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Interactive comment on "Airborne polarimetric Doppler weather radar: Trade-offs between various engineering specifications" *by* Jothiram Vivekanandan and Eric Loew

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Review of GI-2017-45: Airborne polarimetric Doppler weather radar: Trade-offs between various engineering specifications Authors: Jothiram Vivekanandan, and Eric Loew

Summary:

The paper presents a potential configuration of the next Generation of an APAR. A lot of nice technical details were written, the paper is nice to read and understood. I recommend to publish this paper after some modifications:

Printer-friendly version

Discussion paper

Reply to Reviewer # 2

Dear Reviewer,

Thank you for your time and comments toward helping us improve the manuscript. We have revised the manuscript based on your comments. Following is the summary of the revision.

General comment: First of all, I think this paper should be in a series of 3 papers, the first is this one, the second will be to verify all the parametrization for a test period and studying the stability, and the third one for the results which will be more scientific than technic.

A: Thank you for your suggestion for extending the results presented in this manuscript. The authors are in the process of evaluating engineering trade-offs presented in this manuscript using an observation simulation experiment evaluation (OSEE). This study will optimize engineering specifications by simulating the APAR observations for a range of cloud model results. This effort will lead to subsequent manuscripts.

Here are other remarks:

L9: microphysical characteristics of clouds at C-band!! It is too ambitious... Maybe dualpol characteristics for precipitations but not for clouds!!

A: We agree with reviewer's comment that C-band measurements are not as good as cloud radar observations at Ka and W-bands. Nevertheless, the sensitivity of the APAR is expected to be better than -15 dBZ at ranges less than 10 km. A threshold of -17 dBZ is used to distinguish regions of cloud and drizzle (Fox and Illingworth, 1997). Remote measurements alone will not be able to distinguish regions of cloud ice and cloud liquid as the sensitivity of cross polarization observation is also a limiting factor.

L55 – L56: I believe you mean CETP: Centre d'étude des Environments Terrestre et planétaires. By the way, this lab was mixed with another laboratory, and the current name is LATMOS (LaboratoireAtmospheres, Milieux, Observations Spatiales).

A: The sentence is revised as follows: “The ELDORA was jointly developed by NCAR and the Centre d’étude des Environments Terrestre et Planétaires (CETP), France. In the recent years, CETP was merged with LATMOS (Laboratoire Atmospheres, Milieux, Observations Spatiales), France.”

L87-L90 (and in the entire paper): Units, It would be better to use standard units (International systems), but if authors prefer to use the American units (inch, pounds, lb, ...) it would be better to put also the classic units (cm, m, Kg, . . .) between brackets maybe!

A: Units have been changed to the standard international system.

L109-L110 (and in the entire paper): abbreviations, it is recommendable to user abbreviations one the authors define them.

A: Thanks for the suggestion. Abbreviations are used wherever they improved the clarity of the presentation.

L117 – L122 (Major remark): Sensitivity loss (in fig 8 too) is not been considered for Pulse compression mode and short pulse mode! The transition area (in range) must be carefully filtered and weighted!

A: The text will be modified starting at line 362: “Figure 8b shows the sensitivity of the APAR as a function of range as depicted by the green curve. The discontinuity in the curve shows the sensitivity difference caused by the transition from short pulse mode to pulse compression mode. In this illustration, the short pulse region extends to 5 km in range and would be $\sim$9 dB less sensitive than the pulse compression region. This sensitivity loss can be mitigated by optimally positioning the aircraft to maximize the sensitivity of the areas of greatest interest. Care must also be taken to merge the data between the two regions, as pulse compression filtering effects can cause artifacts in the data if not handled properly.”

L132: Antenna is one of the most important parts and it is not really detailed.

A: A brief description of the antenna has been added section 2: “Each radiating element will use a stacked patched microstrip antenna radiator coupled to transmit/receive (T/R) module. The microstrip patch antenna elements can transmit in either horizontal (H) or vertical (V) polarizations. The radiating elements are spaced less than half a wavelength apart to avoid grating lobes over the full scan extent (Wang et al. 2008).” The dual-polarized patch antenna element proposed overcomes the problems of isolation in the diagonal plane and mismatch between the horizontal and vertical co-polarizations by combining the features of a parasitic crosspatch antenna and a ground plane with a cross-shaped aperture and capacitive and inductive loading corners. The patch is fed symmetrically in both horizontal and vertical polarizations.”

