We thank the Reviewer for their comments. In the following we give:

Black -reviewers comments

Purple - Our response

Reviewer 2

The authors address the very relevant topic of the recent development of atmosperic numerical models towards the hectometric scale. The continuous increase of computing power meanwhile allows several Meteorological Services to run their mesoscale models at an hectometric scale, or they are close to it. One obvious application at that scale is to simulate the weather and climate phenomena over urban areas. In the recent years, several Weather Services have developed and integrated urban schemes in their NWP models.

A remaining issue for activating these urban schemes in operational NWP is the availability of observational datasets covering rural and in particular urban areas. The authors present and utilize a dense LiDAR-ceilometer network over Berlin.

General comments:

1) The strategy in this manuscript is focussed on the MURK aerosol scheme in the UM. Could this method also be transferred to a sophisticated aerosol model, if becoming available in UM, or to other atmospheric models in general. There is one sentence like this in section 5, maybe this could be a bit elaborated?

This method could be transferred to a more complex aerosol scheme. Warren et al. (2020) proposed improvements for the MURK scheme to better represent dynamic aerosol processes. More sophisticated aerosols models would likely have improved dynamic aerosol processes, which would be beneficial for a wider range of meteorological conditions. The main input for our algorithm is the aerosol concentration profile which should be available as output from a conventional aerosol scheme. Text added **L461-462**.

A large dependence however is also on the NWP model configuration itself, as the aerosol profile is determined through the dispersion of the aerosol as a passive scalar. An important advantage here is the hm-scale model configuration which allows for explicit turbulence with a high vertical resolution in the mixed layer, compared with for example, kilometre-scale models.

2) Likely also MURK has errors or shortcomings. How much do they influence or limit the general findings of this study?

We have added more detail about MURK and how emissions are dispersed from the surface in the model (**L142-150**; also see **Reviewer 1 response #4**).

MURK scheme intentionally uses simple conversion to aerosol (i.e. aerosol sources via non-emissions) and as previously mentioned Warren et al. (2020) proposes several improvements to the scheme (added at **L463**). For this study, we would expect this impact to be minimal given the clear, dry conditions and short simulation period. Another possible shortcoming is the resolution of the emissions dataset which needs to be interpolated down to a 100 m grid from the 0.1° data. Because of this we lose intracity variability in the emissions which may then translate to a loss in variability in the aerosol profile on the intracity scale. We do expect this to be compensated by the model's resolution of intracity variability however.

3) I find Fig. 4 very convincing. But it stays a bit unclear, why the UM boundary layer diagnostic BLD is so very different from the aerosol-based method, particularly in the afternoon and evening io 4 August. Some literature is quoted confirming this result. Why does the parcel-based BLD not capture the effect that the aerosols are actually further transported verically upward? By which *physical process does this happen? Maybe a figure of the vertical motion (in a cross section) could shed more light on this?*

This is an interesting point. We add Fig. S8 with the environmental lapse rate (averaged to 15-minutes) and Fig. S9 with the vertical velocity (15-minute instantaneous) to provide some explanation.

The BLD diagnostic on 4 Aug (Fig S8b, d) strictly follows a weak inversion throughout the afternoon and evening. Whereas, the majority of strong overturning is below the BLD in the afternoon (Fig. S9b,d). In the evening there is still strong vertical motion reaching above the BLD. Thus, some additional mixing is possible above the weak thermal inversion and may lead to the rise in Z_M even in the late afternoon until sunset. In similar hectometric simulations, Lean et al. (2022) found wave features above the mixed layer which may provide some explanation for what is seen in Fig. S9. Text added at **L251-254.**

