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Résultats d'EPATAN

DIP-NAWDEX



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

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29/01/2019

LATMOS 2019

1



Activity within EarthCare

EPATAN (EarthCare Preparation cAmpaign)

A campaign addressing directly the programmatic needs of EarthCARE Mission

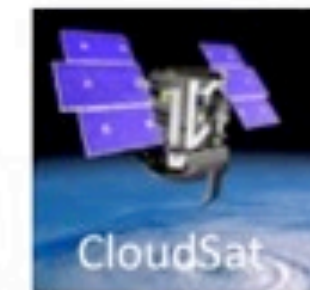
Provide measurements for: development and refinement of Geophysical Product Algorithms

NAWDEX

- Iceland /Period: 15 Sept. – 18 Oct. 2016

Relevance for EarthCARE

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



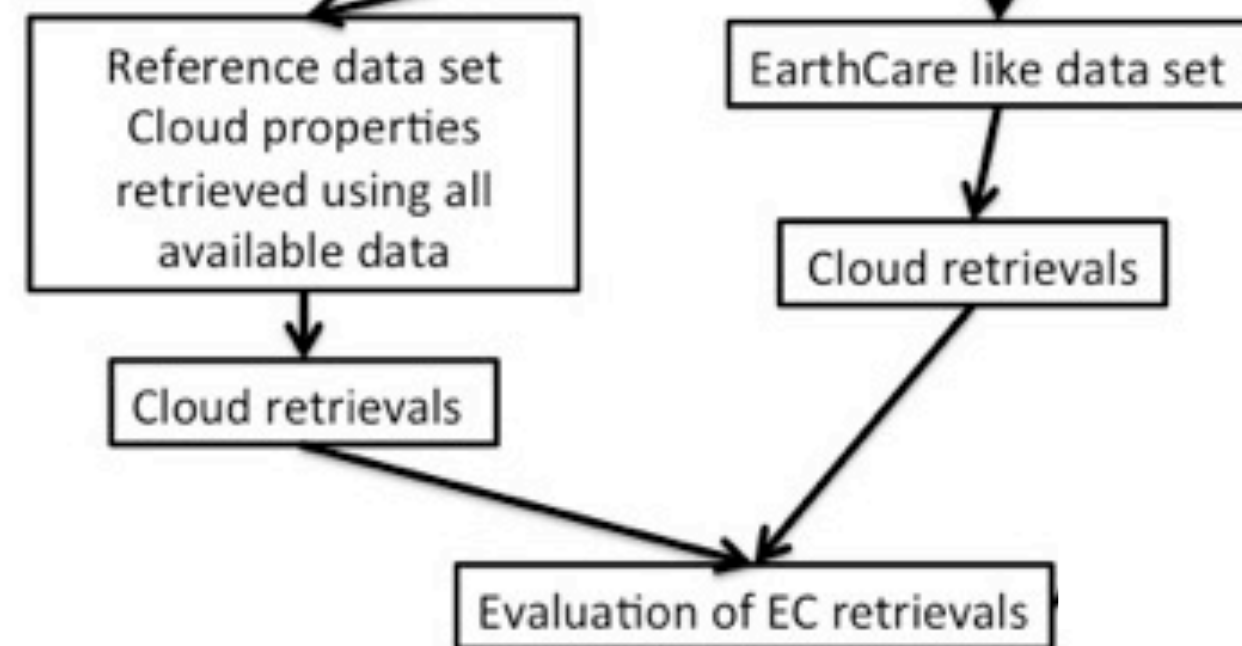
Co-located measurements



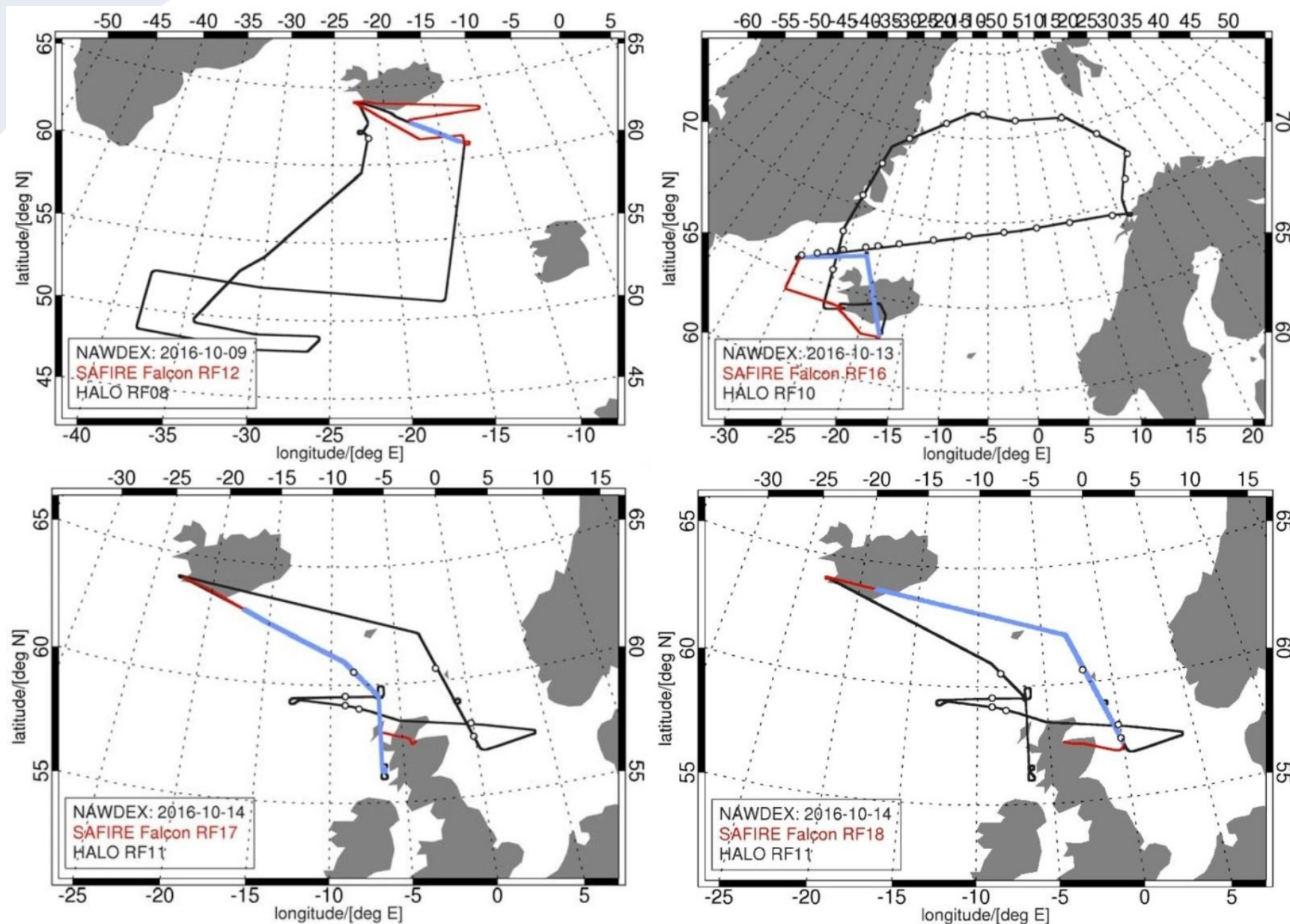
36 GHz radar
532 nm HSR
Radiative package



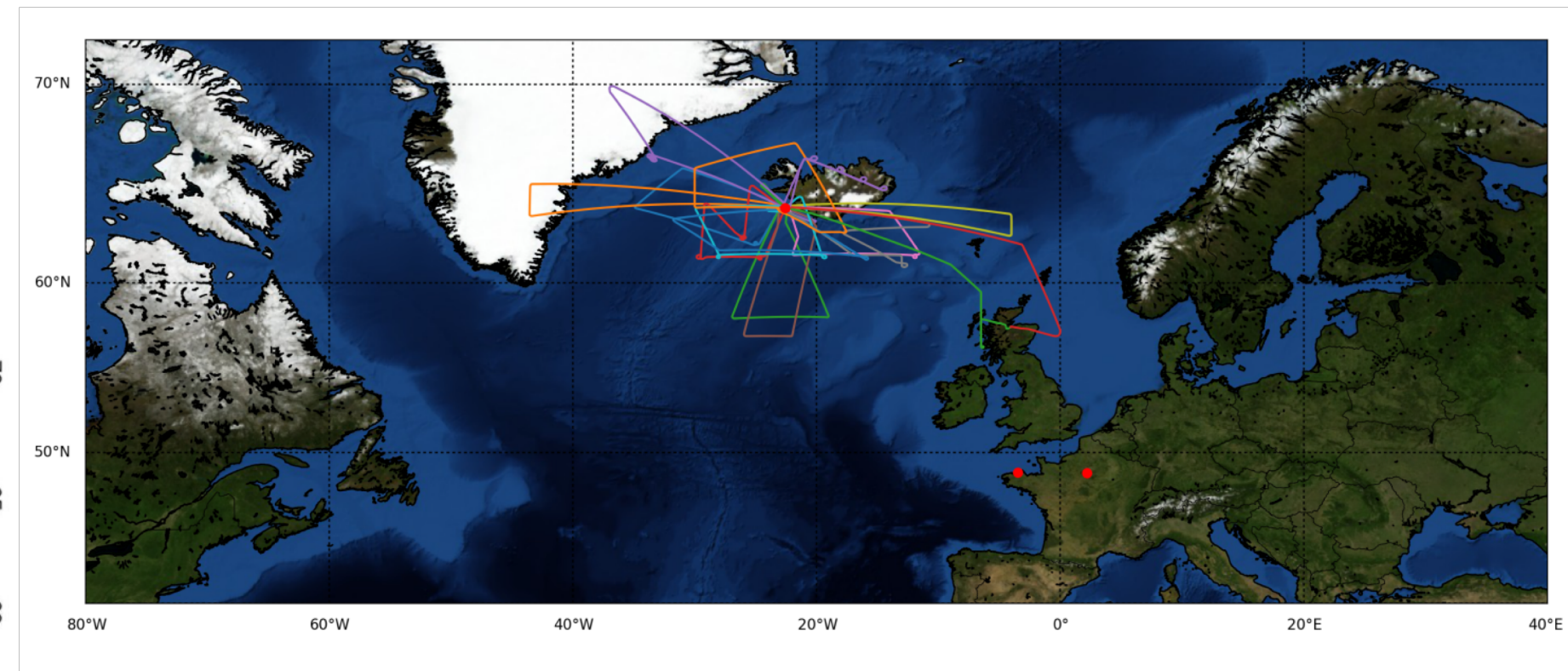
95GHz radar
355 HSR, 532, 1064nm
IR



Field campaign



Common flights of French F20 (red) and HALO (black) during NAWDEX. Common flight tracks are marked blue.



28th of September to 17th of October 2016

- Number of scientific flights: 15 (F5 to F18 scientific purposes, F3 and F19 calibration and tests and not distributed)
- Number of scientific flight hours: 46.5
- Number of released dropsondes: 59
- Number of CloudSat-CALIPSO underpasses: 3
- Number of co-located flights: 5



- 4 common flight legs were performed together with the German HALO research aircraft
⇒ Crucial to investigate the effects of different wavelengths on measured atmospheric parameters and on retrieval results.
- French F20, HALO and the British FAAM, the last performing in-situ sampling of cloud properties below the two other aircraft.
⇒ help to evaluate radar-lidar retrieval results. The second common flight track of the research flight on 14 October 2017 was planned
- A-Train underpasses
⇒ to learn and develop strategies for future EarthCARE cal/val activities.
- Note that RASTA/MIRA and LNG/WALES worked continuously during the campaign. A few flights were affected by misalignment of LNG but there was no degradation during the campaign.



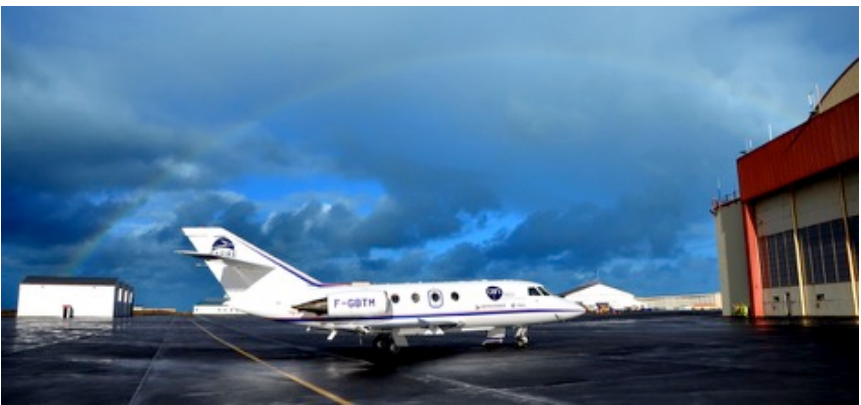
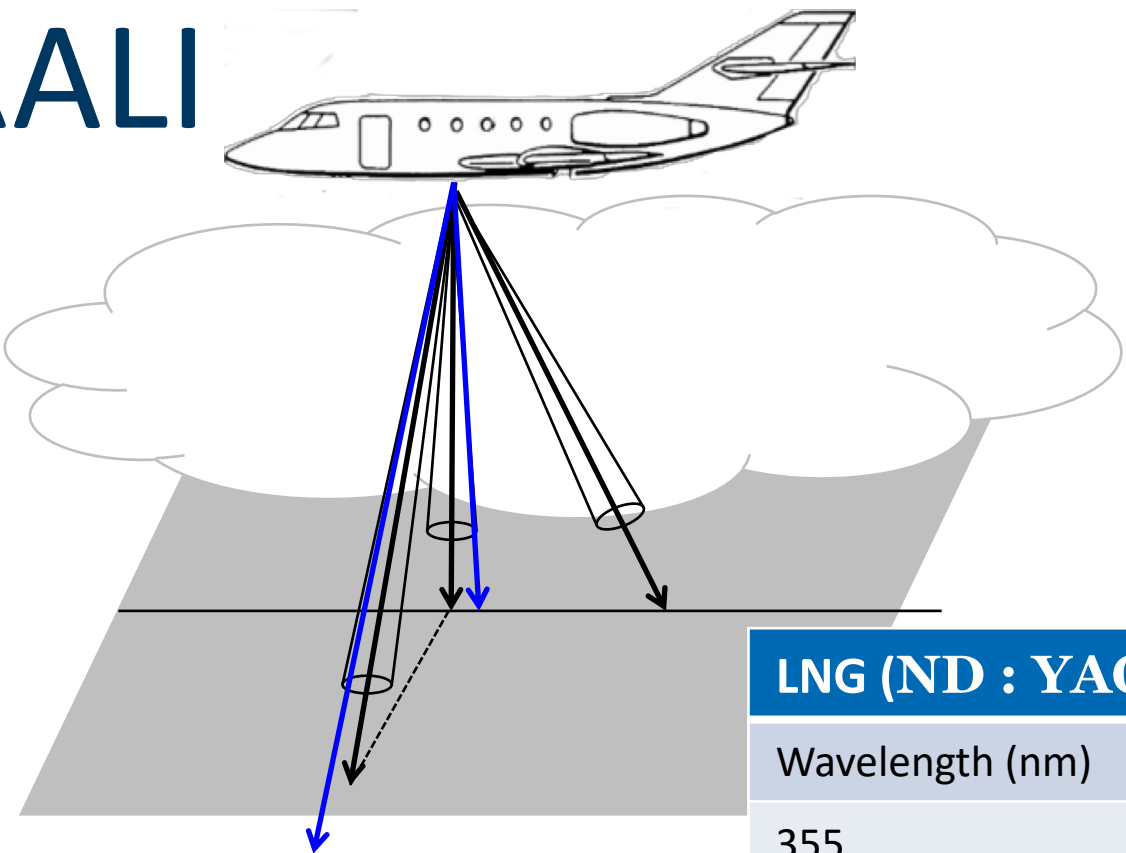
French F20 Payload - RALI

Aircraft:

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

Payload:

- **High spectral resolution (Doppler) lidar** (355 nm), 532 and 1064 nm
- **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



LNG CALIBRATION

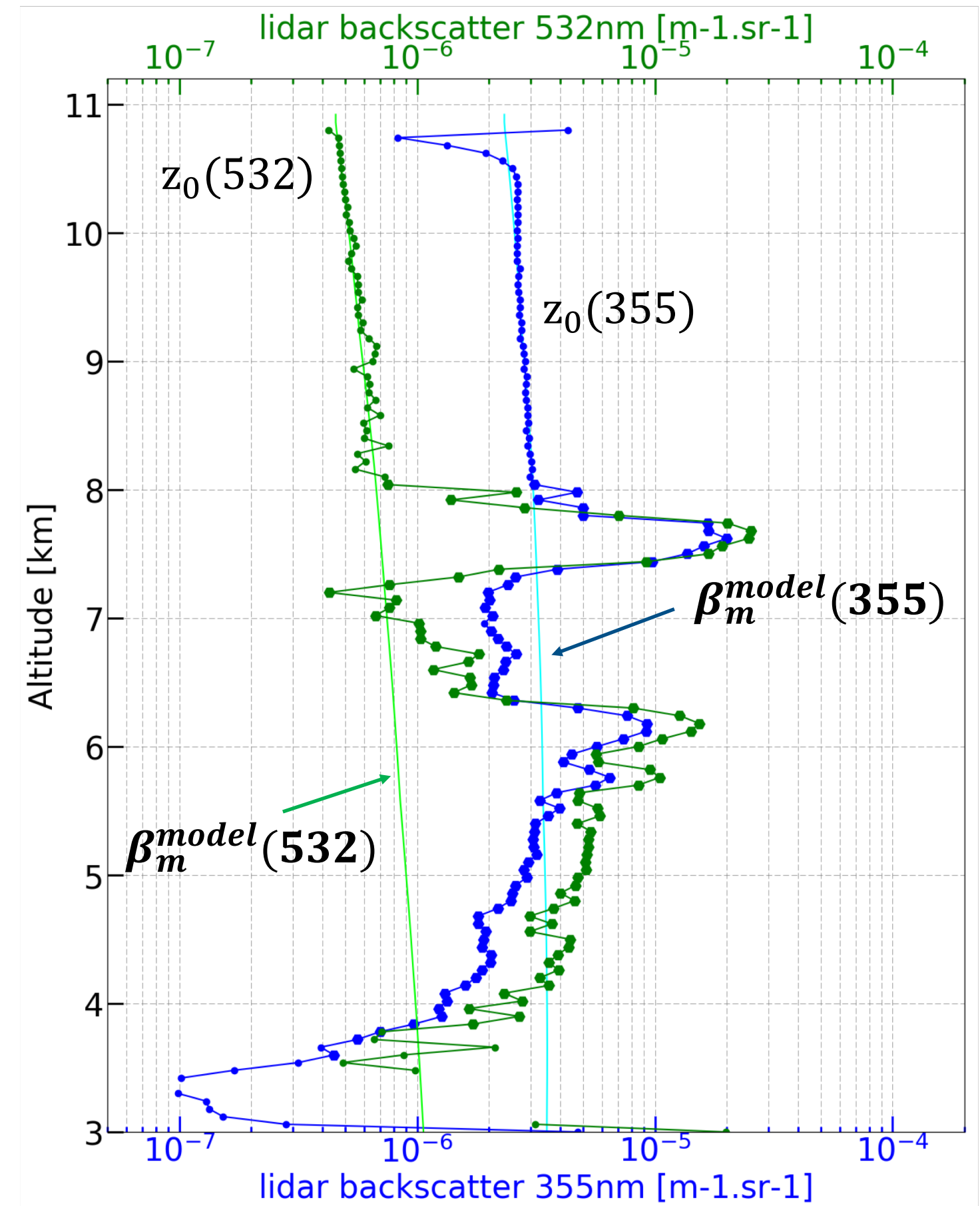
Calibration in clear sky regions between cloud top and aircraft using a model of molecular backscatter

$$\beta_m^{model} = f(T, P)$$

→ T and P are from spatially linearly interpolated ERAI fields (closest time, choice between 0H, 6H, 12H and 18H)

$$C_\lambda(t) = \text{mean}_{z_0 < z < z_0 - 500m} \left(\frac{S(t, z, \lambda)}{\beta_m^{model}(t, z, \lambda)} \right)$$

z_0 depends on the overlap function which depends on the FOV

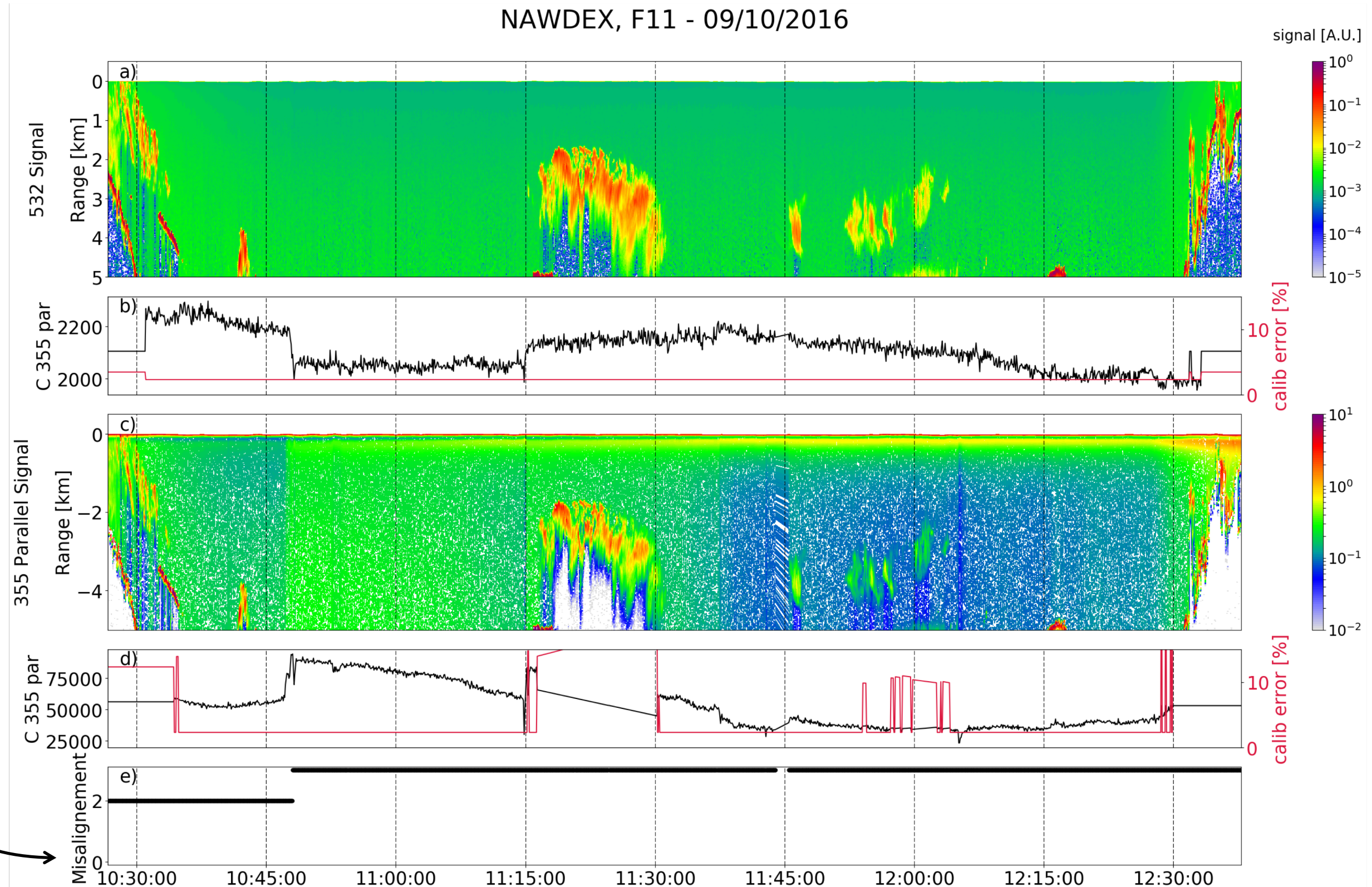


LNG CALIBRATION

- Interpolation when cloud top is too high
- Higher uncertainty on the 355nm channel due to misalignment

