We thank Anonymous Referee 1 for the review and the suggestions for improvement of our manuscript. We give detailed point-by-point answers in the text below. The referee comments are presented in italics and the corresponding replies as normal text below each comment.

1. Were there any problems to use MODIS data from the Aqua satellite?

We have chosen to use Terra data because its measurements started early 2000, whereas Aqua began its measurements in the summer of 2002, which means that from Terra there are effectively 3 years of data more available than for Aqua. With these 3 extra years of data we are able to obtain more robust statistics.

We checked how using data from Aqua would influence our results. Over the period 2003-2008, we find that the cloud droplet concentration as retrieved from Aqua is in general a bit lower than that retrieved by Terra, but that they have a very similar seasonal cycle (see figure below). The correlation coefficient is 0.97. From this we conclude that using Aqua data would not have changed our conclusions qualitatively.

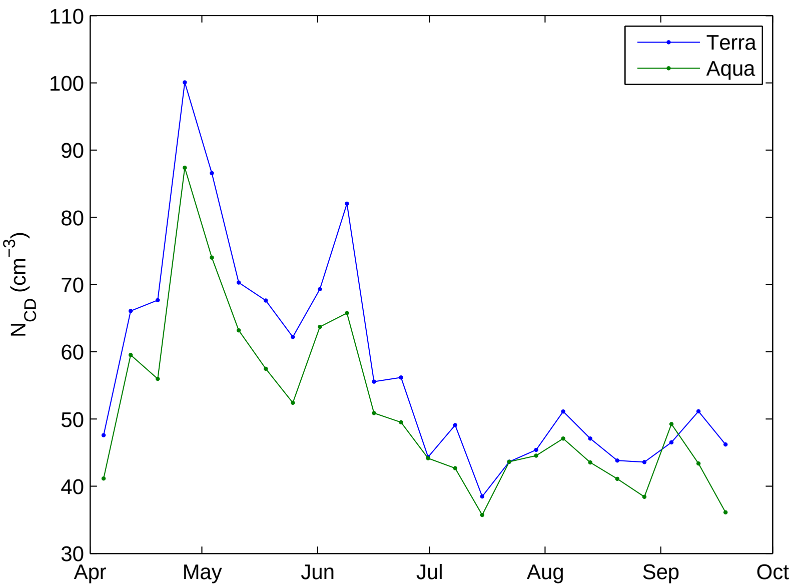

Fig. A: cloud droplet concentration N_{CD} as retrieved for the period 2003-2008 from both the MODIS instrument onboard the Terra and the Aqua satellite.

2. I speculate that Fig. 3b can tell more than is stated in the manuscript. It looks like the bottom error bars for the months April to June are shorter as compared to later months. This implies that the modal size of the accumulation mode aerosol is smaller for those months i.e. less large aerosols are present. The low Reff measured for these months by MODIS can be related to the very low modal size of the aerosols (Fig. 3a) and not to the large number concentration of cloud droplets as calculated by the cloud model (Fig. 3b). In that case the cloud droplet number concentration from the cloud model should be revisited. While the authors claim later in the manuscript that cloud droplet activation is updraft limited, I wonder if the authors considered the above mentioned hypothesis.

We agree with the referee that the bottom error bars are shorter for the mentioned months, which implies that the modal size of the distribution is smaller and that less large aerosols, which could serve as CCN, are present. However, the minimum N_{CCN} at the surface is still for each bin larger than the maximum retrieved N_{CD}, so in principle there are enough CCN present to explain the cloud droplet number.
Moreover, the MODIS R_{eff} retrievals relate to the size of water droplets and not the size of the aerosols. The aerosols themselves will not, or hardly, affect the observed radiances at visible and near-infrared wavelengths. Only in case of an aerosol layer above the cloud, as can for example be found over the Atlantic Ocean, aerosols cause errors in the retrieval of R_{eff} and τ. However, over the boreal forest this is not the case, there the aerosols only serve as CCNs leading only to an increased N_{CD}.

