Environment and Climate Change Canada | Environnement et Changement climatique Canada

THE SOUTHERN ONTARIO LIDAR (SOLID) MESONET: IMPACTS ON AVIATION AND SEVERE WEATHER NOWCASTING

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Environment and Climate Change Canada's 50th anniversary
50e anniversaire d'Environnement et Changement climatique Canada
Meteorological Service of Canada's 150th anniversary
150e anniversaire du Service météorologique du Canada

NROW & NYS Mesonet Workshop
November 15 2025

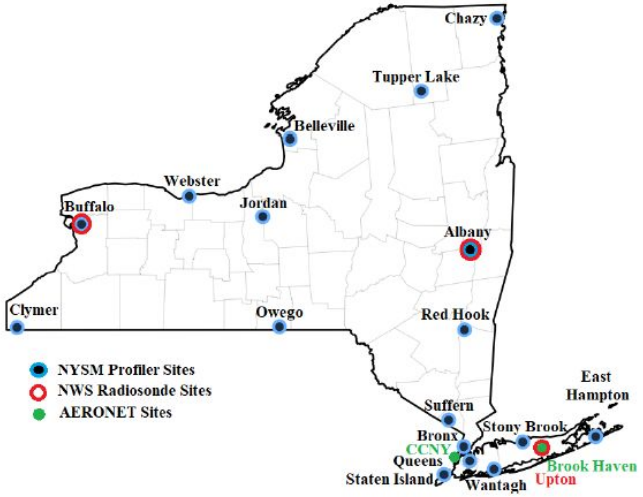
Canada

INVESTIGATING TECHNOLOGIES THAT CAN FILL GAPS IN THE CURRENT UPPER AIR NETWORK

- Support identification, test and implementation of new commercial technologies, including impact analyses and bridge to operations
- Recommend cost-effective integrated observing system which best serves Canadian needs
- Need to reduce dependency on a single technology (radiosondes) by investigating the potential of implementing a mixed network
- Technologies under investigation for increased adoption:
  - AMDAR, GPSMet, Doppler lidar, water vapour lidar, radiometers
- Examples of other agencies deploying Doppler lidar Mesonets for nowcasting:

EU's COST action: PROBE[1]

New York State Mesonet[2]

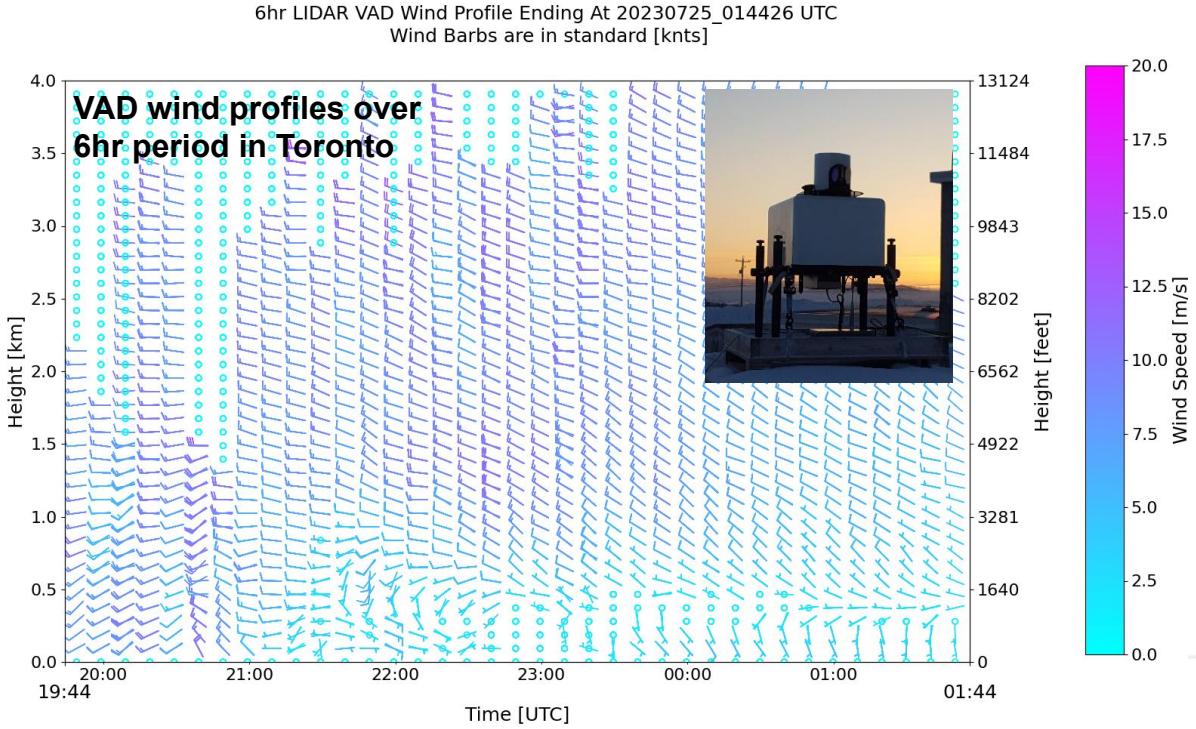


[1]Cimini et al. (2020): ropean scale—introducing
[2]Shrestha et al. (202_): Data." AMT