→ affected areas detected and flagged

- 1: calibration constant unstable with range
- 2: reduction of received power due to misalignment
- 3: both



LNG CALIBRATION

For further studies

- Alignment system added on LNG
- Filter width changed on the UV channel (10nm bandwidth)
- Improving the inter-calibration method for the parallel and cross UV channels (work in progress)





RAI products



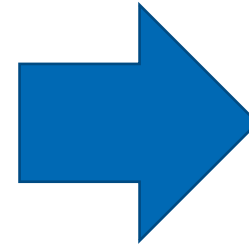
Data products

- RASTA L2 single antenna product (containing L0/L1 data)
- RASTA L2 wind product
- RASTA microphysical product
- RASTA spectral product (on demand)
- LNG L1 product
- RALI product (LNG and RASTA co-located)
(<https://owncloud.latmos.ipsl.fr/index.php/s/M8YaMdmCCULXflP> epatan)
 - Mask
 - Varcloud retrieval



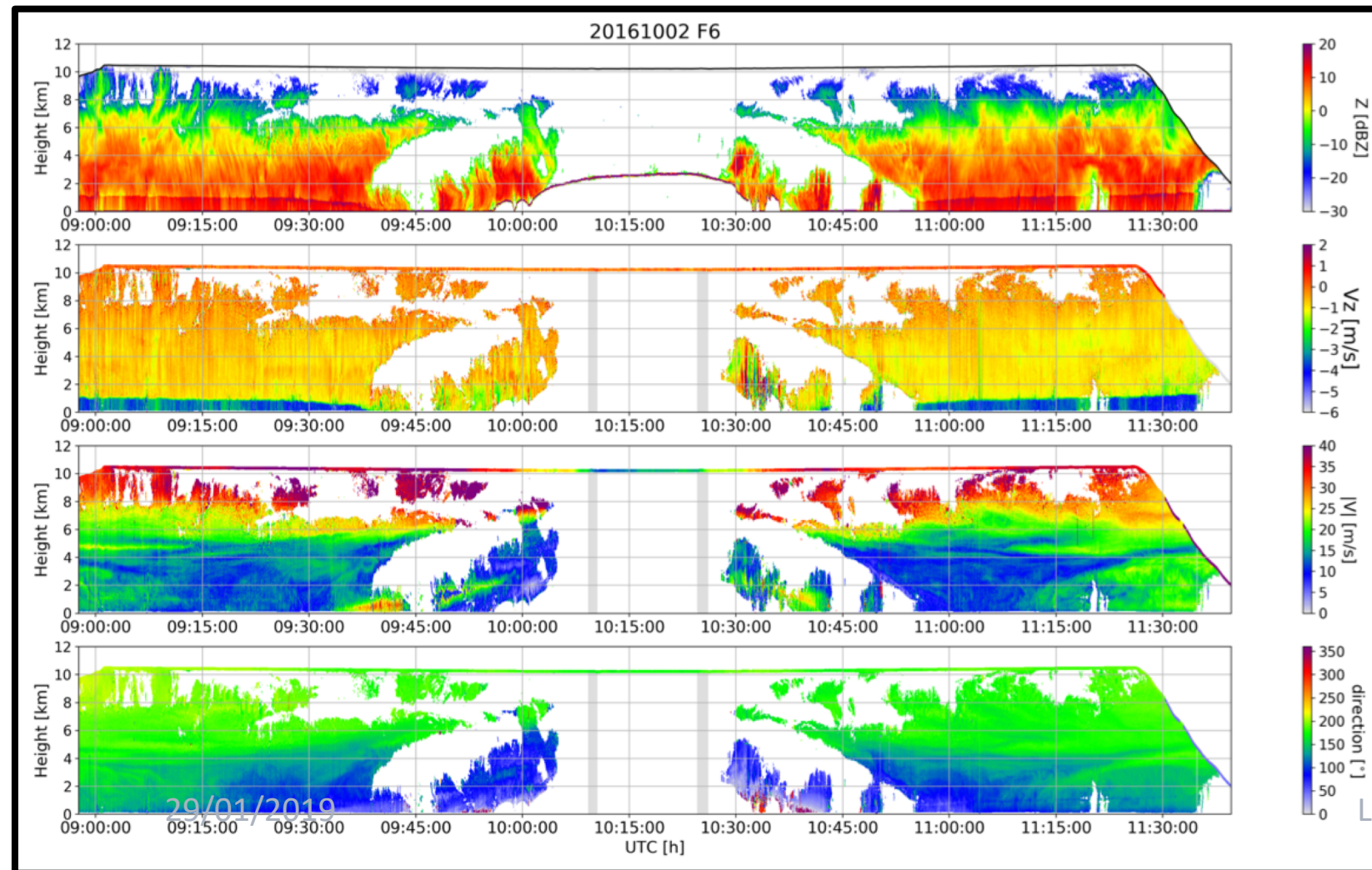
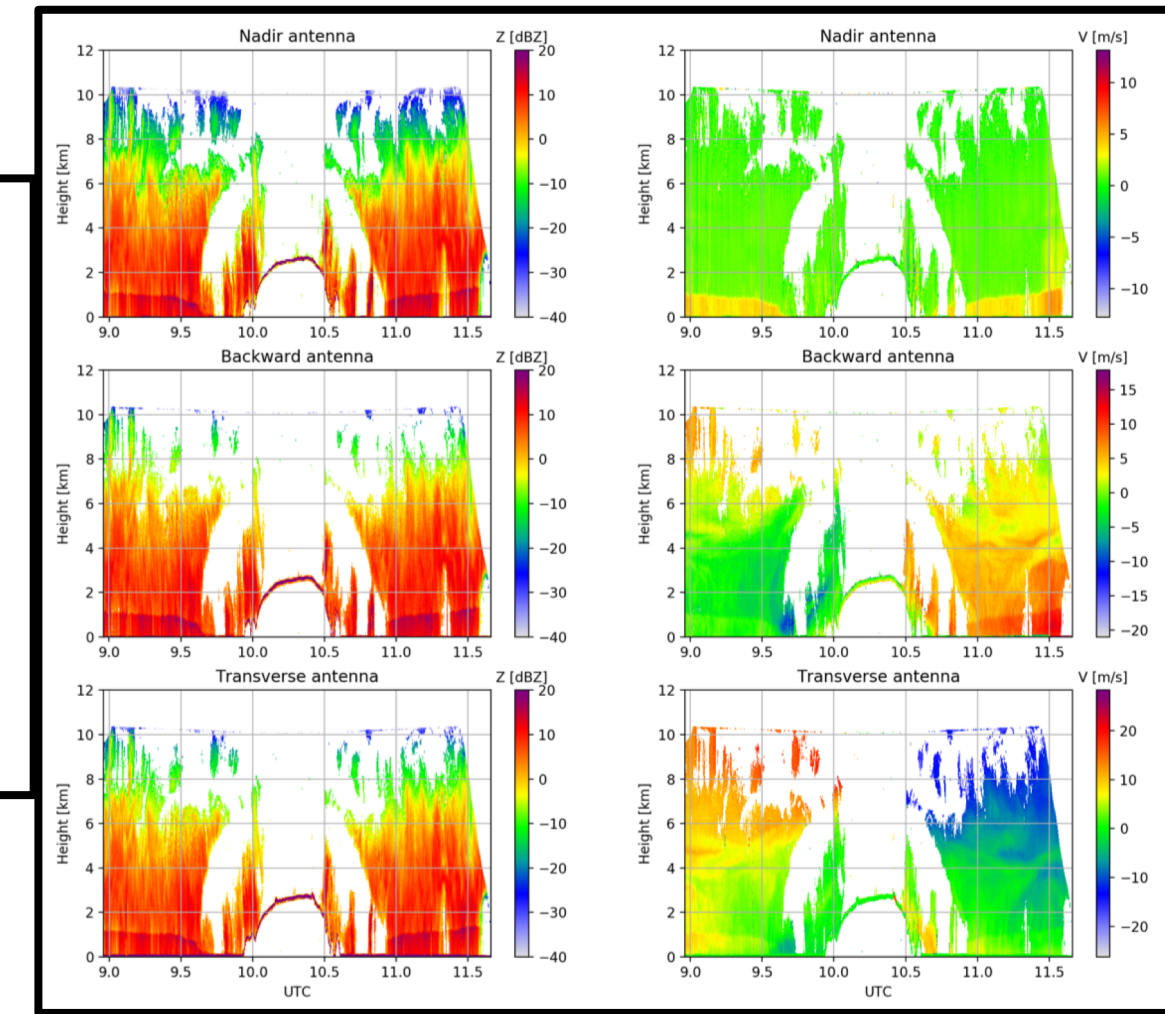
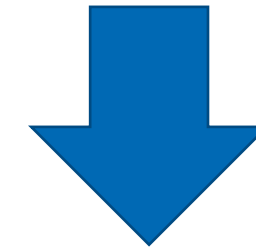
RASTA processing

RAW DATA (L0)
3 antennas:
Nadir/Backward/
Transverse



RAW DATA (L2)
Nadir/Back/Trans

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



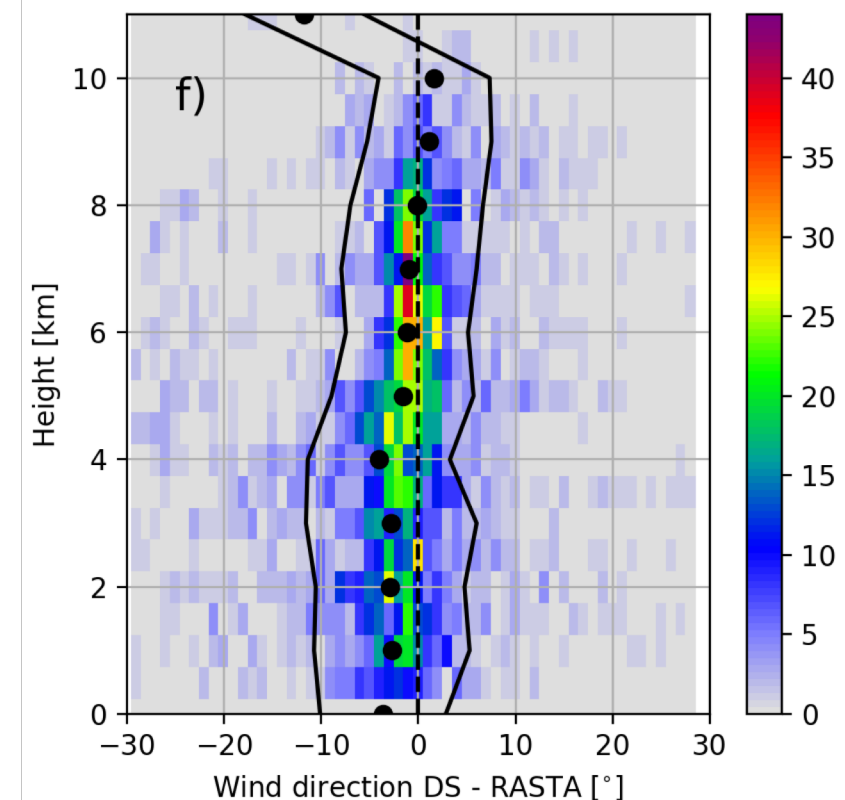
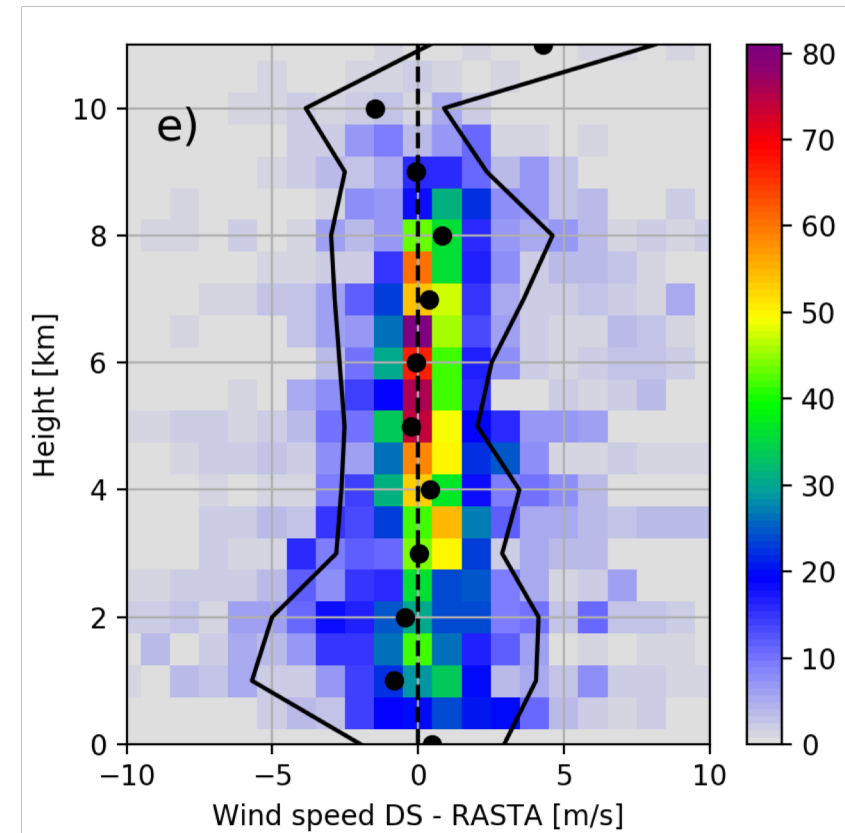
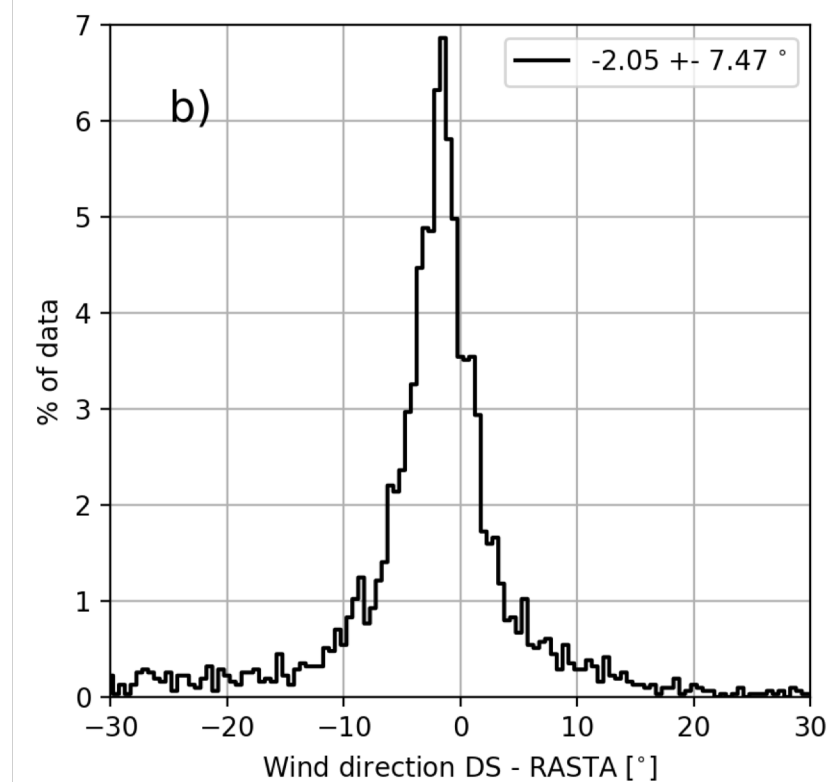
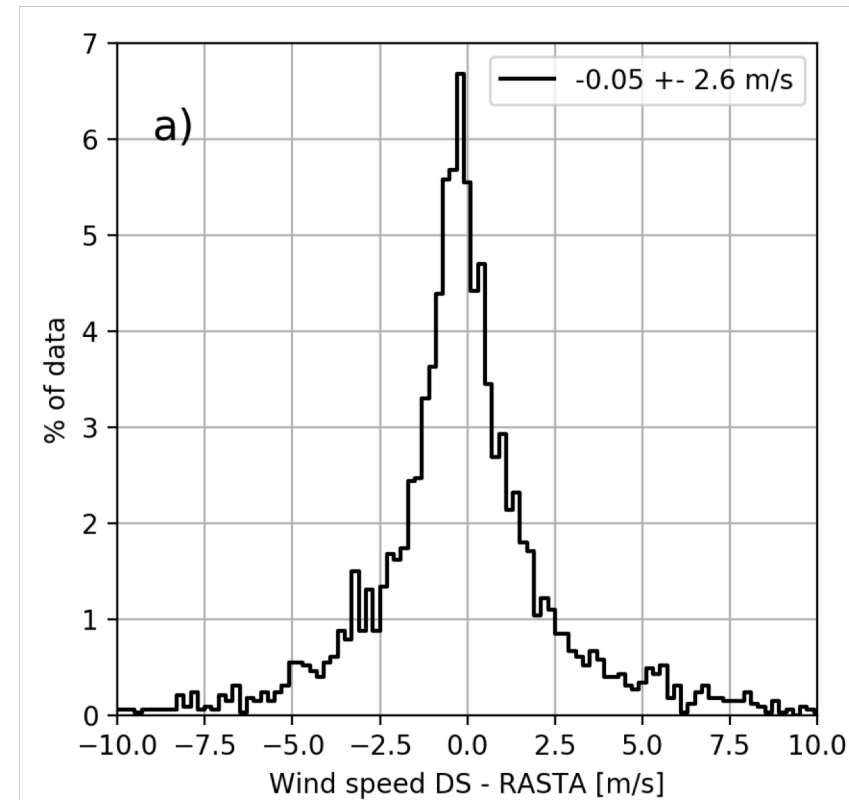
WIND DATA (L2+)
Variational approach:
3 measurements are co-located: V_d (Nadir), V_d (backward), V_d (transverse)
3 components of the wind: V_x (along track), V_y (cross track), V_z (vertical)
 V_x , V_y are used to derive V_N , V_{NE} or V_{dir} and $|V|$
Assumption: volume probed by antennas is homogeneous (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: $-2.05 \pm 7.47^\circ$

