SOFOG3D – Task2

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PROJET FINANCÉ PAR L'ANR - PROJECT FUNDED BY THE ANR

Task 2

The objective is to improve retrievals of key fog parameters (temperature, humidity, fog water and microphysics, fog dynamics) based on the combination of the cloud radar and the microwave radiometer (MWR) measurements. Geostationary satellite data will be extracted to characterize the spatio-temporal evolution and patterns of each fog case

Sub-task 2.1: LWC and fog dynamics retrievals from radar and MWR

Sub-task 2.2: Closure analysis and retrievals assessment

Sub-task 2.3: MWR profiles retrieval constrained by radar LWC

Sub-task 2.4: SEVIRI/MSG retrievals

<u>Deliverables:</u>

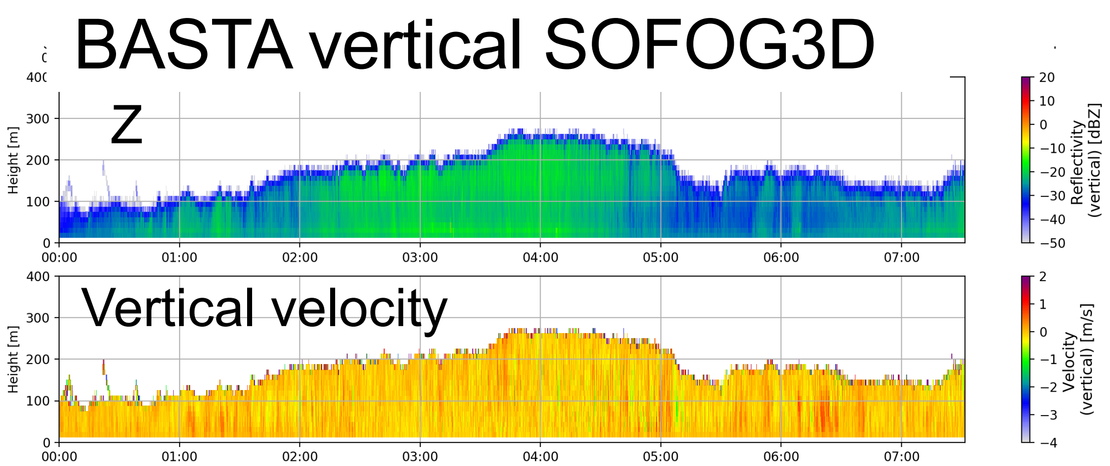
- **D2.1.1:** LWC profiles depending on different constraints from dedicated variational method ✓
- **D2.1.2:** Dynamics of the fog layer from velocity azimuth display technique ✓~
- **D2.2.1:** Evaluation of radar LWC retrieval vs in-situ measurements ✓
- **D2.2.2:** Improve radar forward model thanks 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.

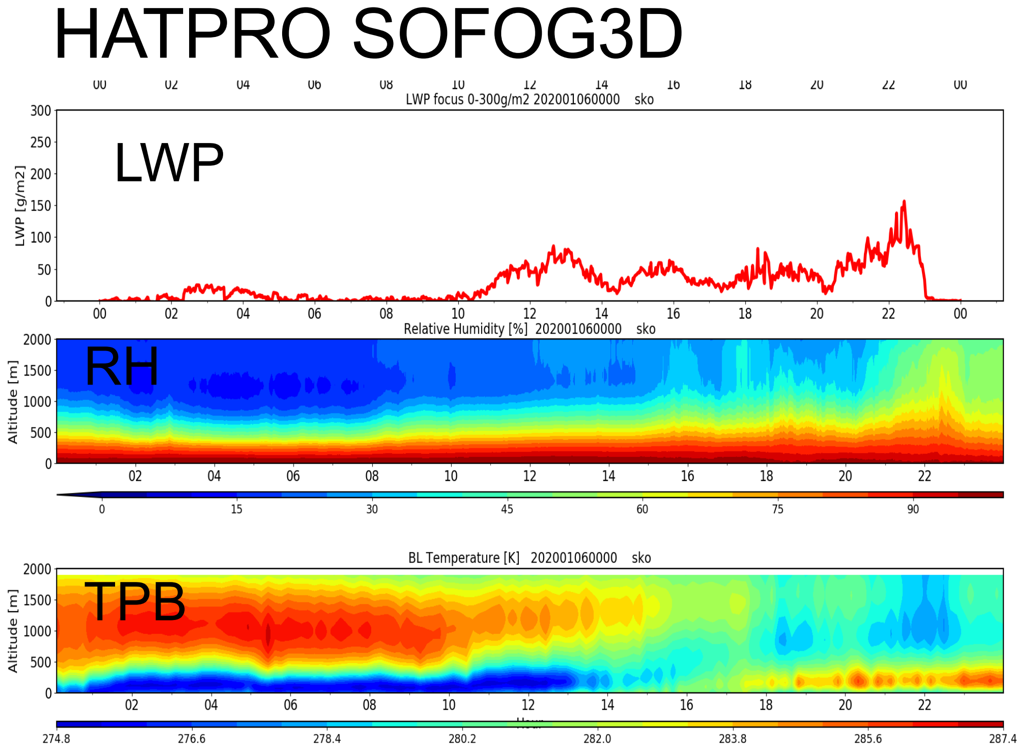
Radar data processing information

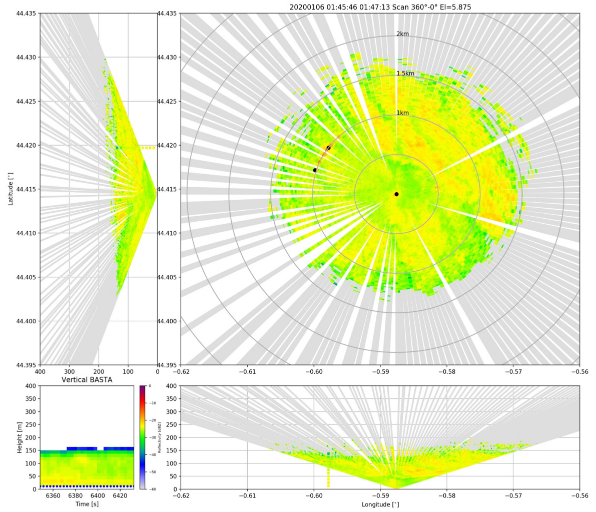
Tasks	State
Installation and operation of instruments at the Supersite	Complete
Radar catalogue for the 3 radars	Complete
Processing of the whole radar database in vertical position (L1)	Complete
Radar BASTA-CNRM processing	Complete
Production of quicklooks and netcdf files	Complete
Website BASTA: Quicklooks availability	Complete
Development of a method for analyzing scan data	Complete
Radar scanner treatment and Quicklooks	Complete
L2a (Agen and Super site) on FTP	Complete
Study: Radar coupling and fog detection	Complete
Study: Calibration transfer between radars	Complete
Study: Radar data and Radiometer data (Radiometer LWP co located with BASTA)	Complete
Balloon impact on the BASTA measurements	Complete

