Environment and Climate Change Canada | Environnement et Changement climatique Canada

Canada

Validation of EarthCARE L2 cloud retrievals using in situ data from ECALOT campaign

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1. ECALOT Flights and *in situ* validation plan

EarthCARE Commissioning **Cal**/Val Campaign in **Ott**awa (**ECALOT**) – NRC Convair-580 + CYOW + Climate Sentinels

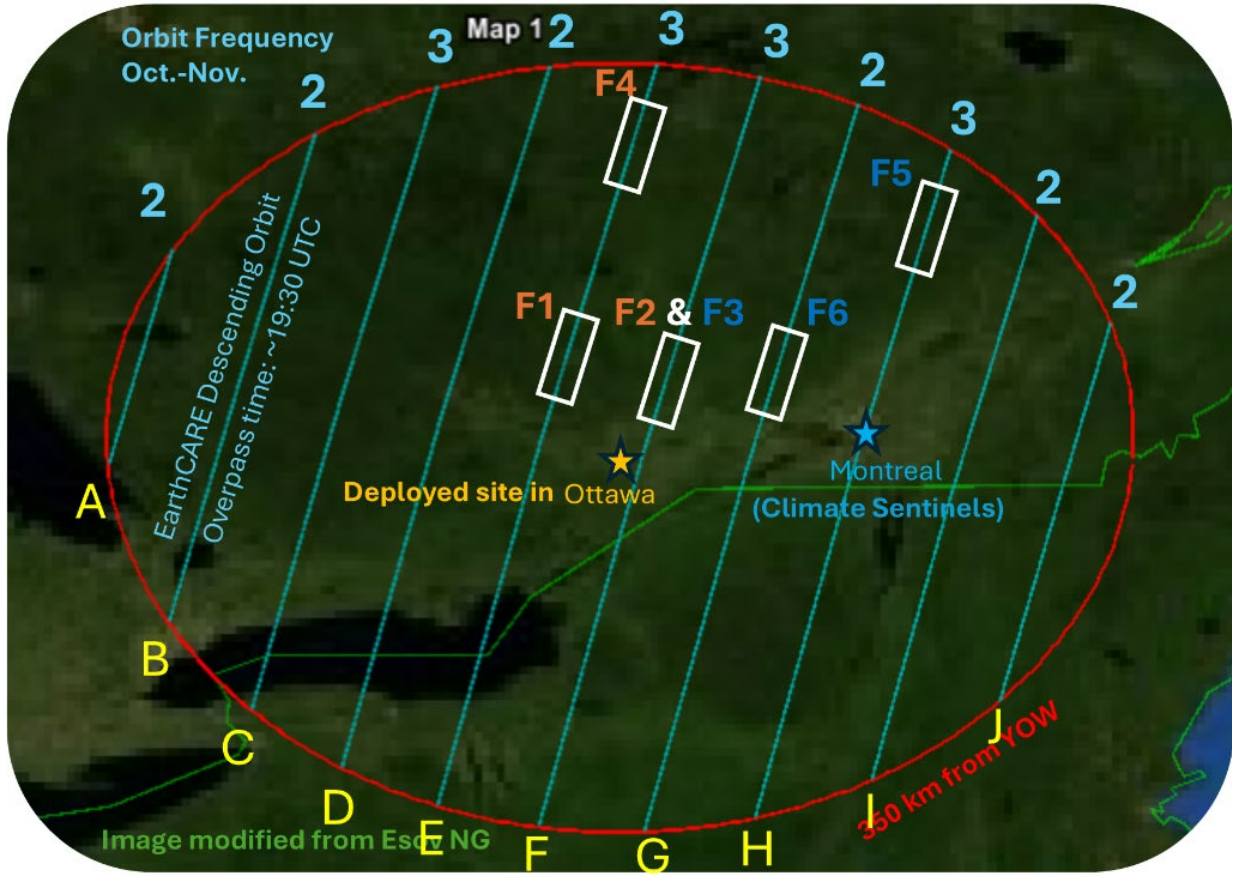
In situ cloud data were recently processed (data consolidation continues)!

Validation focuses on the EarthCARE L2a products:

- C-CLD (cloud retrievals using CPR)
- A-ICE (ice cloud retrievals using ATLID)
- M-COP (cloud retrievals using MSI)

} Combined into Composite product

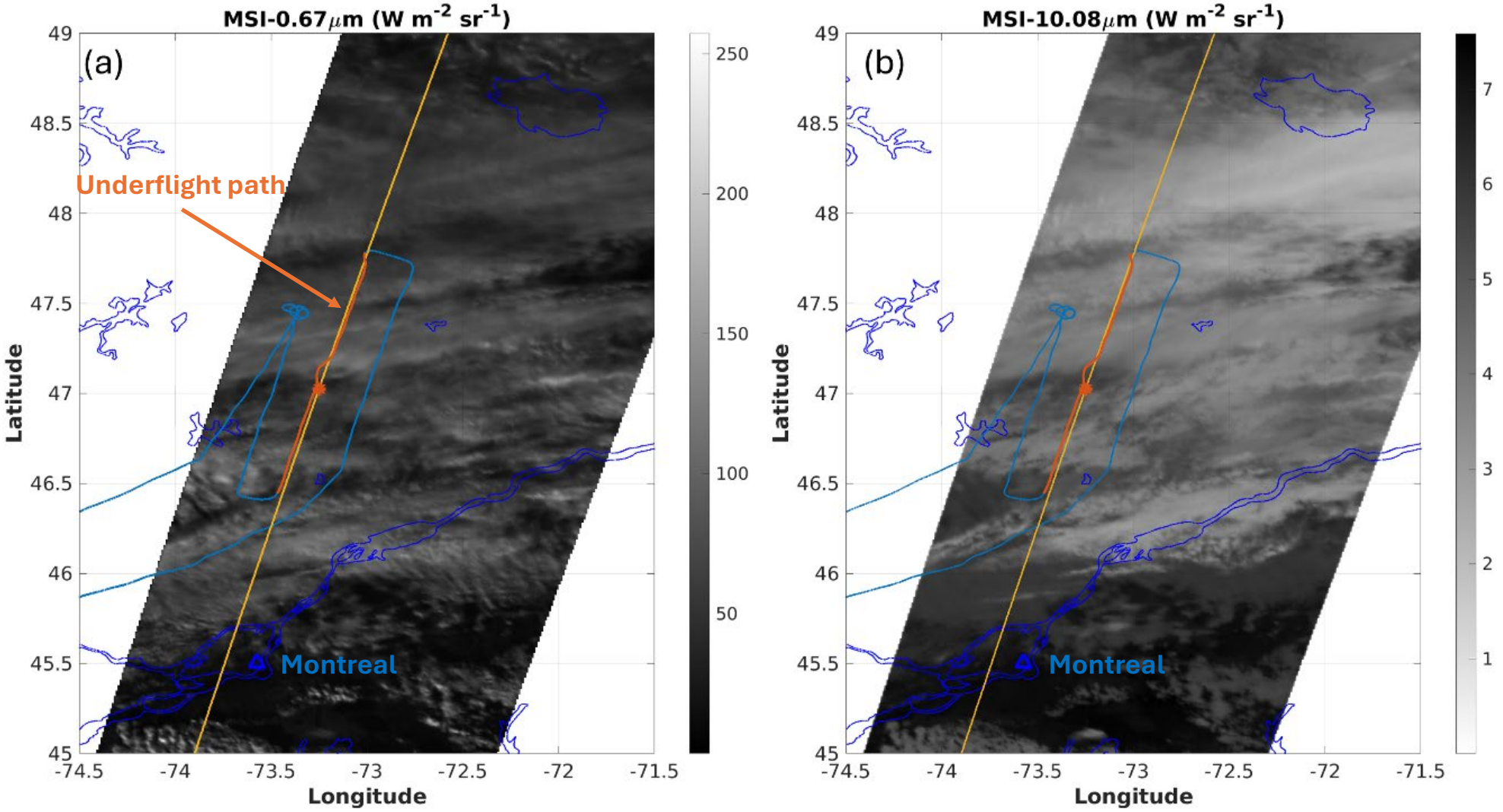
- Synergy retrieval (ACM-CAP)



Airborne observations:

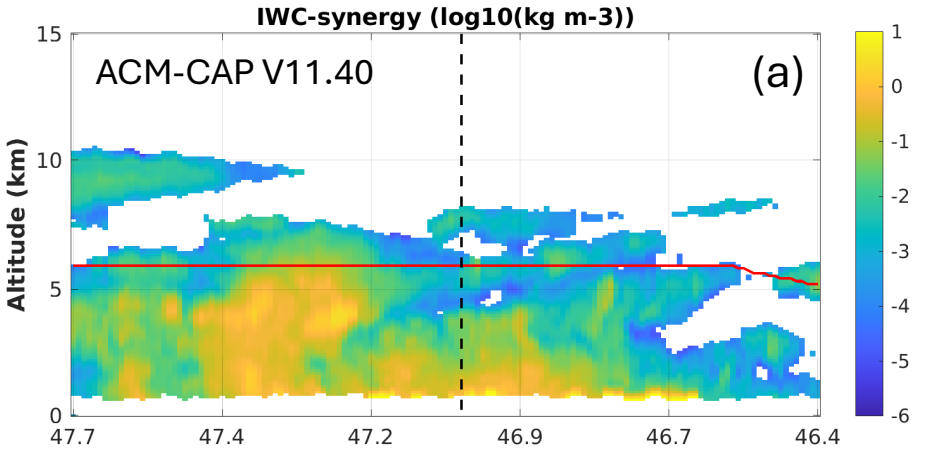
- Flight 1: Oct. 1st – Cu & Sc (no CPR)
- Flight 2: Oct. 10th – Sc + aerosols (gaps in MSI)
- Flight 3: Nov. 4th – NS + large scale rain (C-CLD)
- Flight 4: Nov. 20th – two-layer Sc + aerosols (M-COP & scene construction algorithm)
- Flight 5: Nov. 22nd – Ci + Ns (A-ICE)
- Flight 6: Jan. 27th – Ns + snow (C-CLD)
- Flight 7: March 2025 - TBD

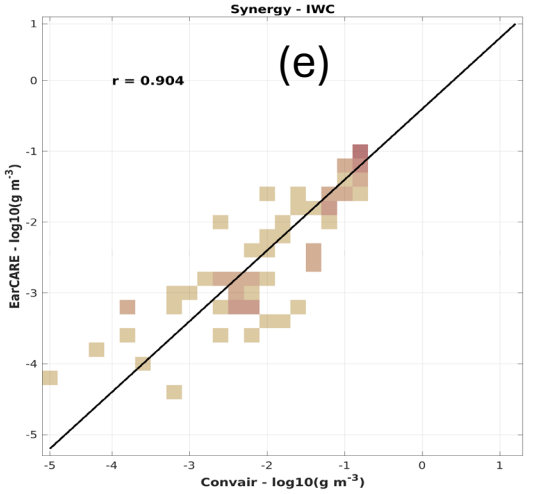
2. A-ICE validation (Flight 5, Nov. 22, 02767D)

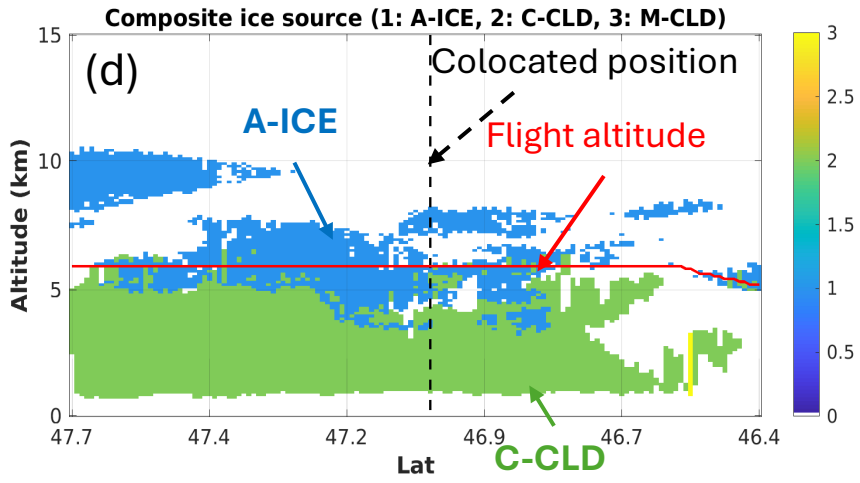


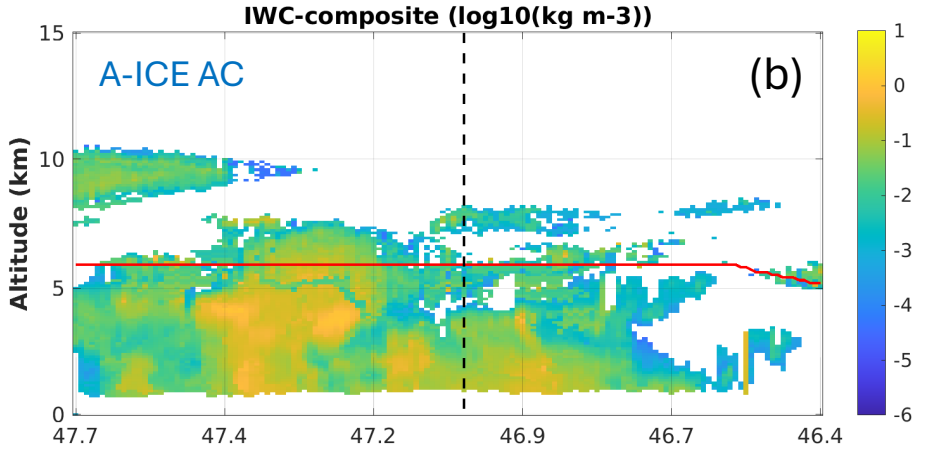
- Cloudy condition with thin ice & supercooled liquid clouds near cloud top (2024-11-22 19:23 UTC)
- Rain with melting layer at ~700 m above ground

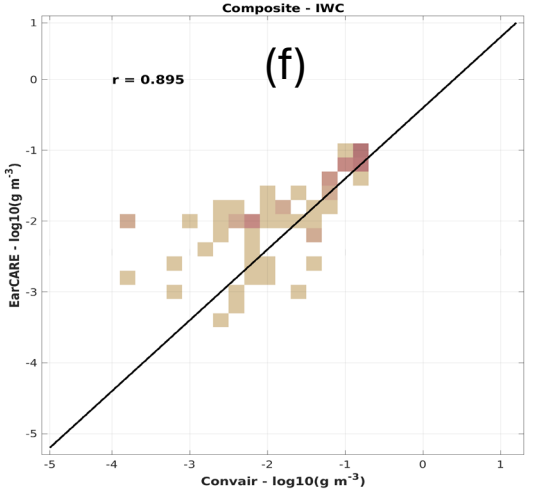
2. A-ICE validation (Flight 5 , Nov. 22 , 02767D)

