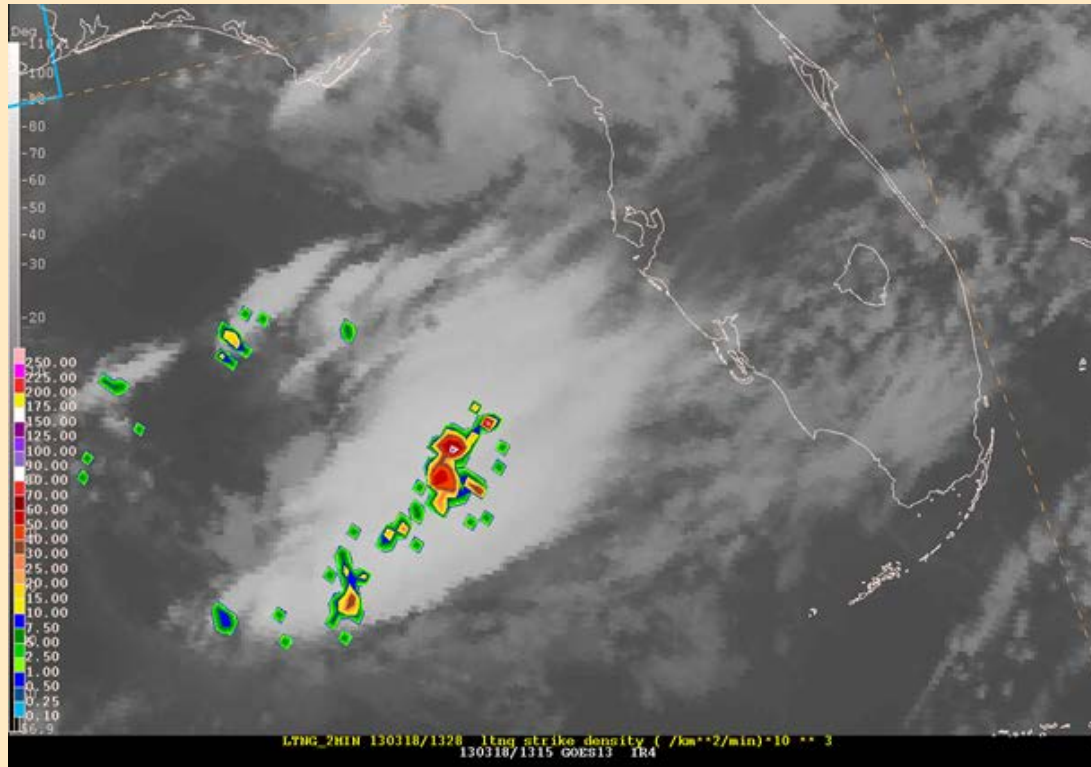


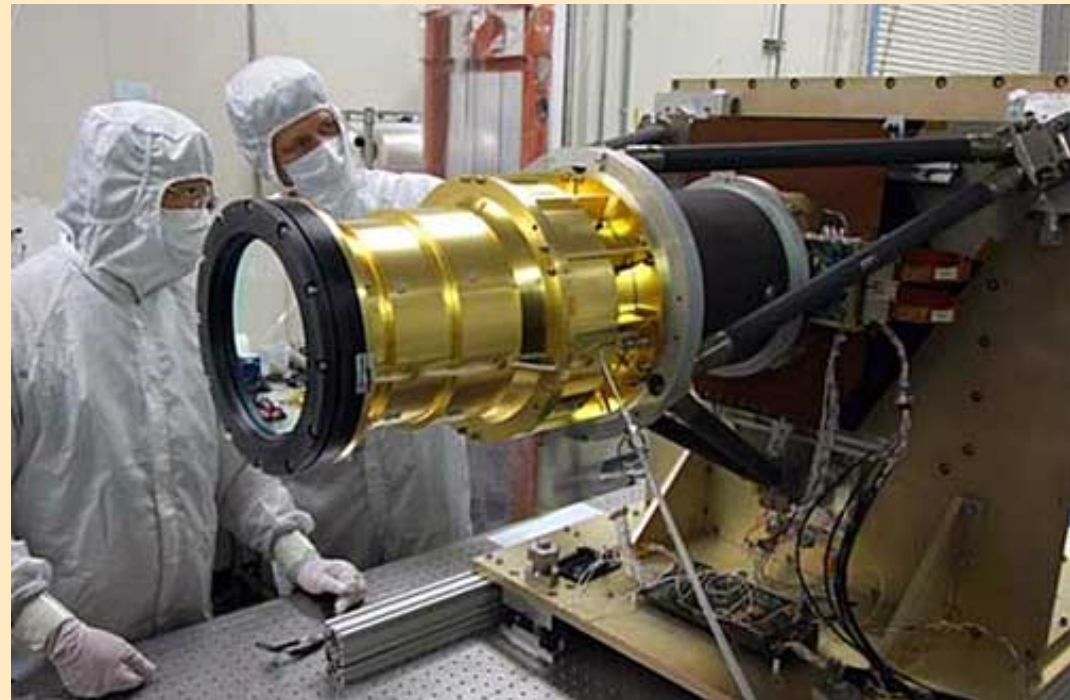
Demonstrating a Lightning Density Product at the Ocean Prediction Center



