A first in-situ comparison between the Airvisual Pro and Horiba fine particle measurements at Diekirch and Beidweiler, Luxembourg.

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Notice: This is a first short report using only data fetched from the various graphs shown on the different websites from Airvisual and emwelt.lu. An upcoming report will use data from the EEA database.

Summary:

The PM 2.5 measurements made by the Airvisual Pro instrument at Diekirch are in good accordance to the PM 10 measurements made at the official governmental station at Beidweiler, under the condition that the Diekirch measurements are corrected for relative humidity.

1. The raw data from Diekirch and Beidweiler

In a prior paper from Nov. 2018 [ref. **1**] a first comparison between the official PM measurement station at Beidweiler (Horiba APDA-371 instrument, BAM principle) and several low cost LLS (laser light scattering) fine particle sensors was made. The reader should refer to this paper for more information on location and operation of these sensors.
The Airvisual Pro instrument from iQAir became definitively operational in meteoLCD's Stevenson hut during January 2019, and has been accepted as a member of the Airvisual cloud. This means that the live PM2.5 data are online available at the website
https://airvisual.com/luxembourg/diekirch/diekirch/meteolcd, with an update every hour.
This very short report compares the readings made during the period from 11 to 27 March 2019 with those available from Beidweiler (ref. 4). All numbers represent daily averages (not 24h running means!) with the big difference that

Beidweiler only publishes PM10 readings (which are a superset of PM2.5 measurements).
Fig.1 shows both series (there are no Airvisual data for the 24th March, due to a shutdown for changing the powerline equipment).

Most days were rather dry, with very low precipitation only during the period 13 to 15 March (0.1, 0.3, 0.1 mm) and the 25th March (0.1 mm). Obviously precipitation increases the difference between the sensors, but the Pearson correlation between both sensors remains significant at R=0.58:

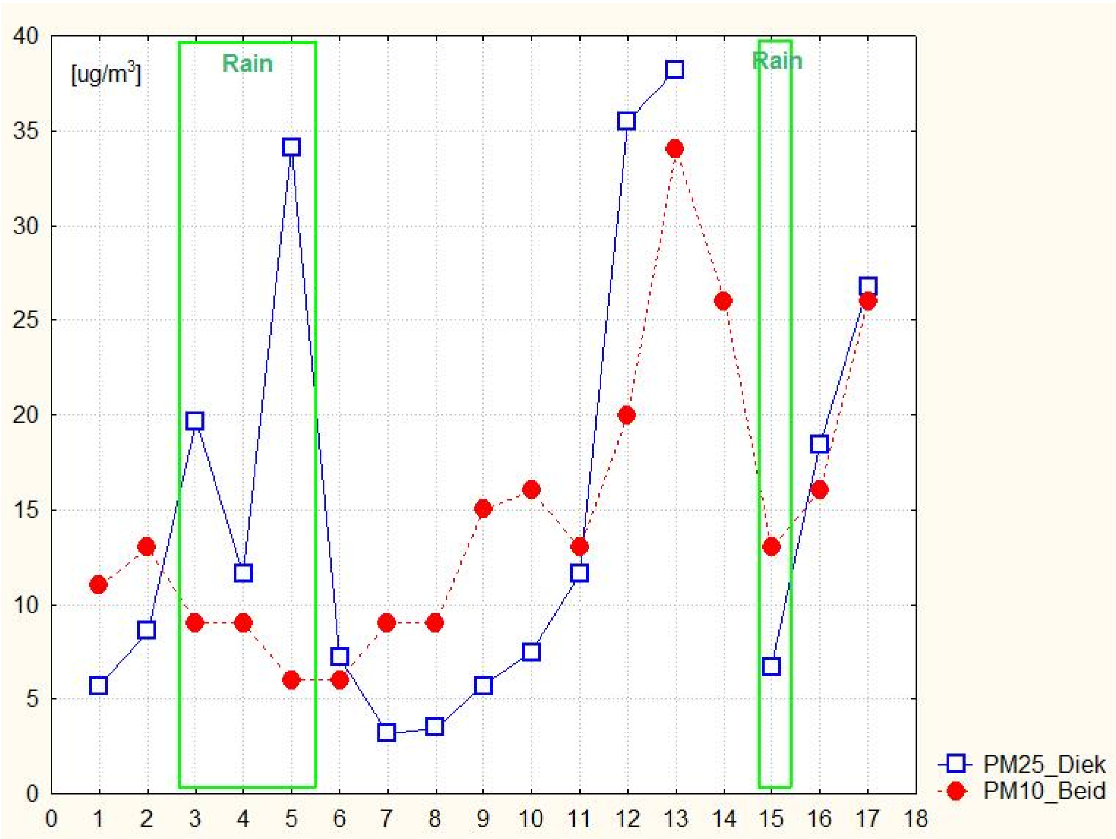

Fig.1. PM measurements (daily averages) from Diekirch (PM2.5, Airvisual Pro) and Beidweiler (PM10, Horiba APDA-371): start = 11 Mar, end = 27 Mar2019

Correlations (1_to_27_Mar2019.sta)
Marked correlations are significant at $p < .05000$
N=16 (Casewise deletion of missing data)

Variable	daily_RH	PM25_Diek	PM10_Beid
daily_RH	1.00	0.07	-0.48
PM25_Diek	0.07	1.00	0.58
PM10_Beid	-0.48	0.58	1.00

Fig.2. Correlation between both measurement series.

The influence of higher relative humidity levels become visible in figure 3. which shows the difference delta = (Diekirch – Beidweiler) together with the relative humidity measured at Diekirch. Normally the PM 2.5 measurement should be lower or close to the PM 10 data. Fig. 3 shows that they are higher when relative humidity is approx. greater than 77% .

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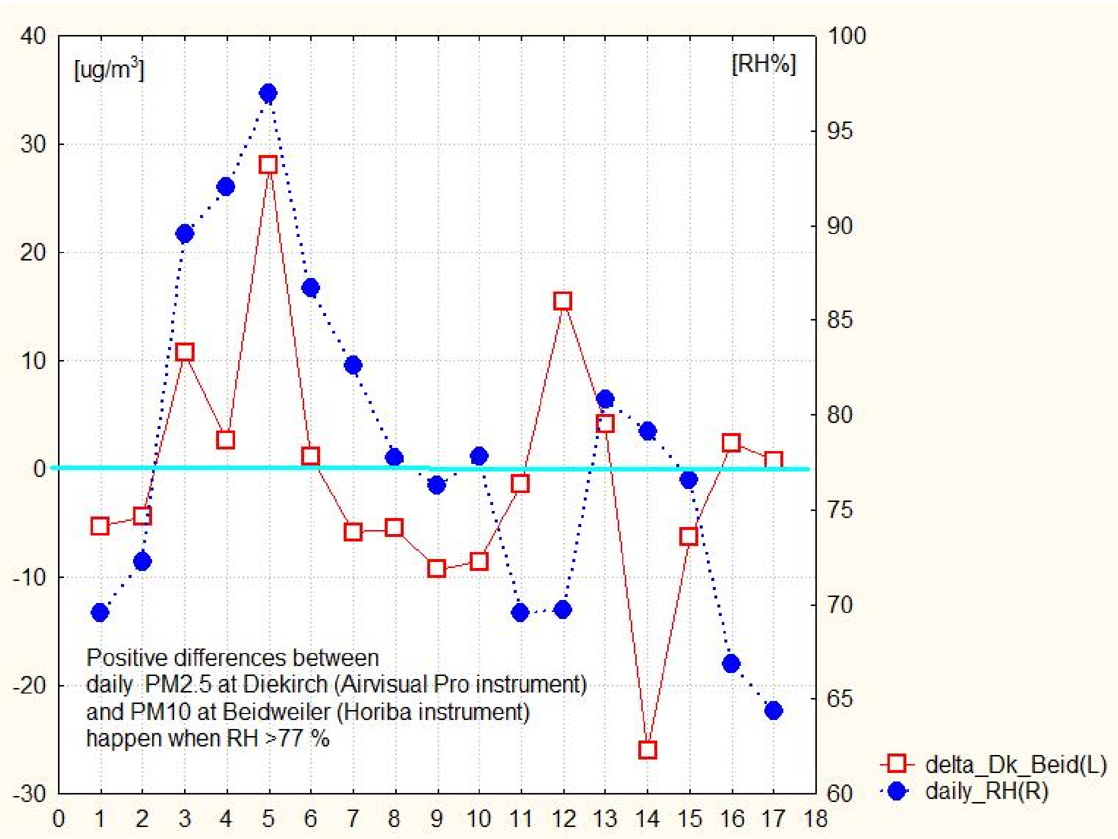