3. I believe that some data about drizzle formation and precipitation in this region may support or disagree with the lack of correlation between ground aerosol concentration and cloud properties. Did the authors have any access to such data? I do suggest to search for documented data about precipitation in the ROI and study whether it agrees with the results.

Indeed, the occurrence of drizzle could impact the retrievals. For drizzle the previous point made by the reviewer would be more valid, i.e., with drizzle the cloud droplets have a bi-modal distribution (cloud droplets and drizzle). Since the MODIS retrievals assume a single-modal distribution of cloud droplets the retrieved R_{eff} may be underestimated. Simulations studies done on this subject reveal an effect here, see for example Bennartz et al. (2010).

The best solution here would therefore be to use cloud radar observations which can detect drizzle in clouds, because in many cases this drizzle does not reach the surface, but affects the droplet size distribution. Since these are not available for this site, the best precipitation data available are the surface measurements at the SMEAR II station at Hyytiälä, even though we acknowledge that point measurements may not accurately represent the occurrence of precipitation over an area of $2x2^o$ or the occurrence of non-ground reaching precipitation. We have used these precipitation data as an additional filter to the data: all satellite data points (spatial averages over the $2x2^o$ box) for which precipitation was reported at the SMEAR II station have been removed from the analysis. We mentioned this in Sect. 2.1 on the satellite data selection:

p. 10005, line 5
'Furthermore, the occurrence of drizzle could affect the MODIS retrievals of cloud droplet effective radius (r_{eff}), since it causes a bi-modal cloud droplet distribution, consisting of cloud droplets and drizzle. Since the MODIS retrievals assume a single-modal distribution of cloud droplets the retrieved r_{eff} may be underestimated in such cases (Bennartz et al., 2010). Therefore, we excluded all satellite observations for which a simultaneous observation of precipitation was done at the SMEAR II station. We acknowledge, however, that this does not rule out the possible occurrence of non-ground reaching precipitation.'

This additional filter did not significantly impact our results. The correlation between N_{CD} and $\Delta\theta_{1000-950}$ is now 0.76 and the correlation between N_{CD} and $N_{>100}$ is -0.24 over all years and ranges between -0.36 and 0.28 for the individual years. We updated these numbers in

Sect.3.2. The updated Figs. 3, 4 and 6 (Figs. 2, 3 and 5 in the discussion paper) are shown below.

