Simulations of Moscow agglomeration climate conditions with COSMO-CLM regional model, coupled with TEB urban scheme, for present and future climate

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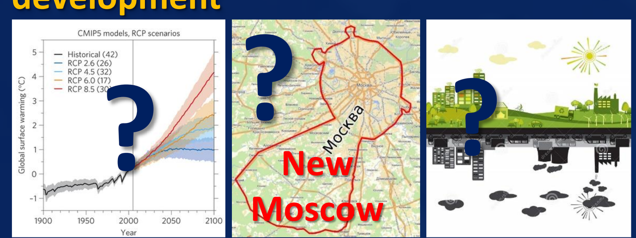
Motivation for research

Idea of the research:

To make a detailed climate forecast for Moscow city for XXI century:

- for different climate change scenarios and **for different scenarios of urban development**



- **using regional climate model**, coupled with specific urban surface model

Model setup, tuning and verification requires detailed understanding of modern climatic features:

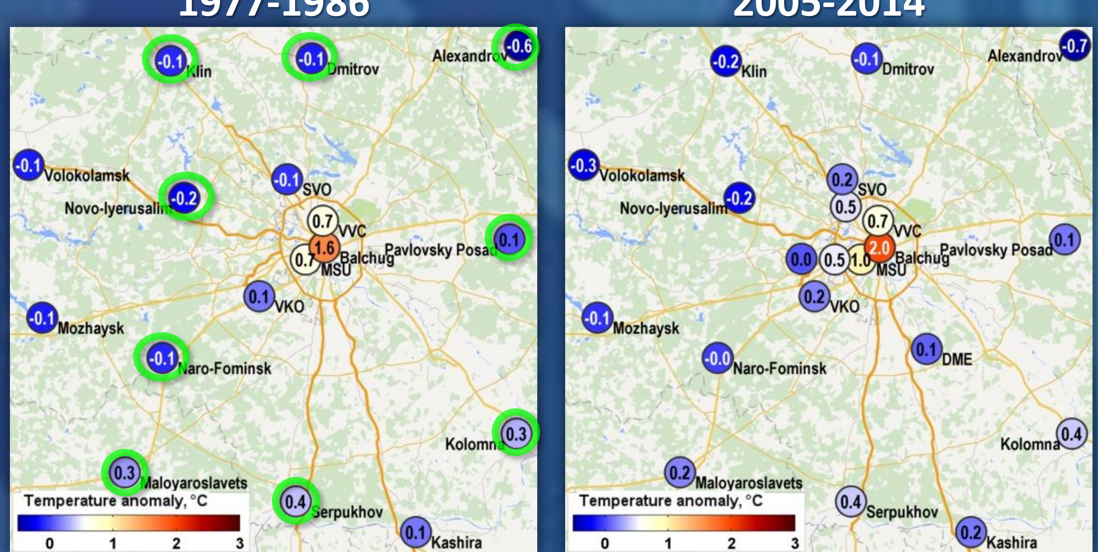
- **Quantitative parameters** for comparison with model simulations;
- **Qualitative description** of local climate features and their behavior in different cases;

Detailed investigation of Moscow megacity climate with usage the newest observation data

Model verification for model climate

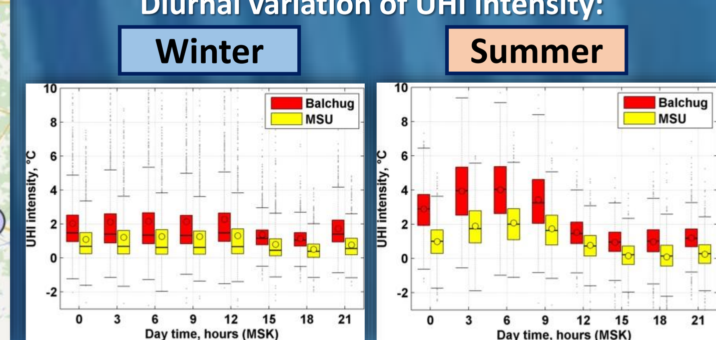
Model runs for future climate – dynamic downscaling of the climate forecasts

