Dual-polarimetric Doppler on Wheels Observations of Long Lake-Axis-Parallel Lake-effect Snow Storms over Lake Ontario

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Introduction

• Most observational studies of the evolution of lake-effect snowstorms have focused on the relatively shallow (generally 1-2 km deep) convective roll-type events over the Western Great Lakes (e.g., Kristovich et al. 2003). This NSF-EAGER grant used the Center for Severe Weather Research (CSWR) Doppler on Wheels (DOW) radar to collect high resolution data on long lake-axis-parallel (LLAP) lake-effect storms over Lake Ontario during the 2010-11 winter.

• Objectives: to demonstrate that the DOW radar can adequately sample lake-effect snow storms in upstate New York during the winter and to show that high resolution dual-polarimetric observations made by the DOW can give new insights into the structure and microphysics of LLAP storms.

Data and Methods

• Platforms: CSWR DOW (Fig. 1), probe truck collecting standard in-situ measurements, three tornado pods, mobile Vaisala, Inc. rawinsonde system, detailed surface observations by ten undergraduate research assistants.

- Sampled 7 events over two months (15 December 2010 – 10 February 2011).
- Steiger and Frame made go/no-go call for deployment ~48 hours before an event to bring in CSWR staff (Wurman, Kosiba, & Walker) from Boulder, CO and mobilize students.
- Did mostly sector scans (< 180°) from beach positions.
- Used SOLO-II software to analyze and edit DOW data.
- Vortex detection done manually using the following criteria: minimum radial velocity difference between couplet cores of 5 m s^{-1} (used contour interval of 1 m s^{-1}), minimum duration 5 minutes, maximum distance traveled between 3 min. sector scans of 3 km to be called same vortex.

Fig. 1. DOW during deployment on 4 January 2011 in Fairhaven, NY. Lake Ontario and a lake-effect storm are shown in the background. Photo courtesy J. Frame.

Results

• Figures 2 and 3 show examples of the many circulations observed by the DOW. The smaller vortices in Fig. 2 originated along a shear line (see radial velocity) while the larger cyclone in Fig. 3 shifted the entire lake-effect band southward by ~10 km after its passage.

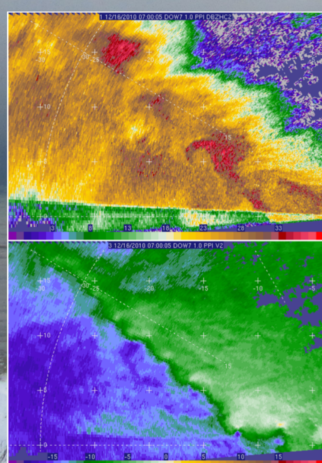

Fig. 2. DOW reflectivity and radial velocity (m s^{-1}) at 070005 UTC 16 December 2010.

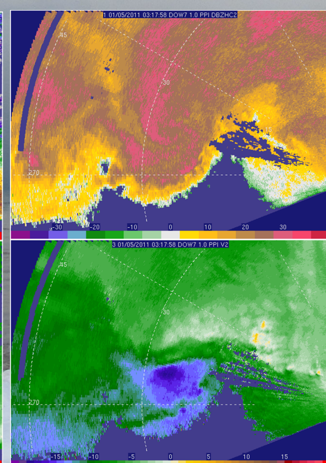

Fig. 3. Same as Fig. 2 but for 031758 UTC 5 January 2011.

Results cont.

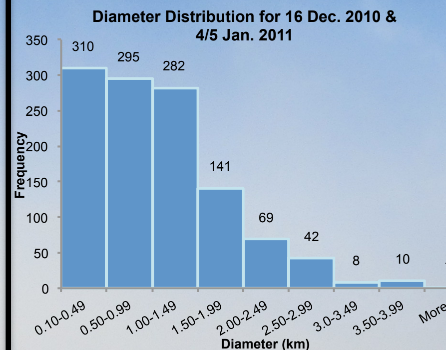

Fig. 4. Distribution of diameter of each circulation detected (includes all observations during the lifetime of a vortex).

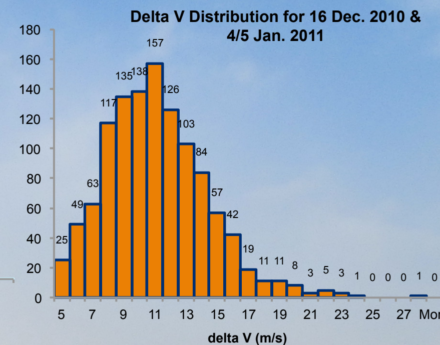

Fig. 5. Same as Fig. 4, except for the radial velocity difference between couplet cores in a vortex.

• Ninety-five and 43 vortices were manually detected during the approximately 7 hours of observation time during each of the 16 December 2010 and 4-5 January 2011 cases, respectively. The distributions in figures 4 and 5 show they were misocyclones with delta-V's peaking near 11 m s^{-1}. Diameter measurements were based on distance between couplet cores. Key ?: how correct measurements for range?

Some other interesting features:

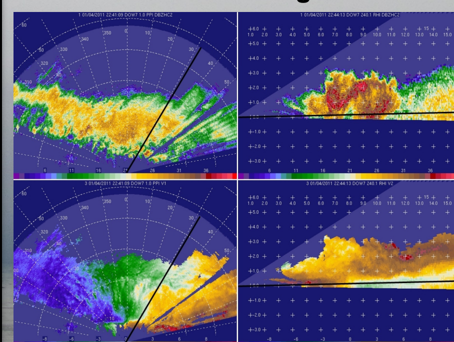

Fig. 6. PPIs (left) and RHIs (right) of radar reflectivity (top) and radial velocity (bottom) showing a bounded weak echo region (BWER) in an area of strong low-level convergence near 8 km range on 4 January 2011. Black lines show locations of RHIs on the PPI imagery and of PPIs on the RHI imagery.

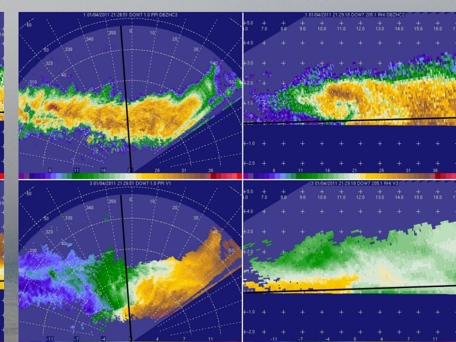

Fig. 7. Same as Fig. 6, except for showing a horizontal vortex on the southern edge of a lake-effect snow band on 4 January 2011.

Discussion and Conclusions

• Misocyclones were associated with elongated shear zones (see Fig. 2) and outflow boundaries (see animation on laptop) suggesting horizontal shear instability (HSI) and stretching played an important role in their formation. The thermal low over Lake Ontario along with the typical synoptic-scale north to south pressure gradient during these events supports the development of strong horizontal shear on the south side of the lake.

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References available upon request