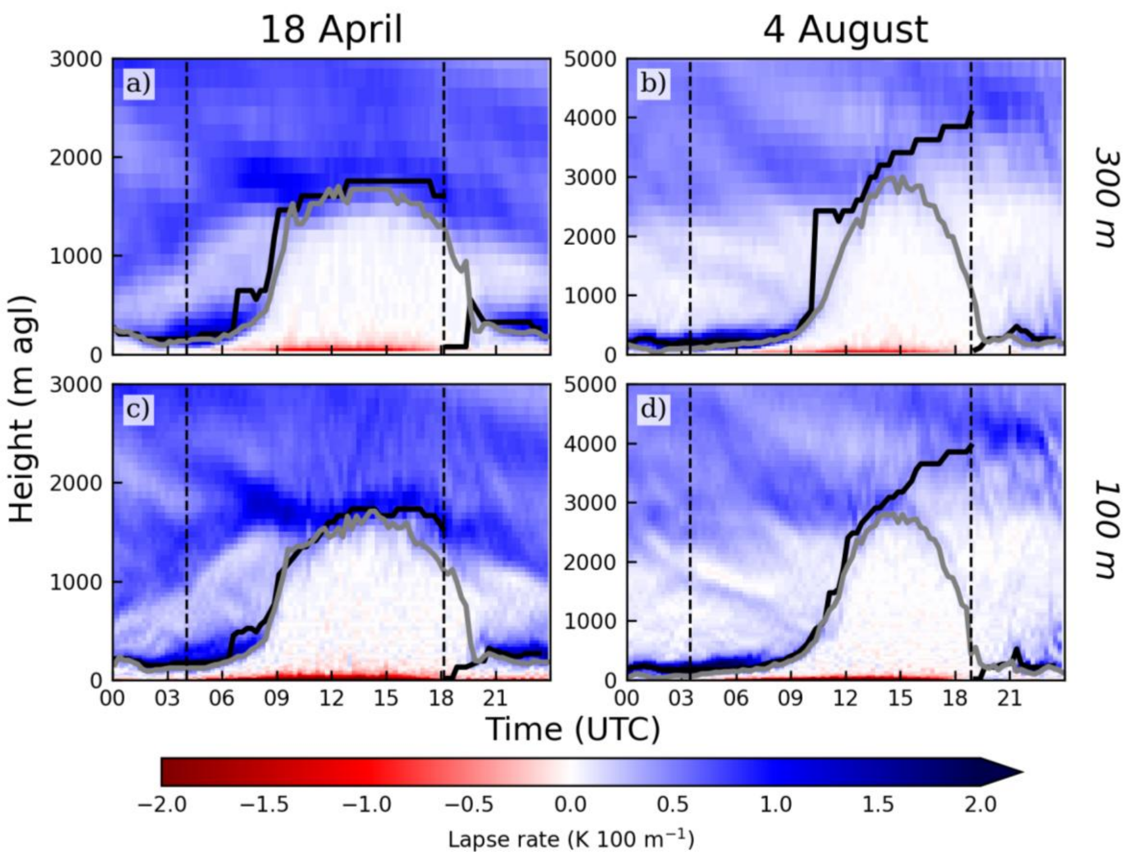

Figure S8. As Fig. 4, but showing the modelled environmental lapse rate per 100 m averaged to 15-minutes (colour bar), with BLD diagnostic (grey lines), Z_M (black lines), and sunrise and sunset (dashed lines).

