Supplement of Geosci. Model Dev., 16, 4551–4579, 2023
https://doi.org/10.5194/gmd-16-4551-2023-supplement

Geoscientific Model Development
Open Access

Supplement of

Simulating heat and CO_2 fluxes in Beijing using SUEWS V2020b: sensitivity to vegetation phenology and maximum conductance

Yingqi Zheng et al.

Correspondence to: Huizhi Liu (huizhil@mail.iap.ac.cn)

Table S1. Land cover fractions for the entire circle before the wind sector filtering (WSF) and the remaining sectors after WSF as described in Section 3. Land cover types include buildings (Bldgs), paved surface (Paved), evergreen tree/shrub (Everg), deciduous tree/shrub (Dec), grass, and water.

	Unit	Bldgs	Paved	Everg	Dec	Grass	Water
Entire circle	–	0.24	0.46	0.02	0.11	0.16	0.01
Remaining sectors	–	0.20	0.48	0.04	0.16	0.11	0.01

Table S2. Notation used in Table S3 and Table S4.

Parameter	Description
α_i	Effective surface albedo (–)
ϵ_i	Effective surface emissivity (–)
$a_{0,wd,we}$	Parameter defining the base Q_F per capita (W m^{-2} (capita^{-1} ha^{-1})$^{-1}$)
$a_{1,wd,we}$	Parameter defining the base CDD per capita (W m^{-2} (capita^{-1} ha^{-1})$^{-1}$)
$a_{2,wd,we}$	Parameter defining the base HDD per capita (W m^{-2} K^{-1} (capita^{-1} ha^{-1}) $^{-1}$)
b	Empirical coefficient in the calculation of drainage (–)
$IrrFr_i$	Fraction of irrigated surface i (–)
$b_{0a,1a,2a}$	Parameters for automatic irrigation (mm, mm K^{-1}, mm d^{-1})
$b_{0m,1m,2m}$	Parameters for manual irrigation (mm, mm K^{-1}, mm d^{-1})
C_i	Interception state of ith surface (mm)
$C_{soil,i}$	Soil water storage (mm)
C^R_{min}	Minimum retention capacity (mm)
C^R_{max}	Maximum retention capacity (mm)
$D_{0,i}$	Drainage rate (mm)
$DaysSinceRain$	Days since rain before the simulation period (–)
I_w	Additional water to water surface type (mm)
res_{cap}	Surface water capacity in LUMPS (mm)
res_{drain}	Drainage rate of water bucket in LUMPS (mm h^{-1})
R_C	Limit when surface is totally covered with water in LUMPS (mm)
S_{pipe}	Maximum depth capacity of pipes (mm)
T_{step}	Time step for water balance calculation (s)

Table S3. Overall model parameter values used in model runs in Beijing (Kokkonen et al. 2019). See Table S2 for parameter description.

Parameter	Value	Parameter	Value
$a_{0,wd,we}$	0.308 (W m^{-2} (capita^{-1} ha^{-1})$^{-1}$)	C^R_{min}	0.05 mm
$a_{1,wd,we}$	0.0099 (W m^{-2} (capita^{-1} ha^{-1})$^{-1}$)	C^R_{max}	0.2 mm
$a_{3,wd,we}$	0.0102 (W m^{-2} (capita^{-1} ha^{-1})$^{-1}$)	$DaysSinceRain$	28
$b_{0,a}$	-19.19 mm	I_w	0 mm
$b_{1,a}$	2.22 mm K^{-1}	res_{cap}	10 mm
$b_{2,a}$	0.78 mm d^{-1}	res_{drain}	0.25 mm h^{-1}
$b_{0,m}$	-5.76 mm	R_C	1.0 mm
$b_{1,m}$	0.67 mm K^{-1}	S_{pipe}	100 mm
$b_{2,m}$	0.24 mm d^{-1}	T_{step}	300 s

Table S4. Model parameters used in SUEWS for different surfaces: buildings (Bldgs), paved surface (Paved), evergreen tree/shrub (Everg), deciduous tree/shrub (Dec), grass, and water (Kokkonen et al. 2019). Initial conditions assume there is no snow on the ground. See Table S2 for parameter description.

	Unit	Bldgs	Paved	Everg	Dec	Grass	Water
$D_{0,i}$	mm	10	10	0.013	0.013	10	−
b	−	3	3	1.71	1.71	0.013	−
α_i	−	0.15	0.12	0.10	0.16	0.19	0.10
ϵ_i	−	0.95	0.91	0.98	0.98	0.93	0.95
$IrrFr_i$	−	0	0	0.31	0.31	0.7	−

Table S5. Adjusted albedo (α_i) for different surfaces: buildings (Bldgs), paved surface (Paved), evergreen tree/shrub (Everg), deciduous tree/shrub (Dec), grass, and water following Ward et al. (2016). The α_i for deciduous tree/shrub and grass are allowed to vary from a lower value in summer to a higher value in winter.

