TEXAS TECH UNIVERSITY™

West Texas LMA

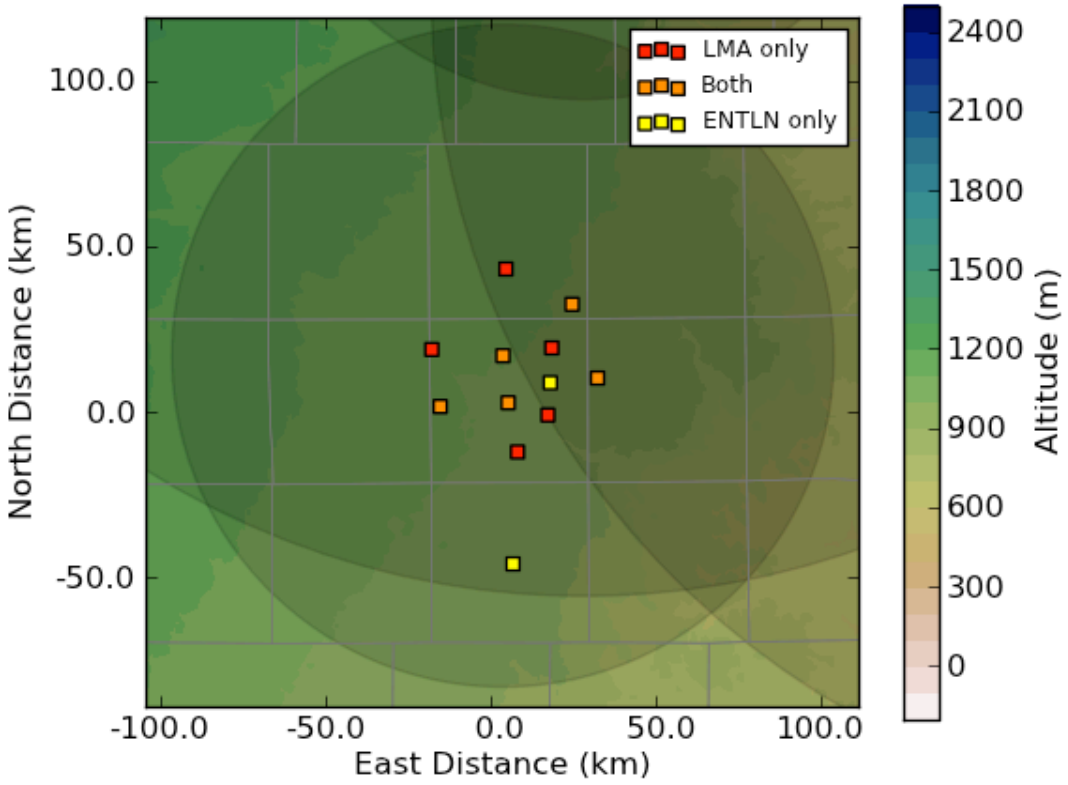
Operational and Research Use

Eric Bruning
TTU Department of Geosciences
Atmospheric Science Group

Contributors: Vanna Sullivan, Steve Cobb, Jason Jordan, Jody James, Joe Jurecka, Camaron Plourde, Jonathan Hart, Jennifer Daniel, Stephanie Weiss, Jerry Guynes, Paul Krehbiel, Bill Rison, Ron Thomas,

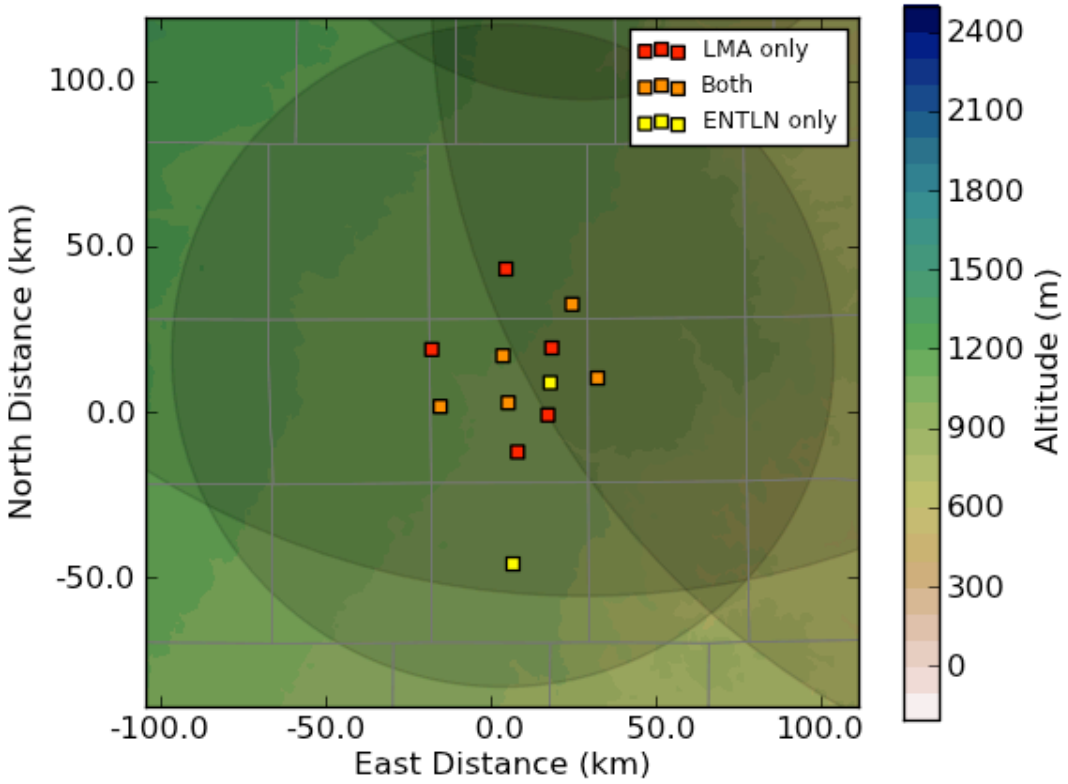
GLM Science Meeting, Huntsville, AL
24-26 September, 2013

West Texas LMA



West Texas LMA

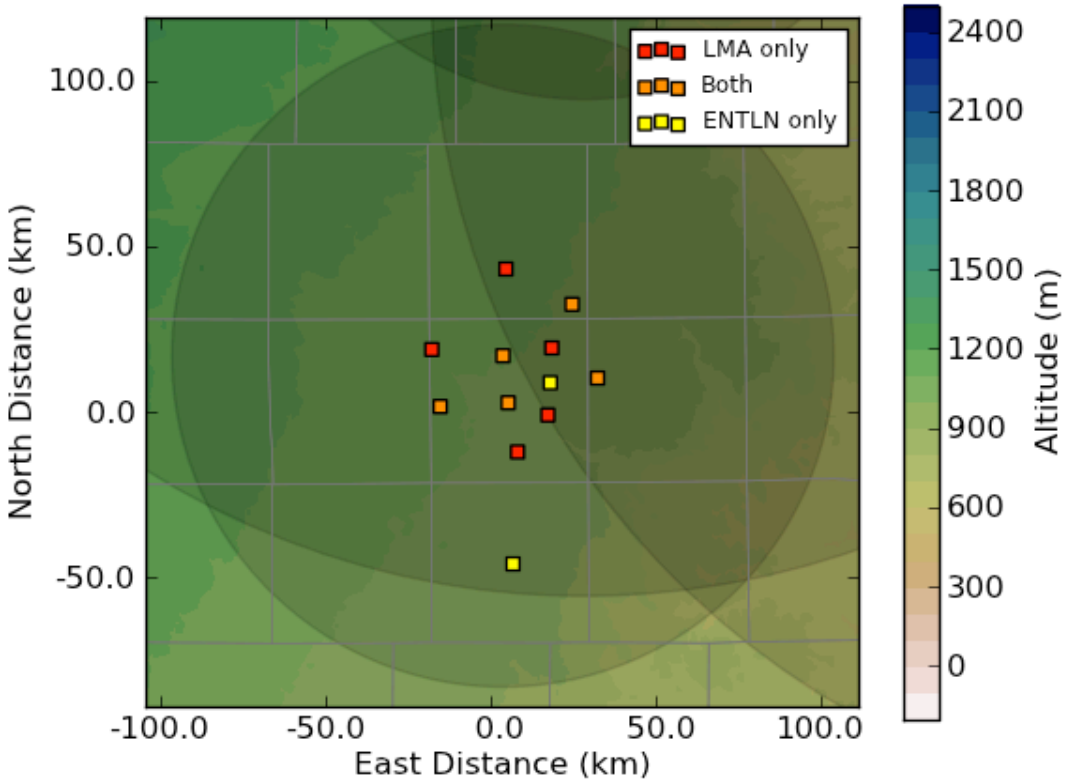
10 stations
(red, orange squares)



West Texas LMA

10 stations
(red, orange squares)

Real-time data (LDM, NMT LiveLMA) to
NWS LUB (and nearby offices), NOAA HWT, NASA SPoRT

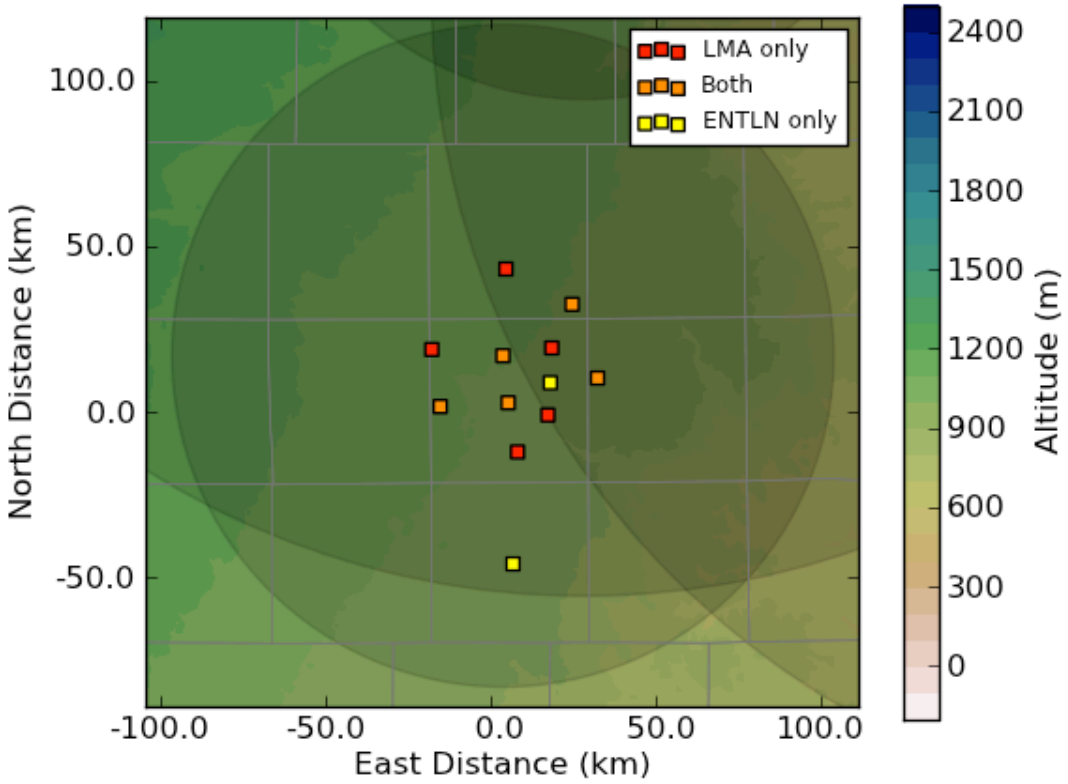


West Texas LMA

10 stations
(red, orange squares)

Real-time data (LDM, NMT LiveLMA) to
NWS LUB (and nearby offices), NOAA HWT, NASA SPoRT

Upgrades during Summer 2013



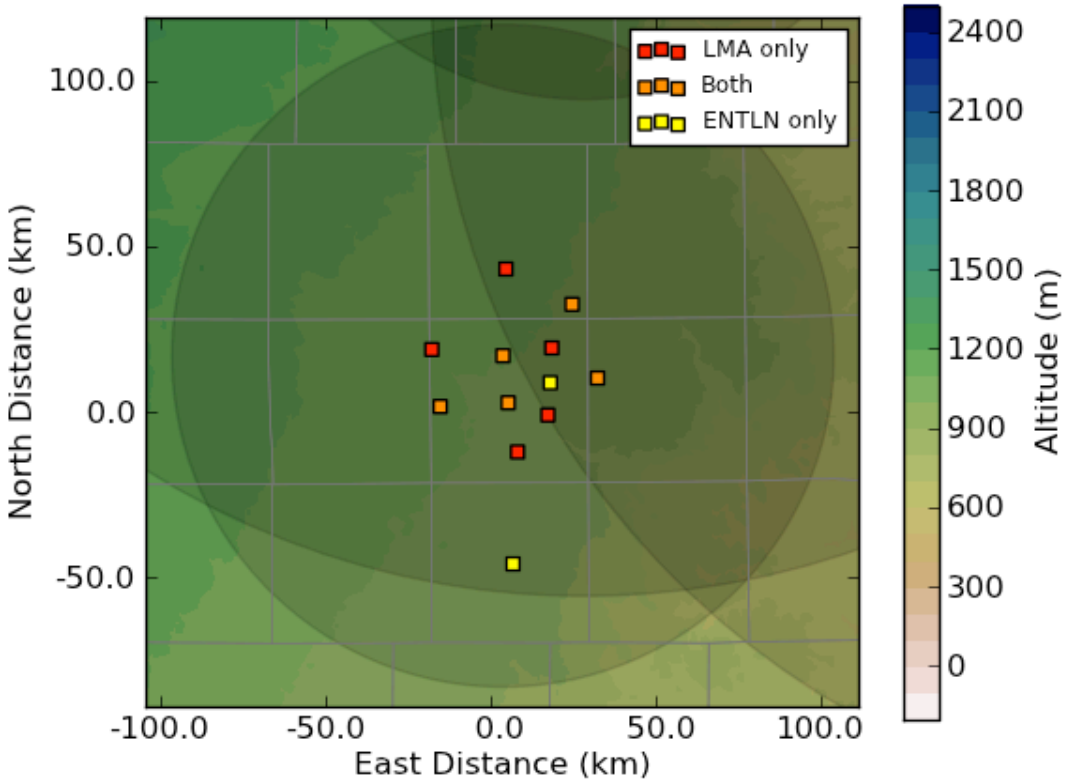
West Texas LMA

10 stations
(red, orange squares)

Real-time data (LDM, NMT LiveLMA) to
NWS LUB (and nearby offices), NOAA HWT, NASA SPoRT

Upgrades during Summer 2013

- New filtered power connectors: increased sensitivity



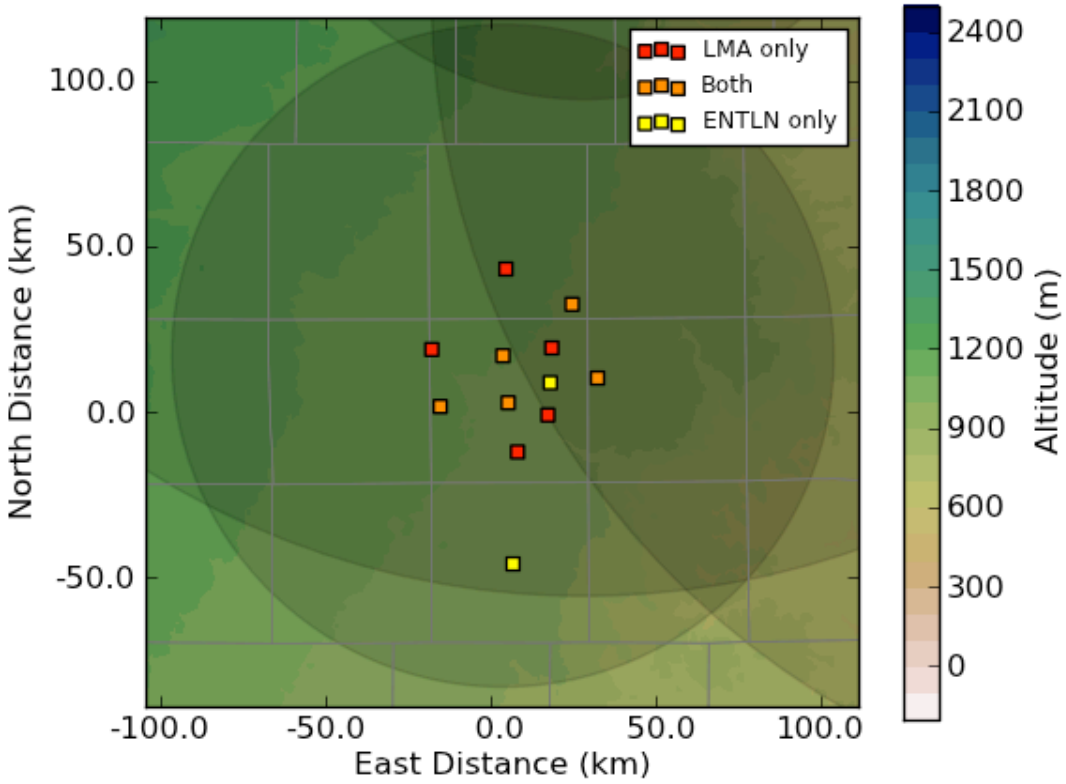
West Texas LMA

10 stations
(red, orange squares)

Real-time data (LDM, NMT LiveLMA) to
NWS LUB (and nearby offices), NOAA HWT, NASA SPoRT

Upgrades during Summer 2013

- New filtered power connectors: increased sensitivity
- Earth Networks Total Lightning sensors
  (orange, yellow)



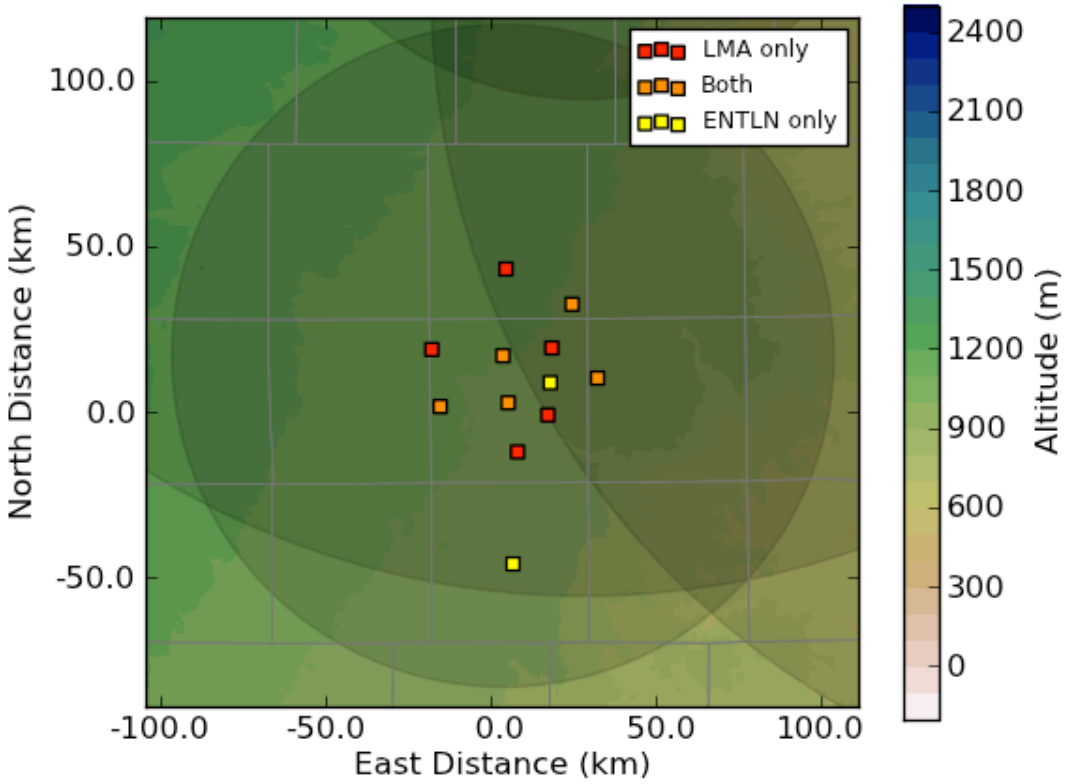
West Texas LMA

10 stations
(red, orange squares)

Real-time data (LDM, NMT LiveLMA) to
NWS LUB (and nearby offices), NOAA HWT, NASA SPoRT

Upgrades during Summer 2013

- New filtered power connectors: increased sensitivity
- Earth Networks Total Lightning sensors
  (orange, yellow)
  - 7 installed



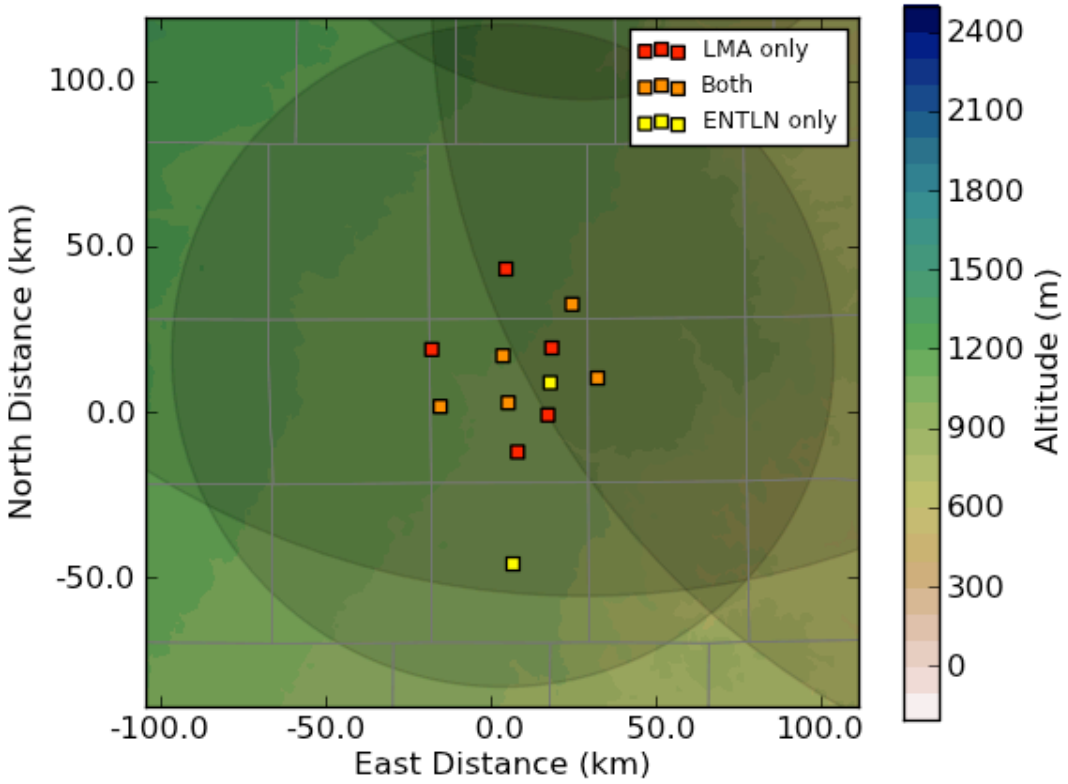
West Texas LMA

10 stations
(red, orange squares)

