Identifying and Predicting Organized Severe Storms over the Northeastern U.S. Coastal Region

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3 Dec 2013: Brookhaven National Laboratory
Identifying and Predicting Weather Impacts on Utility Systems

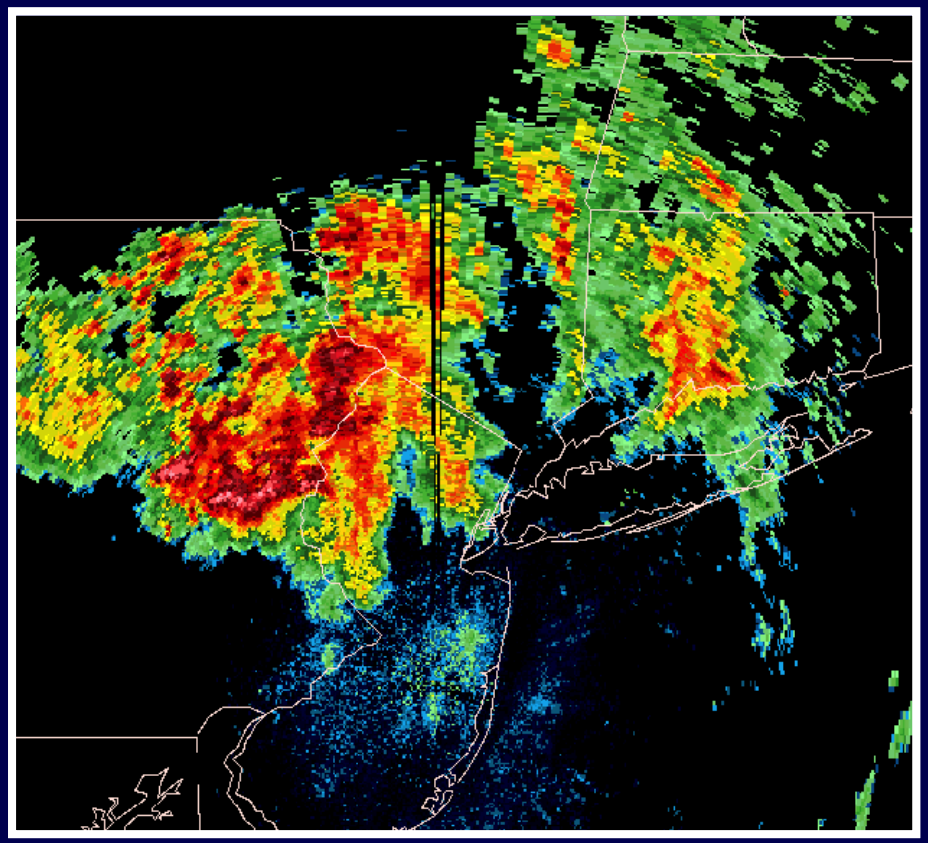
Impacts of Severe Storms

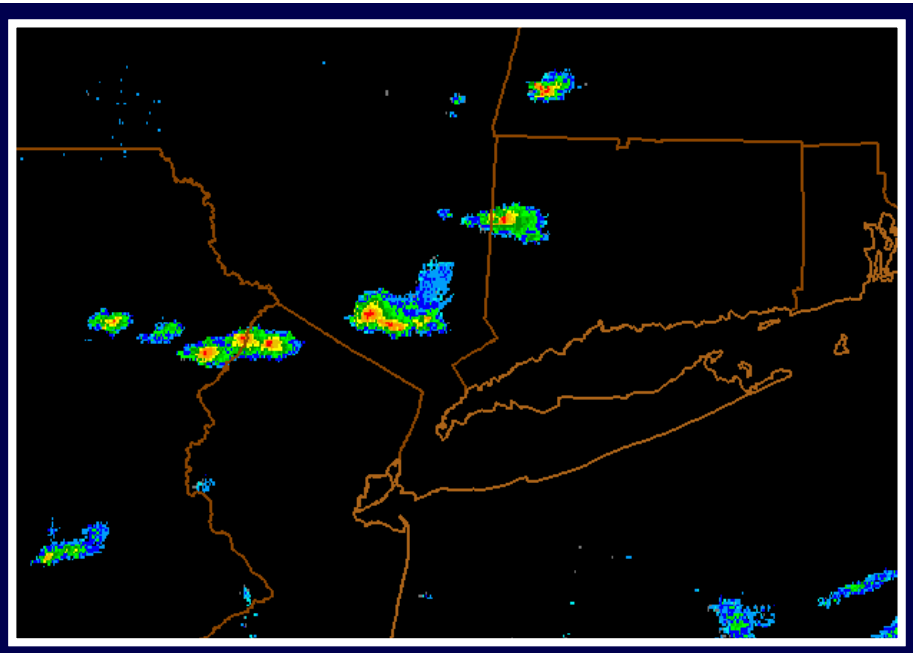
Impacts of Severe Storms

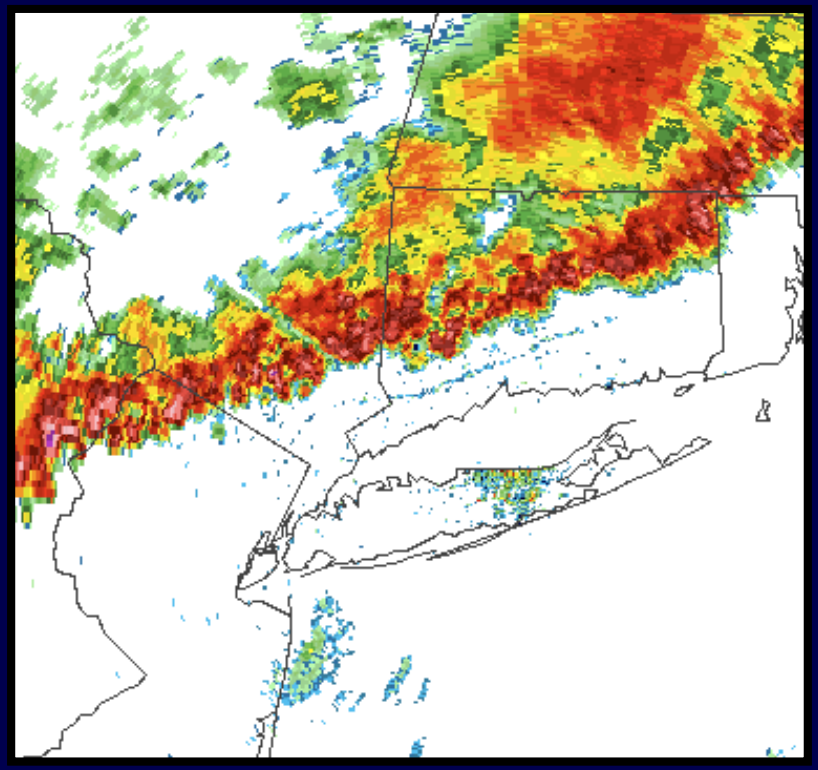
<u>Mitigate Impacts:</u>

Understand *nature* and *timing* of storms

Different Structures of Summertime Storms

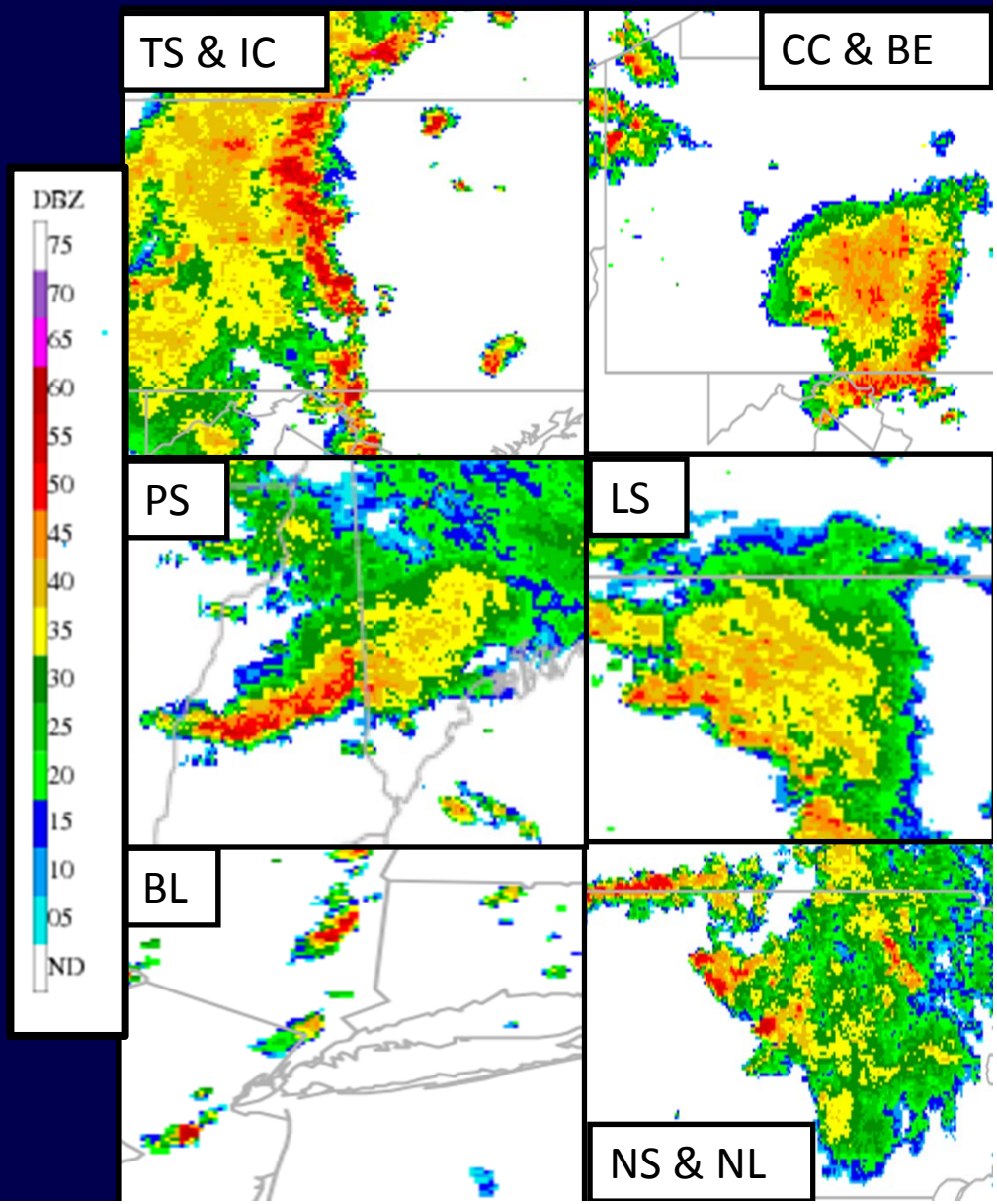






Use Radar to Identify Structures over the Northeast U.S.