Dustin Shea, Scott Rudlosky, Michael Folmer,
Joe Sienkiewicz, Greg McFadden

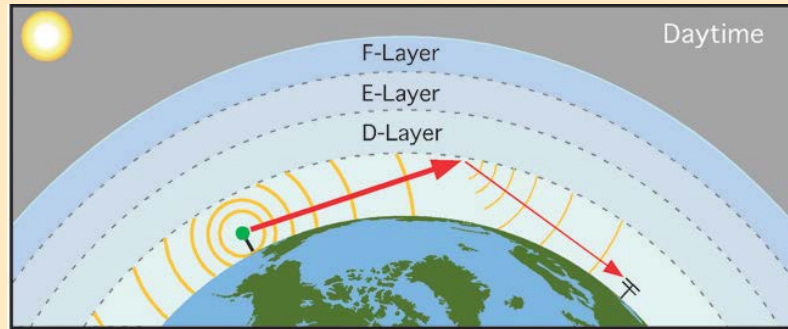
The Geostationary Lightning Mapper

- Lightning imager planned for deployment on GOES-R
- Will provide continuous total lightning observations for the western hemisphere with 8 x 8 km resolution
- Detects changes in radiance at the cloud top
- Based on previous low-earth orbiting lightning imagers (OTD and LIS), which only show ~90 second snapshots
- Total lightning is a better indicator of updraft strength than CG lightning

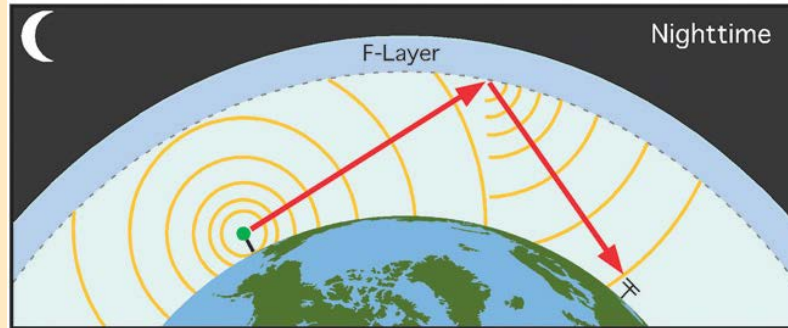


Global Lightning Dataset (GLD360)

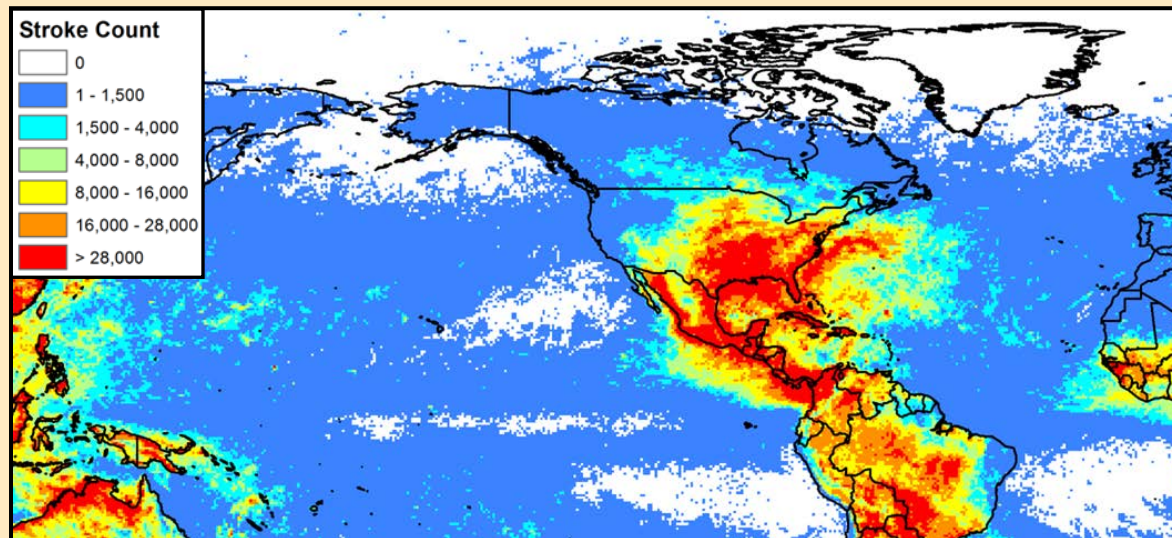
- Ground-based network measures VLF radio waves emitted by lightning
- Earth-ionosphere waveguide traps VLF radio waves allowing them to propagate long distances
- Global coverage, including the oceans
- Lightning strokes are located using primarily time of arrival (TOA)



