Canadian weather radar network renewal and the southern Ontario lidar mesonet

Daniel Michelson and Zen Mariani

High Impact Weather Research, Meteorological Research Division
Atmospheric Science and Technology Directorate
Science and Technology Branch

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Northern Hail Project Workshop
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Canada

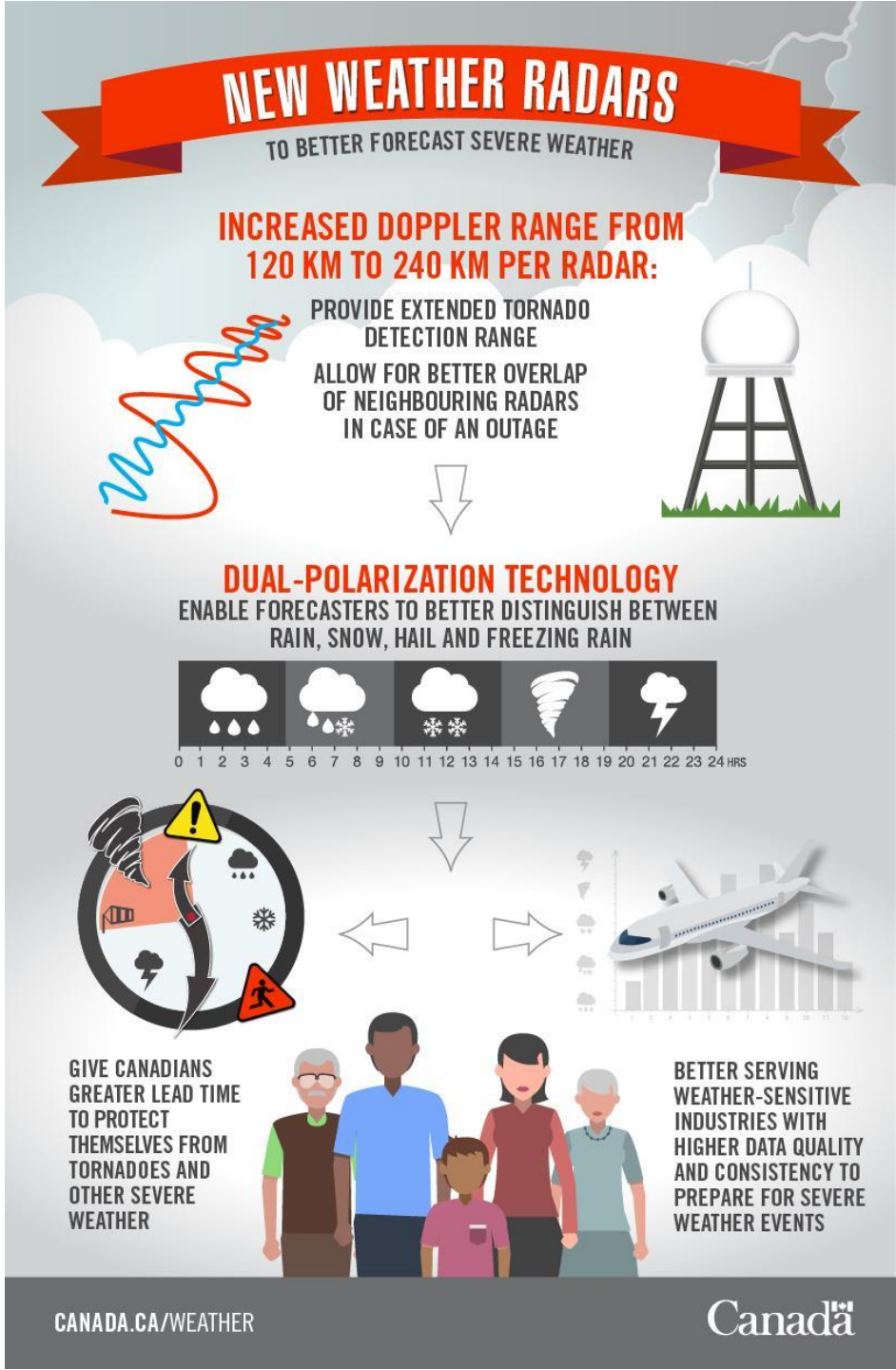
“Generational” renewal

Once-in-a-generation event for the majority of people involved

Generational change of radar technology

- C-band to S-band wavelength
- Magnetron to klystron transmitter
- Conventional (Doppler) to polarimetry
- In-house integration to commercial off-the-shelf (COTS) hardware solution
- Change of industrial vendor
- New data representation (file formats)

