Characteristics of Updraft Regions associated with Snowbands Along the U.S. Northeast Coast Using Radar Observations

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Introduction

- Generating cells near cloud top have long been recognized as an important source of snow in winter storms.
- The lack of knowledge about generating cells results in large uncertainty in forecasting winter snowstorms.
- We investigate the associations between generating cell characteristics and snow bands (linear regions of locally enhanced reflectivity) in four winter storms using Ka-band scanning polarimetric radar measurements at Stony Brook University.

Observation

Stony Brook Radar Observatory (SBRO)

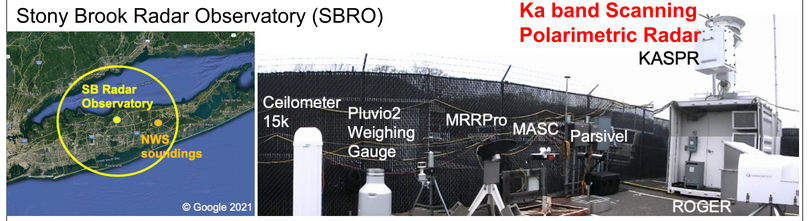
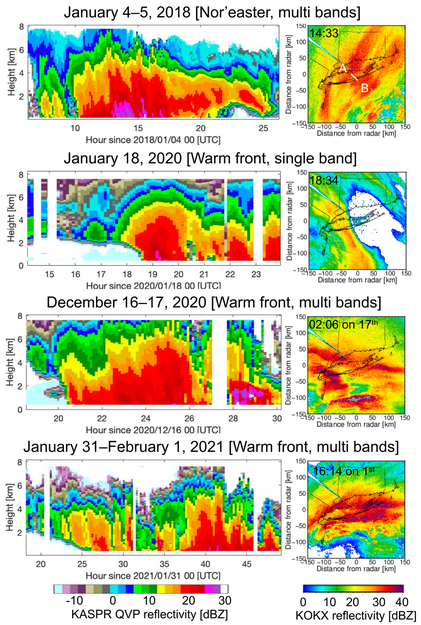
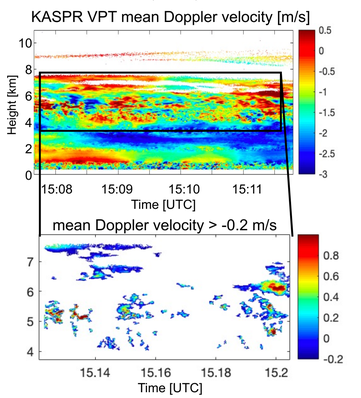


Fig. 1: (left) Location of SBRO and the KASPR observation range (yellow circle). (right) Instruments installed in SBRO.

Cases/Method



Detection of updraft regions: Regions with mean Doppler velocity (DV) from KASPR vertically-pointing measurements (VPT) > -0.2 m/s



▲Fig. 3: (top) Height-time KASPR DV from VPT measurements, and (bottom) regions of KASPR DV > -0.2 m/s. Negative sign indicates downward motion.

◀Fig. 2: (left column) Height-time KASPR reflectivity from quasi-vertical profiles, and (right column) KOKX PPI reflectivity at the lowest elevation angle (0.5°).

Results

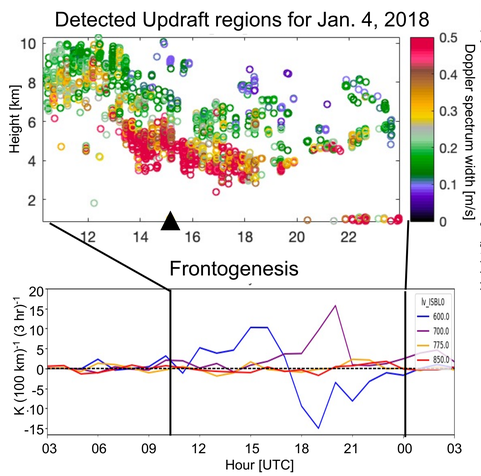


Fig. 4: (top) Locations of detected updraft regions (dots) for a case of Jan. 4, 2018. Color represents spectrum width. (bottom) Frontogenesis estimated at the nearest gridpoint from RAP reanalysis data every hour.

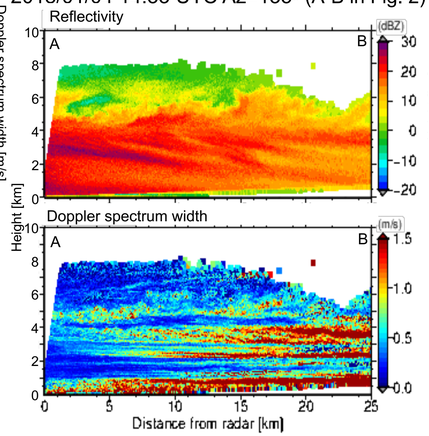


Fig. 5: (top) Reflectivity and (bottom) Doppler spectrum width from a KASPR RHI scan at 14:33 UTC on January 4, 2018 (A-B line in Fig. 2, black triangle in Fig. 4).

