Audit report for physical aerosol properties, Pallas, Finland

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General Comments:

We have found a well equipped and well maintained station. Almost all core measurements recommended for global GAW stations are performed continuously. A beta-gauge has recently been added to the instrumentation to provide continuous measurement of PM_{10} mass concentrations, GAW recommends, however, that two mass fractions should be measured continuously. Light absorption coefficients of the aerosol are measured but not reported to the data base because the available Aethalometers are considered unreliable by the scientific staff of the station. Light scattering coefficients are determined using a thee wavelength integrating Nephelometer. PM_{10} samples for chemical composition (major ions and OC/EC) are collected at the EMEP station nearby. Aerosol optical depth is not measured at Sammaltunturi station. AOD is measured at Sodankylä (approximately 115 km south-east) since June 2004, which is part of the GAW station. Daily maintenance is available at this site.

Scientific personal responsible for the scientific operation of the station was present at the station throughout the whole time period. They have demonstrated their thorough knowledge of their instrumentation. We had access to all relevant information.

Due to the remote location Pallas station is not permanently manned. Scientists visit the station every other month. A station manager performs routine checks twice a week. To overcome possible problems resulting from this schedule all data from Pallas station are available via remote access. Data are automatically downloaded every day to the Finish Meteorological Institute (FMI). A scientist at the FMI is responsible for continuous plausibility control of the downloaded data. We consider this approach appropriate for such a remote station.

Evaluated data are sent to the aerosol data centre; however, current data have not been corrected for STP. We recommend doing this in the future. Estimated errors are in the range from 0-6% depending on the ambient pressure.

Documentation:

Manuals were present for all instruments. A detailed station log is stored on a computer on site and downloaded to FMI every day. It comprises all routine maintenance information of the instruments, calibrations and supporting data such as station access by motorized vehicles. This station log is excellent to provide all relevant information for data analysis and for submission of the data to GAW. Data from Pallas station are routinely submitted to GAW.

Aerosol inlets:

Aerosol is sampled using a custom made, heated inlet approximately 4 meters above the roof of the shelter. This inlet is a acceptable compromise to avoid clogging of the inlet during cloud and snow periods. The estimated cut-off size is 7 µm. The influence of wind-direction on the sampling efficiency of this inlet has not been tested. Due to the asymmetric design it is, however, probably not omni-directional. Sample flow inside the sampling tube is turbulent.

Inside the shelter the air is distributed to the individual instruments by an insulated horizontal duct (approximately 3 m). The newly installed beta-gauge uses a commercially available vertical PM_{10} inlet with heater tape.

Requirements for aerosol inlets are defined in WMO/GAW AEROSOL MEASUREMENT PROCEDURES GUIDELINES AND RECOMMENDATIONS:

An omni-directional high efficiency air inlet is required for aerosol sampling. In other words it should have a high aerosol transmission efficiency that does not vary with wind direction or wind speed. This can be achieved with a vertical air duct with a cover that excludes drizzle, rain and snow mounted on top of the inlet duct. The inlet should have a particle cut-off diameter of 10 micrometers aerodynamic diameter under ambient conditions. Sampling sites that are frequently in clouds or fog (e.g. mountain sites) should use whole air inlets to sample cloud or fog droplets as well as aerosols. This air should be dried rapidly to avoid inertial particle losses. The sample flow should be laminar in the sample tube in order to avoid additional losses of small particles by diffusion and turbulent inertial deposition. A Reynolds number of about 2000 would be ideal. For example, a Reynolds number of 2000 occurs in a pipe of diameter 10 cm and 20 cm with a flow of 150 l/min and 300 l/min at STP, respectively.

We recommend to replace the current inlet head of the common sample line by a defined PM_{10} inlet using a sampling line with a Reynolds number of 2000 in the near future. Because of the special requirements with respect to icing and clogging at this site we recommend, however, to use the available inlet of the beta-gauge to develop an adequate heating strategy for such a commercial PM_{10} inlet prior to any change of the current inlet.

