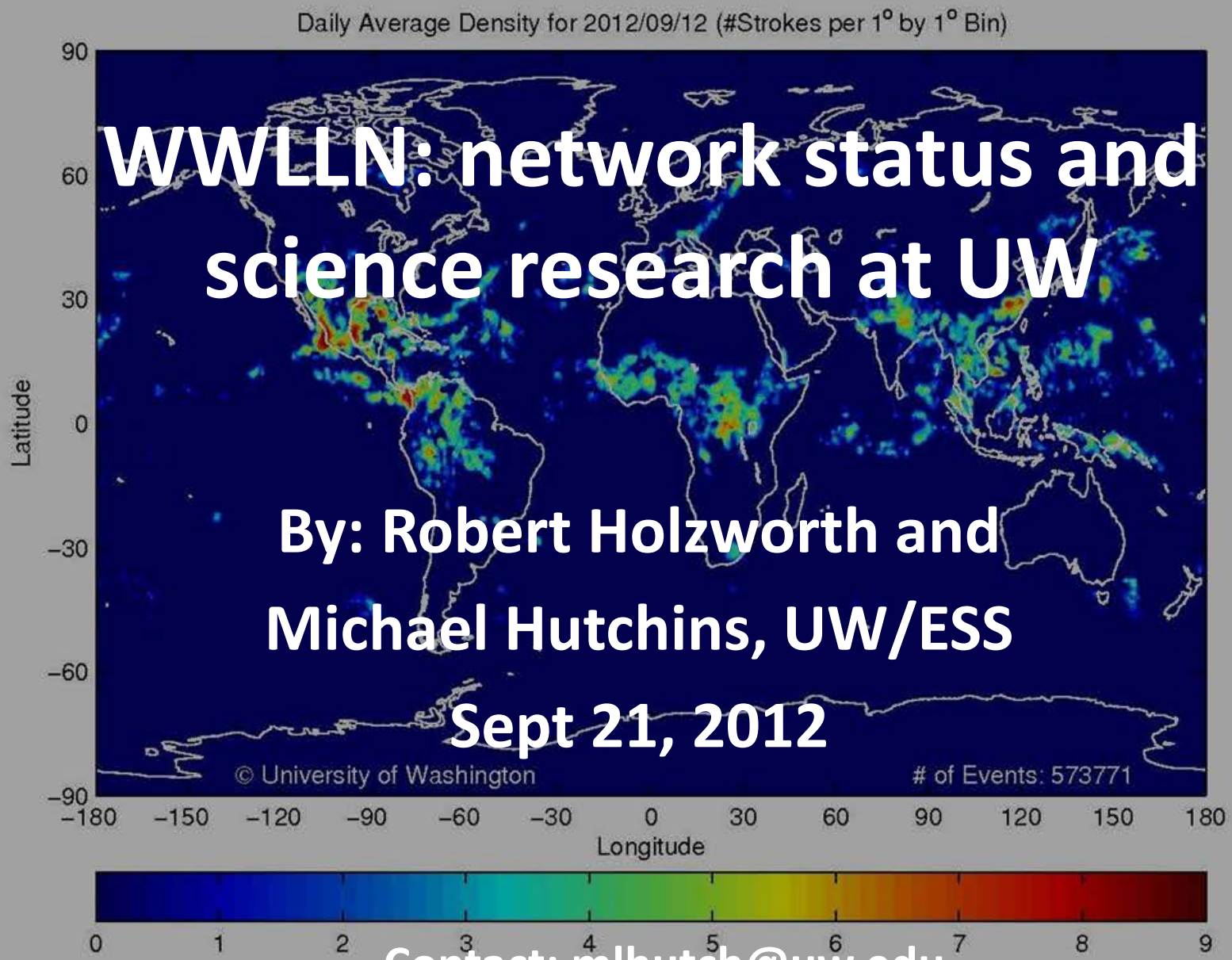
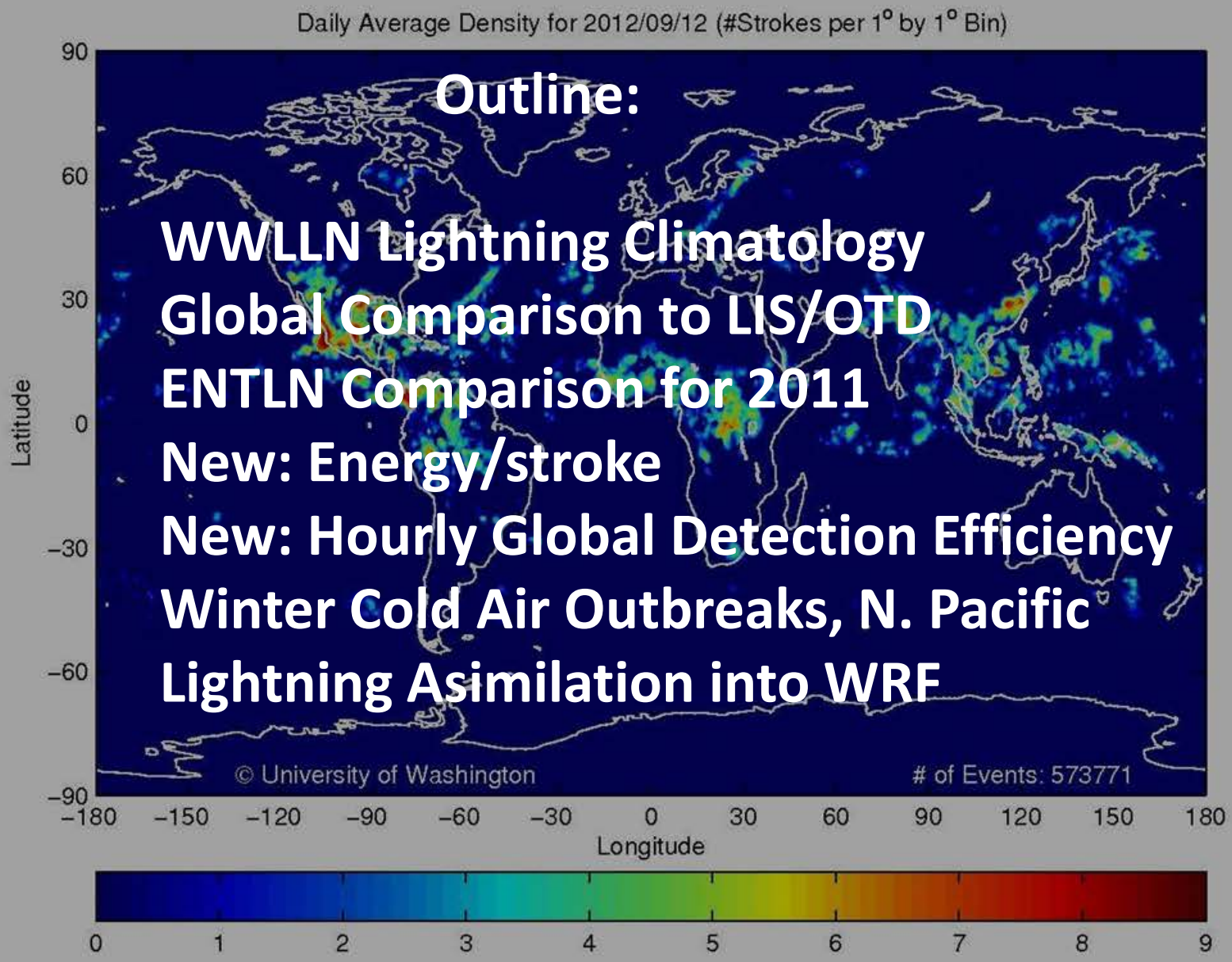
# WWLLN: network status and science research at UW

