



## Intercomparison of Mobility Particle Size Spectrometers

**Project No.: MPSS-2015-1-3**

### **Basic information:**

<b>Location of the quality assurance:</b>	TROPOS, lab: 118
<b>Delivery date:</b>	September 24, 2015
<b>Setup in the laboratory:</b>	October 05, 2015
<b>Comparison period:</b>	October 05, 2015 – October 12, 2015

Principal Investigator	Home Institution	Participant	Instrument
Olga Mayol Bracero	Department of Environmental Science, University of Puerto Rico PO Box 70377 San Juan PR 00936-8377 USA		Puerto Rico TSI-MPSS: model 3080 with LDMA TSI, model 3081 # 70949165 (Dec. 2010) TSI CPC Model 3772 # 71002116 (Jan. 2010)

### **Summary of Intercomparison:**

**Pre-status:**

**The Puerto Rico TSI-MPSS passed the quality standards of ACTRIS and GAW.**

**Final status:**

**The Puerto Rico TSI-MPSS passed the quality standards of ACTRIS and GAW.**

From October 05, 2015 to October 12, 2015, the Puerto Rico TSI-MPSS participated the TROPOS ACTRIS Workshop. The workshop consisted of an entrance test and a final run. In addition to the overnight ambient measurements, we had numerous high voltage checks, zero- and PSL- measurements. The report is divided into three sections. The first section shows the laboratory setup and the PSL measurement. After that, we show for each run the time series of the particle number concentration, correlation plots to the reference total particle counter, and the particle number size distribution. As reference standards, we used CPCs model TSI 3772 for total particle number concentration and two TROPOS mobility particle size spectrometer. The particle counters have been calibrated against a calibrated TSI electrometer 3068 B with the serial number 70838596.

For the PSL-calibrations, we used Latex particles with a nominal size of 203 nm +/- 4 nm. The latex particles have been generated with an aerosol nebulizer. The sheath air flow rate of the candidate system was checked. The Puerto Rico TSI-MPSS showed in the PSL-measurements a particle diameter of 207.0 nm. The zero check passed the requirements in the final run, it means the integral between 10-800 nm is less than 5 #/cm<sup>3</sup>. When we look at the time series and particle number size distributions the system showed systematically a lower total particle number concentration than the Reference Instrument. The TROPOS inversion and diffusion correction could not solve the problem. In the final run the Puerto Rico TSI-MPSS was 13% lower than the reference CPC 3010.

A TSI 3080 classifier (Serial: 70949165, Date: Dec 2009) with a long DMA (TSI 3081) and a TSI 3772 CPC (Serial: 71002116, Date: Jan 2010) have been send to TROPOS under flowing conditions:

- shipped without source → during the workshop we used a TROPOS Kr85 source
- shipped without laptop → we used a TROPOS PC to run the TSI 3080 with a TSI software version 9.0
- the impactor was removed from the classifier
- DMA is checked and cleaned → there are no damages

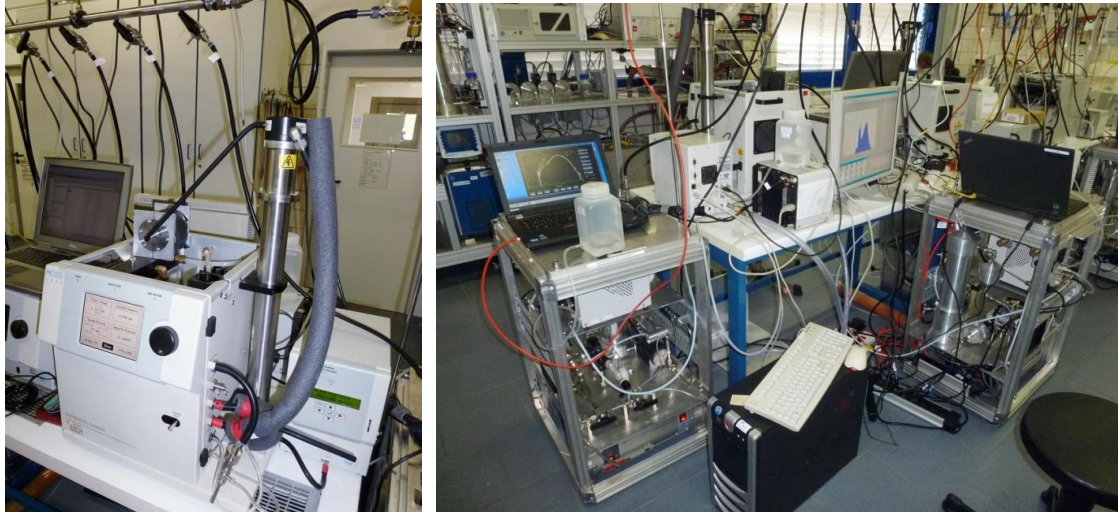


**Figure 01:** Puerto Rico DMA before cleaning.

- CPC Model 3772 is checked and cleaned before the CPC workshop
- CPC-Workshop: The CPC 3772 reached at 30 nm the 100% efficiency. The Dp50 is at 7.5 nm. The CPC efficiency curve corresponds to the standard.
- One of two blower inside the TSI 3080 classifier is broken → we changed the sheath air configurations only to one blower. It's working successful by 5 l/min sheath air. Important: the settings for operating the classifier should be "single mode" for blower.

