## Manuscript amt-2015-171 – Reply to Reviewer 2 comments

The Authors are grateful to the Reviewer for the time spent analyzing the manuscript, and for the constructive criticisms that have helped us to improve its quality. In particular, we have recognized the need of expressing more clearly the goals of our study.

In the following paragraphs, we reply item-by-item to the Reviewer comments, which are enumerated and copied in blue color.

## **General Comments**

1. Comment. This paper provides a summary of dual pol characteristics and inferred microphysics of 2 events sampled by an X-band radar in Italy. The authors describe the events and show results using an analysis of the dual pol characteristics. I find the results interesting in that they illustrate detailed characteristics of hail producing storms as observed by X-band radar. However, as I read the paper I was unclear if the authors were aiming to show new observations of extreme events as sampled with X-band radar or whether the intent was to simply document the occurrence of rain mixed with hail events in this region.

**REPLY.** As also outlined in the reply to the first referee, this paper focus on two short-lasting convective events characterized by high amount of precipitation. These events are quite frequent in Mediterranean, and when affect watersheds characterized by a reduced response time, flash floods occur or landslides are triggered. Consequences are damage of building and infrastructure, and could result in casualties. Often the C-band radar forming national weather radar network are not optimally located to observe these events. X-band dual-polarization radars can be a convenient solution to monitor precipitation in such risky area. The present paper intends to show, through two significant cases, that such systems are able to provide adequate performance in terms of QPE and hydrometeor classification.

ACTION. The aim of the work will be stressed in the revised version of the manuscript.

2. Comment. The analysis for each event was rather short in terms of describing the evolution of these storms only one or 2 cross sections at one particular time. As such, the results come across as a potpourri of observations with no clear focus on particular aspects of the events. Are there plans for further analysis? It would be of interest to document the performance of the QPE for flash flood forecasting.

**REPLY.** There is an ongoing effort to improve observational capabilities of the Italian weather radar infrastructure. The kind of events analyzed in this paper is being the subject of specific investigations.

3. My major criticism of this manuscript is that the English is sloppy and the grammar needs to be cleaned up. As presented, the paper is difficult to read with many awkward sentences. Recommendation: Major revisions

Note that I did not capture all the awkward sentence structure in the manuscript - I gave up after a few pages. I recommend the authors enlist someone who can help them improve the English grammar.

**REPLY.** We are sorry for this inconvenience. **ACTION.** The revised version will undergo a thorough revision of English.

4. Comment. P. 7202, Line 2 "fruitful" – what does that mean?

**REPLY.** The adjective "fruitful" was used metaphorically to indicate something bringing positive results/products (e.g., fruits being desired/expected products for trees) but we recognize it might be misleading.

ACTION. We will change it with "effective" in the revised version of the manuscript.

- Comment. P. 7202, Line 3 "couple" do you mean two? REPLY. Yes, we mean two. ACTION. It will be corrected in the revised paper.
- Comment. P. 7202, Line 6: "It is used" awkward REPLY. Agreed.
   <u>ACTION.</u> The statement will be modified as follows: "The X-band dual-polarization radar operating inside the Catania airport (Sicily, Italy), managed by the Italian Department of Civil <u>Protection, has been considered here."</u>
- Comment. P. 7202, Line 10 "allowing to properly catch" –awkward REPLY. Agreed.
   ACTION. The verb "catch" will be modified with: "capture".
- Comment. P. 7202, Line 15: ". . .fields amount. . ." awkward REPLY. Agreed. <u>ACTION.</u> The manuscript will be modified as follows: "The spatial distribution of precipitation amount was reconstructed "
- Comment. P. 7202, Line 16 "considered storm" storm considered REPLY. Agreed.
   ACTION. The manuscript will be modified accordingly.
- 10. Comment. P. 7202, Line 21: "well retrieve.." awkward REPLY. Agreed.
   <u>ACTION.</u> The manuscript will be modified as follows: "it was possible to retrieve fairly well the storm characteristics ..."
- 11. Comment. P. 7202, Line 25 do you mean sea breeze convection?

**REPLY.** The statement mentioned by the Referee is wrong. According to the NWP forecast it was a Mediterranean low pressure system to originate the MCS. The enclosed Figure, also showing the brightness temperature as retrieved by MSG, clarifies the meteorological situation. **ACTION.** The paper will be modified accordingly.



