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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Contribution of pollen to atmospheric ice nuclei concentrations" *by* J. D. Hader et al.

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We thank Prof. Dr. Jaenicke for his comment. We agree that transmission efficiencies are important and that the upper size limit should have been addressed in the original manuscript.

The inlet piece depicted in Fig. 1 includes a 90 degree bend. The inlet has an inside diameter of 8 mm and it is approximately 1 cm from the entrance to the beginning of the bend. No other sampling line was added.

To assess particle losses in the inlet we calculated the fraction of particles that stay in the streamlines of the airflow through the bend as a function of particle size. Calculations assumed a flow rate of 12.5 L min-1. This corresponds to a flow velocity of 4.14 m

s-1 and a Reynolds number of ∼2210. The Reynolds number indicates the flow is only marginally laminar and therefore we report fractional penetration assuming the worst case scenario of turbulent flow through the bend (Baron and Willike, 2001). Results are shown in Fig. 2, showing that particles with D > 10 μm are expected to impact the inlet wall. This calculation agrees with previously reported collection efficiencies, which extends up to 2 mm particles (Willeke et al., 1998) and is in close agreement with results performed using the Particle Loss Calculator software (von der Wieden et al., 2009).

Investigated particle size ranges fall into two categories. Burst pollen sack particles are in the range of ∼0.5 to 2.5 μm (Suphioglu et al., 1992) while whole airborne pollen grains can reach sizes up to 100 μm, with typical sizes ranging between 30-70 μm for pine tree pollen (Erdtman, 1952; Di-Giovanni et al., 1995). The calculations show that whole pollen grains will leave the airflow and impact on the wall of the inlet. Depending on humidity, particle wetness, and hardness, particles will either stick or bounce off the wall (Juozaitis et al., 1994; Kannosto et al., 2013). Bounce and blow-off fractions for ragweed pollen on non-greased impactor stages are 30-60% (Riediker et al., 2000). In the case of particle bounce, it would be unrealistic for the particles to move against the airflow and leave the aerosol sampler. Therefore, any particles that do bounce are expected to enter the instrument for collection.

As mentioned in the manuscript, the collection vessel needs to be refilled up to ∼20 mL every hour. When assembling the components of the sampler, stop cock grease was employed to seal the joints. To ensure that the grease would not contaminate the sample water, we chose not to disassemble the instrument to refill the collection vessel. Instead we sprayed ultra-pure water through the inlet and let the vacuum system pull the water through the orifices (D = 680 μm) and into the collection vessel. This procedure has the added benefit of washing any particles that stuck to the glass wall into the sample water. We note that this washing was not performed after the last hour of measurement and no quantitative assessment of the collection efficiency for D > 10

μm particles was performed.

Another potential source of reduced capture efficiency of particles is non-isokinetic sampling. Acceleration of the flow into the inlet may result in large particles being diverted from the flow streamlines. However, flow velocities are small ($\sim$ 4 m s-1), and centre streamlines are not affected.

In summary, the collection efficiency for D > 10 μm particles is less than 100%, but likely larger than 50% due to the bounce and blow-off as well as the wash off mechanism. Most importantly, the calculations in Fig. 2 demonstrate that pollen fragments thought to be responsible for significant ice nuclei number are small enough to be sampled with near 100% efficiency. Any enhancement of ice nuclei due to the cytoplasmic debris that can be separated from the pollen sack as micron- and submicron-sized starch granules should have been observed with our method. Furthermore, the ice nuclei emitted from the rain trigger reported previously have D < 10 μm (Huffman et al., 2013) and also effectively sampled with the impinging sampler.

We will include detailed discussion on the collection efficiency and expected particle sizes in the revised version of this manuscript.