Sub-task 2.1: LWC and fog dynamics retrievals from radar and MWR

- **D2.1.1:** LWC profiles depending on different constraints from dedicated variational method ✔







Radar information
Vertical profile and 3D structure/dynamic

Radiometer information
LWP constraint

LWC profile and dynamic

LWC profile with better constraint and dynamic
Temperature & Humidity profiles :
Improved cloud base inversion and humidity retrievals

Temperature Humidity & Profiles

Sub-task 2.1: LWC and fog dynamics retrievals from radar and MWR

- D2.1.1: LWC profiles depending on different constraints from dedicated variational method ✓

2 Retrievals based on variational approach

PhD P. Vishwakarma (LATMOS)

1st approach (instrument oriented) :

- account for attenuation
- dedicated forward model (self adapted Z-LWC relationships)
- Z and MWR LWP included in the observation vector (radar stand-alone available)

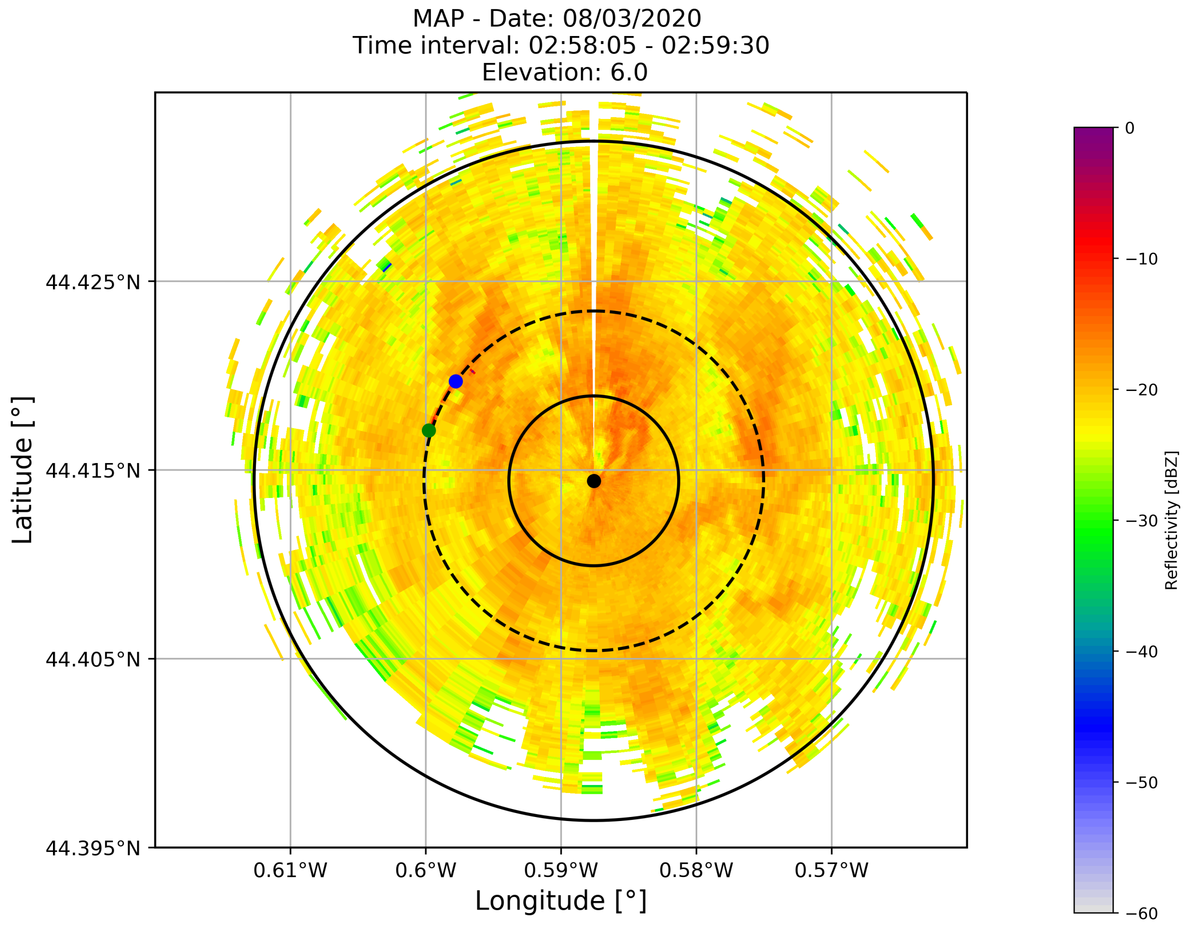
PhD A. Bell (CNRM)

2nd approach (assimilation oriented) :

- Z and MWR TB in the observation vector
- Constrained by a NWP model (currently the AROME model)
- Radar simulator and radiative transfer models used as forward models

Sub-task 2.1: LWC and fog dynamics retrievals from radar and MWR

- **D2.1.2:** Dynamics of the fog layer from velocity azimuth display technique ✓ ~



Data acquisition mode:

Scanning

Products:

MAP/PPI – Plan Position Indicator

The radar holds its elevation angle constant and varies its azimuth angle.