	Unit	Bldgs	Paved	Everg	Dec	Grass	Water
α_i	–	0.12	0.10	0.10	0.12−0.18	0.18−0.21	0.10

Table S6. SUEWS model performance statistics with adjusted albedo (α_i) (Table S5) for radiation fluxes, including incoming solar radiation (K_{down}), outgoing shortwave radiation (K_{up}), incoming longwave radiation (L_{down}), outgoing longwave radiation (L_{up}), and net radiation (Q_N) from May 2010 to June 2011.

	Season	R^2	RMSE	MBE	N
K_{down}	DJF	0.94	52.3	19.5	2160
	MAM	0.93	82.6	19.8	2940
	JJA	0.86	110.4	39.3	2728
	SON	0.93	59.6	16.6	2150
K_{up}	DJF	0.88	8.3	-2.5	2160
	MAM	0.92	10.1	0.2	2940
	JJA	0.88	13.6	4.6	2728
	SON	0.91	8.4	0.6	2150
L_{down}	DJF	0.74	16.0	-2.4	2160
	MAM	0.86	20.5	-10.0	2940
	JJA	0.68	18.1	8.8	2728
	SON	0.88	23.7	12.9	2150
L_{up}	DJF	0.80	15.7	4.0	2160
	MAM	0.90	19.1	3.6	2940
	JJA	0.79	22.5	10.7	2728
	SON	0.90	18.9	9.4	2150
Q_N	DJF	0.94	40.5	15.6	2160
	MAM	0.93	64.6	6.0	2940
	JJA	0.86	88.8	32.8	2728
	SON	0.92	51.8	19.5	2150

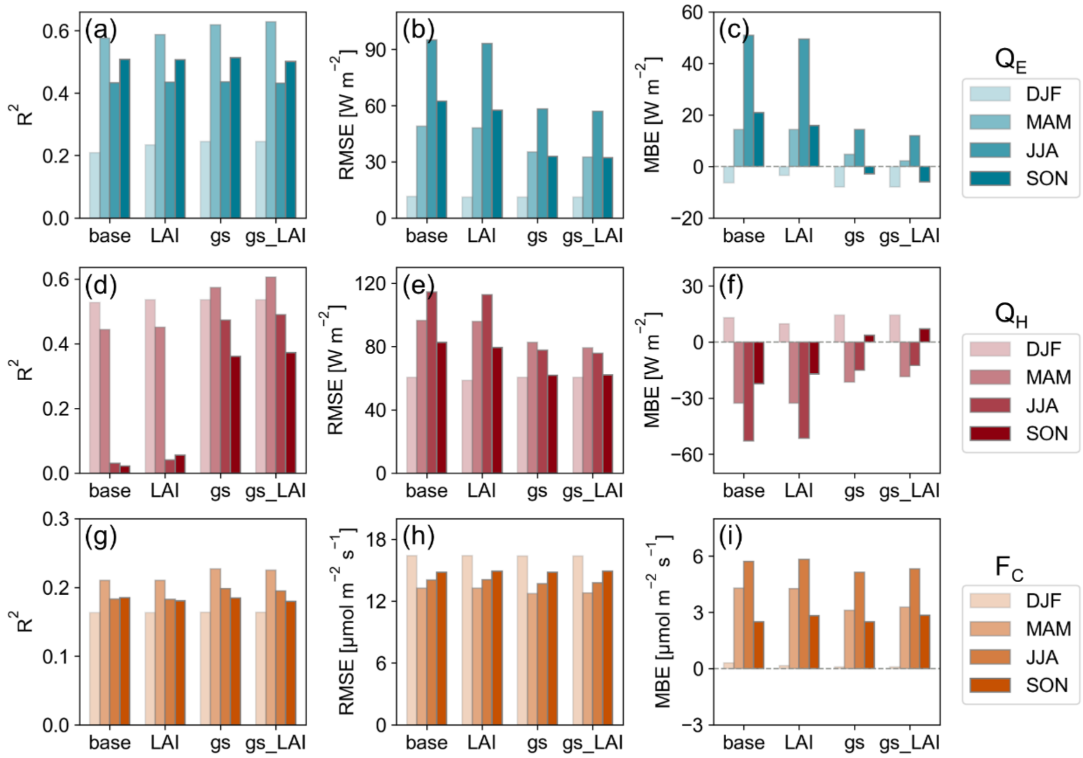

Figure S1. Model performance statistics R^2, RMSE and MBE of (a–c) latent heat flux (Q_E), (d–f) sensible heat flux (Q_H) and (g–i) CO_2 flux (F_C) for the four model cases (case **base**, **gs**, **LAI**, and **gs_LAI**) in the year 2016 using the land cover fractions for the remaining sectors after the wind sector filtering (Table S1).

