Intercomparison of Mobility Particle Size Spectrometers

Project No.: *MPSS-2017-1-3*

Principal Investigator:

Home Institution: *Institute for Environmental Studies, Charles University, Prague*

Participant:

Candidate:	**CZ-IES**
Made by:	TSI
Counter (SN):	TSI CPC Model 3025A; SN: 1431
Software:	TSI AIM 8.0

Location of the quality assurance: TROPOS Leipzig, lab 118

Comparison period: January 23, 2017 – January 27, 2017

Last Intercomparison (with Project No.):

Summary of Intercomparison

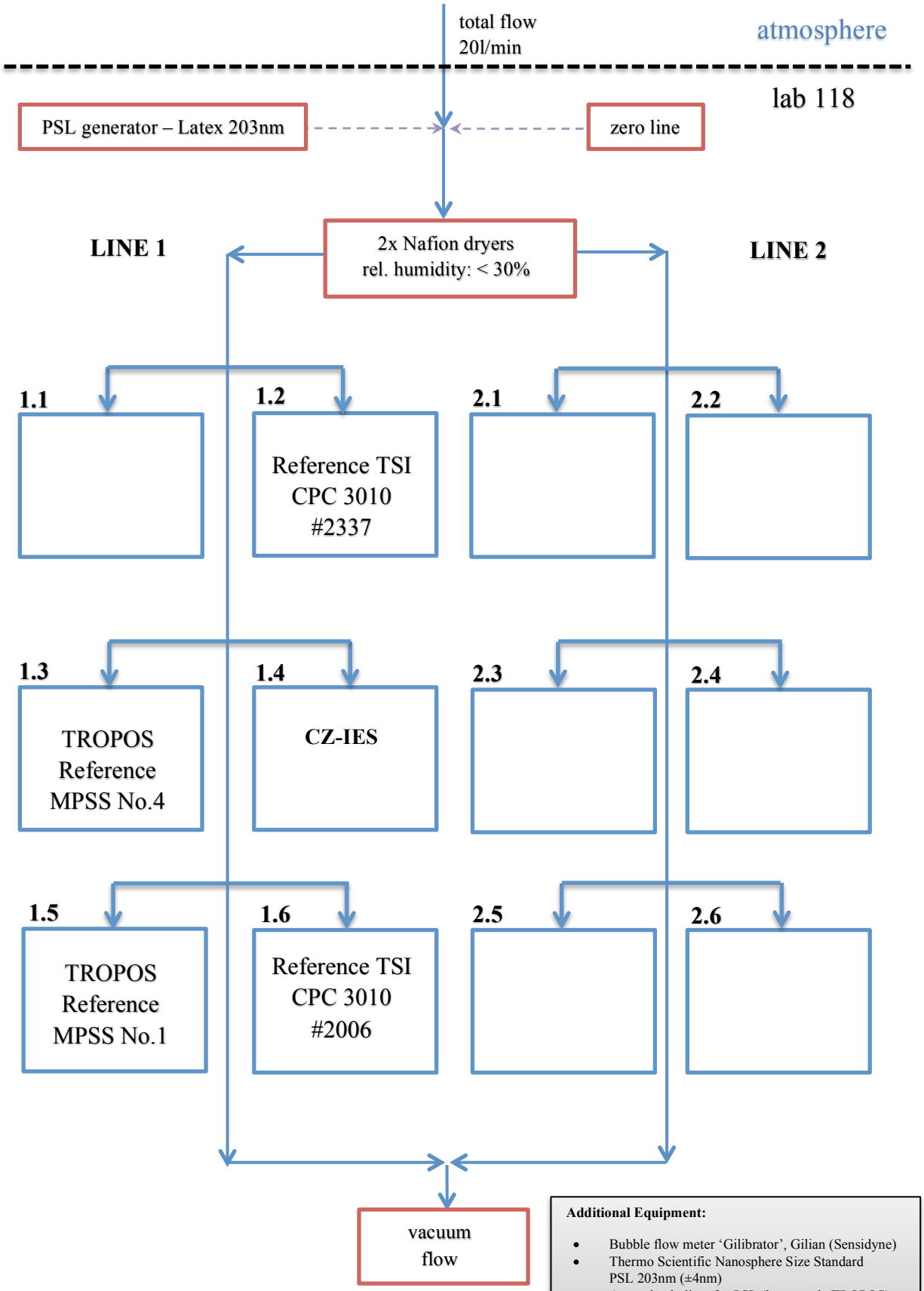
Pre-Status:
The instrument arrived with participant. During the Pre-Status, the performance of the system showed a concentration 19% lower than the TROPOS Reference Instrument No.1. The PSL check showed a correct peak at 199.95 nm. The system is running normally on the station with an impactor and a Kr.85 (2mCr) source from TSI. There is no flow split between the DMA and UCPC. The flow ratio is 0.3:3 l/min. The system was in a good visual condition. During the Pre-status the candidate was operated at station conditions (impactor, Kr85 source from TSI and TSI UCPC model 3025A). The UCPC 3025A showed flow problems and a lower concentration what was seen also during the CPC workshop 25.01.2017. For more information look at the CPC workshop report.

Final Status:
During the Final-Status, the performance of the system showed a concentration 11% lower than the TROPOS Reference Instrument No.1. The candidate used the recalibrated TSI UCPC model 3025A and their own TSI Kr.85 source. TROPOS recommend CZ-IES Prague to run the TSI instrument without impactor. It is necessary to have the TSI UCPC model 3025A checked by TSI, because the internal flow drifts after flow calibration. Under the conditions of the final run in the TROPOS workshop (flow was stable), the candidate passed the quality standards of ACTRIS and GAW.

