Searching for correlations between Swarm and lightning activity - Improvements in the algorithm

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PM2
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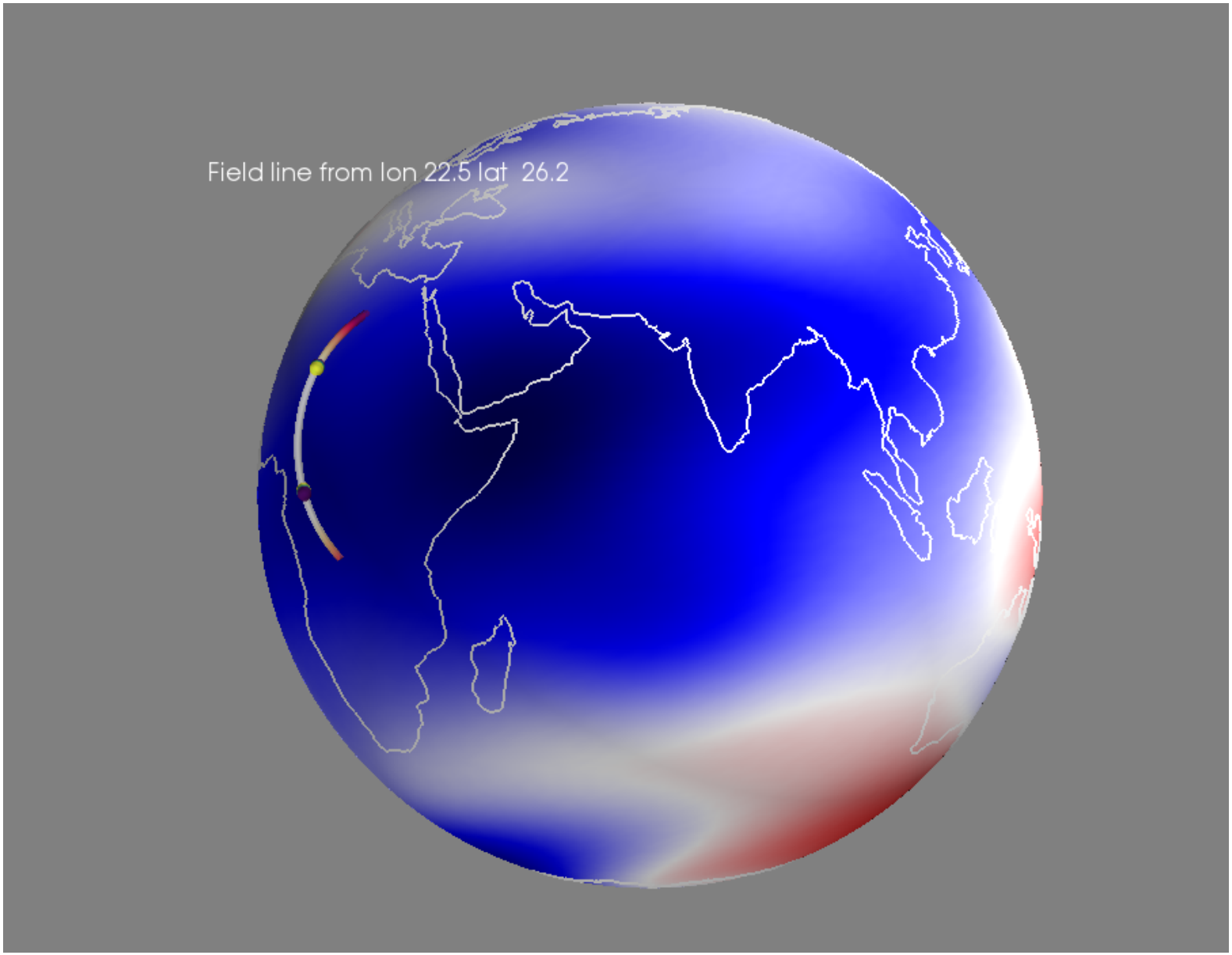
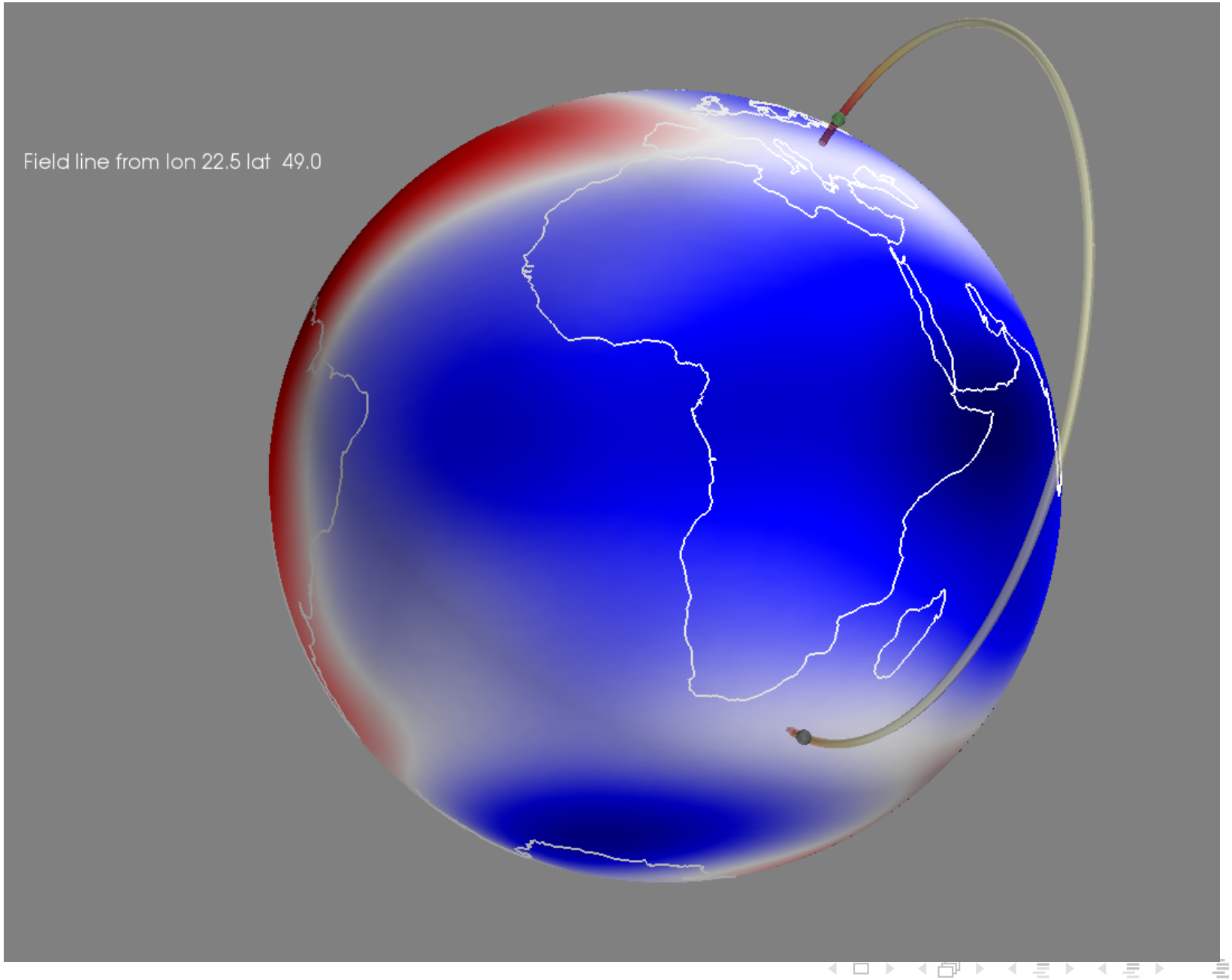
Objectives

- Series of previous attempts led to inconclusive results
- Studies examined excessive amount of events which might not be detected at the altitude of the satellite - Reason: main criterion for correlation was based on **time and location on the ground**. Estimates of time-frame for signal's propagation limited to 10 sec.
- Major change in the algorithm: **apply transformation of coordinates of events from the ground to position of the satellite, along the magnetic field line**

