Evaluation of reflectivity and Doppler velocity structures from EarthCARE's CPR with airborne W-band cloud radar observations during the ECALOT campaign

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JAXA esa

EarthCARE Commissioning Cal/Val Campaign in Ottawa (ECALOT)

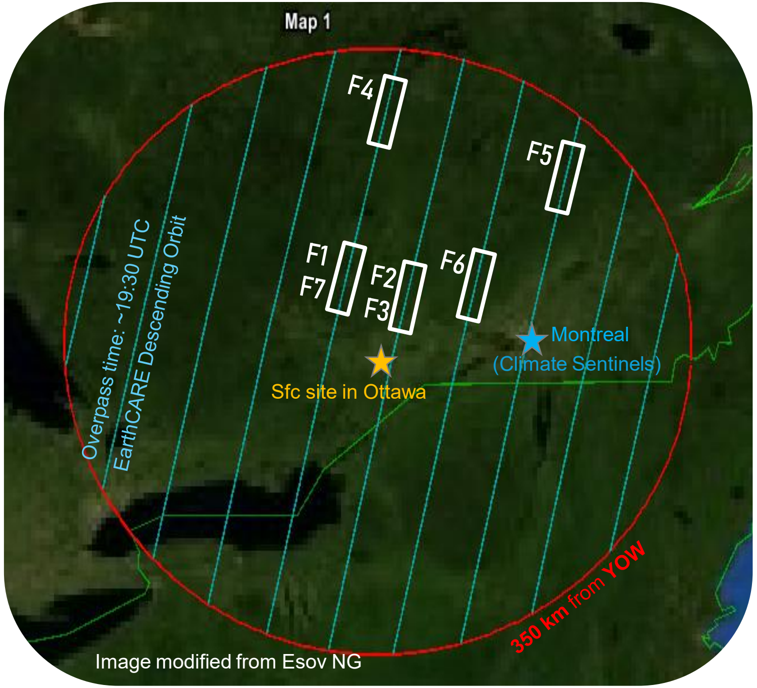
Ottawa, Canada based aircraft/surface calibration/validation campaign: ECALOT

- During EarthCARE's commissioning phase

  Mid-latitude continental fall and winter conditions

  Airborne observations:

  - ✓ Flight 1: Oct. 1st – Cu & Sc
  - ✓ Flight 2: Oct. 10th – Sc + aerosols
  - ✓ Flight 3: Nov. 4th – NS + large scale rain
  - ✓ Flight 4: Nov. 20th – two-layer Sc + aerosols
  - ➢ Flight 5: Nov. 22nd – Ci + Ns
  - ✓ Flight 6: Jan. 27th – Ns + snow
  - ✓ Flight 7: Mar. 25th – mid-low level clouds



EarthCARE Commissioning Cal/Val Campaign in Ottawa (ECALOT)

Antenna systems

Cabin components

	W	X
Frequency	94.05 GHz	9.41 GHz +/- 30 MHz
Peak Transmit Power	1.7 kW	25 kW (split b/w 2 ports)
Pulse Width	0.5 us	0.5 us
Antenna	Nadir: 12" lens ant. single pol. Aft + side" 12" lens ant. dual-pol	Up + Down: 18" single pol. slotted ant. Side: 26" parabolic ant. dual-pol.

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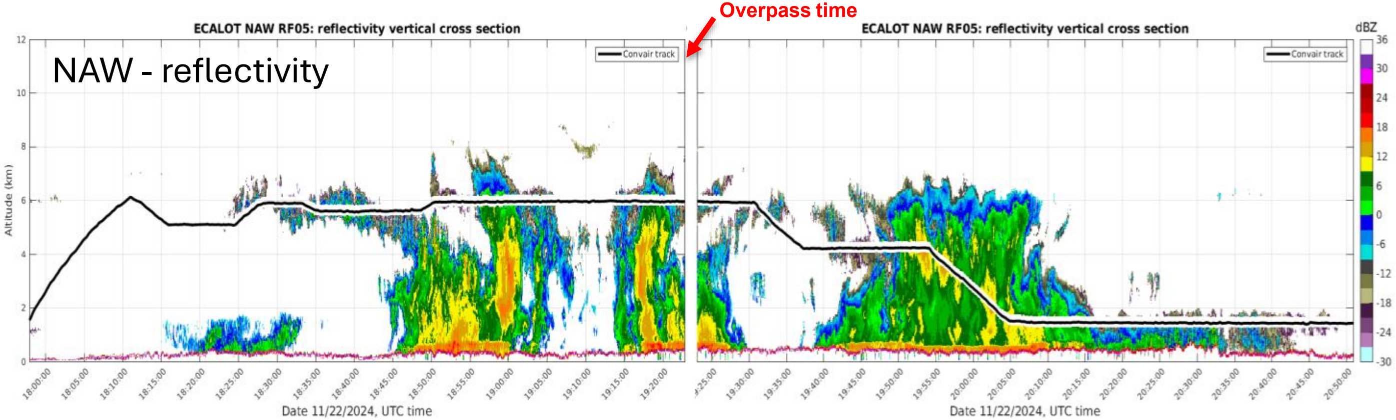
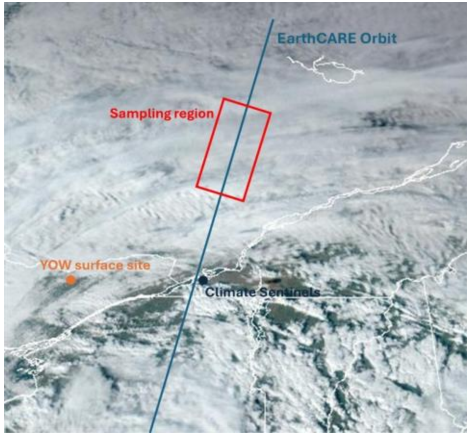
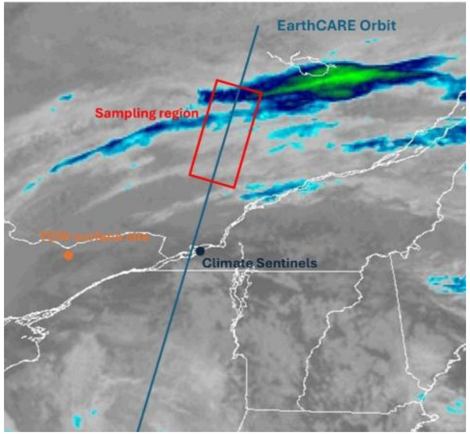
ECALOT F5 – Weather Conditions

