SMART URBAN NATURE

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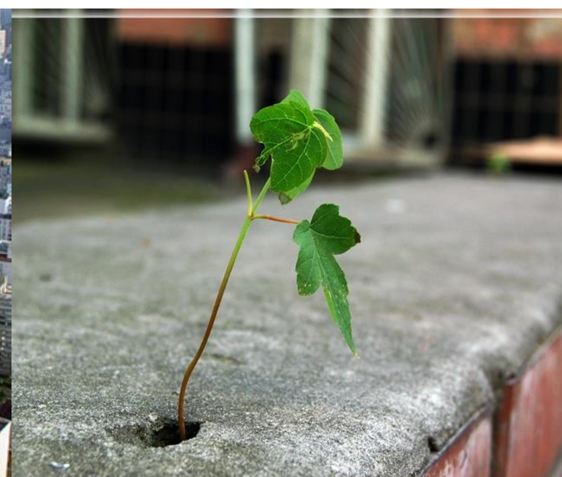
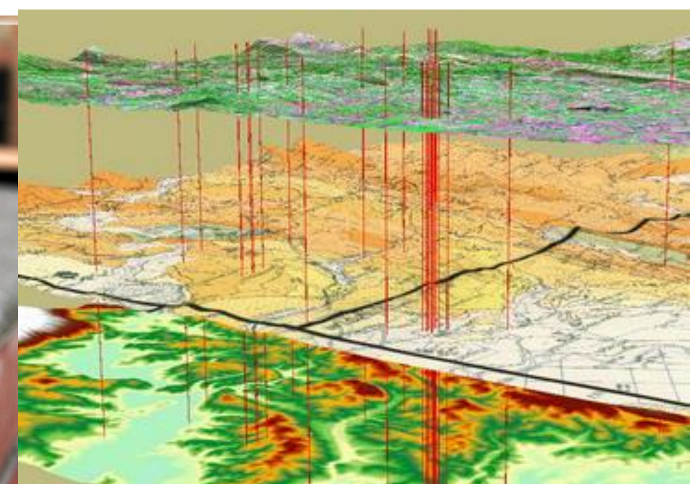
# The effect of urban heat island and other mesoclimatic anomalies on C stocks and $CO_2$ emissions in Moscow megapolis

**Viacheslav Vasenev**, Andrey Dolgikh, Olga Romzaykina, Inna Brianskaia, Mikhail Varentsov, Pavel Konstantinov





# Why soil carbon? Soil functions

***Blum, 2005***

- Protection of humans and environment
- Biomass production
- General reservoir
- Physical basis of human activities
- Source of raw materials
- Geogenic and cultural heritage

**BBodSchG, *1998***

- Water and nutrient cycling
- Ground water protection
- Basis for organisms' life
- Land for settlements
- Land for agriculture
- Deposition of raw materials

…

**Andrews et al, *2004***

- Nutrient cycling
- Water filtering and buffering
- Biodiversity and habitat
- Resistance and resilience
- Physical stability and support

*30 to 50% of distinguished soil functions are directly or indirectly related to soil carbon balance*

# Why soil carbon? Ecosystem services (ES)

## ESs' categories (TEEB, 2010)

| Provisioning | Regulating | Cultural |
| --- | --- | --- |
| ➢Food<br>➢Water<br>➢ Raw materials<br>➢Genetic resources<br>➢Medical resources<br>➢Ornamental resources | ➢Air quality regulation<br>➢Climate regulation<br>➢Moderation of extreme events<br>➢Regulation of water flows<br>➢Water treatment<br>➢Erosion prevention<br>➢Maintenance of soil fertility | •Aesthetic information<br>•Opportunities for recreation and tourism<br>•Inspiration of culture, art and design<br>•Spiritual experience |

| Habitat |
| --- |
| ➢Maintenance of life cycles of migratory species<br>➢Maintenance of genetic diversity |

*25 to 40% of distinguished ecosystem services are directly or indirectly related to soil carbon balance*

