

## ***Interactive comment on “Anthropogenic and natural drivers of a strong winter urban heat island in a typical Arctic city” by Mikhail Varentsov et al.***

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We thank the Anonymous Referee for careful reading of our discussion paper. We find a number of his/her suggestions to be very useful for our study and will revise the manuscript accordingly after the end of public discussion. Detailed responses to each of the comments is presented below and duplicated in the attached PDF file.

Comment: The paper presents results of a unique observation dataset, obtained in the Russian polar area, specifically in the Apatity city and its surroundings. Observed data together with satellite measurements and high-resolution model results give an interesting view in the urban heat island in polar region.

Response: we would like to thank the Referee for so high appreciation of our work,

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that inspires us for further improvements of our study and further developments of this research direction.

Specific comments:

Comment: Page 2, line 15: The winter UHI in mid-latitude cities is not so environmental problem, but it can be significant and also dependent on the anthropogenic heat release. E.g., Bohnenstengel et al. (2012) conclude impact of AH to 1.5 K in December in London. Also model studies (Trusilova et al., 2016; Huszar et al., 2014) found the winter UHI in central European cities.

Response: We agree with the Referee that the UHI in the mid-latitude cities could be significant and intensive also in winter months. Although the wintertime UHI has been recognized in the studies referred to by the Referee and in our manuscript, there were relatively little attention to it so far. Our study does not object the existence of the wintertime UHI in the mid-latitude cities. But it maintains that the winter UHI is not an important environmental problem in contrast to the summer UHI there. We specifically mention that the mean winter UHI is less intensive than that mean summer UHI as the referred studies have demonstrated.

Comment: P. 5, l. 23: What does it mean TERRA-URB switched off – removing of urban fraction from model grid-boxes (annihilation approach, e.g. Baklanov, 2016) or only not using of TERRA-URB parametrization? The second option admits that still some physical properties of the surface are altered for urban grid cells (by default in the model).

Response: The noURB run follows the annihilation approach. The TERRA-URB scheme was switch off AND the urban fraction was removed from model grid cells. The urban fraction in noURB run was set to zero. The land-cover parameters for the urban grid cells were set equal to the nearest non-urban grid cells. We will clarify the issue and will refer to the annihilation approach (Baklanov et al., 2016) in the text.

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Comment: P. 7, l. 10: The conclusion about AHF is too fast. Despite a very low solar radiation, the UHI is not created only by AHF. E.g., a reduced long-wave radiation in the urban environment (due to reduced sky-view factor) can also contribute to the UHI formation in calm anticyclonic situations. Similarly in discussion (p. 8, l. 10-11), the driver could be mentioned.

Response: We agree with the Referee that the AHF scale and impact need further investigation. Concluding the analysis of observations, we formulated a hypothesis about the impact of the AHF on the UHI. We study this hypothesis later in the manuscript, presenting the results of the sensitivity experiments with COSMO-CLM model. In the text, we emphasize that there are other plausible drivers of the UHI in this city. Those drivers, such as long-wave radiation and sky-view factors, have not been addressed in this study. Nevertheless, the model experiments suggest that there is not a big heat budget imbalance to be attributed to other factors than the AHF.

Comment: P. 8, l. 5: It is inaccurately to attribute the temperature difference between U1 and R1 as the “UHI intensity” and moreover, compare it with values for listed megacities. The U1-R1 difference is created not only by anthropogenic factors. Only about 50

Response: We would like to highlight that we specifically avoid calling the temperature difference between the U1 and R1 sites as the UHI intensity in our study. However, such pair of stations characterizes the difference between the city and the nearest WMO station. Without specific knowledge about local microclimates, such difference is often associated with UHI intensity. Strictly speaking, we do not compare our data with the numbers given for the biggest megacities. We used those numbers to put the study into a recognized context. We show to important facts in the perceived comparison: 1) there are very few (typically just one) relevant meteorological stations to get climate information for a medium city, such as Apatity, and this station is not representative for urban environment; 2) there is a surprisingly strong urban-rural temperature difference in Apatity, which is a motivation for further investigation of the driving factors of such

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difference.

Comment: P. 11, l. 5: There is no clear evidence for the conclusion “The AHF during extreme cold days may warm the city center by up to 6 K”. The 50

Response: We do not agree with the Referee. Our observations and modelling results, presented in this study, show that the given estimate of 50

Comment: 7) Abstract: The values of 1.9 K and 11 K are misleading, because there is no information about different altitudes, which has a significant impact (of the same magnitude as the anthropogenic impact).

Response: The given numbers shows the apparent observed temperature difference. Nowhere in the manuscript this difference is referred to as the UHI intensity. Moreover, we investigated what part of this observed difference could be attributed to the UHI intensity within the limitations imposed by the observation network, methodology, period of study and the limitations of the utilized modeling experiments. This context is clarified further down in the Abstract. At the same time, we do agree that those numbers are hooking a potential reader and call for more extensive research. Comment: Abstract: The sentence "... direct anthropogenic heating contributes at least 50

Response: We agree with Referee about this point. We will follow his/her advice and correct this sentence accordingly.

Technical corrections:

Comment: P. 3, l. 15: The sentence and all paragraph (comparison with other studies) belongs rather to discussion. In this part of introduction, aims of study should be specified.

Response: The aim of the study specified above, see p.3 l. 11. We will separate this part of introduction to a separate paragraph. And the paragraph, indicated by Referee, refers to the main findings of the study in the context of state-of-the-art knowledge.

Comment: Figure 4: The shaded area is clearly larger than 1. But the integral from the probability density function over all temperatures should be equal to one. Please, norm the probability values in both figures.

Response: We have specially checked this issue one more time and find that the shaded area is exactly equal to one. For better understanding, we will change the plot type from shaded area to a histogram with vertical bars.

Comment: Figure 7: There should be some warning (or another "name" besides "case") that cases in Fig. 7 are not the same as in Fig. 3, Fig. 5 and Fig. S4.

Response: We agree with Referee that using different cases could create a misunderstanding. We will add according warning to the caption of the figure.

Please also note the supplement to this comment:

<https://www.atmos-chem-phys-discuss.net/acp-2018-569/acp-2018-569-AC1-supplement.pdf>

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