- Updraft regions with large Doppler spectrum width (SW) > 0.4 m/s were found in the heavy snow period provided by multi bands.
- Height of large frontogenesis decreased from 600 hPa to 700 hPa, corresponding to the heights of updraft regions with large SW.
- Ice particles near the cloud top seeded the convective, large SW updraft layer.

Relationship with polarimetric variable (K_{DP}) for multiband cases

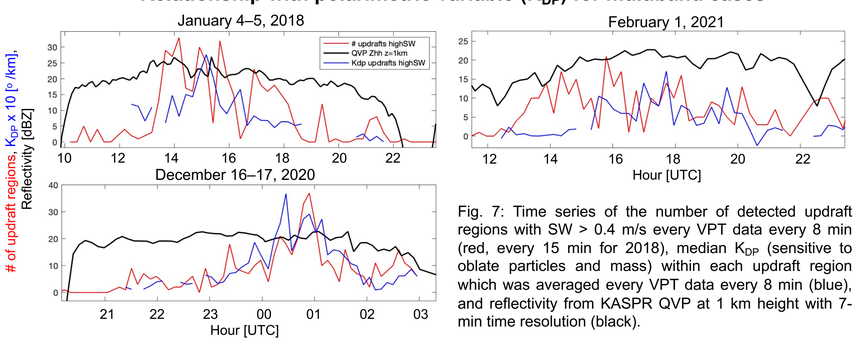


Fig. 7: Time series of the number of detected updraft regions with SW > 0.4 m/s every VPT data every 8 min (red, every 15 min for 2018), median K_{DP} (sensitive to oblate particles and mass) within each updraft region which was averaged every VPT data every 8 min (blue), and reflectivity from KASPR QVP at 1 km height with 7-min time resolution (black).

- The number of updraft regions with SW > 0.4 m/s was well correlated with large K_{DP} values (sensitive to oblate particles and mass) and reflectivity near the surface.

Relationship with Doppler spectrum width (SW) and vertical wind shear

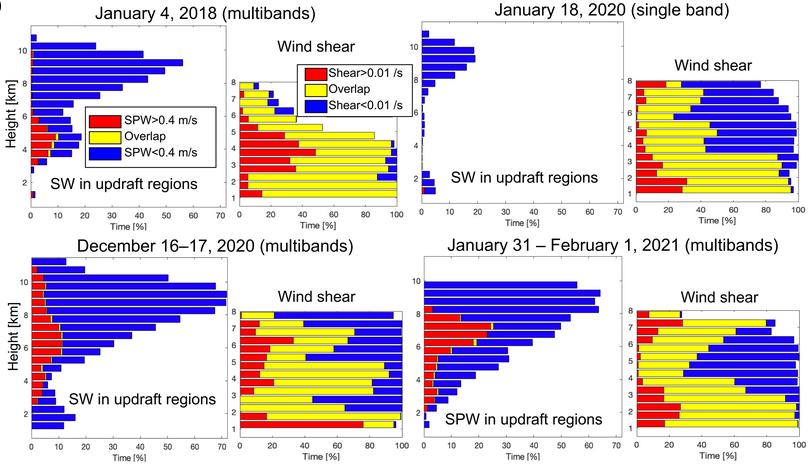


Fig. 7: In each pair of plots: (left) Distribution of updraft characteristics with height, where total length of bar is the percentage of times with updrafts at each altitude range. Color-coded subsets along each bar indicate spectral width characteristics. Based on vertically-pointing scans for 3 min duration every 8 minutes (5-min duration every 15 minutes for the 2018 case). (right) Distribution of vertical wind shear magnitude with height. The wind shear plots from 1–8 km altitude are based on VAD scans every 7 minutes from KASPR PPI at an elevation angle of 15°. The 15-m vertical resolution data were resampled every 0.5 km height. (White blank at each height represents 'no data' for the shear plots.)

- Updraft regions accounted for more than 50% of cloud time near the cloud tops for the three multi-band cases and 20% for the single-band case (Jan. 18, 2020).
- Updrafts with smaller Doppler spectrum width were produced near cloud tops.
- Updrafts with larger Doppler spectrum width were produced at lower altitudes than those with smaller spectrum width for multi-band cases.
- Updrafts with larger Doppler spectrum width were associated with larger vertical wind shear (red+yellow).

Summary/Future Work

- Characteristics of updraft regions observed in snowbands accompanied by four snowstorm cases were analyzed using the Stony Brook University Ka-band scanning polarimetric radar measurements.
- Updraft regions were observed near cloud tops in all cases. They accounted for more than 50% of cloudy time near the cloud tops for multi-band cases.
- The altitudes with higher turbulence (> 0.4 m/s) within updrafts varied from storm to storm.
- Higher vertical wind shear was often included in middle and lower levels collocated with higher turbulence, suggesting roles for both shear and boundary layer instabilities.
- Future work will examine the relationships among updraft regions, and aggregation and riming signatures derived from radar polarimetric signatures and Doppler spectra.