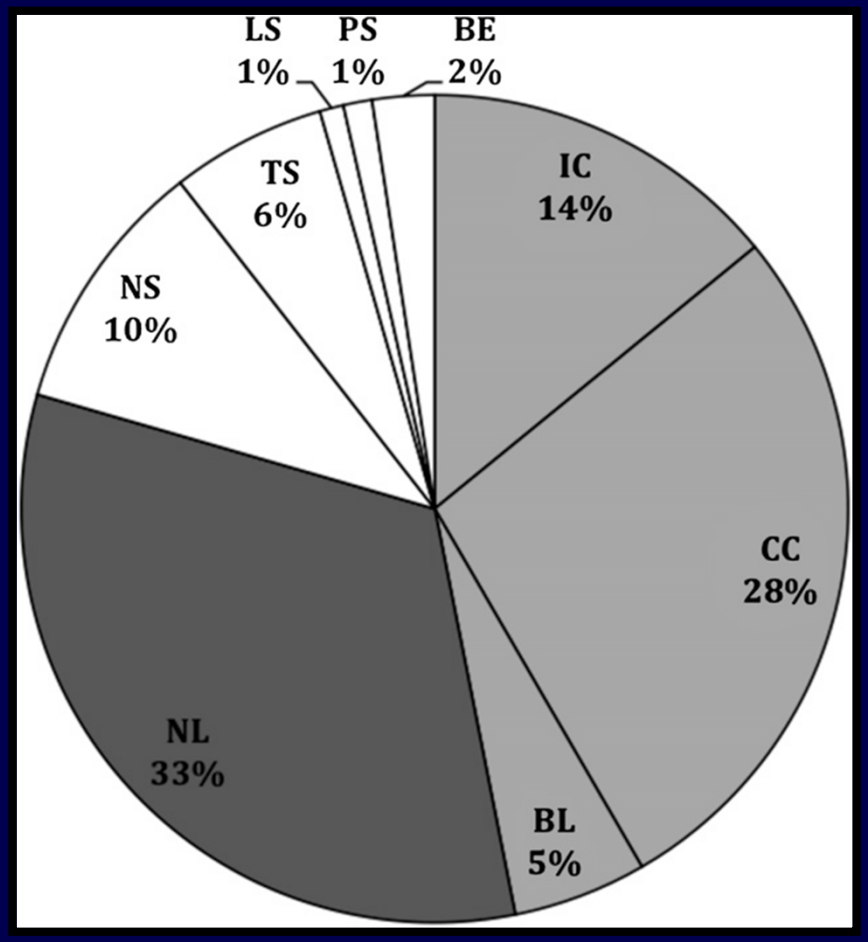
- *How common are these structures?*
- Looked at NOWrad radar reflectivity data for 2 warm seasons; available every 15 minutes; 2-km resolution
- Convective >= 35 dBZ
- High dBZ = Intense storm



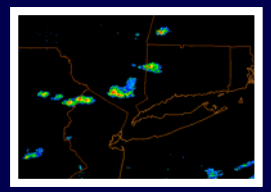
Lombardo and Colle (2010)

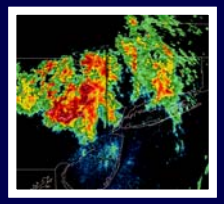
Distribution of Storm Structures over the Northeast U.S.

20 % Linear
(white)



47 % Cellular
(light gray)



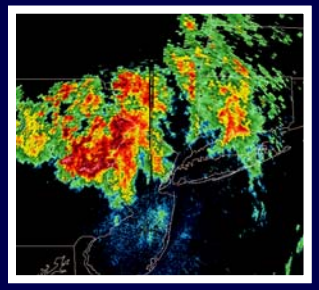


33 % Nonlinear
(dark gray)

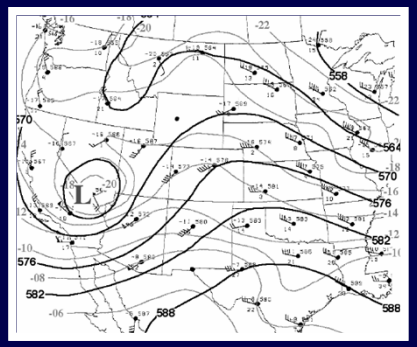
Lombardo and Colle (2010)

Why do we care about convective storm structures?

- Different severe weather threats
  - Probability, common type
  - Inter-regional differences



- Spatial extent of storm influences the number of people impacted
  - Larger storms impact a greater area



- Synoptic climatology for each structure
  - Dynamic and thermodynamic conditions that favor development: predictability

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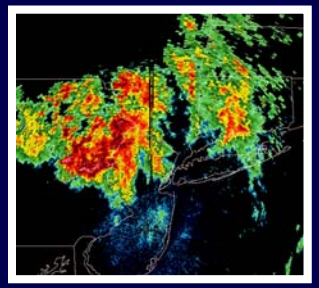

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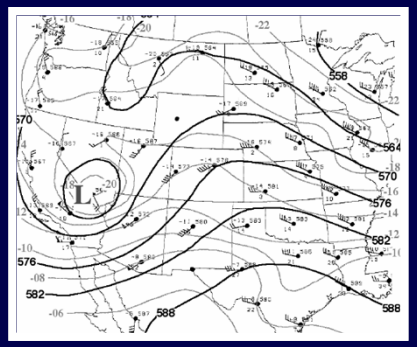
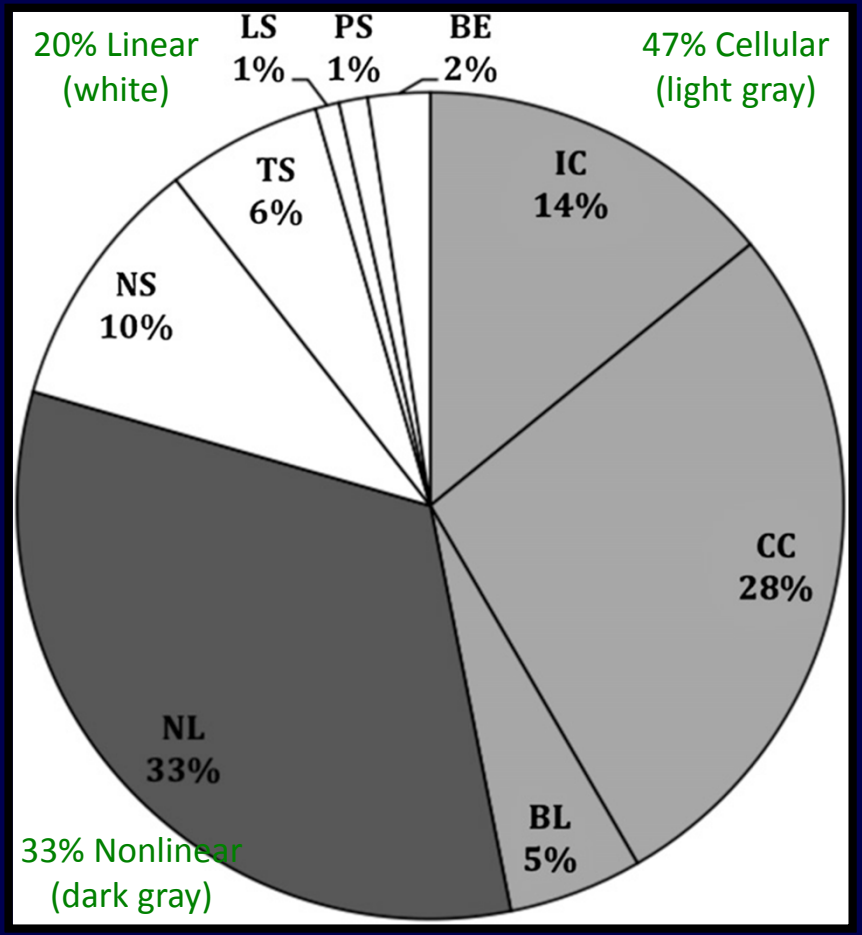


- Synoptic climatology for each structure
  - Dynamic and thermodynamic conditions that favor development: predictability

