

## Audit Report – GAW Station Anmyeon-do, South-Korea

Period: March 05-06, 2018

Auditor: Prof. Dr. Alfred Wiedensohler, WCCAP, Leipzig

Station: Anmyeon-do

Station personnel: Jeongeun Kim, Hae-Jung Lee, Dan Lee, Jeeyoung Ham, Sang-Ok Han (all KMA)



I would like to thank the staff of the Anmyeon-do GAW station for this fruitful audit. Furthermore, I would like to thank Dr. Jeongeun Kim for her engagement, organizing this audit. I would also like to thank Ms. Hae-Jung Lee, Ms. Dan Lee, and Ms. Jeeyoung Ham for the intensive discussions about the instrumentation and how to improve the measurements. Finally yet importantly, I also would like to thank Mr. Sang-Ok Han, the director of the Anmyeon-do GAW station for his interest in our discussion.

#### General station information:

Country: South Korea  
GAW ID: AMY  
WIGOS Station identifier: 0-20008-0-AMY  
Coordinates: 36.5383338928°N, 126.3300018311°E, 46m  
Climate: Warm temperate climate, fully humid, hot summer  
Annual dew point temperature: Up to approximately 25°C, see Figure 1

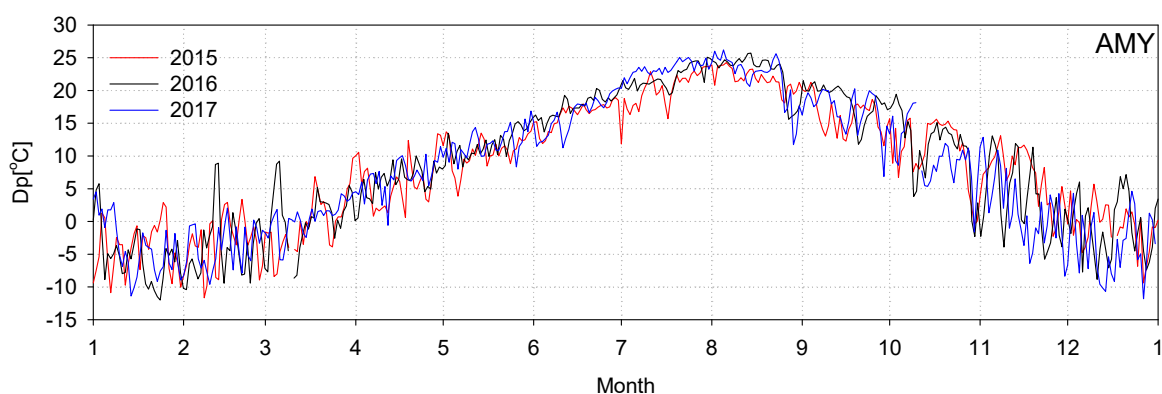


Figure 1: Seasonal variation of dew point temperature at the Anmyeon-do GAW station for the year 2015 to 2017.

Figure 1 illustrates the critical months in terms of aerosol in-situ measurements, when the dew point temperature is above 20°C. This is always the period from June to September. Since the aerosol measurements are strongly influenced by the high dew point temperatures in summertime, some action has to be taken to improve the situation, although it is difficult to condition the aerosol to a relative humidity below 40%.

#### **Recommendation:**

- I recommend diluting the sample aerosol with dry particle-free air, since other drying methods might not be successful.

### Inlets:

In Figure 2, the different inlets are shown and numbered to 1-5, while Figure 3 (number 6) shows the inlet of the outdoor Grimm mass monitor.

1. High flow inlet for particle light scattering and absorption coefficient measurements. The inlet is approximately 9 m above roof level, which is fine. The flow rate is 100 l/min, having Re number is 720, and assuming an inner diameter of 18 cm. Downstream of the main inlet is a splitter configuration, see Figures 4a, 4b, and 4c. PM10 Cyclones for the integrating nephelometer (30 l/min) and the Aethalometer (3 l/min), see Figure 5.
2. "High" flow inlet for particle size spectrometers. The flow rate is unknown. There are 2 sampling tubes inside of the main tube. The excess flow is removed afterwards.
3. Low flow PM10 inlet (16.7 l/min) for a beta-attenuation mass monitor. Tube diameter seems to sufficient for a Re number, maintain a laminar flow.
4. NOAA design inlet (not in use).
5. Low flow PM10 inlet (16.7 l/min) with a thin sampling tube, inner diameter approximately 1 cm. The Re number would be roughly 2170, which is slightly higher than the GAW recommendation of  $Re < 2000$ . It is only temporally used for intercomparisons of two beta attenuation mass monitors. After an intercomparison, it will be connected to particle-into-liquid-sampler.
6. Grimm specific inlet for outdoor Grimm mass monitor. This inlet is poorly designed for sampling of coarse particles (stopping distance too small), therefore the sampling efficiency of coarse particles is undefined. The Grimm mass monitor was not audited. However, this measurement is probably also influenced by the high humidity in the summer period.



