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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Multi-model comparison of urban heat island modelling approaches" *by* Jan Karlický et al.

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We would like to thank to Anonymous Referee #3 for all comments, suggestions and corrections in his review of our manuscript. We addressed all and our point-by-point responses including the modifications in the manuscript follow:

Referee's Comment #1: Figure 1: One more panel illustrating the land use land cover mapping at fine (1 km or so) resolution will help to compare and understand how well the cities have been represented in the 10 km resolved simulations. Also the location of the cities used in analysis should be marked for ease of readers.

Author's response: One more figure similar to Fig. 1 mapping the terrain elevation,

land cover and urban areas in high resolution (1 km) is attached to this reply and will be added to the manuscript. All terrain, land cover and urban features are captured much better in the finer resolution, which is expected. However, it is not possible to run models on large domain as ours with such a fine resolution for a decade, because of high computational cost. Moreover, the major urban areas (like Berlin, Prague, Munich – analysed in our study) are equally well captured at 10 km resolution compared to the fine scale land cover. The location of chosen cities that are discussed in the study will be marked in the revised manuscript.

Author's changes in manuscript: Added new figure mapping the terrain elevation, land cover and urban areas as similar as Fig. 1 but rising from 1 km resolution static data, together with a caption and comment in the text. Figure 1 and its caption changed by marking of cities mentioned in the study.

Referee's Comment #2: Figure 9 and 10: Large uncertainties exist in urban-induced differences in vertical profiles of temperature and wind speed when compared across various configurations. But as also concluded by authors, lack of evaluation limits the ranking of the configurations used. In this regards, evaluation of the vertical profiles of temperature and wind speed against radiosonde observations (over or near these cities) could facilitate improvement in conclusions. Radiosonde observations over the domain of study are available openly from http://weather.uwyo.edu/upperair/sounding.html.

Author's response: The comparison of model vertical profiles of the temperature and wind speed with radiosonde observations are shown in attached figures. Because of the fact that only one measurement per city are available, only the simulations that match the real case (i.e. that include urban surfaces) are evaluated, not differences between urban and no-urban simulations, as in Fig. 9 and 10.

Author's changes in manuscript: Both attached figures will be added in the revised manuscript, together with comments in sections 2.3 (Observational data), 3.1 (Model validation) and 4 (Discussion).

Referee's Comment #3: Figure 11 and 12: Showing the percentage change in SI and VI due to urban surface will better underline the significant of the urban-induced differences in VI and SI.

Author's response: As written in section 3.3, VI and SI distributions do not follow Gaussian distribution and it is not reasonable to represent the entire distribution by one value: the average is not correct for non-Gaussian distribution and modus or median are unrepresentative due to bi-modality in the SI distribution. The percentage change of the entire distribution would have very high range – from 0 to infinity (in terms of distribution shifts).

Author's changes in manuscript: This is clarified in the revised manuscript.

Referee's Comment #4: The conclusion that urban-induced modification enhances pollution dispersion is mainly based on the analysis over Prague. Authors should also check over other big cities in Europe to illustrate robustness of this association.

Author's response: The author made the VI and SI distributions for discussed seasons and cities as Berlin, Munich and Budapest, but the characteristics of distributions and their changes are nearly the same, so they are not presented in the manuscript. The VI and SI distributions for Berlin are added, to show this fact.

Author's changes in manuscript: Added sentence about VI and SI over cities: For other mentioned cities, the VI and SI distribution are nearly the same as in terms of Prague, thus only the Prague data are showed and discussed.

Referee's Comment #5: Many short-term urban sensitivity simulations around the globe have shown that urban surfaces enhance convergence of low level horizontal wind over city center (Shepherd et al., 2005; Lin et al., 2008; Sarangi et al., 2018;

Niyogi et al., 2017; Zhong et al., 2017). This process can enhance the advection of particulate matter towards city center. Please include analysis/discussion about relative changes in convergence compared to VI and SI for these decade scale runs.

