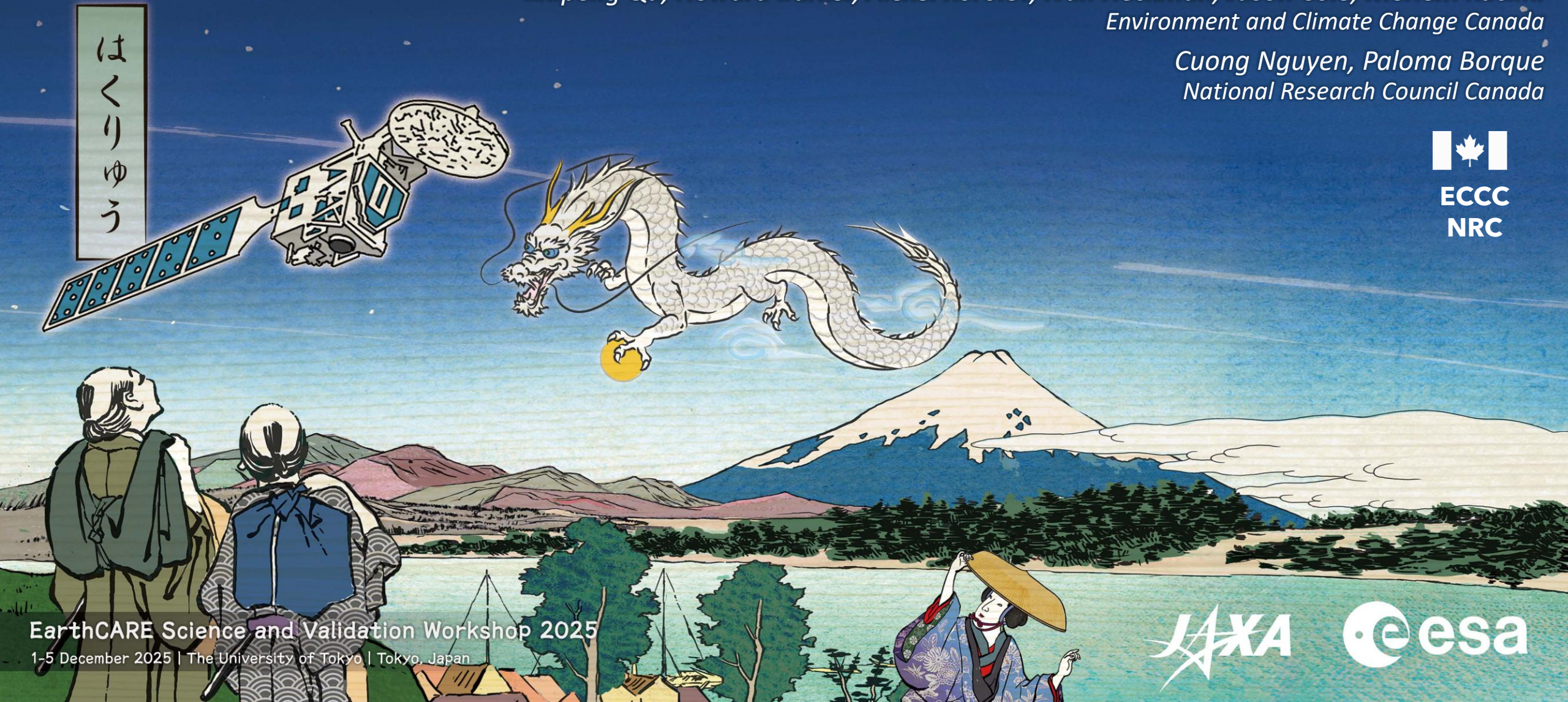


Validation of EarthCARE's 3D scene construction algorithm using in situ and remote sensing data from the ECALOT campaign

Zhipeng Qu, Howard Barker, Alexei Korolev, Ivan Heckman, Jason Cole, Meriem Kacimi
Environment and Climate Change Canada

