Cloud-Top Cooling Over the Upper Midwest

Maria Madsen
NWS La Crosse
Student Volunteer

Dan Baumgardt
NWS La Crosse
Science and Operations Officer

January 22, 2014

Objectives

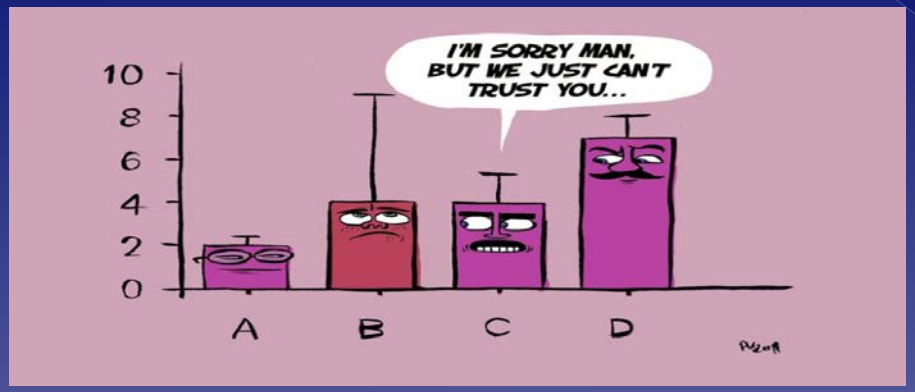
- Mentoring: A productive volunteer experience.
- To explore environments that effect cloud top cooling detections.
- To explore thunderstorm behavior/impacts for varying cloud top cooling rates.

Methodology

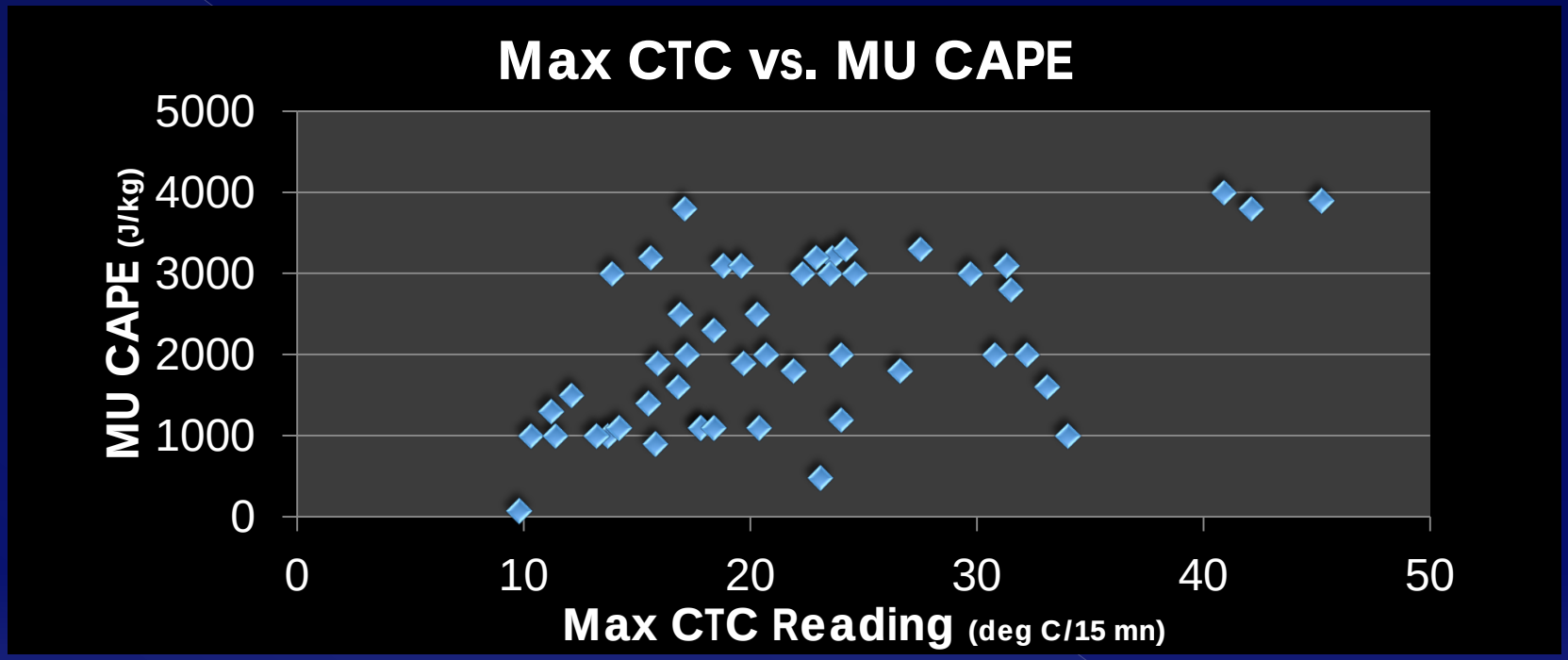
- Identified Cloud Top Cooling (CTC) detections for thunderstorm events in the region, June-August 2013.
  - The greatest cooling rate and time was termed the "CTC detection".
- For each CTC detection, we acquired:
  - 15 minute binned lightning up to 90 minutes after greatest cooling rate.
  - 15 minute binned max composite radar reflectivity up to 90 minutes after greatest cooling rate. (via 5 min radar data)
  - 0-6km Bulk Shear (SPC, from the hour prior to the CTC detection)
  - Most-unstable CAPE (SPC, from the hour prior to the CTC detection)
  - NWS Warnings associated with particular storm
- Collected 49 cases/detections.

