# A Numerical Case study of IOP2 during Project LEE using the Weather Research and Forecasting model

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## Background and Motivation

- Lake-effect snow (LES) is a mesoscale process that develops over a lake due to the temperature difference between the surface of the water and upper air.
- Long lake-axis-parallel (LLAP) LES bands can cause extreme rates of precipitation while only being 50km long and 5km wide (Steiger et al. 2013).
- LES is known to produce CG (cloud-to-ground) and IC (intra-cloud) lightning that may be influenced by tall man-made objects, inflicting damage to property.
- The 2022-23 Lake-Effect Electrification (LEE) Project provides multiple datasets for in-situ and remote sensing measurements of LES that can be used to verify numerical weather prediction models, including the ability to simulate electrification.

## Data and Methodology

- Intensive Observation Period (IOP) 2 occurred from 1830Z 18 Nov to 0630Z 19 Nov 2022
- IMET and Vaisala Radiosondes
- National Severe Storms Laboratory (NSSL) and Georgia Tech Research Institute (GTRI) Lightning Mapping Arrays (LMA)
- KTYX WSR-88D Doppler Radar
- Weather Research and Forecasting Model (WRF) (Skamarock et al. 2008)
  - 3km horizontal resolution
  - Convection permitting

| WRF Model Specifications | |
|---|---|
| Computational Domain | Refer to Fig. 1 |
| Horizontal Resolution | 9.0 km and 3.0 km |
| Cumulus Parameterization | Grell-Freitas and N/A |
| Microphysics Parameterization | NSSL Two moment |
| Lightning Parameterization | LPI (Yair et al. 2010) |
| Boundary Conditions | Hourly ERA5 Reanalysis |

