Band Motion and Precipitation Type Tendencies in Northeast U.S. Winter Storms

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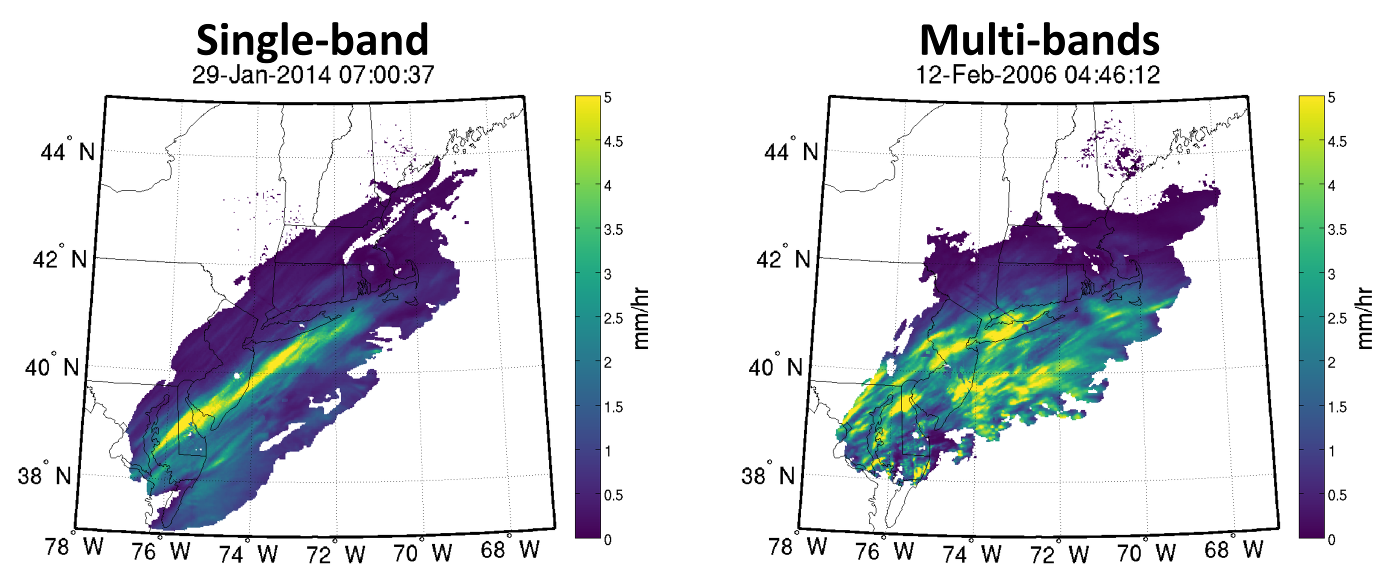
Background

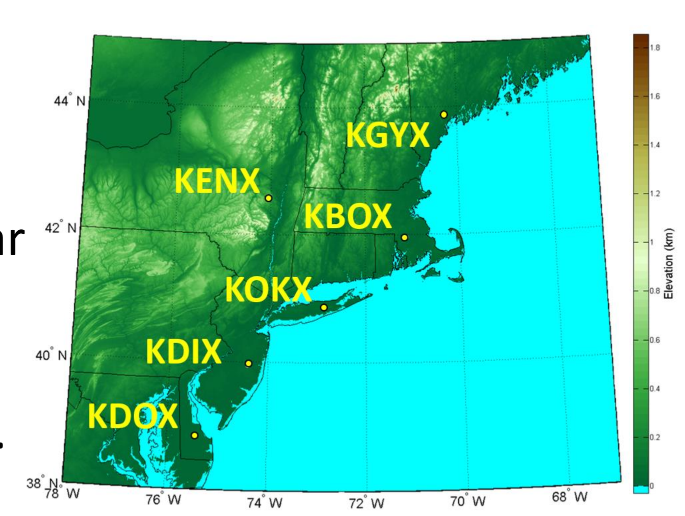
Snow accumulation in storms impacting the northeastern U.S. can be a forecast challenge, partially due to bands of locally higher snowfall rates. These bands can be classified in two ways: single-bands and multi-bands. Single-bands are long (at least 200 km) and narrow, while multi-bands are smaller and generally exist in groups. These bands can move in a number of different ways both in a geographic sense and relative to the low pressure center. This project seeks to better understand the reasons for these different types of motion. Another purpose of this project is to determine which areas are more likely to receive rain rather than snow during these storms, in order to separate rain bands from snow bands.



Estimated snow rate maps showing an example of a single-band on 29 Jan. 2014 (left) and multi-bands on 12 Feb. 2006 (right)

Data and Methods

Seven storms between 2003 and 2014 were analyzed using data from six National Weather Service radars in the Northeast (shown right). Radar reflectivity was converted to estimated snow rate using the methods described in Hoban (2016). Bands can be identified from locally high snow rate values. Pressure, geopotential height, temperature, and wind data were used from the North American Regional Reanalysis (NARR).



