Climatology and Long Term Trends of Convective Storms over the Northeast U.S.

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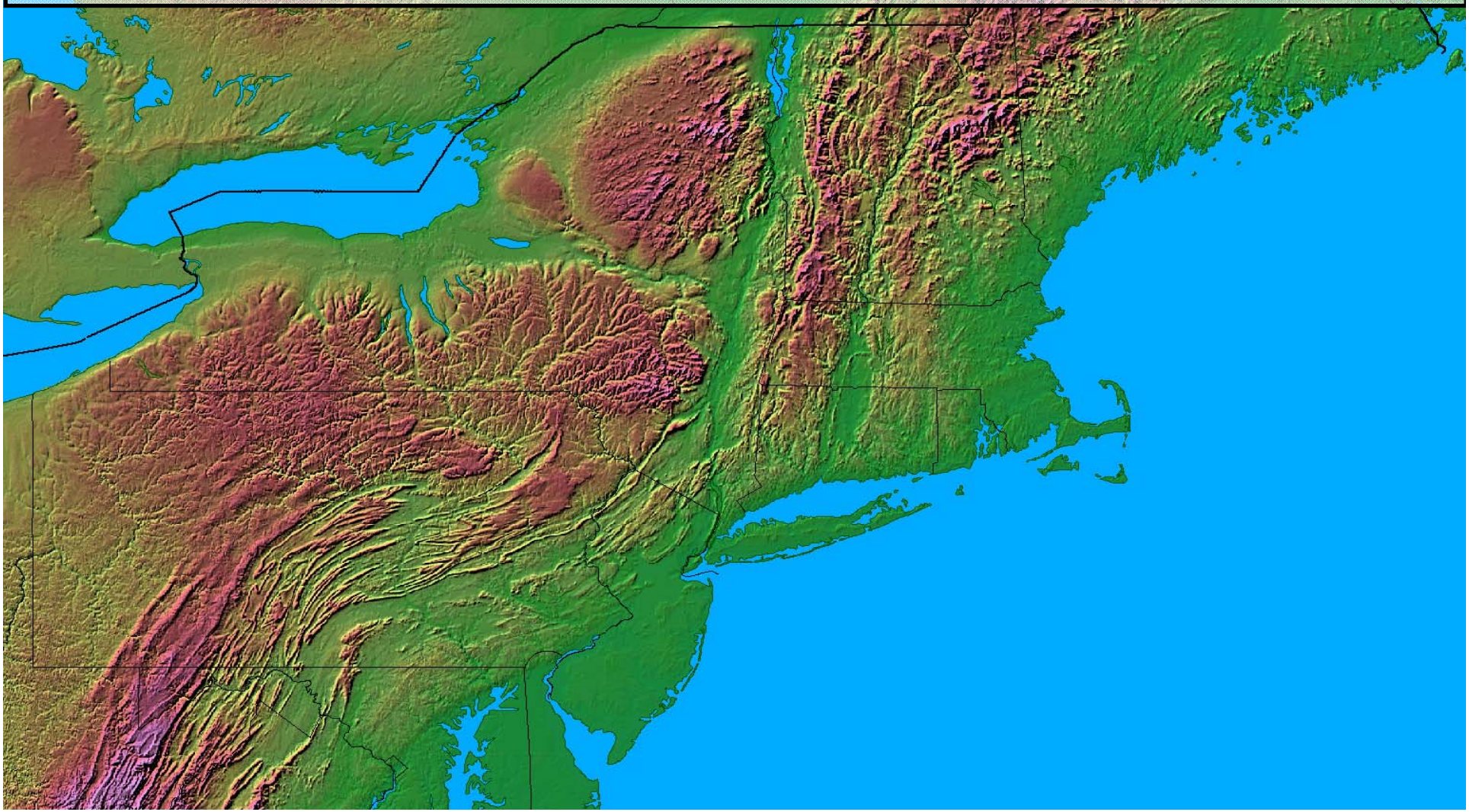
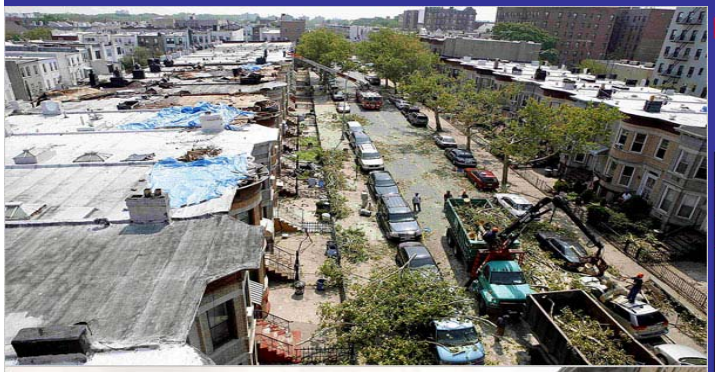
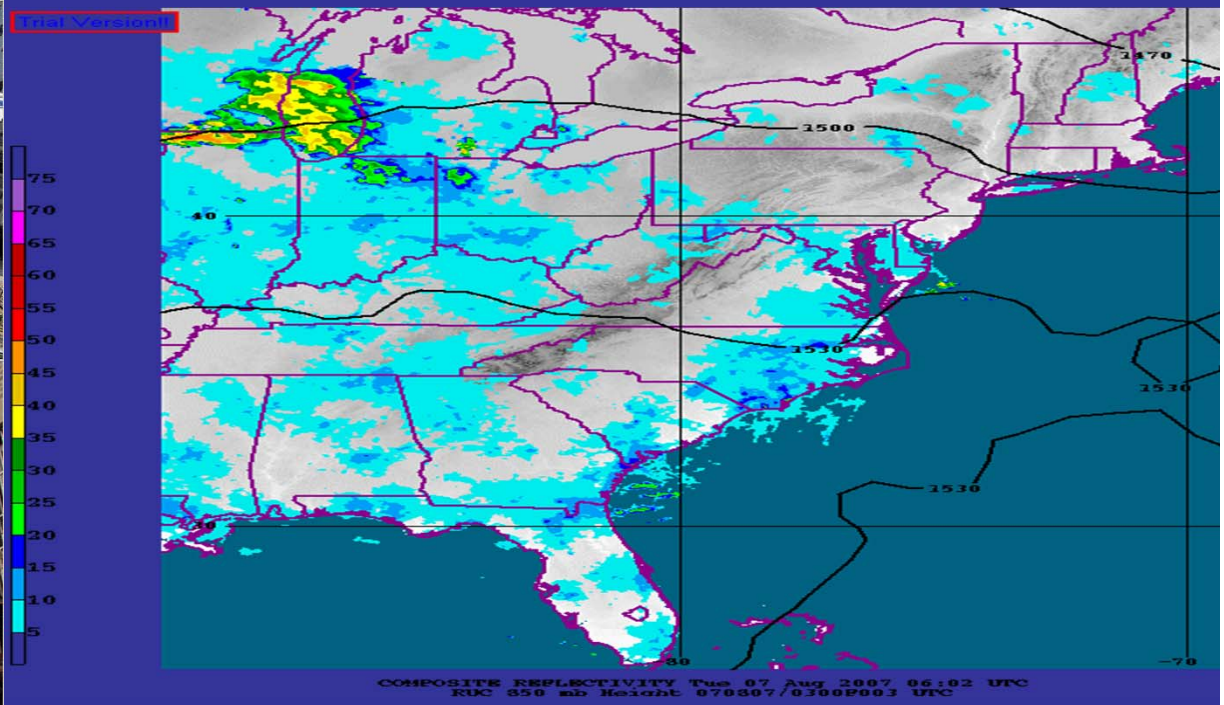
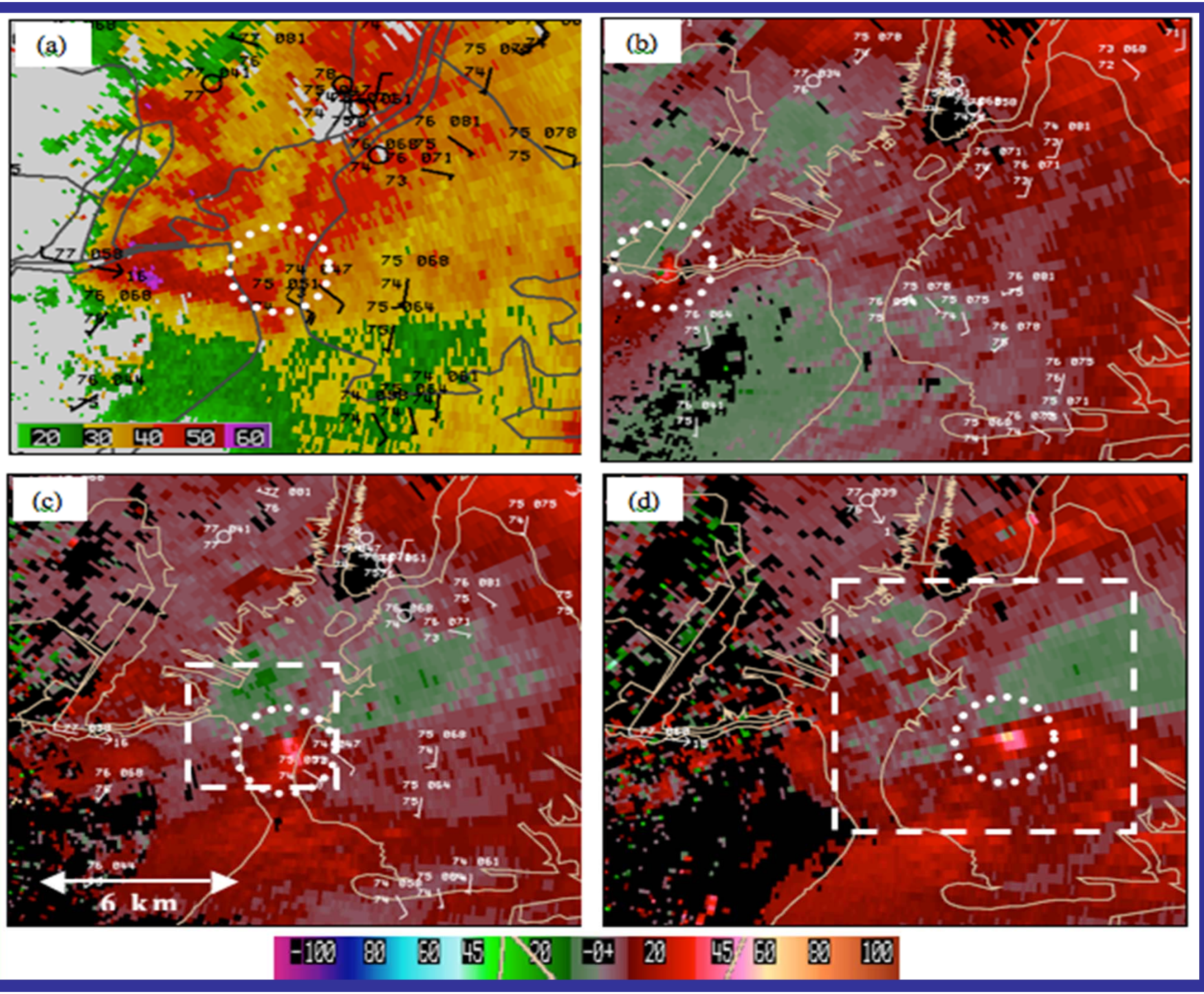


