Student - First Name, Surname

URBAN EXERCISE

The Influence of Metropolitan Areas on Meteorology

Teacher: Alexander Mahura

Model: Enviro-HIRLAM

22-26(27) June 2015
St. Petersburg, Russia

Russian State Hydrometeorological University (RSHU)

Content

1. URBAN EXERCISE: General Information

The Influence of Metropolitan Areas on Meteorology

Model used: **Enviro-HIRLAM**

Read, the general description of the HIRLAM (HIgh Resolution Limited Area Model) model at the HIRLAM official website at:
http://hirlam.org/index.php?option=com_content&view=article&id=64&Itemid=101
See for more details the scientific documentation on the HIRLAM model at:
http://hirlam.org/index.php?option=com_docman&task=doc_download&gid=270&Itemid=70

Teacher: **Alexander Mahura**

Introduction Background:

Urbanization is considered as one of important steps for improvement of numerical weather forecasts in the metropolitan areas and surroundings. This has been also included into the Enviro-HIRLAM model developments, because due to rapidly extending urban areas, the impact of cities on the formation of meteorological fields became more evident. Since the urban areas change diurnal cycles of temperature, wind characteristics, humidity, etc., and hence, these influence the quality of forecasts from the numerical weather prediction (NWP) models. To improve forecasting, modifications of the land surface scheme of the model are required and for Enviro-HIRLAM these modifications include the following:

- Changes in anthropogenic heat flux, roughness, and albedo (AHF+R+A) characteristics in urban areas can be used for grid cells of modelling domain which are attributed to urban areas (Baklanov et al., 2005; Mahura et al., 2008);
- Effects of buildings and street canyons can be implemented through the building effect parameterization (BEP) module (Martilli et al., 2002);
- Re-classified land-use with respect to urban types of surfaces (such as buildings, artificial surfaces with/without vegetation, etc.) and urban districts with detailed morphological characteristics can be included through the soil model for sub-meso scales urban version (SM2-U) module (Dupont et al., 2006ab).

These approaches (to study possible urban effects on meteorological patterns) have been tested & evaluated for the model for both specific case (related to low, typical, & high winds conditions) & long-term studies (Mahura et al., 2005; 2008).

Main Goal:

Study influence of the selected metropolitan area on a formation of meteorological fields above the urban area and surroundings due to modification of the land surface scheme of the numerical weather prediction (NWP) model by analysis of temporal and spatial variability of diurnal cycle for meteorological variables of key importance.

Specific Objectives:

1. Modify the land surface scheme of the Enviro-HIRLAM model: (i) by changing the AHF+R+A - (a) anthropogenic heat flux, (b) roughness, and (c) albedo for urban grid cells; and (ii) by implementation the BEP (Building Effects Parameterization) module;
2. Perform simulations for selected specific cases/dates (meteorological conditions with dominating low and typical wind conditions over the metropolitan area and surroundings) in two modes - the control run and the modified run (with changes: AHF+R+A vs. BEP);
3. Evaluate diurnal cycle variability for – (a) air temperature, (b) wind velocity, (c) relative humidity, (d) sensible heat flux, (e) latent heat flux, and etc. – for two types of runs; estimate

extension and direction of boundaries under influence of metropolitan areas, magnitude and signs of changes due to urban areas, etc.;

4. Summaries findings and results of the exercise in a form of an oral presentation (max 15 minutes).

Literature List:

Before the Summer School, the students should read, at least, the first 2 required publications; the three other papers are highly recommended to read to be useful for the discussions/talks; the additional readings might be useful too.

REQUIRED READINGS

Korsholm U.S., A. Baklanov, A. Gross, A. Mahura, B.H. Sass and E. Kaas, ***2008****: Online coupled chemical weather forecasting based on HIRLAM – overview and prospective of Enviro-HIRLAM. HIRLAM Newsletter,* ***54****: 1-17.*

Korsholm U.S. ***2009****: Integrated modeling of aerosol indirect effects.* http://www.dmi.dk/dmi/sr09-01.pdf

RECOMMENDED READINGS

Baklanov A., Mahura A., Nielsen N.W., C. Petersen, ***2005****: Approaches for urbanization of DMI–HIRLAM NWP model. HIRLAM Newsletter* ***49****: 61-75.*

Mahura A., Petersen C., Baklanov A., B. Amstrup, U.S. Korsholm, K. Sattler, ***2008****: Verification of long-term DMI–HIRLAM NWP model runs using urbanization and building effect parameterization modules. HIRLAM Newsletter* ***53****: 50-60.*

Martilli, A., Clappier, A., and Rotach, M. W., ***2002****: An Urban Surface Exchange Parameterisation for Mesoscale Models, Boundary-Layer Meteorol. 104: 261-304.*

Dupont S., P. Mestayer, ***2006a****: Parameterization of the Urban Energy Budget with the Submesoscale Soil Model. J. of Appl. Meteor. and Climat., 45: 1744-1765.*

Dupont S., P.G. Mestayer, E. Guilloteau, E. Berthier, H. Andrieu, ***2006b****: Parameterization of the Urban Water Budget with the Submesoscale Soil Model. J. of Appl. Meteor. and Climat., 45: 624-648.*

ADDITIONAL READINGS:

Baklanov A., P. Mestayer, A. Clappier, S. Zilitinkevich, S. Joffre, A. Mahura, N.W. Nielsen, ***2008****: Towards improving the simulation of meteorological fields in urban areas through updated/advanced surface fluxes description. Atmos. Chem. Phys., 8: 523-543.*

Mahura A., S. Leroyer, P. Mestayer, I. Calmet, S. Dupont, N. Long, A. Baklanov, C. Petersen, K. Sattler, N. W. Nielsen, ***2005****: Large eddy simulation of urban features for Copenhagen metropolitan area. Atmos. Chem. Phys. Discuss., 5: 11183–11213.*

2. Schedule for the Research Training - Urban Exercise

Day	Period	Total time	Topics to be discussed	Runs	Comments	Assistance
(1) Monday 22 Jun 2015	10:00-14:00+	4 h +	LECTURE on "Physiographic Info: Treatment of Land-Use & Urbanization" INTRODUCTION into exercise SELECTION of specific date TECHNICAL PREPARATION for runs OUTLINE/PLAN of research project + ***INDEPENDENT WORK***	Remote runs: HPC CRAY	Lecture (start/ part 1) on physiography & model urbanization Select date for runs Check implementation Test runs on computer Make presentation on project tasks	Teacher Teacher Ass.
(2) Tuesday 23 Jun 2015	10:00-14:00+	4 h +	LECTURE on "Physiographic Info: Treatment of Land-Use & Urbanization" Research project OUTLINE/TASKS MODEL RUNS at computer VISUALIZATION of modelling outputs ANALYSIS of results + ***INDEPENDENT WORK***	Remote runs: HPC CRAY	Lecture (continue / part 2) on physiography & model urbanization Students present project outline/tasks Test runs on computer Start visualization Continue runs on computer Start analysis	Teacher Teacher Ass.
(3) Wednesday 24 Jun 2015	10:00-14:00+	4 h +	LECTURE on "Physiographic Info: Treatment of Land-Use & Urbanization" MODEL RUNS at computer VISUALIZATION of modelling outputs ANALYSIS of results + ***INDEPENDENT WORK***	Remote runs: HPC CRAY	Lecture (continue / part 3) on physiography & model urbanization Continue runs on computer Continue visualization Continue analysis	Teacher Teacher Ass.
(4) Thursday 25 Jun 2015	10:00-14:00+	4 h +	MODEL RUNS at computer VISUALIZATION of modelling outputs ANALYSIS of results ORAL PRESENTATION preparation + ***INDEPENDENT WORK***	Remote runs: HPC CRAY	Finish runs on computer Continue visualization Continue analysis Draft presentation	Teacher Teacher Ass.
(5) Friday 26 Jun 2015	10:00-14:00+	4 h +	+ ***INDEPENDENT WORK*** ORAL PRESENTATION / Defence of small-scale research project		Finalize analysis Finalize presentation Students present results	Teacher Teacher Ass.
(6) Saturday 27 Jun 2015	10:00-12:00+	2 h +	ORAL PRESENTATION / Defence of small-scale research project	*If necessary in addition to Friday; the defence / presentation of the completed small-scale research project can take place on Saturday*		

3. Items of the Urban Exercise

Introduction into Exercise (Background Discussions)

Introduction into the urban exercise; main items of the exercise (selection of dates, technical aspects and implementations, runs, visualization and analysis of results, making presentation); brainstorming for both teams/groups to outline research and technical tasks required (including main goal, specific objectives, etc.) within groups, etc.

Make a link with consultants (lectors) asking theoretical questions and consider an exchange between teams of students – as research groups - during the exercise; additional talks/discussions on urbanization aspects including (*see Annexes A1-A9*):

- *A0 - Enviro-HIRLAM: NWP–ACT Integrated Modelling System;*
- *A1 - Enviro-HIRLAM: NWP–ACT Integrated Model Scheme;*
- *A2 - Modelling domains (for operational and research purposes);*
- *A3 – High-resolution modelling domains;*
- *A4 - Anthropogenic heat flux and roughness (AHF+R) changes in urban areas;*
- *A5 - Building Effect Parameterization (BEP) module;*
- *A6 - Soil Model for Sub-Meso scales Urbanized version (SM2-U);*
- *A7 - Urban districts classification (on examples for selected metropolitan areas);*
- *A8 - Characteristics of urban districts (on example, for Paris metropolitan area);*
- *A9 - Revised land-use classification (on example, for SM2-U).*

Meteorological situations for selected cases/ dates

Analyze meteorological conditions in the modelling domain over the urban area and surroundings for given dates using available surface maps, diagrams of vertical sounding at the sub-urban station, and surface meteorological measurements at the urban station (data are provided from the DMI meteorological archives). Select the specific date (to be used in runs) and make/write a general summary of meteorological conditions (to be used in final oral presentation by the team).

- *Supplementary material for the URBAN exercise (meteorological conditions for specific dates)*

Technical aspects of modelling and urban implementation

Learn practical technical steps/ tasks / activities in order to make necessary changes in the Enviro-HIRLAM code, implementation of the urban effects (AHF, R, BEP) compile the executable, run the model at different options, save generated output, etc. (*see Annexes B1-B3*):

- *B1. Model – Preparations, Setups & Runs*
- *B2. Urban Implementation - AHF, R, BEP*
- *B3. Call-Tree for BEP Implementation*

Model runs

Perform simulations (note: use maximum forecast length as 24 hours) for the selected date/s for different options of urbanization (AHF, R, BEP), estimate computational times for different runs. Note, all simulations with the Enviro-HIRLAM model will be performed at a high horizontal grid resolution (*see Table in Annex 2*); as well as *see Annexes B1-B3*:

- *B1. Model – Preparations, Setups & Runs*
- *B2. Urban Implementation - AHF, R, BEP*
- *B3. Call-Tree for BEP Implementation*

Possible Enviro-HIRLAM runs for the URBAN exercise are the following:

- Control (reference) run – without any modifications;

- Modified (urbanized) runs at different time steps (30, 60, 90, 120, 240, 360 sec) to select the best suitable / optimal;
- Urbanized run with modified anthropogenic heat flux (AHF) for urban areas (grid cells);
- Urbanized run with extremely high /unrealistic/ AHF of 500 W/m^2;
- Urbanized run with modified roughness (R) for urban areas;
- Urbanized run with both modified AHF and R (AHF+R) for urban areas;
- Urbanized run with including building effect parameterization (BEP) module.

