Lightning Instrument Package (LIP): Performance and Status of Data Processing 2012

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Genesis and Rapid Intensification Processes (GRIP)
Science Team Meeting

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GRIP Lightning Instrument Package (LIP) Support Team Members

Name	Organization	Role
Richard Blakeslee	NASA/MSFC	Principal Investigator
Monte Bateman	USRA	Co-I, LIP Integration Lead, Field and Operations Support
John Hall	UAHuntsville	Software, Networking, and Web Development and Support
Jeff Bailey	UAHuntsville	Conductivity Probe Lead, Field and Operations Support
Chris Schultz	UAHuntsville	Field and Operations Support
Elise Schultz	UAHuntsville	Field and Operations Support
Dennis Buechler	UAHuntsville	Field and Operations Support

GRIP Science Relevance

- Several GRIP science questions will benefit from a detailed knowledge of the electrical conditions of the storms observed.
  - What environmental and inner core factors govern rapid intensification?
  - Do hot towers and convective bursts play a major role or are they merely an indicator of energy conversion processes?
  - What is the predictability of rapid intensification and what observations are most critical to its prediction?
  - What is the role of internal structure changes, including rainbands, eyewall replacement cycles and storm asymmetries on tropical cyclone intensity change?
- Periods of strong convection, indicated by lightning bursts, may be precursors to storm intensity changes … but the lightning bursts themselves are not sufficient to indicate strengthening or weakening in a storm

What LIP Observations Provide

- Provide a detailed close-up view of the electric fields and total lightning (IC and CG) in and around storms investigated by the Global Hawk (*note: network lightning measurements at long range detect primarily Cloud-to-Ground lightning at low, variable DE – hence may miss significant lightning signal*).
- In some cases, the LIP may provide the only lightning and electrical measurements available for a sampled storm.
- LIP measurements will help locate the strong convection within large cloud systems, and as previously noted, monitoring flash rate may provide clues on intensity changes.
- LIP data, with other measurements, will be used to better understand the development, structure and evolution of tropical cloud systems.
- Real-time monitoring of electric fields and lightning supported mission operations and aircraft safety

Global Hawk LIP Observations

Instrumentation

- **Electric Field Mills (*6*)**

Measurements

- **Vector components of electric field (E_x, E_y, E_z)**
- **Aircraft Charge (E_Q)**
- **Lightning statistics (*derive using field changes*)**
- **Storm electric currents**
- **Storm charge structure**

Embedded Linux System (ELS) and Electric Field Mill flown on Global Hawk

Measurement Range / Accuracy

- **Electric Field : few V/m to hundreds's of kV/m 5 - 10%**

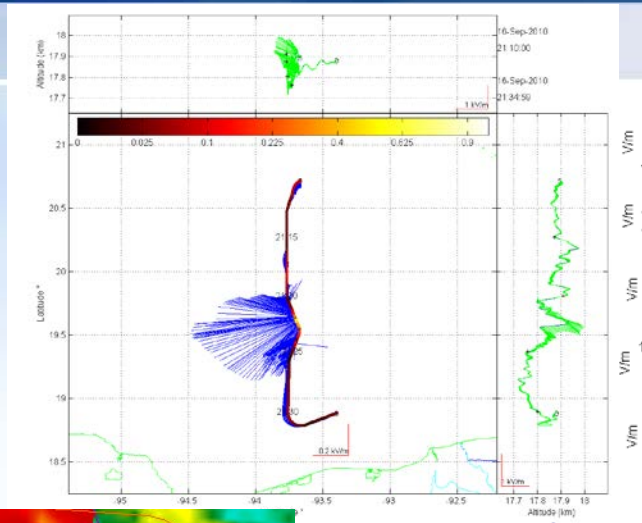
- A LIP has flown in various configurations on several aircraft including ER-2, DC-8, UND Citation, WB-57, Altus UAS, and MU-300.
- Global Hawk offers new long-duration, observational paradigm (hours versus minutes on-station).

