

# The Rapid Intensification of Hurricane Earl (2010): Analysis of Intense Convection, Lightning and Warm Core Evolution

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- What is the relationship between deep, sustained inner core convection and subsequent rapid intensification?
- To what extent does lightning activity reflect the intensification process (intensification that is either about to occur, or already underway)?
- How does the warm anomaly change during periods of rapid intensification?

THIS TALK: Lay out detailed “natural history” of Earl’s RI using multiple satellite and aircraft observations, start to identify key relationships among variables

# Key Questions

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- Met RI criteria of 24 mb/24 hr pressure drop, sustained for 36 hours
- Intensification period 00 Z 8/29 to 00 Z 8/31, TS to Cat 3
- RI began w/ sequence of convective bursts (24+ hrs, < -75 °C)
- Periods of significant inner core lightning during early phase of RI
- Central warming/robust eye appeared at end of RI
- DC-8 flew two missions during this critical period

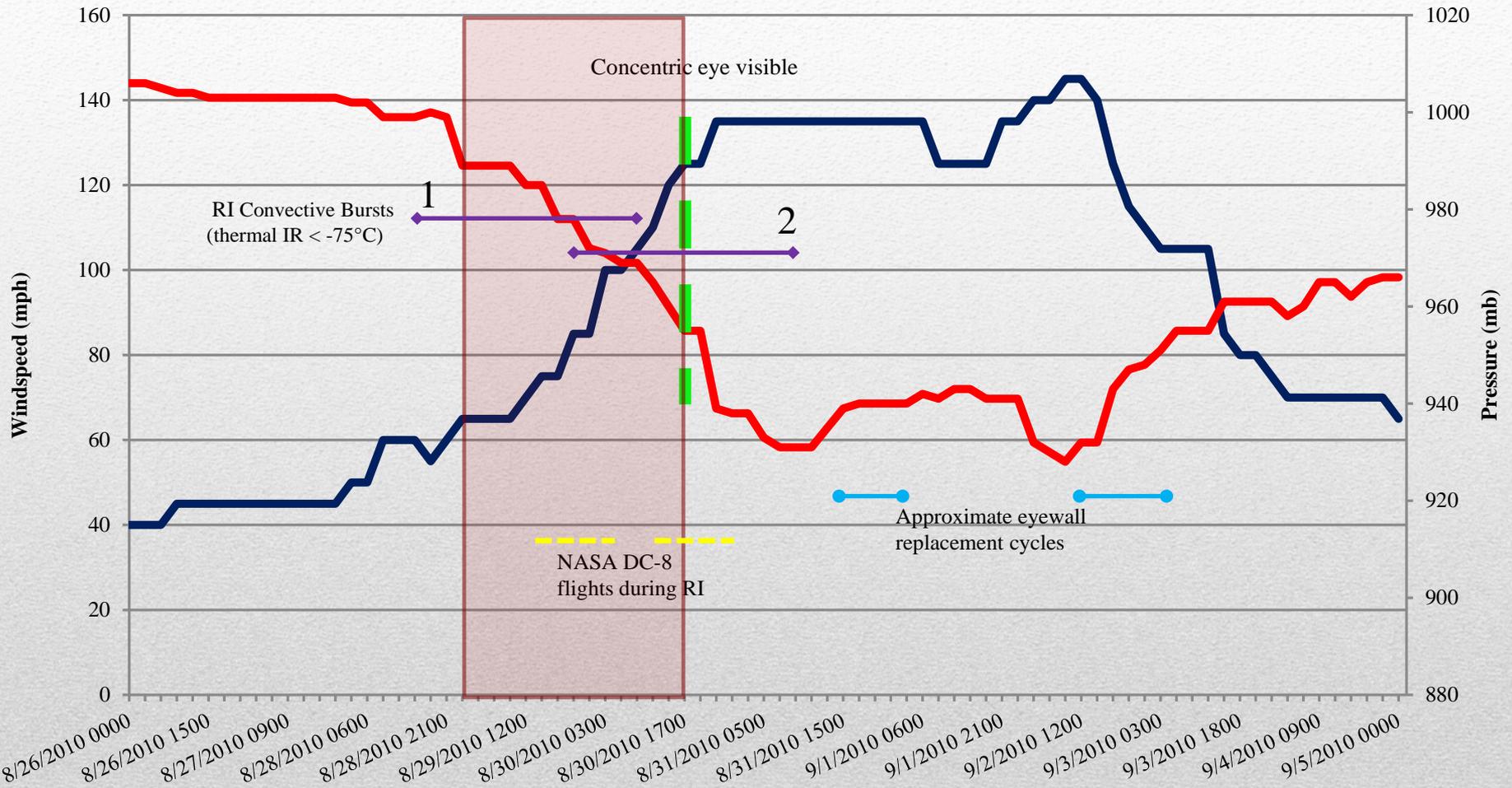
## Summary of Earl's RI

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# Hurricane Earl 2010

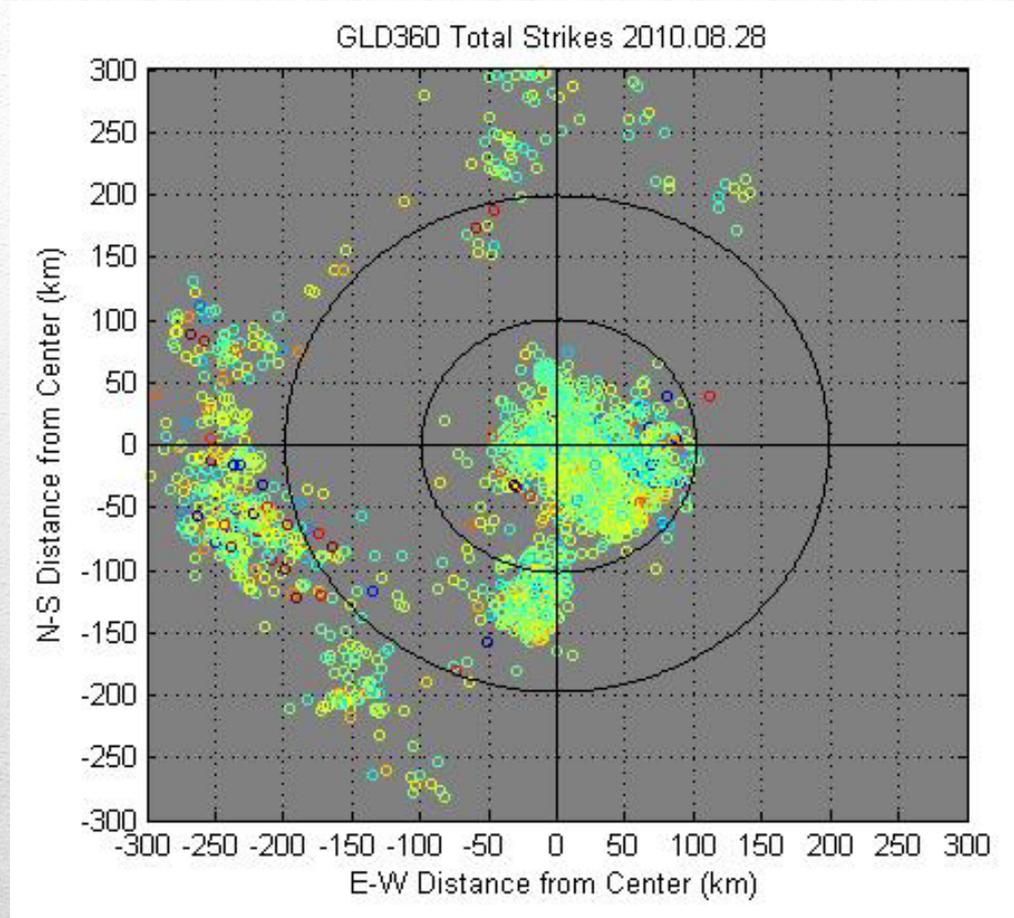
— Windspeed

— Pressure

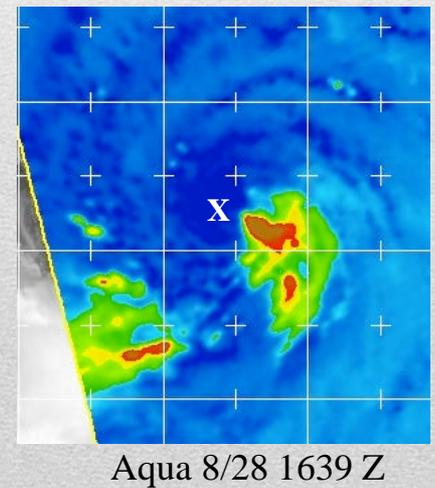
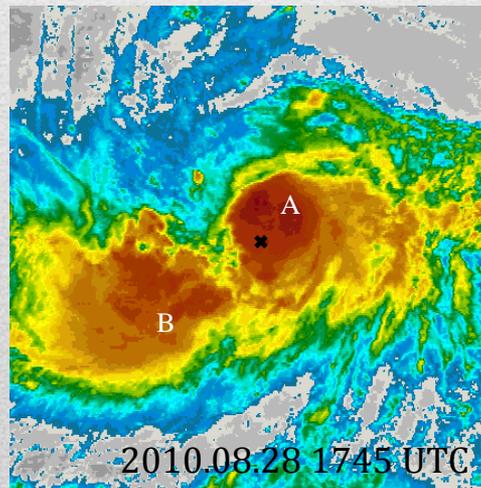
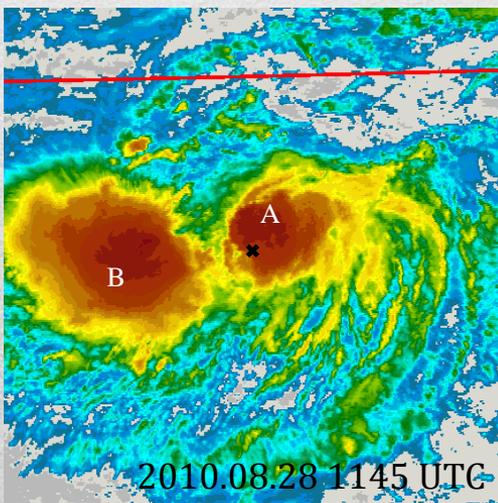
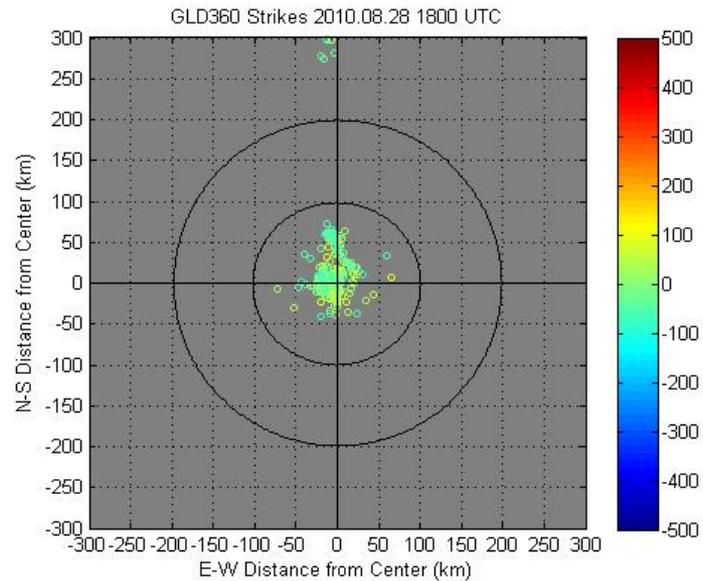
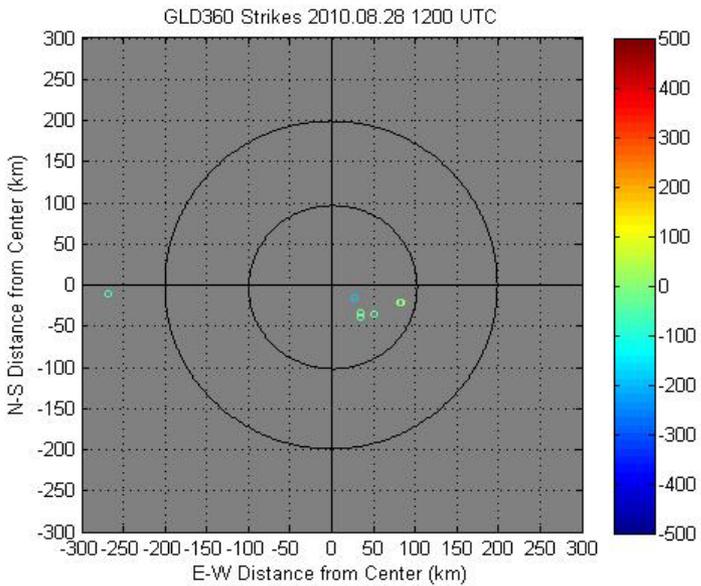


- Global Lightning Detection Network
- Cloud-to-Ground (CG) lightning strokes
- 70% CG Flash Detection Efficiency
- Median location accuracy between 5 and 10 km
- Polarity and peak amplitude for each stroke

-[www.Vaisala.com/products](http://www.Vaisala.com/products)

