Lake-Effect Research At SUNY Oswego And How We Use it to Prepare Others

Presented by: Matthew Seymour, Nicholas Rodick, and Dr. Scott Steiger

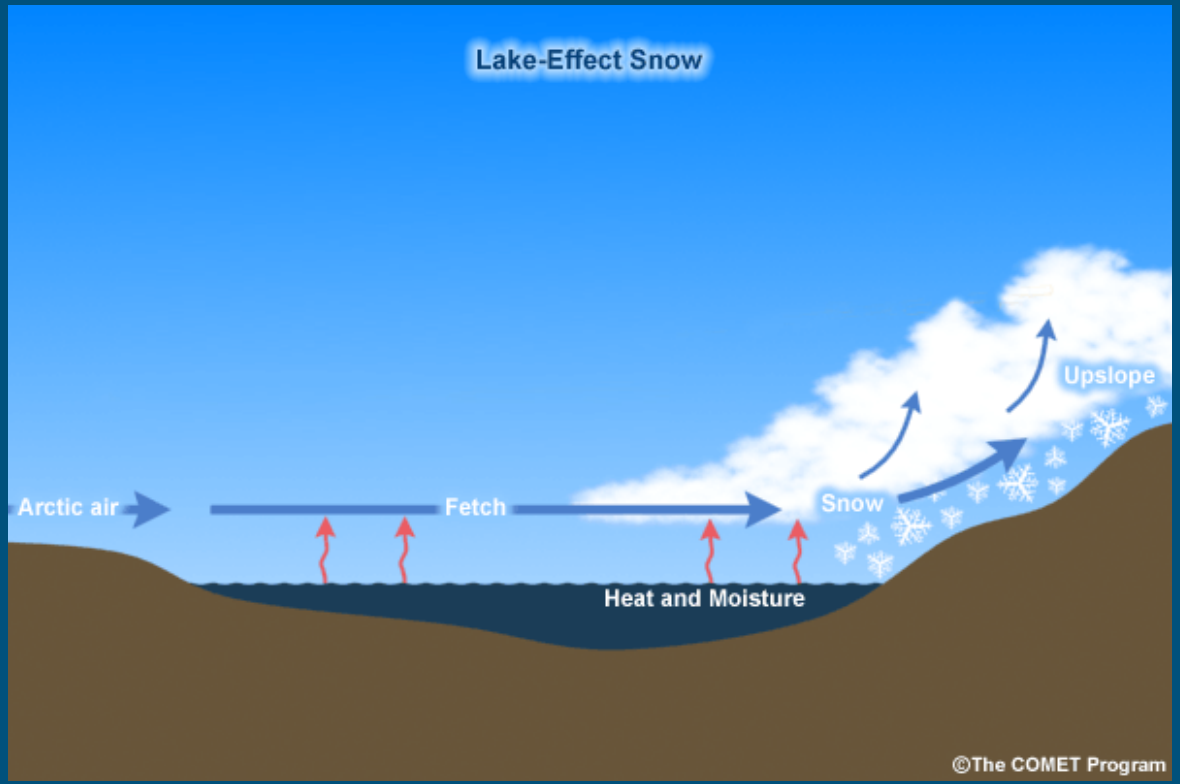
SUNY Oswego

Image: Nicholas Rodick

What is Lake -effect Snow?

- Lake-Effect Snow (LES) occurs commonly in the Great Lakes region during late fall and winter.
- It originates when cold air flows over the relatively warmer open waters of the Great Lakes.
- This often produces snowfall downwind of the lakes.

Formation of LES



(COMET MetEd)

Formation of LES

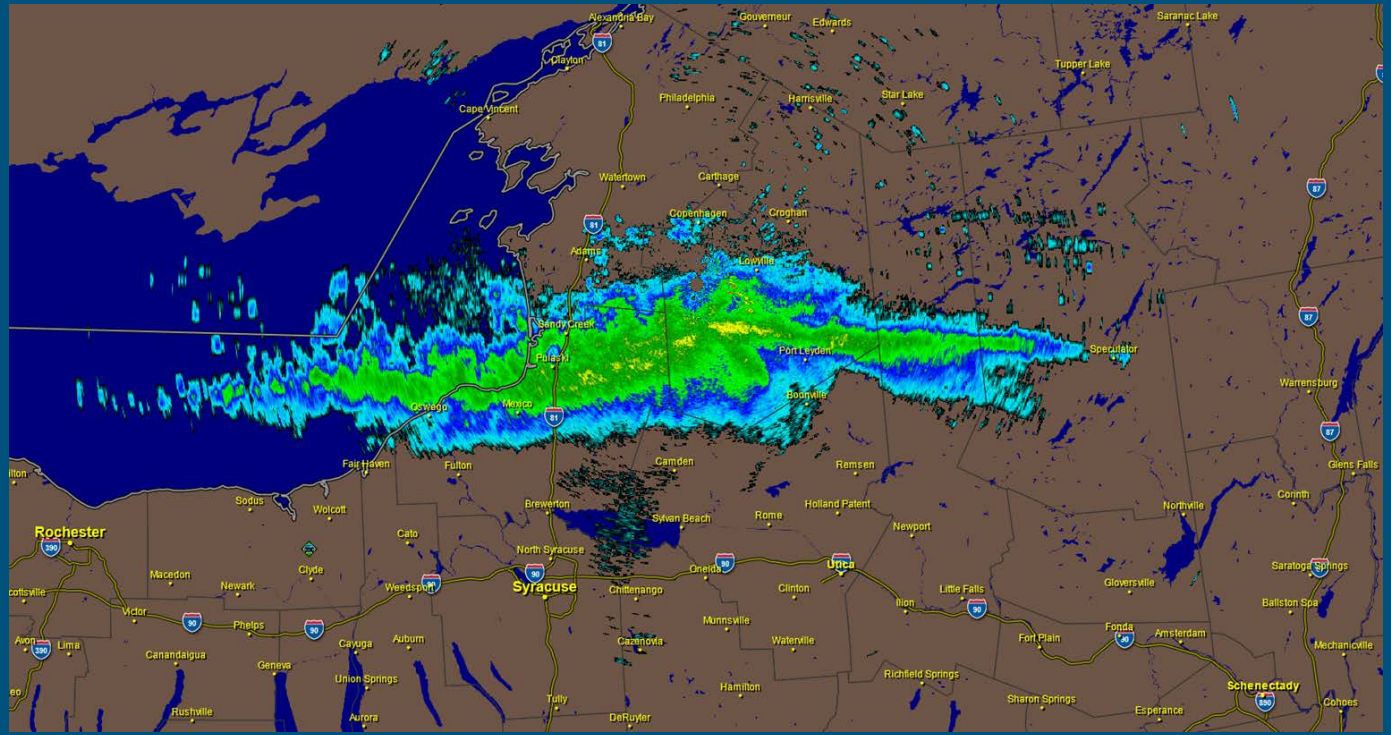
- Several meteorological factors go into the production of LES, including:
  - Temperature difference between lake surface and ~1 mi above surface
  - Wind direction and speed
  - Vertical wind shear
  - Depth of boundary layer
  - Upwind moisture content of air mass
  - Time of day - LES generally stronger at night
  - Ice cover on lake

Sources of Lift

- Can’t make significant LES without a source of lift! Some of these include:
  - Synoptic-scale shortwave trough
  - Weak warm-air advection
  - Orographic lift (Tug Hill)
  - Cold wedge lift
  - Thermally- or frictionally-induced convergence