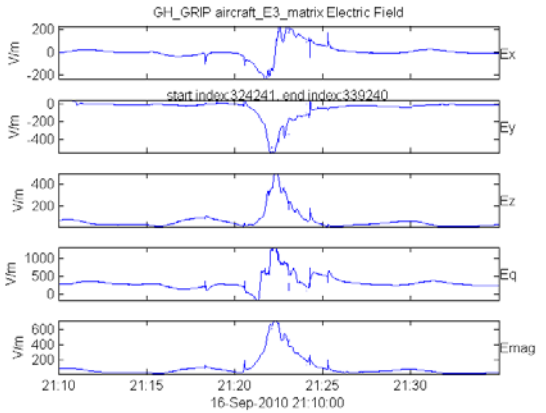
Lightning and Electric Field Data Sets

Aircraft Observations

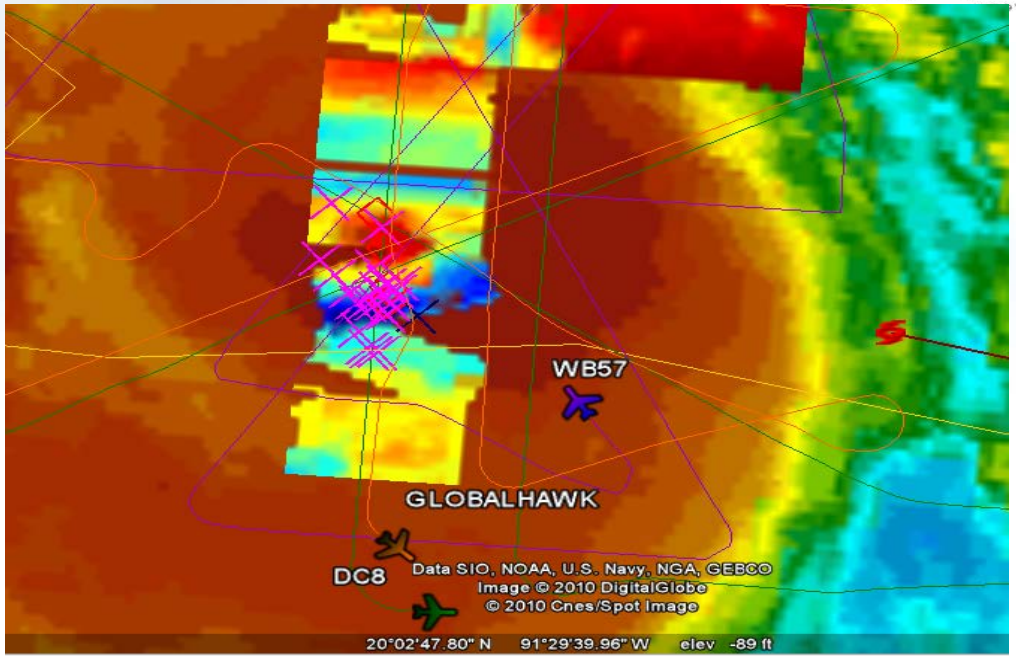
Provide detailed close-up "snapshots" of electric fields and total lightning in and around the storms flown.

- Data will help "calibrate" surface networks





GRIP-LIP output for 16 September 2010 showing the vector electric field and electric field magnitude along the same flight path as the screen capture below/left.



Screen Capture of Real Time Mission Monitor 16 September 2010 showing lightning from long-ranged networks, GOES IR and HAMSR imagery.

