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Recent improvements in the Earth Networks Lightning Network in Argentina

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***Abstract*— The Earth Networks Total Lightning Network (ENTLN) is a global lighting detection network that has been operational since 2009. The ENTLN sensors are broadband electric field sensors that detect both intra-cloud (IC) and cloud-to-ground (CG) flashes and provide timing, location, classification, and peak current measurements of lightning. ENTLN consists of roughly 1800 wideband sensors deployed globally. Since its initial deployment, several improvements were made over the years to enhance its performance and usability. Notable ones are the addition of many new sensors, especially throughout Argentina where a large network was recently deployed, to improve detection efficiency and extend the ENTLN coverage. Firmware improvements have also been made to further increase sensitivity. A performance study was conducted to evaluate the characteristics of the ENTLN within and around Argentina. This analysis compared the ENTLN data with satellite-based lighting detectors, which are known to have uniform and good detection of lightning. The results of the study show that the performance of the ENTLN has significantly improved throughout Argentina.**

Keywords—lightning; thunderstorm; lightning location

I. Introduction

Lightning data has become an integral part of weather observation, especially when it comes to nowcasting. The importance of lighting data is evidenced by the amount of effort that is going into location/observing systems, with ground networks continuously growing globally as well as with recently launched satellite lightning sensors the Lighting Imaging Sensor (LIS) and the Geostationary Lightning Mapper (GLM). These satellite-based systems provide a good dataset with which ground based systems can compare. This benefits both systems through further validation of each system as well as providing measures of accuracy and effectiveness. In this study, we used Earth Networks Global Lightning Network (ENGLN) data, a global network of lightning sensors capable of measure and characterizing both intracloud (IC) and cloud-to-ground (CG) lighting discharges, to compare with GLM and LIS.

II. Data

A. Earth Networks Global Lightning Network

Earth Networks Global Lightning Network (ENGLN) continuously measures lightning stroke occurrence time, location, type (IC and CG), polarity, and peak current, at over 1,800 ground-based stations around the world. ENGLN combines data from the Earth Networks Total Lightning Network (ENTLN) and an enhanced version of the World Wide Lightning Detection Network (WWLLN). ENTLN is comprised of wideband sensors to detect both the IC and CG flash signals efficiently [1][3]. The installment of the network of sensors in Argentina began in October 2018 and was completed near the end of 2018. Fig. 1 shows a map of the Argentinian network. This analysis focuses on a comparison before and after that timeframe to quantify these improvements. WWLLN is a network of lighting location sensors operating at very low frequencies (3-30 kHz), which allows it to detect lightning from relatively large distances. In addition, several ENTLN sensors have been modified so that they contribute to the WWLLN network and improve its detection efficiency. ENGLN provides two datasets, pulses and flashes. Pulses are equivalent to lightning strokes. Flashes are clusters of pulses that are close in time and space, with the clustering criteria being 700 ms and 10 km.

B. Geostationary Lightning Mapper

GLM was launched in late 2017, and uses an optical sensor to detect lightning. After about a year of testing, calibration and validation, GLM reached provisional validation on January 19, 2018 with data dating back to December 20th, 2017 after the move to its final destination. GLM is the first operational lightning mapper in geostationary orbit, which allows for continuous measurements within its field of view, which includes all of South America, North America up to 55° latitude (just north of the Canadian border), and large parts of both the Atlantic and Pacific oceans. It measures total lightning with a predicted location accuracy of +/- 4 km and timing accuracy of +/- 2 ms. GLM also provides lightning area and optically radiated energy. GLM provides data in the form of events, groups and flashes. On October 15th, GLM introduced a parallax correction which greatly improved their location accuracy, especially near the edges of the sensor.

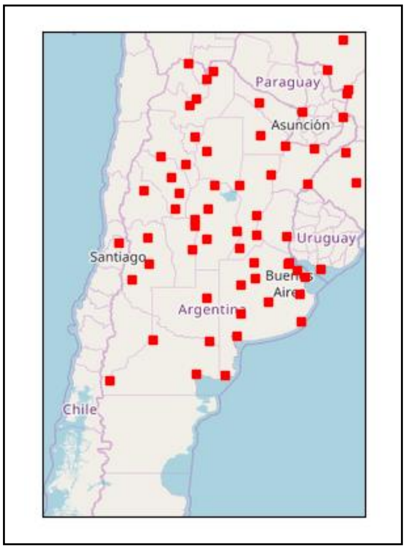

Fig. 1. ENTLN sensor map in Argentina.

C. *Lightning Imaging Sensor*

LIS is a space-based optical lighting sensor. LIS was first launched aboard the Tropical Rainfall Measuring Mission (TRMM) satellite until April 2015. The mission was extended by launching the only spare satellite sensor and mounting it aboard the International Space Station (ISS). ISS LIS launched in late 2017 and, after a few months of testing and calibration, began providing total lightning location data in March 2018. Due to the ISS being in low Earth orbit, ISS LIS circles the Earth 15 times a day and provides measurements between +/- 48 degrees latitude. LIS has a predicted location accuracy of 4-8 km and timing accuracy of +/- 1 ms and provides timing, location, and energy measurements of each discharge. LIS provides data in the form of events, groups and flashes. Events are individual pixels of the imager detecting lightning, groups are clusters of events and are equivalent to strokes and pulses. TRMM LIS has many of the same characteristics as ISS LIS, but the latitude range is between +/- 35 degrees.

