Site audit report Mauna Loa, Hawaii

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Summary: Measurements of physical aerosol properties at the global GAW station Mauna Loa (MLO) were audited by Prof. A. Wiedensohler and Dr. Thomas Tuch and of the WWCAP on December 3rd 2007. Mauna Loa Observatory is located on the Island of Hawaii at an elevation of 3397 m on the northern slope of Mauna Loa volcano (19.539°N 155.578°W, fig. 1). The station has been established 1957.

Figure 1: Global GAW station MLO

Core aerosol measurements are available at the site. Mass concentration is not measured at MLO. Current measurement parameters and status of the instruments are summarized in table 1.

	Instrument	Status	Remarks
Continuous Measurement			
Multiwavelength optical depth	PFR		Inspected by Cristoph Wehrli during audit
Mass in two size fractions	n/a		
Major chemical components in two size fractions	High-Vol		Filter sampling + extraction + IC, inorganic coarse only
Light absorption coefficient	PSAP		
Light scattering coefficient at various wavelengths	TSI 3563		
Hemispheric backscattering coefficient at various wavelengths	TSI 3563		
Aerosol number concentration	TSI 3760		Zero count rate to high
Cloud condensation nuclei at 0.5% supersaturation	n/a		
Intermittent Measurement			
Aerosol size distribution	n/a		
Detailed size fractionated chemical composition	n/a		
Dependence on relative humidity	n/a		
CCN spectra (various supersaturations)	n/a		
Vertical distribution of aerosol properties	Lidars		Operated by NOAA and NASA (JPL)

Fully operational
Available, needs modification, data questionable
Not available

Table 1: Summary of measurements and instrument status at MLO

Documentation: Documentation of all routine and extra maintenance of the system is completely available at the station. Detailed checklists have been filed in the past. Furthermore checklists for all activities are stored in an online log. In addition to the routine logs a detailed log of maintenance performed prior to the audit has been supplied by NOAA (see attachment). All data are automatically sent to NOAA/CMDL and checked on a daily basis. Data from MLO are routinely submitted to the world data centre (table 2).

	Submission class	AOD	LScat	Labs	CN	Size dist	PM Chem	PM	CCN	LIDAR
Alert	1			1989-2001(a)			1992-1995			
Ny Alesund	1/3	2003-2005				2000-2004	1995 (1989-2004)			
Point Barrow	2		1976-1998 (-2005)	1988-1998 (-2005)	1976-1998 (-2005)		1997-2003	1997-2003		
Pallas	1/3		2000-2003		1996-2002 (2003)	2000-2003				
Mace Head	1/3	2001-2005	2000-2004	1989-2002	1991-1994	2000-2005	1992-1994			
Hohenpeissenberg	1	1993-2005	1999-2004 (-2005)		1995-2004 (-2005)	2001-2004 (-2005)	1997-2002			
Zugspitze	1	2003-2004								
Jungfraujoch	1/3	1999-2005	1995-2005	1995-2005	1995-2005	1997-1998	1995 (1993-2001)			
Mount Waliguan		(b)								
Izana	1	2001-2005					1992-1995			
Minamitorishima	1	2003-2004								
Assekrem										
Mauna Loa	2	2000-2005	1975-1999 (-2005)	1990-1999 (-2005)	1975-1999 (-2005)		1992-1995			
Mount Kenya										
Bukit Kototabang										
Arembepe										
American Samoa	2		1977-1991		1977-1997					
Cape Point							1992-1996			
Amsterdam Island										
Lauder										
Cape Grim	1				2003		1993-1996			
Ushuaia										
Neumayer	1		2001-2006		1993-2006					
South Pole	2		1979-1999 (-2005)	1987-1999 (-2005)	1974-1999 (-2005)					

global station/key parameter

1 = narsto by originator
2 = narsto by WDCA
3 = narsto by CREATE

NARSTO format at WDCA
non-narsto format at WDCA
(a) submitted as BC (ng.m-2)

GAWSIS but not WDCA
NARSTO format (CREATE)
(b) broad band pyrheliometer

neither GAWSIS nor WDCA

1 = narsto by originator
2 = narsto by WDCA
3 = narsto by CREATE

Table 2: Data submission status

Manuals for all instruments are available at the site.

Documentation at Mauna Loa is in good condition.

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.

A separate ¼" stainless steel tube operated at a flow rate of 9 l/min (Re=2000) is used 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.

Two Berner type impactors with cutoff-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 rate of the impactors is controlled by a mass flow controller. During the audit the indicator lamps for coarse and fine fraction on the front panel of the rack where not operational. Status of the impactors was however properly recorded by the data acquisition system.

Instrumentation:

Primary flow standard: A dedicated primary flow standard for aerosol measurements is not available at MLO. A suitable dry flow meter (type Bios International drycal) is, however, used for other instruments at MLO.

Unfortunately the reference flow meter brought by us broke during the journey to Hawaii. We were therefore not able to compare the dry flow meter during our audit.

Readings of the available flow meter where well comparable to flow rates recorded by the DAQ system. This system had been calibrated with a NOAA reference flow meter during instrument maintenance prior to the audit. Unfortunately the dry calibrator had already been sent back to NOAA at the time of the audit. The indirect comparison of flow rates with two different dry flow meters (one for calibration of the sensors and the other one used to measure flow rates during the audit) makes us confident that are currently according to specifications. Although "*Calibration of internal sensors for measuring flow rate, temperature, pressure, and relative humidity should be performed on an annual basis, and archived*" (J. Ogren, WMO/GAW AEROSOL MEASUREMENT PROCEDURES GUIDELINES AND RECOMMENDATIONS 153, World Meteorological Organization, WM TD Nr. 1178, 28) it needs to be mentioned that we do not consider yearly verifications of the flow rates sufficient. We suggest more frequent (monthly) flow checks with a reference flow meter.

Absorption Coefficients: A three wavelength PSAP S/N 107 is available at the site. A time series plot of the absorption coefficients during the audit is shown in fig. 2.Note that the elevated noise of the instrument prior to doy 329 is probably due to the reduced flow rate of 0.16 l/min. This problem emphasizes the need of more frequent flow calibrations. It would have helped the site technician to identify this problem.