By: Robert Holzworth and
Michael Hutchins, UW/ESS

Sept 21, 2012




Contact: mlhutch@uw.edu
bobholz@ess.washington.edu

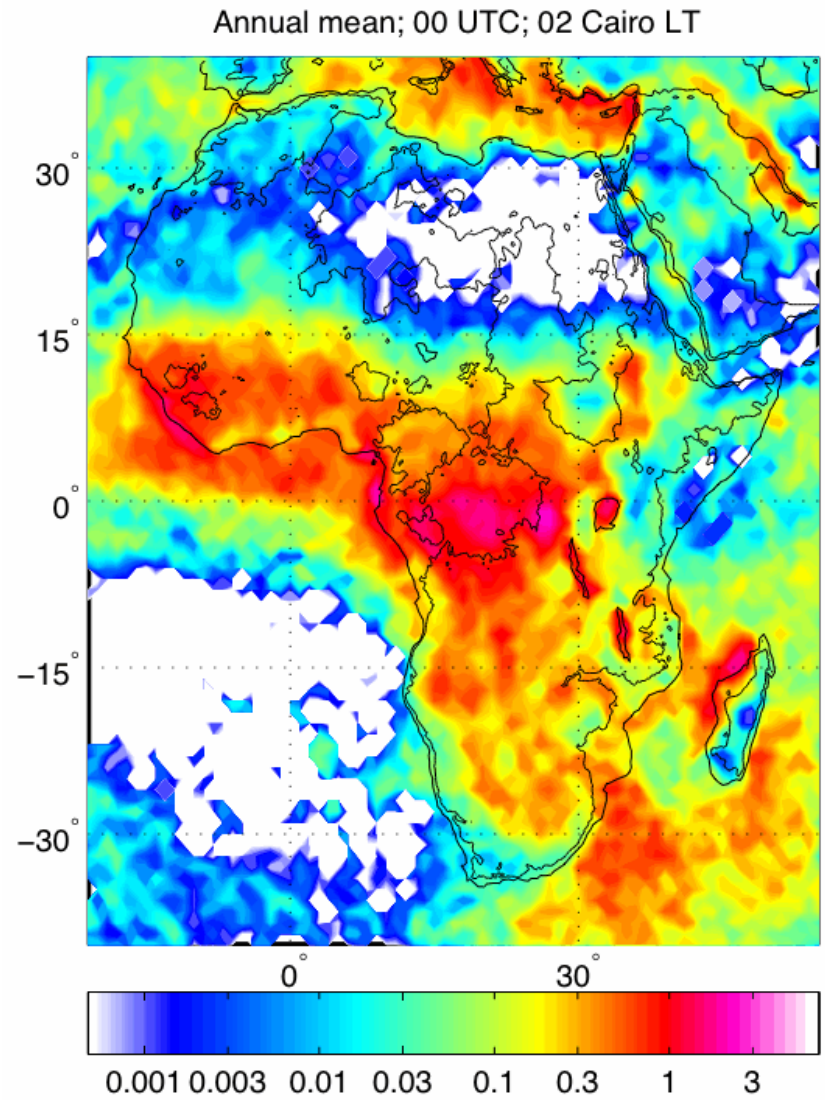


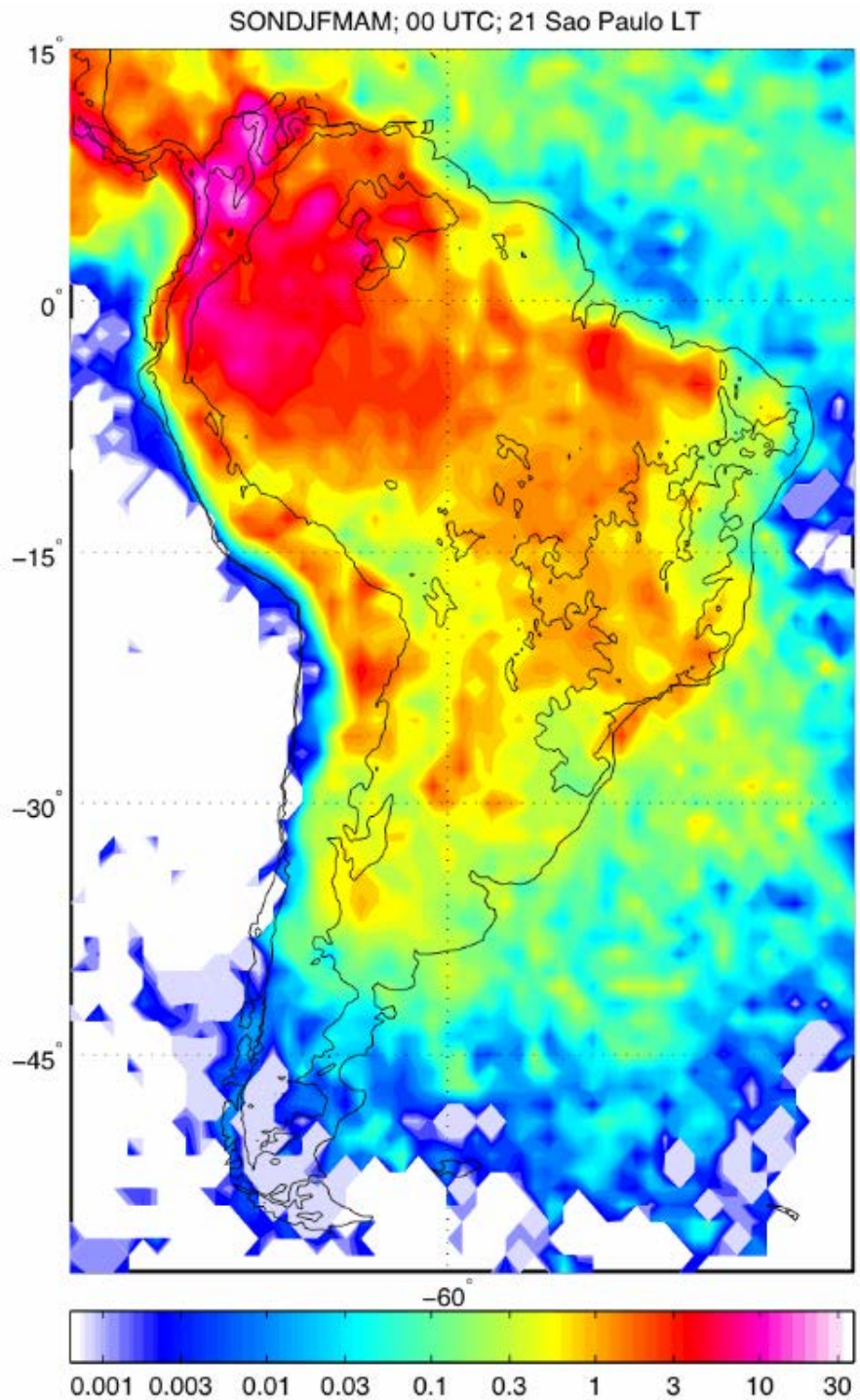

# Outline:

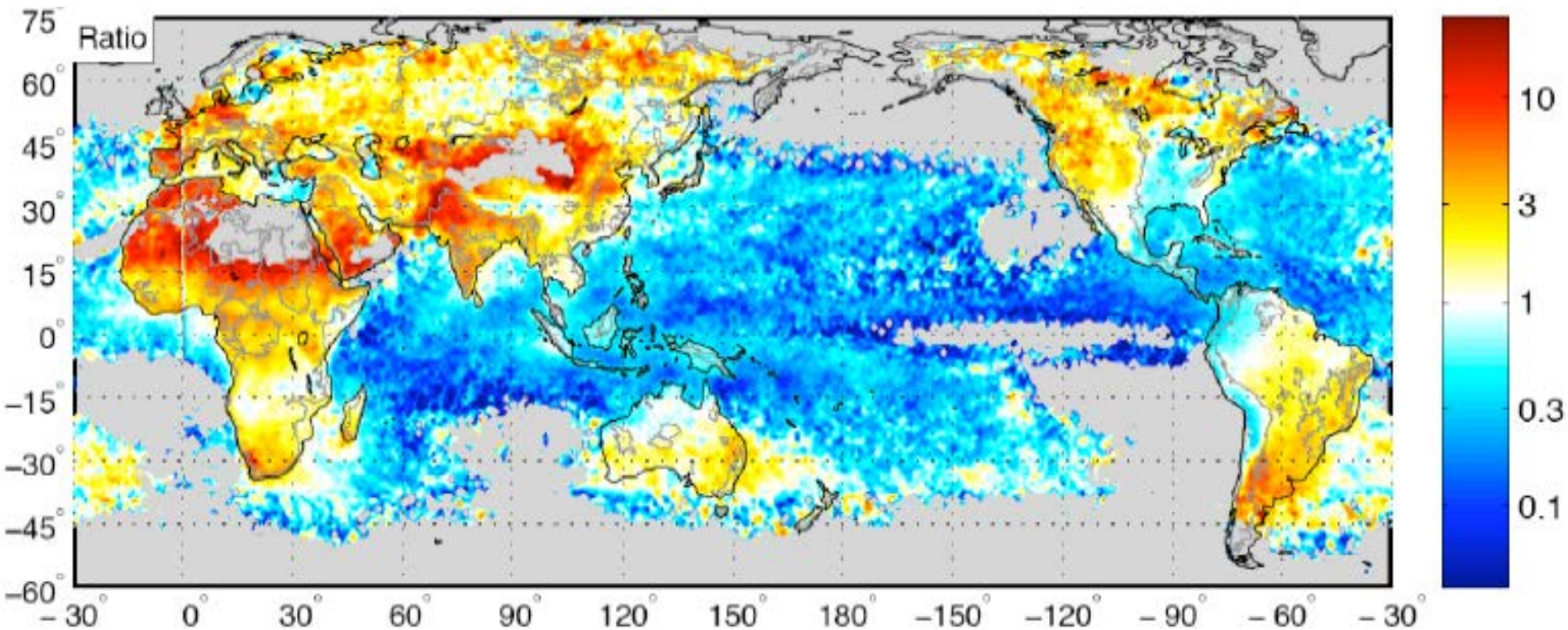
**WWLLN Lightning Climatology**
**Global Comparison to LIS/OTD**
**ENTLN Comparison for 2011**
**New: Energy/stroke**
**New: Hourly Global Detection Efficiency**
**Winter Cold Air Outbreaks, N. Pacific**
**Lightning Asimilation into WRF**

# Lightning Climatology using 4 years WWLLN data

See http://wwlln.net/climate/






# Ratio of LIS/OTD to WWLLN strokes, scaled by the mean of each dataset

Figure 2. of Virts et al, 2012

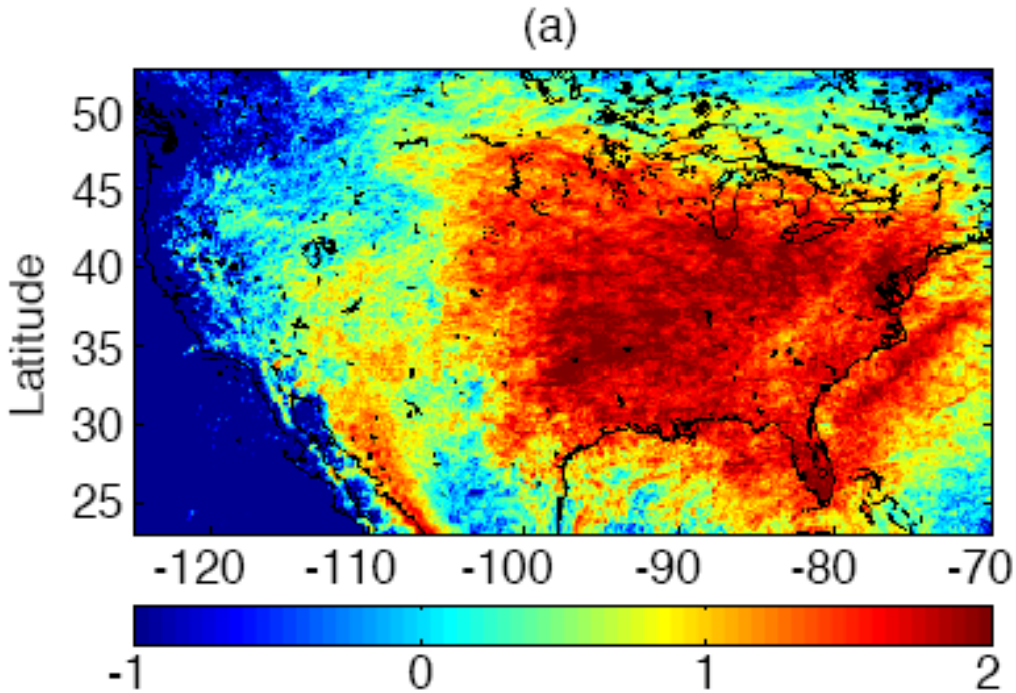
# WWLLN status Sept 2012:

**http://wwlln.net**

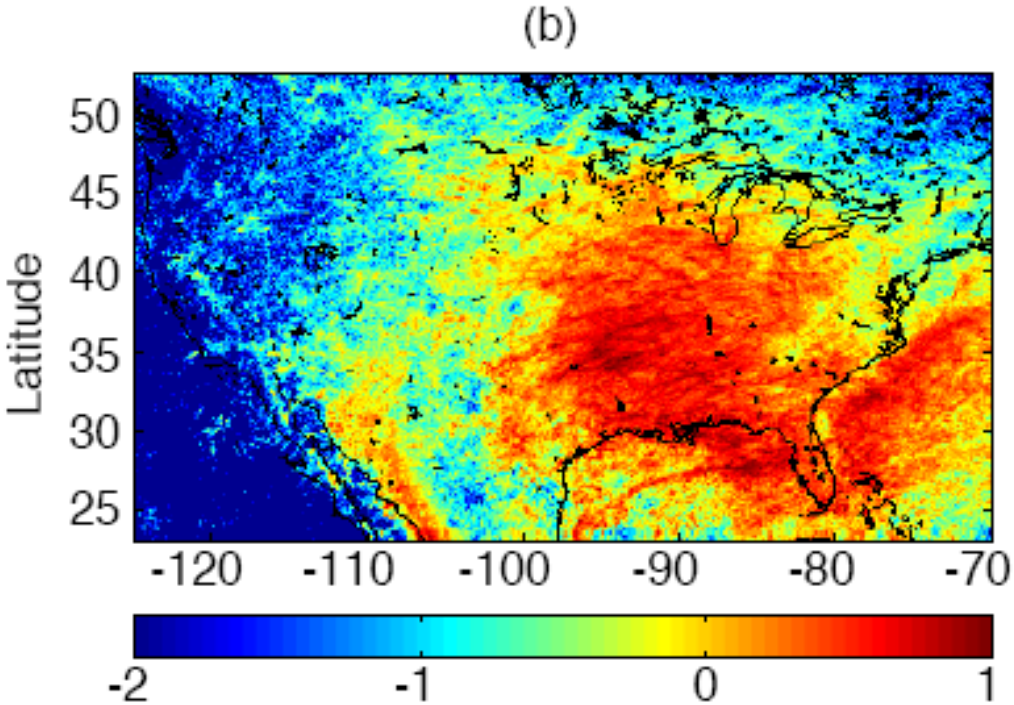
- 66 WWLLN stations (up from 55 this time last year
- Continuous data since August 2004
- Detection Efficiency >50% for CG strokes >40kA
  (>15% all CG strokes)
- Highest Relative DE over the oceans
- Median Location accuracy 3 km
- Timing accuracy ± 16 µs
- >23 peer-reviewed publications since 2010 using WWLLN data (see wwlln.net/publications)

We did a **direct comparison** for a whole year in the CONUS between ENTLN and WWLLN

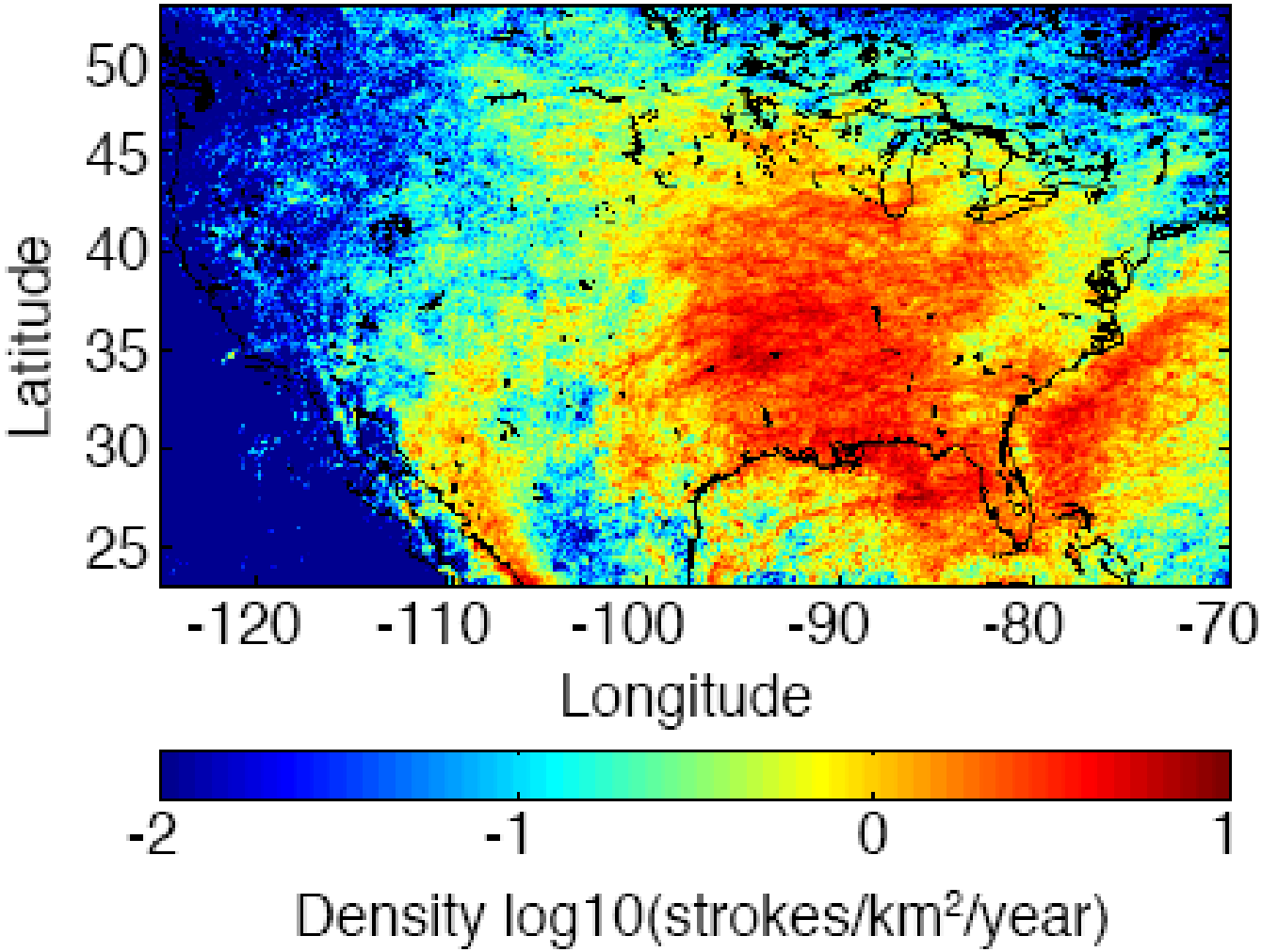
These are the density plots of each data set separately



