A Multiscale Analysis of the 15 May 2018 Severe Weather Outbreak in the Northeastern United States

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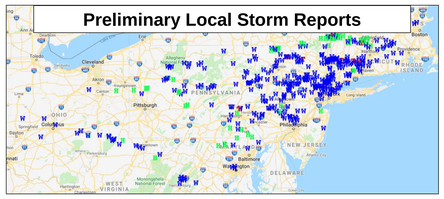
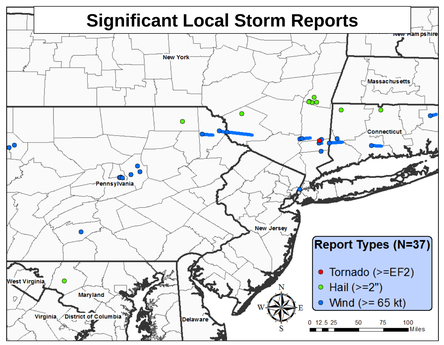
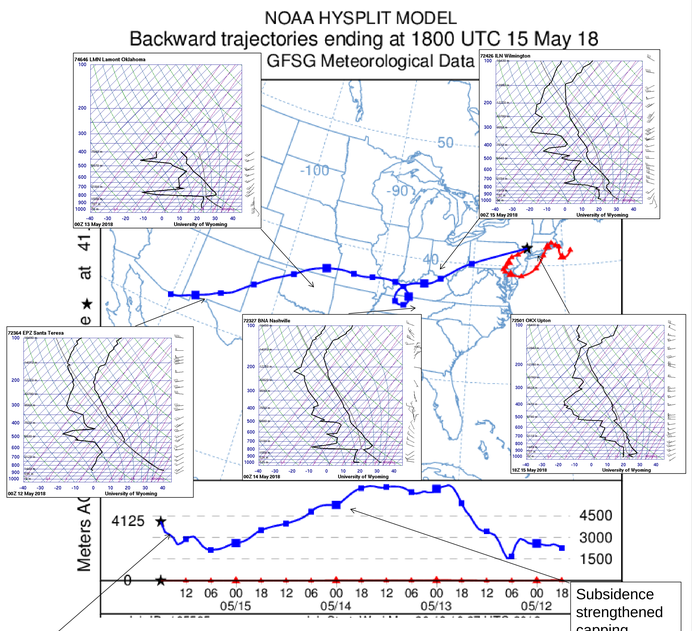
1. Event Overview

- A significant severe weather outbreak occurred across the northeastern US on 15 May 2018. The most extensive damage occurred in portions of PA, NY, NJ, and CT.
- Several swaths of wind damage occurred with 25 significant wind events (gusts ≥ 65 kt).
- At least five fatalities and several injuries occurred mainly as a result of people being struck by falling trees and limbs. Thousands of trees were toppled or snapped, some falling onto homes and resulting in structural damage. Heavy damage to barns and storage buildings was noted, and some poorly anchored structures shifted on their foundations.
- Hail was observed with a few of the storms. There were 11 significant hail events (≥ 2 in) with the largest hailstone measured at 2.75 in. There were reports of hail shattering windows of houses and moving cars.
- Ten brief tornadoes occurred, nine of which were EF0/1 and one was EF2.
- This event caused the greatest storm-related damage in Connecticut since 1989 (CT Dept. of Emergency Services and Public Protection).



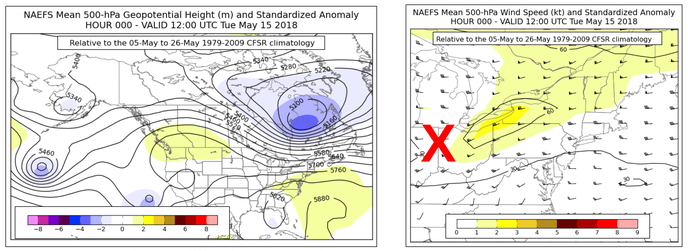


2. Elevated Mixed Layer

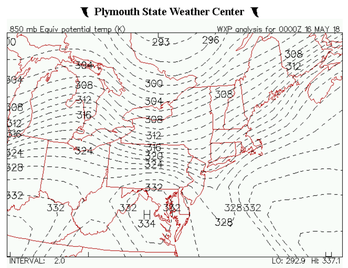


96-hour back trajectory shows parcels ending at around 600 hPa at 1800 UTC 15 May 18 near Poughkeepsie, NY, originated from a mixed layer over the Desert Southwest. This mixed layer was advected eastward and was observed as an elevated mixed layer (EML) on subsequent RAOBs over the next four days. EMLs have been associated with a disproportionate number of fatalities and injuries due to significant severe weather in the northeastern U.S. (Banacos and Ekster 2010).