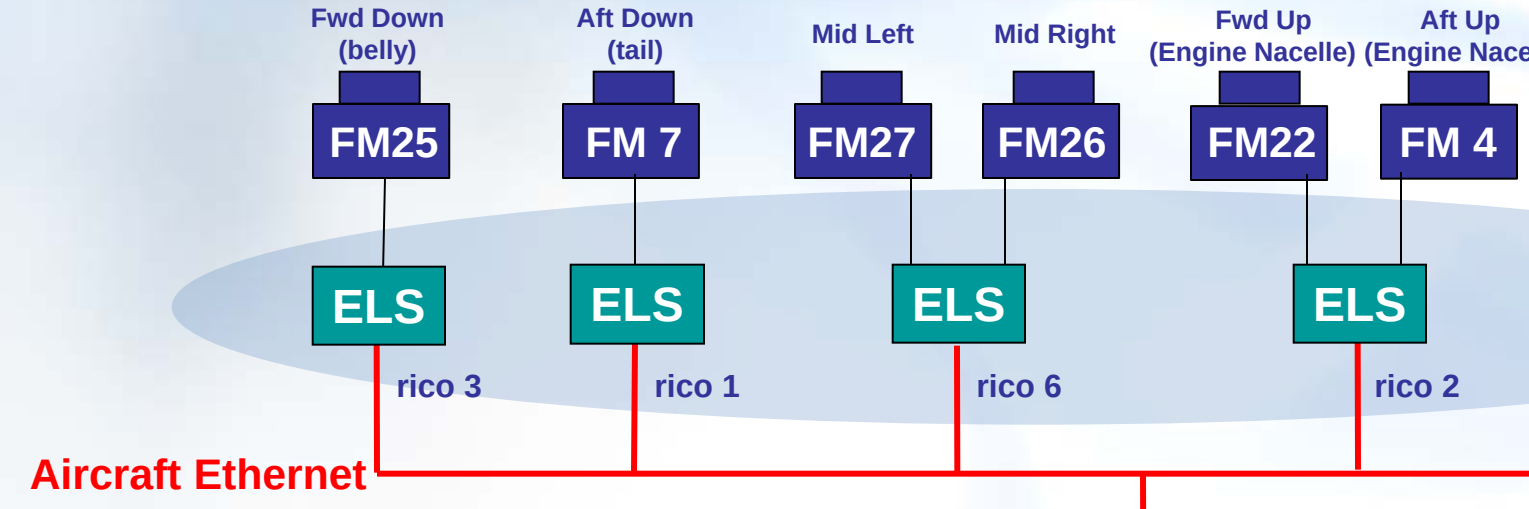
Surface Networks

Offer continuous monitoring of convection with lightning (mostly cloud-to-ground).

- National Lightning Detection Network (NLDN)
- Earth Networks Total Lightning Network (ENTLN)
- Vaisala GLD360 & Long Range
- World Wide Lightning Location Network (WWLLN)

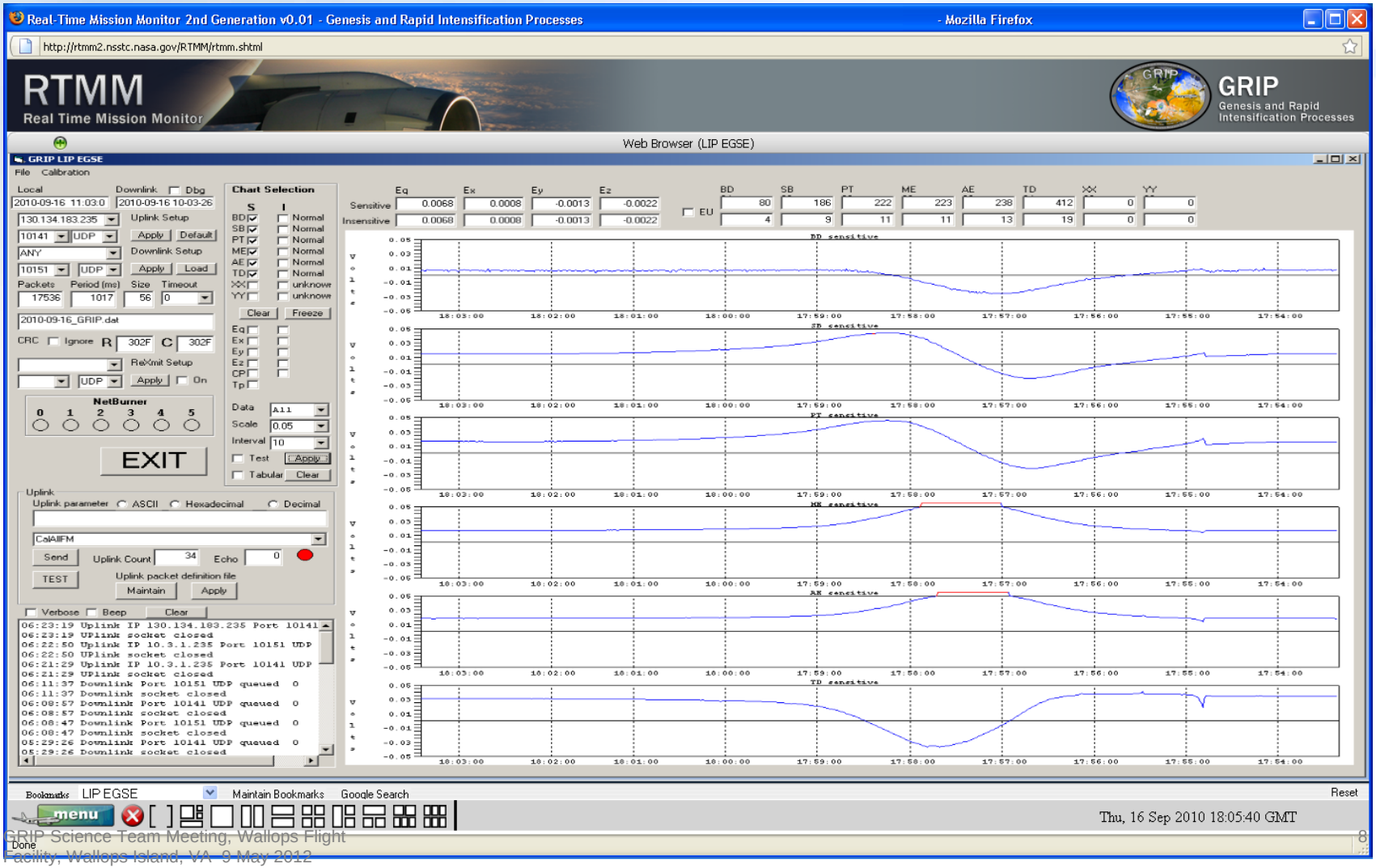
LIP "Sensor Web Enabled" Configuration on Global Hawk

