Jobsheet

GOES-R pseudo-Geostationary Lightning Mapper

Objective:

- To understand and use gridded lightning data for situational awareness and diagnosing storm intensity.

Product Overview:

A pseudo-Geostationary Lightning Mapper (pGLM) product is being created for the Hazardous Weather Testbed (HWT) during the Spring Experiment. This product utilizes total lightning data from four Lightning Mapping Array (LMA) networks (Central Oklahoma, Texas Tech/southern panhandle, Northern Alabama, and Washington DC) and the Lightning Detection and Ranging (LDAR) network (Kennedy Space Center, Florida) that detect VHF radiation from lightning discharges (Fig. 1).

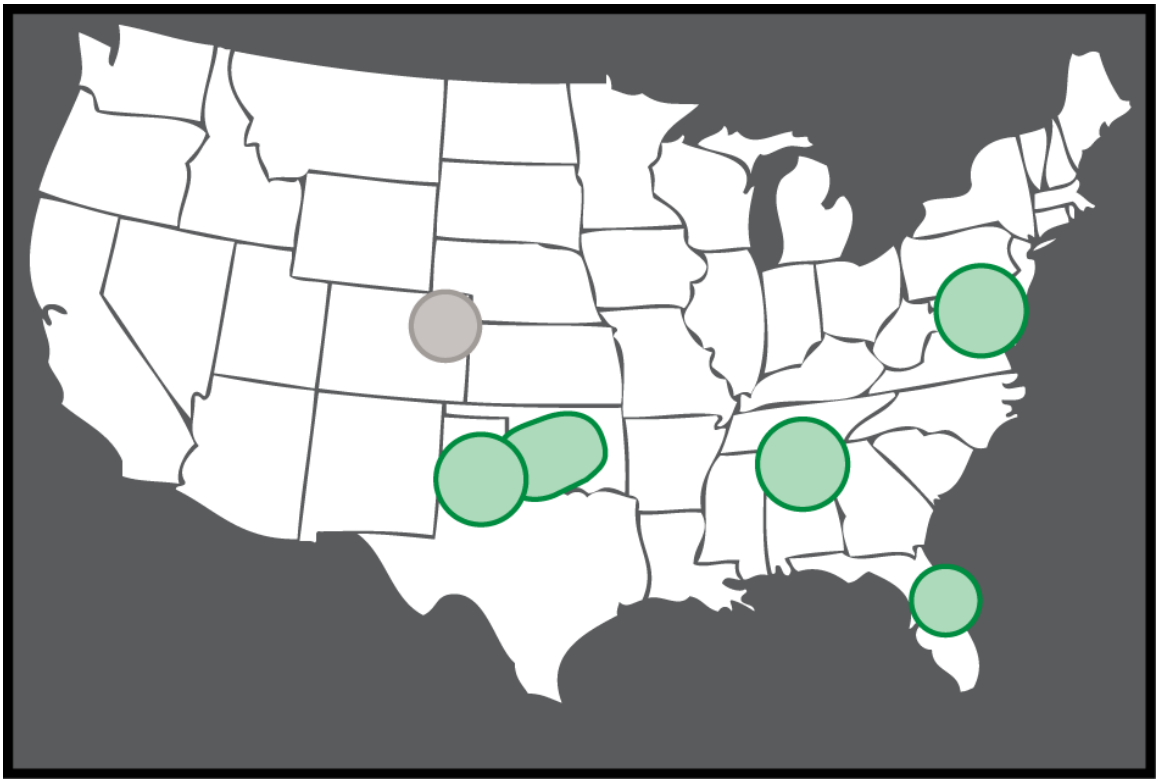

Fig. 1: Ground-based total lightning domains. Available networks include the OKLMA, NALMA, DCLMA, TTULMA and KSC-LDAR. An additional network in NE CO may be available during the Spring/Summer 2012.

