The effect of urban heat island and other mesoclimatic anomalies on C stocks and CO₂ emissions in Moscow megapolis

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### Why soil carbon? Soil functions

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>➢ Protection of humans and environment</td>
<td>➢ Water and nutrient cycling</td>
<td>➢ Nutrient cycling</td>
</tr>
<tr>
<td>➢ Biomass production</td>
<td>➢ Ground water protection</td>
<td>➢ Water filtering and buffering</td>
</tr>
<tr>
<td>➢ General reservoir</td>
<td>➢ Basis for organisms’ life</td>
<td>➢ Biodiversity and habitat</td>
</tr>
<tr>
<td>➢ Physical basis of human activities</td>
<td>➢ Land for settlements</td>
<td>➢ Resistance and resilience</td>
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<tr>
<td>➢ Source of raw materials</td>
<td>➢ Land for agriculture</td>
<td>➢ Physical stability and support</td>
</tr>
<tr>
<td>➢ Geogenic and cultural heritage</td>
<td>➢ Deposition of raw materials</td>
<td></td>
</tr>
</tbody>
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30 to 50% of distinguished soil functions are directly or indirectly related to soil carbon balance
25 to 40% of distinguished ecosystem services are directly or indirectly related to soil carbon balance.
Background

The Development of Approaches to Assess the Soil Organic Carbon Pools in Megacities 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\(^{-1}\)
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

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

Rapid depletion in $C_{\text{org}}$ 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

☐ Project the mesoclimatic effect by linking SOC maps to soil temperature and moisture model outcomes

Complete

Remains
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) + H₂O (0.1 ml / g)

22°C, 24 h
Relationships between BR, soil temperature and moisture

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

\[ R^2_{\text{adj}} = 0.52 \]
Mesoclimatic modelling

\[ \Delta x = 1 \text{ km}, 180 \times 180 \text{ grid cells, } dt = 10 \text{ sec} \]

\[ \Delta x = 500 \text{ m}, 400 \times 400 \text{ grid cells, } dt = 5 \text{ sec} \]
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/m²
✓ In situ respiration of urban soils ranged from 100 to 500 mg C-CO₂ m² 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 CO₂ emission from urban soils