WCCAP Report

Mobility Spectrometer (DMPS/SMPS) workshop, November 2006

1. Evaluated DMPS and SMPS systems

The acquired particle number size distributions of 7 DMPS and 4 SMPS systems which participated in the workshop are evaluated for the actual report. Tabs.1-3 provide some information about the different systems.

Tab.1: Information about the measurement systems of the Institute of Atmospheric Science and Climate Bologna (ISAC), EC Joint Research System (Ispra), University of Stockholm, and Finnish Meteorological Institute (FMI).

Institution:	ISAC	Ispra	Stockholm	FMI
System	DMPS	DMPS	DMPS	DMPS
DMA	Hauke medium (modified)	Hauke medium (version 3.3)	Hauke short	Hauke medium
CPC	TSI-3010	TSI-3010	TSI-3010	TSI-3010 (dT=25°C)
neutralizer	Nickel-63	Krypton-85 (TSI)	Americium	Nickel-63
Flow ratio sheath : aerosol	10 : 1	8 : 1	5 : 1	10 : 1
Size range (nm)	9.3 - 500	10 - 600	10 - 450	7 - 500
Specific comments	--	--	--	--

Tab.2: Information about the measurement systems of the Norwegian Institute for Air Research (NILU), University of Helsinki, and University of Lund.

Institution:	NILU	Helsinki	Lund
System	DMPS	DMPS	TDMPS
DMA	Hauke medium	Hauke medium	Hauke short Hauke medium
CPC	TSI-3010	TSI-3772	TSI-3025 TSI-3010
neutralizer	Nickel-63	Nickel-63	Krypton-85 (10 millical)
Flow ratio sheath : aerosol	5 : 1	20 : 4 5 : 1	20 : 3 6 : 0.9
Size range (nm)	10 - 900	3 - 80 30 - 800	3 - 21 21 - 850
Specific comments	standard CPC efficiency only	high and low flow mode	twin system with 2 DMA

It is obvious that all devices differ in certain issues from each other concerning hardware components and operation modus. However all DMPS systems use Hauke and most SMPS systems TSI DMAs, respectively. The Lund system is a Twin DMPS, i.e. that the ultra-fine and fine particle size range are measured simultaneously. The Helsinki system is also used to measure the ultra-fine particle size range (beside the fine particle sizes) by using a single DMA with a sequence of a high and low flow mode. As a consequence two number size distributions must be merged in a pre-determined overlap size range for both systems in order to present their workshop results.

The Twin SMPS of Clermont had problems with the scanning of the ultra-fine particle size range so that only particle size information above 20 nm is available.

Furthermore it should be noted that the systems measured different size intervals and with different size and time resolution which in addition influences the determination of peak diameters and total concentration and the data inversion procedure.

Tab.3: Information about the measurement systems of the University of Clermont-Ferrand (Clermont), Netherlands Organisation for Applied Scientific Research (TNO), University of Birmingham, and Leibniz-Institute for Tropospheric Research (IFT).

Institution:	Clermont	TNO	Birmingham	IfT
System	TSMPS	SMPS	SMPS	SMPS
DMA	TSI short TSI long	TSI 3/4 (special version)	TSI long (TSI 3081)	Hauke medium
CPC	TSI-3025 TSI-3010	TSI-3010	TSI-3022A	TSI-3010
neutralizer	Nickel-63	Krypton-85 (10 millical)	Krypton-85 (TSI 3077)	Krypton-85
Flow ratio sheath : aerosol	16 : 1.5 6.2 : 1	4 : 1	3 : 0.3	10 : 1
Size range (nm)	3 - 40 20 - 400	10 - 485	12.9 - 820	10 - 900
Specific comments	twin system with 2 DMA	standard CPC efficiency only	TSI inversion software	--

One effort of the workshop was to experimentally derive the size dependent detection efficiency of all CPC's that are part of the DMPS and SMPS systems in order to include this information into the inversion routines. Due to CPC operation problems during the CPC calibration that was not possible for the NILU DMPS and TNO SMPS. Thus standard CPC detection efficiencies were deployed for these systems which should not introduce significant changes since only number size distributions above 10 nm are examined where the CPC efficiencies are quite constant and generally close to unity.

The University of Birmingham is the only participant that uses a commercial TSI inversion software whereas all others apply self-made or has adopted and apply self-made inversion routines.

2. Results

2.1. Measurements

Results of two different experiments are analysed. During the first experiment (17.10.2006 16:00 - 18:45) mono-disperse Latex particles with a size of 200 nm were constantly generated for approximately 3 hours in the lab and then distributed to each measurement system from a mixing chamber. The second experiment (19.11.2006 14:45 - 20.11.2006 07:45) comprised the sampling of ambient aerosol particles into the lab where they are again distributed to each system. With regard to air mass change and different impact of local emissions, three periods of quite different but rather constant particle number size distributions could be identified and are separately analysed. The periods are 19.11.2006 14:45 – 22:15 (7.5 hours), 20.11.2006 01:45 – 05:00 (2.25 hours) and 20.11.2006 06:00 – 07:45 (1.75 hours).

2.2. Presentation of the results

In this report, the evaluation of all 11 sizing systems will be carried out in detail. These results include three different qualities of number size distribution data. At first, the raw data size distributions, given in particle concentration (cm^{-3}) per size bin will be shown in order to access the quality of the measurement. This check is furthermore important, because this raw distribution data is the input for the inversion routines that calculate the physical meaningful and inter-comparable particle number size distributions in $dN/dlogd_p$.

Hereafter, two different inverted number size distributions will be presented. The first is the inversion result of the respective user. The second are number size distributions obtained from one common inversion method applied to all systems, which are labelled as "NA3" (EUSAAR abbreviation). For this common inversion method, the routine developed at IfT was chosen. The transfer function of a TSI and Hauke DMA calibrated for a specific sheath to aerosol flow ratio is imbedded in this inversion routine as required for the respective system. Different flow ratios are simply taken into account by a factor that mathematically describes that deviation. Since the IfT SMPS raw data is originally inverted by the common method, this result is used in the presentations as a relative reference in order to intercompare all systems more easily.

Additionally, time series of the total particle concentration are shown which are inferred from the integration over the single USER and NA3 number size distributions. In a separate sub-chapter the average particle concentration and other parameter like peak or mode diameter deduced from the size distributions are compared for all systems.

The number size distributions are presented as averages over the respective experiment periods. Only for the raw data plots all single distributions are shown in order to clarify their quality and frequency. The raw and user inverted number size distributions are plotted exactly like they were submitted by the different users, e.g. no further smoothing was applied.

2.3. Lab experiment with mono-disperse 200 nm Latex particles

Tab.4: Measurement duration and data availability of all systems for the 200 nm mono-disperse Latex experiment.

System:	measurement period	raw data	USER inversion	NA3 inversion
ISAC	16:01 - 17:51	yes	yes	yes
Ispra	16:02 - 18:42	yes	yes	yes
Stockholm	16:00 - 18:00	yes	yes	yes
FMI	no data	*no*	*no*	*no*
NILU	16:28 - 17:20	yes	yes	yes
Helsinki	17:13 - 17:53	yes	yes	yes
Lund	only data from 20.11.2006	yes	*no*	yes
Clermont	16:01 - 18:26	yes	yes	yes
TNO	15:58 - 16:16	yes	*no*	yes
Birmingham	16:02 - 18:37	yes	yes	yes
IfT	16:01 - 18:34	yes	yes	yes

The data availability of the different measurement systems concerning this lab experiment can be taken from Tab.4.

Due to technical problems no data is available for the FMI DMPS, only data of a measurement from another day is available for the LUND TDMPS (i.e. only qualitative comparisons are possible). Thus raw distributions were provided by all participants except FMI, which were all used to carry out the described NA3 inversion. Only Lund and TNO did not deliver “user” inversions. The measuring time of the Helsinki and TNO system were rather small (cf. Tab.4) so that only 4 and 3 distributions were obtained.

There are two main objectives that can be studied by carrying out an experiment with mono-disperse particles. The particle sizing of the mono-disperse distribution as well as the correction capability of measured multi charged particles by the respective inversion routines can be evaluated, which is done in chapter 2.3.2.

2.3.1. Averaged particle number size distributions and concentration time series

Particle number size distributions and total concentration time series of each system (except FMI) are shown in Figs.1-9. These figures are all organised in the same way. The single raw distributions are qualitatively presented in the upper left panel. Their average as well as the average raw distribution of the IfT SMPS is included in the upper right panel (red and black dashed lines, associated with the right scale). In addition the respective user inverted result and the inversion of the IfT SMPS considered as the relative reference are plotted (red and black solid line, associated to the left scale). Below, this two inverted size distributions are illustrated again together with the NA3 inversion result of the specific system. Finally, the total particle concentration time series derived from the respective system and the IfT SMPS reference are shown in the lower left panel. Unfortunately, an absolute particle concentration reference is missing, because no stand alone CPC was operated during this mono-disperse Latex particle experiment.

The main features observed for each system during this specific experiment is described in the following.

IfT (Figs.1-9)

As already mentioned this system is used as a relative reference, because the measured data is originally inverted by the common NA3 inversion method. Thus the respective number size distributions and total concentration is repeated in Figs.1-9. The averaged size distributions are rather broad and the multi charge correction minimizes the double and triple charge peak substantially. Moreover, there are some few spikes within the otherwise constant particle concentration plots that are caused by a spline fit and not by the inversion method itself.

ISAC (Fig.1)

In comparison to IfT the ISAC size distributions have a narrower Latex peak that is slightly shifted to smaller sizes. The peak maximum is significantly higher so that the total particle concentration is again close to the IfT system. The NA3 inversion result looks quite similar to the user inversion with respect to peak shape and position, concentration and effectiveness of the multi charge correction.

Ispra (Fig.2)

The Latex peak measured with the Ispra system is also a little narrower than measured with the reference but the peak position is identical. Again, the NA3 inversion result looks quite similar to the user inversion with respect to peak shape and position, concentration and effectiveness of the multi charge correction. Particle concentration derived from NA3 and user inversions are slightly lower than the reference values.

Stockholm (Fig.3)

As it is visible in the right panels, the user inversion method has a severe problem to correctly restore a mono-disperse particle size measurement. It creates fluctuations and negative values in the size distribution. Nevertheless, the raw data seems to be reasonable, because the NA3 inversion perfectly reproduces the inversion of the IfT SMPS measurements with respect to shape, position, multi charge correction and concentration.

NILU (Fig.4)

The Latex peak measured with the NILU DMPS looks similar to the reference with respect to width and position. Only the maximum is lower which is most likely due to the insufficient correction of the multi charge peaks. The multi charge correction is much better carried out by the NILU NA3 inversion, so that the maximum of the latex peak and thus the total concentration is closer to the IfT SMPS result.

Helsinki (Fig.5)

For the Helsinki DMPS size information only up to particle diameters of 226 nm were available, so that the right side of the latex peak is not completely covered. User and NA3 inversion results for the Helsinki system are a little bit shifted to smaller sizes with respect to the IfT SMPS and the concentration derived from the NA3 inversion is closer to the reference.

Lund (Fig.6)

The Lund measurements were not carried out simultaneous and no user inversion results were provided, i.e. only the peak position that agrees well with the IfT SMPS result but not the concentration results from the NA3 inversion are compared.