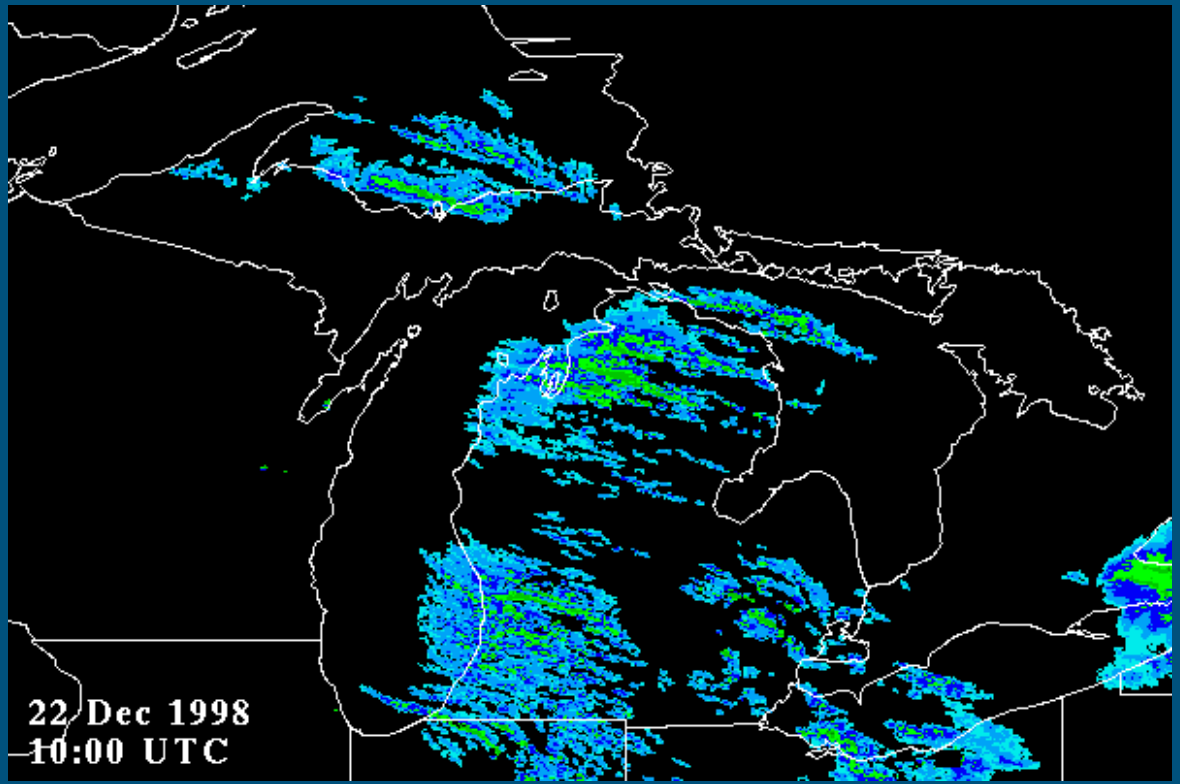
(EOL UCAR)

LES Banding Processes - Wind-Parallel (long fetch)



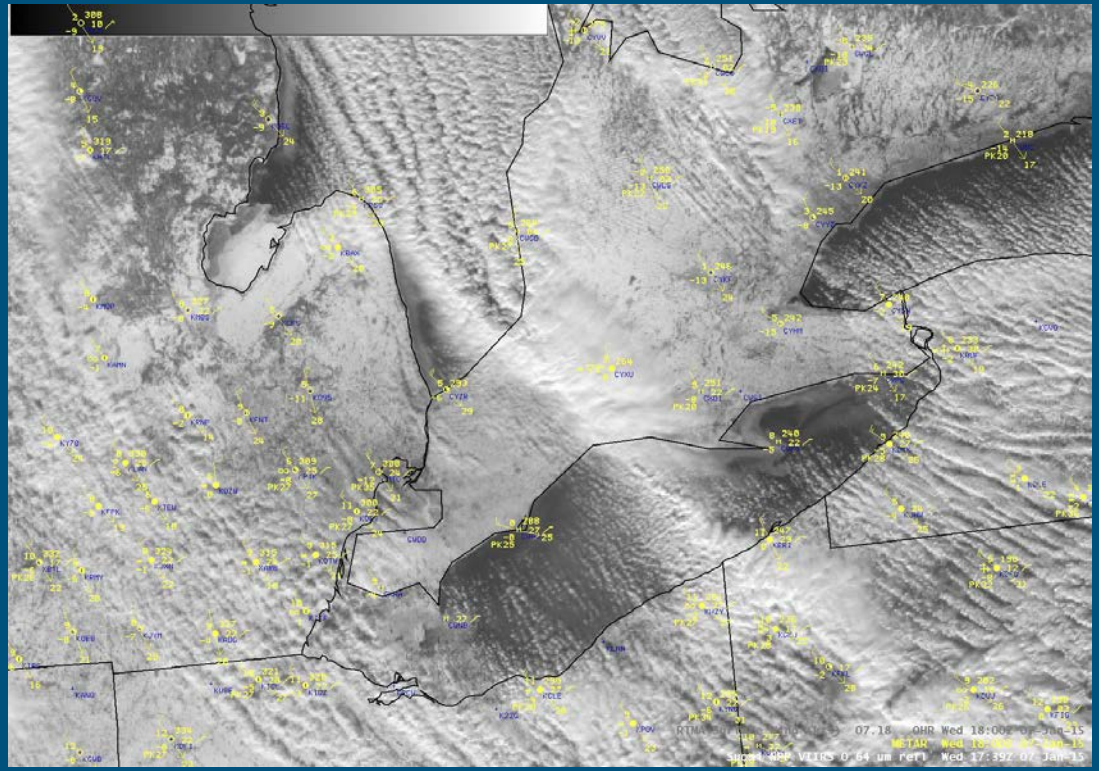
LLAP band east of Lake Ontario in Feb. 2013. Image from syracuse.com

LES Banding Processes - Wind-Parallel (short fetch)



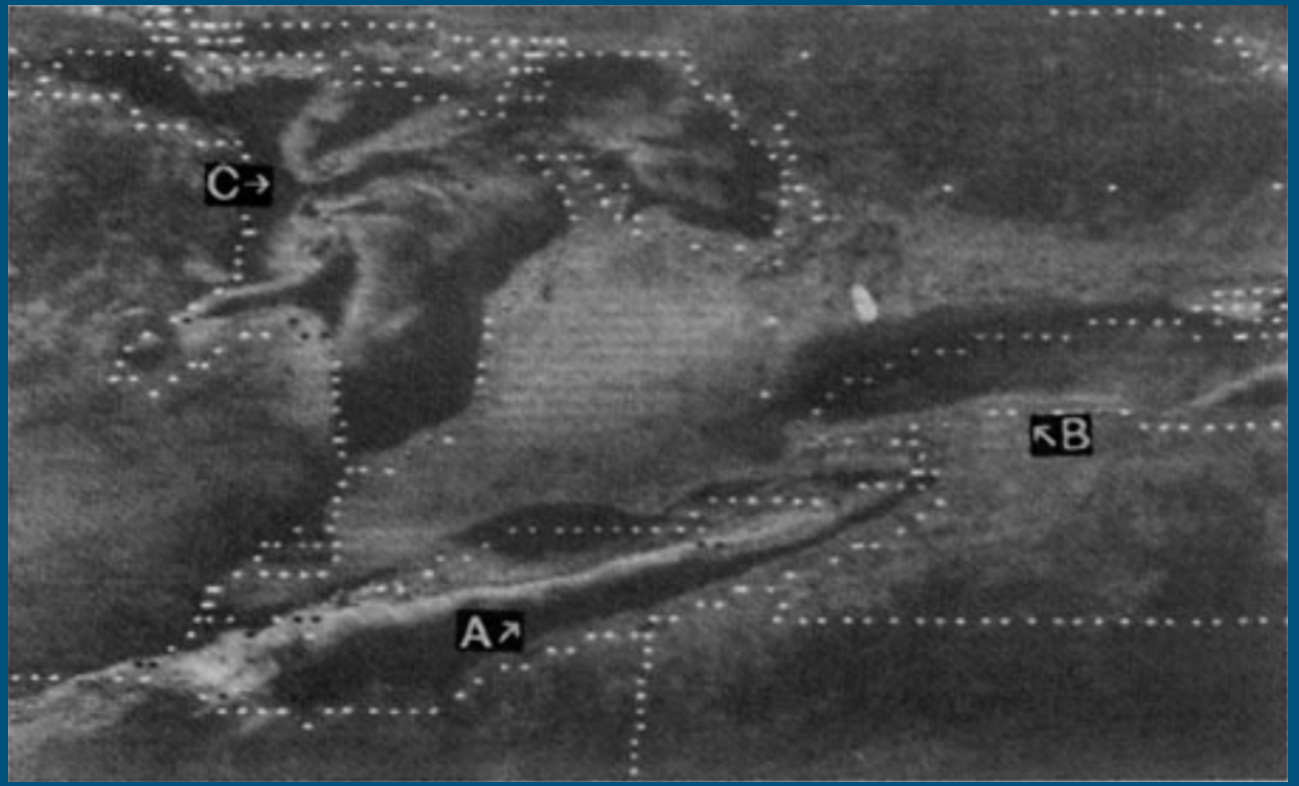
Lake-effect snow east of Lakes Michigan and Superior on Dec. 22, 1998.
Image from UWYO