Visualization of results

Learn on how to use the METGRAF software in order to plot results of simulations in different forms (see Annex C1-C2):

- *C1. Visualization of Results*
- *C2. Examples of Visualization and Analysis*

Urban impact on meteorology: analysis

Analyze and evaluate possible impact of the urban areas on temporal and spatial variability of the simulated meteorological fields for selected meteorological parameters, for example: air temperature, wind speed, relative humidity, sensible heat flux, latent heat flux, and etc; evaluate diurnal cycle variability for analyzed parameters – for two types of runs – control vs. modified (urban); estimate extension and direction of boundaries under influence of metropolitan areas, magnitude and signs of changes due to urban areas, etc.;

- *C2 – Examples of visualization and analysis.*

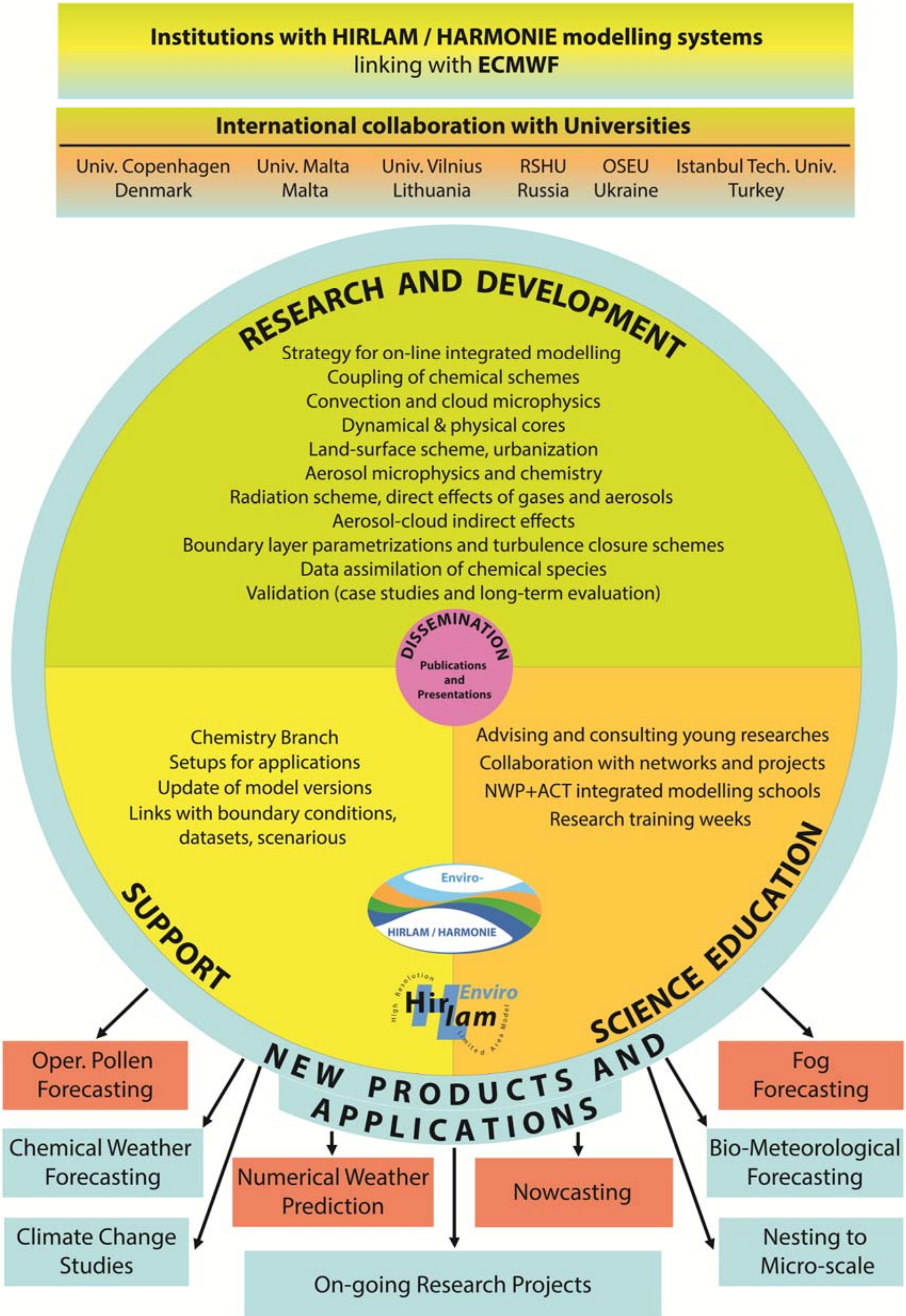
Team presentation

Make your team oral (using any application, preferably MS Power Point) presentation about findings and results obtained; follow the draft guidelines of the presentation, which should, at least, include the title, main aim and specific objectives, methodology and approaches, results and discussions with examples, conclusions, acknowledgements, references, etc.

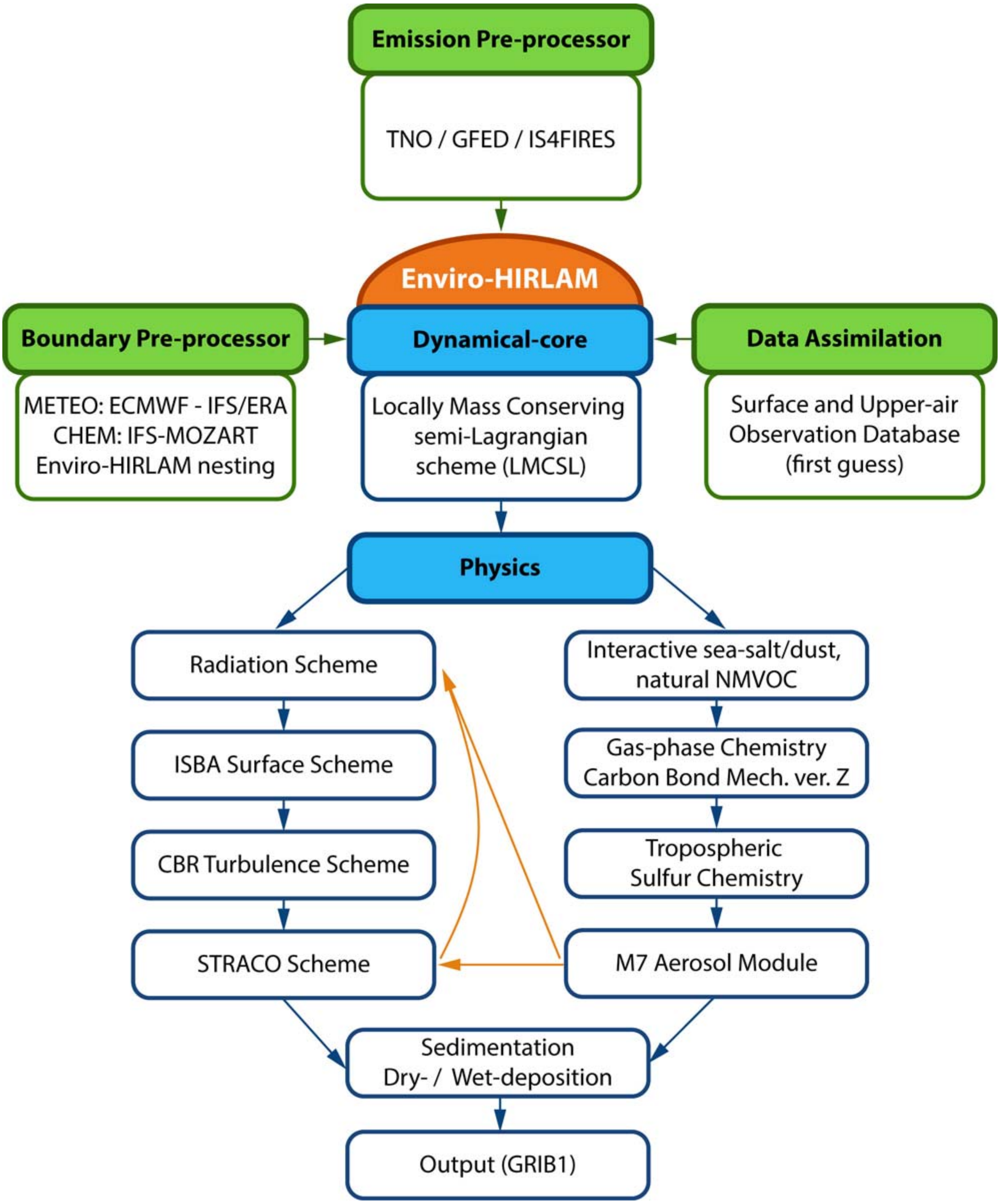
- *C3 – Draft Outline of Presentation.*

ANNEXES

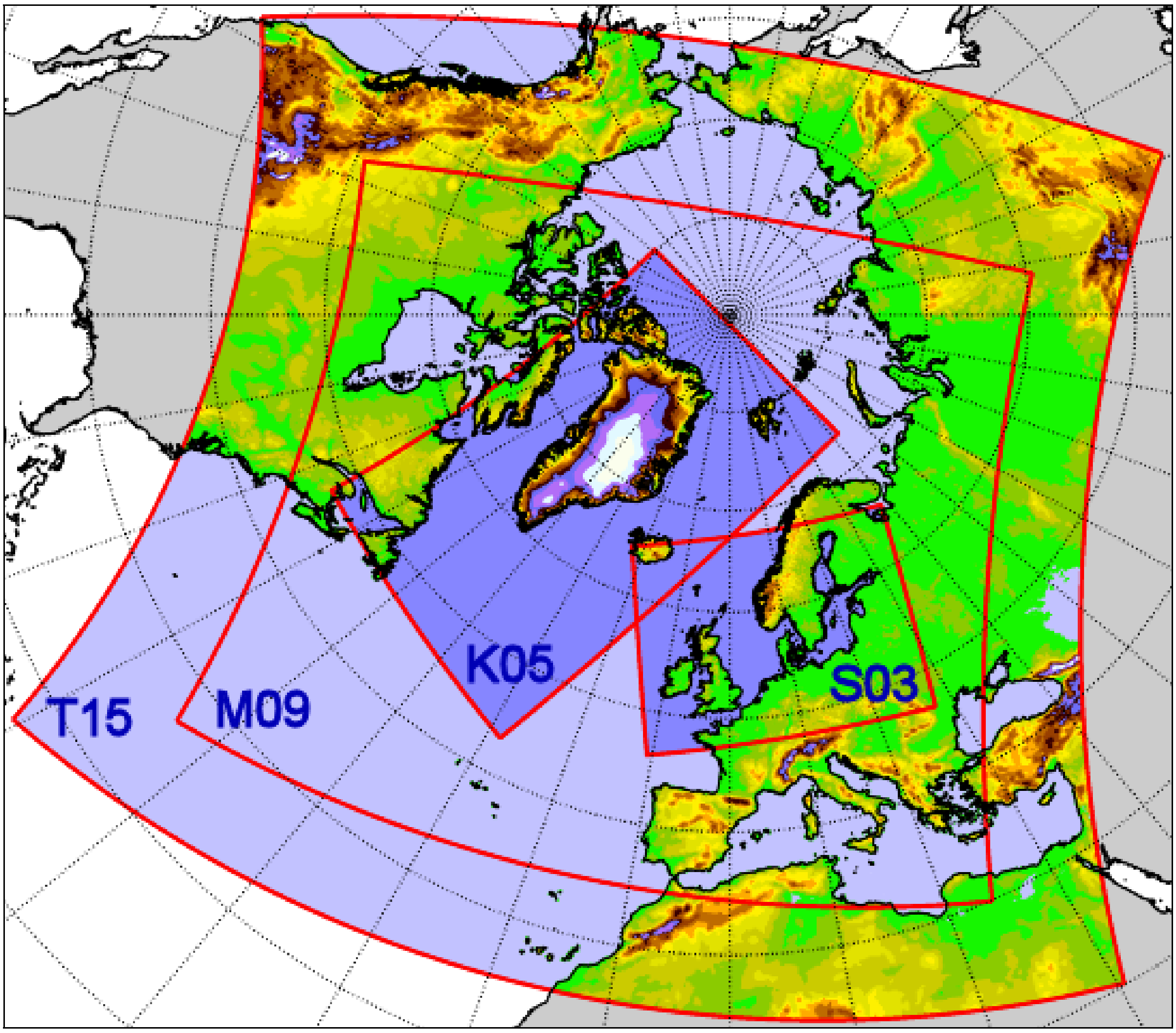
A0. Enviro-HIRLAM: NWP–ACT Integrated Modelling System



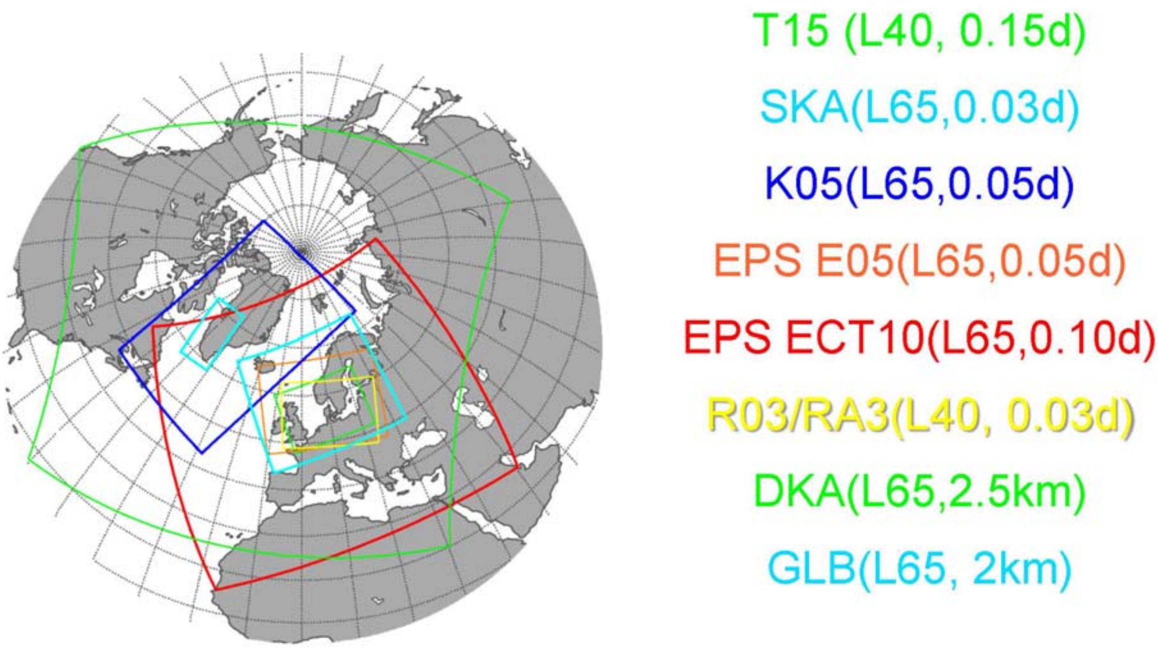
A1. Enviro-HIRLAM: NWP–ACT Integrated Model Scheme



