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Observations with the RALI platform during the NAWDEX campaign



EARTHCARE RALI NAWDEX - EPATAN
ESA Contract No. 4000119015/NL/CT/gp

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LATMOS 2019

1



EPATAN (EarthCare Preparation cAmpaign)

Support: ESA/CNES/INSU/MF and EUFAR

A campaign addressing directly the programmatic needs of EarthCARE Mission / Provide measurements for development and refinement of Geophysical Product Algorithms

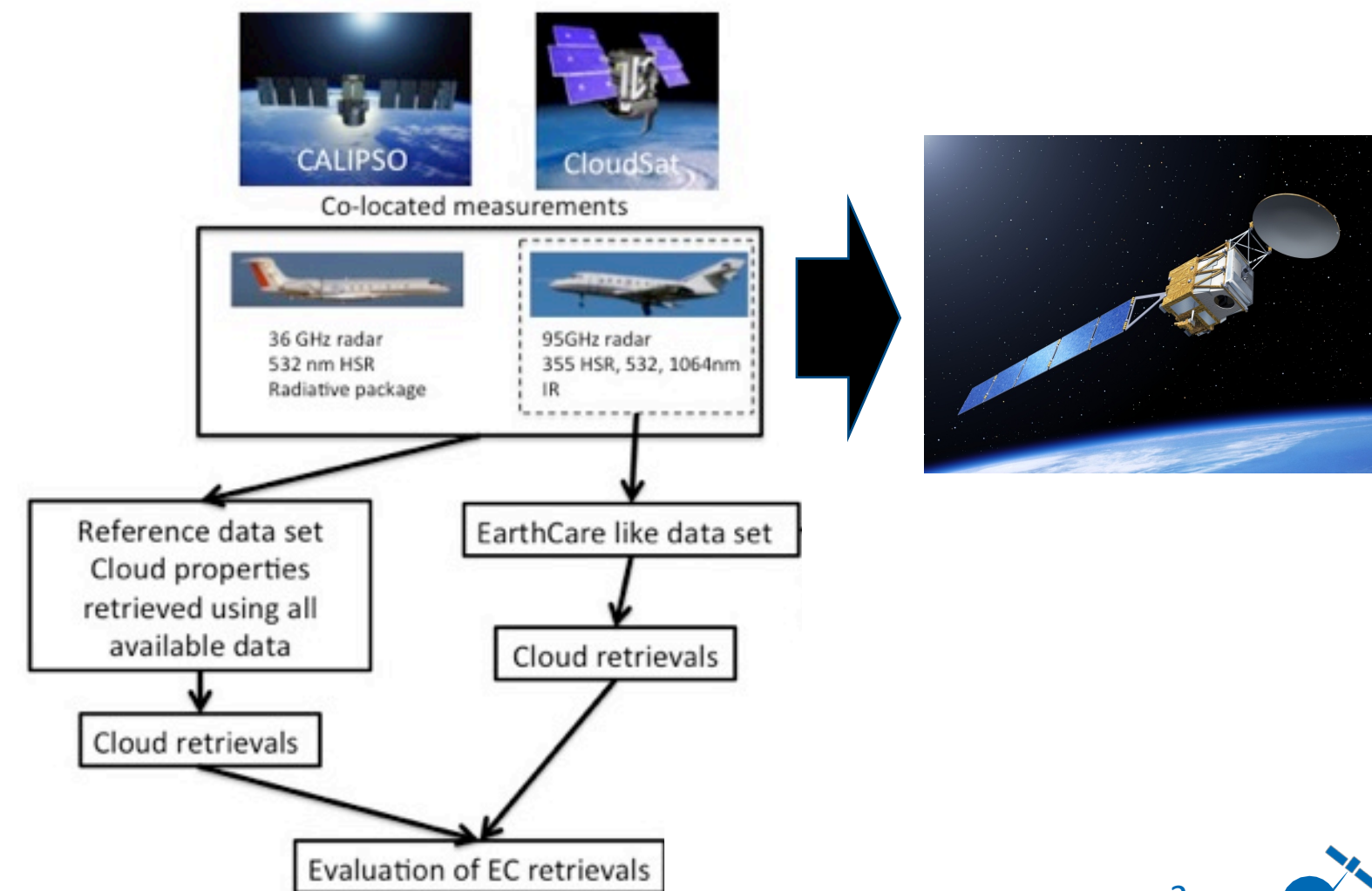
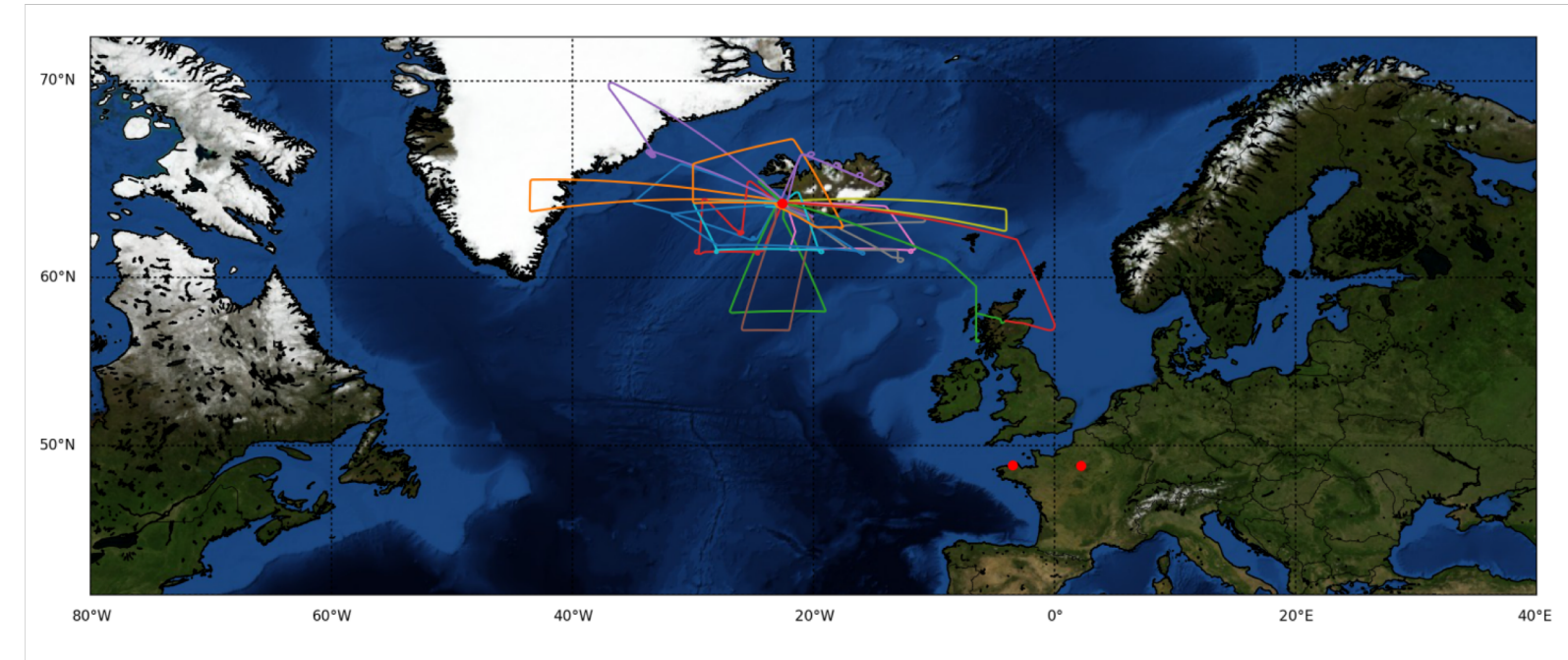
Relevance for EarthCARE

- Airborne tandem-platform (HALO/SAFIRE)
- EarthCARE-like payload++
- Coordinated HALO-SAFIRE flights
- Coordinated A-Train underpasses

NAWDEX

28th of September to 17th of October 2016

- Number of scientific flights: 15
- Number of scientific flight hours: 46.5
- Number of released dropsondes: 59
- Number of CloudSat-CALIPSO underpasses: 3
- Number of co-located flights: 5



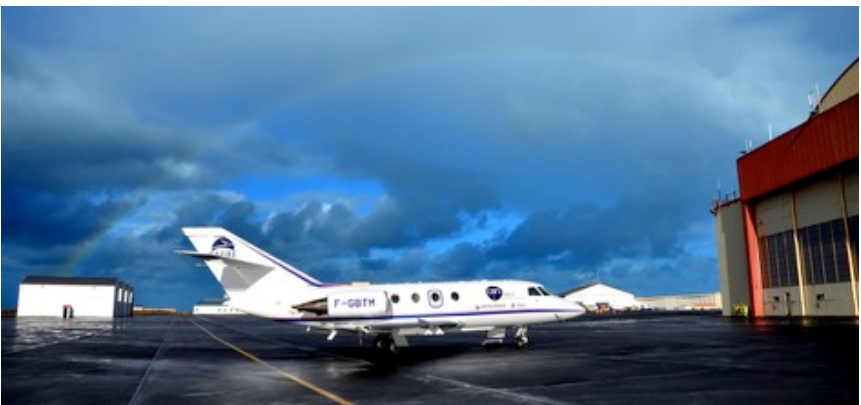
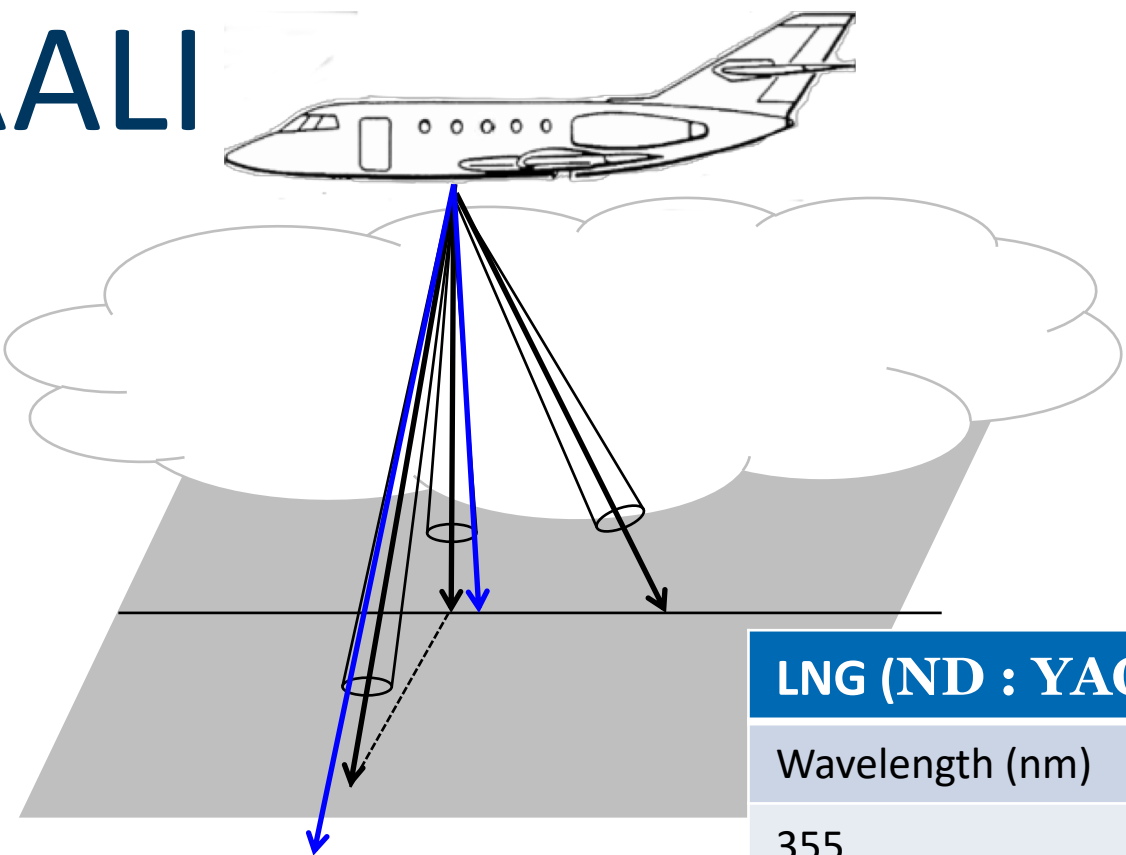
French F20 Payload - RALI

Aircraft:

- Dassault Falcon 20
- Endurance: **3.5 flight hours**
- Maximum cruising altitude: **13 km**

Payload:

- **LNG: High spectral resolution (Doppler) lidar** (355 nm), 532 and 1064 nm
- **RASTA: Doppler cloud Radar** (95 GHz) – 3 antennas looking down
- IR radiometer CLIMAT (brightness temperature **8-10-12 micron**)
- L/S fluxes
- Dropsonde launching (profiles of T, p, hum, u, v)
- Aircraft measurements (attitude, wind, T, p, hum)



