Lightning activity detected by Swarm - multi-instrumental verification of selected events

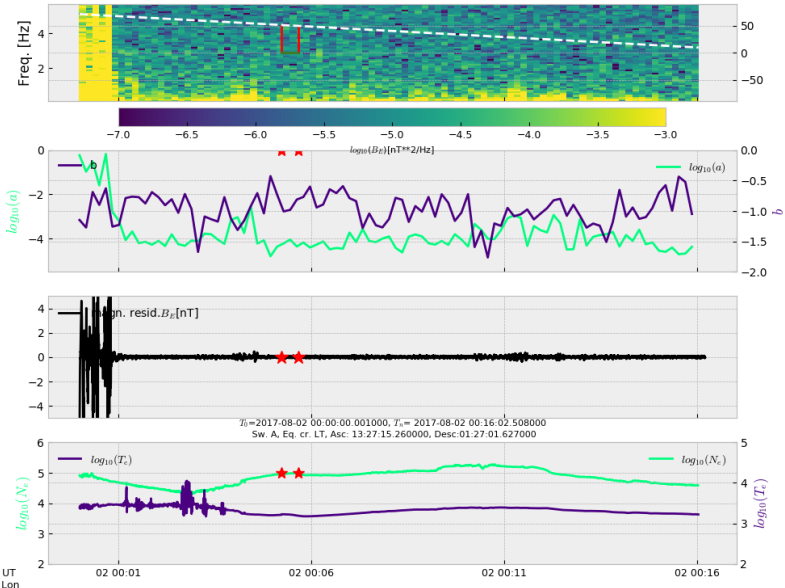
June 26, 2019

Turning point - scalar data

Results

Why we couldn't find signatures of lighting?

- The strongest event, with charge moment **4870** C km, should be seen on Swarm
- Response in δB_i unclear, but strong currents should be seen in δF



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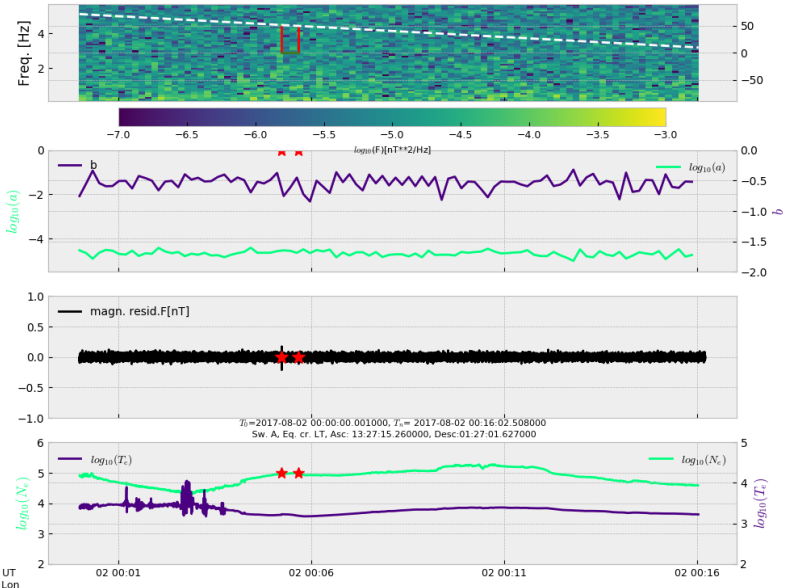