Fig 3. Difference of PM measurements and relative humidity levels at Diekirch: the difference is positive when RH > 77%

2. Correcting for RH

Many papers have studied the influence of humidity on measurements done by LLS sensors on un-dried air. Basically what happens is that for high humidity levels water condenses on the aerosol nuclei, which increases the laser light scattering and pushes measurement results to higher levels (see ref. **2** and **3**).

The next figure from the Jayaratne paper (ref. **2**) gives practically the same RH borderline at 77% above which measurements become badly biased.

The increase can be quantified by a "growthfactor" GF, and several empirical studies have found that GF can be given as

$$GF = a + \frac{b * RH^2}{1 - RH}$$

where relative humidity RH is expressed as a number between 0 and 1 (i.e. RH = RH%/100).:

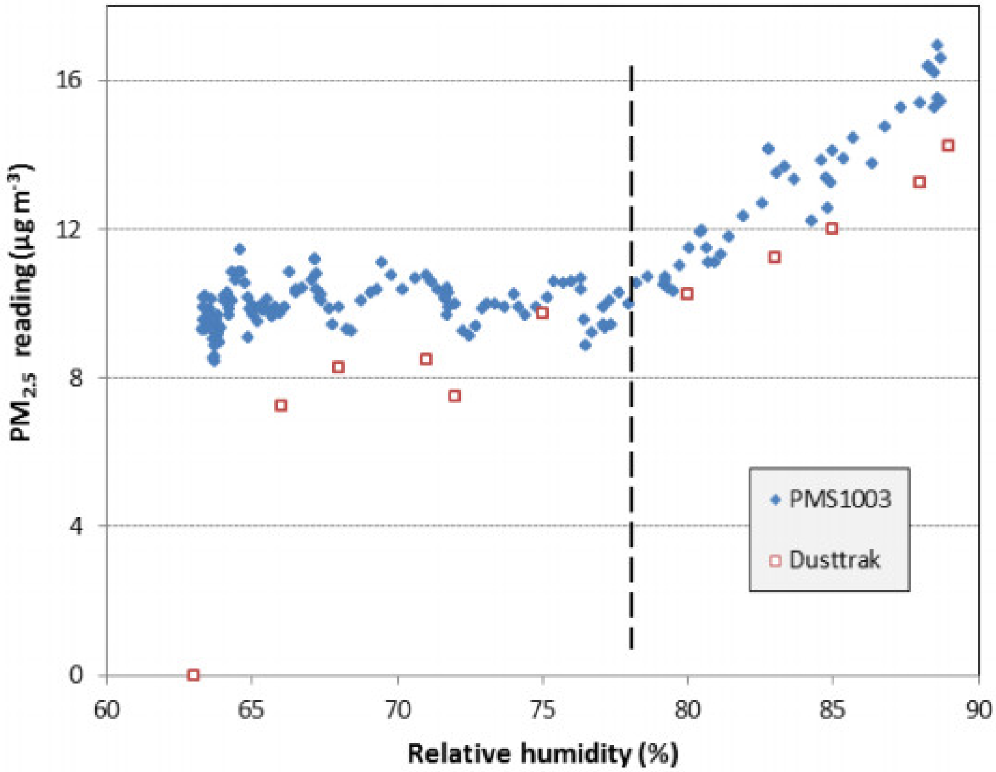

Figure 2. The $PM_{2.5}$ concentration reported by the PMS1003 and the DustTrak as the relative humidity was increased in the laboratory chamber.

