

Using FORTE Data as a Proxy for Upcoming Simultaneous Optical and Radio Frequency Measurements of Lightning Flashes from Geosynchronous Orbit



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Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

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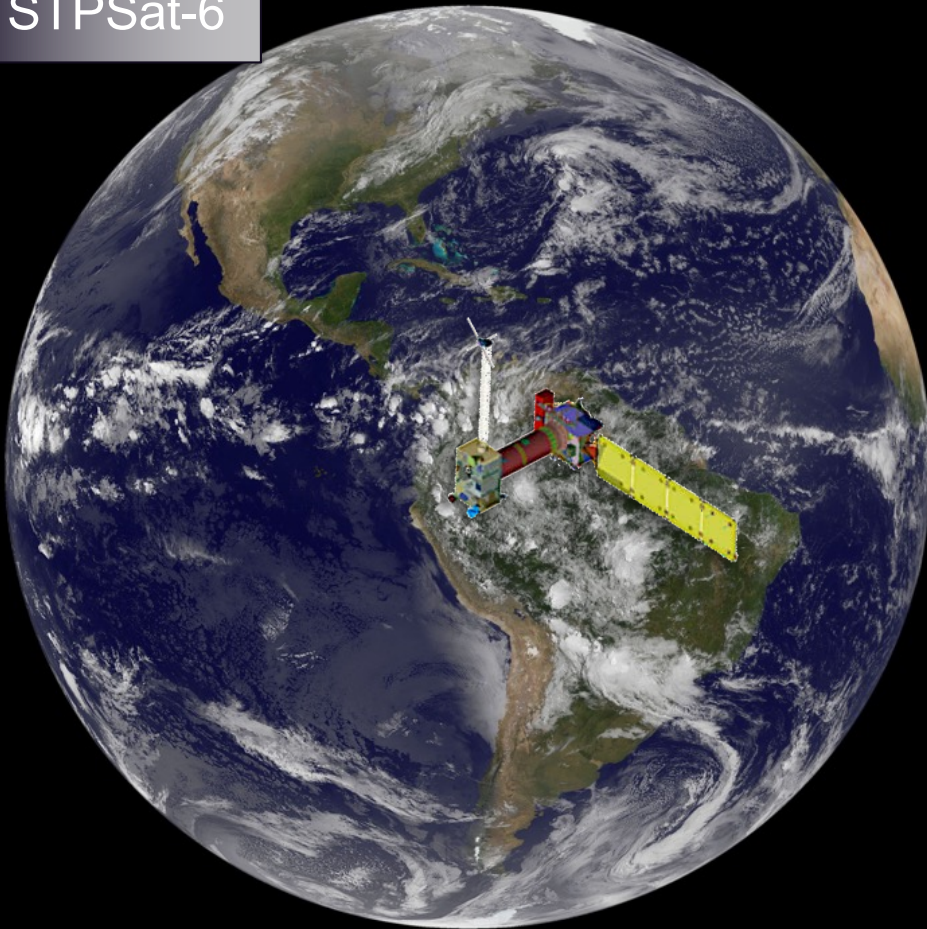
The SENSER Payload

- Space and Endo-atmospheric Nuclear detonation detection Surveillance Experimentation and Risk-reduction (SENSER)
 - Partnership between the US Department of Energy's National Nuclear Security Administration, Los Alamos National Laboratory, and Sandia National Laboratories
- Will consist of a set of flight experiments in geosynchronous orbit
 - **HF** → **UHF RF**: Radio Frequency Sensor (RFS) [LANL]
 - **Optical**: Risk Reduction Optical Experiment (RROE) [Sandia]



