World Calibration Centre
for Aerosol Physics

Audit Report

Station name: SMEARII

Date: May 24, 2016

Auditors: Prof. Dr. Alfred Wiedensohler, Mr. Maik Merkel

Responsible station staff: Dr. Pasi Aalto, Dr. Helmi-Marja Keskinen

General impression:

The general impression is **excellent**. We thank Pasi Aalto and Helmi-Marja Keskinen for their constructive discussions.

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Documentation:

Manuals for instruments available on site: yes

Written logbooks for each instrument yes

The logbook this completely digital and all activities seem to rather well documented. Each instrument has its own logbook. Most of the common services are pre-formatted and all activities can be filled in rather quickly.

Reference flow meter:

Type of reference flow meter: Gilian Flowmeter (Sensidyne)

Serial number: 1105048

Comments:

- The small bubble flowmeter cell (Serial number 1105063-S) is broken and has to be repaired again. Nevertheless, the comparison to the reference bubble flow meter from TROPOS showed just a small difference of plus 1.5 percent.

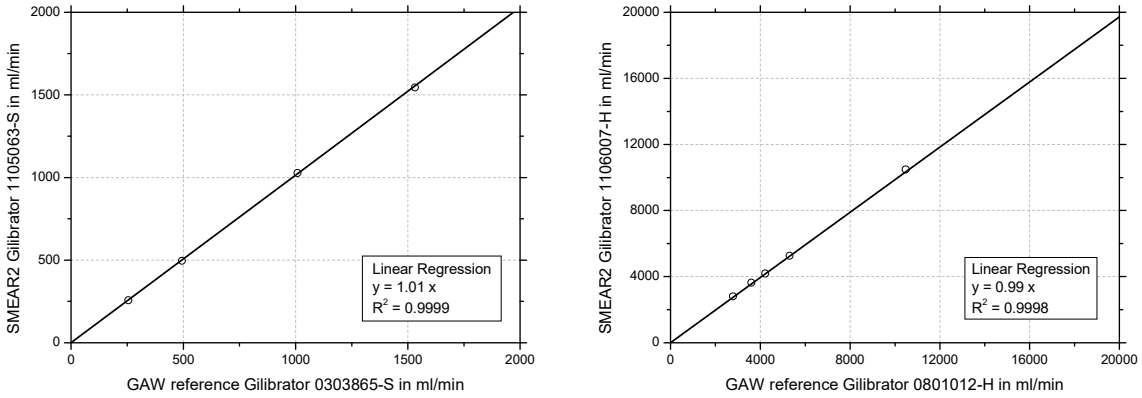

Figure 1: Comparison of SMEAR2 flow cells with GAW reference flow cells.

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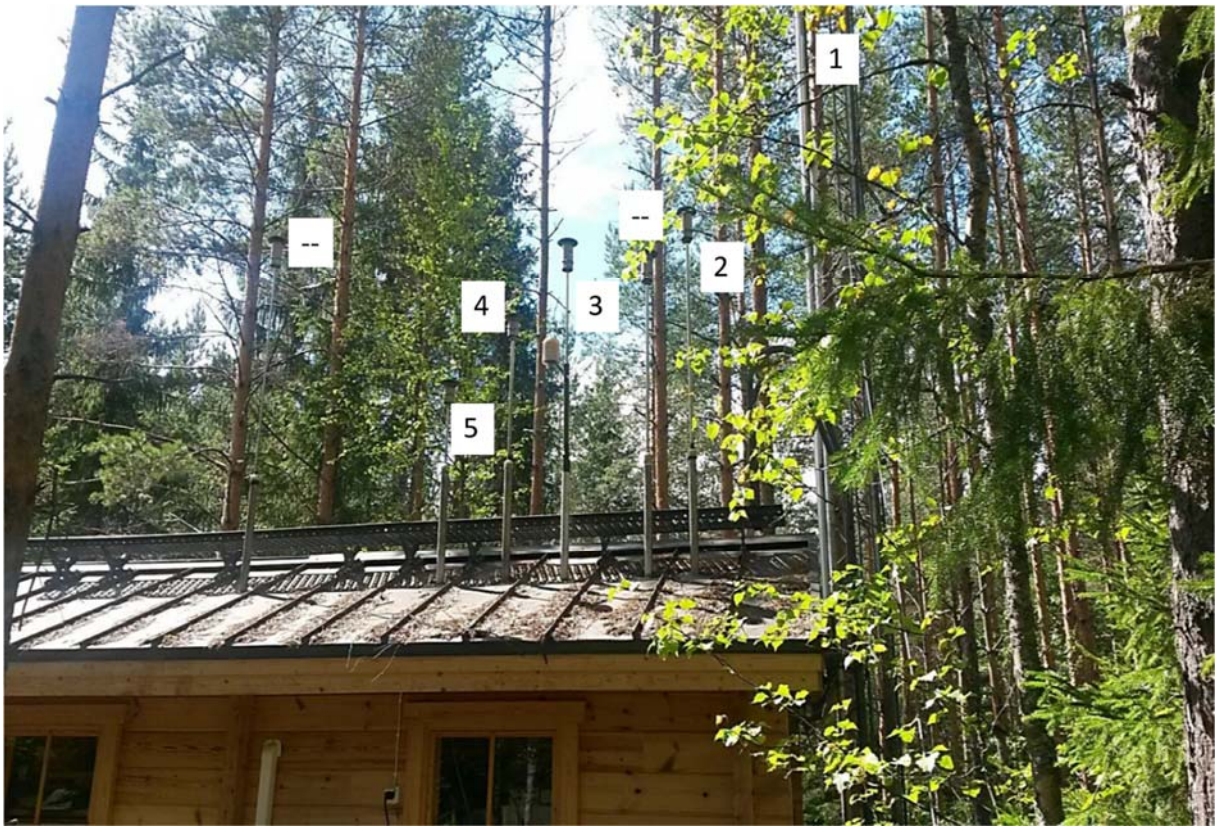
Aerosol inlets:

The station has 7 inlets dedicated to different instruments from which 5 were audited here.



Main Inlet for submicrometer particle number size distribution, total number concentration & concentration of cloud condensation nuclei (1)

Inlet type:	High flow TSP inlet
Material:	Stainless steel
Design:	Custom-made with no pre-separation
Outside:	Vertical 8 m above ground
Inside:	Horizontal
Bends:	1
Tube diameter:	100 mm
Flow rate:	150 l/min
Reynolds number:	ca. 2100 → OK
Aerosol dryer:	No dryer
Relative humidity of aerosol:	not available
Inlet according to recommendations:	The inlet configuration is fine for its application., See however the comments below!

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General comments:

1. The surrounding trees have grown in meanwhile to a height that they might significantly influence the aerosol sampling under certain atmospheric conditions. According to the GAW recommendations, the inlet should not be influenced by surrounding vegetation (WMO-GAW report 227 "… *sample air should be brought into the laboratory through a vertical stack with an inlet that is high enough above ground level to minimize local influences*")
2. As a compromise, I would suggest to cut the trees within a radius of 10 m around the aerosol hut.
3. Since the maximum dew point temperature in summer is lower than 17°C (personal communication Pasi Aalto) and the indoor temperature is always higher, there won't be any condensation.
4. To be able to minimize hygroscopic particle growth within the mobility particle size spectrometer (here a dual DMPS), the indoor hut temperature should be kept around 30°C in summer as a compromise. The responsible scientist (Pasi Aalto) would like to avoid an aerosol dryer for the ultrafine "DMPS" to minimize additional particle losses in the sub-10nm size range due to diffusion.
5. For the other instrumentation (total CPC and CCNC), aerosol dryers are still recommended, see also under "Particle Number Concentration"

<u>Inlet optical instrumentation (2):</u>

Inlet Type:	PM10 (inside alternating PM10 and PM1 using an impactor)
Material:	Stainless steel
Design:	commercial
Outside:	Vertical 5,70 m above ground
Inside:	Vertical
Bends:	inside to separate PM1
Tube diameter:	23 mm
Flow rate:	30 l/min
Reynolds number:	ca. 1700 → OK
Aerosol dryer:	No dryer
Relative humidity of aerosol:	not available
Inlet according to recommendations:	The inlet configuration is fine for its application.,

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Inlet for particle mass concentration (ß-gauge) (3):

Inlet Type:	PM10
Material:	Stainless steel
Design:	commercial
Outside:	Vertical 5,50 m above ground
Inside:	Vertical
Bends:	no
Tube diameter:	16 mm
Flow rate:	16,7 l/min
Reynolds number:	ca. 1350 → OK
Aerosol dryer:	No dryer, heating tube
Relative humidity of aerosol:	not available
Inlet according to recommendations:	The inlet configuration is fine for its application.,