Clermont (Fig.7)

The Clermont SMPS was not able to establish charge equilibrium most likely due to a weak neutraliser so that user and NA3 inversion were not able to correct the peaks originating from the multi charged particles. User and NA3 inversion derived concentration significantly under and overestimate the IfT SMPS reference concentration.

TNO (Fig.8)

The TNO SMPS single raw distributions contained randomly distributed spikes. A mean number size distribution exists only from the NA3 inversion that agrees very well with the IfT SMPS reference regarding shape and position of the latex peak except a slightly larger number concentration.

Birmingham (Fig.9)

Obviously, the raw distribution calculated with the TSI software is not the one needed as input for the NA3 inversion, because this produces much too high particle concentrations. The user inversion (TSI software with and without diffusion losses) reproduces meaningful concentrations additionally demonstrating that diffusion losses are not important for this measurement. The latex peak is narrower and shifted to smaller sizes with regard to the IfT SMPS reference.

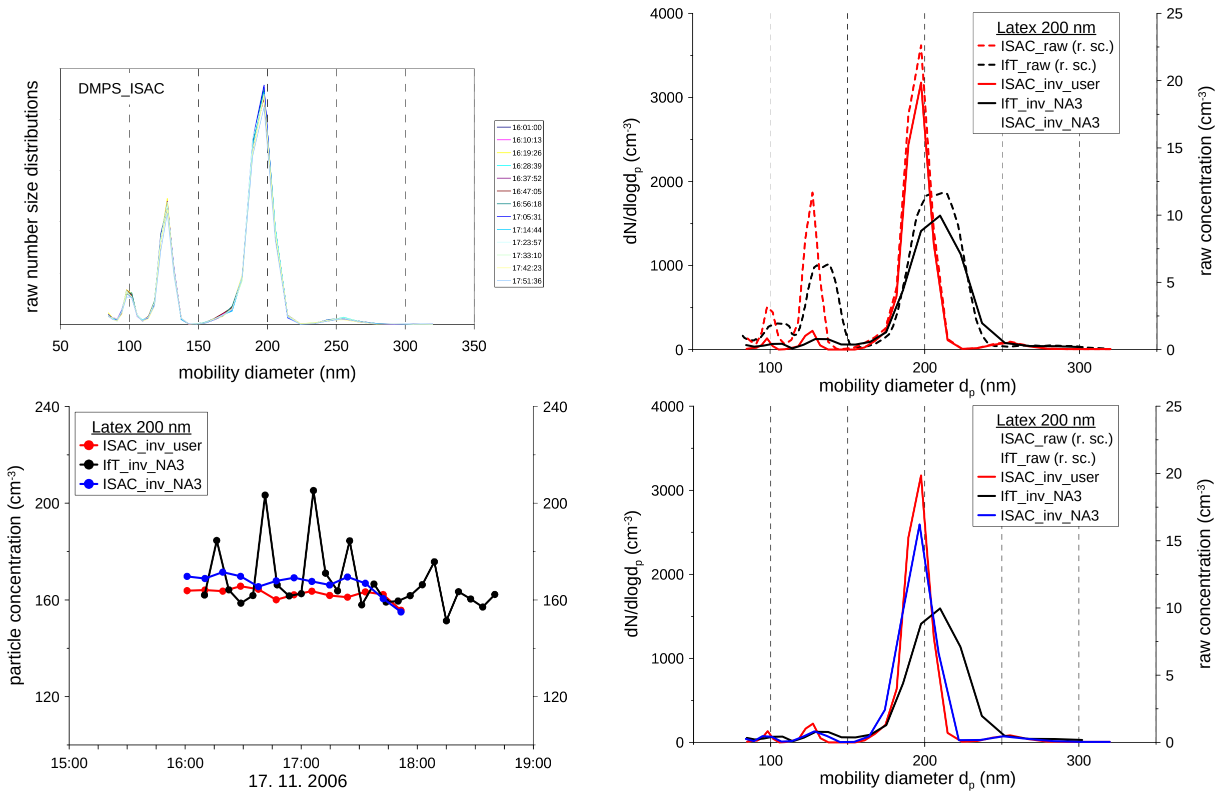

Fig.1: Raw and different inverted particle size distributions and total concentration of the ISAC DMPS in comparison to the same parameters of the IfT SMPS derived from the 200 nm mono-disperse Latex experiment. Explanations of the different curves are given in the legends and the text.

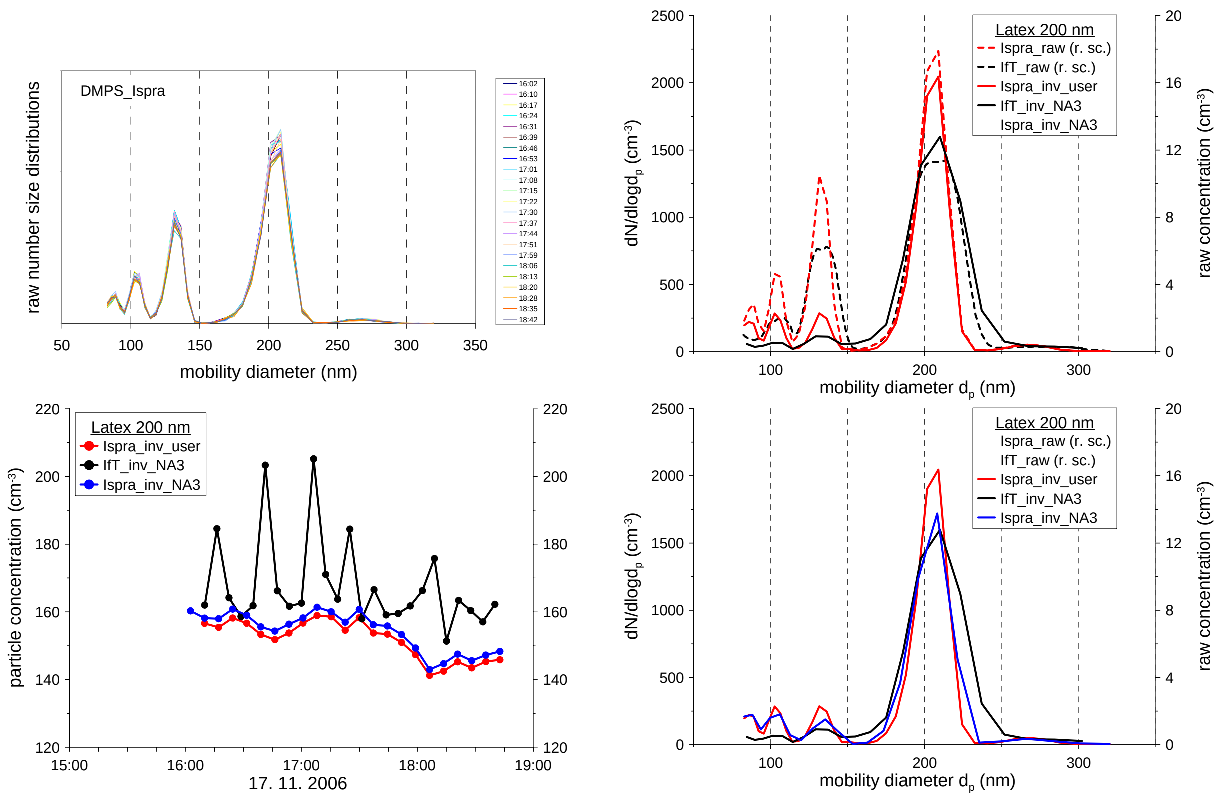

Fig.2: Same as Fig.1 but related to the Ispra DMPS.

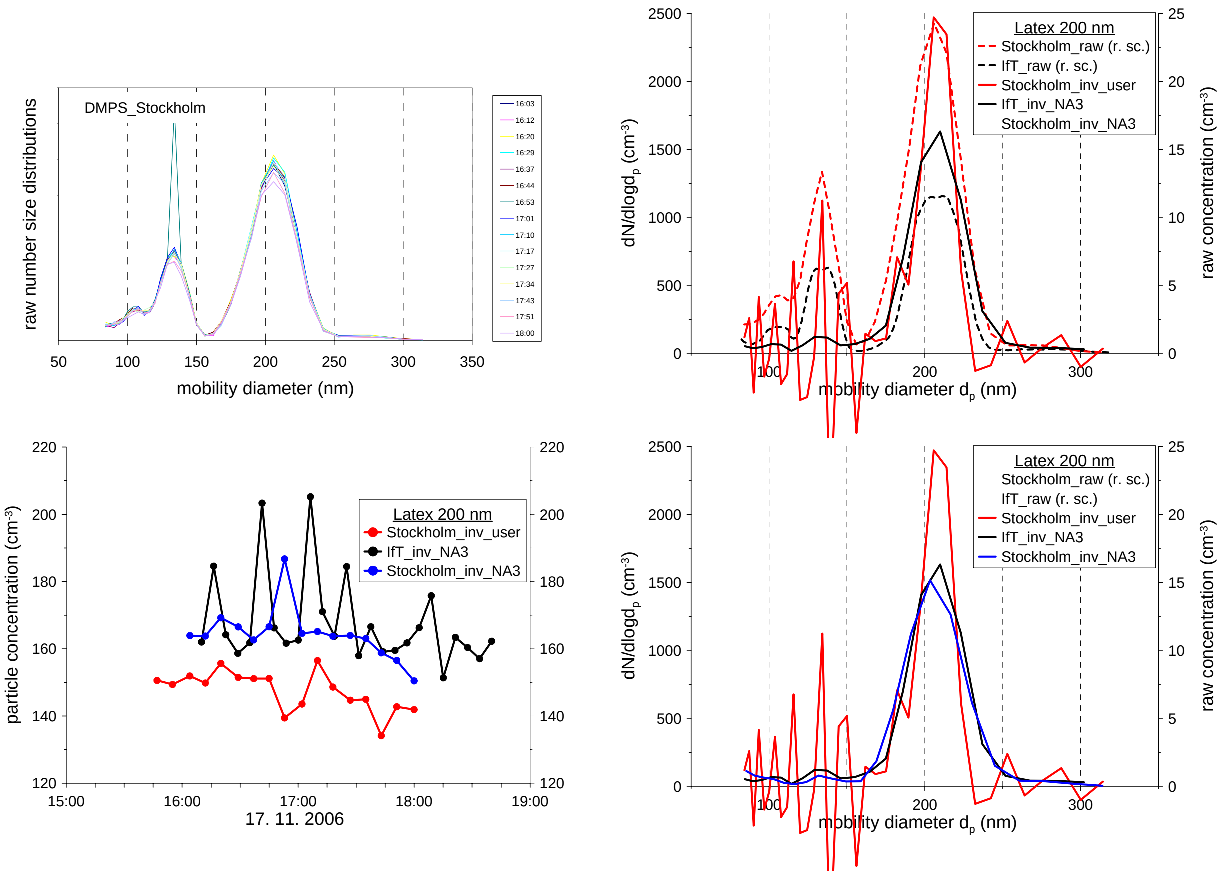

Fig.3: Same as Fig.1 but related to the Stockholm DMPS.