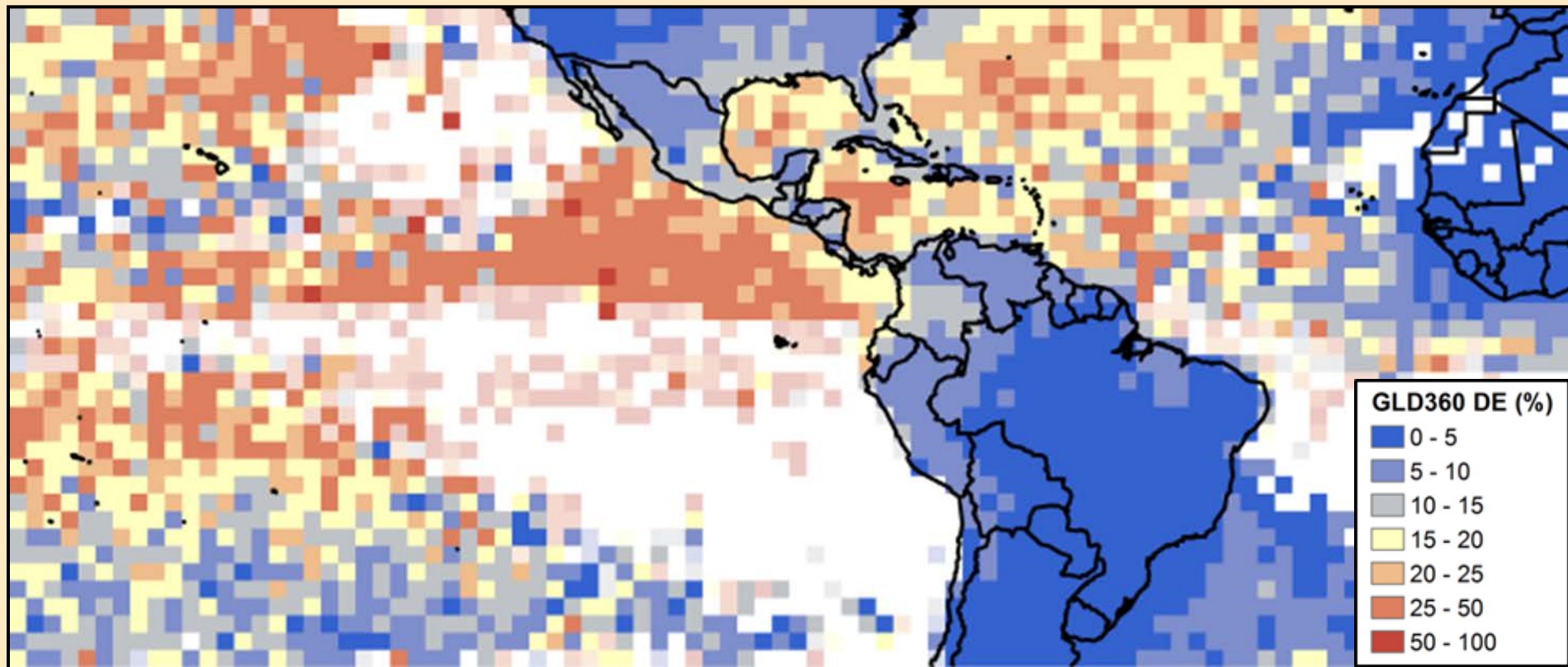
Earth-ionosphere
wave guide



2012 GLD360
Stroke Count

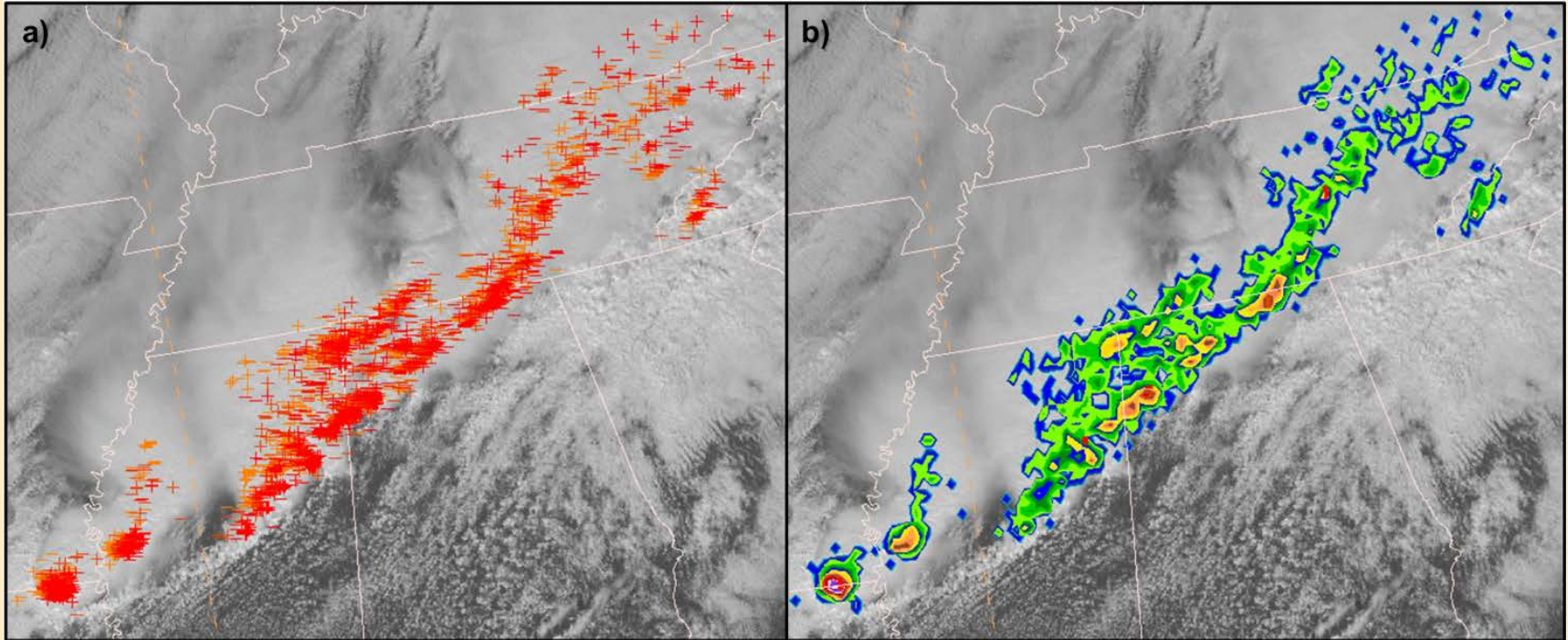


GLD360 Detection Efficiency



Detection efficiency for 2012 relative to the TRMM Lightning Imaging Sensor (LIS). Pixels with less than 15 LIS flashes are reduced in brightness and pixels with no LIS flashes are white. LIS detection efficiency is $\sim 70\%$ at local noon and $\sim 90\%$ at night.

