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Interactive comment on “Parameterizing the vertical downward dispersion of ship exhaust gas in the near-field” *by* Ronny Badeke et al.

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We appreciate the reviewer’s opinion about the paper’s topic and structure. Thank you very much for the comments.

C1: The paper can be defined as a study of the "building downwash" effect due to the ship itself. In this sense the paper is not really innovative, but results are interesting for the many different input parameters studied (wind velocity and direction, gas velocity and temperature and atmospheric stability class). Building downwash effect is present as option in many common dispersion models. Did the authors verified if the use of MITRAS gives different results with respect to, as an example, CALPUFF + building downwash?

Answer to C1:

As to our knowledge, CALPUFF is a Lagrangian Gaussian puff model that calculates building downwash effects via the Huber-Snyder or the Schulman-Scire model approach. Although it can calculate wind-direction in 36 times 10° increments, it only uses the relation of building width to height to account for the downward dispersion. Mitras is able to represent the complex building geometry of a ship with several decks. Therefore, the comparability is limited and we did not compare our results with CALPUFF. However, we did compare stack-only conditions with the integral plume model IBJPluris (Janicke and Janicke, 2001), which can be used to describe the plume dispersion in the momentum-driven regime. It calculates average plume properties like concentration and temperature along the plume centerline and applies a circular Gaussian dispersion around this central axis. IBJPluris does not account for obstacle-induced turbulence effects and is therefore only compared to stack-only conditions in MITRAS. Since the primary output of IBJPluris is the plume centerline and not the downward dispersion, we calculated a similar centerline height for MITRAS to compare the plume behavior. We define this centerline in MITRAS hcenter, MITRAS as the median height of the plume mass (i.e. 50 % of the plume mass lies below and 50 % lies above). It is calculated at the same distance as downward dispersion for a column of 100 m x 100 m (see Fig. 4). Since this is an average of values between a distance of 100 m to 200 m, we calculated IBJPluris centerline heights at a distance of 100 m to 200 m as well (hcenter, Pluris). Table S1 gives an overview of the comparison. △hMITRAS and △hPluris are the differences between plume height (52 m) and centerline height for MITRAS and IBJPluris calculations, respectively. Their minimum difference is given by min(|△hMITRAS - △hPluris|) in Table S1, which represents the closest similarity of both models. Results are given at default settings and selected conditions to compare effects of input parameters. For all selected cases, MITRAS calculates larger centerline height values than IBJPluris. The lowest differences occur at low wind speed, low exhaust temperature and very stable conditions. The strongest differences of over 20 m occur for cases of low exit velocity and high exhaust temperature. By calculating effective ranges,

ri = Δ|min(|ΔhMITRAS - ΔhPluris|)i, max - min(|ΔhMITRAS - ΔhPluris|)i, min|

for a certain input parameter i, one can evaluate which input parameter causes the highest discrepancy between the models. For example, changing the wind speed only results in an effective range of 1 m, while temperature and stability changes both show effective ranges of 10 m. The higher plume rise in MITRAS is consistent with the interaction of the hot plume with the ambient air. MITRAS accounts for the change in the thermodynamic field and the heat balance equation creates an additional buoyancy which is not considered in the simpler approaches. This explains the high effective range for temperature and stability changes. We conclude that the results for stack-only conditions are reasonable and that MITRAS provides a more complex improvement over simple Gaussian approaches. We will include this comparison in the appendix of the paper.

C2: Since the calculation domain is not very large a CFD model could be proposed to perform the same simulations. Do they authors think it could be more accurate?

Answer to C2:

As an obstacle-resolving microscale meteorology model MITRAS can be understood as a CFD model for the atmosphere, but with additional processes taken into account such as Coriolis effect and precipitation. In this special application, effects of the Coriolis force are considered. If necessary, it is possible to create obstacles at even higher resolution. MITRAS has been evaluated following an evaluation protocol that includes the comparison of wind fields for different obstacle geometries with wind tunnel data (Grawe et al., 2013).

C3: For most of the input parameters, the correlation is directly linear. However, in case of atmospheric stability the downward dispersion is linear against a derived parameter sgn$(\Gamma)\Gamma^2$, which has to be distinguished from a direct linear correlation. The good correlations result from the way this downward dispersion is calculated. Due to calculating a column average (above or beyond the stack height) of a column with 100 m x 100 m surface area, a lot of the mentioned turbulence is averaged out. If one calculates the downward dispersion at one specific grid cell, the correlation would probably be lower. However, the averaged results are better to be coupled into city-scale models which is why we preferred them over single-grid cell results.

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Please also note the supplement to this comment:
https://acp.copernicus.org/preprints/acp-2020-753/acp-2020-753-AC1-supplement.pdf

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