Applications: from largely qualitative to qualitative and quantitative



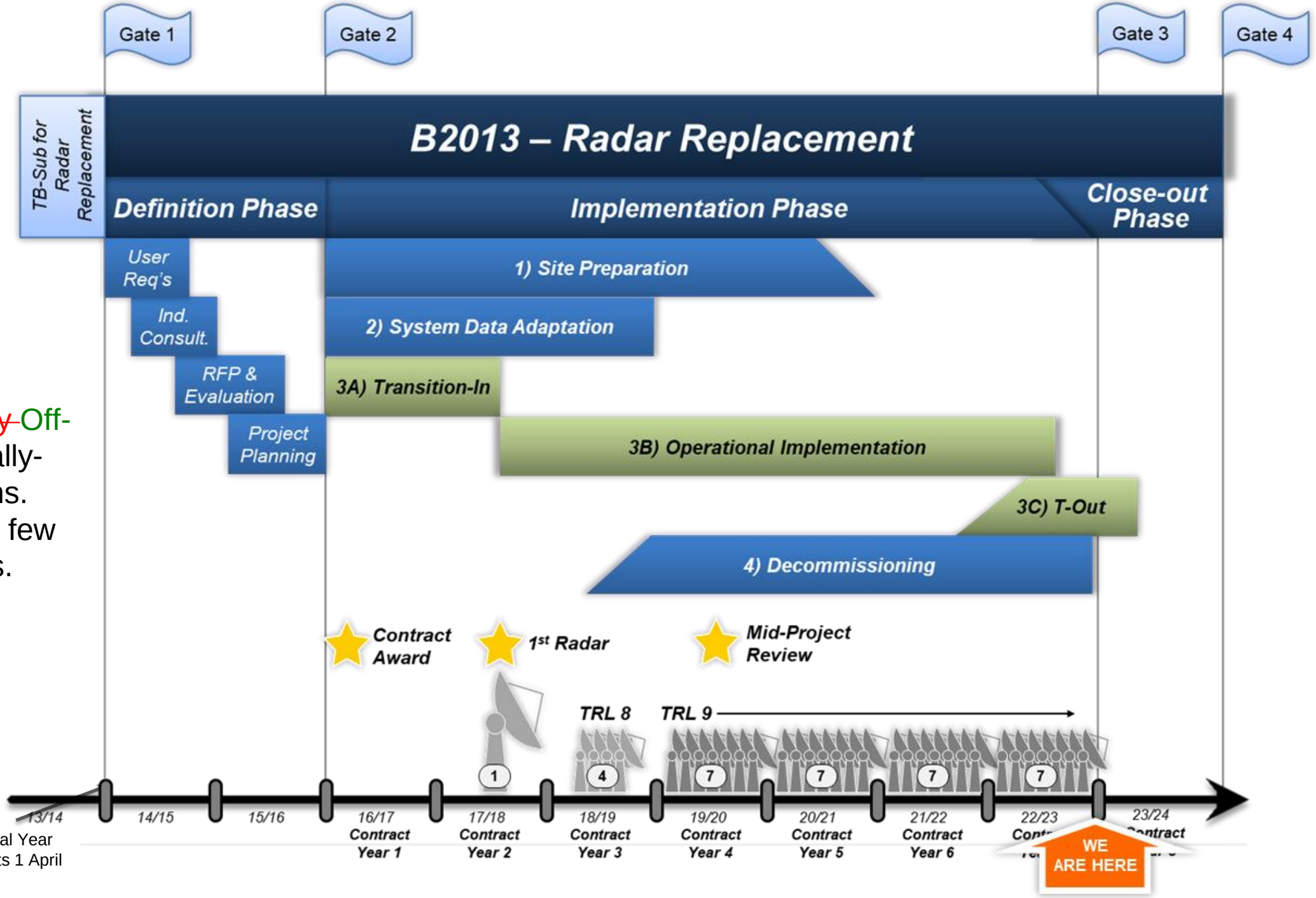
Technology – Key Differences

	98A (Andrews)*	98E (Enterprise)	98R (Raytheon)	**1700S (Selex)**
Operating Band	C-band (5.6-5.65GHz)			**S-band (2.7-2.9GHz)**
Antenna Diameter	6.1 m	4.2 m	4.2 m	**9.15 m**
Antenna Gain	49.2 dB	43.0 dB	42.9 dB	**45.8 dB**
Beam Width	0.62°	1.1°	1.1°	**0.88/0.86°**
Radome Diameter	9.1 m	5.5 m	5.5 m	**11.8 m**
Polarization	Single Pol, H-only *King and Exeter Radars are Dual Pol			**Dual Pol (H+V - STAR)**
Transmitter (Tx)	Magnetron / 250k W			**Klystron / 1MW**
Tx/Rx Location	Ground level at base of tower			**Below Radome**
Reflectivity Range	~250 km (CONVOL)			**240 km (PVOL6S)**
Doppler Range (@48m/s)	120 km			**240 km**
Receiver (Rx) Resolution	12 or 14bit			**16 bit**
Min. Detectable Signal	-107 to -115dBm			**≤ -114dBm**
Signal Processor	RVP7/8			**GDRX**
Operating System	**Linux**			
Monitoring Software	BITEX - Radmon			**RAVIS**
Maintenance Interval	6 / year			**2 / year**

CWRRP continues to be on time and under budget…

Commercial ~~Turn-key~~ Off-The-Shelf operationally-ready site installations. Mostly existing sites, few completely new ones.