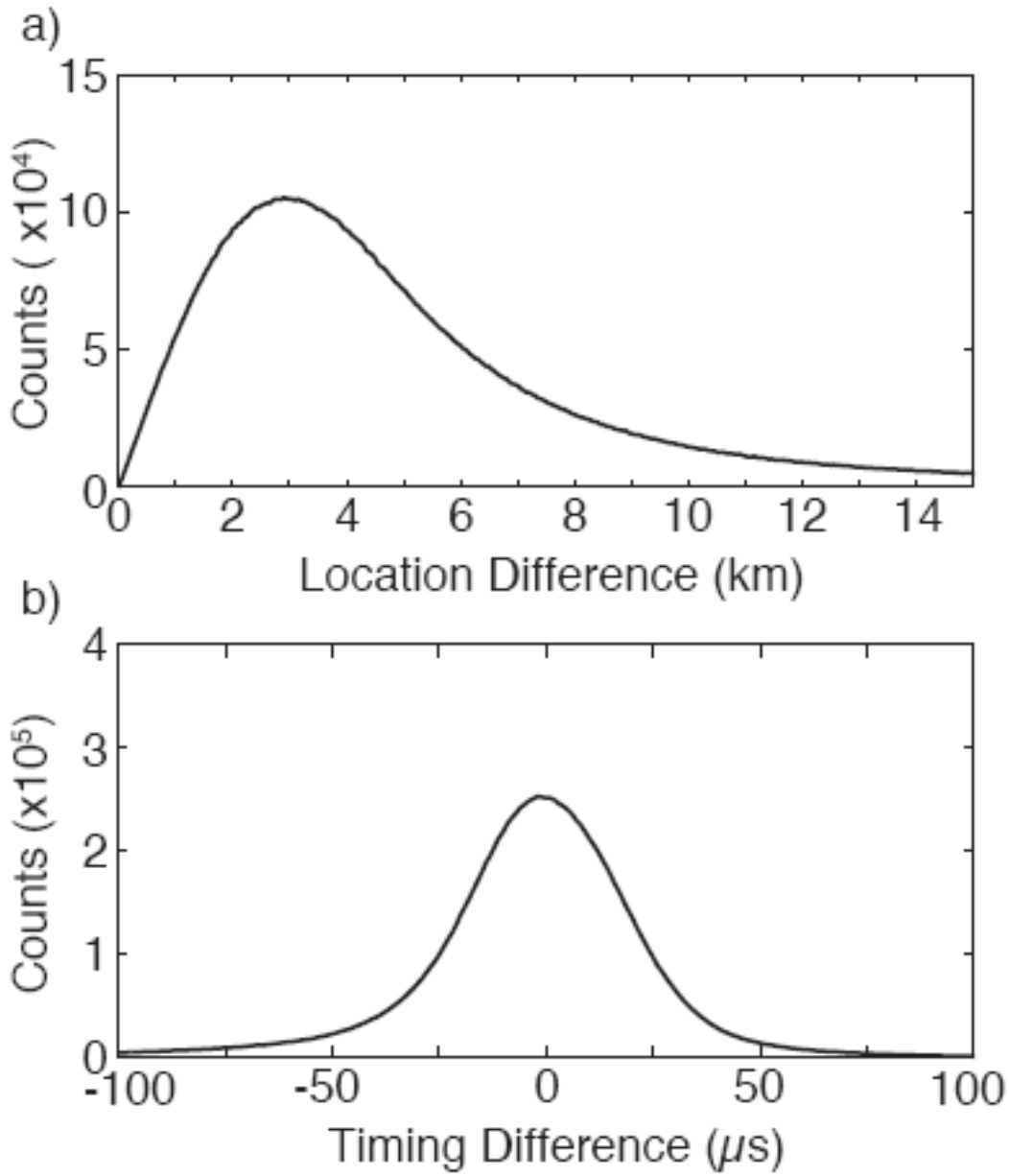

ENTLN




WWLLN




2x10^7 matches between ENTLN and WWLLN in 2011


a)
15
10
5
0
Counts ( x10⁴)
0
2
4
6
8
10
12
14
Location Difference (km)
b)
4
3
2
1
0
Counts (x10⁵)
-100
-50
0
50
100
Timing Difference (μs)

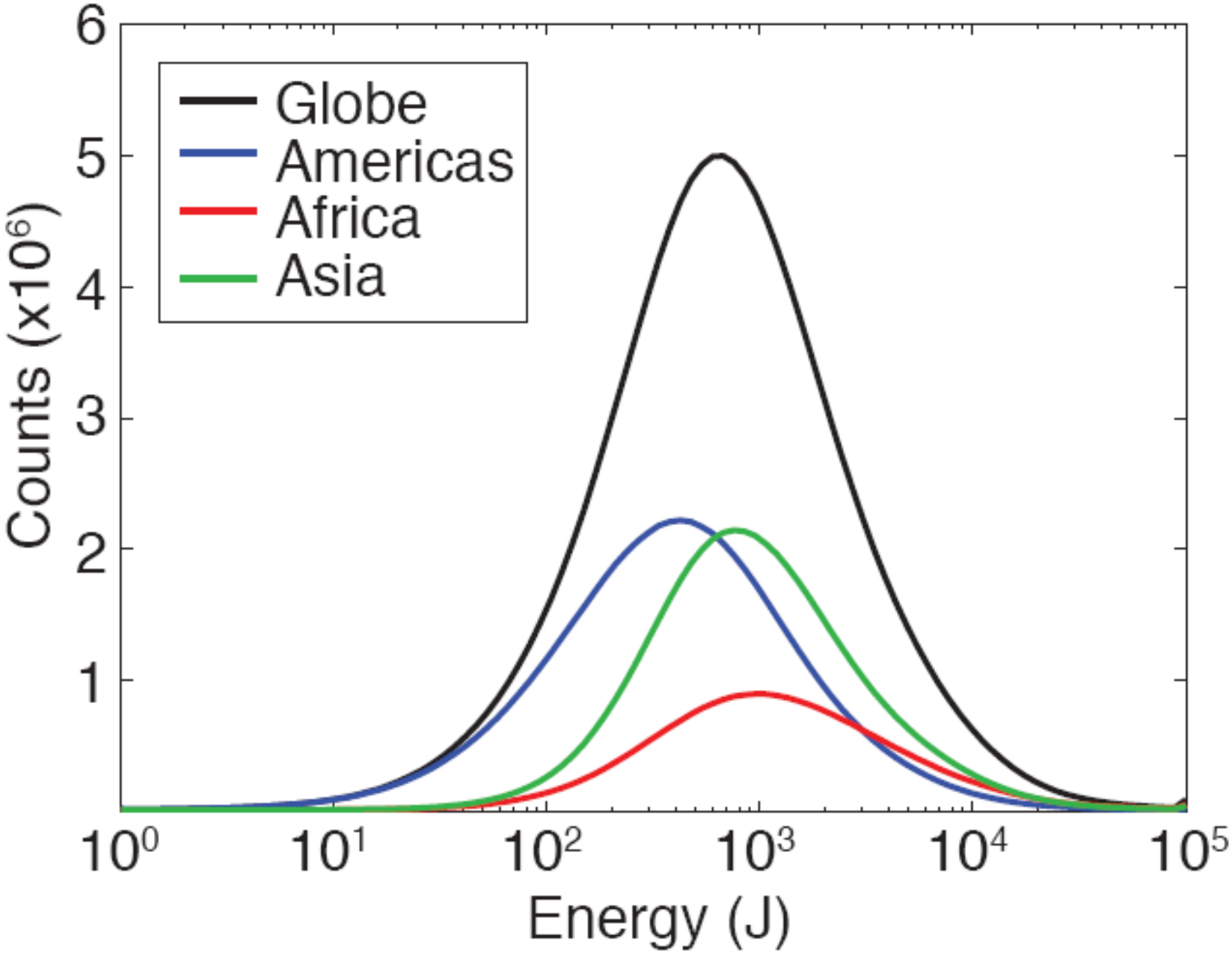
# New Capabilities:

## Energy per stroke

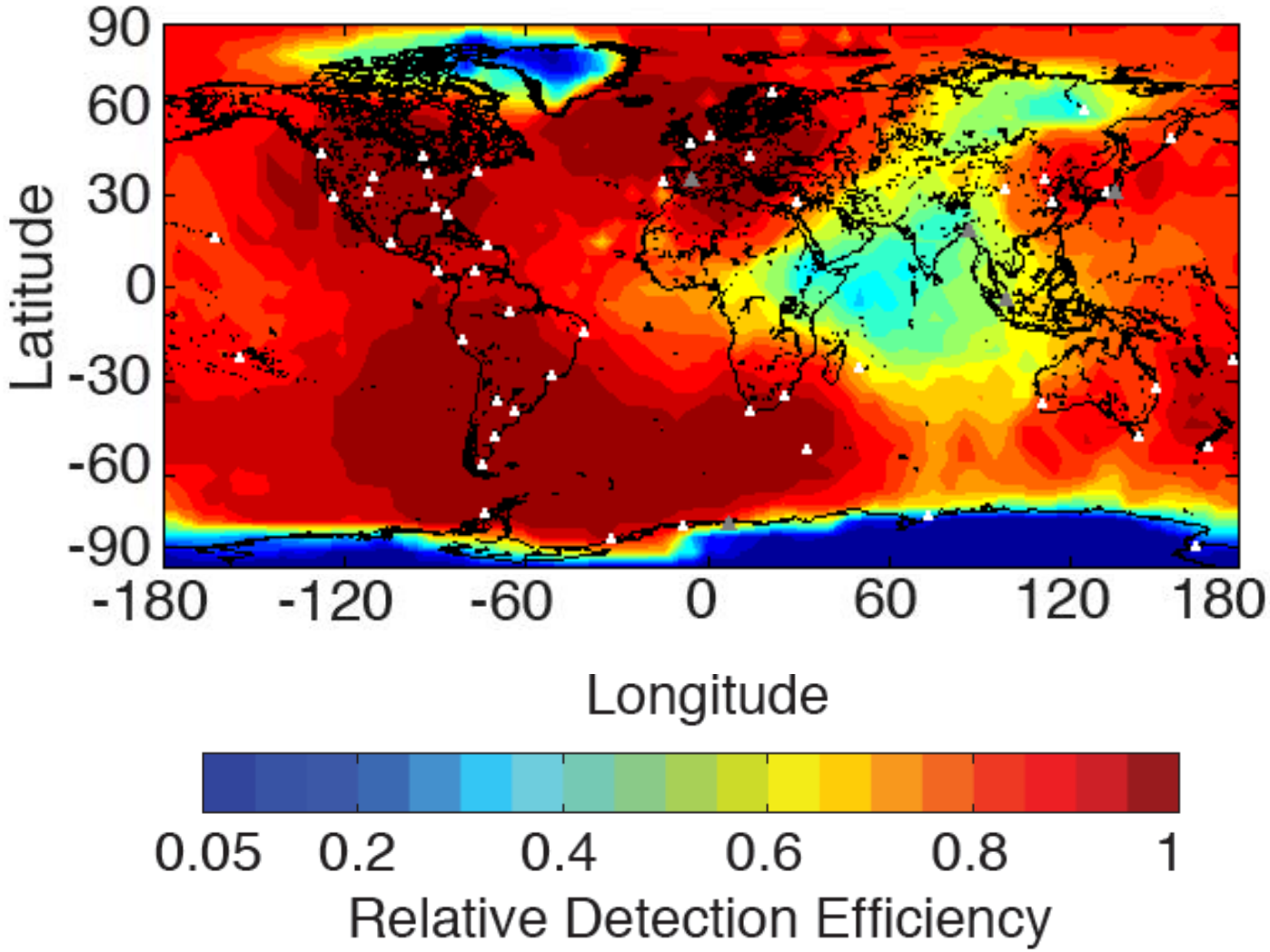
(now available from April 2009)

## WWLLN Relative Detection Efficiency

every hour ($5^o$x$5^o$ or $1^o$x$1^o$ global grid)


Globe
Americas
Africa
Asia
Counts (x10^6)
6
5
4
3
2
1
10^0
10^1
10^2
10^3
10^4
10^5
Energy (J)

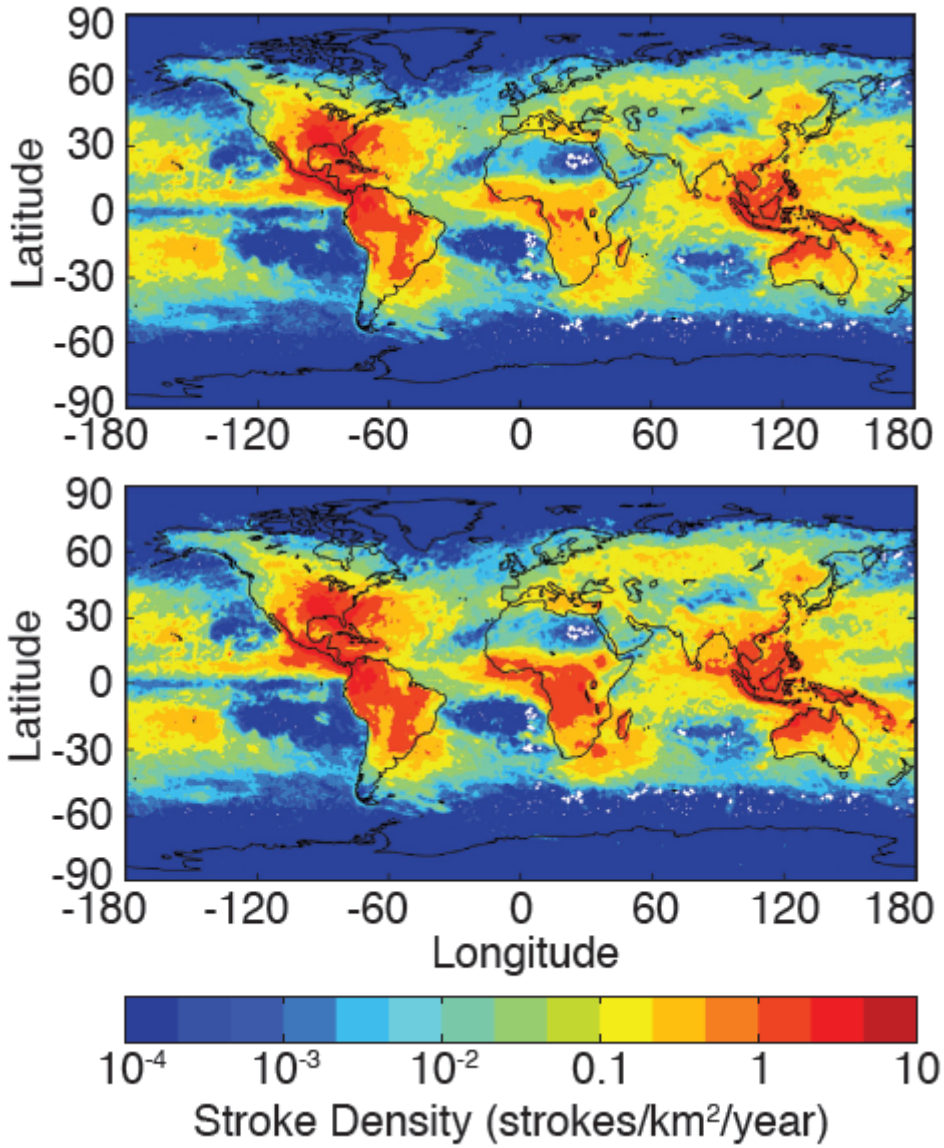
# Relative detection efficiency map for 15 May 2012



