Thunderstorm effects on the atmosphere-ionosphere system/TEA-IS

Correlation study of AGILE TGFs and lightning over Colombia

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Period of work: 20/2 – 3/3, 2012

1. Purpose of the visit

The AGILE satellite detects about 10 TGFs/month in a +/- 2.5 degrees latitude belt across the equator. For this reason, it has been difficult up to now to correlate AGILE TGFs with lightning located by high-resolution ground-based lightning location networks, that are typically deployed well above the equator. The Universitat Politecnica de Catalunya (UPC) have now access to data of a lightning location network based on LINET-like sensors operating in Colombia since September 2011, which cover not exactly the same equatorial region crossed by AGILE, but can detect lightning in this region. This network has nowadays 7 sensors running and two more have been installed during March 2012. The efficiency is clearly better for cloud to ground lightning than for intra-cloud lightning. About 30% of AGILE TGFs are detected above central America. Since AGILE detected the highest TGF/flash ratio above the central America region (Fuschino F. et al., Geophys. Res. Lett. 38, L14806, 2011), this is a unique opportunity to exchange data and correlate AGILE TGFs and lightning over that region.

2. Description of the work carried out during the visit;

1. AGILE data collection

   The following table reports the AGILE TGFs recorded above central America region in the period September - November 2011. The six events highlighted are those close enough to the LINET ground stations to be potentially detectable.

Orbit	Trigger id	Date	Time(UTC)	Long	Lat	Peakflux	Fluence	Hardness
22813	25	2011-09-25	03:14:43,68	-84,92	-0,59	9	12	0,5

22834	42	2011-09-26	16:42:13,16	-64,99	-1,72	5	20	0,67
22965	56	2011-10-05	23:07:22,37	-74,79	1,25	8	29	3,83
23050	1	2011-10-11	20:08:08,61	-60,51	1,89	6	15	0,88
23083	5	2011-10-14	07:31:33,10	-69,46	-1,97	6	16	1
23136	18	2011-10-17	23:51:57,01	-61,15	0,95	11	13	0,86
23391	3	2011-11-05	02:28:50,74	-72,81	-0,85	5	12	0,71
23417	25	2011-11-06	22:37:13,13	-73,37	-2,21	5	22	1,2
23472	13	2011-11-10	19:58:55,11	-76,71	-2,37	4	11	1,2
23570	11	2011-11-17	18:26:12,18	-58,96	-0,78	6	14	1,33
23574	2	2011-11-17	21:50:48,68	-55,63	1,51	9	15	1,5
23574	1	2011-11-17	21:45:41,90	-73,77	0,76	7	16	1,67

2. LINET data collection

   Nowadays, LINET Colomba has 7 antennas distributed in the country. The main feature in the installation places is the variable altitude due to the characteristic mountains of the country, presenting a minimum installation altitude of 47 meters and a maximum altitude of 2752 meters. With the 7 antennas installed nowadays, the detection efficiency of the network is about 90% for cloud-to-ground lightning. The efficiency is still under evaluation, but it is now clear that it is a good efficiency for cloud-to-ground lightning (discharges currents larger than +/- 6.25 kA above ~ 0.5 degrees latitude North), but not yet for intra-cloud.

   Linet provides data in this format:

Date	**Time(UTC)**	**Lat**	**Long**	**Altitude(km)**	**Type**	**Peak Current (kA)**	**Error(m)**
20110925	00:00:17.807	+02.8488	-76.6684	00.0	1	-103.1	2507
20110925	00:00:18.069	+02.8675	-76.6547	00.0	1	-039.1	5987
20110925	00:00:25.317	+03.3365	-75.9167	00.0	1	-010.0	1097
20110925	00:00:36.962	+04.8370	-73.0816	00.0	2	-007.0	313
20110925	00:00:36.966	+04.8193	-73.0637	00.0	1	008.0	325
20110925	00:00:37.597	+00.6068	-75.5695	00.0	2	-036.2	4113
20110925	00:00:46.913	+00.4091	-73.3780	00.0	1	051.2	4926
20110925	00:01:01.486	+04.8546	-67.8589	00.0	1	-052.0	6896
20110925	00:01:12.117	+04.8423	-67.9754	00.0	1	017.8	3351
20110925	00:01:12.158	+00.7650	-72.9779	00.0	1	-019.9	5213
20110925	00:01:14.130	+04.1296	-73.5444	12.7	2	008.1	3396

3. GOES images collection

The Goes images have been taken from INPE/CPTEC (Instituto Nacional de Pesquisas Espaciais/Tempo e Estudios Climaticos) web. We have taken GOES channel 4 images with a product that shows three possible phases of

the convective system life cycle: red=intensifying, yellow=stable, green=de-intensifying.

