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Versatile Cloud Radar



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Cloud Radars

- Cloud radars are still very expensive for scientific community or civil applications
- Networking of cloud radars is costly
- Pulse cloud radars need very powerful transmitters making them very expensive
- A highly portable radar and very versatile system with low power consumption much needed.



BASTA in a Nutshell

- Based on the LATMOS development, Meteomodem distributes the mini-BASTA
- BASTA : Bistatic Radar System for Atmospheric Studies (Delanoë et al. 2016 AMS)
 - Uses FMCW emission
 - System very compact and portable
 - Easy to calibrate (end to end calibration)
 - Wide range of applications over fog and cloud microphysical properties, light precipitation, volcanic ash
 - A tool for decision making and for atmospheric research



A Bit of History

2006: Beginning of the project

2009: First measurements

2010: The first prototype is operational at SIRTa

2013: Collaboration with BOM (Bureau Of Meteorology, Australia)

2014: **BASTA-Aussie** (Darwin) and **BASTA Mobile**

2015:

- Field campaign at Charles De Gaulle airport – Fog nowcasting
- Collaboration with OPAR (Observatoire de Physique de l'Atmosphère de la Réunion)
- Development of **BASTA mini**
- Collaboration with OPGC (First volcanic ashes campaign)
- Technology transfer to **MODEM**

2016: Deployment BASTA-La Réunion at La Réunion

2018:

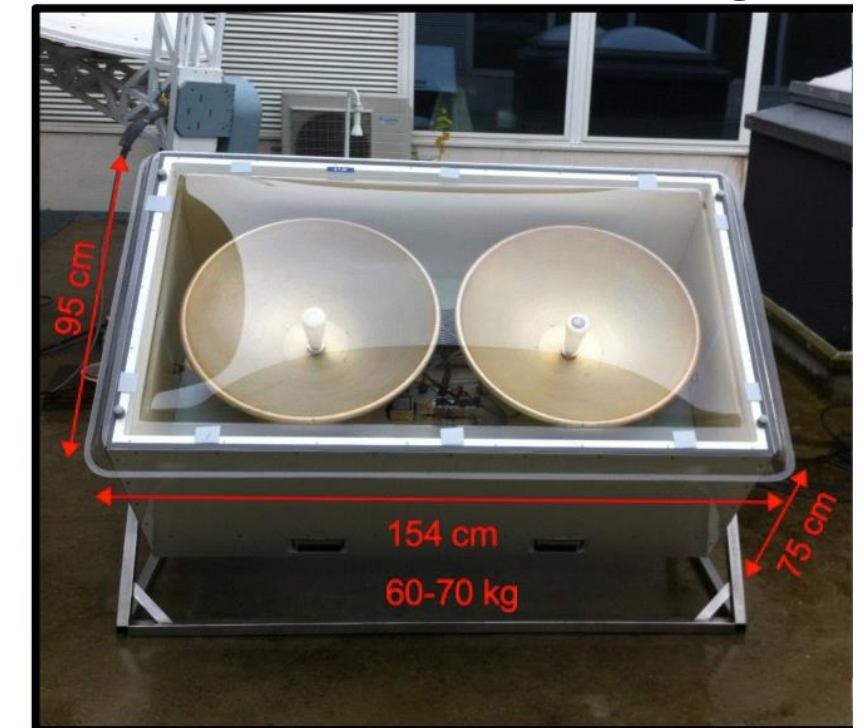
- BASTA for Météo-France
- Airborne BASTA development

2019:

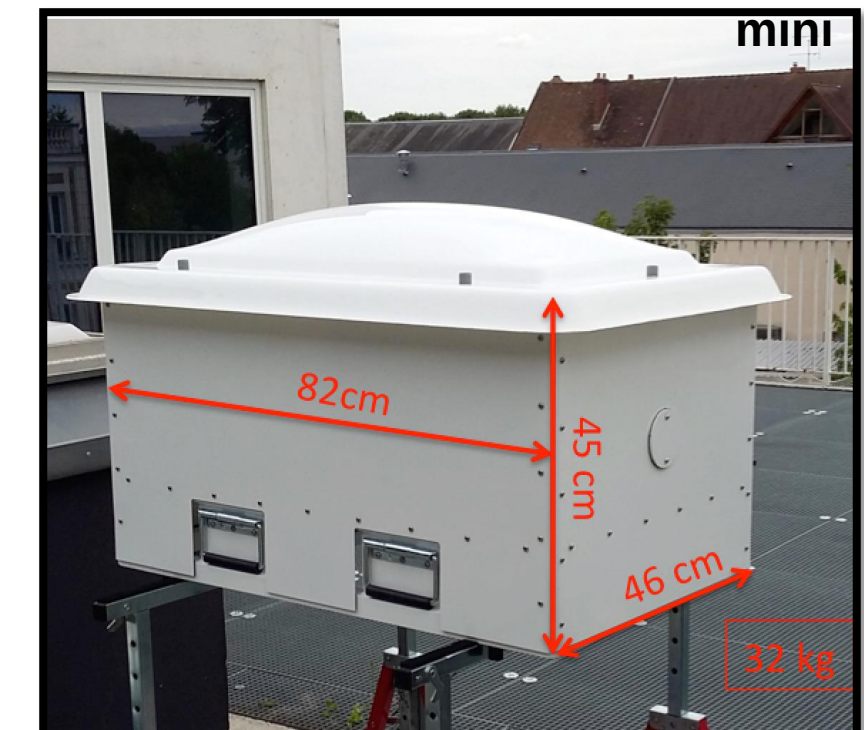
- I and Q
- Airborne BASTA (ATR42-EUREC4A)
- Dedicated BASTA to CCRES (ACTRIS)

Frequency 94-96 GHz
Power ~0.5-1 W
Integration time 0.5-10s
Beam width 0.4-0.8°
Range ~40m-24km
Non-polarized
Temperature & pressure controlled

BASTA



BASTA mini



BASTA – « around the world »

BASTA-SIRTA (J. Delanoë): 2010-2017 and 2017-... ACTRIS/FOG and calibration field campaigns

BASTA-AUSSIE (A. Protat):

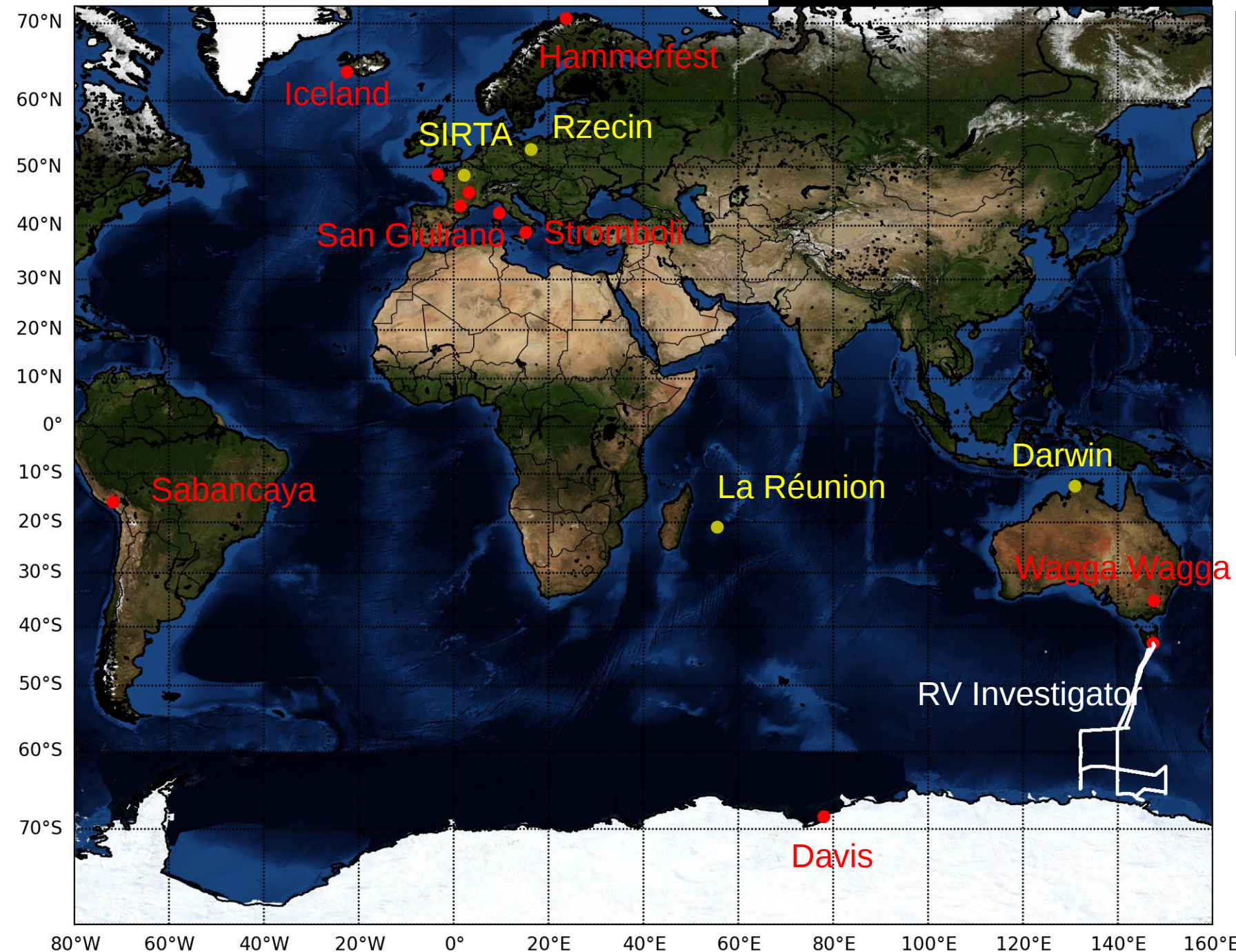
- DARWIN 02/2014-02/2015
- Southern Ocean (Investigator) 20/03/2015-30/03/2015
- Wagga Wagga airport – FOG experiment 05/2015-10/2015
- AAD ACRE (Antarctic Clouds and Radiation Experiment) / US DoE ARM MICRE (Macquarie Island) 03/2016 - 03/2017
- SOCRATES (Southern Ocean Cloud, Rain/Radiation, Aerosol Transport Experimental Study) - Feb/March 2018
- Antarctica Nov 2018 – feb 2019