Real-time data (LDM, NMT LiveLMA) to
NWS LUB (and nearby offices), NOAA HWT, NASA SPoRT

Upgrades during Summer 2013

- New filtered power connectors: increased sensitivity
- Earth Networks Total Lightning sensors
  (orange, yellow)
  - 7 installed
  - 6 more to go



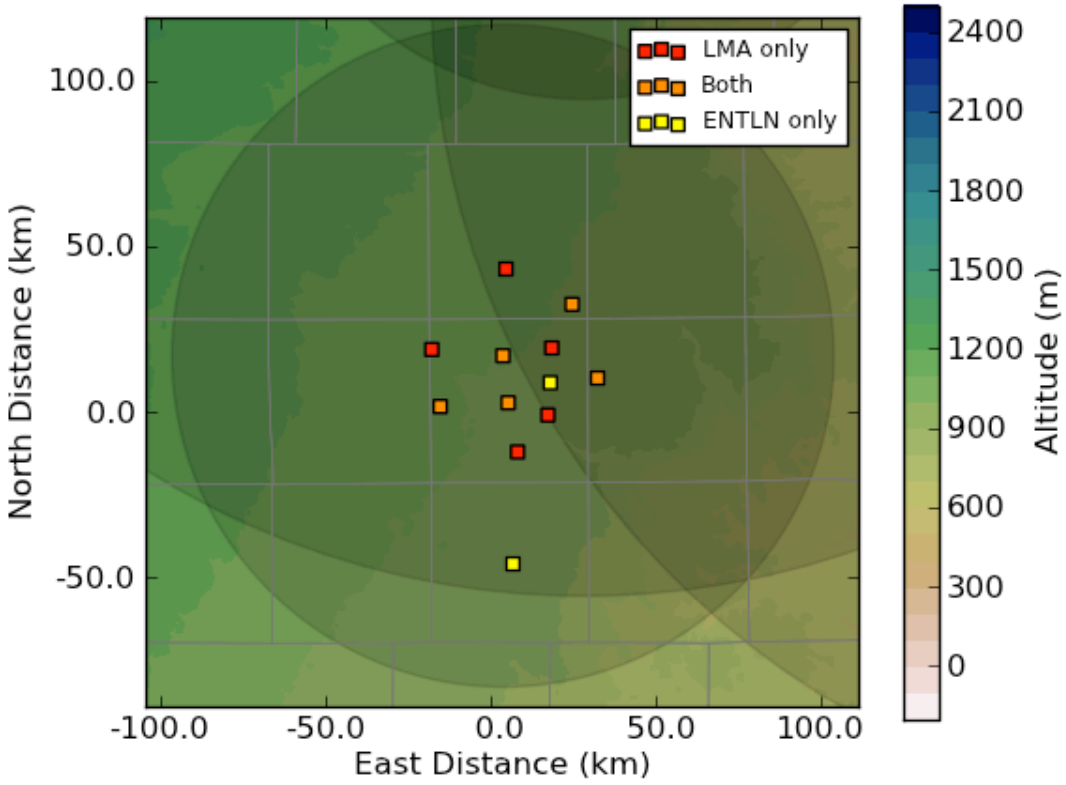
West Texas LMA

10 stations
(red, orange squares)

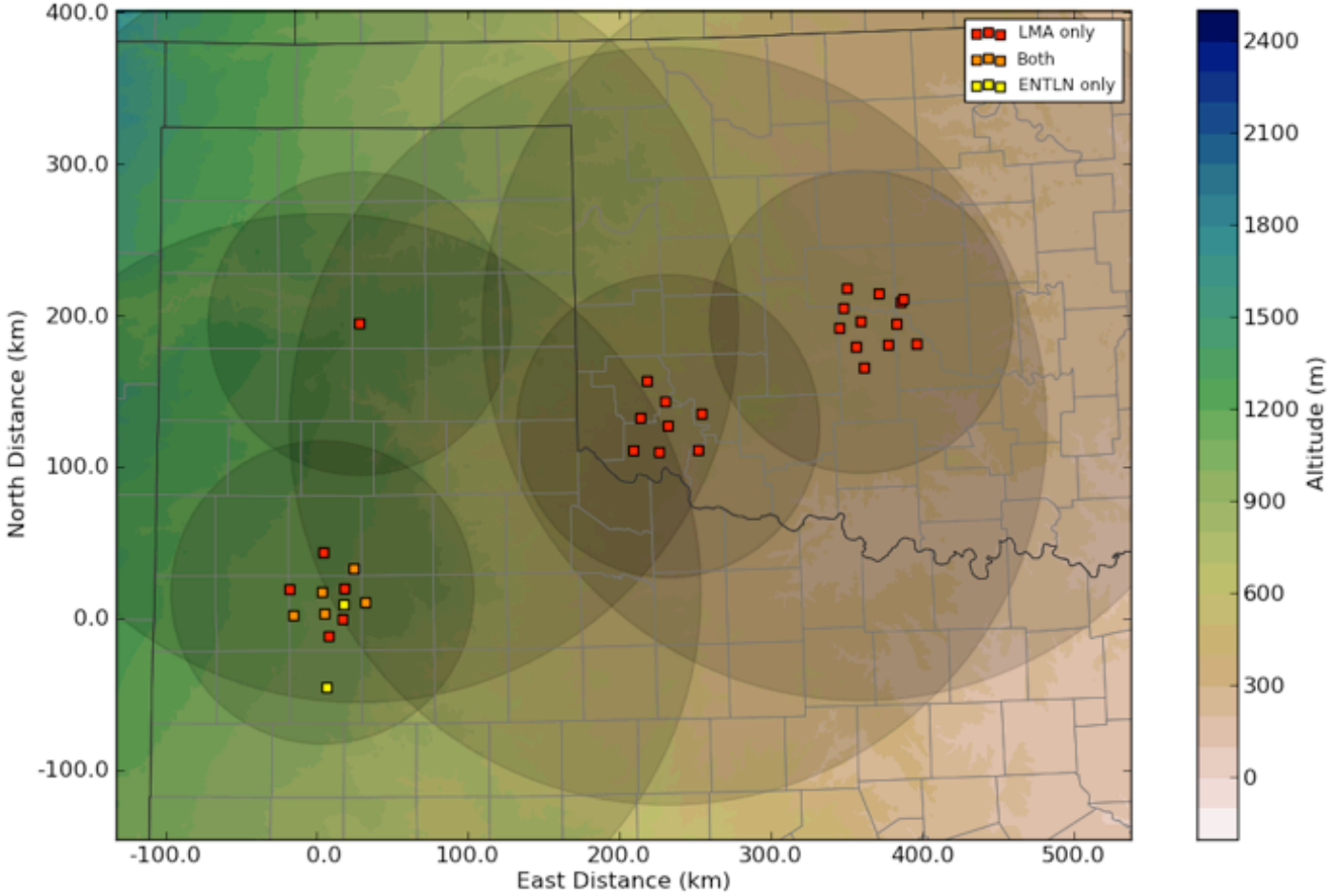
Real-time data (LDM, NMT LiveLMA) to
NWS LUB (and nearby offices), NOAA HWT, NASA SPoRT

Upgrades during Summer 2013

- New filtered power connectors: increased sensitivity
- Earth Networks Total Lightning sensors
  (orange, yellow)
  - 7 installed
  - 6 more to go
  - Should be useful for detailed validation studies, especially with broadband waveform data

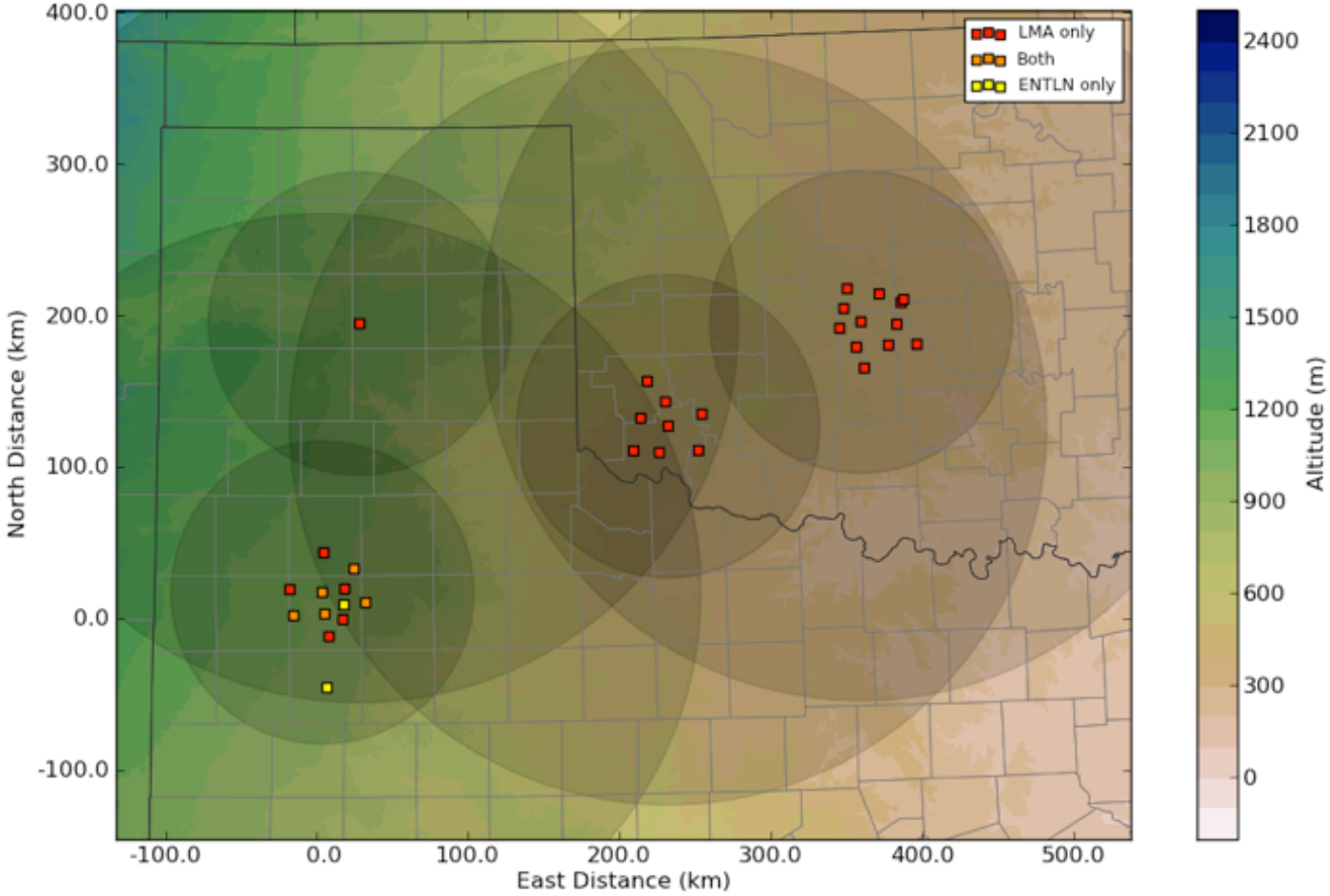


West Texas LMA: Regional Links



West Texas LMA: Regional Links

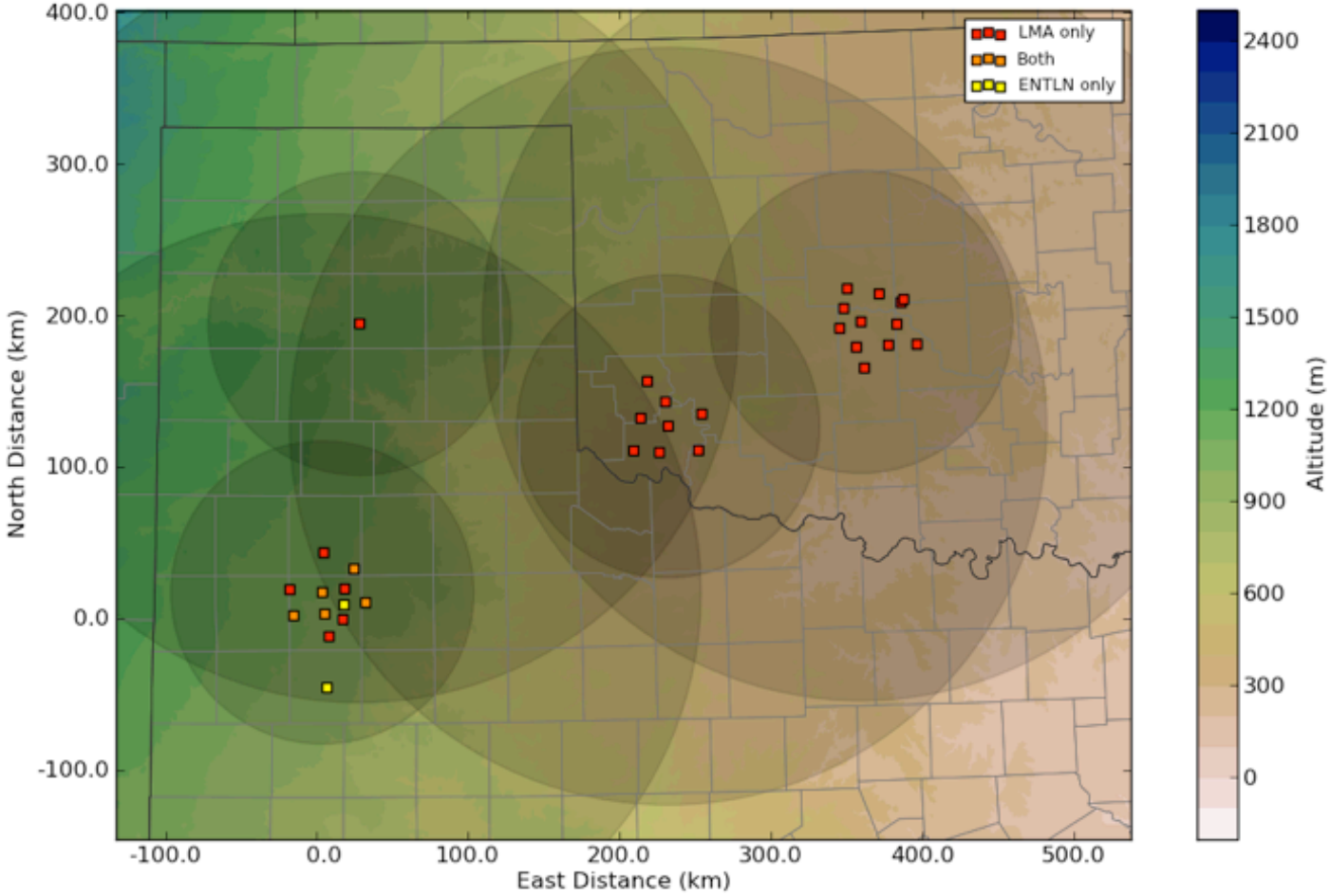
Overlaps with OKLMA coverage



West Texas LMA: Regional Links

Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

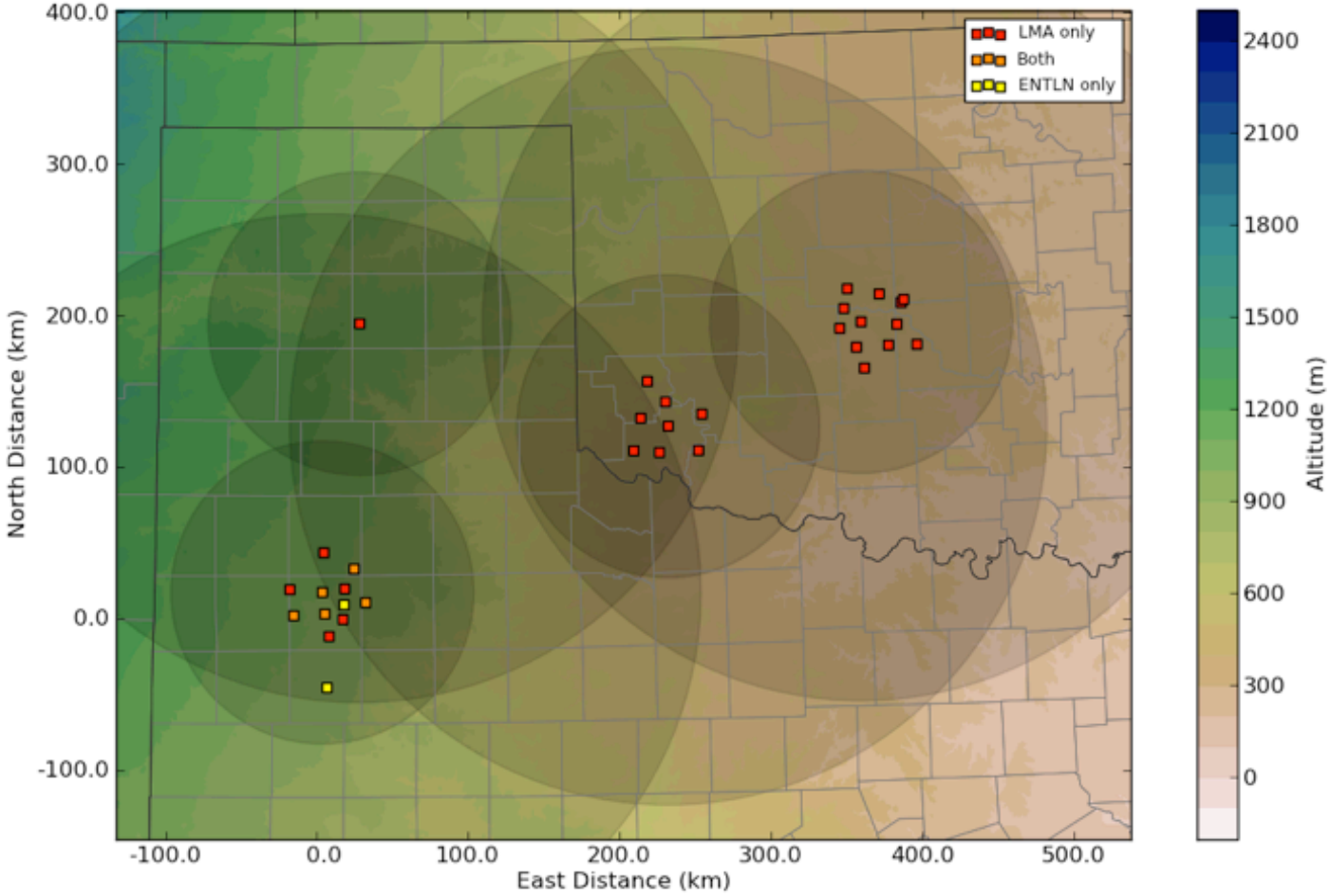


West Texas LMA: Regional Links

Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations

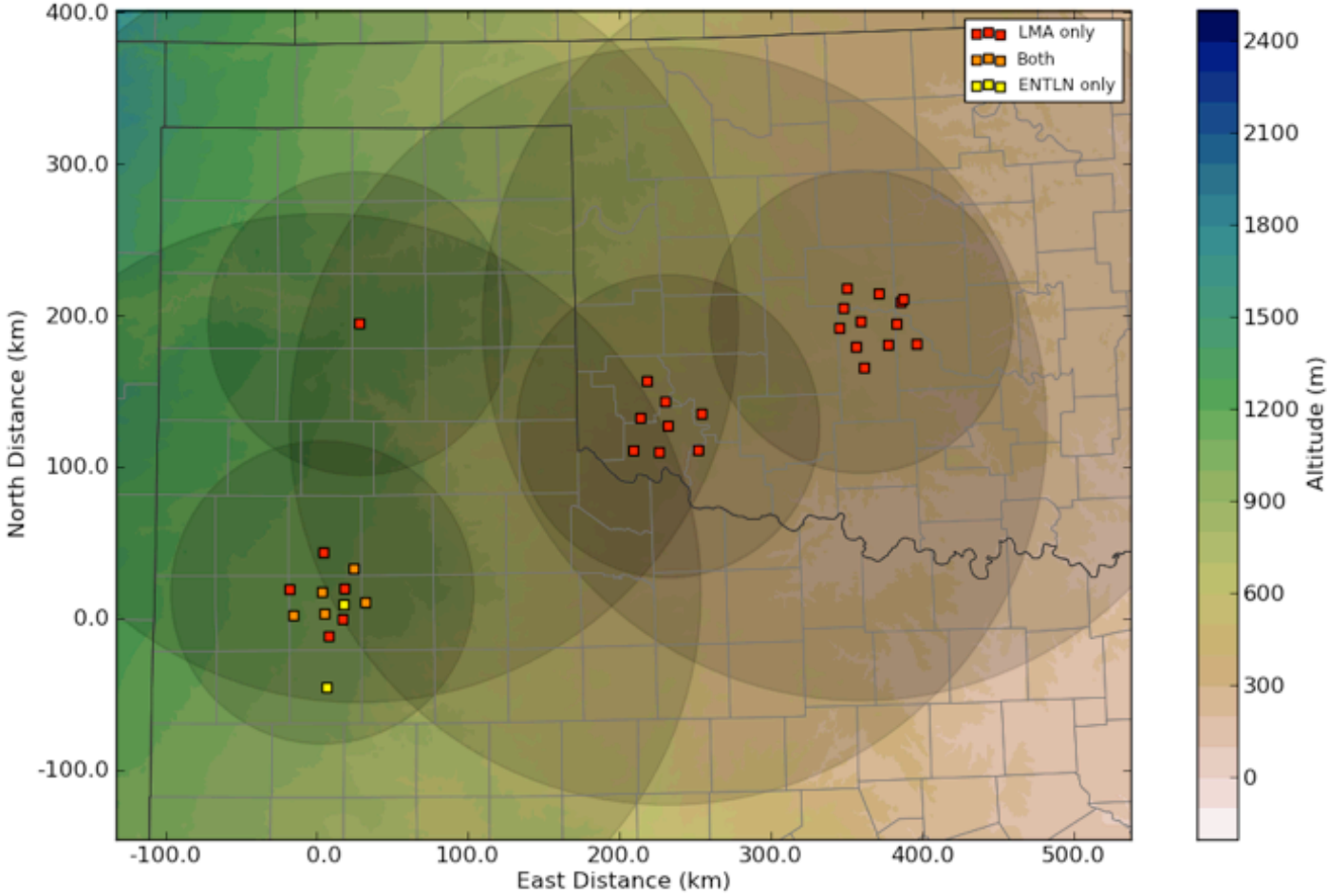


West Texas LMA: Regional Links

Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations
- Expected operations in late 2014

