Experiment of Sea Breeze Convection, Aerosols, Precipitation and Environment (ESCAPE) NRC W and X band (NAWX) airborne radar data

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Data level: 1
NAWX L1 netcdf file is generated for every binary radar data file. When an antenna is not active, data are replaced with filling values.

General notes

- These are the datasets acquired in May-Jun 2022 with two radar systems (W-band (NAW) 94.05 GHz, and X-band (NAX) 9.41 GHz during the ESCAPE project
- The NAWX radar antenna subsystem (three W-band and three X-band antennas and a two-axis motorized reflector plate for one of the W-band antennas) is housed inside an un-pressurized blister radome on the right side of the aircraft fuselage (Fig. 1).
- In normal operational mode, data are available at nadir, zenith and side antennas. In some scenarios, one or two antennas are deactivated (e.g. when the aircraft is flying at low altitude, nadir antennas are terminated to avoid damaging RF components; or when the NAW aft antenna is directed to nadir or side for calibration purpose).
- During ESCAPE project, NAWX radars have a dedicated multiple Inertial Measurement Units (IMU) system installed at the radar rack.

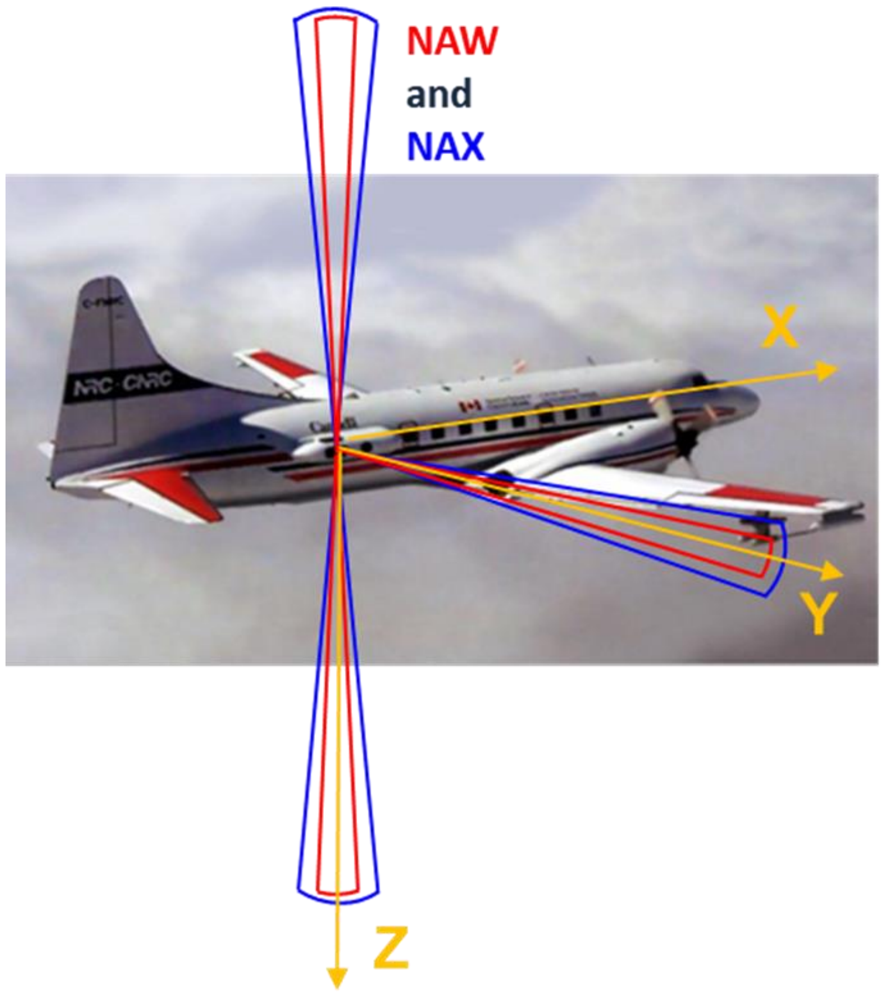

Figure 1: Location and direction of NAWX antenna beams and the aircraft reference system.