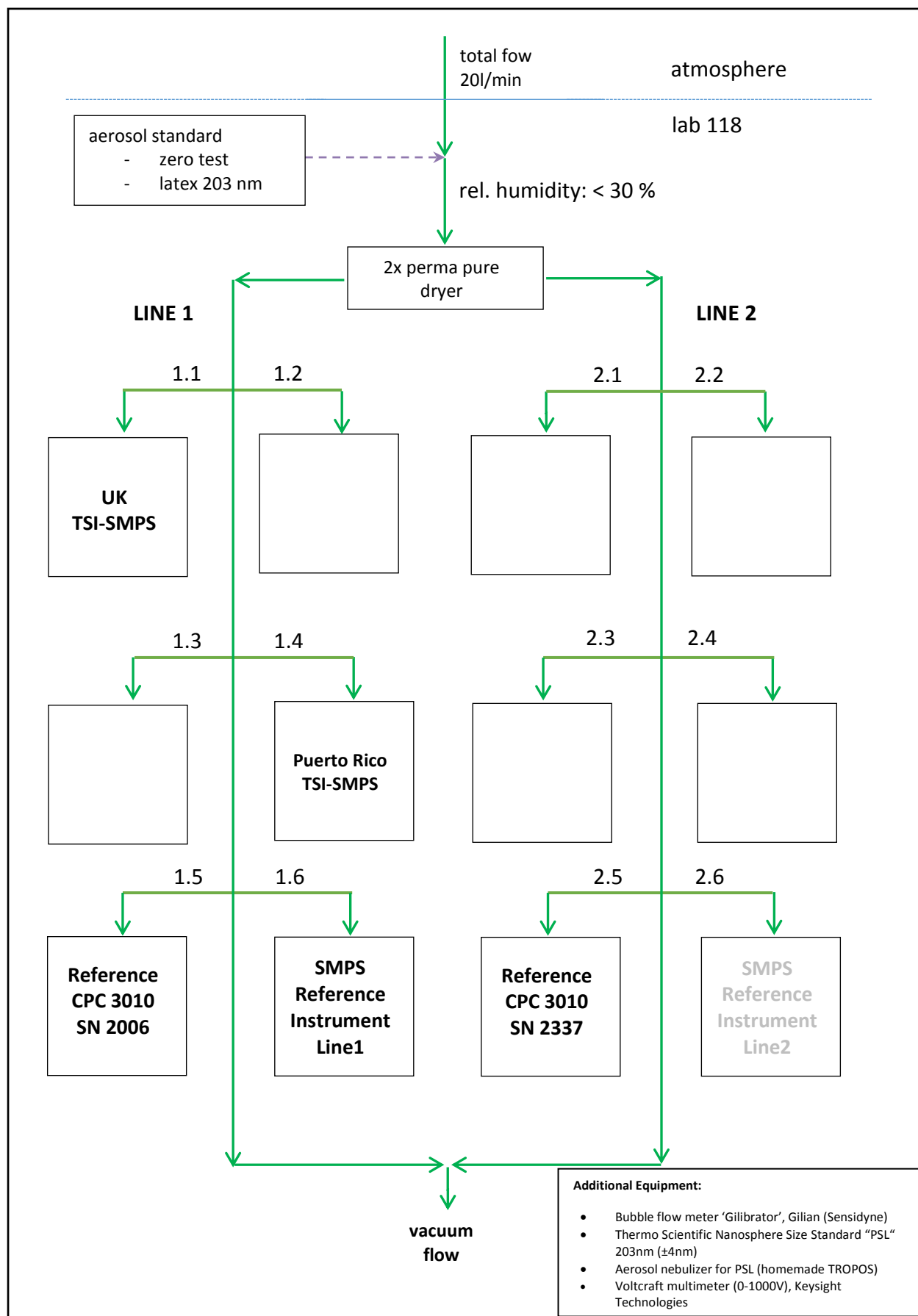
## List of Components

	Specification	Reference System Line1	Puerto Rico TSI-SMPS
Position (Line)		1.6	1
Company		TROPOS	TSI 3080
Software		TROPOS 5.5	Aerosol Instruments 9.0
CPC		Model 3772	Model 3772
Flow ratio		1.0 : 5.0	1.0 : 5.0
Source		Kr85	Kr85 (TROPOS)
HV cassette		positive	negative
DMA		Hauke medium	TSI 3081
Flow meas.	Aerosol	✓	✓
Dryer		✓	X
RH sensor	Inlet	✓	X
T sensor		✓	X
RH sensor	Sheath air	✓	X
T sensor		✓	X
Dryer		✓	X
p sensor		✓	X