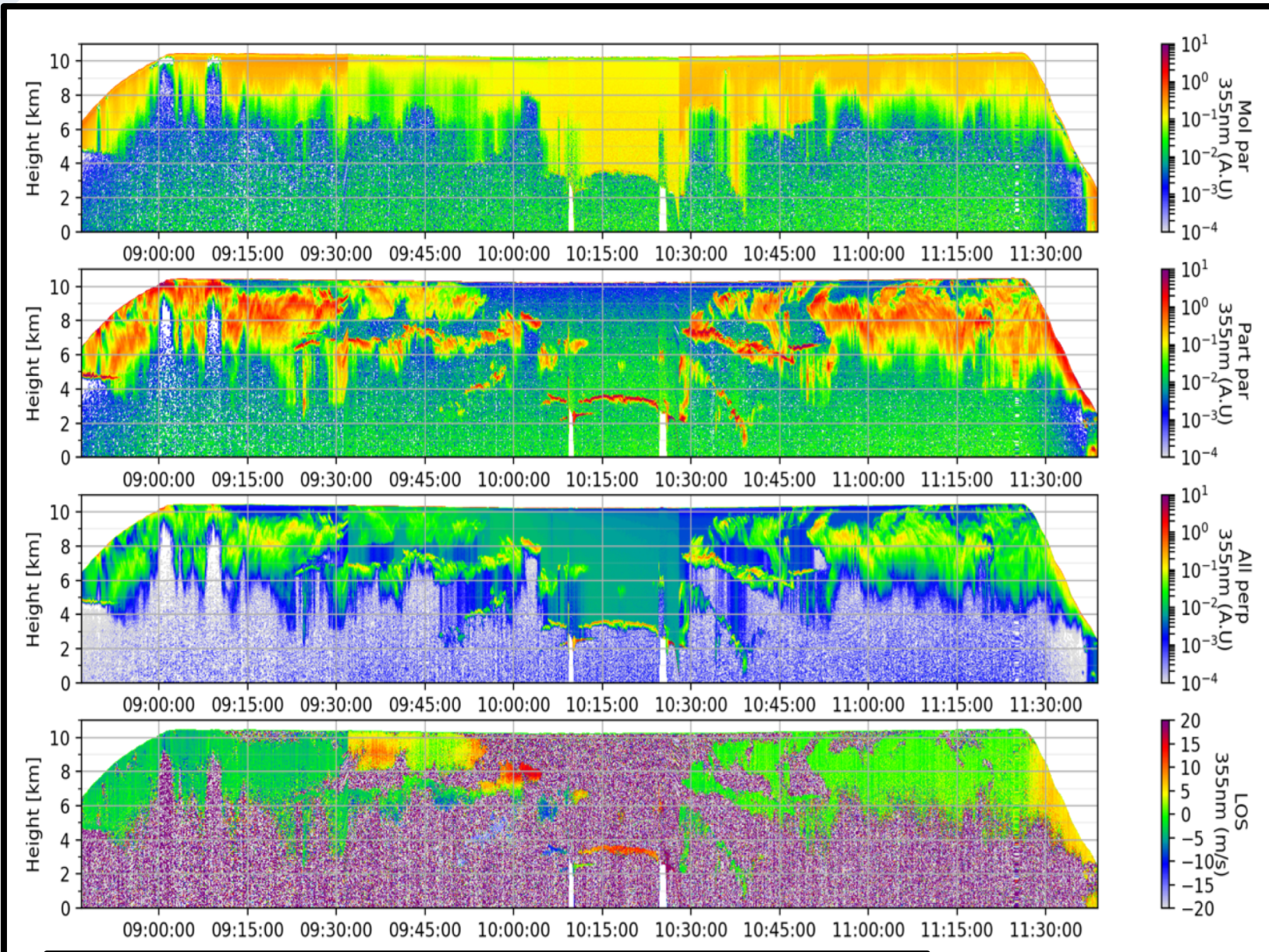
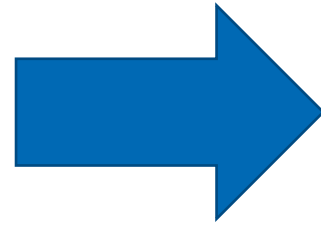


RASTA against
DS (all flights)

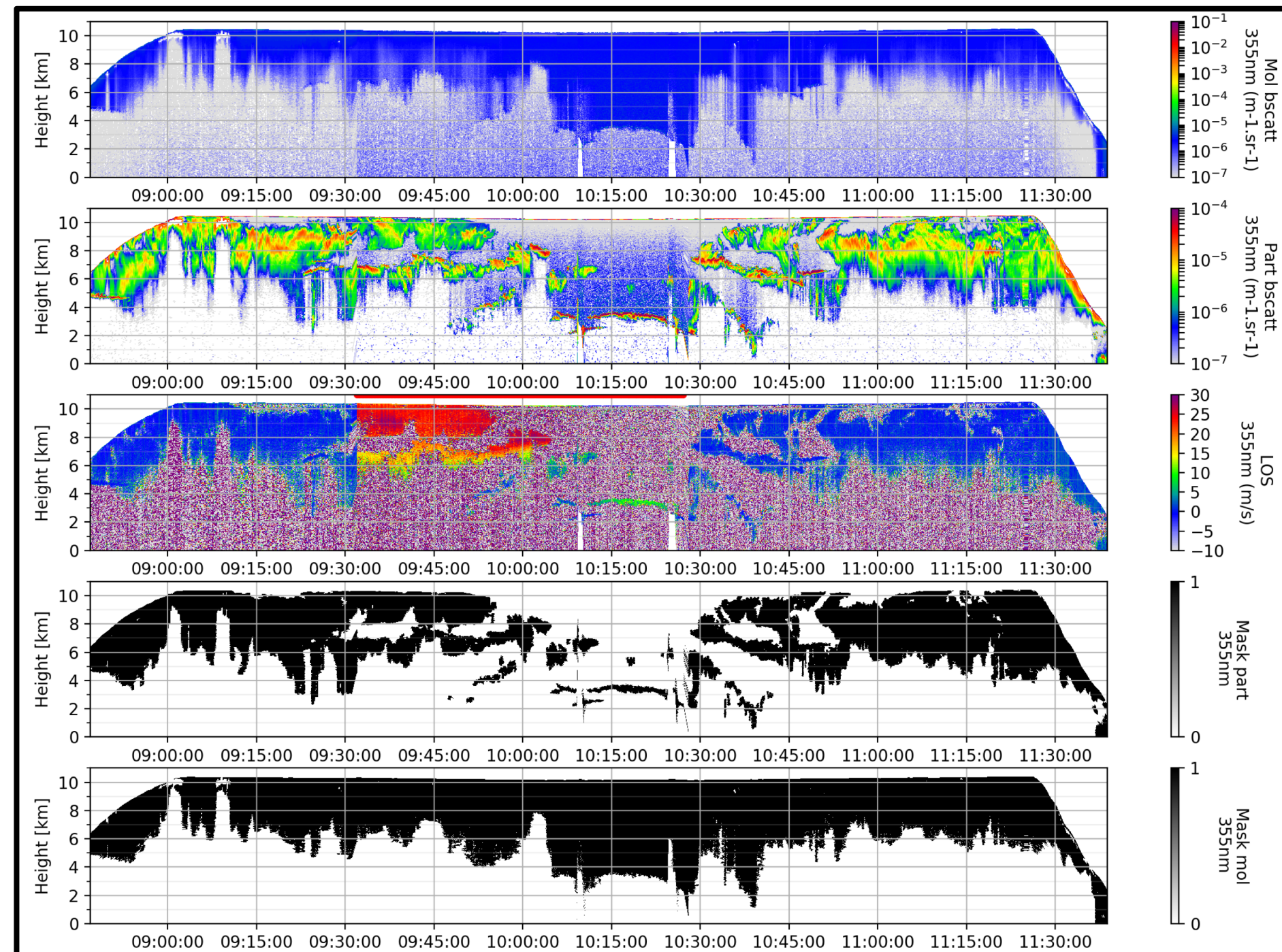
As a function of altitude



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

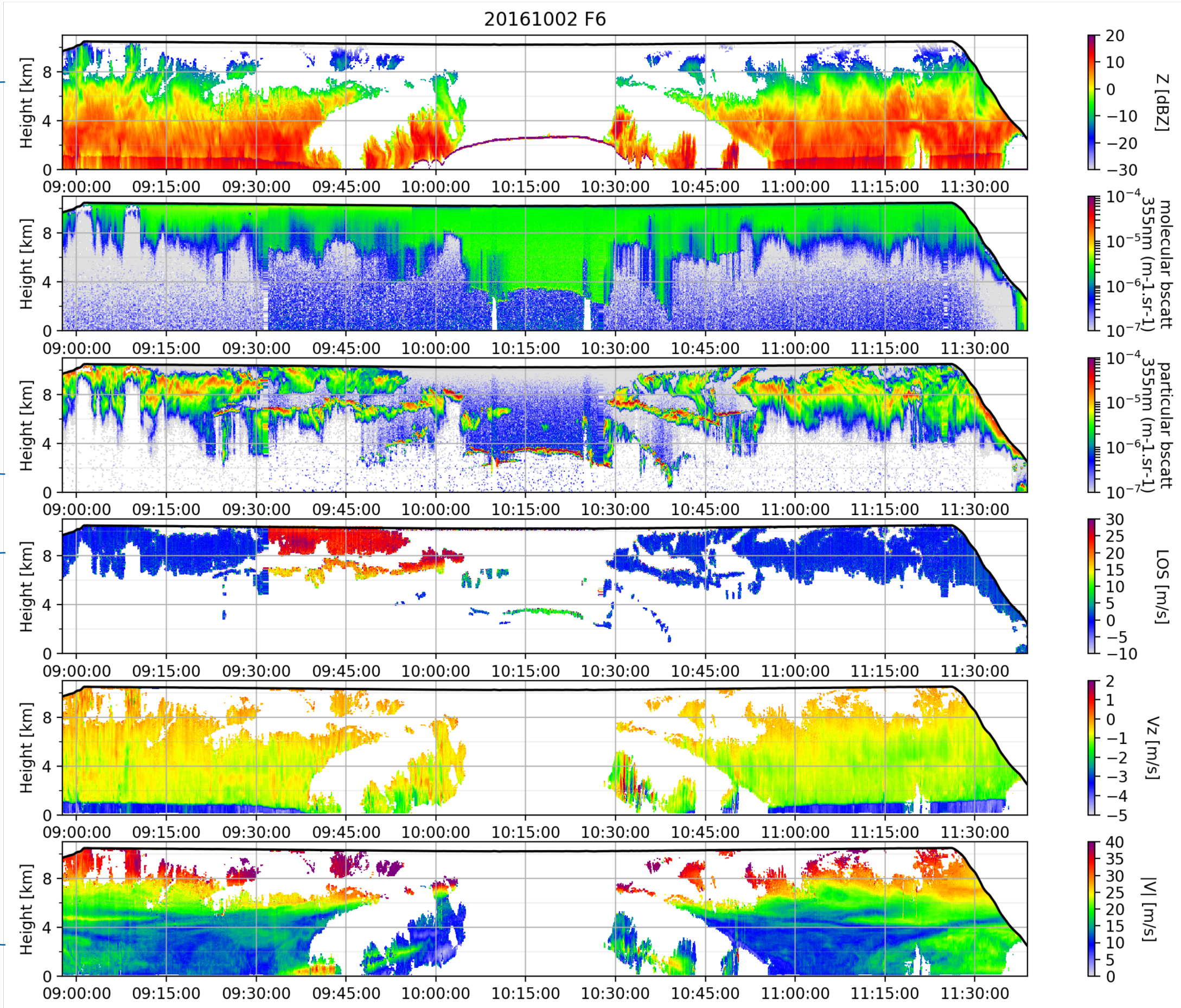


Merge product

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

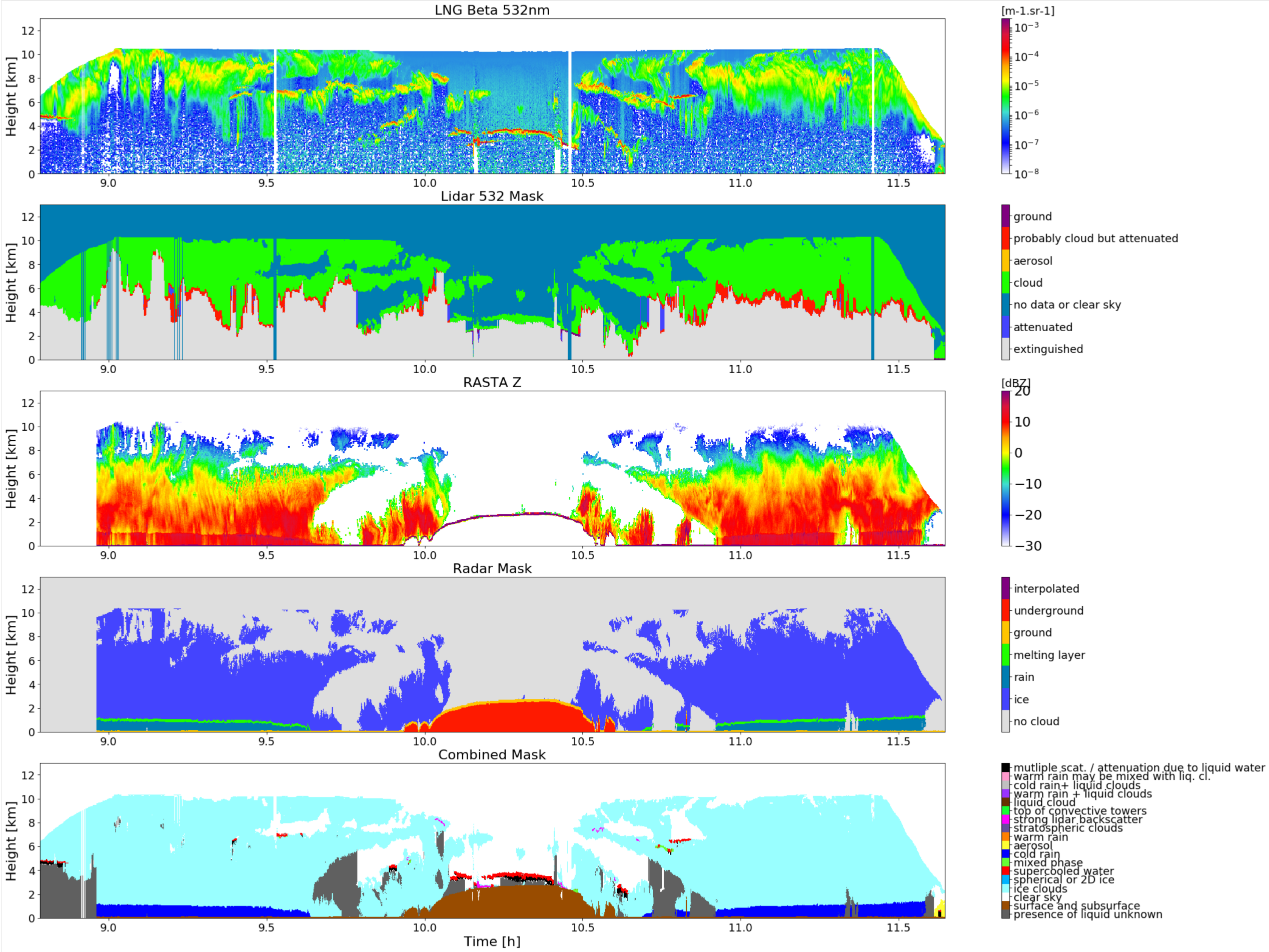
Radiative

Dynamics

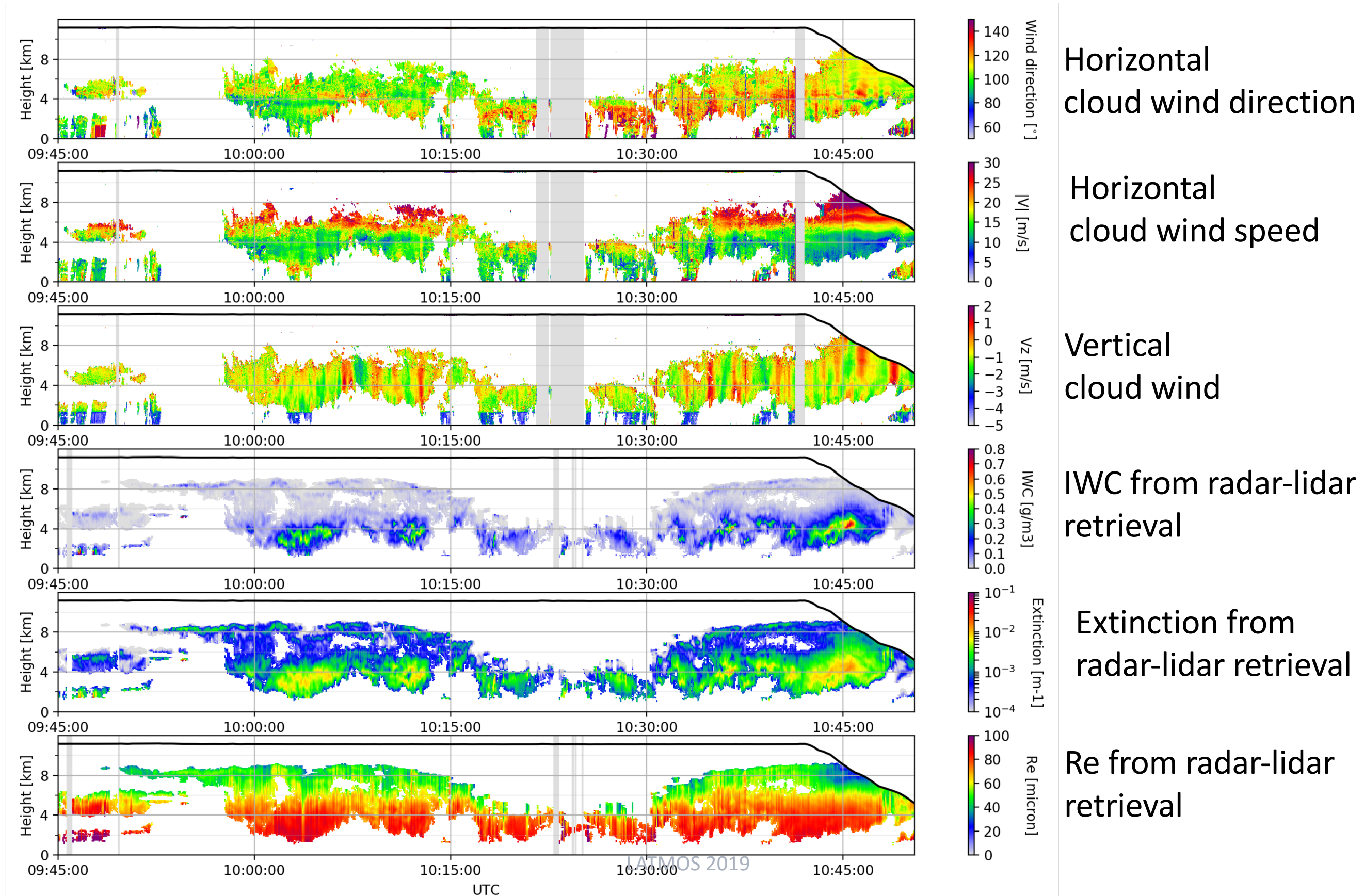


Example of categorisation

Radar + 532 nm Lidar



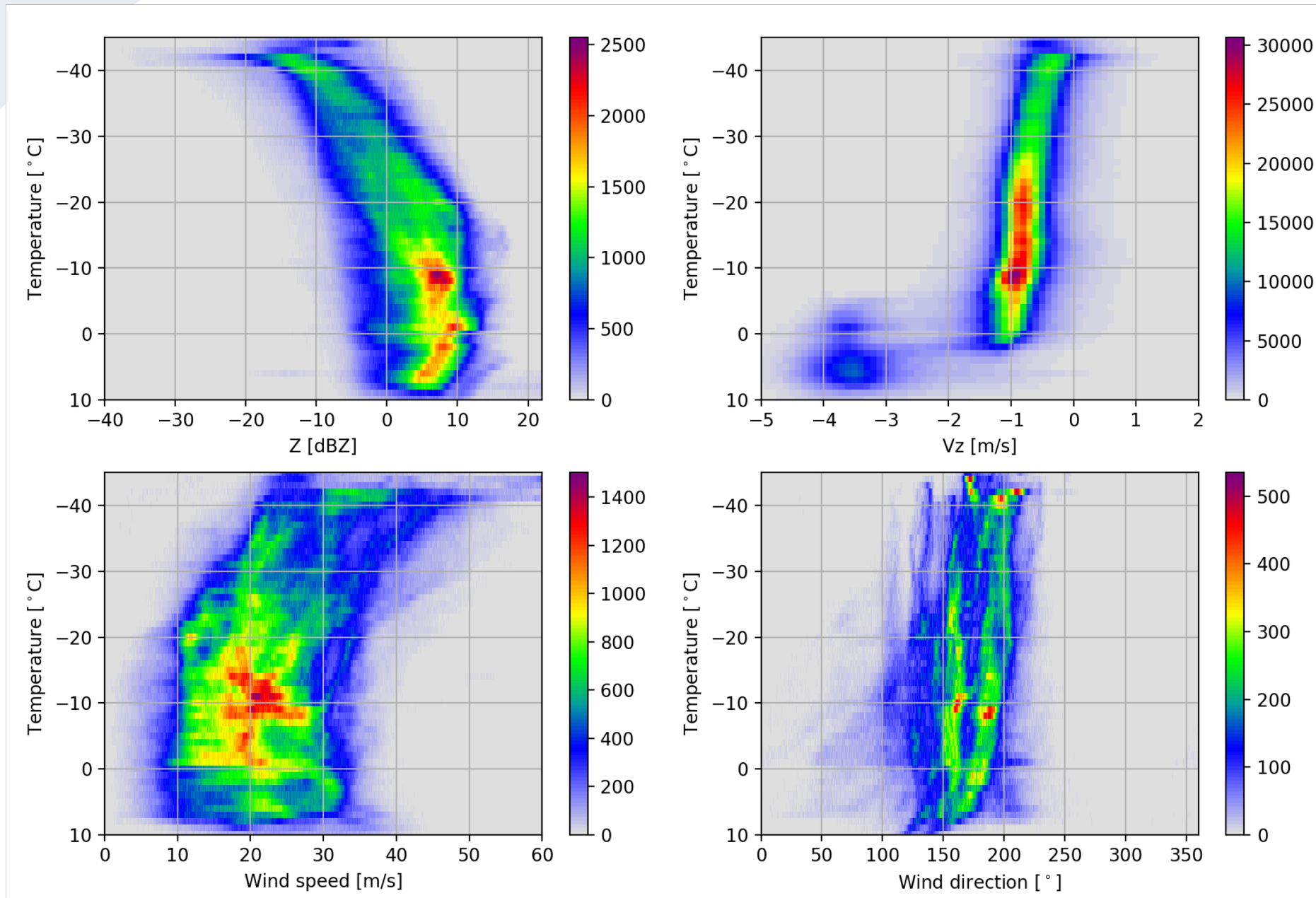
RAI wind and microphysics retrievals



DATA Analysis



Cloud dynamics from RASTA



- Reflectivity
- Vertical velocity (vertical air motion + terminal fall velocity)
- Wind direction and intensity
- Temperature from ERA-I

