

Documentation for NRC LIDAR data in the WINTRE-MIX flight campaign 2022

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Ver. 1.0

NRC AECL 355 lidar system

Airborne Elastic Cloud Lidar (AECL) built by Alpenglöw, Inc. is a compact single wavelength airborne elastic lidar operating at 355 nm and used for the retrieval of vertical profiles of atmospheric properties, such as scattering and extinction properties of clouds and aerosols. The approximate locations of the lidar is shown in Figure 1.

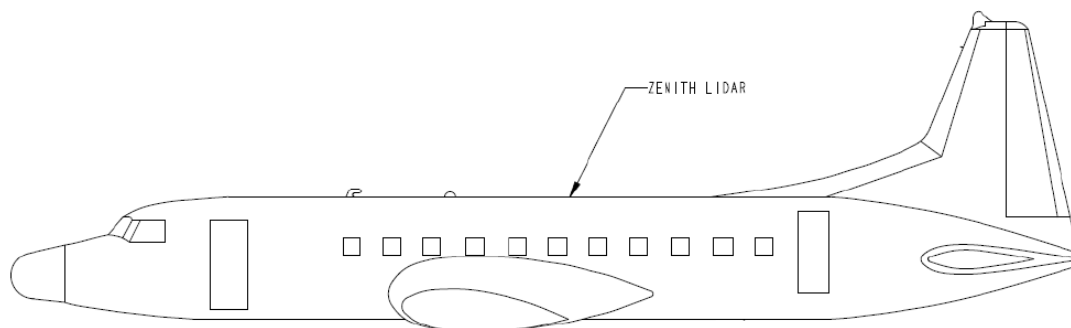


Figure 1: Approximate locations of the AECL zenith system on board the Convair-580 aircraft.

The AECL lidar design is shown in Figure 2 while its main technical specifications are listed in Table 1. Additional details regarding AECL technical specifications can be found in Baibakov et. al. (2016, 2018).

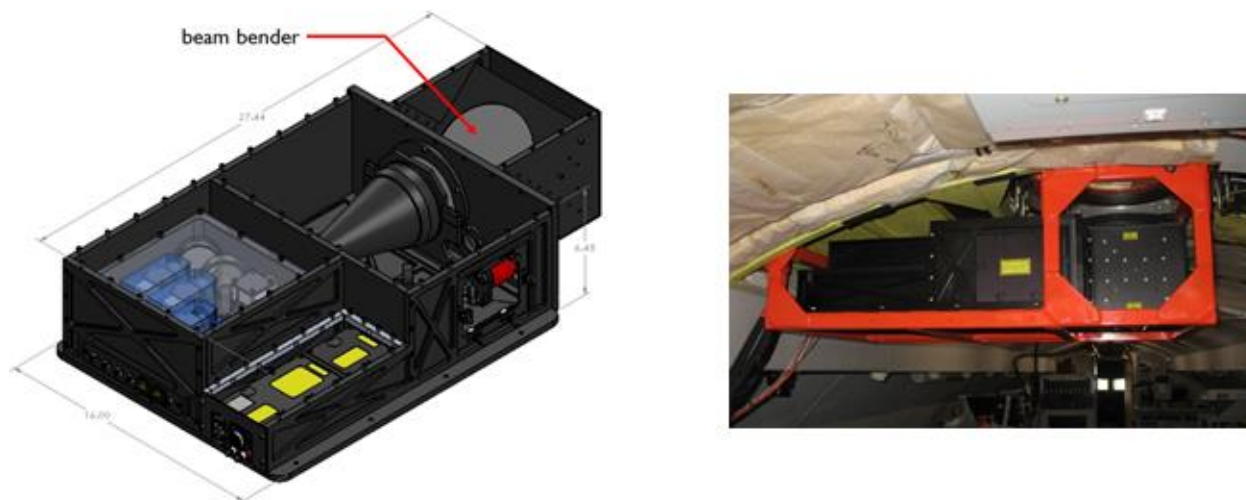


Figure 2: Left: AECL CAD model with dimensions specified in inches. Right: AECL when installed in zenith configuration on board the Convair-580 aircraft.

