Audit report for the GAW station Barrow, Alaska, USA

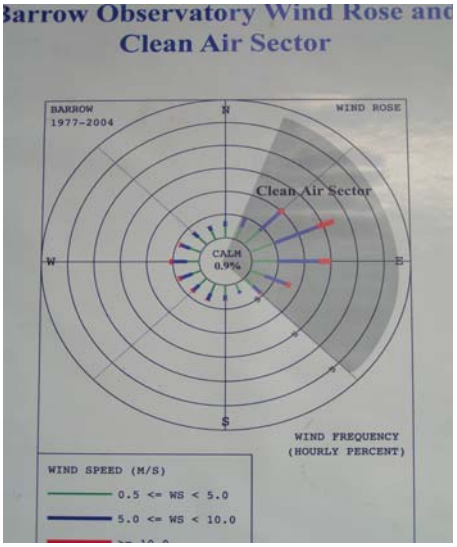
Prof. Dr. Alfred Wiedensohler (Head of the WCCAP)
Dr. Thomas Tuch
World Calibration Centre for Aerosol Physics (WCCAP), Leibniz Institute for Tropospheric Research, Leipzig, Germany

Summary:
From September 16 to 20 2007 Prof. Dr. Alfred Wiedensohler and Dr. Thomas Tuch of the WCCAP performed a site audit of the instrumentation for physical aerosol characterization at the global GAW station Point Barrow (BRW), Alaska, USA. This station is located at the north slope of Alaska at 71.32° north, 156.6° west about 3 km from the Arctic ocean. It is manned year around by 2 engineers/scientists.

Fig. 1: Outer view of GAW station Barrow, Alaska

Prevailing winds at the site originate from the northeast. Because of possible local pollution a large sector of wind directions is not used for data analysis (Figure 2).

Fig.2



Almost all parameters recommended by WMO/GAW aerosol measurement procedures are measured at BRW (Table 1).

	Instrument	Status	Remarks
Continuous Measurement			
Multi-wavelength optical depth	Cimel		Operated by collocated ARM facility
Mass in two size fractions	NOAA		Submicrometer only
Major chemical components in two size fractions	NOAA		Submicron only
Light absorption coefficient	PSAP		
Light scattering coefficient at various wavelengths	TSI 3563		2 Nephelometers dry/wet dry
Hemispheric backscattering coefficient at various wavelengths	TSI 3563		
Aerosol number concentration	TSI 3010		
Intermittent Measurement			
Aerosol size distribution contiunous at 5' time resolution	IFT SMPS		Installed during audit
Detailed size fractionated chemical composition	n/a		Only submicrometer particles, major ions
Dependence on relative humidity Wet and dry Neph	TSI 3563		
CCN spectra (various supersaturations)	DMT		At variable supersaturations .15 to 1.25
Vertical distribution of aerosol properties	MPL		Operated by collocated ARM facility

Fully operational

Available, needs modification, data questionable

Not available

Table 1: Measurements and status of the instruments at BRW

An SMPS operated in cooperation of NOAA and IFT has been installed during this audit. We were pleased to find the station in an excellent condition.

Documentation and manuals:

Documentation of all routine and extra maintenance of the system is completely available at the station. Detailed checklists have been filed in the past.

In addition to these checklists all activities are stored in an online log. All data are automatically sent to NOAA/CMDL and checked on a daily basis. Data from Barrow are routinely submitted to the world data centre.

Manuals for all instruments are available at the site.

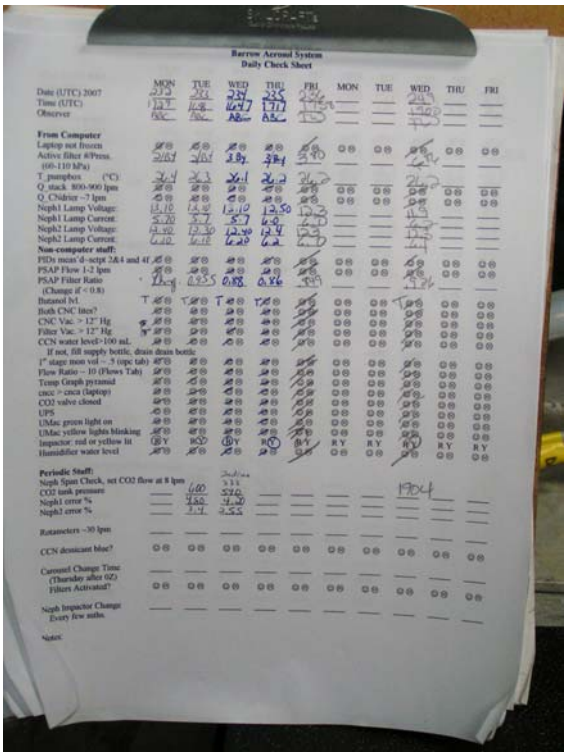


Fig.3: Daily checklist Barrow

<u>Documentation and data handling are in good condition</u>

Inlet:

The station uses a NOAA type turbulent aerosol inlet attached to the measurement tower. Samples are taken from 10 meters above the ground and are transported to the heated aerosol distribution by 20 cm ID PVC tubing at a flow rate of approximately 900 l/min (Fig.4).