Swarm crosses magnetic field-lines - low latitudes

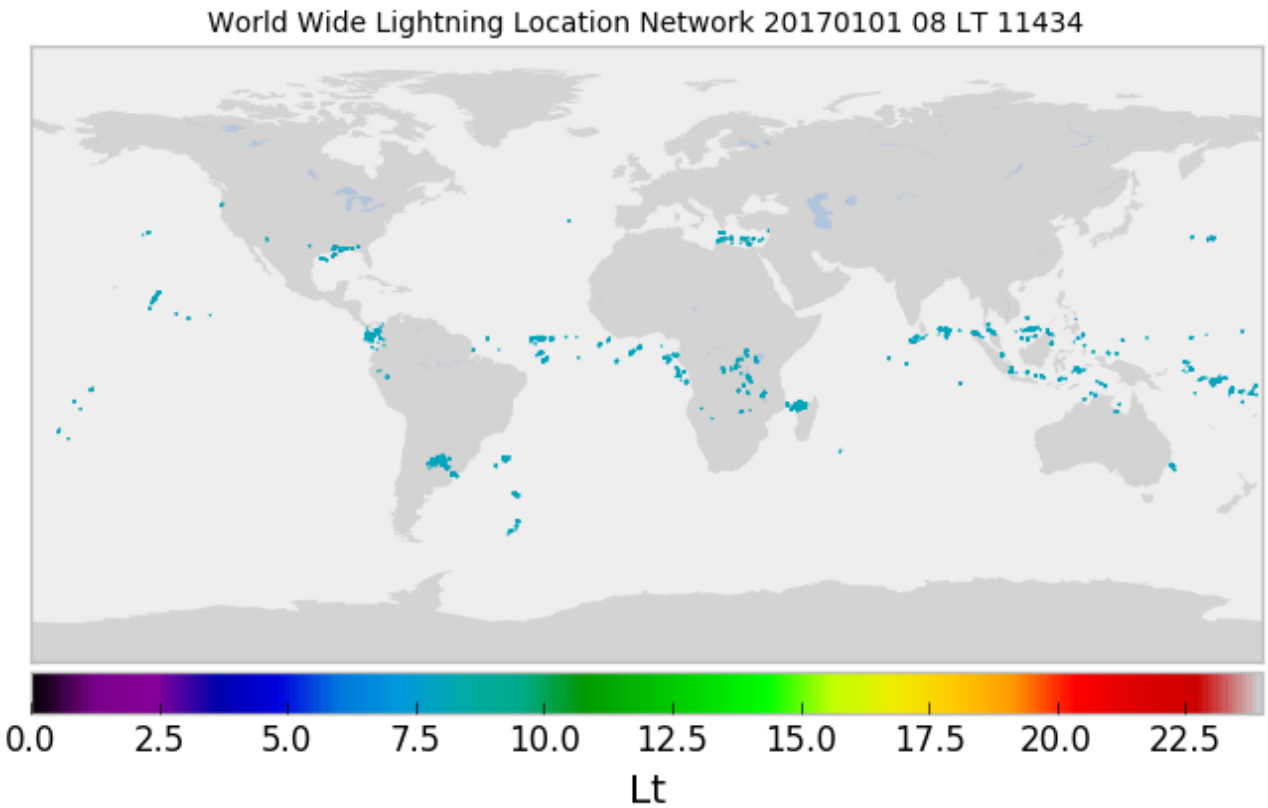


Swarm crosses magnetic field-lines - mid-latitudes



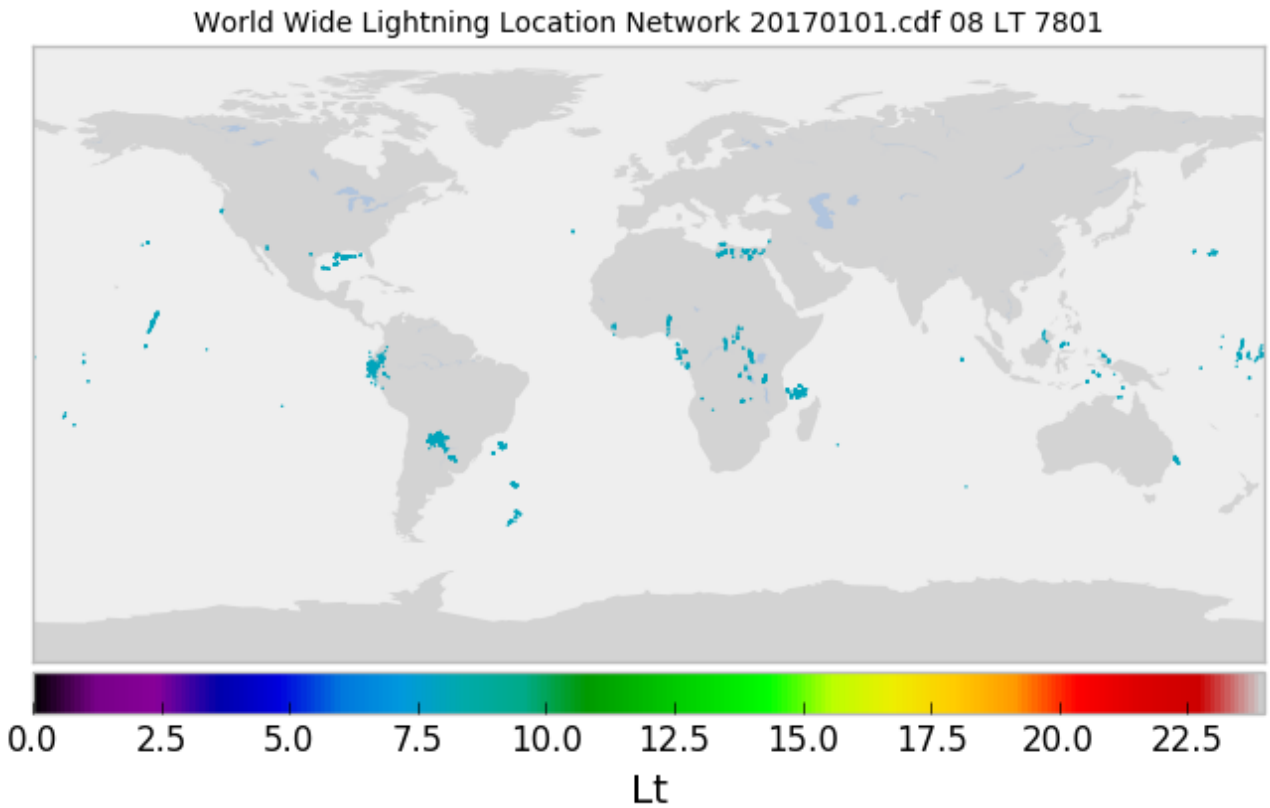
From the ground to the satellite

Location of lightnings in the Earth frame



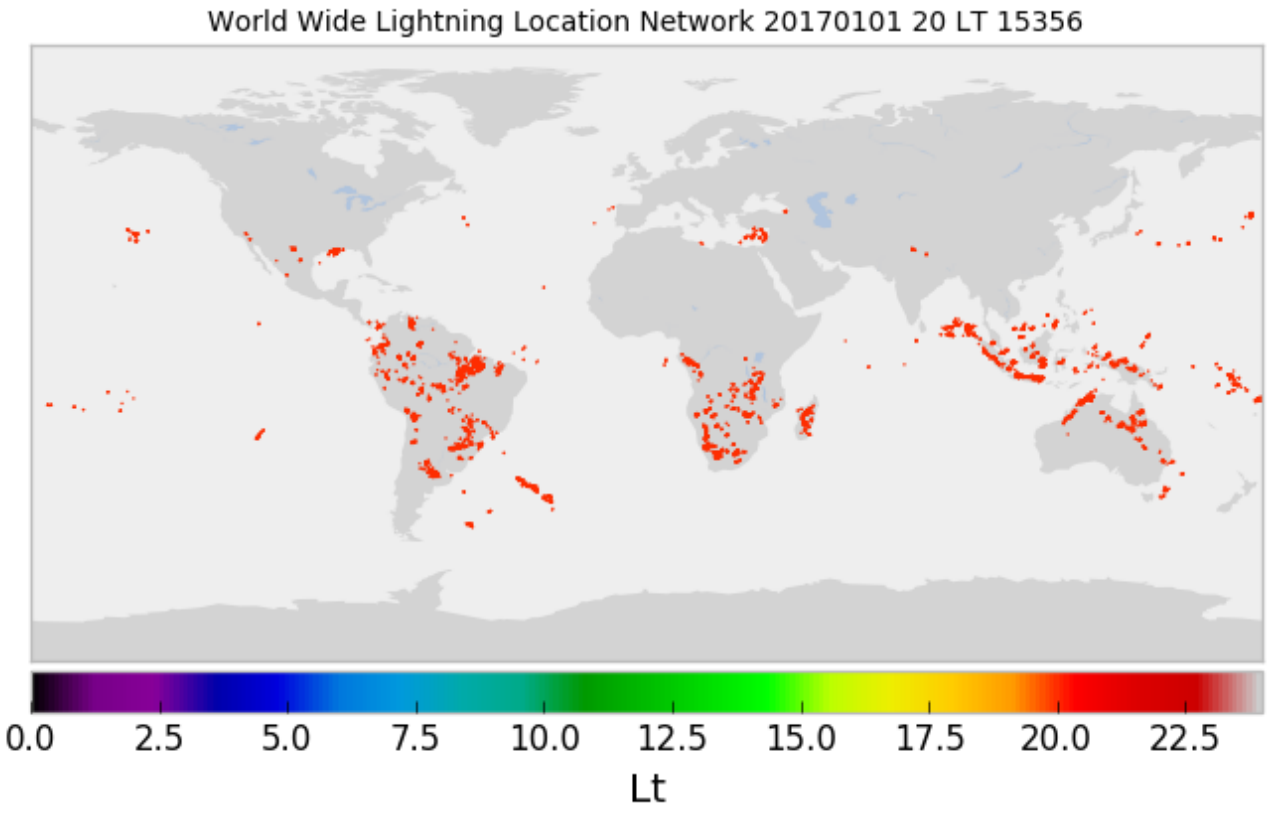
From the ground to the satellite

Location of lightnings in the satellite frame



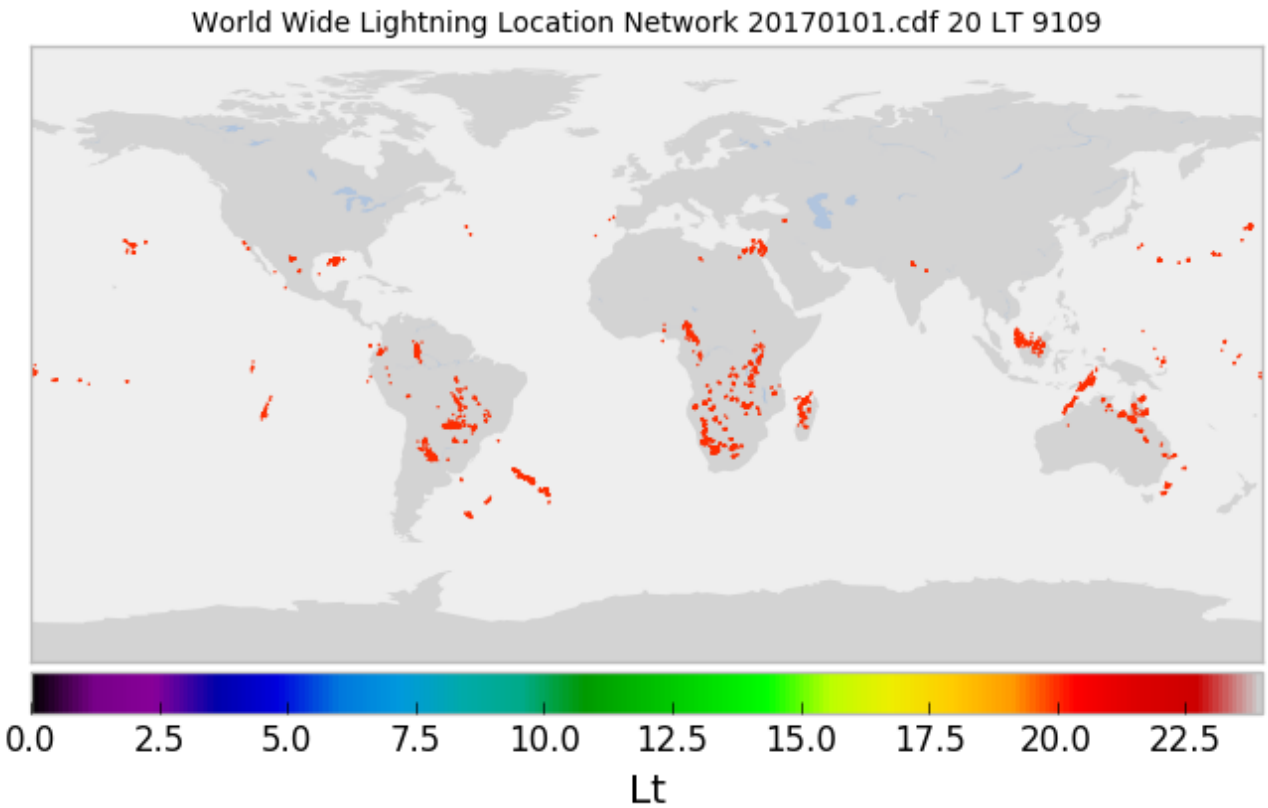
Transformation from the ground to the satellite

Location of lightnings in the Earth frame



Transformation from the ground to the satellite

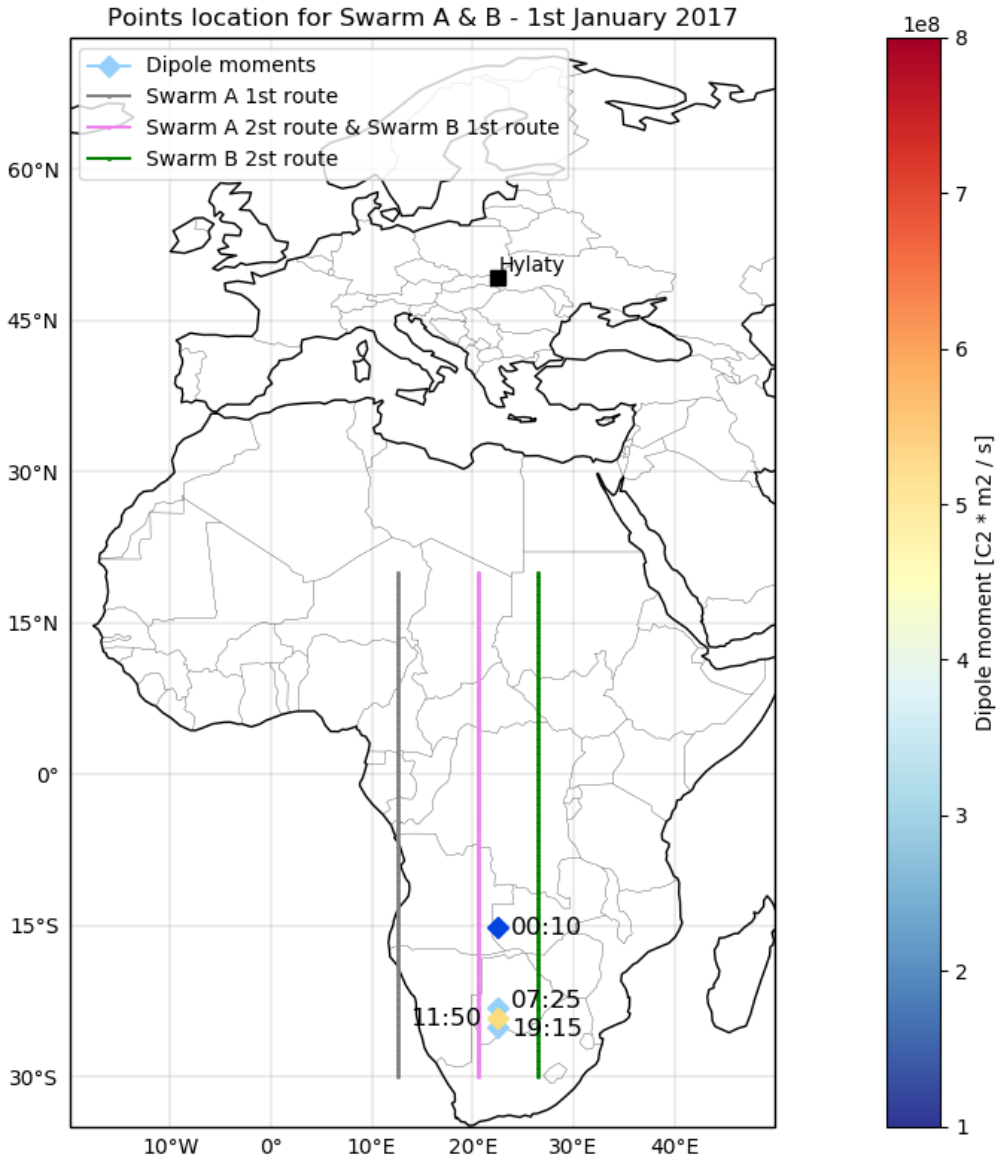
Location of lightnings in the satellite frame



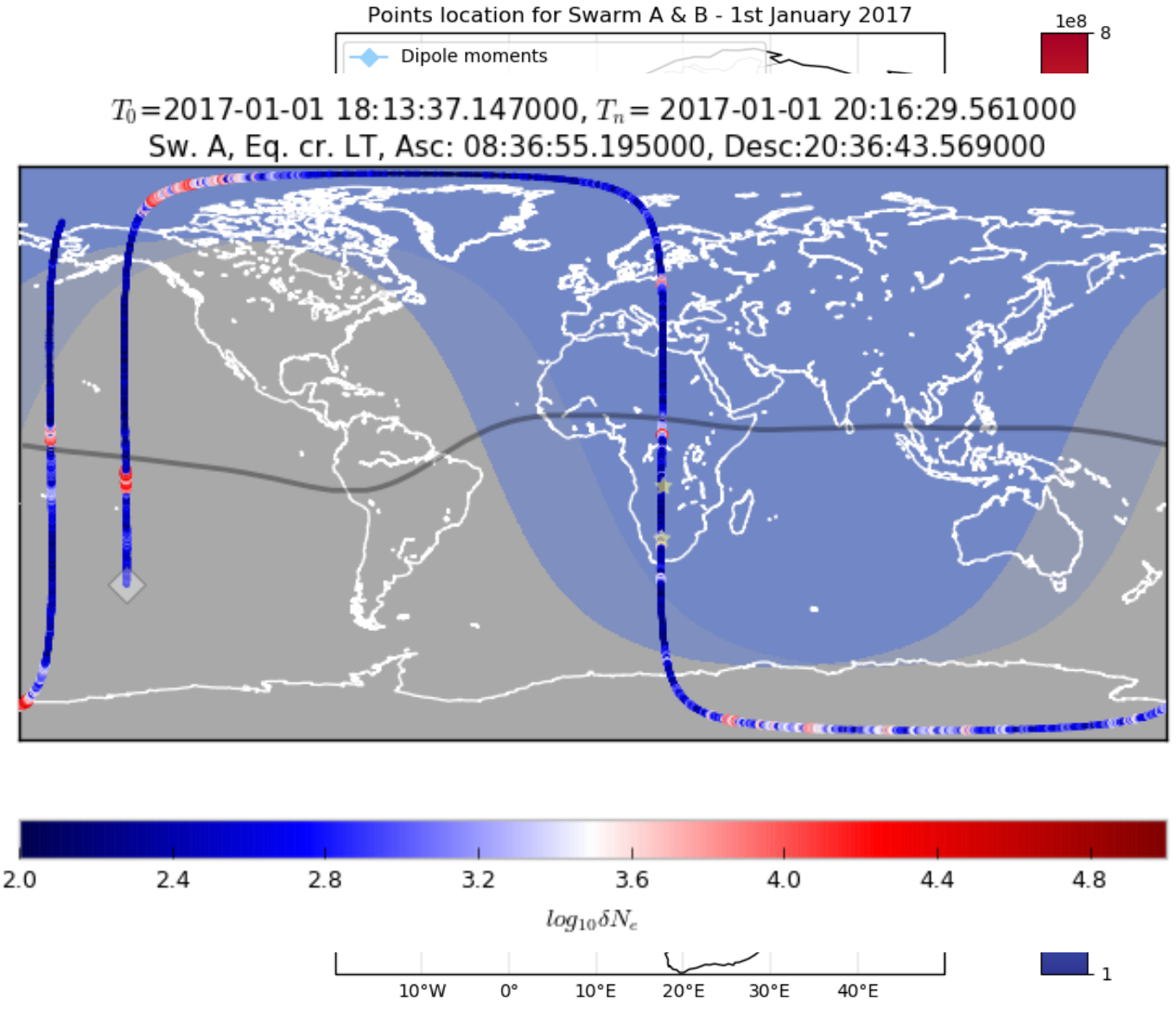
Swarm over the African storm cell

- Continous ground-based observations of the African storm cell are merged with Swarm passes over this region
- Ground data are provided with time resolution of 5 minutes
- For ground-based observations: correlation for localization of Swarm tracks and examined thunderstorms is determined by **9 margin in long**.
- In parallel, for verification of fluctuations in the satellite signal, second set of merged data is obtained with WWLLN
- For WWLLN we have adjusted the searching area margin to ± 3 **along latitude and longitude.**

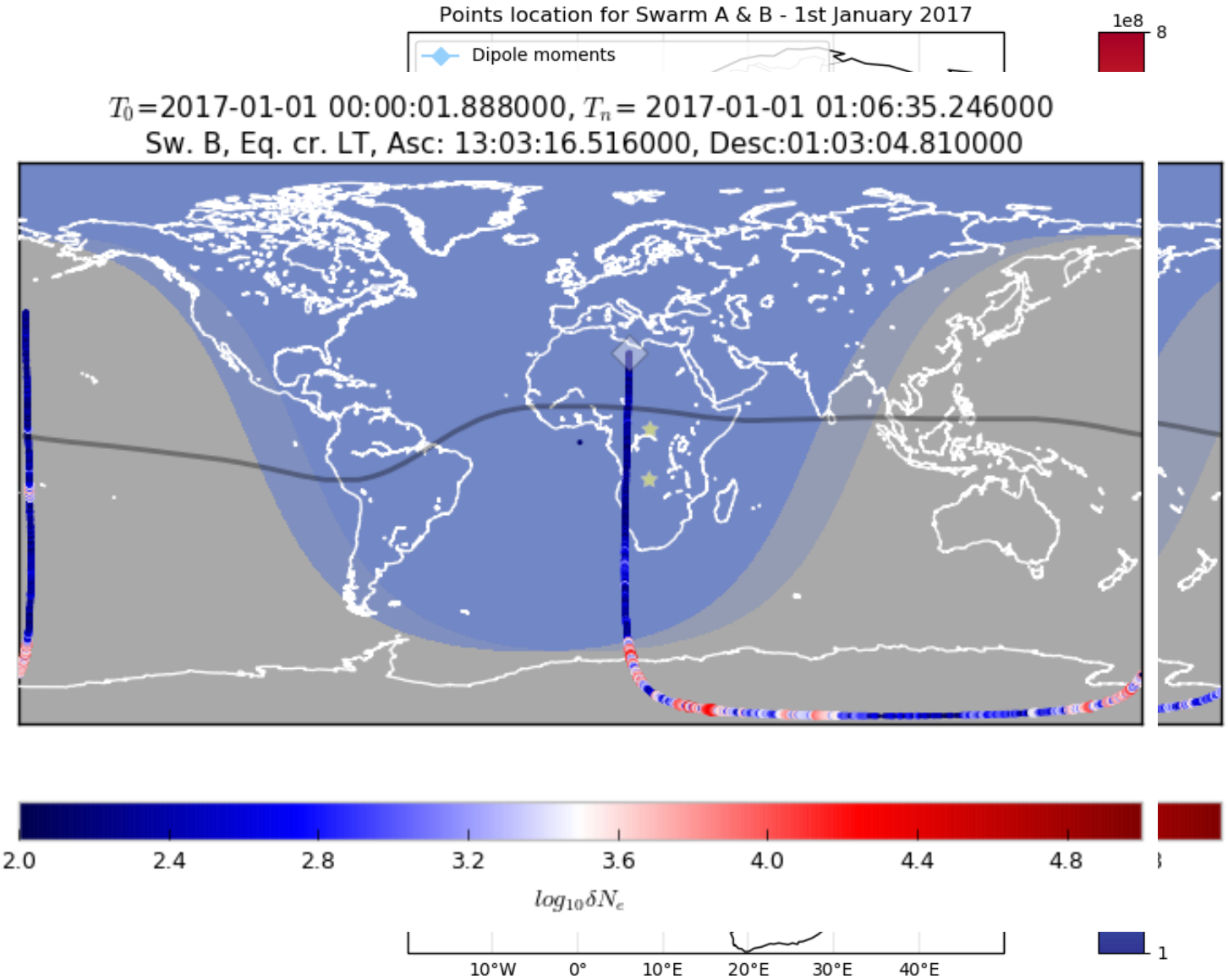
Ground-based maps of thunderstorms and Swarm passes