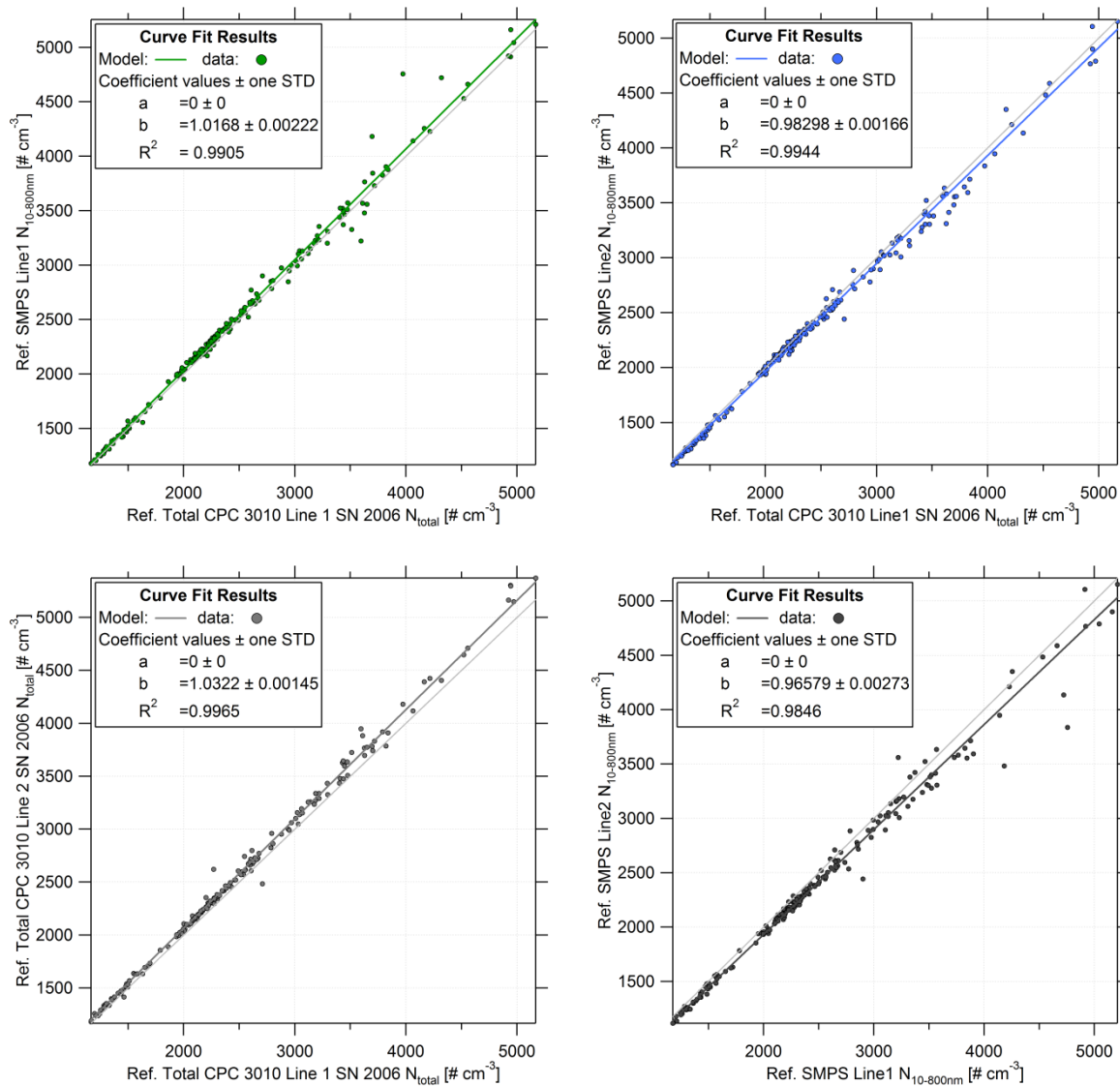


**Figure 02:** Setup of the Puerto Rico TSI-SMPS in the TROPOS lab 118.

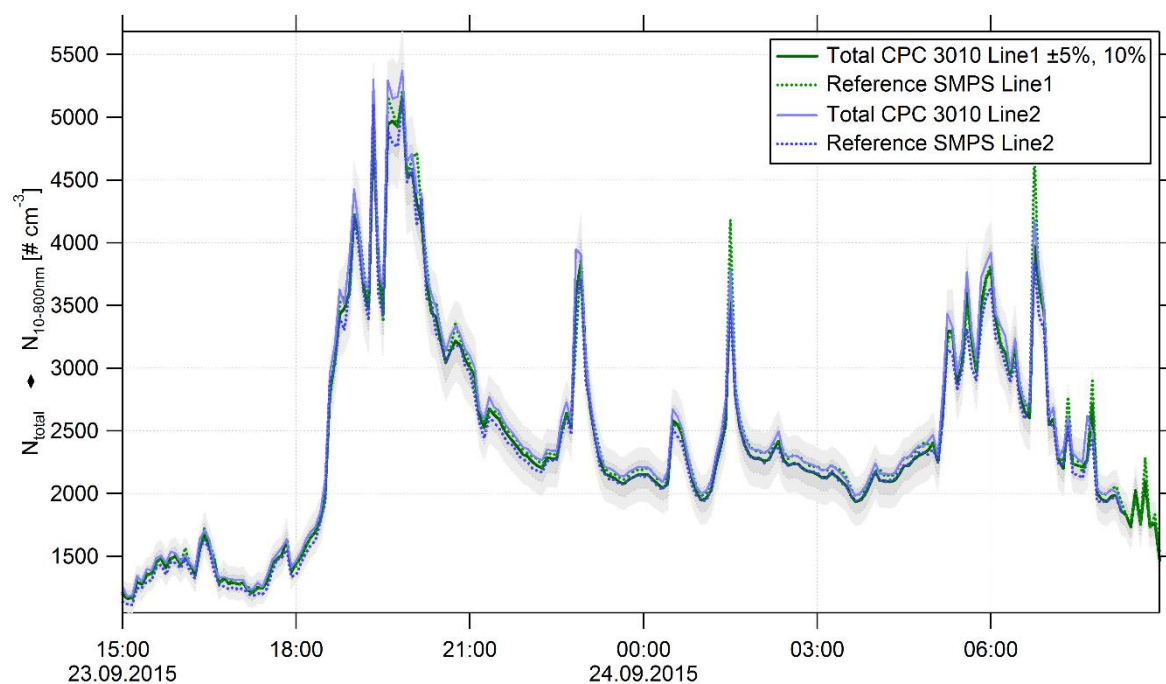
## Laboratory setup



## Pre-Workshop-Status of Reference Instruments in TROPOS



**Figure 03:** Correlations of the TROPOS Reference SMPS systems and TSI Total CPCs Model 3010 of both lines (see laboratory setup). Multiple charge, internal diffusion loss and CPC flow corrections are included.