<u>Primary flow standard:</u>

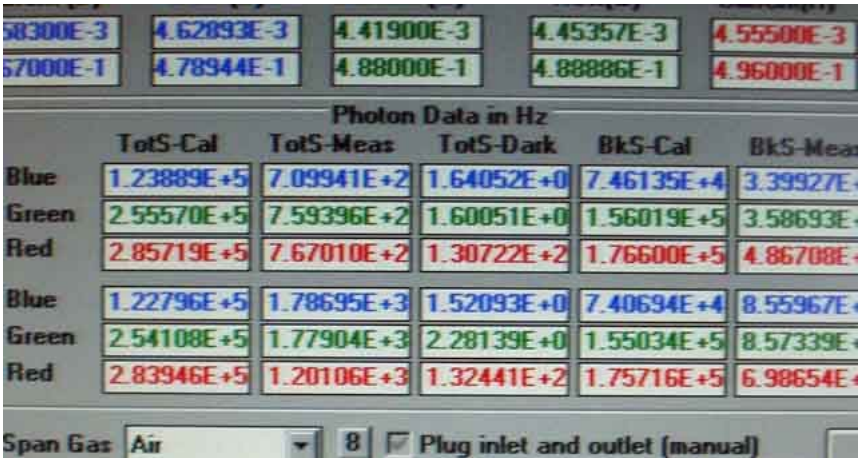
Two mini-buck calibrators model M-5 manufactured by A.P. Buck Inc, Orlando, FA are available on site. Flow rates determined with these instruments agreed within 2 % with the values measured with the Gilibrator from WCCPAP. A Gilibrator can be brought from FMI any time to verify measurements by these instruments. We consider the available flow standards adequate for GAW measurements.

Light Scattering Coefficient – Integration Nephelometer:

The TSI Nephelometer 3563 #1061 has been checked during the 2003 Nephelometer workshop at the WCCPAP in Leipzig. Complete service was performed at that time. Last on site service of the instrument was done July 1, 2004 including exchange of the lamp and gas calibration.

Gas calibration and routine maintenance of the instrument is currently performed twice per year. GAW guidelines require monthly calibration of Nephelometers with air and CO_2. With respect to the scheduled presence of scientist at the site every other month we recommend a gas calibration during every such visit.

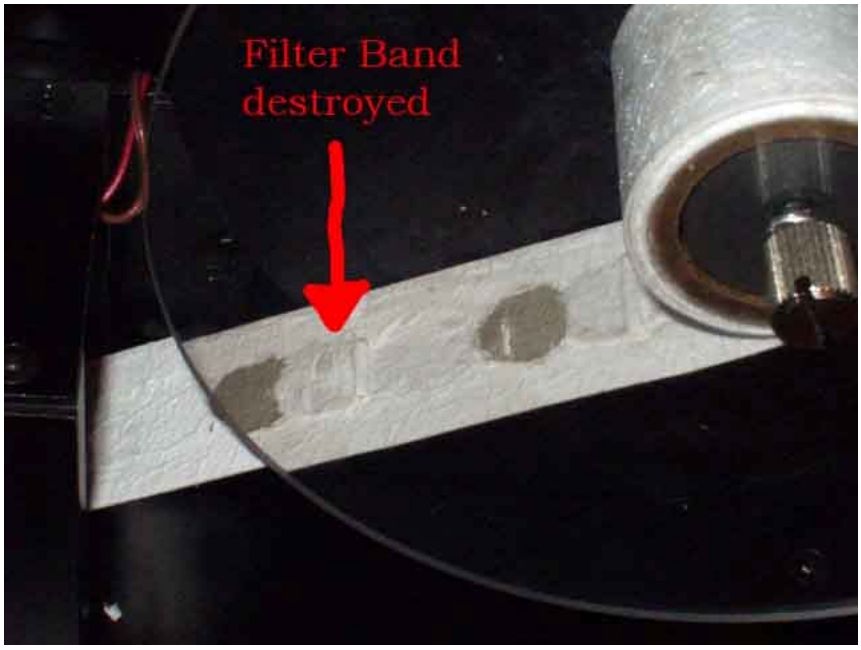
The Nephelometer is attached to the central sampling line. The flow in the instrument is controlled by a critical orifice in the outlet vacuum line. We found, that the instrument has been operated at a flow rate of 40 l/min using a 3/8 " stainless steel sample tube. Flow in this sample line has been highly turbulent. During our audit the critical orifice in the vacuum line has been exchanged. The resulting sample after exchange of the critical orifice is 19.3 l/min (laminar). A calibration with gas and CO_2 was performed by the station personal during our audit. The new calibration factors where close to those determined on two months earlier.



