# TN3.1b
# Test results for the L2B processor

Reference: AE-TN-KNMI-GS-0031b

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# Change Log

| Version | Date | Comment |
|---|---|---|
| 0.1 | 03-Mar-2009 | Initial version |
| | | |
| | | |

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# 1 Introduction

The present document presents the results of the test cases that have been defined for validating the L2B processor, see [RD1].

The software versions used to produce the test results are as follows:

- E2S version 2.08 (Runtime version)
- L1B version 5.01 (Runtime version), with an updated L1B executable LBC_LOBProcMain as provided by Dorit Huber on 02-Dec-2008 [1]
- L2B version 1.33B (development version of Nov17, perforce branch nl8_CY35R1_Nov17) compiled with g95 (v.0.92, dated 05-Oct-2008) and ee_cfi version 3.7.1.
- Matlab Reading and Plotting tools version DLR_V1.00
- matlab version 7.1.0.183 (R14) Service pack 3, dated 02-Aug-2005.

The input files used to produce the test results are as follows:

- default input files as distributed with each software package
- updated E2S default input and schema files from package E2S_V2.08_CharacterisationData_081202.zip
- Note that the latest MRC and RRC calibration files (file: MRC_RRC_ReferenceTDS_E2Sv2.08_L1bPv5.02_090128.zip ) based on E2S v2.08 / L1bP v5.02 where only published 30-Jan-2009 and have not been used for this test run because this was too late. Earlier MRC and RRC files from MRC_RRC_Updates_080421_E2S2.06_L1bP1.10.zip did no longer have the right format, so they also could not be used. Therefore the default MRC and RRC files as delivered with L1B v5.01 have been used.

The deviations of the default software settings used to produce the test results are as follows (unless specifically stated otherwise in the test descriptions):

- E2S: N=20 (lidarInstrumentModeParameters.xml)
- E2S: P=50 (lidarInstrumentModeParameters.xml)
- E2S: AllNoiseFlag=False (lidarInstrumentModeParameters.xml)
- E2S: PoissonNoiseFlag=False (lidarInstrumentDetectorParameters.xml)
- E2S: scanAngleControlBias=0 (aocsErrorParameters.xml)
- E2S: scanAngleDriftFlag=0 (aocsErrorParameters.xml)
- E2S: yawSteeringControlBias=0 (aocsErrorParameters.xml)
- E2S: yawSteeringDriftFlag=0 (aocsErrorParameters.xml)
- E2S: rmsErrorRoll=0 (aocsErrorParameters.xml)
- E2S: rmsErrorPitch=0 (aocsErrorParameters.xml)
- E2S: rmsErrorYaw=0 (aocsErrorParameters.xml)
- E2S: rmsErrorSatelliteAlongTrackPosition=0 (aocsErrorParameters.xml)
- E2S: rmsErrorSatelliteAcrossTrackPosition=0 (aocsErrorParameters.xml)
- E2S: rmsErrorSatelliteAltitude=0 (aocsErrorParameters.xml)
- E2S: cloudBaseHeight=0 (atmosphereCloudParameters.xml)

[1] It was posted on the eRoom in folder AEOLUS > UPLOAD_DLR > For_Uwe, see email by Dorit Huber, dated 09-Dec-2008, titled: "New L1B executable". Since that date it has been removed again from the eRoom.

- E2S: cloudThickness=0 (atmosphereCloudParameters.xml)
- E2S: cloudExtinction=0 (atmosphereCloudParameters.xml)
- E2S: cloudBackscatter=0 (atmosphereCloudParameters.xml)
- E2S: interpolateTemperatureFlag=0 (atmosphereProfileParameters.xml)
- E2S: interpolateHlosWindVelocityFlag=0 (atmosphereProfileParameters.xml)
- E2S: interpolateMolExtinctionFlag=0 (atmosphereProfileParameters.xml)
- E2S: interpolateMolBackscatterFlag=0 (atmosphereProfileParameters.xml)
- E2S: interpolateAerExtinctionFlag=0 (atmosphereProfileParameters.xml)
- E2S: interpolateAerBackscatterFlag=0 (atmosphereProfileParameters.xml)
- E2S: slsNoiseSeed=0 (satelliteParameters.xml)
- E2S: aocsNoiseSeed=0 (satelliteParameters.xml)
- E2S: gpsUtcTimeDifference=0 (satelliteParameters.xml)
- E2S: futureGpsUtcTimeDifference=0 (satelliteParameters.xml)
- L1B: Min_Num_of_Mie_Ground_Echo_Measurement_Bins=1 (L1B AuxPar)
- L1B: Min_Num_of_Rayleigh_Ground_Echo_Measurement_Bins=1 (L1B AuxPar)
- L1B: FWHM_Upper_Threshold=2.3 (L1B AuxPar)[2]
- L2B:FWHM_Upper_Threshold=2.3 (L2B AuxPar) [3]

Test results are presented in sections 4 upto 6. Section 4 provided a base test to demonstrate the proper functioning of all software packages.

[2]the default value was 2.0, this has been changed after advice from Dorit Huber in her email of 09-Dec-2008. This should solve the missing L1B results in L1B v1.10/5.01 that were found in earlier versions of the test resukts.

[3]to follow the change in L1B settings

# 2 Overview of results

Table 1 below gives a short overview of the passed/failed status of the L2BP output of all executed tests.

Table 1: Summary of all test results.

| **Test case** | **Status** | **Reason** |
|---|---|---|
| #0000 Base Reference RMS | Failed | bias too large in L2BP |
| #0001 Molecules only | Failed | bias too large in L2BP |
| #0002 aerosol bias correction on Rayleigh channel | Failed | wrong use of scattering ratio in L2BP |
| #0003 Poisson error levels test | Failed | large biasses around cloud layer in L2BP |
| #0004 | Failed | ... |
| ... | ... | ... |

# 3 Documents and acronyms

## 3.1 Applicable documents

| Code | Title | Reference | Ver. | Date |
|---|---|---|---|---|
| [AD1] | Statement of Work: Definition & Implementation of Aeolus Level 2 Processing Algorithms | AE-SW-ESA-GS-012 | draft | 25-Nov-2003 |
| [AD2] | Statement of Work: Implementation of Aeolus Level 2B/2C Processing Facility | AE-SW-ESA-GS-0117 | 1B | 16-Sep-2004 |
| [AD3] | Statement of Work: Enhanced Aeolus Level 2B/2C Functionalities & Pre-Launch Validation | AE-SW-ESA-GS-023 | 1 | 29-Nov-2005 |
| [AD4] | Statement of Work: Aeolus Level 2B/C Processor Refinement & Support Tasks | AE-SW-ESA-GS-029 | 1 | 12-Jun-2008 |
| | | | | |
| | | | | |

## 3.2 Reference documents

| Code | Title | Reference | Ver. | Date |
|---|---|---|---|---|
| [RD1] | TN3.1a Test cases for the L2B processor | AE-TN-KNMI-GS-0031b | 0.8 | 02-Mar-2009 |

## 3.3 Acronyms

| | |
|---|---|
| ADM | Atmospheric Dynamics Mission |
| AISP | Annotated Instrument Source Packet |
| AOCS | Attitude and Orbit Control System |
| BRC | Basic Repeat Cycle |
| CALIPSO | Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation |
| DE2S | DLR End-To-End Simulator |
| DEM | Digital Elevation Model |
| DWL | Doppler Wind Lidar |
| E2S | End-To-End Simulator |
| ECMWF | European Centre for Medium Range Weather Forecasting |
| HLOS | Horizontal Line-Of-Sight |
| L1B | Level 1B |
| L2B | Level 2B |
| L2Bp | L2B processor |
| LITE | Lidar In-space Technology Experiment |
| LOS | Line-Of-Sight |
| MDA | MacDonald Dettwiler and Associates |
| PBL | Planetary Boundary Layer |
| PSC | Polar Stratospheric Clouds |
| RBC | Rayleigh-Brillouin Correction |
| RMA | Reference Model Atmosphere |
| TDS | Test Data Set |

# 4 General software test case

## 4.1 Test case #0000: Base Reference

**Observations on E2S results**

t.b.d.

**Observations on L1B results**

The L1B observation level Rayleigh results show a small positive bias (at 0 m/s) this disappears at 10 m/s but is stronger at -10 m/s. At -40 m/s it is very strong (around 4 $ms^{-1}$). At +40 m/s the bias becomes negative (around -4 $ms^{-1}$).

On average over all BRC's and rangebins (but excluding the ground reflections) the Rayleigh bias is -0.6 $ms^{-1}$, and this is due to the asymmetry in bias between positive and negative windspeeds. The std of all Rayleigh results is around 2.1 $ms^{-1}$ again reflecting the strong biasses that occur at -40 and +40 $ms^{-1}$.

The L1B observation level Mie results are good. The bias is only 0.19 $ms^{-1}$ and the std only 0.29 $ms^{-1}$. Observation level ground echo hlos results for the Mie channel are close to zero, well below 0.1 $ms^{-1}$. Mie ground correction results are very small as well, most are below 0.1 $ms^{-1}$, except for the case with input hlos wind of -40 $ms^{-1}$, which has a ground correction of -0.17 $ms^{-1}$. These ground correction velocities clearly are not affected by the input ZWC file which has Mie ground correction velocities of typically -1.0 $ms^{-1}$, so each observation does have proper ground echo data.

This indicates that the ground correction works well in removing the input windspeed dependant bias (which is to be expected if the ground echo signal contains some atmospheric signal as well). The ground correction found for the same observations as reported in the L1B ZWC output file do depend on input wind velocity, and confirm this interpretation. Details are given in Table 2. Note that ground corrections are reported relative to LOS, while winds in this example are given as HLOS. Therefore the factor $1/\sin(\phi)$ needs to be applied to the ground correction result before it can be added to the hlos wind.

