Surface Observations for the EarthCARE Commissioning Cal/Val Campaign in Ottawa (ECALOT)

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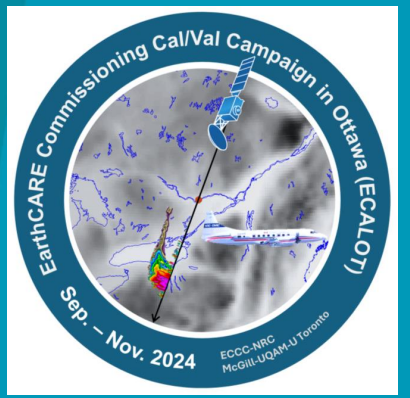
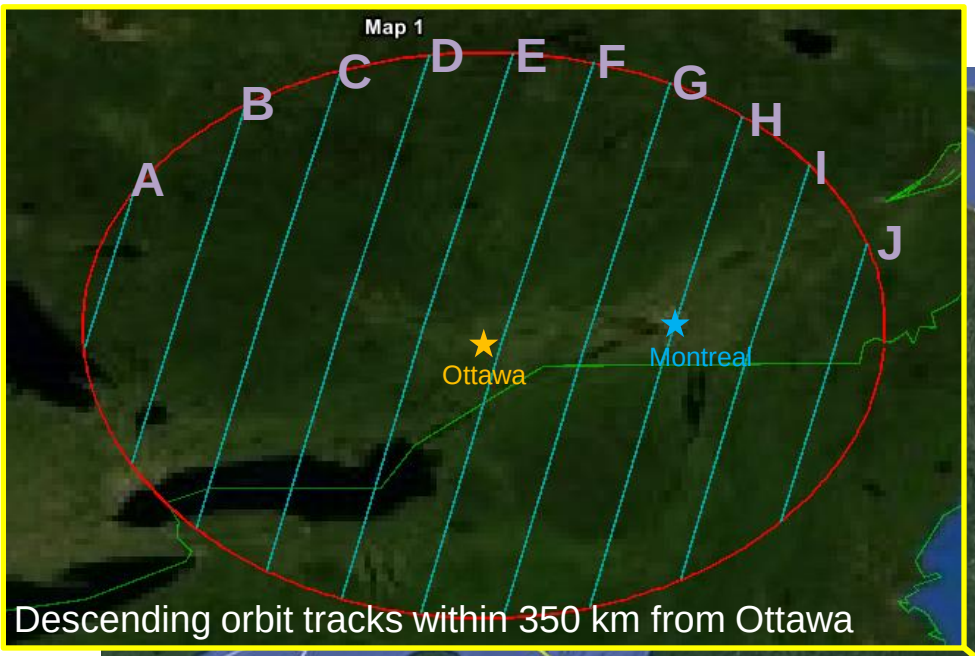


2nd ESA-JAXA EarthCARE in orbit Validation Workshop
March 18 2025

Eastern Canada

Zhipeng Qu's talk on the ECALOT campaign
(this morning)



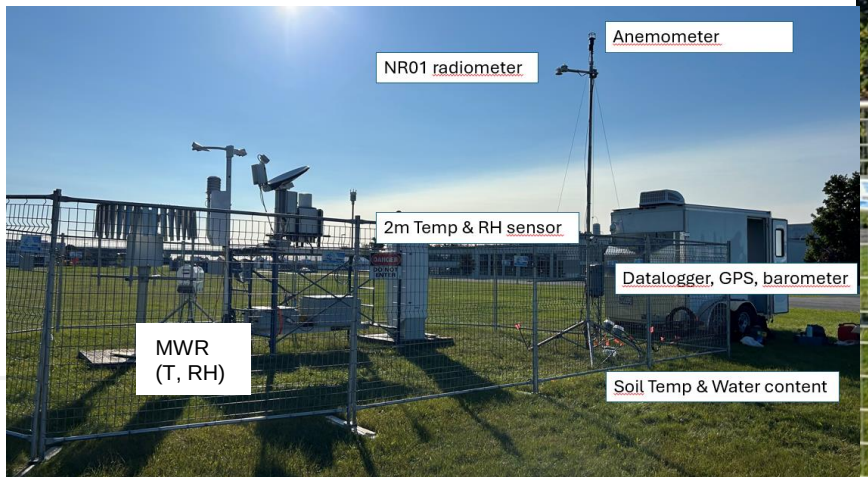
EarthCARE Commissioning Cal/Val Campaign in Ottawa (ECALOT)
Sep. – Nov. 2024
ECCC-NRC
McGill-UQAM-U Toronto

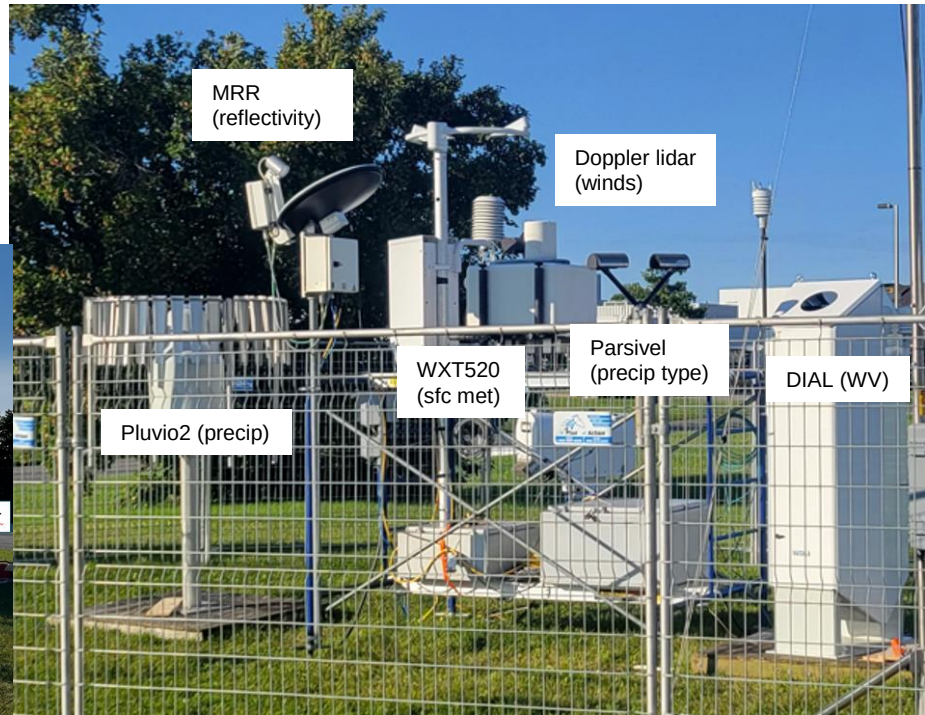
Ottawa Airport (“CYOW”) Site

Surface site (Yellow)
< 1 km from either runway

ECALOT Surface Site: 24/7 Observations

- Surface site deployed September 2024 (pre-campaign)
  - Remote access: all instruments and software are remotely-accessible (enables live status updates, remote troubleshooting, etc.)
  - Minimal downtime (1 hr gap in Doppler lidar during flight 3)
  - MWR Radiometer down for one flight (January)
- ECCC surface Data post-processing & consolidation
  - Raw data acquired by instruments & data loggers, archived and QC'd on-site
  - Quick-look plots ("products") and flat files generated, displayed in real-time and archived
  - Post-processing, data archiving and consolidation underway
  - GEOMS format conversion underway