Cuong Nguyen, Paloma Borque
National Research Council Canada



EarthCARE Science and Validation Workshop 2025

1-5 December 2025 | The University of Tokyo | Tokyo, Japan



The Construction Algorithm

➤ **How reliable the SCA is? How well does it perform with EarthCARE data?**



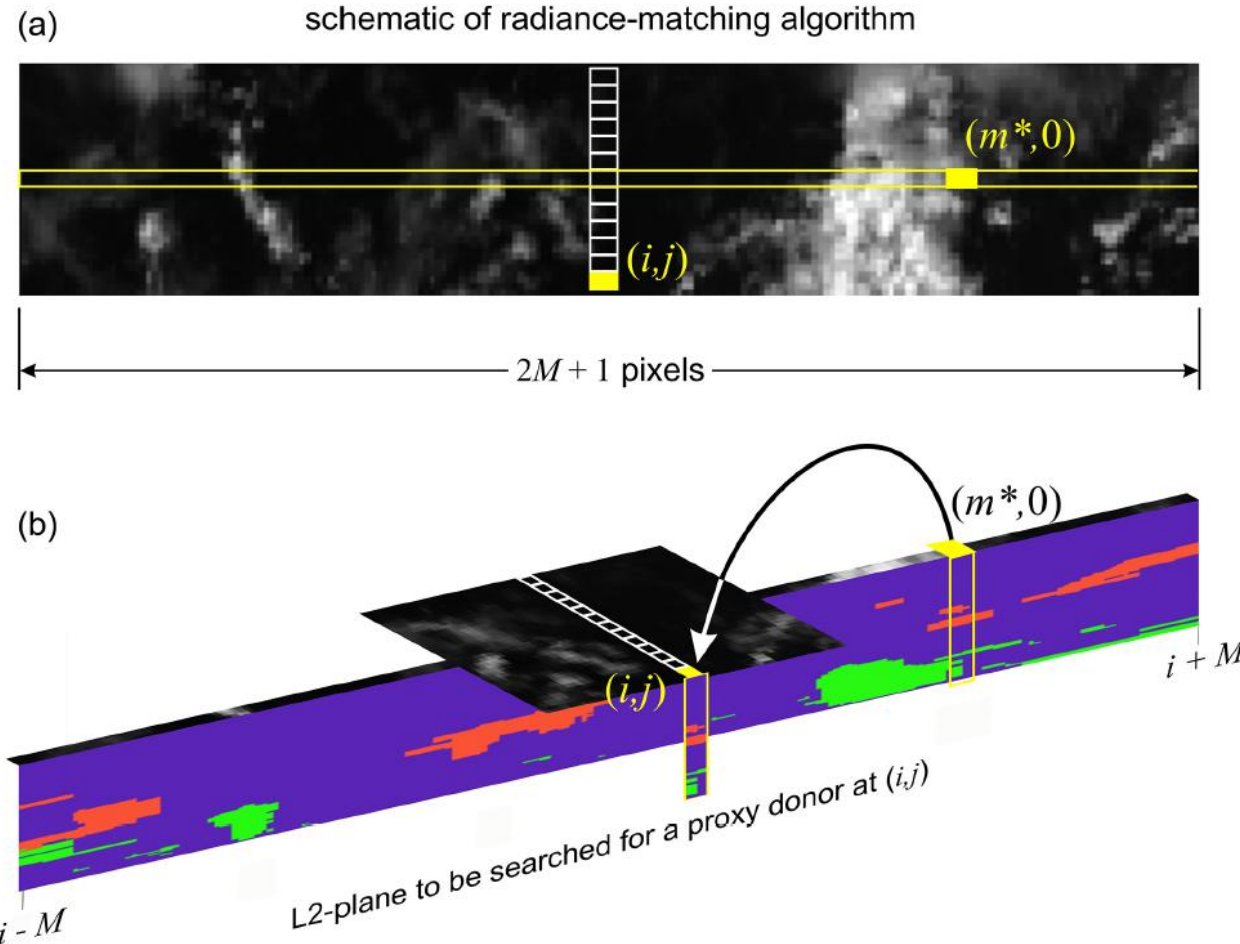
1. EarthCARE's Scene Construction Algorithm



EarthCARE's 3D scene construction algorithm (SCA): a key step before radiative transfer simulation

➤ How reliable the SCA is? How well does it perform with EarthCARE data?

- MSI radiance matching at: 0.67, 2.21, 8.8 and 12 μm .
- Check solar zenith/azimuth angle differences.
- Limited searching distance (configurable), 200 km (BA), 400 km (BC).