A2. Modelling Domains



(used for DMI operational and research purposes before and after Jan 2014)



A3. High Resolution Modelling Domains

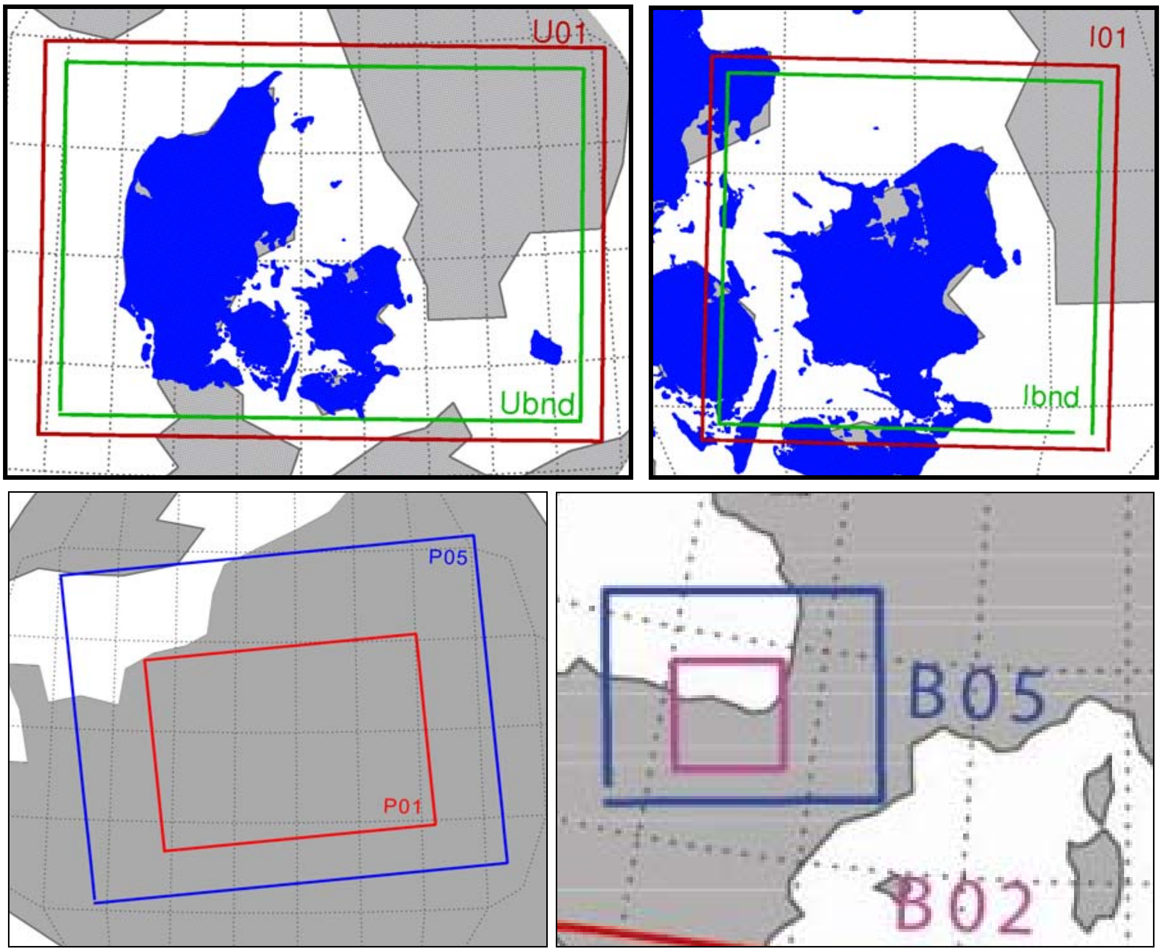
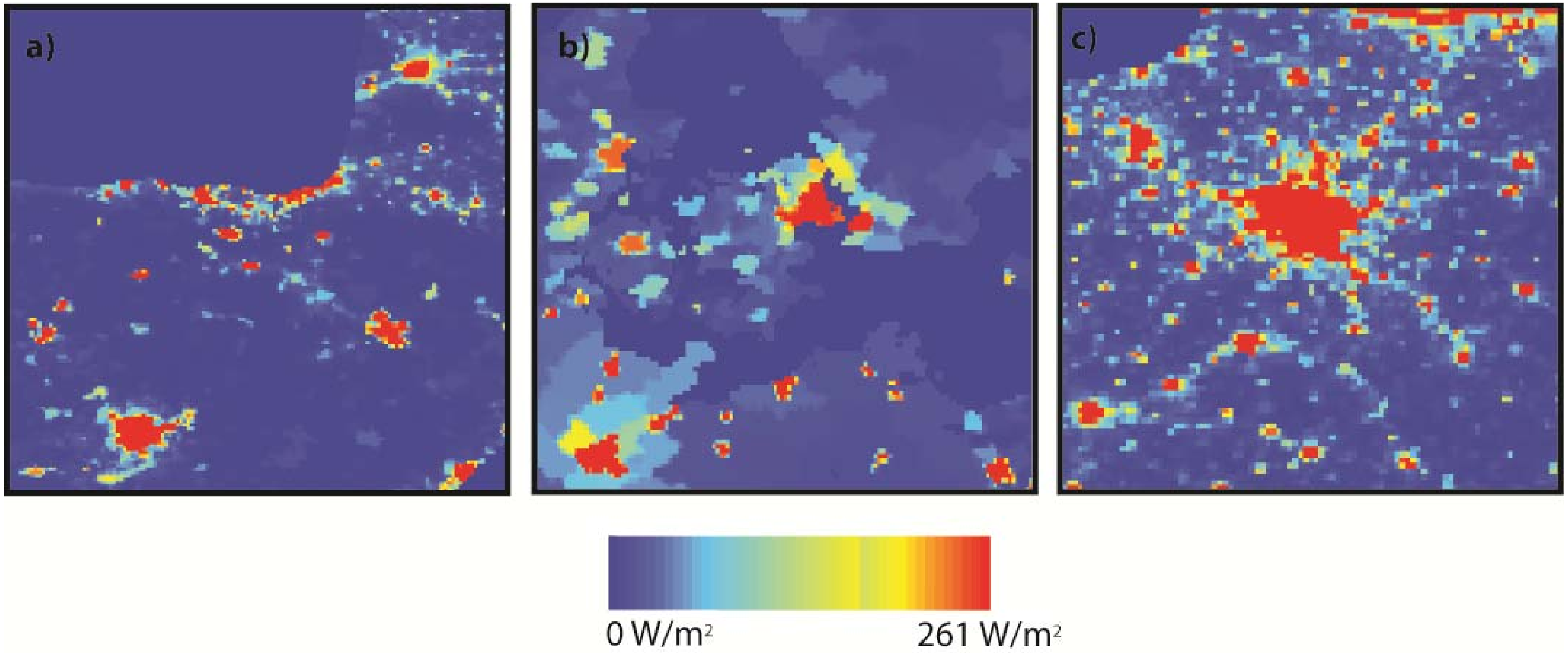


Figure: Geographical boundaries of the modelling domains: B02 - for Bilbao; P01 – for Paris; and U01 –for Copenhagen metropolitan areas located in the center of domains.

Metropolitan area	Domain	Horisonal Resolution (km)	Total # grid points in domain	# Urban grid points in domain	# Metropolitan Grids in domain	Area covered by metropolitan grids (km^2)
Bilbao	**B02**	2.4x2.4	14834	68	16	92.16
Copenhagen	**U01**	1.4x1.4	65022	3080	500	980
Copenhagen	**I01**	1.4x1.4	14632	1850	500	980
Paris	**P01**	2.5x2.5	10148	580	220	1267.2

Table: Summary of characteristics of the modelling domains – B02, U01/I01- and P01 – for the Bilbao, Copenhagen and Paris metropolitan areas, respectively.

A4. AHF - Anthropogenic Heat Fluxes



(a) (b) (c)

Figure: Athropogenic heat fluxes (in W/m^2) for 2005 based on extracted from the LUCY model for the: (a) Bilbao; (b) Copenhagen, and (c) Paris metropolitan areas.

*Allen L., S. Beevers, F. Lindberg, Mario Iamarino, N. Kitiwiroon, CSB Grimmond (**2010**): Global to City Scale Urban Anthropogenic Heat Flux: Model and Variability. Deliverable 1.4, MEGAPOLI Scientific Report 10-01, MEGAPOLI-04-REP-2010-03, 87p, ISBN: 978-87-992924-4-8; http://megapoli.dmi.dk/publ/MEGAPOLI_sr10-01.pdf*

A5. BEP - Building Effect Parameterisation Module

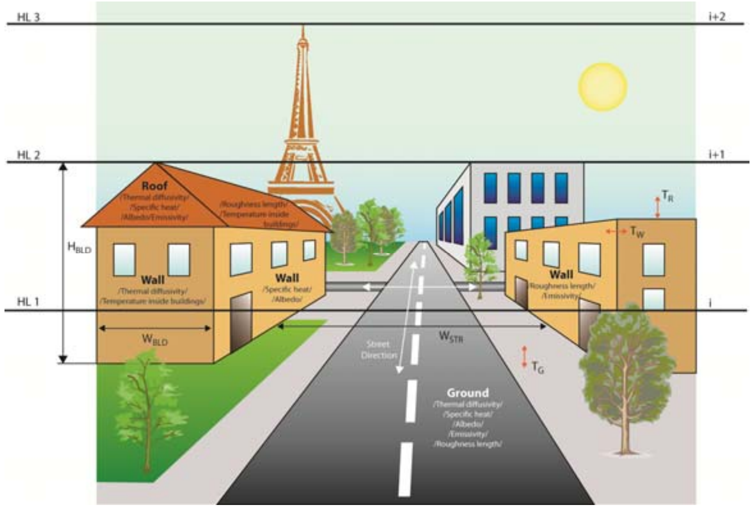


Figure: Schematic representation of urban features and numerical grid in the urban module / *HL1*, *HL2* – model levels; H_{BLD}, W_{BLD} – height and width of the buildings; *SD*, W_{STR} – street direction and width; T_G, T_W, T_R – temperatures of ground, wall and roof surfaces, respectively/.