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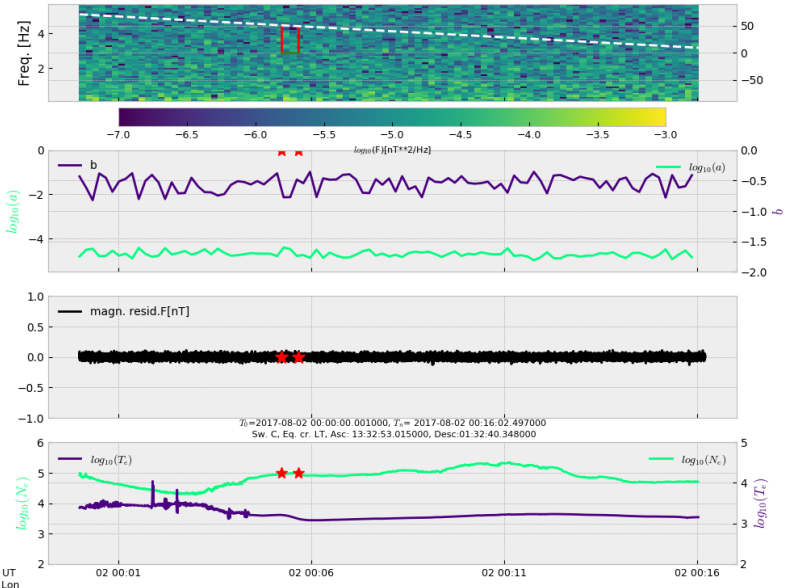
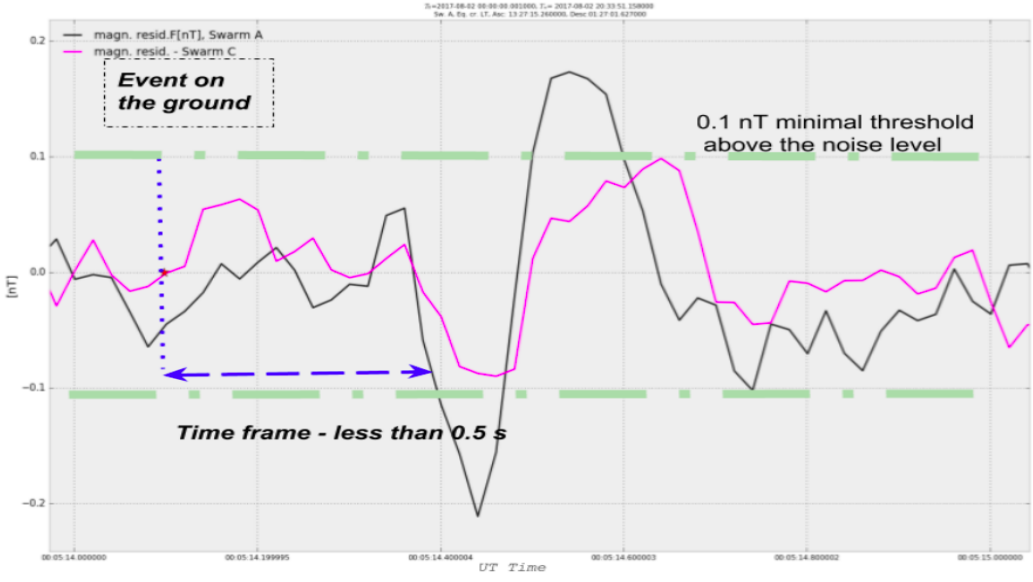
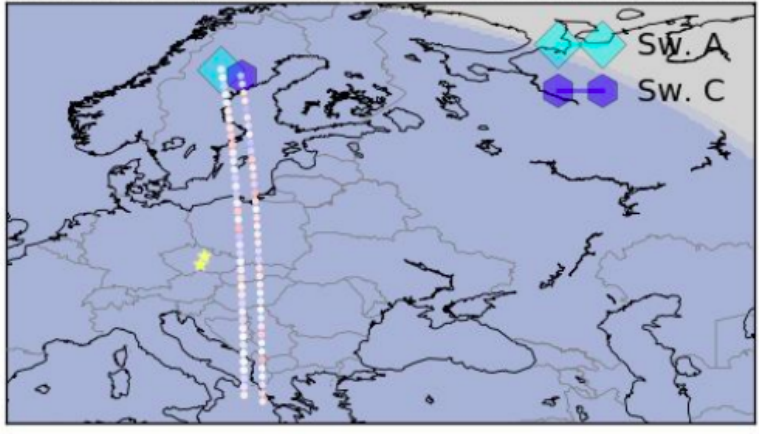


Swarm A/C - Why the effect is only on one satellite



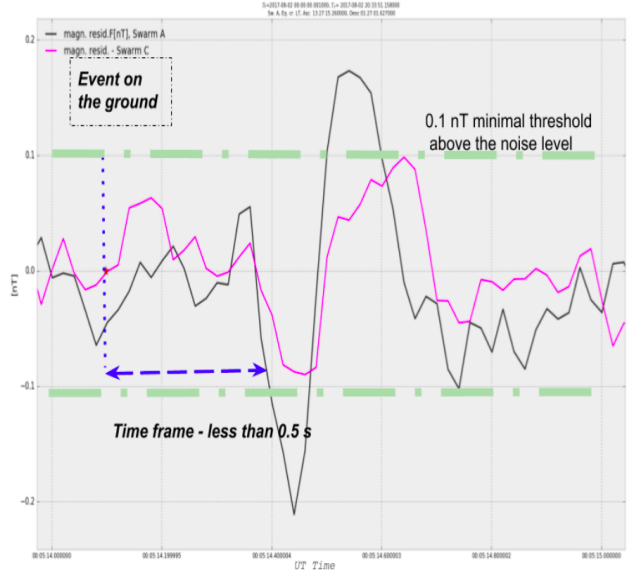
Swarm A/C - Distance between event and the satellite track

T_0=2017-08-02 00:01:42.395000, T_n= 2017-08-02 00:08:31.973000
Sw. A, Eq. cr. LT, Asc: 13:27:15.260000, Desc:01:27:01.627000



Revised approach

- Expected signal - differentiated Gaussian signal
- minimal threshold for detection - above $\pm 1nT$
- analysis of scalar field δF - not components
- looking for a source of currents
- first indicator of lightnings - data from WWLLN (low resolution)
- automatic detection - quality of the fit determines, whether the spike is a good candidate for further analysis