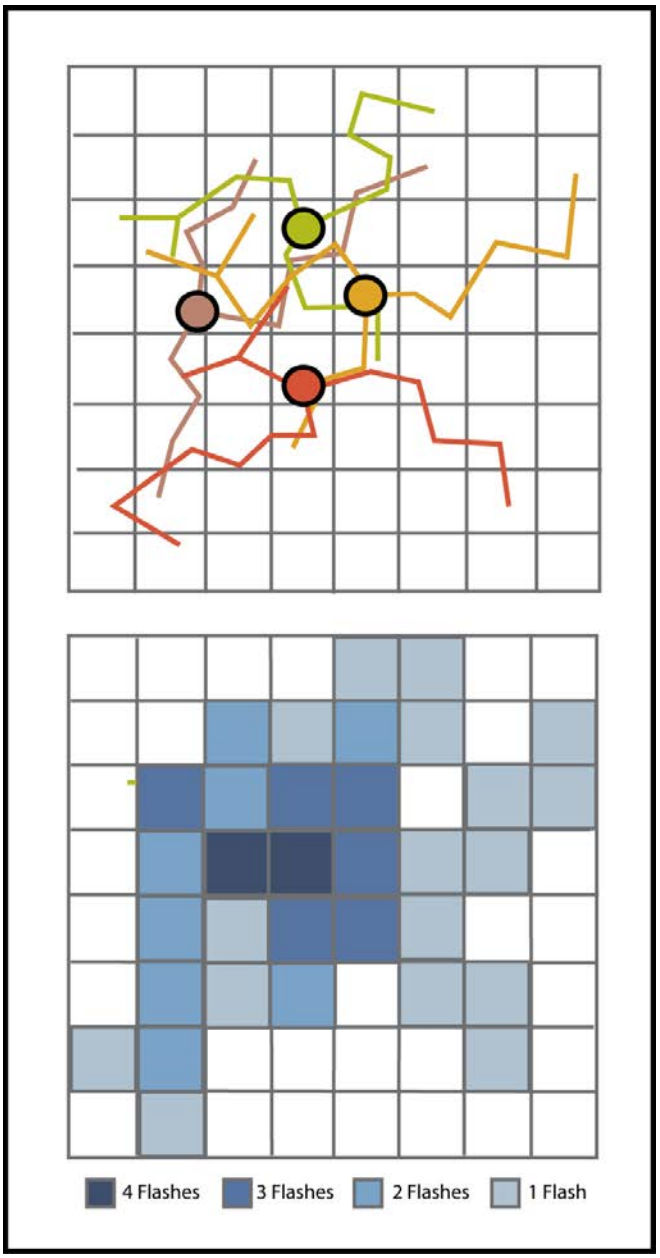

Fig. 2: Top. Sorted flashes from LMA data, each color denotes a different lighting flash.

Bottom: Flash footprint or flash extent density. Each grid color represents the number of individual flashes to cross the region during the previous minute. (Flashes per box; approximately 50 km^2 for GLM).

The real-time lightning data, available in 1 min or 2 min intervals depending on the network, is sorted into flashes using algorithms available through Warning Decision Support System – Integrated Information (WDSS-II). Following flash sorting, a Flash Extent Density product is created at 8-km resolution every minute to match that expected by the GOESR-GLM. Note: GLM data is expected to be available post-GOES-R launch in 2015/2016.

The pGLM product is created by sorting the VHF radiation points into flashes, the flashes are then mapped onto a grid to create a 'flash footprint' (Fig. 2). In addition to the instant flash density there are also 60 and 120 min swaths of maximum flash rate (similar to multi-radar MESH swaths).

Total lightning flash rates (as opposed to ground flash rates) are roughly proportional to the volume and mass flux of updrafts >10 m s^{-1}, to graupel mass and volume, and to ice mass (e.g., Lhermitte and Krehbiel 1979, Goodman et al. 1988, Weins et al. 2005, Diereling et al. 2005, Petersen et al. 2005, Kuhlman et al. 2006, Bruning et al. 2007), all of which are measures of storm intensity. Rapid increases in a storm's total flash rate (sometimes termed a "lightning jump") can be reflective of rapid increases in the updraft intensity, and may be used as a possible precursor to severe weather (Schultz et al., 2011).