Fig.4: Aerosol inlet system at Barrow

A separate ¼" stainless steel tube is used as sampling line for the CPC. At the bottom of the inlet stack air is sampled from the centre of the stack using a stainless steel tube with an ID of 5 cm at an air flow of 150 l/min (non isokinetic). A filter can be attached to this tube for leak checks of the entire aerosol lines and instruments. The air is distributed through 5 ¾" stainless steel tubes at 30 l/min to the measurement instrumentation inside. All aerosol lines are made of stainless steel or conductive silicon tubing. Temperature and relative humidity of the aerosol are monitored continuously.

Calculations for aerosol particle penetration through this inlet have been provided by NOAA/CMDL (Fig.5).

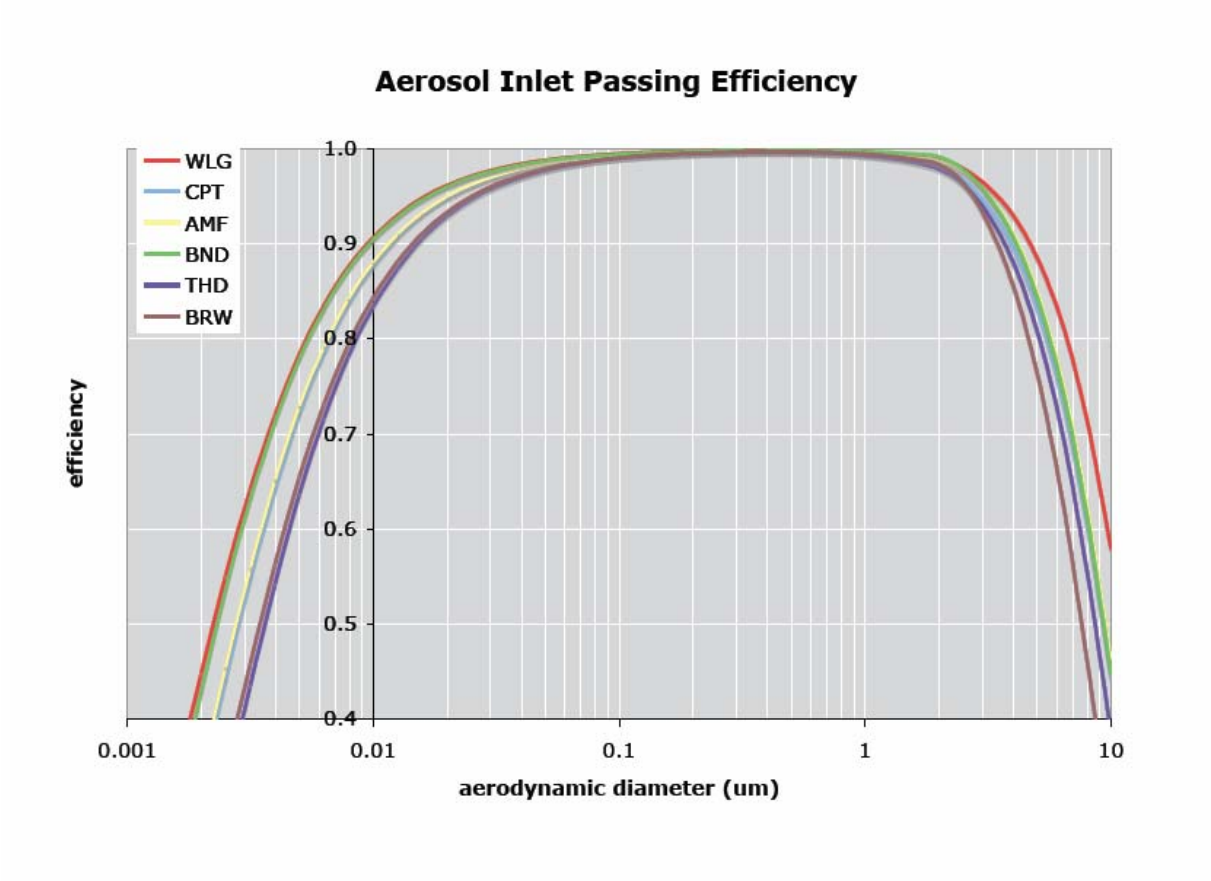


Fig.5: Calculated inlet efficiency of the aerosol sampling inlet at Barrow (aerocalc)

Two Berner type impactors with cut-off diameters of 1 µm and 10 µm are located in the measurement rack. The aerosol path is automatically switched every six minutes to provide alternating measurements for both size fractions. Flow rates of the impactors are controlled by a mass flow controller.