Total contract value: $148M CAD with ~~SELEX~~Leonardo GmbH



Fiscal Year starts 1 April

With completion of the final two radars this year…

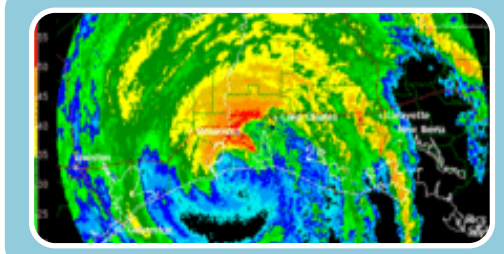
Population Coverage: S-Band Radar	Population Count	% Total Population*
240 km (Doppler Range)	36,538,617	98.774%
330 km (Extended Range)	36,668,160	99.125%

* 2021 Census Population Count: 36,991,981

New sites – west to east
Halfmoon Peak, British Columbia
Fort McMurray, Alberta
Egbert, Ontario (offline, training/testing)
Blainville, Québec

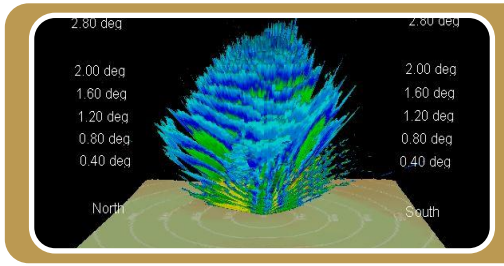
…more than 99% of the population will be within 330 km of a radar.

How to access radar data/products



Real-time Imagery

- Radar layers available via geospatial web services on GeoMet-Weather
- GIF radar imagery available on the MSC Datamart



Real-time Data/Products

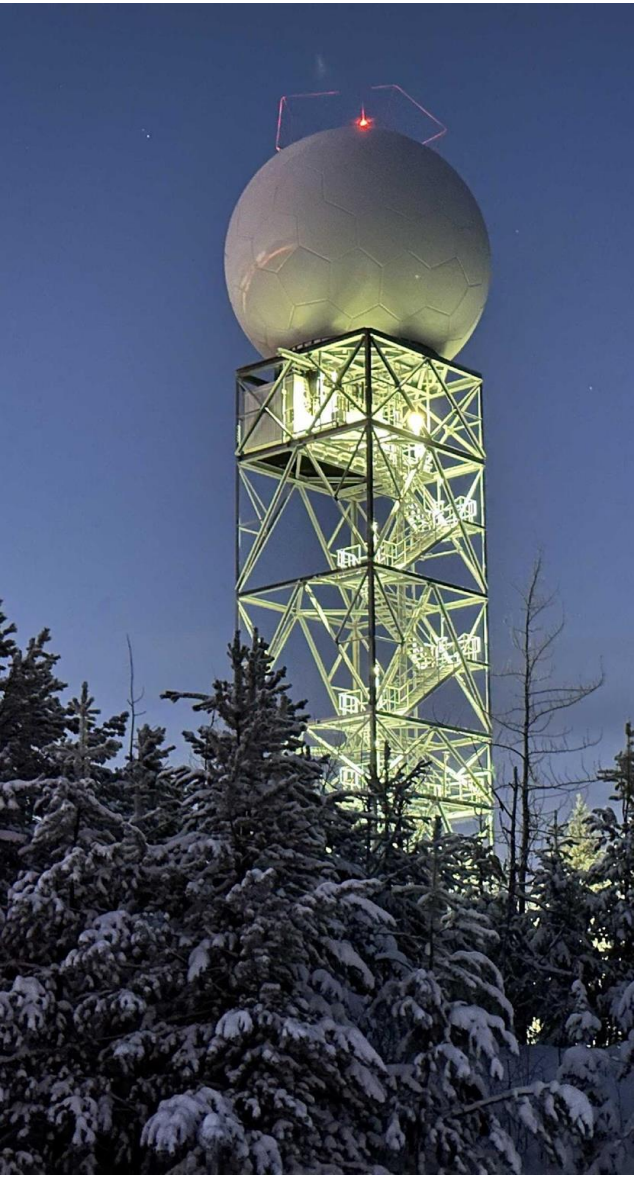
- Provided by a cost-recovered service 24/7 in different formats, e.g. polar volumes (ODIM_H5), Cartesian products (internal)

Archived Radar Data/products

- Historical Radar : free imagery archive
- Provided by a cost-recovered service
- Contact: ec.dps-client.ec@canada.ca

Meteorological Service of Canada's Open Data Pilot Project: eccc-msc.github.io

Prince George BC



Marble Mountain NL

Silver Star BC

Radar Hardware Replacement Summarized

Science & Technology Branch contributions

As Scientific Authority for CWRRP

- Address site quality, e.g. tower heights
- Develop and optimize data acquisition
  - ✓ Scan strategy
  - ✓ Signal processing
- Radar Network Quality Assurance
- Adapt/extend radar processing applications
- Leverage dual-polarization for
  - ✓ Quality Control
  - ✓ Particle Classification
  - ✓ Quantitative Precipitation Estimation
  - ✓ Radar Data Assimilation

Blainville, Québec, 2018

Doppler lidars: observations relevant to the Study of Winter Air Pollution In Toronto - SWAPIT

- Vertical wind profiling (u, v, w)
- Aerosol backscatter profile
- Convective initiation
- Sea (lake) breeze
- Turbulence
- Boundary Layer Dynamics
  - Planetary boundary layer height estimation
  - Cloud cover
- …

Halo lidar deployment at the Experimental Lakes Area
Low-level turbulence observations over the lake boundary
Collaboration with HIWR and RPN-E

