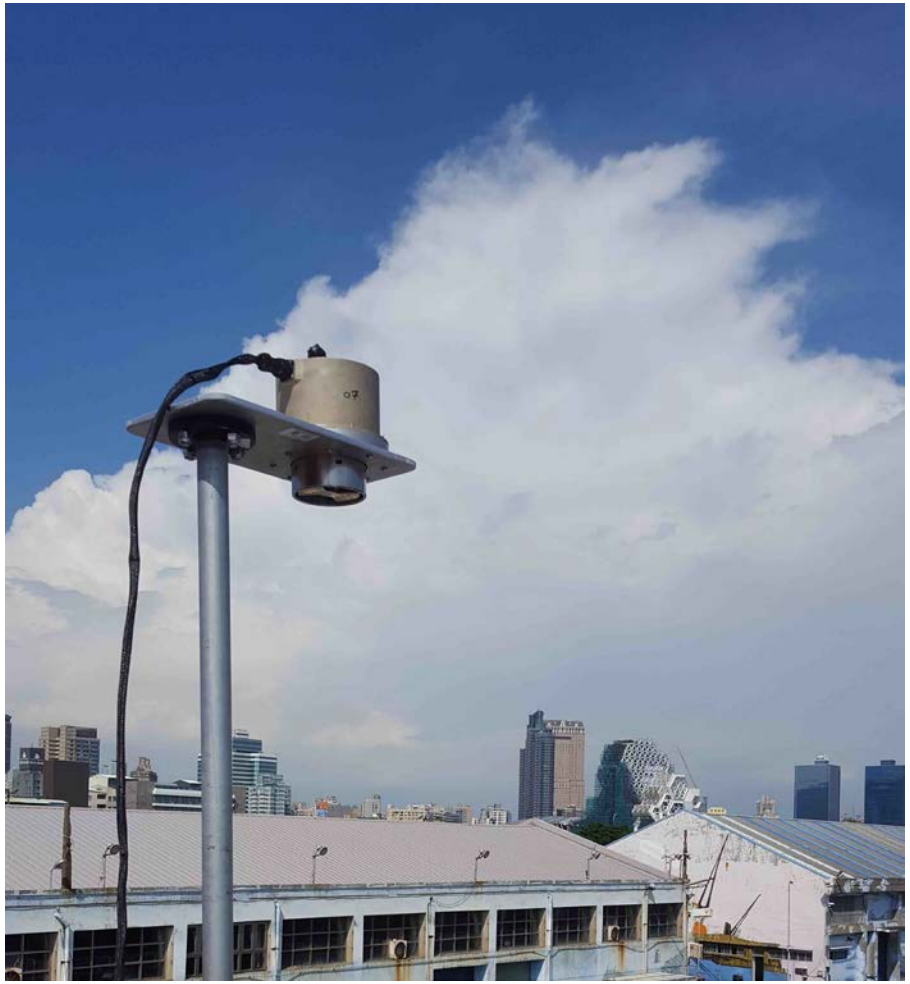
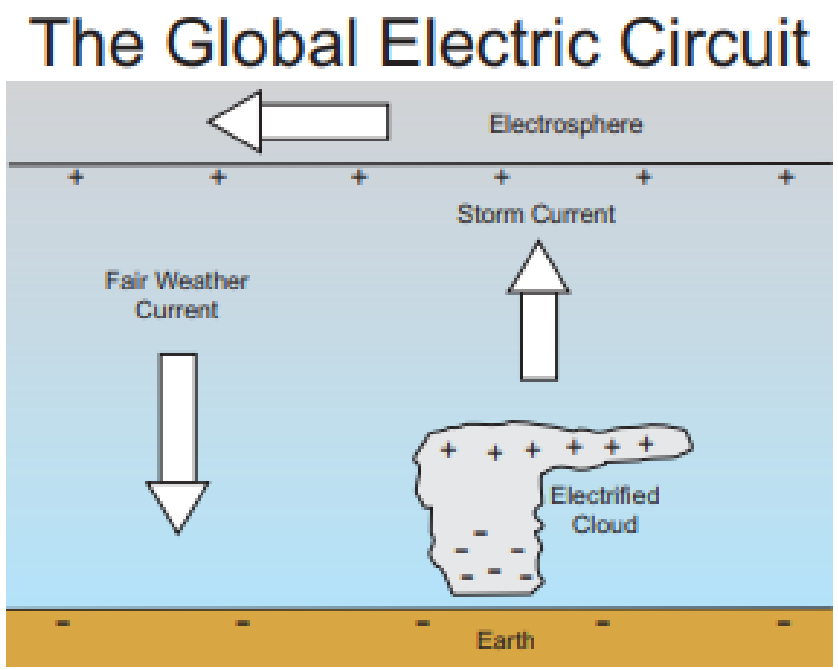
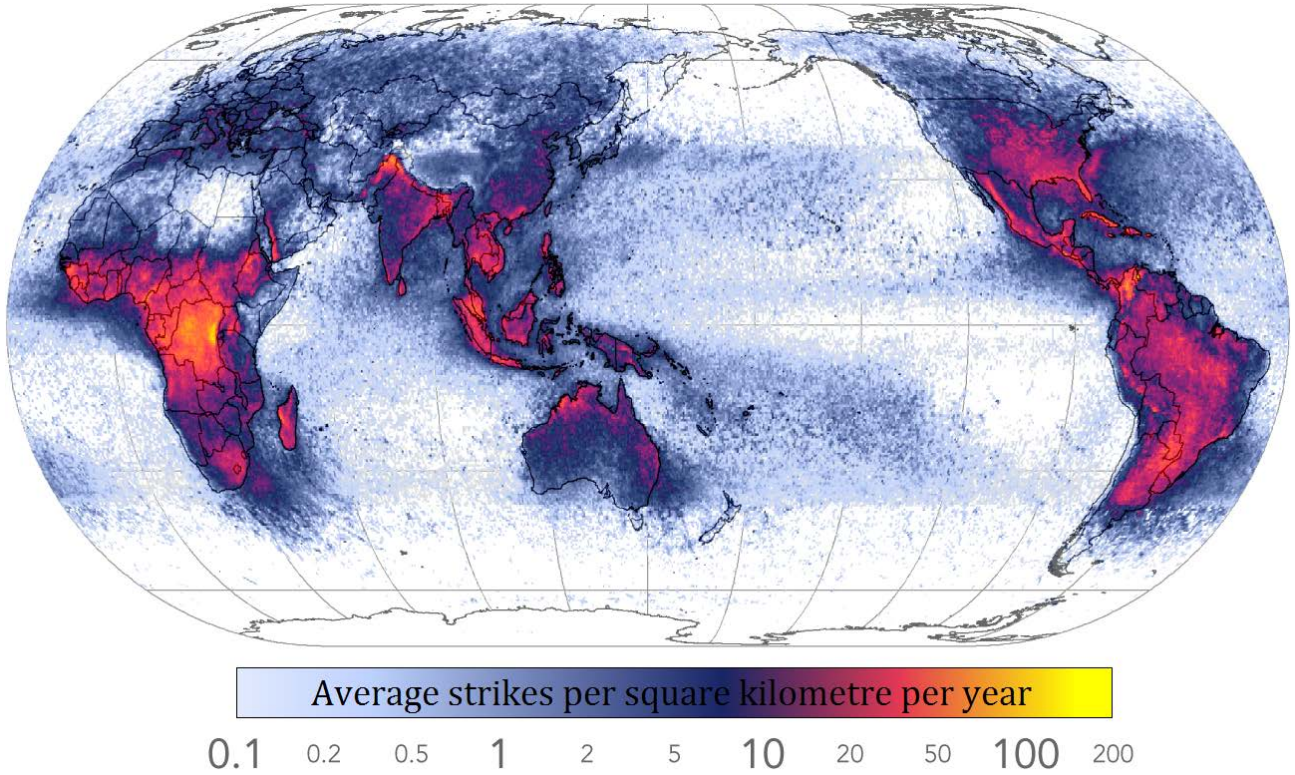


