Update on Radio Frequency Sensor: 2.5 Years of RF Lightning Detection from GEO

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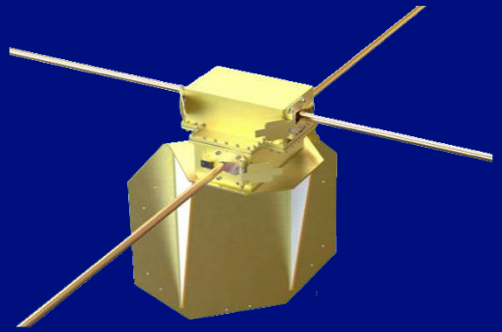
Radio Frequency Sensor : RF Lightning detection at GEO

Recap

- First time for RF lightning detection in GEO
- Launched 6 December 2021: Turn-on 15 January; Operational mode: 20 February 2022
- Triggers on broadband radio frequency transients from lightning
- Hundreds of thousands of lightning events captured so far



Top updates

First RFS paper published

– Radio Frequency Sensor: Very High Frequency Radio Frequency Lightning Detection in Geostationary Orbit, Lay et al., Radio Science, 2024, *doi:10.1029/2023RS007931*

Data set for public release is in progress

RFS example waveforms

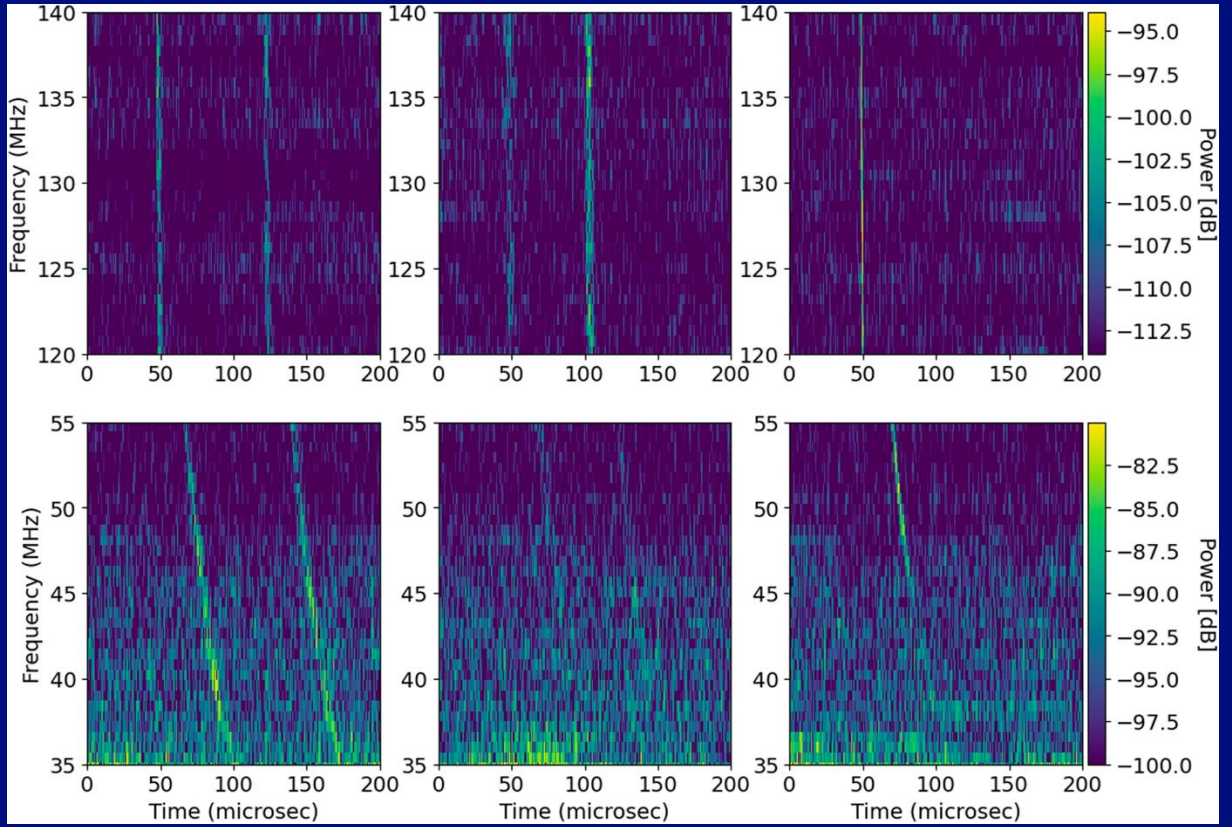
- Event 1:

  Transionospheric pulse pair (TIPP), equal power between pulses, 17.5 km altitude, strong lowband (LB)

- Event 2:
  - TIPP, second pulse has higher power, more polarized, weak LB, 12.5 km altitude

- Event 3:

  -CG seawater attachment, highly polarized, strong LB (45-55 MHz)



[Lay et al., Radio Science, *doi:10.1029/2023RS007931*]

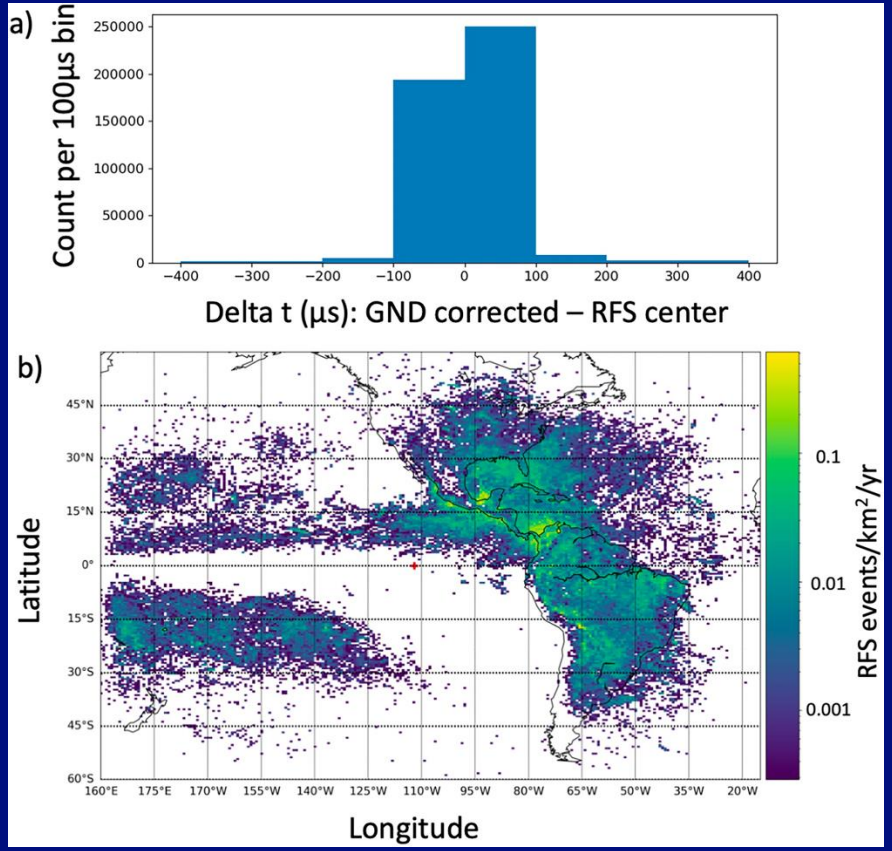
Locations of RFS/ENTLN matches

Table 1
Total Counts of RFS Events and RFS Coincidences With Other Lightning Location Data Sets During the Time Period of 1 March 2022–1 March 2023

	Total counts	Percentage
All RFS w/TEC ≥ 5 TECU	4,97,327	---
ENTLN coinc (100 us)	4,52,336	91.0
WWLLN coinc (100 us)	2,28,084	45.9
ENTLN or WWLLN coinc	4,70,012	94.5
GLM coinc (2 ms)	3,84,174	77.2
GLM only coinc (2 ms)	23,484	4.7

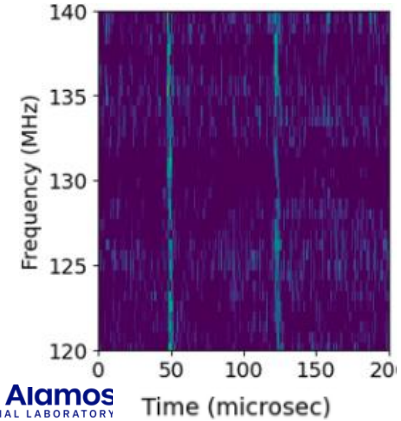
Note. Right column shows percentages.