Instrumentation & Processing

Instrument	Geophysical Variable	Processing Performed
Pluvio2	Snow/rain rate	ECCC: on-site, real-time
Parsivel	Snow/rain rate, hydrometeor classification	ECCC: on-site, real-time
FD71P	Snow/rain rate, hydrometeor classification, visibility	ECCC: on-site, real-time
WXT520	Surface met (P, T, RH, winds, precip rate)	ECCC: on-site, real-time
MRR	Rain rate, etc.	ECCC: on-site, real-time
Doppler lidar	Vertical wind profile Cloud base height PBL height Aerosol backscatter profile	ECCC: on-site, real-time
DIAL (WV) lidar	Vertical water vapour profile Cloud base height Aerosol backscatter profile	ECCC: on-site, real-time by Vaisala software
MP3000 radiometer (“MWR Radiometer”)	Vertical thermodynamic profiling (WV, T)	ECCC: on-site, real-time by Radiometrics software
AERI	Downwelling IR radiation	McGill U (climate sentinel)
NR01 Net radiometer	SW & LW upwelling/downwelling radiative fluxes	McGill U (climate sentinel)

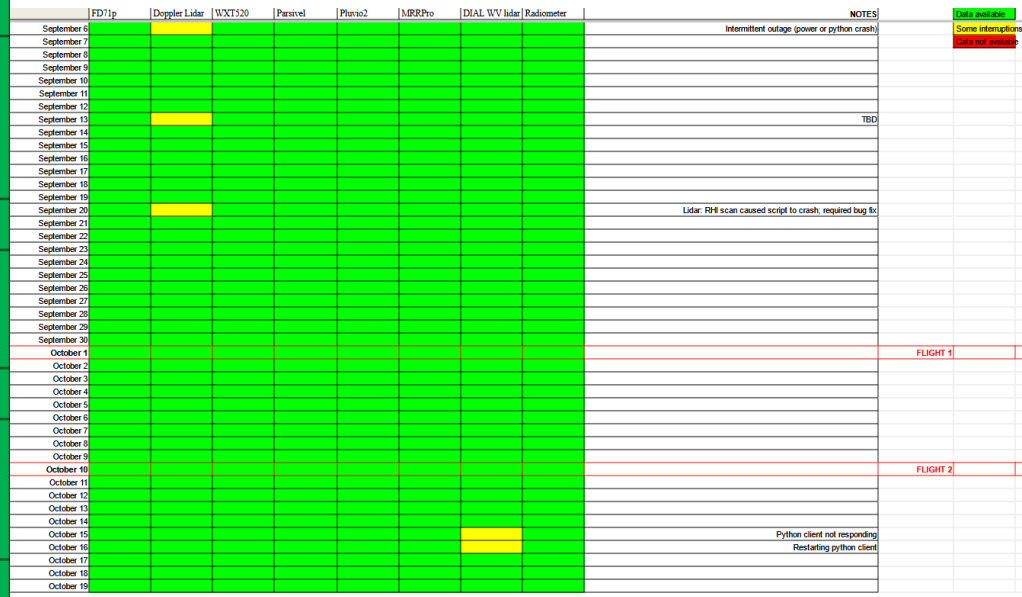
Lei Liu’s talk on AERI results tomorrow

Instrument Status & Reporting during ECALOT

Instrument Status Report for Each Flight

A	B	C	D	E
Instrument	**Raw Data Location**	**Products Location**	**Operational Plan**	**Status**
FD71p	BRICK C:\DAQ\DataFiles\	Not stored locally (Science network)	24/7 automated observations: 1. Luminance 2. Visibility 3. Precipitation rate & type	Operational
Doppler Lidar	BRICK pc C:\halo\data\	BRICK pc C:\halo\PRODUCTS\	10-min Scan sequence: 1. Vertical stare & depolarization ratio 2. VAD 6-bean 4. VAD 8-beam 5. RHI (o TBD pending EarthCARE\) 6. Cloud base height product 7. Planetary boundary layer height product	Operational
WXT520	BRICK pc C:\DAQ\DataFiles\	Not stored locally (Science network)	24/7 automated observations: P, T, RH, winds, precip	Operational
Parsivel Disdrometer	BRICK pc C:\DAQ\DataFiles\	Not stored locally (Science network)	24/7 automated observations: 1. Precipitation type 2. Precipitation intensity 3. Drop size distribution 4. Radar reflectivity (raw data)	Operational
Pluvio2	BRICK pc C:\DAQ\DataFiles\	Not stored locally (Science network)	24/7 automated observations: 1. Precipitation rate & accumulation	Operational
MRRPro	BRICK pc C:\MRR Data\	Not stored locally (Science network)	24/7 automated observations: 1. Radar reflectivity 2. Doppler spectra (vertical velocity) 3. Rain rate 4. Liquid water content 5. Bright band height (melting layer)	Operational
Vaisala DIAL WV lidar	BRICK pc C:\	Not stored locally (Science network)	24/7 automated observations: 1. Backscatter profile 2. Water vapour profile	Operational
Radiometrics Radiometer	Radiometer PC	Not stored locally (Science network)	24/7 automated observations: 1. Temperature profile 2. Water vapour profile 3. Relative Humidity profile	Operational

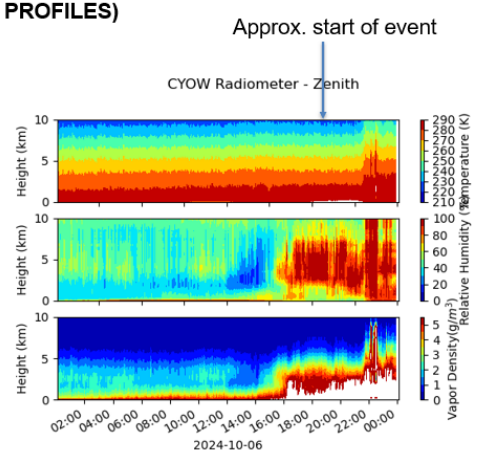
Month at a Glance



Case study: asperitas clouds at CYOW

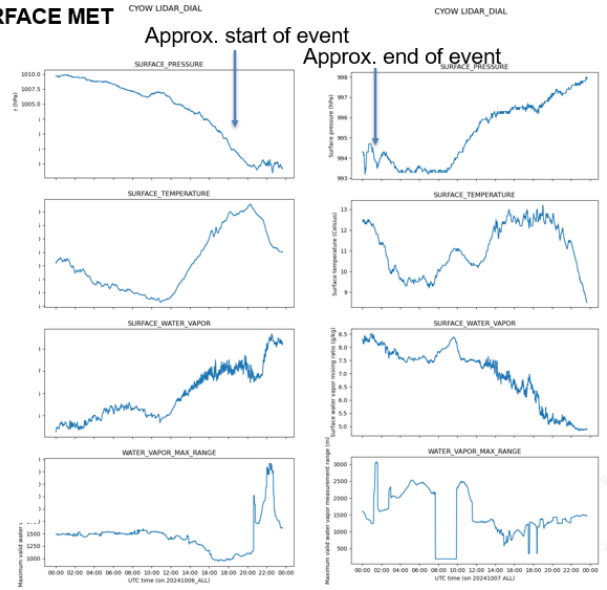
Oct 6 from ~3 EST to ~9 EST 2024

RADIOMETER (T, RH PROFILES)



