Sub-task 2.3 : 1D-Var retrievals of temperature, humidity and LWC from MWR and cloud radar combination.

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Context of the study

Main issue

Fog forecasts remain quite **inaccurate** due to complex highly non-linear fine scale processes

- **Lack** of continuous **measurements** for fog process studies, model evaluation and data assimilation in the **ABL**

Objectives

MWR (22 – 58 GHz)

Temperature / humidity / Liquid water path Profiling / All-sky

95 GHz cloud radar

Cloud microphysics (through reflectivity) and dynamics (through Doppler velocity)

Can the **assimilation** of **MWR** and **cloud radar** improve the **initial state** of **fog** thermodynamics and microphysical properties ?

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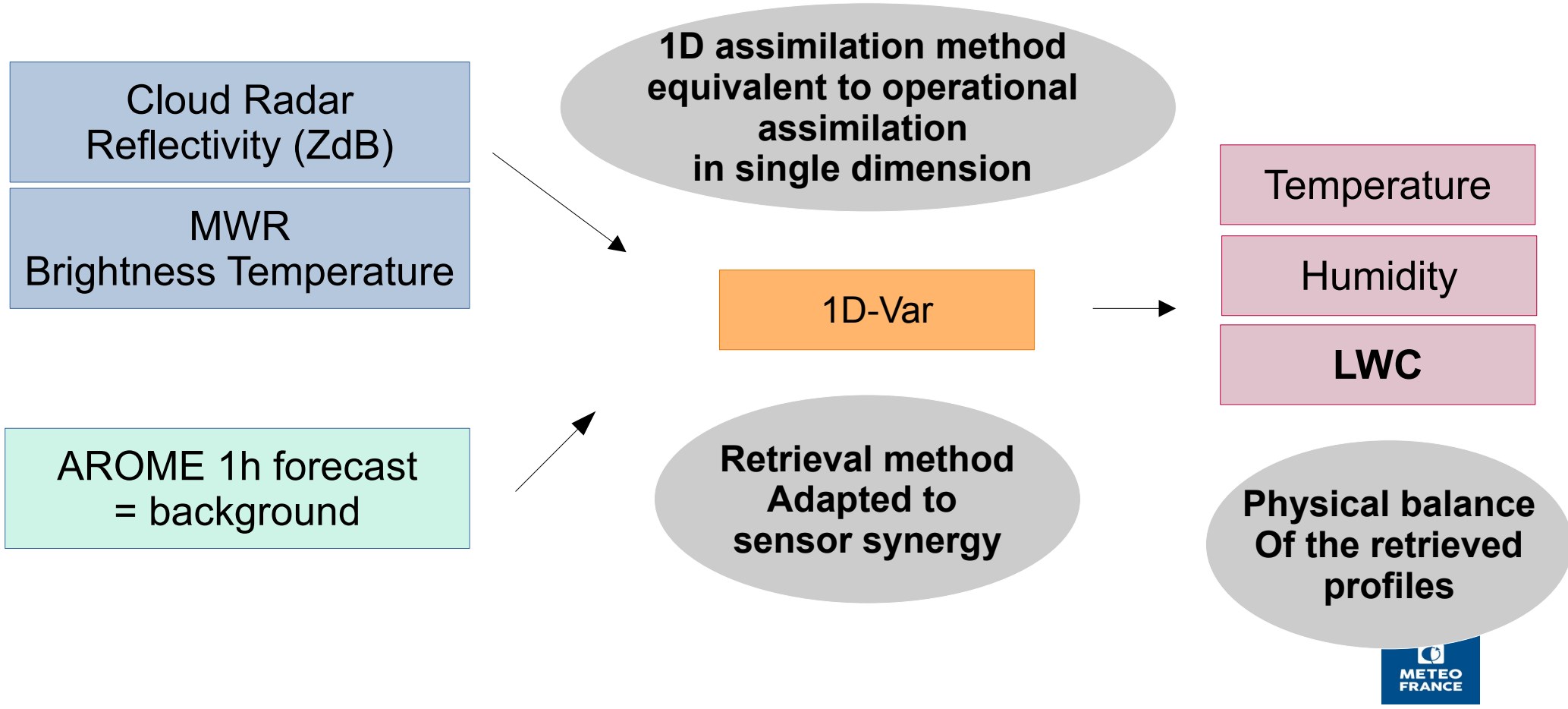
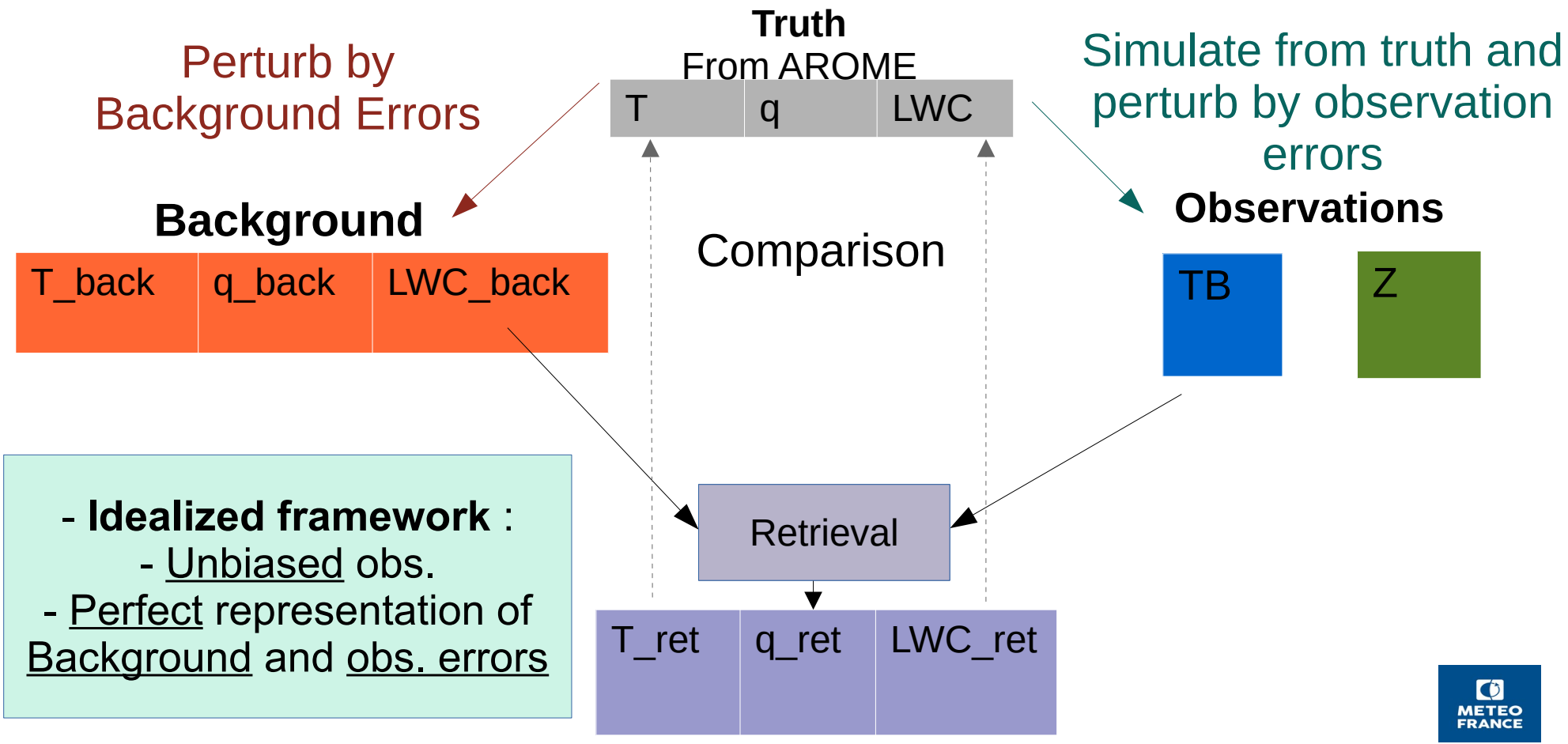
Methodology



With what degree of accuracy can T, Q and LWC be derived under *idealised* fog conditions ?



- **Idealized framework** :
- Unbiased obs.
- Perfect representation of Background and obs. errors

With what degree of accuracy can T, Q and LWC be derived under *idealised* fog conditions ?