Partition between ice and liquid (rain)

The vertical velocity in ice increases with temperature as the size of the hydrometeors statistically increases due to aggregation process

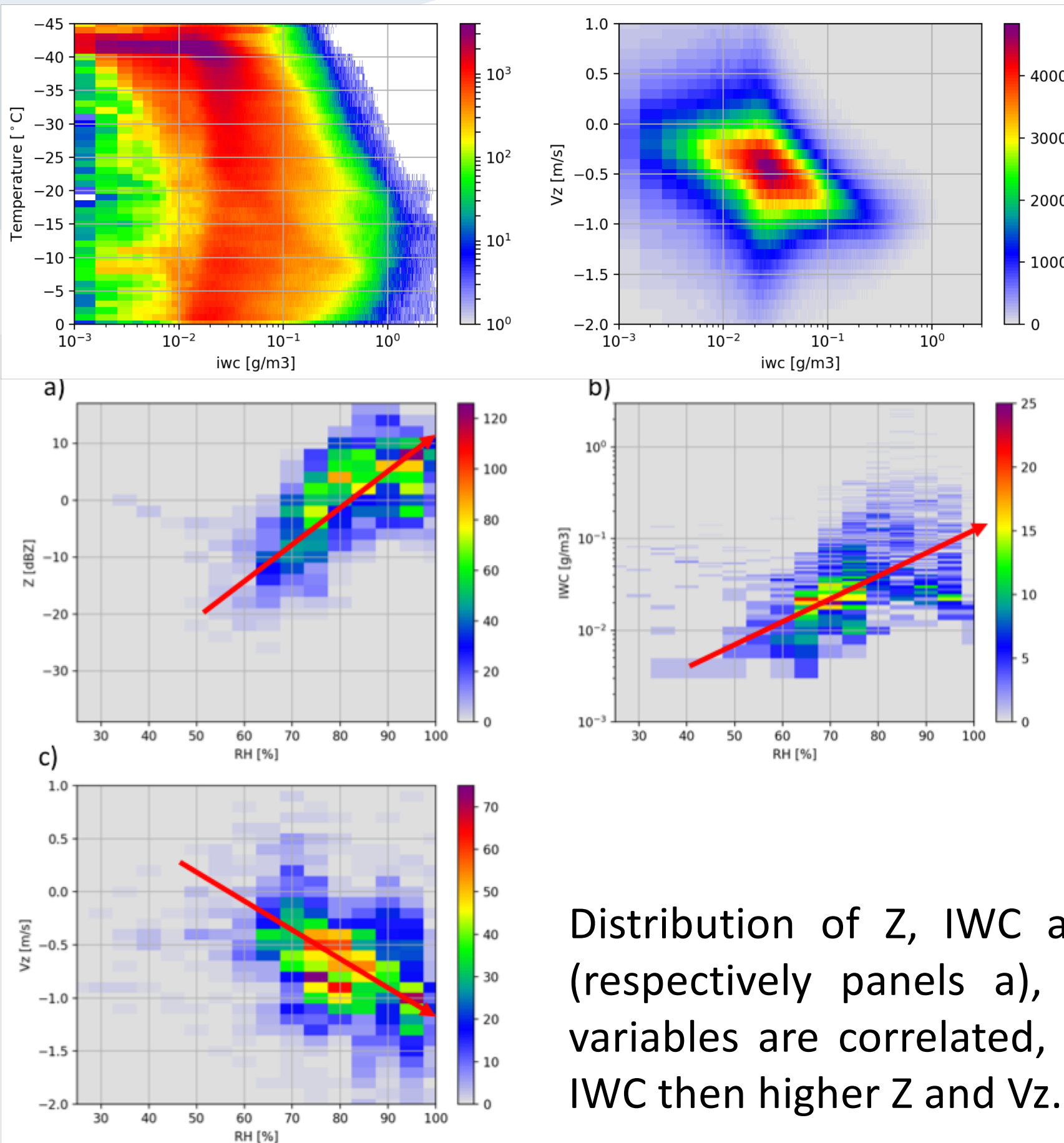
Statistical distribution: nadir reflectivity, vertical velocity, horizontal wind speed and direction retrieved from the combination of the nadir/backward/transverse antennas as a function of temperature.



Microphysics

IWC is increasing up to -10°C and then slightly decreasing above this limit.

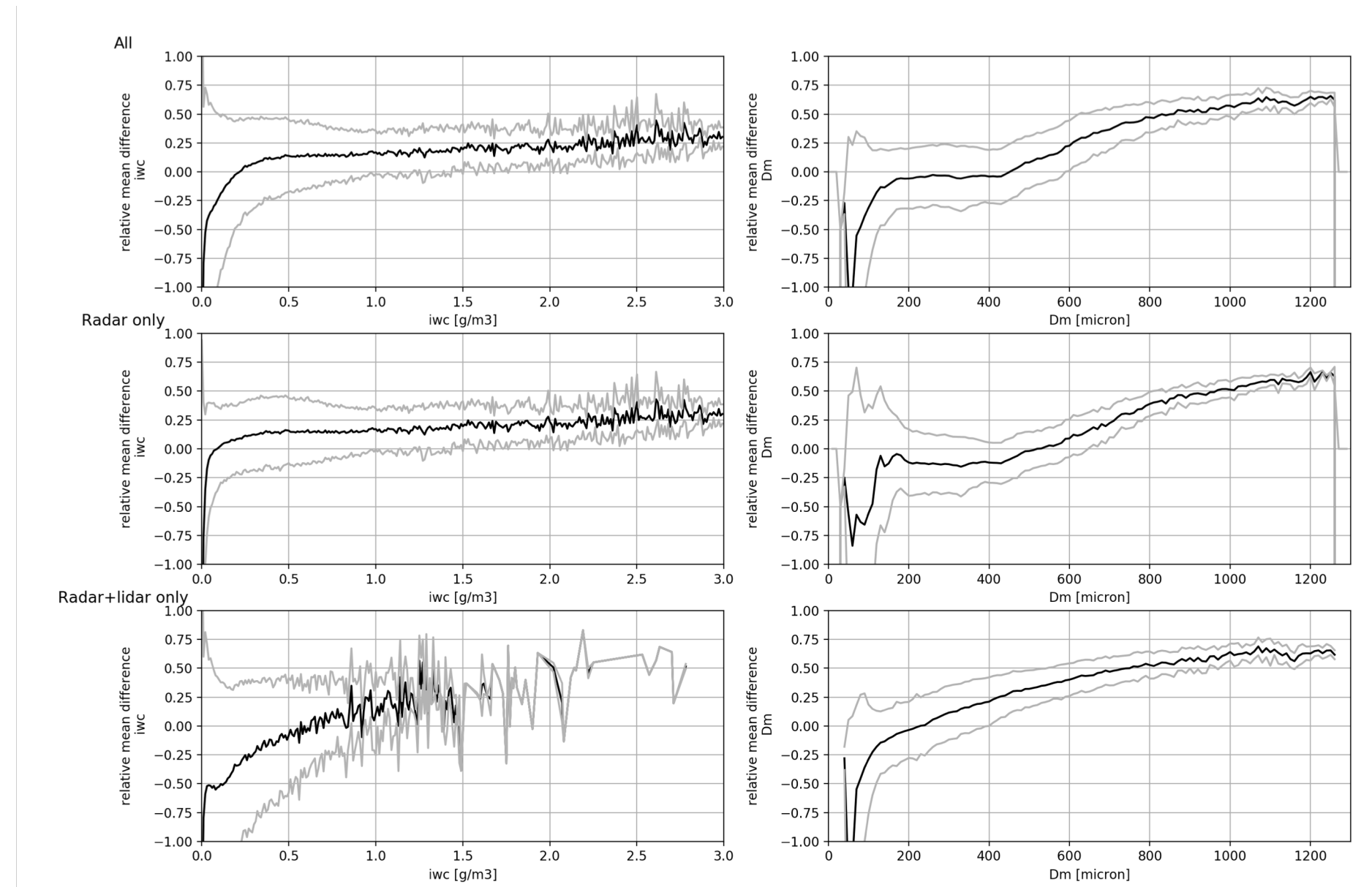
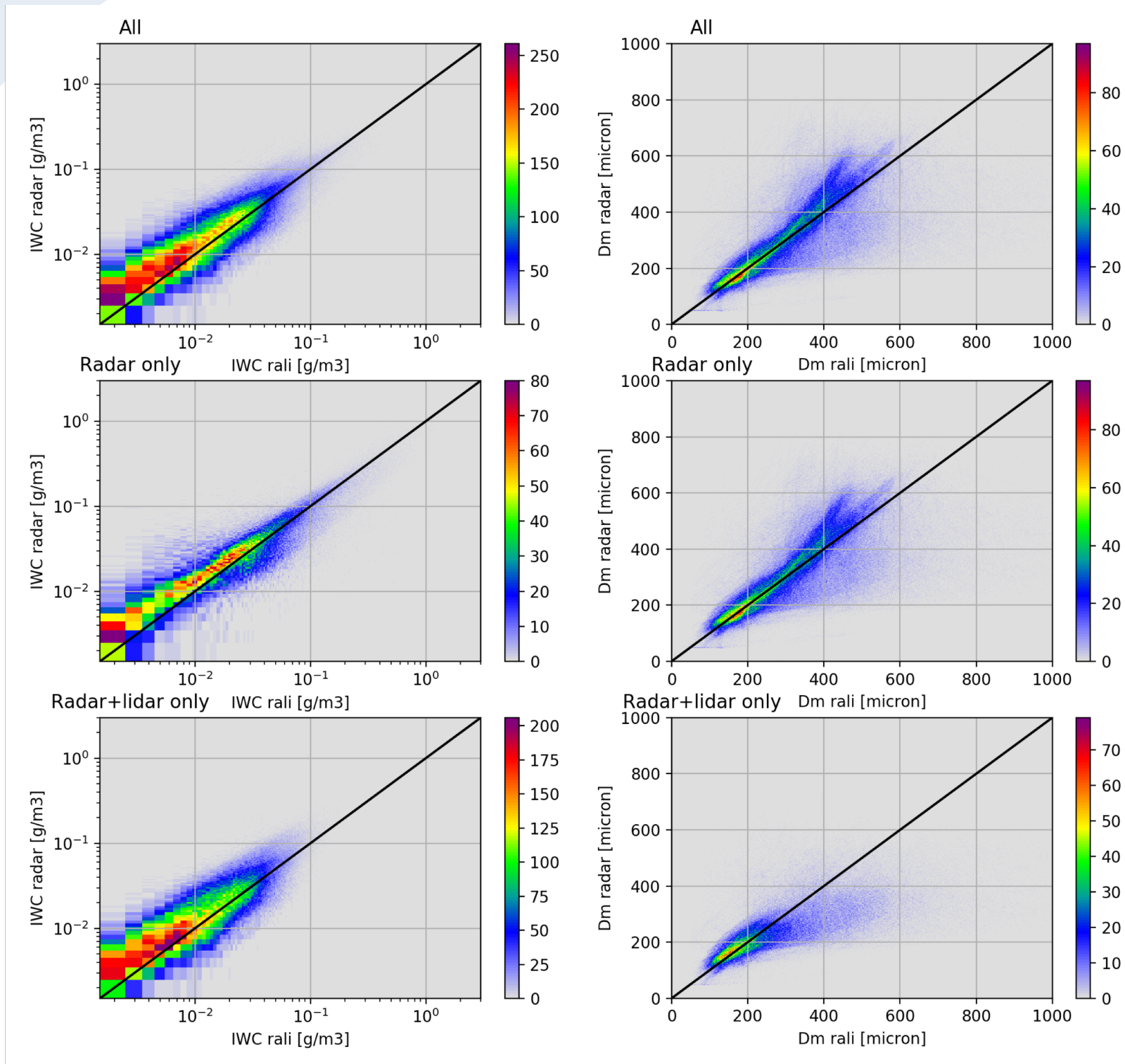
Relationship between IWC and V_z



Distribution of Z, IWC and V_z as a function of the relative humidity (respectively panels a), b) and c)). Relative humidity and the three variables are correlated, an increase in humidity is favourable to higher IWC then higher Z and V_z .



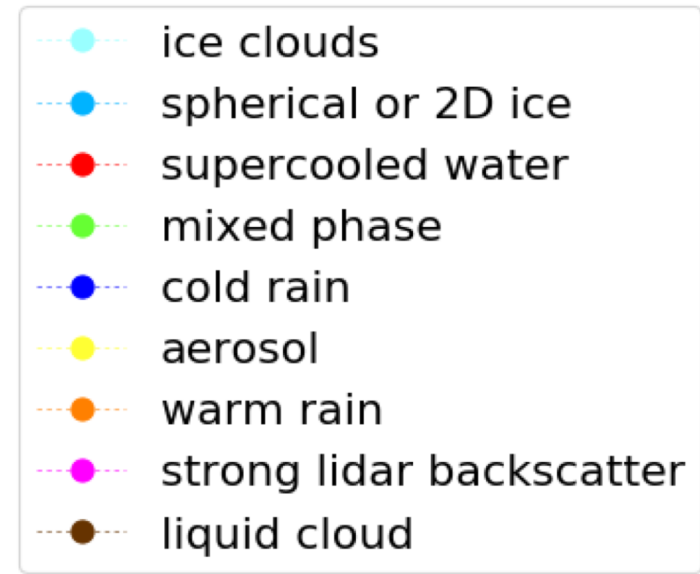
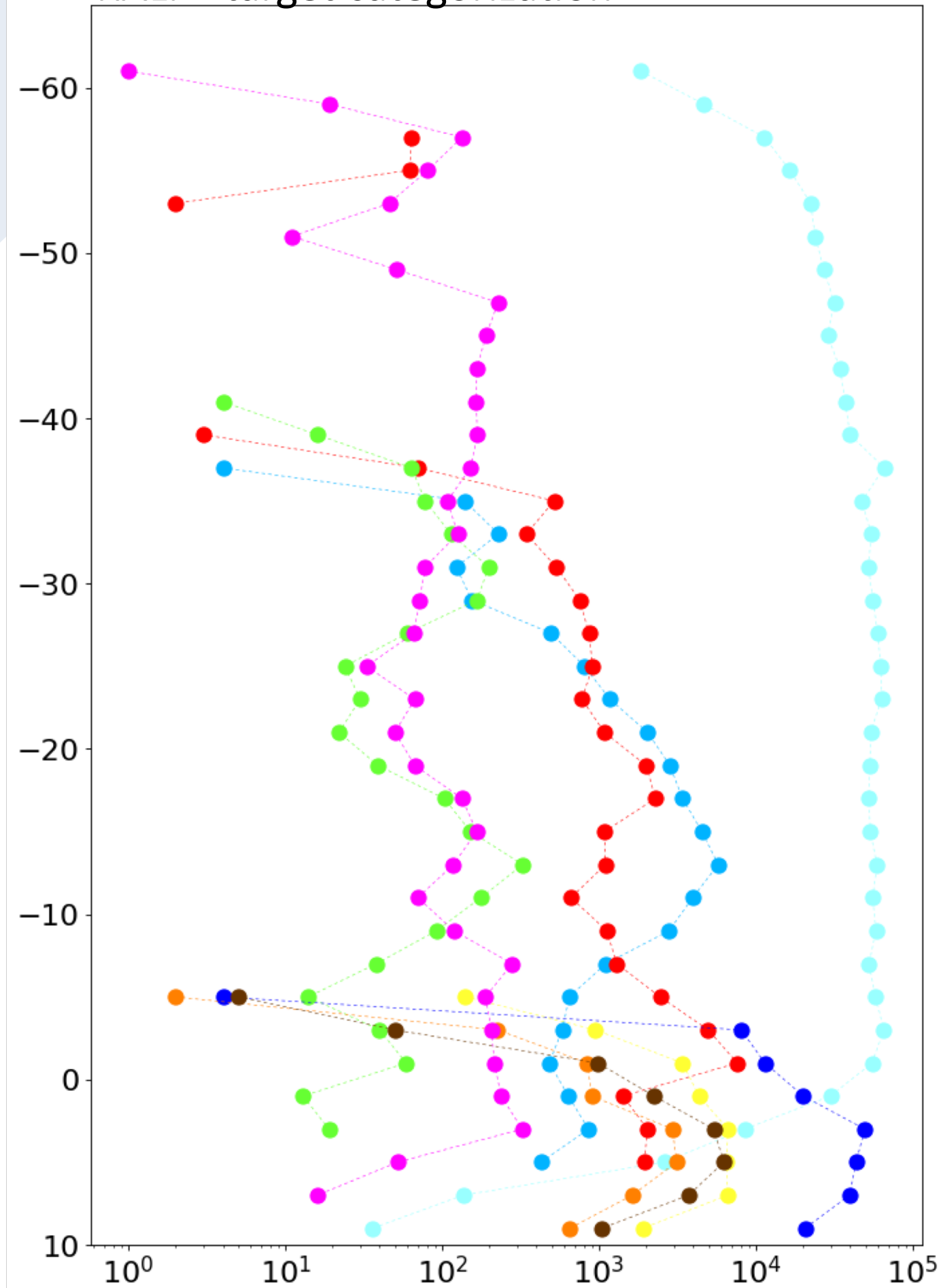
RASTA vs RALI



