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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Validation of conventional Lagrangian stochastic footprint models against LES driven footprint estimates" *by* T. Markkanen et al.

T. Markkanen et al.

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We are grateful to the reviewer 4 for the comments which helped us to improve the manuscript. Reply to major comments:

1) The simulation with Coriolis force (CF) is included to explore the impact of more complete description of dynamics to the results, while the two cases without CF are of higher subgrid scale resolution. Additionally, the pair of results with and without CF introduces us to some of the problems related to the model comparison merely in 1D, such as slight asymmetry of footprint pattern across the mean wind axis which is here due to CF but could also rise from secondary circulation pattern in more complicated shapes. Furthermore, inclusion of CF provides us with a data-set suitable for intro-

ducing a comparison method for footprints in 2D, because the data in of comparable statistical noise as the data-set derived without inclusion of CF. The final notion of the reviewer's that the simulation with CF was ignored in the Conclusions section is to the point and because we find it, nevertheless, relevant for the manuscript we add a statement that such run was performed and comparison with the case without CF revealed pronounced differences at lowest observation height while at other levels, according to the quality categories set in Table 2, the models were of high or moderate agreement.

2) A prominent area of negative footprint, decreasing the cumulative footprint at far distances is indeed present in the convective case 1, as the reviewer states. This was already observed and discussed by Steinfeld et al. (2008) where the same method of solving the footprint function by Kurbanmuradov et al. (1999) was used. This is because the height at which the convective boundary layer mean concentration due to surface source reaches its maximum varies according to the distance from the source. The maximum is located close to the release height at near down-wind distances; close to atmospheric boundary layer (ABL) top at far distances and finally at intermediate ABL heights at yet further distances (see Steinfeld et all, 2008 for the convective case 1 of this study). Given this concentration pattern the particles contributing to high concentration near the ABL top must in average tend downwards at yet further distances. Even thought the pattern has been reported by several authors (e.g. Willis and Deardorff, 1976 for the results of a convection tank experiment and Weil et al., 2004 for the results of a numerical study), one may ask whether the trajectories of this study are nevertheless somehow biased. To argue that that was not the case here we state the following:

- Firstly, the domain that is given in Table 1 of the manuscript is the domain for footprint calculations of the final footprint results whereas the computational LES domain extended 2560 meters each lateral direction and is thus more than four times the ABL height. The table and text will be modified to clarify the domain issue.

- Secondly, in PALM at any time the horizontal mean of the vertical velocity is equal to

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zero implying that the flow field is not biased.

- Thirdly, the particle sources were distributed over the total horizontal extension of the model domain with distances of 8 meters between the different sources, which makes sure there is no bias caused by individual up- and downdrafts.

Thus the concentration pattern is real and explains the area of negative contribution that is caused by the dominance of particles traveling downwards at certain distance.

Minor comments:

P4200, l.23 The dimensions of the computational domain were 2560 m in horizontal and 960 m in vertical. The values will be given in the text.

P4200, l.25 As suggested, the expression 'simulated online' will be changed into 'coupled simulation'

P4201, l. 4 More detailed information of runs, including the numbers of particles will be given in the text.

P4201, l. 12 '...which satisfied the WMC...' will be changed into 'which satisfies the WMC'

P4201, l. 21 R4: The particles were reflected at the surface and at the boundary layer top. References will be given in the text. In backward model runs the particle numbers varied from 262000 to 441000. The range will be given in the text.

P4202, l. 6 The roughness length of 0.14m was selected according to the paper by Leclerc et al. (1997). In all the models it is among the standard initial parameters.

P4202, l. 7 The text in forward model description will be modified to emphasize that release from the canopy top is considered to be representative of the surface sources of the ABL flow and thus 'the surface' of the studied cases introduced later in the text.

P4202, l. 9 In the forward model particle reflection only takes place at the lower sur-

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face whereas the upper surface is not considered at all, which restricts the validity of the model only to the surface layer. At the actual surface the particles are perfectly reflected; i.e. all the components of the velocity vector are inverted for their directions. Total number of released particles was 300000. The text will be modified accordingly.

P4204, l. 19 ON the order of (not of the order of) - to be corrected according to the suggestion.

P4204, l. 25 Colon to be added according to the suggestion: ’...to compare both, sizes of the areas...’.

P4205, l. 22 The nearly neutral case of the manuscript will be modified according to the reviewer 1's suggestion into 'less unstable case' as it is not 'nearly neutral' in most of the ABL depth.

P4206, l. 16 ’grid’ to be replaced by ’grid cell’ as suggested.

P4206, l. 20 'consists', not 'consist' - to be modified.

P4207, l. 27 Table numbering will be corrected.

P4207, l. 28 'schema' to be replaced by 'scheme'.

P4208, l, 14 ’.produced peaks...' will be replaced by 'produced footprint peaks' to clarify that the term 'peak' in this context refers to the peak value of the footprint function.

P4209, l. 15 Because the ratios of footprint areas at the lowest measurement levels are not really visible in the figure 2 we will change the y-axis into logarithmic scale.

P4210, l.2 Figures 6 and 7 are interchanged in the manuscript - this will be fixed.

P4213, l. 21 The reference list will be corrected by giving the author names in the form of the actual papers.

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References

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Interactive comment on Atmos. Chem. Phys. Discuss., 9, 4195, 2009.

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