Observed Characteristics of Mesoscale Banding in Coastal Northeast U.S. Snow Storms

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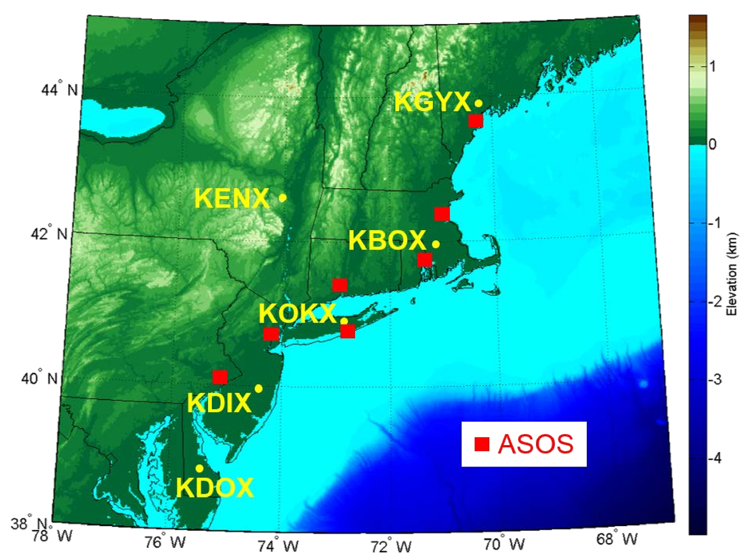
ENVIRONMENT ANALYTICS

Web site with movies of regional radar data for all storms

Introduction

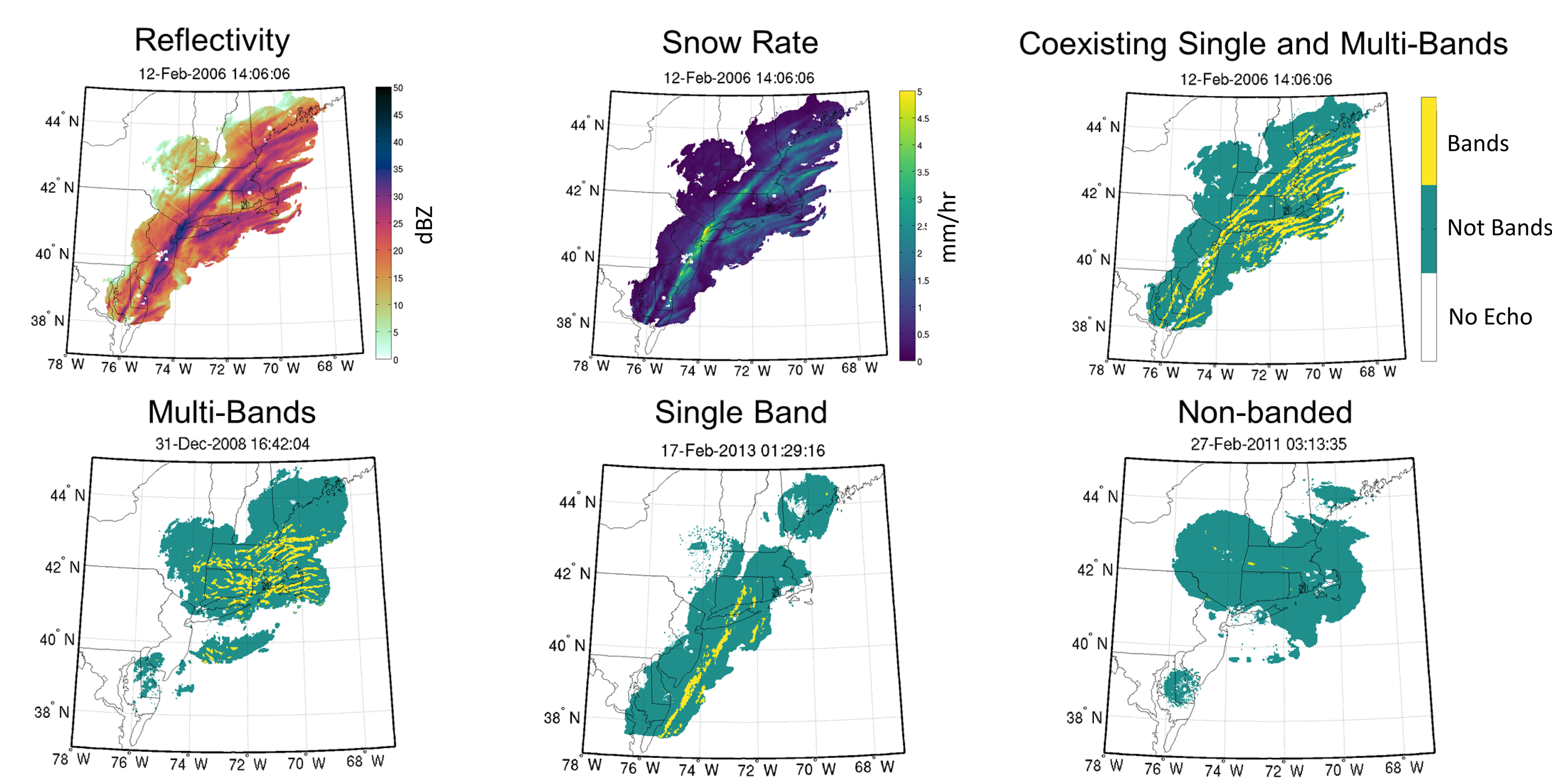
Quantitative precipitation forecasts for extratropical snow storms have long been a challenge. Locally intense snowfall within mesoscale snow bands can have large impacts on snow accumulation. Previous work has shown that longer, single bands > 250 km in length and 20 to 100 km wide are associated with frontal circulations. However, the physical mechanisms originating and maintaining sets of multi bands - two or more snow bands < 250 km length and 10 to 50 km wide - are less clear. This study uses operational WSR-88D radar data along the U.S. eastern seaboard from Delaware to Maine to examine the joint microphysical and dynamical signatures associated with mesoscale snow bands.