LES Banding Processes - Hybrid



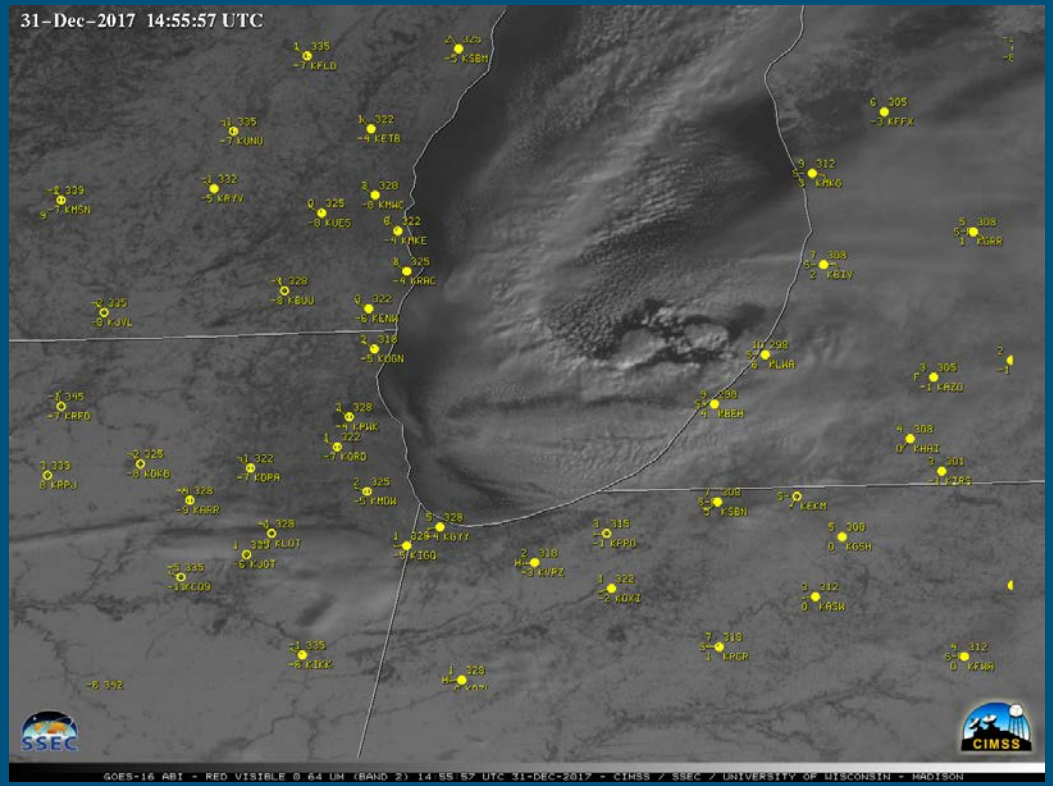
Lake-effect snow bands over Lake Erie in January 2015.
Image from UW-Madison

LES Banding Processes - Land Breeze



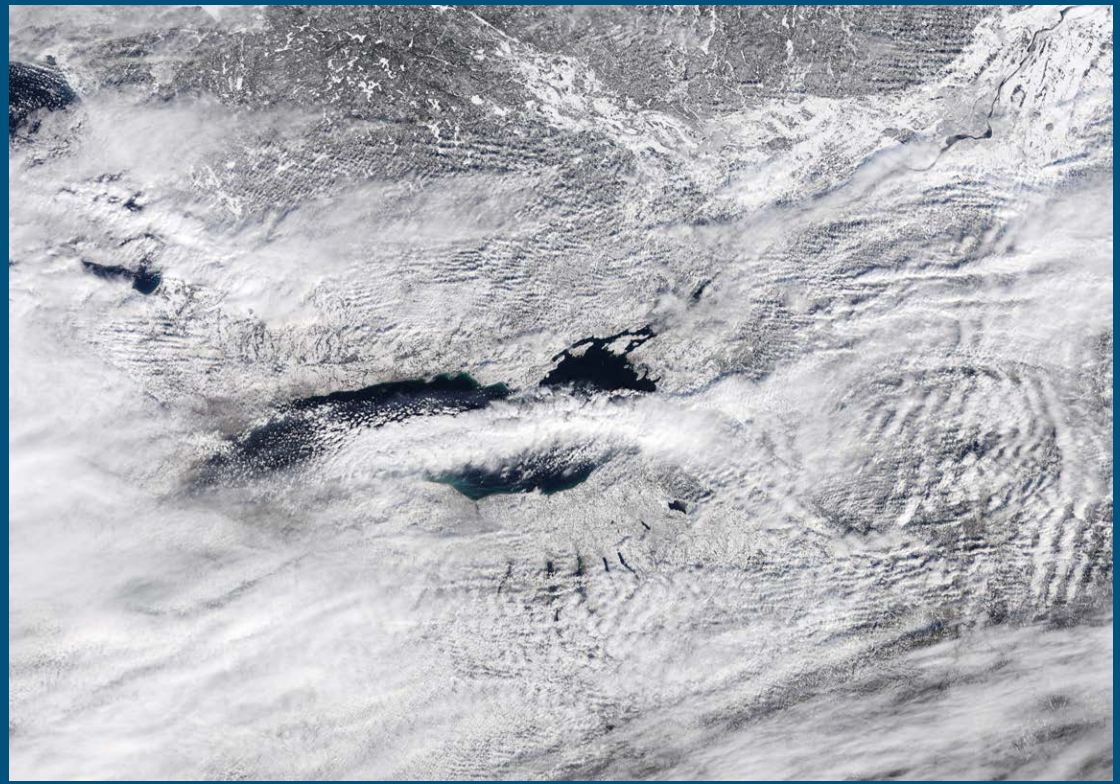
Land breeze lake-effect on December 20, 1983.
From Niziol et al. (1995)

LES Banding Processes - Vortices



Mesovortex over Lake Michigan on Dec. 31, 2017. Image from UW-Madison

Ice Cover



A largely ice-free Lake Ontario on Feb. 3, 2017. Image via Zach Hiris

Ice Cover

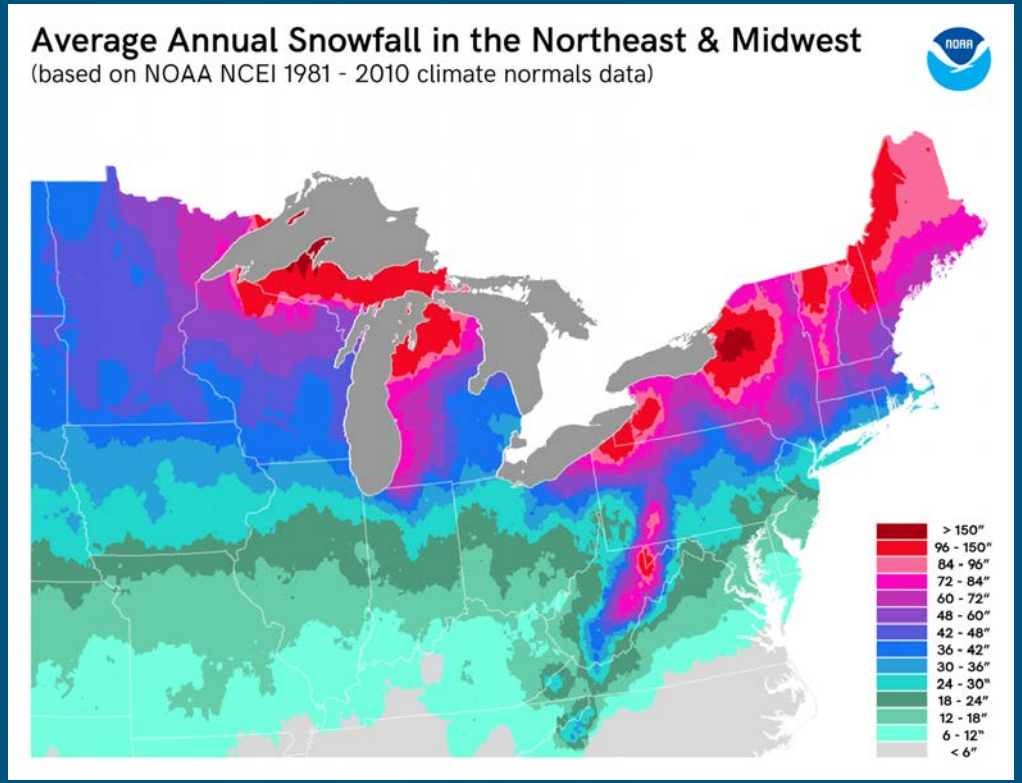
Ice-covered Lake Erie and open Lake Ontario in early February 2015. Image via Zach Hiris