New York City Tornadoes – 8/8/2007





- The NYC tornadoes consisted of an EF-1 tornado that formed over Station Island and an EF-2 tornado that moved across the Verrazano Narrows and into Brooklyn.


(a)
(b)
(c)
(d)
20 30 40 50 60
6 km
-100 80 60 45 20 -04 20 45 60 80 100

Questions

- How can radar and lightning data be used to better understand the spatial distribution of convective storms?
- How does the frequency of convective storms over the Northeast U.S. vary annually, monthly, and diurnally?
- How has the number of convective storms and their ingredients (instability, moisture, and lift) changed for specific regions across the Northeast U.S. from 1979-2011?

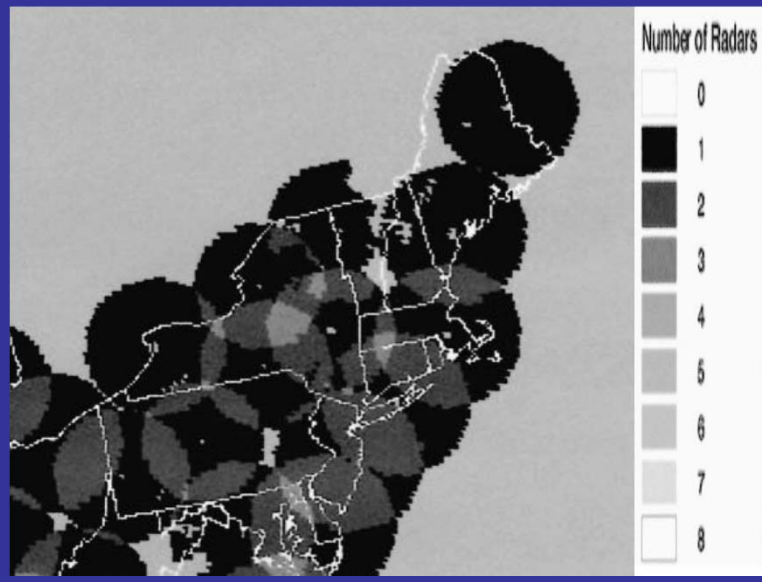
Spatial Distribution of Convection – Murray and Colle (2011)

2 Methods for Quantifying Convection:

1) NOWrad (WSI NCAR): WSR-88D

• Available on a 2x2 km^2 grid at 15 minute intervals (largest reflectivity at a point from surrounding radars)

• Composite from April through September 1996-2007 by counting frequency of reflectivity exceeding 45 dBZ.

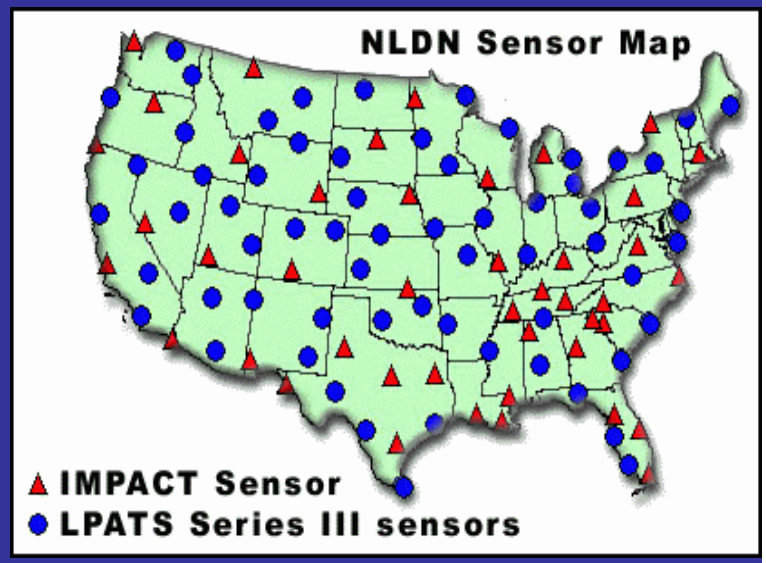


WSR 88D (Maddox et al 2002)

2) Cloud to Ground Lightning Data National Lightning Detection Network (NLDN)

