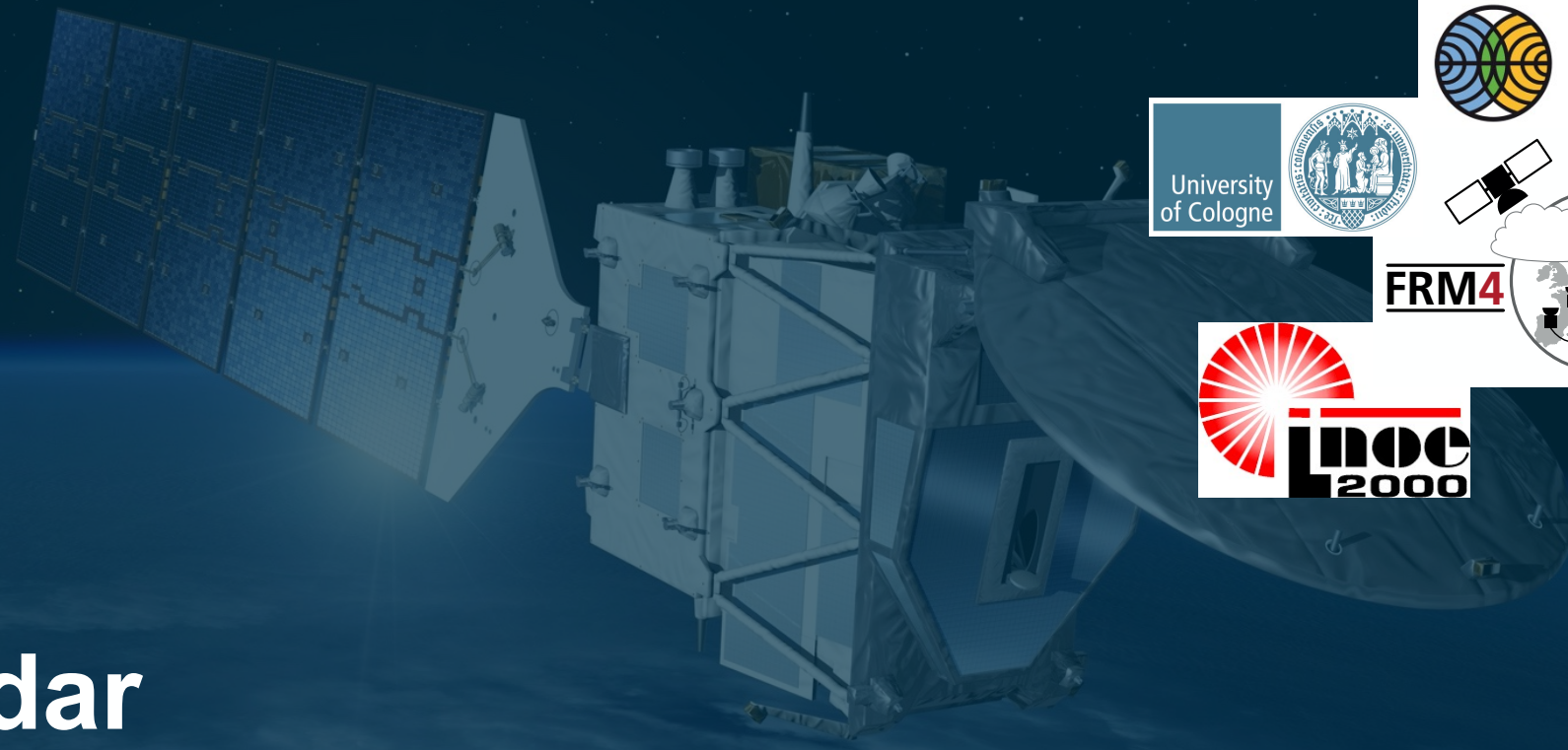


FRM4Radar
Cloud Profiling Radar Network for Satellite Validation

Lukas Pfitzenmaier[1], Pavlos Kollias[1,2], Annika Daehne[1],
Salomon Eliasson[3], Anke Thoss[3], Anca Nemuc[4], Bogdan Antonescu[4], Ewan O'Connor[5],Jonas von Bismarck[6]

1) University of Cologne, Germany, 2) Stony Brook University, NY, USA 3) SMHI, Norköping, Sweden 4) INOE, Bucharest,Romania, 5) Finish Meteorological Institute, Helsinki, Finland 6) Earth Observation Ground Segment Department, ESA / ESRIN, Frascati, Italy

2nd ESA EarthCARE Validation Workshop

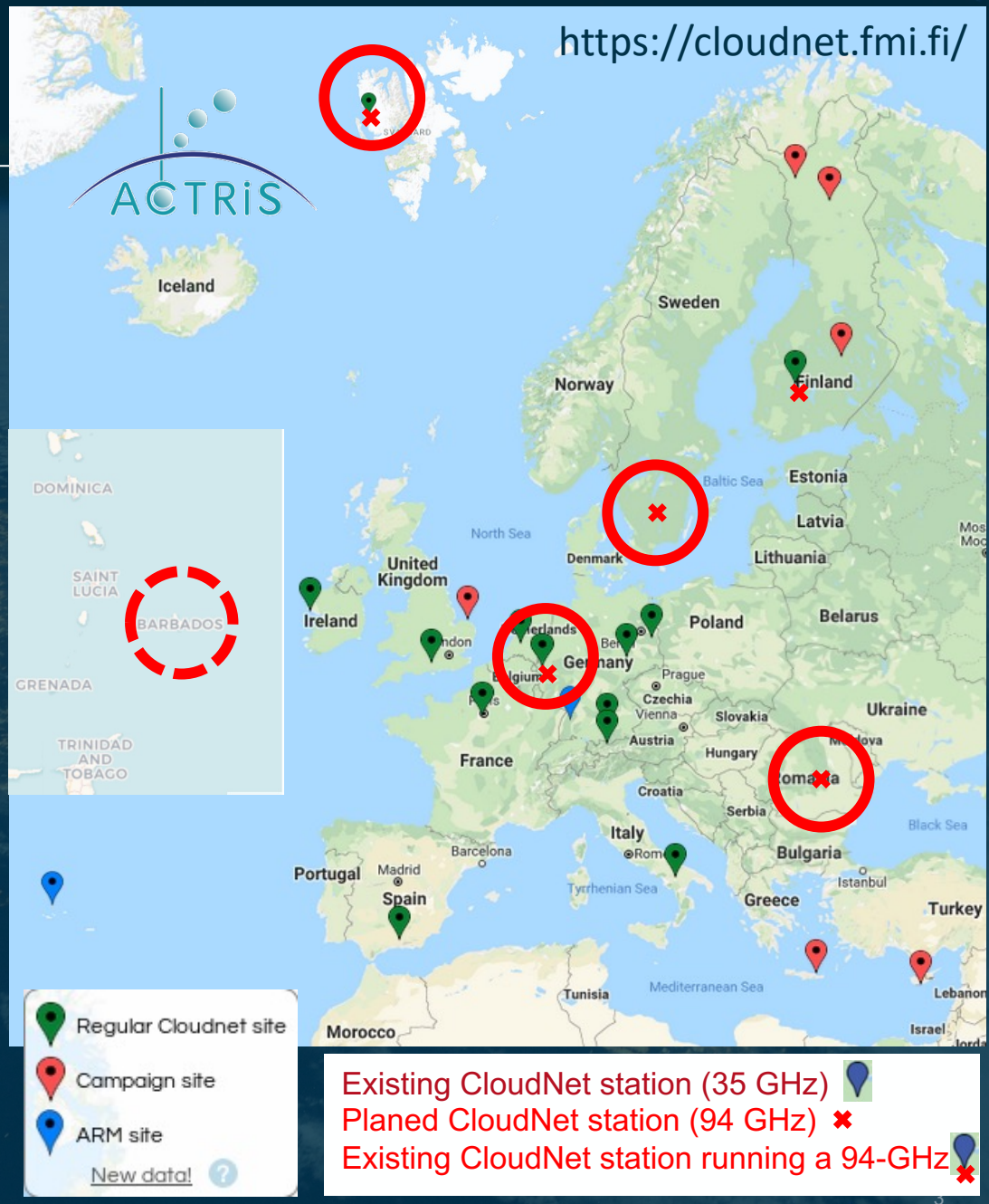
25-28 May 2021 (online)