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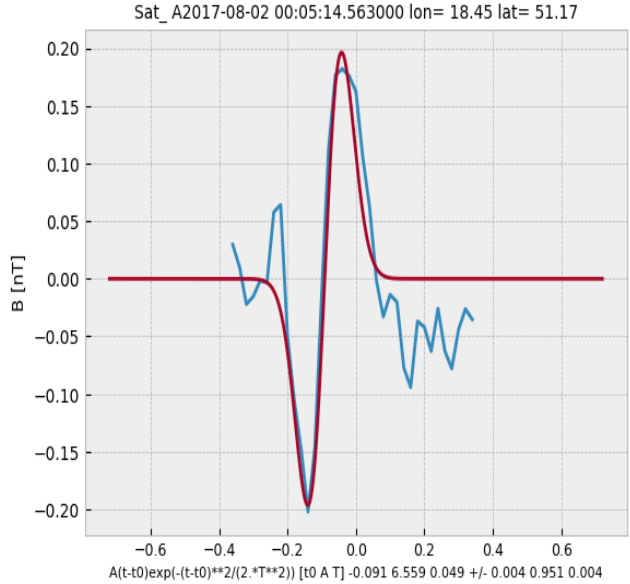
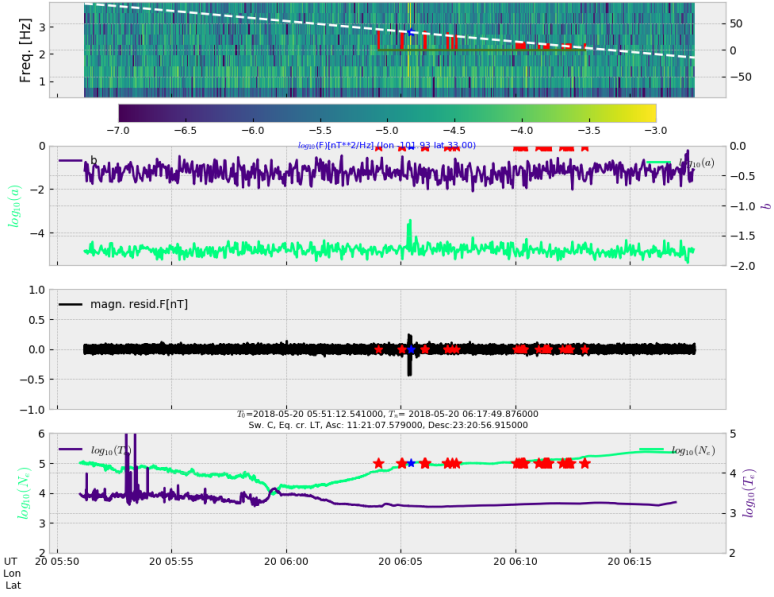


Thunderstorms in Oklahoma - 2018.05.20



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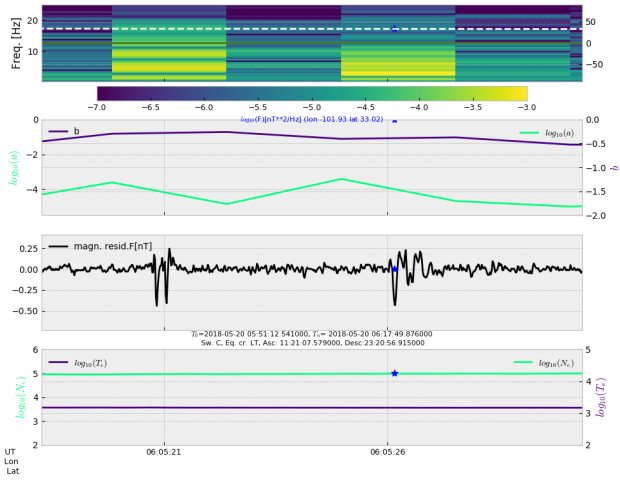
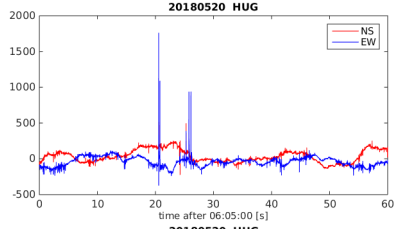
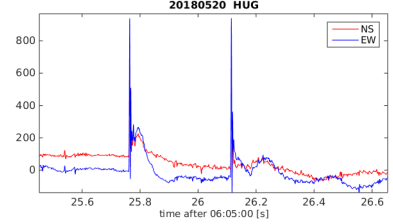
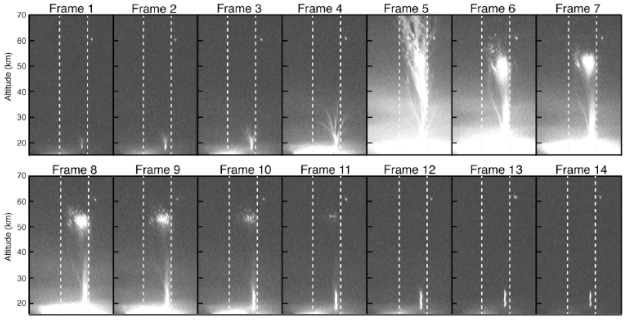