- Multi-layer cloud
- Thin ice clouds
  - 6 km
- Mixed-phase clouds
  - 4 & 1.8 km
- Supercooled liquid layers

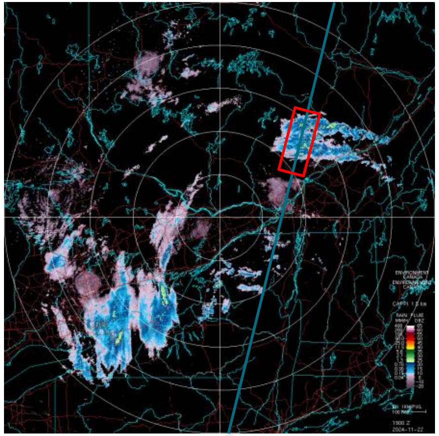




NOAA GOES geo-color image

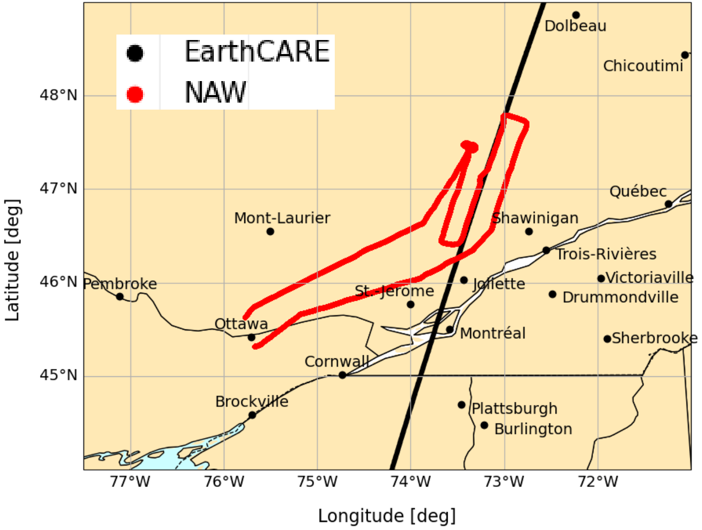


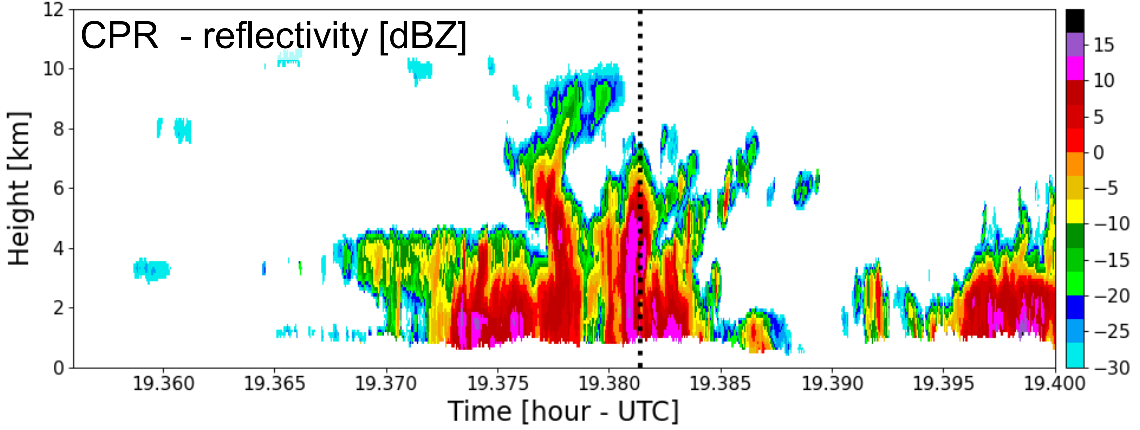
NOAA GOES 10.3-micron image

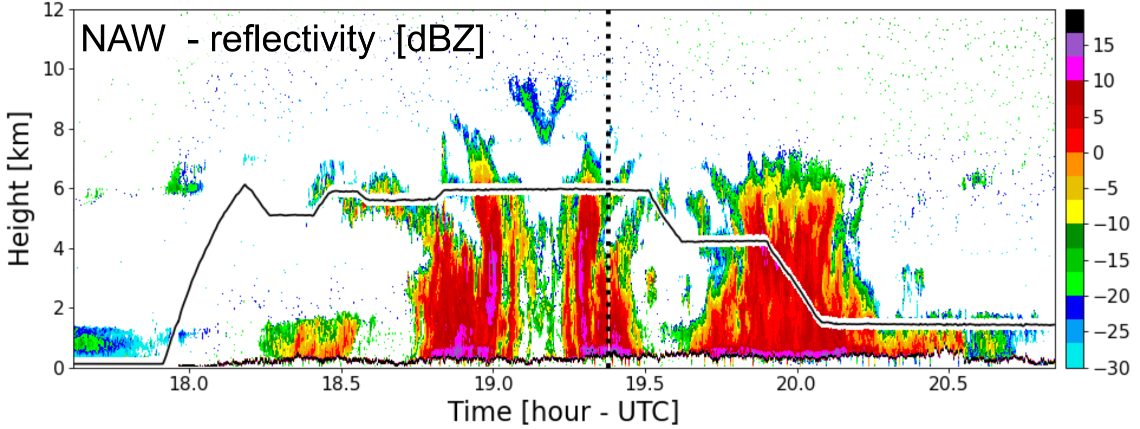