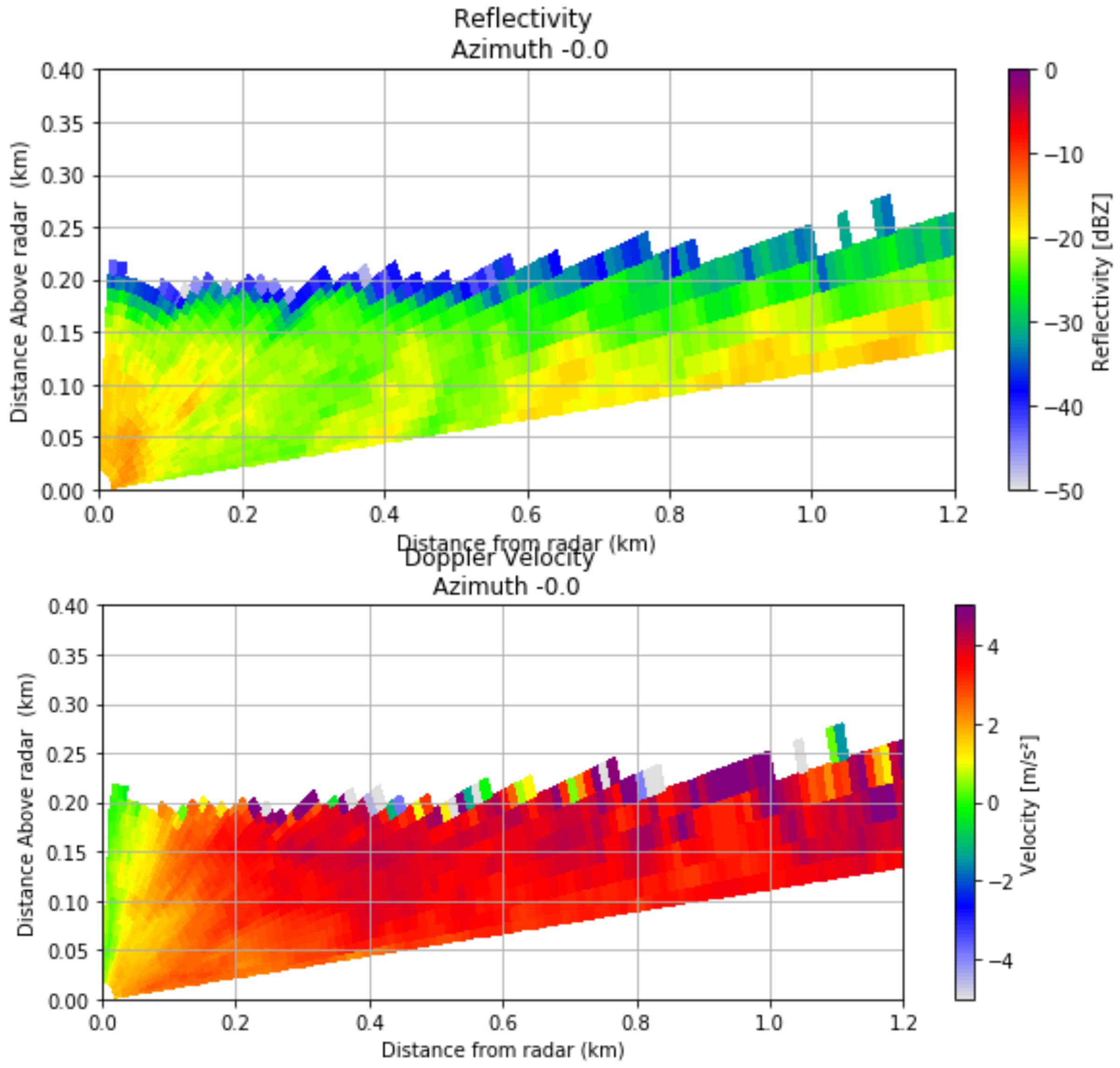
Example:

BASTA mini

LATMOS

08/03/2020

Super site



Data acquisition mode:

Scanning

Products:

RHI– Range Height Indicator

The radar holds its azimuth angle constant and varies its elevation angle.

Example:

BASTA mini

LATMOS

08/03/2020

Super site

Sub-task 2.2: Closure analysis and retrievals assessment

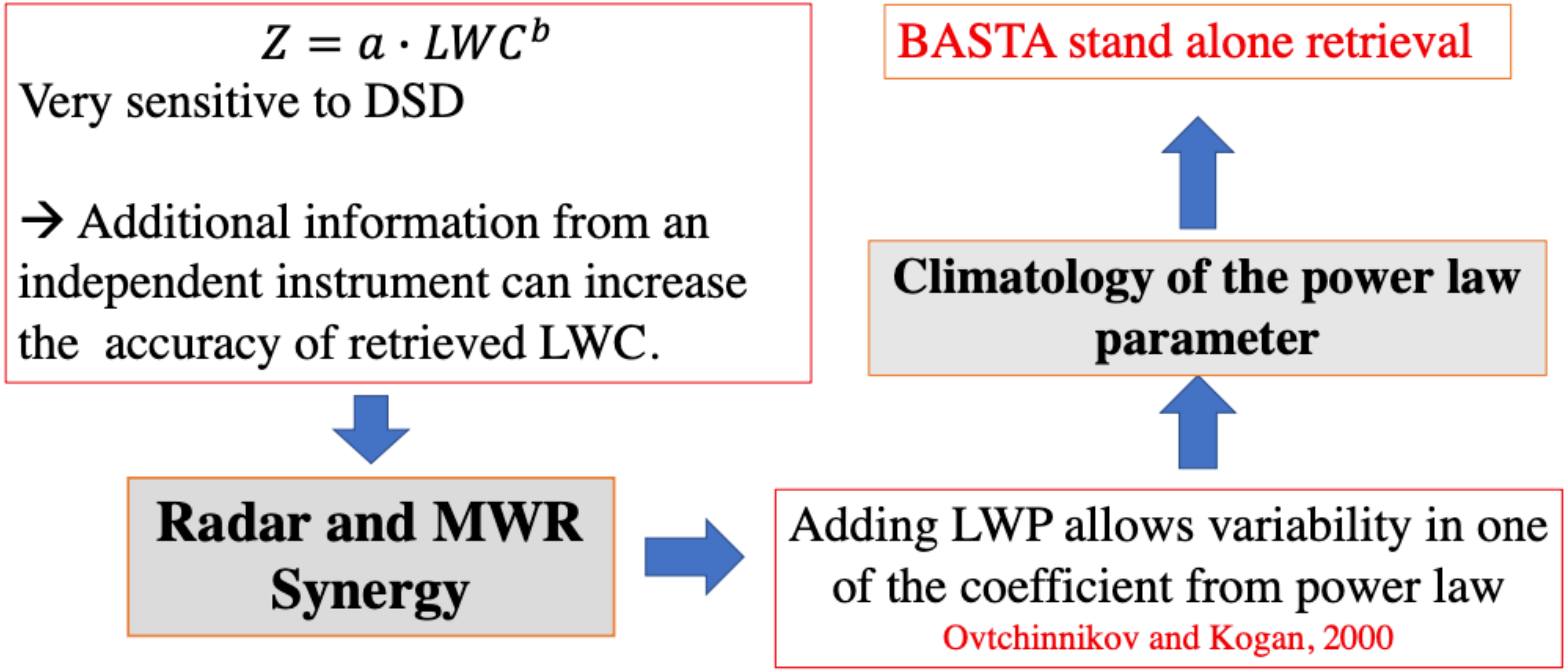
- D2.2.1: Evaluation of radar LWC retrieval vs in-situ measurements ✓
- D2.2.2: Improve radar forward model thanks to calibrated metallic targets ✗