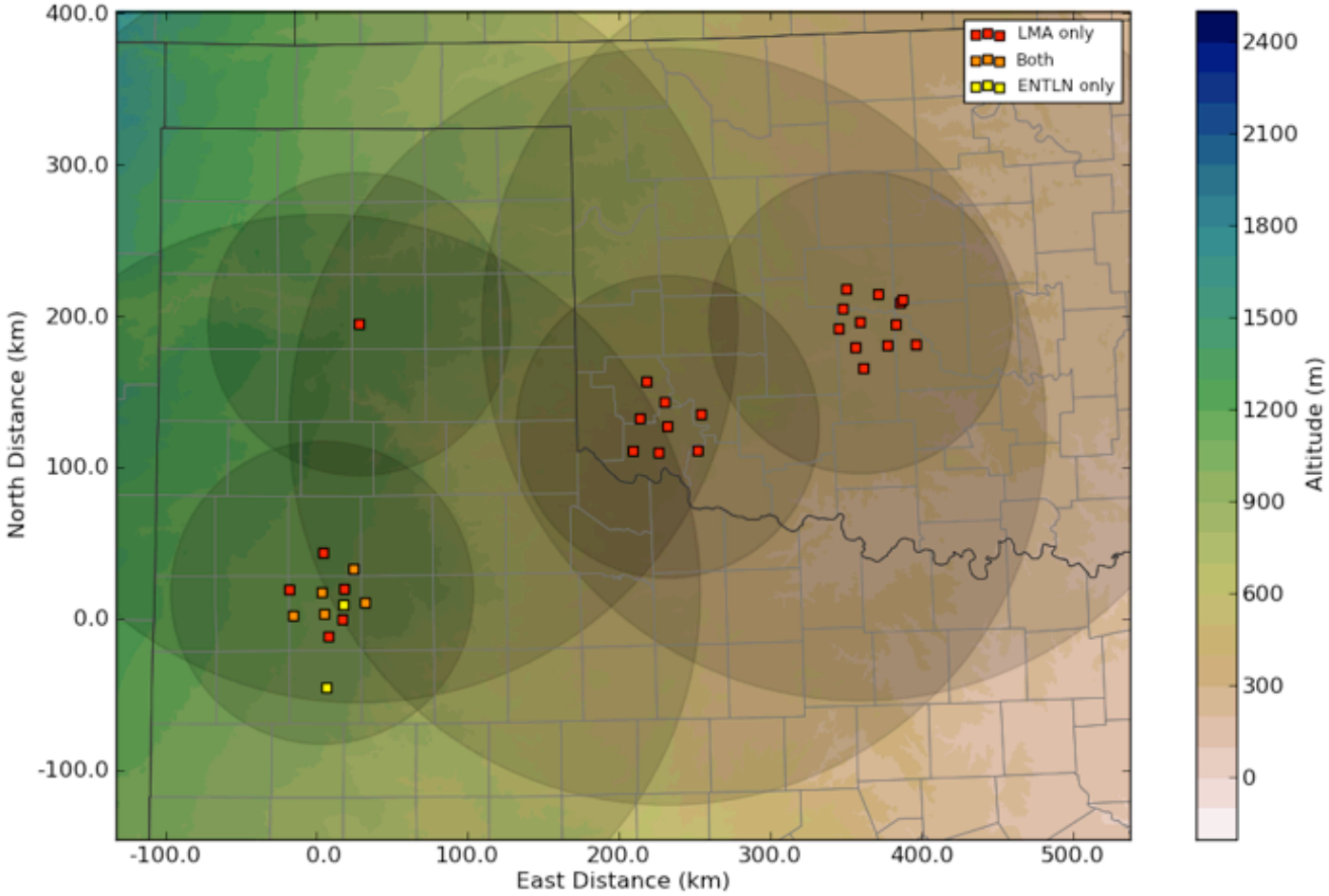


West Texas LMA: Regional Links

Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations
- Expected operations in late 2014
- Operated by Pantex outside the plant's network firewall

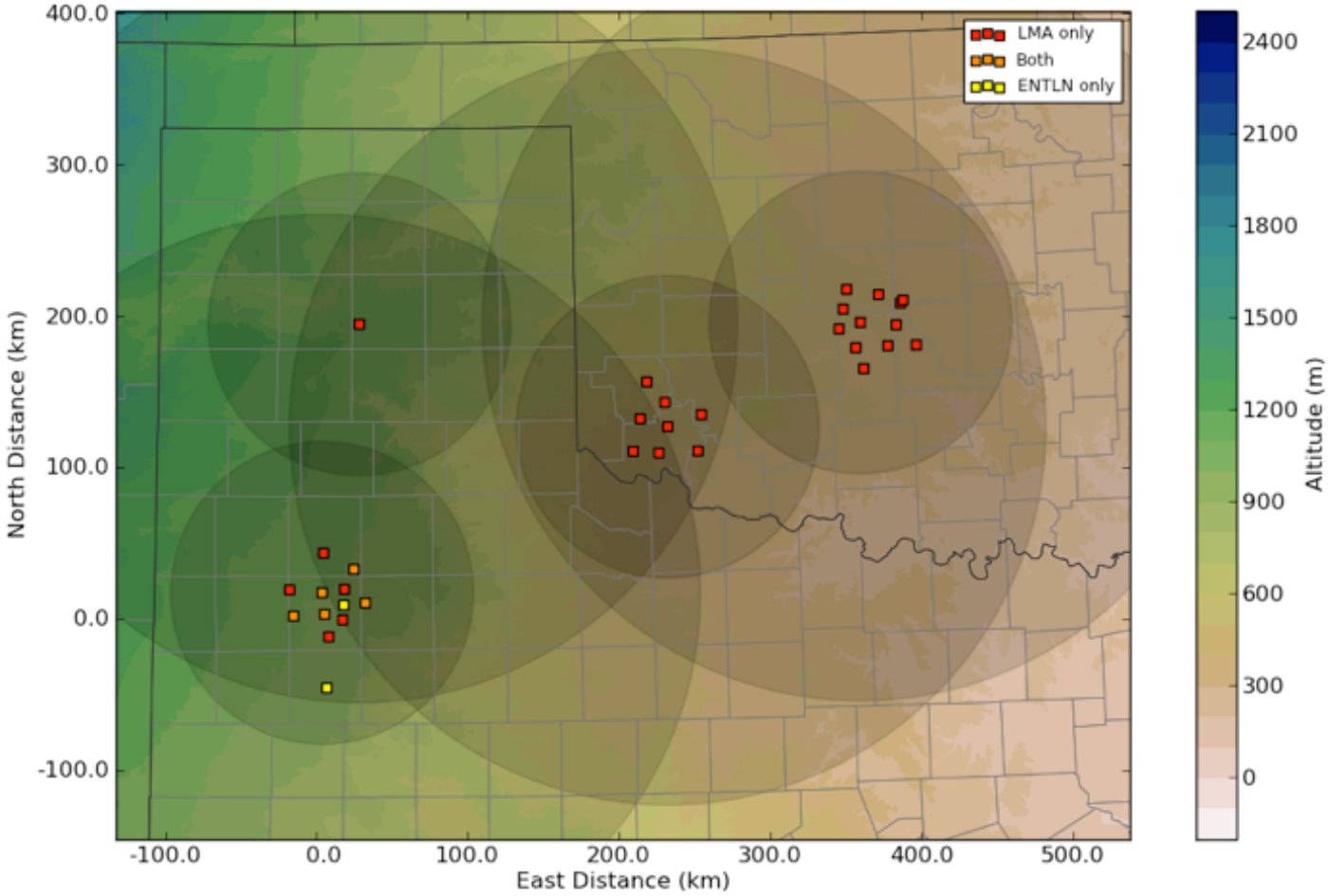


West Texas LMA: Regional Links

Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations
- Expected operations in late 2014
- Operated by Pantex outside the plant's network firewall
  - Should enable sharing of data

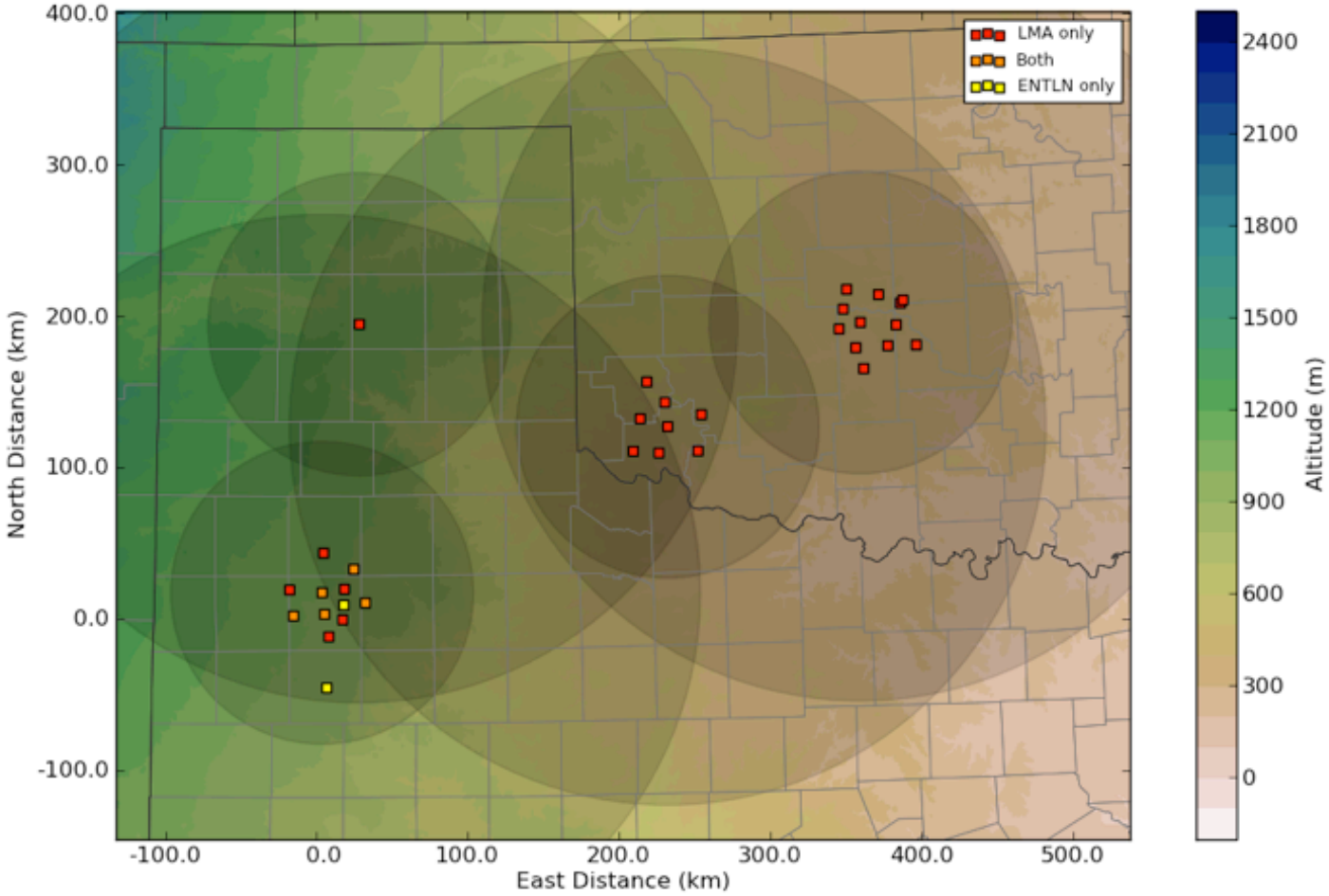


West Texas LMA: Regional Links

Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations
- Expected operations in late 2014
- Operated by Pantex outside the plant's network firewall
  - Should enable sharing of data
- NWS Amarillo



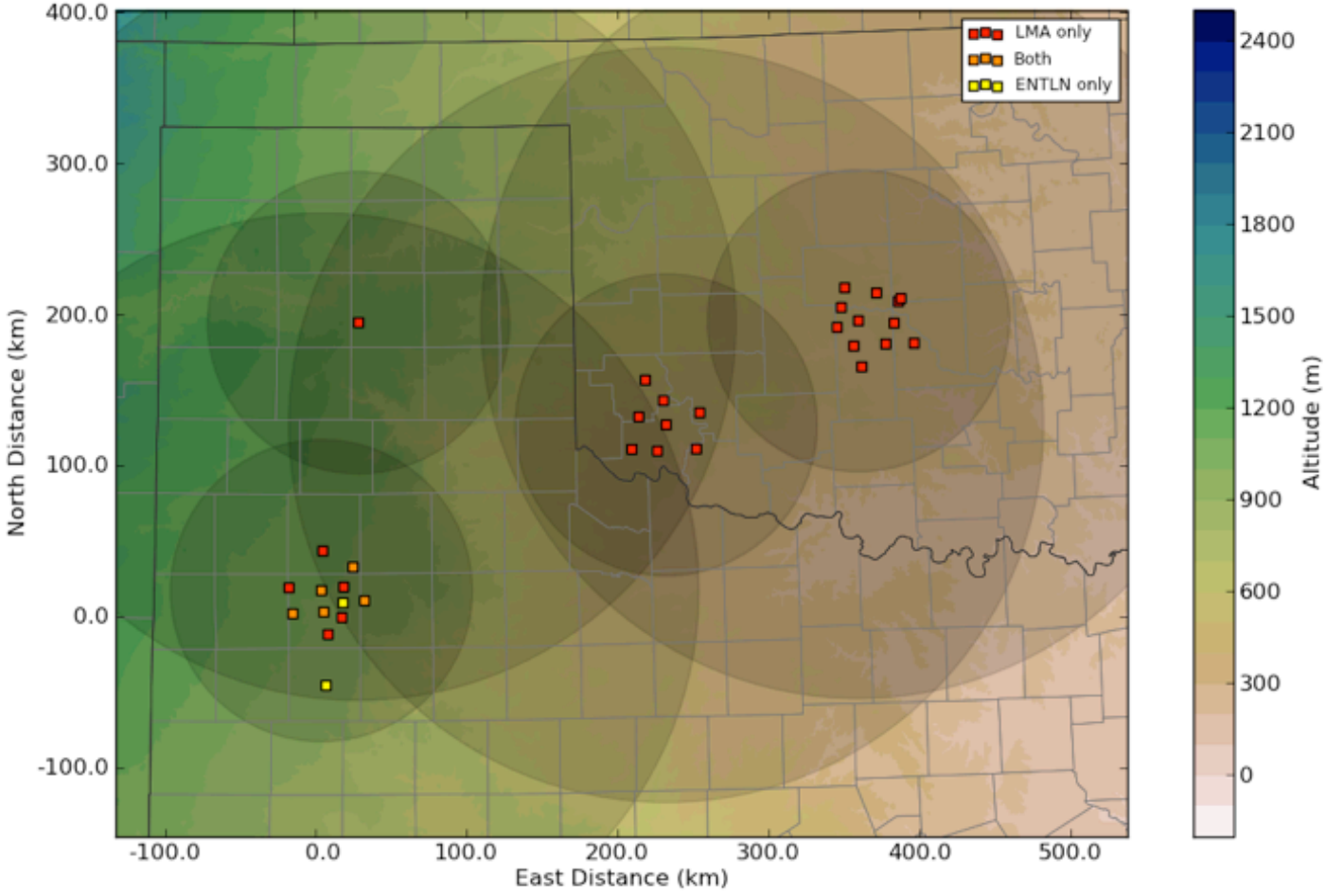
West Texas LMA: Regional Links

Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations
- Expected operations in late 2014
- Operated by Pantex outside the plant's network firewall
  - Should enable sharing of data
- NWS Amarillo

Other local sensors



West Texas LMA: Regional Links

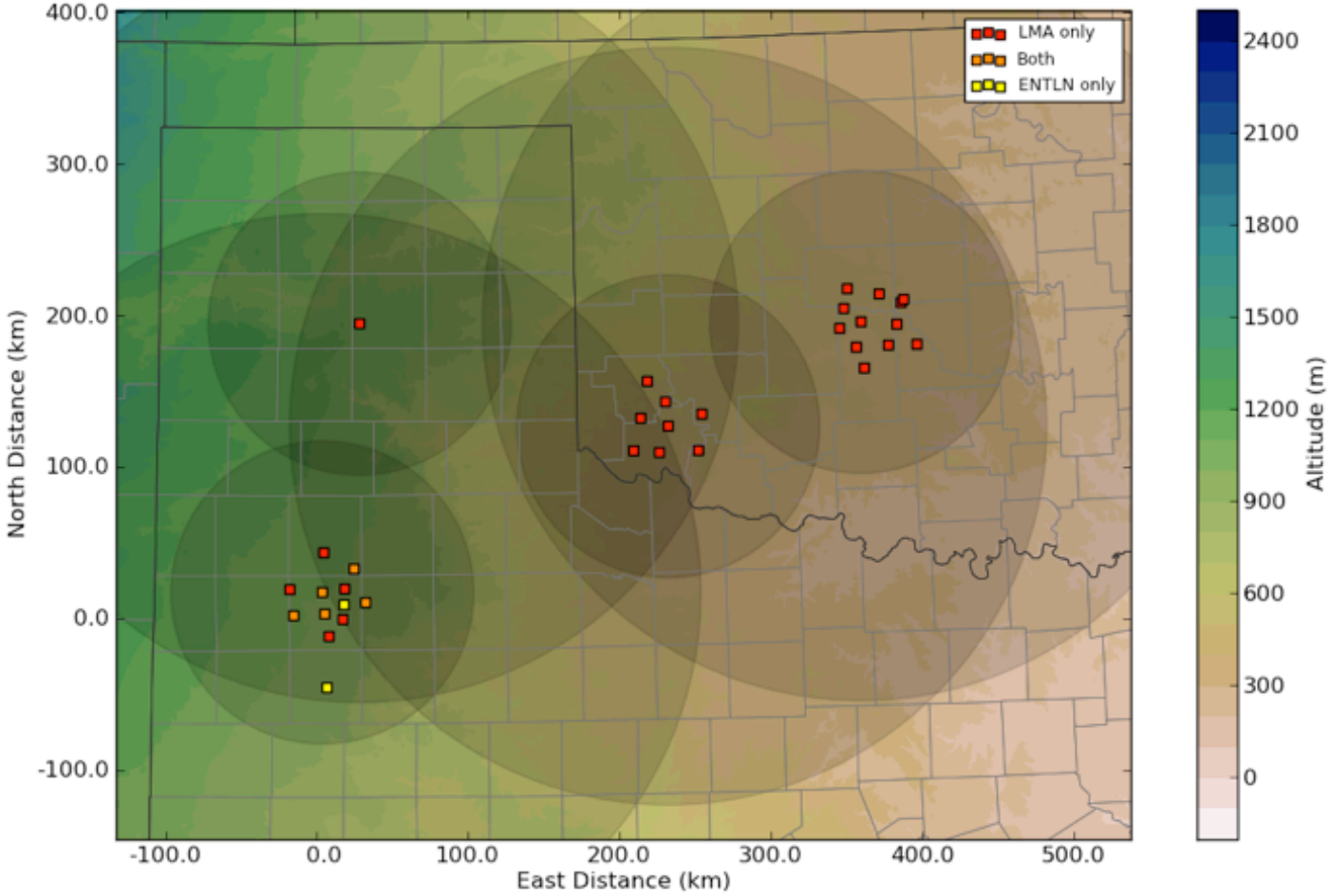
Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations
- Expected operations in late 2014
- Operated by Pantex outside the plant's network firewall
  - Should enable sharing of data
- NWS Amarillo