Inlet for particle mass concentration (impactor) (4):

Inlet Type:	TSP
Material:	Stainless steel
Design:	commercial
Outside:	Vertical 5,10 m above ground
Inside:	Vertical
Bends:	no
Tube diameter:	25 mm
Flow rate:	30 l/min
Reynolds number:	ca. 1550 → OK
Aerosol dryer:	No dryer
Relative humidity of aerosol:	not available
Inlet according to recommendations:	The inlet configuration is fine for its application.,

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Inlet for course number size distribution (APSS) (4):

Inlet Type:	TSP
Material:	Stainless steel
Design:	commercial
Outside:	Vertical 4,70 m above ground
Inside:	Vertical
Bends:	no
Tube diameter:	17 mm
Flow rate:	5 l/min
Reynolds number:	ca. 400 → OK
Aerosol dryer:	No dryer, heating tube
Relative humidity of aerosol:	not available
Inlet according to recommendations:	The inlet configuration is fine for its application.,

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Particle Light Absorption Coefficient:

Aethalometer:

Model:	Magee AE31
Serial Number:	496
Wavelengths:	370, 470, 520, 590, 660, 880, 950
Last calibrated:	Needs to be calibrated within ACTRIS in 2017
Data submitted to data center:	yes, for 2015, but until 2014, the level 1+2 data are missing. Please use the new correction factor and submit also this data
Dryer:	TROPOS-type Nafion
Condition of instrument:	excellent

Multi-Angle Absorption Photometer:

Type:	Filter absorption photometer
Model:	Thermo 5012
Serial Number:	286
Wavelengths:	637
Last calibrated:	Needs to be calibrated within ACTRIS in 2017
Data submitted to data center:	yes

Comments:

- no dryer is included
- might be a problem during summer time
- we strongly recommend to install a dryer

Condition of instrument:	good (because of missing dryer)

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Particle Light Scattering Coefficient:

Type:	Integrating Nephelometer
Model:	TSI 3563
Serial Number:	70539059
Wavelengths:	450, 550, 700
Zero check:	Once per day
Span check:	every month
Gas for span check:	CO_2
Last Calibration:	March 10, 2016
Data submitted to data center:	yes
Dryer:	TROPOS-type Nafion
Condition of instrument:	excellent

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Particle Light Extinction Coefficients:

Type: CAPS

Model: Aerodyne PMex, 530 nm

Serial Number: 211002

Wavelengths: 530 nm

Last calibrated: 11/2015

Data submitted to data center: no

Condition of instrument: good (only because dryer is missing)

Comments:

- no dryer!
- It is planned to have the inlet new including a dryer

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Particle Mass concentration:

Type: Model	Sharp 5030 beta gauge
Serial Number:	3960
Data submitted to data center:	no
Condition of instrument:	good

Comments:

- no dryer included
- the inlet is heated; we recommend to switch of the heating

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Impactor-based Particle Mass Concentration:

Three-stage impactor	PM1, PM2.5, PM10
Nominal sample flow rate	30 l/min
Data submitted to data center:	no
Condition of instrument:	good (only because of missing dryer)

Comments:

- no heating, no drying
- inconsistent to the APSS measurements
- measurements are done three times a week
- undefined humidity especially in summer

Recommendation:

- drying should be done in summer time

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Particle number size distribution (MPSS):

Type of instrument:	Dual DMPS
Manufacturer:	UHEL
S/N:	NO
Type of bipolar charger	C14
Nominal Activity	370 MBq
Date manufactured	2007
Particle Counter:	CPC 3772 S/N: 3772134502; UCPC 3025 S/N: 1108
Aerosol dryer:	No
Sheath air dryer:	yes (silica-based diffusion dryer)
Temperature sensor aerosol:	yes
Temperature sensor sheath air:	yes
Humidity sensor aerosol:	yes
Humidity sensor sheath air:	yes

Nominal sheath air flow rate UDMA:	20 l/min
Nominal aerosol flow rate UDMA:	4 l/min
Nominal sheath air flow rate DMA:	5 l/min
Nominal aerosol flow rate DMA:	1 l/min
Indicated concentration with absolute filter:	zero
Instrument built according to recommendations:	yes (beside missing aerosol dryer)
Data submitted to data center:	yes, however, there are still missing all level 0 data. Please re-submit all this data (when template is available)
Condition of instrument:	excellent

Comments:

- Pasi Aalto is inverting the data including losses
- Particle size distribution from 3 to 1000 nm
- Sheath air dryer is changed when humidity is higher than 25% → good
- For the main inlet there is no loss correction (this should be done!)

