

Interactive comment on “Effect of biomass burning on marine stratocumulus clouds off the California coast” by J. Brioude et al.

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We would like to thank the reviewer for her/his time and effort and appreciate her/his positive review of our paper.

Main comment

My main comment is that stratocumulus clouds have a strong diurnal cycle. It was not clear to me from reading the paper how well this variation is addressed in the satellite observations and in the modelling. Please clarify in sect. 2 what the diurnal sampling is of the GOES satellite products used, and if the same temporal averaging has been performed for satellite and model data. Please clarify in sect. 4 to which diurnal times (or diurnal time averages) the maps and results relate.

C5253

Since shortwave radiation has a strong diurnal cycle, please clarify in sect. 6 to which time (or time average) the radiative forcing results relate.

=> We agree with the reviewer that the fact that we focused on 14:00 local time in the article is not stated clearly enough. While we mentioned in the introduction that we focused our study on 14:00 local time, because we expect an active aerosol indirect effect at this time of the day. We now state this more clearly throughout the text. We used hourly average FLEXPART output and GOES satellite data at 14:00 pm throughout the paper, except for MODIS products which were compared with 12:00 FLEXPART output, which is roughly the overpass time of Terra in the region. We will modify the manuscript to emphasize that more clearly.

Specific comments "Abstract, l. 14 ff: please explain briefly why aerosols above the BL increase cloud fraction and aerosols inside the BL decrease cloud fraction (because this sounds counterintuitive)."

=> We have added a comment in the abstract.

p. 14536, l. 1: over- or underestimate

=> Thanks. Fixed

p. 14537, l. 21: "why was the cloud fraction calculated? was there no standard (operational) cloud fraction available from GOES?"

=> The operational product is at 4-km resolution sampled to 8 km. We preferred to use a higher resolution for the cloud fraction.

p. 14538: - l. 3: was a specific time of the day used, or were the daily-mean satellite cloud products used?

=> Yes, the study is focusing on 14:00 local time.

- l. 12: "arbitrary model concentrations": please clarify and refer to the next section.

C5254

=> The mass concentration of anthropogenic and BB aerosol is arbitrary because we don't simulate all the primary aerosol production and secondary production. So we used the aerosol mass concentration product from MODIS to convert our "arbitrary" aerosol tracers into a realistic one.

- I. 16: does the BL height in Fig. 1a follow from observations or from a model?

=> The boundary layer height comes from FLEXPART. We added this information in the caption.

p. 14539: - first paragraph: now Fig. 1d is discussed before Fig. 1c, which is not logical; please change the figure order

=> We modified the order.

- I. 9: is different from what?

=> We added "different than inland" in the text.

- I. 12: "... compared to the MBL further offshore": please discuss or show in Fig. 1 the tracer profile further offshore

=> We added a comment in the text.

- in the second paragraph, the terms "near the coast", "offshore", and "further offshore" should be differentiated more clearly

=> We stated that "further offshore" means more than 1000km from the coast.

- sect. 4.1: which version of the MODIS aerosol product was used? Reference?

=> This information has been given in section 2.2

p. 14540, I. 6 ff: the correlations in Fig. 2 are quite poor. Please discuss the reason(s). Is the FLEXPART model of sufficient quality?

=> This poor correlation can be the consequence of MODIS aerosol retrieval inaccuracy, the inaccuracy of the transport of FLEXPART passive tracers, and the size of the grid over which the relationships are calculated. We added a comment in the text.

C5255

racy, the inaccuracy of the transport of FLEXPART passive tracers, and the size of the grid over which the relationships are calculated. We added a comment in the text.

p. 14541: - I. 7: please do not start the discussion with Fig. 3c but with 3a (or change the order of the figures).

=> We changed the order.

- I. 12: microphysics:

=> Corrected

- I. 13: LPW > LWP (2x) ; and please remove the brackets after ln (4x); they have no function

=> Thanks. Corrected.

p. 14542: - I. 1: "biomass burning aerosols" > "the biomass burning aerosols in this case".

=> Thanks. Corrected.

- I. 1: are these Californian aerosols less hygroscopic than the aerosols in previous studies?

=> Yes because the previous studies didn't focus on biomass burning aerosols but on anthropogenic aerosols.

- I. 5: dependency on what?

=> dependency of IE on LWP. We modified the sentence.

- I. 5 ff: another possible reason for the low IE values in this paper could be the accuracy of the tracer model used.

=> We agree with the reviewer. We added a comment in the text.

- I.16-17: please cite the IE values of Breon et al.

C5256

=> We added in the text that they found 0.085 over the oceans and 0.04 over land.

- I. 18 and I. 20: the term “biomass burning” is often used in this paper where “biomass burning aerosols” are meant. Please correct in the relevant places.

=> Thanks. We added "aerosols" when needed.