# Background

DEGRADATION, REHABILITATION,
AND CONSERVATION OF SOILS

**The Development of Approaches to Assess the Soil Organic Carbon Pools in Megapolises and Small Settlements**

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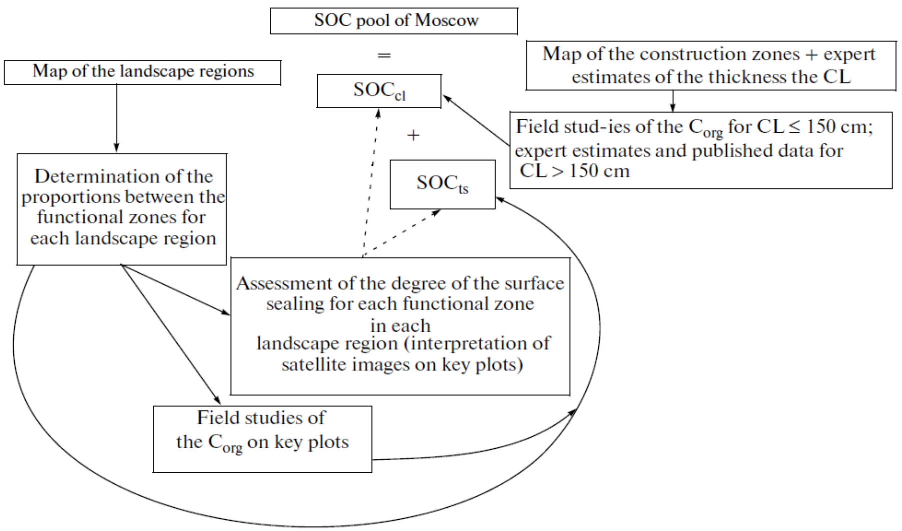


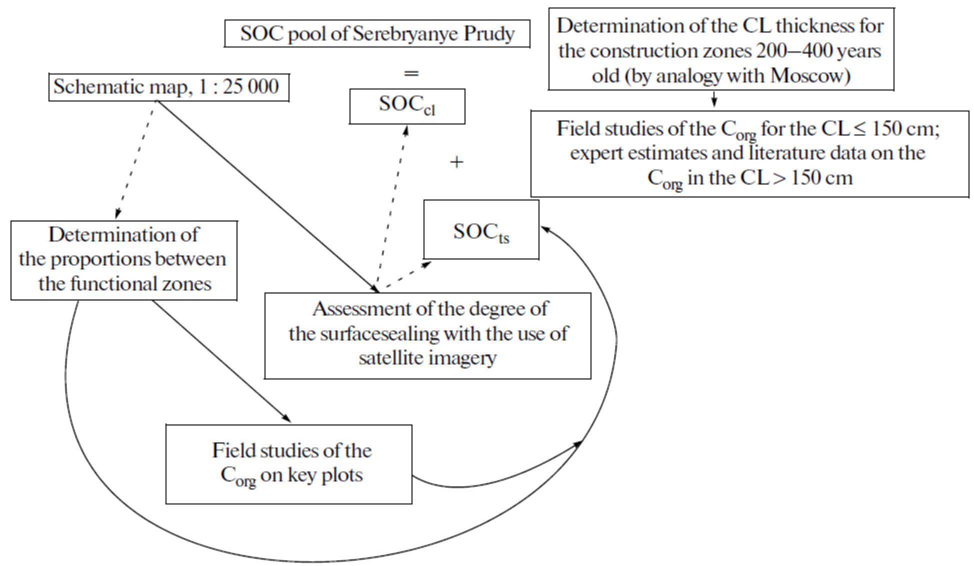


SOC stocks in 0-150 cm of urban soils in Moscow

From 70 to 800 t ha$^{-1}$

SOC stocks in 0-150 cm of urban soils Serebryanye Prudy village

From 900 to 1100 t ha$^{-1}$

# Background

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

How to map soil organic carbon stocks in highly urbanized regions?