Moscow agglomeration climate: observation data

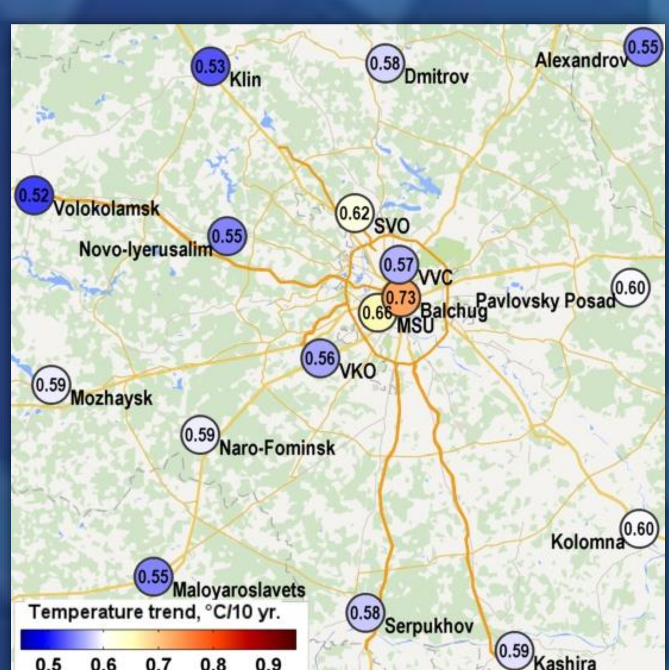


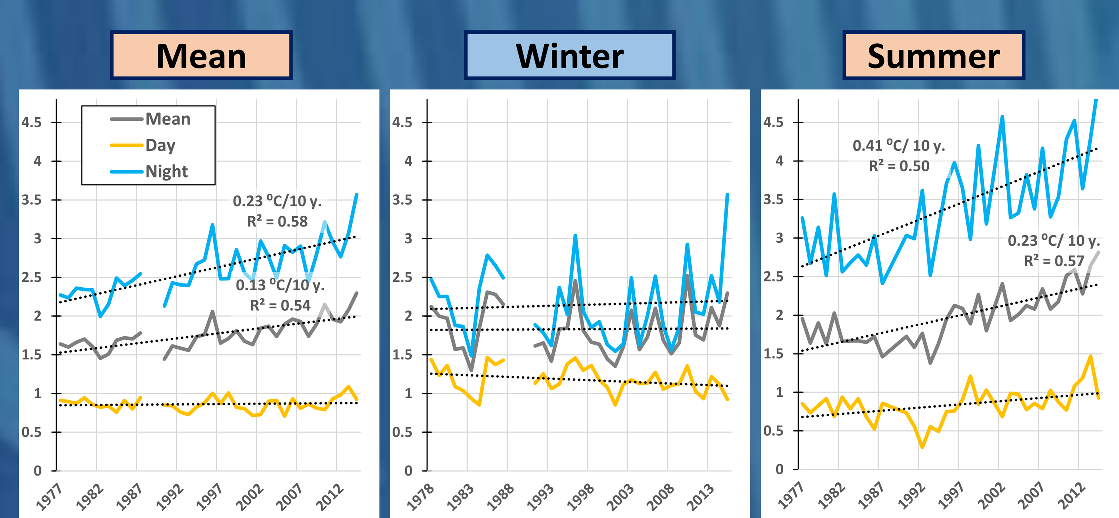
$$\Delta T\,(UHI) = T_{urban} - 1/n \sum_{i=1}^{n} T^{i}_{rural}$$

Diurnal variation of UHI intensity:



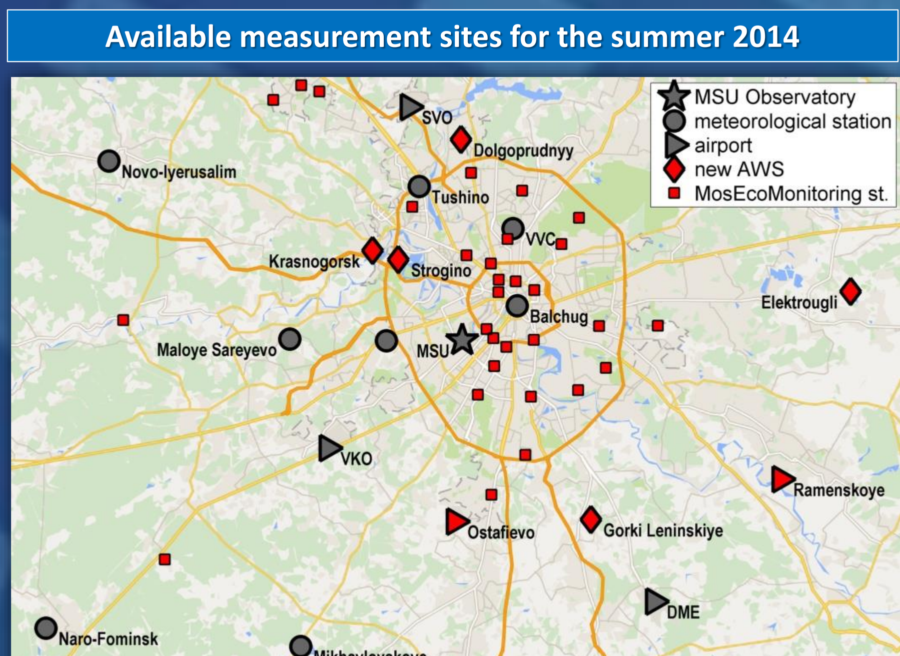
UHI intensity (°C) inter-annual variations and trends for Balchug station