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Recommendations:

- Aerosol dryer for the long DMA
- Flow rate correction for CPC 3772 in DMPS of 1.03
- All CPC's should be frequently compared in the hut
- if there are spare CPC's → calibration of particle counters could be done at ECAC

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Size calibration of the UHEL DMPS

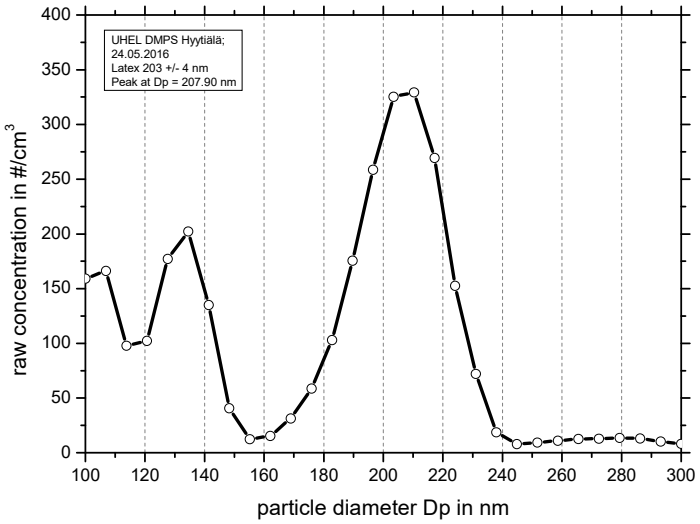

Figure 2: Measurement of latex 203 nm: Particle size distribution (raw concentration) for latex 203 nm on May 23rd, 2016 for the UHEL DMPS Hyytiälä.

Comparison of the particle number size distribution

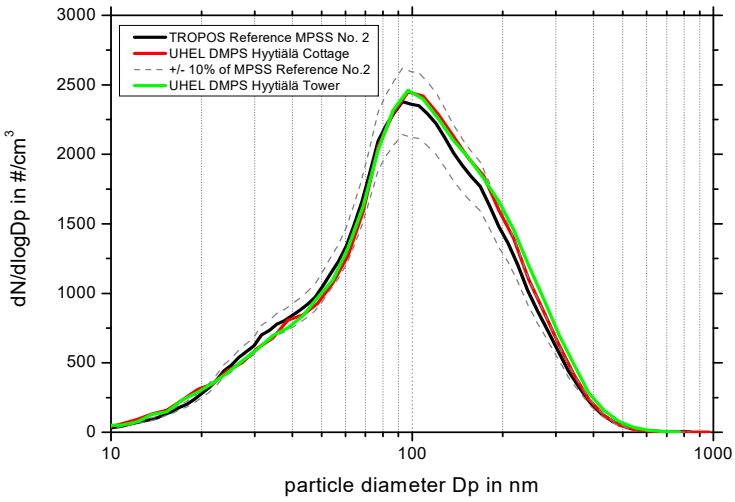

Figure 3: Comparison of mean particle number size distribution of TROPOS Reference MPSS No.2, UHEL DMPS Hyytiälä Cottage (red) and UHEL DMPS Hyytiälä Tower (green) from May 23, 2016 12:00 pm until May 26, 2016 10:00 am. The inversion for the MPSS Reference No. 2 was performed using TROPOS software. Multiple charge correction, internal diffusion losses and CPC efficiency are included. The inversion for the UHEL DMPS Hyytiälä was performed by Pasi Aalto, including multiple charge correction, internal losses and CPC efficiency.

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Correlations:

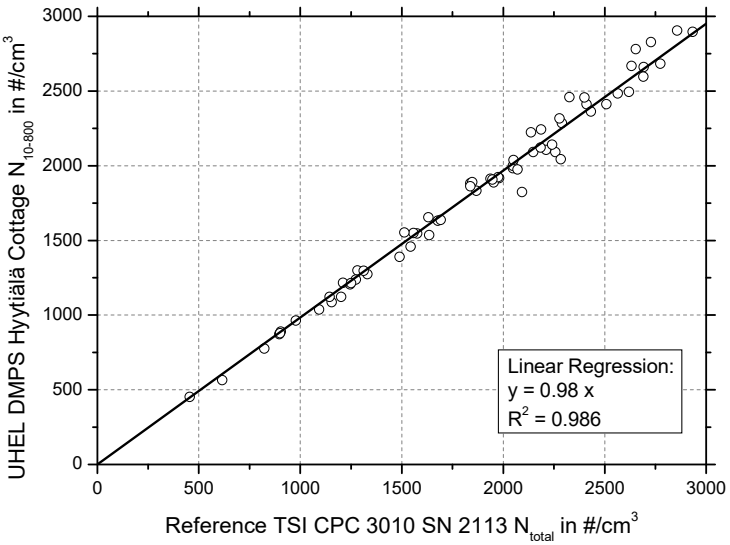

Figure 4: Linear regression between the number concentrations of the Reference TSI CPC 3010 SN 2113 and UHEL DMPS Hyytiälä hut. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

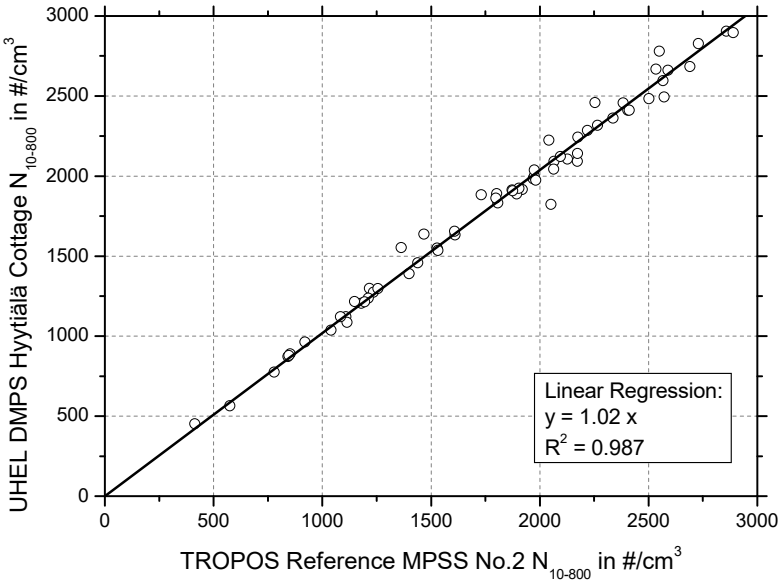

Figure 5: Linear regression between the number concentrations of the TROPOS Reference MPSS No.2 and UHEL DMPS Hyytiälä hut. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

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Tower station:

Type of instrument:	DMPS
Manufacturer:	UHEL
Serial Number:	None
Type of bipolar charger	C-14
Nominal Activity	370MBq
Date manufactured	2007
Particle Counter:	TSI3025+TSI3010
Aerosol dryer:	TROPOS-type Nafion drier
Sheath air dryer:	No
Temperature sensor aerosol:	Yes
Temperature sensor sheath air:	Yes
Humidity sensor aerosol:	Yes
Humidity sensor sheath air:	No

- UHEL-type DMPS is working fine
- We recommend also to us dryers for the sheath air

Correlations:

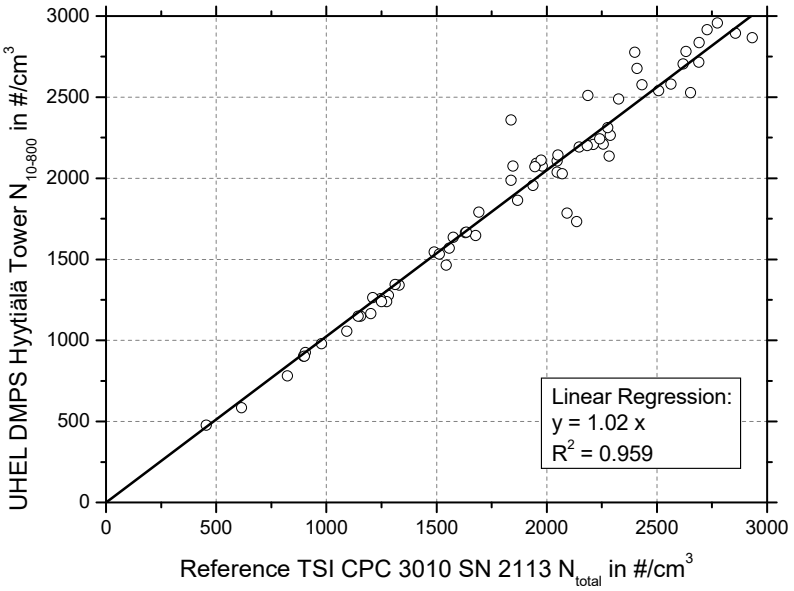

Figure 6: Linear regression between the number concentrations of the Reference TSI CPC 3010 SN 2113 and UHEL DMPS Hyytiälä Tower. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

