

Characterization of the clouds observed during NAWDEX with the synergistic HALO Radar-Lidar observations

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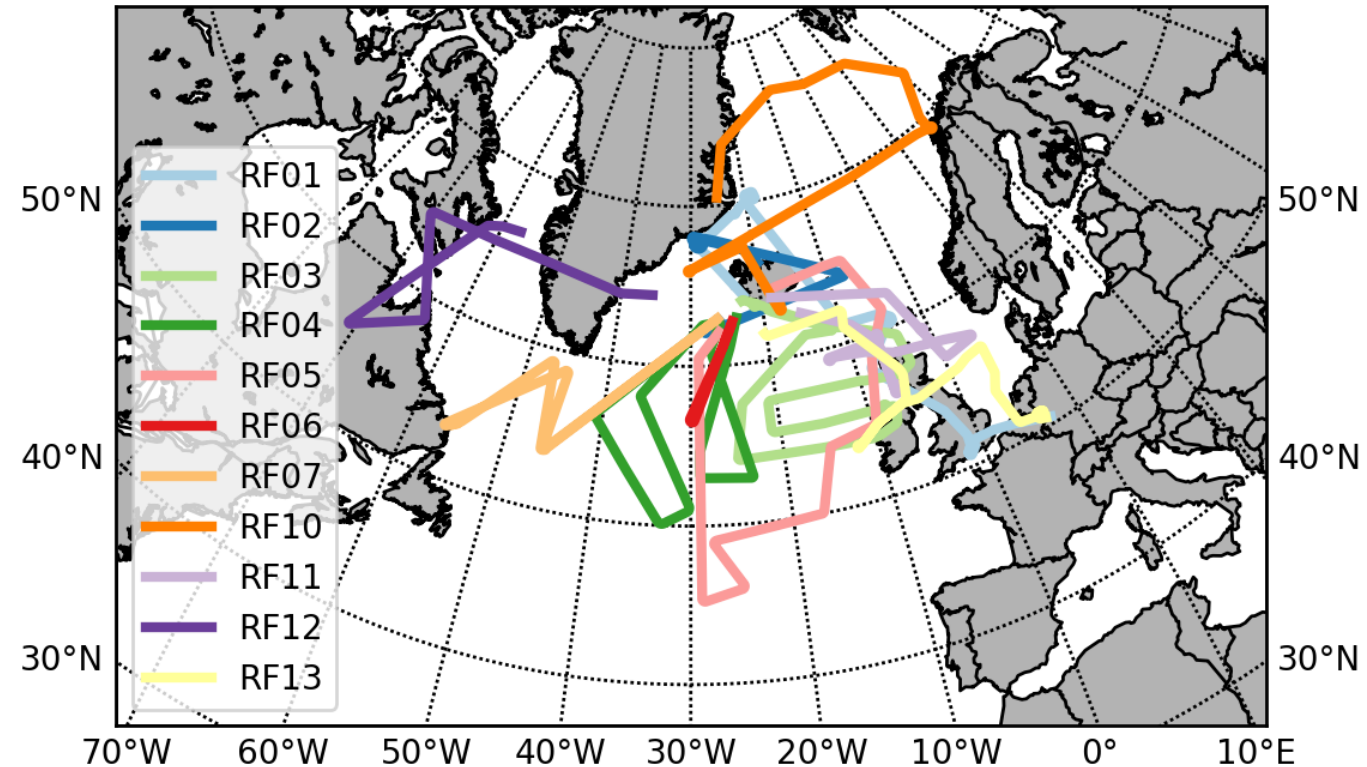
Knowledge for Tomorrow



Outline

- Aerosol-Cloud discrimination on HALO Radar-Lidar measurements
- Cloud Characterization during NAWDEX

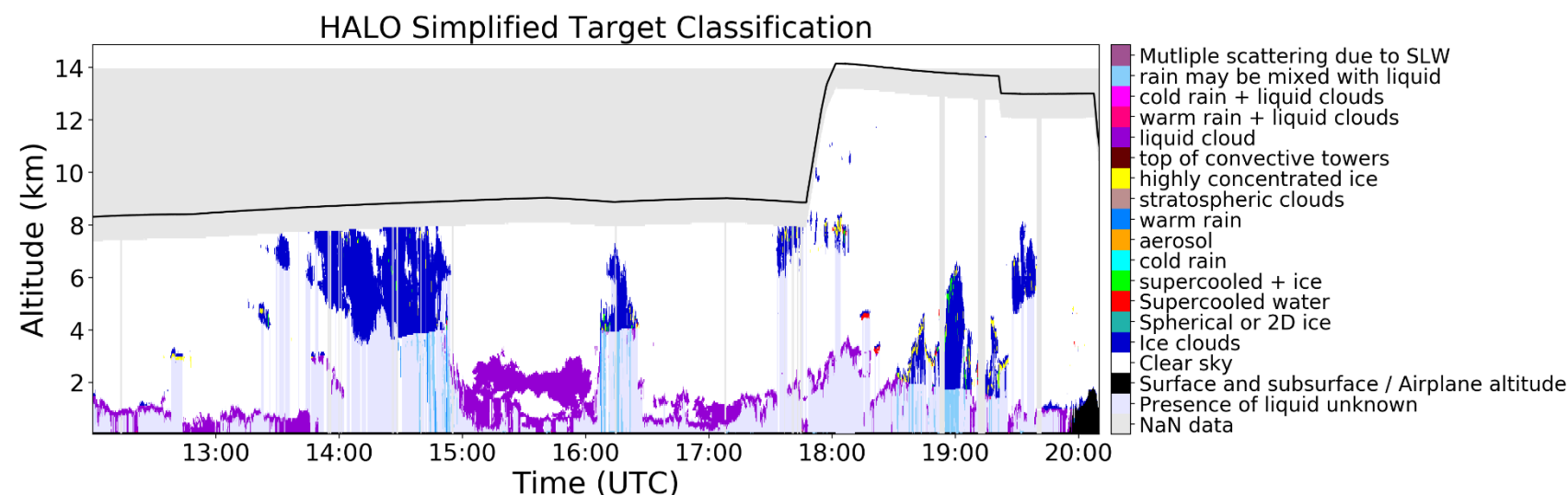
NAWDEX HALO flight tracks



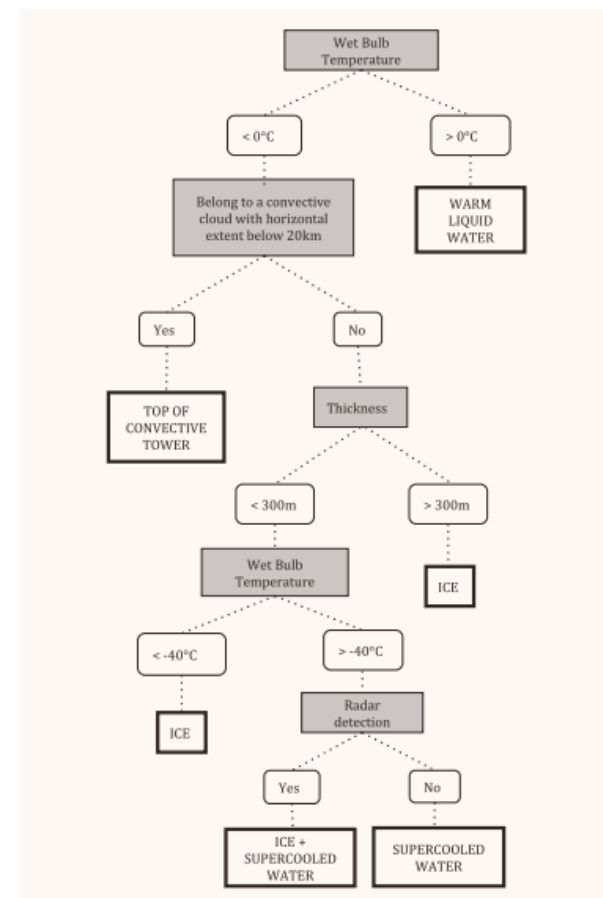
HALO target categorization

Current HALO categorization:

- Based on the DARDAR cloud classification of Ceccaldi et al., 2013
 - Originally developed for CALIPSO-Cloudsat collocated observations
 - Aerosol-cloud separation based on CALIPSO VFM product
 - Further classification of the cloud features (ice, liquid clouds, supercooled water, supercooled + ice, warm rain, cold rain ect.)