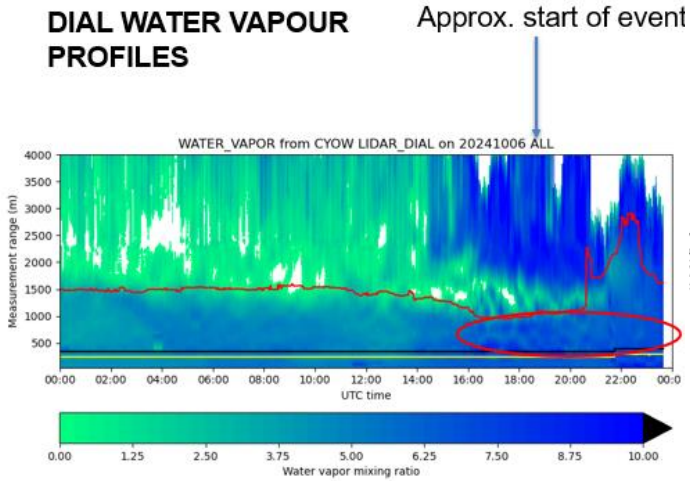
- Vertical mixing of T and WV at higher altitudes during the event
- To do: Compute CAPE

SURFACE MET



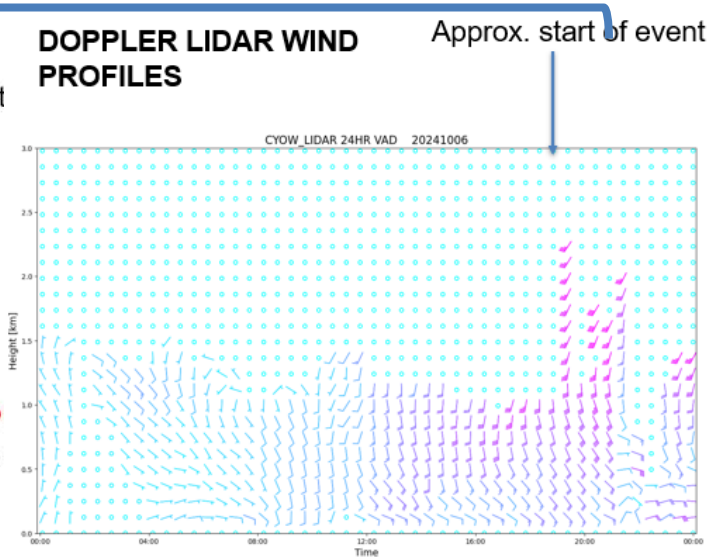
Spike in WV at the surface during the event

DIAL WATER VAPOUR PROFILES



- Strong increase in WV during the event up to cloud base
- Red circle: rippled, layered WV at onset of event (mixing? Turbulence? Instability?)