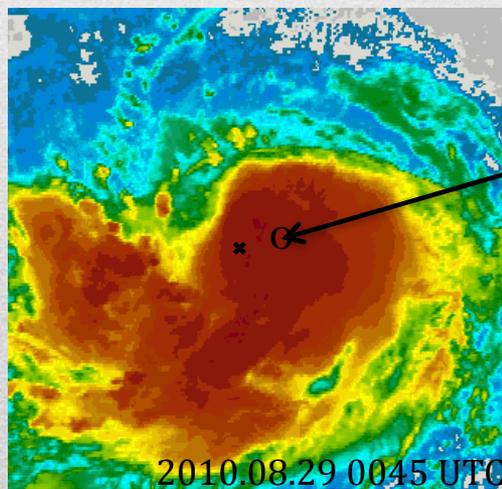
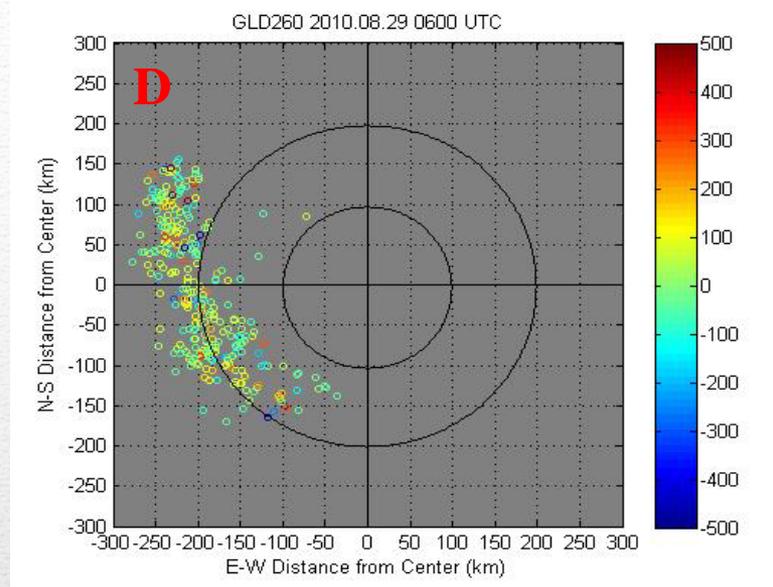
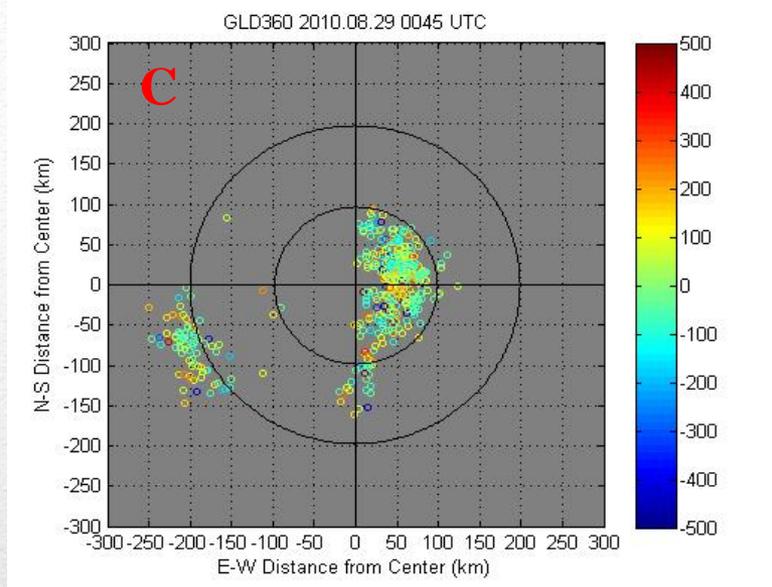


# Vaisala GLD 360

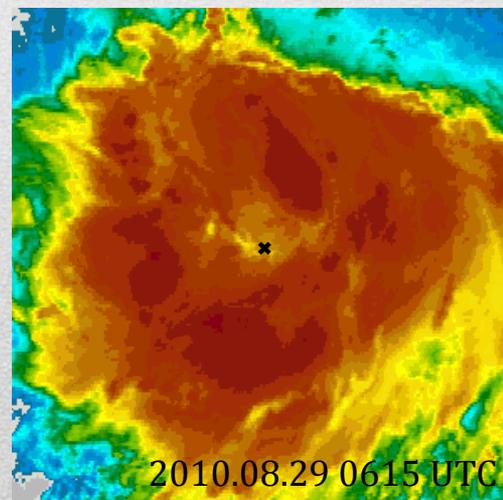


BURST 1: 12 hours before  
RI began

BURST 1: 6 hours before RI  
began

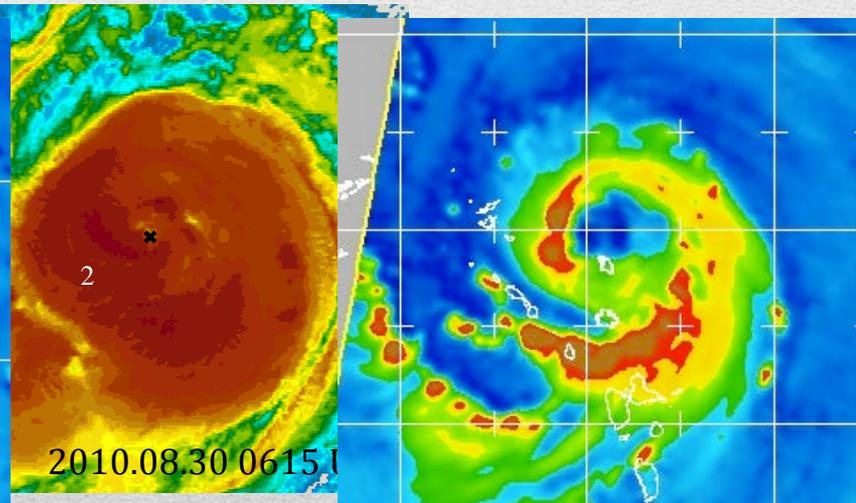
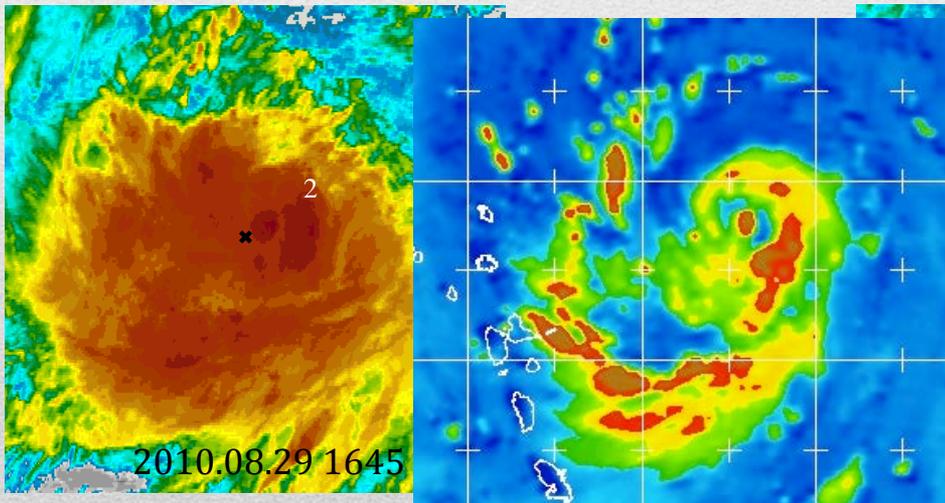
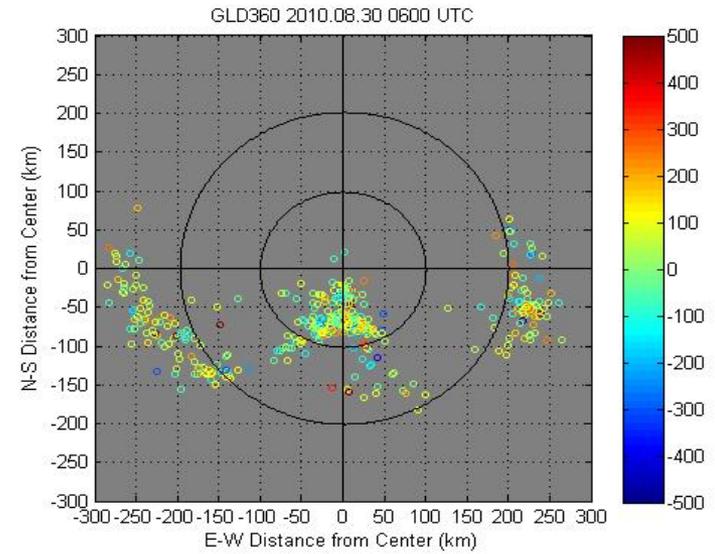
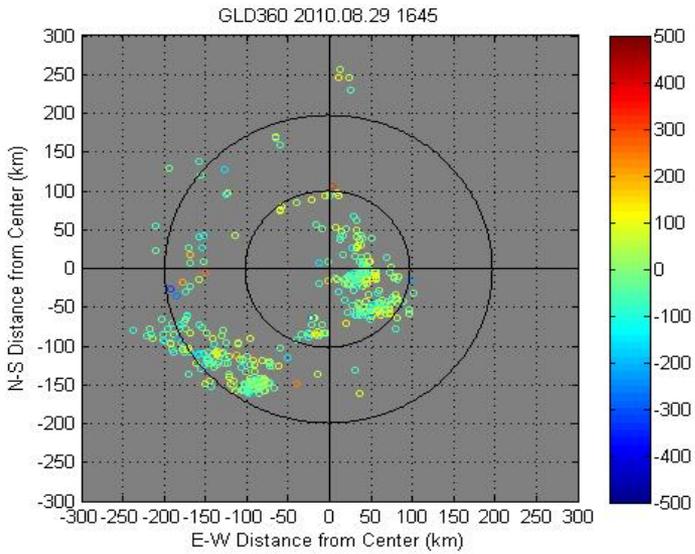