LIDARS

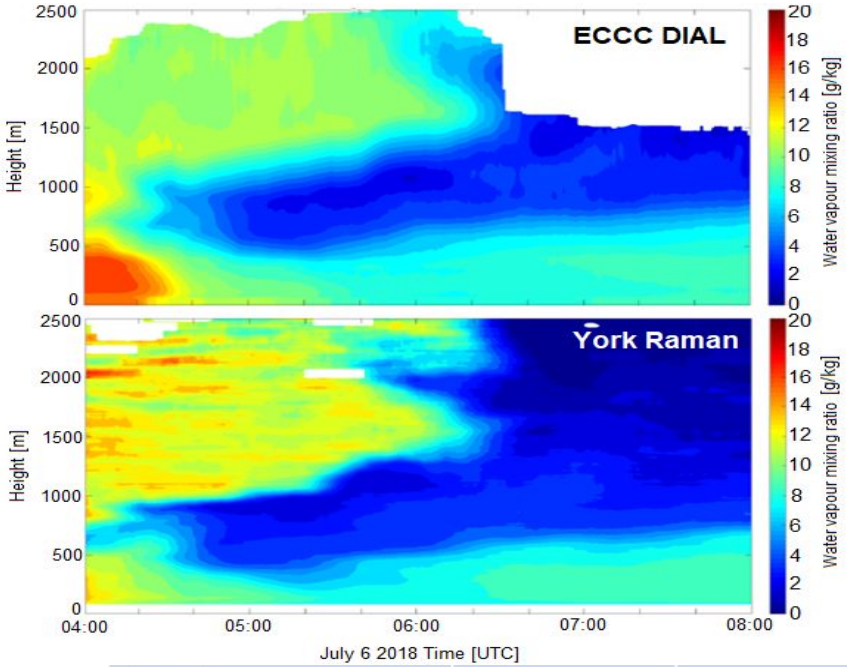
Doppler (wind) Lidar

- Mixed network design
  - 5 Halo Streamline XR+
  - 3 Leosphere 100S Windcube
- 24-hr PBL wind profiles every 3* m up to ~4 km
  - *Halo overlapping range gates
- Scanning strategy established
  - PPI, 8-beam VAD, vertical stare



Vaisala DIAL Water Vapour Lidar

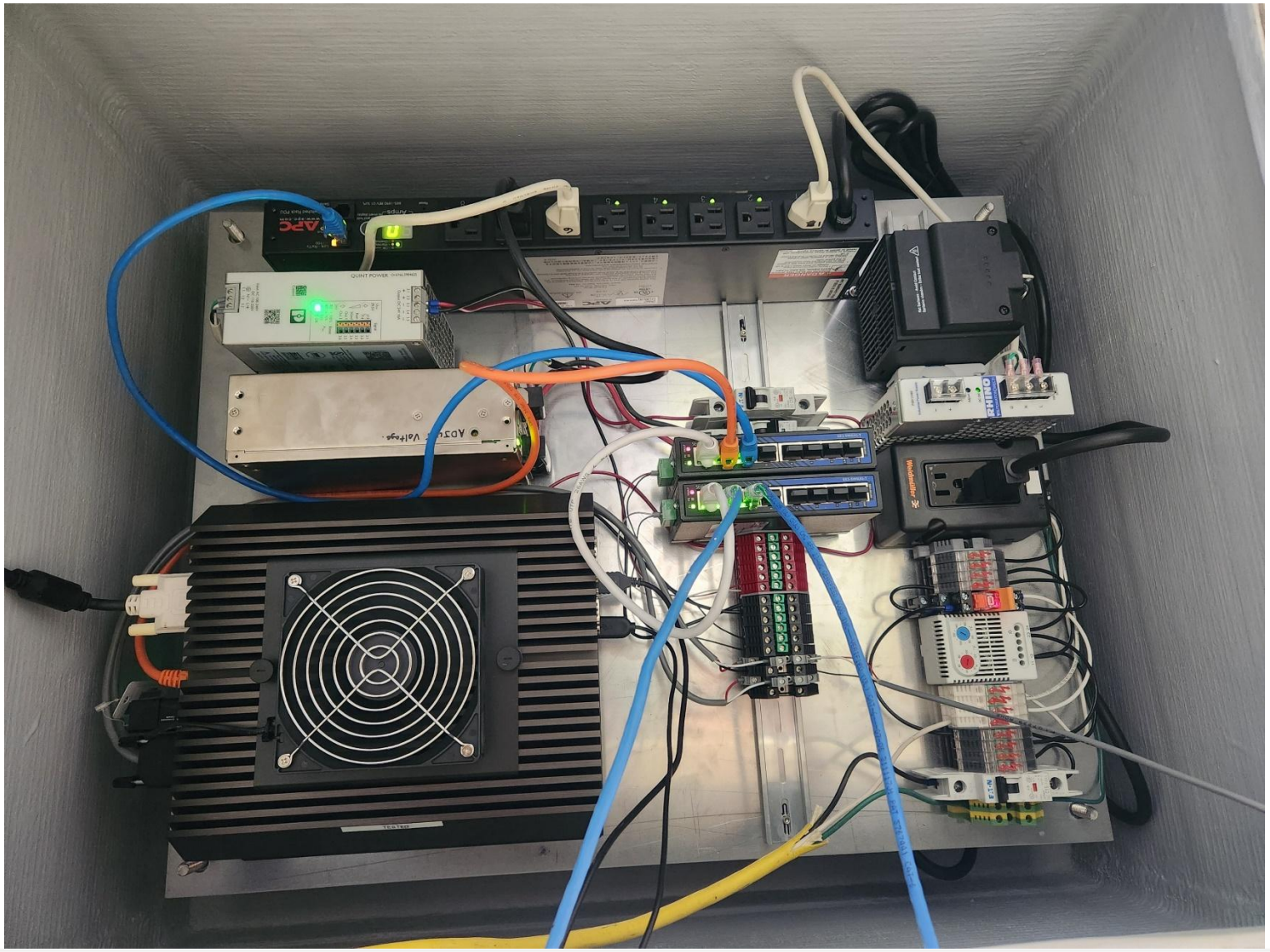
- 24-hr PBL water vapour profiles every ~100 m up to 3 km
- New commercial version deployed to Ottawa airport (fall 2024)
  - Co-located with a Halo lidar and a Radiometrics MWR Radiometer



Results in Toronto using the pre-commercial version

Mariani et al. (2020): Toronto water vapour lidar intercomparison campaign. *Remote Sens.*

DATA COLLECTION SYSTEM



Visible:

- Network Power Switch/Bar
- Heater
- Multiple 24VDC P.S.
- 110VAC Duplex (For UPS)
- Breakers
- Terminal Blocks
- Thermostat
- Brick PC (Windows Data Acq.)
- Dual Network Switches

Under Base Plate

- UPS
- Cellular Modem

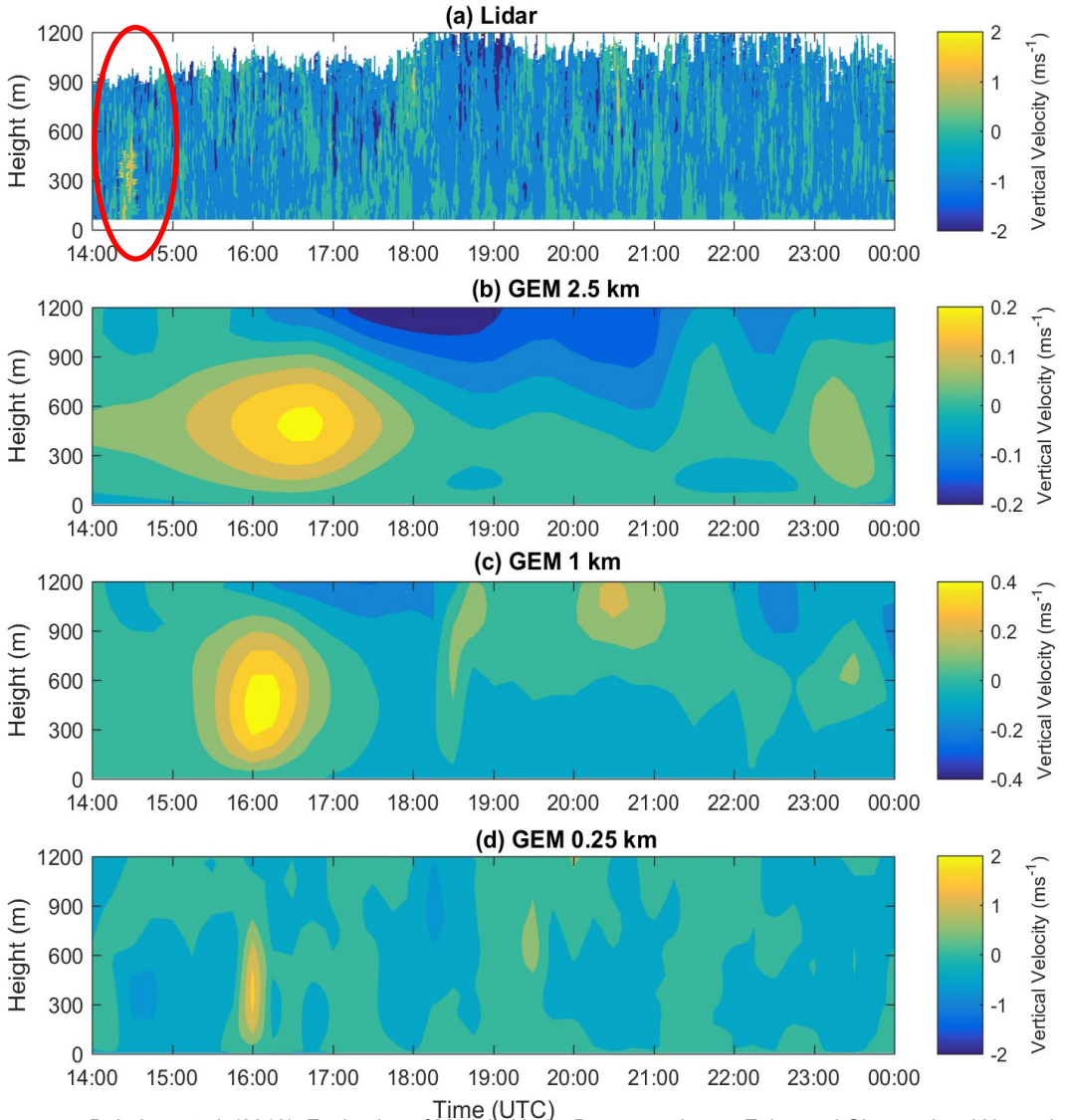
Not Shown: USB HDD

Data is processed and quality-controlled on-site, then FTP'd to ECCC servers for routing and near-real time display

DOPPLER LIDAR OBSERVATIONS: RELIABILITY

- 24/7 autonomous operation during all weather
  - >90% instrument uptime for 6 lidars since 2015
  - Two lidar failures in the past two months: aging hardware (10yrs)?
- Multi-year, multi-site comparisons indicate excellent agreement in the lidar's wind profile observations
  - Average bias against radiosonde < 0.27 m/s[1]
  - Comparisons against ECCC GEM had similar biases[1]
- Comparisons against radar confirm the ability to detect wind shears and stratified wind layers[2]
- Can detect and track fast-moving meteorological features such as the lake breeze front[3]
- Can detect low level jets, enhanced convection (w), cloud base height, and other features

Doppler lidar observation of the lake breeze front at Toronto Island



Dehghan et al. (2018): Evaluation of Modeled Lake Breezes using an Enhanced Observational Network in Southern Ontario: Case Studies *J. Appl. Met. and Clim.*

1: Mariani, Z.; Crawford, R.; Casati, B.; Lemay, F. (2020). A Multi-Year Evaluation of Doppler Lidar Wind-Profile Observations in the Arctic. Remote Sens. 2020, 12, 323. https://doi.org/10.3390/rs12020323
2: Mariani, Z., A. Dehghan, G. Gascon, P. Joe, D. Hudak, K. Strawbridge, and J. Corriveau: Multi-instrument observations of prolonged stratified wind layers at Iqaluit, Nunavut. Geophys. Res. Lett., 45 (3), 1654-1660.
3: Mariani, Z., A. Dehghan, D.M. Sills, and P. Joe: Observations of Lake Breeze Events during the Toronto 2015 Pan-American Games. Boundary-layer Meteor. (Open Access), 166(1), 113-135, DOI: 10.1007/s10546-017-0289-3.