Objectives of the FRM4Radar project

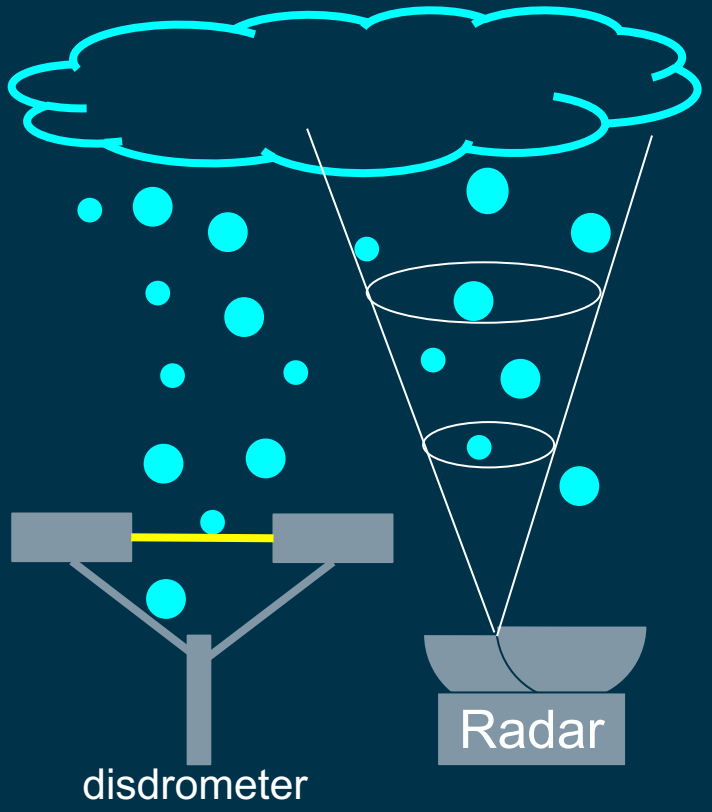
- Pave the way towards Fiducial Reference Measurements (FRM) for the EarthCARE Cloud Profiling Radar (CPR) L2 ESA products
- Increase confidence in the L2 ESA CPR products by means of ground-based radar observations
  - Quality check of data: C-FMR, C-CD
  - Quality check of retrieval products: C-CT, C-CLD
- Complementary 94-GHz radar network sites as part of CloudNet
  - Use to the **same wavelength as the EarthCARE CPR**
  - Fill geographical gaps in the European ground-based network
- Foster the development of new Cal/Val products
- Long term monitoring of the data – over years

THE FRM4Radar NETWORK

- Compliment the existing ground based radar network in the EU
  - fill gaps in under sampled regions
    (Sweden and Romania)
  - coverage of different cloud climate regimes (Svalbard and Babados)
- Operation of the radars
  - 24-7 operation
  - near real time data processing and visualization
  - with "GEOMS data format"
- Quality checks
  - received power calibration
  - antenna pointing characterization



EXAMPLE – Received power calibration



Disdrometer: optical particle counter to measure the droplet size distribution **N(D)**

→ Forward modeling of expected radar Ze based on measured N(D)

→ Offset calculation by the statistical comparison of Ze_disdro to the Ze_radar

Kollias et al., 2019, AMT ; Myagkov et al., 2020, AMT

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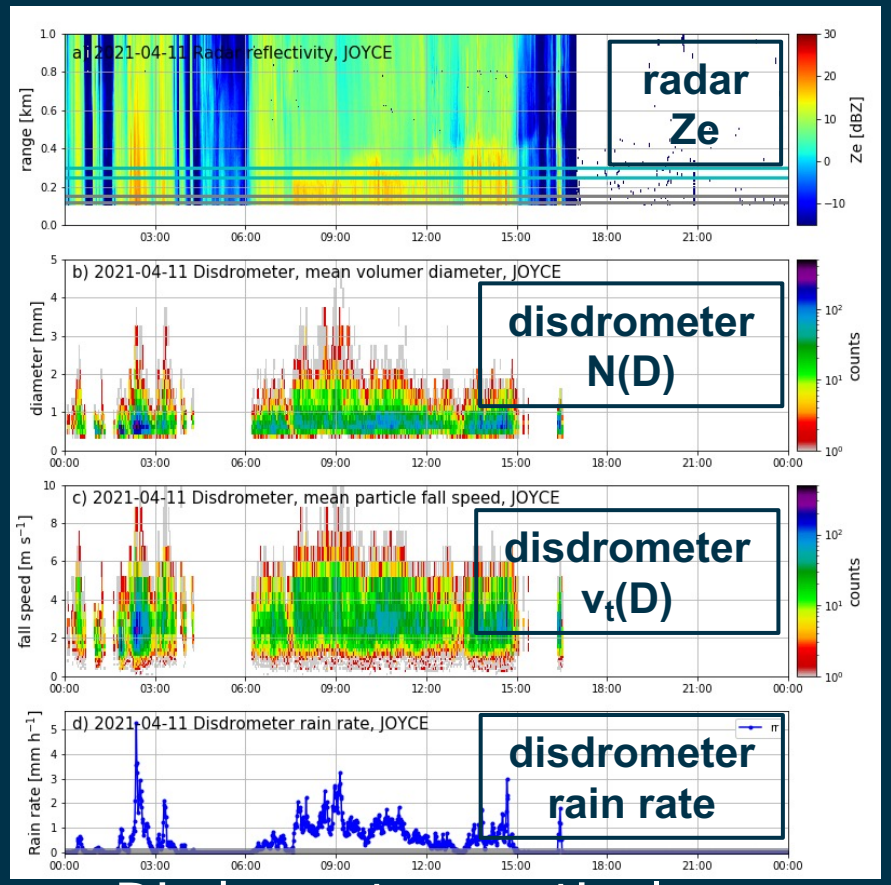

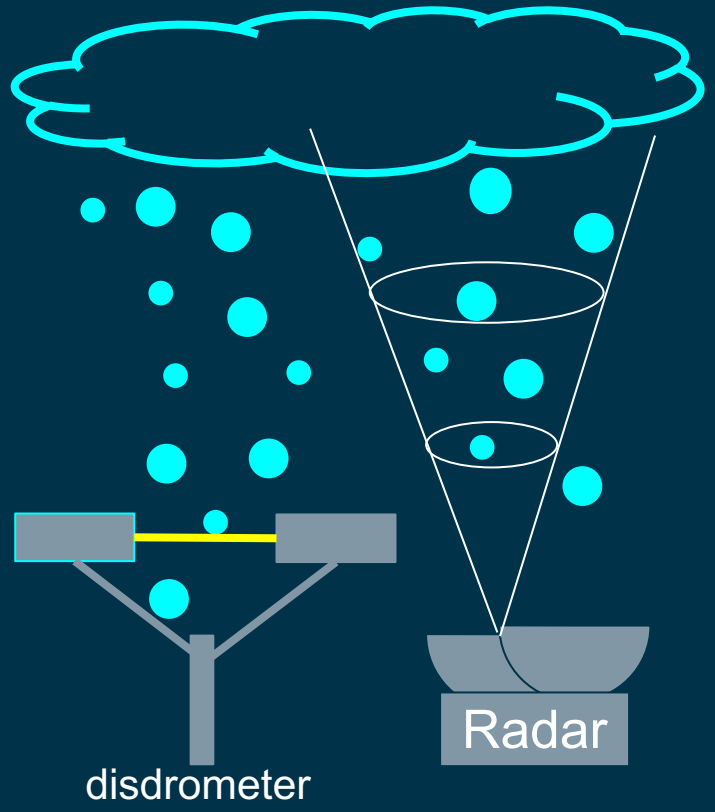

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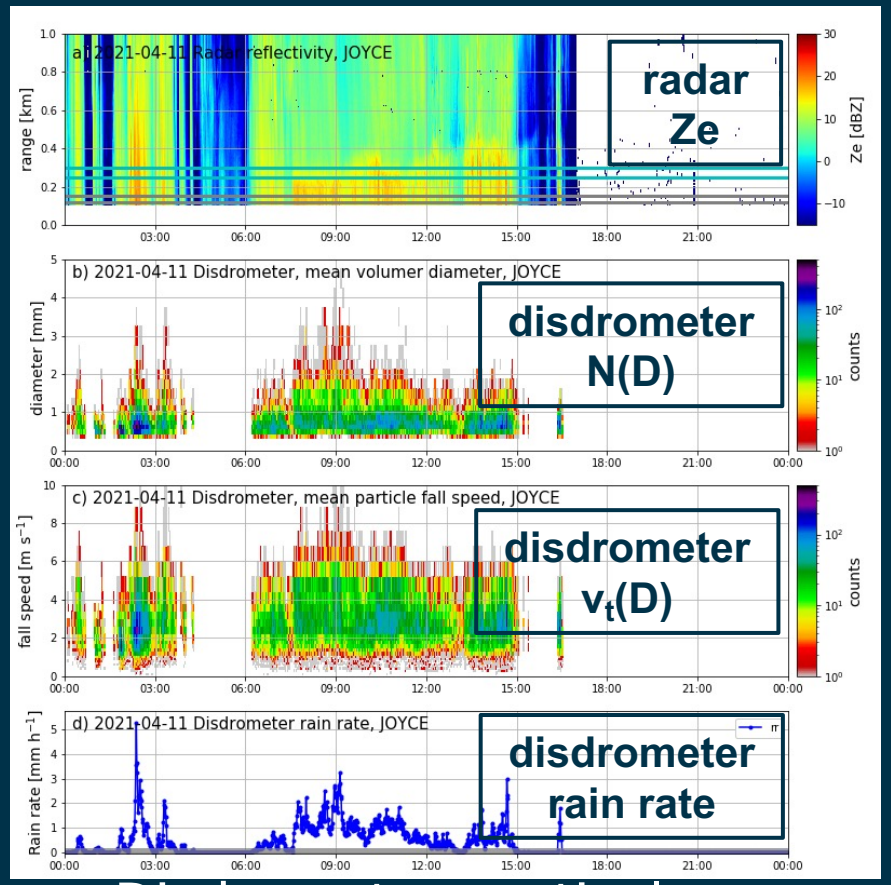