BASTA-OPGC (Franck Donnadieu) :

- Peru (Sabancaya) May 2018 – Volcanic stuff
- EXAEDRE July-Oct 2018 - storm/lightning

BASTA-Réunion (O. Bousquet/J. Delanoë) :
St Denis 2015-...

More than 1 year of data
Field campaign (a few months)



BASTA-LATMOS (little one) (J. Delanoë):

Many times at SIRTA
September-October 2015 Stromboli (Volcanic stuff)
Hammerfest, Norway (PARCS) (May 2016)
NAWDEX-EPATAN, Iceland (September-October 2016)
EXAEDRE, Corsica – San Giuliano (June-October 2018)

BASTA-LATMOS (big one) (J. Delanoë):

Many times at SIRTA
CDG airport - Fog (Fall 2015 to February 2016)
CAPRICORN Southern Ocean March-April 2016
NAWDEX Lannion, September-October 2016
POLIMOS (Rzecin Poland, ESA) 2018-2019

BASTA-CNRM (A. Dabas):
Fog campaigns

BASTA-dev (J. Delanoë):
In the lab...



BASTA and mini-BASTA Performances

- 4 nominal modes up to 24 km (modes can be easily modified depending on needs)

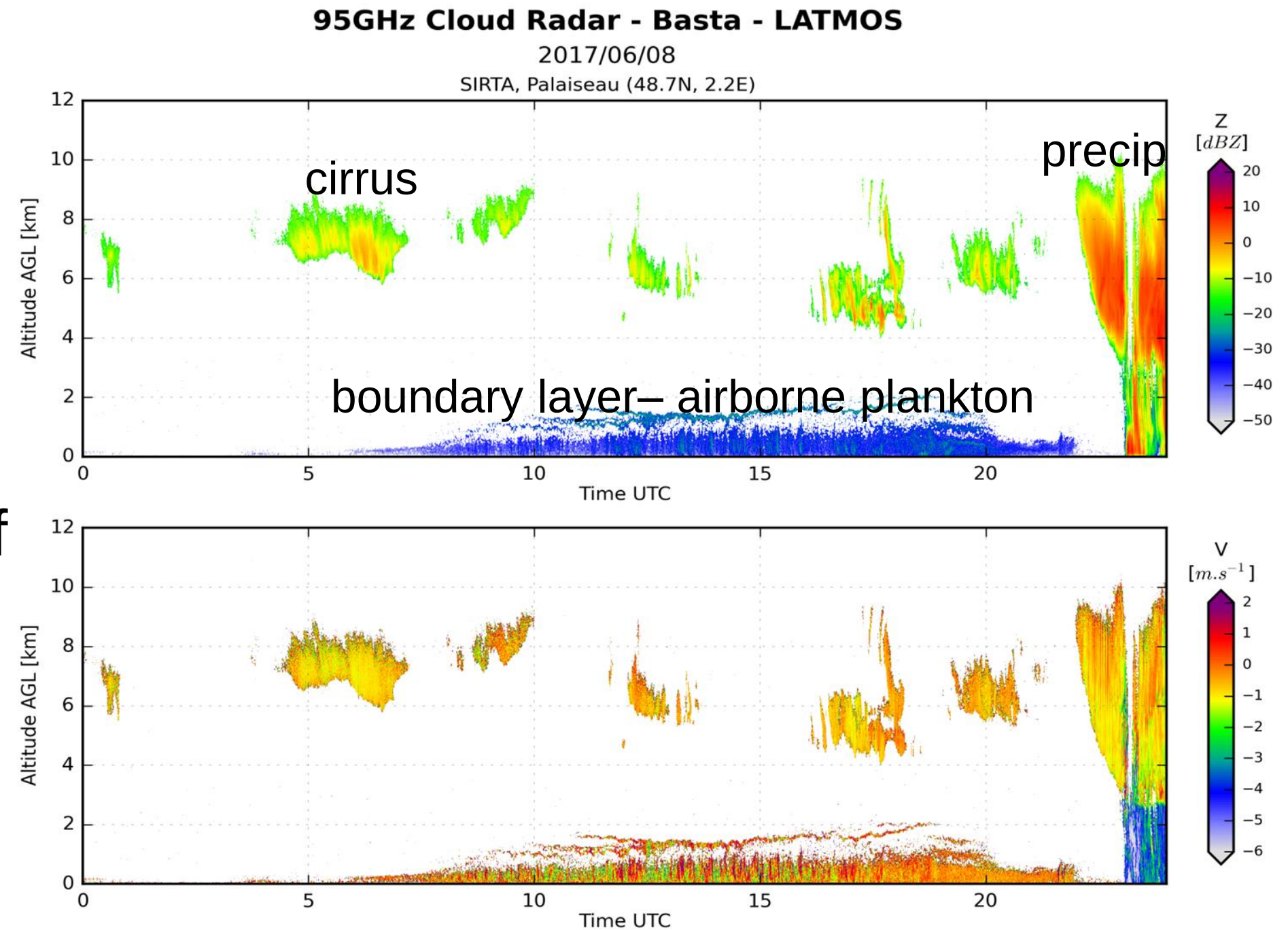
Mode	Maximum range (km)	Maximum ambiguous vel (m/s)	$Z_{\min}$ - $Z_{\max}$ big/mini @1 km and @4 km (3s) and 0.5W	Target
12.5 m	12	± 10	-39.5/-33.5 – 22 dBZ -25.5/-19.5 – 22 dBZ	Fog/Rain/drizzle
25 m	18	± 5	-44/-38 – 22 dBZ -30/-24 – 22 dBZ	All
100 m	18	± 5	-50/-44 – 22 dBZ -36/30 – 22 dBZ	Thin ice clouds / cirrus
100 m	24	± 2.5	-51.5/-45.5 – 22 dBZ -37.5/31.5 – 22 dBZ	Very thin ice clouds / cirrus



BASTA Observations

A vertically pointing BASTA observes:

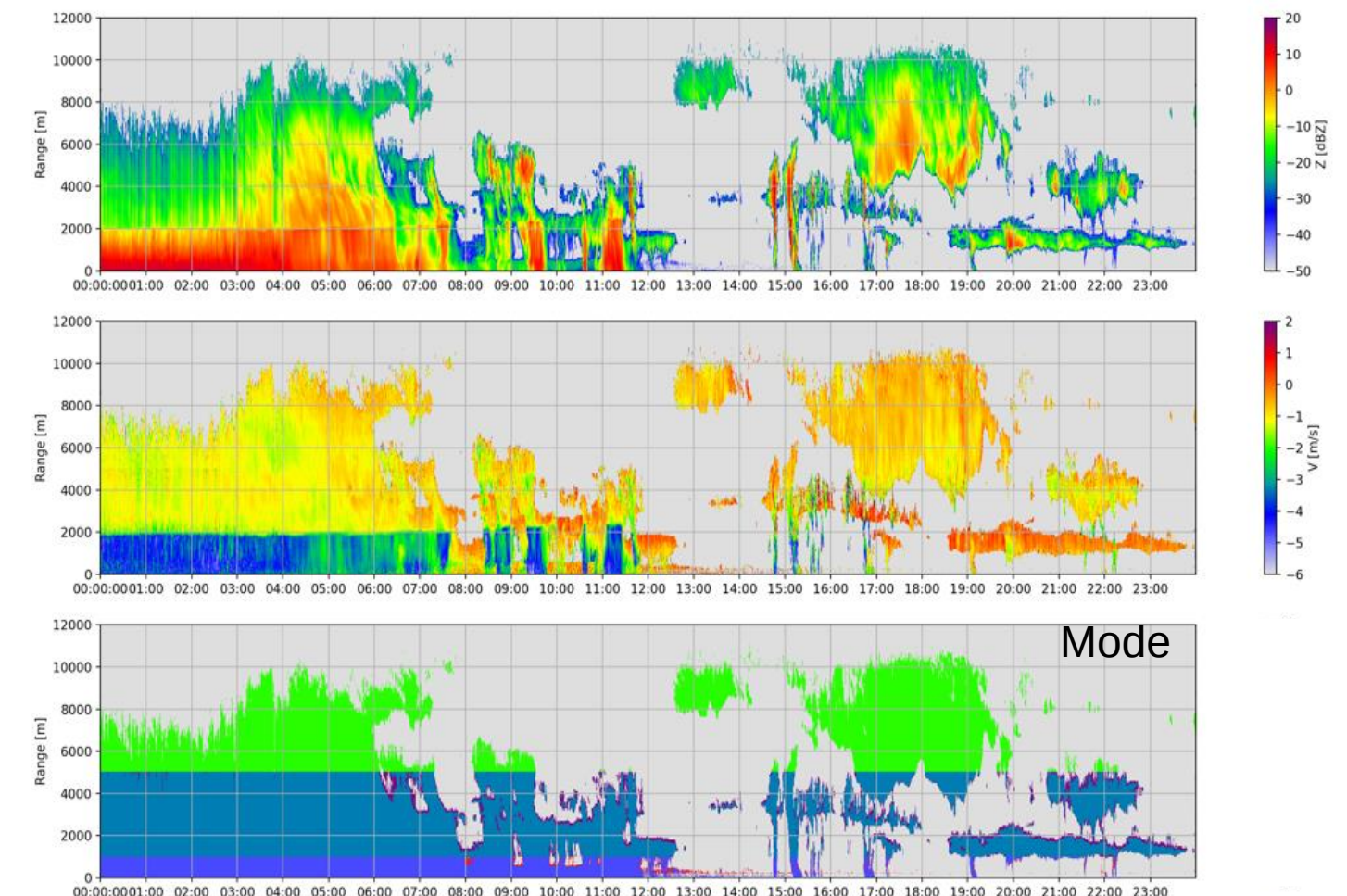
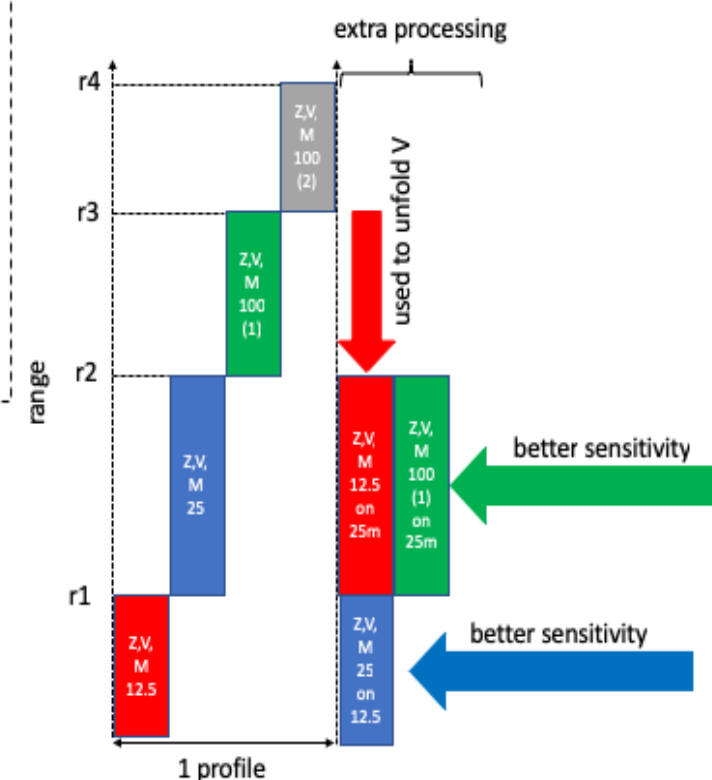
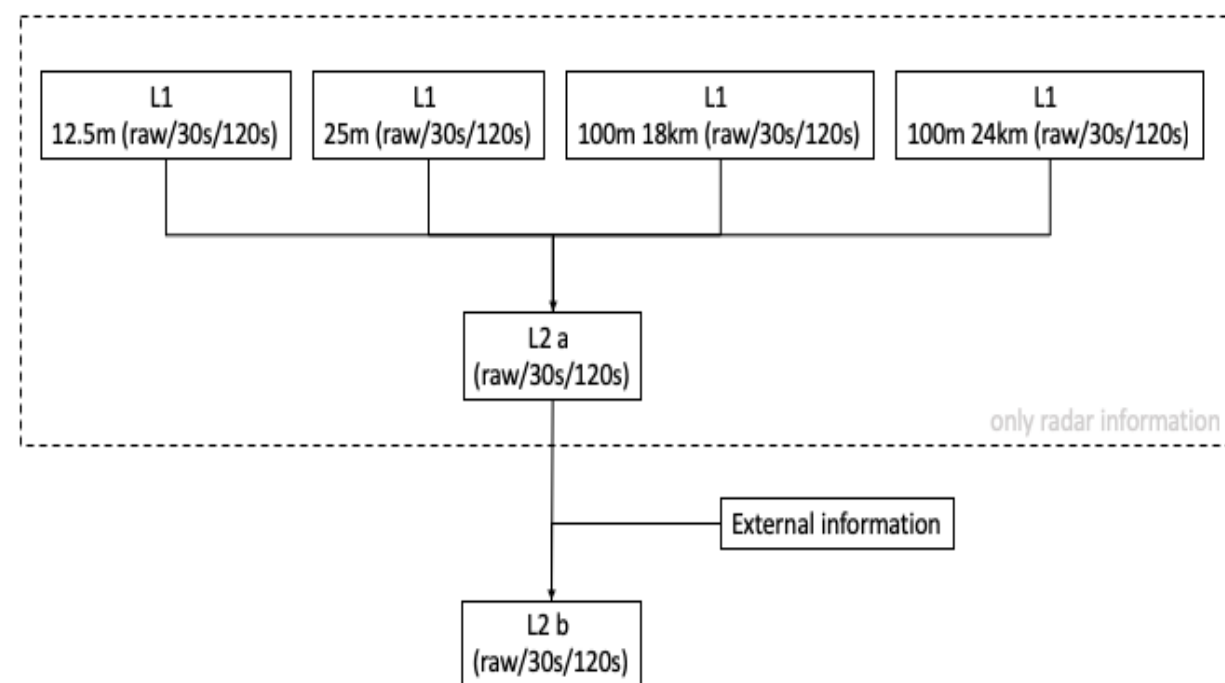
- 2D Reflectivity (dBZ)
- 2D Doppler speed (ms^{-1})
- Microphysical properties of Clouds, Fog and light precipitation



12.5m vertical resolution and 3 sec time resolution

Level 2 BASTA Merged Product

- L2a combines different vertical resolution (modes) to derive a merged product.
- L2a is a new vertical grid which is a combination of 3 or 4 modes.