Other local sensors

- LASA



West Texas LMA: Regional Links

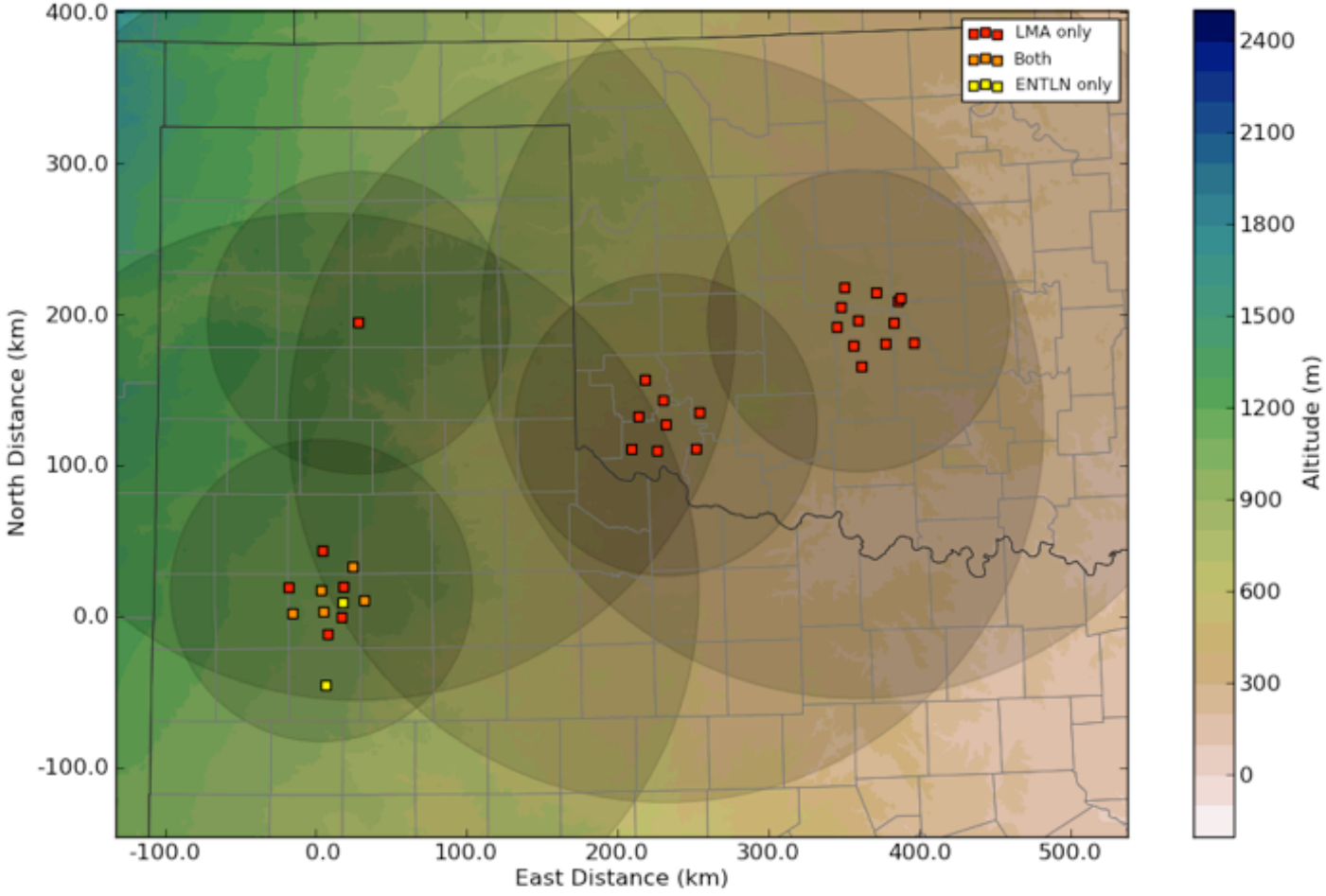
Overlaps with OKLMA coverage

New network near Amarillo, operated by Pantex

- 8 stations
- Expected operations in late 2014
- Operated by Pantex outside the plant's network firewall
  - Should enable sharing of data
- NWS Amarillo

Other local sensors

- LASA
- Duke Univ. sprite camera; LF/CMC



LUBBOCK FORECAST OFFICE INTERACTION

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have
    - Always current LiveLMA data (1 s latency) has been a favorite feature;

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have
    - Always current LiveLMA data (1 s latency) has been a favorite feature;
      Complicated display hasn't been an issue with training

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have
    - Always current LiveLMA data (1 s latency) has been a favorite feature;
      Complicated display hasn't been an issue with training
  - *Continued use of typical local flash size to monitor convective state*

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have
    - Always current LiveLMA data (1 s latency) has been a favorite feature;
      Complicated display hasn't been an issue with training
  - *Continued use of typical local flash size to monitor convective state*
    - Convective vs. stratiform

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have
    - Always current LiveLMA data (1 s latency) has been a favorite feature;
      Complicated display hasn't been an issue with training
  - *Continued use of typical local flash size to monitor convective state*
    - Convective vs. stratiform
    - Active / growing convection vs. "softening," less-forced updrafts

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have
    - Always current LiveLMA data (1 s latency) has been a favorite feature;
      Complicated display hasn't been an issue with training
  - *Continued use of typical local flash size to monitor convective state*
    - Convective vs. stratiform
    - Active / growing convection vs. "softening," less-forced updrafts
    - Adds confidence in marginal warning continuance situations

LUBBOCK FORECAST OFFICE INTERACTION

- Continued use of WTLMA data in operations
  - *Builds on implementation training efforts reported last year*
  - *Display*
    - Last year: reported AWIPS II ingest / display of NOAA HWT products
      Ready and awaiting rollout for office-wide use in operations
      Loops and direct cross-sensor comparison will be good to have
    - Always current LiveLMA data (1 s latency) has been a favorite feature;
      Complicated display hasn't been an issue with training
  - *Continued use of typical local flash size to monitor convective state*
    - Convective vs. stratiform
    - Active / growing convection vs. "softening," less-forced updrafts
    - Adds confidence in marginal warning continuance situations
  - *Decision support remains a major use of WTLMA data*

Operational successes: Football Operations

Operational successes: Football Operations

- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock

Operational successes: Football Operations

- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock
  - *All parties prepared to minimize weather impacts*

Operational successes: Football Operations

- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock
  - *All parties prepared to minimize weather impacts*
  - *Athletics had prepared draft call-to-action for Public Address*

Operational successes: Football Operations

- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock
  - *All parties prepared to minimize weather impacts*
  - *Athletics had prepared draft call-to-action for Public Address*
  - *Thresholds for notice (15 mi), action (6 mi), resumption (30 min)*

Operational successes: Football Operations

- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock
  - *All parties prepared to minimize weather impacts*
  - *Athletics had prepared draft call-to-action for Public Address*
  - *Thresholds for notice (15 mi), action (6 mi), resumption (30 min)*
- Lightning during TTU vs. SFA kickoff, Sep. 7, 2013, 6 pm

Operational successes: Football Operations

- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock
  - *All parties prepared to minimize weather impacts*
  - *Athletics had prepared draft call-to-action for Public Address*
  - *Thresholds for notice (15 mi), action (6 mi), resumption (30 min)*
- Lightning during TTU vs. SFA kickoff, Sep. 7, 2013, 6 pm
  - *2 pm, 4 pm forecast briefings by NWS LUB on-duty forecasters*

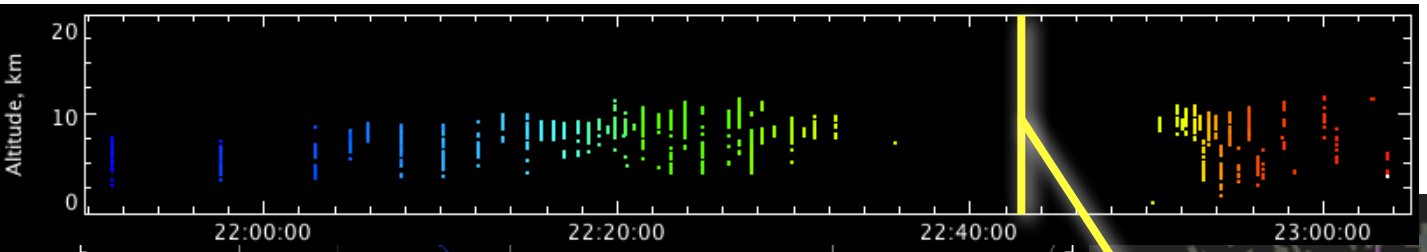
Operational successes: Football Operations

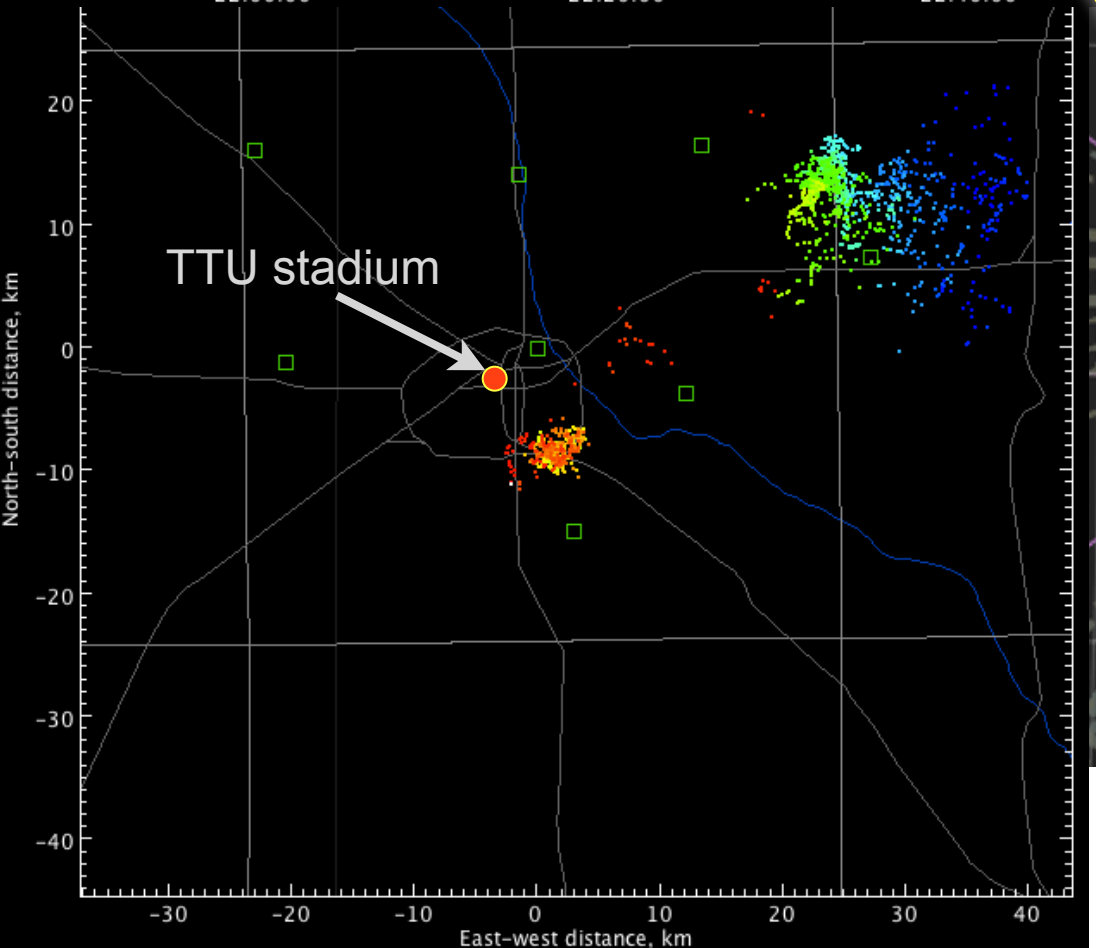
- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock
  - *All parties prepared to minimize weather impacts*
  - *Athletics had prepared draft call-to-action for Public Address*
  - *Thresholds for notice (15 mi), action (6 mi), resumption (30 min)*
- Lightning during TTU vs. SFA kickoff, Sep. 7, 2013, 6 pm
  - *2 pm, 4 pm forecast briefings by NWS LUB on-duty forecasters*
  - *TTU ATMO faculty in stadium operations booth 1.5 hour prior to kickoff*

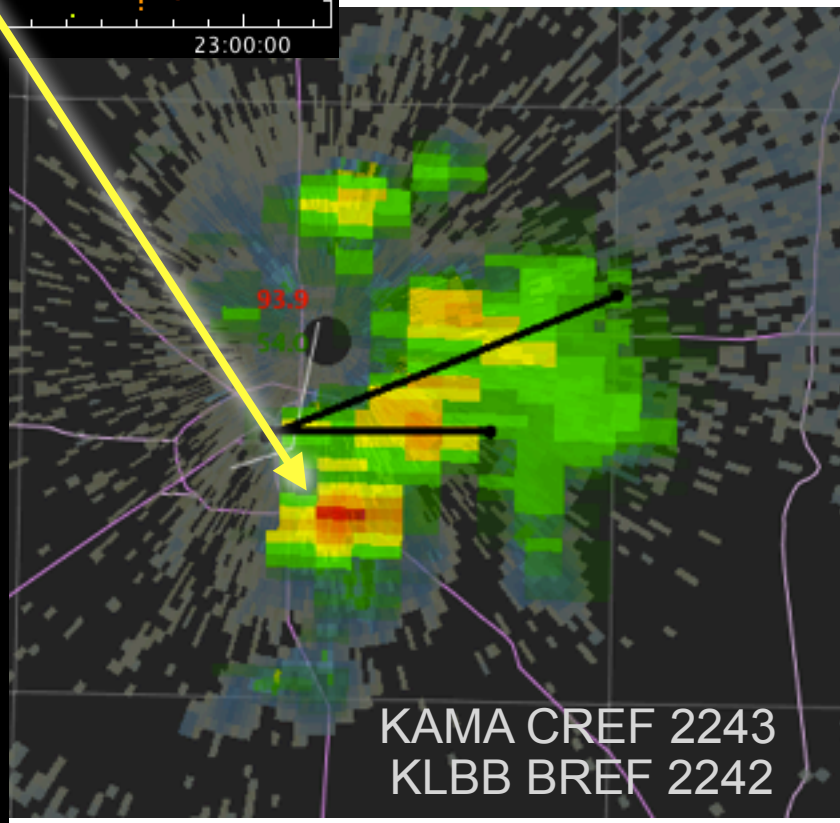
Operational successes: Football Operations

- Prior to season, Lightning Safety Awareness training delivered to TTU Athletics by NWS Lubbock
  - *All parties prepared to minimize weather impacts*
  - *Athletics had prepared draft call-to-action for Public Address*
  - *Thresholds for notice (15 mi), action (6 mi), resumption (30 min)*
- Lightning during TTU vs. SFA kickoff, Sep. 7, 2013, 6 pm
  - *2 pm, 4 pm forecast briefings by NWS LUB on-duty forecasters*
  - *TTU ATMO faculty in stadium operations booth 1.5 hour prior to kickoff*
- Knowledge (from forecast, lightning, and radar) of storm mode and its typical flashing pattern gave high confidence in imminent ground strikes within action radius upon the first flash.

Operational success: TTU Athletics

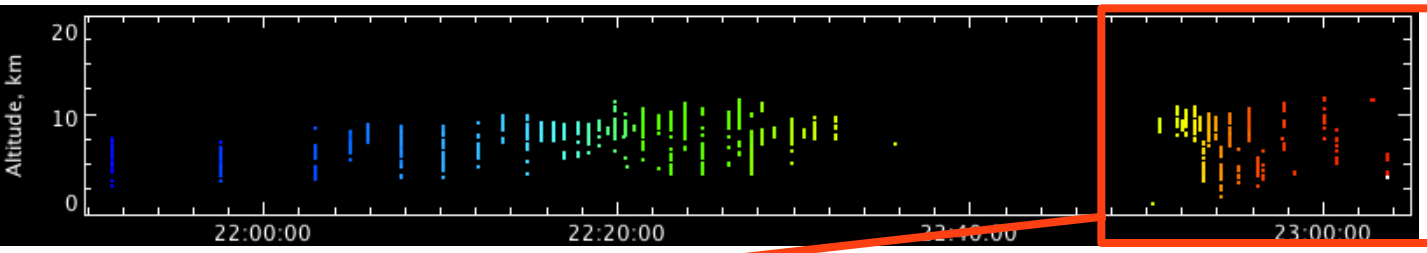


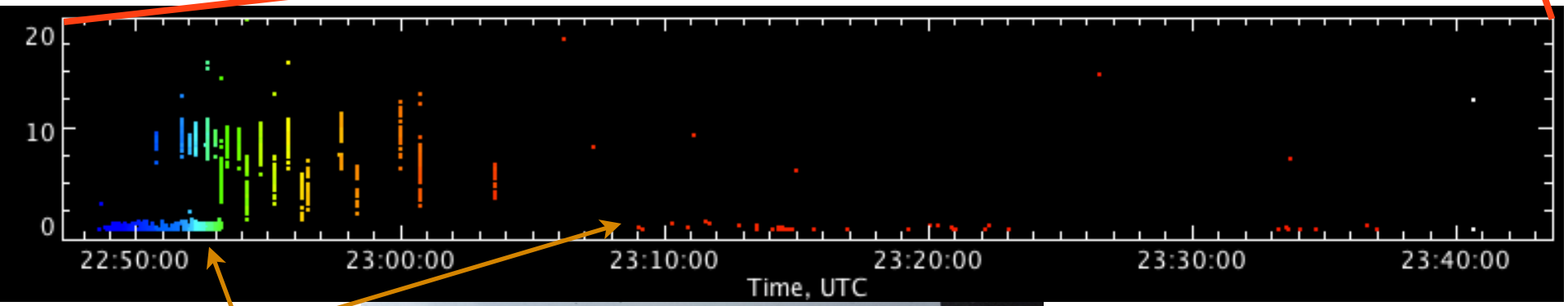




Total lightning gave 3 min lead time on first low-level flash (~CG)

Benefit of sensitivity upgrade: discharges from tall tower in SE Lubbock





Tower discharges: about -10 dBm

Temporarily end with the first low-level flash

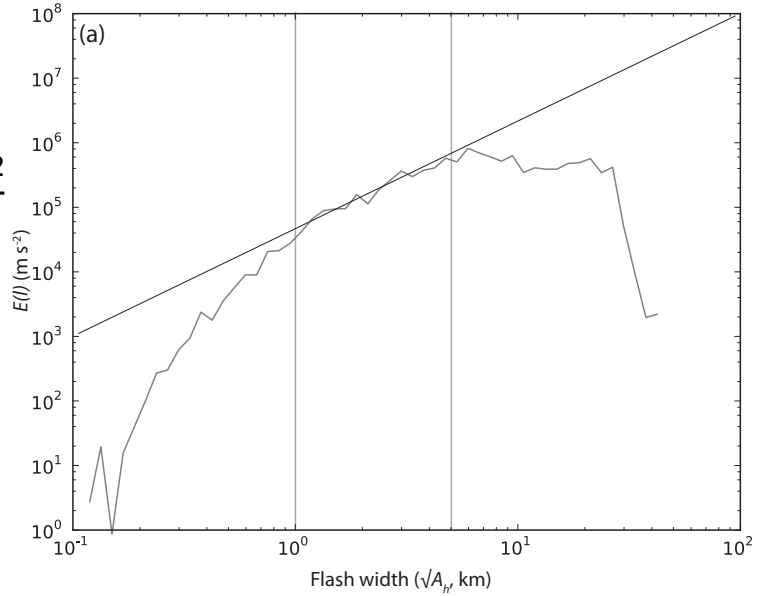
Scattered tower sources continued ~30 min after last flash, ending as anvil overhead moved away and/or charge overhead dissipated

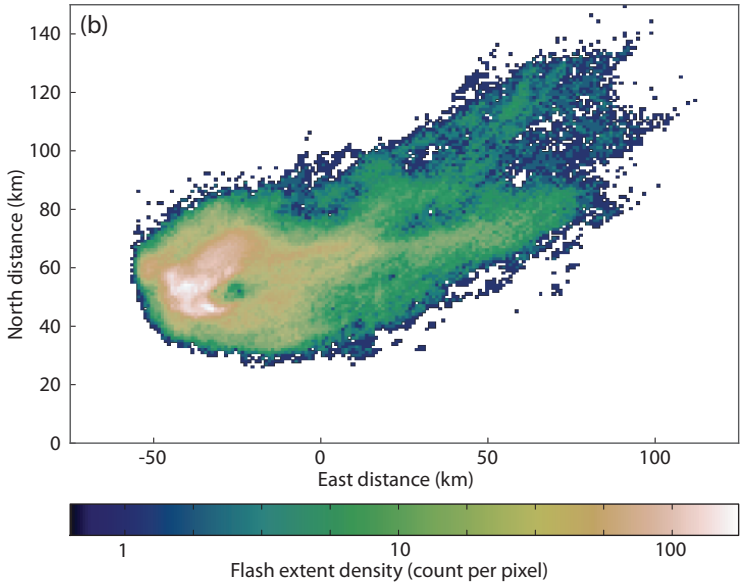
ENERGETIC SCALING IN THE FLASH SIZE SPECTRUM: RELEVANT QUANTITIES FOR TOTAL LIGHTNING PRODUCTS

$\frac{\text{area} * \text{rate}^2}{\text{bin width}}$

vs.

