Supplementary Text S1. Practical steps for reproducing the WRF implementation of SLUCM+BEM v2.0

SLUCM+BEM v2.0 can be reproduced in WRF using the following procedure.

(1) Select a supported WRF version. In this study, WRF v4.3.2 was used for the scientific evaluation. Implementation compatibility was also tested for WRF v4.5.1, v4.6.1, and v4.7.1.

(2) Apply the corresponding modified source files for the selected WRF version. The modified source files are summarised in Table 5.

(3) Recompile WRF after the modified source files have been applied.

(4) In namelist.input, select the land-surface model and urban option. For Noah-LSM, set sf_surface_physics = 2; for Noah-MP, set sf_surface_physics = 4. For SLUCM+BEM v2.0, set sf_urban_physics = 1.

(5) Prepare the urban input data in WPS/geogrid. In this study, Japan's National Land Numerical Information dataset (three urban categories) was used. The implementation is also compatible with MODIS, LCZ, and distributed urban parameters for SLUCM.

(6) Select the appropriate urban parameter table and options. Use URBPARM.TBL or URBPARM_LCZ.TBL as appropriate, and specify the corresponding urban options such as SBEMOPTION, AH_TRAFFIC, AHDIUPRF, TARGTEMP, HSEQUIP_SCALE_FACTOR, HSEQUIP, AB_BUILD_RATIO, AC_FLOOR_RATIO, AC_USAGE_RATIO_CL, AC_USAGE_RATIO_HT, COPOPTION, COP, VENT_RATE, ALHOPTION, ALHSEASON, ALHDIUPRF, IMP_SCHEME, IRI_SCHEME, GROPTION, and FGR according to the intended application.

(7) Run a short test simulation to confirm successful compilation and stable model execution before conducting full simulations.

For the results presented in this paper, the above procedure was applied using WRF v4.3.2, Noah-LSM, Japan's National Land Numerical Information dataset, and the urban parameter settings described in Section 2 and Table 5.

Supplementary Table S1. User-selectable settings relevant to the implementation of SLUCM+BEM v2.0 in WRF.

File	Variable / item	Example or tested value	Purpose / note
namelist.input (&physics)	sf_surface_physics	2	select Noah-LSM
namelist.input (&physics)	sf_surface_physics	4	select Noah-MP
namelist.input (&physics)	sf_urban_physics	1	Activate the SLUCM-based urban option used for SLUCM+BEM v2.0 and/or urban hydrological processes
WPS / geogrid input	Urban / land-use data	Japan's National Land Numerical Information dataset	Configuration used in this study
WPS / geogrid input	Urban / land-use data	MODIS	Compatible option
WPS / geogrid input	Urban / land-use data	LCZ	Compatible option; use URBPARM_LCZ.TBL
WPS / geogrid input	Urban / land-use data	Distributed urban parameters for SLUCM	Compatible option
URBPARM.TBL or URBPARM_LCZ.TBL	SBEMOPTION	0 or 1	SLUCM+BEM option, where 0 = SLUCM+BEM does not work, 1 = SLUCM+BEM works
URBPARM.TBL or URBPARM_LCZ.TBL	AH_TRAFFIC	User-specified	Anthropogenic heat from traffic
URBPARM.TBL or URBPARM_LCZ.TBL	AHDIUPRF	User-specified	Diurnal profile of anthropogenic heating
URBPARM.TBL or URBPARM_LCZ.TBL	TARGTEMP	User-specified	Target temperature by the HAC system
URBPARM.TBL or URBPARM_LCZ.TBL	HSEQUIP_SCALE_FACTOR	User-specified	Peak internal heat gain
URBPARM.TBL or URBPARM_LCZ.TBL	HSEQUIP	User-specified	Proportional change in HSEQUIP_SCALE_FACTOR over time
URBPARM.TBL or URBPARM_LCZ.TBL	AB_BUILD_RATIO	0.0–1.0	Ratio of abandoned houses/buildings to all houses/buildings in a city block
URBPARM.TBL or URBPARM_LCZ.TBL	AC_FLOOR_RATIO	0.0–1.0	Ratio of air-conditioned floor area to total floor area;
URBPARM.TBL or URBPARM_LCZ.TBL	AC_USAGE_RATIO_CL	0.0–1.0	Proportion of cooling AC usage
URBPARM.TBL or URBPARM_LCZ.TBL	AC_USAGE_RATIO_HT	0.0–1.0	Proportion of heating AC usage
URBPARM.TBL or URBPARM_LCZ.TBL	COPOPTION	0 or 1	A switch that determines whether COP is fixed or variable, where 0 = fixed COP and 1 = COP simulated by SLUCM+BEM
URBPARM.TBL or URBPARM_LCZ.TBL	COP	User-specified	Coefficient of performance
URBPARM.TBL or URBPARM_LCZ.TBL	VENT_RATE	User-specified	Ventilation rate
URBPARM.TBL or URBPARM_LCZ.TBL	ALHOPTION	1	Anthropogenic latent heat option
URBPARM.TBL or URBPARM_LCZ.TBL	ALHSEASON	User-specified	Seasonal setting for anthropogenic latent heat
URBPARM.TBL or URBPARM_LCZ.TBL	ALHDIUPRF	User-specified	Diurnal profiles setting for anthropogenic latent heat
URBPARM.TBL or URBPARM_LCZ.TBL	IMP_SCHEME	2	Impervious-surface related option
URBPARM.TBL or URBPARM_LCZ.TBL	IRI_SCHEME	0 or 1	Irrigation-related option
URBPARM.TBL or URBPARM_LCZ.TBL	GROPTION	0 or 1	Rooftop-greening option
URBPARM.TBL or URBPARM_LCZ.TBL	FGR	0.0–1.0	Fraction of rooftop greening

Note. The settings listed here summarize the options relevant to the practical use of SLUCM+BEM v2.0. Users should select the appropriate combination according to the target WRF version, land-surface model, and urban input dataset.