SOFOG3D

15/05/2020

Outline

- SOFOG3D objectives and tasks recall
- Where we are…
- Description of the data set (L1/L2 processing) and catalogue
- Studies carried out by Susana:
  - Coupling effect
  - Fog detection
  - Radar inter calibration

TASK-2 SOFOG3D

Fog retrievals based on remote sensing measurements

Sub-task 2.1: LWC and fog dynamics retrievals from radar and MWR <= lead - LATMOS

Sub-task 2.2: Closure analysis and retrievals assessment <= lead - LATMOS

Sub-task 2.3: MWR profiles retrieval constrained by radar LWC <= contribution - LATMOS

Sub-task 2.4: SEVIRI/MSG retrievals

Deliverables:

- **D2.1.1:** LWC profiles depending on different constraints from dedicated variational method
- **D2.1.2:** Dynamics of the fog layer from velocity azimuth display technique
- **D2.2.1:** Evaluation of radar LWC retrieval vs in-situ measurements
- **D2.2.2:** Improve radar forward model thanks to calibrated metallic targets
- **D2.3.1:** Improved MWR temperature and humidity profiles retrieved with cloud radar LWC
- **D2.3.2:** Feasibility study of cloud radar LWC assimilation within the MWR 1D-Var framework
- **D2.4.1:** Time series of 2-D maps of cloud classes using a classification adapted for fog and low stratus evolution tracking (e.g. separating core fog, dissipation fog, formation fog pixels)
- **D2.4.2:** Time series of fog evolution indicators, such as distance to fog boundaries, cloud albedo and evolution of brightness temperature of the different cloud classes.

Before addressing these points…

- Deploy and operate radar instruments during the field campaign SOFOG3D
- Prepare and process the data

Tasks	State
Installation and operation of instruments at the Supersite	Complete
Radar catalogue for the 3 radars	Complete
Processing of the whole radar database in vertical position (L1)	Complete
Radar BASTA-CNRM processing	Complete
Production of quicklooks and netcdf files	Complete
Website BASTA: Quicklooks availability	Complete
Development of a method for analyzing scan data	Complete
Radar scanner treatment and Quicklooks	Complete
L2a (Agen and Super site) sur FTP	Complete
Study: Radar data and Radiometer data	Pending

Additional Tasks	state
Radar coupling study and fog detection	Complete
Calibration Transfer between radars	Complete

Next steps

- Pre retrieval:
  - Radiometer LWP co located with BASTA
  - Balloon impact on the BASTA measurements
  - Look at the results of the target
  - In-situ => radar forward model and evaluation of the one from literature

- How to use the scans for dynamic and 3D structure of fog?

- Retrieval:
  - Test the first version of the algorithm (Pragya's work)
  - Interaction with assimilation team

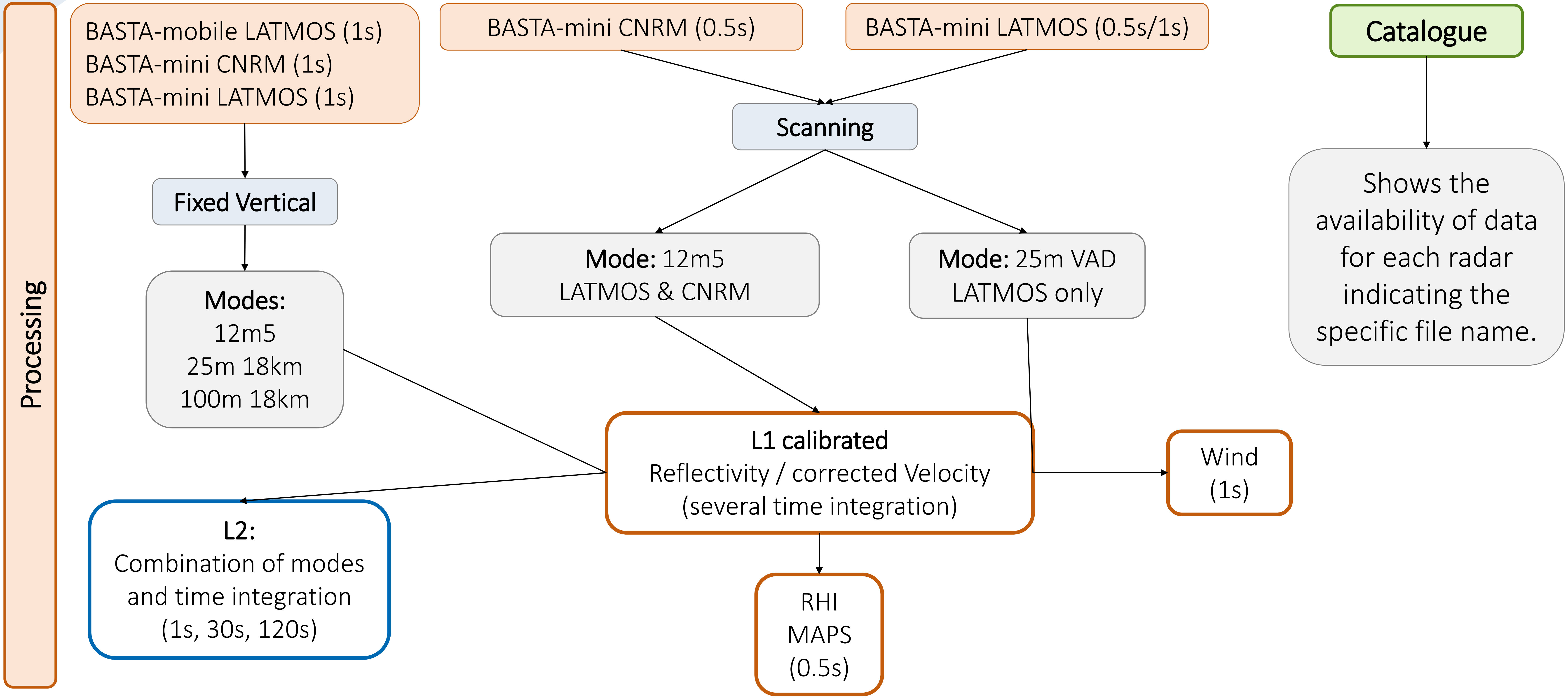
- Dynamic and microphysics analysis

SOFOG3D

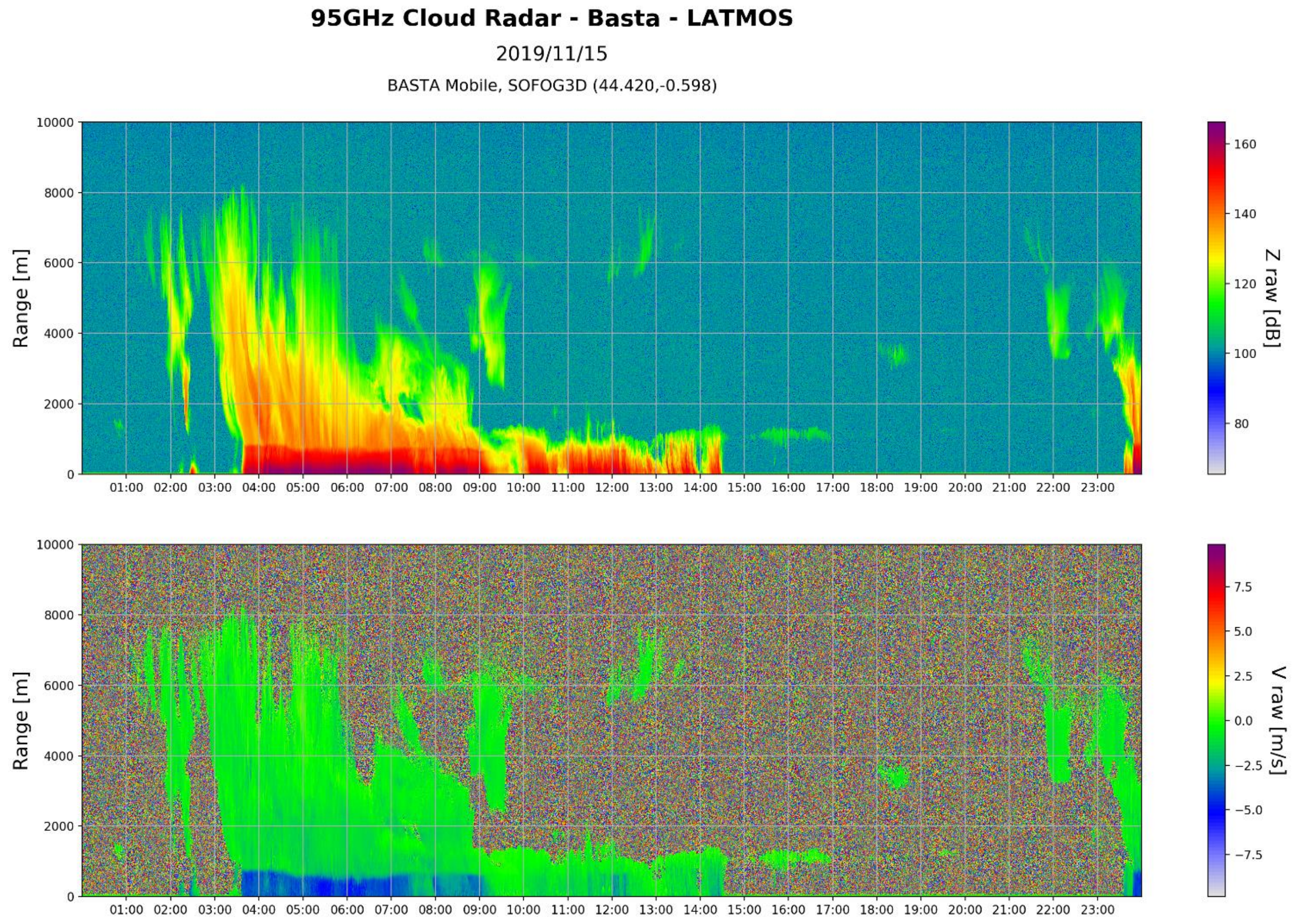
Document availability

15 May 2020

Documents and Data Availability



Data L0 → L1

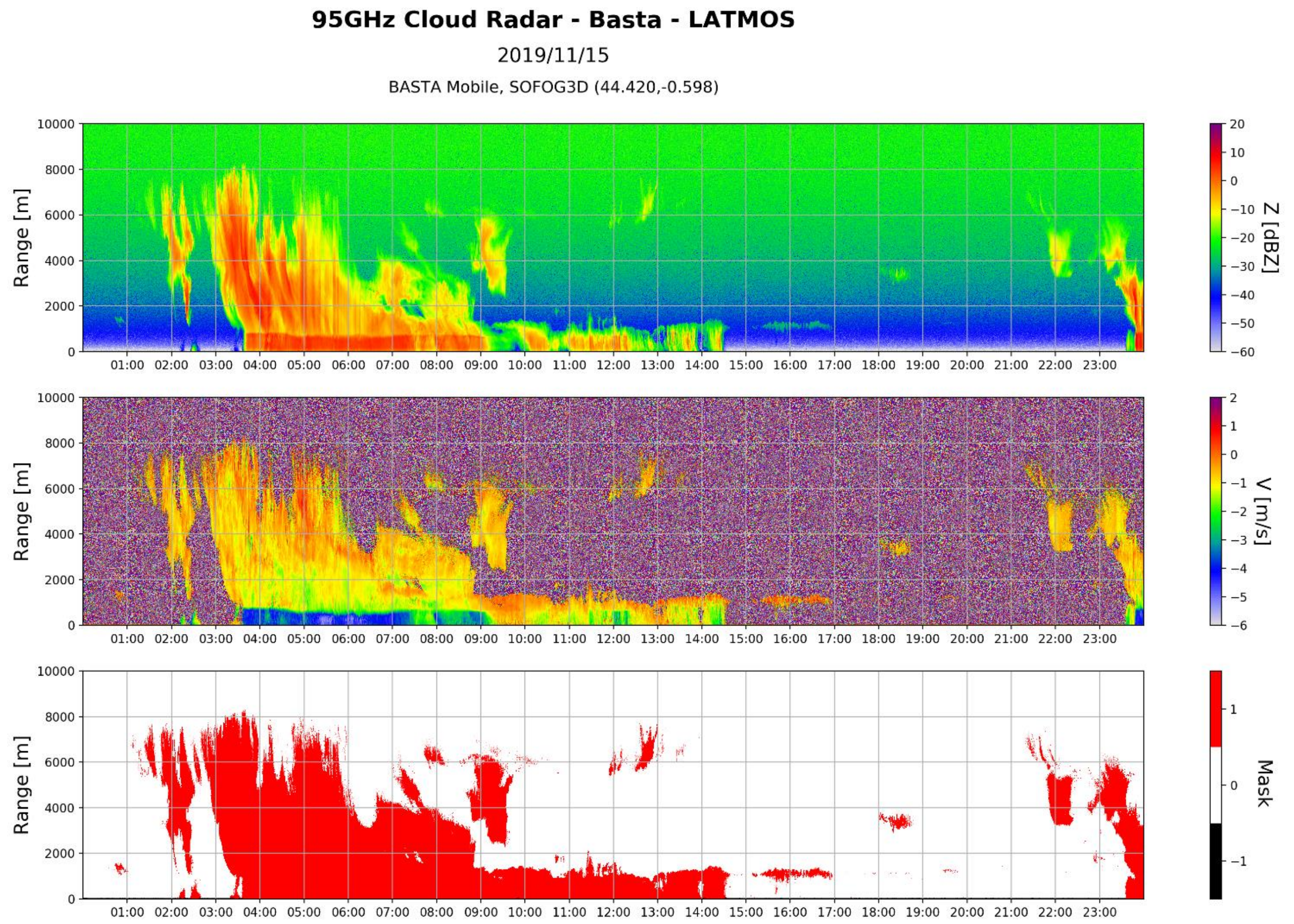


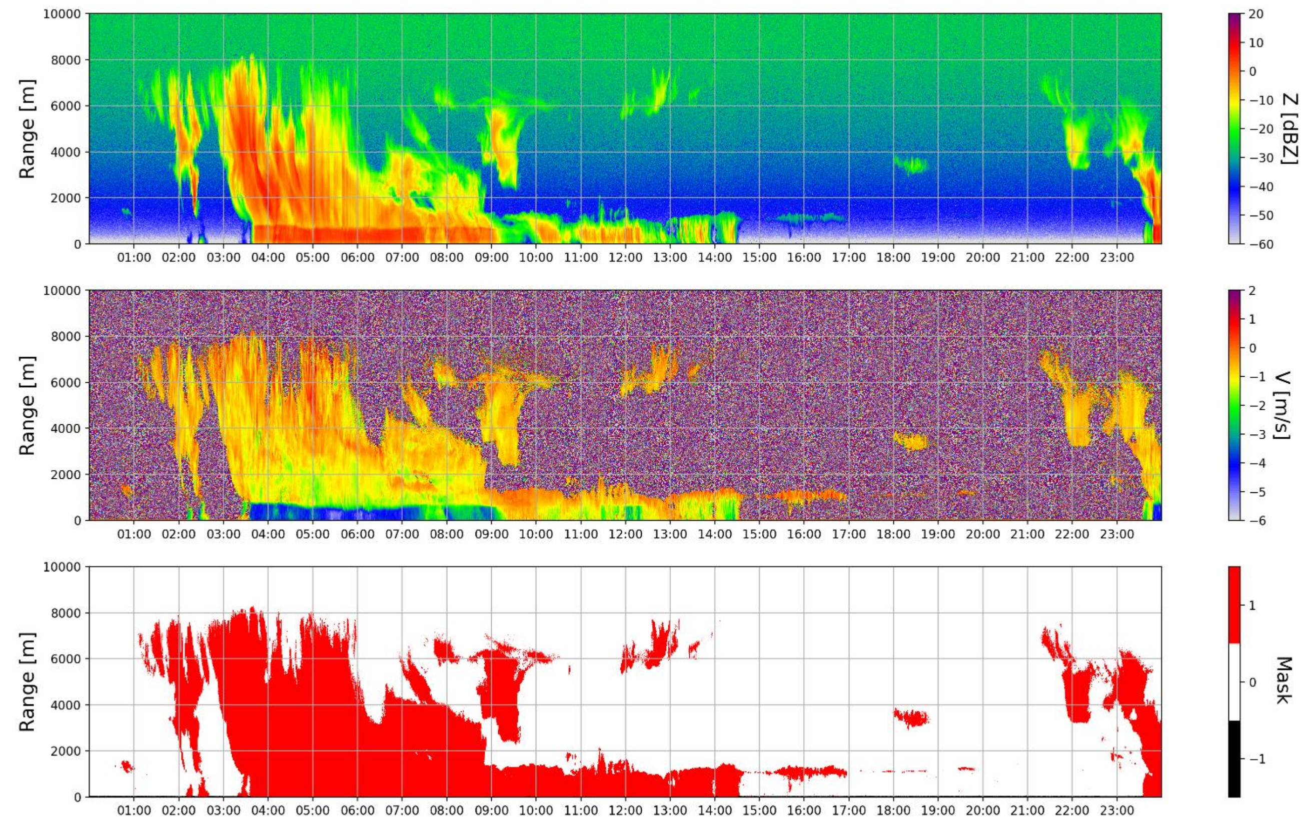
For any mode

raw time resolution

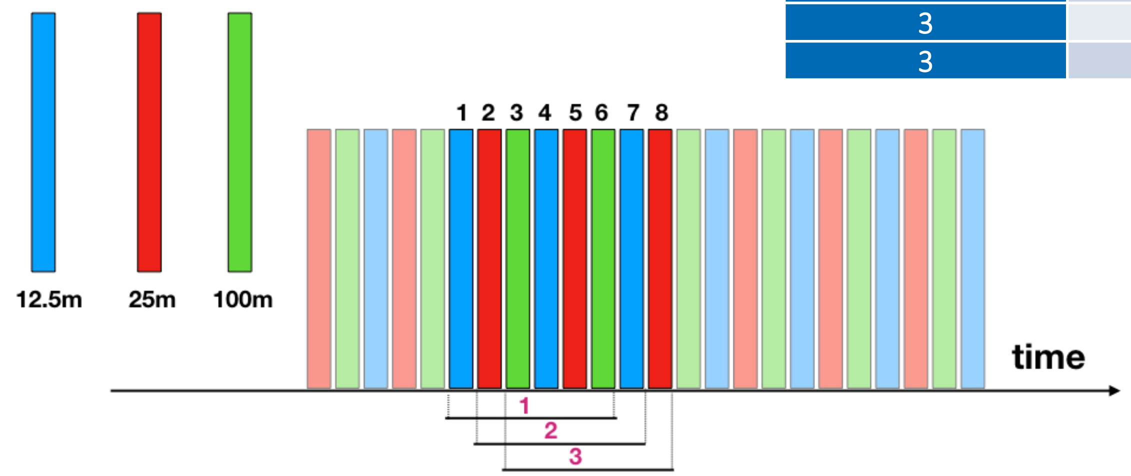
Reflectivity is calibrated
Velocity is unfolded (1st step)
data flag: comment = "-2: transmitter likely off; -1: coupling; 0: background noise; 1: good signal";
Overlap correction in 12.5m mode

post integration

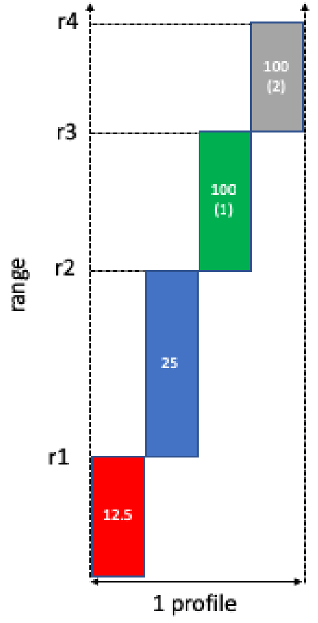




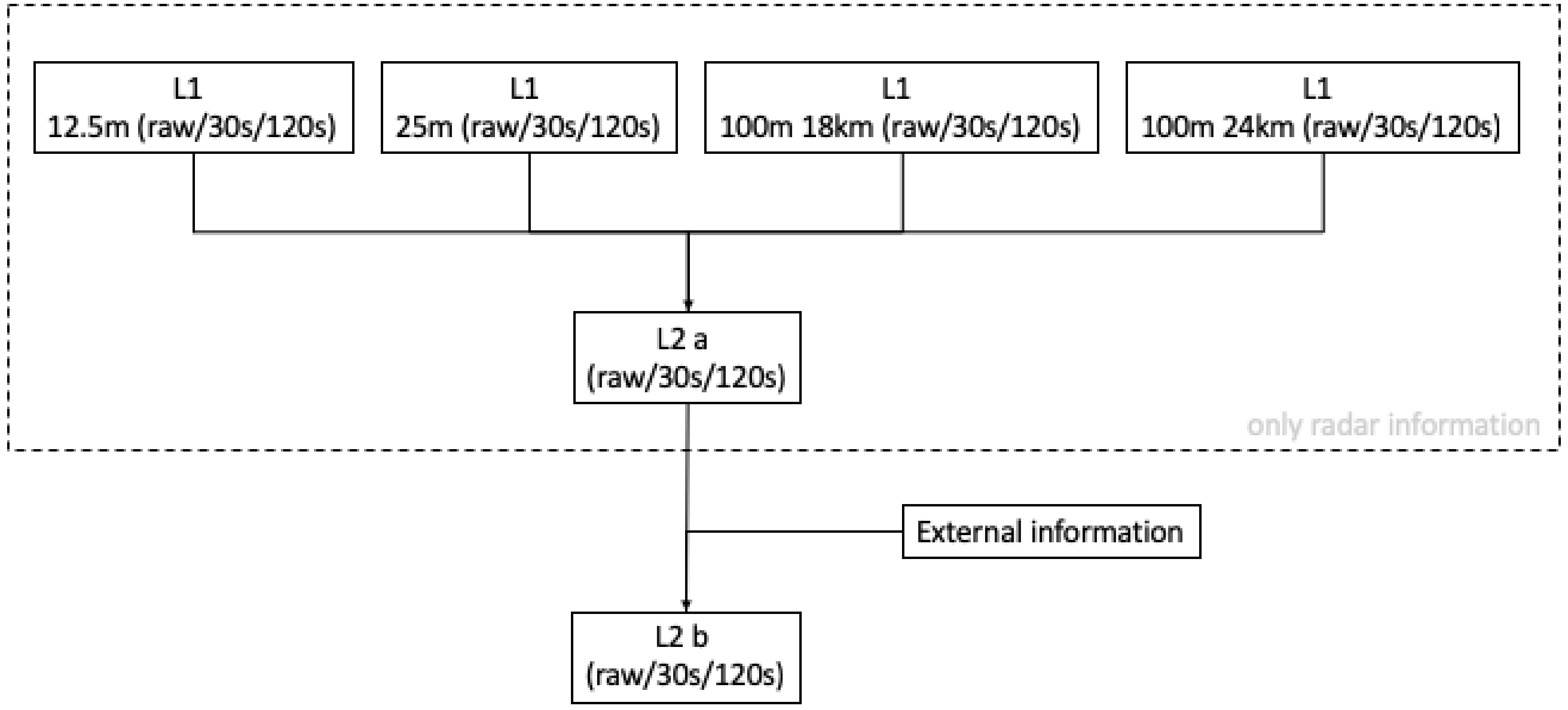
Raw integration (s)	Integration period (s)	Number of integrations	Sensitivity improvement (dB)
3	18	6	3.9
3	30	10	5
3	120	40	8