SOLID MESONET: IMPACT ASSESSMENT

Observations:

- 8 Doppler lidars are deployed around Toronto, including one at the Toronto Pearson Airport (CYYZ), forming a Mesonet. Observations are made, processed, & available in near-real time
- One DIAL (water vapour profiling) and MWR radiometer (Radiometrics) are also deployed

Study Period: November 2022 to ongoing

Operational Scopes / Areas of Responsibilities:

- OSPC-DOWNSVIEW (analyze observations from the entire Mesonet **regional forecasters**)
- CMAC-EAST (analyze observations from the Doppler lidar at Pearson **aviation forecasters**)

Study Parameters:

- Observations will be provided to operational forecasters continuously (every 10 minutes, 24/7) during the study period
- Compile case studies and provide qualitative feedback on the impact of Doppler lidar observations on the nowcast
- Collaboration with other governmental departments and federal agencies
- Near-real time product delivery to ECCC's internal data management system and NinJo display software for operational forecasters

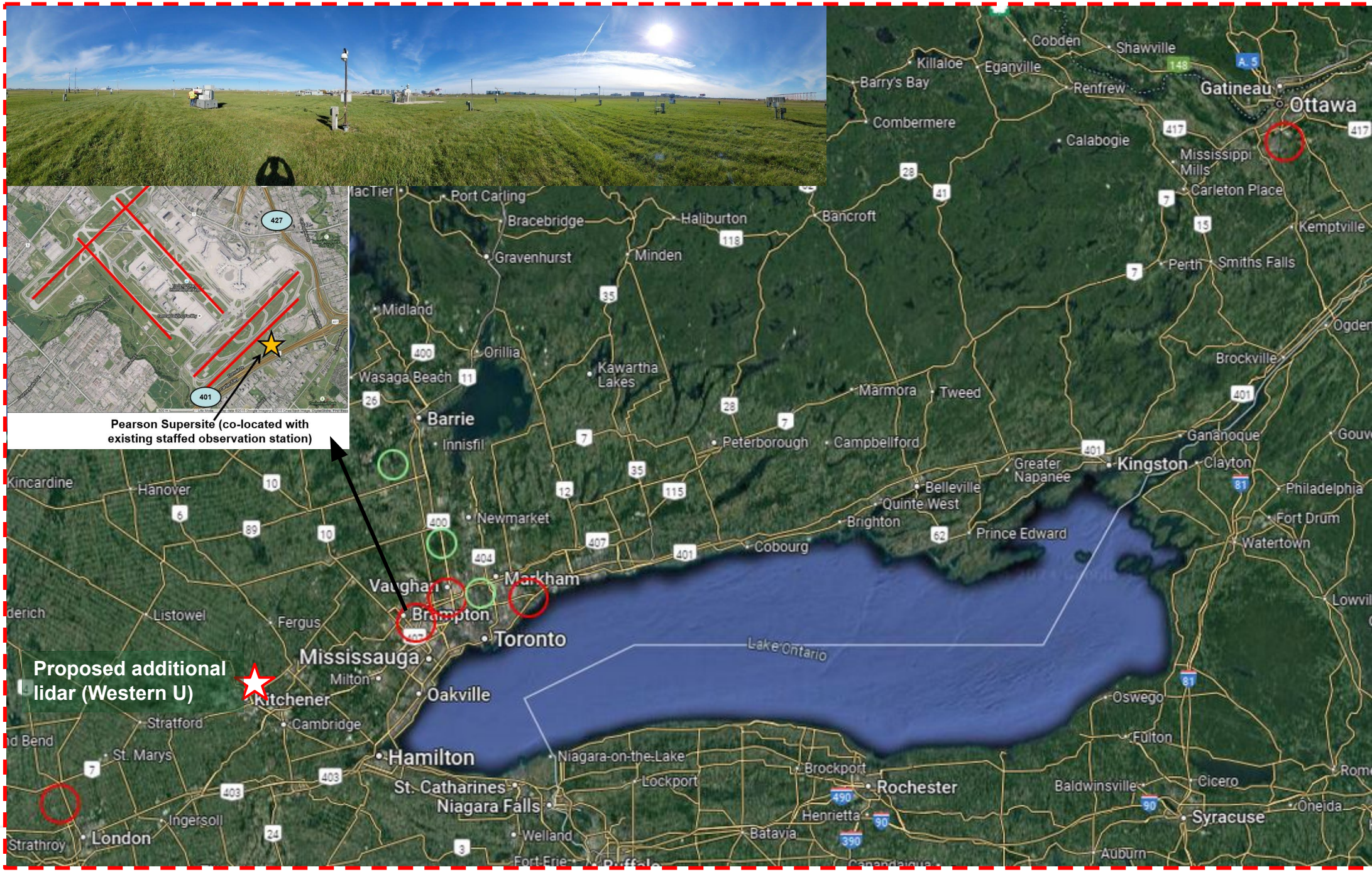
Complementary Mesonets with Similar Instrumentation

The **SOLID Mesonet** is centered around Toronto and is adjacent to U Albany's **NYS Mesonet**