Statistiques NAWDEX

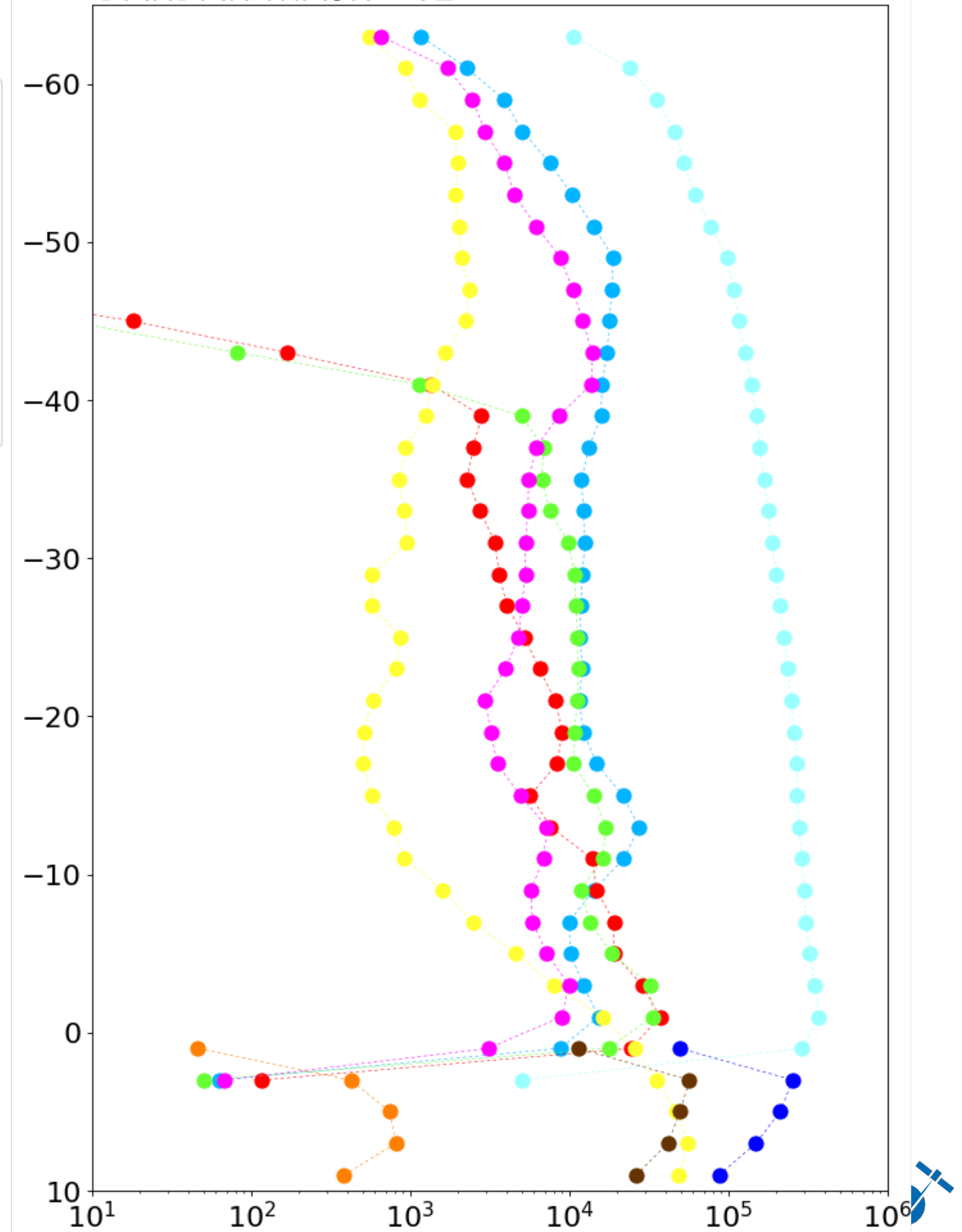


RALI – target categorization

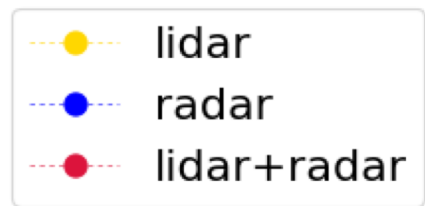
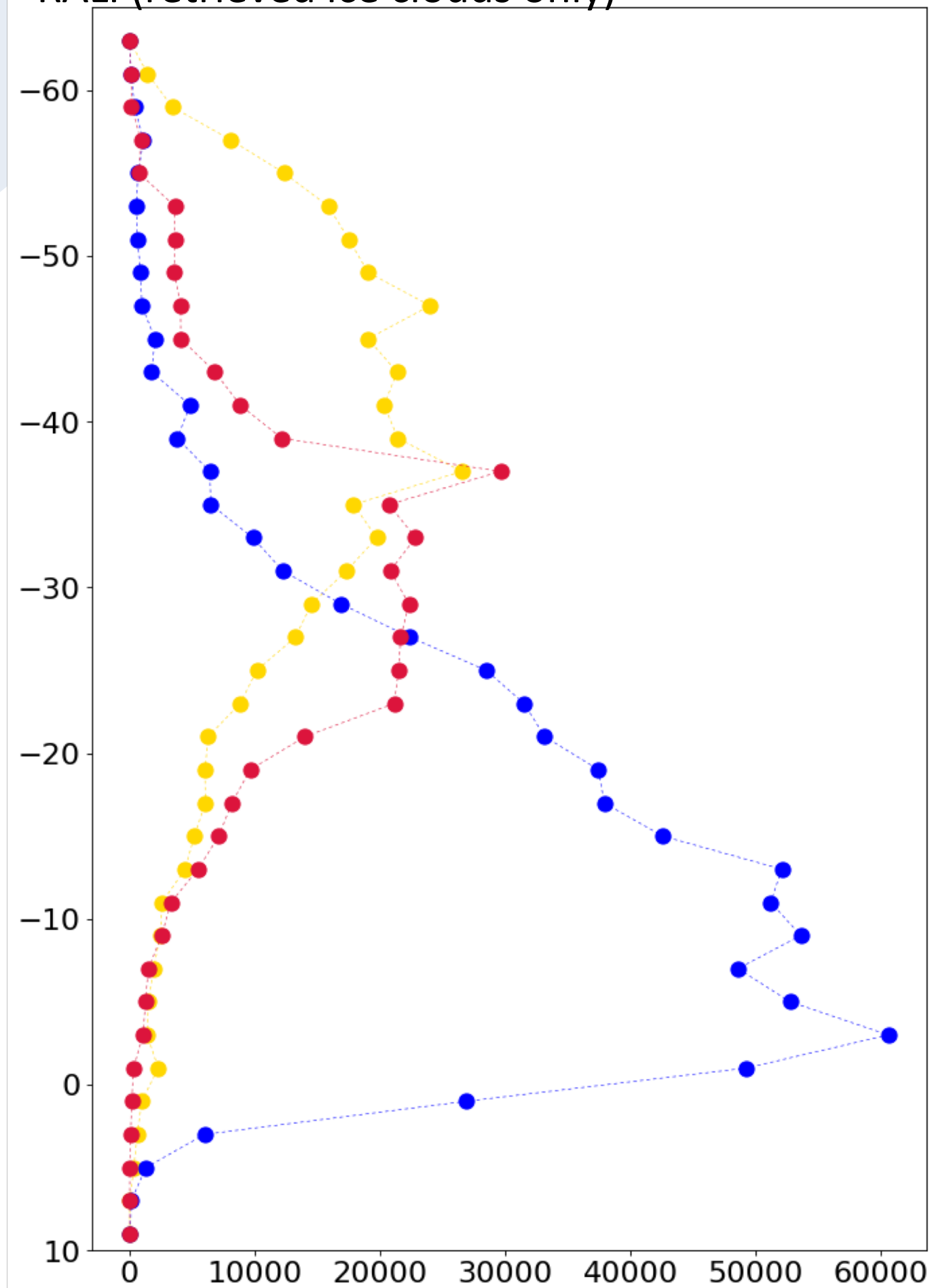


DARDAR: Sept – Oct
2016 dans une zone
de 50°N à 70°N et de
0°W à 40°W

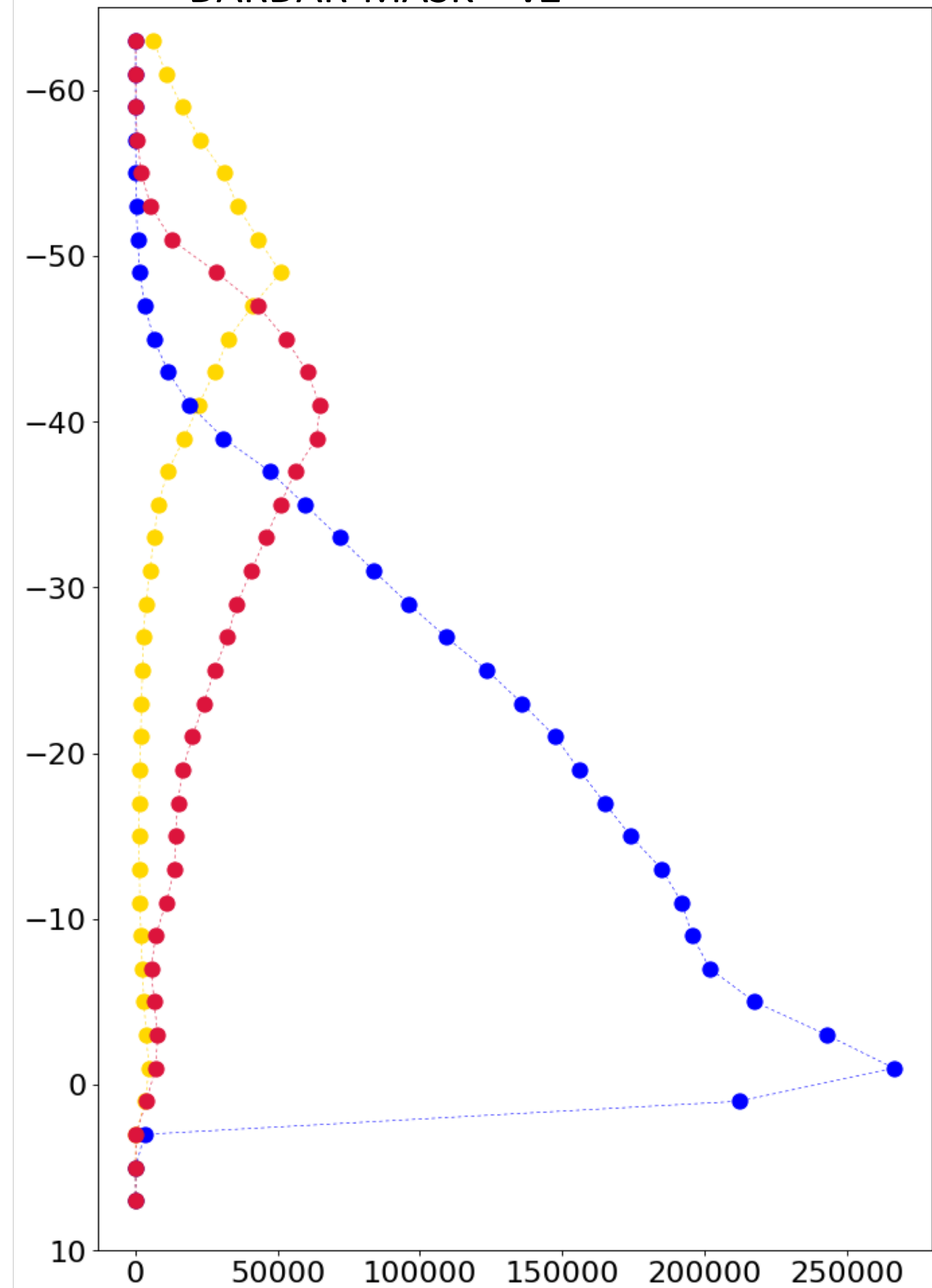
DARDAR-MASK – v2

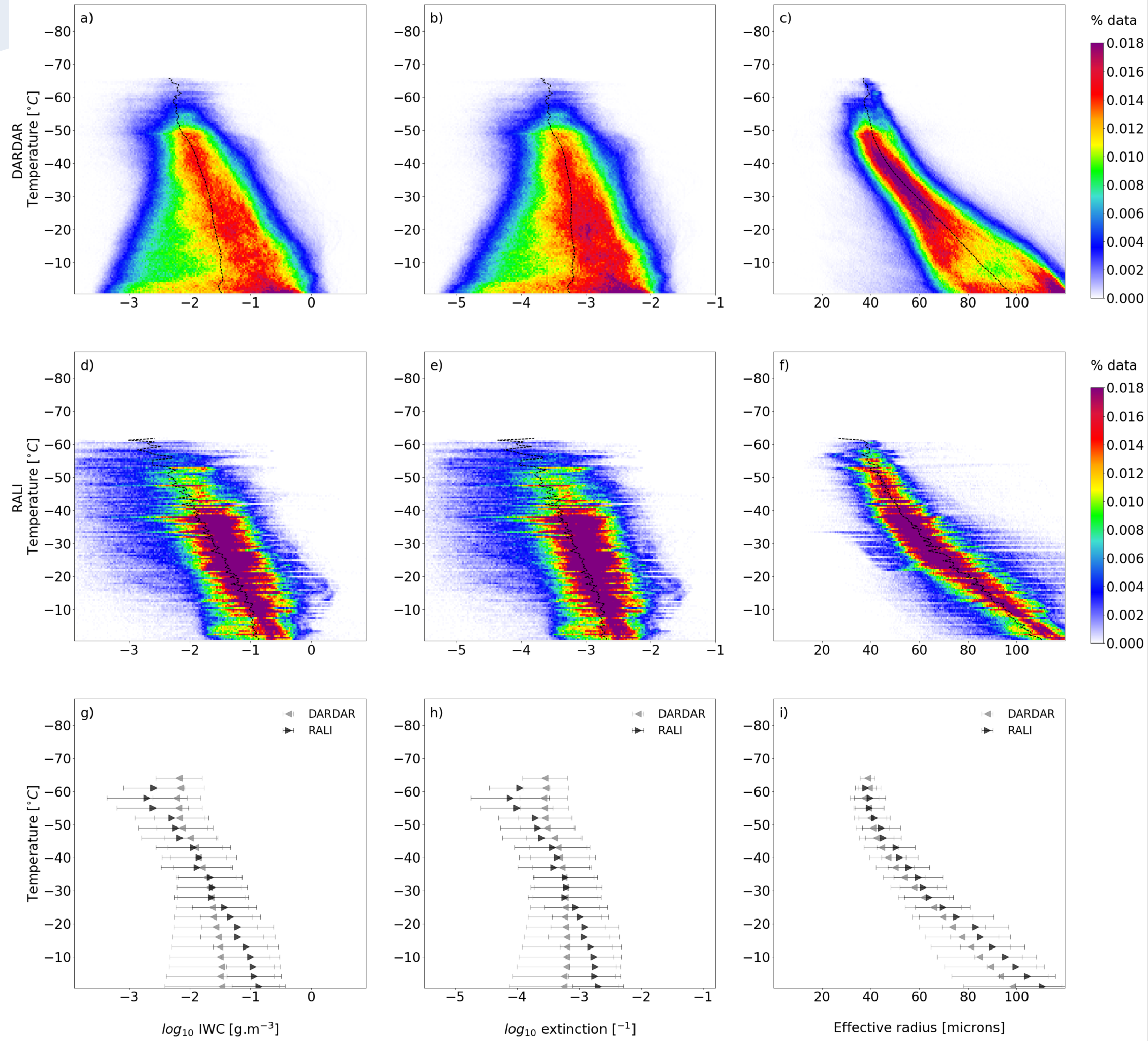


RALI (retrieved ice clouds only)



DARDAR-MASK – v2





Underpasses and comparisons

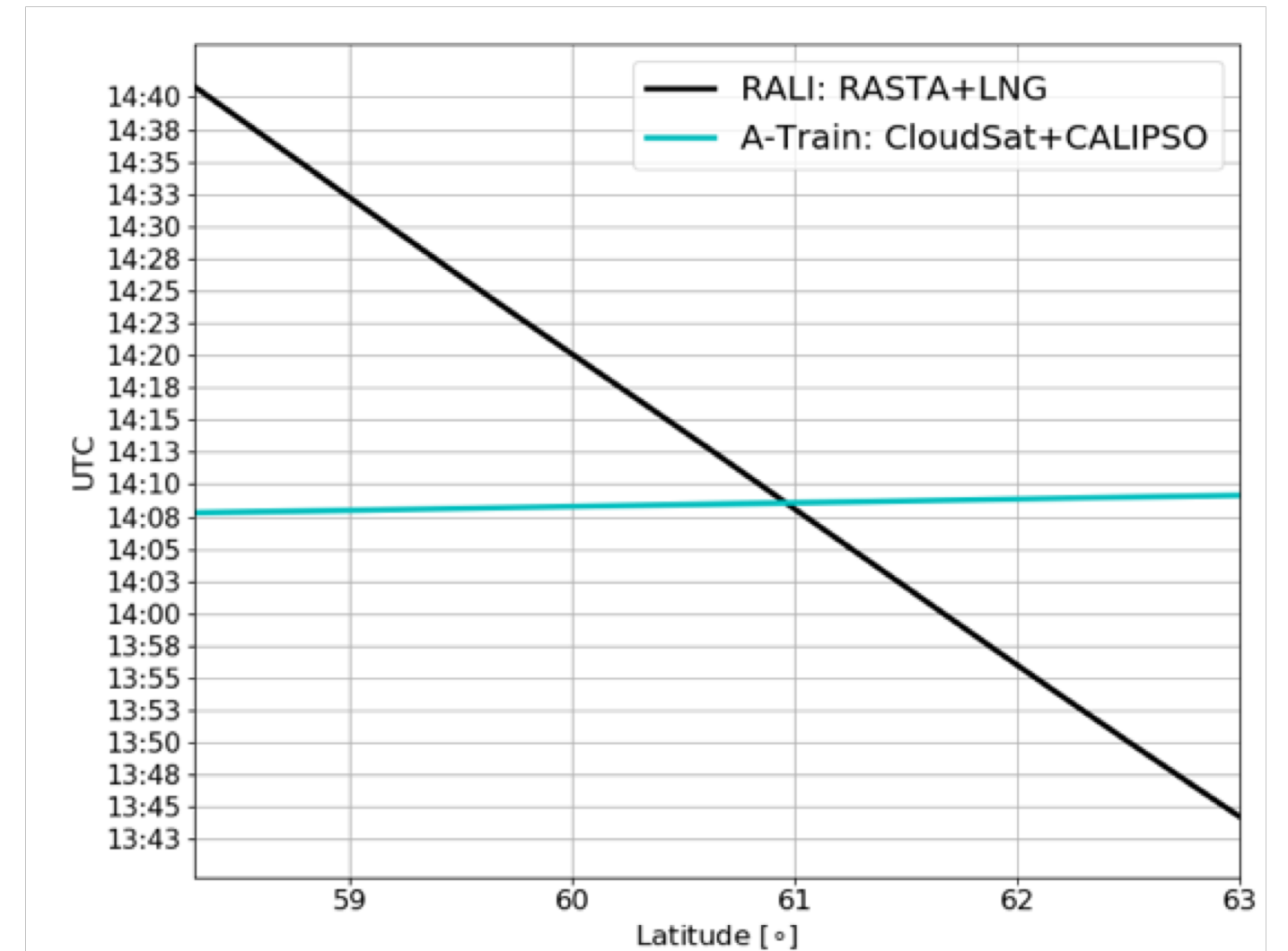
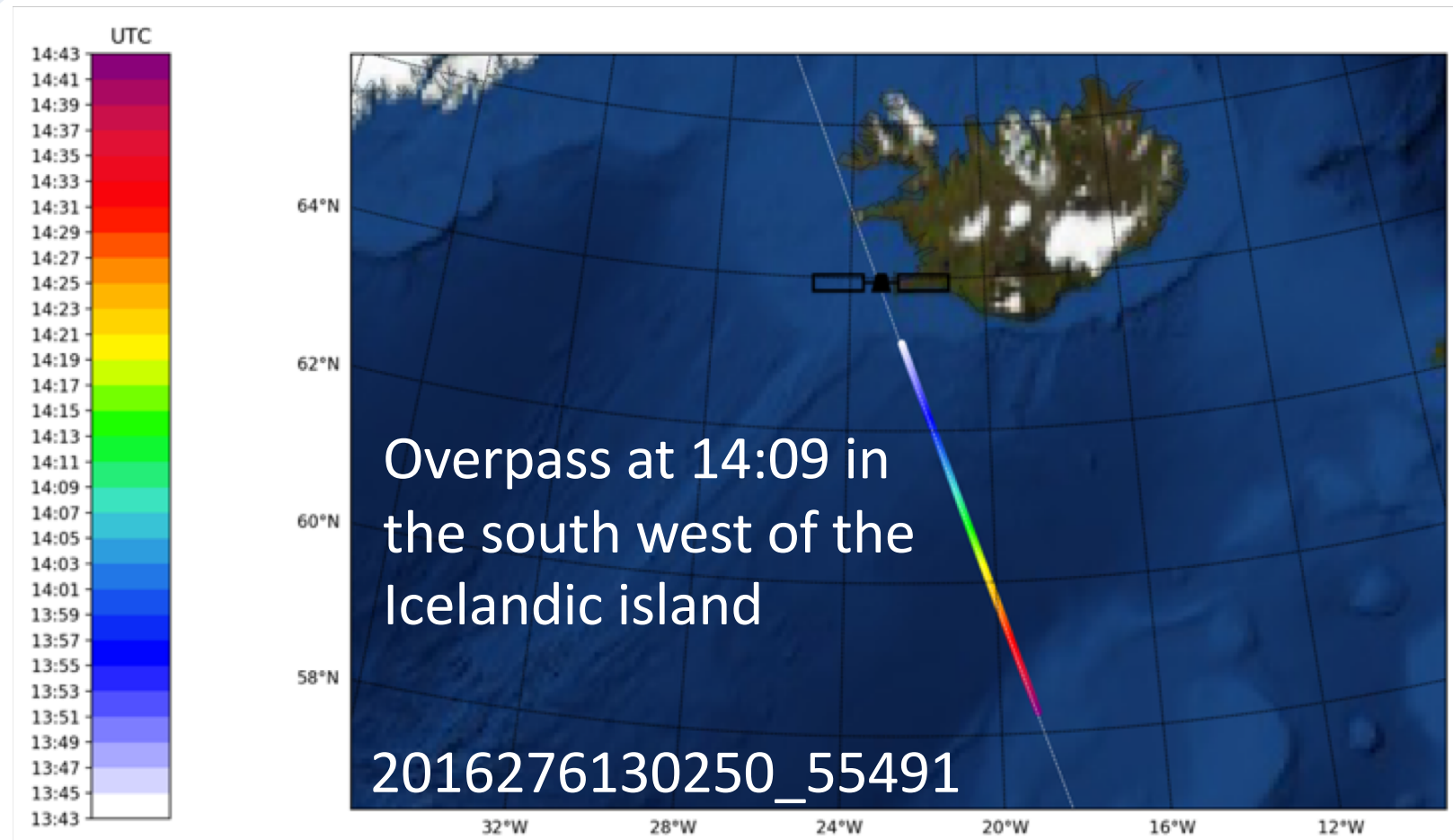


CC – underpasses and comparisons

- 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).



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.

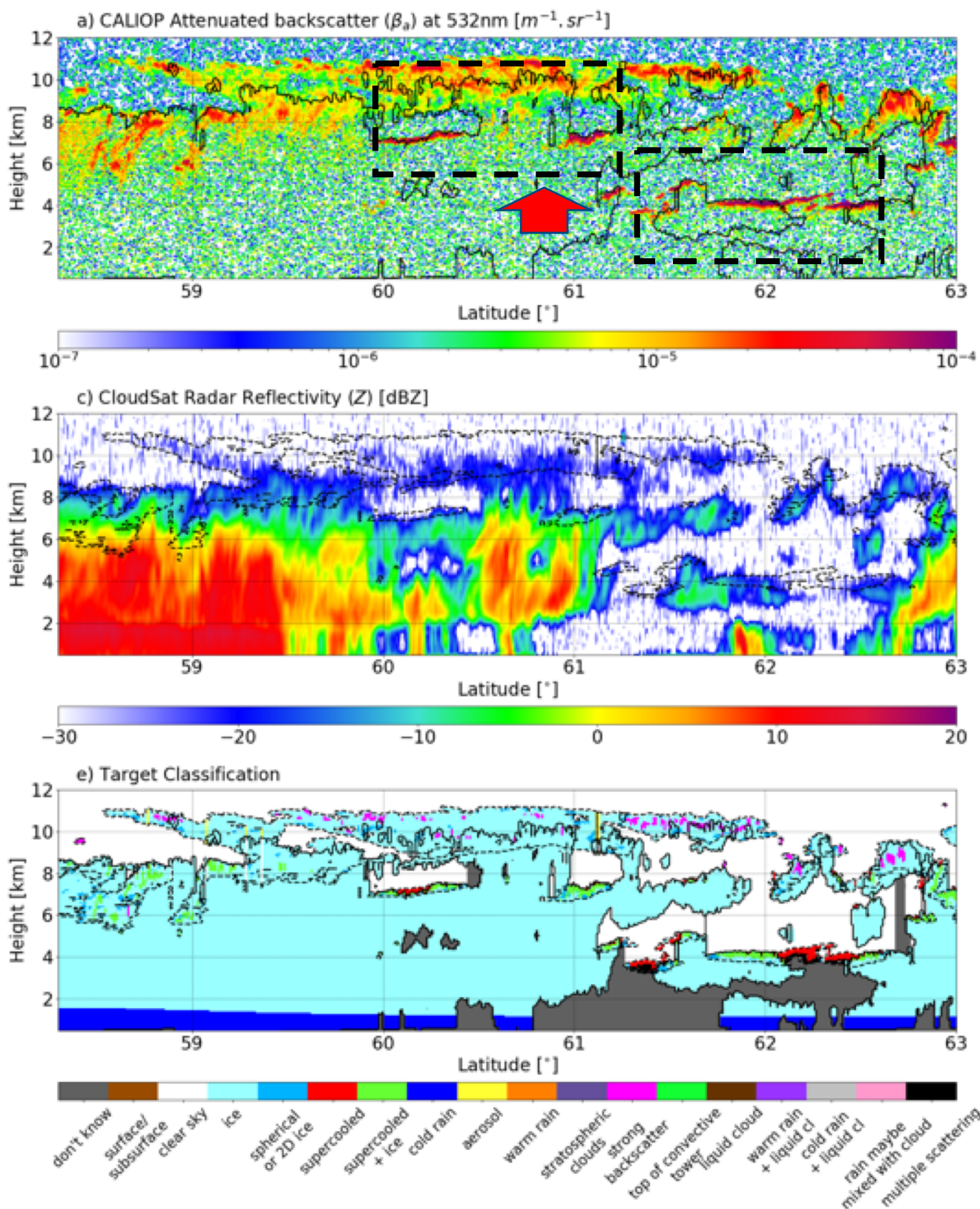
CloudSat and CALIPSO were flying from south to north while the F20 was sampling the scene in the opposite direction.