Author's response: All listed studies use high-resolution models where the vertical velocity and thus convergence is explicitly computed. In our study, at 10 km horizontal resolution with hydrostatic approximation, only the large-scale vertical velocity is computed, while sub-grid scale vertical motion is parametrized, so models need compensate only large-scale vertical motions by the horizontal convergence. For this reason, the convergence is not correctly captured in our study and thus is not possible to correctly evaluate it. On the other hand, the impact of cities on the vertical velocity (or convection) can be expressed by SI (Fig. 12), which tends to be higher in cities, thus also the convection is expected to be more intensive, with positive impact on the pollution via enhancing vertical transport from the boundary layer.

Referee's Comment #6: Also, the impact of urban surfaces on vertical velocity should be analysed/discussed in context to the urban-induced changes in VI simulated.

Author's response: As written above, we are not able to reasonably analyse the urban impact on the vertical velocity, because only the large-scale component of the vertical velocity is computed.

Shepherd, J. M. (2005). A review of current investigations of urban-induced rainfall and recommendations for the future. Earth Interactions,9(12), 1–27. https://doi.org/10.1175/EI156.1

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Sarangi, C., Tripathi, S. N., Qian, Y.,Kumar, S., Ruby Leung, L. (2018).Aerosol and urban land use effect onrainfall around cities in Indo-GangeticBasin from observations and cloudresolving model simulations. Journal ofGeophysical Research: Atmospheres, 123,3645–3667. https://doi.org/10.1002/2017JD028004

Niyogi, D., Lei, M., Kishtawal, C., Schmid, P., Shepherd, M. (2017). Urbanization impacts on the summer heavy rainfall climatology over theEastern United States. Earth Interactions, 21(5), 1–17. https://doi.org/10.1175/EI-D-15-0045.1

Zhong, S., Qian, Y., Zhao, C., Leung, R., Yang, X.-Q. (2015). A case study of urbanization impact on summer precipitation in the greaterBeijing metropolitan area: Urban heat island versus aerosol effects. Journal of Geophysical Research: Atmospheres, 120, 10,903-10,914.https://doi.org/10.1002/2015JD023753

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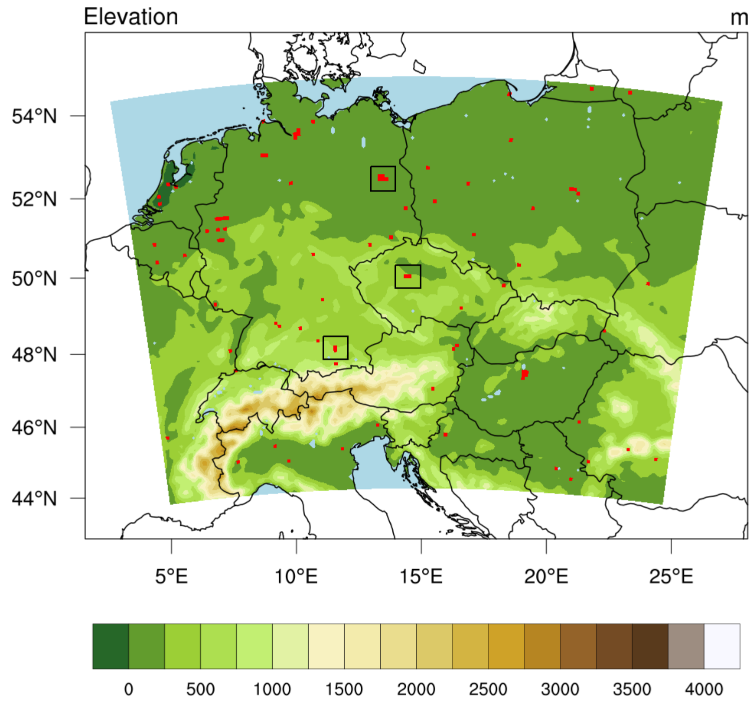