4. TGF / Lightning time correlation

   No one-to-one correlation between detected lightning and TGF was found (closer association is ~1 sec from TGF).

Since no one-to-one association was found it was necessary to change the analysis approach. In particular it was not possible to study the weak AGILE triggers and the triggers in the South Atlantic Anomaly.

It was necessary to follow a statistical approach:

1. identify the possible causative storms (nearest to TGF event) looking IR GOES images.

2. study the evolutionary phase of the nearest storms based on IR images and correlate with lightning data.

3. Study the evolution of the nearest storms, in a time interval 2 hours before/after the TGF event

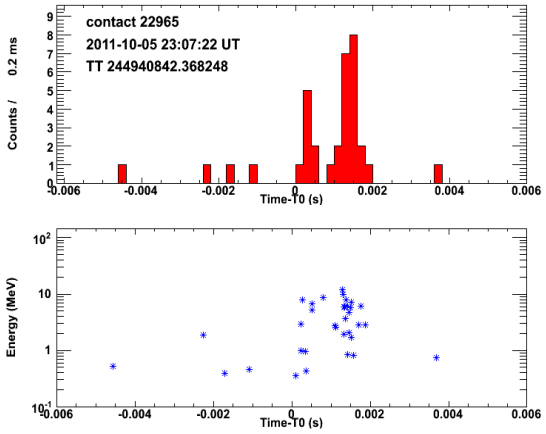
4. “Lightning rate” and “distance of lightning to TGF event” with no selected storms in different time intervals before/after the TGF event (1 minute, 5 minutes, 10 minutes, 15 minutes and 60 minutes),

3. Description of the main results obtained

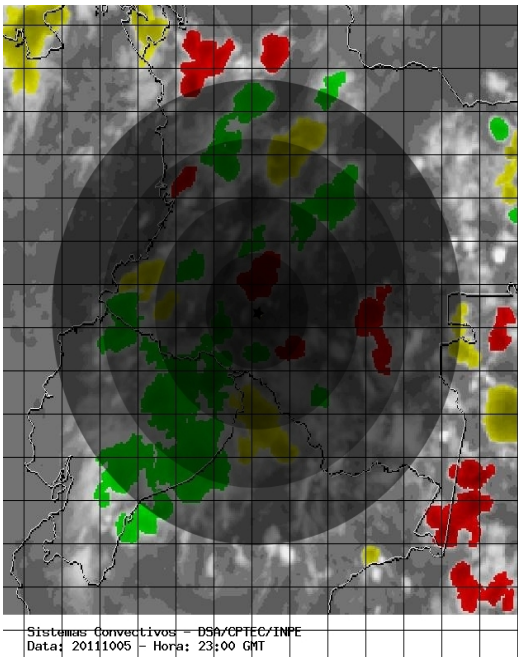
Because of the location of TGF events, we have selected 6 of them that were in the detection area of Linet network. These events are marked in yellow in table 1.

We show one of the cases:
Case study: #22965 – 2011-10-05 – 23:07:22 UT - lon = -74.8° lat = 1.3°