Table 2: Ground HLOS results and ZWC results for the Mie channel as found in test #0000. The ground bin hlos results were obtained by rerunning the test without applying ground correction. Note that ground corrections are reported relative to LOS, while winds in this example are given as HLOS.

| BRC nr | input hlos wind ($ms^{-1}$) | ground bin hlos with ground correction ($ms^{-1}$) | ground bin hlos without ground correction ($ms^{-1}$) | Mie Ground Correction Velocity ($ms^{-1}$) |
|---|---|---|---|---|
| 1 | 0.0 | -0.000184 | -0.121929 | -0.074394 |
| 2 | 0.0 | 0.001555 | -0.121485 | -0.075183 |
| 3 | 0.0 | -0.013508 | -0.134681 | -0.074040 |
| 4 | 10.0 | -0.054323 | -0.079236 | -0.015222 |
| 5 | 10.0 | 0.060567 | 0.044433 | -0.009858 |
| 6 | 10.0 | -0.062682 | -0.078200 | -0.009481 |
| 7 | -10.0 | 0.014754 | -0.099911 | -0.070055 |
| 8 | -10.0 | -0.001456 | -0.116652 | -0.070378 |
| 9 | -10.0 | 0.005790 | -0.110918 | -0.071300 |
| 10 | 40.0 | -0.004693 | 0.062761 | 0.041208 |
| 11 | 40.0 | 0.040768 | 0.093843 | 0.032423 |
| 12 | 40.0 | 0.028144 | 0.086955 | 0.035927 |
| 13 | -40.0 | -0.022063 | -0.313759 | -0.178185 |
| 14 | -40.0 | -0.033737 | -0.300220 | -0.162781 |
| 15 | -40.0 | -0.042311 | -0.311149 | -0.164215 |

Observation level ground echo hlos results for the Rayleigh channel do show a significant bias, almost independent of input wind. The ground velocity is always found to be around +0.66 $ms^{-1}$. This indicates that the ground correction works well in removing the input windspeed dependant bias (which is to be expected if the ground echo signal contains some atmospheric signal as well), but leaves a remaining constant bias.

The ground correction found for the same observations as reported in the L1B ZWC output file do depend on input wind velocity, and confirm this interpretation. Details are given in Table 3. Note that ground corrections are reported relative to LOS, while winds in this example are given as HLOS. Therefore the factor $1/\sin(\phi)$ needs to be applied to the ground correction result before it can be added to the hlos wind.

However the remaining strong bias of 0.66 $ms^{-1}$ in the Rayleigh channel hlos is strange and should not occur.

The input ZWC file has Rayleigh ground correction velocities varying around zero, with a std of around 0.1 $ms^{-1}$, so these are clearly not used here, so each observation does have proper ground echo data.

Table 3: Ground HLOS results and ZWC results for the Rayleigh channel as found in test #0000. The ground bin hlos results were obtained by rerunning the test without applying ground correction. Note that ground corrections are reported relative to LOS, while winds in this example are given as HLOS.

| BRC nr | input hlos wind ($ms^{-1}$) | ground bin hlos with ground correction ($ms^{-1}$) | ground bin hlos without ground correction ($ms^{-1}$) | Rayleigh Ground Correction Velocity ($ms^{-1}$) |
|---:|---:|---:|---:|---:|
| 1 | 0.0 | 0.664496 | 0.691702 | 0.016624 |
| 2 | 0.0 | 0.667158 | 0.691168 | 0.014671 |
| 3 | 0.0 | 0.655044 | 0.679810 | 0.015133 |
| 4 | 10.0 | 0.660023 | 0.924812 | 0.161788 |
| 5 | 10.0 | 0.660486 | 0.915295 | 0.155686 |
| 6 | 10.0 | 0.655259 | 0.908985 | 0.155019 |
| 7 | -10.0 | 0.683033 | 0.509452 | -0.106050 |
| 8 | -10.0 | 0.665807 | 0.486707 | -0.109419 |
| 9 | -10.0 | 0.672360 | 0.488064 | -0.112590 |
| 10 | 40.0 | 0.653861 | 1.543054 | 0.543214 |
| 11 | 40.0 | 0.666625 | 1.554815 | 0.542587 |
| 12 | 40.0 | 0.664954 | 1.602918 | 0.572980 |
| 13 | -40.0 | 0.677564 | -0.177266 | -0.522182 |
| 14 | -40.0 | 0.687856 | -0.184288 | -0.532747 |
| 15 | -40.0 | 0.682714 | -0.195567 | -0.536482 |

The bias in Rayleigh hlos results might be caused by a non-perfect RRC calibration file, but this should be compensated by the ground correction, which clearly is not doing the right thing here.

### Observations on L2B results

Mie results show a small bias even though the L1B Mie results are almost perfect. This Mie bias is typically around 0.6 $ms^{-1}$and does not depened on input wind. The magnitude of the bias suggests a connection to the bias found on the Rayleigh channel in the L1B results.

The Rayleigh results are very good, very small bias at 0, -10, +10 m/s, typically below 0.25 $ms^{-1}$. At -40 and +40 m/s a bias occurs of around 0.8 $ms^{-1}$.

On **average** over all BRC's and rangebins (but excluding the ground reflections) the Rayleigh bias is only 0.01 $ms^{-1}$, this is due to the symmetry in the reported biasses. The std of all Rayleigh results is around 0.54 $ms^{-1}$ but this is mainly caused by the biasses that occur at -40 and +40 $ms^{-1}$. L2B Mie results show an average bias of 0.55 $ms^{-1}$and a std of 0.19 $ms^{-1}$.

There is no L2B Rayleigh ground echo result, and the Mie ground echo result shows a similar negative bias.

### Observations on plotting tool results

The scattering ratio E2S input is not plotted correctly. Above 17km the plot is white, even though the atmosphere is defined upto 30 km. This is probably related to the fact that a single point at 30 km has been added manually, and the regular profile definition is only present between 0 and 17 km. The same problem is present in the E2S HLOS input plot The same problem is present for the E2S input HLOS data in the 1D wind plots.

**Passed or failed**

The std in the windresults for a given input windspeed is typically around 0.15 $ms^{-1}$ and 0.1 $ms^{-1}$ for the Rayleigh channel, so fairly close to the requirement. However, the wind results clearly show an unexplained bias, especially for large input winds, and the bias is way above the allowed threshold of 0.001 $ms^{-1}$for both the Mie and the Rayleigh channel. Therefore this test **failed**.

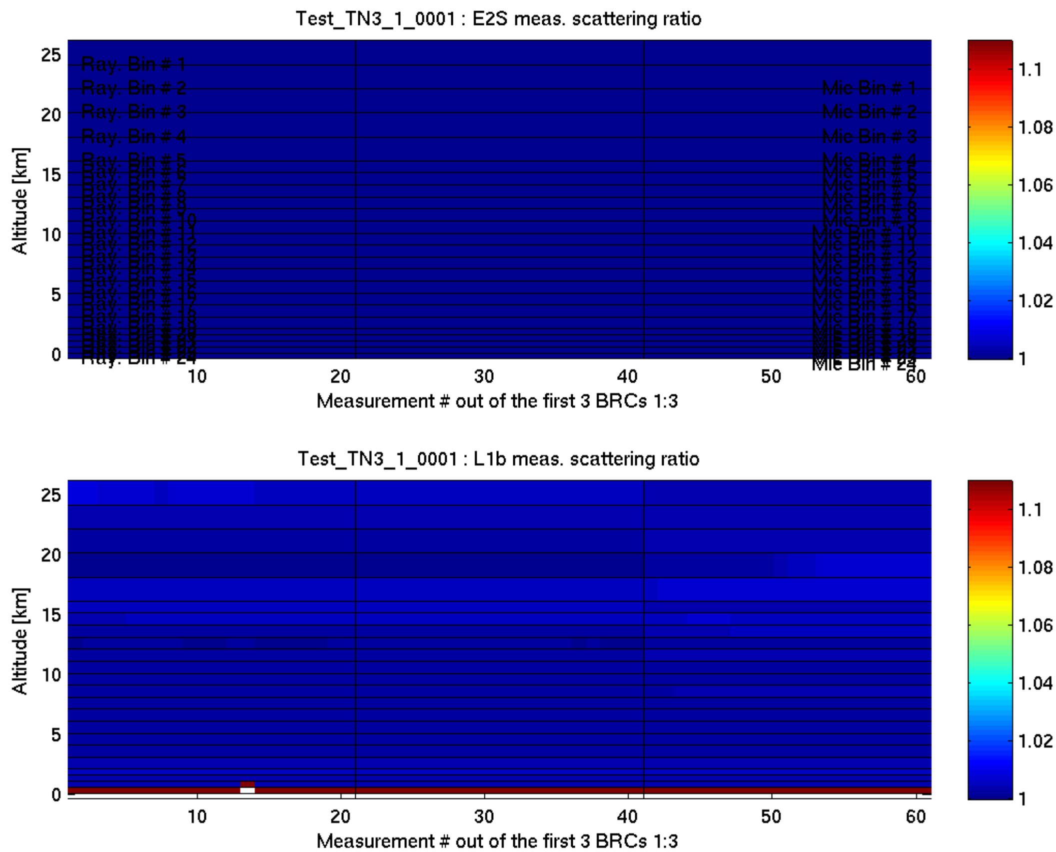


Figure 1: Scattering ratio as used for input by test #0001 (upper panel) and as retrieved by the L1B processor (lower panel).

# 5 L2B academic cases defined at Météo-France

## 5.1 Test case #0001: Molecules only

### Observations on E2S results

t.b.d.

