Response to reviewer 1 of amt-2019-135

In this document we provide answers to the comments of reviewer 1 of the paper amt-2019-135. Our answers to the reviewer are given in *italic* font. Proposed changes to the manuscript are highlighted in blue color.

The paper “Analysis of the lightning production of convective cells”, by Figueras i Ventura and colleagues, presents a radar-based study on the lightning production capabilities of convective cells occurred in summer 2017 in Switzerland. Weather C-band, Doppler, polarimetric radar reflectivity data are processed to automatically detect and track convective development, while lightning data were recorded from the EUCLID network, and from a Lightning Mapping Array VHF network, deployed for this campaign. The main results is that the altitude of rimed particles column is a promising predictor of lightning activity in convective cells, especially for Intra Cloud flashes: cells with less lightning activity had a shallower column, a lower proportion of hail and in general lower reflectivity values and higher values of co-polar correlation coefficient, indicating smaller and more homogeneous particles.

The paper is well written and addresses an important topic, contributing with new data and experiments. I think the paper should be published on AMT, after the minor corrections I suggest below.

We thank the reviewer for his/her positive review

Introduction. I think the literature review does not consider relevant papers that analysed convective systems lighting activities and cloud microphysical structure: e.g. Emersic et al., 2011, Mon. Wea. Rev., 139, 1809–1825, Wapler, 2017, Atmospheric Research 193, 60-72; Marra et al, 2017, Atmospheric Research, 192, pp. 72-90; among others.

The link between microphysical structure and lightning was discussed in a previous paper by the authors. We have now explicitly referenced that paper and added the suggested references:

Polarimetric weather radar networks provide extremely useful information about the state of the atmosphere in precipitating systems, particularly in convective ones. They offer a large coverage of the 3D cube of the atmosphere (from altitudes close to ground to about 20000 mMSL), with high spatial resolution (on the order of hundreds of m) and relatively high temporal resolution, typically 5 min for operational systems. Numerous studies have been conducted combining information from both lightning detectors and polarimetric radars. Furthermore, various direct and indirect links between polarimetric signatures and lightning activity have been reported in the past (see the introduction of Figueras i Ventura et al. (2019) for an overview).

From early on, the scientific community has realized that there is a strong link between the distribution of different hydrometeors, particularly their vertical distribution, and the lightning activity of the system. Consequently, significant effort has been placed in characterizing the vertical structure of precipitation, either from ground-based or from satellite measurements. For example, Marra et al. (2017) reported on a violent hailstorm in the Gulf of Naples that produced over 37000 strokes in 5 h and hailstones with a maximum size in the order of 7-10 cm. The storm happened to be observed by an overpass of the Global Precipitation Measurement Mission Core Observatory (GPM-CO). The on-board Dual-frequency Precipitation Radar (DPR) observed 40 dBZ echo top heights of up to 14 km, indicative of strong updraft, and observations from both DPR and ground-based radar indicated the presence of large graupel/hail particles at the time where there was an increase in the intracloud positive stroke fraction as observed by the lightning network LINET. Buiat et al. (2017) analyzed a total of 12 convective events over Italy that were observed by the Cloud Profiling Radar (CPR) on board of the CloudSat satellite. A high correlation was found between the 5 number of strokes, detected by LINET, and the vertical distribution of ice particles, as estimated from the CPR products. A high ice water content and large effective radius of the ice particles favoured and increase in CG stroke occurrence.

Phase-array radar technology may have the potential to greatly improve the characterization of the precipitating systems where lightning occurs thanks to the fact that their fast scanning may better capture the evolution of the rapidly evolving convective cells. In this context a study by Emersic et al. (2011) is noteworthy. The authors examined data of a hail-producing storm on 15 August 2006 in Oklahoma obtained by the National Weather Radar Testbed Phased-Array Radar. Interestingly, it was found that, while there was a first surge in lightning when the storm's updraft first intensified, a second updraft later on actually coincided with a decrease in total flash rate. The authors attribute this behaviour to the formation of wet hail preventing hydrometeor charging.