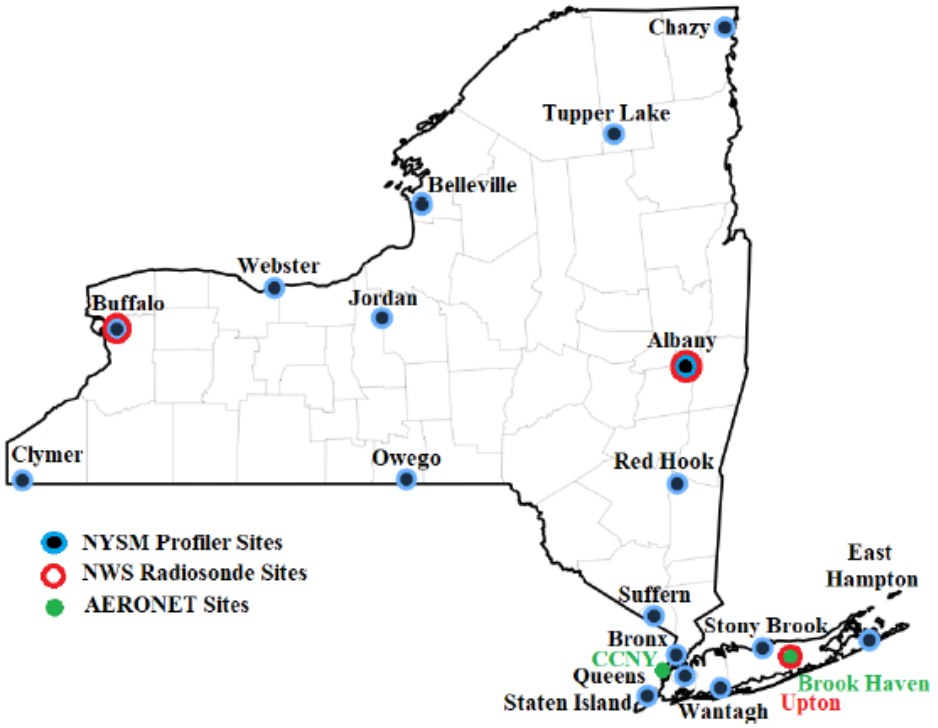
University of Toronto – Scarborough Campus
Doppler lidar rooftop site co-located with air quality instruments
Photo: Dan Weaver (UTSC)

Examples of lidar mesonets

- Examples of other agencies deploying Doppler lidar Mesonets for nowcasting:

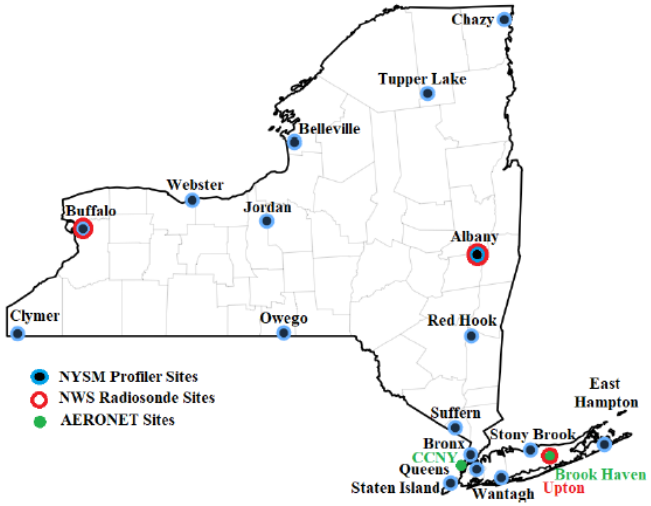
EU's COST action: PROBE[1]

New York State Mesonet



NYS Mesonet: forecaster feedback

- Observations sent to the National Weather Service (NWS) in near-real time since 2016 to support NWS operations
- NWS operations have mentioned lidars in their reports for:
  - Forecast confirmation / changes,
  - Severe storm development,
  - Monitor, predict VFR conditions
  - Low-level advection, wind channeling, cloud development
- Positive feedback from Storm Prediction Centre (Oklahoma):
  - Severe storm watches over NY
  - Identification of low-level jets and sea breeze days
  - Observations used “regularly”
- Challenge: visualization (currently not in their AWIPS system)



SO lidar mesonet – SOLID – impact assessment

Observations: Several Doppler lidars will be deployed across Southern Ontario (SO), including one at Pearson Airport (CYYZ), forming a Mesonet. Observations will be made available in near-real time.

Study Period: Ongoing since November 2022

Operational Scopes / Areas of Responsibilities:

- Ontario Storm Prediction Centre - DOWNSVIEW (analyze observations from the entire Mesonet)
- Canadian Meteorological Aviation Centre - EAST (analyze observations from the Doppler lidar at Pearson)

Study Parameters:

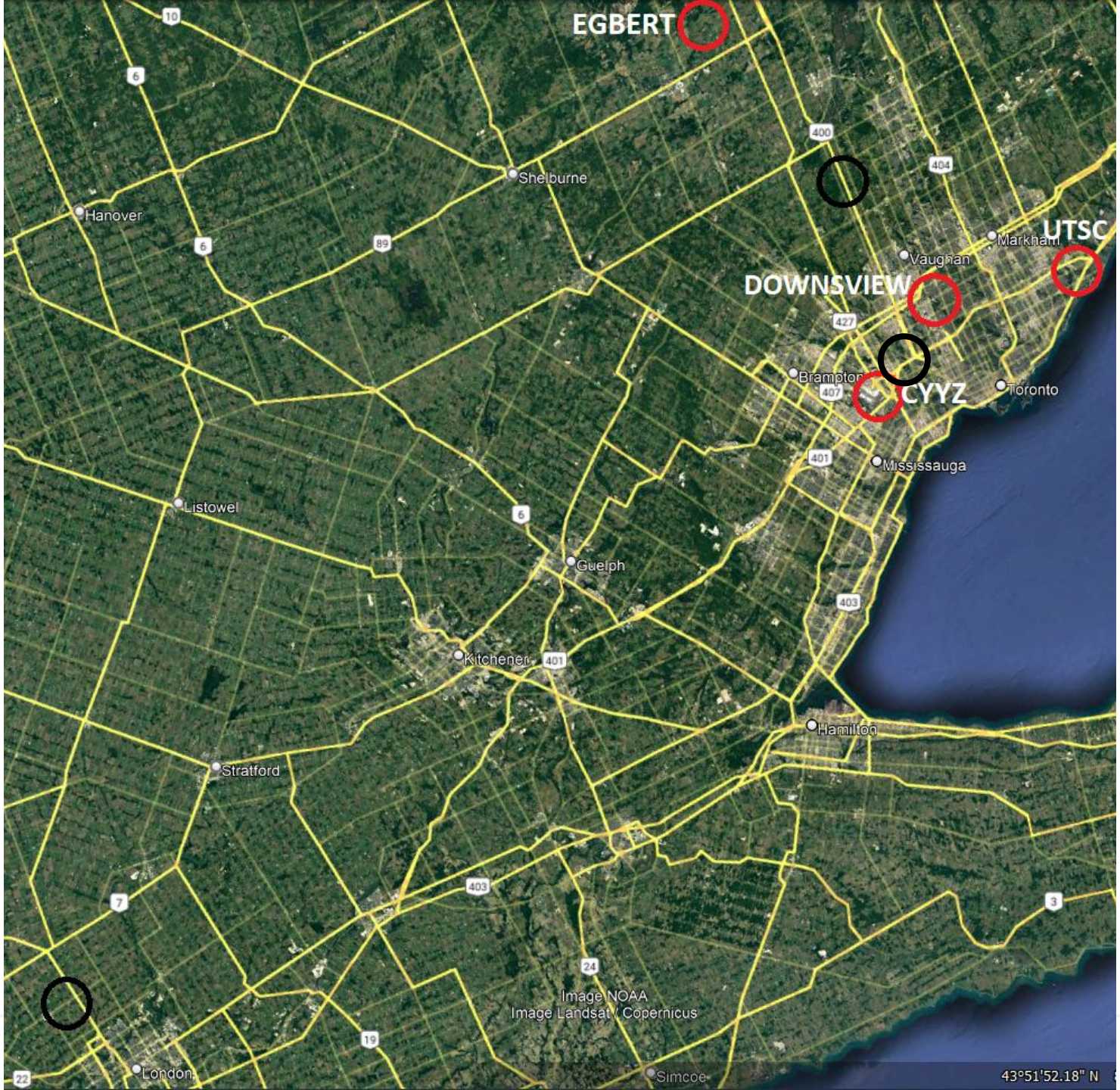
- Observations will be provided to operational forecasters continuously (every 10 minutes, 24/7) during the study period
- Compile case studies and provide qualitative feedback on the impact of Doppler lidar observations on the nowcast
- Collaboration with among MRD-HIWR, MSC-OSE, and MSC-DMS
- Near-real time product delivery to GTS and NinJo display software for operational forecasters

MRD-HIWR PEARSON SITE
“CYYZ”
(SINCE 2009)

+SWAPIT INSTRUMENTS

Pearson Supersite (co-located with existing staffed observation station)