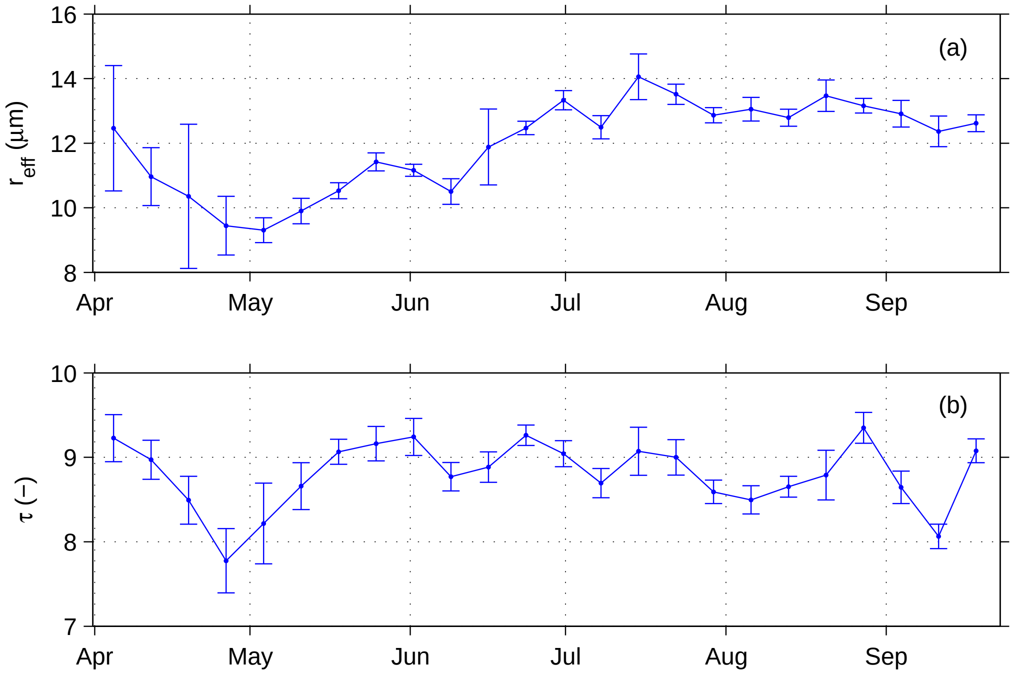

Fig. 3. Seasonal cycle in **(a)** MODIS effective radius r_{eff} and **(b)** cloud optical thickness τ over Hyytiälä for the years 2000 to 2008. Each datapoint corresponds to one of 24 bins, each representing the median value of the variable over all years.