LNG (ND : YAG pulsed 20Hz)

Wavelength (nm)	measurements
355	β , High spectral resolution (MZI), δ , Doppler
532	Backscatter only
1064	Backscatter only

3 antennas	RASTA characteristics
Frequency (GHz)	95 (3.2 mm)
Vertical resolution (m)	60
Horizontal resolution (m)	225 to 300 depending on aircraft speed
Range (km)	15
Integration time (ms)	250 (measurement every 750ms for each antenna)
Energy (kW)	2 (pulse 0.4 μ s)
Ambiguous velocity (m s ⁻¹)	8
Antenna size (cm)	45 (0.5° beam width)
Sensitivity at 1km (dBZ)	Down backward: ~-22 / Nadir: ~-30 / Down transverse: ~-26

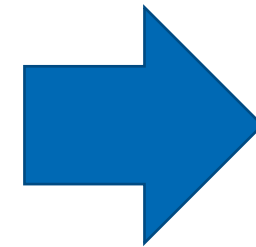
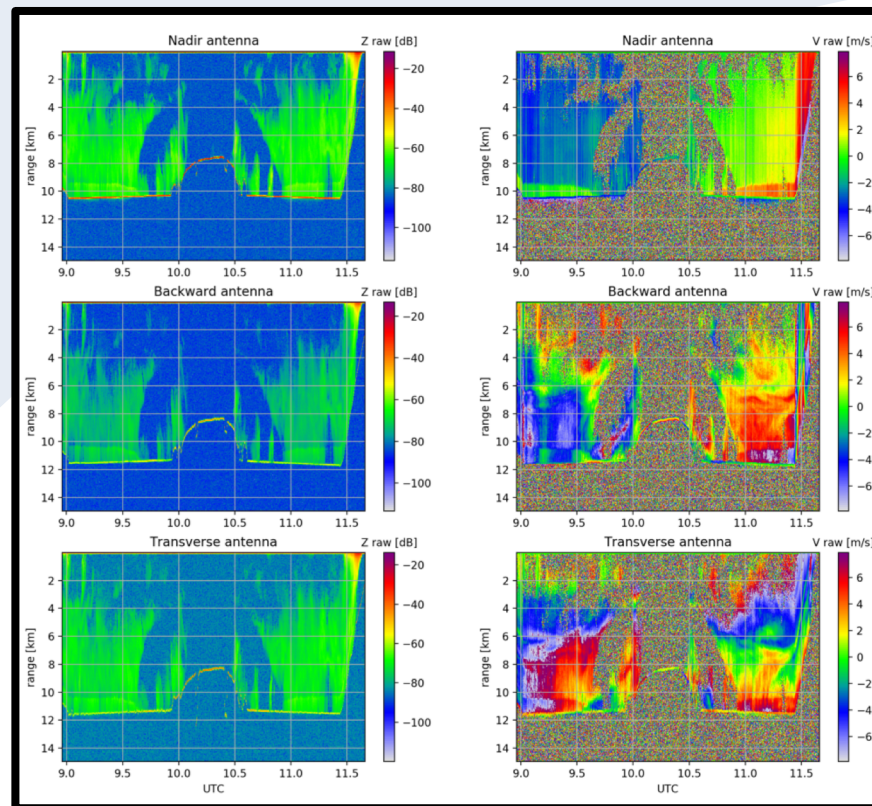


Data products

- RASTA L2 single antenna product (containing L0/L1 data)
- RASTA L2 wind product
- RASTA microphysical product (**new with rain retrieval**)
- RASTA spectral product (on demand)
- LNG L1 product
- RALI product (LNG and RASTA co-located)
 - Mask
 - Varcloud retrieval
- DATA have been delivered to ESA and will be available on ESA campaigns website



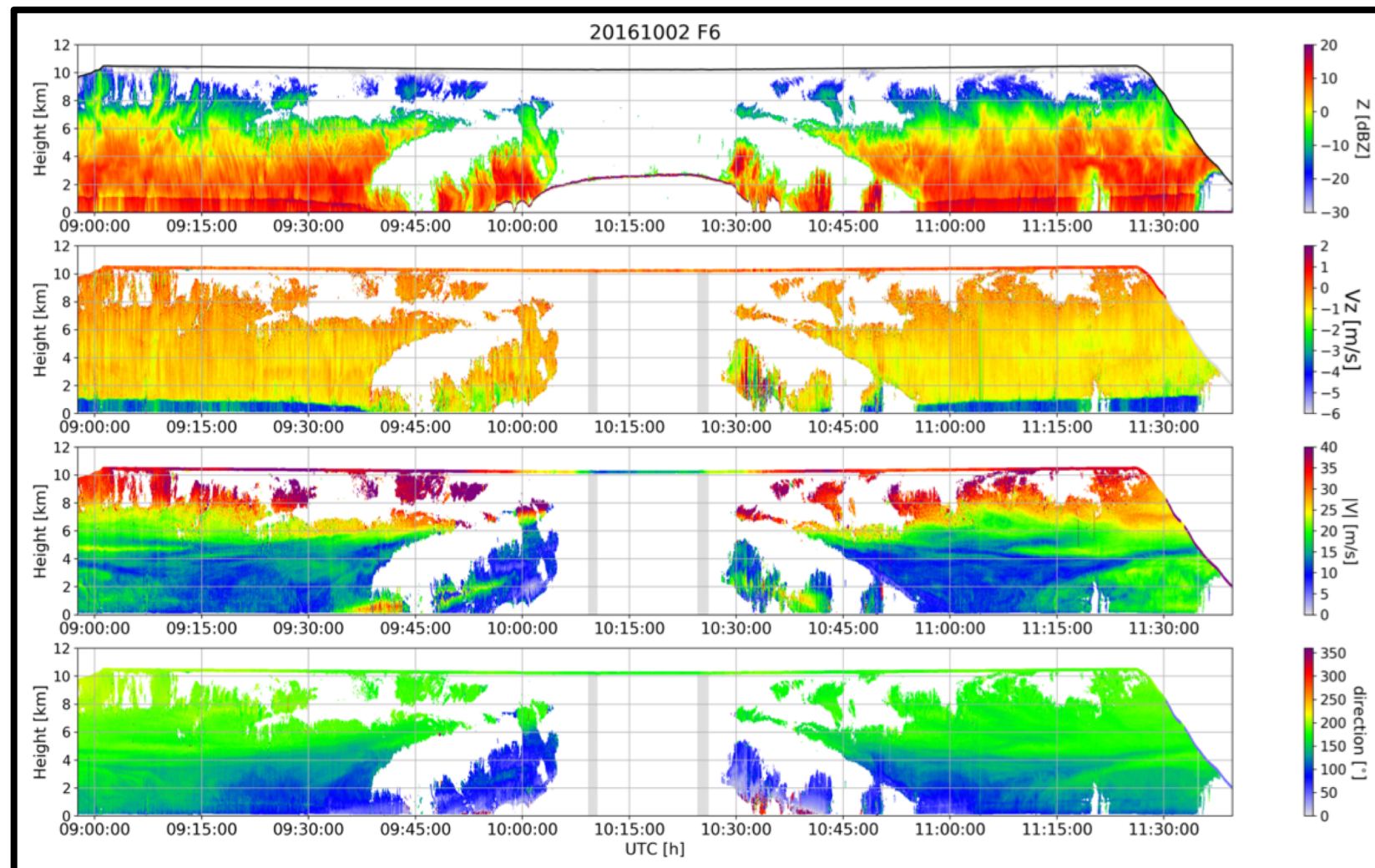
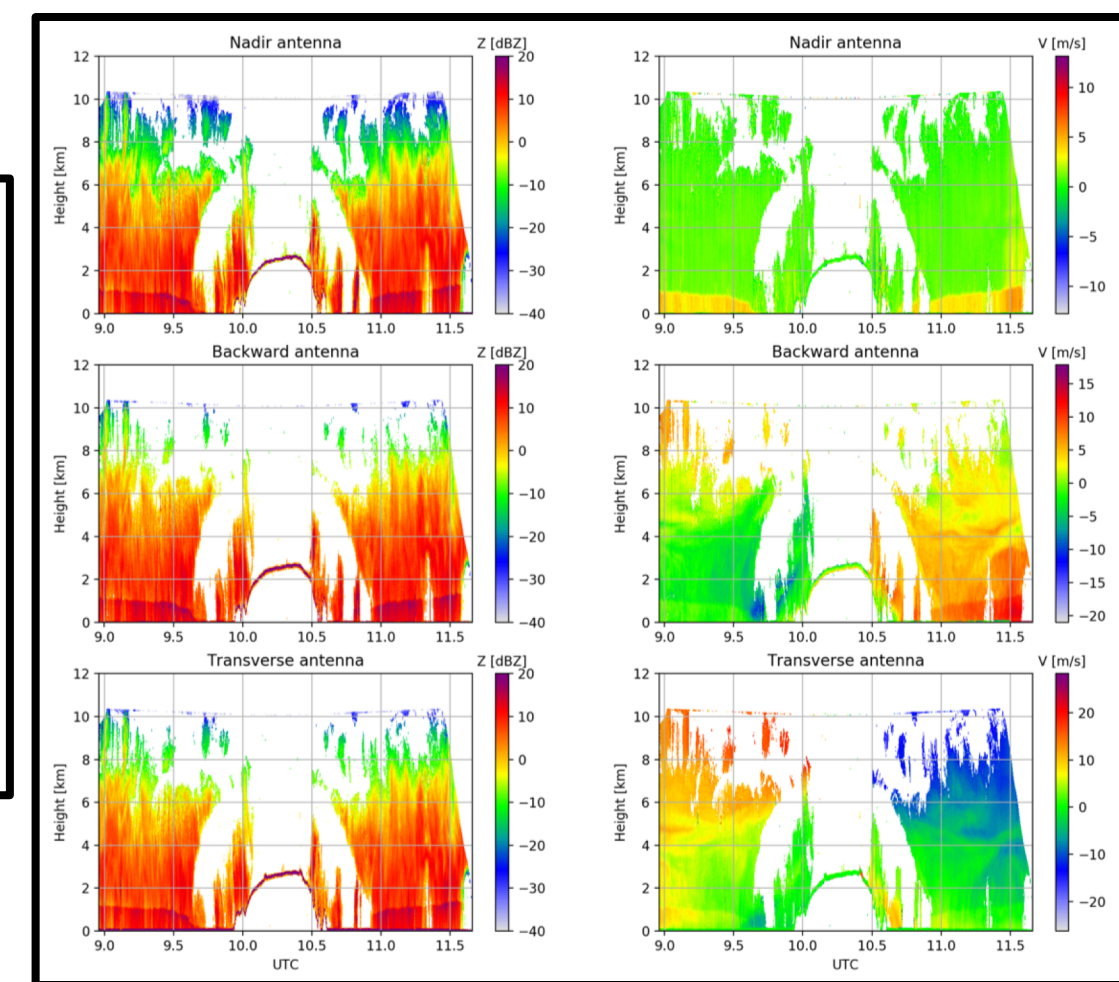
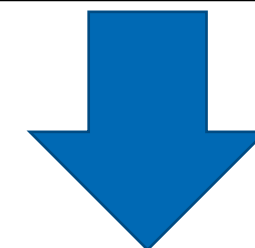
RASTA processing



RAW DATA (L2)

Nadir/Back/Trans

- Range corrected reflectivity
- Velocity correction (folding/aircraft motion)
- Geolocation (lat/lon/alt)



WIND DATA (L2+)

Variational approach:

3 measurements are co-located: V_d (Nadir), V_d (backward), V_d (transverse)

3 components of the wind: V_x (along track), V_y (cross track), V_z (vertical)