Post-Check:
Due to the discussed problems with the TSI UCPC model 3025A, TROPOS did an intercomparison against the TROPOS Reference MPSS No.1 with a TSI CPC model 3772 from TROPOS. The flow ratio was set to 1:5. The performance check indicates:

1. if there is a correct communication between the classifier 3081 and a TSI CPC model 3772
   Conclusion: It is possible to run the candidate with a TSI CPC model 3772
2. performance of the candidate using TSI software without diffusion losses
   Conclusion: Evaluation of the data is possible. However, to have a final data, diffusion loss correction is necessary
3. performance of the candidate using TSI software with diffusion losses
   Conclusion: The TSI software will overestimate the small particles, by using a wrong diffusion loss correction.
4. performance of the candidate using TSI software but with diffusion losses from TROPOS
   Conclusion: The inversion is done by TSI software. For calculating the internal diffusion losses, we measured the whole inlet by using the correct effective lengths for the parts (Kr.85 source, angles, DMA,…) of the instrument. With these configurations, the candidate showed still a higher concentration against the TROPOS Reference MPSS No. 1, but the diffusion loss correction is not overestimating the lower particle sizes. We are on the upper end of the 10%.

Laboratory setup:



Additional Equipment:

- Bubble flow meter 'Gilibrator', Gilian (Sensidyne)
- Thermo Scientific Nanosphere Size Standard PSL 203nm (±4nm)
- Aerosol nebulizer for PSL (homemade TROPOS)
- Voltcraft multimeter (0-1000V), Keysight Technologies

Information about the instruments:

Date of check: 23.01.2017

List of Components	TROPOS Reference MPSS No.1	TROPOS Reference MPSS No.4	Candidate
Position	1.5	2.5	1.4
Company	TROPOS	TROPOS	TSI
Software	TROPOS	TROPOS	TSI
CPC-MPSS	TSI CPC, Model 3772	TSI CPC, Model 3772	TSI UCPC, Model 3025A
CPC-total	TSI CPC, Model 3010	TSI CPC, Model 3010	-
flow ratio	1.0 : 5.0	1.0 : 5.0	0.3 : 3.0
source	Kr85	Kr85	Kr85 2mCi
HV power supply	positive	positive	negative
DMA	Hauke medium	Hauke medium	TSI 3081
aerosol dryer	✓	✓	
aerosol RH- sensor	✓	✓	
aerosol T-sensor	✓	✓	
sheath RH-sensor	✓	✓	
sheath T-sensor	✓	✓	
Sheath dryer	✓	✓	
pressure sensor	✓	✓	

Date of check (Pre-Status): 23.01.2017

CPC status	TROPOS-MPSS	TROPOS-total	Candidate-MPSS	Candidate-total
power/status	LED green	LED green	LED green	-
saturator temp	39 °C	-	37.1 °C	-
condenser temp	22 °C	-	10.1 °C	-
optics temp	40 °C	-	39.1 °C	-
cabinet temp	32.1 °C	-	-	-
ambient pressure	100.4 kPa	-	-	-
orifice pressure	74.1 kPa	-	-	-
nozzle pressure	2.6 kPa	-	-	-
laser current	50 mA	LED green	-	-
liquid level	full	full	full	-

Date of check (Final-Status): 23.01.2017

CPC status	TROPOS-MPSS	TROPOS-total	Candidate-MPSS	Candidate-total
power/status	LED green	LED green	LED green	-
saturator temp	39 °C	-	37.1 °C	-
condenser temp	22 °C	-	10.2 °C	-
optics temp	40 °C	-	39.1 °C	-
cabinet temp	32.3 °C	-	-	-
ambient pressure	100.4 kPa	-	-	-
orifice pressure	74.5 kPa	-	-	-
nozzle pressure	2.6 kPa	-	-	-
laser current	50 mA	LED green	-	-
liquid level	full	full	full	-

Instrument: TROPOS Reference MPSS

date	23.01.2017	24.01.2017		
total CPC flow	1.024 l/min	1.029 l/min		
aerosol flow (DMA)	0.947 l/min	0.952 l/min		
aerosol flow (UDMA)	-	-		
aerosol flow (total)	0.947 l/min	0.952 l/min		
zero	0 #/cm³	0 #/cm³		
PSL 203 nm	203.24 nm	-		
HV – 0 V	0 V	0.1 V		
HV – 4 mV	5.0 V	5.0 V		
HV – 80 mV	99.8 V	99.6 V		
HV – 800 mV	1000.7 V	999.7 V		

Instrument: Candidate

date	23.01.2017	24.01.2017		
total CPC flow	-	-		
aerosol flow (DMA)	0.294 l/min	0.296 l/min		
aerosol flow (UDMA)	-	-		
aerosol flow (total)	0.294 l/min	0.296 l/min		
zero	17 #/cm³	25 #/cm³		
PSL 203 nm	199.95 nm	-		
HV – 0 V	0 V	-		
HV – 10 V	10 V	-		
HV – 80 mV	-	-		
HV – 200 V	200 V	-		

Special Information regarding to the Candidate:

Was it necessary to:	yes/no (date)	old part (ID/SN)	new part (ID/SN)	information
clean the aerosol inlet	no			
change aerosol Nafion dryer	no			
change sheath Nafion dryer	no			
check source	no			
change HV power supply	no			
clean/change DMA	no			
change aerosol RH/T-sensor	no			
change sheath RH/T-sensor	no			
change pressure sensor	no			