[Lay et al., Radio Science, *doi:10.1029/2023RS007931*]

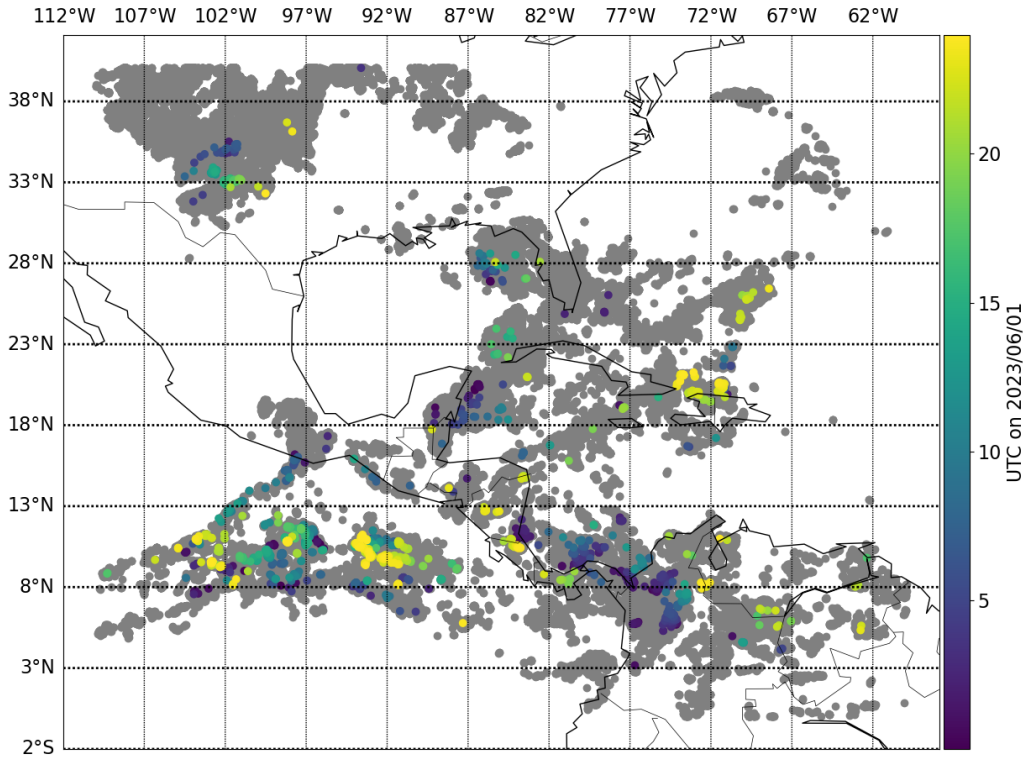


Transionospheric Pulse Pairs (TIPPs) Case Study 06/01/2023

- 85-90% of RFS detections are TIPPs (found to correspond to CIDs, NBEs)
- Machine learning to automatically identify thousands of TIPPs
- Time difference + geolocation gives altitude
- Can track storm development in height with TIPPs



Gray = NLDN/GLD360
Color = RFS match (time)