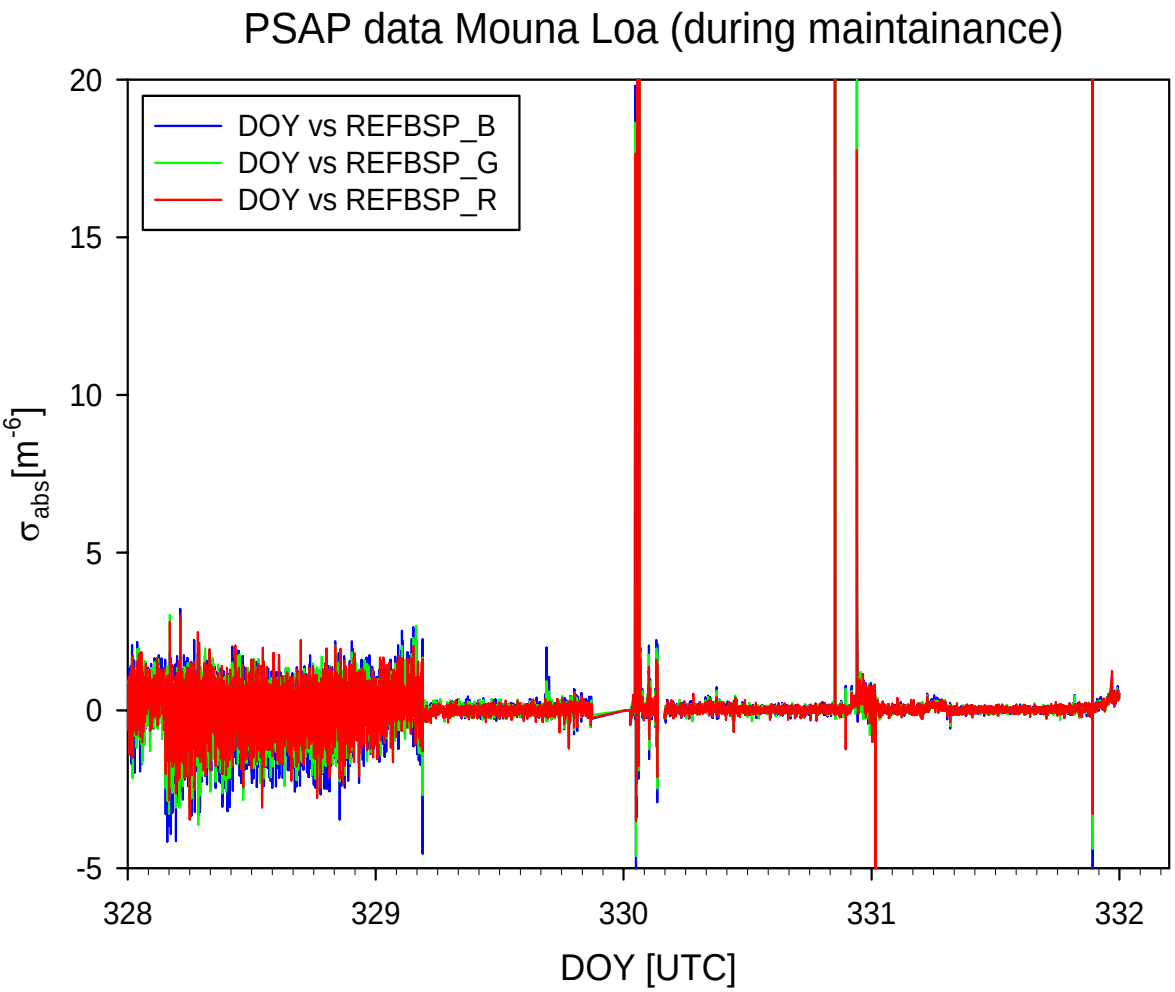


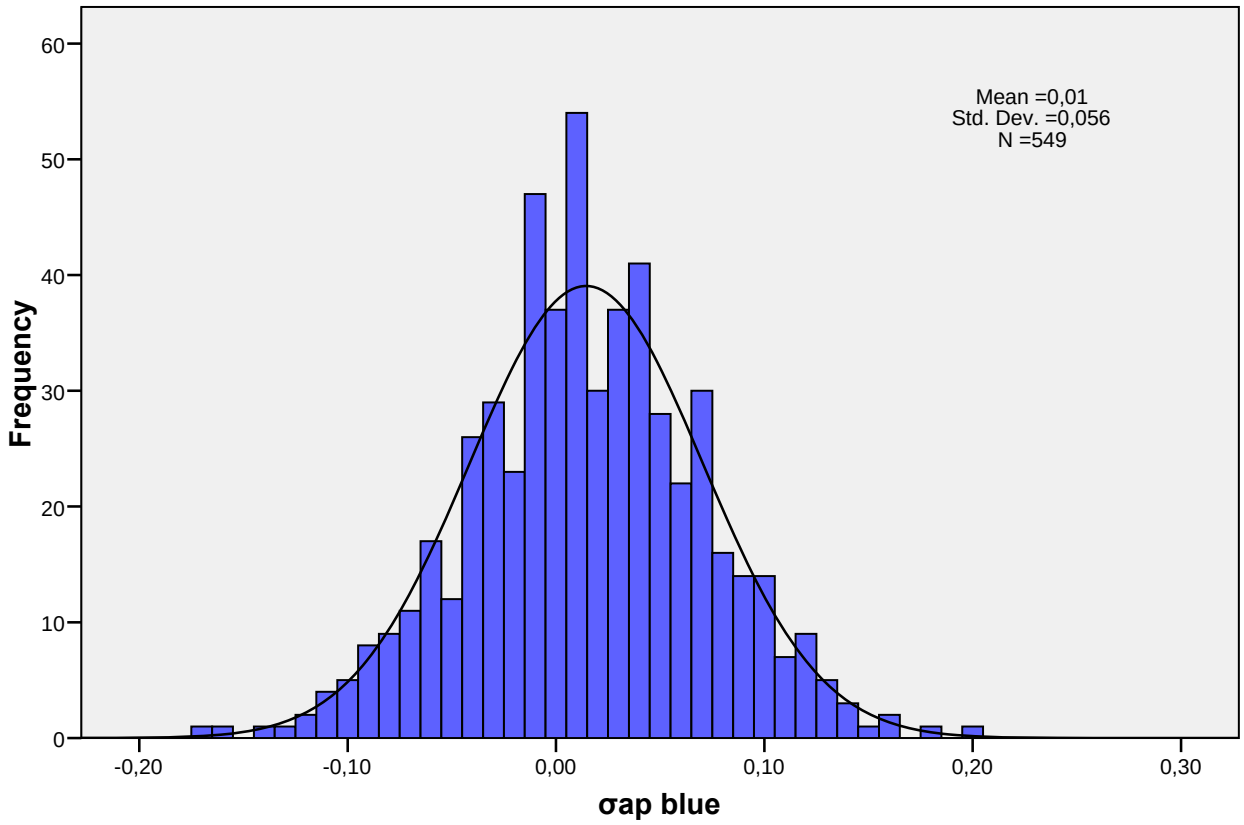
Figure 2: Absorption coefficients prior to the audit of MLO (1minute data), DOY 328 = 24.11.2007

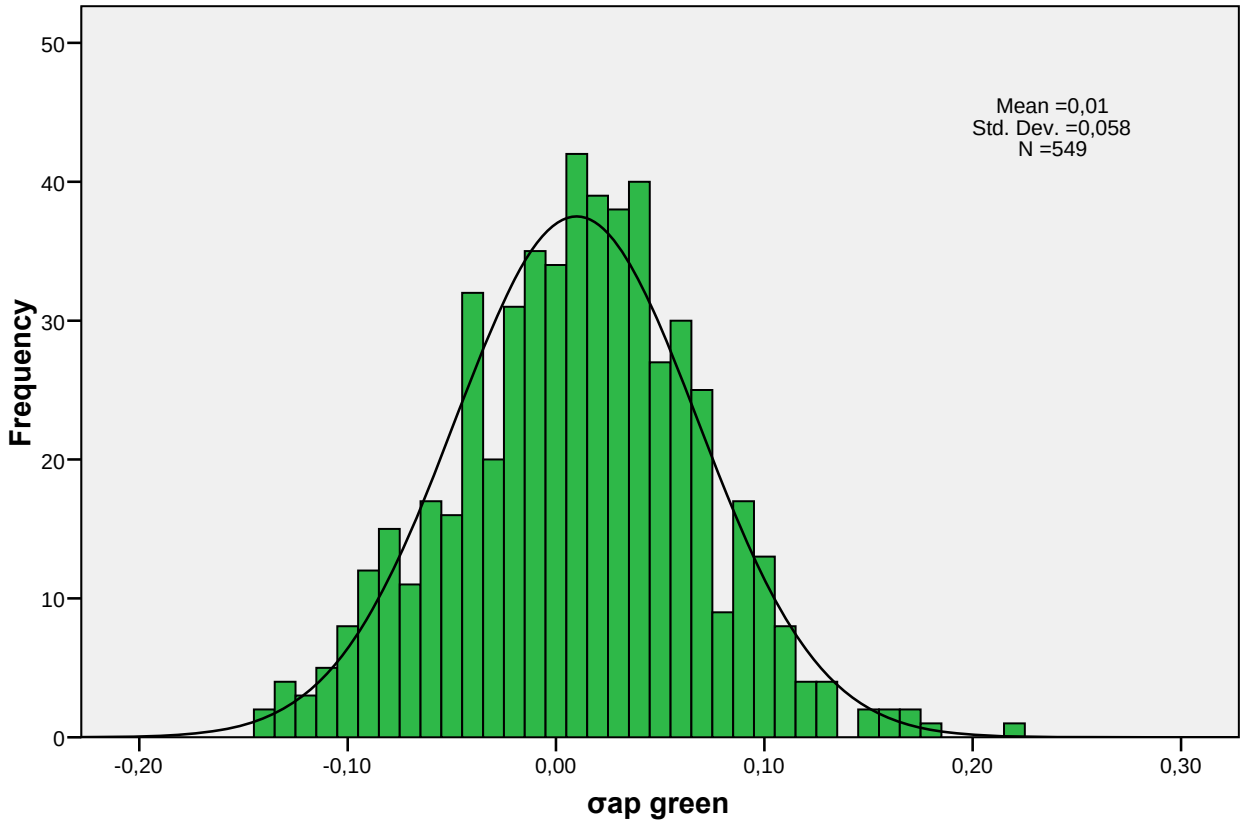
A high efficiency filter at the inlet was used to check instrument zero for a time period of 9 hours after maintainance (DOY 331.31944. to 331.70000). The inlet impactor was fixed to 10 µm cutoff size during this time period. Statistical parameters of one minute data are summarized in table 3.

	N	Mean	Median	Std. Deviation
σ_{abs} blue	549	0.01452	0.01000	0.0561
σ_{abs} green	549	0.00984	0.01000	0.0584
σ_{abs} red	549	0.01339	0.01000	0.0673

Table 3: Basic statistical parameter of the PSAP zero measurement

Figure 3 shows the frequency distribution of 1 minute absorption coefficients for all three wavelengths during the zero filter measurements.


Mean =0,01
Std. Dev. =0,056
N =549
Frequency
60
50
40
30
20
10
0
-0,20
-0,10
0,00
0,10
0,20
0,30
σap blue


Mean =0,01
Std. Dev. =0,058
N =549
Frequency
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30
20
10
0
-0,20
-0,10
0,00
0,10
0,20
0,30
σap green

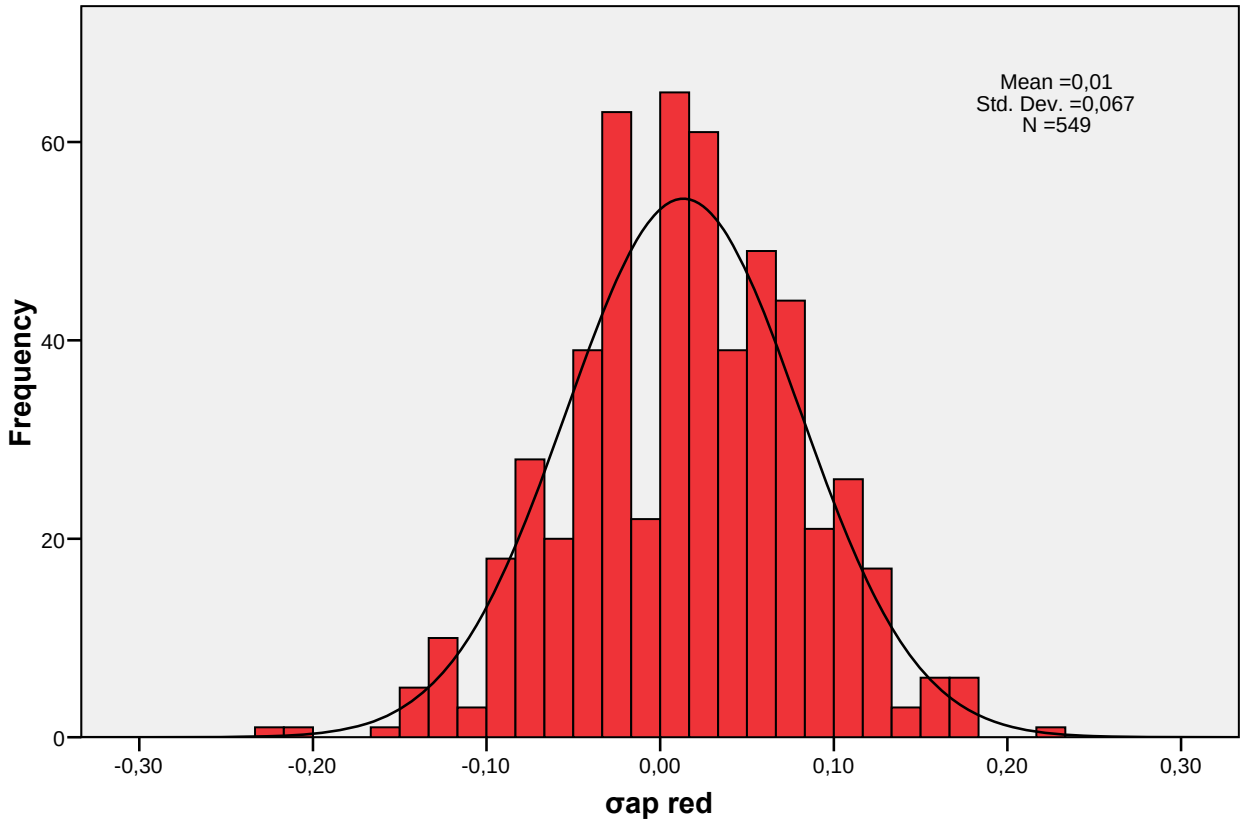


Fig.3: Frequency distribution of zero measurements of the PSAP at MLO

The PSAP at MLO is in good condition.