Ice-covered Lake Erie and mostly ice-covered Lake Ontario in late February 2015. Image via Zach Hiris

LES Climatology

- LES often occurs during the late fall and winter months
  - Peak season for Lake Ontario typically December-January
- All of the Great Lakes produce LES
  - Upstream connections occasionally enhance Lake Ontario LES
- Similar to the lake-effect process, sea-effect snow occurs in other regions of the world
  - Atlantic Canada
  - Sea of Japan
  - Black Sea

LES Climatology



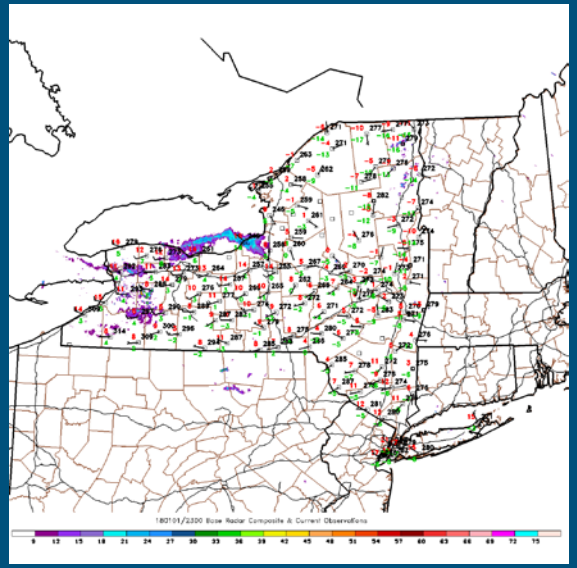
(NWS Chicago)

Forecasting LES - Observations

- The first step of lake effect snow forecasting is to look at current and past conditions!

(Radarscope, January 1, 2018)

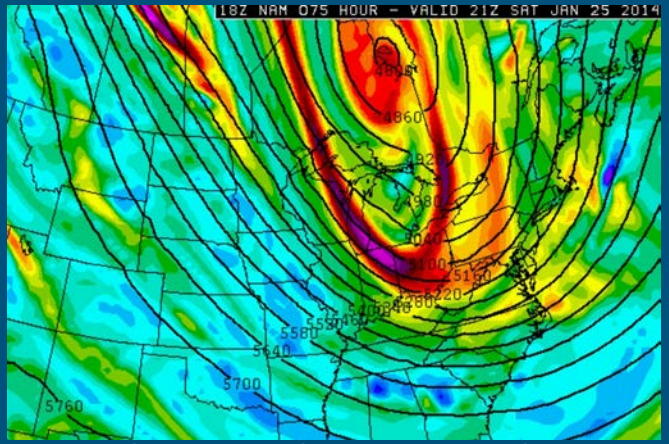
(NYS Mesonet Oswego, January 1, 2018)



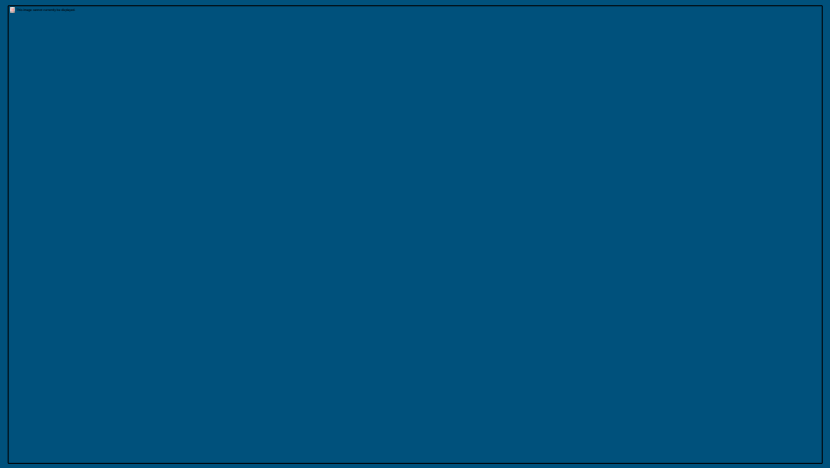
(NYS Mesonet data, January 1, 2018)

Forecasting LES - Blending Models and Humans

- In the 21st century, computer models have become a big part of weather forecasting, but studies show the combination of computers and humans, have much better results.
- Forecasting experience matters!



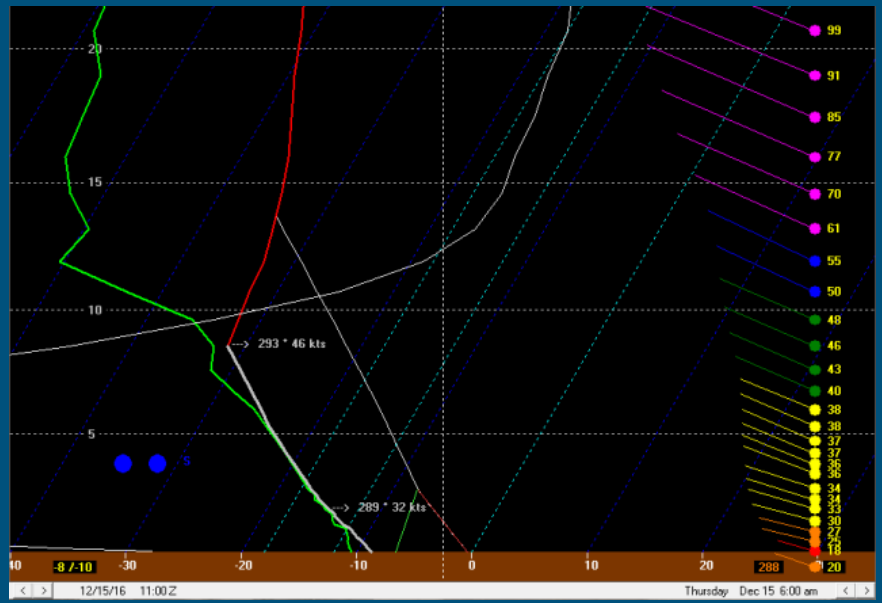
(COD Meteorology, January 2014)



(COD Meteorology, December 2016)

Forecasting LES - BUFKIT Software

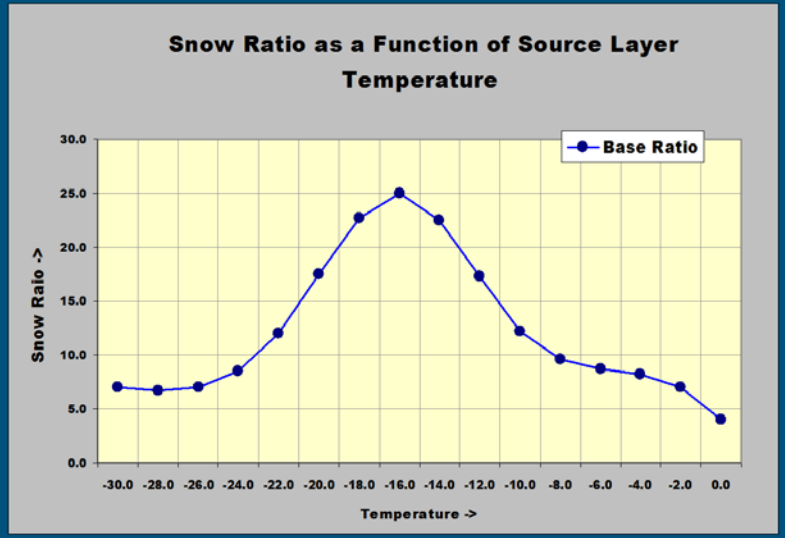
- Bufr Forecast Profile Toolkit



(BUFKIT, December 2016)

Forecasting LES - Snow Ratios

- Forecasting snow to liquid equivalents is a big part of LES forecasting. For lake effect snow, generally ratios are 15-25 of snow per 1 inch of liquid, but can be much higher (>30:1).



