RELAMPAGO CSU Tech report 001
Calibration of CSU-CHIVO during RELAMPAGO
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Sep. 2019

Abstract: This report describes the initial data quality check performed for CSU-CHIVO radar during the RELAMPAGO field campaign in Argentina. The Data are corrected for Z_{dr} and azimuth calibration. In addition, files are converted into NetCDF cfradial format for the convenience of the scientific user community.

1. Introduction

CHIVO (C-band Hydrometeorological Instrument for Volumetric Observation) is CSU C band weather radar which has dual polarization capability that produces products such as reflectivity, Z_{dr}, Φ_{dp}, K_{dp}. During the RELAMPAGO field campaign, CHIVO was deployed for about 3 months of continuous operation with good performance. CHIVO started operation in Argentina on November 10 and was continuously working until December 22. As per the agreement between the PIs, CHIVO was off during Christmas break (Dec22-Dec 26) and restarted operations on December 27 until January 31.

Figure 1. CSU-CHIVO south of Cordoba Argentina

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CHIVO site was located south of Cordoba city and it was about 30 minutes driving from Alta Gracia and 45 minutes drive from Villa Carlos Paz where the Observation Center was located. The following picture shows the location of the radars deployed in RELAMPAGO.

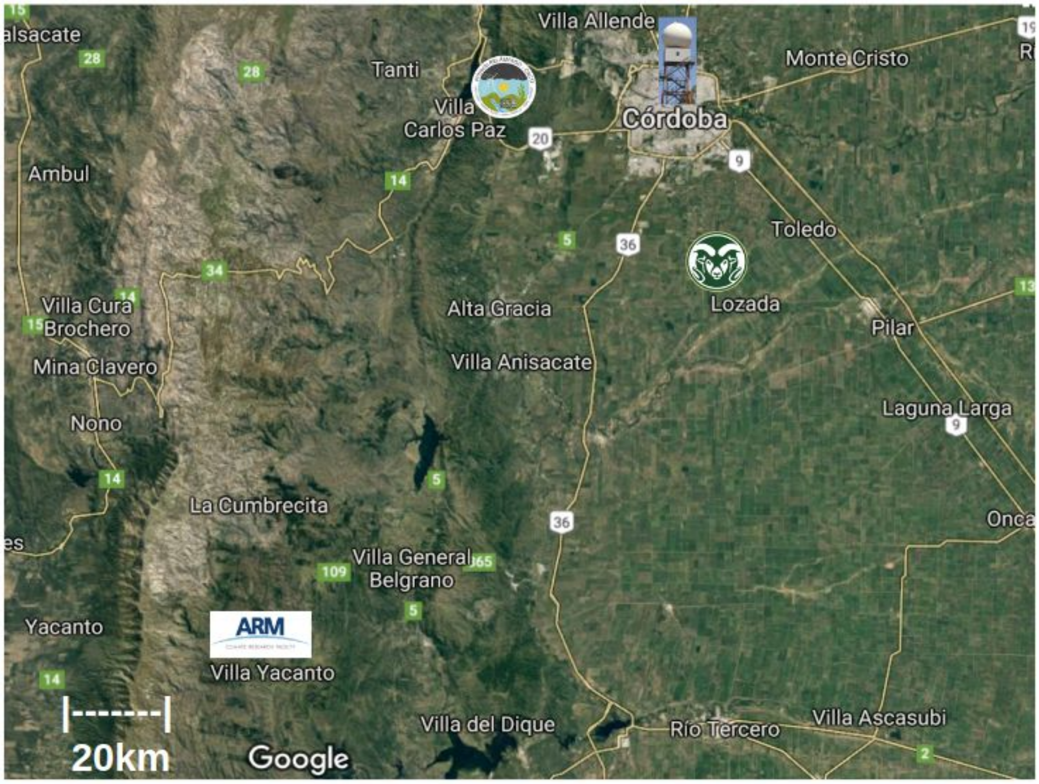

Figure 2. Map with location of radars. CSU logo means CHIVO, ARM is the location for CSAPR, RELAMPAGO means Obs. Center in Villa Carlos Paz and radar in Cordoba City is the RMA site Radar Meteorologico Argentino

During the campaign, the built in functions for attenuation correction and ground filters were disabled in the data and signal processor of CHIVO in order to archive the most unprocessed data as possible. This is important because we want to be able to capture signals that might be filtered out by this functionality in the Sigmet processor.

