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Reply on RC1

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Author comment on "Adapting potential evapotranspiration from climate stations to the urban canyon for hydrological models" by Merle Koelbing et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-24-AC1, 2021

Dear anonymous revier#1,

we appreciate the time for reading our paper and the effort that you have dedicated to provide your feedback on the manuscript. We are grateful for your comments that we like to reply to below:

1) We kept the surface parameterized to a reference crop (even though this does not represent the ground cover directly at all measurement locations – but in close proximity there was also gras cover) to create comparable boundary conditions at all measurement locations. Our estimates of FAO56 potential evapotranspiration do therefore not reflect actual plant water use, but rather a measure of the atmospheric water demand under the assumptions in the PET model. Under this assumption we were then able to examine the sensitivity of the different variables included in the FAO56-penman-monteith equation to observed changes in the climatic input that occurred at street level in an urban canyon. Such a sensitivity analysis is only possible using a comparable approach and we decided to focus on the idea of potential evapotranspiration – as explained below.

Usually, in urban hydrological models (but also in catchment models or groundwater recharge models that may include urban areas), actual evapotranspiration is simulated (sometimes only for the fraction of unsealed surfaces) dependent on potential evaporation (Ep) and the physical behavior of soils and plants (e.g. Grimmond & Oke, 1991; Mitchell et al., 2001; Berthier et al., 2006; Rodriguez et al. 2000; Rodriguez et al., 2008 (these studies are cited in the manuscript)). Therefore, these models ask for an input time series of potential evaporation (Ep). Input variables for estimating Ep are usually observed at one or several reference climate stations that are representing a mesoscale urban foot print area (e.g. airport climate stations) or rural conditions. To our knowledge, no adaption of input Ep to the urban microclimate was made so far in common urban hydrologic models. By using these mesoscale Ep rates, we neglect (at least) that climate variables can vary considerably within the city on a small spatial scale.

With our approach, we deliver a method that can easily be combined with all those existing hydrologic models. By choosing a reference grass surface for the estimation of potential evapotranspiration we take into account that most parks and gardens in central European cities are cultivated as well watered lawns. We could have also chosen another surface, but since the surfaces in cities are highly complex, we believe that results of such a sensitivity analysis would be comparable.

For example Zipper et al. (2017) were using a similar approach to investigate the urban heat island effect on the evapotranspiration demand in Madison, WI (USA). In a first step, they used FAO56-Penman-Montieth reference potential evapotranspiration for all urban (and rural) measurement locations to focus only on differences in atmospheric conditions between urban and rural sites (which in their study was limited to air temperature and vapor pressure deficit). Wind and radiation input were observed at two rural meteorological stations. Our study goes much further by also including urban/microscale wind speed and shortwave radiation leading to a new result: If only focusing on urban heat, we tend to overestimate urban potential evapotranspiration because the shading of areas on street level is neglected.

2) We considered Q_G for hourly time steps as given in Allen et al. (1998) eq (45): $Q_G = 0.1 * Q^*$ as ground heat flux of a reference grass surface. We did not consider the surface heat flux of the urban canyon walls. Potential evapotranspiration thus is likely to be overestimated by not reducing net radiation by the surface heat flux of the walls. Neglecting wall heat fluxes was mainly due to missing observation data. We could have estimated the heat flux of the building walls with values taken from the literature (e.g. in Miao et al., 2012 (Table (4)); Nunez and Oke, 1977) which of course would have improved the results in terms of estimating real plant water use. On the other hand, we were focusing on a method for improving input Ep for mesoscale (urban) hydrologic models which can easily be applied without too many assumptions that have to be made beforehand. We approached our goal by performing a sensitivity analysis on the climatic input (and in addition incoming longwave radiation). If, in terms of mesoscale urban hydrologic modelling, the surface heat flux for the area under investigation was approximated by a coefficient multiplied by net radiation, we can assume that the overall relationship of our linear regression and the strong sensitivity to changes in incoming shortwave radiation would not change.

Our suggestion for improvement of our manuscript are:

- to change the title of the manuscript more towards the hydrologic aspect of our study
- to explain better the hydrologic point of view and the aim of the study
- to include the handling of the surface heat flux more detailed in the method and the discussion section.

Literature not cited in the manuscript:

Miao, S., Dou, J., Chen, F. et al. Analysis of observations on the urban surface energy balance in Beijing. Sci. China Earth Sci. 55, 1881–1890 (2012). https://doi.org/10.1007/s11430-012-4411-6

Nunez M, Oke TR (1977) The energy balance of an urban canyon. J Appl Meteorol 16:11–19

Zipper, S. C., J. Schatz, C. J. Kucharik, and S. P. Loheide II (2017), Urban heat island induced increases in evapotranspirative demand, Geophys. Res. Lett., 44, doi:10.1002/2016GL072190.