(Graph from a powerpoint presentation by Daniel Cobb).

OWLeS

- The Ontario Winter Lake-Effect Systems (OWLeS) project took place during the winter of 2013-14.
- Twenty-four Intensive Observation Periods (IOPs) took place through the duration of the project.
- Many research facilities were utilized during this campaign
  - Three mobile Doppler-On-Wheels (DOW) radars
  - University of Wyoming King Air (UWKA) research aircraft
  - University of Alabama Huntsville's Mobile Integrated Profiling System (MIPS)
  - Radiosonde launches
  - Surface snow observation sites
  - And more!

OWLeS

- Project organized around 3 components of LES:
  - Surface and atmospheric influences on lake-effect (SAIL)
  - Long-lake axis parallel (LLAP)
  - Interactions between LES and terrain (i.e. Tug Hill)

From Kristovich et al. (2017)

OWLeS

- Project goals
  - Interactions of boundary layer and lakes
  - Differences between Finger Lakes and Great Lakes
  - Inland extent of LES
  - Relation of atmospheric physics to lake-effect processes
  - Dynamic and microphysical processes related to electrification of LES
  - In-situ validation of dual-polarization radar data
  - Influences of topography on LES

OWLeS

Students performing observations in the field during OWLeS.

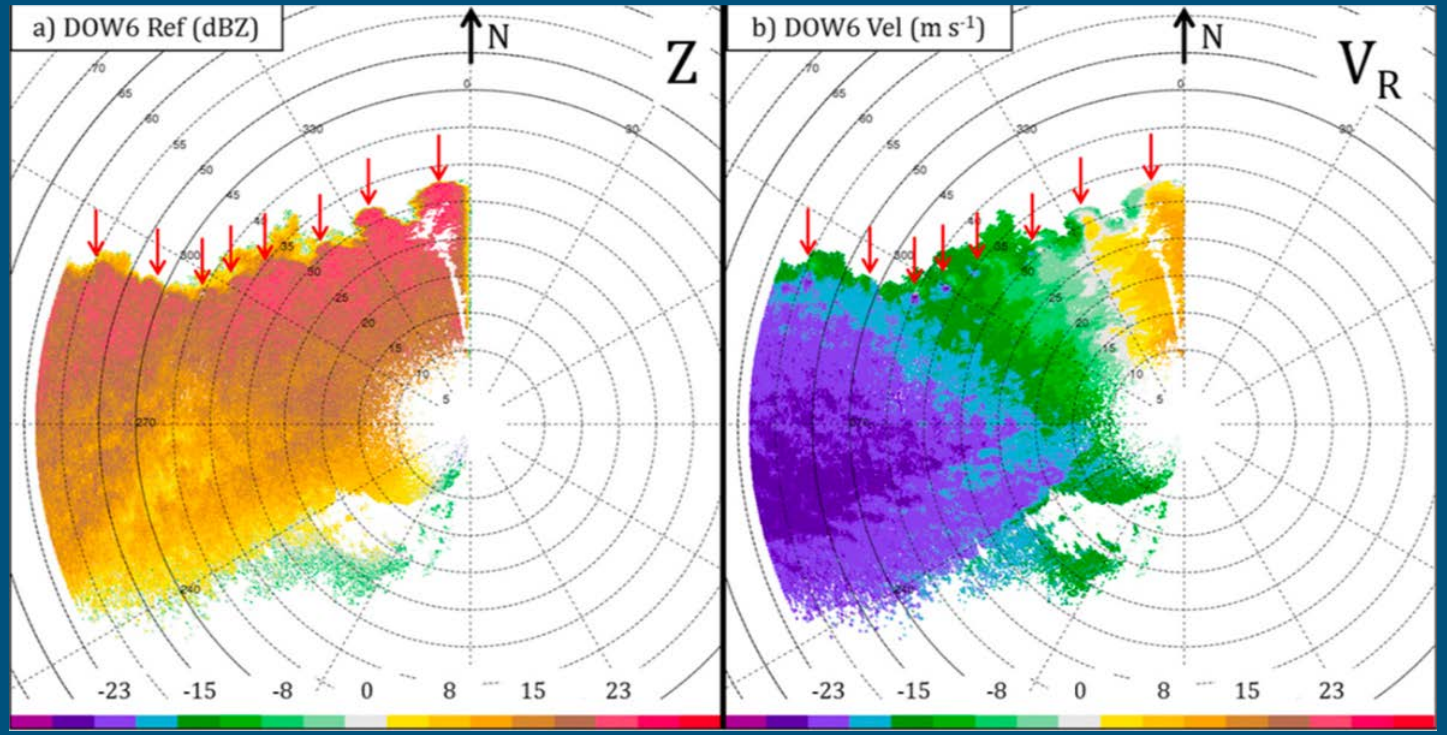
From Kristovich et al. (2017)

Lake-effect Research at SUNY Oswego

- Several studies related to lake-effect processes have been conducted using data collected during OWLeS.
  - Misovortices
  - Lightning
  - DOW and Wyoming King Air data correlation

(OWLeS Field Catalog)

Misovortices

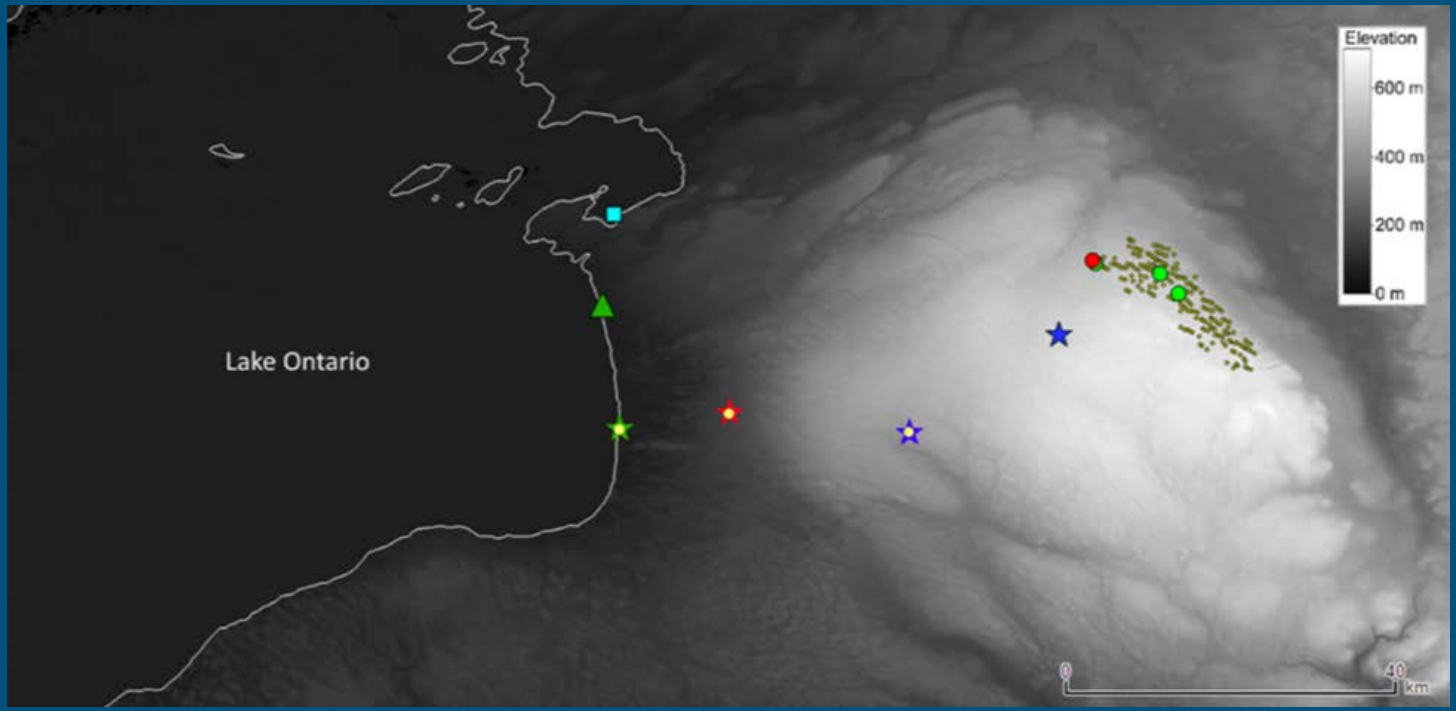


From Mulholland et al. (2017)