V_x , V_y are used to derive V_N , V_E or V_{dir} and $|V|$

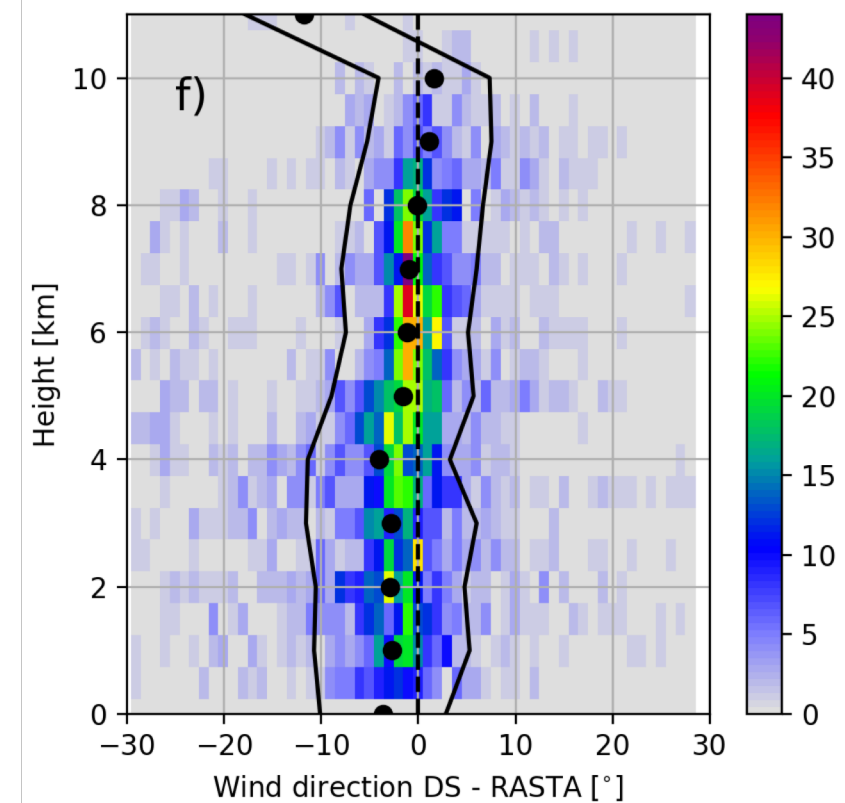
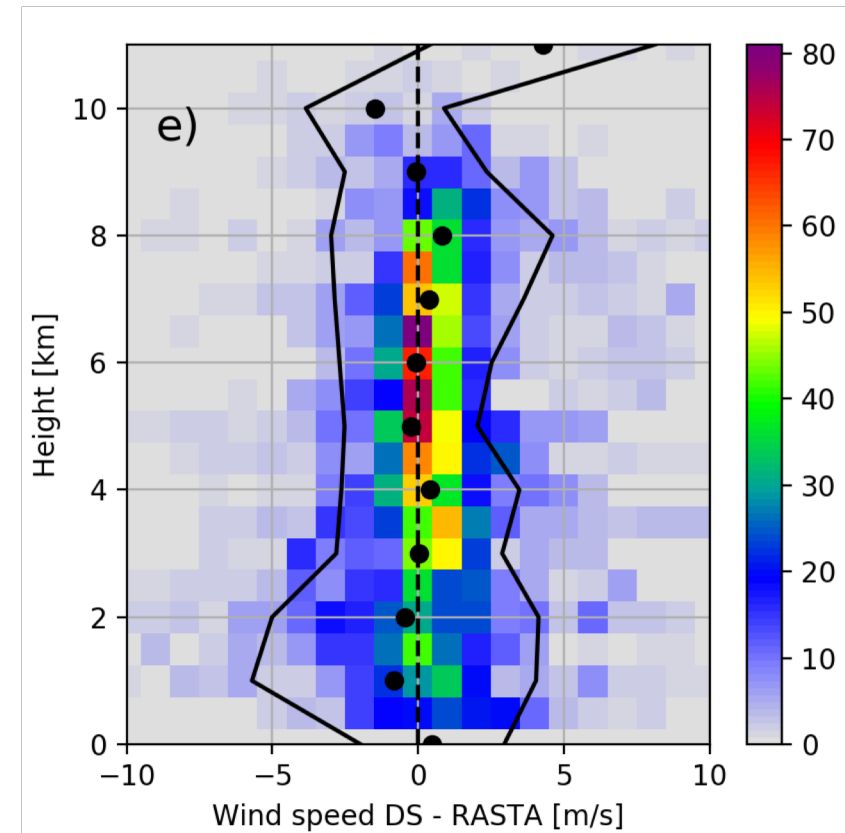
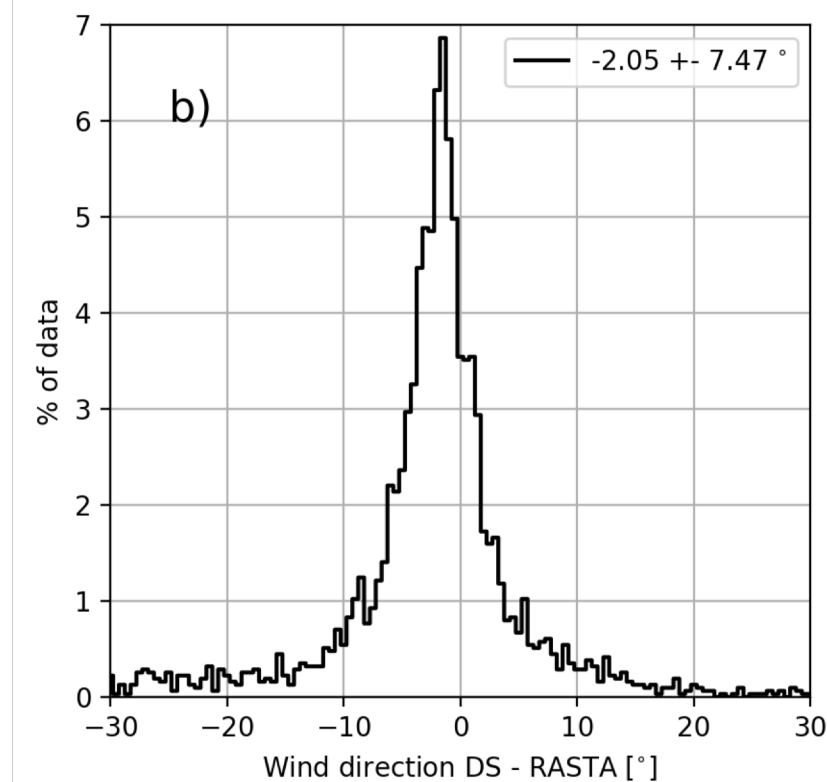
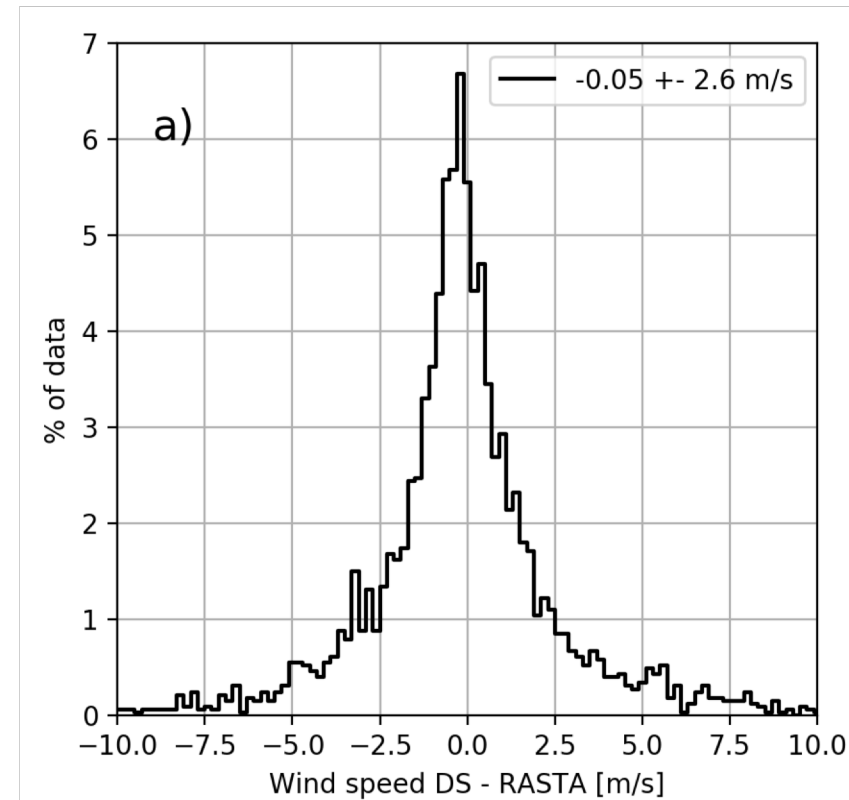
Assumption: volume probed by antennas is homogeneous (volume increasing with distance)



RASTA WIND retrieval assessment

Dropsonde launch
time with a 10s
window for RASTA
measurements

Wind speed: 0.05 ± 2.6 m/s
Wind direction: $-2.05 \pm 7.47^\circ$

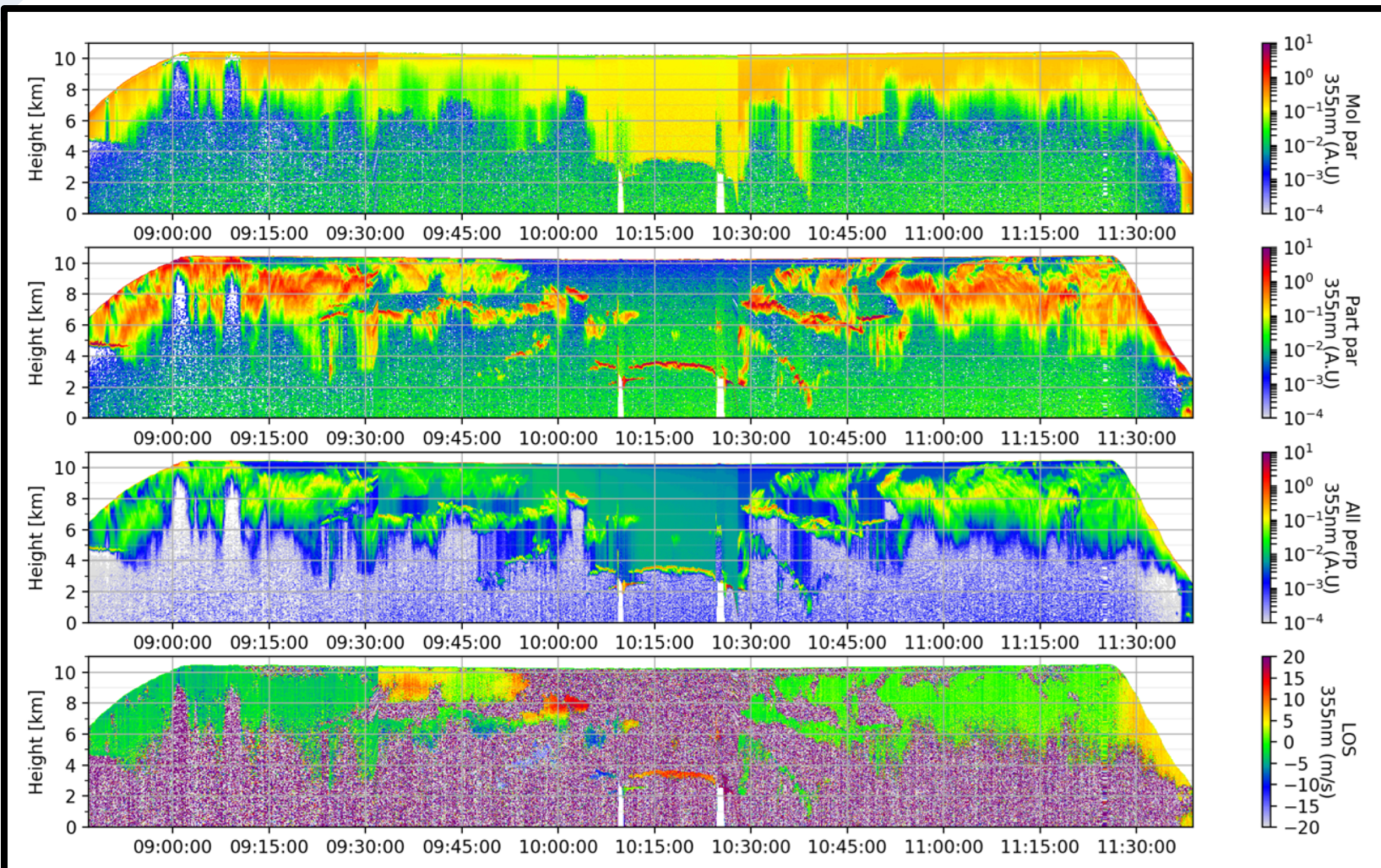


RASTA against
DS (all flights)