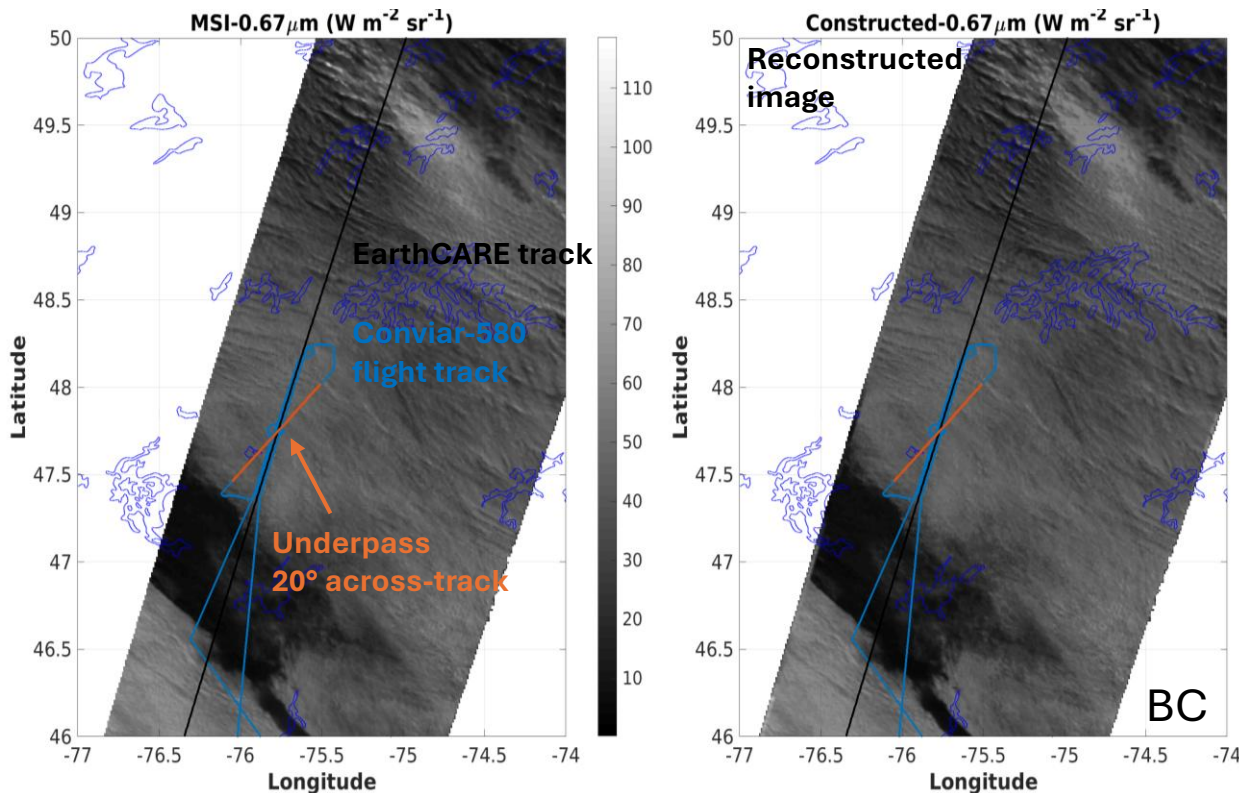
Barker et al. 2011; Qu et al. 2023

2. Validation with In Situ Data

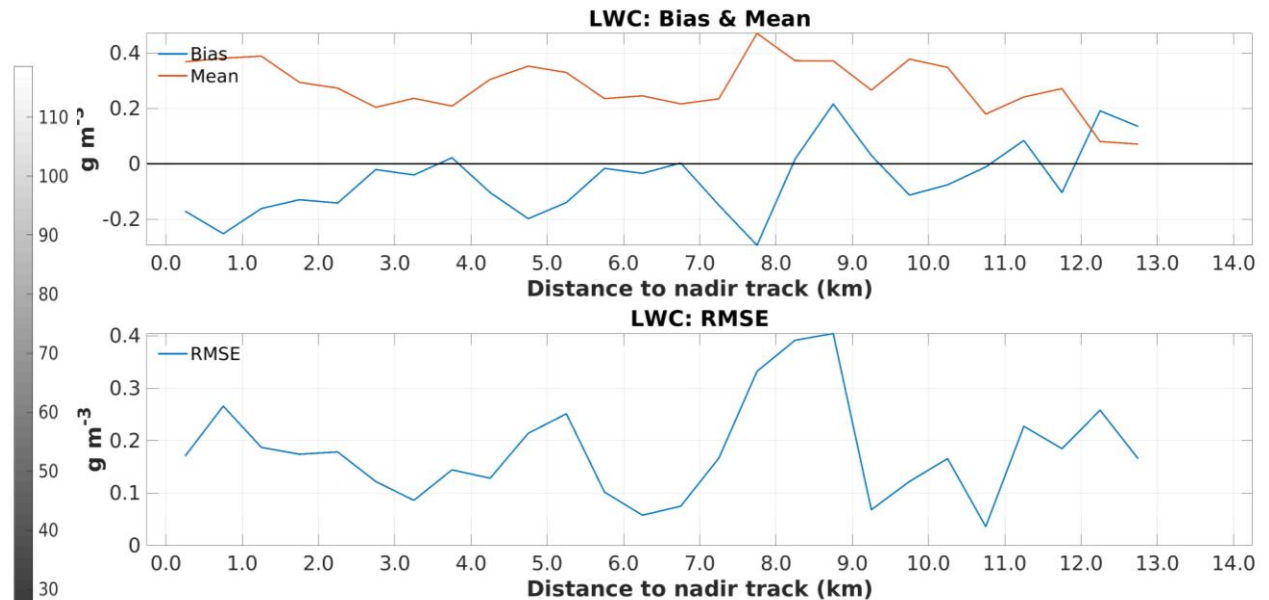


Evaluation using in situ cloud data from ECALOT Flight 4 (2024-11-20, 02736D)

- Stratocumulus case (overpass time: 19:34 UTC) – liquid cloud
- Convair-580 under-flight at 20° angle across track → sampling off-nadir clouds for SCA evaluation