Unfortunately, data quality of the target measurements are not good enough for making progress on this

Radar- MWR synergy D2.1.1&D2.2.1

Vishwakarma 2022 and Vishwakarma et al. 2022

- Combine radar and MWR measurements to retrieve liquid clouds properties, including fog (no model inputs)
- Classical approaches use Z-LWC relationships (all quite different)– we never know which one to use



We have therefore in a common framework (accounting for attenuation):

- Radar+MWR (lna and LWC)
- Radar only (LWC)

A sensitivity analysis to understand the behaviour of the algorithm

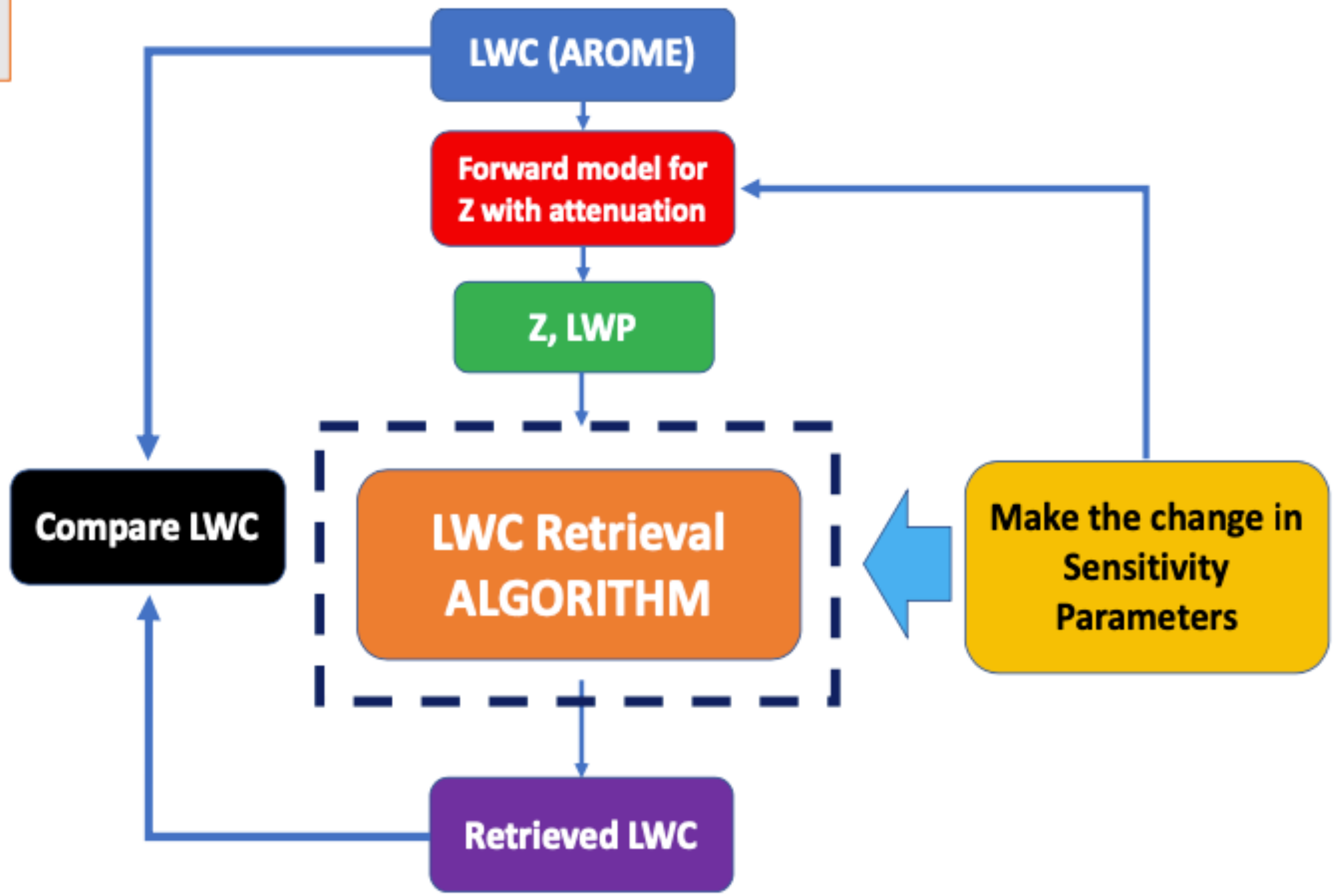
Structure of Sensitivity Analysis

AROME

NWP model for fog forecast with 1.3 km resolution
Bell et al. [2021]

→LWC from a fog forecast at the nearest grid location of SIRTA are considered the truth