Electric field and lightning observations during PISTON 2018

Timothy Lang
NASA Marshall Space Flight Center



NASA

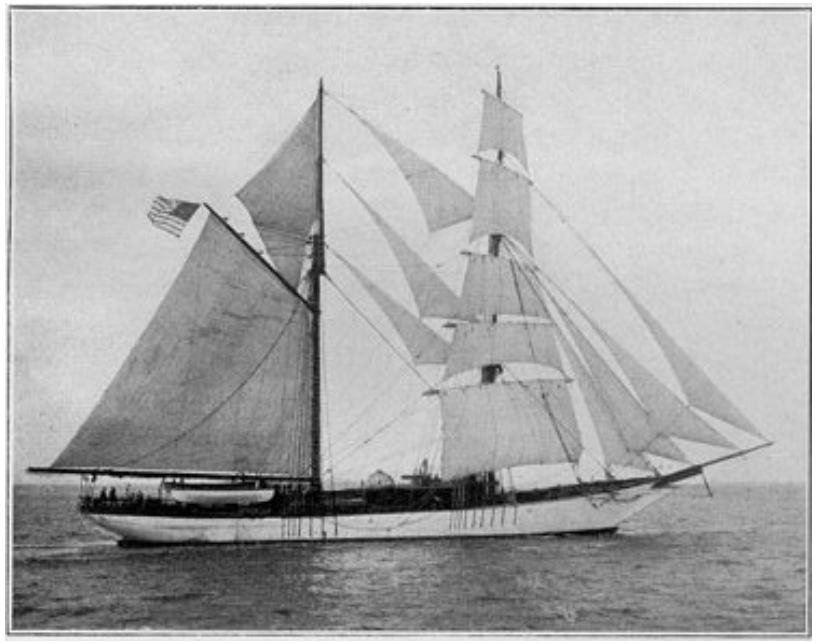


Wikipedia

- Global electric circuit is driven by charge separation and lightning in thunderstorms
- Leads to sustained electric field in atmosphere, even during fair weather
- Diurnal variability in thunderstorms leads to diurnal variability in fair wx electric field