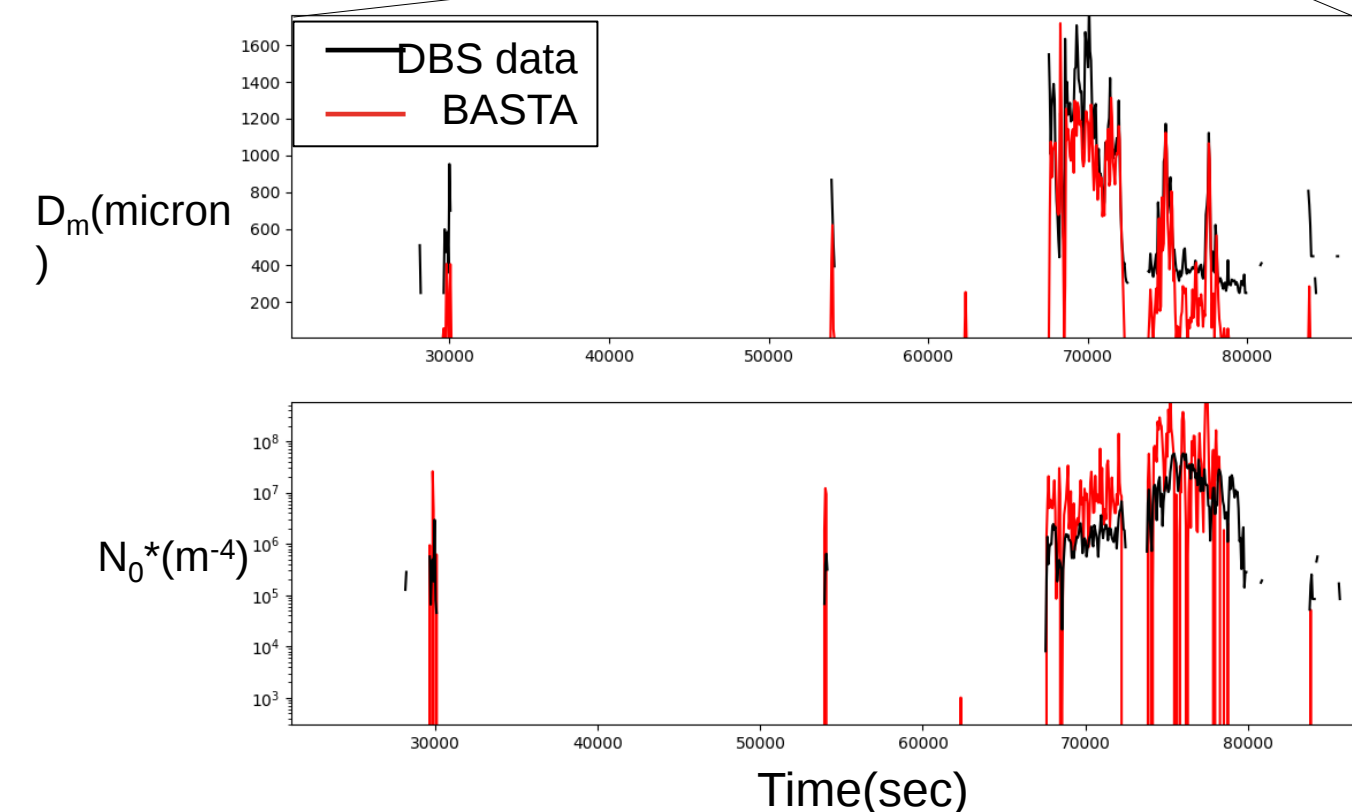
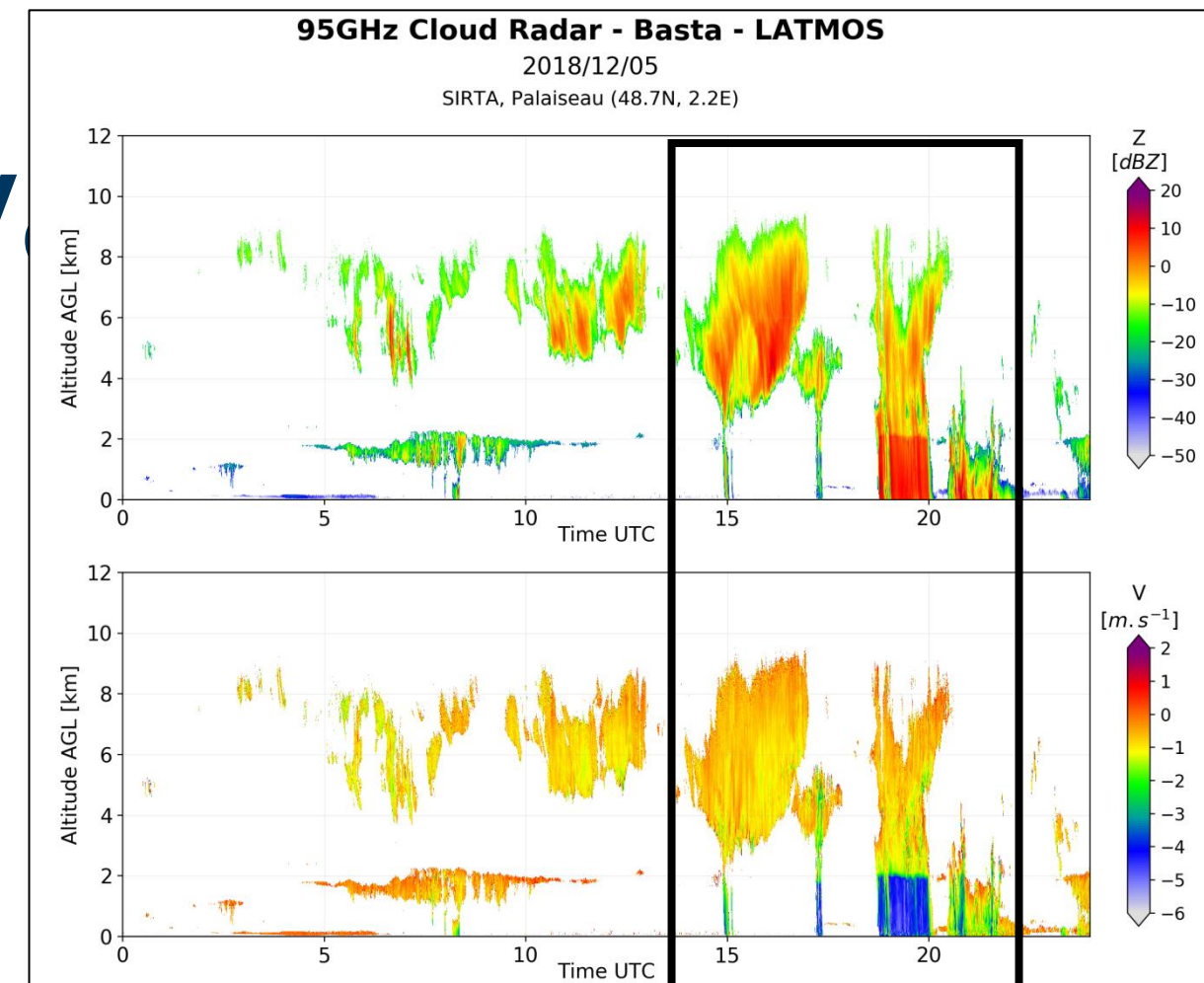
Rain and Liquid Retrieval

Thesis Objective:

- Development in classification of hydrometeors using doppler spectrum.
- Improvement in the rainfall and liquid cloud retrieval algorithm using a variational approach (combining Z and V)
- Good agreement is observed when compared with DBS data

Spectropluviometer DBS at SIRTa (*Delahaye et al. 2006*)