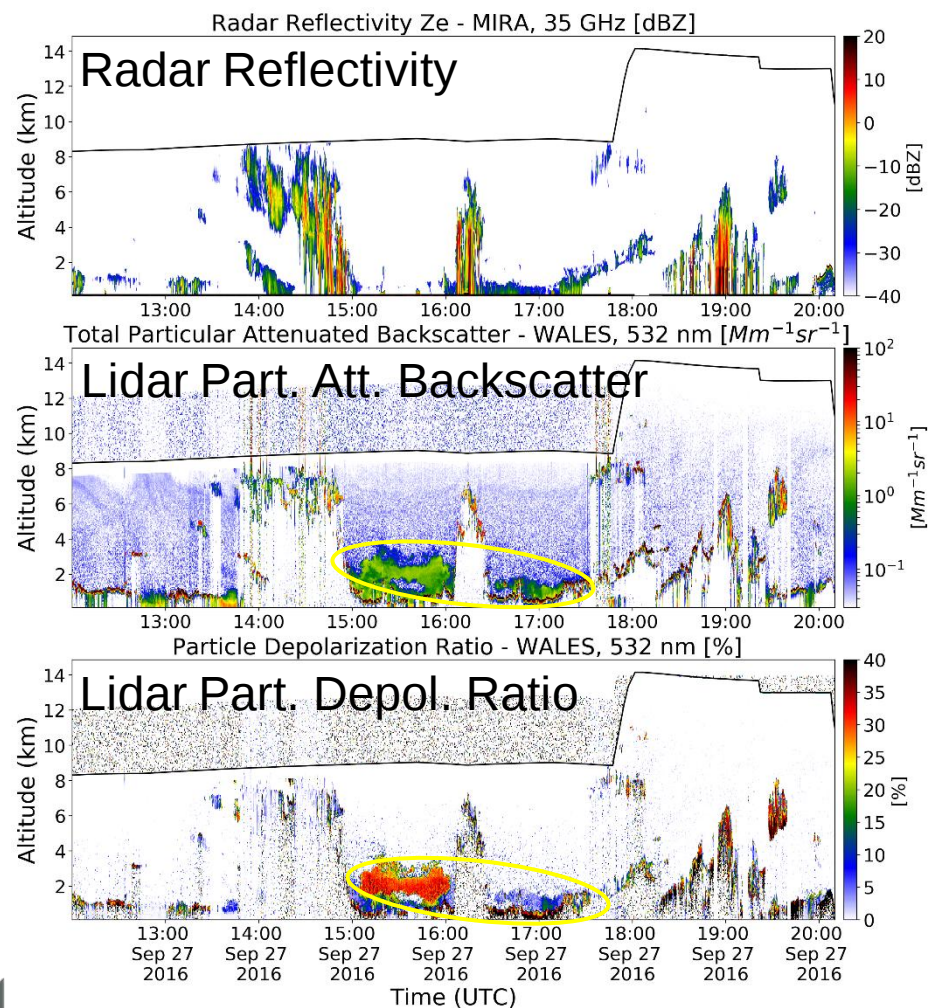


Decision tree for classifying cloud layers in Ceccaldi et. al., JGR, 2013



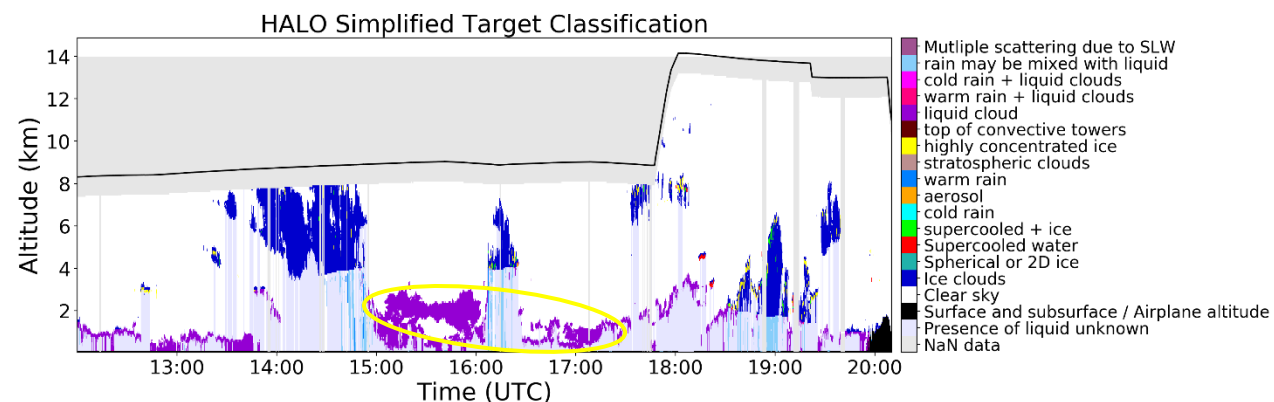
HALO target categorization – Aerosol misclassification

Radar – Lidar observations



Target categorization

HALO RF05 27/9/2016



Aerosol features in HALO mask are misclassified as clouds

Develop an aerosol-cloud target classification based on the Radar-Lidar collocated observations:

- Radar reflectivity
- Lidar particle attenuated backscatter coefficient at 532nm
- Lidar particle depolarization ratio at 532nm
- Current target categorization

New HALO Aerosol - Cloud target categorization

HALO RF05 27/9/2016

Aerosol – Cloud target classification

If detected Z_e : Clouds, surface and/or insects

If lidar and radar signals are totally attenuated: presence of liquid unknown

If $\beta_{\text{par}} > 2 \times 10^{-5} \text{m}^{-1} \text{sr}^{-1}$: Clouds

If $\beta_{\text{par}} < 1 \times 10^{-8} \text{m}^{-1} \text{sr}^{-1}$: Clear sky

If $\delta_{\text{par}} < 1\%$ or $> 38\%$: Clouds

Liquid cloud top and bottom: Cloudnet*

If $T < 0$ and there is an adjusted cloud: Cirrus fringe

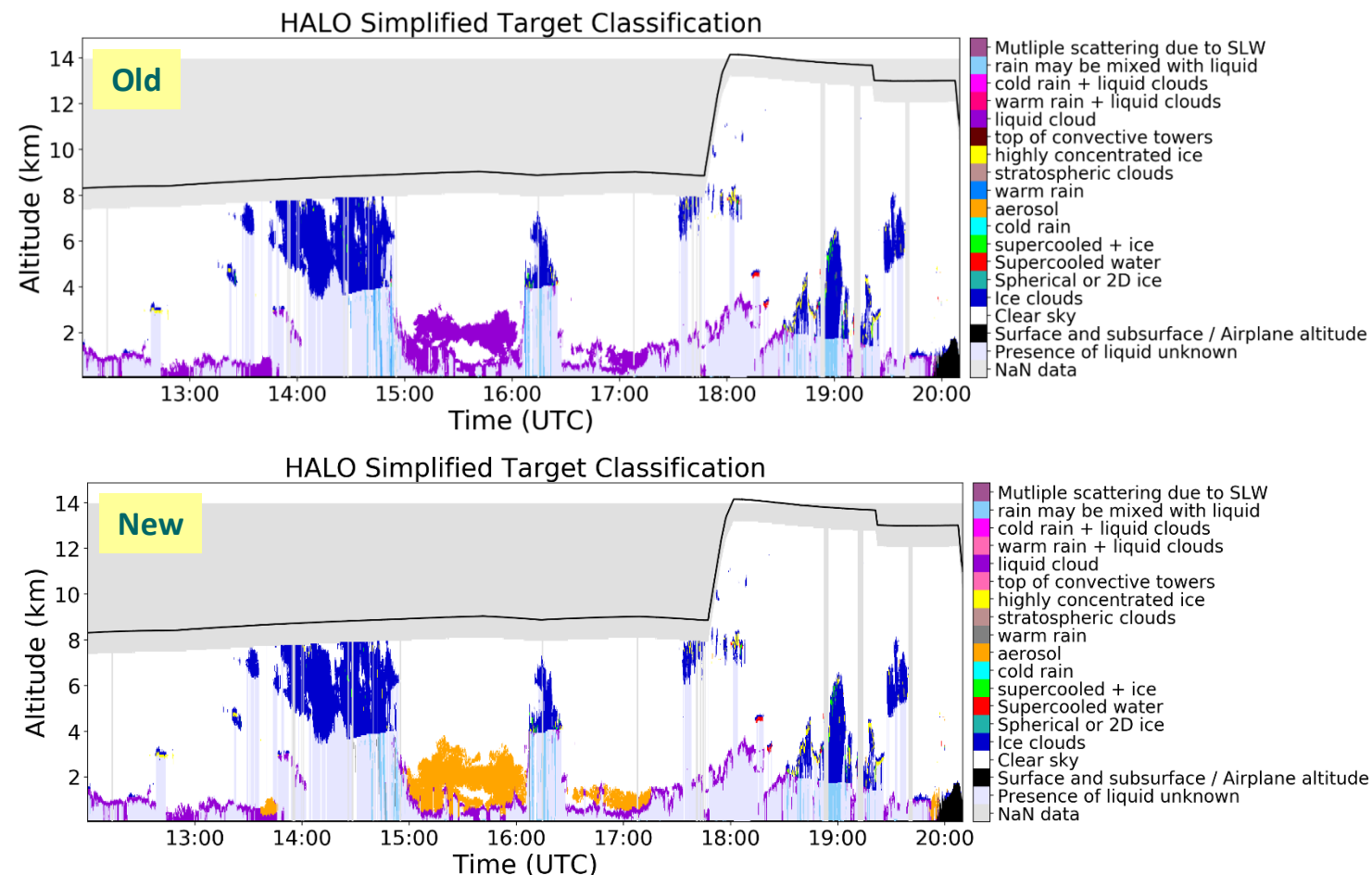
If in the 3x3 cell around a target bin clear sky prevail: Clear sky

