Contribution to AEVUS PT by RHM & Moscow State University: Key results and recent updates

Mikhail Varentsov[1,2*], Gdaly Rivin[1,2], Inna Rozinkina[1,2], Denis Blinov[2], Timofey Samsonov[1]

and other contributing colleagues

[1)] Lomonosov Moscow State University, Russia

[2)] Hydrometeorologycal Research Center of Russia, Moscow

* *mvar91@gmail.com*

Outline

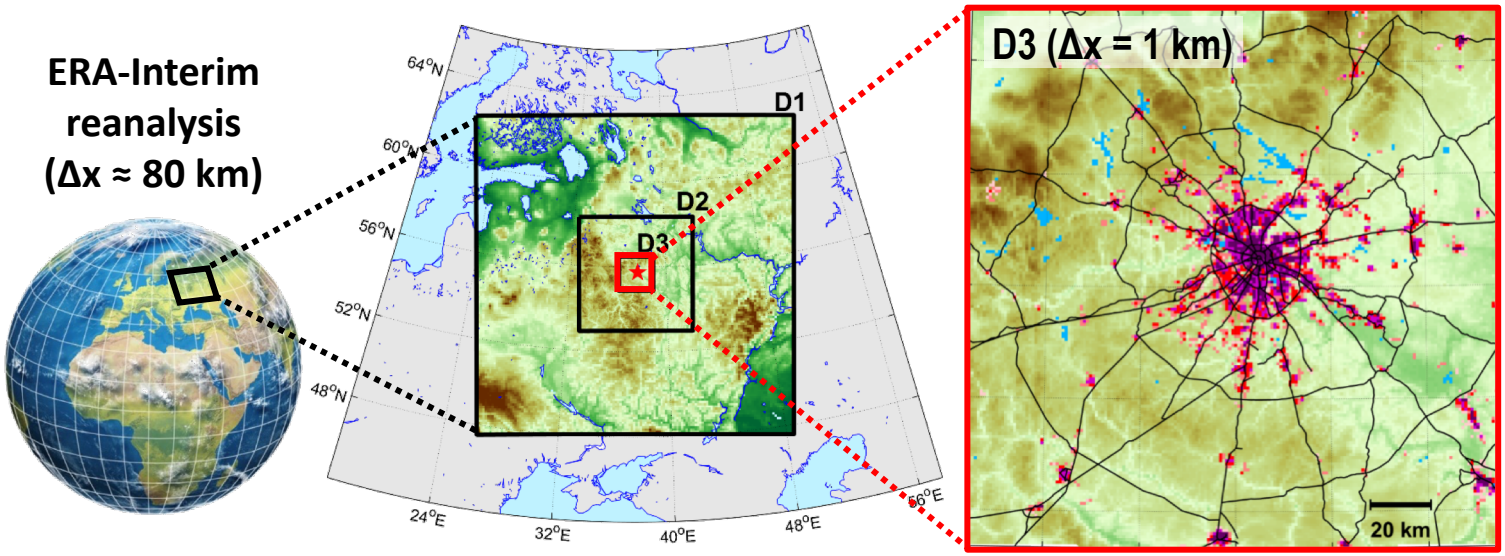
1. Key results of AEVUS activities from Moscow (based on the report)
2. Towards AEVUS 2 and even more: our recent steps beyond the AEVUS tasks

RHM contribution to AEVUS PT

Overview of the modelling framework for Moscow megacity

The testing of the new COSMO versions including TERRA_URB (5.05g_urb1, …urb4) was performed using the same modeling framework as was used in the previous studies for Moscow with older climate version COSMO 5.0_clm9_urb), described in (Varentsov et al., 2018):

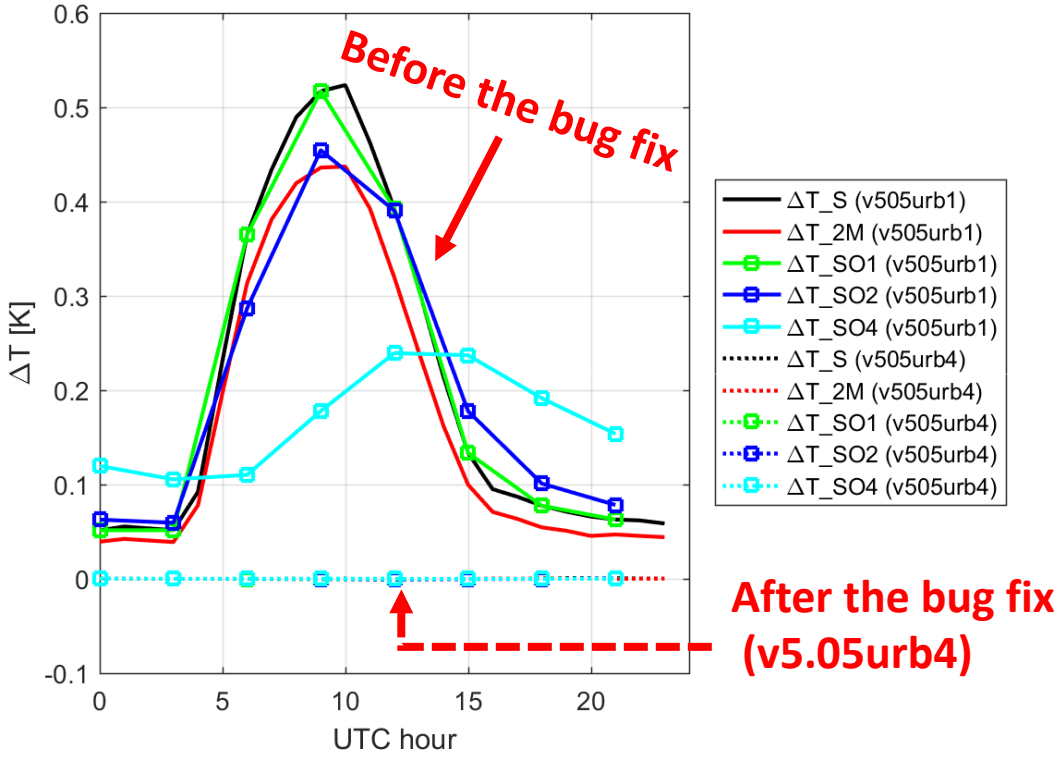
- Downscaling of the ERA-Interim reanalysis in continuous simulations for selected case studies (10-15 days) using three nested domains D1-D3
- TERRA_URB is used for the finest domain D3 with 1-km horizontal grid step
- Urban canopy parameters (FR_PAVED/ISA & AHF) are clarified using OpenStreetMap data according to the original GIS-based technology (Samsonov et al., 2015; Varentsov et al., 2017)
- Simulations at supercomputers Lomonosov-2 of Moscow State University and Cray-XC40 of RHM



RHM contribution to AEVUS PT

Debugging of the new model versions

The problem of the unphysical heating of rural areas: in the COSMO 5.05urb1/2/3, switching on the TERRA_URB leads to the unphysical heating even in case of complete absence of urban areas (FR_PAVED=0 and AHF=0 allover the domain). **The problem was eliminated in 5.05urb4 release, after intensive debugging performed by Ulrich Schaettler.**

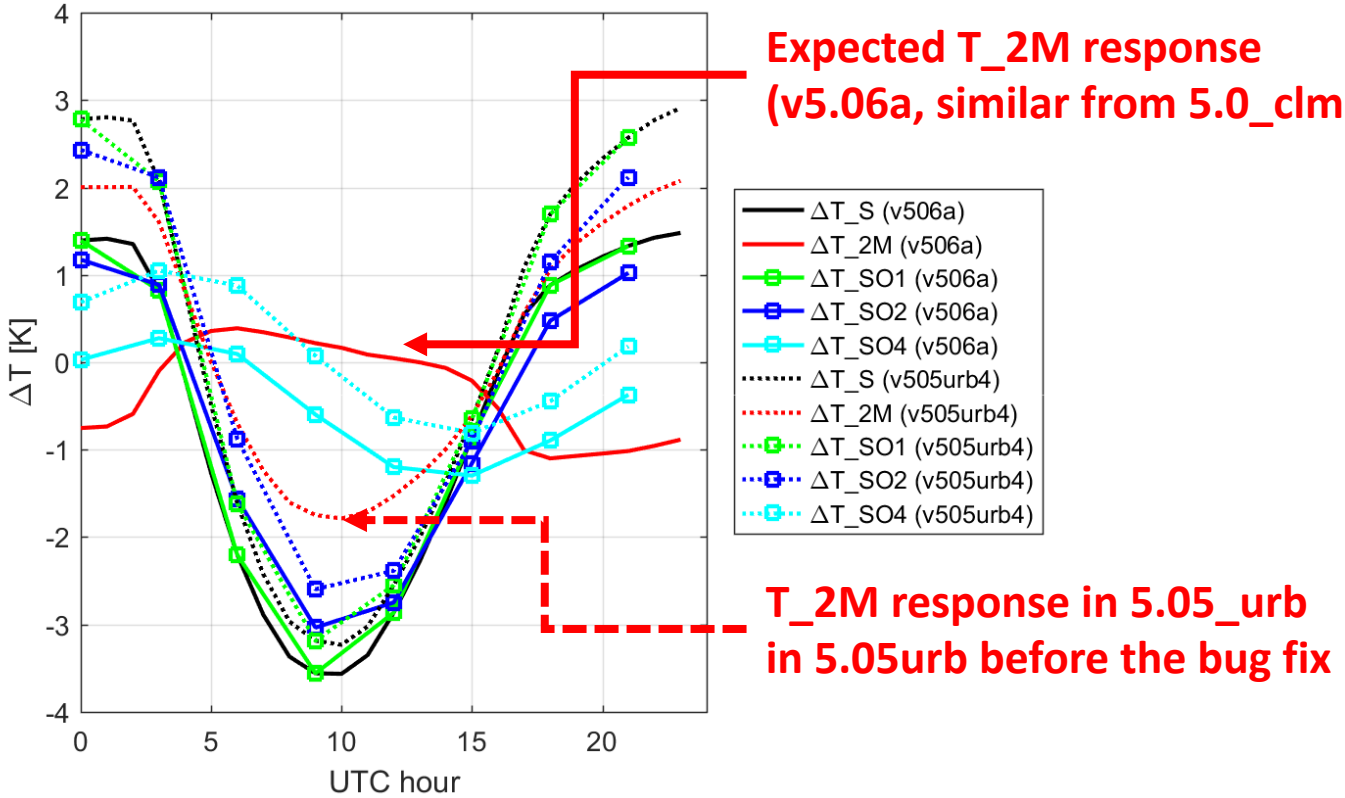


The diurnal variation of the model responses to switching the TERRA_URB on in the fields of air, surface and soil temperatures, for the simulations with FR_PAVED=0 and AHF=0, averaged over all land grid cells and over 15 days in May 2014.