Location of Rob Roger's  
18 km hot tower



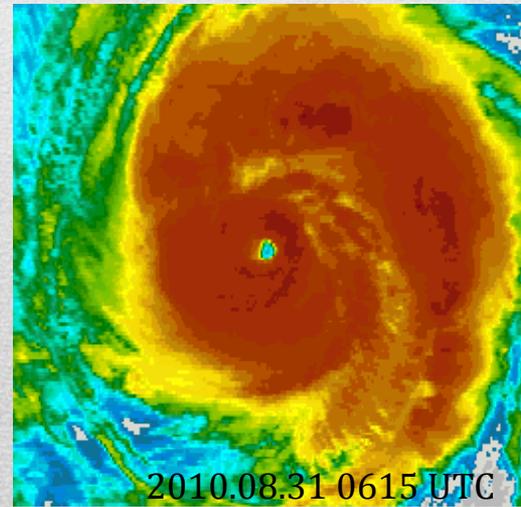
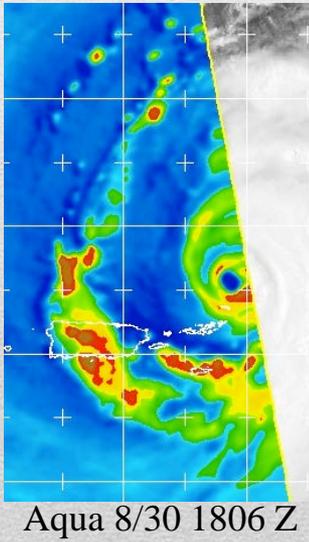
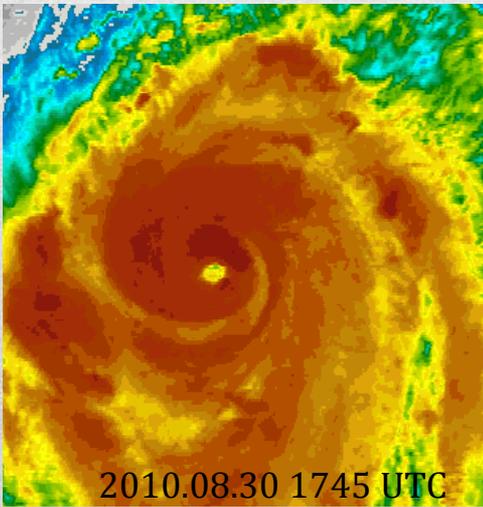
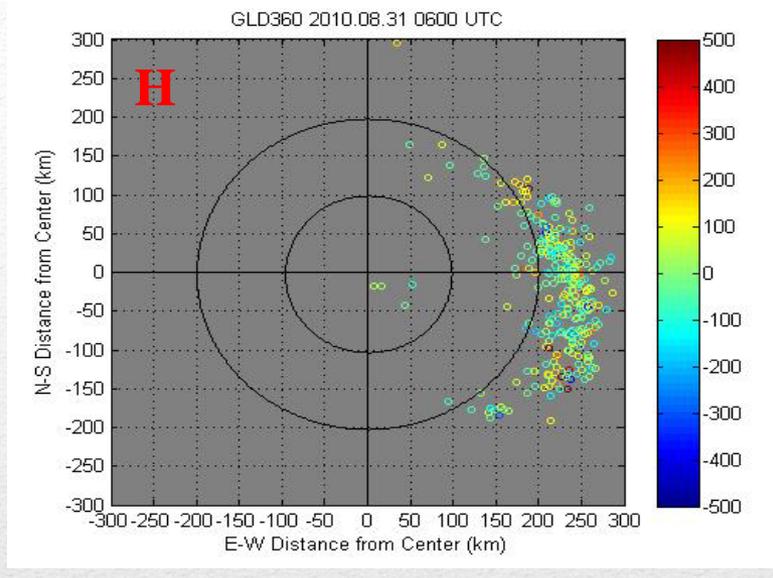
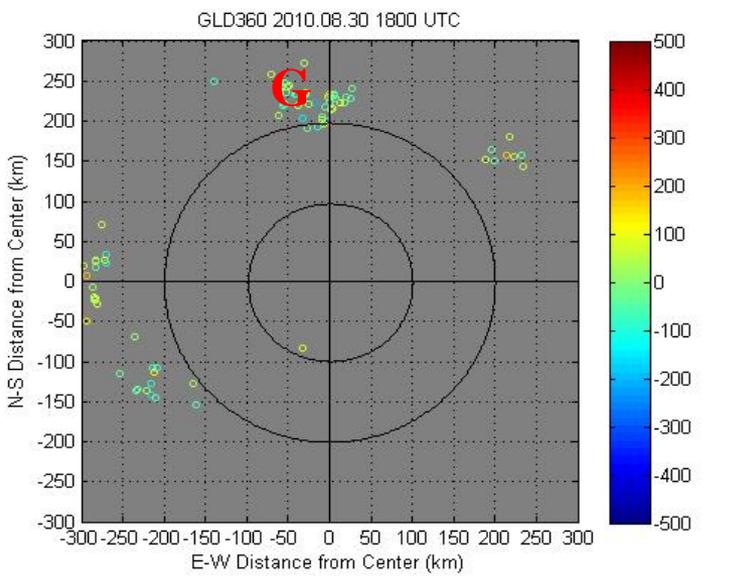
BURST 1: Onset of RI