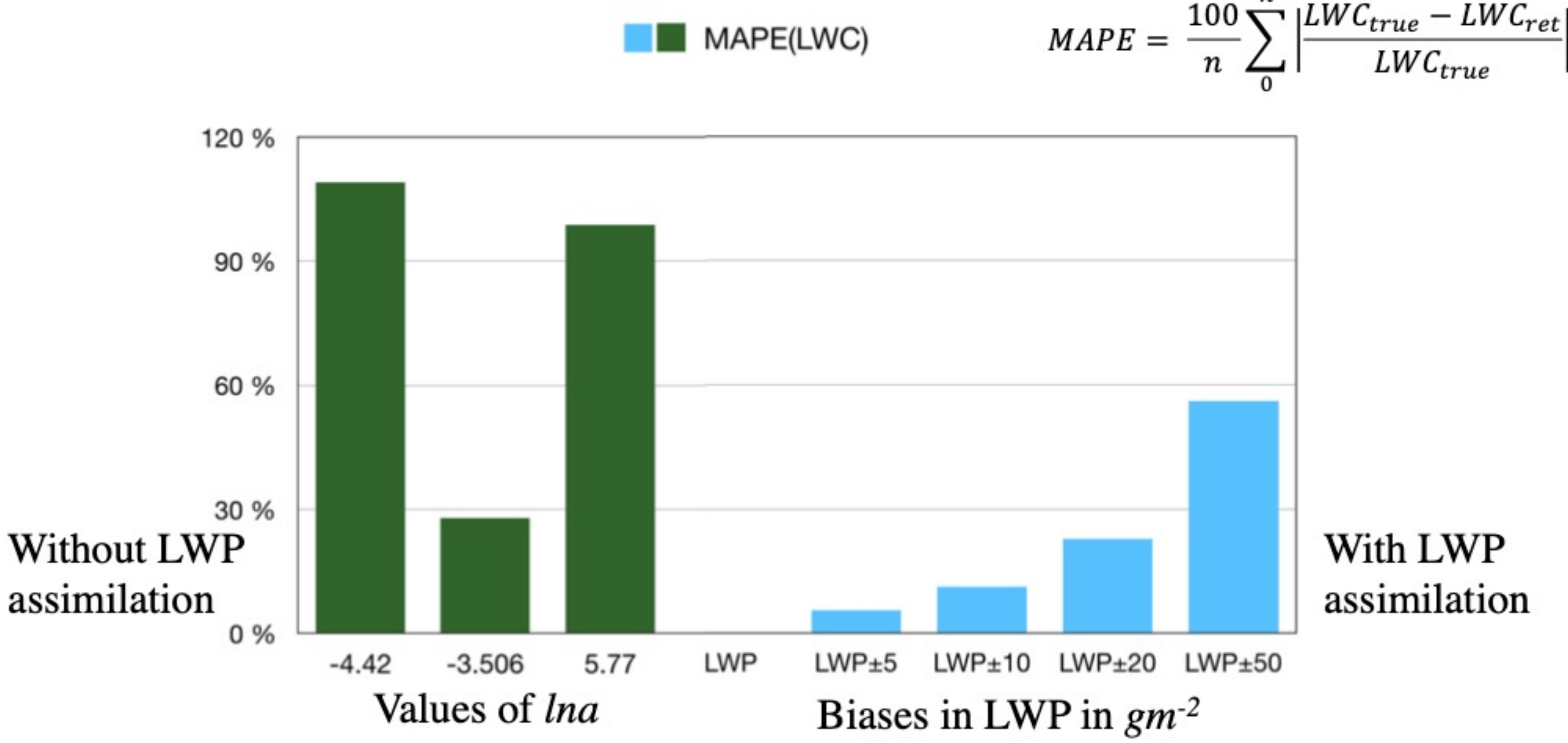
→This true LWC is used to simulate Z and LWP (synthetic profile)