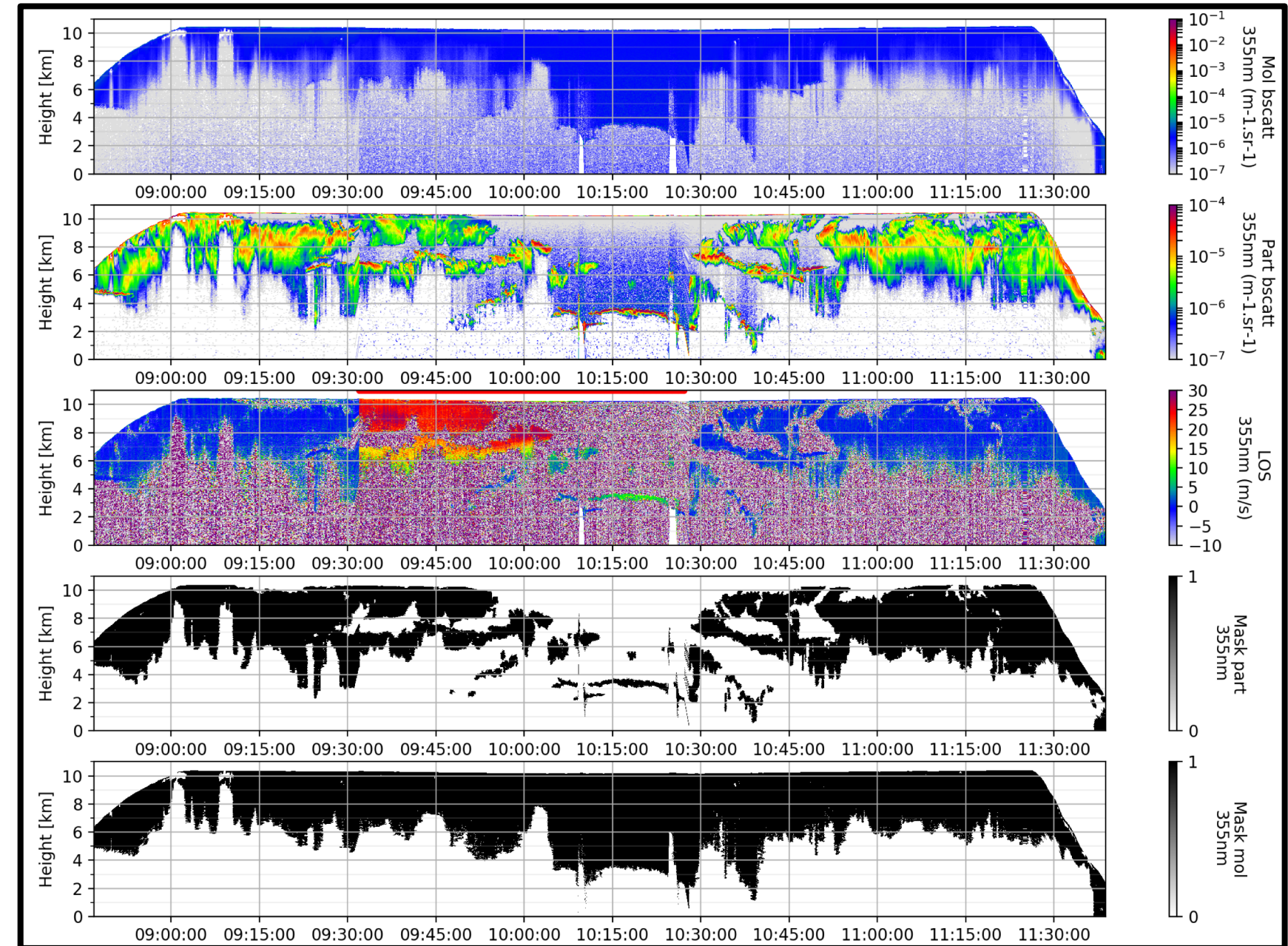
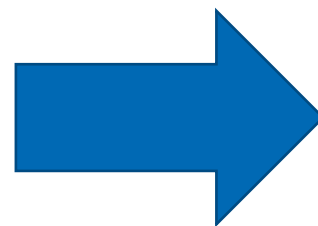
As a function of altitude



LNG processing



RAW DATA (L0)
2 views: Nadir and ADM
Radiative and dynamics



Processed DATA (L1)
2 views: Nadir and ADM
Radiative (calibrated) and dynamics
Masks

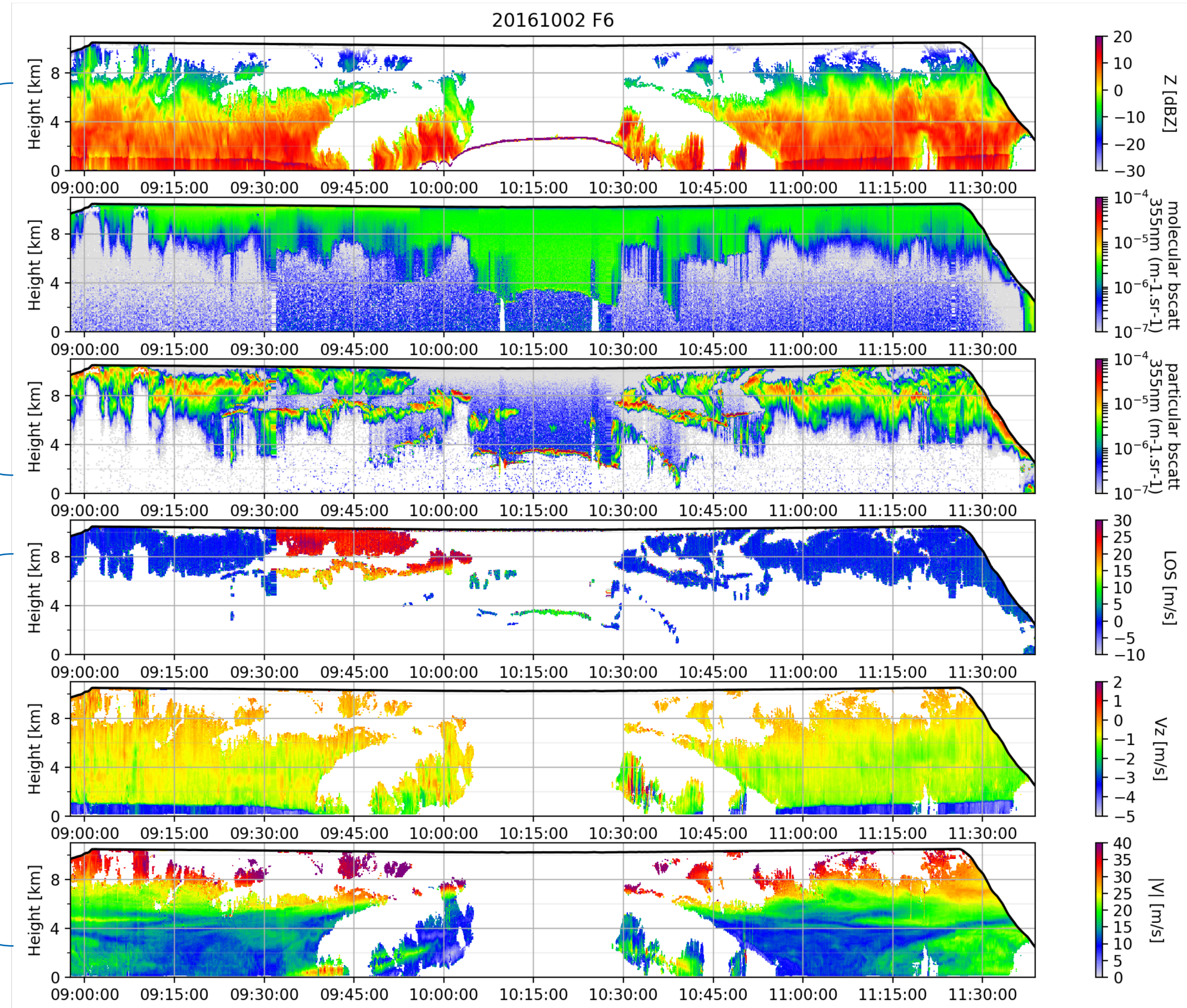


Merge product

RASTA and LNG
measurements/retrievals
⇒ Same grid (5s, 60m)
⇒ Co-located in space and
time