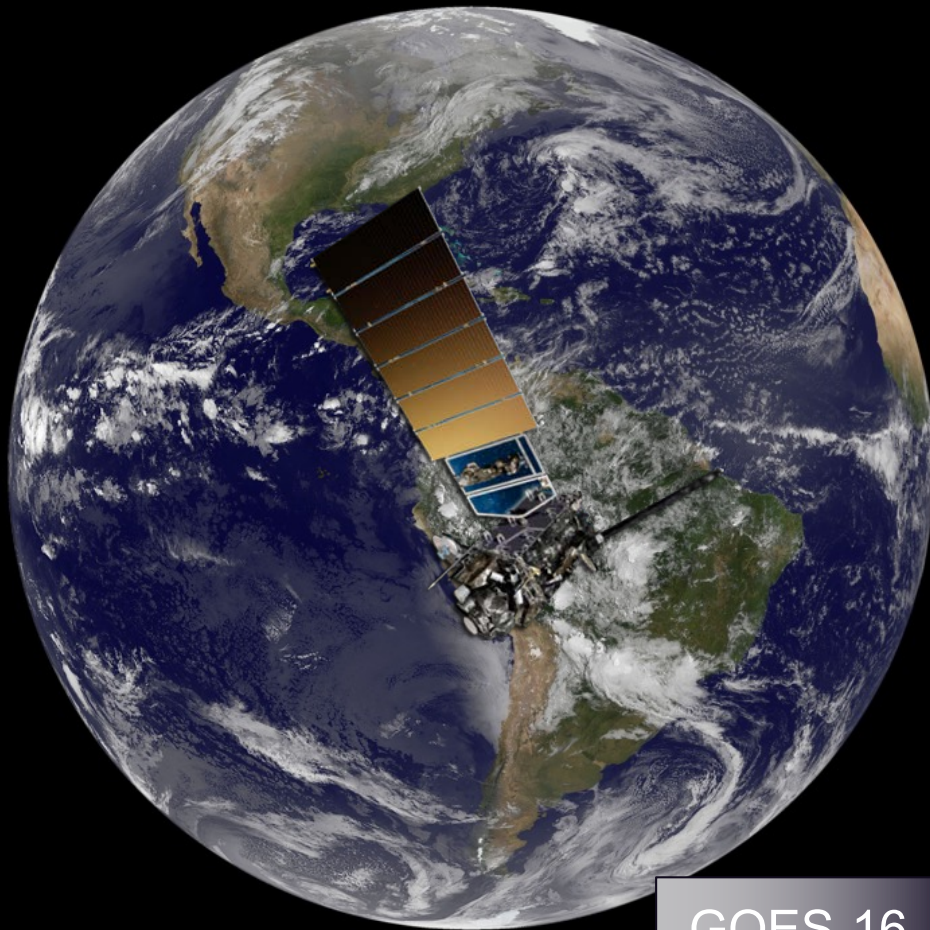
SENER in Geosynchronous Orbit

STPSat-6



- Payload on STPSat-6
 - Planned launch ~~2019~~ **2020**
 - Geosynchronous orbit in western hemisphere slot
- Mission duration: 12 months
 - Possibility for continued operations
- Anticipated high volume data downlink
 - State of health information
 - Event timeseries
 - Trigger information

Geostationary Lightning Mapper (GLM)

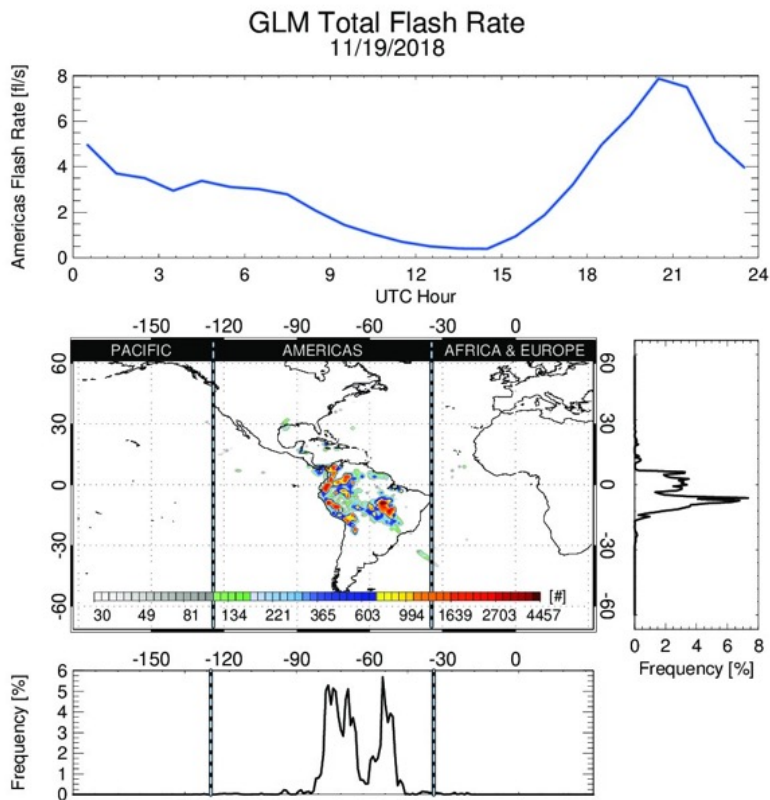


GOES-16

- Instrument on NOAA GOES16 (75° W) and GOES17 (135° W) satellites
 - Operational total lightning data available in real time
- Staring optical imager that detects transient signals across the hemisphere
 - Frame rate: 500 FPS
 - Pixel size: 9 km at nadir