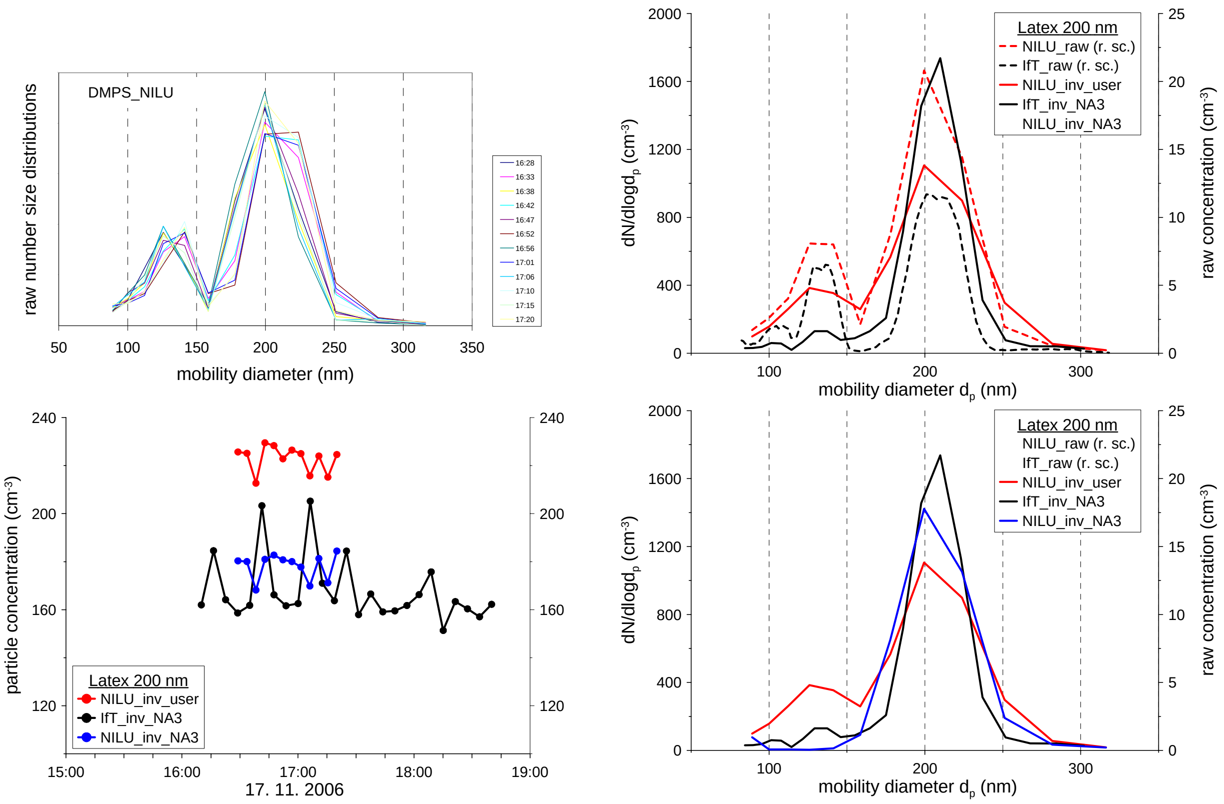

Fig.4: Same as Fig.1 but related to the NILU DMPS.

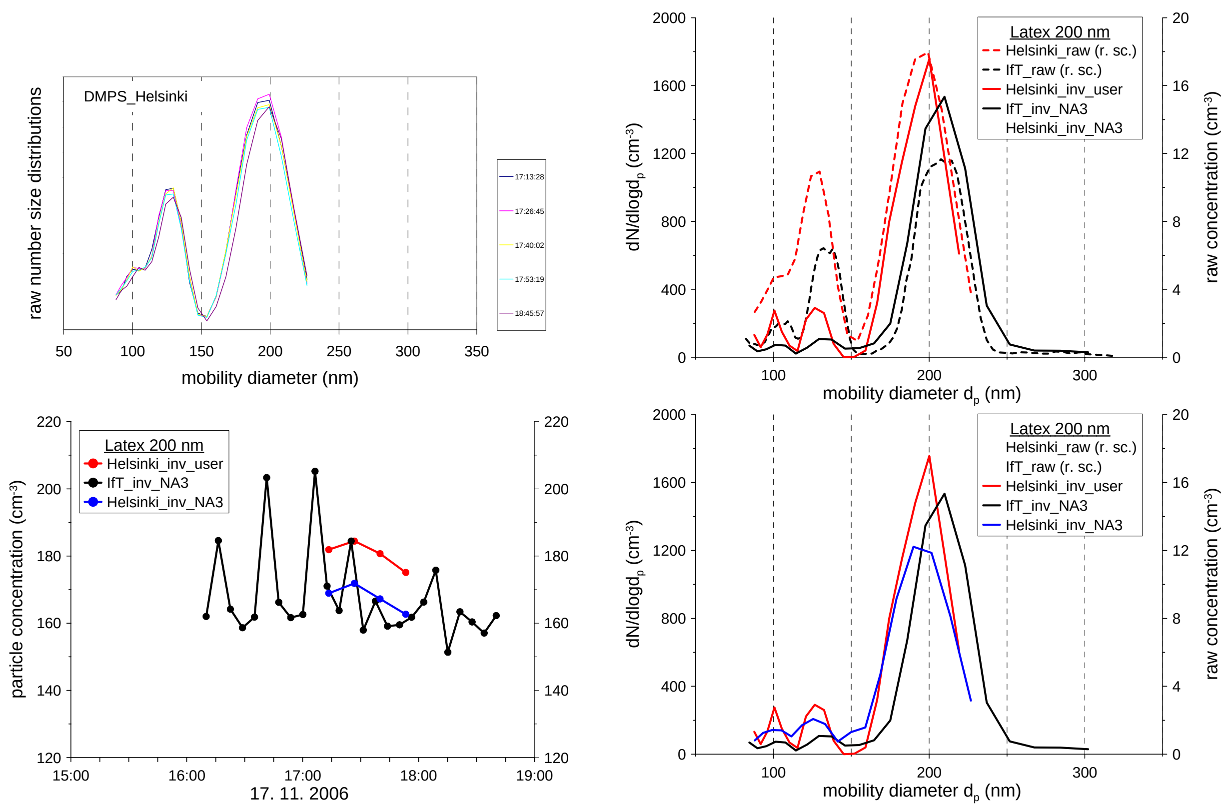

Fig.5: Same as Fig.1 but related to the Helsinki DMPS.

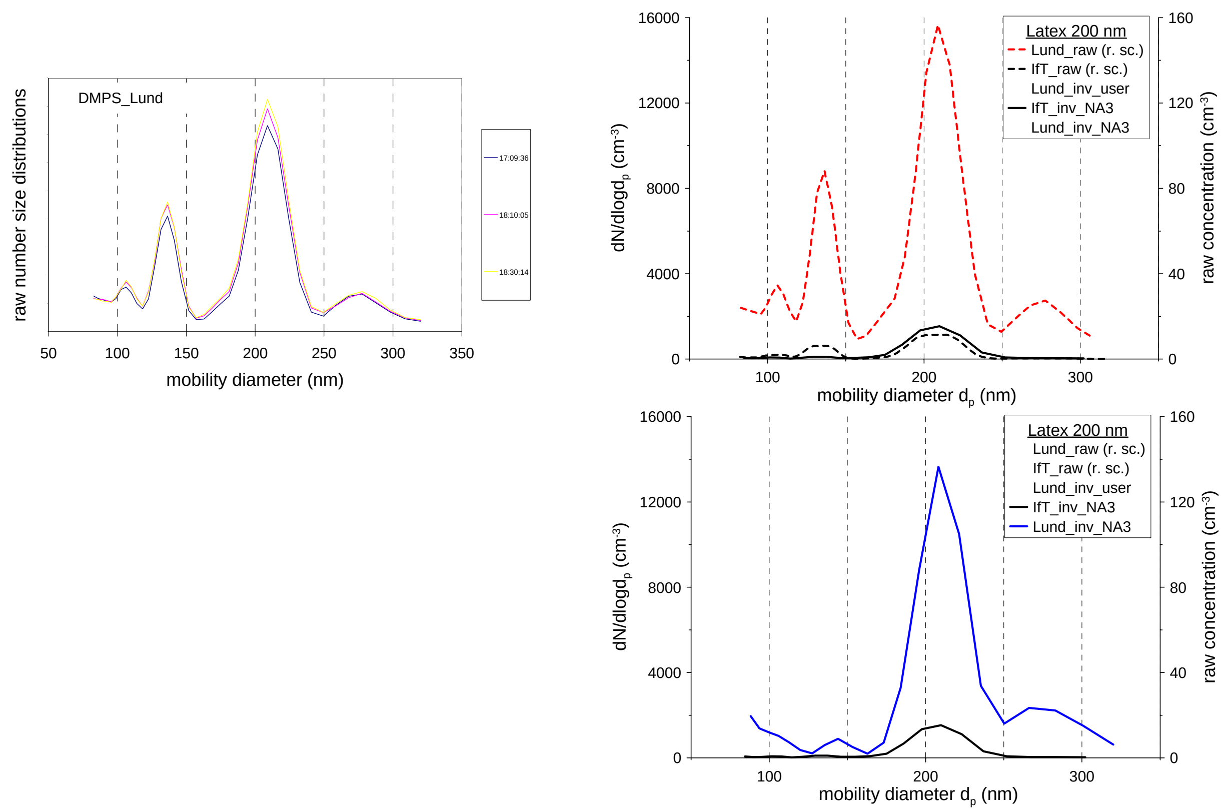

Fig.6: Same as Fig.1 but related to the Lund TDMPS.

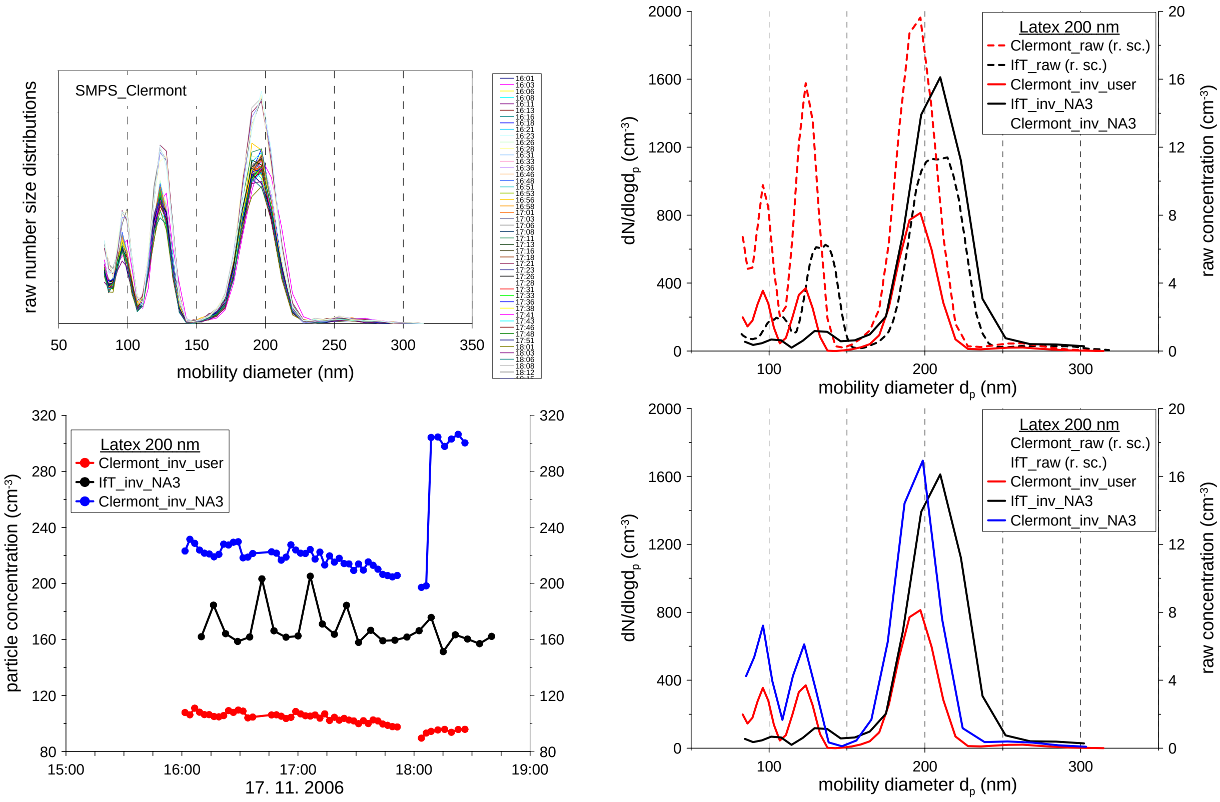

Fig.7: Same as Fig.1 but related to the Clermont SMPS.

