Snow Multi-Band Development in an Idealized Baroclinic Wave Model

Nicholas Leonardo and Brian A. Colle
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

1. Introduction and Objectives

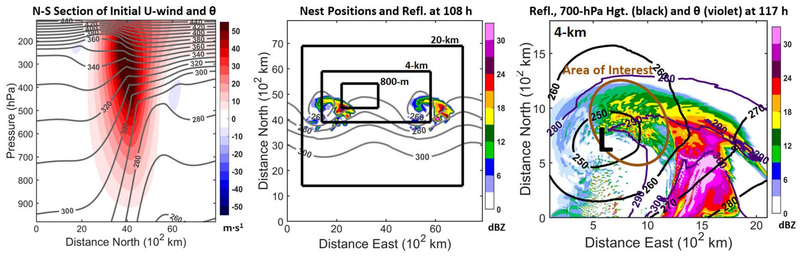
The comma-head region of winter storms often has one or more precipitation bands. While single-bands have been widely studied, multi-bands remain less understood.

Idealized simulations are used to address the following:

1. What mechanisms are responsible for the genesis and longevity of multi-bands?
2. How sensitive is the development of multi-bands to vertical stability, baroclinicity, and horizontal shear?

2. Data and Methods

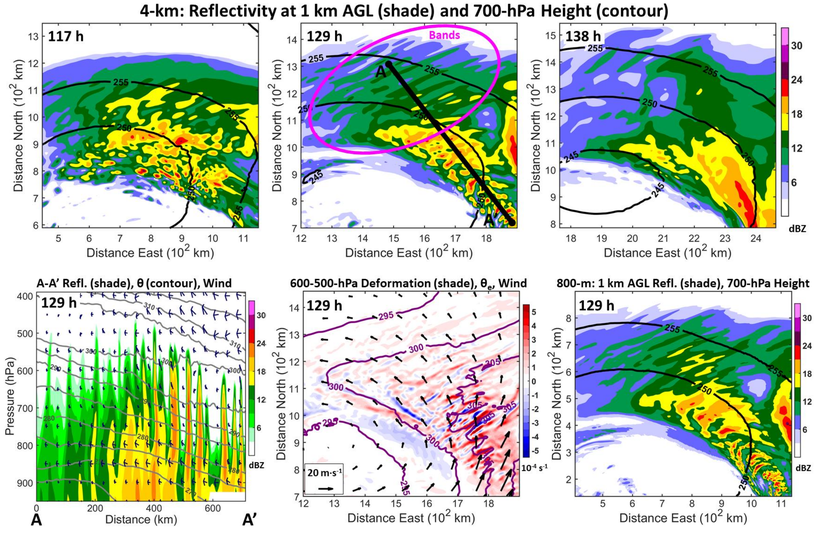
- WRF (v3.4.1) idealized baroclinic wave at 100-km grid spacing, adding 20-km, 4-km, and 800-m nests at 108 h.
- Ran additional tests modifying the initial conditions:
  1. Increase/decrease the lapse rate by 0.5-1 K·km^{-1}.
  2. Increase/decrease the θ gradient by 10-30%.
  3. Add 1×10^{-4} s^{-1} (anti)cyclonic horizontal shear.



3. Results

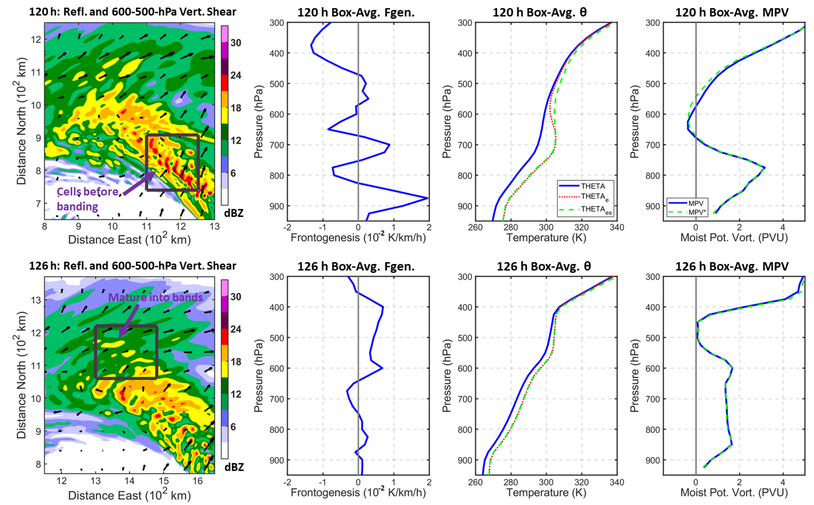
Control Run

4-km: Reflectivity at 1 km AGL (shade) and 700-hPa Height (contour)