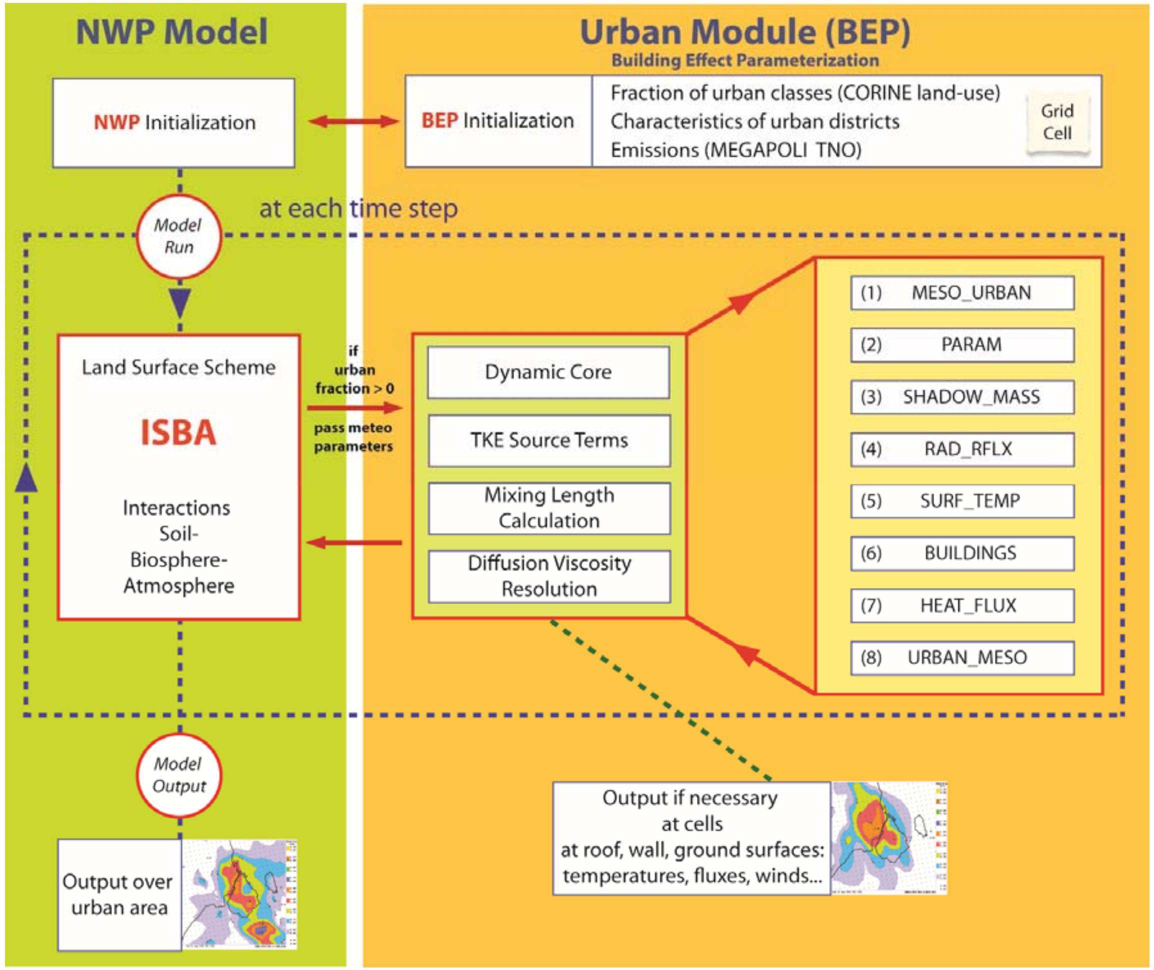
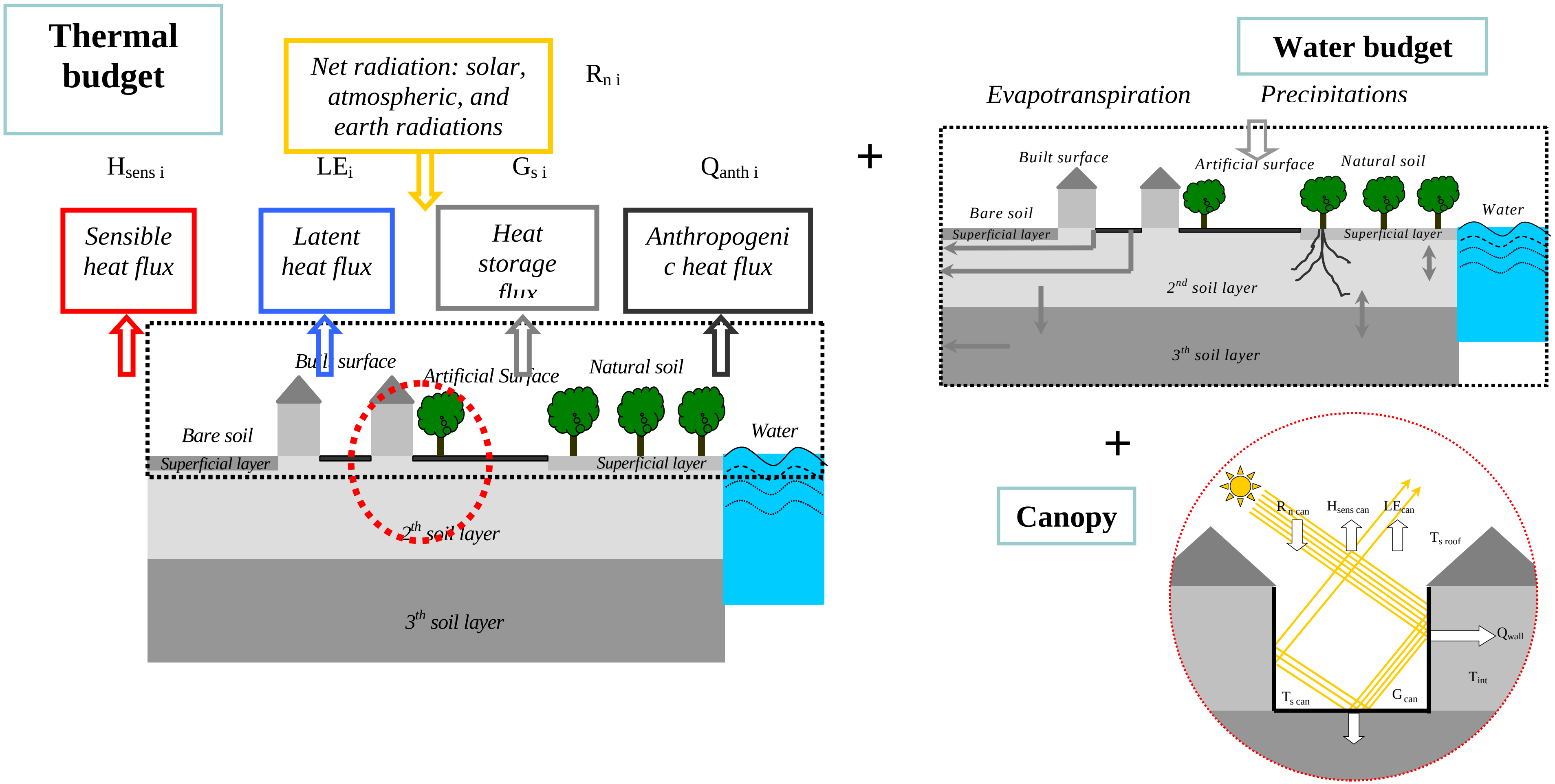


Figure: General scheme of the BEP module for the model urbanization with a structure of the subroutine conception.

A6. SM2-U - Soil Model for Sub-Meso scales Urban version



from Dupont et al. (2006ab)

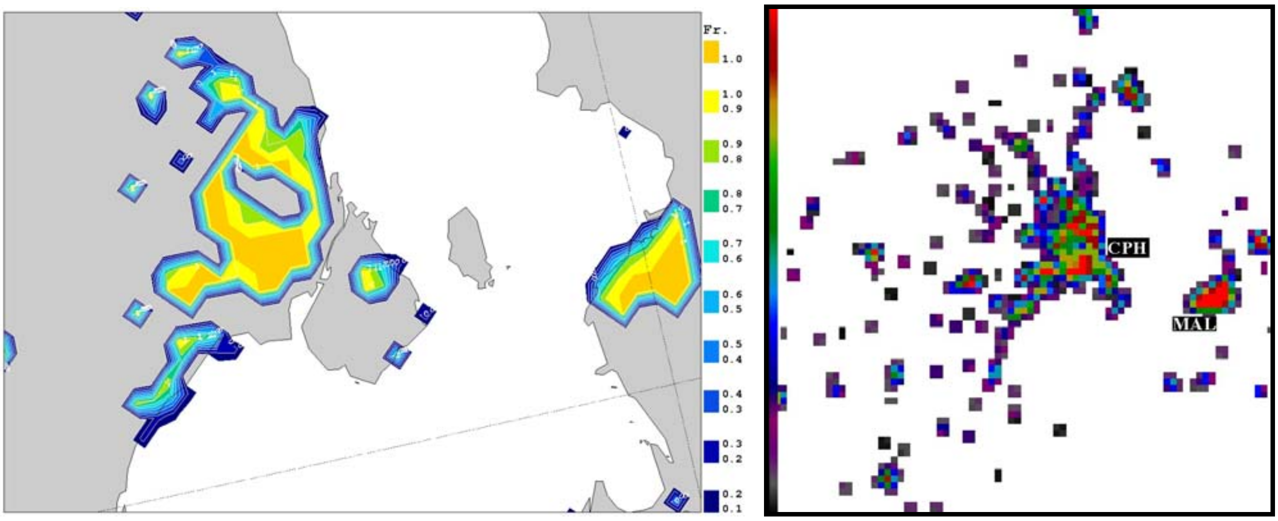
A7. Urban Districts Classification

A7.1 - Copenhagen Metropolitan Area (Denmark)

Residential District (RD)

Industrial Commercial District (ICD)

High Buildings District / City Center (HBD / CC)



(a) (b)

Figure: Urban class presentation for the Copenhagen (CPH), Denmark and Malmö (MAL), Sweden metropolitan areas and surroundings
/on left side of figure (b): scale in fractions of urban class representation in grid cell: top as 1, bottom as 0.01, white – no urban class presented in grid cell/

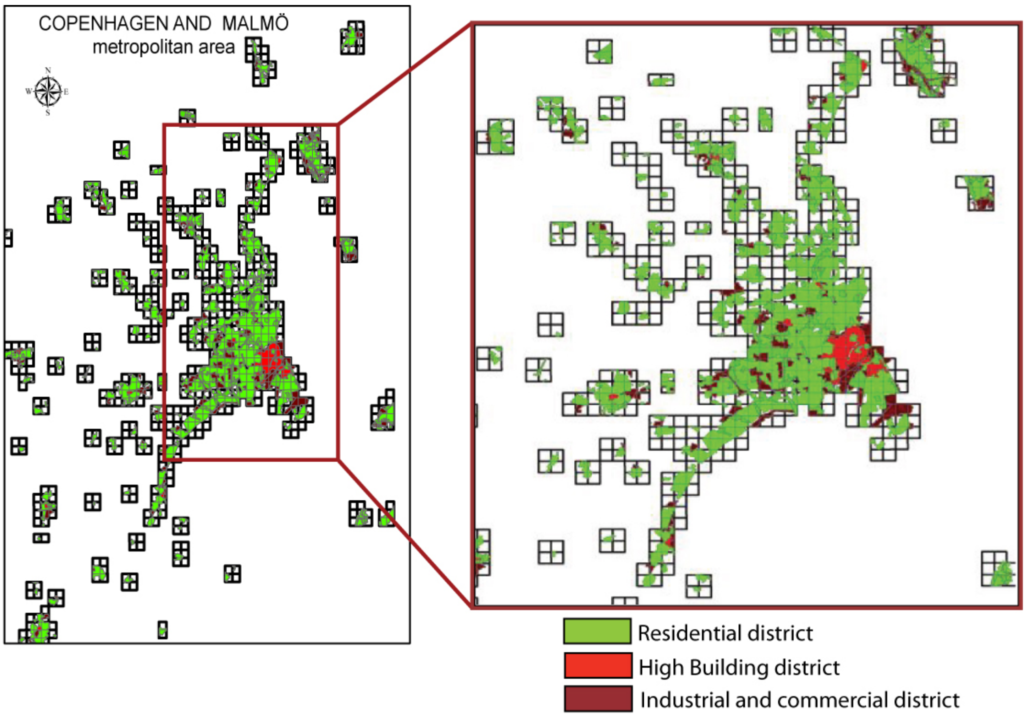
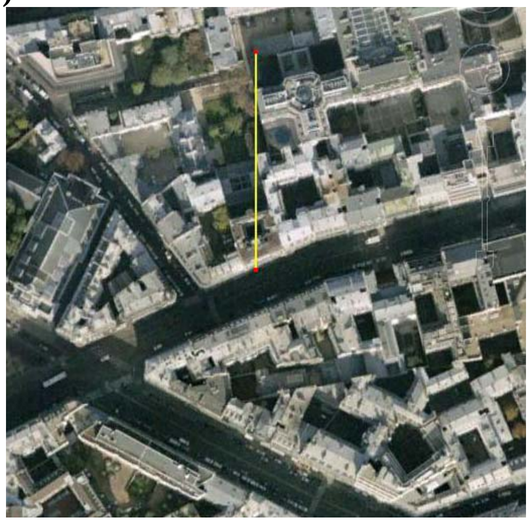


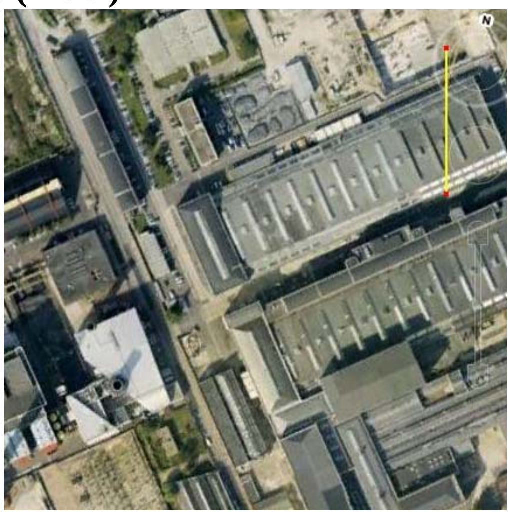
Figure: Urban re-classification into different urban related districts based on the CORINE 2000 for the Copenhagen metropolitan area.