Possible Errors

- Radar sampling may not be ideal
  - Ex: Taylor County
- Estimated lightning within the storm
- Gaps in the data
- Limited cases: <50

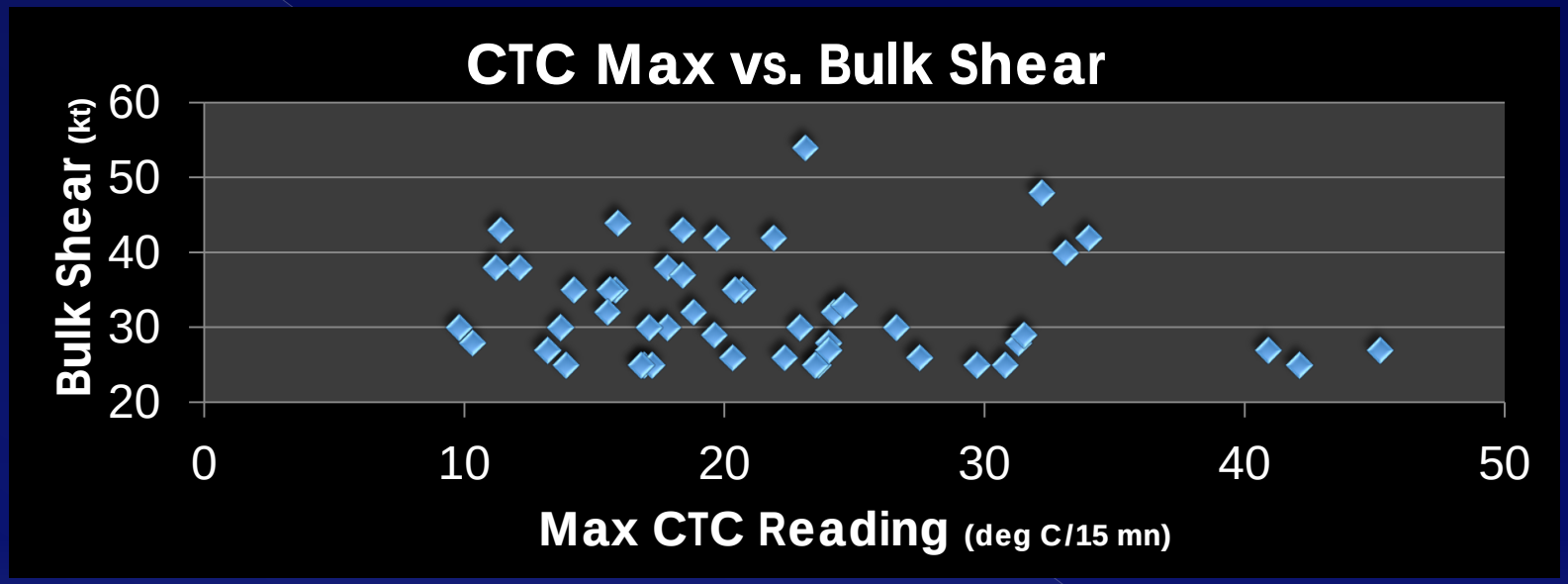


Most Unstable (MU) CAPE



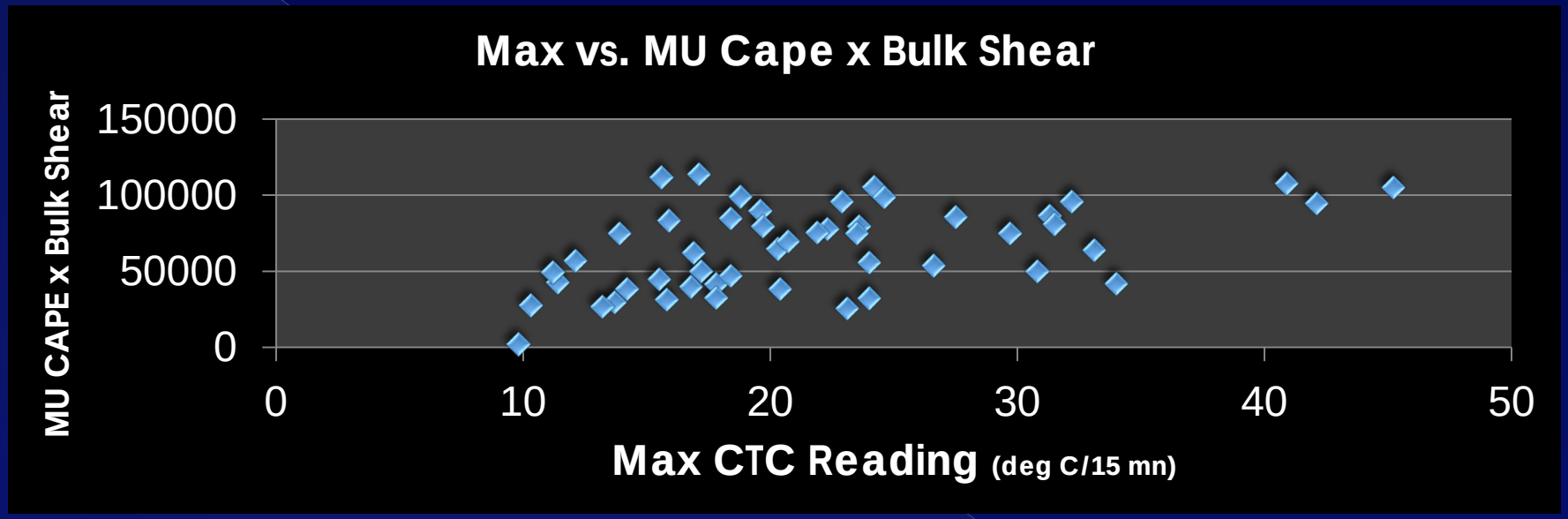
- *Gradual MU* CAPE yields higher CTC values
- Correlation Coefficient → 0.53
  - ≈ 25% of the variance in the CTC is explained by MU CAPE
  - Poor-fair relationship

Bulk 0-6 km Shear



- All storms in sample had greater than 20kts of bulk shear
- Negative correlation coefficient
  - -0.13
  - No notable relationship

