Boundary layer aerosol size distribution data from Birkenes, Norway

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Introduction

The Birkenes location (58º 23'N, 8º 15'E) has been part of NILU's nation-wide sampling net since 1973 and is situated in an area with limited industrial activity and low population density, separated from densely populated and industrialized areas of Europe by the North Sea and Skagerak. Airborne concentrations reaching Birkenes are largely due to long-range transport of air masses from areas 500 – 1000 km away. Thus, as demonstrated by Amundsen et al. (1992), Birkenes is well suited to monitor long-range atmospheric pollution from continental Europe. Van Dingenen et al. (2004) categorized Birkenes as a natural background station in their network of 31 European sites. The station is operated mainly for the Norwegian Pollution Control Authority (SFT), but it also serves as part of the Norwegian contribution to the EMEP network. The size distribution of aerosols is an important parameter that impacts the transport and deposition properties of particles in the atmosphere, their optical properties, and their ability to act as cloud condensation nuclei. Detailed information on particle size distribution can provide valuable information for the validation of air pollution models (EMEP (2003)), for source attribution, and for understanding the formation, transport and deposition of particles in the atmosphere (Tunved et al (2003)).

Methods

Particle size distributions (20-630 nm) are measured using a Differential Mobility Particle Sizer (DMPS). The differential mobility analyzer (DMA) is of the Hauke-type with an inner electrode length of 22 cm. A condensation particle counter model TSI3010 is used to count particles downstream the DMA, respectively. Raw mobility distributions were recorded in stepping mode, leading to a time resolution of the measurement of 2 min. Sheath air is provided using a membrane pump in a closed loop set up, where the flow is controlled using a critical orifice. Ambient aerosol was sampled at a flow rate of ca 1 l min-1 through a ca 3 m stainless steel tubing with a ¼ inch outer diameter and rain cover on the top. The inlet height is ca. 2 m above the ground. No dryer was used.

Results

The integrated total number concentrations were at the maximum in the late spring and summer and at a minimum in the winter months and the variations are higher in the winter months than in the summer months. In figure 1 the median (small square boxes) are at a higher value than the mean value, due to high peak number concentrations all through the three years of data.

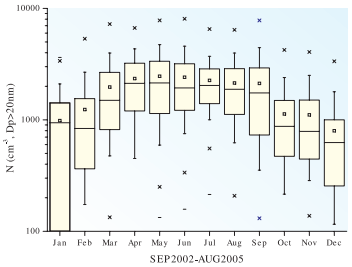

Figure 1: Integrated total number concentrations on monthly basis at Birkenes in the period between September 2002 and August 2005.

The individual size distributions observed at Birkenes were clustered according to shape and number concentrations using kmeans function provided in Matlab. 8 clusters where chosen to capture the different stages of the aerosol lifecycle. 8 clusters proved sufficient to capture aerosol properties likely connectable to typical processes affecting the atmospheric aerosol. The clusters are displayed as cluster 1 – 8 in figure 2. The fraction number of size distributions contribution to each cluster is given at the right of each frame.

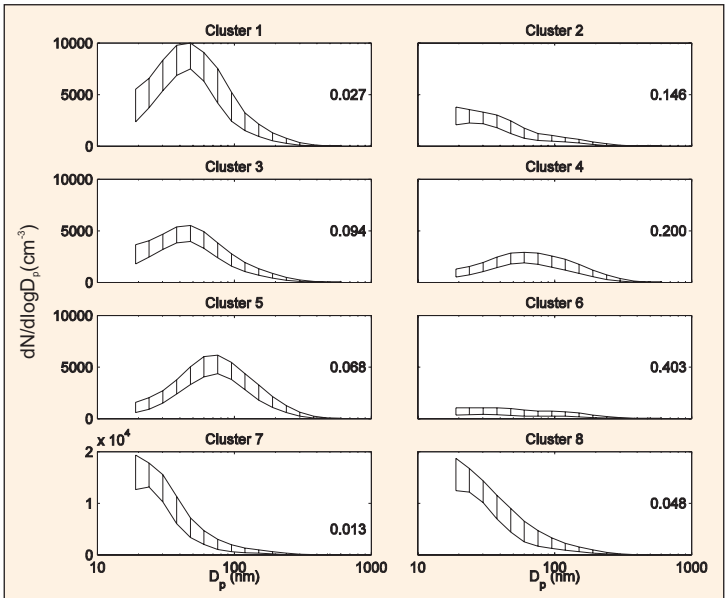

Figure 2: Number size distribution clusters. Fraction number of size distribution contributing to each cluster is given in the figure.

