**Atmospheric
Chemistry
and Physics
Discussions**

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

Anonymous Referee #1

Received and published: 27 August 2009

General

This paper addresses the topic of indirect and semi-direct effects of aerosols by a combination of satellite observations and atmospheric modelling. Specifically, the paper studies the impact of biomass burning aerosols on the stratocumulus clouds off the coast of California. The paper not only quantifies the cloud fraction and cloud particle radius effects of biomass burning aerosols (BBA), but also estimates the radiative impact of these cloud effects.

This is an excellently thorough paper. It is well written; it has a good introduction, complete and informative; it is creative in the combination of GOES satellite data with FLEX-PART tracer model results; it has a thorough analysis of measurements and model results; it is complete in the discussion of other effects than aerosol effects. In short, this

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paper presents an important quantitative contribution to the study of aerosol effect on clouds (indirect effect), and should be accepted, after clarification and minor revisions as indicated below.

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

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 counter-intuitive).

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

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

p. 14538:
- l. 3: was a specific time of the day used, or were the daily-mean satellite cloud products used?
- l. 12: "arbitrary model concentrations": please clarify and refer to the next section.
- l. 16: does the BL height in Fig. 1a follow from observations or from a model?

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

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change the figure order
- l. 9: is different from what?
- l. 12: "... compared to the MBL further offshore": please discuss or show in Fig. 1 the tracer profile further offshore
- in the second paragraph, the terms "near the coast", "offshore", and "further offshore" should be differentiated more clearly
- sect. 4.1: which version of the MODIS aerosol product was used? Reference?

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

p. 14541:
- l. 7: please do not start the discussion with Fig. 3c but with 3a (or change the order of the figures).
- l. 12: microphysics:
- l. 13: LPW > LWP (2x) ; and please remove the brackets after $\ln$ (4x); they have no function

p. 14542:
- l. 1: "biomass burning aerosols" > "the biomass burning aerosols in this case".
- l. 1: are these Californian aerosols less hygroscopic than the aerosols in previous studies?
- l. 5: dependency on what?
- l. 5 ff: another possible reason for the low IE values in this paper could be the accuracy of the tracer model used.
- l.16-17: please cite the IE values of Breon et al.
- l. 18 and l. 20: the term "biomass burning" is often used in this paper where "biomass burning aerosols" are meant. Please correct in the relevant places.
- please add to sect. 4 that Fig. 3a and 3b are two independent determinations of IE, and discuss their quantitative agreement.

p. 14544:
- l. 12: temperature.
- l. 18 and l. 19: biomass burning *aerosol*

p. 14545:
- l. 4: 2.25 deg x 2.25 deg; please use the unit deg x deg for grid cells; this also occurs in other places
- l. 7: differences: between what and what? Please indicate the sign.

p. 14546:
- l. 5-6: please number the equations; this also holds for the equations in sect. 6
- l. 20: please define ϵ_f and ϵ_A in a formula for clarity.
- l. 20: subscript Alb > A

p. 14547:
- l. 6 ff: radiative flux > shortwave radiative flux
- l. 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.
- l. 12: how was T calculated?
- l. 15: due to *the* biomass burning *aerosol* indirect effect
- l. 18: variations > changes

p. 14548:
- l. 4: biomass burning aerosol
- please clarify if δF is an instantaneous forcing (for one time of the day) or a diurnal-mean forcing

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

- same lines: where is this information on the concentrations in the three years coming from?
- Fig. 10 is unclear; please also show the emissions per year, and not only the forcings

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?

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

Figures

Generally, the figure captions should be clarified to be better understandable "stand-alone". 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

Fig. 2: mention 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.

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

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).

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

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

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

Fig. 9, legend: radiative impact > radiative forcing

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.

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