If in the 3x3 cell around a target bin clouds prevail: Clouds

If in the 3x3 cell around a target bin aerosols prevail: Aerosols

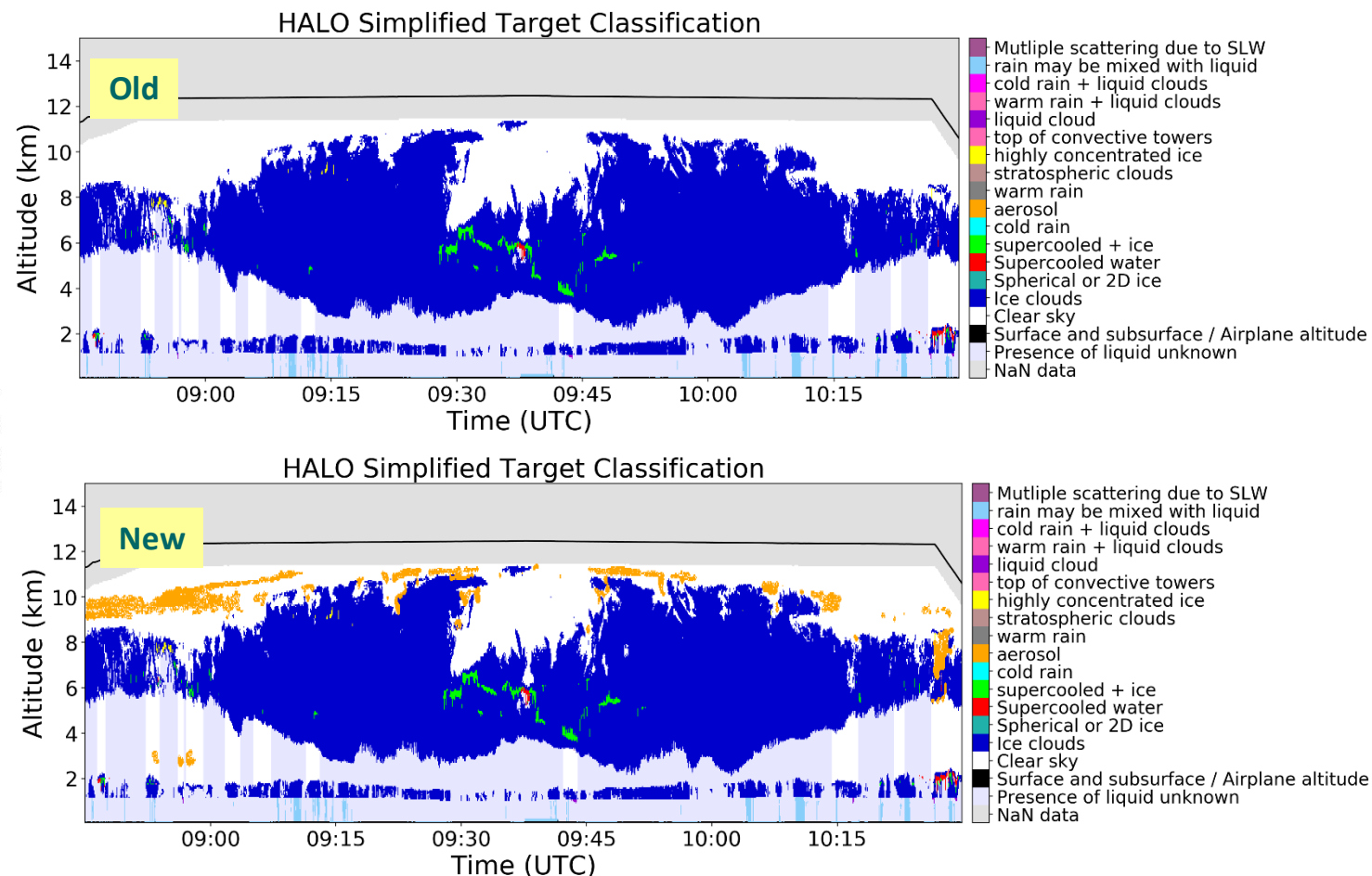
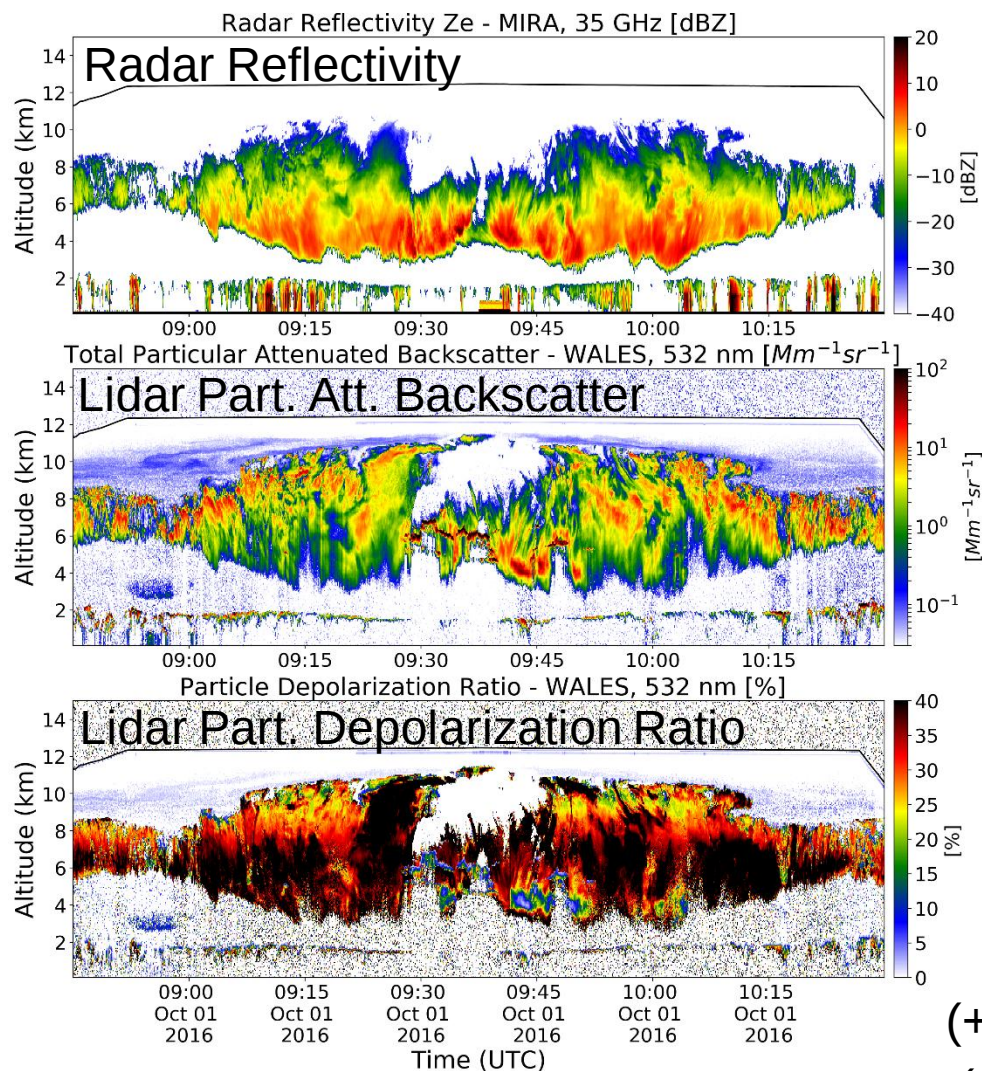
All the remaining uncategorized targets: Aerosols