### Observations on L1B results

Unexpectedly the scattering ratio retrieved by the L1BP on measurement level seems to show some structures, see Figure 1. It is slightly increased around 17 km altitude (to about 1.01). Also some BRC's show a gradient inside the BRC (from 1.00 to 1.01).

The observation level L1B Rayleigh hlos results show a clear response to the temperature as expected, for non-zero windspeeds. This causes errors upto 4.6 $ms^{-1}$. The lowest valid rangebin has a larger bias of 14 $ms^{-1}$, possibly due to ground contamination, because there is one measurement in this first BRC (out of the 20 measurements per BRC in this experiment) that shows some orography (clearly visible in the L1B scattering ratio plot, see lower panel of Figure 1).

The zero wind case shows still a clear bias of around 0.6 $ms^{-1}$in the Rayleigh hlos. Note that this testcase has no aerosols, so no Mie results are present, except for the ground echo.

Rayleigh ground echo hlos results are -0.46, 0.69 and 3.91 $ms^{-1}$, so 2 of them close to zero, but the 3rd one almost 4 $ms^{-1}$off. Mie ground echo hlos results are all close to zero, reported values are -0.20, -0.097

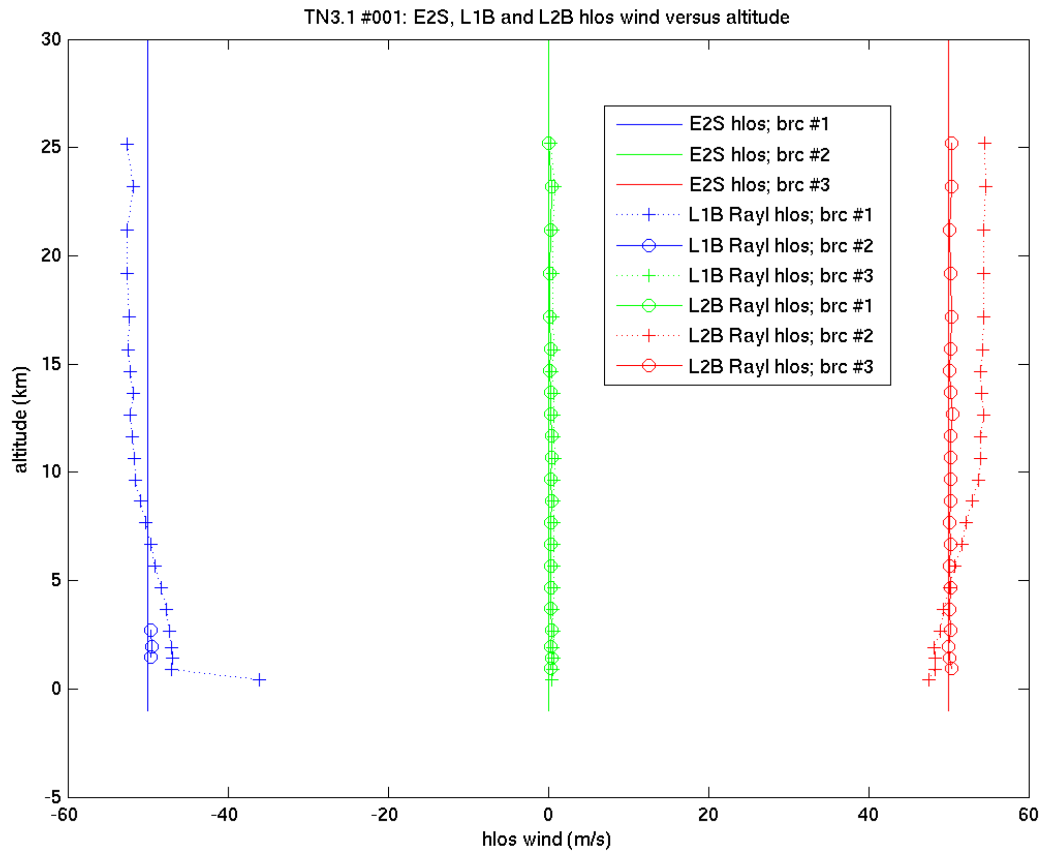


Figure 2: hlos values as retrieved by the L1B and L2B processors for the 3 BRC's of test #0001, compared to the value used for E2S input.

and -0.21 ms$^{-1}$.

The generated Mie ground correction velocities are -0.10, -0.093, -0.11 ms$^{-1}$. The generated Rayleigh ground correction velocities are -0.69, 0.017, 2.03 ms$^{-1}$.

### Observations on L2B results

L2B scattering ratio is missing for the negative windspeed case (-50 ms$^{-1}$), except for the 6 lowest rangebins. This is caused by a too strict threshold checking on the value of corr0drho produced by the L2B Rayleigh processing step. Current Thresholds are set to -1 (min) and +5 (max) values. This testcase produces values between -2.3 and -1.0 for the -50 ms$^{-1}$ input wind case.

This threshold is for now hardcoded in the hlos_retrieval module. The values have been adapted for release 1.40 to accept a wider range of cases. Moving these hardcoded values into the AuxPar file to allow easier tuning by the user will only be implemented after the 1.40 release.

L2B Rayleigh hlos results show a small bias, typically of about 0.3 ms$^{-1}$, not dependent on input wind. This is most probably caused by a non-optimal calibration file. There is no clear direct relation to the ground correction velocities reported at L1B level. The std around the retrieved hlos wind is around 0.15 ms$^{-1}$

### Observations on plotting tool results

t.b.d.

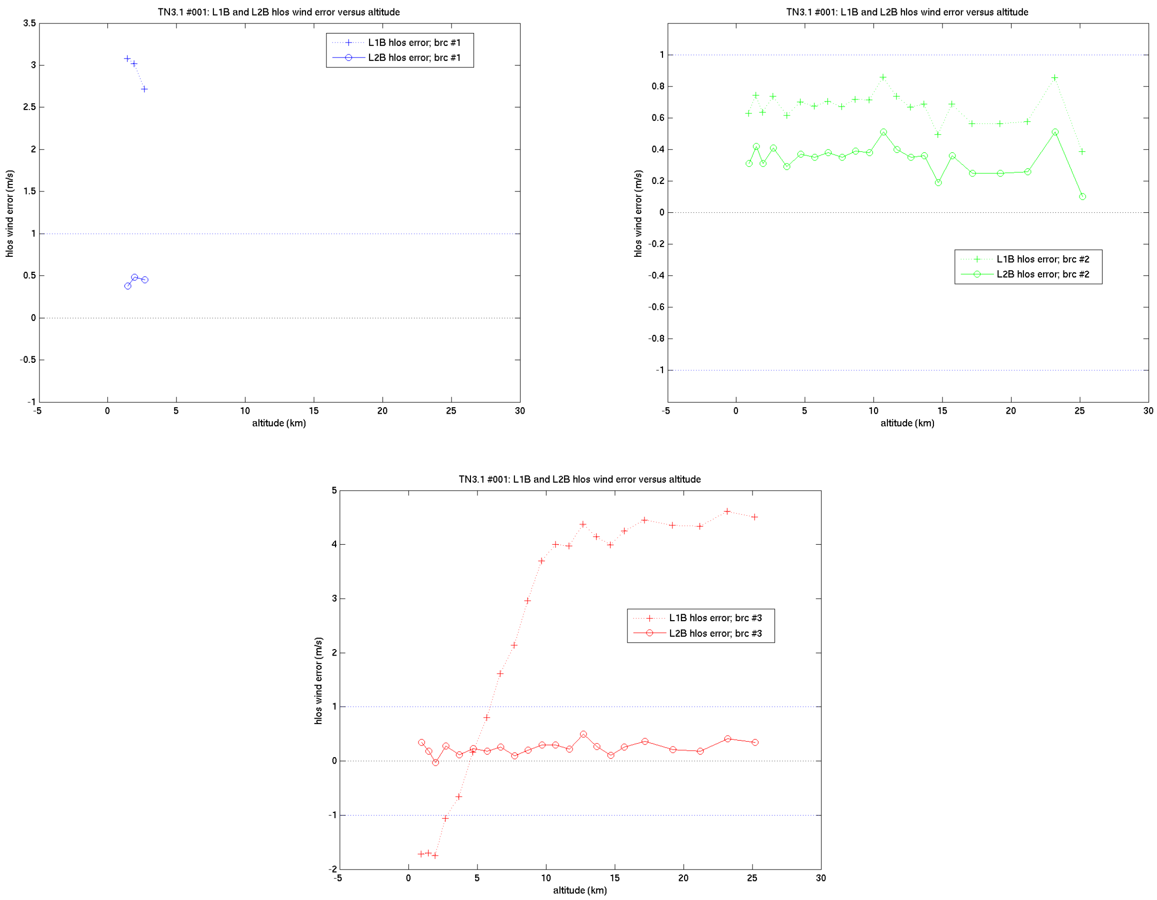


Figure 3: Error in the retrieved hlos for the L1B and L2B retrievals for brc 1 (upper left panel, input wind -50 ms$^{-1}$), brc 2 (upper right panel, input wind 0 ms$^{-1}$) and brc 3 (lower panel, input wind 50 ms$^{-1}$) as produced by test #0001. The straight lines represent the pass-fail criteria.

#### Passed or failed

The std around the retrieved L2B hlos wind is around 0.15 ms$^{-1}$, so fairly close to the requirement for the noiseless cases of 0.1 ms$^{-1}$. The errors in all L2B winds are within the required range of +/- 1 ms$^{-1}$, see Figure 3. Also the derivative of HLOS wind with respect to temperature is around the required values of -10, 0, and +10 cm.s$^{-1}$K$^{-1}$, see Figure 4. However, the results show a small positive bias of around 0.3 ms$^{-1}$, independent of input windspeed. Therefore this test **failed**.