ECCC CAPPI

ECALOT F5 – NAW vs CPR reflectivity comparison







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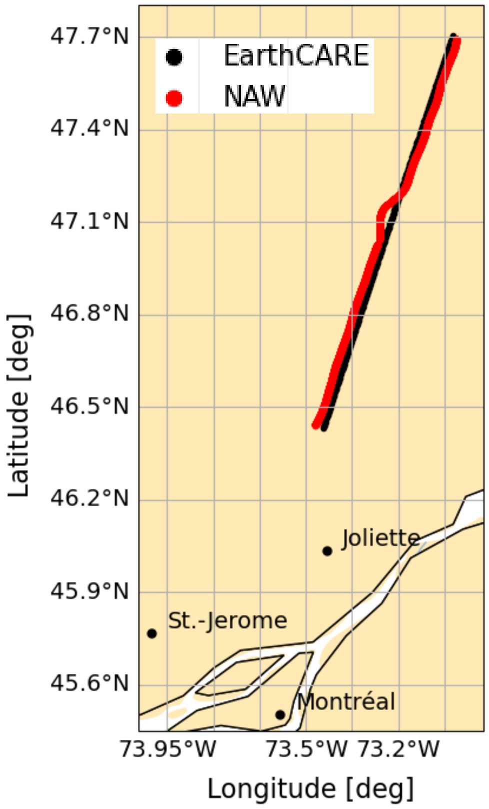
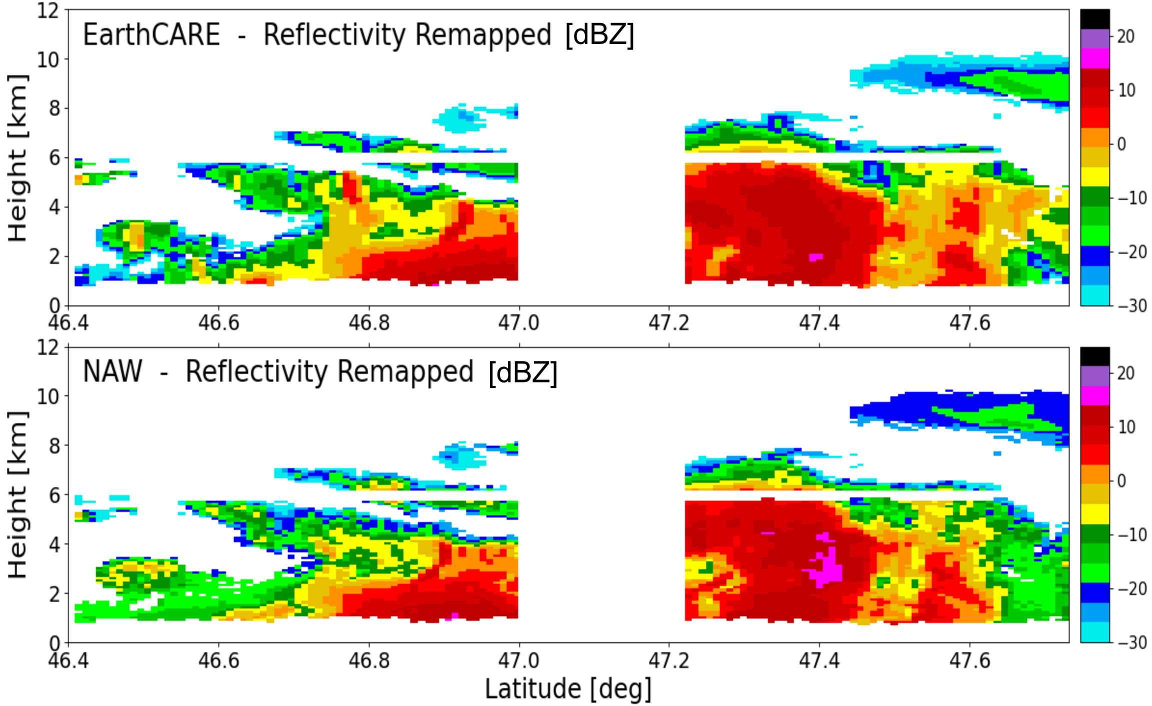


- Remove ground clutter, profiles at overpass time, and heights around flight track.
- Remap NAW to CPR sampling resolution