This paper is organized as follows. Section 2 shows the procedures that are used to find Zdr and azimuth calibrations. Results and Conclusions are showed in Section 3 and 4 respectively.

2. Methodology

Z_{dr} bias: Z_{dr} bias was computed using two independent methods: a) vertical pointing analysis and b) reflectivity versus differential reflectivity dispersion [1]. Birdbath scans were used for vertical pointing analysis while low elevation sweeps were used for differential reflectivity dispersion. To perform a birdbath scan, the radar is positioned at approximately 90° elevation and rotated to perform a 360° azimuth sweep. The melting layer, also known as the 0° level, is found using radiosonde information. The data collected below the melting layer is used to find the bias from vertical pointing analysis. Ideally, when a water drop is seen vertically, the Z_{dr} is expected to be zero. Thus, a finite deviation in the value of Z_{dr} in these cases is considered biased in Z_{dr}. Any azimuth variation due to external factors are averaged out using a full 360 degree scan. The following pictures shows an example for both methods respectively.

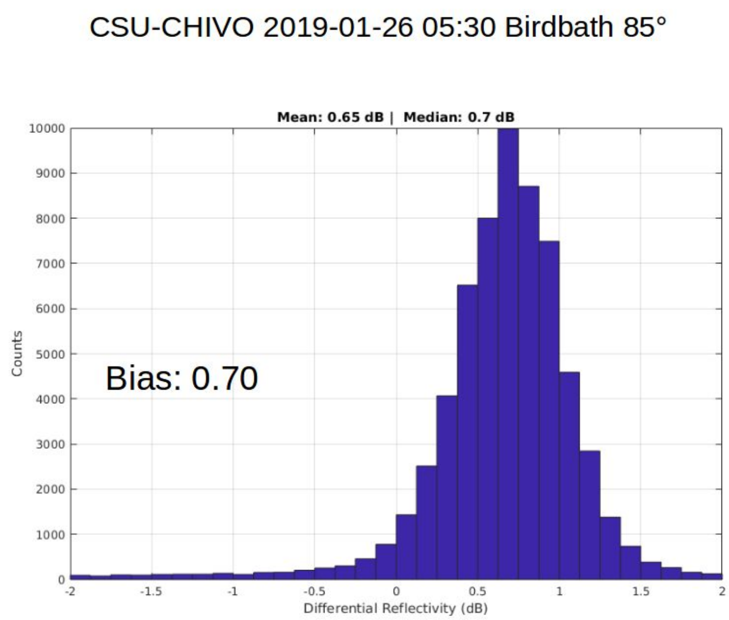

Figure 3.a. Histogram of Z_{dr} for a vertical pointing scan

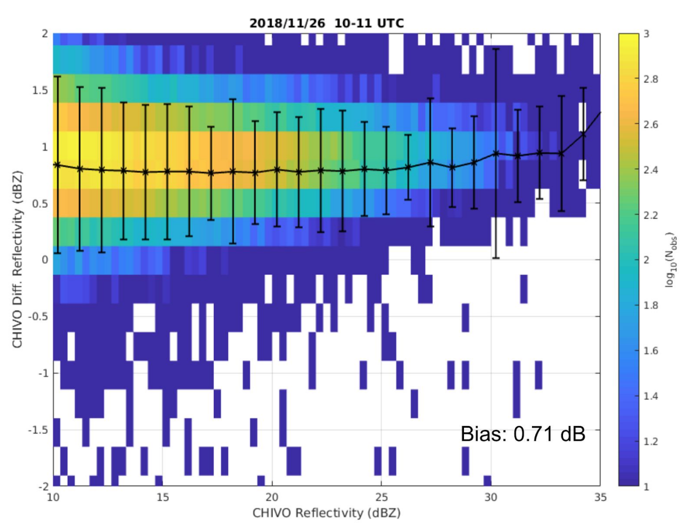

Figure 3.b. Z vs Z_{dr} dispersion for a light rain case, Zdr bias is 0.71

Azimuth Correction: During preliminary analysis it was found that the azimuth reference was shifting due to some loose positioning devices. This was further confirmed by several simple tests such as monitoring the Sun. Therefore it was decided to check and calibrate the azimuth for each experimental day. Subsequently three independent procedures were developed to perform azimuth calibration, namely a) the Sun, b) position of persistent radio interference targets and c) position of ground targets.