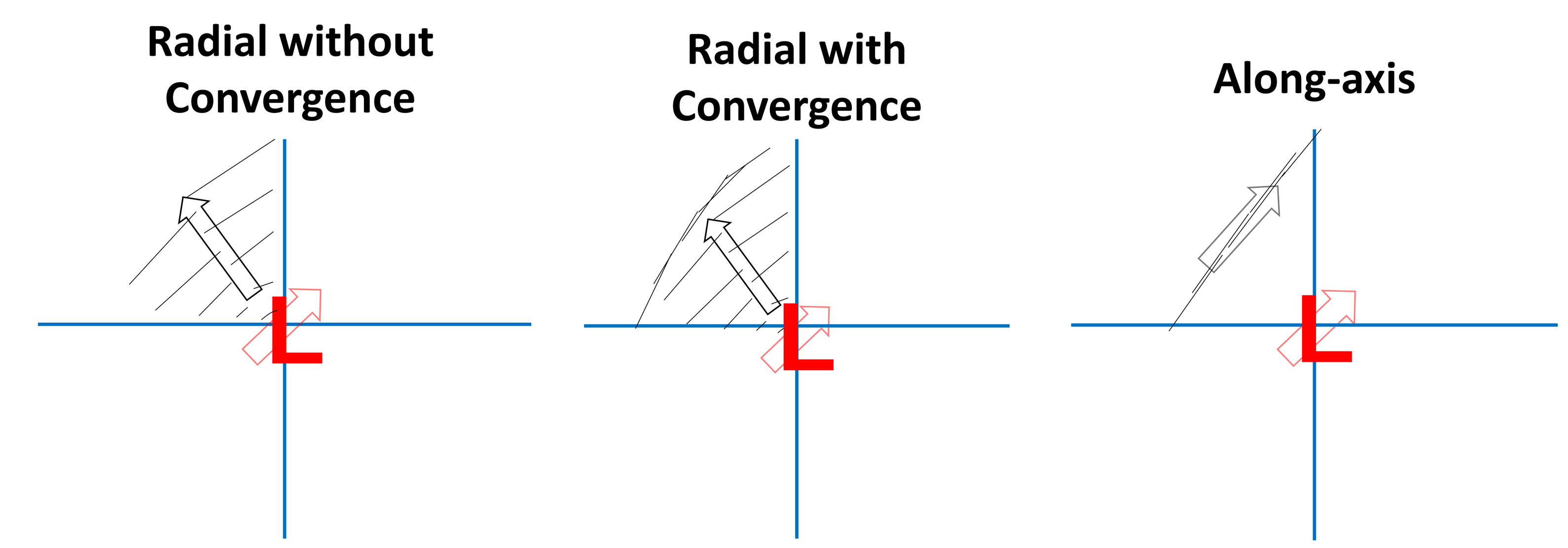
The low pressure center was found and tracked throughout the duration of each storm. The motion of snow bands can then be viewed in a Lagrangian framework (i.e. relative to the motion of the low).

The location and motion of bands were compared to the height, wind, and vertical wind fields at the 700 hPa level.

Temperature fields were combined with radar data to create maps showing the frequency of rain and snow for locations in our domain. We used 0°C at 10 m as the cutoff value between rain and snow; however, this cutoff varies in reality.