RHM contribution to AEVUS PT

Debugging of the new model versions

The problem of the incorrect behavior of a skin-layer temperature scheme: in the COSMO 5.05urb1/2/3/4, switching on the Jan-Peter's skin-layer temperature scheme (itype_canopy = 2) leads to the decreasing the air temperature diurnal range instead of its expected increasing. **The problem was eliminated after fixing a code bug in sfc_utilities.f90, subroutine diag_snowfrac_tg.**

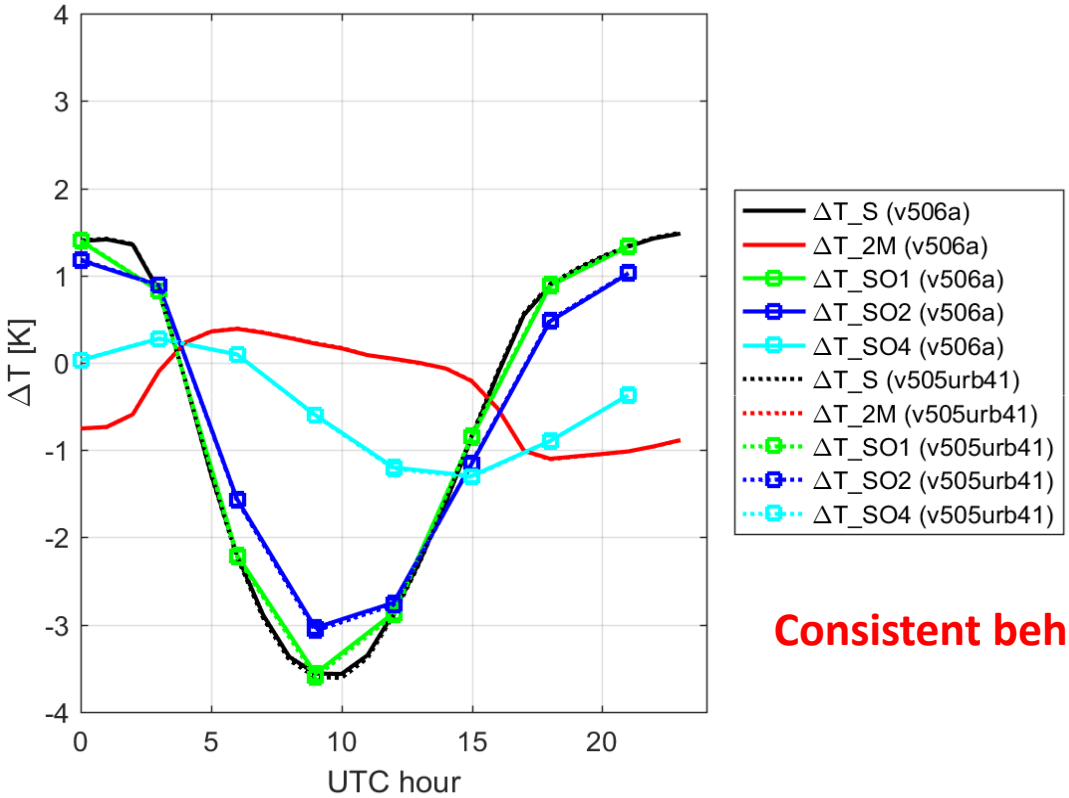


The diurnal variation of the model response in the fields of air, surface and soil temperatures to switching the skin-layer temperature scheme.

RHM contribution to AEVUS PT

Debugging of the new model versions

The problem of the incorrect behavior of a skin-layer temperature scheme: in the COSMO 5.05urb1/2/3/4, switching on the Jan-Peter's skin-layer temperature scheme (itype_canopy = 2) leads to the decreasing the air temperature diurnal range instead of its expected increasing. **The problem was eliminated after fixing a code bug in sfc_utilities.f90, subroutine diag_snowfrac_tg.**

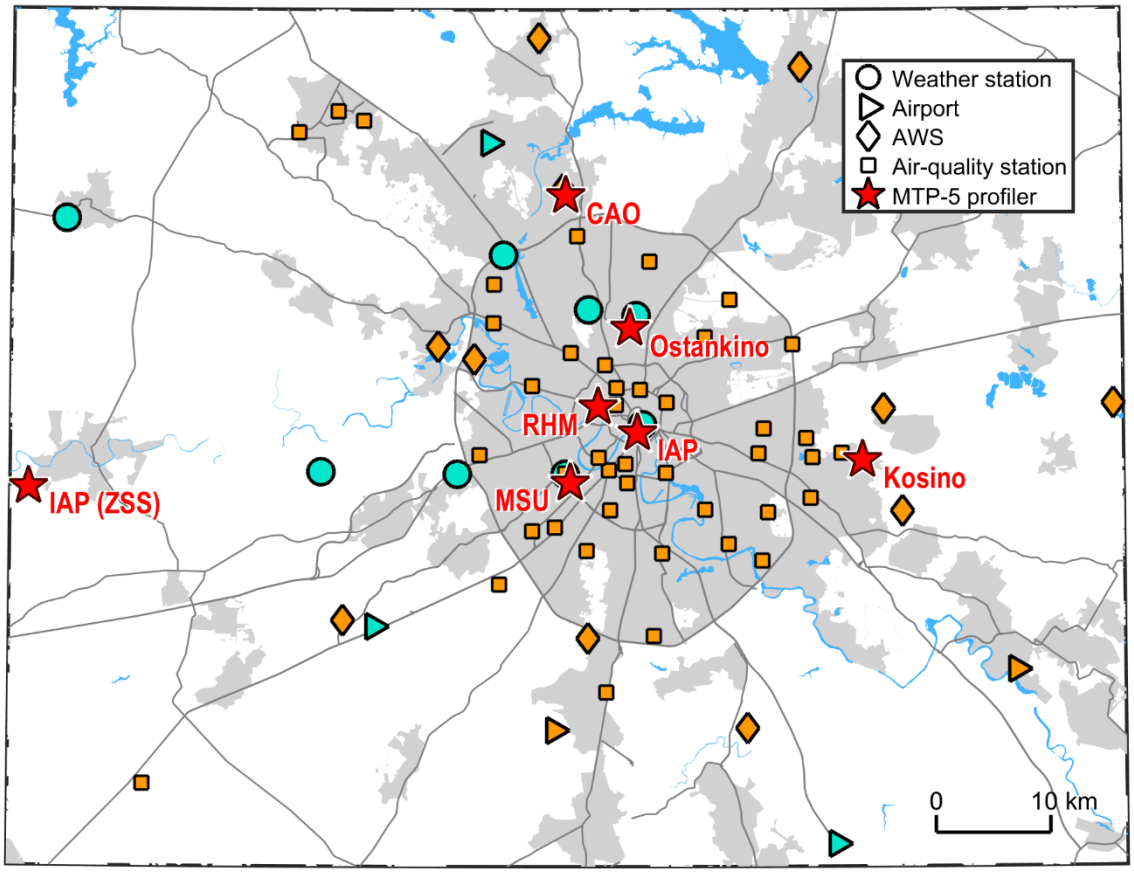


Consistent behavior after a bug fix

The diurnal variation of the model response in the fields of air, surface and soil temperatures to switching the skin-layer temperature scheme.

RHM contribution to AEVUS PT

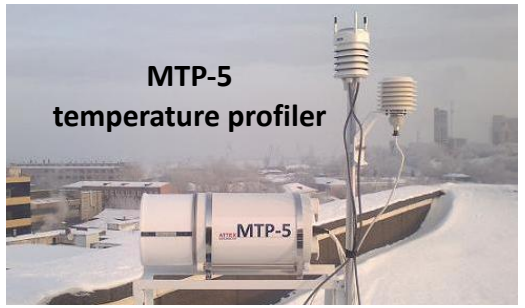
Data used for a model verification

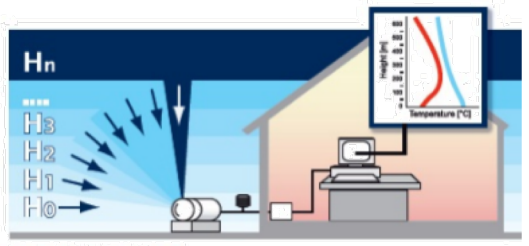


Data provided by RHM, A.M. Obukhov Institute of Atmospheric Physics (by Dr. Irina Repina and Arseiny Artamonov), Moscow State University (Dr. Vladislav Yushkov), Central Aerological Observatoty (Eugeny Miller) Mosecomonitoring agency

Observations used:

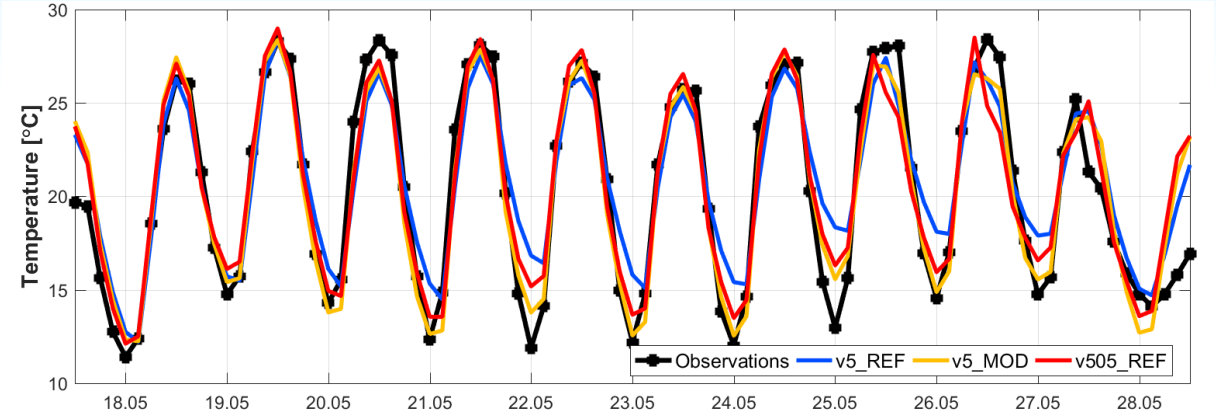
- Weather stations, including new AWSs
- Air-quality monitoring stations of Mosecomonitoring agency
- **A unique network of microwave temperature profiles MTP-5** (vertical profiles up to 1000 m)



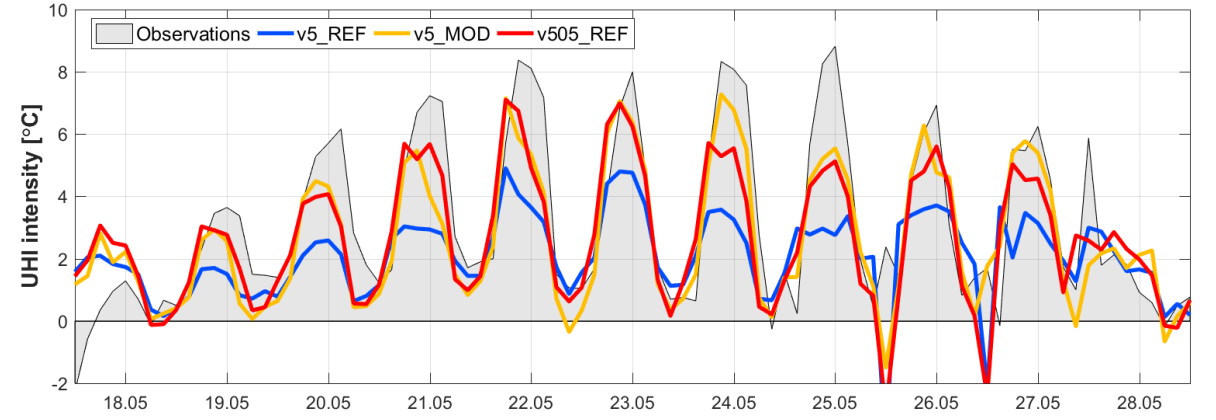


RHM contribution to AEVUS PT

Model verification for a summer case (17-28 May 2014)