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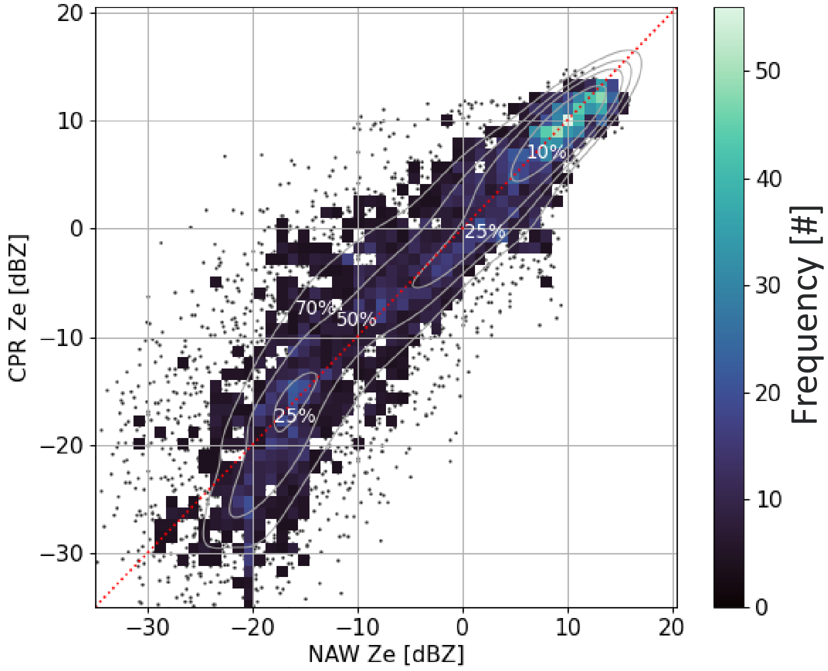
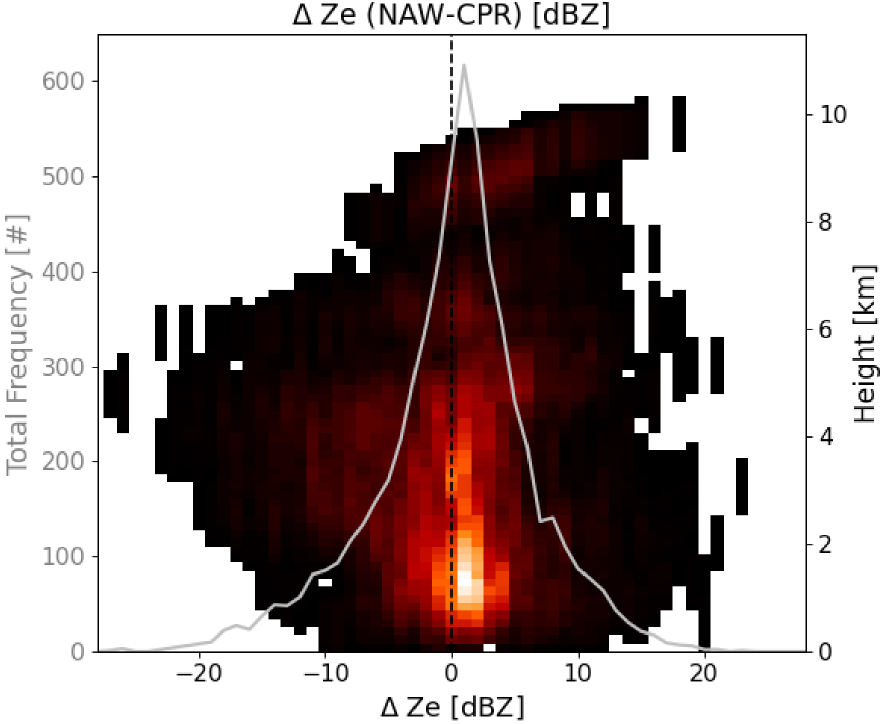
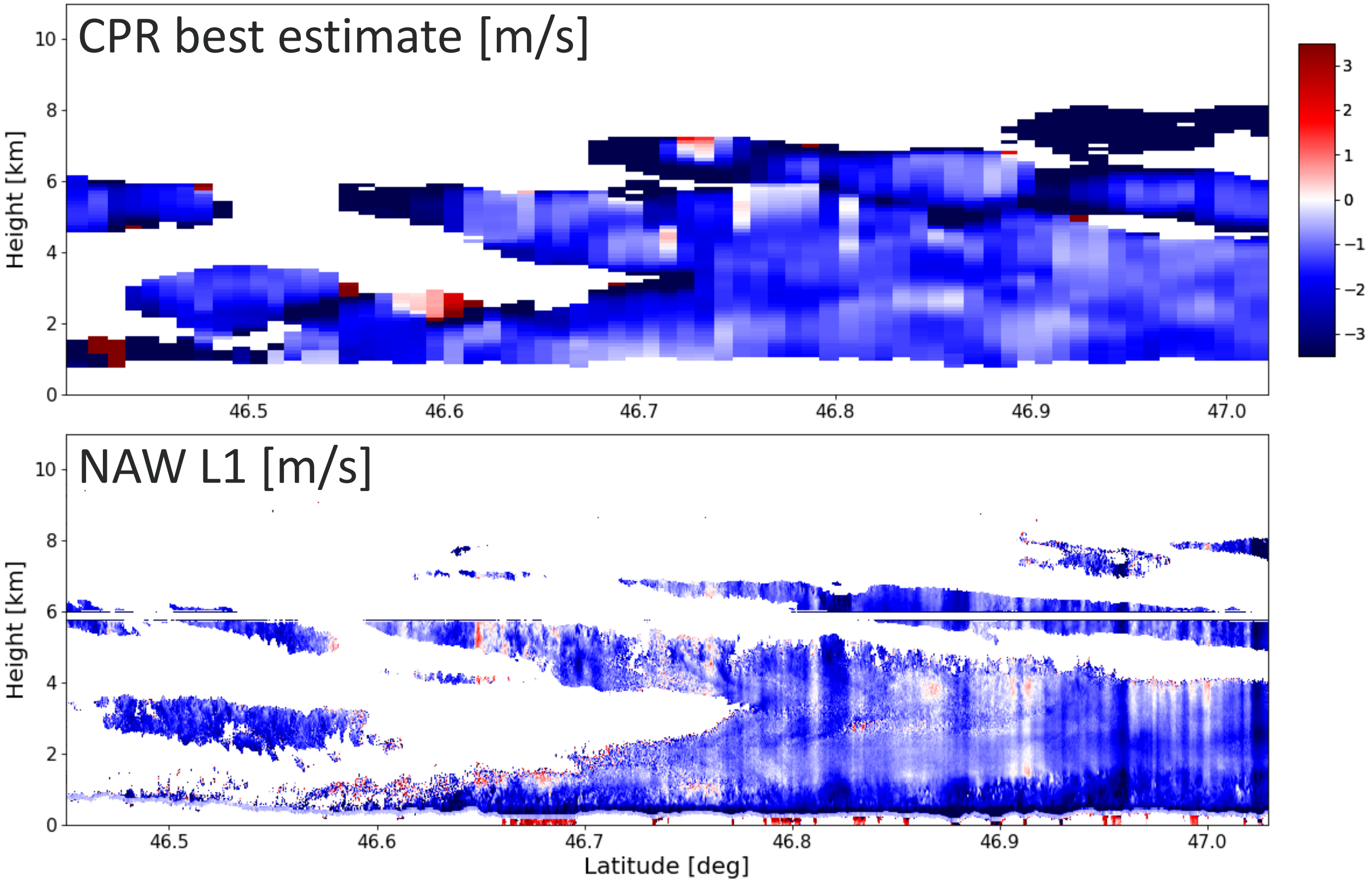