A7.2 - Paris Metropolitan Area (France)

City Center (CC)



High Buildings District (HBD)



Industrial Commercial District (ICD)

Residential District (RD)

Rural Area (RUR)

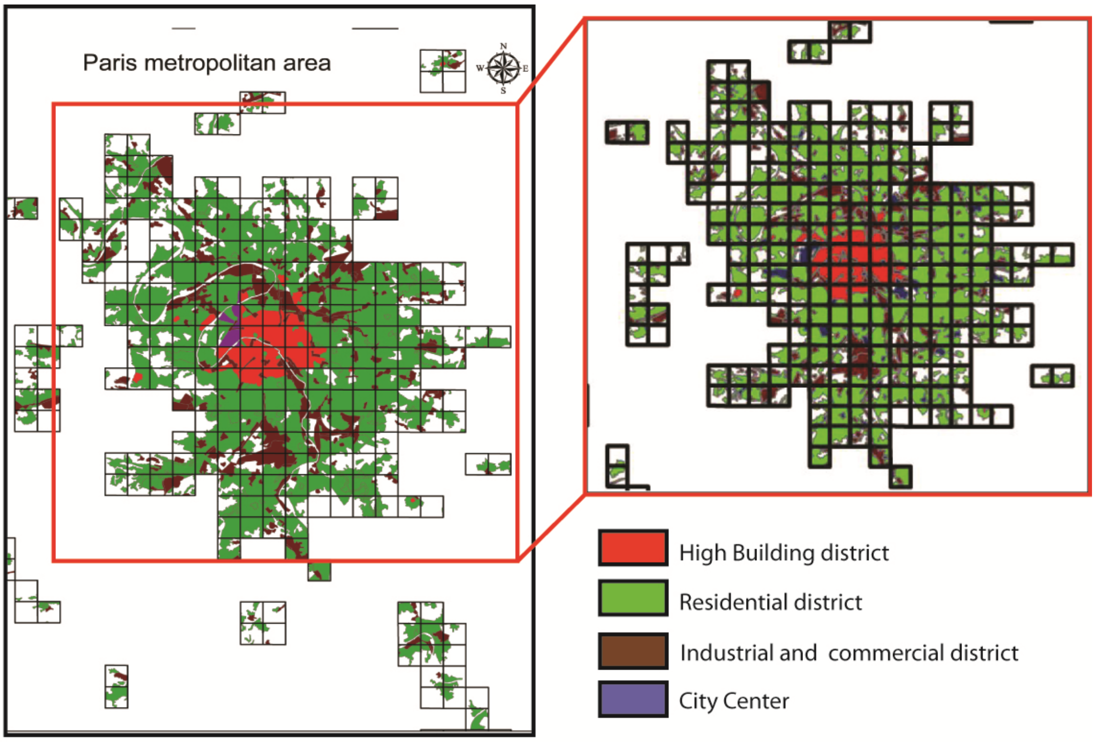


Figure: Urban reclassification into districts based on CORINE 2000 for the Paris metropolitan area.

A7.3 - Bilbao Metropolitan Area (Spain)

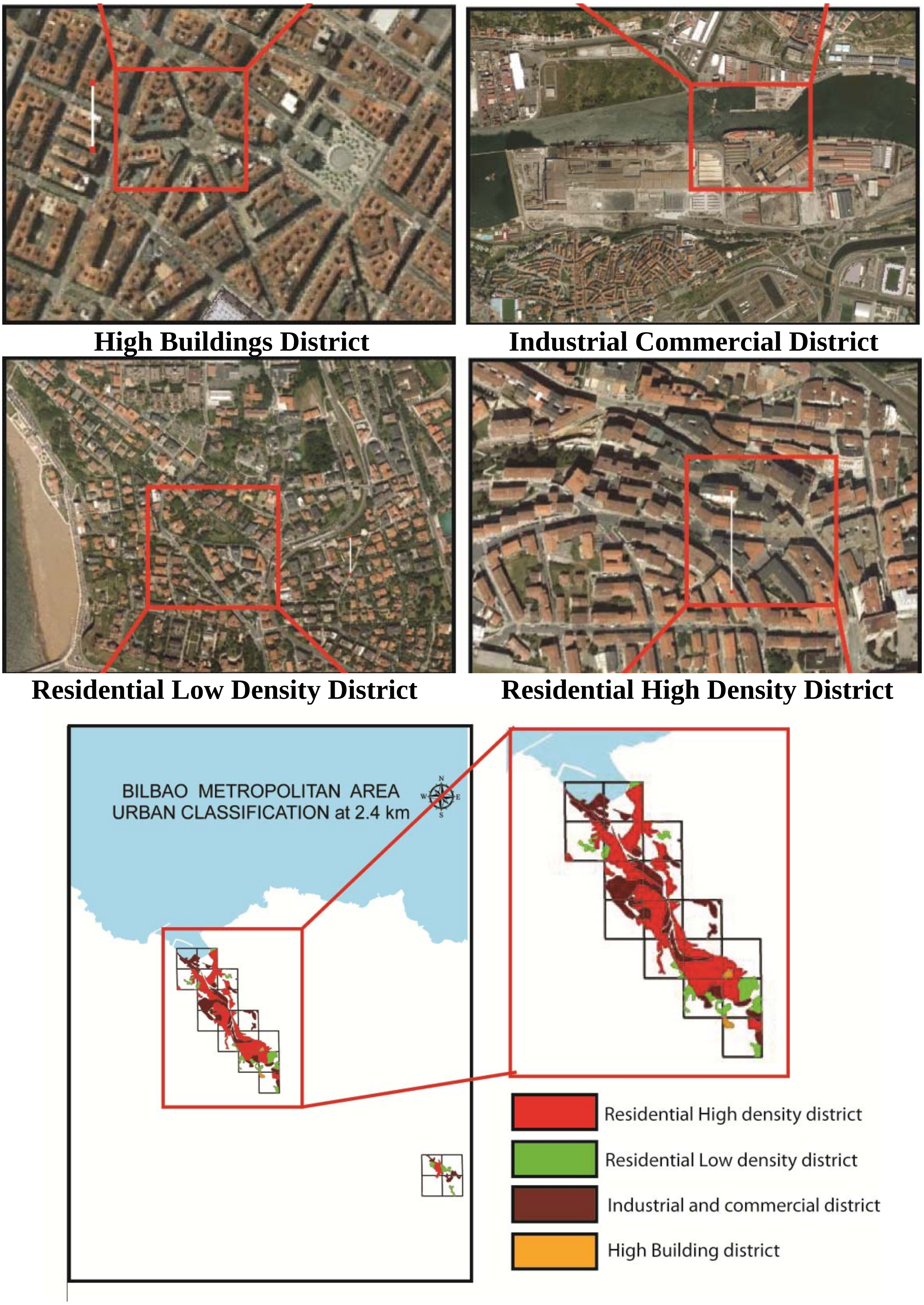


Figure: Urban reclassification into different districts based on the UDALPLAN 2009 for the Bilbao metropolitan area.

A8. Characteristics of Districts (on example of Paris)

Each of districts is described by a set of parameters which includes the thermal diffusivity, specific heat, temperature inside the buildings, albedo, emissivity; roughness length; streets' direction, length, and width; buildings' width and height as well as its probability distribution. Most of these parameters are defined for the ground, wall, and roof surfaces. Summary of districts' parameters (evaluated from different sources) is given in Table.

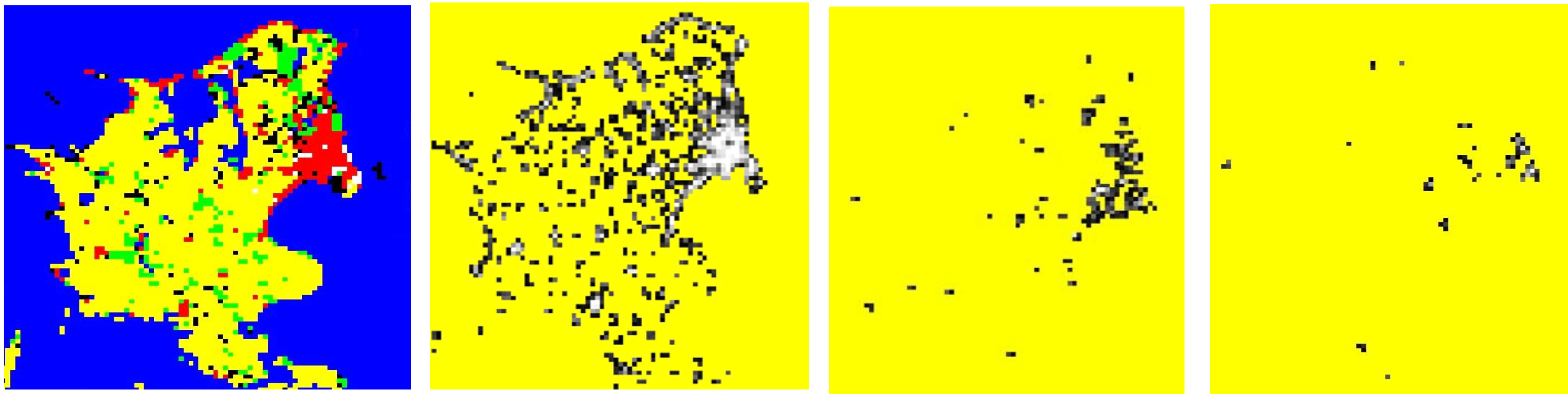
[*] *own rough estims*
[1] *http://de.wikipedia.org/wiki/Temperaturleitf%C3%A4higkeit & http://en.wikipedia.org/wiki/Thermal_diffusivity*
[2] *Derived form Table1, Albedo Concrete and Other Materials & Figure with albedo*
[3] *http://www.infrared-thermography.com/material.htm*
[4] *Ref. Tab. 15, p.38, EPA report 2009*
[5] *Table 5, EPA report, p. 15*
[6] *Ref. Tab. 10, p.23, EPA report 2009*

Table : Characteristics of urban districts for the Paris metropolitan area.

			Urban Districts					
Parameters	**Type**	**Units**	**RD**	**ICD**	**CC**	**HBD**	**RUR**	**Ref**
Thermal diffusivity	Ground	$m^2\ s^{-1}$	3,60E-07	3,60E-07	3,60E-07	3,60E-07	3,60E-07	1
	Wall	$m^2\ s^{-1}$	5,02E-07	3,32E-06	1,53E-06	1,06E-06	3,71E-07	1
	Roof	$m^2\ s^{-1}$	3,40E-07	5,40E-07	5,40E-07	5,40E-07	3,40E-07	1
Specific heat	Ground	$J\ m^3\ K^{-1}$	1,74E+06	1,74E+06	1,74E+06	1,74E+06	1,74E+06	
	Wall	$J\ m^3\ K^{-1}$	1,54E+06	1,54E+06	1,54E+06	1,54E+06	1,54E+06	
	Roof	$J\ m^3\ K^{-1}$	1,50E+06	1,50E+06	1,50E+06	1,50E+06	1,50E+06	
Temperature inside buildings	Wall	K	291	298	295	293	290	*
	Roof	K	293	300	297	295	292	*
Albedo	Ground		0,2	0,1	0,15	0,2	0,15	2
	Wall		0,2	0,25	0,175	0,2	0,15	2
	Roof		0,2	0,18	0,5	0,2	0,2	2
Emissivity	Ground		0,95	0,95	0,95	0,95	0.28	3
	Wall		0,72	0,9	0,9	0,91	0,72	3
	Roof		0,9	0,78	0,92	0,91	0,9	3
Roughness length	Ground		0.67/1.10	0.61/0.74	0.72/0.98	0.86/1.05	0.67/1.01	4
	Roof		0.67/1.10	0.61/0.74	0.72/0.98	0.86/1.05	0.67/1.01	4
Number of street direction (SD)			*2*	*2*	*2*	*2*	*2*	*
Street length	SD 1	m	100000	100000	100000	100000	100000	*
	SD 2	m	100000	100000	100000	100000	100000	*
Street direction	SD 1	radian	0,785	0,785	0,785	0,785	0,785	5
	SD 2	radian	2,355	2,355	2,355	2,355	2,355	5
Street width	SD 1	m	9	10	13	16	7	*
	SD 2	m	9	10	13	16	7	*
Building width	SD 1	m	15	112	30	20	10	*
	SD 2	m	15	112	30	20	10	*
Number of height levels (HL)			*2*	*2*	*2*	*2*	*2*	
Building height	HL1	m	5,7	6,09	105,9	21	5,02	6
	HL2	m	5,7	6,09	105,9	21	5,02	6
Probability of building height	HL1	m	100	75	50	60	100	*
	HL2	m	0	25	50	40	0	*

A9. Revised Land-Use Classification for SM2-U (Types of Surfaces)

BARE	Bare soil without vegetation
NAT	Bare soil located between sparse vegetation elements
VEGN	Vegetation over bare soil
VEGA	Vegetation over paved surfaces
ART	Paved surfaces located between the sparse vegetation elements
BAT	Building/roofs
EAU	Water surfaces



Dominate type (a) **BAT type** (b) **VEGA type** (c) **ART type** (d)

Figure: (a) Distribution of dominated types of surfaces; and Distribution of fractions for surface types - (b) bat, (c) art and (d) vega - in grid cells of model domain.