Figure 2: Aerosol inlets number 1 to 5



Figure 3: Grimm TSP inlet

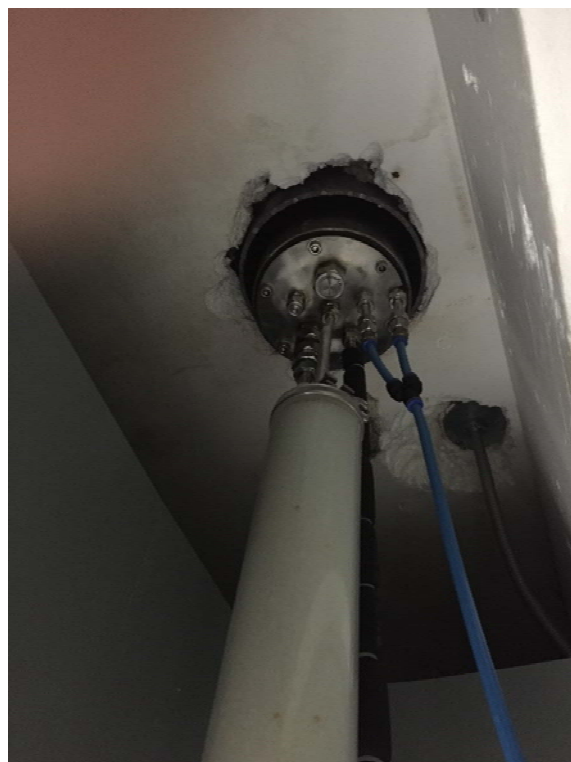


Figure 4a: Splitter configuration of Inlets number 1.

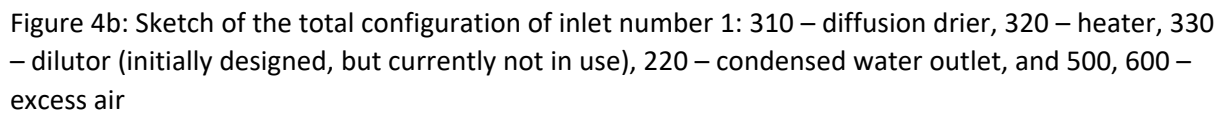




Figure 5: heating configuration of the aerosol flow tubes for the TSI integrating nephelometer (left) and the Aethalometer (right), including PM10 cyclones, respectively.

**Recommendation:**

- I recommend diluting the sample flow with dry particle-free air to reduce the relative humidity.
- I recommend installing the Grimm mass monitor also in the laboratory after drying.



Particle light scattering coefficient:

Instrument: Integrating Nephelometer: TSI model 3563

Serial Number: 70933005

Zero check: Every hour

Span check: CO<sub>2</sub> once per month, last Feb 22, 2018

RH regulation: Done by heating the airflow upstream of the IN. The RH is measured directly after the heating section. The tubes afterwards are insulated.

Last instruments intercomparison: never

Last manufacturer check: Nov 2017

Frequency of cleaning the instrument: bi-annually

Data submitted to WDCA: Not yet

Comments:

- Principally, there should be an intercomparison at the world calibration center every 2-3 years. I suggest doing this in near future.
- Data should be submitted to the WDCA. The plans are submit data from this year on, including previous data. Previous data have to be flagged for times with RH greater than 40% inside of the integrating nephelometer.

**Recommendations:**

- I recommend changing the zero check to once per day to minimize loss of data.
- I recommend moving the RH sensor to the inlet of the integrating nephelometer.
- I suggest diluting the aerosol flow in front of the cyclone by a factor of two (15 l/min particle-free dry air from a compressor system), since the annual measurements show high RH during the summer period (see Figure 6).

