Audit report for the EMEP station Vavihill, Sweden

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Summary:

Measurements of physical aerosol properties at the EUSAAR site Vavihill were audited by Alfred Wiedensohler and Thomas Tuch of the WWCAP on October 20th 2008. The site is located at 56.01ºN, 13.09ºE, 172 m above sea level. Surroundings of the site are dominated by deciduous forest. The nearest populated site is some 10km away. The area of Malmö and Copenhagen, with about 2 million inhabitants, is situated about 60-70 km to the SSW.

Two summerhouses are located close to the site (Figure 1). Both houses do have chimneys and barbecue sites next to them which are possible intermittent source of local pollution. A NO_x monitor was supposed to be installed at the site to identify local pollution but was not yet available in October 2008. Measurement data from approximately 270° to 360° may therefore need to be excluded from the existing data set.

The site is operated by Department of Nuclear Physics, Lund University. Driving from Lund to the site takes about one hour. Routine visits to the site are scheduled once per week. The maximum time between visits in 2008 was, however, 21 days. This frequency of routine visits is not sufficient to ensure data quality according to EUSAAR standards.

Detailed routine maintenance instructions are available in the electronic log for the station including procedures for every site visit as well as procedures to be repeated in longer cycles. Unfortunately many of these instructions have either not been followed or not been logged in 2008. This causes extended periods of unreliable data e.g. for the Nephelometer.

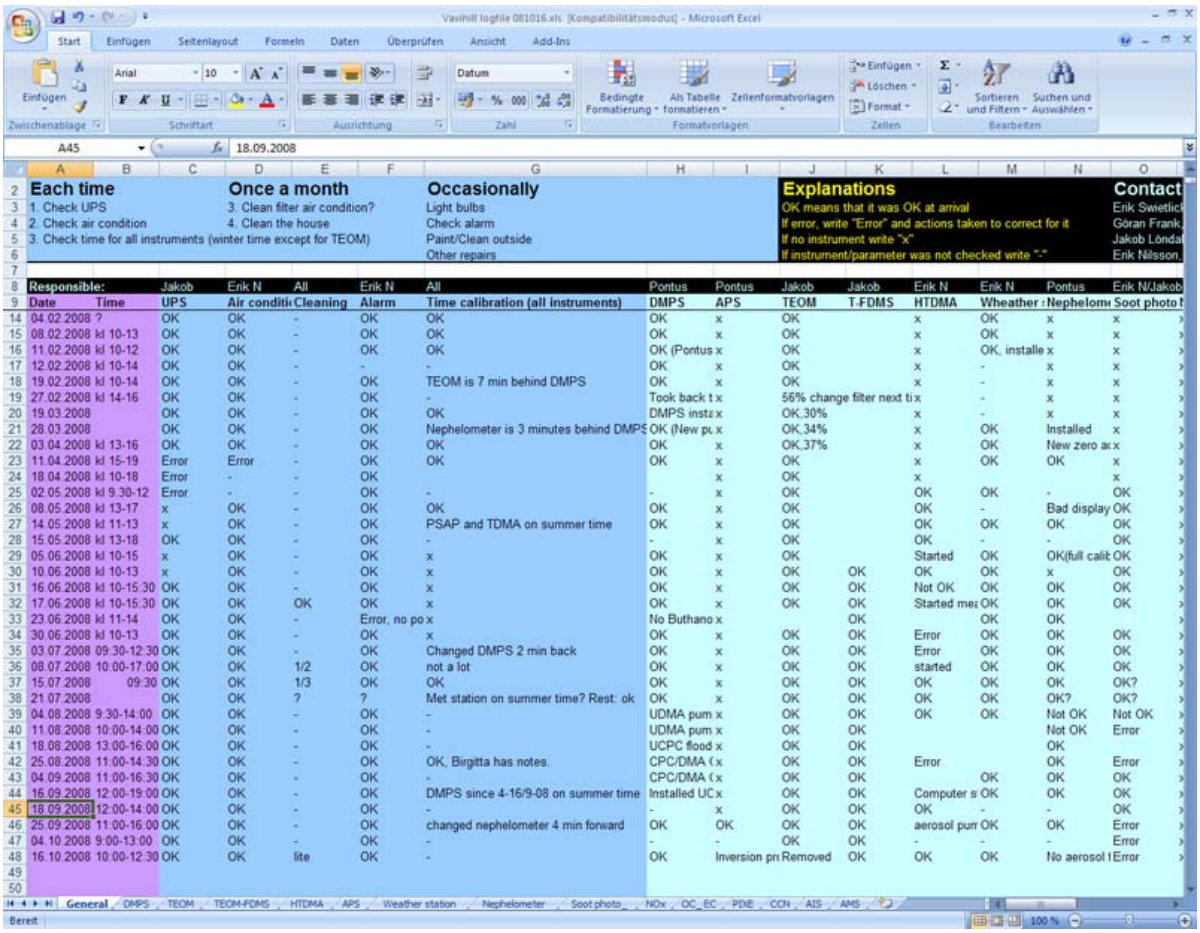
Measurement strategies for physical aerosol properties at the EUSAAR site Vavihill still leave some room for improvement

Figure 1: Vavihill monitoring site with nearby possible local sources. Indicated distances obtained from GPS data.

Documentation:

Manuals for the CPCs and the APS were not available at the site during the audit.

