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Classification of intermediate air ion formation events at urban area

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The importance of new particle formation on the Earth climate has been discussed in many of the recent papers (Enghoff & Svensmark, 2008), but the mechanism and species responsible for the nucleation are not well known so far. Air ions (cluster ions and electrically charged aerosol particles) mainly determine the electrical state of the atmosphere, but they can be involved also in the nucleation process.

In this paper we present the results of a statistical analysis of the nucleation events based on long-term measurements of air ion mobility distributions from April 2004 to December 2008 in urban environment, in the centre of Tartu, Estonia (58˚22'N, 26˚43'E).

The BSMA (Balanced Scanning Mobility Analyzer) measured the mobility spectra of natural ions in the mobility range of 0.032 - 3.2 $cm^2V^{-1}s^{-1}$ (the size range 0.4 - 7.5 nm). In addition, the BSMA can provide the data about aerosol nucleation burst events (Tammet, 2006).

We have classified the intermediate air ion (or 1.6 - 7.4 nm charged particle) formation events at Tartu using similar classification principles as given by (Hirsikko et al., 2007), modified by (Komsaare et al., 2007).

Class 1. The formation and subsequent growth of particles had a clear shape. The concentration of new generated particles was sufficiently high and their growth starting from the cluster ion mode up to the upper size of 7.5 nm was clearly seen during several hours. The gap between the cluster ion mode and larger ions was filled with ions indicating that cluster ions were involved in the nucleation process.

Class 2. Similarly to class 1, the formation of particles started from the cluster ion mode, but due to some reason, the growth of particles was suppressed in the size range about 3 - 5 nm. The reason might be consumption of nucleating vapours.

Class 3. The particle formation did not start from the cluster ion mode and we saw a gap between cluster ions and larger ions at about 1.6 - 3 nm. The event might be due to the particle formation by homogeneous nucleation with a subsequent charging of neutral particles by cluster ions. Those particles may contain VOC substances.

Class 4. During the nucleation event the concentrations of intermediate ions was quite low. The event lasted for 1 - 6 hours. These events can be considered also as uncertain cases.

Results of the statistical analysis of all categories of events are given in Table 1 and Figure 1. As follows, the most pronounced events (class 1) with clear formation and growth of nanometer particles occurred most frequently during spring, the second maximum was recorded in autumn. Class 2 events occurred preferably first half-year and class 3 events mainly during warm period, when vegetation was most active. Class 4 events, as weak and sometimes uncertain events, occurred throughout a year, preferably in spring.

Table 1. Summary of nucleation events (+ ions/-ions) according to event classes (cl.1...cl.4) and total measurement days during year.

Year	cl.1	cl.2	cl.3	cl.4	days
2004	7/7	8/10	4/4	19/19	140
2005	13/13	17/25	8/9	42/42	305
2006	8/8	12/22	2/3	36/39	279
2007	28/31	16/21	11/11	41/41	310
2008	9/13	21/32	7/6	31/36	346

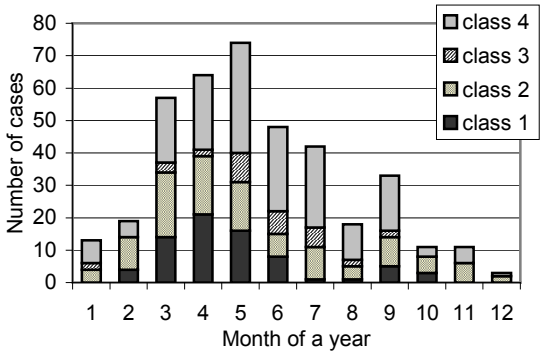

Figure 1. Cumulative monthly distribution of the number of cases when the nucleation event of negative ions was observed.

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