The pGLM lightning product can be examined in multiple ways for various situations. The exercise below will have you compare it to multiple products to help familiarize yourself with some of these options. Feel free to develop different procedures within the AWIPS/AWIPS2 framework for your time in the HWT.

Jobsheet Overview:

The pGLM product can be examined in multiple ways for various situations. This jobsheet is broken into 4 sections showing methods in which the pGLM products can be integrated alongside other AWIPS datasets. There are 4 questions to answer with this jobsheet. Answers to these questions will be provided in the answer key document.

Product Set #1: Total Lightning vs. Cloud-to-Ground (CG) Lightning

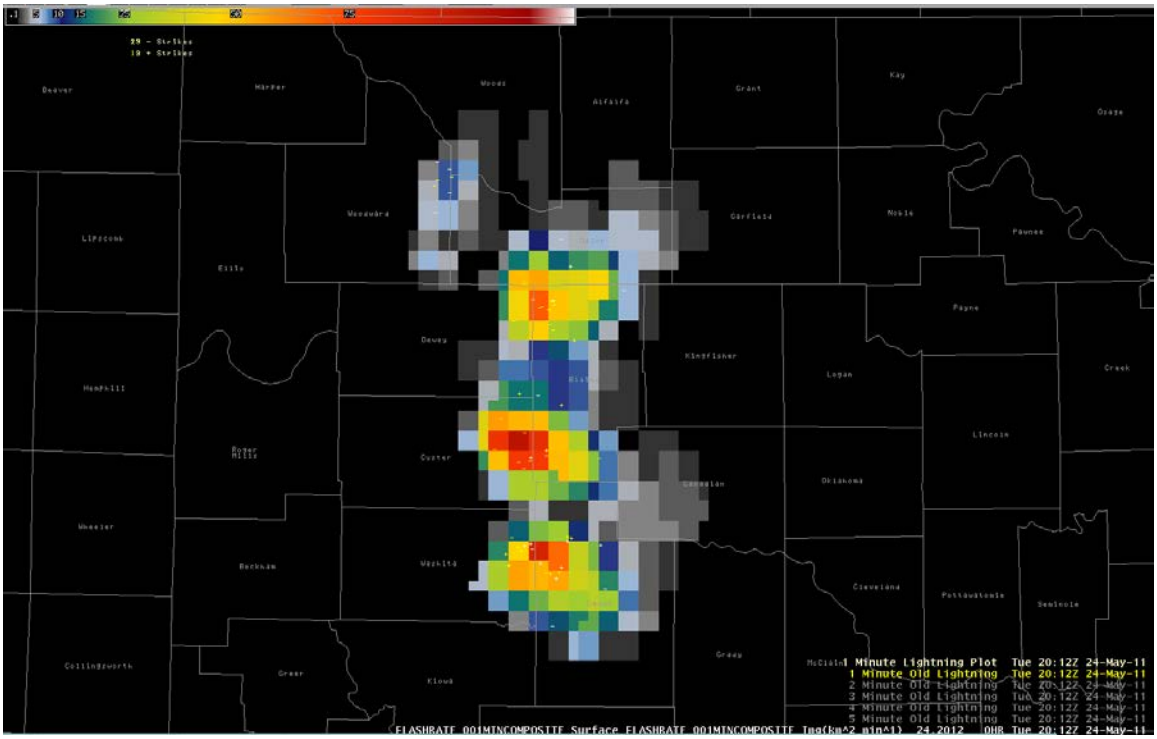

Fig. 3: pGLM (flashes per box per min) and NLDN (+/- locations and polarity) lightning for 1-min period ending 2012 UTC on 24 May 2011.