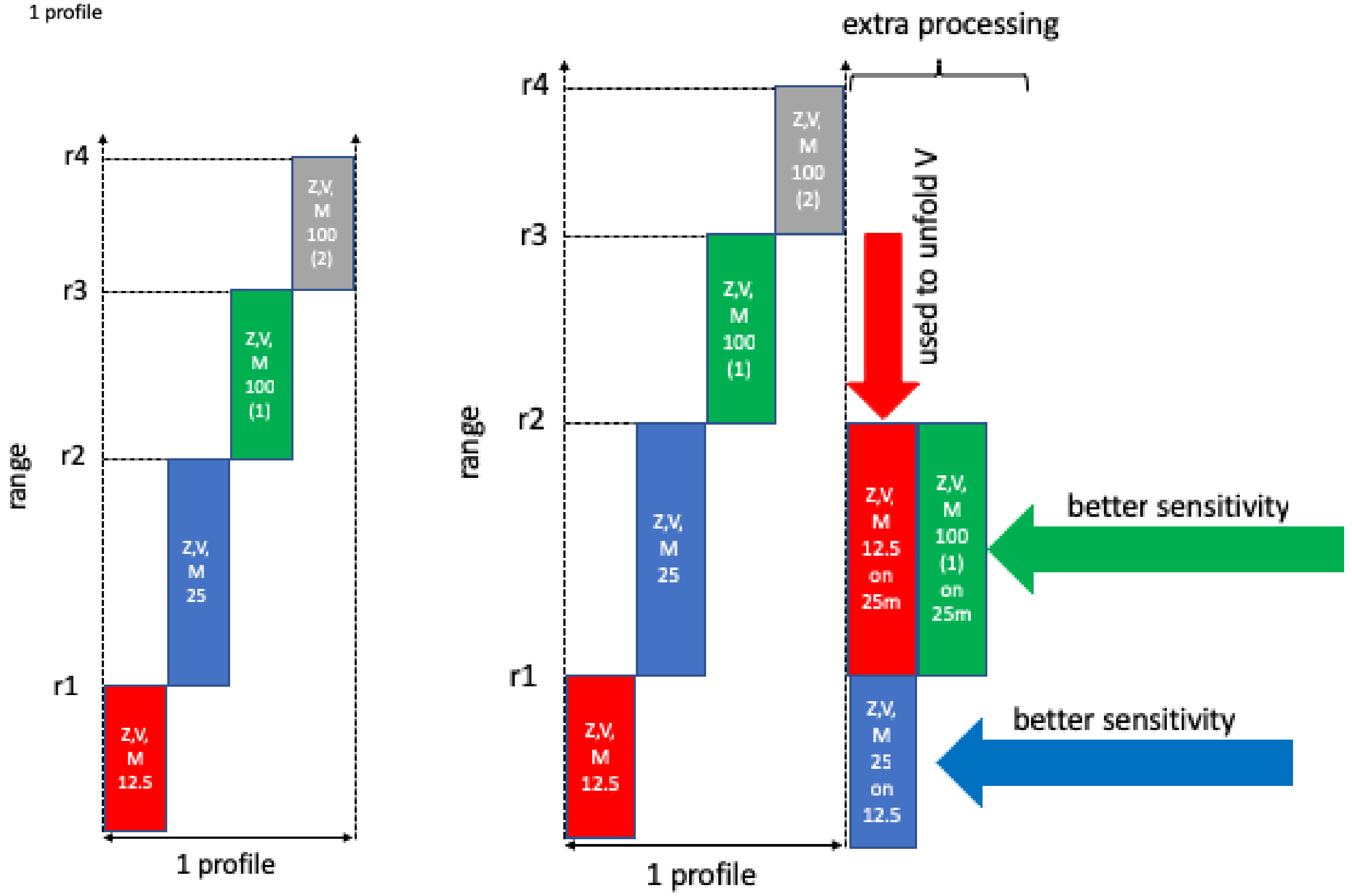


Data L1 → L2



r1, r2, r3 and r4 can be set up (depends on the BASTA location for example)
We cumulate 3 to 4 profiles to build a new profile, from 0 to r1 we use the 12.5m resolution, from r1 to r2 the 25m resolution, r2 to r3 the 100m (18km) resolution and from r3 to r4 the also 100m resolution.
Based on 4 profiles of 3s we will have one profile every 12s.

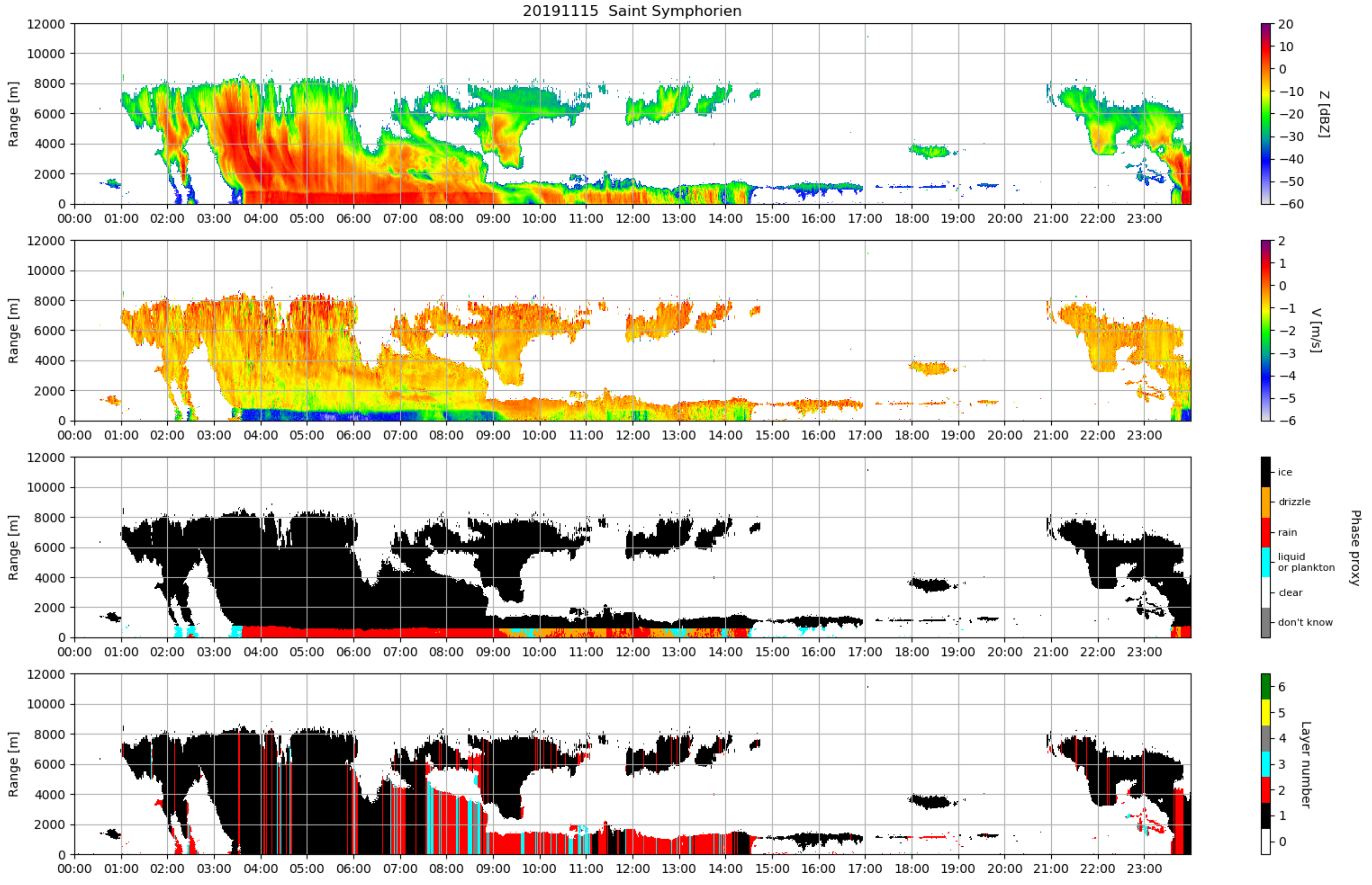


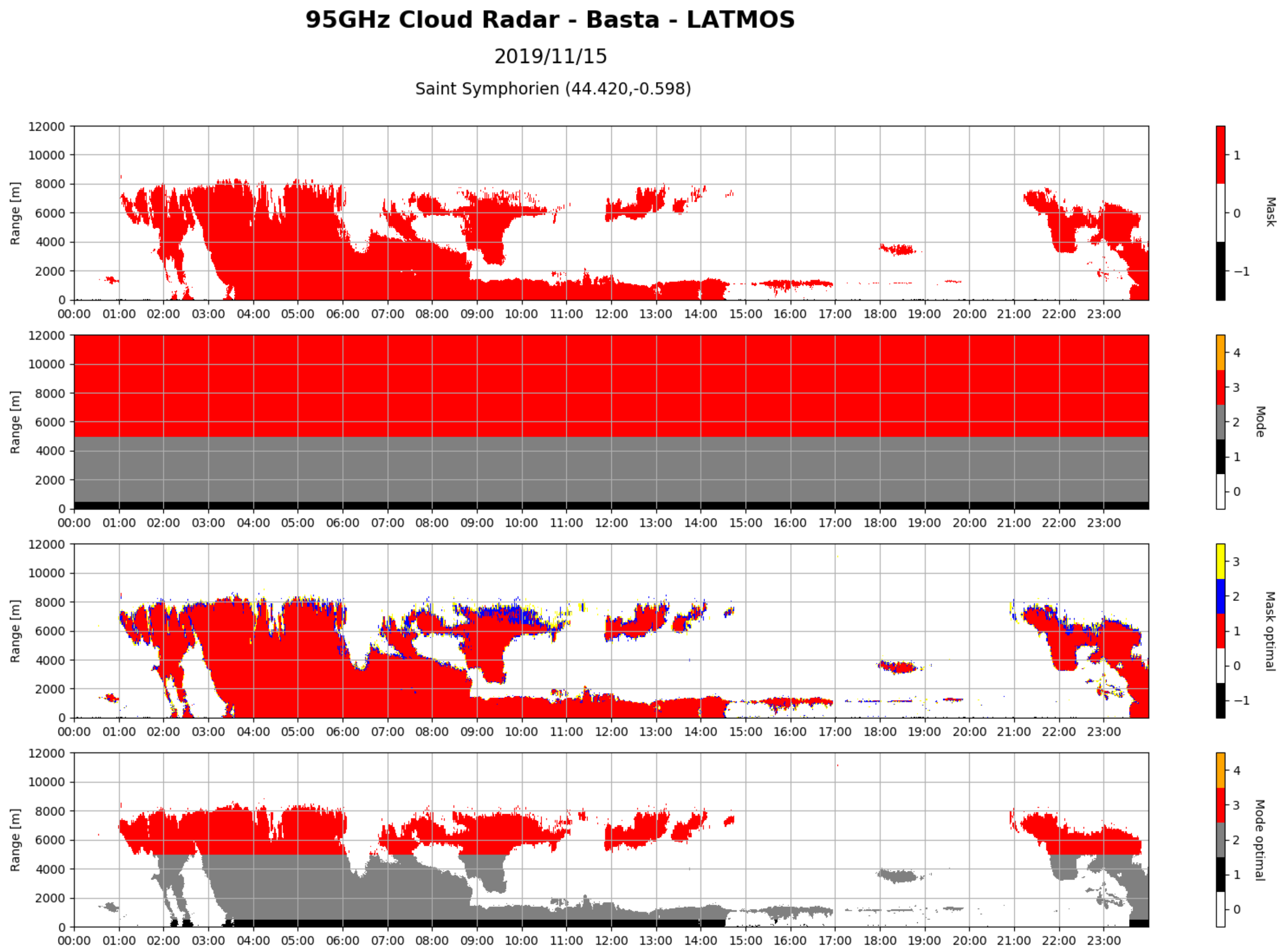


Data at 25m resolution are put on the 12.5m grid (closest value). 100m resolution data are also gridded on the 25m grid. 12.5m data are averaged and follow the 25m grid. Note that for the mask we use the most probable value (4 pixels, the most representative is used).

The 12.5m on the 25m grid is used to unfold the velocity (large ambiguous velocity). The largest range resolution data is used for their higher sensitivity.

Data L1 → L2


20191115 Saint Symphorien
Range [m]
Z [dBZ]
V [m/s]
ice
drizzle
rain
liquid or plankton
clear
don't know
Phase proxy
Layer number


95GHz Cloud Radar - Basta - LATMOS
2019/11/15
Saint Symphorien (44.420,-0.598)
Range [m]
Mask
Mode
Mask optimal
Mode optimal

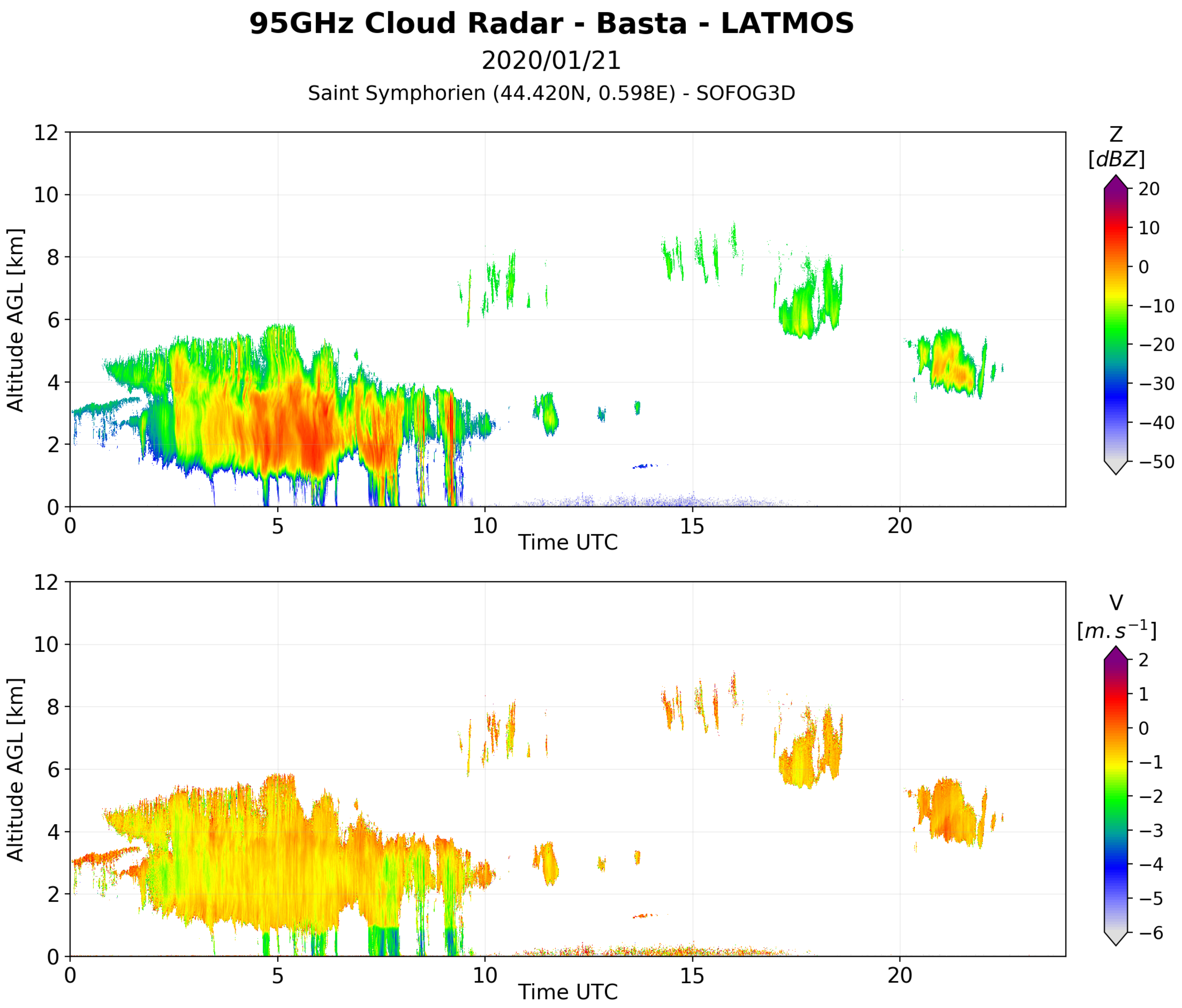
Quicklooks

Example	
Radar:	BASTA-mobile LATMOS
Data Acquisition mode:	Fixed vertical
Sampling mode:	12m5
Data:	Reflectivity / Velocity 30s

<u>File name:</u>

BASTA_QL_12m5_20191110_000005_30s

Mode Date data level



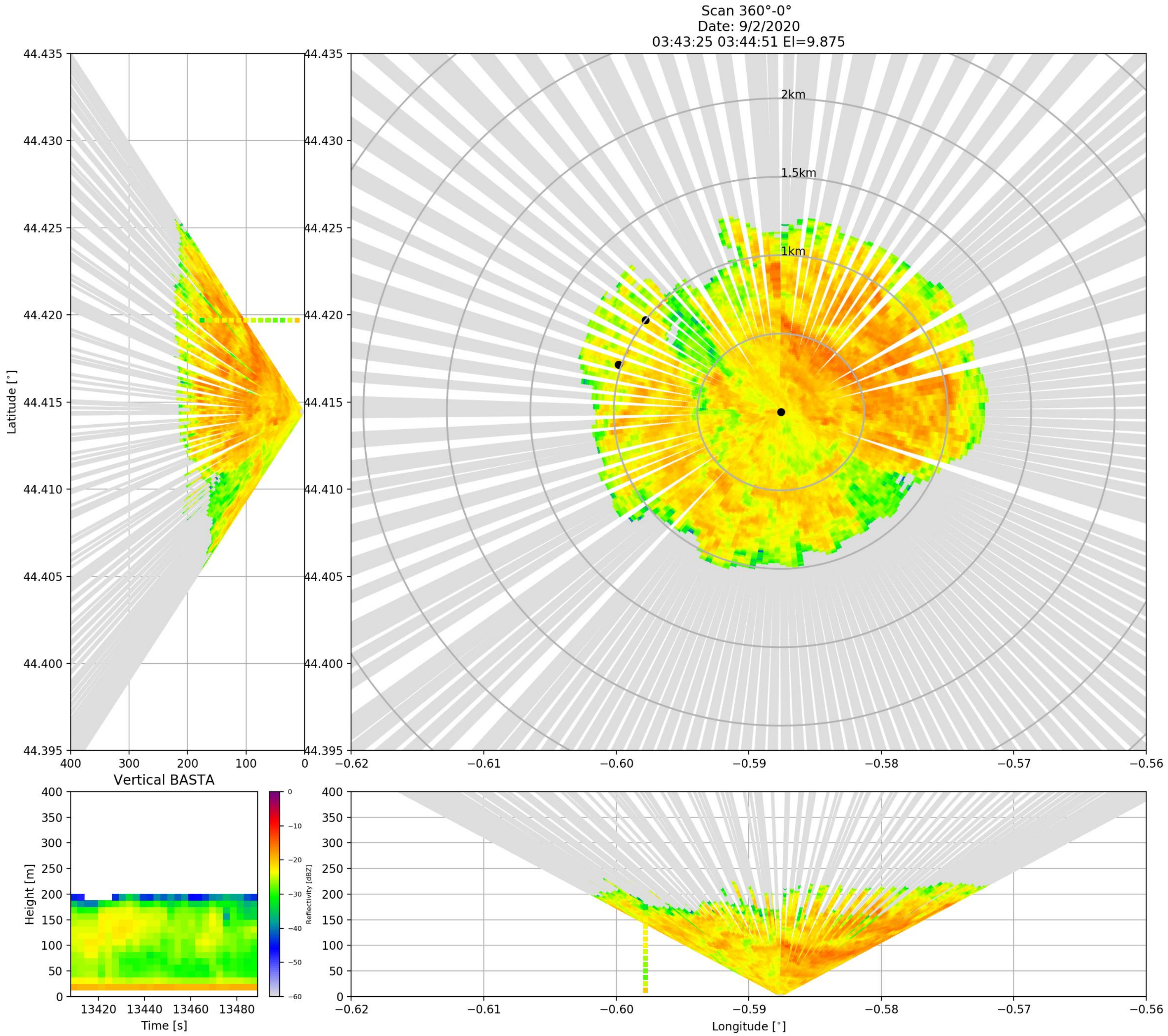
Quicklooks

Example	
Radar:	BASTA-mini LATMOS
Data Acquisition mode:	Scanning
Sampling mode:	12m5
Data:	MAPS

File name:

seq_16_maps_360_0_20200209_034325_034451_El=9.875

Date — Time interval — Elevation

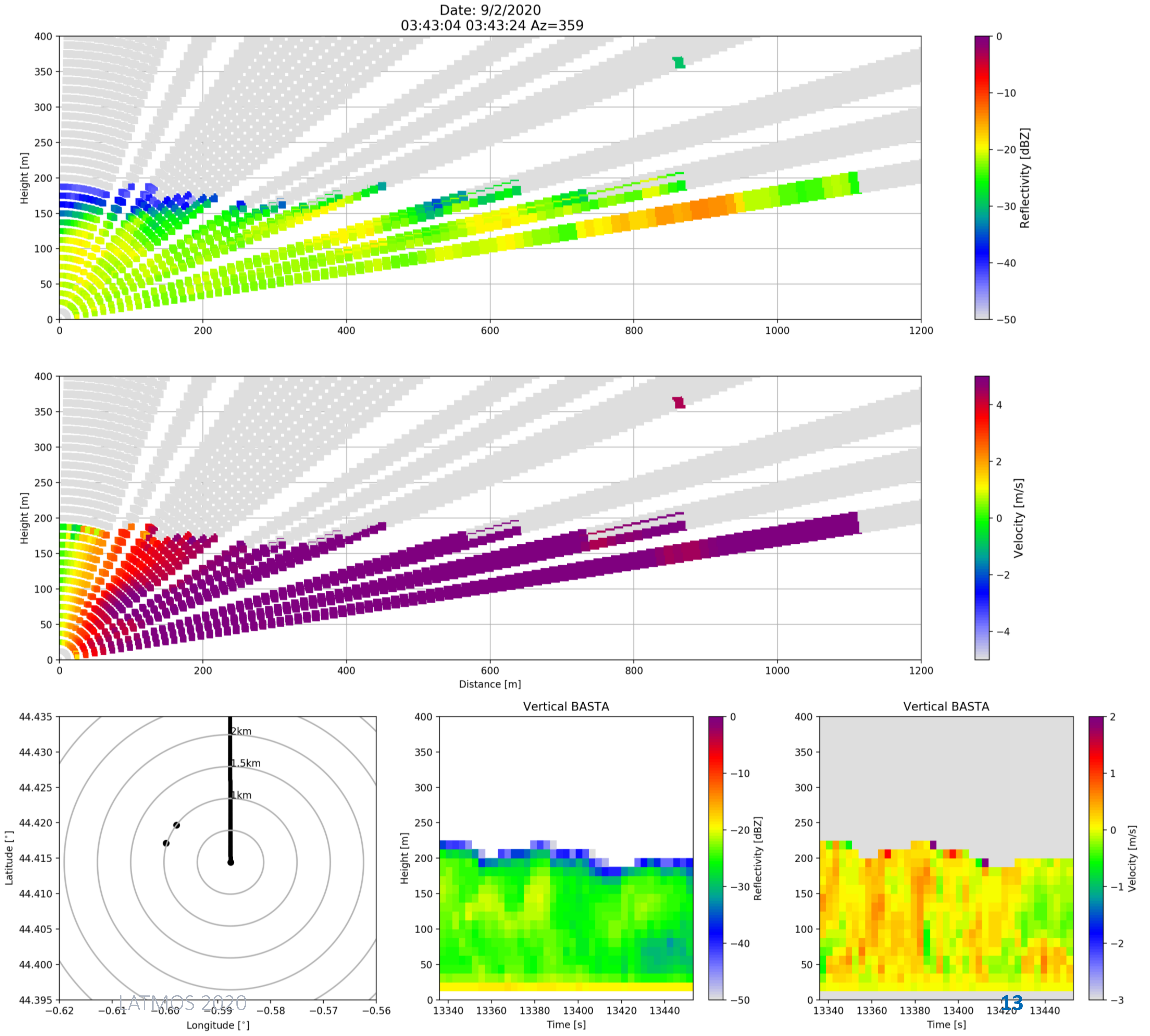


Quicklooks

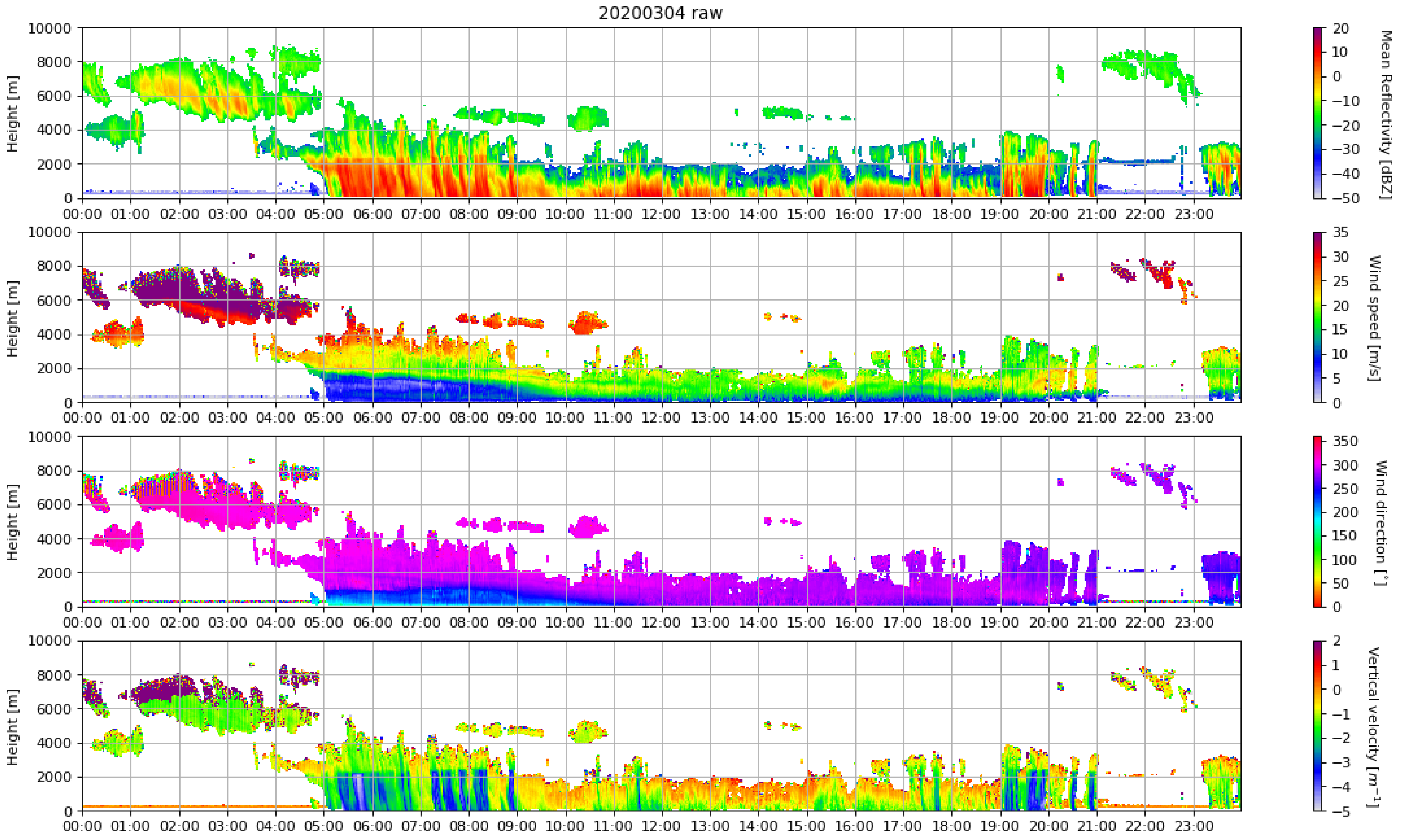
Example	
Radar:	BASTA-mini LATMOS
Data Acquisition mode:	Scanning
Sampling mode:	12m5
Data:	RHI

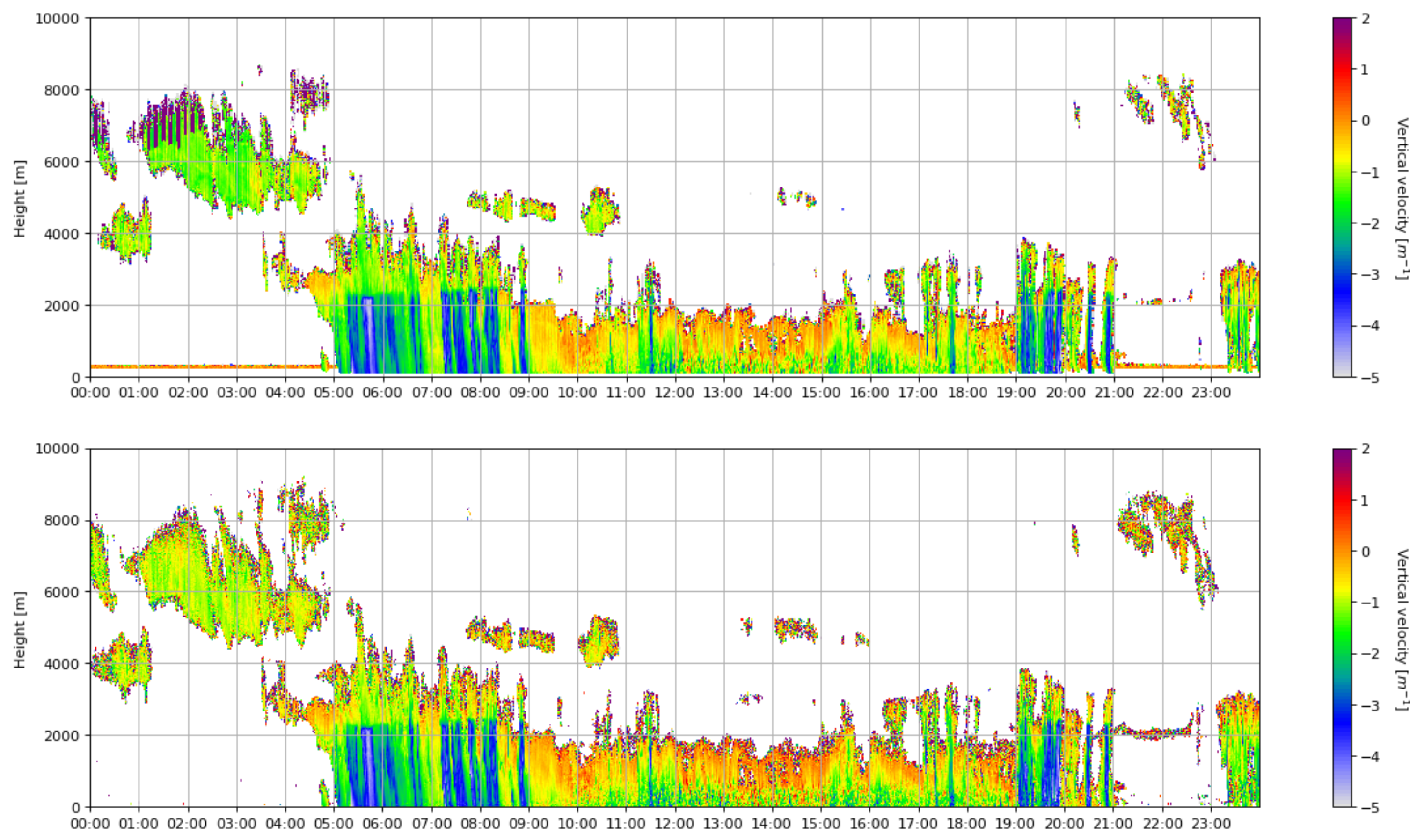
File name:
RHI_20200209_034304_034324_Az=359deg

Date | Time interval | Azimuth



Quicklooks





NOTE:

Not fog related: First results, needs more work...

Catalogue

How to read the catalogue:

- Each tab corresponds to one instrument → BASTA-mobile LATMOS, BASTA-mini LATMOS, BASTA-mini CNRM
- Tables are divided for each mode and indicate the availability of each file

BASTA-mobile LATMOS and BASTA-mini CNRM:

Date	Mode			Vertical Files		
	12m5	25m	100m 18km	12m5	25m	100m_18km
1	● (green)	● (green)	● (red)	BASTA_L1_12m5_20200101_000000.nc	BASTA_L1_25m_20200101_000001.nc	
2	● (green)	● (red)	● (green)	BASTA_L1_12m5_20200102_000002.nc		BASTA_L1_100m_18km_20200102_000001.nc

NOTES

Sampling mode availability:
12m5 / 25m/ 100m 18km

- ● (green) Available
- ● (yellow) Partially available / Delay
- ● (red) Problem or not available (see notes)

Files names for each mode
- 12m5
- 25m
- 100m 18km

Comments / Notes

Catalogue

BASTA-mini LATMOS:

Acquisition mode

	Vertical Position					
Date	Mode			Files		
	12m5	25m 18km	100m 18km	12m5	25m 18km	100m_18km
1	🟢	🟢	🟡	BASTA_L1_12m5_20191201_000001.nc	BASTA_L1_25m_18km_20191201_000002.nc	BASTA_L1_100m_18km_20191201_093750.nc
2	🟢	🔴	🟢	BASTA_L1_12m5_20191202_000000.nc		BASTA_L1_100m_18km_20191202_000002.nc

Sampling mode availability:
12m5 / 25m 18km / 100m 18km

- 🟢 Available
- 🟡 Partially available / Delay
- 🔴 Problem or not available (see notes)

Files name for each mode

- 12m5
- 25m 18km
- 100m 18km

Catalogue

BASTA-mini LATMOS:

Acquisition mode

	Scanner					
Date	Mode 12m5	Mode 25m 12km	Start Time	End Time	Files 12m5	Files 25m_12km
1	🟢	🔴	21:31	23:58	BASTA_L1_12m5_20200101_213119.nc	
2	🟢	🟢	00:00	08:24	BASTA_L1_12m5_20200102_000000.nc	BASTA_L1_25m_12km_20200102_083429.nc

Sampling mode availability:
12m5 / 25m 12km

- 🟢 Available
- 🟡 Partially available / Delay
- 🔴 Problem or not available (see notes)

If the radar worked in scanner mode:
- Start time
- End time

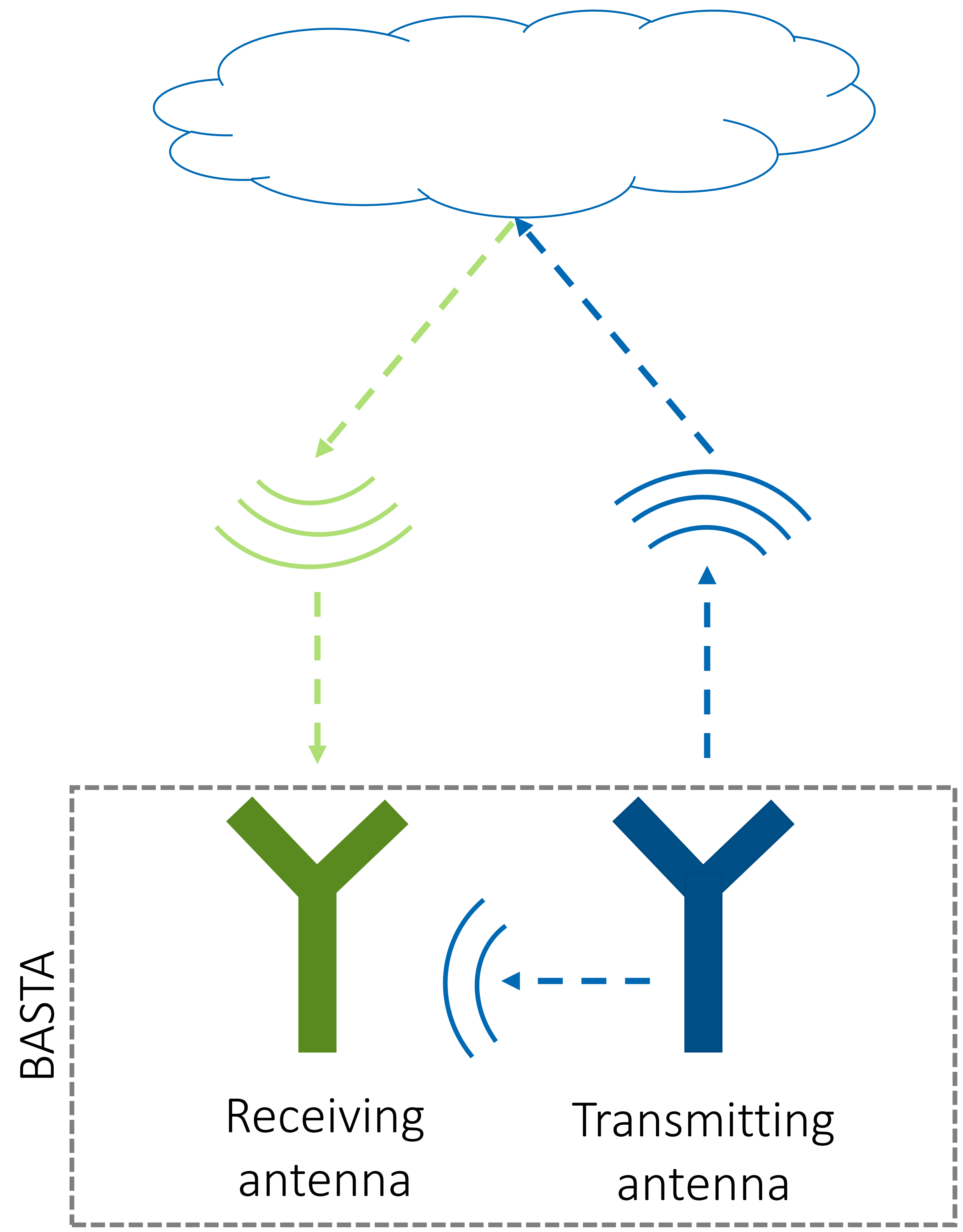
Files name for each mode
- 12m5
- 25m 12km

SOFOG3D

Studies

15 May 2020

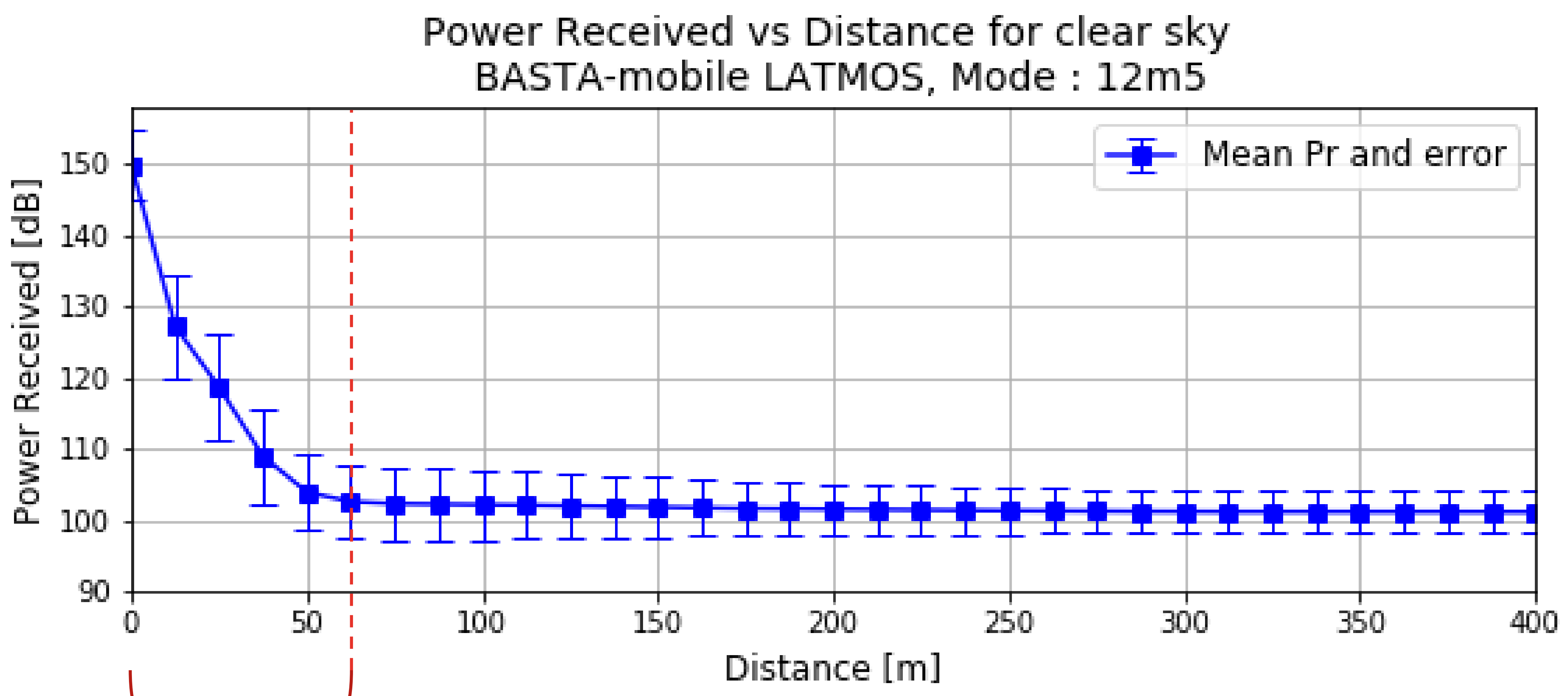
The problem



Coupling

- Coupling occurs when the Receiving antenna receives directly energy/signal from the Transmitting antenna
- It depends on the relative separation, orientation and isolation of each antenna and their physical characteristics.
- When the target is too close to the antennas, signal can be confused with coupling. For example, this can happen for **Fog**
- It can't be removed, just attenuated with radar design.
- We can use the variable 'Power Received' to study the coupling.

The problem



Antenna coupling zone
(from gates 1 to 6)

Fog thickness
range

We define two problems to study:

1. Antenna Coupling

How to characterize antenna coupling?

2. Fog detection on the first gates

Is it possible to detect low fog (0-70m) using only the cloud radar?

Antenna Coupling

15 May 2020

Methodology

Data:
BASTA-mobile LATMOS
Surface data

- To study the antenna coupling, we use the radar variable Power Received (Pr)
- Data selection: Clear sky and partially cloudy profiles

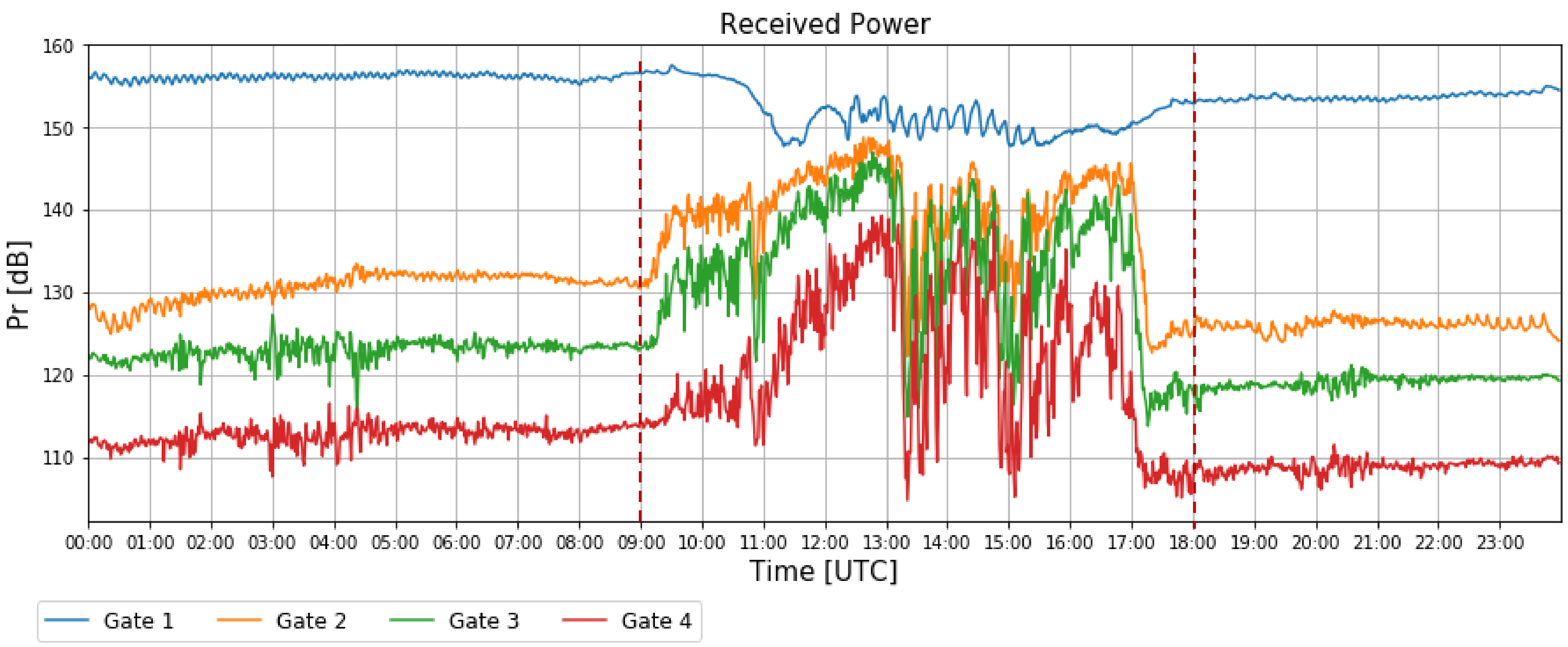
Daily Cycle:
Coupling

<u>Objectives:</u>
- To observe the coupling daily cycle

Daily Cycle Examples:
Temperature, Relative Humidity and Radiation

<u>Objectives:</u>
- To observe the daily cycle of each variable and determine which variables have more influence in the variability of the coupling

Daily Cycle: Coupling



Period with more variability

Plot:

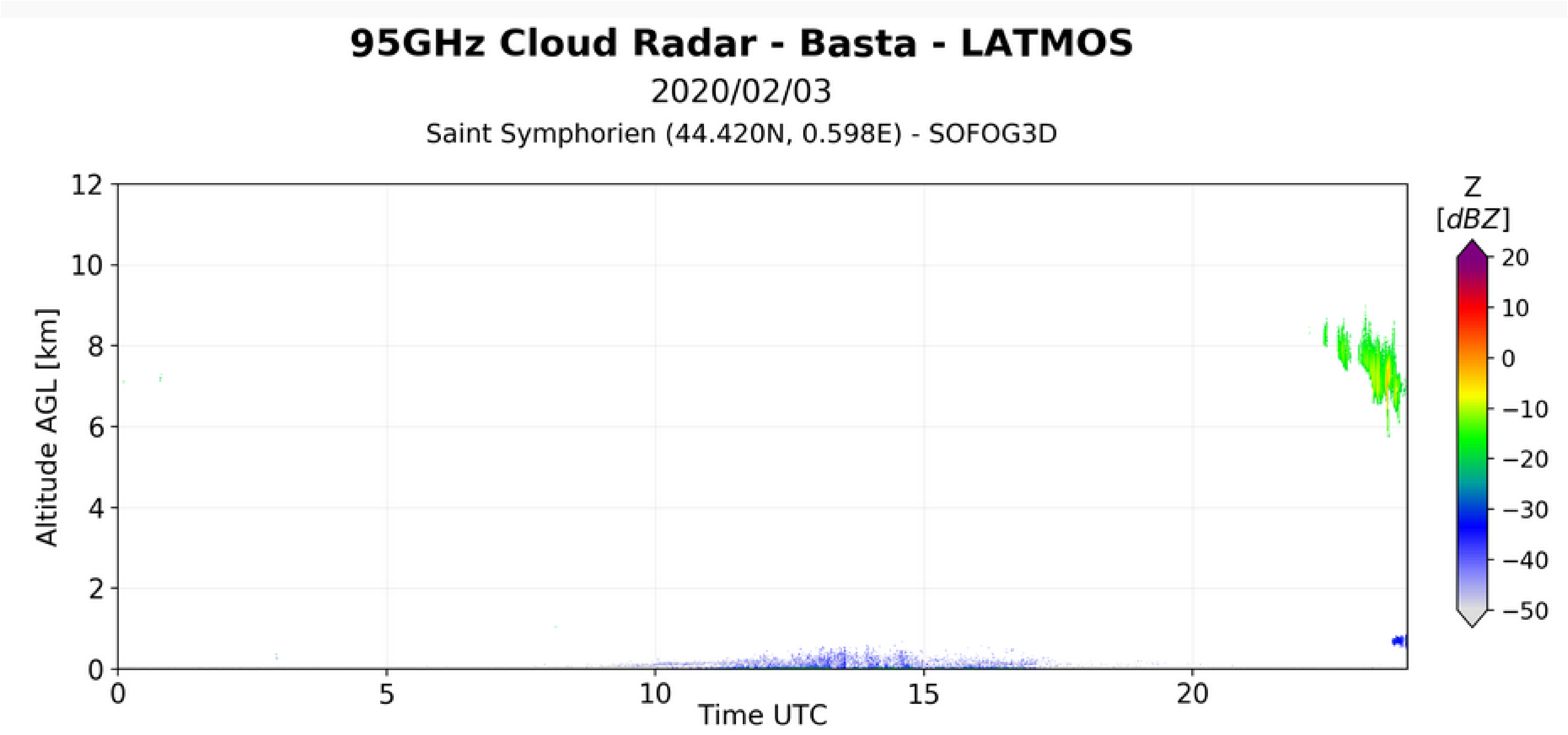
- Coupling daily cycle. For gates 1 to 4