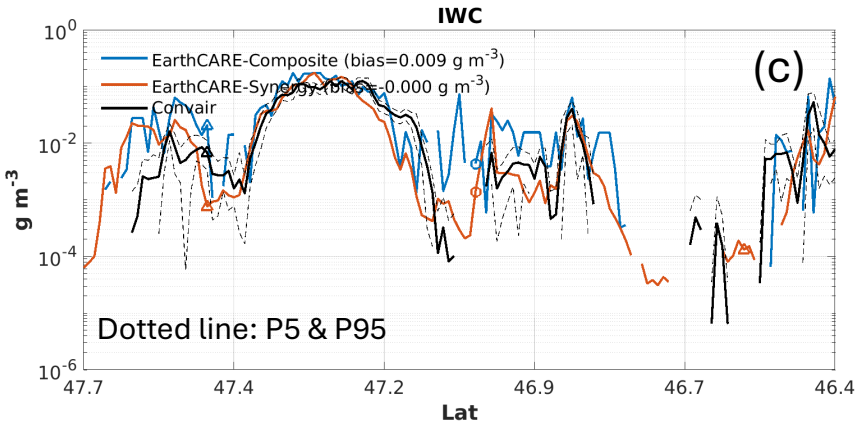








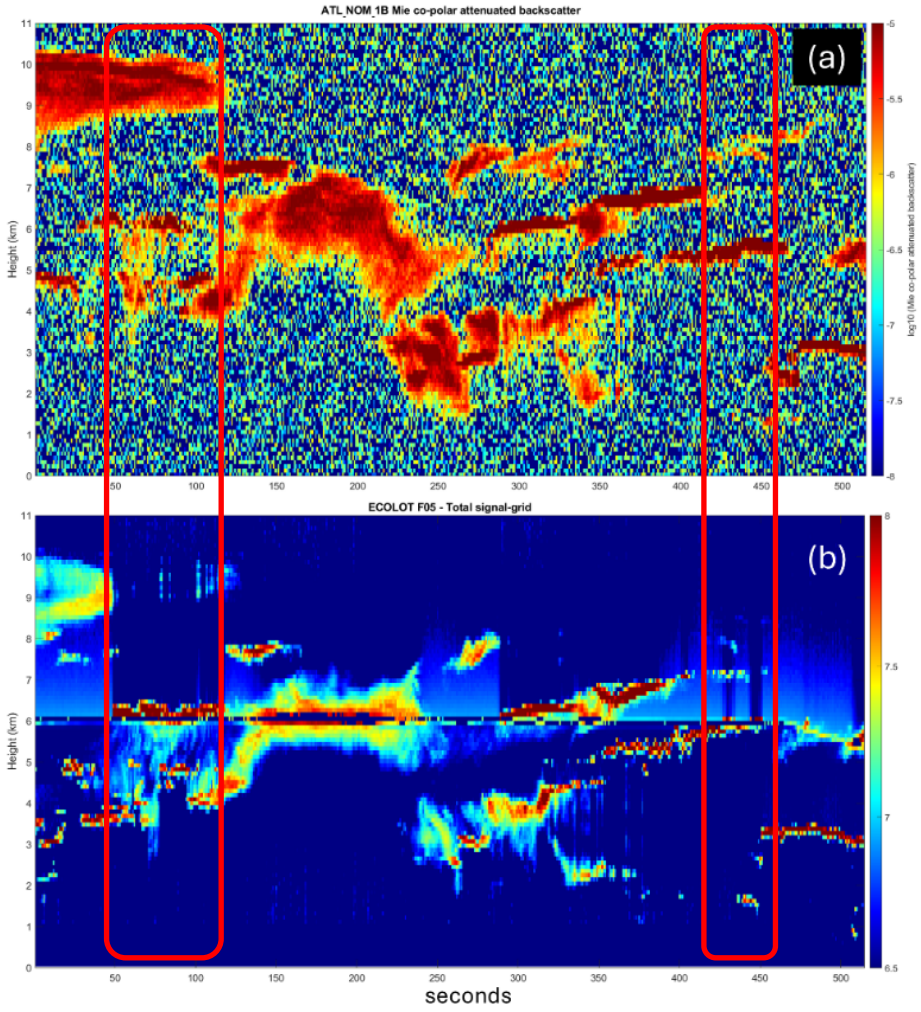


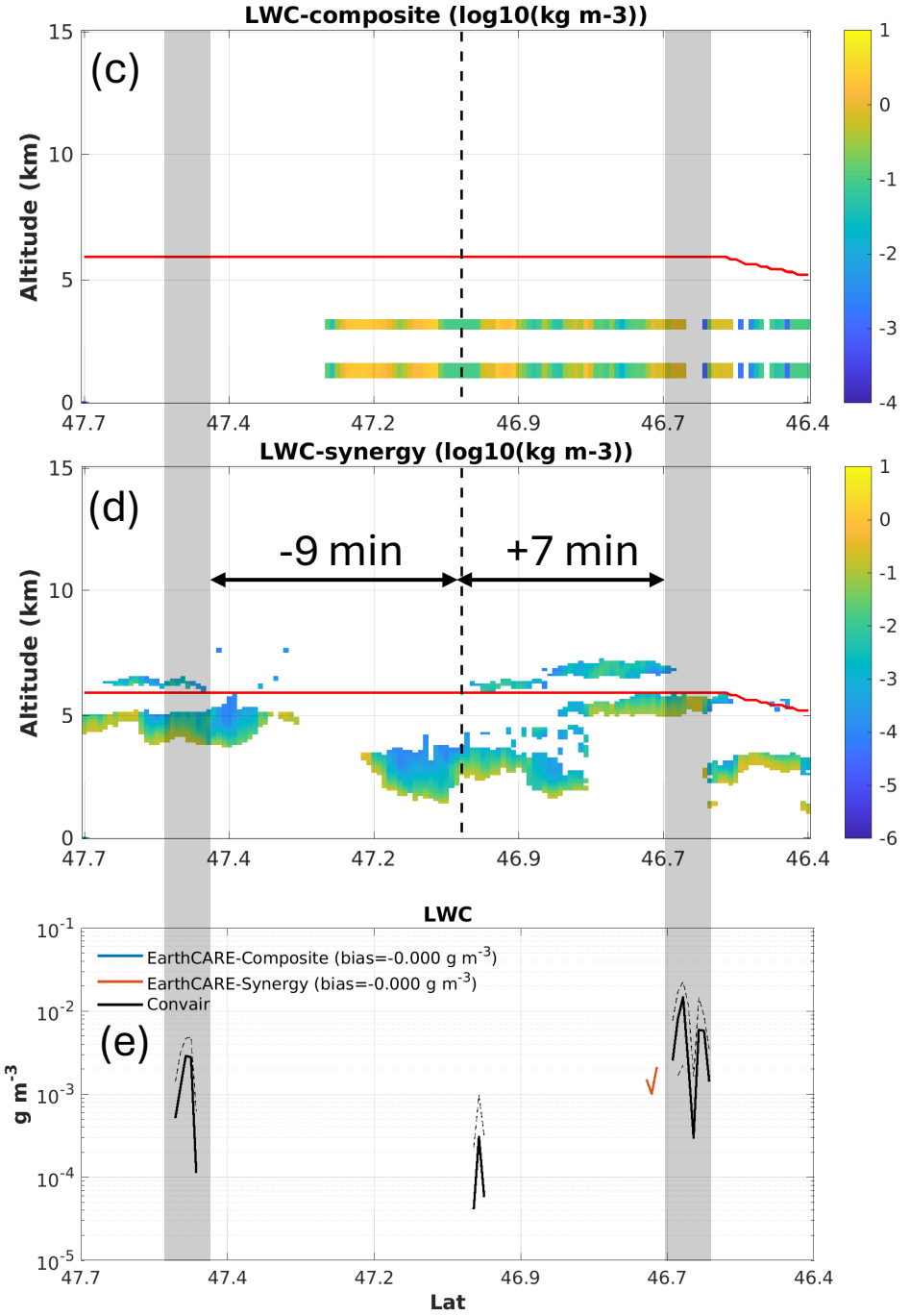


- $IWC_{in\text{-}situ}$: OAP composite distribution of D>100um
- Good agreement (slight overestimation from A-ICE, no bias from ACM-CAP)
- Good correlation (r > 0.89)

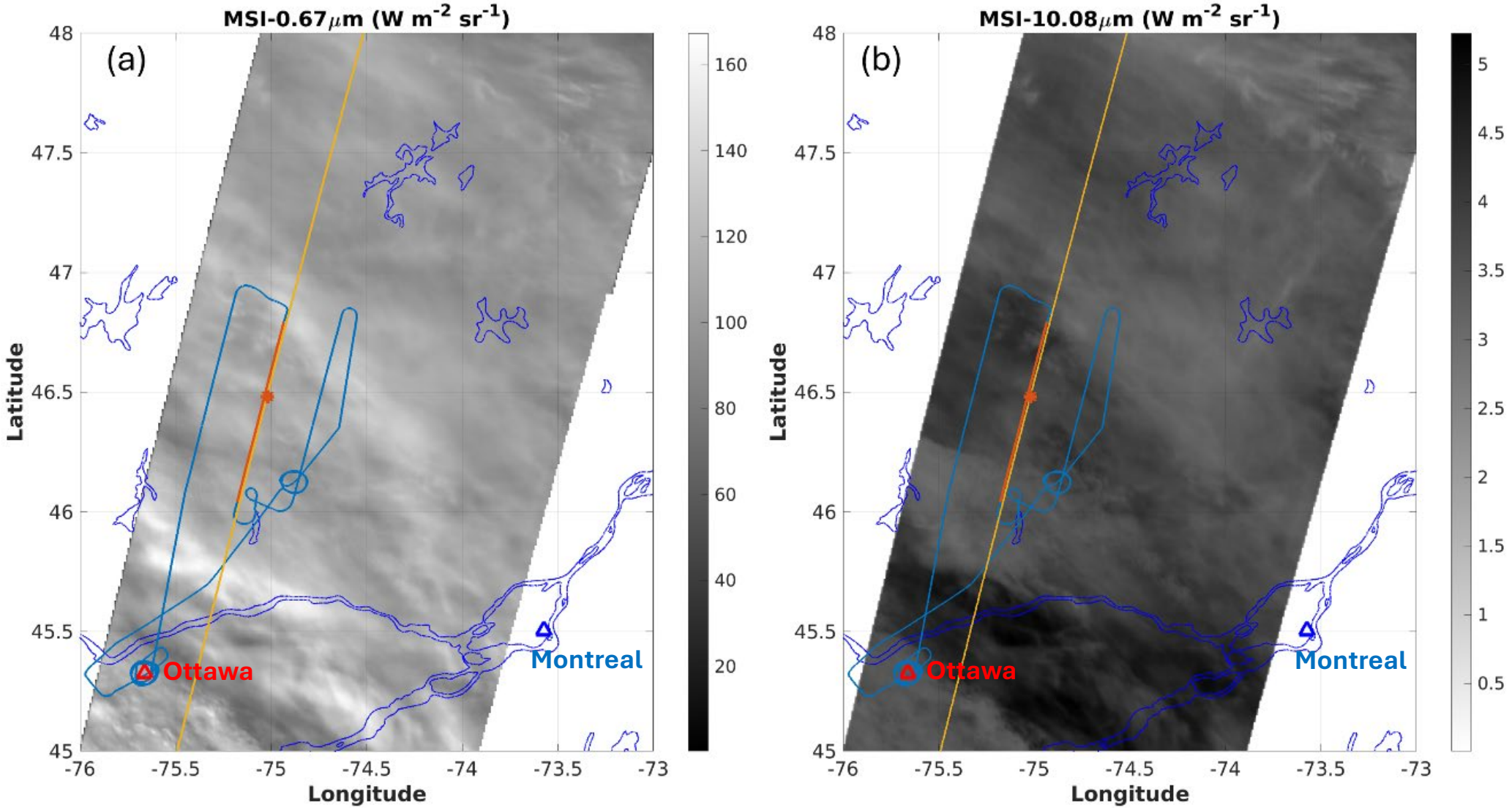
2. A-ICE validation (Flight 5 , Nov. 22 , 02767D)