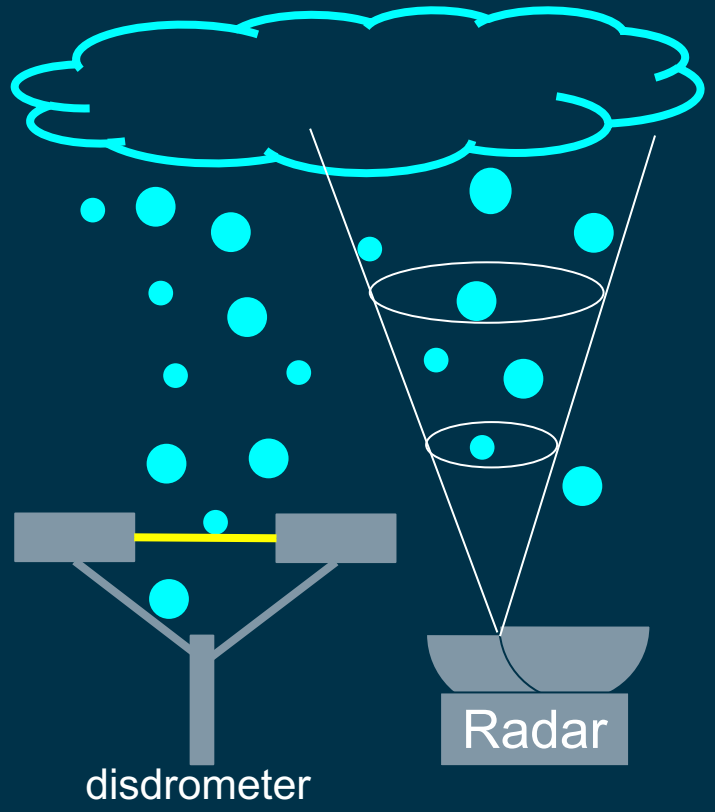

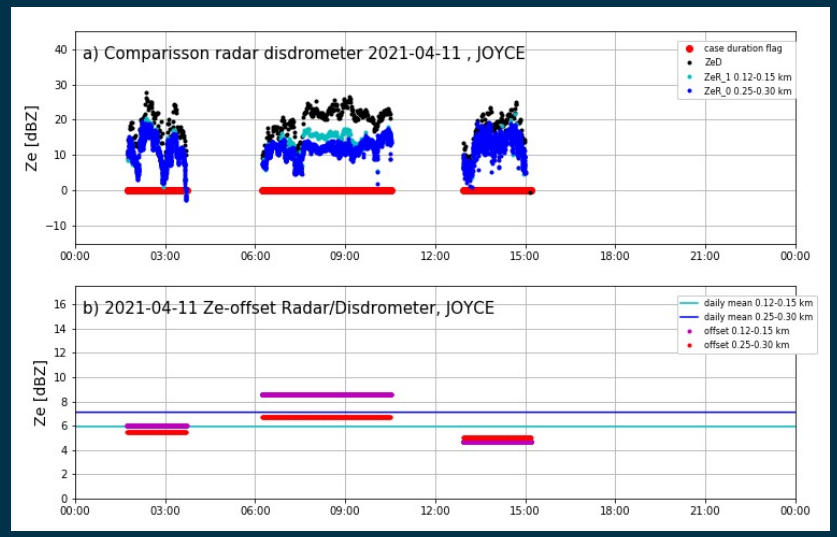

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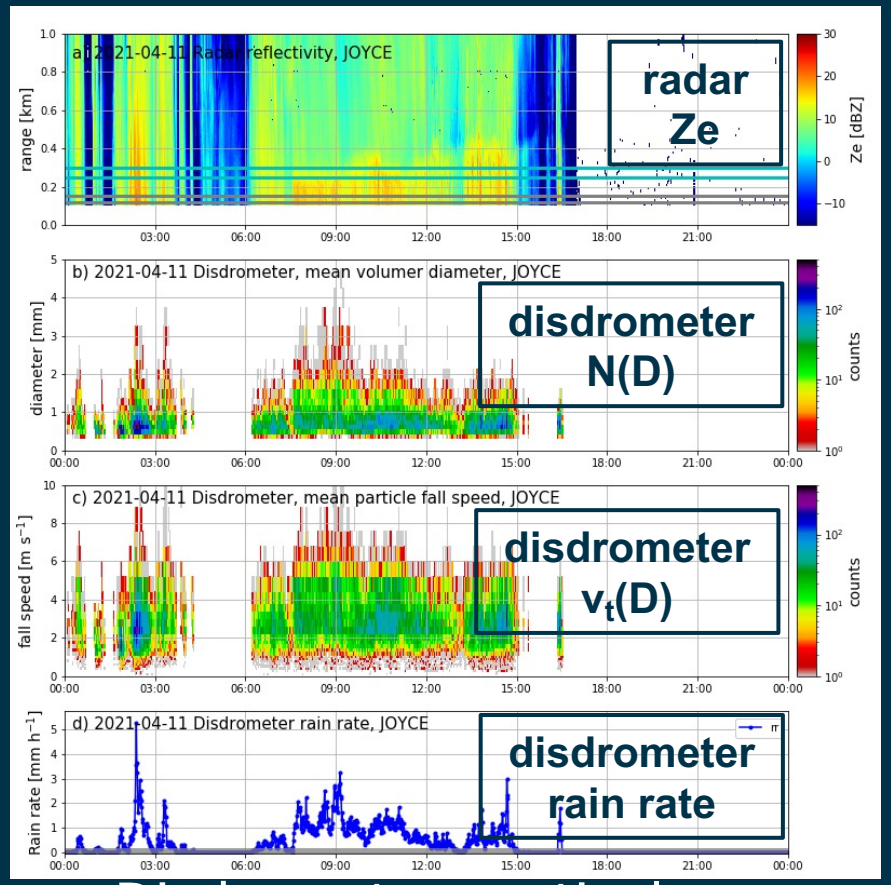
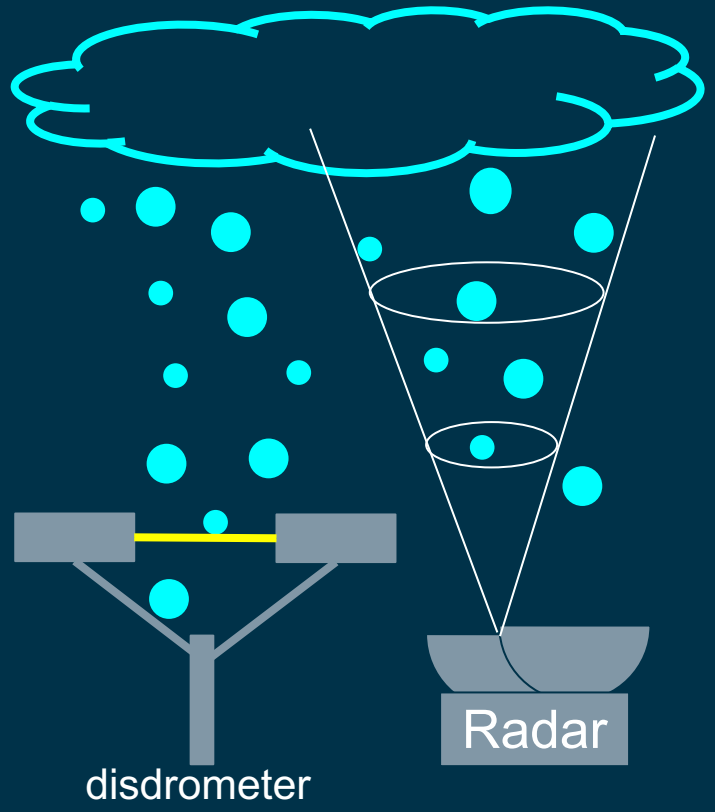
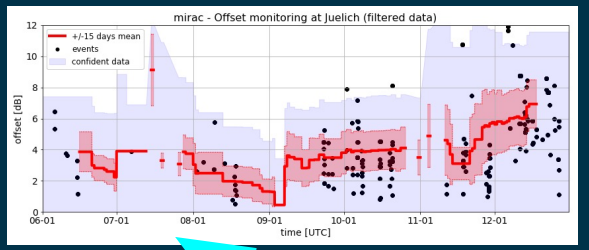
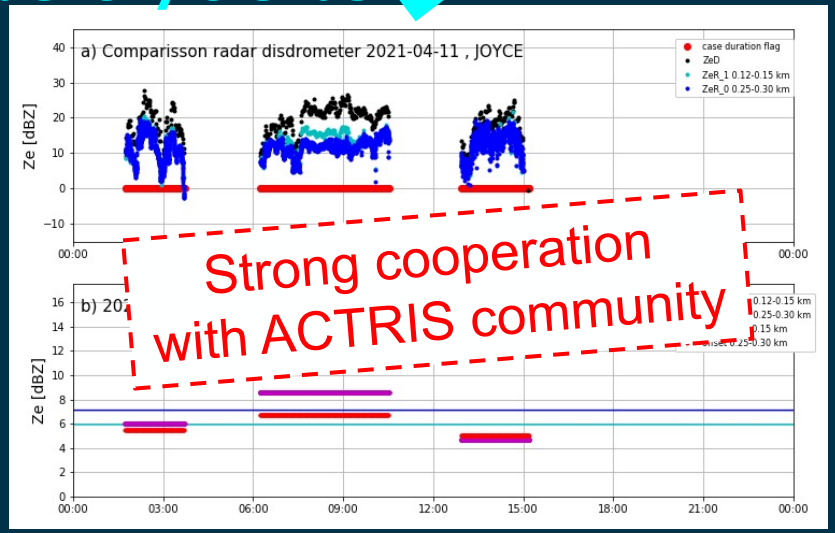