Instrumentation:

Primary flow standard: A primary flow standard has not been available at BRW in the past. A dry flow meter (type Bios International DryCal SN 1458) has been brought to the site recently. This instrument agrees with the reference Gilibrator of the WCCAP within 1 %. (Fig. 6)

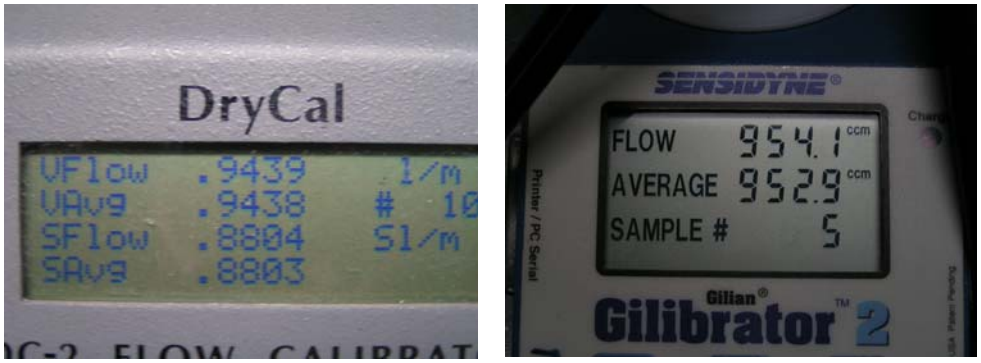


Fig.6: Check of the primary flow standard

This instrument is well suitable as a flow reference for most of the aerosol instrumentation. The pressure drop of this instrument is, however, to high for the calibration of the aerosol flow sensor of the SMPS. We recommend therefore replacement of the dry flow meter by a low pressure drop reference (e.g. Gilibrator).

The primary flow calibrator is in good condition, but is not suitable to calibrate SMPS flows

Absorption Coefficients: A three wavelength PSAP S/N 22 is available at the site. Computer indicated flow was in good agreement with the flow rate measured by the Gilibrator

SLPM dry calib : 1.729 sl/min
Flow indicated PC : 1.71 sl/min
Flow indicated PSAP : 1.609 l/min
Gilibrator : 1.700 l/min

A time series plot of the absorption coefficients during the audit is shown in fig. 7.

