Total Lightning in a Multi-Sensor Approach to the Detection of Convectively Induced Turbulence

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Topics: Lightning and Severe Weather

Program: GOES-R3

Introduction

- Substantial losses to the commercial aviation industry on the order of 2 billion dollars each year from thunderstorm related hazards and associated delays
- Objective: Investigate the potential for GOES-R multi-sensor detection of turbulence and other aviation hazards associated with rapidly growing and mature convective cells.
- Approach: Utilize Advanced Baseline Imager (ABI) proxy cloud top cooling and overshooting top (OT) detection and Geostationary Lightning Mapper (GLM) proxy total lightning flash rates for diagnosis of storm intensity and growth rate

Methodology

- GLM proxy total lightning data are obtained from the VHF-based Lightning Mapping Array (LMAs) over Alabama. Comparison with Earth Networks Total Lightning Network (ENTLN)
- Cloud top cooling and overshooting top detection are obtained from Geostationary Operational Environmental Satellite (GOES) observations over the LMA operational domains (< 150 km from LMA center)
- Turbulence occurrence is determined objectively using eddy dissipation rate (EDR) data from the NCAR turbulence algorithm applied to commercial aircraft navigation data over the LMA domains
- Thunderstorm tracking accomplished through the use of the W2segmotion algorithm in the Warning Decision Support System-Integrated Information (WDSS-II)

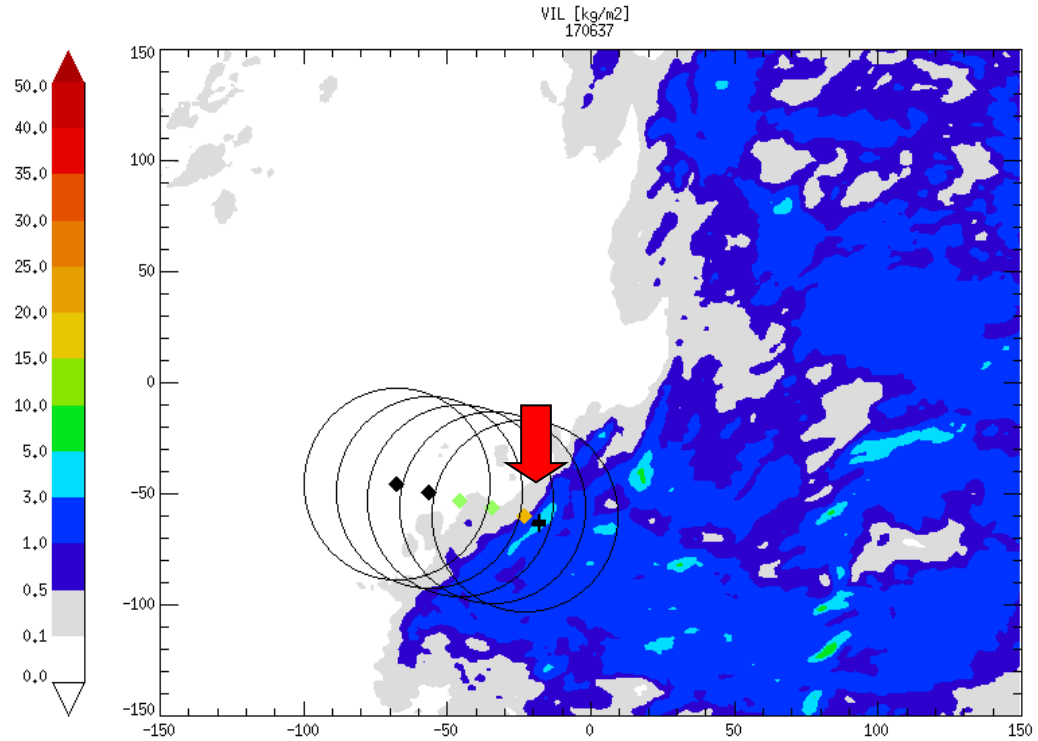
Expected Results

- The inclusion of GLM-proxy total lightning data to aviation planning and routing operations will provide valuable information to airlines regarding the turbulence potential of storms in and near aircraft routes
  - Multiple cases of aircraft attempting to “shoot the gap” between convective cells
  - Total Lightning data and trends (as a proxy for updraft strength) can reveal a storm’s potential for turbulence generation
- Enhanced temporal resolution of the ABI over current GOES imagers will give valuable information on trends in storm strength and turbulence generation potential to flight planning and routing operations