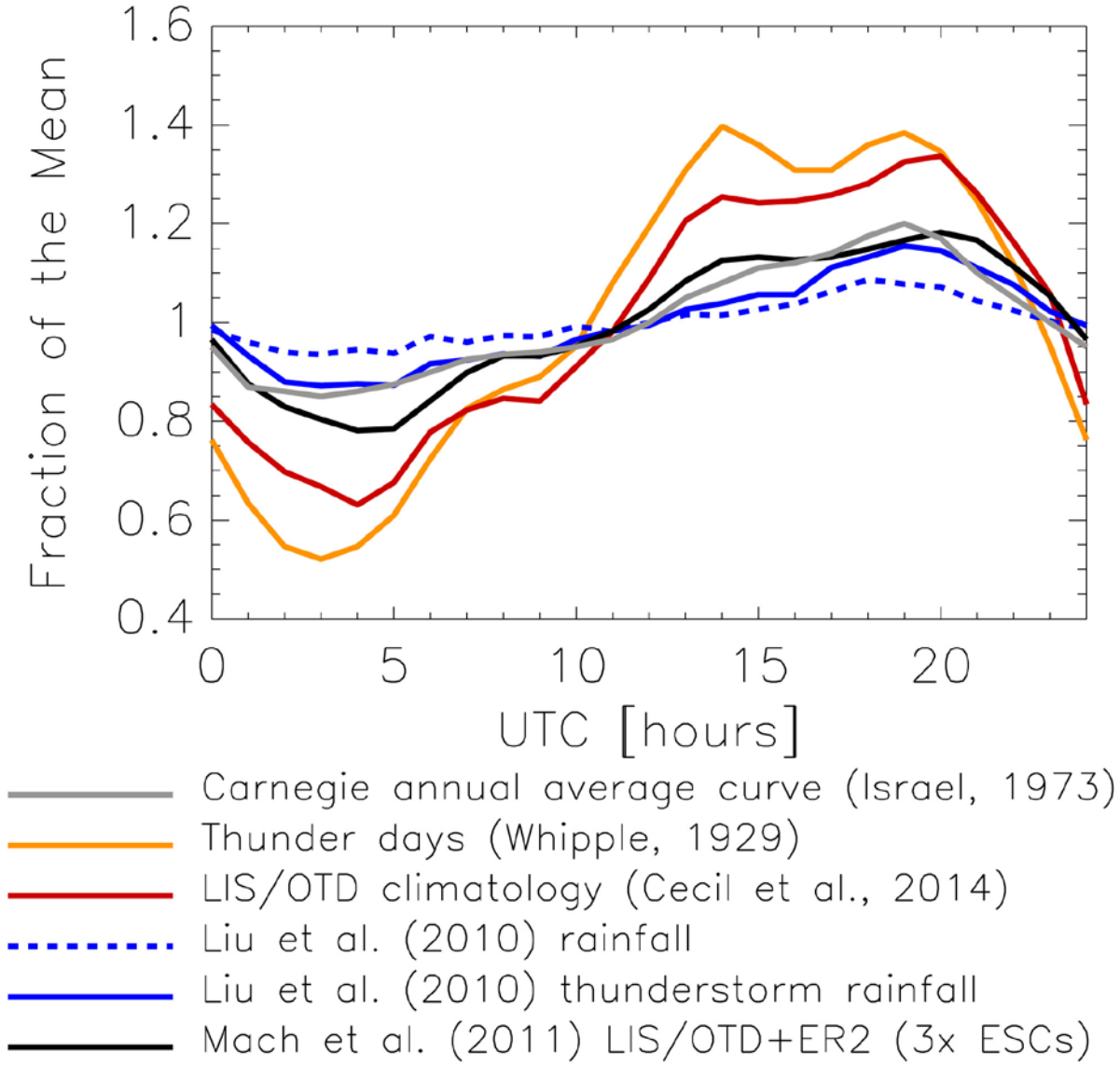
Carnegie Curve

- The global diurnal variability in fair wx **E**



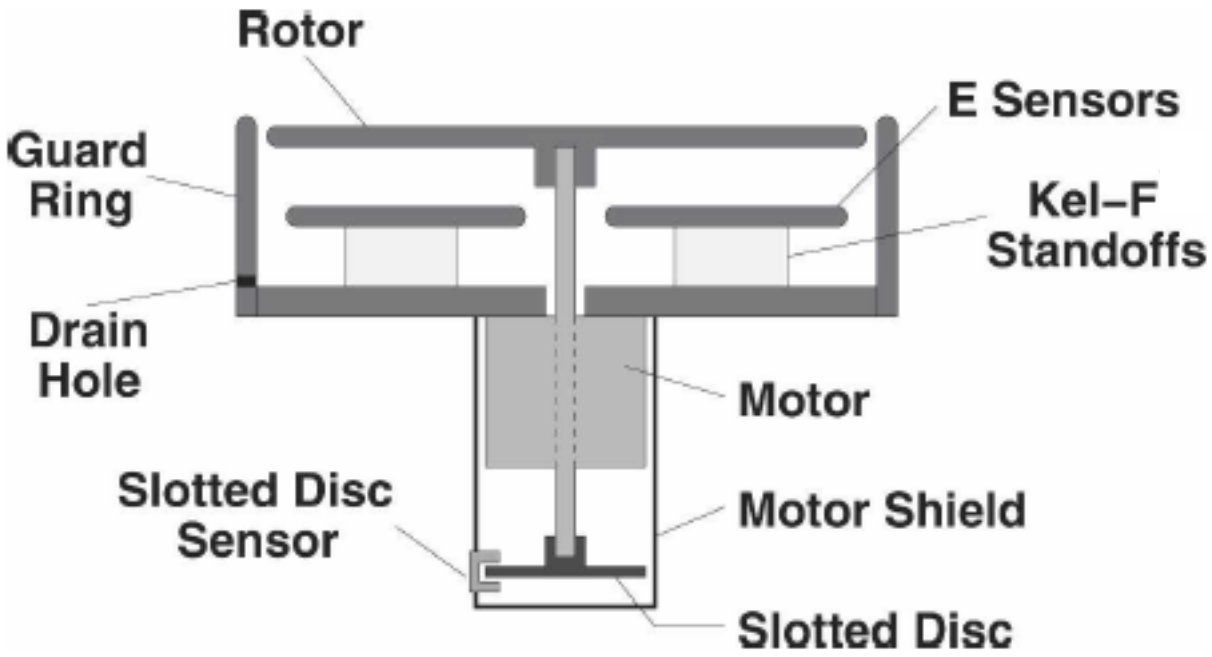
Wikipedia

Carnegie Institution of Washington
Seven cruises (1909-1929)
Destroyed in fuel explosion in Samoa



Peterson et al. (2017)

Electric Field Meter (EFM) Overview



Bateman et al. (2007)

Rotating shield alternately exposes and shields E-field sensors to environmental electric field. This induces charge, which is then converted to a measured voltage.

Voltage related to electric field component normal to sensors.

Resolution ~1 V/m
Dynamic range – up to ~500 kV/m

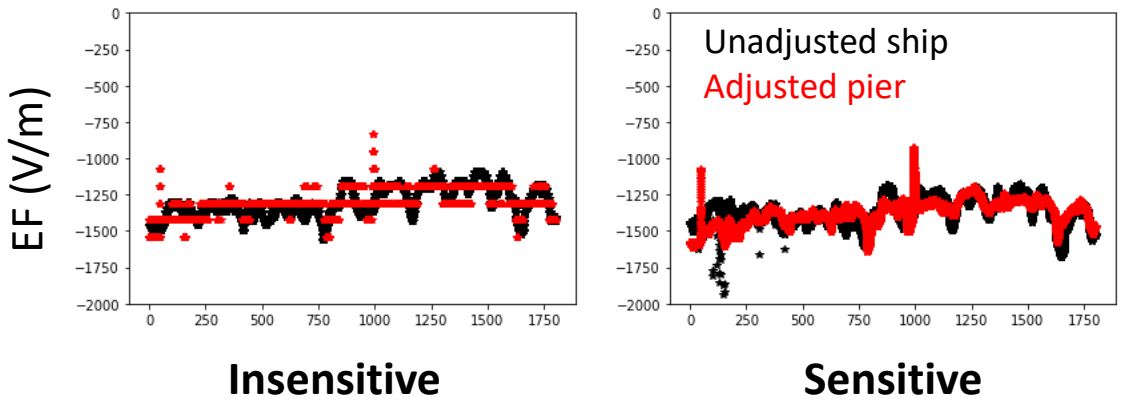
EFM Installation

- EFMs adapted from normal airborne installation
- Passive sensor, sensitive and insensitive channels
- Loaned to CSU from NASA MSFC