Observations:

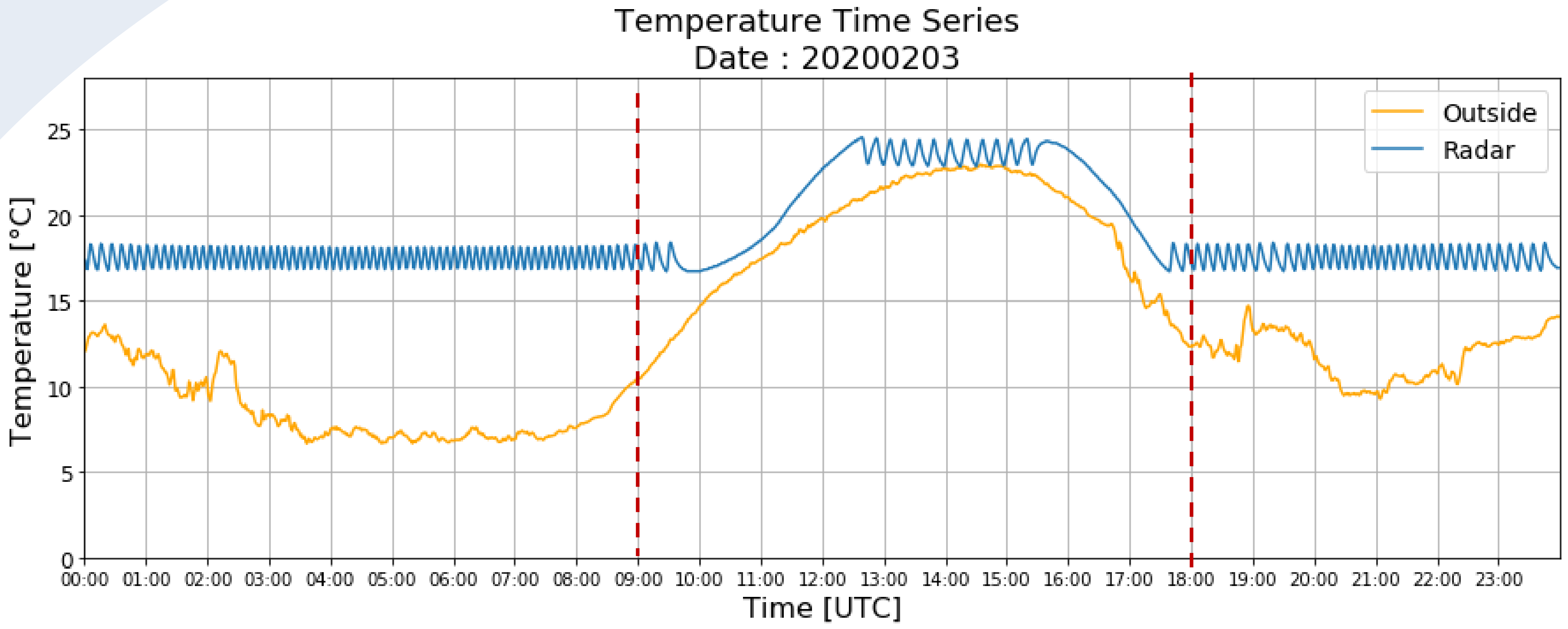
- Each gate has different Pr values.
- The farther we are from the antenna, the lower the Pr values
- Gates 2 to 4: more variability between ~9 am to ~6pm compare to gate 1

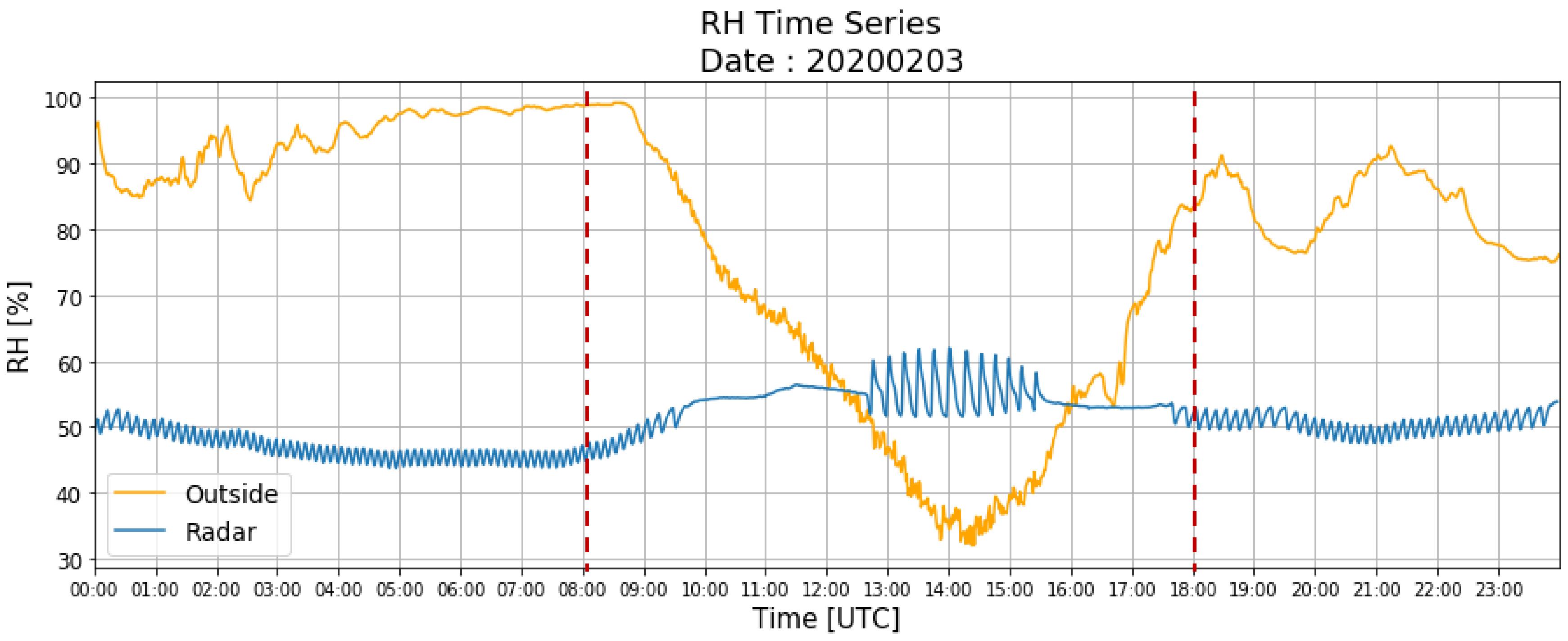
Example: Clear sky

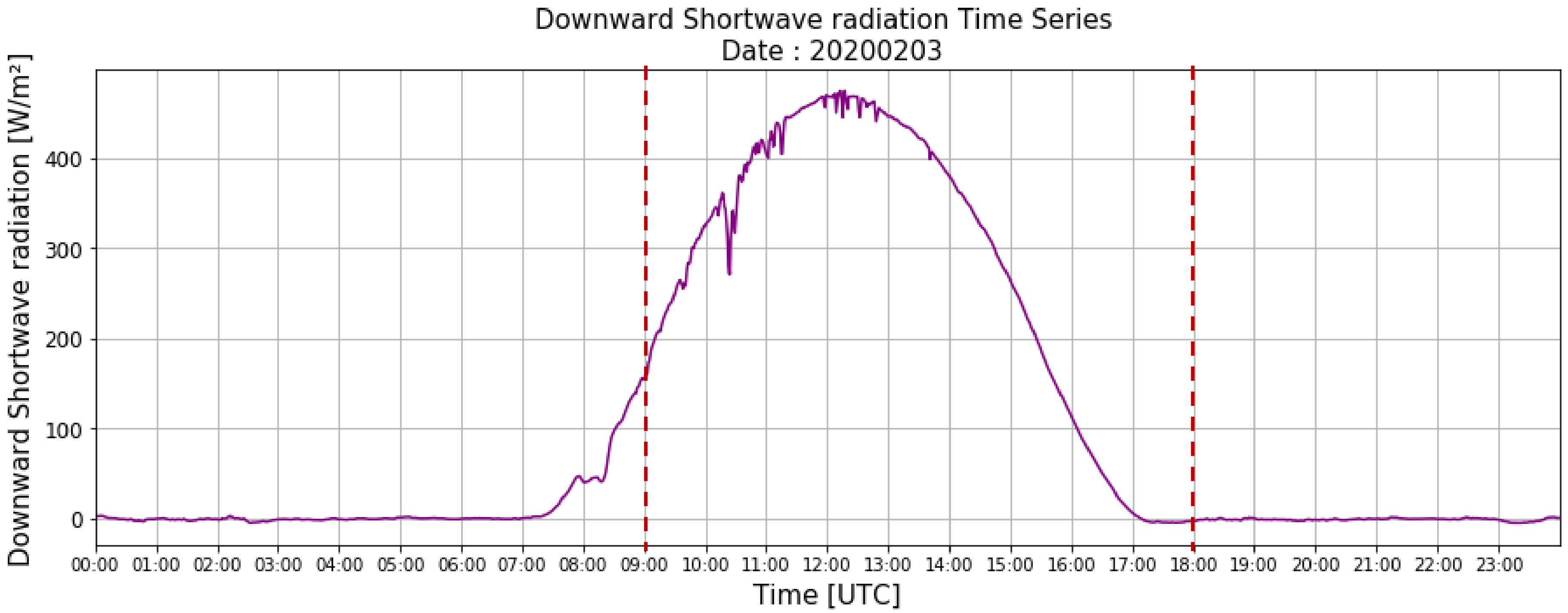
Example:
03/02/2020
Clear sky



Daily Cycle: Clear sky





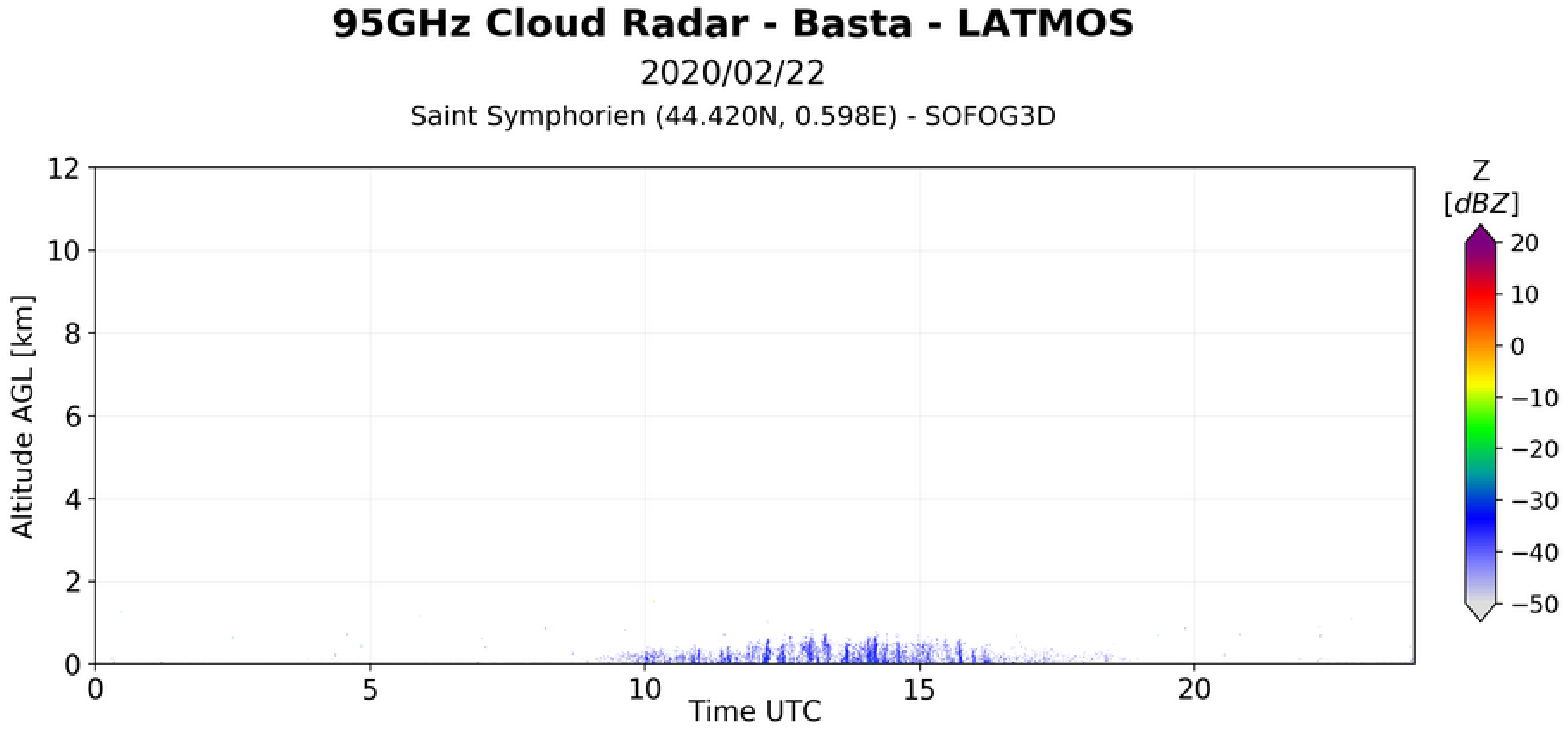


Observation:

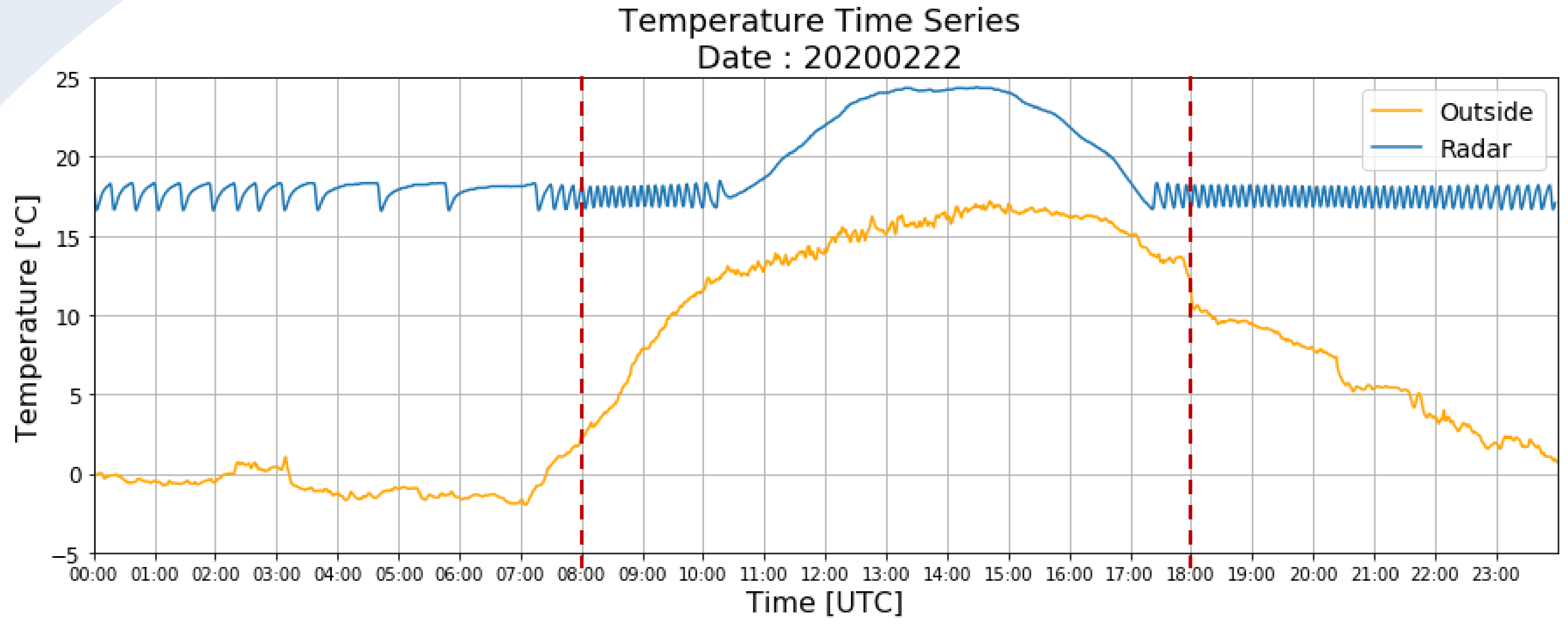
- Higher temperatures can cause problems in the temperature control inside the radar

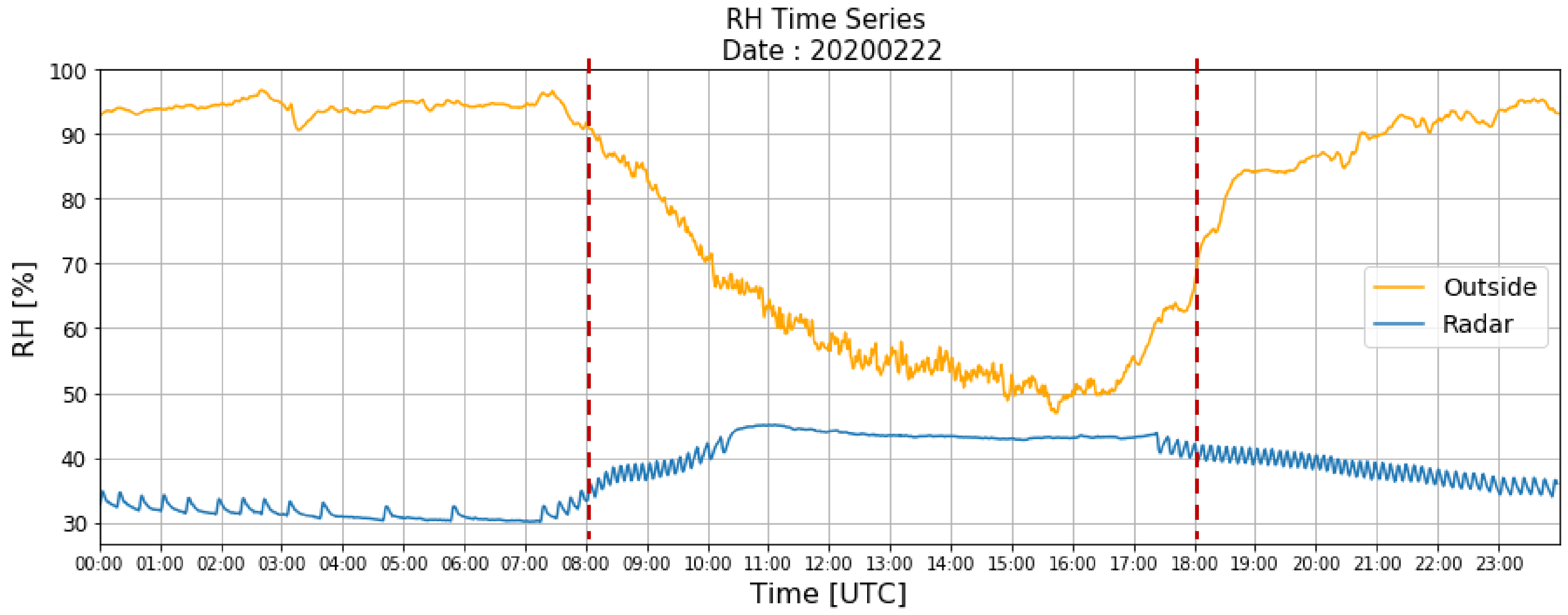
Example: Clear sky / Lower Temperature

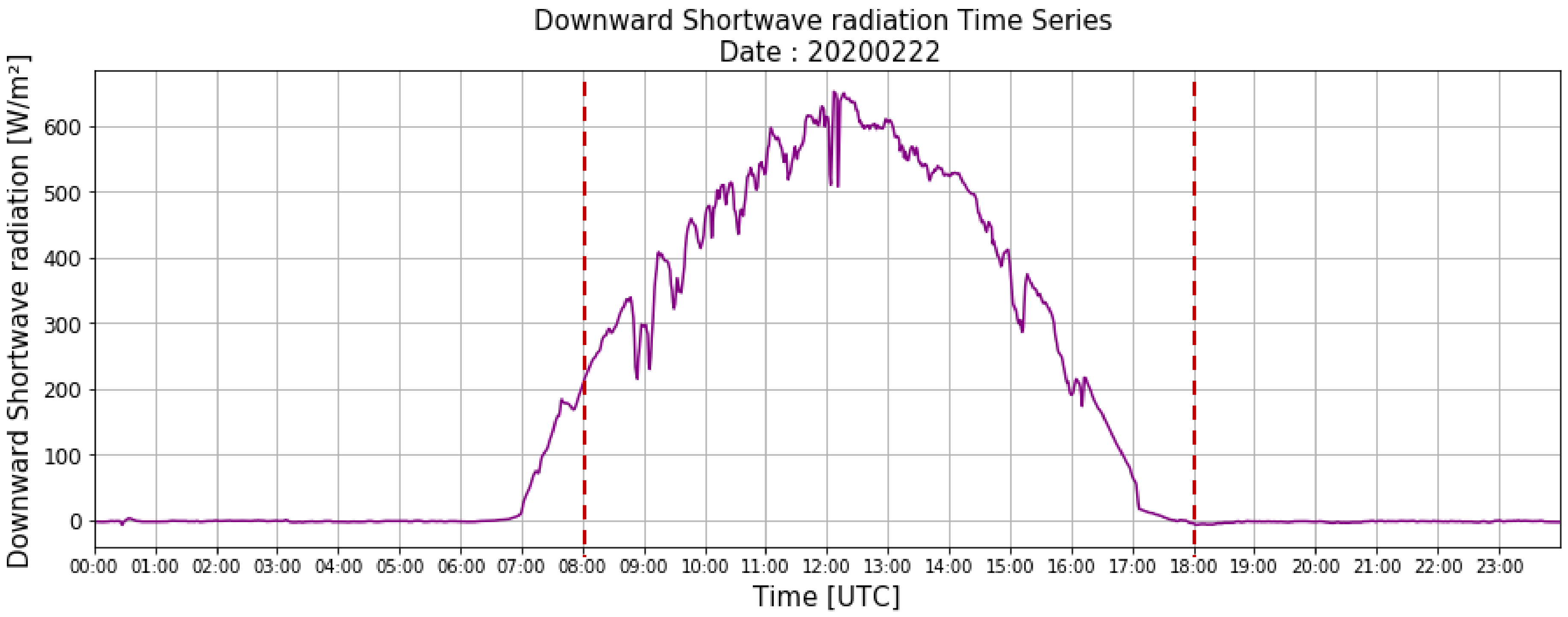
Example:
22/02/2020
Clear sky
Lower temperature



