Validation of cloud distributions from multiple ATLID L2 products (A-TC, A-FM, A-CTH) using airborne HSRL lidar observations

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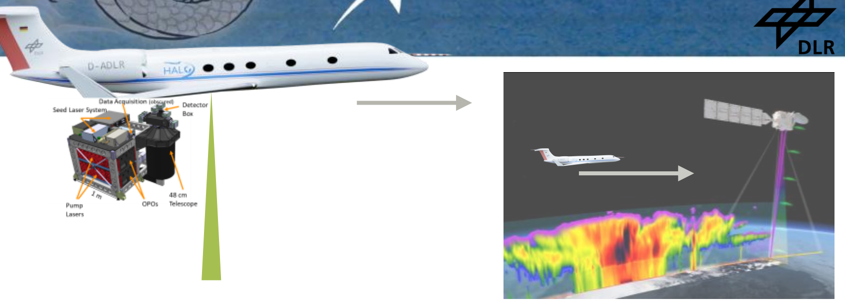
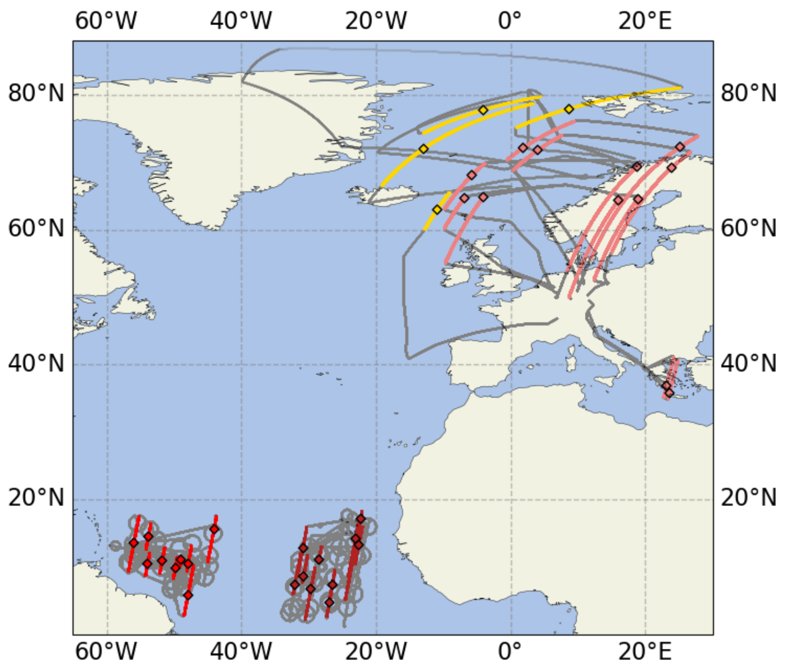
EarthCARE underflights with HALO



- Airborne high spectral resolution lidar WALES
  - molecular / particle backscatter (532 and 1064 nm)
  - particle depolarization, lidar ratio,…