L126 (in the table): AZ and EL scan range should be shown.

A: Table 1 has been revised to include Az and El scan ranges.

L189-L190: Agree, but the authors are talking about dual-pol radar, so the attenuation can be considered!

A: The following sentences have been added: “In the case of rain, the specific propagation phase (KDP) is proportional to rain intensity. Attenuation (AH) and specific differential attenuation (ADP) are almost linearly proportional to KDP (Bringi et al,. 1990). As KDP is unaffected by attenuation, radar system bias due to change in transmit power, and antenna and receiver gain factors, it is more commonly used for attenuation correction.”

Section 3: I am not really convinced by the Cband. Anyway, it is a choice but: figure 3 is not the good way to show the attenuation. It is known that S is better than C and X, same for C and X but why comparing until 100km or more, for X-band we are talking about 30 to 50 km and is the intention is to go more than 100km? For what? And on which direction? Additionally, a vertical cut through clouds by APAR shows usually less attenuation compared to a classic PPI scan from stationary radar! By the way, I believe X-band is better for microphysics!

A: Figure 3 is used only for a relative comparison of attenuation effects at S, C, and X-bands and show subtle differences due to Mie scattering at higher frequencies. The C-band is chosen for achieving similar angular resolution as in the ELDORA and also for keeping the cost of the radar system lower. Since in the airborne research community, the ELDORA's measurement is considered to be the standard, the desired goal for the proposed APAR is to meet the current sensitivity of the ELDORA. On the C-130 maximum, allowable antenna aperture size is 1.93 m (76"). It will produce a narrower beamwidth at X-band, but it would require four times the number of T/R elements and consequently would be more expensive.

L230-L234: it is better to add a reference.

A: Bringi and Chandrasekar, 2001 reference has been included in support of cross-polarization isolation requirement.

L246-L248: can the authors add numerical values?

A: The sentence has been revised as follows: "Second, isolation between the co-polar and cross-polar channels must be at least 6 dB greater than the desired LDR lower limit."

L253- 256: different font type.

A: The font has been corrected.

L268 and L300: 20âŮę and 0âŮę (typo error).

A: The typographical error has been corrected.

L439: -100 dBm?

A: Yes, the –ve sign has been added.

For the polarization, authors should not only consider the polarization change of the co-polar pattern during beam steering-they should also consider the fact that the pol

pattern rises when the beam is steered. To avoid that differential feeding should be applied for the phase excitation of the array must be used. I invite the authors to read these 2 references for more details: - Vollbracht, D.: Understanding and optimizing microstrip patch antenna cross polarization radiation of element level for demanding phased array antennas in weather radar applications, Adv. Radio Sci., 13, 251-268, doi:10.5194/ars-13-251-2015, 2015. - Vollbracht D.: "Optimum phase excitations and probe- feed positions inside antenna arrays for the reduction of Cross Polarization radiation in demanding phased array weather radar applications", 10th European Conference on Antennas and Propagation (EuCAP) Switzerland, Davos, 2016

A: Thank you for providing latest references for microstrip patch antenna design and development. They are helpful. The current version of the microstrip patch antenna is excited symmetrically in both horizontal and vertical polarizations. Also, to limit the effect of differential gain and beam pattern on polarimetric measurements, co-polarization measurements will be collected only up to 200 from broadside.

References

Bringi, V., V. Chandrasekar, N. Balakrishnan, and D. Zrnic, 1990: An Examination of Propagation Effects in Rainfall on Radar Measurements at Microwave Frequencies. J. Atmos. Oceanic Technol., 7, 829–840.

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Wang, H., D. Fang, Y. L. Chow, 2008: Grating lobe reduction in a phased array of limited scanning. IEEE Trans. Ante. Prop., 1581-1585.

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