Evaluation of a 95 GHZ Radar Simulator for the retrieval of fog Microphysical Properties by cloud radar and Microwave radiometer synergy

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PhD Director : Olivier Caumont (GMME/PRECIP)
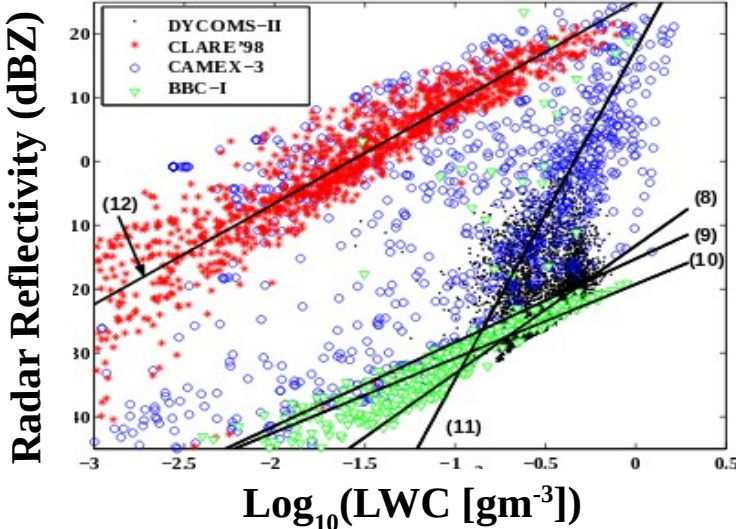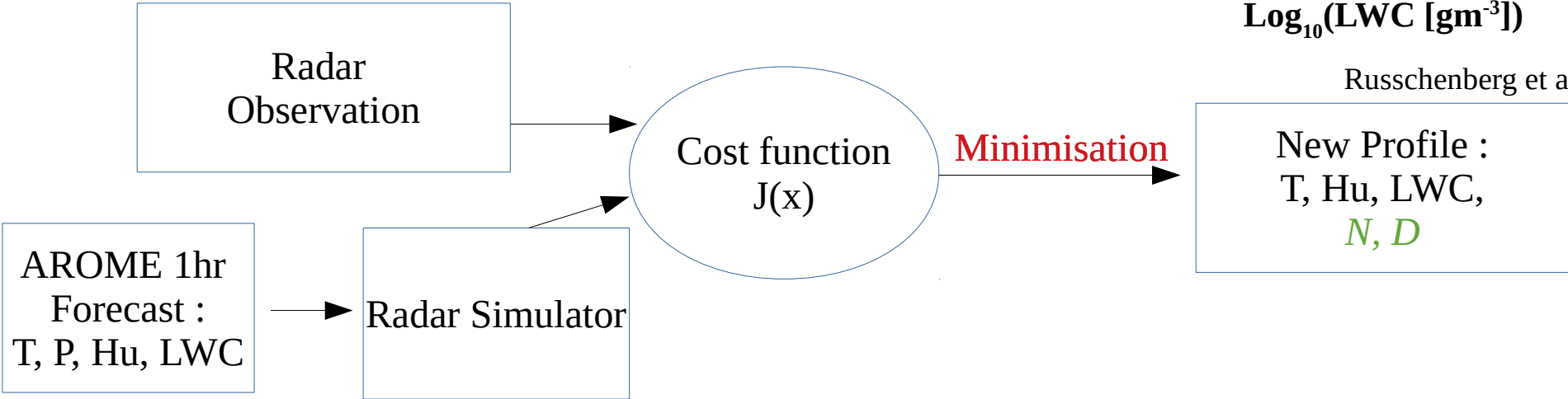PhD Co-director : Pauline Martinet (GMEI/MNPCA)
PhD supervisor : Benoît Vié (GMME/PHYNH)

Retrieval of LWC from Radar Reflectivity

- LWC power relations of form : $Z = a \cdot LWC^b$
- Variational retrieval methods

One-Dimensional Variational Retrieval (1D-VAR)
- Advantage – information from other source(s) used to constrain retrieval

Russchenberg et al. 2004

Radar Observation

AROME 1hr Forecast : T, P, Hu, LWC → Radar Simulator

Cost function J(x)