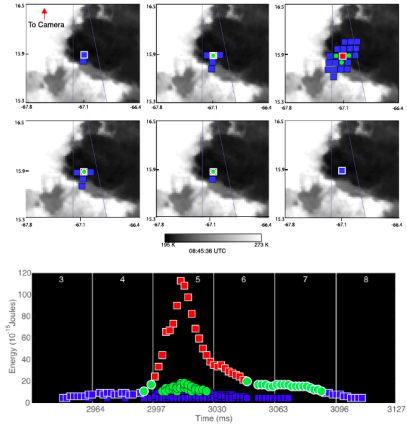




Additional source of data - GLM

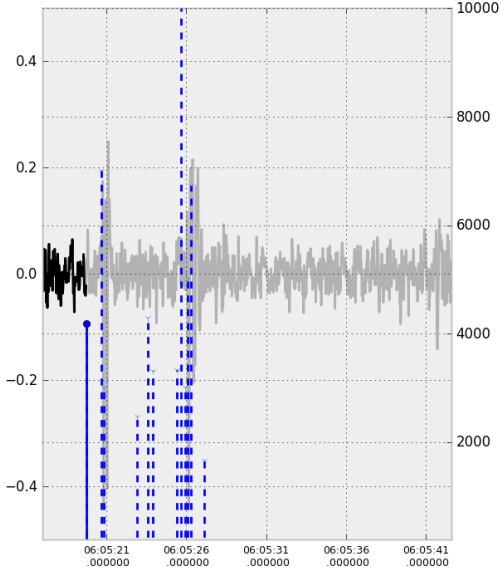


Low-light-level images of the 08:46 UTC gigantic jet on **19 August 2017**. Frame 1 - 08:46:02.864 UTC *Source: First Observations of Gigantic Jets FromGeostationary Orbit (Levi D. Boggs, doi:10.1029/2019GL082278*



For flash on: 8:46:02 (462) UTC, Duration of series of events: 160 ms, Max event En: 112.9 (fJ), **Flash Max En. 3,067.2 (fJ)**

Thunderstorms in Oklahoma - 2018.05.20 - Swarm + GLM



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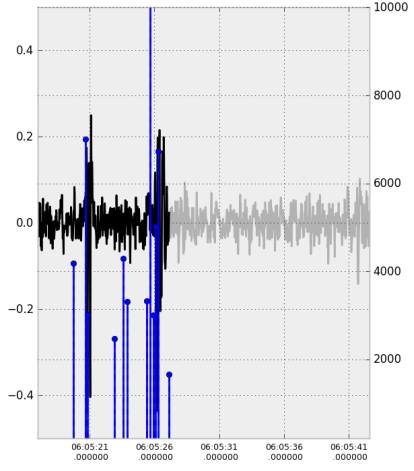

Three-dimensional covariance matrix in analyzing the polarization properties of plane waves

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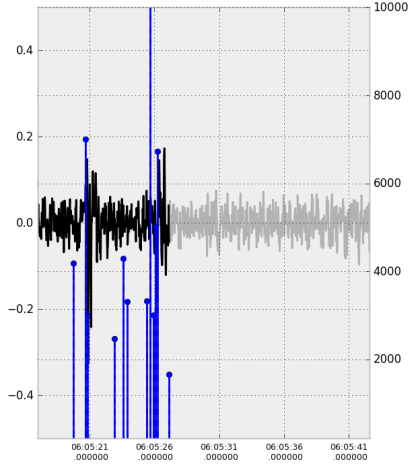
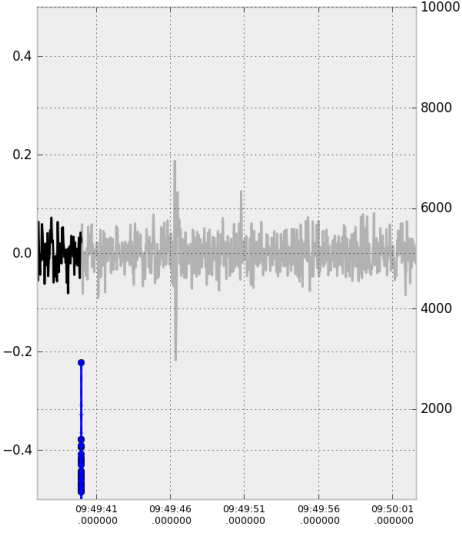


Three-dimensional covariance matrix in analyzing the polarization properties of plane waves