Fig. 4: PM2.5. levels increase when RH exceeds a level between 75 and 80% (the PMS1003 is a typical LLS sensor).

The best parameters found for SDS011 type LLS sensors are a =1 and b = 0.25 which gives

$$GF = 1 + \frac{0.25 * RH^2}{1 - RH}$$

Fig.5 shows the raw and RH corrected series of the Airvisual Pro sensor together with the Beidweiler PM10 data. The effects of the RH correction are dramatic for the first 3 days where a small rainfall happened. The Pearson correlation also increases spectacularly from 0.58 to 0.82 with the RH correction, as seen in the following table (fig.6):

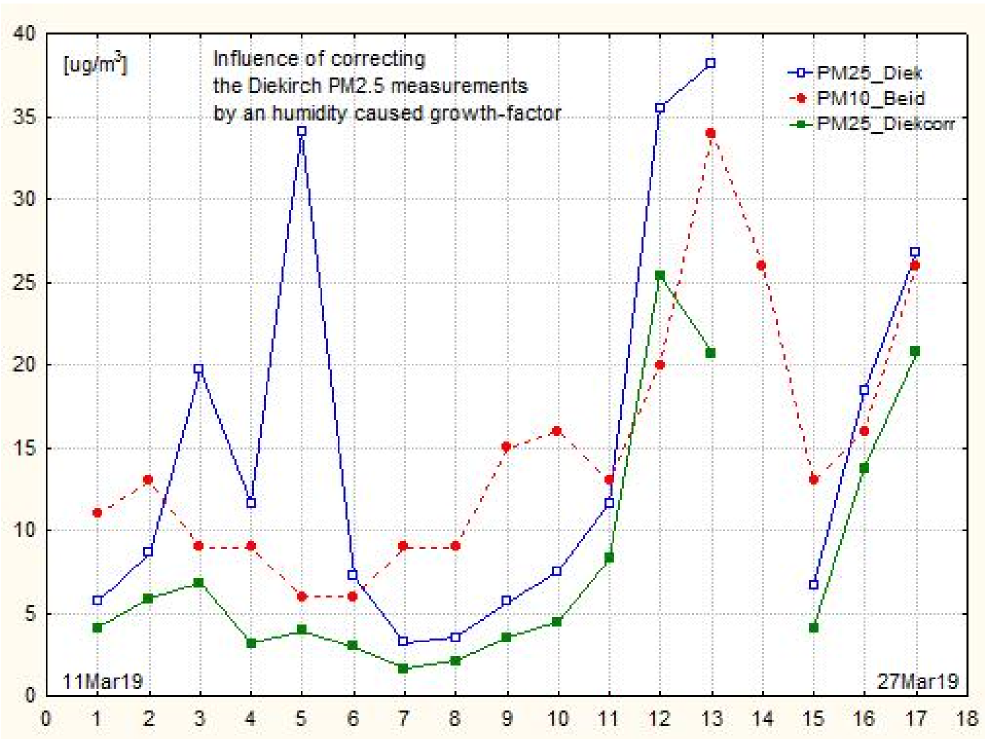

Fig.5. Series of raw and RH corrected PM2.5 readings at Diekirch and PM10 measurements at Beidweiler (daily averages)

	Correlations (1_to_27_Mar2019.sta) Marked correlations are significant at p < .05000 N=16 (Casewise deletion of missing data)			
Variable	**daily_RH**	PM25_Diek	PM10_Beid	PM25_Diekcorr
daily_RH	1.00	0.07	-0.48	-0.48
PM25_Diek	0.07	1.00	0.58	0.79
PM10_Beid	-0.48	0.58	1.00	0.82
PM25_Diekcorr	-0.48	0.79	0.82	1.00

Fig.6. Correlation increases from 0.58 to 0.82 when RH correction is made on the Diekirch Airvisual Pro measurements.