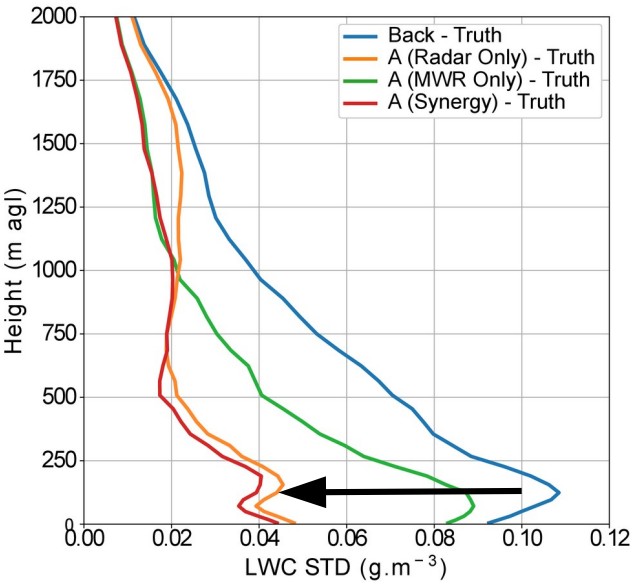
Background

Retrieval MWR

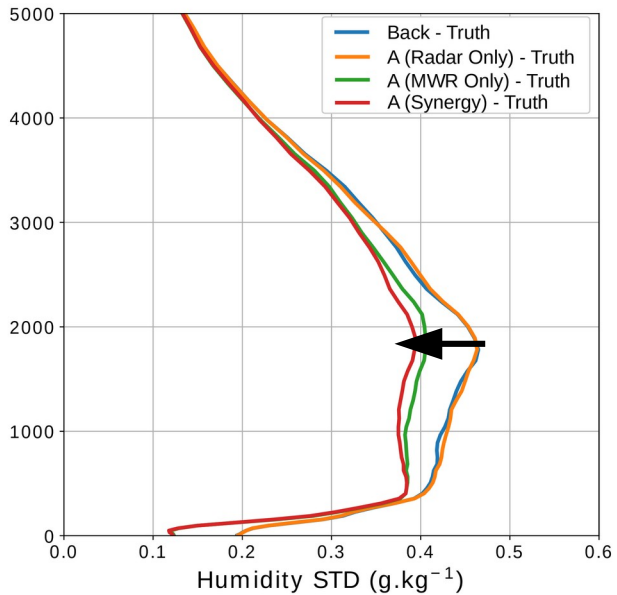
Retrieval Radar

Retrieval Radar+MWR

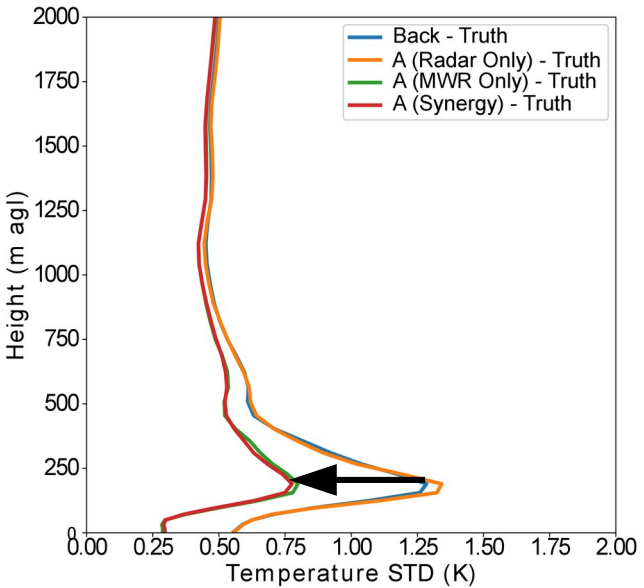
STD (Profile – Truth) LWC



STD (Profile – Truth) Q



STD (Profile – Truth) T



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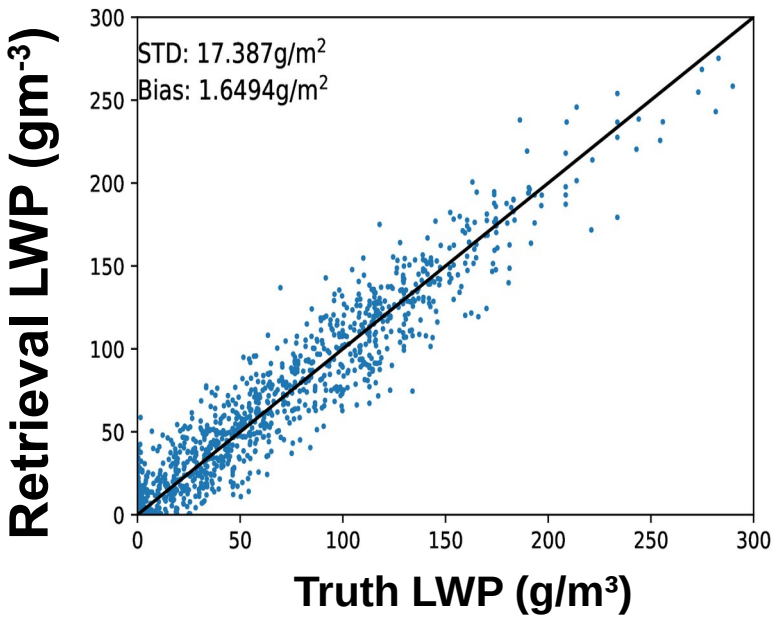