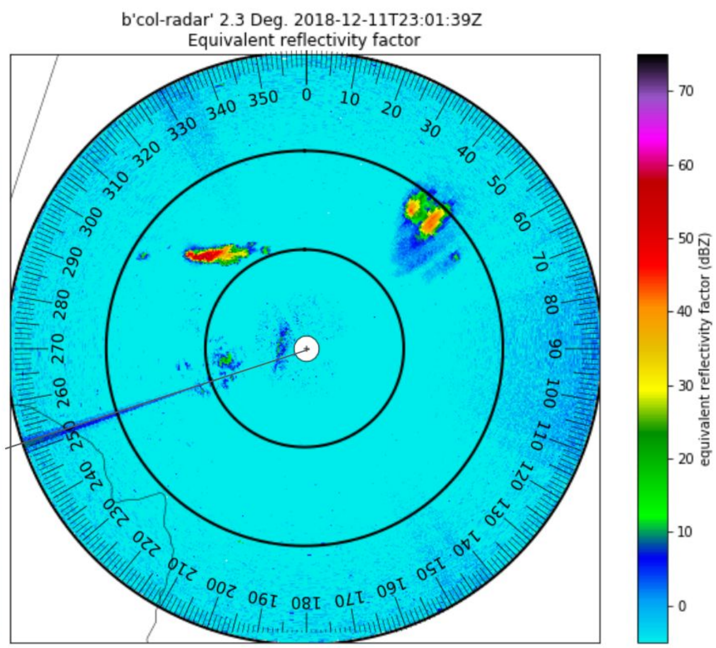

Figure 4. Azimuth correction using the sun

Sometimes, the ***sun*** is captured by the radar when the elevation and azimuth coincide with the position of the sun while the radar is scanning as it is possible to see in fig. 4. For those cases, the observed position of the sun was then compared with the expected solar position using the solar position computations. While the azimuth was corrected the elevation was found to match the solar position and did not need any correction.

Radio Frequency Interference is not always bad. For this study, we use it to keep track of the true azimuth taking into account that interference sources don't change the location. The following figure shows the RFIs used for this purpose, one in the north and the other in the southwest. These RFIs were selected amount the other observed interferences because they are isolated and they showed up in almost every low elevation sweep.

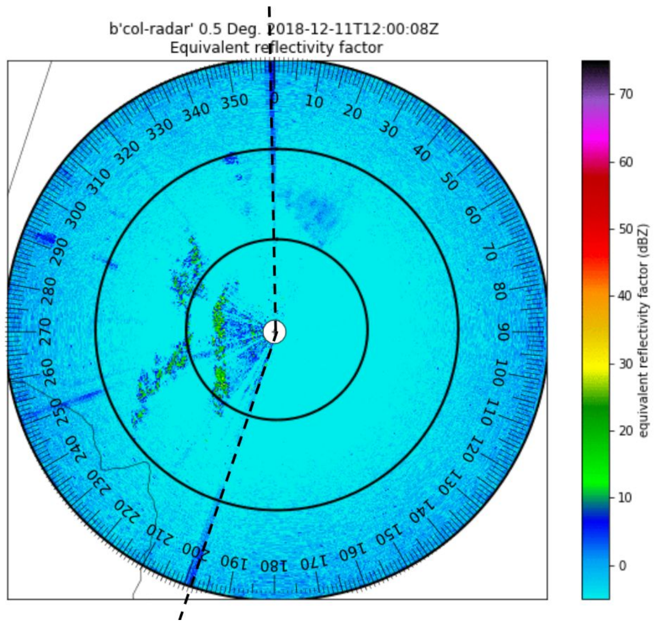

Figure 5. Radio Frequency Interference received from North and South West

The true location of the RFIs was determined using data on Nov 13, 2018, on which sun calibration was performed on CHIVO. The azimuth difference was obtained subtracting the true location of the azimuth to the angle where they show up in low elevation scans.

Additionally of radio frequency references, **fixed targets** were used to add more information and reduce the uncertainty of the azimuth evolution. To select good targets, fixed targets that meet the following condition for each low elevation sweep were chosen:

(1) Reflectivity over 45 dBZ
(2) RHOHV below 0.85
(3) No other fixed target in a neighborhood around, i.e. isolated targets

The azimuth locations of the targets were monitored and tracked. Previous azimuth information from the sun and RFIs is used to start looking for the fixed targets in a neighborhood around their location plus the expected rotation. The difference in azimuth of each individual target is averaged and then a final difference is computed per each low elevation sweep. Since we are averaging many fixed targets, this leads to a more smooth retrieval.