Daily Cycle: Clear sky / Lower T





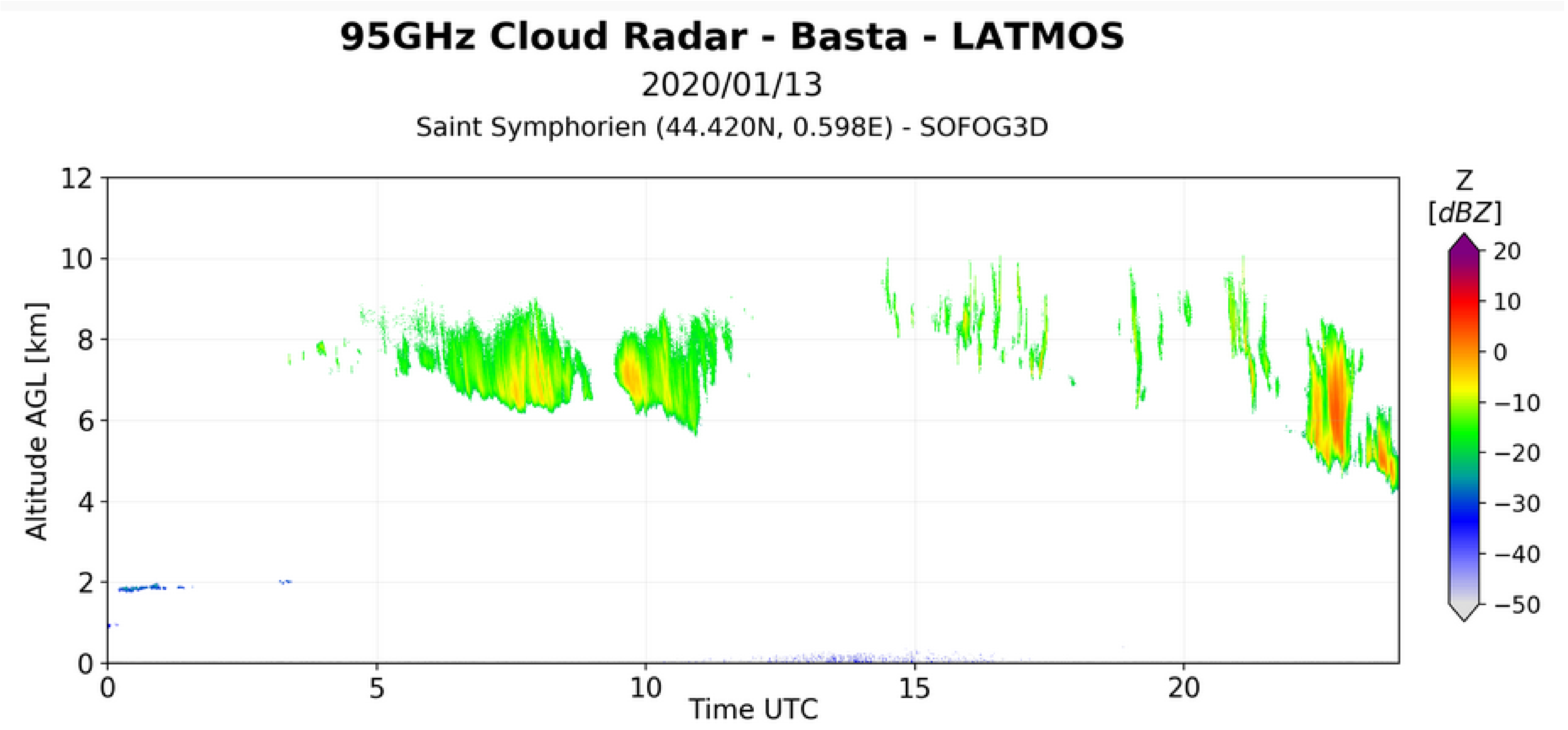


Observations:

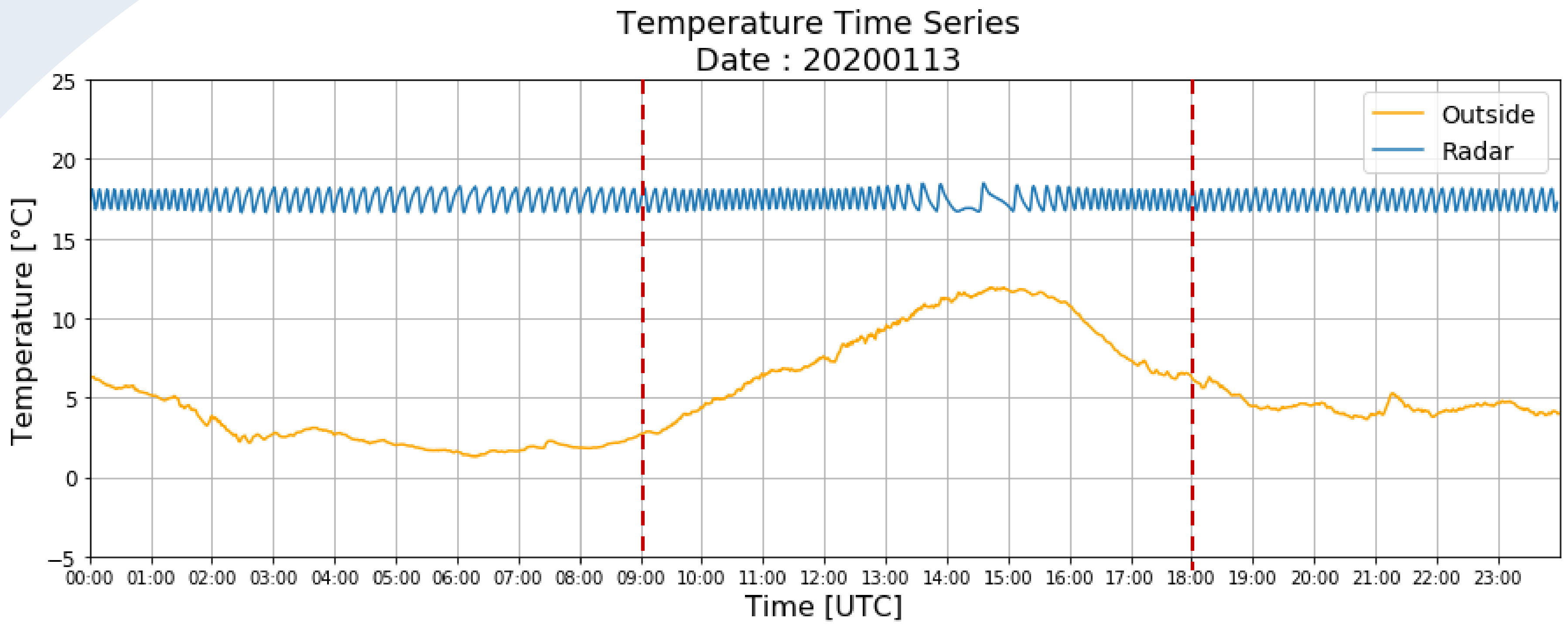
- With lower temperatures we observe the same problem
- Can radiation play an important role?

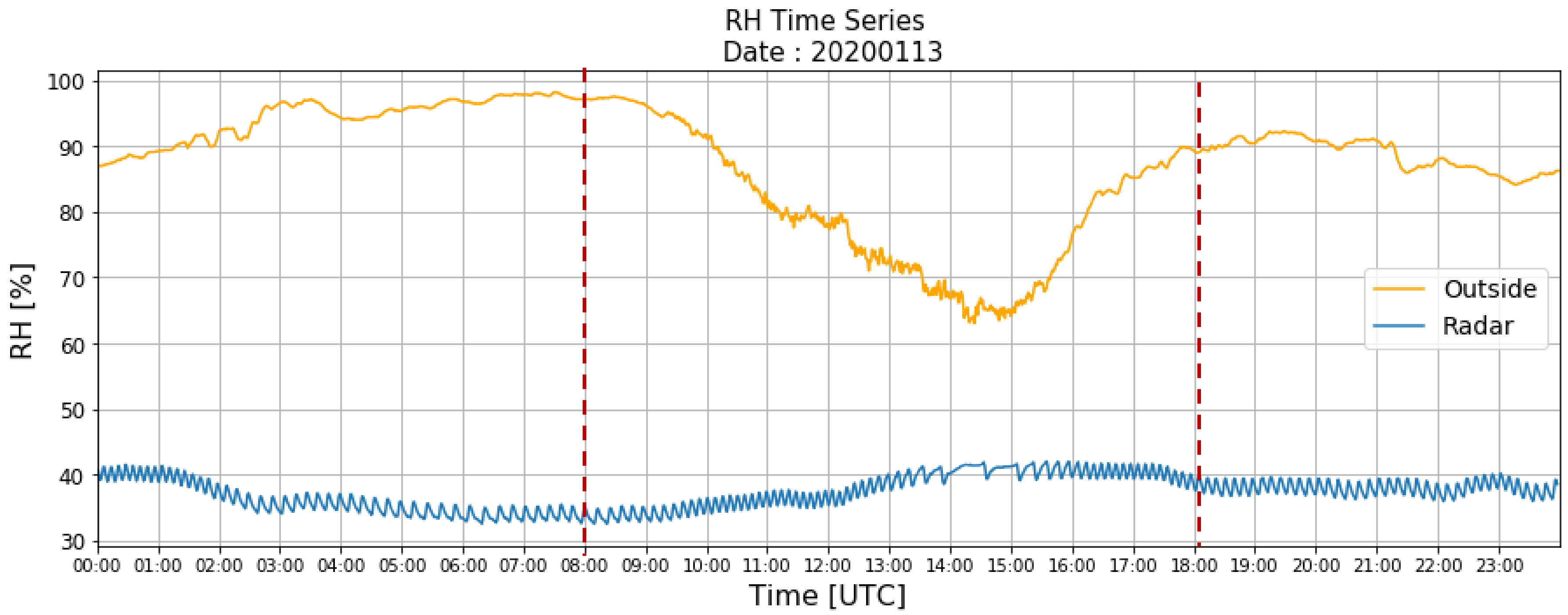
Example: Partial Cloudiness

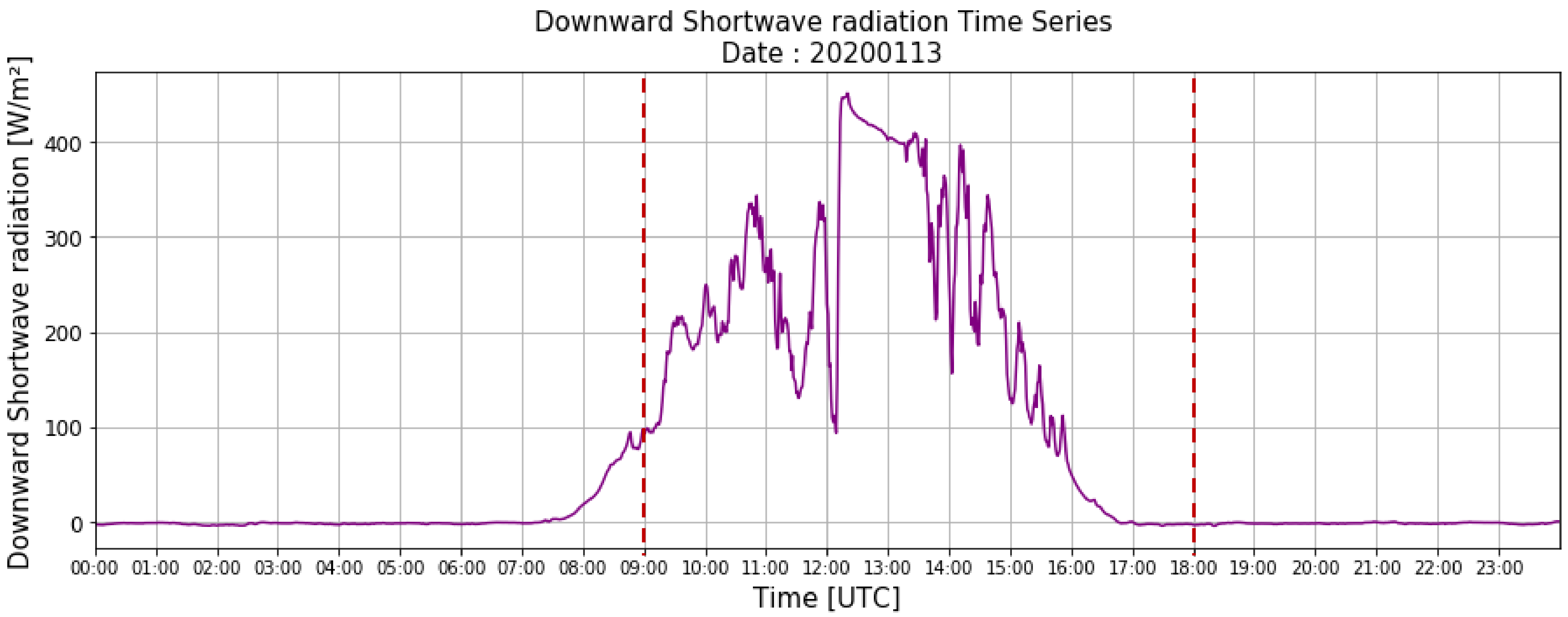
Example:
03/02/2020
Partial Cloudiness



Daily Cycle: Partial Cloudiness



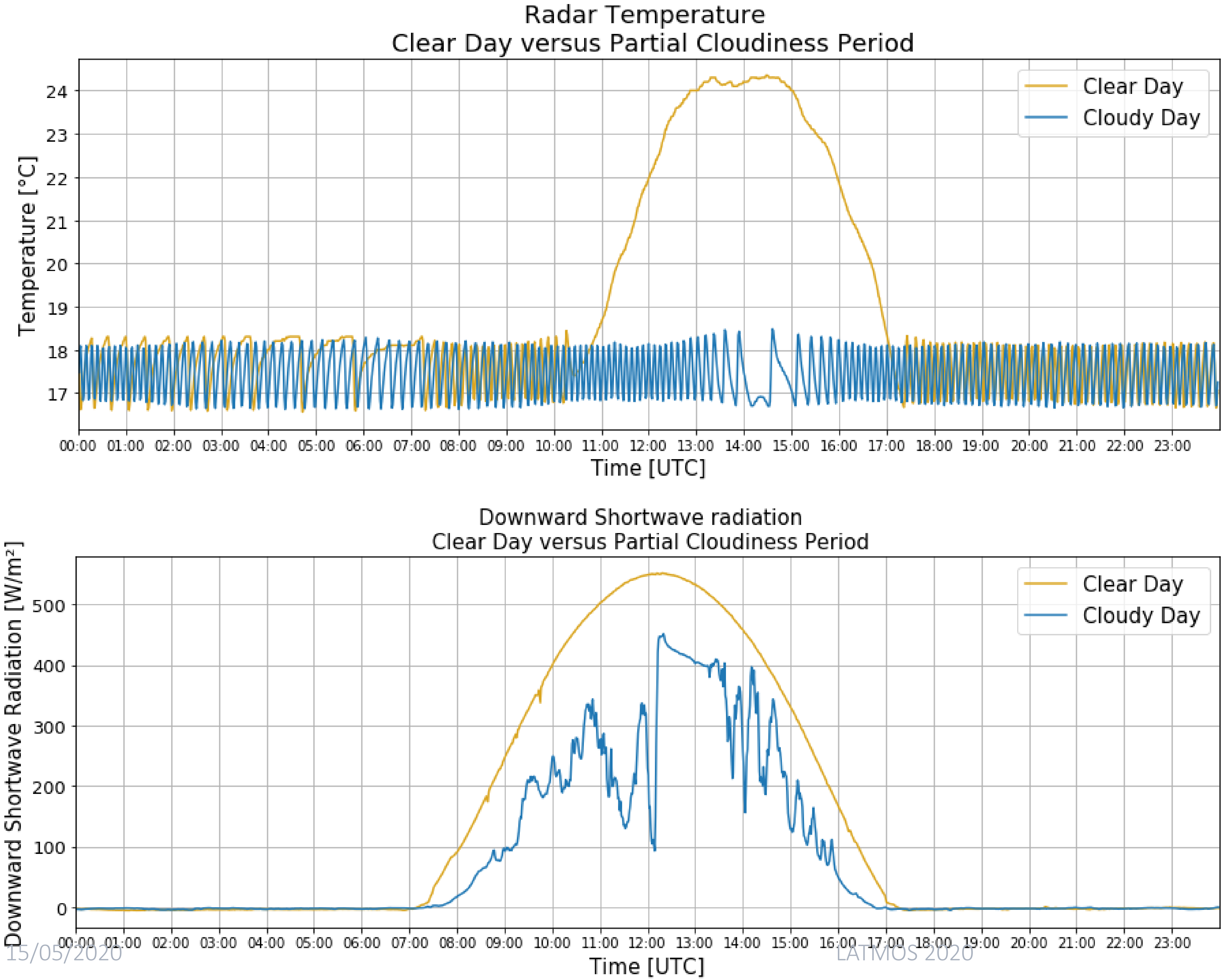




Observations:

- When it's cloudy, there is no problem
- Can radiation play an important role?

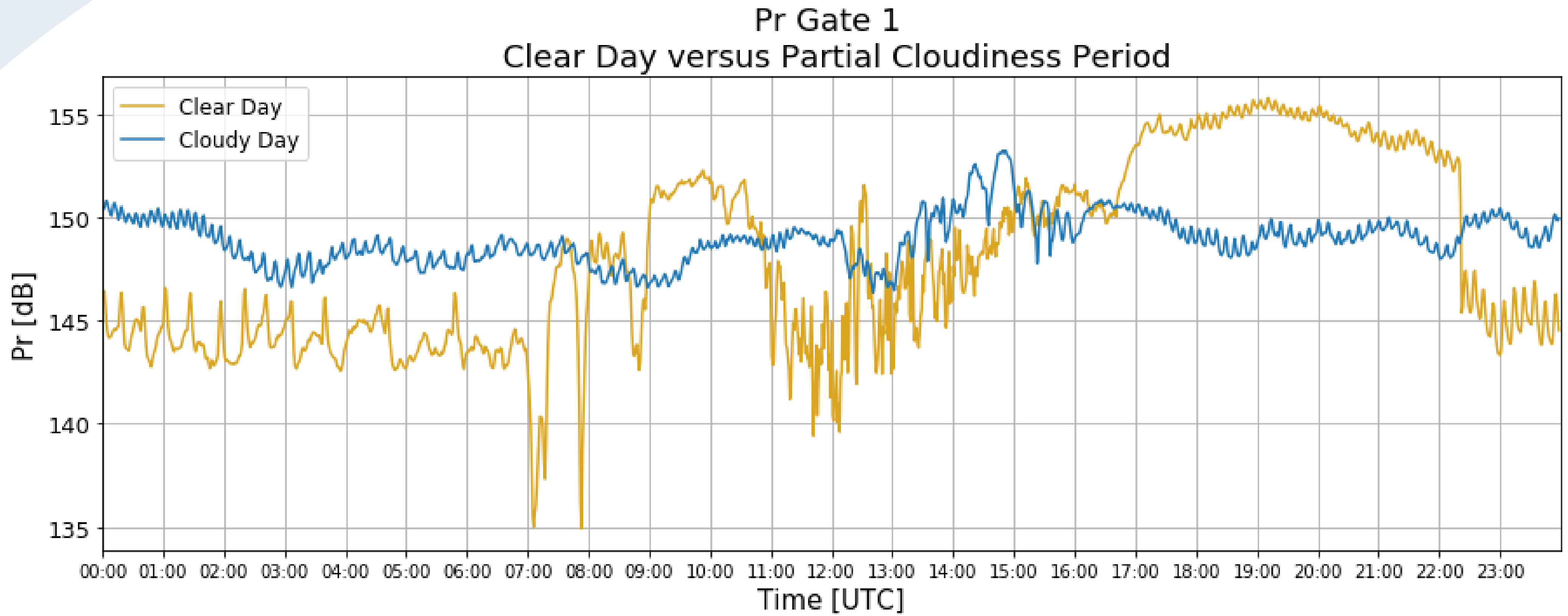
Radiation and Radar Temperature

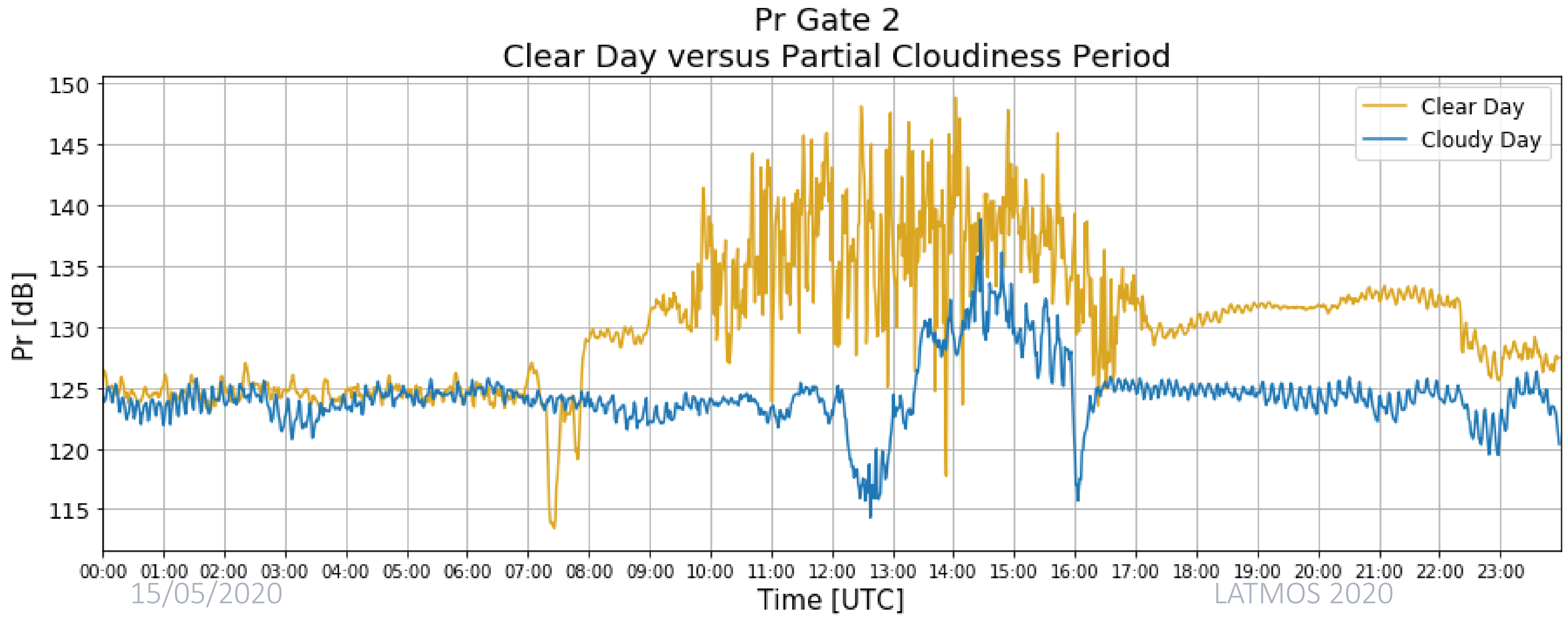


<u>Observations:</u>

- Better temperature control when the radiation is lower
- But what happens with Pr?