PERCUSION and ASCCI underflight legs

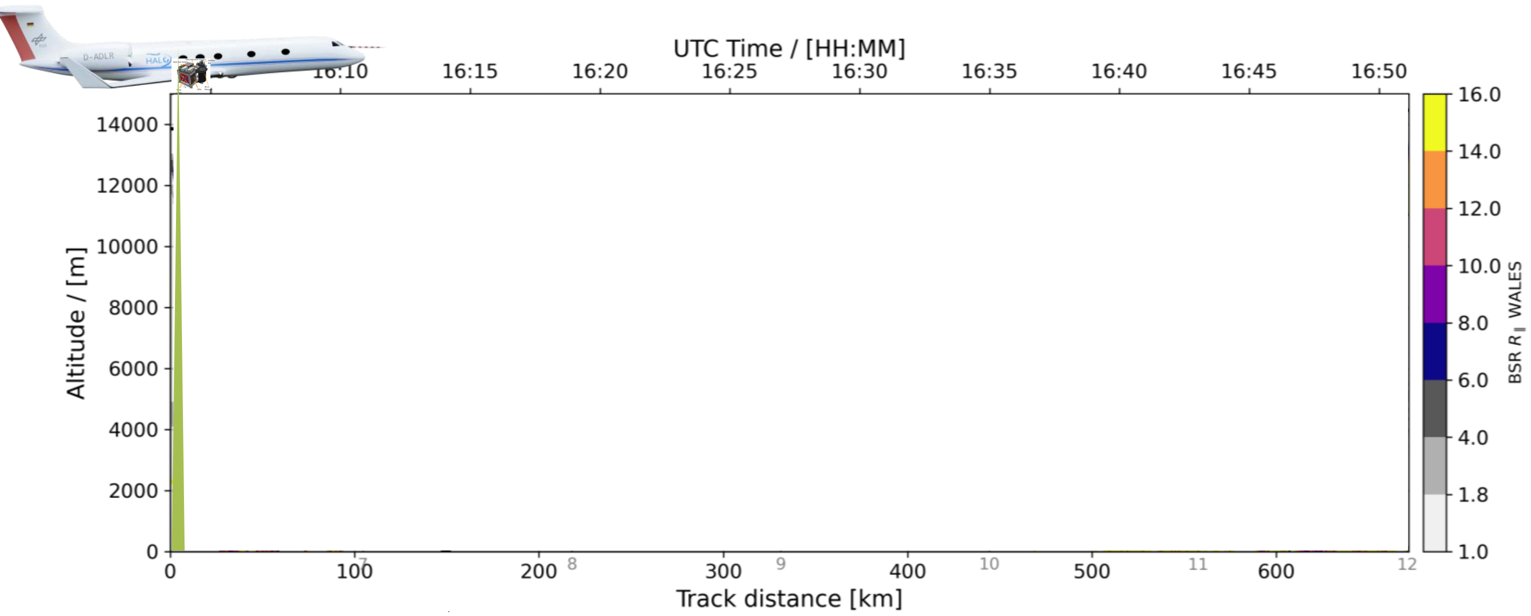


- PERCUSION and ASCCI campaigns
  - HALO flights with 35 coordinated EarthCARE underpasses
  - > 100,000 profiles ~30,000 km flight track
  - Aerosol and cloud conditions in the tropics, and the Arctic

➢ Validation of multiple ATLID level 2 cloud products based on WALES backscatter ratio: **A-TC, A-FM, A-CTH**

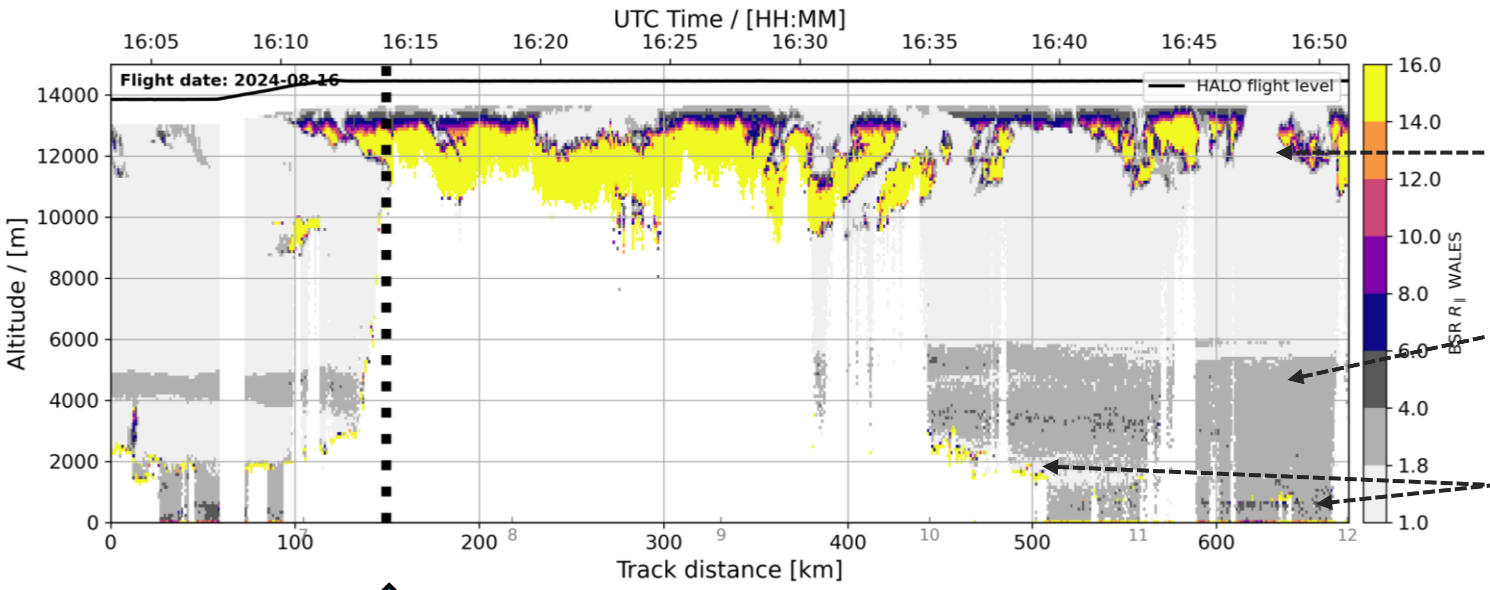
EarthCARE underpass on 16 August – Cape Verde

WALES backscatter ratio (BSR) measurements



EarthCARE underpass on 16 August – Cape Verde

WALES backscatter ratio (BSR) measurements



High altitude ice clouds
(low to high BSR)

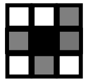
Saharan dust layer
(intermediate BSR values)