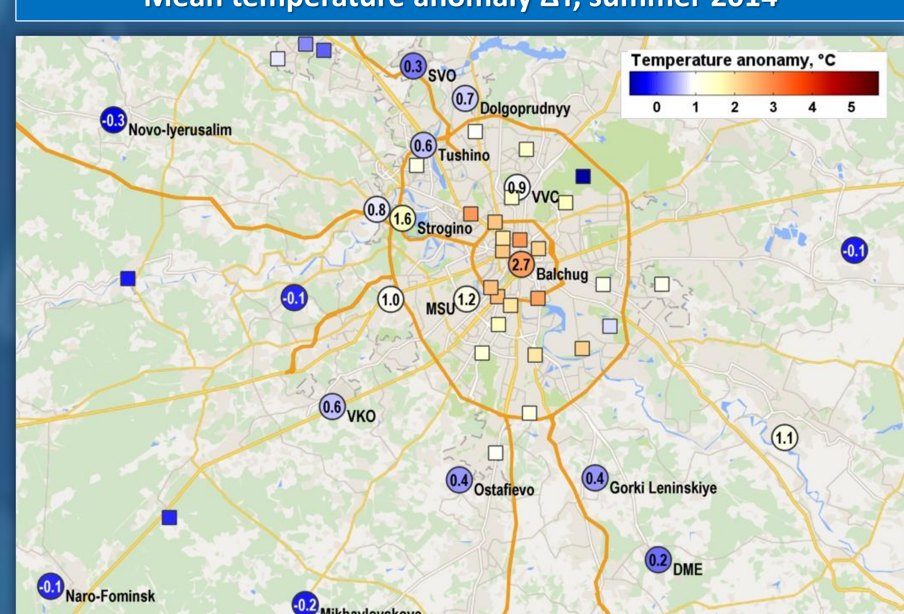


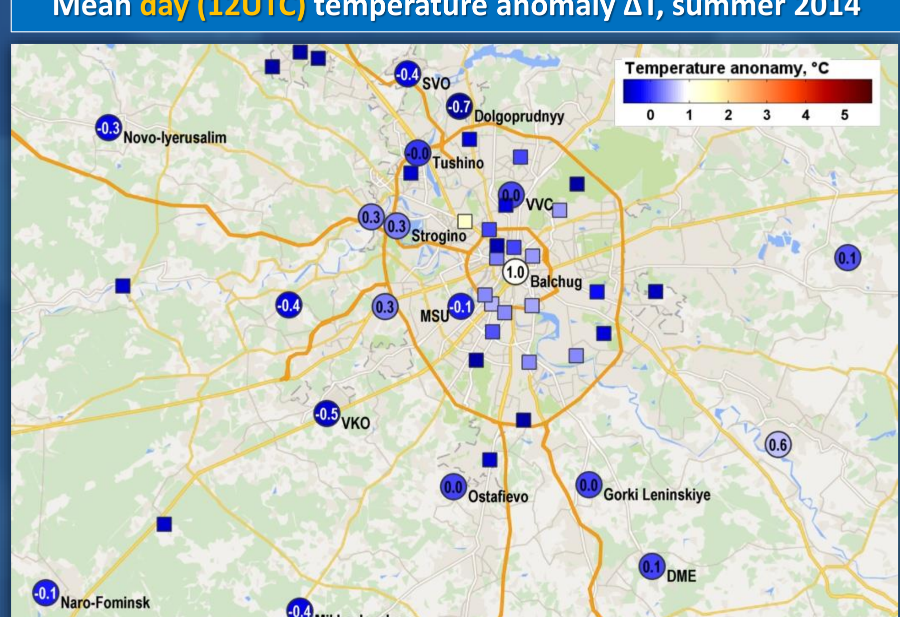


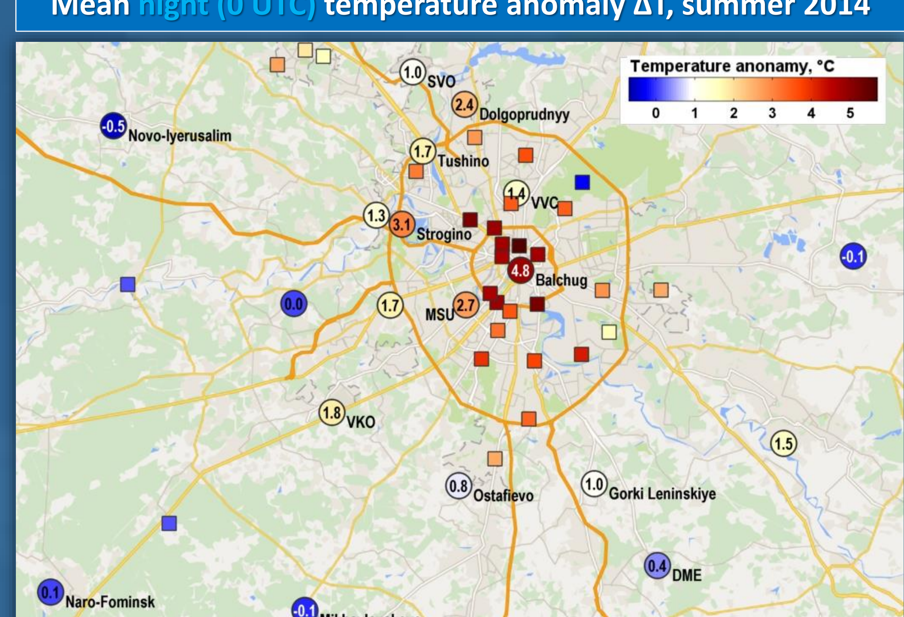
Urban amplification warming is observed for Moscow

Detailed spatial structure of Moscow