Figure 1 - Brightness temperature retrieved on the 21 August 2013 at 06:00 UTC by the geostationary Meteosat Second Generation (MSG) satellite. The contour lines shows the geopotential at 500 hPa.

- Comment. P. 7203, Line 1: "even though" although ? REPLY. Agreed.
   ACTION. The manuscript will be modified accordingly.
- Comment. P. 7203, Line 20: "enhanced up" –unclear– do you mean enhanced, leading to signal extinction REPLY. Agreed.

ACTION. The manuscript will be modified accordingly.

 14. Comment. P. 7203, Line 25: "if the objective" **REPLY.** Fixed. <u>ACTION.</u> The manuscript will be modified with "Moreover, to analyze the internal structure of..."

15. Comment. P. 7203-7204: Not sure what the point of this discussion is: to argue for using other dual pol parameters in the discrimination of rain and hail? This section needs to be more focused.

**REPLY.** This section is aiming at providing a review of radar techniques for rain/hail observation.

ACTION. The manuscript will be modified and shorten accordingly.

- 16. Comment. P. 7204: Line 1: State here what other information is needed (e.g., Zdr). **REPLY.** Need of further measurements is discussed in the rest of the section.
- 17. Comment. P. 7204: Line 14: Zdr when used in combination with Zh and/or other parameters is used for hail. Zdr by itself doesn't necessarily mean hail.

## 18. **REPLY.** Agreed

ACTION. The manuscript will be modified accordingly.

Comment P. 7206, Line 4 need "an" before "applied fuzzy logic" **REPLY.** We propose to change it with "A Fuzzy Logic…" **ACTION.** The manuscript will be modified accordingly.

Comment P. 7206, Line 24: "shortly summarized" - summarized briefly **REPLY.** Agreed **ACTION.** The manuscript will be modified accordingly.

19. Comment P. 7207, Line 3: "A Fuzzy-Logic based approach resorting to the concept of data quality is applied" I don't know what this means

**REPLY.** The clutter filtering technique is based on a Fuzzy-Logic approach which try to discriminate non-weather from weather echoes. The output is a "fuzzy" variable expressing the degree of membership D (ranging between 0 and 1) to the class "non-weather". The complementary Q=1-D can be interpreted as the quality of the data meaning that the higher is the degree of membership to the class "weather return" the higher is the data quality. **ACTION.** This concept will be expressed in the revised manuscript

20. Comment .How is backscatter differential phase addressed? Some of the "jumps" in Phidp raw are suspicious and suggest backscatter.

**REPLY.** The iteration scheme is conceived to deal with both system noise and backscatter differential phase, as proposed by Hubbert and Bringi (1995). **ACTION.** This concept will be expressed in the revised manuscript

- Comment .P. 7208, Line 3"In advance" awkward REPLY. Agreed.
   ACTION. This statement will be removed.
- 22. Comment .P. 7208, Line 7 "is" required before "shorter" REPLY. Agreed.ACTION. The manuscript will be modified accordingly.
- 23. Comment .P. 7208, Line 18: one of the coefficients should be for "DP" the other for "H" REPLY. Agreed.
   <u>ACTION</u>. The manuscript will be modified accordingly.
- 24. Comment .P. 7208, Line 22 "increasing rainfall regimes" what does this mean?
   REPLY. We meant to say at increasing rainfall intensities.
   ACTION. The manuscript will be modified accordingly.
- 25. Comment. P. 7209: Why use MP relation for R(Z) if you have all the DSD measurements why not come up with a tuned R(Z) since your tuning R(Kdp) and the attenuation coefficients? It seems strange to use an "off the shelf" R(Z) but tuned a tuned R(Kdp) relation. **REPLY.** The work applies a polarimetric algorithm based on the combination of Z and K<sub>DP</sub>. It has been designed to mostly use Z for low to medium rainfall rates and K<sub>DP</sub> for medium to high values. To our knowledge, MP works relatively well in such precipitation regime. Notwithstanding, a Z-R relationship, derived by the same DSD measurements, was also tested (results not shown in the paper) although the performance was slightly worse than MP.
- 26. Comment . P. 7209, Line 19: "cold system"? you mean system with cold cloud top temps. . **REPLY.** The Reviewer is right.