Applications of Geosynchronous Lightning Detection

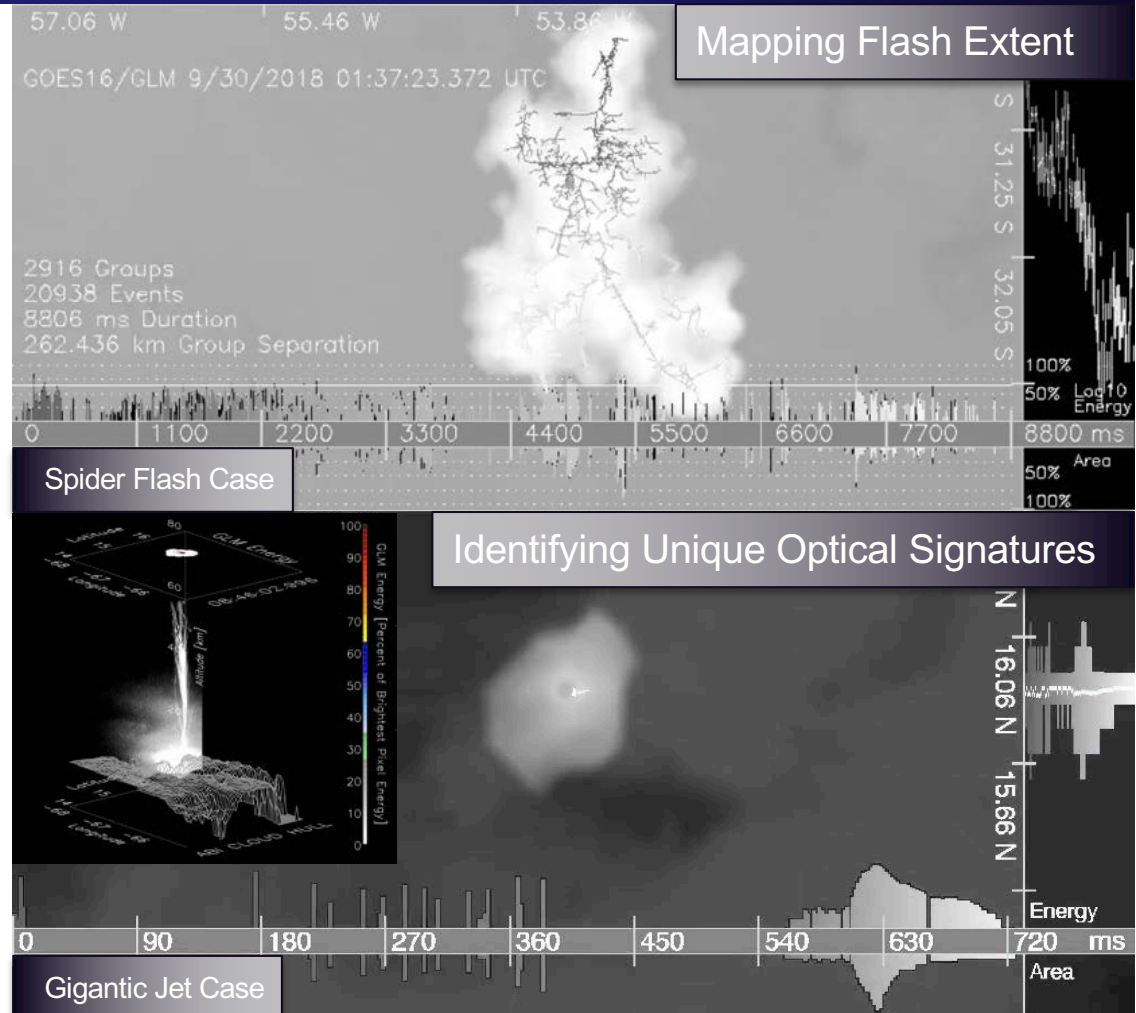
Lightning Trends / Climatologies



Monitoring Thunderstorm Evolution

Applications of Sub-Flash Optical Measurements

- GLM records flash evolution
 - Latitude / longitude / energy of signals escaping the cloud top
 - 2D integrated view of the 3D flash structure with increasing attenuation towards lower altitudes due to scattering
- Unique optical signatures may be used to infer underlying processes in some cases