- ELS makes all sensors fully sensor-web enabled.
- All systems are time-synchronized via NTP.
- LIP sensors and support software all flight proven.

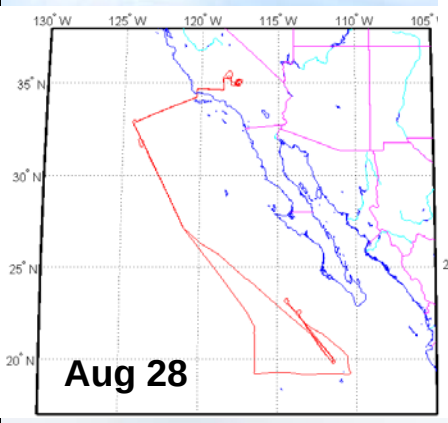


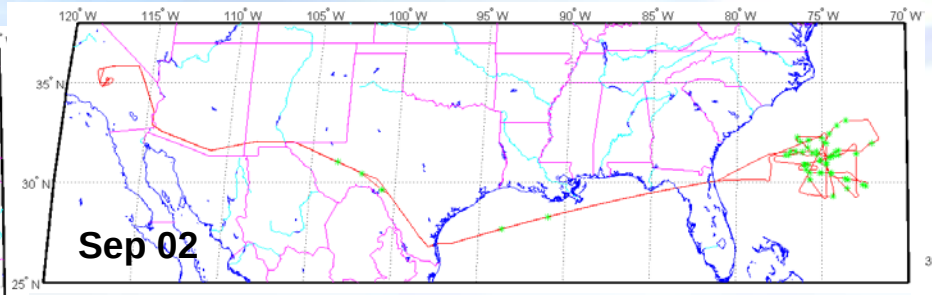
Command/Control of LIP via Sat Com Link

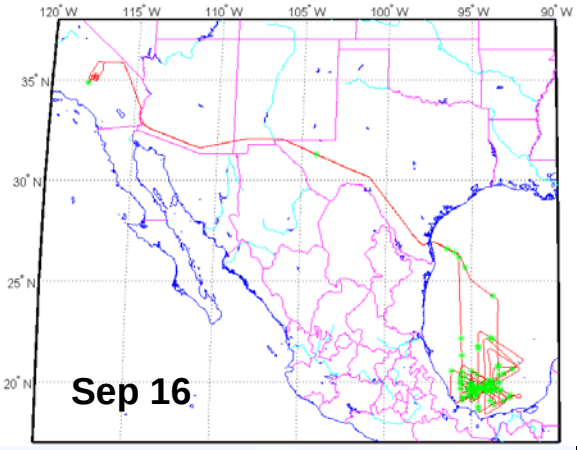
Screen capture of Command/Control Display operated from the Global Hawk Operations Center (GHOC), passed on to RTMM.



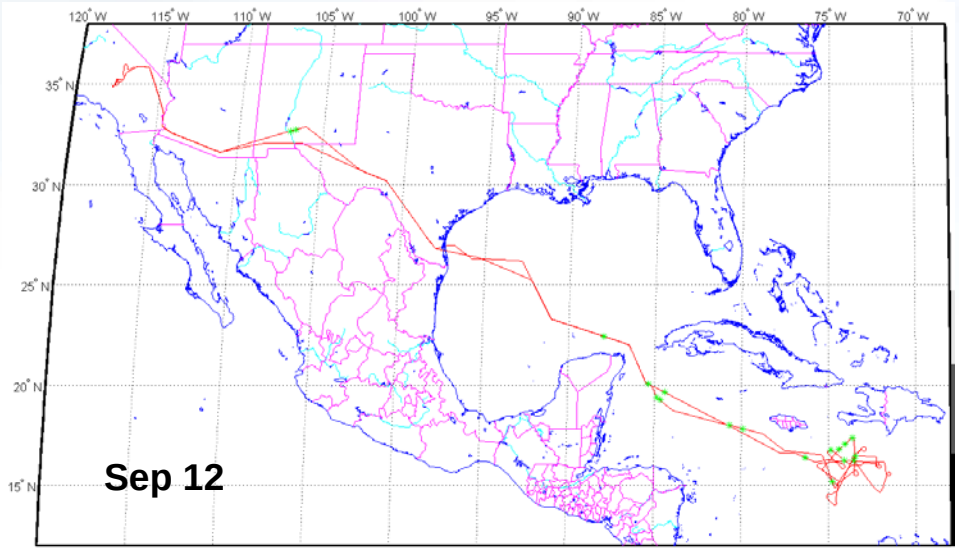
Electrified Storm Overpasses Along Flight Paths

