Atmos. Chem. Phys. Discuss., 11, C34–C39, 2011
www.atmos-chem-phys-discuss.net/11/C34/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "

Bacteria in the ECHAM5-HAM global climate model" *by* A. Sesartic et al.

C. Hoose (Referee)

corinna.hoose@kit.edu

Received and published: 27 January 2011

General comments

In this manuscript, Sesartic et al. present a highly interesting modelling study with the ECHAM5-HAM GCM, in which bacteria and their interactions with other aerosols, radiation and clouds are fully included. The focus of the analysis is the effect of bacteria as ice nuclei. The results presented here confirm my own recent findings, namely, that bacterial ice nucleation is on global average small. This study contributes to answering a long standing question within the scope of ACP. However, I recommend that

the following three major and a number of minor points should be addressed before publication:

- There are serious inconsistencies between the numbers listed in the tables, shown in the figures and cited literature (see comments below on emissions and burden). This has to be checked carefully and corrected.
- The treatment of bacteria as fully interacting aerosols, which undergo collisions, coatings, contribute to the direct radiative effect and act as CCN, could be further exploited. E. g., I would be curious what fraction of the bacteria is mixed with other particles in your model and how much that matters.
- What is ignored in this study is the fact that even within INA bacteria species/strains, by far not all cells act as IN (see for example also Santl Temkiv et al, Table 1, or many other studies). The Diehl & Wurzler parameterization, as it is used here, doesn't consider this: in Fig. 1, the frozen fraction reaches 100%. This is not very realistic and should be discussed as a limitation of the parameterization, or (preferably) amended. Applying some lower ice nucleating fraction will further reduce the simulated impact of bacterial ice nuclei. (See also Phillips et al 2009, Hoose et al 2010, Diehl & Wurzler 2010.)

Detailed comments

- p 1459, line 14: It's important to note that the cited number fraction from Gruber et al. refers only to particles with r$> 0.2\mu$m. With respect to total aerosol number, the biological fraction is probably much smaller.
- p 1460 l 5: This is somewhat picky, but the cited paper states "Screening of 69 bacterial isolates showed that 8 isolates were ice nucleation active at – 10 °C, which corresponds to 12 %" - not 9%.

- p 1460 l 5: "their" experimental data: actually the data on bacteria freezing temperatures were from Levin & Yankofsky (1983), not from Diehl et al themselves. It would be of interest at this point to be more precise about what bacteria species the IN data are referring to.
- p 1460 l 25: "various modelling studies on potential impacts of biological aerosols on clouds": Actually, Möhler et al (2008) does not include any modelling, and Burrows et al. (2009) is not about impact on clouds. Two other papers which should be named here are Diehl & Wurzler (2010), Ariya et al (2009) and Sun et al (2010).
- p 1462 l 19: Is the changing leaf area index used in this study?
- Equation (1): It would be worthwhile to repeat the values of F_i which you are using, because Burrows et al (2009a) is giving a range of different values and it is not clear which ones you are referring to.
- p 1463 l 12: Is coagulation with sea salt excluded? Why? (I don't think it's important.)
- p 1463 l 25: It would be good to give the mean diameter (although that can be calculated from the mass and density).
- p 1464 l 5: Are the direct effects and bacteria acting as CCN included as well?
- p 1464 l 11: Here you could also cite our recent ERL paper (Hoose et al, 2010b), in which the PBAP-MAX simulation also allows all bacteria to act as IN plus emissions are significantly increased.
- p 1465 l 11: What is meant by "extrapolated"? This contradicts the caption of Fig. 4 ("for the gridbox containing the measurement location").

- p 1467 l 7: "size of crystals" - as this has not been shown, could you give some information on how large this effect is.
- Table 2: Some numbers got mixed up here. Burrows et al (2009a), in Table 6, last row, give global emissions of 0.4 to 1.8 Tg/yr, with a best estimate of 0.74 Tg/yr, not 0.7 to 3.5 Tg/yr. The global burden estimate in the Burrows et al (2009a) paper is 8.7 Gg, i.e. 0.0087 Tg, not 0.04-1.8 Tg. Jacobson & Streets give emissions of 28.1 Tg/yr, not 8.0 Tg/yr (their Table 4). I suggest that you also list my results of 0.75 Tg/yr emissions and 0.0043 Tg burden, as this shows that using the same emissions can still lead to very different results, if the subsequent model assumptions differ. Your burden is by more than a factor 100 larger than the ones which Burrows et al obtained, that's quite dramatic. The text should discuss in some detail where these differences stem from.
- Table 3: Are the units correct here? These numbers don't agree with the ones in Table 2 (multiplying them by the Earth's surface of 5.1e14 m^2) or Fig 3.
- Table 3: As you compare to observations, are the model data over land only? What about the model data at the corresponding location? Please give more details about this comparison.
- Fig. 4: I'm surprised by the low observed bacteria concentrations shown here. Are the publications included here counting total or viable bacteria? This should be stated at some point; as you are using the Burrows et al. emissions, these refer to total bacteria, and viable bacteria concentrations can be much lower.
- In Fig 1, I actually find it a bit surprising that immersion freezing of bacteria starts "only" below -10°C. In Diehl et al (2004), a median freezing temperature of -7°C is given. Is this an artifact of the droplet size dependence? For what droplet size are the values in Fig. 1?

Technical comments

- p 1465, l 7: What is "it"?
- p 1465, l 28: "maximum in ICNC" - shown is the difference in ICNC.
- Table 2: Remove 'Tg yr^{-1}' from the third column.
- Table 3: For the OBS Wet Dep. data, the numbers seem to be misformatted.
- Fig. 3 e) and f): The colortable extends to 300000 and the units are given as g/m2. This is impossible.
- Fig. 4: If the error bars refer to the observations, they should be horizontal.
- References: For Hoose et al (2010), please add volume and page numbers.
- Shaffer and Lighart should read Shaffer and Lighthart.
- The Phillips et al (2009) paper has a different title and also more authors than listed here.
- Simmons and Gibson: Shin?eld

References

Ariya, P., J. Sun, N. Eltouny, E. Hudson, C. Hayes, and G. Kos (2009): Physical and chemical characterization of bioaerosols -implications for nucleation processes. Int. Rev. Phys. Chem., 28 (1), 1–32.

Diehl, K., Wurzler, S. (2010), Air parcel model simulations of a convective cloud: Bacteria acting as immersion ice nuclei, Atmospheric Environment, doi:10.1016/j.atmosenv.2010.08.003

Hoose, C., J. E. Kristjánsson and S. M. Burrows (2010): How important is biological ice nucleation in clouds on a global scale? Environmental Research Letters 5, 024009, http://stacks.iop.org/1748-9326/5/024009

Sun, J., P. A. Ariya, H. G. Leighton, and M. K. Yau (2010): Mystery of ice multiplication in warm-based precipitating shallow cumulus clouds, Geophys. Res. Lett., 37, L10802, doi:10.1029/2010GL042440.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 1457, 2011.