*Cloudnet target categorization: Hogan & O'Connor, 2004.
<https://www.researchgate.net/publication/228821899>



New HALO Aerosol - Cloud target categorization

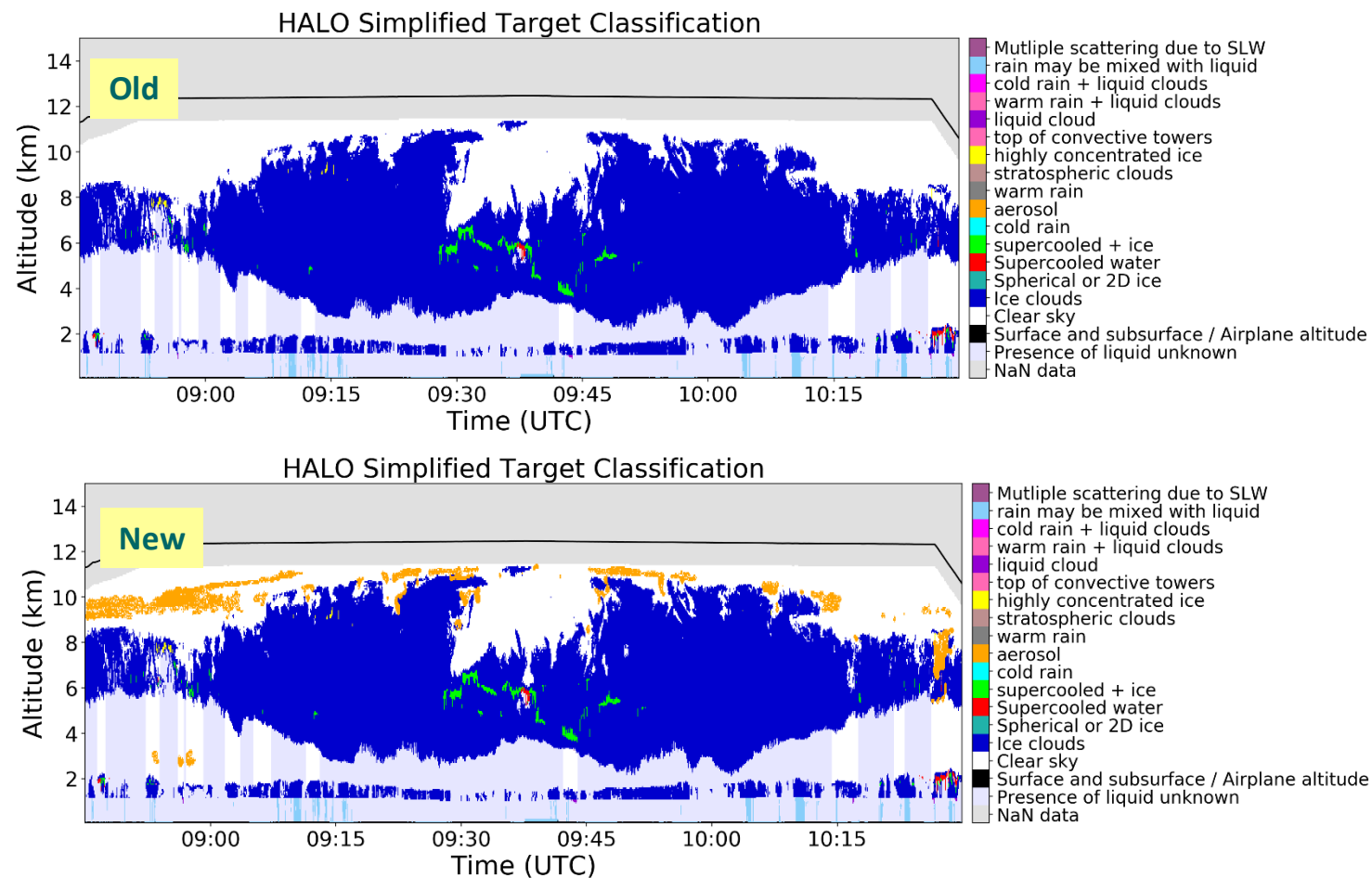
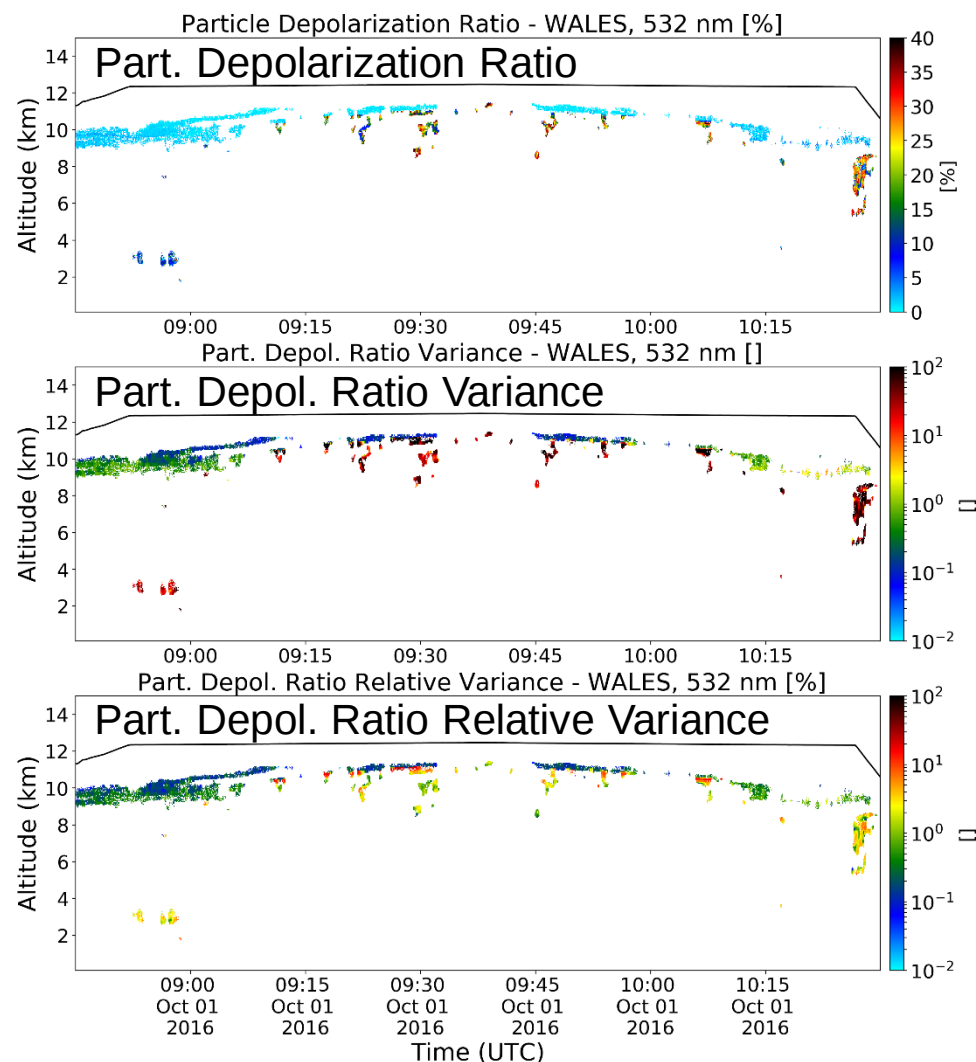
HALO RF06 01/10/2016



- (+) The new mask is able to detect thin layers that were previously lost
- (-) Misclassification of thin cirrus & thin cirrus edges as aerosols