Scattering coefficients: A TSI Nephelometer 3563 is used to measure 3 wavelength scatter and backscatter coefficients at MLO.

A span check of the Nephelometers was performed during the audit. The average deviation from the last calibration was 1.5%. (Fig. 4). Typical average span check deviations are shown in figure 5.

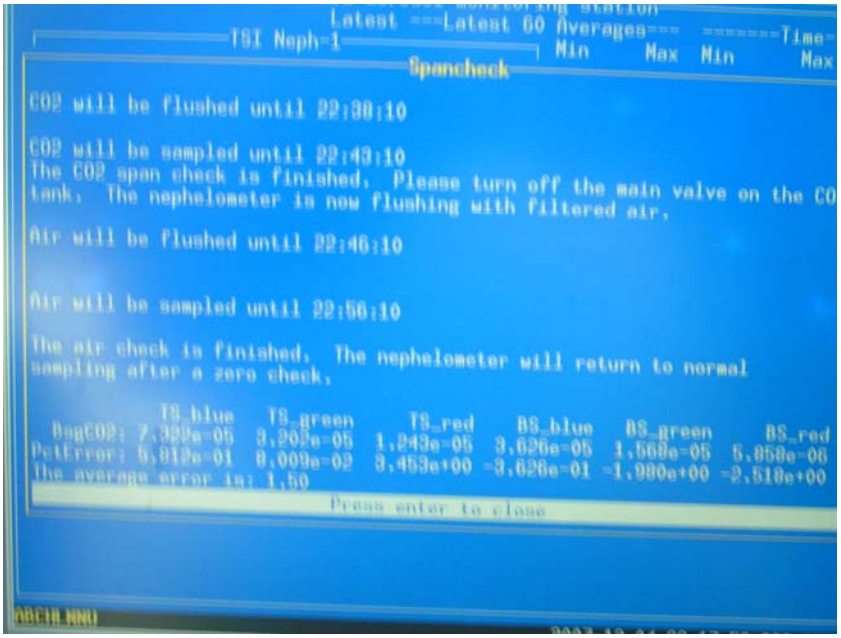
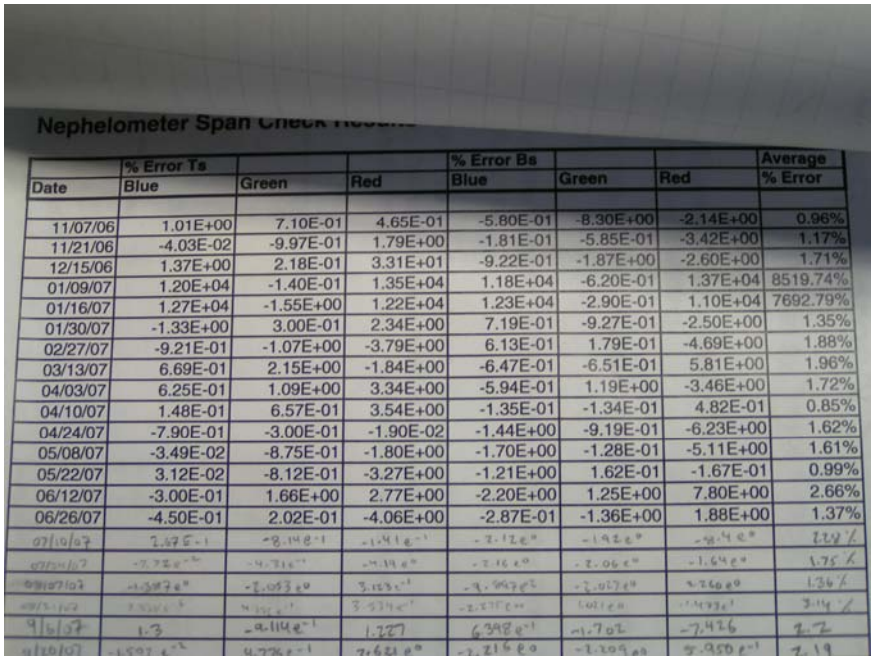


Figure 4: Span check of MLO Nephelometer



Nephelometer Span Check

Date	% Error Ts Blue	Green	Red	% Error Bs Blue	Green	Red	Average % Error
11/07/06	1.01E+00	7.10E-01	4.65E-01	-5.80E-01	-8.30E+00	-2.14E+00	0.96%
11/21/06	-4.03E-02	-9.97E-01	1.79E+00	-1.81E-01	-5.85E-01	-3.42E+00	1.17%
12/15/06	1.37E+00	2.18E-01	3.31E+01	-9.22E-01	-1.87E+00	-2.60E+00	1.71%
01/09/07	1.20E+04	-1.40E-01	1.35E+04	1.18E+04	-6.20E-01	1.37E+04	8519.74%
01/16/07	1.27E+04	-1.55E+00	1.22E+04	1.23E+04	-2.90E-01	1.10E+04	7692.79%
01/30/07	-1.33E+00	3.00E-01	2.34E+00	7.19E-01	-9.27E-01	-2.50E+00	1.35%
02/27/07	-9.21E-01	-1.07E+00	-3.79E+00	6.13E-01	1.79E-01	-4.69E+00	1.88%
03/13/07	6.69E-01	2.15E+00	-1.84E+00	-6.47E-01	-6.51E-01	5.81E+00	1.96%
04/03/07	6.25E-01	1.09E+00	3.34E+00	-5.94E-01	1.19E+00	-3.46E+00	1.72%
04/10/07	1.48E-01	6.57E-01	3.54E+00	-1.35E-01	-1.34E-01	4.82E-01	0.85%
04/24/07	-7.90E-01	-3.00E-01	-1.90E-02	-1.44E+00	-9.19E-01	-6.23E+00	1.62%
05/08/07	-3.49E-02	-8.75E-01	-1.80E+00	-1.70E+00	-1.28E-01	-5.11E+00	1.61%
05/22/07	3.12E-02	-8.12E-01	-3.27E+00	-1.21E+00	1.62E-01	-1.67E-01	0.99%
06/12/07	-3.00E-01	1.66E+00	2.77E+00	-2.20E+00	1.25E+00	7.80E+00	2.66%
06/26/07	-4.50E-01	2.02E-01	-4.06E+00	-2.87E-01	-1.36E+00	1.88E+00	1.37%

Figure 5: Record of weekly span checks at MLO

Note that the huge errors in January 2007 could be attributed to an instrument failure using the available information in the instrument logs.

The time series of scattering and backscattering coefficients during routine maintenance prior to the audit is shown in figure 6.