Ground-based maps of thunderstorms and Swarm passes



Ground-based maps of thunderstorms and Swarm passes



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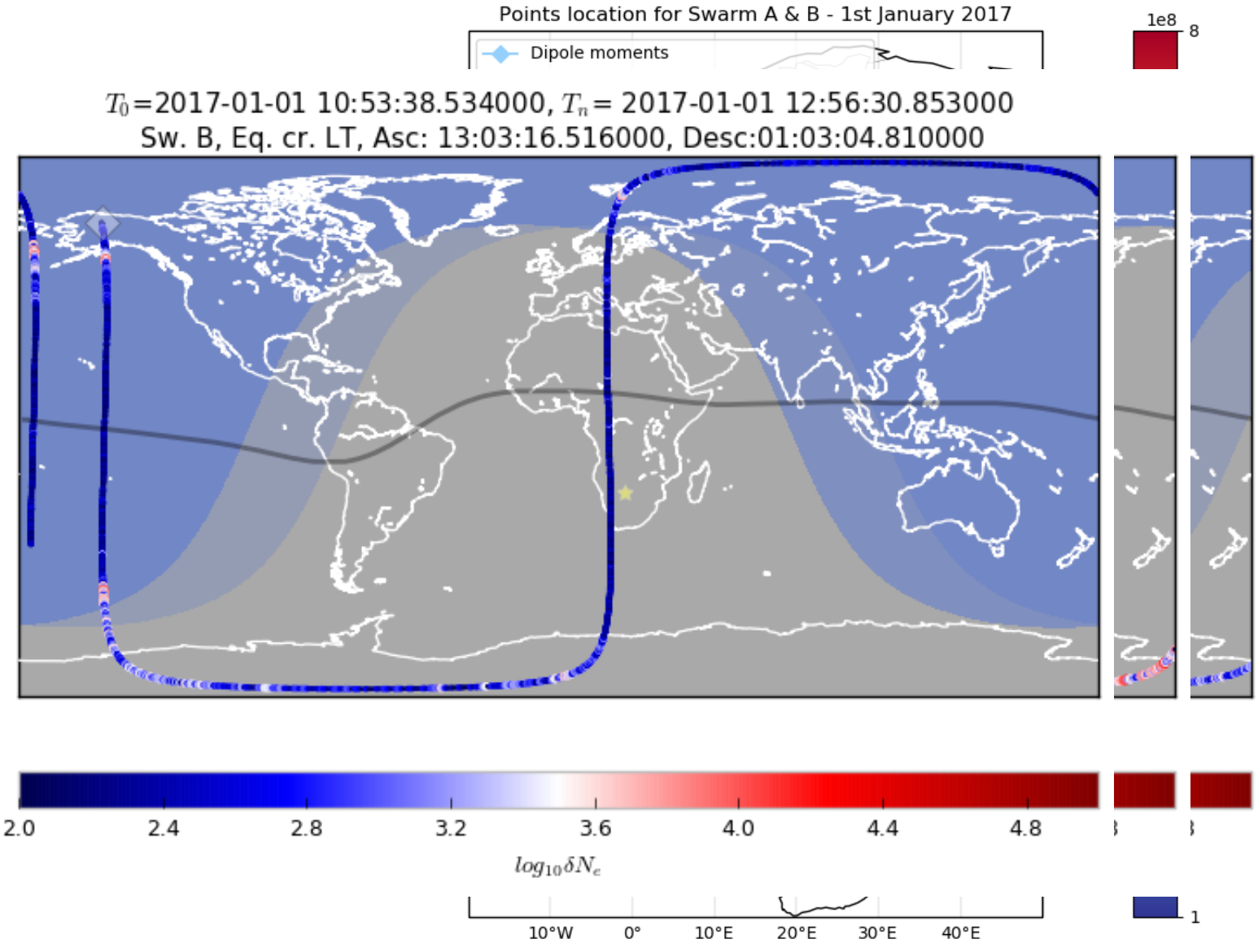
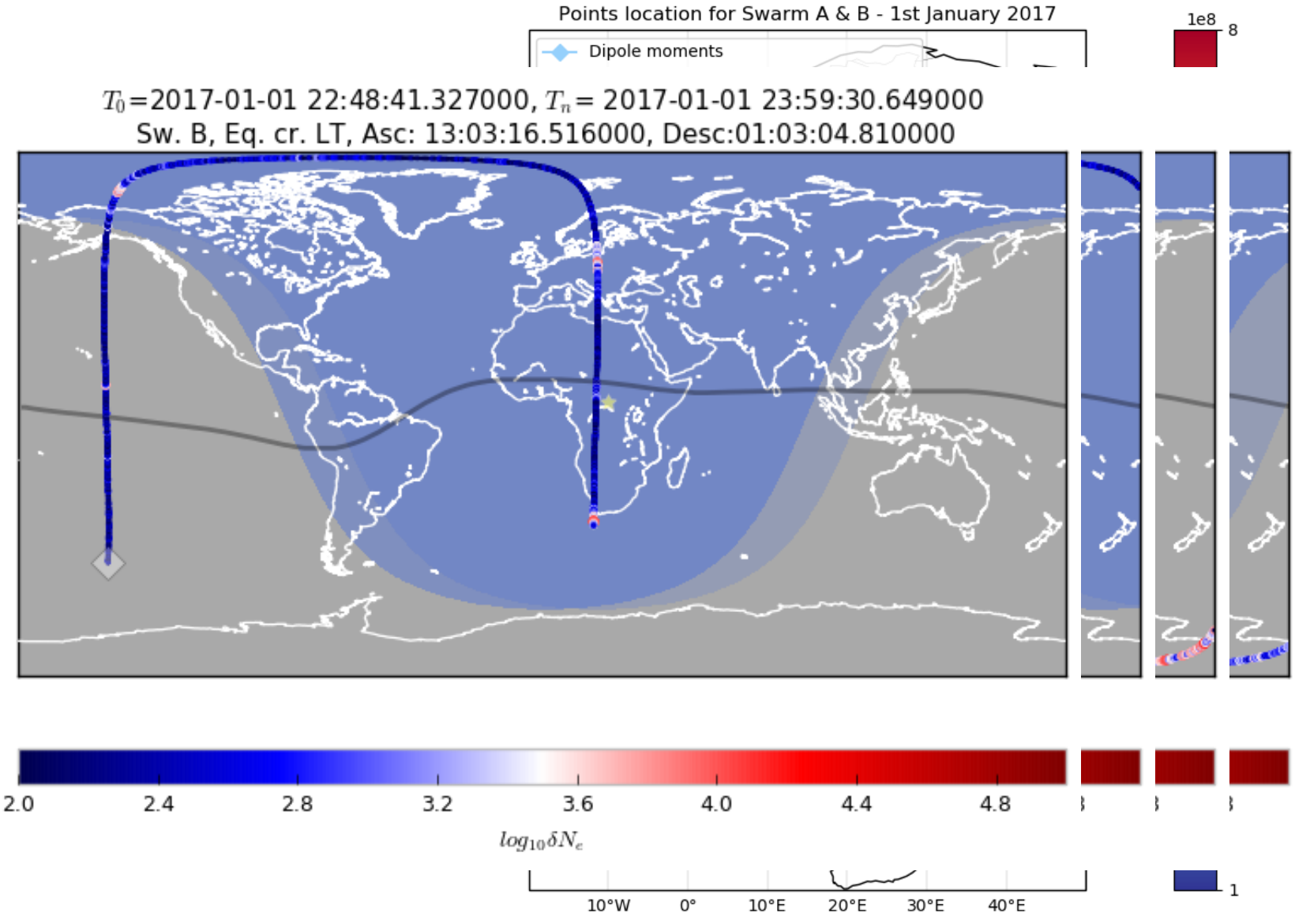
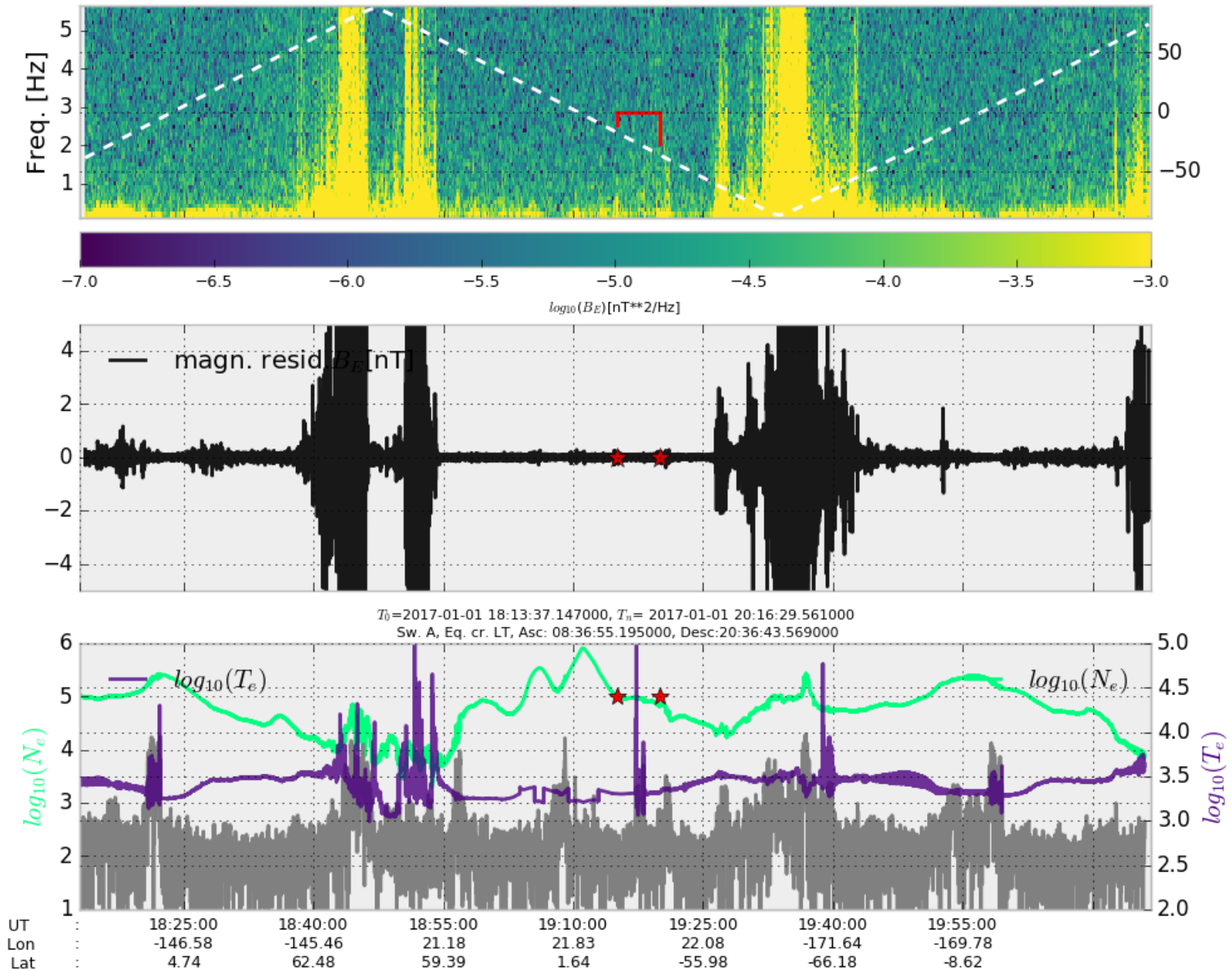


Ground-based maps of thunderstorms and Swarm passes



Swarm A synchronized with ground-data (**Case 1**)



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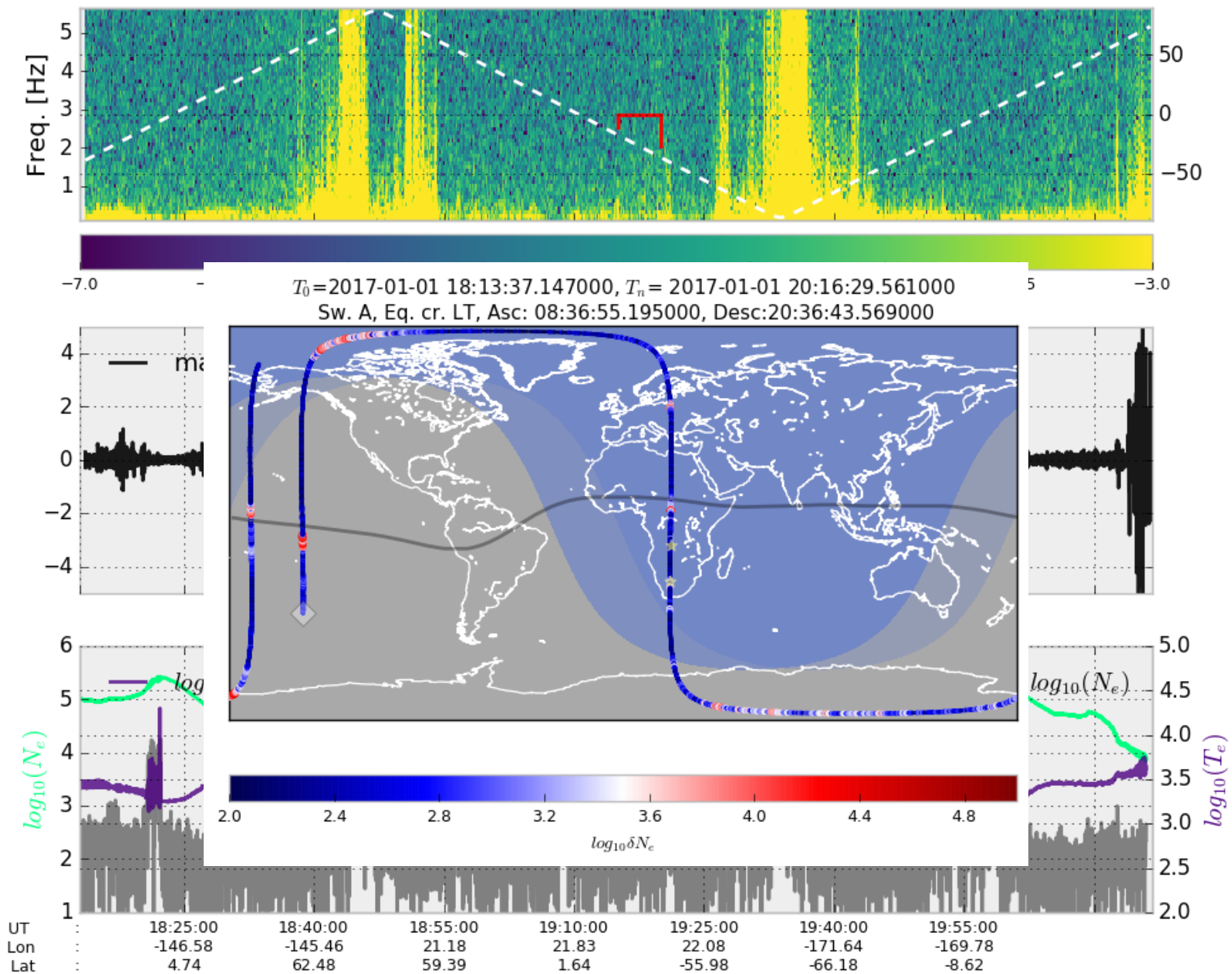
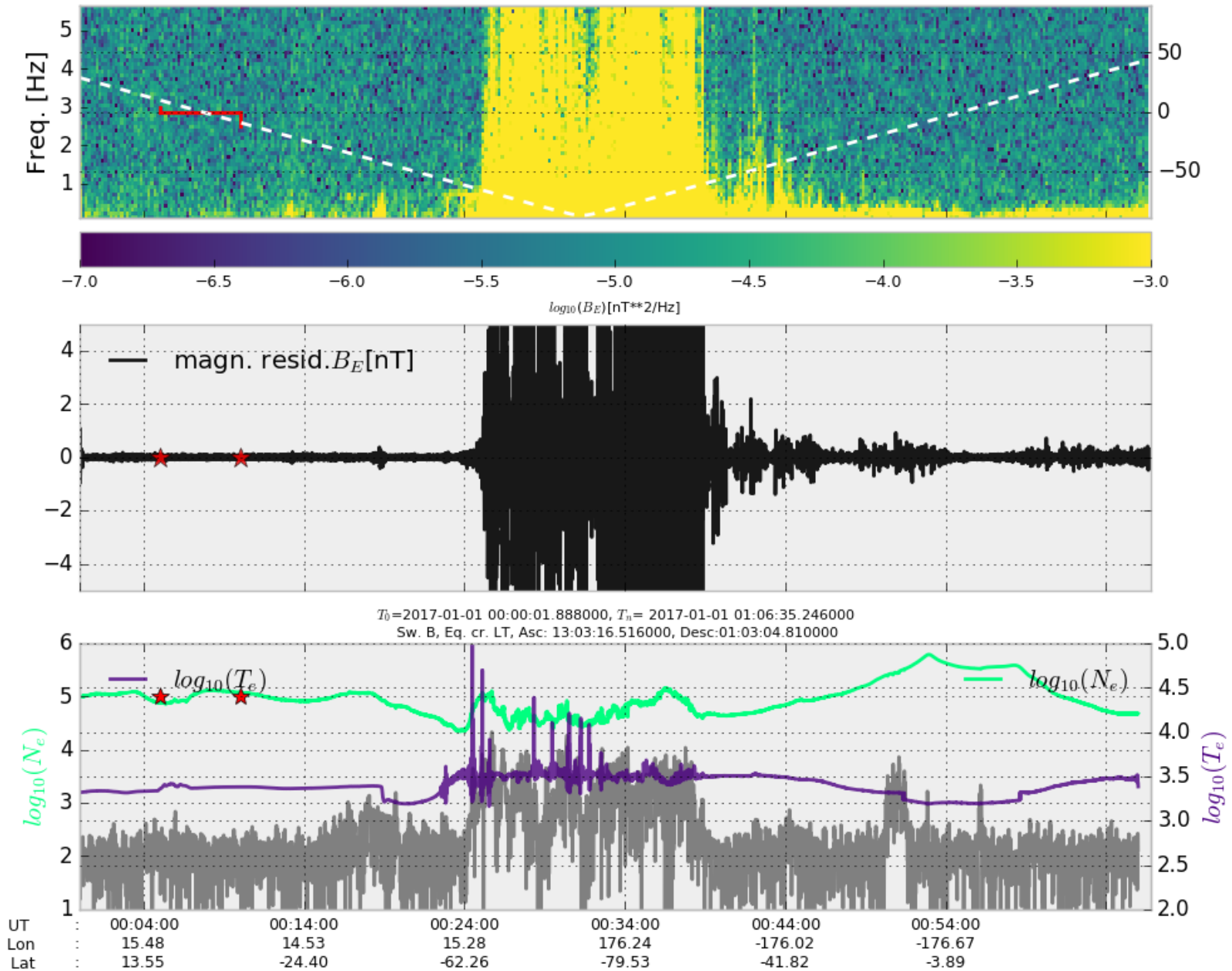
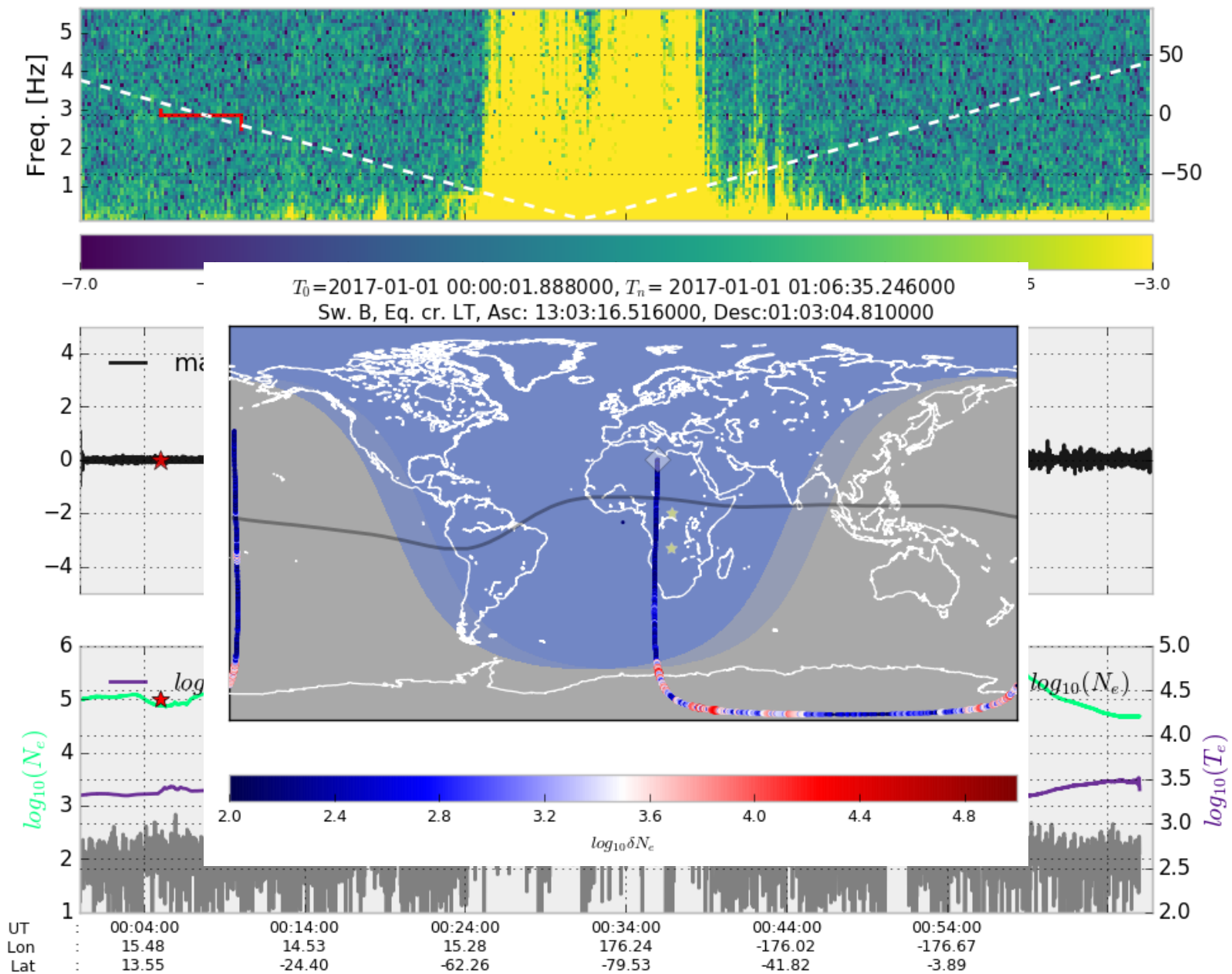