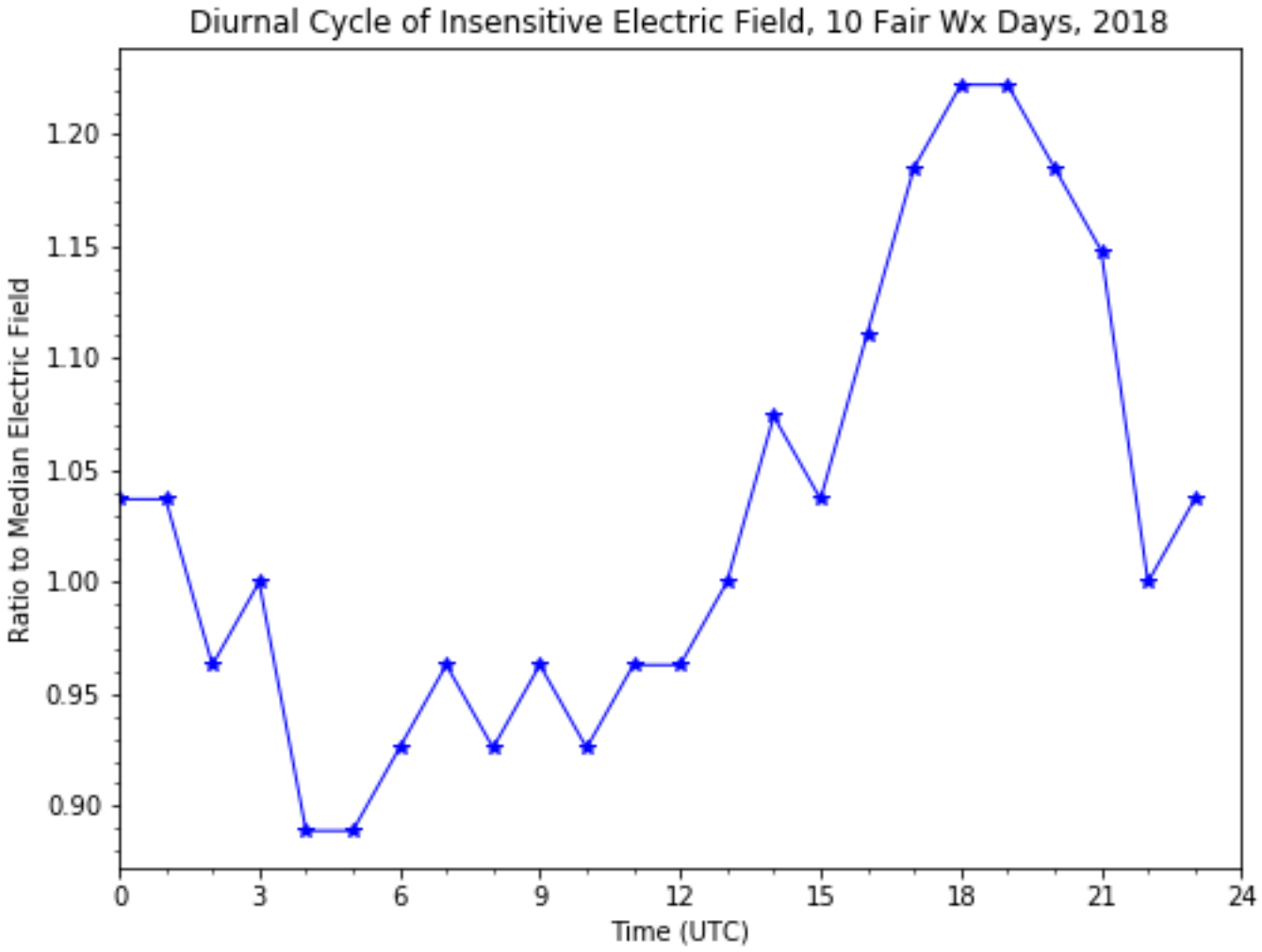
- Installed on forward O2 deck
- Pole mounted, sensor head oriented downward
- Data system strapped to railing inside dry bag
- Sensor head later wrapped in foil-covered plastic bag
- Power supply and network connection hosted in NOAA W-band seatainer
- NASA laptop in computer lab for data monitoring and management

Calibration Analysis

- Ship mounting introduces electric field enhancement factor
- To account for this, concurrent measurements with a second ground-plane sensor are needed
- Ground plane built from foil-covered cardboard
- Three attempts:
  - 8/12 (nearby pier, successful)
  - 9/13 (nearby pier, sensor failure)
  - 10/16 (athletic field, sensor failure)
- Enhancement factor ~4x, further calibration would require modeling pier arrangement

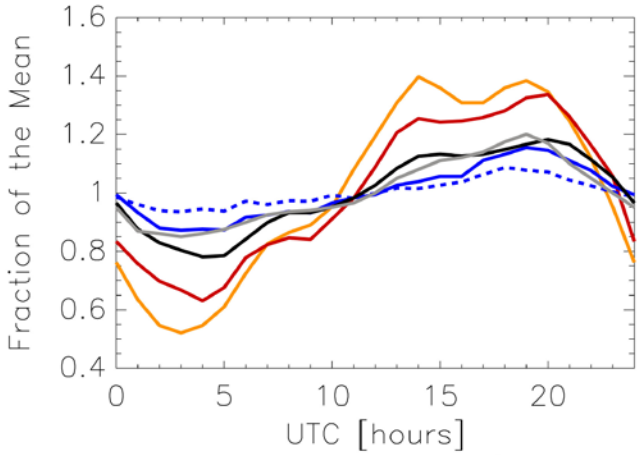


PISTON 2018 Carnegie Curve



10 days in 2018 selected:

- Fair weather
- Good sensor performance
- 8/26, 8/27, 8/30, 9/17, 9/22, 10/5, 10/6, 10/7, 10/8, 10/9



Peterson et al. (2017)

EFM Data Info

- Data submitted to PISTON repository
- 4.0x enhancement factor and periodic calibration pulse removed
- Daily netCDF files, include sensitive and insensitive channels

EFM Data Issues

- EFMs intended for episodic airborne use, and previously untested for long-term “always-on” deployments
- EFMs not designed for harsh marine environment
- Unplanned outages: 9/4-7, 9/18-19, 9/25-30, 10/3-4, 10/10-12, 10/14 (partial outages on bookend days)
- Calibration uncertainty, recommend only use data for relative analyses