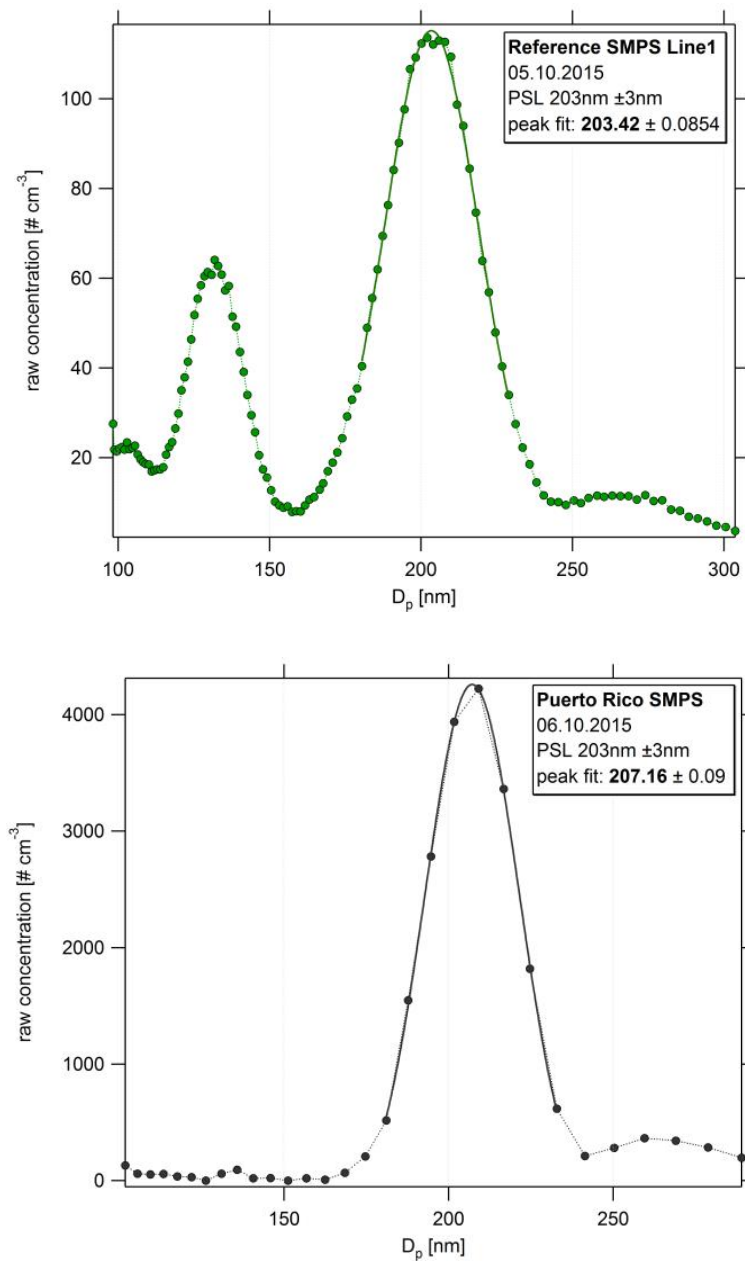


**Figure 04:** Intercomparison between the two Lines. For each Line there is a TROPOS Reference SMPS and a TSI Total-CPC Model 3010, which are calibrated against an electrometer. Multiple charge, internal diffusion loss and CPC flow corrections are included.

### Pre-Workshop-Status of the Candidate (05.10.2015 – 06.10.2015)

Institut	System	Components	CPC Model + Serial No.	Line	Flow		Zero	
TROPOS	Ref1	SMPS	3772 SN 71011009	1.6	<b>1.040</b>	l/min	0	# cm <sup>-3</sup>
TROPOS		Total CPC	3010 SN 2006	1.5	<b>1.035</b>	l/min	0	# cm <sup>-3</sup>
TROPOS		Total CPC	3010 SN 2337	2.5	<b>1.022</b>	l/min	0	# cm <sup>-3</sup>
	Puerto Rico	TSI SMPS	3772 SN 71002116	-	<b>0.554</b>	l/min	-	# cm <sup>-3</sup>