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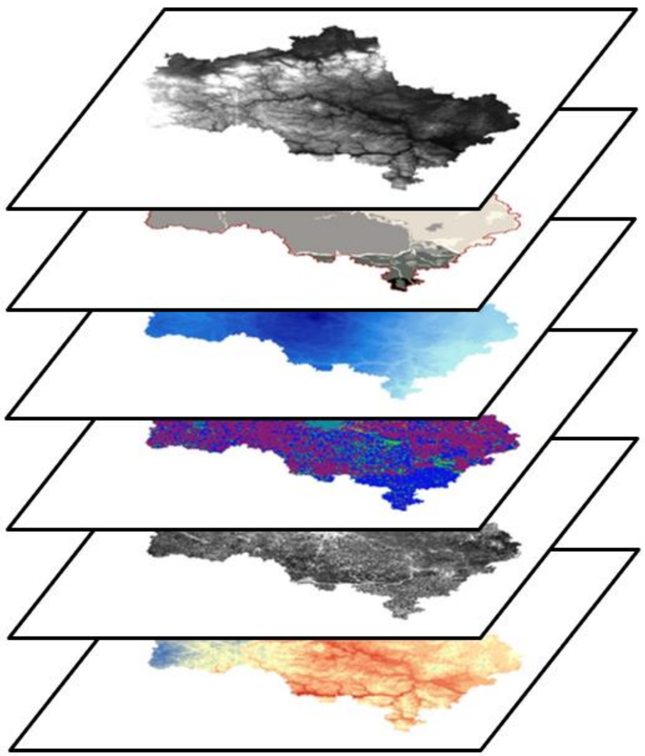
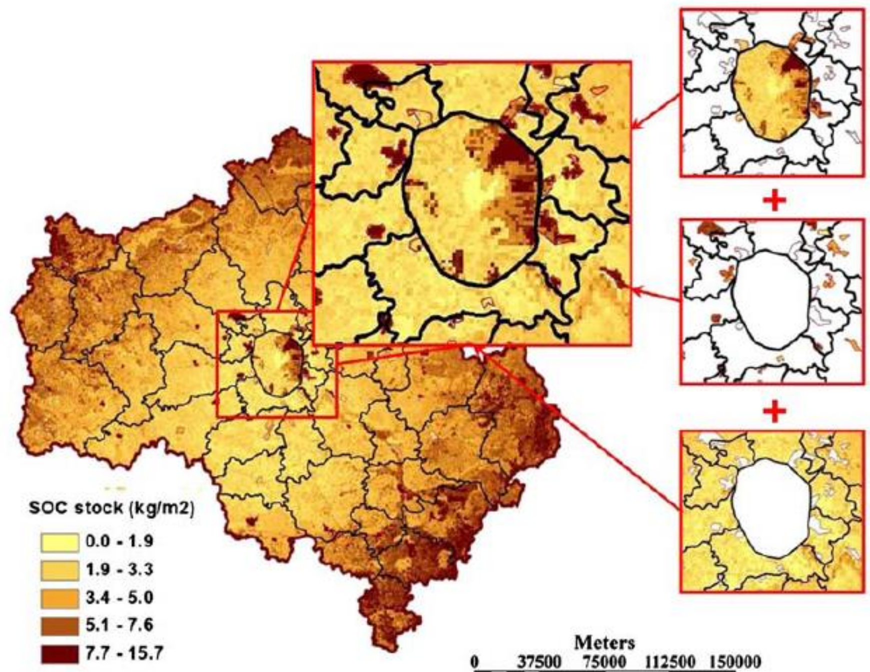