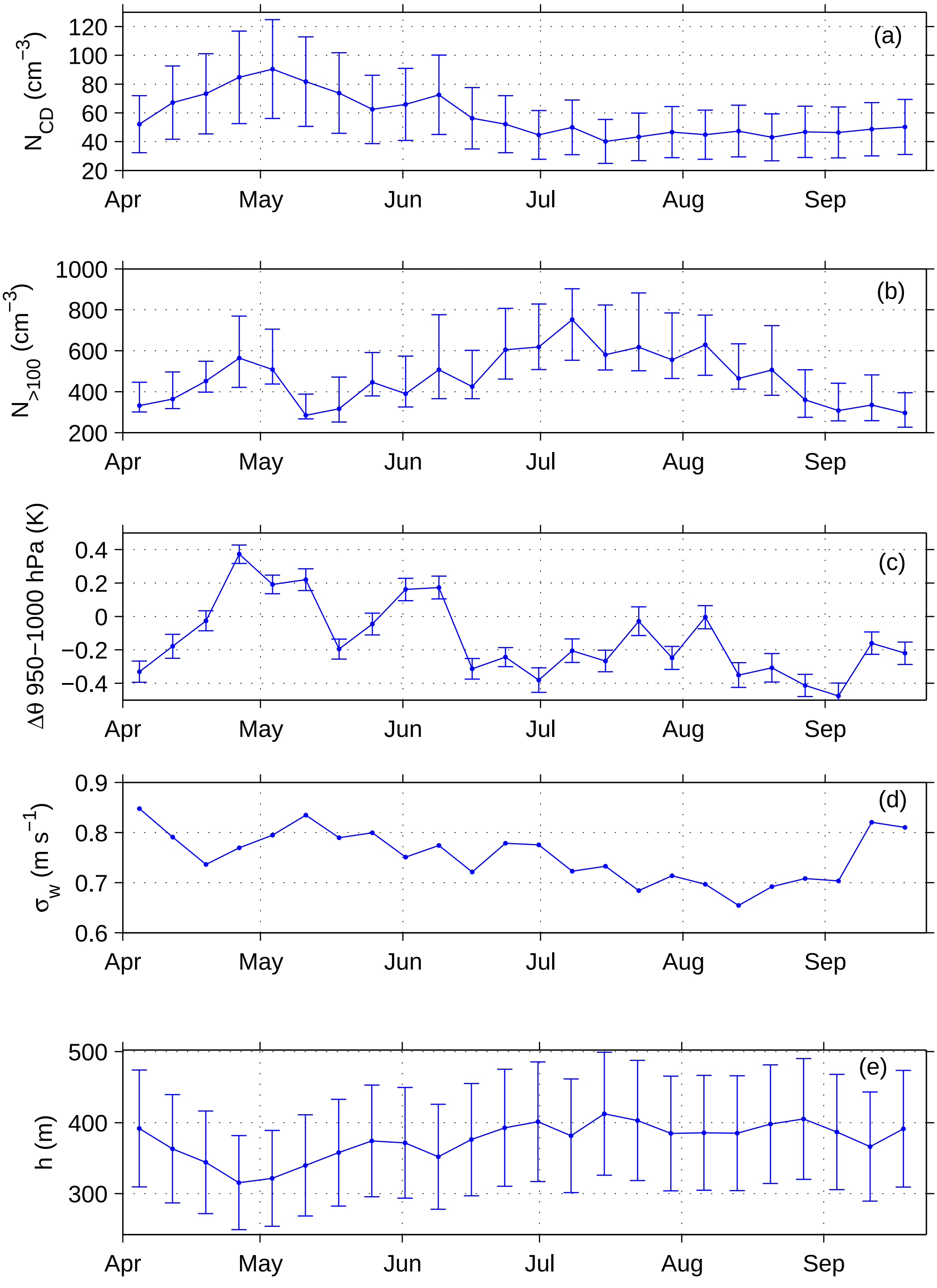

Fig. 4. Median seasonal cycle over 2000–2008 in **(a)** cloud droplet number concentration N_{CD}, **(b)** surface observations of CCN-proxy concentrations $N_{>100}$, **(c)** potential temperature

difference between the 1000 and 950 hPa-level $\Delta\theta_{1000-950}$, **(d)** standard deviation of the vertical wind speed σ_w and **(e)** cloud depth h. The errorbars in N_{CD} and h indicate the uncertainty as calculated in Sect. 2.4. The errorbars in $N_{>100}$ indicate the concentrations of aerosols larger than 80nm ($N_{>80}$, upper limit) and larger than 120nm ($N_{>120}$, lower limit), respectively, to account for the seasonal variation in critical diameter for CCN-activity of aerosols at Hyytiälä (Sihto et al., 2010). Errorbars in $\Delta\theta_{1000-950}$ designate the standard error. Meaning of datapoints as in Fig. 2.