GLD360 Lightning Density Product



- Same resolution as the GLM (8 x 8 km), but GLD360 detects primarily CG lightning and has a much lower detection efficiency
- The number of strokes in a grid cell within a given period of time, calculated as strokes per km² per min, then multiplied by 1000
- 2-min, 5-min, 15-min, and 30-min density products
- Allows easier visualization of lightning intensity than the legacy stroke location product

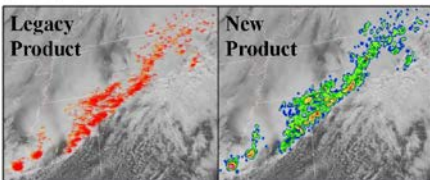
Training Quick Guide

GLD360 Lightning Density Product (Operational Use)



GLD360 Lightning Density Product

- Lightning density is the number of strokes in a grid cell over a given period of time.
- Density units are strokes per km² per min, and are multiplied by a scaling factor to obtain the scale units.
- The frequency of lightning strokes often is indicative of convective intensity.
- Product is provided at 2-min, 5-min, 15-min, and 30-min intervals on 8×8 km grids.



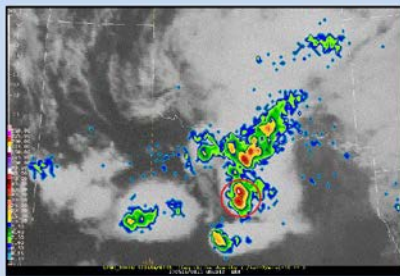
Operational Usage and Benefits

- Track convective cells beneath cloud shields
- Distinguish thunderstorms from rain-only areas
- Identify strengthening or weakening convection
- Monitor convective mode and thunderstorm evolution
- Diagnose initial atmospheric conditions
- Supplement/verify short-term model forecasts

Suggested Product Pairings

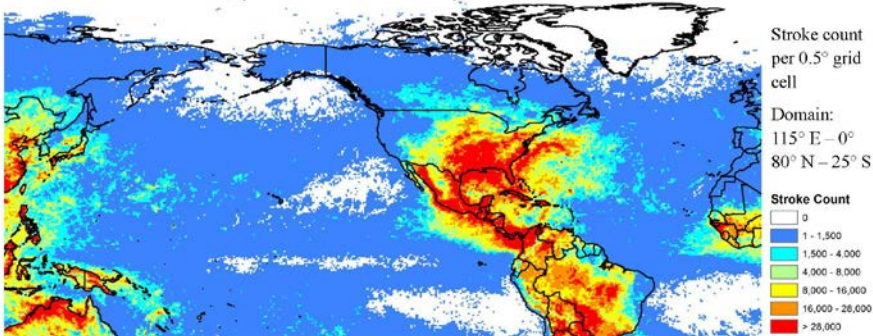
- Visible and IR Imagery
- RGB Imagery
- Wind Vectors
- Surface Map
- Model Precipitation Estimates
- Sea Surface Temperatures
- Overshooting Top Detections
- Convective Initiation
- Cloud Top Cooling

Example Usage: Identify Splitting Supercells

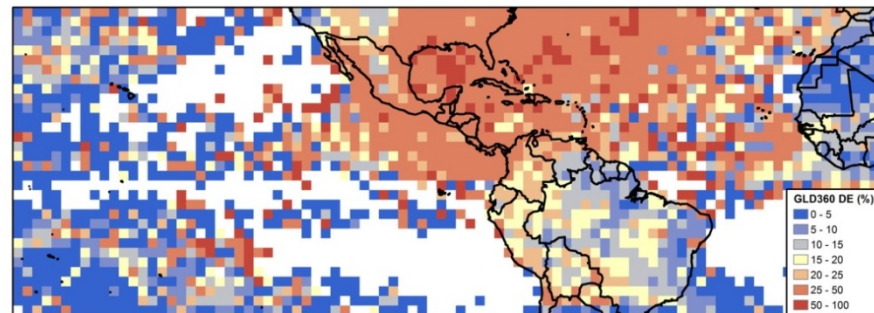


Animated Examples: <http://alturl.com/24iqz>

GLD360 2012 Stroke Distribution



GLD360 Lightning Density Product (Data Properties)



GLD360 Detection Efficiency (DE)

- GLD360 DE was computed relative to the polar-orbiting TRMM Lightning Imaging Sensor (LIS).
- Analysis assumes that LIS observes all flashes, but the actual LIS DE varies from 90% during night to 70% at noon.
- The map above displays the fraction of all LIS flashes that were detected by the GLD360 during 2012.
- White cells indicate no LIS flashes for comparison.
- Regional Detection Efficiencies:
W. Hemisphere = 25.3% Oceans = 33.0%
North America = 33.4% South America = 17.5%

GLD360 is not the GOES-R GLM

- GLD360 detects VLF radio waves emitted by lightning, while the GLM is an optical detector.
- GLD360 detects primarily CG strokes, whereas the GLM will detect total lightning (IC + CG).
- GLD360 detected 25% of LIS flashes in the Western Hemisphere during 2012, while GLM will detect at least 70% of all flashes in its field of view.
- GLD360 detection efficiency varies spatially, while GLM will provide nearly uniform observations.
- Despite these differences, both systems provide instantaneous observations at the same spatial scale.

GLD360 Detection Method

- The GLD360 is a global network of ground-based sensors which detect very low frequency (VLF) radio waves emitted by lightning.
- Global coverage is achieved with relatively few sensors because the VLF radio waves are trapped by the earth-ionosphere waveguide and propagate for thousands of kilometers with minimal attenuation.
- Uses a combination of arrival time, arrival azimuth angle, range estimation, and amplitude to locate strokes. Strokes must be detected by at least three sensors to be accurately located.
- GLD360 detects primarily cloud-to-ground (CG) strokes, but also detects some strong intra-cloud (IC) flashes (network does not distinguish between CG and IC).