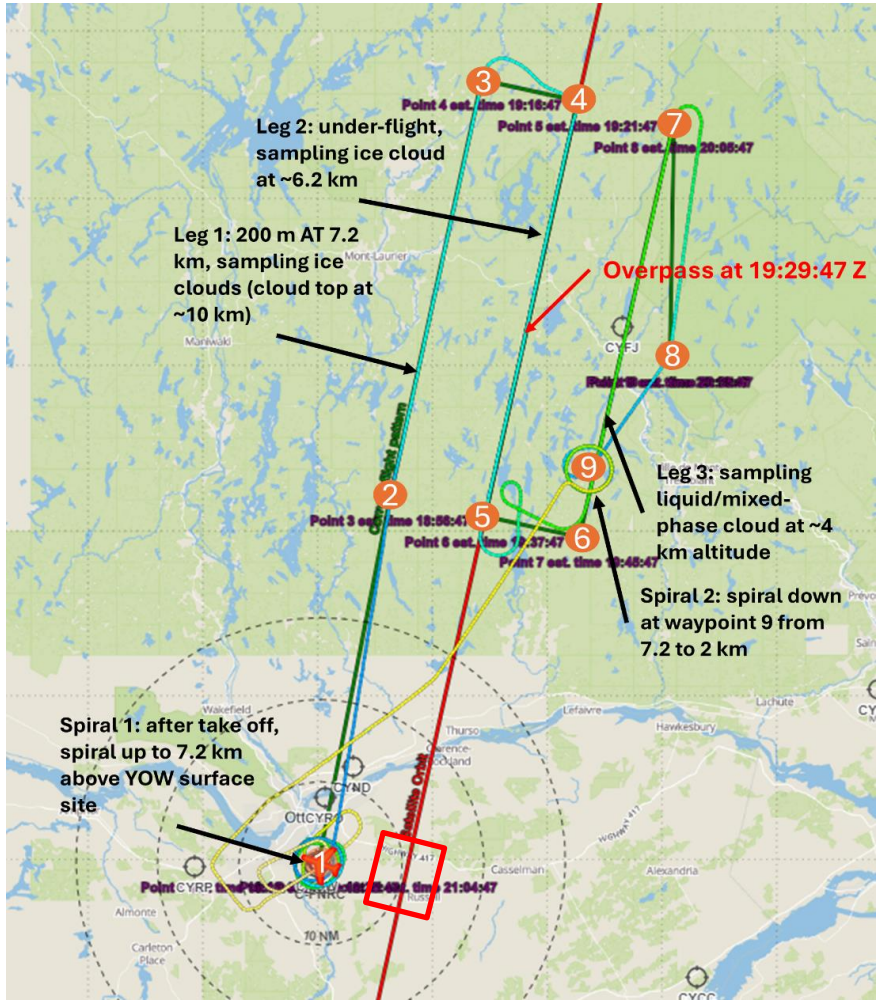
DOPPLER LIDAR WIND PROFILES



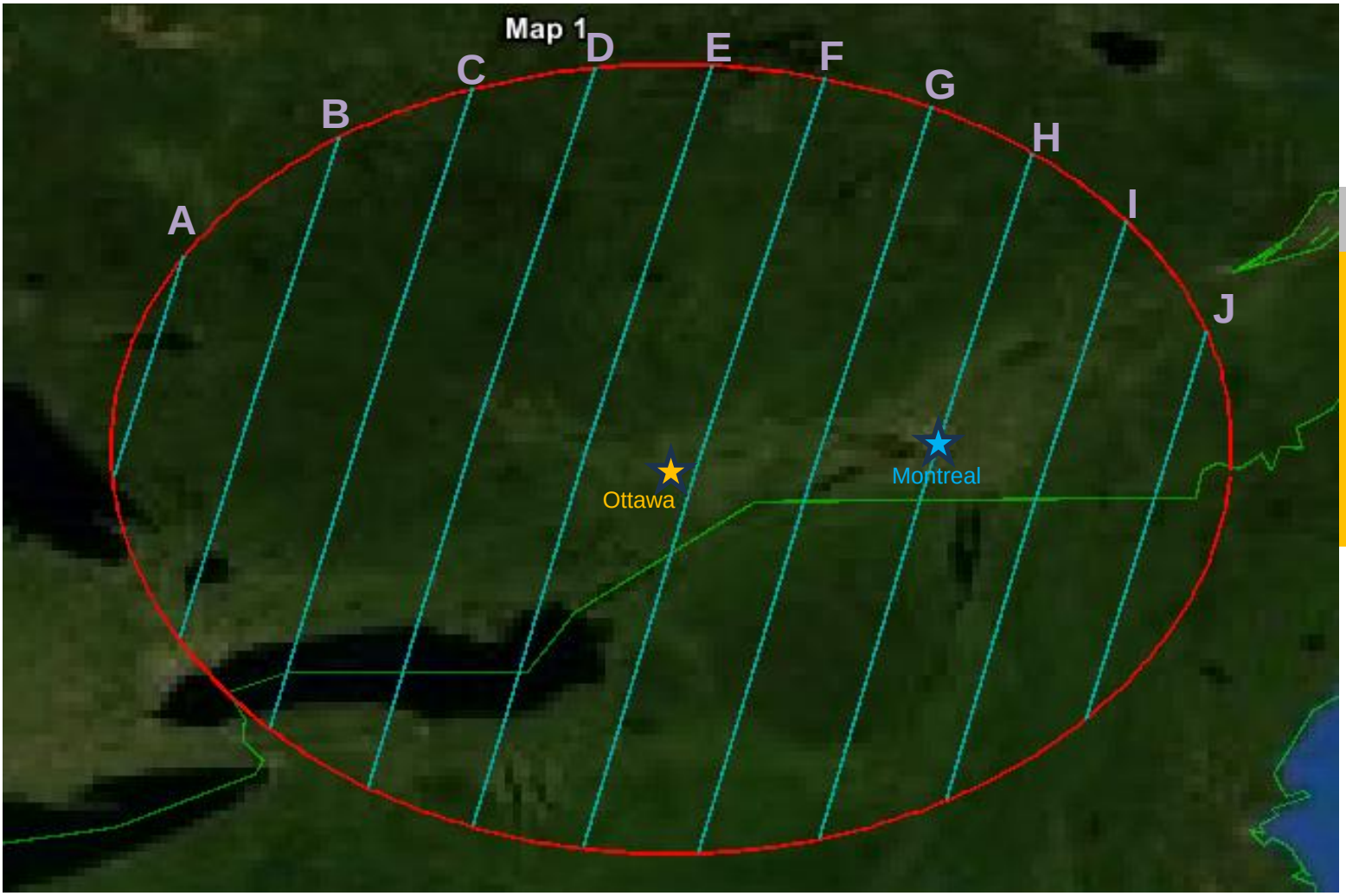
- Strong increase in winds, particularly at higher altitudes and above the cloud base
- Shear: curling and rotation, particularly below cloud base heights and near the surface
- Rotation occurs only during the storm (~nil before and after)

Initial Comparisons with EarthCARE X-MET AUX and lvl2 products

- X-MET defines the atmospheric state (T, WV, and GHGs) used for the rad transfer calculations.
  - Used in the ACM-RT processor for rad closure assessment of the retrievals with the broadband radiometer measurements.
  - If there are biases in this information, it will affect the rad closure.
- X-MET AUX data resolution: 9 km
  - Same as ECMWF model res.
- Example (**right**): Flight 3 (Nov 4 2024) overpass near Ottawa
- Comparisons between CYOW surface site and the nearest available X-MET and Lvl2 products for six overpasses
  - **X-MET**: q, T, vv, uu
    - Note: we are comparing a point observation against a 9km swath
  - **Level2** Products: CPR_TC (Hydrometer_classification) and CPR+ATLID (derived cloud base height)



Descending Orbits

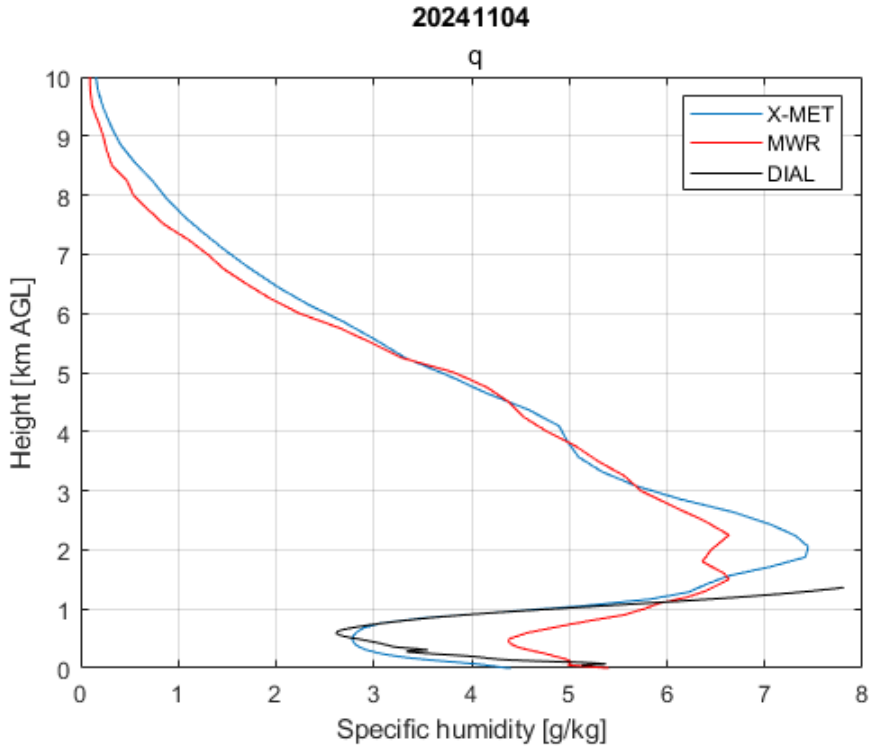


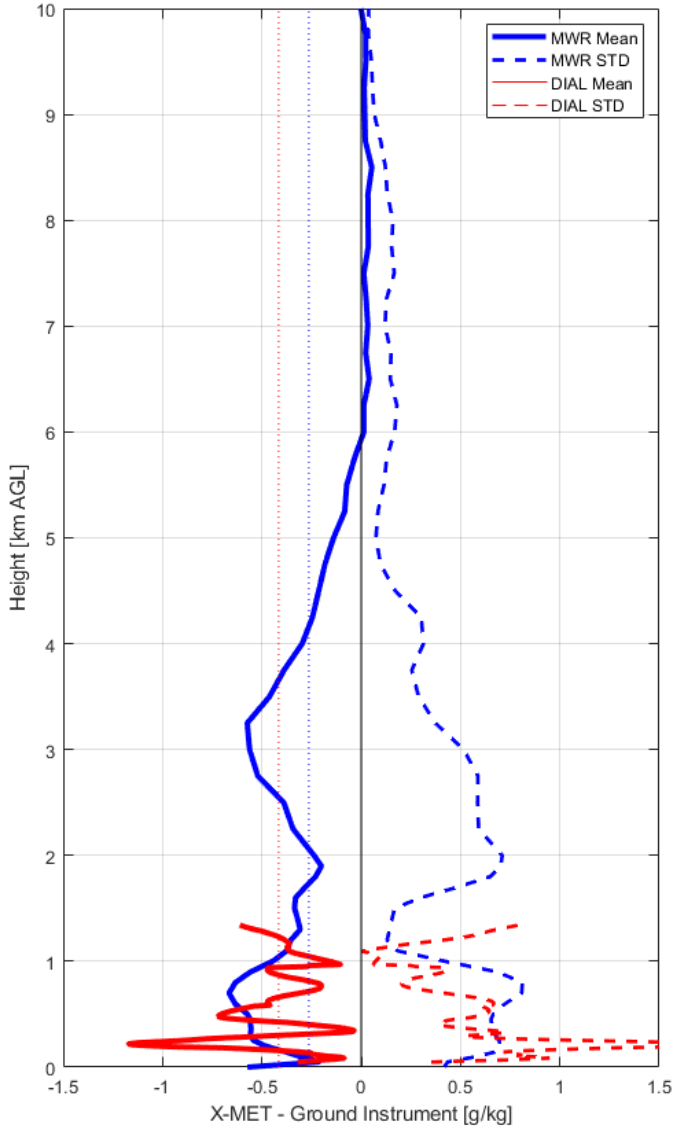
#	Date	Orbit #	UTC start time	UTC end time	Orbit Track # (in the map)
4	10/10/2024	2098	'19:29'	'19:31'	F
14	11/4/2024	2487	'19:29'	'19:30'	F
24	11/29/2024	2876	'19:28'	'19:30'	F
10	12/24/2024	3265	'19:28'	'19:30'	F
20	1/18/2025	3654	'19:27'	'19:29'	F
5	2/12/2025	4043	'19:27'	'19:29'	F

