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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Climate effects of seasonally varying biomass burning emitted carbonaceous aerosols (BBCA)" *by* G.-R. Jeong and C. Wang

Anonymous Referee #2

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Review of "Climate effects of seasonally varying biomass burning emitted carbonaceous aerosols (BBCA)" by G.-R. Jeong and C. Wang

General Comments

This paper investigates the climate effects of seasonally varying biomass burning carbonaceous aerosols (BBCA) using an aerosol-climate model. The main conclusion is that seasonally varying BBCA has significant local and remote climate impacts, in particular on clouds and precipitation that extend throughout the year; seasonally varying BBCA is therefore necessary for robust climate simulations.

The climate effects of BBCA are quantified by comparing a model experiment with monthly varying biomass burning emissions to a corresponding experiment with non-seasonal BBCA emissions (all months have the annual mean emission). Both model runs possess the same fossil fuel and biofuel BC and OC emissions. Experiments are run with both a slab ocean model (to estimate climate effects with feedbacks) and climatological SSTs (to estimate the direct radiative forcing without feedbacks).

Seasonally varying BBCA results in an increase in external mixtures of BC and OC, with maximum changes near the BB source regions. The change in BC- and OC-sulphate mixtures, however, extend beyond the BB source regions and seasons. The TOA direct radiative forcing (DRF) is generally negative (global annual mean values of -0.11 W/mˆ2 without feedbacks and -0.24 W/mˆ2 with feedbacks), implying cooling of the climate system. Compared to non-seasonally varying BBCA, this represents an increase of 58% and 15%, respectively, although much larger seasonal changes exist, especially for MAM. These TOA DRF changes are larger for all-sky fluxes, as opposed to clear sky fluxes, implying the importance of clouds.

Consistent with the above, the authors find that the climate effects of seasonally varying BBCA extend beyond the BB source regions, in space and time (i.e. large signals exist in non-BB seasons). This is attributed to climate feedbacks arising primarily from cloud changes. The main climate signal is a northward displacement of the ITCZ, as represented by changes to convective precipitation (PRECC) and convective cloud (CONCLD).

The main conclusion of this paper is new and important and I recommend eventual publication. The manuscript is also relatively well written and the methodology appears sound. However, I found the manuscript lacked sufficient interpretation of the results. The majority of the paper presents the climate effects of BBCA, without much interpretation, or attempts to explain the resulting signals. For example, the authors appeal to cloud changes to explain the effects of seasonally varying BBCA on DRF. However, this is a blanket explanation, without detailed analysis. We do not know if seasonally varying BBCA results in a net increase or decrease in cloud cover and if that is con-

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sistent with the change to DRF. Furthermore, if cloud changes are so important, what causes the cloud changes? Are they changing due to general circulation effects (like the northward CONCLD/ITCZ change), or are they changing due to stability effects, changes to relative humidity, etc?

In addition, the climate signal that is explained–the northward shift of the ITCZ–is lacking sufficient support. The authors suggest that the northward shift is due to more NH warming. But they never show the NH warms more than the SH, nor is it intuitive that this would be the case. Furthermore, why is the shift northward in all months except DJF, when it moves southward? An analysis of the temperature change, beyond the Hovmoller Tsfc plot in Figure 10a, would be very useful in general, as well as to support the ITCZ argument. This is further warranted by the fact Figure 10a appears to show more SH, as opposed to NH, Tsfc warming, which would be inconsistent with the above argument. Also, are Tsfc changes related to the cloud changes?

As another example of insufficient interpretation, Figure 10a also shows significant mid and high-latitude warming, yet no BBCA emissions occur here (especially poleward of 60 degrees). Yet this signal–which appears to be a significant and important response–is never discussed.

The revision needs to include more interpretation and explanation of the climate response, such as those just mentioned.

Specific Comments

1. Please explicitly state that you are modeling and investigating direct effects only and that indirect (i.e. cloud microphysical) effects are not considered. This needs one, if not two sentences. Unless I am mistaken and you are using "direct" radiative forcing in a completely unconventional way? Perhaps explicitly defining DRF would be useful.

2. Not only do BB aerosols possess significant seasonal variation, but interannual variation as well. I think this should be mentioned, since it adds to the importance of

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BBCA. Also, it appears your results may suggest the importance of BBCA during warm versus cold phases of ENSO, etc.

Abstract

1. line 7 says there is a decrease in internal mixtures. Isn't there an increase in MOS?

2. line 12 says differences in Tsfc and heat fluxes are limited to BB source regions. I do not understand this, since Figure 10 shows otherwise. Also, the subsequent sentence seems to imply Tsfc is not affected by cloud changes, which I do not understand.

3. I do not follow the last sentence.

Introduction

1. page 9434, line 6. Wang 2004 is referenced to support BC-induced global scale climate changes. Yet, this paper concludes the climate effects of BC aerosols are more significant on the regional, rather than the global, scale.

2. page 9434, line 12. Are BC aerosols associated with the positive or negative phase of ENSO?

3. page 9434, line 1. Remove "at" from "...which it is a..."

4. line 11. GEIA=Global Emissions Inventory Activity. How do the GEIA estimates compare with others (e.g. GFED)?

5. The vertical distribution of aerosols, relative to clouds, has a significant impact on whether cloud cover increases or decreases. This should be mentioned, along with a reference.

Model and configuration

1. Page 9437, line 24. Remove "the difference as"

Results

1.Page 9438. Discussion of the tables is confusing. Try to re-structure the paragraph to be more clear/concise on the main points of the tables.

2. Page 9438, line 26. More negative relative to what?

3. Page 9442, line 25. Figure 10 should be 11. Although there is inconsistency with Figures 10 and 11, between what the text says, and what those figures show. For example, Figure 11 does not show monthly means of CONCLD. No figure does.

Tables

1. Tables 1 and 2 are a bit confusing. I suggest adding a sentence to the caption saying, “Top two rows show all-sky values, bottom two rows show clear-sky values”.

2. Replace the caption of Table 2 with, “As in Table 1, except for online runs”.

3. Remove the four instances of “in” in "...relative to in non-seasonal..."

Figures

1. The Hovmoller plots are very useful and a concise way to show the monthly effects.

2. Generally, the figures are too small, which is probably because most include several panels. But maybe this is not an issue for pdfs/online viewing.

3. Figure 1. Units?

4. Figure 8. Change scale label resolution.

5. Figure 9. What are the white areas?

6. Figure 10. At what level is QRS taken? Is it the column average?

7. Figures 11 and 12. To explicitly show a northward shift, the control values (e.g. PRECC, CONCLD) should also be plotted.

8. Again, I suggest a spatial plot of Tsfc or T_troposphere, and more analysis of the temperature response.

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Interactive Comment

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 9431, 2010.

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