Long term statistics to identify trends



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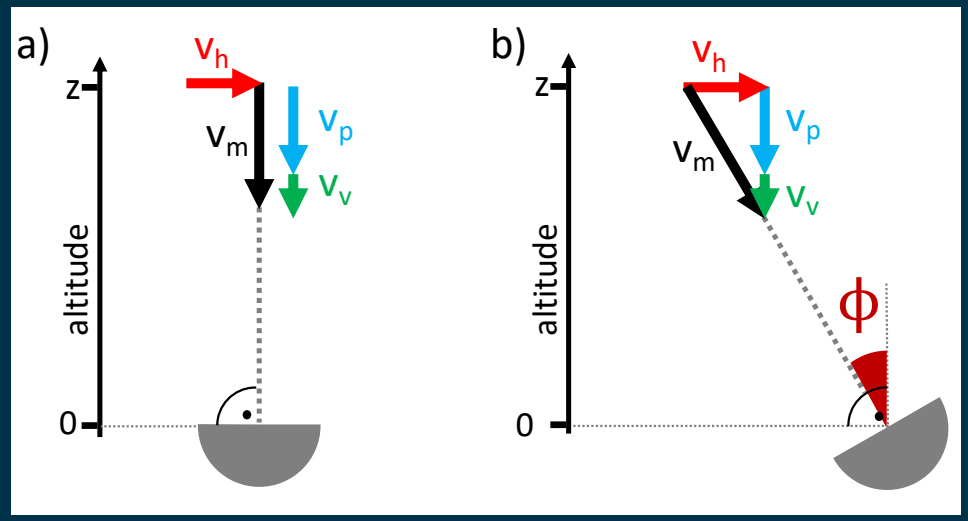
Example – antenna pointing characterization

zenith pointing off-zenith pointing



Error in the measured Doppler velocity (v_m) is a function of ϕ, v_h, and wind direction

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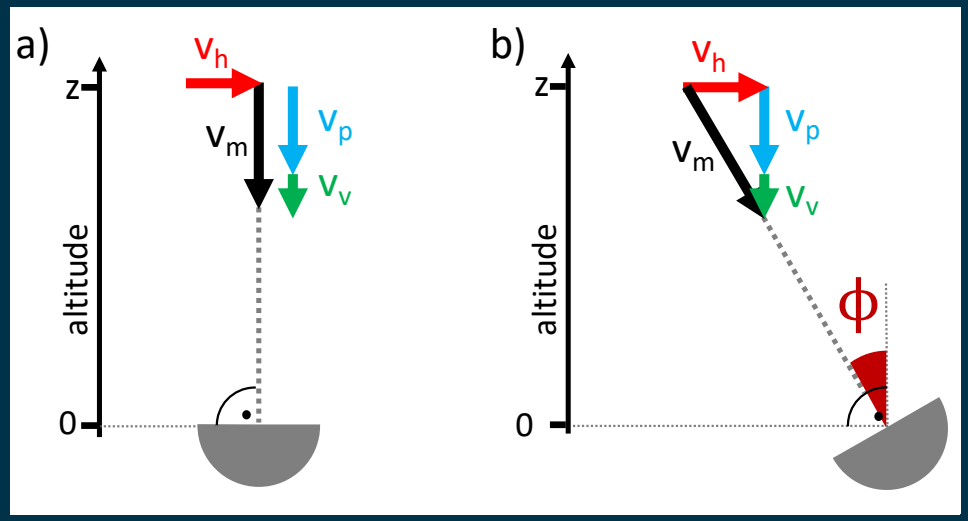
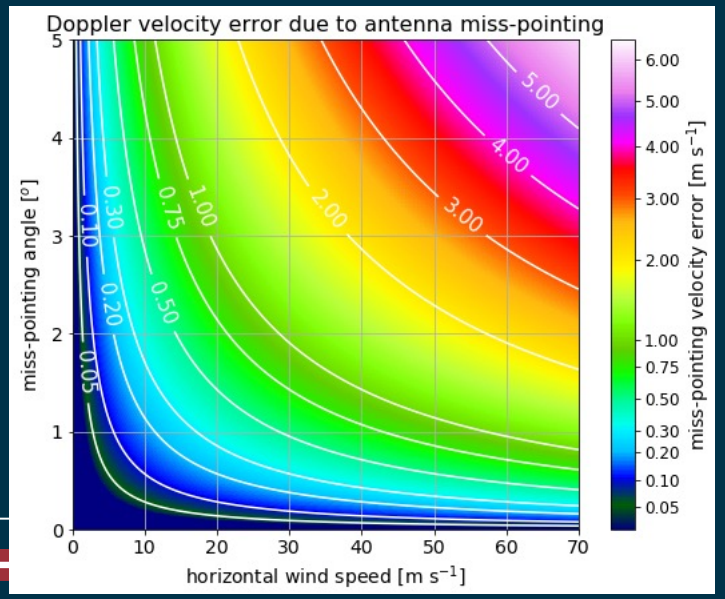


Error in the measured Doppler velocity (v_m) is a function of ϕ, v_h, and wind direction

Retrieval is based on: 3 month statistical analysis of wind and Doppler velocity

For cirrus clouds:
Miss-pointing can cause up to 0.2 ms^{-1} error in v_m



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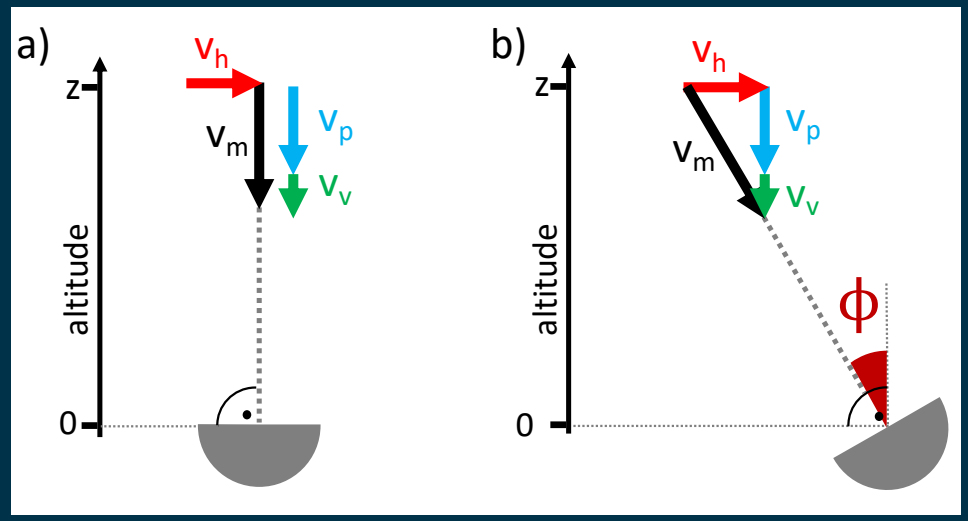
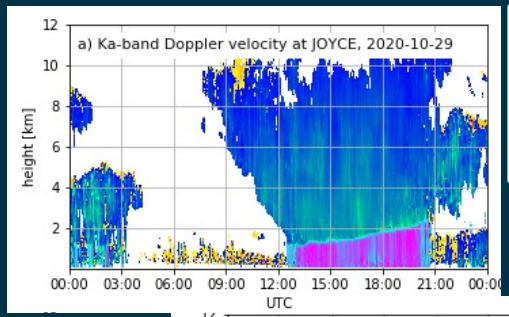
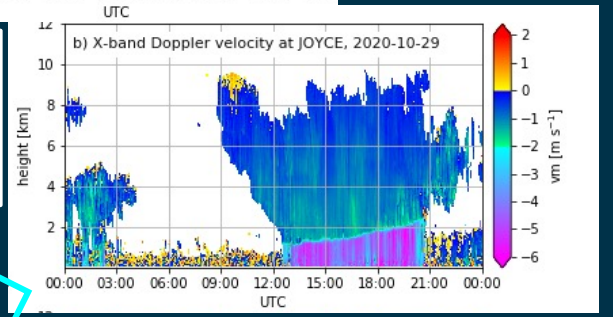