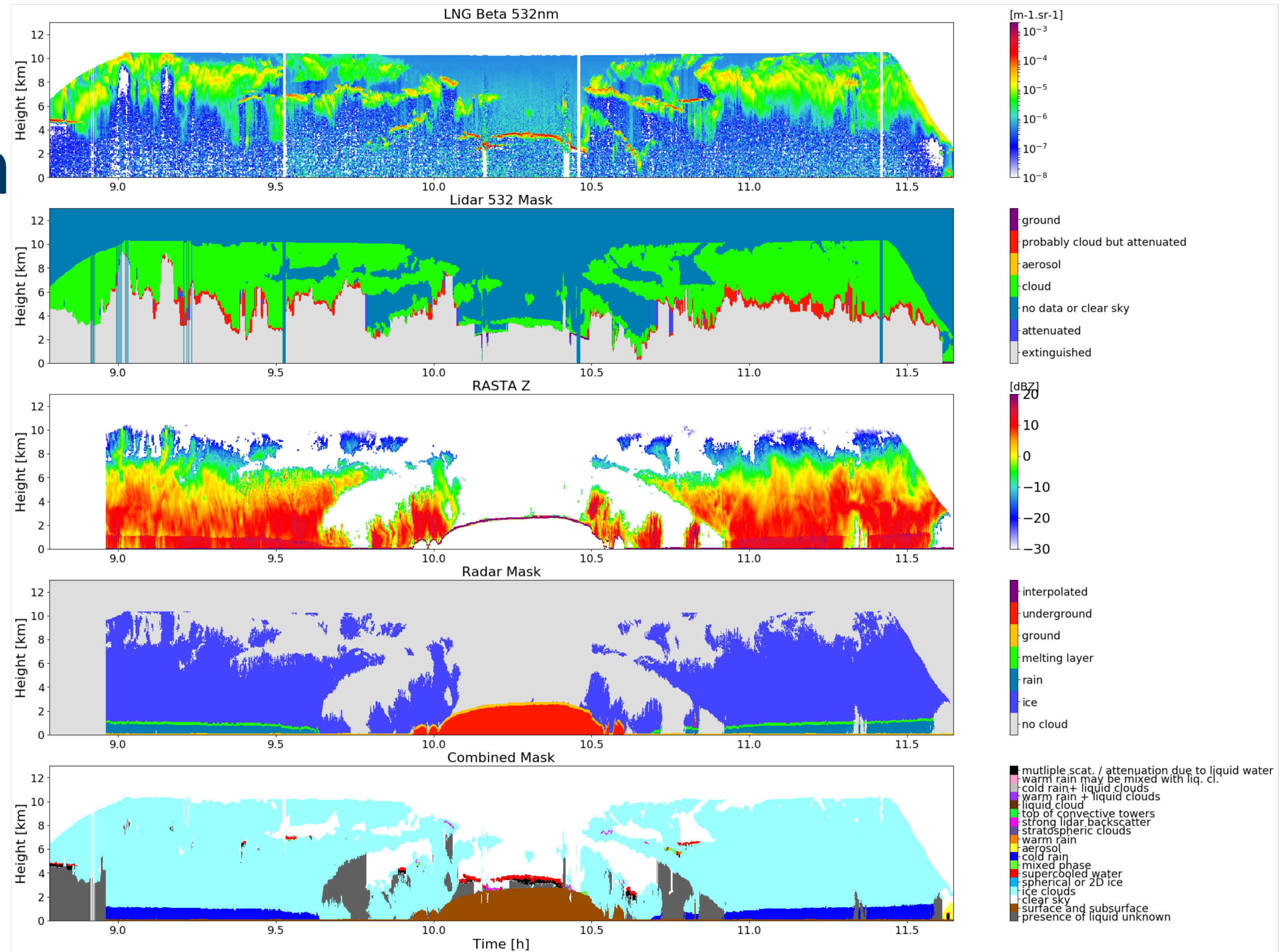
Radiative

Dynamics

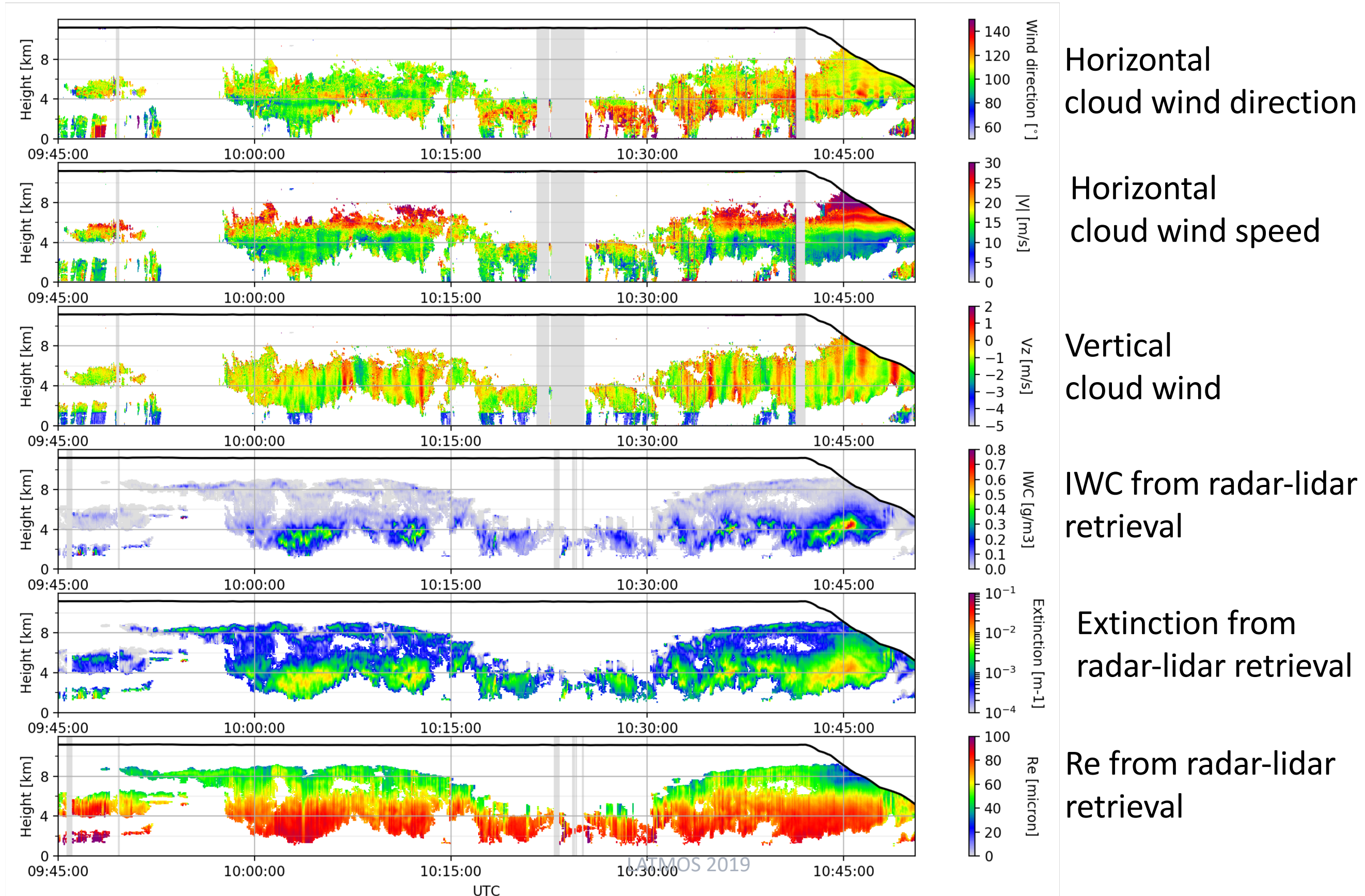


Example of categorisation

Radar + 532 nm Lidar



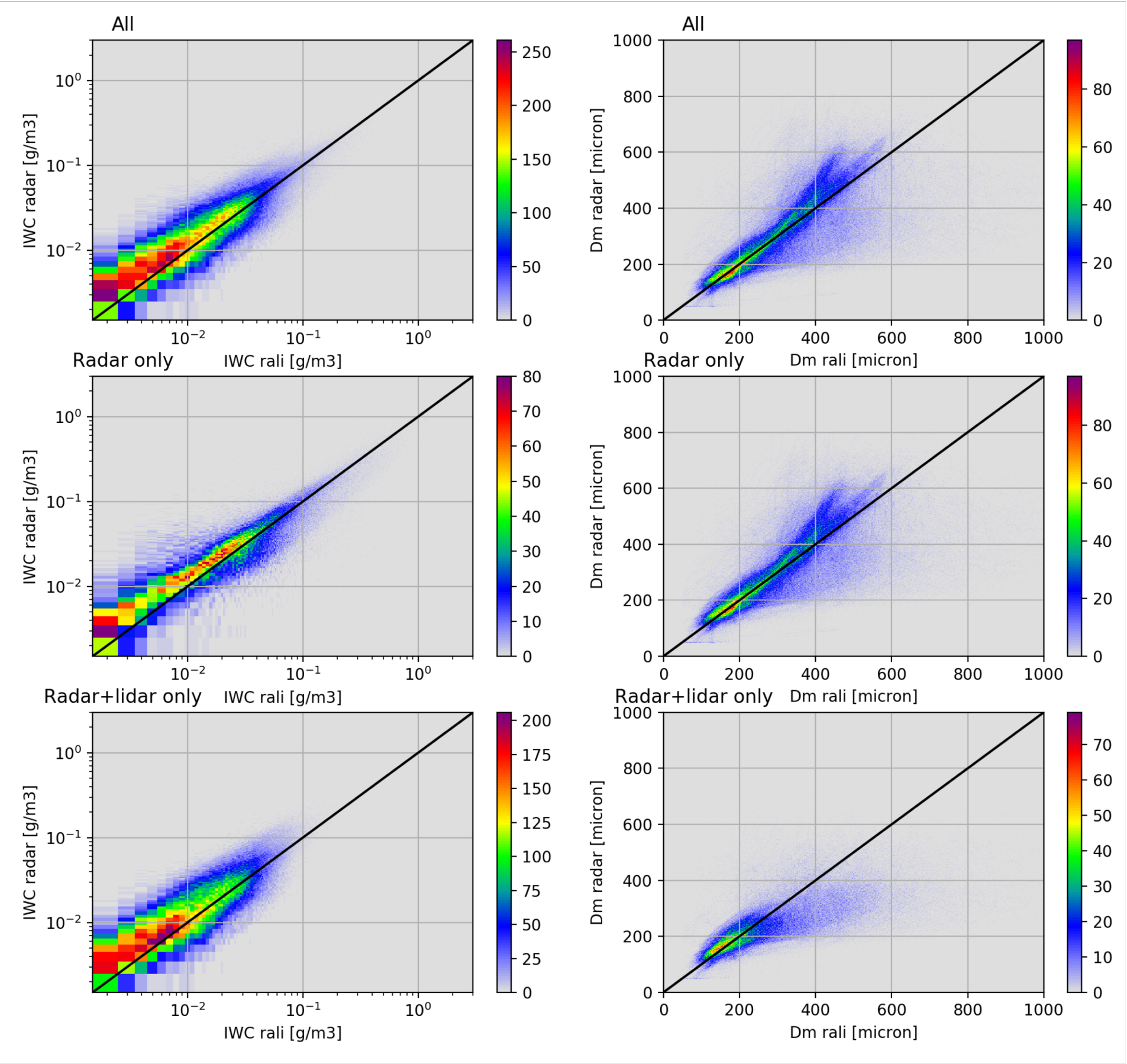
RAI wind and microphysics retrievals



DATA Analysis



RASTA vs RALI



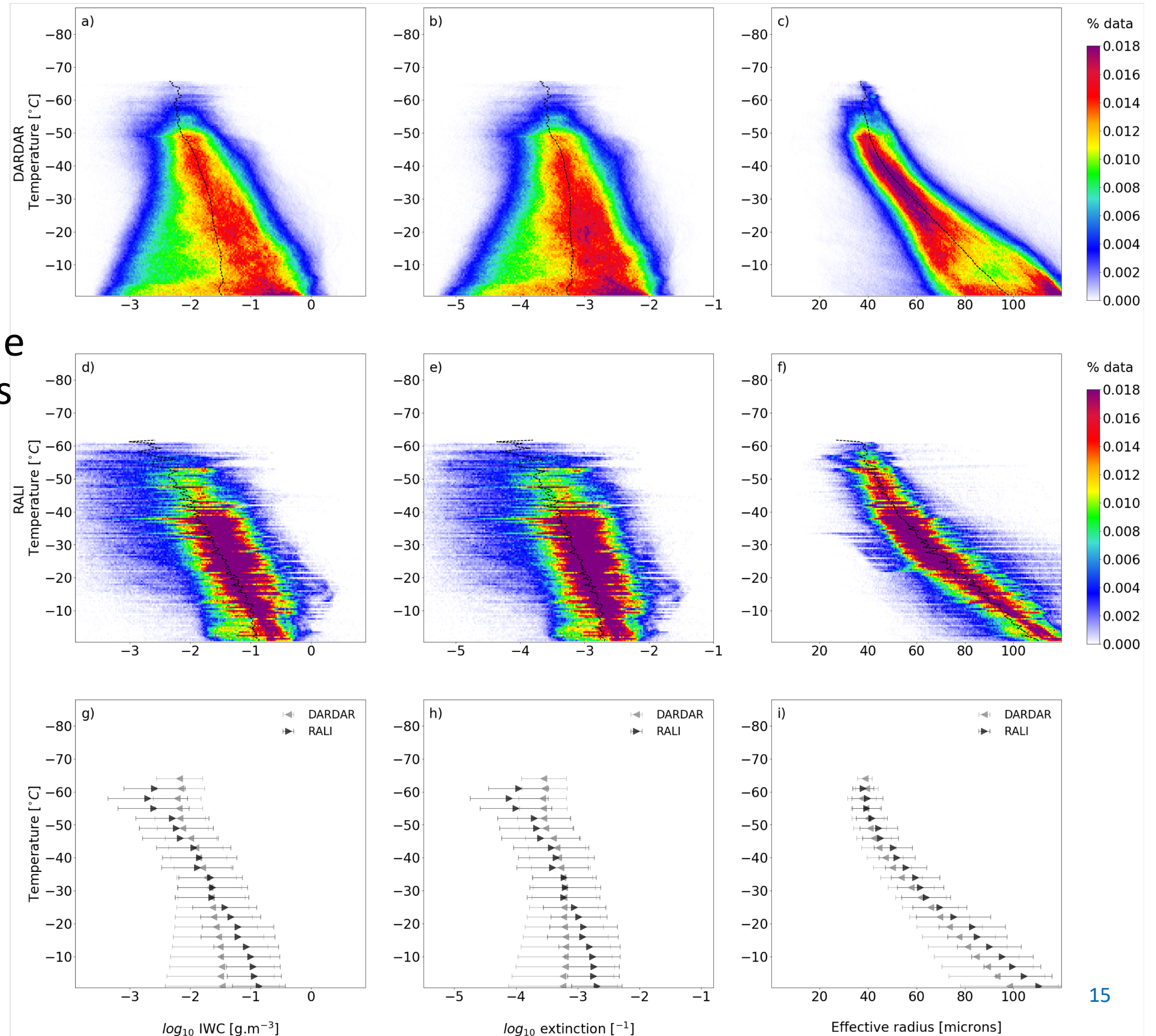
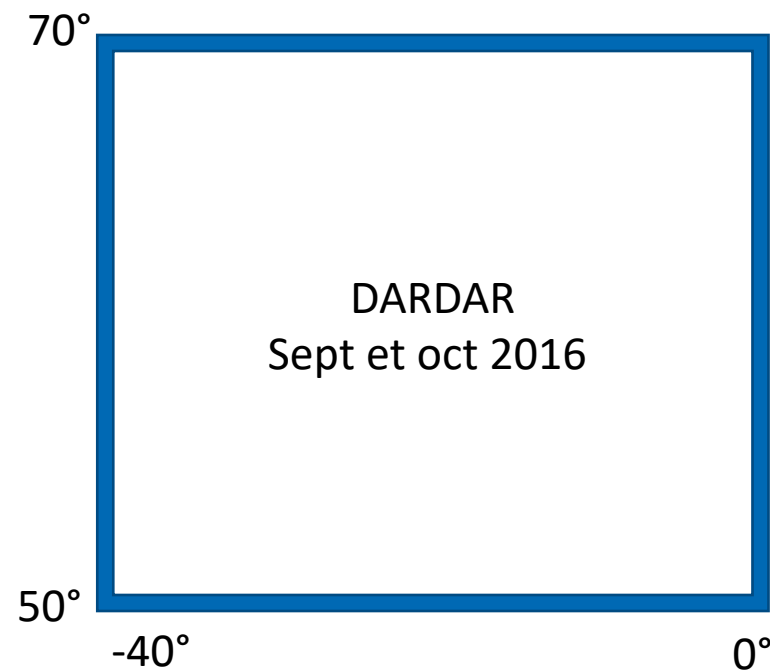
CC – underpasses and comparisons

- EarthCare cal/val rehearsal
- 3 CloudSat-CALIPSO underpasses (FF20): 2nd, 5th and 14th of October 2016. CALIPSO was not operating during the 5th of October
- CloudSat and RASTA comparison (corr. for cal convention)
- Comparison between measurements and radar-lidar products: Aircraft data are compared against DARDAR product (MASK-V2 and CLOUD-V2).