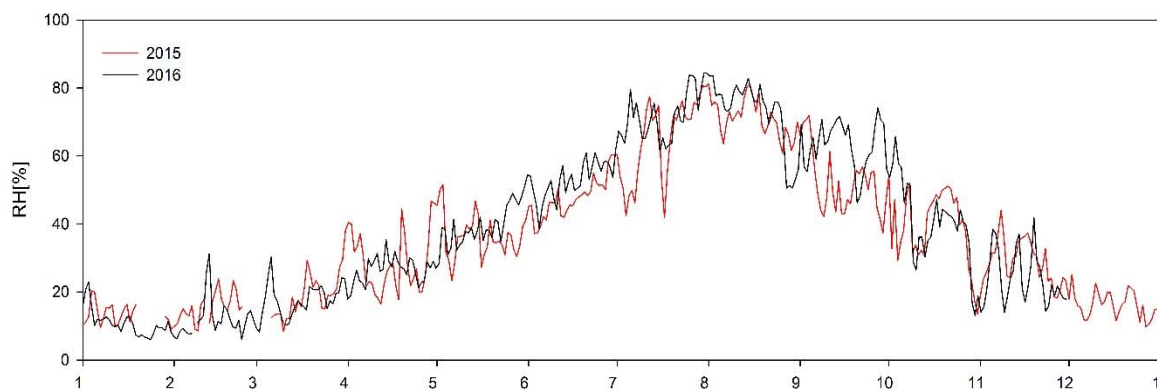


Figure 6: Time series of the daily average of the relative humidity in the integrating nephelometer for the years 2015 and 2016.

As shown in Figure 6, the RH inside of the integrating nephelometer is generally too high for the periods June to September, as also shown by the dew point temperature in Figure 1.

### Particle light absorption coefficient

Instrument:	Absorption Photometer: Aethalometer model Magee AE 31
Serial Number:	1007:1004
Zero check:	Never done
RH regulation:	Done by heating the airflow upstream of the AE31. The RH is measured directly after the heating section. The tubes afterwards are insulated.
Last instruments intercomparison:	never
Last manufacturer check:	Sep. 2017 (done every second year)

#### Comments:

- Do a zero check from time to time, using a HEPA filter
- Principally, there should be on the base of 2 years an intercomparison at the world calibration center, also for cleaning (best including a person for capacity building)
- Data should be submitted to the WDCA. The plans are submit data from this year on, including previous data. Data with high RH should be flagged.

#### Recommendation:

- I recommend also doing here a dilution by particle free dry air to reduce the noise created by the water absorbed on the filter material.
- I recommend moving the RH/T sensor to the inlet of the AE31.



### Particle number size distribution

Instrument:	MPSS: Grimm model 5.416
Serial Number:	54161607
Zero check:	Monthly by a small HEPA filter
RH regulation:	Diffusion dryer upstream of the instrument
Last instruments intercomparison:	never (purchased Dec. 2016)
Last CPC calibration:	never
Last manufacturer check:	no
Last PSL size calibration:	never
Aerosol flow check:	monthly
Cleaning of DMA and charger:	bi-monthly

### Comments:

- Due to GAW recommendations, following diagnostic parameters should be provided: RH&T for the aerosol and sheath flow rates, pressure, and aerosol and sheath flow rates. Sheath flow rate could be checked by PSL calibration, see also WMO-GAW report 227 and Wiedensohler et al. (2012)
- PSL calibration best monthly as well, using a 203 nm certified PSL standard, see also Wiedensohler et al. (2018)
- The system was operating with non-optimum settings, leading to noisy particle number size distributions. A local Grimm technician changed the settings during the auditing period. The particle size spectrum looks reasonable now.
- The instrument uses a 3.7 MBq Am241 bipolar diffusion charger, which might be too weak as shown in previous studies. This should be investigated, best during a calibration workshop.
- There is no pre-impactor in the system. This is ok, since the scans go up to 1000 nm and above are almost no particles anymore.
- Data are not submitted to the WDCA. The data quality is not clear yet.

### Recommendation:

- I recommend adding RH/T sensors to the aerosol (after dryer and before bipolar charger) and sheath air tubes. Please look also at Wiedensohler et al. (2012).
- I recommend replacing the diffusion dryer (which has high diffusional losses for ultrafine particles) by a SS2100 Nafion dryer, operated under vacuum for the counter flow (or alternatively with dry air). The pump should be able to create a pressure of 200 mbar or lower, with a volume flow rate of 2 l/min at the entrance of the pressure reducing needle valve. The inner Nafion tube needs to be replaced yearly.
- **I strongly recommend that the responsible person from the station staff participate with the mobility particle size spectrometer in a calibration intercomparison at the world calibration center to understand the data quality of the instruments.**
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## References:

