

Interactive comment on “Effects of resolution on the relative importance of numerical and physical diffusion in atmospheric composition modelling” by M. D’Isidoro et al.

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We acknowledge the comments made by Professor Odman (referee #2) that helped us improving the quality of the paper. Taking inspiration from its introduction, we highlighted in a stronger way the importance of the problem when reducing the mesh size.

We tried to explain explicitly some concepts about diffusion and sub-diffusion also giving additional references.

The Referee’s comments also gave us the opportunity to clarify the meaning of the non-dimensional quantities and their roles.

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Detailed answers to all specific comments follow:

Now that typical grid scales are around 4 km and pushing towards 1 km, numerical diffusion is not sufficient to yield realistic plume dispersion, so parameterized diffusion is necessary

This point has been carefully discussed in the new Introduction.

1) Their formulations are functions of time. First, you should explain why the variance for the parameterized subgrid-scale diffusion is a function of time.

The variance growth with time is due to physical diffusion ($\propto t$) and numerical diffusion ($\propto t^\beta$, $\beta < 1$ for WAF scheme). When the latter prevails the “diffusion coefficient” turns out to be a function of t .

Then you should explain (better) the meaning of non-dimensional time. Most important, you should discuss how one can use this. Most important, you should discuss how one can use this knowledge of non-dimensional time in air pollution models

The text now states that the so-defined non-dimensional time represents the time needed for an air parcel to travel across the source and it is used to describe the problem in general terms.

2) I urge you to consider and discuss the cases of resolution approaching unity and getting smaller than unity. An adaptive grid version of the Community Multiscale Air Quality (CMAQ) model that I developed recently is reducing the grid size to the level of 100 m in order to better resolve the plumes.

The resolution ρ we used in this work is not the grid resolution but a non-dimensional quantity. In current air quality simulations real point sources have a scale smaller than the grid mesh size, so that their representation in the model results in one grid mesh and $\rho = 1$. We added a sentence in the text to clarify this concept.

3) How does the numerical diffusion of this particular advection scheme (WAF) com-

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pare to the numerical diffusion of some other advection schemes? It would be nice if you could identify two popular schemes, one more diffusive and another less diffusive than WAF. Discuss how different the results (i.e., non-dimensional time) would be for the less diffusive scheme.

In this paper we focused on WAF because it is the scheme used in the BOLCHEM model. Furthermore, we believe this work defines a methodology that can be of some value by itself. The application of this methodology for comparison to other schemes is deferred to further work.

4) It would be nice if you added some illustrations to show your experimental setup: For example, show the Gaussian shaped source terms for A, B, C, : : , I, as a function of grid size, so that they can be visually compared to each other. Also, consider showing what happens to those sources after a while.

A figure has been added showing the initial and final shapes for two extreme resolutions.

Minor Comments: 1) I believe there is a typo in the subscripts of Equation 11.

Typo has been corrected.

2) I am not sure what makes you say that "variations of the resolution induce large amounts of increase in variance while varying the Courant number has a weaker impact" (lines 14-15 of page 22871). Going from H to I (i.e., changing the resolution from 0.25 to 0.125) seems to have the same effect as changing the Courant number from 0.1 to 0.9. How do you compare the variations in two different parameters?

The referee is right. The concept we wanted to express was that the variations due to ν in the range from 0.1 to 0.9 are smaller than those resulting from the variations of ρ in the considered range. The text has been modified accordingly.

3) Explain what you mean by "sub-diffusive" in the second bullet of the conclusion (line 14 of page 22874)

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Sub-diffusive means that $\beta < 1$. Conclusions have been rephrased to clarify this and other points.

4) In Figure 2b, what is the smallest value of the exponent on the y-axis? Is it ranging from 0 to 1?

The value was missing. The y-axis now has been corrected.

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