3. Synoptic Scale

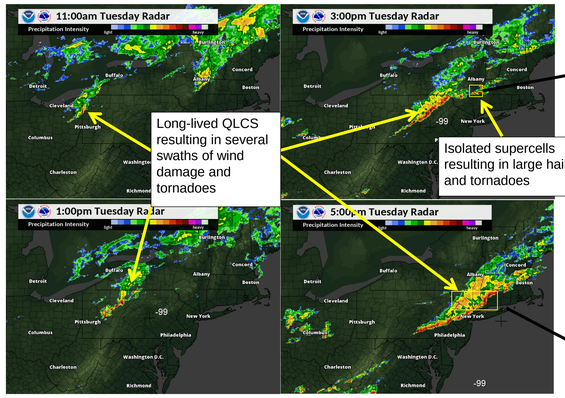


Anomalously strong 500-hPa flow existed between a deep low over eastern Canada and flat ridging over the mid-Atlantic. Red X marks location of MCV at 1200 UTC downstream of which a long-lived QLCS developed.

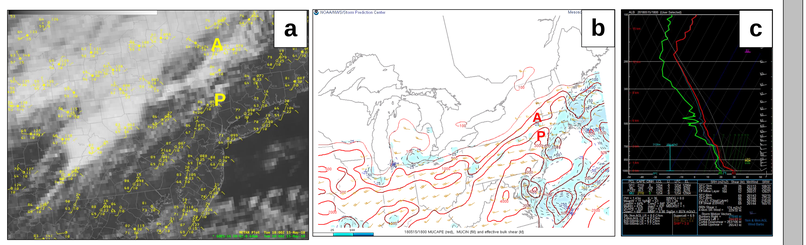


850-hPa θ_e analysis valid 0000 UTC 16 May 18. Gradient > 20 K over 400 km indicative of strong low-level forcing for ascent. Gradients of this magnitude have been associated with significant severe weather over the northeastern US (Stuart and Cebulko, 2018).

4. Regional Radar



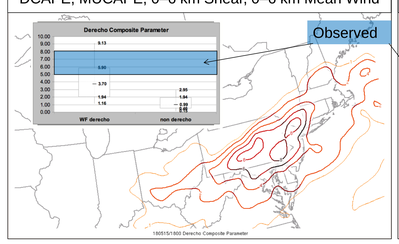
5. Mesoanalysis



(a) Visible satellite and surface observations, (b) SPC mesoanalysis of MUCAPE (J kg^{-1}) and effective bulk shear (kt) valid 1800 UTC and (c) 1800 UTC Albany, NY RAOB modified with Poughkeepsie, NY surface observations. Locations denoted by "A" and "P", respectively. Insolation in advance of QLCS allowed boundary layer to warm and instability to build northward into an area of 45–60 kt effective bulk shear.

18Z Derecho Composite Parameter

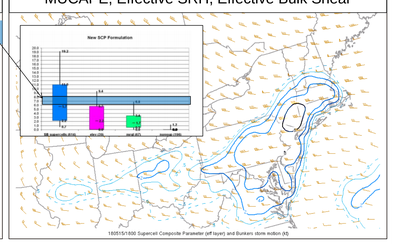
DCAPE, MUCAPE, 0–6 km Shear, 0–6 km Mean Wind



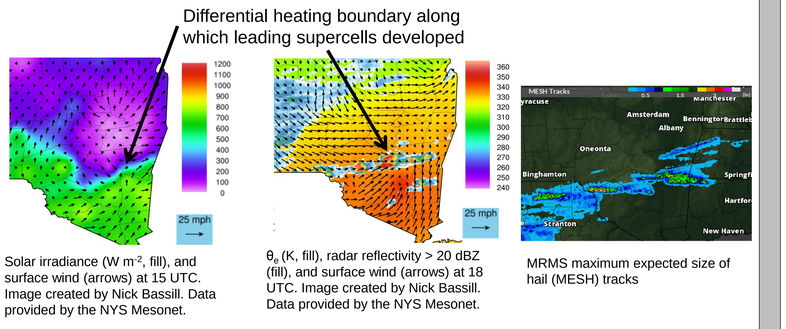
Derecho Composite Parameter (Evans and Doswell 2001) values of 5–8 were favorable for a sustained cold pool-driven wind event.

