Influences of Orography and Coastal Geometry on Lake- and Sea-Effect Snowstorms

Improved understanding of the ways in which orography and coastal geometry affect lake- and sea-effect storms is crucial for snowfall prediction downstream of major bodies of water. This dissertation employs observational datasets and Weather Research and Forecasting (WRF) model simulations to examine orographic and coastal effects on lake- and sea-effect snowstorms in two regions. The first is Tug Hill, which lies east of Lake Ontario in eastern North America and observes some of the most intense snowstorms in the world. The second is the Ishikari Bay region of western Hokkaido Island, Japan, where sea-effect generated by the Sea of Japan produces prolific cool-season snowfall accumulations.

In the storms examined, orographic forcing and coastal geometry affected the distribution and intensity of lake- or sea-effect snowfall in both regions. Over Tug Hill, ascent along a land-breeze front that cut obliquely across the lake-effect system contributed to precipitation enhancement. Orographic ascent also produced an overall increase in the coverage and frequency of radar echoes, broadening the more strongly forced, long-lake-axis-parallel bands over Tug Hill and generating more consistent upland coverage during non-banded, broad coverage periods. Over Hokkaido Island, low-level orographic flow blocking combined with thermal and roughness gradients between water and land around Ishikari Bay produced convergence and ascent over Ishikari Bay and the Ishikari Plain, leading to a quasi-stationary region of enhancement that intensified transverse-mode bands as they progressed through the region. Similar synergistic contributions of orography and coastal geometry are likely found in other lake- and sea-effect regions, with implications for numerical weather prediction and operational forecasting.

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