The LMA networks (as well as the future GLM) detect total lightning (IC and CG) whereas the NLDN by Vaisala detects primarily CG lightning (Cummins et al., 2006). The +/- sign shown within the AWIPS display for the NLDN lighting represents the polarity of the leader connecting with ground (i.e., positive or negative) and the location the leader connected. Any individual CG flash is likely to have horizontal extent within the cloud as well the connection point to ground, this horizontal extent should be detected by the LMA (GLM) and will be displayed in AWIPS as the flash footprint. For every CG flash detected, there are likely to be many other flashes occurring in the storm. In fact, the higher the ratio of total lightning to CG lightning (e.g., 3:1 = 3 IC & 1 CG), the more likely the storm is to be severe (e.g., MacGorman et al.,1989; Carey et al., 2009). Also, as mentioned above, whereas total lightning flash rates are closely tied to the storm's updraft and intensity, CG lightning rates show little to no correlation with severe weather (e.g., Schultz et al., 2011). However, viewing the two together can help give the forecaster a view of the total electrical activity in the storm.

WES Instructions:

1. If AWIPS D2D is not currently open, double-click on the Launch AWIPS D2D icon to start up an AWIPS D2D session.

2. Left click on the D2D clock in the lower-right corner of D2D.

3. Inside the "Set Time" window, set the D2D clock to **2011 May 24 22:55** UTC (don't bother changing the seconds) and check the "Freeze Time at This Position" box.

4. Set the map scale to **WFO**.

5. Set the frame count to **64**.

6. Load the pGLM 1 minute flash density product by doing the following:
    a. Launch the Volume Browser GUI by selecting **Volume → Browser…**
    b. Under the **Edit** dropdown menu, select **Clear All**
    c. Under the Fields section, select **EWP → Lightning (pGLM) → pGLM Flash Rate Density (1 min)**
    d. All other fields will populate, so click the **Load** button at the bottom of the GUI

7. Load the 1 minute lightning sequence plot through the following menu tabs: **Obs →Lightning → 1min Lgtng Seq**. You can de-select the old lightning products in the D2D legend.