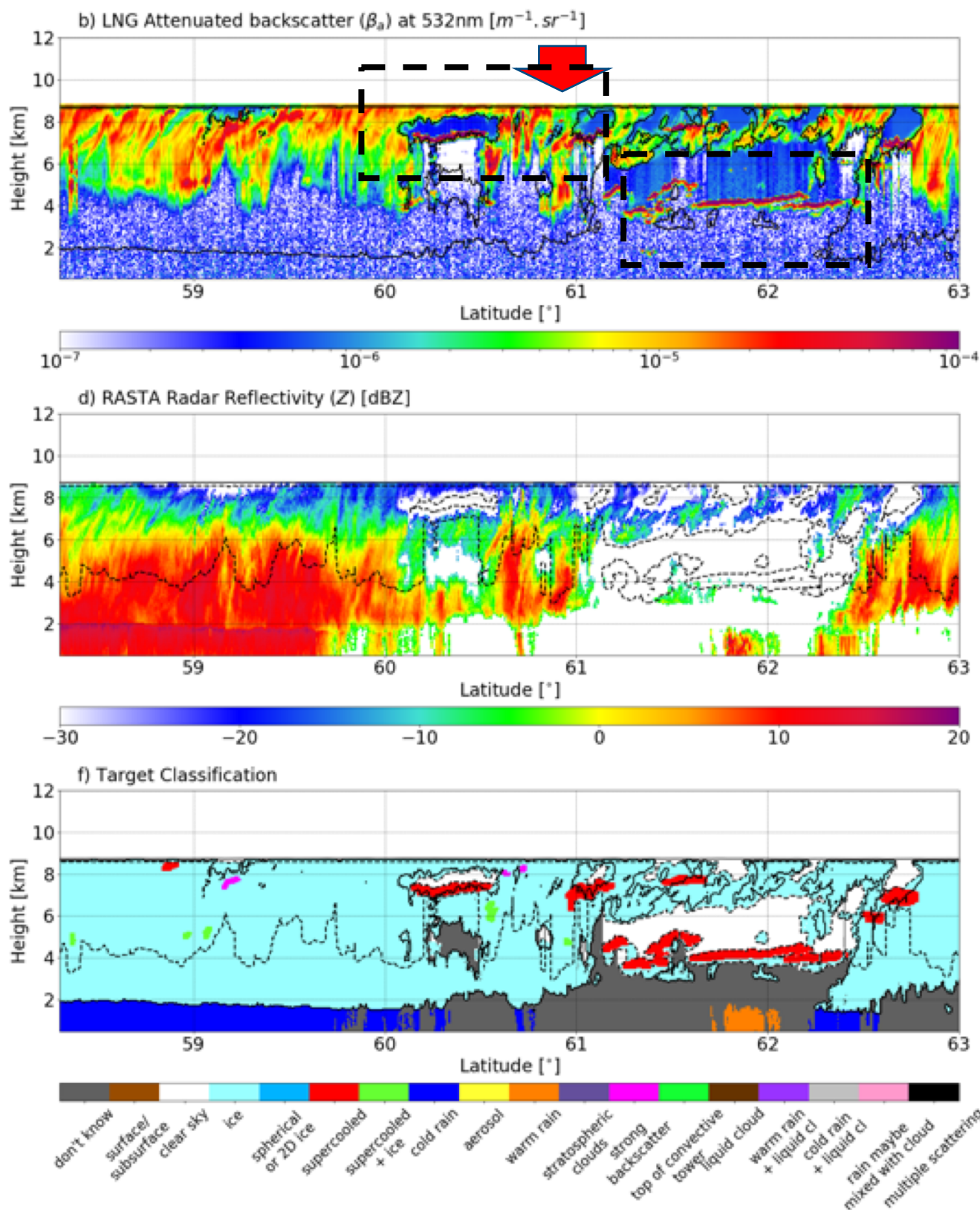
dt=30 min

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

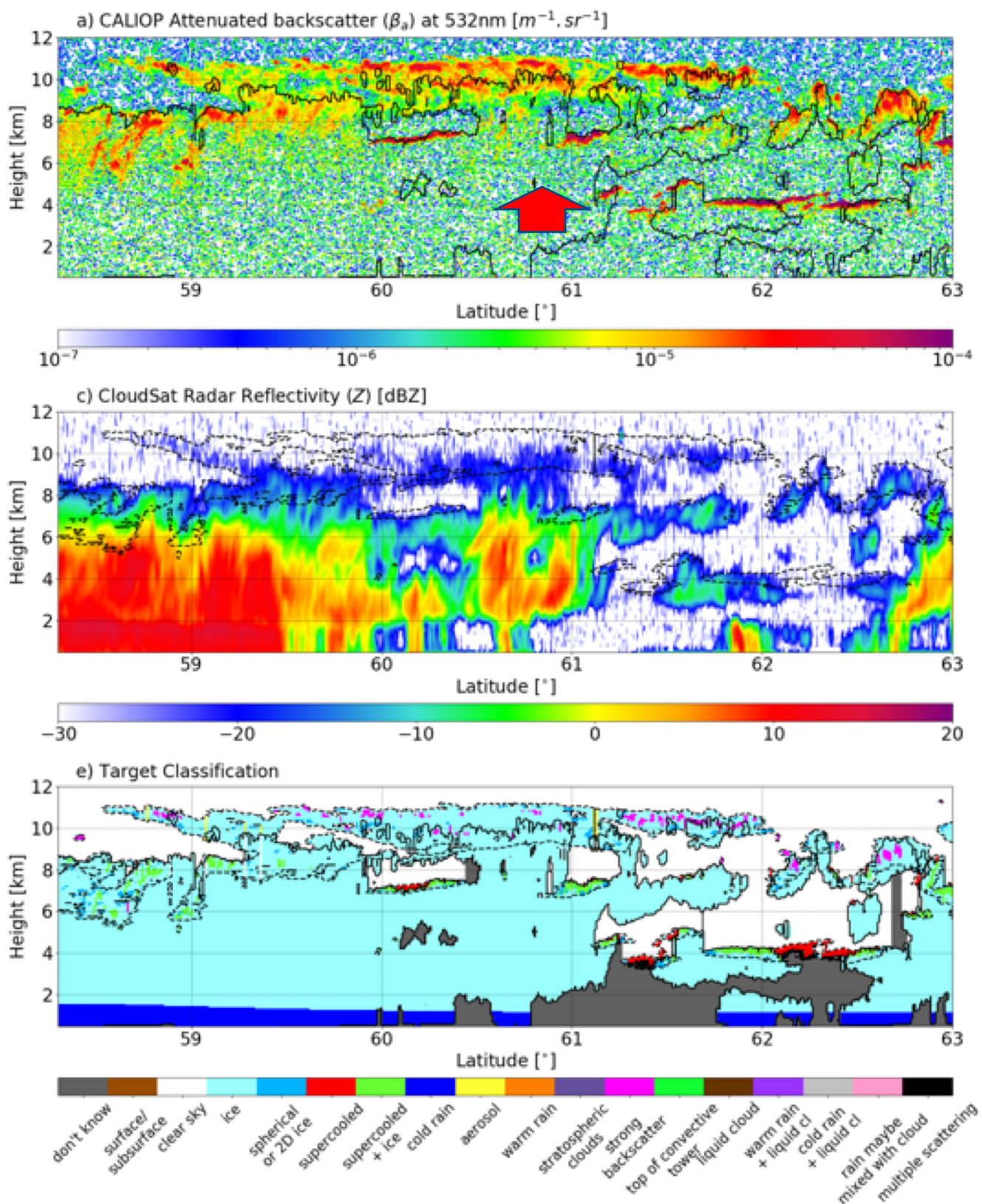
RASTA and CloudSat also very similar patterns and the differences are due to the time shift and the less homogeneous situation.



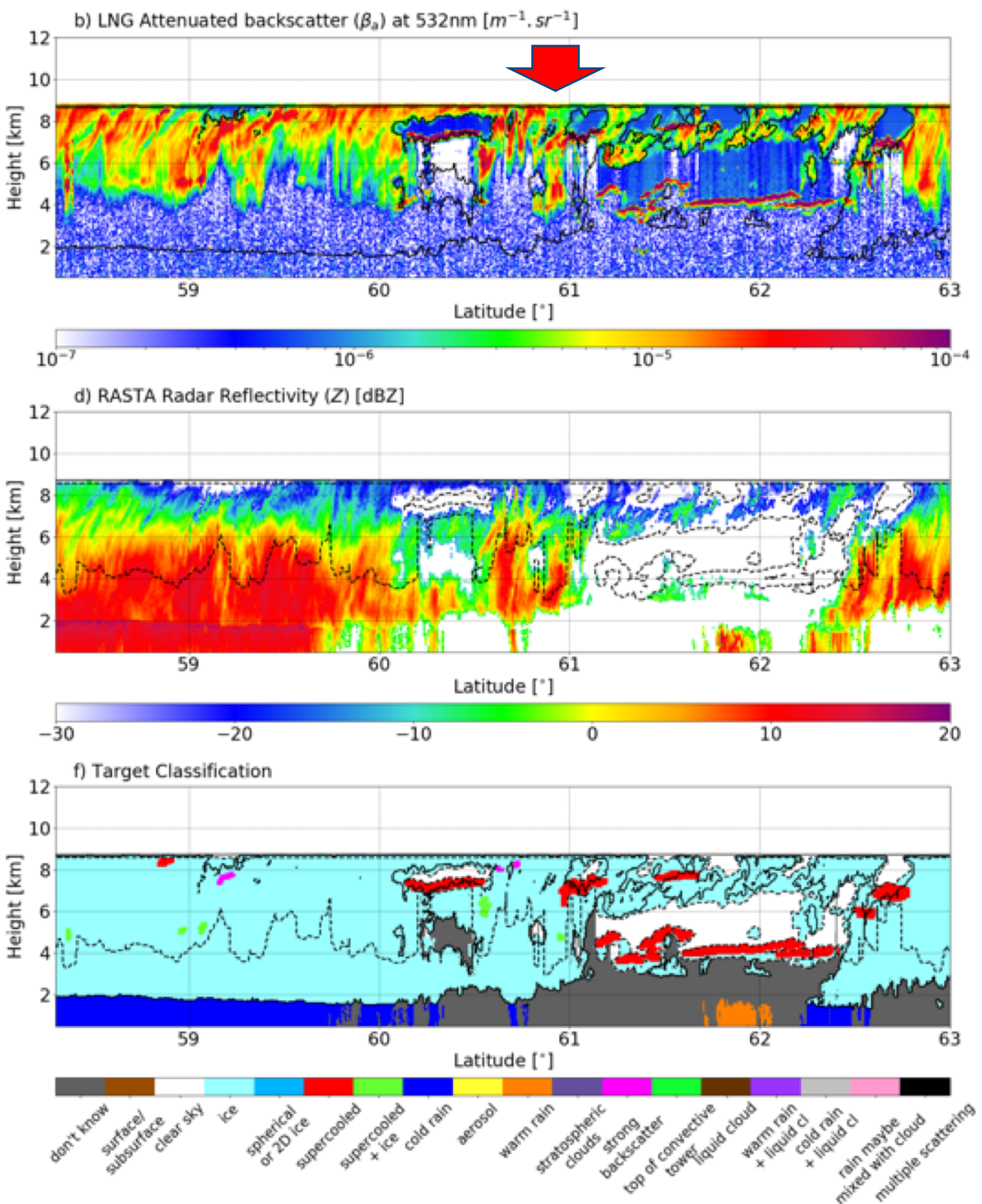
dt=30 min

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

dt=25 min



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

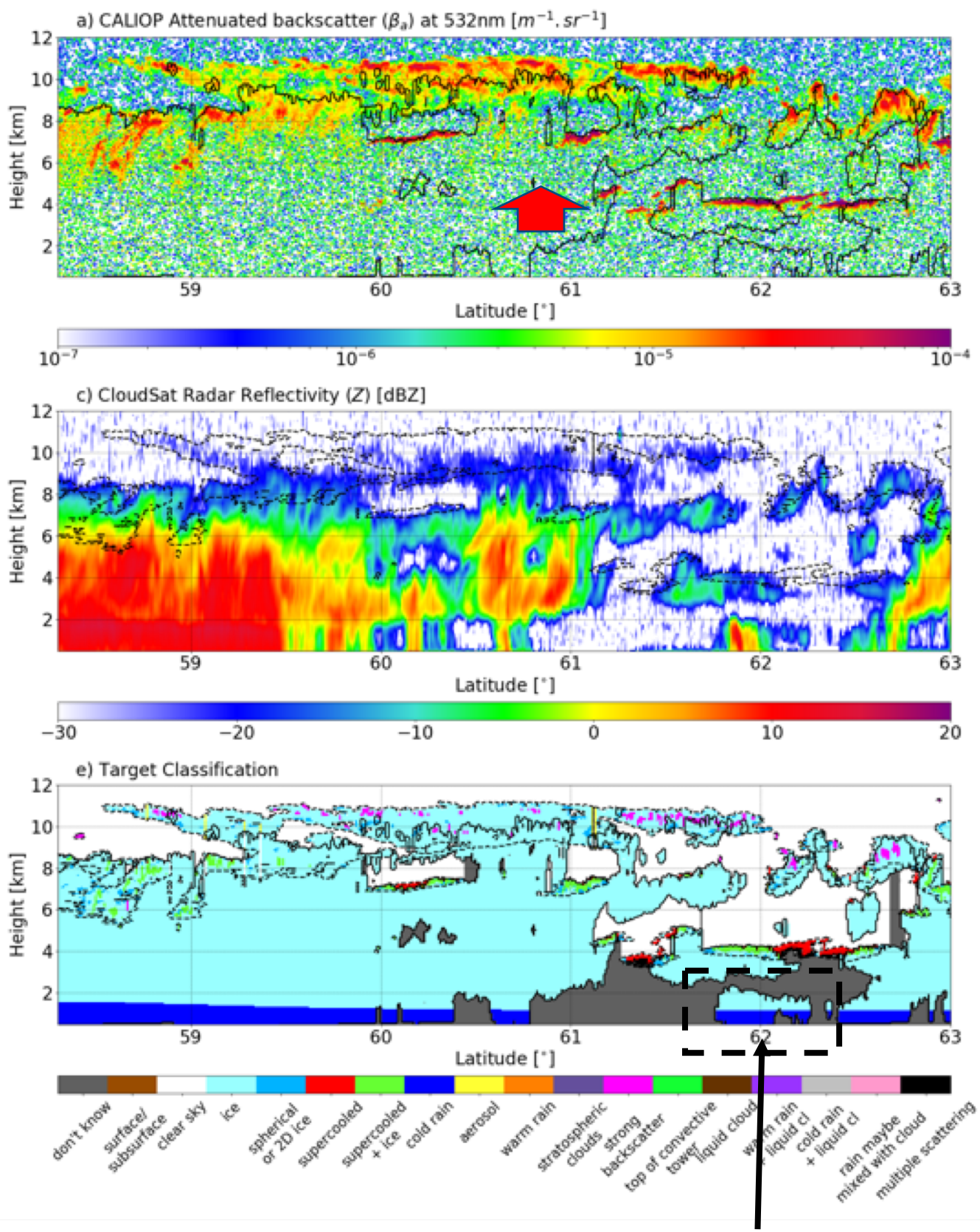
Supercooled layers detection is consistent but the mixed phase attribution is slightly different due to the radars sensitivity. The presence of ice is mainly highlighted by the radar signal in these layers.



dt=30 min

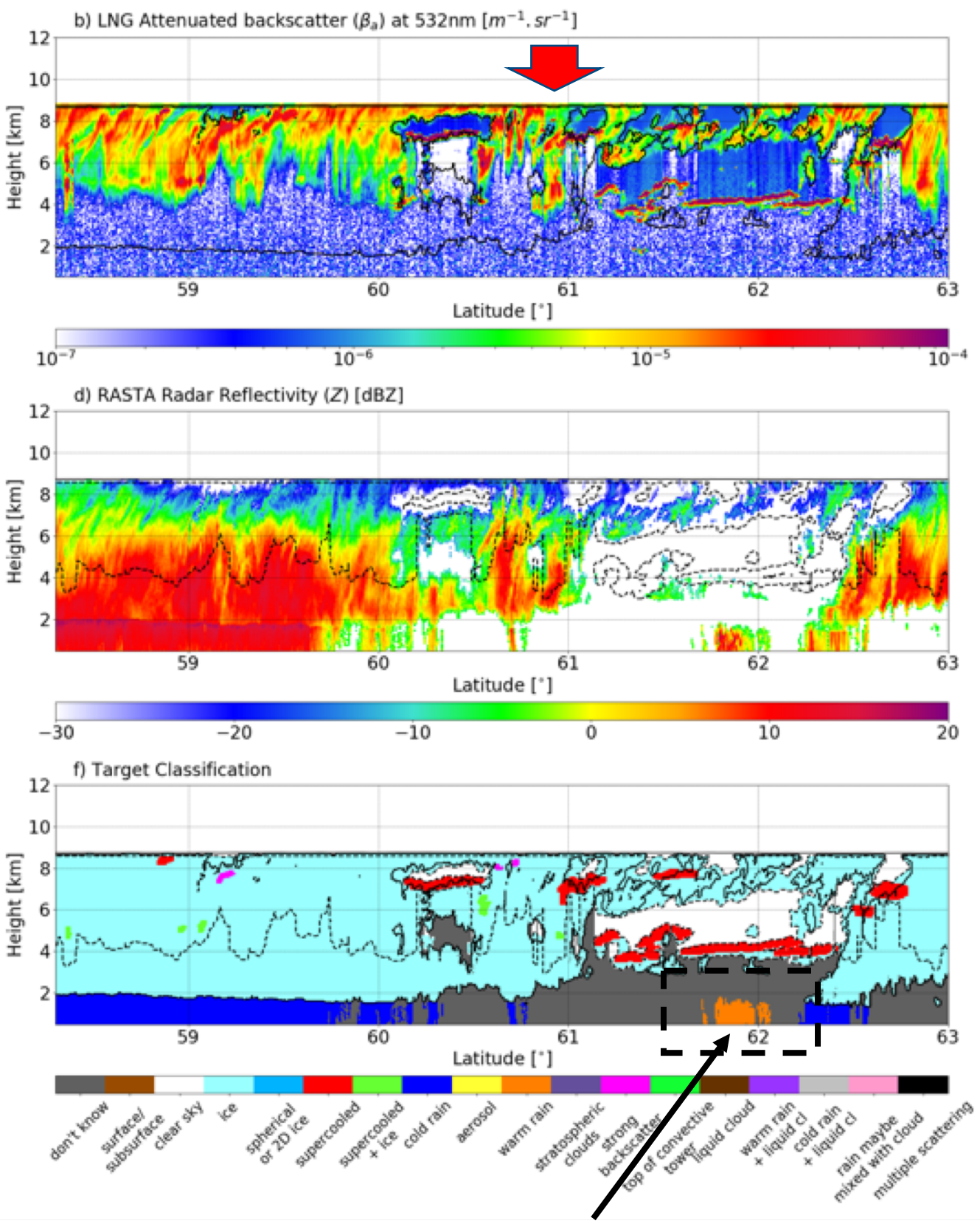
dt=25 min

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



cold rain

RALI 2016/10/02: RASTA and LNG



warm rain

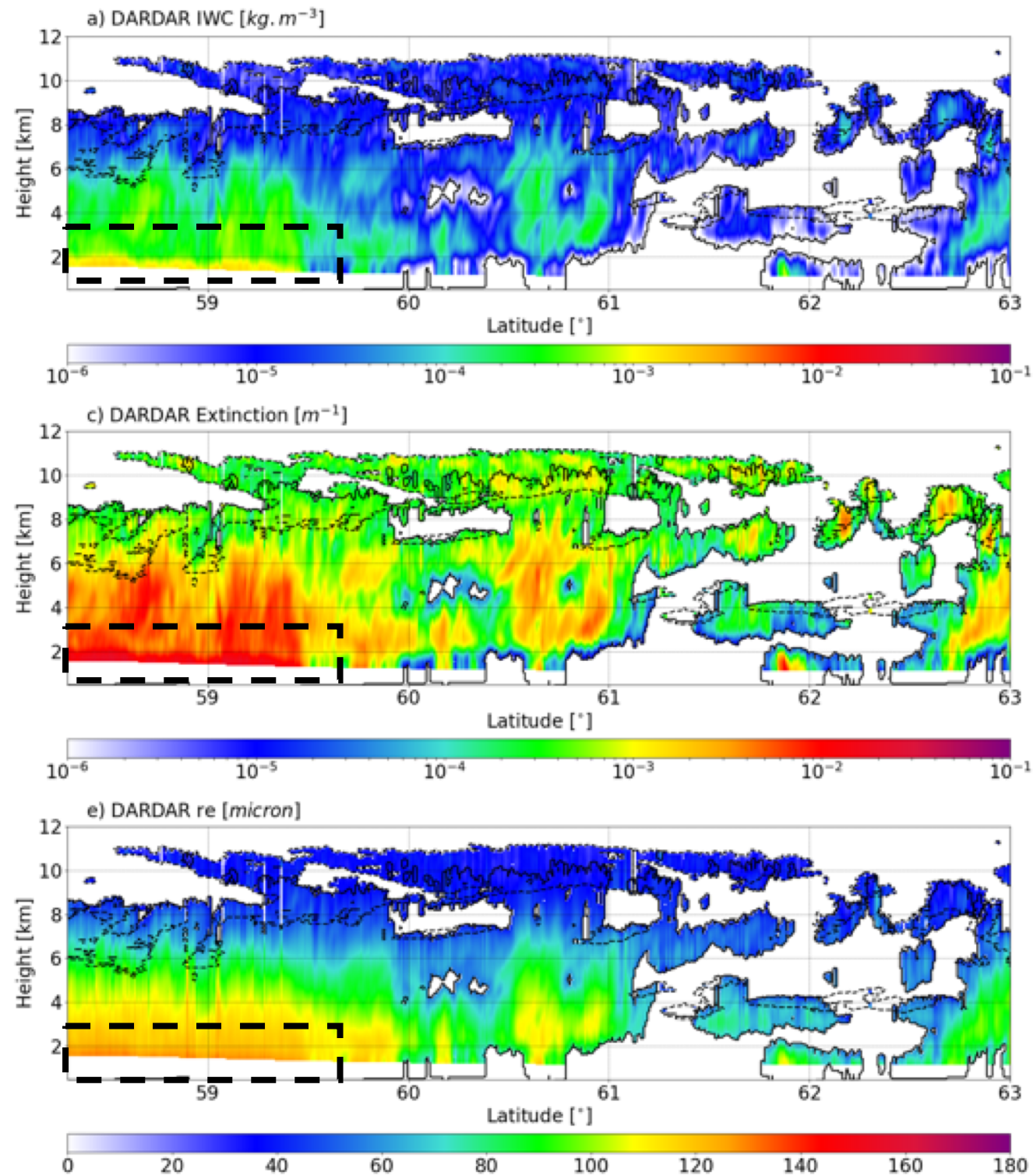
Rain area complicated for the satellite :

- 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.