Ex. #2: Gulf of Mexico - Distance from the source vs. amplitude of fluctuations



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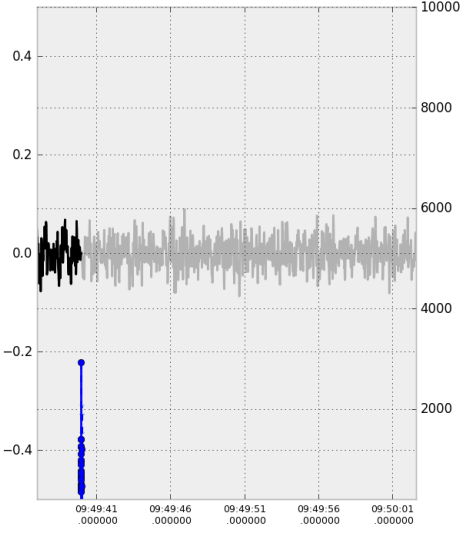
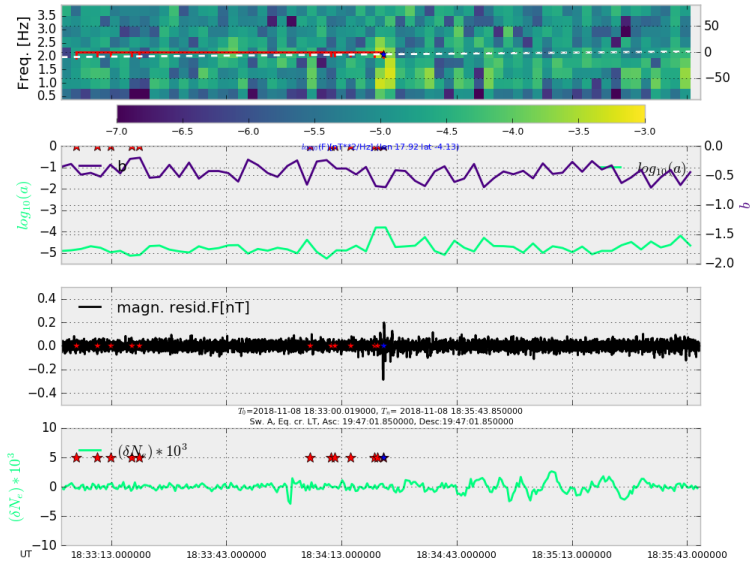


Ex: #3: African storm



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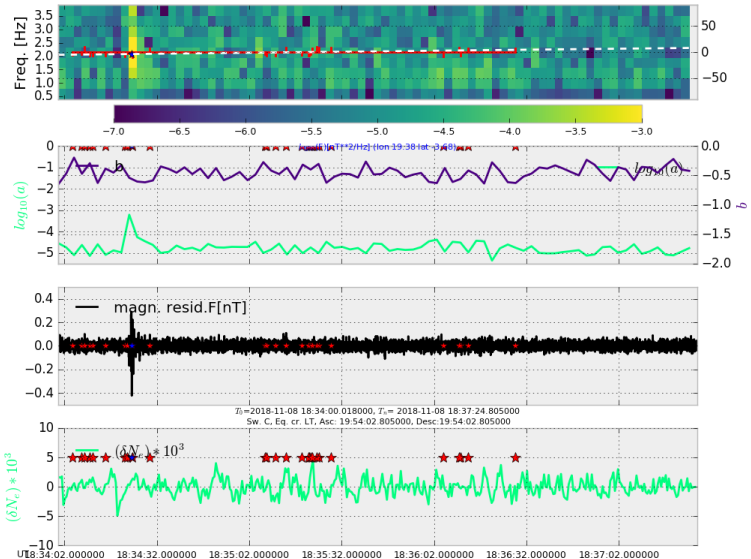
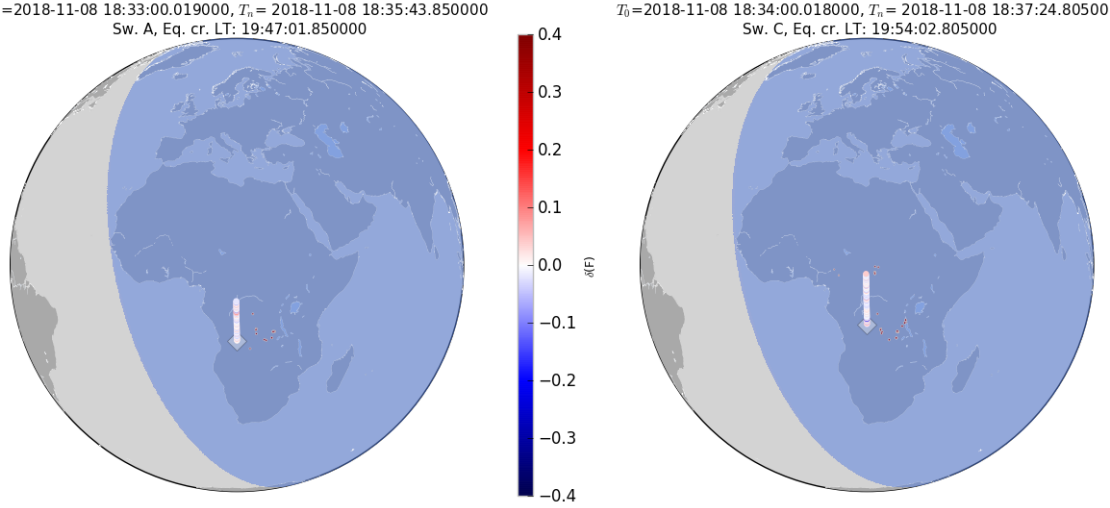
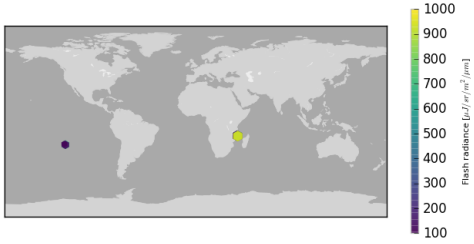
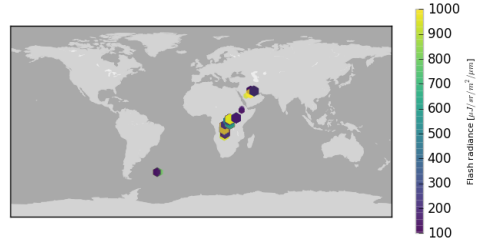