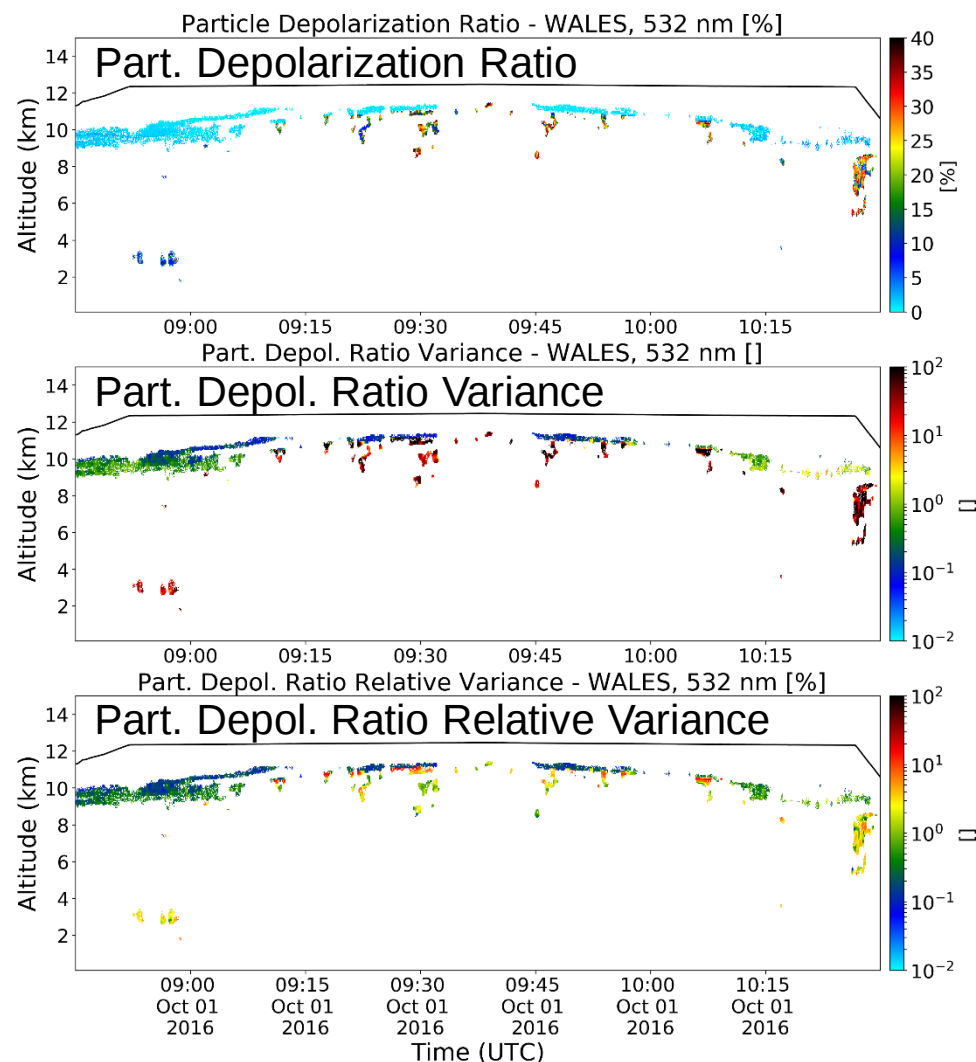
New HALO Aerosol - Cloud target categorization

HALO RF06 01/10/2016

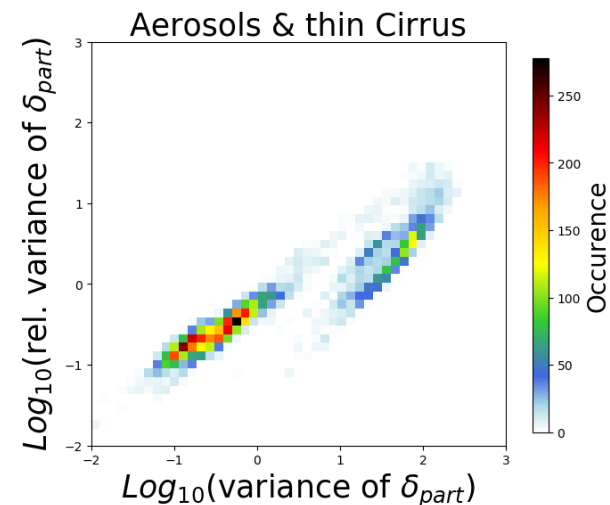


New HALO Aerosol - Cloud target categorization

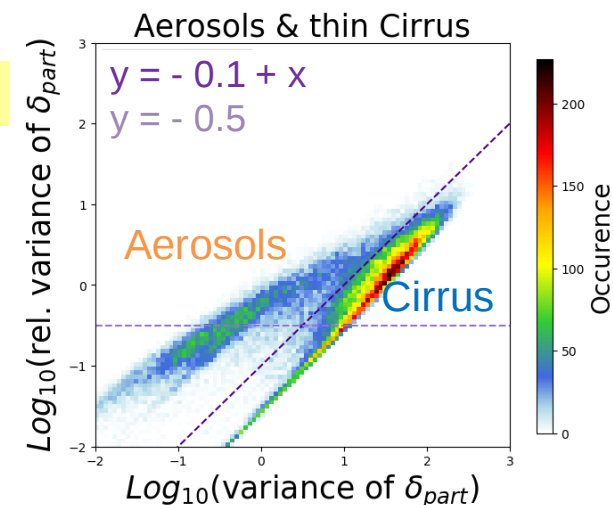
HALO RF06 01/10/2016



RF06



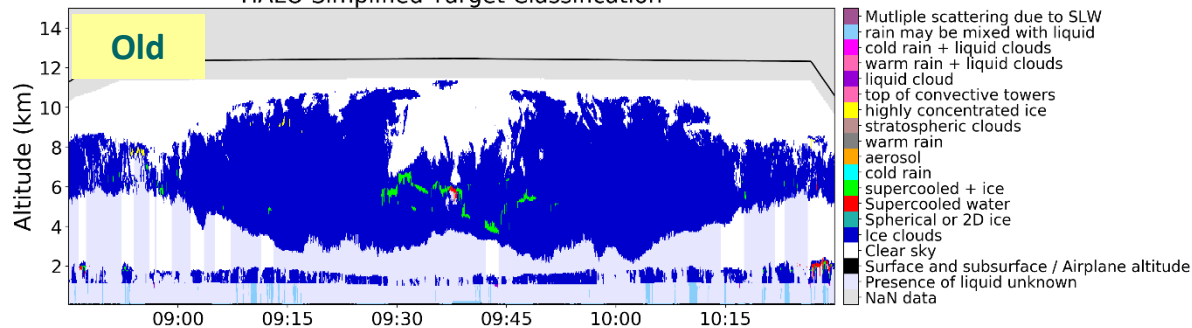
All NAWDEX



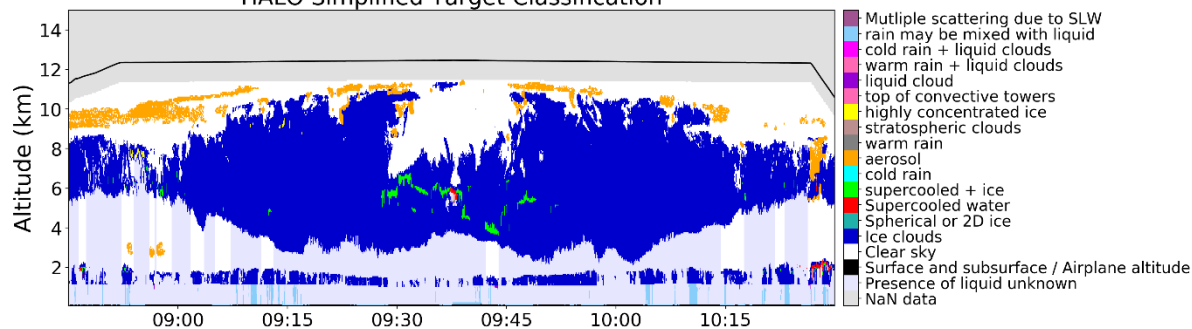
New HALO Aerosol - Cloud target categorization

