Response to Anonymous Reviewer 3

We would like to acknowledge the reviewer, whose comments greatly helped us to improve the overall quality of the paper.

Point to point response:

The authors present a method by which they combine radar calibration results obtained in several different ways, with the aim of providing an online tool for the monitoring of radar calibration. The work relies on existing methods for the base methods, and the new contribution is the combination of the methods to a single tool. This is a good approach, but the authors are not reaching to the level they are aiming at. Instead of a new tool the final result comes in a form of presenting the methods of the original methods in a single figure. The paper is generally well written and the methods and results clearly presented. The authors should consider the following comments to improve the manuscript.

General comments
1) No effort is made to combine the calibration data of the methods into a single quantity, or even to present the results in a graphical form in a way that the observer can combine the results visually. Hence the outcome if far from a “robust online tool to monitor the stability of the radar calibration”, as stated in the abstract. It would help to see a plot of the x-mean(x) (x is here ground clutter or sun calibration subtracted by the observatory flux) in a single plot. Maybe one could add the self-consistency results to the plot as well. After that it will be possible to judge whether joining the two datasets provides information beyond any one dataset.

2) The method used to calibrate the differential reflectivity is not well presented. Obviously the standard zenith scan calibration was not done. At the end of section 4.2.3 it is stated that the solar Zdr bias is “considered to correct the Zdr measurement in the radar post-processing chain. The solar analysis monitors only the receiver part and hence no transmitter chain effects are included. Hence solar analysis is not sufficient for Zdr calibration, and correct calibration is coincidental. In Section 4.1 observations in drizzle are used. Please clarify.

We acknowledge the reviewer to gave us the opportunity to clarify and improve the paper.

1) We worked to improve this point. Actually, the aim of the paper is to present the calibration techniques in a way that allows to draw specific conclusions about the radar calibration. The self-consistency has been performed for the same cases for which the intercalibration was already available and added to the final plot, as also others reviewers suggested. The final plot shows together all the calibration monitoring techniques analyzed in this work and it allows to compare the trend and differences between the observations and the reference values. Furthermore, we introduced the transmission and reception calibration which combines the ground

clutter and self consistency techniques in a unique value. This estimator is shown to be more robust and stable, compared to the single techniques.

2) As others reviewer suggested, we clarify the Zdr calibration. The differential reflectivity is calibrated using the observation in drizzle media. The criteria for the zdr calibration in drizzle are reported in the text. Meanwhile, since we can not modify the operative scan to introduce the vertical pointing and since the accuracy of the Zdr calibration in drizzle is about 0.5dB, the Zdr calibration is monitored by the Sun calibration, which shows a higher accuracy. We will investigate how to increase the accuracy of the Zdr calibration in drizzle and to implement an online tool.

Specific comments: (P: page, L: line)

Page 1, L2 and L 22: Is "short-term weather prediction" really a quantitative application?

Yes, the radar data are used as input for the nowcasting systems.

Page 1, L4: the methods are not yet really "integrated", but presented together

We have worked on this aspect, and added the transmission and reception calibration, computed combining the self consistency and ground clutter calibration procedures.

Page 7, L6: References to Huuskonen and Holleman (JTECH, 2007,pp 476-483), Hollman et al (JTECH, 2010, pp 881-887) and Huuskonen et al (JTECH, 2013, pp 1704-1712) missing on the list.

Added

Page 2, L11: The intercalibration method is obvious, but yet one could add reference to some recent papers.

Included references:

-Zlatko Vukovic, Environment Canada, Canada, and M.C. Jim Young, Norman Donaldson: Inter-radar comparison accounting for partially overlapping volumes, Erad 2014, Garmish Partenkirchen Germany.

-Ribaud, J.-F., Bousquet, O., Coquillat, S., Al-Sakka, H., Lambert, D., Ducrocq, V. and Fontaine, E. (2015), Evaluation and application of hydrometeor classification algorithm outputs inferred from multi-frequency dual-polarimetric radar observations collected during HyMeX. Q.J.R. Meteorol. Soc. doi:10.1002/qj.2589

Page 2, L12-14: This describes authors' own practices, please place in the data section

Moved to the data section

Page 3, L1: Is the subsection header necessary, what about replacing section header “Data” with this.

Subsection removed.

Page 3, L2-29: Information is presented both in text and the table (altitude, parameters, parameters). Duplicated information should be removed.

Information removed from the table.

Page 4, L29: notation z_dr (lower case) is fully unnecessary, as it appears only here.

