Environmental Conditions Associated with Different Snow Band Structures within Northeast U.S. Winter Storms

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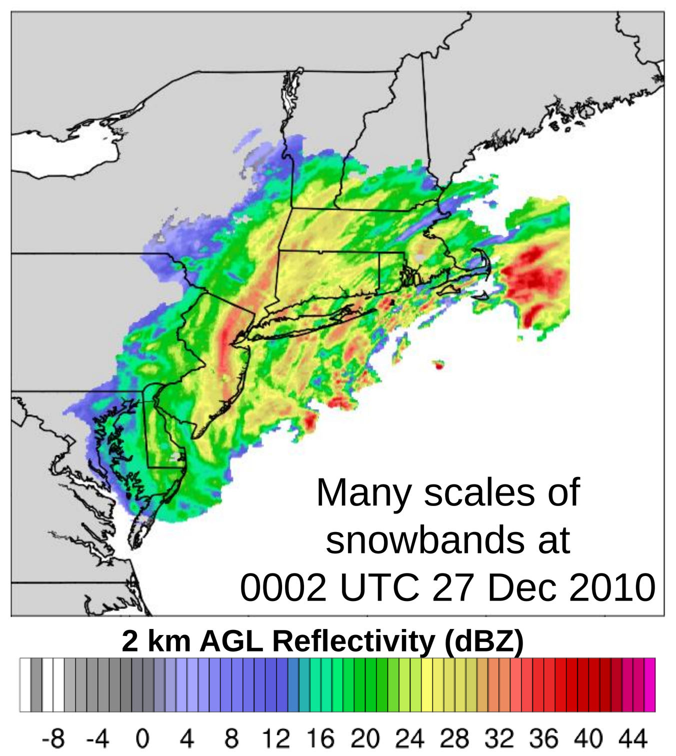
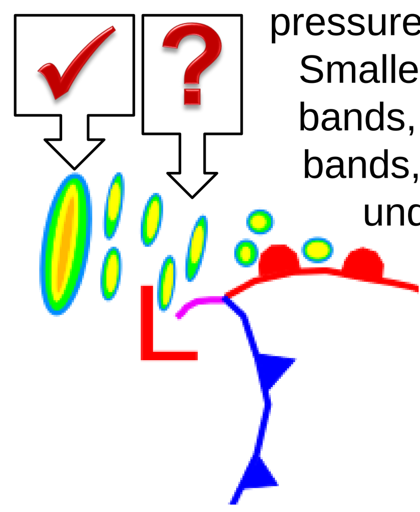
1. Introduction

For snowbands, does one mechanism *really* fit all?



Most snowstorms exhibit a large range of sizes of bands. Previous research focused on large, single bands that typically form to the NW of a mature surface low pressure system. Smaller parallel bands, or multi-bands, are less understood.



This region NW of a surface low contains favorable environmental ingredients for bands including:

- sufficient moisture present in the comma head
- forcing for lift via frontogenetical circulations
- weak moist symmetric stability to enhance upward motions

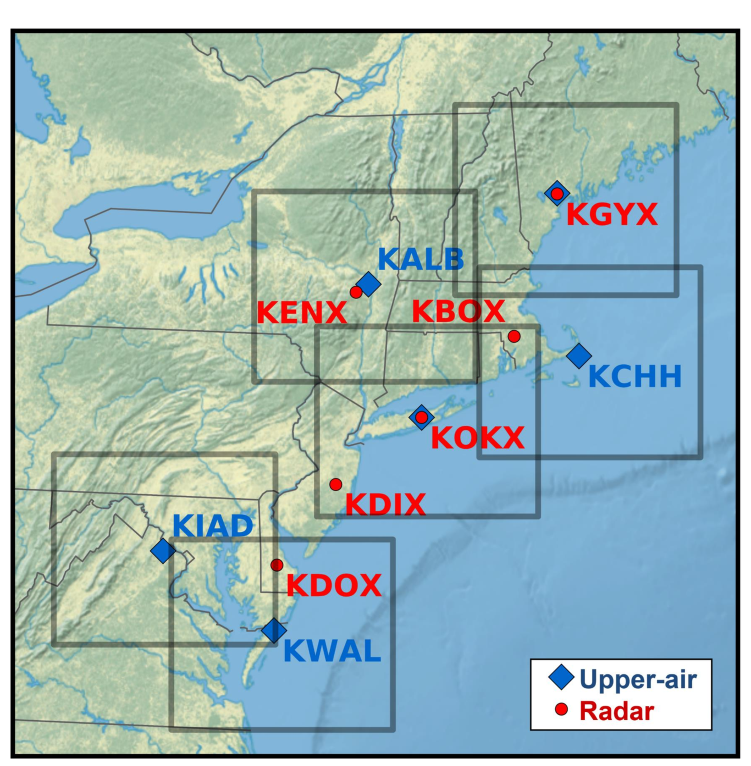
It is hypothesized that large single snowbands are occurring due to these well-known processes.