# Comparison

Raw WWLLN densities (top),

Relative DE corrected (bottom)



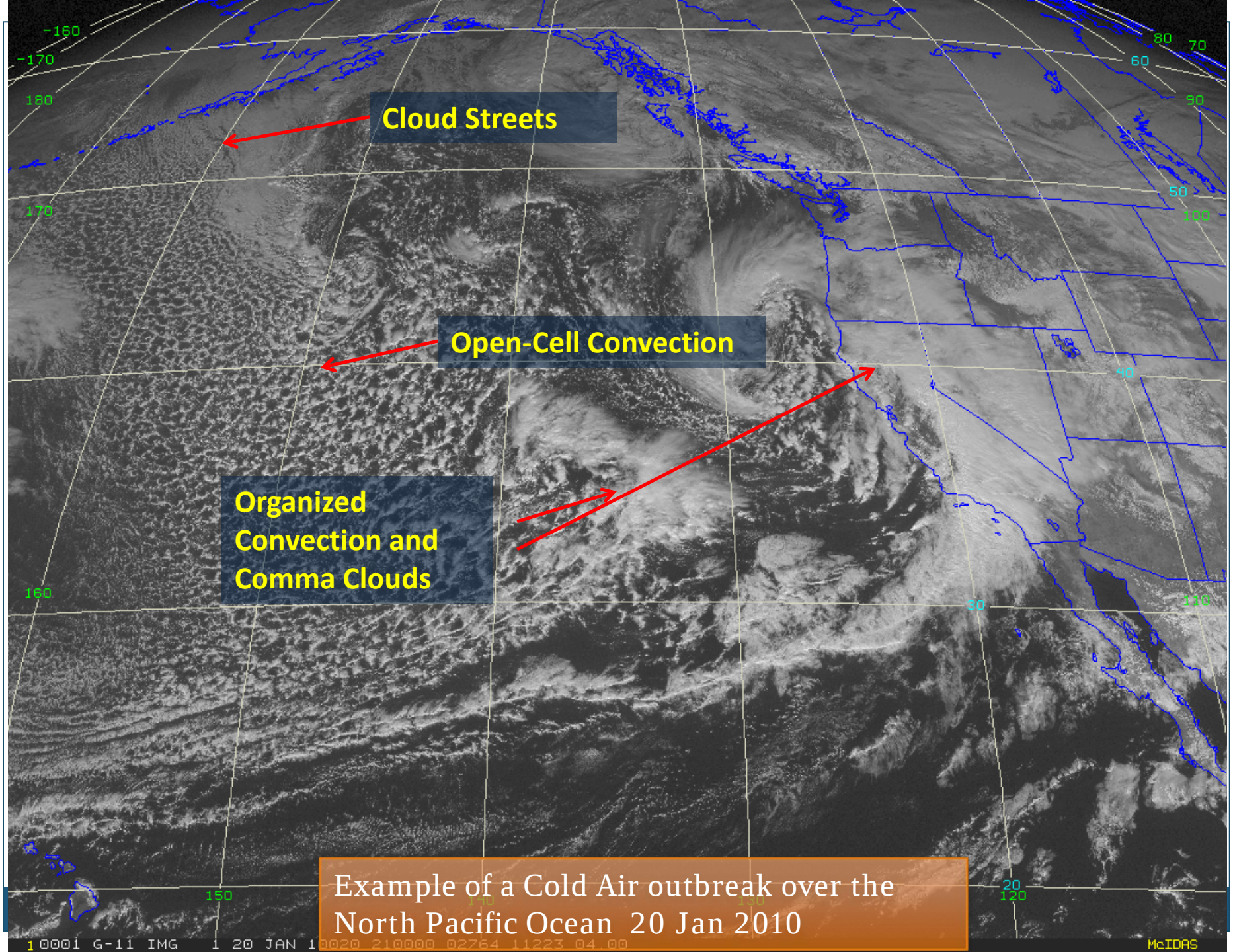
# WWLLN uses in Meteorological Forecasting:

Winter Cold Air outbreaks over N. Pacific, comma clouds

(see McMurdie et al, AMS meeting Jan 2013)

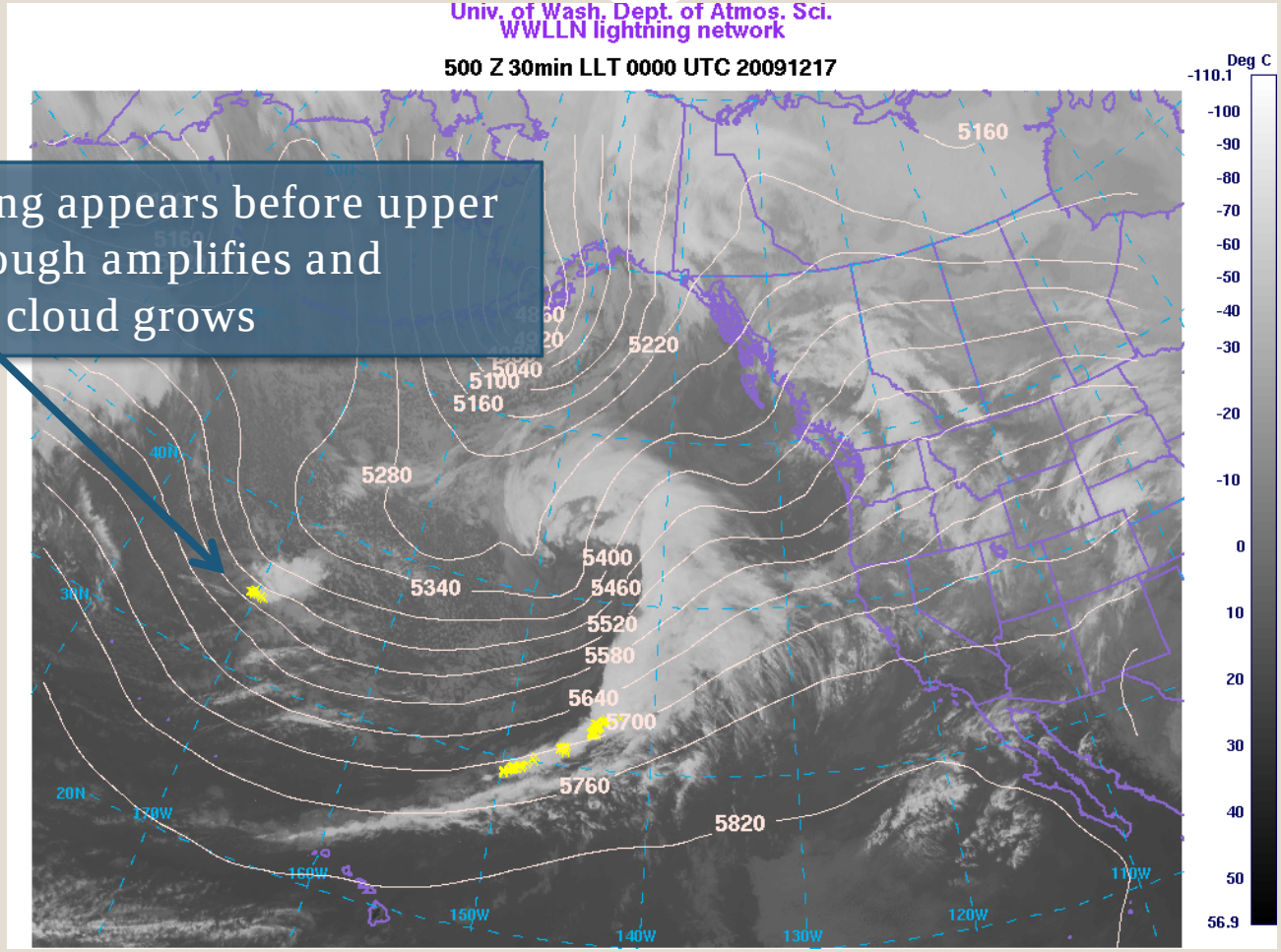
Lightning assimilation into WRF prediction model

(preliminary results from Cliff Mass, et al)