Bulk Shear and CAPE

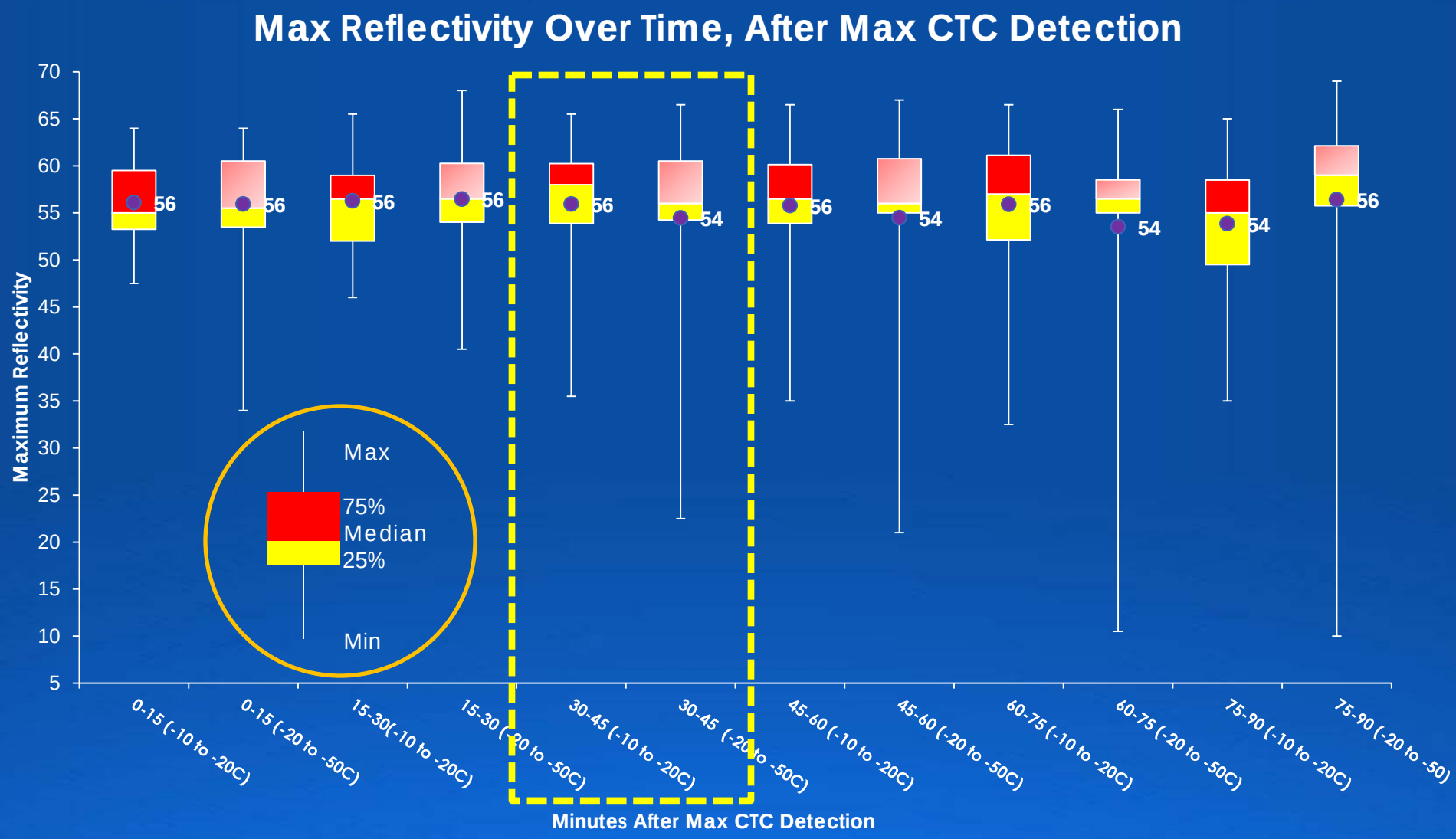


- Correlation Coefficient → 0.48
  - No better relationship than MU CAPE alone

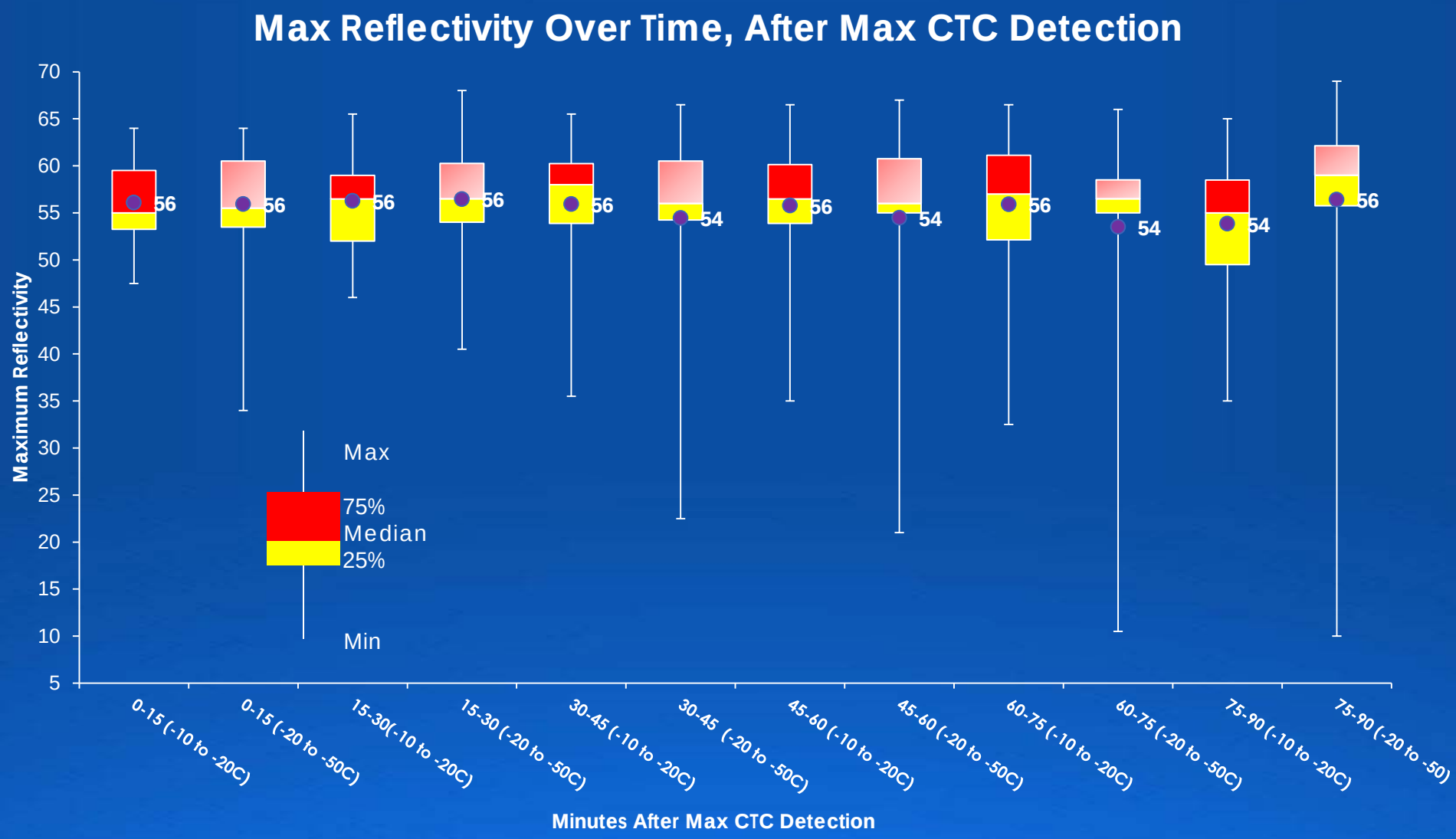
Bulk Shear and MU CAPE Conclusion

- Small correlation coefficients between Shear, MU CAPE, and Max CTC Rate
  - Shear and Cape not a huge determining factor on CTC rate and vise-versa
    - Multiple factors involved (such as surface convergence, dynamical forcing)

