Atmos. Chem. Phys. Discuss., 6, S7447–S7453, 2007
www.atmos-chem-phys-discuss.net/6/S7447/2007/

Atmospheric
Chemistry
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Discussions

Interactive comment on "Including the sub-grid scale plume rise of vegetation fires in low resolution atmospheric transport models" *by* S. R. Freitas et al.

S. R. Freitas et al.

Received and published: 1 June 2007

Response to Anonymous Referee #2 The paper deals with the injection of buoyant plumes of gases and aerosols from biomass burning regions. Typically 3-d atmospheric and chemistry transport models treat very simply (or not at all) the vertical injection of these materials from biomass burning sources. Because of the differences in the wind speed in the planetary boundary layer from the winds aloft, there are important implications for gas and aerosol lifetimes, chemistry, and morphology when considering or neglecting the vertical dis-tribution of these materials over source regions. The authors present a 1-D cloud resolving model that simulates the buoyant transport of air and material over a fire, taking as input the atmospheric vertical profile of temperature and moisture and information about fire size and fire energy. This model returns as output

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the injection altitude of the emissions from the fire. Embedded in a 3-D atmospheric and chemistry transport model and coupled to a database of biomass burning regions the cloud-resolving model leads to prediction of the injection altitude associated with the fires. The paper is generally well written and interesting, and the work should be especially useful to global and regional scale modelers interested in the important problem of how to properly account for the vertical injection of materials from biomass burning fires.

We thank the referee for his/her kind words, the replies (A) to the specific comments (Q) are given below.

There are several comments to make however: Q1) In the introduction, the first paragraph should be split into two paragraphs, with the second paragraph beginning at the sentence In spite of the continuous increase in computing power... (page 11523, line 3). This could be further clarified: the first paragraph introduces the general importance of biomass burning events; the second paragraph should more smoothly connect the problem to a description of why modelers care, which is sort of neglected at the moment.

A1)We agree, thanks for your suggestion. The introduction now follows this way.

Q2) Page 11523, line 22, should read ...in an arbitrary way...

A2)Done.

Q3) In the paragraph continuing over onto page 11525, are all of these locations (Serra do Maranhao and Maraba) in Brazil?

A3)Yes, this information is now clearly stated.

Q4) Page 11529, lines 7-9, something doesnt make sense about how the fire size is treated in cases where there is no information about the instantaneous fire size. How then is the mean instantaneous fire size arrived at? I assume this is a typo.

A4)As stated above lines 7-9 of that page, the mean instantaneous fire size is calculated using all data for the 2002 dry season (July to November). Then, if a specific fire count has not valid information about the fire size, the mean value of entire distribution is used. To make this information clearly, the original sentence: “For WF ABBA detected fires that have no information about the instantaneous fire size, the mean instantaneous fire size is used” was replaced by: “This mean value is used when a specific fire count has not valid information about the instantaneous fire size”.

Q5) Page 11530, line 25: This begins a bulleted list outlining how the 1-D model is implemented in the 3-D model. Something not clear at this point in the text is how smoldering phase is handled. Does the plume rise model only apply to the flaming phase? Why or why not? How are the flaming and smoldering phases distinguished?

A5) Yes, the plume rise model is applied only to the flaming phase since the smoldering phase is much colder. In this case, the emissions will remain much closer to the boundary layer and it does not matter if one uses the plume model or release the emission just above model surface to be mixed up only by the turbulence scheme. These phases are simply distinguished using the “flaming phase consumption” parameter described at Table 1.

Q6) The final two paragraphs on page 11530 and into the bulleted list connect the 1-D cloud-resolving model to the problem of 3-D transport models. This requires a little more explanation. Steady state for the 1-D model is arrived at in 50 minutes, but this is larger than the time-step of typical 3-D transport models (which may be more like 5 - 15 minutes). So what are the implications here if the ambient atmospheric state is changing on something less than the time allowed for the 1-D model to reach equilibrium?

A6)The time of 50 minutes is the maximum time allowed to the plume model to reach the steady state. However, at most of the cases it is reached within 20 to 30 minutes or even less for small fires. Anyway, in our approach there isn’t any synchronism between the plume and the 3d atmospheric models. We just inquire to the plume model the injection layer should exist for a specific environmental condition provided by the 3d atmospheric model and use this information at the source emission field. This is a valid approach since the environmental condition changes at lower time scales and can be envisioned at Figure 7 (B).

Q7) Page 11531, line 16 (and other places in the text) word diel is used, and what I believe is meant is diurnal. This may be a difference of language, but I am unfamiliar with diel and suggest diurnal instead.

A7)Done, “diurnal” instead off “diel” is used.

Q8) Page 11532, line 16: please clarify here that the dry case is insensitive to the heat flux. The wet case has sensitivity, although it is confounded also by the fire size.