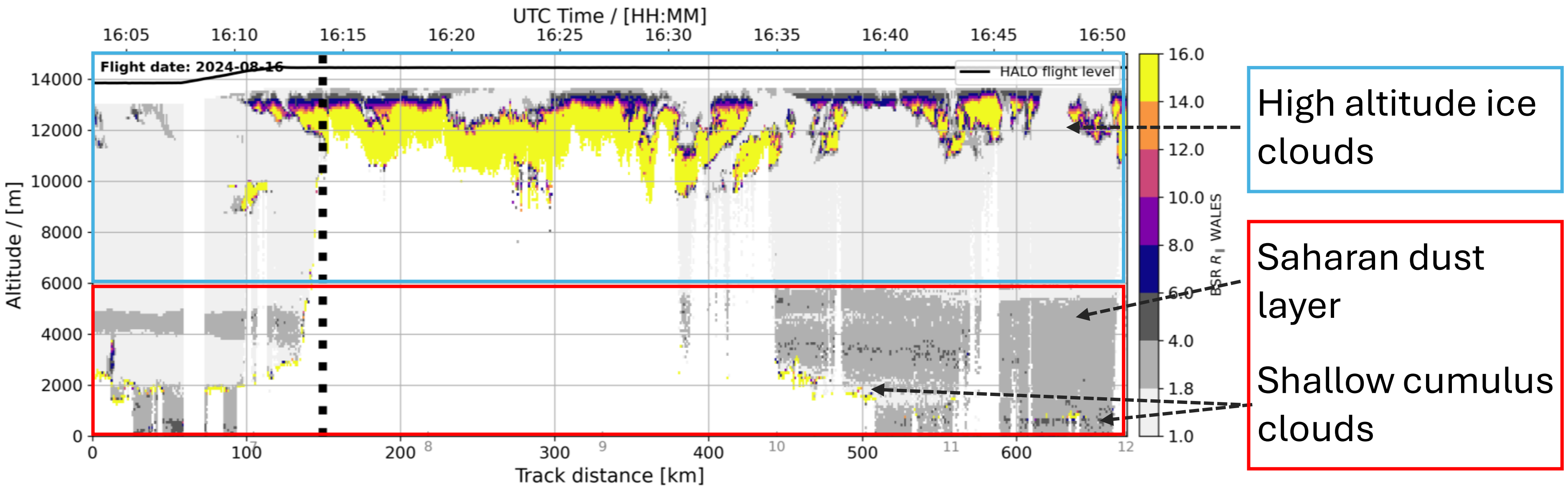
Shallow cumulus clouds
(high BSR values)

Satellite overpass

➢Application of **altitude-dependent thresholds** allows to derive cloud masks from WALES

Cloud mask from WALES backscatter ratio

- Cloud mask algorithm: 3x3 Kernel  → decision: cloud or no cloud



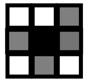
>6 km: BSR > 1.8

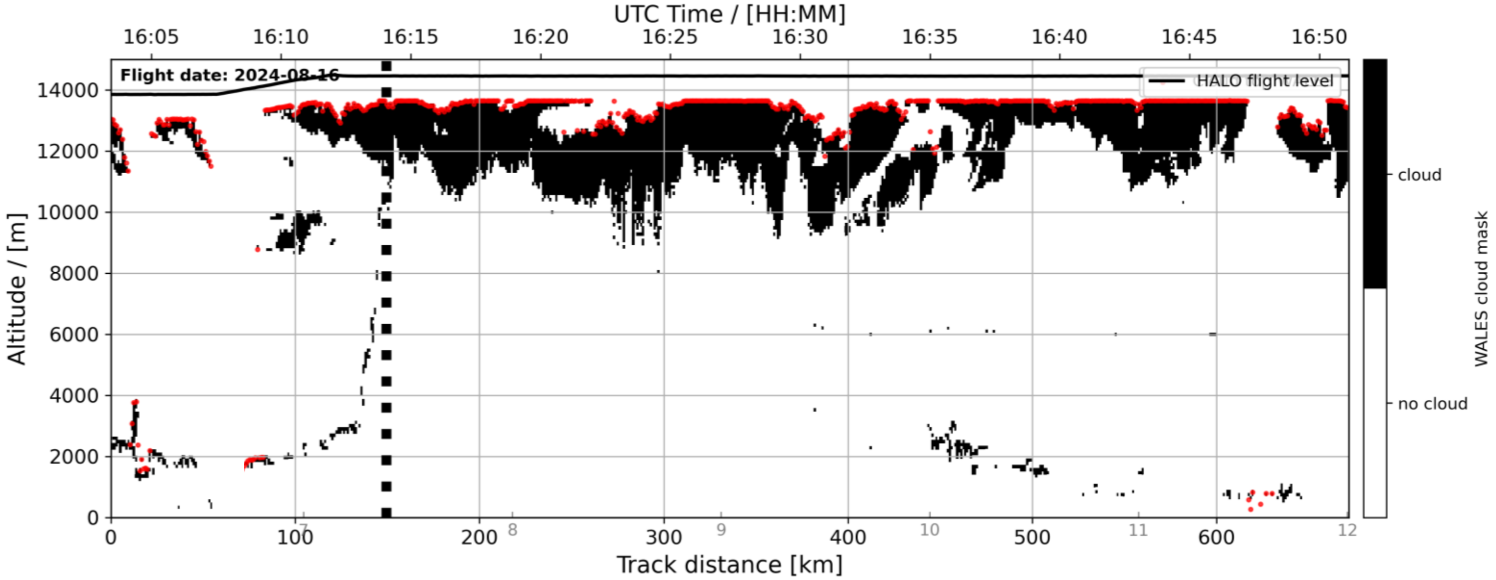
< 6 km: BSR > 6

➢Application of **altitude-dependent thresholds** allows to derive cloud masks from WALES