UHI according to the newest observations

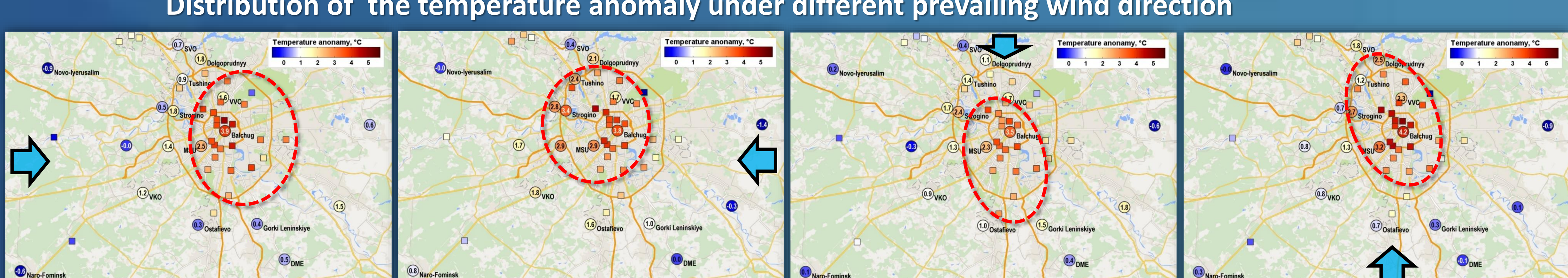






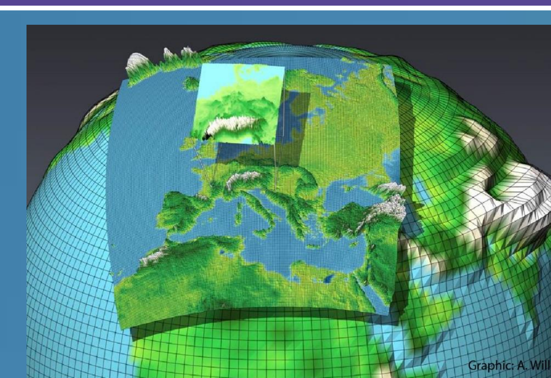


Distribution of the temperature anomaly under different prevailing wind direction