8. Step through the dataset and use cursor sampling to get a feel for how these 2 products are displayed together.

Product Set #2: Total Lightning vs. Satellite

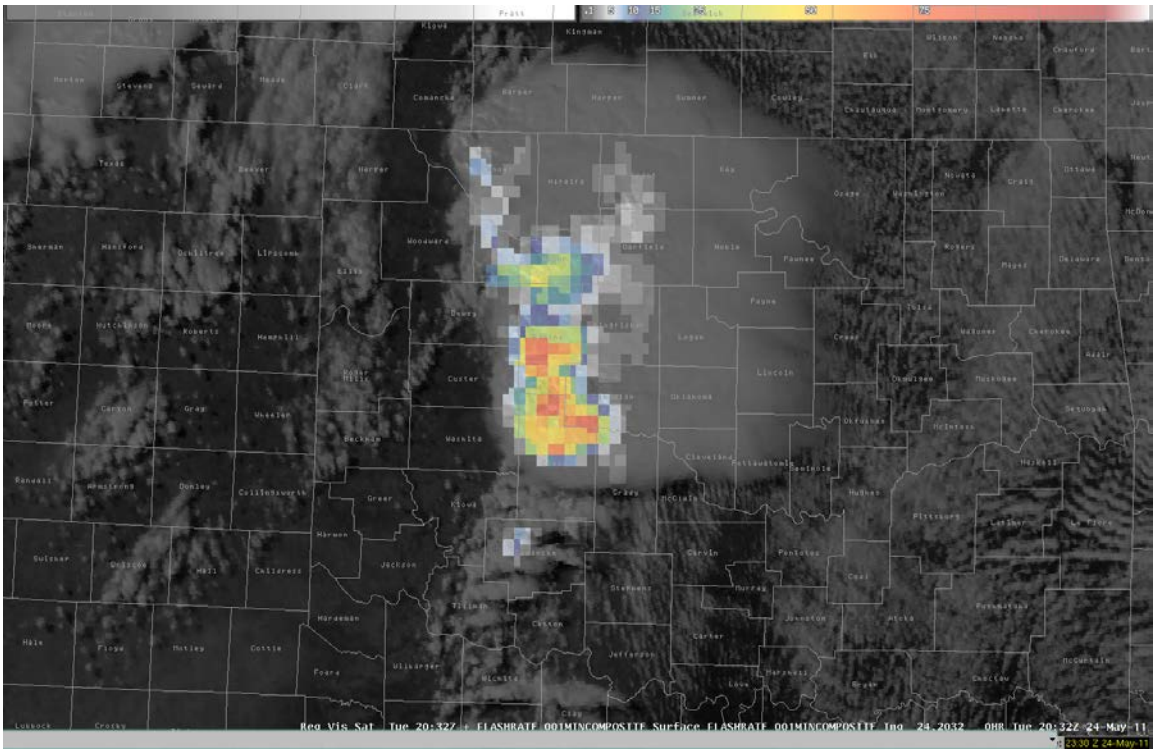

Fig. 4: pGLM (flashes per box per min) and visible satellite imagery from 2032UTC on 24 May 2011.

Combined with other satellite data, total lightning can provide as estimation of the areal extent of electrical activity of the storm, including first lightning relative to convection initiation and anvil lightning. The screenshot below provides a view of visible satellite and pGLM lightning at 2030 UTC within AWIPS. Note the extent of lighting from the northern storms in the anvil over Grant and Garfield Counties as well as the first lightning with the cell in Comanche Co. (Also note the drop of lightning rates in NW Oklahoma – Woods Co., this is not necessarily because the storms are producing fewer lightning flashes, but most likely due to the exponential fall off of detection efficiency with range outside the network domain, see Fig. 1 for domain coverage).

WES Instructions:

1. If AWIPS D2D is not currently open, double-click on the Launch AWIPS D2D icon to start up an AWIPS D2D session.

2. Left click on the D2D clock in the lower-right corner of D2D.

3. Inside the “Set Time” window, set the D2D clock to **2011 May 24 19:45** UTC (don’t bother changing the seconds) and check the “Freeze Time at This Position” box.

4. Set the map scale to **WFO**.

5. Set the frame count to **64**.

6. Load the pGLM 1 minute flash density product by doing the following:
    a. Launch the Volume Browser GUI by selecting **Volume → Browser…**
    b. Under the **Edit** dropdown menu, select **Clear All**
    c. Under the Fields section, select **EWP → Lightning (pGLM) → pGLM Flash Rate Density (1 min)**
    d. All other fields will populate, so click the **Load** button at the bottom of the GUI

7. Load the NLDN lightning and visible satellite product by doing the following:
    a. Select the **Toggle Image Combination** button
    b. Load the visible satellite data through the following tabs: **Satellite → Visible**
    c. Load the 1 minute lightning sequence plot through the following menu tabs: **Obs →Lightning → 1min Lgtng Seq**. You can de-select the old lightning products in the D2D legend.

8. Step through the dataset and answer the following questions:

Question 1: At what time do you see the first evidence of lightning in any of the storms in Oklahoma and in what country does this occur?

Question 2: Using the NLDN data, at what time does the first CG flash occur with this storm?

Product Set #3: Lightning combined with multi-radar MESH and single Radar data

As mentioned previously, due to the strong tie between lightning flash rate and updraft mass flux (and graupel volume), total lightning flash rates can be used to help monitor and diagnosis storm intensity. Figure 5 below shows a possible image combination with pGLM, multi-radar, and single radar products.