HALO RF06 01/10/2016

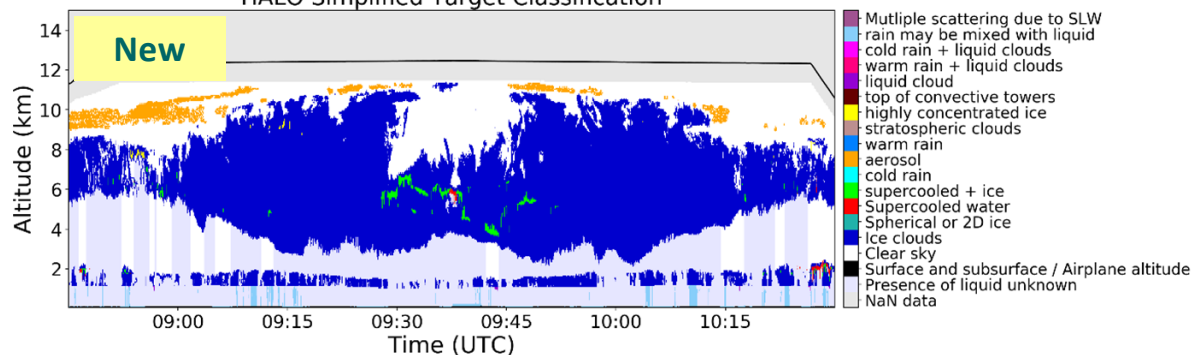
HALO Simplified Target Classification



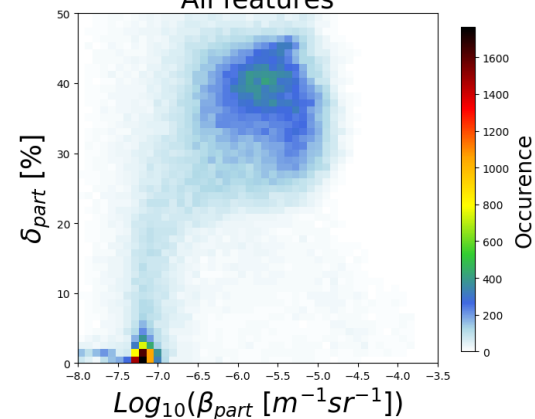
HALO Simplified Target Classification



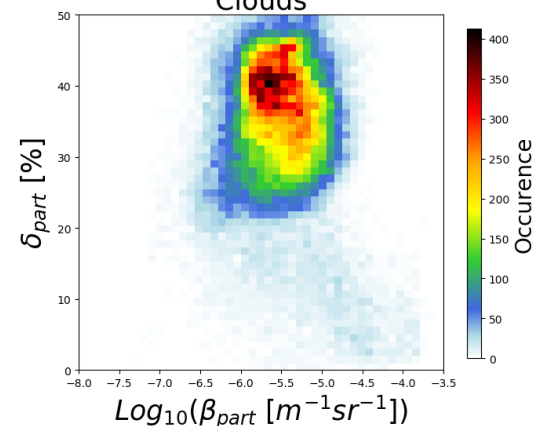
HALO Simplified Target Classification



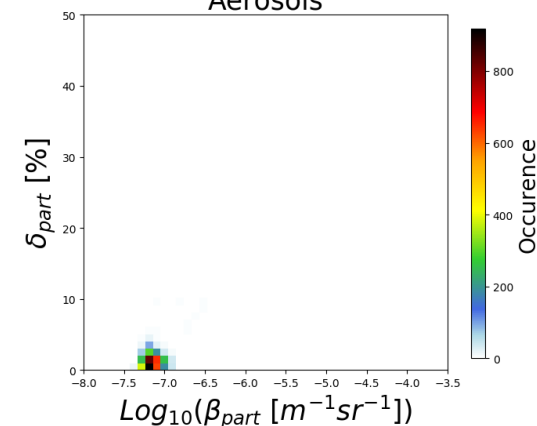
All features



Clouds



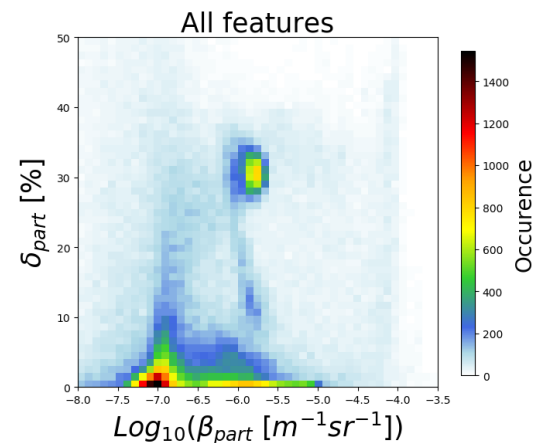
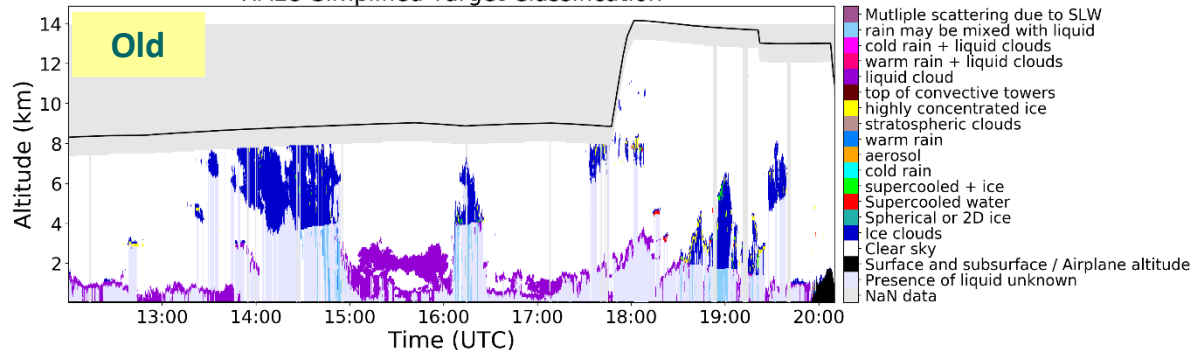
Aerosols



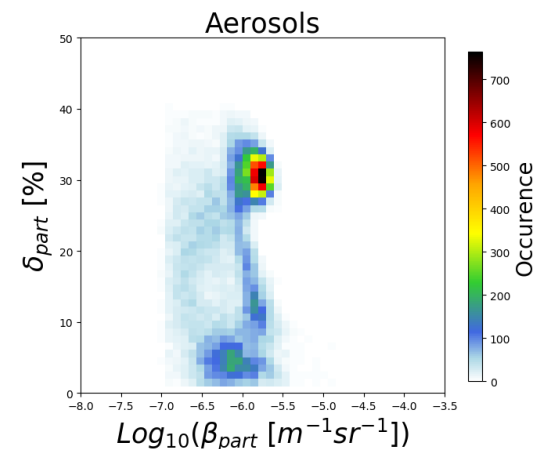
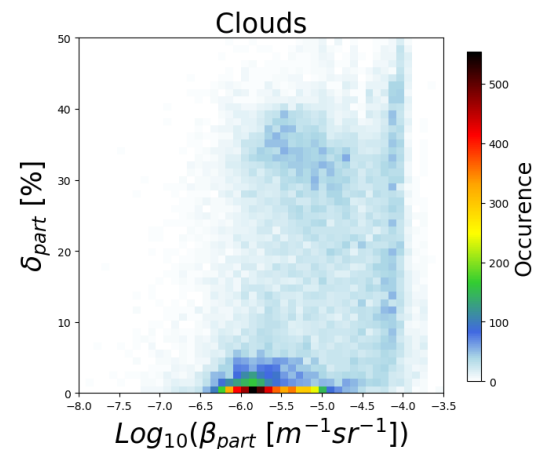
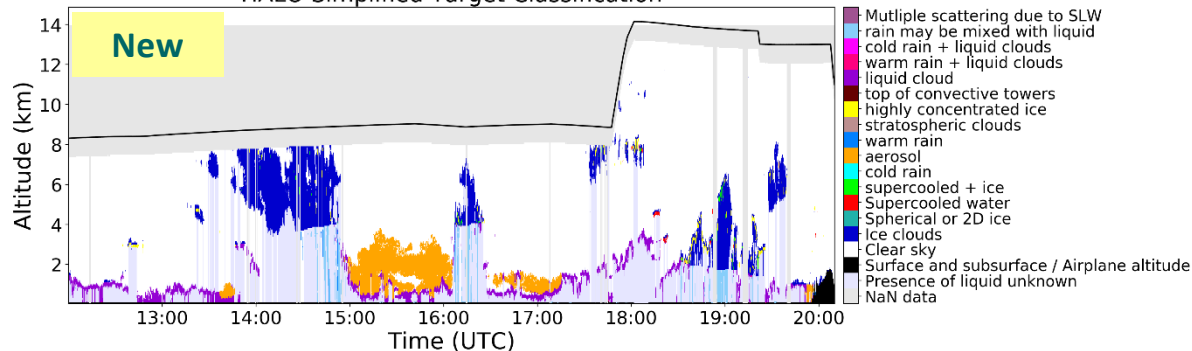
New HALO aerosol - cloud target categorization