SOC stocks in 0-150 cm of urban soils in Moscow region

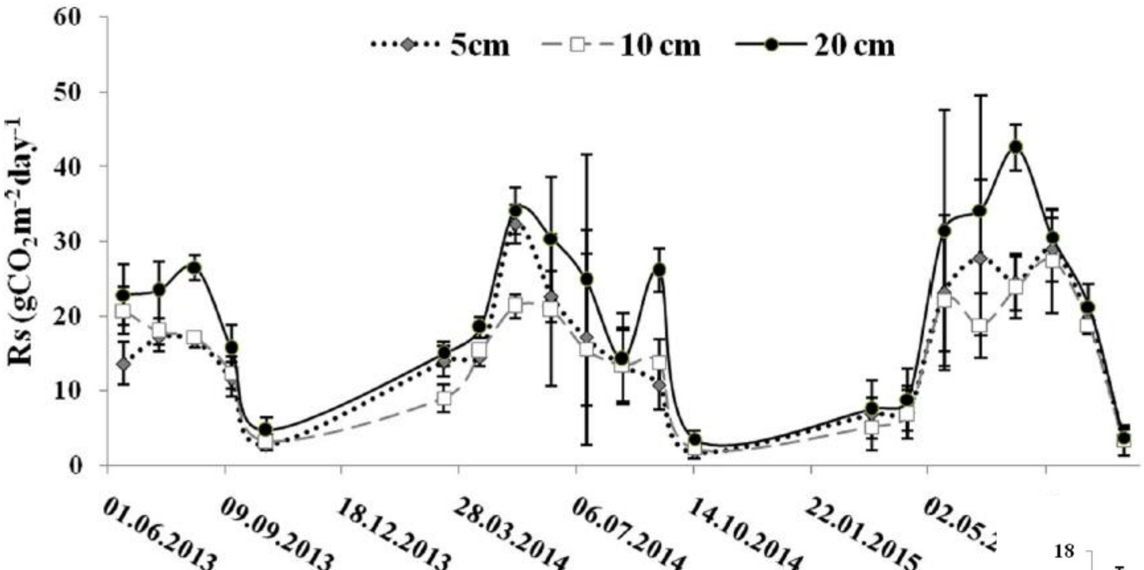
From 200 to 300 t $ha^{-1}$

# Background

Urban Ecosyst
DOI 10.1007/s11252-016-0594-5

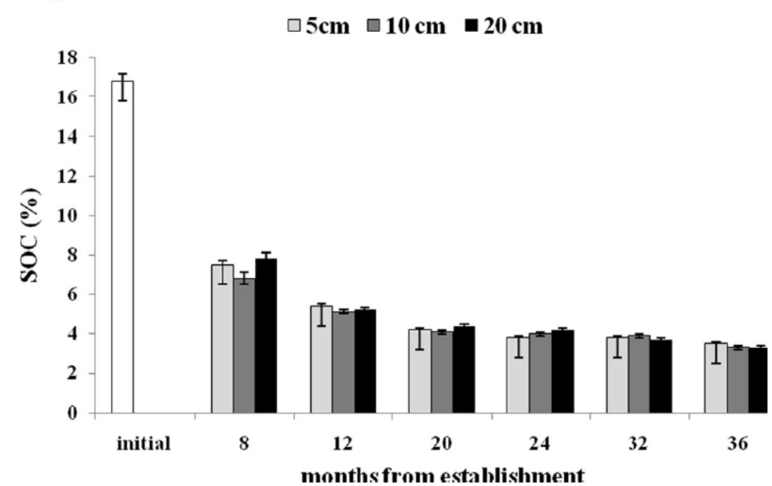
**Changes of soil organic carbon stocks and $CO_2$ emissions at the early stages of urban turf grasses' development**

A. S. Shchepeleva[1] · V. I. Vasenev[1,2] · I. M. Mazirov[2] · I. I. Vasenev[2] · I. S. Prokhorov[2] · D. D. Gosse[3]




Seasonal dynamics in 2013-2015 (summer period gave up to up to 60% of annual emissions)

Rapid depletion in $C_{org}$ stocks after the 1st year and stabilization by the 3rd year



# Research questions and tasks

✓Mapping and assessment of SOC stocks in Moscow megapolis

✓Quantifying relationships between microbial (basal respiration), soil properties and meteorological parameters (lab experiment)

✓Analyze dynamics in soil respiration, soil temperature and moisture in situ

✓Climate monitoring and modeling

Complete

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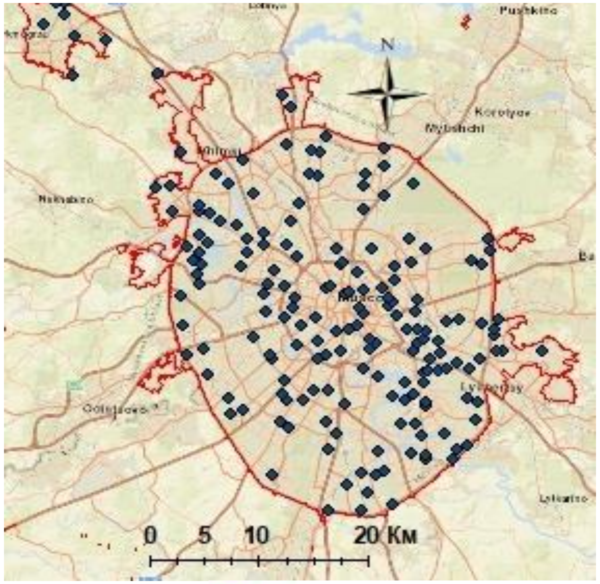
Remains

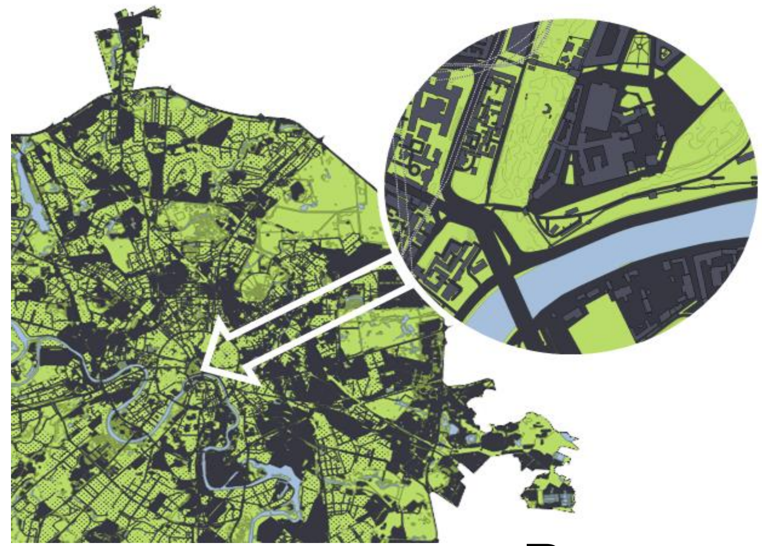
- [ ] Project the mesoclimatic effect by linking SOC maps to soil temperature and moisture model outcomes