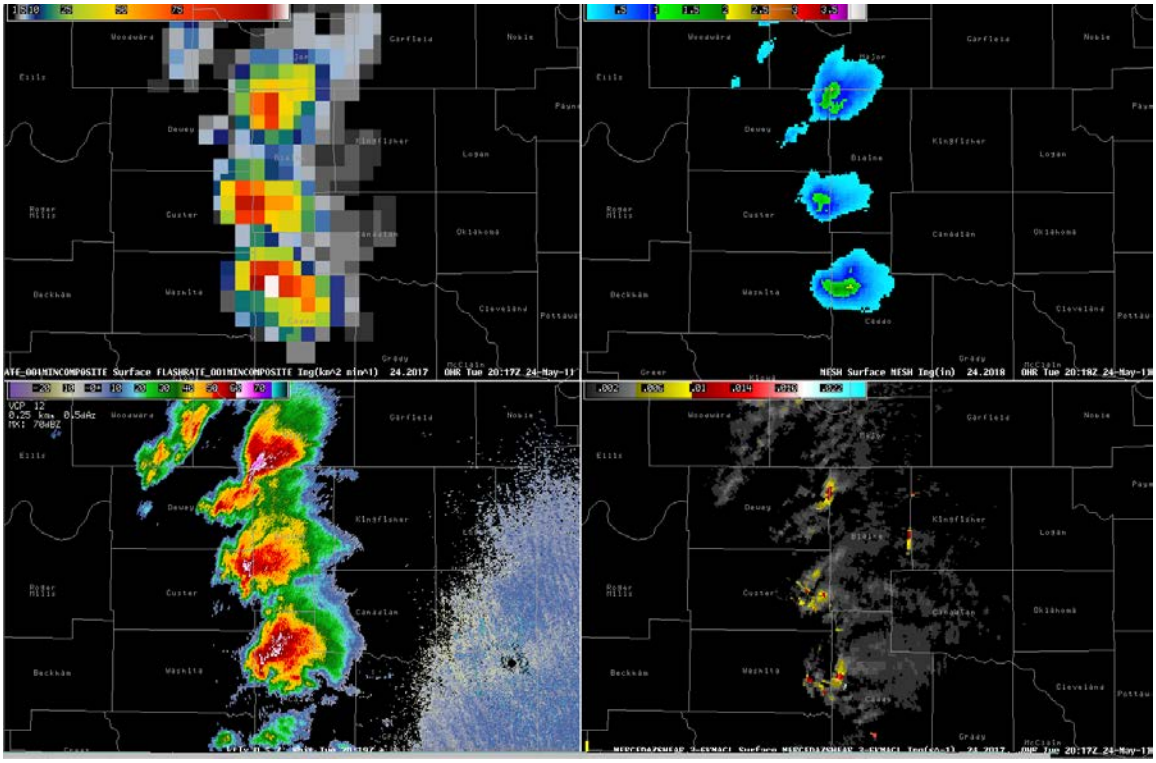

Fig. 5: A 4-panel AWIPS display with pGLM flash rate (upper-left), multi-radar MESH (upper-right), 0.5º reflectivity (lower-left), and multi-radar Azimuthal Shear (lower-right) at 2017UTC on 24 May 2011.

WES Instructions:

1. If AWIPS D2D is not currently open, double-click on the Launch AWIPS D2D icon to start up an AWIPS D2D session.

2. Left click on the D2D clock in the lower-right corner of D2D.

3. Inside the "Set Time" window, set the D2D clock to **2011 May 24 20:25** UTC (don't bother changing the seconds) and check the "Freeze Time at This Position" box.

4. Set the map scale to **WFO**.

5. Set the frame count to **36**.

6. Right-click on the D2D window and select Four Panel Layout.

7. Populate the 4-panel window with the following products:
    a. Upper-Left window – pGLM 1min Flash Rate:
        i. Right-click in the upper-left window and select **Load to this Panel**
        ii. Launch the Volume Browser GUI by selecting **Volume → Browser…**
        iii. Under the **Edit** dropdown menu, select **Clear All**
        iv. Under the Fields section, select **EWP → Lightning (pGLM) → pGLM Flash Rate Density (1 min)**
        v. All other fields will populate, so click the **Load** button at the bottom of the GUI
    b. Upper-Right window – Multi-Radar MESH:
        i. Right-click in the upper-right window and select **Load to this Panel**
        ii. Launch the Volume Browser GUI by selecting **Volume → Browser…**
        iii. Under the **Edit** dropdown menu, select **Clear All**
        iv. Under the Fields section, select **EWP → NSSL MRMS → Multi-Radar MESH**
        v. All other fields will populate, so click the **Load** button at the bottom of the GUI
    c. Lower-Left window – 0.5º Reflectivity from KTLX
        i. Right-click in the lower-left window and select **Load to this Panel**
        ii. Under the **ktlx** D2D menu, select **ktlx Best Res Refl → 0.5 Refl**
    d. Lower-Right window – Multi-Radar Azimuthal Shear:
        i. Right-click in the lower-right window and select **Load to this Panel**
        ii. Launch the Volume Browser GUI by selecting **Volume → Browser…**
        iii. Under the **Edit** dropdown menu, select **Clear All**
        iv. Under the Fields section, select **EWP → NSSL MRMS → 3-6km AGL Az Shear**
        v. All other fields will populate, so click the **Load** button at the bottom of the GUI

8. Move back in time to 2017 UTC and answer the following questions below:

Question 3: What is the maximum flash rate seen at this time?

