Response to reviewer comment on "The contribution of air temperature and ozone to mortality rates during hot weather episodes in eight German cities during the years 2000 and 2017" by Alexander Krug et al.

Anonymous Referee #1

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We sincerely thank you for the overall feedback of our work as well as the constructive comments on the manuscript. This is highly appreciated. We reply to the reviewer comments below. Reviewer comments are in black and italic, authors' responses in blue.

RC1: "I have a comment regarding the period of the analysis. The study is performed to annual time series, and the authors tested long-term annual trends. But, given the strong seasonality of MDA8, which usually reaches the highest values in summer, I would expect the most important interaction HWE and MDA8 in summer. Did the authors take into consideration this?"

Answer: The method used in this study regresses between both process variables of air temperature magnitude (TA_{Mag}) and mean 8-hourly average ozone concentration ($MDA8_{M}$) as well as mean mortality rates as effect variable. Regressions are calculated only between the process and the effect during previously detected episodes of the whole analyzed period from 2000 to 2017. Although it was not aim of this study to investigate the effects of seasonal variances in air temperature or ozone concentrations, we fully agree with your expectation of increasing interaction during episodes of highest values of both air temperature and ozone. An indicator of possible higher impacts of interaction can be seen in Fig. 3 in the manuscript. At least four cities (Leipzig, Cologne, Frankfurt and Stuttgart) show increasing explained variance (r^2) of the interaction term with increasing air temperature threshold (TA_{Thres}). As episodes of exceeding high threshold values are likely to occur in mid-summer, results reveal the most interaction during these episodes (high r^2). Lower TA_{Thres} includes an increasing number of episodes which are more likely to occur in early or late summer. A lower r^2 for the interaction term of these episodes can be seen in Fig. 3 of the manuscript. Concerning the other investigated cities, a lower r^2 of the interaction term for episodes of lower TA_{Thes} is less visible, which is mainly due to lower values of the explained variances of these three variables. Yet, it cannot be excluded. We fully agree with your expectation of most pronounced interaction for episodes during the mid-summer time. Nevertheless, an investigation of different seasonal impacts or differences between distinct episodes are not in the focus of this study.

RC2. "Line 83: The analysis of HWE is based on daily average of air temperature (TA), and I understand that as in other studies, TA can be a suitable predictor. However, I was wondering if the authors have tested maximum temperature instead."

Answer: The decision to select daily average air temperature as predictor for mortality rates has been mainly made based on results of studies that are cited in section 2.1.1. According to your comment, we tested T_{min} and T_{max} as predictor variables in the regressions as well. The results for all investigated cities are displayed below. They reflect that T_{max} is less suitable than T_{min} and T_{mean} to predict mortality rates during hot weather episodes (HWE), considering all cities. T_{min} and T_{mean} show higher values of r^2 than T_{max}. This confirms results of cited studies in section 2.1.1. and leads to our decision to use the daily average air temperature in our study. Furthermore, it reflects in a more general view, that night-time air temperature plays an important role for urban populations. T_{mean} reflects the thermal situation of the entire day compared to T_{min} or T_{max}. In addition to this, T_{mean} better captures the urban heat island effect, which is commonly most pronounced in the first phase of the night and therefore not at the time of T_{min} occurrence, commonly shortly before sunrise. According to these points, we selected T_{mean} as thermal predictor for mortality in this study.

