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

Short Visit

Scientific Report

***Proposal Title*:** **Investigating RHESSI and AGILE TGFs in Colombia**

***Application Reference N°*:** **5705**

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Amount requested: 1775 Euro

Period of work: 22/9 – 6/10, 2013

1. Purpose of the visit

TGFs are very short (up to ms) but powerful (up to 100 MeV) terrestrial gamma ray bursts, and they are thought to be consequence of high energy electron Bremsstrahlung emissions. Since their accidental discovery in 1994 by BATSE CGRO (*Fishman et al.,* 1994), some other instruments have been developed specifically for TGF detection: RHESSI (*SMITH et al.,* 2005), AGILE (*Marisaldi et al.*, 2010) and FERMI (*Briggs et al.*, 2010). All works carried out with TGF data of these instruments confirms the relation between TGFs and thunderstorm and lightning activity. Some of the results shows that global world TGF occurrence is consistent with global thunderstorm and lightning occurrence, being greater over land and tropics , although regional differences in lightning/TGF ratio has also been reported (*Fuschino et al.*, 2011). A non negligible number of TGFs has been linked to specific thunderstorms showing a preferential occurrence during declining thunderstorm phase (*Smith et al.*, 2010) and thunderstorm altitudes between 13.6 km and 17.3 km (*Splitt et al.*, 2010). Moreover, correlations between TGFs and specifics lightning discharges (*Cohen et al.*, 2010) and

theoretical models (*Williams et al.,* 2006) indicate that TGFs may be produced by intra-cloud upward negative leaders, occurring near the tropopause, where the attenuation is lower and can easily escape to the space.

The purpose of this visit is to check the new RHESSI TGF catalog (*Gjesteland et al.*, 2012) and AGILE TGF catalog with LINET (lightning location network) data in Colombia and countries around to find TGF/lightning specific correlations. It is also thought to define a method to find out preference thunderstorm meteorological features (like storm size, CAPE, CIN and Top Cloud temperature and altitude) to produce a TGF.

2. Description of the work carried out during the visit

In order to achieve the main objective described above, three specific objectives has been defined.

1. Find out general features atmosphere preferences for TGF occurrence. Study of satellite passes over South America.
2. Find out meteorological thunderstorms preferences for TGF production. TGF/lightning correlations
3. Contribute to the study of TGF production mechanisms focusing on TGF/lightning correlations and LMA lightning examples.

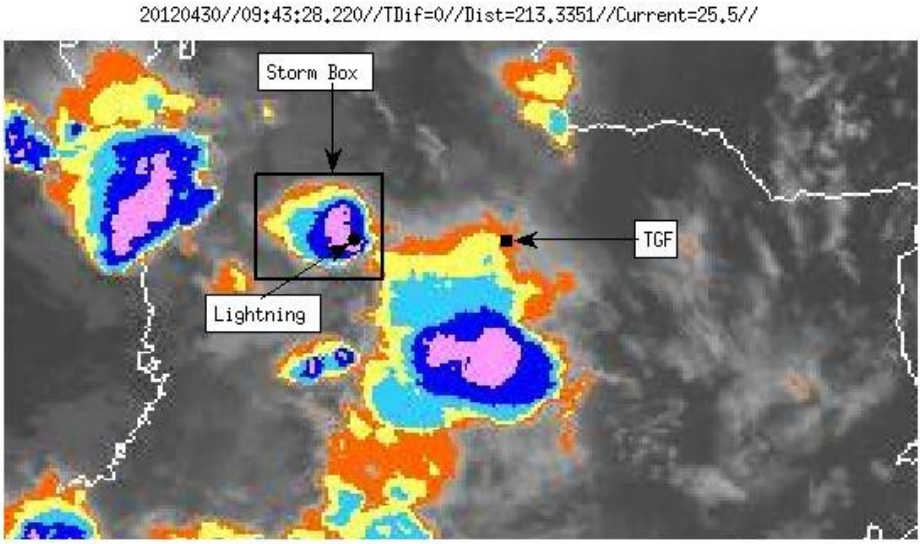
The data available for this work is described below:

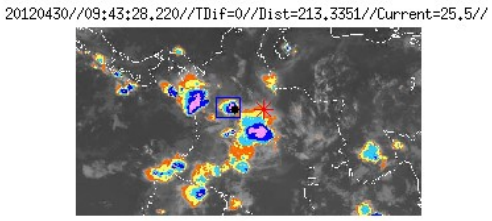
		TGF		**Lightning**		
		RHESSI	**AGILE**	**LINET**	**WWLN**	**STARNET**
Geographic window	**LAT**	-30 to 30	-2.5 to 2.5	-5 to 14	World	S America
	LON	Total	Total	-86 to -66	World	S America
Data time available		Aug 2005 -	Apr 2009 -	Oct 2011 -	2011	2004-2013

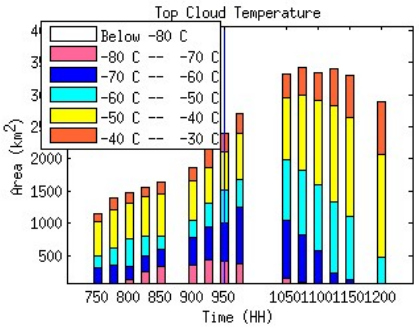
During the visit, the main goal has been the concrete TGF/ lightning correlations between RHESSI and LINET data. We have analyzed RHESSI TGFs (Gjesteland's catalog) between October 2011 (when LINET network begins to operate) and December 2012. Eleven correlations have been obtained with a time difference less than 10 ms between lightning and TGF. For these cases we have analyzed what follows

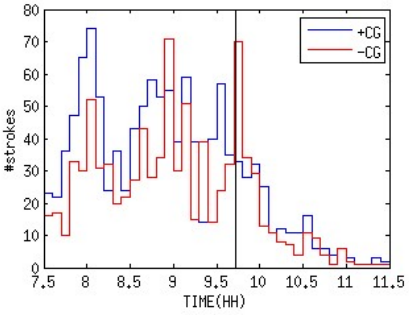
- Time difference, by now available to ms.
- TGF lightning related features: Peak current, Type and Polarity.
- Distance from subsatellite point and lightning location.
- Video of satellite images as a control method for the square selected to study the thunderstorm evolution.
- Thunderstorm phase, based on lightning frequency time evolution and Top Cloud Temperature time evolution.
- Current Study of lightning in within +- 2h. around TGF time (+-CG and +-IC occurrence and current graphics).

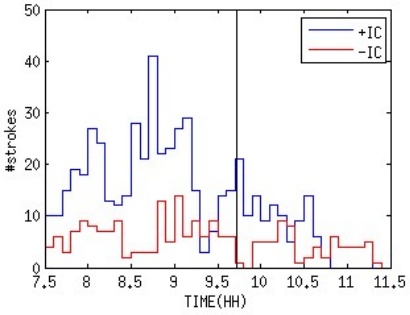
Here are shown the graphics obtained for one of the correlations on 2012-04-30 (the same has been done for the other correlations; the results are summarized in section 3).