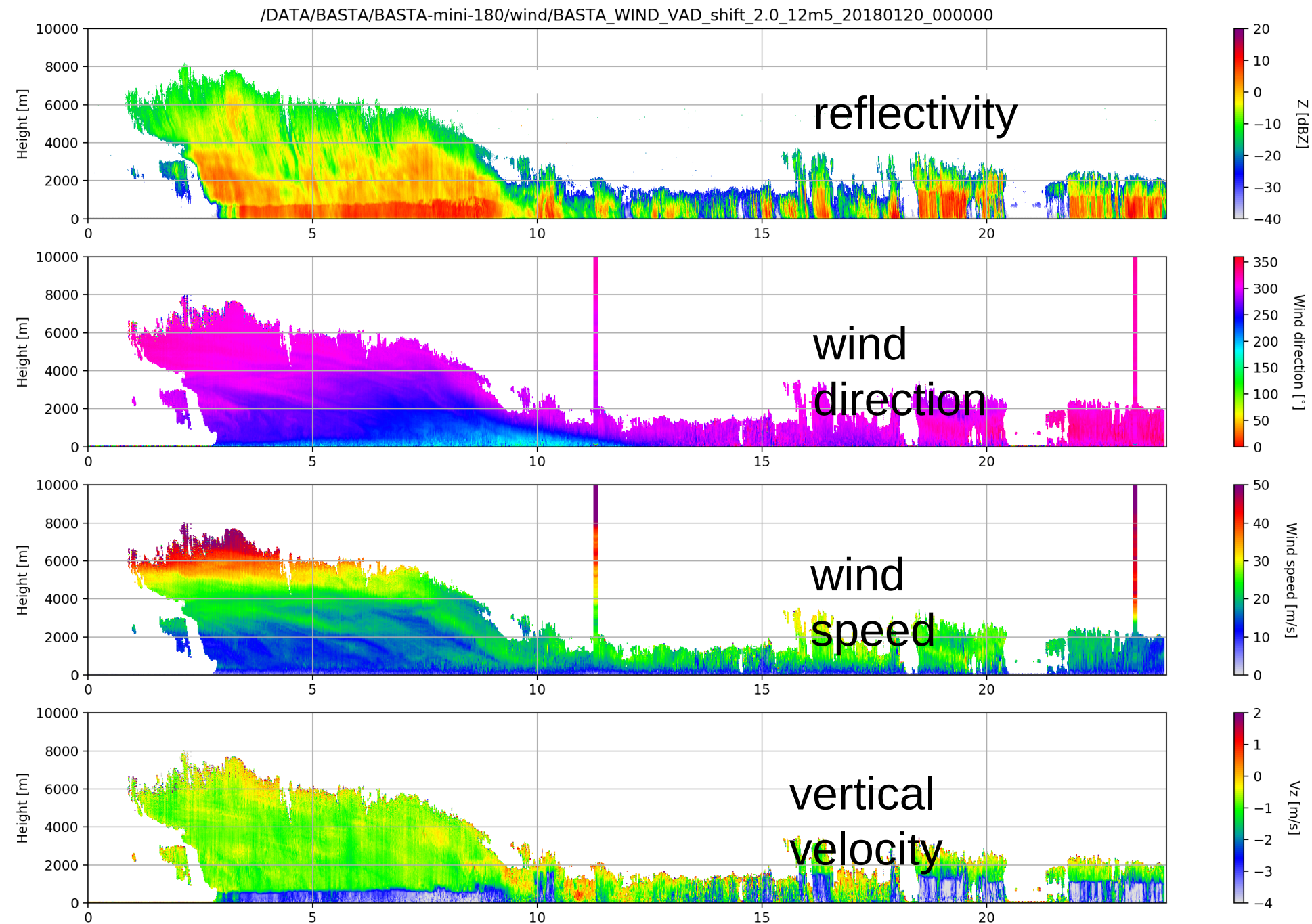
L. Barthes and A. Chazottes



Cloud and Precipitation Wind

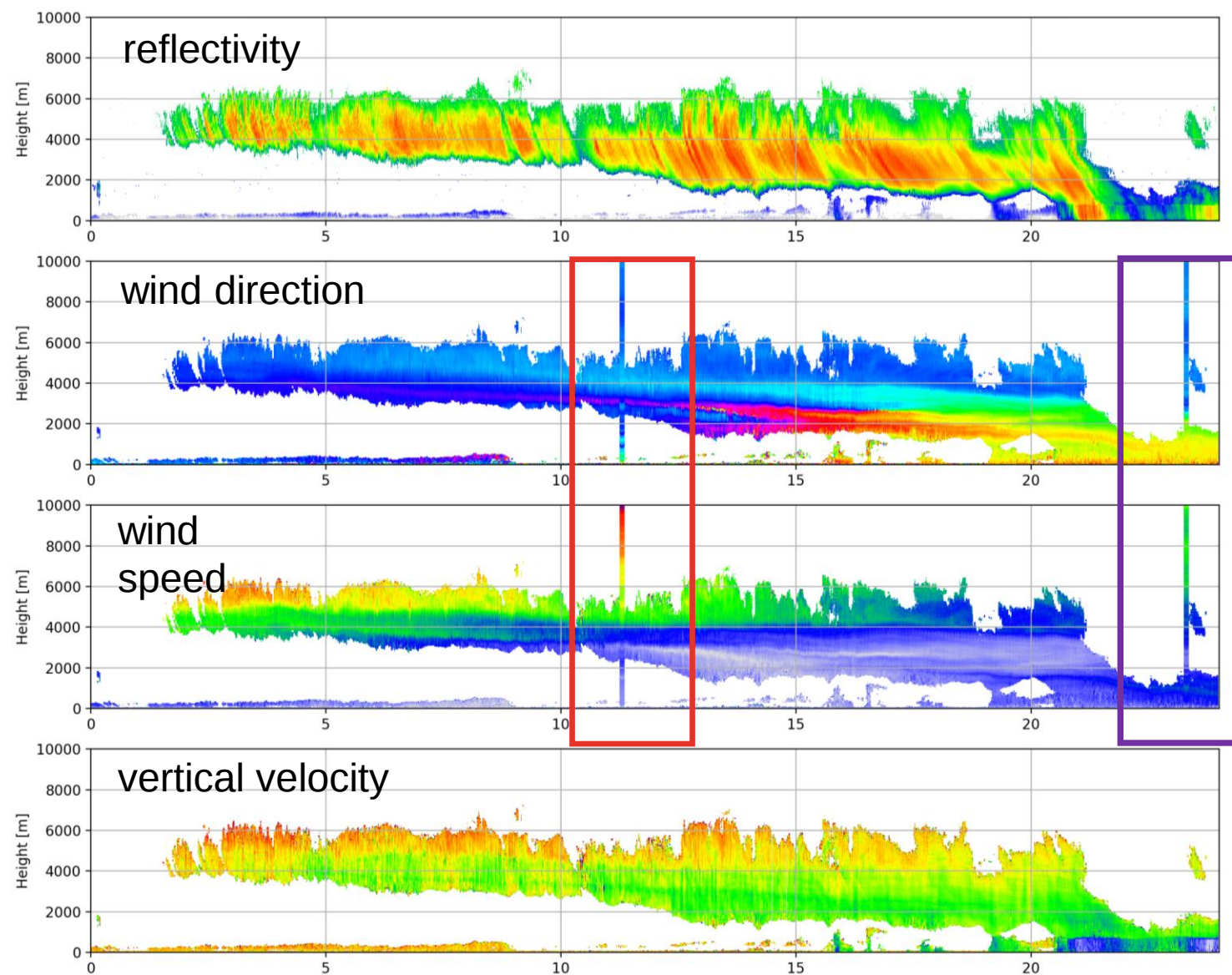
Scanning mini-BASTA observes

- 3D Reflectivity (dBZ)
- 3D Doppler speed (m.s⁻¹)
- 3D cloud speed and wind direction
- VAD technique: 30s to 1min30 temporal resolution at 75° elevation
- Calibration mode (Poster by Felipe TOLEDO on May 21st 3pm)