Wiedensohler, A., W. Birmili, A. Nowak, A. Sonntag, K. Weinhold, M. Merkel, B. Wehner, T. Tuch, S. Pfeifer, M. Fiebig, A. M. Fjåraa, E. Asmi, K. Sellegri, H. Venzac, P. Villani, P. Laj, P. Aalto, J. A. Ogren, E. Swietlicki, P. Roldin, P. Williams, P. Quincey, C. Hüglin, R. Fierz-Schmidhauser, M. Gysel, E. Weingartner, F. Riccobono, S. Santos, C. Gruning, K. Faloon, D. Beddows, R. Harrison, C. Monahan, S. G. Jennings, C. D. O'Dowd, A. Marioni, H.-G. Horn, L. Keck, J. Jiang, J. Scheckman, P. H. McMurry, Z. Deng, C. S. Zhao, M. Moerman, B. Henzing, G. d. Leeuw, G. Löschau and S. Bastian (2012). Mobility Particle Size Spectrometers: Harmonization of Technical Standards and Data Structure to Facilitate High Quality Long-term Observations of Atmospheric Particle Number Size Distributions. *AMT* 5, 657–685.

Wiedensohler, A., A. Wiesner, K. Weinhold, W. Birmili, M. Hermann, M. Merkel, T. Müller, S. Pfeifer, A. Schmidt, T. Tuch, F. Velarde, P. Quincey, S. Seeger and A. Nowak (2018). Mobility Particle Size Spectrometers: Calibration Procedures and Measurement Uncertainties. *Aerosol Science & Technology* 52(2), 146–164.

### Particle number size distribution

Instrument:	APSS: Aerodynamic Particle Size Spectrometer TSI model 3321
Serial Number:	70520426
Diluter	TSI 3302A
Serial Number	70520324
Zero check:	Monthly by a small HEPA filter
RH regulation:	Diffusion dryer upstream of the instrument
Last instruments intercomparison:	never
Last manufacturer check:	Nov. 2017
Last size calibration:	never by staff
Aerosol flow check:	monthly
Total flow check:	monthly
Change of HEPA filter:	bi-annually

#### Comments:

- There is no need for a diluter in from of the APSS for atmospheric concentrations. I wonder why TSI has recommended this.

Data have been submitted to the WDCA (data available from year 2012 data) .

#### Recommendation:

- I recommend removing the diluter to improve the counting statistics.
- I recommend that PSL sizing checks (if possible with three sizes) should be done bi-annually. The size accuracy should be with in 10%. (Pfeifer et al; 2016).
- I recommend placing a RH/T sensor in front of the instrument.

#### References:

Pfeifer, S., T. Müller, K. Weinhold, N. Zikova, S. Santos, A. Marinoni, O. F. Bischof, C. Kykal, L. Ries, F. Meinhardt, P. Aalto, N. Mihalopoulos and A. Wiedensohler (2016). Intercomparison of 15 Aerodynamic Particle Size Spectrometers (APS 3321): Uncertainties in Particle Sizing and Number Size Distribution. AMT 9, 1545–1551.

### Particle mass concentration

Instrument:	Mass monitor: Thermo FH62C14 (beta-attenuation)
Serial Number:	CM2633
Zero check:	Last March 5, 2018; monthly
RH regulation:	Heating upstream of the instrument
Last instruments intercomparison	
to reference:	see scatter plot (short period in Winter 17/18)
Aerosol flow check:	monthly

#### Comments:

- The heating is set to approximately 40°C. This will likely evaporate e.g. ammonium nitrate, leading to lower particle mass concentrations in wintertime. The effect of heating to reduce RH is minimum, since the pipe is almost at room temperature again at the instrument inlet.

#### Recommendation:

- I recommend performing a yearlong intercomparison between the FH62C14 and the reference method (24h filter; gravimetric).
- I recommend replacing the heating by a large diffusion dryer, if the diffusion dryer doesn't produce particles
- I recommend placing a RH/T sensor at the inlet of the instrument to obtain the real RH in the monitor.

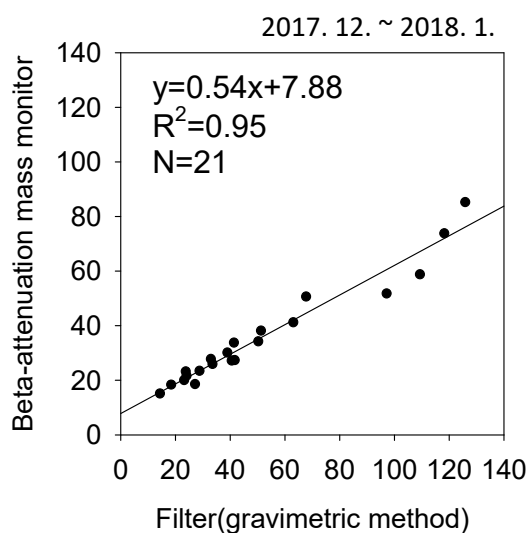


Figure 7: Comparison of the 24h average of the beta-attenuation mass monitor against the reference (gravimetric method)