Data Sets and Storm Classification



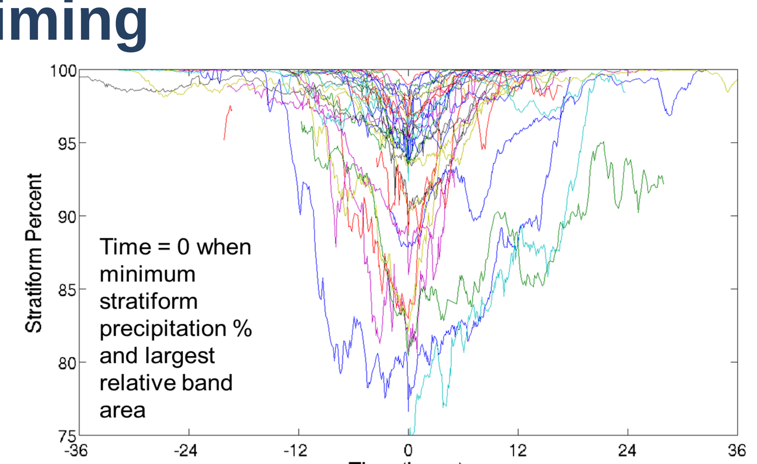
We identified 108 snow storms during the cold season (October – March) from 1996 – 2016 from ASOS snow measurements. Data from six radars (KOKX, KBOX, KDIX, KENX, KGYS, KDOX) are combined to make regional maps every 6-10 minutes of radar reflectivity and estimated liquid equivalent snow rate (Sn in mm/hr, Rasmussen et al. 2003) during each storm. We have approximately 3,000 hours of data from the KOKX radar alone.

Mesoscale snow bands are identified using a variation of a convective/stratiform precipitation identification algorithm that utilizes a local peakedness criterion to identify areas of local precipitation enhancement. Following Ganetis et al. (2015), snow storms were classified based on the geometry of snow band structures identified throughout the storm's duration. The four categories are: single band, coexisting single and multi-bands, multi-band, and non-banded. Snow storms with only multi-bands were found to be the most common followed by snow storms with coexisting single and multi-bands, snow storms with no band features, and snow storms with only single bands.