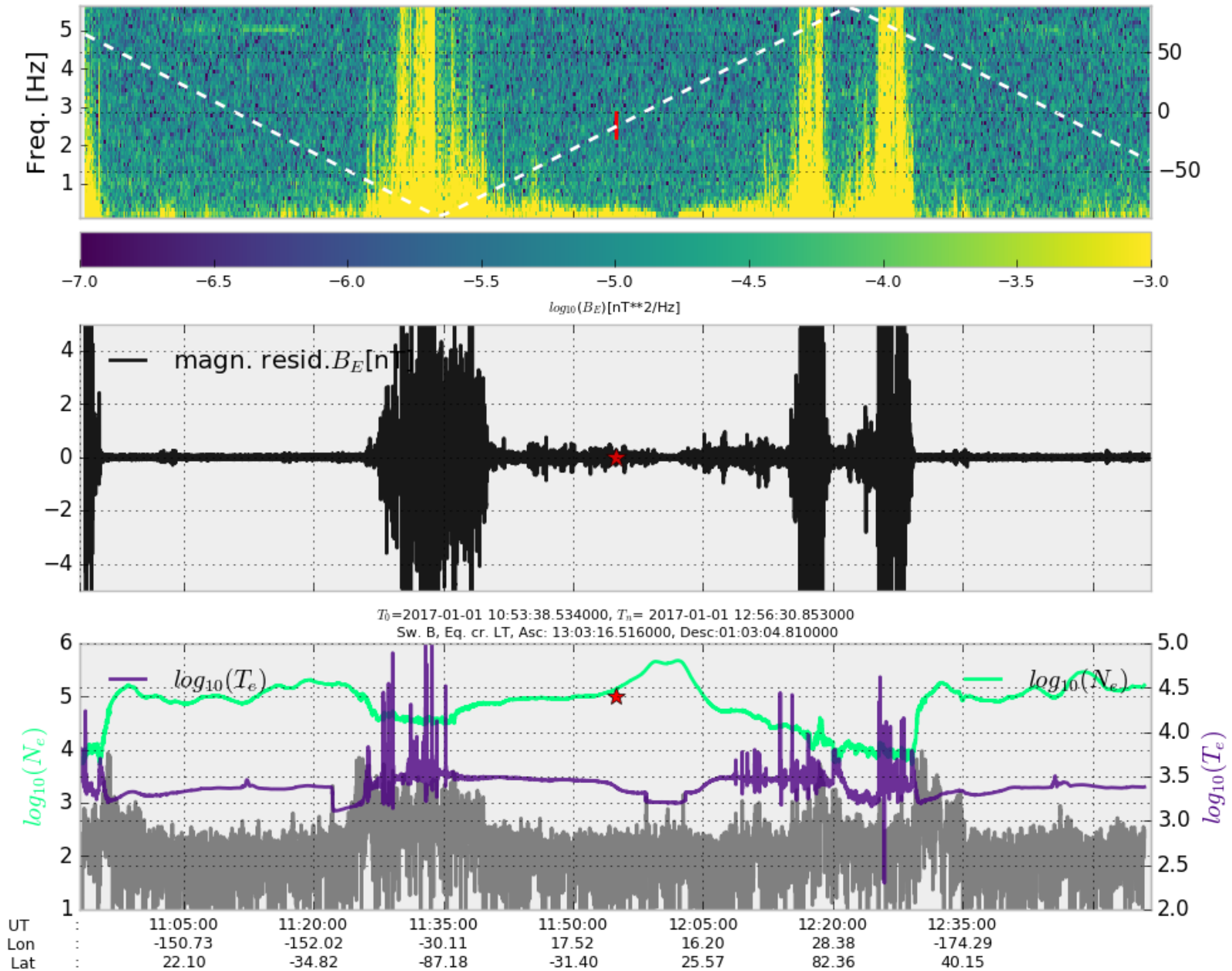
Swarm B synchronized with ground-data - Case 2



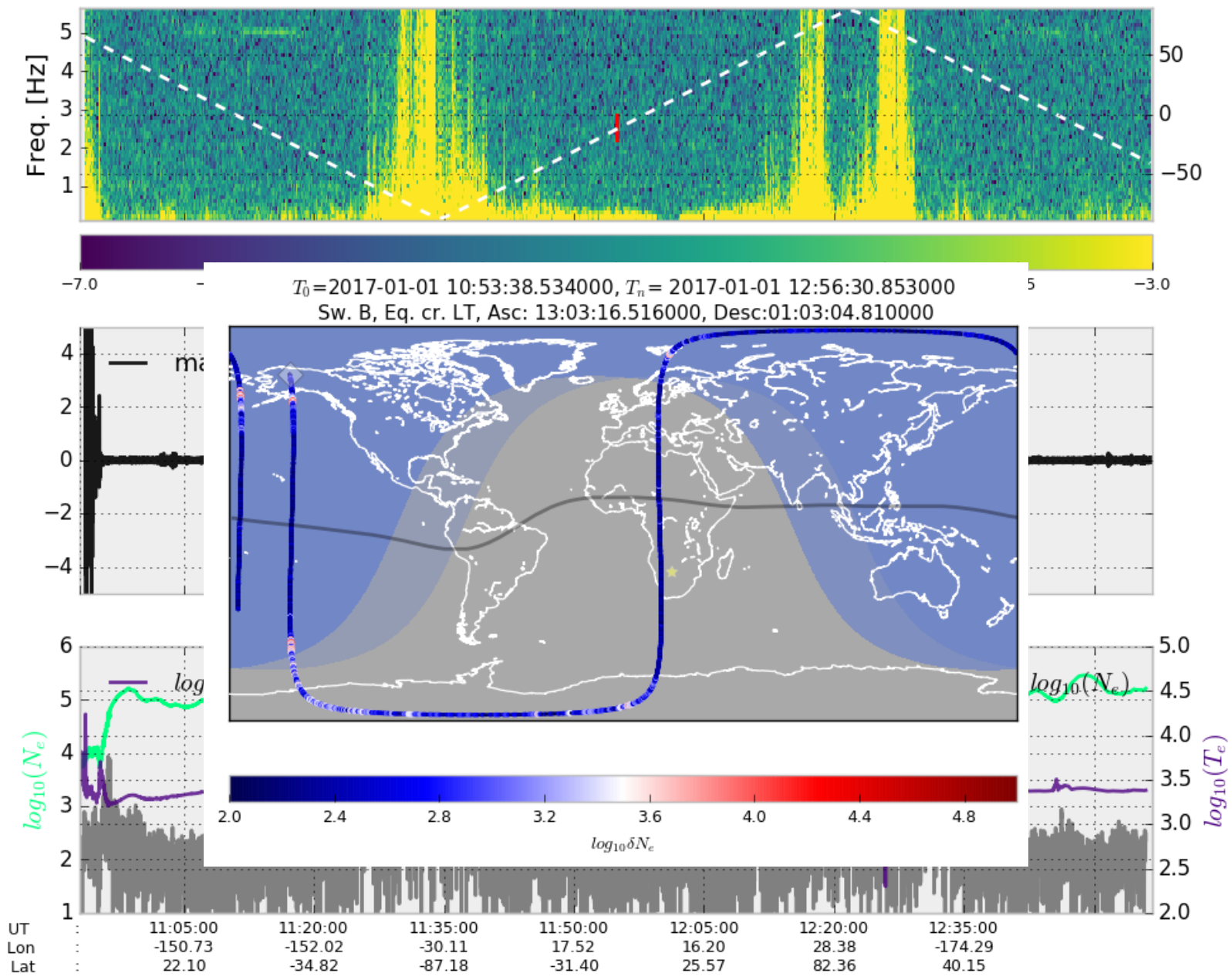
Swarm B synchronized with ground-data - Case 2



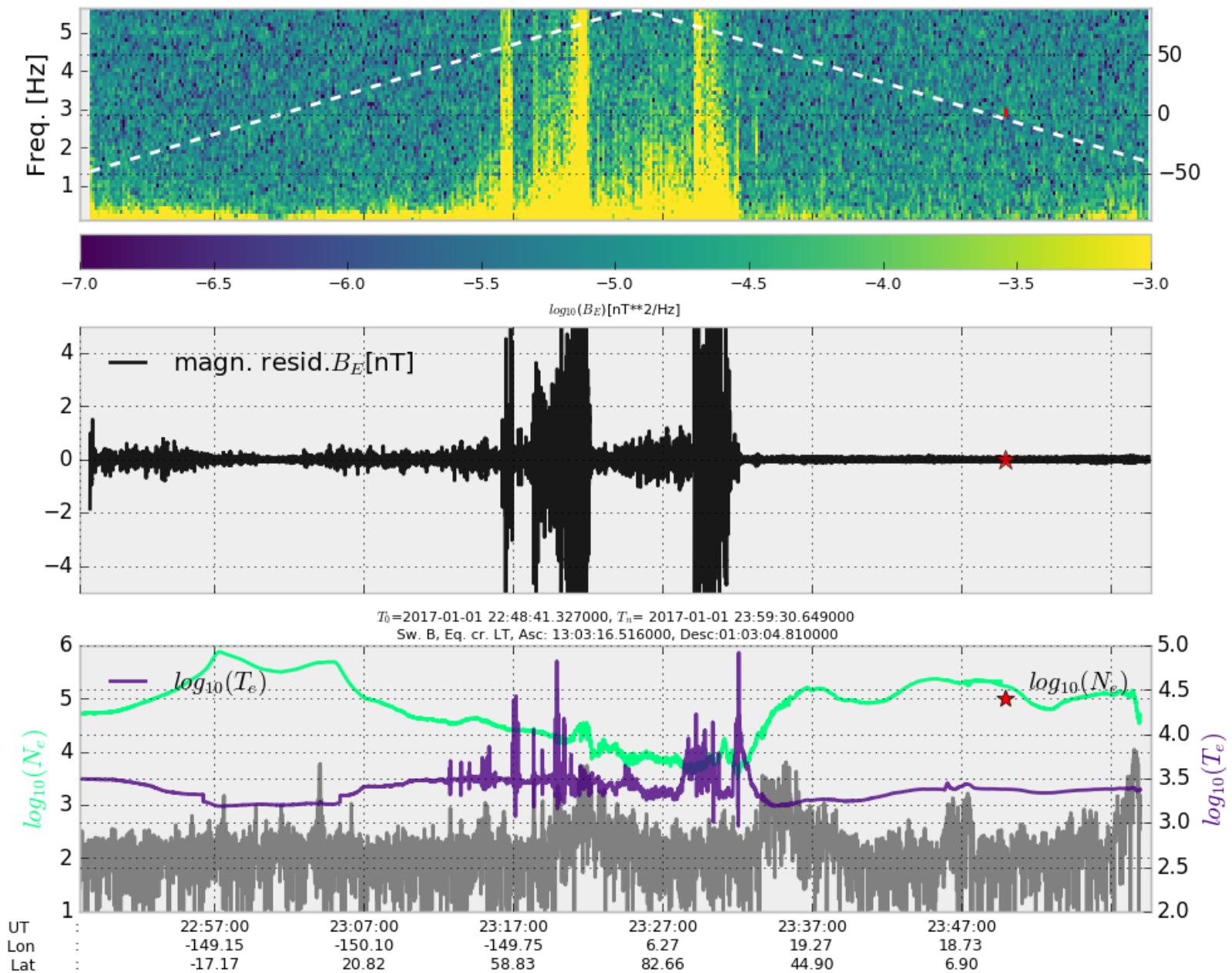
Swarm B synchronized with ground-data - Case 3



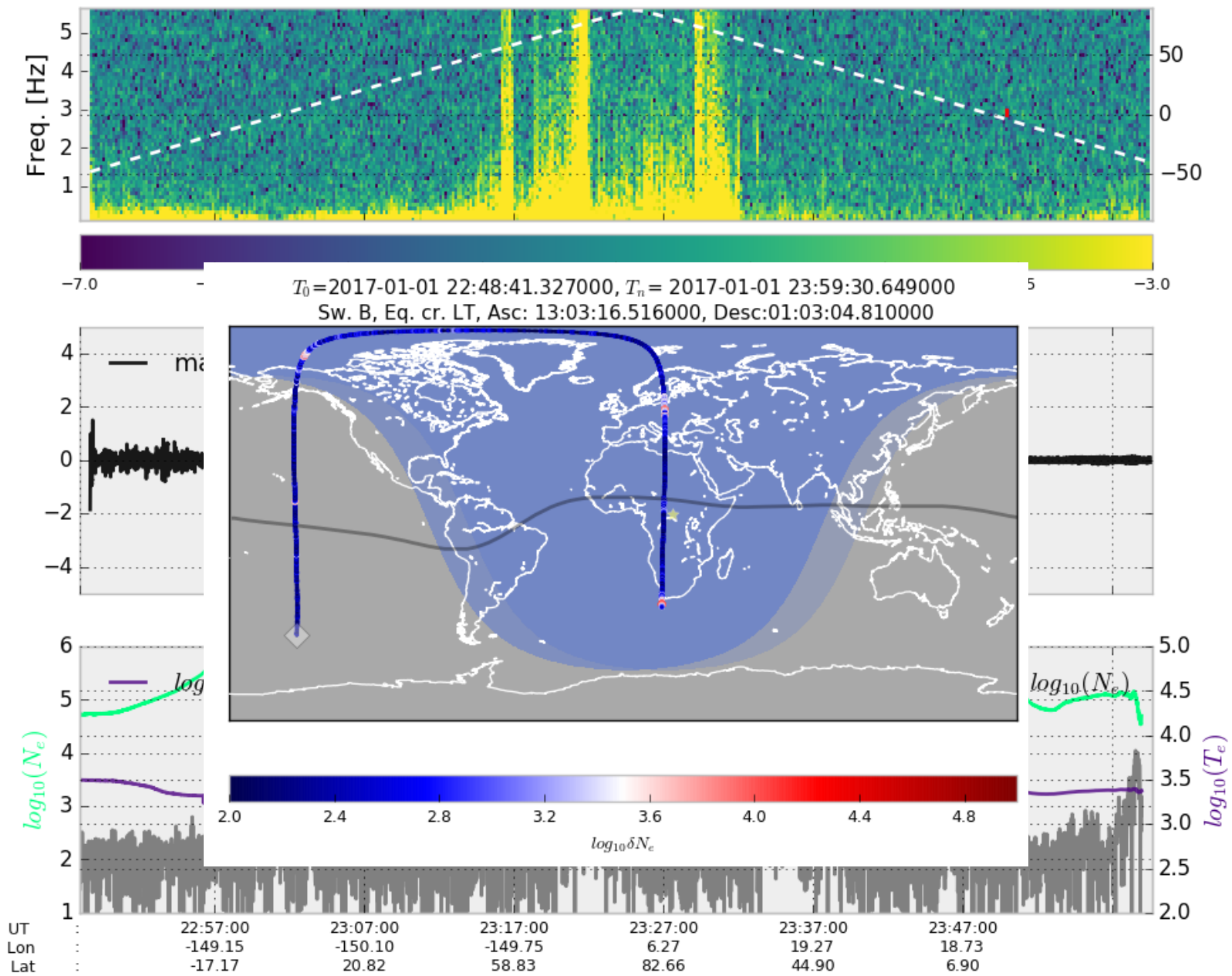
Swarm B synchronized with ground-data - Case 3