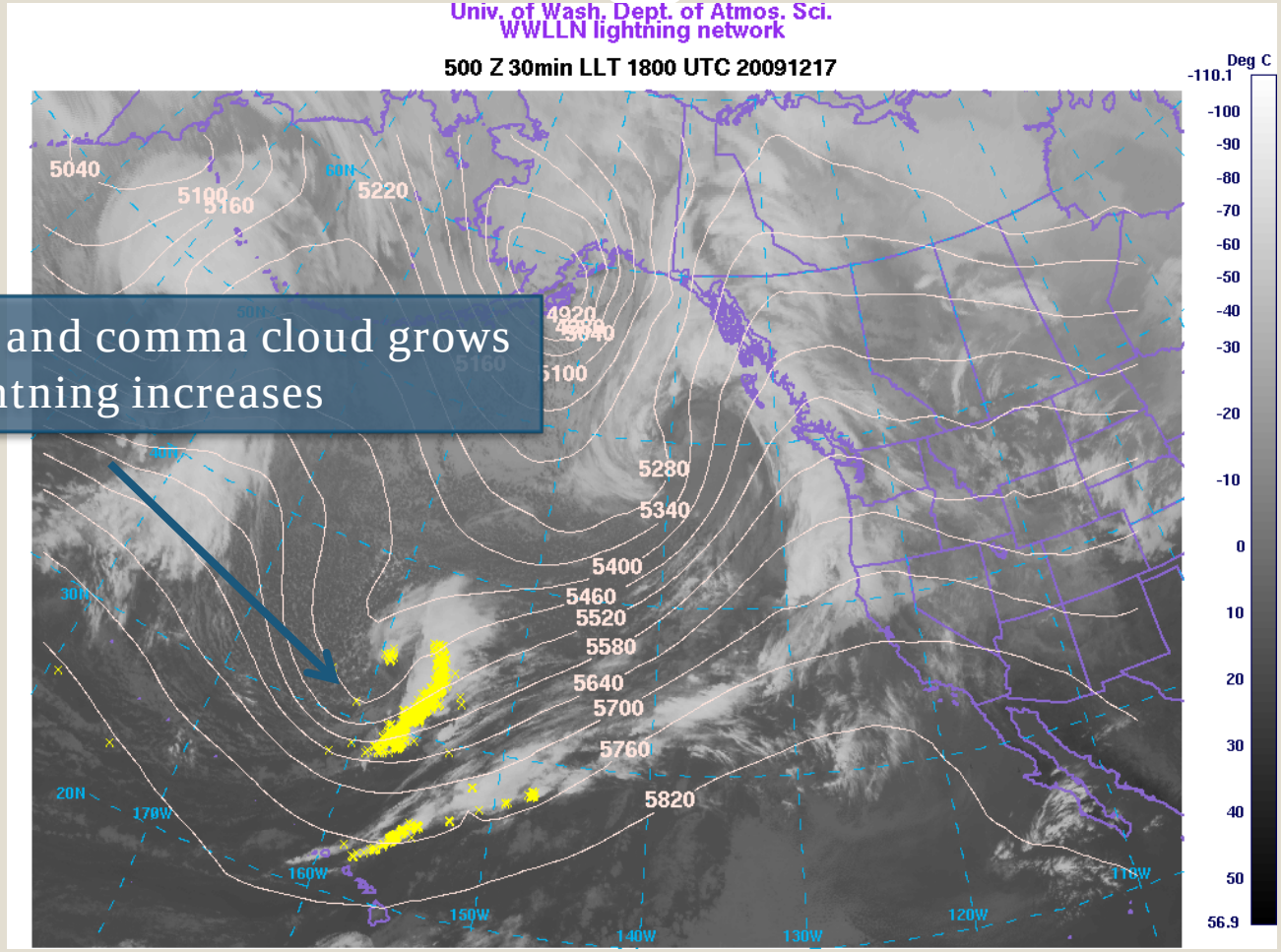

Example of a Cold Air outbreak over the North Pacific Ocean 20 Jan 2010

# Lightning as a precursor to Upper-level trough amplification




Lightning appears before upper level trough amplifies and comma cloud grows

# Lightning as a precursor to Upper-level trough amplification




Trough and comma cloud grows and lightning increases

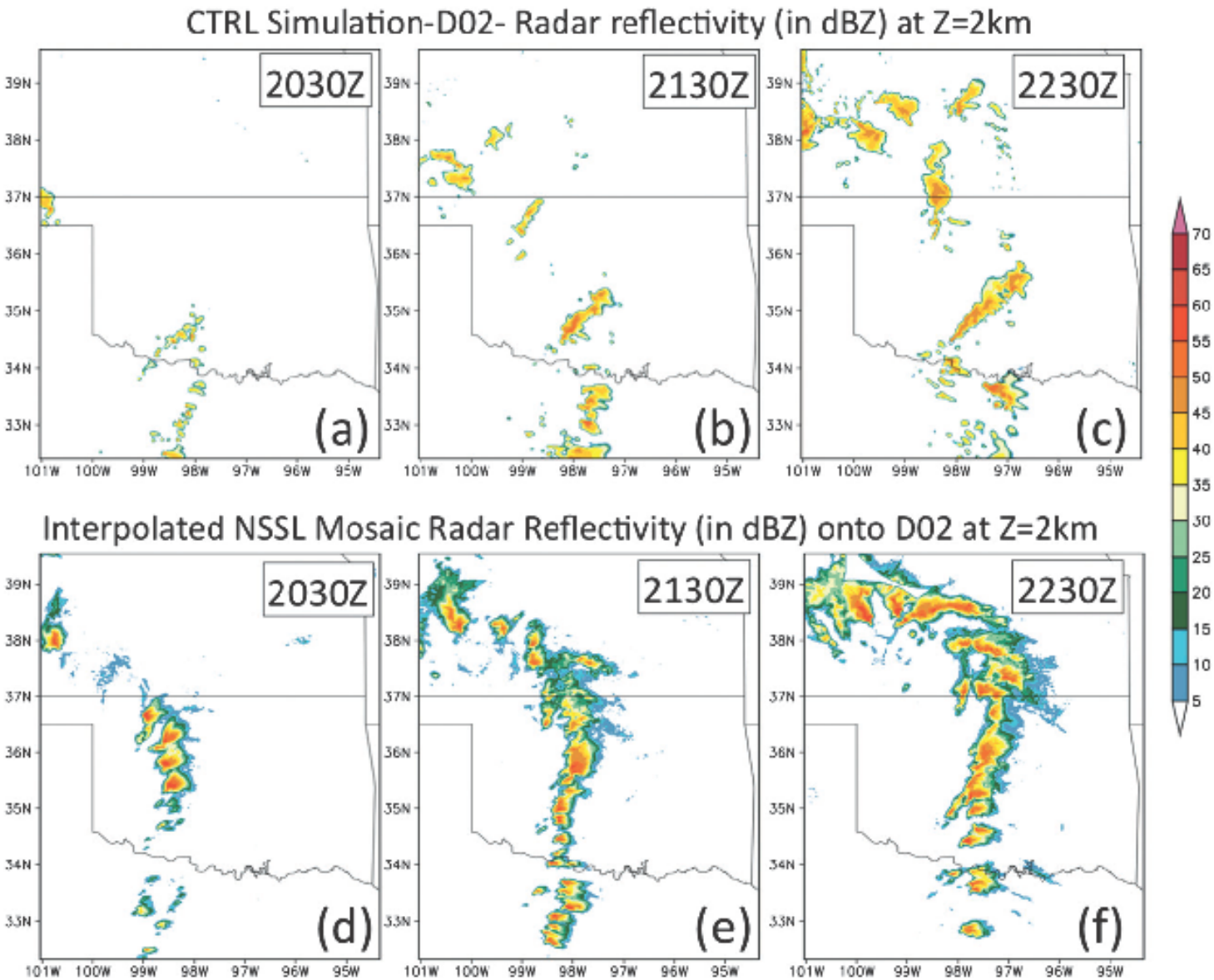



FIG. 9. (a)–(c) Simulated radar reflectivity (in dBZ) for the CTRL run at 2030 (during assimilation period), 2130 (end of assimilation period or analysis time), and 2230 UTC (1-h forecast) for the D02 simulation, respectively. Note that in this and all subsequent plots, the domain boundaries of D02 were cropped to the size of the D03 domain to focus on the OK convection and to allow an easy comparison between all grids later on. (d)–(f) As in (a)–(c), but for interpolated radar reflectivity from the NMQ product onto the 3-km (D02) grid again using the same domain boundaries as D03. Legends for shadings are shown on the right.

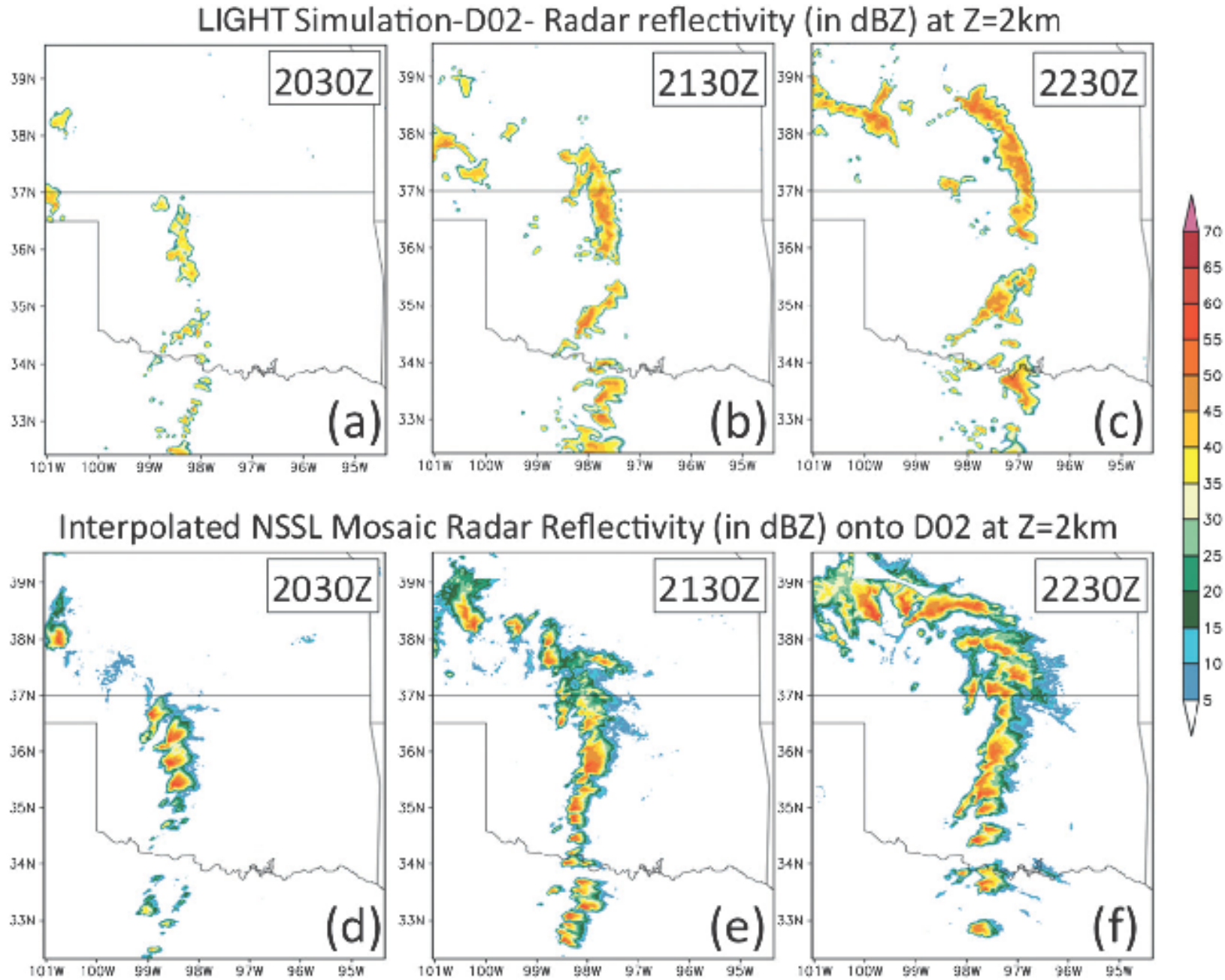



FIG. 12. As in Fig. 9, but for the LIGHT lightning assimilation run.

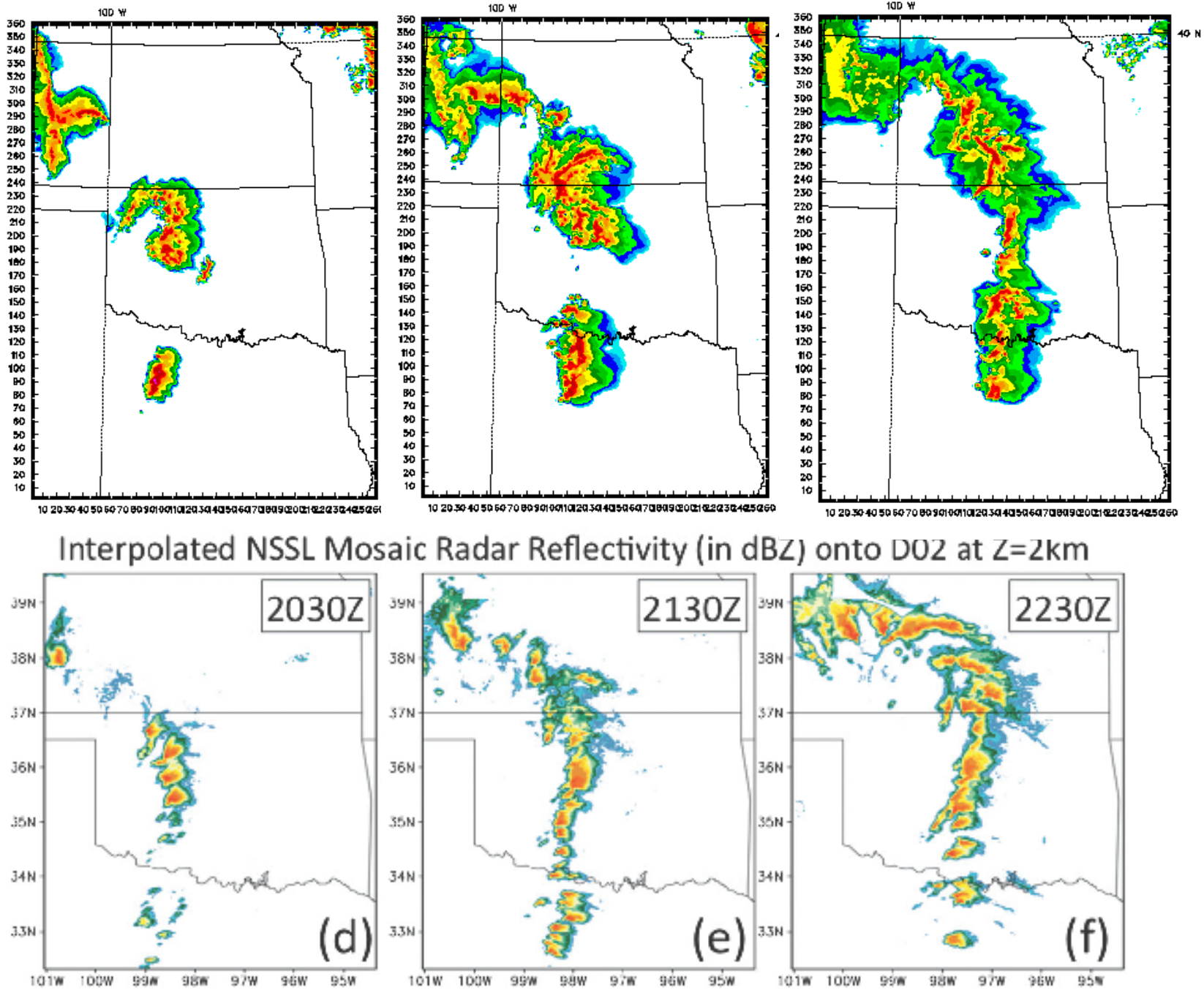


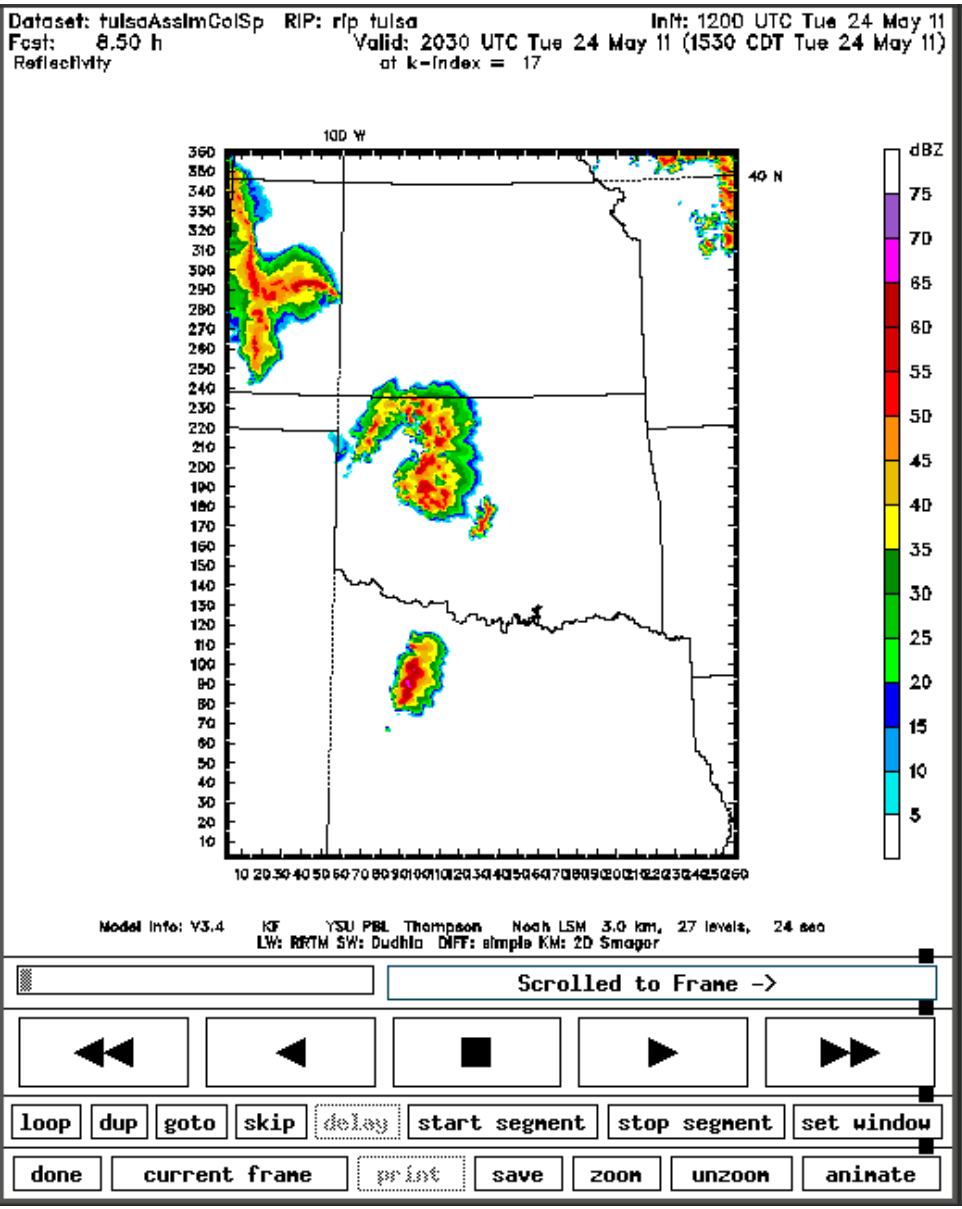

FIG. 12. As in Fig. 9, but for the LIGHT lightning assimilation run.