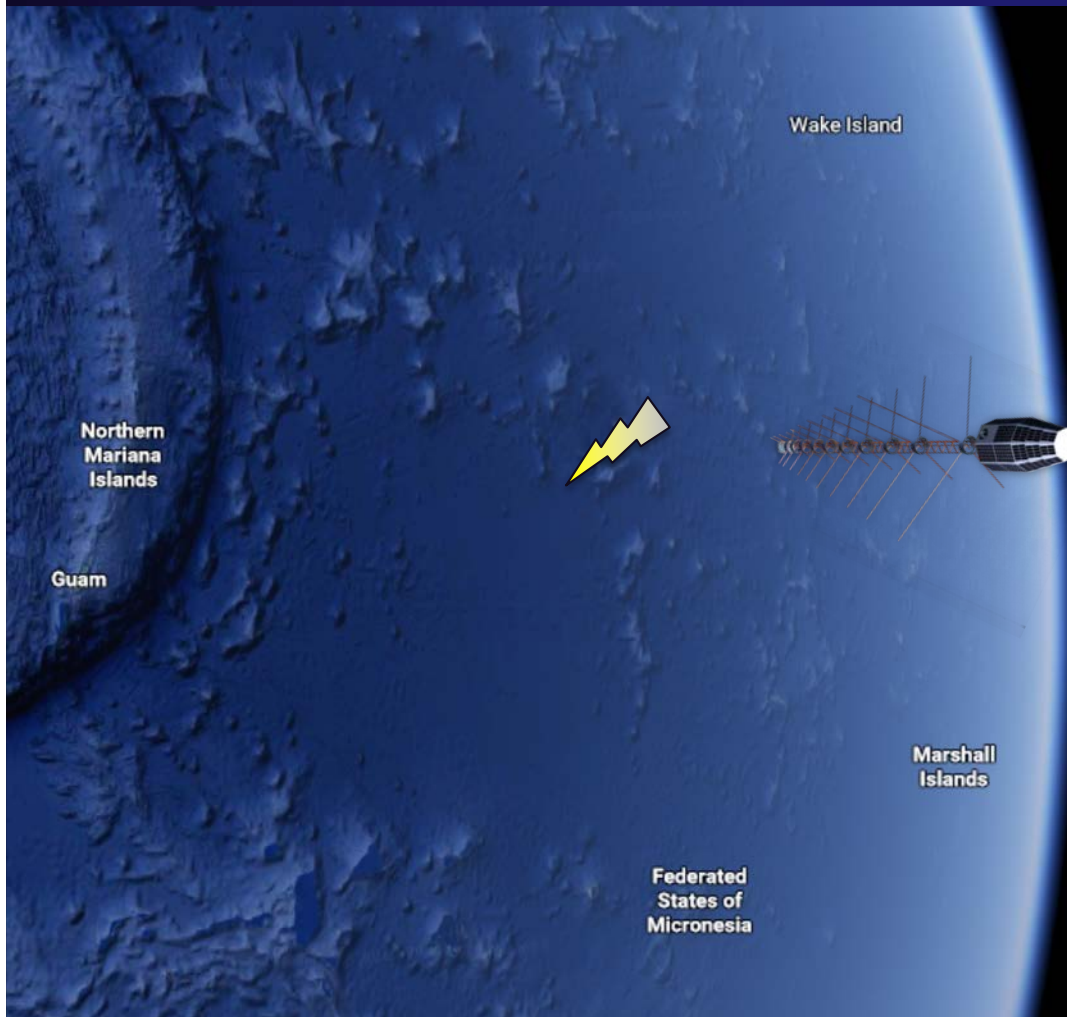
RF + Optical Measurements by the FORTE Satellite



