Shape of Lake Ontario generates white-out blizzards, study shows

November 15 2017

Snowblowing tractors helped scientists in their snow research on New York's Tug Hill Plateau. Credit: University of Utah

A 6-foot-wide snow blower mounted on a tractor makes a lot of sense when you live on the Tug Hill Plateau. Tug Hill, in upstate New York, is one of the snowiest places in the Eastern U.S. and experiences some of the most intense snowstorms in the world. This largely rural region, just east of Lake Ontario, gets an average of 20 feet of snow a year.

Hence the tractor-mounted snow blower.

The region's massive snow totals are due to lake-effect snowstorms and, it turns out, to the shape of Lake Ontario.

Lake-effect storms begin when a cold mass of air moves over relatively warm water. The heat and moisture from the water destabilize the air mass and cause intense, long-lasting storms. Lake-effect snow is common in the Great Lakes region and in areas downwind of large bodies of water, including the Great Salt Lake.

Researchers, including the University of Utah's Jim Steenburgh and University of Wyoming's Bart Geerts, now report that these intense snowstorms are fueled by air circulation driven by the heat released by the lake, and that the shoreline geography of Lake Ontario affects the formation and location of this circulation. The result? Very heavy snowfall.

The findings, published in three papers, show how the shorelines of lakes may help forecasters determine the impacts of lake-effect storms.

"Lake Ontario's east-west orientation allows intense bands of snow to form," said Ed Bensman, a program director in the National Science Foundation's (NSF) Division of Atmospheric and Geospace Sciences, which funded the research. "This study found that the shape of the lake's shoreline can have an important influence on the low-level winds that lead to bands of snow for long periods of time—and to heavy snow totals. The research team analyzed the strength of these snow bands, and their formation and persistence. Snow bands were often active for several days."

Why does New York's Tug Hill Plateau get so much snow? Scientists faced blizzards to find out. Credit: University of Utah

Lake-effect

When land breezes move offshore from places where the coastline bulges out into a lake, unstable air masses form and drive a narrow band of moisture that dumps its moisture as snow on a strip of land downwind of the lake.

Steenburgh said it's long been known that breezes coming from the shore onto a lake help initiate and direct the formation of snow bands. Steenburgh and Geerts, and colleagues from universities in Illinois, Pennsylvania and upstate New York, traveled to Lake Ontario as part of an NSF-funded project called Ontario Winter Lake-effect Systems (OWLeS). The scientists investigated several questions about lake-effect systems:

- What environmental factors have the greatest influence on the amount of snowfall and location of snowbands over and near Lake Ontario?

- How does the interplay between wind and clouds produce long-lived snowbands far downstream of open water?
- How does the local terrain influence the strength and longevity of these systems?

To find out, Geerts' team flew a Wyoming King Air research plane through winter storms, and Steenburgh's group set up weather monitoring equipment, including profiling radars and snow-measurement stations, to monitor the arrival of lake-effect storms near Tug Hill.

The researchers witnessed the region's intense snowfall, including one storm that dropped 40 inches in 24 hours. Snowfall rates often exceeded 4 inches per hour. "That's an amazing rate," Steenburgh said. "It's just an explosion of snow."

The role of the bulge

Wyoming Cloud Radar aboard the King Air plane detected an intense secondary air circulation across the main snow band. "This circulation had a narrow updraft, creating and lifting snow like a fountain in a narrow strip that dumped heavy snow where it made landfall," Geerts said. Using a weather model, Steenburgh's team found that this circulation's origin was a land breeze generated by the lake's uneven shoreline geography.

The start of a typical day of field work on the Tug Hill Plateau. Credit: University of Utah

In some cases, another land breeze generated a second snow band that merged with the first. "The intense secondary circulation, with updrafts up to 20 miles per hour, had never been observed before," Geerts said.

One particular shoreline feature played a large role: a gentle, broad bulge along Lake Ontario's southern shore that extends from about Niagara Falls in the west to Rochester, New York, in the east.

"This bulge was important in determining where the lake-effect snow bands developed," Steenburgh said. "A bulge near Oswego, New York, on the southeast shore, also contributed to an increase in the precipitation downstream of Lake Ontario over Tug Hill."

Steenburgh says the residents of the region take the heavy snowfall in stride. Roads are kept plowed, and the team found that on many days, the biggest challenge was just getting out of the driveway of the house they stayed in. Once the tractor-snow blower was fired up, however, the researchers had a clear shot.

"We're a bunch of snow geeks," Steenburgh said. "We love to see it snowing like that. It's really pretty incredible. And our friends on Tug Hill made sure we could do our research."

Better forecasts

Incorporating considerations of shoreline geography into weather forecast models can help predict which communities might be most affected by snowstorms, Steenburgh said. Understanding the effect of breezes that arise from the shore's shape is the key.

"If we want to pinpoint where the lake-effect is going to be, we're going to have to do a very good job of simulating what's happening along these coastal areas," he said.

Provided by National Science Foundation