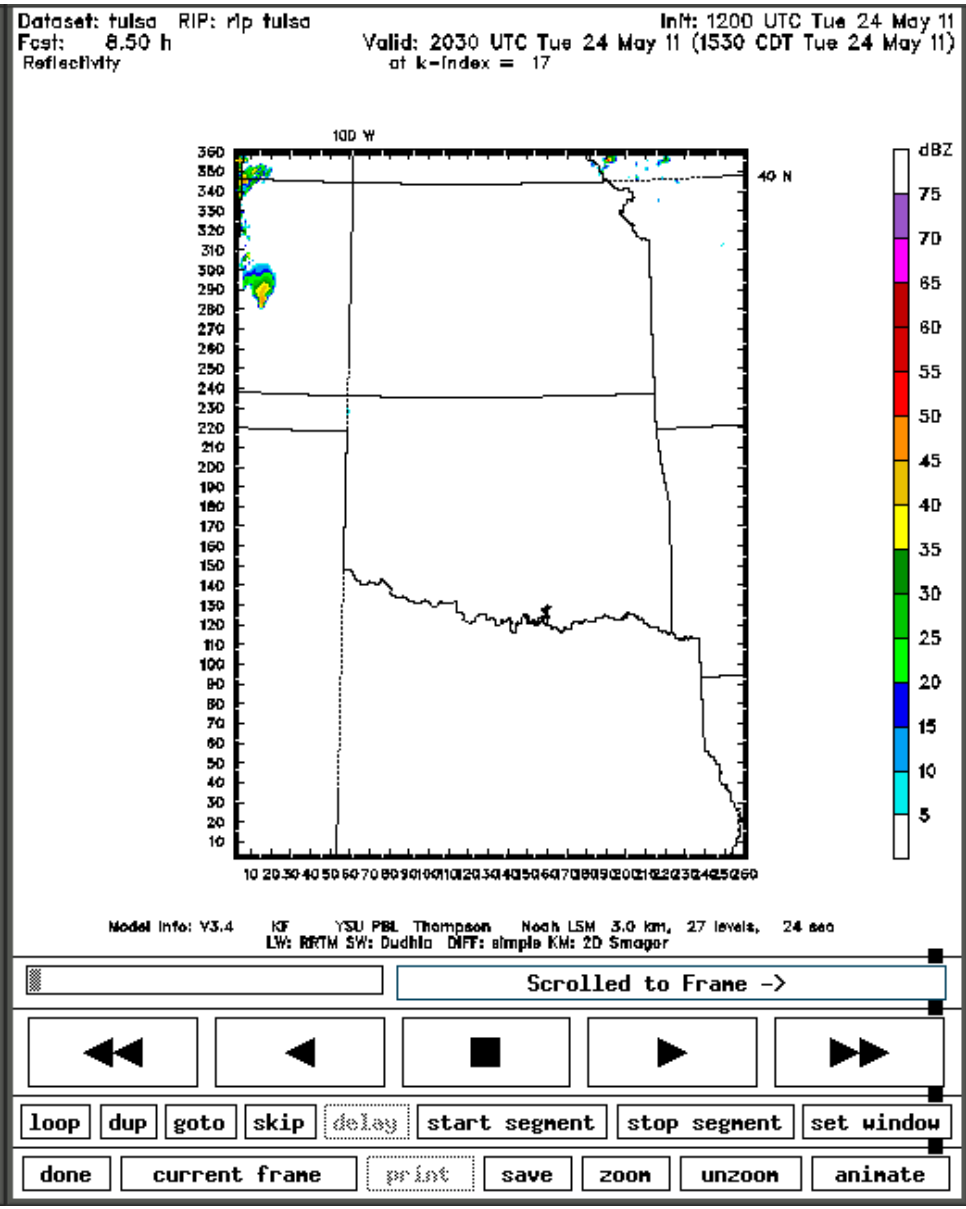
# Summary

- WWLLN network continues to expand with 11 new stations in last year.
- Detailed comparison to ENTLN in CONUS was conducted (Paper by Hutchins et al, submitted 2012)
- Global Lightning Climatology(Virts et al, in press, 2012)
- New Capability: Energy per stroke and relative Detection Efficiency
- Using WWLLN data in forecasting cold air outbreaks, and in data assimilation into WRF

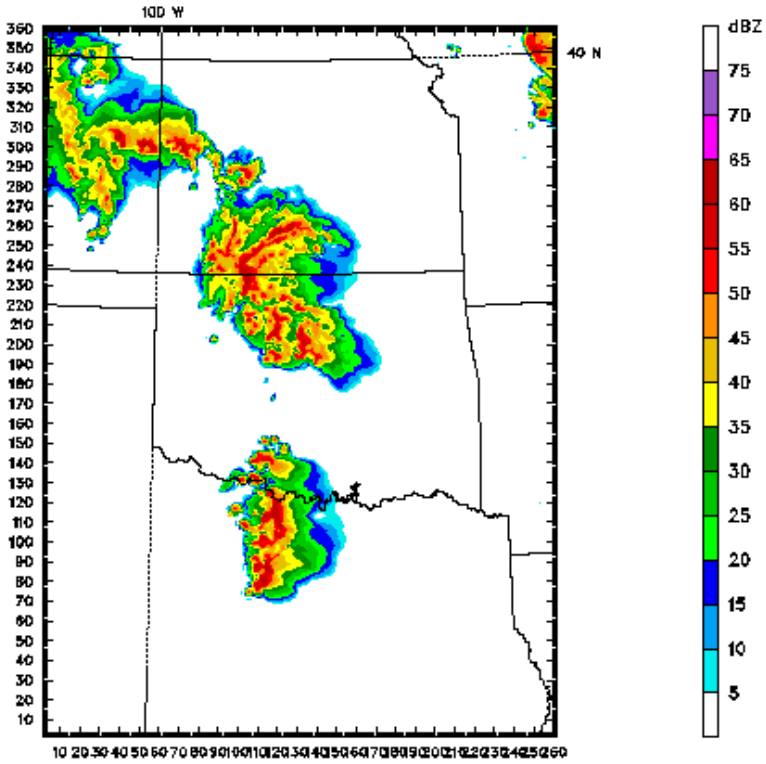
**Contact: mlhutch@uw.edu, bobholz@ess.washington.edu**

Extra slides


Dataset: tulsaAssimColSp RIP: rip tulsa
Init: 1200 UTC Tue 24 May 11
Fcst: 8.50 h
Valid: 2030 UTC Tue 24 May 11 (1530 CDT Tue 24 May 11)
Reflectivity
at k-index = 17
100 W
40 N
dBZ
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Model Info: V3.4 KF YSU PBL Thompson Noah LSM 3.0 km, 27 levels, 24 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor
Scrolled to Frame ->
loop
dup
goto
skip
delay
start segment
stop segment
set window
done
current frame
print
save
zoom
unzoom
animate


Dataset: tulsa RIP: rip tulsa
Init: 1200 UTC Tue 24 May 11
Fcst: 8.50 h
Valid: 2030 UTC Tue 24 May 11 (1530 CDT Tue 24 May 11)
Reflectivity
at k-index = 17
100 W
40 N
dBZ
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Model Info: V3.4 KF YSU PBL Thompson Noah LSM 3.0 km, 27 levels, 24 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor
Scrolled to Frame ->
loop
dup
goto
skip
delay
start segment
stop segment
set window
done
current frame
print
save
zoom
unzoom
animate

Dataset: tulsaAssimColSp RIP: rip tulsa Init: 1200 UTC Tue 24 May 11
Fcst: 9.50 h Valid: 2130 UTC Tue 24 May 11 (1630 CDT Tue 24 May 11)
Reflectivity at k-index = 17



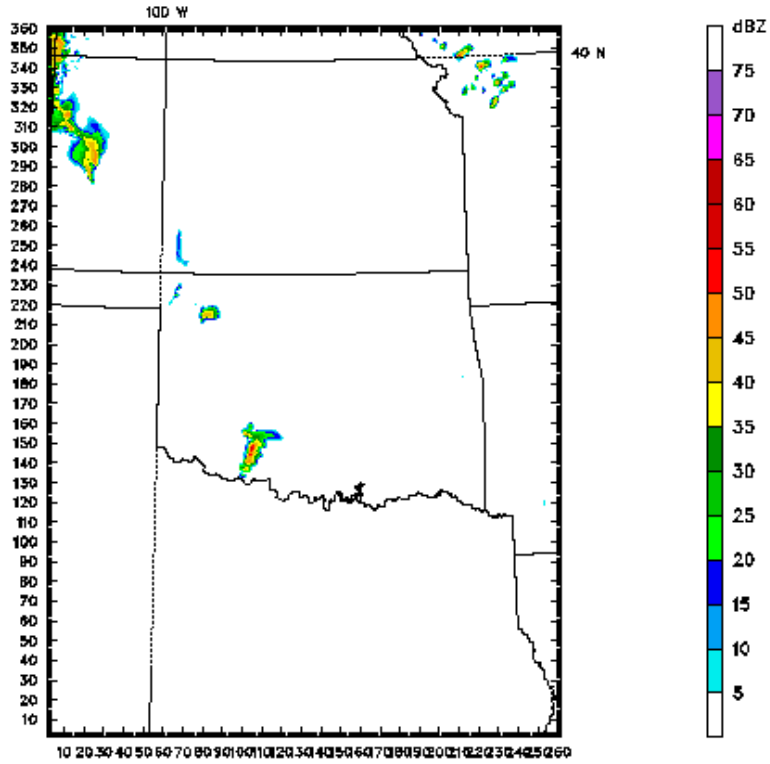

Model Info: V3.4 KF YSU PBL Thompson Noah LSM 3.0 km, 27 levels, 24 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

Scrolled to Frame ->

loop dup goto skip delay start segment stop segment set window

done current frame print save zoom unzoom animate

Dataset: tulsa RIP: rip tulsa Init: 1200 UTC Tue 24 May 11
Fcst: 9.50 h Valid: 2130 UTC Tue 24 May 11 (1630 CDT Tue 24 May 11)
Reflectivity at k-index = 17