Minimisation

New Profile : T, Hu, LWC, *N, D*

$$J(x) = (x - x_b)^T B^{-1} (x - x_b) + (y - F(x))^T R^{-1} (y - F(x))$$
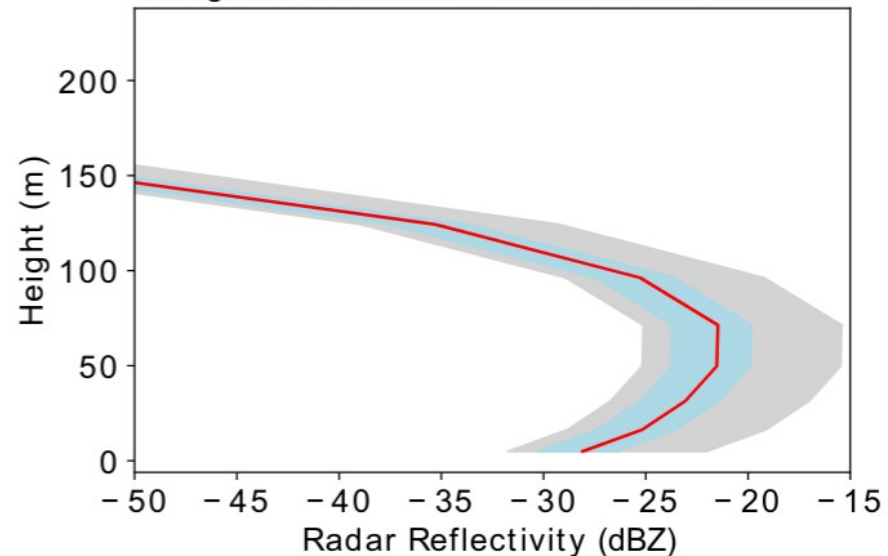
Sensitivity of Forward Operator

- In the forward operator, main source of uncertainty comes from assuming size distribution

