Atmos. Chem. Phys. Discuss., 9, C8716–C8718, 2009
www.atmos-chem-phys-discuss.net/9/C8716/2009/

Atmospheric Chemistry and Physics Discussions

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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Received and published: 19 December 2009

I commend the authors for re-addressing this important problem and contributing to its solution. As the grid scales of air pollution models are getting smaller, what used to be a non-issue is becoming significant. When I tackled the same problem (Odman, 1997), the scales were just being reduced from 80 km. At those scales, no parameterization of horizontal turbulent diffusion was necessary because numerical diffusion was more than sufficient to disperse the plumes. 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.

In this paper, the authors estimated the increase in variance of a plume due to numerical diffusion and due to sub-grid scale turbulent diffusion, and compared the two. Their formulations are functions of time. First, this seemed odd to me because, in my study, I was trying to compare the instantaneous diffusivities. However, as I have noted in my paper (Odman, 1997), "as the plumes are being dispersed they would experience a decreasing amount of numerical diffusion." Therefore, it is probably a good idea to approach the problem by looking at the evolution of diffusion on the same plume instead of trying to look at instantaneous diffusion on plumes of different dimensions.

Hoping the authors would empathize with my desire to get more out of them, I am making the following recommendations, which I sincerely believe would increase the value of their contribution.

Major comments: 1) First, you should explain why the variance for the parameterized subgrid-scale diffusion is a function of time. Then you should explain (better) the meaning of non-dimensional time. Most important, you should discuss how one can use this knowledge of non-dimensional time in air pollution models. 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. 3) How does the numerical diffusion of this particular advection scheme (WAF) compare 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. 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.

Minor Comments: 1) I believe there is a typo in the subscripts of Equation 11. A picture describing the advection scheme might be very useful. 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? 3) Explain what you mean by “sub-diffusive” in the second bullet of the conclusion (line 14 of page 22874) 4) In Figure 2b, what is the smallest value of the exponent on the y-axis? Is it ranging from 0 to 1?

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 22865, 2009.