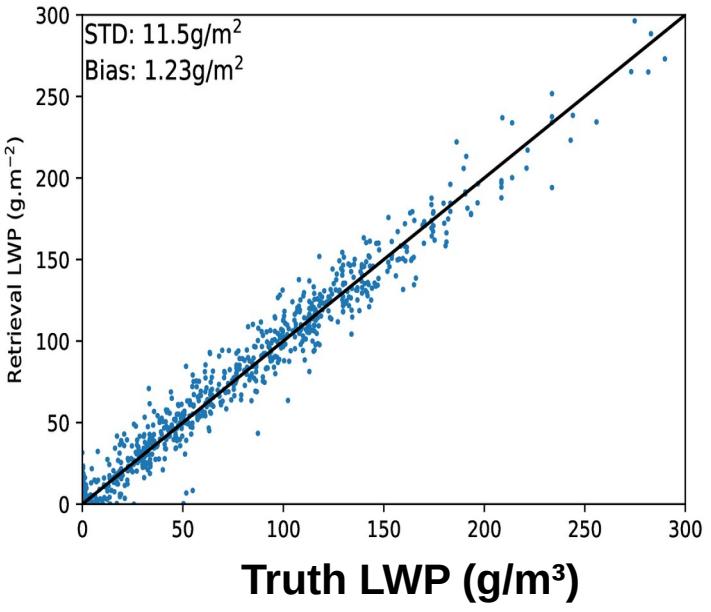
With what degree of accuracy can LWP be derived under *idealised* fog conditions ?

- LWP uncertainty from **MWR only ~ 17 g/m²** (in agreement with literature)
- Significant improvement with the **CR synergy**, uncertainty reduced to **11 g/m2**