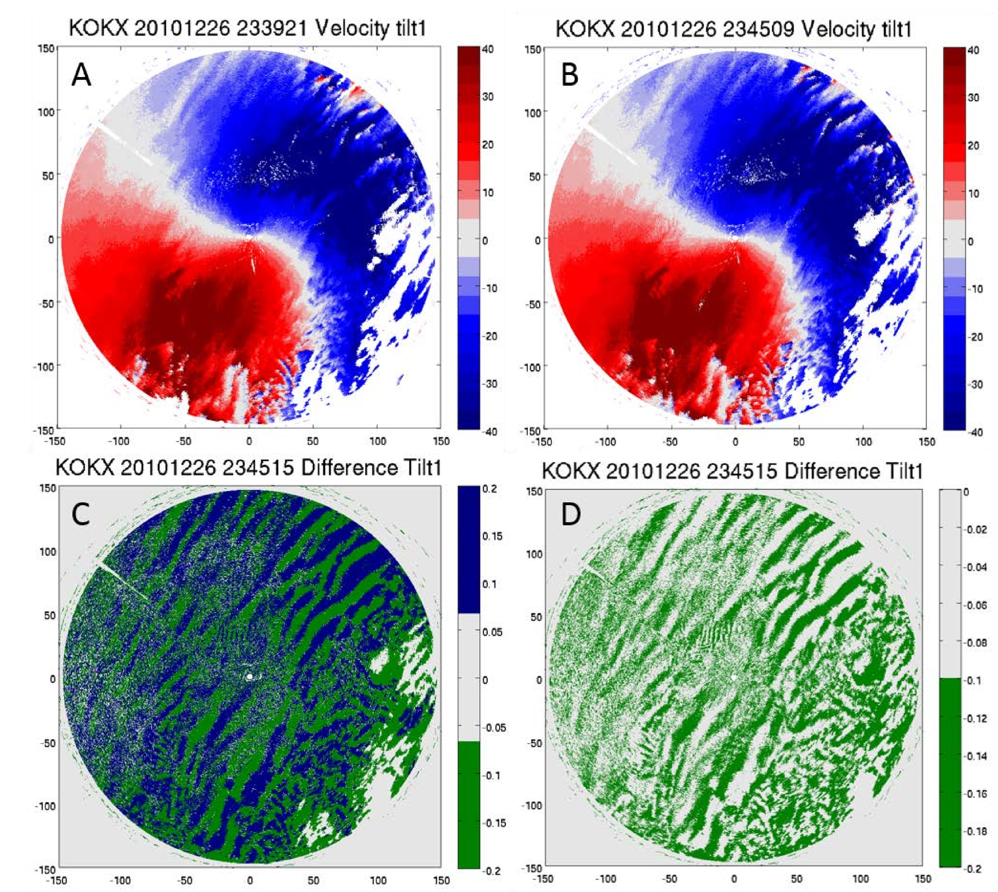
Snow Band Timing

Within snow storms, weaker, more stratiform precipitation tends to form first during the developing stage of the cyclone. Snow bands more frequently occur during the mature stage of the cyclone after the warm conveyor belt splits and a portion of warm, moist air wraps around the low.