An online Excel log is used for all instruments. This log includes a general section for all instruments as well as sections for each instrument. A screenshot of the logbook is shown in figure 2. (OK at arrival, If error, write "Error" and actions taken to correct for it, If no instrument write "x", If instrument/parameter was not checked write "-")



Each time	Once a month	Occasionally	Explanations	Contact
1. Check UPS	3. Clean filter air condition?	Light bulbs	OK means that it was OK at arrival	Erik Swietlicki
2. Check air condition	4. Clean the house	Check alarm	If error, write "Error" and actions taken to correct for it	Göran Frank,
3. Check time for all instruments (winter time except for TEOM)		Paint/Clean outside	If no instrument write "x"	Jakob Londa
		Other repairs	If instrument/parameter was not checked write "-"	Erik Nilsson,

Responsible:		Jakob	Erik N	All	Erik N	All	Pontus	Pontus	Jakob	Jakob	Erik N	Erik N	Pontus	Erik N/Jakob
Date	Time	UPS	Air conditi	Cleaning	Alarm	Time calibration (all instruments)	DMPS	APS	TEOM	T-FDMS	HTDMA	Wheather	Nephelom	Soot photo
04.02.2008	?	OK	OK	-	OK	OK	OK	x	OK		x	OK	x	x
08.02.2008	kl 10-13	OK	OK	-	OK	OK	OK	x	OK		x	OK	x	x
11.02.2008	kl 10-12	OK	OK	-	OK	OK	OK (Pontus	x	OK		x	OK, installe	x	x
12.02.2008	kl 10-14	OK	OK	-	-	-	OK	x	OK		x	-	x	x
19.02.2008	kl 10-14	OK	OK	-	OK	TEOM is 7 min behind DMPS	OK	x	OK		x	-	x	x
27.02.2008	kl 14-16	OK	OK	-	OK	-	Took back t	x	56% change filter next ti		x	-	x	x
19.03.2008		OK	OK	-	OK	OK	DMPS insta	x	OK,30%		x	-	x	x
28.03.2008		OK	OK	-	OK	Nephelometer is 3 minutes behind DMPS	OK (New pu	x	OK,34%		x	OK	Installed	x
03.04.2008	kl 13-16	OK	OK	-	OK	OK	OK	x	OK,37%		x	OK	New zero a	x
11.04.2008	kl 15-19	Error	Error	-	OK	OK	OK	x	OK		x	OK	OK	x
18.04.2008	kl 10-18	Error	-	-	OK			x	OK		x			x
02.05.2008	kl 9.30-12	Error	-	-	OK	-	-	x	OK		OK	OK	-	OK
08.05.2008	kl 13-17	x	OK	-	OK	OK	OK	x	OK		OK	-	Bad display	OK
14.05.2008	kl 11-13	x	OK	-	OK	PSAP and TDMA on summer time	OK	x	OK		OK	OK	OK	OK
15.05.2008	kl 13-18	OK	OK	-	OK	-	-	x	OK		OK	-	-	OK
05.06.2008	kl 10-15	x	OK	-	OK	x	OK	x	OK		Started	OK	OK(full calil	OK
10.06.2008	kl 10-13	x	OK	-	OK	x	OK	x	OK	OK	OK	OK	x	OK
16.06.2008	kl 10-15:30	OK	OK	-	OK	x	OK	x	OK	OK	Not OK	OK	OK	OK
17.06.2008	kl 10-15:30	OK	OK	OK	OK	x	OK	x	OK	OK	Started mea	OK	OK	OK
23.06.2008	kl 11-14	OK	OK	-	Error, no po	x	No Buthano	x		OK		OK	OK	
30.06.2008	kl 10-13	OK	OK	-	OK	x	OK	x	OK	OK	Error	OK	OK	OK
03.07.2008	09:30-12:30	OK	OK	-	OK	Changed DMPS 2 min back	OK	x	OK	OK	Error	OK	OK	OK
08.07.2008	10:00-17:00	OK	OK	1/2	OK	not a lot	OK	x	OK	OK	started	OK	OK	OK
15.07.2008	09:30	OK	OK	1/3	OK	OK	OK	x	OK	OK	OK	OK	OK	OK?
21.07.2008		OK	OK	?	?	Met station on summer time? Rest: ok	OK	x	OK	OK	OK	OK	OK?	OK?
04.08.2008	9:30-14:00	OK	OK	-	OK	-	UDMA pum	x	OK	OK	OK	OK	Not OK	Not OK
11.08.2008	10:00-14:00	OK	OK	-	OK	-	UDMA pum	x	OK	OK			Not OK	Error
18.08.2008	13:00-16:00	OK	OK	-	OK	-	UCPC flood	x	OK	OK			OK	
25.08.2008	11:00-14:30	OK	OK	-	OK	OK, Birgitta has notes.	CPC/DMA (	x	OK	OK	Error		OK	Error
04.09.2008	11:00-16:30	OK	OK	-	OK	-	CPC/DMA (	x	OK	OK		OK	OK	OK
16.09.2008	12:00-19:00	OK	OK	-	OK	DMPS since 4-16/9-08 on summer time	Installed UC	x	OK	OK	Computer s	OK	OK	OK
18.09.2008	12:00-14:00	OK	OK	-	OK	-	-	x	OK	OK	OK	-	-	OK
25.09.2008	11:00-16:00	OK	OK	-	OK	changed nephelometer 4 min forward	OK	OK	OK	OK	aerosol purr	OK	OK	Error
04.10.2008	9:00-13:00	OK	OK	-	OK	-	-	-	OK	OK	-	-	-	Error
16.10.2008	10:00-12:30	OK	OK	lite	OK	-	OK	Inversion pr	Removed	OK	OK	OK	No aerosol	Error

Figure 2: Screenshot of the electronic log at Vavihill

Documentation at Vavihill complies with EUSAAR requirements but manuals for all instruments must be available at the site.