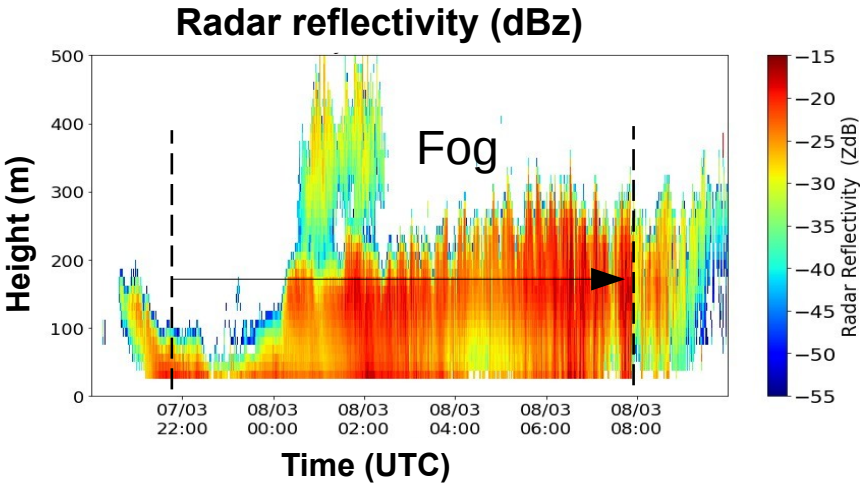
MWR only

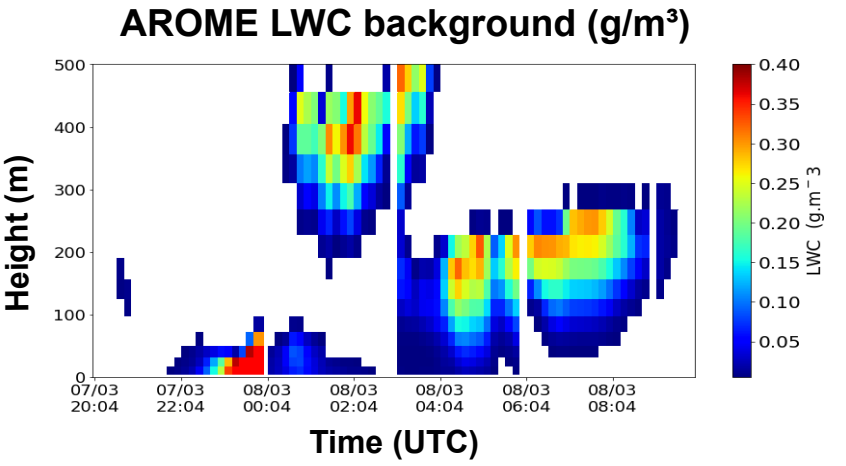


MWR + CR

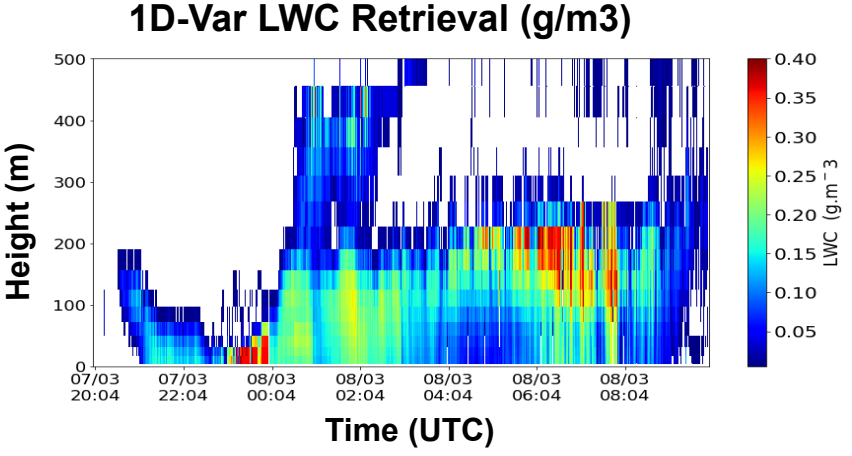


Evaluation on real measurements from the SOFOG3D experiment
Fog case study on 08/03





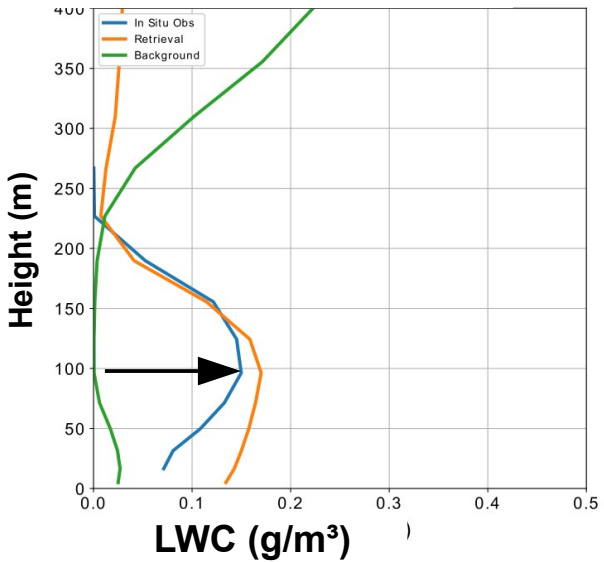
- Significant **errors** in the **fog vertical structure** and **temporal evolution** in the AROME initial background
- **1D-Var analyses** significantly **improve** the **fog lifecyle** and **thickness** compared to the AROME background.