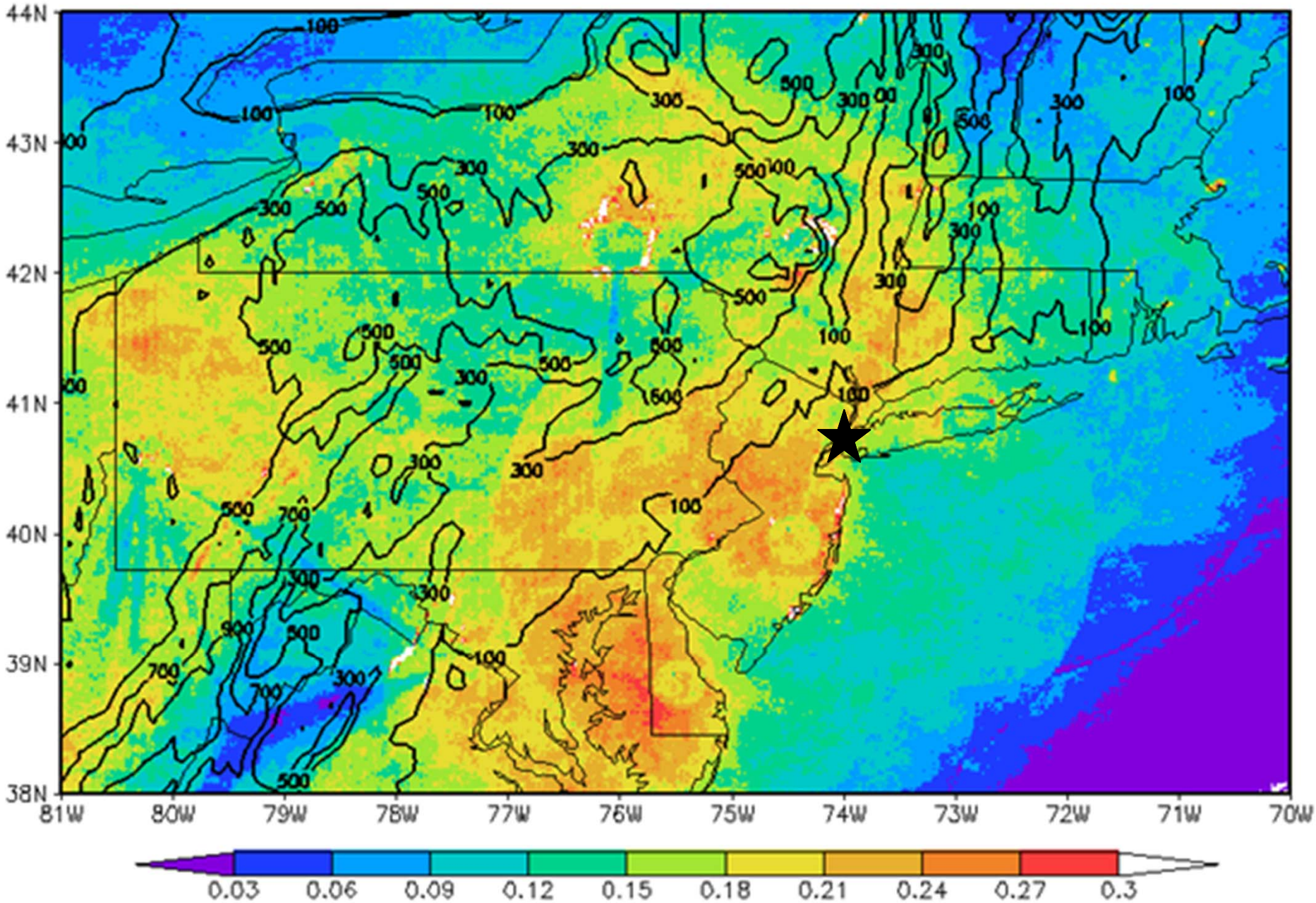
•Interpolated to a 10x10 km grid centered over the Northeast U.S.

•Available from 2000-2007.