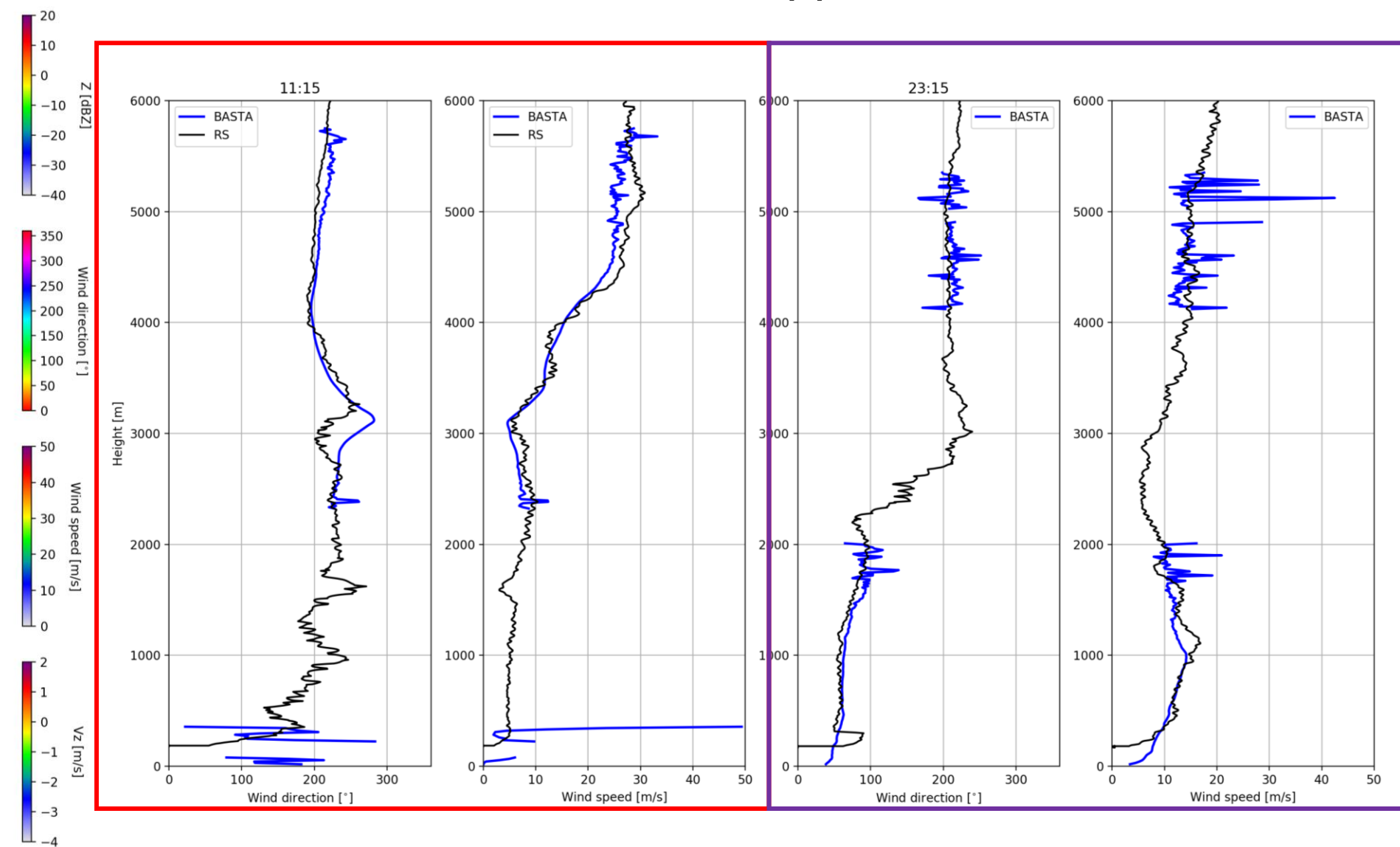


Validation with RS

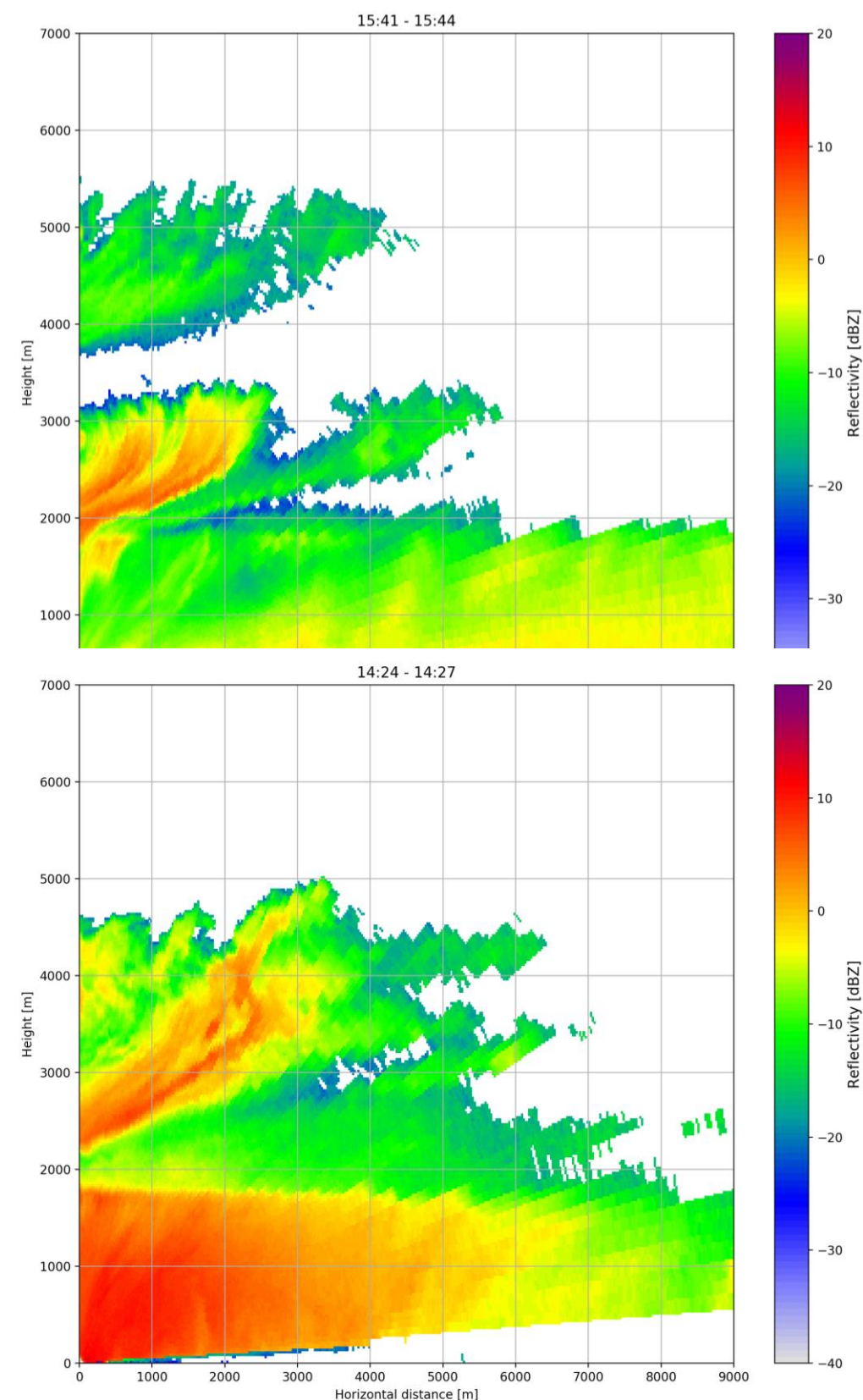
6/01/2018



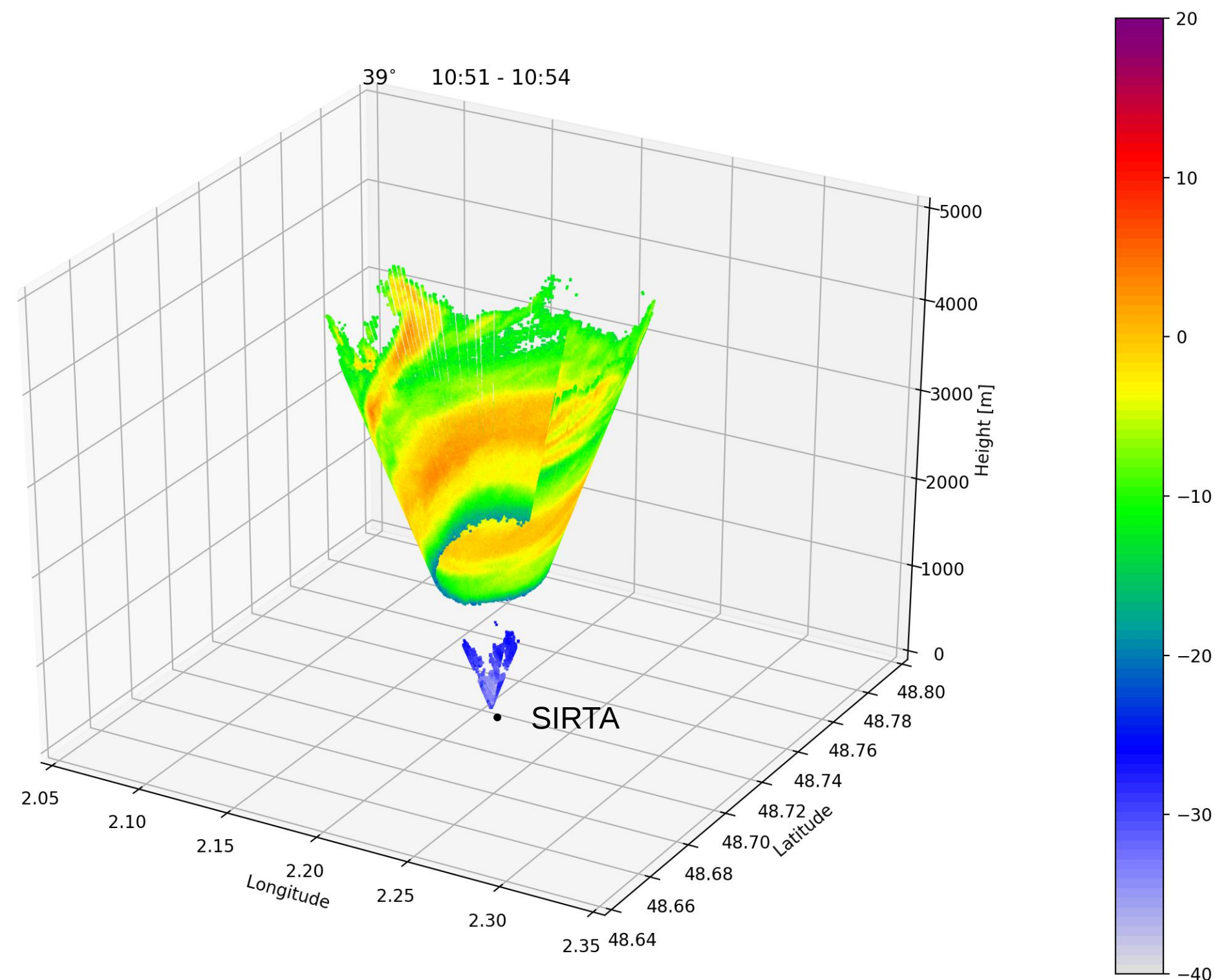
RS Trappes



Scanning BASTA - RHI and PPI



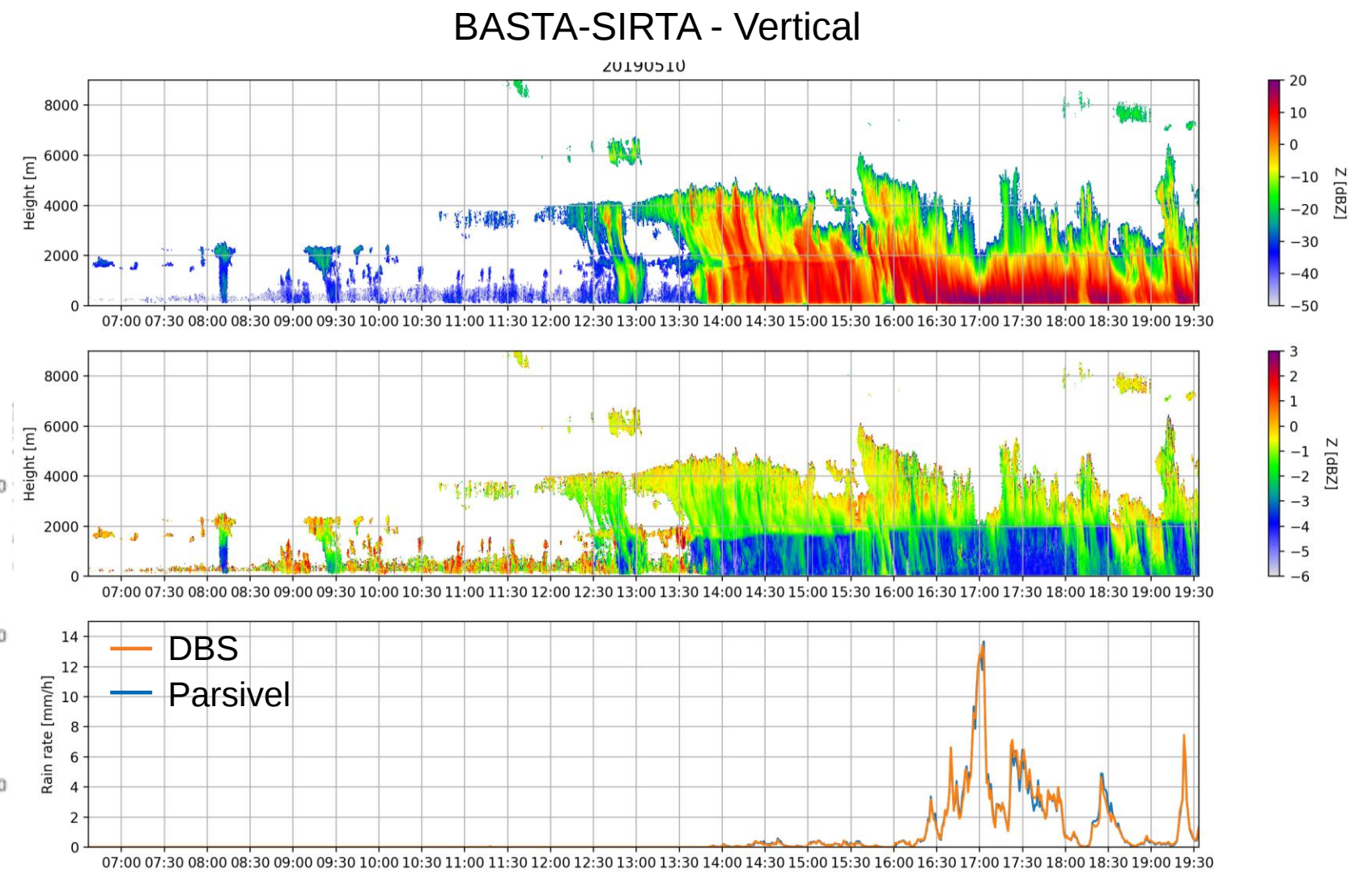
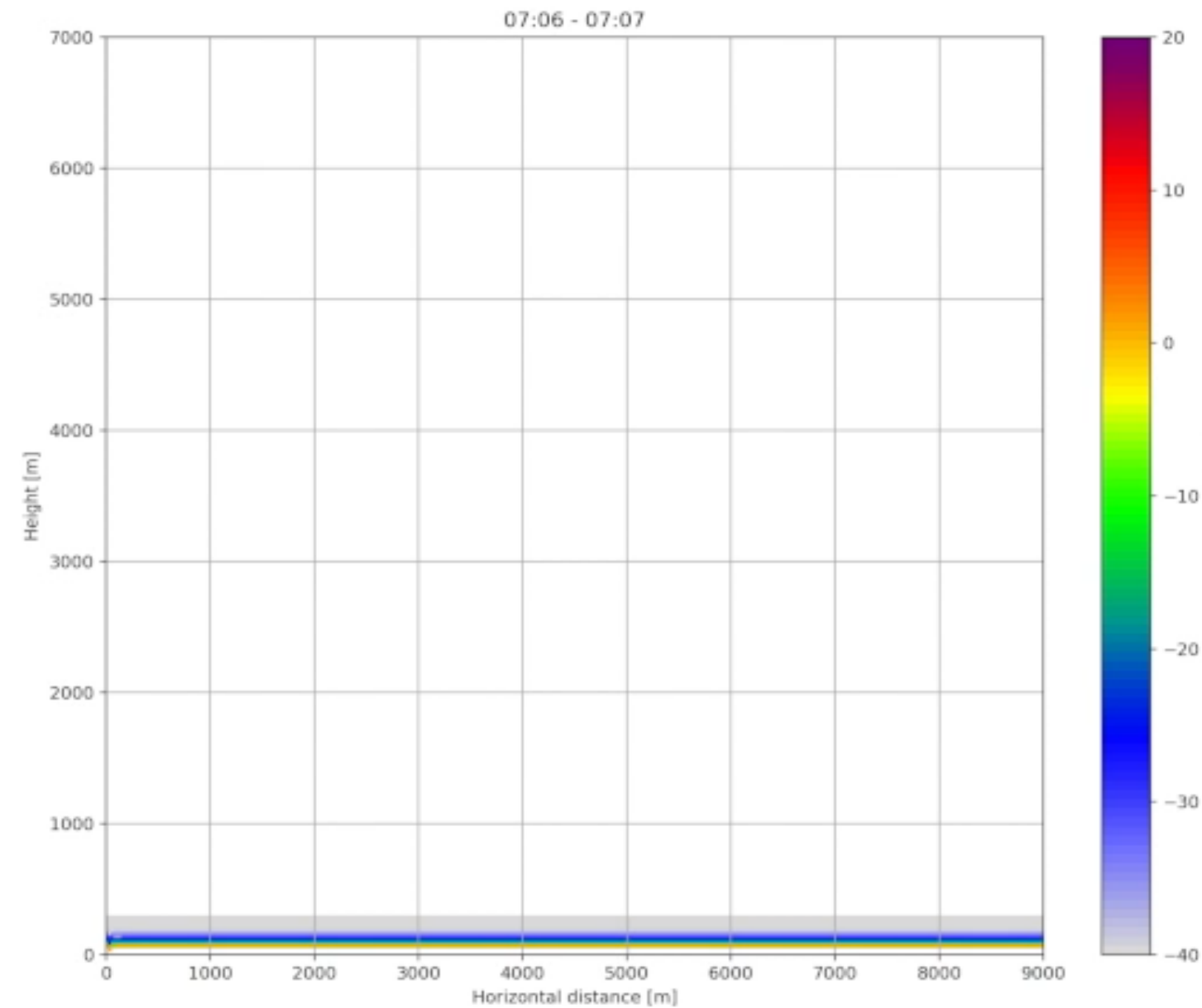
RHI



PPI at 39°
elevation



Scanning mode BASTA



On-going developments

New retrieved products and development:

- Classification of hydrometeors
