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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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We thank Referee #2 for the careful evaluation of our paper. Here we present our response to the discussion points marked by Referee #2.

For the more general claim ("First, the authors should address the comments raised by C. Morris and D. O'Sullivan") we refer to our answers to the specific comment.

1) I suggest modifying the title so that it accurately reflects all the topics covered in this manuscript.

ANSWER: We changed the title to "Suspendable macromolecules are responsible for ice nucleation activity of birch and conifer pollen" (see comment to C. Morris).

2) The freezing temperature for Snomax is warmer than what some have reported in the literature (See for example reference 1). What is the reason for the difference?

ANSWER: The exact freezing temperature depends on the experimental setup, the freezing mode and IN concentrations, so variations by some Kelvin might occur. Ps. syringae cultures show nucleation temperatures up to 271 K. One example is Fig. 4 in the paper by Missous et al., 2007, which shows the temperature dependency on the concentration. We think that our results (270 K in the chamber, 268 K in the oil matrix) fit into the picture quite well, as we applied rather high concentrations.

Missous, G., Thammavongs, B., Dieuleveux, V., Guéguen, M., and Panoff, J. M.: Improvement of the cryopreservation of the fungal starter Geotrichum candidum by artificial nucleation and temperature downshift control, Cryobiology, 55, 66-71, doi:10.1016/j.cryobiol.2007.05.004, 2007.

3) What was the mode of freezing in the chamber experiments (i.e. deposition freezing, immersion, etc.)?

ANSWER: It was immersion freezing, as we nebulized a pollen suspension into the chamber. Growth of droplets was caused by condensation due to adiabatic expansion, however, this process cannot be considered condensation freezing, which starts from a dry particle.

4) In the chamber experiments the authors used artificial rainwater. Do the components of the rainwater affect freezing, and if so, is it appropriate to use the chamber experiments to validate the emulsion experiments?

ANSWER: Artificial rainwater contains salts, so freezing points decrease. However, concentrations are in the mM-range, leading to an effect in the range of other errors. Despite the expected decrease, some samples (Snomax, birch, ragweed) showed higher T50 values than the pure water droplets in the oil emulsion setup. We admit that we cannot quantify all errors of the chamber and that T50 values of the same sample differ between the methods, however, our primary intention of the chamber measurements was to back-up our data, while the emulsion measurement results are the central data of this study.

5) The authors used the data from Table 1 to make conclusions on the relative ice nucleation efficiencies of different pollens. The authors should consider either the surface area available for nucleation or the number of pollen particles in each droplet if they want to compare directly the ice nucleation efficiencies of different pollens. For example, Birch pollen may give the warmest freezing temperatures because the experiments had more Birch pollen in the droplets. The warmer temperatures may have nothing to do with the ice nucleation efficiencies.

ANSWER: All pollen concentrations were the same (see response to C. Morris, C11431). We added to our paper at p.27222, line 22: "50 mg pollen per ml water were added, as this concentration led to the highest amount of droplets containing exactly 1 or 2 pollen grains."

6) Abstract, line 12-14. "Once extracted, they can be distributed further through the atmosphere than the heavy pollen grains and so augment the impact of pollen on ice cloud formation even in the upper troposphere." This is a strong statement and should be better supported. What is the mechanism by which the ice nuclei are removed from the pollen surface and re-suspended? What concentrations can be generated by this mechanism? Are the concentrations high enough to influence ice clouds in the upper troposphere? If the statement made by the authors cannot be strengthened, it should be removed or weakened.

ANSWER: It is known that pollen material can be removed from the whole grain and can be detected separately in the atmosphere in high concentrations, even if the pollen grains already deposited. We expanded our discussion, starting from p. 27231, line 22, with following information: "It is known, that pollen constituents, such as allergens and sugars, can indeed leave the pollen body and be distributed independently. The

most probable mechanism is the pollen grain bursting by rain, which releases material, like allergens (Schäppi et al., 1999). As a consequence allergenic material was found in aerosol particles smaller than 5 μm, which contained no pollen or bigger fragments (Solomon et al., 1983). The release of material by bursting of wet pollen has been observed by electron microscopy (Swoboda et al., 2001). Not only allergens, but also sugars originating from pollen can be detected in the atmosphere (Yttri et al., 2007). These authors see pollen rupture and wood burning as their main sources in the atmosphere. The contrast between the hydrophilic properties of many of the surface components and the relative hydrophobia of the sporopollenin boosts the suspension of surface components in water droplets. According to that we conclude that the impact of pollen on the global atmosphere might have been underestimated." The absolute impact of pollen cannot be estimated by these data alone, but it is sure that the impact is fairly higher than it would be, if pollen IN were stuck to the pollen grain surface. Pollen can release high amounts of organic material (Solomon et al., 2001), which is consistent with our findings in the measurements of washing water.

Schäppi, G. F., Taylor, P. E., Pain, M. C. F., Cameron, P. A., Dent, A. W., Staff, I. A., and Suphioglu, C.: Concentrations of major grass group 4 allergens in pollen grains and atmospheric particles: implications for hay fever and allergic asthma sufferers sensitized to grass pollen allergens, Clin. Exp. Allergy, 29, 633-641, 1999.

Solomon, W. R., Burge, H. A., and Muilenberg, M. L.: Allergen carriage by atmospheric aerosol: Ragweed pollen determinants in smaller micronic fractions, J. Allergy Clin. Immunol., 72, 443-447, 1983.

Swoboda, I., Grote, M., Verdino, P., Keller, W., Singh, M., B., DeWeerd, N., Sperr, W. R., Valent, P., Balic, N., Reichelt, R., Suck, R., Fiebig, H., Valenta, R., and Spitzauer, S.: Molecular characterization of polyglacturonases as grass pollen specific marker allergens: expulsion from pollen via submicronic respirable particles, J. Immunol., 172, 6490-6500, 2004.

Yttri, K. E., Dye, C., and Kiss, G.: Ambient aerosol concentrations of sugars and sugar-alcohols at four different sites in Norway, Atmos. Chem. Phys., 7, 4267-4279, doi:10.5194/acp-7-4267-2007, 2007.

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