Intercomparison of integrating nephelometers
Project No.: IN-2020-2-2

Basic informations:

Location of the quality assurance:	TROPOS, Lab 121
Date:	29 June - 03 July 2020

Principal Investigator	Home Institution	Participant	Instrument
S. Crumeyrolle	LOA	S. Crumeyrolle	17-0818

1 Intercomparison summary

Status on arrival

No issues due to transportation or other damages. The inlet system is slightly modified, but fully functional.

Zerocheck

The noise level of the instrument is in the normal range. The average noise (1σ) for the all wavelengths was less eqal $0.69\,\mathrm{Mm}^{-1}$ for one minute averaging time. The background level was acceptable with deviations of less equal $0.56\,\mathrm{Mm}^{-1}$ for all wavelengths.

Spancheck

The span check was acceptable with deviations of less equal 4.5 %.

Inspection

The measuring cell was contaminated with a few larger particles. The mesuring cell was cleaned. Due to the good performance (and the selected high number of angles), the device was not recalibrated.

Comparison to reference nephelometer

Before inspection and recalibration

The results from intercomparisson to reference device were acceptable with deviations in the range of $-7.0\,\%$ to $1.8\,\%$.

After inspection and recalibration

The results from intercomparisson to reference device were acceptable with deviations in the range of $-6.2\,\%$ to $2.4\,\%$.

Recommendations

No recommenations.

Overall assessment

The instrument meets the requirements.