FORTE

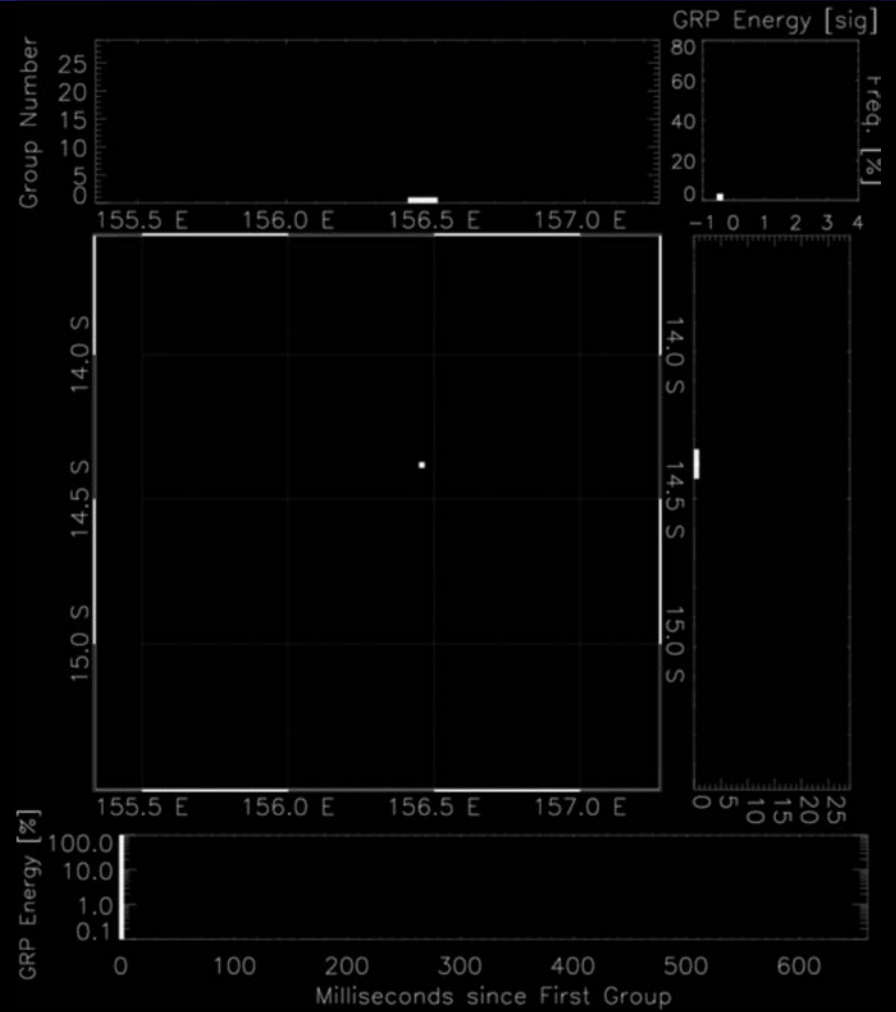
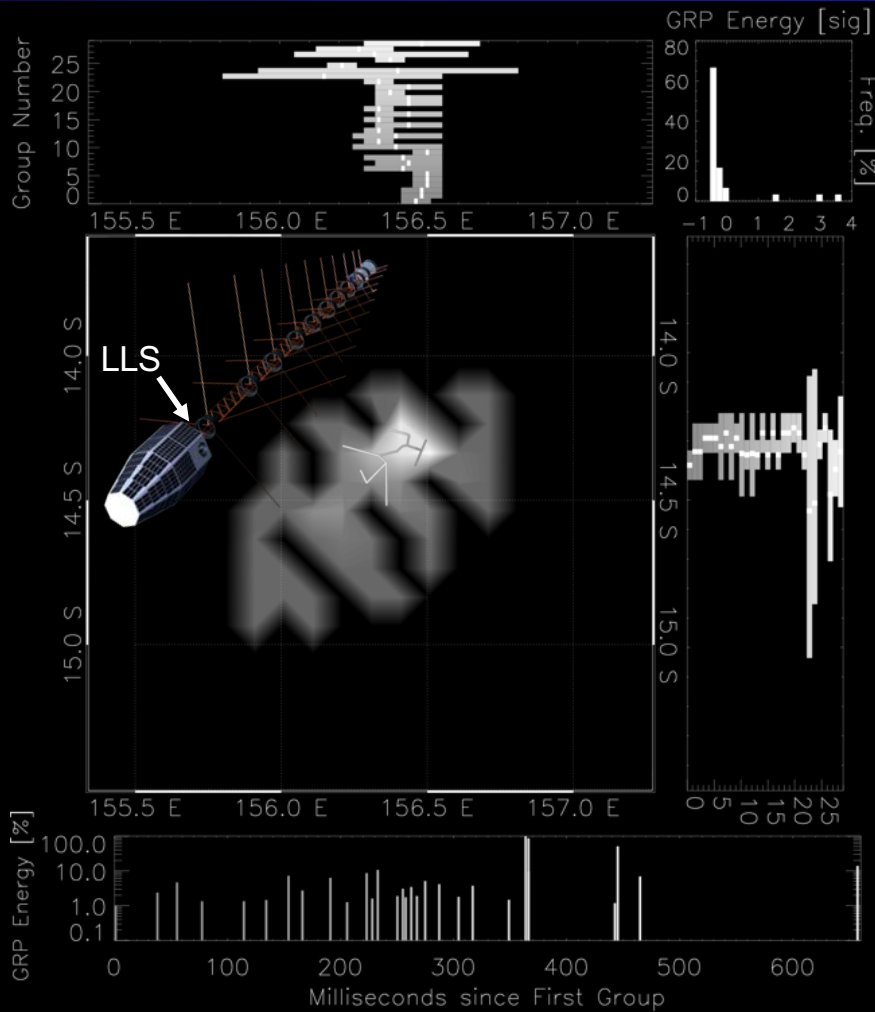
- Fast On-Orbit Recording of Transient Events (FORTE)
 - 12 years of operation in Low Earth Orbit
- Optical Lightning System
 - High-speed photodiode
 - Lightning Locating System
 - Staring CCD imager like GLM
 - 10 km pixel resolution
- Radio Frequency System
 - VHF radio receivers covering 30 – 300 MHz