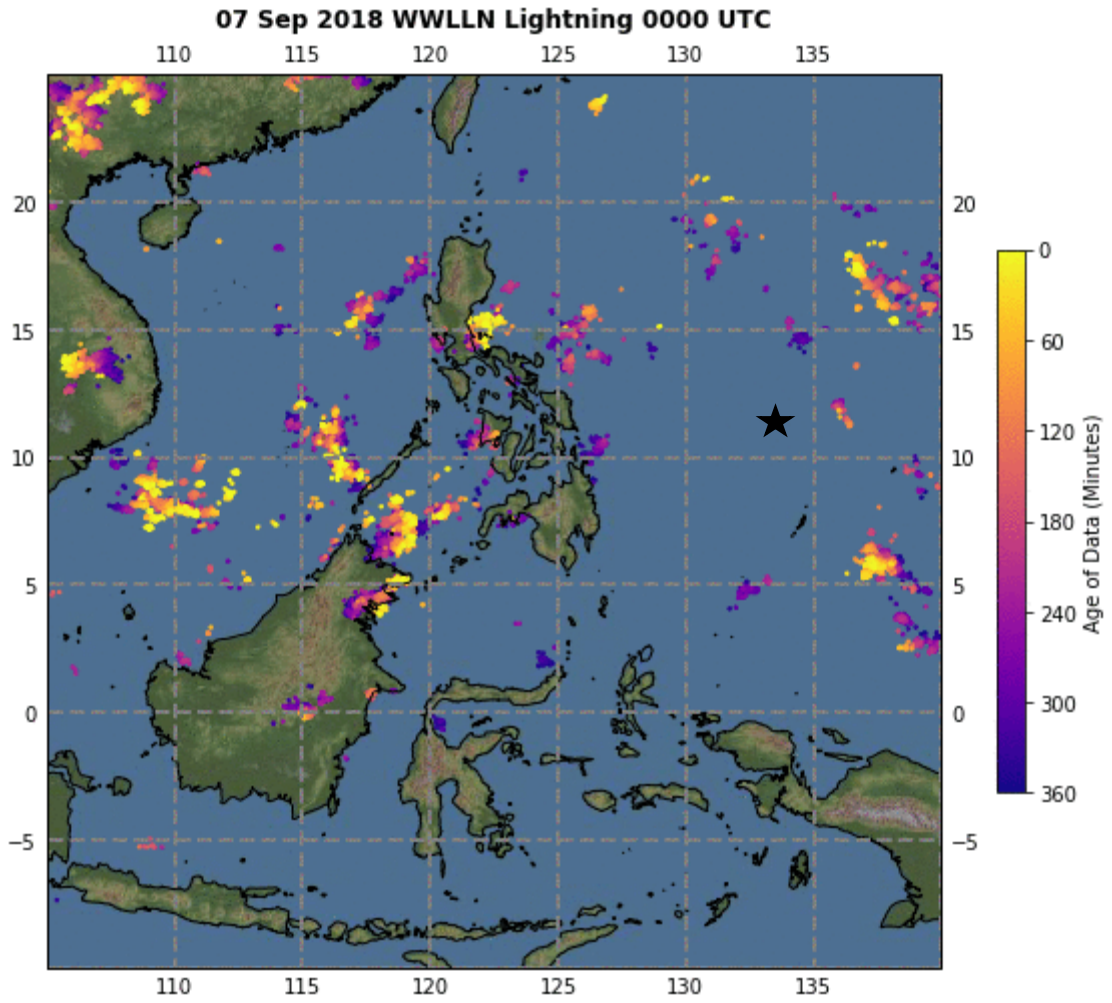
World-Wide Lightning Location Network (WWLLN)

- Global network of VLF sensors
- Primarily sensitive to energetic return strokes
- Good for locating thunderstorms, not good for total lightning monitoring

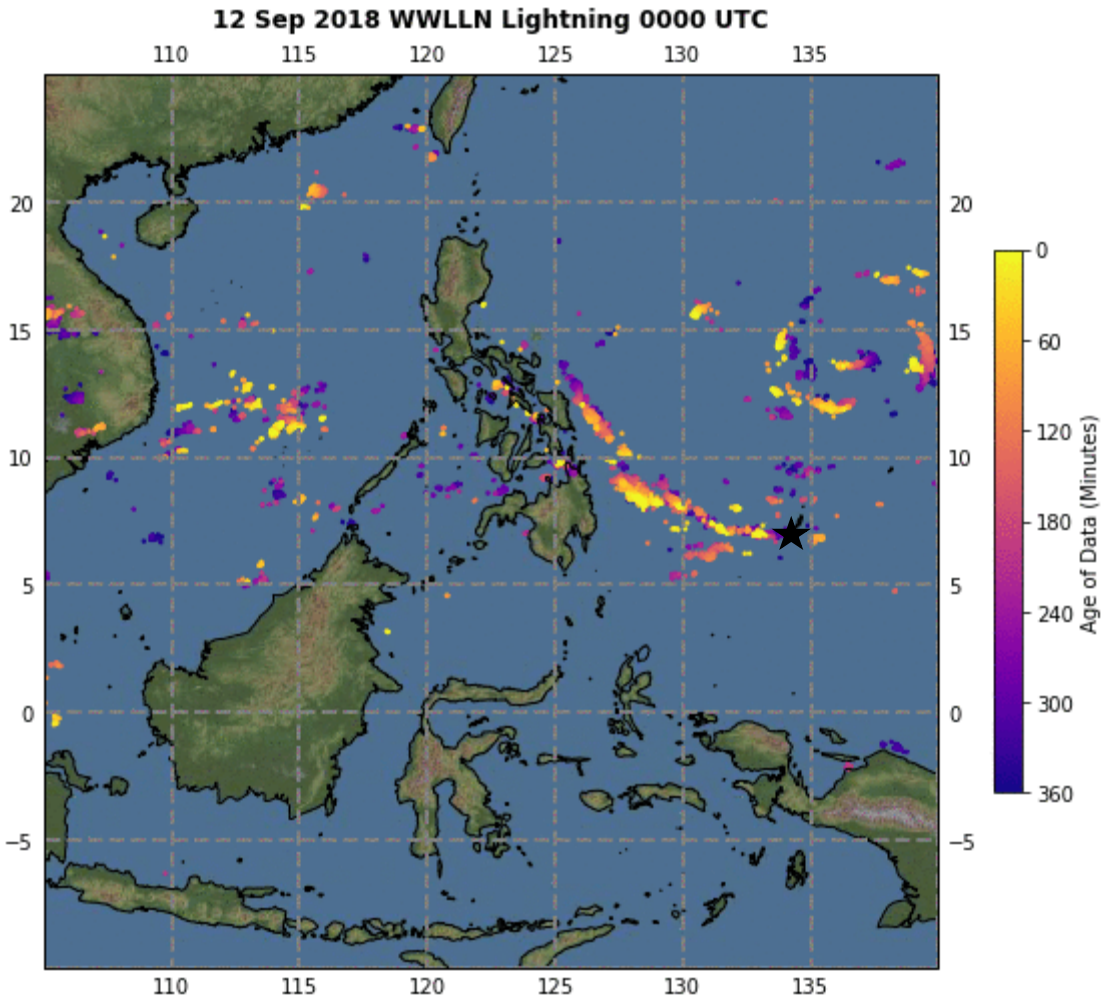
- Data purchased from University of Washington, archived at NASA MSFC
  - Aug-Oct 2018
  - Global