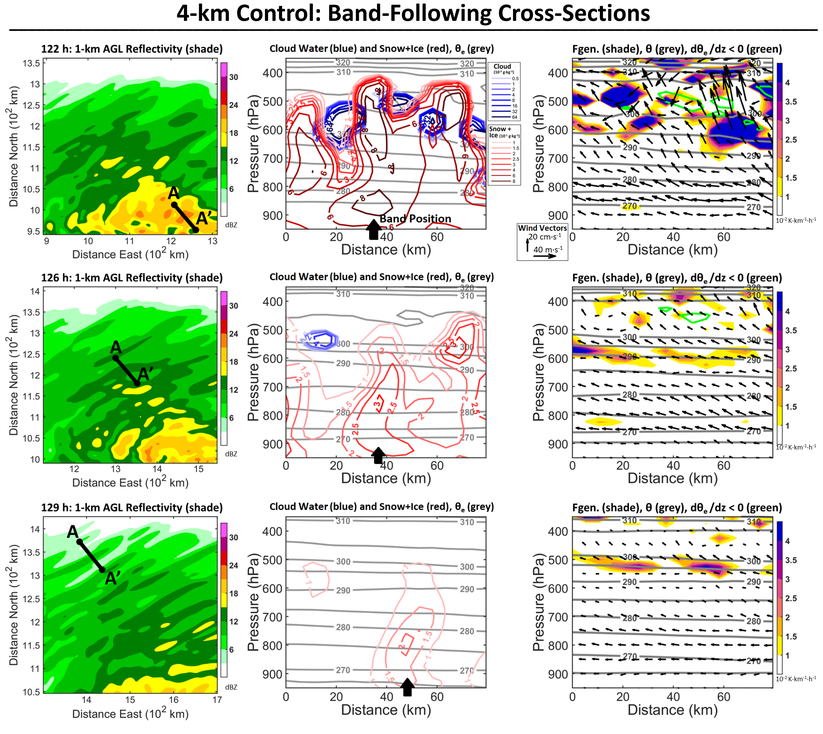


3. Results (continued)

4-km Control: Profiles During Band Development and Maturity



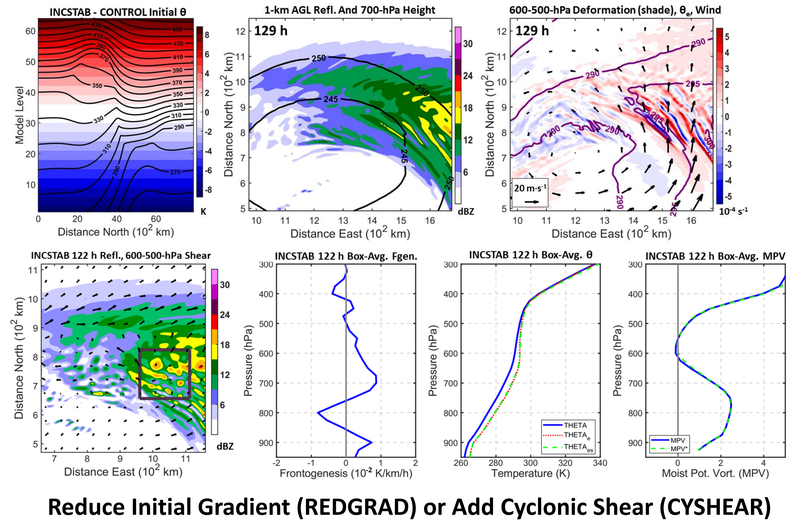
4-km Control: Band-Following Cross-Sections



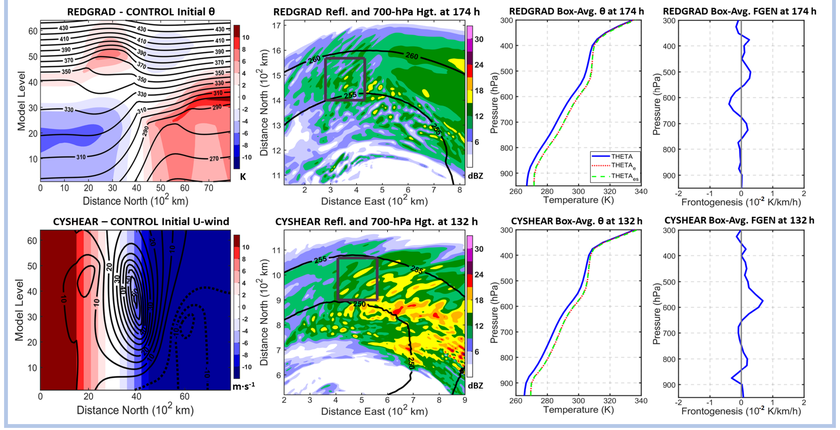
Animations are given by the QR codes to the right. The left code has reflectivity (shaded), MSLP, and the low position. The right shows cross-sections of reflectivity (shaded), θ (contour), and wind vectors.

3. Results (continued)

Increase Initial Stability (INCSTAB)



Reduce Initial Gradient (REDGRAD) or Add Cyclonic Shear (CYSHEAR)



4. Conclusions

- Bands evolve from cells that grew in 700-600-hPa conditional instability and ~900-hPa frontogenesis east of the low.
- The cell activity deepens to the north and organizes into bands in a deformation mean flow at 600-500 hPa. The bands mature within the comma head as the mid-level frontogenetical forcing weakens and ambient instability decreases.
- Thus, instantaneous diagnosis of the forcing and instability at band maturity may miss an important prior stage of growth to the south.
- Increasing the initial stability by ~10% reduces the number of multi-bands, suggesting large sensitivity to initial conditions within models.
- Decreasing the temperature gradient or increasing the cyclonic shear delays the low's development, but multi-bands eventually form in a similar area.