Yellow rows: six overpass above Ottawa site (~20 km horizontally displaced) from October to current

Orbit tracks within 350 km from YOW

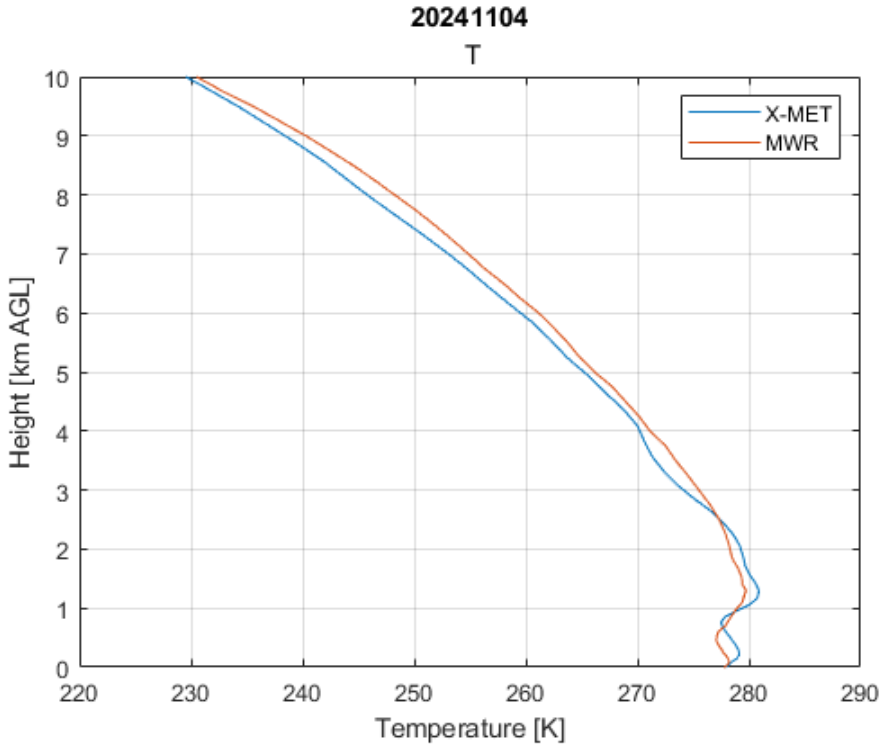
X-MET COMPARISONS: Q

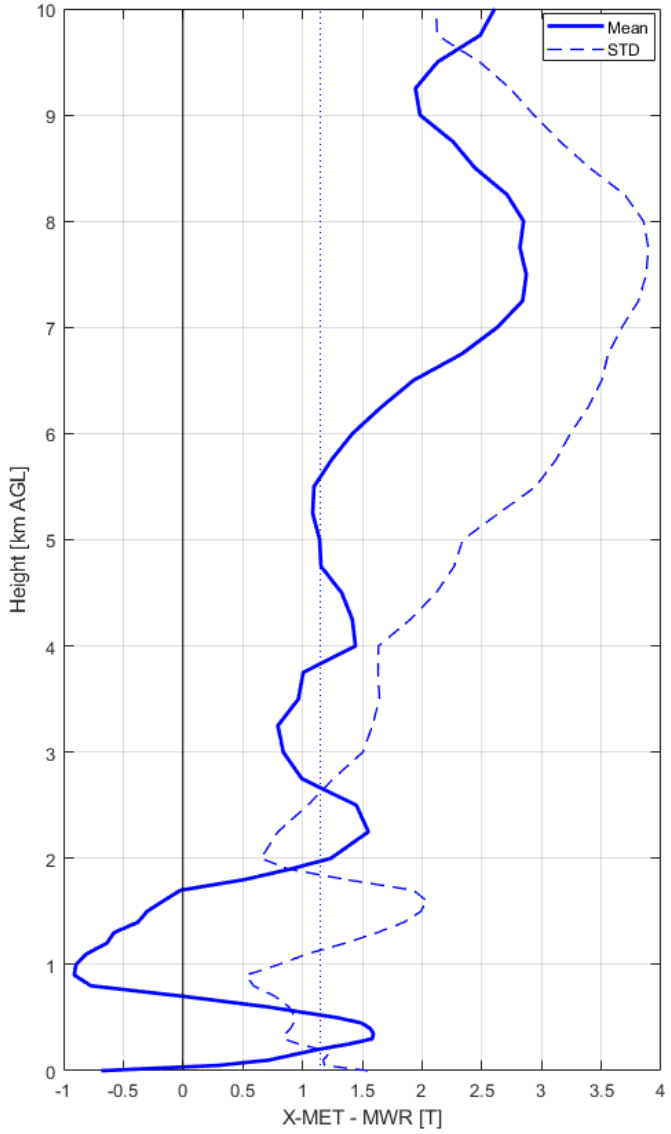




- Comparisons between X-MET product and observations from the MWR (blue) and DIAL (red). One profile shown on the left as an example; average differences (mean bias, std) shown on the right.
- Note: DIAL has higher vertical resolution but limited vertical range; shows significantly more oscillation in DIAL profile.