- Radome attenuation characterization/correction
- Spectral analysis (thanks to I and Q)
- Forward model operator (assimilation or variational retrieval)
- Fog analysis (Details in the poster by Alister Bell during Poster session 2)

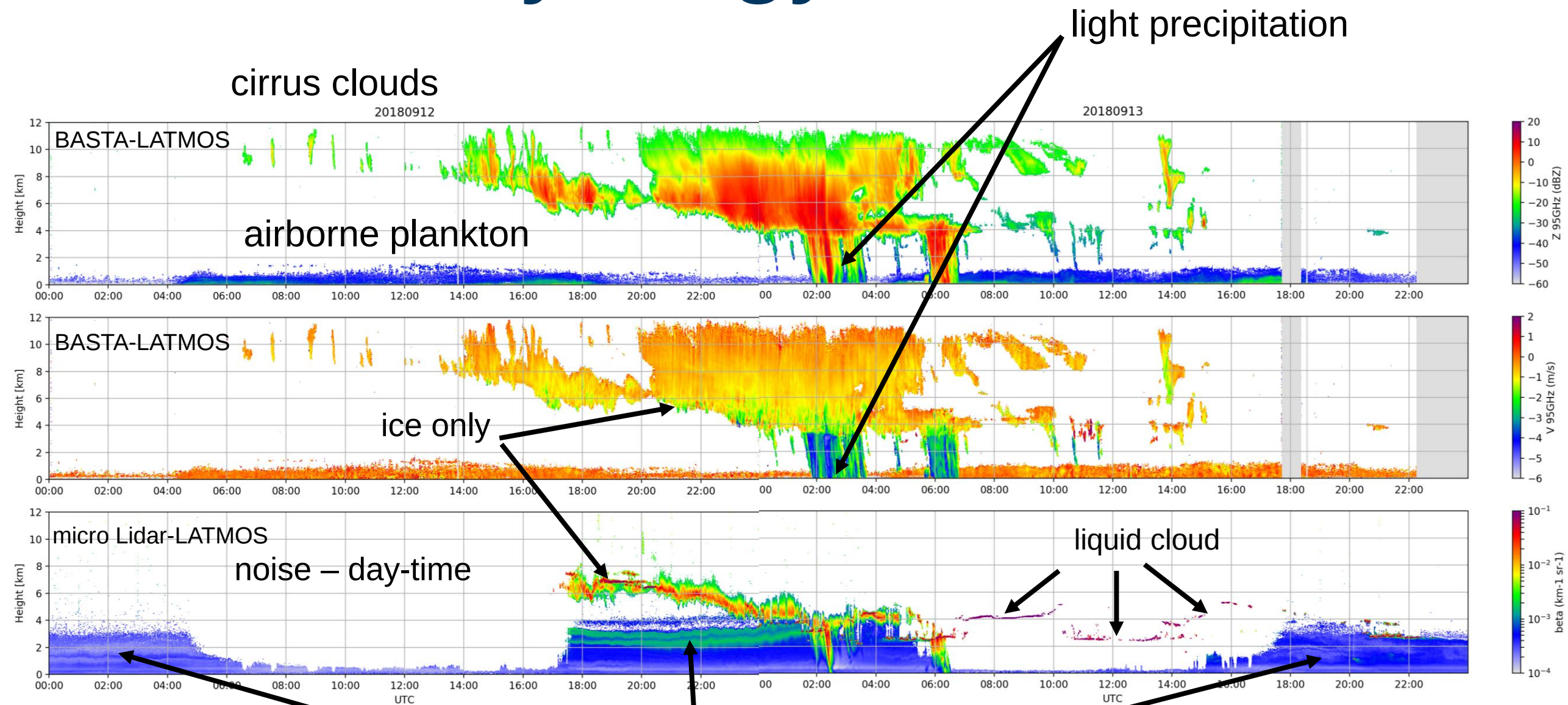
Instrument evolution

- New design, easier handling, weight reduction, improved thermal regulation
- Monostatic for ultra-portability