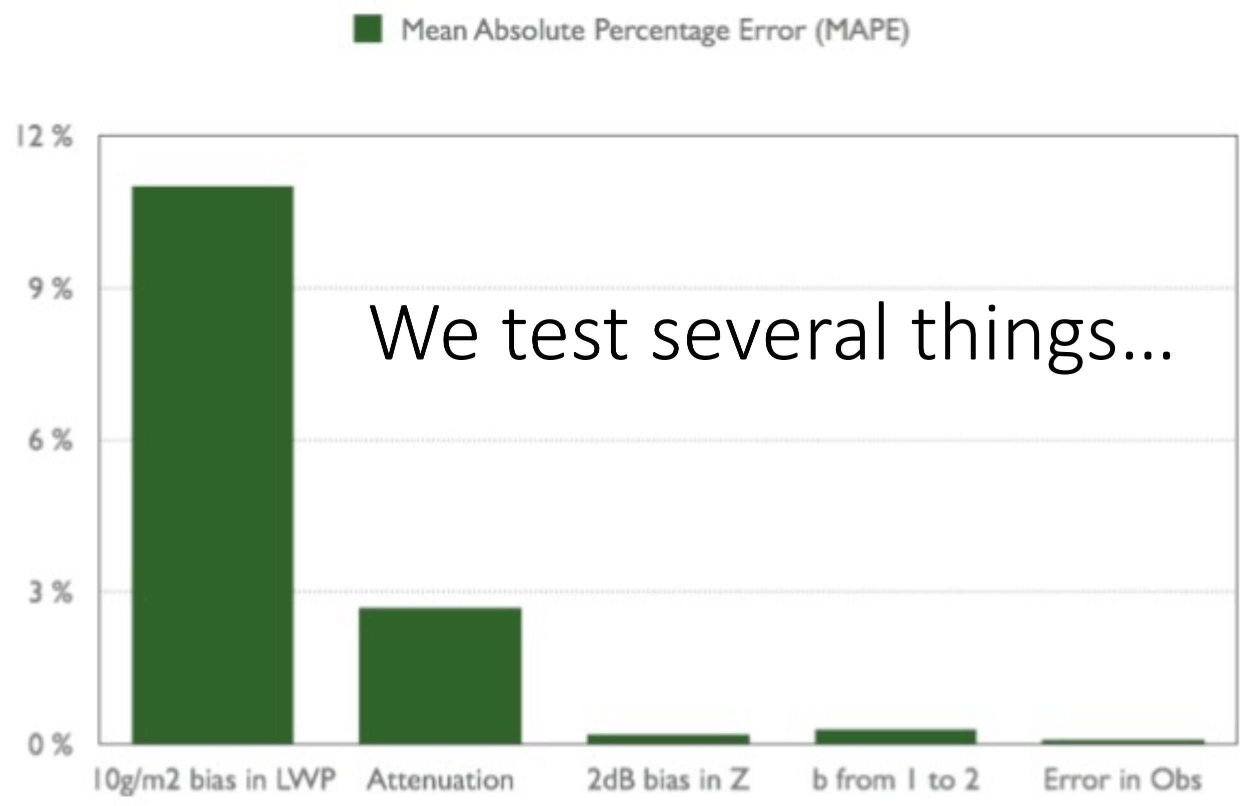


A sensitivity analysis to understand the behaviour of the algorithm

Impact of LWP Assimilation

$$MAPE = \frac{100}{n}\sum_{0}^{n}\left|\frac{LWC_{true} - LWC_{ret}}{LWC_{true}}\right|$$