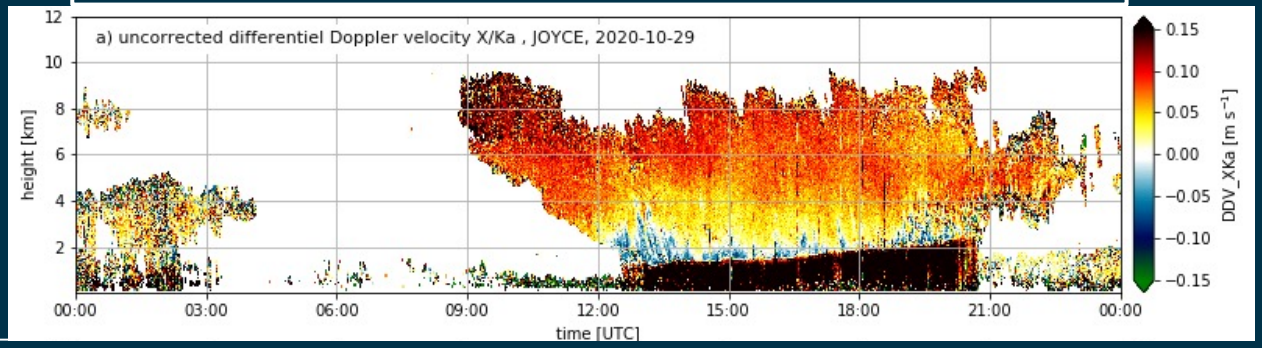


Ka-band v_m

X-band v_m

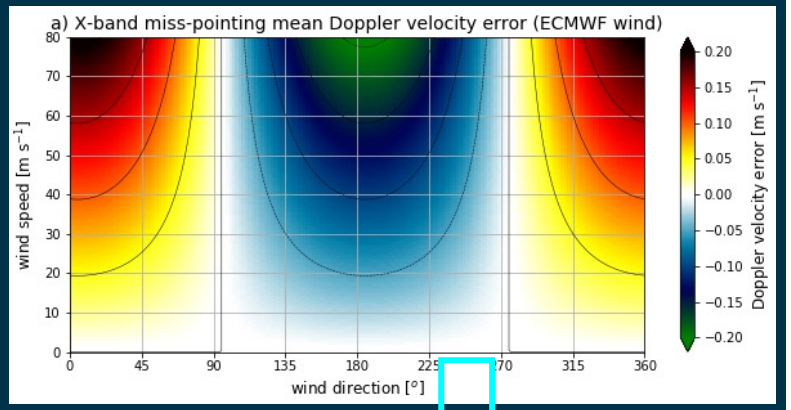


if antennas point zenith
X-band v_m- Ka-band v_m ~ 0 ms^{-1} in the cloud
this is not the case here



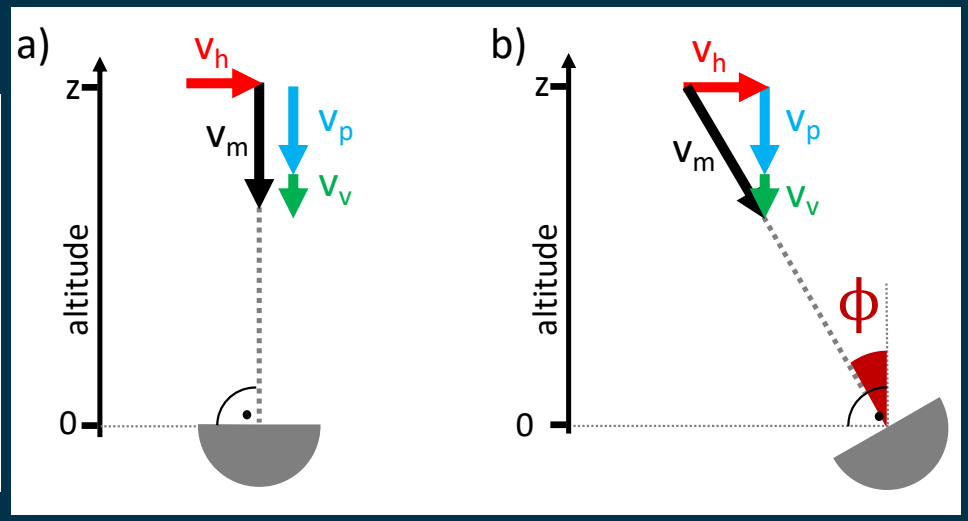
Example – antenna pointing characterization

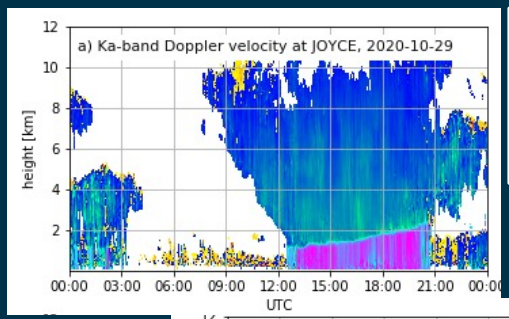
Retrieval of miss-pointing angles:
Ka-band = 0.04°
X-band = 0.15°