SOLID MESONET



Lidar observations available at centre of each circle every 10 minutes

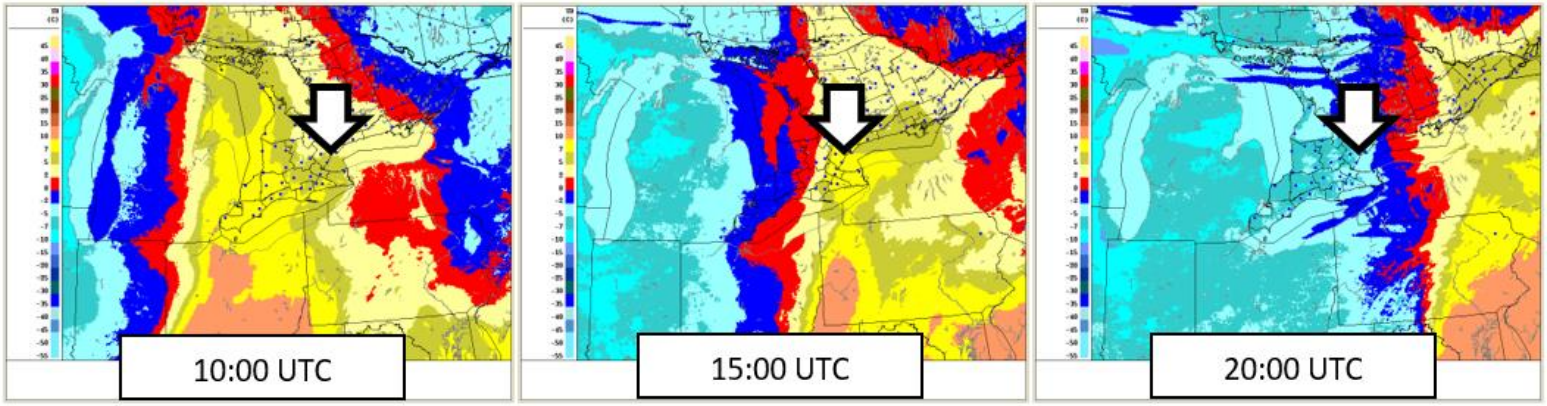
Red = current
Black = planned

SOLID MESONET

Lidar observations available at centre of each circle every 10 minutes

Red = current
Black = planned

Nowcasting Case study: cold front



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

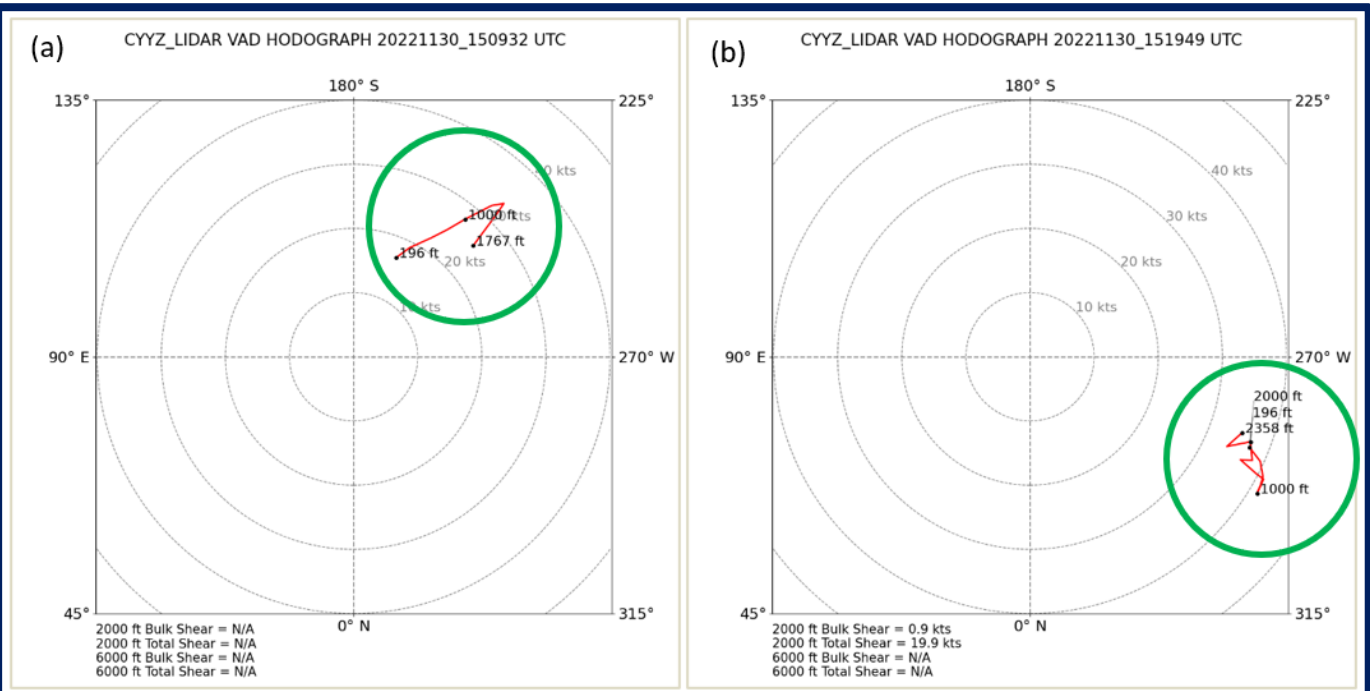


Figure 11: Hodographs illustrating the complete change in winds caused by the front at CYYZ between 15:09-15:19 UTC on November 30, 2022. Note how the winds change at all altitudes in the range.