Storms exhibit many different scales of snowbands often simultaneously.

- What are the distributions of snowband structures observed in Northeast U.S. winter storms?
- What are the environmental ingredients for diverse banding?

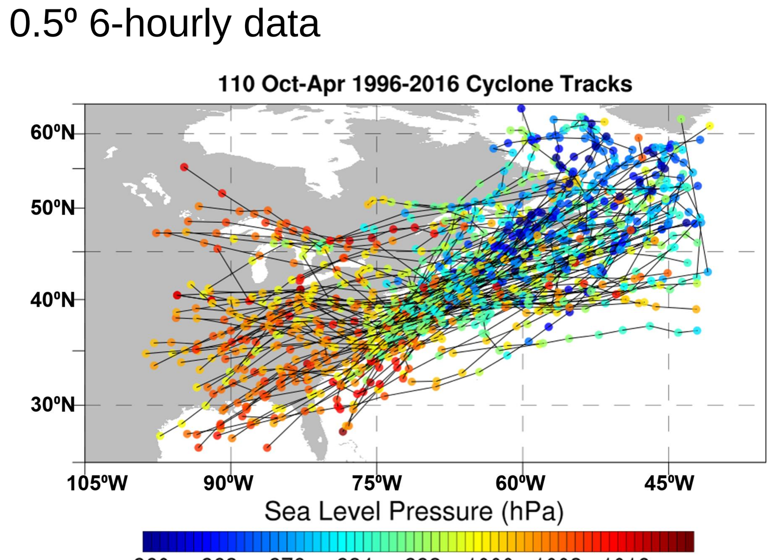
2. Case Selection & Datasets

110 cool season (Oct – Apr) extratropical cyclones that produced ≥ 0.75 in liquid equivalent snowfall in NYC metropolitan area were identified in 19 seasons from 1996 – 2016.



Datasets used in this study included:

- 2-km by 2-km composited 2-km AGL radar reflectivity from 6 radar sites (see WAF Poster #133)
- Upper-air profiles
- Climate Forecast System Reanalysis (CFSR) and Climate Forecast System v. 2 (CFSv2) 0.5º x 0.5º 6-hourly data
  - cyclone tracks via Hodge's cyclone tracker using sea level pressure
  - vertical profiles at upper-air sites



3. Identification & Classification of Bands

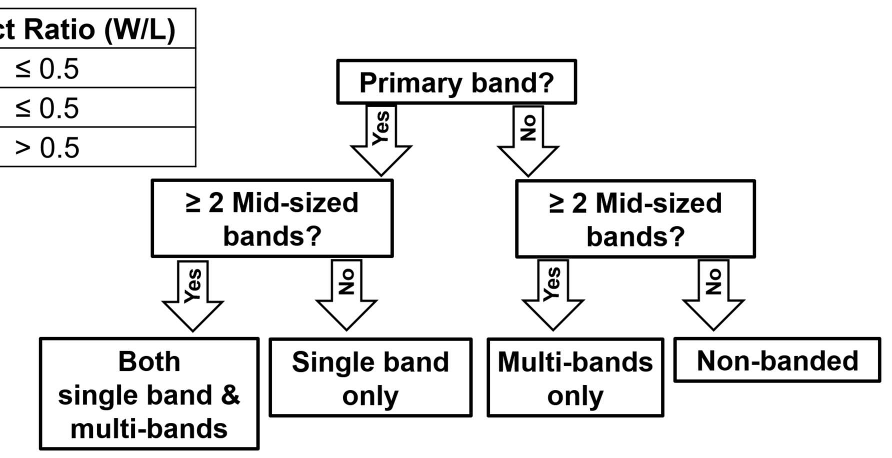
For each storm, during peak banding precipitation activity (±1 h from time of sounding launch), the closest sounding domain was used to create a 2-h subset of radar data that was used to determine the classification of banding.

