# Site audit report Melpitz, Germany

Dr. Pasi Aalto

University of Helsinki

Department of Physics

Finland

## General

Measurements of physical aerosol properties at the GAW-ACTRIS site in Melpitz have been audited by Dr. Pasi Aalto, September 2016. The Melpitz site is a rural background site located in Germany near the city of Torgau in the glacial valley of the river Elbe (12°56’E, 51°32’N, 86 m a.s.l.). The research station Melpitz is operated by the Leibniz-Institute of Tropospheric Research (TROPOS), Leipzig, Germany. The site is integrated in EMEP (level 3, code DE44) in collaboration with the German Federal Environment Agency and is also a GAW regional station. The station is located on a flat meadow surrounded by agricultural land. The distance to Leipzig in the southwest is 41 km. A federal main road (B87) crosses the region in a minimum distance of 1.5 km in the northern direction (Fig. 1).


Figure 1: Google Earth view of the area near the TROPOS-research station. “S” marks the station place

Figure 2: Picture of the site. Aerosol container is the second from the right

## Instrumentation

Station was equipped  with following scientific instruments

- Twin Scanning Mobility Particle Sizer. Instrument  is equipped with a custom made thermo denuder. Instrument is designed and manufactured by TROPOS
- Integrating Nephelometer (TSI 3563)
- Absorption photometer (Thermo Scientific 5012 MAAP)
- Aerodynamic Particle Sizer (TSI 3321 APS)
- Cloud Condensation Nucleus Counter (DMT CCN-100)
- Digitel automated aerosol samplers for aerosol chemistry

### Standard tools

- Flow measurement: Gilian flow meter with cell s/n 1309003H and 1301048S were checked against the calibration laboratory standard in 2015. It performed very well. The medium low cell deviated one percent from the standard and the high flow cell showed exactly the same as the standard.
- High voltage measurements: A multimeter, unknown brand. It should be checked  against a standard laboratory instrument  sometimes.

- Differential Mobility Analyzer (DMA) sizing capacity: A solution with Poly Styrene Latex (PSL) particles (Thermo catalog number 3200 and 3220A 203nm+-5nm with standard deviation of 5.3nm) was prepared in the laboratory in Leipzig and used at the site over a period of one year for the SMPS sizing check. For the APS instrument, the sizing accuracy was performed with PSL (Thermo) with a diameter 1 um.

## Data logging

- Computer time is kept in UTC. A local time server is located at the station. It is adjusted to the correct time via internet with the NTP protocol. Measurement computers get their time from the server. The computer time were checked at the station and during the audit they were in time.
- Local pollution occurs mainly from the Melpitz village, not very severe.
- Local pollution is not flagged.
- Manuals are available as PDF files at the station.
- Data is stored locally. It is copied to the local server and copied to the laboratory twice a week.
- Data is saved at the institute as ASCII files, backups are done on a regular basis.
- Final data is shared via NILU data portal.
- There exist no version information in the processed data. However, there has been no major changes in the way how the raw data is processed.

## Inlet

- Same Digitel PM10 inlet with a flow rate of1 $m^3/h$ is used for all the instruments. A custom-made automated aerosol drier is installed on the roof of the container (Tuch et al. 2009). Additionaly, a custom-made Permapure Nafion drier system was later added to the setup. The performance of the drier is defined with laboratory tests (private communication). Inner diameter of the drier is 15mm leading to a Reynolds number of 1550. In the actual drier and the sampling line tube diameter is larger. After the main line there is a flow spilt for the instruments. MAAP and nephelometer have 3/8” lines and rest of the instruments have 1/4” lines.
- RH in the sample line has been 93% of the time below recommended 40% and 99% of the time below 50%. This is acceptable.
- The inlet is cleaned every second or third year. The cleaning should be done more often. The actual PM10 inlet is now quite difficult to access. It should be made more accessible to enable more frequent service.