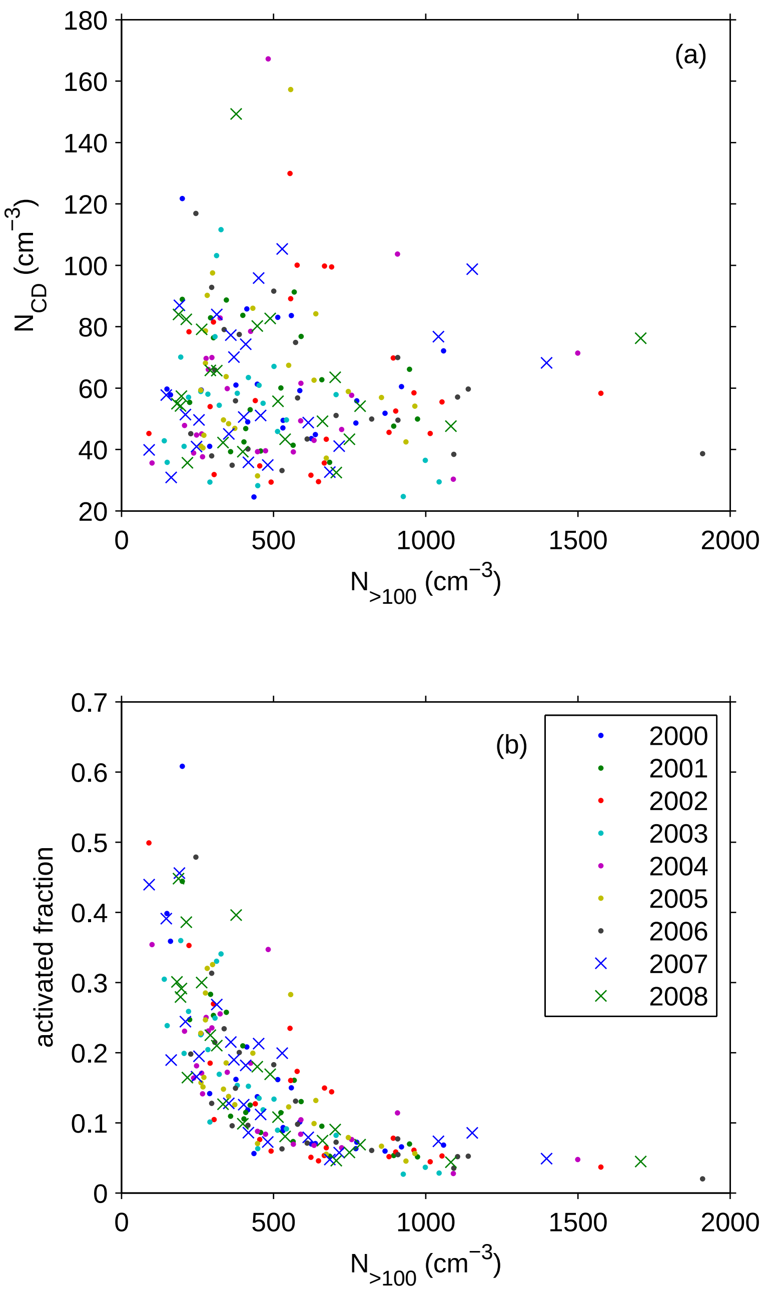

Fig. 6. (a) Comparison of CCN-proxy $N_{>100}$ and cloud droplet number concentration N_{CD} and **(b)** the activated fraction, defined as the ratio of N_{CD} and $N_{>100}$. Each data point represents the median of one bin, each bin representing a period of about one week over the years 2000 to 2008. The different marker colors and styles indicate the different years, as shown in the legend.

4. p. 10004, line 12 – What is the meaning of the word "about"?

We agree that the use of the word "about" is a bit ambiguous. Therefore we added an explanation that we divided the data over 24 bins, which for a period of 182 days resulted in ~7.6 days per bin:
p. 10004, line 12
'We calculated median values of the satellite, aerosol and meteorological data, divided over 24 bins. For a period of 182 days, this resulted in a bin size of 7.6 days.'

5. p. 10004, sec. 2.1 – A map of the ROI will be very helpful for the readers who are not familiar with the Hyytiälä area.

A map of the research area indicating the location of Hyytiälä and the 2x2^{o} box is included in the paper as Figure 1 (see below).