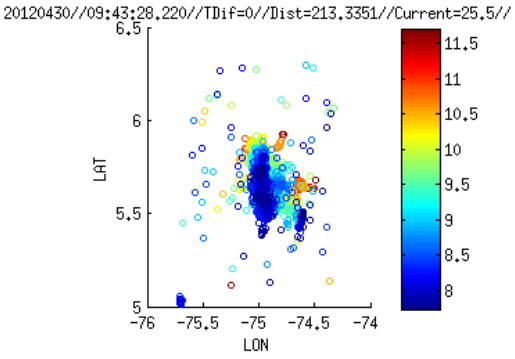


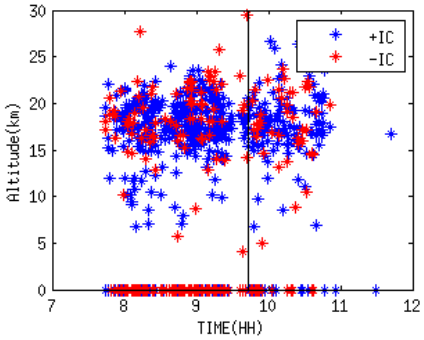

20120430//09:43:28.220//TDif=0//Dist=213.3351//Current=25.5//

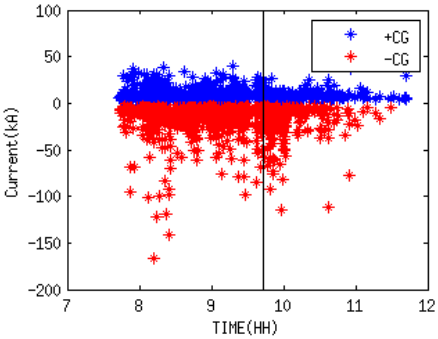

Top Cloud Temperature
Below -80 C
-80 C -- -70 C
-70 C -- -60 C
-60 C -- -50 C
-50 C -- -40 C
-40 C -- -30 C
Area (km2)
Time (HH)

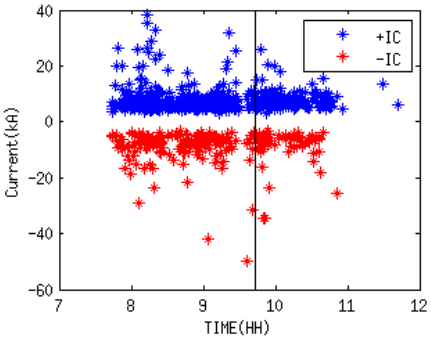

+CG
-CG
#strokes
TIME(HH)


+IC
-IC
#strokes
TIME(HH)


20120430//09:43:28.220//TDif=0//Dist=213.3351//Current=25.5//
LAT
LON


+IC
-IC
Altitude(km)
TIME(HH)


+CG
-CG
Current(kA)
TIME(HH)


+IC
-IC
Current(kA)
TIME(HH)

3. Description of the main results obtained

We present here a summary of the main results and conclusions of this study described in section 2.

- First of all, correlations between RHESSI TGFs and LINET lightning has been checked. A total of 41 TGFs (Gjesteland's catalog) were detected by RHESSI in the LINET area of detection during October 2011 and December 2012. Using a correlation criteria of time difference < 10 ms, 11 correlations has been found. In 3 of the cases, the distance between lightning location and RHESSI subsatellite point was > 600km, what is thought to be too much.

- Time difference has to be corrected because of a RHESSI offset of +1.9 ms and due to RHESSI is detecting TGFs when reaches the satellite, not when is produced. Assuming that TGF is produced in the lightning location and knowing satellite altitude, we can easily calculate time that light travels on air to satellite and correct this time has to be implemented. Before the time correction and the study of the lightning waveforms, up to time precision of microsecond, the temporal relation between lightning and TGF will be established.

- In the 11 cases, the lightning related was a Cloud-to-Ground lightning. 4 were positive and 7 negative. The minimum positive peak current was of 25.5 kA and the maximum 107.4. For the negative ones, the peak current was between -16 kA and -138.3 kA. 4 of the lightning has a multiplicity bigger than 1.

- We cannot say anything conclusive about the storm phase when a TGF occurs. Similarly, the causative storms has different sizes, altitudes and top cloud temperatures. What we can say is that in all of the cases the storm systems are long-live, reaching 4,5 or 5 hours duration

Once these analysis is done, what it has to be improved or developed is:

- TGF time correction.
- Review selected storms.
- Reanalyze lightning raw data,
- Study the storm meteorological transcendent variables like CAPE, CIN or Top Cloud altitude.

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

It is planned to develop the three main objectives explained in section 2 in the next 2-3 months. AGILE TGFs data and STARNET data will be added to the study.

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, the basic idea is to do 3 articles, one for each main objectives explained in section 2.