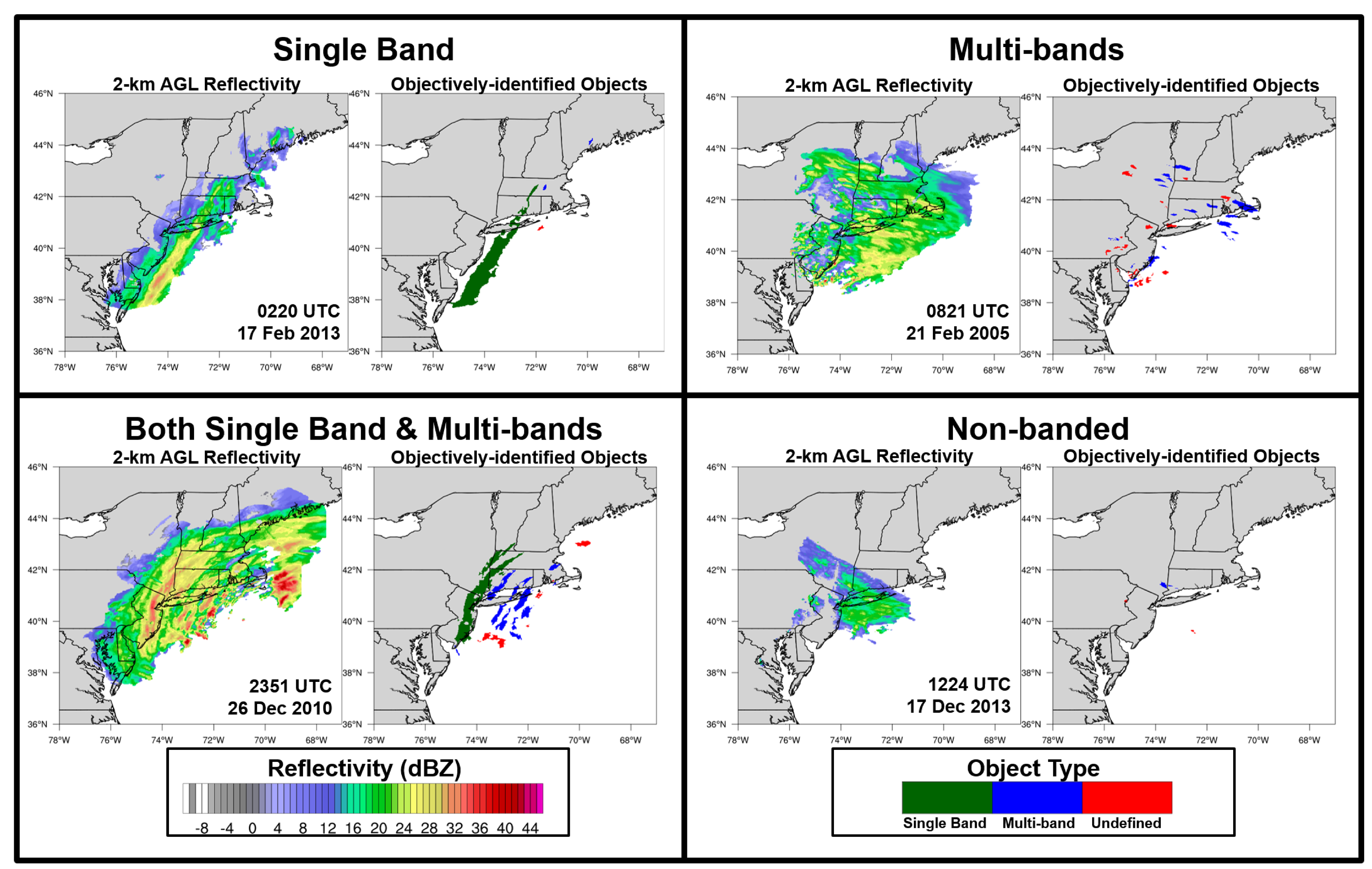
Snowbands were objectively identified within the composite reflectivity in each storm using the Method for Object-Based Diagnostic Evaluation (MODE) tool within the Model Evaluation Tools (MET) developed at the Developmental Testbed Center (DTC) at the Research Applications Laboratory (RAL) at the National Center for Atmospheric Research (NCAR). Objects were identified using a raw threshold of the upper-sextile of each ~5-min composite time within a storm. Object attributes including length and width were used to objectively classify bands by the criteria in the table below.