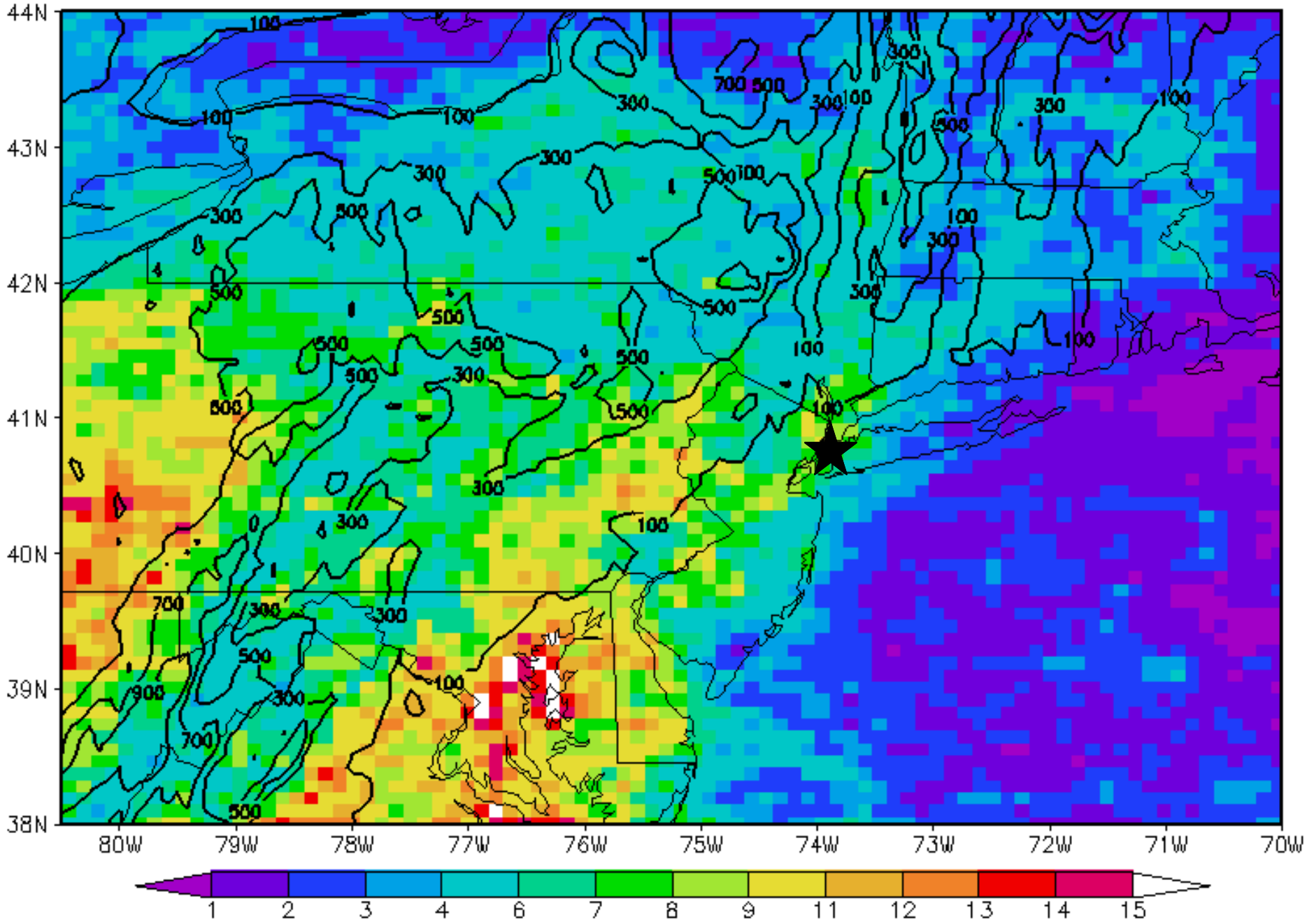


From thunder.msfc.noaa.gov

Probability of ≥ 45 dBZ for any 15-min period



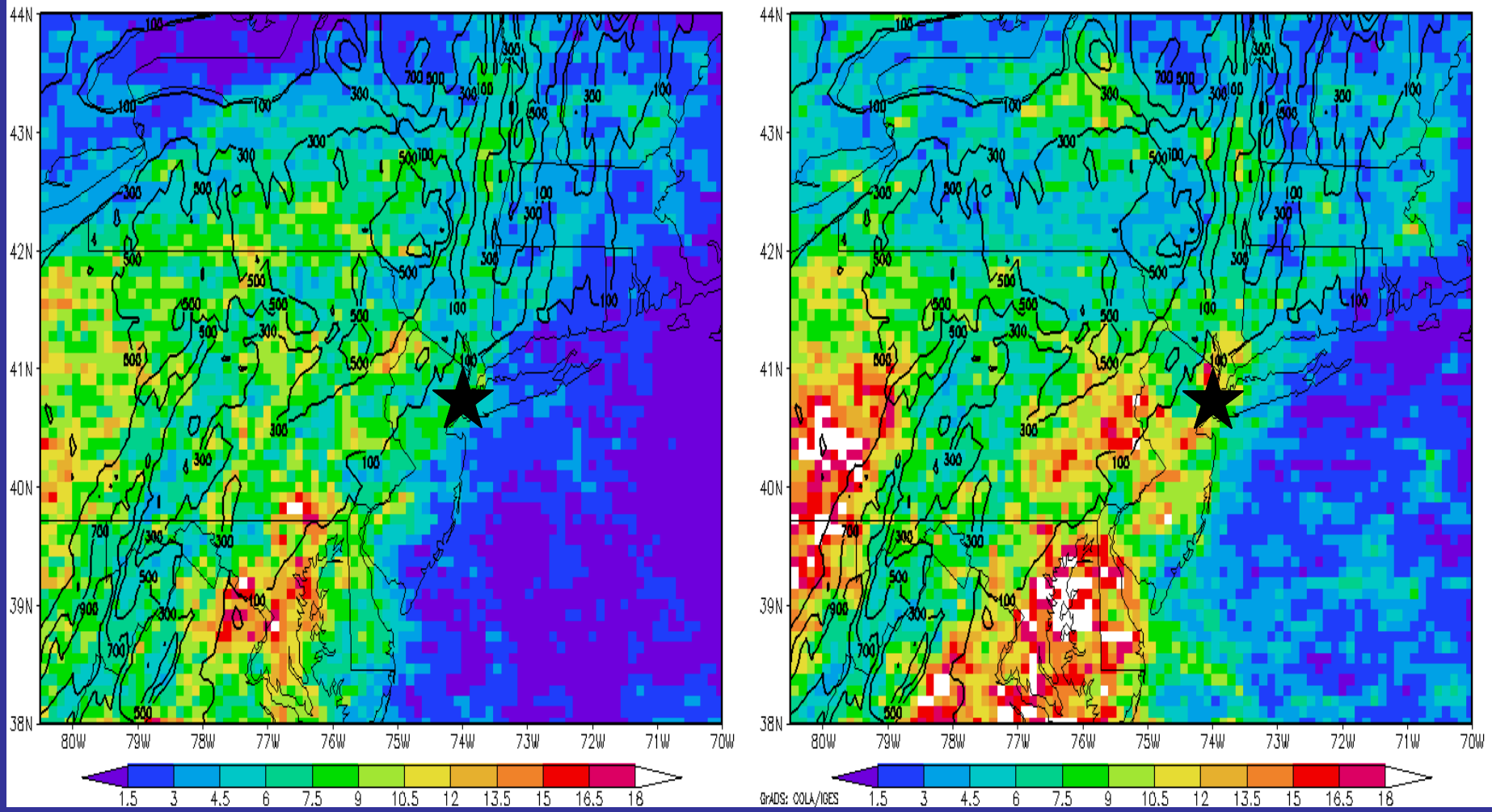
Average Monthly Lightning Frequency per 10 km^2



Early vs Late Warm Season

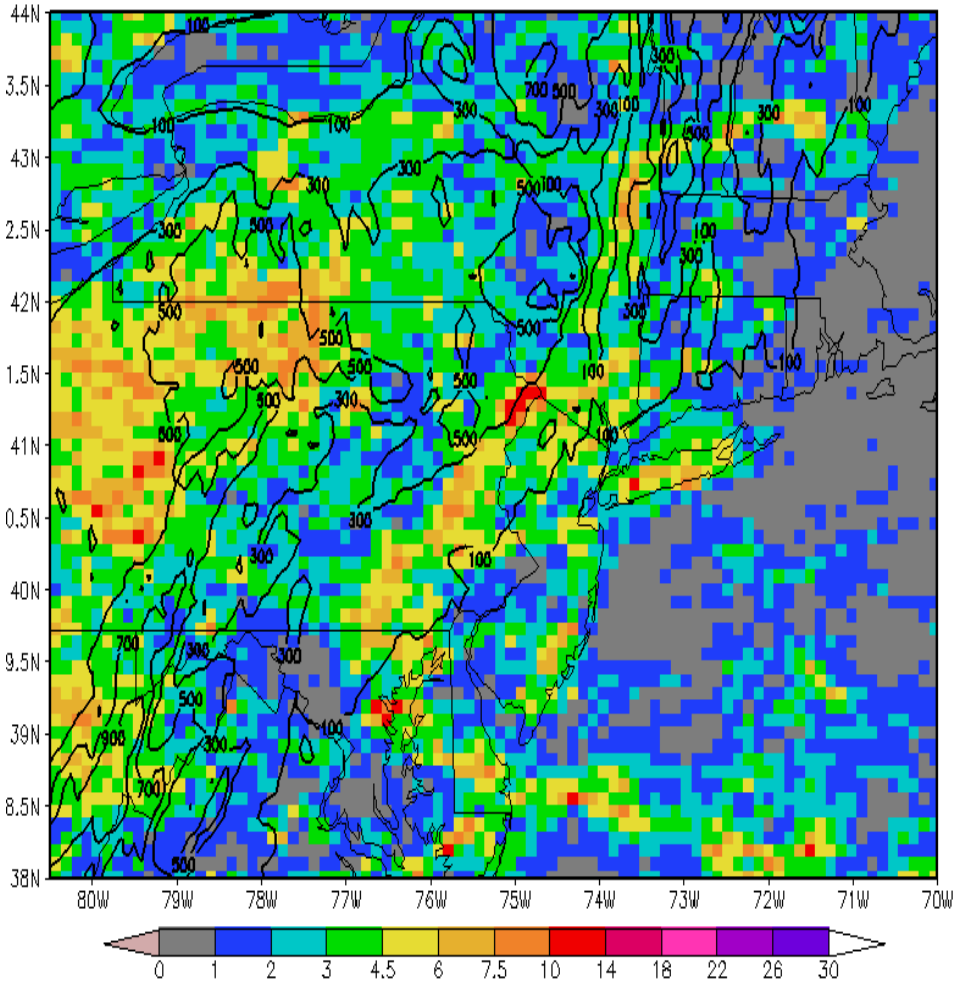
May and June

July and August

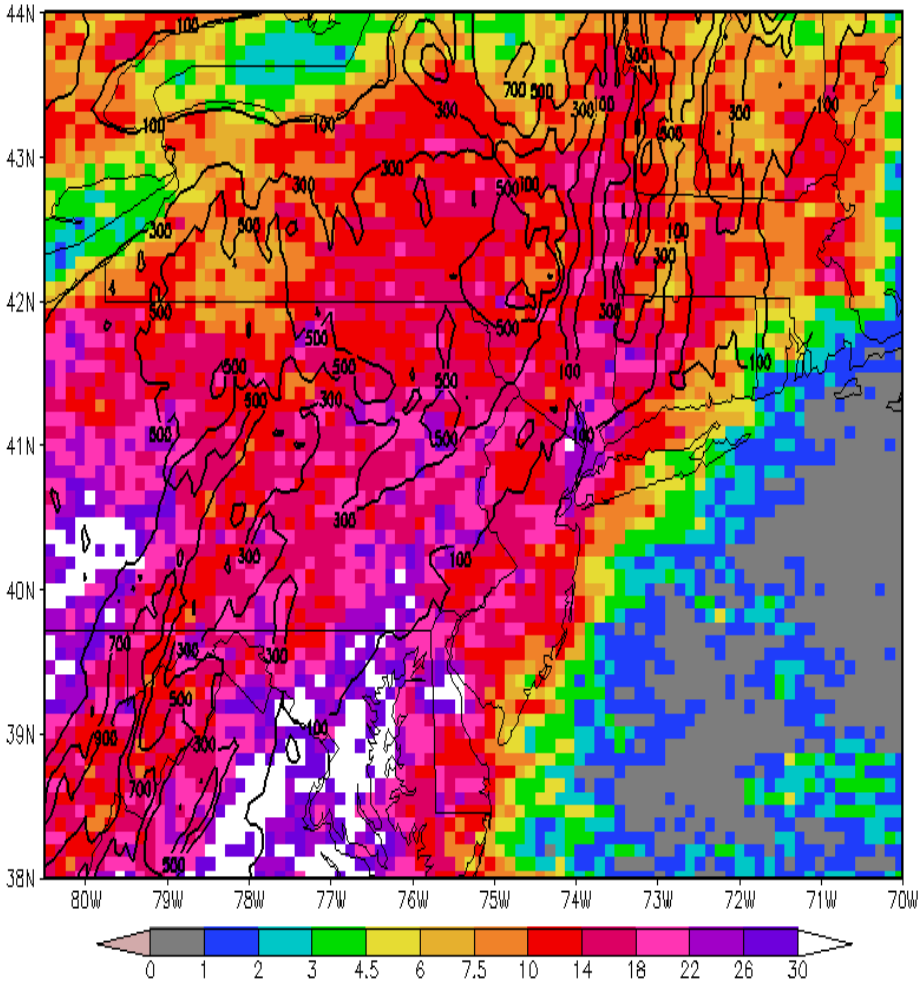


Diurnal Frequency of Lightning (Morning to Early Evening Hours)