Fig. 1. Improved Fig. 1

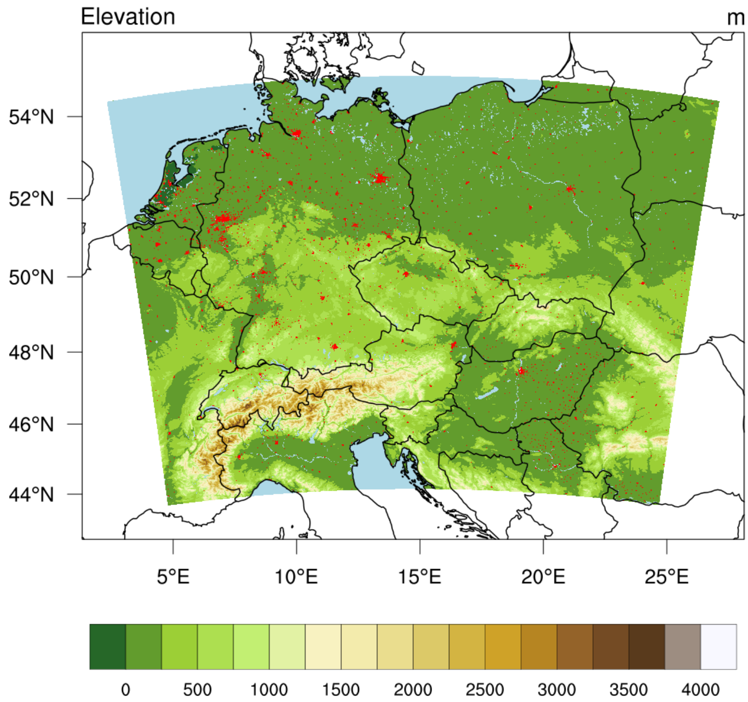

Fig. 2. Added figure, as Fig. 1 but from 1 km resolution static data

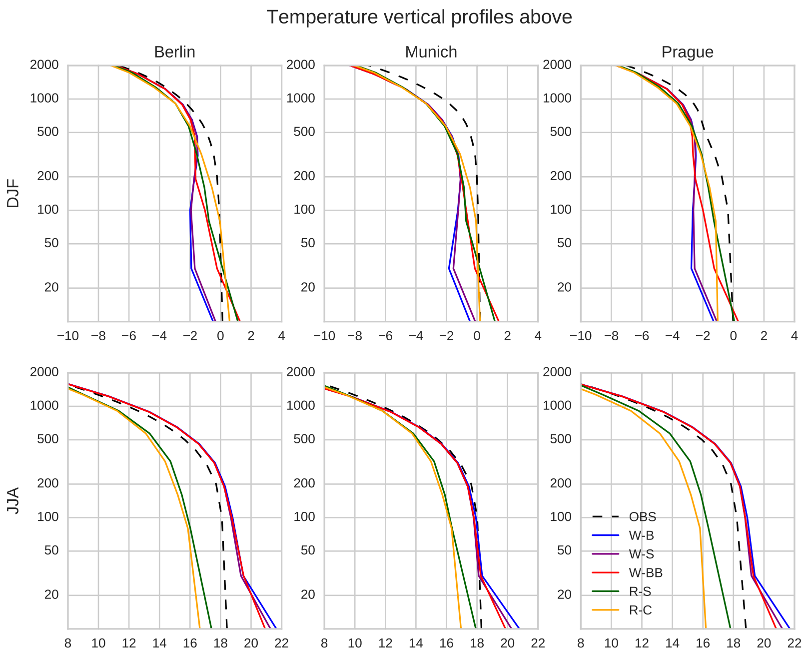

Fig. 3. Added figure, temperature profile comparison with radiosonde observations