Coupling at Gate 1 and 2

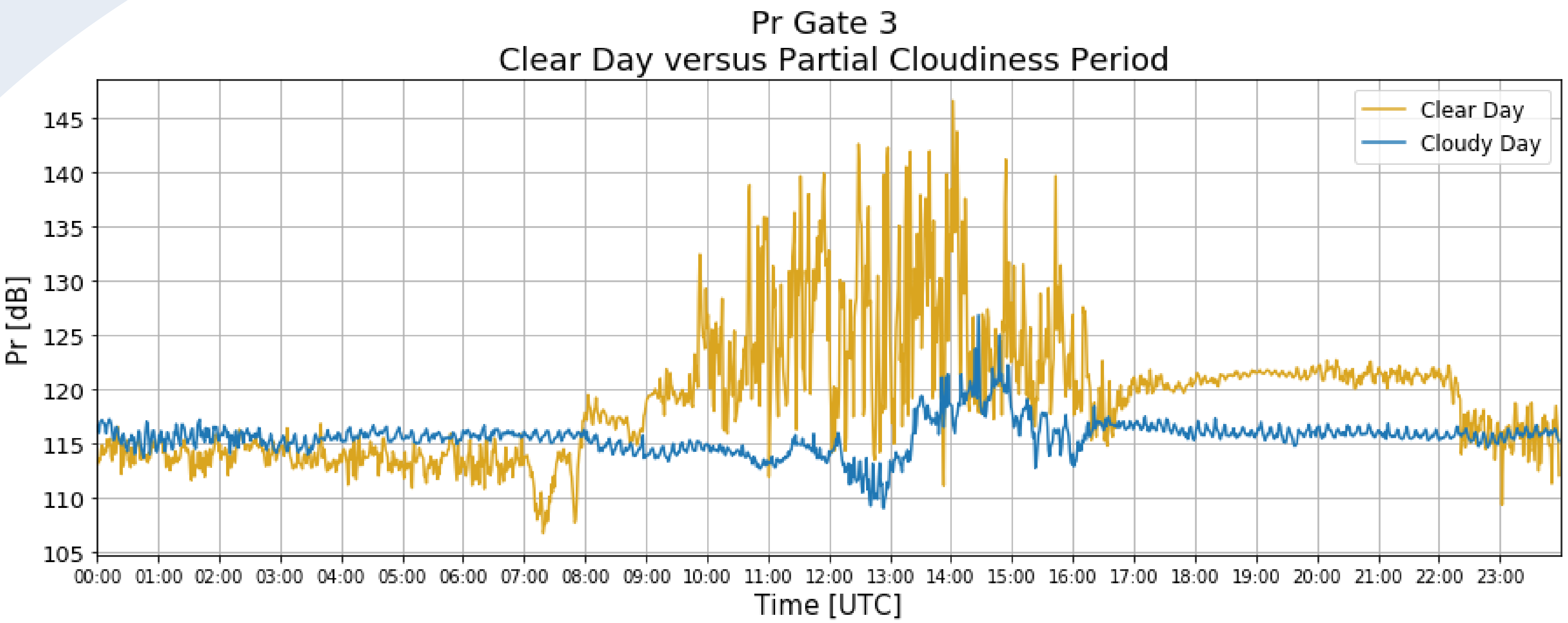


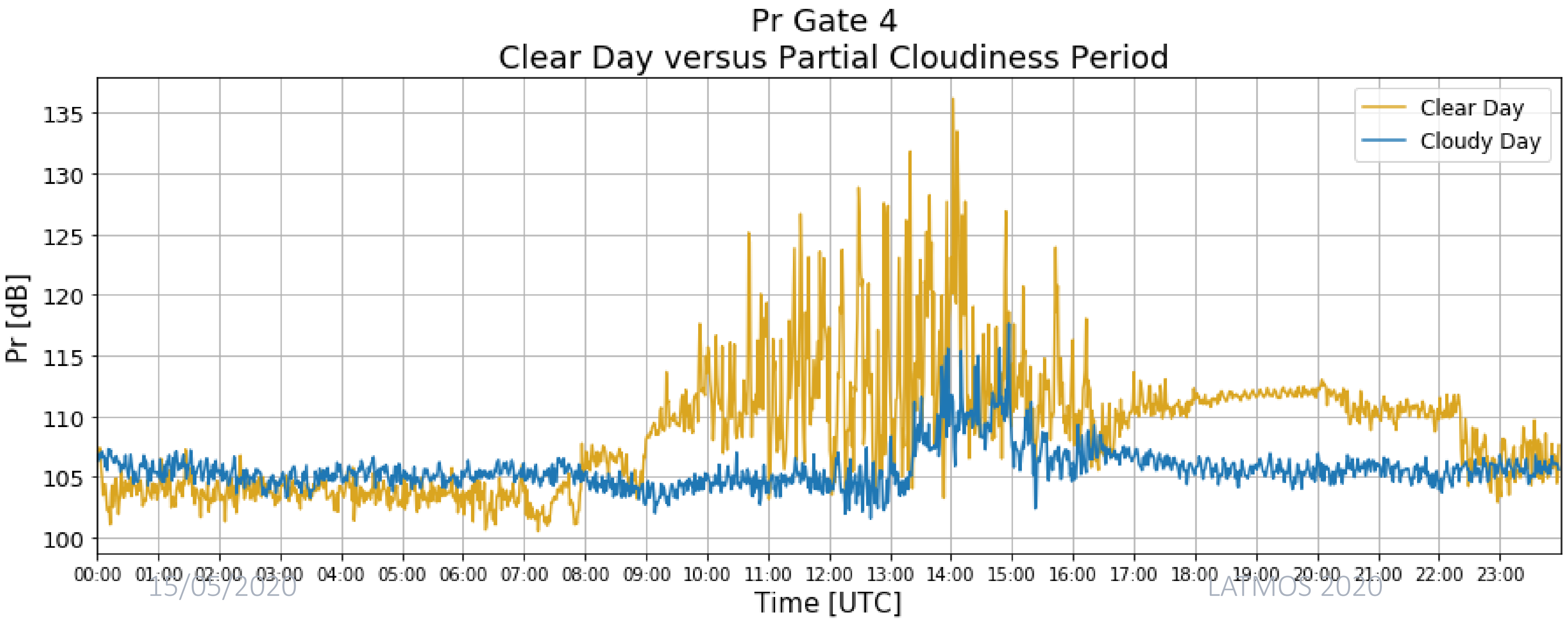


Observations:

- Pr is more variable with clear sky and high radiation

Coupling at Gate 3 and 4





Observations:

- Pr is more variable with clear sky and high radiation

Shortwave Radiation

Conclusions

- Radiation impacts the radar temperature, introducing a larger variability in the coupling.
- Does coupling allow fog detection on the first gates?

This leads us to our 2nd study

2. Fog detection on the first gates

Is it possible to detect low fog (0-70m) using only the cloud radar?

Fog detection

15 May 2020

Methodology

Period selection

a) Full days with clear sky (background coupling)
b) Fog and mist events

	Time interval	Amount of periods
Clear sky	00:00 – 23:59	9
Fog	Variable	9
Night mist	00:00 – 06:00	8

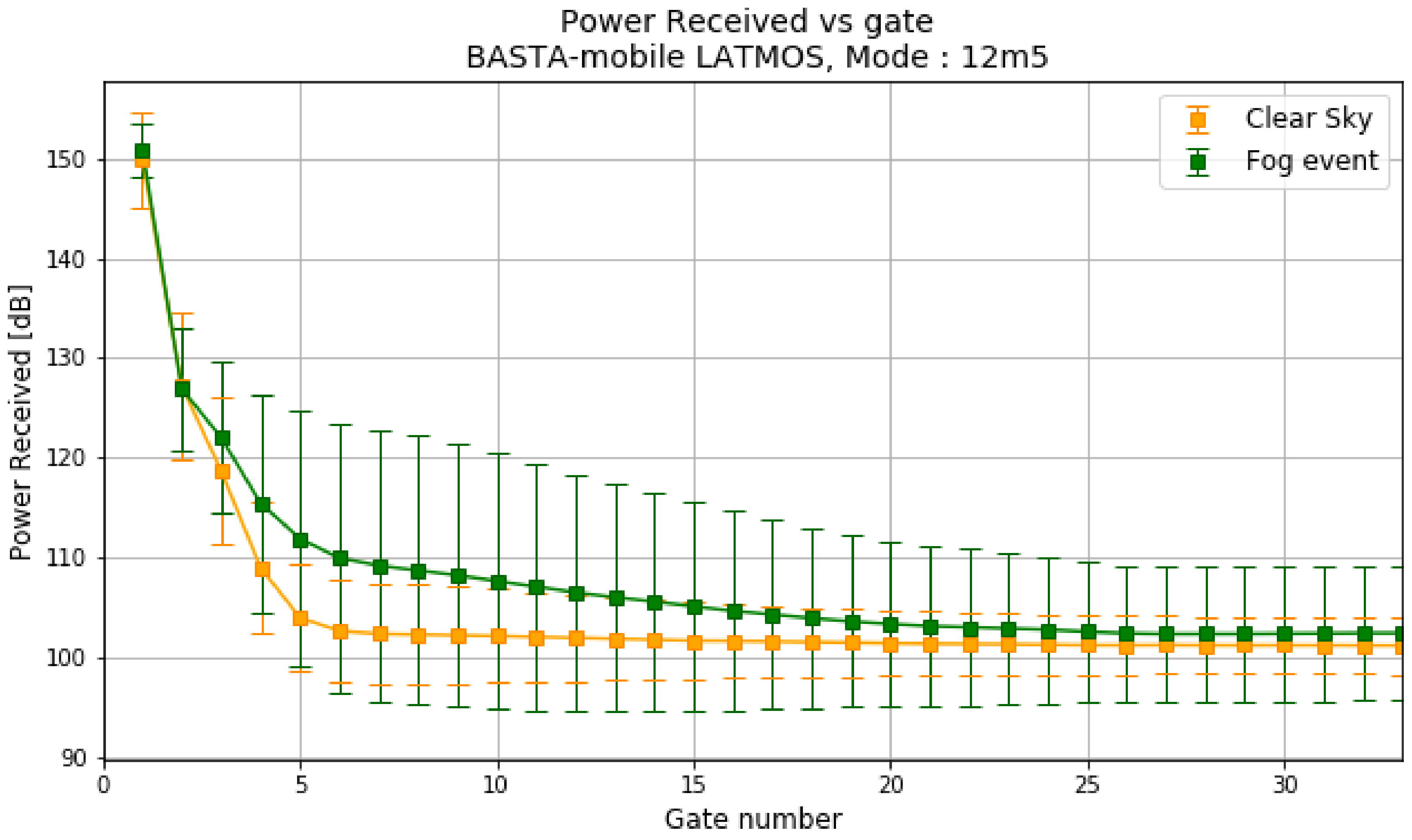
Plot :
Power Received versus Distance

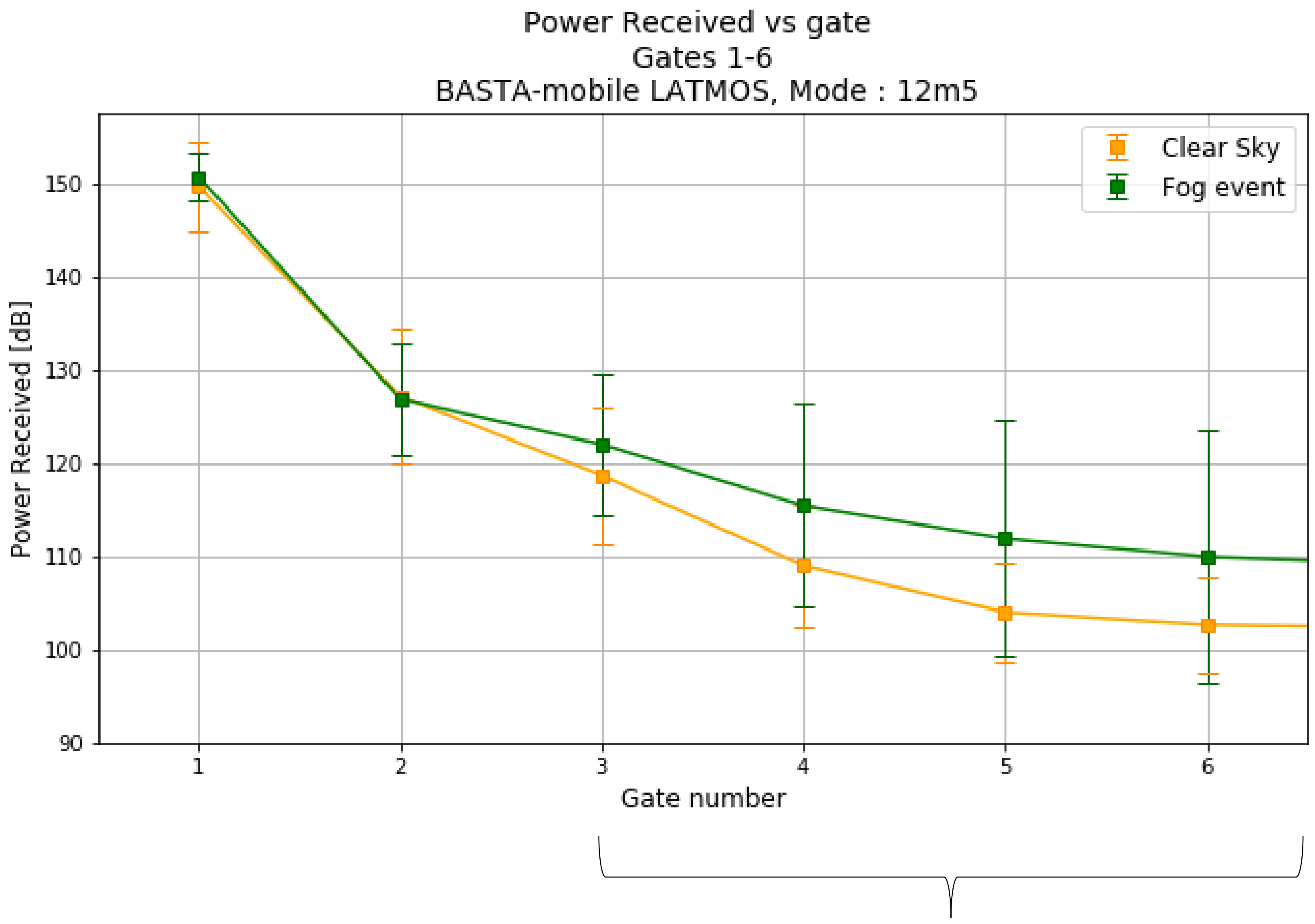
Objectives:
- To compare the values of Power Received in fog events with those of the background coupling cases
- To determine from which gate it's possible to detect fog

Pr Histograms :
Fog event versus background case

Objectives:
- To compare Power Received distributions between fog events and the background cases for the first gates (1 – 6).
- Determine the minimum Power value for fog detection at each gate

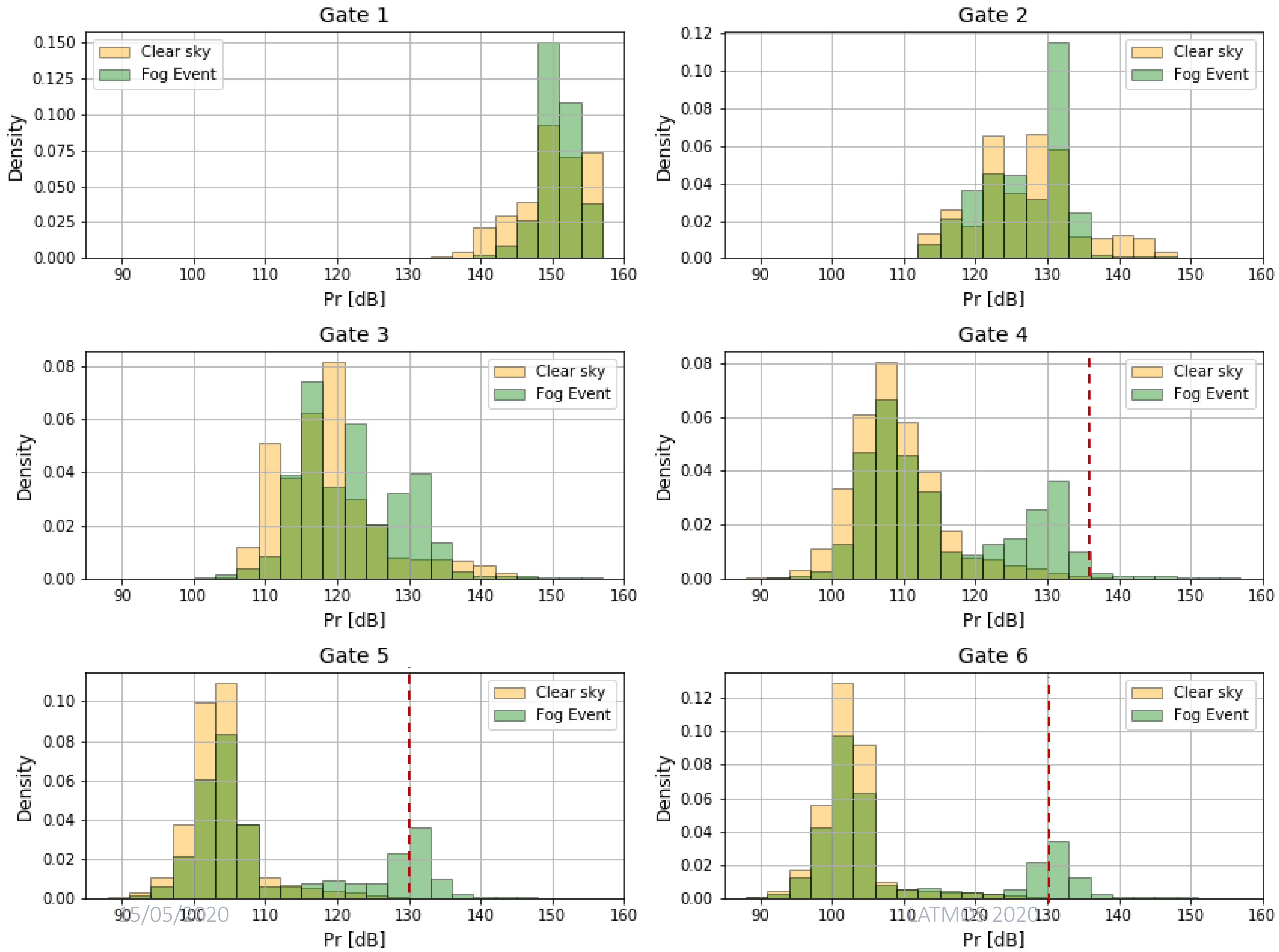
Results





Fog detection?

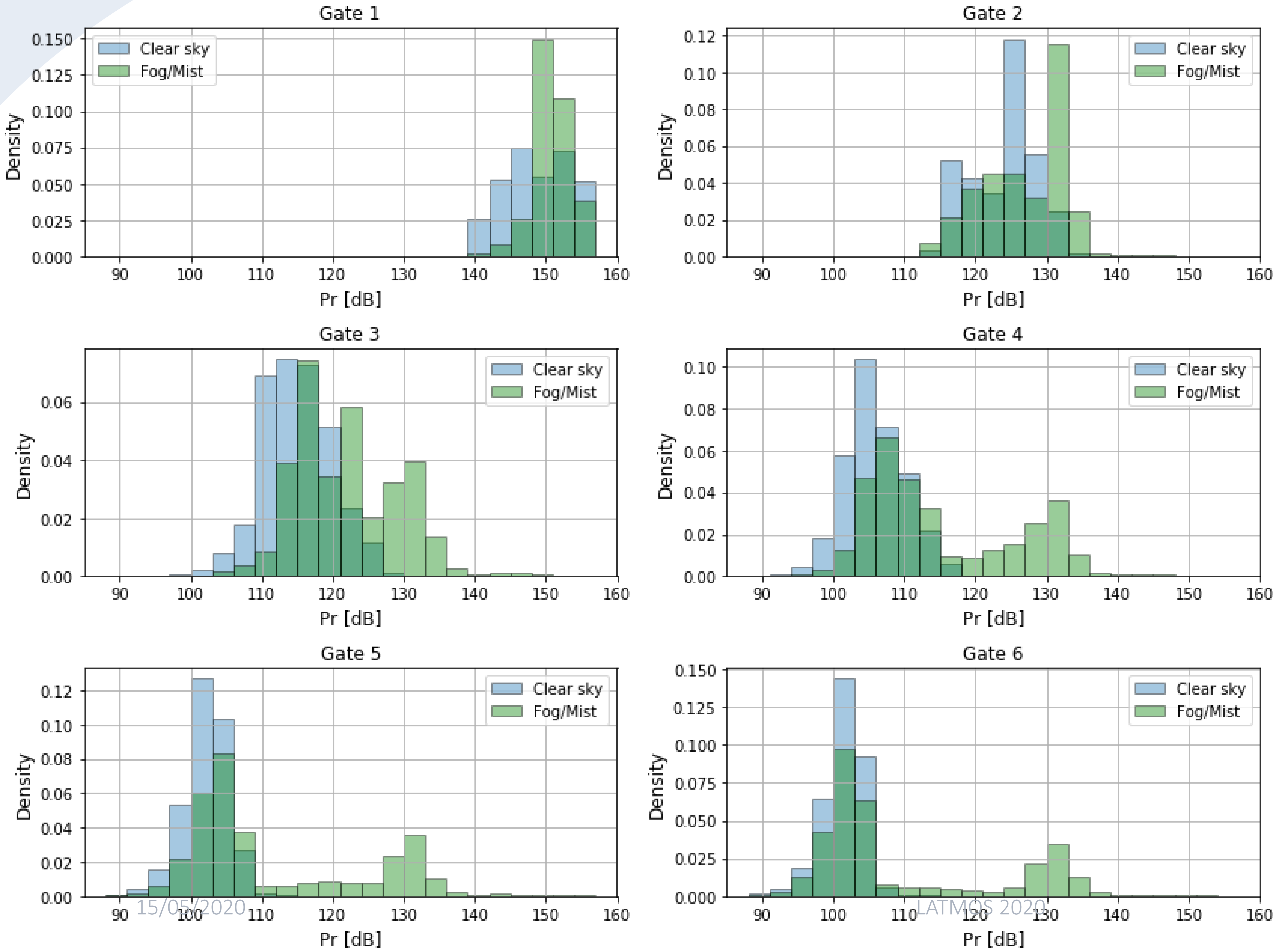
Results - Day



Clear Sky and fog event comparison

Conclusions	
Fog detection	Gate 1 : ✗
	Gate 2 : ✗
	Gate 3 : ✗
	Gate 4 : 136 [dB]
	Gate 5 : 130 [dB]
	Gate 6 : 130 [dB]

Results - Night



Fog detection at night.
*Sometimes with the presence of mist.

Conclusions		
Fog detection	Gate 1 :	✗
	Gate 2 :	✗
	Gate 3 :	128 [dB]
	Gate 4 :	119 [dB]
	Gate 5 :	112 [dB]
	Gate 6 :	110 [dB]

Observations:

- It is possible to detect even mist with the radar from the 3rd gate

Conclusions

- Background Coupling is larger during the day.
- Fog detection is possible from the 4th gate by day. Threshold value: 136 [dB]
- Fog and mist detection is possible from the 3rd gate by night. Threshold value: 128 [dB]

Calibration Transfer

15 May 2020

Objectives

- To determine if it is possible to transfer the calibration constant between two radars separated by a kilometer of distance, using the statistics of their reflectivity measurements.