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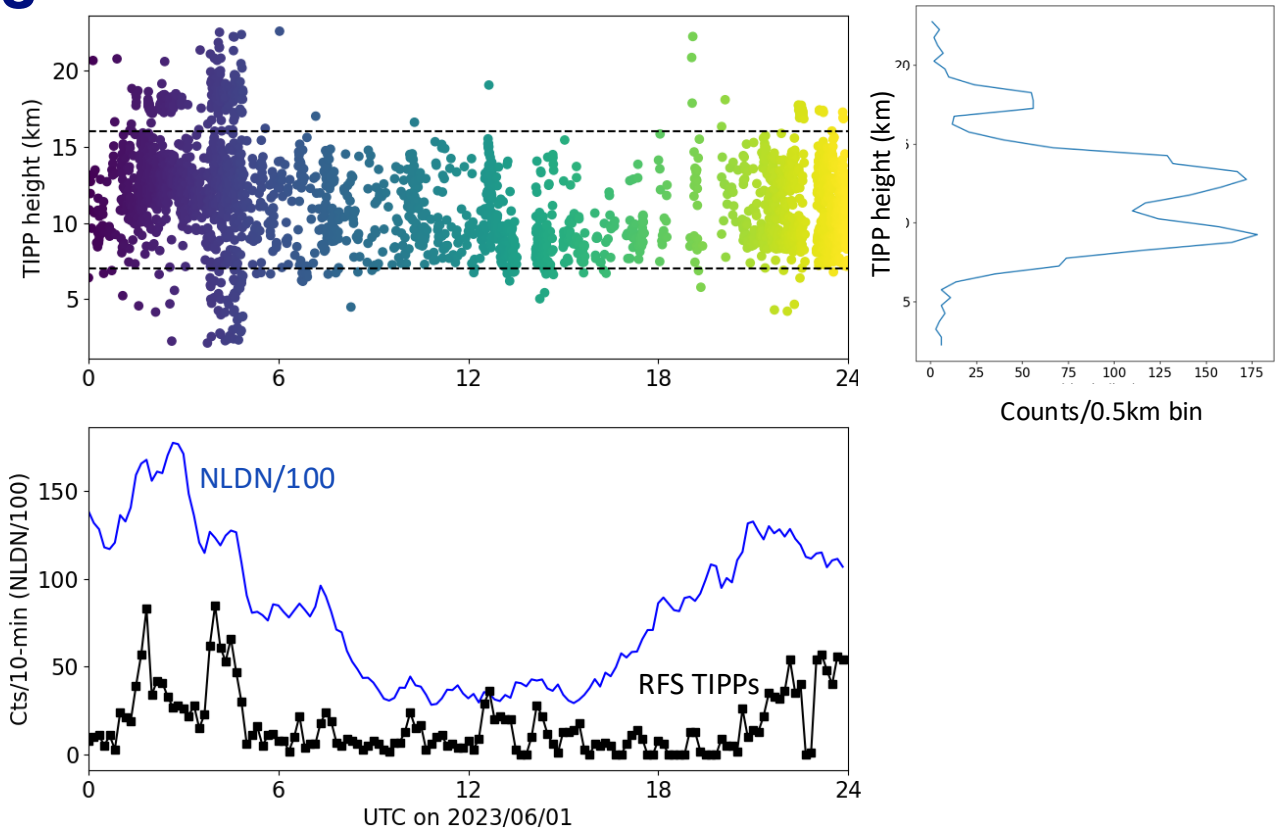
Transionospheric Pulse Pairs (TIPPs) Case Study 06/01/2023



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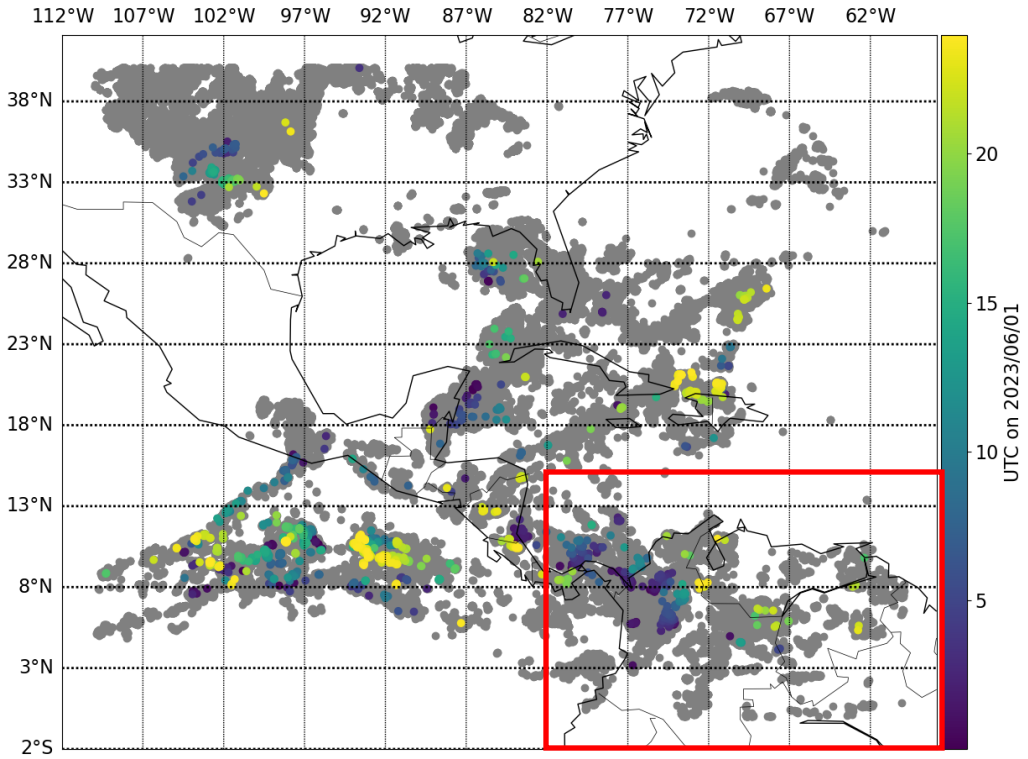