Primary flow standard:

A Gilibrator is available as primary flow standard at the site. Both flow cells have been verified against the WCCAP reference during this audit. (figure 3). Note that WCCAP values have been corrected for the known deviation of this cell (-1.5%). The average deviation of the high flow cell was found to be + 0.9 % whereas the deviation of the small cell was less than -0.1%

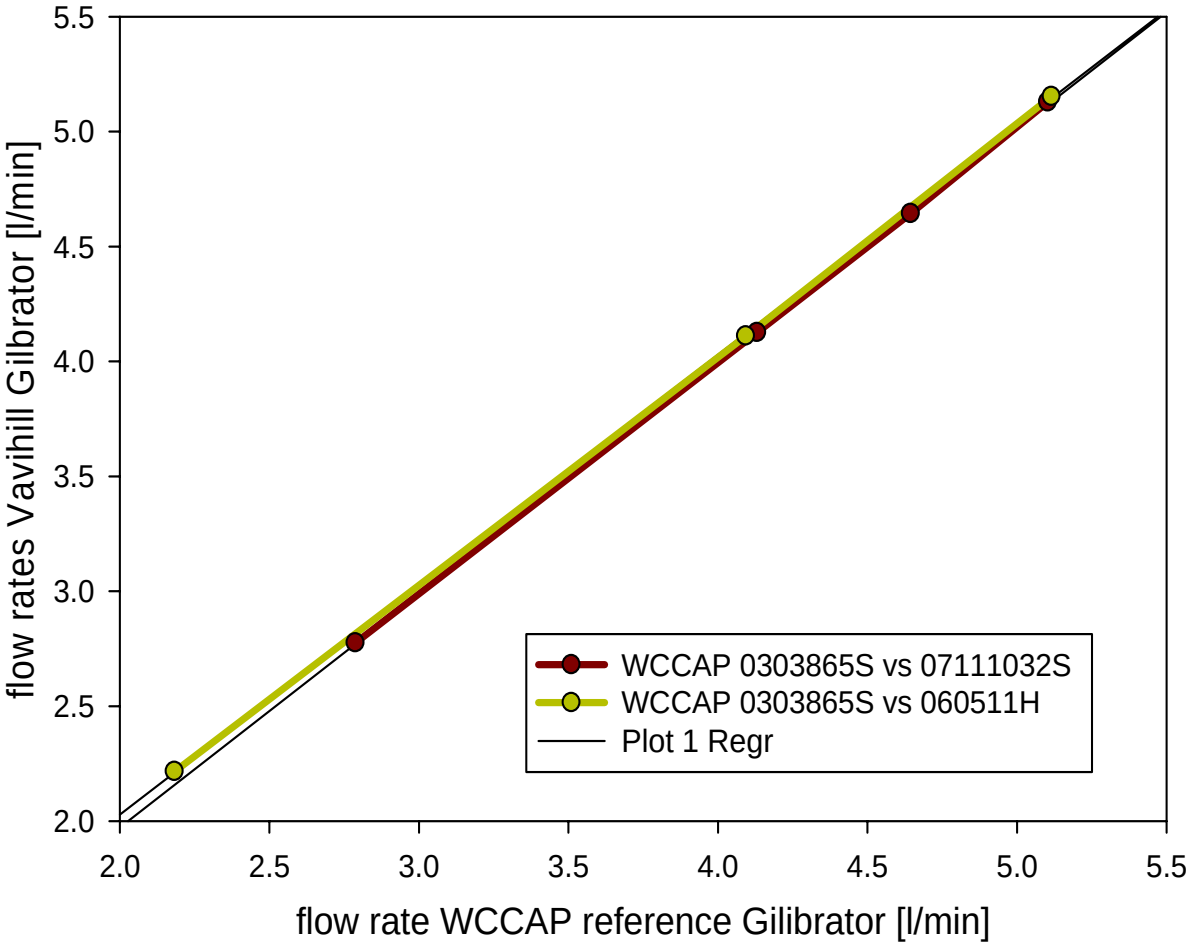


Figure 3: Comparison of flow standards at Vavihill with WCCAP standard.

The primary flow standards comply with EUSAAR requirements

Aerosol inlets:

Three separate aerosol inlets with commercially available PM10 sampling heads are used at Vavihill (figure 3). There was no adapter available during our audit to check inlet flow rates with a primary flow standard. The missing adaptor is probably the reason for the missing flow checks of the TEOM addressed later in this report.

