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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Modelling transport and deposition of caesium and iodine from the Chernobyl accident using the DREAM model" *by* J. Brandt et al.

J. Brandt et al.

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The authors would like to thank Dr. Pudykiewicz (reviewer 2) for his very useful and constructive comments and recommendations. Answers to the specific concerns are described below.

Specific Comments

1) Reviewer: [page 1] It is not true that "At the time of the accident only one simple model developed in France was operational (Piedelievre et al., 1990), and used to describe the development of the plume from the nuclear power plant". Immediately following the accident, the transport of radionuclides from Chernobyl was simulated by a relatively complex, operational three-dimensional atmospheric dispersion system ARAC (Atmospheric Release Advisory Capability); the model was executed at

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Lawrence Livermore National Laboratory.

Answer: The sentence about the French model has been removed from text.

2) Reviewer: [page 2] It is quite optimistic to state: "However, models have improved considerably since the time of the Chernobyl accident with respect to the treatment of numerical methods, quality of parameterizations and model resolution, partly due to much faster computers." In fact, the model described by the authors is not much different when compared to models used following the accident. In particular, the treatment of aerosol processes is still ignored despite of their importance. I suggest either to remove this statement or just to state that now we have much more powerful computers than those in mid-eighties so current models are executed on grids with relatively high resolution.

Answer: The sentence has been changed to describe improvements in model resolution due to much faster computers. However, the model described in the paper is different to models used following the accident with respect to the combined use of a Lagrangian model in the near source area and an Eulerian model in the whole domain. Both types of models have advantages, which is utilized in the combined model that has been developed.

3) Reviewer: [page 3] The basic equation of the Eulerian model considered by the authors is cast in the following form:

See equation (1) in the paper

There is most likely an error in the description of function C in equation (1). The authors stated: C is the tracer mixing ratio. On the other hand in the legend of Table 1, where emission term is defined, the authors stated: "Release rates in Bq/day and relative distribution of material released in different heights of 137Cs, 134Cs and 131I in the period of the release..." Considering the definition of the source term given in Table 1, I believe that C is not a mixing ratio but the specific activity field (units [Bq/kg]).

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This issue should be clarified. Furthermore, it would be quite useful to say whether C represents radioactivity transported in the gas phase or in the form of radioactive particles? Similarly, the reader would appreciate the more precise description of kr; the authors stated: kr is representing the radioactive decay, what is numerical value of kr?

Answer: C is definitely the specific activity field with [Bq/kg] and not the mixing ratio and this error has been corrected in the manuscript. For iodine, C represents radioactivity transported in the gas phase and for caesium, C represents radioactivity transported in the form of radioactive particles. This is also stated in chapter 4. The numerical value of the radioactive decay is given by kr = log(2)/half life time. This has now been included in the text.

4) Reviewer: [page 3] The statement "Kx, Ky, K_sigma are the dispersion coefficients" should be changed to "Kx, Ky, K_sigma are the eddy diffusion coefficients". Similarly, "u, v, (sigma dot) are the wind speed components in the x, y, sigma directions, respectively" should be changed to: u and v are the wind speed components in the x, and y directions respectively, and sigma dot is the vertical motion in the sigma coordinate system.

Answer: The corrections suggested by the reviewer has been included in the manuscript.

5) Reviewer: [page 4] It is not precise to say: "The model has been split into three sub-models (Brandt and Zlatev, 1998) including: 1) three-dimensional advection, horizontal dispersion and emission, 2) vertical dispersion and dry deposition, and 3) wet deposition and radioactive decay." I would like to suggest to say simply that equation (1) is solved using the fractional steps method.

Answer: The corrections suggested by the reviewer has been included in the text.

6) Reviewer: [page 5] The reference to (Hass et al., 1990) is not the best choice in

the context of the description of the source term, I would like to suggest to refer to the original document where the source term was described.

Answer: The original reference has been inserted in the text.

7) Reviewer: [page 7] The authors stated: "The change in the air mixing ratio due to dry deposition is calculated using the flux F from the air to the surface and is applied as a lower boundary condition for the vertical dispersion in the Eulerian model and is proportional to the mixing ratio C" This statement should be corrected, C is not the mixing ratio but the specific activity.