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BURST 2: Onset of RI  
Partial Eyewall

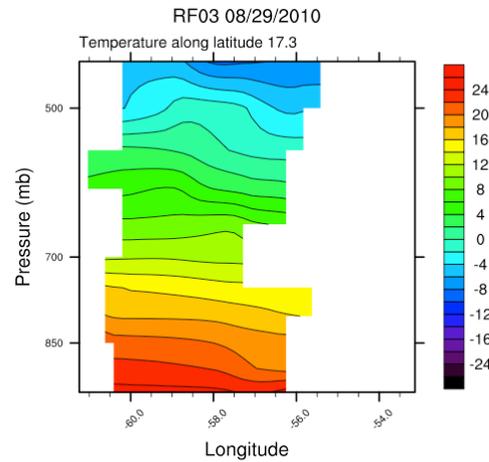
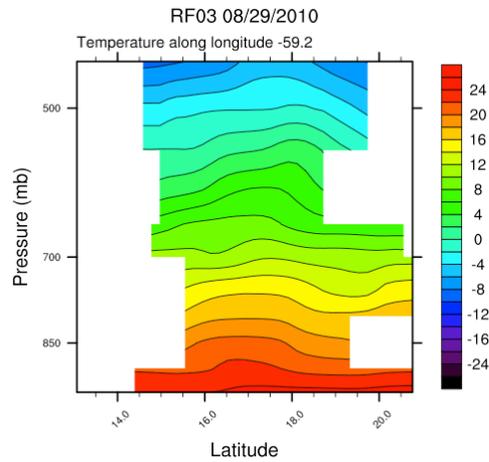
BURST 2: Onset of RI  
Complete Eyewall



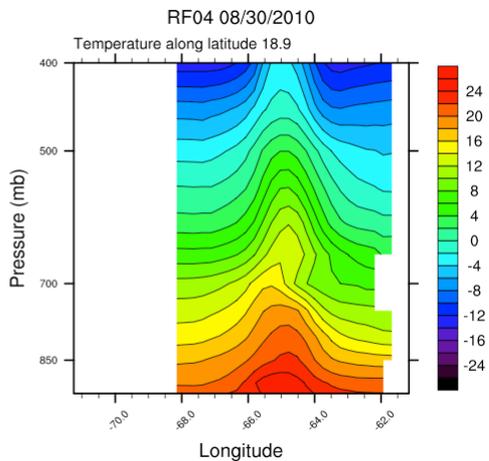
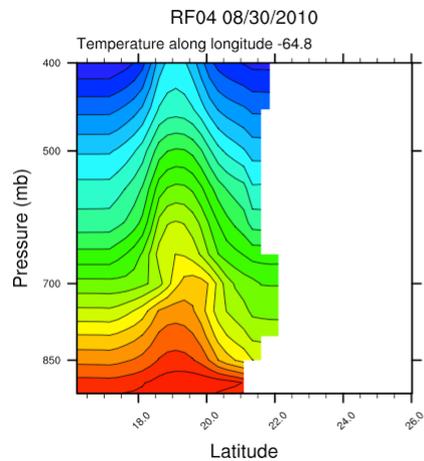
Closed Eyewall  
Central Warming

Eye Formation





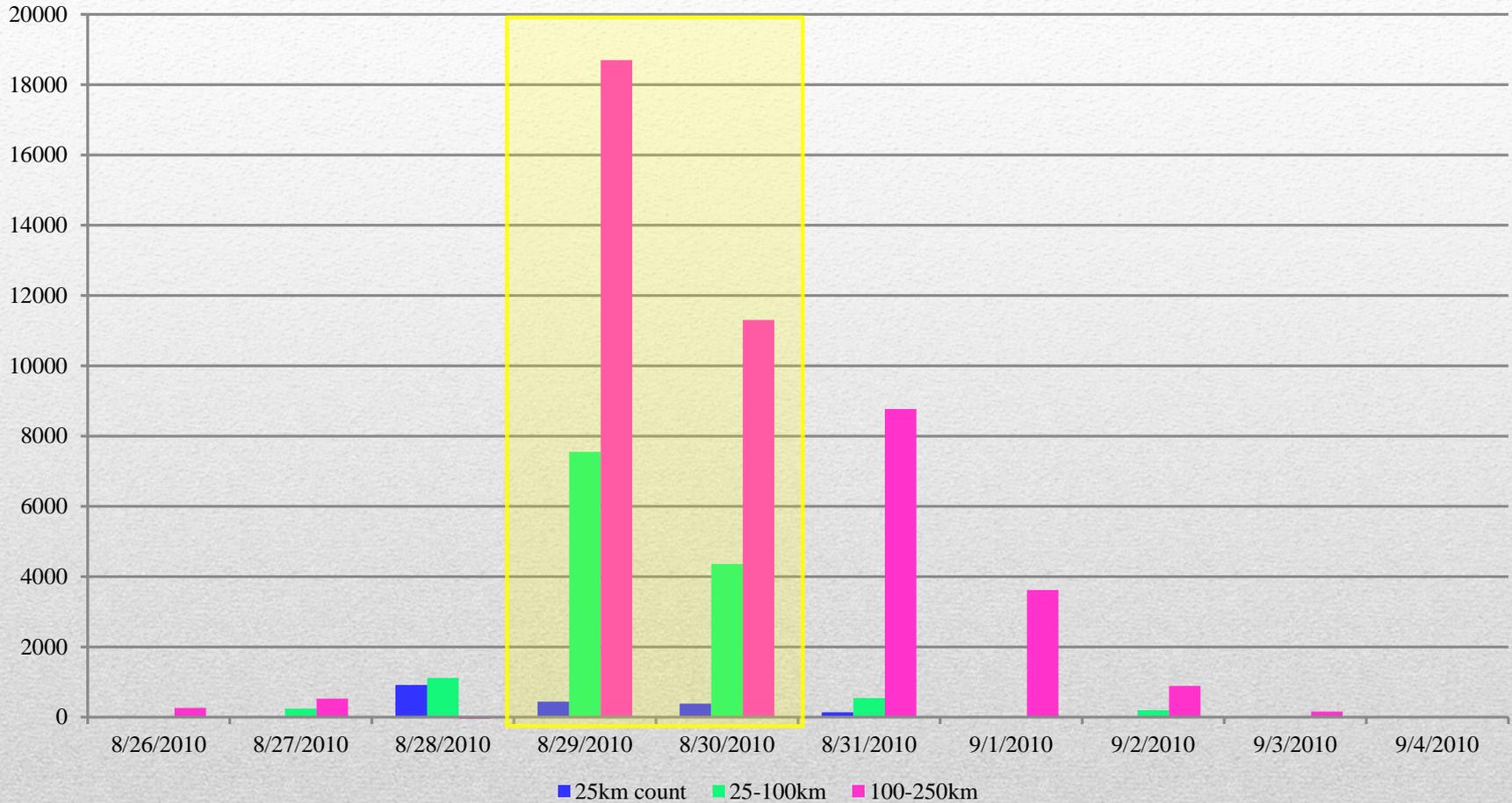
8/29/10  
Tropical Storm  
RI in progress



