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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Birch and conifer pollen are efficient atmospheric ice nuclei" *by* B. G. Pummer et al.

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SCHNELL: Interesting that northern climates have higher IN as found in the leaf derived nuclei we studied at the University of Wyoming 40 years ago. With respect to the temperature ranges of the pollen ice nuclei and labeling them as being efficient I might note that when we were screening biological materials including pollens we did not classify any as good ice nuclei unless they were active (T50 in a 100 drop sample) of 260K or warmer. IN bacteria were T50 at 270K, most good leaf litters had a T50 of 265K and good marine nuclei a similar T50. We generally did not continue testing a material that had a T50 colder than 258K as there were so many better than that temperature. The pollen you tested are active at much colder temperatures. Maybe the IN community could come up with a scale where say for instance biological materials

active at warmer than 270K are call extraordinarily active; 270-267K are highly active; 267-263K are active; 263-258K weakly active and colder than -258K relatively inactive.

ANSWER: We thank Dr. R. Schnell for his contribution and agree that some bacterial and fungal species are the most efficient biogenic ice nuclei known. Nevertheless, we used the word “efficient” for the best nucleating pollen, because they are more efficient than many other atmospheric particles which have been investigated concerning their IN behaviour. High efficient atmospheric ice nuclei seem to be restricted to a small fraction of species, as IN activity of some clay and leaf litter samples could be tracked down to bacteria growing on the particle surface, presented e.g. by Vali et al. 1976 (with you as co-author). Pollen IN, however, show totally different properties as bacterial IN, so the situation is not comparable. As one question of referee C. Morris pointed into the same direction, we expanded the discussion about this issue. You mentioned screening of biological material. Have you published data concerning pollen, please give a reference.

Many other atmospheric aerosols (e.g. mineral dust, fresh soot) are far less efficient, as we have already presented in our answer to referee C. Morris. So in fact pollen is among the most efficient classes of IN, only excelled by a few other IN classes (e. g. bactINP).

You are right, that we will need a classification in the future to make results better comparable, but the classification suggested by you is in our opinion too extreme, as it puts freezing at 255 K in one bin with freezing at 240 K, while the homogenous freezing range lies at 238 K – 233 K.

But no matter to what our discussion here leads, this task will have to be worked on by the whole community in order to gain maximum support of the decisions that have to be made.

Furthermore, all given nucleation temperatures have to be seen in relation to the homogenous freezing temperature of each study. Many of the publications dating back

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longer did not even go down with the temperatures so far and measured "homogenous" nucleation temperatures in the range of 260 K to 245 K or did not even determine it at all. Besides median freezing temperatures are a helpful tool to compare the IN activity within one defined setup, but if they should be compared with other studies, many more parameters have to be accounted for, like concentration, droplet size, freezing mode, experimental setup, the homogeneous nucleation temperature, etc.

We added a further paragraph at the end of chapter 4 (p. 27228, line 10) in order to discuss median freezing temperatures, nucleation rates and efficiency:

"Nucleation rates in the sense of equation (1) are superior to median freezing temperatures, as they account for the droplet size (which is an approximate and relative measure for IN numbers per droplet). Median freezing temperatures are difficult to compare between studies, as they do not contain information about droplet size, concentration or the measurement setup. They are ideal for a plain comparison of different samples within one measurement series, but should not be seen as absolute values. Currently nucleation rates are the most advanced tool to compare the efficiency of ice nuclei, but to make studies better comparable it will need a measure which includes all parameters influencing nucleation temperature: IN concentration, droplet size, the homogenous nucleation temperature (as a reference point) and the nucleation mode. Alternatively one could define two standard reference points, e.g. the median freezing temperatures of Snomax® and of pure water, relative to which all other data should be compared."

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 27219, 2011.

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