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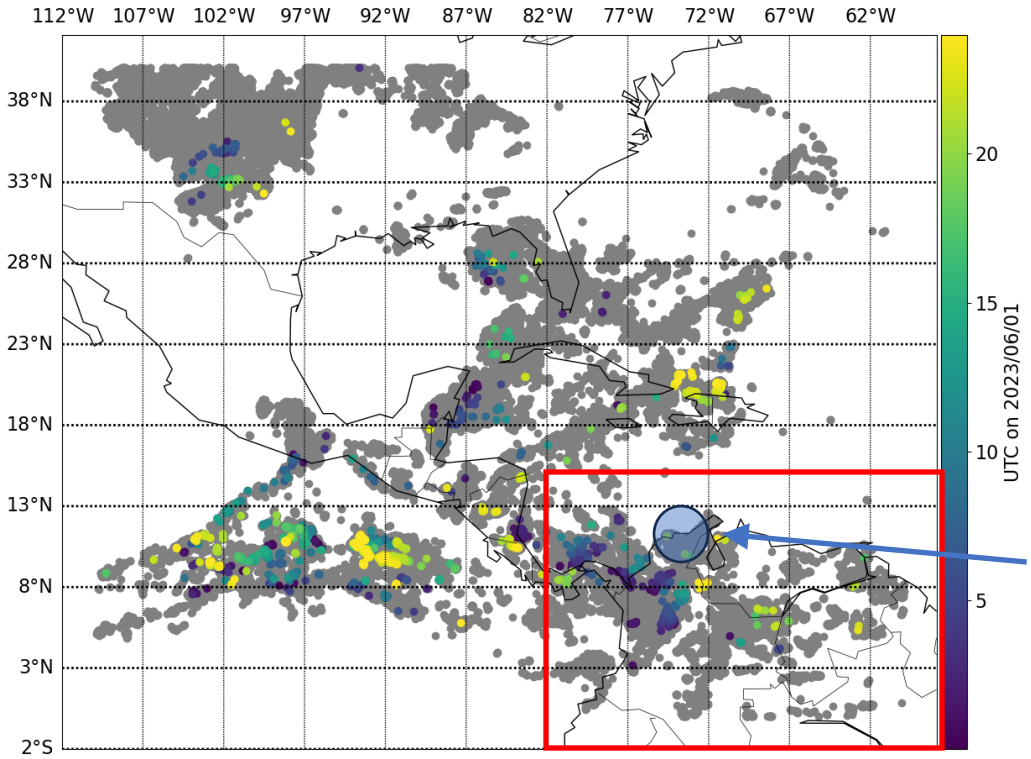