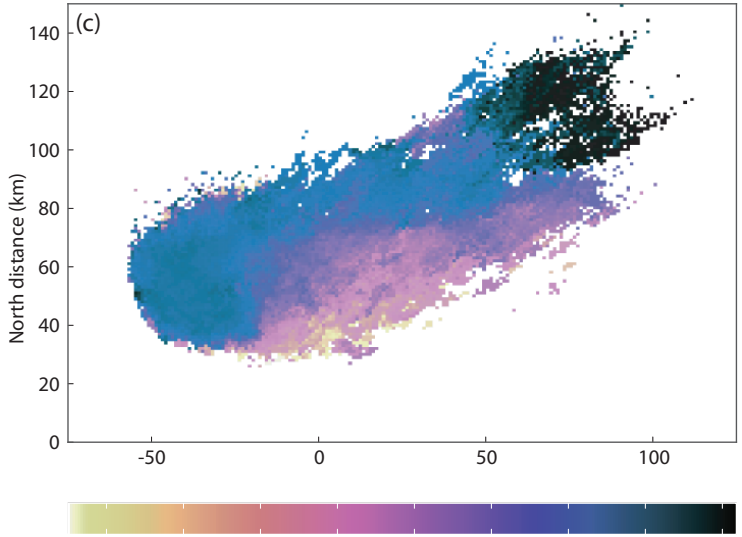
√ area

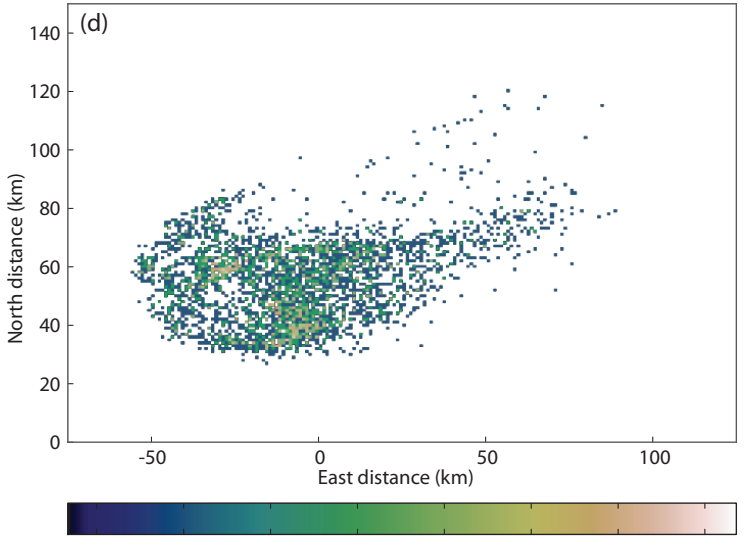




Flash extent density

Average area

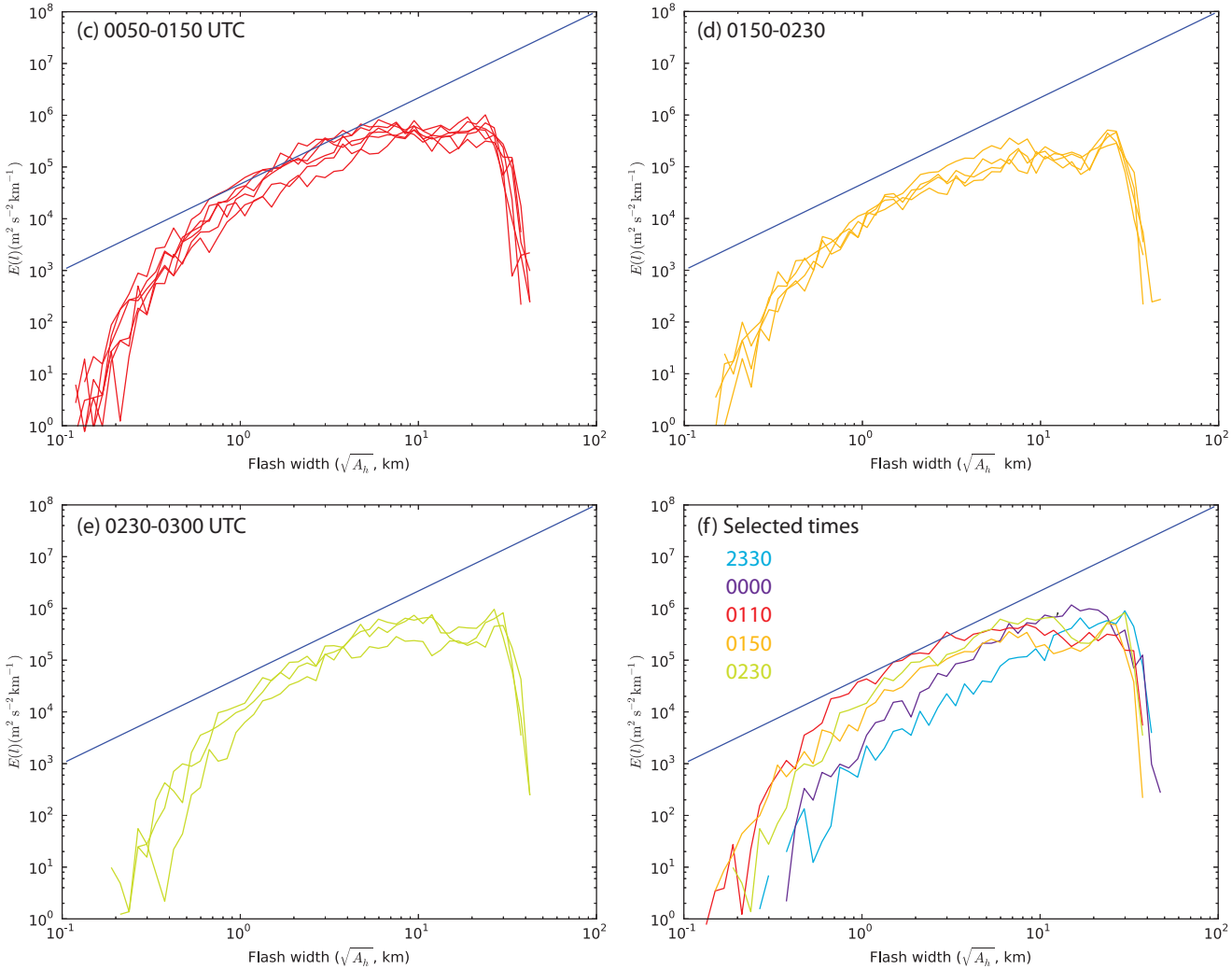




Flash initiation density

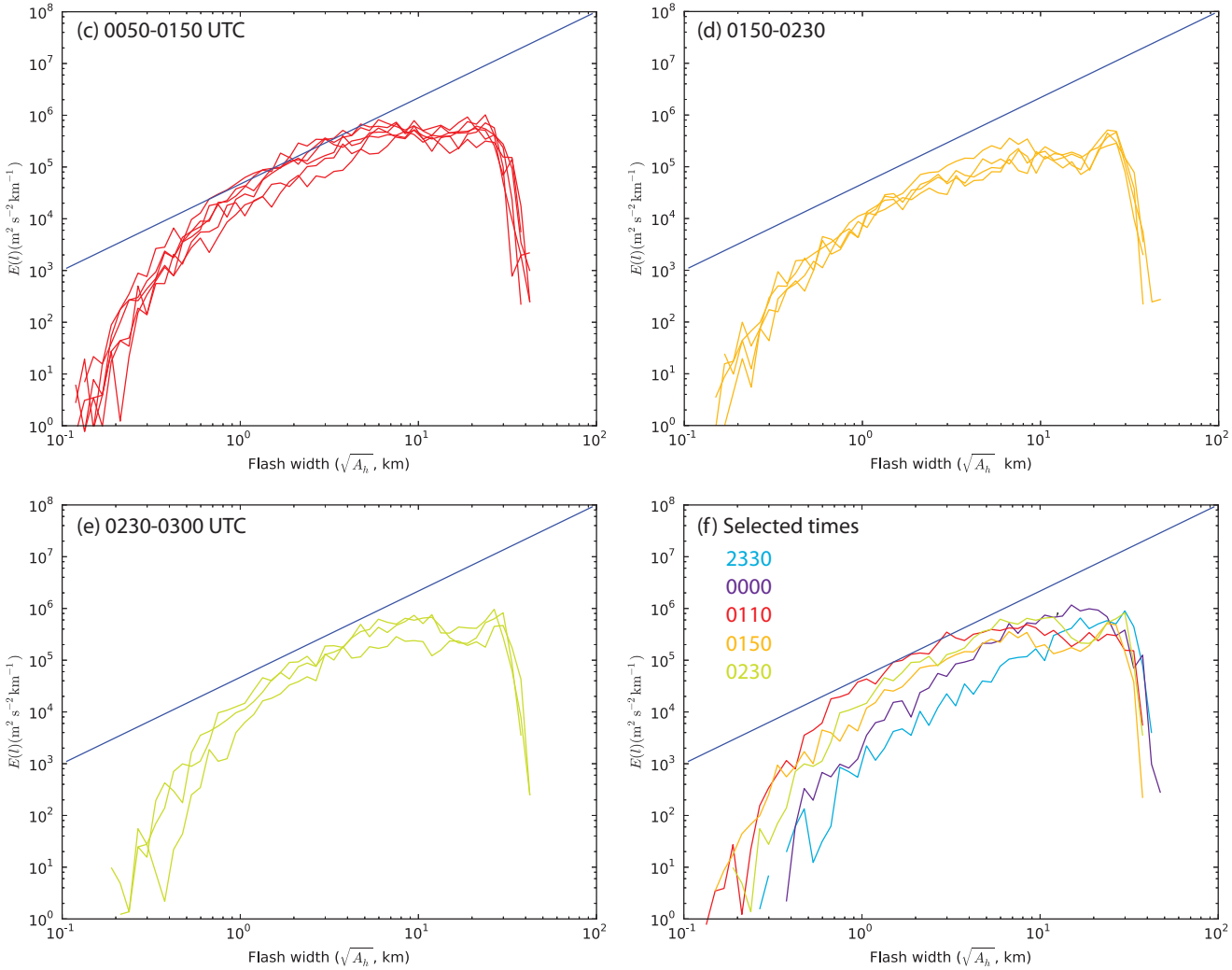
Flash energy spectrum: Consistent in time and across storm modes

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1



Flash energy spectrum: Consistent in time and across storm modes

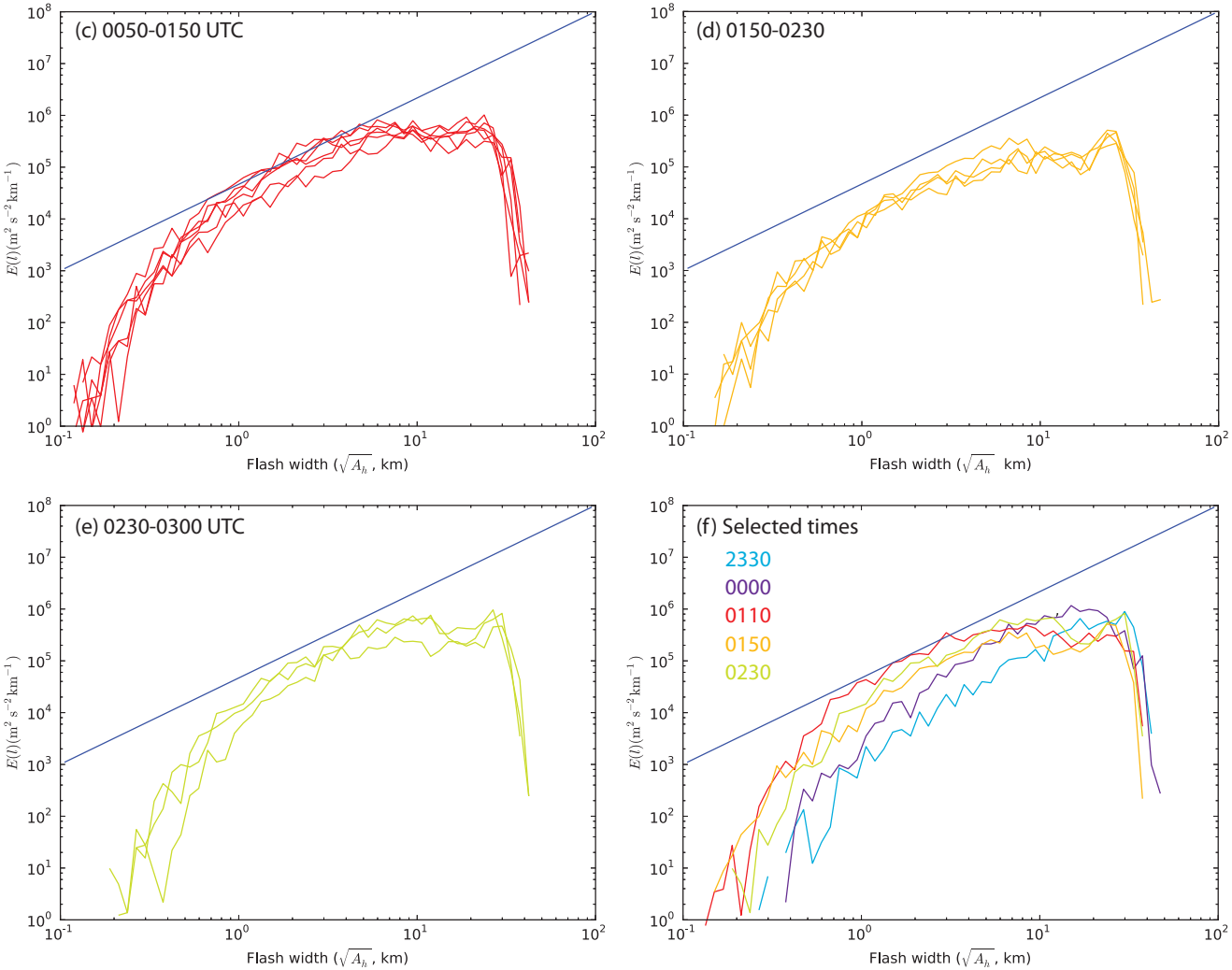
Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1



29-30 May 2004, Geary HP Supercell

Flash energy spectrum: Consistent in time and across storm modes

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

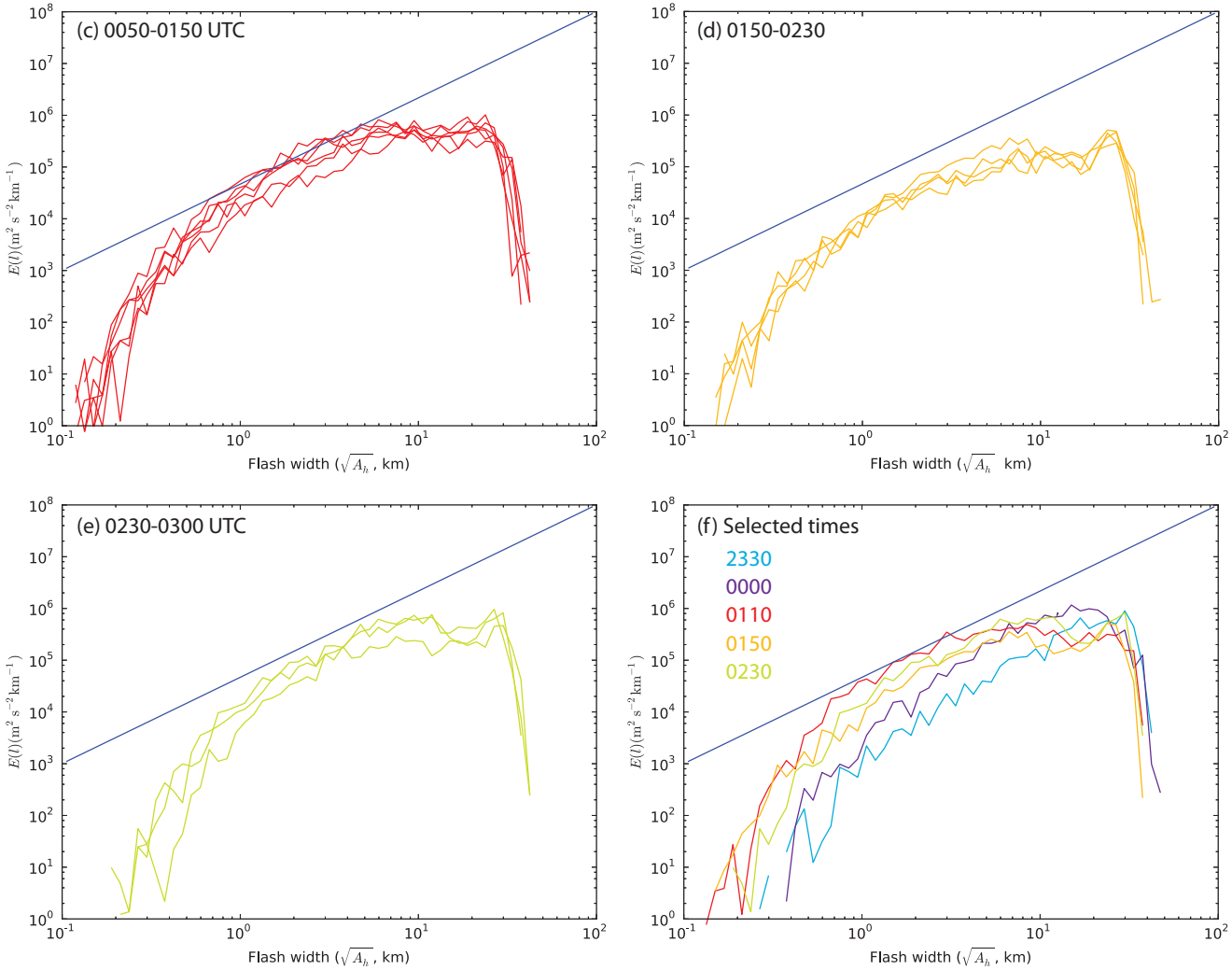


29-30 May 2004, Geary HP Supercell

- Remarkable consistency in shape (each line is 10 min of data)

Flash energy spectrum: Consistent in time and across storm modes

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

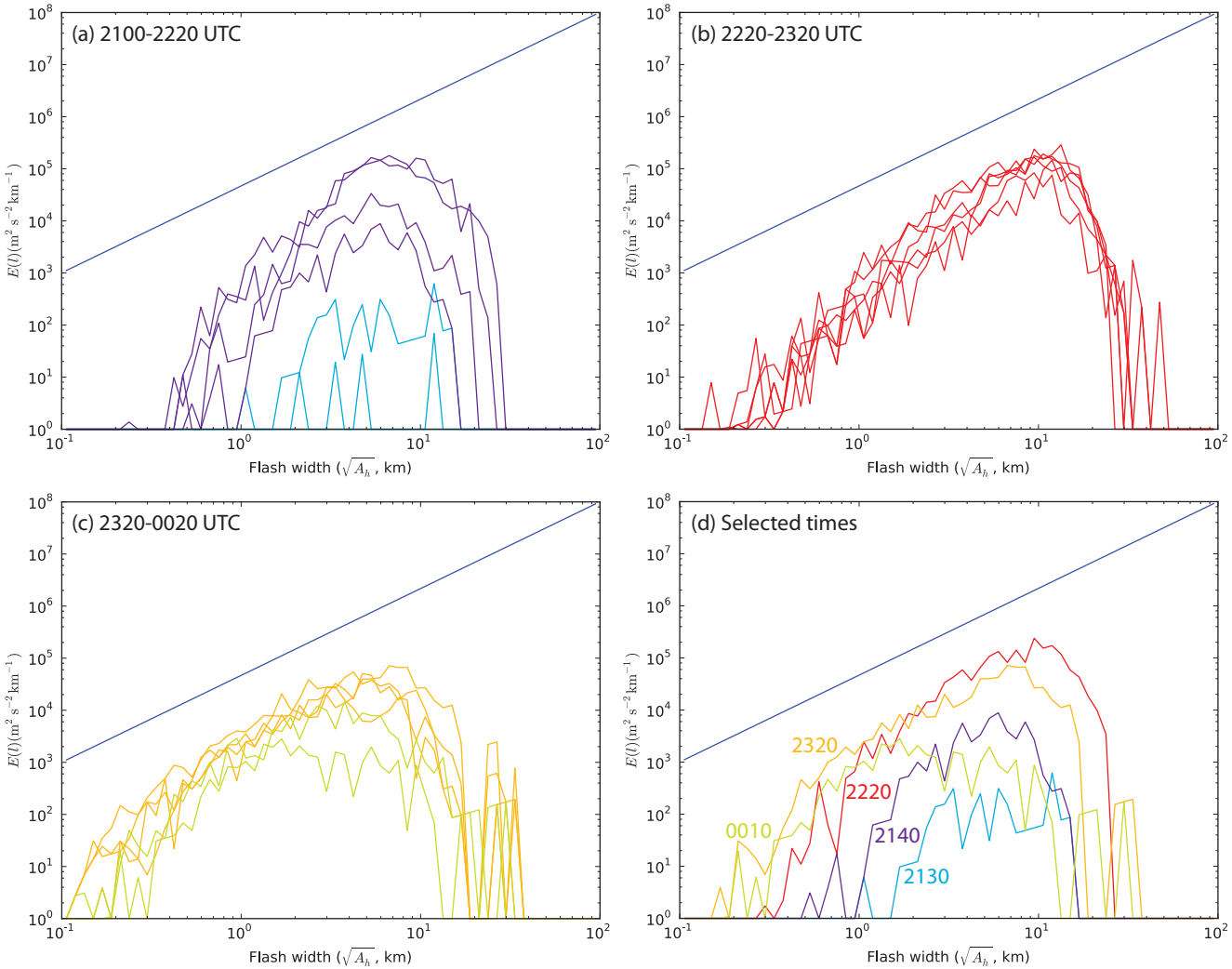


29-30 May 2004, Geary HP Supercell

- Remarkable consistency in shape (each line is 10 min of data)
- Modulations in flash rate change the height of spectrum