Data files

Format: The NAWX processed data are provided in a netCDF format. Detailed information about radar parameters are provided in the netCDF variables attributes.

Variables: The NAWX L1 data include radar equivalent reflectivity factor and Doppler velocity corrected for aircraft motion for each antenna. In addition, antenna beam pointing vector information are provided. The complementary measurements of aircraft state parameters that were recorded in real time by the NAWX data acquisition systems are included for reference only.

Processing: The reflectivity data are processed with noise subtraction. For NAW, different noise masks are available. For NAX, data are processed with noise subtraction, ground clutter filtering (see the Data Quality section), and also with a 2 dB above noise level mask applied. In addition to noise masks, there are masks for surface clutter, sub-surface, leak, etc. but these are primarily for reference purposes. Accurate detection of surface gates is a challenging task due to the substantial variation in surface return powers, which depend on antenna beam incidence angles and surface types/conditions. In most cases, these factors remain unknown.

NRC preformed dedicated radar calibration maneuvers for both reflectivity as well as antenna beam pointing. In addition, cross-calibration (between antennas and W vs. X) was done to make sure that the data are consistent. The reflectivity values included in this release have accuracies of 1-1.5 dBZ for the W-band and 1-2 dBZ for the X-band and Doppler estimates have bias less than 0.5 ms^{-1} for the W-band and 1 ms^{-1} for the X-band. Basic information about the NAWX radar is given in Wolde and Pazmany (2005). A detailed descriptions of the NAWX data processing can be found in Nguyen et al. (2019).

For both radars, aircraft motion contribution at each antenna is estimated and subtracted from the measured Doppler velocity.

Quicklooks: For each flight there could be multiple files, which correspond to the raw radar files as recorded by the NAWX Data Acquisition Systems. A new radar files are generated every time the radar configuration files changes during the flight, or when the size of the radar data reaches a certain size threshold. To assist data users, we have provided quicklook files in PNG format for vertical cross-sections, side reflectivity, and Doppler velocity. When the NAW aft antenna is in the down-forward position, the vertical cross-section data includes only the nadir antenna. In these quicklook files, the aircraft altitude is represented as a solid line (see Fig. 2 and 3).