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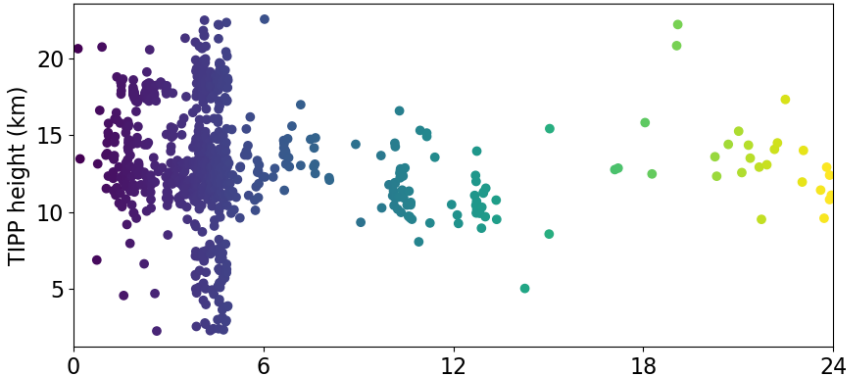
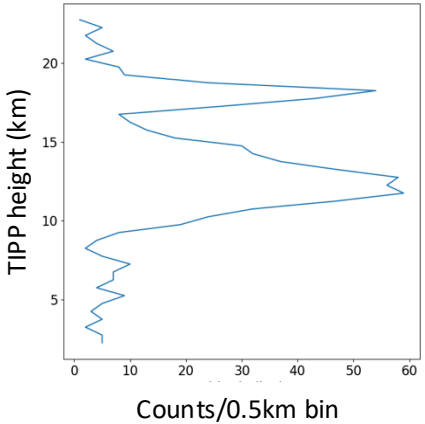
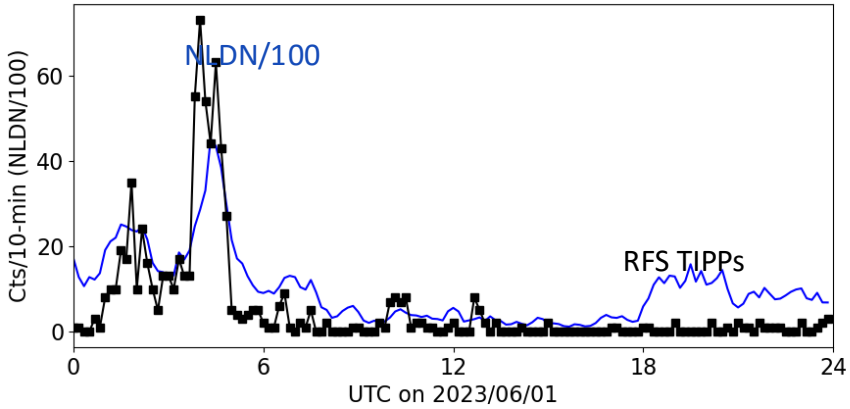
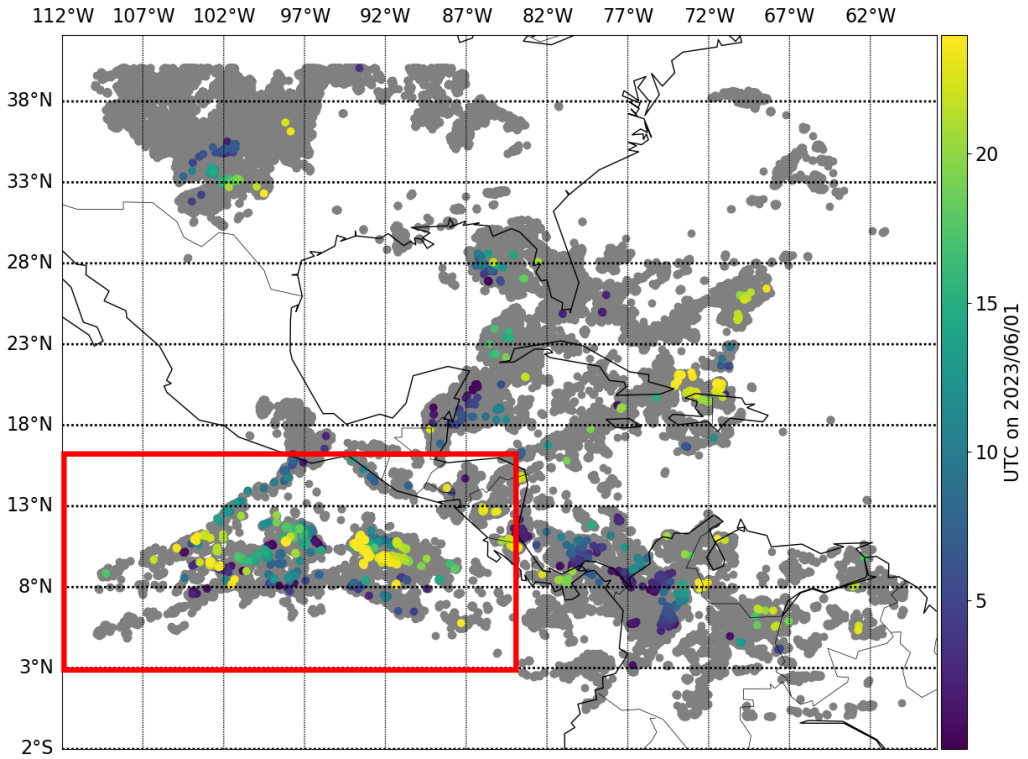






- TIPP activity tracks NLDN/GLD360 (with factor of 1/100) very well at beginning, not so much at end.
- TIPP activity shows some very high and very low sources from one storm.