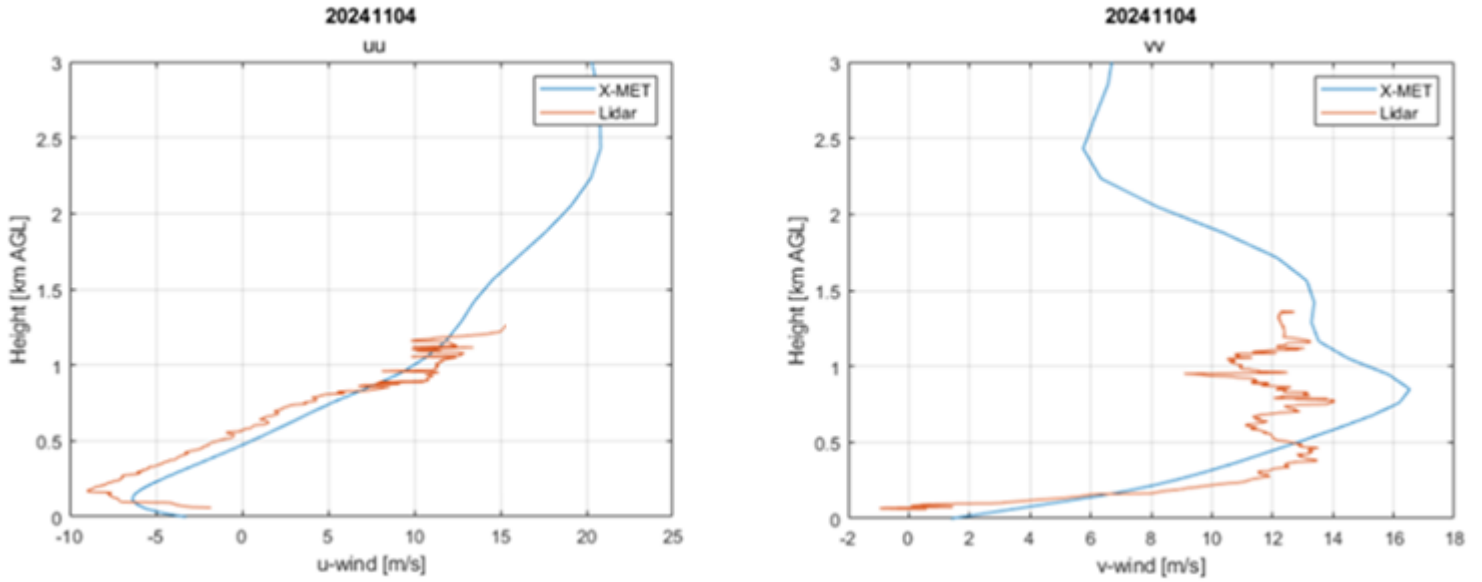
X-MET COMPARISONS: T

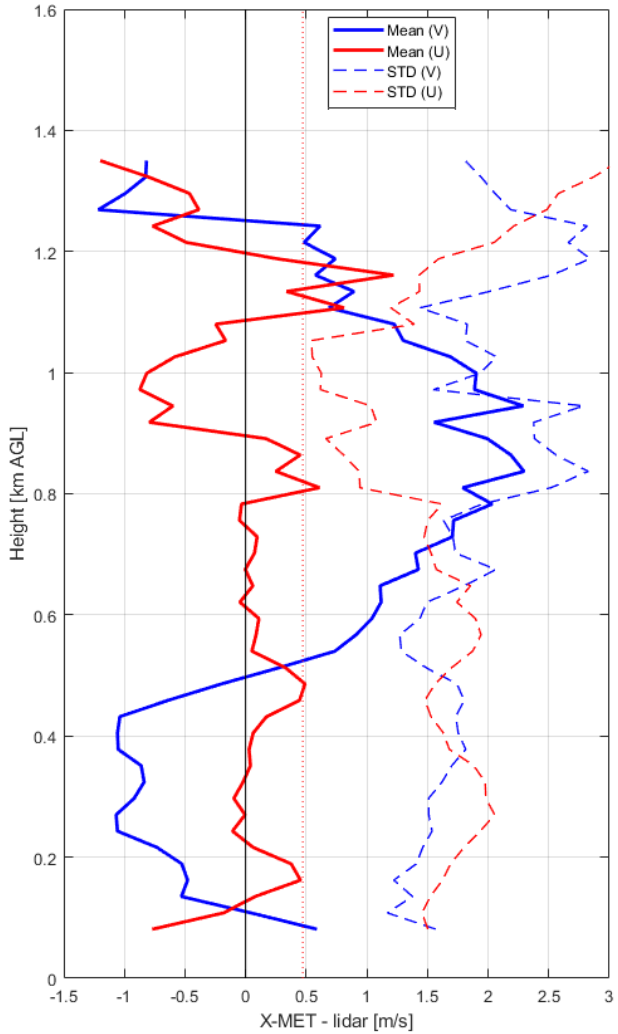




Comparisons between X-MET product and observations from the MWR (blue). One profile shown on the left as an example; average differences (mean bias, std) shown on the right.

X-MET COMPARISONS: WINDS



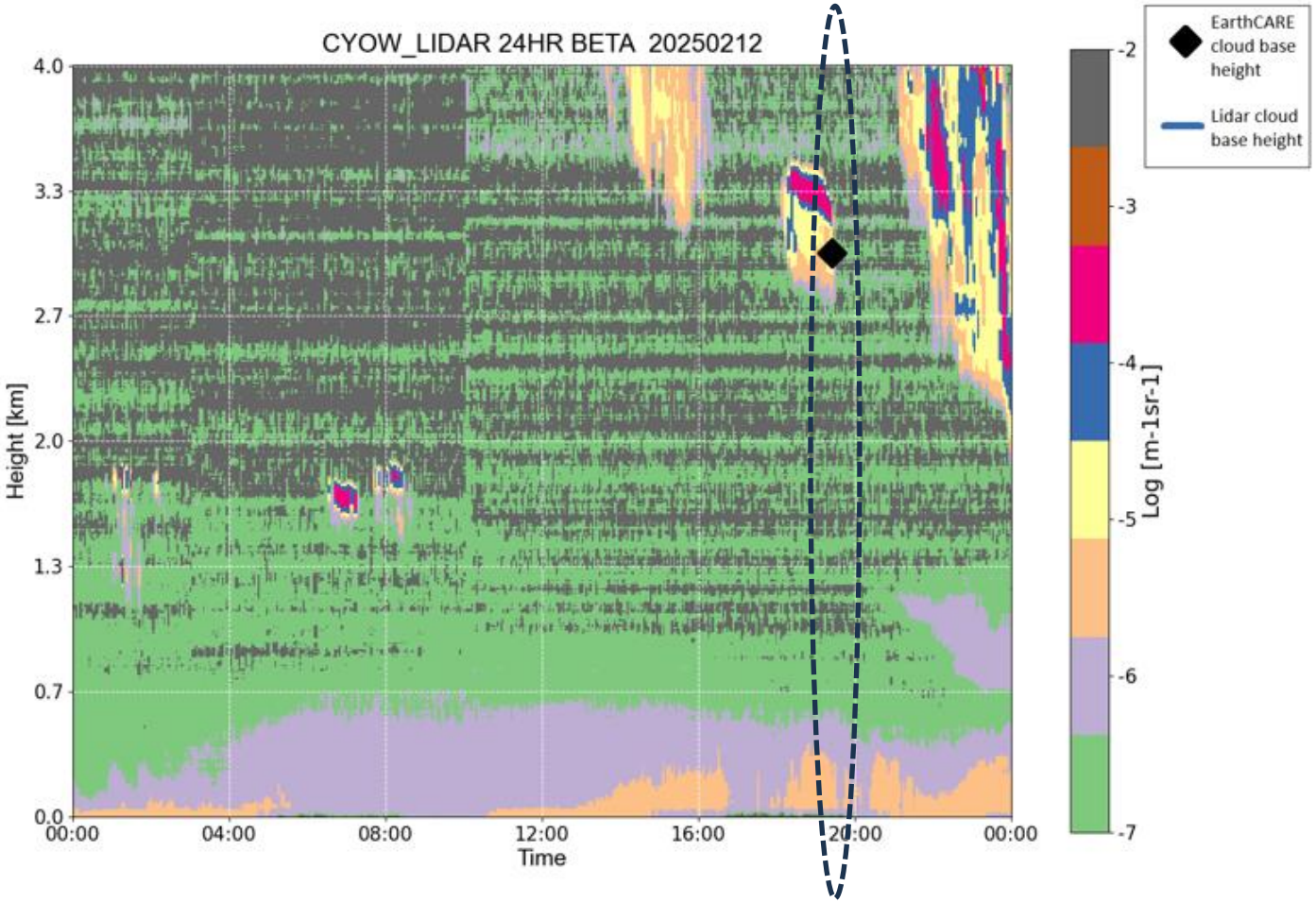


- Comparisons between the X-MET wind (u, v) product and observations from the Doppler lidar. One profile shown on the left as an example; average differences (mean bias, std) shown on the right.
- Note: differences are comparable to previous studies conducted comparing Doppler lidar observations to numerical weather prediction models (ECCC GEM) in Canada