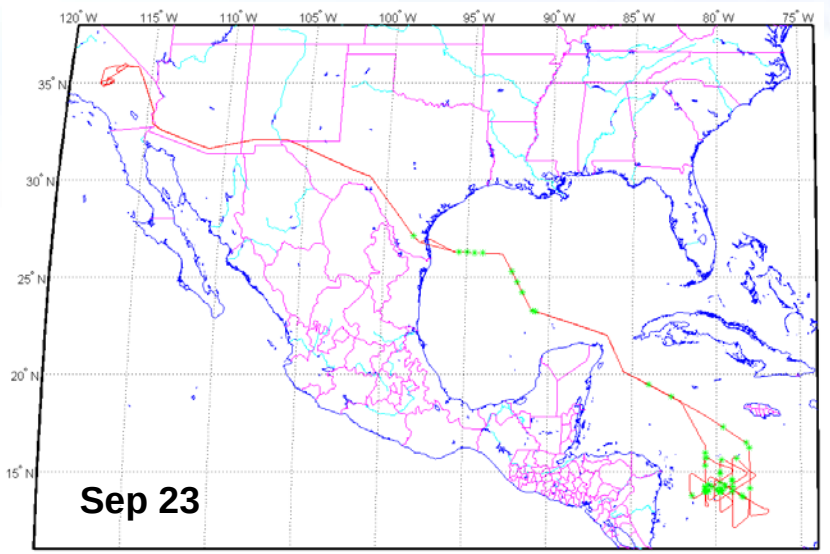






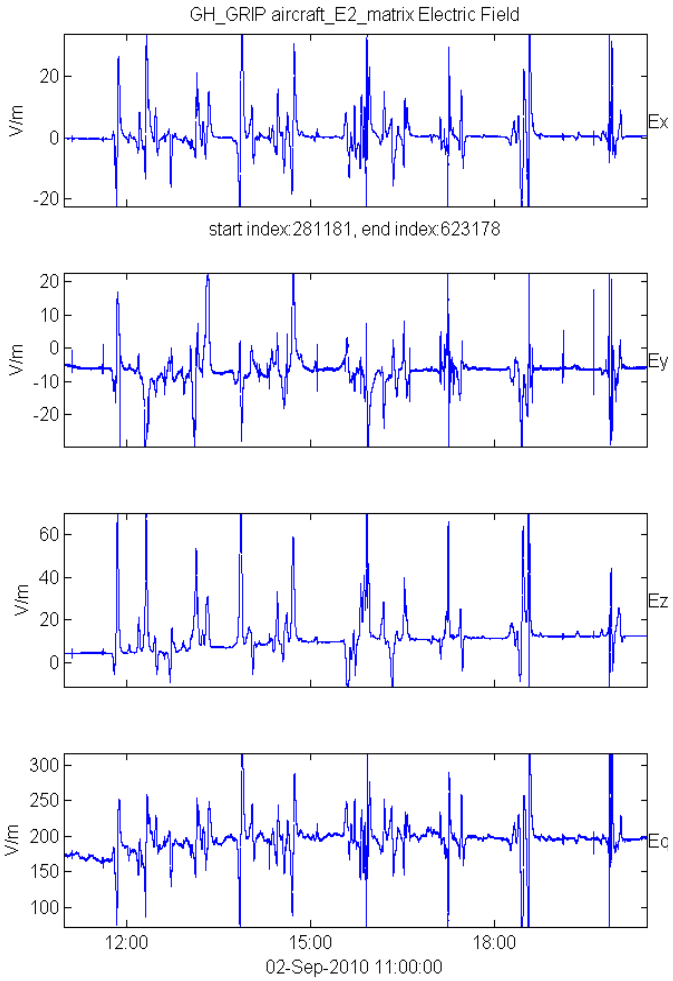
Global Hawk flight tracks. (*) indicate where electrified clouds were overflown.