- Perturbation of ICE-3 gamma law parameters

- In fog, the number concentration of droplets can vary significantly

- N more significant to uncertainty than other parameters in distribution

- Uncertainty estimated to be 6dBz for LWC of 0.12 gm^{-3}

—— Median   ▉ 25th-75th Percentiles   ▉ All other values

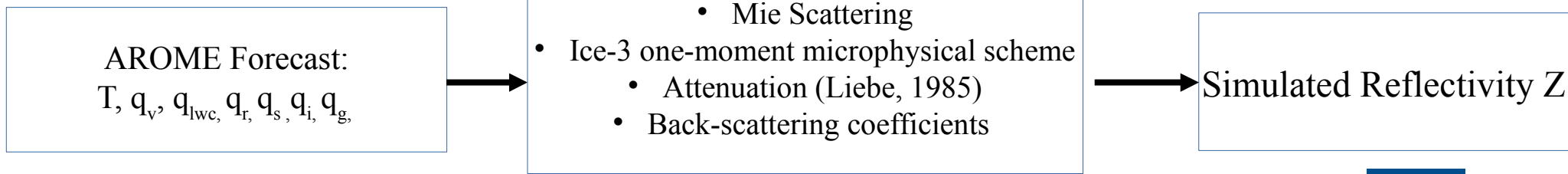Distribution of Simulated Reflectivities with Changes to α and ν Parameters
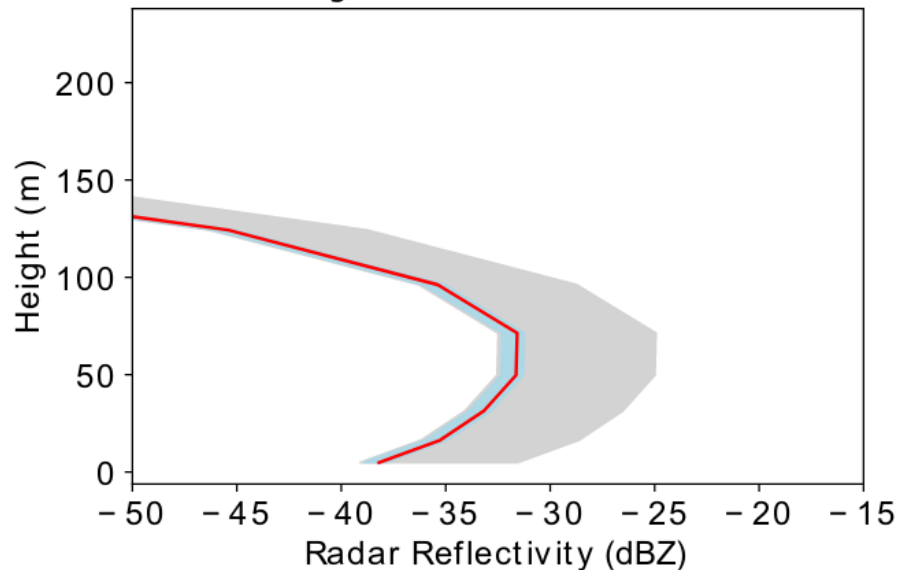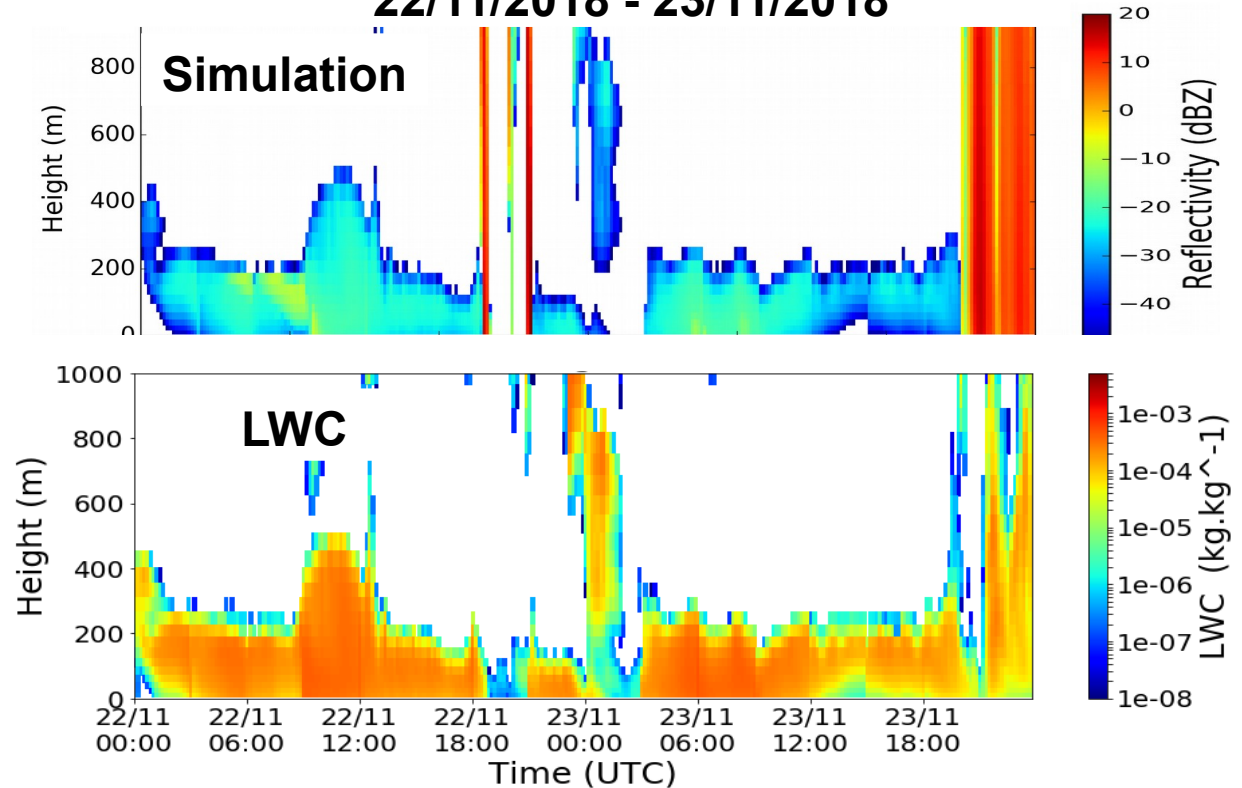