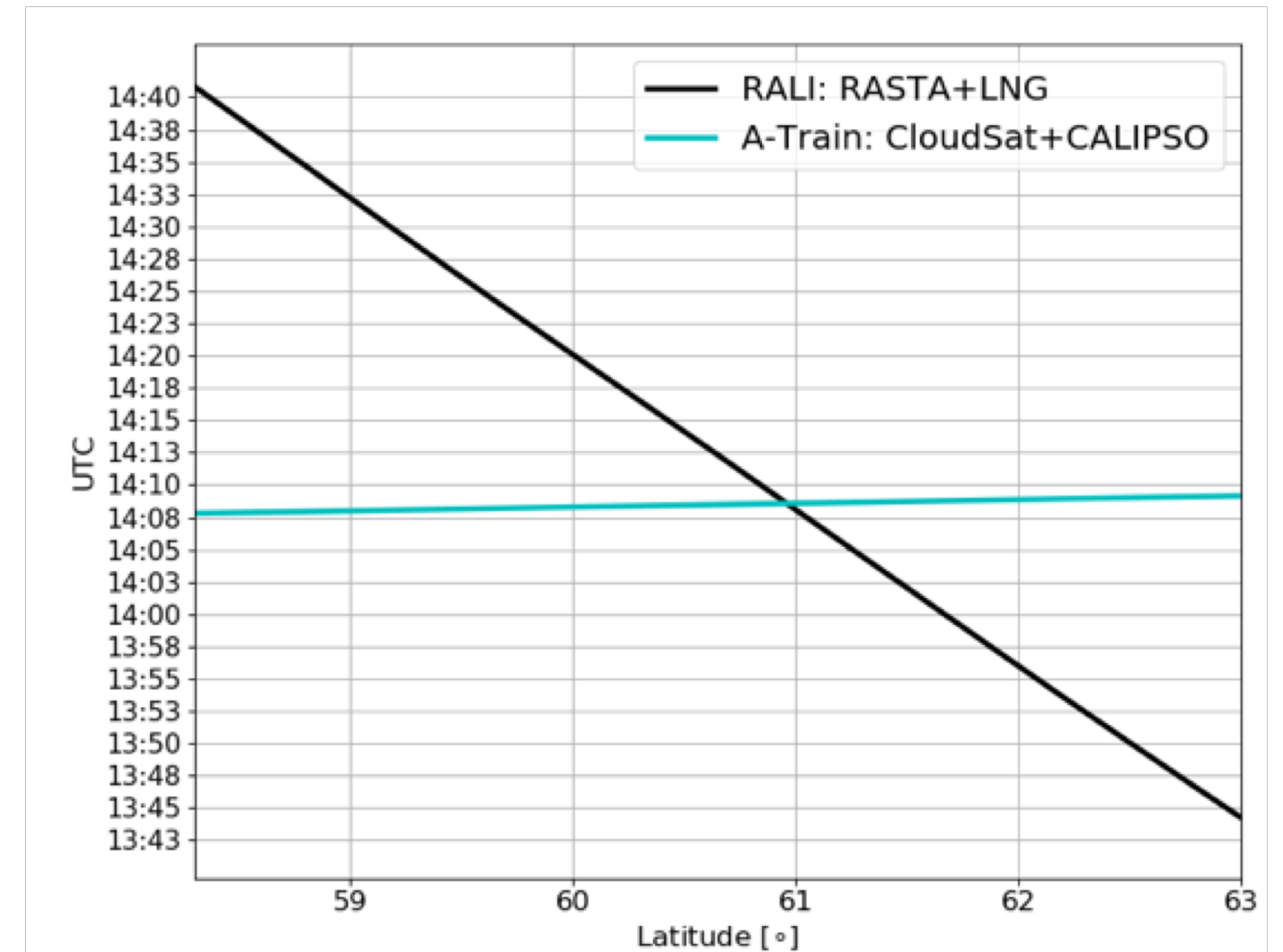
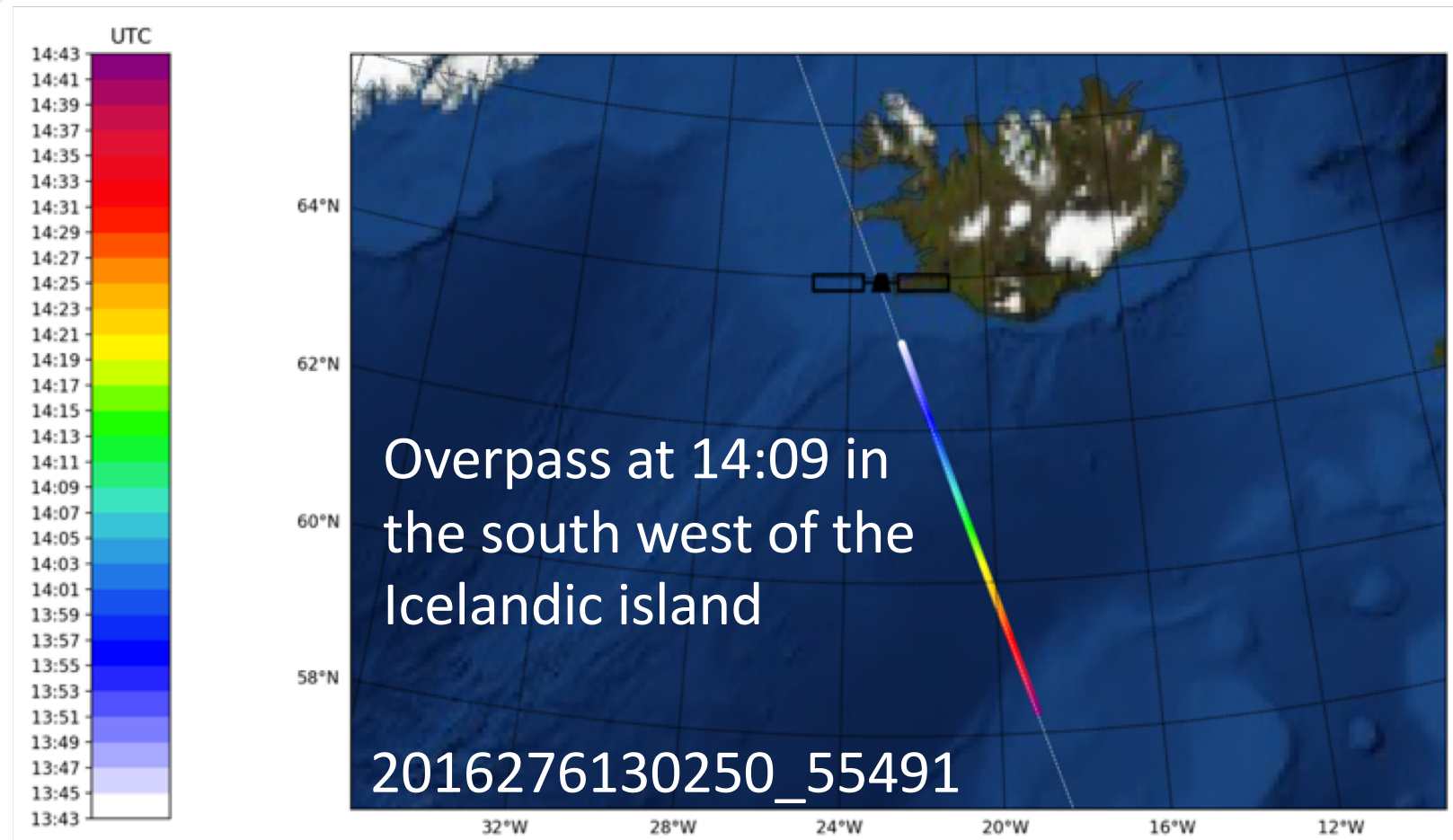


Comparison with satellites

- Statistical approach : during the NAWDEX campaign DARDAR vs RALI



Underpass #1 : 2016/10/02 (F7-French Falcon)



The F20 was sampling the inflow of a warm conveyor belt in cloudy conditions just below 9 km.

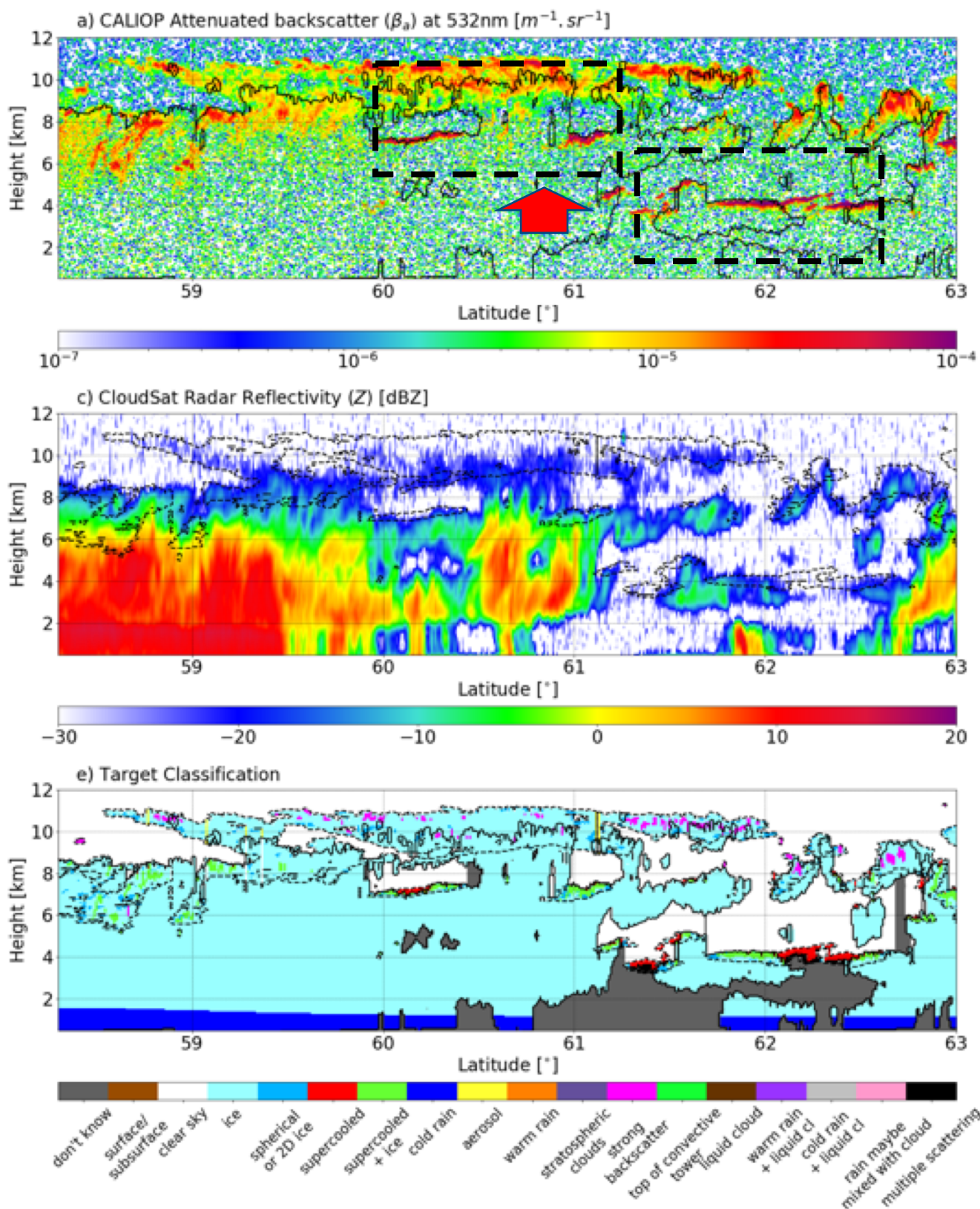
CloudSat and CALIPSO were flying from south to north while the F20 was sampling the scene in the opposite direction.



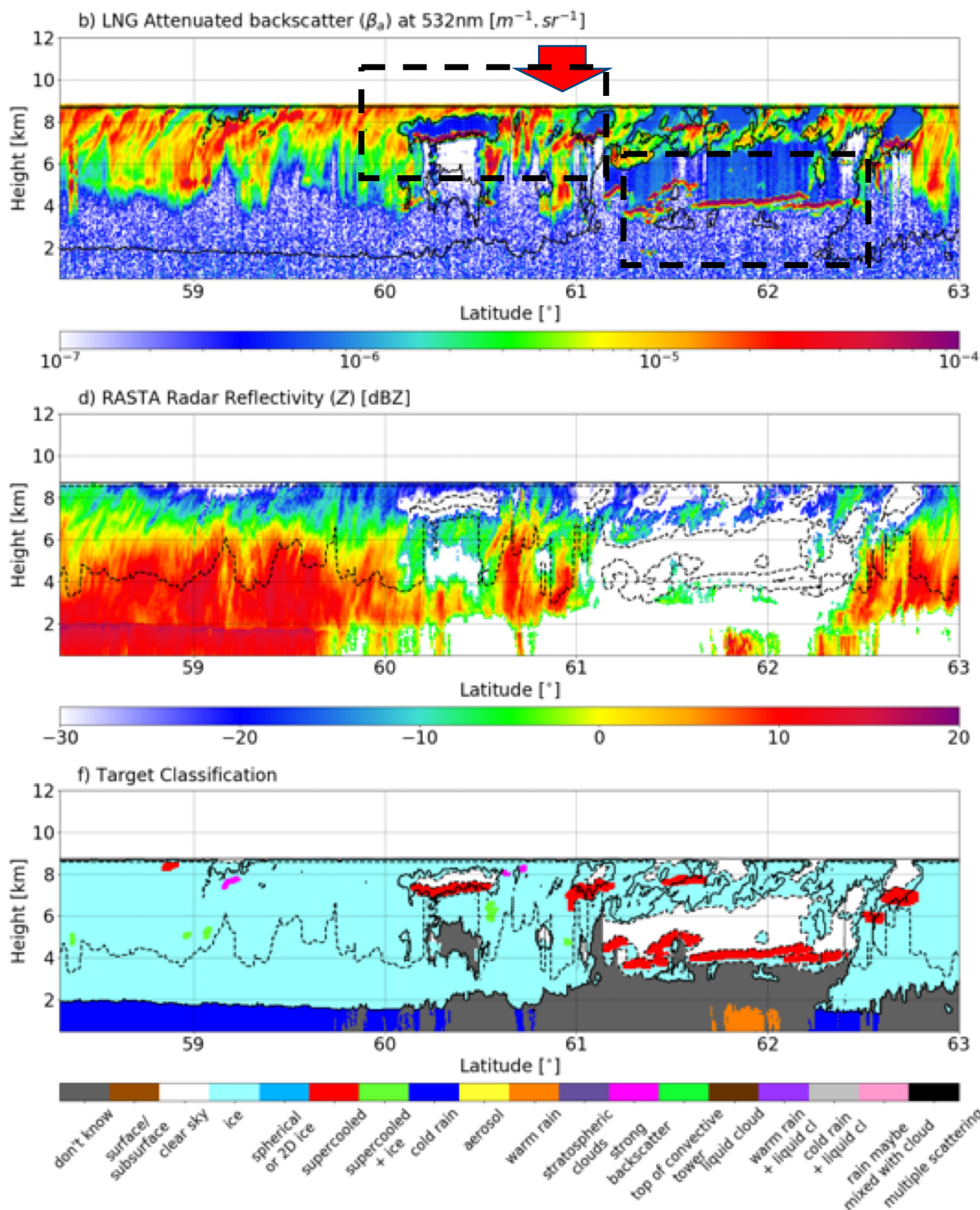
dt=30 min

dt=25 min

A-Train 2016/10/02: Cloudsat and CALIPSO



RAI 2016/10/02: RASTA and LNG



CALIPSO background signal suffered from a strong contamination Issue for ice and aerosol less impact for liquid