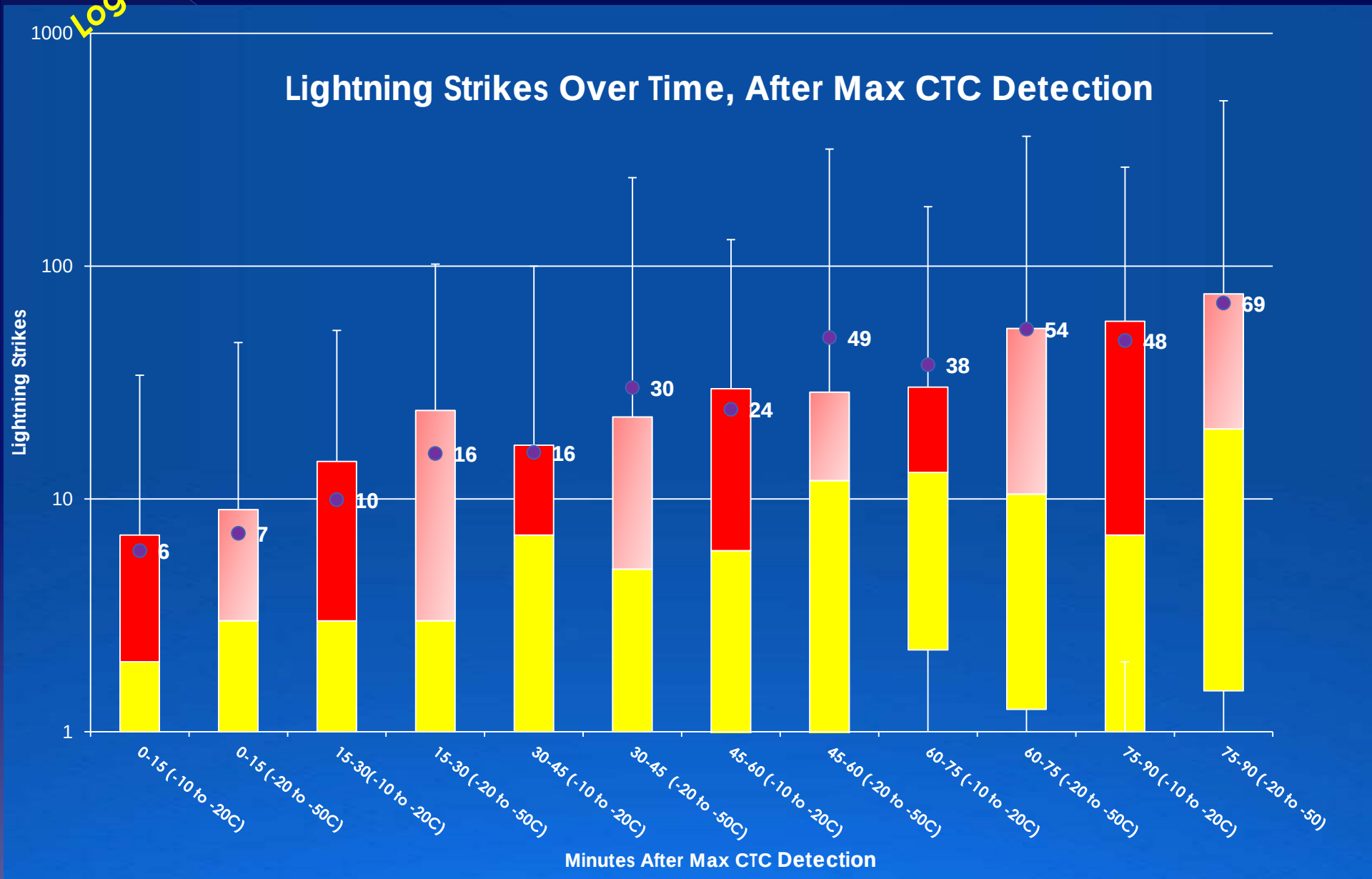
Reflectivity



Reflectivity



Lightning


Log Scale!
Lightning Strikes Over Time, After Max CTC Detection
1000
100
10
1
Lightning Strikes
6
7
10
16
16
30
24
49
38
54
48
69
0-15 (-10 to -20C)
0-15 (-20 to -50C)
15-30(-10 to -20C)
15-30 (-20 to -50C)
30-45 (-10 to -20C)
30-45 (-20 to -50C)
45-60 (-10 to -20C)
45-60 (-20 to -50C)
60-75 (-10 to -20C)
60-75 (-20 to -50C)
75-90 (-10 to -20C)
75-90 (-20 to -50)
Minutes After Max CTC Detection