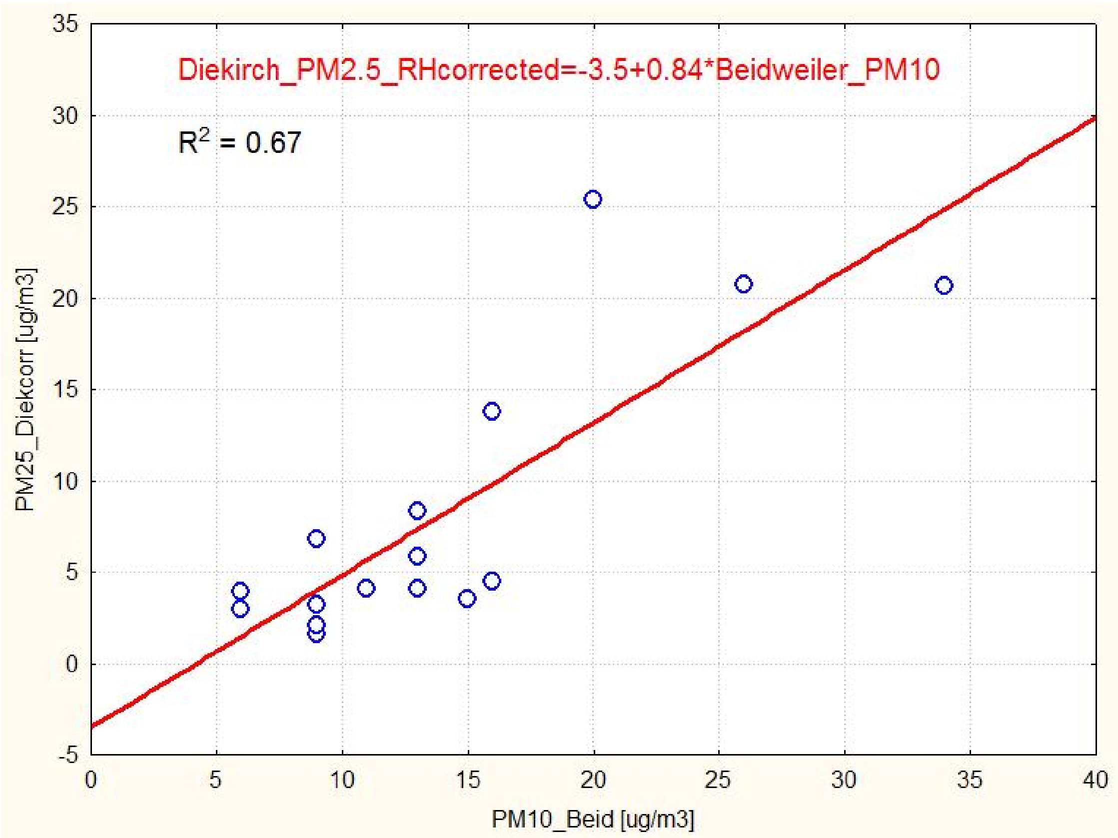

Fig. 7. Linear regression between the RH corrected Diekirch Airvisual Pro measurements and those made at Beidweiler.

The "calibration" curve between both sensors has a slope lower than 1, which should be expected as PM10 measurements include PM 2.5 data plus all particles between 2.5 and 10 um.

Comparing PM 2.5 measurements to PM 10 may be seen as foolish, but in effect the Airvisual Pro data of both categories are very close, as shown in figure 8 from a month long running instrument in an office environment; actually an upcoming planned report will compare both PM2.5 and PM10 measured by the two instruments. PM10's data of the Airvisual Pro can be locally downloaded from its flash memory, but are not available on the cloud. PM 2.5 data from Beidweiler must be fetched from the "discomap" website of the EEA.