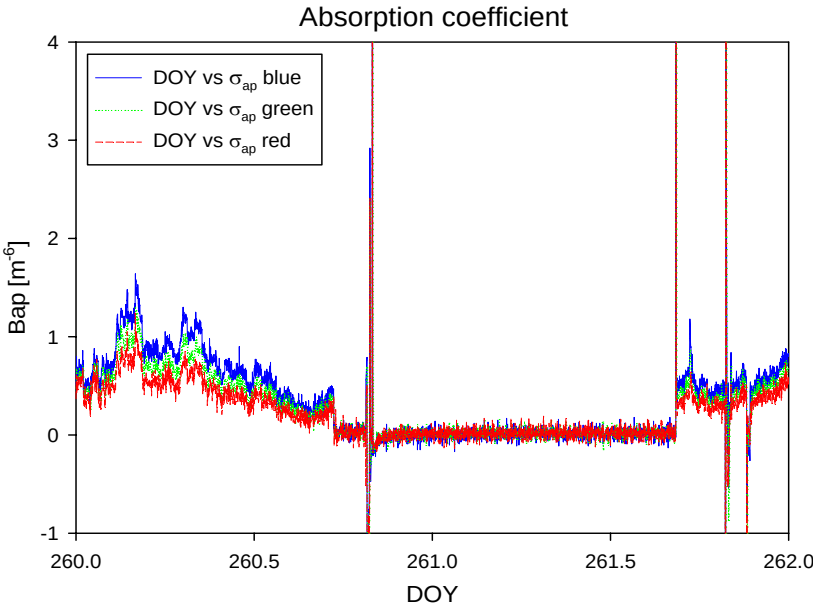


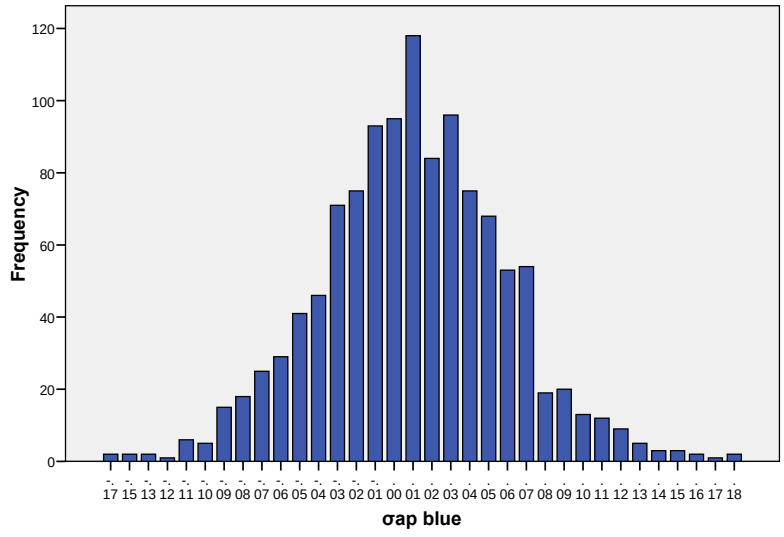
Fig. 7: Absorption coefficients during the audit of BRW (1minute data)

We used a high efficiency filter at the inlet to check instrument zero for a time period of 20 hours. Statistical parameters of one minute data are summarized in table 2.

		σ_{ap} blue	σ_{ap} green	σ_{ap} red
N	Valid	1165	1165	1165
	Missing	0	0	0
Mean		.0106	.0167	.0184
Median		.0100	.0200	.0200
Std. Deviation		.04900	.04455	.05091

Table 2: Basic statistical parameter of the PSAP zero measurement

Figure 8 shows the frequency distribution of 1 minute absorption coefficients for all three wavelengths during the zero filter measurements.



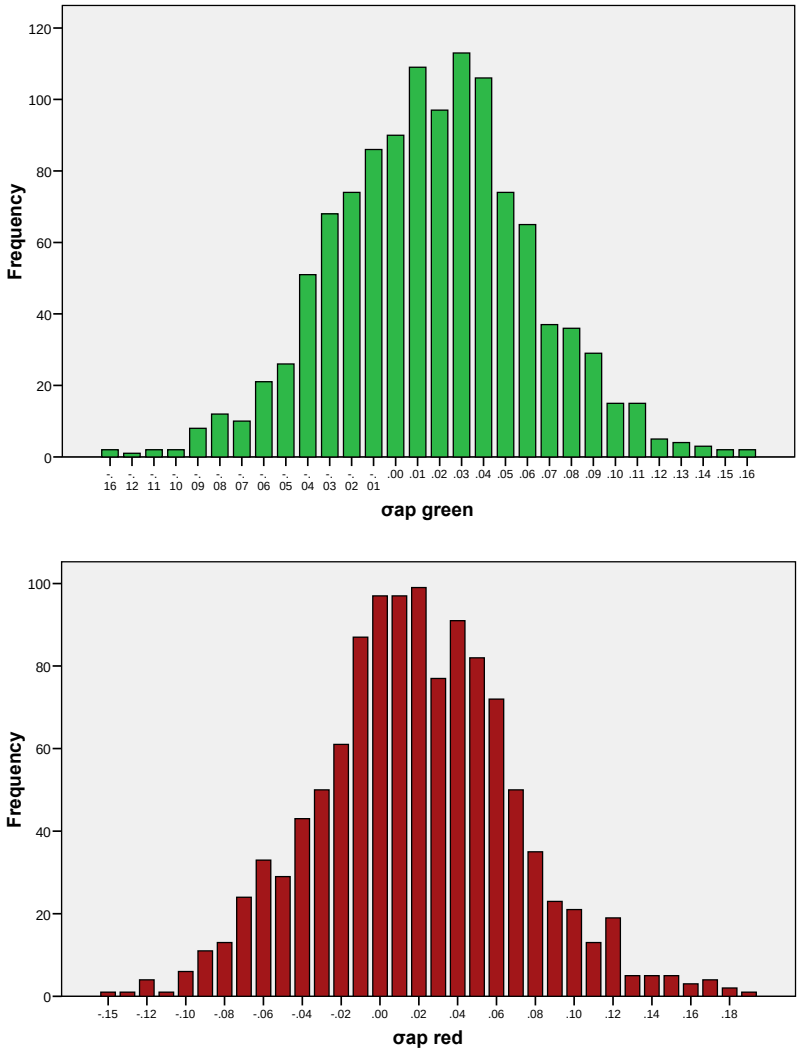


Fig.8: Frequency distribution of zero measurements of the PSAP at Barrow

<u>The PSAP at Barrow is in good condition.</u>

Scattering coefficients:

Two 3-wavelength TSI Nephelometers are used to measure scatter and backscatter coefficients at BRW. The first Nephelometer S/N 1012 measures dry aerosol. The aerosol from the first Nephelometer is passed through a humidifier into the second instrument (S/N 1087) at a flow rate of 30 l/min. The humidity of the second Nephelometer is cycled between 30% and 80% rH every hour (Fig. 9).