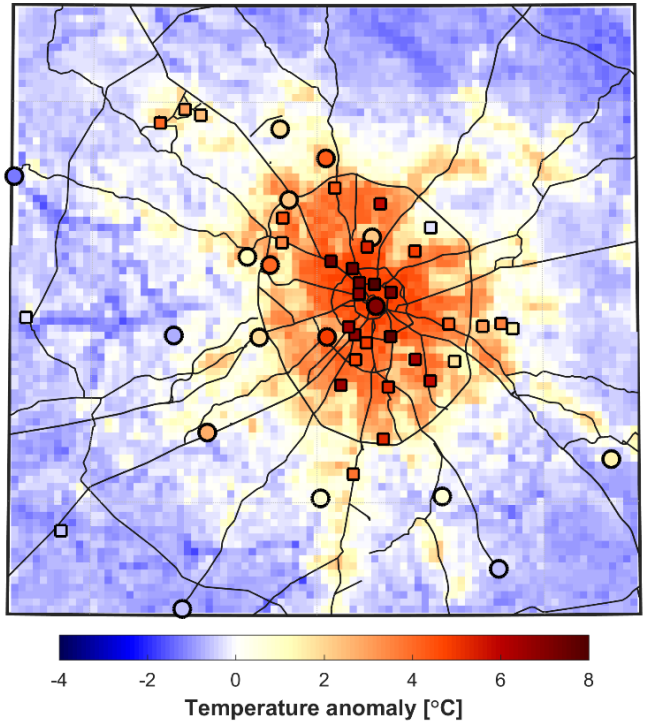


Mean rural temperature (averaged over 9 stations)



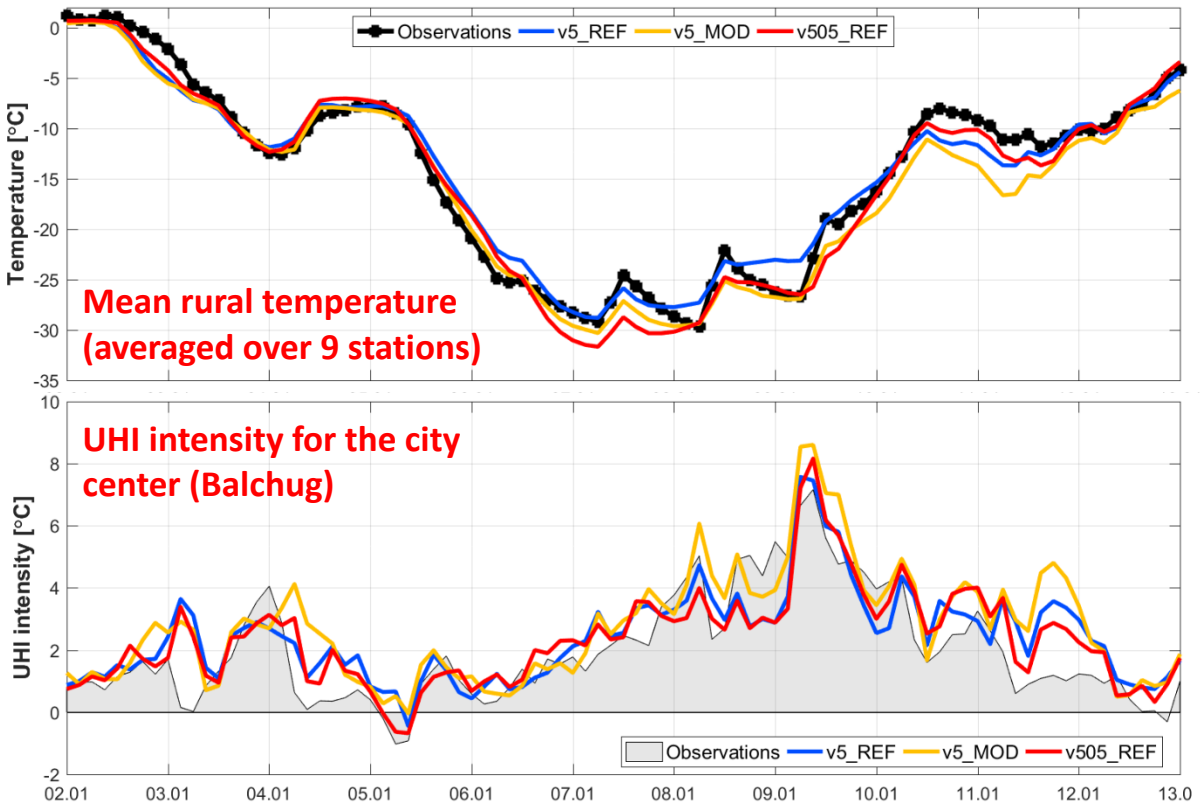
UHI intensity for the city center (Balchug)

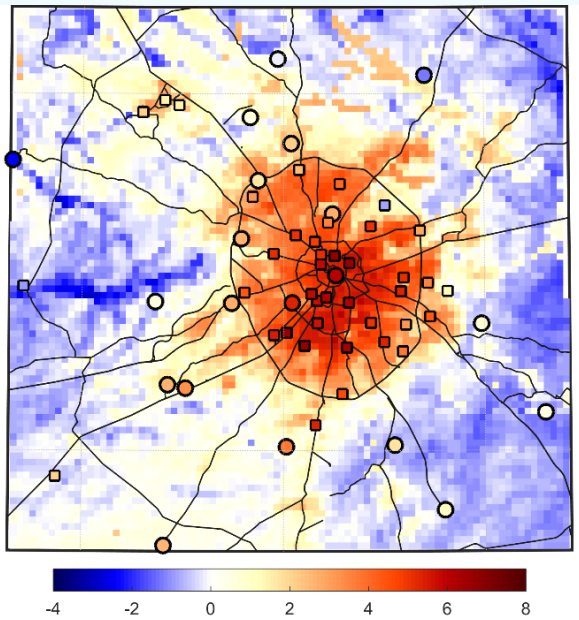
Mean nighttime (0 UTC) temperature anomaly



RHM contribution to AEVUS PT

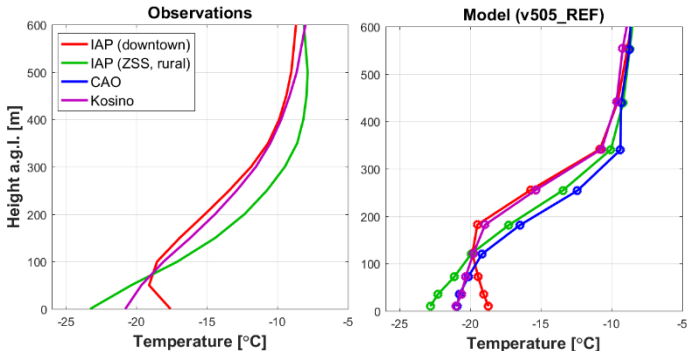
Model verification for a winter case with extreme frosts (1-15 Jan 2017)





Mean temperature anomaly over 9th of January [°C]

One of the coldest periods in Moscow region in XXI century with T_{min} = -35 °C in the north of the region



Mean temperature profiles over 9th of January [°C]

Key results from RHM work in AEVUS

1. The most important bugs have been revealed and found
2. The framework for detailed evaluation and verification have been developed
3. The results obtained with the new model version 5.05urb are consistent with results obtained with old 5.0_clm9_urb
4. Even without an accurate tuning, the new model version shows almost good results as a carefully-tuned old version

Outline

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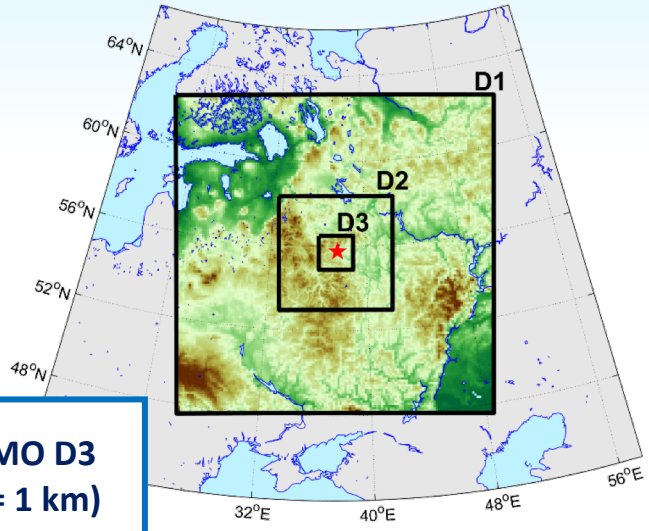
2. Towards AEVUS 2 and even more: our recent steps beyond the AEVUS tasks

New ICON-driven simulations

ICON forecasts to "reanalysis:

Forecast from 0 UTC	0	3	6	9	12	…
Forecast from 6 UTC	0	3	6	9	12	…
Forecast from 12 UTC	0	3	6	9	12	…



Old downscaling chain:

ERAI (Δx ≈ 80 km) → **COSMO D1** (Δx = 12 km) → **COSMO D2** (Δx = 3 km) → **COSMO D3** (Δx = 1 km)

New downscaling chain:

ICON (Δx ≈ 13 km) → **COSMO D2** (Δx = 3 km) → **COSMO D3** (Δx = 1 km)

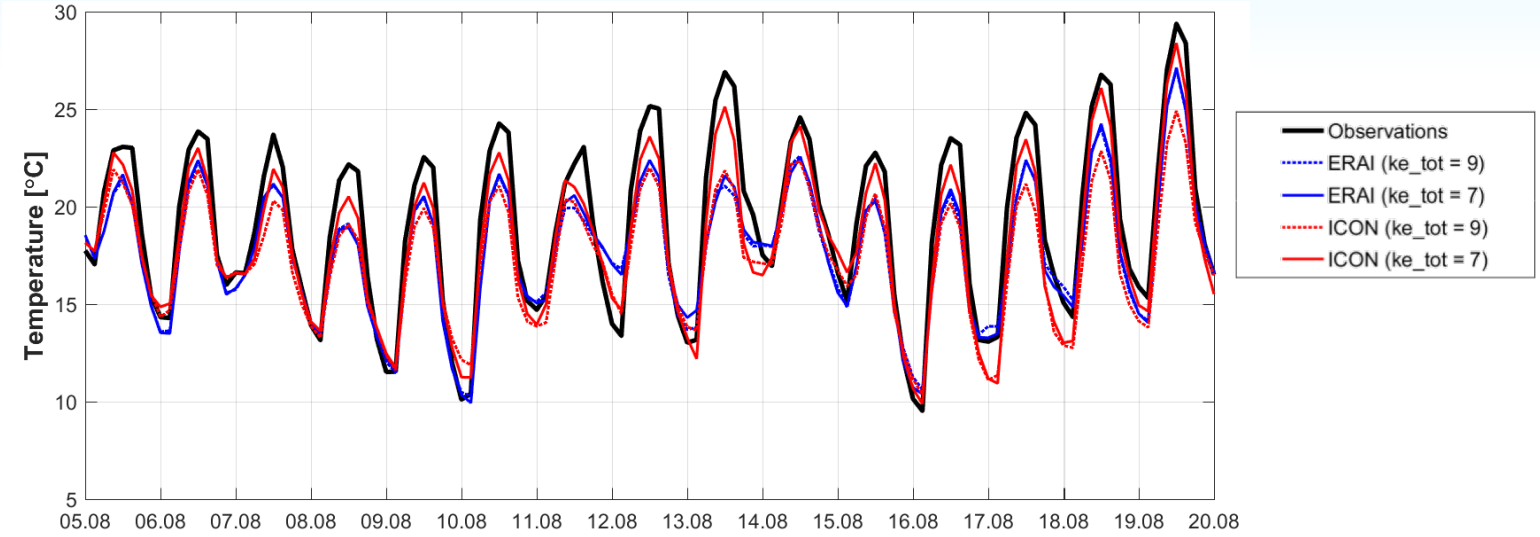
ICON (Δx ≈ 13 km) → **COSMO D1** (Δx = 12 km), **only for testing**