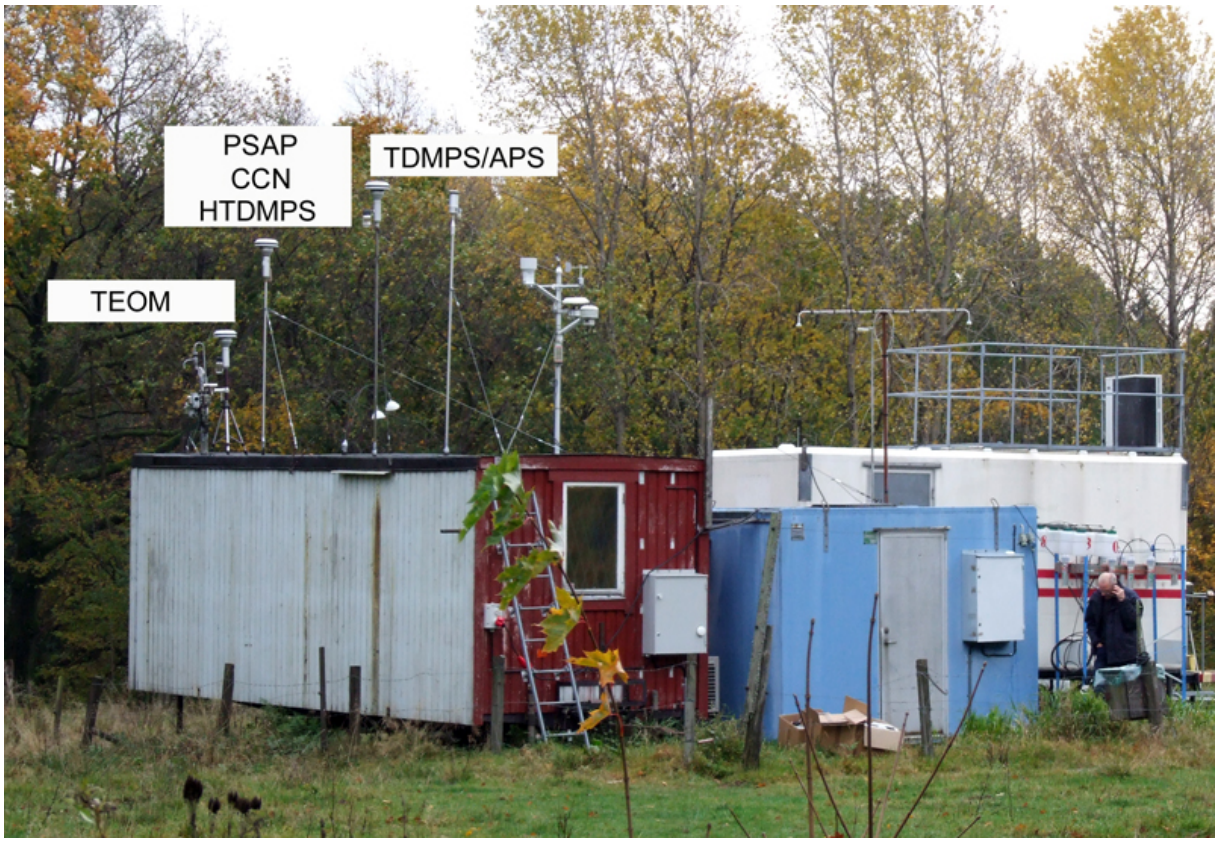


Figure 3: Aerosol inlets at Vavihill.

The first inlet from the right is used for the TDMPS system and the APS. The flow splitter for this system is shown in figure 4. Note that the major flow of this flow splitter (~ 13 l/min) is drawn perpendicular to the aerosol sample flows. This design may act as a virtual impactor influencing measured size distributions. A plastic nafion dryer is used for humidity conditioning of the APS sample whereas a stainless steel nafion dryer is used for the TDMPS. Note that the sample line to the TDMPS was made of Tygon tubing which may cause losses of ultrafine particles. This tubing has been replaced by TSI black conducting tubing during the audit.

The inlet used for the HTDMA, CCNC and the PSAP is shown in figure 5. Its design is similar to the TDMPS inlet. Tygon tubing is again used as sampling line to the PSAP. Note that all aerosol lines in an inlet or in an instrument should be made of stainless steel or conductive black tubing to avoid particle losses due to image forces.

Figure 4: Inlet TDMPS/APS

Figure 5: Inlet CCNC/PSAP/HTDMA

After replacement of Tygon tubing by stainless steel or conductive black tubing aerosol inlets at Vavihill comply with EUSAAR standards. Possible effects of the flow splitters on the size distribution need to be investigated.

Absorption Photometer:

A homemade PSAP is available for measurement of the absorption coefficient at Vavihill. When we visited the site this instrument was not working. During the audit a broken cable was identified as the reason for the malfunction. This fault was then repaired on site towards the end of our audit. We could therefore only do a quick zero check on this instrument which yielded an negative offset of 1 m^{-6}.

The PSAP is connected to the flow splitter by Tygon tubing which should be replace by stainless steel or conductive black tubing. According to the electronic log the flow rate of this instrument (measured by a TSI flowmeter) has not been checked since May 2nd 2008. Flow checks are scheduled monthly.

The PSAP at Vavihill seems to be in good working condition after repair.

Nephelometer:

A three wavelength Nephelometer M9300 S/N 07-1541 is used to measure scattering coefficients at Vavihill at a flow rate of 2.5 l/min. This instrument has not yet been upgraded to the most recent light source which was only released by the manufacturer after this audit.

The instrument operates without an aerosol drier. It has been agreed that aerosol rH should be lower than 50%. During the audit the humidity measured inside the Nephelometer was 48%. It is therefore very likely that a dryer is needed to comply with EUSAAR recommendations.

Nephelometer

Each time
1. Span check with CO2 (section 4.1 in manual)
2. Zero check (section 4.1 in manual)
3. Check data looks OK, Compare with Mie model for DMPS data

Once a month
4. Backup data
5. Clean measurement cell (every 3 m
6. Two-point calibration (every 3 month

Date	Time	Span 450 nm	Span 520 nm	Span 700 nm	Zero 450 nm	Zero 520 nm	Zero 700 nm	Mie model
28.01.2008	kl 10	OK	Error	Error	OK	OK	OK	
28.01.2008	kl 12	OK	OK	OK	OK	OK	OK	
21.03.2008	kl 17	OK	OK	OK	OK	OK	OK	
28.03.2008	kl 10-13				OK	OK	Error*	Good agreement
03.04.2008	kl 13-16	OK (44.65)	OK (24.83)	OK (6.517)	OK (-0.886)	OK (-0.44)	Error* (-1.696)	Good agreement
11.04.2008	kl 15-19	OK	OK	OK	OK	OK	OK	Good agreement
08.05.2008	kl 13-17	-	-	-	-	-	-	-
14.05.2008	kl 11-13	OK (45.4)	OK (24.711)	OK (6.758)	OK (0.2969)	OK (-0.534)	OK (-0.288)	Good agreement
05.06.2008	kl 10-15	OK(46.647)	OK(25.863)	OK(7.5276)	OK(0.7789)	OK(-0.337)	Error(-1.61)	Good agreement
10.06.2008	kl 10-13	-	-	-	-	-	-	-
16.06.2008	kl 10-15:3(	-	-	-	-	-	-	-
17.06.2008	kl 10-15:3'	-	-	-	-	-	-	Deviates about 100%
23.06.2008		OK (45.891)	OK(25.054)	Error(11.49895	Error(3.2352)	Error(3.4661)	Error(5.8943)	Deviates about 100%
30.06.2008	kl 10-13	OK(44.421)	OK(25.692)	OK(7.4052)	OK(-0.743)	Error(-1.834)	Error(-1.45)	Deviates about 50 %
03.07.2008	kl 09:30-12	-	-	-	-	-	-	Deviates about 50 % at
15.07.2008	11:00				0.47	-0.11	1.27	Deviates 20%
21.07.2008	13:10-13:3	-	-	-	-2.2	-1.3	-0.4	Deviates about 100%
04.08.2008	kl 09:30-14	OK (45.923)	OK(26.353)	Error(5.2965)	OK(0.6218)	OK(0.6045)	OK(0.7777)	-
11.08.2008	09:30-14:0	45.313	26.277	Error(16.985)	0.3409	-0.05	0.3385	Deviates about 50 %
18.08.2008	13:00-16:0	-	-	-	-	-	-	Deviates about 50 %
25.08.2008		-	-	-	-	-	-	Mie model ~a factor of
04.09.2008	11:00-16:0	-	-	-	-	-	-	Mie model ~a factor of
16.09.2008	14-15	-	-	-	-0.4	-0.2	-0.3	Very good agreement
25.09.2008	kl 11-16	-	-	-	-	-	-	Very good agreement
16.10.2008	kl 10-12	43.7	23.1	6.8	-1.191	-0.852	-0.25	Not so good