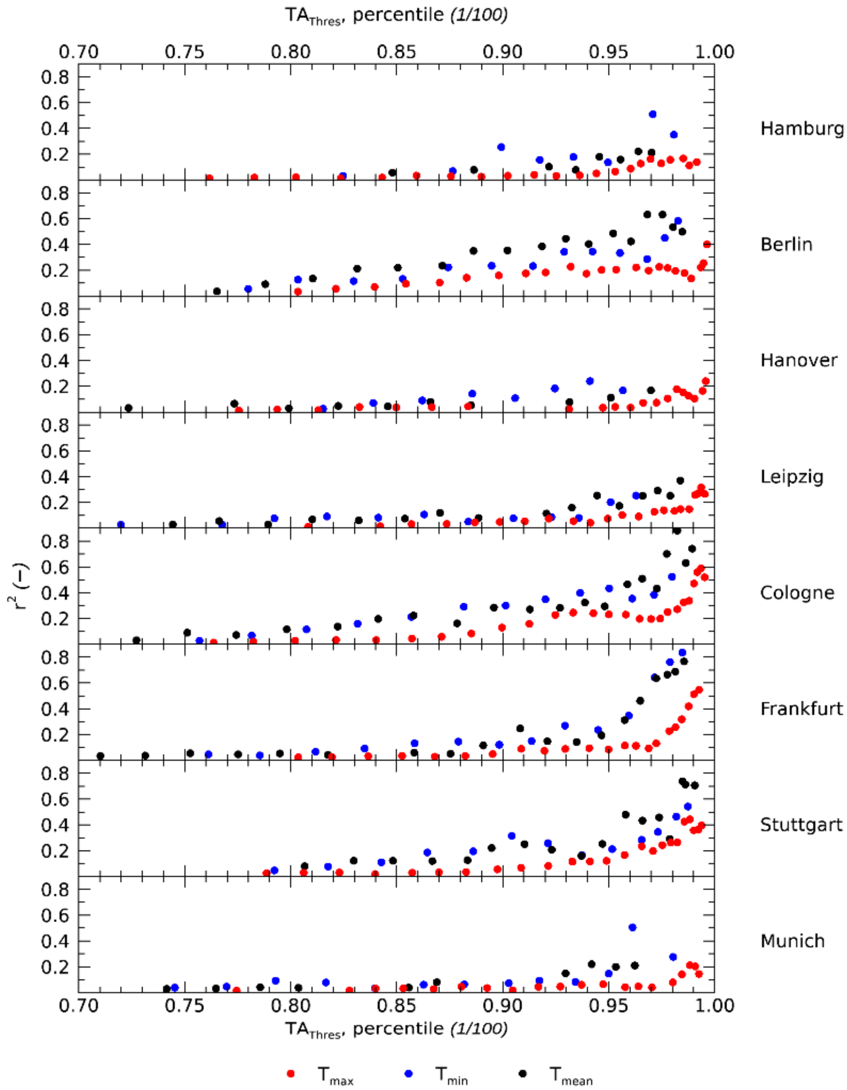

Figure 1: Comparison of regression analysis based on different predictor variables T_{min} (blue), T_{mean} (black) and T_{max} (red). Each panel displays results for one city. X axis: percentile of the respective air temperature distribution, y axis: explained variance (r^2) of regression models.

RC3. "Line 233. In Berlin, it is observed a higher contribution from MDA8M at the lower TAThres, which is somehow surprising, since I would expect a higher contribution from MDA8 at higher TAThres. Why? The authors mention that it could due to stagnant conditions (dry, sunny days..) in early summer, but this is only observed in Berlin, do the authors have further explanations?"

Answer: In Fig. 3 of the manuscript, the light gray bars reflect the part of the variance of the mean mortality rate during episodes which can be explained by the variance of $MDA8_M$. Although all episodes were detected via air temperature thresholds, the regressions reveal that the variance of the mortality rate cannot only be explained by the variance of the air temperature magnitude (TA_{Mag}), but mostly by the variance of $MDA8_M$. This is visible not only in results for Berlin, but also for Stuttgart and Cologne. The reason for this can be similarly discussed as we did in the answer to your comment RC1. Lower TA_{Thres} capture more episodes, which occur in early or late summer. Especially in early summer, MDA8 can reach high values due to intense solar radiation and high photo-oxidative production rate. MDA8 values of up to 170 µg m³ for episodes of TA_{Thres} ≥ 16 °C can be seen in Fig. 4. With increasing TA_{Thres}, the explained variance of $MDA8_M$ decreases and the air temperature becomes the most pronounced factor in explaining the variance of the mortality rate during these episodes. This does not mean, however, that MDA8 is not relevant for mortality rates during episodes of higher TA_{Thes} in which the highest MDA8 concentrations may occur (Fig. 4). As shown in Fig. 3, the explained variance of $MDA8_M$ appears as a statistically inseparable part (the interaction term) of the variance of the air temperate magnitude (TA_{Mag}).

The specific contribution of TA_{Mag}, $MDA8_M$ and their interaction to mortality rates is spatially highly heterogeneous. Not only meteorological factors such as wind or humidity may influence the city specific relationship between these three variables. The topography or the emission rate of precursors through vegetation as well as population-specific factors (e.g. demography, socio-economy) may influence the city-specific relationship as well. This makes it more difficult to deduce similarities among different cities especially for the role of ozone. This fact mainly follows the results of other studies focusing on the relationship of air temperature, ozone and mortality, as cited and discussed in the manuscript. We will consider this comment in the discussion in sections 4.2. and 4.3. in the revision of the manuscript to make this clearer to the reader.

Technical corrections:

All your technical comments will be considered in the revised manuscript.