Table 1. Technical specifications of the AECL transmitter, receiver and data acquisition system

Transmitter	
Laser Wavelength	355nm YAG
Pulse Repetition Frequency	20 Hz
Pulse Width	≈8 ns
Pulse Energy	12mJ
Beam Divergence	0.4×10^{-3} radians
Receiver	
Diameter	≈100 mm
Field of View	≈1000 μrad
Data System	
Number of Channels	Four: Low and high gain parallel and perpendicular signals
Detector	PMT
Range Resolution	1.5m, 3.0m, 6.0m, 12m (programmable)

AECL data acquisition during the WINTRE-MIX campaign

Table 2. AECL data acquisition during WINTREMIX

IOP #	NRC flight #	From	To
IOP1	F01	03-Feb-2022 01:59:30	03-Feb-2022 06:30:00
IOP3	F02	12-Feb-2022 00:17:00	12-Feb-2022 05:10:00
IOP4	F03	18-Feb-2022 03:18:00	18-Feb-2022 07:05:00
IOP5	F04	22-Feb-2022 23:40:00	22-Feb-2022 03:44:40
IOP6 (TAIWINDemo)	F04 TAIWIN		
IOP7	F05	01-Mar-2022 20:44:00	02-Mar-2022 01:10:00
IOP8	F06	06-Mar-2022 13:09:00	06-Mar-2022 17:14:21
IOP9 (2 flights)	F07	07-Mar-2022 16:09:00	07-Mar-2022 20:06:00
	F08	07-Mar-2022 21:39:00	08-Mar-2022 01:41:00
IOP10	F09	12-Mar-2022 03:45:00	12-Mar-2022 07:51:00

AECL data processing

The description of AECL data processing can be found in Baibakov et al, 2019. In short, there are several levels of processing.

Low level processing consists of a background subtraction and a range correction. The former ensures that the signal is zero when no laser return is being registered¹ while the latter corrects for the R^2 signal drop off as the laser pulse propagates away from the emitter.

Once the low-level processing is completed, the lidar return is corrected for altitude. The altitude correction is needed to transform the relative height above/below aircraft to absolute altitudes above mean sea level which is done using the data from aircraft sensors.

Depolarization

AECL can estimate a degree of particle-induced depolarization of the emitted laser pulse by separately measuring parallel and perpendicular polarization components of the return signal, P_{\parallel} and P_{\perp} . The ratio of the measured cross-polarized power (P_{\perp}) to the co-polarized power, (P_{\parallel}) is defined as the linear depolarization ratio, LDR :

¹ The signal might effectively not be zero due to various electronic and/or (undesirable) optical sources affecting the detector.

$$\text{LDR} = \frac{P_{\perp}}{P_{\parallel}} \quad (1)$$

LDR can often provide an insight into the types of particles encountered by the laser beam, with lower LDR values often associated with spherical particles, most often liquid drops.

Examples of lidar measurements during the WINTRE-MIX campaign

Figure 4 shows examples of AECL measurements made between 04:00 and 05:00 during flight 1 (IOP01) on Feb. 03, 2022. The top and bottom panes show vertical profiles of uncalibrated lidar (co-polarized) return and a linear depolarization ratio, respectively.