- $LWC_{in\text{-}situ}$: CDP
- LWC missing in Composite clouds
- Synergy retrieve better mixed-phase clouds!





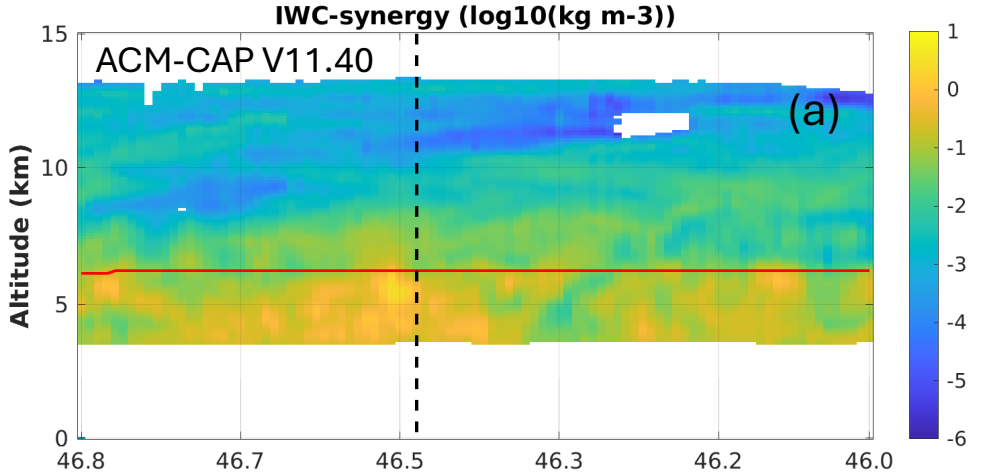
3. C-CLD validation (Flight 3, Nov. 4, 02487D)

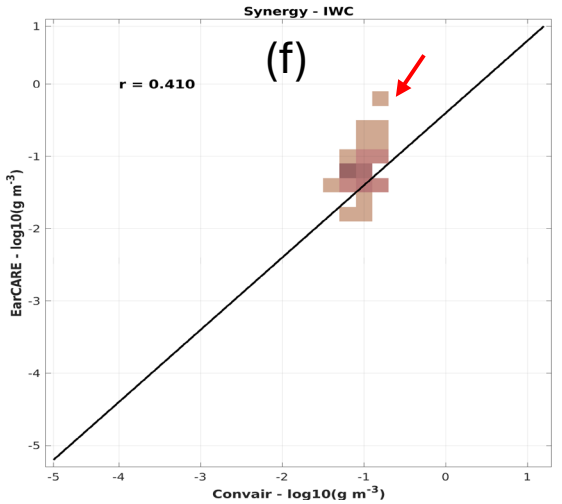


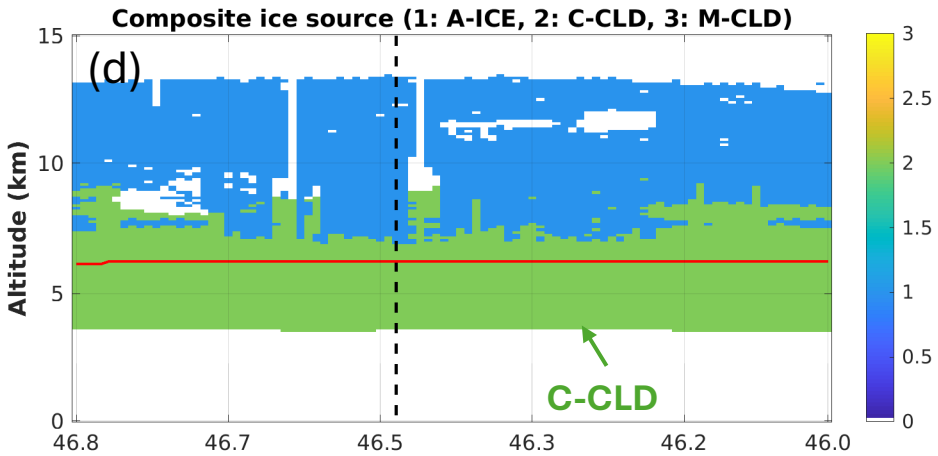
- Cloudy condition with higher level ice clouds (2024-11-04 19:30 UTC)
- Rain condition with melting layer at ~3.5 km

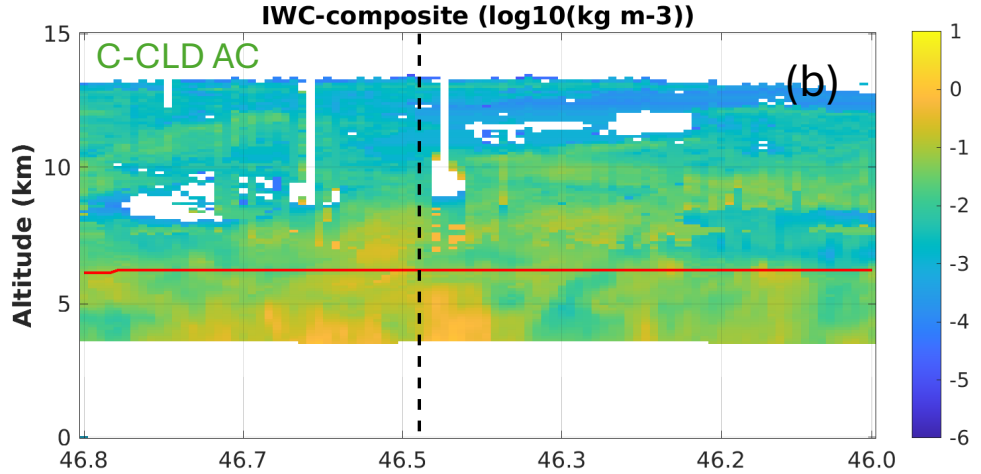
3. C-CLD validation (Flight 3 , Nov. 4 , 02487D)

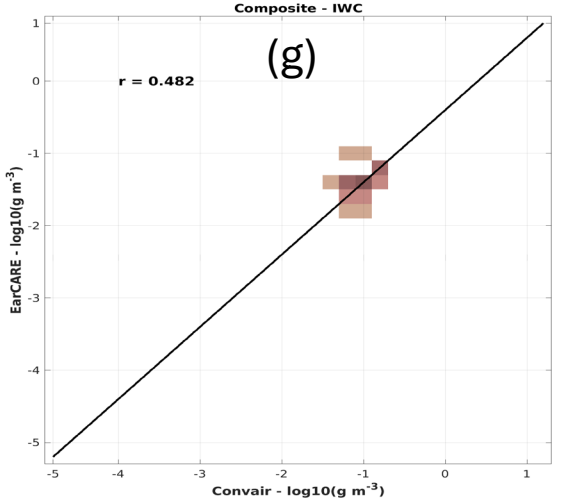
- $IWC_{ACM\text{-}CAP} > IWC_{C\text{-}CLD} \approx$ in situ