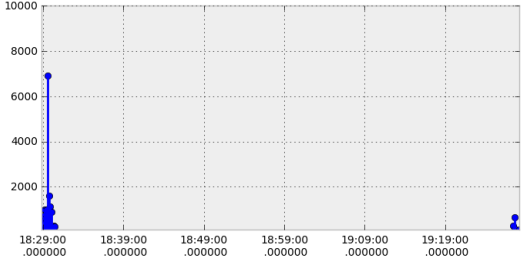
Ex: #3: African sector

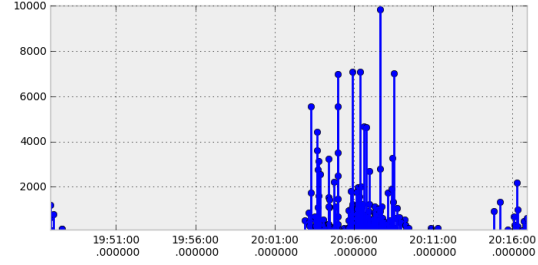


Ex: #3: African sector - LIS on ISS









Ex: #4 "Gauthier's whistlers"

"Let's take an atlas ..."

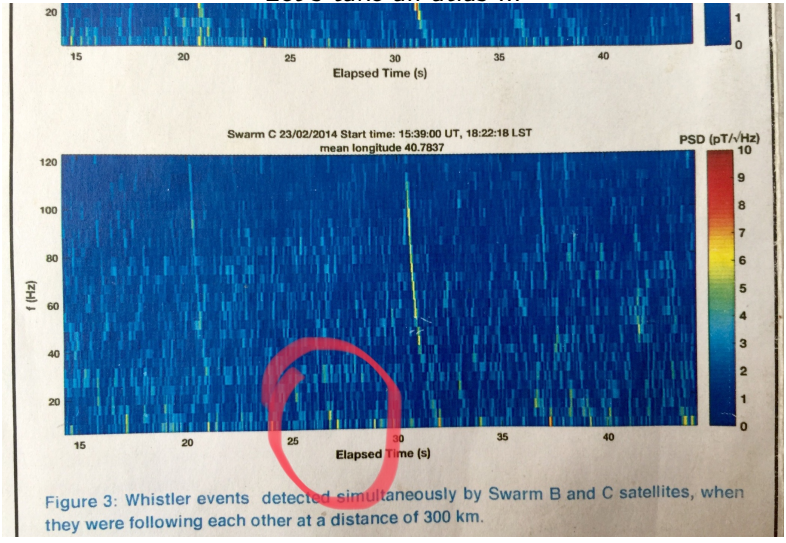


Figure 3: Whistler events detected simultaneously by Swarm B and C satellites, when they were following each other at a distance of 300 km.

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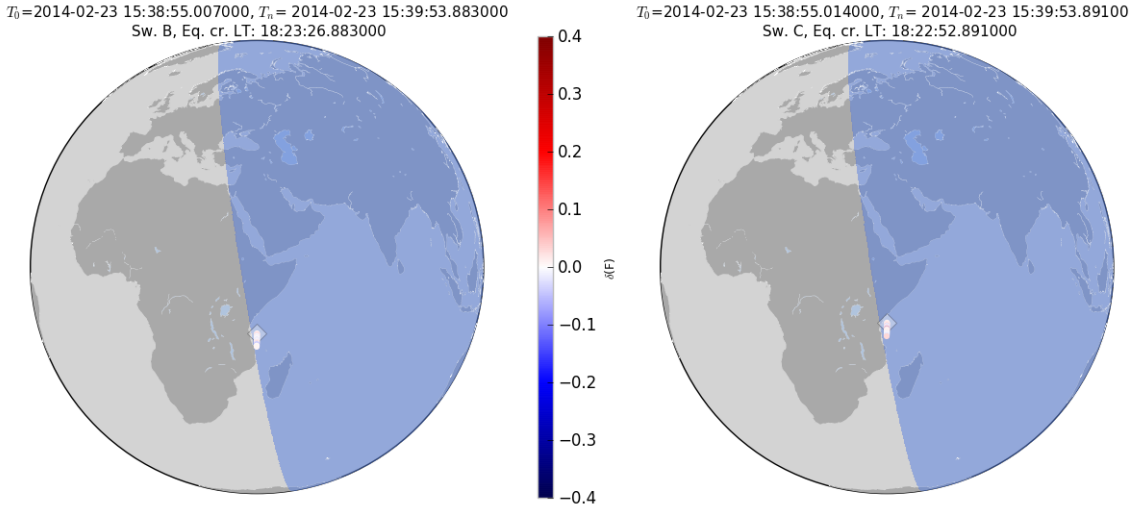