## 5.2 Test case #0002: aerosol bias correction on Rayleigh channel

#### Observations on E2S results

t.b.d.

#### Observations on L1B results

The retreived measurement level L1B scattering ratio is as expected, see Figure 5. The 2 rangebins fully inside the cloud retrieve the correct scattering ratio. The range bin below the cloud, which partially overlaps with the cloud, gives a reduced value due to averaging over the range bin, as expected. Also the aerosol layer above the surface is retrieved well for all 3 BRC's

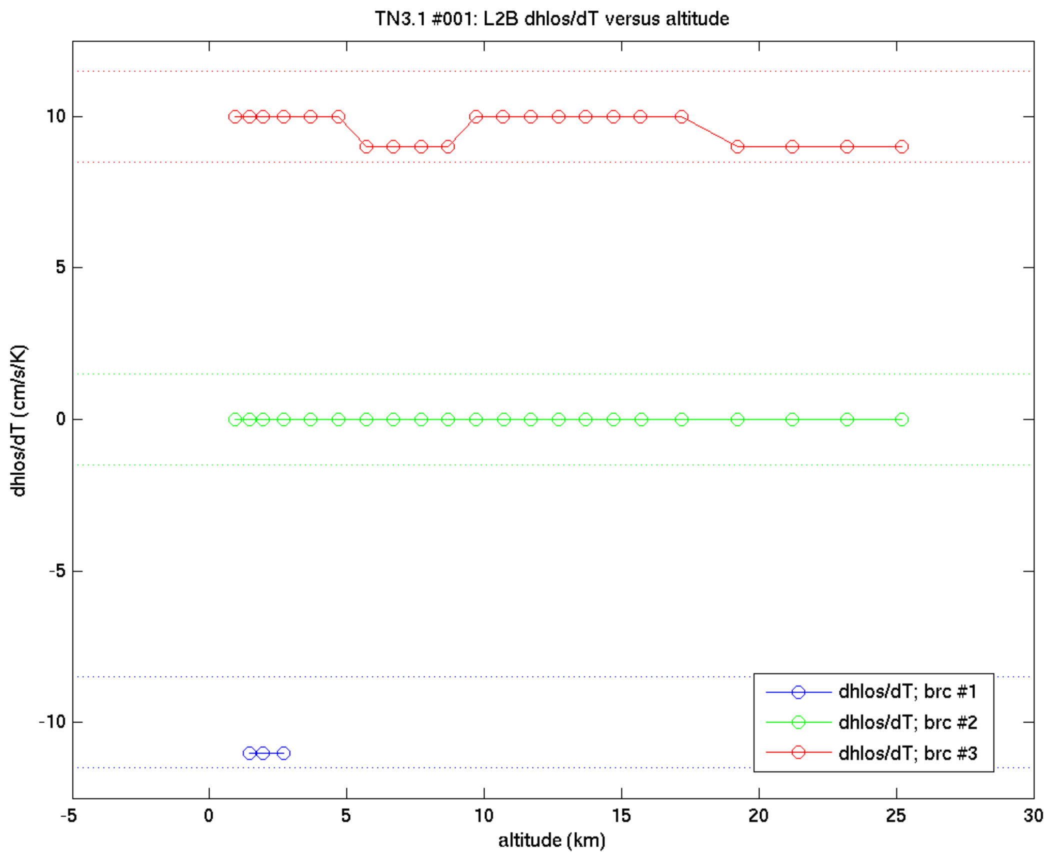


Figure 4: First order derivative of hlos to temperature for the 3 BRCs in test #0001.

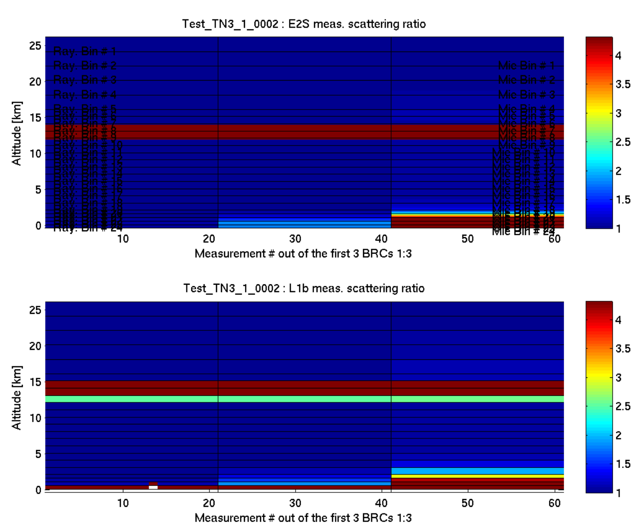


Figure 5: Scattering ratio as used for input by test #0002 (upper panel) and as retrieved by the L1B processor (lower panel).

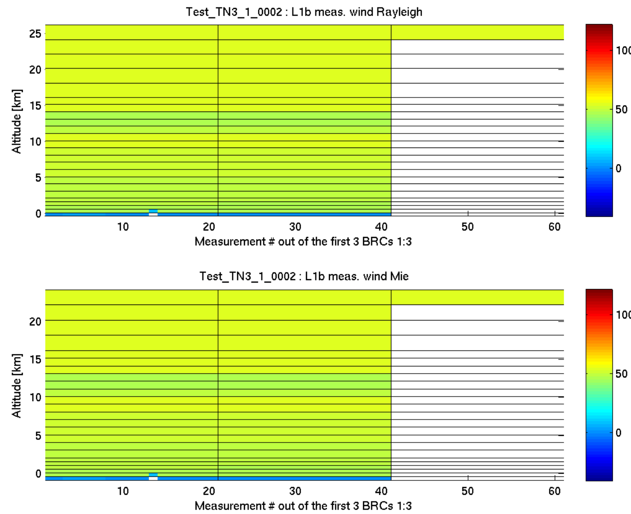


Figure 6: measurement level hlos results for test #0002 and as retrieved by the L1B processor, for the Rayleigh channel (upper panel) and the Mie channel (lower panel).

The measurement level L1B wind retrievals are clearly affected by the not-corrected cross-talk at the cloud location. For some reason most hlos results for the 3rd BRC (highest aerosol load) are missing, see Figure 6.

The observation level L1B wind retrievals are nevertheless present for allmost all rangebins for all 3 BRC's, see Figure 7. They show a clear temperature effect, and are clearly affected by the not-corrected cross-talk at the cloud location. By coincidence the two effects partially cancel each other at the location of the cloud layer.

The Rayleigh ground echo results are 1.9, 1.2 and 13.3 $ms^{-1}$. The very hight value in the 3rd BRC can be explained by the extremely high aerosol load close to the ground (without matching increased extinction).

The results reported in the ZWC file are very close to zero for both channels for the first 2 BRC's. The Mie results are -0.074, -0.035 $ms^{-1}$. The Rayleigh results are 0.78 and 0.36 $ms^{-1}$. The results of the 3rd BRC are skipped due to QC.

### Observations on L2B results

The L2B classification scheme correctly devides the scenario in clear and cloudy based on the scattering ratio retrieved in the L1B stage, both for the Mie channel, see Figure 8, and for the Rayleigh channel, see Figure 9.

However, the actual scattering ratio values plotted in this figure, as used by the L2BP are wrong. There seems to be an offset of 1 rangebin, causing the clear rangebin above the cloud to have a very high scattering ratio of above 4, and the lowest part of the cloud (which was only partially covered by the cloud) to have a scattering ratio of close to 1, see Figure 10.

The L2B wind results generally look very good, except for the cloud layer. For the Rayleigh channel, the cloudy results show a bias of 0.7, 2.5 and 2.9 $ms^{-1}$ for the 3 bins inside the cloud for all 3 BRC's. The wrong lower 2 values are caused by the shift of the scattering ratio values used to correct for the cross-talk. Only the upper cloudy rangebin has a correct scattering ratio, and thus applies this correction well and has only a small bias of 0.7 $ms^{-1}$. The aerosol affected bins in BRC 3 still give good Rayleigh results, with errors below 0.3 $ms^{-1}$. The shift in observation level scattering ratio used by the L2BP are illustrated by Figure 11.

The clear Rayleigh results show in general very good results, a bias of only 0.1 $ms^{-1}$ and a std of about 0.15 $ms^{-1}$. The exception is the rangebin just above the cloud, which uses the wrong backscatter ratio retrieved inside the cloud. This causes a bias of 5.5 $ms^{-1}$. Also the closest valid rangebin above the ground