ACTION. The manuscript will be modified as follows: "a relatively high system (the cloud top temperature being lower than 220 K)"

- 27. Comment . Fig. 3: Please include a description of lightning detection obs in lower left panel REPLY. The lower left panel shows all the lightning observations recorded between 15:00 and 18:00 UTC, the cross mark (+) refers to positive charges, generally originated by the cloud top toward the ground (cloud to ground lightning, CG) or the cloud base (intra-cloud lightning, IC). Whereas the x-mark (X) refers to negative charges, generally originated by the cloud base toward the ground (CG), which typically occur during the mature stage of the storm. The map confirms that most of convective activity developed close to Sicily and Calabria coast line. ACTION. It will be clarified in the revised text, whereas the time interval already reported in the Figure caption will be also reported in the legend (lower right panel).
- 28. Comment . P. 7210, Line 1: "azimuth average" is misleading if this is vertical incidence data. REPLY. Actually data are collected rotating antenna. <u>ACTION. It will be clarified in the revised text.</u>
- 29. Comment . P. 7210, Line 3: "overpassed" passed over.
   REPLY. Agreed
   ACTION. The manuscript will be modified accordingly.
- 30. Comment. What is height of zero deg isotherm based on bright band signature? Very weak in this case is that due to vertical incidence? **REPLY.** Combining top of bright band and minimum  $\rho_{HV}$ . The latter signature tends to be more evident in case of weak bright band signature (Baldini and Gorgucci, 2006).
- 31. Comment . P. 7210, Line 6: what does low rhohy imply about the hydrometeor distribution that particles are melting? If this is true, please say so in the manuscript.
   REPLY. Agreed
   ACTION. The manuscript will be modified accordingly.
- 32. Comment . P. 7210, Line 8: what does VMI represent?
  REPLY. The Vertical Maximum Intensity (VMI) is a map of maximum intensity (reflectivity) in the vertical (Fabry 2015), widely used for operational monitoring.
  ACTION. This description will be added to the revised manuscript.
- 33. Comment. Can Fig 5 be enlarged? hard to see details Same for Fig. 6. Suggest removing contour lines and perhaps filtering blowup region of interest. Details of Zh and rhohv look odd in these cross sections Zh attenuated but then recovers at farther range?
   <u>ACTION.</u> The figure resolution will be improved as much as possible.
- 34. Comment. Fig 7 =Kdp of 13 deg/km? is that real? What kind of rainrate is that?

**REPLY.** Looking at the  $\Phi_{DP}$  profile at range distance comprised between 6 and 8 km from the radar, a shift of about 50 deg can be noticed. This phase shift corresponds to an average K<sub>DP</sub> of 12.5 deg/km, the estimated peak is 15 deg/km. The corresponding rain rates (above 150 mm/h) are high but not unrealistic.

35. Comment. P. 7211, Line 4: "swiftly decrease" swift decrease

**REPLY.** Agreed. **ACTION.** The manuscript will be modified accordingly.

36. Comment. P. 7211, Line 22: land sea breeze???

**REPLY.** Se reply to comment # 11.

37. Comment. P. 7211, Line 27: need a "was" before "observed" REPLY. Agreed.<u>ACTION.</u> The manuscript will be modified accordingly.

38. Comment. Rainfall analysis: please include units in Table 1. Is the comparison done against 1 gauge or multiple gauges? Hourly rainfall or some other time interval? Are these statistics good in the sense that they captured the gradients and amounts fairly accurately compared to other X-band QPE analyses?

**REPLY.** As stated in the figure caption the comparison is carried out on hourly basis using all the available rain gauges (about 20 distributed mainly along the coastline registered precipitation). The benchmark is provided by the rain gauge network. A statistics with mean BIAS close to 0.9 for  $R_K$  and 0.8 for  $R_C$ , should, in our opinion, denote a fairly good performance. Of course, we are not trying to derive any conclusive results.

ACTION. It will be clarified in the revised manuscript.

## References

Baldini L. and E. Gorgucci, 2006: Identification of the melting layer through dual-polarization radar measurements at vertical Incidence. *J. Atmos. Oceanic Technol.*, **23**, 829–839. doi: <u>http://dx.doi.org/10.1175/JTECH1884.1</u>

Fabry, F., 2015: Radar Meteorology: Principles and Practice. Cambridge University Press, pp 272 **ISBN-10:** 1107070465

Hubbert, J. and V. N. Bringi, 1995: An interactive filtering technique for the analysis of copolar differential phase and dual-frequency radar measurements. *J. Atmos. Oceanic Technol.*, 12, 643–648.