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Evaluating GLM in South America by means of STARNET, LINET and RINDAT)

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***Abstract*— This study shows a preliminary comparison about Geostationary Lightning Mapper (GLM) performance over South America by comparing with 3 existing lightning detection networks in Brazil: Sferics Timing And Ranging NETwork – STARNET [Morales et al, 2011], LINET [Betz et al., 2009] and RINDAT [Pinto et al., 2006]. The evaluation is performed at thunderstorm level and grid boxes. Thunderstorms areas are delineated by GOES infrared images, while grid boxes are defined as areas of 0.1 x 0.1 up to 1 x 1 degrees. Preliminary analysis with STARNET observations during the period of May and June 2017 on thunderstorm areas show that: a) GLM describes very well the lightning activity in South America, it even details the topography features in Colombia and Andes mountain; b) there is a day and night detection variation – GLM detects more IC and CG during nighttime period than daytime; c) the detection efficiency decreases southward and eastward (curvature effects). For the conference, such comparisons will be extended until January 2018 and the statistics obtained with LINNET and RINDAT will be presented.**

Keywords—GLM, VLF measurements

I. INTRODUCTION

Since the launch of GOES R (16) on November 2016, a new step on severe weather monitoring has been accomplished with the deployment of Geostationary Lightning Mapper (GLM). During this one year of operation, GLM has been on experimental mode and different scientific research groups are evaluating and validating its measurements (see reports on GLM Science Team Meeting). Upon that, STORM-T laboratory of University of São Paulo is participating in this effort by means of the long range lightning detection network – STARNET (Morales et al., 2011) and the total lightning network – LINET (Betz et al., 2009)

II. DATA SET

STORM-T laboratory operates two lightning networks in Brazil: STARNET and LINET-SP. STARNET is a long range lightning detection network that measures the radio noise emitted by cloud to ground (CG) strokes at very low frequency (Morales et al., 2011). STARNET uses vertical electrical field waveforms that propagate several thousand of km trough the waveguide formed by the ionosphere and earth surface, Morales et al. (2011). STARNET measures CG over South America by means of 12 VLF stations installed in South America, Africa and in the Caribbean, Figure 1a. LINET though, measures VLF/LF magnetic waveforms emitted by both intra-cloud (IC) and CG (Betz et al., 2009), Figure 1b, that propagate either by ground waves or line of sight. LINET can detect the 3D position of lightning strike in addition to its peak current. The 3D solution is restricted to 200 km from the sensor, while the 2D solutions can extend up to 600 km away from the sensors. LINET-SP was deployed with 9 sensors installed in the state of São Paulo, Paraná and Minas Gerais as illustrated in Figure 1b

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III. RESULTS

For this article, GLM measurements are compared with STARNET during the period of May and June 2017 in the domain defined as 90-30W and 40S-10N, while LINET-SP a simple comparison is done for August 20th 2017.

III.I Spatial Distribution

Figure 2 show the number of events detected by GLM during the period of May and June of 2017 with flag 1 and the number of sferics measured by STARNET on a grid box of 0.1 x 0.1 degrees. As it possible to observe, GLM and STARNET present the same spatial lightning features, except for a region delimited by 0 e 5ºS where GLM has a notable reduction. The topography signature over the Andes mountains are clearly depict by GLM, where is possible to the mountain and valley contours. As expected, GLM measures more than STARNET as it is measuring total lightning

III.II Day and Night detection

In order to analyze how GLM detects during day and night, we computed the ratio of the number of GLM groups (flag 1) by the number of STARNET sferics in a thundercloud. The thunderstorms are identified on IR images by clustering clouds with temperature lower than 258 K.

TABLE I. DAYTIME GLM/STARNET RATIO

Day	90-70W	70-50W	50-30W
0-20N	4.98	4.21	1.25
20S-0	4.93	2.88	0.86
40S-20S	0.92	0.28	0.21

TABLE II. NIGHTTIME GLM/STARNET RATIO

Night	90-70W	70-50W	50-30W
0-20N	26.25	42.33	4.67
20S-0	16.94	13.79	8.08
40S-20S	4.32	4.24	1.32

Furthermore, we computed the mean ratio for areas of 20 x 20 degrees and separate in daytime (Table 1) and nighttime (Table 2). It is possible to observe that during nighttime, GLM measures as much 5 time more than during daytime for the same region, along 90-70W. As we go further east and south this difference can reach higher values and it can be attributed to parallax effects, since GOES-16 was initially at 89.5ºW.