Good agreement between the two lidars for strong backscatter

RASTA and CloudSat also very similar patterns and the differences are due to the time shift and the less homogeneous situation.



dt=30 min

dt=25 min

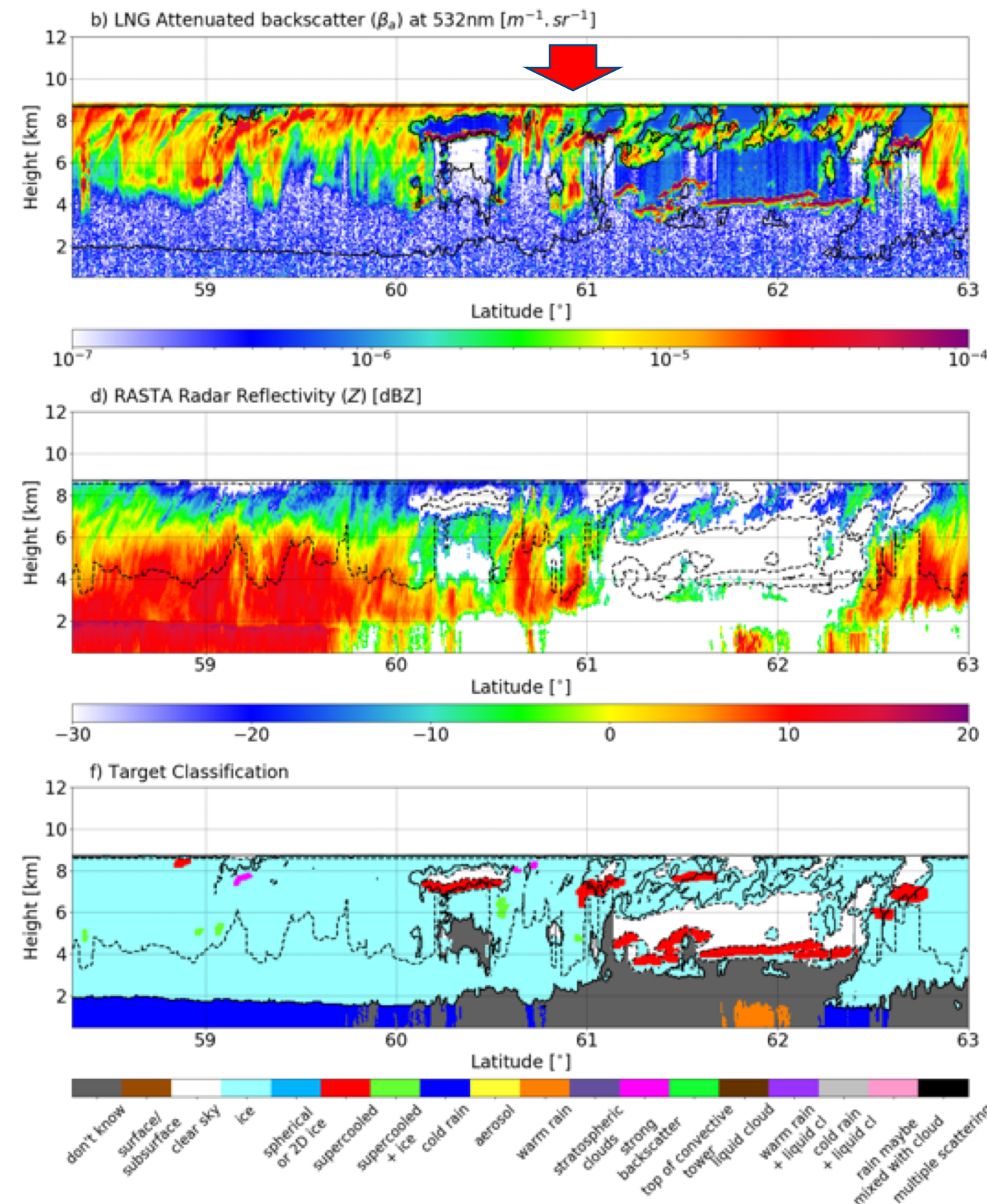
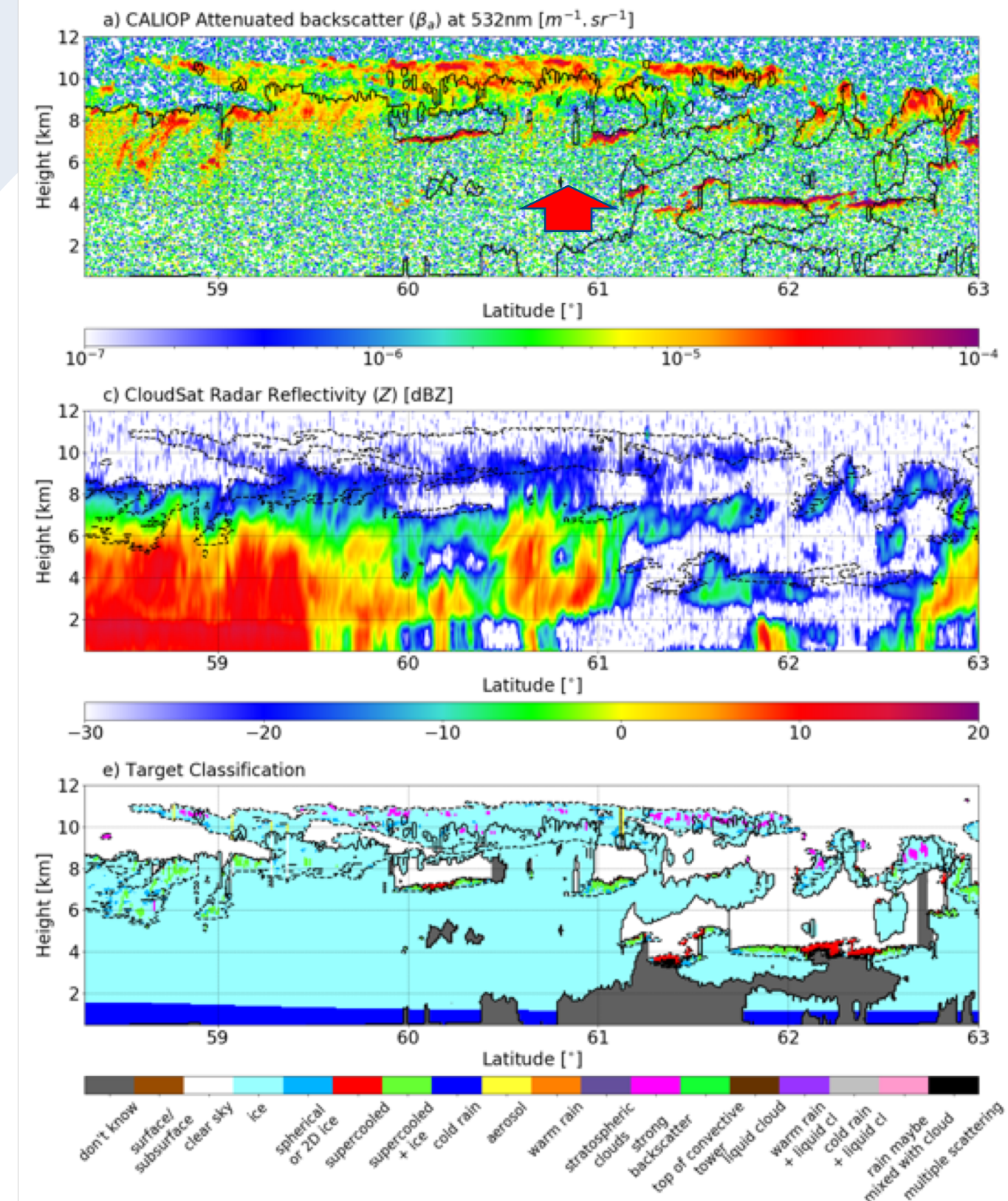
A-Train 2016/10/02: Cloudsat and CALIPSO

RALI 2016/10/02: RASTA and LNG

DARDAR and RALI target classifications agree for the large pictures

Discrepancies: time shift and higher noise in CALIOP backscatter & the lower sensitivity of RASTA

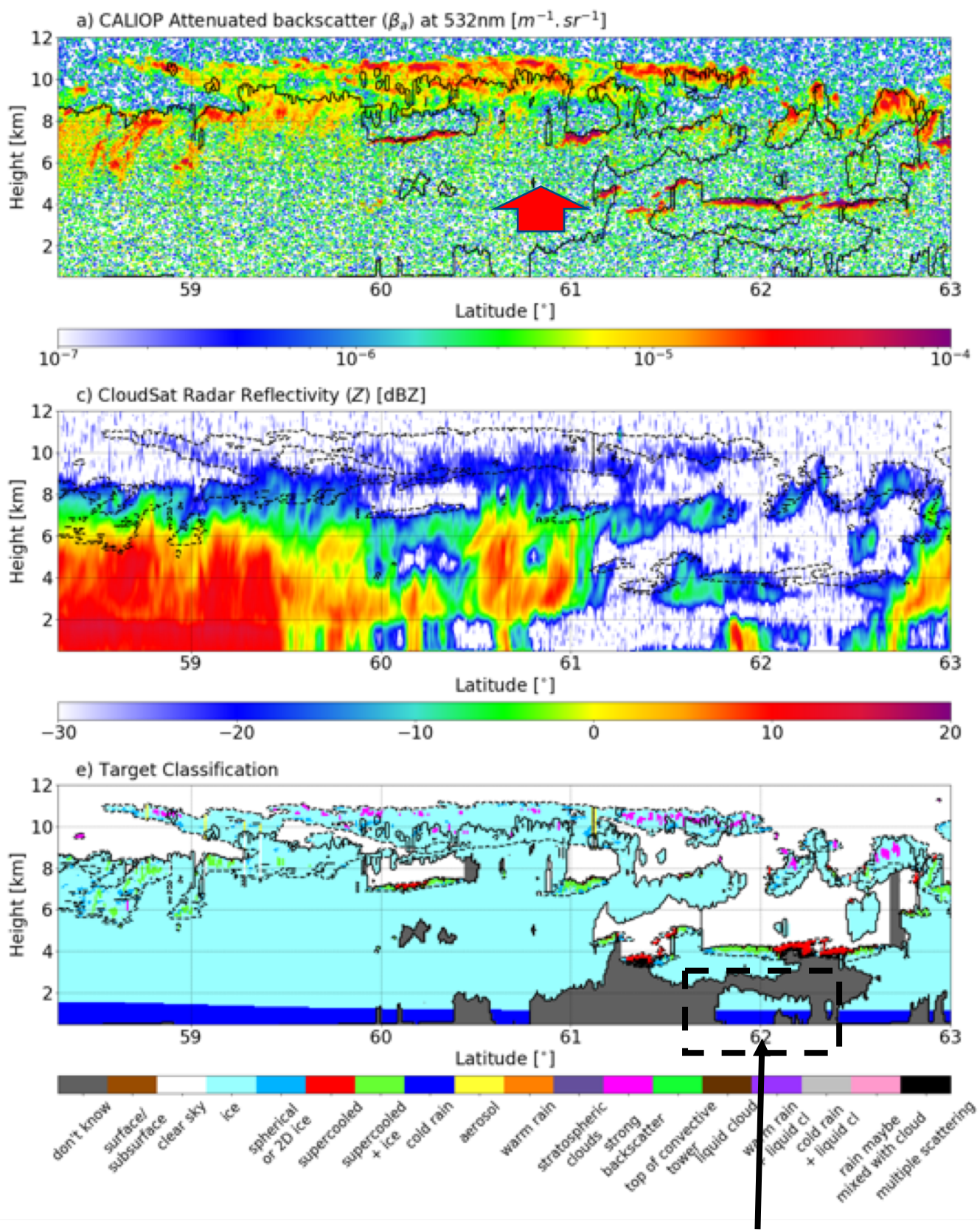
Supercooled layers detection is consistent but the mixed phase attribution is slightly different due to the radars sensitivity. The presence of ice is mainly highlighted by the radar signal in these layers.