III. Methodology

The improvement of the total lightning DE of the ENGLN is first analyzed by comparing with past results. A study conducted by [2] found the relative flash DE of ENGLN for TRMM LIS flashes in 2013. In that study, individual LIS flashes were matched with ENGLN strokes with the matching criteria being 330 ms and 25 km. In this study we compare ENGLN with GLM and LIS (TRMM and ISS) flashes directly. This analysis used the same matching criteria as [2] when comparing to LIS data. The matching criteria for the GLM analysis were 50 km and only required that the flashes overlap in time. We also require at least 10 LIS and 100 GLM flashes per grid box.

Two timeframes are analyzed in this study. First, to assess the performance of the ENGLN prior to Argentinian network deployment, we compared against LIS data from March 2017 – August 2018. This dataset was used to compare against the study from 2013. The second time frame is January – April 2019, which provides an assessment of the performance of ENGLN after the Argentinian network has been completely deployed.

IV. Results

We begin by presenting a comparison of the ENGLN total relative flash DE with past published results. Fig. 2 shows the results published in [2] using data from 2013. The relative flash DE is above 70% over much of the East and Central U.S.A. and off those coasts, and above 30% in parts of Brazil and Western Africa. Over the entire field-of-view, the relative flash DE of the ENGLN was reported to be 31.4% in 2013.

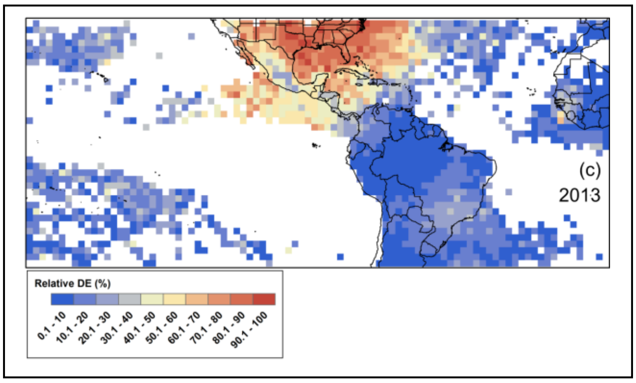

Fig. 2. ENGLN total flash DE compared to TRMM-LIS flashes, obtained from [2].

Next, we compare the pre- vs post- installement of the Argentinian network, which occurred between October – December 2018. Fig. 3 shows the ENGLN relative total flash DE from March 2017 – August 2018 (prior to the network deployment), which shows slight improvements compared to the 2013 data. Fig. 4 is similar to Fig. 3, but from January – April 2019 (following the network deplomment). There are considerable improvements and if we compare the average DE from 2017-2018 to that of 2019, we observe an improvement from 10% to 57%, or 570%.

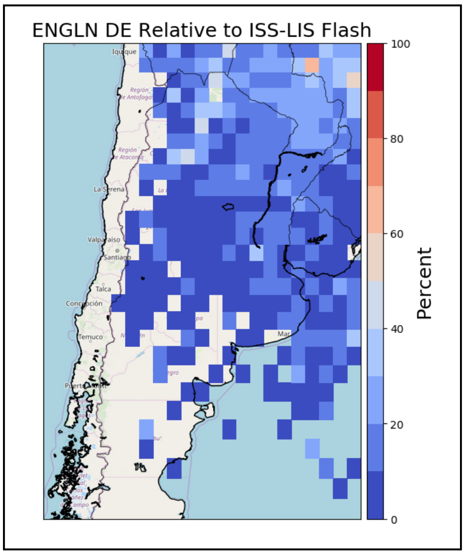

Fig. 3. ENGLN total relative flash DE compared to ISS-LIS flashes from March 2017 – August 2018, prior to the network deployment.

Since ISS-LIS is orbiting, it takes many months to accumulate enough data for significant statistics, as can be seen from the relatively sparse map in Fig. 4. For this reason, we also compare with GLM, which is shown in Fig. 5. The same general trends are observed with the relative flash DE being above 70% for most of Argentina and parts of Brazil. The average relative flash DE in this region is 48%, which is lower than when comparing to ISS-LIS. As will be discussed below, this lower result for DE is thought to be partly due to artifacts in the GLM data.