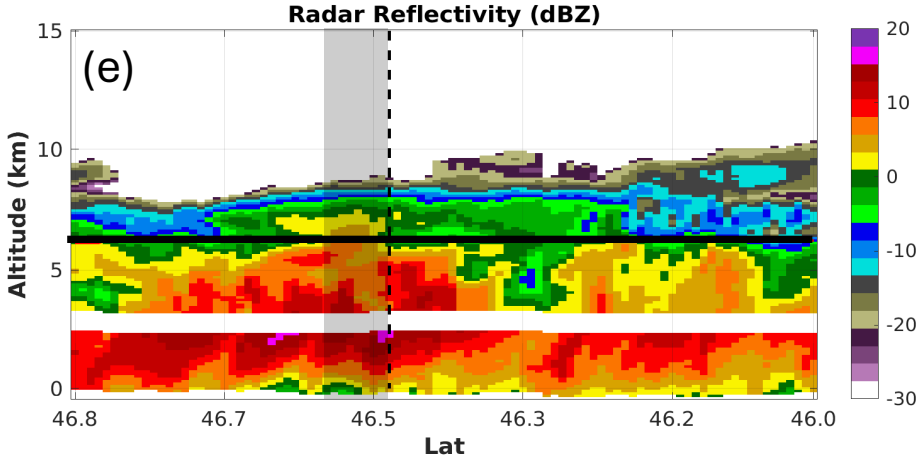


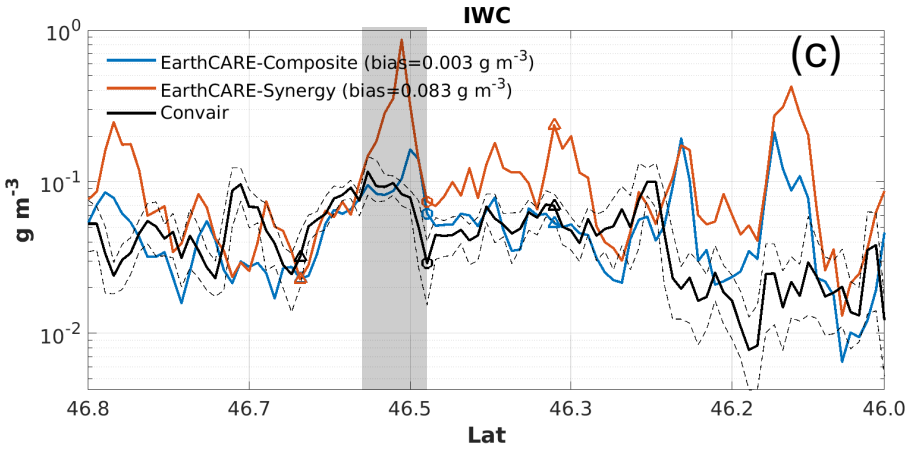






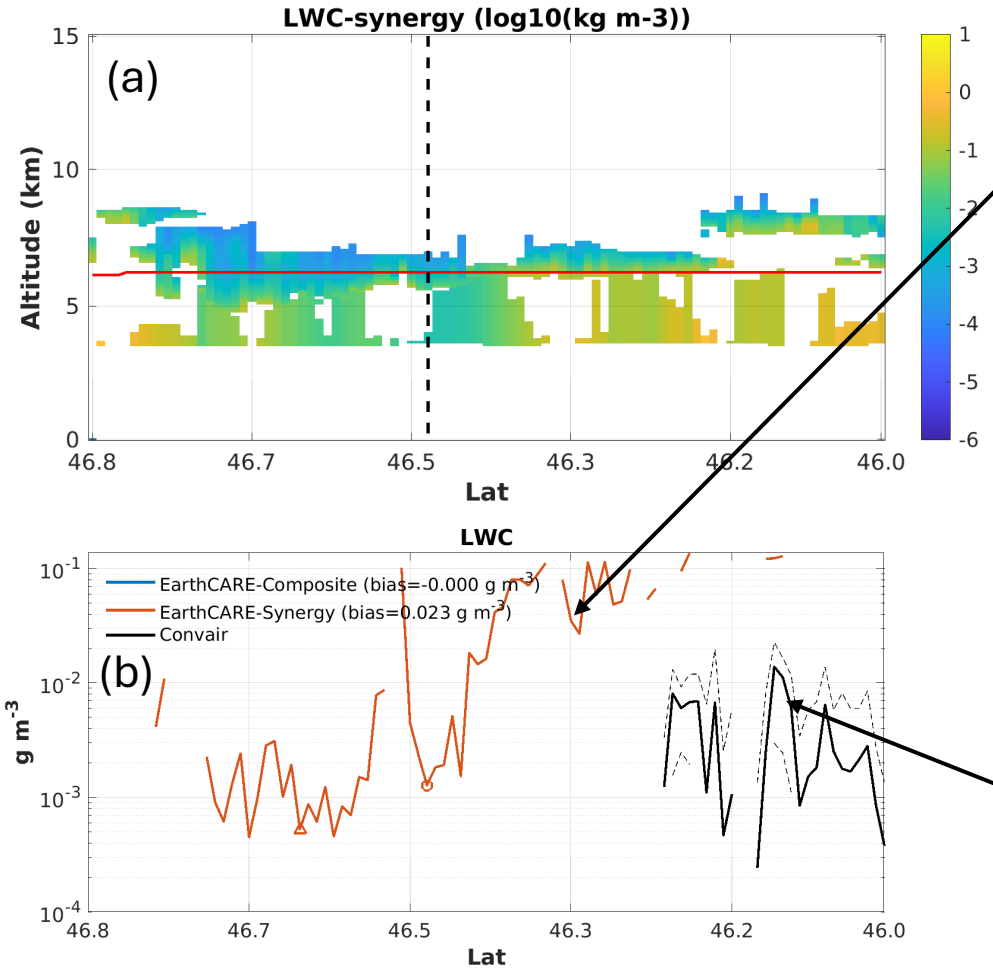


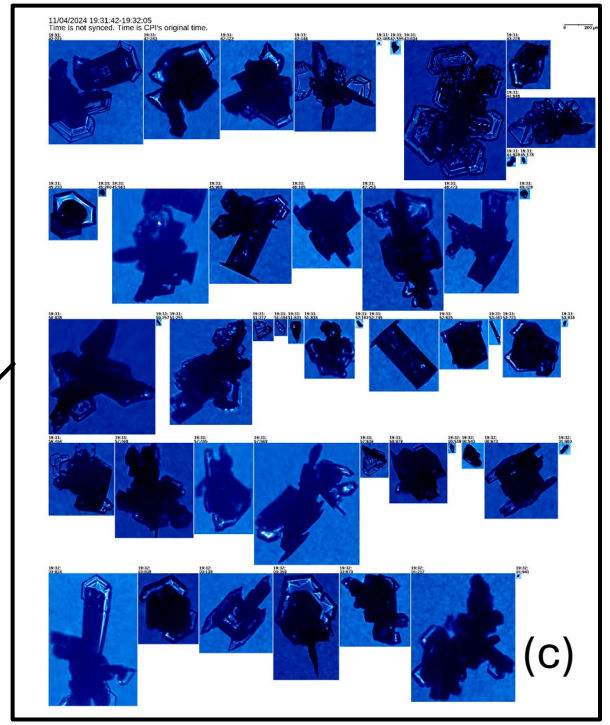


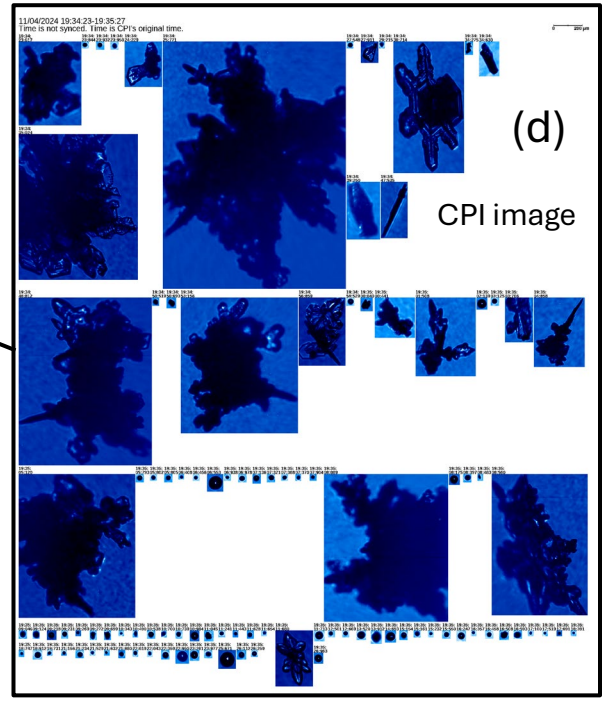