Lower case zdr removed.

Page 6, L1: Which distance is 40 km, distance between a radar and the cell or what? Please clarify.

40km represents the difference of the distances between the center of the selected cell and the two radars, i.e. (distance radar A to the center of the cell) - (distance radar B to the center of the cell) = 40 km.

Page 7, L15-16: Holleman et al (2010, pp 159-166) shows that the gain is determined within 0.2 dB (not 1.3 dB). They do not show results on pointing. Huuskonen and Holleman (JTECH, 2007) shows that the elevation angle is determined within 0.05 deg (not 0.2 deg).

Corrected.

Page 7, L17: The radio sun is typically estimated at 0.57 deg, i.e. slightly larger than the optical sun

Corrected.

Page 7, L16: The width Delta_r is only defined in table 3. It is assumed to be the same for elevation and azimuth, which is not correct, as pointed out in the prior literature.

Delta_r represents the radar beamwidth, we referred to Table 2 of Altube et al, 2015 to compute the antenna-Sun convolution.

Page 7, L18: The authors have used a three parameter model, i.e. assumed the width values in Eq.(9). There is no information given which values have been used and how they were obtained. The width values are not important for pointing studies, but crucial for the power determination. Hence very relevant for the present paper. Using the antenna width is not correct.

We followed the literature (Holleman et al, 2010) and we used the antenna-Sun convolution (Altube et al, 2015).

Page 9, L7-10: The authors apparently use the observations in the drizzle to check the calibration of the differential reflectivity. The standard deviations of the drizzle observations are about 0.5 dB. Was this uncertainty taken into account in the analysis? (See also general comments)

This uncertainty was used to compute the uncertainty in the self-consistency procedure. If the standard deviation of Zdr is about 0.5dB, the system gain bias computed by the self-consistency is approximately 1dB, as we can note in the following table for the Bric della Croce radar during 13 October 2014.

Zdr bias (dB)	Computed Zh bias (dB)
-0.5	+0.5
0	-0.5
+0.5	-1.6

Page 11, L14: and elsewhere: 95th percentile (or .95 quantile). This is correct in places!

Corrected, we use “95th percentile”.

Page 12, L14: How is differential reflectivity determined? Is the method presented by Holleman et al (JTECH 2010b, pp 881-887) used are something else. Please clarify.

Differential reflectivity is not determined by the method presented by Holleman et al. We show the mean value of Zdr measured along the solar ray. As future development, we will computed the Zdr bias by the method presented by Holleman et al.

Page 12, L19: Here it looks as if the Zdr bias determined from the solar signal is used as the Zdr calibration. As mentioned in the general comment 2) a correct calibration is coincidental, which ought to be mentioned here.

Zdr is calibrated using observation in drizzle medium.

Page 12, L25: Please see the general comment 1)

See answer of the general comment 1.

Page 12, L28: The ground clutter calibration shows significant level increases (e.g. Bric della Croce, end of September) which the authors apparently do not interpret as

changes in the calibration level. Please specify the method used to determine which points are trusted upon.

We re-analyzed the data and we compared the results to the meteorological information retrieved from nearby radio soundings. Computing the refractive index of air in the first two kilometers of the atmosphere, we noticed that in those day the anomalous propagation of the radar beam could have increased the 95th percentile values

Page 13, L3: The prior papers on the solar method describe various methods to prevent the radio interferences from affecting the solar analysis. These data should be reanalyzed which would increase the number of results considerably.

In this preliminary work we did not implement a method to remove the radio interferences before applying the Sun calibration. It will be developed in the future.

Page 13, L32-35: The final conclusions are well written, and in agreement with the contents of the paper (as compared to the conclusions in the abstract)

Thanks.

Table 2: Could be combined with table 1 and many entries are not relevant to the paper (sidelobe, gain, transmitter, frequency, peak power, PRF)

Tables removed.

Table 3: Please specify if "a" is one- or two-way attenuation.

One-way attenuation.

Figure 3: The panels are small and difficult to read

Increased size of the panels.

Figure 12: Good figure, but labels on the insert are small. Maybe put only few but with a larger font size

Decreased the number of labels and increased the size.

Figure 13: Please zoom a little to show the data better

Corrected.

Figure 16: What about putting elevation and azimuth data to the same axis and Zdr (Fig. 17) as the second panel

We prefer to keep separated the pointing biases and the Zdr monitoring, since the antenna pointing is computed by a gaussian fit while the zdr monitoring shows only the mean values of the solar zdr.