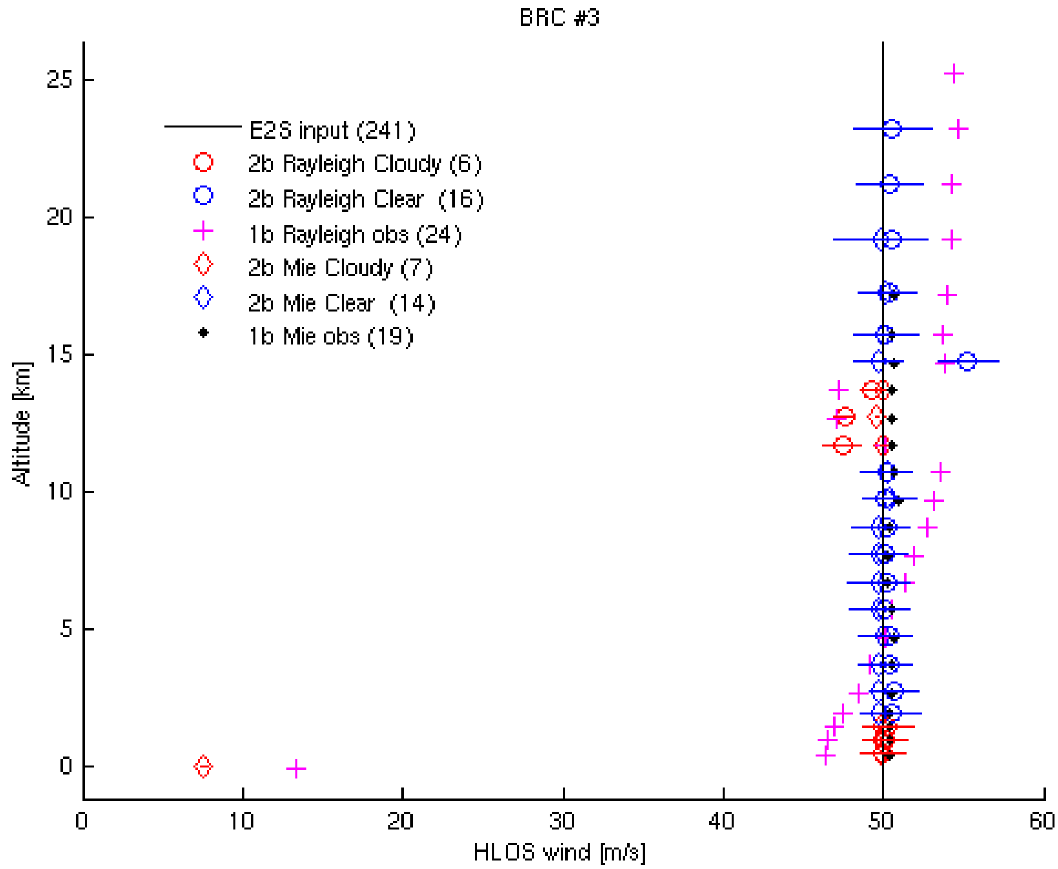


Figure 7: Observation level hlos results for test #0002 and as retrieved by the L1B and L2B processors, compared to the E2S input wind, for BRC 3.

has an increased error (or 2 bins for BRC 3).

The L2B cloudy Mie results are very good in the cloud layer. A bias of below 0.02 $ms^{-1}$ and a std of only 0.04 $ms^{-1}$ is found for the first 2 BRC's. The 3rd BRC which also includes a number of aerosol affected rangebins close to the surface, still has good results, a bias of 0.2 $ms^{-1}$ and a std of 0.1 $ms^{-1}$, except for the lowest rangebin which is contaminated by the ground echo.

The L2B clear Mie results also are very good when present (BRC 1 has no such cases due to the low aerosol content). BRC 2 shows a bias of 0.4 $ms^{-1}$ and a std of 0.3 $ms^{-1}$. BRC 3 shows a bias of only 0.14 $ms^{-1}$ and a std of 0.25 $ms^{-1}$.

The L1B and L2B hlos results are compared with the pass-fail criteria in Figure 12. The problematic Rayleigh cloud retrievals are still well within the pass-fail region, except for the rangebin just above the cloud. The Mie results are all well within the pass-fail region, except for the ground contamination present in BRC 3.

### Observations on plotting tool results

t.b.d.

### Passed or failed

The bias caused by the wrong use of scattering ratio is too large. Therefore this test **failed**.

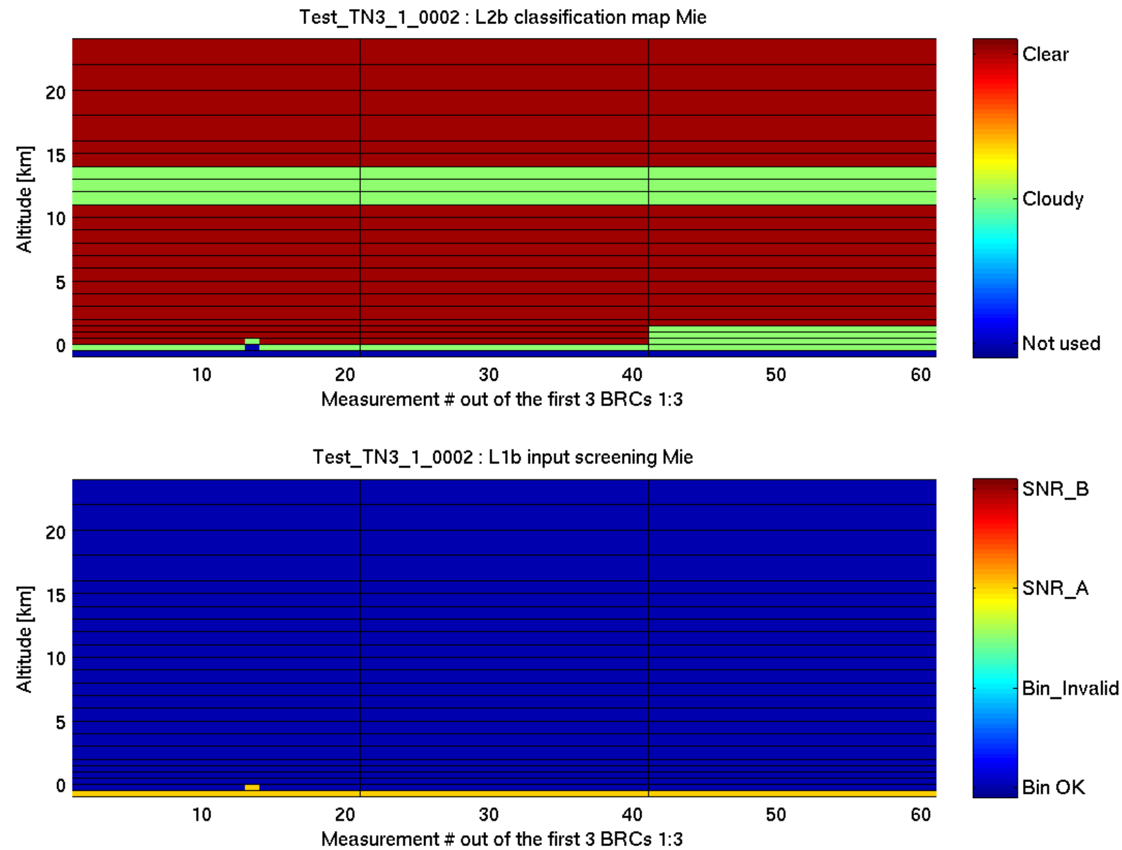


Figure 8: Classification decision by the L2B processor for the Mie channel in test #0002 (upper panel) and the L1B input screening result (lower panel).

## 5.3 Test case #0003: Poisson error levels test

### Observations on E2S results

t.b.d.

### Observations on L1B results

L1B scattering ratio results for this test look very good. Again the values inside the cloud are retrieved well, and the layer below the cloud shows a mixed result as may be expected, see Figure 13.

L1B measurement level hlos results are missing for many measurements, except for the highest rangebin, see Figure 14. This was not expected, since especially inside the cloud layer significant backscatter is present, and the L1B processor should be able to retrieve a good result there at least for the Mie channel.

### Observations on L2B results

L2B classification based on measurement level L1B scattering ratio results works fine. However, as in test #0002, the observation level scattering ratio used by the Rayleigh processing is wrong and seems shifted one level. This causes the rangebin above the cloudlayer, and the lowest rangebin inside the cloudlayer to be processed with wrong scattering ratio values, see Figure 15.

The summary statistics for this test show that the L2B Clear Rayleigh hlos results have a std and bias depending on altitude. The highest rangebin has a std of 1.8 $ms^{-1}$, gradually decreasing to a std of

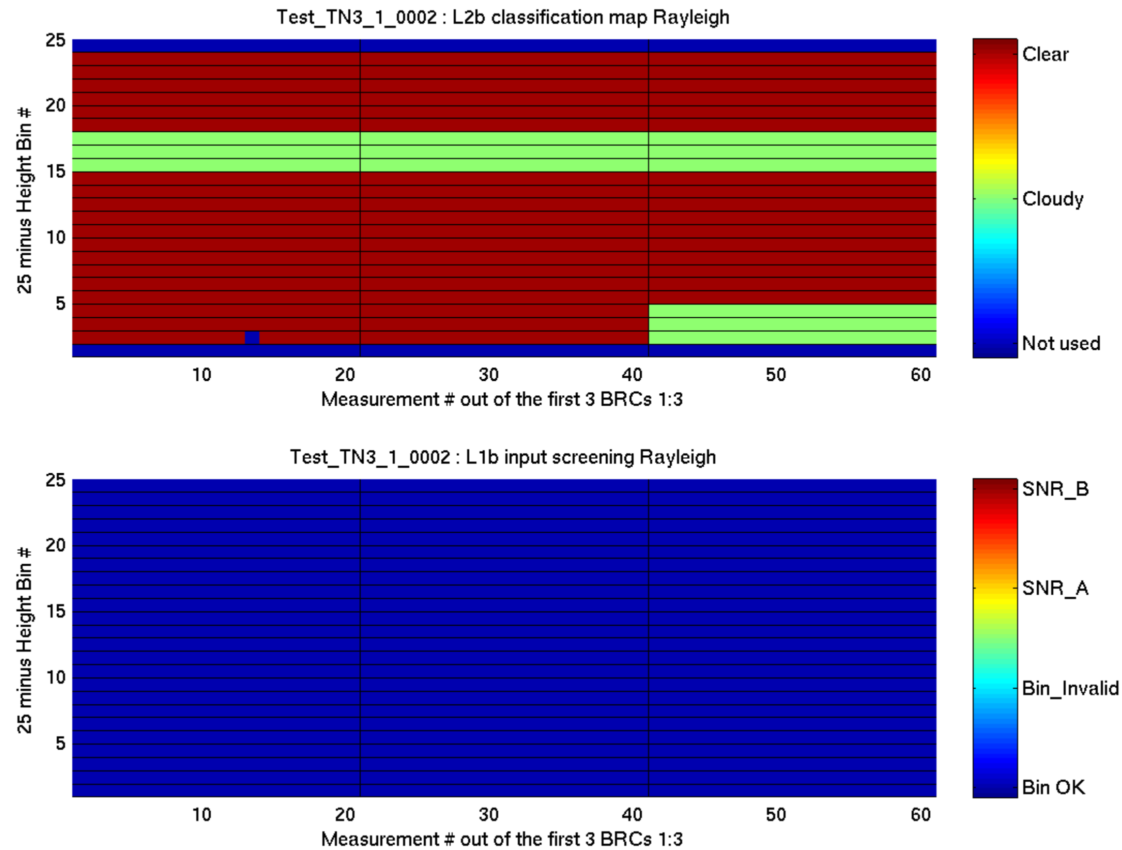


Figure 9: Classification decision by the L2B processor for the Rayleigh channel in test #0002 (upper panel) and the L1B input screening result (lower panel).