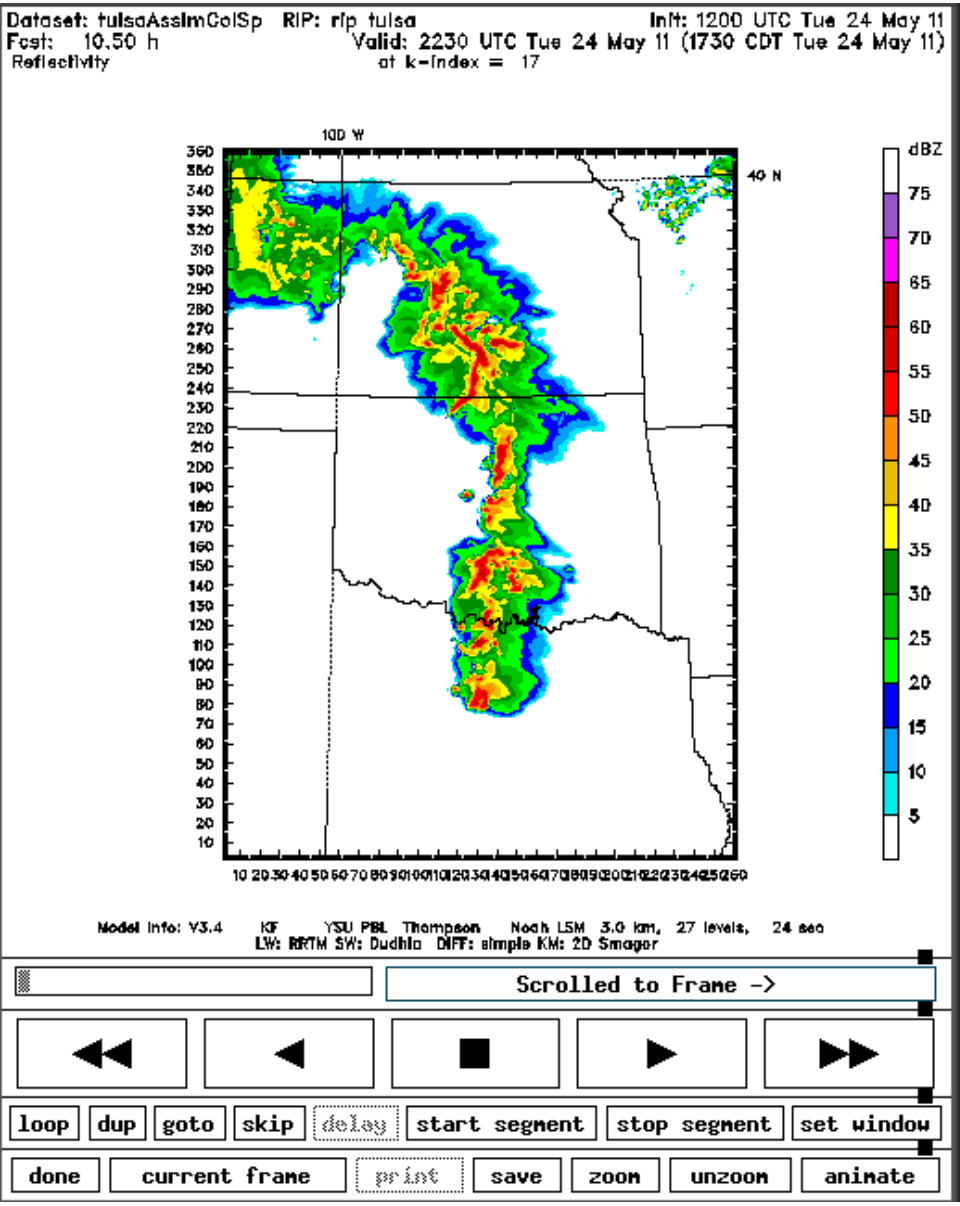


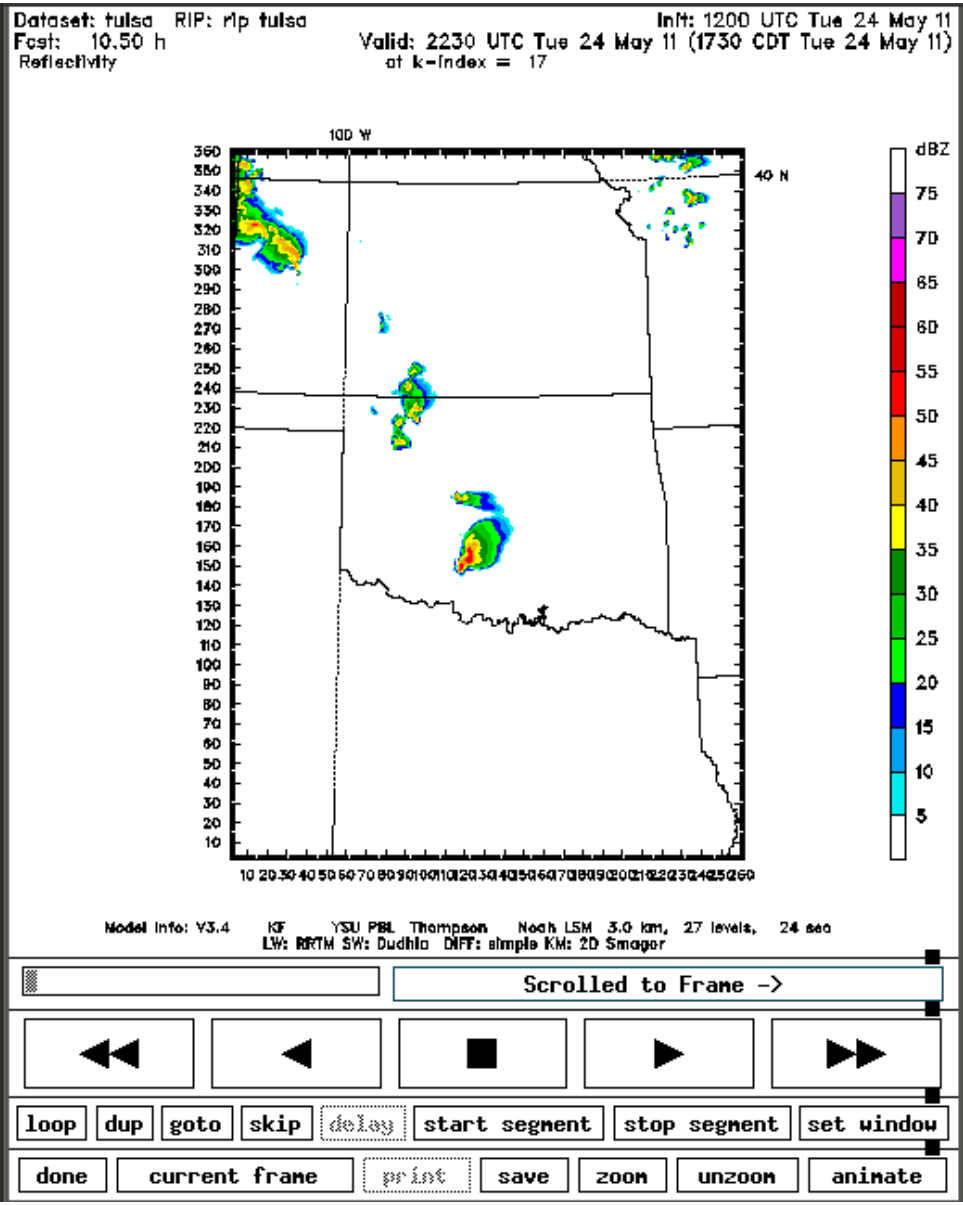

Model Info: V3.4 KF YSU PBL Thompson Noah LSM 3.0 km, 27 levels, 24 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

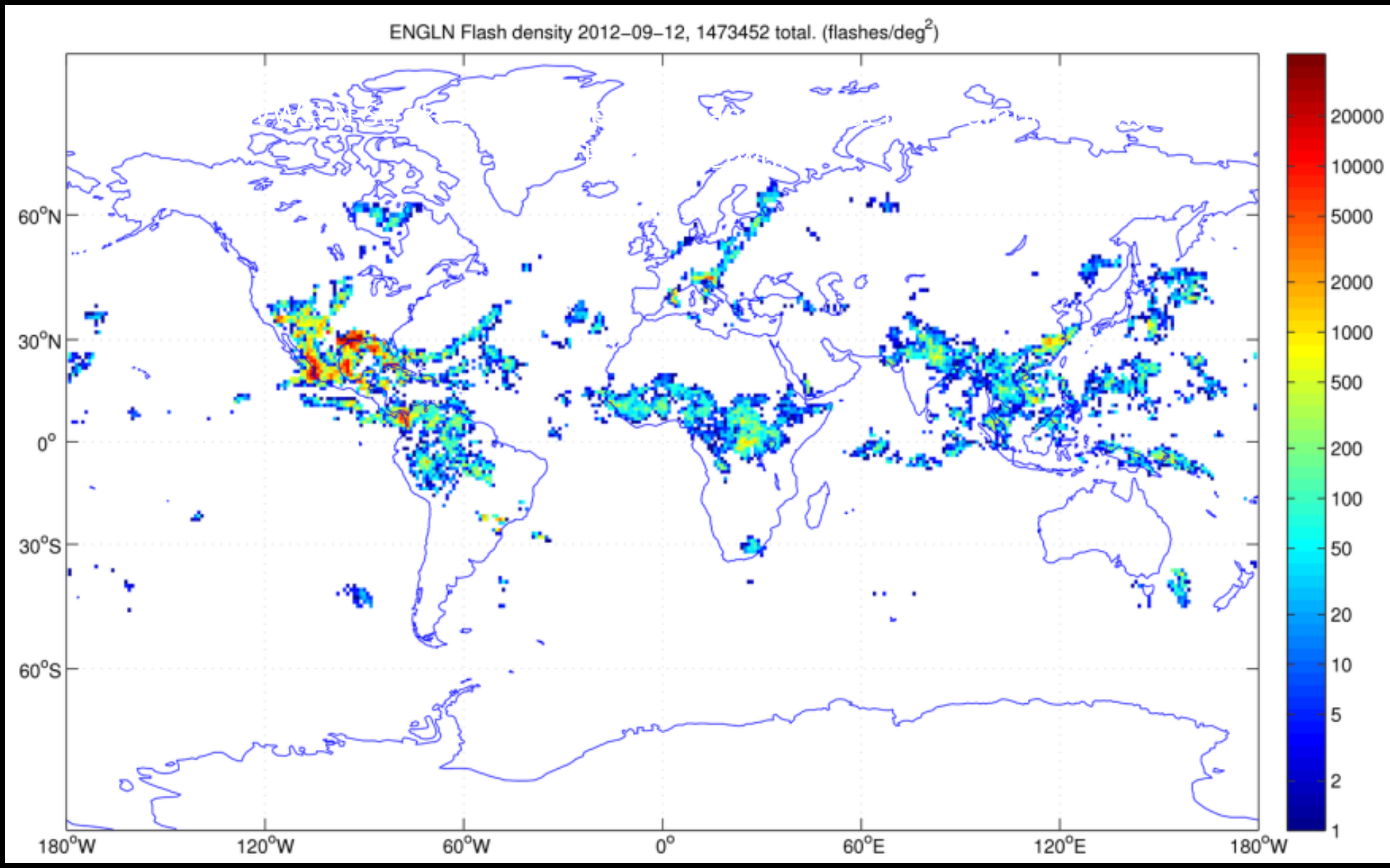
Scrolled to Frame ->

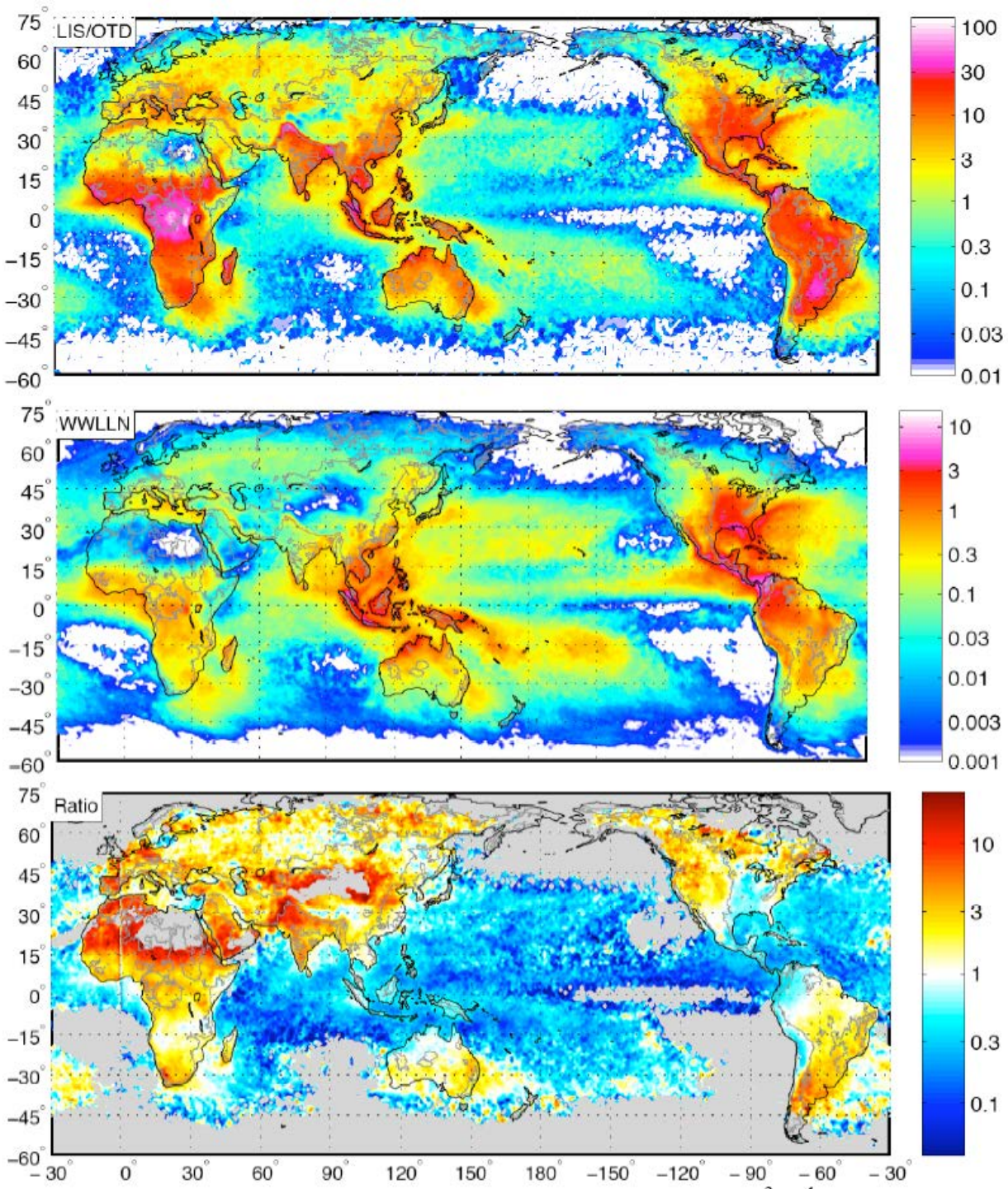
loop dup goto skip delay start segment stop segment set window

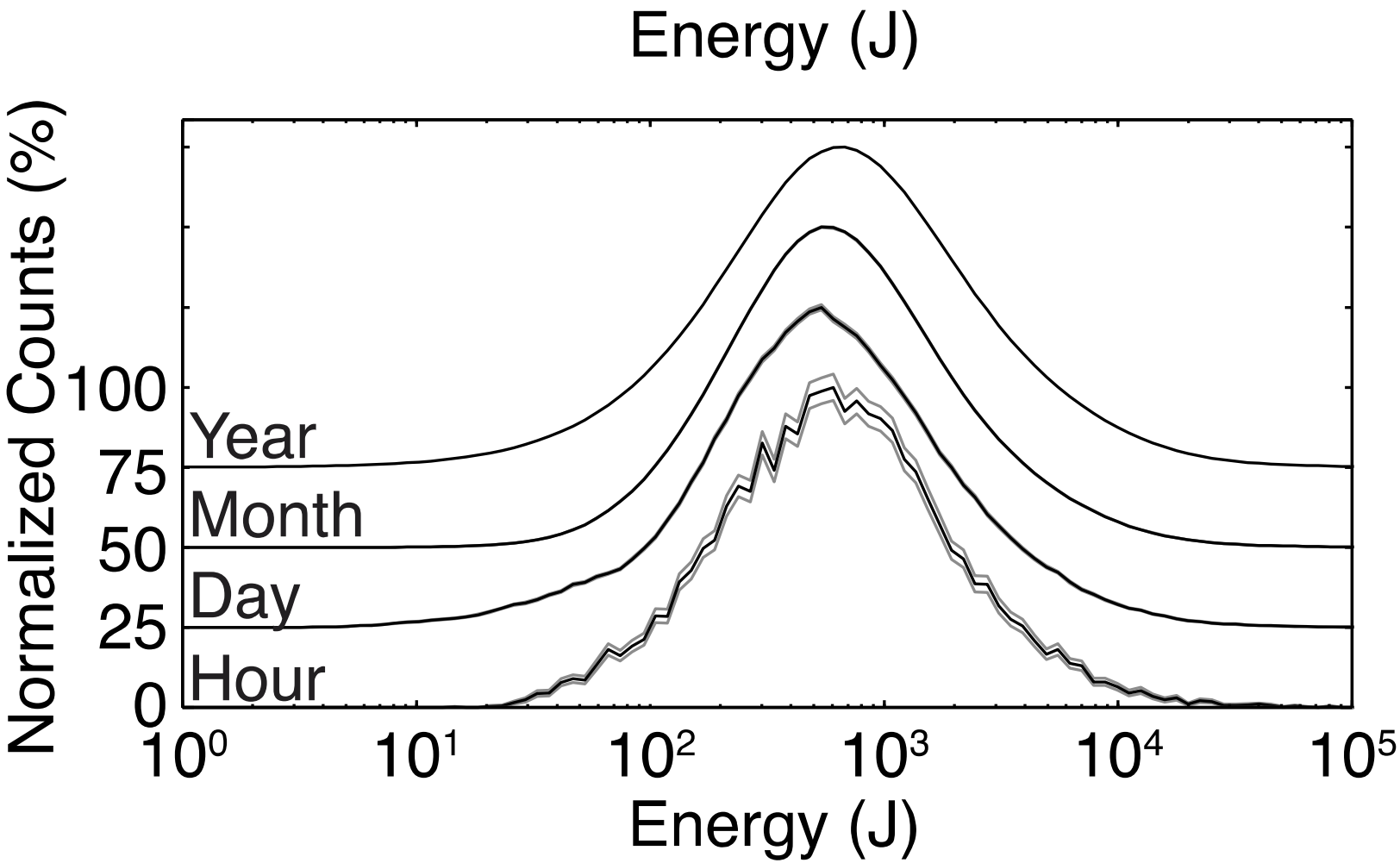
done current frame print save zoom unzoom animate