## Overview

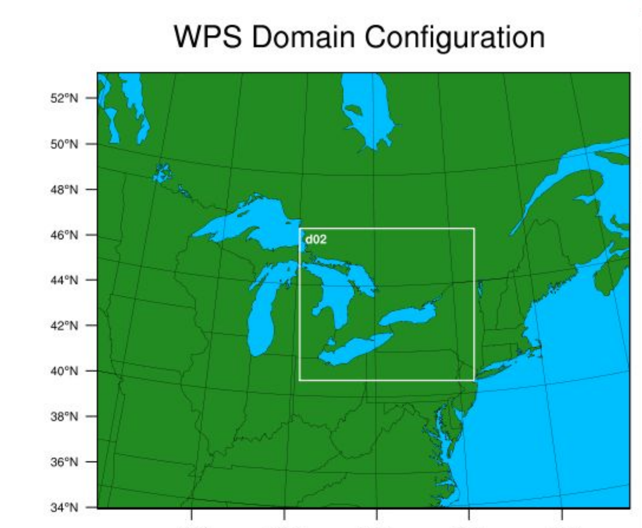


*Fig. 1. Computational domains (outer and inner nest) of WRF simulation*

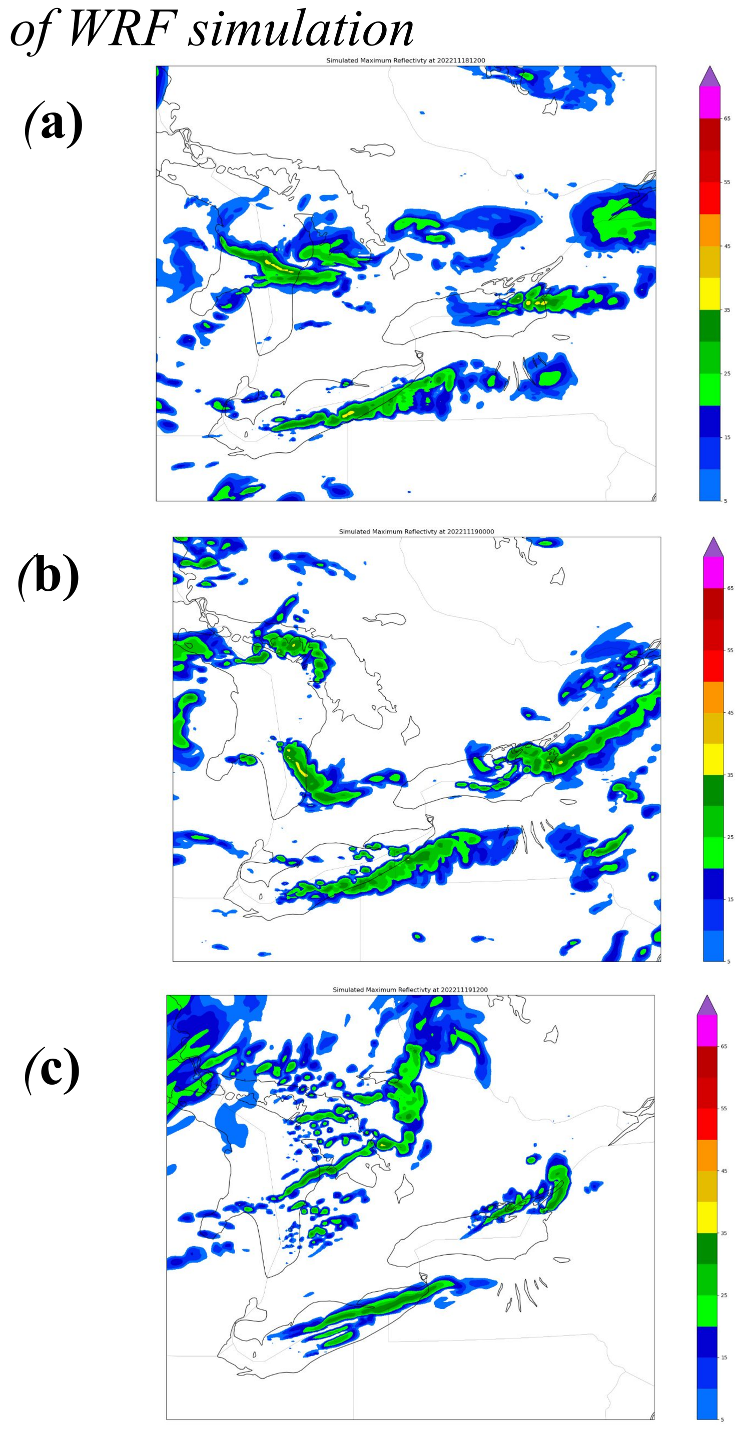


*Fig. 2. Map displaying simulated maximum reflectivity (mdbz) valid at a) 12Z 18 Nov 2022, b) 00Z 19 Nov 2022, c) 12Z 19 Nov 2022*

- A LLAP band developed over eastern Lake Ontario on 18 Nov 2022.
- The band continued to develop over Lake Ontario while continually shifting a few km north.
- High MDBZ values (35-40 dBZ) were simulated within the band, indicating intense convective cells capable of high snowfall rates and graupel.

## Results

### KTYX Radar Observations and Comparison to WRF Model

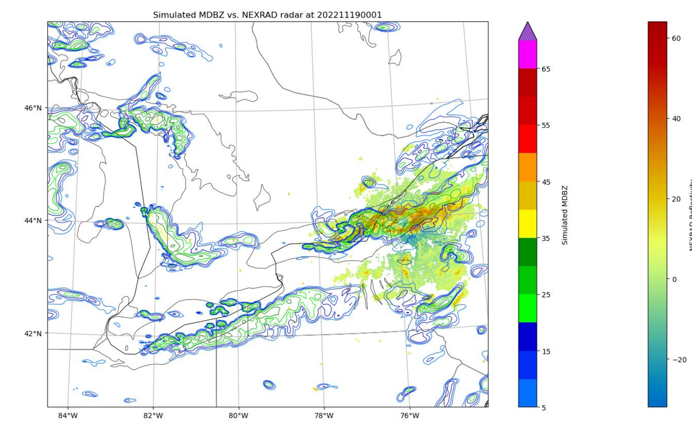

*Fig. 3. KTYX Radar observations and WRF simulated mdbz (line contours) valid at 00Z 19 Nov 2022*

- Model simulated maximum reflectivity is reasonably comparable to observed values.
- Strong convective cells can be seen in both the model and observed radar.
- Band location in model is nearly identical to band location based on KTYX.