HALO RF06 27/09/2016

HALO Simplified Target Classification



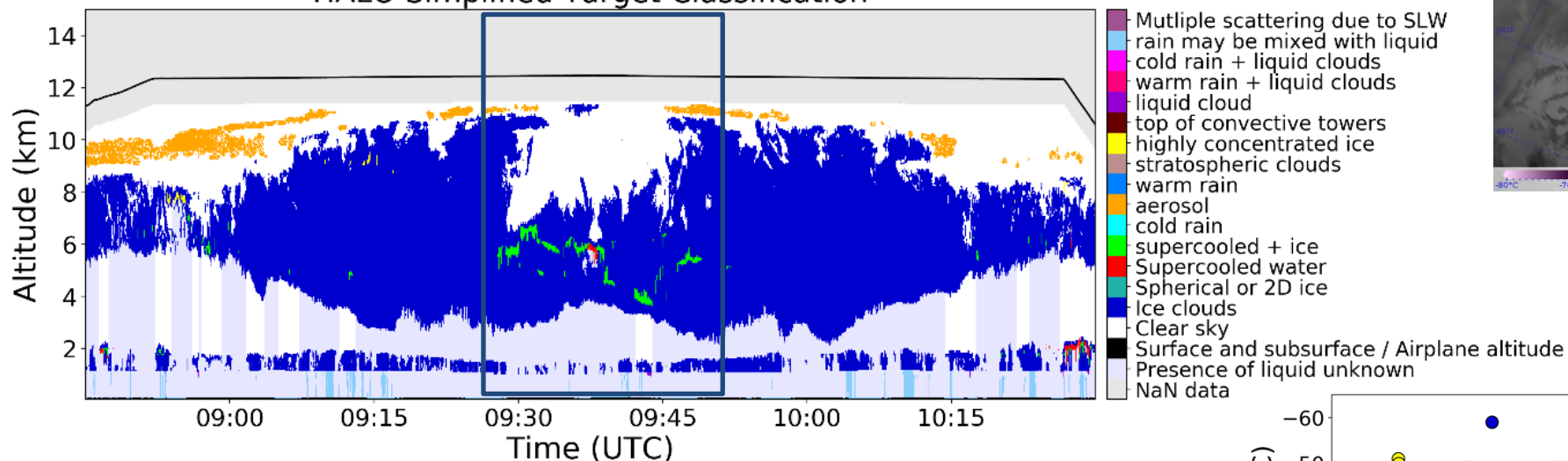
HALO Simplified Target Classification



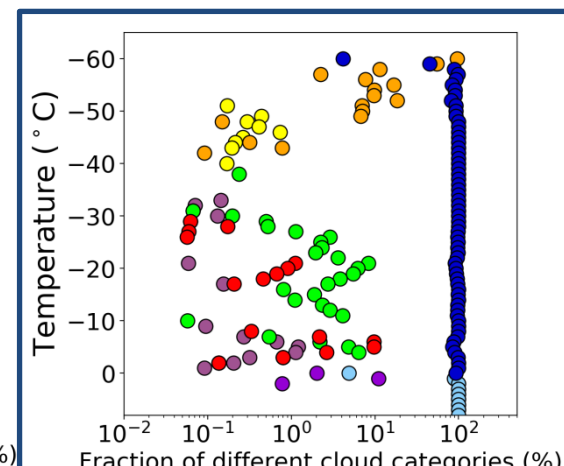
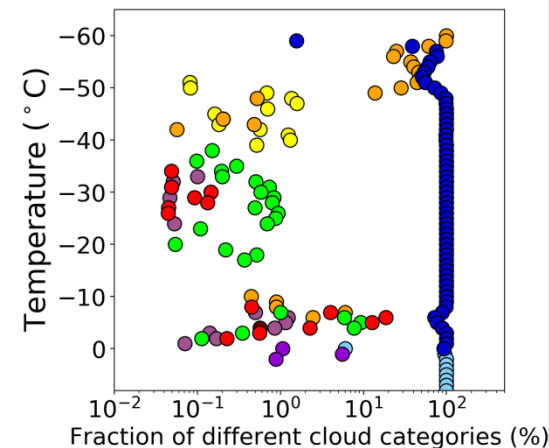
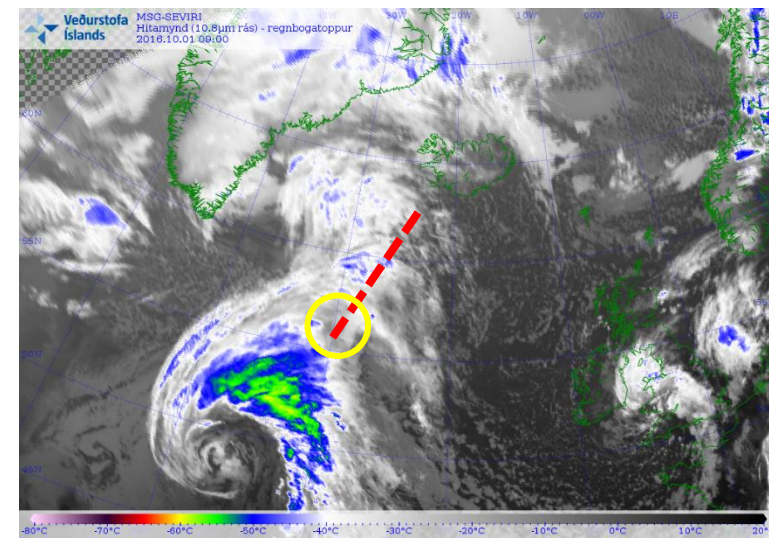
NAWDEX HALO cloud characterization

1/10/2016: Approaching “Stalactite” Cyclone

HALO Simplified Target Classification



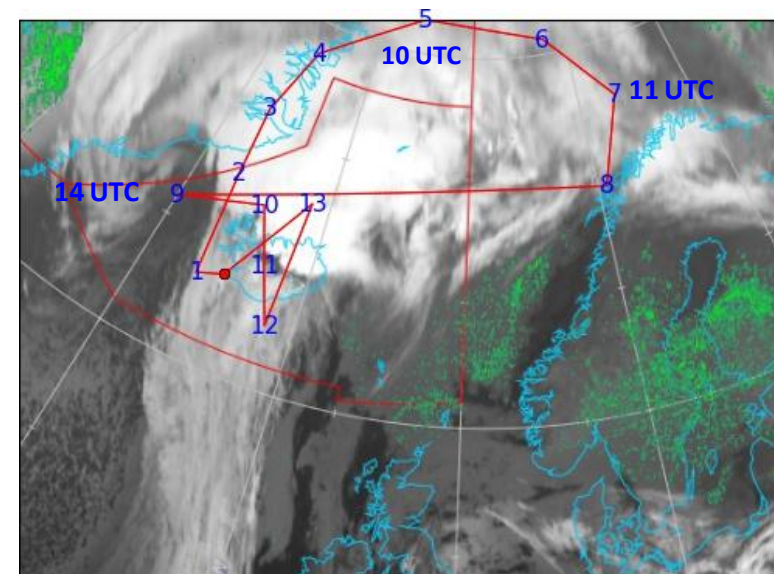
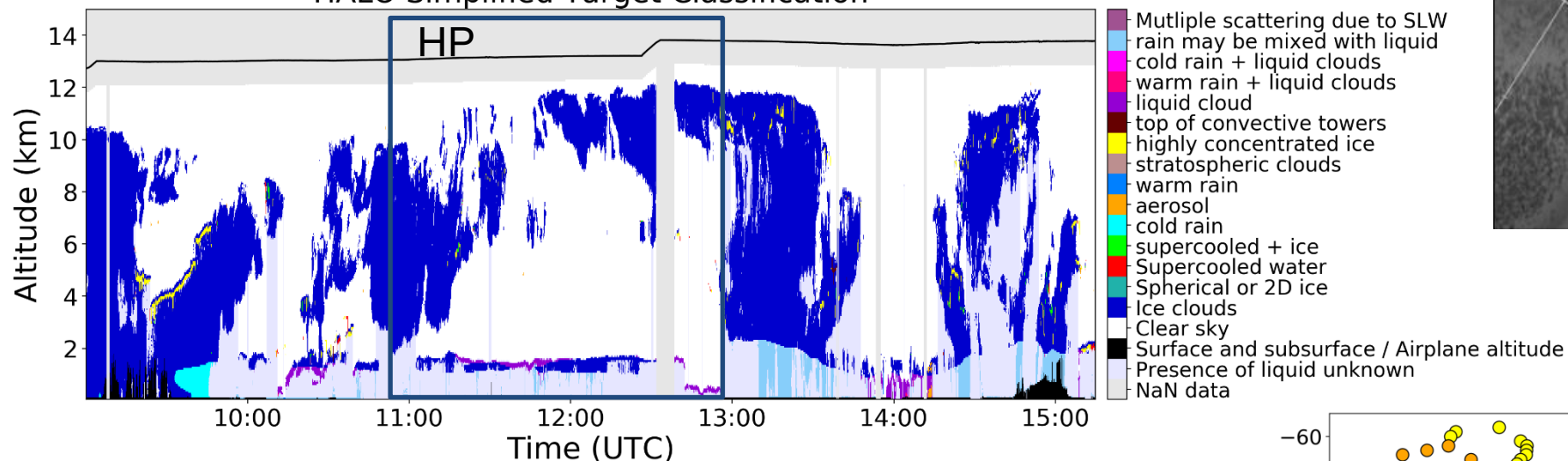
- Multiple cloud decks in > 50% of the profiles
- Cloud top: 100% ice
- 09:20 – 09:50 UTC: 70% of the total profiles have supercool + ice layers between 4-7 km: 10% of the cloud observations at -20°C & 0.4% -30°C