Answer: The statement has been corrected according to the reviewer.

8) Reviewer: [page 9] The authors stated: "Little research has, however, been carried out in this field for the radioactive compound, iodine, and given the lack of experimental data and the uncertainties in determining the surface resistance for this species a fixed value of rc has been used. I would like to suggest to include the reference to Chamberlain and Chadwick (1966) (Chamberlain A. C. and R. C. Chadwick, (1966) Transport of iodine from atmosphere to ground, Tellus 18, 226-237).

Answer: The reference to Chamberlain and Chadwick (1966) has been included in the text.

9) Reviewer: [page 11] Please note that (RH - RHt)/(RHs - RHt) is a fractional cloud cover as defined by Sundqvist (1981) (Sundqvist, H., 1981, Prediction of stratiform clouds: Results from from a 5-day forecast with a global model, Tellus, 33, 242-253). We can write the "simple scheme" in the following alternative form:

Gamma = 0 If U less than Ut (no subgrid-scale cloudiness)

Gamma = beta lambda_a If U greater than or equal Ut (subgrid scale condensation)

where Gamma is the scavenging coefficient, U is the relative humidity, Ut is the relative humidity from which the subgridscale condensation can be initiated, Us = 1, beta = (U

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- Ut)/(Us - Ut) is the fractional cloudiness and lambda_a = 3.5x10E-5 is the typical in-cloud scavenging rate for submicron particles estimated assuming average cloud water content of precipitating clouds. The rationale for selecting this value of lambda_a is quite simple. The long range transport of radioactivity from Chernobyl was associated mainly with particles in the submicron range for which in-cloud scavenging processes are much more important than below cloud scavenging, see Warneck (1988) (Warneck, P. (1988) Chemistry of the natural atmosphere, Academic Press, page 390)

Answer: All the suggested changes have been included in the paper.

10) Reviewer: I would like to suggest that the scheme given by equation (23) be described as subgrid-scale averaging scheme.

Answer: The scheme given by equation (23) is now described as the subgrid-scale averaging scheme in the paper.

11) Reviewer: [page 15] The authors stated: "The parameterization based on relative humidities is, in all cases, performing better than the parameterization based on precipitation rates, with respect to the global ranks. This indicates that the precipitation rates are relatively uncertain in the meteorological model." This statement should be changed to: The parameterization based on subgrid-scale averaging is, in all cases, performing better than the parameterization based on precipitation rates (with respect to the global ranks).

Answer: The text has been changed according to suggestion made by the reviewer.

12) Reviewer: The fact that the parameterization based on subgrid-scale averaging "is, in all cases, performing better than the parameterization based on precipitation rates, with respect to the global ranks" can be explained relatively well by the arguments presented in point 9 of this comment.

Answer: The authors are not sure what the reviewer means when saying that it is clear why the subgrid-scale averaging scheme is performing better than the scheme based

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on precipitation rates. Furthermore, we are not sure why this could be explained by using the theory of the wet scavenging process, considering the size of particles involved in the transport of radioactivity over long distances. It is clear that "The long range transport of radioactivity from Chernobyl was associated mainly with particles in the submicron range for which in-cloud scavenging processes are much more important than below cloud scavenging". However, the scheme based on precipitation rates should also be able to describe this process since the in-cloud scavenging process is also included in this scheme. In both schemes a scavenging coefficient is calculated either by using the relative humidity fields or by using the precipitation fields from the MM5 model. The performance of the two schemes depend on how accurately the relative humidity or the precipitation is described in the MM5 model and on the accuracy of the parameterization of the scavenging coefficients in the two schemes. Of course, one can say, that given the better performance of the subgrid-scale averaging scheme, this confirms that the in-cloud scavenging process is more important for the submicron particles than the below cloud scavenging Ű probably due to in-cloud condensation processes. One important issue could also be the hydroscopic characteristics of the radioactive particles. The authors have not been able to find anything about this in the literature for the three species included in the study. This discussion has now been included in the conclusions of the manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 2, 825, 2002.