3. C-CLD validation (Flight 3 , Nov. 4 , 02487D)

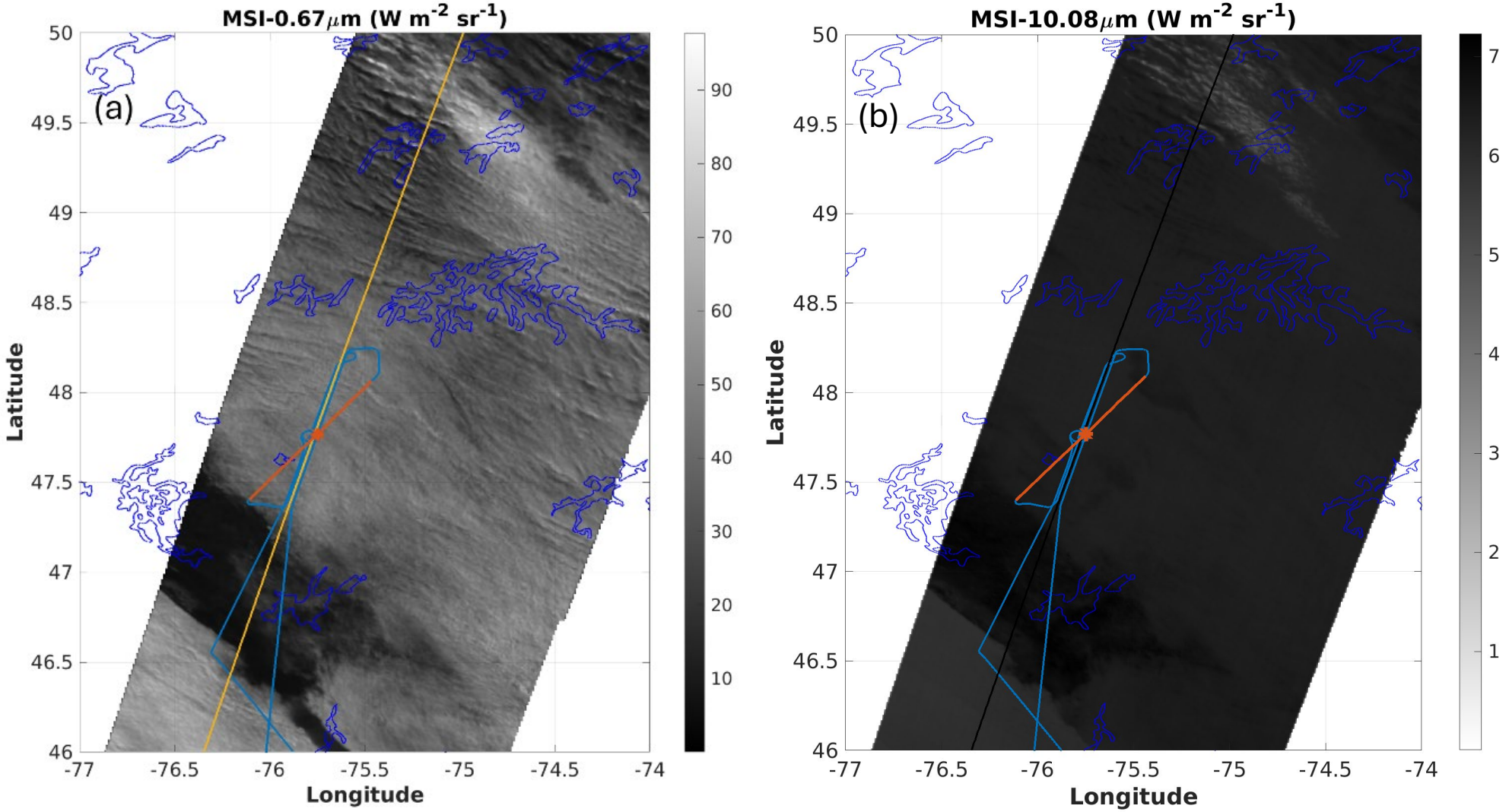
- **Mixed-phase clouds**: the Synergy product offers improved LWC estimation but results in a higher frequency of liquid cloud occurrences