A8)The dry case is not totally insensitive to the heat flux, but presents a weak dependence for a fixed fire size (typically the height changes around ˜ 2 km for a heat flux spanning from 1 to 160 kW m-2). The situation for the wet case is not the same because here the effect of water vapor condensation is much larger. In addition, small changes in the flux heat can induce the air parcels reach the condensation level providing extra buoyancy due the latent heating release.

Q9) Page 11532, line 20: referring again the dry case, the parameterized dependence of height on heat flux is pointed out to be smaller than that in Manins, but I dont understand the point, since nothing else is said. The next sentence states that the results are also consistent with the finding from Heikes... These sentences seem out of order or out of context. Please clarify why these results are meaningful.

A9) Manins (1985) proposed a simple approximation to estimate the plume rise (Z, meters) in a stably stratified atmosphere in terms of the heat flux (P, GW): Z = 1434 (P)1/4. This formulation is frequently used to provide the height reach by wildfires plumes (e. g., Ferguson, et al.: Modeling the Effect of Land-Use Changes on Global

Biomass Emissions, in Biomass Burning and its inter-relationships with the climate system. Editeb by J. L. Innes, M. Beniston and M. Verstracte, pp 33-50, Kluwer Acad., Norwell, Mass., 2000). By the other hand, Heikes et al. (1990) used a 2-D model for simulate the plume rise from slash fires varying the size fire for a fixed heat flux. Their findings are consistent with ours for the dry case. This discussion situates our model results in the context of similar previous works.

Q10) Page 11533, lines 17-18: you mean that ...we could not perform more comparisons... and that More thorough comparisons... will appear later.

A10)Yes, thanks. This error was fixed.

Q11) Page 11535, line 4: thoses should be those.

A11)Done.

Q12) Page 11535: in discussing the frequency with which the 1-D model is called, since this model is clearly intended for inclusion in 3-D transport models, can you provide some statistics on how costly exactly this model is to run?

A12)The cost of this approach depends a lot on the spatial resolution of the 3d model. At very high resolutions the aggregation approach described on page 11528 is not efficient and the cost can be even prohibitive. In our case the cost is about 2 times the execution time without this approach.

Q13) Page 11535 and Figure 6: The caption to the figure (6a and 6d) indicates a dotted line, but I see a solid grey line. In general, the lines in these plots could be made larger and more distinct. Also, referring to the text, it is simply not clear how we are to determine the injection altitudes from 6b and 6e. Particular for 6e, I do not understand how the 3 km height is arrived at, or what it means. Does the smoke go uniformly from the surface to 3 km? The high heat flux line on 6e reaches nearly zero vertical velocity at about 1.5 and 3.5 km; which altitude is relevant to the injection height?

A13)New improved figure was drawn and we will ask to the Production Office to make larger plots. As stated at pages 11530 and 11531, the final rise of the plume is determined by the height which the vertical velocity of the in-cloud air parcel is less than 1 m/s with the searching algorithm starting from the top of the model. This is done for each heat flux and provides lower and upper limits which define a vertical layer. Then we assume that this layer is the most probably region where flaming material should be released.

Q14) Although some sensitivity of the model is explored to fire size and heat flux and atmospheric state on injection altitudes, what is not explored here is the interaction of those sensitivities on the distributions arrived at dynamically in the 3-D model. Can this be explored at all? In other words, although the plume rise versus surface injection is explored in Figure 7, what is the sensitivity to these other variables in a similar fashion?

A14)Thanks for asking, this is certainly a point worthwhile to be mention in the text (the discussion below was included at conclusions): The uncertainty in the injection height associated with the uncertainty of the fire size and heat flux are expected to not affect significatively the smoke distribution in the 3-D model because it is typically of the order of 1 - 3 vertical layers of the 3-D transport model at that levels (above boundary layer, the thickness of model vertical layers increases from ˜ 400 to 850 meters), This in particularly true for a typical dry season situation like that one showed at Figure 2 A. On the other side, it is important to emphasize that the plume rise model sensitivity to the environmental thermodynamic is much more significant, like showed at Figure 7 B, and, so, it fully justify the choose for an ‘on-line’ and coupled approach of the plume rise model with the 3-D transport model.

Q15) Figure 9 - 13: These lines are very hard to tell apart. I suggest that the two panels of each plot be made somewhat wider and the colored lines thicker so that the studies are easier to tell apart.

A15)As we send encapsulated postscript files to ACPD, they can easily make bigger and ticker figures keeping high quality. We will ask to the Production Office to do that.

Q16) What would really make this 1-D model more compelling is if the plume rise and surface injection cases were compared in the context of a horizontal plot showing geographic CO distributions. This seems curiously missing.

A16)We did not show horizontal plots because these results were published and discussed at the previous paper: Freitas, S. R., Longo, K. M., and Andreae, M. O.: Impact of including the plume rise of vegetation fires in numerical simulations of associated atmospheric pollutants, Geophys. Res. Lett., 5 33, L17808, doi:10.1029/2006GL026608, 2006.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 11521, 2006.

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