TROPOS Reference Systems during the pre-status: Time Series

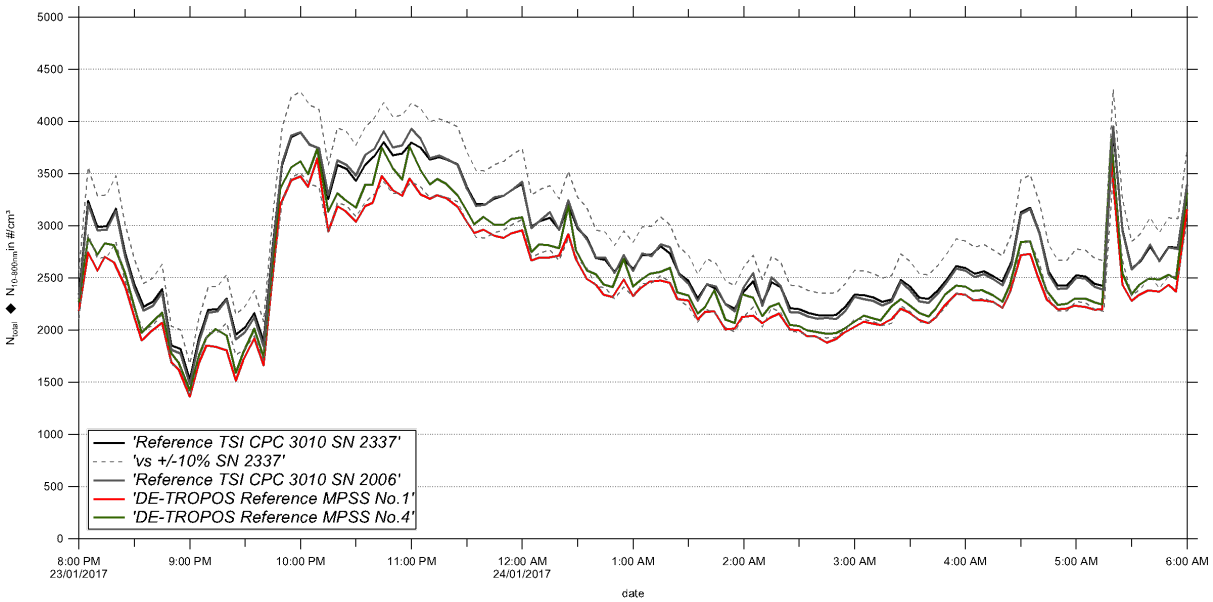


Figure 01: Time series (January 23, 2017 08:00 PM – January 24, 2017 06:00 AM) of the integrated particle number concentration ($N_{10\text{-}800nm}$) of the TROPOS Reference MPSS and total number concentration (N_{total}) of the Reference TSI CPC 3010. The inversion was performed using TROPOS software. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

PSL Scan and calibration: Latex 203 nm +/- 4 nm

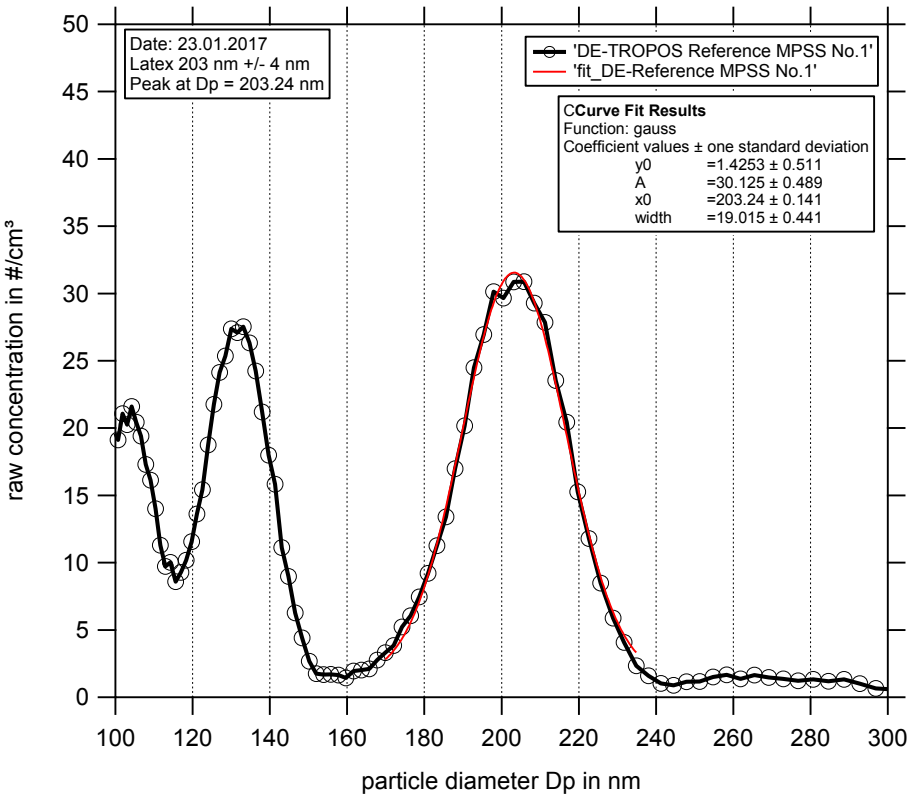


Figure 02: Measurement of latex 203 nm: Particle size distribution (raw concentration) for latex 203 nm on January 23rd, 2017.

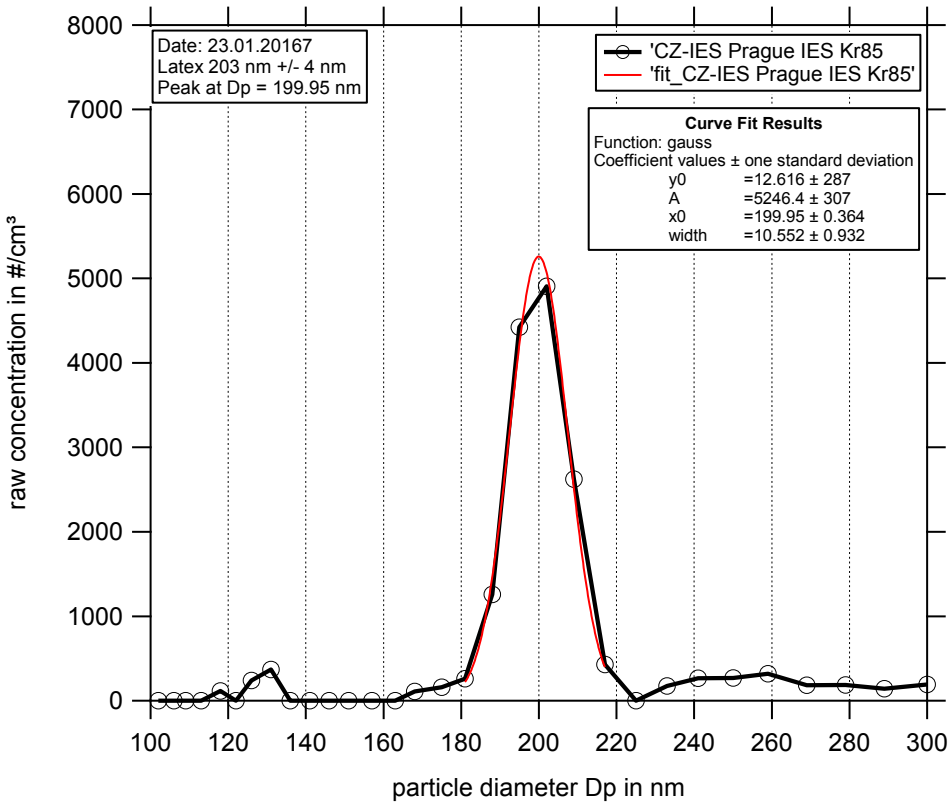


Figure 03: Measurement of latex 203 nm: Particle size distribution (raw concentration) for latex 203 nm on January 23rd, 2017.