WALES cloud mask for ATLID L2 validation

WALES cloud mask for the example flight

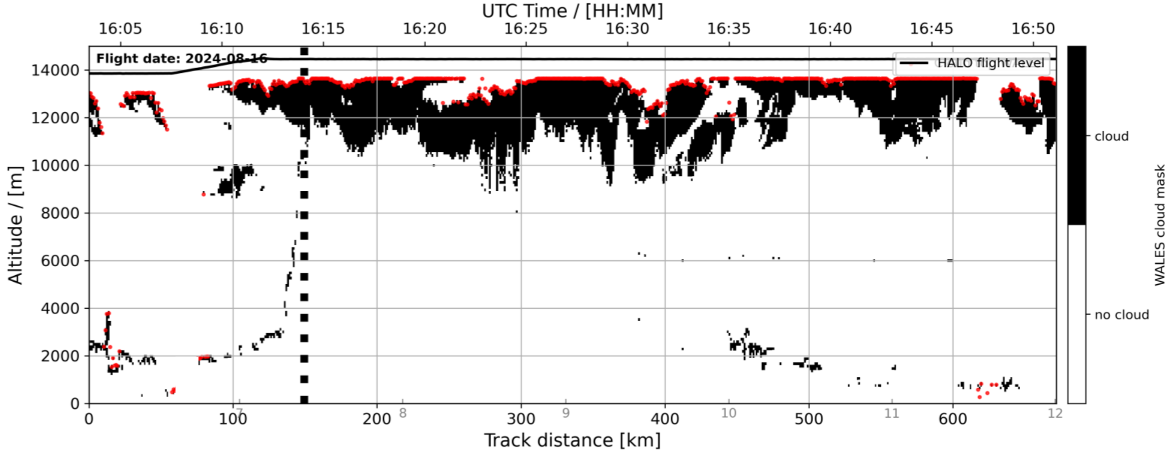
- Cloud mask algorithm: 3x3 Kernel  cloud or no cloud



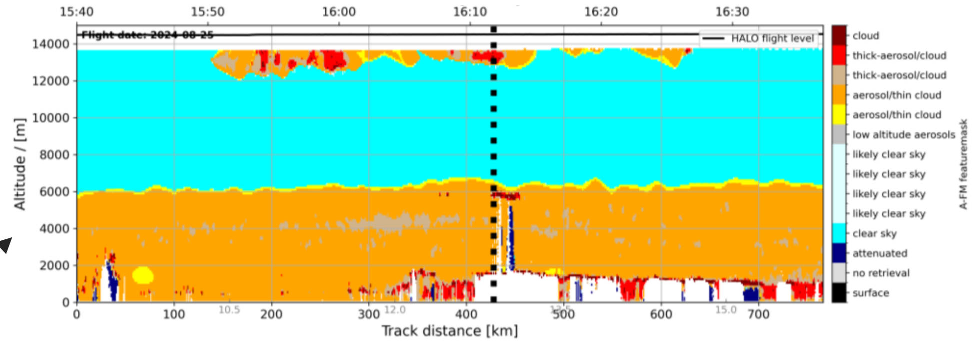
- Cloud features remain, aerosol pixels (Saharan dust) efficiently removed
- Cloud pixels and cloud top height degraded to ATLID resolution (100 m ↕ x 1 km ↔)

ATLID level 2 validation

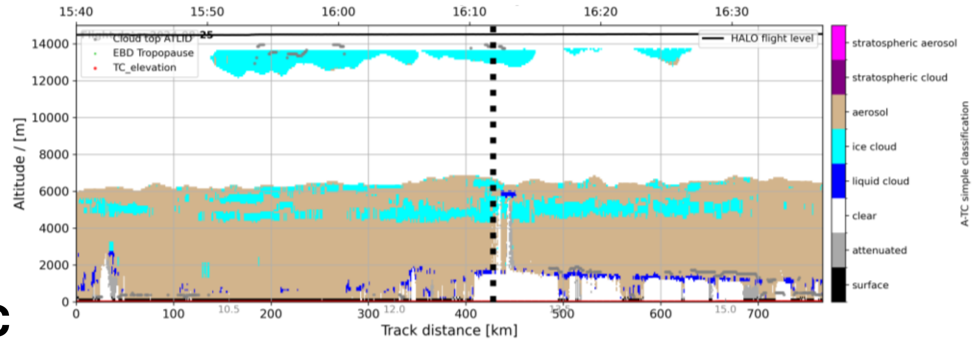
- Comparison of WALES cloud mask with **A-TC** and **A-FM** cloud distribution
- Comparison of cloud top heights (**A-CTH**)