Question 4: What is the maximum MESH value at the location of the maximum flash rate?

Product Set #4: Tracks of Maximum Flash Rate

1 hr and 2 hr tracks of maximum flash rate are also available within this training case & in the HWT in AWIPS2. These tracks can be used to examine historical intensity (trends) of the storm by evaluating if the flash rate increasing, decreasing, or remaining constant. Figure 6 below shows a comparison of 2-hour maximum flash rate and MESH tracks.

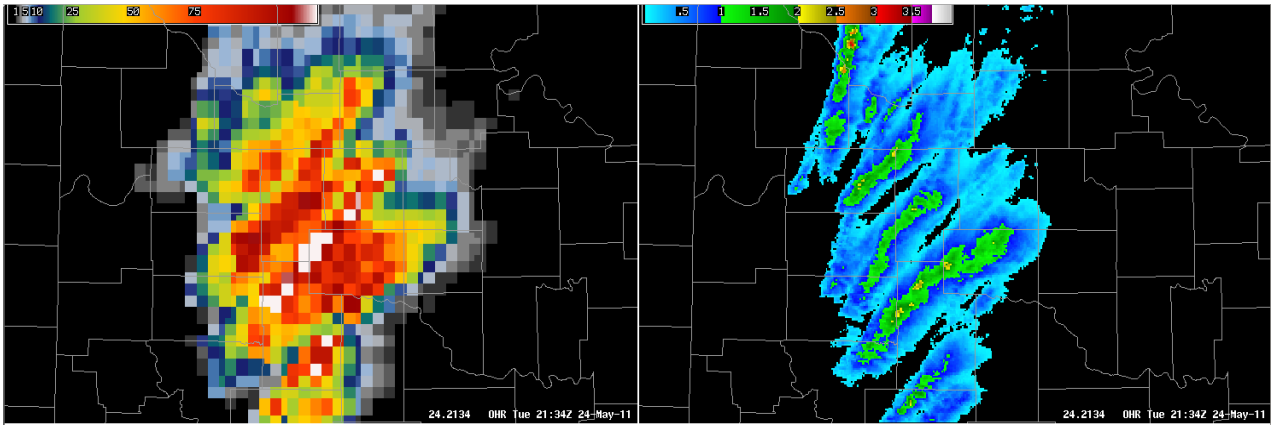

Fig. 6: A comparison between 120-minute pGLM maximum flash rate (left) and 120 minute multi-radar MESH (right) at 2134UTC on 24 May 2011.

Note that the peak regions of flash rate should mirror the track of the main updraft core (you may also want to compare the lightning data to the 3DVAR data available from NSSL such as the updraft and vorticity tracks).

It is also possible to combine the 60 min flash rate track with the 1 hr of NLDN CG locations (Figure 7). During this window, you can also see the drop off in detection efficiency by the LMA (flash rate density) with range from the network center in NW Grady County. Within 150 km of the center there is little effect, but outside begins a close to exponential drop off; this will not be an issue with actual GLM data.