1.0 ms$^{-1}$for rangebin 17, and then increasing again. This can be explained by the raise in signal level due to increasing pressure when going down, and the increase in extinction when going even further down below rangebin 17. The only exception is the bottom of the cloud layer, where the hlos std is 3.4 ms$^{-1}$. The bias mostly is in between -0.3 and -0.7 ms$^{-1}$, but again stronger values of 2.8 and -5.3 ms$^{-1}$ are seen at the bottom and top of the cloud layer. This reflects the wrong Mie contamination correction due to the wrong scattering ratio applied at these levels. The L2B Cloudy Rayleigh results show a std between 0.5 and 0.9 ms$^{-1}$ in the cloud layer and larger values near the ground due to ground contamination for some of the BRCs. The Cloudy hlos bias is significant, above 2 ms$^{-1}$ inside the cloud.

The L2B Clear Mie hlos results show good results, std below 1 ms$^{-1}$, near the bottom layer of the cloud and in the aerosol layer near the ground. However, also very large values of 4.9 ms$^{-1}$ above the cloud, and 1.9, 3.9 and 8.0 ms$^{-1}$ in the aerosol layer are seen (although for the worst 2 cases only 2 out of 100 BRCs have a result). The aerosol std can be attributed to the mountains in this scene causing significant ground contamination for the lower 8 rangebins. The bias for these cases is modest, below 1 ms$^{-1}$ for most cases, but some huge biases occur kust below and just above the cloud (-16.8, -8.4, and 18.9 ms$^{-1}$). The reason is not yet clear.

The L2B Cloudy hlos results are very good. Inside the cloud std is only 0.2 ms$^{-1}$ and the bias is only 0.3 ms$^{-1}$. Closer to the surface again large std and bias are found due to mixing of ground echos and atmosphere, except for the lowest level (rangebin 23) which has almost only ground echo signal. This gives a hlos bias of 50.08 ms$^{-1}$ and std of only 0.3 ms$^{-1}$.

These results all indicate that more effort is needed to separate rangebins affected by ground echos, from

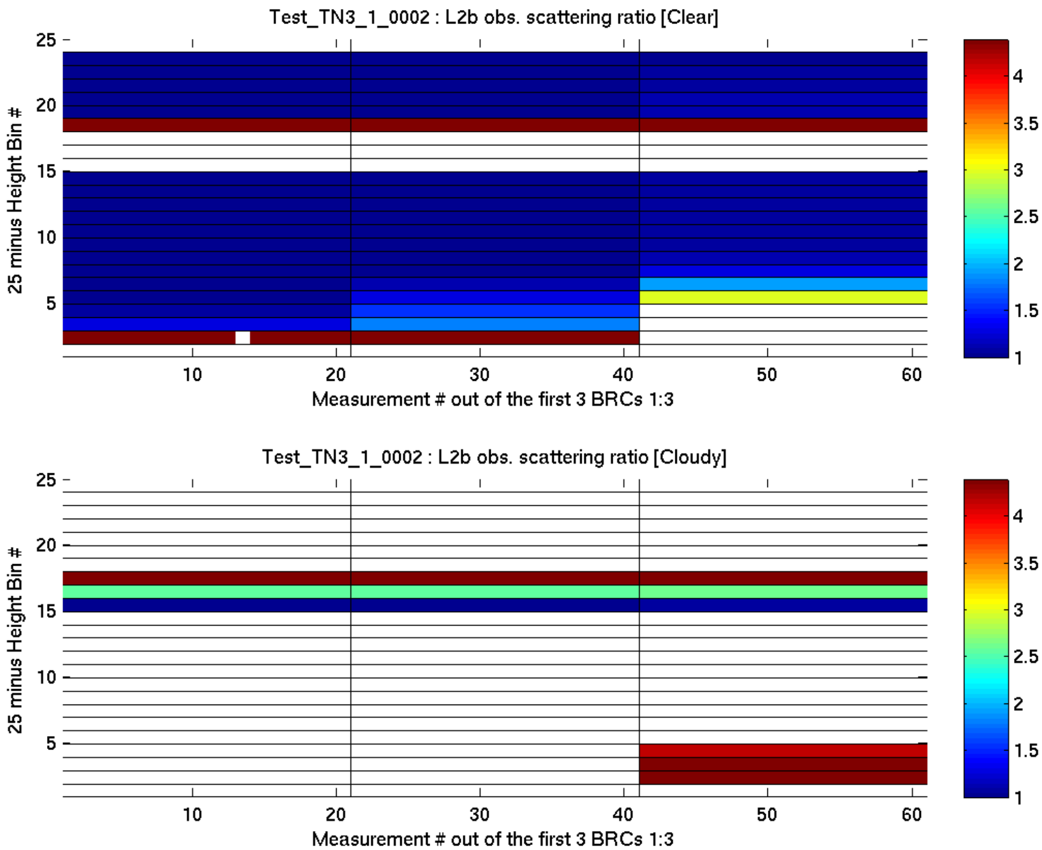


Figure 10: Scattering ratio as used by the L2B processor for the Rayleigh brillouin Correction scheme in test #0002, for clear cases (upper panel) and cloudy cases (lower panel).

the ones with atmospheric returns only.

### Observations on plotting tool results

The lower 6 rangebins of BRC 49 (to take an example on a location with a high mountain) give at first sight strange results, see Figure 16. Cloudy Mie results are plotted at 0 ms$^{-1}$ for L1B and L2B. Clear L2B Mie results are close to the input of 50 ms$^{-1}$, suggesting that the scene was correctly split into clear atmospherric rangebins, and rangebins with ground contamination. The L1B Rayleigh results are scattered and this may be caused by the strong orography causing ground contamination at many different altitudes. Some adaptation of the plotting tool to indicate which results may be affected by ground echos is needed here to allow a usefull interpretation of the result.

### Passed or failed

Very large biasses seem to occur around the cloud layer. Also the scattering ratio is used incorrectly in the L2BP. Therefore this test failed.

## 5.4 Test case #0004: Cloud detection test

### Observations on E2S results

t.b.d.

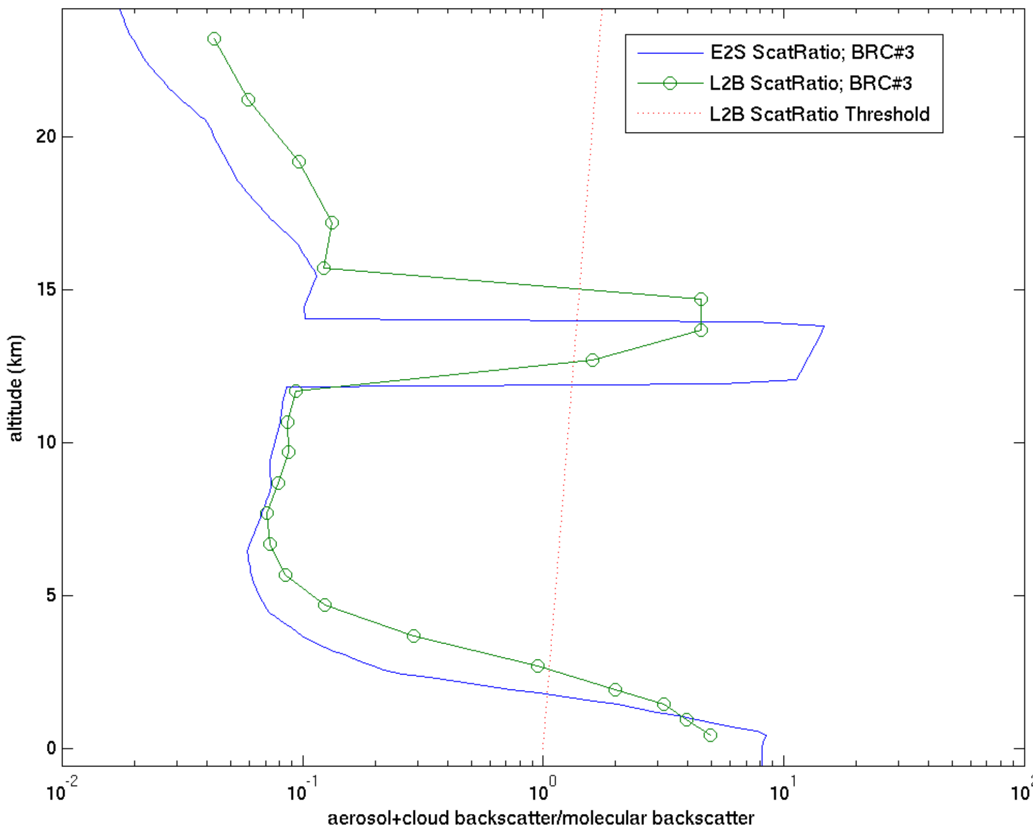


Figure 11: Scattering ratio as used by the L2B processor for the Rayleigh brillouin Correction scheme in test #0002, for BRC #3. A clear vertical shift between input and found values is seen.

