**eWUDAPT workshop Working group III Modelling.**

Version 0.1

**GABLS-urban**

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Context

Urban areas are characterized by a clearly different meteorology than rural areas. With the refinement of the resolution of numerical weather prediction models, the consideration of the surface energy balance of urban areas require a specific representation to account for radiative trapping, urban vegetation, anthropogenic heat flux, heat storage in the urban fabric. Many urban canopy models of different complexity have been developed in the last decades. Grimmond et al (2010, 2011) compared a myriad of the models on the performance of the surface energy balance, and identified a ranking in the essentials of processes to be represented and parameter space. In that particular study the models were driven by observations taken above the canopy, which is a state of the art method to evaluate land surface models. However, in the real world, these urban canopy schemes are operating in conjunction with boundary-layer schemes that are responsible for transport of heat, moisture and momentum from the surface through the lower atmosphere, as well as with the free atmosphere due to entrainment. This coupling leads to feedbacks and dependencies on the schemes that have so far not been quantified. Here we propose a modelling experiment in which we further evaluate the modelling infrastructure for the urban boundary layer coupled to the urban land surface. This modelling exercise specifically aims to:

-Evaluate single-column models coupled to the urban surface for the urban environment against field observations at the surface as well and in the PBL.

-Identify key strengths and weaknesses in these model approaches.

-Identify feedbacks and their strengths between urban canopy schemes and boundary-layer scheme.

-Provide a benchmark case study for later use in the community.

In this sense the proposed work build upon earlier experiments in the GABLS (Holtslag et al, 2013) and DICE (Best and Lock, 2016) communities.

**Case selection**

Since this will be the first model comparison study for urban areas, we propose to start relatively simple and search for a clear-sky period with relatively low winds (geowind < 5 m/s) for a period of 48-72 h. In general vertical information of the structure of the atmosphere is scarce from observations, though for London (Bohnenstengel et al 2013) a wide suite of observations is at hand. Therefore we propose to select a case study for London.

**Workflow**

Since the setup of such a case study is not a trivial thing to do, we propose to perform the intercomparison in two phases. **Phase 0** covers the time available at the eWUDAPT workshop in which the participants thoroughly prepare the intercomparison and analyse pro and cons of the setups. In **phase 1** the single column model intercomparison is being released to the whole research community, and results will be discussed at later workshops (e.g. during ICUC-2018).

Moreover, each phase will cover multiple stages.

Stage 1: In this stage only the urban land surface schemes will be evaluated, analogous to PILPS-urban. Urban morphological parameters will be provided by WG1 in the eWUDAPT workshop and formulated in terms of local climate zones.

Stage 2: In this stage the same urban morphological parameters will be provided as in stage 1, but now to the single column model will be run. In this way one can identify the model behaviour of the land surface scheme in connection to the PBL scheme.

Stage 3: In this stage modellers are asked to apply their default model settings for the urban scheme. This allows for model evaluation against real world observations.

For phase 1 identical steps will be undertaken, but for the whole community.

**Role of science Engineer.**

During the eWUDAPT workshop, an eScience engineer is available to accelerate the model intercomparison process. His/here role as foreseen is to develop a webportal that receives model output files in netcdf format as input and which creates a series of plots of the surface radiation and energy balance as well as vertical profiles for all models and available observations. The webportal facilitates communication between participants and model comparison coordinators, and in a later stage it can act as an archive to provide model results as open access data.

**References**

Grimmond, C.S.B., M. Blackett, M. Best, J. Barlow, J.-J. Baik, S. Belcher, S.I. Bohnenstengel, I. Calmet, F. Chen, A. Dandou , K.Fortuniak, M. Gouvea, R. Hamdi, M. Hendry, H. Kondo, S. Krayenhoff, S.-H. Lee , T. Loridan, A. Martilli, V. Masson, S. Miao, K. Oleson, G. Pigeon, A. Porson, F. Salamanca, L. Shashua-Bar, G.J. Steeneveld, M. Tombrou, J. Voogt, N. Zhang, 2010: The International Urban Energy Balance Models Comparison Project: First results from Phase 1, J. Appl. Meteor. Clim., 49, 1268-1292.

Grimmond, C.S.B., M Blackett, MJ Best, J-J Baik, SE Belcher, J Beringer, SI Bohnenstengel,I Calmet, F Chen, A Coutts, A Dandou, K Fortuniak, ML Gouvea, R Hamdi, M Hendry, M Kanda, T Kawai, Y Kawamoto, H Kondo, ES Krayenhoff, S-H Lee, T Loridan, A Martilli,V Masson, S Miao, K Oleson, R Ooka, G Pigeon, A Porson, Y-H Ryu, F Salamanca, G.J. Steeneveld, M Tombrou, JA Voogt, D Young, N Zhang, 2010: Initial Results from Phase 2 of the International Urban Energy Balance Comparison Project, Int. J. Climatol., 31, 244-272.