Vertical wind profile available at centre of each circle every 10 minutes

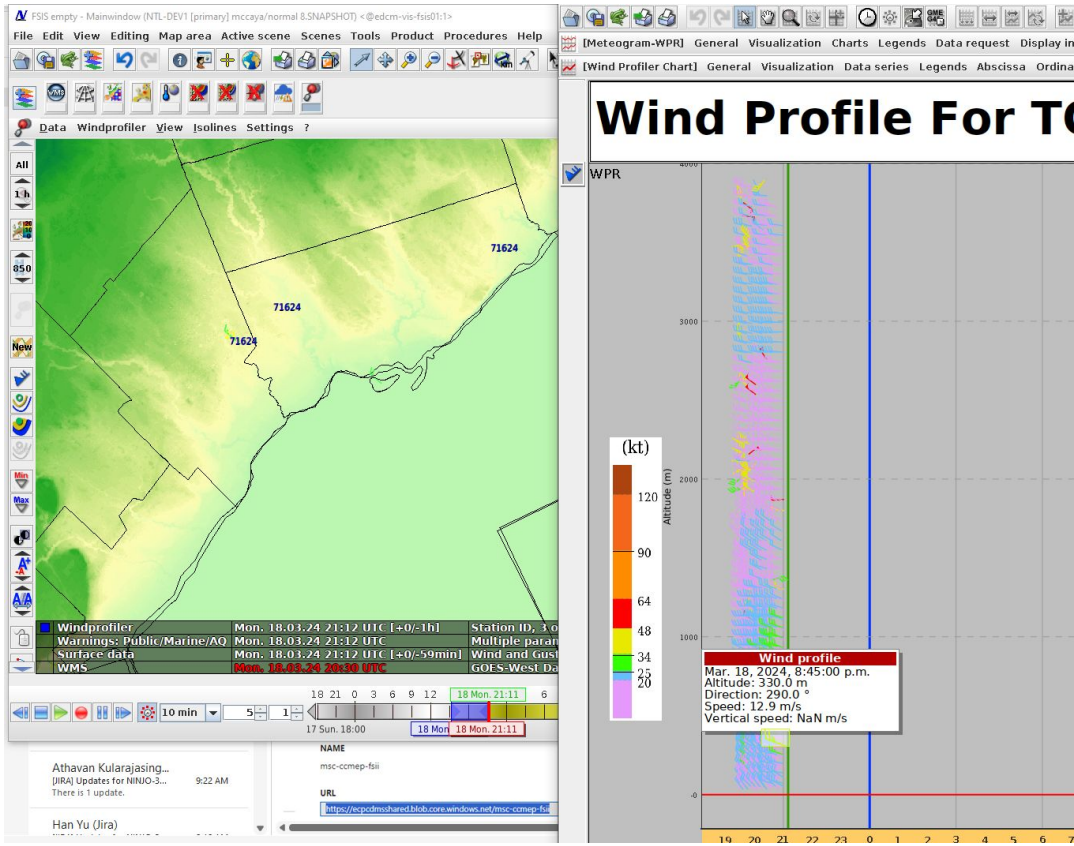
Red = Halo

Green = Leosphere



FORECASTER FEEDBACK: MAIN TAKEAWAYS

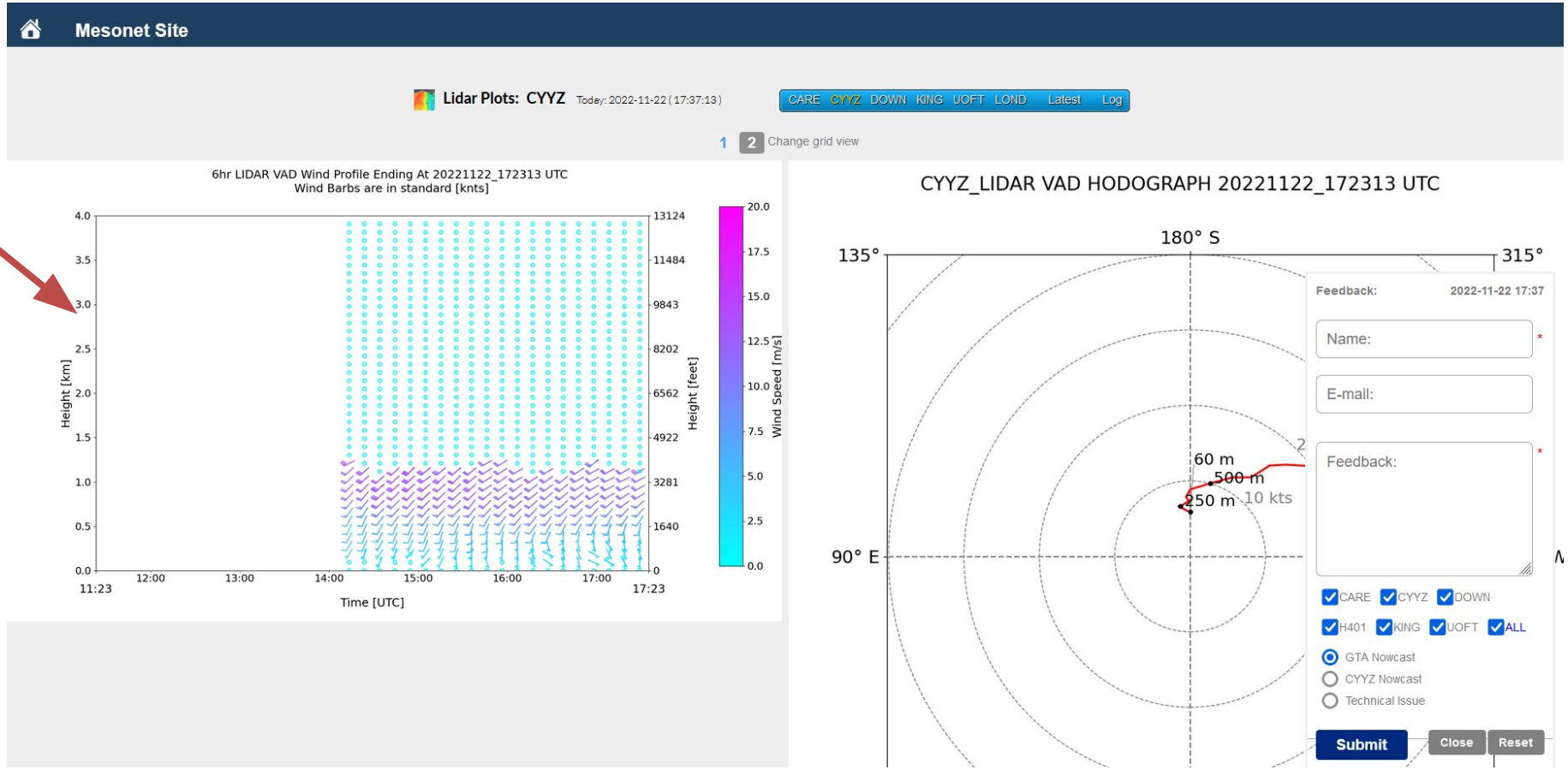
- Positive impact assessment thus far
  - Strong user uptake
  - Investigating potential nowcasting applications
- Primary benefit: aviation nowcasting
  - Increasing confidence in reporting upper air winds
  - Upper air wind data also sent to NavCanada and Pearson Airport Authority
  - Incident reporting and investigations
- Severe weather detection & tracking
  - Convective initiation
  - Storm track adjustments
  - Lake breezes
- Impact analysis ongoing for:
  - Gap-filling upper air observations (complement radiosondes)
  - Potential (?) for derecho and tornado events
  - Network design optimization