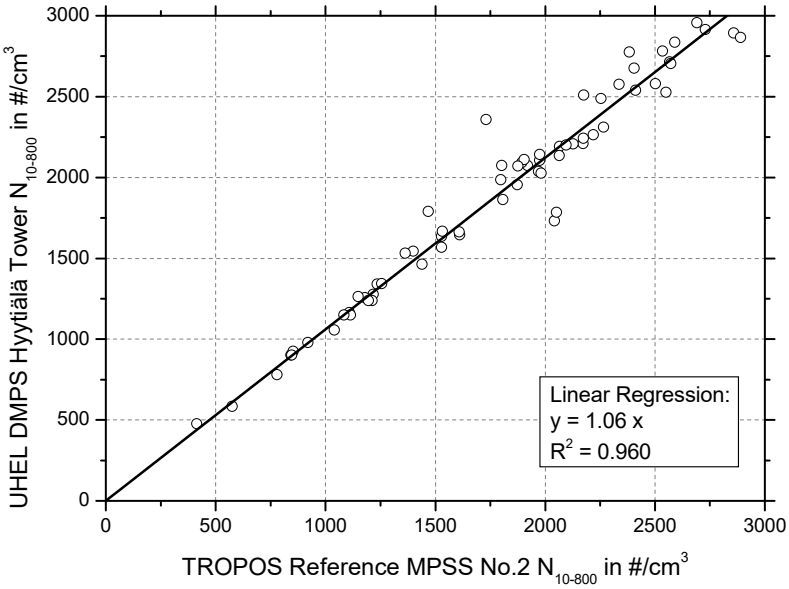

Figure 7: Linear regression between the number concentrations of the TROPOS Reference MPSS No.2 and UHEL DMPS Hyytiälä Tower. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

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Particle number concentration (CPC)

Manufacturer:	TSI model 3775
S/N:	3775134704
Last flow check:	May 18, 2016
Last Calibration:	not calibrated yet
Zero test:	zero
Data submitted to data center:	yes
Condition of instrument:	good

Comments:

- Reason for model 3775. High concentrations
- Diffusion dryer is used, causing losses
- No diffusion dryer, high losses especially for small particles
- Test with and without dryer should be done

Recommendation:

- Use of a Nafion dryer
- Should be sent to the ECAC for calibration

Comparison of CPCs

Time Series:

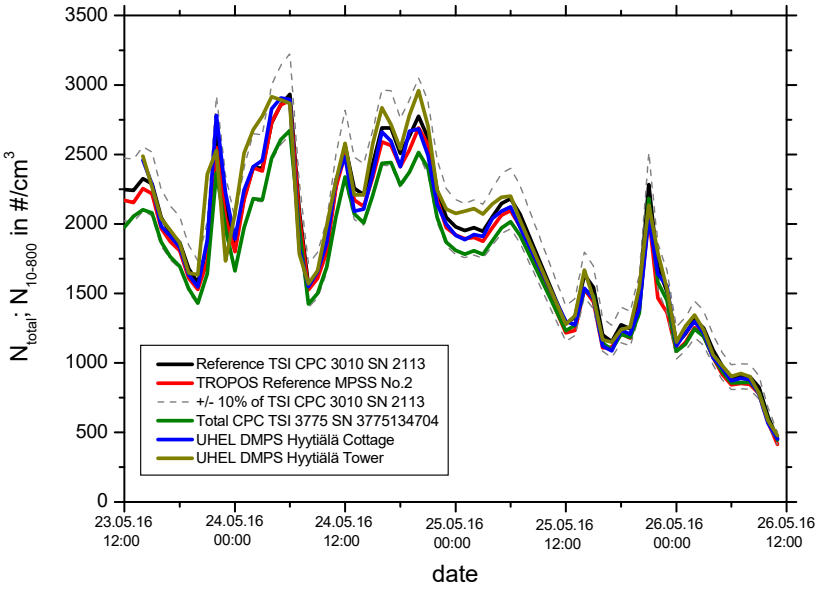

Figure 8: Time series (May 23, 2016 12:00 pm – May 26, 2016 11:00 am) of the integrated particle number concentration ($N_{10\text{-}800nm}$) of the different mobility particle size spectrometers and total number concentration (N_{total}) of the Total CPC 3010 and 3775.