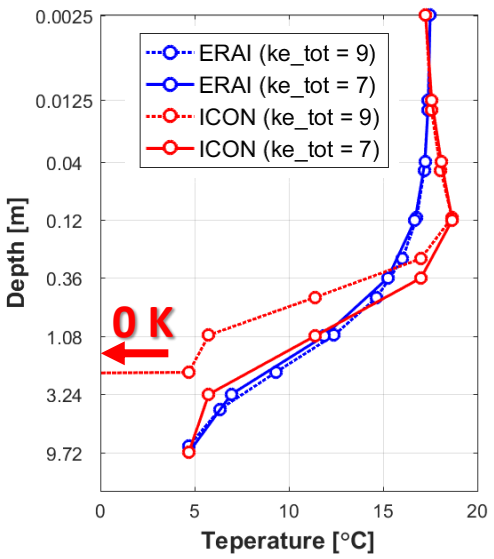
COSMO D2 (Δx = 3 km) → **COSMO $D3_{hr}$** (Δx = 500 m)

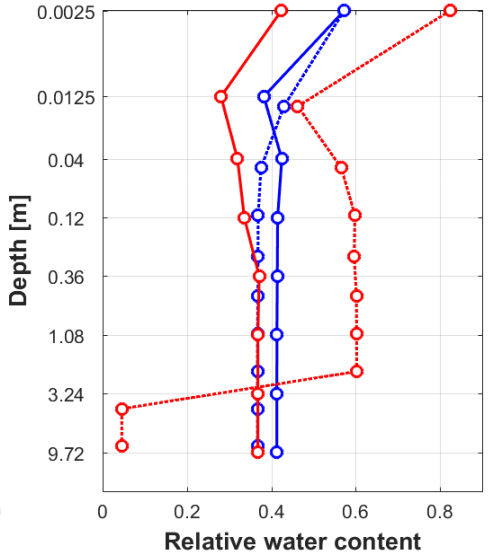
Motivation for new downscaling chain: we want to eliminate the errors which comes from the initial conditions on soil temperature and humidity, and from the imperfect model physics on the rough resolution of the basic domain (D1)

New ICON-driven simulations

Difference in initial conditions for soil moisture







- **With ke_tot=7** and default soil levels, ICON-driven simulations are initialized with less moist soil than ERAI-driven simulations, **which reduces cold & moist temperature bias**.
- **With ke_tot=9** and used-defined soil levels, something goes completely wrong with initial soil moisture & temperature profiles in ICON-driven simulations.
- **Soil temperature is initialized as absolute zero at 2 lowest soil levels, but model still works.**
- **Is it bug or feature???**

Towards the higher-resolution simulations

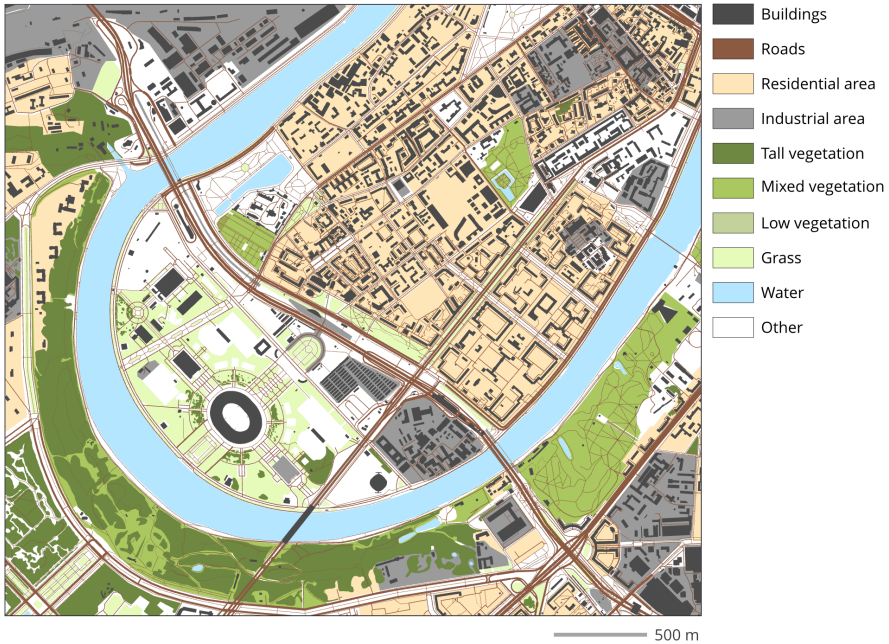
External parameters for TERRA_URB

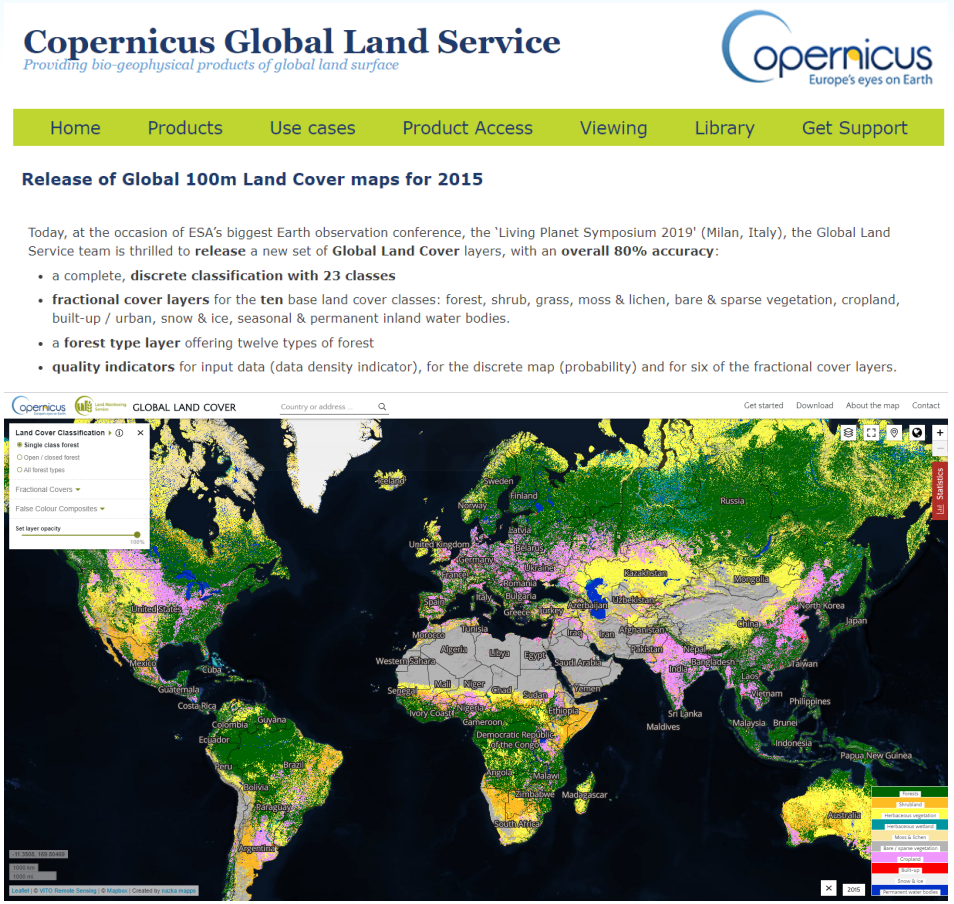
Old approach (for Δx = 1 km):

1) OpenStreetMap data
2) Empiric estimates

New approach (for Δx = 500 m):

1) New Copernicus Global Land Cover data
2) OpenStreetMap data
3) High-resolution (10 m) vegetation data from Sentinel images