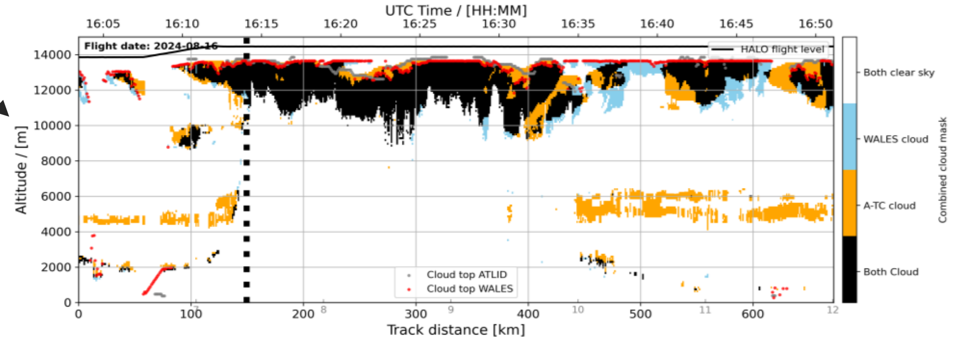
A-FM



A-TC



WALES+A-TC +A-CTH

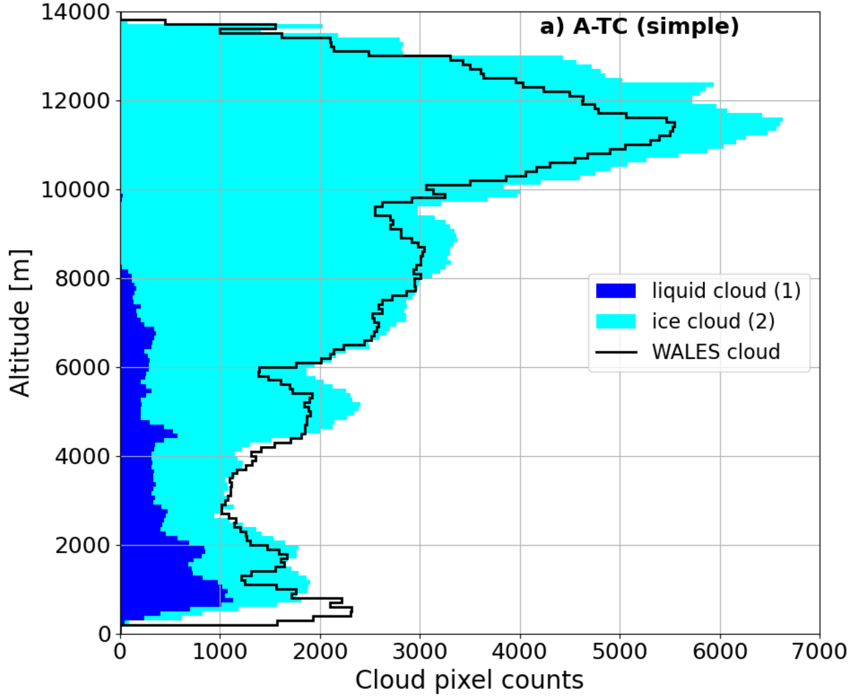


➢ Statistical comparison (all underflights)

Validation of A-TC and A-FM cloud pixel distribution

Statistical comparison covering 35 underflights

A-TC tropospheric cloud flags



A-FM thick (!) features

Cloud pixel distribution well-covered by A-TC!

A-TC

Cloud pixel overestimation (20-30%)