Swarm B synchronized with ground-data - Case 4



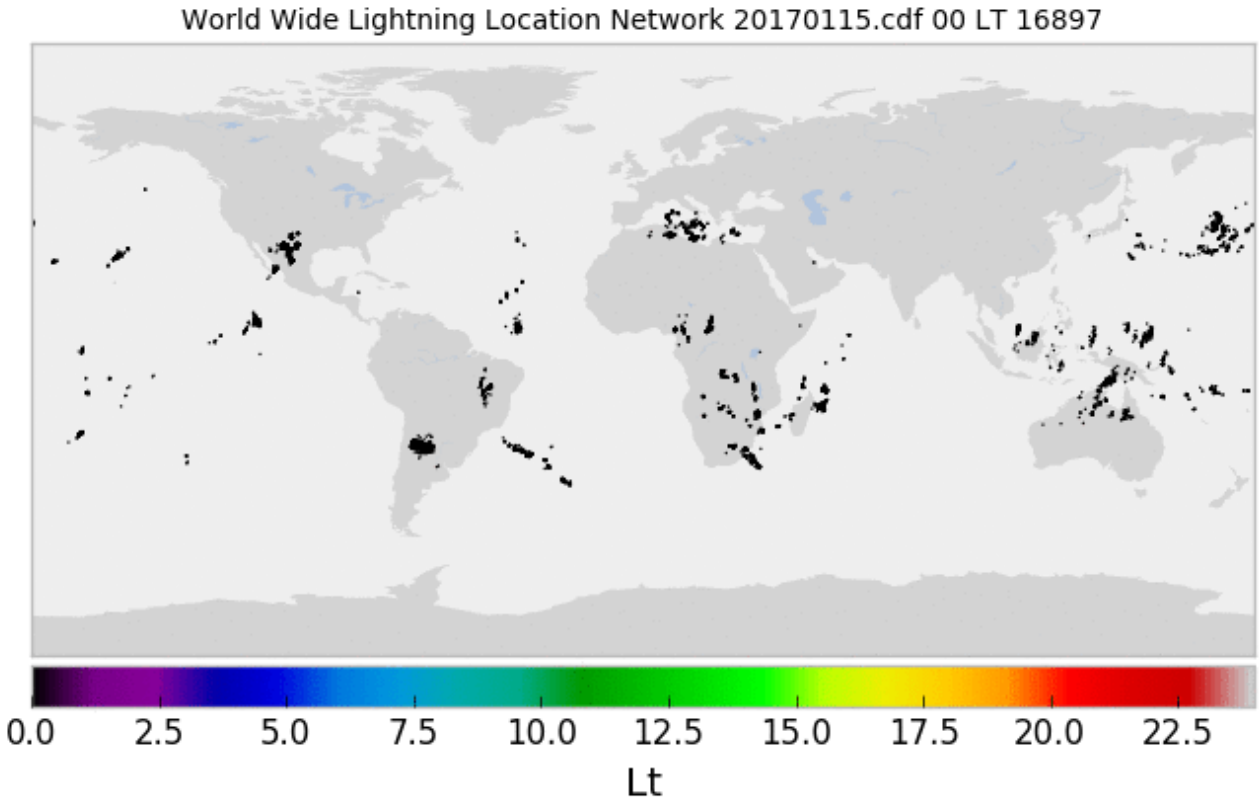
Swarm B synchronized with ground-data - Case 4



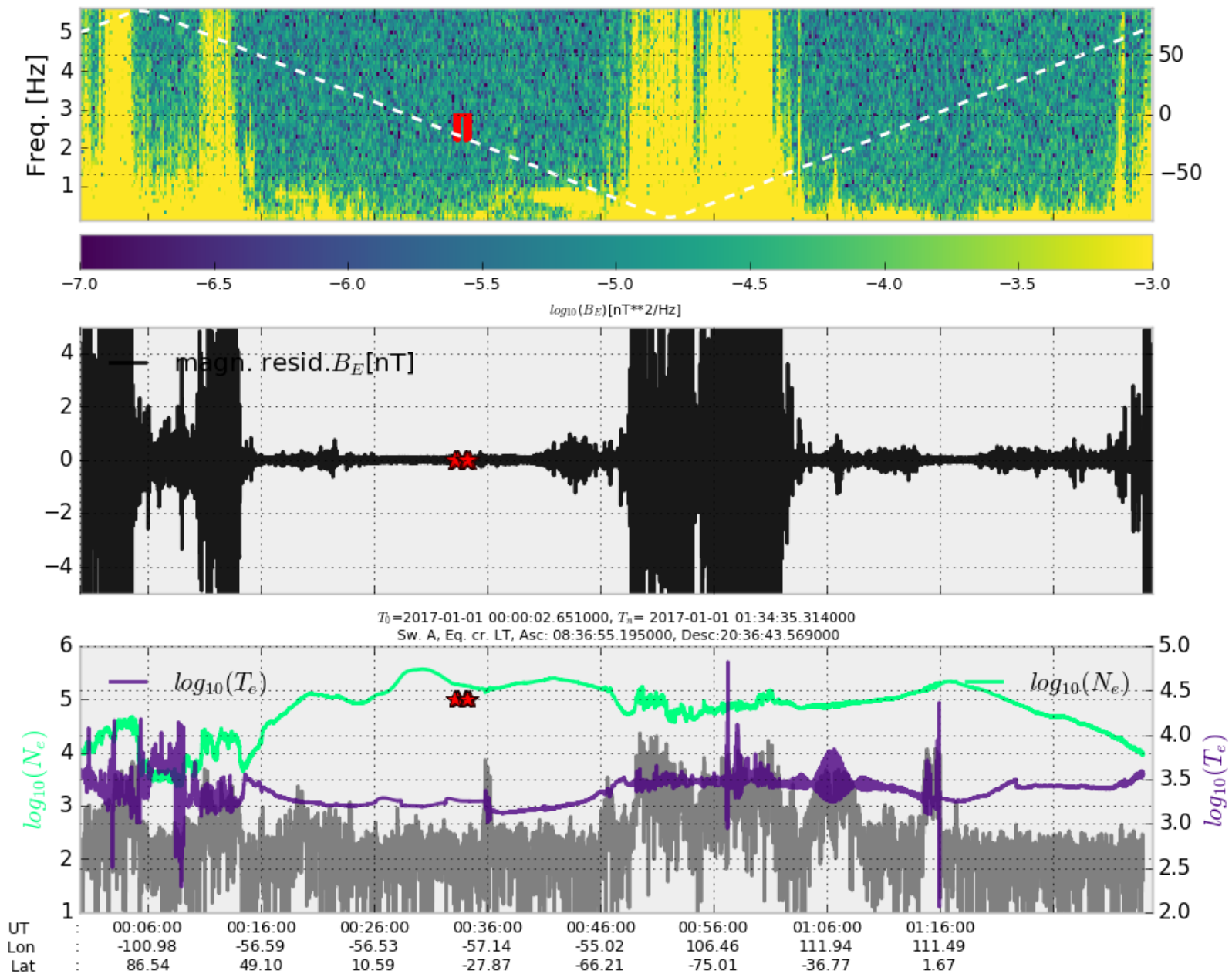
If results are not convincing in the African sector...

- in other regions we observe significant variations in the signal;
- thus, we still keep WWLLNN as a backup with external information;
- Local time dependence is also important for lightnings

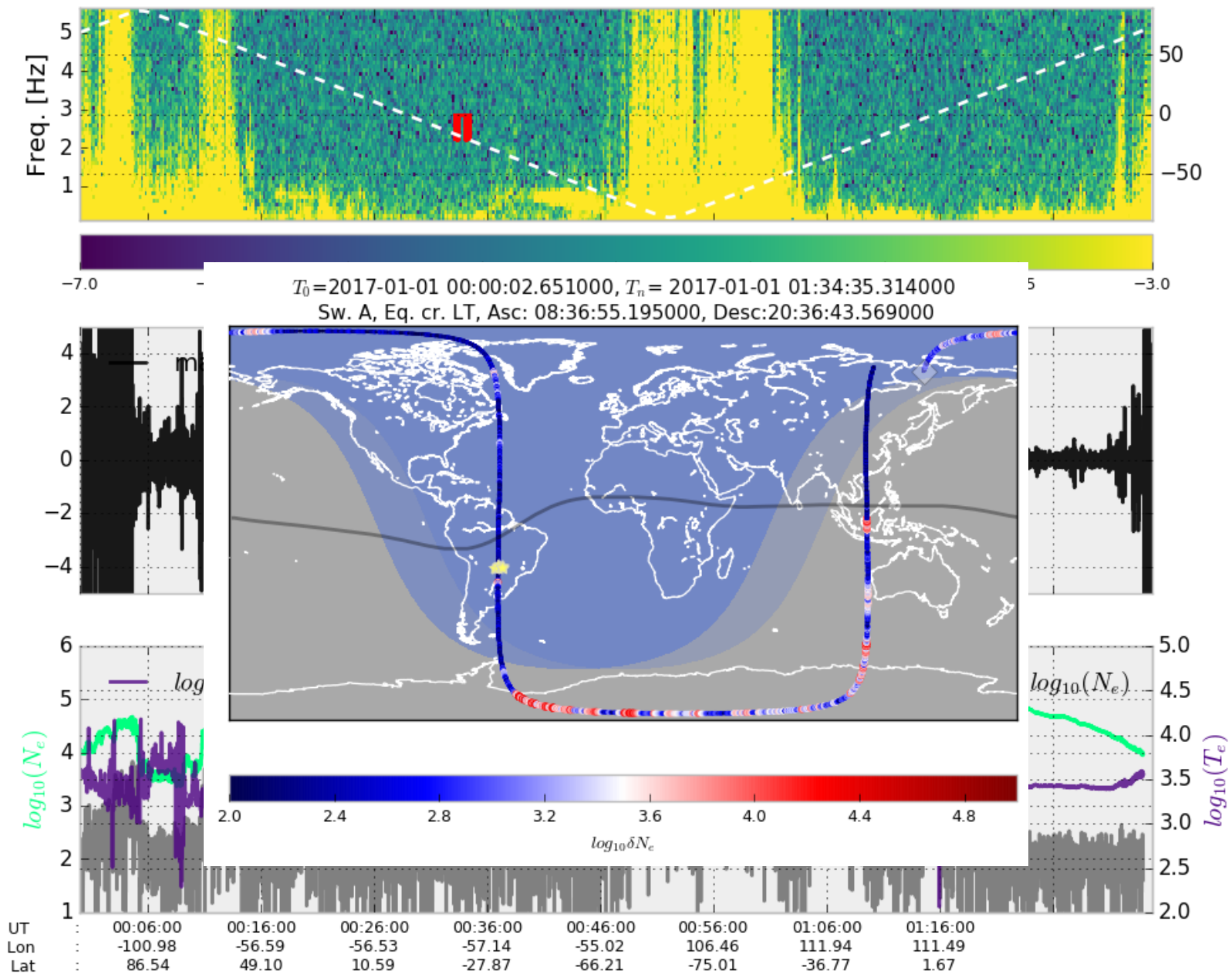
Daily variations of lightnings for a given LT