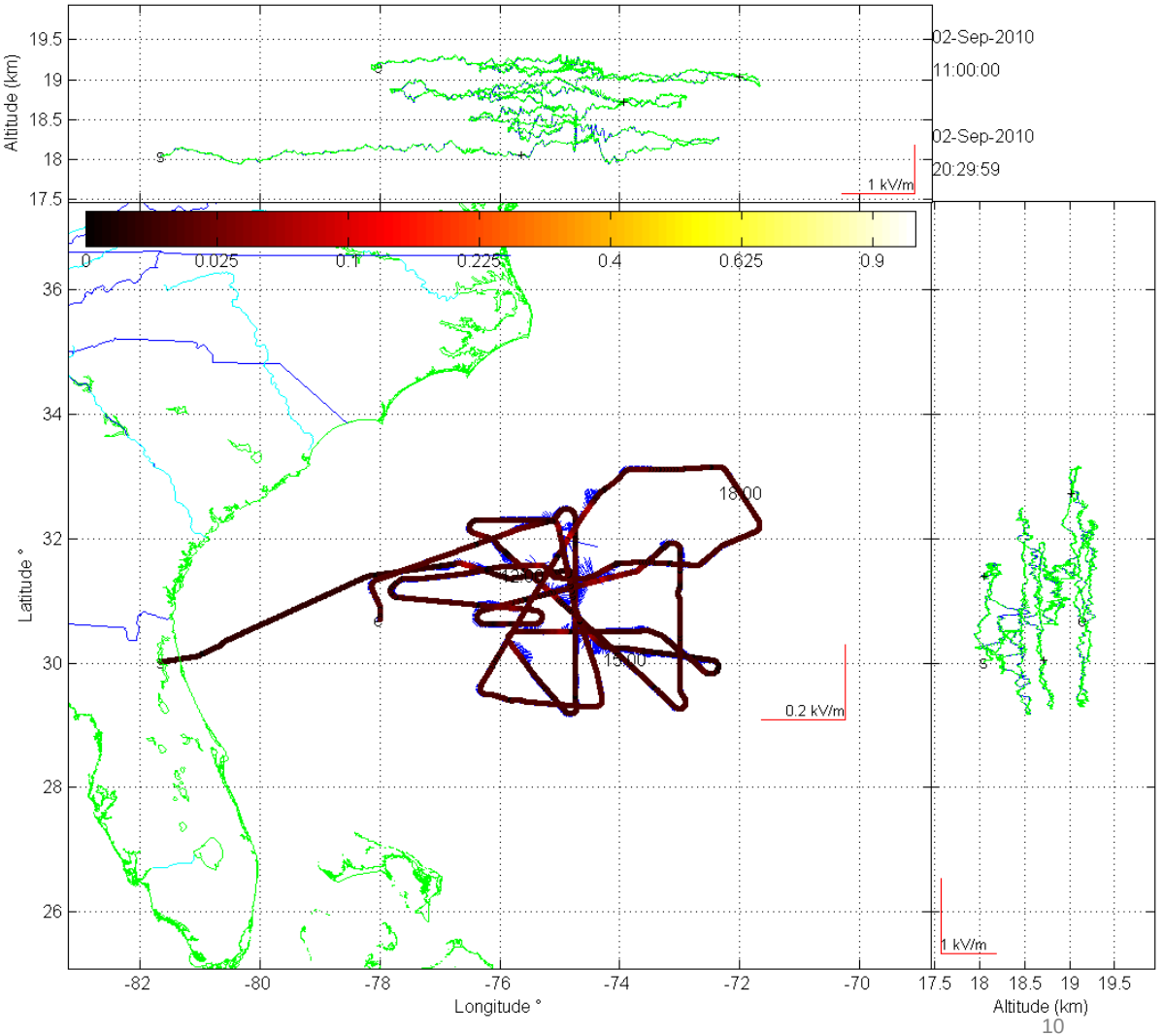




LIP Example of Electric Field Observations

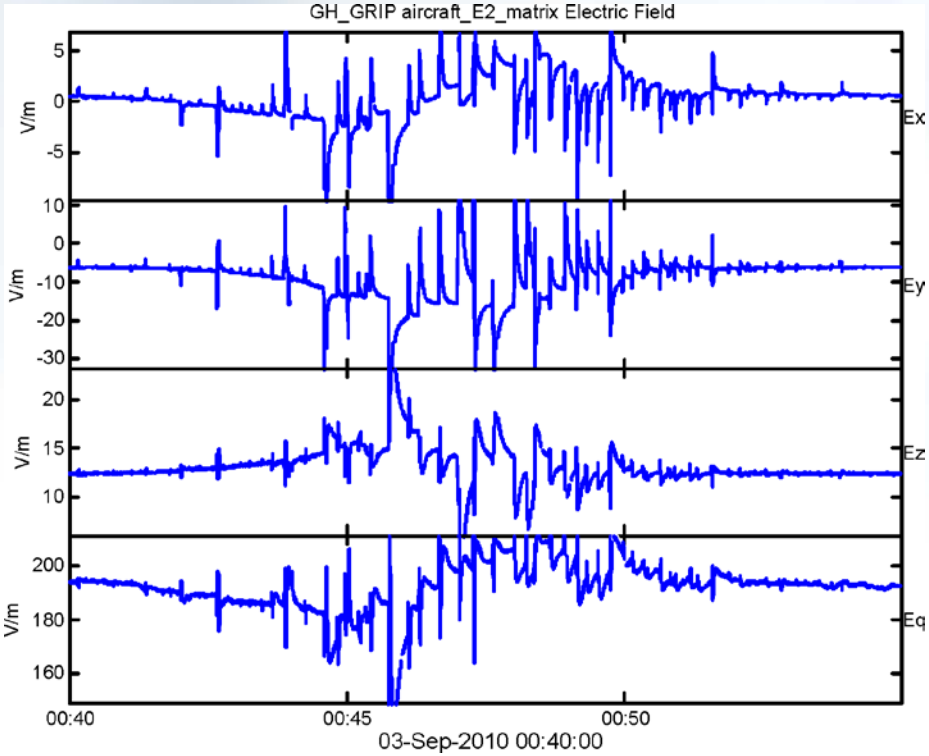
Global Hawk electric field observation of multiple passes of Earl on 2 Sept. 2010 (9.5 hours of DATA)

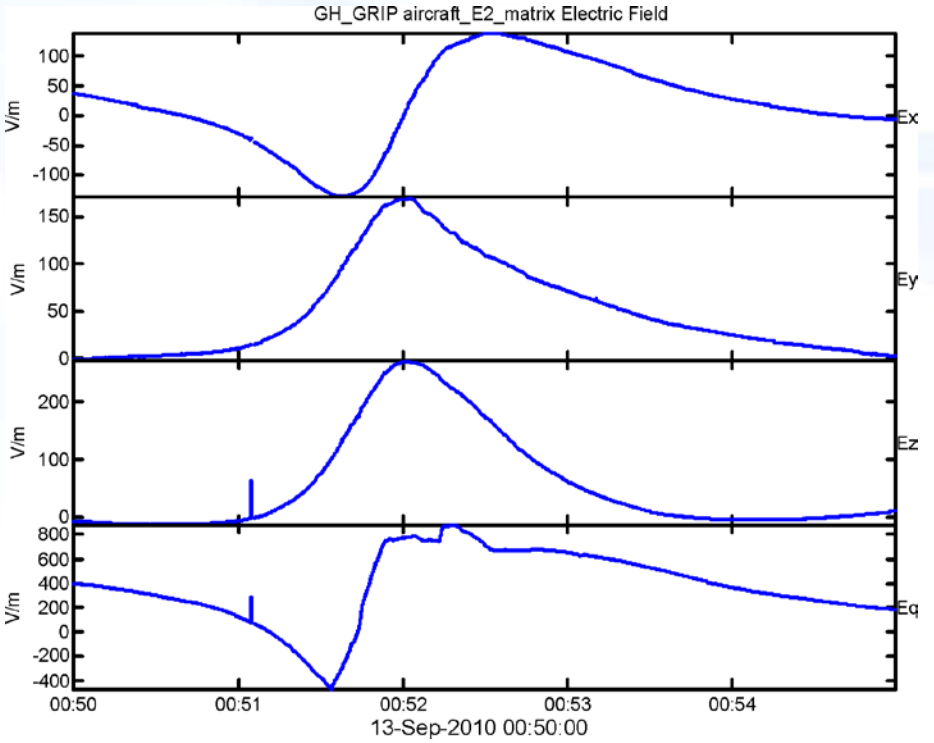




Example of Storm Overpasses With and Without Lightning

Global Hawk LIP electric field observations of a single pass near a storm with lightning (left) and without lightning (*note: the small field values and the E_y component indicate that we passed to the side of these electrified clouds rather that passing directly over the storm core*)





LIP Data Summary

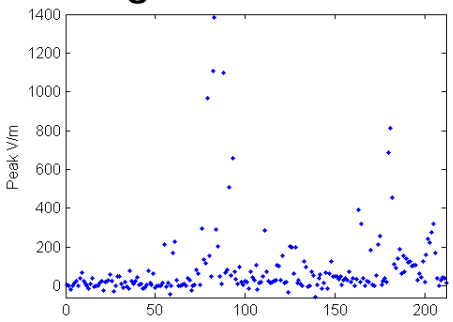
LIP Statistics from Global Hawk overflights