Comparison against in-situ Cloud Droplet Probe (CDP) measurements
Fog case study on 08/03

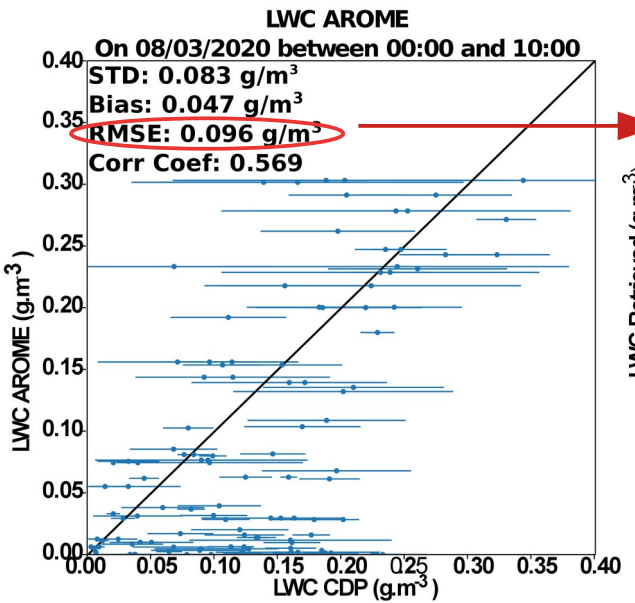
- Significant **improvement** of the **LWC profiling** during a 200m thick fog profile

CDP versus **AROME** / **1D-VAR** LWC profile

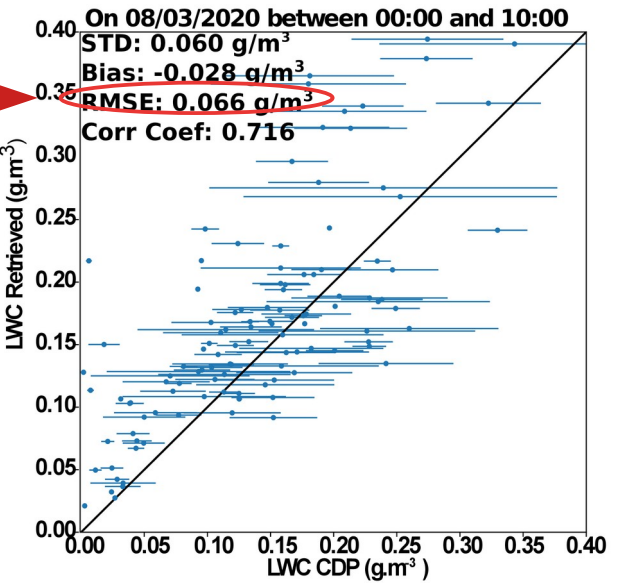


- Statistical evaluation : **RMSE** reduced from **0.096 g/m³ to 0.066 g/m³**
- **Correlation** coefficient improved from **0.57 to 0.72**.