Pre- Status of the Candidate: Particle Number Size Distribution

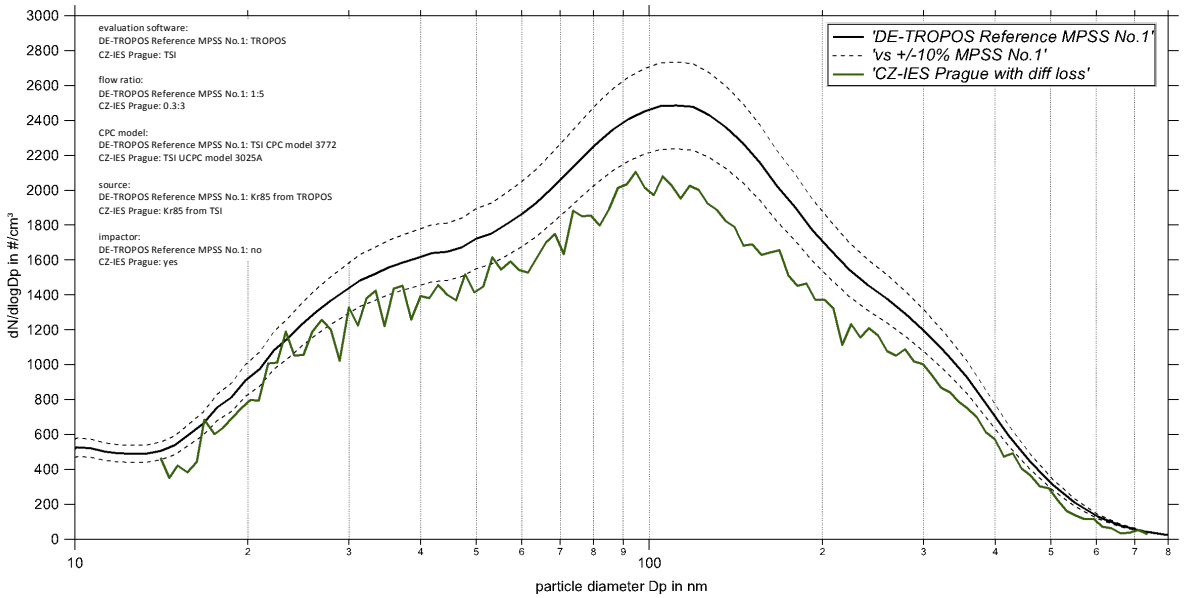


Figure 04: Comparison of mean particle number size distribution of TROPOS Reference MPSS No.1 against CZ-IES Prague from January 23, 2017 08:00 PM until January 24, 2017 06:00 AM. Multiple charge correction, internal diffusion losses and CPC efficiency are included for both of the instruments.

Pre- Status of the Candidate: Time Series

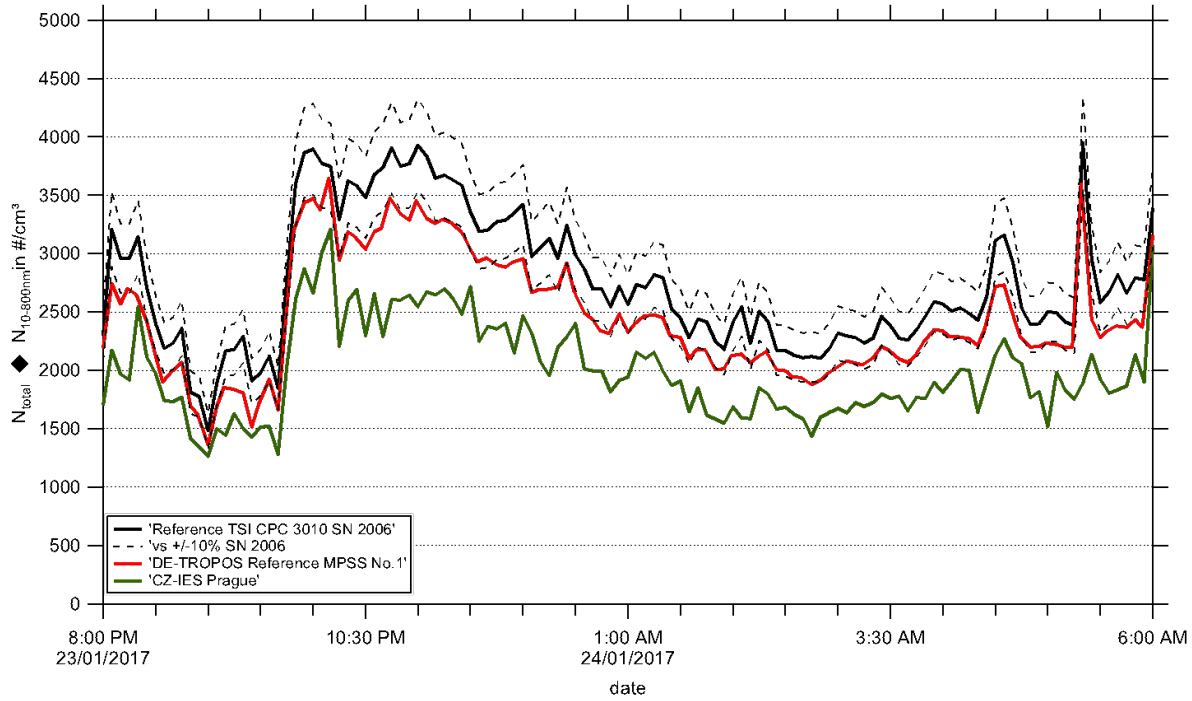


Figure 05: Time series (January 23, 2017 08:00 PM – January 24, 2017 06:00 AM) of the integrated particle number concentration ($N_{10\text{-}800nm}$) of the MPSS and total number concentration (N_{total}) of the Reference TSI-CPC Model 3010. The inversion for the candidate was performed using TSI software. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