Another study, by Carey and Rutledge (2000), reported on a tropical convective complex over the Tiwi Islands on 28 November 1995, observed by a C-band polarimetric radar. It is noteworthy that in its initial phase the storm was dominated by warm rain processes. During this phase, no-significant lightning activity was detected despite of the considerable rainfall rate. At a later stage, a gust front contributed to the formation of more intense convective complexes that were dominated by mixed-phase precipitation processes. It was during this phase that all the lightning occurred. The presence of rimed particles was thus, again, decisive in the electrification of the storm. Finally, noteworthy for its extent,Wapler (2017) analyzed 600 hailstorms that occurred over a period of 8 years in various parts of Germany. Among other findings it is shown that hail bearing storms are far more likely to have a high stroke rate than regular storms. The stroke rate tends to increase minutes before hail reaches the ground and decreases after that.

Pag. 6. Lines 9-10. How are the number of EUCLID and LMA computed for each cell? In should be done when the cells are in the reduced domain. This figure should be discussed with more details.

For clarification we have added the following text to section 2.1.3 describing how the number of LMA flashes per cell are computed:

A similar rationale is used to extract data obtained by the LMA within the TRT cell footprint. Any LMA-detected lightning is assigned to the cell if it has sources located within the TRT cell area (regardless of its origin) within the time resolution of the TRT algorithm (i.e. in the last 5 min from the current TRT time stamp). Out of the resultant data, products such as the total number of flashes, total number of sources and vertical profile of the number of flashes and sources can be computed.

We also have added the following text to section 2.1.2 regarding how the number of EUCLID lightning strokes per cell are computed:

Among them, the number of lightning strokes is computed by counting all the strokes detected by the EUCLID network within the area covered by the cell and within the time resolution of the TRT cell (i.e. within the 5 min. prior to the current time stamp).

We also modified the highlighted lines as follows:

Fig. 2 shows a scatter plot of the number of flashes detected by the LMA network versus the number of CG strokes detected by the EUCLID network within a TRT cell. Only the lightning activity of cells transiting through the reduced LMA domain have been plotted. As it can be seen, there is a low correlation between the number of flashes detected within a TRT cell by the LMA network and the CG strokes detected by the EUCLID network. Consequently, it can be inferred that there is no linear relation between the intra-cloud and the cloud-to-ground lightning activity.

And we have also modified the caption of Fig.2 :

Scatter plot of the number of flashes detected by the LMA network with respect to the number of CG strokes detected by the EUCLID network within TRT-cells when transiting through the reduced domain.

Pag. 8 line 28 and following. I do not understand how figures 14 and 15 are drown. In abscissa it is time, but looking at the pictures especially for cell 2, it seems that PPI beams show up in the right part of the figure. What does it mean that (for cell 2) at 8000s the cloud has layers with no hydrometeors? I general I suggest to better comment these figures, and to use labels to better mention them in the text.

We have added the following text to section 2.1.3. regarding the generation of these plots:

More specifically, the vertical profile is constructed by taking statistics of all the valid data at a particular height interval. In the cases shown in this study, the height resolution was set to 250 m, e.g. all data at altitudes ranging from 0 to 250 m were used to compute statistics valid for that height interval. Notice that depending on the size of the cell and its position with respect to the radar, there may be height intervals where no data is present simply because no radar beam covers the sampled volume.

Conclusions. The first item is not a conclusion: Authors just say that the two systems measures different things in different places. A careful detection efficiency study of the two networks should be made before the intercomparison.

In this item we wanted to highlight that while in general terms the intra-cloud lightning activity (i.e. mostly LMA detected) and the cloud-to-ground lightning activity (i.e. detected using the EUCLID network) are related, it is not a linear relation and there are instances where a high IC activity does not imply high CG activity and vice-versa. We have re-formulated the item as follows:

In general terms, an increase of IC lightning activity (as detected through the LMA) resulted in an increase of CG activity (as detected through the EUCLID network). However, there were several outliers. In one case, an excess of 500 LMA flashes resulted in few CG strokes while in another, 30 CG strokes were detected without any apparent IC activity. We can thus conclude that there is no linear relation between IC and CG lightning activity.