**Modelling recipe.**

1. **Input**

**I Meteorological input**

**<to be determined based on the case selection>**

**Location, initial profiles of theta, q, u, v, TKE, advection terms of the latter quantities, U\_geo, V\_geo, Initial soil temperature and moisture.**

**II Morphological input**

1. **Requested output**

We ask for a NetCdf file which contains:

##surface variables

##profiles of state variables at full levels

##profiles of fluxes on half levels

##profiles of soil parameters

##profiles of forcings as prescribed for this case at model levels

##profiles of the initial state as prescribed for this case

All data should be given as 10-min averages.

***Filename***

The filename should be composed as:

gabls\_urban\_scm\_<institute>\_<model>\_<ver>.nc

where

<institute> name or acronym of your institute

<model> acronym of your model

<phase> phase of the experiment (0 or 1)

<stage> stage of the experiment (1-3)

<ver> version of your submission (v10, v11, etc)

example: gabls\_urban\_scm\_wur\_wrf\_0\_1\_v03.nc

***Global attributes***

All relevant meta information should be added to the file as global attributes. This should include:

*General:*

-reference to the model

-contact person.

-type of model where the SCM is derived from (climate model, mesoscale weather prediction model, regional model) ?

-time step

*Surface scheme properties*:

Describe the level op complexity of the urban canopy scheme.

Is there a tile approach?

*Turbulence scheme*:

Turbulence scheme (e.g., K profile, TKE-l, ...)

Formulation of eddy diffusivity K.

For E-l and Louis-type scheme: give formulation length scale.

For K-profile: how is this profile determined ? (e.g., based on Richardson, Brunt-Vaisala frequency (N^2), Parcel method, other.

*Initial profiles*

Include the initial profiles in the mean state section as the first time step at 0 seconds.

Here we assume that the model is in eta coordinates and has a specific structure in the use of full levels and half level. If your model differs in this respect please adapt the output to fit with your model.

*Sign convention*

Surface energy fluxes (shf, lhf, g, qf) are positive when directed away from the surface. Surface radiation fluxes (qdw, qup, ldw, lup) are positive.

NetCdf dimensions and variables

Variables and dimensions should have the names as specified below between curled brackets (all lower case) . Exclude the curled brackets from the name.

Use the unlimited option for the "time" dimension or at least be sure that "time" is the slowest varying dimension in two dimensional variables.

Each variable should have an attribute "units" with the unit prescribed as below between brackets. Exclude the brackets from the unit.

Each variable should have an attribute "long\_name" which explains the meaning of the variable. The exact formulation is free, but could be taken from the description below. If a variable is not available for your model, use the attribute \_FillValue to prescribe the numerical value that defines not available.

All physical variables should be of type float

*Dimensions:*

{time} output times

{levf} full levels

{levh} half levels

{levs} soil levels

*Variables:*

1. Model levels {levf}

{afull}

{bfull}

2. Model levels {levh}

{ahalf}

{bhalf}

3. Time series output {time}

{time} seconds since 2006-07-01 12:00:00 [s]

{ldw} long wave downward radiation at surface [W/m2]

{lup} long wave upward radiation at surface [W/m2]

{qdw} short wave downward radiation at surface [W/m2]

{qup} short wave upward radiation at surface [W/m2]

{tsk} temperature skin layer [W/m2]

{g} soil heat flux [W/m2]

{shf} sensible heat flux [W/m2]

{lhf} latent heat flux [W/m2]

{qf} anthropogenic heat flux [W/m2]

{ustar} friction velocity [m/s]

{hpbl} boundary layer height [m]

{t2m} 2m temperature [K]

{q2m} 2m specific humidity [kg/kg]

{u10m} 10m u-component wind [m/s]

{v10m} 10m v-component wind [m/s]

{cc} cloud cover fraction [0 1]

4. Mean state {time} {levf}

{zf} height of full level [m]

{pf} pressure at full level [Pa]

{t} temperature [K]

{th} potential temperature [K]

{q} specific humidity [kg/kg]

{u} zonal component wind [m/s]

{v} meridional component wind [m/s]

5. Prescribed forcings {time} ({levf} or {levh})

{ugeo} u-component geostrophic wind [m/s]

{vgeo} v-component geostrophic wind [m/s]

{dudt\_ls} u-component momentum advection [m/s/s]

{dvdt\_ls} v-component momentum advection [m/s/s]

{dtdt\_ls} temperature advection [K/s]

{dqdt\_ls} moisture advection [kg/kg/s]

{ome} vertical movement [Pa/s]

6. Fluxes {time} {levh}

{zh} height of half level [m]

{ph} pressure at half level [Pa]

{wt} vertical temperature flux [Km/s]

{wq} vertical moisture flux [kg/kg m/s]

{uw} vertical flux u-component momentum [m2/s2]

{vw} vertical flux v-component momentum [m2/s2]

{Km} eddy diffusivity momentum [m2/s]

{Kh} eddy diffusivity heat [m2/s]

{TKE} turbulent kinetic energy [m^2/s^2]

{shear} shear production [m2/s3]

{buoy} buoyancy production [m2/s3]

{trans} total transport [m2/s3]

{dissi} dissipation [m2/s3]

7. Soil variables {time}{levs}

{zs} height of soil level [m]

{ts} soil temperature [K]

{ths} soil water content [m3/m3]