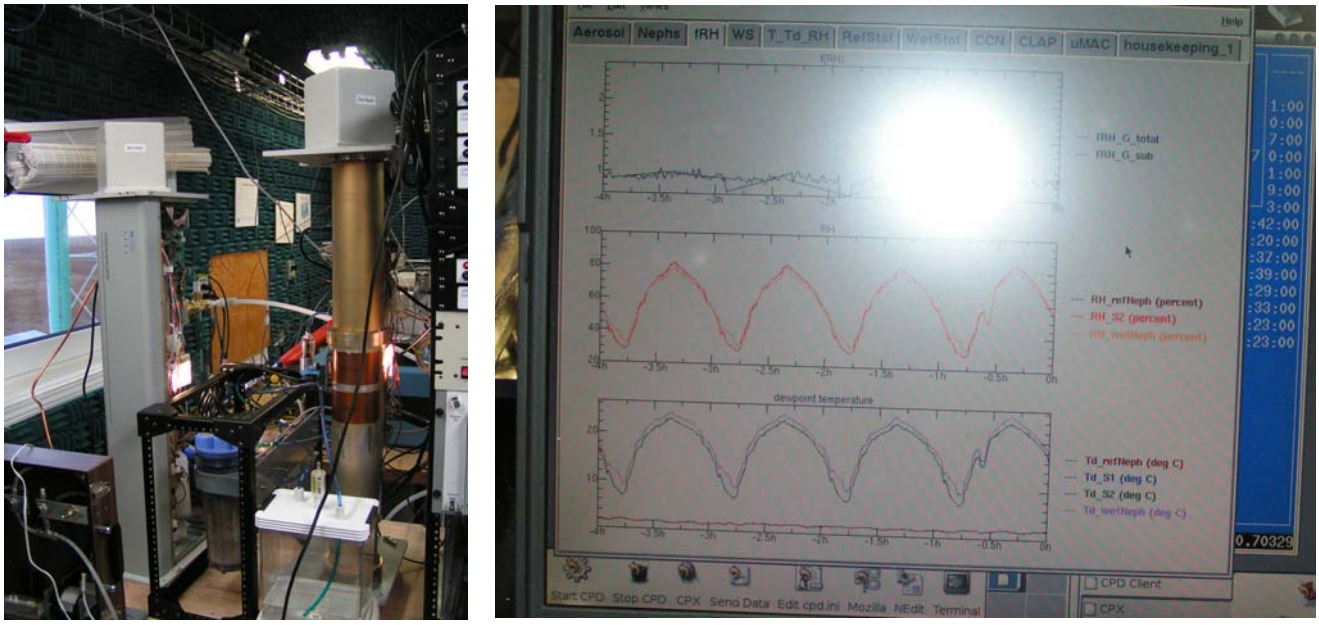


Fig. 9: Wet and dry Nephelometer and rH cycle of the wet instrument

A routine span check with filtered air and CO_2 is performed on a weekly basis.

A span check of the Nephelometers was performed during the audit. The average deviation from the last calibration was less than 2%. This is, however, only true if the humidifier of the wet Nephelometer is turned off. With humidifier we observed a 20% deviation of the wet Nephelometer (Fig. 10).