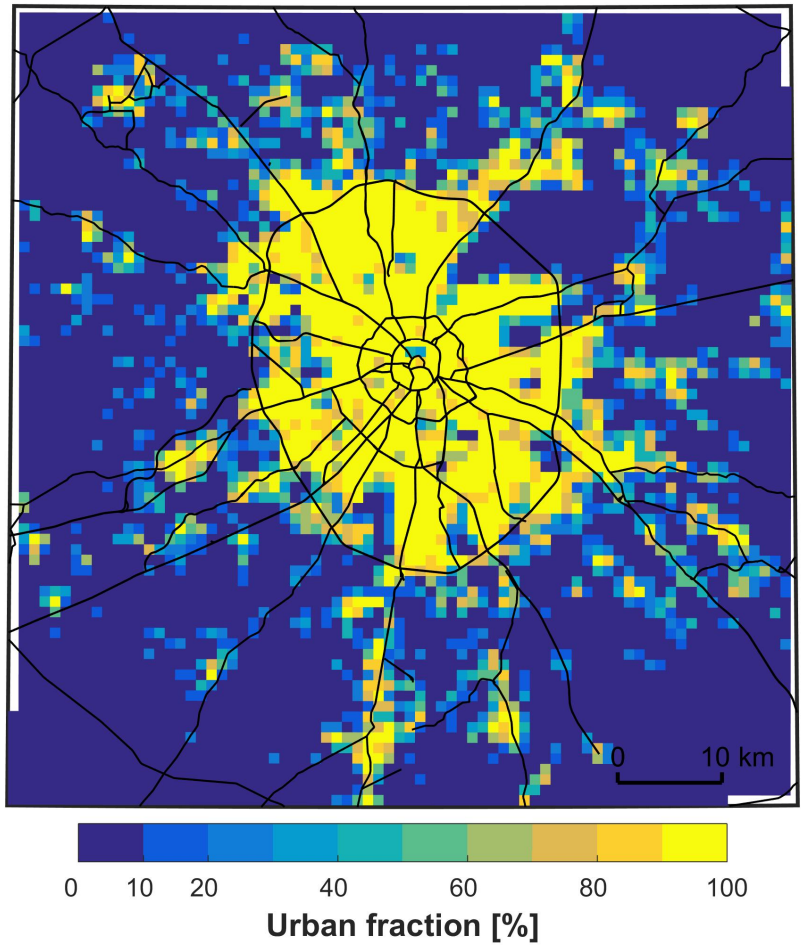




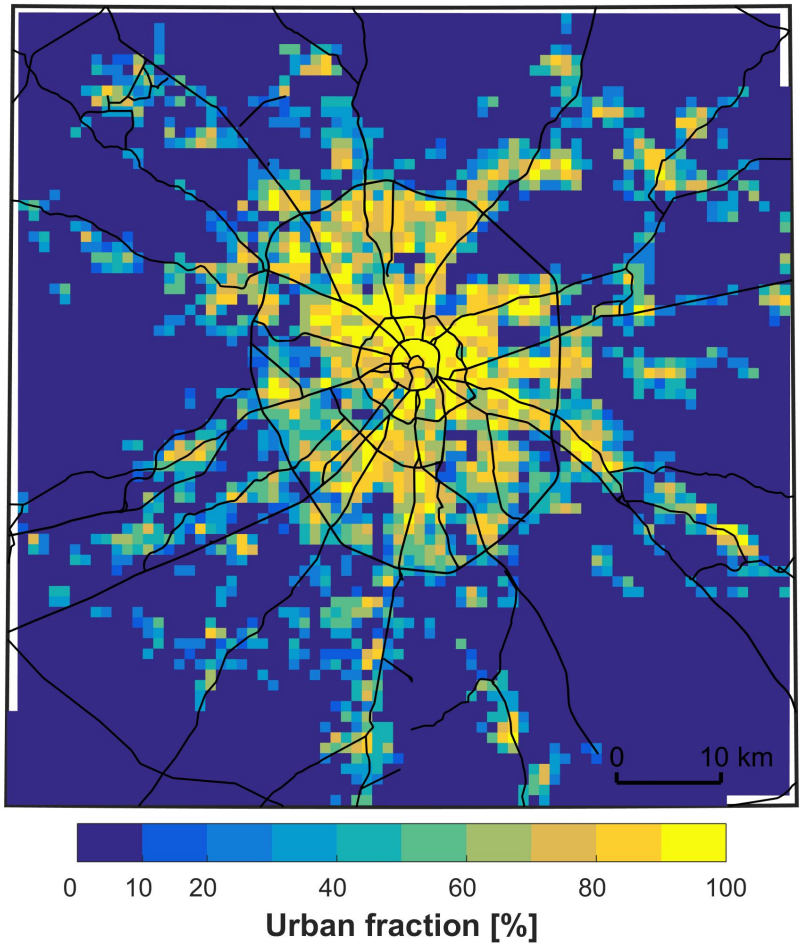
Towards higher-resolution simulations

External parameters for TERRA_URB: urban fraction **(Δx = 1 km)**

EXTPAR/WebPEP output
(Globcover data, URBAN field)



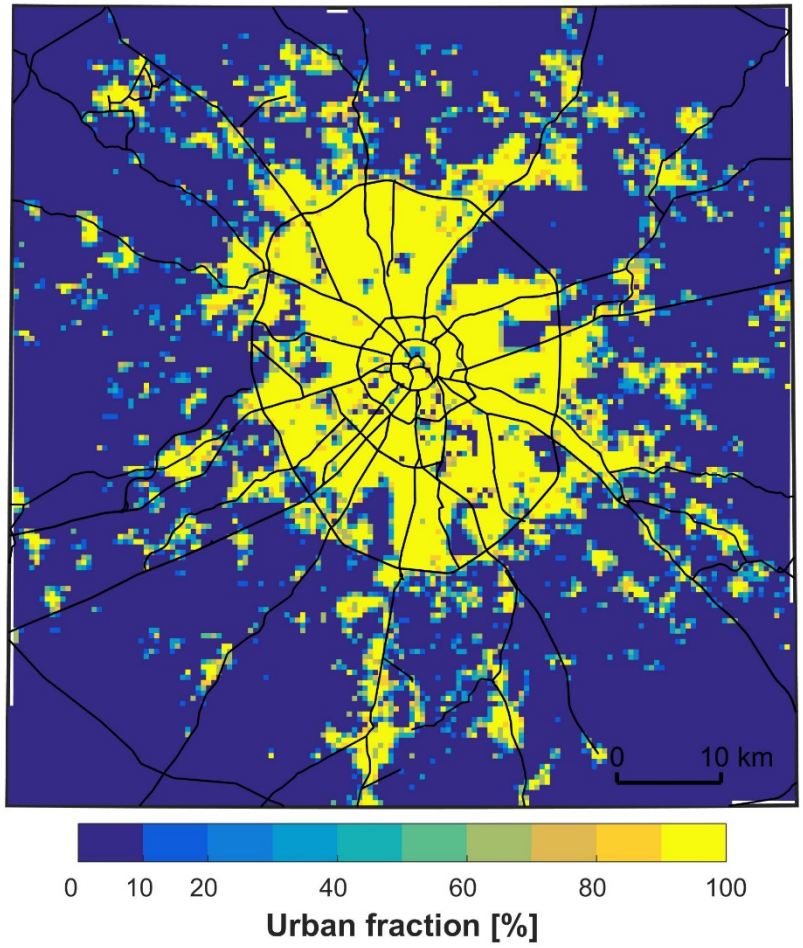
What we used for 1-km runs
(based on OpenStreetMaps data and empiric estimates)



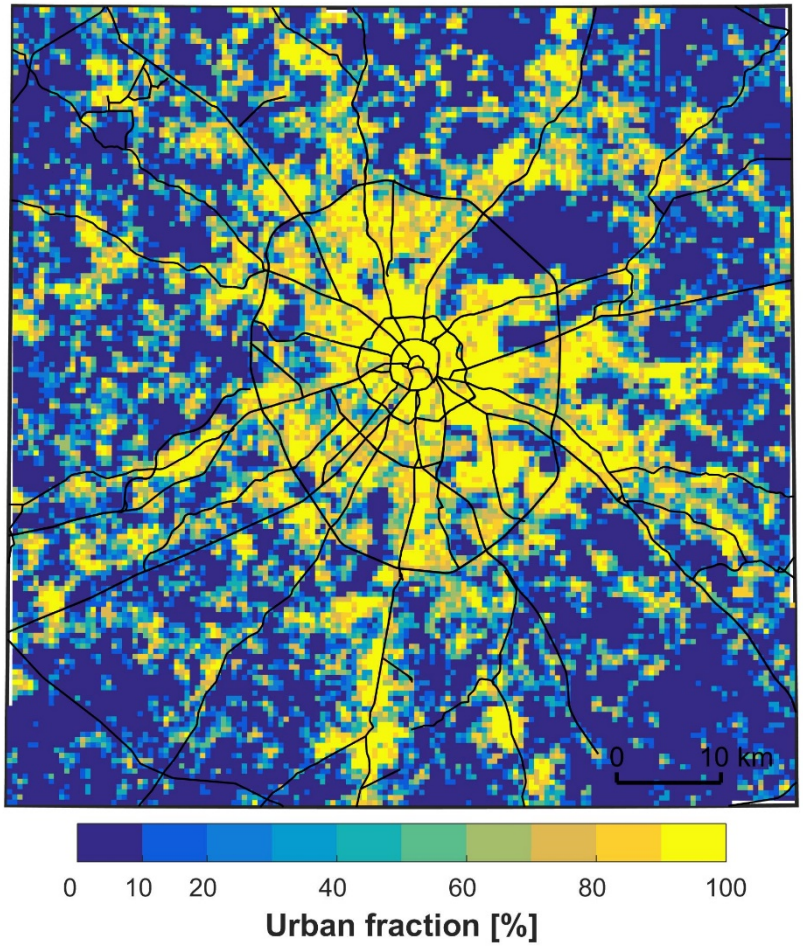
Towards higher-resolution simulations

External parameters for TERRA_URB: urban fraction **(Δx = 0.5 km)**

EXTPAR/WebPEP output (Globcover data, URBAN field)



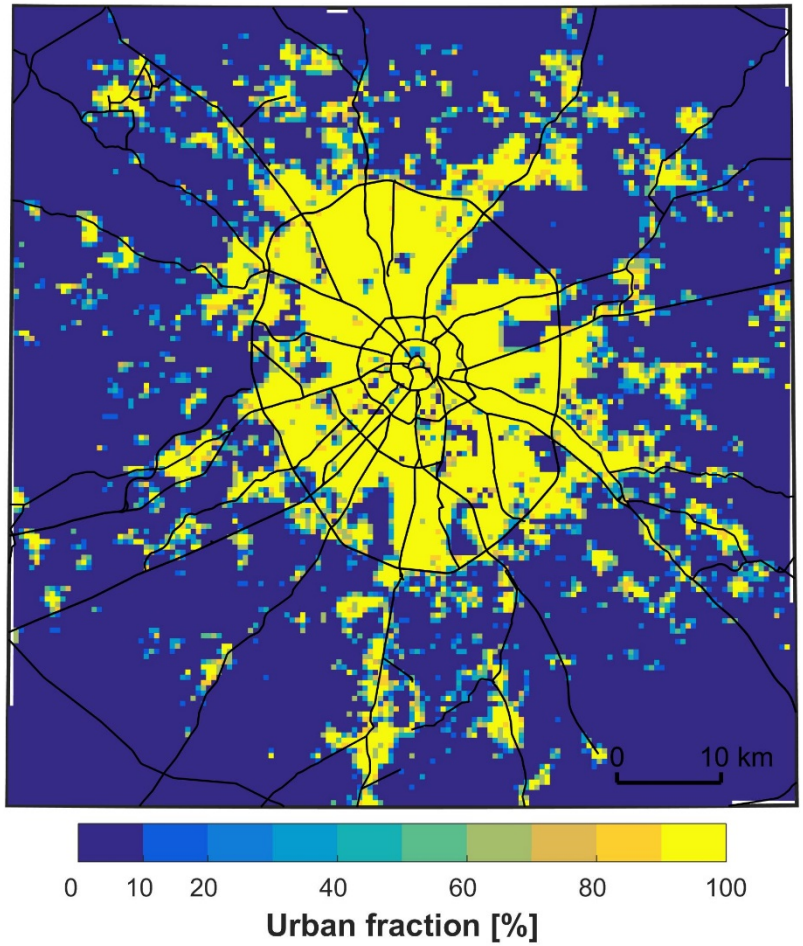
New CGLC data (after averaging of the original data on 100-m grid)



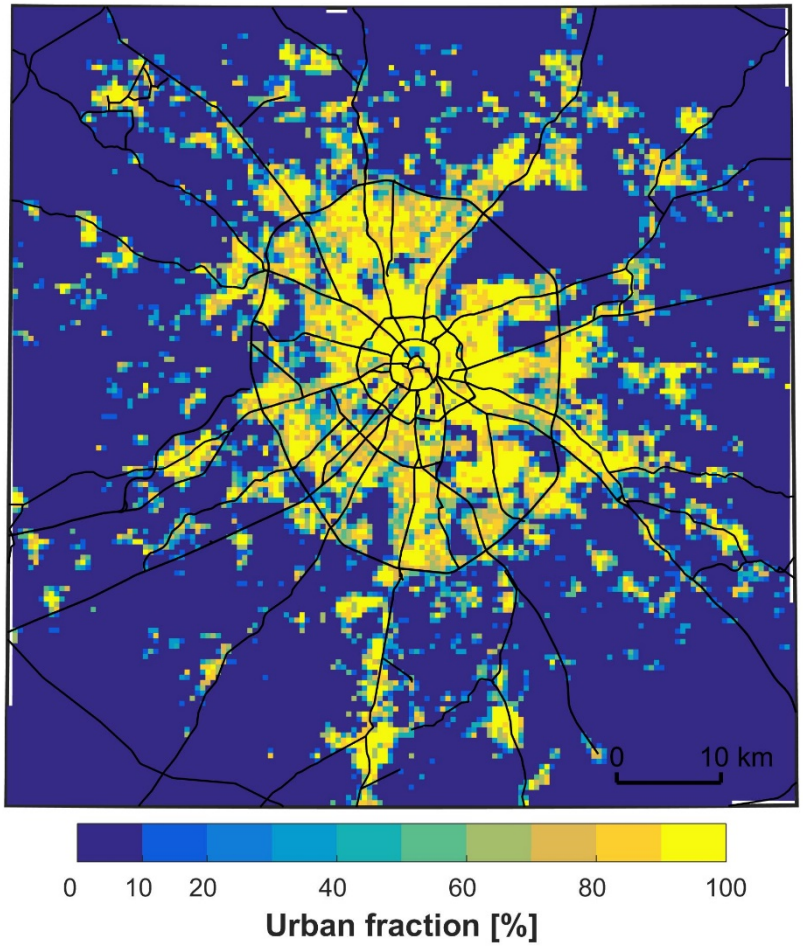
Towards higher-resolution simulations

External parameters for TERRA_URB: urban fraction **(Δx = 0.5 km)**

EXTPAR/WebPEP output
(Globcover data, URBAN field)