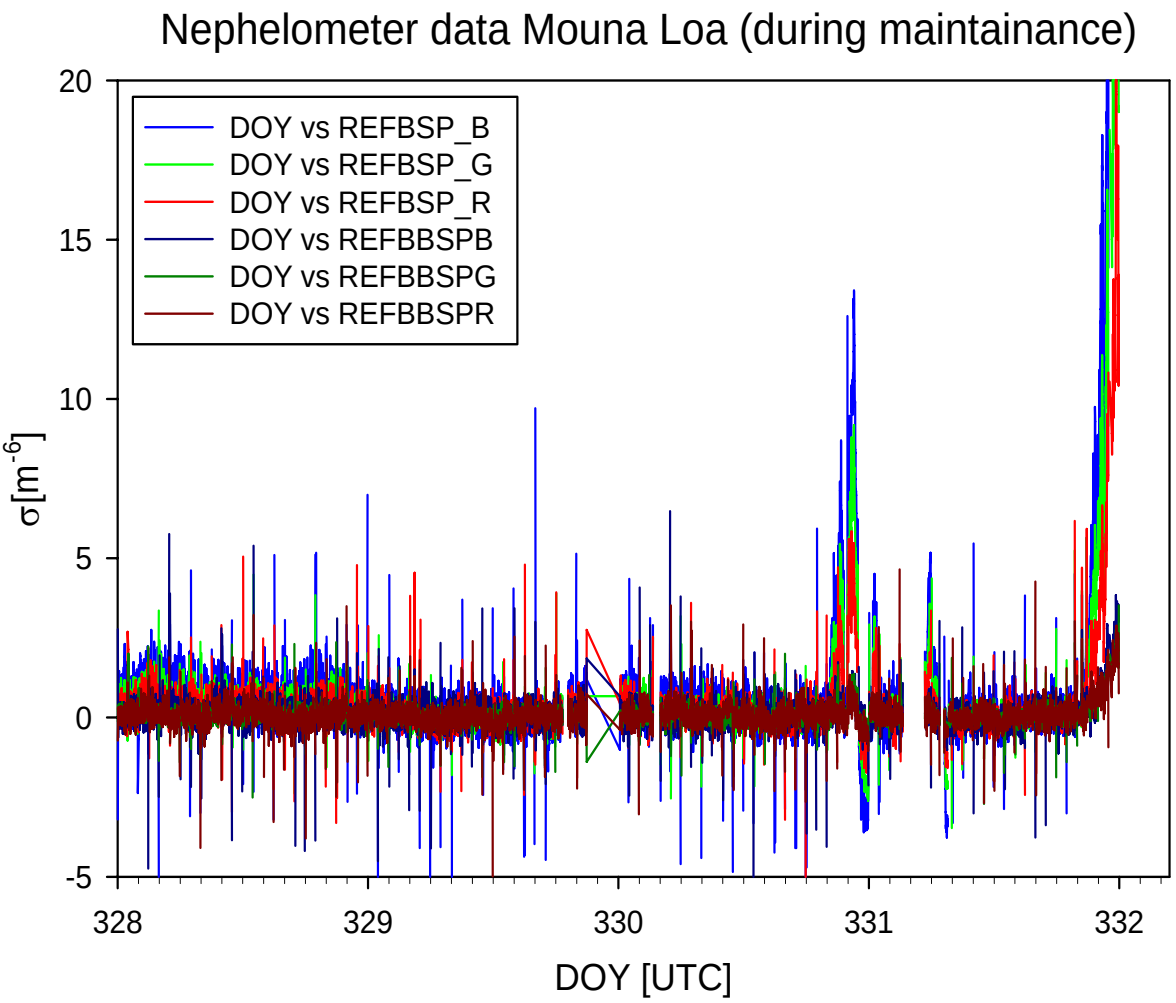


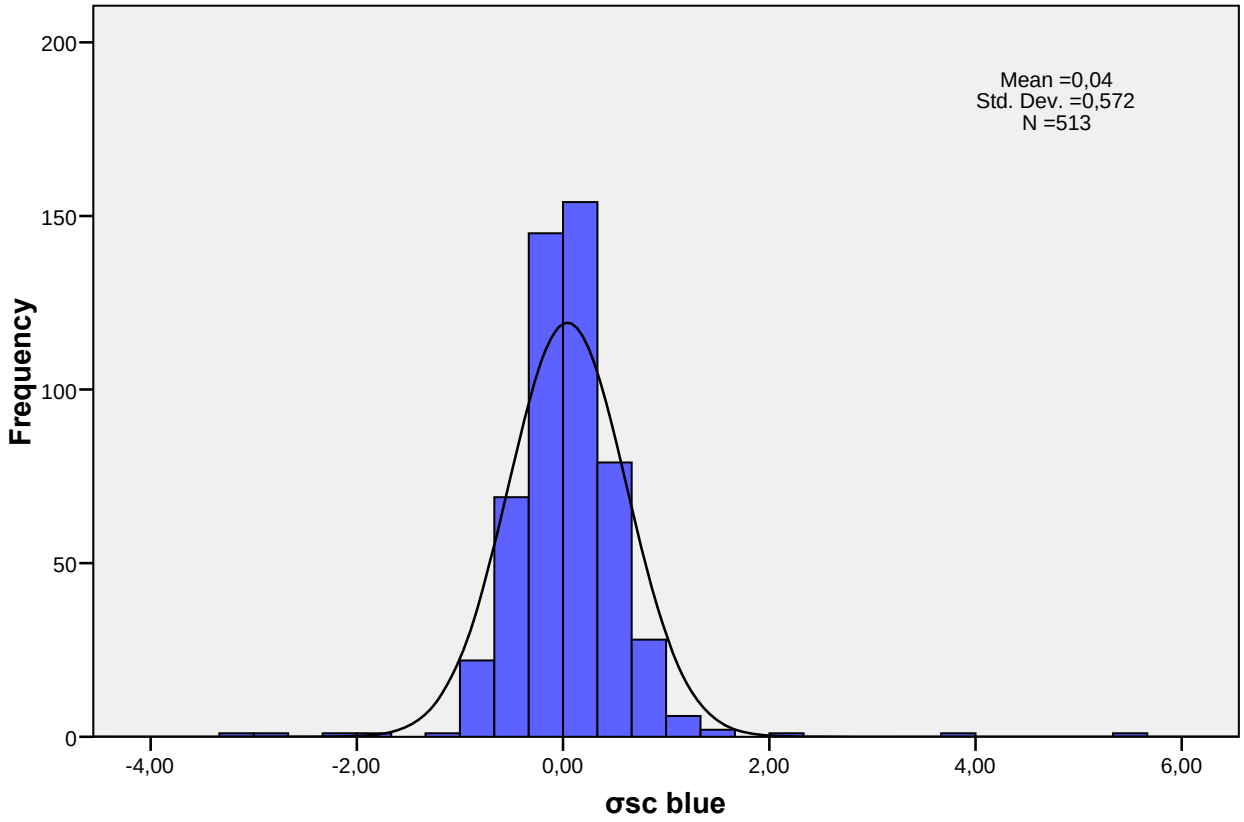
Figure 6: Time series of 1 minute Nephelometer data during the routine maintenance prior to the audit.

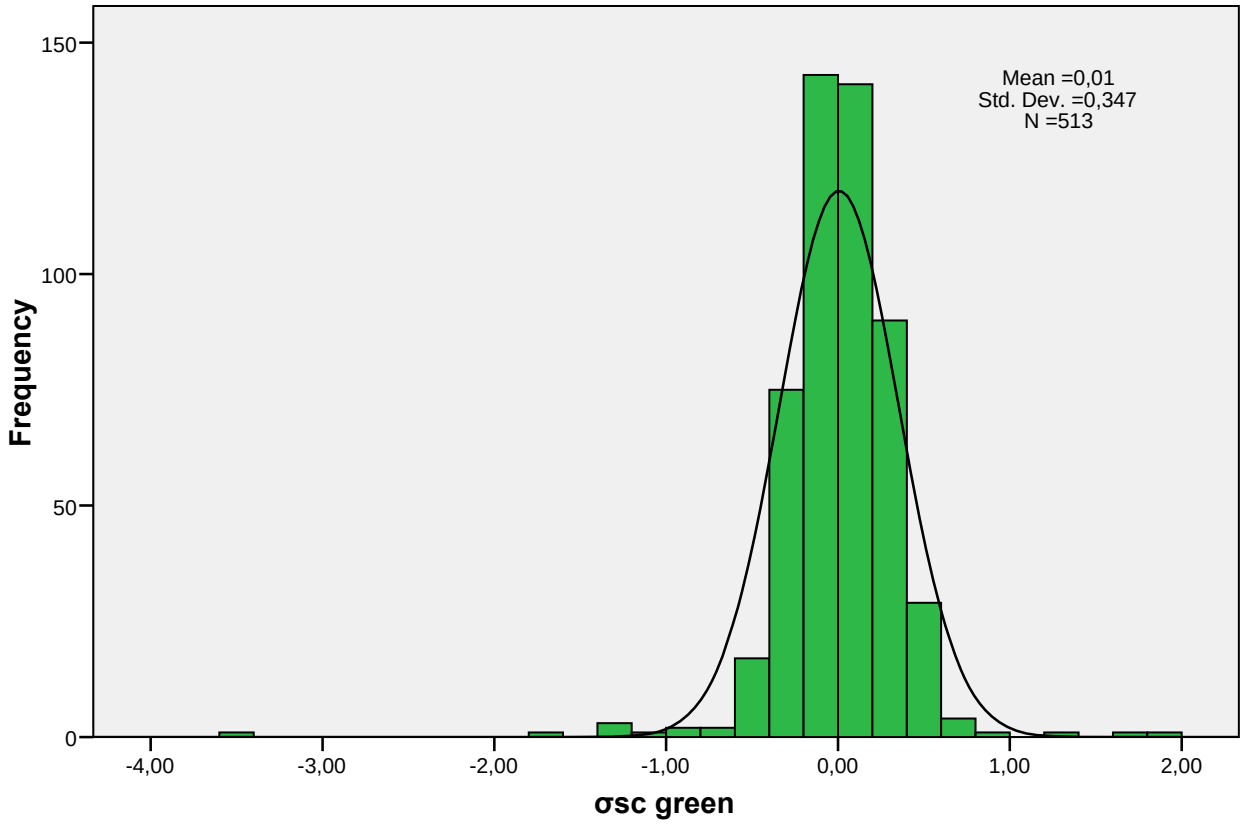
Statistical Parameters during the zero measurements prior to the audit are summarized in table 4. Note that mean values of the zero measurements are in the range of real scattering coefficients which may occur during measurements under clean air conditions at MLO.

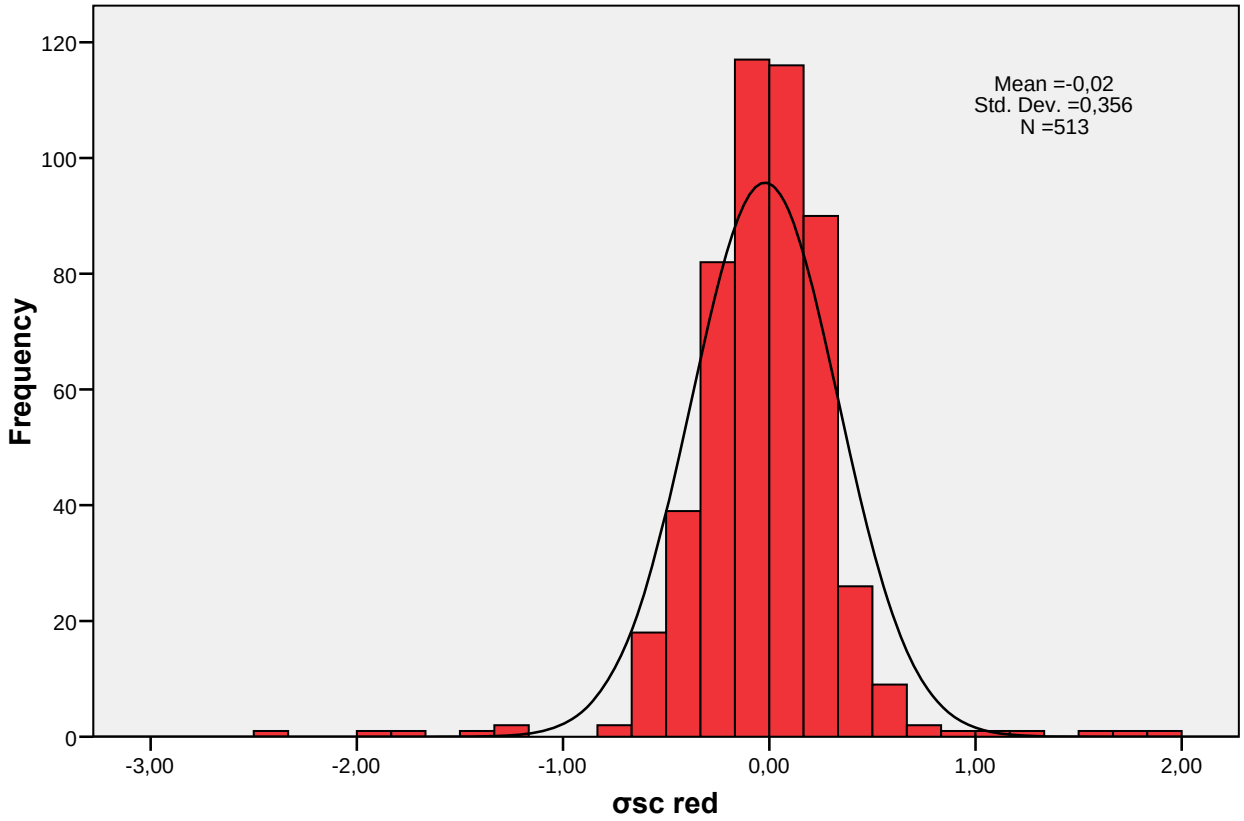
	N	Mean	Median	Std. Deviation
σ_{sp} blue	513	0.04320	0.04000	0.5720
σ_{sp} green	513	0.00579	0.01000	0.3469
σ_{sp} red	513	-0.02115	-0.01000	0.3562
σ_{bsp} blue	513	-0.01827	-0.03000	0.4441
σ_{bsp} green	513	-0.03216	-0.04000	0.2399
σ_{bsp} red	513	0.01400	0.01000	0.4258