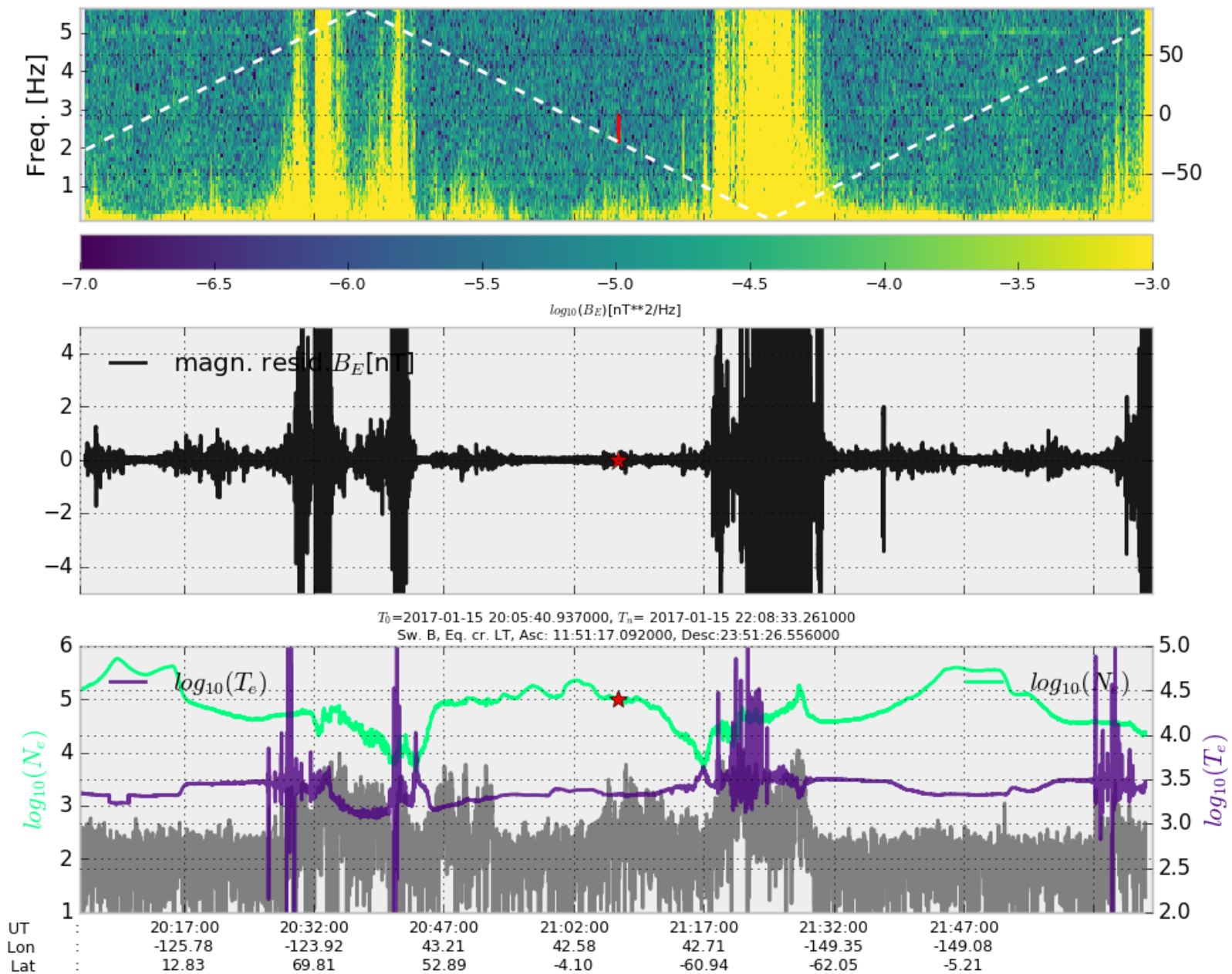
External data (like WWLLN) still needed



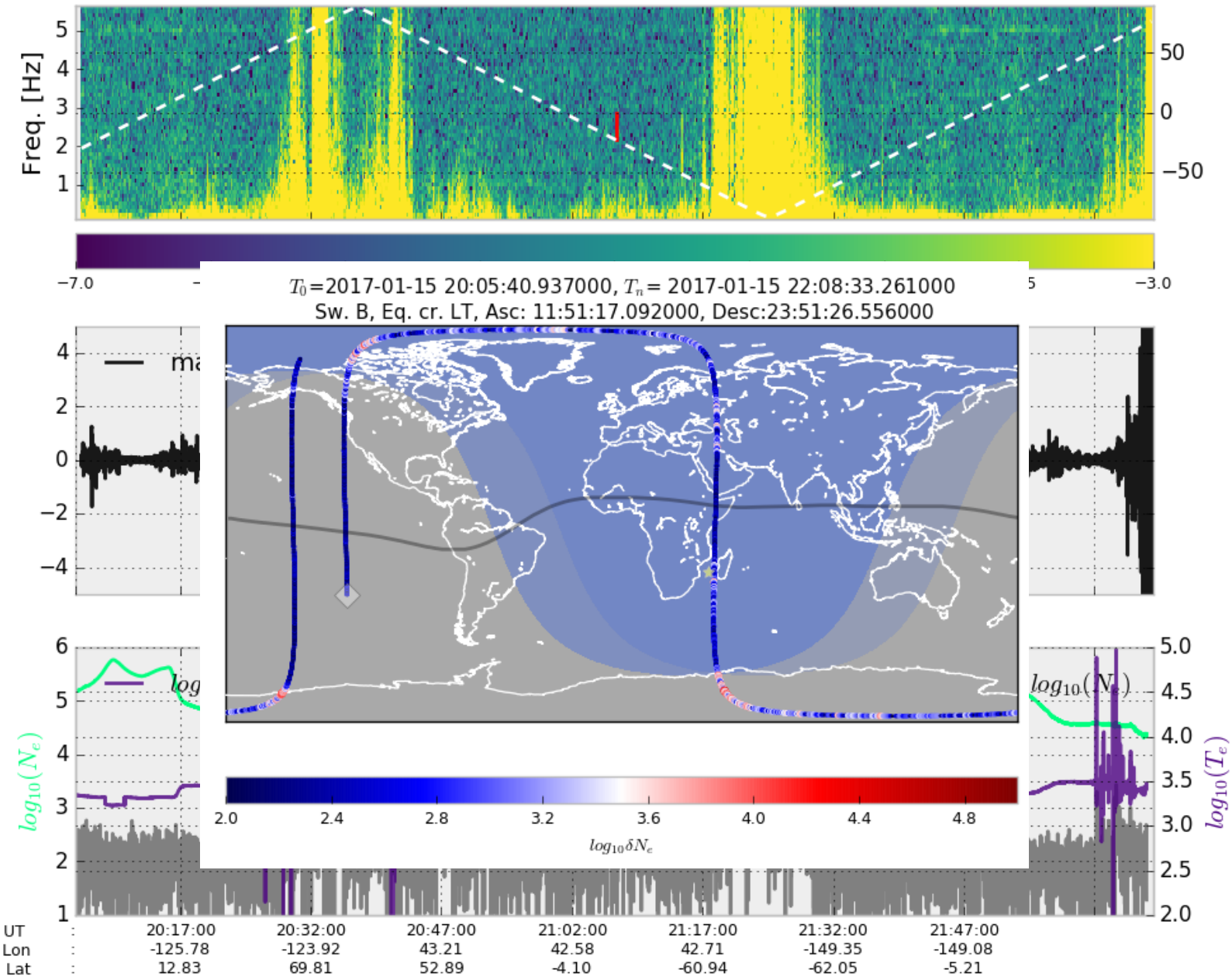
External data (like WWLLN) still needed



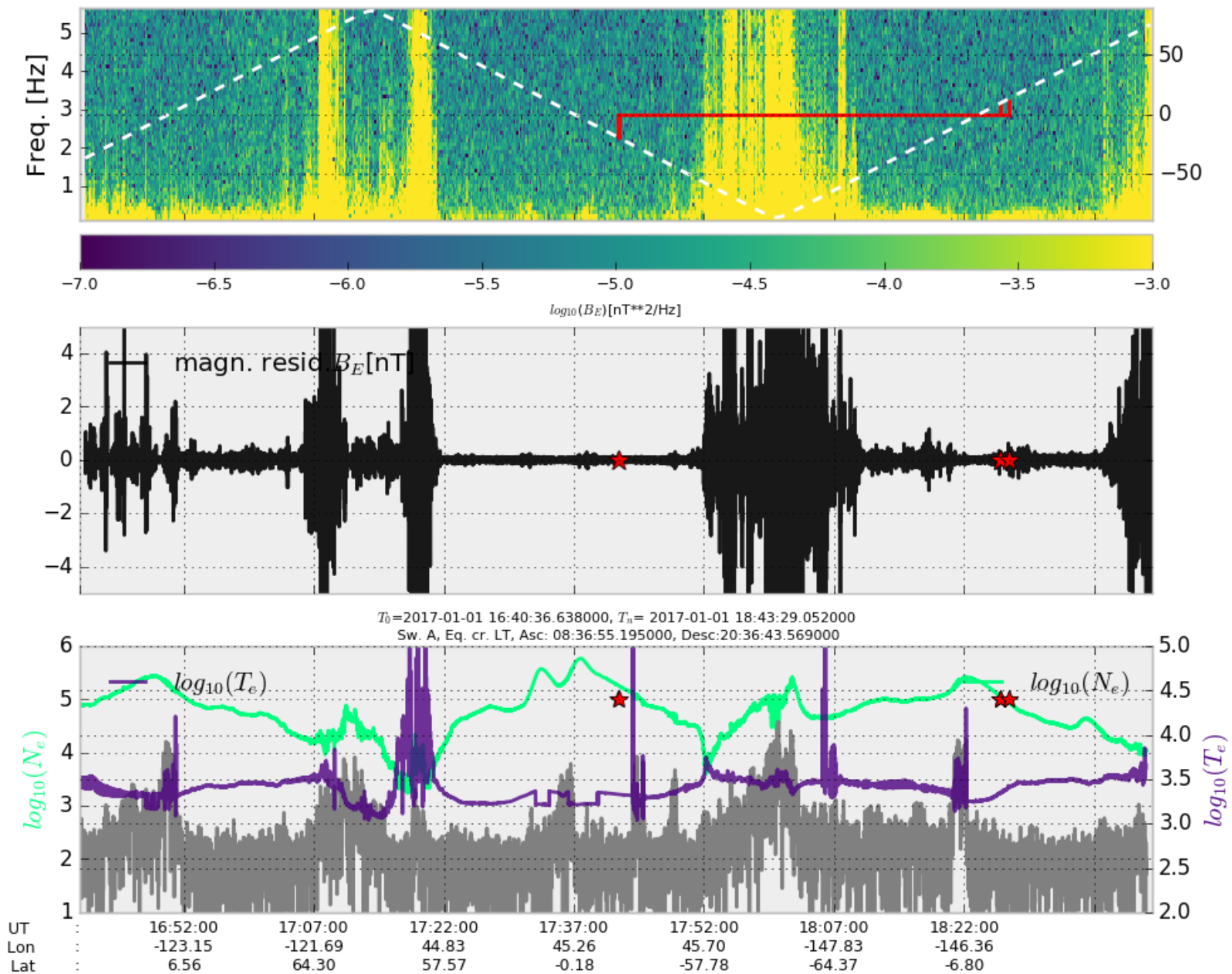
Surroundings of the African cell - WWLLN - Swarm B



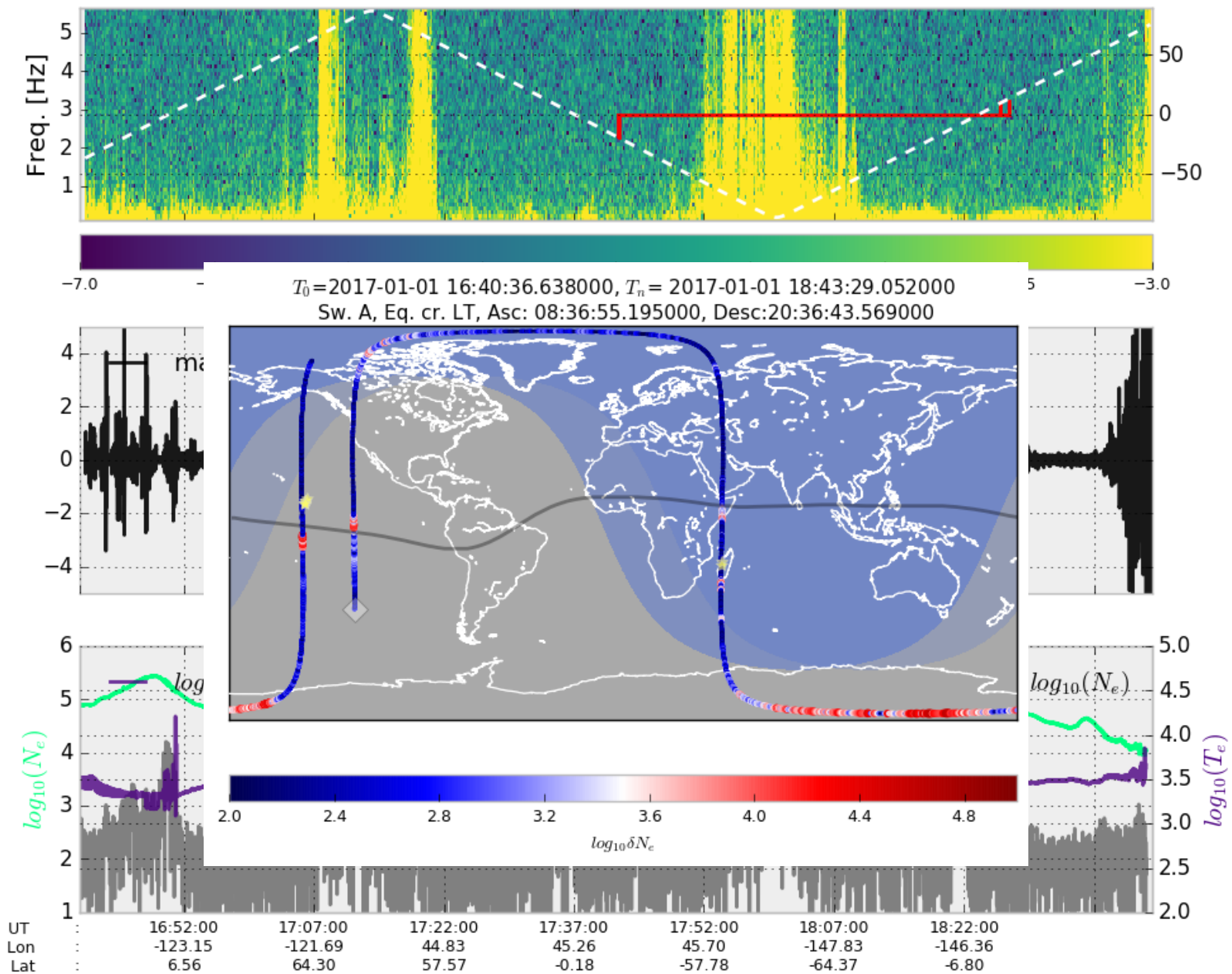
Surroundings of the African cell - WWLLN - Swarm B



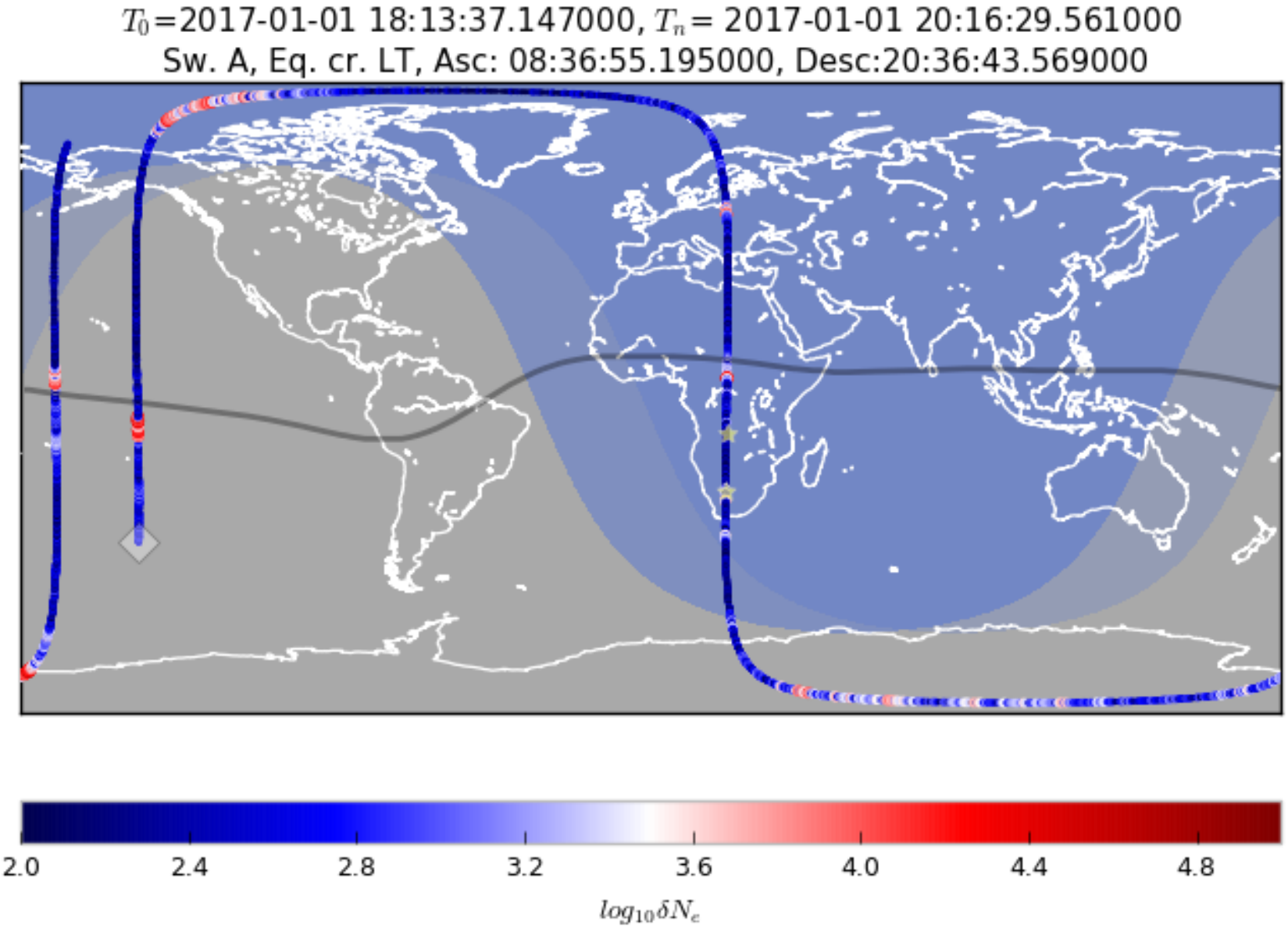
Surroundings of the African cell - WWLLN - Swarm A



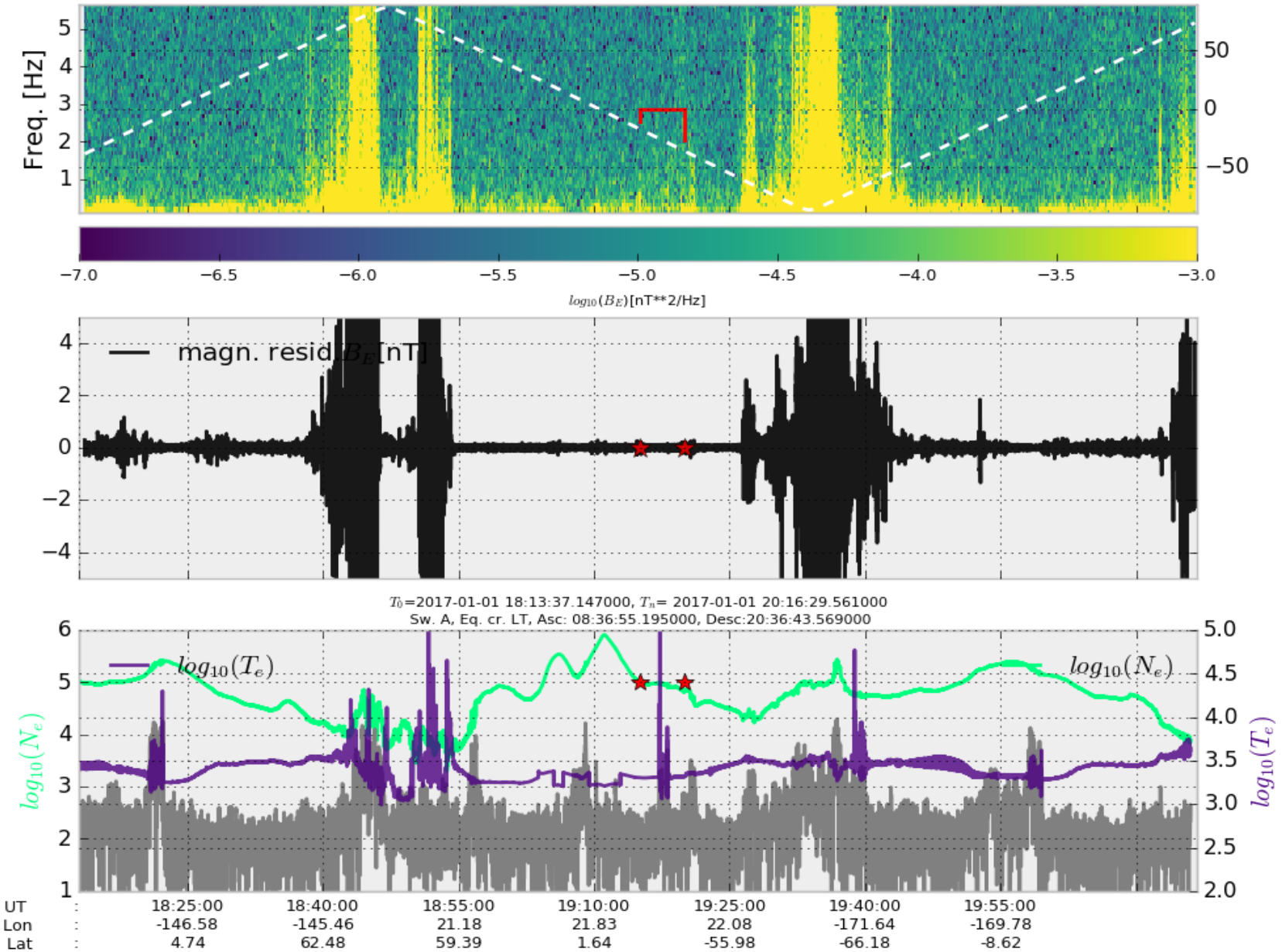
Surroundings of the African cell - WWLLN - Swarm A