18Z Supercell Composite Parameter

MUCAPE, Effective SRH, Effective Bulk Shear



Supercell Composite Parameter (Thompson et al. 2003) values of 6–8 were favorable for right-moving supercells.

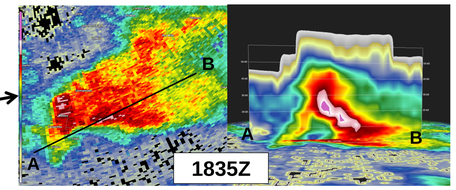


Solar irradiance (W m^{-2}, fill), and surface wind (arrows) at 15 UTC. Image created by Nick Bassill. Data provided by the NYS Mesonet.

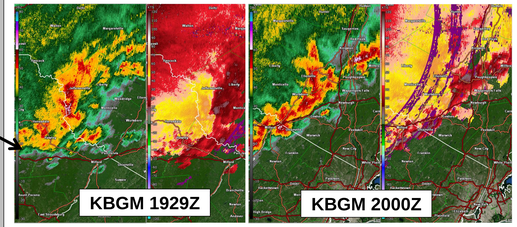
θ_e (K, fill), radar reflectivity > 20 dBZ (fill), and surface wind (arrows) at 18 UTC. Image created by Nick Bassill. Data provided by the NYS Mesonet.

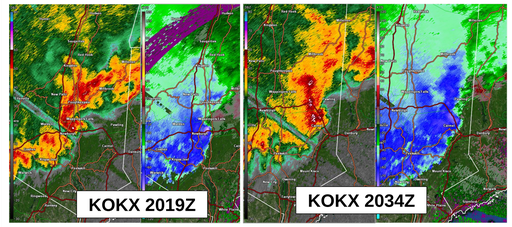
MRMS maximum expected size of hail (MESH) tracks

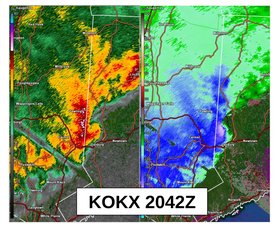
6. Storm-Scale Radar



Isolated supercell over Columbia County, NY, that resulted in 2–2.75 in hail. KENX radar plan view of 0.5° reflectivity (left) and cross section (right). Cross section shows 50, 60, and 70 dBZ reflectivity up to 45, 32, and 26 kft AGL, respectively, along with a bounded weak echo region.







Evolution of significant wind-producing bowing segment over southeast NY and western CT. 0.5° reflectivity (left panels) and velocity (right panels). Paired rear and front inflow notches, front reflectivity nub, and extreme velocity magnitudes as high as 95 kt at 3800 ft AGL suggested likelihood of significant wind damage and QLCS tornadoes.

7. Key Points

- An elevated mixed layer originating from the Desert Southwest resulted in steep midlevel lapse rates over the Northeast.
- The steep midlevel lapse rates along with a warm and moist boundary layer in a relatively cloud-free area downstream of a MCV/QLCS contributed to a tongue of mixed-layer CAPE of 1000–2000 J kg^{-1}. This unstable airmass was collocated with 45–60 kt bulk shear which allowed the QLCS to strengthen as it moved east, resulting in numerous reports of wind damage.
- A portion of the QLCS bowed and accelerated significantly over SE NY and W CT, resulting in six confirmed micro/macrobursts with winds up to 110 mph and five tornadoes. Winds with this portion of the QLCS resulted in four fatalities and at least two injuries. Impacts were likely magnified by these storms occurring during rush hour.
- Effective storm-relative helicity > 200 m^2 s^{-2} contributed to an environment favorable for supercells, which formed along a differential heating boundary in SE NY and resulted in 2–2.75 in hail and three tornadoes.
- 75% of the significant severe weather reports during this event had impact-based warning tags greater than the base 60 mph wind/1 in hail, suggesting NWS warning forecasters were able to identify the high-end nature of the threat with these storms.