ECALOT F5 – NAW vs CPR Doppler Velocity comparison



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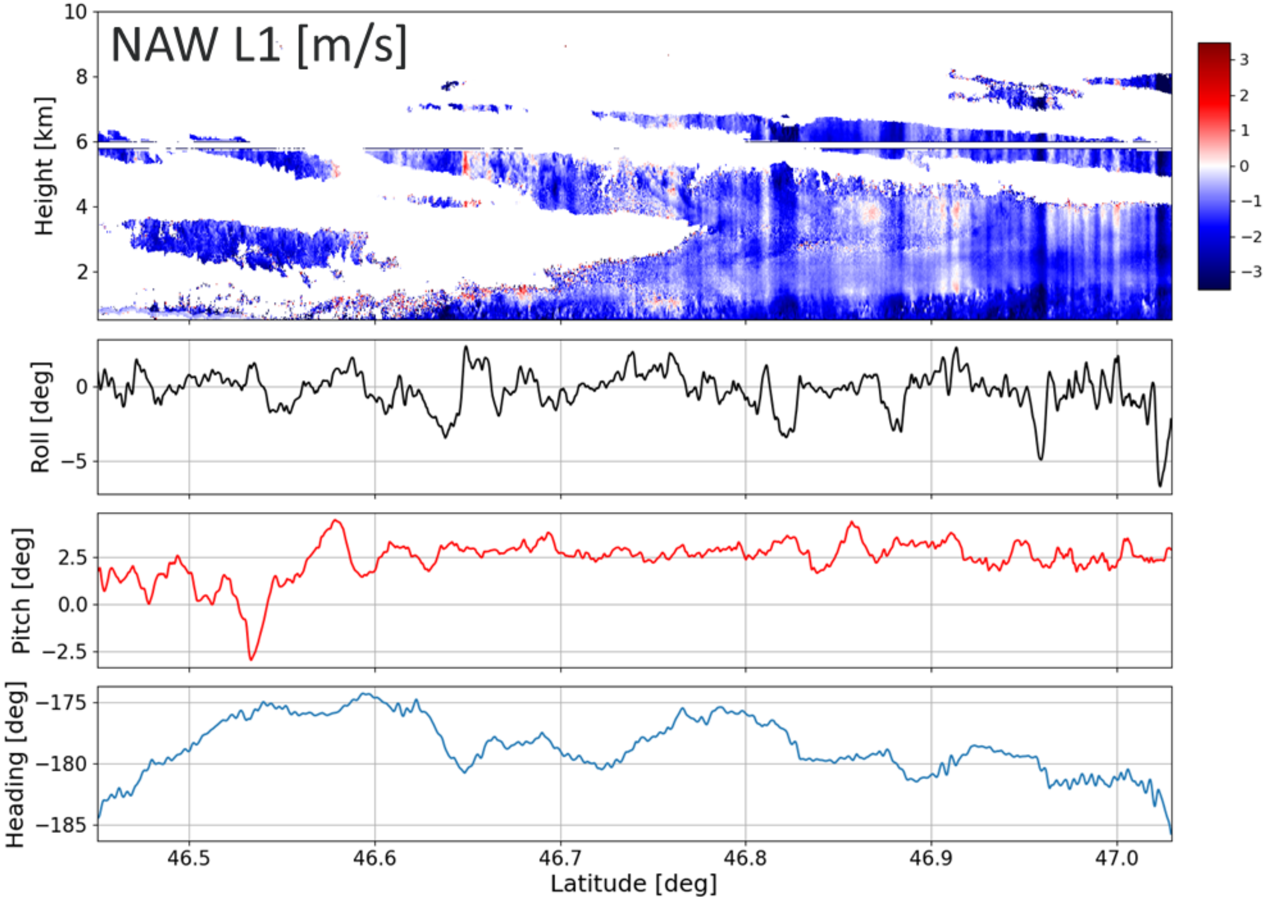