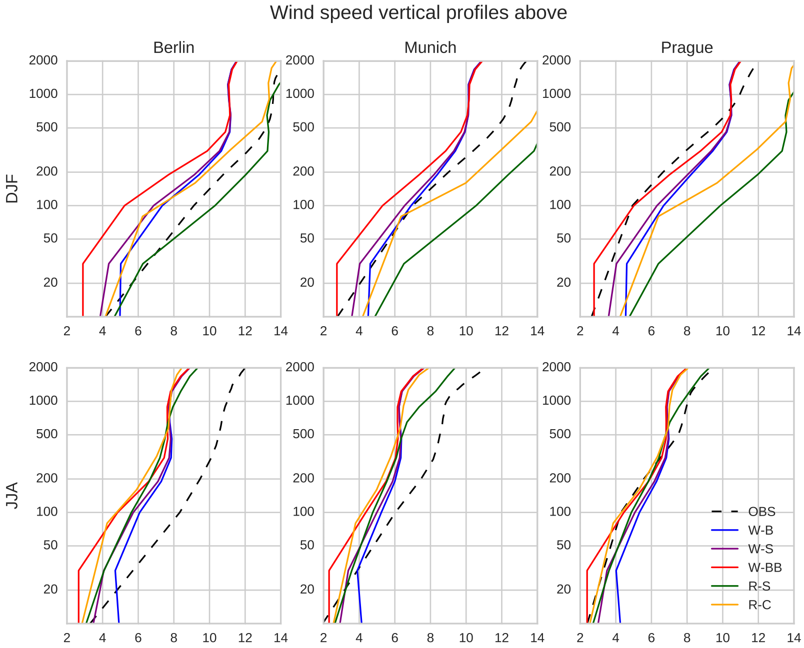

Fig. 4. Added figure, wind speed profile comparison with radiosonde observations

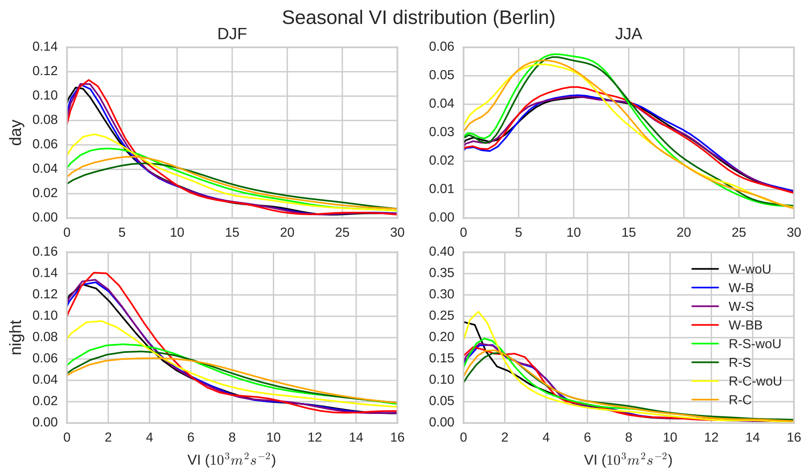

Fig. 5. The VI distribution in Berlin

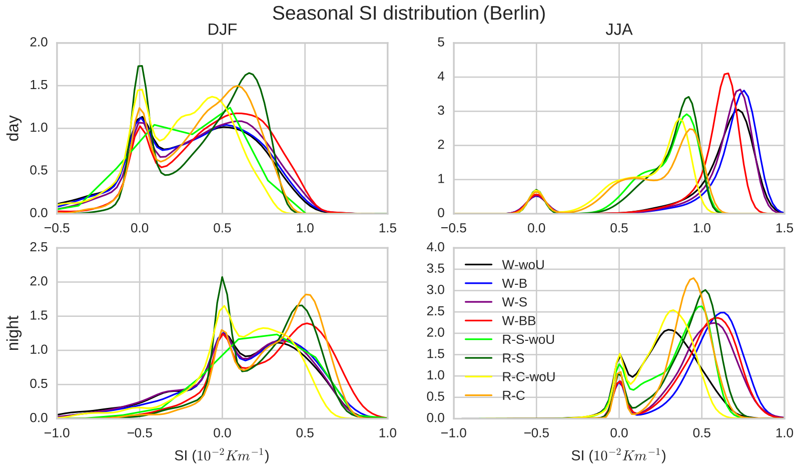

Fig. 6. The SI distribution in Berlin