Table S1. Average evaluation indices comparing hourly WRF simulations and observations.

Index / Variable	PCC	RMSE	ME
WS	0.586	2.172 (m/s)	1.069 (m/s)
HP	0.234	3.920 (mm/h)	-0.294 (mm/h)
T	0.933	2.553 (°C)	-1.125 (°C)
RH	0.794	16.491 (%)	-8.759 (%)
PS	0.989	9.068 (hPa)	-8.549 (hPa)

Note. We evaluate the WRF simulations of May 2015 by Pearson correlation coefficient (PCC), RMSE, and ME. We use data from 13 weather stations located in 13 districts of Beijing, the center of the BTH region. We extract and compare five variables from simulations and observations, namely the wind speed at 10 m height (WS), hourly precipitation (HP), the temperature at 2 m height (T), the relative humidity at 2 m height (RH), and pressure at the surface (PS).

Table S2. Descriptions of the selected and computed physical quantities from WRF simulations.

Variable	Description	Units
WVMR	Water vapor mixing ratio at pressure levels of 850 hPa, 700hPa, and 500hPa	(kg/kg)
RH	Relative humidity at pressure levels of 850 hPa, 700hPa, and 500hPa	%
U	X-wind velocity at pressure levels of 850 hPa, 700hPa, and 500hPa	m/s
V	Y-wind velocity at pressure levels of 850 hPa, 700hPa, and 500hPa	m/s
W	Z-wind velocity at pressure levels of 850 hPa, 700hPa, and 500hPa	m/s
PW*	Precipitable water	mm/m^2
K	K index. K = (t_850 - t_500) + td_850 - (t_700 - td_700), where t and td denote temperature and dewpoint, respectively, and 850, 750, and 500 denote corresponding pressure levels with units hPa	K
MCAPE*	Maximum convective available potential energy	J/kg
MCIN*	Maximum convective inhibition	J/kg
EPTD	The equivalent potential temperature difference between the pressure levels of 500 hPa and 850 hPa. EPTD = theta_500 - theta_850, where theta denotes equivalent potential temperature and 850 and 500 denote corresponding pressure levels with units hPa	K
LR	Temperature lapse rate between the pressure levels of 500 hPa and 700 hPa. LR = (t_700 - t_500) / (h_500 – h_500), where t and h denote the temperature and height, respectively, and 700 and 500 denote corresponding pressure levels with units hPa	K/km
VWS	Vertical wind shear between the pressure levels of 850 hPa and 200 hPa. VWS = sqrt((u_200 - u_850) ** 2 + (v_200 - v_850) ** 2), where u and v denote X-wind velocity and Y-wind velocity, respectively, and 200 and 850 denote corresponding pressure levels with units hPa	m/s
SRH*	Storm relative helicity	m^2/s^2
UH*	Updraft helicity	m^2/s^2

*This physical quantity is calculated from WRF simulations using the Python third-party library WRF-Python (Ladwig, 2017)