Case Selection from FORTE OLS / LLS Flash Clusters

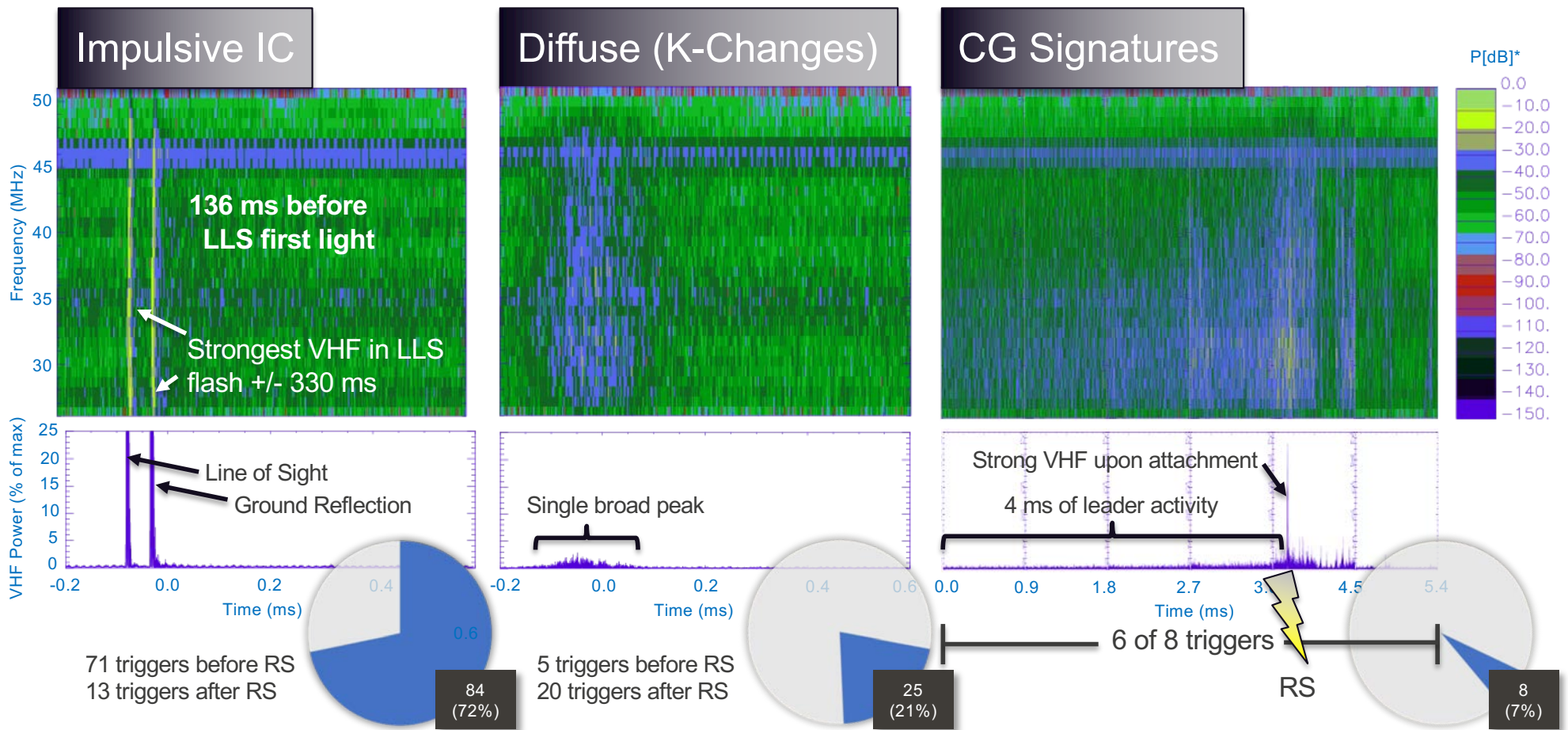


- Flash cluster algorithm applied to OLS / LLS data
- Cases selected from flash optical characteristics
 - Looking for probable CG case with either continuing current or subsequent strokes
 - Ideally with notable IC activity
- Pacific Ocean case identified
 - 120 km flash diameter
 - 3 high energy groups ($>3\sigma$)
 - 30 groups in 656 ms