Figure 6: Logbook entries for the Nephelometer.

A valid span check of the instrument was performed during the audit. Full calibration is scheduled every three months. Full calibrations are, however, performed more frequently than scheduled if Mie calculations of the scattering coefficients differ significantly from measured values. Zero and span checks are scheduled every

week. Unfortunately this is not done all the time (see screenshot of the logfile where a minus sign indicates that no zero/spancheck was performed, figure 6). We have noticed excessive zero and span drift in Eccotech Nephelometers at other sites. Most likely this is also true for the instrument at Vavihill (see zero/span check 23.6.08 13 days after the last check. Zero and span checks of the Nephelometer must be performed at least once per week.

The Nephelometer at Vavihill is working properly. Zero and span checks need to be performed according to maintenance schedule.

Number size distribution: The TDMPS at Vavihill consists of a Hauke medium type DMA with a closed loop air flow system a chemical absorption drier with CPC 3760 with no visible serial. A short Hauke type DMA connected to a TSI 3025 UCPC S/N 1314 is used for ultra-fine particles. Large particles are measured by an APS 3310 S/N 363 with separate data acquisition software. Aerosol temperature and relative humidity are not measured in this system. The TDMPS system has performed reasonably well during the particle size spectrometer intercomparison workshop at the IFT in 2006 (see fig.7 for 200 nm Latex particles).

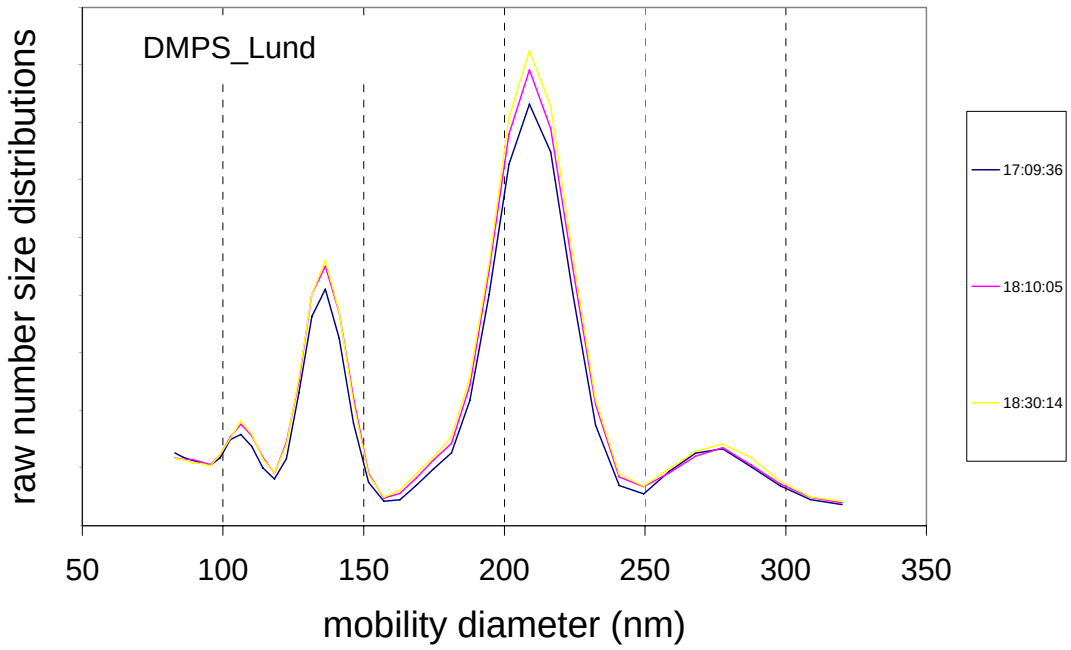


Figure 7: Raw number size distribution of 200 nm Latex measured with Vavihill system during the Intercomparison workshop in Leipzig 2006 (Nowack).

Tygon tubing was used to connect the system inlet to the aerosol dryer and the DMA to the charger. Tygon tubing was replaced by conductive tubing during the audit. According to station personnel the Tygon tubing has been only installed recently due to a leak, but there is no notice in the station log.

The APS was standing on the floor and did not appear to be well maintained (figure 8). The inlet of the APS was leaking (figure 10).

An interesting feature of the system is the automatic MIE calculation for rural and urban aerosol types allowing comparison of model results from TDMPS measurements with actual measured scattering and absorption coefficients (figure 9). This feature is used for onsite quality control.