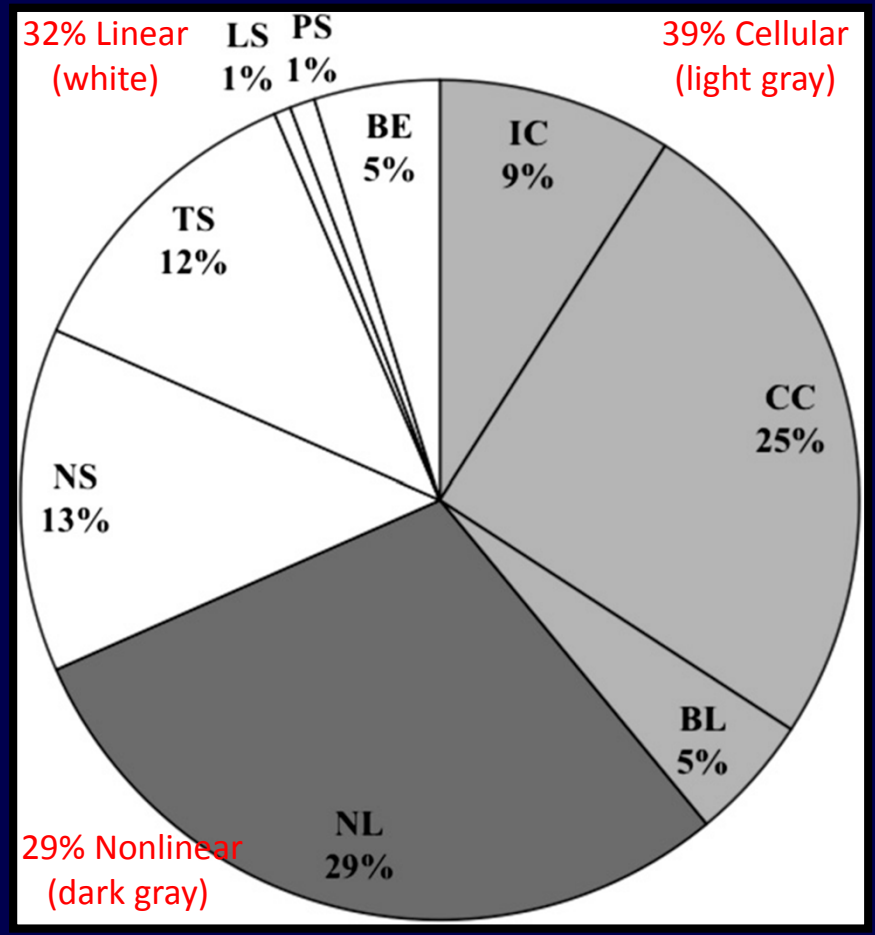
  Predictability of squall lines near NYC/LI

Probability of Severe Weather for Storm Structures

Distribution of Storm Structures over the Northeast

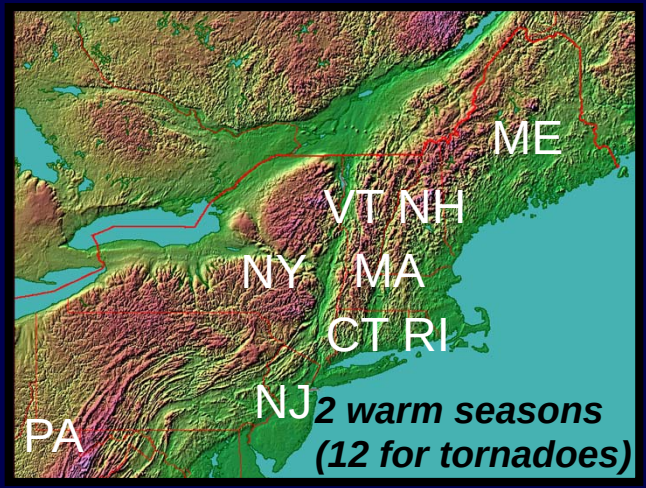


Percent of Severe Events from each Structure over the Northeast

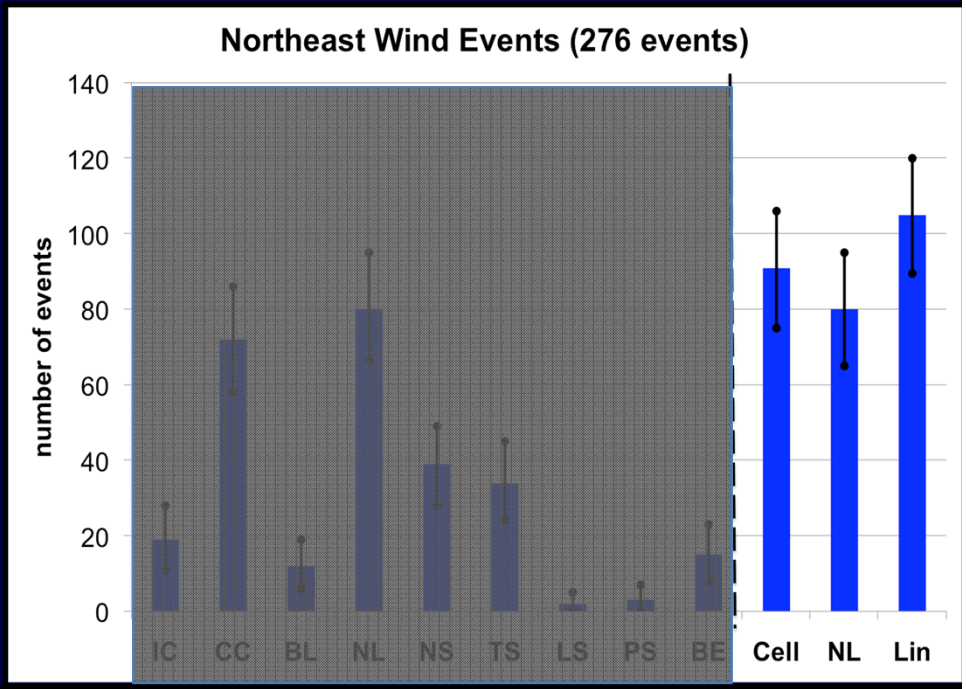


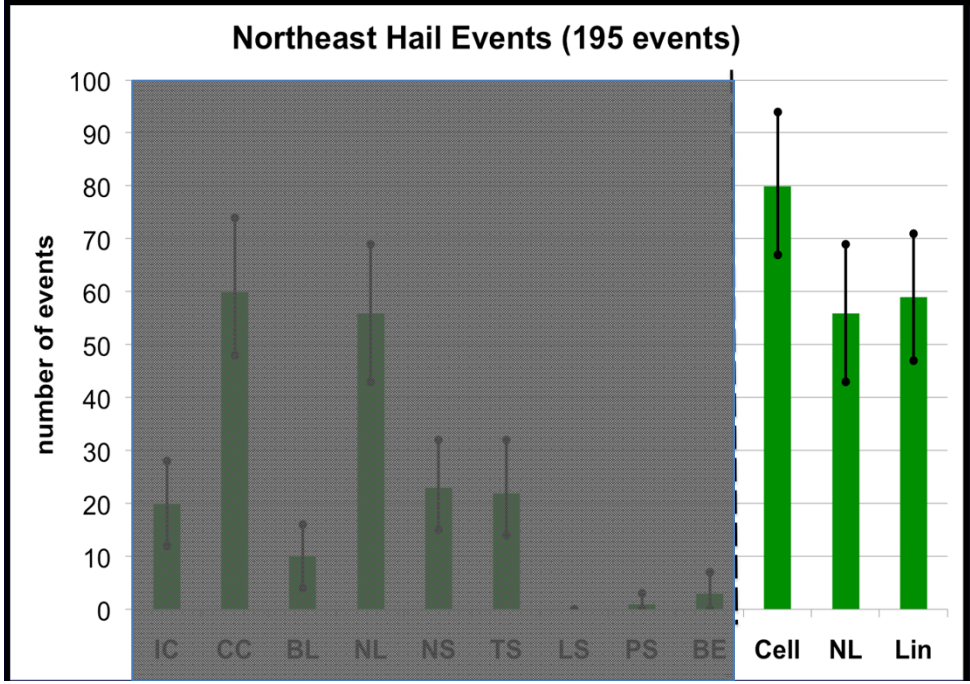
Linear Storms: 1/5 of all convective modes create 1/3 of the severe weather events

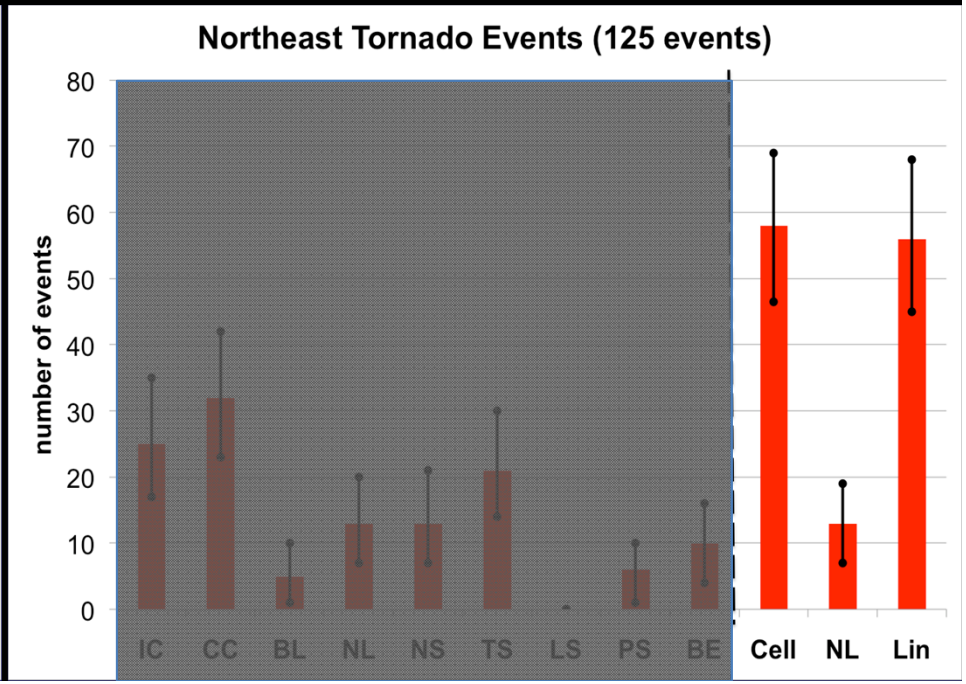
Severe Weather Type over the Northeastern U.S.