B1. Model – Preparations, Setups & Runs

IMPORTANT START NOTE: all model runs are performed remotely at DMI HPC Cray-XT5

1. *COMPILE EXECUTABLE AND RUN MODEL --- **CTRL***
   - **A.** Make experiment directory **$HOME/hl_home/EXPNAME/**
   - **B.** **alias Hirlam ~xiaohua/hirlam_release/chemgas20100304/config-sh/Hirlam**
   - **C.** Go to the directory **$HOME/hl_home/EXPNAME/**
   - **D.** **Hirlam setup -r chemgas20100304 -d ~xiaohua/hirlam_release -h xtpgi**
   - **E.** Build/Recompile model executable and run the model using command:

     Hirlam start DTG=YYYYMMDDHH DTGEND=YYYYMMDDHH LL=FL

       DTG – starting date
       DTGEND - ending date
       (YYYY – year, MM – month, DD – day, HH – hour)
       LL – forecast length (select 06/24 hours)

     fx: *URBAN* -> **Hirlam start DTG=2009070300 DTGEND=2009070300 LL=24**
     fx: *AEROSOL* -> **Hirlam start DTG=2010071700 DTGEND=2010071718 LL=06**

     ... waiting for an executable to be compiled and steps of model run…
     ***tail –f /data/*$USER/hl_home/EXPNAME/hirlam.log**
     … through steps of compilation, initialization, climate files generation, preparation of boundary conditions, and steps of forecasting … until the run is completed

2. *COMPILE EXECUTABLE AND RUN MODEL --- **MODIFIED***
   - Repeat step **1(A,B,C,D)**
   - Modify scripts and source code accordingly (see call tree in appendix and teacher's explanation)
   - Follow step **1E**

3. *PRODUCED OUTPUT*
   - Go to the directory **/data/$USER/hl_arc/EXPNAME/YYYY/MM/DD/HH**
   - The generated output files to be analysed are the following:
     - **fcYYYYMMDD_HH+0LL** - 3D meteo. fields
     - **fcYYYYMMDD_HH+0LLmd** - surface meteo. fields

IMPORTANT NOTE:
*After each run finished - **ALWAYS** (!) change the name of the produced output directory:*
- Go to the directory called **/data/$USER/hl_arc/EXPNAME/**
- Rename the output directory called **EXPNAME** to **EXPNAME_run_YYYYMMDD**

B2. Urban Implementation - AHF, R, BEP

MAKE CHANGES FOR THE URBANIZATION OF THE MODEL:

1) For inclusion URBAN effects – Anthropogenic heat flux (AHF) & Roughness (R)

- Go to the directory called **$HOME/hl_home/EXPNAME/phys**
- Using any text-editor make necessary changes in the file called **isbah4.F**
  i.e. modify the anthropogenic heat flux from 10 to 200 (unrealistic 500) W/m^2
- Using any text-editor (vim, emacs, nano, mcedit) make necessary changes in file called **ini_veg.F**
  i.e. modify the roughness (from default value up to 1 and 2 meters or higher)

2) For inclusion URBAN effects – Building Effects Parameterization

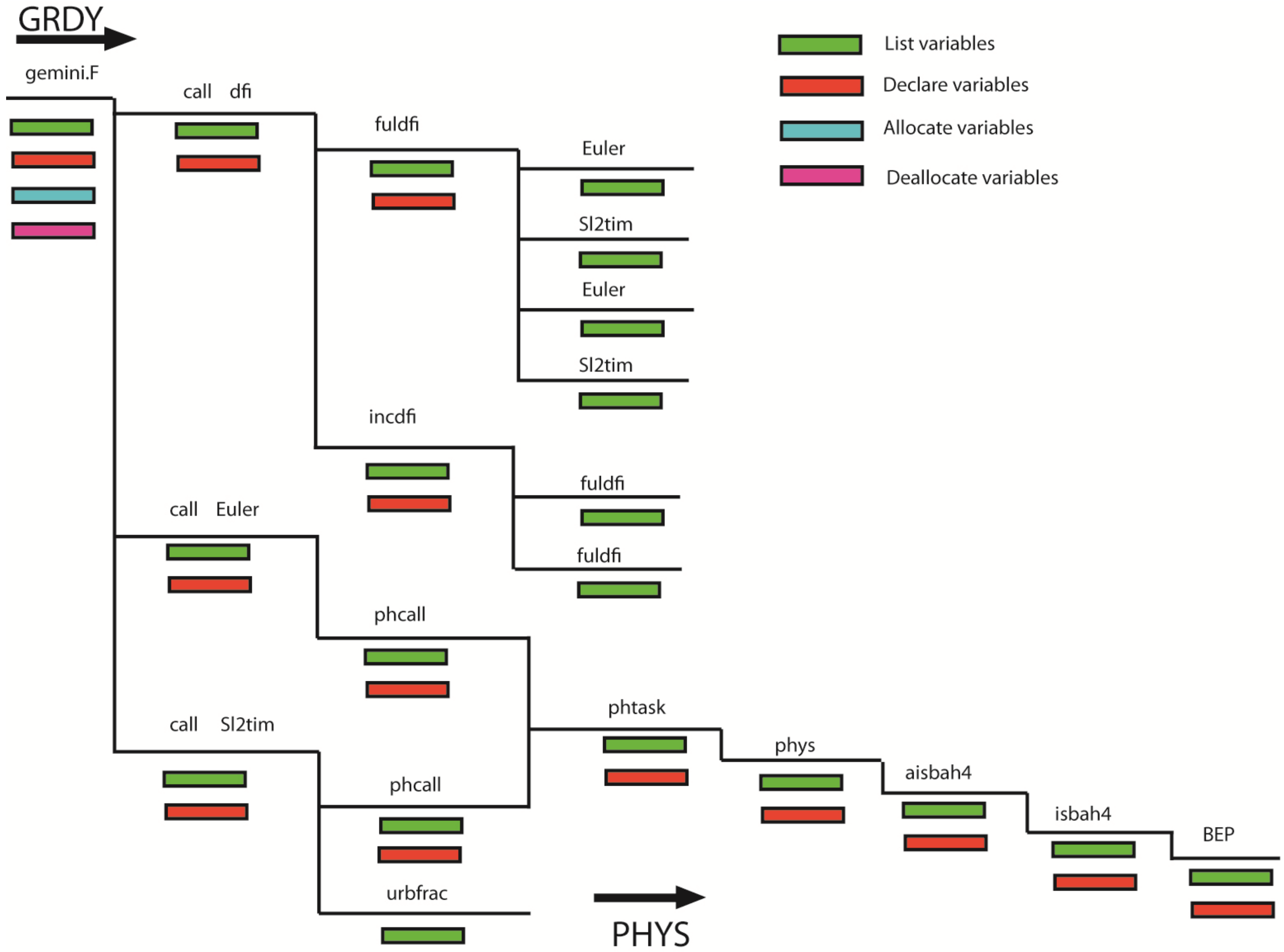
- Go to the directory called **$HOME/hl_home/EXPNAME/src/grdy**
- Using any text-editor make necessary changes (*see Call-Tree; Annex B3*) in the files:
  gemini.F
  dfi.F
  euler.F
  sl2tim.F
  fildfi.F
  incdfi.F
  urbfrac.F

- Go to the directory called **$HOME/hl_home/EXPNAME/src/phys**
- Using any text-editor make necessary changes (*see Call-Tree; Annex B3*) in the files:
  phcall.F
  phtask.F
  phys.F
  aisbah4.F
  isbah4.F
  bep.F

3) Measurement stations in the metropolitan areas and surroundings for Paris and Bilbao

Metropolitan Area	***Measurement site***	***Type of the site***	***Latitude, deg***	***Longitude, deg***
Paris	LHVP	Urban	2.359 °E	48.828 °N
	SIRTA	Suburban	2.208 °E	48.718 °N
	CHARTES	Rural	1.500 °E	48.500 °N
Bilbao	DEUSTO	Urban	-2.966 °W	43.289 °N
	DERIO	Rural / Inland	-2.852 °W	43.293 °N
	FALRA	Rural / Coastal	-3.033 °W	43.373 °N

B3. Call-Tree for BEP Implementation



C1. Visualization of Results

METGRAF software
PRE-STEP:

- Go to the directory called **$HOME/metgrafenviro**
- Run the METGRAF application by typing: **source metgraf_cray** and then: **metgraf**

Step 1: ***See below examples of "Graphical illustrations for METGRAF"***
Select FIELDS / ADD NEW FIELD / SELECT FILE /
i.e. choose the name of the Enviro-HIRLAM output file to be plotted from directory
/data/$USER/hl_arc/EXPNAME_run_YYYYMMDDHH/YYYY/MM/DD/HH/
+ **fcYYYYMMDD_HH+0LLmd** - surface meteo.fields
+ **fcYYYYMMDD_HH+0LL** - 3d meteo.fields

(GRIB file 1: …path to the file …) – for plotting original field for 1 parameter
+ as time allowed also:
and by choosing also the second file
(GRIB file 2: …path to the file …) – for plotting difference between 2 fields (delta fields) of the same parameter

Step 2: Select parameter to be printed through GRIB parameters: Table/ Level Type/ Level/ Param
For original fields:

1. air temperature at 2 m (T2m, in K or subtract: 273.15 to get in C) - 1/ 105/ 2/ 11 (scale 1; contours: 0-30; step 2)
2. wind speed at 10 m (W10m, in m/s) - 1/ 105/ 10/ 33 (scale 1; contours: 0-25; step 1)

+ as time allowed also:

3. relative humidity at 2 m (%) - 1/105/2/52 (*md; scale 100; contours: 0-100; step 10)
4. total cloud cover (%) - 1/ 105/ 0/ 71 (*md; scale 1; contours: 0-1; step 0.1)
5. surface temperature (in K or subtract 273.15 to get in C) - 1/ 105/ 0/ 11 (*md; scale 1; contour: 0-50; step 2)
6. PBL height (Hpbl, in m) - 1/ 105/ 0/ 67 (*md; scale 1; contour: 0-3000; step 200)

For delta fields:

7. air temperature at 2 m (T2m, in K or Subtract: 273.15 to get in C) - 1/ 105/ 2/ 11 (scale 1; contours: -5/+5; step 0.5)
8. wind speed at 10 m (W10m, in m/s) - 1/ 105/ 10/ 33 (scale 1; contours: -5/+5; step 0.5)

+ as time allowed also:

9. relative humidity at 2 m (%) - 1/105/2/52 (*md; scale 100; contours: 0-100; step 10)
10. total cloud cover (%) - 1/ 105/ 0/ 71 (*md; scale 1; contours: 0-1; step 0.1)
11. surface temperature (in K or subtract 273 to get in C) - 1/ 105/ 0/ 11 (*md; scale 1; contours: -5/+5; step 0.5)
12. PBL height (Hpbl, in m) - 1/ 105/ 0/ 67 (*md; contour: -500/+500; step 50)

+ extras

13. max & min air temperature at 2 m, dew temperature at 2 m, latent and sensible heat fluxes at surface, etc.

Step 3: Select type of the field to be plotted: as an original field or as a difference field (Diffs)

Step 4: Select: Field options, Legend options, Wind Arrow options, Extreme values options, etc., Contours (use the user-defined contours/shades button) to play + choose the best visible and readable presentation of the results obtained

Step 5: Press button - DRAW – to draw/redraw the plot

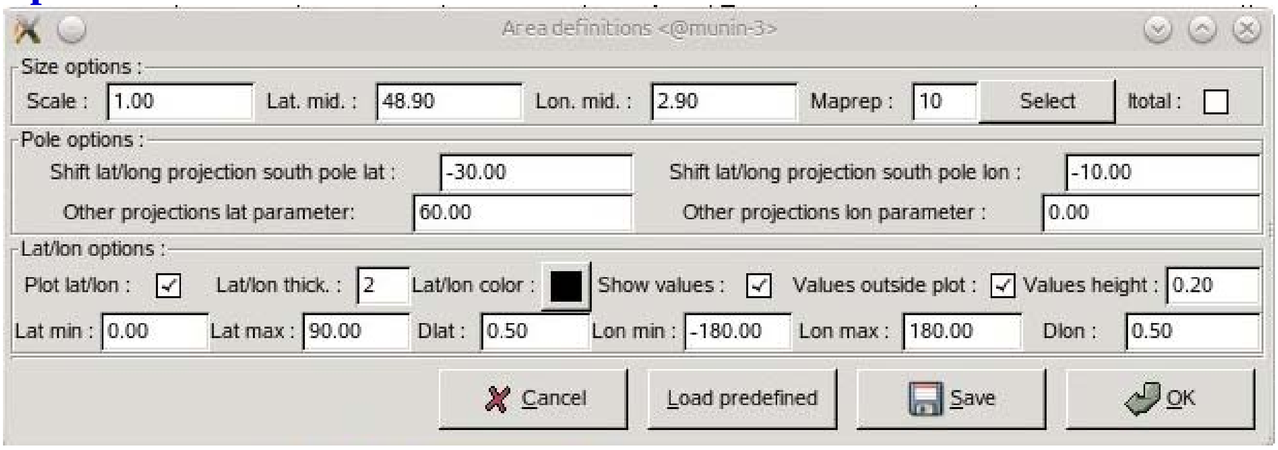
HINT: Always redraw plot after making changes by pressing button DRAW

NOTE: In order to select the area of domain to be plotted choose from the METGARF menu through the OPTIONS/ AREA *the setting options such as* SCALE/ LAT.MID/ LONG.MID/ etc.