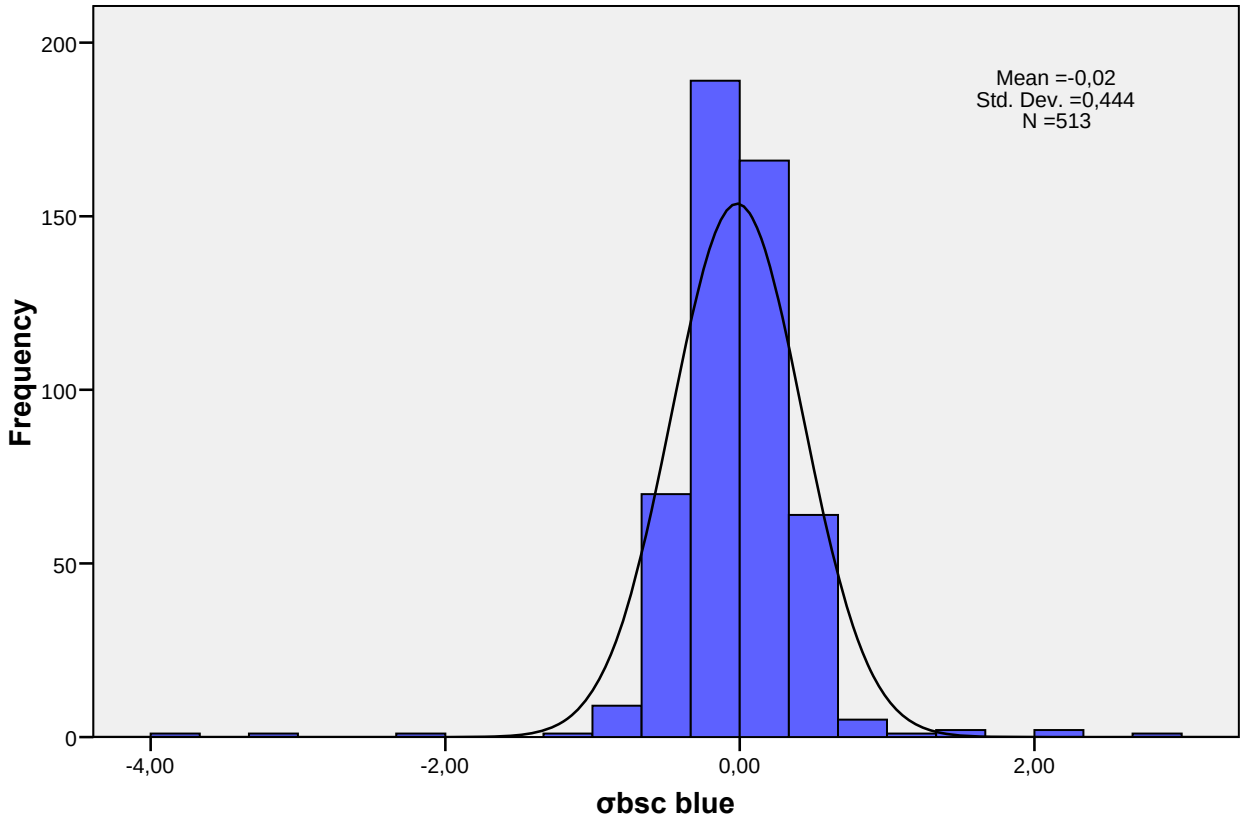
Tab. 4: Means and standard deviation of 1 minute Nephelometer zero measurements

Figure 7 summarizes the results of the noise check of the Nephelometer prior to the audit. Instrument noise for this instrument is in the typical range for TSI Nephelometers.




Mean =0,01
Std. Dev. =0,347
N =513
Frequency
150
100
50
0
-4,00
-3,00
-2,00
-1,00
0,00
1,00
2,00
σsc green


Mean =-0,02
Std. Dev. =0,356
N =513
Frequency
120
100
80
60
40
20
0
-3,00
-2,00
-1,00
0,00
1,00
2,00
σsc red


Mean =-0,02
Std. Dev. =0,444
N =513
Frequency
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150
100
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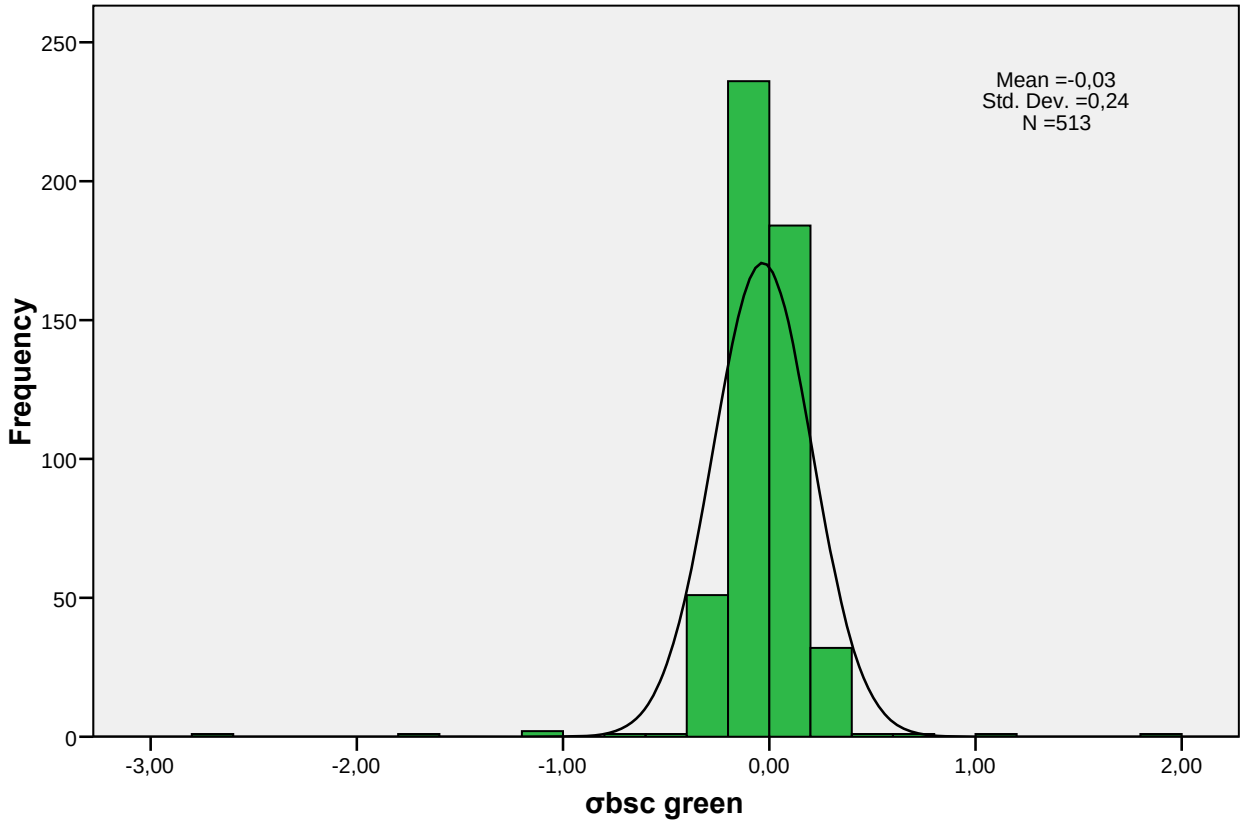
-2,00
0,00
2,00
σbsc blue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Std. Dev. =0,24
N =513
Frequency
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100
50
0
-3,00
-2,00
-1,00
0,00
1,00
2,00
σbsc green

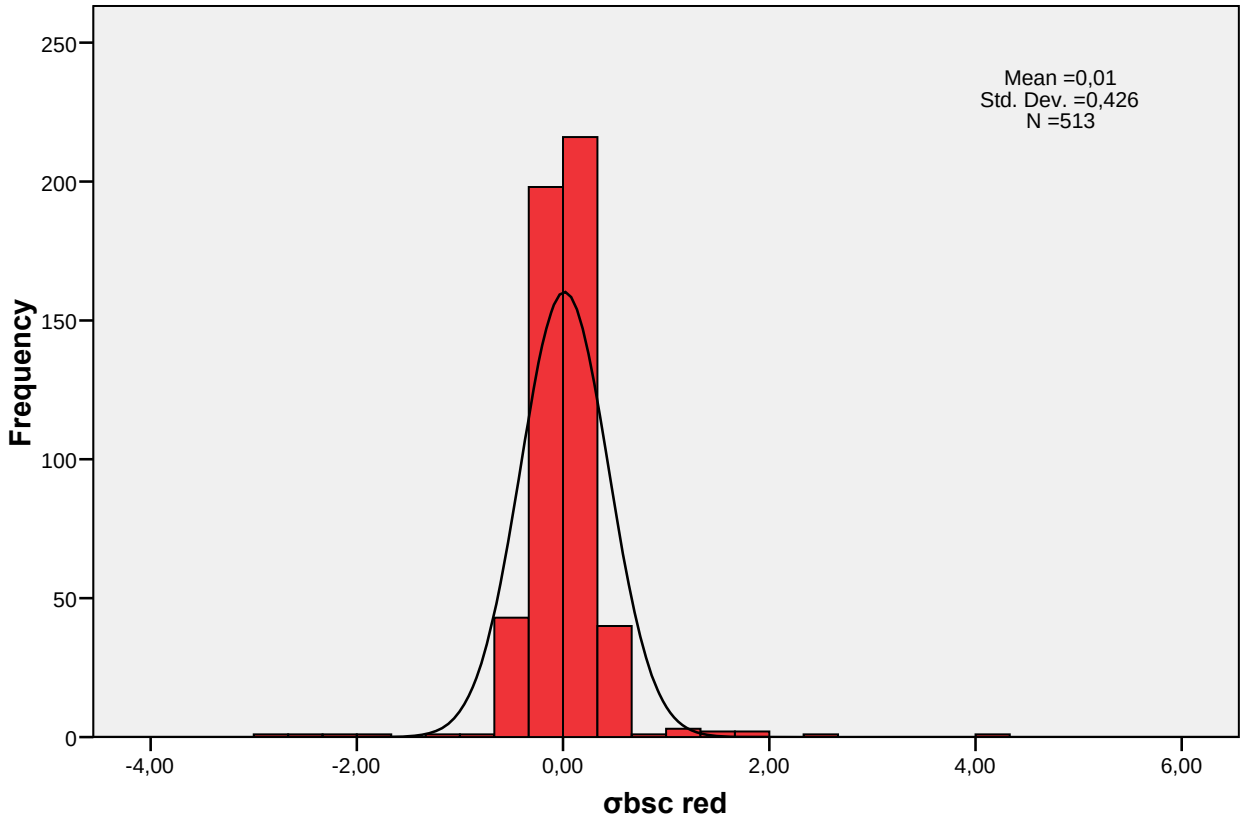

Figure 7: Noise check (with absolute filter) of the TSI Nephelometer, 1 minute data

The Nephelometer at MLO is in good condition

Particle number concentration: A TSI 3760 SN 189 is used to measure the particle number concentration at MLO. This instrument is primarily used to monitor local contamination. During routine maintenance this instrument was compared to a second CPC 3760 SN 405 (see attached maintenance record). Count rates of the MLO CPC where slightly lower than those of the reference CPC. During the zero check count rates were elevated (19 cm^{-3}), figure 8. There was, however, no significant difference between measurements with the two different impactors (with different pressure drop), table 5.

