Overview of the source code modifications, numerical simulations, and postprocessing scripts described in the research article "Multi-layer coupling between SURFEX-TEB-v9.0 and Meso-NH-v5.3 for modelling the urban climate of high-rise cities", Geoscientific Model Development

Regular source code of SURFEX-TEB and Meso-NH

The regular Meso-NH-v5.3 source code can be downloaded via http://mesonh.aero.obs-mip.fr/mesonh53/. In includes SURFEX-TEB-v8.0. The stand-alone SURFEX-v8.0 or SURFEX-v8.1 source code can be downloaded via https://www.umr-cnrm.fr/surfex/spip.php?article387. The model developments presented in the research article will be included in SURFEX-TEB-v9.0.

Atmospheric forcing data

The 6 hourly high-resolution operational forecast analyses from the European Centre for Medium-Range Weather Forecasts (ECMWF) Integrated Forecasting System are provided for a domain covering southern China and the South China Sea in the file ECMWF_FORCING.tar.

Modified source code

The file MODIFIED_Schoetter_etal_GMDD_Multilayer.tar.gz contains the routines of SURFEX and Meso-NH including the model developments discussed in the research article.

The main scientific modifications of the SURFXE-TEB and the Meso-NH-v5.3 equations described in the present article are the following:

- The drag force the buildings exert of the horizontal wind components, the production of turbulent kinetic energy by the wind shear close to the buildings, and the tendencies of potential temperature and water vapour mixing ratio due to the heat and moisture fluxes from the building walls and roof (Equations 1-4 and Equations 7-9) are considered in the routine MNH/drag_bld.f90.
- The extraction of the Meso-NH variables for the forcing of SURFEX-TEB with several atmospheric model levels (Equations 10-16) is made in MNH/ground_paramn.f90. The Meso-NH routine ground_paramn.f90 calls the SURFEX routine SURFEX/coupling_surf_atmn.F90, which is technically modified to accept 2D forcing fields instead of 1D forcing fields. These 2D forcing fields are further passed to SURFEX/coupling_townn.F90, SURFEX/coupling_teb_orographyn.F90, and SURFEX/coupling_tebn.F90.
- In SURFEX/coupling_tebn.F90, the logical switch LATM_CANOPY read from the SURFEX namelist “NAM_PREP_TEB” controls whether the 1D column model described by Hamdi and Masson (2008) is used for the calculation of a vertical profile of the meteorological variables in the urban canopy layer, using the first atmospheric

layer as upper boundary condition (LATM_CANOPY=F) or whether the meteorological forcing from multiple Meso-NH levels is directly used as meteorological forcing for the ground surfaces, building walls, and roofs (LATM_CANOPY=T) (Equations 17 to 23).

- The value of the drag due to the roofs (Equations 5-6) is calculated in SURFEX/coupling_tebn.F90.

Numerical simulations

The simulation directories for the numerical simulations conducted to test the different coupling approaches for the heat waves in 2009 and 2018 are provided in the following directories, whose names correspond to those used in the manuscript.

- HK_HWMay2018_CLASSICAL.tar.gz
- HK_HWMay2018_NEW.tar.gz
- HK_HWMay2018_SURFFLUX.tar.gz
- HK_HWSep2009_CLASSICAL.tar.gz
- HK_HWSep2009_NEW.tar.gz
- HK_HWSep2009_SURFFLUX.tar.gz

Urban morphology data are given in SURF_FILES.tar.gz, the Sea Surface Temperature forcing data in SST_FILES.tar.gz. The European Centre for Medium-Range Weather Forecasts (ECMWF) Integrated Forecasting System high-resolution operational forecast analyses are preprocessed by the PREP_REAL_CASE program (in the 002_COUPLING folder), which provides the lateral forcing of the coarsest resolution model domain.

The multi-layer coupling is activated in the Meso-NH namelists (EXSEGNN.nam with NN the domain number, located in the TEMPLATES folder) via the new namelist NAM_COUPLING_LEVELSn. In this namelist, NLEV_COUPLE = NLEV indicates the number of Meso-NH levels to be coupled with SURFEX. In the SURFEX namelist NAM_PREP_TEB, LATM_CANOPY=T needs to be specified to activate the multi-layer coupling. Incoherent specification of the Meso-NH and the SURFEX namelist will lead to a model abort. Building drag (LDRAGBLDG=T) and building heat and moisture fluxes at multiple atmospheric levels (LFLUXBLDG=T) can be activated via the new Meso-NH namelist NAM_DRAGBLDGn.

Postprocessing scripts

The scripts to postprocess the observations and model results in order to calculate the model evaluation measures or to create the figures are provided. These scripts are written in R and python.

General postprocessing of the different simulations including unit conversions, averaging over selected time periods, extraction of grid points nearest to the station location:

- ONLINE_PLOT_HongKong_HW2009_CLASSICAL.R
- ONLINE_PLOT_HongKong_HW2009_Final.R (for the NEW coupling approach)
- ONLINE_PLOT_HongKong_HW2009_SURFFLUX.R

- ONLINE_PLOT_HongKong_HW2018_CLASSICAL.R
- ONLINE_PLOT_HongKong_HW2018_Final.R (for the NEW coupling approach)
- ONLINE_PLOT_HongKong_HW2018_SURFFLUX.R
- ONLINE_PLOT_HongKong_May2018.R (the simulation covering entire May 2018)

CALC_EVALMEASURES_HongKong.R: Calculation of the model evaluation measures for different coupling approaches.
PLOTEVALMEASURES_HongKong_scenarios.R: Creating the figures synthetising the evaluation measures for all stations and coupling approaches.
PLOT_PROFILE.R: Plotting the vertical profiles to compare with radiosoundings.
BUDGETS.py: Postprocessing of the budgets calculated by Meso-NH.
Plot_Budgets.R: Plot the results of the budgets.
subloadobs.R: Load the observation data.
subplot.R: Subroutines related to plotting.