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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ship plume dispersion rates in convective boundary layers for chemistry models" *by* F. Chosson et al.

F. Chosson et al.

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We first wish to thank you for your comments that, we think, contributed to improve the quality of this paper. We hope that all the questions you raised have been correctly addressed in the revised version.

Reviewer specific comment 1: There are indeed some errors in the formulation of Equation (6). The obvious one, as spotted by the referee, is that the time-like arguments of p_1 should be $t - t'$ and not t' . We would like to mention that we wrote Equation (6) only to show how obtain a 3D concentration field of a "generic puff" at time t from the scattered simulated particles positions. This recombined concentration field $C(x, y, z, t)$ is defined in a coordinate x, y, z that can be related to the simulated particles positions $x_p(t), y_p(t), z_p(t)$ following:

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$$x = x_p(t) - x_0 - U(t - t') \quad (1)$$

$$y = y_p(t) - y_0 - V(t - t') \quad (2)$$

$$z = z_p(t) \quad (3)$$

Although the position coordinates should be stricto senso the same in both sides of the equation (as suggested by the referee), we decided to maintain its actual form that keep these relations more visible. The referee is absolutely right to remark that equation (6) can be applied to any moving source and wind speed configuration by simply interpret (U, V) as the relative wind speed components, instead of the mean BL wind speed, as indicated in the text. We added this remark in the revised paper. The ability of equation (6) to accurately describe the behavior of any generic puff is effectively limited by the relation between mean wind speed and the turbulence statistics. Equation (6) is indeed valid in the case of convective boundary layers (which is the topic of the paper) but should be recast to account for shear-driven boundary layers.

Reviewer specific comment 2: The slender plume approximation is valid if the cross-wind spread is small compared to the downwind distance traveled. In practice, it can be invoked in much broader spectra of situations, provided that the wind speed is not nil, and that one does not consider dispersion very close to the source. This is the case of ship plume description in chemical models. However, we admit that we are unable to provide quantitative boundaries to describe domains where this approximation is valid or not. In section 4.1, the dilution rate $D(t)$ (note that we relabeled $F(t)$ to distinguish the buoyancy flux) is derived from a coarse description of the plume, i.e. from the time evolution of its cross-wind surface A_p. As stated before, the plume is seen as a superposition of generic puffs, defined at each time step by its concentration field $C(x, y, z, t)$ following equation (6). Together with the slender plume approximation, the plume cross-wind surface concentration field $C_{plume}(y, z, t)$ at time t after release (age of the plume) can thus be written as: $C_{plume}(y, z, t) = \int C(x, y, z, t)dx$. For a

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given choice of the definition of the plume/background interface, we can then derive the cross-wind plume surface Ap from $C_{plume}(y, z, t)$. We agree that this explanation is needed for a better understanding of the method, and have been implemented in the revised paper.

Reviewer specific comment 5: We are grateful to the referee for this constructive remark that has been added in the revised paper.

Reviewer specific comment 6: Table 2 refers to all boundary layer scenarios together. The power-law function (equation 12) used to fit the results, depends on the convective boundary layer turn-over time scale which is a characteristic parameter of the given boundary layer scenario. We did not include the initial buoyancy flux in the Table, as it is treated separately to evaluate the impact on the dilution rates. The purpose was to find a way to parameterize the dilution rate in chemistry transport model using available parameters. And t* is one of them, but not the initial buoyancy flux.

Reviewer specific comment 7: We corrected.

Reviewer specific comment 8: Pg. 6802, l.21: "However, the heat flux at"; This sentence may appear redundant, but it now concerns the simulation results, whereas in the previous paragraph, it is related to in-situ observations. The paragraphs will be clarified in the revised version.

Reviewer specific comment 9: The extreme simplification of the parameterization of ship plume dilution, as proposed in equation (13), for coarse chemical transport model, have two reasons. First, there is a huge difference between chemical box models and chemical transport models. Even though the previous parameterization represented in equation (12) can appear to be simple enough, the implementation of a parameterization of dilution which is by itself a function of time is indeed a supplementary numerical challenge for models that have to treat with advection. This is also particularly not suitable to model the nearly background continuous emission that is the world ship traffic. The second reason is that the single timescale represented by equation (13) can be

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easily implemented directly into the model description of the chemical reaction as a lifetime of the related chemicals species. This approach is proposed in Cariolle (2007) and Paoli et al. (2008).

Reviewer specific comment 10: We hope that all corrections and references are properly included in the revised paper.

Sincerely yours, the authors.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 6793, 2008.