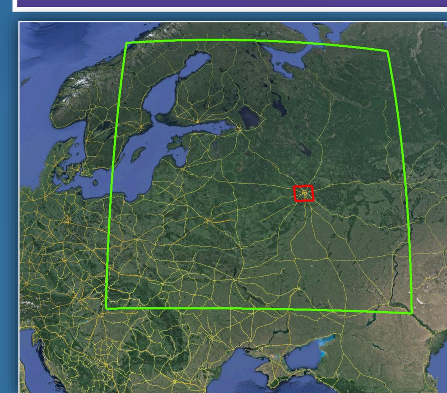


COSMO-CLM regional climate model

- Nonhydrostatic atmospheric model
- Same code as COSMO weather forecast model (DWD, Roshydromet)
- Resolution from 1 to 50 km; long-term runs
- Easy-to-use tools for preparing of model domains (landuse, ect.);
- Easy-to-use archives of global modelling data (ERA-Interim, NCEP, CMIP5) for boundary conditions
- Coupled with TEB urban surface scheme (Trusilova et. al., 2013)
- Installed and running on "Lomonosov" supercomputer;

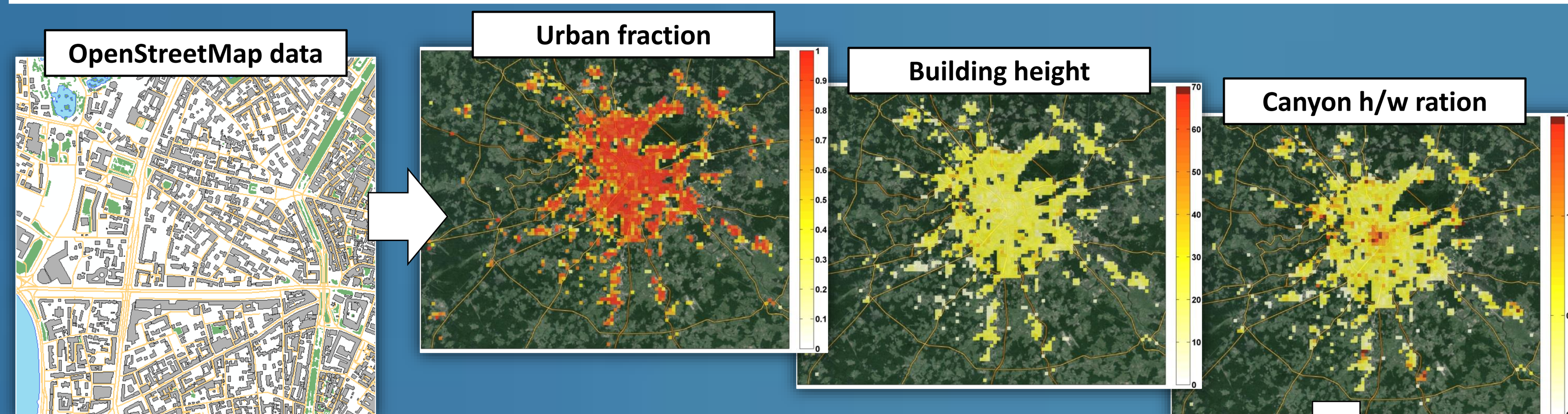


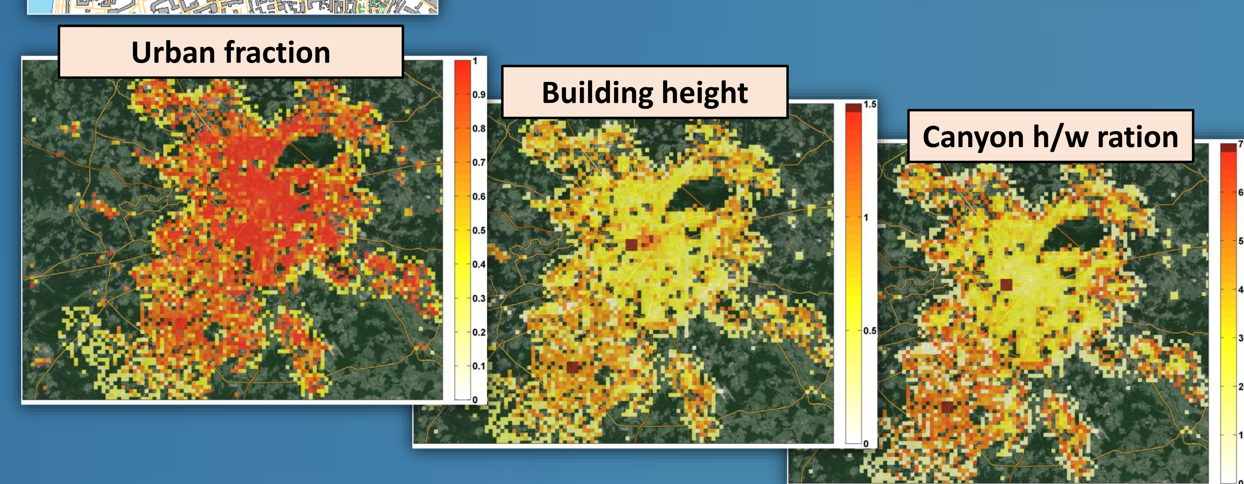
Configuration of the numerical experiments



- Models runs for summer seasons (May-August) for each year in period 2002-2011 (10 years) and 2046-2055 (10 years)
- Initial & boundary conditions from MPI-ESM-LR global climate model, from "historical" run for 2002-2005 yy., from RCP 4.5 run for 2005-2011, from RCP 8.5 run and 2046-2055 yy.
- Basic domain with 10-km resolution (200*200 cells) and nesting domain with 1-km resolution and TEB urban scheme (120*100 cells)