## Latex 203 nm



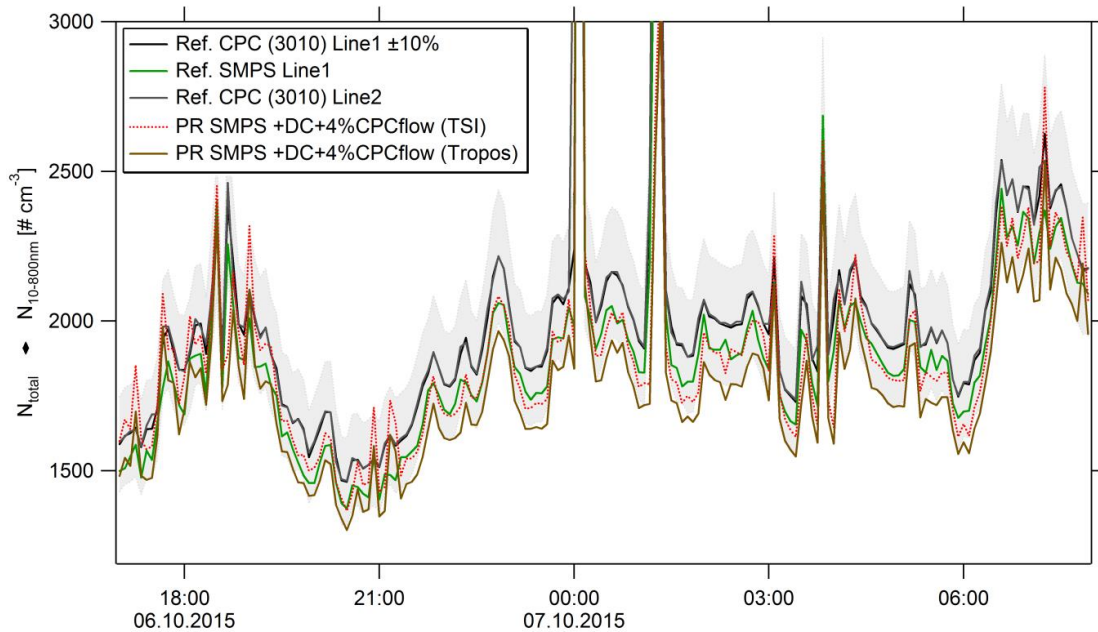
**Figure 05:** Measurement of latex 203 nm: Particle size distribution (raw concentration) for latex 203 nm on October 05, 2015.

### **Settings for Puerto Rico system:**

- ✓ 240sec scan, 15 sec cleaning DMA, every 5min,
- ✓ no impactor
- ✓ Kr85 source from TROPOS (TSI)  $\rightarrow$  DMA  $\rightarrow$  CPC
- ✓ 1:5 flow rate

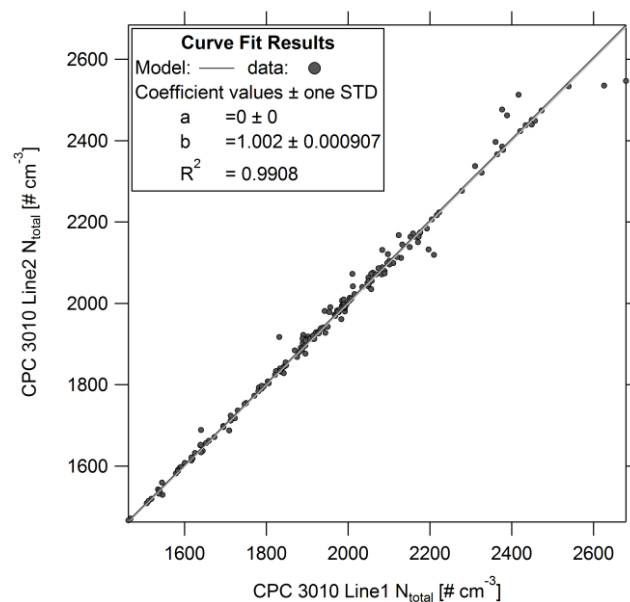


## Time series



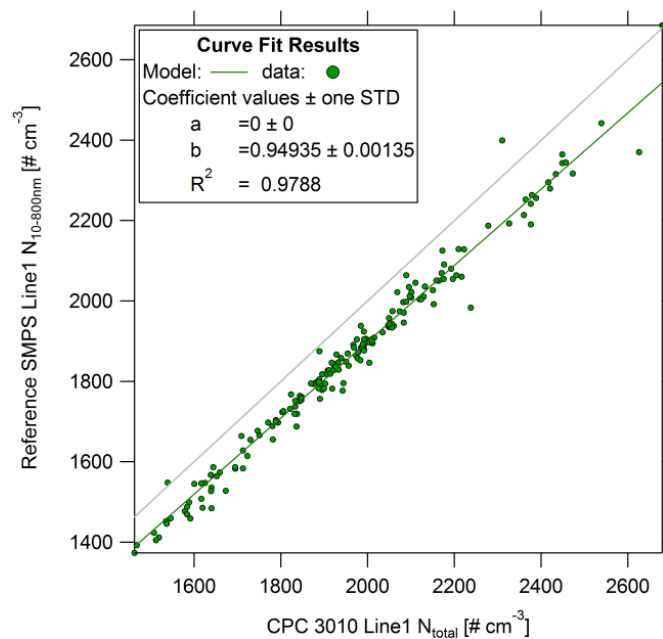
**Figure 06:** Time series (October 06, 2015 17:00 pm – October 07, 2015 08:00 am) of the integrated particle number concentration ( $N_{10-800nm}$ ) of the SMPS and total number concentration ( $N_{total}$ ) of the CPCs. Multiple charge correction, internal diffusion losses (DC) and CPC flow corrections are included.

## Correlation between the reference CPCs



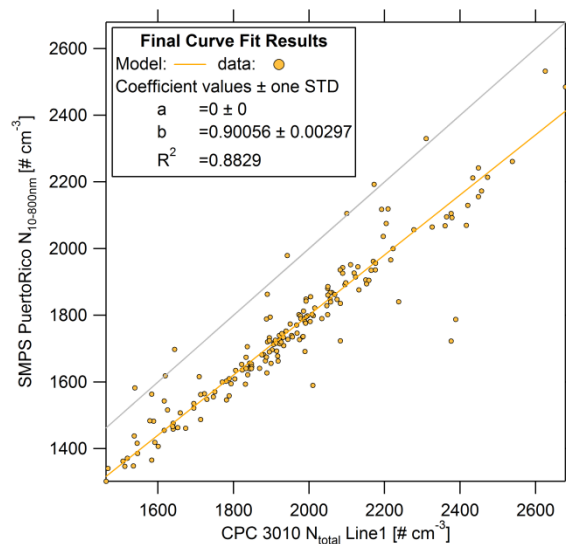
**Figure 07:** Comparison between two TROPOS total Reference CPCs Model 3010 from October 06, 2015 17:00 pm until October 07, 2015 08:00 am.