Radar–Lidar Synergy



Radar-Lidar Synergy



Lidar : Higher sensitivity (night time)/
detect liquid and aerosols

Radar : Penetrates cloud with higher optical depth

aerosol layers

Lidar developed at LATMOS
by J. Pelon and V. Mariage



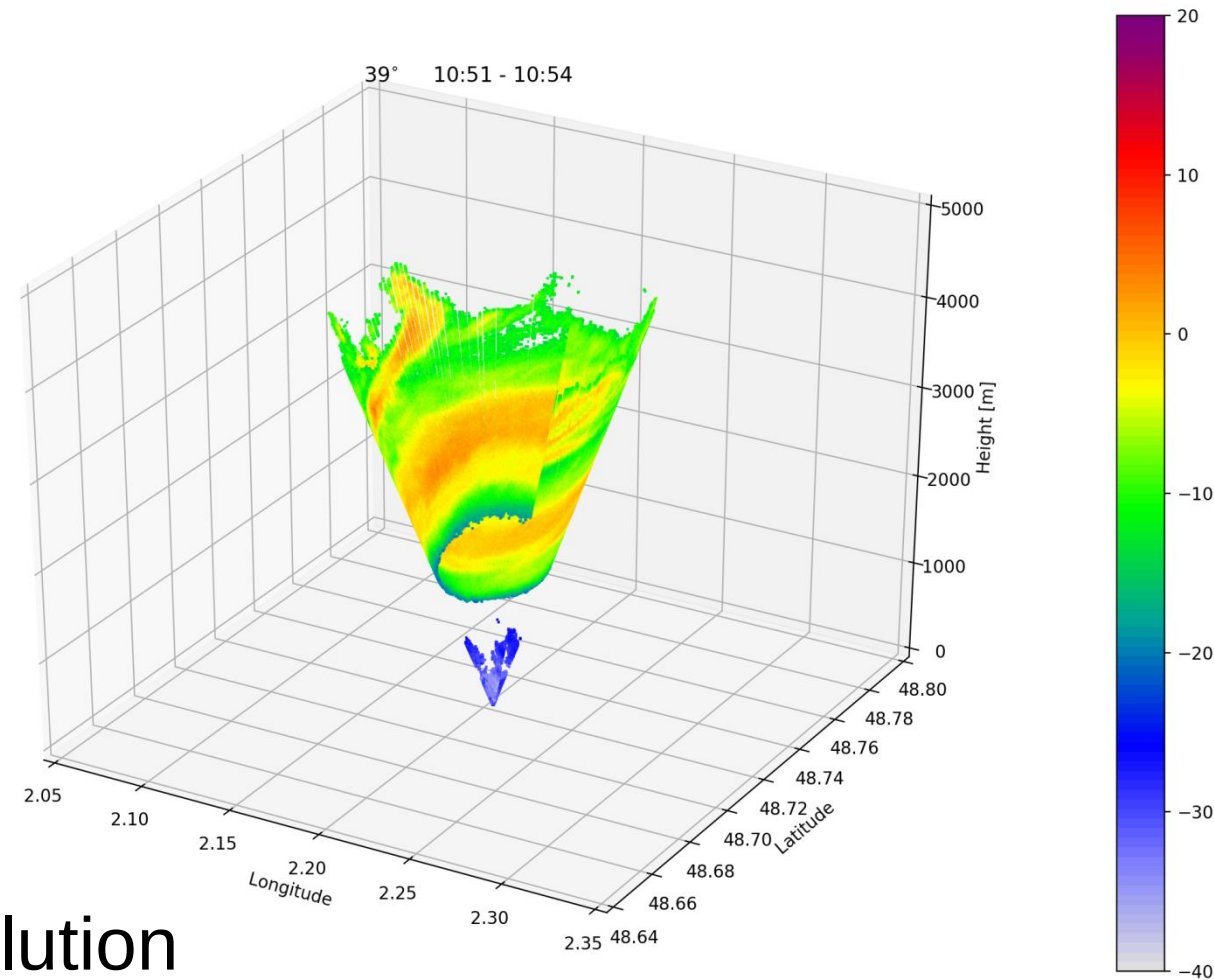
Thank you for your attention!



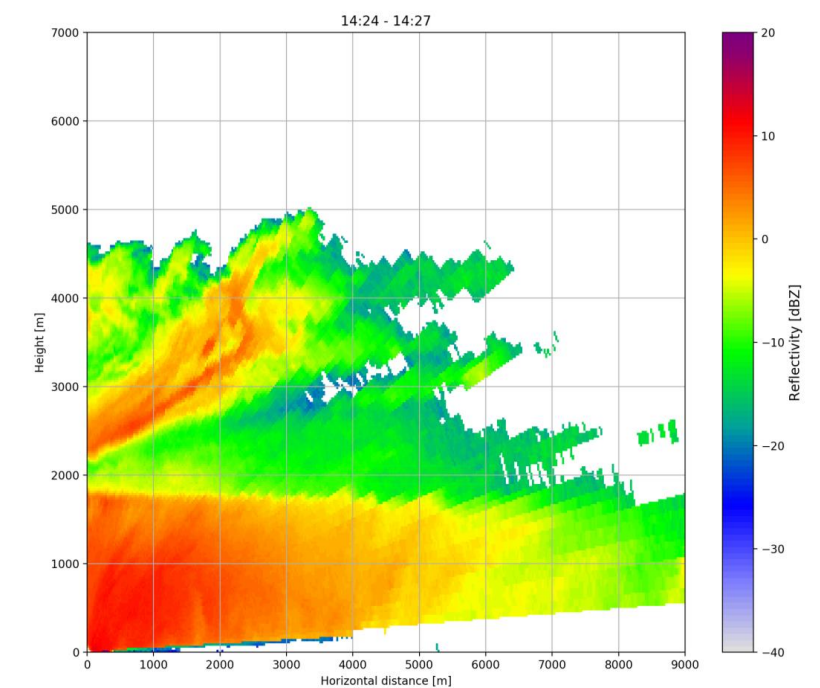
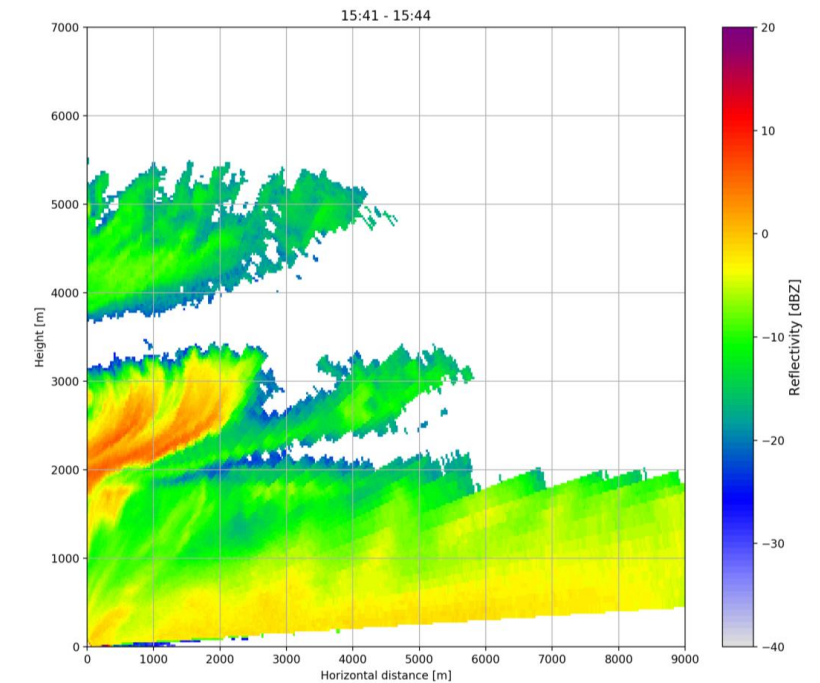
Scanning BASTA - RHI and PPI

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• SIRTA



RHI

PPI at 39°
elevation