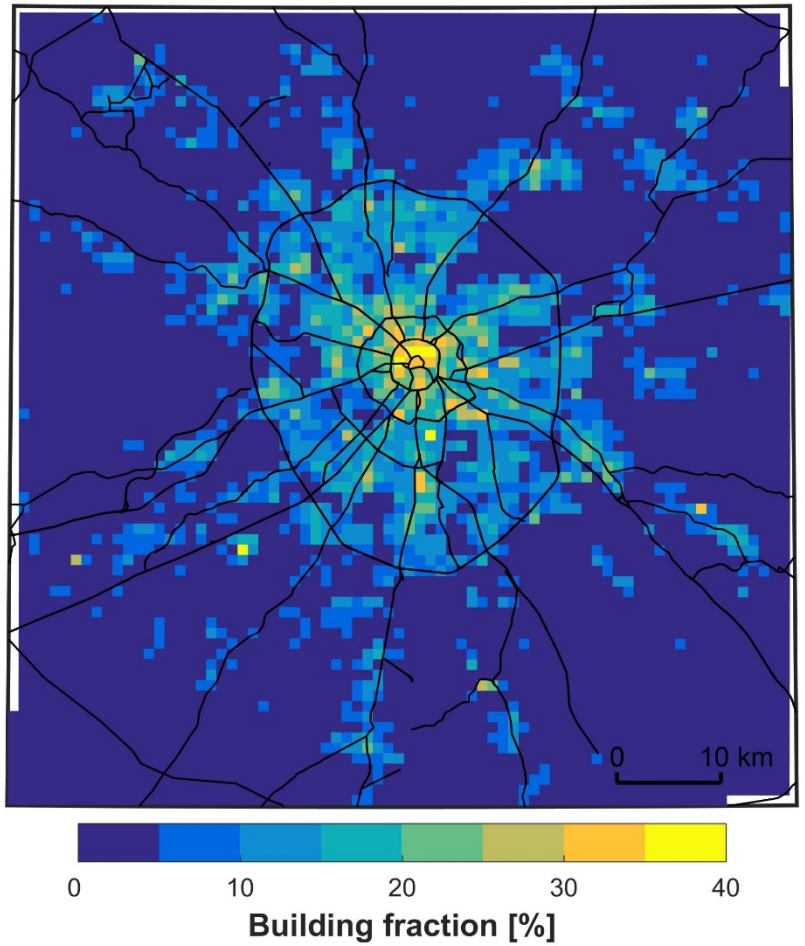
What we use for test simulations,
Urbfr = min (GGLC, Globcover)

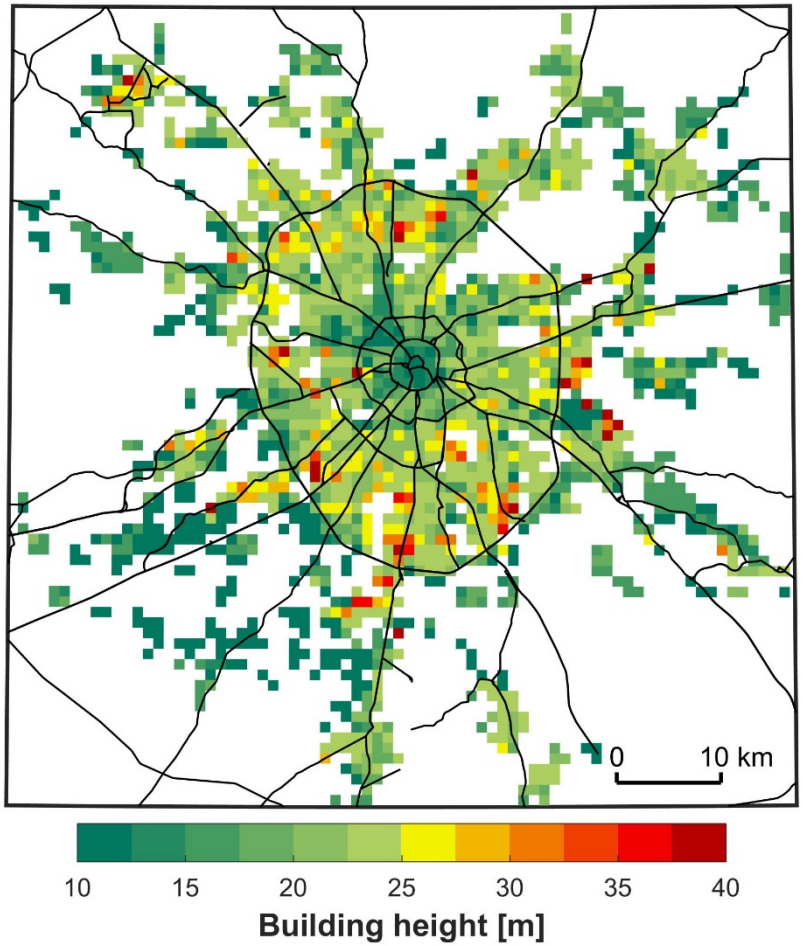


Towards higher-resolution simulations

New 2D external parameters **(Δx = 1 km)**

Parameters, used in previous 1-km simulations with 5.0_clm9_urb model version (based on OpenStreetMap data)

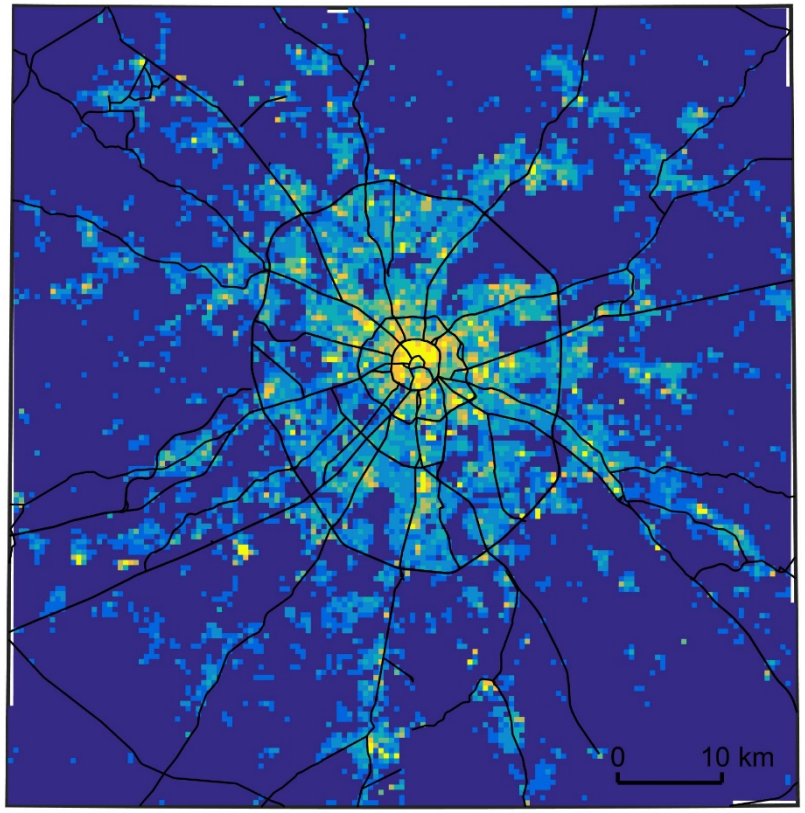


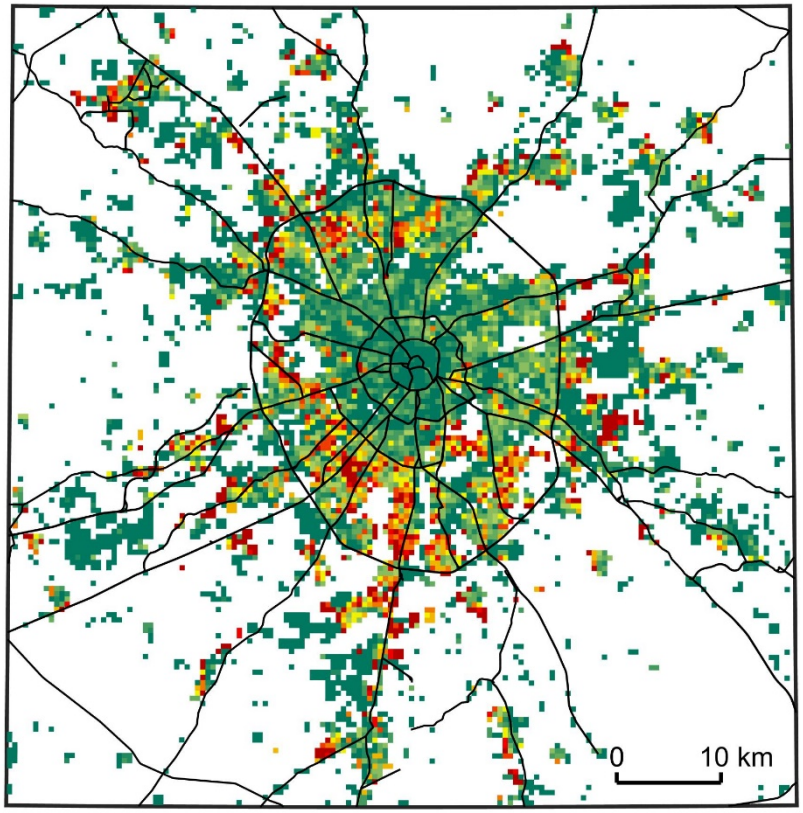


Towards the higher-resolution simulations

New 2D external parameters **(Δx = 0.5 km)**

Parameters, prepared for new 500-m simulations, not used yet (based on OpenStreetMap data)