BASTA-mini LATMOS - Supersite
BASTA-mobile CNRM - Supersite

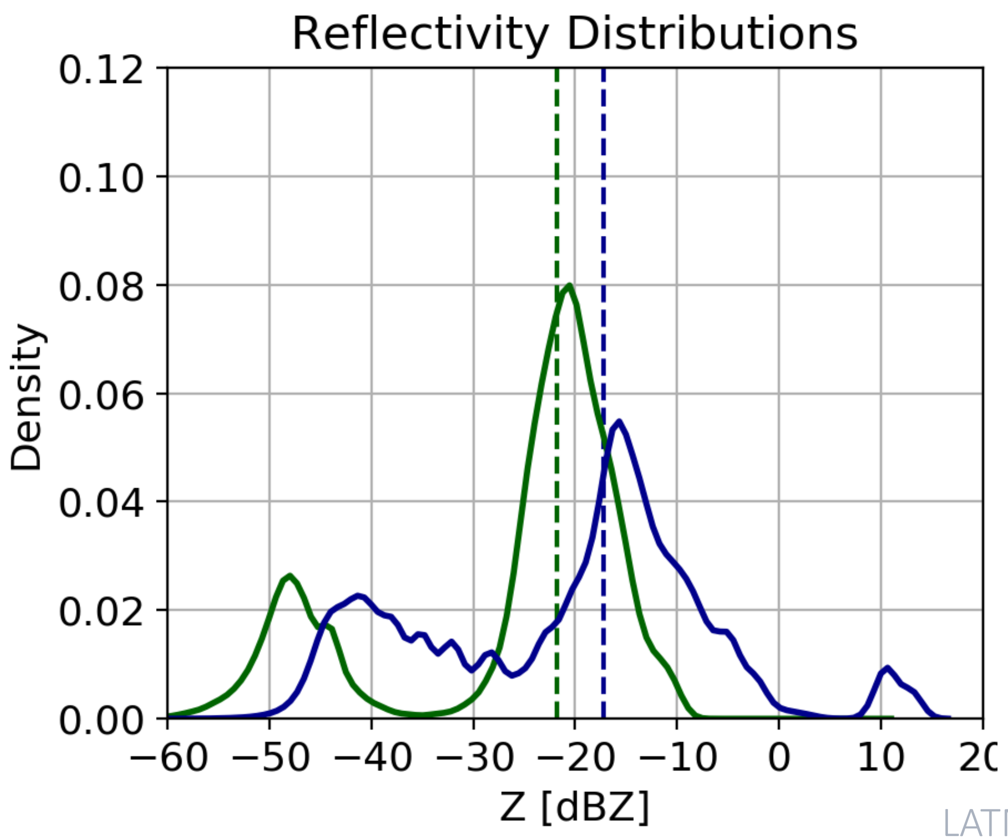
- To apply the same methodology to two radars separated by a greater distance (X km).

BASTA-mini LATMOS - Supersite
BASTA-mini CNRM - Agen

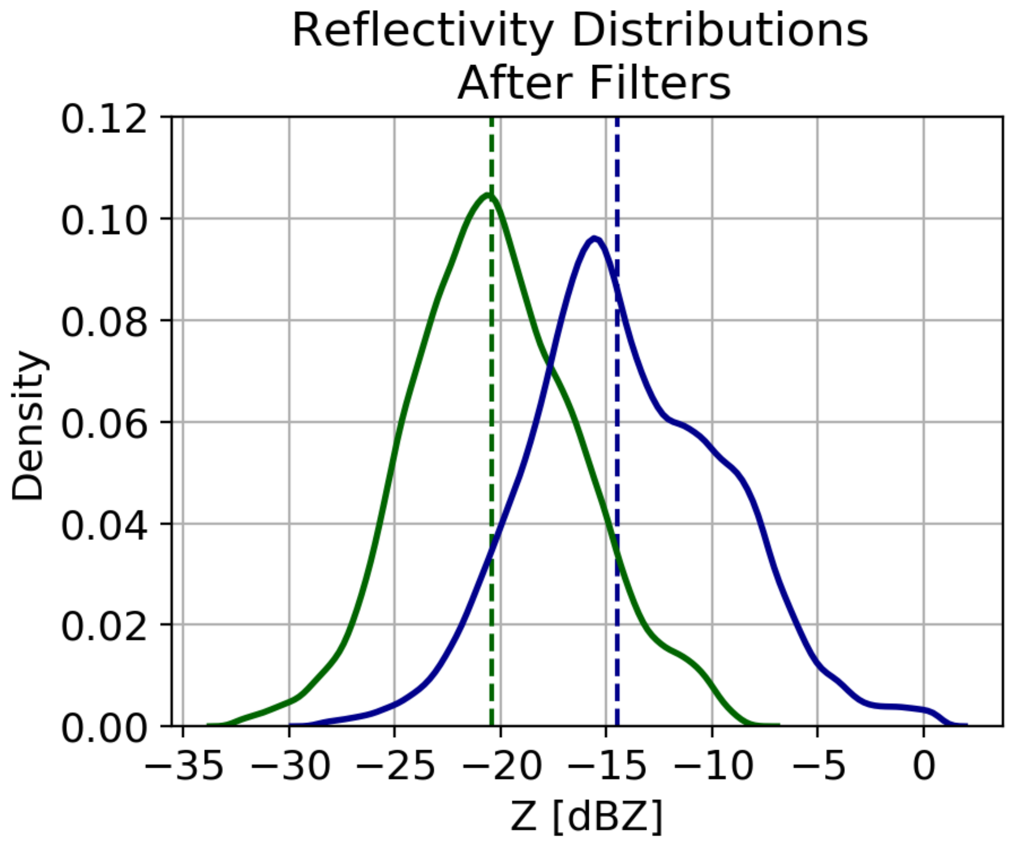
<u>Hypothesis:</u> Cloud reflectivity statistics are the same between the Supersite and Agen.

How to get…

From here



To here

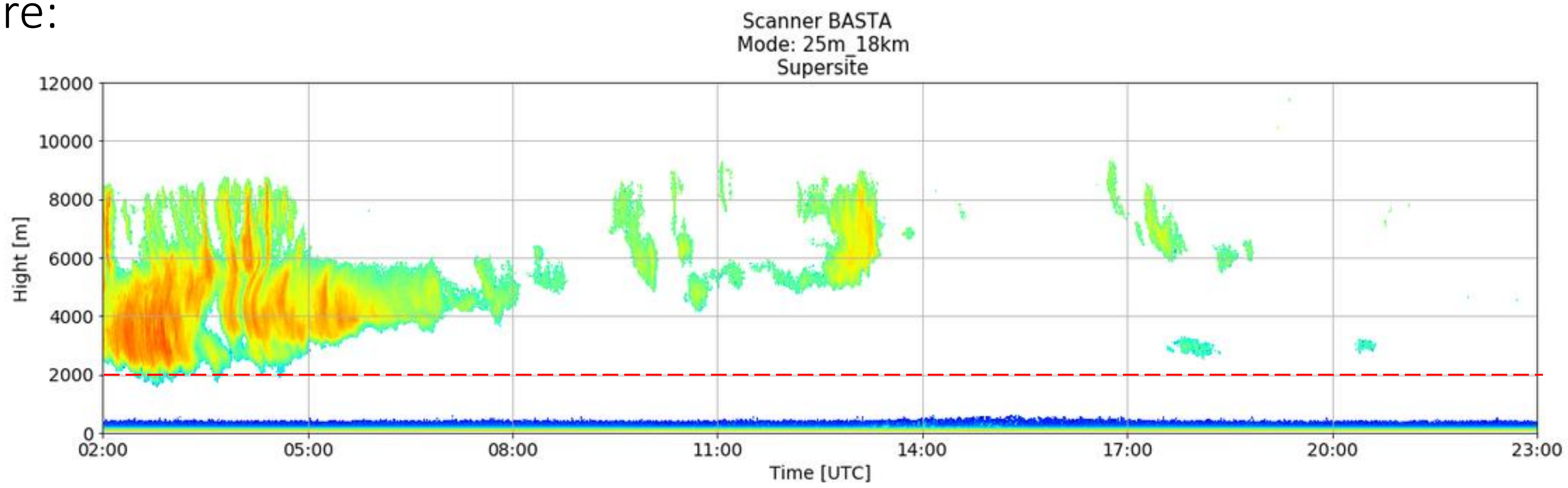


Methodology

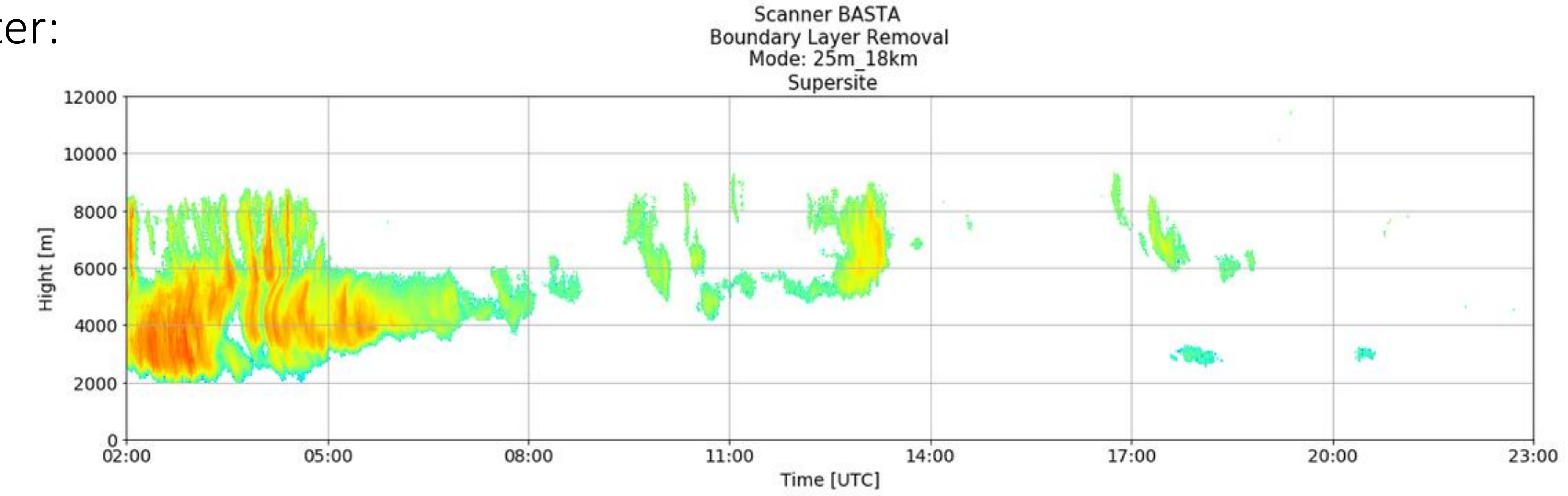
1. Boundary Layer Removal
2. Outlier filter
3. Dynamic Range Filter
4. Quality Control
5. Correction Value C_0

Remove data under 2000 m of height

Before:



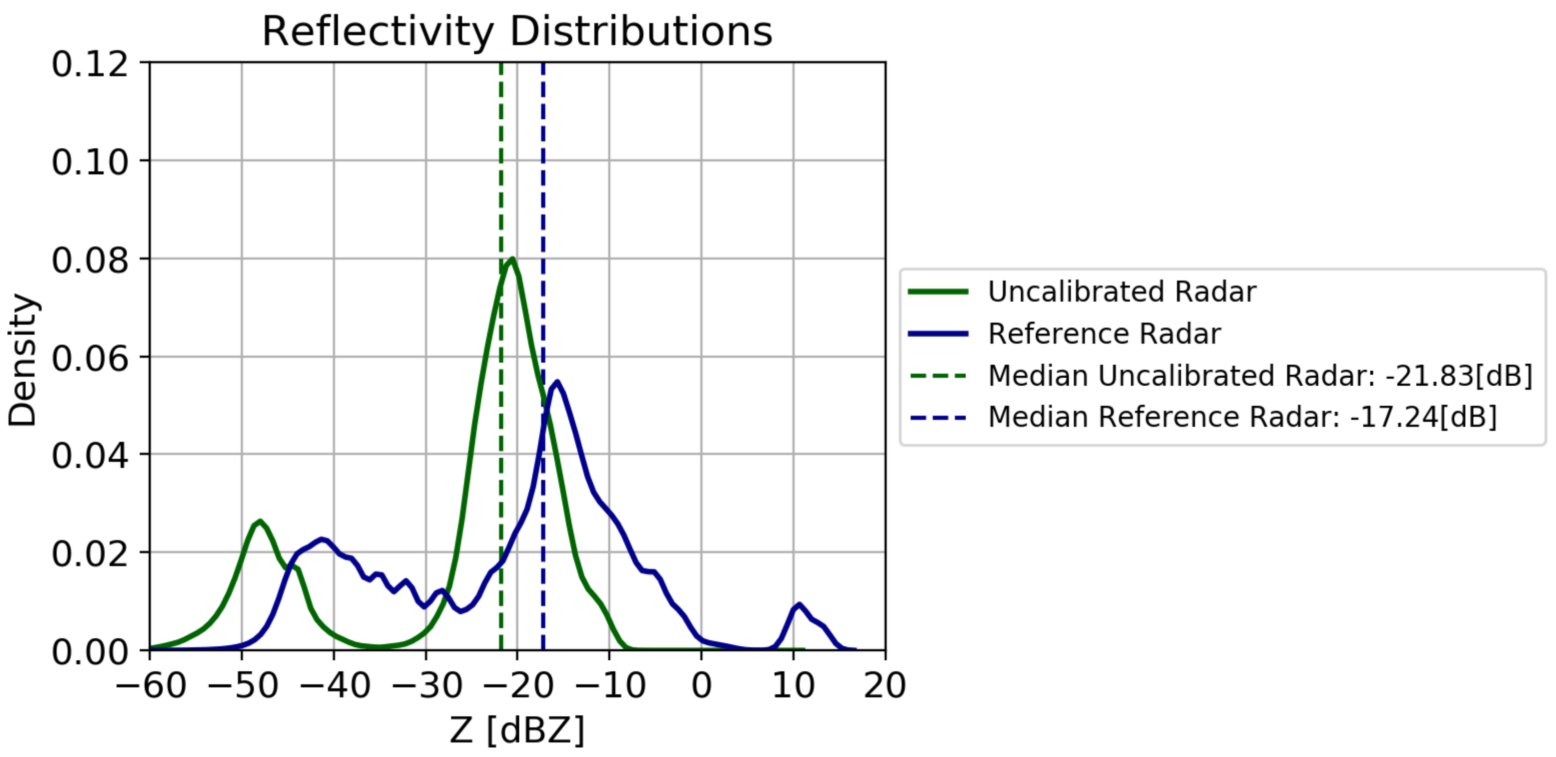
After:



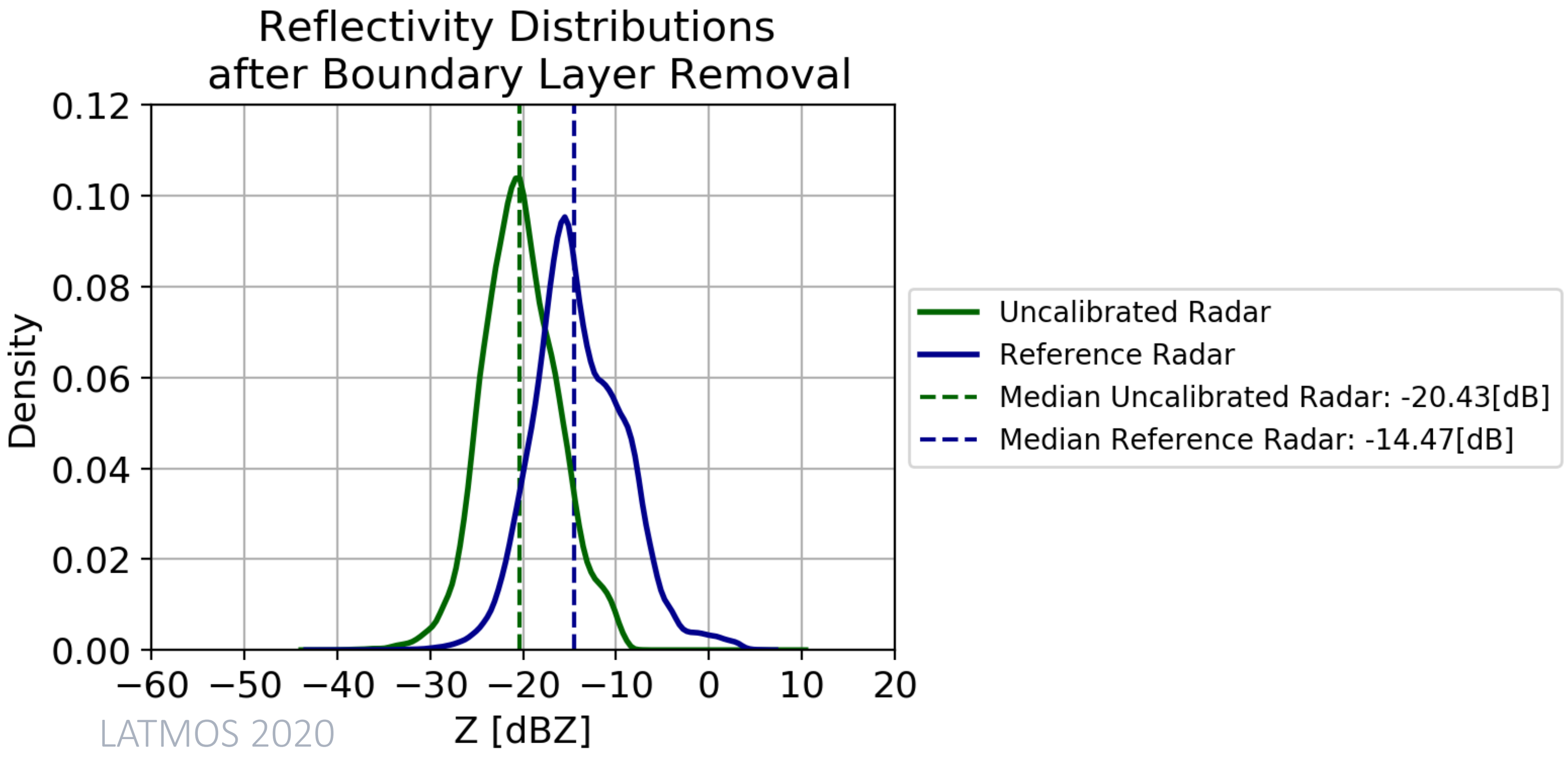
Methodology

1. Boundary Layer Removal
2. Outlier filter
3. Dynamic Range Filter
4. Quality Control
5. Correction Value C_0

Before:



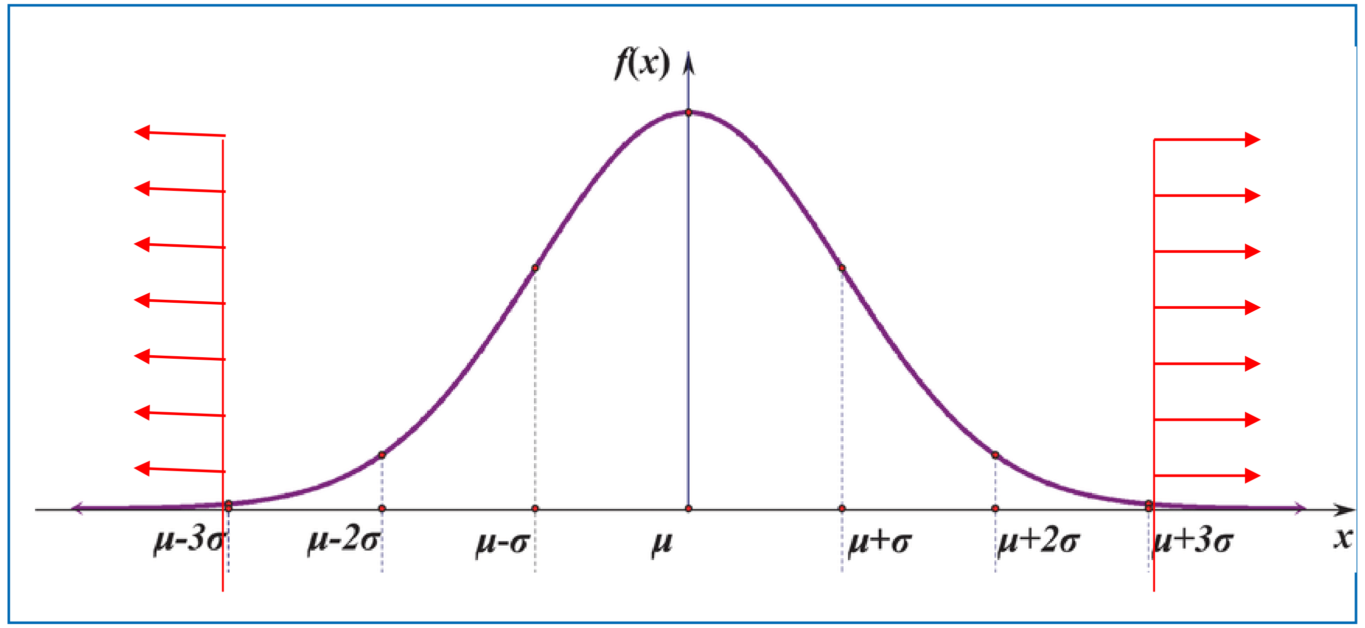
After:



Methodology

1. Boundary Layer Removal
2. Outlier filter
3. Dynamic Range Filter
4. Quality Control
5. Correction Value C_0

3-σ filter:
Remove all data with reflectivity values farther than 3 σ from the mean



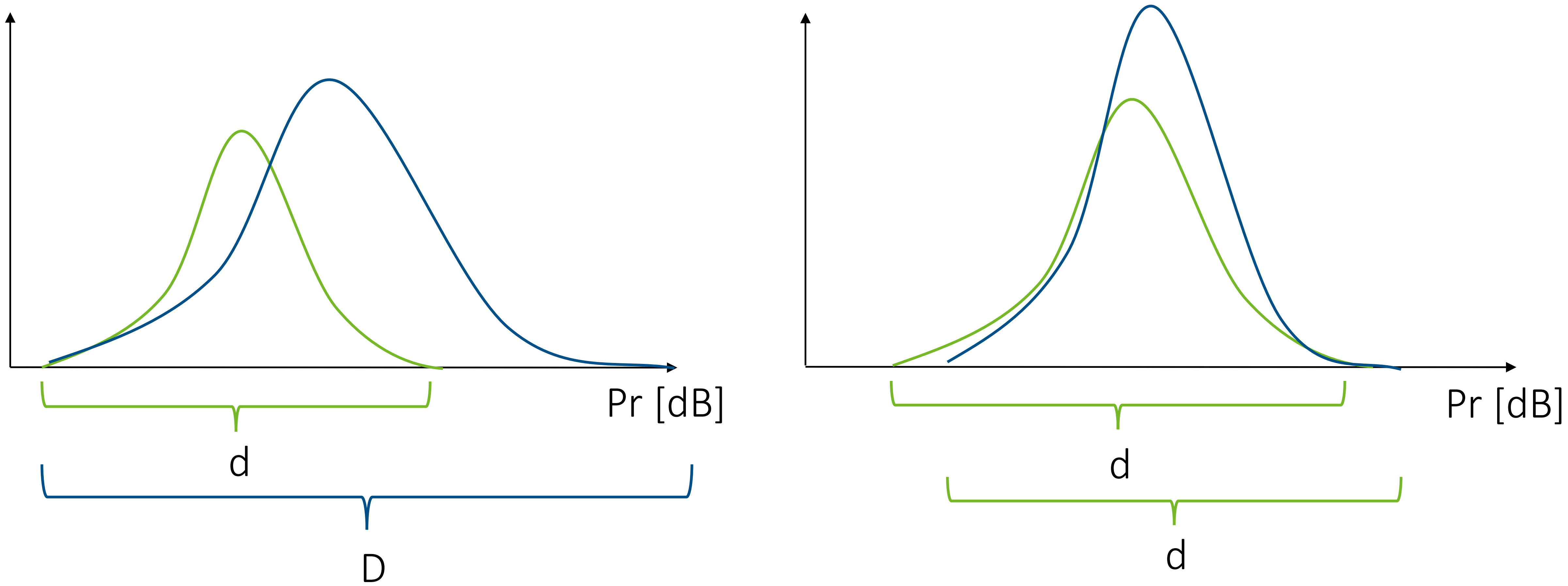
Methodology

1. Boundary Layer Removal
2. Outlier filter
3. Dynamic Range Filter
4. Quality Control
5. Correction Value C_0

Filter data from the most sensitive radar to match the dynamic range of the less sensitive one