Forecaster Notes:

June 12-13, 2013 Lightning Density + GOES IR

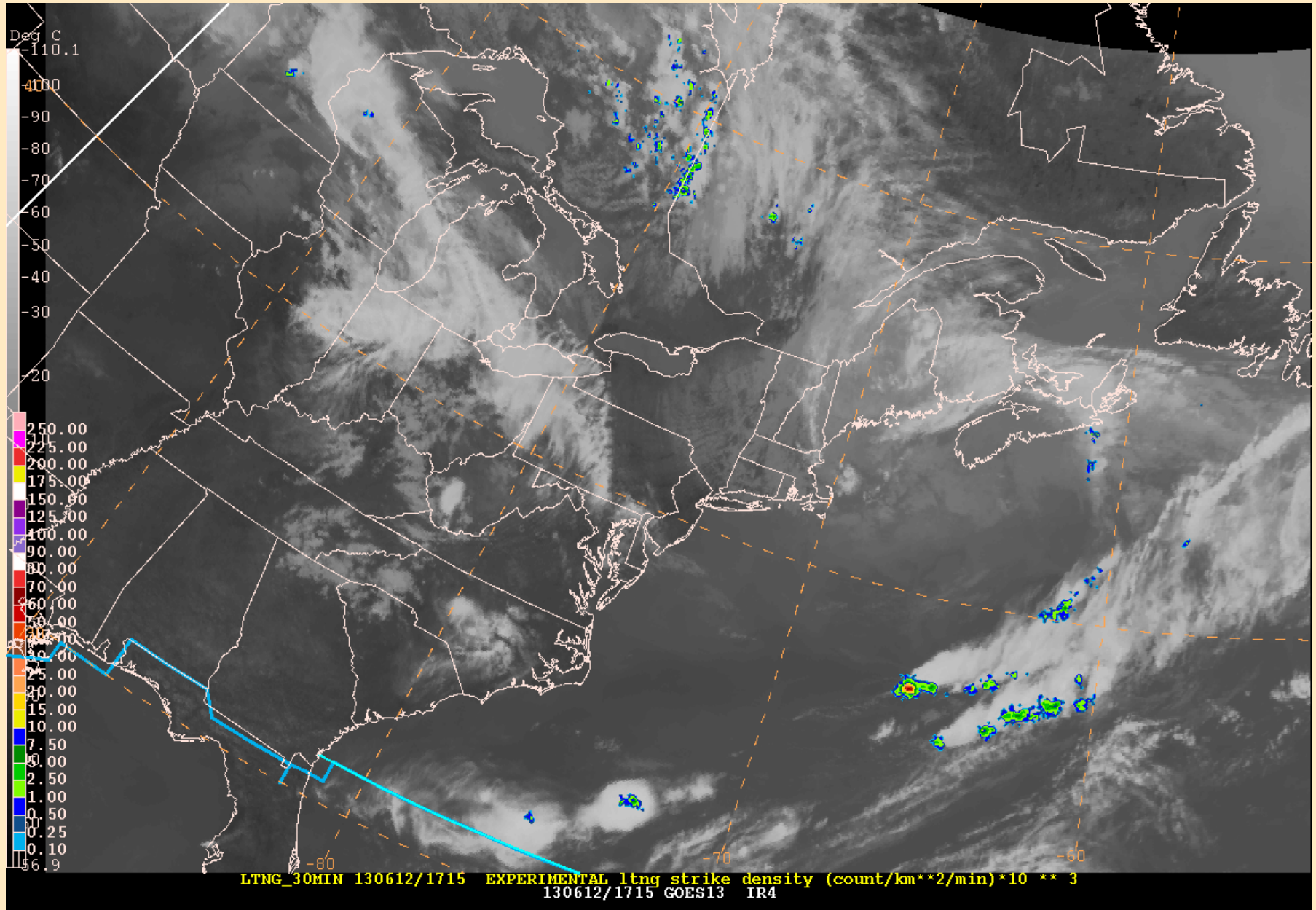
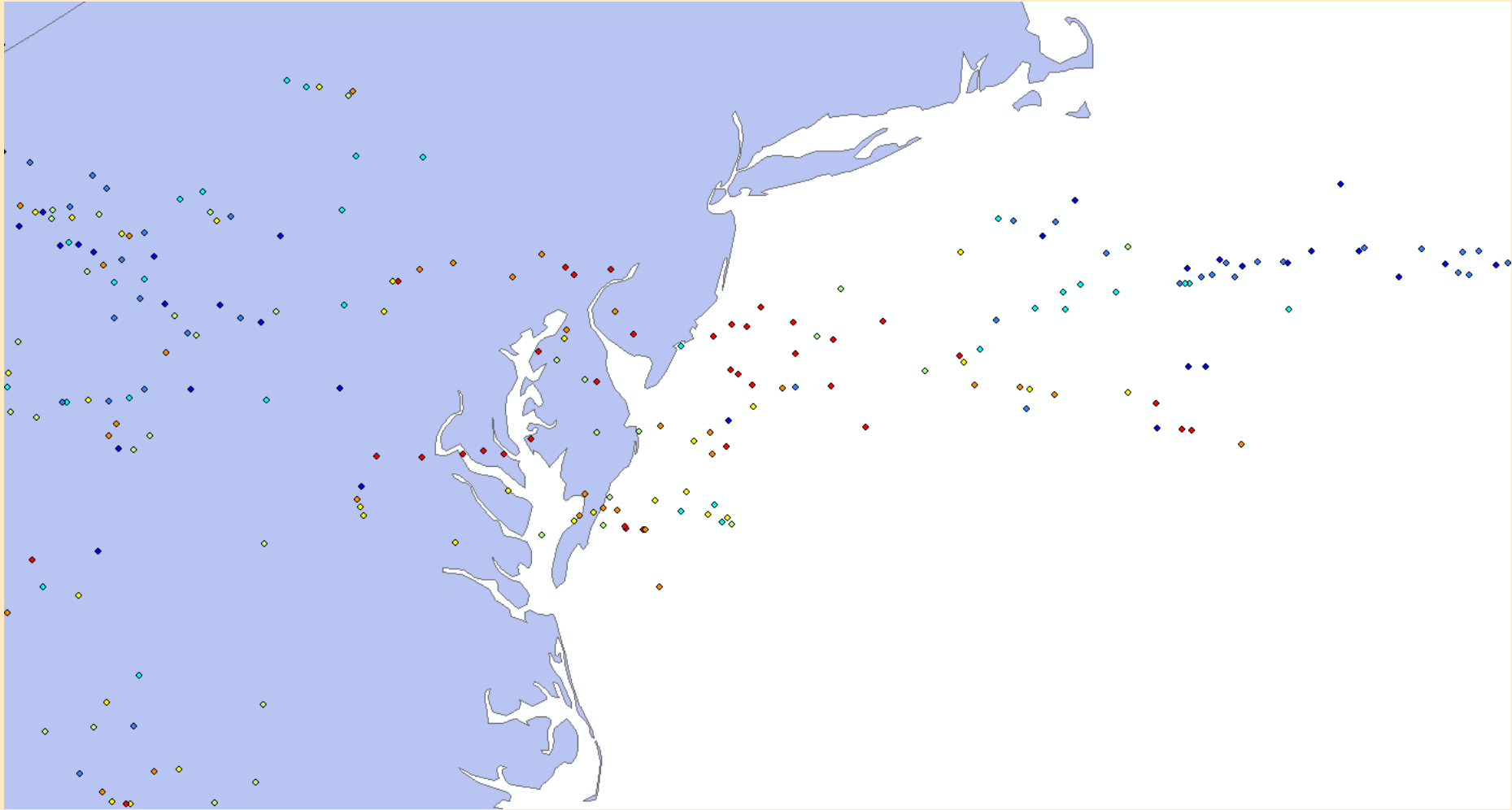




