov.cn/
Hefei	http://wjw.ah.gov.cn/
Nanchang	http://hc.jiangxi.gov.cn/
Xian	http://sxwjw.shaanxi.gov.cn/
Chengdu	http://wsjkw.sc.gov.cn/
Tianjin	http://wsjk.tj.gov.cn/
Beijing	http://wjw.beijing.gov.cn/
Nanjing	http://wjw.jiangsu.gov.cn/
Wuhan	http://wjw.hubei.gov.cn/
Zhengzhou	http://wsjkw.henan.gov.cn/
Guangzhou	http://wsjkw.gd.gov.cn/
Shanghai	http://wsjkw.sh.gov.cn/
Chongqing	http://wsjkw.cq.gov.cn/

Table S1. City-wise collected data source.

SNF	*r*-value			*p*-value		
	Case	**Death**	**Recovery**	**Case**	**Death**	**Recovery**
Temperature	-0.018	-0.002	0.414	0.923	0.993	0.021
Humidity	0.339	0.238	0.724	0.062	0.198	0.000
Visibility	-0.399	-0.188	-0.204	0.026	0.311	0.270
Barometric pressure	0.341	0.205	0.671	0.060	0.270	0.000
Wind speed	-0.015	-0.365	-0.245	0.937	0.043	0.185
Aerosol	-0.457	-0.020	-0.041	0.010	0.917	0.828
Vegetation	0.155	-0.080	0.313	0.406	0.670	0.086

Table S2. Correlation and significance between pandemic variables and single natural factors.

Reported data		Unreported data	
	1-22-2020		12-31-2019
	1-23		1-1-2020
	1-24		1-2
	1-25		1-3
	1-26		1-4
	1-27		1-5
	1-28		1-6
	1-29		1-7
Invalid human response time	1-30	**COVID-19 virus spread naturally**	1-8
	1-31		1-9
	2-1		1-10
	2-2		1-11
	2-3		1-12
	2-4		1-13
	2-5		1-14
	2-6		1-15
	2-7		1-16
	2-8		1-17
	2-9		1-18
	2-10		1-19
	2-11		1-20
	2-12		1-21
	2-13		
	2-14		
	2-15		
	2-16		
	2-17		
	2-18		
	2-19		
Increasing valid human response time	2-20		
	2-21		
	2-22		
	2-23		
	2-24		
	2-25		
	2-26		
	2-27		
	2-28	**COVID-19 virus spread under the control of human response**	
	2-29		
	3-1		
	3-2		
	3-3		
	3-4		
	3-5		
	3-6		
	3-7		
Steady human response time	3-8		
	3-9		
	3-10		
	3-11		
	3-12		
	3-13		
	3-14		
	3-15		
	3-16		
	3-17		
	3-18		

Table S3. The delayed effect of the human intervention to the COVID-19 transmission.