### Correlation between the reference CPC and TROPOS Reference Instrument Line 1



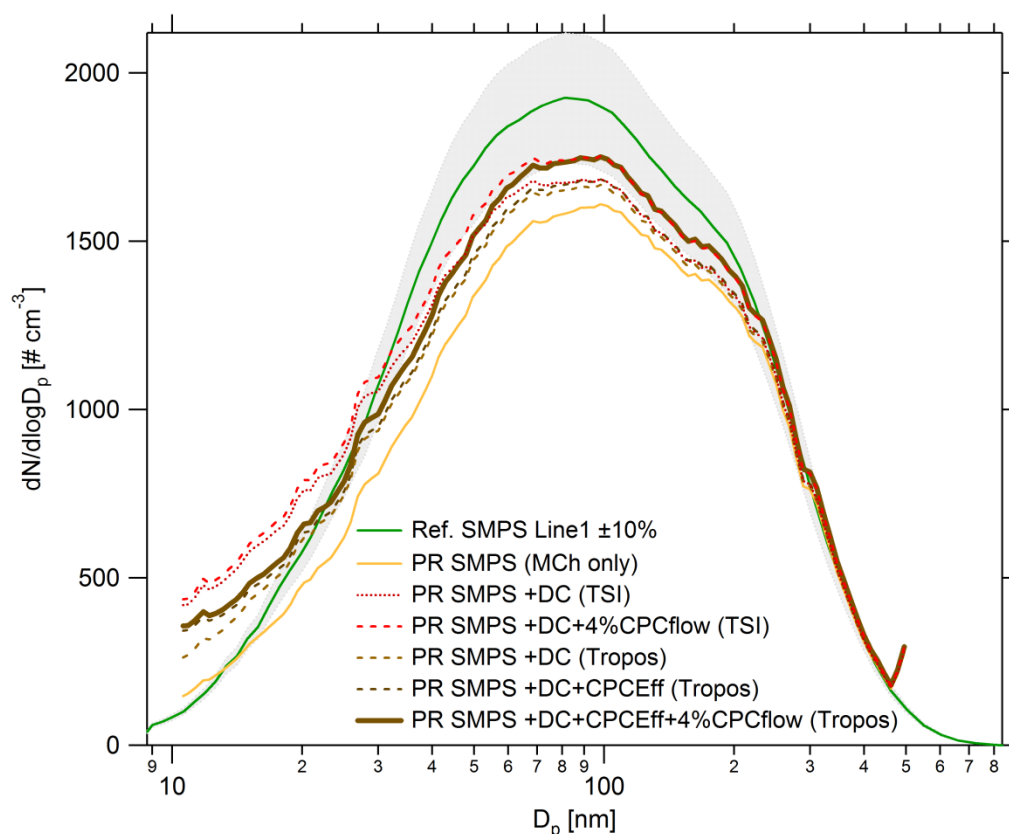
**Figure 08:** Linear regression between the number concentrations of the TROPOS reference instrument line 1 and TROPOS reference CPC in line 1. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

### Correlation between the reference CPC and Puerto Rico TSI-SMPS



**Figure 09:** Linear regression between the number concentrations of the Puerto Rico TSI-SMPS and TROPOS reference CPC in line 1. The inversion was performed using TROPOS software. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