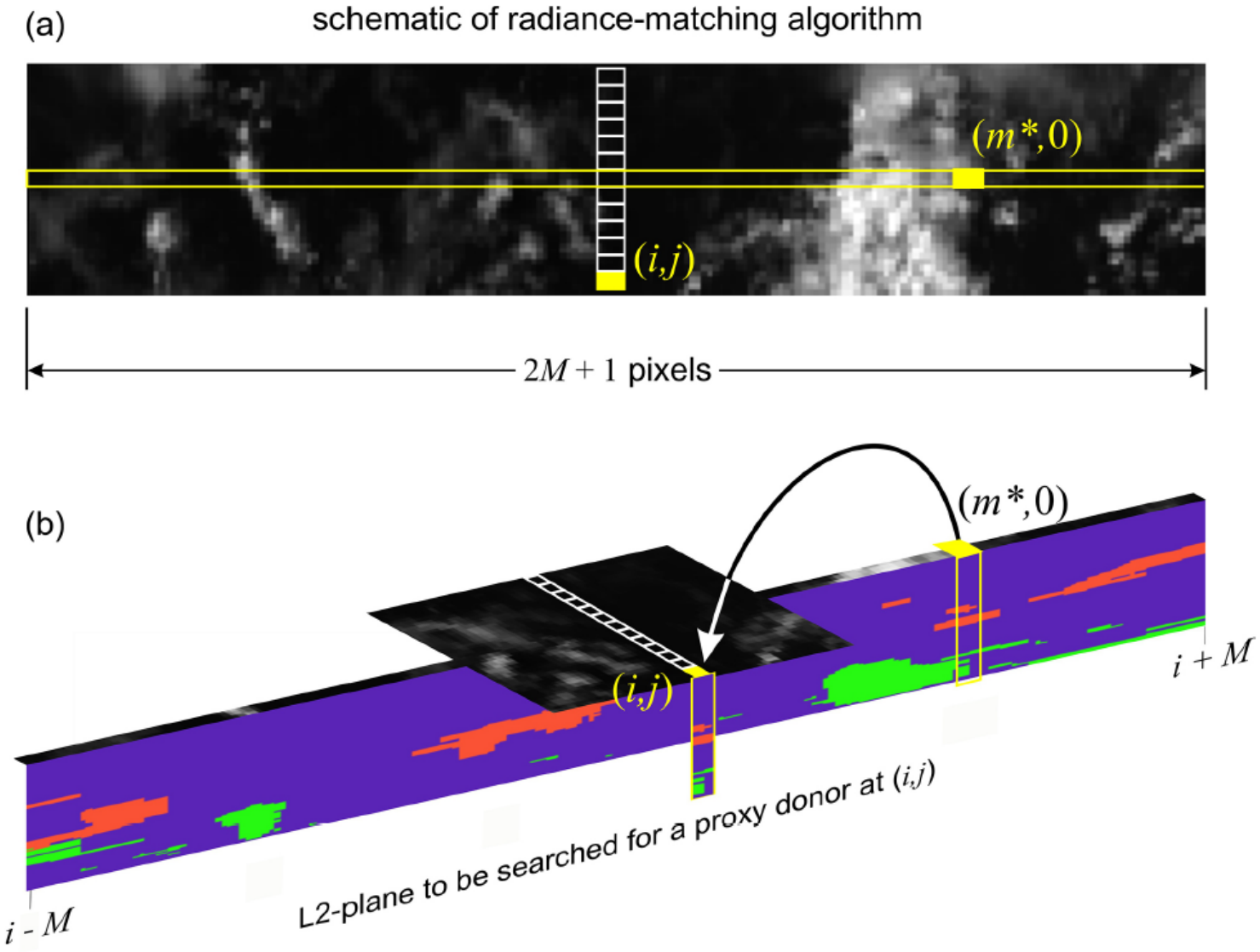


4. M-COP & Scene Construction Algorithm (SCA) validation (Flight 4, Nov. 20, 02736D)



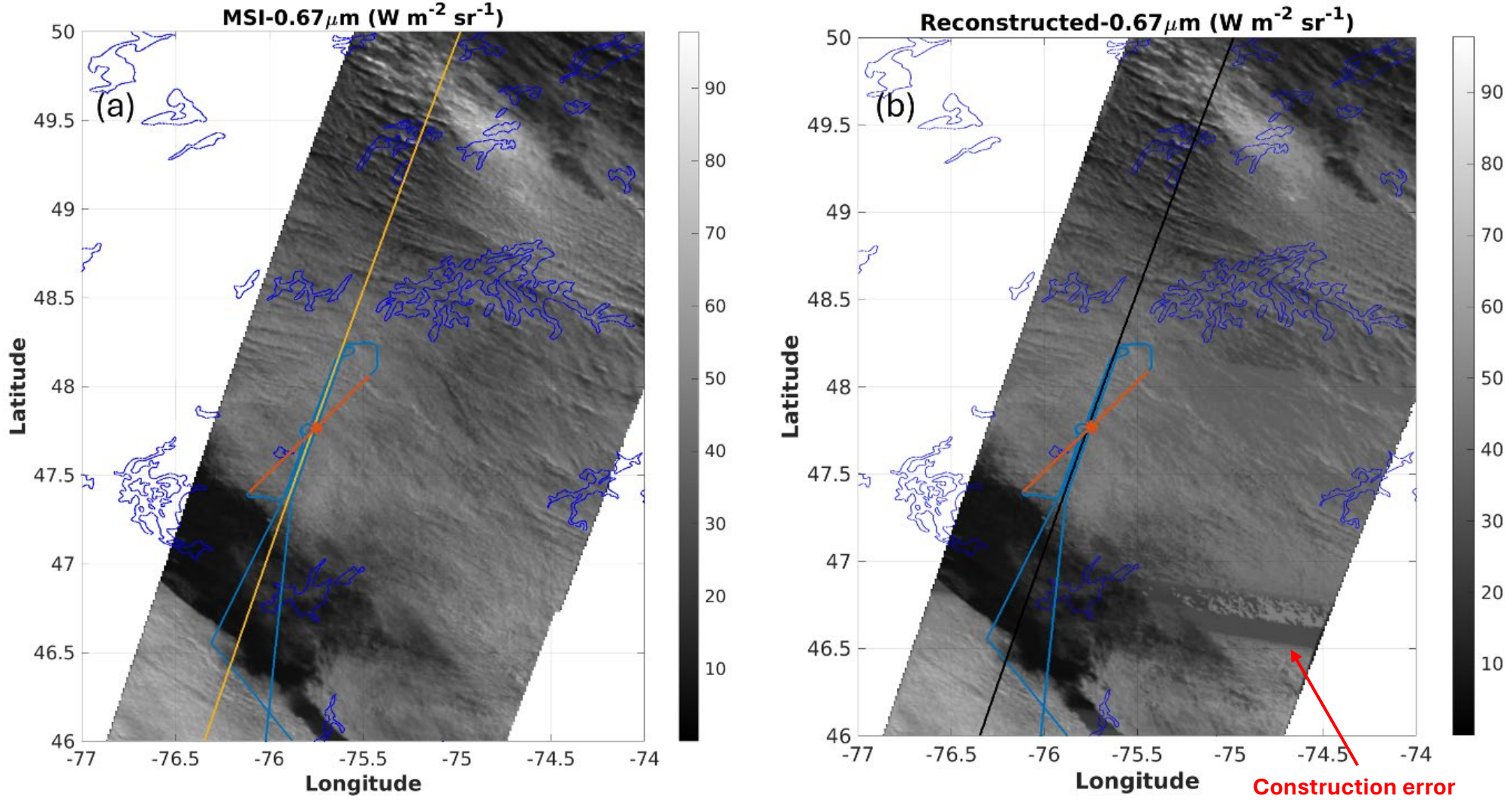
- Cloudy condition with low level stratocumulus clouds (2024-11-20 19:34 UTC)
- Under-flight at 20° angle → scene construction algorithm validation
- Radiance construction quality is very good, some errors in the region far away from orbit

4. M-COP & SCA validation (Flight 4, Nov. 20, 02736D)



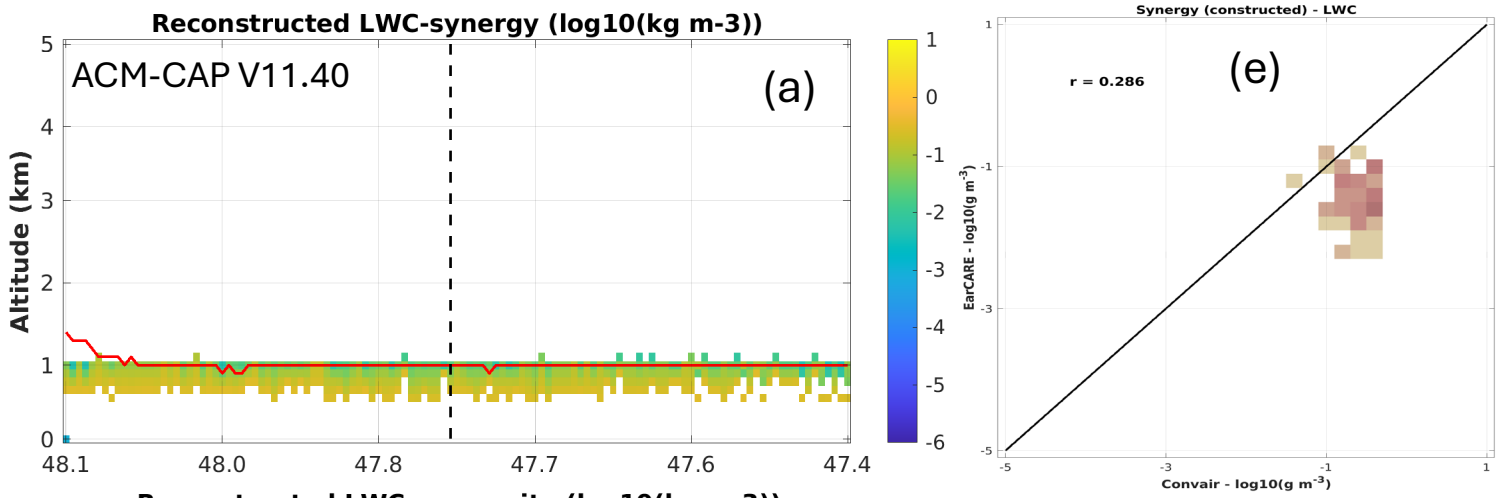
ACMB-3D: 3D scene construction algorithm

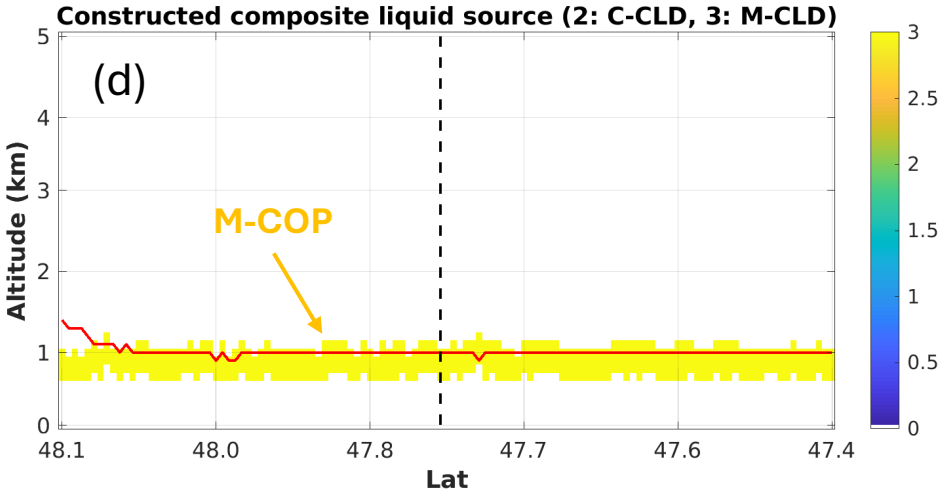
4. M-COP & SCA validation (Flight 4, Nov. 20, 02736D)