8/30/10  
Cat 1 Hurricane  
+6 °C warming  
Greatest in mid-upper levels  
*This is during the period over  
which Rob Rogers showed eye  
subsidence along the 18 km  
deep hot tower*

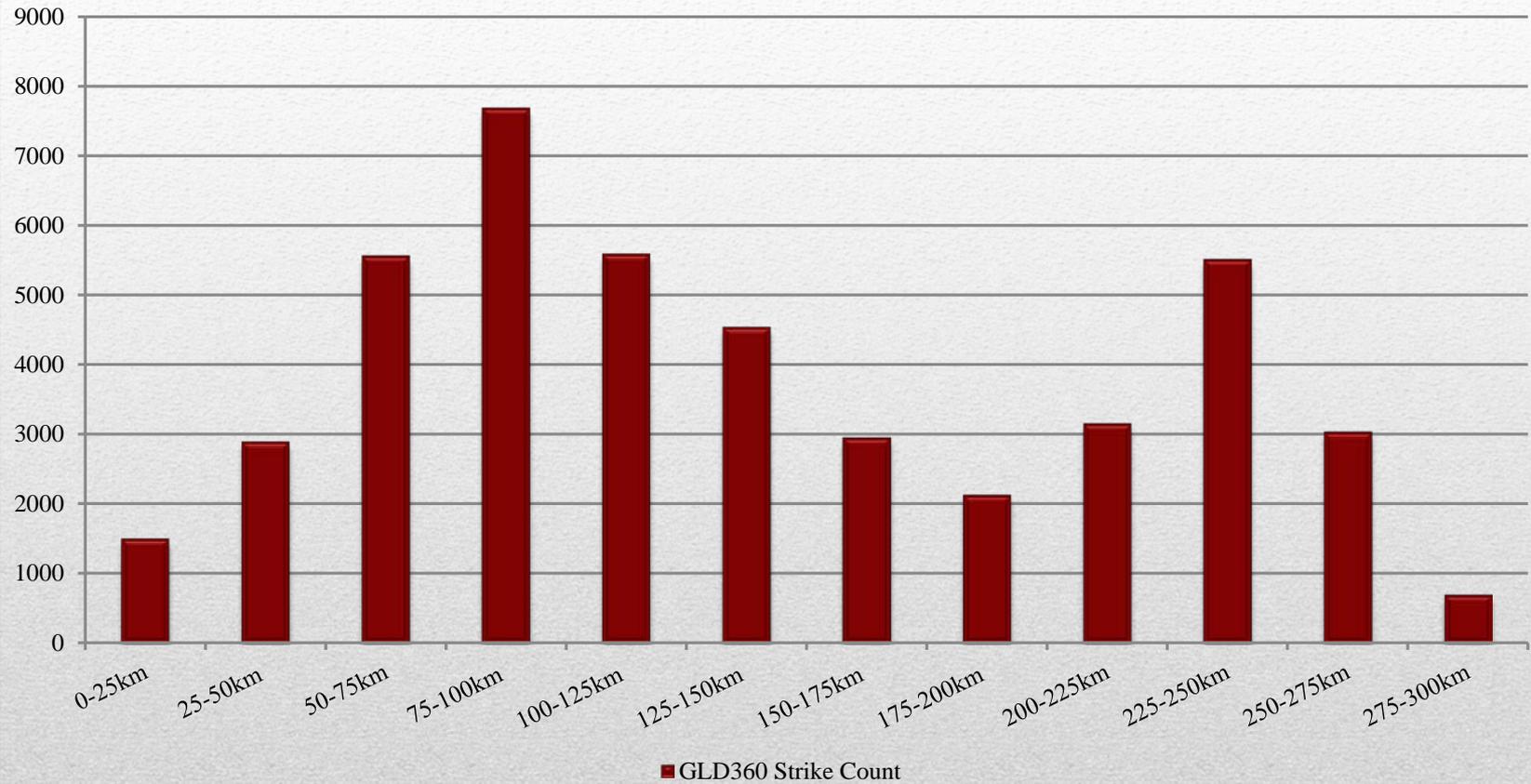
## Warm Core Evolution – dropsondes

## Daily Lightning Frequency

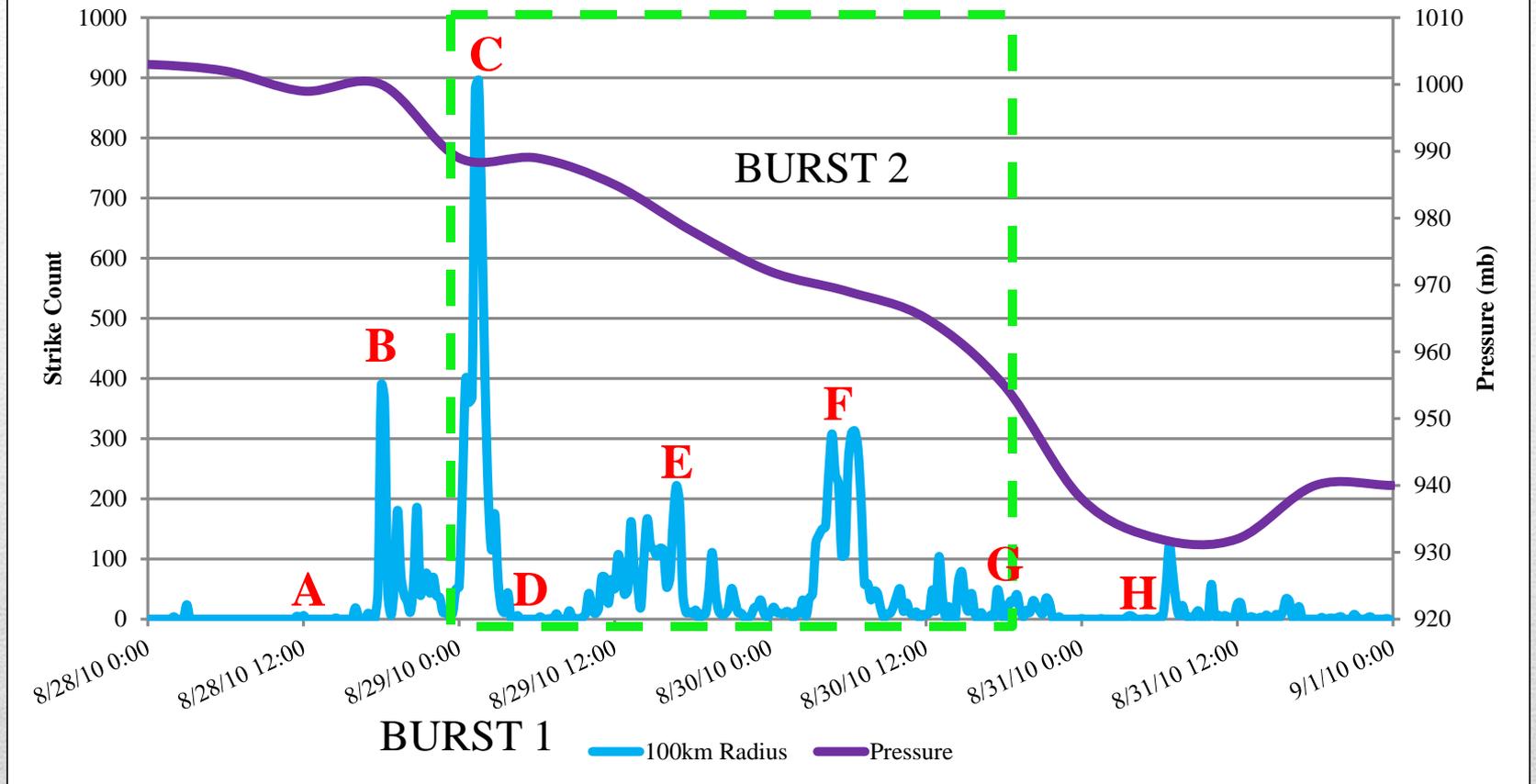


Define "Inner Core" As Radius < 100 km

## Radial Distribution of Lightning During RI 00 UTC 2010.08.29 - 18 UTC 2010.08.30

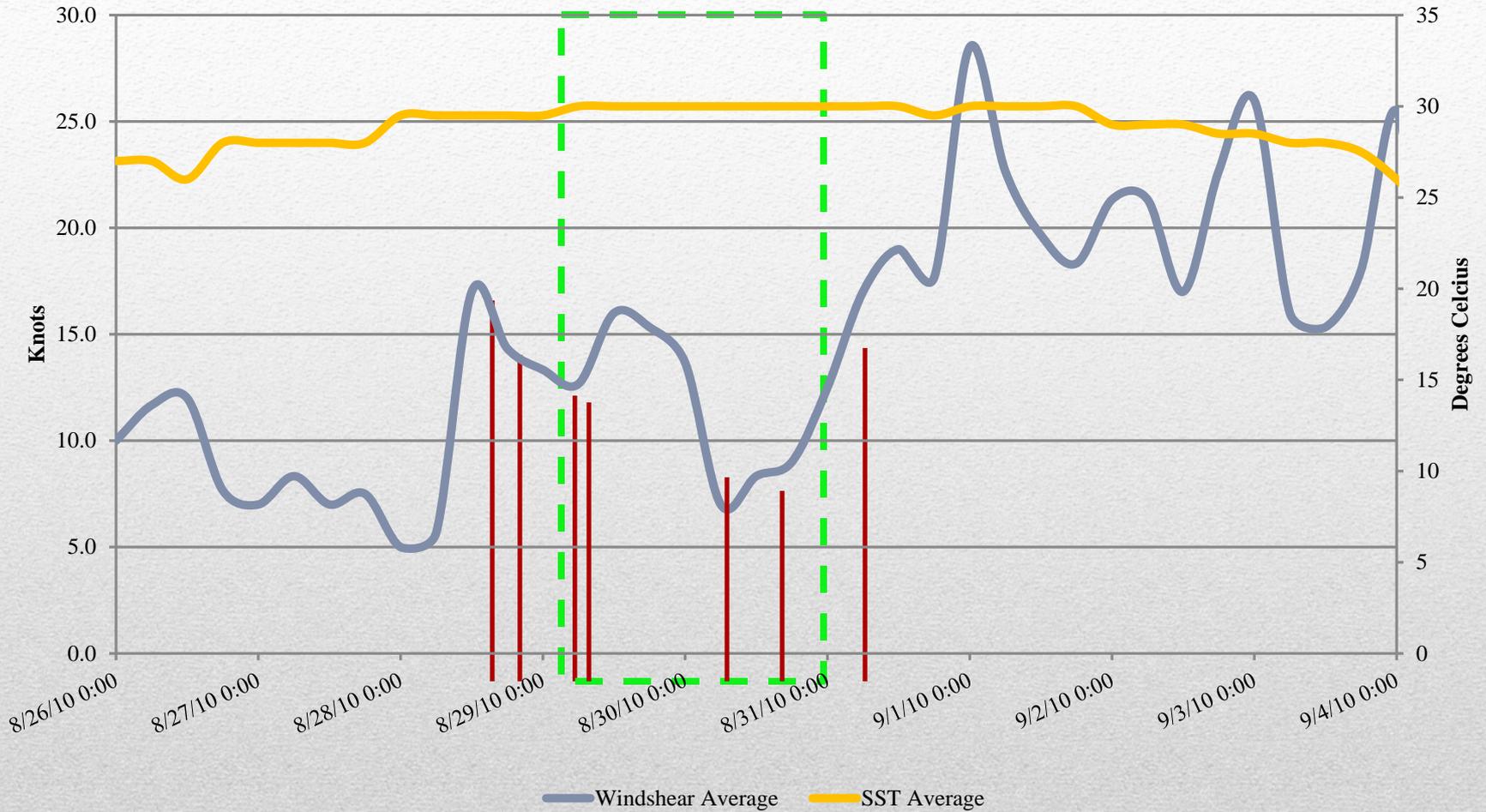


# Inner Core Strike Frequency



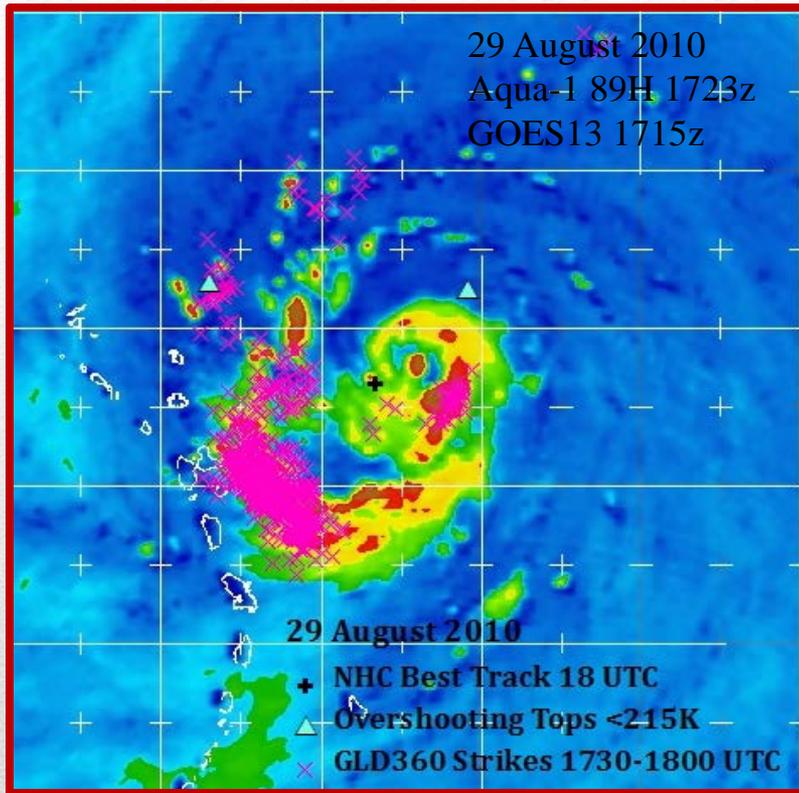


## Windshear & SST



OHC GRADIENT IS ALSO IMPORTANT



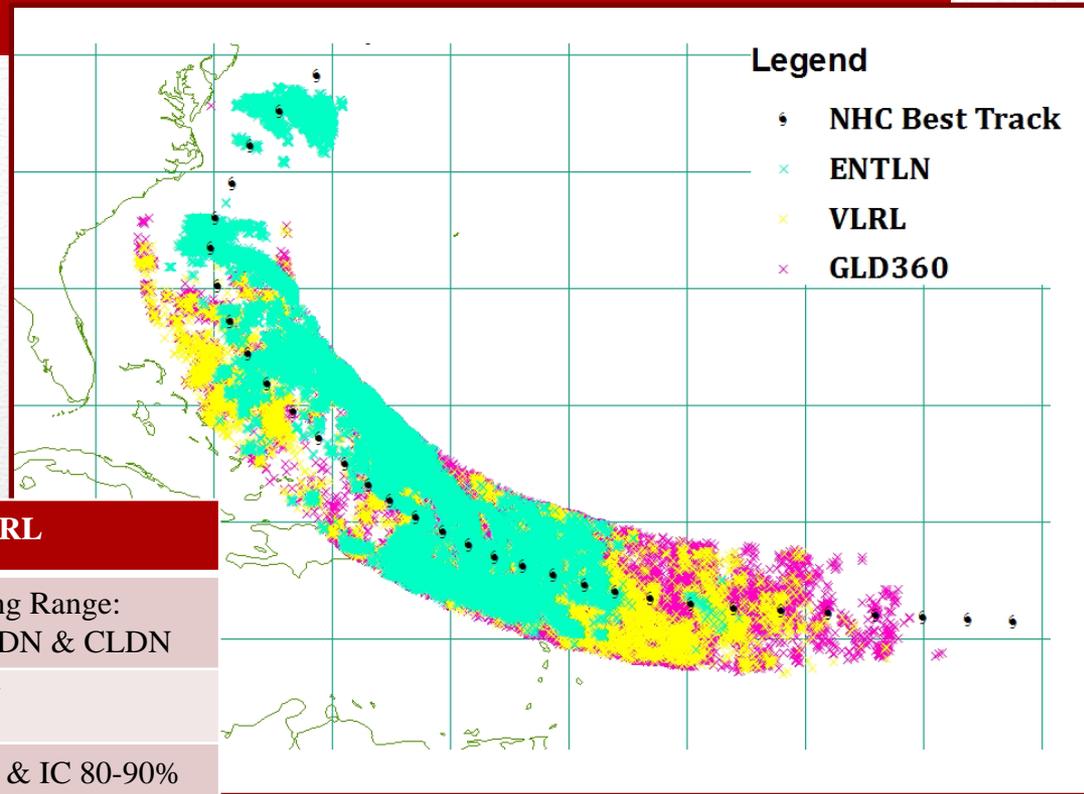


- GOES-13 “Overshooting Top” files were created in near-real time during the GRIP mission. This algorithm does not include tropopause temperature but criteria includes only tops <215K. These will be used to further examine intense convective locations.
- CAPE being examined from DC-8 dropsondes during the period of RI, post-RI
- Ongoing modeling study of Earl (SLU) examining evolution of warm core