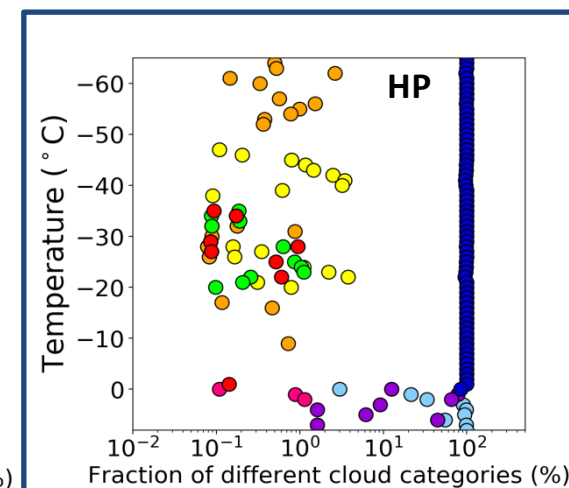
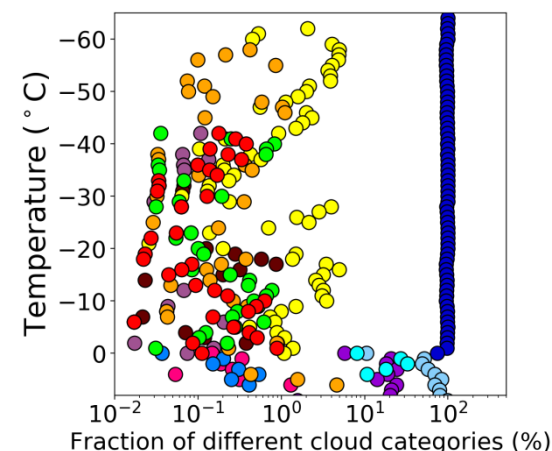
NAWDEX HALO cloud characterization

13/10/2016- RF10: Tropopause ridge “Thor”

HALO Simplified Target Classification



- HP region: 48% of the low level cloud tops are liquid [0,1°C]
- Crossing the frontal clouds:
29% of the profiles: highly concentrated ice (HCI)
4% supercooled + ice, 3% supercooled water
- HCI layers depth: $\leq 240\text{m}$ in 70% of the cases

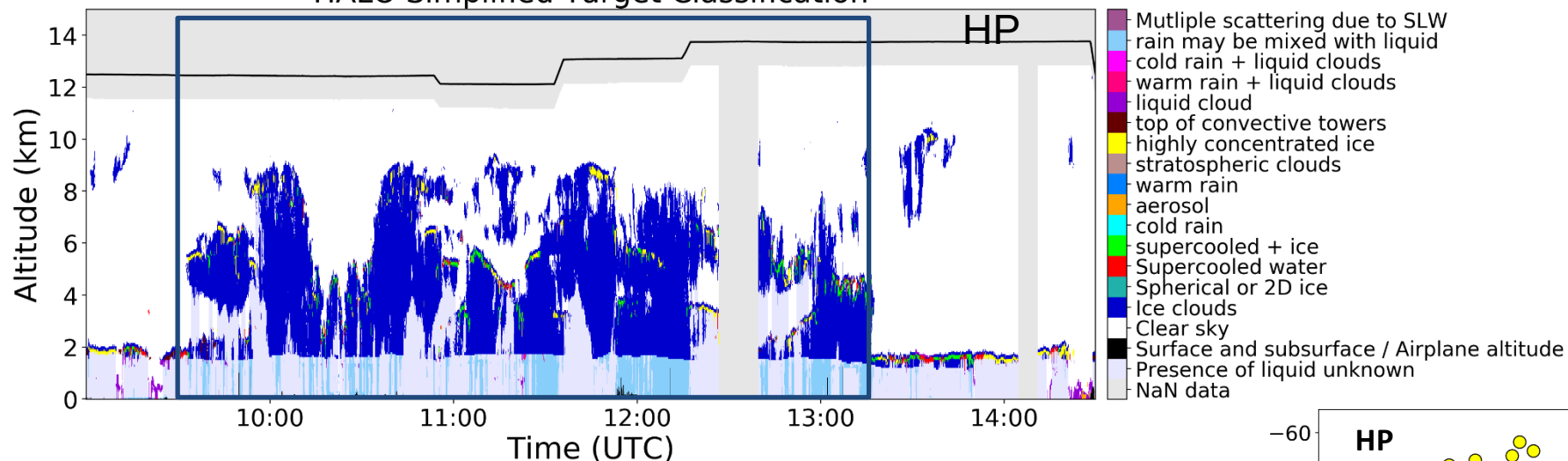


* HP: High sea level pressure

NAWDEX HALO cloud characterization

14/10/2016- RF11: Anticyclonic situation on the northern Atlantic with few cyclonic activity

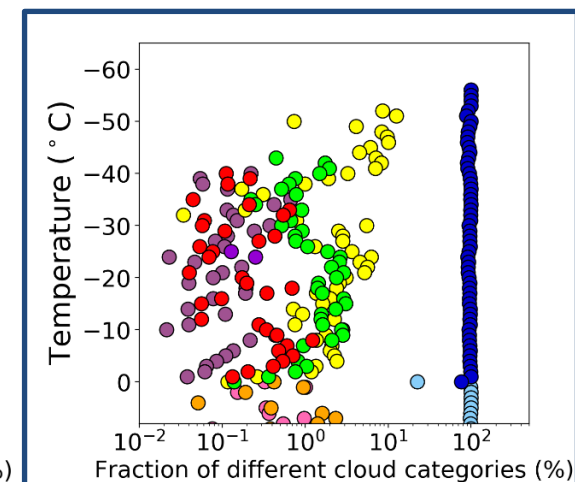
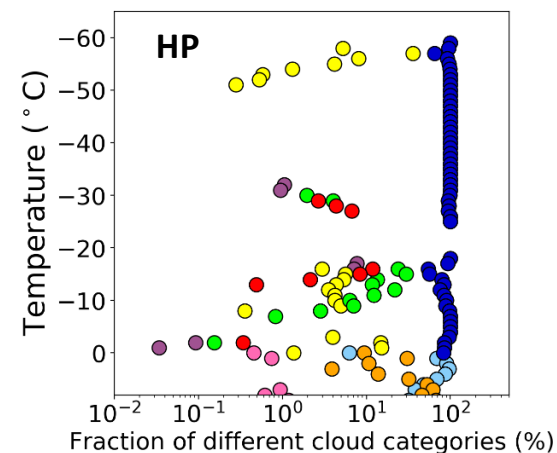
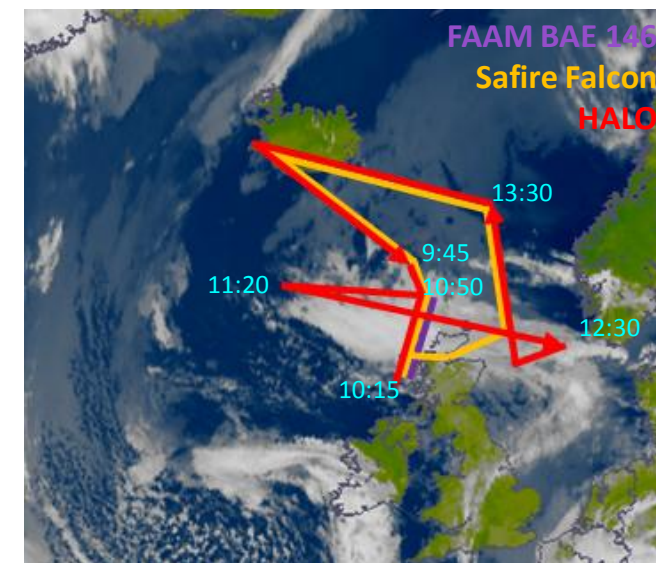
HALO Simplified Target Classification



- Over the ridge:
All clouds: $< 0^{\circ}\text{C}$, 33% with HCl, 20% supercooled + ice
- Convective region: 46% with HCl, 27% supercooled + ice, 6% supercool water
- The HCl occurrence is higher in lower temperatures
- High updrafts observed



*LP: Low sea level pressure
HP: High sea level pressure



Conclusions

- Full target classification from HALO Radar-Lidar measurements
- Possibility to provide statistics of each flight and overall