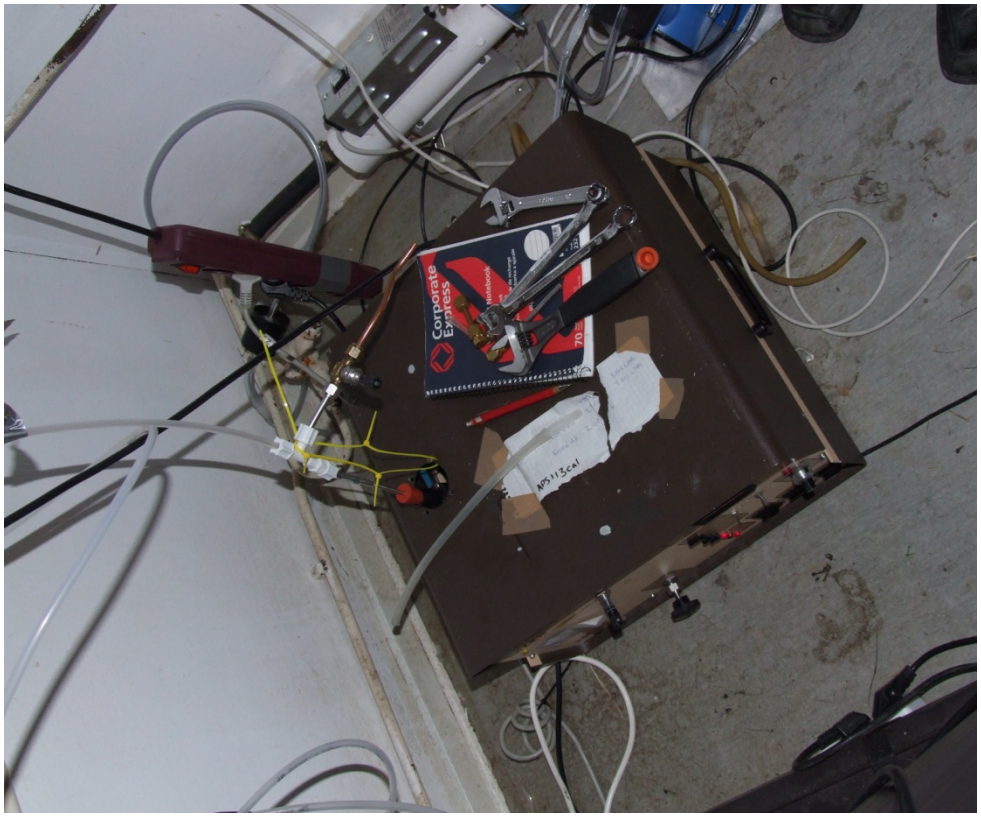


Figure 8: APS at Vavihill.

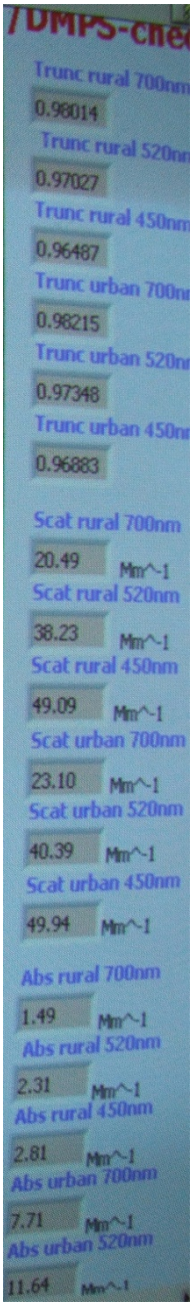


Figure 9: Automatic Mie Calculation.