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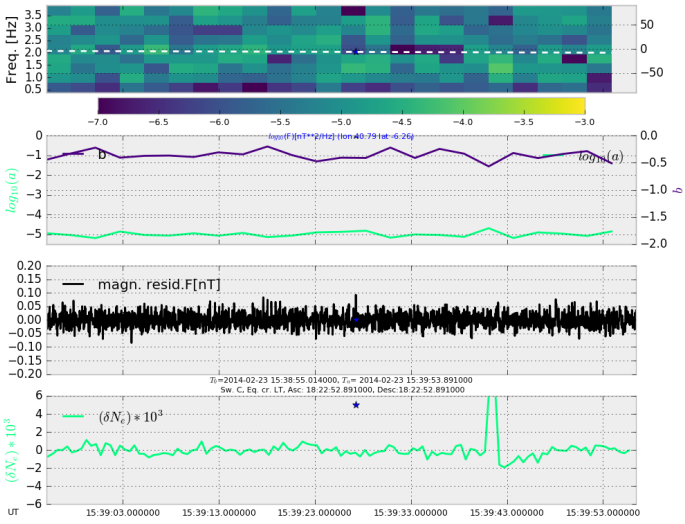

- amplitude δF below 0.1 nT, which implies that whistlers detected on ASM with "Burst mode" are triggered by regular thunderstorms, which do not produce such strong currents

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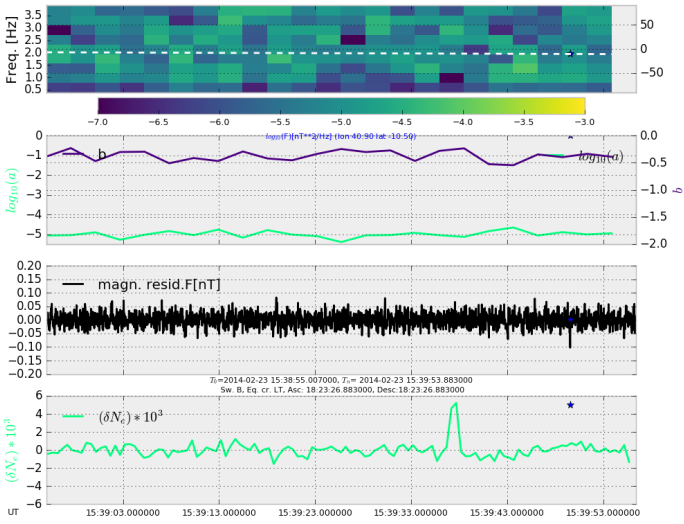

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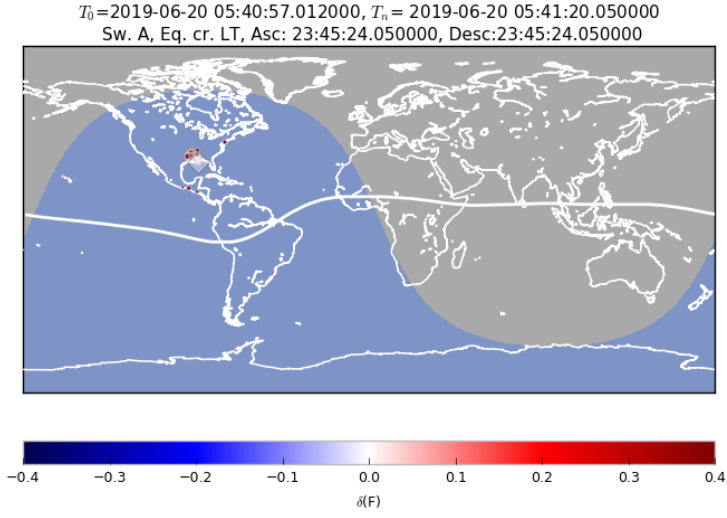
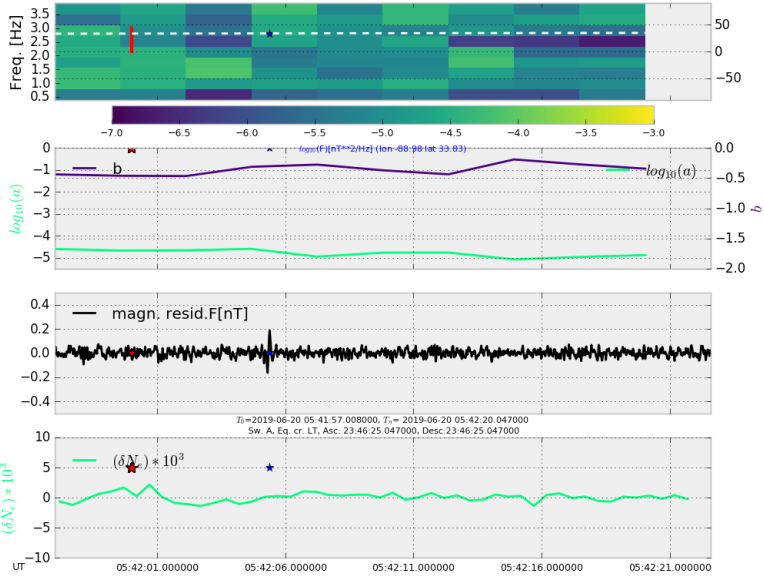
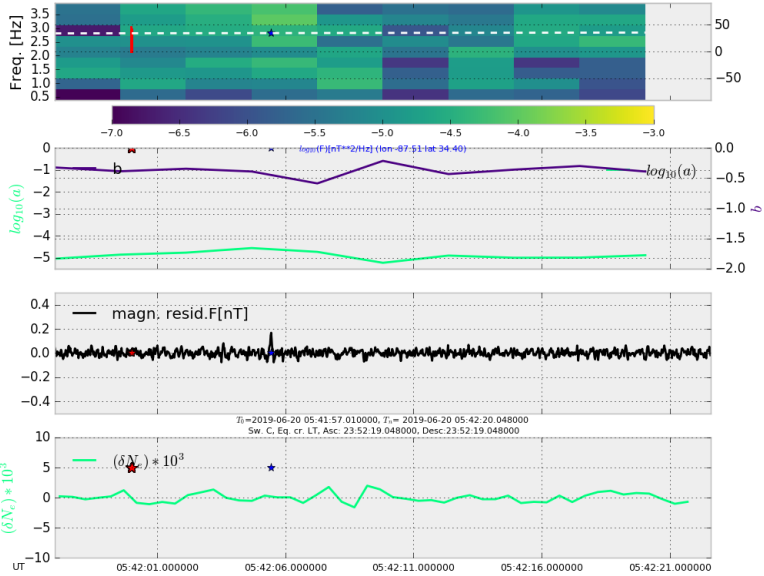
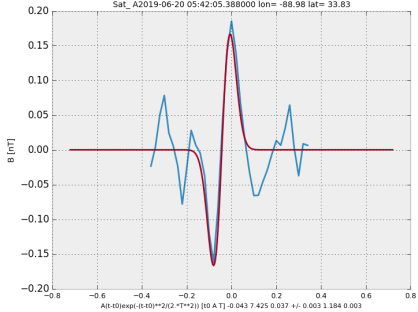
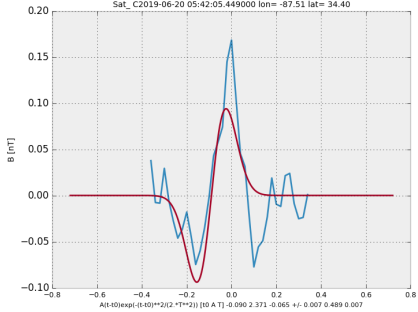
Ex: #5 Last week in US