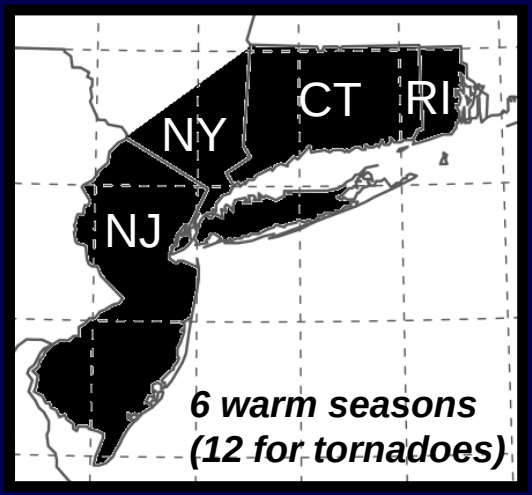
Lombardo and Colle (2011)







Severe Weather Type over the Northeast Coastal Region



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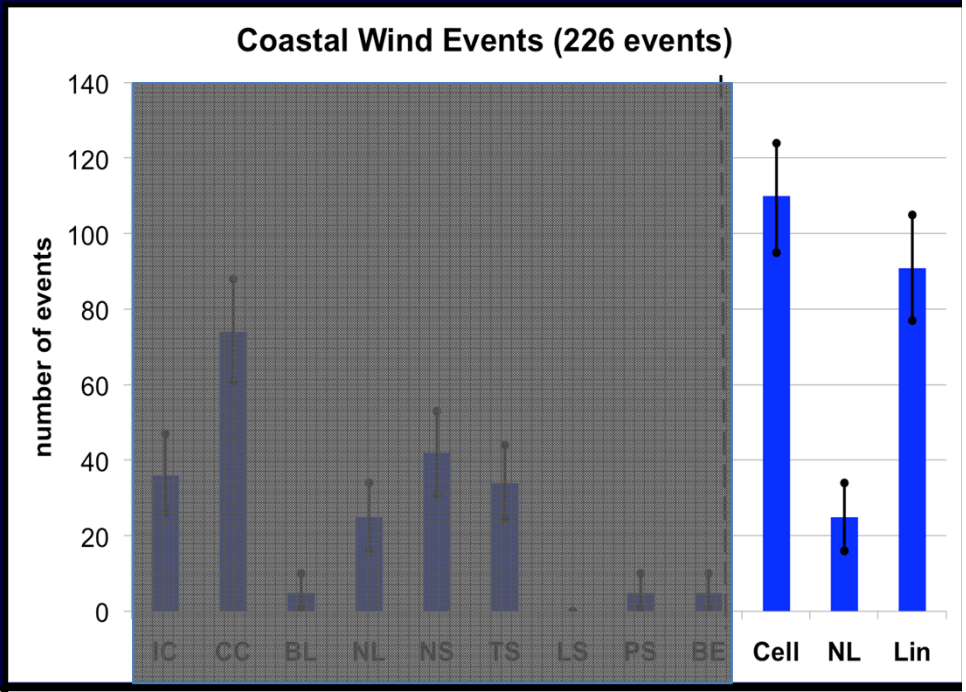
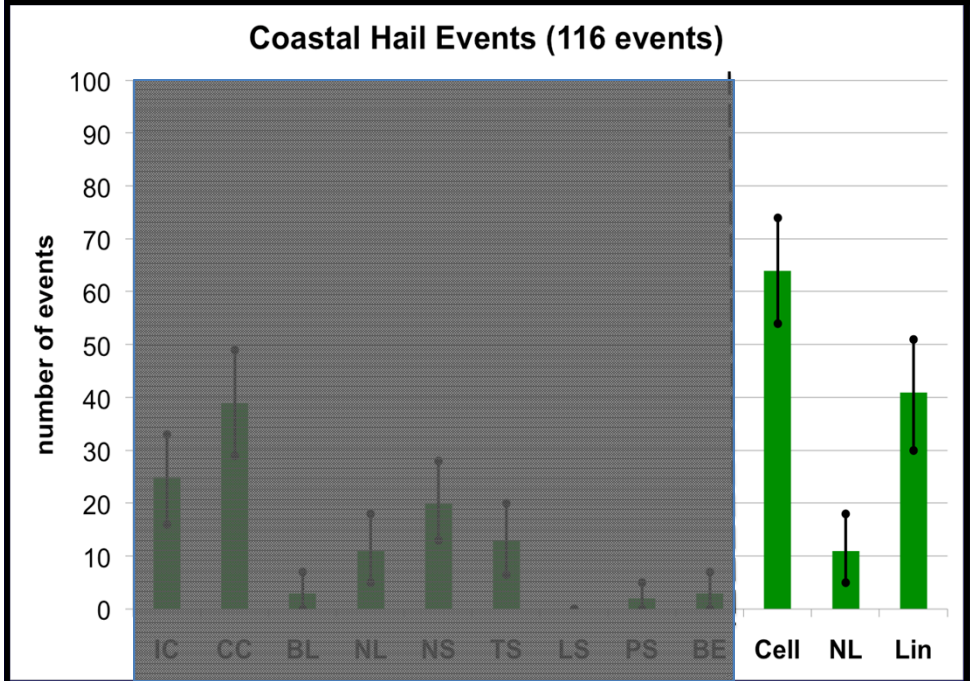
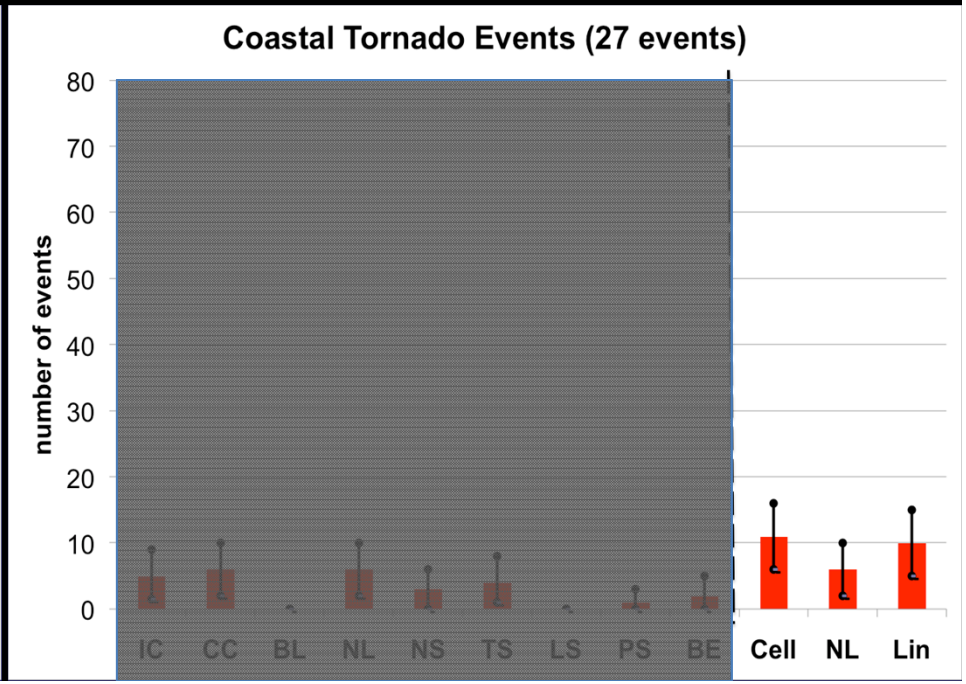
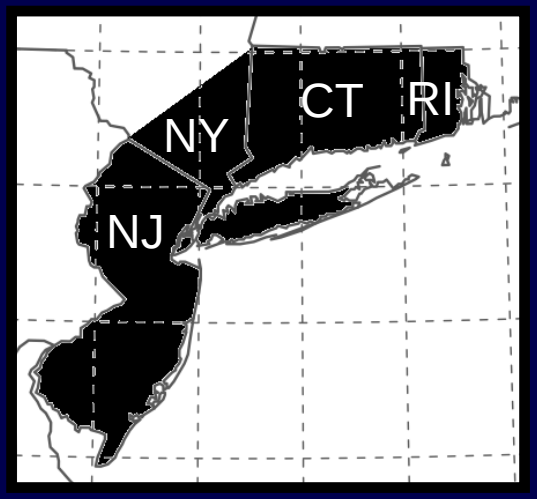






When do these Coastal Storms Create Severe Weather?



