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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Bacteria in the global atmosphere – Part 1: Review and synthesis of literature data for different ecosystems" *by* S. M. Burrows et al.

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1 Response to referee comments

We thank Referee #2 for comments on the manuscript and for the overall very positive evaluation. The referee made the following comments on our manuscript:
In addition to the influence of localized point sources on the bacterial concentration of a given aerosol there is the potential for more global influences on the amount of bacteria the atmosphere. The work by Griffin, Kellogg and others on the role of desert dust in atmospheric microbiology is referenced but needs to be discussed in greater detail

in the context of long-term temporal shifts due to anthropogenic activities. Giant dust storms from northwestern Africa and central Asia due to increasing desertification have been shown to carry bacteria across oceans to other continents. Satellite imagery for the study of long-range bacterial dispersal also needs to be discussed in greater detail.

In this manuscript, we focus on reviewing measurements of the concentration and surface flux of atmospheric bacteria. The connections between dust transport and microbiology, as well as possibilities of using satellite imagery, have been discussed in detail in the work of Griffin, Kellogg, some of which we have referenced. The potential for global transport is in fact one of the topics discussed in the companion paper (Part II), in terms of the transport between different ecosystems.

We have no information about biological and health effects of intercontinental transport of soil bacteria that are transported with dust. Some recent research results, however, provide insight into their potential impact as ice nuclei.

Prenni et al. (2009) observed ice nuclei at a measurement tower in the Amazon basin. They report that in the absence of Saharan dust, the ice nuclei observed were primarily carbonaceous and presumably from local sources, while during intermittent dust events the ice nuclei are primarily dust, from intercontinental transport.

Pratt et al. (2009) sampled cloud ice-crystal residues at about 8 km altitude over Wyoming, USA, and report that mineral dust accounted for ˜50% of the residues and biological particles for ˜33%, and that both represent a larger fraction of cloud ice residues than of the particle count in clear air. Based on their observations, they suggest that "biological particles can enhance the impact of desert dust storms on the formation of cloud ice".

Each of these two studies presents evidence that both biological and mineral particles can make important contributions to ice nucleation. However, they differ in their conclusion about the source of the biological particles, partly due to differences in the region and the conditions under which the observations were made. While Prenni et al. interpret the concentrations of IN as being influenced by a primarily local biological source and a primarily distant mineral source, Pratt et al. stress the possibility that distant sources contribute both biological and mineral IN. However, in our view their results do not exclude the possibility that the observed biological particles entered the air mass through convective mixing of vegetatively-influenced air either locally or along the air mass back trajectory. While the observations provide compelling evidence of the importance of biological particles for ice nucleation, it is uncertain whether the biological particles came exclusively or mainly from a distant desert source. In order to resolve this question, it would be necessary to conduct a more extensive model analysis of the possible source regions. For instance, in one such study by Stohl et al. (2003), air from a North American pollution plume was sampled during an aircraft measurement campaign in Europe. Using back-trajectories, the source regions contributing to the observed carbon monoxide pollution were shown to include much of the United States east of the Missippi, as well as areas in southern California and the eastern coast of Mexico. Such a broad basin may also be contributing to the aerosols observed by Pratt et al. (2009) over Wyoming.

The observations reviewed in this manuscript and the results of the accompanying model study suggest that bacteria are emitted from deserts at lower rates than in naturally vegetated regions, agricultural regions, or urban centers. On the other hand, the atmospheric residence time of particles emitted from deserts is much longer than for most other emission regions, so that they have a better chance of participating in long-distance transport. This is a result of the combination of strong dry convection and a lack of removal by precipitation in desert regions, which have been identified as important factors in studies of dust transport processes in general (e.g. Schulz et al., 1998). As the referee notes, with increased desertification, the number of bacteria and other biological particles transported in this way can be expected to increase.

We would therefore expect that long-distance transport of bacteria from deserts (together with dust) will contribute to bacteria concentrations elsewhere; however, in most

regions this contribution will be both intermittent and small compared to local sources of bacteria.

Although we only discuss bacteria here, similar patterns are likely to apply for other types of biological particles, such as fungal spores and decayed plant matter, which are mainly emitted in biologically active regions.

We will expand our discussion of this aspect and include some of the above information in the revised manuscript, as well as in the revised Part II manuscript.

2 References

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