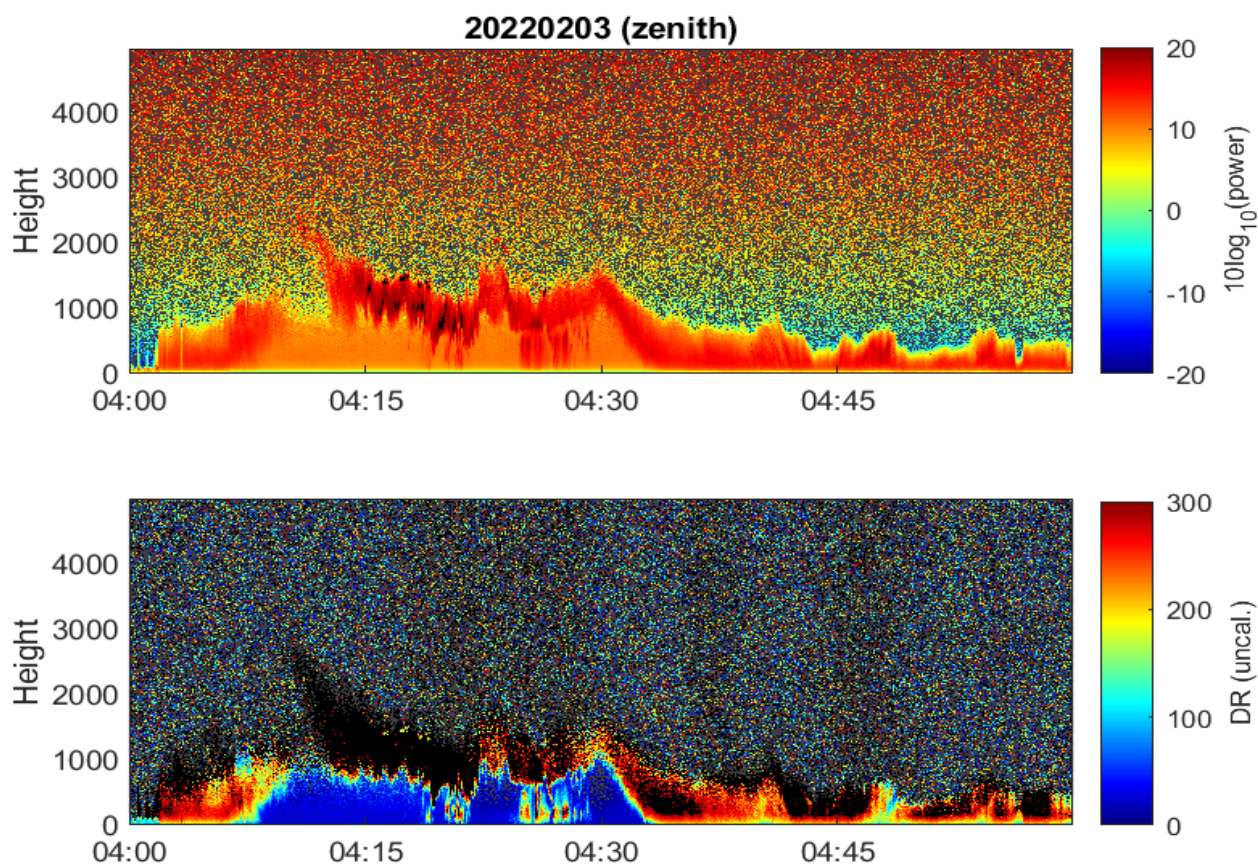


Figure 3: AECL uncalibrated return (top) and depolarization ratio (bottom) during flight 1 on Feb. 02, 2022.

Dataset structure

Here we describe the variables of the AECL lidar datasets.

Variables:

time

Dimensions: time

Datatype: double

Attributes:

long_name = **'time of measurement'**

units = 'seconds since 1970-01-01T00:00:00 +0000'

range

Dimensions: range

Datatype: double

Attributes:

Long name = **'Range bins above the aircraft'**

Unit = 'km'

lat

Dimensions: time

Datatype: double

Attributes:

long_name = **'Aircraft latitude from KVH1750 IMU, in units of degrees North'**

units = 'deg'

comments = 'Data produced by combining GPS and IMU observations via a Kalman Filter in
real time'

lon

Dimensions: time

Datatype: double

Attributes:

long_name = **'Aircraft longitude from KVH1750 IMU, in units of degrees East'**

units = 'deg'

comments = 'Data produced by combining GPS and IMU observations via a Kalman Filter in
real time'

alt

Dimensions: time

Datatype: double

Attributes:

long_name = **'Aircraft altitude from KVH1750 IMU, in units of metres'**

units = 'm'

comments = 'Data produced by combining GPS and IMU observations via a Kalman Filter in
real time'

CoPolHi

Dimensions: time,range

Datatype: double

Attributes:

Long name = **'Co-Polarized High Gain'**

Unit = 'Uncalibrated power'

CrossPolHi

Dimensions: time,range

Datatype: double

Attributes:

Long name = **'Cross-Polarized High Gain'**

Unit = 'Uncalibrated power'

DRHi

Dimensions: time,range

Datatype: double

Attributes

Long name = **'Depolarization ratio CoPol/CrossPol (uncalibrated)'**

Unit = 'Unitless'

References

- Baibakov, K., Wolde, M., Nguyen, C. and Korolev, A., (2019), Airborne elastic cloud lidar for ice-water content retrievals during the HAIC-HIWC 2015 campaign, NRC technical report, 58 p., doi: 10.5281/zenodo.3585578.
- Baibakov, K., Wolde, M., Nguyen, C., Korolev, A., Wang, Z., and Wechsler, P., (2016), Performance of a compact elastic 355 nm airborne lidar in tropical and mid-latitude clouds, Proc. SPIE 10006, Lidar Technologies, Techniques, and Measurements for Atmospheric Remote Sensing XII, 100060C; <https://doi.org/10.1117/12.2242112>
- Baibakov, K., Wolde, M., Nguyen, C., Korolev, A., Heckman, I., (2018), Retrievals of ice-water content from an airborne elastic lidar in tropical convective clouds, EPJ Web Conf. 176 0505; <https://doi.org/10.1051/epjconf/201817605051>