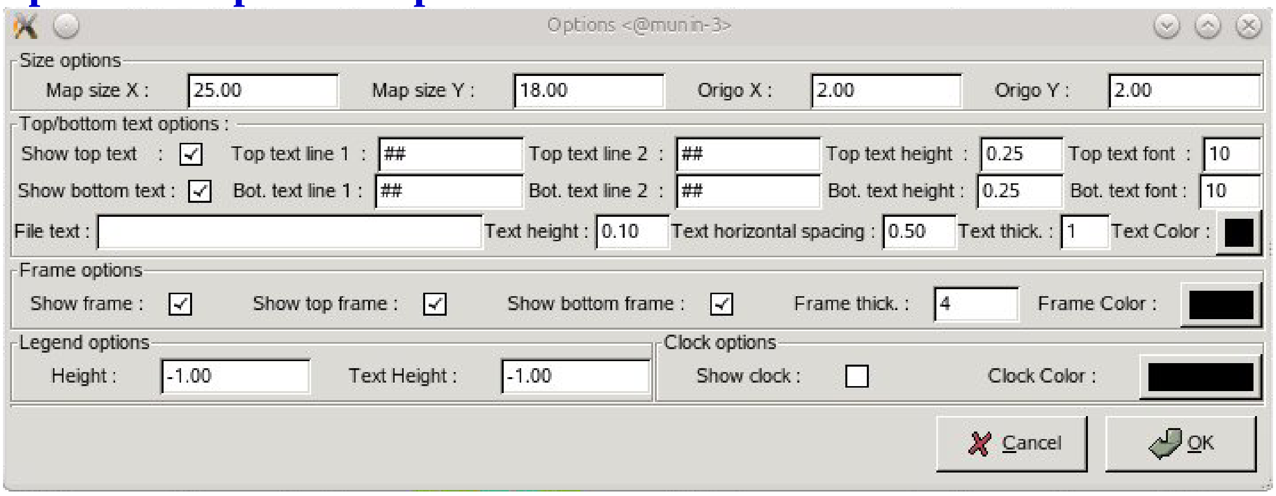
NOTE: To save the newly defined domain: FILE/ SAVE – select path to the directory called **$HOME/metgrafenviro/RESULTS/namelist_EXPNAME_run**
At the end, use this **namelist_EXPNAME_run** *as a template to draw the similar plots*
Do the similar for the OPTIONS/ OPTIONS *and* OPTIONS/ COASTLINES *as needed*

Graphical illustrations for METGRAF

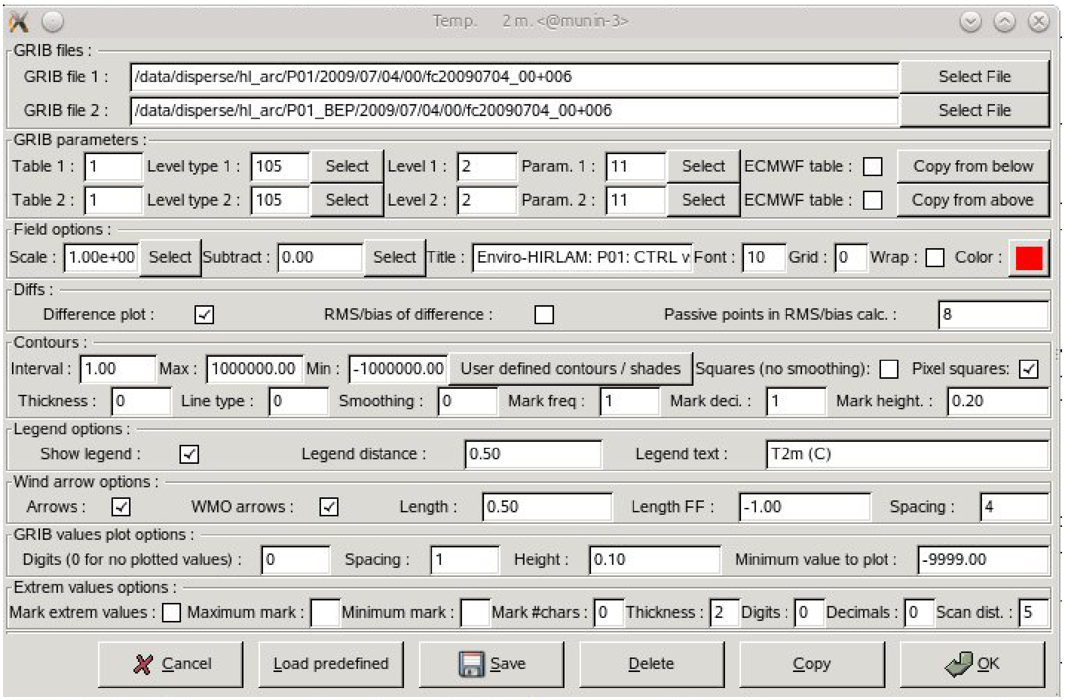
Options -> Area : AREA DEFINITIONS



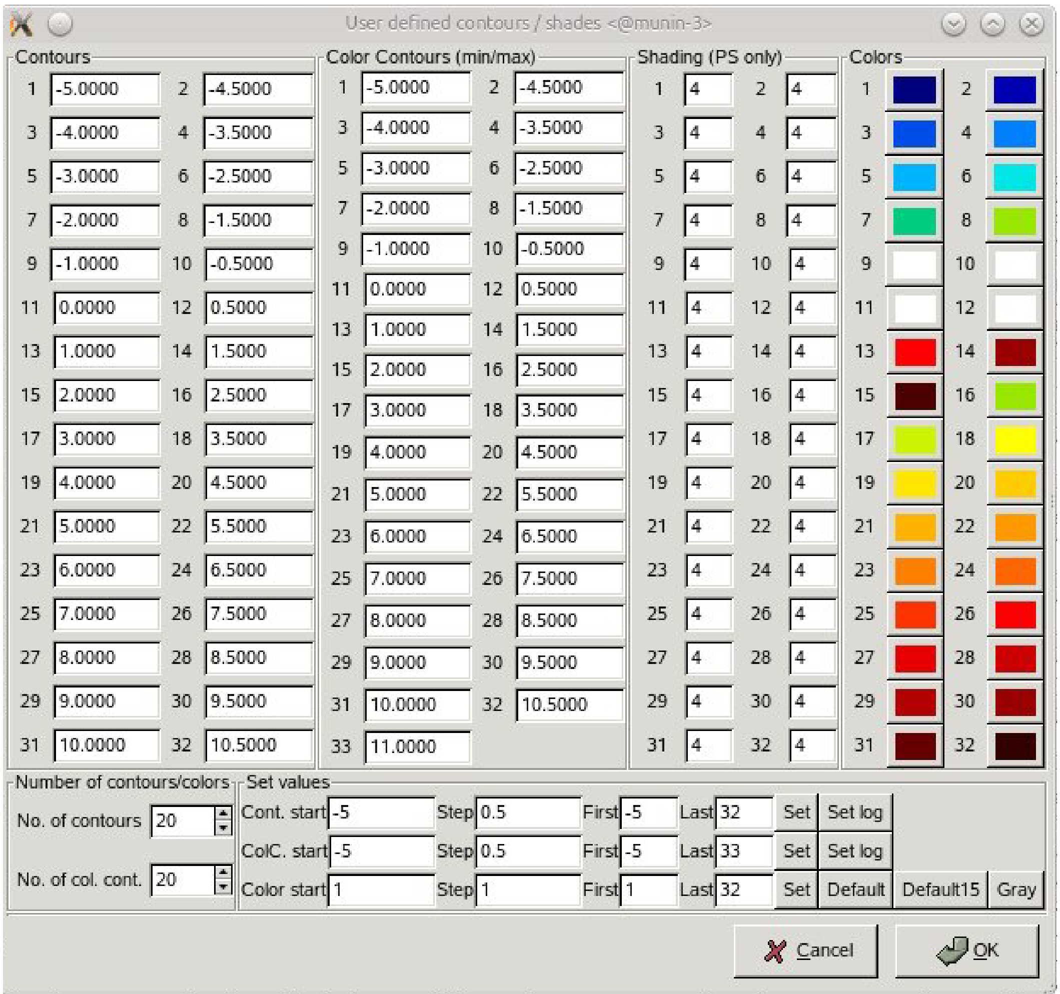
Options -> Options : Options



Fields -> Add new field



-> User defined contours / shades



C2. Examples of Visualization and Analysis

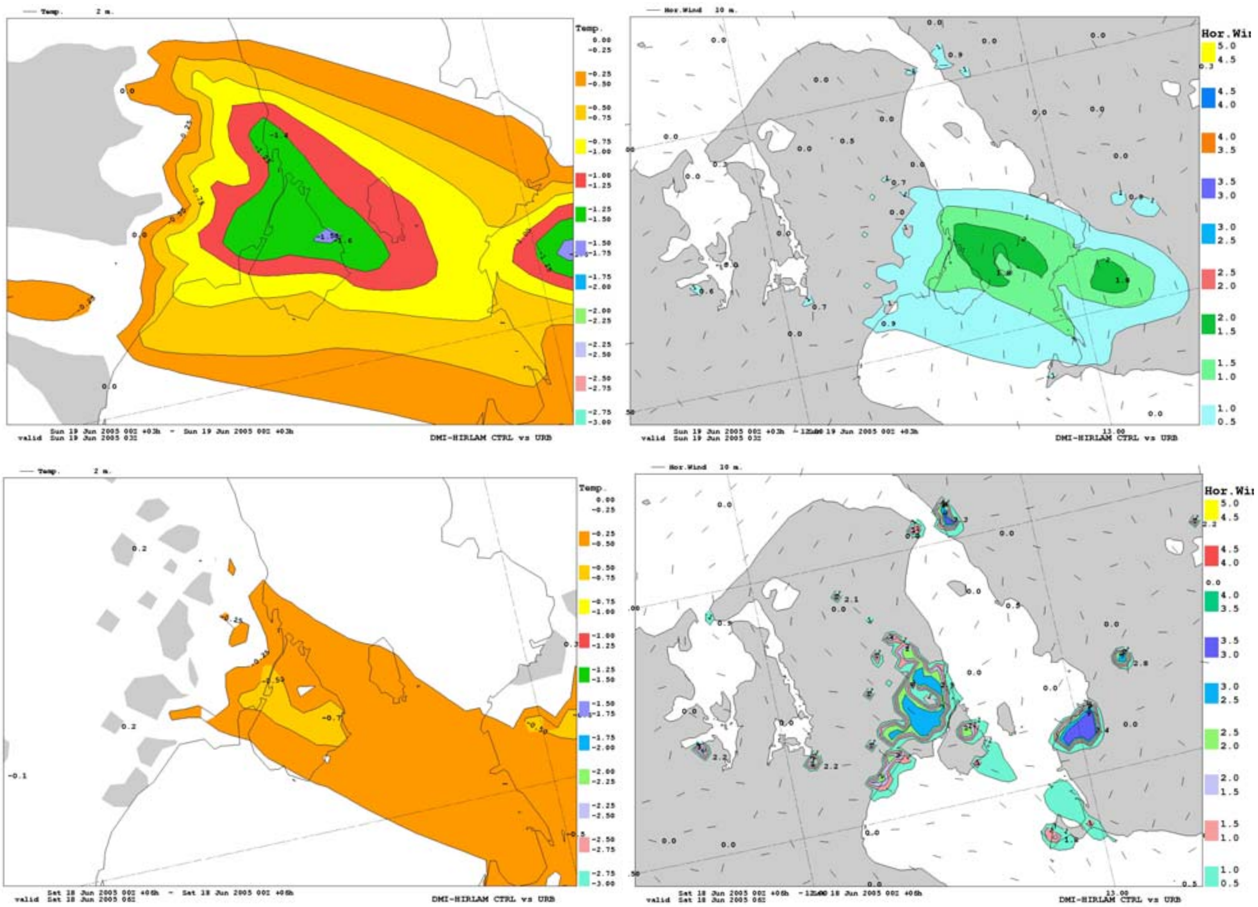


Figure / Example: Difference fields between the modified (urbanized: for AHF, R, BEP) and control runs of the model for the air temperature at 2 m and wind speed at 10 m on SELECTED DATE, TIME for the SELECTED metropolitan area.
(*on example of Copenhagen metropolitan area, Denmark*).

Difference in fields	**Wind velocity at 10 m, m/s**				**Temperature at 2 m, ºC**			
Roughness, z_0	1m		2 m		1 m		2 m	
Location **UTC term**	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R
00								
01								
02								
03								
…								
23								

Table / Example. Diurnal variation on DATE of difference fields for wind velocity at 10 m and temperature at 2 m for roughness values of 1 and 2 m for the SELECTED metropolitan area /U-urban site; S – suburban site, R – rural site/.