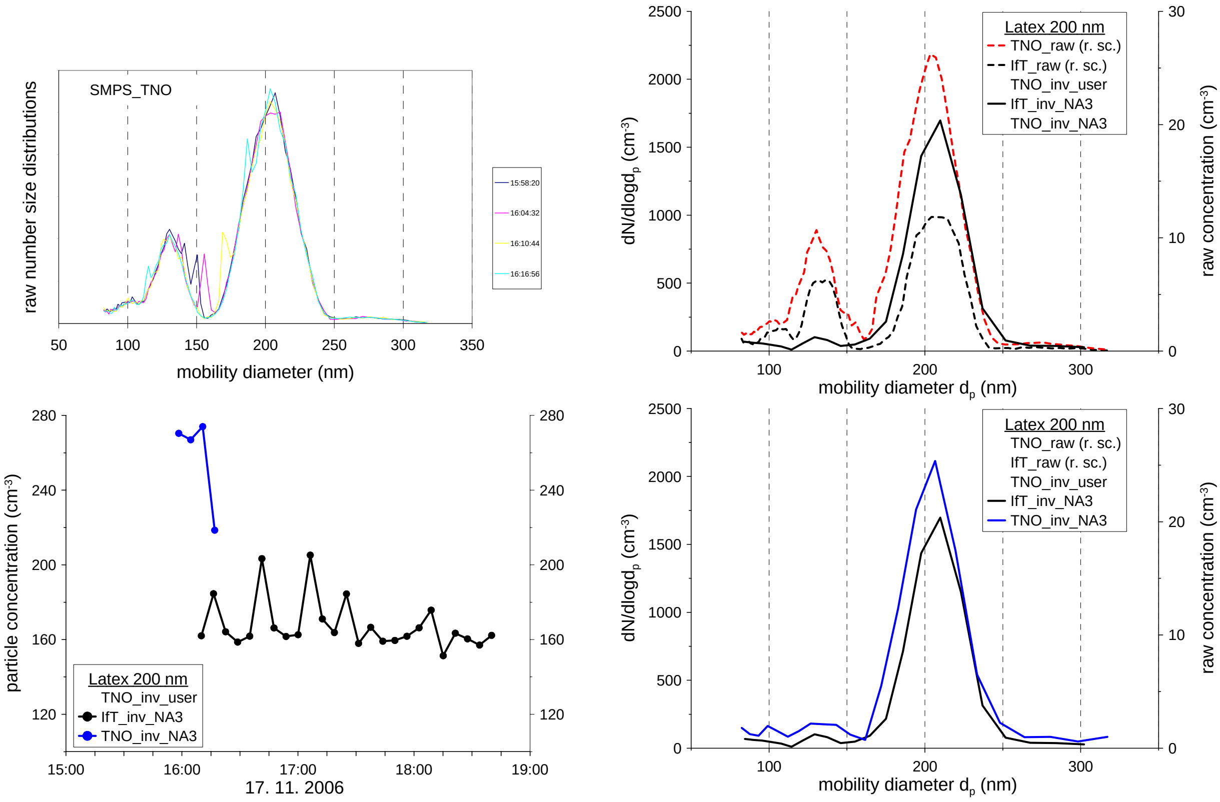

Fig.8: Same as Fig.1 but related to the TNO SMPS.

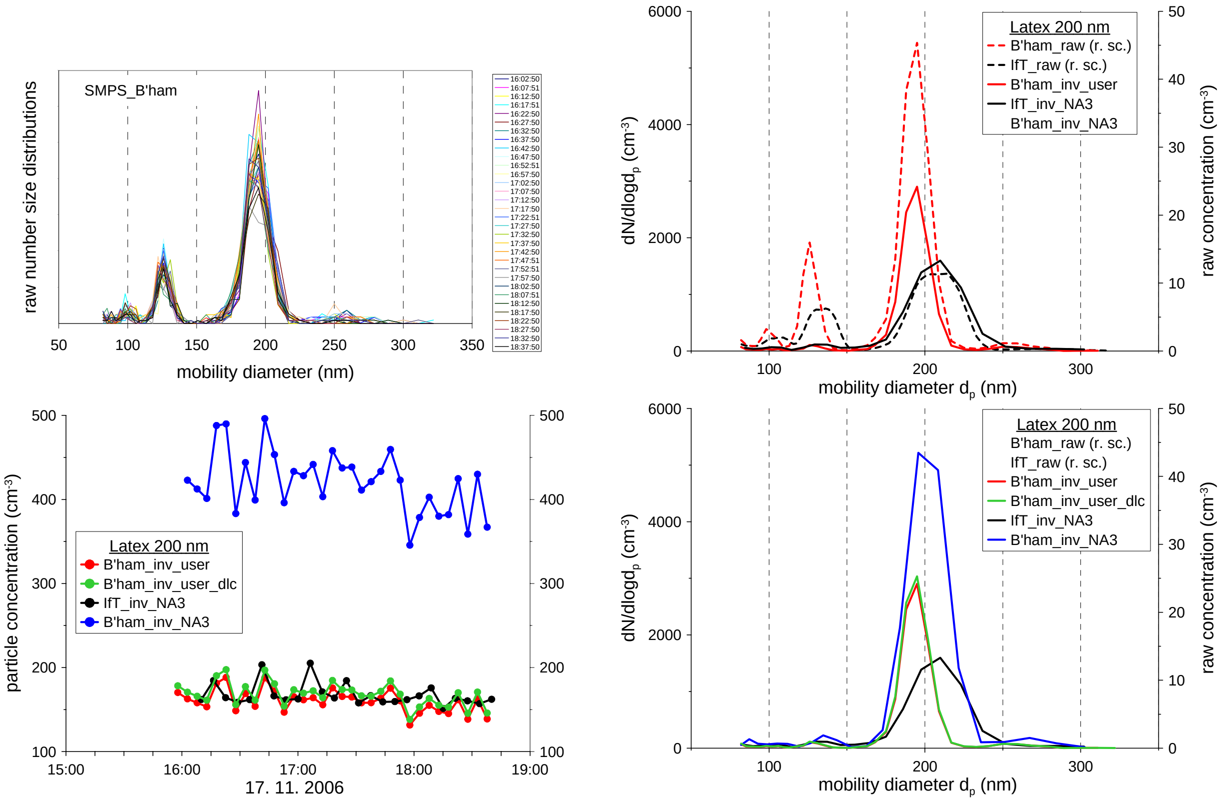

Fig.9: Same as Fig.1 but related to the Birmingham SMPS. Red and green curves denote inversion results derived with TSI software without and with diffusion losses taken into account.

2.3.2. Evaluation of the particle number size distribution and concentration measurements

Fig.10 shows three bar charts that illustrate deviations of each system with respect to concentration, sizing and multi charge correction. The upper panel represent the relative deviations from the average particle concentration of 167 cm^{-3} obtained from the IfT SMPS. Results from user and NA3 inversions in general agree within ±12 and ±8 %, respectively. Exceptions are Clermont (-38 %) and NILU (+34 %) with respect to the user and Clermont (+37 %) with respect to the NA3 inversion (not including Birmingham).

Deviations in particle size determination are illustrated in the middle panel assuming a latex particle diameter of exactly 200 nm. Here the individual user inversions and the common NA3 inversions agree within ±5 %. Interestingly, the NA3 inversion systematically reduces and increases the peak diameter for DMPS and SMPS systems with regard to the user inversions, respectively.

The lower panel shows the relative reduction of the double charged peak for the individual user and NA3 inversion. This plot demonstrates that the charge neutralisation was insufficient with respect to the highly charged latex particles for the Clermont, NILU and Helsinki system. On average, the NA3 inversion more efficiently corrects for multi charged particles than the individual user inversions.

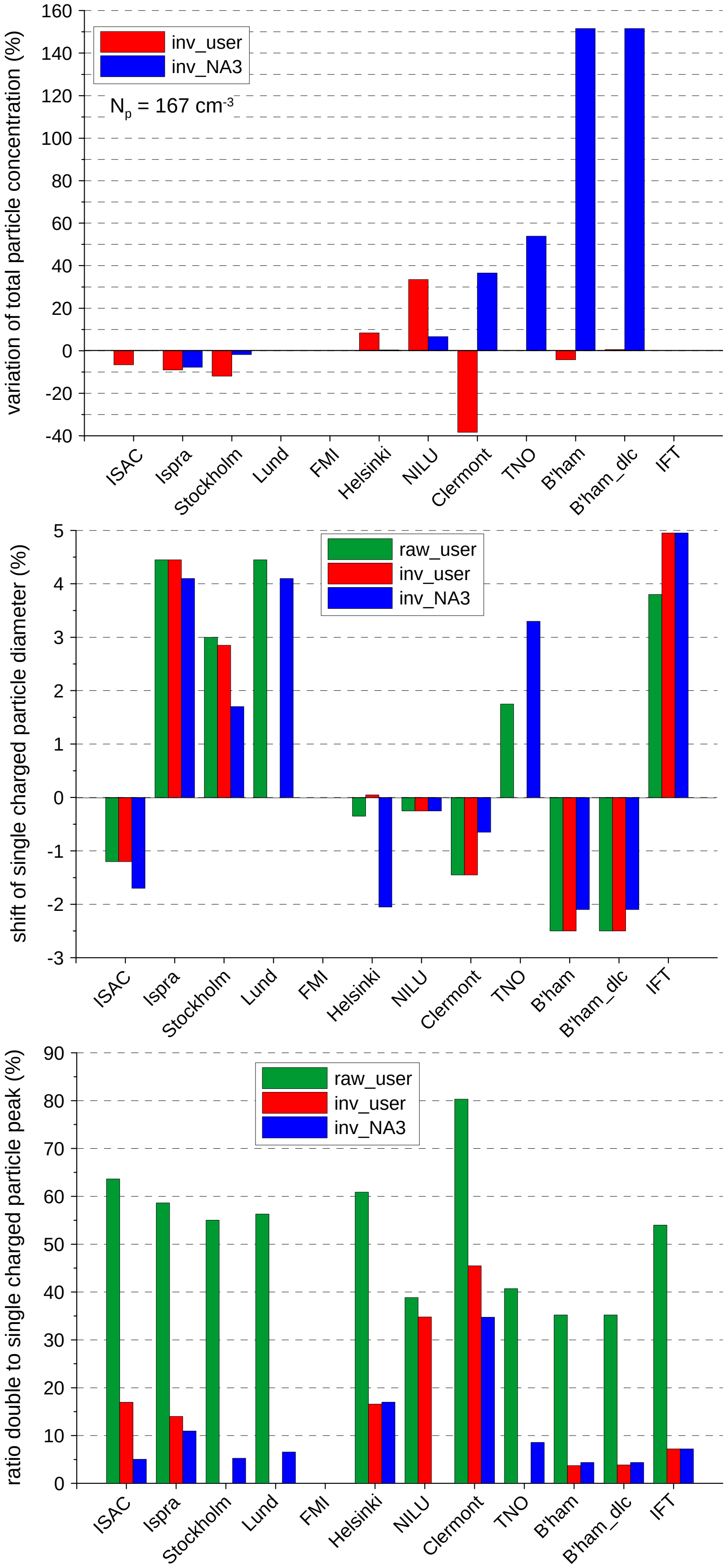

Fig.10: Deviations of each system with respect to concentration (upper panel), sizing (middle panel) and multi charge correction Lower panel). Green, red and blue bars denote results from raw, user inverted and NA3 inverted particle number size distributions.

