

EGU22-11614

<https://doi.org/10.5194/egusphere-egu22-11614>

EGU General Assembly 2022

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Impact of Moscow city on intense summer precipitation: statistical analysis based on long-term observations

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Large cities are especially vulnerable to heavy precipitation events, which can lead to significant economic losses. This topic is relevant both due to the observed increase in the frequency of dangerous weather phenomena (including extreme precipitation [Ye et al., 2017; Chernokulsky et al., 2019]) in midlatitudes in general, and due to the previously noted facts of intensification of deep atmospheric convection and associated rainfall over urban areas [Han et al., 2014; Liu, Niyogi, 2019]. Yet, despite the numerous studies, the magnitude of urban effects on intense precipitation and their physical drivers are not fully understood.

In this study, we investigate urban effects on intensity and frequency of summer precipitation events exemplified by Moscow megacity, Russia. Previously, increase of mean summer precipitation amount by 10% over Moscow was revealed according to COSMO-CLM simulations for multiyear period [Varentsov et al., 2018]. Here we use long-term (1988-2021) observations at urban and rural weather stations. Statistical analysis is performed separately for categories of precipitation intensity. Moreover, using ERA5 reanalysis data [Hersbach et al., 2020] we estimated atmospheric convective instability and frontal parameters in order to classify precipitation cases according to the synoptic situation. This will help us to understand the physical mechanisms of precipitation intensification better. The assumption is that megacity influence on frontal systems is less noticeable than its influence on local convective clouds and convective systems in the low pressure gradient field. Also we collected a catalogue of extreme precipitation cases in Moscow region exceeding 0.999 quantile values and studied most interesting cases among them.

Eventually, we obtained qualitative and quantitative estimates of the Moscow impact on the characteristics of intense precipitation for various synoptic conditions.

Acknowledgements:

The study was supported by the Russian Ministry of Science and Higher Education (grant of President of Russian Federation for young PhD scientists No. MK-5988.2021.1.5, agreement No.

2020-220-08-5835).

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