Transionospheric Pulse Pairs (TIPPs) Case study 06/01/2023



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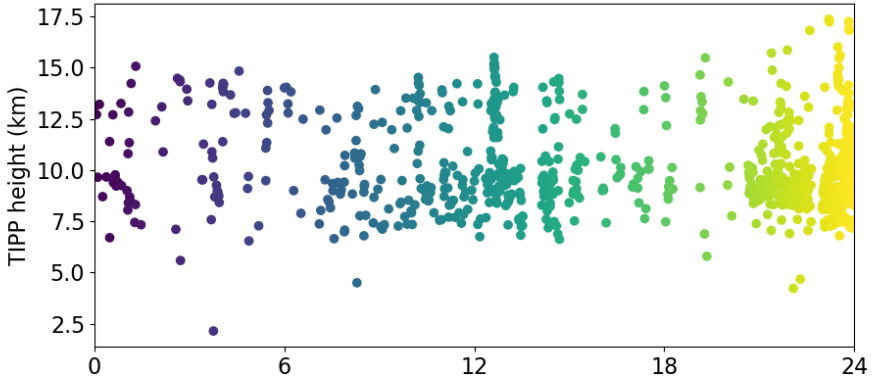
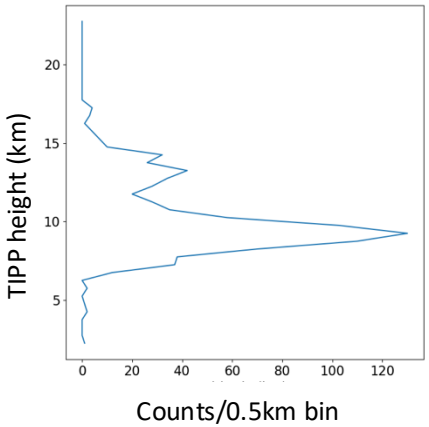
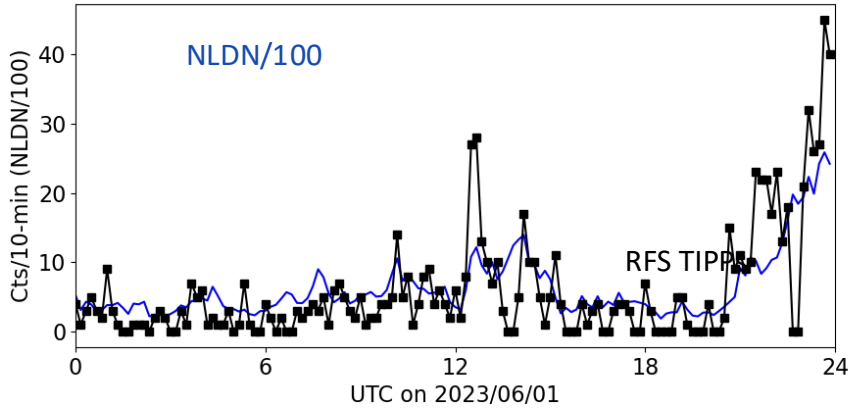
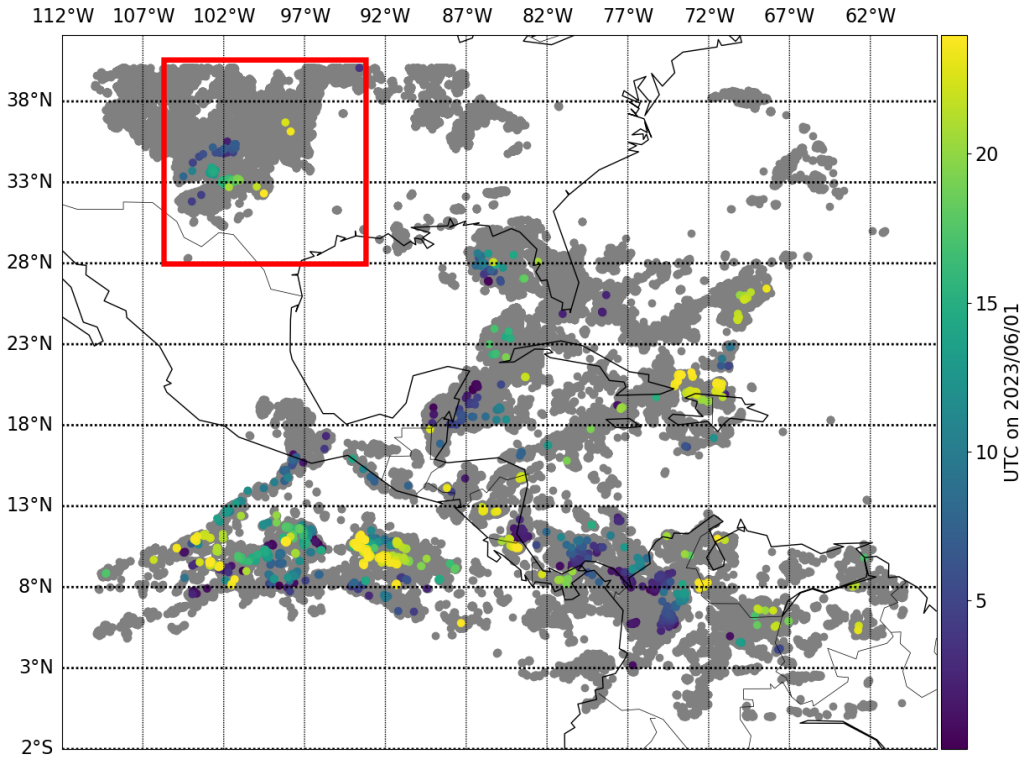