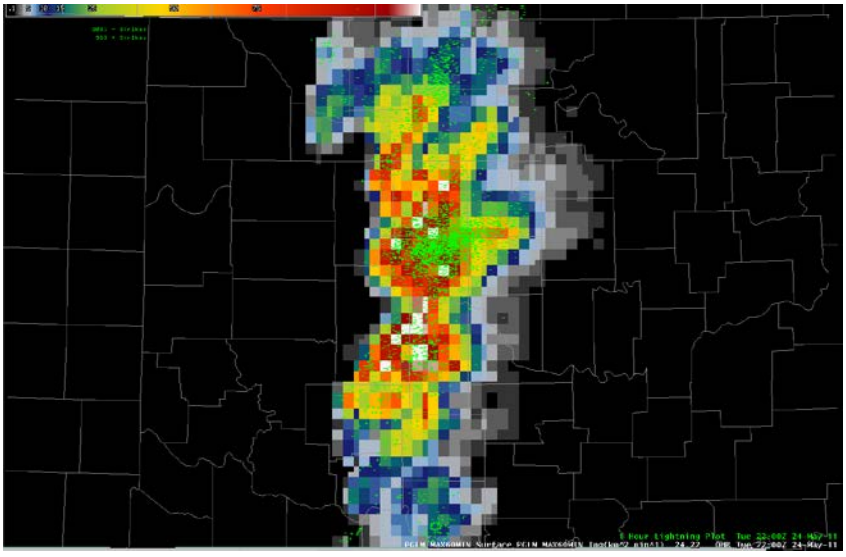

Fig. 7: A display of 60-minute pGLM maximum flash rate and the 1-hour NLDN lightning plot at 2200UTC on 24 May 2011.

WES Instructions:

Comparing pGLM tracks to multi-radar MESH tracks

1. If AWIPS D2D is not currently open, double-click on the Launch AWIPS D2D icon to start up an AWIPS D2D session.

2. Left click on the D2D clock in the lower-right corner of D2D.

3. Inside the "Set Time" window, set the D2D clock to **2011 May 24 22:00** UTC (don't bother changing the seconds) and check the "Freeze Time at This Position" box.

4. Set the map scale to **WFO**.

5. Set the frame count to **36**.

6. Right-click on the D2D window and select Four Panel Layout.

7. Populate the 4-panel window with the following products:
    a. Upper-Left window – pGLM 120min Flash Rate:
        i. Right-click in the upper-left window and select **Load to this Panel**
        ii. Launch the Volume Browser GUI by selecting **Volume → Browser…**
        iii. Under the **Edit** dropdown menu, select **Clear All**
        iv. Under the Fields section, select **EWP → Lightning (pGLM) → pGLM Max Density Track (120 min)**
        v. All other fields will populate, so click the **Load** button at the bottom of the GUI
    b. Upper-Right window – Multi-Radar MESH 2-hour Track:
        i. Right-click in the upper-right window and select **Load to this Panel**
        ii. Launch the Volume Browser GUI by selecting **Volume → Browser…**
        iii. Under the **Edit** dropdown menu, select **Clear All**
        iv. Under the Fields section, select **EWP → NSSL MRMS → MESH 2hr Swath**
        v. All other fields will populate, so click the **Load** button at the bottom of the GUI

Combining pGLM tracks to NLDN 1-hour data

1. If AWIPS D2D is not currently open, double-click on the Launch AWIPS D2D icon to start up an AWIPS D2D session.

2. Left click on the D2D clock in the lower-right corner of D2D.

3. Inside the "Set Time" window, set the D2D clock to **2011 May 24 22:00** UTC (don't bother changing the seconds) and check the "Freeze Time at This Position" box.

4. Set the map scale to **WFO**.

5. Set the frame count to **36**.

6. Load the pGLM 1 minute flash density product by doing the following:
    a. Launch the Volume Browser GUI by selecting **Volume → Browser…**
    b. Under the **Edit** dropdown menu, select **Clear All**
    c. Under the Fields section, select **EWP → Lightning (pGLM) → pGLM Max Density Track (120 min)**
    d. All other fields will populate, so click the **Load** button at the bottom of the GUI

7. Load the 1 minute lightning sequence plot through the following menu tabs: **Obs →Lightning → 1hr Lgtng Plot**.

References:

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Wiens, K. C., S. A. Rutledge, and S. A. Tessendorf, 2005: The 29 June 2000 supercell observed during STEPS. Part II: Lightning and charge structure. *J. Atmos. Sci.*, 62, 4151–4177, doi: 10.1175/JAS3615.1.