# Future Work

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# GLD360 vs ENTLN vs VLRL



	GLD360	ENTLN	VLRL
<b>Coverage</b>	Global	Global	Long Range: NLDN & CLDN
<b>Sensors</b>	??	~ 600	187
<b>Detection Type &amp; Efficiency</b>	CG-70%	CG- 95% IC- 66%	CG & IC 80-90%
<b>Location Accuracy</b>	Median: 5-10km	??	500m
<b>Details</b>	Polarity and peak amplitude for each stroke	Wide-band sensors (1Hz- 12MHz)	

## Lightning Stroke Comparison

- Two periods of intense deep convection were sustained (18-24 hr) throughout the RI of Earl.
- Inner core (within 100km radius<sup>1</sup>) lightning spikes were detected by GLD360 within the convective bursts during the RI period of Earl.
- Inner core lightning activity began just before and peaked at the onset of RI.
- Warm core rapidly intensified during end of first convective burst, early period of second burst
- Inner core lightning was null after Earl reached peak intensity.

## Conclusions

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- Closed eyewall developed during early stages of second convective burst
- Emergence of eye contemporaneous with rapid inner core warming
- Total lightning showed an abrupt increase during RI including the peak in outer rainband lightning activity almost doubling that of inner core.
- Electrified activity gradually decreased through intensification to null after Hurricane Earl's peak intensity of Category-4 was reached on 2 September 2010.

## Conclusions

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1. Austin M, Fuelberg H. Assessing relations between changes in tropical cyclone intensity and lightning patterns using gis based methods, Orlando (FL): 2010, 12 p.
2. Black, R. A., and J. Hallet, 1999: Electrification of the hurricane. *J. Atmos. Sci.*, 56, 2004-2028.
3. Molinari, J., P. Moore, and V. Idone, 1999: Convective structure of hurricanes as revealed by lightning locations. *Mon. Wea. Rev.*, 127, 520-534.
4. Price, C., M. Asfur, and Y. Yair, 2009: Maximum hurricane intensity preceded by increase in lightning frequency. *Nat. Geo-sci.*, 2, 329-332.

# References

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# CIMSS Deep Layer Wind Shear (300-850mb)

C: < 100km radius activity  
O: 100-300km radius activity