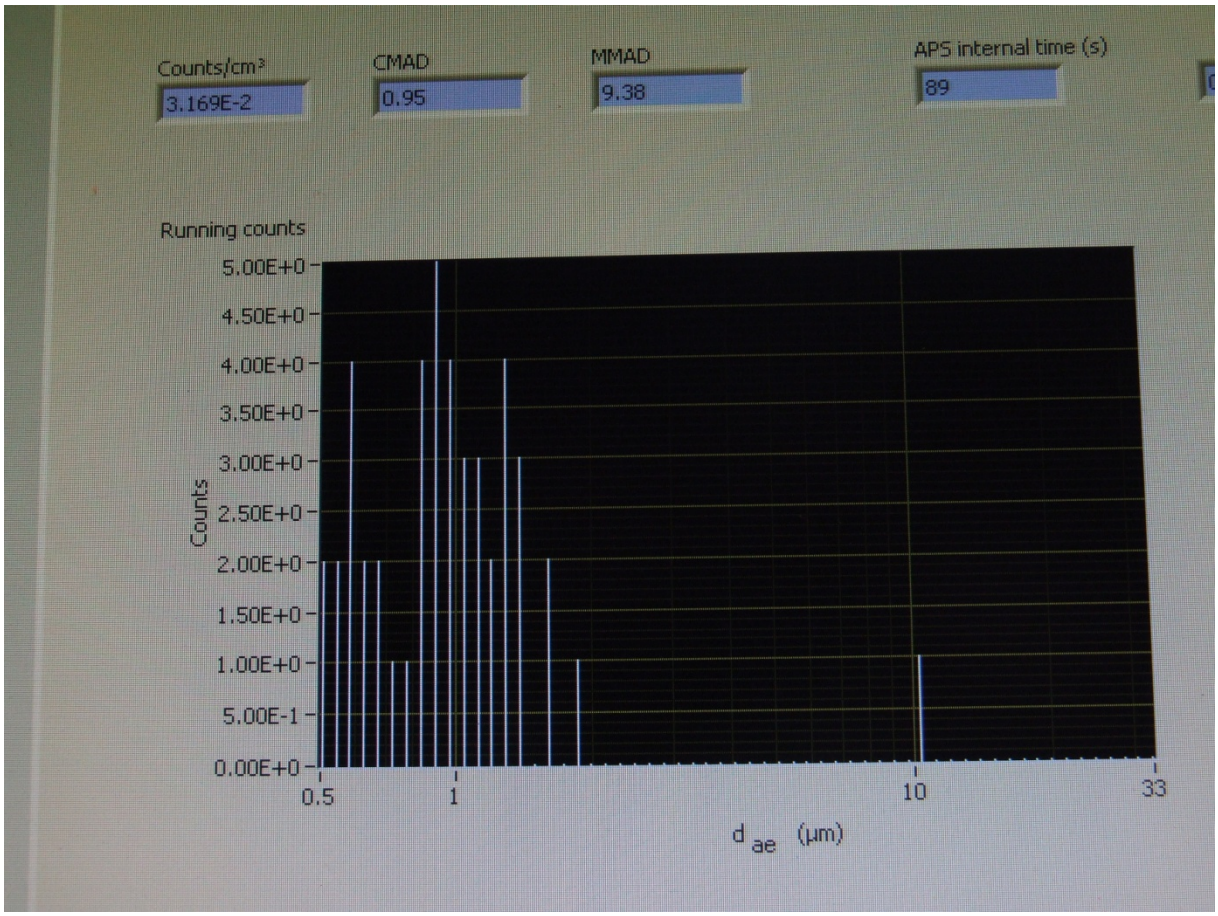


Figure 10: Counts of the APS with an absolute filter.

With high voltage switched off CPC and UCPC counted 3 and 0 false counts in 3 minutes respectively. A scan with an absolute filter attached to the inlet did yield an integral particle number concentration of 0 cm^{-3}.

The flow rate of the UCPC was 1.454 l/min. The indicated flow rate in the data acquisition software was 1.65 l/min. This discrepancy has, however, only little influence on the transfer function of the UDMA. Only the partial flow after the flow split in the UCPC is used for concentration calculation. The flow of the CPC was measured at 0.914 l/min and indicated as 0.91 l/min in the software. Sheath air flows are not automatically logged by the system. These flow rates are measured manually during every site visit. We measured a sheath air flow of 18.8 l/min for the UDMA with a recorded value of 19 l/min. The sheath air flow of the DMA was found to be 0.591 l/min according to 5.9 l/min in the station log.

The TDMPS at does not fully comply with EUSAAR requirements. Temperature and relative humidity as well as sheath air flow rates need to be measured and logged automatically by the system.

HTDMA:

The HTDMA has participated in the Intercomparison workshop in March 2008. First results from this workshop suggest, that the instrument compares well to the other HTDMAs used in EUSAAR. Measurements of several single chemical compounds agree well with theory. The presentation of these initial results can be downloaded from the EUSAAR website:

http://internal.eusaar.net/Workshops/tabid/478/language/en-US/Default.aspx

During the audit the HTDMA was obviously leaking with an absolute filter in front of the system. (figure 11).