Reflectivity & Lightning

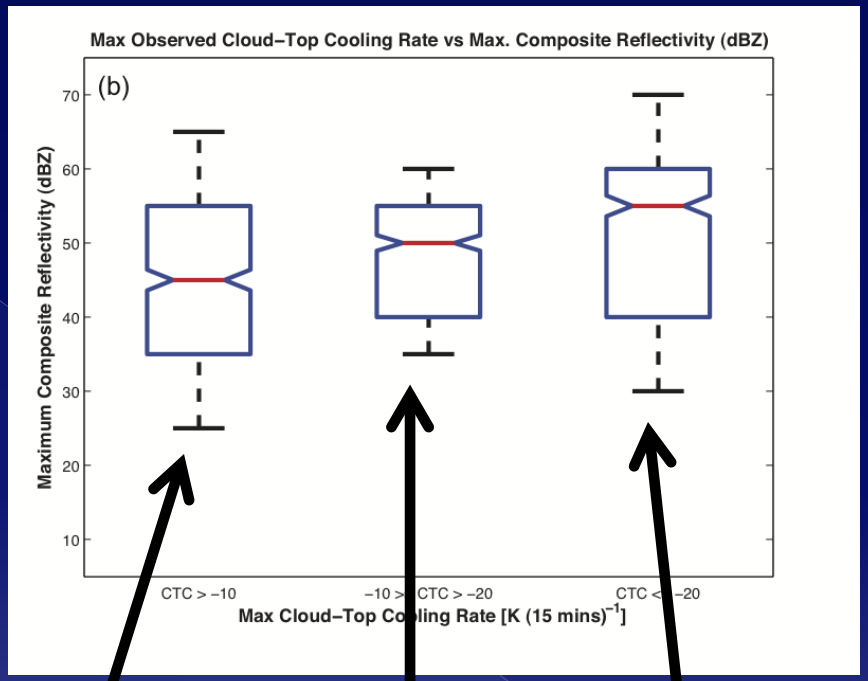
- Reflectivity
  - Range of means → 54-56 dBZ
  - No increase in reflectivity with larger cloud top cooling detections or time
- Lightning
  - Slightly more strikes for larger cloud top cooling rates
  - Strike count increases further into storm lifecycle
  - CTC detections provide lead time on lightning
    - Little to no lead time after max CTC rate
    - More minutes from 1st CTC detection