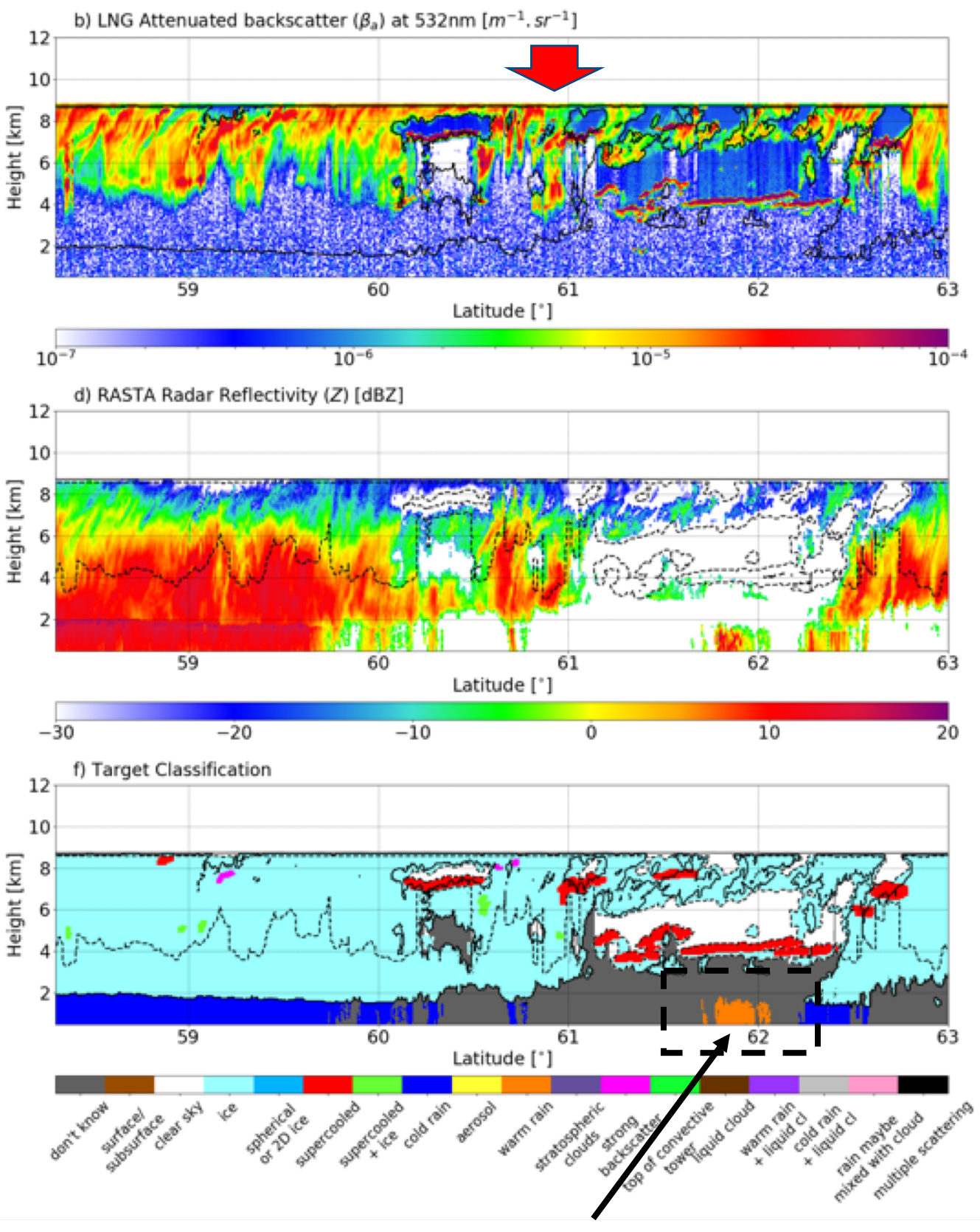
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A-Train 2016/10/02: Cloudsat and CALIPSO



RALI 2016/10/02: RASTA and LNG



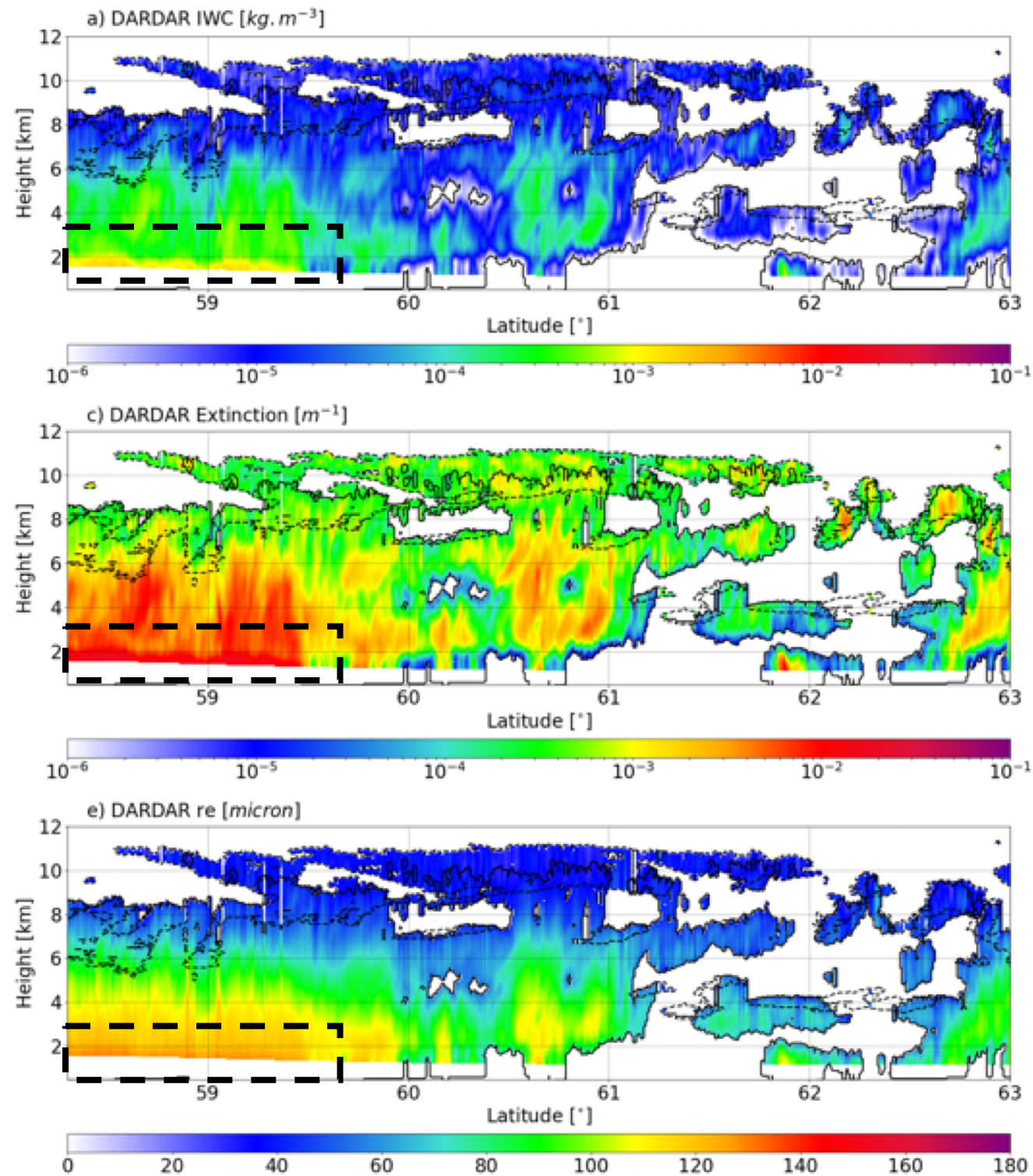
Rain area complicated for the satellite :

- Vertical resolution
- CloudSat is not Doppler, the gradient in vertical velocity cannot be used to identify the ice particles / rain drops conversion.
- Satellite product remains strongly dependant on the model temperature.

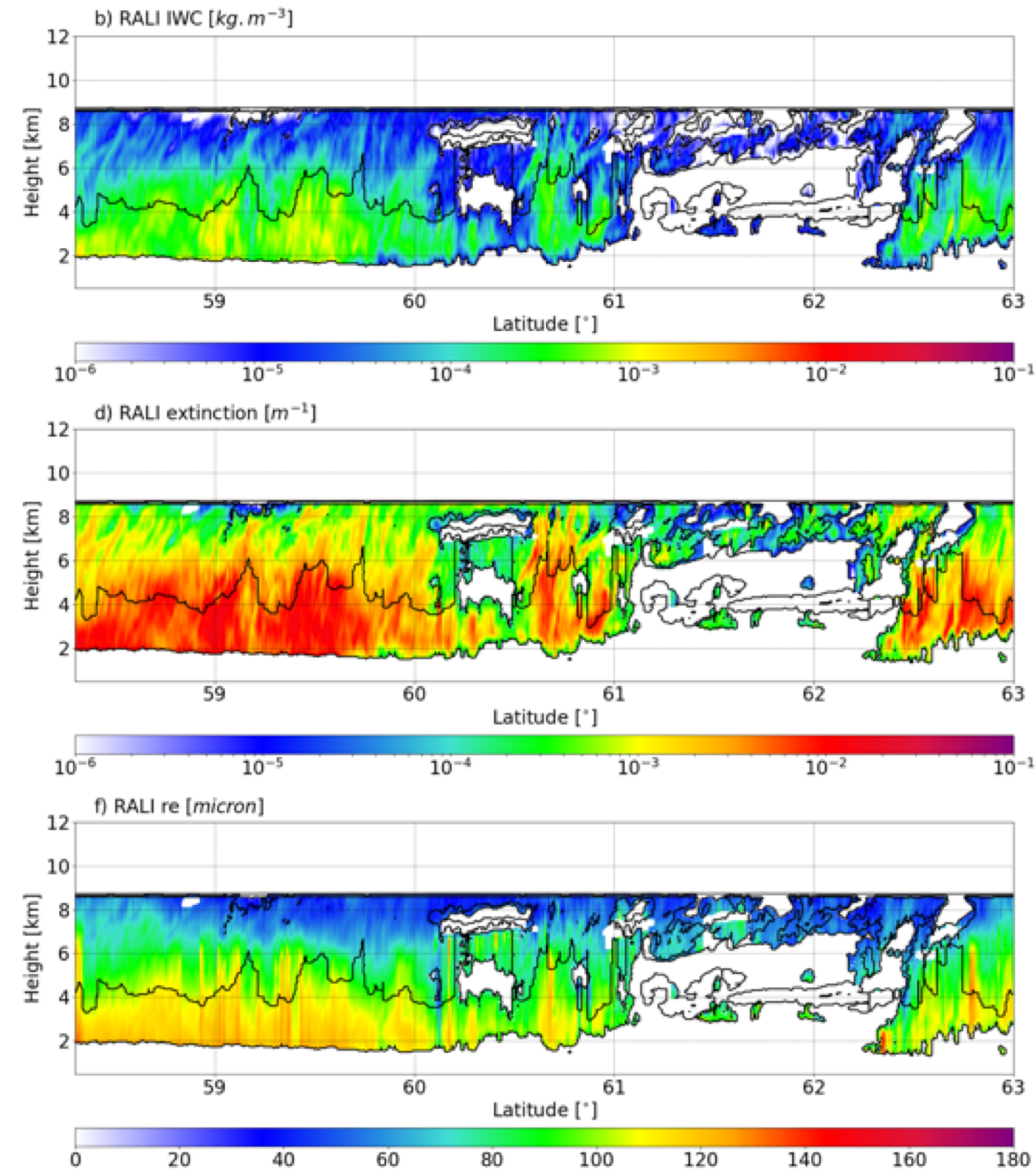
The 0°C limit is decisive to decide the nature of the precipitation and unfortunately the lidar cannot help due to the supercooled layer above which extinguished the signal.



A-Train 2016/10/02: Cloudsat and CALIPSO



RALI 2016/10/02: RASTA and LNG



Similar patterns and order of magnitude.

DARDAR retrieved cloud parameters suffer from the melting layer location leading to an artificial increase in IWC, extinction and effective radius

It remains difficult to carry out direct comparisons due to co-location issues (in time and space).