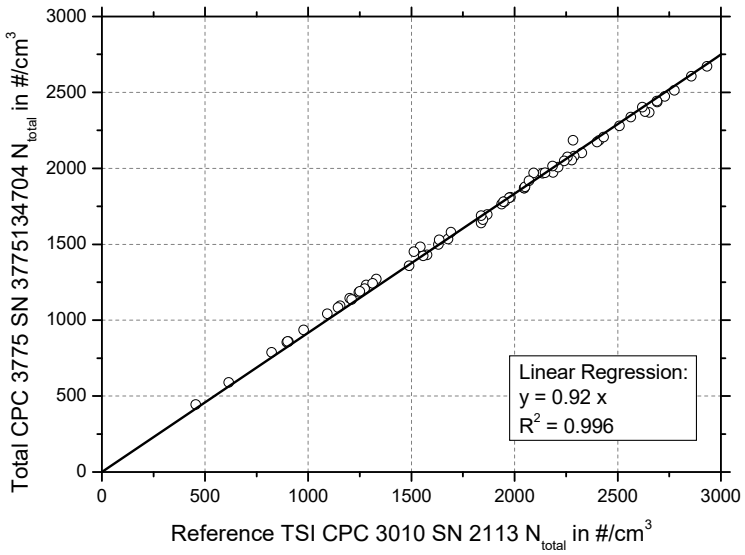

Figure 9: Linear regression between the number concentrations of the Reference TSI CPC 3010 SN 2113 and Total CPC 3775 SN 3775134704. CPC flow corrections are included.

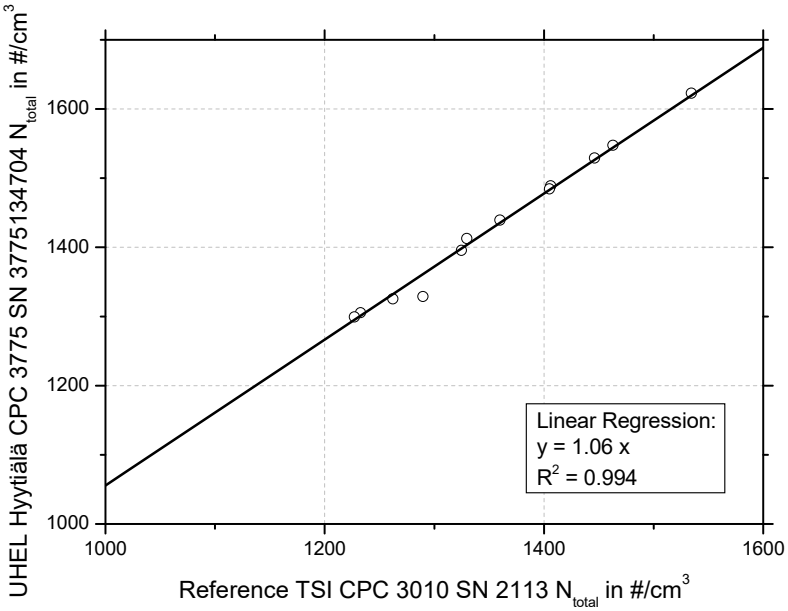

Figure 10: Linear regression between the number concentrations of the Reference TSI CPC 3010 SN 2113 and UHEL Hyytiälä CPC 3775 SN 3775134704, without diffusion dryer. CPC flow corrections are included.