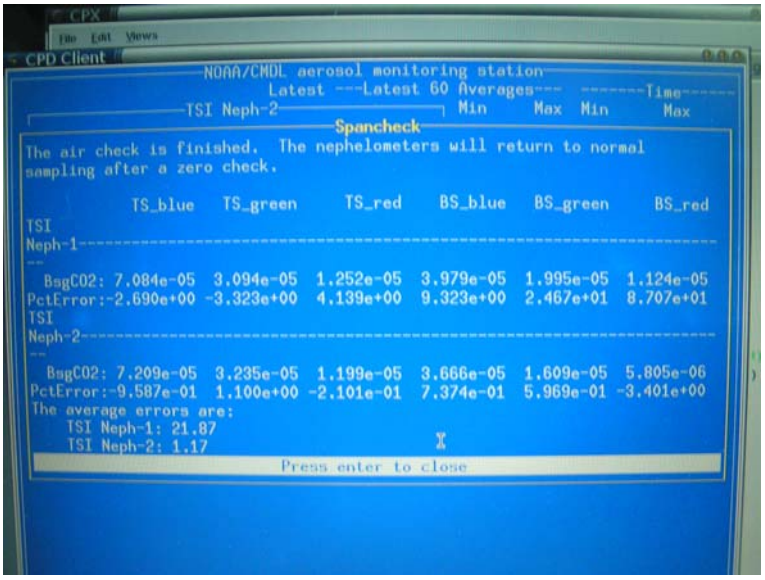


Fig. 10: Span check of Nephelometers with humidifier on

Time series of the measurements with both Nephelometers are shown in fig.11

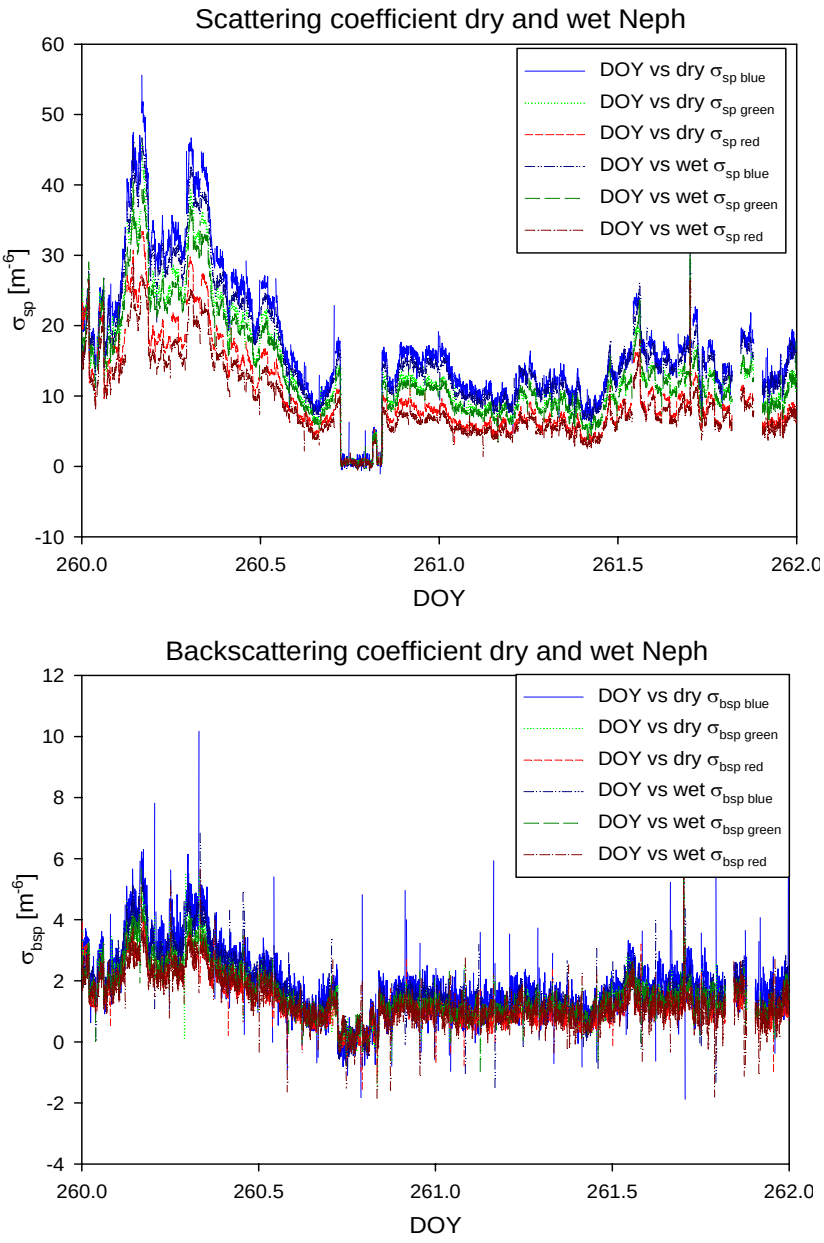


Fig.11: Time series of 1 minute Nephelometer data during the audit.

Statistical Parameters during the zero measurements of both instruments are summarized in table 3. Note that mean values of the zero measurements are in the range of real scattering coefficients which may occur during measurements under clean air conditions at BRW.