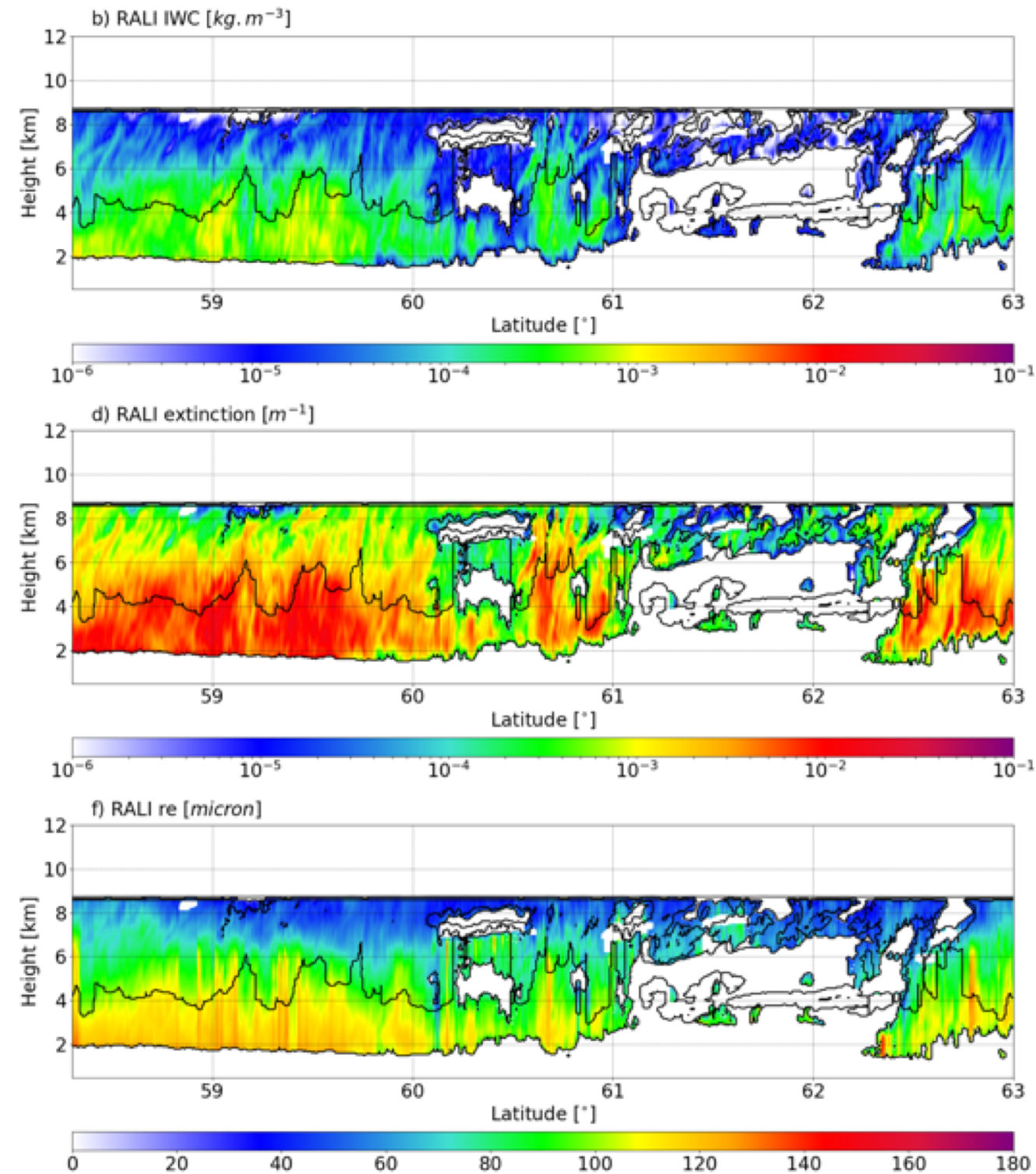
The 0°C limit is decisive to decide the nature of the precipitation and unfortunately the lidar cannot help due to the supercooled layer above which extinguished the signal.



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



RALI 2016/10/02: RASTA and LNG

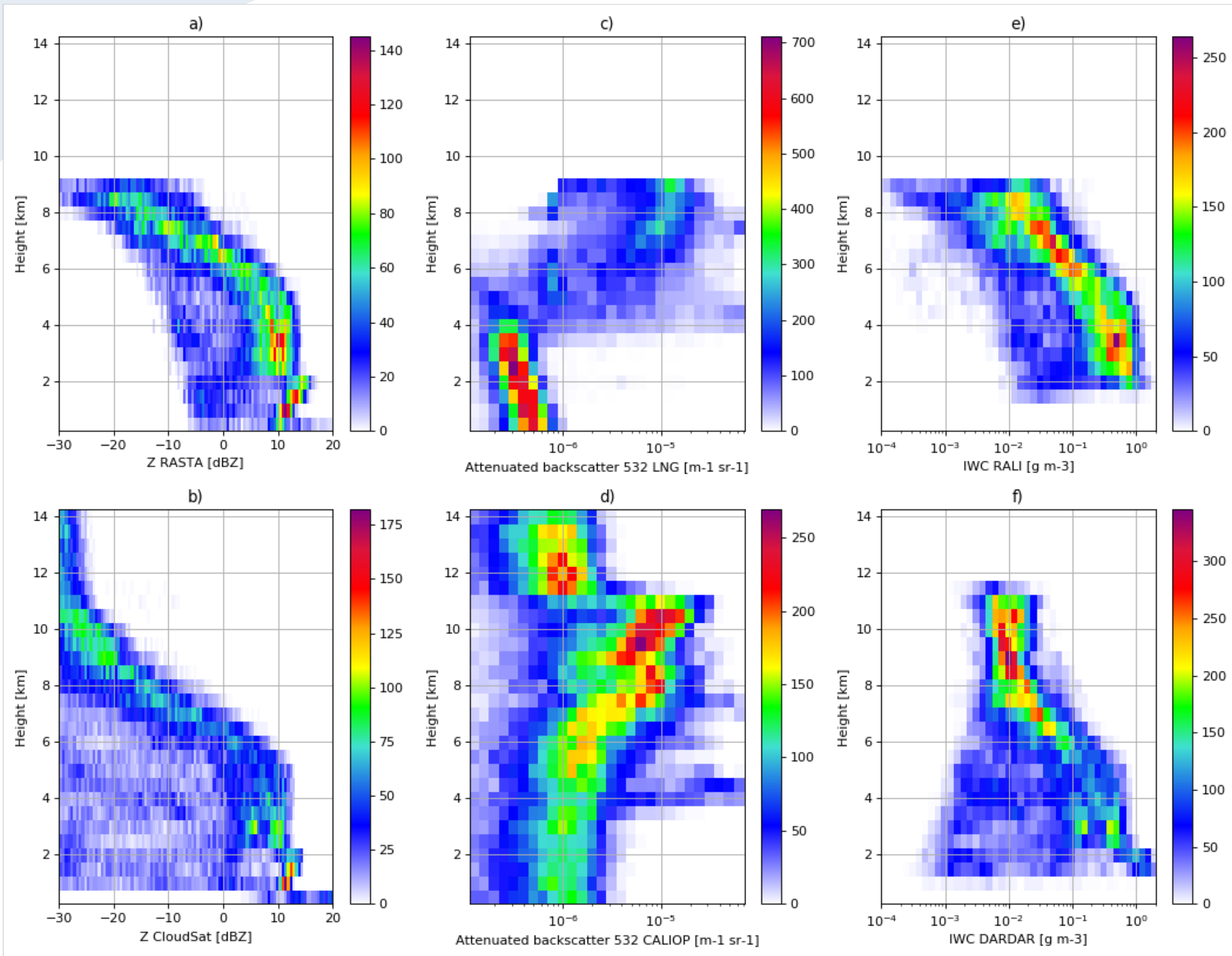


Similar patterns and order of magnitude.

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).





For the largest values of IWC (i.e. larger than 10^{-2} g/m^3) => very consistent.

Lowest values of IWC show large differences
=> lack of the sensitivity of the RASTA compared to CloudSat

=> Distributions of the reflectivity as a function of height.

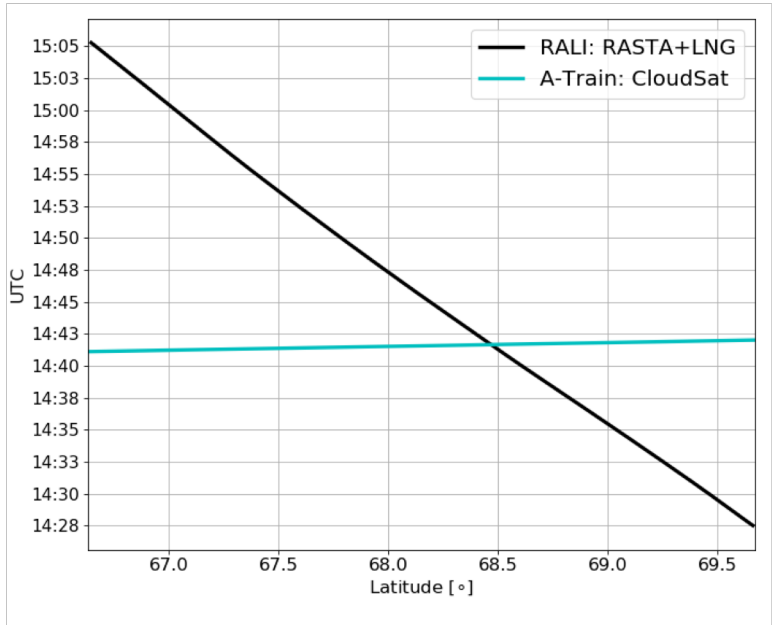
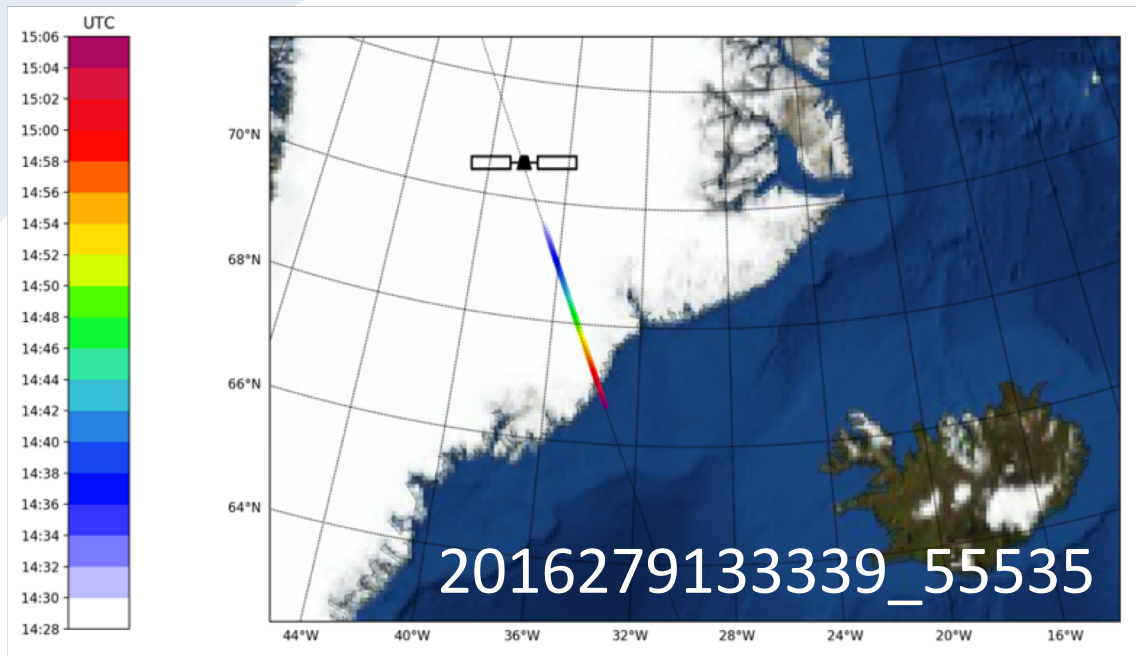
=> The distributions of the largest reflectivity are very similar but not the same dynamic range of reflectivity.

=> Unfortunately, the lidar measurements cannot compensate the lack of sensitivity of the radar in this situation as the lidar is most of the time already extinguished.

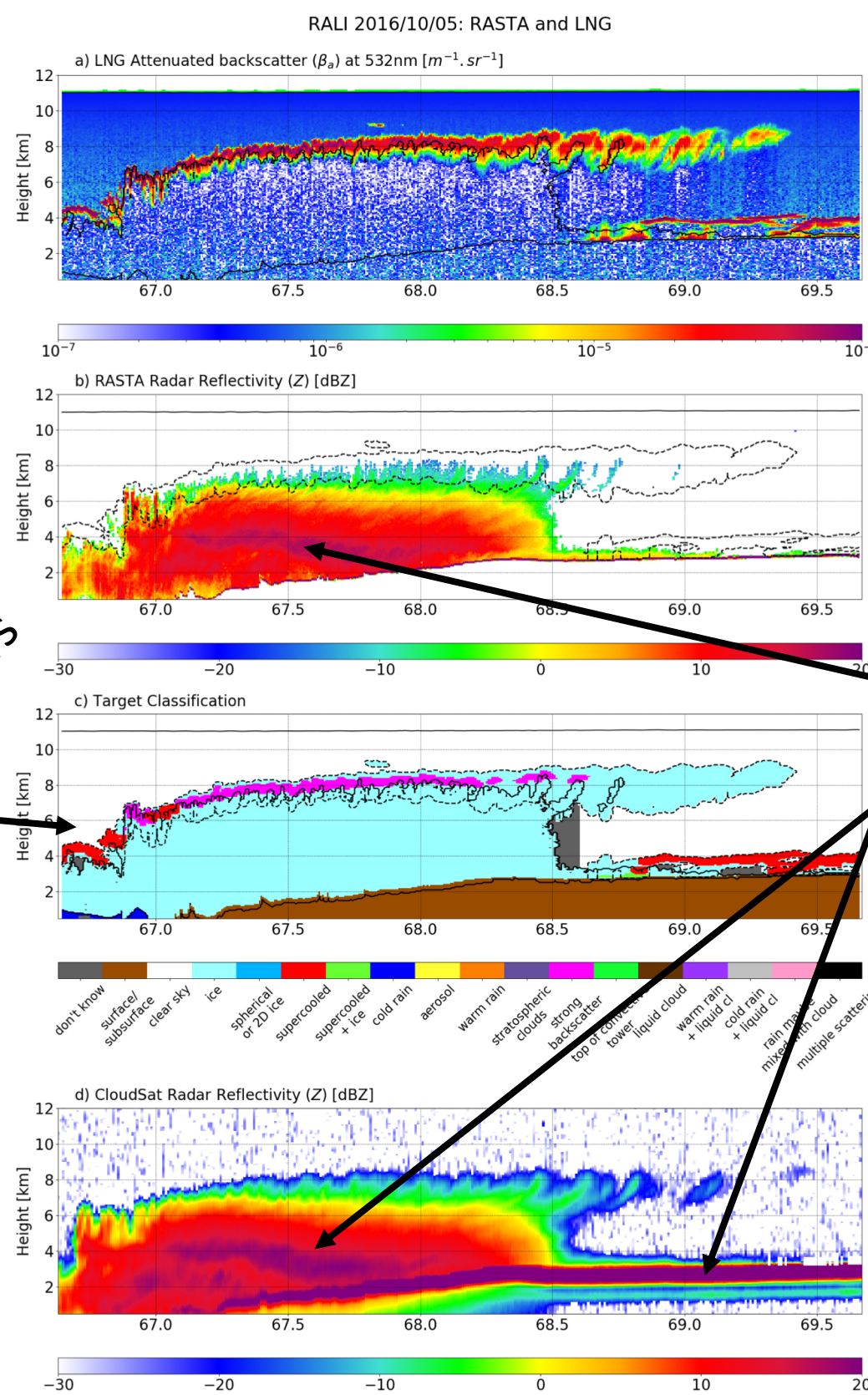
=> The impact of the solar contamination is obvious on the CALIOP signal with a flat molecular signal below 4 km.



Underpass #2 : 2016/10/05 (F9-French Falcon)



A diabatic Rossby wave in North-west Atlantic was evolving into a very deep low between Iceland and Greenland.



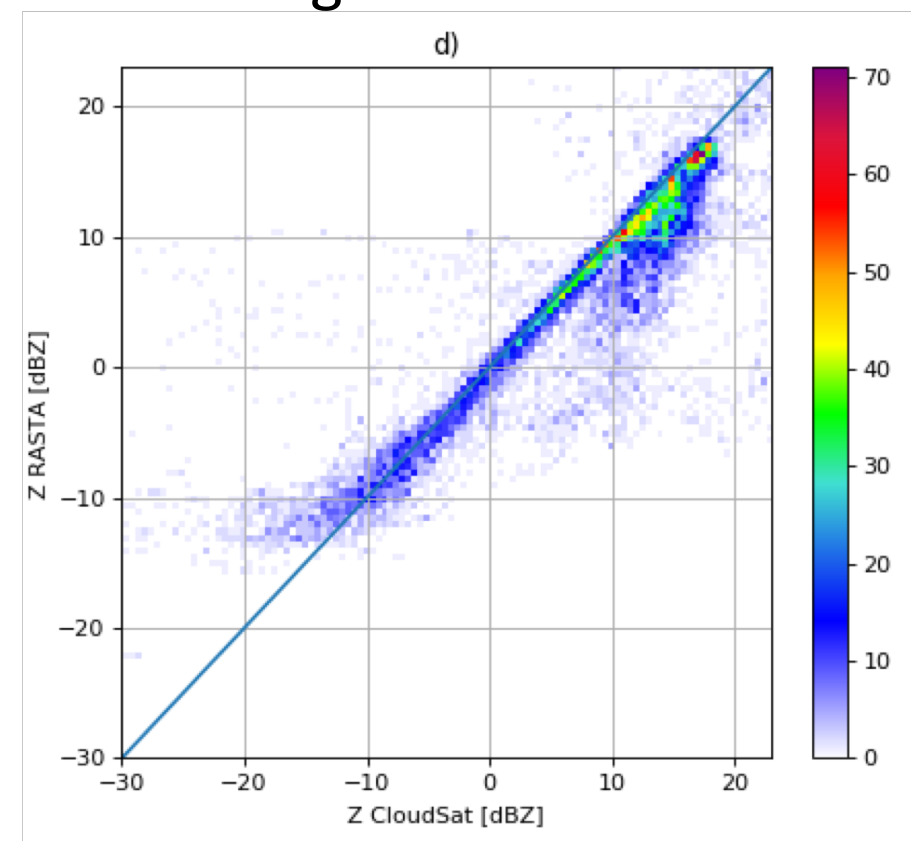
Supercooled layers

A very strong backscatter is observed at the cloud top in addition to the very low reflectivity (detected by Cloudsat) => particles are small and highly concentrated