- In situ data: version-3 from optical array probes (2D-S & HVPS-3)
- Liquid water content (LWC): composite based on ATLID with empirical correction (slight underestimated)



(2024-11-20, 19:34 UTC)



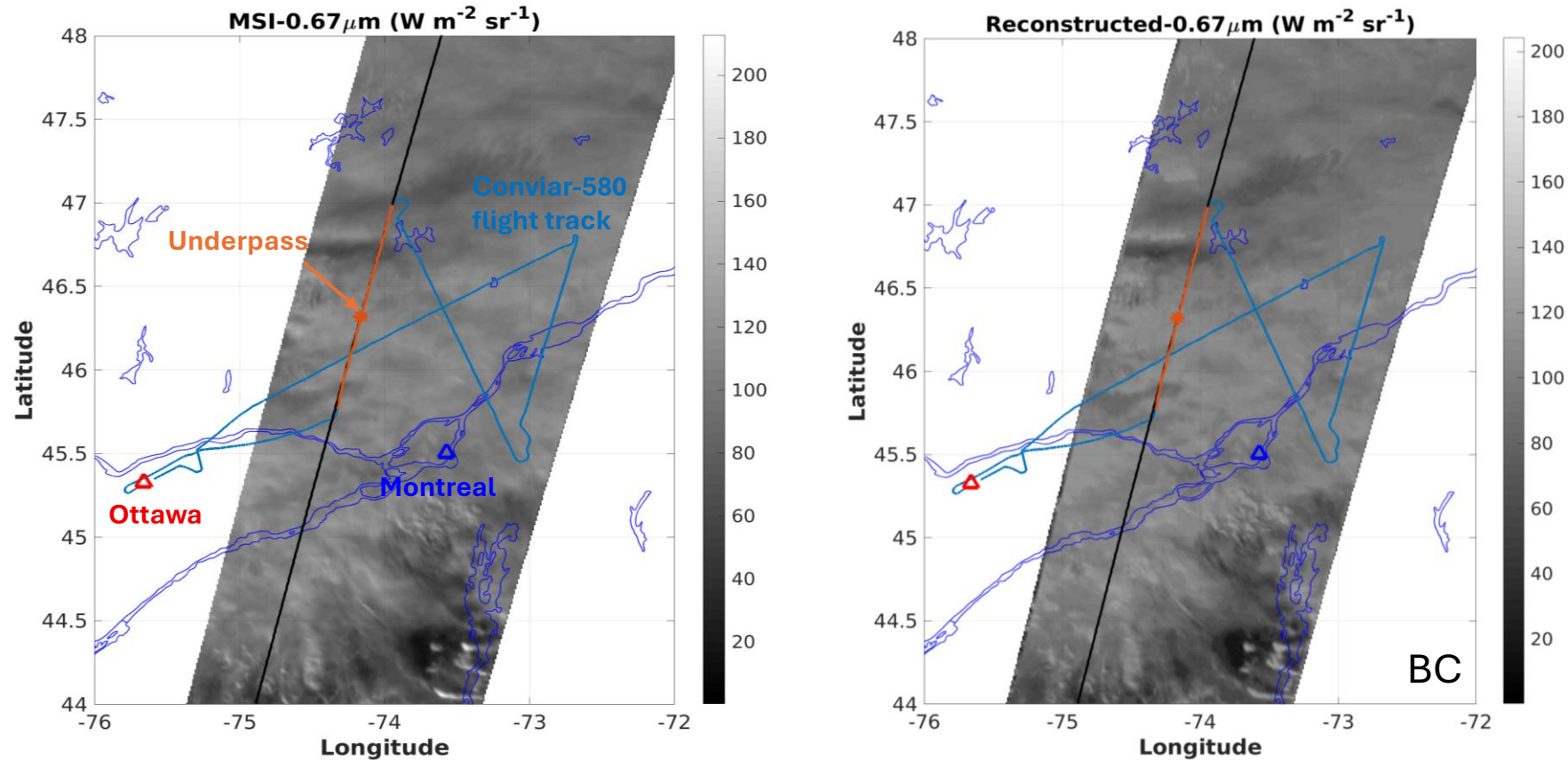
- ✓ MBE & RMSE are not increasing → far from nadir
- ✓ Currently, LWC retrievals has negative (synergy, ATLID based without correction) or positive (M-COP) bias, to be assessed later.