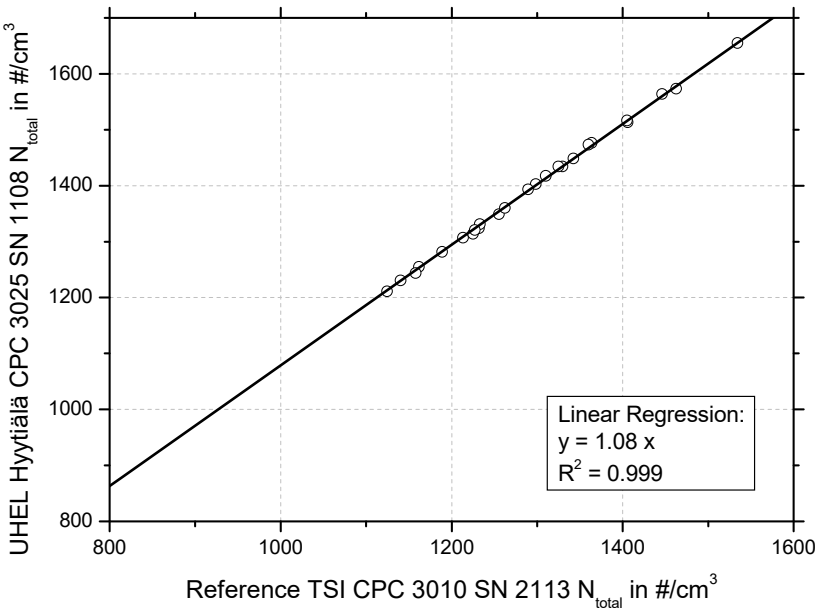

Figure 11: Linear regression between the number concentrations of the Reference TSI CPC 3010 SN 2113 and UHEL Hyytiälä CPC 3025 SN 1108. CPC flow corrections are included.

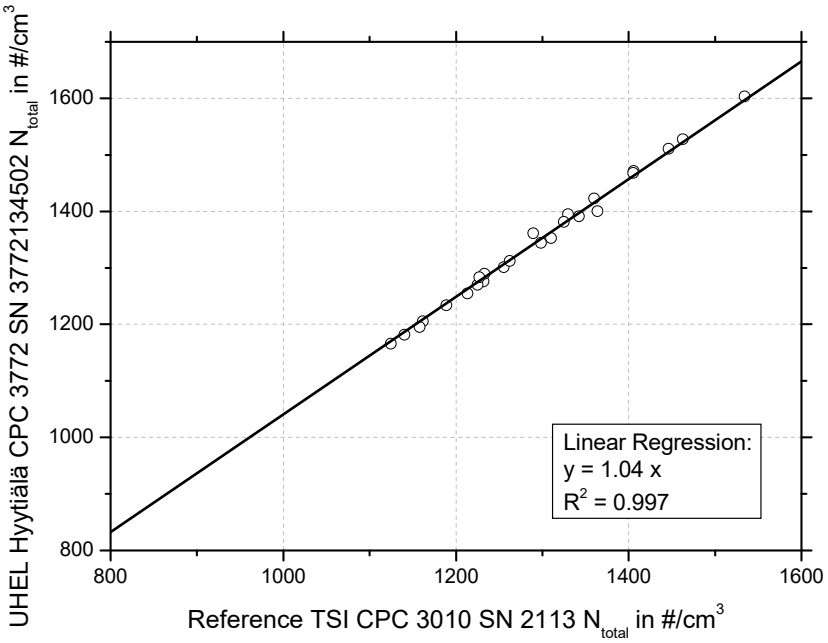

Figure 12: Linear regression between the number concentrations of the Reference TSI CPC 3010 SN 2113 and UHEL Hyytiälä CPC 3772 SN 3772134502. CPC flow corrections are included.

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Particle number size distribution (APSS):

Manufacturer:	TSI model 3321
S/N:	1202
Aerosol dryer:	No
Temperature sensor aerosol:	yes, inside
Data submitted to data center:	no
Condition of instrument:	good

Comments:

- Heated inlet, which is no recommended
- T(inlet) is too high, > 40°C
- Instrument temperature is logged
- If heating, then is should be controlled to max. 35°C

Recommendation:

- Use of a big Nafion dryer instead of heating

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Cloud condensation nuclei concentration (CCNC)

Manufacturer:	Droplet Measurement Tech.
S/N:	50059
CPC:	model 3772
S/N	71033136
Supersaturations:	0.1 0.2 0.3 0.5 1.0
Last flow calibration:	May 18, 2016
Last supersaturation calibration:	in meantime at ECAC in Oct. 2016)
Material	$(NH_4)_2SO_4$
Data submitted to data center:	no
Condition of instrument:	excellent

Comments:

- Flow rates are measured every week
- Sample flow rate in CCNC is not measured
- Calibrated four times a year
- Next calibration will be done in June 2016
- 1.5 h time resolution
- Total concentration is measured after each scan

Recommendation:

- We strongly suggest to submit all data from the last years to the data center (due to Helmi Keskinen, this will be done)