**Case Study of Moderate Turbulence: January 24, 2010**

We utilized the WDSS-II wave-motion algorithm to track reflectivity at 5 kilometers (-10 C) for this case. Cells were tracked from -17:40-18:20 UTC. We then used storm centroid data to interrogate two cells: cell #53 (south of aircraft track) and cell #42 (north of aircraft track) near the time of the MDT turbulence (17:50 UTC).

We can use the Warning Decision Support System -- Integrated Information (WDSS-II) to objectively track clouds that have the potential of CIT. An example of this tracking from Sept 2 is shown at left.

Cloud Top Cooling (CTC) can be detected in growing object (arrow in middle image). A rapidly developing updraft associated with CTC is a potential cause of CIT. For information on CTC and CIT, see poster P.265.

**Goals and Approach**

**Objective:** Investigate the potential for GOES-R multi-sensor detection and short-term forecasting of other and aviation hazards associated with rapidly growing and mature convective cells.

**Approach:** Utilize Advanced Baseline Imager (ABI) proxy cloud top cooling and overshooting top detection (OT) detection and Geostationary Lightning Mapper (GLM) proxy total lightning flash rates for diagnosis of storm intensity and growth rate.

- **GLM proxy total lightning data are obtained from the VHFR-lightning Mapping Arrays (LMAs) over Alabama (see Figure to right for network diagram), Florida, Oklahoma and Washington DC.
- **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.

**Co-Evolution of NA-LMA Total Lightning and GOES Overshooting Cloud Top Detections**

<table>
<thead>
<tr>
<th>Mean Number Of NA-LMA Flashes Per OT At 1-Minute Intervals Before, During, and After 1606 GOES-13/13 OT Detections</th>
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<tbody>
<tr>
<td><strong>OT – Lightning Co-Evolution Within 1-Minute GOES-14 SRSO Data</strong></td>
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<td>Total lightning flashes from NA-LMA and Earth Networks Total Lightning Network (2011) were examined for a 1-min interval between 15 km of the center of a OT-producing storm cell south of Huntsville, AL. OTs were detected by the GOES-R algorithm for 30 consecutive GOES scans, though an OT was not detected in GOES imagery prior to 23:32 UTC. The length of the OT-induced shadow in visible imagery was used to compute OT penetration height, which was added to the equilibrium level (16.2 km) to derive a cloud top height. Radar VIL and enhanced echo top height were obtained from the Huntsville and Birmingham, AL WSR-88D.</td>
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**GENERAL FINDINGS**

1. Lightning activity began to increase in association with IR cloud top cooling and an increase in echo top height. The NA-LMA and ENLTL lightning time trends follow each other quite well though there is a significant difference in flash counts between the two detection systems.  
2. Echo top and visible shadow-based cloud top heights are well correlated. 
3. Lightning maximized near time of a severe wind event at 23:50 UTC. The minimum IR BT (maximum VIL) preceded the maximum flash rate by ~7 minutes, though a secondary maximum in echo top and IR BT occurred at time of severe wind. 
4. Rapid increase and maximum in VIL is physically correlated to subsequent increase and peak in flash rate due to non-inductive charging and strong downdraft and surface severe wind due to precipitation loading and melting in collapsing cloud. 
5. The times when OTs were first detected correspond with the beginning of a significant increase in lightning activity and VL. Although detection of continuous OTs is extended due to the partially significant of evaluating the cloud top heights, the combined presence of continuous OTs, high VIL, and strong increase flash rate may be indicative of improving high impact weather and may improve the forecasters situational awareness.

**Using Object Tracking to Identify Cloud Properties Associated with Turbulence**

**Example with manual object tracking:** May 2, 2010

We can use the Warning Decision Support System -- Integrated Information (WDSS-II) to objectively track clouds that have the potential of CIT. An example of this tracking from Sept 2 is shown at left.

Cloud Top Cooling (CTC) can be detected in growing object (arrow in middle image). A rapidly developing updraft associated with CTC is a potential cause of CIT. For information on CTC and CIT, see poster P.265.

Using WDSS-II, manually tracked the 2 cells through which aircraft flew to identify potential cloud properties that caused turbulence.  

Example of display to identify cloud properties potentially associated with aircraft turbulence.  

Both aircraft flew into the storm system, as evident by the cloud heights being higher than the flight height. Neither cloud cluster appears to be growing from IR.