Results

January 24th, 2010

- Aircraft is flying through relatively benign looking convection from a radar perspective, as indicated by low VIL values (<5 kg/m^2)
- Inclusion of lightning data could have alerted pilot to turbulence potential of weak convective cell
- Red arrow points to single flash detection by NALMA (cell had a history of flashes in the 15 minutes prior to MDT EDR report—yellow diamond)

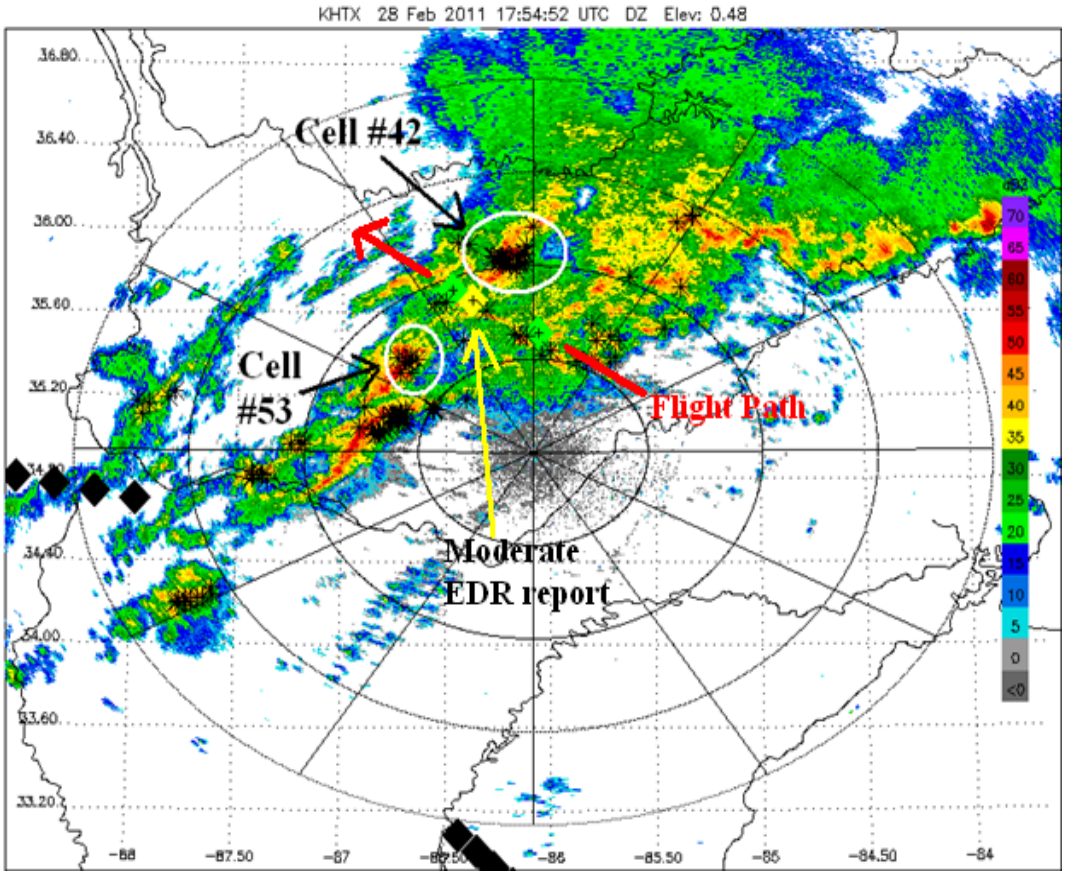


Aircraft reported EDRs with 20 mile range rings, VIL (kg/m^2 from KHTX), and NALMA flash data indicated by '+' symbols. Axis shows distance from NALMA center

Results

February 28th, 2011

- 2 strongly electrified cells on either side of track as aircraft shoots the gap
- Many NALMA flashes (black asterisks) detected under flight path near MDT EDR report (yellow diamond)
- Total lightning data could have alerted the pilot to turbulence potential of more benign (lower reflectivity) cells along flight path