## SMPS

- Home made Twin-SMPS is certified including all the CPC's with it in July 2016
- Major checks are performed once per month. Logbooks are available in electric form. Technician at the station is performing some visual checking of data and operation twice a week.
- Major check includes zero a test with a filter in the inlet, 200nm PSL check, CPC inlet flow check with online Gilian bubble flow meter. The SMPS2 sheath flow is adjusted according to the PSL results, not measured with an external flow instrument. TSI mass flow meters (without display, no pressure sensor) are in the sheath flow lines. Laminar flow deltaP devices are in the aerosol inlet lines. The aerosol inlet flow is not measured with the external flow instrument. High voltage (HV) is checked from both instruments in low voltage range and adjusted accordingly. The applied HV is checked against a standard multimeter. The monitor voltage is not recorded. All the checks done during the audit were satisfactory. The instrument showed zero with the filter and with zero DMA voltage. The aerosol flows on the screen were 1.49 LPM and 1.005 LPM, and measured 1.36 LPM and 0.996, respectively for the SMPS1 and SMPS2. The aerosol flow in was measured to be 1.37 LPM and 0.995LPM. Aerosol flows in the DMAs were in balance. There were no leaks. The SMPS1 aerosol flow deviated from the set point. The sheath flows on the screen were 13.9 LPM and 5.00 LPM, respectively for the SMPS1 and SMPS2. They were measured to be 13.9 and 4.85 LPM. The PSL sizing test was done with the SMPS2. The result showed a deviation of just 0.5nm from the nominal 203 nm. The DMA voltages were tested against the multimeter and were only 0.1-0.2V off the set points during the size scan.
- T/RH/P devices are calibrated in laboratory during the major service (certification available)
- TSI3776 and TSI3010 concentrations are compared with ambient air in 40nm diameter when there is a reason to suspect a deviation. The inversion program adjusts the SMPS1 size distribution to SMPS2 size distribution using its own algorithm (calculating ratios between the instruments at the overlapping size range over longer periods of time).
- The SMPS delay times are fixed according to the laboratory measurement during the certification. The SMPS2 delay times are checked according to the PSL check (up and down scan). SMPS1 delay times are not checked outside the laboratory, however the changes are considered minor duo to short delay times and fairly long scanning times.
- Results from CPC calibrations in the laboratory are utilized in the inversion to take account the CPC detection efficiency.
- Other losses are taken into acccount as described in Wiedensohler et al. 2012.
- Drier losses are taken into account based on data from published articles or from unpublished laboratory tests.

- Charging efficiency in the inversion taken from Wiedensohler, 1988.
- The inversion algorithm was compared against other algorithms during the ACTRIS project. The results show that the algorithms produce very similar results.
- There is no CPC at the station to compare the measured total concentration.
- All the data is submitted to NILU. The data coverage is better that 90%.
- Near real time (NRT) data is submitted to NILU, but not processed at NILU.

### Auditor's note on the procedures

- SMPS sheath flow rate is adjusted according to the PSL calibration. This procedure can be used to fine tune the DMA to the nominal size, but not to correct large deviations. Maximum allowed deviation in sizing was defined to be +- 3.5% in Wiedensholer et al. 2012. If the deviation is larger than that, one should try to find the reason for the problem, not to correct it by tuning sheath flow or DMA length. The deviation in the sizing might be due to other causes than sheath flow, for example non-ideal performance of the DMA. If the sheath flow is not correct, it will affect also the concentration. With the Melpitz SMPS this was not an issue. The measured deviation in the SMPS2 sheath flow corresponds 2% error in sizing, which is acceptable. I would recommend anyhow checking the sheath flow sensor against the standard flow meter during the major checks. It would be good to check also the aerosol inlet flow rate at the same time. Since the sheath flow meter is a mass flow meter, not volume flow meter, one should be sure that the volumetric flow rate is really constant. A change in pressure has to be taken into account. I wasn't able to check that during the audit. It is good that the CPC concentrations are checked against each others during the monthly check. It would be good to compare the sizing of the two SMPS systems by feeding for example 30 nm particles from one SMPS to the other. An additional CPC at the station would improve the data quality as it would act as an independent measurement of the total concentration. Comparing CPC and SMPS total concentrations would help data quality checks. Generally the instrument is maintained well. The recommended actions will improve the long term verification of the instrument data quality.

## Integrating Nephelometer

- The instrument is calibrated every month with $CO_2$ and air using an old TSI program. The calibration constants are saved to the instrument. The sample flow is measured after the calibration. The calibration data seems to be quite stable, for example green and blue parameter K4 varies between 0.48 and 0.52 over the years. For the parameter K2, the variation is even smaller. The instrument was calibrated, the flows were checked and the zero was measured during the audit. Everything looks good.
- Tha data is collected with a program made in NILU. The scattering and backscattering coefficients, calculated by the instrument, are corrected with the standard truncation error formula. Averaging time is one minute and the aerosol flow was 3 LPM. The zero is measured

every day using 300 second flush time and 600 second averaging time. The data is submitted to NILU also as NRT. Inlet is the common PM10 inlet.