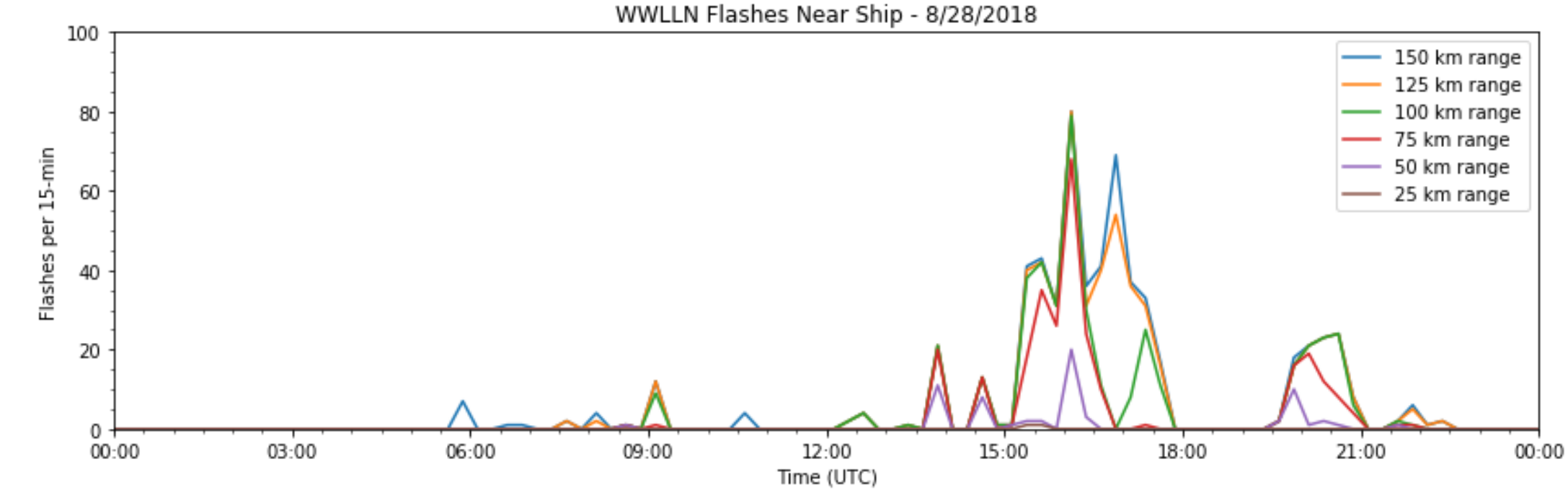
- Similar Aug-Oct 2019 data purchase planned
- 2018 data now available from Timothy Lang (timothy.j.lang@nasa.gov), co-authorship required

