Atmos. Chem. Phys. Discuss., 14, C709–C714, 2014
www.atmos-chem-phys-discuss.net/14/C709/2014/
© Author(s) 2014. This work is distributed under
the Creative Commons Attribute 3.0 License.

Atmospheric Chemistry and Physics Discussions
Open Access

ACPD
14, C709–C714, 2014

Interactive Comment

Interactive comment on "Constraining CO_2 emissions from open biomass burning by satellite observations of co-emitted species: a method and its application to wildfires in Siberia" *by* I. B. Konovalov et al.

I. Konovalov

konov@appl.sci-nnov.ru

Received and published: 25 March 2014

I thank the reviewer for the thorough evaluation of our paper, for the thoughtful comments and useful suggestions. The reviewer's comments will be carefully addressed in the revised paper, and our in-detail response will be published in the interactive discussion later. As the leading author, here I would like to express my opinion concerning major issues raised in the "general comments" of the reviewer.

First of all, I would like to note that since our manuscript covers a wide range of topics (as it is mentioned also by the reviewer), we had to make special efforts aimed at keeping the length of the paper limited. In view of the reviewer's comments, I admit that, partly as a result of these efforts, several important points might have been addressed in the paper insufficiently.

The reviewer noted that the "the approach suggested in the paper tries to constrain the major component of the plumes by observing two minor ones" and concludes that "one can never obtain good accuracy with this". I agree with the first part of this statement but I cannot fully agree with the conclusion. Indeed, we constrain CO2 emissions through optimization of the FRP (Fire Radiative Power) to BBR (Biomass Burning Rate) conversion factors. And, while optimizing these factors, we do not involve any information or assumptions about the relation between the measured species and CO2 emissions. Moreover, the fact that CO2 is a major component of the plumes is responsible for a very small uncertainty of the CO2 emission factors, which is added in our analysis to a much larger uncertainty of the FRP-to-BBR conversion factors. The key factors limiting the accuracy of our estimates of the conversion factors (and, consequently, of CO2 emissions) are uncertainty in the emission factors of the observed species (this uncertainty can, in principle, be reduced by extensive dedicated measurements of the emission factors in a study region), the measurement errors (the progress in satellite measurements of tropospheric composition during the last several years is spectacular, and if it continues, these errors will be strongly reduced) and the model errors (which, likely, will also become smaller in the future). This is why I'm very optimistic about the potential of the approach suggested in our manuscript. As far as I know, there is yet no sensible alternative to it (in particular, satellite CO2 measurements can hardly be very helpful in this respect due to the fundamental reasons mentioned in Introduction).

The reviewer argues that errors in the CO and PM emission factors can be correlated, particularly because "both CO and PM fractions in smoke refer to poor-combustion conditions". I agree that, in principle, it can be so, and that a corresponding point should have been discussed in the paper in much more detail. However, in my opinion,

ACPD
14, C709–C714, 2014

CC BY

this potential correlation is actually not strong enough as to invalidate major results of our study. The arguments supporting this opinion are following.

First, the fact that our estimates of the FRP-to-BBR conversion factors are in a good agreement with the direct local measurements by Wooster et al. (2005) indicates that most of biomass burning (BB) emissions in Siberia come from flaming fires (rather than from smoldering fires in poor-combustion conditions). Second, a direct statistical analysis of the random (that is, varying in space and time) errors in our estimates of the FRP-to-BBR conversion factors derived independently from CO and AOD measurements shows that the covariance of these errors is, on the average, at least 40 times smaller than the respective variances and, moreover, is negative. To perform such analysis, the whole data set was randomly divided (without intersection) into N subset (2<=N<=20), and the FRP-to-BBR conversion factors were derived independently from each subset (the emission factors were fixed and equal to values listed in Table 1). One could expect that if the random parts of the errors in the CO and PM emission factors strongly covariated in time and space, and if the contribution of these errors to the errors in the FRP-to-BBR conversion factors were significant, then the above mentioned covariance would be large and positive. Since it is not the case, we conclude that at least one of these conditions is not satisfied. Third, we interpret the systematic uncertainties in the average emissions factors (that is, the uncertainties listed in Table 1 and prescribed in our Monte Carlo experiment) as the discrepancies between emission factor measurements performed in an ecosystem of a given type by different groups in different regions of the world. Typically, the different series of measurements covered a variety of burning conditions, so we assume that the discrepancies between the data of different groups reflect mostly regional differences between vegetative population as well as measurement uncertainties. Unfortunately, available data of emission factor measurements are presently too scarce and do not allow us to prove this assumption. Nonetheless, plotting 6 available data points of contemporary CO and OC emission factor measurements in the case of "Savanna and Grassland" land cover category from the database of M.O. Andreae (unpublished data, 2013) reveals that correlation be-

ACPD
14, C709–C714, 2014

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

CC BY

tween the emission factors of these species is indeed quite negligible (r<0.08). In view of these arguments, I'm not sure that taking hypothetical (and actually not known) covariances between errors in the CO and PM emission factors into account and further serious complication of our study are really necessary, and I hope that presentation of the additional analysis outlined above in the revised manuscript will provide a sufficient response to the reviewer's concern.