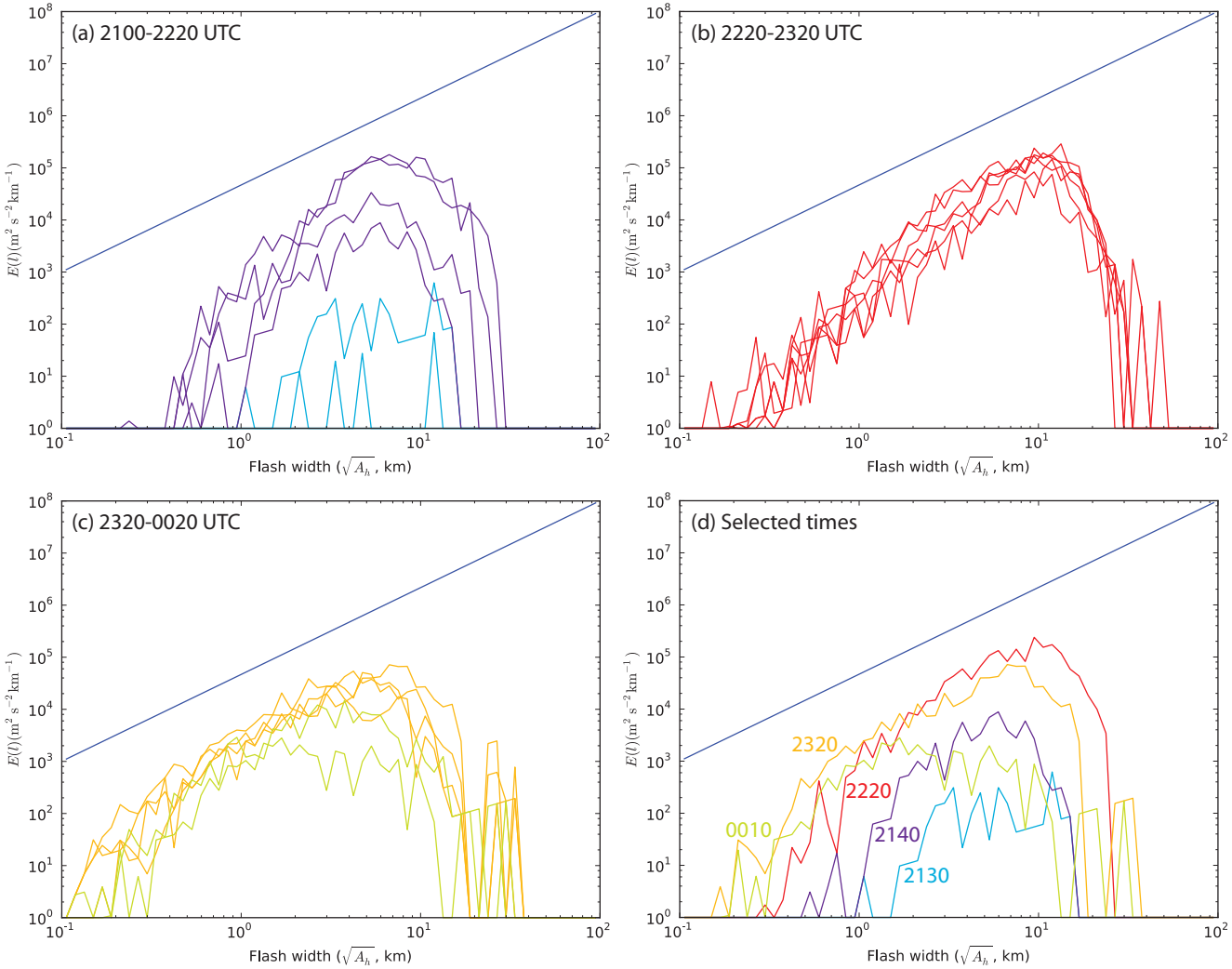
Flash energy spectrum: Consistent in time and across storm modes

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1



Flash energy spectrum: Consistent in time and across storm modes

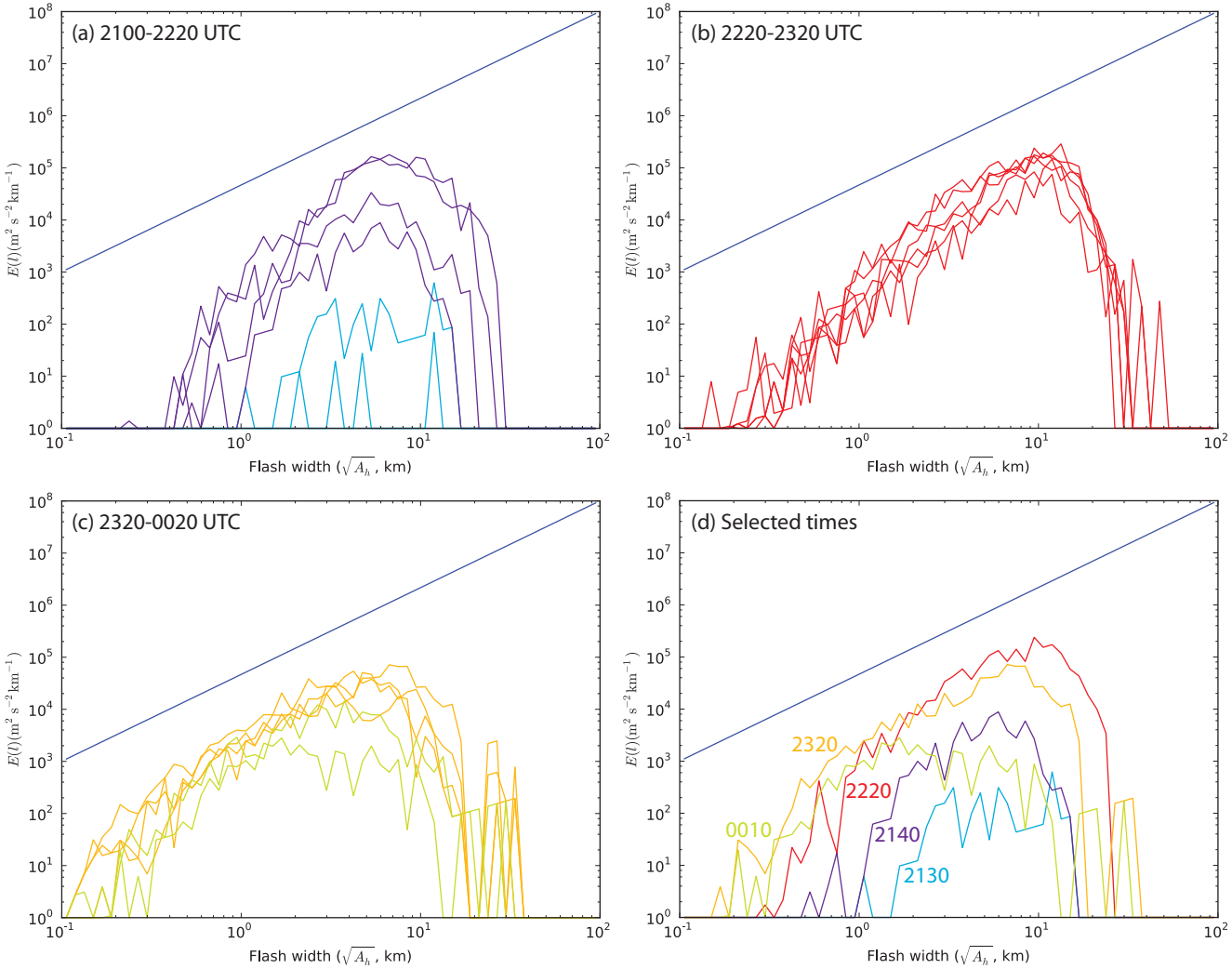
Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1



26-27 May 2004, Hinton Classic/LP Supercell

Flash energy spectrum: Consistent in time and across storm modes

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

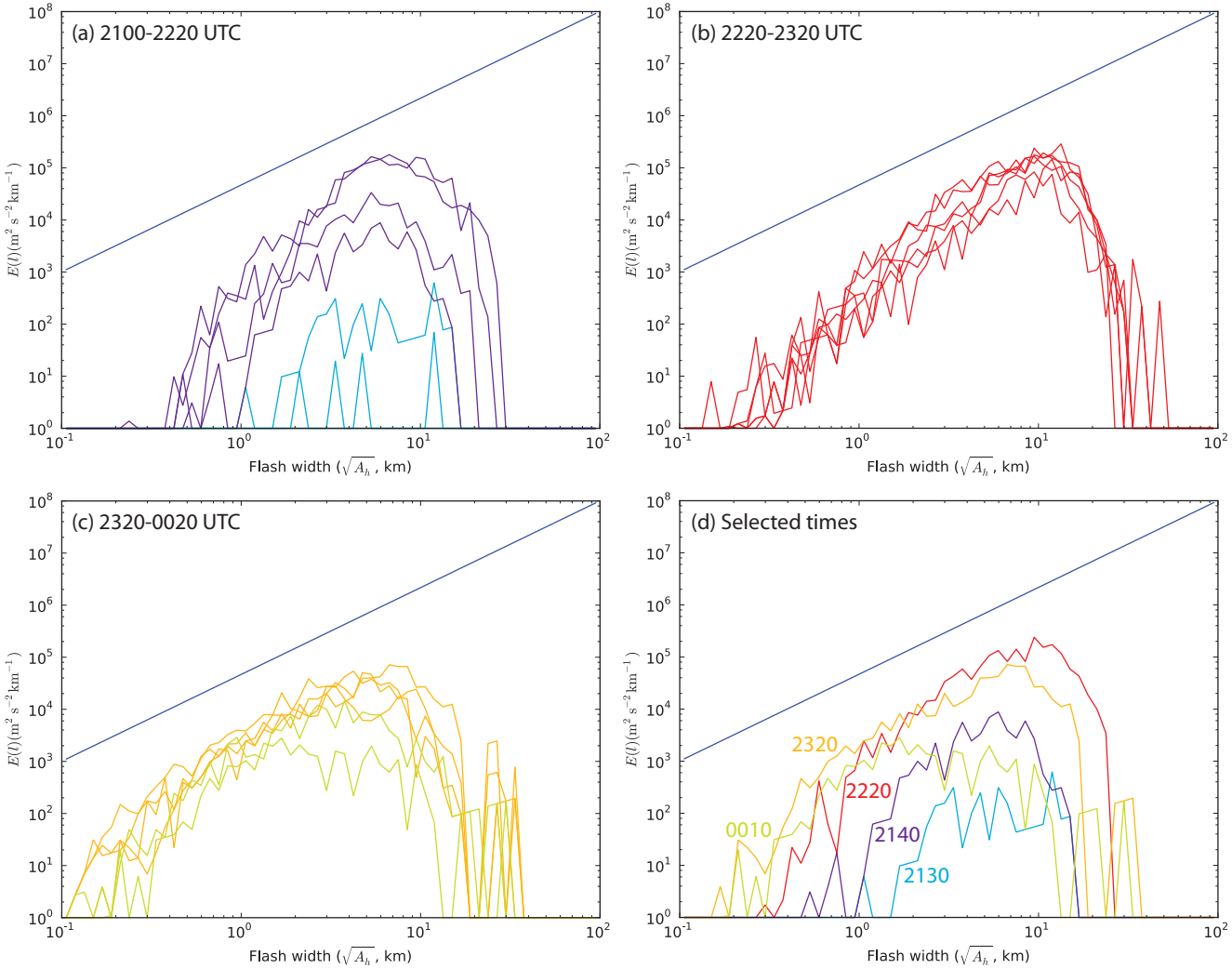


26-27 May 2004, Hinton Classic/LP Supercell

- Spectral shape, length scale of power-law regime change with time

Flash energy spectrum: Consistent in time and across storm modes

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

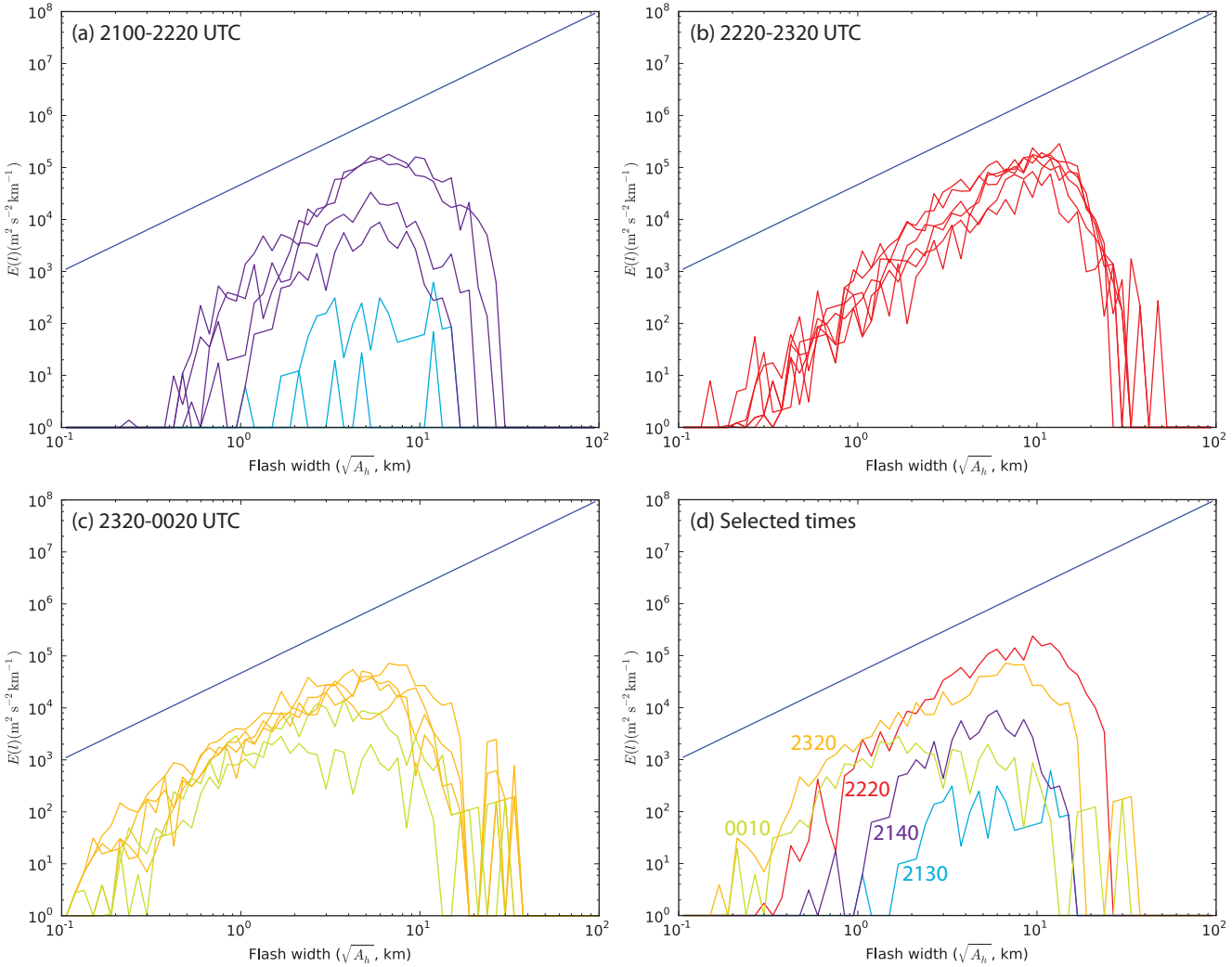


26-27 May 2004, Hinton Classic/LP Supercell

- Spectral shape, length scale of power-law regime change with time
- Storm was less steady, as reflected in lightning

Flash energy spectrum: Consistent in time and across storm modes

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

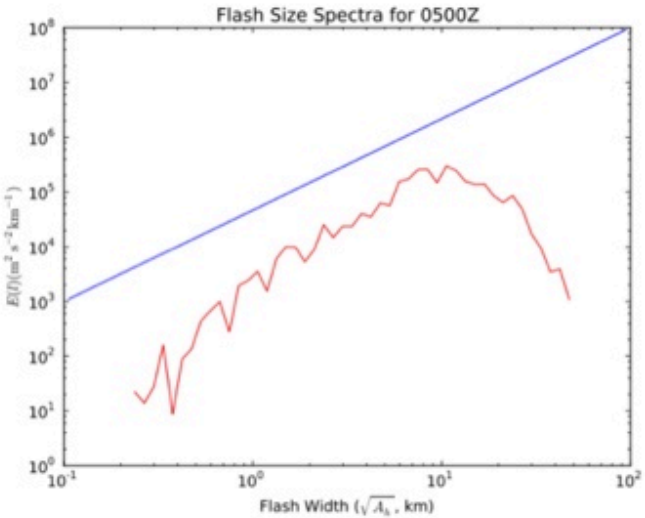


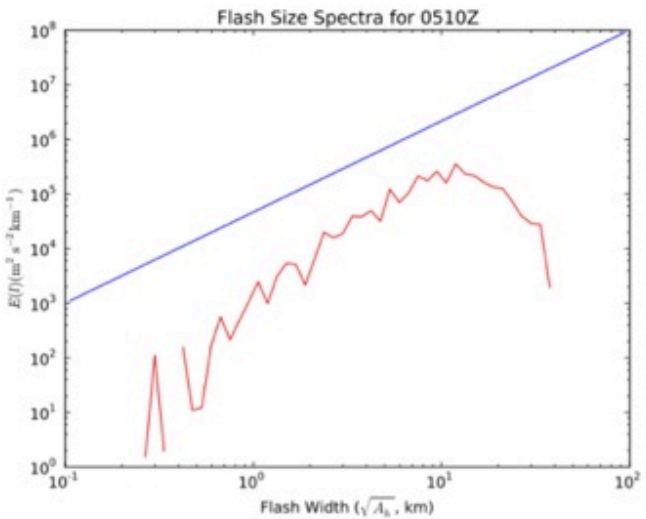
26-27 May 2004, Hinton Classic/LP Supercell

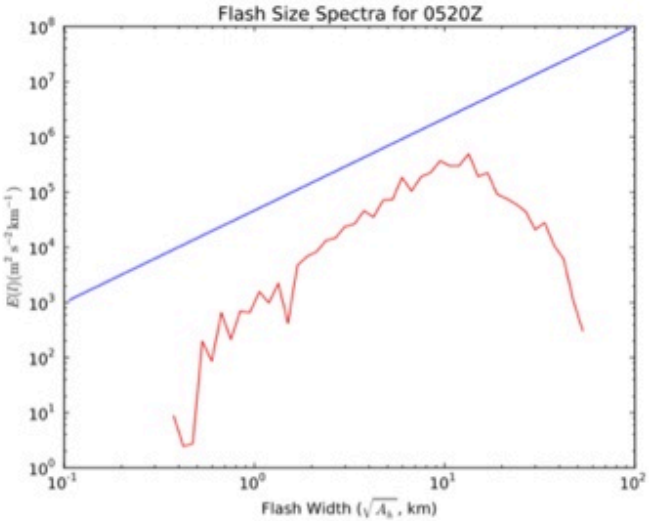
- Spectral shape, length scale of power-law regime change with time
- Storm was less steady, as reflected in lightning
- Need about 200 flashes to resolve the spectrum

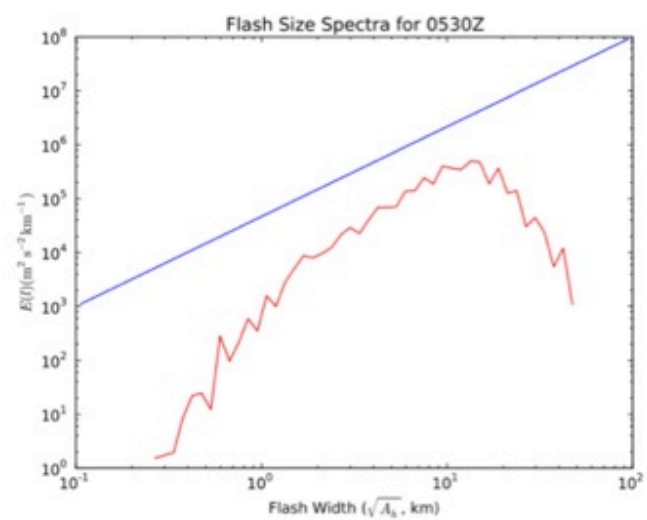
Flash energy spectrum: Consistent in time and across storm modes

Plourde, C., 2013, M.S. Thesis, TTU



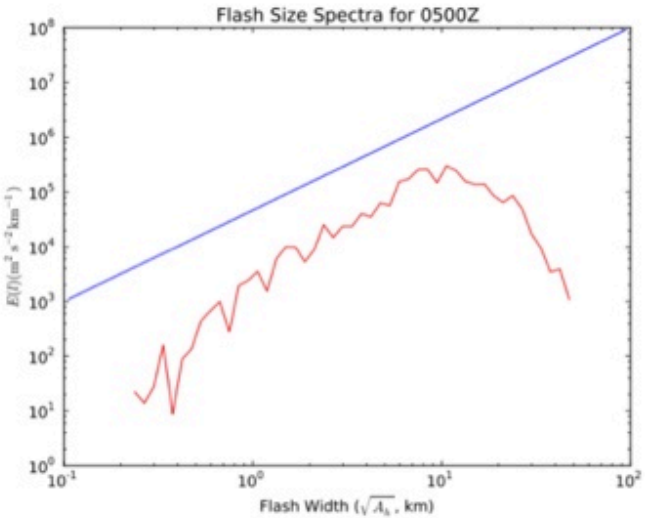


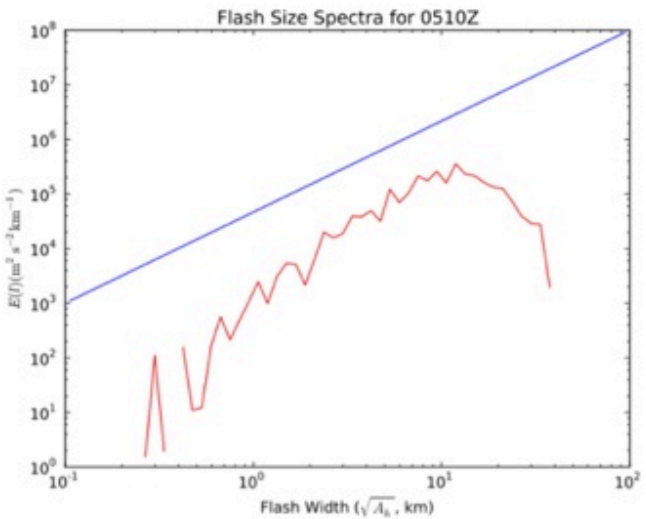




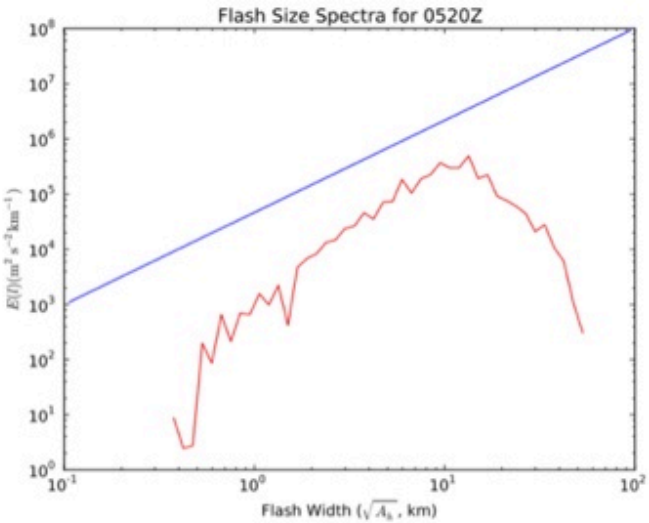
Flash energy spectrum: Consistent in time and across storm modes