## Particle Number Size Distribution

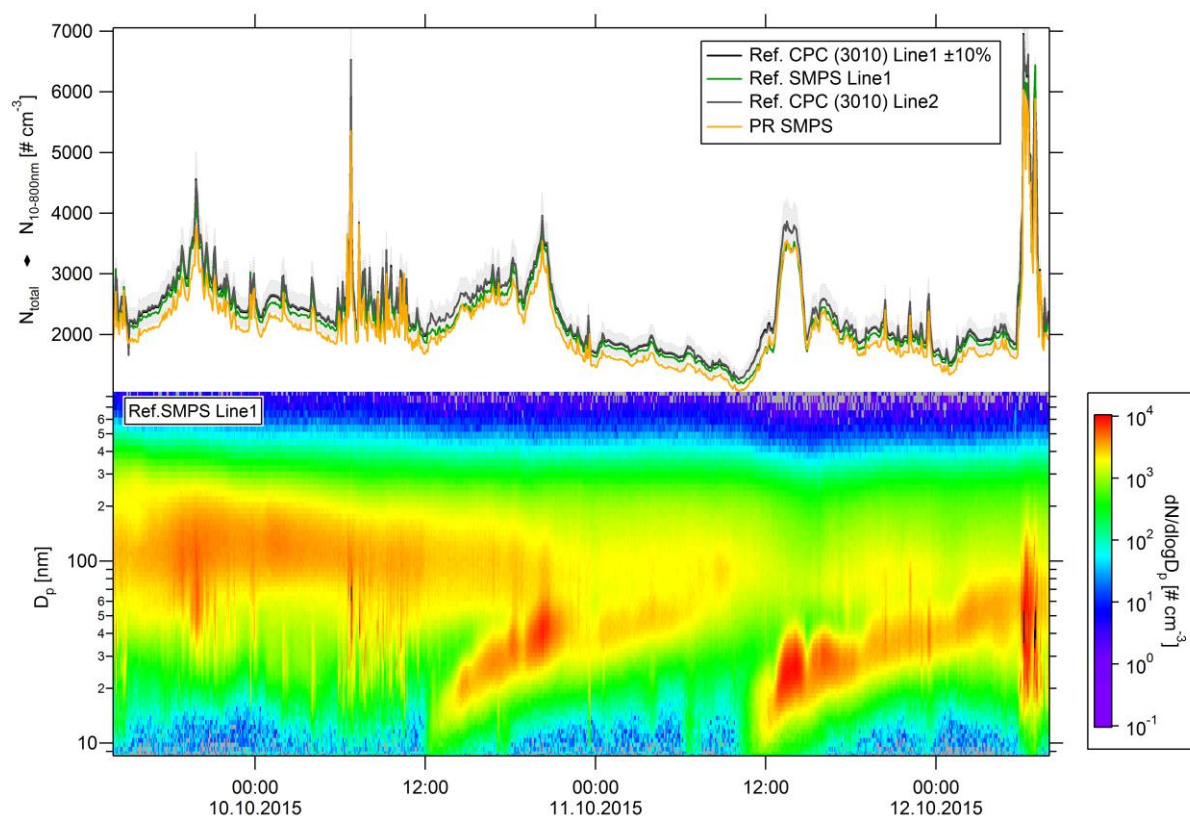


**Figure 10:** Comparison of mean particle number size distribution of Puerto Rico TSI-SMPS and TROPOS reference instrument line 1 from October 06, 2015 17:00 pm until October 07, 2015 08:00 am. The inversion was performed using TSI and TROPOS software, respectively. Multiple charge correction (MCh), internal diffusion losses (DC), CPC flow corrections and CPC efficiency are in steps included.

## Final Status of the Candidate (10.10.2015 – 12.10.2015)

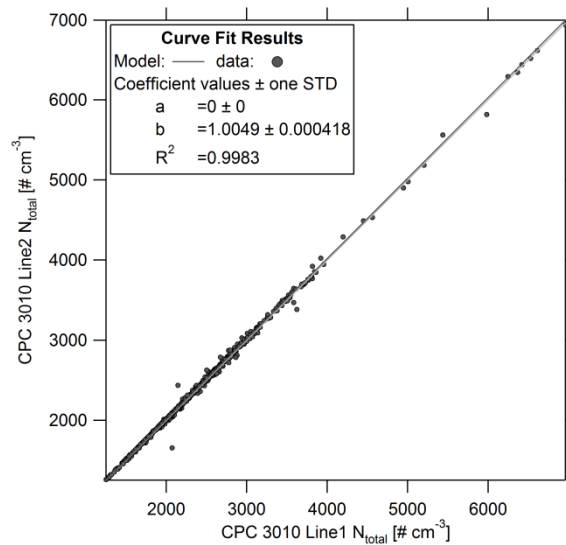
Institut	System	Components	CPC Model + Serial No.	Line	Flow		Zero	
TROPOS	Ref1	SMPS	3772 SN 71011009	1.6	<b>1.044</b>	l/min	0	# cm <sup>-3</sup>
TROPOS		Total CPC	3010 SN 2006	1.5	<b>1.043</b>	l/min	0	# cm <sup>-3</sup>
TROPOS		Total CPC	3010 SN 2337	2.5	<b>1.024</b>	l/min	0	# cm <sup>-3</sup>
	Puerto Rico	TSI SMPS	3772 SN 71002116	1.4	<b>0.964</b>	l/min	0	# cm <sup>-3</sup>

## Time Series



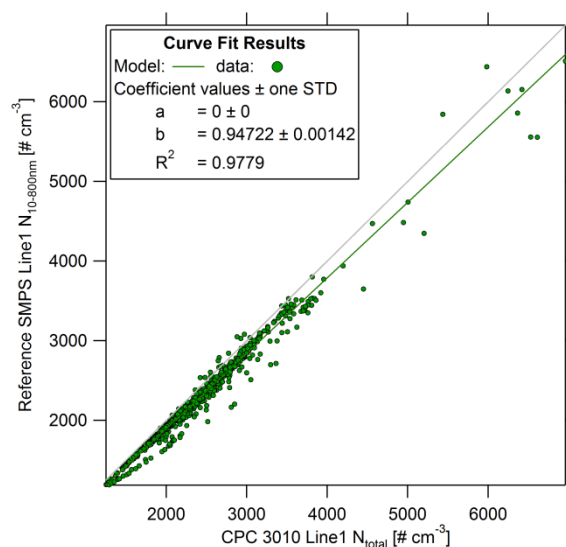
**Figure 11:** Time series (October 10, 2015 14:00 pm – October 12, 2015 08:00 am) of the integrated particle number concentration ( $N_{10-800\text{nm}}$ ) of the SMPS and total number concentration ( $N_{\text{total}}$ ) of the CPCs. The inversion was performed using TROPOS software. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

### Correlation between the total CPCs Model 3010



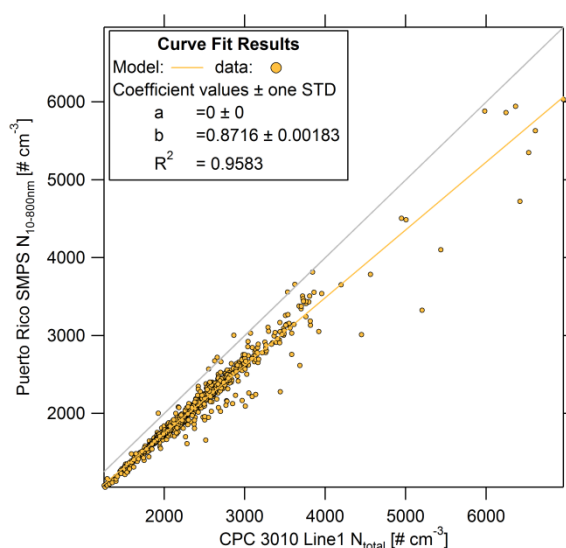
**Figure 12:** Comparison between two TROPOS total Reference CPCs Model 3010 from October 09, 2015 14:00 pm until October 12, 2015 08:00 am.