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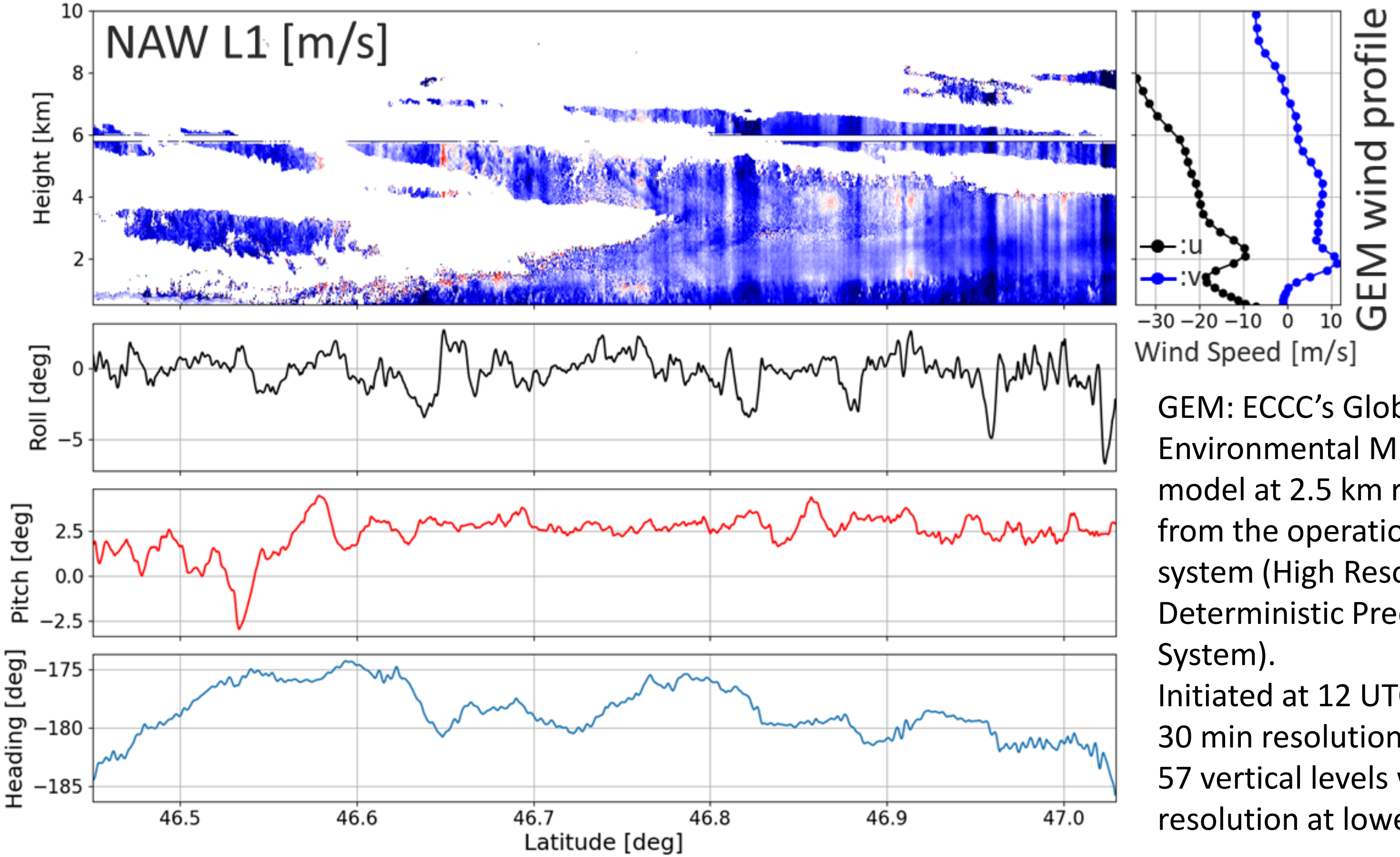
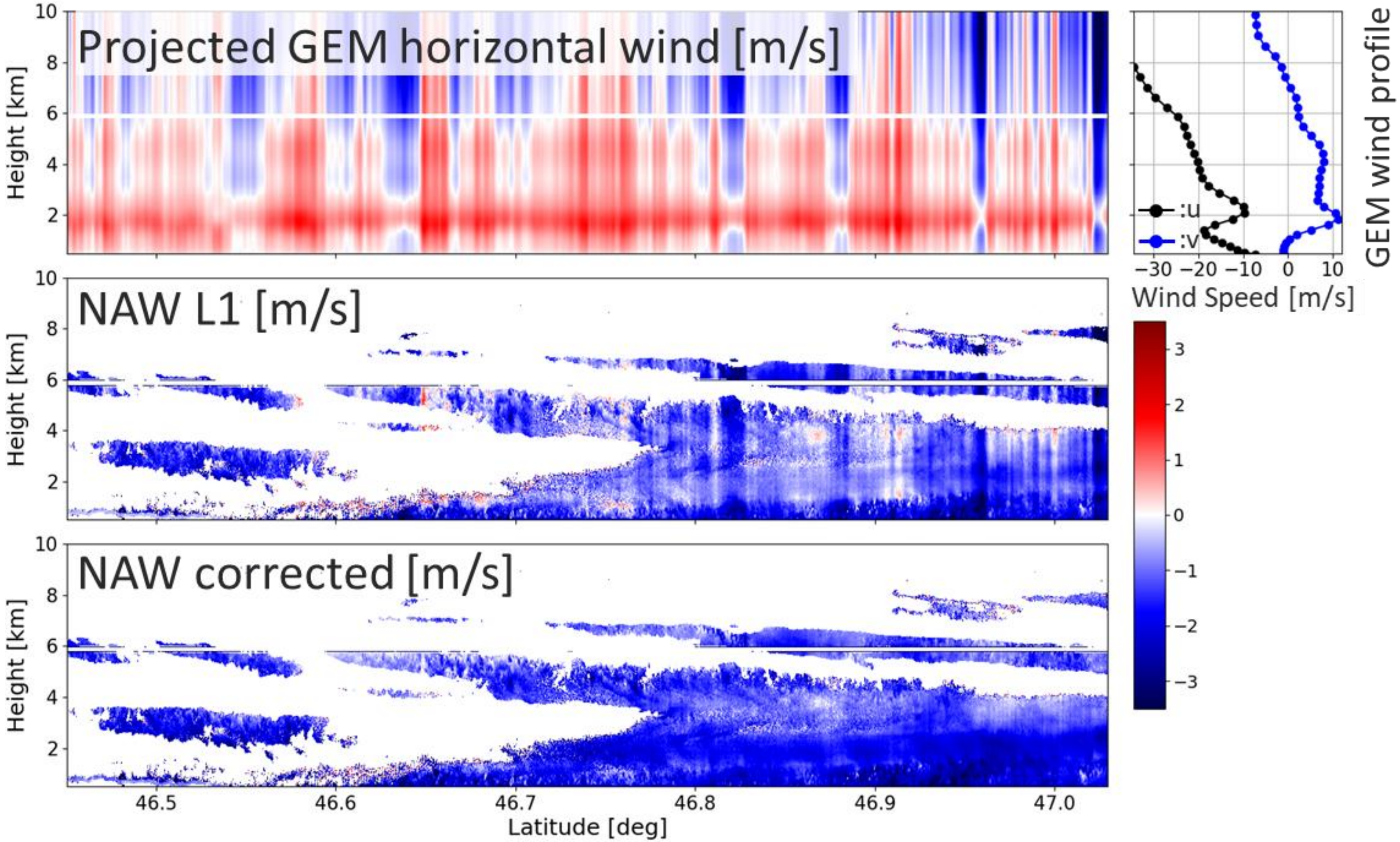