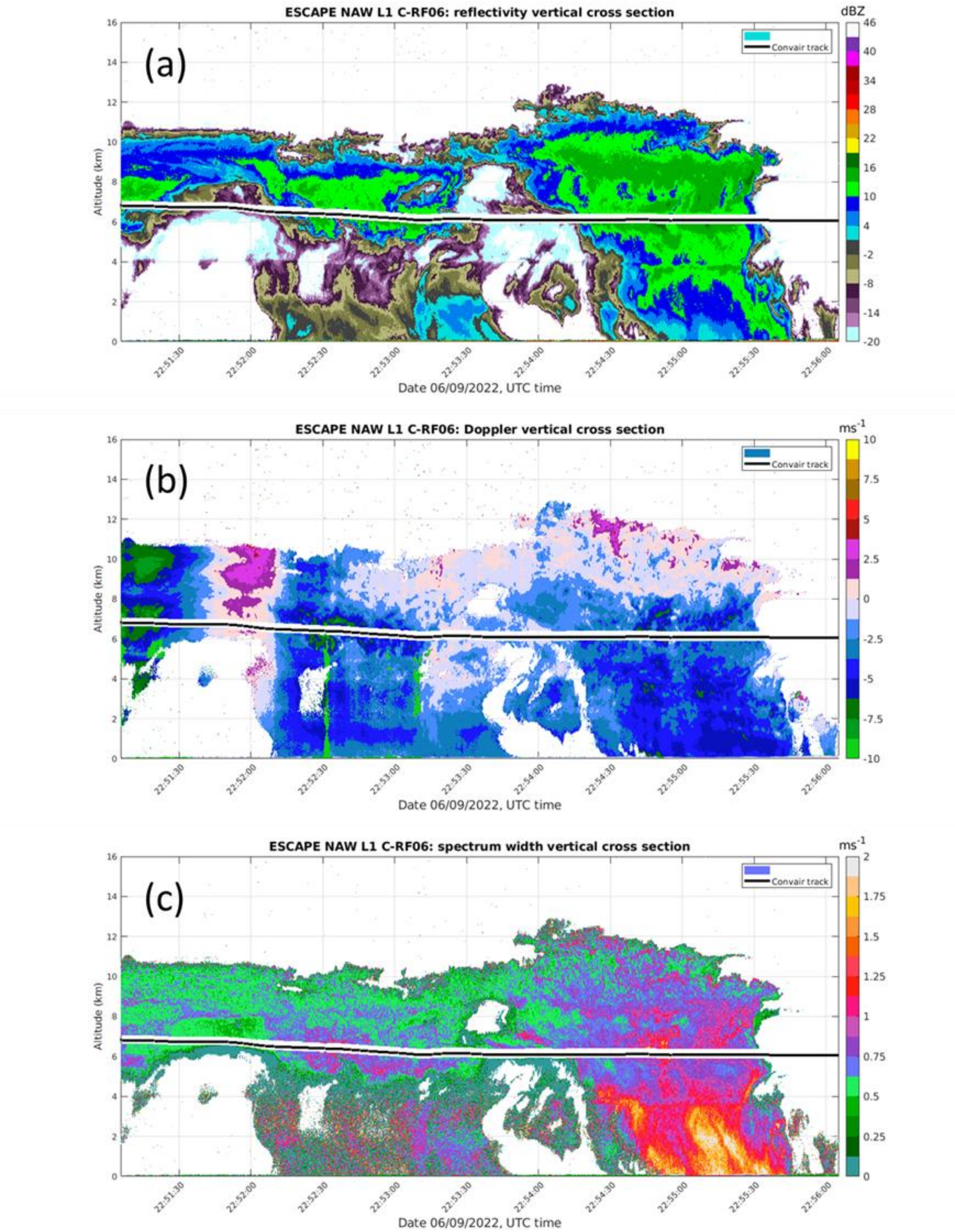

Figure 2: Example of NAW reflectivity (a), Doppler velocity (b), and spectrum width (c) quicklooks for a segment of ESCAPE flight 06 on 09 Jun, 2022.