8AM- 2PM

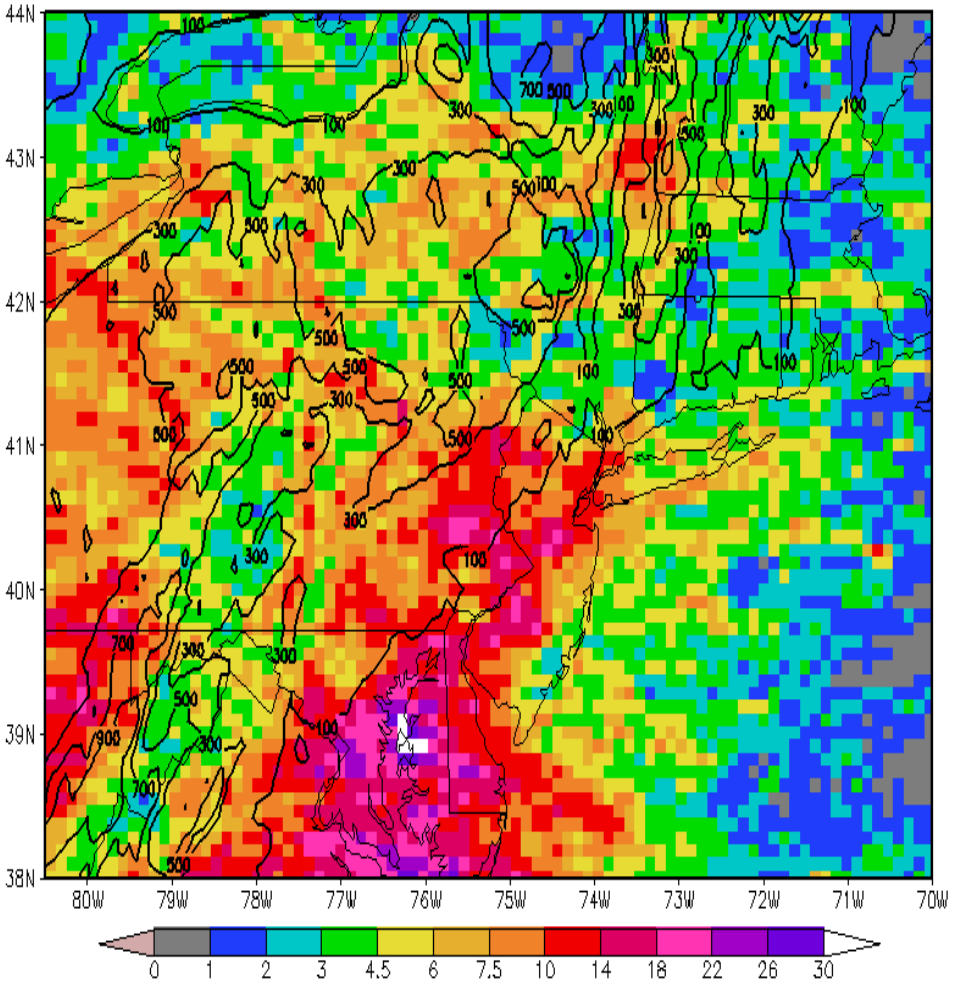


2PM – 8PM

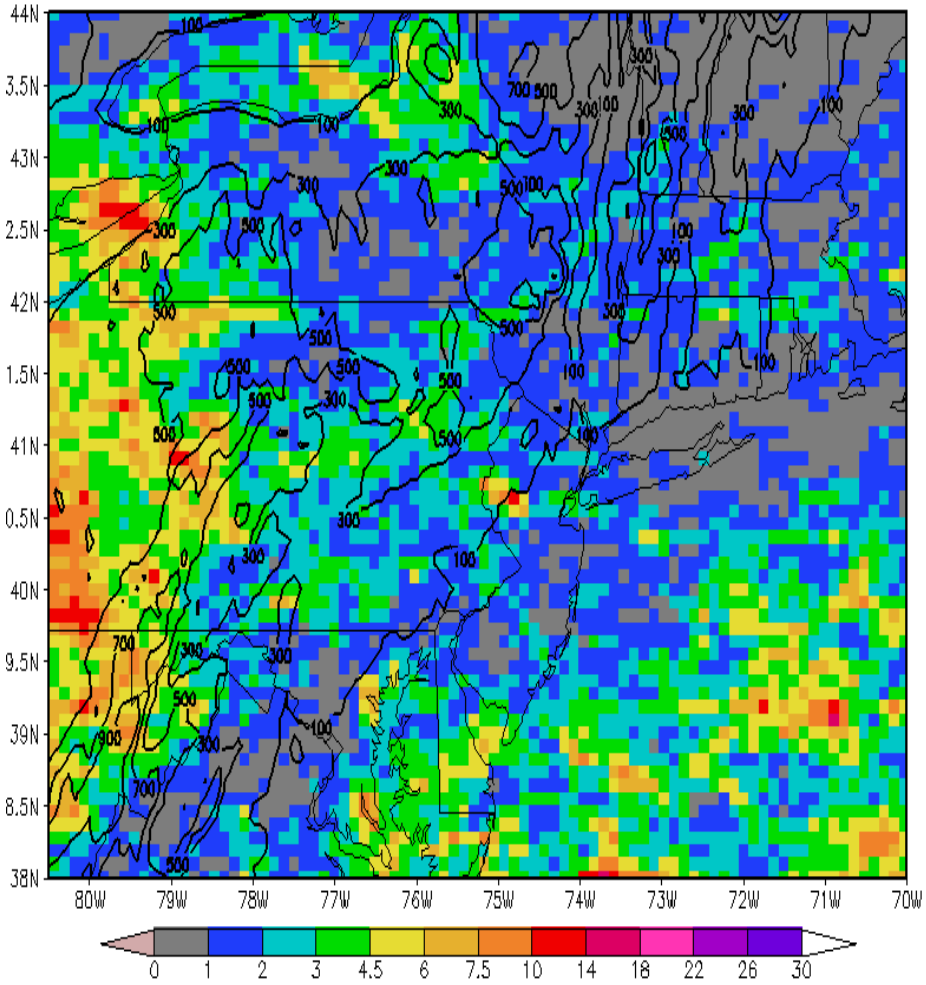


Diurnal Frequency of Lightning (Night to Morning Hours)