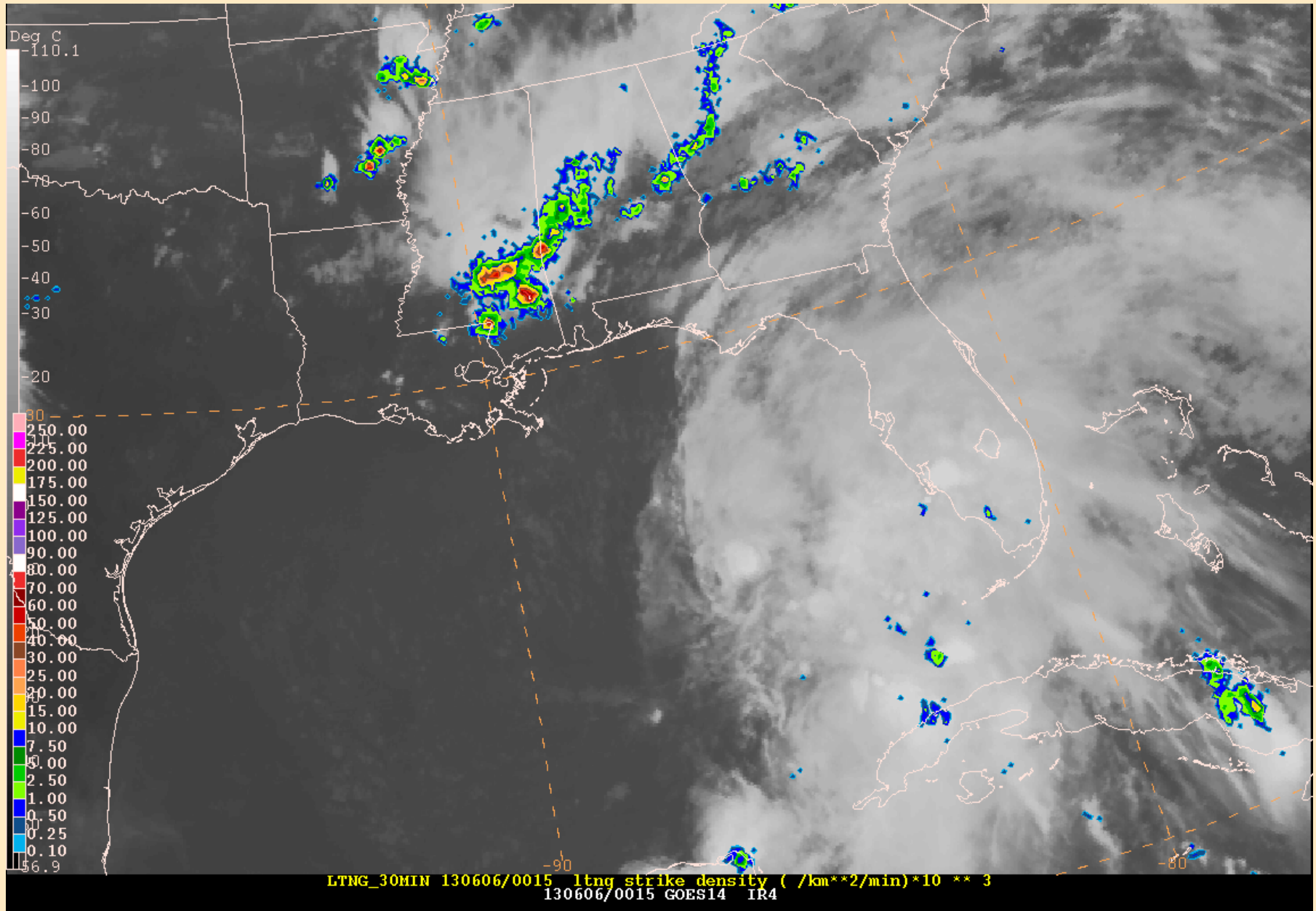
Photo: Buddy Denham

Relationships Between Lightning Data and Other Storm Parameters