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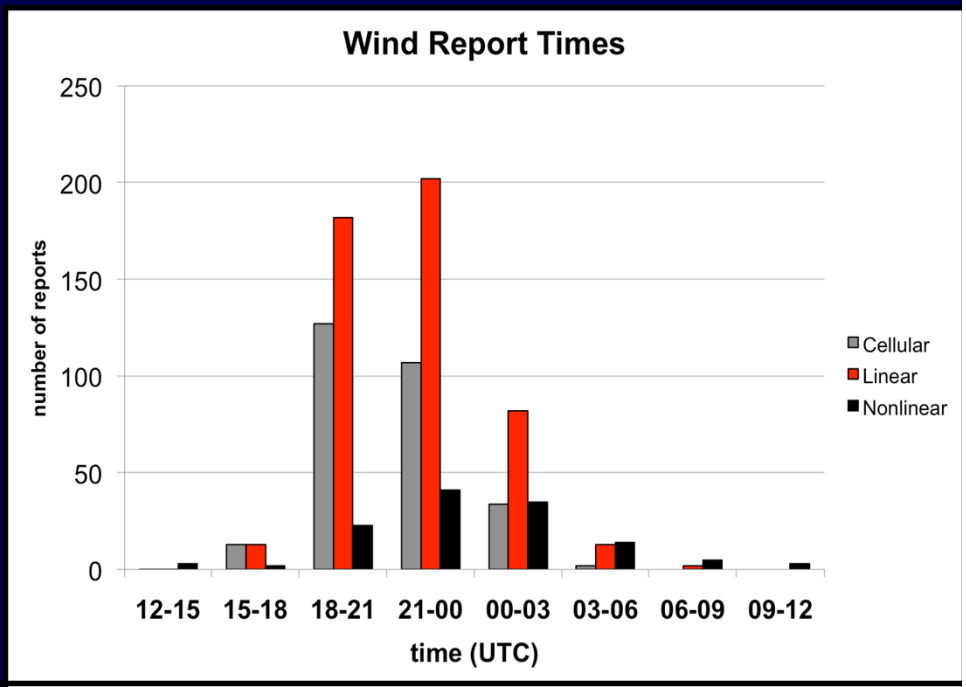
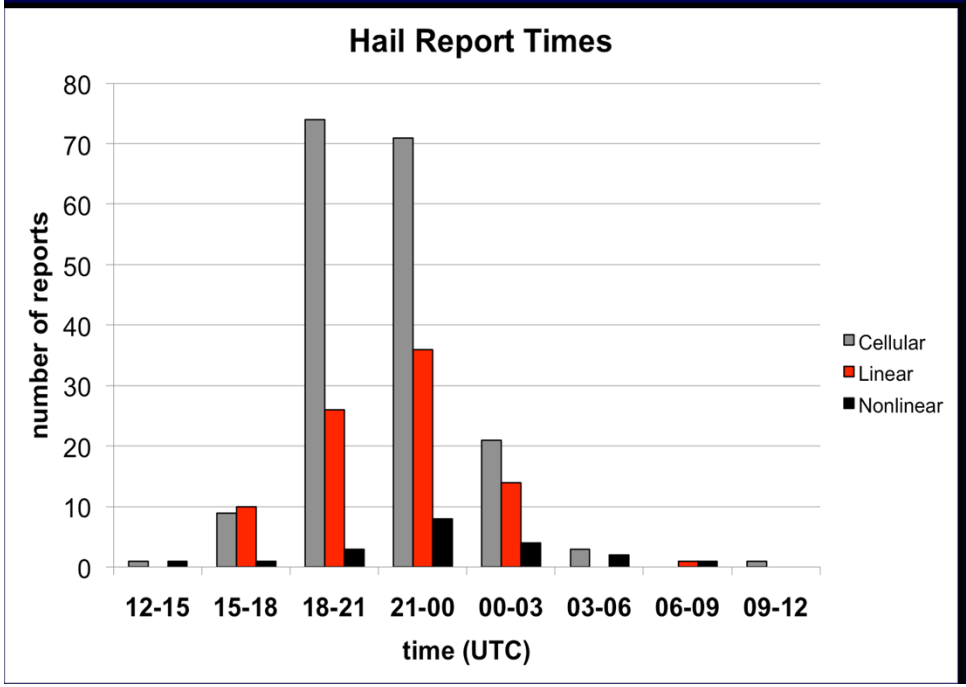
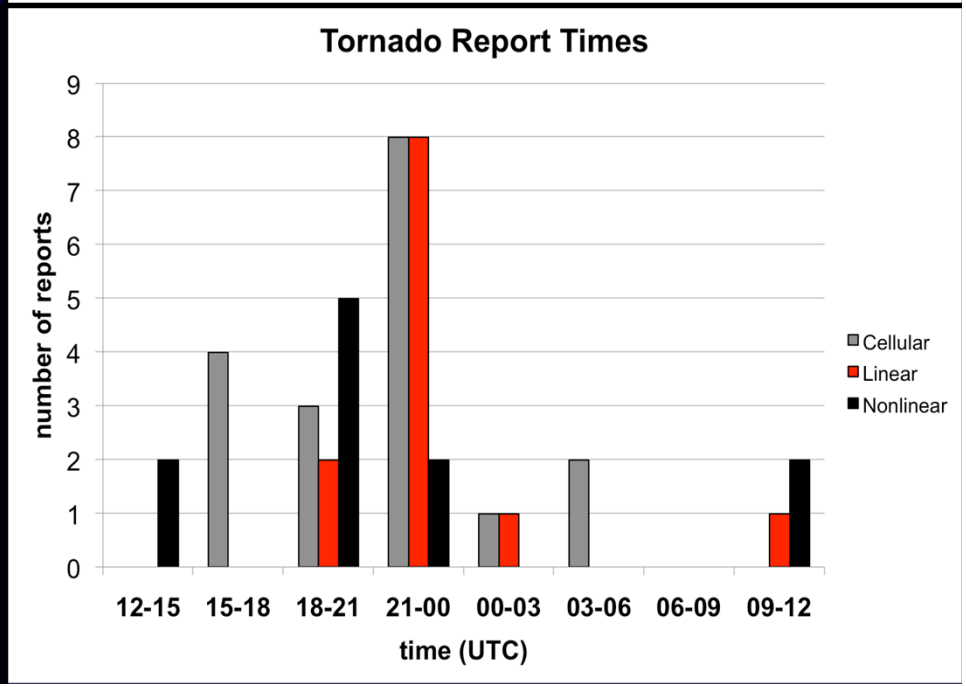
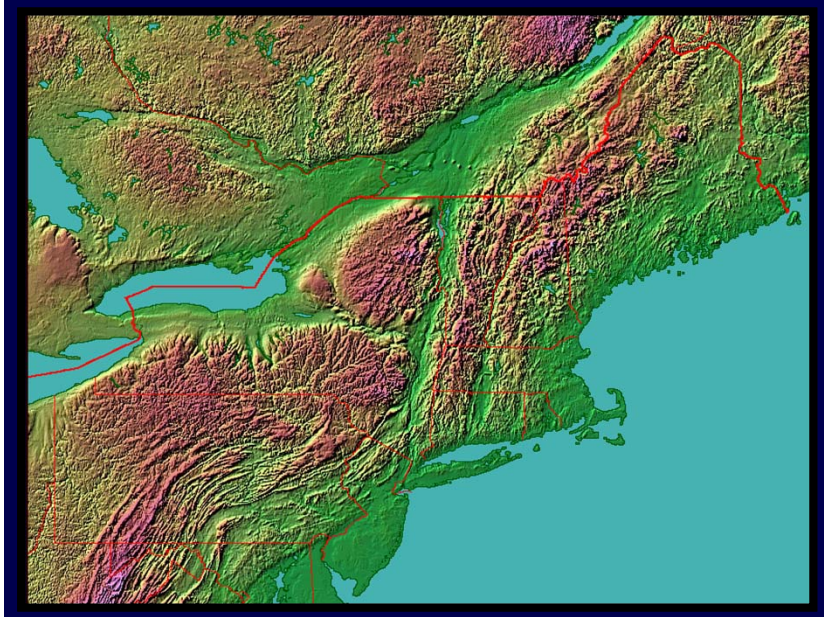