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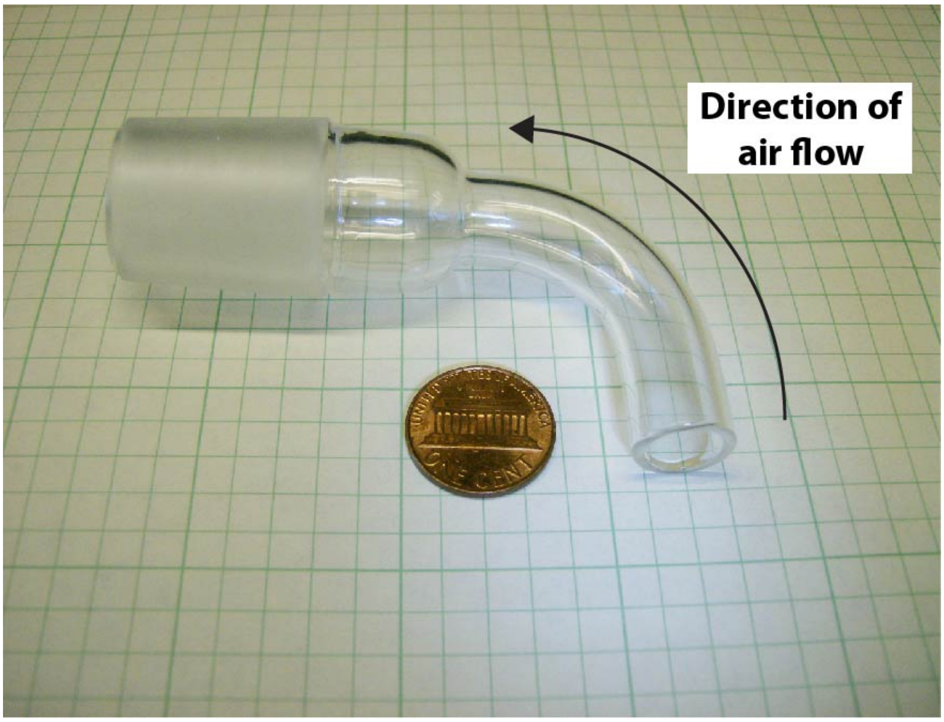

Fig. 1. Swirling aerosol collector (manufactured by SKC, Inc.) inlet with a USA penny for size comparison.

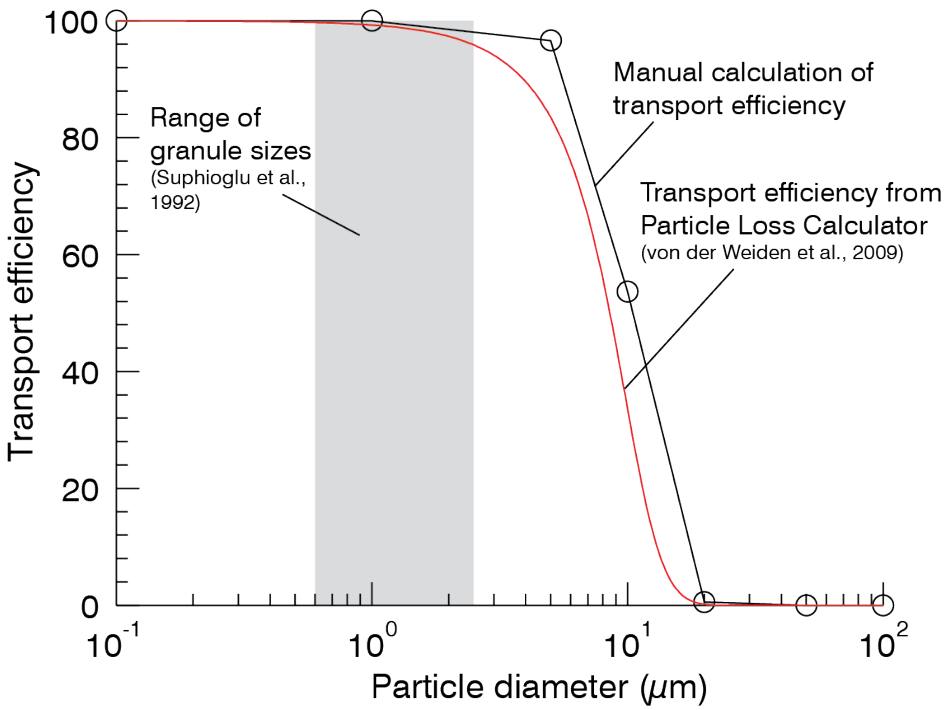

Fig. 2. Particle transport efficiency as a function of particle size through the inlet of the SKC swirling aerosol collector. Black line is calculated using Eq. 8-67 from Baron and Willeke (2001).