

Interactive comment on “Microbiology and atmospheric processes: chemical interactions of Primary Biological Aerosols” by L. Deguillaume et al.

L. Deguillaume et al.

Received and published: 11 April 2008

We thank the reviewer for helpful and relevant remarks that have been taken into account and should improve the paper's quality. The manuscript has been revised (especially Sections 1 and 2) and several points raised by the reviewer have been clarified. In the following, please find our comments to the general and specific criticisms, and how we modified the manuscript to answer to the various issues.

Response to general comments:

"The paper seems to overextend itself when it summarizes the large range of aerosol processes in the atmosphere, including cloud processes. This is meant as a framework for considering the participation of bioaerosols in these processes, and that is natural.

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Yet, it might be better to assume a certain degree of familiarity on the readers; part with these issues and focus more directly on the special features that relate to the bioaerosol."

The introduction and most of the sections of the paper have been rewritten to simplify the presentation of aerosol processes and better focus on PBA special features.

"Section 2 sets out to generate an appreciation for the abundance of bioaerosols. This goal is only partially accomplished. The examples seem somewhat anecdotal rather than comprehensive, and the authors do not indicate their assessments of the importance of one or another finding."

Section 2 has been restructured and is now organized as follows: (1) Description of PBA sources and variability; (2) Details on their abundance in atmospheric aerosols and clouds (sporal, HULIS, OC). The title has also been modified to "Sources and abundance of primary biological aerosols in atmospheric aerosols and clouds".

"In Section 3, exemplifying the comment I made at the beginning, the first paragraph is poor, whereas the second and subsequent paragraphs are much clearer and more useful. The paper begins to "take off" with this material."

First, Figure 1 has been clarified with indication of processes specifically related to PBA (in red) amongst other aerosol processes. Secondly, beginning of Section 3 has been rewritten as "Airborne micro-organisms have a potential role in cloud chemistry as illustrated in Figure 1. They can be activated into cloud droplets (Möhler et al., 2007) and consume chemical compounds in the aqueous phase, thereby competing with photochemistry and multiphase processes (dissolution, reactivity, scavenging and deposition)."

"With respect to Section 4, the impression is that it is focussed on processes at the expense of directing attention to completing what is known about the cycles of PBA from sources to removal, characterization of sizes and cloud nucleating ability, and

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dependence on location (land, sea, land cover, ...), season, altitude, etc. That focus is in accord with the title of the paper and most of its content (except Section 2), but it is difficult to think of priorities and to consider approaches to attacking the problems listed without the perspective provided by these diagnoses."

Section 4 does focus on supplementary aspects of PBA processes rather linked to atmospheric chemistry. For instance, cloud nucleating ability is also mentioned at the end of Section 4 to underline a renewed interest now turned towards modifications of PBA surface properties by chemical processes.

"It would be helpful if the authors settled on one set of terminology to the maximum extent possible. Now there is "air particulate matter" and "aerosol". There is "bioaerosol" and "airborne micro-organisms" and "primary biological aerosol". If some important distinctions are meant, that should be made clear, or, if they are used only for a variation in sound than their equivalence should be made evident."

We have chosen in the manuscript to refer to "PBA" for the inert and active biological particles and to "airborne micro-organisms" for metabolically active ones. This is specified in the introduction with the following sentence: "PBA are ubiquitous in the atmosphere (Gregory, 1961). They can be viable organisms capable of metabolic reactions which can involve atmospheric organic compounds and oxidants (airborne micro-organisms) (Ariya and Amyot, 2004; Sun and Ariya, 2006). They also comprise either biological particles including alive, dead cells and cell fragments, capable of nucleating cloud droplets and ice particles via physical processes (Möhler et al., 2007; this issue) or any kind of organic substances deriving from biomolecules and contributing to aerosol masses." This also has been modified through the whole manuscript avoiding multiple designations.

Response to the "technical comments":

-pg 842, In 18: This reference to the spread of diseases is probably meant as a historical one, in the sense that knowledge of those events constituted early diagnoses of the

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fact that microorganisms can spread through the air. This emphasis would be better than the current one that seems to focus on the fact itself. Also, there are broader references for this than the one given (Gregory, P. H., 1961: The microbiology of the atmosphere, Leonard Hill [Books] Ltd., London, New York, xv+251 pp.; Gregory, P. H., 1971: The Leeuwenhoek Lecture, 1970: Airborne microbes: Their significance and distribution. Proc. Roy. Soc. Lond., 177, 469-483; Edmonds, R. L., 1979: Aerobiology: The ecological systems approach. US-IBP (International Biological Program) Synthesis Series No. 10, 386 pp.).

The first paragraph of the introduction has been revised following the reviewer's comments. References indicated above have been added in the reference list.

- pg 842 In 25: *Vali (1996) has no co-authors.*

Vali et al., (1996) has been replaced by Vali (1996).

- pg 843 In 17: *Remove the word "particles".*

The word "particles" has been deleted from the title.

- pg 844 In 14: *The inclusion of 'components' in the definition may have to be refined, since PBA can become attached to other materials while in the air, as well as becoming airborne together.*

Section 2 has been rewritten following this remark and the general comment on consistency in terminology.

- pg 846 In 19: *Use "aerosol", not "aerosols".*

The "s" has been deleted.

- pg 846 In 23: *This paragraph goes through many different measures of bacterial abundance without any ready basis for comparisons because of the variety of methods and units. This is confusing. In line 26 it is not clear if the units are per volume of air or volume of water. Would a table be more direct? Also, ranges might be as revealing as*

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mean values.

There is a mistake line 26. The number of micro-organisms ranges from 10^3 to 10^5 cells mL^{-1} of water. Measurements of the number of micro-organisms in water are given per mL^{-1} of water. When the cloud liquid water content is available, we indicate the air equivalent concentration of micro-organisms (number per m^{-3} of air). The scope of this section is to provide the available density of micro-organisms in atmospheric water. The variety of methods to measure bacterial abundance is detailed elsewhere in the paper of Georgakopoulos et al. submitted to Biogeosciences Discussion in the same special issue.

- pg 847 In 17: In Fig. 1. it appears that 'Particules' is used for non-biological material. A new definition? This just adds emphasis to the comment made earlier about consistency in terminology.

As indicated in the response to general comments, the terminology for the "biological material" has been clarified in the whole manuscript. Figure 1 has also been clarified with indication of processes specifically related to PBA (in red) amongst other aerosol processes. The word "particles" has been replaced by "aerosols".

- pg 847 para 1: It seems to say that the liquid phase is "exchanging chemical molecules" with the condensed phase. Too many words here without proper scrutiny. The second sentence ascribes the indirect effect to liquid phase chemistry; that is not correct.

The first paragraph of Section 3 has been rewritten as indicated in the response to the general comments. Therefore, errors raised by the reviewer have been eradicated.

- pg 848 In 1: "chemical molecules" is a redundant phrase.

"Chemical molecules" has been replaced by "chemical species".

- pg 852 In 27: The implication of a cause-effect relationship between chemical composition and the concentration of micro-organisms is probably not what the authors

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5, S324–S329, 2008

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meant. Some correlations maybe. In any case, shouldn't this be in Section 2?

This sentence is unclear, as indicated by the reviewer, and has been replaced by "The concentration of micro-organisms and the chemical composition of cloud water are clearly correlated".

- pg 853 In 5: Qualifying the processes here discussed as 'feed-backs' is not explained.

This sentence was not relevant and does not exist anymore in the revised version.

Interactive comment on Biogeosciences Discuss., 5, 841, 2008.

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