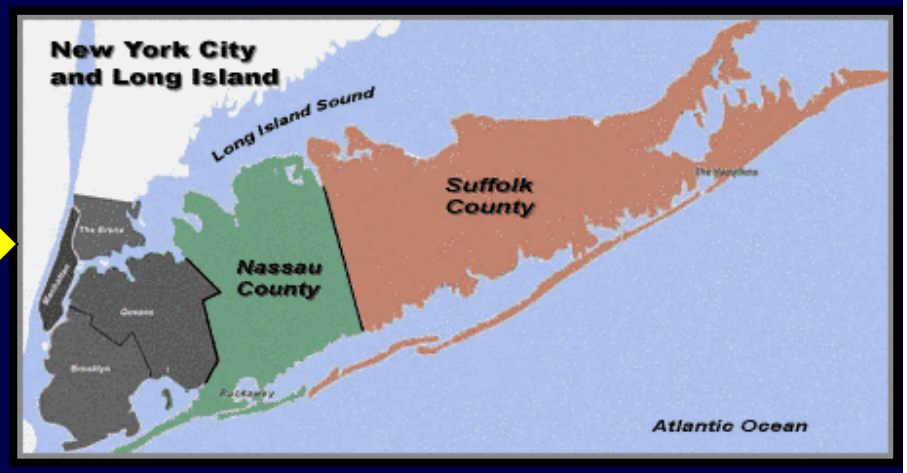




Predictability: Need to Understand Local Impacts

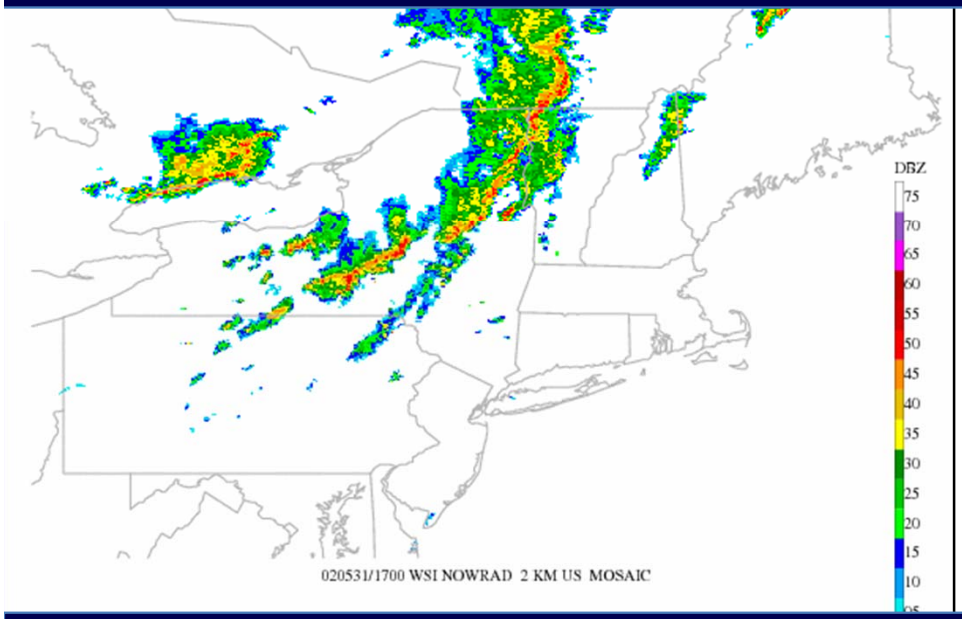
- Regional climatologies provide us with a general idea of our biggest threats
- Local Scale: Who will it impact? When will it impact them?



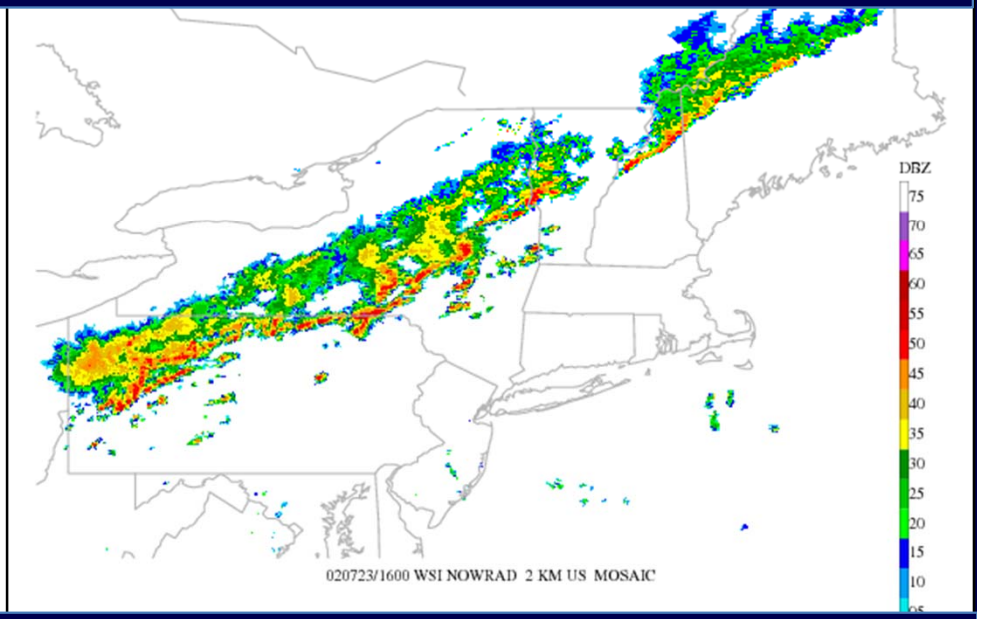


Coastal Squall Lines: Tricky Forecasting Problem

- Responsible for 1/3 of all severe weather over NE, ~40% over coastal region (*Lombardo and Colle 2010, 2011*)
- Spatially large = High impact
- Flash flooding events



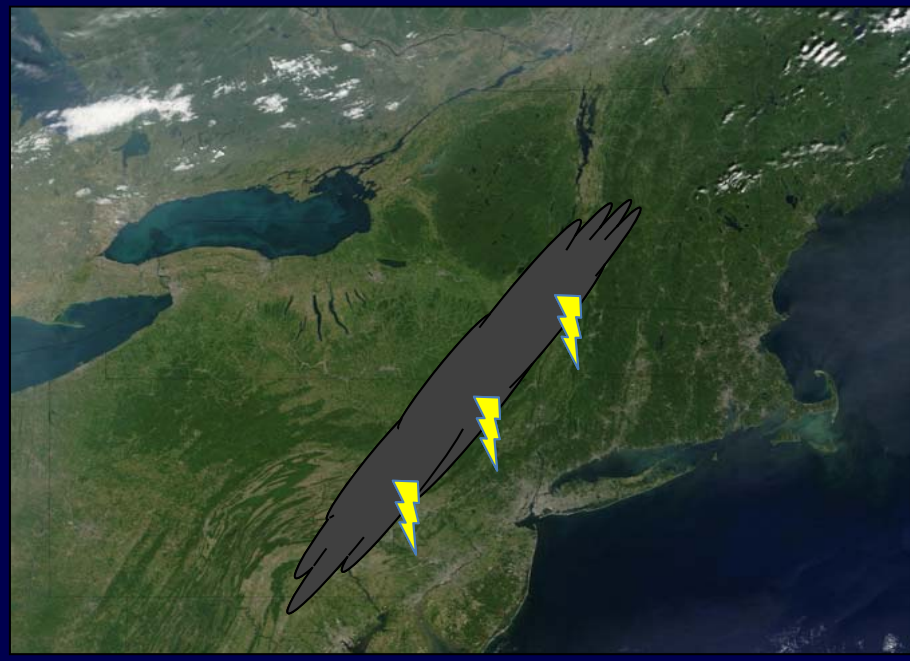
31 MAY 2002 1700 UTC –
01 JUN 2002 1000 UTC



23 JUL 2002 1600 UTC –
24 JUL 2002 0400 UTC

Predicting Coastal Squall Lines

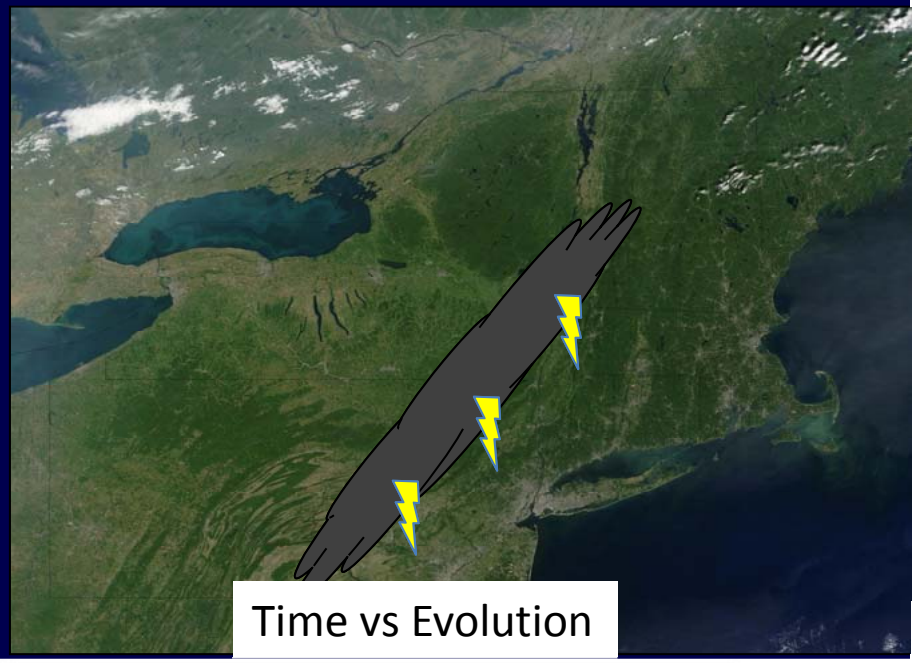
- Constructed dataset of squall lines
  1. decay at the coastline (*limited threat*)
  2. decay just offshore (*NYC threat*)
  3. survive over LI/Atlantic waters (*LI threat*)



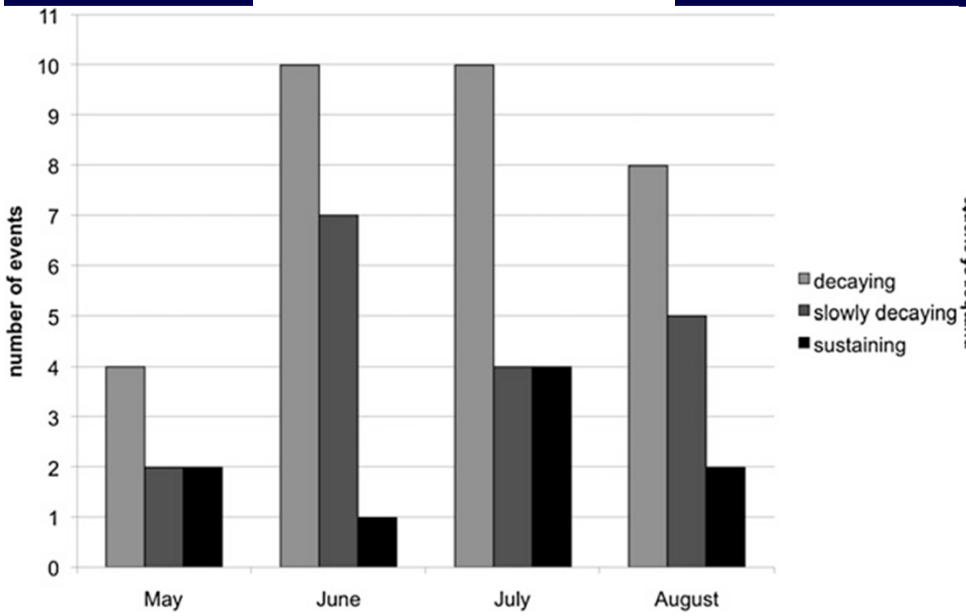
Lombardo and Colle (2012)