2 Details

Configuration parameters

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CONFIGURATION REPORT=, 25/06/2020 05:42:40
Serial Number        =, 170818
Version Major        =, 1
Version Minor        =, 37
Version Revision     =, 1
Date Format          =, D/M/Y
Temperature Unit     =, C
AtmPressureUnit      =, mb
Int Heater           =, 1
Ext Heater           =, 0
Desired RH           =, <60%
Normalise to         =, 0C
AutoCal Frequency    =, 24hrs
Span Gas             =, CO2
Full Scale Coeff     =, 2000
CalibrationMinTime   =, 30
CalibrationMaxTime   =, 30
CalStabilityTarget   =,  95.000
CalPressureX         =,  1007.900024
CalPressureY         =,  26525.001953
CalThermistor Fctr   =,  18338.511719
CalVaisalaTempOff    =,  233.320709
Module Address       =, 0
Baud Rate 0          =, 38400
Baud Rate 1          =, 38400
Parity 0             =, 0
Parity 1             =, 0
RH Buffer            =,  2.000000
Cal RH Gradient      =,  1.000000
Cal RH Offset        =, -1.027412
Logging Period       =, 1 min
Auto Cal Type        =, ZroChk
Output ServicePort   =, 1 sec
Custom Span Gas      =,  1.000000
Filtering Method     =, Kalman
RH Reset             =,  0.030000
RH Deriv             =,  0.030000
RH Gain              =,  1.000000
Smart 1 Enabled      =, 255
Smart 2 Enabled      =, 255
Smart 3 Enabled      =, 255
STP Correction       =,  1.000000
ST Correction        =,  0.700, 0.650, 0.150
Wavelength 1         =, 635nm
Wavelength 2         =, 525nm
Wavelength 3         =, 450nm
SLKal R span         =,  0.000200, 0.000200, 0.000200
SLKal R zero         =,  0.000300, 0.000300, 0.000300
SLKal sample period  =,  1.000, 1.000, 1.000
SLKal R spike prot   =,  2.500, 2.500, 2.500
SLKal Q upper lim    =,  0.400, 0.400, 0.400
SLKal Q lower lim    =,  5.000, 5.000, 5.000
SLKal Q tau          =,  20.000, 20.000, 20.000
SLKal R tau          =,  600.000, 600.000, 600.000
SLKal min gain       =,  0.010, 0.010, 0.010
SLKal max gain       =,  0.500, 0.500, 0.500
Cal Amb Pressure X   =,  0.000000
Cal Amb Pressure Y   =,  0.000000
Service Port         =, Menu
BackScatterEnabled   =, 1
WetNeph humidifier   =, 0
UncalibratedStatus   =, 0
Data Log Param       =, Sigmas
Angle Count          =, 18
Angle List           =, 0,10,15,20,25,30,35,40,45,50,55,60,65,70,75,80,85,90
Calibration Ms    1 =,  0.000176, 0.000177, 0.000178, 0.000187, 0.000190, 0.000184, 0.000187,
     0.000186, 0.000187, 0.000194, 0.000183, 0.000187, 0.000191, 0.000189, 0.000194, 0.000198,
     0.000194, 0.000182
Calibration Ms    2 =,  0.000210, 0.000203, 0.000209, 0.000207, 0.000210, 0.000211, 0.000210,
     0.000210, 0.000214, 0.000209, 0.000211, 0.000213, 0.000209, 0.000211, 0.000214, 0.000208,
     0.000215, 0.000215
Calibration Ms    3 =,  0.000169, 0.000168, 0.000169, 0.000170, 0.000170, 0.000171, 0.000172,
     0.000172, 0.000171, 0.000171, 0.000172, 0.000173, 0.000172, 0.000173, 0.000177, 0.000174,
     0.000175, 0.000179
Calibration Cs    1 =,  0.004728, 0.004568, 0.003510, 0.002737, 0.002667, 0.002751, 0.002744,
     0.002767, 0.002811, 0.002816, 0.003020, 0.003104, 0.003264, 0.003474, 0.003662, 0.003982,
     0.004313, 0.004775
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Calibration Cs     2 =,  0.004059, 0.004163, 0.003180, 0.002723, 0.002634, 0.002592, 0.002630,
     0.002657, 0.002672, 0.002886, 0.002978, 0.003165, 0.003543, 0.003840, 0.004165, 0.004825,
     0.005272, 0.005870
Calibration Cs     3 =,  0.003211, 0.003280, 0.002453, 0.001990, 0.001950, 0.001892, 0.001913,
     0.001933, 0.002039, 0.002182, 0.002325, 0.002551, 0.002894, 0.003312, 0.003681, 0.004366,
     0.004937, 0.005539