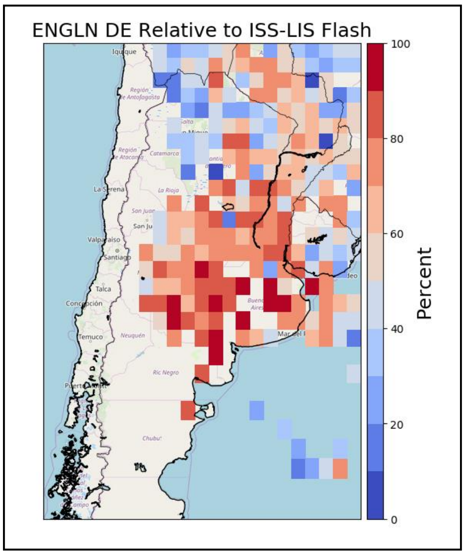

Fig. 4. ENGLN total relative flash DE compared to ISS-LIS flashes from Janurary – April 2019, following the network deployment.

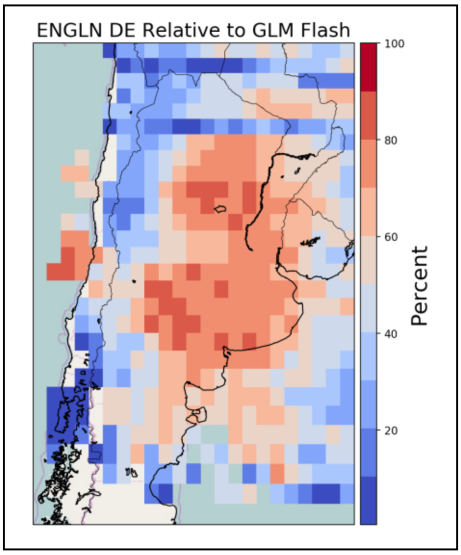

Fig. 5. ENGLN total relative flash DE compared to GLM flashes from Janurary – April 2019.

Fig. 6 and Fig. 7 illustrate the average GLM flash area for ENGLN matches and non-matches, respectively. In general, the matched flashes have larger areas than the missed flashes, with is to be expected since larger flashes tend to be more easily detectable. In the northern parts of Argentina and central Brazil, there are rows of low DE values. This is most likely due to artifacts within the GLM dataset, such as glint, which cause a large number of false alarms. ENTLN does not locate these false alarms, and as a result the calculated DE in these regions is artificially reduced. This is coroborated in two ways. First, the DE map compared to ISS-LIS does not show the same trend. Second, for the same location as the horizontal, low-DE values in Fig. 5, the average area of the missed flashes is very low compared to the surrounding pixels. The sames pixels in the matched cases (Fig. 6) do not show the same unexpected trends in the average flsah area. Therefore, we suspect that those low DE values are biased low.

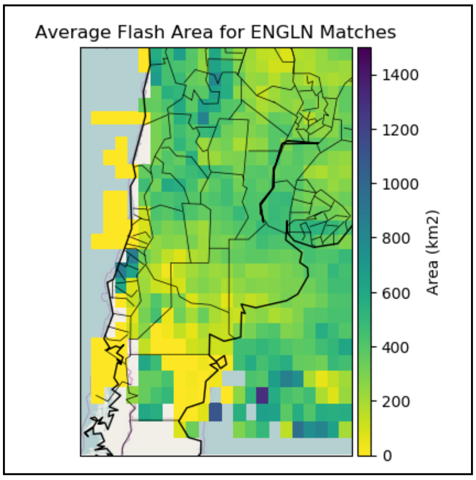

Fig. 6. Average flash area from GLM for flashes that ENGLN also detected from Janurary – April 2019.

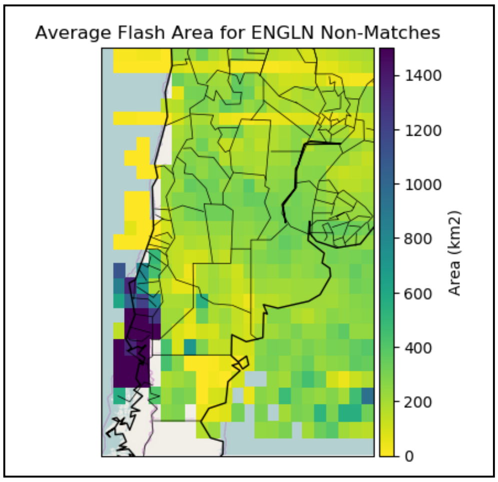

Fig. 7. Average flash area from GLM for flashes that ENGLN did not detect from Janurary – April 2019.

V. CONCLUSIONS

Th goal of this study was to investigate improvements of the ENGLN performance in Argentina, which has recently had a significant number of sensors installed. We compared past published results to current comparisons of the ENGLN data with satellite-based sensors, LIS and GLM, to quantitatively measure these improvements and provide a general overview of the networks current capabilities. Past studies as well as this study have shown that ENGLN has continued to improve between 2013 and 2019. We found that the overall relative total flash DE of the ENGLN in and around Argentina in 2019 is between 48% (GLM) and 57% (LIS). This constitues an increase of 570% compared to pre-instalment results and is primarily attributed to this network deployment. When comparing with GLM data, we find several artifacts that negatively affect the DE results artificially, however, we still find a significant increase compared to prior to the Argentinian network deployment.

REFERENCES

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