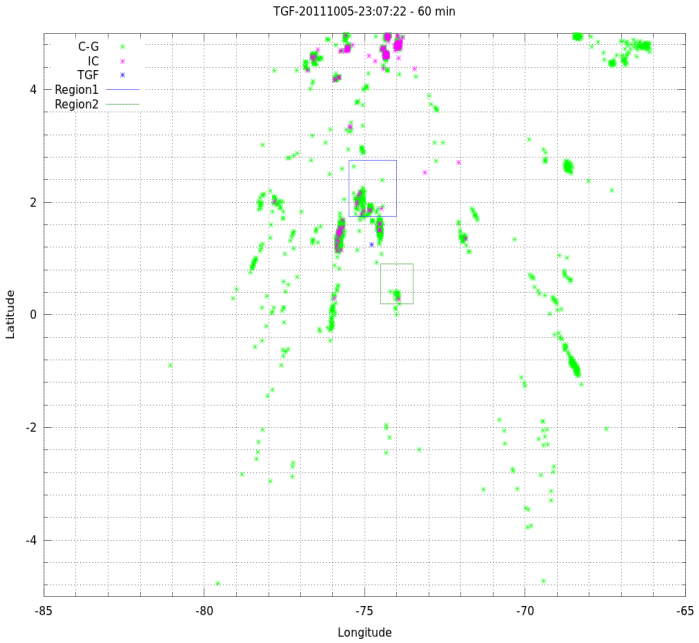
Agile Light curve



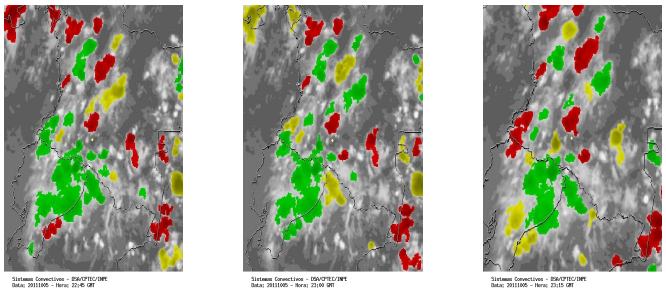
IR GOES image close in time to TGF



LINET lightning detection (T0 +/- 60 min)

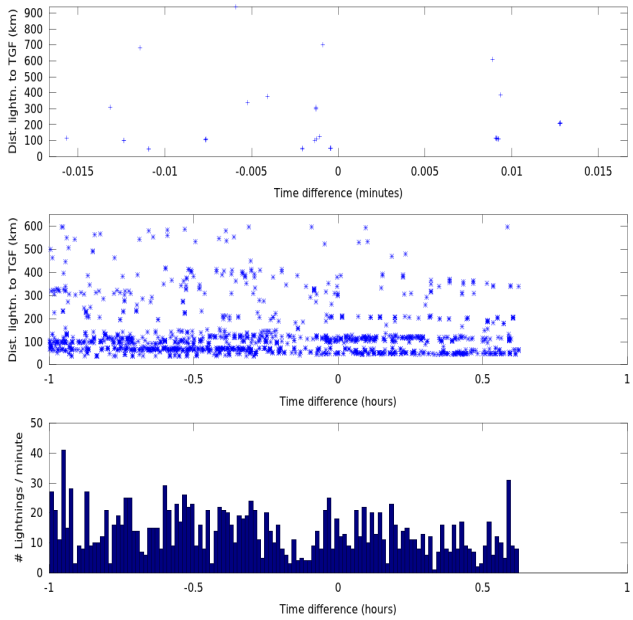


Storm evolution from GOES images:



22:45 23:00 23:15

Lightning rate (no storms selected)



We have clearly seen in the different cases that close in time to the TGF event there are a lot of convective systems inside a circle of 300 km of radius centered in the satellite footprint at the TGF time. We have also seen that the majority of closest convective systems to TGF event were intensifying when the TGF event occurs.

A radial pattern in the lightning location has been found. This is because there are some sensors aligned, and the parabola solutions in regions a little bit far from the efficient area of the center of th network it becomes narrow. With the two new sensors installed during March of 2012 this effect will be reduced and a better efficiency will be achieved, too. This also means that the probability to find a one-to-one correlation will increase.

4. Future collaboration with host institution (if applicable);

We plan to go on with the collaboration addressing the following points:

1. Put the lightning points on top of the IR images to see the storm evolution.
2. Identify storms and do lightning analysis for the closest / most interesting storm (flash rate divided by flash type (IC, CG)).
3. Identify the dimension of storms.
4. Ask for radar data, if available.
5. INAF will provide new AGILE TGFs to increase statistics.
6. Understand the climatology in Colombia. Study the tropopause height and other meteorologic parameters.
7. Do same for cases when AGILE doesn't detect any event over this region

5. Projected publications / articles resulting or to result from the grant (ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant);

Depending on the results. Basic idea: detailed analysis of TGF-producing storms over Central America.