Group Statistics

	VAR00002	N	Mean	Std. Deviation	Std. Error Mean
VAR00003	.00	302	19.5219	2.38809	.13742
	10.00	305	19.6413	2.65194	.15185

Table 5: Number concentration with zero filter by impactor cut size (var00002, impactor flag)

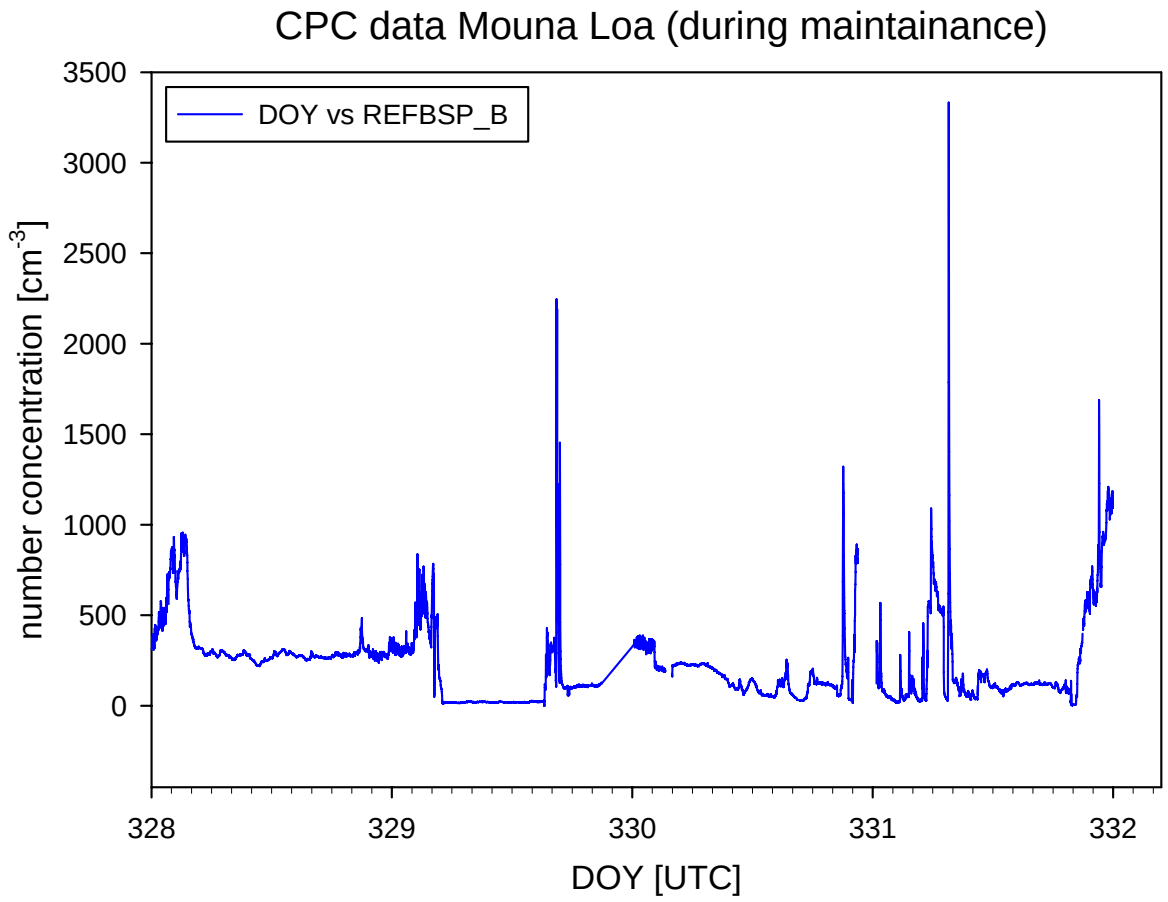

Fig. 8: Time series of CPC and CCN measurements prior to the audit at MLO

The problem with the elevated count rate was persistent during our audit. We found out, that the count rate of the CPC increases with increased pressure drop at the inlet of the instrument suggesting a leak in the instrument itself. Although the instrument is only used to identify local pollution this instrument needs to be fixed as soon as possible.

The CPC at MLO was not working according to specifications

The CPC has been exchanged after the audit

Conclusion: Mauna Loa Observatory contributes valuable data to GAW. Most instruments have been in excellent condition during our audit. Documentation of measurements and maintenance ensure high data quality. We wish to thank you for the pleasant time in Hawaii.

Attachment: Service report prior to audit provided by John Ogren

MLO Annual Maintenance
November 24-27, 2007
John Ogren

11/24	1500 HST = 0100 UTC Start of maintenance visit
	Review CPD screens.
OK	Neph impactor dP = 4.2 hPa (1 um), 0 hPa (10 um)
OK	UPS alarm bytes 00,14 ➔ "Check inverter"
	Aethelometer process is running, no comms
OK now	Discrepancy: RH T Td Inlet 17.0 13.0 -11.5 F_Sample 20.5 13.0 -9.1 refInlet 2.1 26.2 -25.2 refSample 1.9 30.7 -25.2
	PSAP flow 0.16 LPM – why so low? – Trevor says normal is 1.0 slpm
	Other than the above noted discrepancies, all CPD screens show nominal values
	Installed mixing chamber, CPC#2 is 3760#405.
1840 HST	Configured for overnight zero check, HEPA filter on inlet to impactor box.
	Adjusted PSAP flow up to normal 1.0 lpm
	CPC#2 reads nearly a factor of ten lower than #1. Checked pulse counter, and the pulse count rates show same discrepancy. Why? Perhaps #1 is counting spurious pulses? Or #2 is counting low, either low vacuum, not stabilized yet, or damaged in transit,
	Took mixing chamber inlet off normal CPC sample line. Installed Parker capsule filter in mixing chamber inlet @ 0500 UTC
11/25	
	Checked CPC zero counts by putting a Parker filter directly on the inlet to each CPC. Count rates dropped immediately to zero
	Did CPC comparisons with both counters on mixing chamber and fan inside chamber turned on. Comparisons look much more reasonable now. CPC#1 reads a bit lower thn #2, but not enough to warrant a swap.
	CPC#2 (s/n 3760#405) flowrate check (burst mode, avg of 10 readings) 1.508, 1.507, 1.507 lpm volumetric (25.12 cc/s)
	CPC#1 (s/n 3760#189) flowrate check (burst mode, avg of 10 readings) 1.556, 1.556, 1.556 lpm volumetric (25.93 cc/s)
OK	Current cpd.ini flowrate entries: #1=26.16 cc/s => (26.16-25.93)/25.93=0.89% high #2=25.2 cc/s => (25.2-25.12)/25.12=0.32% high
	Updated cpd.ini with new CPC flow calibration results
	Serial port assignments: [UMAC1] Port=/dev/ttyUSB0:9600N81 [CNC1] Port=/dev/ttyUSB1:9600E71 [NEPH1] Port=/dev/ttyUSB2:9600E71 [PSAP3] Port=/dev/ttyUSB3:9600N81 [BESTUPS] Port=/dev/ttyUSB4:1200N81 [AETHALOMETER] Port=/dev/ttyUSB5:9600N81 (not working) GPS is connected to ttyUSB7, not currently in use
	Reconfigured to use GPS as another time standard…

	Change /etc/gps to point to /dev/ttyUSB7 Uncomment line in /etc/ntp.conf for using local GPS
	Comment out startup of aethalometer process in cpd.ini
	Analog channel assignments: Chan_dP_Pitot=8 Chan =9 – not connected Chan_Q_CNDrier=10 – not connected Chan_Q_CN=11 – not connected Chan_Q_Analyzer=12 Chan_Wind_S=13 (white) Chan_Wind_D=14 (green) Chan_Stack_T=15; (white wire from Vaisala cable) Chan_Stack_RH=15; Stack_RH sensor is not connected to anything Chan_Inlet_T=16 (white) – splitter bypass line Chan_Sample_T=16 – splitter bypass line Chan_Inlet_RH=17 (green) – splitter bypass line Chan_Sample_RH=17 – splitter bypass line Chan_Rack_T=18 (white) Chan_Pumpbox_T=19 (white) Chan_dP_Spare2=20 – dP sensor #1, connected to primary vacuum manifold Chan_dP_NephImp=23 Chan_uMAC_T=60
OK	Neph span check gave consistent errors with log sheet recordings, avg error 1.6%, mostly due to red channels. No need to recalibrate neph.
	Vaisala sensors to check: Stack (ch09=RH?; ch15=T?) Sample/Inlet (ch16=T, ch17=RH) Rack Pumpbox
?	Both CPC's show a cyclical pattern, 15 cycles in the past hour. P/P amplitude around 10/cc riding on a baseline of about 100/cc
	Got a kernel panic when rebooting system. Second try booted just fine
	Upgraded to 20071115 version of LiveCPD
	Removed butanol trap. It was not plumbed in at a place where it would actually do any good.
	Document flow connections
	Remove and inspect PSAP #107. No discrepancies noted. Reference filter is plumbed in series with sample filter. Inlet heater is installed.
OK	Removed PSAP filter holder. Upper o-ring on sample side was missing. Need to add a visual check of o-rings to daily PSAP operating procedure.
	Documented connections inside uMAC. Found a couple of loose wires. One was a ground from a Vaisala sensor, the other was one of the input capacitors.
	Checked HEPA capsule filter upstream of Q_analyzer MFC. It looked clean, and was labeled "MLO new 03/03/07". Left the filter in, since MLO is so clean and the filter only has 8 months of usage on it. NOTE: Trevor says no one from MLO would have changed the filter. So the date must refer to 2003-03-07, which corresponds to a site visit by Anne Jefferson
	Impactor box: 10 um lamp (green) inoperative
	BIOS Davis_WX neph Rack Room T 27.0 28.2 25.2 Room P 677 676.6 675