2.4. Ambient aerosol particle Experiment

As seen in Tab.5 all systems measured during all three selected periods described above and only for the TNO SMPS no user inversion has been carried out. The following analysis will be restricted to period 1, because it is by far the longest period, i.e. that statistical errors are lower due to the longer averaging time and because the contribution of particles below 10 nm which were only measured by a few systems was smallest.

Tab.5: Data availability of all systems for the ambient aerosol particle experiment.

System:	measurement period	raw data	USER inversion	NA3 inversion
ISAC	1, 2, 3	yes	yes	yes
Ispra	1, 2, 3	yes	yes	yes
Stockholm	1, 2, 3	yes	yes	yes
FMI	1, 2, 3	yes	yes	yes
NILU	1, 2, 3	yes	yes	yes
Helsinki	1, 2, 3	yes	yes	yes
Lund	1, 2, 3	yes	yes	yes
Clermont	1, 2, 3	yes	yes	yes
TNO	1, 2, 3	yes	*no*	yes
Birmingham	1, 2, 3	yes	yes	yes
IfT	1, 2, 3	yes	yes	yes

As already mentioned in chapter 1, the Helsinki and Lund system use different size scans to cover a larger particle diameter range which needs to be merged in the respective overlap region. The integrated particle concentration results from all systems are now compared to the reading of a TSI-3025 condensation particle counter that was operated in parallel.

The raw and inverted particle number size distributions show one maximum around 100 nm so that beside an intercomparison with respect to total concentration, the diameter position of this maximum can be compared between all systems, which is additionally done in chapter 2.4.2.

2.4.1. Averaged particle number size distributions and concentration time series

The Figs.11-20 of this chapter are organised in the same way as in chapter 2.3.1. The single raw distributions are qualitatively presented in the upper left panel. Their average as well as the average raw distribution of the IfT SMPS is included in the upper right panel (red and black dashed lines, associated with the right scale). In addition the respective user inverted result and the inversion of the IfT SMPS considered as the relative reference are plotted (red and black solid line, associated to the left scale). Below, this two inverted size distributions are illustrated again together with the NA3 inversion result of the specific system. Finally, the total particle concentration time series derived from the respective system, the IfT SMPS reference and from the CPC are shown in the lower left panel.

The main features observed for each system during this specific experiment is described in the following.

IfT (Figs.11-20)

As already mentioned this system is used as a relative reference, because the measured data is originally inverted by the common NA3 inversion method. Thus the respective number size distributions and total concentration is permanently repeated in Figs.11-20. The excellent agreement with the CPC with respect to total particle concentration justifies the choice as a reference.

ISAC (Fig.11)

It is visible that the user and NA3 inverted size distribution of the ISAC DMPS agree very well among each other and additionally to the IfT SMPS reference distribution. Small deviations are seen for the maximum diameter for all three inversion results. ISAC DMPS derived particle concentrations are little lower for both user and NA3 inversion with respect to the CPC concentration time series but slightly higher for the latter.

Ispra (Fig.12)

All inverted number size distributions (user, NA3 and IfT SMPS) agree very well concerning shape and mode position. In contrast to the Latex experiment, the Ispra DMPS derived particle concentrations are this time slightly but systematically higher than the CPC results, whereby the number concentration calculated from the NA3 inversion is again slightly higher than those from the user inversion.

Stockholm (Fig.13)

As easily visible the Stockholm user inversion behaves much more reasonable for these poly-disperse particle distributions in comparison to the NA3 Stockolm and the IfT SMPS inversion results. However, user inverted number size distribution averaged for 5 hours still contains discontinuities in the region 10 to 60 nm. Interestingly, this does not affect the derived particle concentration which is identical to the NA3 derived number and both only slightly lower than the CPC reference values.

NILU (Fig.14)

The number size distribution of the NILU user inversion and the IfT reference looks similar with respect to shape and position but reproduces a higher particle concentration, which is identical to the NILU NA3 derived concentration. Between 50 and 60 nm the user and NA3 inversion of the NILU raw data intersects, demonstrating that the NA3 inversion yields more particles at sizes below and less particles at sizes above this diameter.

Helsinki (Fig.15)

A distinct bend at 30 nm is seen in the raw distributions. This is the diameter position where the separately measured distributions from the high and low flow scans are merged. Only the small diameter range (particle diameter < 30 nm) fits perfectly with the IfT SMPS average raw distribution. Obviously, the user inversion seems to somehow correct for the unbalanced raw data, because the user inverted and the IfT SMPS number distributions are quite similar. This unknown correction is not included in the NA3 inversion for the Helsinki system, which leads to an underestimation of the particle distribution between 10 to 50 nm. The NA3 inversion only corrects for the flow ratio of aerosol to sheath air flow (which is identical for the two different flow modes, cf. Tab.2) but not for the absolute flows (that might change the DMA transfer function), which can be a possible reason for the discrepancy. Moreover, the measured Helsinki distributions end at a very small diameter of 274 nm, so that the right side of the accumulation mode is not detected, which should lead to an underestimation for the inferred total particle concentration. Actually the contrary is found for the user inversion whereas the NA3 inverted particle concentration is qualitatively consistent with this conclusion, which implies that the mentioned merging correction in the user inversion might cause an overestimation of the particle concentration.

Lund (Fig.16)

The Lund raw distributions have a small discontinuity close above 20 nm caused by the merging of the simultaneous UDMA and DMA scans, which is more pronounced during the measurement periods 2 and 3 at the presence of more small particles. As it looks like, this discontinuity seems to broaden the user inverted particle size distribution in this size range (indeed it creates an additional Aitken mode for period 2 not shown here). Like before the common NA3 inversion treats the UDMA and DMA scan in the same way, because the flow ratios are identical. Thus, the NA3 inverted distributions show a rather sharp bend at the corresponding diameter. The particle concentrations derived from the user and NA3 inversions agree very well, despite the different shapes of their number distributions, but both are systematically than the CPC reference values.

FMI (Fig.17)

In contrast to the problems during the Latex experiment, the FMI system worked properly during the ambient aerosol experiment. Shape and positioning of the FMI and IfT system raw and inverted number size distributions agree quite nicely. The inferred particle concentration shows systematic differences depending on the system and the inversion routine. Both, user and user FMI derived number concentration (user FMI > NA3 FMI) are found to be higher than the CPC reference results.

Clermont (Fig.18)

Although the Clermont system as an SMPS measured much more scans with a higher size resolution the raw and thus the inverted number size distribution are more “noisy” than those recorded by the IfT SMPS. Above 80 nm the accumulation mode measured by the Clermont system decreases more rapidly. Similar to the NILU system an interception exists between the user and NA3 inverted size distribution at about 60 nm where the NA3 inversion reproduces more smaller but less larger particles. Nevertheless, the number concentration derived from the user and NA3 inversion agree and are lower than the CPC reference concentration. This is reasonable, because the Clermont system missed particles smaller than 20 nm.

TNO (Fig.19)

Like as during the Latex experiment the TNO SMPS single raw distributions contained randomly distributed spikes. A mean number size distribution exists only from the NA3 inversion that agrees very well with the IfT SMPS reference regarding shape and position of the accumulation mode. However, the inferred NA3 particle concentration is significantly larger than the CPC reference concentration.

Birmingham (Fig.20)

No definite shape of the size distribution is visible from the series of single raw distributions. However their average has a similar shape (but much more noisy, which also applies for the inverted distributions) and positioning compared to the IfT SMPS. Obviously, the raw distribution calculated with the TSI software is not the one needed as input for the NA3 inversion, because this produces much too high particle concentrations. The user inversions (TSI software with and without diffusion losses) slightly underestimate the particle concentration, whereby the diffusion loss corrected values are closer to the CPC reference ones. The activation of the diffusion loss correction in the TSI software also produces number size distributions that agree much better with the IfT SMPS distributions at diameters below 100 nm.

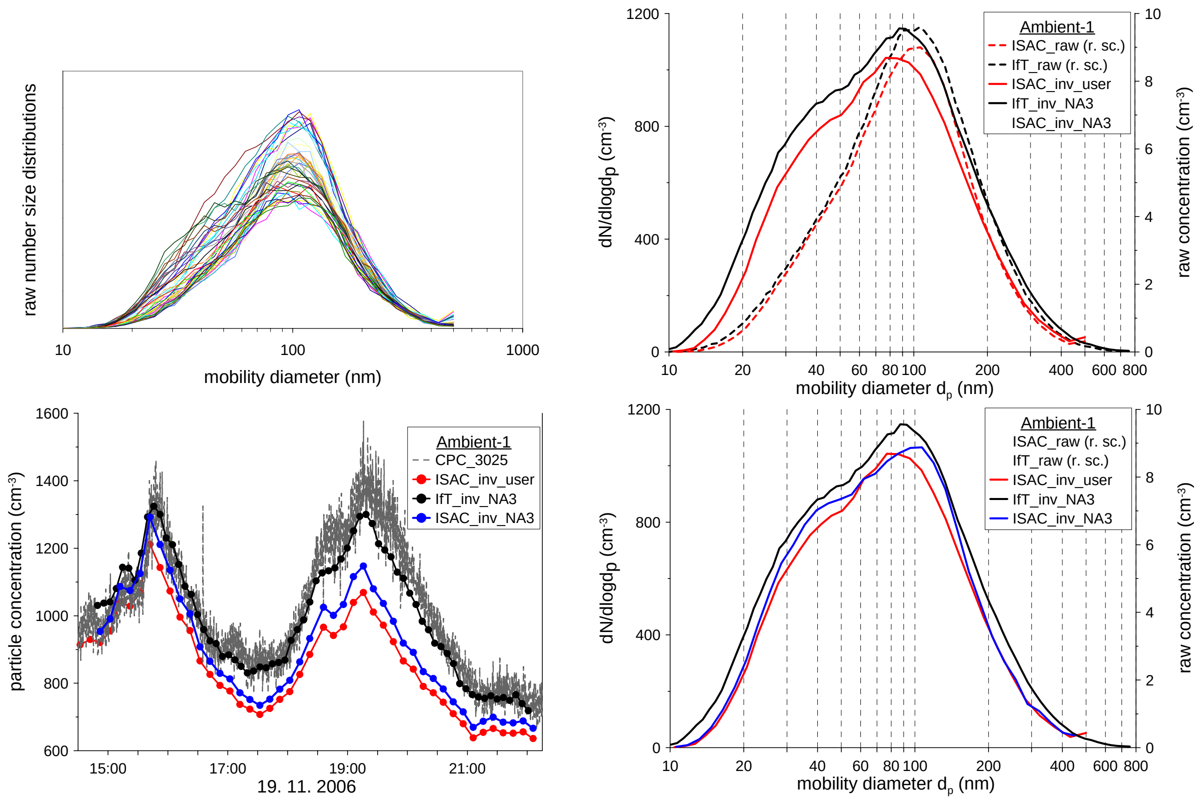

Fig.11: Raw and different inverted particle size distributions and total concentration of the ISAC DMPS in comparison to the same parameters of the IfT SMPS and CPC derived from the ambient aerosol experiment, period 1. Explanations of the different curves are given in the legends and the text.