Pre- Status of the Candidate: Correlation

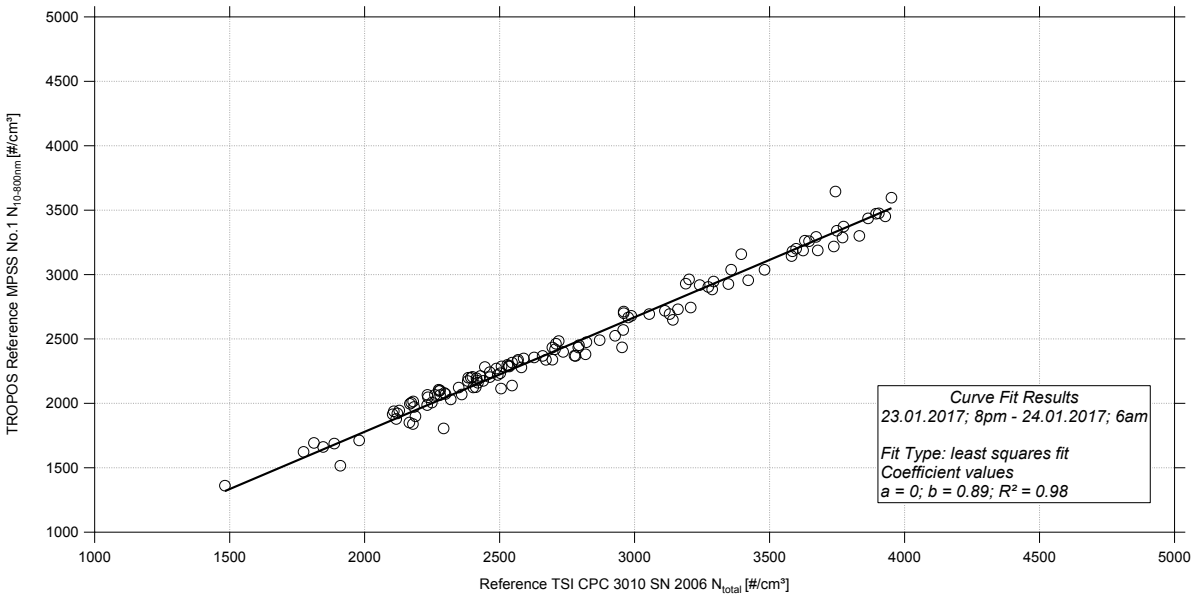


Figure 06: Linear regression between the number concentrations of the TROPOS Reference TSI CPC Model 3010 SN: 2006 and TROPOS Reference MPSS No.1. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

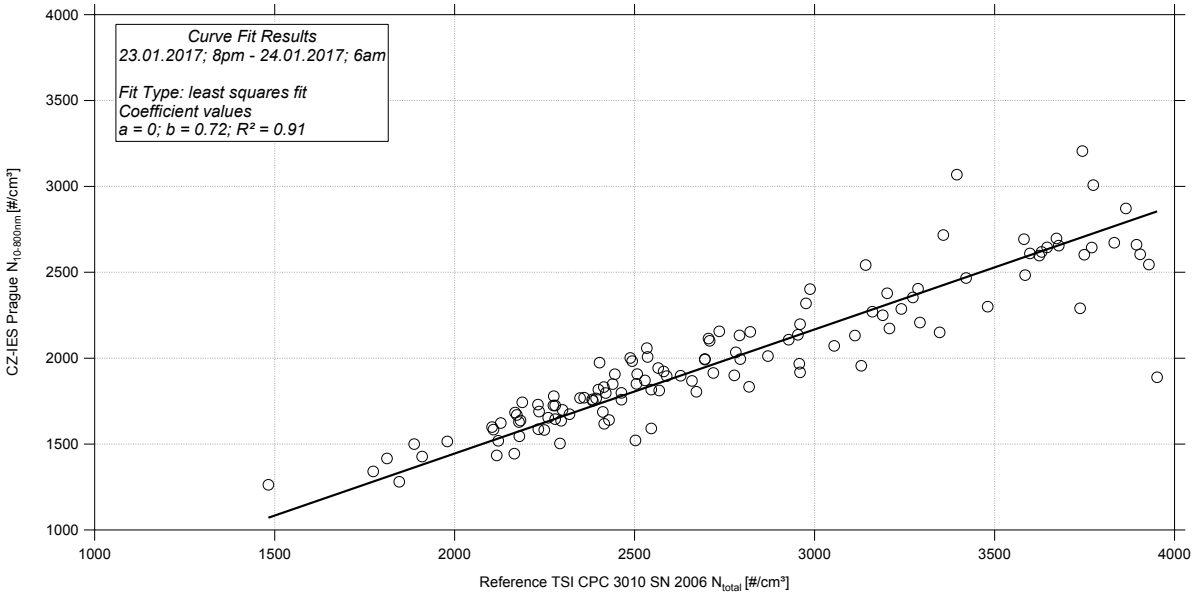


Figure 07: Linear regression between the number concentrations of the TROPOS Reference TSI CPC Model 3010 SN: 2006 and CZ-IES Prague. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