Calibration Walls 1 =,  81.022, 80.595, 76.242, 70.938, 70.512, 72.372, 72.746, 73.767, 74.695,
      74.860, 78.062, 78.993, 80.257, 82.170, 83.362, 84.991, 86.933, 89.320
Calibration Walls 2 =,  58.901, 60.615, 53.659, 50.550, 49.993, 50.147, 51.464, 52.682, 53.463,
      57.002, 58.636, 61.078, 65.349, 68.137, 70.690, 75.331, 77.372, 80.221
Calibration Walls 3 =,  43.313, 44.269, 37.428, 32.935, 32.967, 32.830, 33.789, 34.893, 37.109,
      39.855, 42.358, 45.722, 50.289, 54.816, 58.258, 64.026, 67.925, 71.250
Last Span Checks  1 =,  11.690, 11.158, 11.011, 10.477, 10.345, 9.861, 9.491, 9.277, 8.901,
     8.809, 8.155, 7.504, 7.792, 7.246, 6.612, 6.694, 5.938, 5.427
Last Span Checks  2 =,  24.190, 23.212, 23.808, 22.836, 22.359, 21.842, 20.529, 19.800, 19.349,
      18.141, 17.222, 16.802, 15.732, 14.965, 14.738, 13.707, 13.643, 12.430
Last Span Checks  3 =,  43.311, 42.309, 42.077, 41.524, 40.337, 39.751, 37.847, 37.336, 35.069,
      33.503, 32.461, 30.935, 29.353, 27.213, 26.634, 25.135, 23.873, 22.842
Last Zero Checks  1 =, −0.090,−0.779,−0.582,−0.544,−0.934,−0.403,−0.348,−0.346,−0.327,−0.457,
     0.064,−0.412, 0.001, 0.107,−0.321,−0.052,−0.139, 0.354
Last Zero Checks  2 =, −0.281,−0.142,−0.412,−0.126,−0.341,−0.381,−0.550,−0.404,−0.271,
     0.069,−0.169,−0.238, 0.216, 0.143, 0.195, 0.537, 0.641, 0.669
Last Zero Checks  3 =,
     −0.741,−0.402,−0.377,−0.209,−0.369,−0.495,−0.339,−0.460,−0.279,−0.274,−0.012,
     0.105,−0.028, 0.280, 0.530, 0.438, 0.451, 0.609
Cal Span Xs       1 =,  16.402, 16.216, 15.990, 15.682, 15.302, 14.859, 14.366, 13.834, 13.275,
      12.699, 12.116, 11.533, 10.955, 10.387, 9.828, 9.280, 8.738, 8.201
Cal Span Xs       2 =,  35.101, 34.704, 34.219, 33.560, 32.747, 31.800, 30.745, 29.606, 28.409,
      27.177, 25.929, 24.681, 23.445, 22.228, 21.033, 19.859, 18.701, 17.551
Cal Span Xs       3 =,  65.039, 64.304, 63.405, 62.184, 60.676, 58.922, 56.967, 54.858, 52.640,
      50.356, 48.043, 45.731, 43.441, 41.187, 38.973, 36.797, 34.651, 32.520
Cal Span Ys       1 =,  0.007616, 0.007437, 0.006362, 0.005662, 0.005577, 0.005490, 0.005425,
     0.005334, 0.005294, 0.005284, 0.005234, 0.005257, 0.005359, 0.005441, 0.005568, 0.005816,
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Cal Span Ys       2 =,  0.011447, 0.011219, 0.010344, 0.009671, 0.009505, 0.009314, 0.009099,
     0.008882, 0.008739, 0.008563, 0.008458, 0.008425, 0.008444, 0.008524, 0.008669, 0.008946,
     0.009294, 0.009645
Cal Span Ys       3 =,  0.014173, 0.014052, 0.013150, 0.012561, 0.012293, 0.011991, 0.011689,
     0.011342, 0.011053, 0.010773, 0.010579, 0.010450, 0.010354, 0.010434, 0.010561, 0.010764,
     0.011018, 0.011369
Cal Span Temp        =,  300.359
Cal Span Pressure    =,  1011.087
Cal Zero Xs       1 =,  6.288, 6.217, 6.130, 6.012, 5.866, 5.697, 5.508, 5.304, 5.089, 4.869,
     4.645, 4.421, 4.200, 3.982, 3.768, 3.558, 3.350, 3.144
Cal Zero Xs       2 =,  13.457, 13.305, 13.119, 12.866, 12.554, 12.191, 11.787, 11.350, 10.892,
      10.419, 9.940, 9.462, 8.988, 8.522, 8.064, 7.614, 7.169, 6.729
Cal Zero Xs       3 =,  24.935, 24.653, 24.308, 23.840, 23.262, 22.590, 21.840, 21.031, 20.181,
      19.305, 18.419, 17.532, 16.654, 15.790, 14.941, 14.107, 13.284, 12.467
Cal Zero Ys       1 =,  0.005835, 0.005668, 0.004603, 0.003859, 0.003783, 0.003801, 0.003772,
     0.003752, 0.003763, 0.003762, 0.003869, 0.003929, 0.004067, 0.004228, 0.004393, 0.004685,
     0.004961, 0.005346
Cal Zero Ys       2 =,  0.006892, 0.006868, 0.005927, 0.005387, 0.005268, 0.005169, 0.005110,
     0.005043, 0.004998, 0.005062, 0.005079, 0.005181, 0.005422, 0.005636, 0.005892, 0.006405,