3. Validation with Side-Pointing Radar



Evaluation using side-pointing radar data from ECALOT Flight 6 (2025-01-25, 03794D)

- Nimbostratus case (overpass time: 19:24 UTC) – Ice cloud
- Convair-580 under-flight along EarthCARE track, with starboard-side pointing W-band radar beam



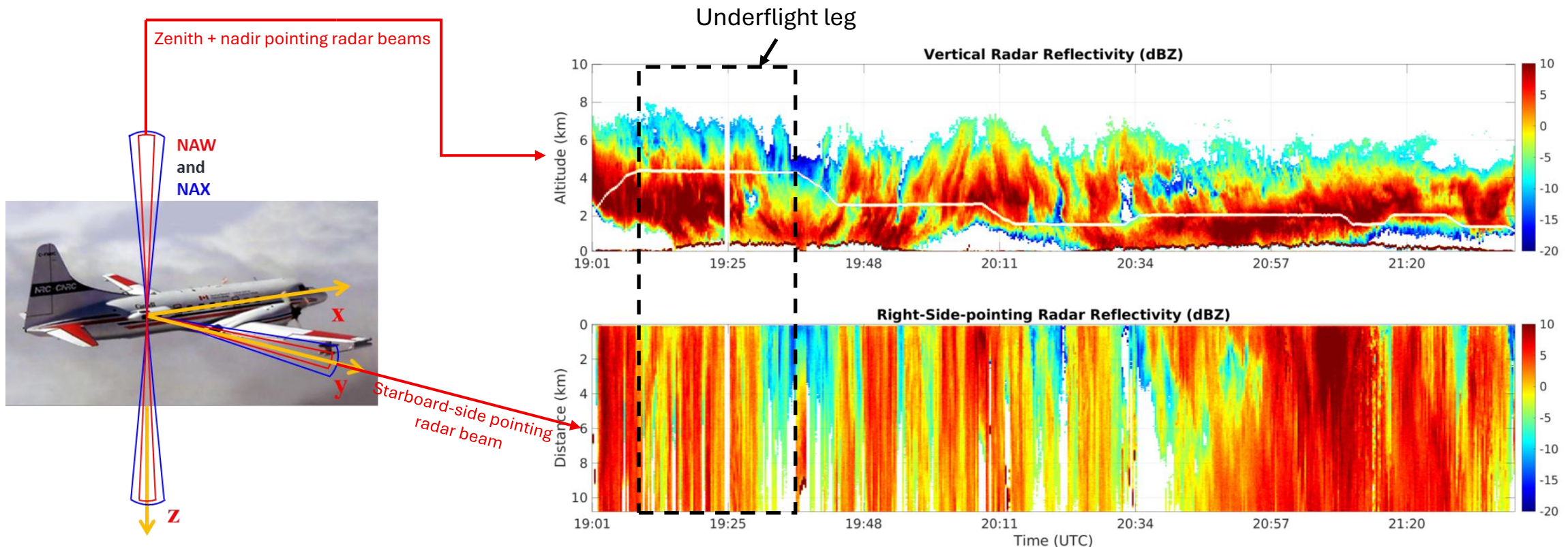
(2025-01-27, 19:24 UTC)