zenith pointing

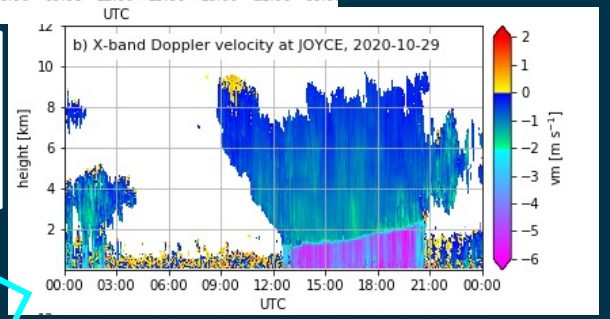
off-zenith pointing



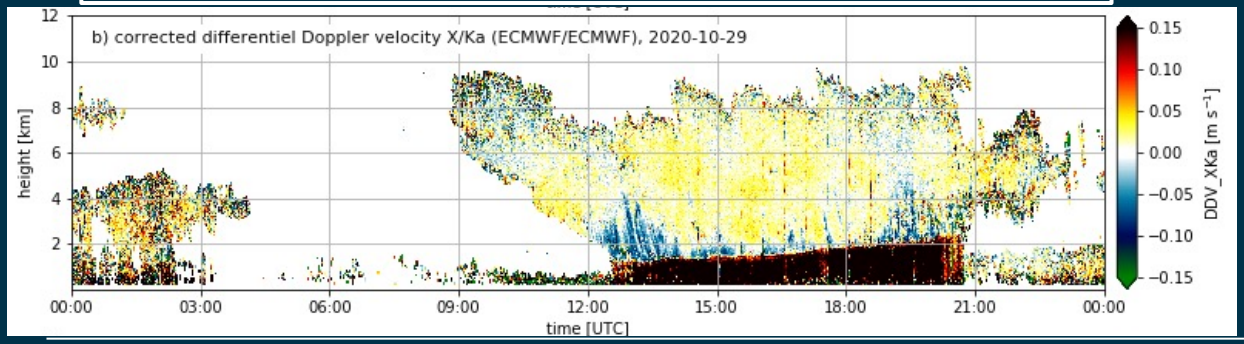


Ka-band v_m

X-band v_m



corrected off-zenith pointing in the v_m fields:
X-band v_m- Ka-band v_m ~ 0



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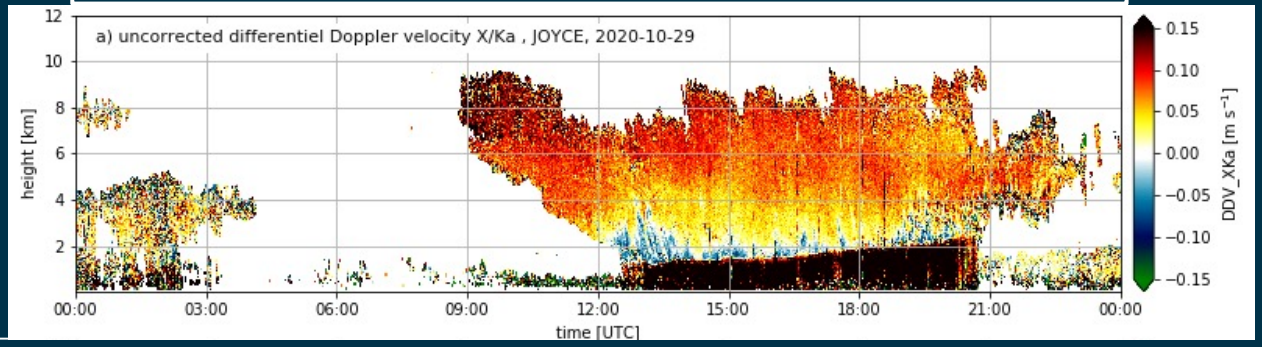
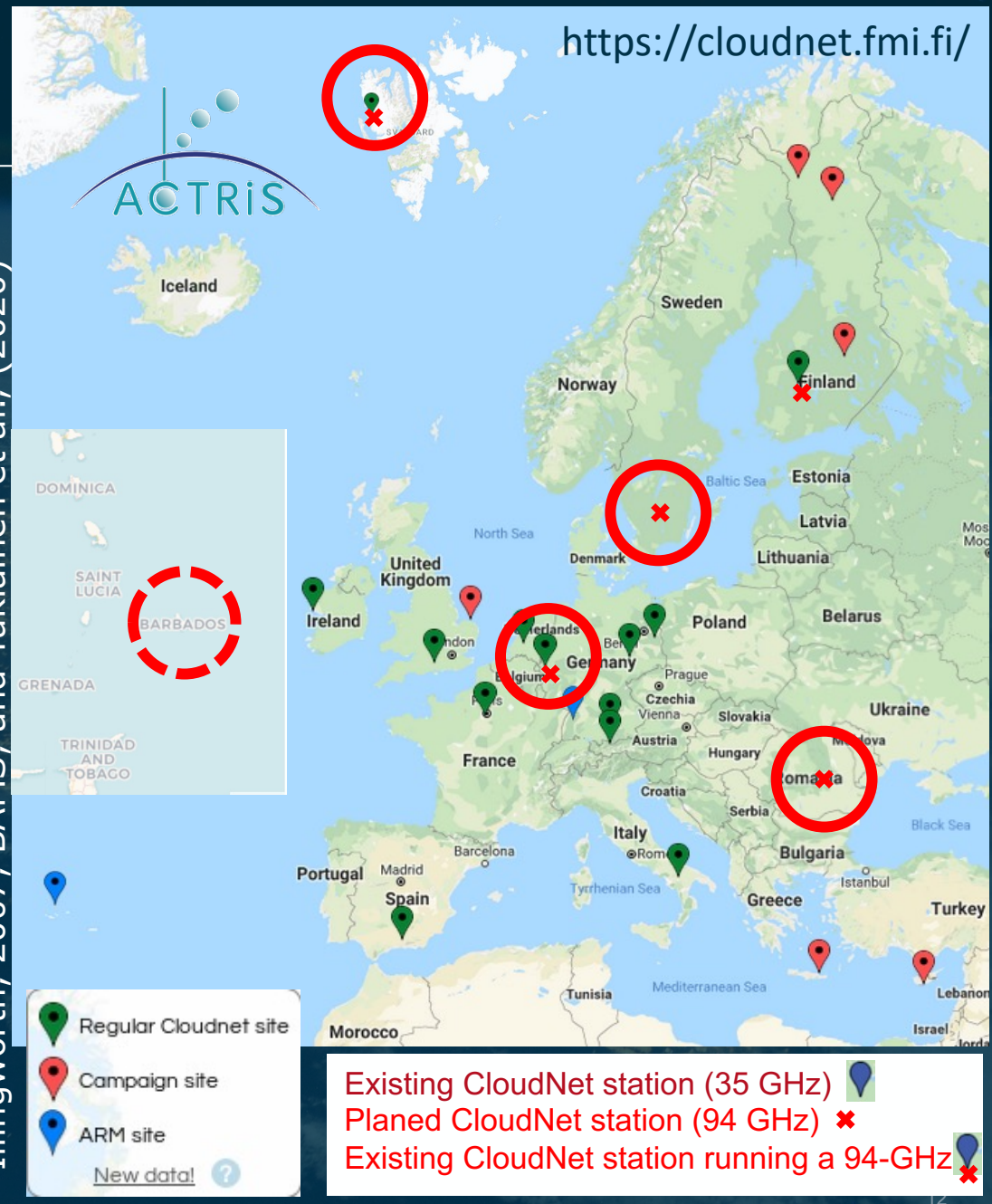


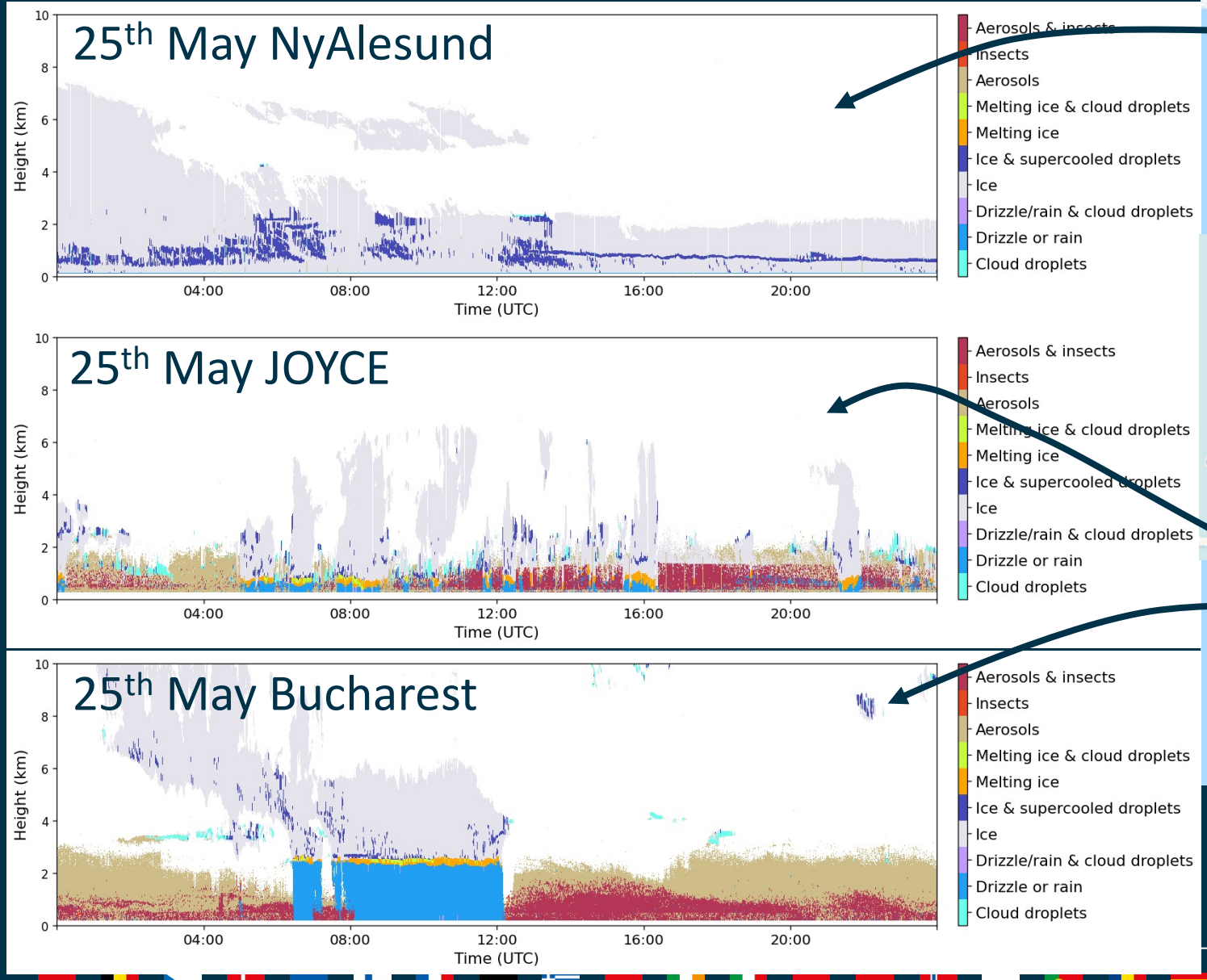
THE CLOUDNET ALGORITHM

- Compliment the existing ground based radar network in the EU
  - fill gaps in under sampled regions
  - coverage of different cloud climate regimes (Svalbard and Babados)
- Operation of the radars
- Quality checks
  - Collaboration with the ACTRSI network
- Instrumental synergy with ceilometer
  - run 94-GHz version of Cloudnet algorithm (no microwave radiometer needed)*
  - target classification algorithm*
  - improve CloudNet coverage in Europa