Band Motion Types

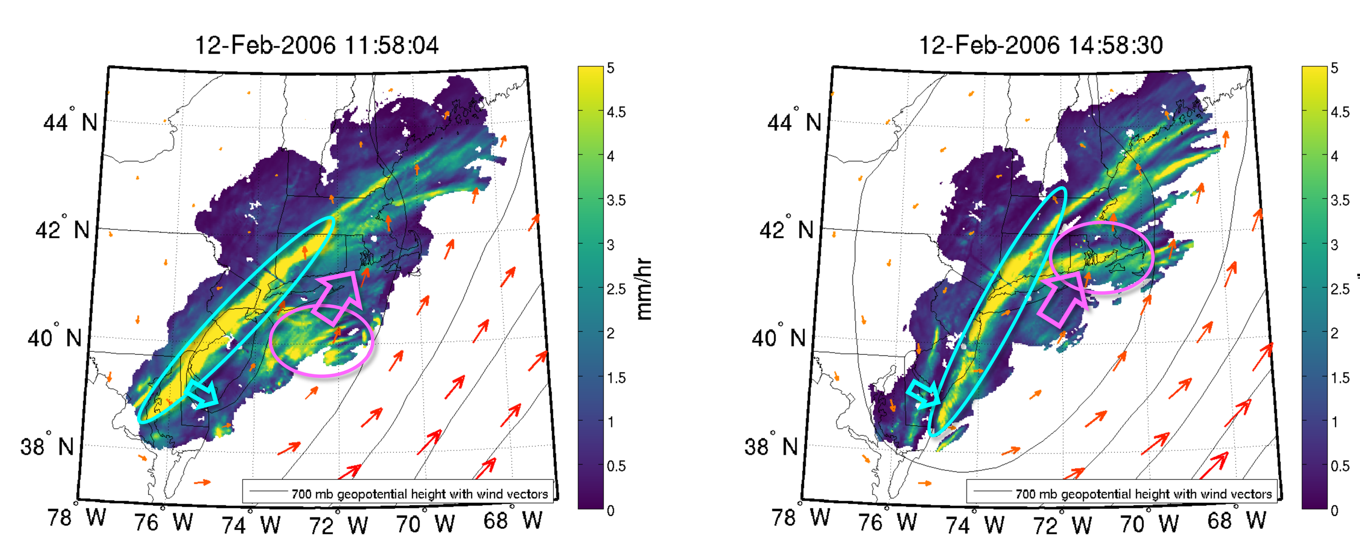
Five types of band motion were observed and defined. Among the seven cases studied, one had quasi-stationary band motion relative to the low, three had radial motion with convergence, one had radial motion without convergence, one had motion along the band axis, and one had mixed motion.



Three types of band motion defined. Note that along-axis motion can also occur with multi-bands. Quasi-stationary and mixed motion are not pictured.

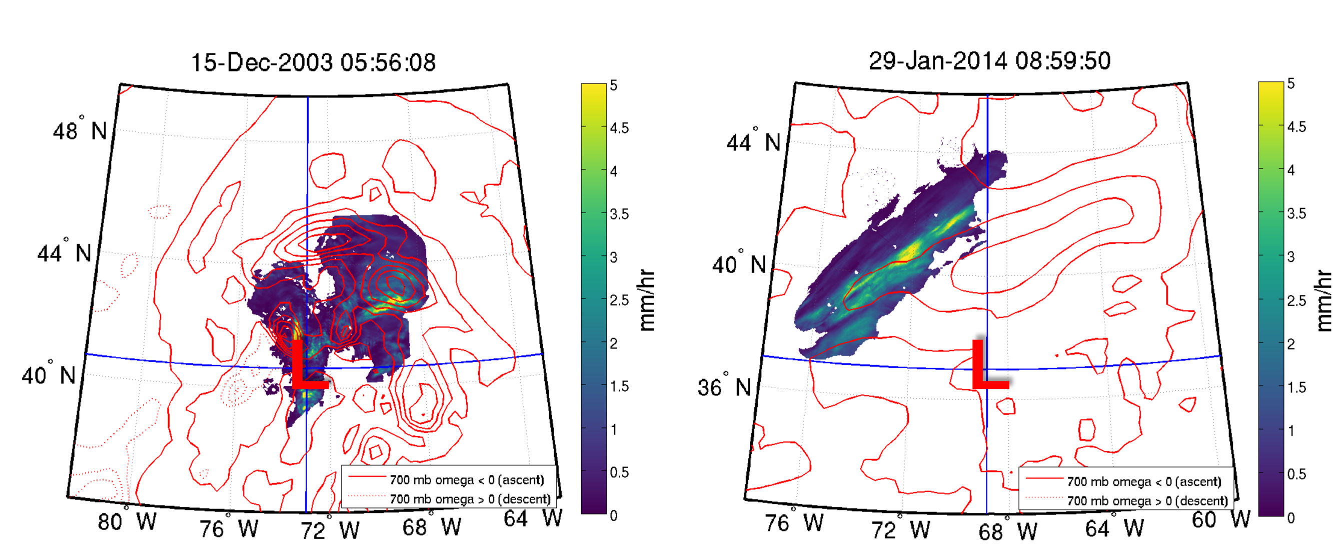
700 hPa Winds and Band Location

In general, 700 hPa horizontal winds were effective at indicating the motion of both the storm and the bands within. The 700 hPa wind did not exactly indicate the motion, but differences between the two were almost always minor.



Two example images showing snow rate, 700 hPa heights, and 700 hPa wind vectors in a geographic framework. These two images are both from the same storm (12 Feb. 2006) and are three hours apart.