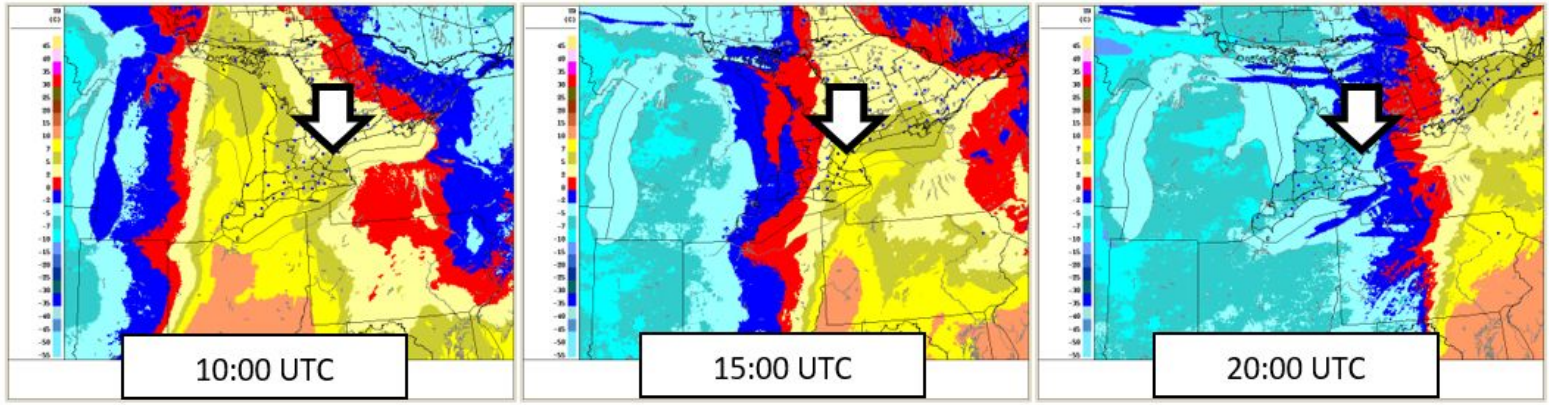
Example real-time wind barb display for operational forecasters on NinJo software

SOLID MESONET REAL-TIME DATA FEED

- Wind profile data is quality controlled & delivered to forecasters in real-time
- NinJo feed available
  - External webpage http://hiwr.ca/mesonet.php to view wind profiles in real-time
- New profile every 10 minutes
- Timelapse available
- Real-time products:
  - Vertical wind profile (u, v),
  - Vertical velocity (w),
  - Cloud base height,
  - Boundary layer height (PBLh)
- Also available: water vapour (from the DIAL) and thermodynamic profiling (from the radiometer)
  - Not yet available in Ninjo



NOWCASTING CASE STUDY 1: COLD FRONT



ages showing the movement of the cold front across Southern Ontario on
e arrows indicate the location of Toronto Pearson Airport. Retrieved from
e Change Canada. (2022). GEM forecast [Dataset].