     0.006814, 0.007317
Cal Zero Ys       3 =,  0.007413, 0.007410, 0.006554, 0.006043, 0.005915, 0.005764, 0.005661,
     0.005540, 0.005495, 0.005476, 0.005489, 0.005579, 0.005754, 0.006043, 0.006319, 0.006818,
     0.007268, 0.007774
Cal Zero Temp        =,  300.142
Cal Zero Pressure    =,  1010.986
Cal ZeroAdj Xs    1 =,  6.288, 6.217, 6.130, 6.012, 5.866, 5.697, 5.508, 5.304, 5.089, 4.869,
     4.645, 4.421, 4.200, 3.982, 3.768, 3.558, 3.350, 3.144
Cal ZeroAdj Xs    2 =,  13.457, 13.305, 13.119, 12.866, 12.554, 12.191, 11.787, 11.350, 10.892,
      10.419, 9.940, 9.462, 8.988, 8.522, 8.064, 7.614, 7.169, 6.729
Cal ZeroAdj Xs    3 =,  24.935, 24.653, 24.308, 23.840, 23.262, 22.590, 21.840, 21.031, 20.181,
      19.305, 18.419, 17.532, 16.654, 15.790, 14.941, 14.107, 13.284, 12.467
Cal ZeroAdj Ys    1 =,  0.005835, 0.005668, 0.004603, 0.003859, 0.003783, 0.003801, 0.003772,
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     0.004961, 0.005346
Cal ZeroAdj Ys    2 =,  0.006892, 0.006868, 0.005927, 0.005387, 0.005268, 0.005169, 0.005110,
     0.005043, 0.004998, 0.005062, 0.005079, 0.005181, 0.005422, 0.005636, 0.005892, 0.006405,
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Cal ZeroAdj Ys    3 =,  0.007413, 0.007410, 0.006554, 0.006043, 0.005915, 0.005764, 0.005661,
     0.005540, 0.005495, 0.005476, 0.005489, 0.005579, 0.005754, 0.006043, 0.006319, 0.006818,
     0.007268, 0.007774
Cal ZeroAdj Temp     =,  300.142
Cal ZeroAdj Pressure=,  1010.986
Span Stability    1 =,  95.515, 94.325, 95.172, 96.771, 96.222, 95.919, 93.806, 92.812, 94.298,
      95.959, 94.219, 95.694, 92.248, 95.993, 95.084, 95.589, 94.856, 94.166
Span Stability    2 =,  96.309, 95.799, 96.624, 96.818, 95.708, 95.869, 95.623, 95.068, 96.321,
      95.796, 96.145, 95.551, 96.652, 96.442, 97.114, 95.905, 96.183, 96.775
Span Stability    3 =,  97.082, 96.945, 97.478, 97.050, 97.417, 96.992, 96.235, 96.944, 97.196,
      97.057, 97.869, 96.742, 97.600, 96.463, 95.524, 97.460, 97.758, 96.686
Zero Stability    1 =,  94.951, 95.457, 93.634, 89.429, 93.831, 93.889, 94.557, 94.049, 94.591,
      95.375, 94.364, 94.211, 93.206, 95.743, 95.301, 93.151, 95.720, 96.053
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Zero Stability    2 =,  91.767, 95.716, 96.418, 94.650, 95.255, 94.239, 93.407, 91.303, 95.268,
      95.510, 94.740, 94.958, 95.406, 95.427, 94.516, 94.270, 96.660, 95.620
Zero Stability    3 =,  97.085, 96.157, 95.553, 96.824, 96.737, 94.738, 96.039, 95.210, 95.695,
      95.443, 95.659, 96.064, 95.072, 95.246, 95.258, 94.653, 95.879, 96.631
Lightsource version =, 4
LED 1 Wiper         =, 120
LED 2 Wiper         =, 160
LED 3 Wiper         =, 105
Backscatter 90 deg  =, 175
Backscatter poly A  =,  5.847801
Backscatter poly B  =, -6.867001
Backscatter poly C  =,  1.167700
Backscatter poly D  =,  7.800900
V out 1 Param       =, asp 1
V out 2 Param       =, ST
I out 1 Param       =, asp 3
I out 2 Param       =, ST
I out 1 Range       =, 0-20mA
I out 2 Range       =, 0-20mA
I out 1 Zero        =,  431.
I out 1 Full        =,  3226.
I out 2 Zero        =,  431.
I out 2 Full        =,  3226.
I out 1 Offset      =, None
I out 2 Offset      =, None
V out 1 Zero        =,  409.
V out 1 Full        =,  3685.
V out 2 Zero        =,  409.
V out 2 Full        =,  3685.
V out 1 Offset      =, None
V out 2 Offset      =, None
Full Scale sigma    =, 2000
Flow Control        =, Off
MFC Size            =,  10.000000
Set Point           =,  0.000000
Flow                =,  0.000000
Voltage Mult        =,  1.000000
Readout Mult        =,  1.000000
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Zerocheck