Predicting Coastal Squall Lines

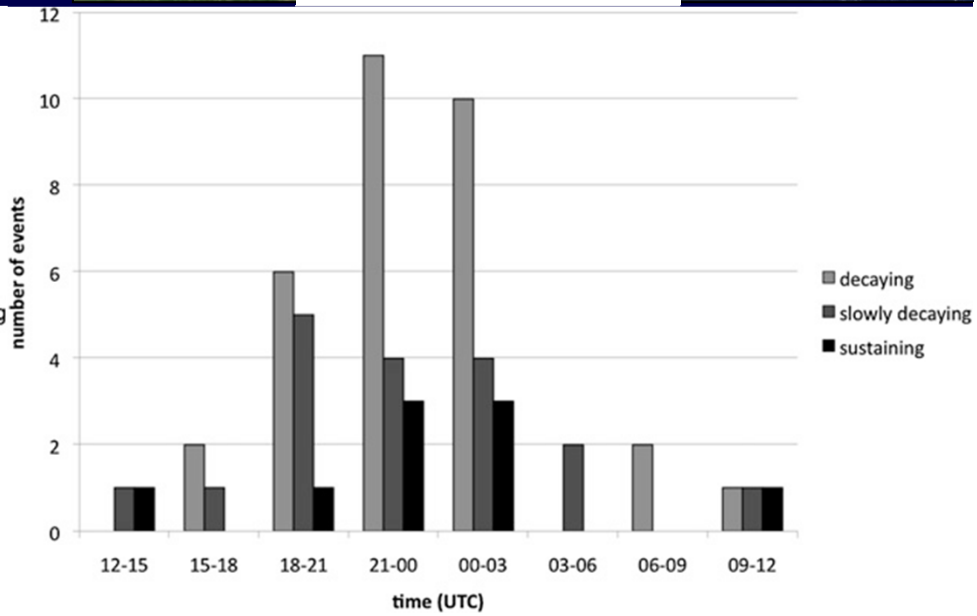
- Constructed dataset of squall lines
  1. decay at the coastline
  2. decay just offshore
  3. survive over LI/Atlantic waters
- Survival/Decay not related to month
- Survival/Decay not related to time of day



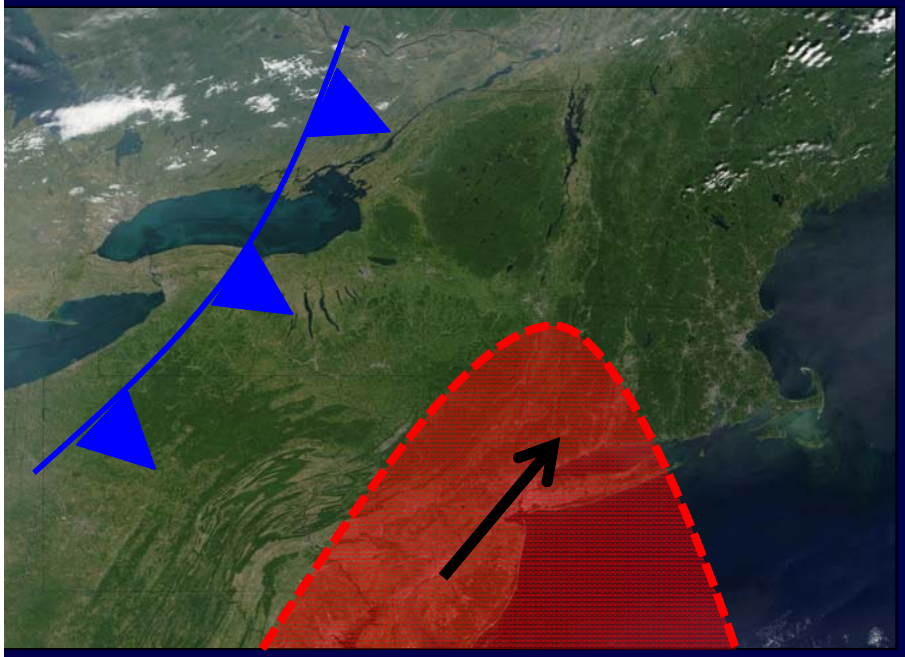
Month vs Evolution



Time vs Evolution



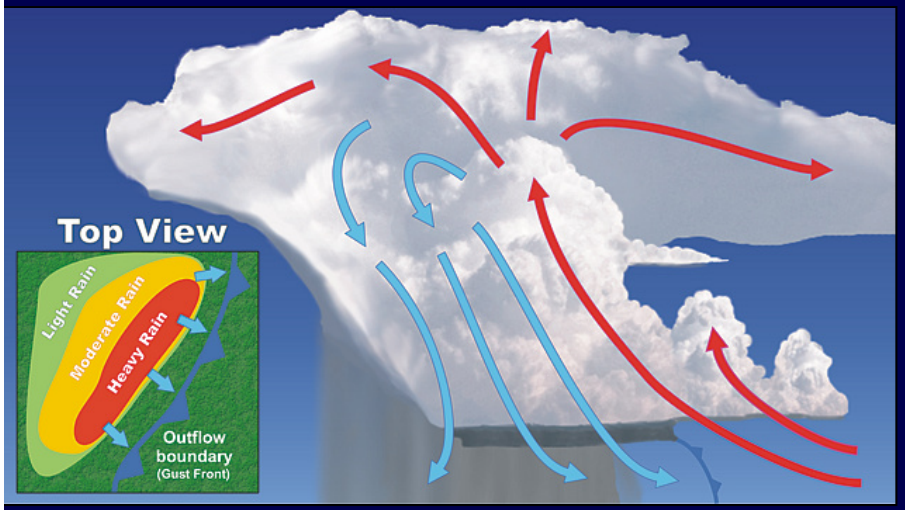
Predictable Atmospheric Conditions



Large Scale: 12-24+ hrs

Decaying systems are associated with larger offshore instability, cold fronts (frontogenesis maximum)

Sustaining systems are associated with a maximum in low-level warm air advection



Storm Scale: 1-12 hrs

For *sustaining* systems:

Stronger low-level shear (0-3 km) over the coastal waters

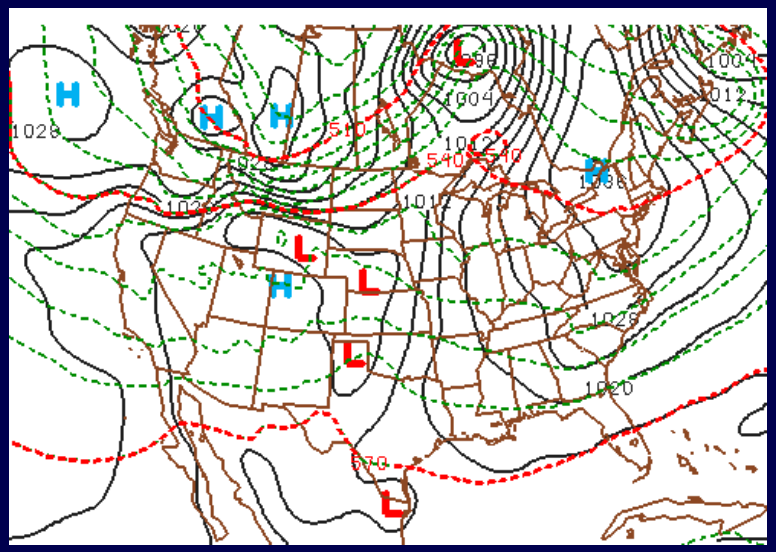
Deeper, more stable marine boundary layer over the coastal waters

(Lombardo and Colle 2012, 2013)

The Role of Numerical Models

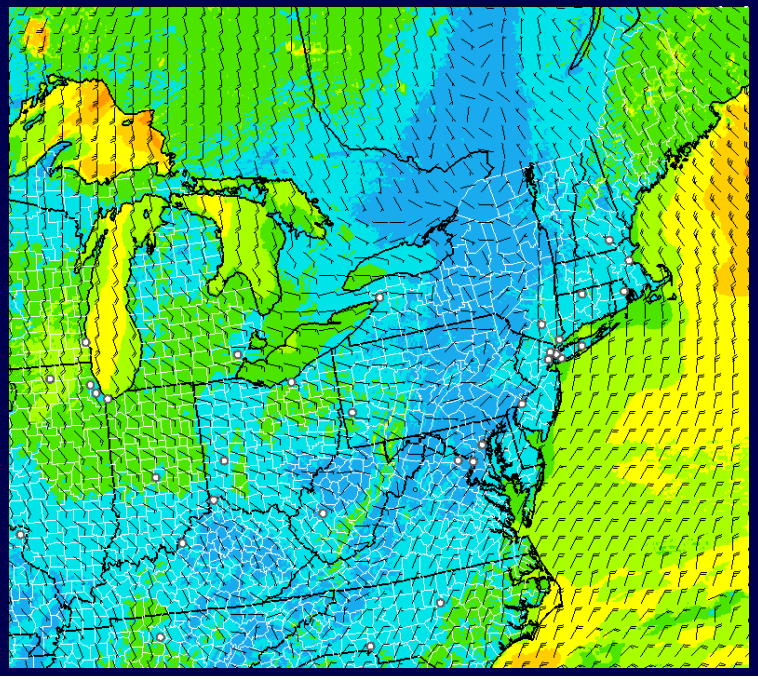
Relatively Coarse Models (i.e. 12km, 28km)