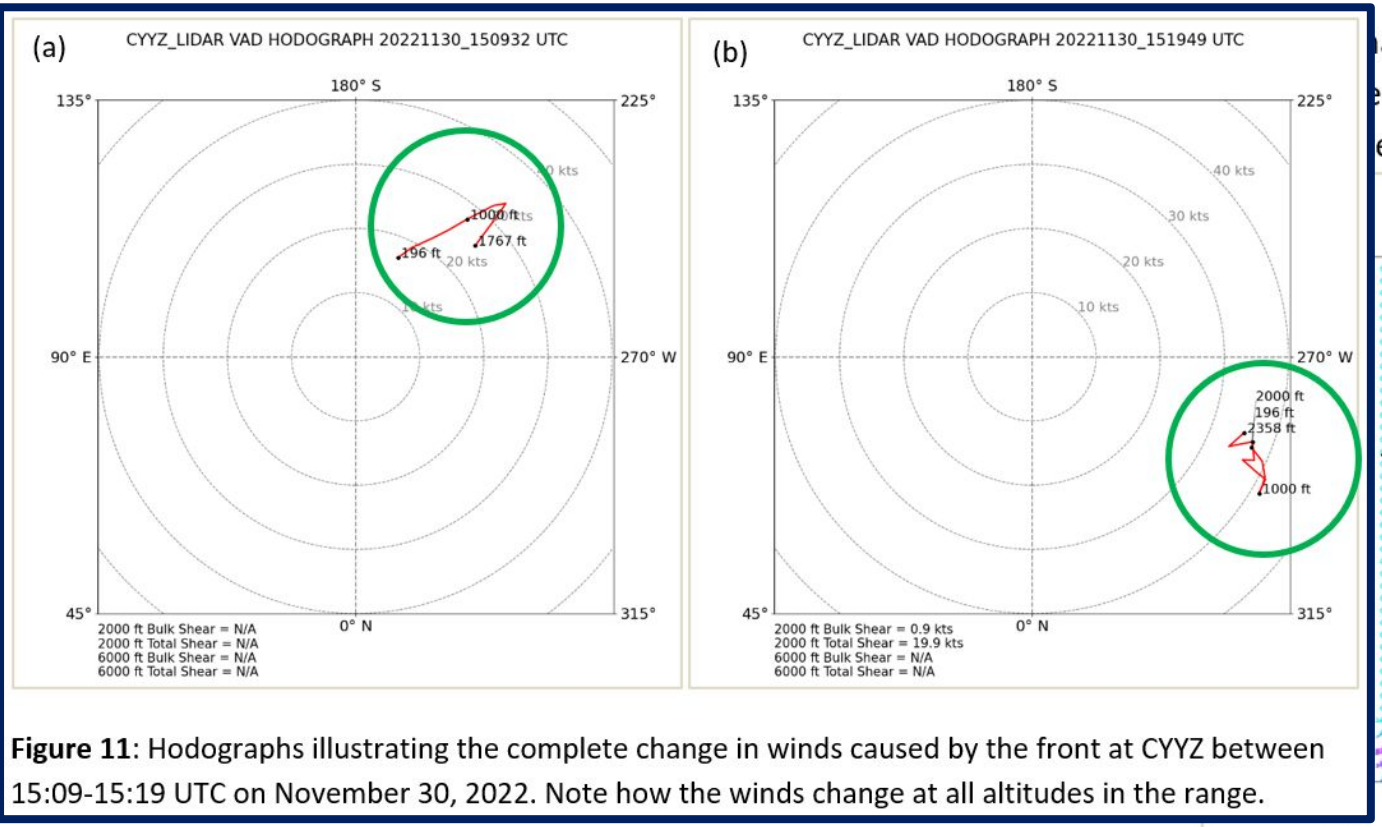


Figure 11: Hodographs illustrating the complete change in winds caused by the front at CYYZ between 15:09-15:19 UTC on November 30, 2022. Note how the winds change at all altitudes in the range.

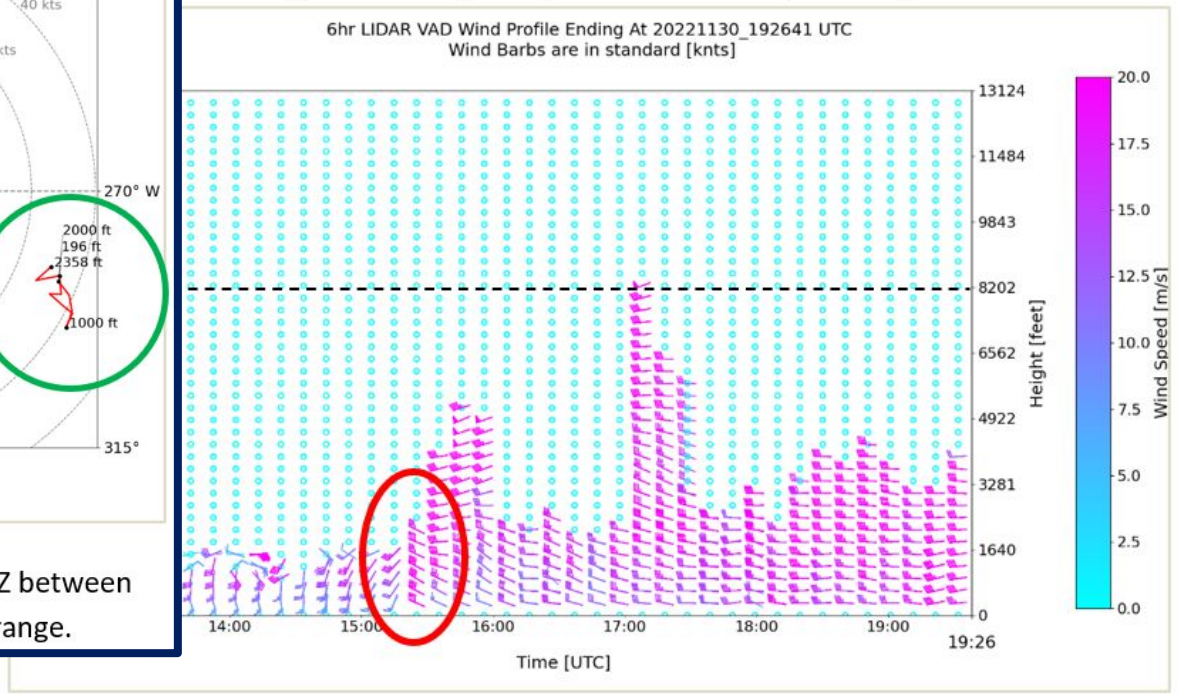
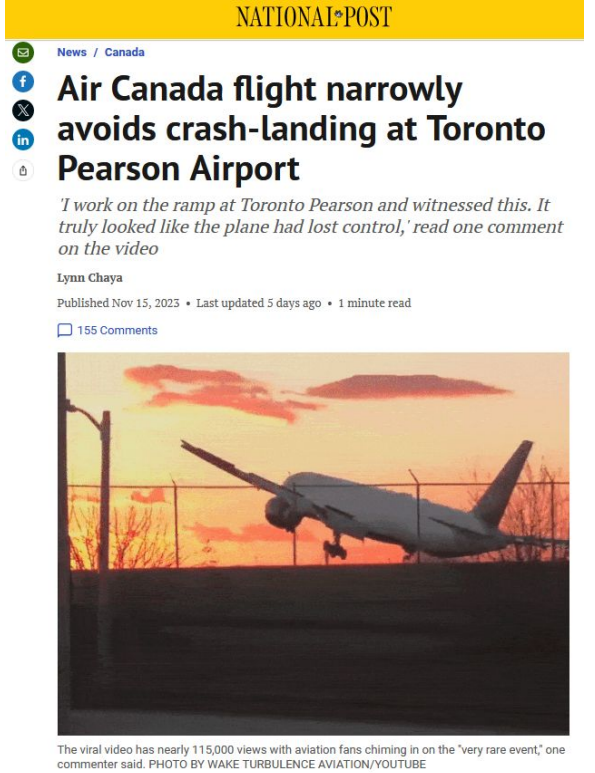


Figure 10: 6-hour VAD wind barb plot from 13:26-19:26 UTC on November 30, 2022 showing the abrupt change in wind speed and direction when the cold front passed the CYYZ site.