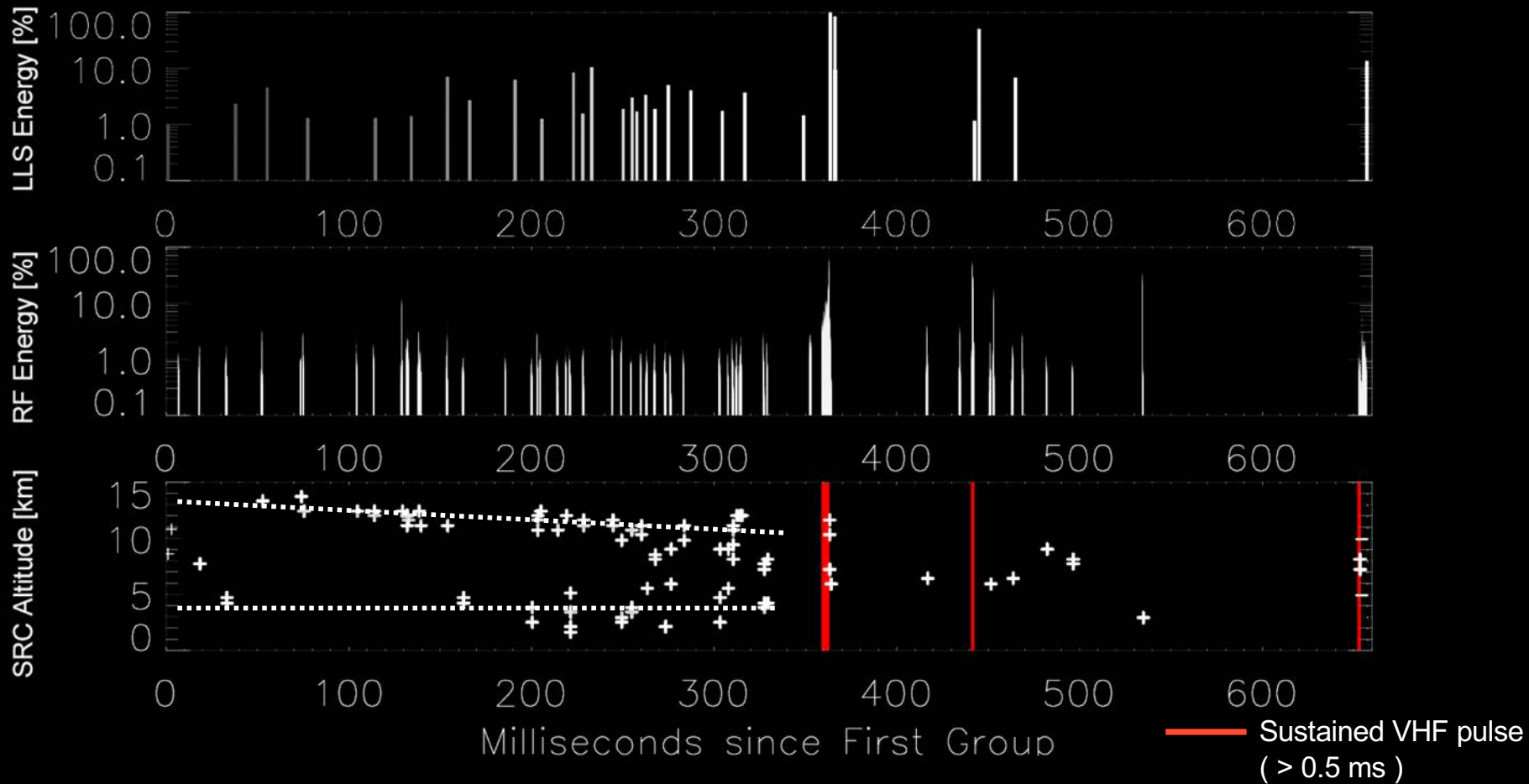
FORTE OLS / LLS Flash – 10/13/1999 10:50:16 UTC