UW-Madison Findings

- Stronger UW-CTC rates correlates to higher composite reflectivity when compared to weaker UW-CTC rates
  - Weak UW-CTC Median Composite : 45 dBZ
  - Mod. UW-CTC Median Composite : 50 dBZ
  - Strong UW-CTC Median Composite : 55 dBZ

- Strongest UW-CTC rates have strongest 1σ composite reflectivity (70 dBZ)

An Intercomparison of UW Cloud-Top Cooling Rates with WSR-88D Radar Data
Daniel C. Hartung, Justin M. Sieglaff, Lee M. Cronce, and Wayne F. Feltz (WAF, 2012)

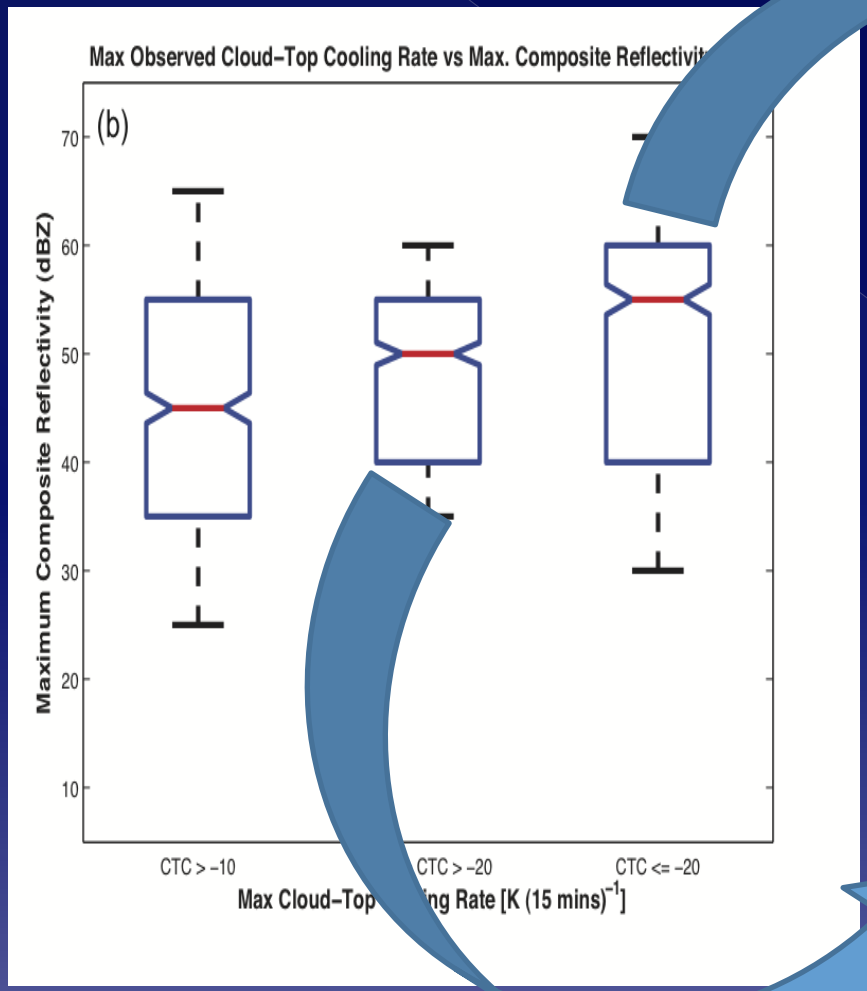


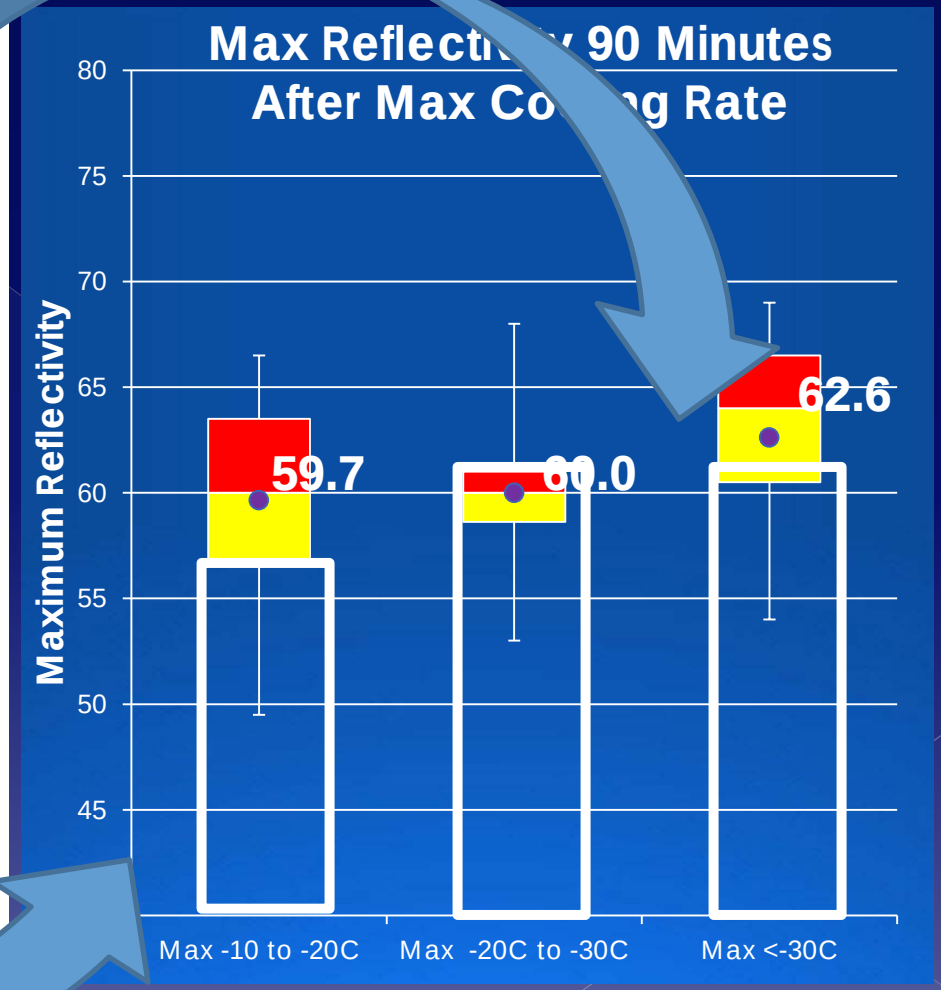
Weak UW-CTC > -10 K

Moderate UW-CTC -10 >= CTC > -20

Strong UW-CTC <= -20

Reflectivity





Warned-on Storms

- Warned-on storms have:
  - Greater average CTC rates (5C/15min)
  - More lightning strikes in the next 90 minutes
- Instability and wind shear environments were very similar
- Average lead time on severe → 63 minutes after max CTC
  - 48 mins after CTC into AWIPS

	Number of Storms	Average Max CTC Rate	Average 90 Minute Lightning	Total 90 Minute Lightning	Averag e Bulk Shear	Average MU CAPE
Warned-on	**19**	**25**	**232**	**4414**	**33**	**2220**
No Warning	**30**	**20**	**134**	**4510**	**32**	**1996**

Conclusion

- Bulk Shear & MU CAPE
  - Not much relationship with CTC rates
- Max reflectivity over next 90 minutes has a slight increase with larger CTC rates
- Lightning
  - More strikes on average with larger CTC rates and time after max detection
- Warned-on Storms
  - Had more lightning strikes & larger CTC rates
  - Average forecast lead time → 48 minutes after max cooling rate
- Need larger dataset
- Errors in sampling are inherent to this work

Cloud-Top Cooling Over the Upper Midwest

Maria Madsen
NWS La Crosse
Student Volunteer

Dan Baumgardt
NWS La Crosse
Science and Operations Officer

January 22, 2014