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Interactive Comment

# *Interactive comment on* "Modelling the impact of sub-grid scale emission variability on upper-air concentration" *by* S. Galmarini et al.

**Anonymous Referee #1**

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Review of the manuscript entitled : Modelling the impact of sub-grid scale emission variability on upper-air concentration, by S. Galmarini et al..

General comments :

This paper is motivated by the issue of emission heterogeneity at the surface, and the fact that this heterogeneity is not taken into account in atmospheric models, from meso to global scale models. The paper proposes a new method to account for the sub-grid scale emission variability, by introducing an emission variance representative of this emission heterogeneity. This emission variance impacts the upper-air by generating a concentration variance. This paper is very interesting because the authors approach is new: they have parameterized the emission variability, in order to introduce it in

Reynolds-Averaged models equations. Their approach was brought by the idea of making an analogy between parameterizing turbulence and parameterizing emission heterogeneity, which both create variability around the concentration mean.

The issue addressed in this paper is relevant within the scope of ACP. The manuscript is well written and introduces the concepts very clearly, in details and using simple words (even for a non-modeller). The simulations and the results are clearly described as well. Before publication in ACP, a few comments/suggestions should be taken into account.

In the results presented in this paper concerning the evaluation of the parameterization, the impact of the emission fine structure and the impact of turbulence are combined, and it is difficult to distinguish which part of the concentration variance is due to emission variance and which part is due to turbulence. In fact, in the LES model, we have both a better representation of the turbulence, and a better representation of the emission fine structure. Thus, when comparing the 2 models, the discrepancies in the concentration variances are to be attributed both to the accuracy of the turbulence representation and the emission variability representation. The part due to emission variance cannot be isolated, and thus it is difficult to evaluate it. Considering this, it would be interesting to discuss in more details (in section 4) these discrepancies in the concentration variances between the 2 models.

Related to this question, would it be interesting to do the following :

- Run the RANS and LES models with the emission scenario covering 100% of the C grid cell (and the equivalent sub-domain for LES), and compare the results in concentration variances (same as plots 7,8,9). Since there is no emission variance (in C cell), the comparison would show the effect of turbulence in both models, depending on the model resolution.

- Run also the RANS and the LES models without introducing turbulence (or very low turbulence), but taking into account the emission variability as you did in your simula-



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tions, for the 3 emission scenarios. Even if this doesnt reflect reality, the comparison could help assessing the relevance of the emission variability parameterization in the horizontal dimensions (for horizontal advection). Does this make sense?

In your emission scenarios, the emission source is always centered in the emitting grid cell. I assume that if the emitting point was in one corner of the cell, the results of the simulation would be different. As mentioned in the manuscript, you have not studied this issue which is however inherent to sub-grid emission heterogeneity. Therefore, could you mention more explicitly this issue about the spatial localisation of the emitting points inside the grid cell.

In the conclusions, it would be nice to have the answers of the questions addressed in the introduction, because for some of them, the answers are not necessarily obvious.

Specific and technical comments:

Abstract: 'the results show an excellent... ' (an)

1. Introduction: 'The emission heterogeneity can be seen ... for a specific specie...' (specie)

2. Parameterizing sub-grid scale emission variability:

Equation (2) is the one dimensional (along vertical axis z) version of equation (1): in equation (2), the second left term (the advection term) has been removed, probably because the average vertical wind speed equals to 0. But the reason is not explicitly explained. Is it what you mean by in conditions of horizontal homogeneity? ; if so, it is not clear to me. Perhaps you could clarify this, as people are not necessarily familiar with turbulent-mixing equations.

The equation (8), which is directly comparable to equation (2) (except the extra term 2cE), seems to be not coherent in the signs with equation (2) : all the right terms have a minus sign in eq. (2), while the second right term has a plus sign in equation (8).



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3. Reynolds-averaged modeling vs Large Eddy simulation.

3.1 The models and their set-ups: at the end of the paragraph, 'At the end of the first hour temperature and wind profiles are provided to the RANS models as initial conditions... ' (provided and conditions)

4. Sub-grid scale emissions: evaluation of the parameterization.

Paragraph 1: 'Figures 3b and c show the subsequent stages of evolution of emissions...' (the)

Paragraph 2: 'As anticipated earlier, first we want to test the parameterization on a mesoscale average grid ; secondly 1x1 km2 would have reduced...': add a punctuation mark before secondly.

Paragraph 3: ' The correlation coefficient has been calculated also for other surfaces sizes than the four analysed here'. (the and calculated)

Paragraph 4:

Figures 7, 8, 9 show the vertical profile of concentration variance calculated by the RANS model and the LES for the 64, 44, 28% values of emission variance respectively. The sentence should be rewritten, since it is a bit confusing: one could understand that 64, 44, and 28% are the values of the variance, instead of the surface occupied by the emission source.

'In the vertical its values are relevant in the first half of BL and decreases rapidly from there to the top' (remove the or its)

Paragraph 5: 'In both figures the shaded area covers the c+c'2 where the standard deviation is the result of ...' The standard deviation is the root square of c2, so I guess it should be: 'In both figures the shaded area covers the C+rootsquare(c'2) ...' .

Conclusions: 'A finite number of species in the atmosphere fulfill this requirement ... should be taken into account' (taken)



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Figures:

Figure 1 description: 'Schematic representation of the two models' : remove the extra the 'Cell C contains ... ranging from 100% coverage of the grid... ' (from and coverage)

Figure 3 description: '(a) top view of...' : not 24% but 28%

Figure 6 description: 'The different samples give...' (samples)

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