	Length (L)	Width (W)	Aspect Ratio (W/L)
Primary Band	≥ 200 km	20 ≤ W ≤ 100 km	≤ 0.5
Mid-sized Band	< 200 km	10 ≤ W ≤ 50 km	≤ 0.5
Undefined/Cell	10 ≤ L ≤ 100 km	10 ≤ W ≤ 100 km	> 0.5

Each case was then subjectively classified into

- SINGLE – primary band only
- MULTI – ≥ 2 mid-sized bands only
- BOTH – both primary and ≥ 2 mid-sized bands
- NONE – non-banded





The counts of each case classification is as follows:

- SINGLE – 2
- MULTI – 12
- BOTH – 59
- NONE – 37

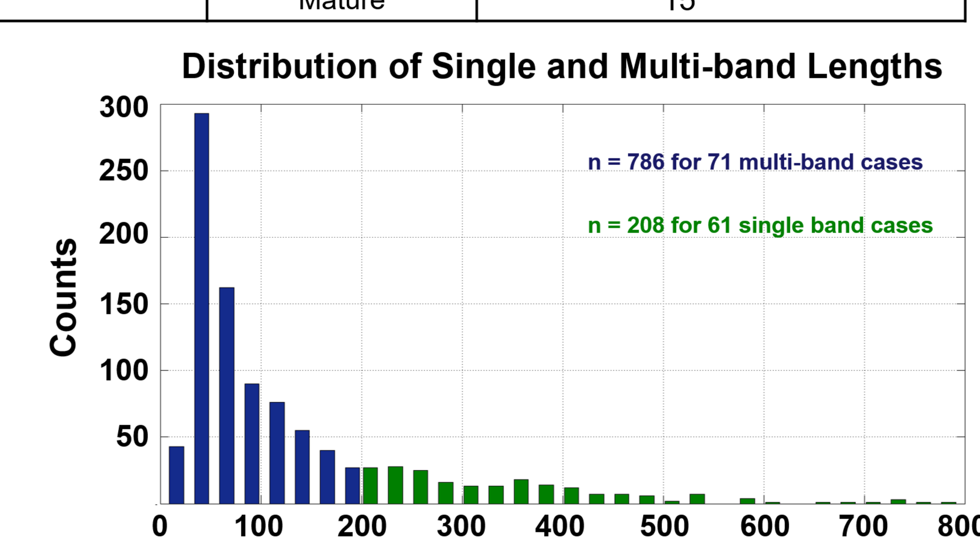
Classification	Cyclone Stage	Number of Storms Perpendicular (Parallel) Movement to Cyclone Center
Single Band	Developing	0 (0)
	Mature	0 (2)
Multi-bands	Developing	2 (4)
	Mature	4 (2)
Both Single & Multi-bands	Developing	15 (11)
	Mature	28 (5)
Non-banded	Developing	22
	Mature	15

Storms were also analyzed to compare 56 stronger, mature storms with 54 weaker, developing storms with the following classifications favored:

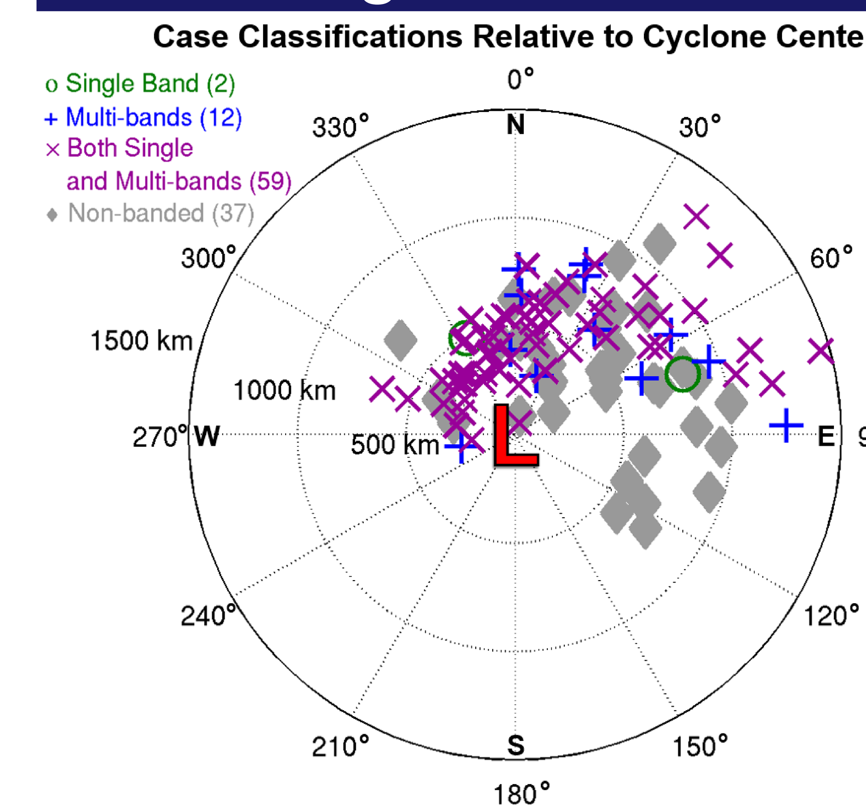
- Developing storms: NONE (22) & BOTH (26)
- Mature storms: BOTH (33)