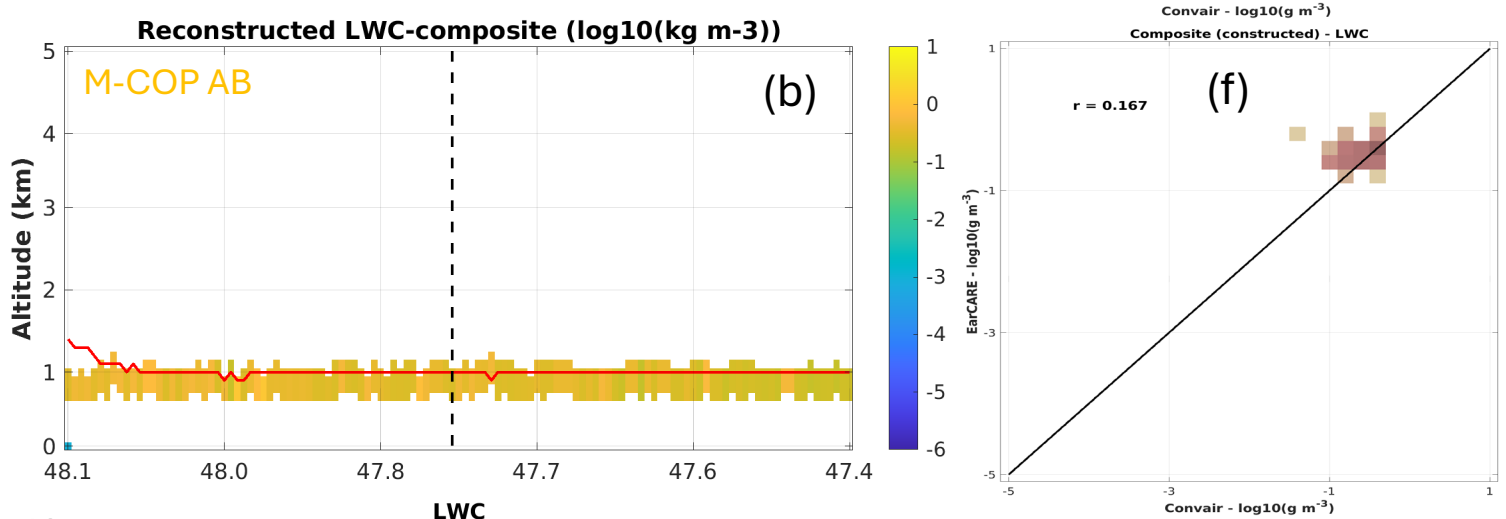


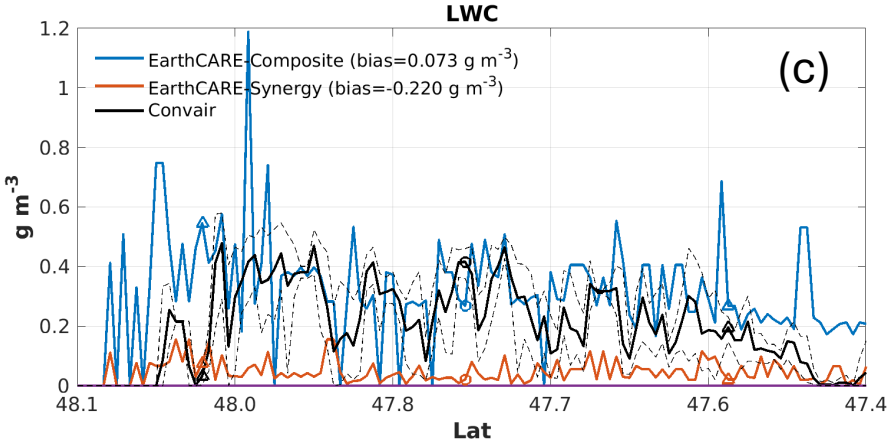
- Cloudy condition with low level stratocumulus clouds (2024-11-20 19:34 UTC)
- Under-flight at 20° angle → scene construction algorithm validation
- Radiance construction quality is very good, some errors in the region far away from orbit

4. M-COP & SCA validation (Flight 4 , Oct. 10 , 02736D)







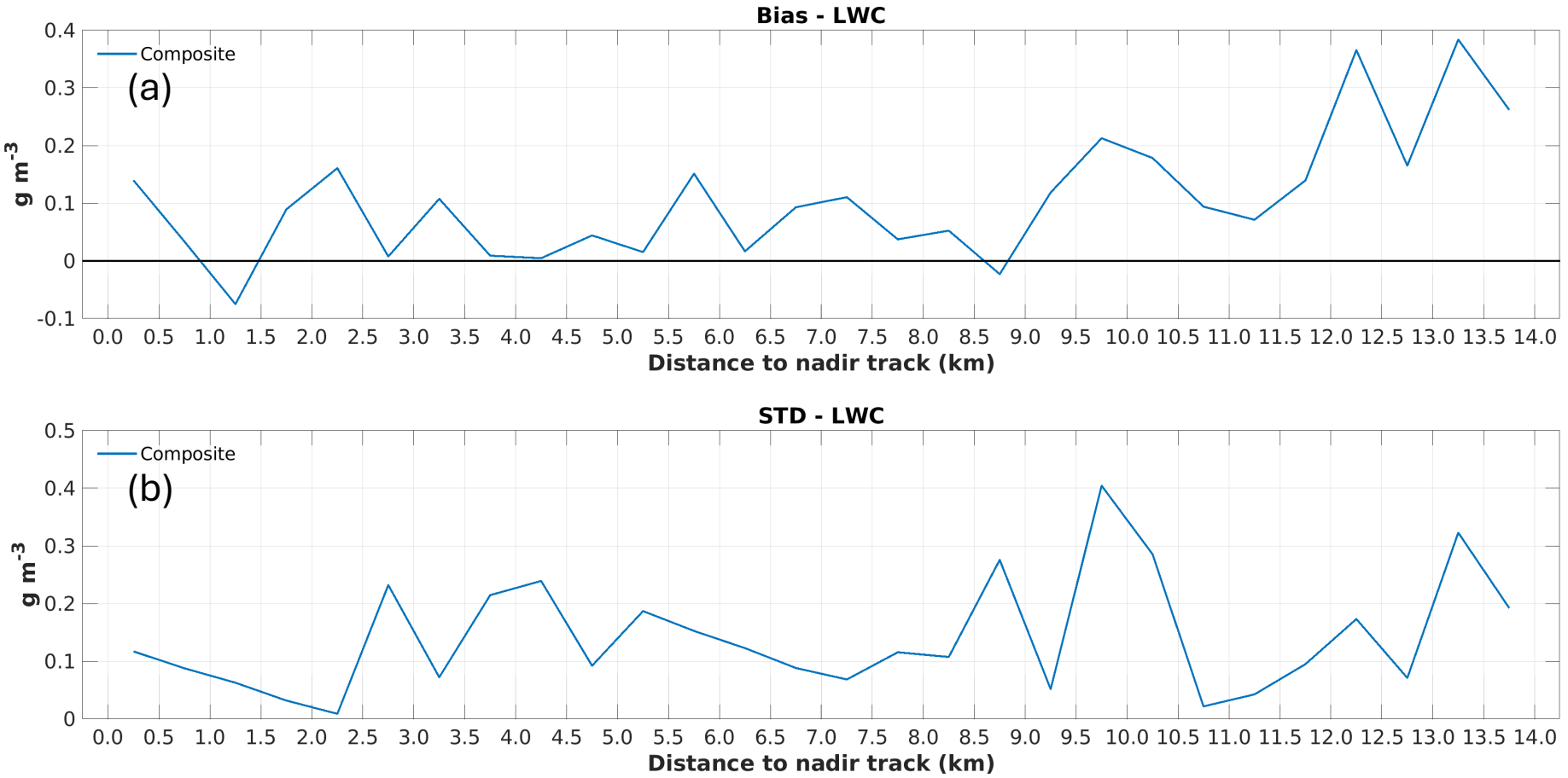


Stratocumulus clouds (liquid):

- Good range of LWC from M-COP
- $IWC_{ACM\text{-}CAP}$ (V11.4) has smaller LWC

4. M-COP & SCA validation (Flight 4 , Oct. 10 , 02736D)

Scene construction algorithm performed well for most cases.
ECALOT Flight 4 (Nov. 20) for the frame 02736D



No significant increases of error from nadir to ~14 km away → Scene construction algorithm worked well!

4. Conclusion & Perspectives

Nimbostratus/Cirrus:

Near cloud top (F05): $IWC_{A\text{-}ICE} \approx IWC_{ACM\text{-}CAP} \approx$ in situ (F05)

Deeper in cloud:

- Fall rain condition (F03): $IWC_{ACM\text{-}CAP} > IWC_{C\text{-}CLD} \approx$ in situ
- ACM-CAP showed improved LWC retrievals for F05 but encountered challenges for F03

Stratocumulus (F04):

$LWC_{M\text{-}COP} \approx$ in situ $> LWC_{ACM\text{-}CAP}$

SCA performance degraded only slightly for the first 14 km away from nadir track (dist < 2.5/7.5 km for 1D/3D RT!)

Future work:

Collaboration with DISC L2 team: improve IWC and LWC retrievals

Particle/droplet size distribution

Additional validations using data from off-nadir flight paths

Assessing the impact of cloud retrieval quality in radiative closure from surface:

- Broadband SW & LW
- Spectral FIR

  → see Lei Liu's validation using AERI (Wednesday, radiation and synergy session)

  → see Zen Mariani's validation of T, Q using surface site data (Aerosol, Cloud and Precipitation session)

Other research topics