- Cleaning is done every 1-2 years according to the calibration data. On site intercomparison is done against a certified instrument. No results are available from the intercomparison. The instrument at the site is not certified.
- RH is sometimes a bit too high in the inlet line, but due to the temperature increase fine inside the instrument.
- I can't see any problems here. The instrument should be certified during the project.

## Apsorption Photometer

- A standard PM10 inlet is used to extract the sample from the atmosphere. Same small problems exist with RH and cleaning cycle of the PM10 inlet as with other instruments. A standard MAAP pump is in use.
- The flow is checked and adjusted every third month. The adjustments of the flow have been quite small, 0.2-0.4LPM, which is well inside the error limits reported by the manufacturer. Spot area is not measured. The spot shape is checked visually during the flow checks. Also the filter holder tightness is checked visually. Zero is measured occasionally overnight. When zero was checked during the audit, Full width at half maximum (FWHM) value was quite high, around 0.1ug/m3. However the zero air was filtered room air with a strongly varying RH due to the air conditioning device. The test should have be done with filtered ambient air. Flow was checked during the audit to be 9.0 LPM with variation 0.1LPM. The spot seems to be symmetric. All checks are fine except the zero test.
- The cleaning is done when the data does not look visually pleasing.
- The instrument is not certified instrument, but participated in the 2013 workshop as a reference instrument. There is not much that could be done better.
- The data is submitted to NILU also as NRT.

## APS

- The APS is measuring from the common inlet. The flows were measured to be 3.99LPM and 1.03LPM. The PSL test with 1.02 um PSL particles showed a mode in channel corresponding to 1.04 um.
- The instrument was checked against an another instrument in spring 2016. The instrument performed well in the 2016 TROPOS APS workshop. I cant see any problems in how the instrument is operated..

## CCNC

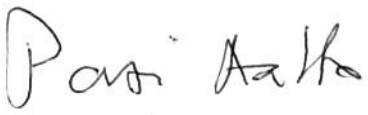
- CCNC takes the sample from the main inlet. The aerosol flow is not dried as recommended, just the sheath flow. The neutralizer has a Kr-85 radioactive source, which is checked during every major maintenance. The DMPS is using a closed loop sheath flow arrangement with vacuum pump and a mass flow controller. Notice that it should be the volumetric flow rate, not mass flow, that needs to be controlled.
- The regular maintenance recommended by the manufacturer has not been done. Service is performed, when calibration data look strange. The instrument has not been calibrated during the past year. It should be calibrated at least twice a year. The CPC of the setup has been certified a long time ago. The DMPS has not been in intercomparison workshops. The DMPS should be taken to a intercomparison workshop as soon as possible
- The sheath flow was measured to be 15.2LPM. A mass flow meter shows 14LPM (0 degC, 1013 hPa). The CPC flo w was measured to be 1.00LPM, while the CCNC flow was 0.503 LPM. The CCNC aerosol flow rate is not measured on a routine basis. The DMPS aerosol flow was 1.51 LPM. It seems that there are no leaks in the system. Temperature and pressure sensors were checked against other station sensors. A comparison was good. RH sensor was not compared. It was calibrated four years ago. Zero check was done and no extra counts were detected. The DMPS was checked with 203 nm PSL particles. The DMPS showed a peak around 213nm, which is a too high a value. The peak shape was also not optimal. The DMPS has to be checked in the laboratory.
- The last data submitted to NILU is from 2014. Year 2015 data should be submitted. Just the monodisperse data is measured. Total CN and CCN concentrations are not measured. Submitted polydisperse data is calculated from the monodisperse data. I recommend that also the polydisperse data is measured. It would be good to compare the measured size distribution and total concentration against the station SMPS regularly.
- The CCNC instrument is not operated according to the standard operation procedures. Also we found some problems with the instrument. We decided not to calibrate the instrument since the TROPOS CCNC workshop was scheduled for a near future. We were not able to check, if the calibration is done according to the recommendations as the results from the workshop are not yet available.

## Other instruments

- CIMEL sun photometer and ACSM were not operational during the audit.
- Aerosol chemistry is studied with Digitel automated samplers. Filters are prepared in the laboratory an brought to the station. The sampler flow rate sensor, temperature sensor and pressure sensor are calibrated twice a year. The inlets are cleaned with regular intervals

## Conclusion

The overall impression of the Melpitz field station was very good. Most of the instruments had only minor issues and some of those issues are just a matter of an opinion. The only instrument with major problems was the CCNC setup. I hope that during the 2016 CCNC workshop these issues were taken under consideration  and in future the instrument is operated in the recommended way, according to the ACTRIS SOP.



Pasi Aalto Helsinki 2017-10-03