Misovortices - Conclusions

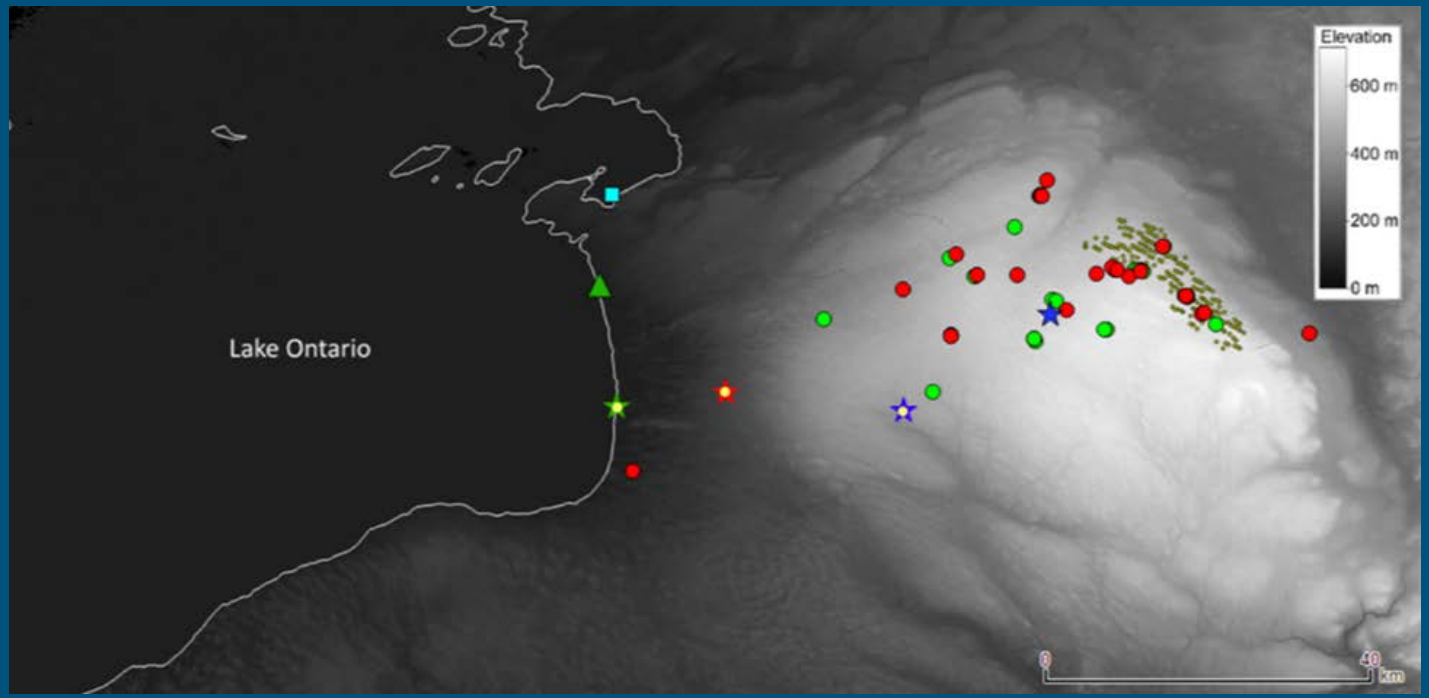
- Misovortices were observed along a horizontal shear/convergence zone on the sharp reflectivity gradient of the observed LLAP band.
- Horizontal shear/convergence zone is created by low pressure north of Lake Ontario and higher pressure south of Lake Ontario, with faster westerly winds south and slower westerlies north.
- Results support that HSI (Horizontal Shear Instability) helps create misovortices.

Lightning



Lightning observations during IOP5 on Dec. 18, 2013.
From Steiger et al. (2018)

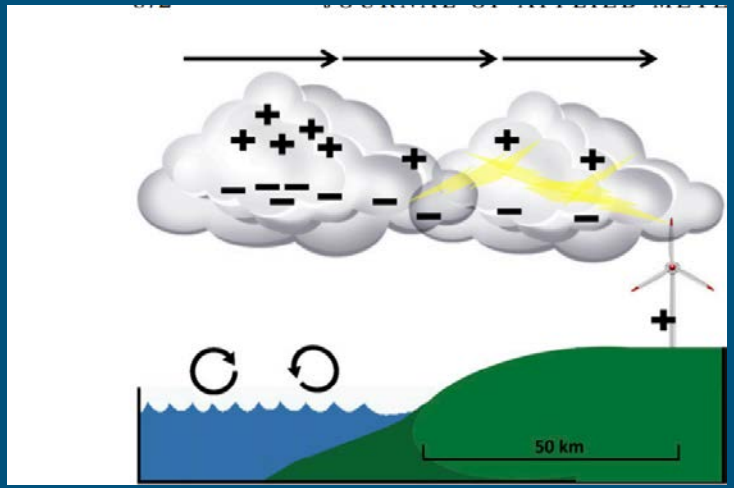
Lightning



Lightning observations during IOP7 on January 7, 2014.
From Steiger et al. (2018)

Lightning - Conclusions

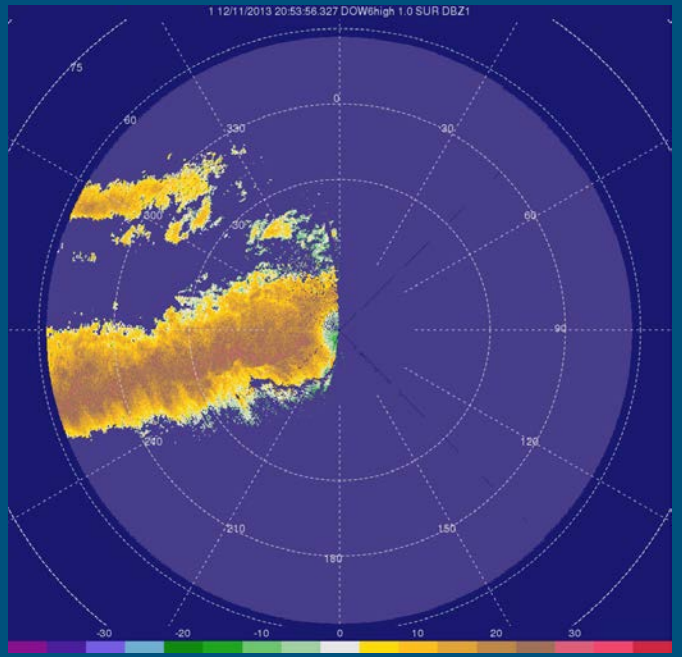
- Lightning occurred with more stratiform precipitation on the Tug Hill versus over the lake, due to the charge separation not being strong enough until manmade objects were encountered inland.
- 2 modes of lightning in LES
  - Tall structures not required
  - Tall structures required



From Steiger et al. (2018)