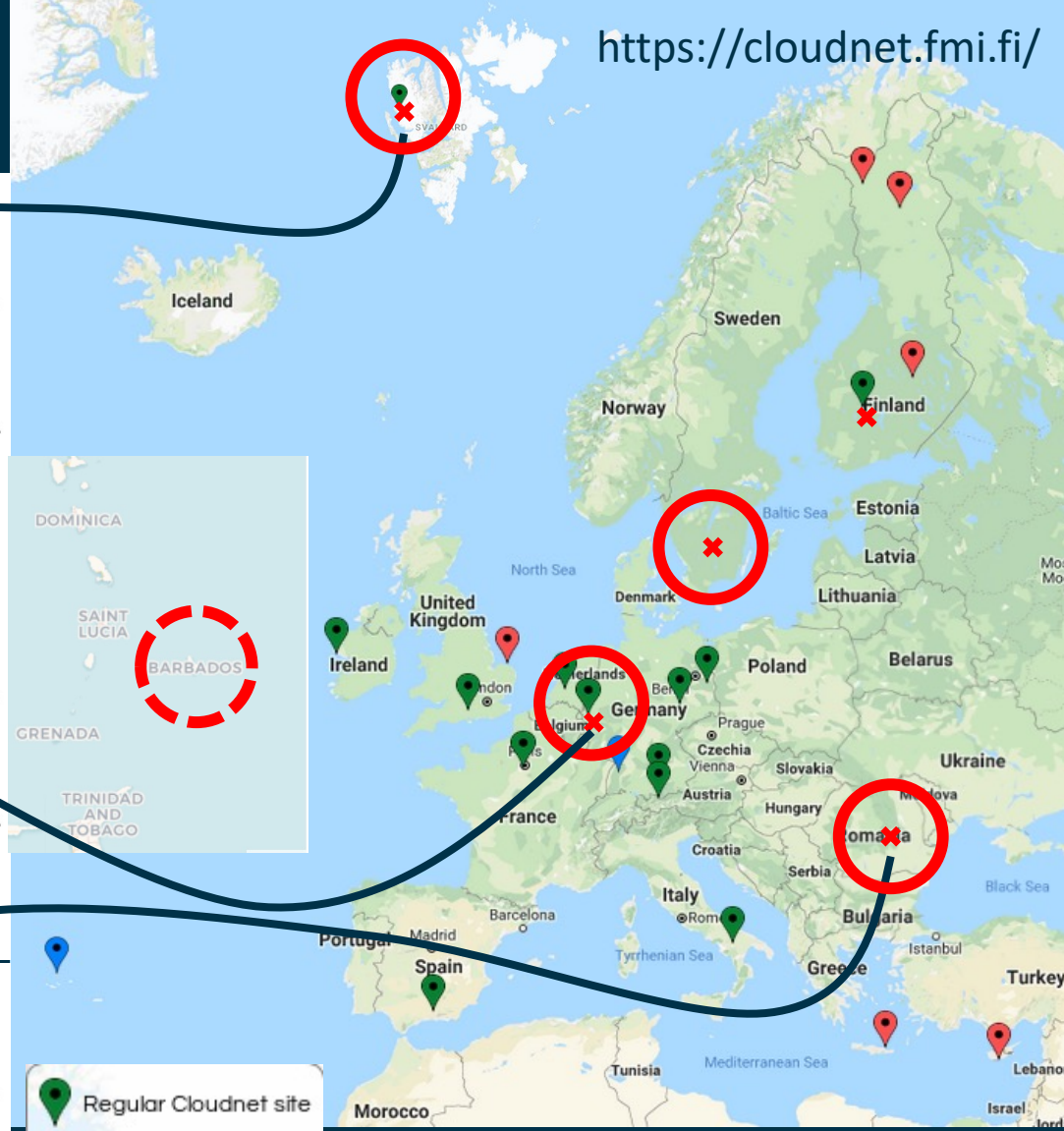


*Illingworth, 2007, BAMS, and Tukiainen et al., (2020)

THE CLOUDNET ALGORITHM



https://cloudnet.fmi.fi/

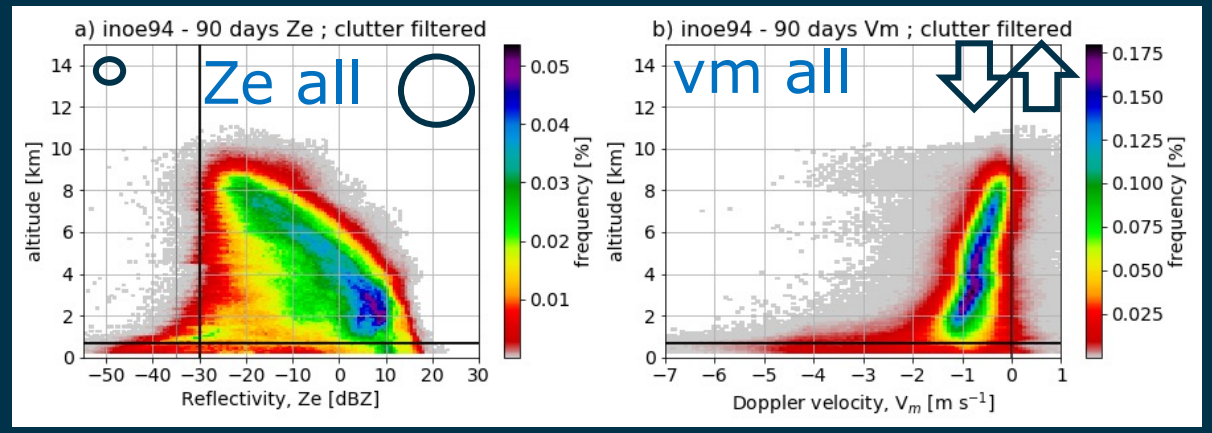


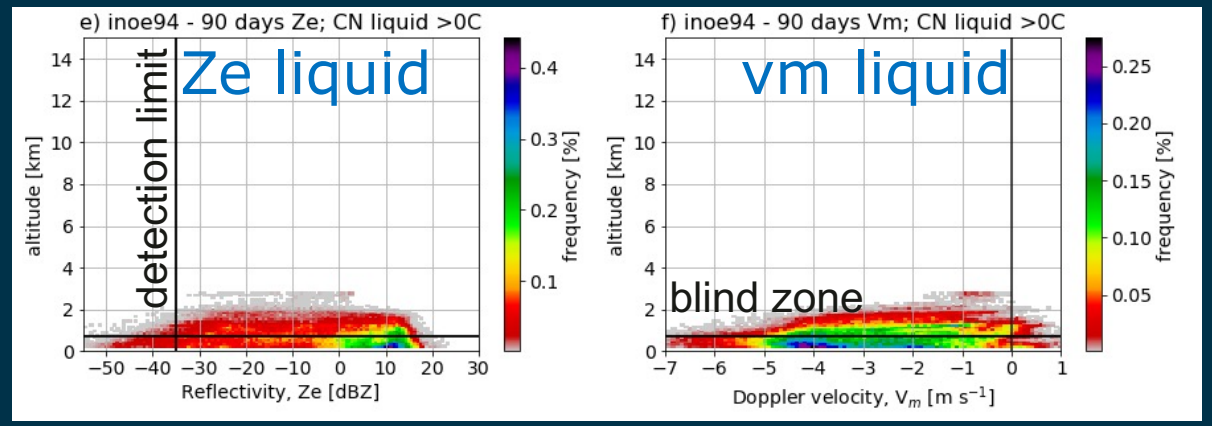
Existing CloudNet station (35 GHz)
Planed CloudNet station (94 GHz)
Existing CloudNet station running a 94-GHz

Example:
Comparison of INOE and SMHI winter 2020 Observations

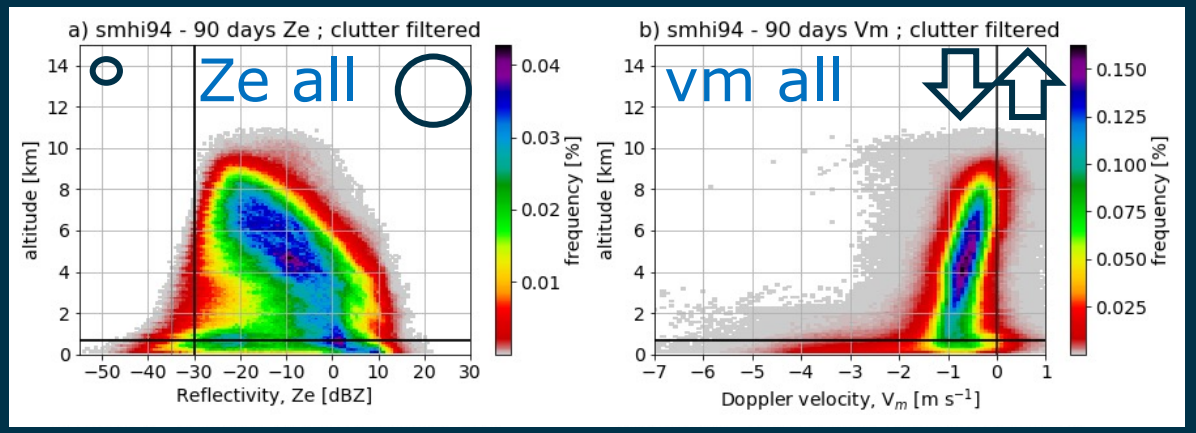
Comparison of liquid precipitation and target classification