3. Validation with Side-Pointing Radar



ECALOT Flight 6 (2025-01-27): large Ns clouds, mostly ice clouds above 2 km

- **Reference:** starboard-side pointing radar reflectivity (Z_{side}) & IWC retrieval based on Z_{side}
- **Construction:**
 - Reflectivity at aircraft level: average of the 1st valide Z_{nadir} & Z_{zenith}
 - Construction index: ACMB-3D Baseline BA (11.3) & BC (11.4)
- **Validation range:** across-track: 0 to 10 km east side of the nadir track; along-track: 130 km



3. Validation with Side-Pointing Radar

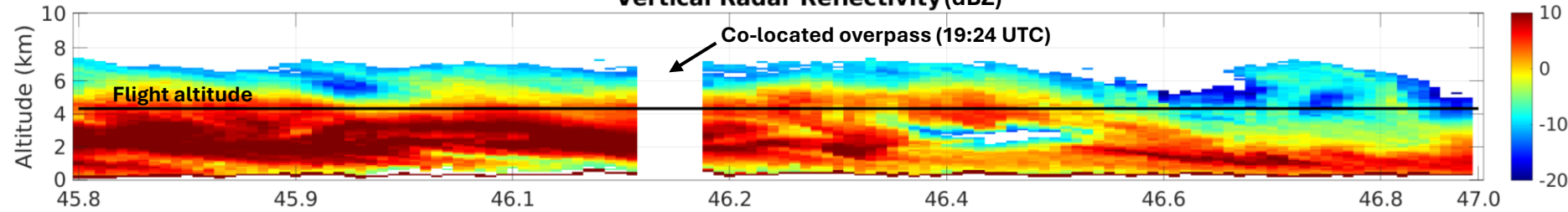


Underflight comparison for the EarthCARE frame 03794D

All data interpolated into JSG grid resolution

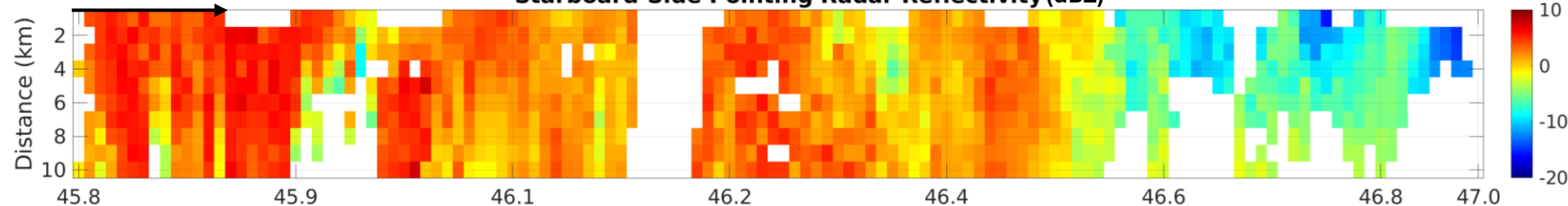
NAW construction - SCA v11.3 - JSG Resolution

Vertical Radar Reflectivity (dBZ)