GEM: ECCC's Global Environmental Multi-scale model at 2.5 km resolution from the operational HRDPS system (High Resolution Deterministic Prediction System).
Initiated at 12 UTC.
30 min resolution.
57 vertical levels with higher resolution at lower levels.

ECALOT F5 – NAW vs CPR Doppler Velocity comparison



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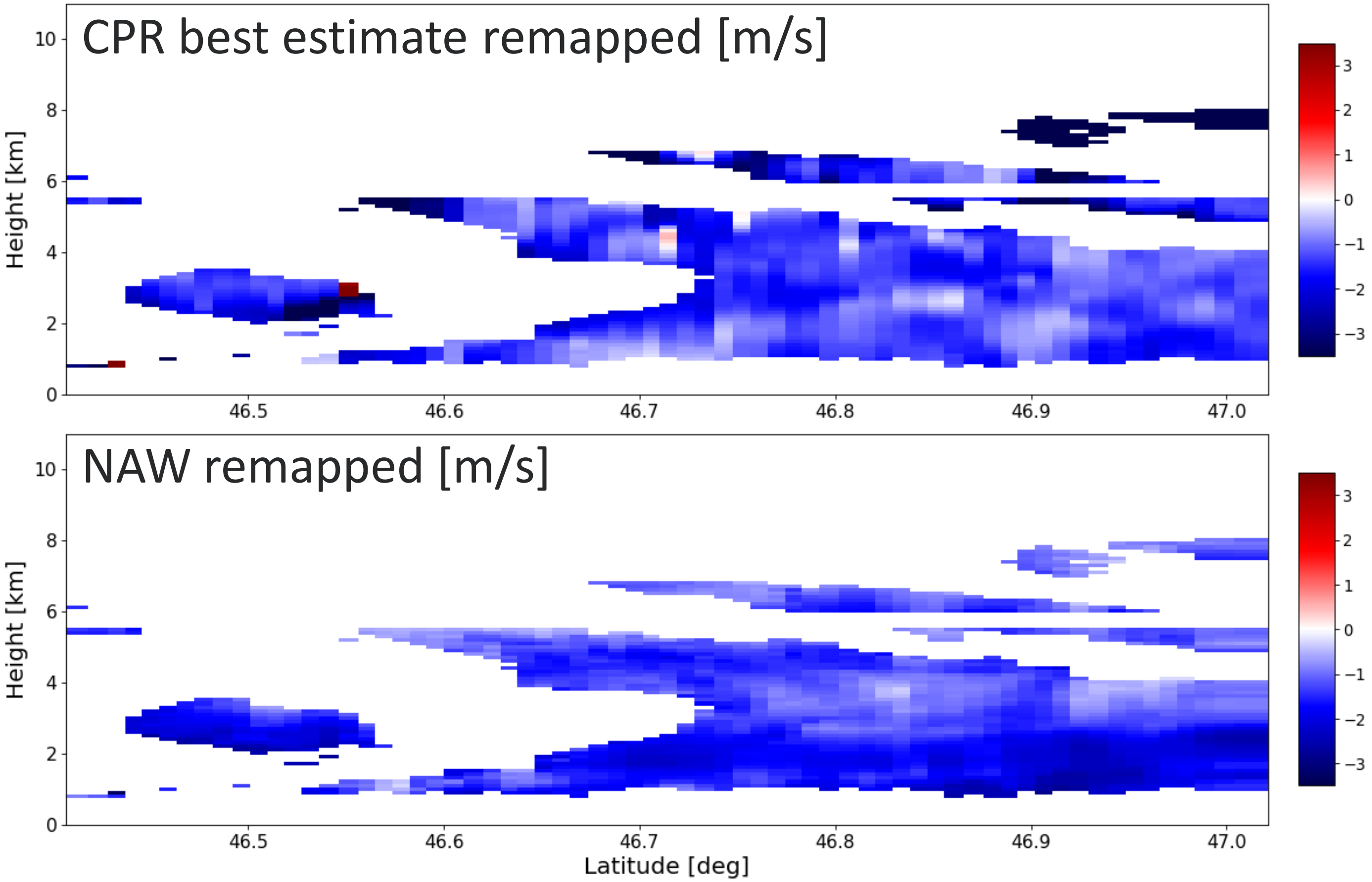