- 1-6 km (particularly in tropics!)
- 7-14 km in ice clouds

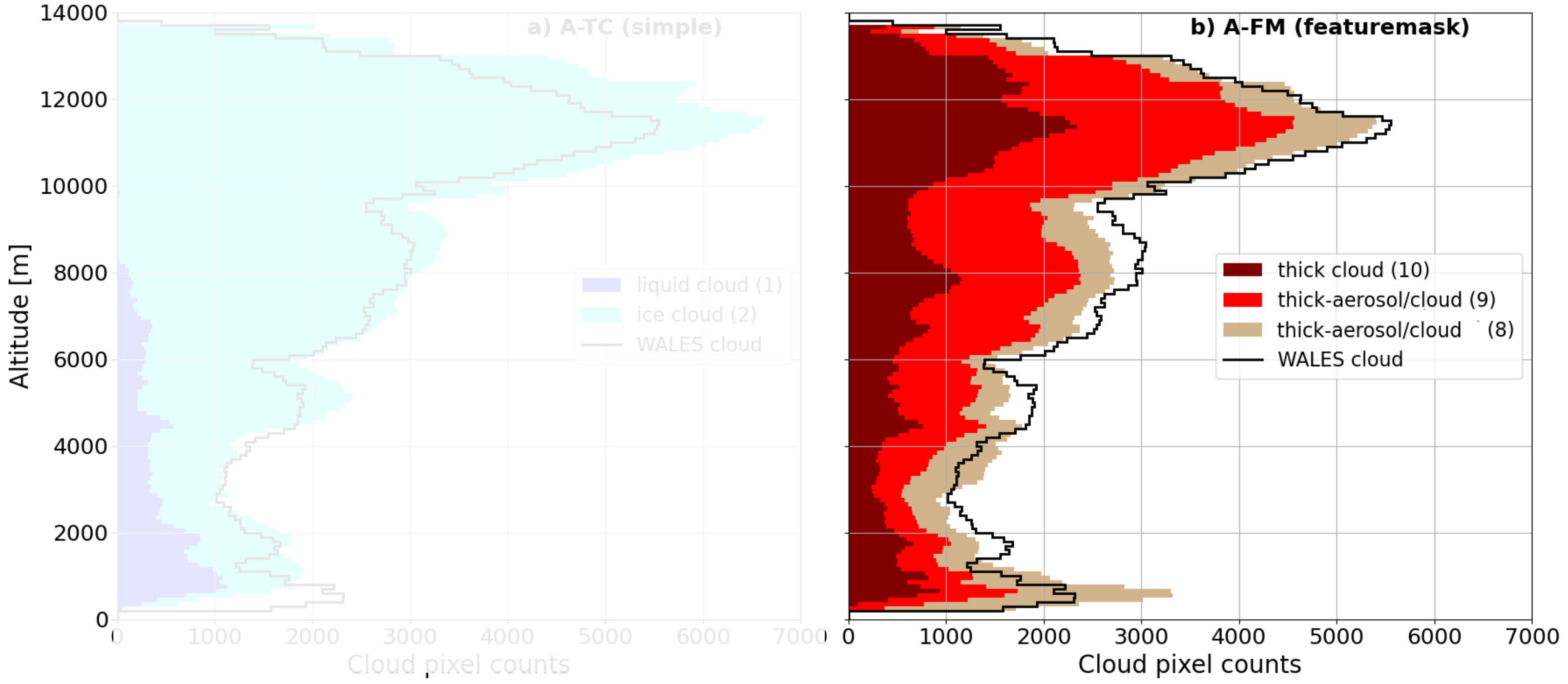
Baseline: BA

Validation of A-TC and A-FM cloud pixel distribution

Statistical comparison covering 35 underflights

A-TC tropospheric cloud flags

A-FM thick (!) features



Cloud pixel distribution well-covered by both products!

A-TC

Cloud pixel overestimation (20-30%)

- 1-6 km (particularly in tropics!)
- 7-14 km in ice clouds

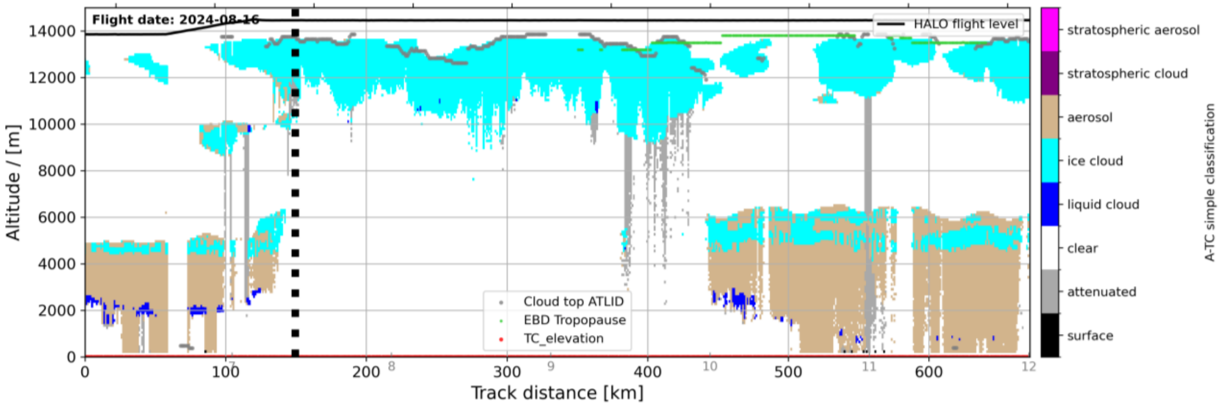
A-FM

- „ thick flags“ good match to WALES at high altitudes (ice clouds)
- Overestimation in lowermost troposphere