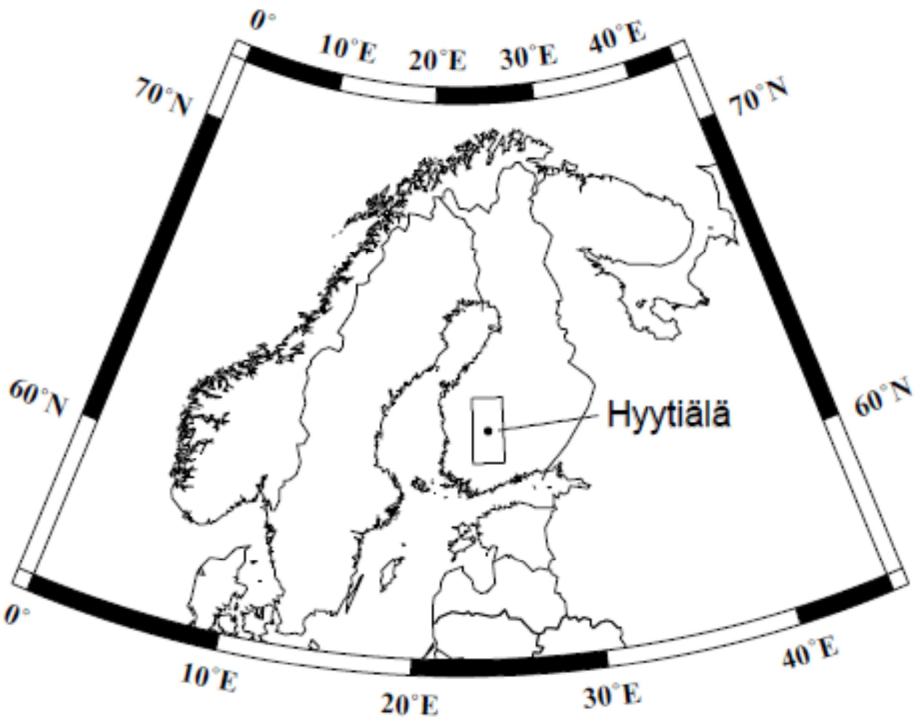

Fig. 1. Map indicating the location of the SMEAR II field station at Hyytiälä, Finland and the 2 x 2^{o} latitude-longitude box over which the MODIS and ECMWF-data are averaged.

6. p. 10005, line 11-14 – The sentence should be reworded

The sentence is rephrased. It now reads: "During the growing season (April-September), the air masses that arrive at the site are mostly of marine origin, except for the months of April when advection of continental air dominates and July when advection of marine and continental air masses have equal shares (Sogacheva et al., 2008)."

7. Fig. 6 – Further discussion is needed about the differences between the activation ratio definitions. Perhaps the authors can show what would be the activation ratios in the cases *where they have data about aerosol concentration, CCN concentration and calculation of the cloud droplet concentrations.*

We will combine this point with the similar comment 6 of referee 2 (*How would the results change for Fig. 5 b), when the different definitions of the activated fraction (Fig. 6) were used? Can the authors discuss briefly what they would expect?*) and add it to Sect. 3.2.We have added a figure (see below) showing the activation ratios following definitions (1) and (3) for the period July-September 2008, for which there are data for aerosol, CCN and cloud droplet concentration available and added the following text:

p. 10015, line 18

'To illustrate the different activated fractions, we have calculated $F_{act(1)}$ and $F_{act(3)}$ for the period that we have data for N_A, N_{CCN} and N_{CD}, i.e. July to September 2008. Fig. 8 shows that N_{CCN} increases with increasing N_A. $F_{act(1)}$, which is the ratio of these, does not have a clear pattern over this period, but when looking at a longer period, Sihto et al. (2010) found a seasonal cycle in $F_{act(1)}$ at this site. The behaviour of $F_{act(3)}$ for this period is similar to that of the whole measurement period, showing little sensitivity of N_{CD} to $N_{CCN0.2}$. How $F_{act(2)}$ would behave, can be illustrated by the following limiting cases: 1) if CCN-activation is transport limited, meaning that few CCN are transported from the surface to cloud base, we would expect a high $F_{act(2)}$, since few CCN reach cloud base, but those that do are activated. 2) If CCN-activation is limited by the activation itself, many CCN reach cloud base, but few are activated, resulting in a low $F_{act(2)}$. In reality, these 2 effects will be combined, but based on our results we cannot make a separation between them.'