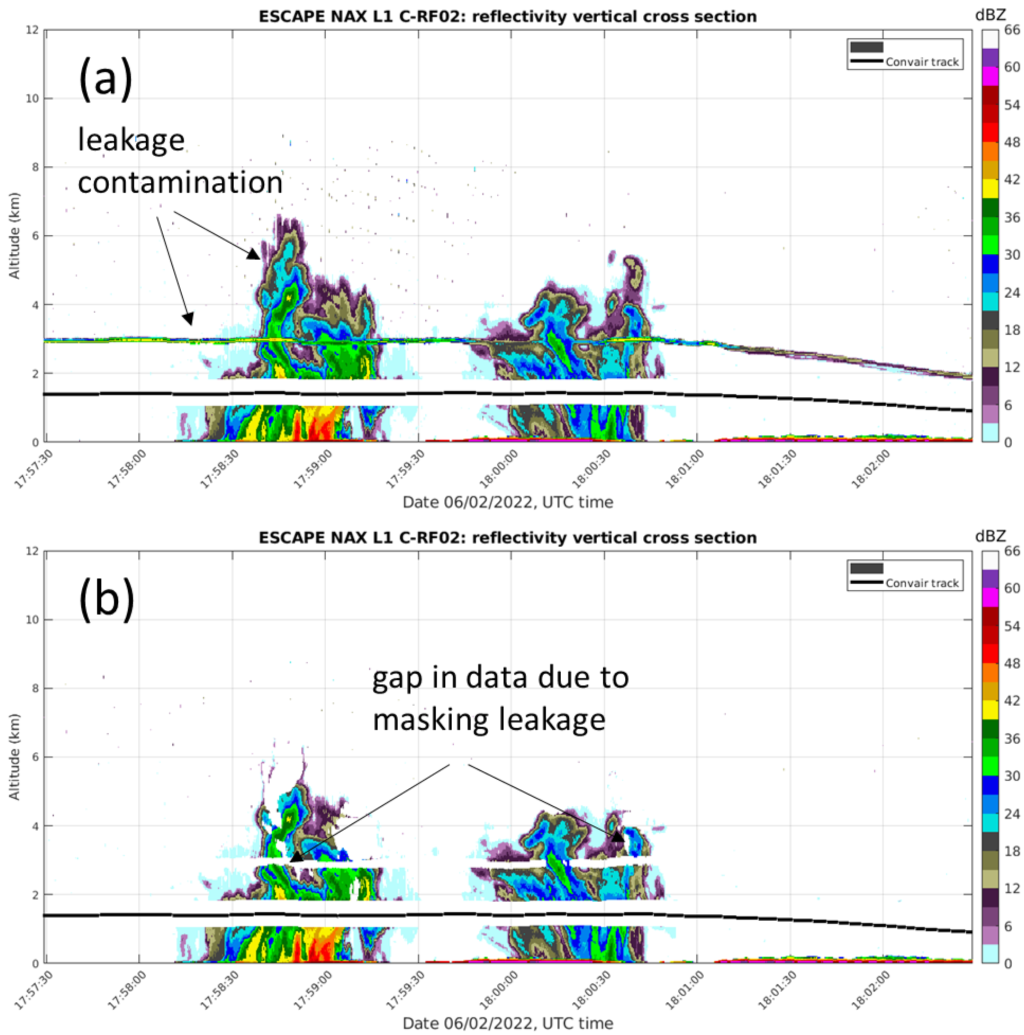

Figure 3: Example of NAX nadir and zenith antenna data before (a) and after (b) masking leakage signals.

Data Quality: The NAW radar boasts excellent receiver isolation and high-performance antennas, which ensure the acquisition of high-quality data. In contrast, the NAX radar exhibits a lower circulator isolation factor and suboptimal sidelobe performance, primarily due to its limited antenna size. This leads to interference signals between the radar channels. Specifically, a portion of the returned signal power from one antenna can leak into the receiver of the other antenna, particularly within a pair of nadir/zenith or side H/V antennas, through their respective circulators and splitters.

In the case of zenith-looking antennas, the leakage is most noticeable at ranges corresponding to the ground range of the nadir antenna or at ranges with strong precipitation targets such as the melting layer or heavy rain areas. For side-looking antennas, significant sidelobes are present at around 90°, and when they intercept strong returns from targets below the aircraft, such as the Earth's surface or a storm's melting layer, these sidelobe returns can contaminate signals received via the antenna's main lobe. When interferences are particularly strong, the filtering process can result in data gaps, sometimes of significant size (see Fig. 3).

As a result, in this release, we have included two datasets for NAX: one with leakage/sidelobe masking and one without.

References

Nguyen, C., Wolde, M., and Pazmany, A.: The NRC W- and Xband Airborne Radar Systems: Calibration and Signal Processing, 39th Conf. on Radar Meteorology, Iraka, Nara, Japan, 16–20 September 2019, Amer. Meteor. Soc., C000368, 2019.

Wolde, M. and Pazmany A.: NRC dual-frequency airborne radar for atmospheric research, 32nd Conf. on Radar Meteorology, Albuquerque, NM, 24–29 October 2005, Amer. Meteor. Soc., P1R.9, 2005.