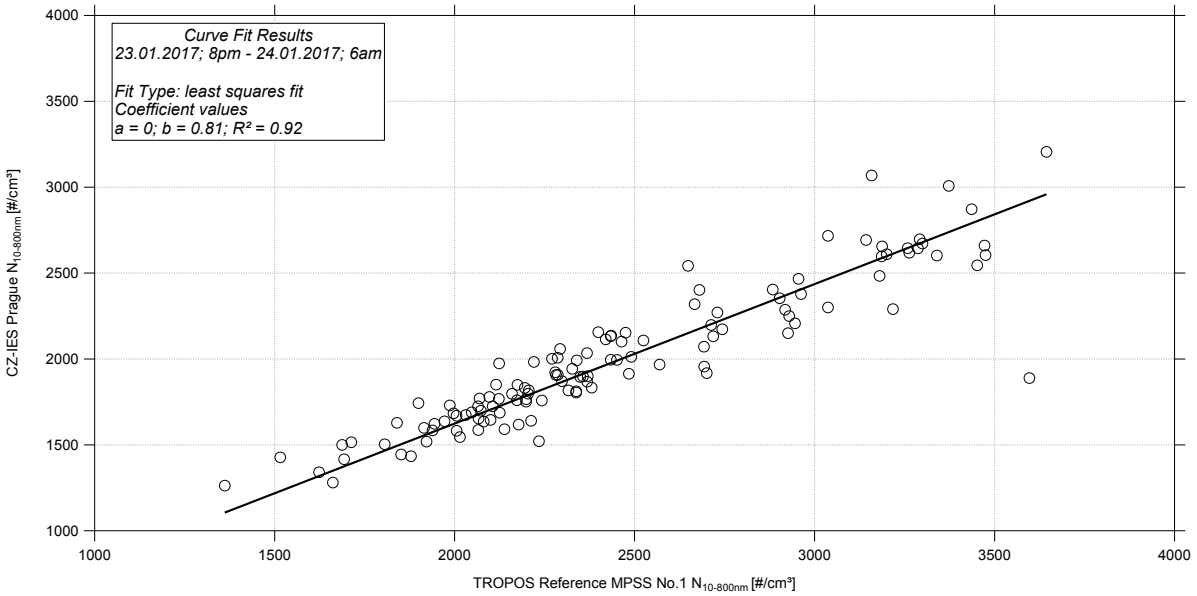


Figure 08: Linear regression between the number concentrations of the TROPOS Reference MPSS No.1 and CZ-IES Prague. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

Final Status of the Candidate: Particle Number Size Distribution

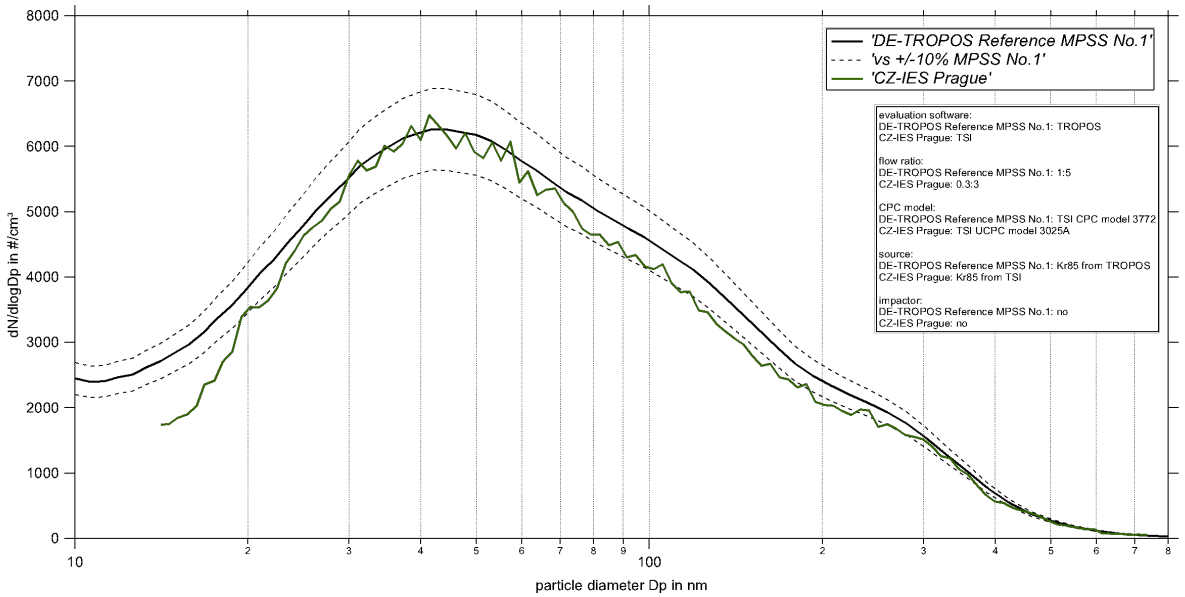


Figure 09: Comparison of mean particle number size distribution of TROPOS Reference MPSS No.1 against CZ-IES Prague from January 26, 2017 08:00 PM until January 27, 2017 06:00 AM. Multiple charge correction, internal diffusion losses and CPC efficiency are included.