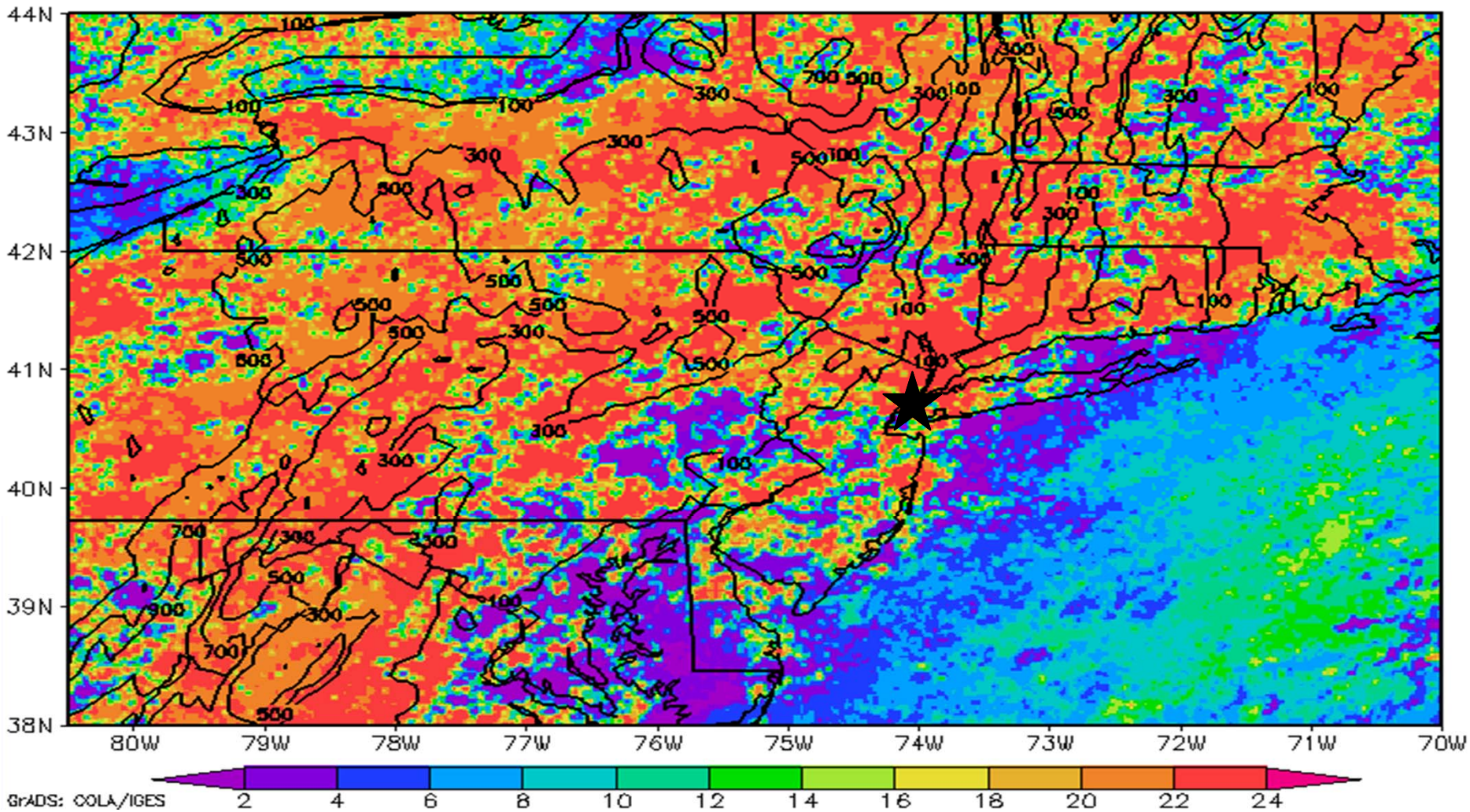
8PM-2AM



2AM-8AM

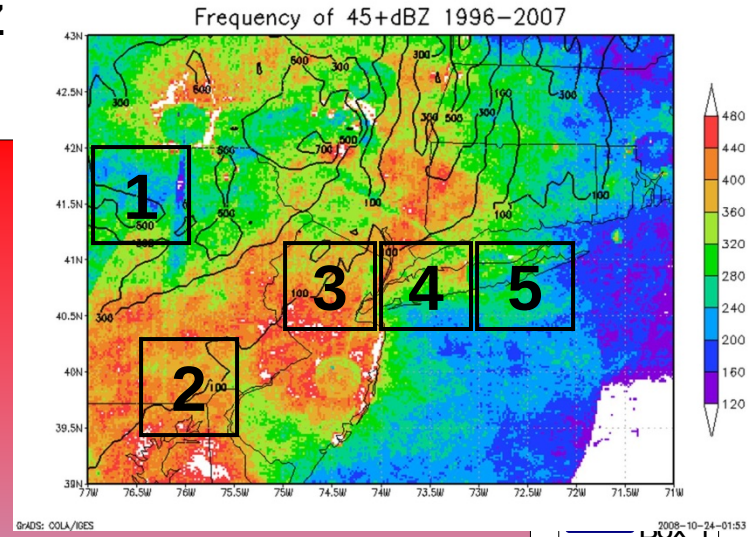


Hour (shaded in UTC) of Maximum Frequency Exceeding 45 dBZ



Frequency of 45+dBZ

Storm frequency versus time of day



Frequency

40
35
30
25
20
15
10
5
0

1
2
3
4
5

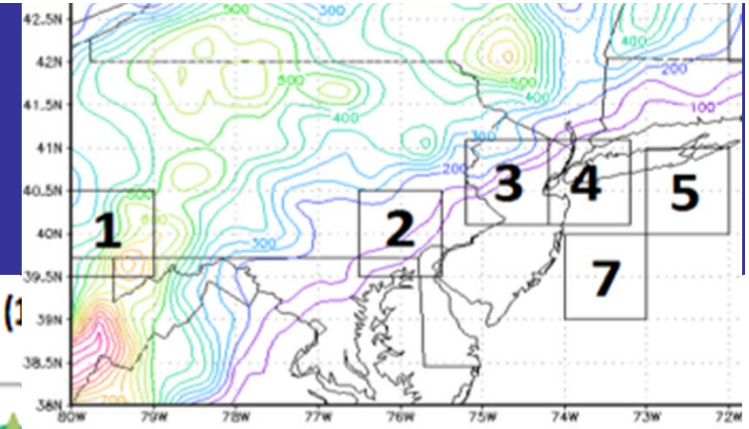
Box 2
Box 3
Box 4
Box 5

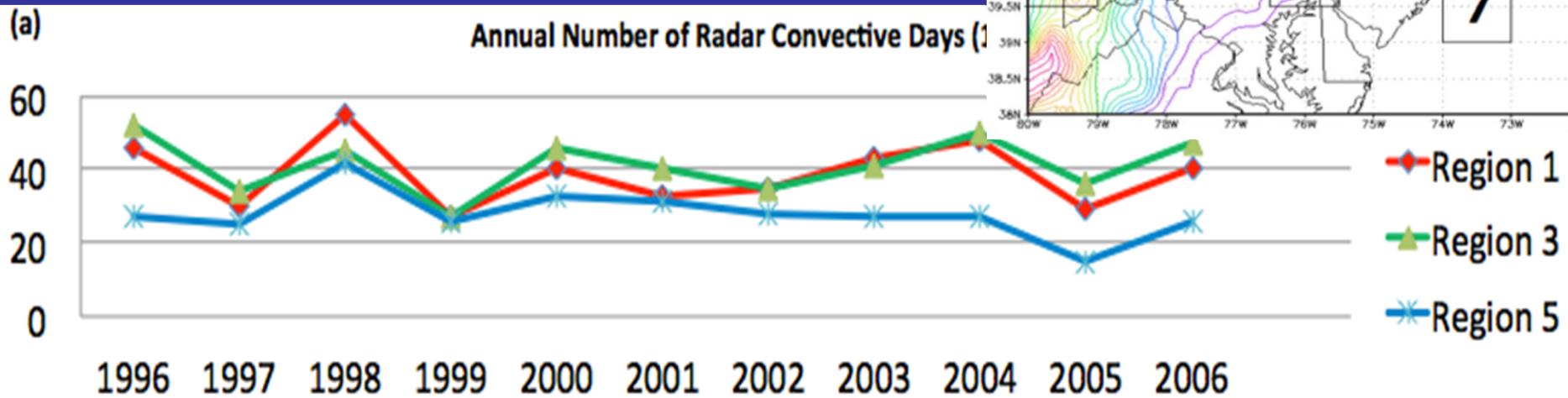
12Z-13Z
13Z-14Z
14Z-15Z
15Z-16Z
16Z-17Z
17Z-18Z
18Z-19Z
19Z-20Z
20Z-21Z
21Z-22Z
22Z-23Z
23Z-00Z
00Z-01Z
01Z-02Z
02Z-03Z
03Z-04Z
04Z-05Z
05Z-06Z
06Z-07Z
07Z-08Z
08Z-09Z
09Z-10Z
10Z-11Z
11Z-12Z

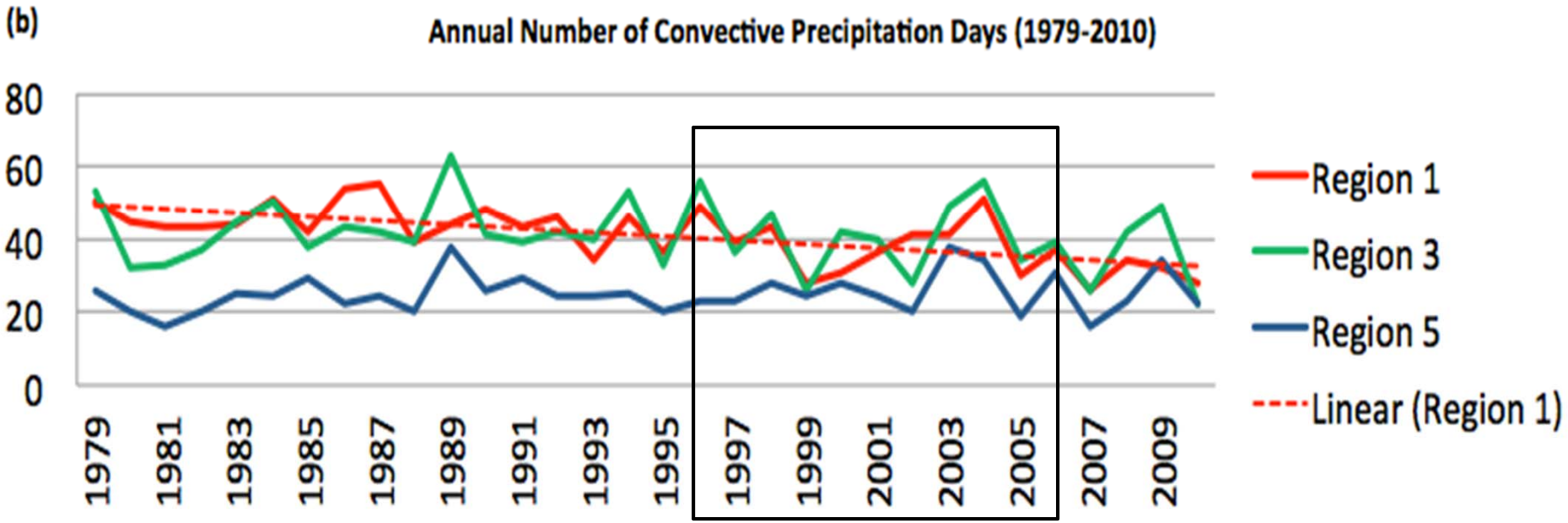
Time (UTC)