### Correlation between the total CPCs Model 3010 and TROPOS Reference Instrument Line 1



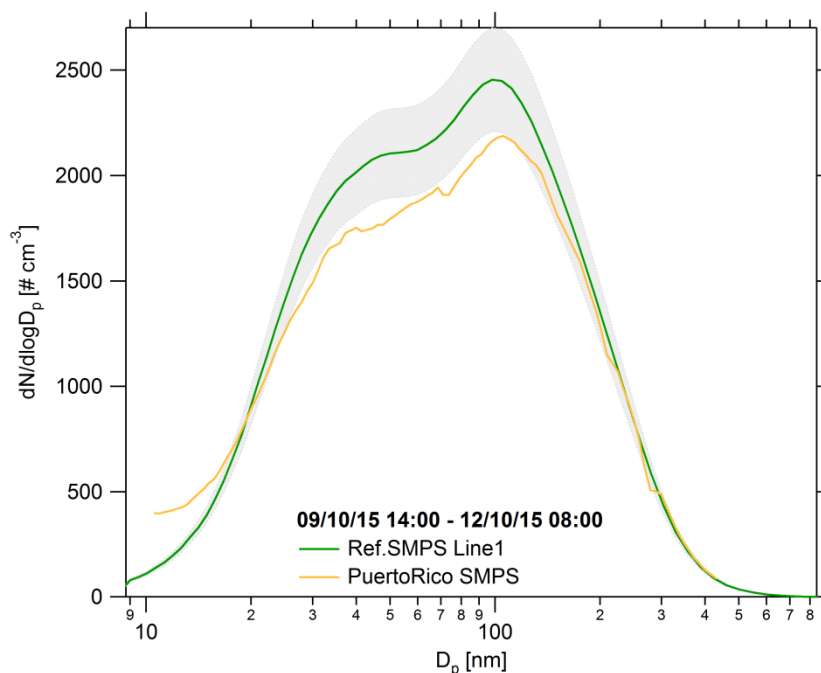
**Figure 13:** Linear regression between the number concentrations of the TROPOS reference instrument line 1 and TROPOS reference CPC in line 1. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

## Correlation between the reference CPC and Puerto Rico TSI-SMPS



**Figure 14:** Linear regression between the number concentrations of the Puerto Rico TSI-SMPS and TROPOS reference CPCs in each line. The inversion was performed using TROPOS software. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

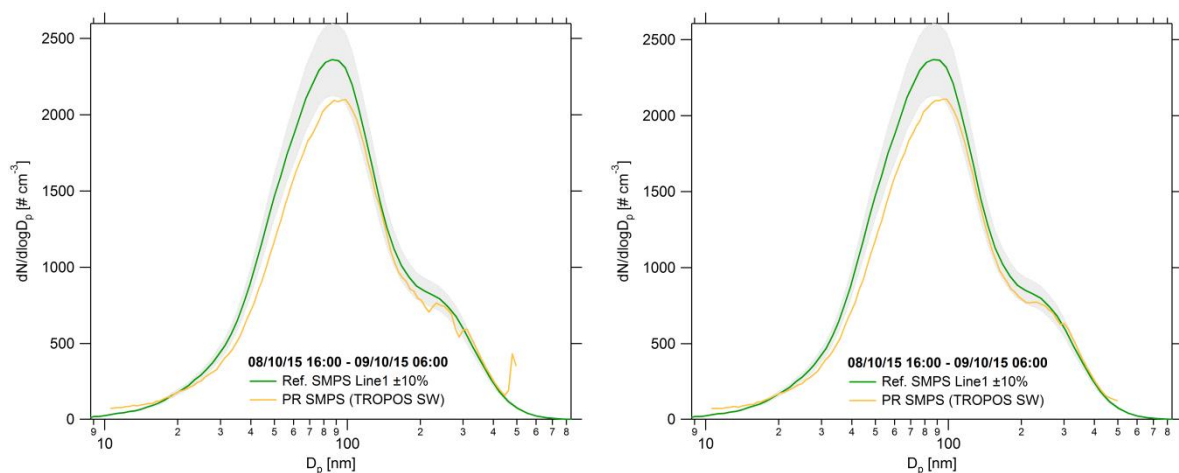
## Particle Number Size Distribution



**Figure 15:** Comparison of mean particle number size distribution of Puerto Rico TSI-SMPS and TROPOS reference instrument Line 1 from October 10, 2015 14:00 pm until October 12, 2015 08:00 am. The inversion was performed using TROPOS software. Multiple charge correction, internal diffusion losses and CPC efficiency are included.

## Scanning artefacts in Puerto Rico SMPS

A problem occurring every run was the occasional presence of peaks at the upper end of the size distribution from the Puerto Rico SMPS. These artefacts are varying in intensity. Skipping the last channel of 495.8 nm in the final run only shifted the peak into the other channels. Removing the scans with the most significant artefacts in the time series of both TROPOS and Puerto Rico system resulted in following plots.



**Figure 16:** Comparison of the PNSD of Reference instrument at line1 and the Puerto Rico TSI SMPS. Left side: original data, right side: scans with artefact peaks removed in both data sets.