### Observations on L1B results

L1B scattering ratio results for this test look very good. Again the values inside the cloud are retrieved well, and the layer below the cloud shows a mixed result as may be expected, see Figure 17.

L1B measurement level hlos results look very good. A small hlos deviation is seen inside the cloud due to uncorrected cross-talk, but this is to be expected for the Rayleigh channel, see Figure 18. By coincidence these errors compensate for the error caused by the varying temperature, which results in better Rayleigh results inside the cloud.

### Observations on L2B results

Again, as was reported for the previous 2 tests, the scattering ratio used at observation level for Rayleigh processing is wrong. See Figure 19.

This causes wrong L2B Rayleigh results just above the cloud layer. Apart from this, the classification into cloudy and clear works fine, and the winds are retrieved to sufficient precision. See Figure 20

### Observations on plotting tool results

t.b.d.

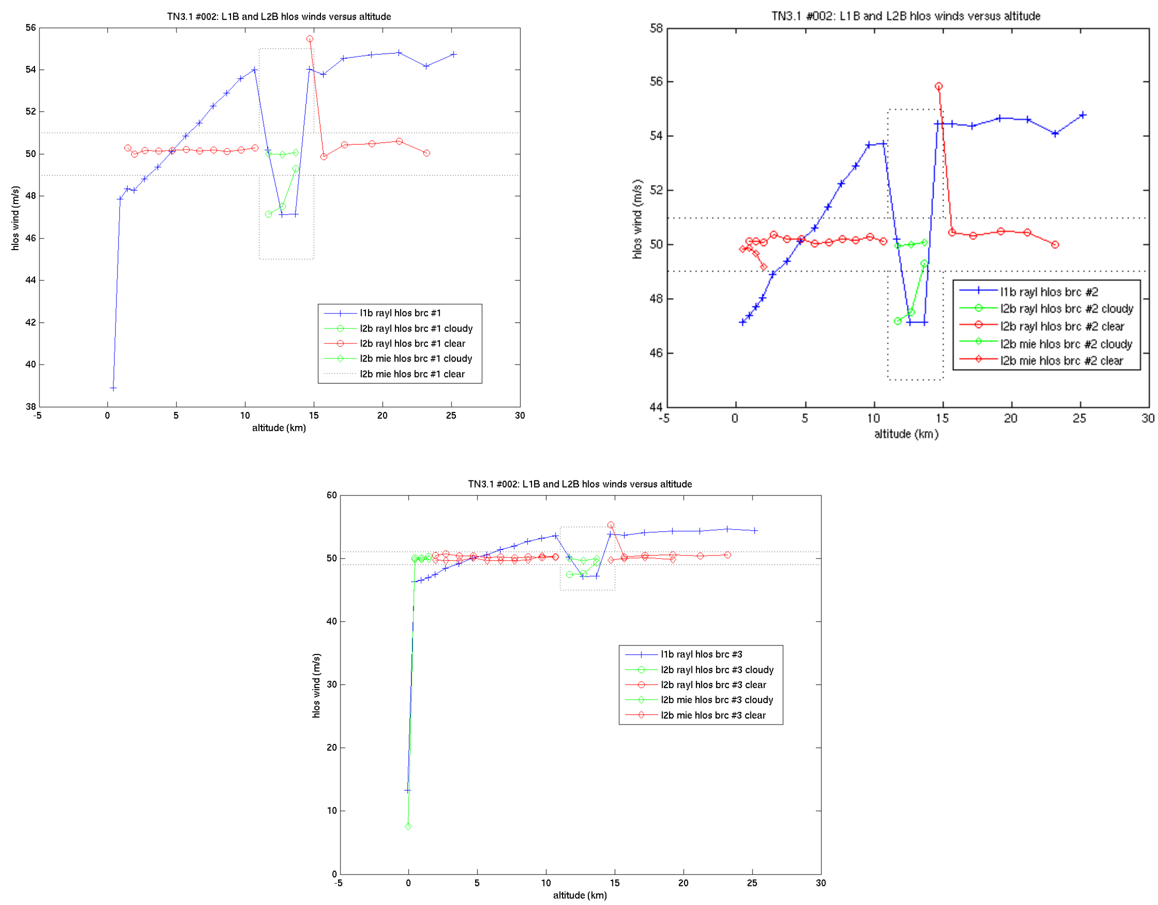


Figure 12: Retrieved L1B and L2B hlos values for brc 1 (upper left panel, low aerosol load), brc 2 (upper right panel, medium aerosol load) and brc 3 (lower panel, high aerosol load) as produced by test #0002. The dotted straight lines and squares represent the pass-fail criteria.

### Passed or failed

t.b.d. Therefore this test **failed**.

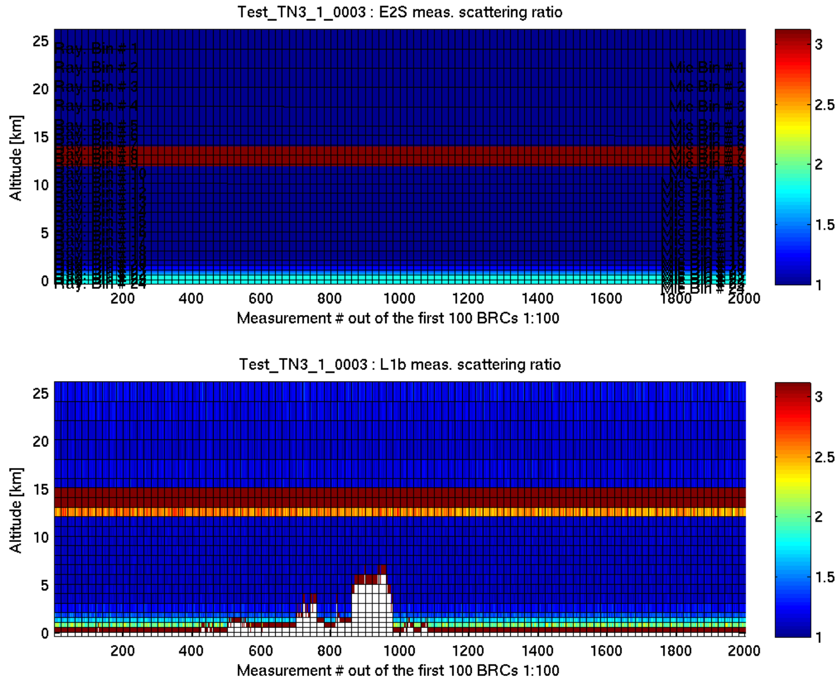


Figure 13: Scattering ratio as used for input by test #0003 (upper panel) and as retrieved by the L1B processor (lower panel).

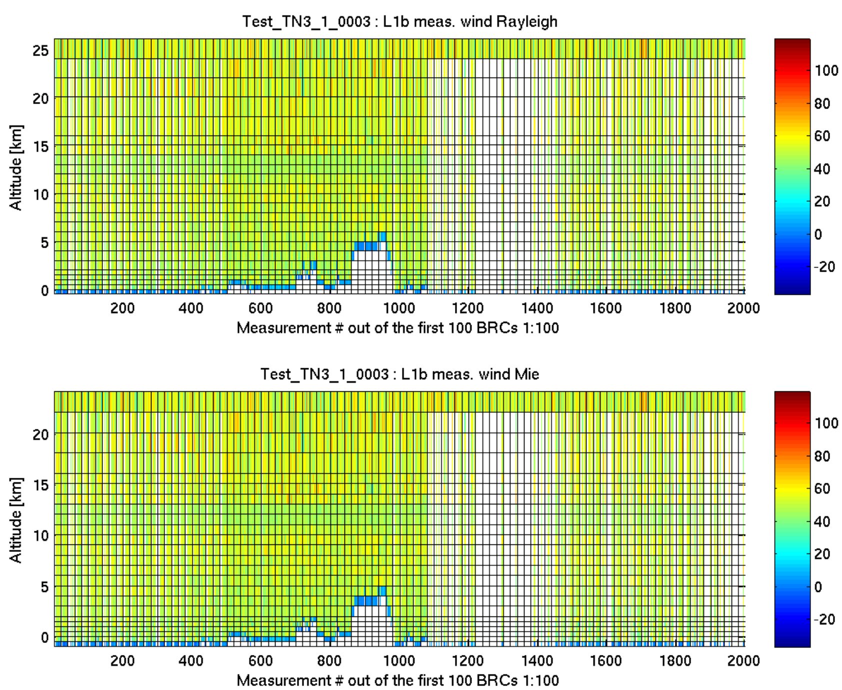


Figure 14: Measurement level L1B hlos results by test #0003, Rayleigh channel (upper panel) and Mie channel (lower panel).

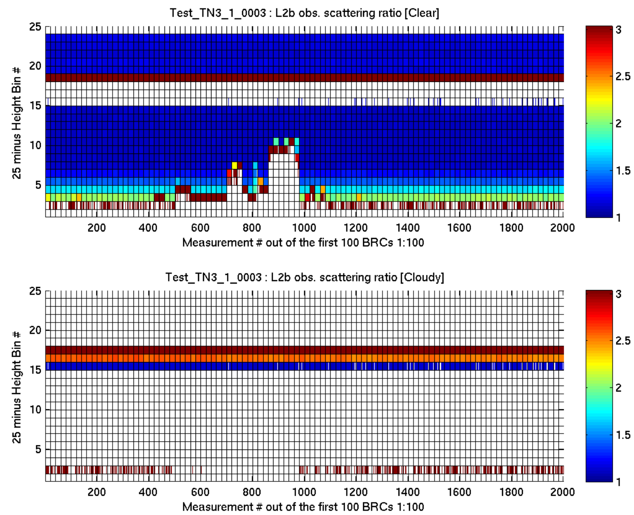


Figure 15: Observation level scattering ratio as used for input by test #0003 for clear (upper panel) and cloudy (lower panel) range bins.