Calculation building parameters for TEB

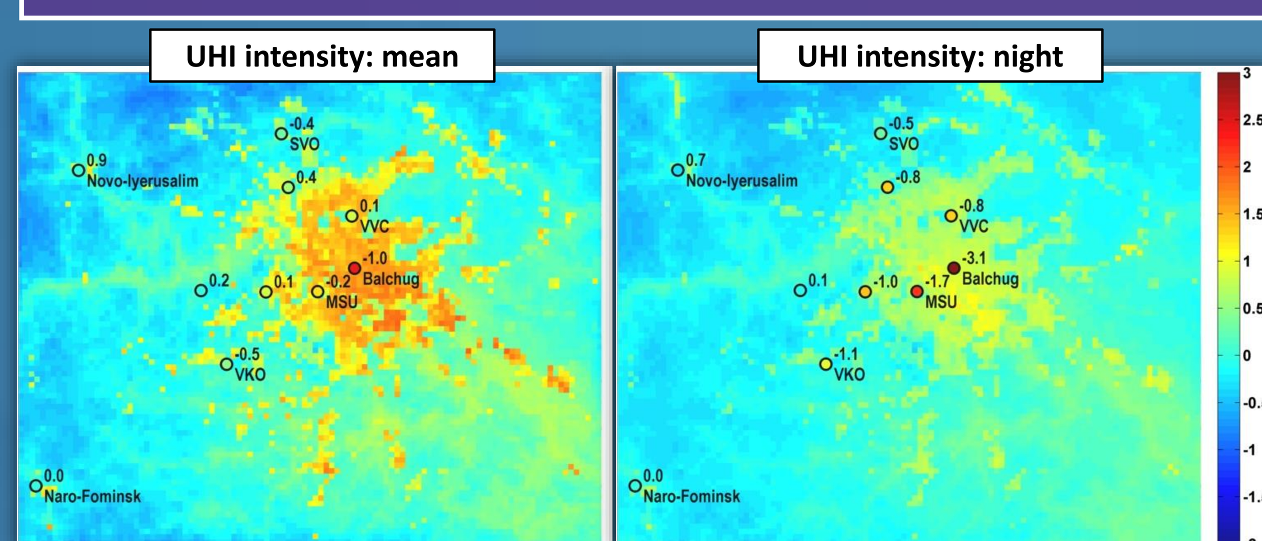


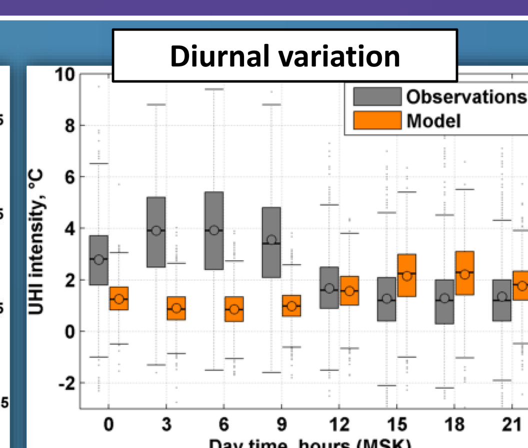


Radical city extension scenario

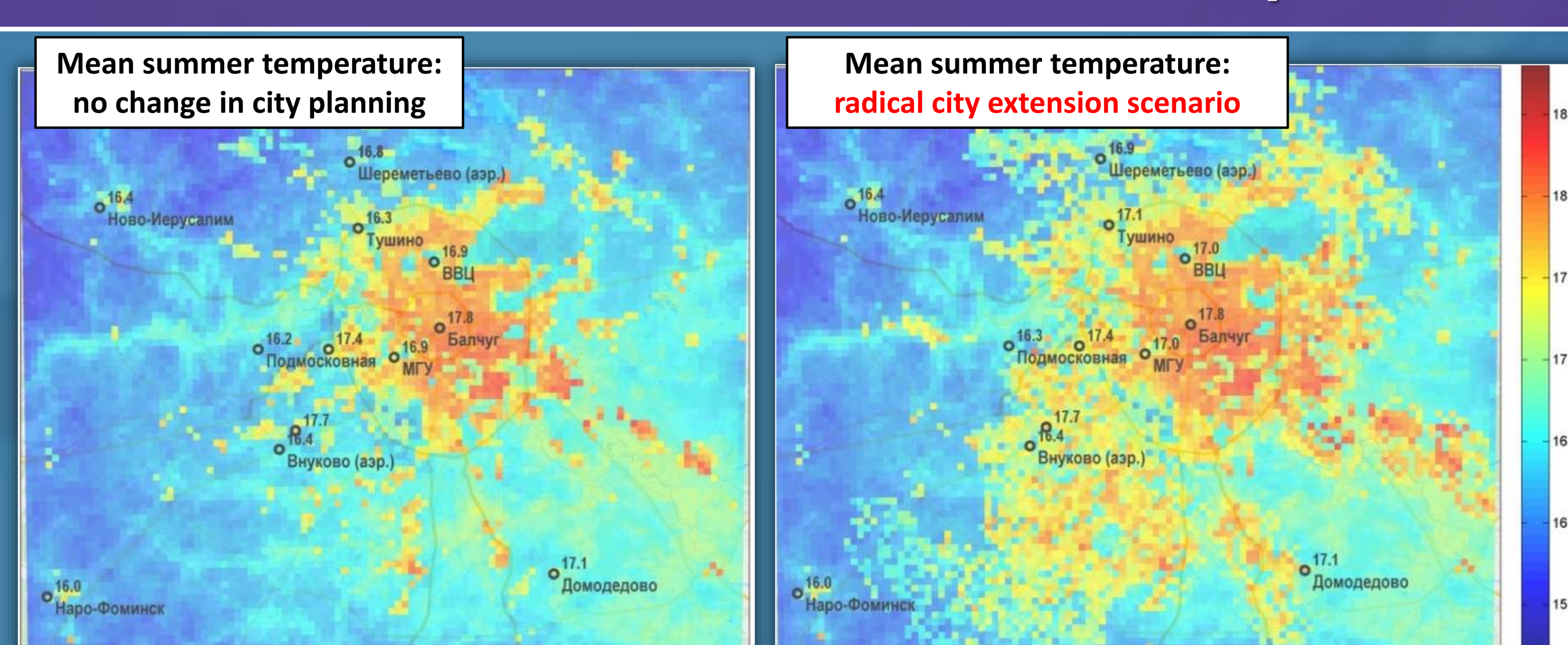
- Building "New Moscow" territory, including new high-rise business district, living blocks of flast and low-rise housing
- Extension of the city to other directions
- Building part of modern parks and green zones inside the city

Model verification for modern climate





Simulation for future climate: the first experience



Summary:

Observation data analysis shows:

- Specific features of UHI spatial structure, such as smooth temperature gradients between city center and its edges;
- Significant urban amplification of global warming in Moscow;

Modelling experiments shows:

- Selected configuration of CCLM+TEB relatively good simulates mean UHI intensity;
- Diurnal variation of UHI intensity is inversed in model;
- Model didn't simulate expected effect of urban amplification of global warming even in case of very radical urban extension scenario.
- Model seems to simulate too sharp temperature gradients between urban and rural cells;