Before Dynamic Range filter

After Dynamic Range filter

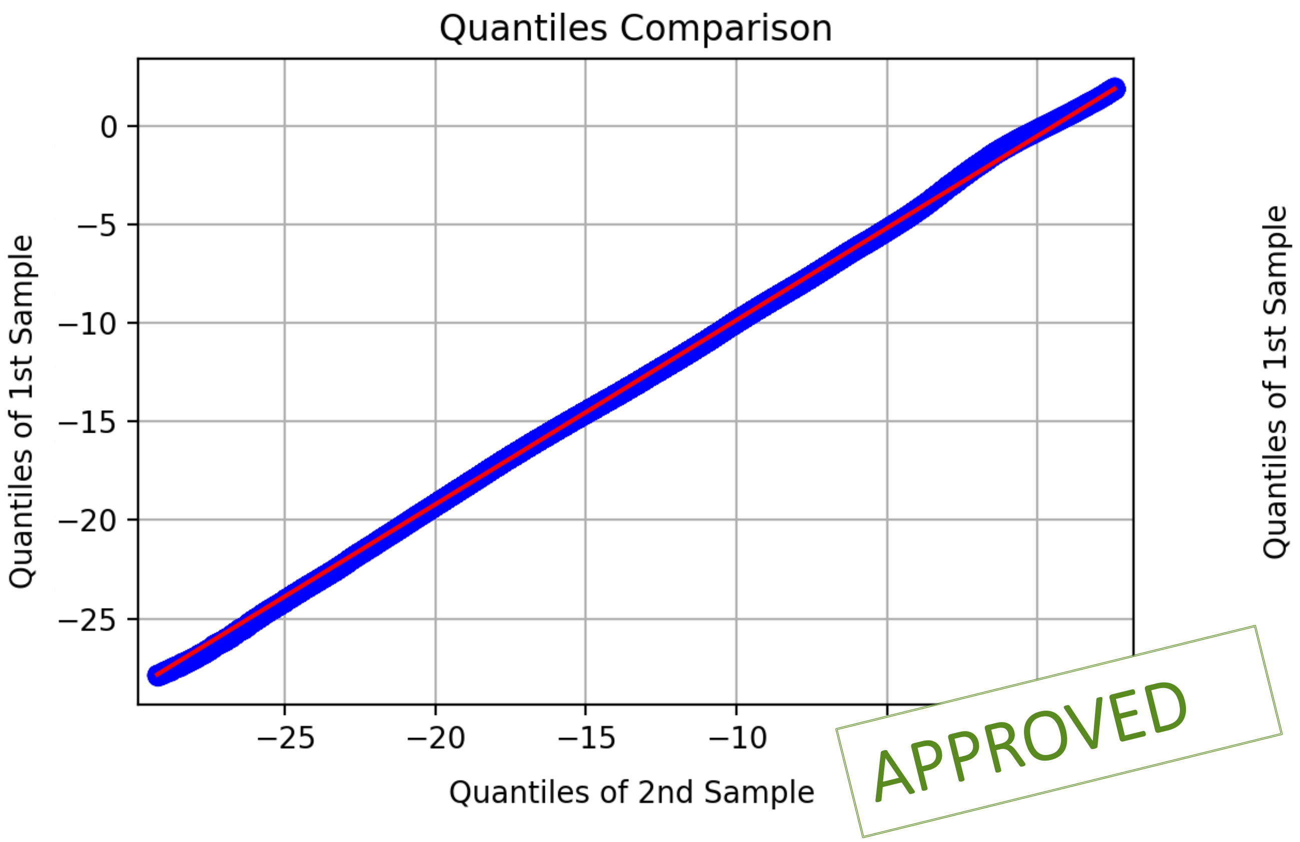


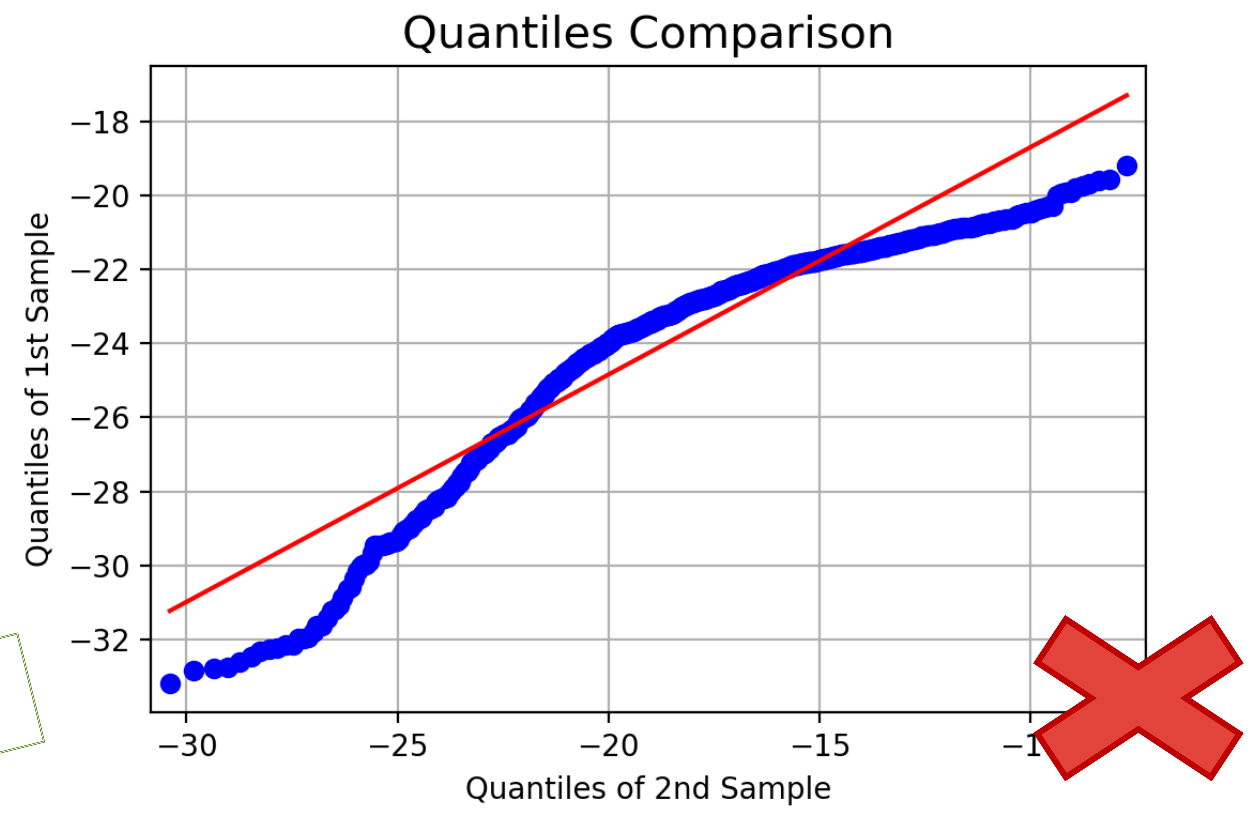
d: Less sensitive radar dynamic Range
D: More sensitive radar dynamic range

Methodology

Q-Q plot is a visual tool to determine how similar are the two distributions

1. Boundary Layer Removal
2. Outlier filter
3. Dynamic Range Filter
4. **Quality Control**
5. Correction Value C_0





- It compares each quantile of both distributions.
- The BLUE points are the quantile-quantile comparison.
- The RED line shows the "perfect fit". That means that both radars have the same reflectivity distributions.
- If the blue points do not match the red line, that means that distributions are not the same, then the previous filters didn't work as expected. → data selection again

Methodology

1. Boundary Layer Removal
2. Outlier filter
3. Dynamic Range Filter
4. Quality Control
5. Correction Value C_0

Difference between the reflectivity means after filters

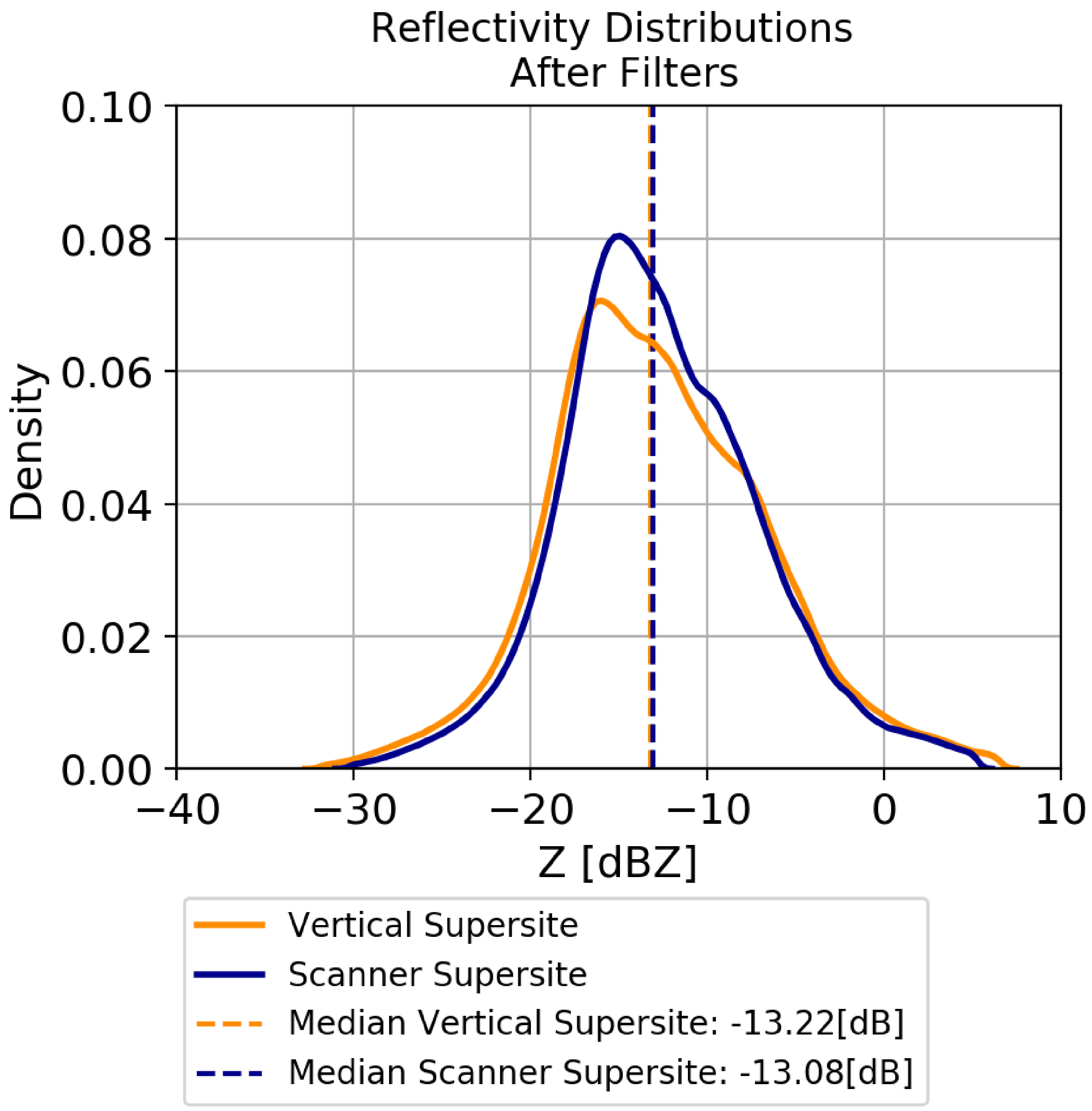
$$C_0 = \overline{Z}_{reference} - \overline{Z}_{uncalibrated}$$

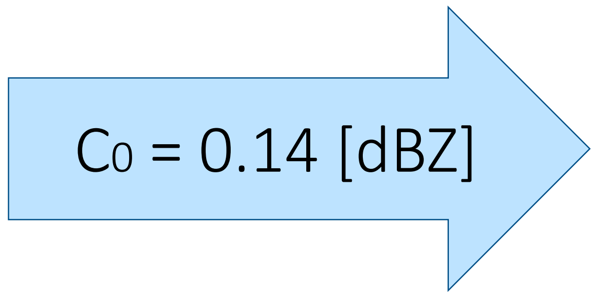
Therefore

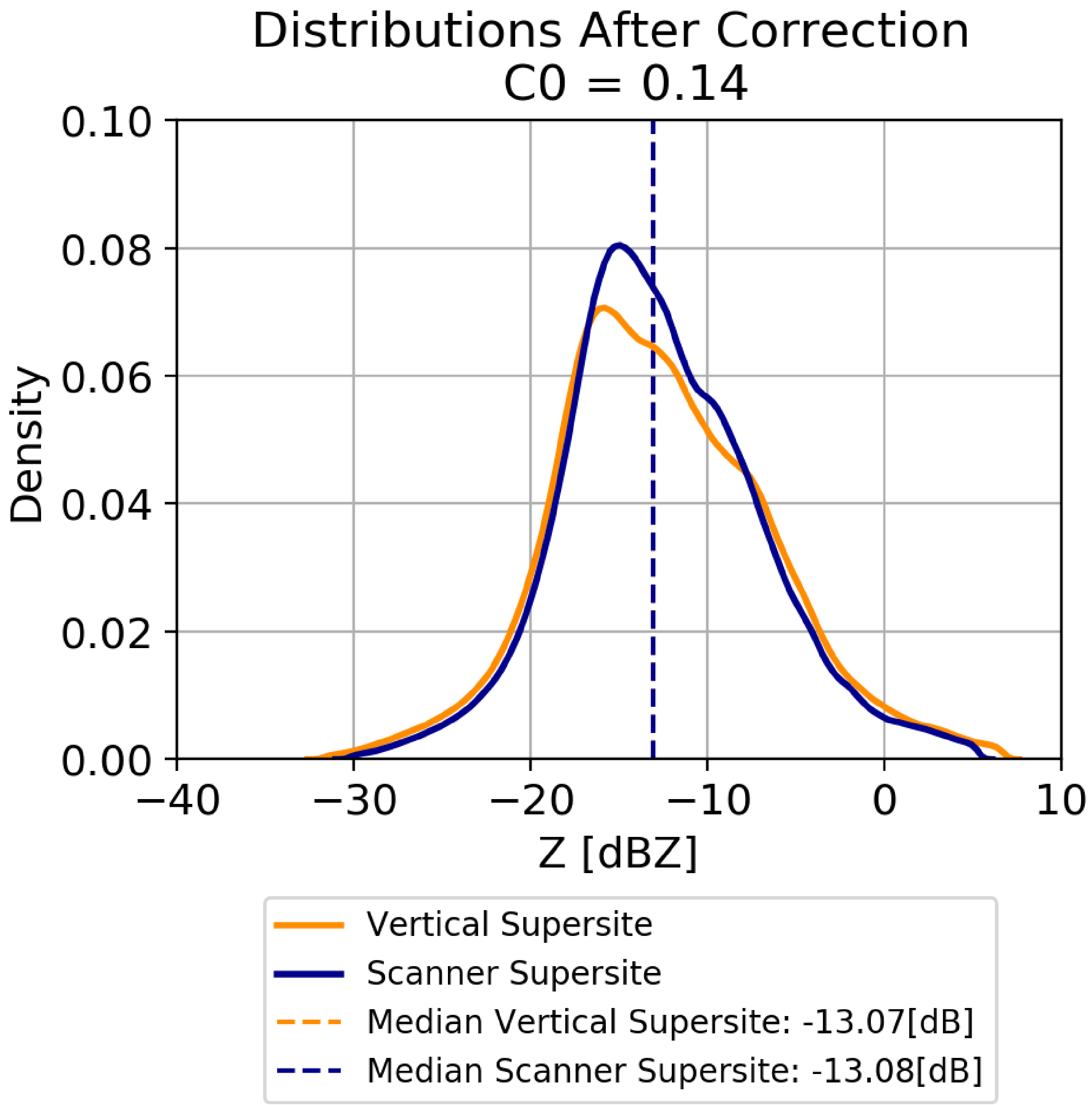
$$Z_{new\_calibrated} = C_0 + \overline{Z}_{uncalibrated}$$

Results: Supersite

Reference Radar: BASTA-mini LATMOS / Scanner
Uncalibrated Radar: BASTA-mobile LATMOS / Vertical

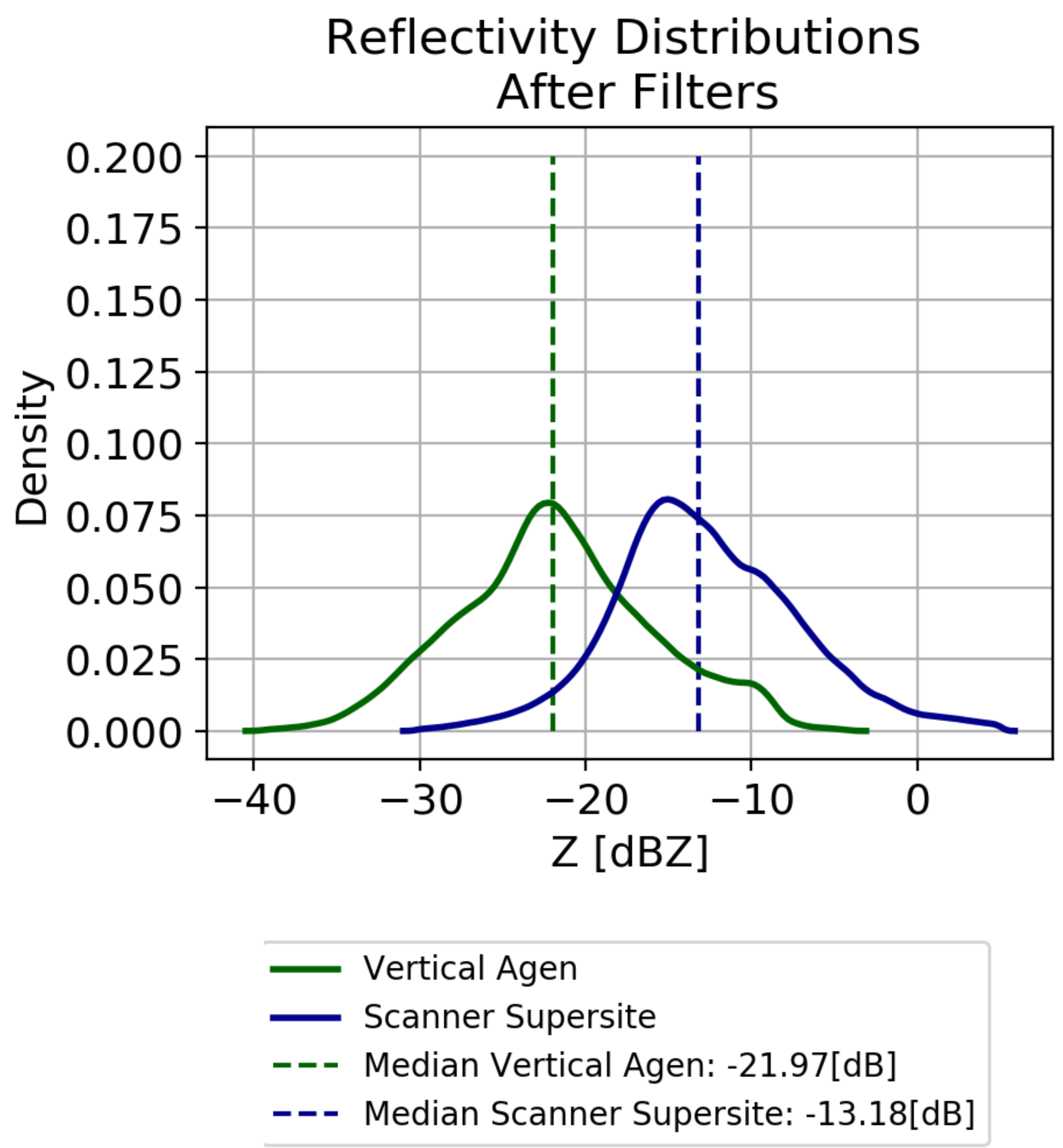




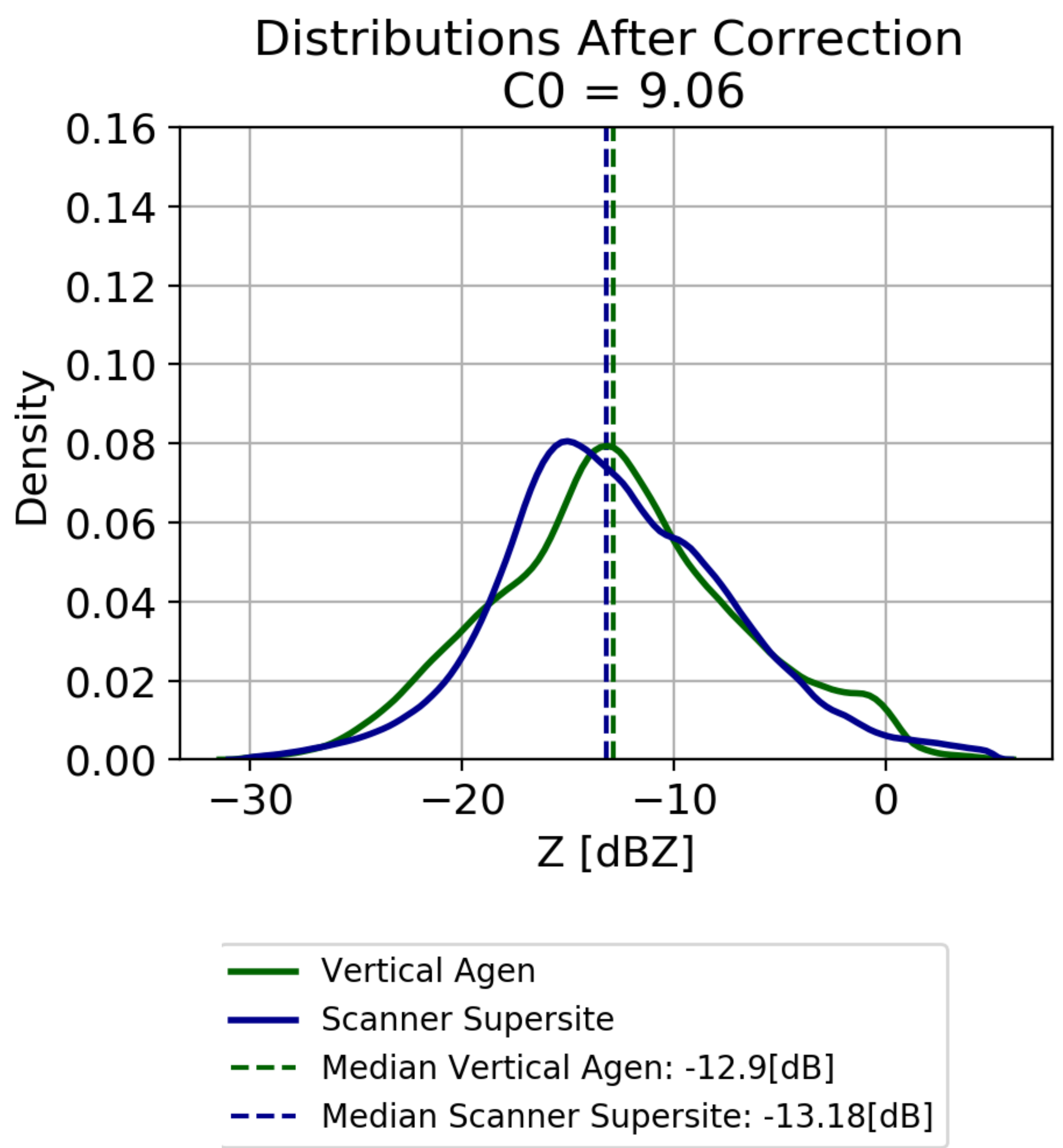


Results: Supersite - Agen

Reference Radar: BASTA-mini LATMOS / Scanner
Uncalibrated Radar: BASTA-mini CNRM/ Vertical



C_0 = 9.06 [dBZ]



Conclusions

- Calibration Transfer Supersite: 0.14 [dBZ]
- Calibration Transfer Supersite – Agen: 9.06 [dBZ]
- It is recommended to recalibrate Agen radar