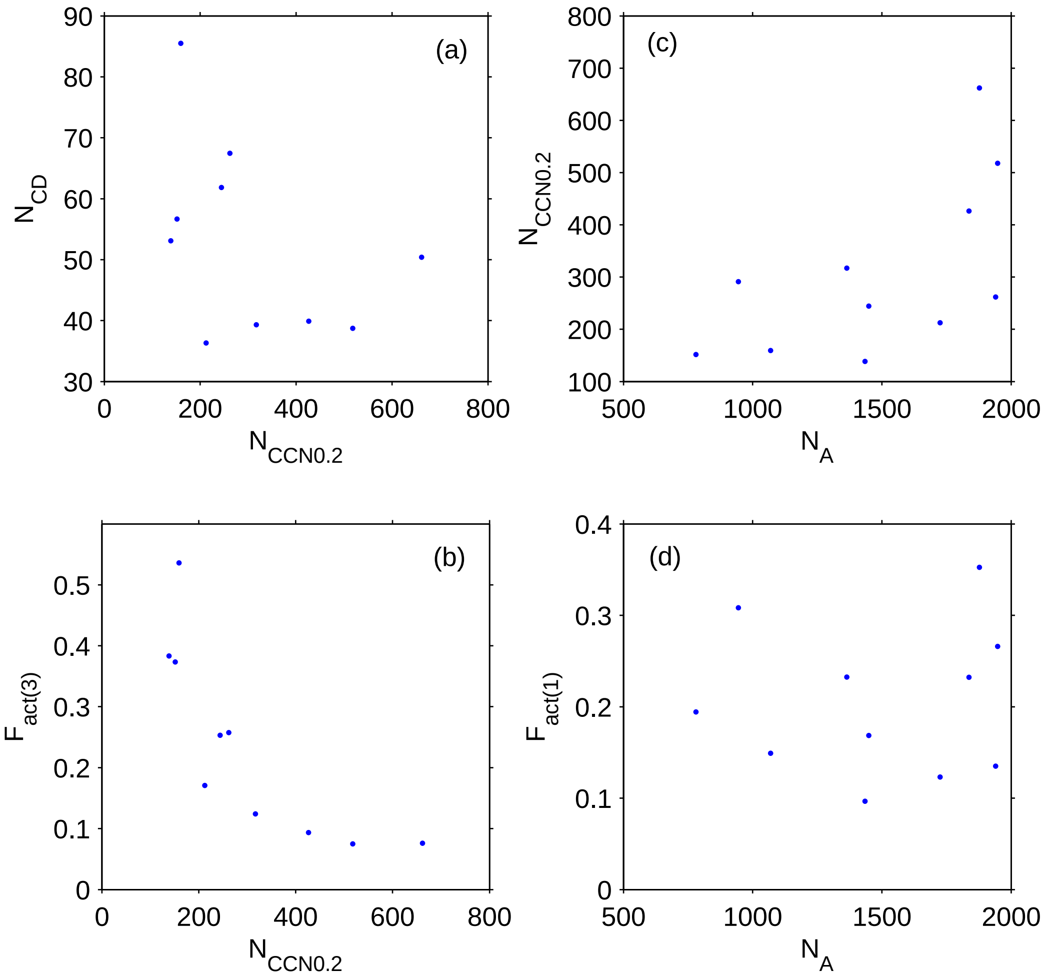

Fig. 8. The activated fraction F_{act} for the period July-September 2008, for which there are data available of aerosol concentration N_A, CCN-concentration at 0.2% supersaturation $N_{CCN0.2}$ and cloud droplet concentration N_{CD}. **(a)** Comparison of $N_{CCN0.2}$ and N_{CD}, **(b)** $F_{act(3)}$, defined as the ratio of N_{CD} and $N_{CCN0.2}$, **(c)** comparison of N_A and $N_{CCN0.2}$ and **(d)** $F_{act(1)}$, defined as the ratio of $N_{CCN0.2}$ and N_A.

References

Bennartz, R., Watts, P., Meirink, J. F., and Roebeling, R.: Rainwater path in warm clouds derived from combined visible/near-infrared and microwave satellite observations, J. Geophys. Res., 115, D19120, doi:10.1029/2009JD013679, 2010.

Sihto, S. L., Mikkilä, J., Vanhanen, J., Ehn, M., Liao, L., Lehtipalo, K., Aalto, P. P., Duplissy, J., Petäjä, T., Kerminen, V. M., Boy, M., and Kulmala, M.: Seasonal variation of ccn concentrations and aerosol activation properties in boreal forest, Atmos. Chem. Phys. Discuss., 10, 28231-28272, 2010.