- TIPP activity tracks NLDN/GLD360 (with factor of 1/100) very well.
- TIPP activity consistent over time, no extremely high or low altitudes calculated.

Transionospheric Pulse Pairs (TIPPs) Case study 06/01/2023



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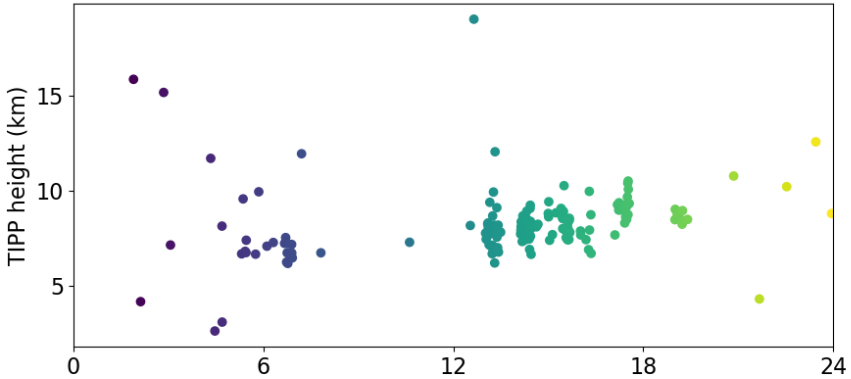

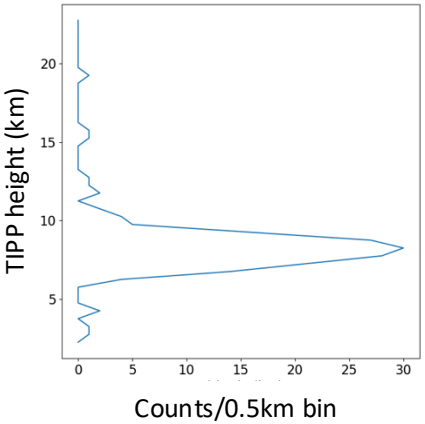

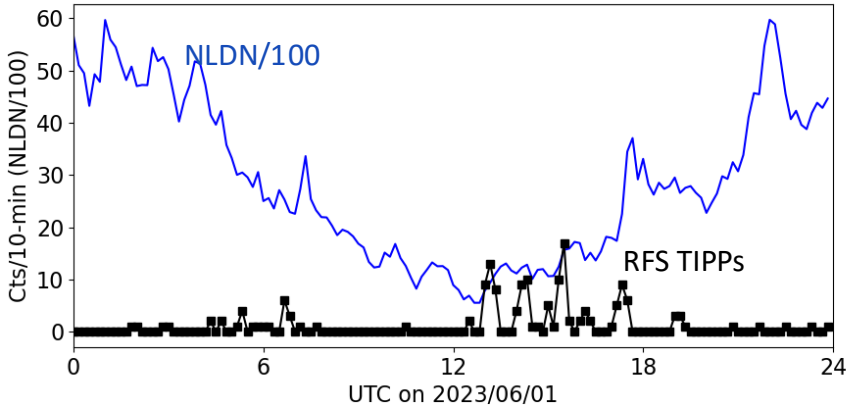

- TIPP activity low over U.S. storm
- NLDN/GLD360 detects far more non-TIPP-coincident lightning compares to other regions
- TIPPs/CIDs/NBEs over continental U.S. come in bursts

Work in progress

- General data processing pipeline
- Data products for public release
- Automated TIPP-finding algorithm with pulse time difference
- Differentiating types of TIPPs and their associated storms
- Comparisons with BLUEs (337 nm) – ASIM recently re-pointed to nadir
- Studying the most powerful lightning (RF and Optical)
- Collaboration with ground-based campaigns (Columbia LMA)