Final Status of the Candidate: Time Series

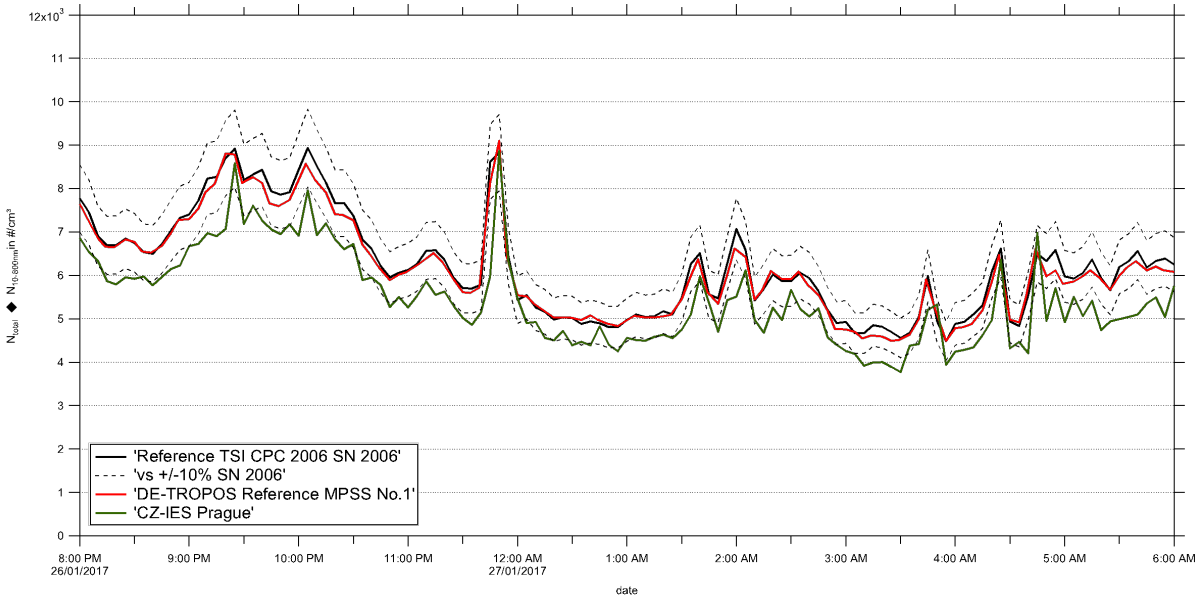


Figure 10: Time series (January 26, 2017 08:00 PM – January 27, 2017 06:00 AM) of the integrated particle number concentration ($N_{10\text{-}800nm}$) of the MPSS and total number concentration (N_{total}) of the reference TSI-CPC Model 3010. The inversion for the candidate was performed using TSI software. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

Final Status of the Candidate: Correlation

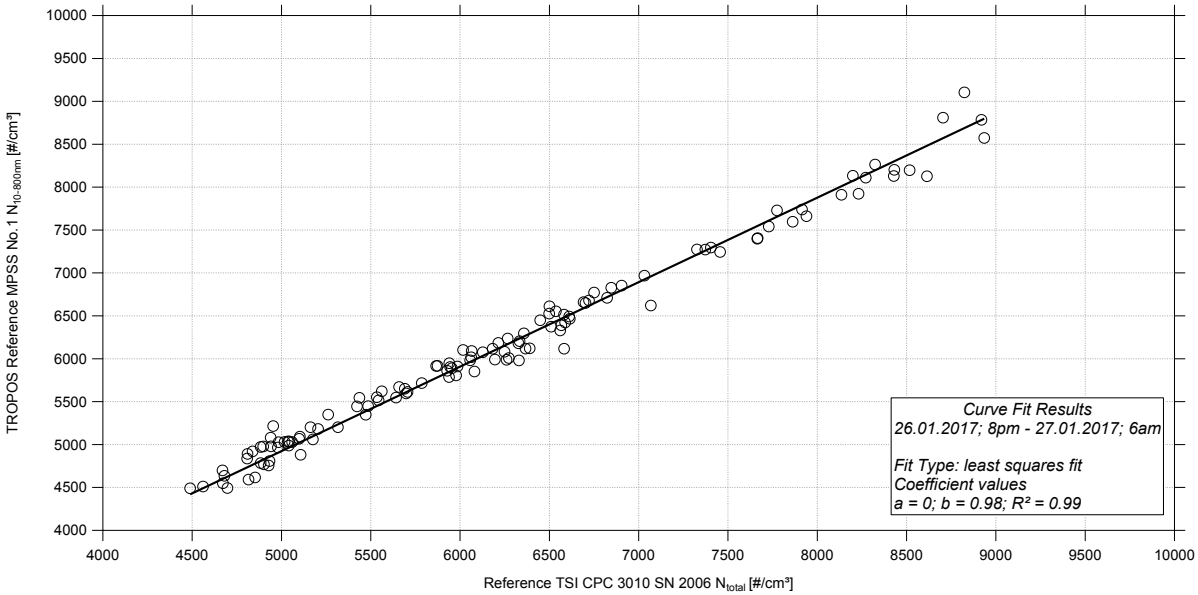


Figure 11: Linear regression between the number concentrations of the TROPOS Reference TSI CPC Model 3010 SN: 2006 and TROPOS Reference MPSS No.1. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

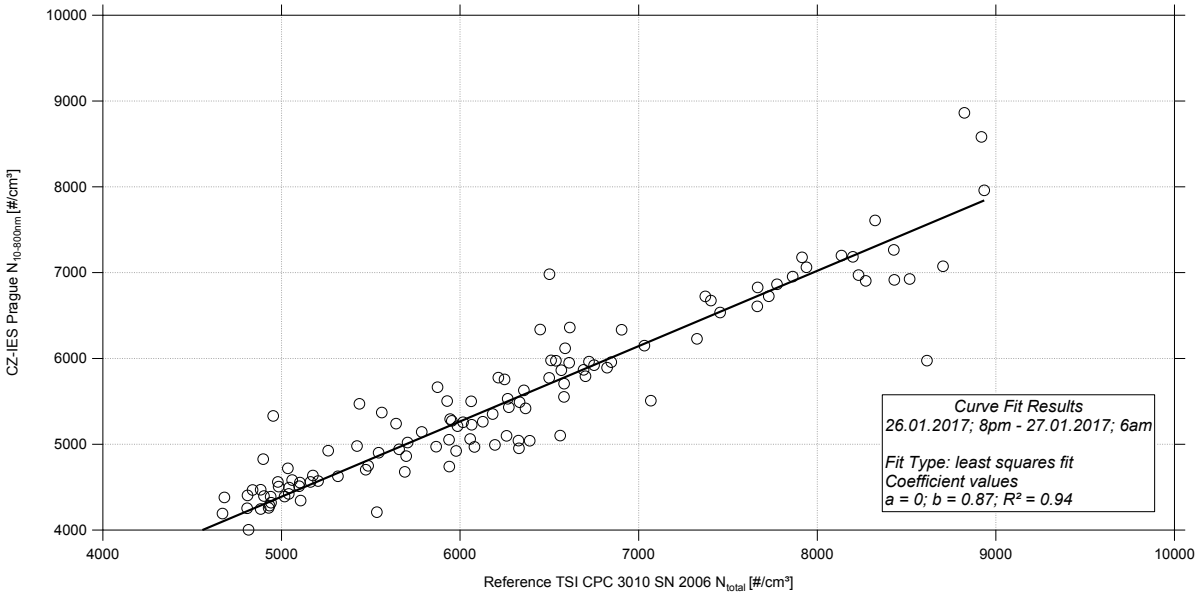


Figure 12: Linear regression between the number concentrations of the TROPOS Reference TSI CPC Model 3010 SN: 2006 and CZ-IES Prague. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