Anthropogenic Heat Flux, W/m²	200		100		50		10	
Location UTC term	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R
00								
01								
02								
03								
…								
23								

Table / Example: Diurnal variation on DATE of difference fields (in ºC) for temperature at 2 m for the anthropogenic heat flux values for the SELECTED metropolitan area /U- urban site; S – suburban site, R – rural site/.

Change in	**Latent Heat Flux (W/m²)**			**Sensible Heat Flux (W/m²)**		
AHF (W/m²)	**50**	**100**	**200**	**50**	**100**	**200**
Location **UTC term**	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R	U/S/R
1						
2						
3						
…						
23						

Table / Example: Diurnal variation on SELECTED DATE of difference fields (in W/m²) for the latent and sensible heat fluxes due to anthropogenic heat flux for the SELECTED metropolitan area /U- urban site; S – suburban site, R – rural site/.

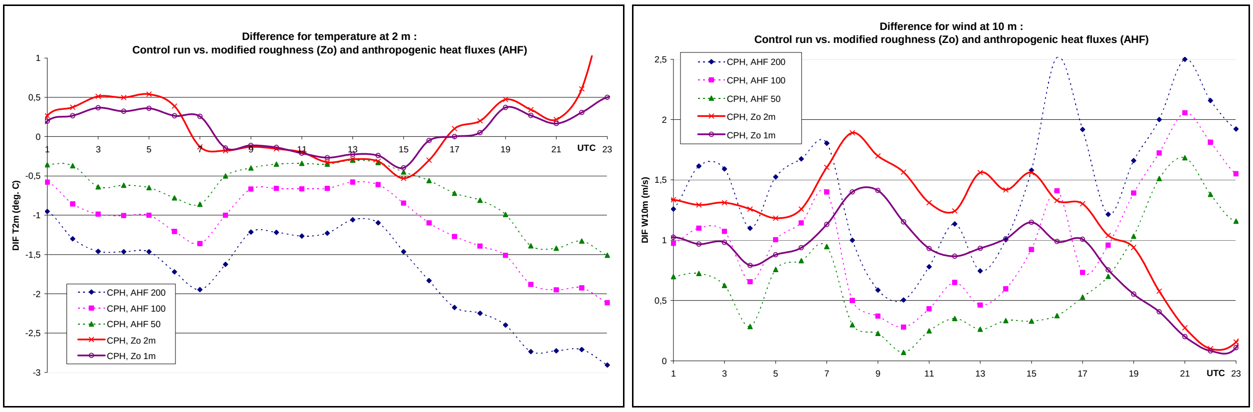
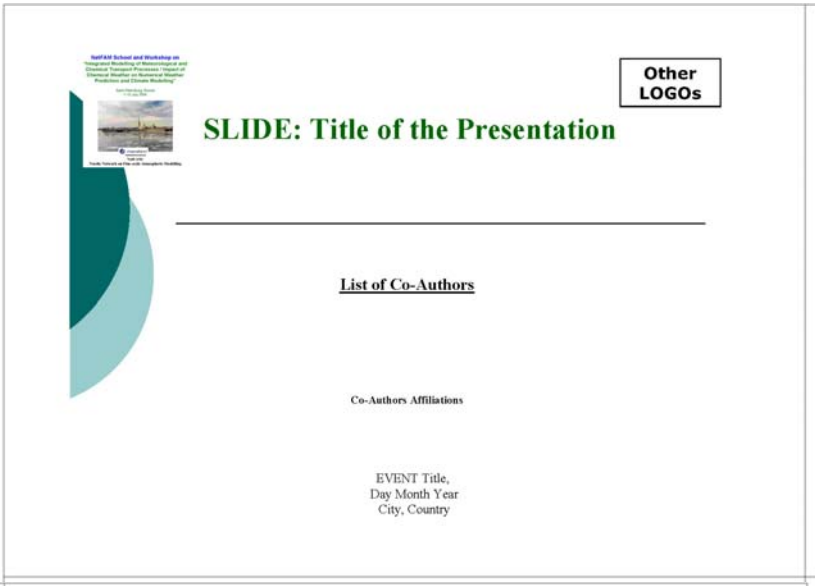
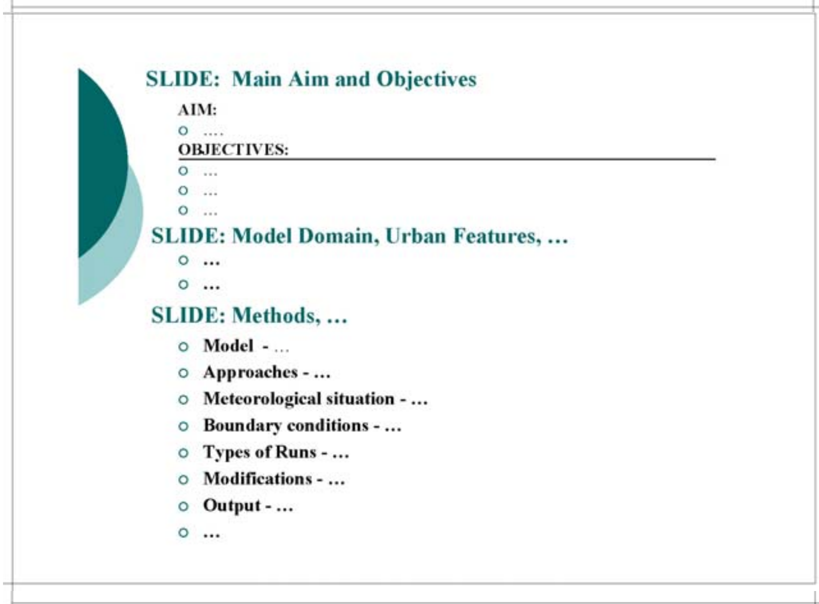
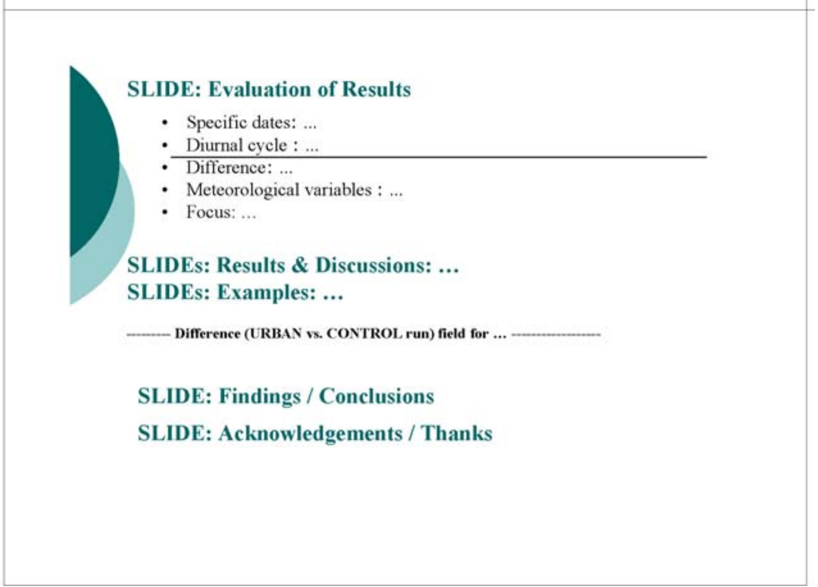


Figure / Example: Diurnal variation on DATE of difference fields (in ºC) for temperature at 2 and (in m/s) for wind speed at 10 m - for the roughness and anthropogenic heat flux for the SELECTED metropolitan area at DIFFERENT locations/sites.

C3. Draft Outline of Presentation







D1. Useful readings afterwards

Allen L., S Beevers, F Lindberg, Mario Iamarino, N Kitiwiroon, CSB Grimmond (**2010**): Global to City Scale Urban Anthropogenic Heat Flux: Model and Variability. Deliverable 1.4, *MEGAPOLI Scientific Report 10-01, MEGAPOLI-04-REP-2010-03, 87p, ISBN: 978-87-992924-4-8;* http://megapoli.dmi.dk/publ/MEGAPOLI_sr10-01.pdf

Baklanov A., A. Mahura, R. Sokhi (Eds). (2010): Integrated Systems of Meso-Meteorological and Chemical Transport. Springer, 242 p., ISBN 978-3-642-13979-6, DOI 10.1007/978-3-642-13980-2

Baklanov A., Mahura A., Nielsen N.W., C. Petersen, (2005): Approaches for urbanization of DMI-HIRLAM NWP model. HIRLAM Newsletter 49, Dec 2005, pp. 61-75.

Baklanov A., S. Grimmond, A. Mahura, M. Athanassiadou (Eds) (2009): Urbanization of Meteorological and Air Quality Models. Springer Publishers, 169 p., ISBN 978-3-642-00297-7; DOI 10.1007/978-3-642-00298-4.

Baklanov, A., P. Mestayer, A. Clappier, S. Zilitinkevich, S. Joffre, A. Mahura, N.W. Nielsen, (2008): Towards improving the simulation of meteorological fields in urban areas through updated/advanced surface fluxes description. Atmospheric Chemistry and Physics, 8, 523-543.

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CORINE, **2000**: The European Topic Centre on Terrestrial Environment: Corine land cover (CLC90) 100 m - version 12/2000. Web-site:

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González-Aparicio I., R. Nuterman, U.S. Korsholm, A. Mahura, J.Á. Acero, J. Hidalgo, A. Baklanov (**2010**): Land-use Database Processing Approach for Meso-Scale Urban NWP Model Initialization. *DMI Scientific Report 10-02; 32p., ISBN: 978-87-7478-593-4;* www.dmi.dk/dmi/sr10-02.pdf

Grimmond CSB., M. Blackett, M.J. Best, et al. (**2010**): Urban Energy Balance Models Comparison. Deliverable D2.3, *MEGAPOLI Scientific Report 10-07, MEGAPOLI-10-REP-2010-03, 72p, ISBN: 978-87-993898-0-3;* http://megapoli.dmi.dk/publ/MEGAPOLI_sr10-07.pdf

Grimmond, C. S. B. and Oke, T. R.: **2002**, Turbulent Heat Fluxes in Urban Areas: Observations and a Local-Scale Urban Meteorological Parameterization Scheme (LUMPS), *J. Appl. Meteor*., **41**, 792-810.

Grimmond, C. S. B., Cleugh, H. A., and Oke, T. R.: **1991**, 'An Objective Urban Heat Storage Model and its Comparison with other Schemes', *Atmos. Environ*. **25**B, 311-326.
http://dataservice.eea.eu.int/dataservice/metadetails.asp?id=309

Korsholm U.S., Mahura A., Baklanov A., (**2010**): Effects of Paris on regional meteorological and chemical weather in the context of the EC-project MEGAPOLI. *Abstracts of the European Geosciences Union (EGU) General Assembly, 2-7 May 2010, Vienna, Austria; Geophysical Research Abstracts, Vol. 12, EGU2010-10650.*

Mahura A., A. Baklanov, S. Hoe, J.H. Sørensen, C. Petersen, K. Sattler, (**2007**): Evaluation of land surface scheme modifications on atmospheric transport and deposition patterns in Copenhagen metropolitan area. Developments in Environmental Sciences, Eds. E. Renner, A. Ebel, Springer Elsevier Publishers, Vol 6, pp. 64-72, doi:10.1016/S1474-8177(07)06017-2

Mahura A., Baklanov A. (Eds.) (**2010**): Hierarchy of Urban Canopy Parameterisations for Different Scale Models. Deliverable D2.2, *MEGAPOLI Scientific Report 10-04, MEGAPOLI-07-REP-2010-03, 50p, ISBN: 978-87-992924-7-9;* http://megapoli.dmi.dk/publ/MEGAPOLI_sr10-04.pdf

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Mahura A., Petersen C., Baklanov A., Amstrup B., (**2008**): Evaluation of Building Effect Parameterization Module for Urbanized Numerical Weather Prediction Modelling, pp-371-380; In "Urban Climate and Bioclimate", (Eds. Klysik K., Wibig J., Fortuniak K.), ISBN: 978-83-7525-243-9.

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Oke, T.R., **1978**: Boundary layer climates. London, Methuen & Co Ltd, J. Wiley & Sons, New York, 359 p.

Rodríguez E., B. Navascués, J.J. Ayuso, S. Järvenoja, **2003**: Analysis of surface variables and parameterization of surface processes in HIRLAM. Part I: Approach and verification by parallel runs. Norrköping. *HIRLAM Technical Report* 58, 52 p.

Sass B., N.W. Nielsen, J.U. Jørgensen, B. Amstrup, M. Kmit, K.S. Mogensen, **2002**: The operational DMI-HIRLAM system - 2002-version. *DMI Technical Report* 02-05, 60 p.

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Unden, P., L. Rontu, H. Järvinen, P. Lynch, J. Calvo, G. Cats, J. Cuhart, K. Eerola, etc. **2002**: HIRLAM-5 Scientific Documentation. December 2002, *HIRLAM-5 Project Report*, SMHI.

Notes