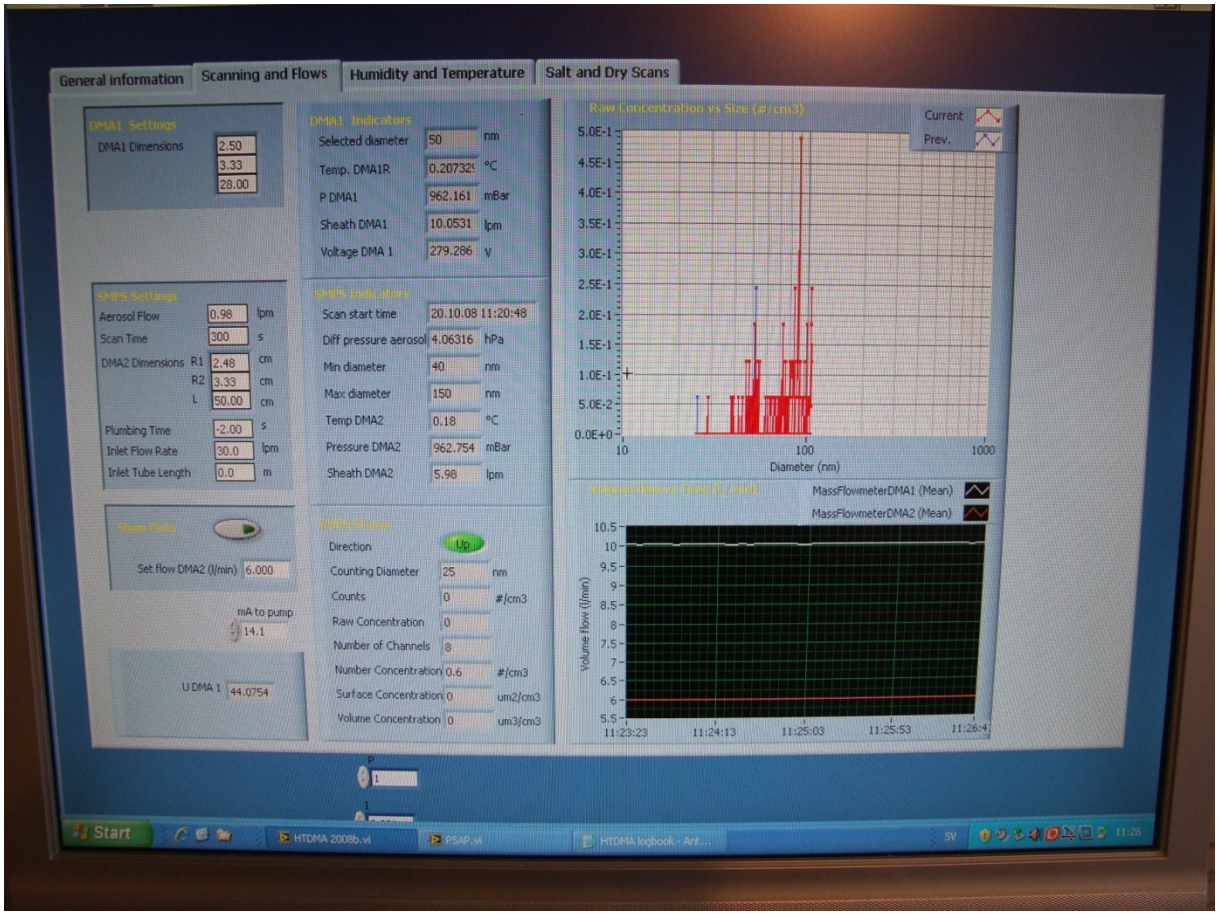


Figure 11: HTDMA measurement with an absolute filter

A flow difference of 40 ml between inlet and CPC indicated presence of a leek which may have been caused by different reasons like bad connections as shown in figure 12.

Figure 12: Connection of a CPC in the HTDMA

The sheath air flow of the first DMA was measured at 5.93 l/min and indicated 5.91 l/min. The sheath air flow of the second DMA was measured at 9.6 l/min and indicated at 9.6 l/min causing a sizing offset of the second DMA in the system. Sheath air flow rates recorded in the log file were 6 and 10 l/min respectively.

If the leak in the system can be fixed the HTDMA at Vavihill will be in good working condition.

Cloud condensation nuclei counter:

A DMT CCN-100 S/N: 0108-0052 is used to measure cloud condensation nuclei at Vavihil. This instrument is measuring at supersaturations of 0.1, 0.2, 0.4, 0.7,1 during each 38 minute cycle. Measurements at the lowest supersaturations last 10 minutes, all other supersaturations are measured for 7 minutes.

The total aerosol flow of the instrument was found to be 492.4 cm^3/min corresponding to an indicated flow rate of 500 cm^3/min. The sample flow rate was measured at 46.27 cm^3/min and indicated as 45.11 cm^3/min. A first calibration of the sample flow of this instruments was performed during the audit.

According to manufacturer specifications false count rates should be less than 5/s. During 40 minutes with an absolute filter we observed false count rates of 0 to 2.58 false counts per second with an average of 0.011 +- 0.12 false counts per second. The instrument operated 100% of the cycle time within specifications. A frequency distribution of one second false count rates is shown in table 1.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	2442	99.2	99.2	99.2
	1.28	3	.1	.1	99.3
	1.29	15	.6	.6	99.9
	1.30	1	.0	.0	100.0
	2.58	1	.0	.0	100.0
	Total	2462	100.0	100.0	

Table 1: Frequency of false counts per second of the CCNC at Vavihill

The CCNC at Vavihill is in good working condition.

AIS:

An air ion spectrometer is available at the site. (figure 13 AIS and figure 14 inlet). Currently there are no audit procedures available for this instrument.

Figure 13: AIS

Figure 14: Inlet

The AIS was not audited.

TEOM:

A TEOM S/N 140AB270100712 equipped with an FDMS system has been installed at the site in June 2008. Because of the FDMS system measurement of the sample flow is not possible inside the laboratory trailer. The flow adaptor fitting the TEOM inlet to a primary flow standard was not available at the site during the audit. We could, therefore, only measure the bypass flow of the instrument at 13.86 l/min (corrected to standard conditions) with an indicated flow rate of 13.76 on the front panel of the TEOM. This is a reasonably good agreement. Nevertheless all flow rates (sensor flow and bypass flow) need to be checked at least on a monthly basis using a reference flow meter. This corresponds to the maintenance schedule in the online log of the station. According to the screenshot of this log shown in figure 15 TEOM flows rates have never been measured since this instrument was installed at the site.

TEOM

Each time	Once a month	Once a year
1. Check filter (replace if >50%)	4. Backup data	9. Clean Inlet
2. Check computer download	5. Update virus program	10. Service (call Oleico AB)
3. Check data looks OK	6. Update Windows	Mikael Ramström, 08-59497030
	7. Check mainflow filters	
	8. Calibrate flow controller (Manual 8.4) (see help files)	

Date	Time	Filters	Computer	Backup	Filters	Flow	Update	Service
10.06.2008	kl 10-13	-	OK	-	-	-	-	Peter Ramström installed new FDMS TEOM
23.06.2008	kl 11-14	OK	OK	OK	-	-	-	
11.08.2008	kl 10-14	OK	Error	OK	-	-	-	
25.08.2008	kl. 11:47-12:(	Changed	?					Stop: 11:47. Filter changed. Start 12:06.
04.09.2008	kl 11-16	OK	OK	OK	-	-	-	
16.09.2008	kl 12-19	OK	Stopped	-	-	-	-	
20.09.2009	kl 12-14	OK	OK	-	-	-	-	
25.09.2008	kl 11-16	OK	OK	-	-	-	-	
04.10.2008	kl 9-13	Changed	OK	OK	-	-	-	
16.10.2008	kl 10-11	OK	Ok	-	-	-	_	

Figure 15: Maintenance log of the TEOM.

Flow rates of the TEOM need to be checked regularly to ensure data usability.

Conclusion:

We did find several problems at the site which need to be addressed in the near future. All technical problems can, however, be solved without excessive effort. This will ensure good data quality from Vavihill. The detailed electronic logbook of this site can serve as an example for other stations. It was a helpful tool to identify problems that might have been missed during the audit. Information contained in the log will be even more helpful for data analysis.

Solving the problem of the nearby local sources will be more difficult. Currently data from the affected wind sector should be at least flagged unreliable. Relocation of the measurement site may be necessary in the future to ensure reliable data quality for (not so uncommon) winds from West to North.

We wish to thank all persons involved in this audit for the hospitality and hope that our findings during the audit will help to improve measurements of physical aerosol properties at Vavihill.