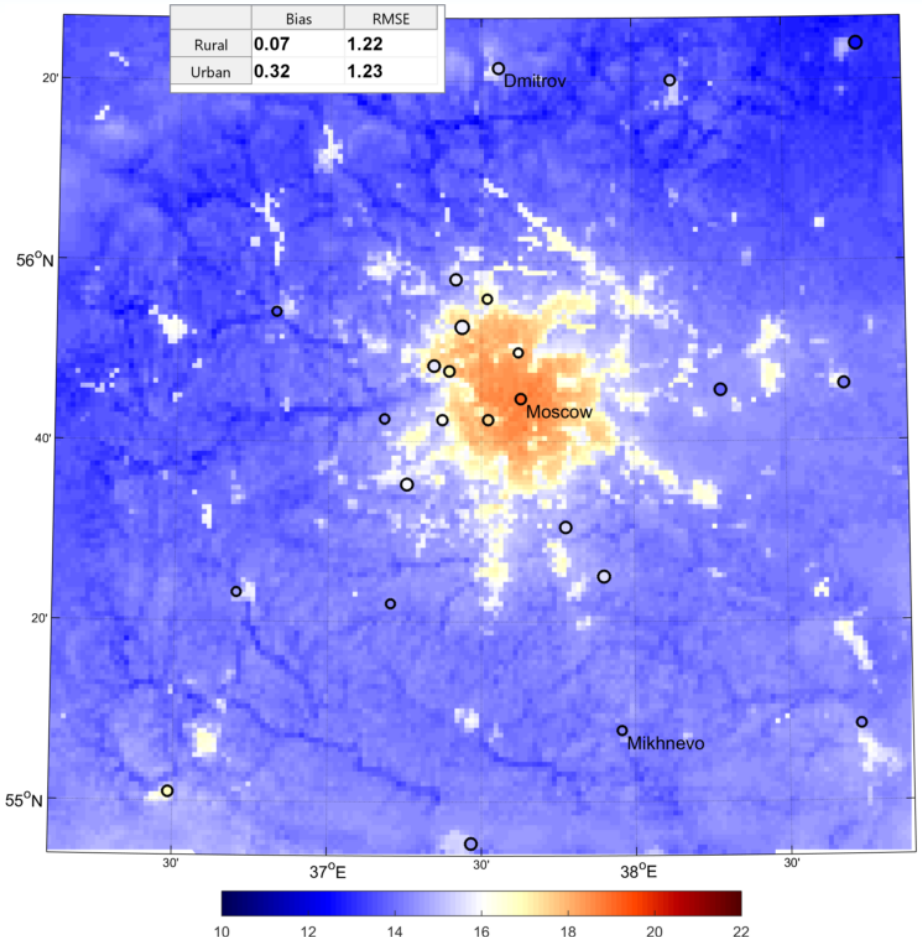




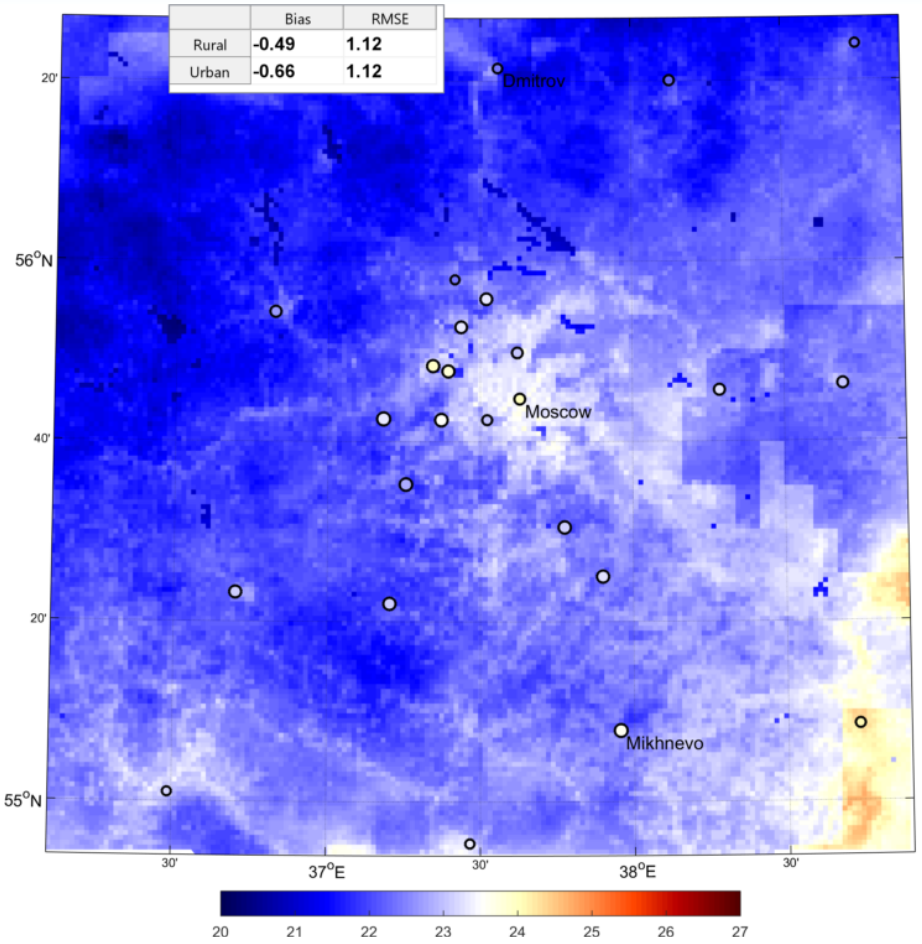
Towards higher-resolution simulations

Model verification for a summer case (5-20 August 2017)

Δx = 1 km (0.009°), 180x180 grid cells, dt = 10 sec



Mean nocturnal temperature (0 UTC)

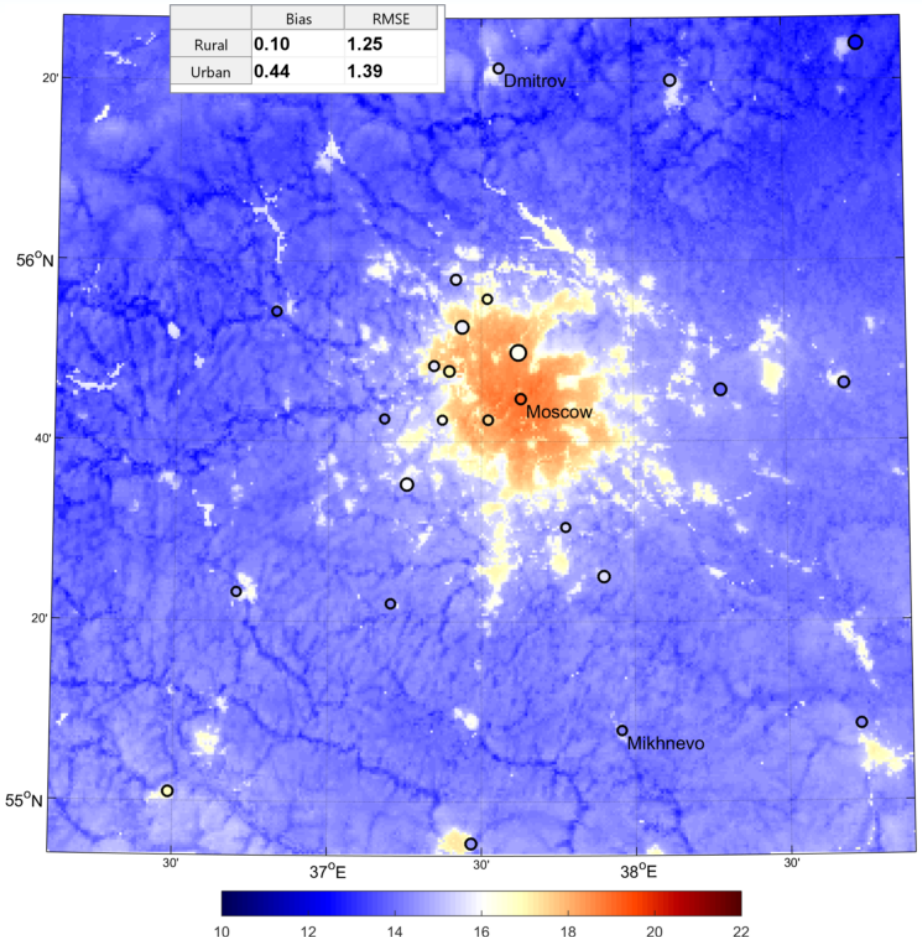


Mean daytime temperature (12 UTC)

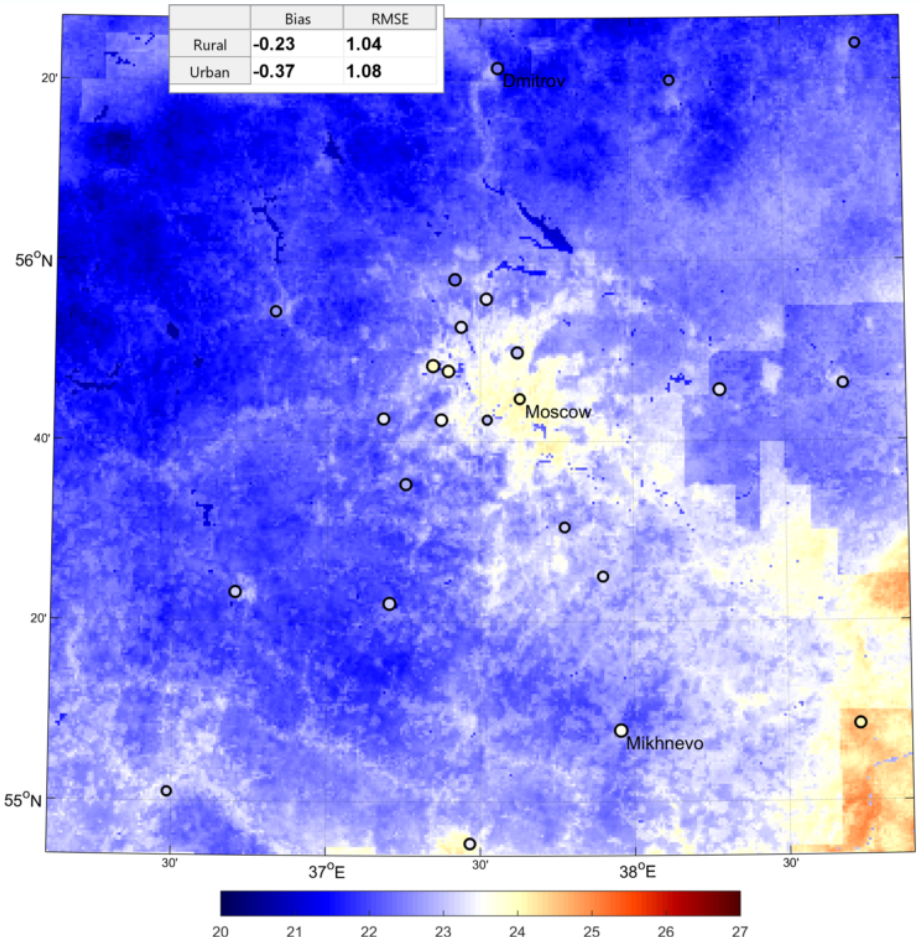
Towards the higher-resolution simulations

Model verification for a summer case (5-20 August 2017)

Δx = 500 m (0.0045°), 400x400 grid cells, dt = 5 sec



Mean nocturnal temperature (0 UTC)

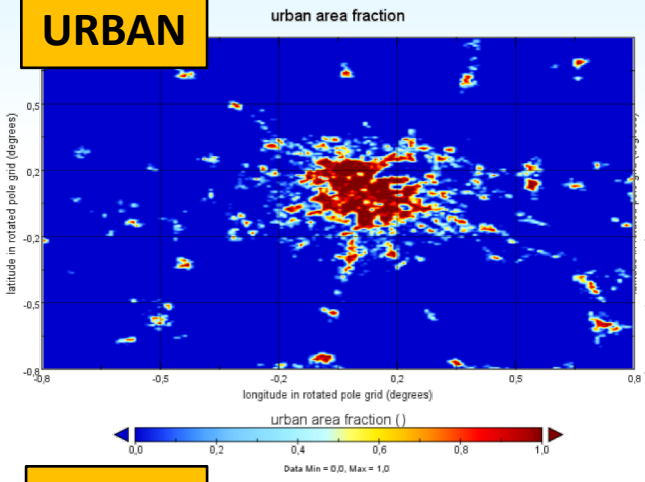


Mean daytime temperature (12 UTC)

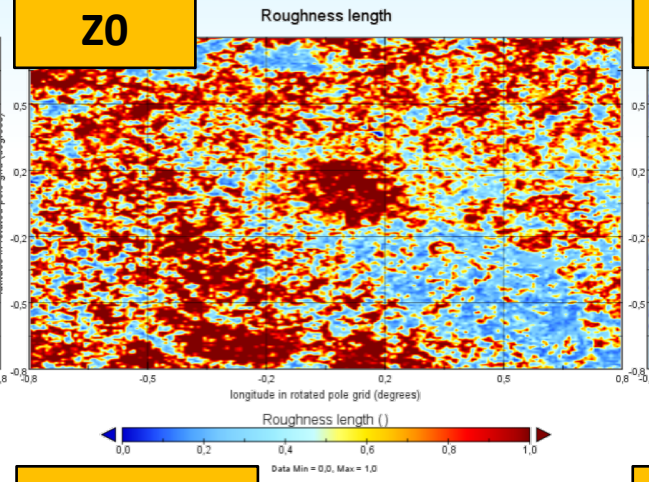
Any suggestions on the namelist settings for "gray-zone" simulations?