Freq. [Hz]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
50
0
−50
−7.0
−6.5
−6.0
−5.5
−5.0
−4.5
−4.0
−3.5
−3.0
log_{10}(F)[nT**2/Hz] (lon -88.98 lat 33.83)
b
$log_{10}(a)$
$log_{10}(a)$
0
−1
−2
−3
−4
−5
0.0
−0.5
−1.0
−1.5
−2.0
magn. resid.F[nT]
0.4
0.2
0.0
−0.2
−0.4
T_0=2019-06-20 05:41:57.008000, T_n= 2019-06-20 05:42:20.047000
Sw. A, Eq. cr. LT, Asc: 23:46:25.047000, Desc:23:46:25.047000
$(\delta N_e) * 10^3$
$(\delta N_e) * 10^3$
10
5
0
−5
−10
UT
05:42:01.000000
05:42:06.000000
05:42:11.000000
05:42:16.000000
05:42:21.000000


Freq. [Hz]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
50
0
−50
−7.0
−6.5
−6.0
−5.5
−5.0
−4.5
−4.0
−3.5
−3.0
$log_{10}(F)[nT**2/Hz]$ (lon -87.51 lat 34.40)
b
$log_{10}(a)$
$log_{10}(a)$
a
0.0
−0.5
−1.0
−1.5
−2.0
magn. resid.F[nT]
0.4
0.2
0.0
−0.2
−0.4
T_0=2019-06-20 05:41:57.010000, T_n= 2019-06-20 05:42:20.048000
Sw. C, Eq. cr. LT, Asc: 23:52:19.048000, Desc:23:52:19.048000
$(\delta N_e) * 10^3$
$(\delta N_e) * 10^3$
10
5
0
−5
−10
UT
05:42:01.000000
05:42:06.000000
05:42:11.000000
05:42:16.000000
05:42:21.000000





Plenty of daily updates with Jets:

https://twitter.com/paulmsmithphoto

Summary

- Joint analysis between Swarm and GLM confirms, that spikes with amplitudes higher than 0.1 nT, can be produced by TLEs
- Detection of 'regular' thunderstorms is harder, because signal is below assumed threshold.
- Joint analysis with upcoming lightning imagers on board the MTG-I satellites, will improve observation in the European and African sector
- *MTG will see the launch of six new geostationary (imaging and sounding) satellites from 2021 onwards.*
- **After more than 2 years..., we think that at least we know how to look at data to be successful in identification of TLEs**
- Scientific questions: Strong dumping of the signal - the amplitude of disturbances and distance from the source?
- some technical issues pending verification: Very often delay between the event and detected spike is 5s. In case of G.H. analysis - mean delay is 2.5 s