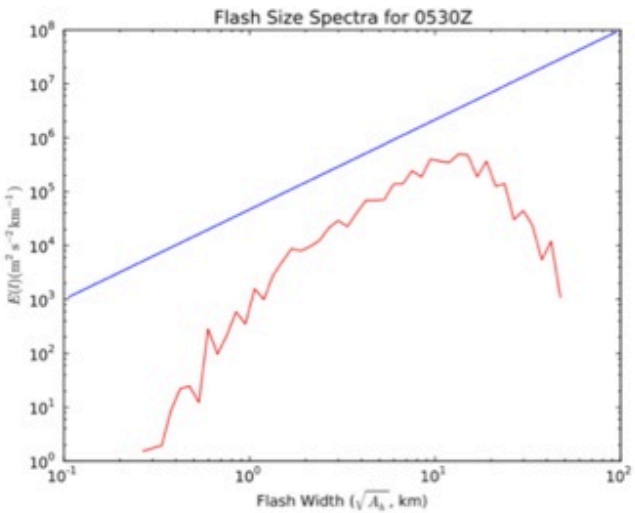
Plourde, C., 2013, M.S. Thesis, TTU





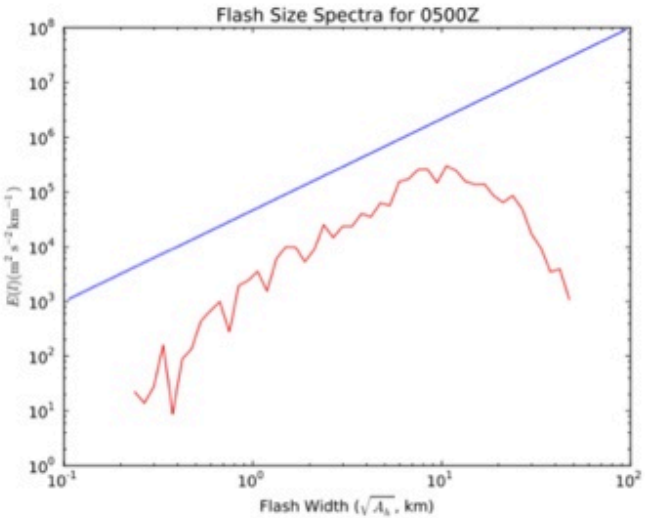
19 March 2012

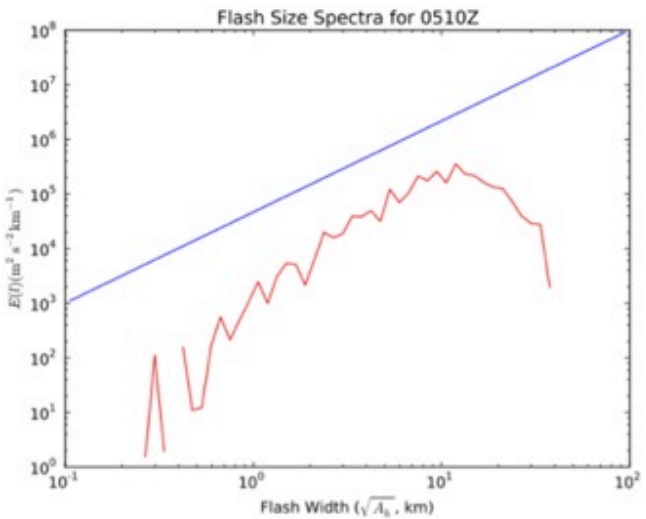


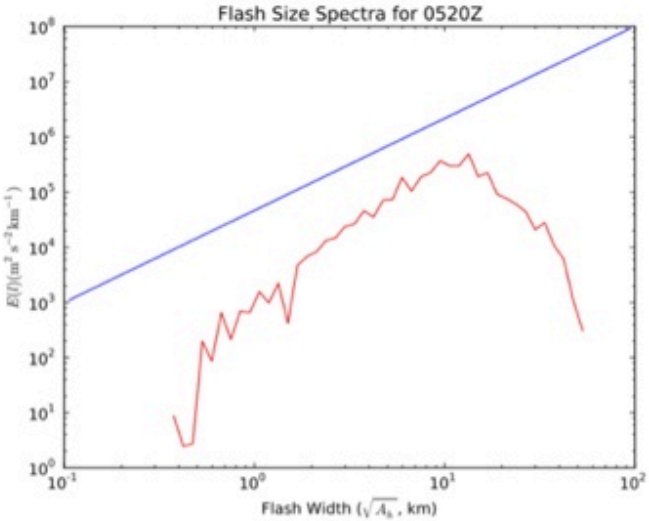


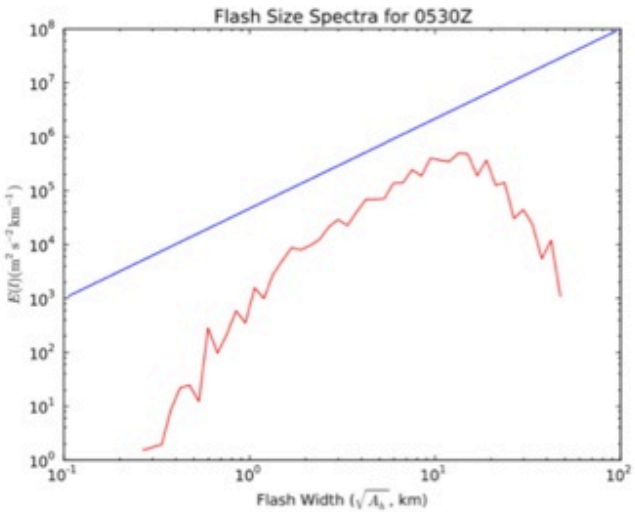
Flash energy spectrum: Consistent in time and across storm modes

Plourde, C., 2013, M.S. Thesis, TTU







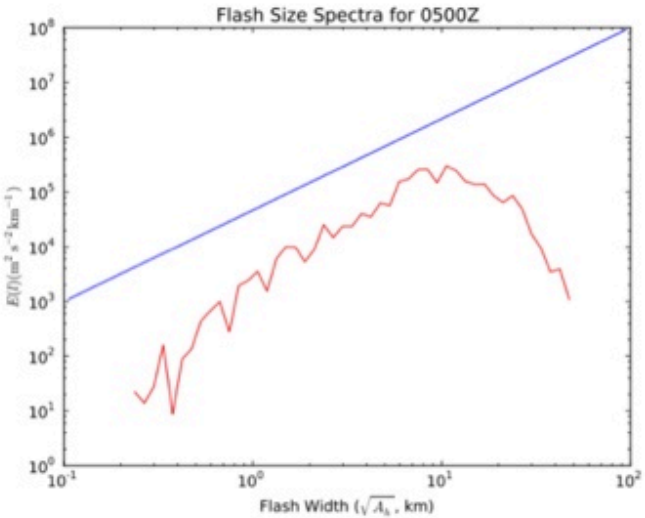


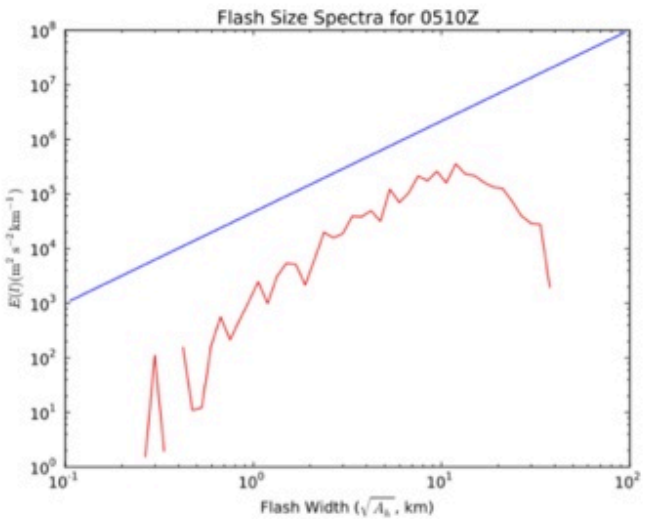
19 March 2012

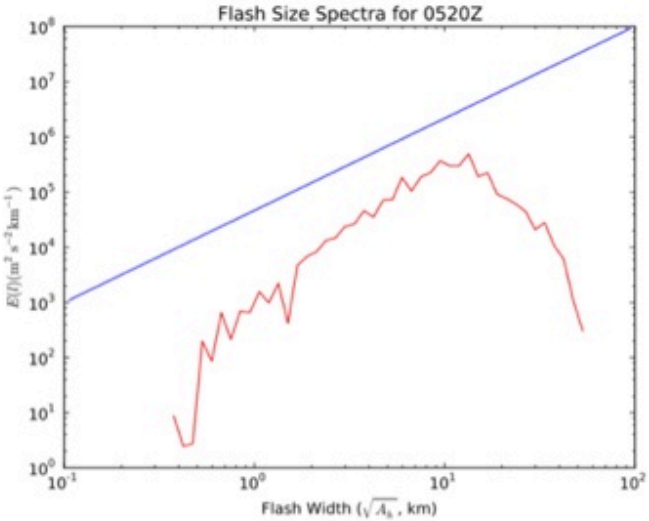
- 300 km severe QLCS, minimal stratiform region

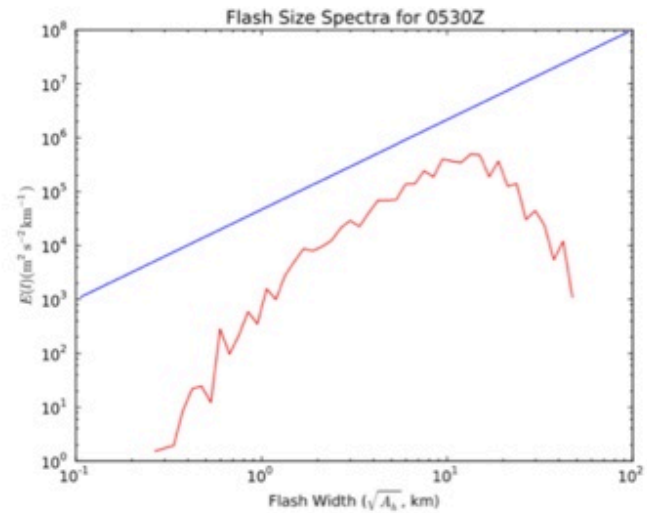
Flash energy spectrum: Consistent in time and across storm modes

Plourde, C., 2013, M.S. Thesis, TTU







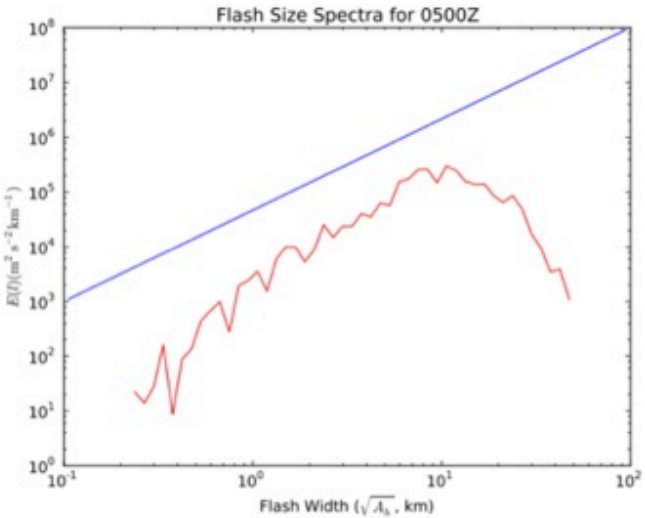


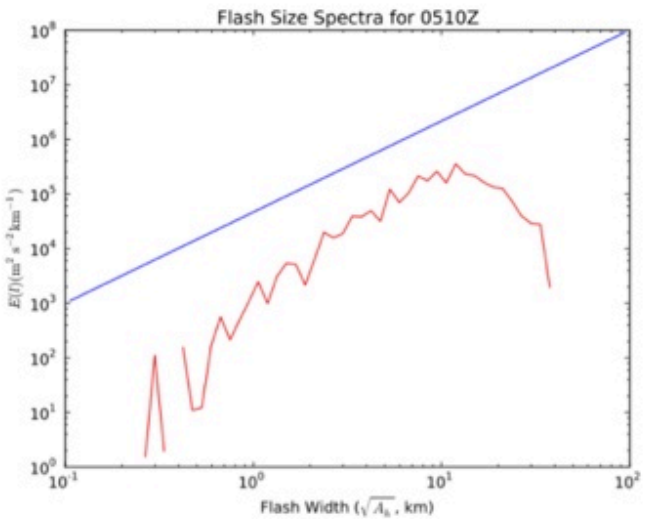
19 March 2012

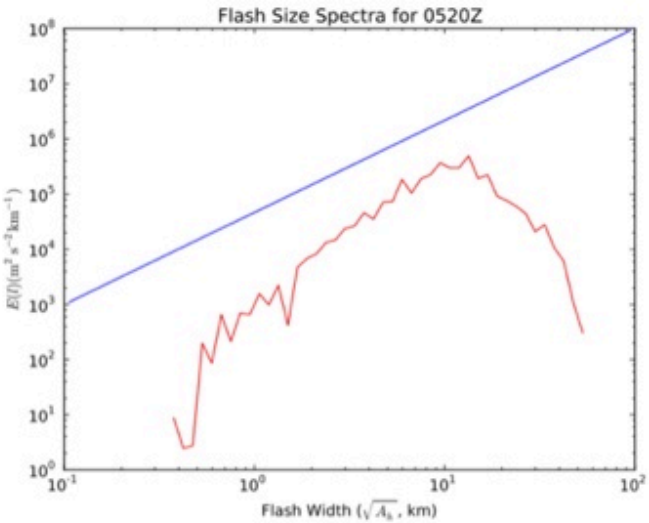
- 300 km severe QLCS, minimal stratiform region
- Line-total spectra when line was centered on the WTLMA

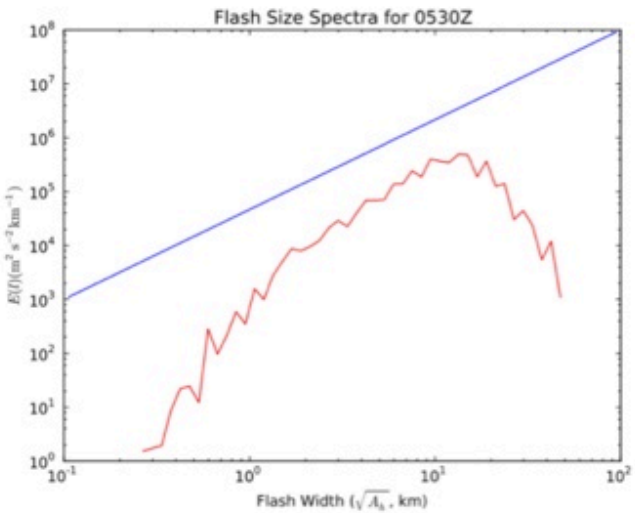
Flash energy spectrum: Consistent in time and across storm modes

Plourde, C., 2013, M.S. Thesis, TTU









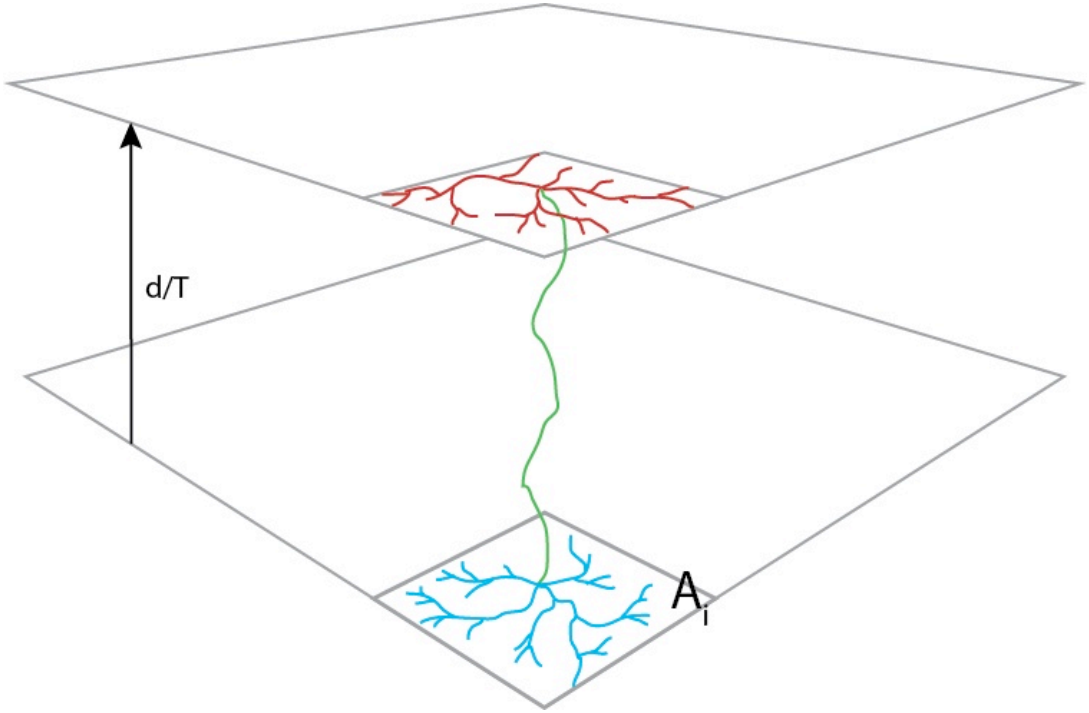
19 March 2012

- 300 km severe QLCS, minimal stratiform region
- Line-total spectra when line was centered on the WTLMA
- Perhaps surprisingly, same spectral shape, and some modulation in shape / scale as storm evolves

Flash energy spectrum: Coupling between convective motion and flash size

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

$$E_W = \frac{W_i}{\rho_a V_I} = \frac{1}{2}\frac{Q_i^2}{\rho_a \epsilon_0}\frac{d^3}{V_I^3} A_i \eta_i^2 T^2$$

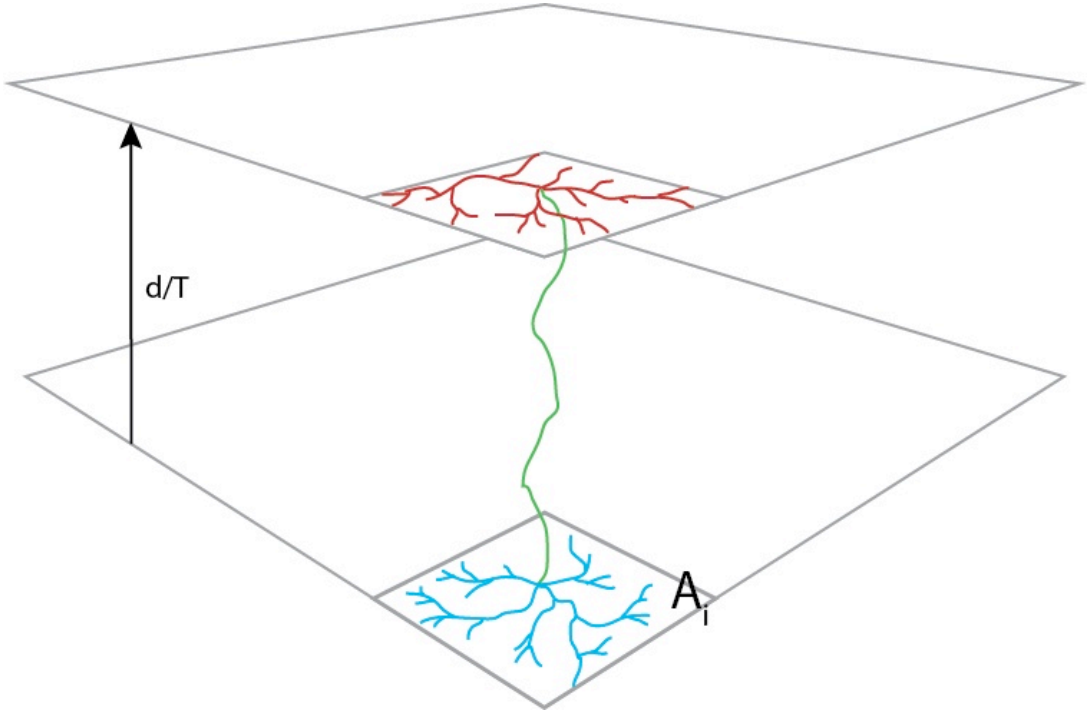


Flash energy spectrum: Coupling between convective motion and flash size

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

$$E_W = \frac{W_i}{\rho_a V_I} = \frac{1}{2}\frac{Q_i^2}{\rho_a \epsilon_0}\frac{d^3}{V_I^3} A_i \eta_i^2 T^2$$

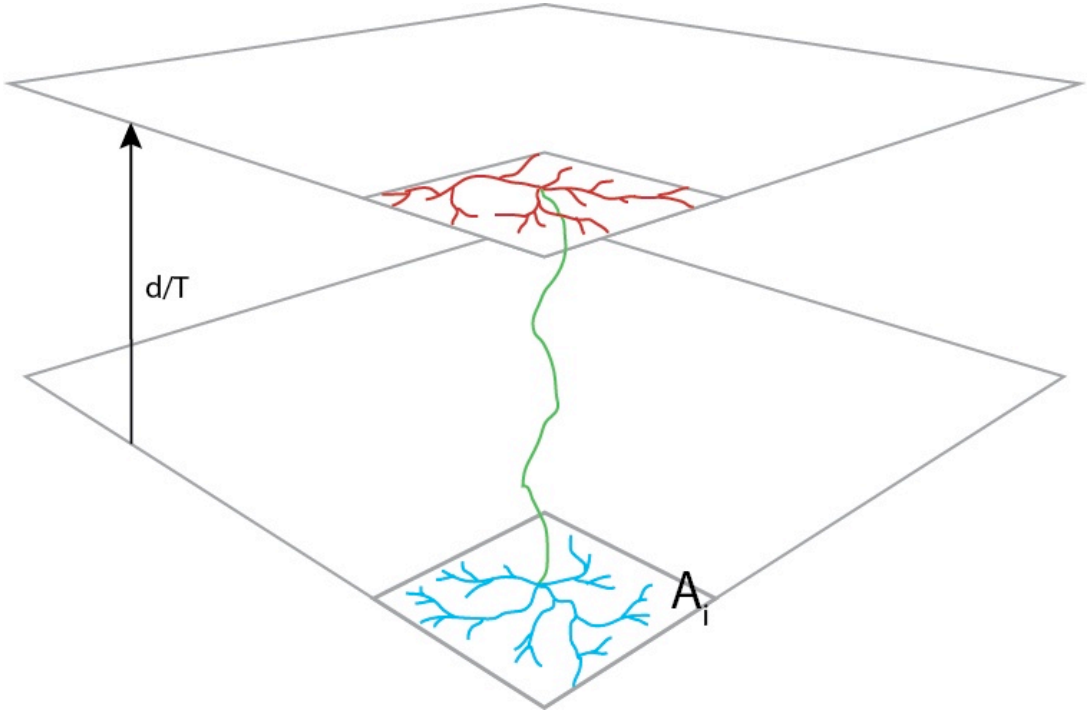
Partitioned capacitor flash model



Flash energy spectrum: Coupling between convective motion and flash size

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

$$E_W = \frac{W_i}{\rho_a V_I} = \frac{1}{2}\frac{Q_i^2}{\rho_a \epsilon_0}\frac{d^3}{V_I^3} A_i \eta_i^2 T^2$$