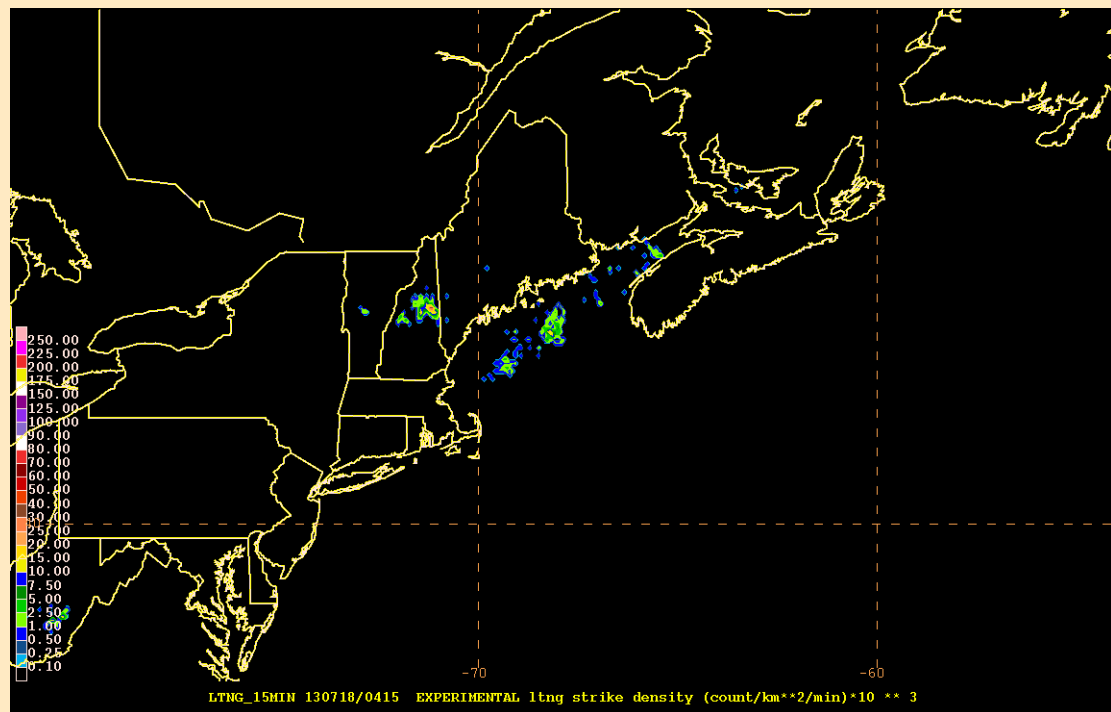
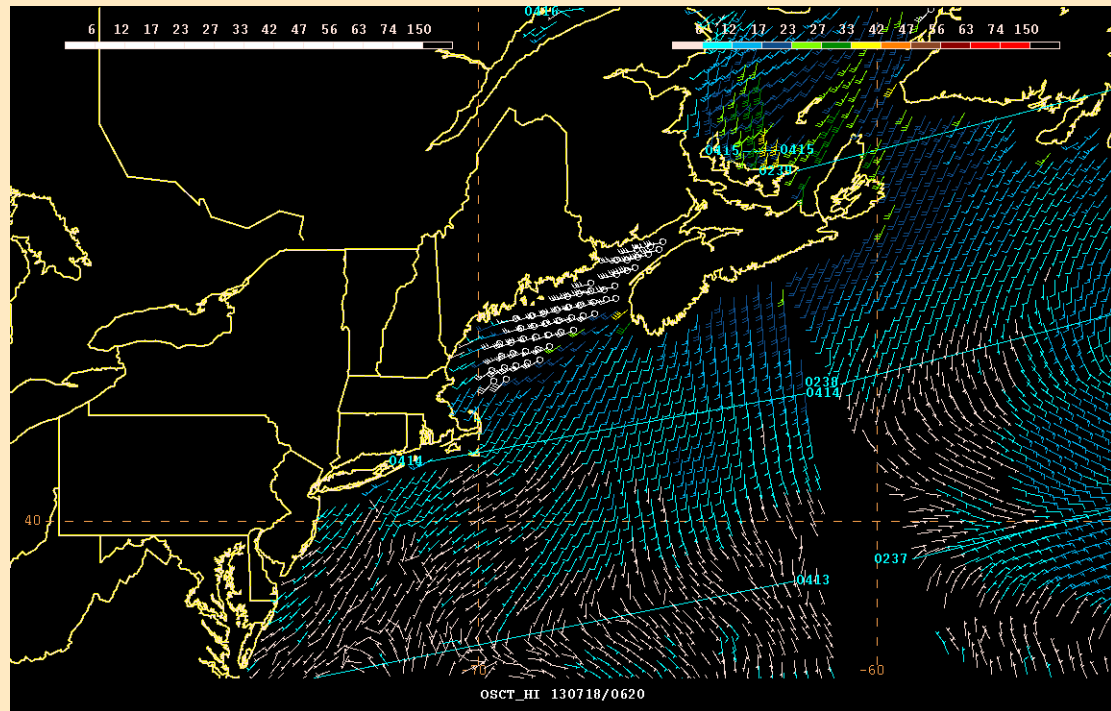
Locations of overshooting tops with number of lightning sources. June 12-13, 2013.