AROME versus CDP



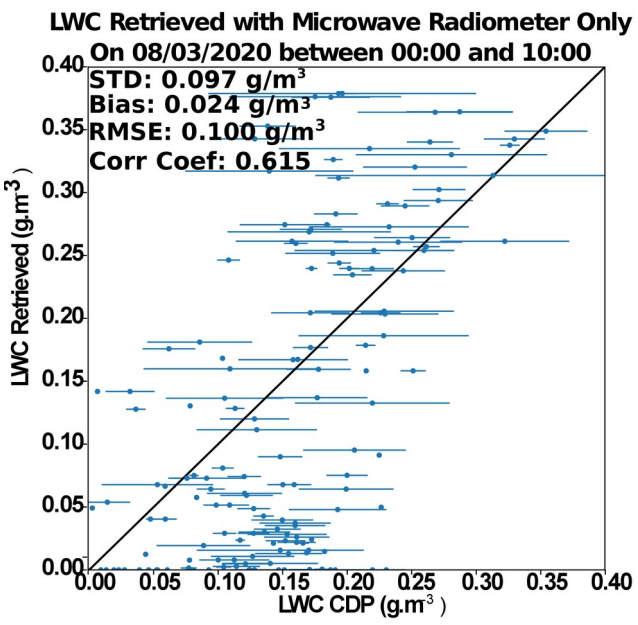
1DVAR (MWR+CR) versus CDP



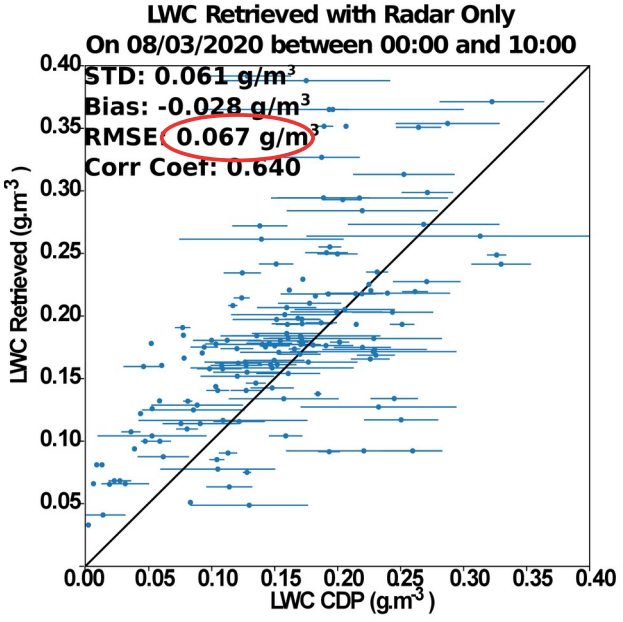
Impact of the sensor synergy on the LWC retrievals
Fog case study on 08/03

- **MWR alone** have **little information** on the LWC profile with a **RMSE a 0.1 g/m³**
- Using the **CR alone**, the **RMSE** is already reduced from **0.1 to 0.7 g/m³**
- Combining **MWR and CR**, increase in the **correlation coefficient** from **0.64 to 0.72**

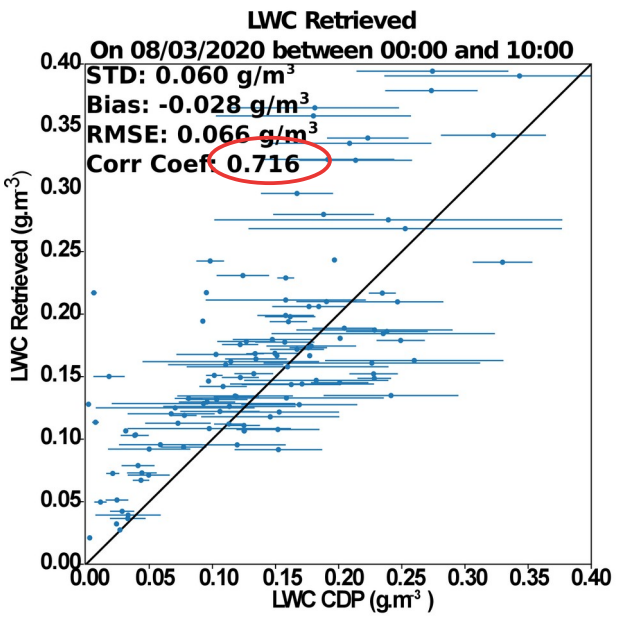
1DVAR (MWR only) versus CDP



1DVAR (Radar only) versus CDP



1DVAR (MWR+CR) versus CDP



Conclusion and perspective

Conclusion

- 95 GHz cloud radar and MWR observations offer new capabilities to improve the initial state of fog forecast
- A 1D-Var algorithm demonstrated the capability of correcting significant initial AROME errors in the fog structure and time evolution
- Significant improvement of the analyzed LWC values by comparison with in-situ CDP measurements

Prospects

- Improved 1D-Var retrievals: inclusion of ice clouds, extended synergy with other instruments, combination with a 2-moment microphysical scheme…
- 3D-EnVar assimilation of the retrieved T, Q and LWC profiles

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Thanks for your attention ! Questions ?

References :

→ 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.

→ Martinet, P., Unger, V., Burnet, F., Georgis, J-F., Hervo, M., Huet, T., Löhnert, U., Miller, E., Orlandi, E., Price, J., Schröder, M., Thomas, G. : Database of temperature, humidity and liquid water path retrievals from a fog dedicated network of ground-based microwave radiometers, BAST, in review, 2022.

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