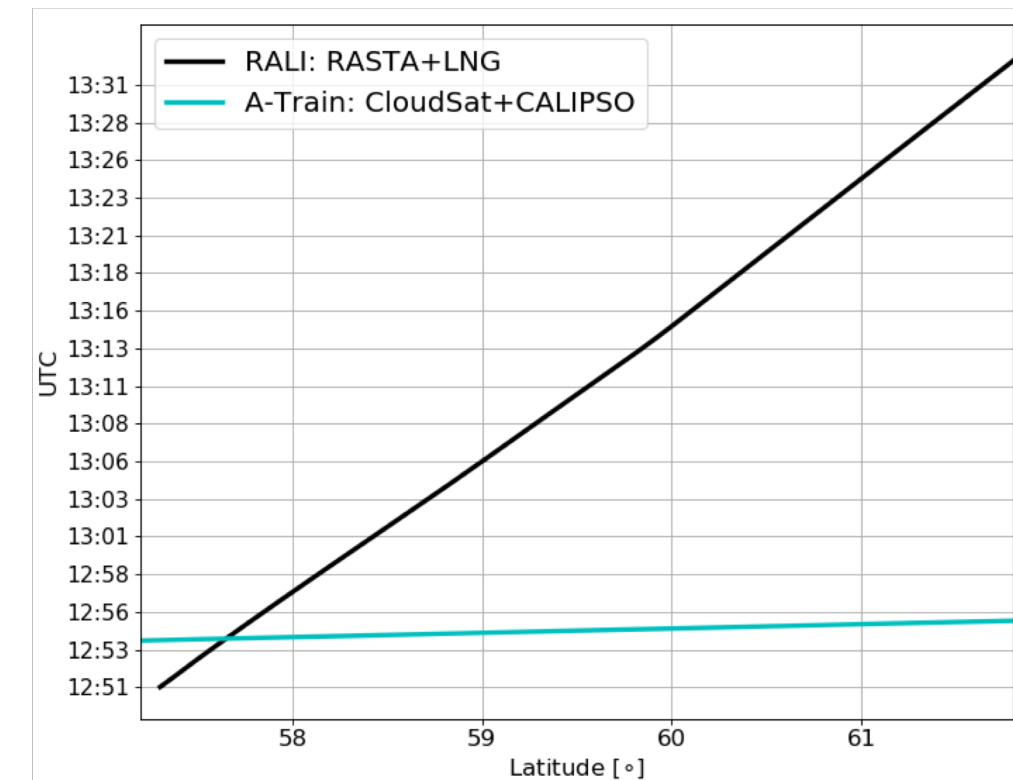
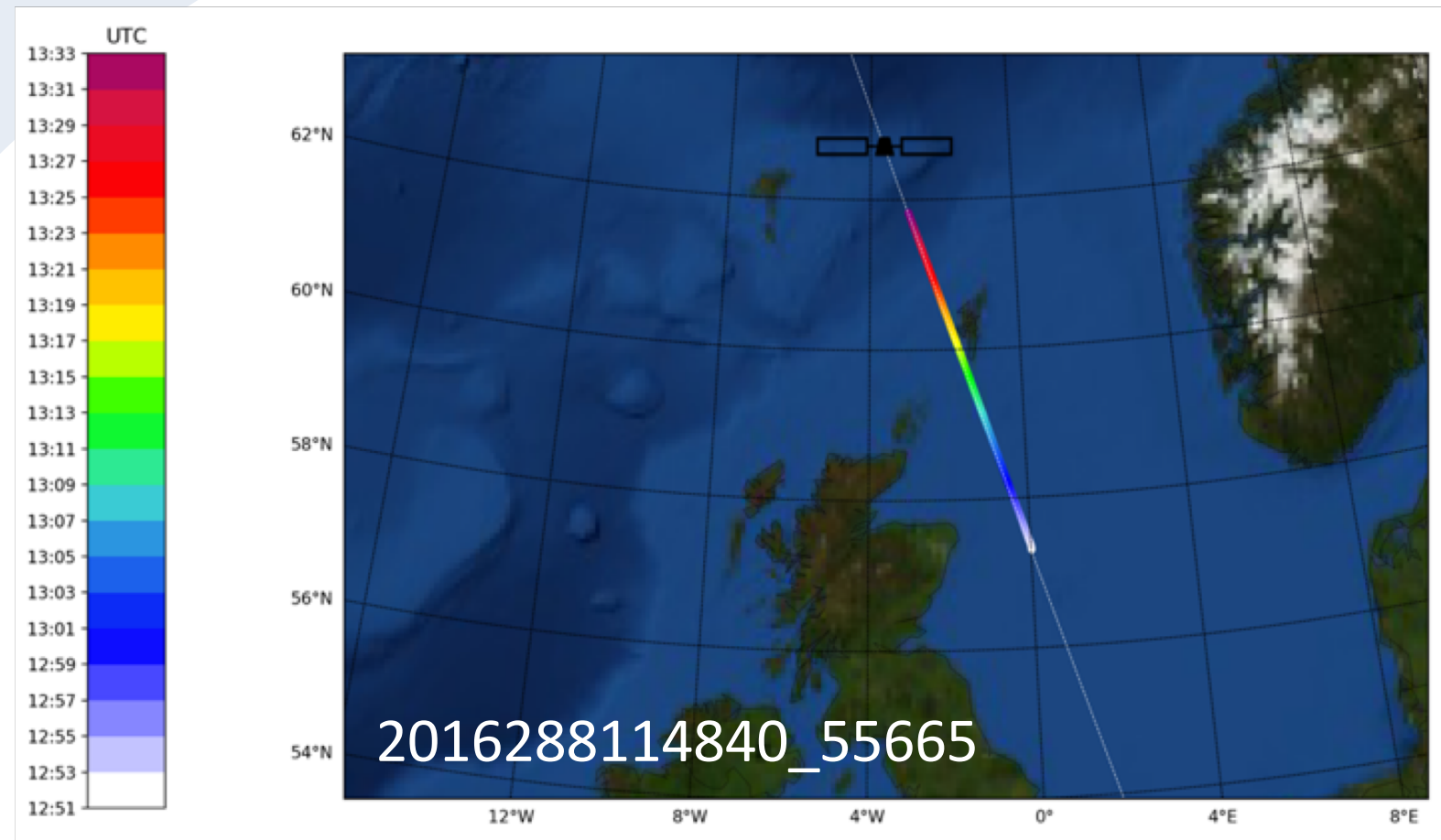
RASTA and CloudSat reflectivities => agree

CloudSat more affected by clutter

Slight reflectivity enhancement seen on CloudSat could be due to multiple scattering



Underpass #3 : 2016/10/14 (F18-French Falcon)



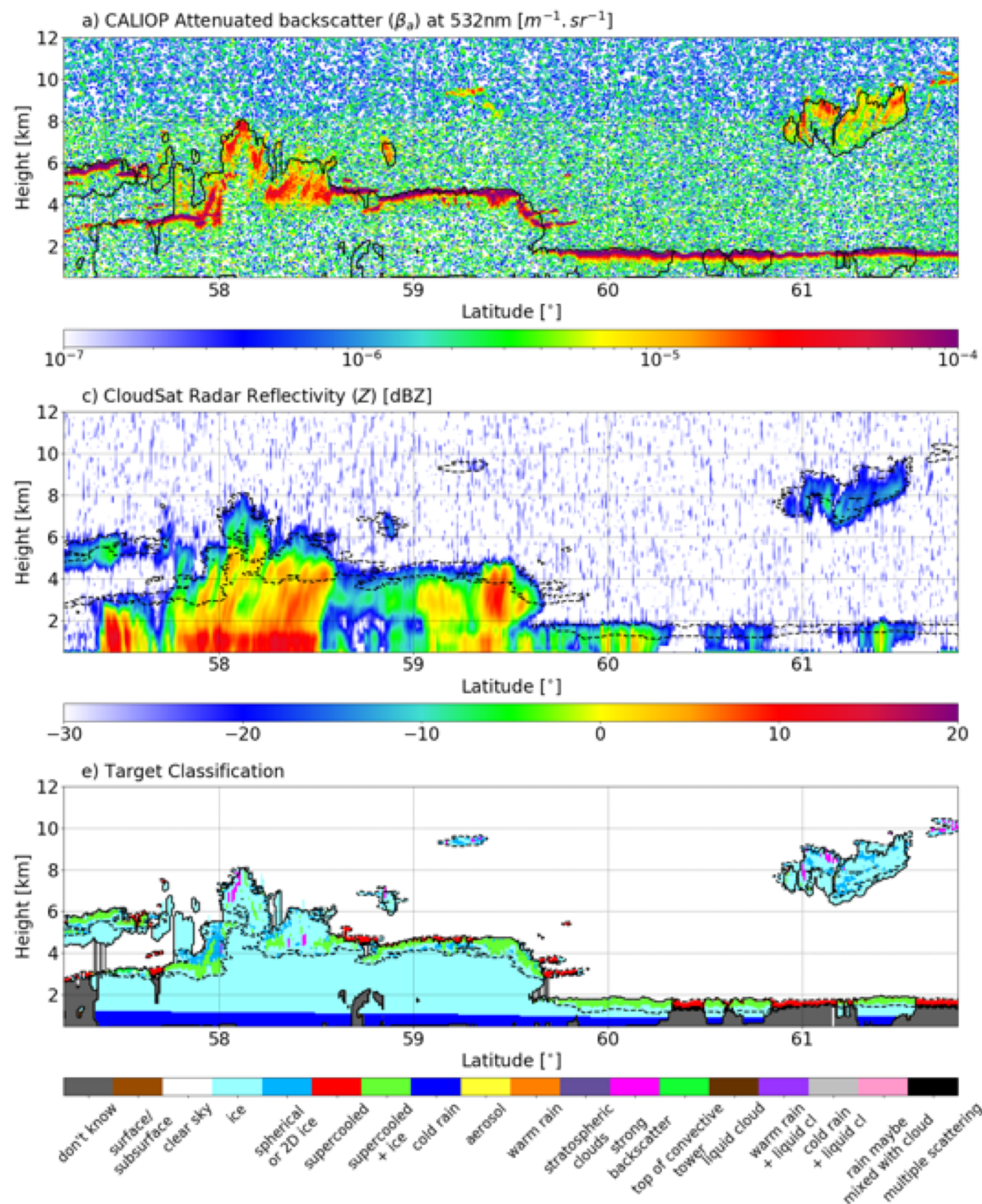
Anticyclonic situation on the northern Atlantic with a cyclonic activity around British The cloudy region located in the north of Scotland was favourable for intercomparisons between the aircraft and the A-Train underpass



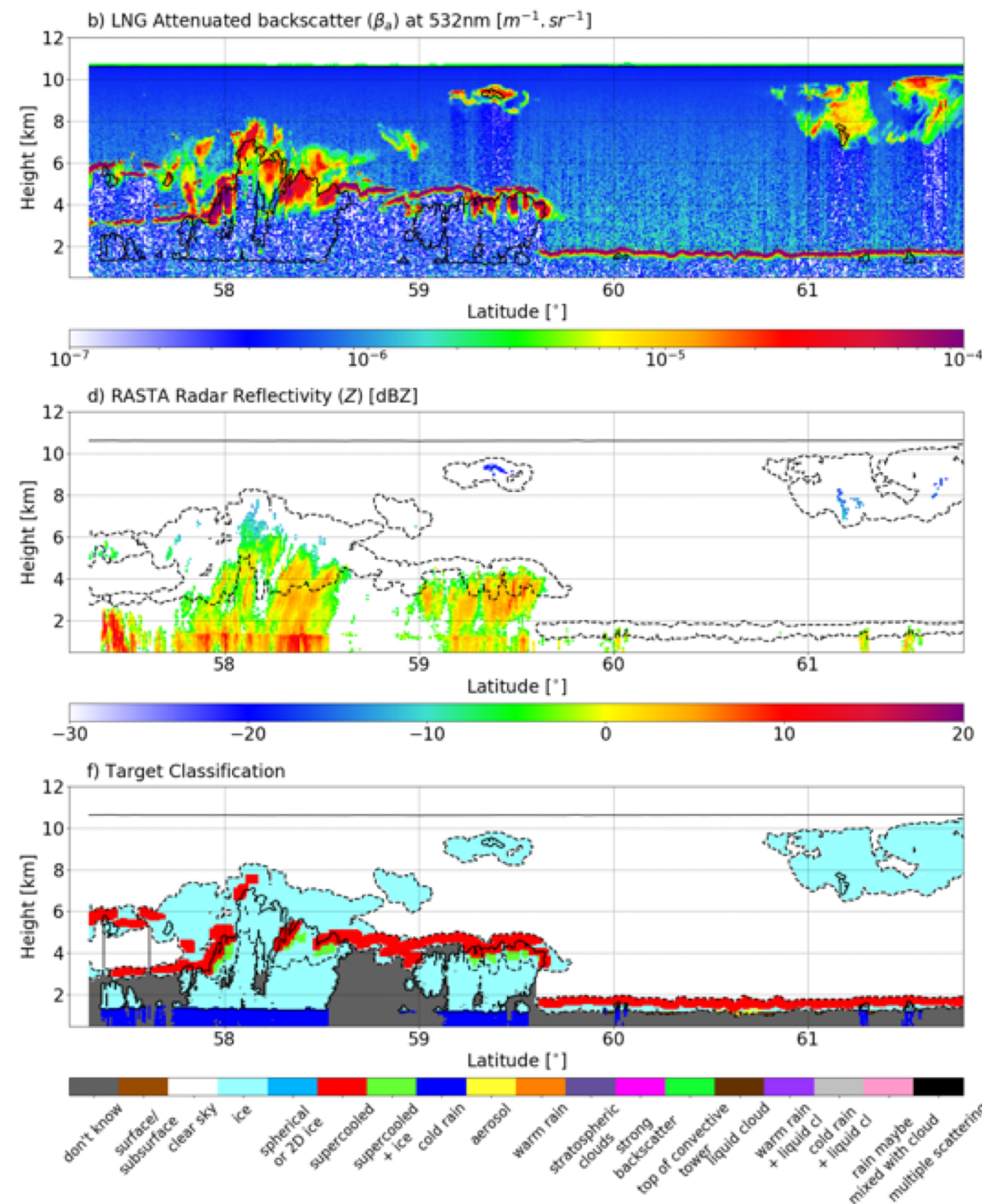
< 5 min

A-Train 2016/10/14: Cloudsat and CALIPSO

40 min

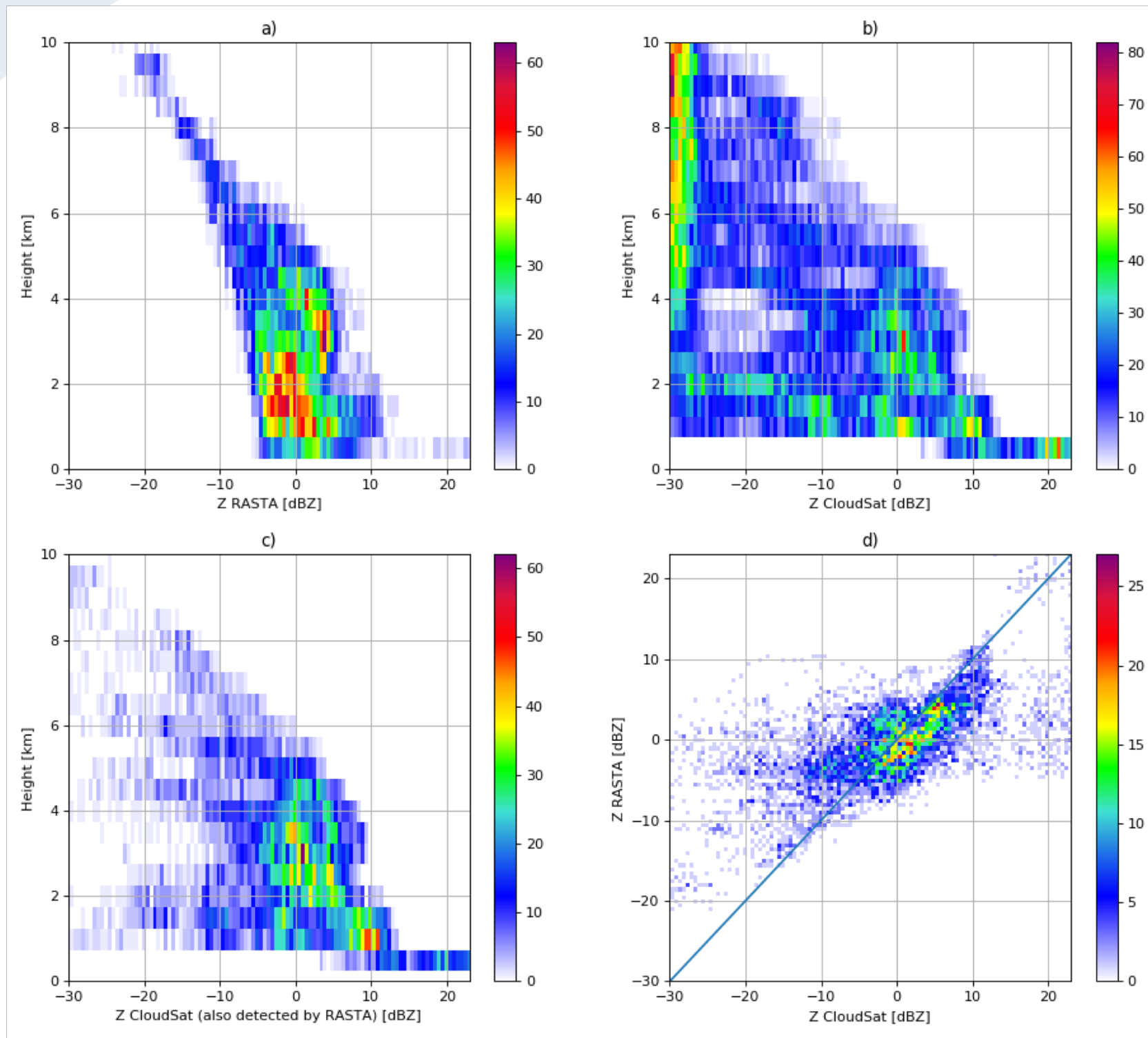


RALI 2016/10/14: RASTA and LNG



Complicated situation with heterogeneous cloud layers





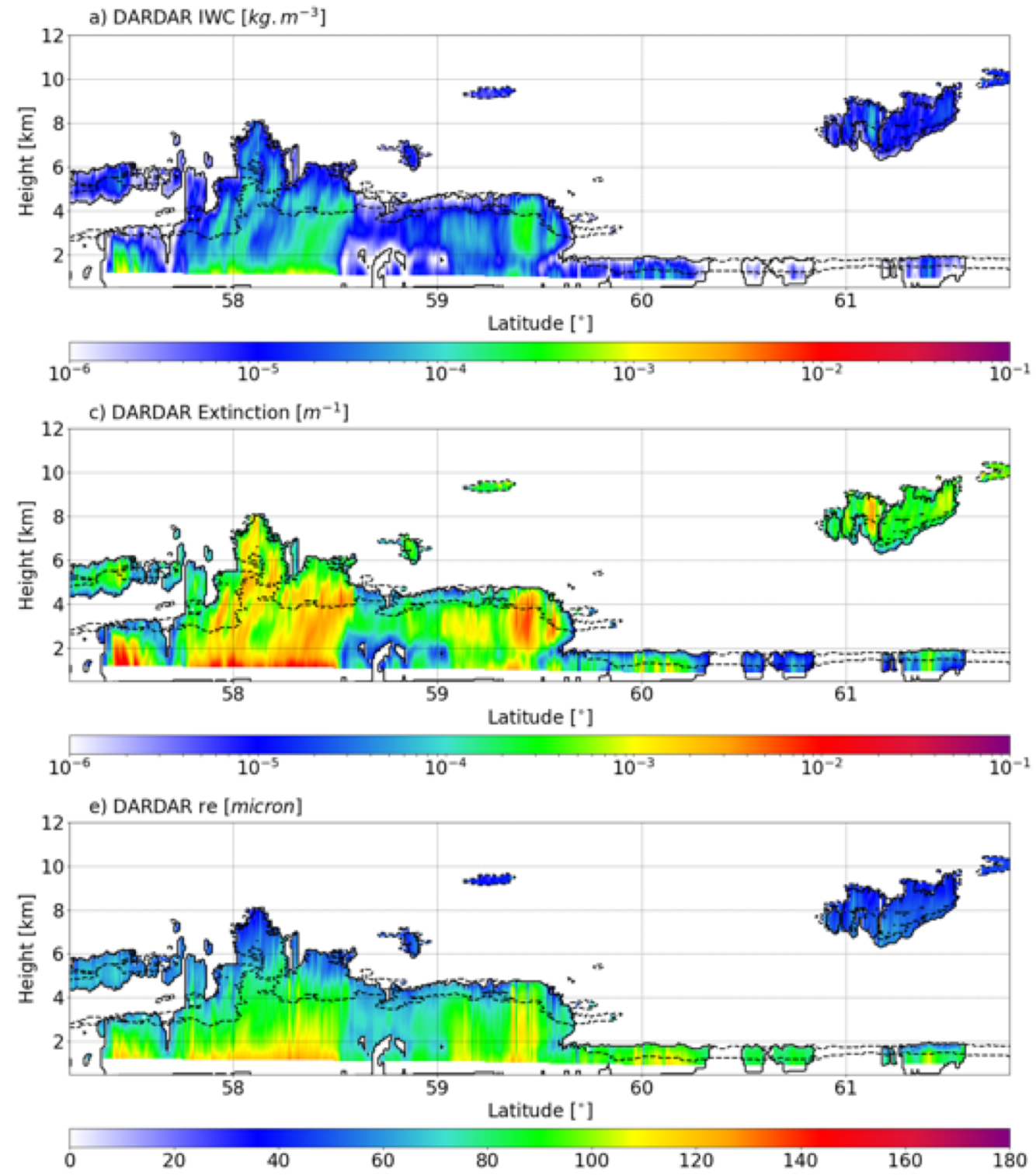
There is no obvious bias that could be due to a calibration issue so we could assume that the differences are due to mis-location of the cloud/precipitation system

In some cases, RASTA observes larger Z and in other cases lower values than CloudSat.

- ⇒ we cannot expect a good agreement between the retrieved properties.
- ⇒ The differences in reflectivity are also critical here as the lidar contribution is rather limited due to the strong extinction coming from the supercooled located at cloud top.



A-Train 2016/10/14: Cloudsat and CALIPSO



RALI 2016/10/14: RASTA and LNG