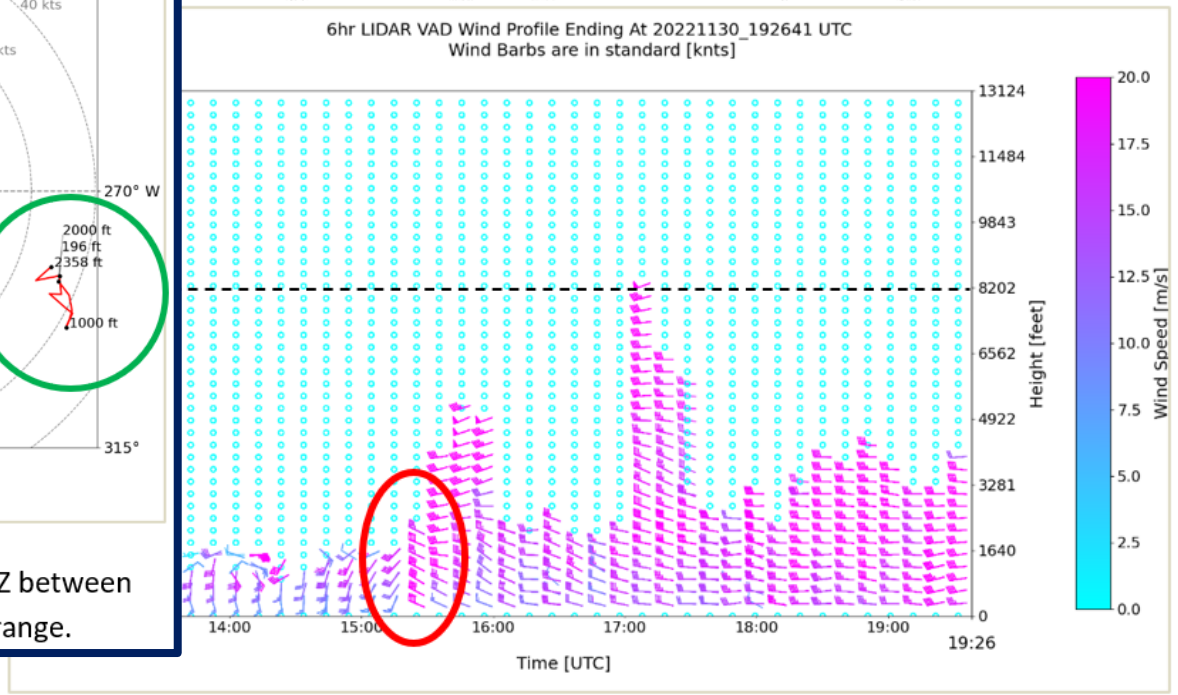


Figure 10: 6-hour VAD wind barb plot from 13:26-19:26 UTC on November 30, 2022 showing the abrupt change in wind speed and direction when the cold front passed the CYYZ site.