The problem of inconsistent EXTPAR data

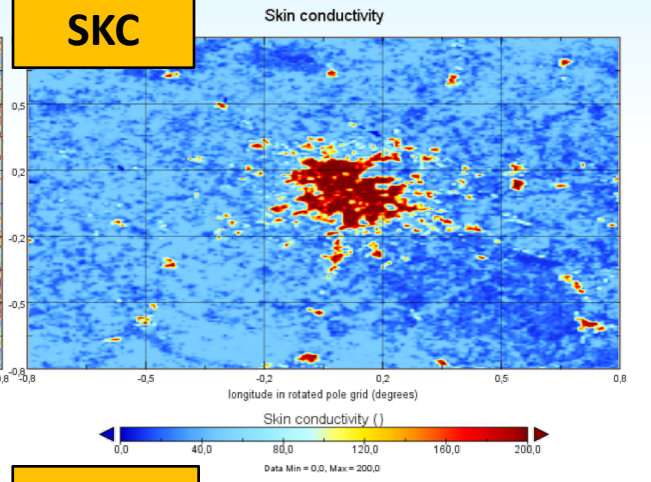
URBAN



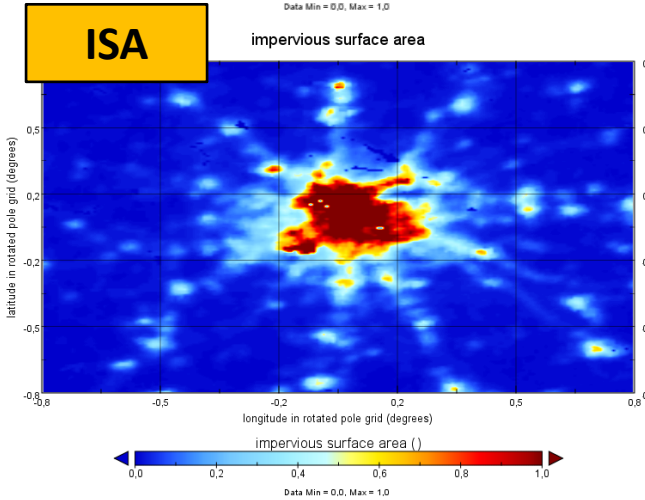
Z0



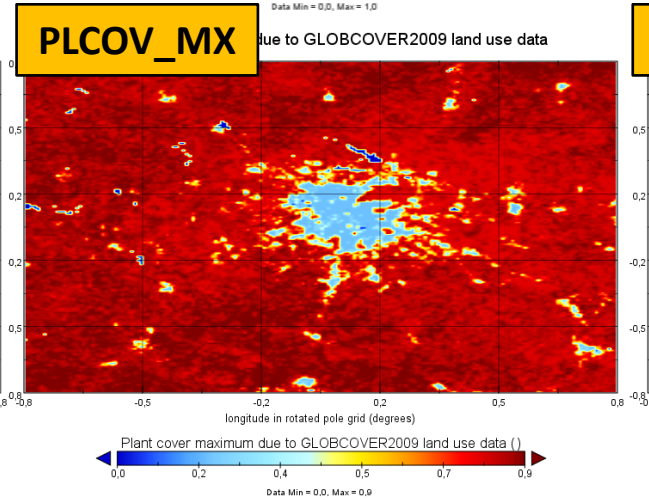
SKC



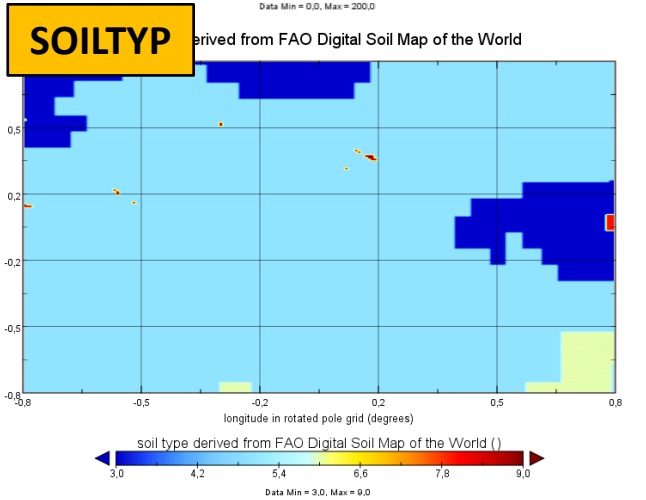
ISA



PLCOV_MX



SOILTYP



Specific problems that should be considered in AEVUS-2:

1) ISA/FR_PAVED data is inconsistent with URBAN variable and with other dependent variables
2) Double-accounting of urban effects when TERRA_URB is switched on (e.g. via Z0, SKC and PLCOV)
3) Very poor resolution of the data on soil types -> unphysical effects in simulated fields

Thank you for attention!

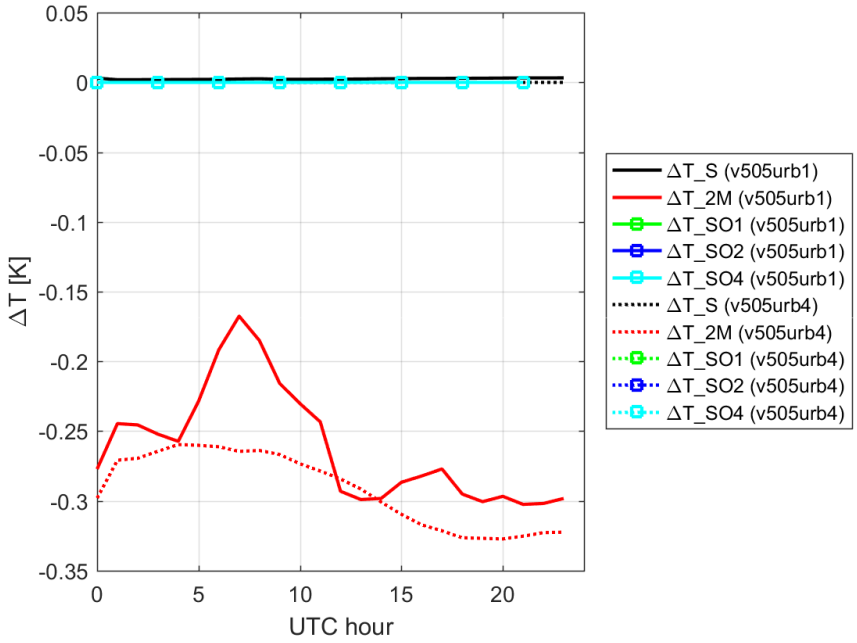
Any questions?

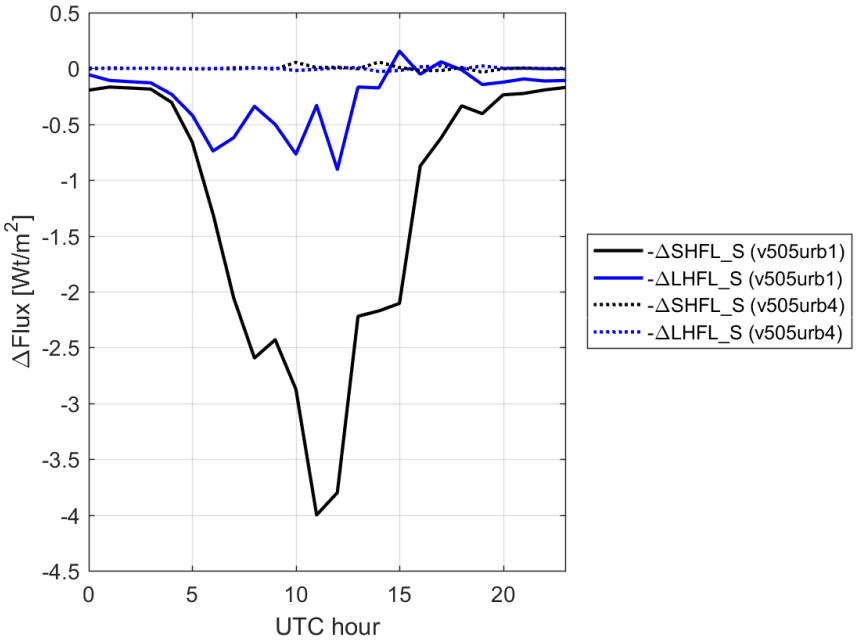
RHM contribution to AEVUS PT

Debugging of the new model versions

Remained minor bugs:

1. The problem of writing constants to the output files (**lffd*c.nc)**: model crash or writing wrong data with lwrite_const = .TRUE.
2. The inconsistency related to the external parameter names ISA & FR_PAVED. The model could read the both, but only the FR_PAVED is actually used, and no error is thrown when ISA is available and FR_PAVED is unavailable
3. Unphysical response to switching on the TERRA_URB scheme over lakes:





RHM contribution to AEVUS PT

Model settings for the evaluation runs

	v5_REF	v5_MOD	v505_REF*
Model version	**5.0_clm9**		**5.05urb4**
PHYCTL			
Itype_rootdp	1	2	2
Itype_evsl	1	4	4
Itype_heatcond	1	2	3
Itype_canopy	1	2	1*
calamrur	-	30	-**
TUNNING			
tkmmin & tkhmin	0.4	0.1 or 0.05	0.75
pat_len	500	100 or 50	100
DYNCTL			
hd_corr_(t, u, p…)	defaults	0.25 for all	defaults

/PHYCTL/	OLD	NEW
itype_evsl	2	4
itpye_heatcond	1	3
itype_root	1	2

***Defaults for "new" physics**

(Different Configurations for the COSMO-ICON Physics, 2018)

**Jan-Peter's skin-layer temperature scheme for 5.05_urb was under debugging and hence not used in these runs