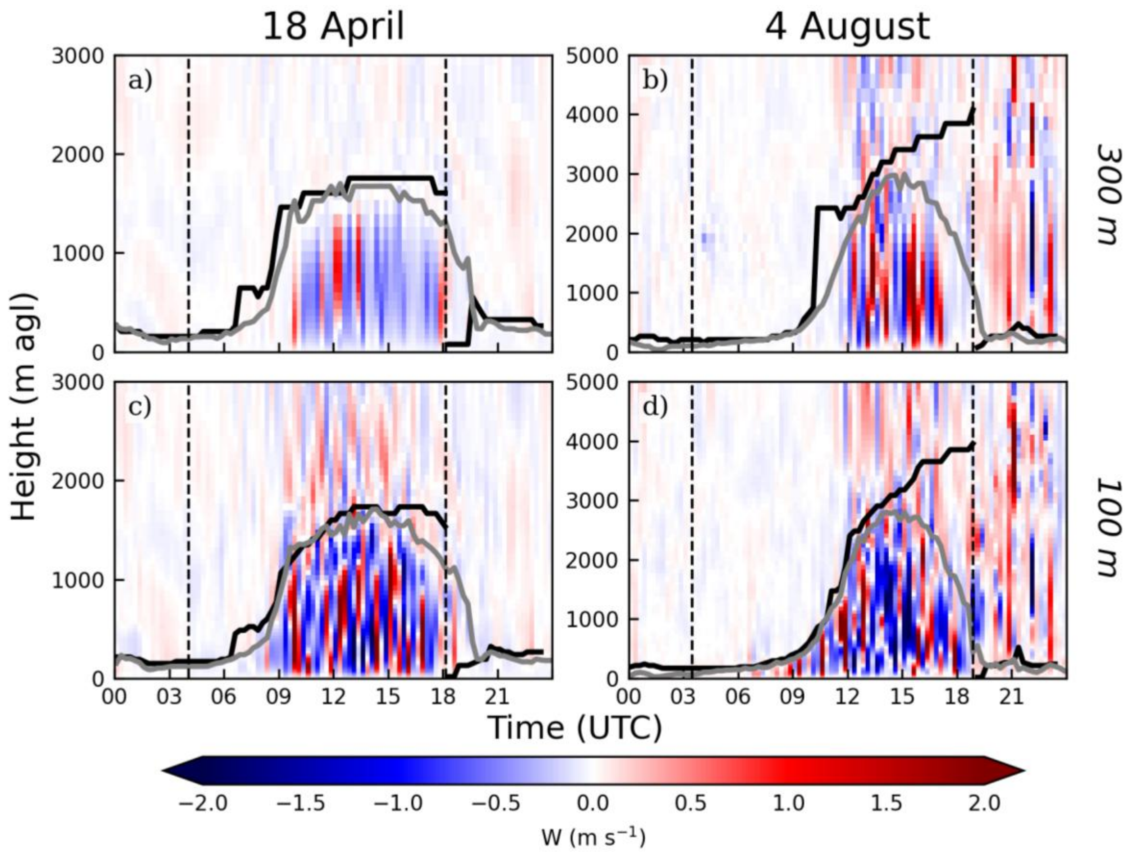

Figure S9. As in Fig. S8 but showing the 15-minute instantaneous vertical velocity (W [m s^{-1}]) .

4) Section 4.2 has a very descriptive character. Would it possible to also find some reasoning or explanations for the things described?

See also **Reviewer 1 response 7**. We have added Table 2 and 3 along with text in Section 4.2 which offer quantitative results to go along with what is seen in Fig. 7 and 8. We believe the results in Section 4.2 are clearer when grouping stations by rings (i.e. urban-rural variability) or by upwind/downwind of the city.

5) Figs. 9-12 look very convincing. Anyway, are there ideas about the (remaining) differences between model and obs in Figs.10 and 12?

The April case appears to have a low bias in the evening (Fig. 10), which we attribute to the difficultly with weaker and finer gradients in the evening. Another possible explanation is the cold bias noted when comparing to ERA5 (see **Reviewer 1 Minor comment #4**) which may have led to a shallower mixed layer in our simulations, compared to the ceilometers.

Minor comments:

- Fig. 1: The rings are not explained well. The explanation comes in the caption of Fig. 2. Maybe move this to caption of Fig. 1, or refer to Fig. 2?
Fig. 1 caption updated to explain this.

- Fig. 2: The descriptions of rings A to C are not so easy to find. Maybe different colour?
Fig. 2 rings labels enlarged and made bold.

- L. 172: … observed MLH (from now on referred to as Z_O) …

modified to (hereafter Z_O)
- L. 174: Similar with model MLH Z_M.
modified to (hereafter Z_M)

- L. 209: WEDD: Maybe add the name „Wedding“ of the quarter (for the readers who know Berlin 😉).
‘[Wedding]’ added to Fig. 2 caption. Incorrect reference to ‘Fig. 1b’ at **L233** corrected to Fig. 2b.