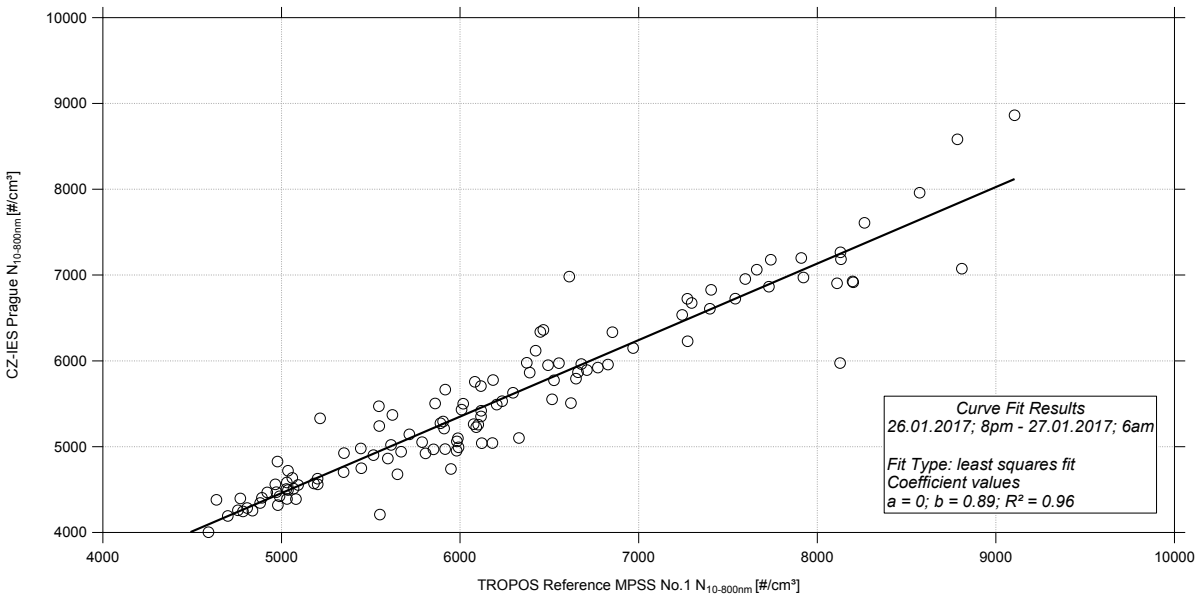


Figure 13: Linear regression between the number concentrations of the TROPOS Reference MPSS No.1 and CZ-IES Prague. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

Post-Check of the Candidate: Particle Number Size Distribution

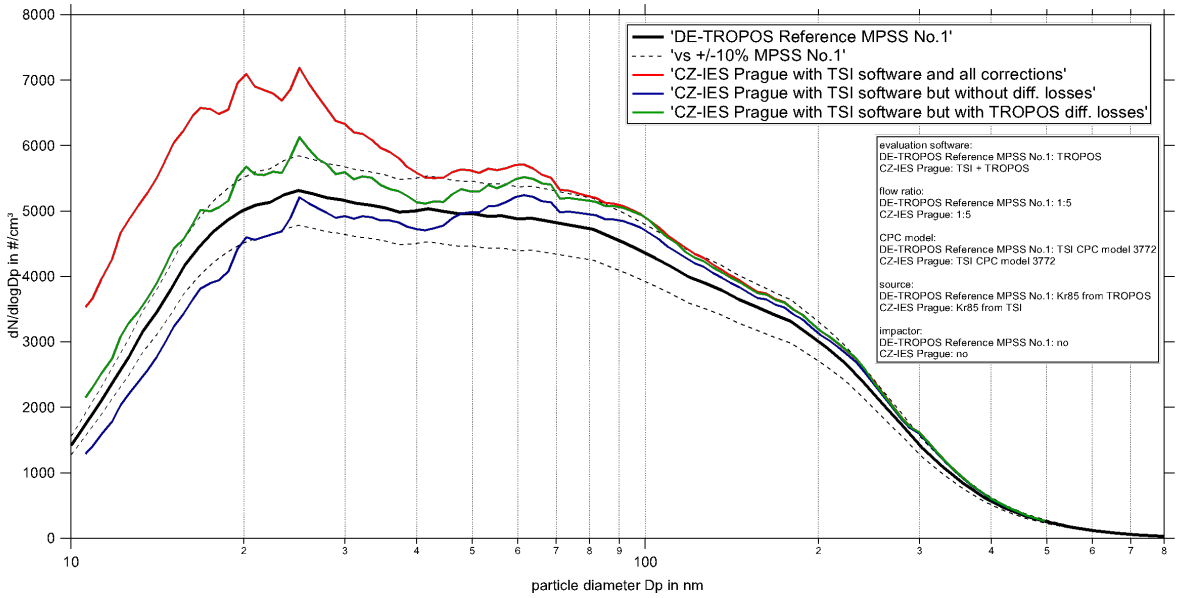


Figure 14: Comparison of mean particle number size distribution of TROPOS Reference MPSS No.1 against CZ-IES Prague from January 26, 2017 09:00 AM until January 26, 2017 02:00 PM. Different colors shows the evaluation steps. The black line shows the TROPOS Reference MPSS No.1 including the TROPOS multiple charge correction, internal diffusion losses and CPC efficiency. The red line shows the candidate CZ-IES Prague evaluated with the TSI software including multiple charge correction, internal diffusion losses and CPC efficiency. The blue and green line shows the candidate CZ-IES Prague evaluated with the TSI software but once without (blue) and with diffusion losses by TROPOS software (green).