III.III LINET

On August 20th of 2017, a frontal system propagated through the states of Paraná and São Paulo, Figure 3a, during the early hours of the day. On Figure 3b it is presented the number of strokes per minute measured by GLM, LINET and STARNET in Figure 3a domain. It is interesting to note that the first lightning burst, 5-10 am, is followed by GLM and LINET. GLM measures as much as 10 times more than LINET. A second peak, 10 – 12am, all 3 systems are in phase and have comparable lightning rates. After 12 pm, GLM decreases its measurements and both LINET and STARNET are now in phase

(a)

(b)

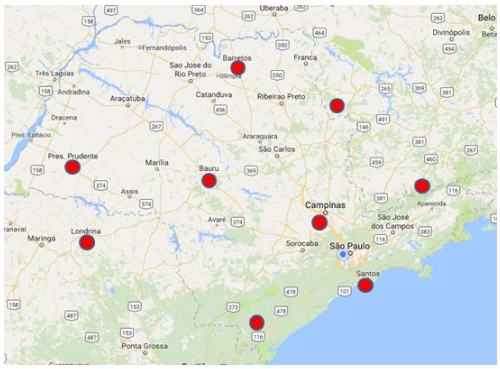

Fig. 1. Location of the STARNET (a) and LINET-SP (b) antennas.

I. CONCLUSIONS

This article presented preliminary comparisons between GLM and STARNET during May and June of 2017, when GOES-16 was still at 89.5ºW. Through the comparisons it was possible to find a day and night detection efficiency

dependency on GLM. Basically GLM detects more lightning events during nighttime than daytime, when computing the ratio GLM/STARNET strokes in a thunderstorm. Furthermore, parallax errors might produce a decrease on the detection efficiency.

For the conference, more detailed statistics will be presented for a longer period of time, using both STARNET, LINET and RINDAT as well.

(a) (b)

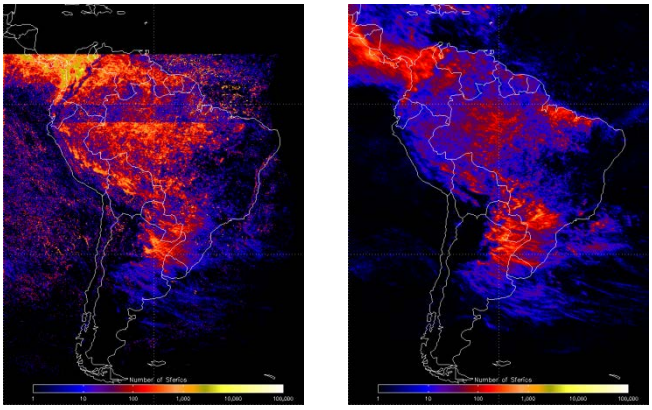

Fig. 2. Number of strokes measurements by GLM (a) and STARNET (b) in an area of 0.1 x 0.1 degrees during the months of May and June 2017.

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(a) (b)

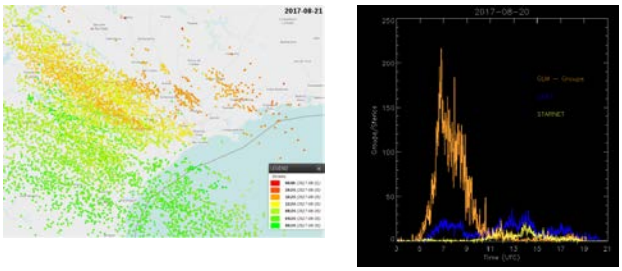

Fig. 3. LINET measurements during August 20th 2017 and number of lightning per minute measured by GLM, LINET and STARNET

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