# Soil survey and SOC interpolation in Moscow

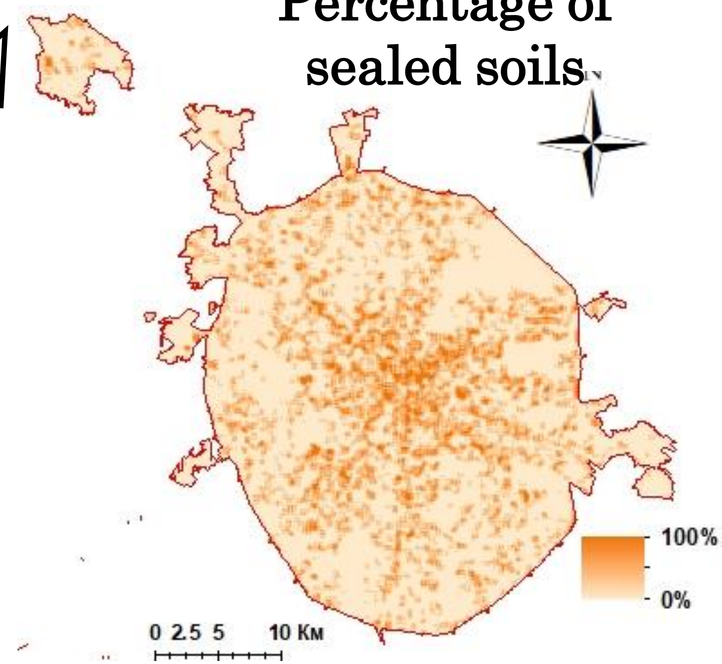
Sampling campaign



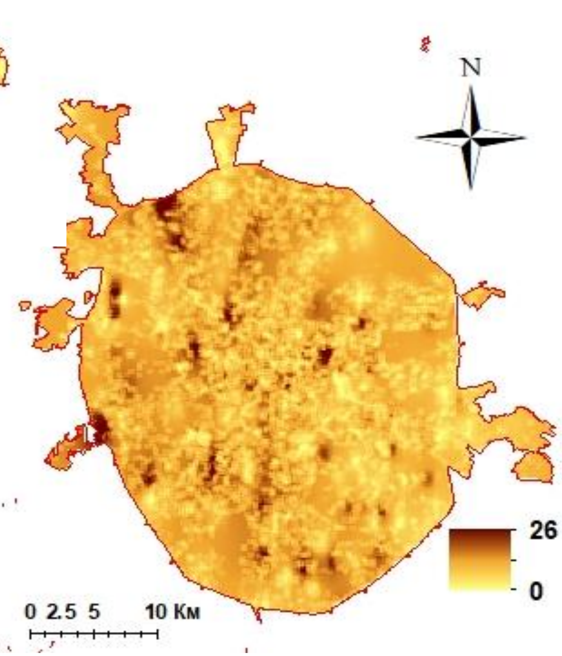

Soil sealing (OSM-based)