- please add to sect. 4 that Fig. 3a and 3b are two independent determinations of IE, and discuss their quantitative agreement.

=> We added a comment in the text.

p. 14544: - I. 12: temperature.

=> Fixed

- I. 18 and I. 19: biomass burning aerosol

=> fixed

p. 14545: - I. 4: 2.25 deg x 2.25 deg; please use the unit deg x deg for grid cells; this also occurs in other places

=> We changed the unit.

- I. 7: differences: between what and what? Please indicate the sign.

=> We have modified the sentence.

p. 14546: - I. 5-6: please number the equations; this also holds for the equations in sect. 6

=> The equations are numbered now.

- I. 20: please define ε_f and ε_A in a formula for clarity.

=> We agree. We added 2 equations for more clarity.

- I. 20: subscript Alb > A

C5257

=> Thanks. Fixed

p. 14547: - I. 6 ff: radiative flux > shortwave radiative flux

=> Fixed

- I. 11: in this equation two terms are missing: (1) The cloudfree sky (Rayleigh+aerosol) reflection part, having weight 1-f. (2) The radiative interaction between aerosol layer and cloud layer. Even if T includes the aerosol extinction, it should be made clear that this simple equation only considers the first-order radiative effect of clouds.

=> (1) because the underlying surface is the ocean, and because we assume that the ocean has an albedo equal 0, this term is not necessary. (2) We will make it more clearly

- I. 12: how was T calculated?

=> T is not calculated in the paper. However, because T includes aerosol radiative effects, we divided the variation of F by the incoming flux and T^2 to get the variation of F in percent due to aerosol indirect effect only. If we had calculated T, we would have been able to calculate δF in Watt per square meters. However, a radiative model is needed to do that.

- I. 15: due to the biomass burning aerosol indirect effect

=> Fixed

- I. 18: variations > changes

=> Fixed

p. 14548: - I. 4: biomass burning aerosol

=> Fixed

- please clarify if δF is an instantaneous forcing (for one time of the day) or a

C5258

diurnal mean forcing

=> δF is valid at 14:00 local time. We added a comment.

p. 14549: - l. 22-26: biomass burning > biomass burning aerosol

=> Fixed

- same lines: where is this information on the concentrations in the three years coming from?

=> The information comes from FLEXPART and the fire detection from GOES satellite.

- Fig. 10 is unclear; please also show the emissions per year, and not only the forcings.

=> See the comment below.

p. 14550: - l. 22-23: please clarify if this is an instantaneous forcing (for one time of the day) or not; note that on p. 14551, l. 11, it is mentioned "throughout the rest of the day ...": so to which time of the day does the analysis relate? =>
We clarified it.

Caption Table 1: high continental tracer > high continental tracer load

=> Fixed

Figures Generally, the figure captions should be clarified to be better understandable "standalone". Please indicate where the data points come from (model or observation).

Fig. 1:

- unit on x-axis of (a) missing

- units on x- and y-axis of (b) missing (or explain in caption, and mention that it is a map)

- in caption say that these are (?) FLEXPART model results

C5259

=> We corrected the figure and the caption.

Fig. 2: mention FLEXPART in the caption

=> We added FLEXPART in the caption

Fig. 3: please use decimal notation for the IE values in the plots. In the caption please mention that the lines are power law fits, and that the BBA concentrations are FLEXPART model results.

=> We modified the figure.

Figs. 4, 5, 6, 8, 9: say in the caption that these are maps (and give x-y-units).

=> We added this information in the different captions

Fig. 4: averaged over June-July 2006-2008 ?

Fig. 5, caption: variation > change or difference? Is this variation or difference really (a)-(b)? It would be more logical to show (b)-(a).

=> We used the word "difference". We made a mistake in the caption. (a) is subtracted from (b), so yes the values show the results for (b)-(a).

Fig. 6, caption: differences: what minus what? In the bottom right plot: (m) > (deg C).

=> We modified the caption to make it clearer.

Fig. 7, caption: please give more information on the data points: where do they come from?

=> Each data point is the average of 50 points in cloud fraction and cloud albedo bins of 0.05.

Fig. 8, caption: aerosols: BB aerosols or other types of aerosols?

C5260

=> here "aerosols" mean "anthropogenic aerosols".

Fig. 9, legend: radiative impact > radiative forcing

=> Corrected

Fig. 10: This figure suggests a higher sensitivity of clouds to aerosols in 2008 as compared to the other years. Therefore, the figure should also show the BBA concentrations (emissions) per year. Please make three subplots, one for each year, to have a clearer comparison.

=> We don't think that the emission per year is suitable. What matters is the concentration of BB aerosols in offshore continental airmasses. We added the average concentration of BB aerosols for the 3 different years in the caption, and added in the text the percentage of time when a offshore continental airmass were associated with BB aerosols. We think also that the colored areas on this figure can potentially be misleading, and decided to remove them.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 14529, 2009.