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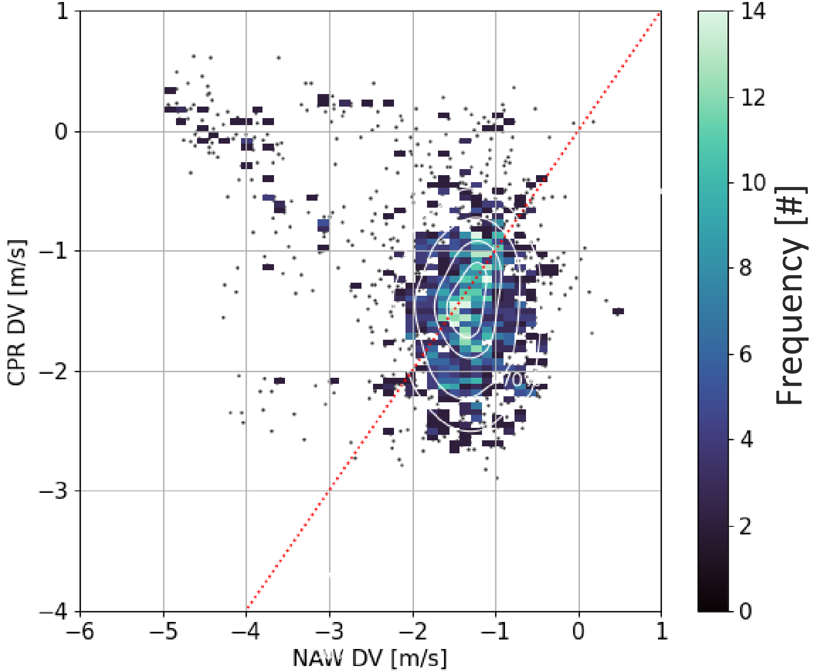

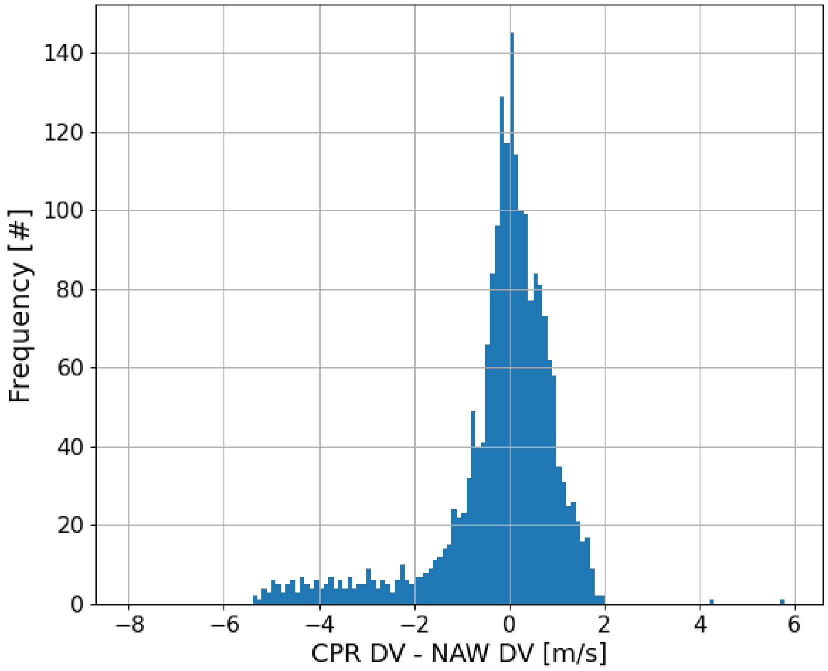

Main Points

- ECALOT campaign took place around the Ottawa, Canada during Fall & Winter 2024/2025:
  - First aircraft/surface calibration/validation campaign in North America.
  - Provided good quality data for targeted flights to sample mid-latitude continental weather to validate EarthCARE observations, with onboard radar (NAW) operating at the same frequency of CPR.
- Sampled clouds by CPR and NAW show very similar internal structure, even for the fine internal vertical and horizontal structure of convective cells.
- Each ECALOT underpass flight provided more than 10,000 points of comparison between the NAW and CPR.
- Comparison between CPR's L2 and NAW's Reflectivity values shows a high correlation, $r^2 > 0.96$, with no clear offset.
- Comparison between CPR's L2 Doppler Best Estimate and NAW's Corrected Doppler Velocity shows an overall good performance but with large spread.
- Scheduled EarthCARE cal/val activities during PONEX (POlar Night EXperiment) in January 2026!

Thank you

Doppler correction methodologies

- Measured mean Doppler = mean Doppler of scatters in the radar volume + Doppler contribution from the aircraft motion.
- Correcting Doppler = properly removing the aircraft contribution → need to know the antenna beam pointing vector
- For nadir (and side) antennas, beam pointing vectors are results of an optimization where variables = 3 components of beam vector and objective function = ground Doppler (*Haimov et al. 2015*).
- For zenith antennas without ground reference: <u>modify the cost function</u>
- Main sources of error:
  - Quality of INS data
  - Beam width

$$\hat{v}_{grnd} = \boldsymbol{b} \cdot (\boldsymbol{v_{aFGRS}T})$$

$$\widehat{\boldsymbol{V}}_{grnd} = \left[\hat{v}^1_{grnd}, \hat{v}^2_{grnd}, \dots, \hat{v}^N_{grnd}\right]^T$$

$$\min_{\boldsymbol{b}} \left\{ \left(\widehat{\boldsymbol{V}}_{grnd} - \boldsymbol{b} \cdot (\boldsymbol{V_{aFGRS}T}) \right)^T \left(\widehat{\boldsymbol{V}}_{grnd} - \boldsymbol{b} \cdot (\boldsymbol{V_{aFGRS}T}) \right) \right\}$$

$$\text{subject to } |\boldsymbol{b}| = \sqrt{b_x^2 + b_y^2 + b_z^2} = 1$$

Doppler correction methodologies