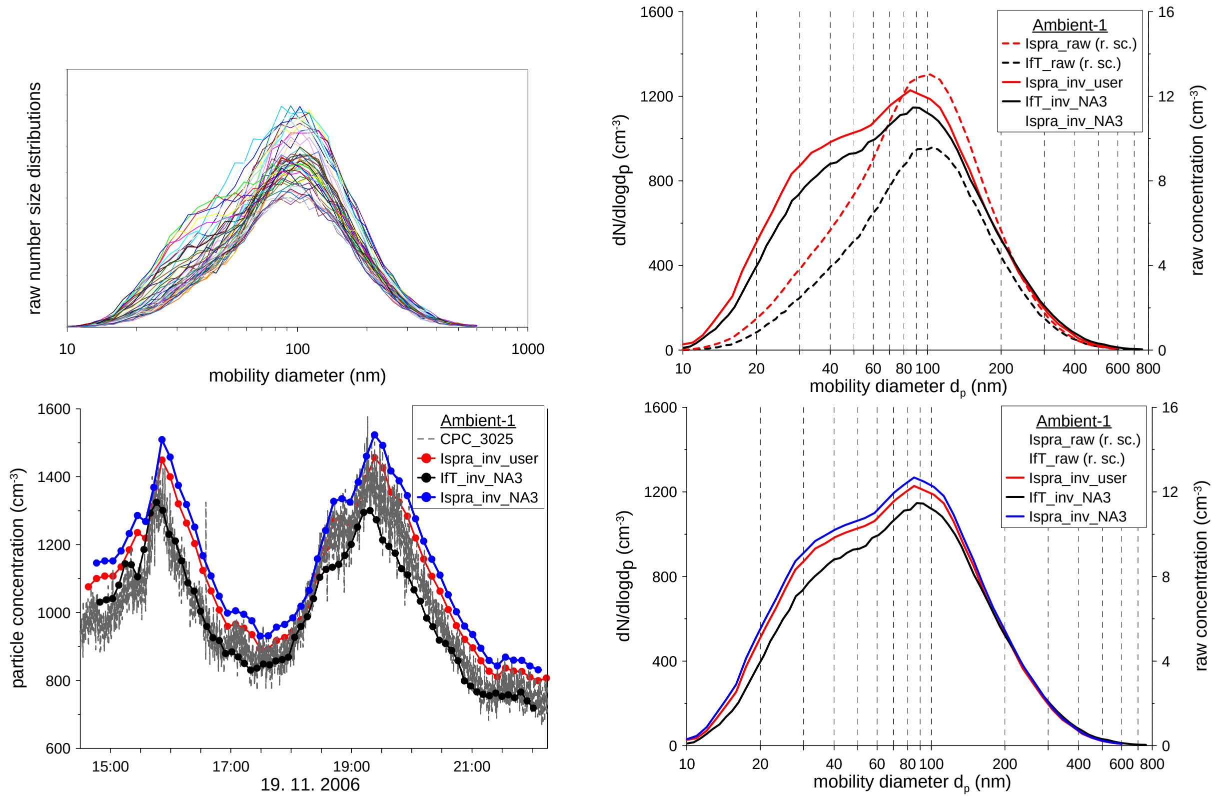

Fig.12: Same as Fig.11 but related to the Ispra DMPS.

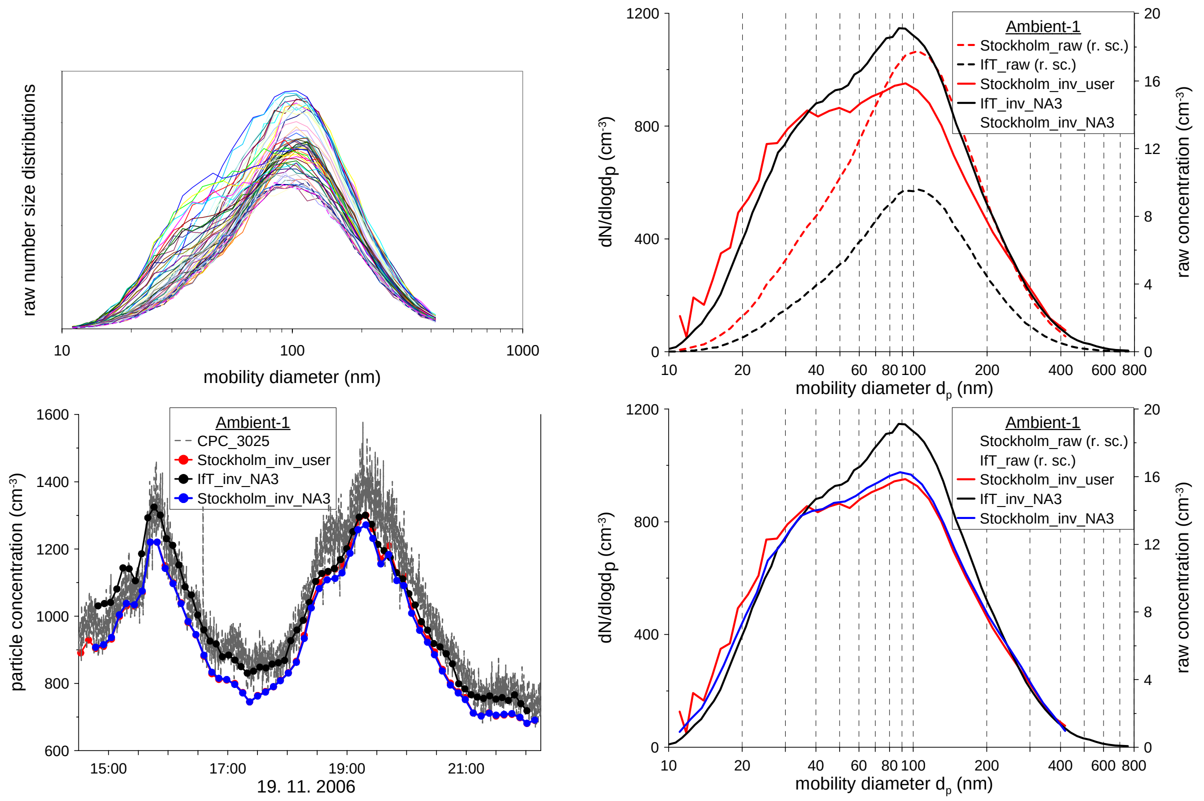

Fig.13: Same as Fig.11 but related to the Stockholm DMPS.

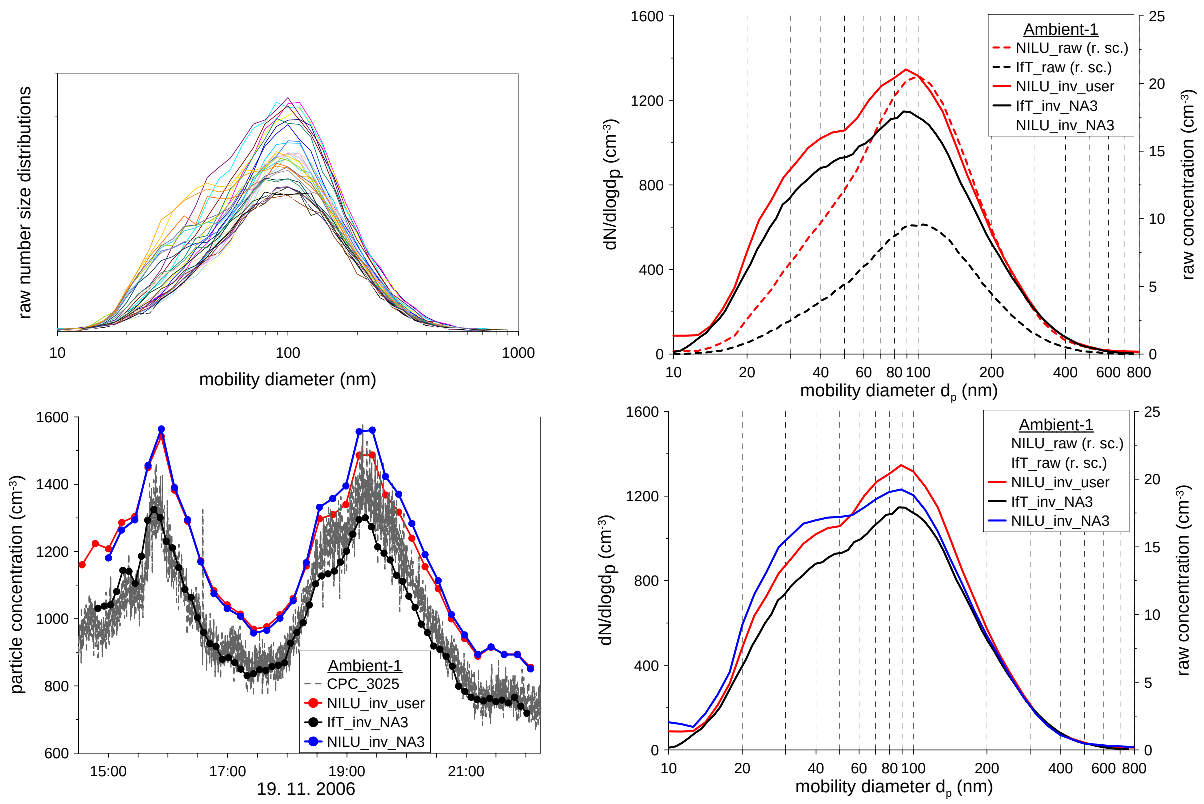

Fig.14: Same as Fig.11 but related to the NILU DMPS.