NOWCASTING CASE STUDY 2: HARD LANDING AT TORONTO PEARSON AIRPORT

- Cold frontal passage at the arrival time of the Air Canada 777 flight on Nov 13, 2023
- Stronger, surprising NW winds as 100% cross winds immediately prior to landing
- Peak in upwards motion along the cold front, and then rapid switch to descent in behind the front (vertical velocity plot: blue = downward motion)
- **Mesonet is the only source of upper air wind data**
- Case is still under investigation



NATIONAL POST

News / Canada

Air Canada flight narrowly avoids crash-landing at Toronto Pearson Airport

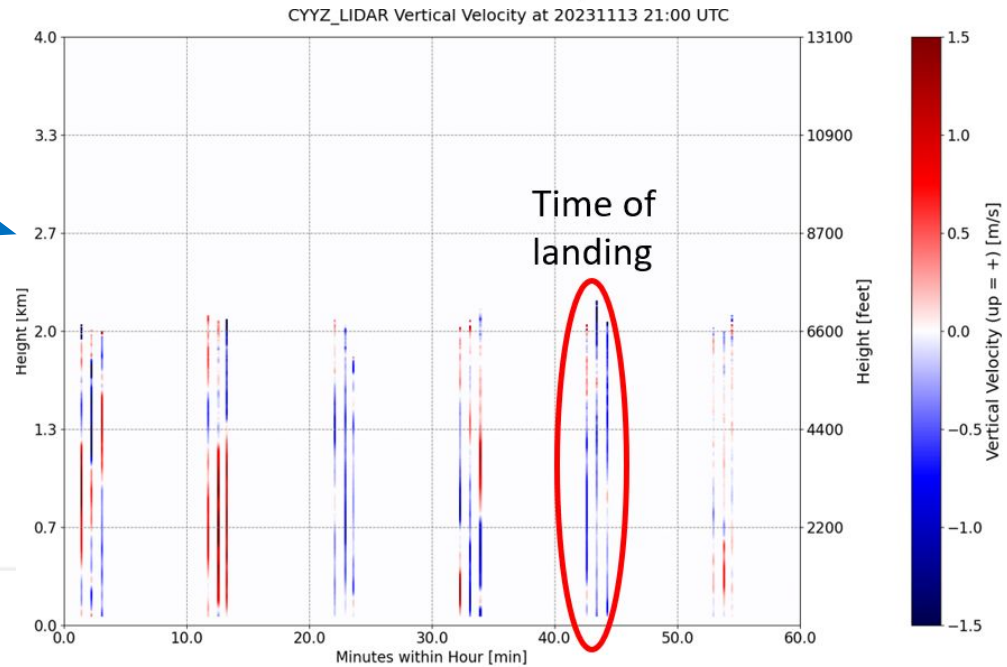
'I work on the ramp at Toronto Pearson and witnessed this. It truly looked like the plane had lost control,' read one comment on the video

Lynn Chaya

Published Nov 15, 2023 • Last updated 5 days ago • 1 minute read

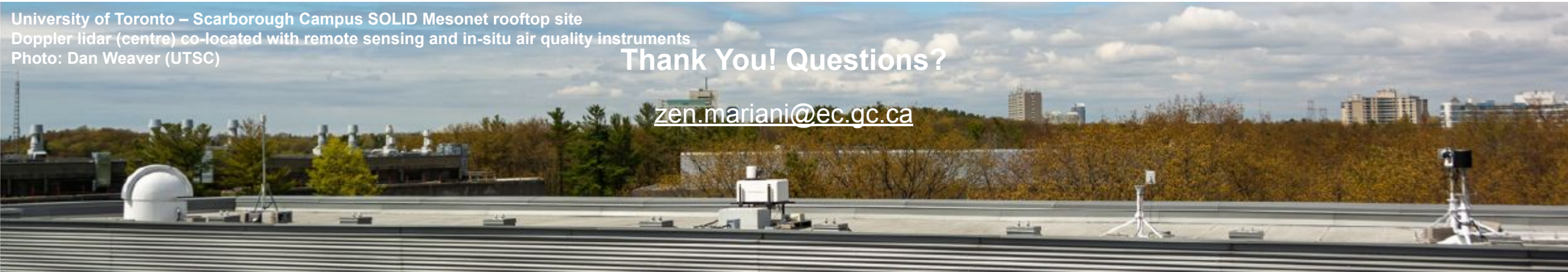
155 Comments

The viral video has nearly 115,000 views with aviation fans chiming in on the "very rare event," one commenter said. PHOTO BY WAKE TURBULENCE AVIATION/YOUTUBE



Conclusions

- SOLID Mesonet provides 24/7 observations to operational forecasters from 8 Doppler lidars, one DIAL (water vapour profiling), and one radiometer (T, water vapour profiling)
- Data is openly available (archive or real-time, raw vs. products, all available)
- Focus has been on winds: demonstrated need for co-located thermodynamic profiling
- Positive impact assessment and user feedback from operational forecasters
- Additional applications:
  - Developing interpolated meteorological indices (SOLID+NYS Mesonet) on the grid for severe weather indices
  - SOLID Mesonet observations for air quality studies and modelling (e.g., Study of Winter Air Pollution in Toronto, SWAPIT campaign, winter 2024)
  - Ottawa airport site aircraft calibration/validation campaigns (e.g., the current ESA EarthCARE and FORUM satellite cal/val campaigns)



Thank You! Questions?

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