Interp

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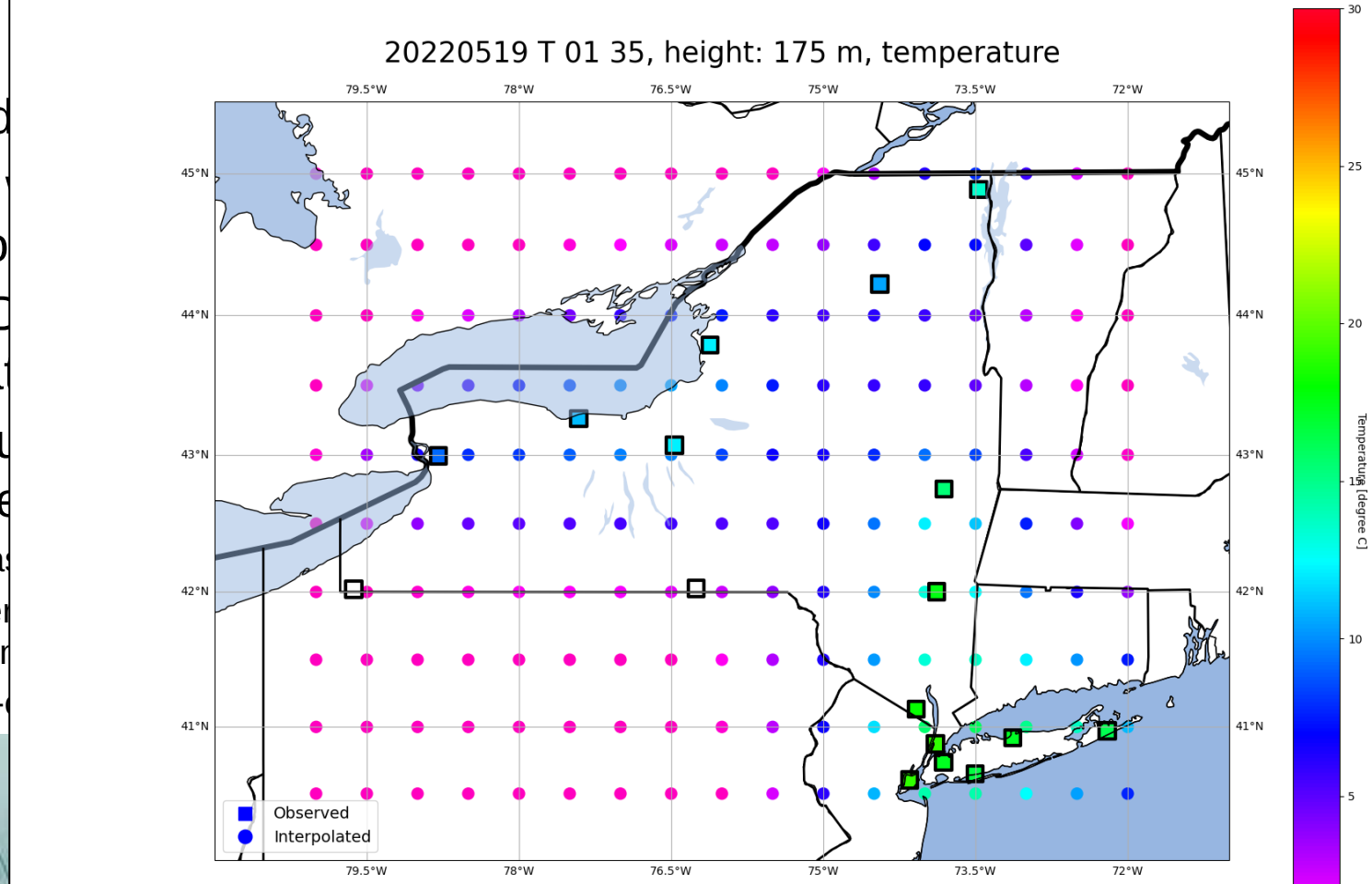
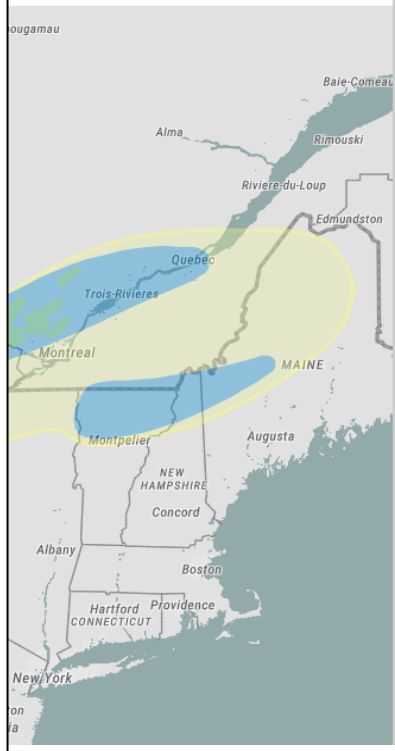
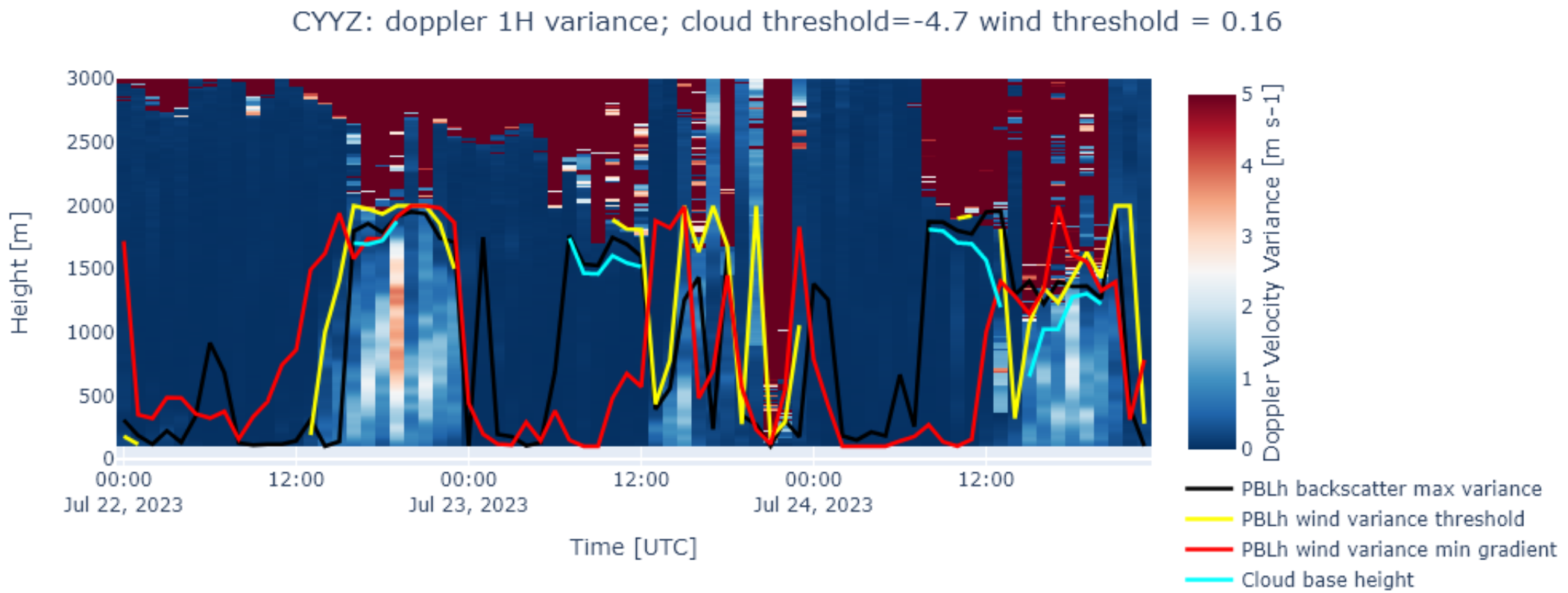




Cloud Base Height and Planetary Boundary Layer height (PBLh) observations

- Cloud base height product available
- Three updated PBLh algorithms developed
  (backscatter, Doppler velocity variance, Doppler velocity threshold)
  - Each method has its own advantage/disadvantage depending on conditions
- Available at each site at high temporal resolution (e.g., 10 – 60 min)
- Output in simple text files or quick look plots are also available



Thank you
Merci