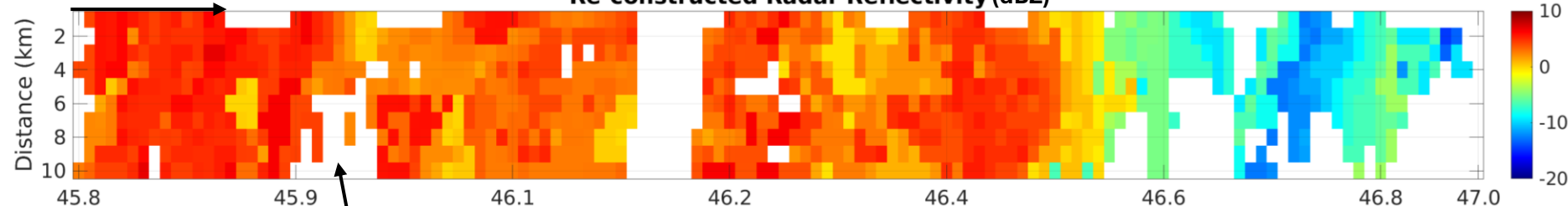
Nadir track

Starboard-Side Pointing Radar Reflectivity (dBZ)



Nadir track

Re-constructed Radar Reflectivity (dBZ)



Blank areas: with high signal-to-noise ratio, or construction index out of range of the underpass

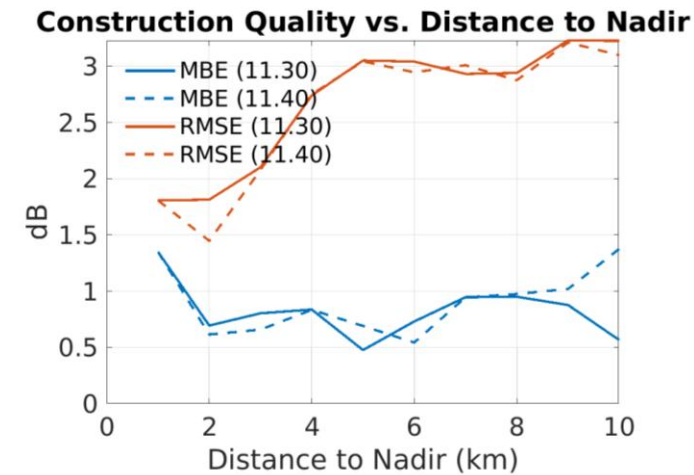
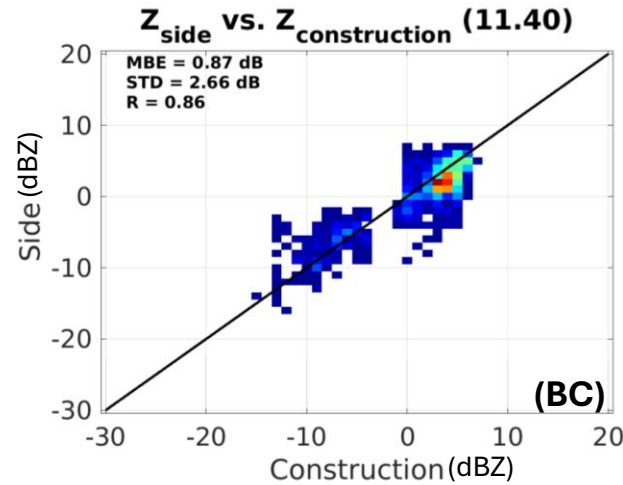
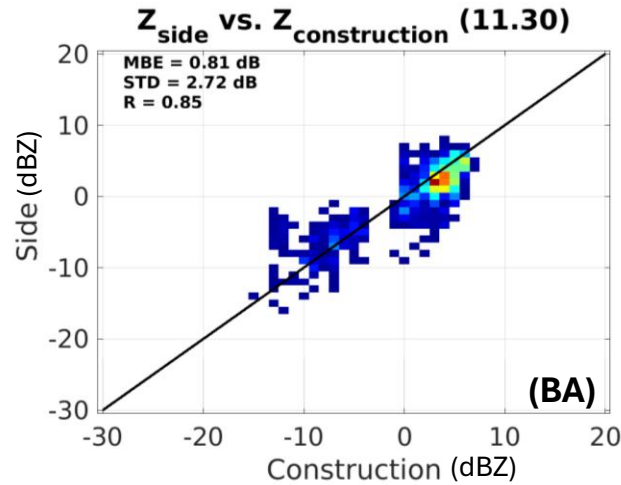
3. Validation with Side-Pointing Radar



- Good agreement for both Z & IWC.
- Similar performance for BA & BC baselines (better when close to nadir track).