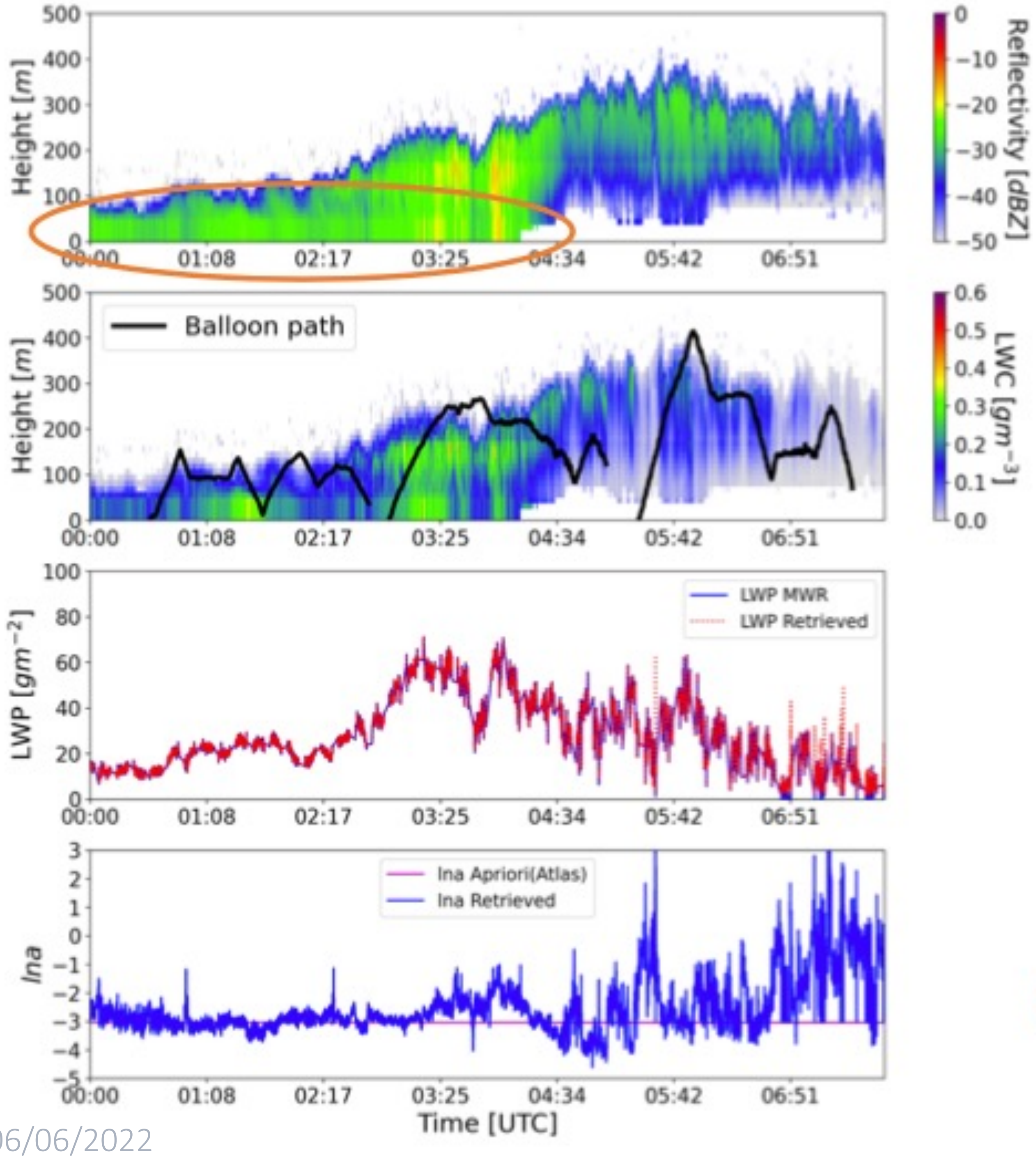


We test several things…

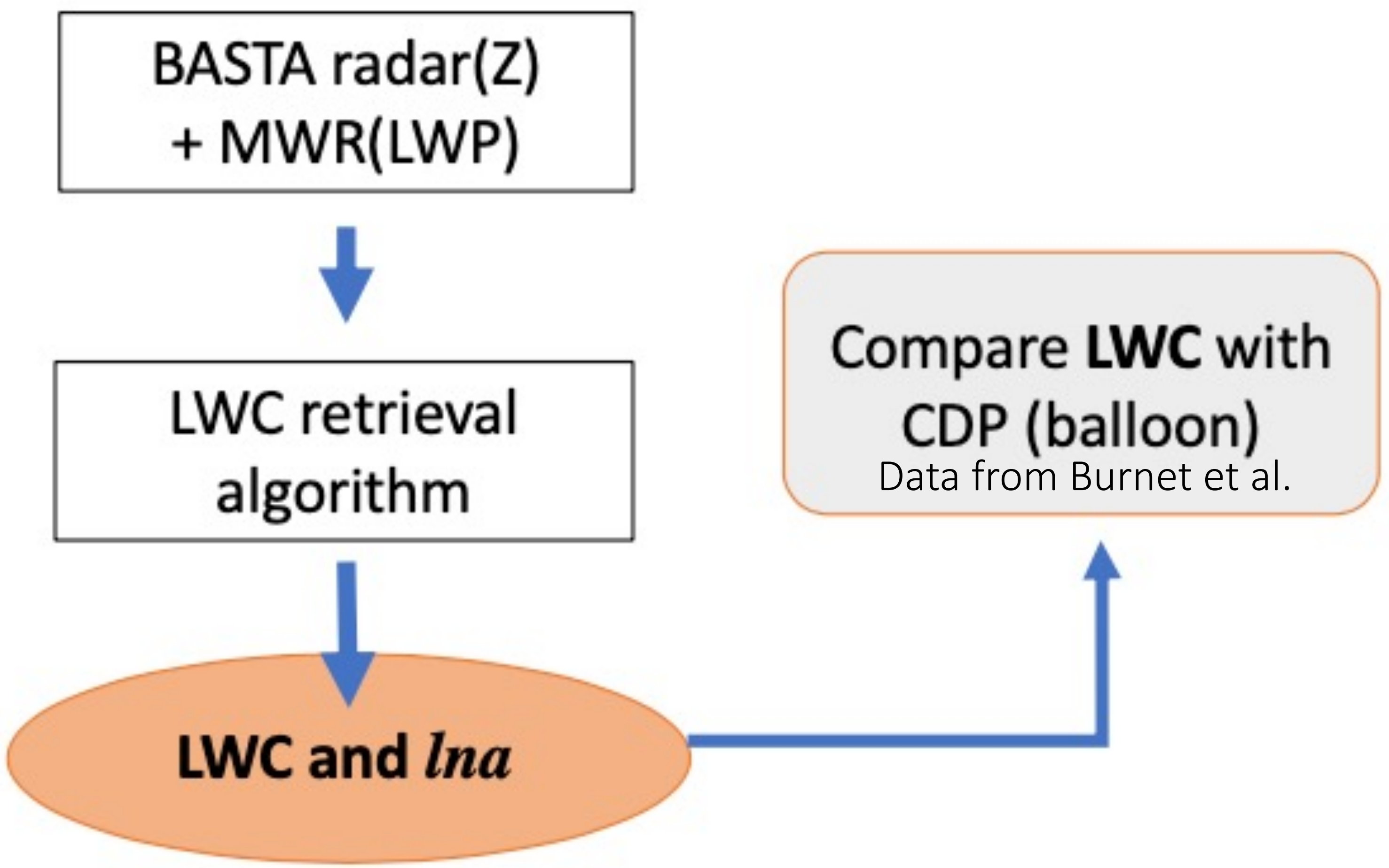
Results using SOFOG3D data

09 February 2020 case at SOFOG-3D super-site

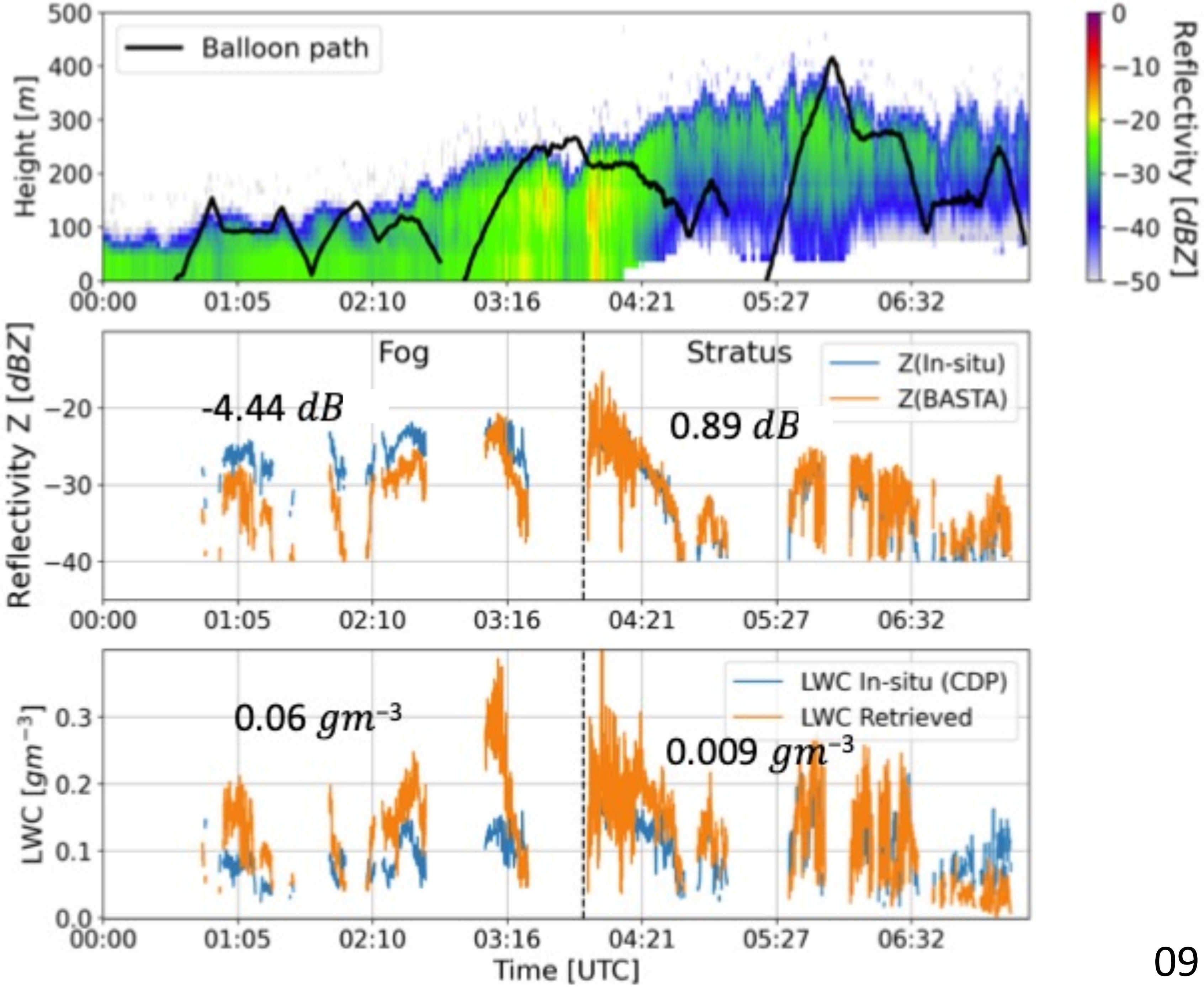
LWC Retrievals (SOFOG-3D) and comparison strategy