The instrument is in good working condition.

Light Absorption Coefficient - Aethalometer:

Currently two Mage Scientific Aethalometers (#A950502, routine instrument and #4920405, additional instrument) are operated in parallel at Pallas station. Both instruments exhibit the typical problems of Aethalometers. Flow rates of both instruments deviated from both indicated flow rates and from set points (Flow rate of the additional instrument was calibrated to 6.2 l/min indicated = 6.15 l/min flow standard). The station standard instrument operated at a flow rate of 21 l/min. This may be due to the available filter band which seems not to work in this old instrument. Due to the known problems with the Aethalometers, data from these instruments have not been reported to aerosol data base.



We suggest to replace the Aethalometers at Pallas by a Multi-Angle Absorption Photometer, MAAP (Carusso, Thermo Environmental Inc.) to provide reliable data for absorption measurements.

PM10 Mass Concentration - Beta Gauge:

Routine measurements of PM10 with a Beta-gauge (Environnemt SA, model MP 101 M, #1136) have started one week prior to the site audit. The instrument seems to be in good working condition. Current plumbing of the inlet does not allow easy access to the sampling line. We could therefore not check the flow rate of this instrument. We recommend to change the plumbing of the inlet line to allow for easy flow checks.

Total Number Concentration - CPC 3010:

A TSI CPC 3010 (#2121) is used as a total particle counter. The counter is attached to the central sampling line. The flow rate is 1021 ml/min. Currently the control LED for flow rate is not working. This does not influence operation of the instrument. More frequent manual checks of the flow rate under these conditions are desirable.

A zero check of the instrument gave 10 false counts in 15 minutes. This value is not critical for a total particle counter ($6.7x10^{-4}$ false particles cm^{-3}). Because these false counts may be an indicator of an immanent failure of the laser diode zero checks should be performed more frequently under such conditions. Currently the instrument is in good working condition.

Number Size Distribution - DMPS:

Particle size distributions in the size range from 7 to 450 nm are measured by a custom made DMPS system. The system consists of a Hauke type DMA (28 cm effective length) a Ni^{63} neutralizer, a programmable high voltage supply (12.5 kV) and a dried closed loop sheath air/excess air system. Aerosol flow rate of this system is 979.5 ml/min, sheath air flow rate is 10.44 l/min. Flow rates are checked during every visit of a scientist at the station with the primary flow standard. A rotameter for the sheath air flow is checked by the station manager twice a week. Temperature, relative humidity and pressure are recorded by the LabView software in addition to flow rates and number concentrations.

Currently, the system runs with a time resolution of 5 minutes. Due to the weak counting statistics under the given low ambient aerosol concentrations we recommend to increase the measurement time for one size distribution to 10 minutes.

Data inversion is done at the FMI. Currently the size distribution displayed on site uses the wrong flow rates for size calculation. Because of the subsequent correct data inversion at the FMI this does not affect data quality. We suggest, however, that the program should be changed to the correct flow rates in order to allow a quick look at the data on site.

The system was checked using a zero air filter. No false counts were measured during three subsequent measurement cycles. Certified 404 nm latex particles have been used to check the sizing of the instrument. The peak was found in the correct size bins. The instrument is in good working condition.

Final remarks:

We wish to thank all personal of the Pallas GAW station for their great hospitality. We have been impressed by the quality of their work. We think that Pallas provides valuable data for GAW and hope that our recommendations will help to improve the already excellent quality of the data from this site.