Utilizing a Semi-idealized Modeling Framework to Understand Meso- and Convective-scale Dynamics of Severe Lake-effect Snowstorms

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Introduction
A semi-idealized modeling framework is developed to explore what modulates long lake axis-parallel band location, shape, and intensity. Initial model experiments are used to investigate:

What caused cross-band asymmetry during the catastrophic Buffalo Snowstorm November 17-19, 2014?

Idealized lake-land geometry and simplified boundary conditions allow for controlled variations of the model state space.

Numerical Experiment Design:

- Model forced with idealization of upwind 122 11/18/14 RAP sounding
- Suite of experiments examine controlled perturbations to wind direction:
  - Winds rotated 10° CW from lake’s long axis [Control]
  - Winds parallel to lake’s long axis [Rot0]
  - Winds rotated 5° CW from lake’s long axis [Rot5]
  - Winds rotated 15° CW from lake’s long axis [Rot15]

Simulated Lake-effect Snow-band Morphology:

- Control simulation recreates observed band asymmetry, structure, and precipitation rates without lake shape asymmetry, terrain, and lake surface temperature variability, suggesting that these characteristics are not fundamental to band morphology

- By varying the geostrophic wind direction within a range of 15 degrees, it is possible to obtain snow-bands of opposite asymmetries

Conclusions

- Simplified model recreates observed lake-effect band structure
- Buoyancy gradients across lake-effect snow bands appear to drive outflow dynamics that cause observed cross-band asymmetry
- More-symmetric snow-bands, with smaller cross-band buoyancy gradients, may create more total snowfall

Future Work

- Test the robustness of results with different physics parameterizations, higher resolution, and more complex model configurations (i.e. added wind shear, terrain, lake-temperature variations).
- Develop a conceptual model for how boundary layer flow interacts with surface fluxes to create observed buoyancy gradients and snow-band structure
- Test hypothesis using data from the Ontario Winter Lake-effect Systems field campaign

Additonal references available upon request.