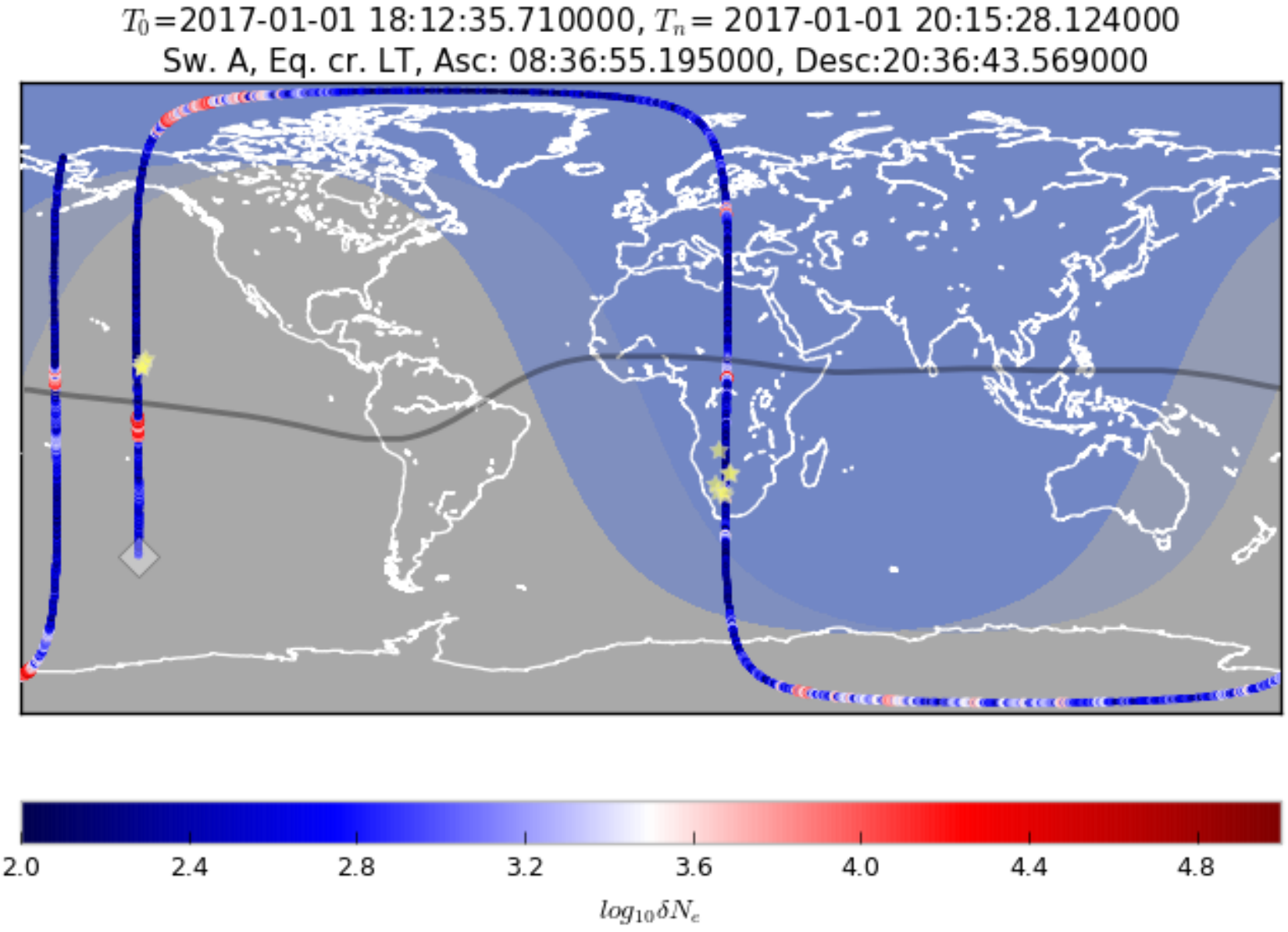
Passes over active thunderstorms - AGH data



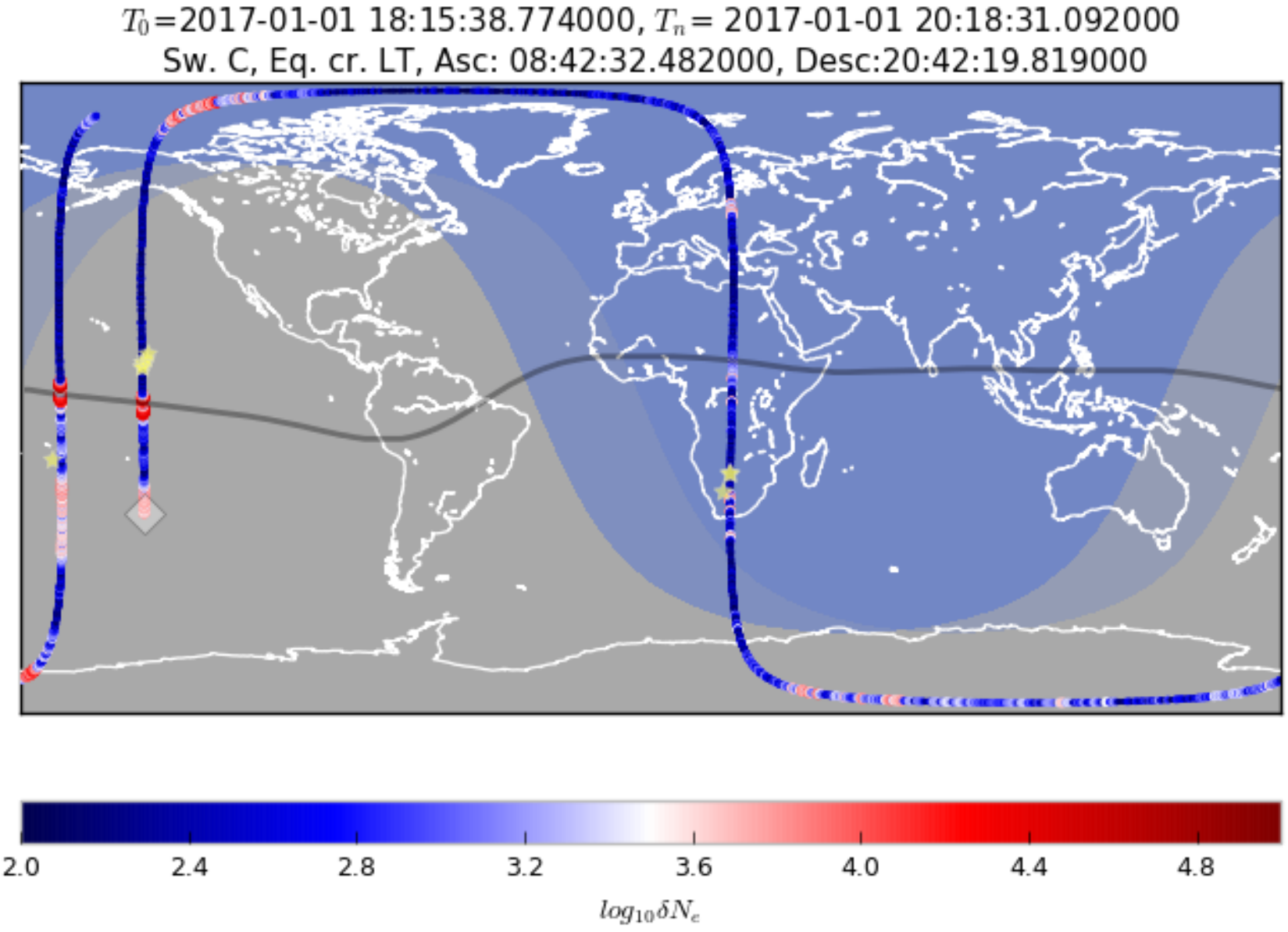
Passes over active storms - AGH data



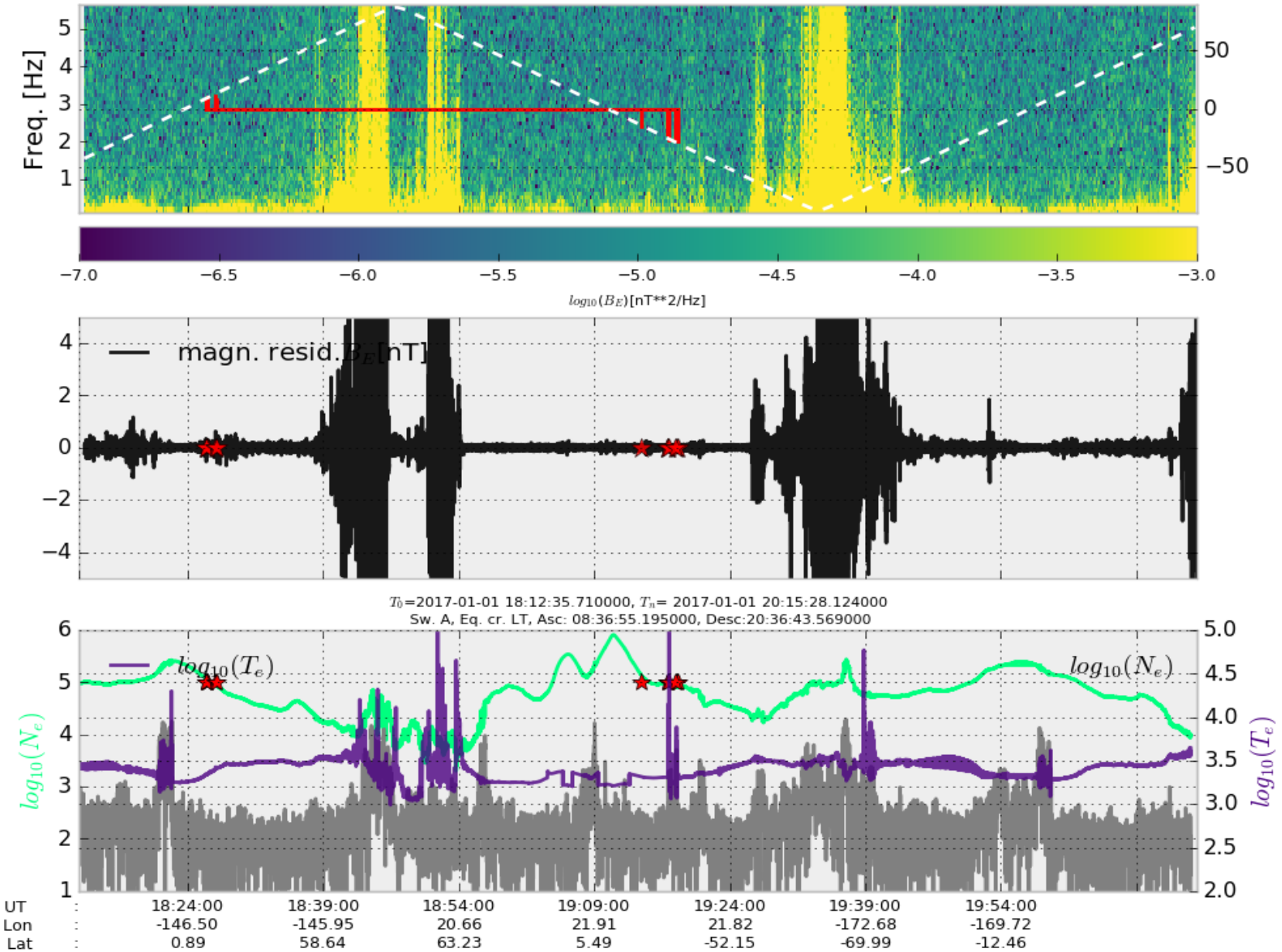
Passes over active thunderstorms - WWLLN data added



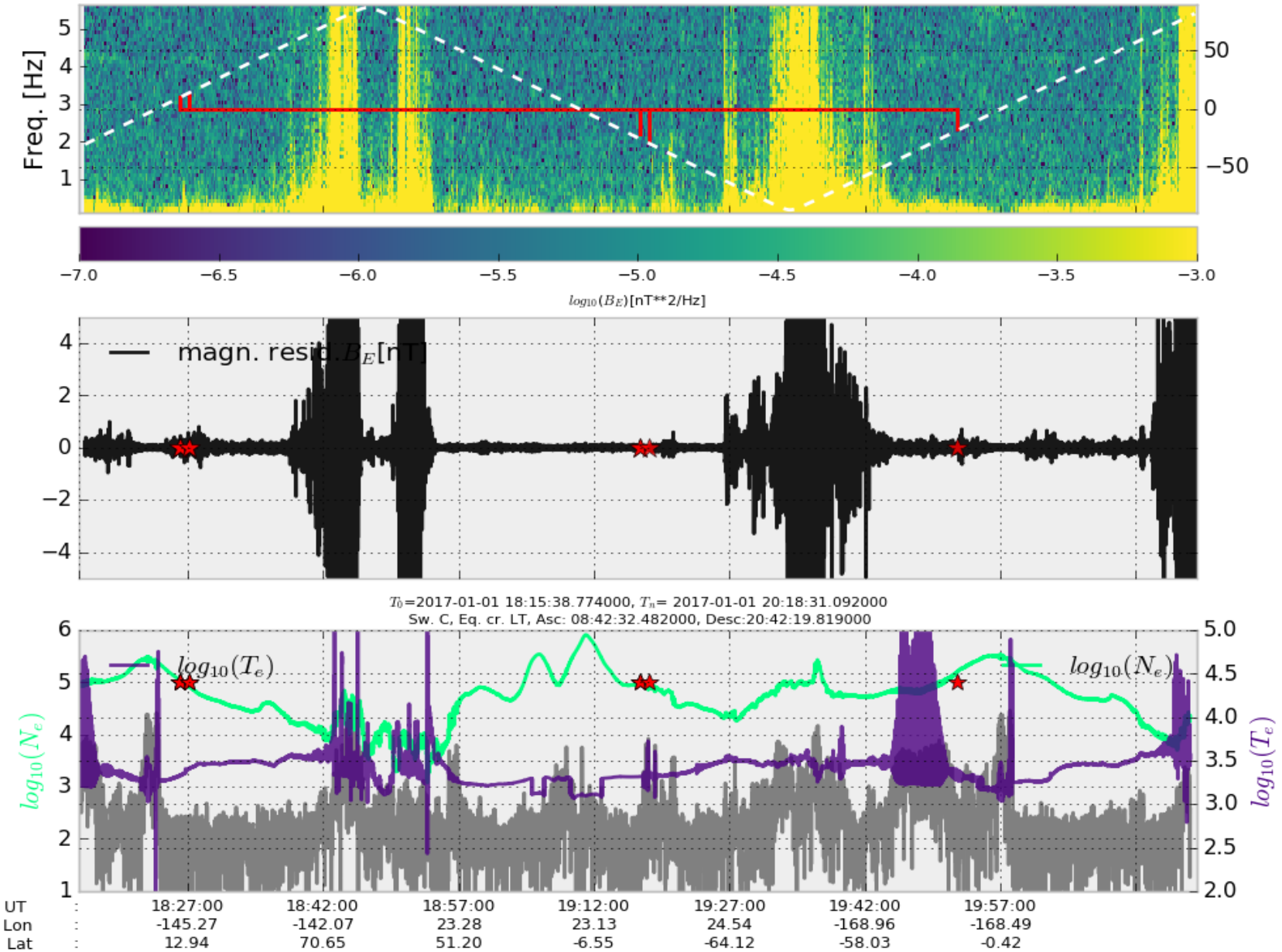
Passes over active thunderstorms - WWLLN data added