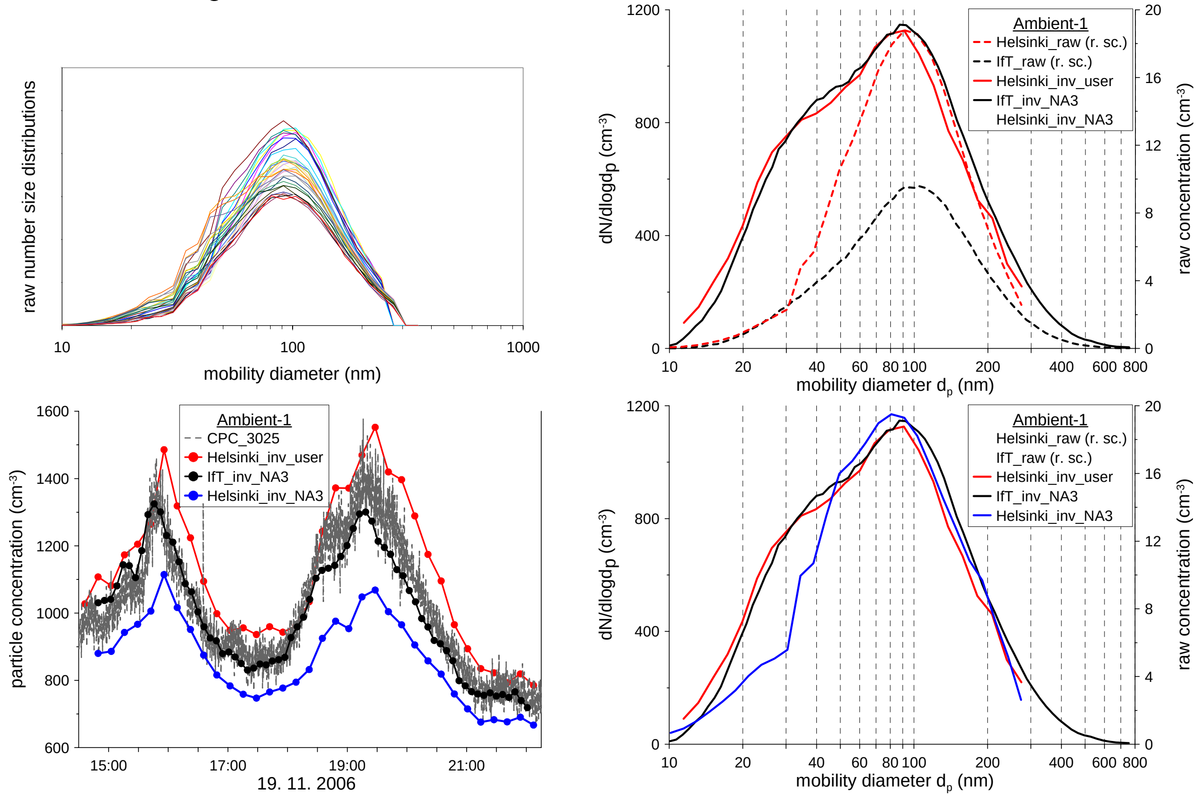

Fig.15: Same as Fig.11 but related to the Helsinki DMPS.

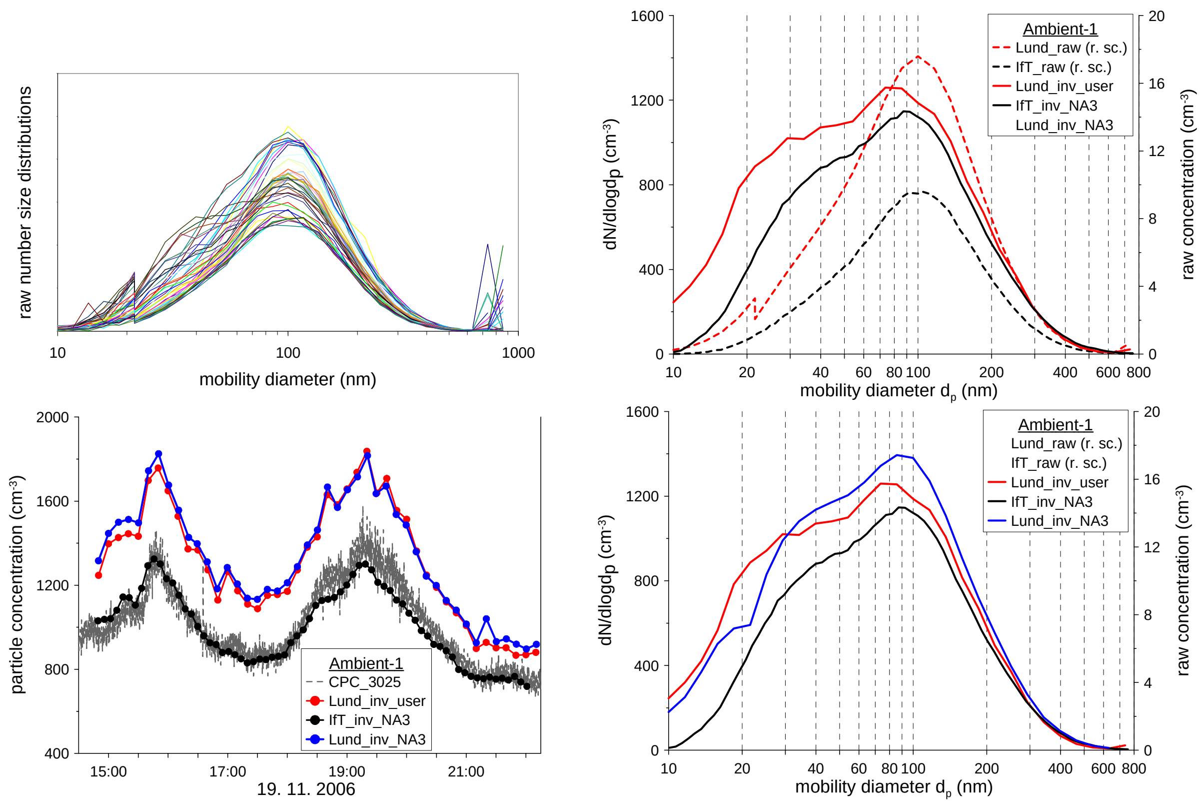

Fig.16: Same as Fig.11 but related to the Lund TDMPS.

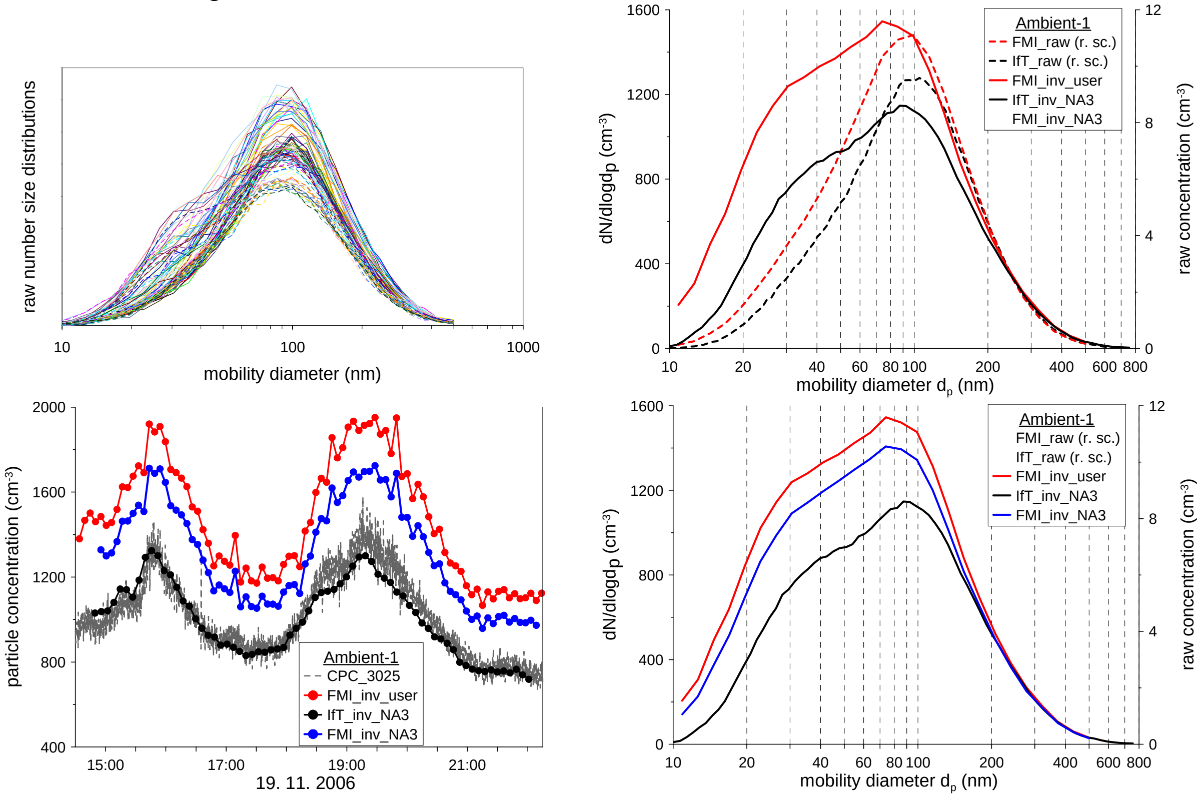

Fig.17: Same as Fig.11 but related to the FMI DMPS.

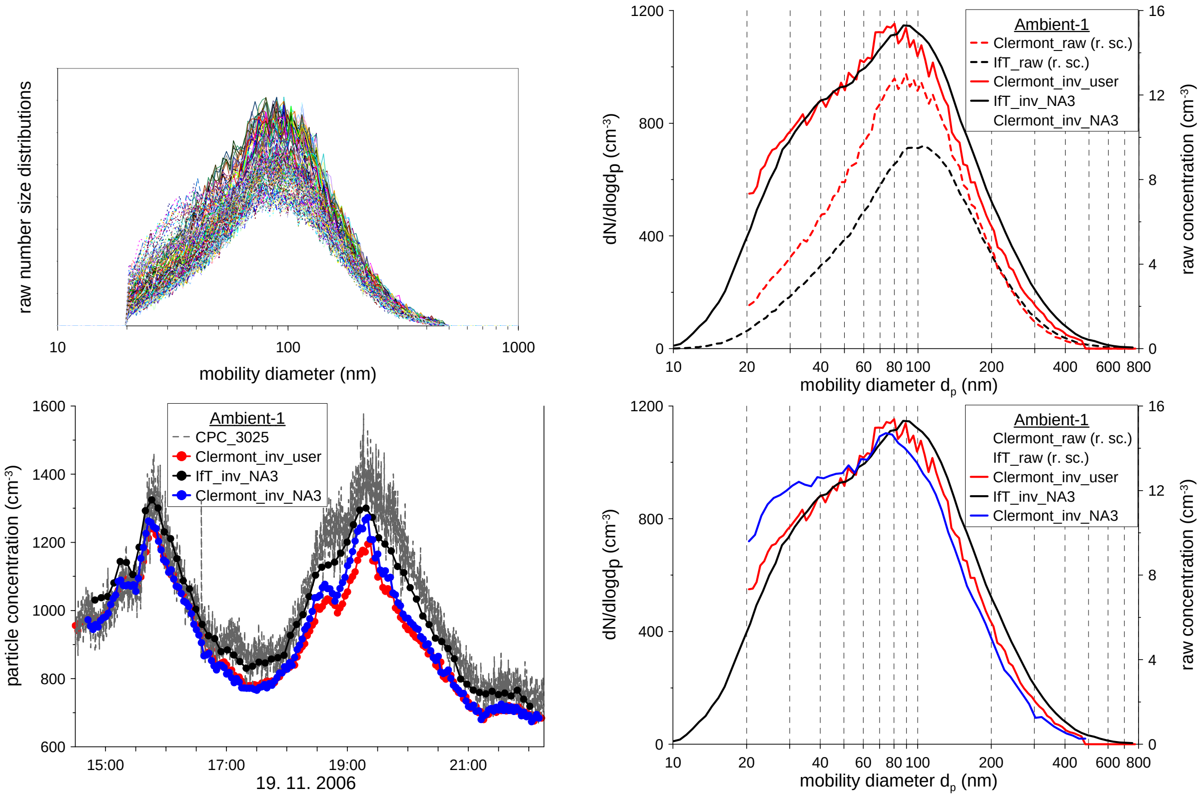

Fig.18: Same as Fig.11 but related to the Clermont SMPS.