		N	Mean	Std. Deviation
Dry Nephelometer	σ_{sp} blue	135	3.1399	5.01083
	σ_{sp} green	135	2.6115	4.10118
	σ_{sp} red	135	2.1429	3.07451
	σ_{bsp} blue	135	.4287	.76222
	σ_{bsp} green	135	.2667	.47176
	σ_{bsp} red	135	.2833	.49455
Wet Nephelometer	σ_{sp} blue	135	2.6212	4.55370
	σ_{sp} green	135	2.3580	3.72177
	σ_{sp} red	135	1.7024	2.52221
	σ_{bsp} blue	135	.4145	.61311
	σ_{bsp} green	135	.4801	.47329
	σ_{bsp} red	135	.4107	.56561

Tab. 3: Means and standard deviation of 1 minute Nephelometer zero measurements

We compared both Nephelometers with switched off humidifier for a time period of 3 hours. The average relative humidity measured inside the dry Nephelometer was 20.2% rH and the humidity of the wet Nephelometer was 31.8% rH. Statistical parameters of this intercomparison are given in table 4.

dry Nephelometer				wet Nephelometer				
	N	Mean	Std. Deviation		N	Mean	Std. Deviation	Wet/Dry
σ_{sp} blue	195	14.97	1.76	σ_{sp} blue	195	13.58	1.49	1.10
σ_{sp} green	195	11.60	1.32	σ_{sp} green	195	10.80	1.19	1.07
σ_{sp} red	195	8.25	0.99	σ_{sp} red	195	6.74	0.79	1.22
σ_{bsp} blue	195	1.53	0.60	σ_{bsp} blue	195	1.44	0.35	1.06
σ_{bsp} green	195	1.20	0.29	σ_{bsp} green	195	1.22	0.23	0.98
σ_{bsp} red	195	1.09	0.26	σ_{bsp} red	195	0.96	0.39	1.13

Tab. 4: Statistical parameters of 1 minute data of parallel measurements with both Nephelometers

The Nephelometers at BRW are in good condition

CPC: A TSI 3010 SN 2452 has been recently brought from Boulder to replace the previous 3760. This instrument has been cleaned in March 2007. Measured aerosol flow is in good agreement with the flow used by the computer to calculate number concentration.

Flow rate Gilibrator : 952.9 cm^3/min

Flow rate from computer : 946.8 cm^3/min

Dry cal : 943.8 cm^3/min

The CPC has a slightly elevated false count rate. CPC zero check showed 39 particles in 10 minutes equivalent to false particle counts of 0.0041 particles/cm³. At typical ambient concentration this error is negligible for a total particle counter. Because of the low aerosol concentrations at BRW this instrument may however not be used for SMPS. False counts at low diameters may cause substantial overestimation of the total number concentrations from SMPS measurements.

The CPC at Barrow is in good condition (total counter only)

CCN: A CCN counter type DMT SN 007 is operated at BRW. The flow rate of 0.5 l/min was verified with the WCCAP Gilibrator (0.514 l/min). Cleaning of the mirrors of the OPC was scheduled during the audit (with reference values still within nominal boundaries). There was, however, no sufficiently pure acetone available at BRW (transport of flammable liquids by aircraft is severely restricted). Mirrors were therefore not cleaned during the audit. We recommend making small quantities of ultra-pure solvents available for cleaning purposes in the future. Figure 12 shows the time series of CNC and CPC data during the audit. Note that false counts with filter on stack (2.708 +- 0.542) and with filter in front of the instruments (0.092 +- 0.106) are significantly different. Zero values with filter on stack are close to measured values after DOY 261.0. A possible reason for this behaviour could be the slight underpressure (about 6 hPa) in the main sampling line with the filter attached to the system.