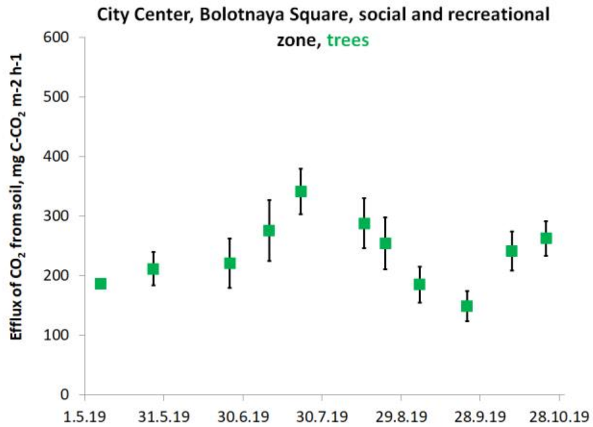
Percentage of sealed soils

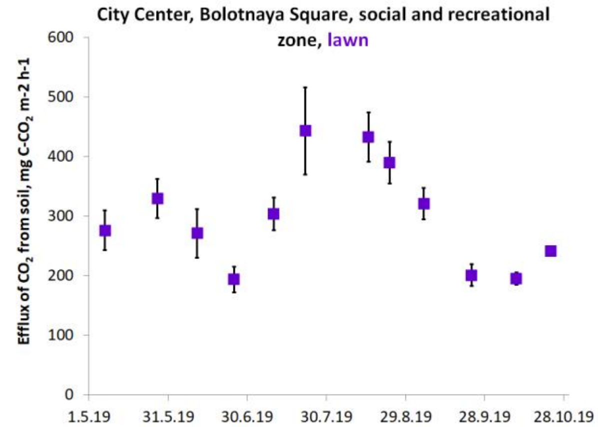


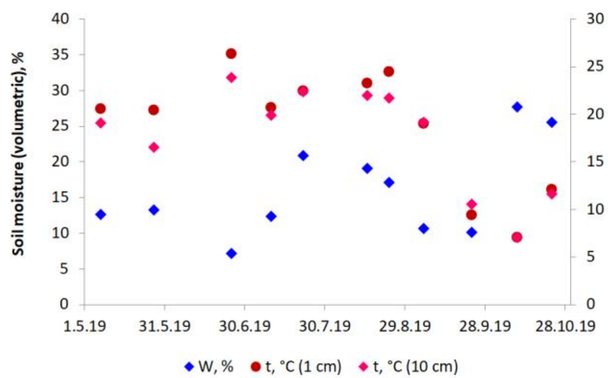

SOC stocks (g m$^2$)

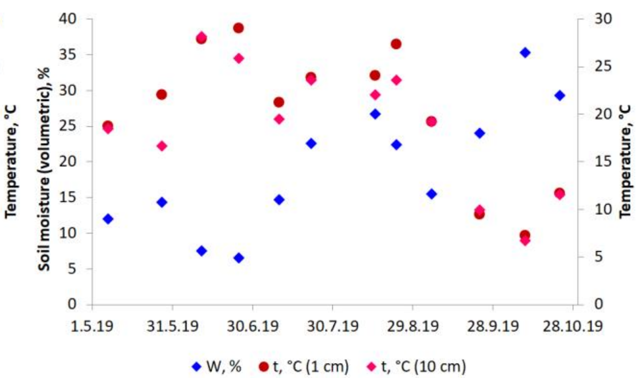


# Soil respiration in situ measurements



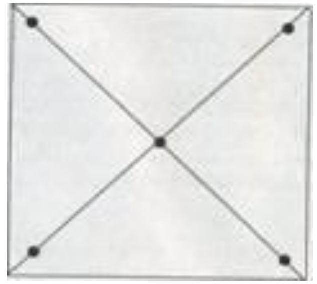



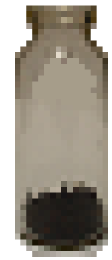

✓Seasonal dynamics driven by soil temperature and moisture

✓Considerable difference in $CO_2$ emissions between different surfaces (trees, shrubs, lawns) at the local scale

# Lab experiment



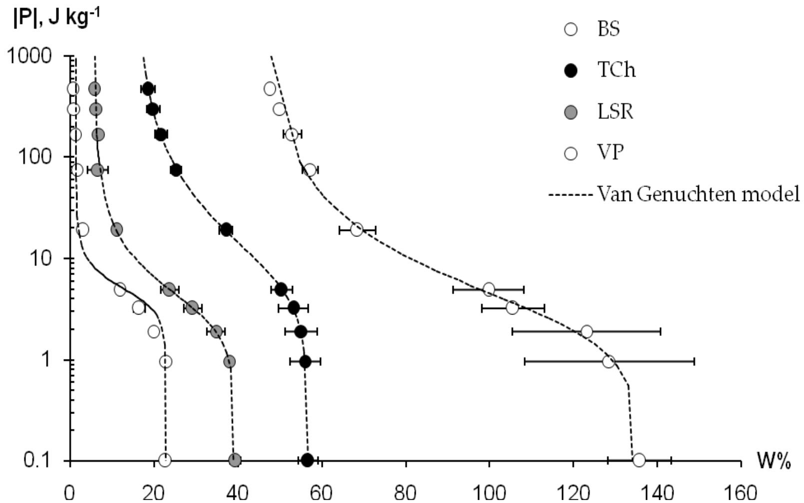
Soil sample
(2 g)