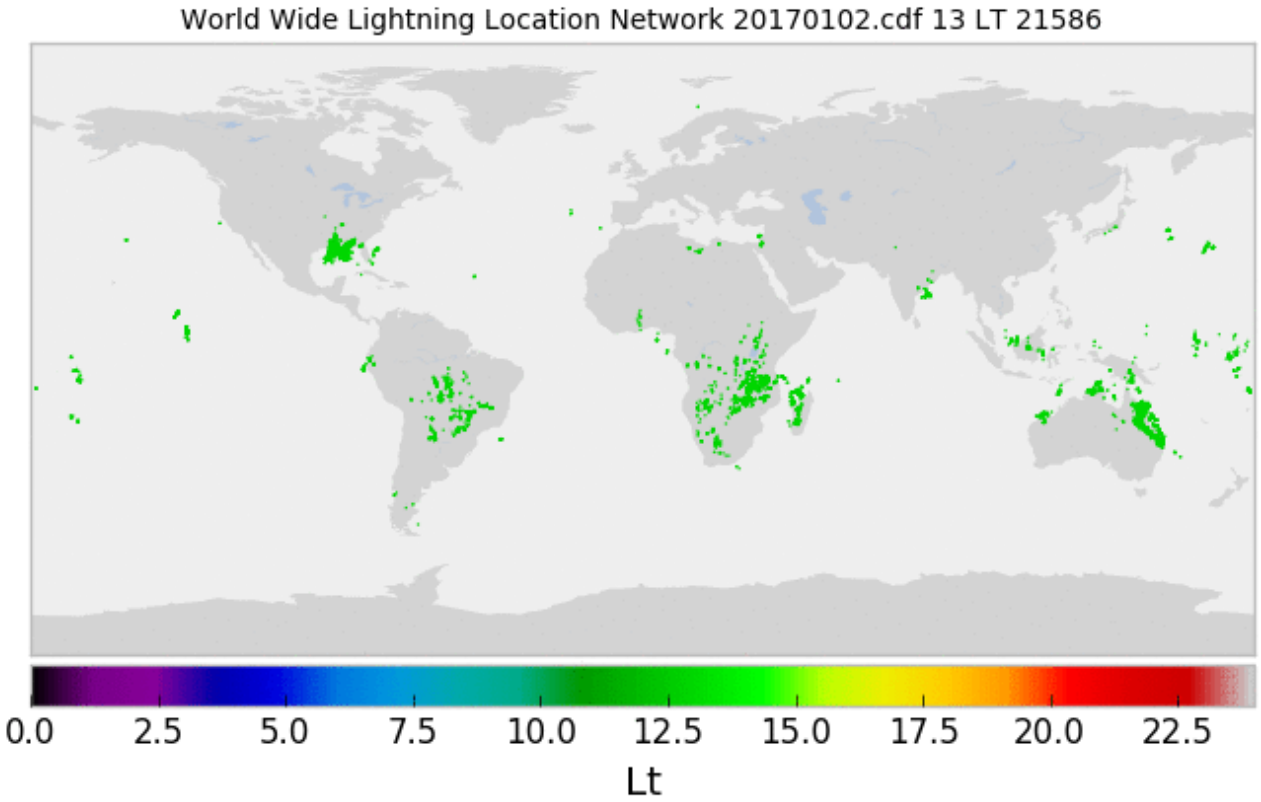
Passes over active storms - WWLLN data



Passes over active storms - WWLLN data



Day-to-day variations of lightnings for a given LT

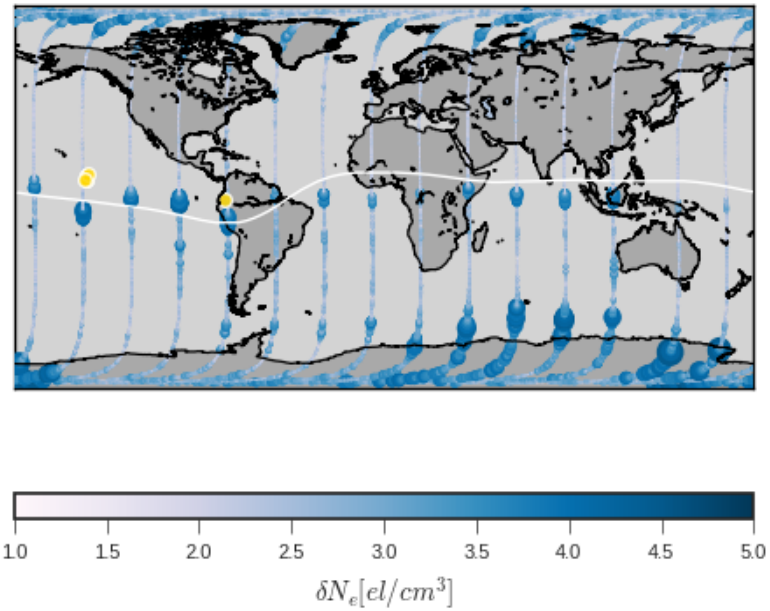


"Seeding" of plasma irregularities

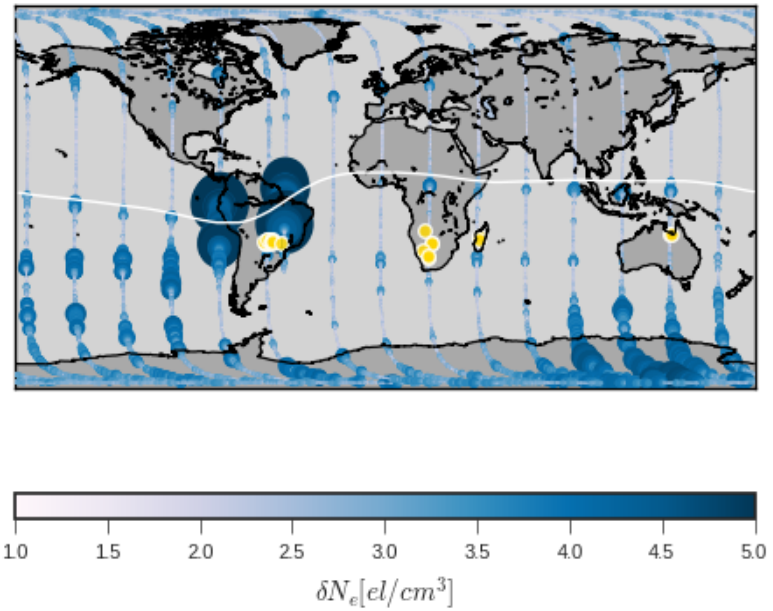
- If the main approach in the project fails: Magnetic field observations at 50Hz with Swarm do not show convincing correlation with ground observations.
- Improved database allows to assess statistical representation of regions more prone to plasma irregularities.
- In such way, we can verify the concept of "seeding" instabilities through lightning strikes.
- Such mechanism may not be globally uniform. For instance configuration of the magnetic field in certain regions may play a role, allowing for much easier formation of instabilities - like Brazilian region.

Passes over active storms - WWLLN data

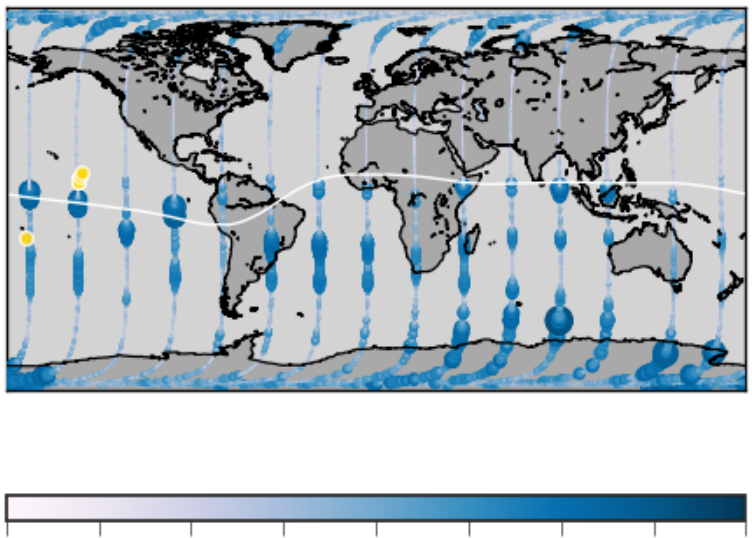
Swarm A, 20170101 - 20170101, Ascending passes,
Strikes #: 7



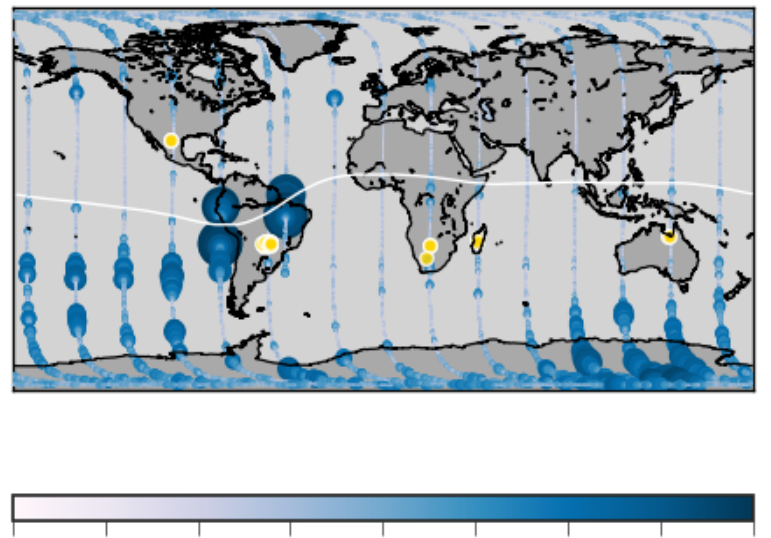
Swarm A, 20170101 - 20170101, Descending passes,
Strikes #: 40



Swarm C, 20170101 - 20170101, Ascending passes,
Strikes #: 7

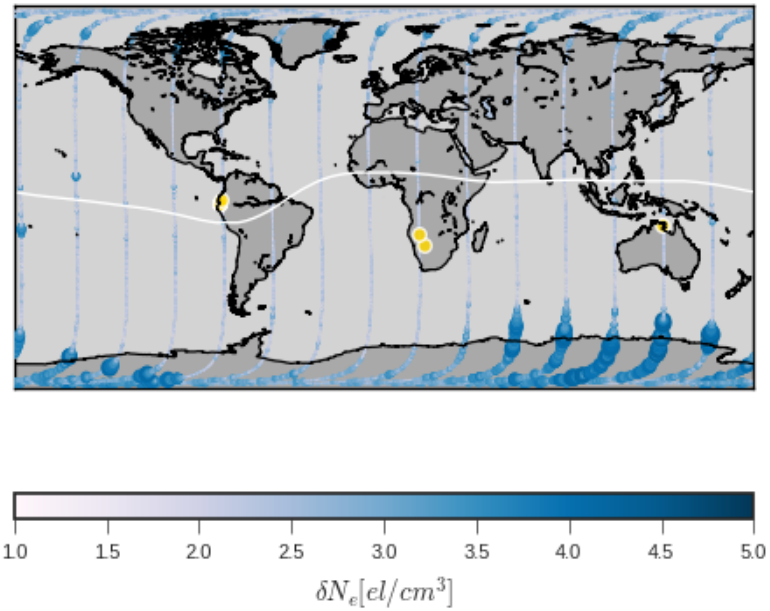


Swarm C, 20170101 - 20170101, Descending passes,
Strikes #: 37

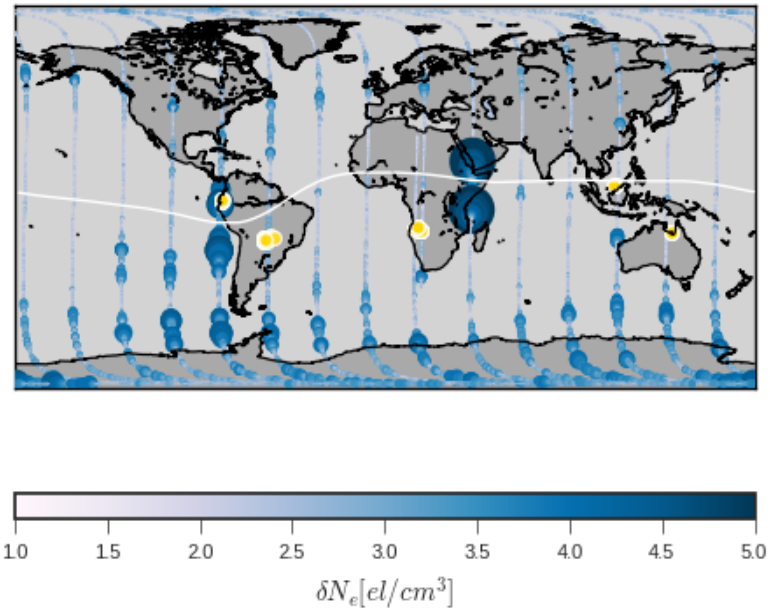


Passes over active storms - WWLLN data

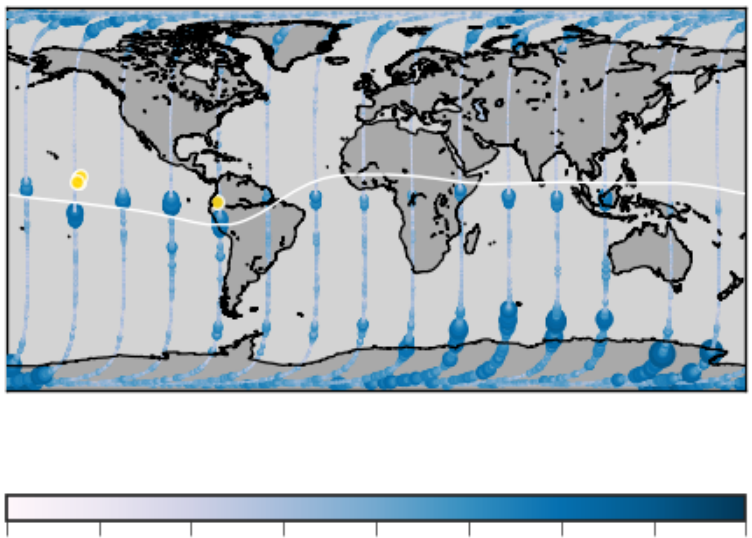
Swarm B, 20170101 - 20170101, Ascending passes,
Strikes #: 13



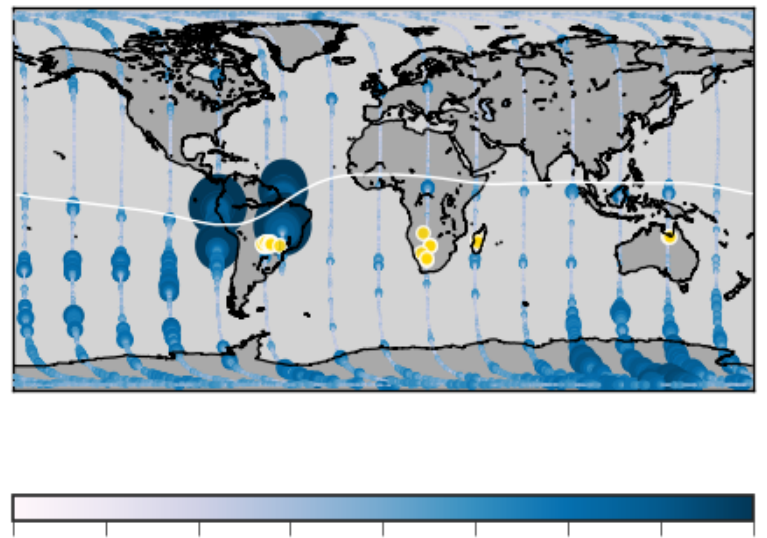
Swarm B, 20170101 - 20170101, Descending passes,
Strikes #: 76



Swarm A, 20170101 - 20170101, Ascending passes,
Strikes #: 7

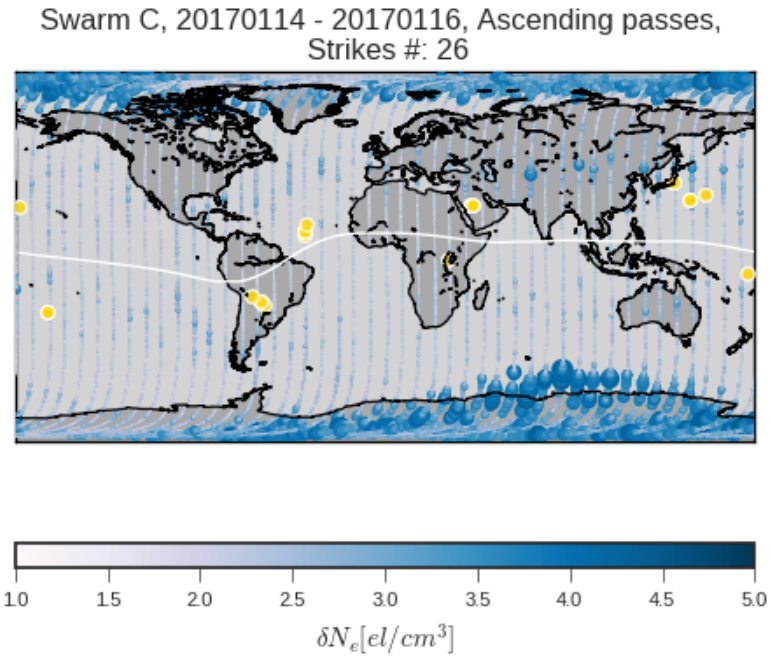


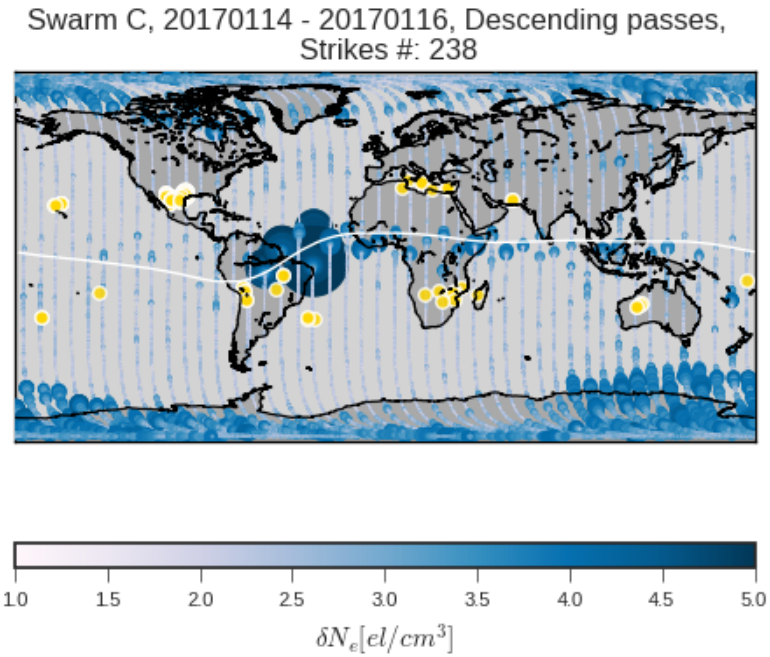
Swarm A, 20170101 - 20170101, Descending passes,
Strikes #: 40



Multi-day composites

ASC: 07LT/ DESC: 19LT





Multi-day composites

ASC: 11-12LT/ DESC: 23-00LT