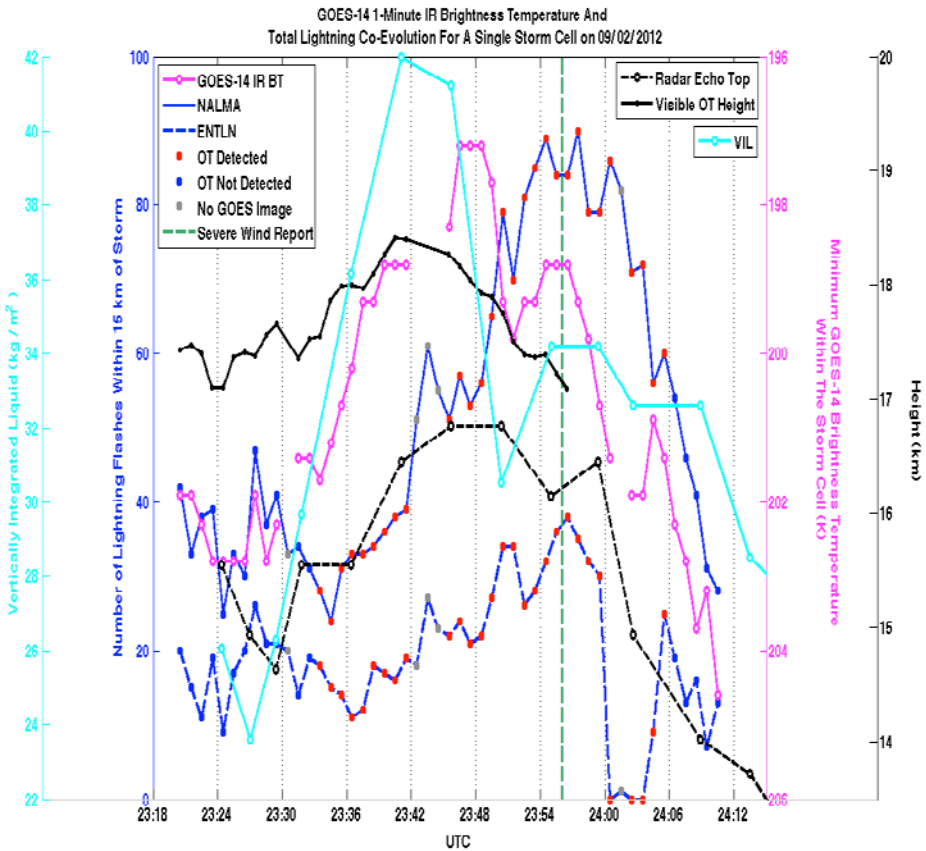


KHTX base reflectivity (dBZ), NALMA flash origins (*), and EDR reports

Results

September 2nd, 2012

- This cell was observed by multiple platforms (satellite, radar, and lightning networks)
- Comparison between flash data from NALMA (dark blue solid line) and ENTLN (dark blue dotted line) show similar trends but different magnitudes
- A *lightning jump* was identified in NALMA data at **23:42**; providing 14 minutes of lead time before severe wind report (green dashed line)
- Lightning activity from both networks peaks very near the time of severe report (**23:56** UTC)



For more detailed information on this cell see Kris Bedka's virtual poster

Possible Path to Operations

- Presence of GLM-proxy total lightning data can enhance information gleaned from radar, especially when radar metrics (VIL/low level reflectivity) only indicate a marginal threat to aircraft safety
- The mere presence of lightning indicates that an updraft is of sufficient strength and vertical extent to generate potential icing and turbulence hazards to aircraft
- Use of GLM total lightning data and ABI OT detection algorithm will provide useful information in regions where traditional radar data is sparse or nonexistent (mountainous regions and over oceans)

Future Plans

- Further investigate the temporal and spatial relationships between total lightning properties, overshooting-tops (OTs), infrared (IR) cooling rates and CIT events
- Perfect the use of WDSS-II object-tracking tools optimized for radar, total lightning and/or IR objects to calculate GLM-proxy flash rate and OT trends in convective cells leading up to EDR-CIT events
- Compose a journal article outlining the relationships found between total lightning data and other intensity metrics on a storm-based scale

Publication List

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