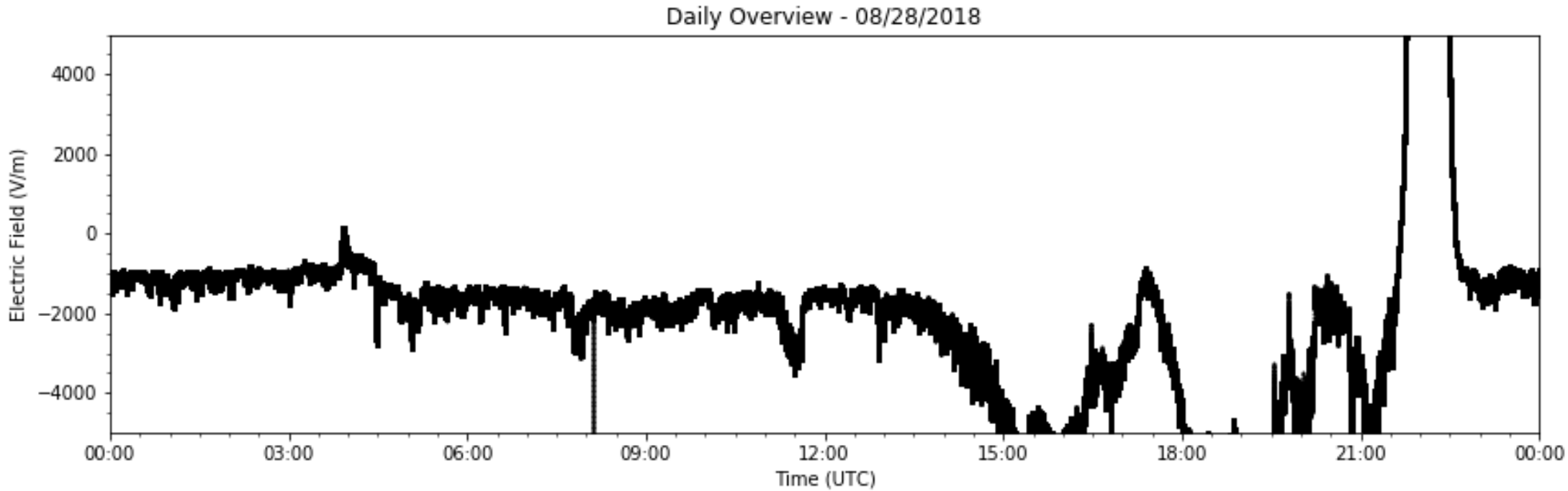
Lightning near ship

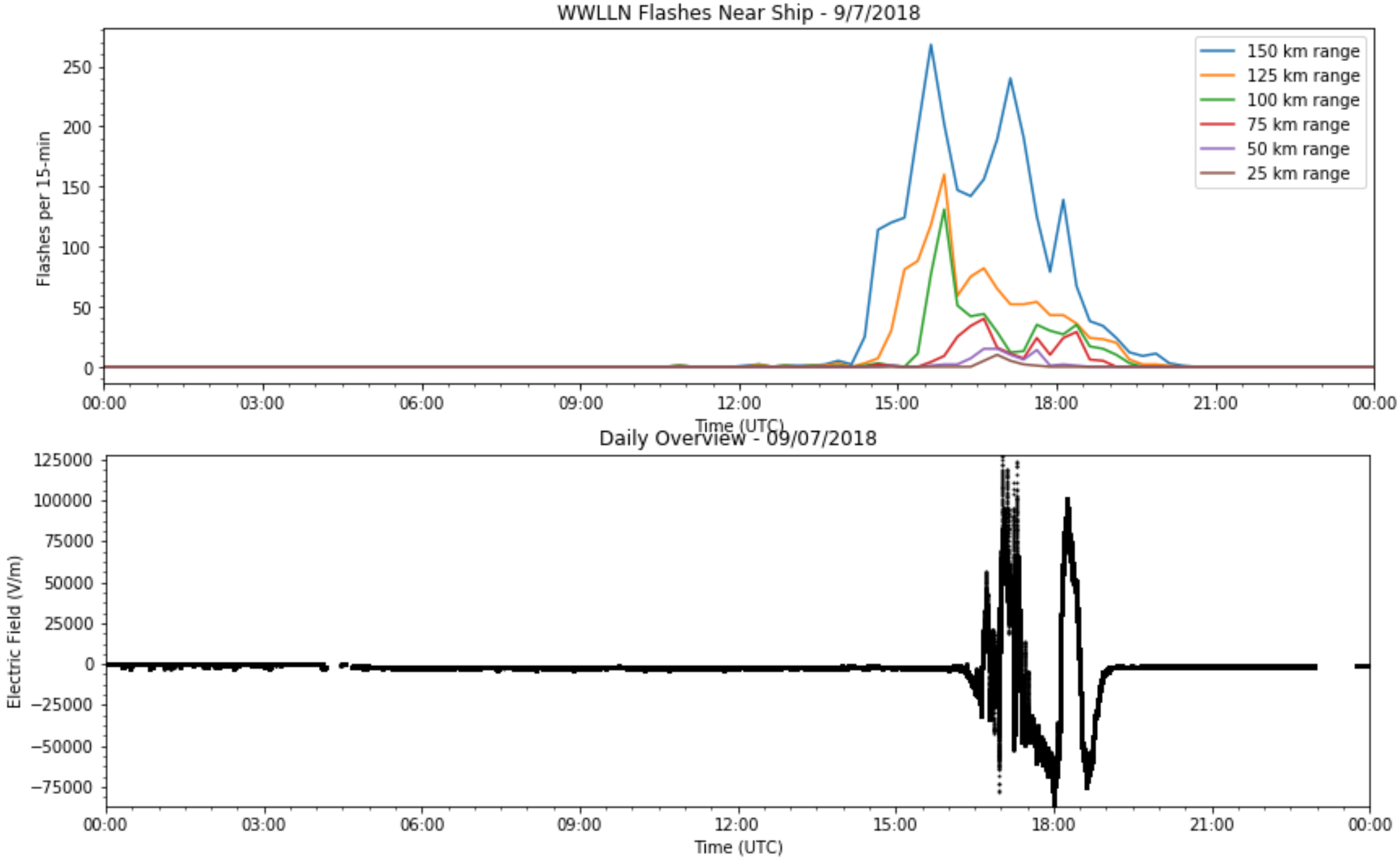


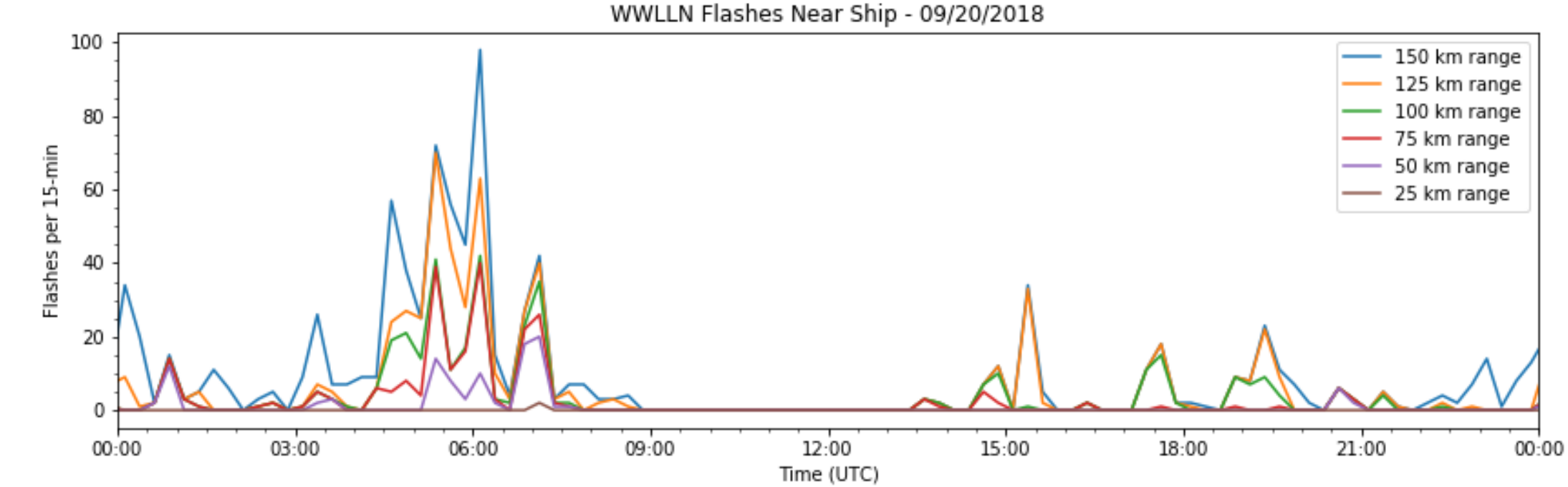
Typhoon Mangkhut

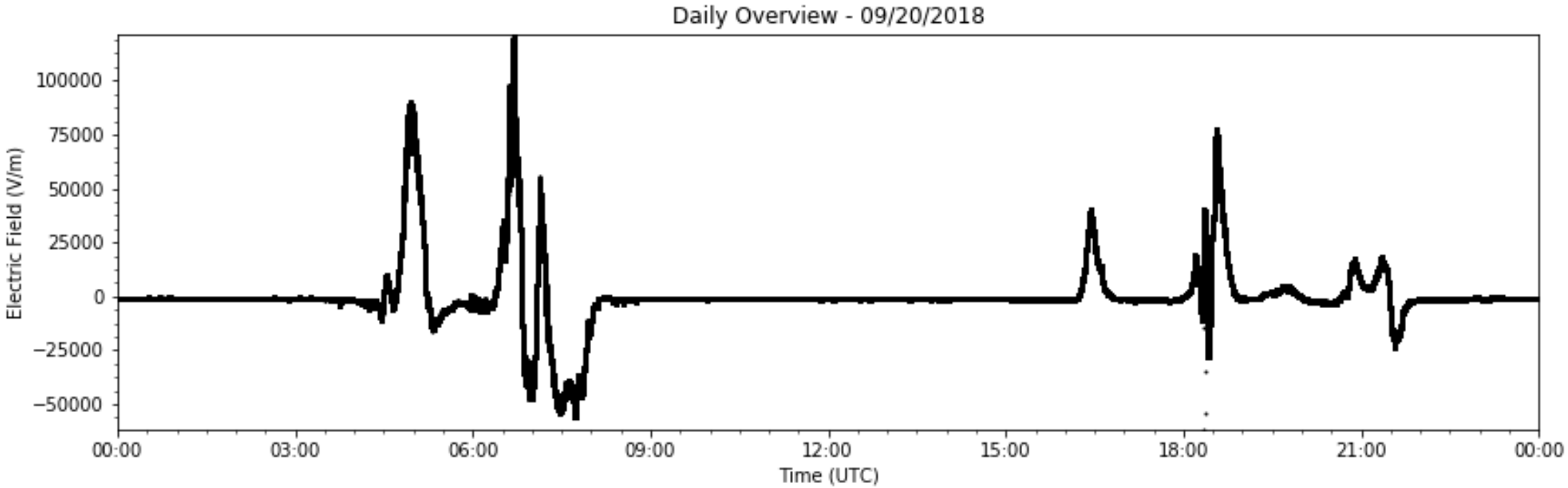


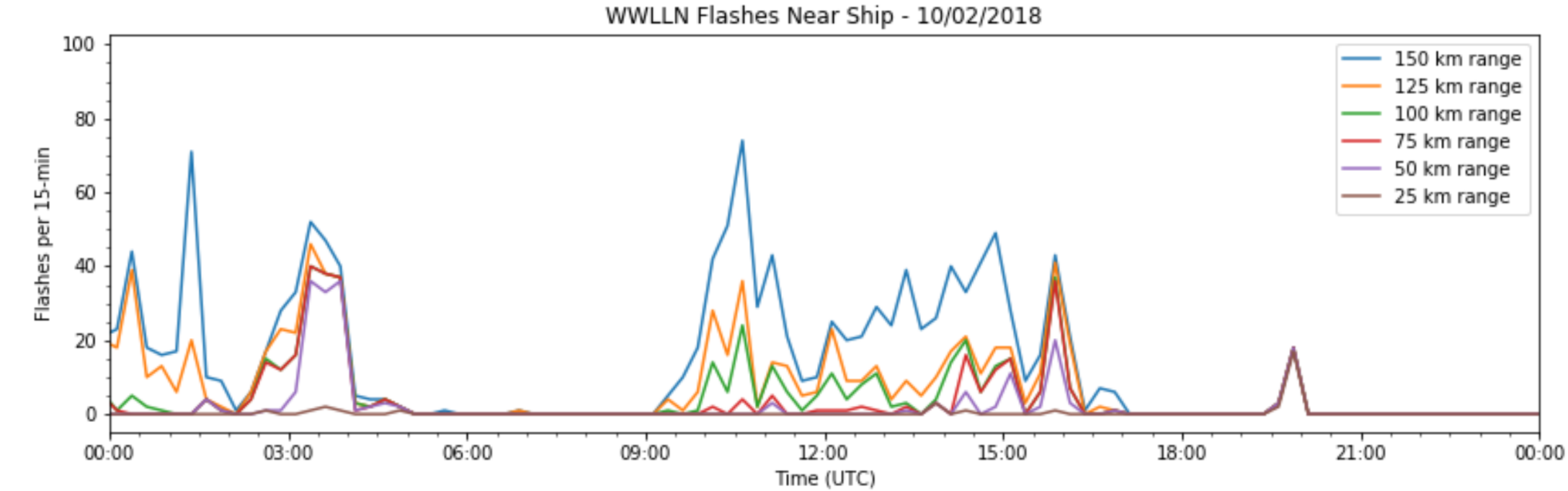

WWLLN Flashes Near Ship - 8/28/2018
Flashes per 15-min
Time (UTC)
150 km range
125 km range
100 km range
75 km range
50 km range
25 km range
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00

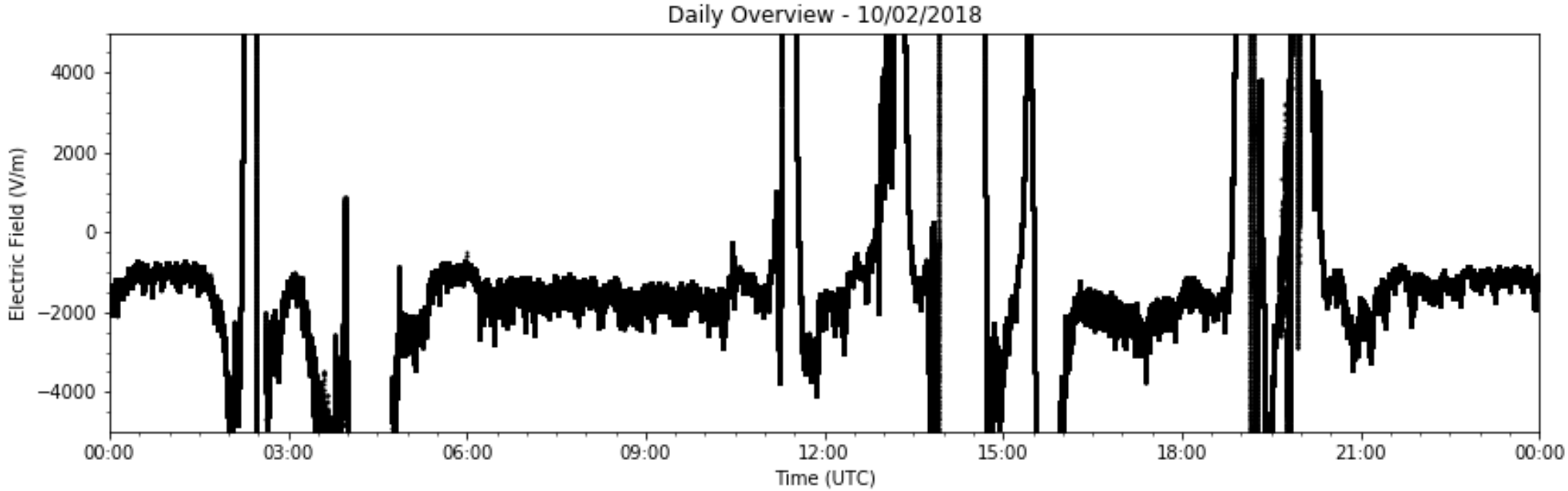

Daily Overview - 08/28/2018
Electric Field (V/m)
Time (UTC)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00


WWLLN Flashes Near Ship - 9/7/2018
Flashes per 15-min
0
50
100
150
200
250
150 km range
125 km range
100 km range
75 km range
50 km range
25 km range
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time (UTC)
Daily Overview - 09/07/2018
Electric Field (V/m)
125000
100000
75000
50000
25000
0
−25000
−50000
−75000
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Time (UTC)


WWLLN Flashes Near Ship - 09/20/2018
Flashes per 15-min
Time (UTC)
150 km range
125 km range
100 km range
75 km range
50 km range
25 km range
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00


Daily Overview - 09/20/2018
Electric Field (V/m)
Time (UTC)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00


WWLLN Flashes Near Ship - 10/02/2018
Flashes per 15-min
Time (UTC)
150 km range
125 km range
100 km range
75 km range
50 km range
25 km range
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00


Daily Overview - 10/02/2018
Electric Field (V/m)
Time (UTC)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00

Lightning and Electric Field Conclusions

- EFM deployed on forward O2 deck during both 2018 cruises
- EFM data submitted to PISTON repository
- Multiple EFM outages, particularly on the second cruise
- Calibration uncertainty, use data for relative analyses

- Carnegie curve observed for group of 10 fair weather days
- Good correspondence between enhanced electric fields and nearby WWLLN-detected lightning
- WWLLN lightning data for 2018 available from Timothy Lang (timothy.j.lang@nasa.gov), co-authorship required.