(Mariani et al., 2020, A Multi-Year Evaluation of Doppler Lidar Wind-Profile Observations in the Arctic)

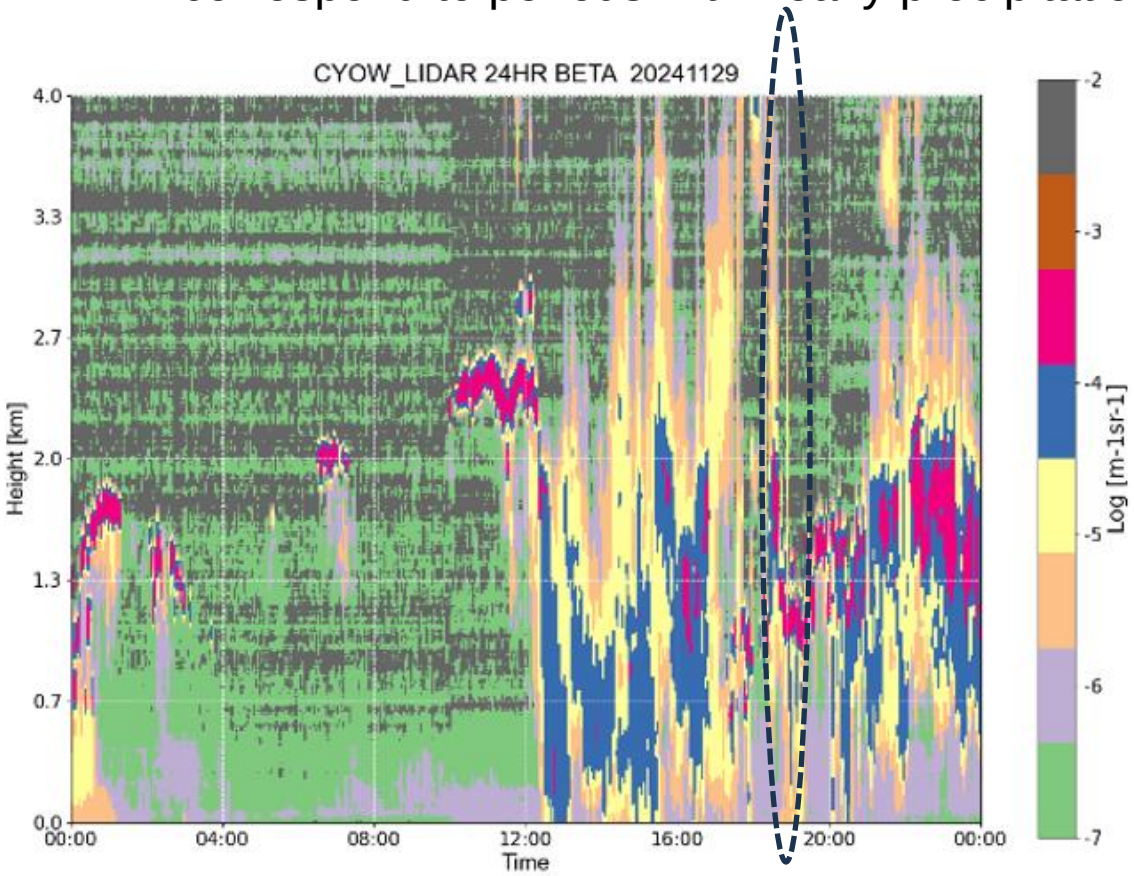
CLOUD BASE HEIGHT (CBH) COMPARISONS

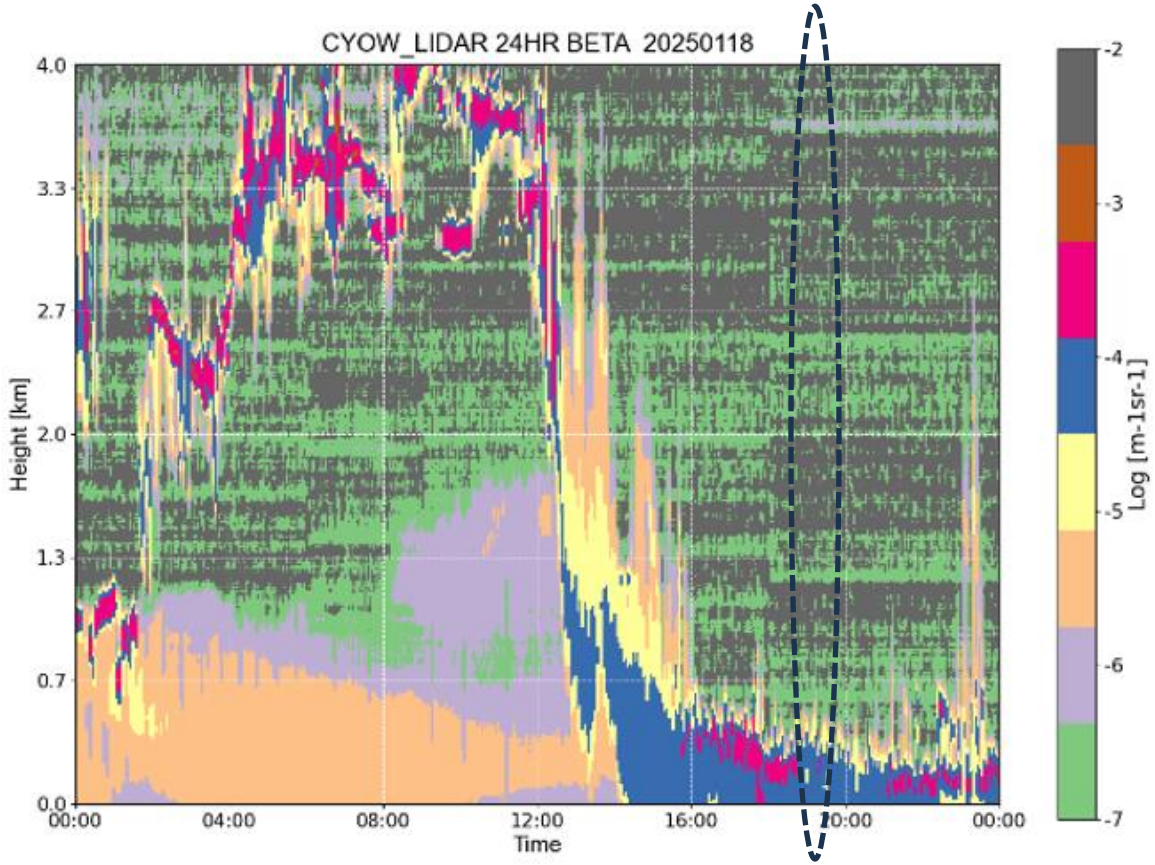
- CBH method: 1 km pixel resolution, scene construction index to reconstruct the cloud/aerosol field over the CYOW site. Target classification from CPR and ATLID were used based on this pixel value.
  - Future work: use an average value over a slightly larger region & include updated C-CLD product
- Right: Doppler lidar vertical aerosol backscatter on Feb 12 2025. The lidar-based CBH is estimated just above (< 100 m) the EarthCARE CBH estimate.