- Good at predicting mass fields (highs/lows) and thermodyanmic (temperature/moisture) environments
- 12-24+ hrs lead time



High Resolution Models (<4 km)

- Can resolve storm scale processes
- Simulate storm structure, time/location of initiation/decay, storm evolution
- 1-12 hrs lead time



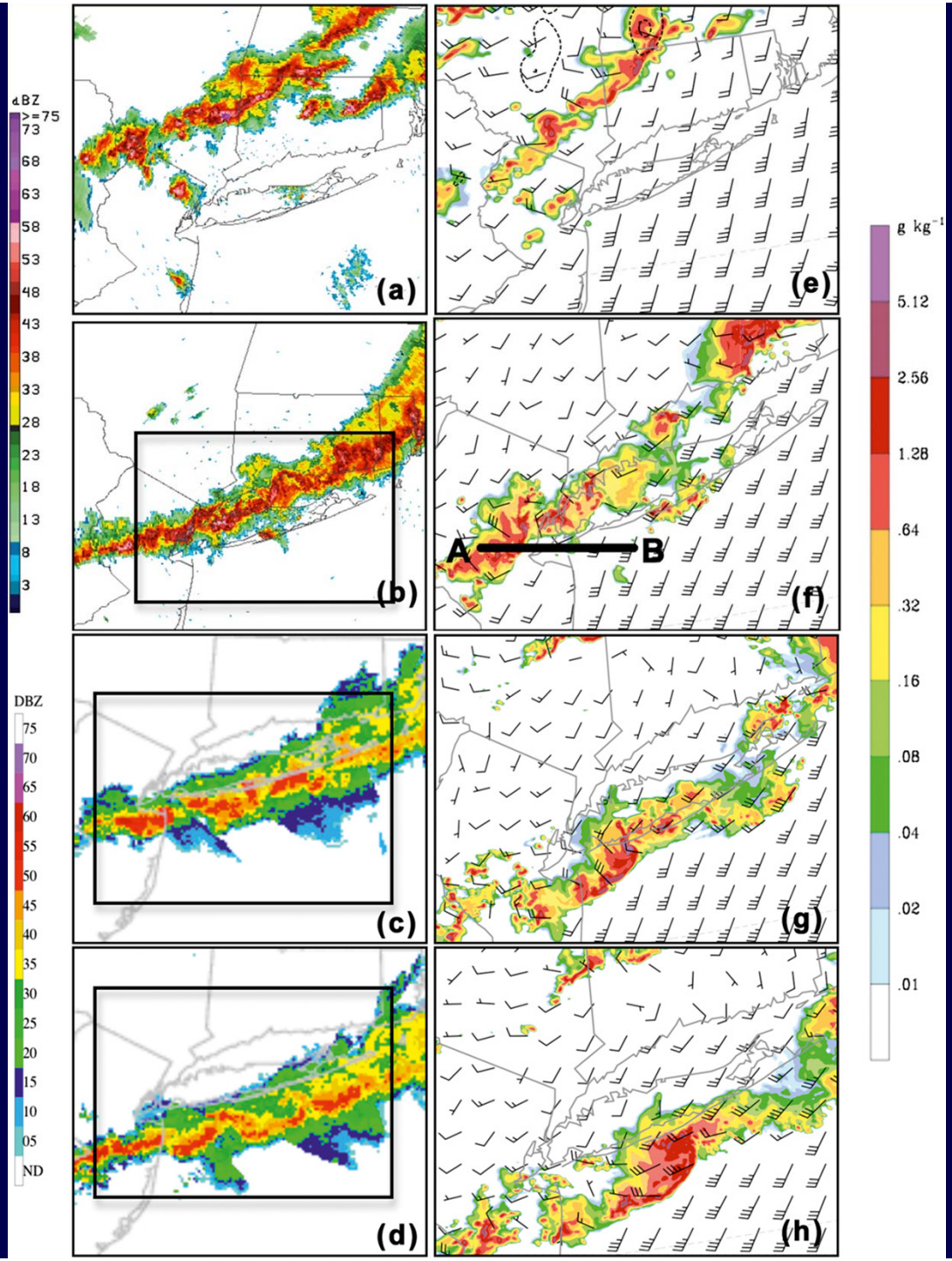
Sustaining Squall Line

31May 02
2258 UTC

1 June 02
0043 UTC

1 June 02
0145 UTC

1 June 02
0215 UTC



31 May 02
2215 UTC

31 May 02
2345 UTC

1 June 02
0030 UTC

1 June 02
0100 UTC

Lombardo and Colle (2013)

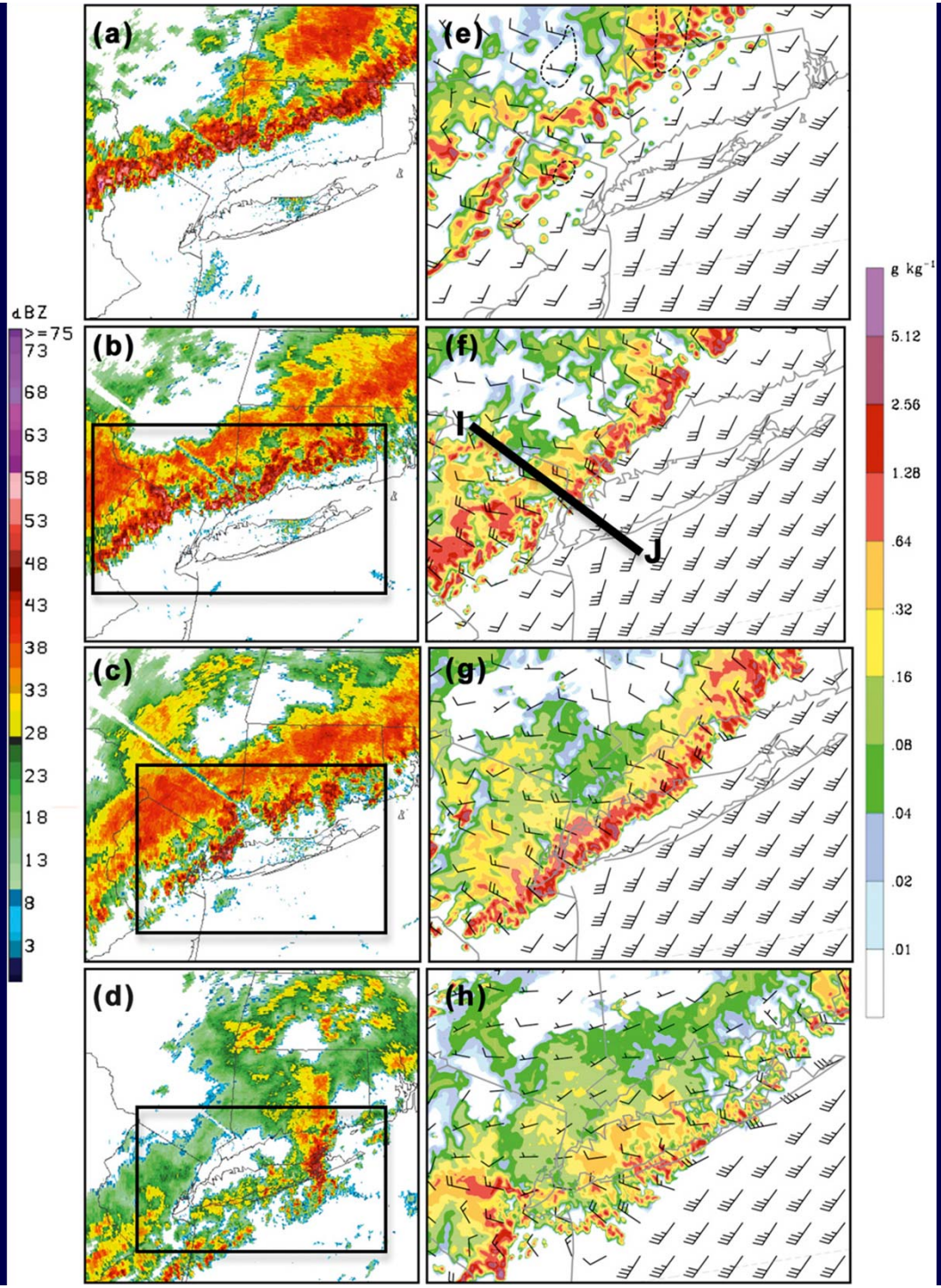
Decaying Squall Line

23 July 02
2016 UTC

23 July 02
2115 UTC

23 July 02
2215 UTC

24 July 02
0005 UTC



23 July 02
2015 UTC

23 July 02
2115 UTC

23 July 02
2200 UTC

23 July 02
2300 UTC

Lombardo and Colle (2013)

Summary: Identification & Prediction Tools

- Radar reflectivity is a useful tool when classifying the structure of warm season storms
  - * *Spatial extent of storm threat, most probable type of severe weather*
- Synoptic/thermodynamic situations favor different storm structures
  - * *Lead time order of days; Heightened awareness of potential threat*
- High resolution numerical models provide additional guidance for storm structure, more precise timing/location for initiation/decay
  - * *Lead time order of hours*

References

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: Convection storm structures and ambient conditions associated with severe weather over the Northeast U.S., Wea. Forecasting, 26, 940-956.

Lombardo, K., and B. A. Colle, 2010: The spatial and temporal distribution of organized convective structures over the Northeast and their ambient conditions, Mon. Wea. Rev., **138**, 4456-4474.