The clustering resulted in average size distribution properties indicating recent particle formation (i.e. homogenous nucleation (1, 7, 8)) intermediate aged properties (i.e. growing aitken mode, 2 & 3) and two different types of aged aerosols; either aging under influence of clouds and precipitation and aging under the influence of condensation and coagulation only (4 & 6 and 5, respectively).

Table 1: Type of particle formation and frequency of occurrence associated with each cluster.

Particle properties	Clusters	Frequency of occurrence (%)
Recent formation (i.e. homogenous nucleation)	Cluster 1 Cluster 7 Cluster 8	2,7 1,3 4,8
Intermediate aged (i.e. growing Aitken mode)	Cluster 2 Cluster 3	14,6 9,4
Aged (i.e. accumulation mode)	Cluster 4 Cluster 6 Cluster 5	20 40,3 6,8

Table 1 shows that almost 70% of the size distributions properties belong to clusters indicating aged or aging aerosols, 25% to clusters indicating intermediate aged aerosols and around 9% that indicating recent particle formation.

The seasonal contribution to each cluster was investigated. Increased global radiation during the summer months increases the photochemical reactions. During fall and winter the wet deposition rate increases due to more frequent precipitations.

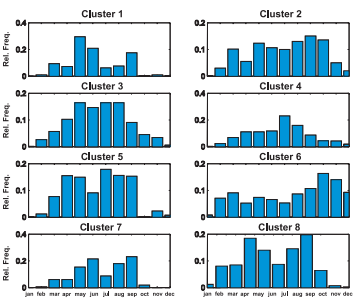

Figure 3: The relative frequency of observations per month for each of of the initial clusters

Cluster 1 and 7 lacks size distributions in the DJF (Dec, Jan, Feb) period, due to lesser nucleation during this period. Cluster 4 and 6 has their contributions spread over the whole year. Cluster 6 (the clearly bimodal distribution) is more well represented during DJF and SON. This is probable due to more frequent precipitation combined with lesser particle formation. Figure 4 represent the frequency of in cloud events along transport. This is defined as occasions with RH>94%. It is thus clear that bimodal size distribution in cluster 6 is more frequently processed by clouds compared to other cases.

Conclusions

Particle size distribution measurements performed at Birkenes, Norway has been investigated during a three-year period between September 2002 and August 2005. The basic behavior of the aerosol number size distribution in terms of seasonal and diurnal variations are similar to what is reported from other Nordic background stations (Aspvreten, Hyytiälä, Värriö, Pallas and Vavihill). The integrated total number concentrations were at the maximum in the late spring and summer and at a minimum in the winter months. Almost 70 % of the size distributions properties belong to clusters indicating aged or aging aerosols, 25% to clusters indicating intermediate aged aerosols and around 9 % that indicating recent particle formation. Recent particle formations (i.e. homogenous nucleation) are almost not observed from December to February, due to lesser nucleation during this period. While aged aerosols are more well represented during September to February.

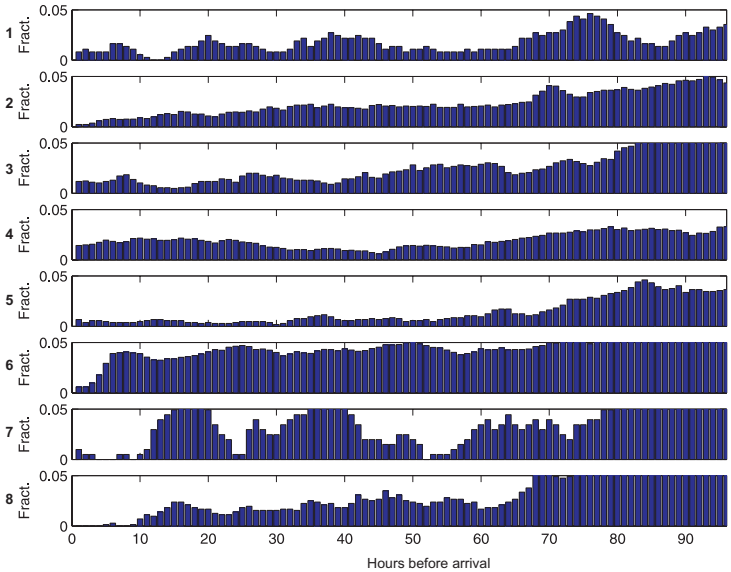

Figure 4: Frequency of in-clouds occasions as derived from the RH>94% profiles from the HYSPLIT4 model, hours before arrival. Corresponding from cluster 1 to 8, from above.

Acknowledgements

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References

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