Morning
Afternoon
Evening
Late night

Number of convective storms using radar (top) and reanalysis data (convective pcp -bottom)







Longer-Term Trends Using Parameter-based Predictions of Convective Days

- Use daily-averaged NARR: Surface convective available potential energy (CAPE), precipitable water, and vertical motion (averaged from 500 and 700 hPa).

- Use Linear discriminant analysis (LDA) with CAPE, vertical wind shear, omega, and precipitable water to develop a threshold predictor for a convective day in a particular region, similar to Brooks et al. (2003) for severe weather (they used shear and CAPE).

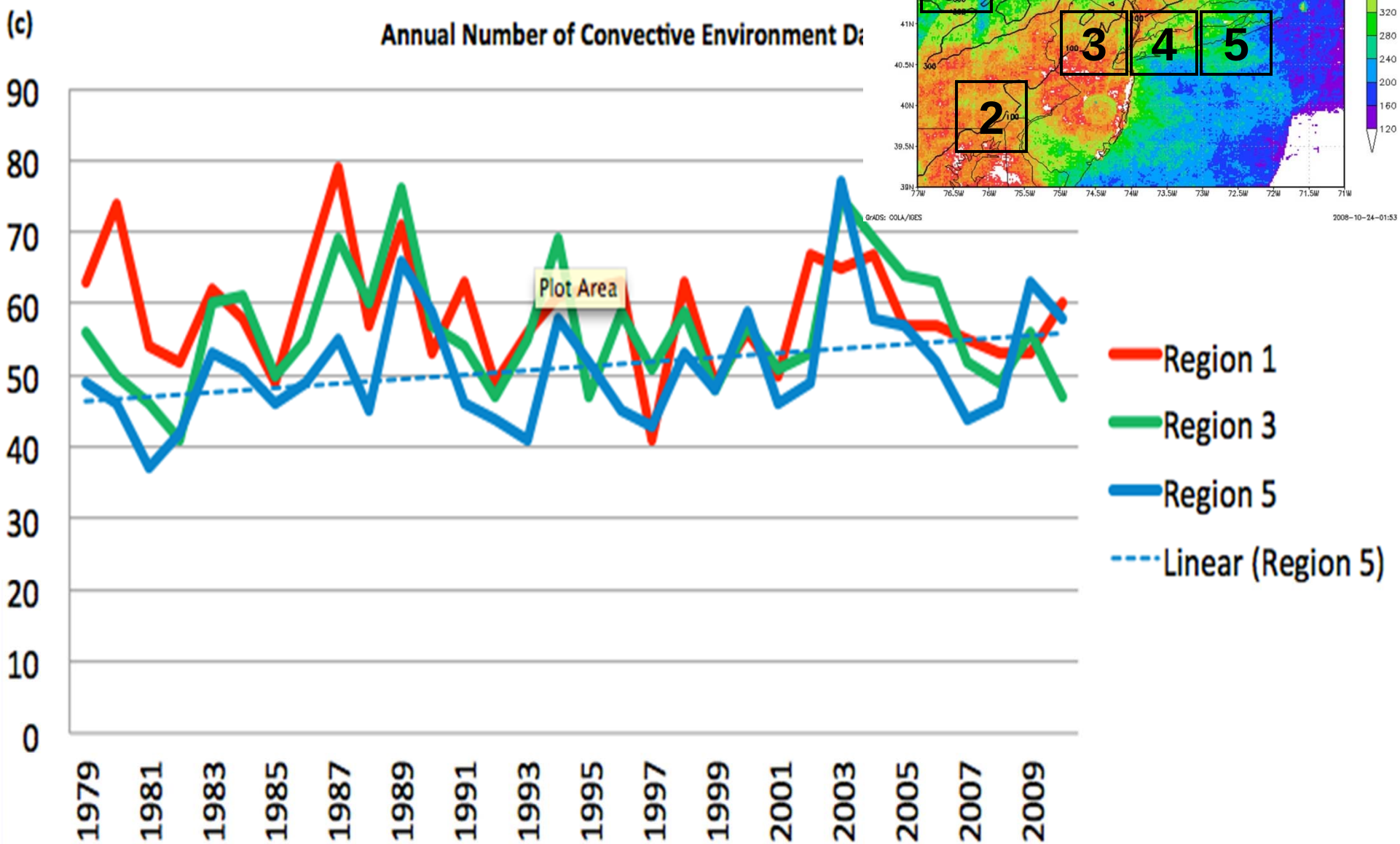
- A convective day is defined as a day in which the areal sum of > 45 dBZ within a 1-degree boxed region is greater than 1000 (~0.4% given number of 2-km points and daily 15-min times).

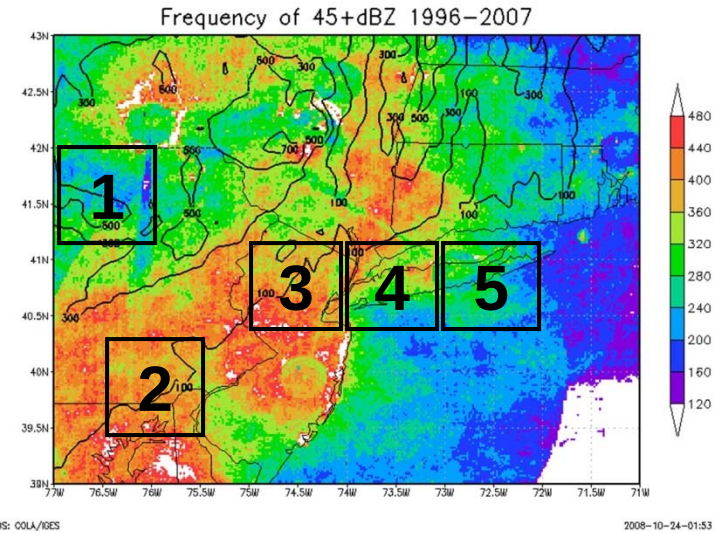
- Analyze the interannual and spatial trends in convective frequency predicted by the thresholds.