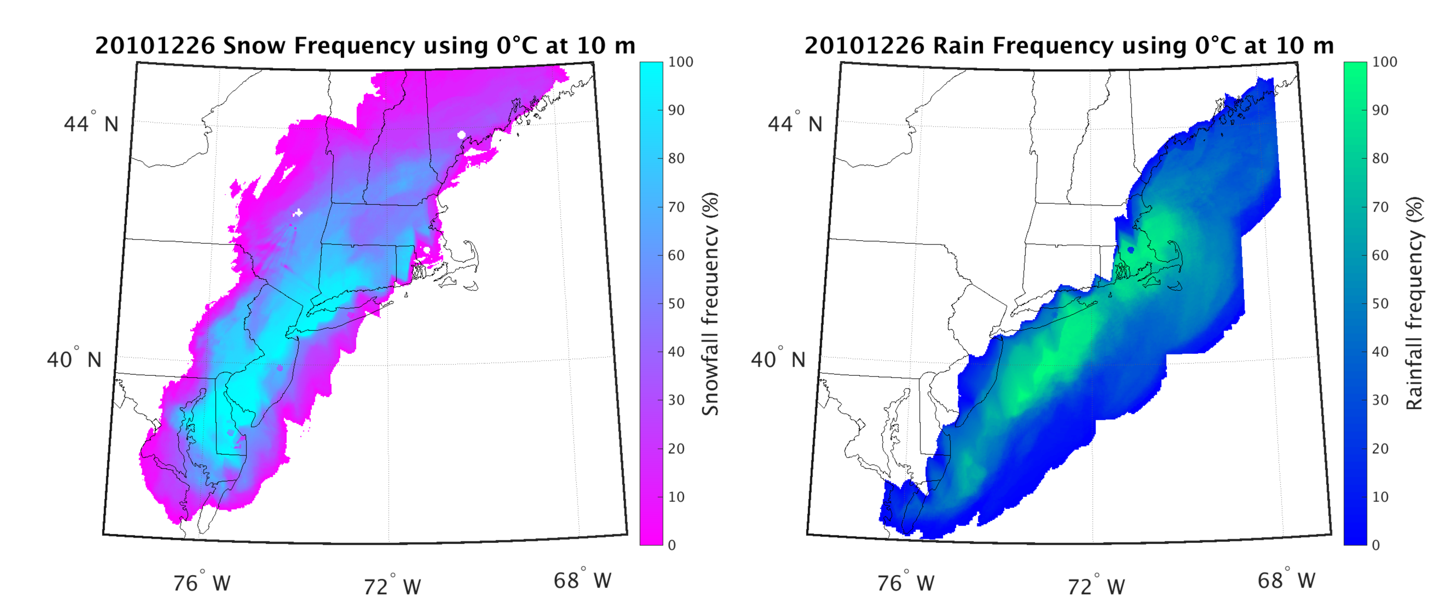
700 hPa vertical wind indicated rising air around most locations with bands (pictured below, left). However, this was not as clear for the case with motion along the band axis relative to the low (below, right). It was also less clear for the case with quasi-stationary motion relative to the low, which appeared to have along-axis motion when viewed in a geographic framework (not pictured).



Left: Snow rate and 700 hPa vertical wind for ~6 UTC on 15 Dec. 2003 (case with radial, non-convergent motion)
Right: Snow rate and 700 hPa vertical wind for ~9 UTC on 29 Jan. 2014 (case with along-axis motion)
Both are centered on the low

Precipitation Type

Temperature contours were often found to be roughly parallel to the coastline, with warmer temperatures over the ocean. This implies that snow is more likely to fall over land, and rain is more likely to fall over the ocean (shown below).



Percentage of radar volumes during 26-27 Dec. 2010 case with snowfall (left) and rainfall (right) as indicated by "snow rate" > 0.5 mm/hr and a 10 m temperature below 0°C and above 0°C, respectively.

Conclusions

- In the cases studied, band motion appears to closely line up with the 700 hPa horizontal wind field.
- Band locations appear to follow areas of ascending air at 700 hPa, but this may not necessarily be the case for storms with motion along the band axis.
- Temperatures offshore tend to be warmer, and rain should therefore be more likely over the ocean than over land.

Future Work

More cases should be analyzed in order to generalize these findings. In particular, more cases with along-axis motion should be studied to compare band locations with the 700 hPa vertical wind field.

The best method of determining whether rain or snow is falling given a three-dimensional temperature field should be found. The NARR temperature field seemed to be warmer than observed temperatures during the precipitation events studied in this project, sometimes by a significant amount. Because of this, a different reanalysis product could be used in future work.

Reference: Hoban, N.P., 2016: Observed Characteristics of Mesoscale Banding in Coastal Northeast U.S. Snow Storms, M.S. Thesis, Dept. of Marine, Earth, and Atmospheric Sciences, North Carolina State University.
Acknowledgements: Special thanks to Michael Tai Bryant, Levi Lovell, and Emma Scott for their assistance and advice. This research is supported by NSF grant AGS-1347491.