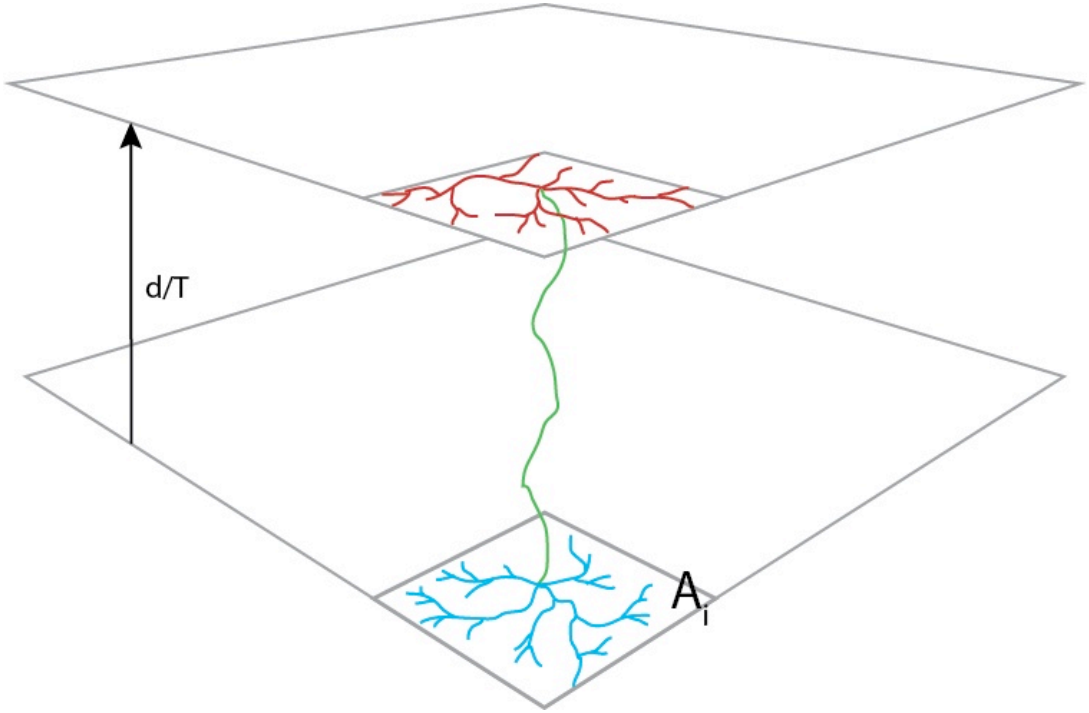
Partitioned capacitor flash model

- Total volume $V_I = A_I d$ is partioned into η_i flashes with area A_i in T seconds at scale i

Flash energy spectrum: Coupling between convective motion and flash size

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

$$E_W = \frac{W_i}{\rho_a V_I} = \frac{1}{2}\frac{Q_i^2}{\rho_a \epsilon_0}\frac{d^3}{V_I^3} A_i \eta_i^2 T^2$$



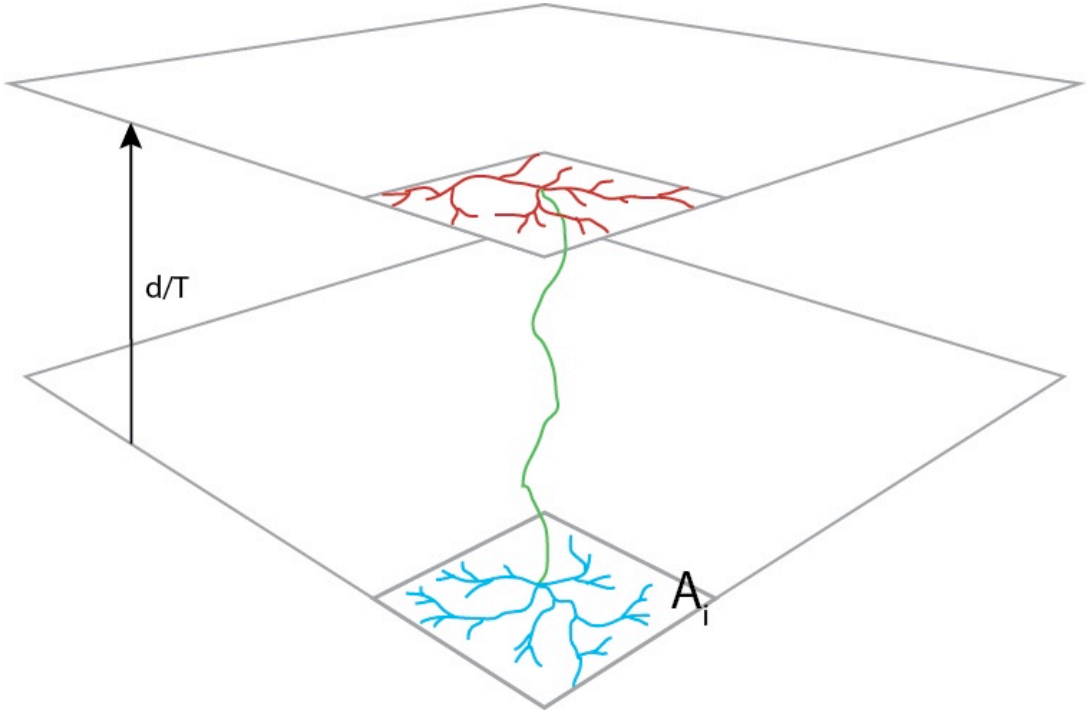
Partitioned capacitor flash model

- Total volume $V_I = A_I d$ is partioned into η_i flashes with area A_i in T seconds at scale i
- Plates separated by convective velocity d/T

Flash energy spectrum: Coupling between convective motion and flash size

Bruning and MacGorman 2013, Theory and observations of controls on lightning flash size spectra
http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-0289.1

$$E_W = \frac{W_i}{\rho_a V_I} = \frac{1}{2}\frac{Q_i^2}{\rho_a \epsilon_0}\frac{d^3}{V_I^3} A_i \eta_i^2 T^2$$



Partitioned capacitor flash model

- Total volume $V_I = A_I d$ is partioned into η_i flashes with area A_i in T seconds at scale i
- Plates separated by convective velocity d/T
- Coupling of advective motion with simple model of energy discharged shows validity of energy spectrum based on area*rate^2

VALIDATION: IMPORTANCE OF REGIONAL VARIABILITY 4 JUNE 2012

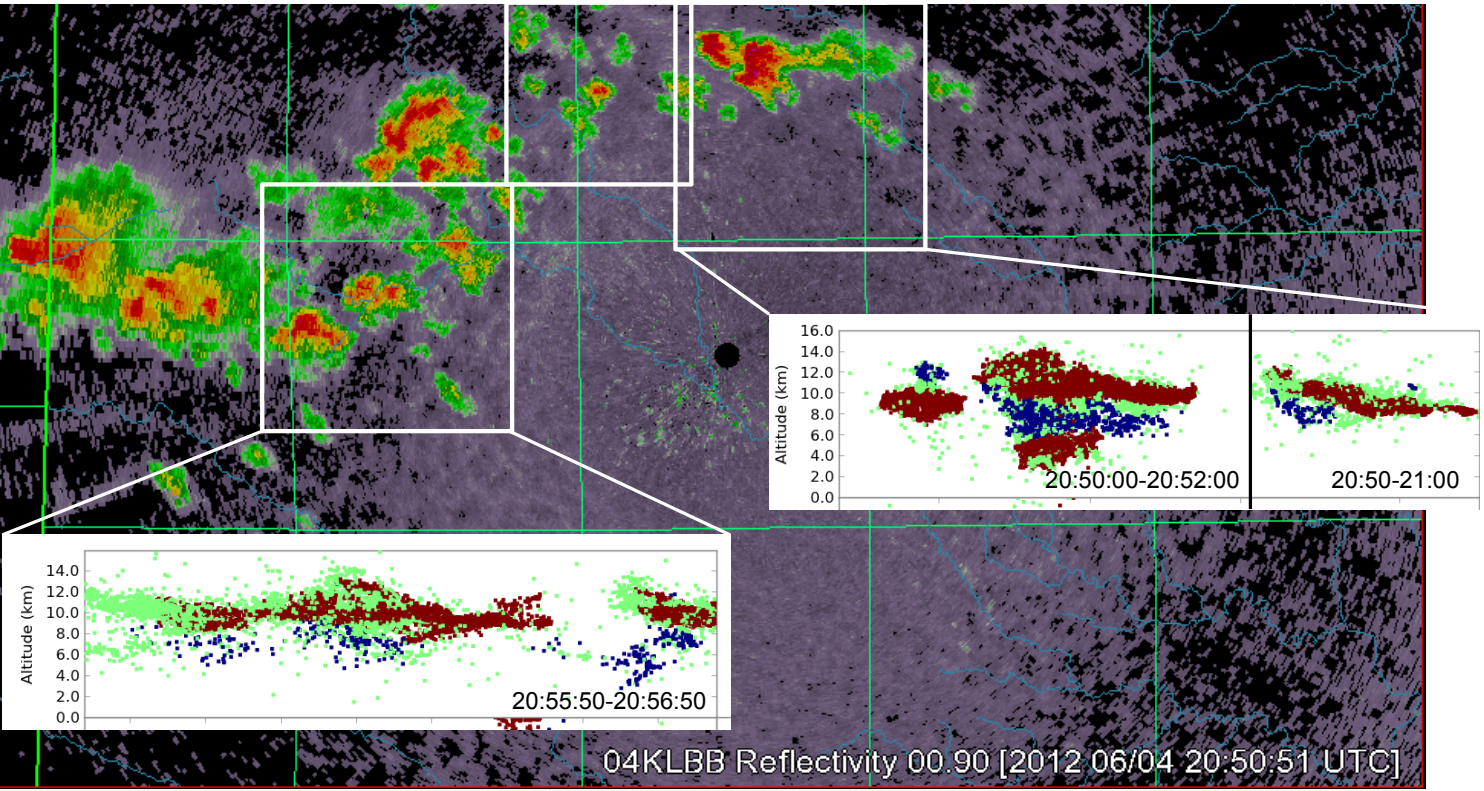
VANNA SULLIVAN - ONGOING PH.D. WORK

Some storms have typical multicellular electrical structure

- Upper +IC, lower -IC/CG

Within 5 km, other cells appear anomalous

- Upper -ICs



Validation: Importance of regional variability
4 June 2012

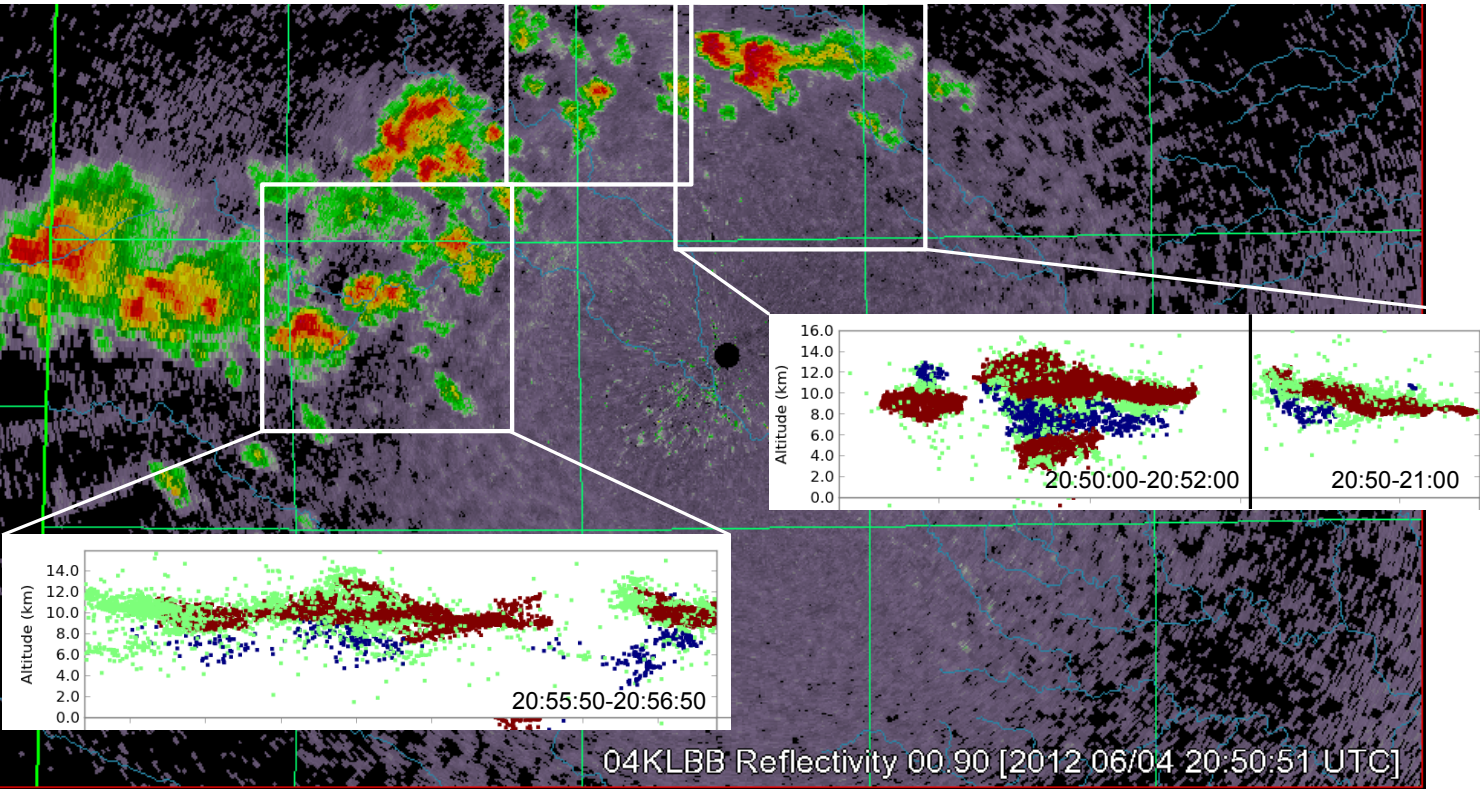
Vanna Sullivan - ongoing Ph.D. work

Some storms have typical multicellular electrical structure

- Upper +IC, lower -IC/CG

Within 5 km, other cells appear anomalous

- Upper -ICs



Not all storms produce a "typical" distribution of flashes. Size (energy) per flash appears to not be normally distributed, and the vertical distribution also varies.

Validation: Importance of regional variability
4 June 2012

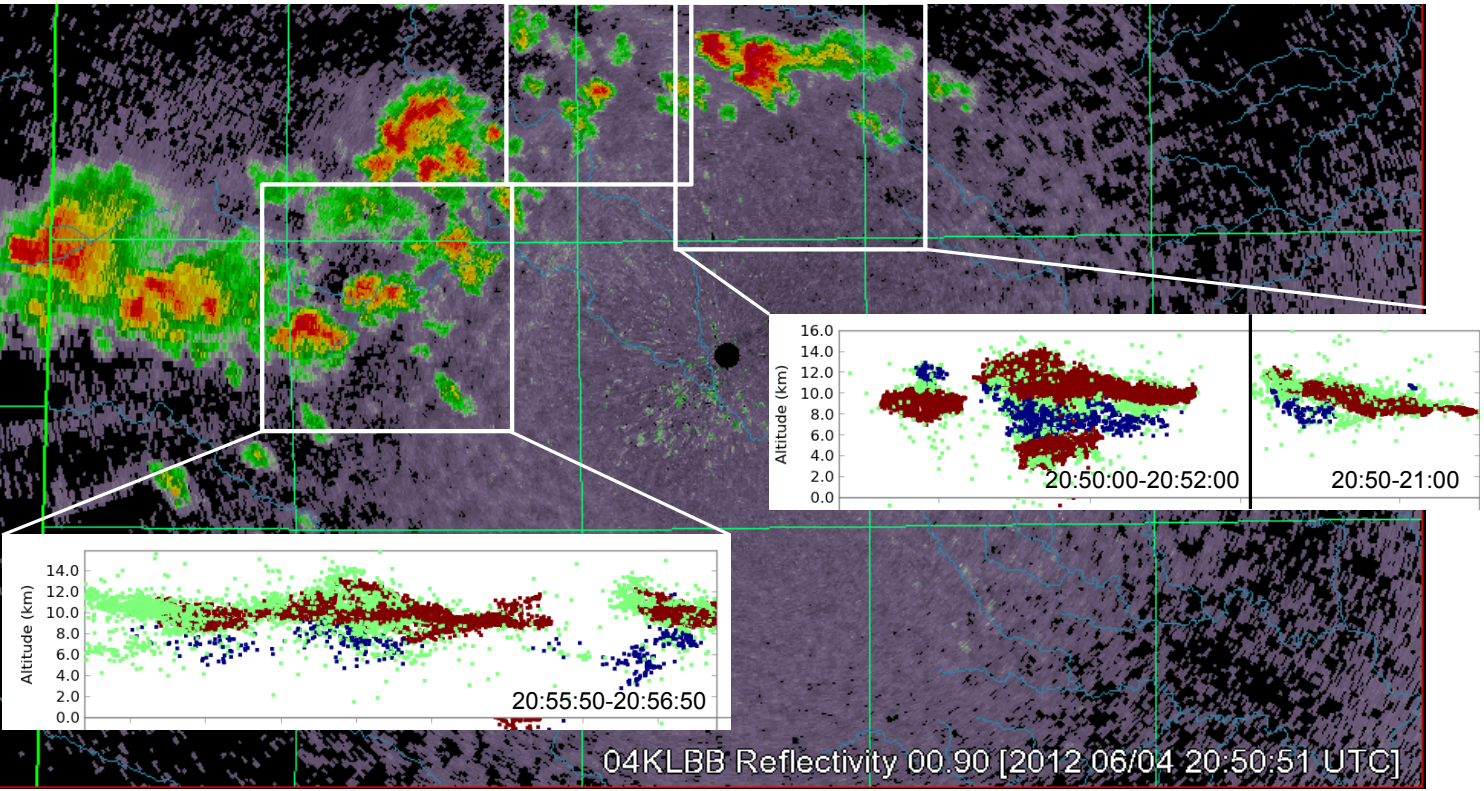
Vanna Sullivan - ongoing Ph.D. work

Some storms have typical multicellular electrical structure

- Upper +IC, lower -IC/CG

Within 5 km, other cells appear anomalous

- Upper -ICs



Not all storms produce a "typical" distribution of flashes. Size (energy) per flash appears to not be normally distributed, and the vertical distribution also varies.

Are there implications for expected distribution of optical pulse characteristics in different regions, with different relative weight of flashing at high and low levels? (Thomas et al. 2000, GRL)

Software

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]
  - *DBSCAN algorithm*[2]

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]
  - *DBSCAN algorithm*[2]
  - *Uses results from machine learning literature*

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]
  - *DBSCAN algorithm*[2]
  - *Uses results from machine learning literature*
- Data processing and display pipeline for integrated multidimensional, multisensor analysis

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]
  - *DBSCAN algorithm*[2]
  - *Uses results from machine learning literature*
- Data processing and display pipeline for integrated multidimensional, multisensor analysis
- Streams, displays live WTLMA data

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]
  - *DBSCAN algorithm*[2]
  - *Uses results from machine learning literature*
- Data processing and display pipeline for integrated multidimensional, multisensor analysis
- Streams, displays live WTLMA data

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]
  - *DBSCAN algorithm*[2]
  - *Uses results from machine learning literature*
- Data processing and display pipeline for integrated multidimensional, multisensor analysis
- Streams, displays live WTLMA data

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* [1]
  - *DBSCAN algorithm*[2]
  - *Uses results from machine learning literature*
- Data processing and display pipeline for integrated multidimensional, multisensor analysis
- Streams, displays live WTLMA data

(1) Bruning, E. C., 2013: Streamed clustering of lightning mapping data in Python using sklearn. Twelfth Conference on Scientific Computing with Python (SciPy), URL http://www.youtube.com/watch?v=0Z17Q22HEMI.

SOFTWARE

Open-source software for LMA display and analysis (http://github.com/deeplycloudy/brawl4d)

- Flash clustering using Python's *scikit-learn* (1)
  - *DBSCAN algorithm*(2)
  - *Uses results from machine learning literature*
- Data processing and display pipeline for integrated multidimensional, multisensor analysis
- Streams, displays live WTLMA data

(1) Bruning, E. C., 2013: Streamed clustering of lightning mapping data in Python using sklearn. Twelfth Conference on Scientific Computing with Python (SciPy), URL http://www.youtube.com/watch?v=0Z17Q22HEMI.

(2) Ester, M., H. P. Kriegel, J. Sander, and X. Xu, 1996: "A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise, *Proc. 2nd Int'l Conf. on Knowledge Discovery and Data Mining*, Portland, OR, AAAI Press, pp. 226–231.