	Looks like good consistency, use BIOS T/P for flow calibrations
	PSAP flow calibration (slpm, BIOS readings are bursts of 10) Lpm lpm PSAP BIOS 0.040 0 valve closed 0.160 0.154 single reading 0.397 0.424 0.575 0.611 0.799 0.841 0.985 1.028 1.195 1.237 1.402 1.438 1.604 1.635 1.795 1.819 1.996 2.009 Least-squares analysis showed that a 2nd order fit was needed. Calibration shift at normal setpoint of 1 slpm is -0.9%. A0 -0.030343506 A1 1.134870901 A2 -0.058496085
	MFC setpoint on controller is 18.0
	MFC calibration: Volts SLPM AI12 BIOS -0.112 0.320 valve closed 0.263 3.664 0.515 5.937 0.767 8.251 1.026 10.57 1.265 12.69 1.513 14.89 1.772 17.22 2.017 19.37 2.261 21.59 2.518 23.95 2.774 26.26 3.012 28.62 Regression analysis results: A0 1.294967677 A1 9.009107254
	Replaced Balston filter in CN drier line inside impactor box with Parker filter
	Remove Permapure drier, disassemble, remove drier element. No twists in element, inside looks clean, no obstructions or deposits. Reassemble with new drier element and new o-rings, reinstall in impactor box.
	Check CN drier flowmeter calibration: Rotameter readings at center of ball, indicated lpm BIOS readings are volumetric lpm Rota BIOS

	6.5 8.08
	Inspect and service impactors. Both are old design with plastic clamping system, need to order new stainless steel end pieces for both of them. N-1-11 N-10-6 Impactors were properly assembled and are being maintained properly.
	CN is sampling from separate, high-speed, ¼" tube
11/26	
	Spot check of aerosol vs. station wind birds looks good. Station: 165 deg, 20 mph Aerosol: 160 deg, 6 m/s
	Updated Q_analyzer calibration, changed MFC set point to 20.5 indicated on meter
	Climb tower, inspect all guy wires, wire clamps, unistrut. All looks very good. The unistrut has a thin layer of rust, but no structural rust.
	Flushed CN inlet line at top of stack with EtOH
TODO	Checked wind bird calibration IN14 =0.024V front pointed towards Mauna Kea IN14 = 0.517V rear pointed towards Mauna Kea IN14=0.161 front pointed "Shantyville" (ASHRA MLO site) IN13 = 0.005V with anemometer stopped Need to look up bearings from aerosol stack to Mauna Kea summit telescopes, as well as the ASHRA Shantytown.
	Leak test, CNC sampling from neph exhaust, size cut locked on "fine" w/o filter, Ncnc=180-200/cc, dP_neph_imp=5 hPa with filter, Ncnc=35-40/cc, dP_neph_imp=16 hPa
	Inspected inlet pipe from bottom, looks like a very thin coating of dust. Cleaned 2" inlet pipe with EtOH and large bottle brush. Dust coating gone after cleaning.
	Gast pump was installed in June 2007, while troubleshooting a problem that turned out to be caused by a bad power outlet. Length of new vanes = 39 mm Length of used vanes = 39 mm No need to change vanes. Return pump to normal operation
	Check calibration of T-stack and T-pumpbox against Omega temperature sensor CPD Omega Cal offset T_stack 10.0 12.2 +2.2 T_pump 16.2 16.5 +0.3
	Check calibration of pressure transducer on pitot tube, analog input channel 8 I08_V dP_inches_H2O 0.076 0.00 blower off 0.223 0.22 <= operating point when I arrived 0.356 0.45 Verified that Tygon tubing has a tight press fit onto pitot tube Regression analysis results (hPa): A0 Intercept 0.315679791 A1 I08_V 3.995479957

	Remove and inspect pitot tube. It was aligned just a tiny bit off-axis, perhaps 5 degrees. Tip is within a couple of millimeters of center of tube. Slight corrosion at tip of tube, static ports look just fine, though. Cleaned with ScotchBrite and EtOH, flushed thoroughly, returned to service.
	Replaced fiberglass filter mat in pump exhaust filter. Old filter was pretty black on outside, but hadn't broken through on the inside.
	Cleaned splitter. Very little observable deposit on inside of tubes. Splitter had been sealed to 2" sample tube with silicone sealant. Applied a layer of silicone vacuum grease to internal o-rings in splitter. Re-installed splitter, applied a bead of silicone vacuum grease at joint between splitter and 2" tube. Reconnected sample lines to splitter.
SEND	Brass ½" Swagelok tee, with side branch bored out for Vaisala probe. (Current plastic fitting has marginal threads on one side)
	Calibrate RH_inlet sensor (AIN#17). Reference is Vaisala sensor #1, calibrated 2007-05 by Anne Jefferson, eqn is RH_true=-0.9342+0.9935*RH_ind. Used RH readout box for reading reference sensor. RH_ind AIN#17 82.5 1.542 159.3 0.816 swapped cables, just for a reality check. 19.7 0.229 31.3 0.348 48.1 0.532 60.2 1.033 <= huge jump in response. I don't trust this sensor, replacing it with a spare sensor
	Repeat calibration with replacement Vaisala sensor RH_ind AIN#17 59.4 0.600 75.1 0.764 58.7 0.607 51.7 0.540 40.9 0.435 30.2 0.320 23.1 0.250 19.9 0.219 Results of linear regression: A0 Intercept 3.337590361 A1 AIN#17 100.6408629 1-point temp check Omega AI#16 (T_sample) 24.0 0.651 This indicates we need to apply an offset of -1.1 degrees to T_Inlet calibration
	Replaced HEPA filter in CNC box with a new filter
	Removed neph for inspection and servicing. The base plate was not screwed to the bottom of the optics tube! Why? The three missing screws were sitting on top of the UPS. Neph is s/n 1034, CD0000651476
	Replaced neph HEPA and Parker filters. Replaced CO2 Balston filter w/Parker filter.

	Also used a Parker filter in neph.
	Removed neph sample RH/T sensor from neph and installed it in the sample chamber of the RH reference box. Internal RH calibration constants in neph: SAR => 0,100% SCR => 267,113,620,750 Let's see if we can do a neph RH calibration: RH_ind Neph_RH 19.2 18.3 30.8 28.4 50.3 45.9 69.7 66.5 53.4 51.5 43.3 41.4 34.8 33.4 Linear regression results look very reasonable: A0 Intercept -0.418901072 A1 Neph_RH 1.036906649
	Calibrate uMAC delta-P sensors with 0-15 psi Magnehelic gauge VOLTS Psig CH20 CH21 CH22 CH23 8.8 5.788 5.832 5.754 5.716 6.1 4.147 4.189 4.111 4.097 4.2 2.939 2.982 2.902 2.905 2.0 1.663 1.707 1.625 1.647 0.0 0.422 0.467 0.382 0.421 Regression analysis results: A0 A1 CH20 -47.77281671 113.2172434 CH21 -52.88406843 113.2666379 CH22 -43.19814272 113.0900701 CH23 -48.30190713 114.7285833
	Compare neph temperature sensors with Omega standard Omega T_sample T_inlet 24.5 298.4K 298.8K 298.4K = 25.3 deg C Calibration offsets: T_sample: -0.8 T_inlet: -1.2
11/27	
1905Z	Restarted CPD after all new calibrations had been entered into cpd.ini
	Adjust setpoint on heater PID controller to 38.0%, to account for new calibration of

	RH_Inlet sensor.
SEND	Replacement 3-way valve for CPC inlet. Current valve leaks, can't do a proper leak check.
SEND	Replacement UPS batteries
	Adjust blower to give 0.25" H2O on Magnehelic, 835 lpm indicated in cpd
DEFER	Connected tube from neph exhaust to CPC inlet valve (the non-leaky port), put HEPA filter on neph inlet. Counts dropped from 140/cc (room air) to 5/cc. Pressure drop on HEPA filter is minimal, though. Added a Parker filter to inlet of HEPA filter to get another 100 hPa of delta-P. CN rose to 50/cc. This indicates that the neph leaks some with 100 hPa of vacuum. Either that, or the plumbing between the neph and CPC leaks a bit. This should be investigated further on next maintenance visit.
DEFER	Need to evaluate results from both overnight noise checks on neph and PSAP
	Re-wrapped inlet lines with foil-backed bubble-wrap
	Inventoried equipment, supplies, spares
2330Z	Finished annual maintenance, system back to normal operation

MLO online system status during maintenance and audit.
Note entries labelled USER are manual operator entries, other entries are automatic

MLO,2007,329.03272,USER: Start of annual maintenance /jo
MLO,2007,329.15166,USER: interrupting vacum to connect CPC#2
MLO,2007,329.16034,USER: modified cpd.ini for CNA=CNC#2, on CHAN2 of pulse counter. Haven't calibrated flowrate yet, though. Restarting CPD next
MLO,2007,329.16058,uMAC-1: comms restored
MLO,2007,329.16058,uMAC-1: unable to init comms
MLO,2007,329.16183,USER: CNC#2 sampling room air
MLO,2007,329.16473,USER: aded butanol to both CPC's
MLO,2007,329.17568,USER: taking CNC#1 off ambient air
MLO,2007,329.17998,USER: both CPC's sampling from mixing chamber, which is sucking from normal CNC sample line (front of impactor box)
MLO,2007,329.18142,USER: mixing chamber valve closed, should be flushing with filtered air
MLO,2007,329.18285,USER: turning off inlet heater
MLO,2007,329.18571,USER: opening up inlet to impactor box, installing HEPA filter
MLO,2007,329.18964,USER: HEPA filter connected to inlet of impactor box. All instruments on filtered air
MLO,2007,329.19063,USER: adjust PSAP flow to normal 1.0 slpm
MLO,2007,329.21164,USER: install Parker capsule filter on inlet to mixing chamber
MLO,2007,329.63307,USER: removing Parker filter from mixing chamber inlet, move to inlet of CPC#1 (s/n 189)
MLO,2007,329.63436,USER: CPC#1 count rate dropped immediately to zero with Parker filter on inlet.
MLO,2007,329.63574,USER: take filter off CPC#1, move to #2
MLO,2007,329.63697,USER: CPC#1 on room air, #2 on filter. CPC#2 count rate dropped immediately to zero with filter
MLO,2007,329.63880,USER: CPC#1 sampling from mixing chamber, which is connected to impactor box CPC sampling port
MLO,2007,329.64039,USER: connecting CPC#2 to mixing chamber
MLO,2007,329.64101,USER: both CPC's on mixing chamber now