The reviewer criticizes our handling of the large difference between the CO and AOD measurement based estimates of FRP-to-BBR conversion factors. In general, I agree with the criticism, and we will try to address this point more carefully in the revised manuscript. In particular, CO2 emission estimates based only on CO and only on AOD measurements will be presented in addition to the combined estimates which will be accompanied by an appropriate caveat. I believe that in spite of the fact that some earlier studies indicated large discrepancies between the bottom-up and top-down estimates of PM emissions, our AOD measurement based estimates of the FRP-to-BBR conversion factors and of CO2 emissions are sufficiently reasonable and valuable. Indeed, it has never yet been proven that the PM emission factors reported in the literature are totally wrong; rather, it is known that they exhibit very large uncertainties which can explain a large part of the discrepancies (as it is in our case). It has also never been proven that the state-of- the-art chemistry transport model results concerning evolution of BB aerosol are fundamentally flawed. On the contrary, several studies (including this one) showed that the models are capable of reproducing both spatial structure and temporal evolution of aerosol rather adequately. Moreover, different studies (cf., e.g., Kaiser et al., 2012; Konovalov et al., 2011; Pereira et al., 2009) came to quite different conclusions regarding the character and even existence of the mentioned discrepancies. Accordingly, we believe that despite (and even because of the mentioned problem) different top-down emission estimates derived from AOD measurements by using the state-of-the-art models remain quite interesting and stimulating. Note that presently the authors investigate a possibility to explain and eliminate large discrepancies between the bottom-up and top-down esti-

ACPD
14, C709–C714, 2014

CC BY

mates of BB aerosol emissions by applying the alternative (volatility basis set) modeling approach (see, e.g., http://meetingorganizer.copernicus.org/EGU2014/EGU2014-5036.pdf). However, it seems so far unlikely that this approach will soon allow us (or other groups) to make quite definite conclusions regarding the origin of the discussed discrepancy; indeed, values of many parameters of this method in the case of biomass burning are presently too uncertain.

The reviewer also strongly criticizes the re-use of the same data (initially used for optimization) for validation purposes. In principle, I agree with this reviewer's comment. The main reason for this re-use is our desire to reduce the uncertainties in our emission estimates by considering as much data as possible. It should be noted that while we optimize only two parameters, we compare the spatial temporal fields of AOD and CO simulations and measurements, which have effectively many more degrees of freedom. Obviously, such optimization could not help if the fire emissions were totally wrong (for example, were random or constant both in space and time). Nonetheless, following the reviewer's suggestion, we will update our analysis and results by splitting the whole dataset into two parts. In particular, it is already found that when each two consecutive days in the period considered are allocated to the optimization subset and the third one is attributed to the validation subset, our results change quite insignificantly (compared to the case when all the data were used for optimization).

References

Kaiser, J. W., Heil, A., Andreae, M. O., Benedetti, A., Chubarova, N., Jones, L., Morcrette, J.-J., Razinger, M., Schultz, M. G., Suttie, M., and van der Werf, G. R.: Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power, Biogeosciences, 9, 527-554, doi:10.5194/bg-9-527-2012, 2012.

Konovalov, I. B., Beekmann, M., Kuznetsova, I. N., Yurova, A., and Zvyagintsev, A. M.: Atmospheric impacts of the 2010 Russian wildfires: integrating modelling and measurements of an extreme air pollution episode in the Moscow region, Atmos. Chem.

ACPD
14, C709–C714, 2014

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

Phys., 11, 10031-10056, doi:10.5194/acp-11-10031-2011, 2011.

Pereira G., S.R. Freitas, E.C. Moraes, N.J. Ferreira,Y.E. Shimabukuro, V.B. Rao, K.M. Longo, Estimating trace gas and aerosol emissions over South America: Relationship between fire radiative energy released and aerosol optical depth observations Atmospheric Environment 43, 6388–6397, 2009.

Wooster, M.J., Roberts, G., Perry, G.L.W., and Kaufman Y.J.: Retrieval of biomass combustion rates and totals from fire radiative power observations: FRP derivation and calibration relationships between biomass consumption and fire radiative energy release, J. Geophys. Res., 110, D24311, doi:10.1029/2005JD006318, 2005

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 3099, 2014.