June 6, 2013 Lightning Density + GOES IR



OPC Application: Adjusting the Local Wind Field

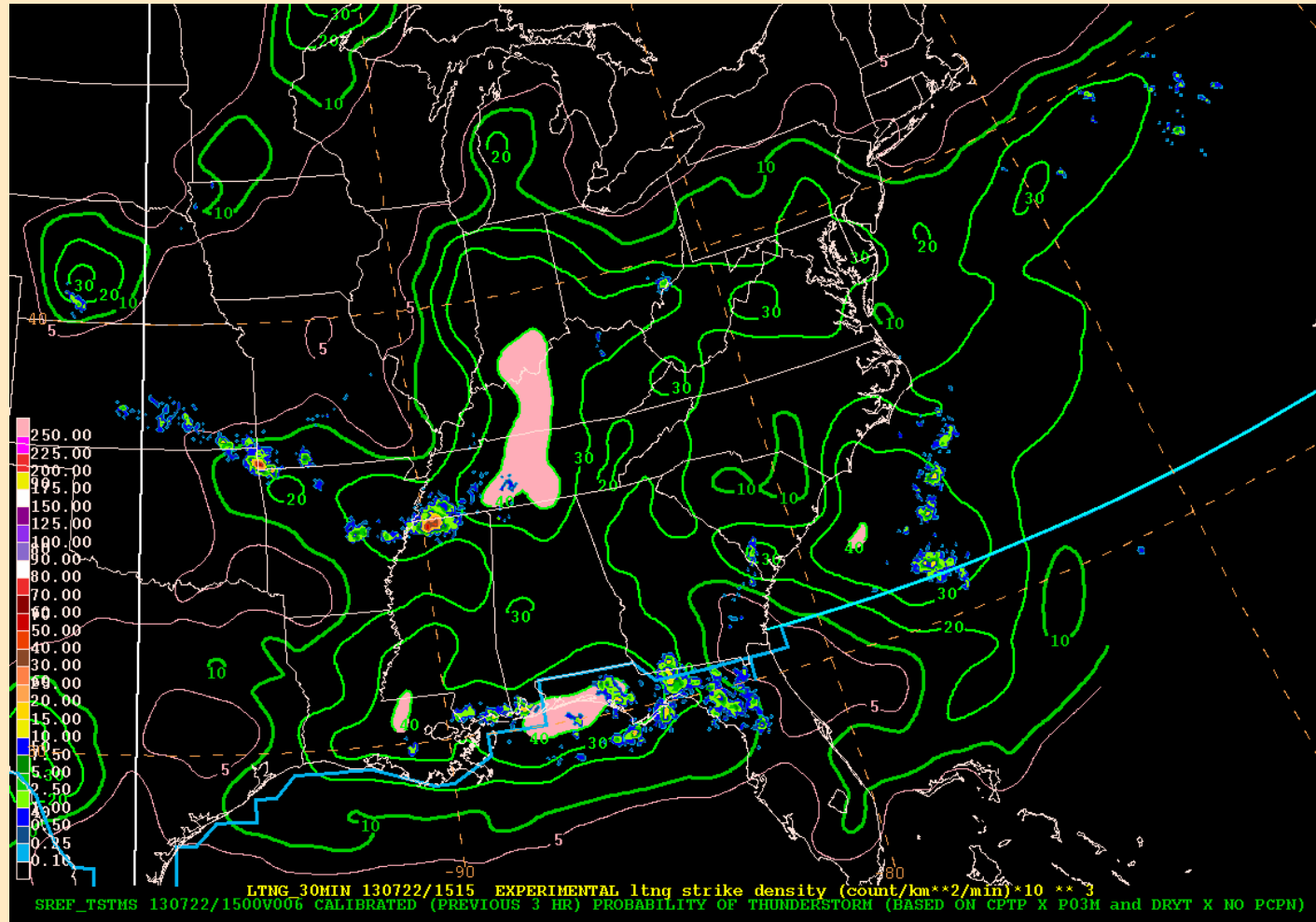
- Large region of 45+ knot surface winds identified by Oceansat-2 scatterometer, but flagged as contaminated retrievals
- 35-40 knot winds near Nova Scotia not flagged as contaminated
- Model output populating the grids does not show thunderstorms or high winds. Are the winds real?
- Lightning density product clearly shows convection in the area



OPC Application: Assessing Model Output

SREF 3-hour Thunderstorm Probability + Lightning Density

- Compare lightning density to thunderstorm probability at the current time
- Gives confidence in model output for future times
- Lightning density can also be overlaid with other model data



Summary

- Project goals
 - Give forecasters experience with a lightning density product in preparation for GOES-R GLM
 - Provide a tool for evaluating offshore convection
 - Gather feedback on the product and the training to improve prior to broader distribution
- GLM will provide continuous total lightning observations with hemispheric coverage at 8 x 8 km
- GLD360 is a ground based network measuring VLF radio waves with high CG detection efficiency but limited IC detection
- Lightning density makes it easier to visualize lightning intensity than the legacy stroke location product
- GLD360 lightning density product is used together with satellite imagery, model output, scatterometer winds, etc.