MLO,2007,329.68307,USER: CPC#2 looks pretty unresponsive, reading fairly constant 100/cc. CPC#1 more variable, and higher
MLO,2007,329.68360,USER: mixing chamber now sampling room air
MLO,2007,329.68493,USER: created CN burst with butane lighter
MLO,2007,329.68850,USER: turned on internal fan in mixing chamber
MLO,2007,329.68931,USER: another CN burst generated w/butane lighter
MLO,2007,329.69830,USER: CPC's are tracking much more closely now that fan in mixing chamber is on
MLO,2007,329.69944,USER: another CN burst generated
MLO,2007,329.70681,USER: CPC#1 counts ~25% low at high conc (1000/cc), only about 10% low at low conc (10/c)
MLO,2007,329.70734,USER: switching mixing chamber inlet back to normal sample port on impactor box
MLO,2007,329.70795,USER: now sampling out side air with mixing chamber
MLO,2007,329.73895,USER: restart cpd with new CPC flow cal. Cal shift since last year is 0.9%.
MLO,2007,329.73912,uMAC-1: comms restored
MLO,2007,329.73912,uMAC-1: unable to init comms
MLO,2007,329.74013,USER: both cpc's back on mixing chamber
MLO,2007,329.74071,USER: ending neph and PSAP filtered air check
MLO,2007,329.77659,TSI Neph-1: span check started
MLO,2007,329.77703,USER: CO2 tank 400psi, regulator 25psi
MLO,2007,329.77957,USER: CO2 flow 7 lpm
MLO,2007,329.79464,TSI Neph-1: span check ended normally
MLO,2007,329.82657,uMAC-1: unable to init comms
MLO,2007,329.82659,uMAC-1: comms restored
MLO,2007,329.87362,USER: shutting down for inspection
MLO,2007,330.00586,CN3760-1: comms restore failed
MLO,2007,330.00586,CN3760-1: unable to init comms
MLO,2007,330.00586,PSAP-3W: unable to init comms
MLO,2007,330.00586,uMAC-1: unable to init comms
MLO,2007,330.00587,uMAC-1: comms restored
MLO,2007,330.00590,PSAP-3W: comms restore failed
MLO,2007,330.00686,CN3760-1: comms restored

MLO,2007,330.00772,CN3760-1: comms lost
MLO,2007,330.00774,CN3760-1: comms restored
MLO,2007,330.01700,USER: RH_Inlet and RH_sample are read from the same physical sensor, but have different calibrations. RH_sample cal is from 2006, RH_Inlet cal has no date. Use RH_Sample
MLO,2007,330.01747,USER: Updating cpd.ini to remove confusion about different calibrations for same physical sensor RH_Inlet/Sample
MLO,2007,330.01824,USER: restarting with revised cpd.ini
MLO,2007,330.01847,PSAP-3W: unable to init comms
MLO,2007,330.01847,uMAC-1: comms restored
MLO,2007,330.01847,uMAC-1: unable to init comms
MLO,2007,330.01851,PSAP-3W: comms restore failed
MLO,2007,330.02742,PSAP-3W: comms restored
MLO,2007,330.02751,USER: PSAP sampling room air
MLO,2007,330.06376,CN3760-1: comms lost
MLO,2007,330.06380,CN3760-1: comms restore failed
MLO,2007,330.06404,CN3760-1: comms restored
MLO,2007,330.17197,uMAC-1: comms restored
MLO,2007,330.17197,uMAC-1: unable to init comms
MLO,2007,330.17655,uMAC-1: comms restored
MLO,2007,330.17655,uMAC-1: unable to init comms
MLO,2007,330.18003,USER: running LiveCPD ver 2007-11-15
MLO,2007,330.18448,USER: drained butanol from CPC#2, running on fumes now
MLO,2007,330.76049,USER: wind speed and direction agree well with station wind bird.
MLO,2007,330.76140,USER: statioon 165 deg at 20 mph. Aerosol wind bird 160 deg at 6 m/s.
MLO,2007,330.76367,uMAC-1: comms restored
MLO,2007,330.76367,uMAC-1: unable to init comms
MLO,2007,330.82457,USER: restart cpd with new Q_Analyzer calibration
MLO,2007,330.82476,uMAC-1: comms restored
MLO,2007,330.82476,uMAC-1: unable to init comms
MLO,2007,330.85249,USER: disconnected CPC sample line at back of impactor box
MLO,2007,330.89644,USER: lock on 1um cut for leak testing
MLO,2007,330.89690,USER: switching CNC to sample from neph exhaust

MLO,2007,330.89760,USER: dP_neph 5.8 hPa, Ncnc=210/cc
MLO,2007,330.90141,USER: dP neph = 16 hPa, Ncnc=35 with filter on main inlet
MLO,2007,330.91238,USER: re-enable cutpoint scanning
MLO,2007,330.91315,uMAC-1: comms lost
MLO,2007,330.91317,uMAC-1: comms restore failed
MLO,2007,330.91370,uMAC-1: comms restored
MLO,2007,330.92878,USER: reconected CN sample line
MLO,2007,330.92885,USER: removed splitter
MLO,2007,331.13591,TSI Neph-1: comms lost
MLO,2007,331.13598,TSI Neph-1: comms restore failed
MLO,2007,331.13598,TSI Neph-1: unable to stop neph reports
MLO,2007,331.22409,TSI Neph-1: comms restored
MLO,2007,331.22536,TSI Neph-1: comms lost
MLO,2007,331.22824,TSI Neph-1: comms restored
MLO,2007,331.25721,Aerosol Contamination: Neph impactor dP too high, analyzers bypassed. Check the manual ball valve
MLO,2007,331.26215,Aerosol Contamination: Neph impactor dP bypass lock released
MLO,2007,331.26273,Aerosol Contamination: Neph impactor dP too high, analyzers bypassed. Check the manual ball valve
MLO,2007,331.26346,Aerosol Contamination: Neph impactor dP bypass lock released
MLO,2007,331.26348,Aerosol Contamination: Neph impactor dP too high, analyzers bypassed. Check the manual ball valve
MLO,2007,331.26400,Aerosol Contamination: Neph impactor dP bypass lock released
MLO,2007,331.26402,Aerosol Contamination: Neph impactor dP too high, analyzers bypassed. Check the manual ball valve
MLO,2007,331.26436,Aerosol Contamination: Neph impactor dP bypass lock released
MLO,2007,331.26441,Aerosol Contamination: Neph impactor dP too high, analyzers bypassed. Check the manual ball valve
MLO,2007,331.26486,Aerosol Contamination: Neph impactor dP bypass lock released
MLO,2007,331.28201,TSI Neph-1: comms lost
MLO,2007,331.28207,TSI Neph-1: comms restore failed
MLO,2007,331.28207,TSI Neph-1: unable to stop neph reports
MLO,2007,331.30201,TSI Neph-1: comms restored
MLO,2007,331.30648,USER: Sample heater ON

MLO,2007,331.30672,USER: All instruments connected, but still using old calibrations.
MLO,2007,331.31422,USER: add butanol to cpc#1
MLO,2007,331.31635,USER: heater off
MLO,2007,331.31831,USER: HEPA filter on inlet to impactor box, cutpoint scanning OFF, cut size 10um, for overnight noise check
MLO,2007,331.70289,uMAC-1: comms restored
MLO,2007,331.70289,uMAC-1: unable to init comms
MLO,2007,331.79484,USER: restarting cpd with all new calibrations entered into cpd.ini /jo
MLO,2007,331.79528,Aerosol: cannot open cn ambient counter: "CNC2"
MLO,2007,331.79528,Aerosol: PORT_openshm: open: No such file or directory
MLO,2007,331.79528,CN3760#405: cannot open CN counter, aborting
MLO,2007,331.79528,CN3760#405: PORT_openshm: open: No such file or directory
MLO,2007,331.79528,uMAC-1: comms restored
MLO,2007,331.79528,uMAC-1: unable to init comms
MLO,2007,331.80263,USER: After calibration of RH_Inlet, the PID display reads 41.1 when cpd shows 43.1. Adjust PID setpoint to 38% percent to account for difference /jo
MLO,2007,331.80398,USER: reconnected sample line to impactor box inlet, end of filtered air test
MLO,2007,331.80446,USER: CPC inlet tube a back of impactor box had broken off. Replaced it.
MLO,2007,331.80700,Aerosol: cannot open cn ambient counter: "CNC2"
MLO,2007,331.80700,uMAC-1: comms restored
MLO,2007,331.80700,uMAC-1: unable to init comms
MLO,2007,331.80867,USER: Inlet heater ON
MLO,2007,331.82148,USER: heater off for some more leak tests, CPC switched to sample from neph outlet.
MLO,2007,331.82306,USER: filter on neph inlet, dP across filter is about 110 hPa. Used an old Parker at inlet to HEPA filter to get more presure drop
MLO,2007,331.82669,USER: 3-way valve at CPC inlet is leaky. The side port is secured with silicone sealant only, and it's loose. Need to send a replacement 3-way valve.
MLO,2007,331.82683,USER: Can't do leak checks with a leaky valve.
MLO,2007,331.84376,USER: connect 1/4" tube from neph outlet to inlet port of 3-way valve on CPC (not side port)
MLO,2007,331.84450,USER: HEPA filter on neph inlet

MLO,2007,331.84503,USER: Ncnc dropped from 140/cc to 6/c with HEOP filter on neph inlet

MLO,2007,331.84569,USER: Neph is essentially at room pressure, though. HEPA filter alone at 30 lpm has minimal pressure drop

MLO,2007,331.84608,USER: attaching a Parker filter at inlet to HEPA filter on neph inlet to give more pressure drop

MLO,2007,331.84719,USER: Parker filter gave another 10 hPa of pressure drop. Now Ncnc is up to 50/cc. This suggests a leak in the neph or associated tubing.

MLO,2007,331.85233,USER: return neph and CPC to normal sampling configuration, inlet heater back ON

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MLO,2007,337.91095,TSI Neph-1: span check started

MLO,2007,337.91285,USER: CO2 330 psig, 25 psi, 7 lpm /jo

MLO,2007,337.92900,TSI Neph-1: span check ended normally

MLO,2007,338.03249,USER: reboot to move USB flash drive to a different port /jo

MLO,2007,338.03872,Aerosol: cannot open cn ambient counter: "CNC2"

MLO,2007,338.03872,uMAC-1: unable to init comms

MLO,2007,338.03873,uMAC-1: comms restored

MLO,2007,338.04909,USER: replaced leak check valve at CPC inlet with a new valve /jo