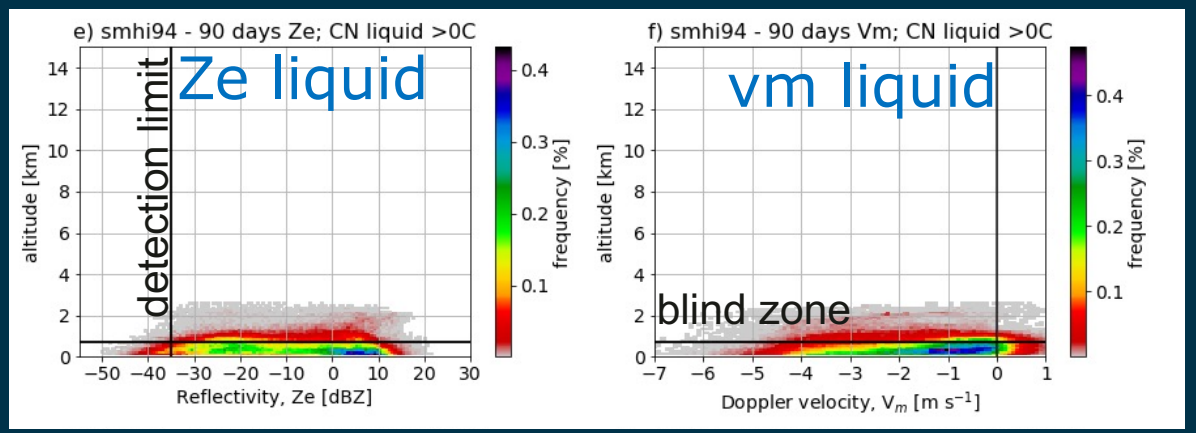
Bucharest, Romania





Norunda, Sweden





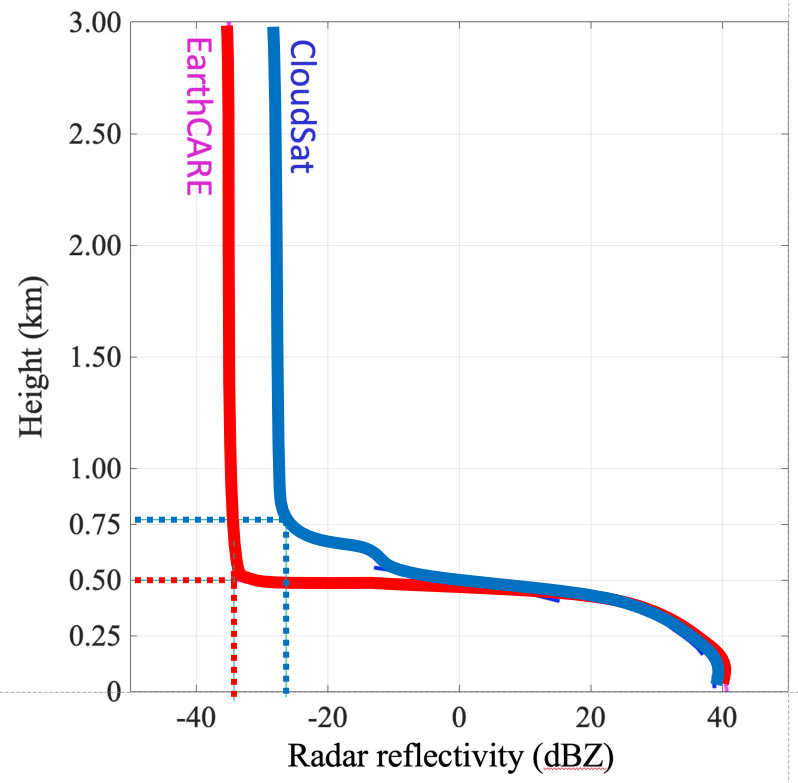
almost all rain below detection limit

Use of long term observations for model and CPR evaluation

- Long data set with good quality (GEOMS)
- Cloudnet target classification
- Covering different cloud climate regimes (Arctic, mid and continental EU, Caribbean)

- EarthCARE has an improved detection
- We need to account for differences in sensitivity, attenuation effects, and the surface blind zone

Performance in low-level clouds



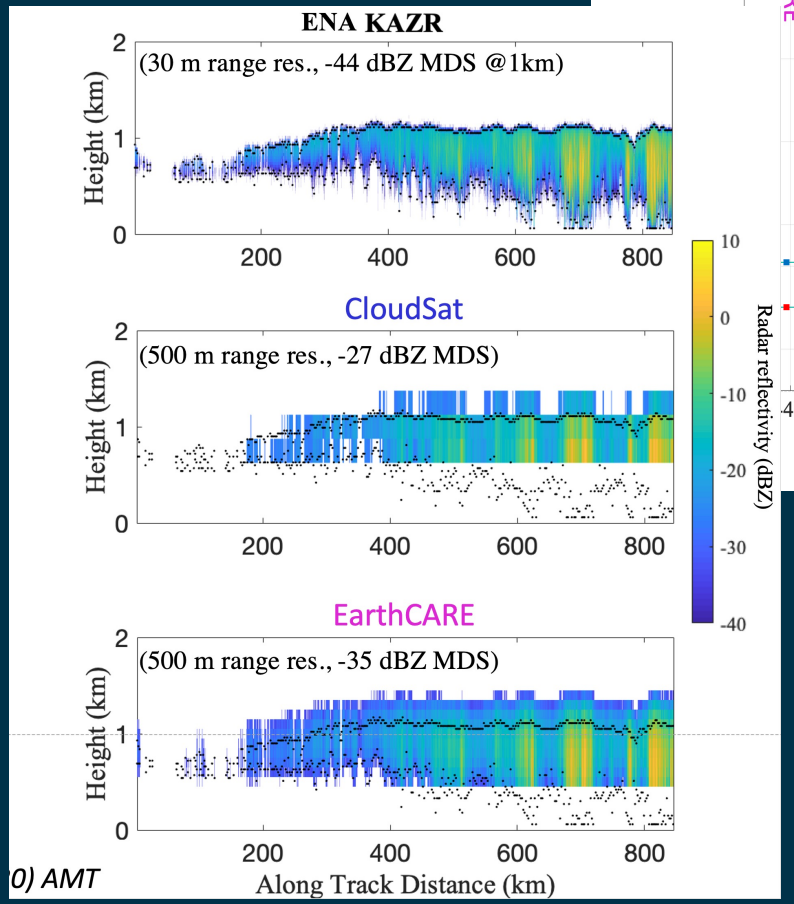
Lamer et al., 2020, AMT and IEEE

Use of long term observations for model and CPR evaluation

In the next phase:

- develop a simple radar forward model based on Lamer et al., 2020 that will account for differences in:
  - sampling
  - sensitivity
  - surface clutter

  between the ground-based and space-based observations.
- Apply the simulator to the FRM4Radar observations to convert them to a top-down view (CPR)
- enable a more objective comparison between the CPR and FRM4Radar measurements.
- The same framework can be applied to model - CPR comparisons.



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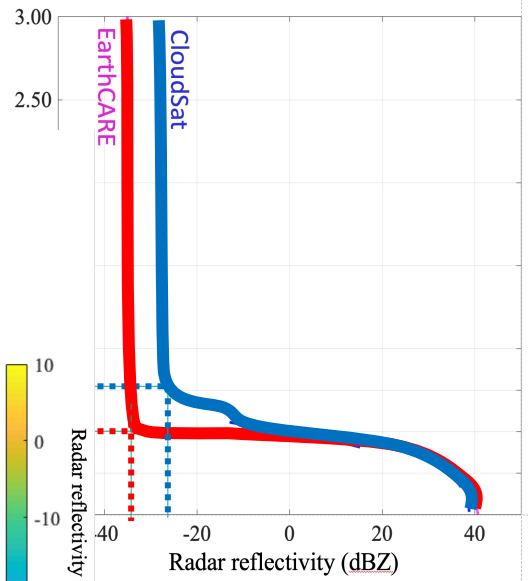

Lamer et al., 2020, AMT and IEEE

FRM4Radar project summary

FRM4Radar home page:

- Documentation of radar operation and procedure for quality control
- https://geomet.uni-koeln.de/forschung/frm4radar

Online quicklook archive

- Measurements, instrument status and soon quality control products
- https://geomet.uni-koeln.de/forschung/frm4radar/quicklooks

Data available via CloudNet web portal

- https://cloudnet.fmi.fi/

3 month test data set till end of the year (GEOMS)

- Spectral data -> I.pfitzenmaier@uni-koeln.de