Baseline: BA

Validation of A-TC and A-FM cloud pixel distribution

A-TC target classification product



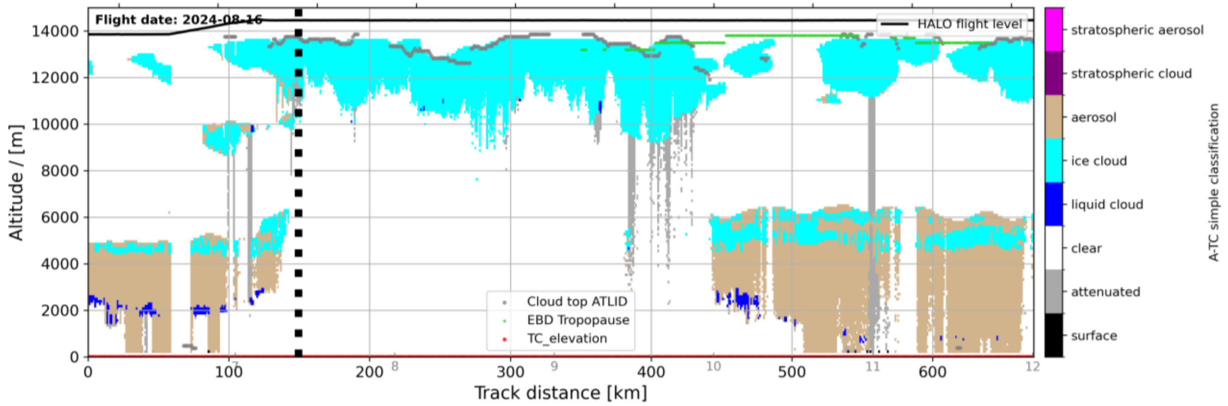
A-TC

- Overestimation of ice cloud pixels
  - 1-6 km → ice clouds embedded in aerosol layers
  - 6-14 km → systematic increase of cloud length and cloud depth → gap filling effect
- Underestimation near surface → resolution effect

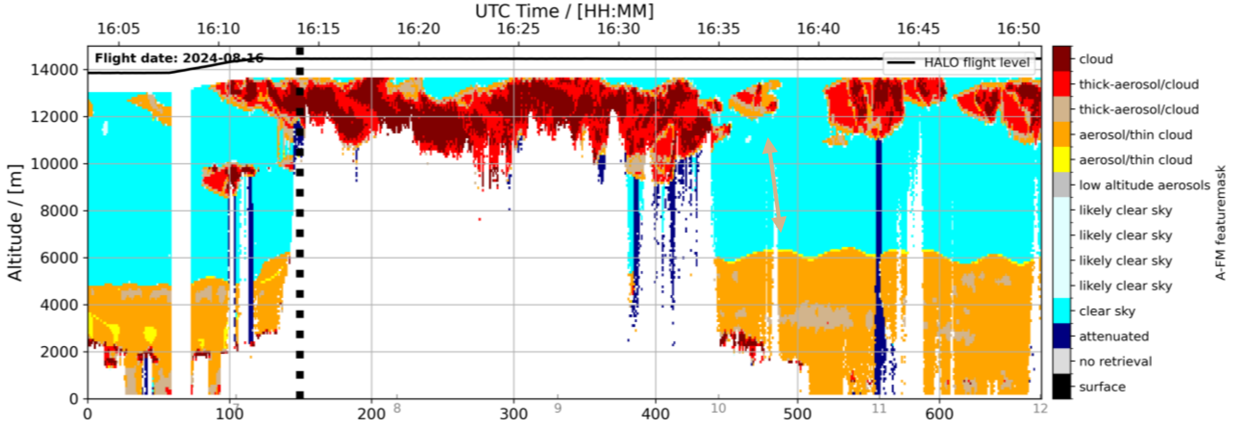
Baseline: BA, frame: 01240E

A-TC and A-FM for the example flight

A-TC target classification product



A-FM feature mask



A-TC

Overestimation of ice cloud pixels

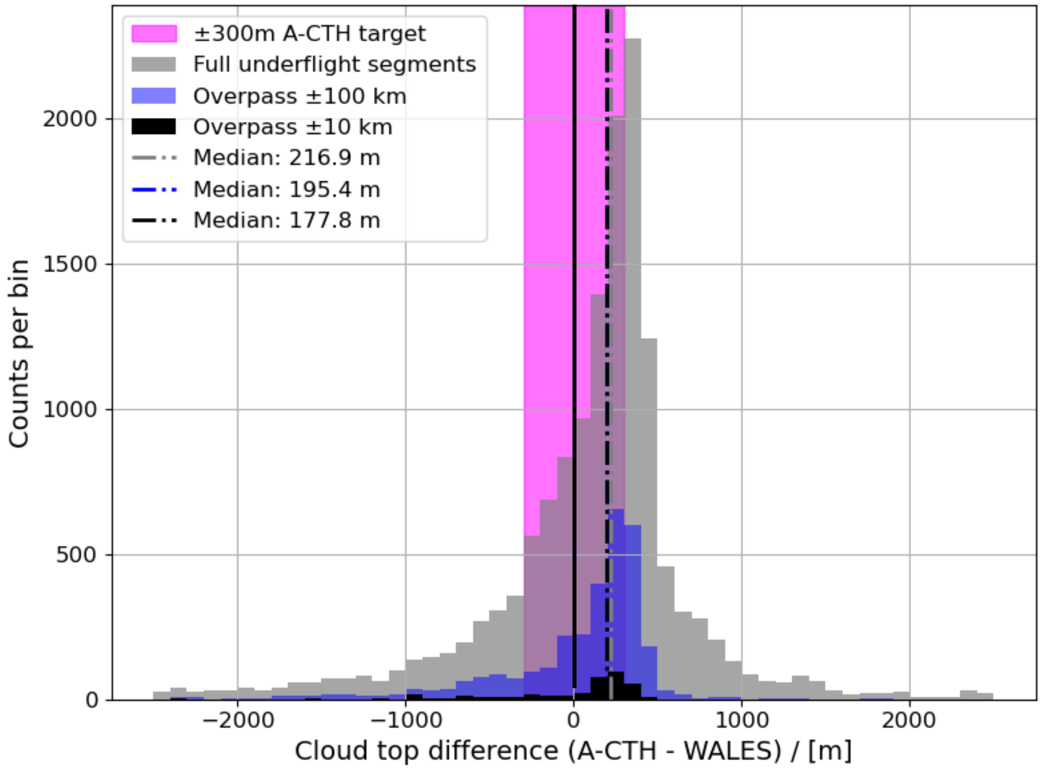
- 6 km →ice clouds embedded in aerosol layers
- 6-14 km →systematic increase of cloud length and cloud depth → gap filling effect