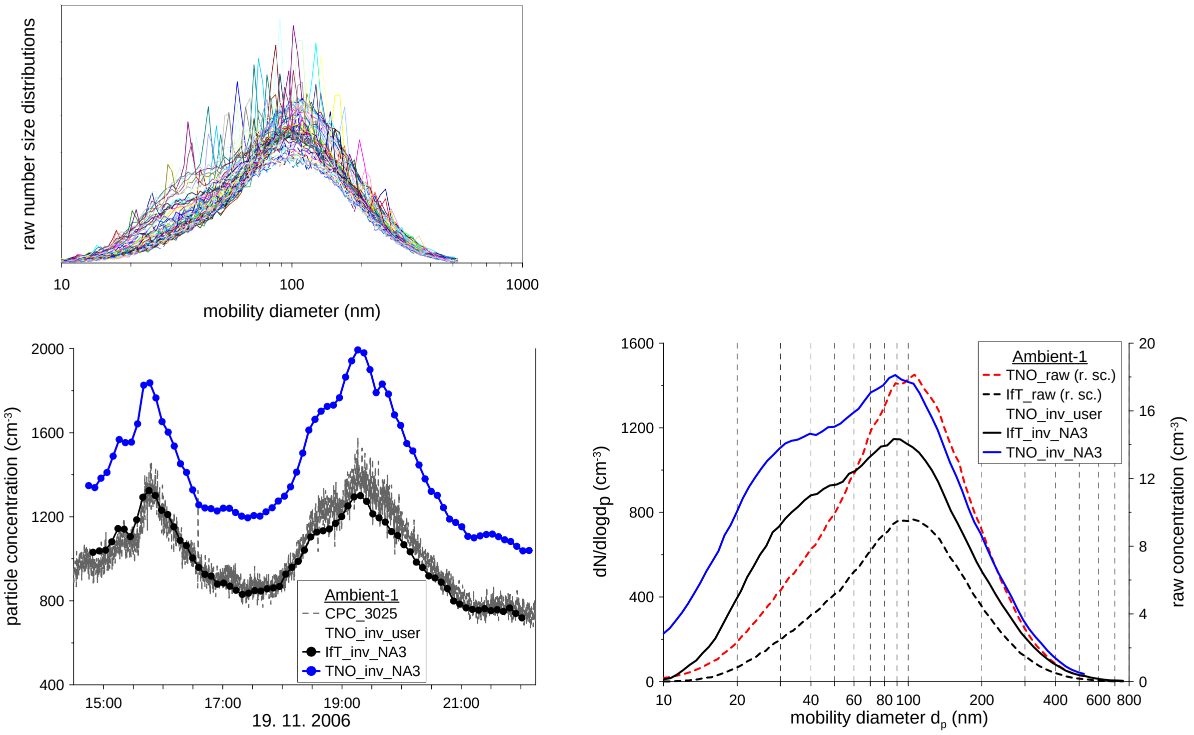

Fig.19: Same as Fig.11 but related to the TNO SMPS.

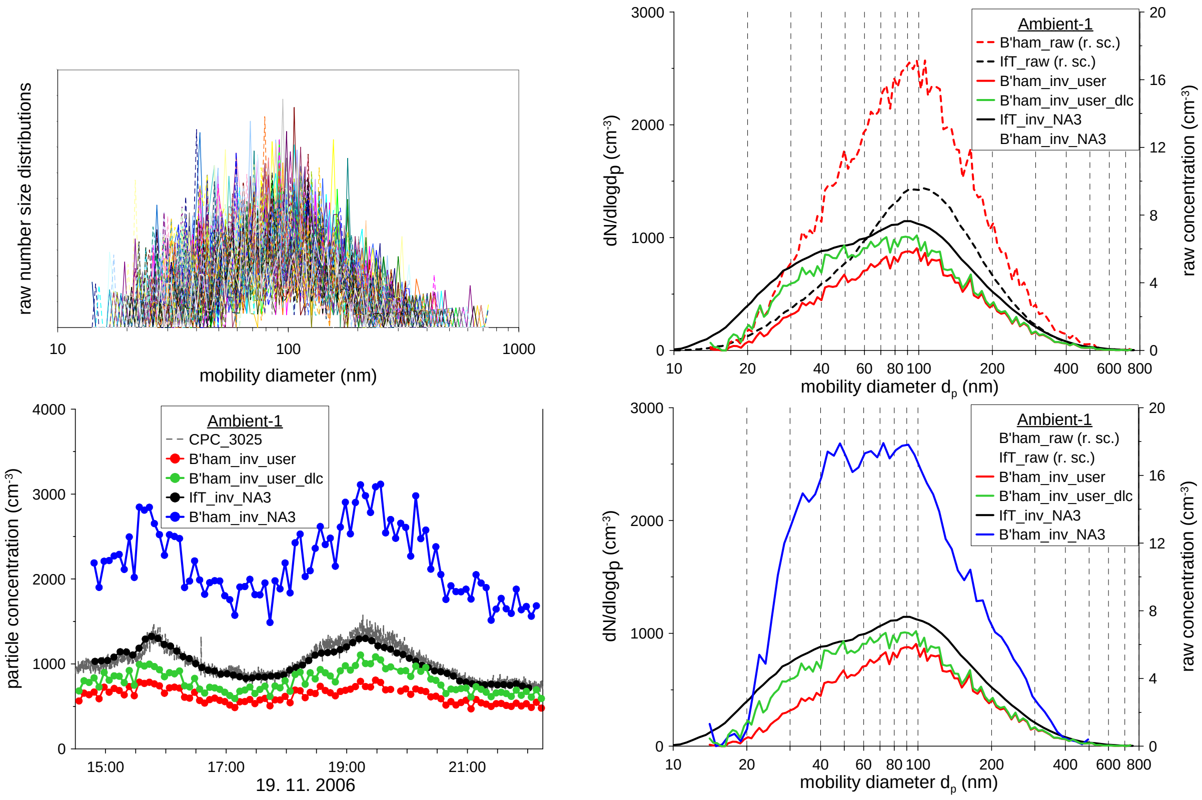

Fig.20: Same as Fig.11 but related to the Birmingham SMPS. Red and green curves denote inversion results derived with TSI software without and with diffusion losses taken into account.

2.4.2. Evaluation of the particle number size distribution and concentration measurements

Fig.21 shows two bar charts that illustrate deviations of each system with respect to total particle concentration, and mode diameter determination. The upper panel represent the relative deviations from the average particle concentration of 1017 cm^{-3} measured with the CPC TSI-3025. Results from user and NA3 inversions for the same system agree within ±5 %. Exceptions are FMI (-13 %), Helsinki (-31 %) when excluding Birmingham (because the NA3 inversion is quantitatively not meaningful due to the lack of knowledge concerning the raw data).

An absolute intercomparison of all systems is difficult, since at least the Helsinki and Clermont system were strongly constricted in their measured size range and thus did not detected the small and large diameter tails of the ambient particle size distribution. For the remaining DMPS/SMPS systems (again excluding Birmingham for the same reason as before) a deviation range from -14 to +45 % and from -12 % to +32 % are observed for the individual user and the common NA3 inversion, indicating that the NA3 inversion reproduces the number concentration more realistic.

Deviations in mode diameter determination are illustrated in the lower panel of Fig.10 with regard to a mean value derived from all systems of 85.5 nm. In absolute terms, all systems agree within ±15 % and most most of them even 6 of 11 systems within ±9 %. The individual user inversions and the common NA3 inversions for a single system agree within ±10 % for 8 systems. The ISAC (+11 %) and the Helsinki (-13 %) system are close to that limit and the only outlier is Birmingham with -28 %. This large deviation is most likely caused by the highly uncertain determination of the mode diameter due to the noisy size distributions.

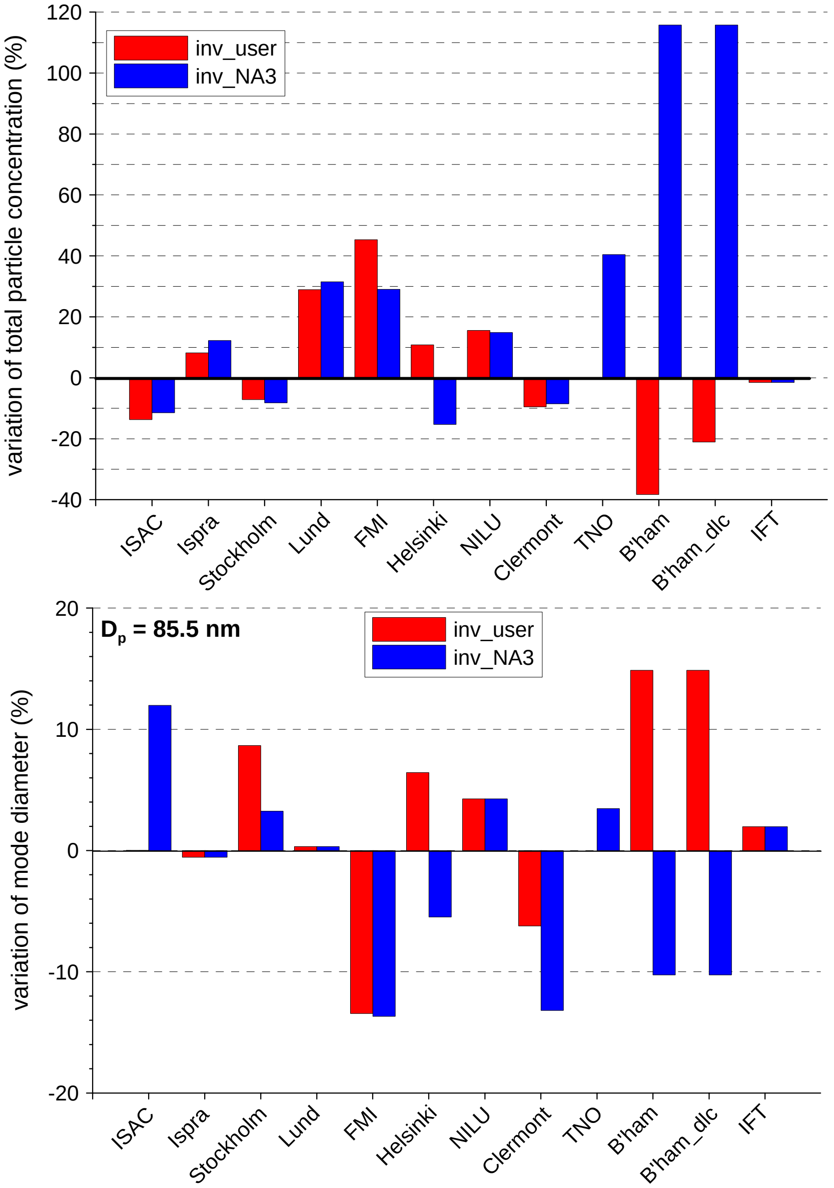

Fig.21: Deviations of each system with respect to particle concentration (upper panel) and determination of the accumulation mode diameter (lower panel). Red and blue bars denote results from user and NA3 inverted particle number size distributions.