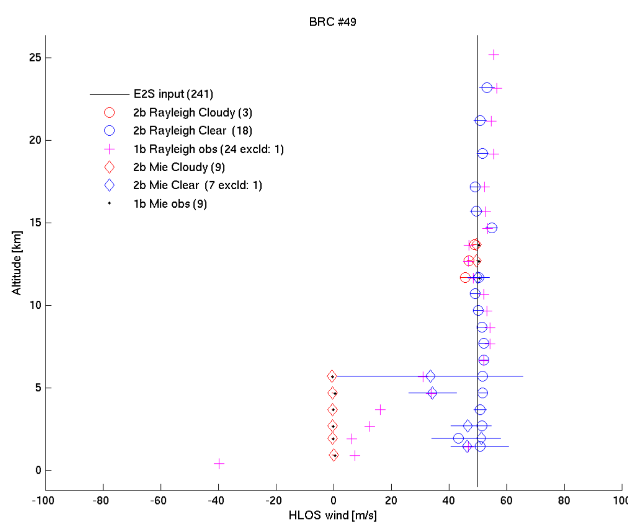


Figure 16: Observation level hlos results for L1B and L2B for test #0003. Clearly many points at the lower 6 rangebins are affected by ground echos.

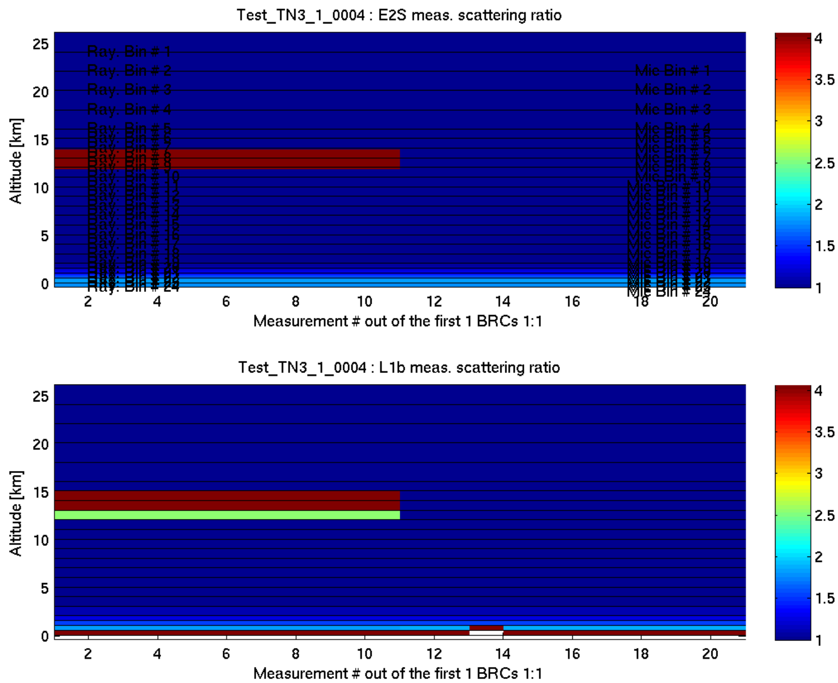


Figure 17: Scattering ratio as used for input by test #0003 (upper panel) and as retrieved by the L1B processor (lower panel).

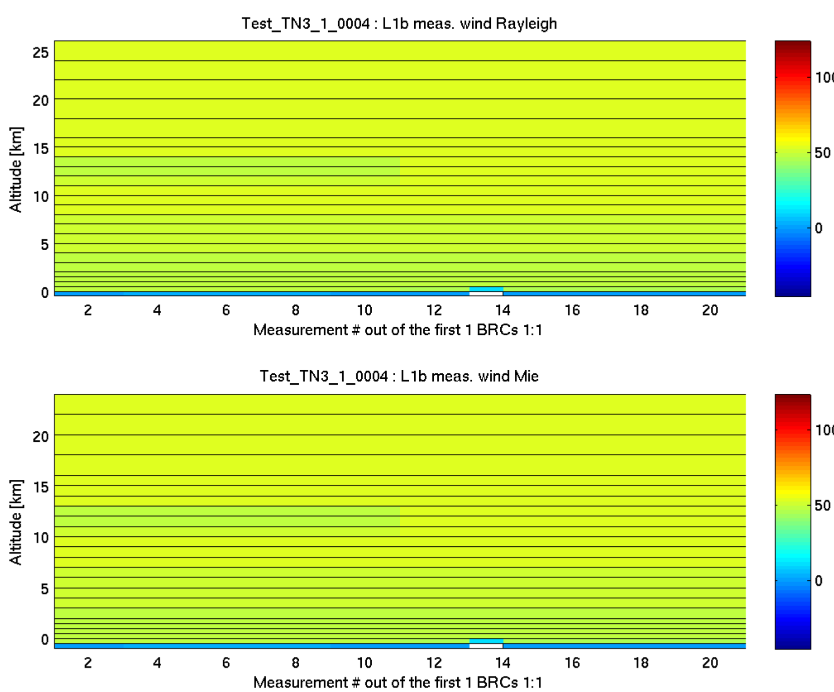


Figure 18: Measurement level L1B hlos results by test #0004, Rayleigh channel (upper panel) and Mie channel (lower panel).

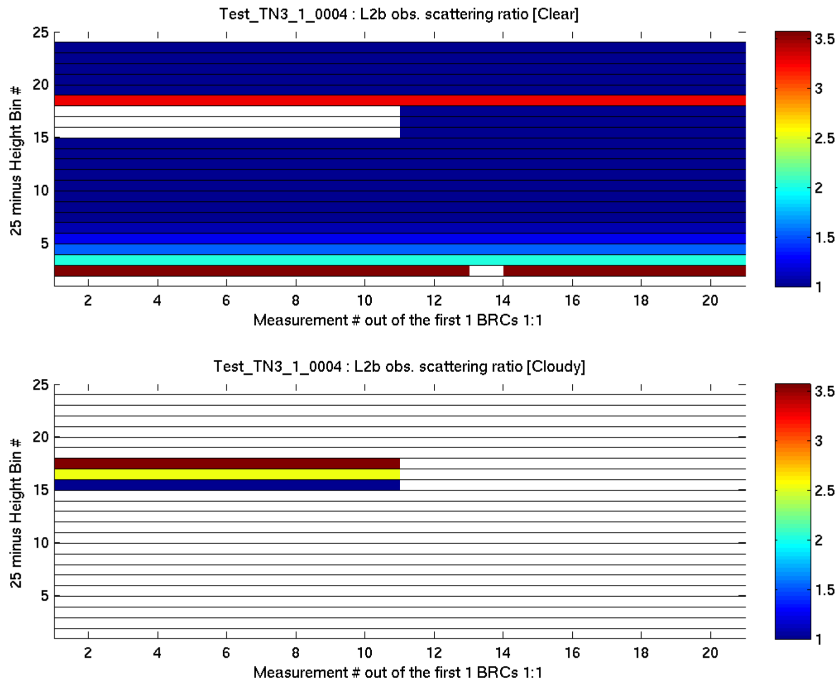


Figure 19: Observation level scattering ratio as used for input by test #0004 for clear (upper panel) and cloudy (lower panel) range bins.

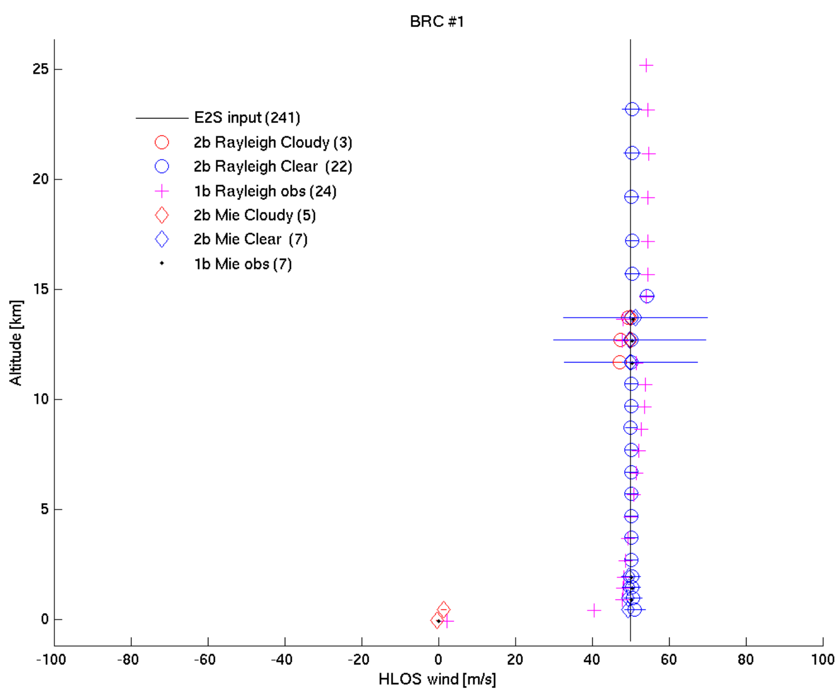


Figure 20: Observation level hlos wind results for test #0004.

## 5.5 Test case dummy

**Observations on E2S results**

t.b.d.

**Observations on L1B results**

t.b.d.

**Observations on L2B results**

t.b.d.

**Observations on plotting tool results**

t.b.d.

**Passed or failed**

t.b.d. Therefore this test is **passed/failed**.

# 6 Mispointing cases

## 6.1 Test case #0201: Mispointing (part 1)...

### General observations

t.b.d.

### Passed or failed

t.b.d. Therefore this test is **passed/failed**.