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Interactive Comment

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 1 for the comments which helped us to improve the manuscript. Response to general comments:

1) We explored the behavior of a narrow set of stabilities and actually stable case is indeed missing. With an intention to make simulations comparable to those made by Leclerc et al. (1997) we selected one set of boundary conditions for LES runs producing similar ABL characteristics. Another selection of boundary conditions was bound to produce less unstable ABL. This we called near neutral which term the reviewer justly disapproved as it does not hold for most of the ABL depth. However, we do not totally agree with the reviewer that the case of Obukhov length of L=-77m should be consid-

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ered very unstable, as it is effectively neutral close to the surface. E.g. for a height of 4 m the stability parameter is z/L = 0.05, which is according to Monin and Obukhov (1954) in the neutral dynamical sublayer. As the critics are nevertheless to the point for the larger measurement heights we modify the text as explained in the reply to the specific comment 1 (see below). When it comes to the narrowness of the data set stability-wise we argue that our intention was not thoroughly validate the models for whole parameter-space. The main goal of the study was to develop a method with that different footprint models can be compared and to show that it is not sufficient to compare the crosswind integrated footprints and for such an aim this data set is large enough. Moreover, our study reveals the importance of consideration of the resolution applied in the comparison of gridded footprint data set. We emphasize the last points in the introduction.

2) To introduce the comparison method we used the two conventional models in their original forms and the LES model in the form presented in the original paper by Steinfeld et al (2008). The adjustable parameters of the two conventional models, one simulating dispersion backward one forward in time, were derived from the LES according to the Table 1 of the manuscript, while their turbulence description was in the forms they have been in their many applications. On the other hand, the differences of turbulence parameterizations (Foken 2008; Kaimal and Finnigan 1994) and their impact on the footprint predictions have been studied elsewhere (Rannik et al 2000, 2003; Göckede et al 2007) and was not aim of this study. On the contrary, this work utilizes the differences among the three data sets derived from three different model concepts to explore the importance of comparing results in 2D and the impact of the grid resolution in this consideration.

3) The coupling method between LES and LS is described in detail in Steinfeld et al. (2008) and based on Weil et al. (2004). The only extra feature of our coupling is the online coupling. The simulated time in the LES simulations was 5 hours. The particles were released after 10800 s and particle trajectories were evaluated over the

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following 7200 s. The horizontal distance between two sources of particles was 8 m and alltogether 8 particles were released at each source. We add the preceding information on the properties of the performed LES runs according to reviewer's comments.

Specific comments: 1) We modify all the reference to the 'near neutral' case into 'case 2' as this case is not near neutral for most of the ABL as the reviewer pointed out.

2) Pg.4197, line 19: "andthe" changed into "and the" as suggested.

3) Pg.4199, line 28-29: The misconception about special normalization removed.

4) Pg.4200: According to Rannik et al (2000) the concentration footprint tends to infinity as according to Kurbanmuradov et al. (1999) every particle observed at the measurement point adds positively to the concentration. Normalization here is adopted from the original study by Rannik et al (2000).

5) Pg.4201,line 6-8: more details of the LES-LS model running and footprint calculation added according to the suggestion.

6) Pg.4205, line 10-20: The particles don't get thoroughly mixed all through the CBL in the LES runs but remain to certain degree correlated under the presented boundary conditions. Regarding the changing ABL height, Weil's method (Weil et al., 2004) of on-line footprint calculation has basically problems in cases in that the ABL height changes considerably with time, but that we are aware of these problems. For this reason we prescribed a strongly stable stratification above the neutrally stratified layer at the beginning of the simulation. In fact the boundary layer height did not change much with time. In the case 1, after 10800 s when the particles were released the boundary layer height was 530 m, 2h later the boundary layer height had not increased above 550 m. We include these measures of the ABL height change among the LES characteristics to be added according to reviewer's suggestion.

7) Pg.4205, line 22: 'nearly' replaced by less unstable.

8) Pg.4205, line 26-27: Negative contribution arises to some degree from correlated

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particles even at long distances and they are included, this is meant by the 'total contribution'. We edit the sentence more clearly to point out that both positive and negative contribution is included.

9) Pg.4208, line 8: For discussion on the implications of the Coriolis force (CF) inclusion see the reply on the specific comment 10 (below). The intention to validate the models with LES runs is indeed too ambitious and the term 'validate' is changed into 'compare', which implies that also the title of the manuscript will be changed into 'Comparison of conventional Lagrangian stochastic footprint models against LESdriven footprint estimates.'

10) Pg.4208-4209: Comparison among the LES with and without CF is included to show that it does make some difference which is of course to be expected as pointed out by the reviewer in the previous point. However, the latter point of the reviewer is partly due to badly formulated explanation on the selection of 'effective' mean wind direction for with CF runs in the manuscript. The mean wind directions of both model versions were set identical in comparison separately at each measurement height investigated. This is in a way self evident and mentioning it separately is possibly confusing. Nevertheless the matter is worth of emphasizing so that to oppose it to the case of using for instance a vertical mean over the whole boundary layer mean wind directions as a reference. When it comes to pressure gradient, in PALM we do not prescribe the large-scale pressure gradient directly. Instead in the equations of PALM the term of the pressure gradient force is modified by making use of the geostrophic relationship ug=-1/(rho f) dp/dy, vg=1/(rho f) dp/dx. The simulations presented here have been performed for a latitude of phi=38°, which means for a Coriolis parameter f=2 Omega sin (phi) =8.95*10ˆ(-5). For the original Leclerc case 1 we prescribed a geostrophic wind of 4 m/s, while for the case 2 we prescribed a geostrophic wind of 10 m/s. In both cases there was no v-component of the geostrophic wind. Thus, there is only a large-scale pressure gradient along the y-direction with a value of 0.000385 Pa/m in the original Leclerc case and a value of 0.000895 Pa/m in the modified Leclerc, less unstable case.

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The reviewer is right that the cases without Coriolis force are cases in that the flow is decaying. There is no Coriolis force (f=0) and therefore also no pressure gradient force in our simulations. This might of course impact our footprint results. Without any assessment simulations done on this matter we expect that the decaying flow might especially influence the results for sources at larger distances from the measurement point.

11) Pg. 4210, line 20: To be edited according to the comment. 12) Pg.4212, line 6-7: We argue according to the reviewer's comment that the discrepancy may be due to difference in mean winds. 13) and 14) to be modified according to the reviewer's comments.

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