The objective band attributes were used to quantify the average lengths (L) of each category of bands from hourly data.

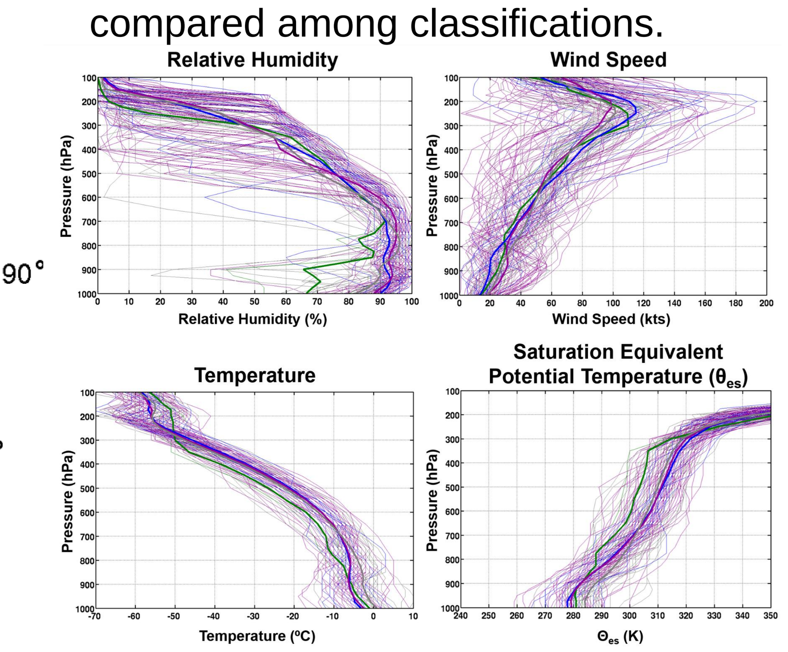
- Primary bands within SINGLE and BOTH cases: L = 345 km
- Mid-sized bands within MULTI and BOTH cases: L = 72 km