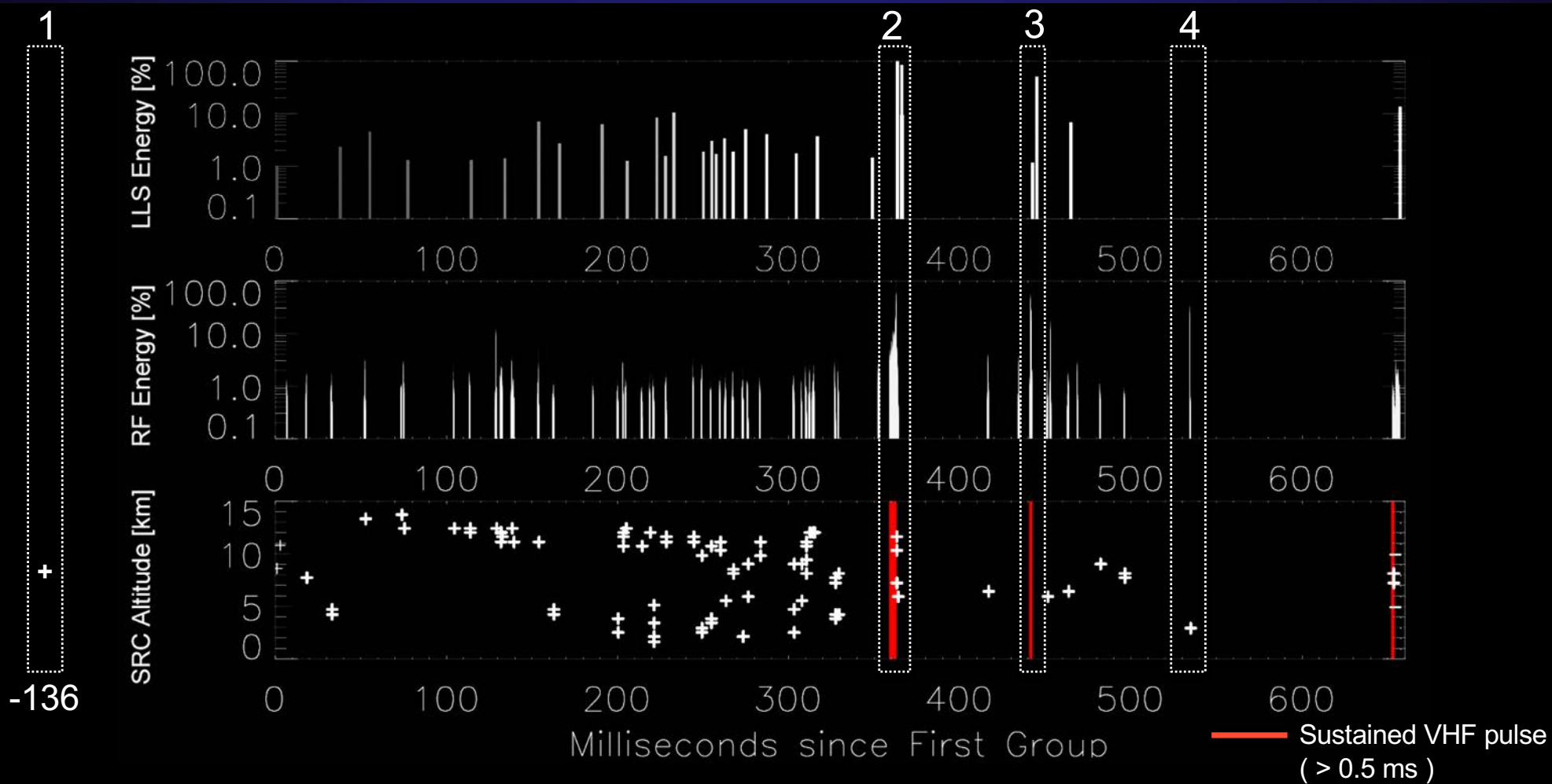
Types of RF Signals Recorded during LLS Flash



Optical and RF Timeseries



Top RF Triggers



CONCLUSION

- SENSER is scheduled to join GLM in a western hemisphere geosynchronous slot in 2020
 - At least 12 months of HF – UHF RF data collection from Americas lightning
- FORTE observations demonstrate the value of coincident RF / optical measurements of the same event
 - Optical sensors can map flash evolution and lateral development
 - RF sensors clarify underlying physical processes and add altitude information for impulsive IC sources
- SENSER + GLM will enable continuous FORTE-type analyses across the Americas and will thus be a valuable tool for studying lightning physics across the hemisphere