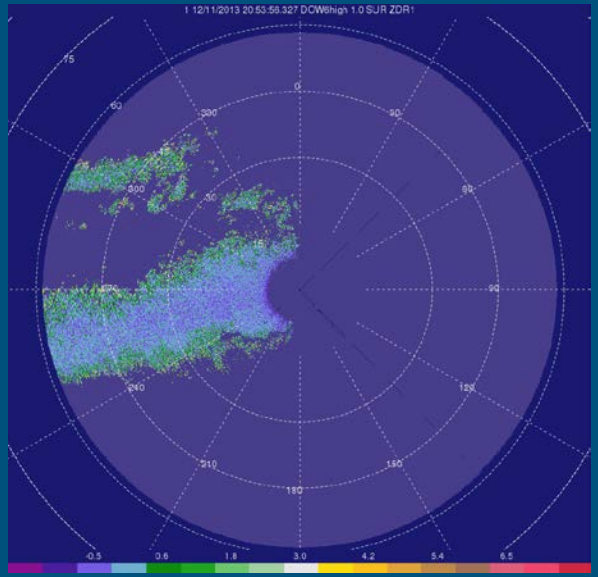
Hydrometeor Classification

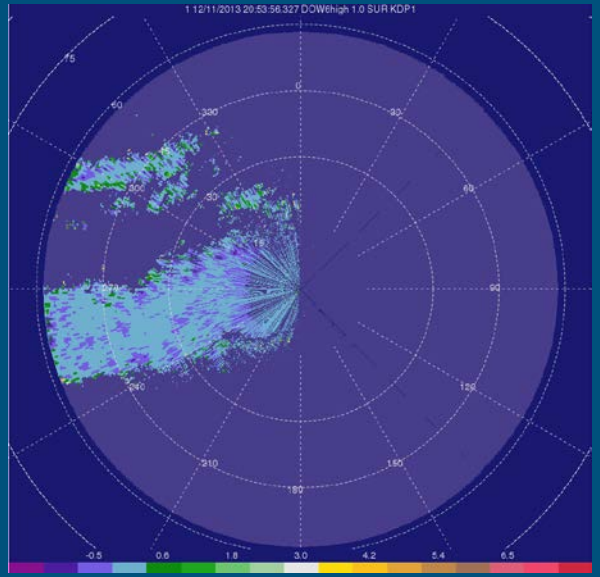
- Relate DOW samplings during OWLeS to hydrometeor classification within a lake - effect cloud using in situ observations
- Case study: IOP 2b

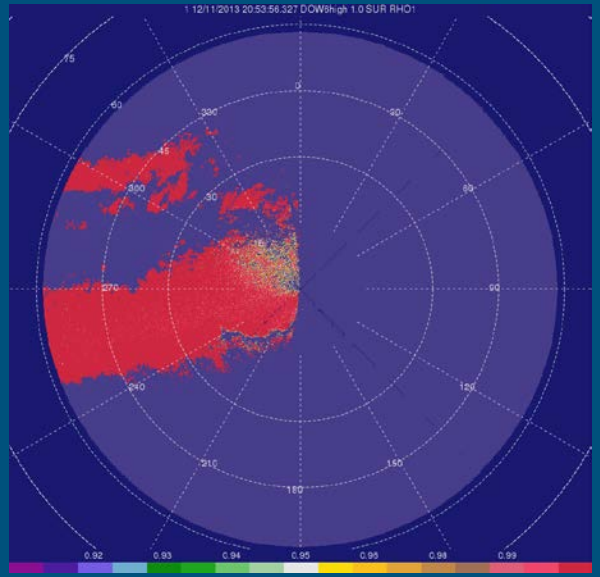


DOW6 Reflectivity, 2053 UTC 11 Dec 2013. Image via Matthew Seymour

Hydrometeor Classification







ZDR

ρHV

KDP

Images via Matthew Seymour

Hydrometeor Classification

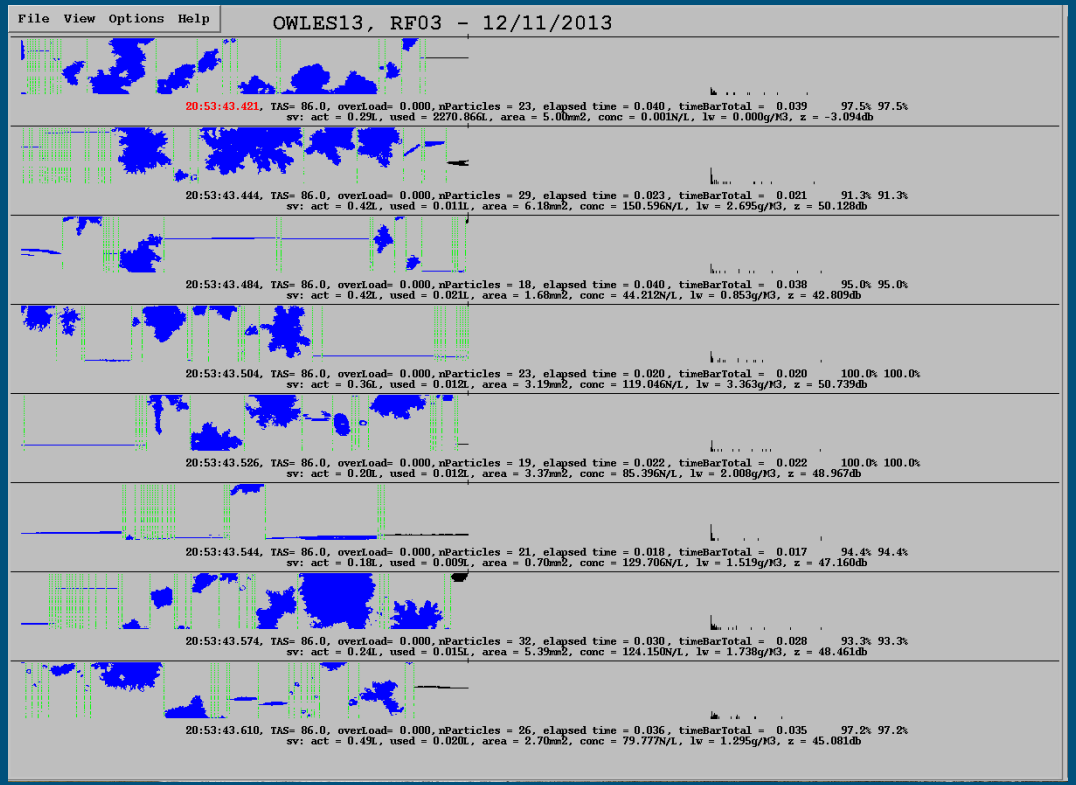


Image via Matthew Seymour

Hydrometeor Classification - Conclusions

- Samplings from the DOW related well both to pre-existing knowledge, and to in situ observations from the UWKA and surface
- More IOPs to be analyzed in the future
  - More variety to observed hydrometeors (i.e. graupel, variation in snowflake type)

Benefits of Lake -effect Research

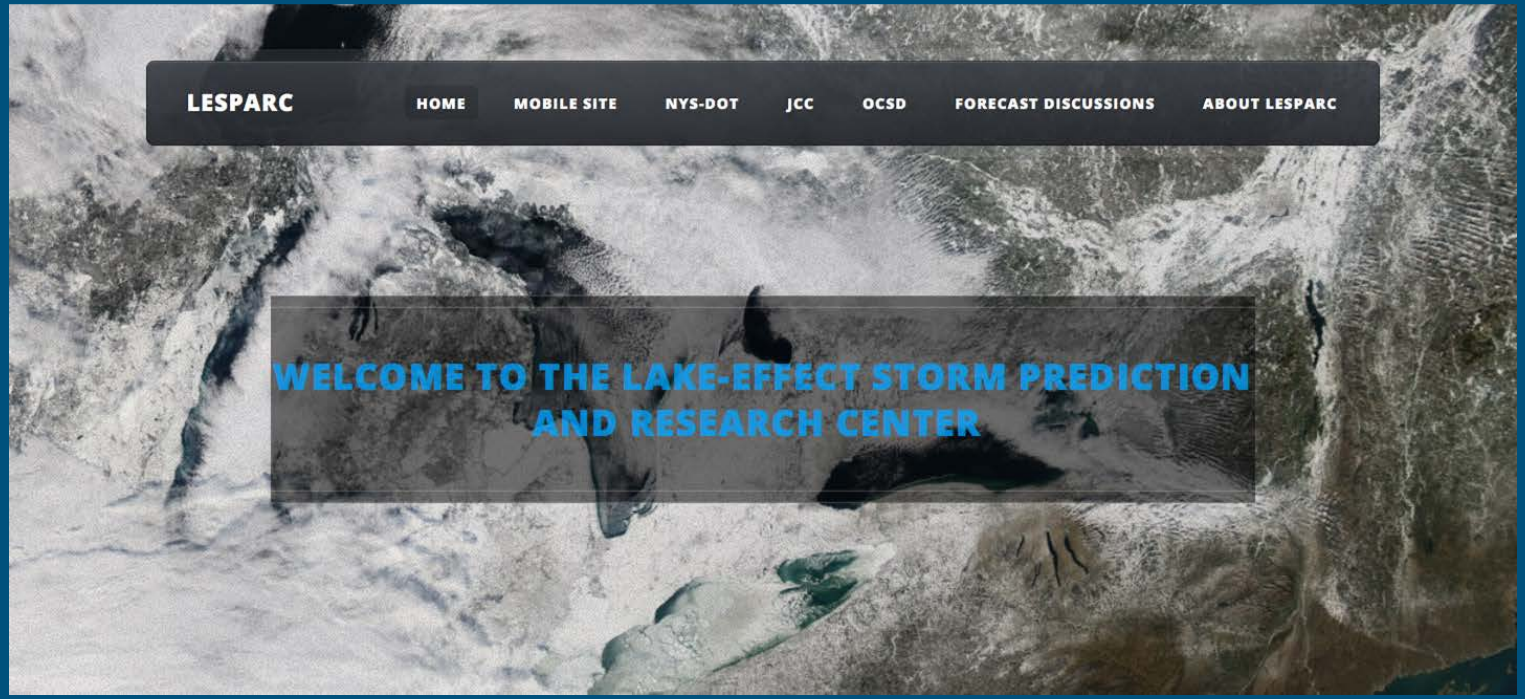
- Ever-evolving forecast techniques
- Snowfall rate forecasting improvements
- Understanding mechanisms that govern lake effect bands can help with modeling and forecasting of said bands.