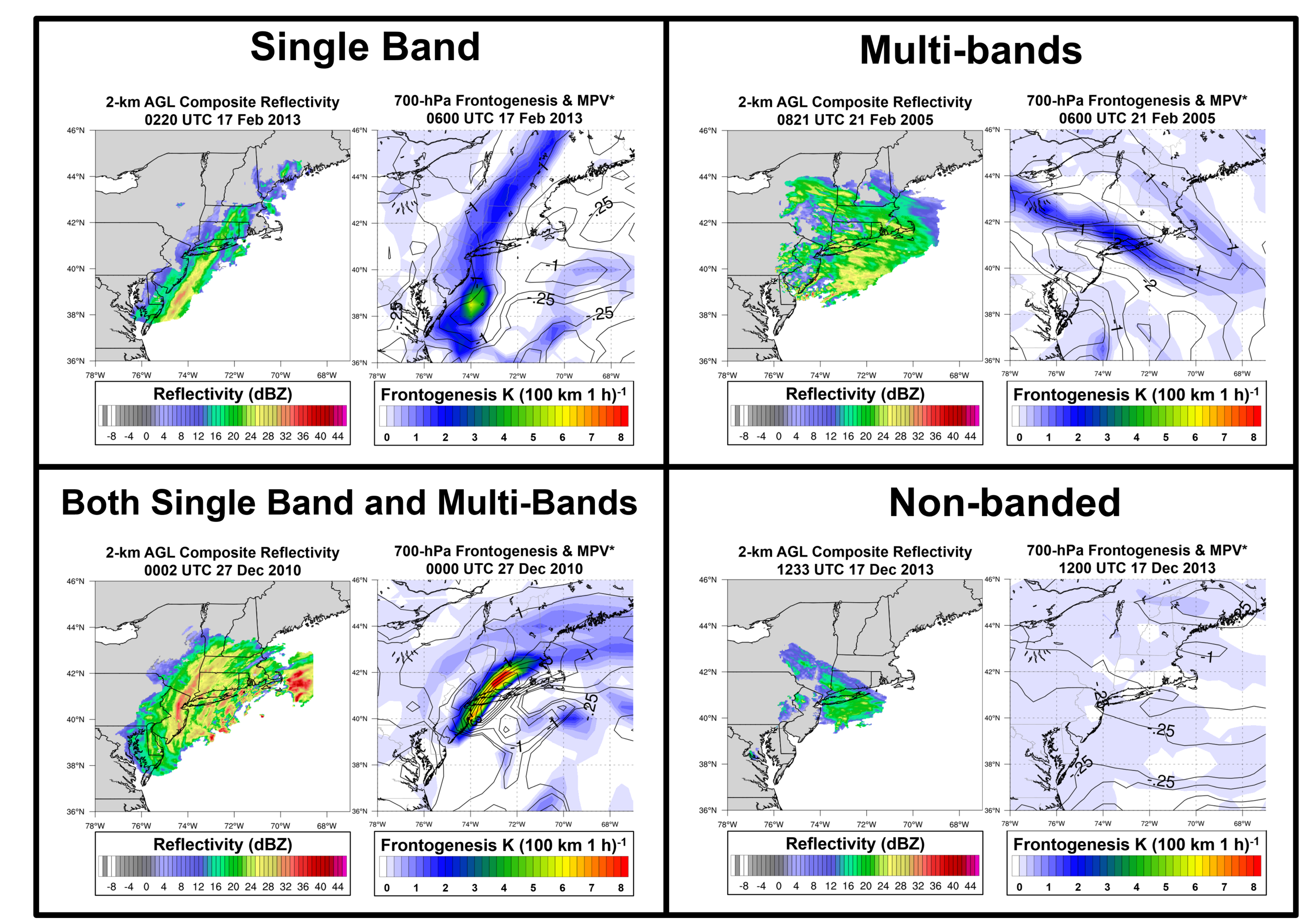
4. Banding Environment

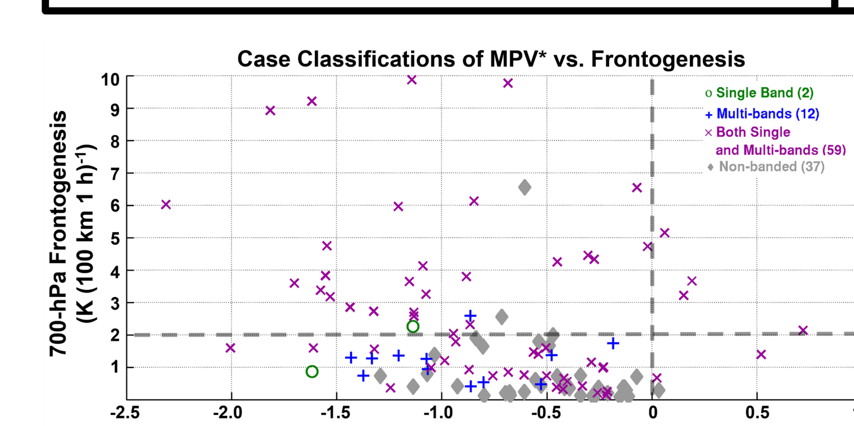


Classified upper-air locations were plotted relative to the cyclone center and one vertical profile per case was compared among classifications.



Specific banding ingredients, i.e. mid-level (700-hPa) frontogenesis and saturation equivalent potential vorticity (MPV*), were compared for each classification.





For all 110 cases:

- MULTI and NONE cases were associated with weak frontogenesis.
- BOTH cases were associated with strong frontogenesis likely given the proximity to the single band.

5. Summary & Future Work

- Multi-bands, i.e. multiple snowbands with lengths ≤ 200 km, occurred in 71 out of 110 Northeast U.S. winter storms and constitute the majority of enhanced snowfall area.
- Multi-bands occurred within 300 km of a primary band in 59 out of 110 storms, while single bands, or primary bands without the presence of multi-bands, only occurred in 2 storms.
- Primary bands in the presence of multi-bands were forced via frontogenetical ascent but multi-bands were removed from the frontogenesis maximum.
- Multi-band forcing mechanisms are the subject of ongoing work.

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Recommended Observations:
More frequent thermodynamic profiles from more locations are needed to provide insight into the complex banding environments within winter storms.

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