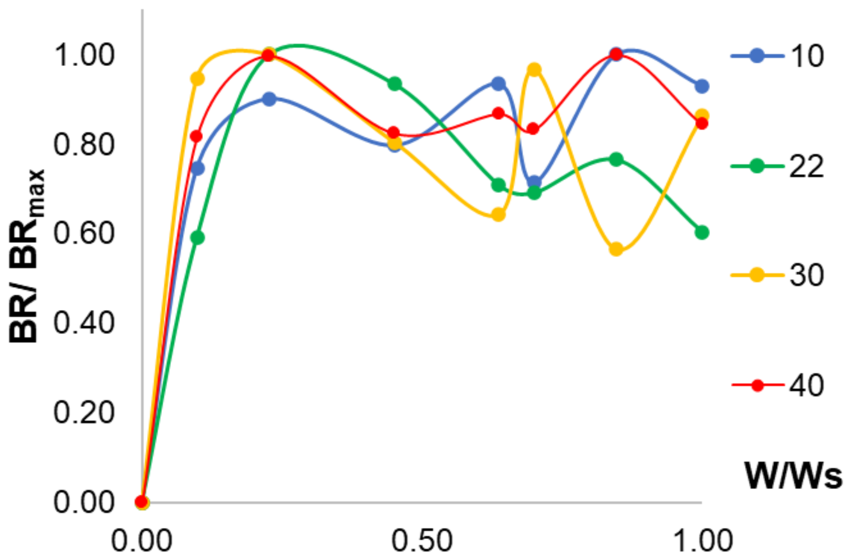


+ $H_2O$
(0.1 ml / g)

22°C, 24 h

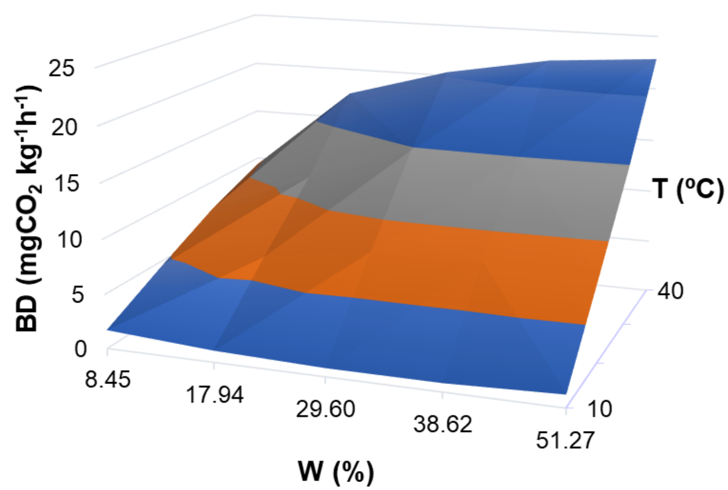
# Relationships between BR, soil temperature and moisture