### Lightning Potential Index

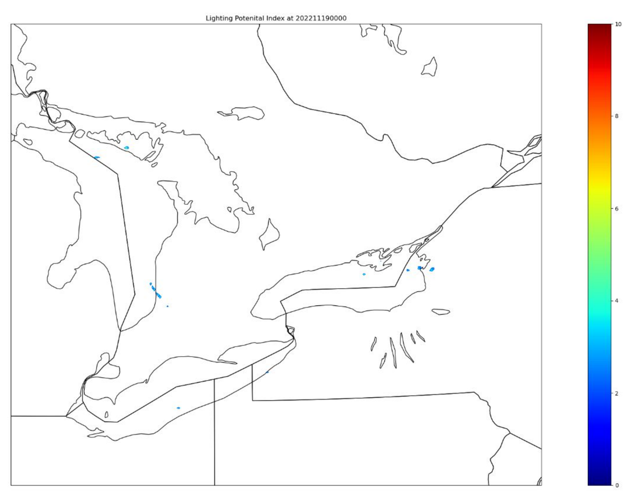

*Fig. 4. Lightning Potential Index (LPI) valid at 00Z 19 Nov 2022*

- LPI values of 4 J/kg seen on the eastern shore of Lake Ontario near Watertown, NY.
- LPI indicates intense convection in the LLAP band.
- Observed lightning less than 1km from eastern most LPI value.

### Sounding Observations and Comparison to WRF Model

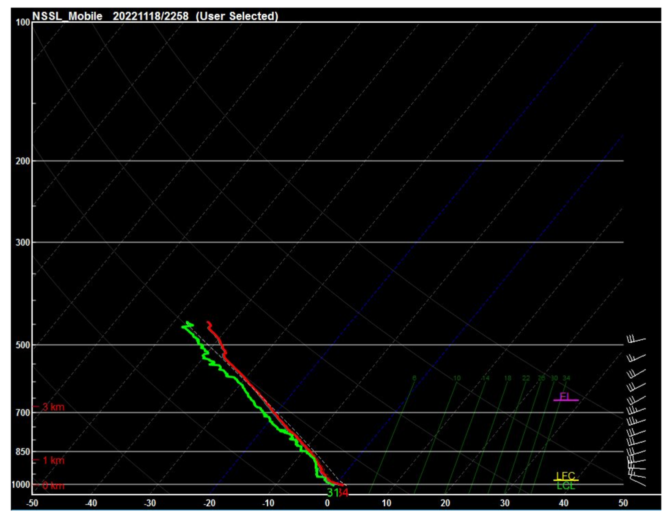

*Fig. 5. Sounding in/near lake band plotting T, Td, and wind barbs valid at 23Z 18 Nov 2022*

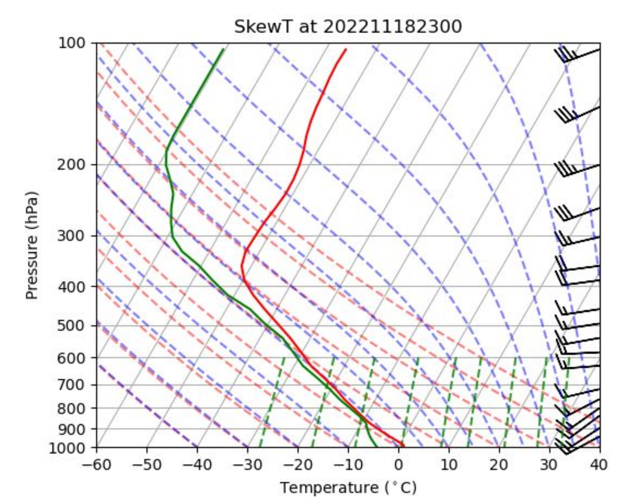


*Fig. 6. Simulated Sounding at Oswego, NY plotting T, Td, and wind barbs valid at 23Z 18 Nov 2022*

- Observed sounding (Fig. 5) shows deep saturated layer up to 500mb.
- The simulated sounding (Fig. 6) shows similar deep boundary layer.

## Conclusions

- The structure and development of the LES event are well-represented by the WRF model.
- LPI is useful in predicting lightning in lake-effect.
- Future work will analyze the properties of lake-effect lightning using the WRF-Electrification model.

## Acknowledgements

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- Thank you to all the LEE scientists and students

*References Available upon request*