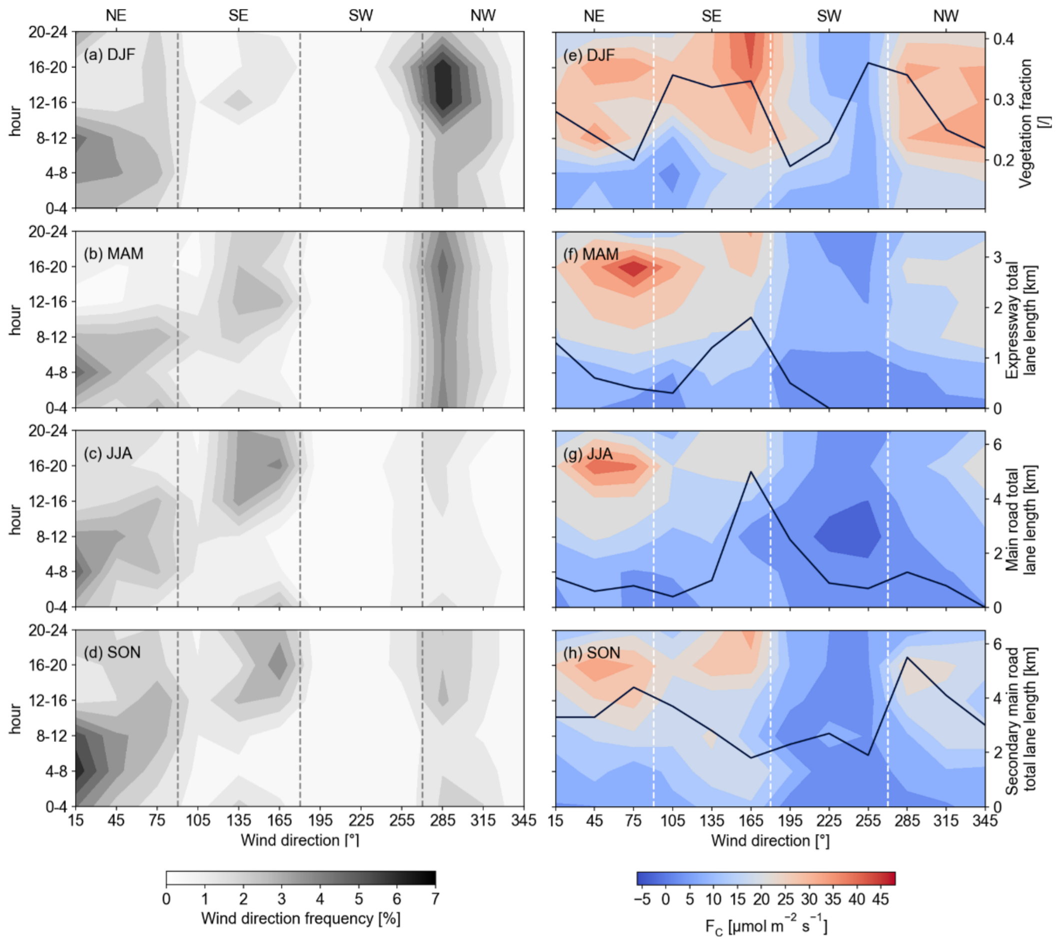

Figure S2. The diurnal pattern of (a–d) wind direction frequency, and (e–h) median of CO_2 flux (F_C) by wind sector and by season. Note that the data shown at (a–d) is the wind direction frequency after the quality control as described in Section 3. Wind directions are in 30° bins, and hours are in 4-hour bins.

Reference

Kokkonen, Tom V, Sue Grimmond, Sonja Murto, Huizhi Liu, Anu-Maija Sundström, and Leena Järvi. 2019. 'Simulation of the radiative effect of haze on the urban hydrological cycle using reanalysis data in Beijing', *Atmospheric Chemistry and Physics*, 19: 7001-17.

Ward, Helen C, Simone Kotthaus, Leena Järvi, and C Sue B Grimmond. 2016. 'Surface Urban Energy and Water Balance Scheme (SUEWS): development and evaluation at two UK sites', *Urban Climate*, 18: 1-32.