Convective thresholds created using LDA on NARR data and radar storm frequency for even years between 1996 and 2007 (use every other year for evaluation below)

Region	Threshold	False Alarm Rate	Non-detection Rate	Interannual Correlation with CPCP days (R^2)
1	$1.98 \times 10^{-4}(CS) + 0.0566(PRWTR) - 3.79(OMEGA) > 2.19$	16.3%	14.2%	0.154
2	$1.50 \times 10^{-4}(CS) + 0.0400(PRWTR) - 5.67(OMEGA) > 2.03$	12.4%	19.8%	0.453
3	$1.06 \times 10^{-4}(CS) + 0.0541(PRWTR) - 5.13(OMEGA) > 2.21$	14.8%	17.8%	0.550
4	$6.29 \times 10^{-5}(CS) + 0.0582(PRWTR) - 5.37(OMEGA) > 2.15$	19.3%	19.1%	0.429
5	$-1.41 \times 10^{-7}(CS) + 0.0700(PRWTR) - 5.64(OMEGA) > 2.50$	18.7%	16.1%	0.446

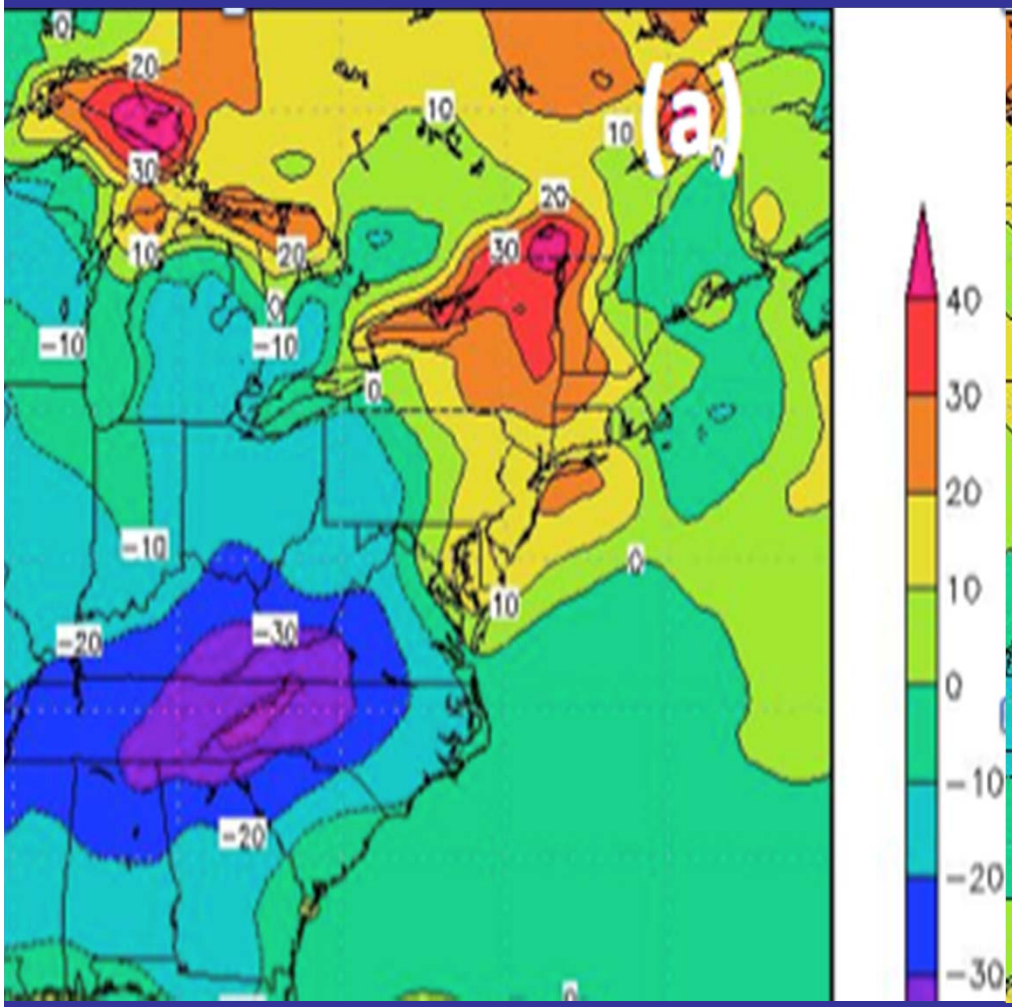
Number of convective environment days 1979 to 2011



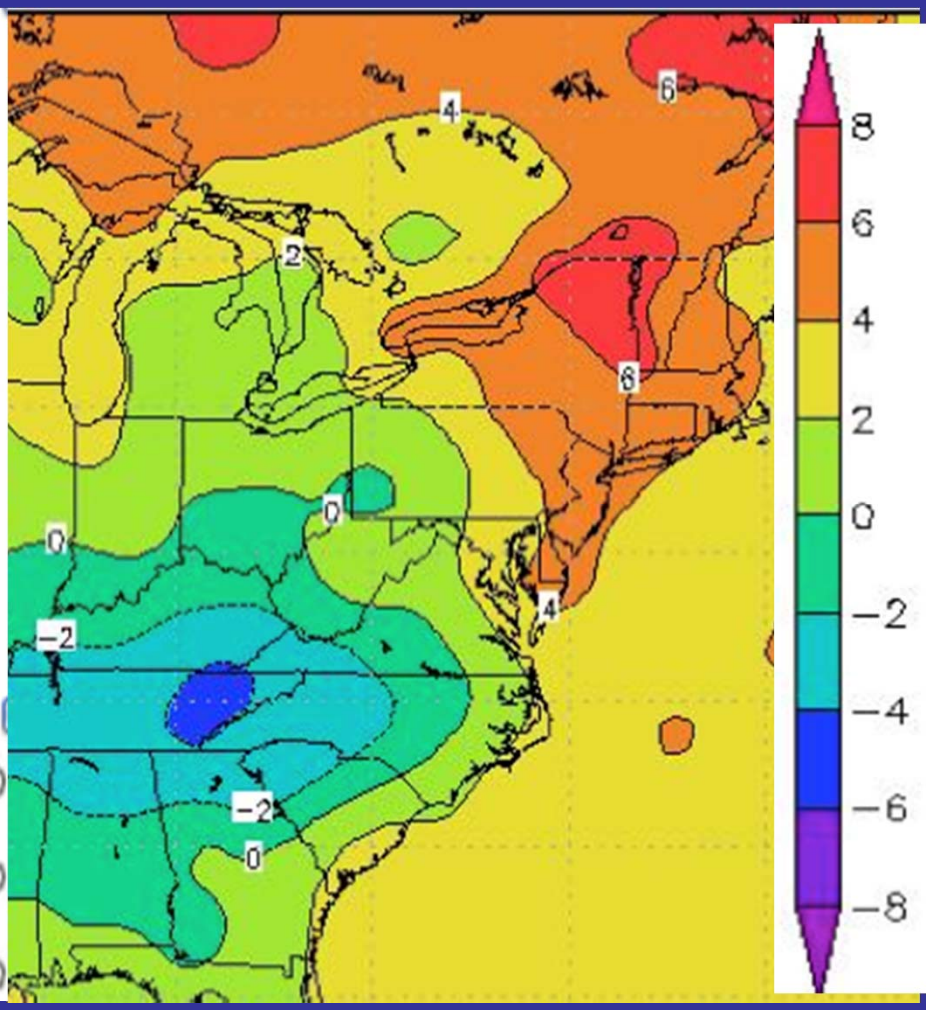


Percentage difference in instability and moisture from (2000-2009) minus (1980-1989)

Instability (CAPE)



Low-level Moisture



Summary and Conclusions

- Convective frequency varies across the region, with localized maxima across western PA, Hudson Valley and along the VA to NJ coastal plain. There is a sharp gradient in convective frequency across the coast and over southern New England.

- Convection reaches a maximum over inland areas during the day (18-00 UTC) and over the coastal plain during the late night (00-12 UTC)

- There is large interannual variability related in part to the strength and frequency of synoptic troughs during the warm season.

- Linear Discriminate Analysis (LDA) using NARR (CAPE, vertical motion, and precipitable water) can realistically obtain the convective days for various subregions.

- There has been an increase in the number of convective environment days over Long Island and coastal waters related to increased instability and moisture.

For More Information

Colle, B. A., K. A. Lombardo, J. Tongue, W. Goodman, and N. Vaz, 2012: Tornadoes in the New York Metropolitan Region: Climatology and multiscale analysis of two events. *Wea. Forecasting*, **27**, 1326-1348.

Lombardo, K, and B. A. Colle, 2013: Processes controlling the structure and longevity of two quasi-linear convective systems crossing the southern New England coast. *Mon. Wea. Rev.,* **141**, 3710–3734.

Lombardo, K, and B. A. Colle, 2012: Ambient conditions associated with the maintenance and decay of quasi-linear convective systems crossing the northeastern U.S. coast. *Mon. Wea. Rev.,* **140**, 3805-3819.

Lombardo K., and B. A. Colle, 2011: Convective storm structures and ambient q conditions associated with severe weather over the Northeast U.S. *Wea. Forecasting*., **26**, 940-956.

Lombardo, K., and B. A. Colle, 2010: A climatology of convective structures over the Northeast U.S. and the associated ambient conditions. *Mon. Wea. Rev,* **138***,* 4456–4474.

Murray, J., and B. Colle, 2011: A climatology of convective storms over the Northeast United States. *Mon. Wea. Rev.,* **139**, 992-1012.