→ **Reflectivity extrapolated**
(assuming the fog properties are same between ground and first available gate)

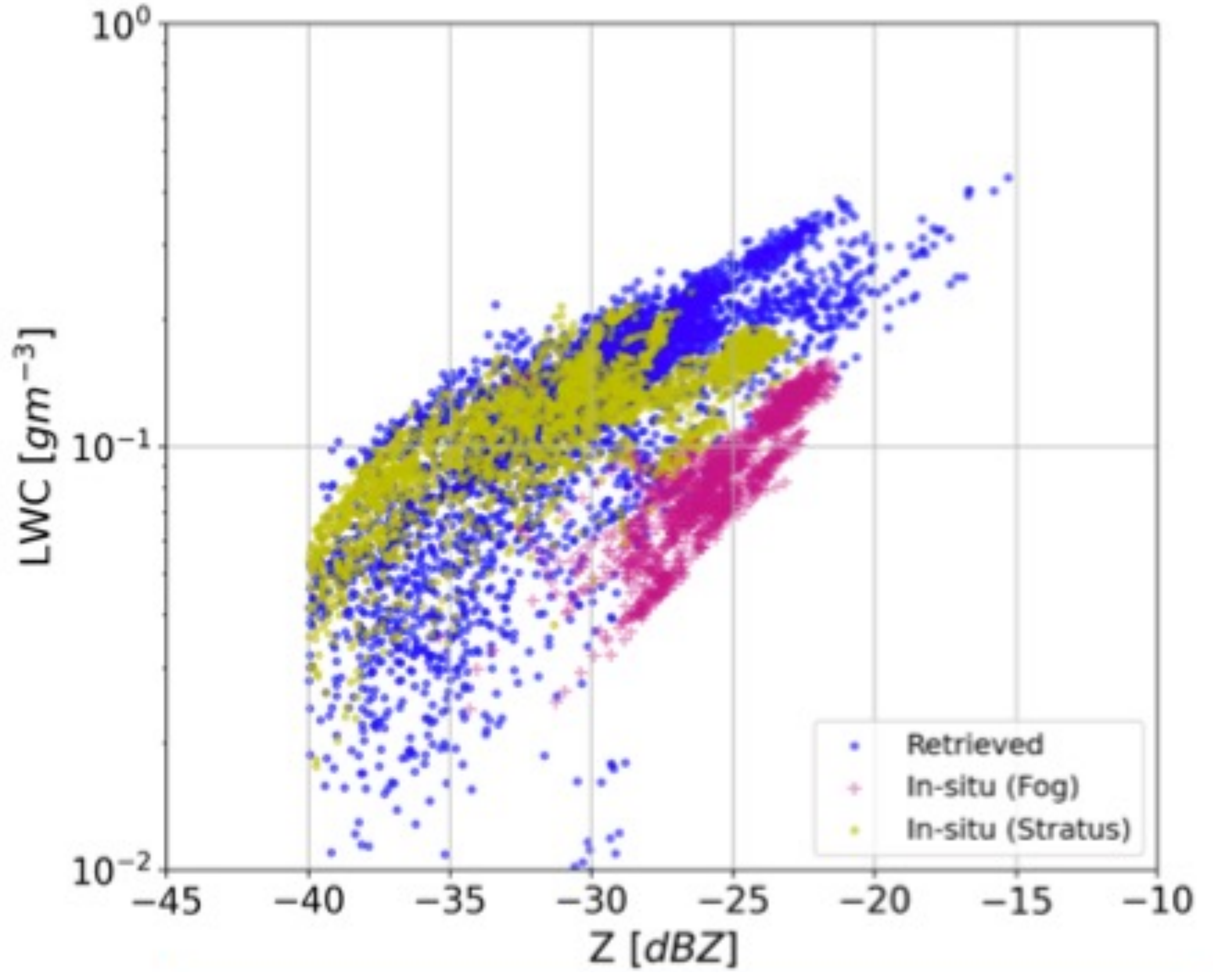


Results using SOFOG3D data



Better agreement for stratus than fog

Z(in-situ) → 6th moment of DSD from CDP



09 February 2020 case at SOFOG-3D super-site

What could be done next

- Compare retrievals for LWC
- How to use the scans for dynamic and 3D structure of fog?
- Dynamic and microphysics analysis

Communications

- Bell, A., Martinet, P., Caumont, O., Vié, B., Delanoë, J., Dupont, J.-C., and Borderies, M.: W-band radar observations for fog forecast improvement: an analysis of model and forward operator errors, Atmos. Meas. Tech., 14, 4929–4946, https://doi.org/10.5194/amt-14-4929-2021, 2021.
- Bell, A., Martinet, P., Caumont, O., Burnet, F., Delanoë, J., Jorquera, S., Seity, Y., and Unger, V.: An Optimal Estimation Algorithm for the Retrieval of Fog and Low Cloud Thermodynamic and Micro-physical Properties, Atmos. Meas. Tech. Discuss. [preprint], https://doi.org/10.5194/amt-2022-30, in review, 2022.
- Vishwakarma, P., Delanoë, J., Jorquera, S., Martinet, P., Burnet, F., Bell, A., and Dupont, J.-C.: Climatology of estimated LWC and scaling factor for warm clouds using radar – microwave radiometer synergy, Atmos. Meas. Tech. Discuss. [preprint], https://doi.org/10.5194/amt-2022-3, in review, 2022.

Theses:

- Bell, A., PhD thesis (2022)
- Vishwakarma, P., PhD thesis (2022)

Presentation:

- Martinet, P., Bell, A., Caumont, O., Vié, B., Burnet, F., and Delanoë, J.: Optimal estimation of thermodynamic and microphysical profiles within fog events from ground-based microwave radiometer and cloud radar synergy., EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-12410, https://doi.org/10.5194/egusphere-egu22-12410, 2022.