A-FM

- „ thick feature flags“ (8-10) good match to WALES in ice cloud altitudes →clouds less thick/more broken
- Lowermost troposphere (overestimation) (flag 8!)

Baseline: BA, frame: 01240E

Distribution of cloud top height differences



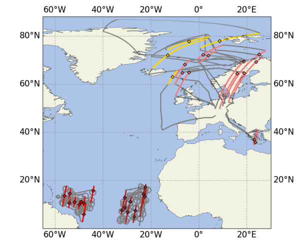
A-CTH cloud top validation results

- Cloud top difference distribution shifted →pointing towards a slight overestimation of top heights (~200 m)
- Overestimation found independently for all cloud types/altitudes, except for very shallow clouds
- Majority of the A-CTH products are within the targeted **±300 m** accuracy requirement interval
- A-CTH does not produce a cloud top height for „misclassified ice clouds“ e.g. in Saharan dust in the A-TC product

Baseline: BA

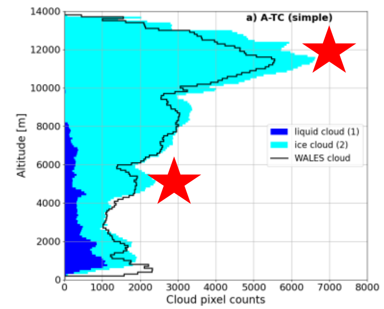
Summary / Recommendations / Ideas

A-TC/A-FM/A-CTH in good shape ✓ … still potential for improvements



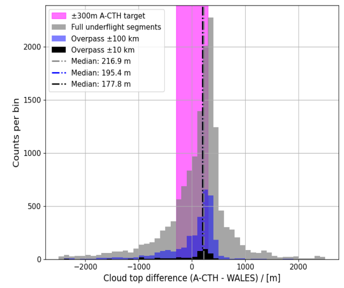
A-TC/A-FM - cloud pixel distribution

1. Systematic occurence of ice cloud pixels in aerosol layers, particularly in tropical Atlantic in mineral dust layers (E-frames affected)
2. Cloud pixel overestimation in high altitude ice clouds
   - ➢Likely caused by L2 processing (ice clouds more spread, gaps are filled)
   - ➢A-FM thick feature flags very realistic for cirrus cloud representation→ changed communication between A-FM and A-TC?



A-CTH - cloud top height

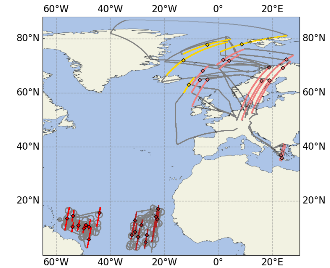
3. Systematic cloud top differences
   - ➢Overestimation of nearly all clouds: Adjusting wavelet dilation
   - ➢Understimation of cloud tops in tropics: surface influence? resolution?



Summary – Validation of A-TC, A-FM, A-CTH

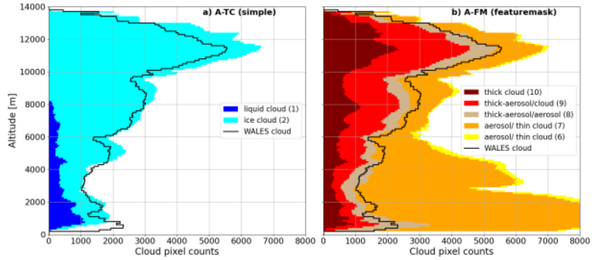
Validation of cloud pixel distribution in multiple ATLID products

- 35 EarthCARE underflights during PERCUSION and ASCCI
- HSRL observations with WALES representing ATLID aboard EarthCARE



Validation of cloud pixel distribution in A-TC and A-FM

- Vertical distribution of cloud pixels well-covered by both products ✓
- A-TC slightly overestimates clouds at distinct altitude levels
  - High altitudes →gap filling effect in the L2 processing
  - Lower altitudes (E-frames)→ice cloud pixels inside aerosol layers
- A-FM
  - Strong agreement between „thick features“ and WALES cloud pixels
  - Enhanced presence of flag 8 → overestimation in lowermost 2 km



Validation of cloud pixel distribution in A-TC and A-FM

- Cloud top height estimation within accuracy requirement for majority of profiles ✓
- Systematic overestimation of cloud top height (~200 m)