Since there are three methods to evaluate azimuth calibration, each day all the methods were used and a mean curve was produced with a resolution of 6 hours. In addition a standard deviation in the mean bar was also calculated and plotted on the top of the mean. Based on the standard deviation of the mean, the accuracy of the azimuth calibration estimates are about 0.1 degree

3. Results

The following table summarizes the results for the Z_{dr} bias:

Table I.A. Z_{dr} bias via Z vs Z_{dr} dispersion

Case	Z vs Zdr Bias (dB)
2018/11/22 15-18 UTC	0.89
2018/11/26 09-12 UTC	0.71
2018/11/26 21-24 UTC	0.80
2018/12/01 09-12 UTC	0.87
Average:	0.81

Table I.B. Z_{dr} bias using vertical pointing scans

Bias from birdbath (dB)
2018/11/26 0.68
2019/01/26 0.70

Average: 0.69

Note that the Z_{dr} bias remains stable during the field campaign and also it is possible to see that it is consistent for both methods of calculation. Based on these results, the suggested Z_{dr} bias is 0.75 +- 0.05 dB. This value was used to correct the data in the new files.

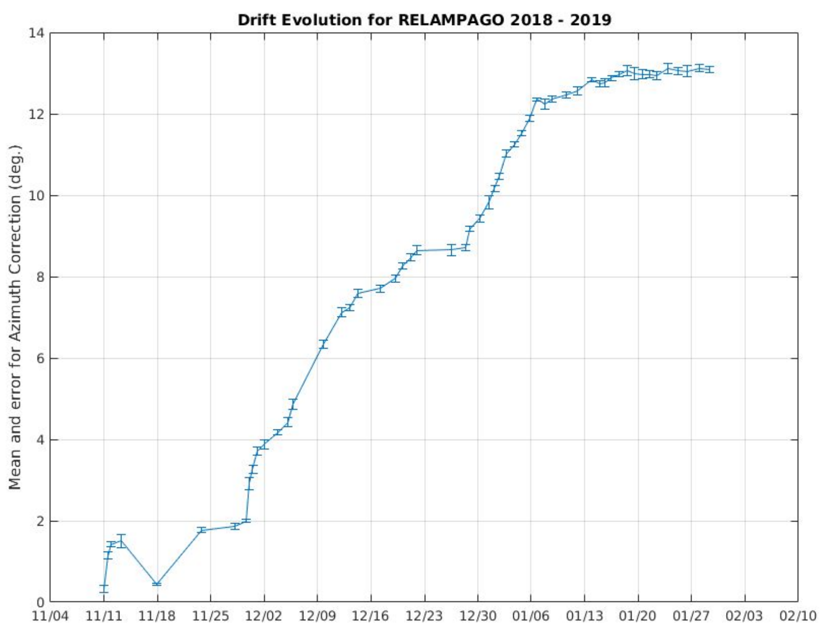

Figure 6. Statistical analysis of the azimuth Correction

Fig. 6 shows the mean and the standard deviation of the mean for the azimuth correction. Note that the error is a fraction of a degree and stays stable during the campaign.

4. Summary

Zdr and azimuth biases were found for CHIVO data during RELAMPAGO campaign and corrected for level 1a data. Zdr shows a bias of 0.75 dB with an uncertainty of 0.05 dB. Also Zdr bias shows a stable behavior during both the IOP and the extended period. Azimuth correction was done using three independent methods for consistency of the retrieval and to reduce uncertainties. The correction uncertaintinity is of the order of tenths of a deg.
Calibration of reflectivity is beyond the scope of this document, but a separate document is being prepared for that. Nevertheless, initial results show the reflectivity is accurate to within 0.5 db.

References

[1] V. Chandrasekar, L. Baldini, N. Bharadwaj and P. L. Smith, "Calibration procedures for global precipitation-measurement ground-validation radars," in URSI Radio Science Bulletin, vol. 2015, no. 355, pp. 45-73, Dec. 2015. doi: 10.23919/URSIRSB.2015.7909473

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[4] RELAMPAGO EOL Field Catalog, URL: http://catalog.eol.ucar.edu/relampago