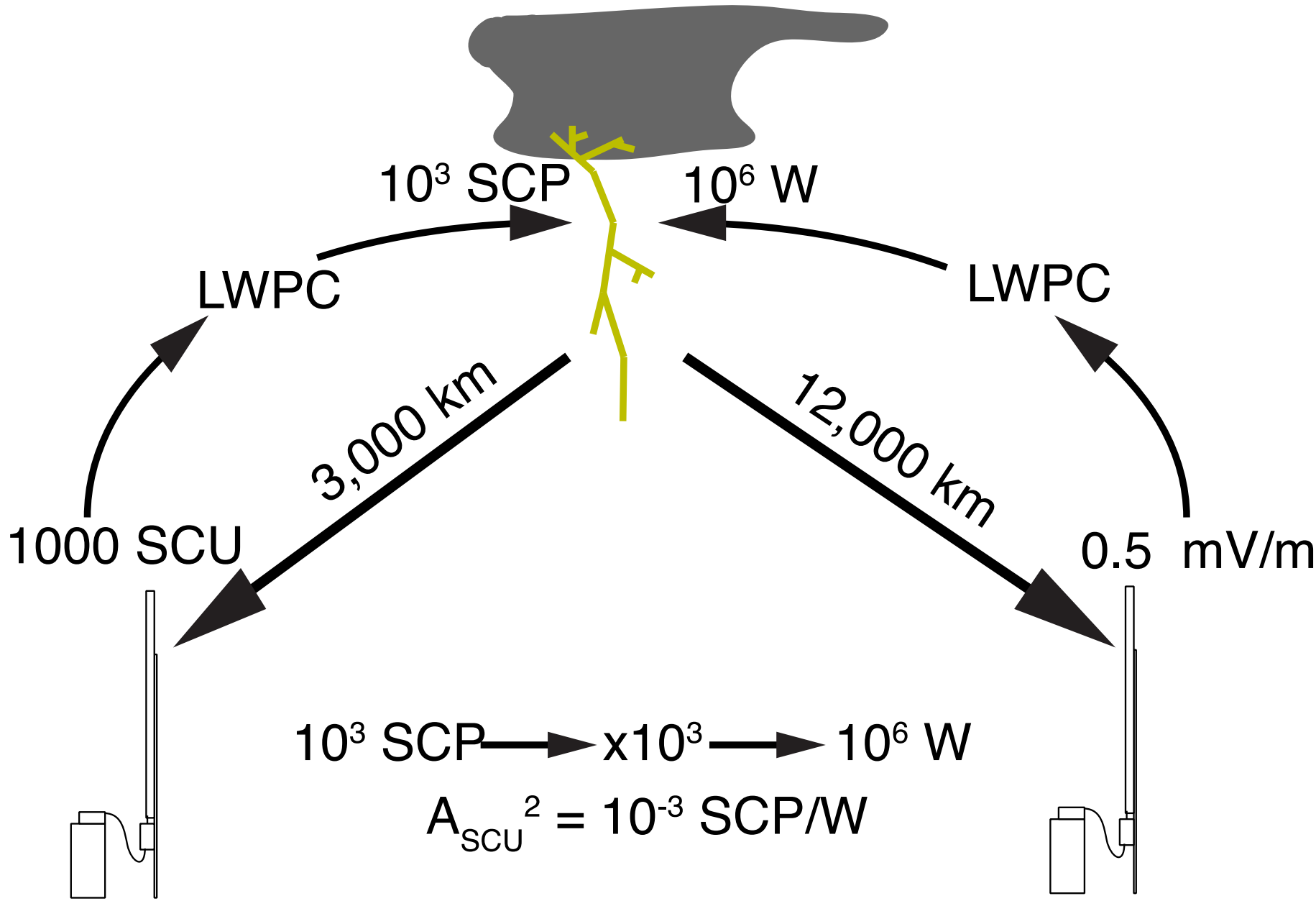

Dataset: tulsaAssimColSp RIP: rip tulsa
Init: 1200 UTC Tue 24 May 11
Fcst: 10.50 h
Valid: 2230 UTC Tue 24 May 11 (1730 CDT Tue 24 May 11)
Reflectivity
at k-index = 17
100 W
40 N
dBZ
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Model Info: V3.4 KF YSU PBL Thompson Noah LSM 3.0 km, 27 levels, 24 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smager
Scrolled to Frame ->
loop
dup
goto
skip
delay
start segment
stop segment
set window
done
current frame
print
save
zoom
unzoom
animate

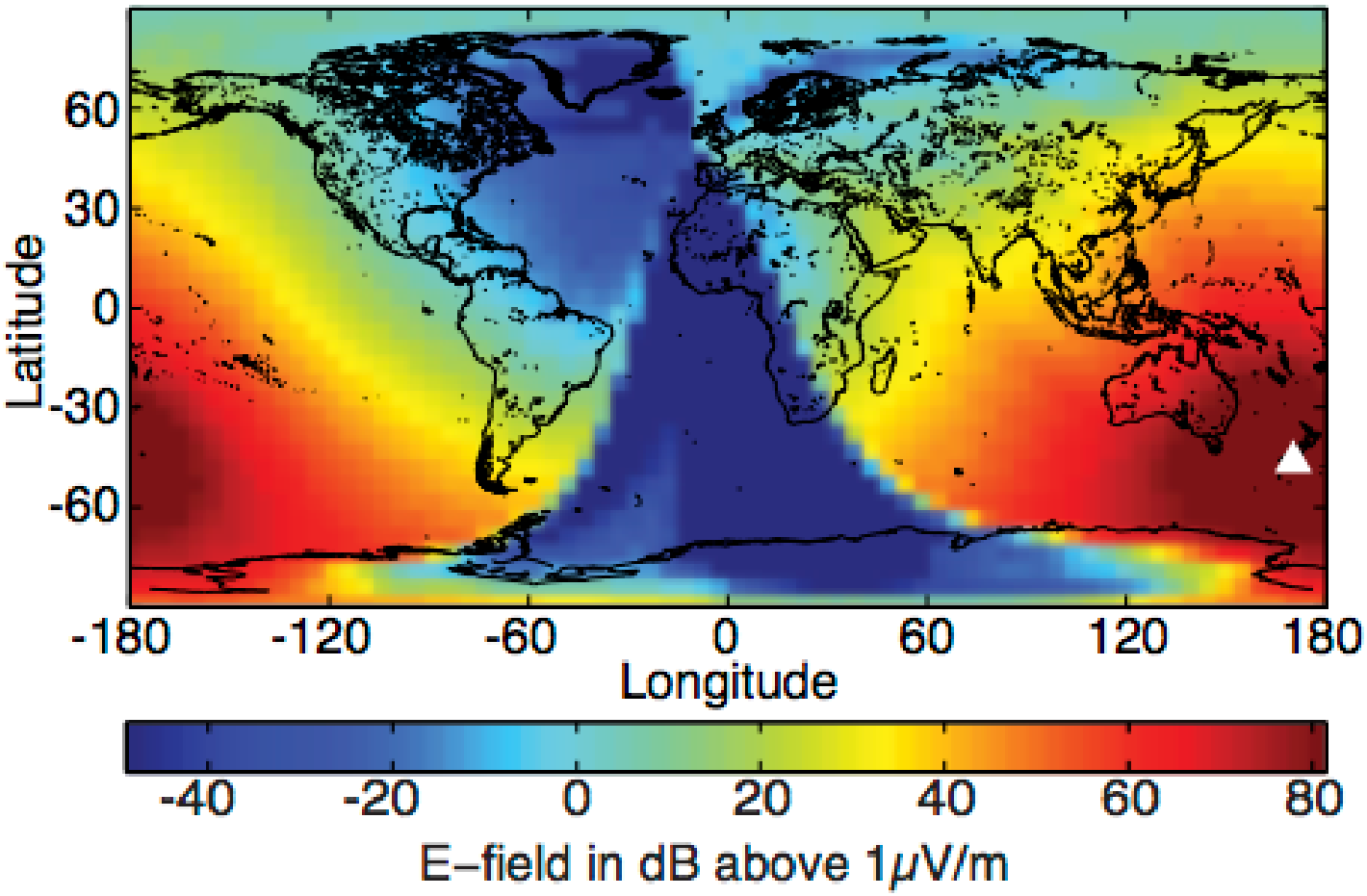

Dataset: tulsa RIP: rip tulsa
Init: 1200 UTC Tue 24 May 11
Fcst: 10.50 h
Valid: 2230 UTC Tue 24 May 11 (1730 CDT Tue 24 May 11)
Reflectivity
at k-index = 17
100 W
40 N
dBZ
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Model Info: V3.4 KF YSU PBL Thompson Noah LSM 3.0 km, 27 levels, 24 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smager
Scrolled to Frame ->
loop
dup
goto
skip
delay
start segment
stop segment
set window
done
current frame
print
save
zoom
unzoom
animate

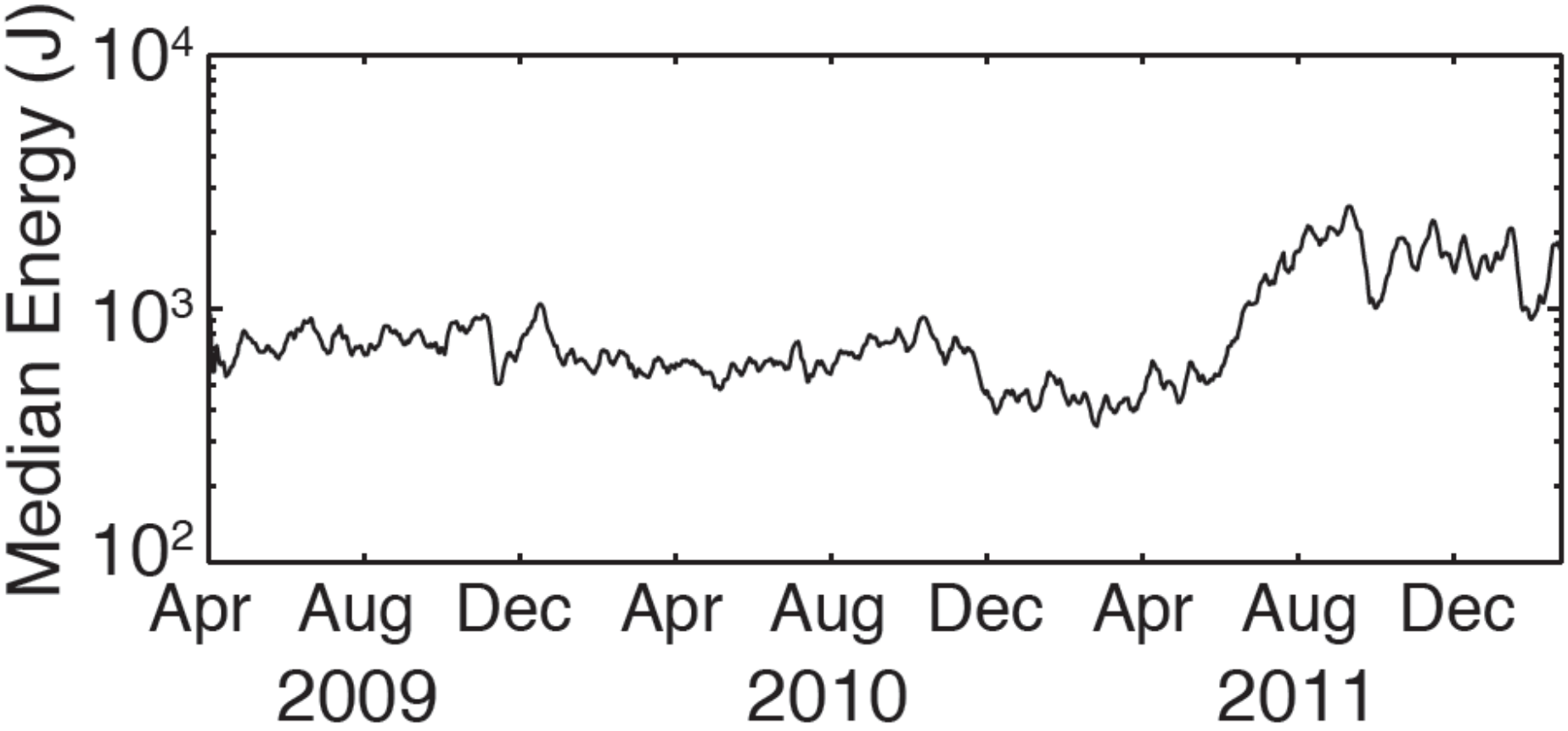

ENGLN Flash density 2012–09–12, 1473452 total. (flashes/deg$^2$)
60°N
30°N
0°
30°S
60°S
180°W
120°W
60°W
0°
60°E
120°E
180°W
20000
10000
5000
2000
1000
500
200
100
50
20
10
5
2
1


LIS/OTD
100
30
10
3
1
0.3
0.1
0.03
0.01
WWLLN
10
3
1
0.3
0.1
0.03
0.01
0.003
0.001
Ratio
10
3
1
0.3
0.1
75°
60°
45°
30°
15°
0°
−15°
−30°
−45°
−60°
− 30°
0°
30°
60°
90°
120°
150°
180°
−150°
−120°
− 90°
− 60°
− 30°


Energy (J)
Normalized Counts (%)
100
75
50
25
0
Year
Month
Day
Hour
$10^0$
$10^1$
$10^2$
$10^3$
$10^4$
$10^5$
Energy (J)


10³ SCP
10⁶ W
LWPC
LWPC
3,000 km
12,000 km
1000 SCU
0.5 mV/m
10³ SCP → x10³ → 10⁶ W
A_SCU² = 10⁻³ SCP/W


60
30
0
-30
-60
Latitude
-180
-120
-60
0
60
120
180
Longitude
-40
-20
0
20
40
60
80
E–field in dB above 1μV/m


Median Energy (J)
$10^4$
$10^3$
$10^2$
Apr
Aug
Dec
Apr
Aug
Dec
Apr
Aug
Dec
2009
2010
2011

Energy/stroke
Relative DE
ENTLN-WWLLN comparison

Chuva
Lynn
Cliff/Ken
Other (Cnofs)