CLOUD BASE HEIGHT COMPARISONS: CON'T

- EarthCARE CBH algorithm output: cases with "no melting layer, the snow reaching the ground" correspond to periods with heavy precipitation (examples below)

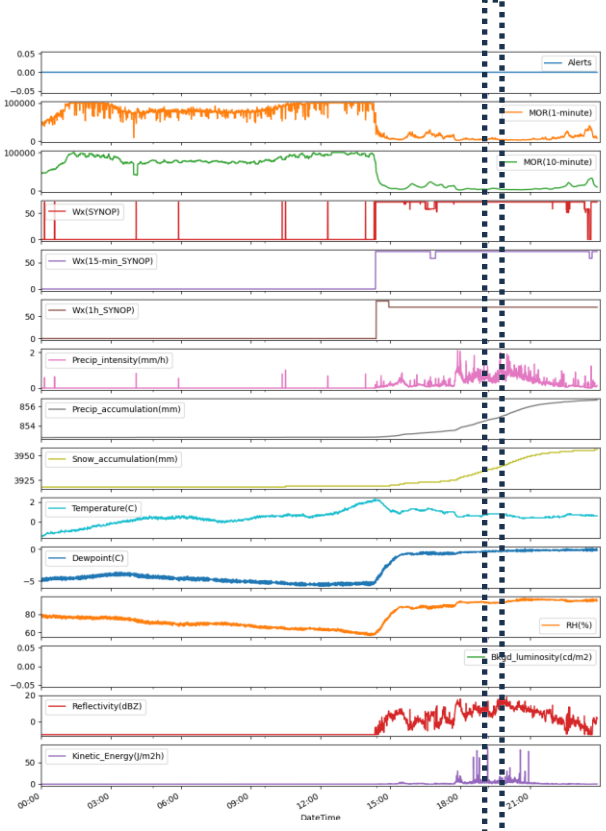


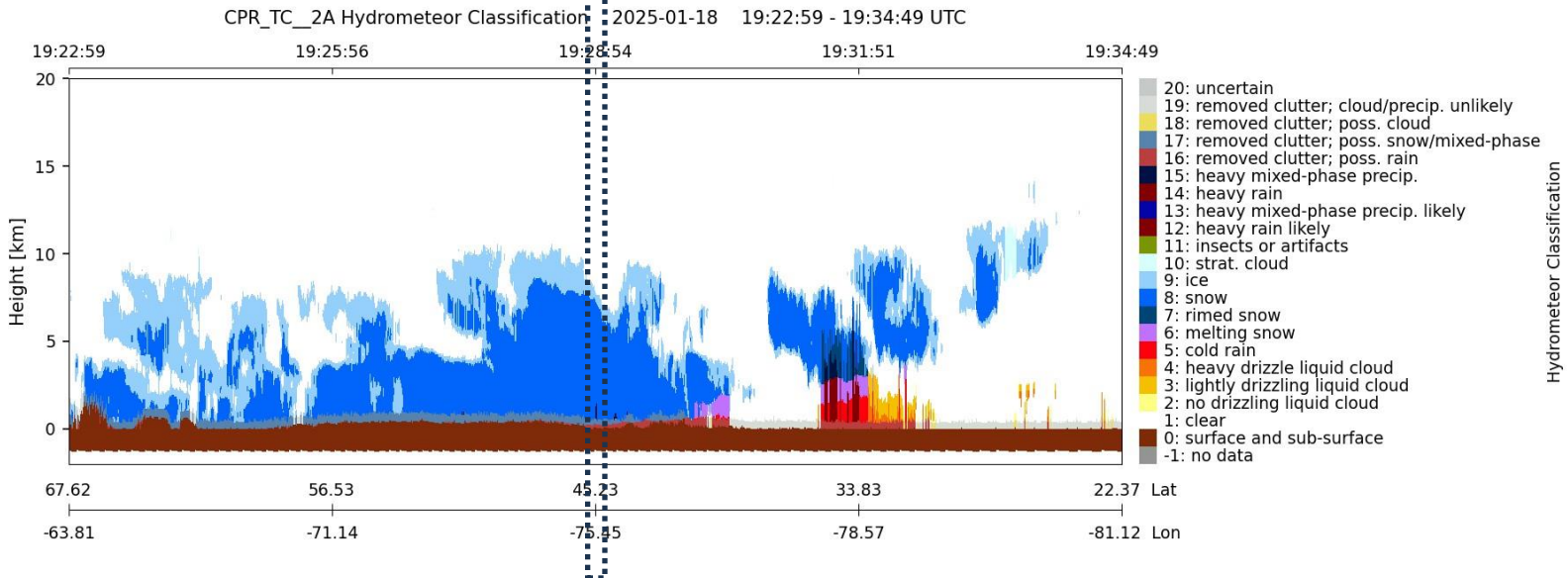


CPR_TC
Hydrometeor classification

January 18 2025 Case

Preliminary comparisons using the EarthCARE observations ~20 km from the CYOW site: no scene reconstruction above CYOW yet (to do)





Surface:

- Slight Snow (S-) measured @ 0.71 mm/hr

CPR:

- Snow (8) reaching the surface

Similar agreements found for other orbits for ‘clear’ and ‘slight snow’ precip

Conclusions

- Surface site located at the Ottawa airport to support the EarthCARE Commissioning Cal/Val Campaign in Ottawa (ECALOT) prior, during, and after cal/val flights (Sept 2024 - ongoing)
- Suite of automated remote sensing (upper air) and surface observations available 24/7: data openly available
- Verification of EarthCARE **X-MET AUX** product:
  - X-MET is used in the ACM-RT processor for rad closure assessment of the retrievals with the broadband radiometer measurements.
  - Results indicate good agreement for q, T, and winds with some biases expected given difference in resolution
- Verification of lvl2 **CPR** & **ATLID clouds** (CBH) and **CPR_TC precip type**:
  - Excellent agreement in cloud base height & precip type found for several cases
- Next steps:
  - Impact meteorological conditions have on agreement
  - Refine CBH algorithm, perform statistical comparisons & use updated C-CLD product
  - Hydrometeor classification: use atmospheric scene construction algorithm to compare hydrometeor_classification at CYOW
  - Comparisons to the mass flow from C-CLD (mm/hr)
- Additional variables to investigate:
  - aerosol_backscatter_profile (ATL_EBD),
  - boundary_layer_height,
  - upward_air_velocity,
  - hydrometeor_diameter
  - Others?

Thank you!

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