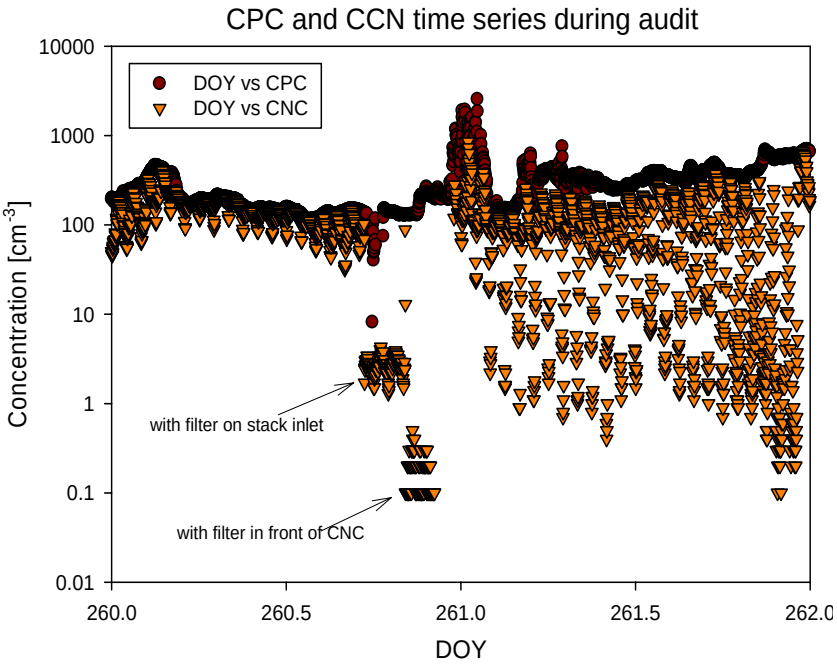


Fig. 12: Time series of CPC and CCN measurements during the audit at BRW

The CCN counter at BRW is in good condition

SMPS: The SMPS was set up by us during the site audit. All sensors have been calibrated to nominal standards. A leak check was performed several times during the audit resulting in. False particle counts did never exceed 2 particles during a 5 minute scan. On average less than 1 false particle count was encountered during each scan. Fig. 13 demonstrates the good agreement between CPC (42.7 cm^{-3}) and SMPS (44.89 cm^{-3}) derived number concentrations at extremely low ambient aerosol concentration. Data from the SMPS can be viewed live from the IfT allowing remote checks of the system. Basic operation instructions have been prepared for the station personnel. These instructions are included at the end of this report.

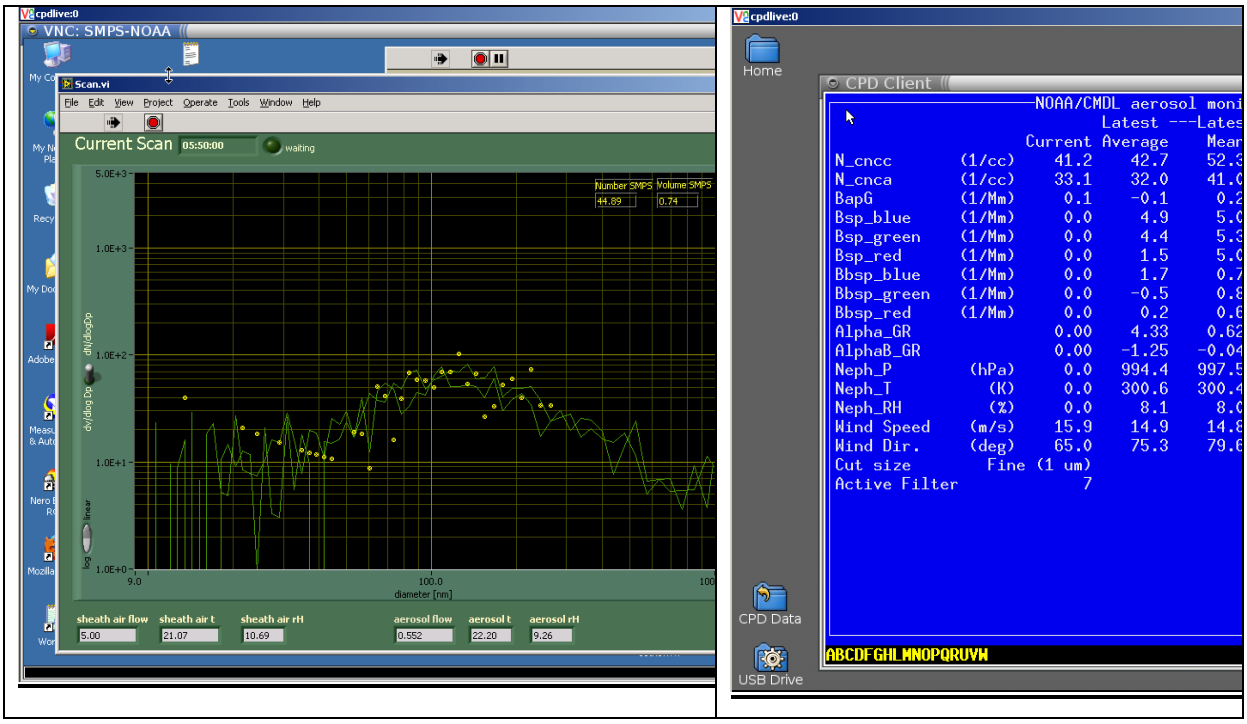


Fig. 13: Agreement between SMPS derived number concentration and CPC

The SMPS at BRW is in good condition

Conclusion:

We were pleased with the status of the site at Barrow and appreciate the great effort to operate a high quality site at this remote location. We are confident that the high quality of the data from Barrow will be maintained in the future. We wish to thank all station personnel for the hospitality.