Table 1: Noise parameters of nephelometer (SN 17-0818) measured with filtered air.

Wavelength [nm]	total scattering mean [Mm^{-1}]	total scattering std.dev. [Mm^{-1}]	backscattering mean [Mm^{-1}]	backscattering std.dev. [Mm^{-1}]
450	0.47	0.69	0.56	0.62
525	0.21	0.51	-0.07	0.58
635	-0.09	0.56	-0.11	0.48

Spancheck

Table 2: Percentage deviation of measured values from nephelometer (SN 17-0818) to theoretical values for CO2

Wavelength [nm]	total scattering deviation [%]	backscattering deviation [%]
450	-1.2	-3.2
525	-4.5	-3.5
635	-2.7	-2.9

Comparison to reference nephelometer before inspection and recalibration

Table 3: Comparison of nephelometer (SN 17-0818) to reference nephelometer Aurora4000 (SN 14-1408) before inspection and recalibration. Testaerosol is ammonium sulfate.

Wavelength	total scattering		backscattering	
[nm]	slope	R2	slope	R2
450	0.978	1	0.93	0.997
525	0.966	0.999	0.963	0.997
635	1.018	0.999	1.003	0.985

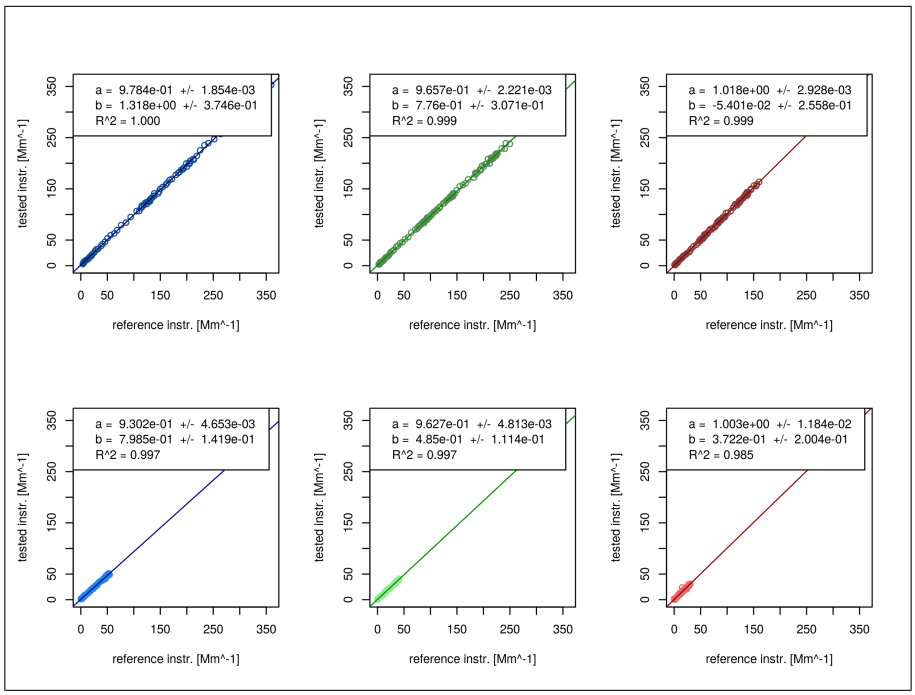

Figure 1: Correlation of scattering coefficients from nephelometer (SN 17-0818) and reference nephelometer Aurora4000 (SN 14-1408) before inspection and recalibration. Testaerosol is ammonium sulfate.

Comparison to reference nephelometer after inspection and recalibration

Table 4: Comparison of nephelometer (SN 17-0818) to reference nephelometer Aurora4000 (SN 14-1408) after inspection and recalibration. Testaerosol is ammonium sulfate.

Wavelength	total scattering		backscattering	
[nm]	slope	R2	slope	R2
450	0.989	0.999	0.938	0.994
525	0.982	0.999	0.968	0.993
635	1.009	0.998	1.024	0.991

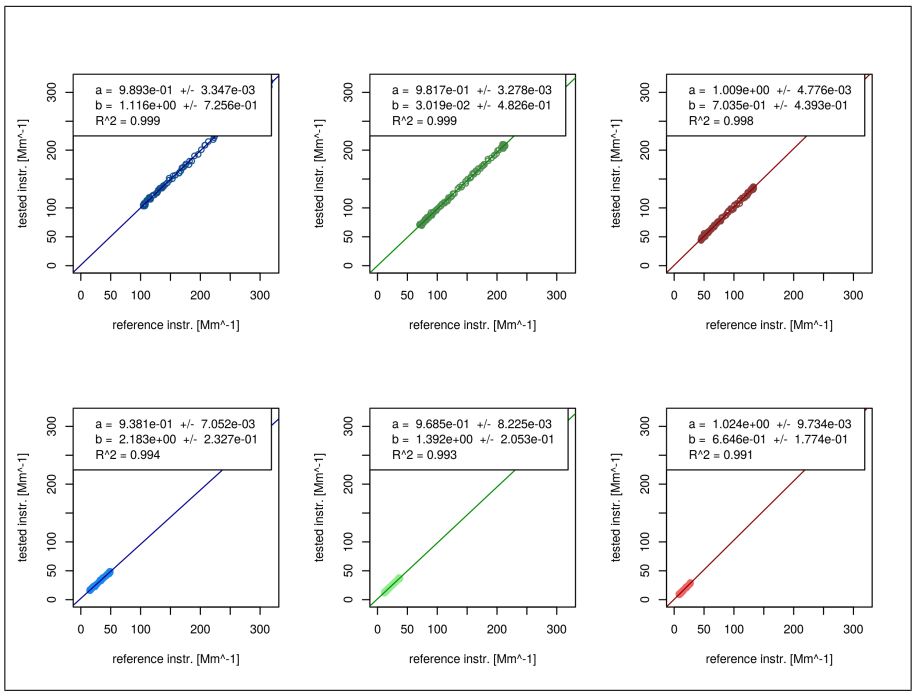

Figure 2: Correlation of scattering coefficients from nephelometer (SN 17-0818) and reference nephelometer Aurora4000 (SN 14-1408) after inspection and recalibration. Testaerosol is ammonium sulfate.