Reflectivity

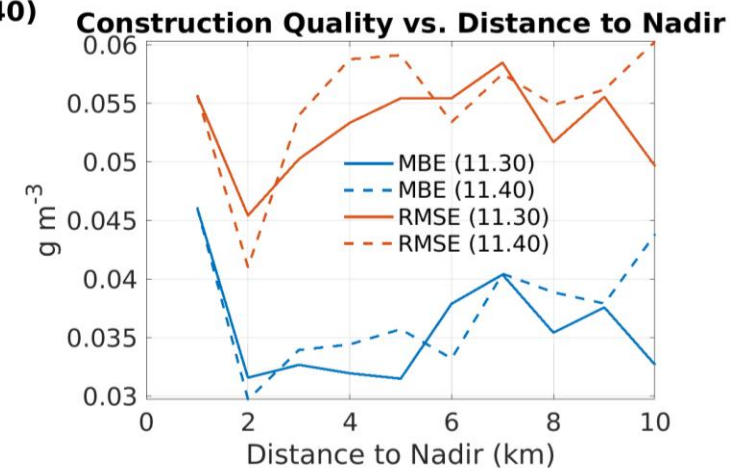
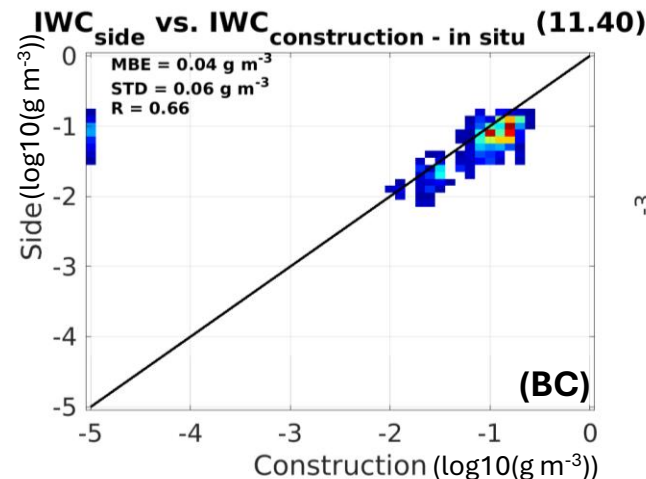
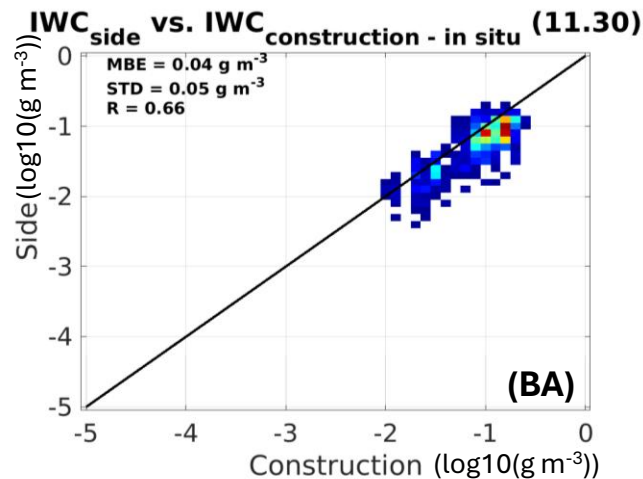
Z_{side}
vs.
Construction with nadir Z



Ice Water Content

Retrieval based on Z_{side}
vs.
Construction with Nevzorov
probe data

Retrieval method based on:
 $IWC = aZ^b$



4. Summary



- **Liquid cloud:**
 - Validation with in situ data → no increase of MBE & RMSE when moving away from nadir track (12 km)
 - Caveat: current LWC retrievals have biases, to be improved
- **Ice cloud:**
 - Validation with side-pointing NAW radar Z & IWC → good agreement up to 10 km from nadir track
 - Better agreement when it's closer to nadir track
 - Similar performance between BA and BC
 - Construction with EarthCARE C-NOM & ice retrieval (not shown)
 - good agreement
 - but lower R than using NAW's Z & IWC
- **Continue check with new baselines in the future**
- **Poster using SCA:** Annex39 (Lei Liu and Yi Huang) – surface spectral radiative closure

ECALOT Flight 6 (2025-01-25), north of Montreal

**Thank you for your attention!
Any questions?**