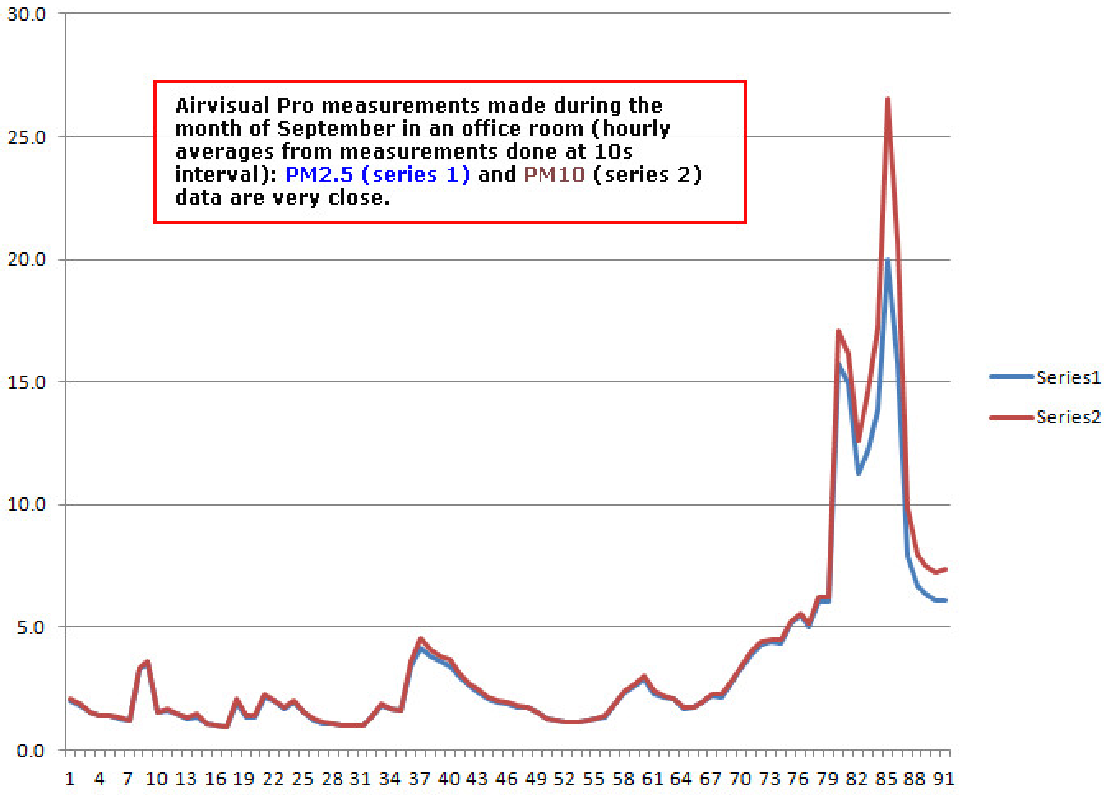

Fig. 8: Airvisual Pro PM 2.5 and PM 10 measurements are close.

4. Conclusion

This first analysis of the AirvisualPro measurements made at the definitive location in the Stevenson hut on the meteoLCD terrace shows that the PM 2.5 readings track the PM10 measurements made at Beidweiler in a plausible manner under the condition that they are corrected for relative humidity (division by the growth factor GF). So the Airvisual data could also be useful in detecting an eventual malfunction of either sensor or to fill in missing data.
Even if fig.3. (and the paper in ref.2) suggest that the influence of RH becomes noticeable only at levels above 77%, a systematic RH correction seems to be a prudent option.

4. References

1. Massen F. et al: A short study in fine particles measurement at meteoLCD by inexpensive LLS sensors, Nov 2018.
https://meteo.lcd.lu/papers/short_study_fine_particles_19NOV2018.pdf

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