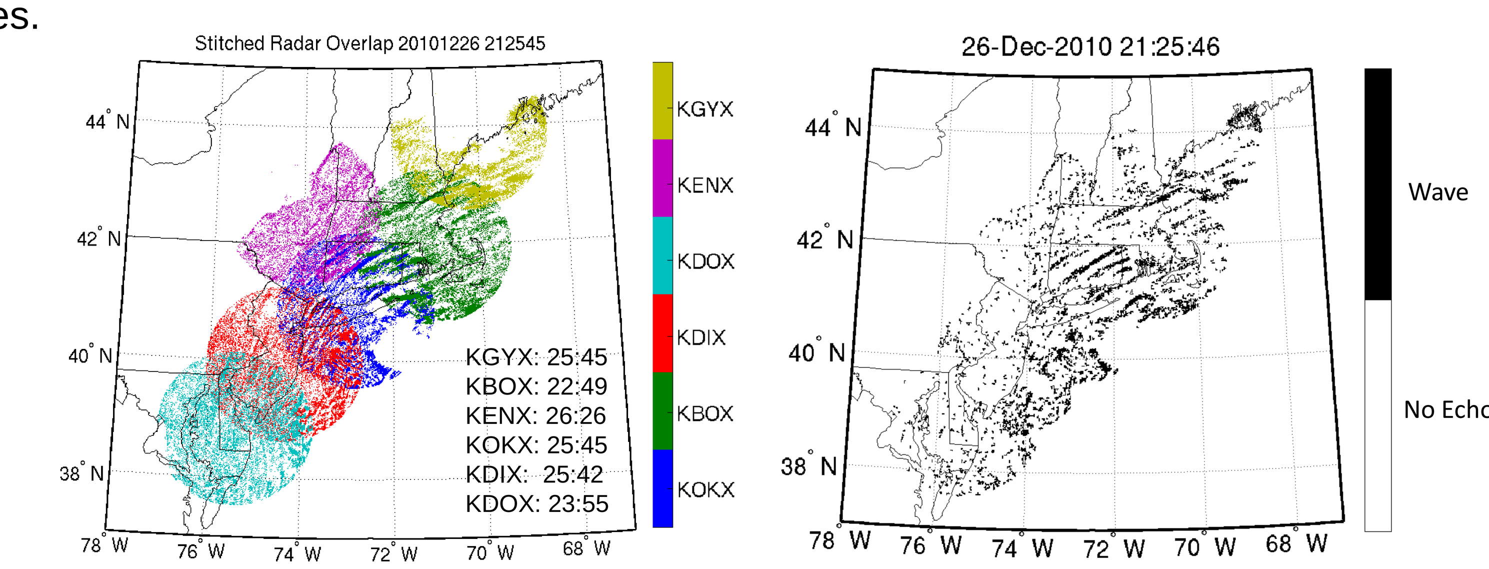


Velocity Band Detection Method

Velocity bands within the Doppler radial velocity fields were identified by subtracting two consecutive fields (A & B) yielding a temporal difference field (C). To obtain spatial separation between the velocity bands, only the negative portion of the temporal difference field is used (D).

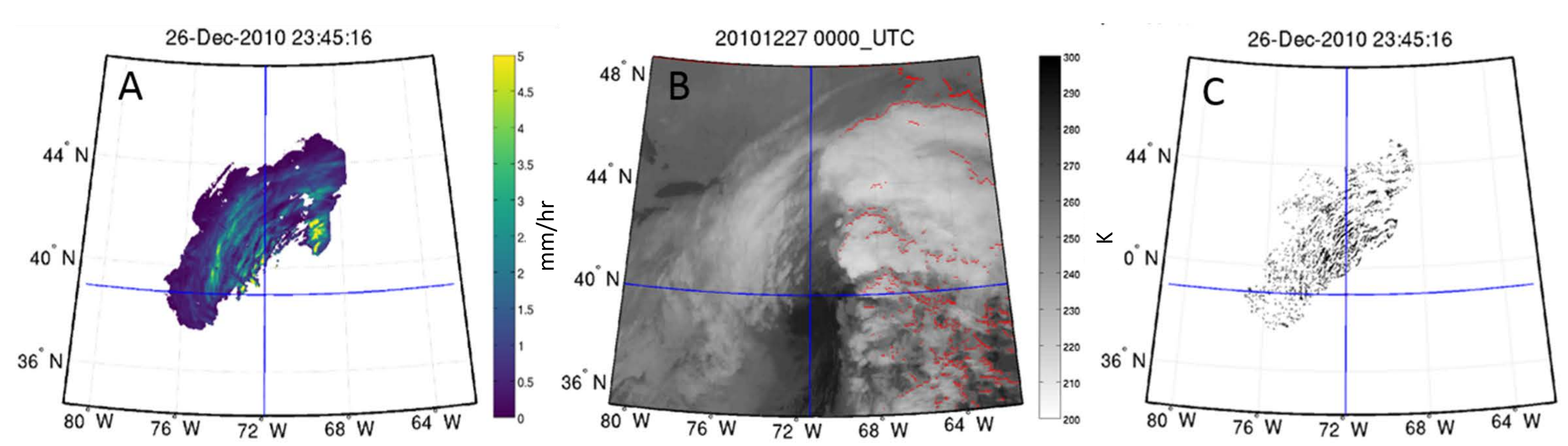


Velocity bands identified in multiple radars were combined to make regional maps. The motion of the bands relative to the low level flow suggests that these velocity features may be gravity waves.



Cyclone-centric Framework

Cyclone low pressure center tracks from 3 hourly NARR output were used to place radar and satellite data from each storm into a Lagrangian coordinate system centered on the low. Using the Lagrangian framework, we are able to see the movement of the bands relative to the cyclone low and determine in which quadrants the snow bands and velocity bands occurred.