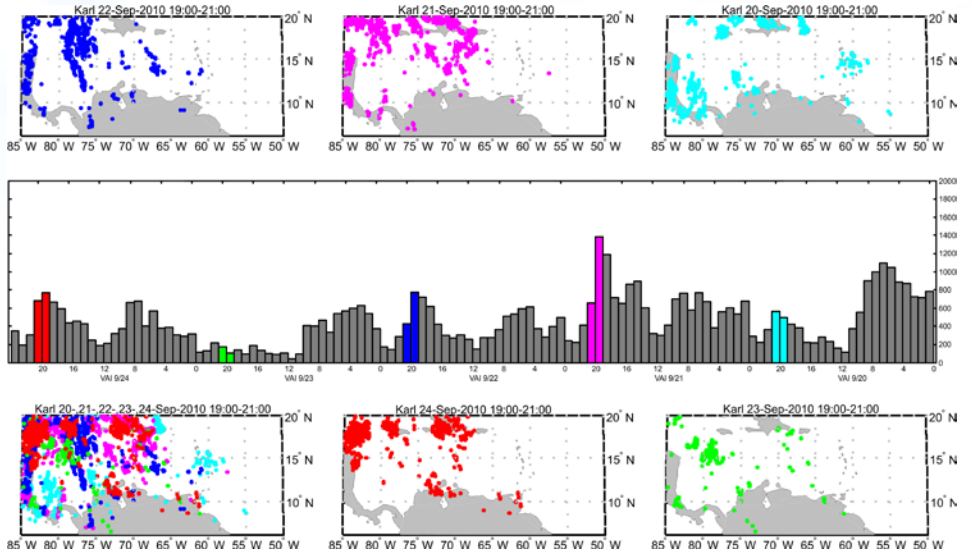
Flight Date	Start Time (UTC)	End Time (UTC)	Total Data Collection Time (Hours)	Total Electrified Overpasses (L/O/T)*	Overpasses With Lightning (% of total)	Total Lightning Flashes	Max Flash Rate	Max Peak E	Min Peak E	Mean Peak |E|
28-Aug-10	28-Aug-10 1223	29-Aug-10 0327	15.2	0/0/0	0	0	0	-	-	-
2-Sep-10	02-Sep-10 0311	03-Sep-10 0402	24.9	3/48/51	8 (16%)	203	6.5 fl/min	78 V/m	-26 V/m	21 V/m
12-Sep-10	12-Sep-10 1109	13-Sep-10 1152	24.7	2/16/18	5 (28%)	56	4.0 fl/min	225 V/m	-44 V/m	45 V/m
16-Sep-10	16-Sep-10 1208	17-Sep-10 1428	26.3	2/89/91	20 (22%)	65	1.3 fl/min	1380 V/m	-55 V/m	121 V/m
23-Sep-10	23-Sep-10 1452	23-Sep-10 1704	26.2	4/49/53	15 (28%)	57	2.0 fl/min	813 V/m	0 V/m	132 V/m
Totals	-	-	117.3	11/202/213	48 (23%)	381	6.5 fl/min	1380 V/m	-55 V/m	93 V/m

*(Land/Ocean/Total)

LIP Status

- LIP performed well during GRIP.
- Calibration of FM on aircraft complete.
  - Despite limitations with maneuvers (altitude, aircraft control), calibration was straight forward due to mill placement and electrically quiet aircraft
- Initial LIP processing (quick look data) complete.
  - Quick look data provided to the GRIP archive
- Detailed electric field analysis is complete.
  - An order of magnitude more data acquired per flight than past missions (i.e., 26 hours versus 2-3 hours).
- Providing data to collaborators.
  - Reinhart/Fuelberg
  - Deierling





Future Work

- Provide the detailed LIP data analysis results to the GRIP archive.
- Continue to collaborate with other GRIP teams engaged in hurricane-lightning studies.
  - Collaborations are underway.
  - Provide electric field and lightning data to other GRIP research groups (and as noted above to the GRIP archive)
- Determine storm current output and other parameters in support of global electric circuit studies.
  - The Global Hawk GRIP flights will increase by more than 20% the existing database of storm current output observations (from 850 to 1063).
  - GRIP LIP parameters (storm polarity/location/lightning) already being used in global electric circuit studies (paper submitted to ICAE conference publication)