November 17-19th 2014 Buffalo, NY Snowstorm. From Pinterest

LESPaRC

- The Lake-effect Storm Prediction and Research Center (LESPaRC) is a SUNY Oswego student-run organization that forecasts for Central and Northern NY during the winter season of November to April.
- Forecasters are assigned one day of the week to produce forecasts, twice on that day (4x a day during Active Mode)
- Forecasts are delivered to the D.O.T. and a number of school districts
- Co-Forecast Leaders write forecast discussions prior to significant events
- LESPaRC is a 24/7 operation

LESPaRC



(SUNY Oswego LESPaRC website)

LESPaRC

Time of Update: 12:00 AM on December 21st
Time of Next Update: 12:00 PM on December 21st

I-81 @ Adams

Time	Weather Conditions	Snowfall Rates	Temperature	Wind	Wind Chill	Visibility
12:00 AM	Mostly Cloudy	None	24°	SW 10-15 mph	11-14°	10 Miles
1:00 AM	Mostly Cloudy	None	23°	SW 10-15 mph	10-13°	10 Miles
2:00 AM	Cloudy	None	23°	W 10-15 mph	10-13°	10 Miles
3:00 AM	Snow Showers	Trace-0.1 in/hr	22°	W 10-15 mph	9-12°	3-5 Miles
4:00 AM	Snow Showers	Trace-0.1 in/hr	22°	W 10-15 mph	9-12°	3-5 Miles
5:00 AM	Snow	0.25-0.5 in/hr	23°	W 10-15 mph	10-13°	0.5-1 Miles
6:00 AM	Heavy Snow	1-2 in/hr	23°	W 10-15 mph	10-13°	<.25 Miles
7:00 AM	Heavy Snow	2-3 in/hr	24°	W 10-15 mph	11-14°	<.25 Miles
8:00 AM	Heavy Snow	1-2 in/hr	24°	W 10-15 mph	11-14°	<.25 Miles
9:00 AM	Snow	0.5-1 in/hr	25°	W 10-15 mph	12-15°	0.25-0.5 Miles
10:00 AM	Snow	0.25-0.5 in/hr	26°	W 10-15 mph	13-16°	0.5-1 Miles
11:00 AM	Snow Showers	0.1-0.25 in/hr	27°	W 10-15 mph	15-18°	1-3 Miles
Noon	Sctd. Snow Showers	Tr-0.1 in/hr	28°	W 10-15 mph	16-19°	3-5 Miles
1:00 PM	Sctd. Snow Showers	Tr-0.1 in/hr	29°	NW 10-15 mph	17-20°	3-5 Miles
2:00 PM	Sctd. Snow Showers	Tr-0.1 in/hr	30°	NW 10-15 mph	18-21°	3-5 Miles
3:00 PM	Sctd. Snow Showers	Tr-0.1 in/hr	30°	NW 10-15 mph	18-21°	3-5 Miles

(SUNY Oswego LESPaRC website)

LESPaRC

Meteorologist on Call: Matthew Seymour **Email:** mseymour@oswego.edu

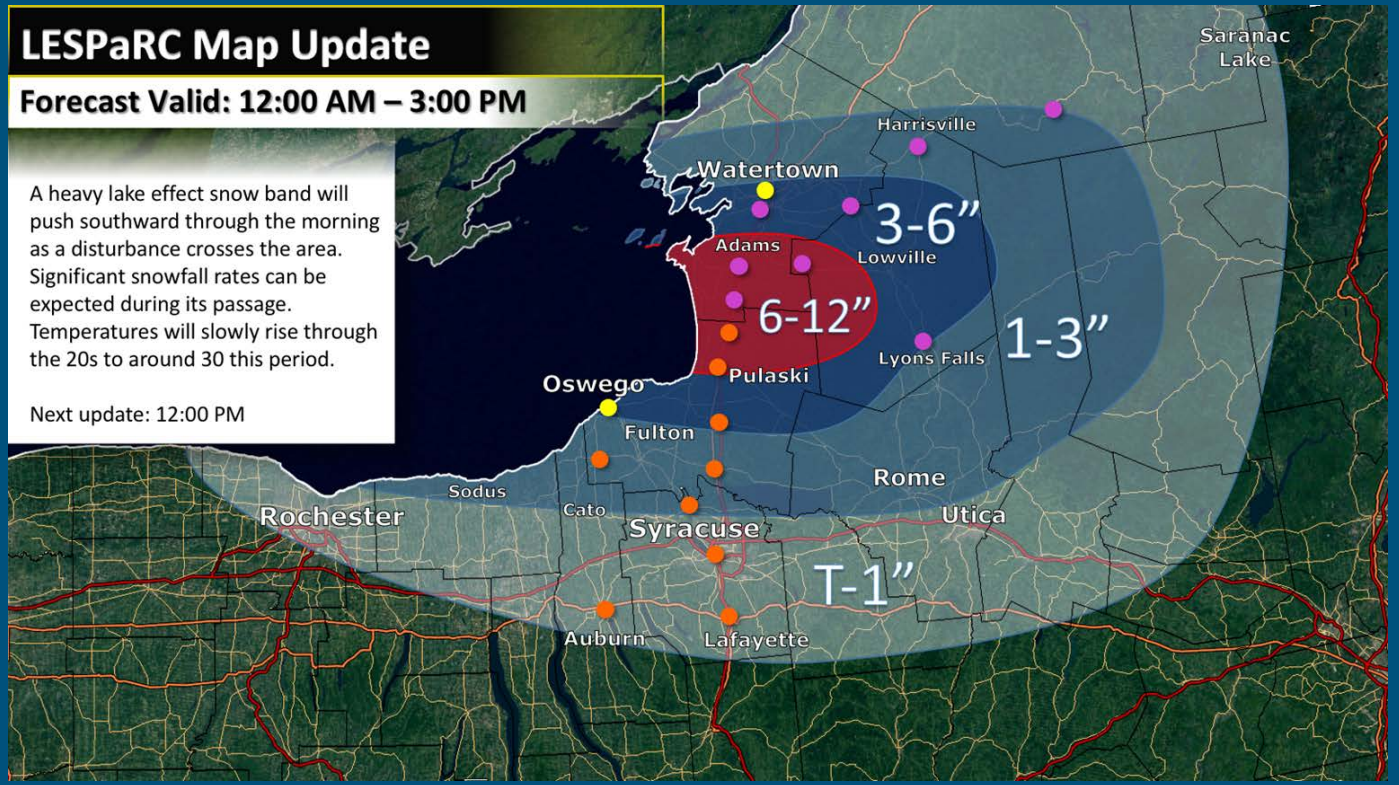
Alerts: Winter Weather Advisory in effect until 4pm

Forecast Discussion: A band of lake-effect snow is projected to gradually move southward through this period. Within the core of the snow band, snowfall rates of 2-3 in/hr are possible, making for very low visibility. Gusty winds of 10-20mph may cause some areas of blowing and drifting. Temperatures will slowly rise through the 20s.

Level of Confidence: High

(SUNY Oswego LESPaRC website)

LESPaRC



(SUNY Oswego LESPaRC website)

LESPaRC- How research can help us!

- Snowfall rate and visibility
- Snow-liquid ratio
- Storm total snow

Lake-effect snow in Boonville, NY on Dec. 19, 2015. (northcountrypublicradio.org)