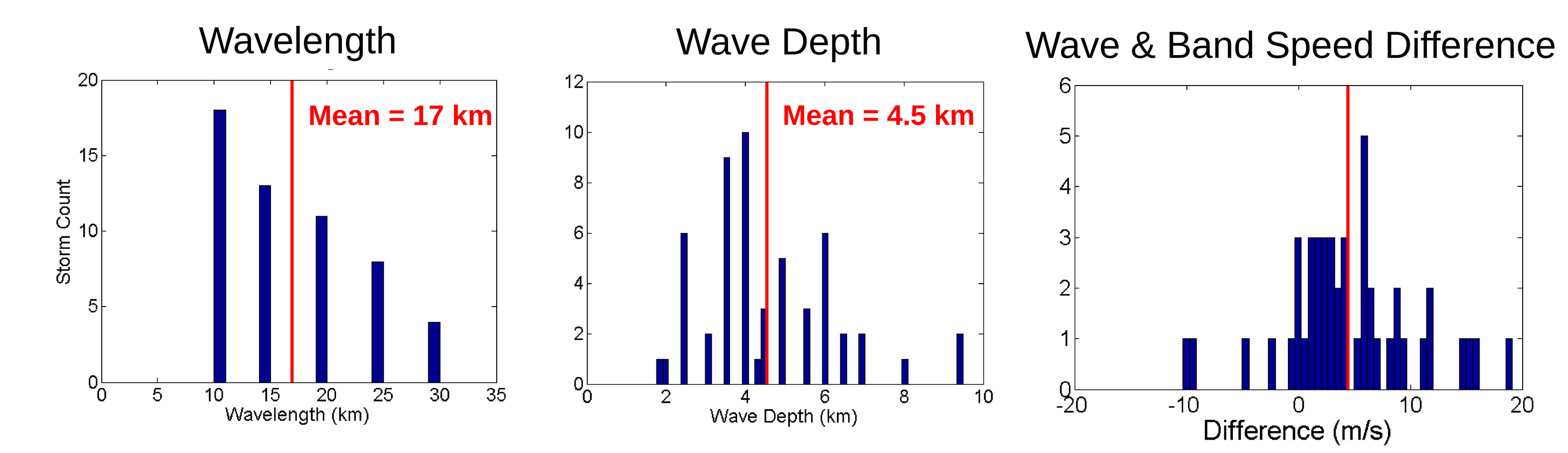


Both snow bands and velocity bands were most frequently found in the northwest quadrant followed by the northeast quadrant. Snow and velocity bands often moved northwest, radially outward from the vicinity of the low and perpendicular to the typical low pressure center's motion toward the northeast. In some storms, the snow bands were relatively stationary respective to the low and moved parallel to storm motion.

Associations Between Velocity Waves and Snow Bands

Velocity bands tend to be associated with multi-bands. Snow storms without multi-bands rarely had velocity bands associated with them. Velocity and snow bands were found to move in similar directions in the lower atmosphere (0 – 2 km). Within the same storm, velocity bands usually moved faster than snow bands indicating these velocity features are not locked to the snow bands.

	All Snow Storms			Parallel Movement to Cyclone Center		Perpendicular Movement to Cyclone Center	
Storm Classification	Number of Storms with Waves	Number of Storms without waves	Total	Number of Storms with Waves	Number of Storms without waves	Number of Storms with Waves	Number of Storms without waves
Multi-Band	25	14	39	6	3	19	11
Single and Multi-Band	25	7	32	5	2	20	5
Single Band	1	6	7	1	4	0	2
Non-Banded	3	27	30	NA	NA	NA	NA
Total	54	54	108	12	9	39	18



The difference between snow band and waves was calculated for times when the difference in their direction of movement was less than 45 degrees. A positive speed difference represents a time when waves are moving faster than snow bands.

Conclusions and Implications

- No clear, sustained convergence signatures were found to be locked with multi-bands across 108 snow storms. Multi-bands do not consist of persistent, active updrafts in contrast to convective-scale generating cells. With or without snow bands present, generating cells are nearly ubiquitous in the upper levels of snow storm radar echo.
- We discovered moving bands of velocity change within snowstorms. The bands are consistent across adjacent radar domains and appear to originate outside of the precipitation echo. These features move perpendicular to the mean low level flow in a manner similar to gravity waves.
- 70% of the occurrences of multi-bands (with or without coexisting single bands) are associated with velocity waves. The velocity waves were found to generally move faster (average of 4.5 m/s faster) than the snow bands. The frequent co-occurrence and similar orientations of the velocity waves and multi-band snow bands suggest a connection.
- Future work: Determine the mechanism and origination of the velocity waves and their potential roles in snow band initiation and maintenance. Determine if radially moving snow bands and parallel moving snow bands have similar physical mechanisms.

References: Ganetis et al. (2015): Simulations of Multi-bands in the Comma Head of Northeast U.S. Winter Storms. Abstracts, 16th Conference on Mesoscale Processes, 3-6 August 2015, Boston, MA.
Rasmussen et al. (2003): Snow nowcasting using real-time correlation of radar reflectivity with snow gauge accumulation. JAMC, 42, 20-36.

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