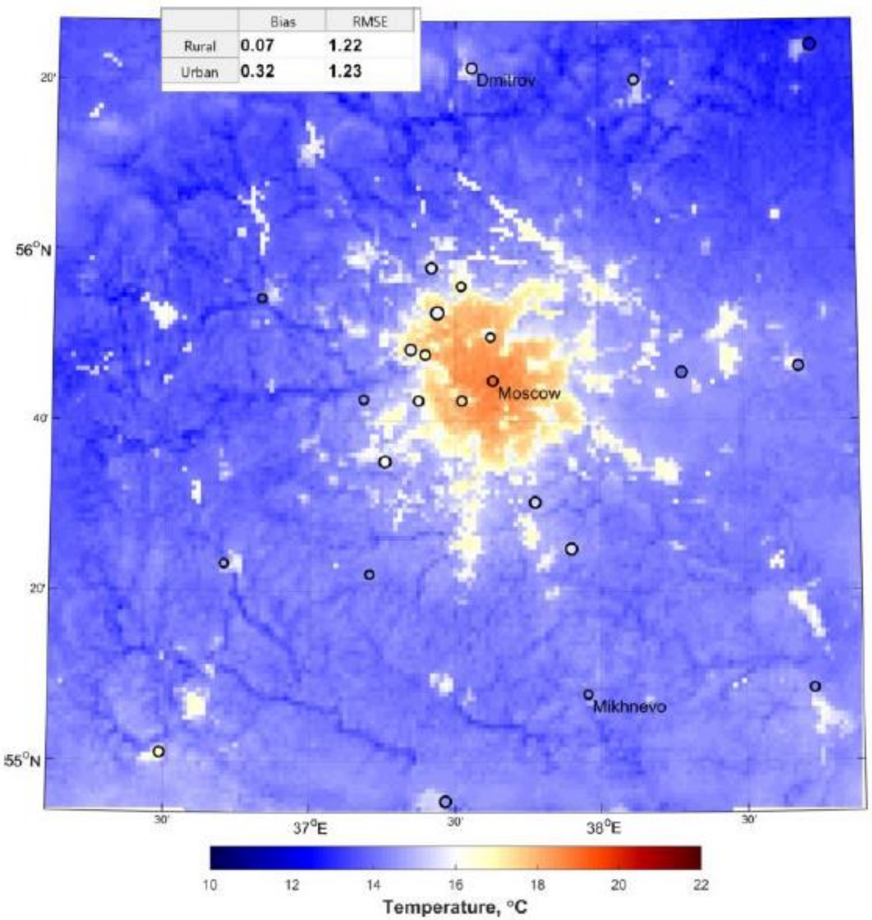

$$BR = 13.1 + 0.54\,T - 0.26\,pH + 0.4\,SOC + 0.01\,W$$

$$R^2_{adj} = 0.52$$

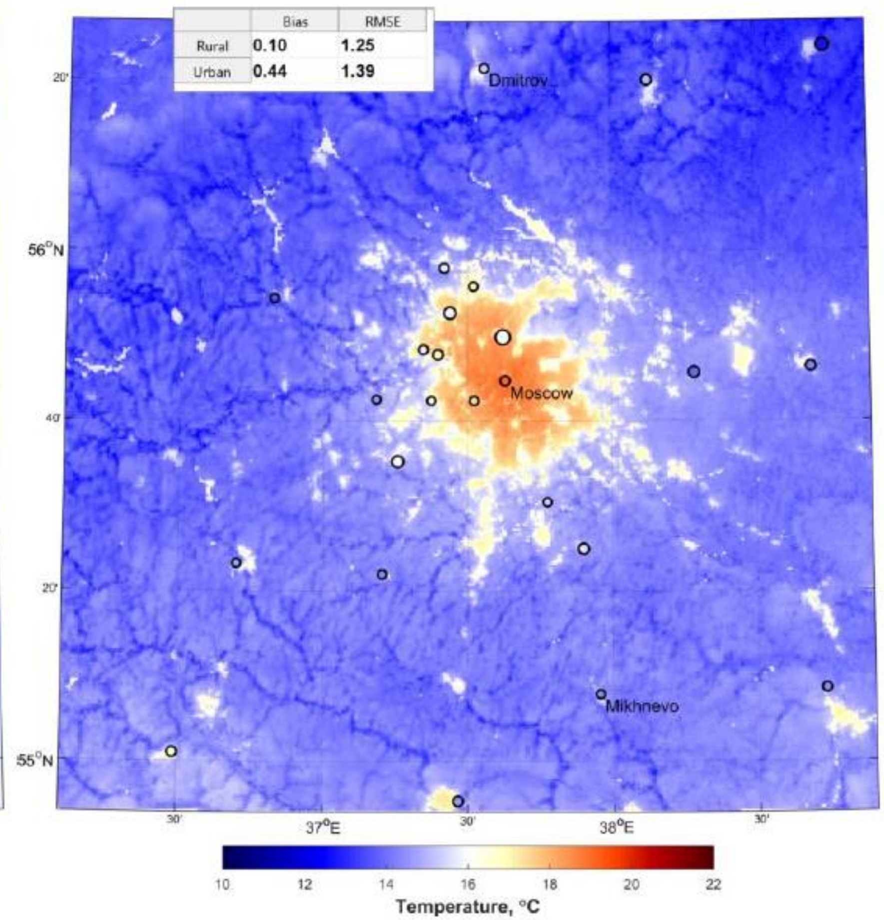


# Mesoclimatic modelling

$\Delta x$ = 1 km, 180x180 grid cells, dt = 10 sec




$\Delta x$ = 500 m, 400x400 grid cells, dt = 5 sec



# Preliminary outcomes and next steps

✓SOC stocks in topsoils (20 cm) of Moscow megapolis were over 8000 and SOCD ranged from 0 to 24 $g/m^2$

✓ In situ respiration of urban soils ranged from 100 to 500 mg C-$CO_2$ $m^2$ $h^{-1}$ and was more sensitive to land cover than to the level of anthropogenic load or functional zoning

✓Basal respiration was significantly correlated to soil temperature, SOC and pH and was not influenced by soil moisture linearly.

✓ Different approaches to model Moscow climate agree on a clear pattern with higher temperatures in the central area due to urban heat island

✓Mesoclimatic maps will be linked to SOC map via the obtained regression equations to project dynamic changes in potential $CO_2$ emission from urban soils