Distribution of Simulated Reflectivities with Changes to the Number Concentration Parameter

The Forward Operator / Radar Simulator

- Radar Simulator was designed by Borderies et al.* which was adapted for ground based radar

- Forecasts from high-resolution NWP model AROME was used to initialise simulator

Simulated Radar Reflectivity and LWC at Sirta 22/11/2018 - 23/11/2018

| AROME Forecast: T, q_v, q_{lwc}, q_r, q_s, q_i, q_g, | → | • Mie Scattering
• Ice-3 one-moment microphysical scheme
• Attenuation (Liebe, 1985)
• Back-scattering coefficients | → | Simulated Reflectivity Z |

*Borderies, Mary, Caumont, Olivier, Augros, Clotilde, Delanoë, Julien, Ducrocq, V., Le Bastard, Tony. (2017). Toward the Assimilation of W-Band Radar Data in a Kilometer-Scale NWP Model.

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Selecting a Background Profile

- Often, a fog forecast can contain temporal or spatial errors

- The quality of a retrial is linked to the quality of information contained in the background profile

- Correcting errors inside the background profile is likely to lead to improved retrievals

- Model profile selected from a 20 km x 20 km domain with a time window of ± 3 hours

- Radar Reflectivity simulated for all profiles

- Minimised weighted rmse (ZdB_Obs – ZdB_Simulation) – most resembling profile (MRP)
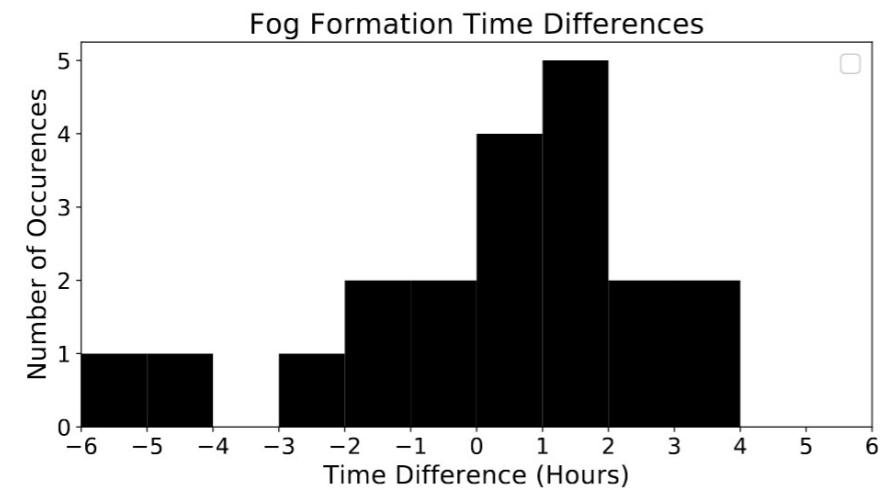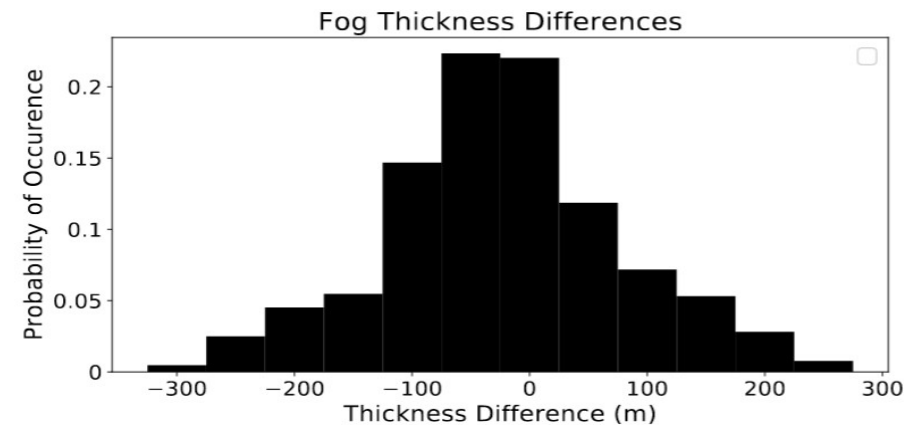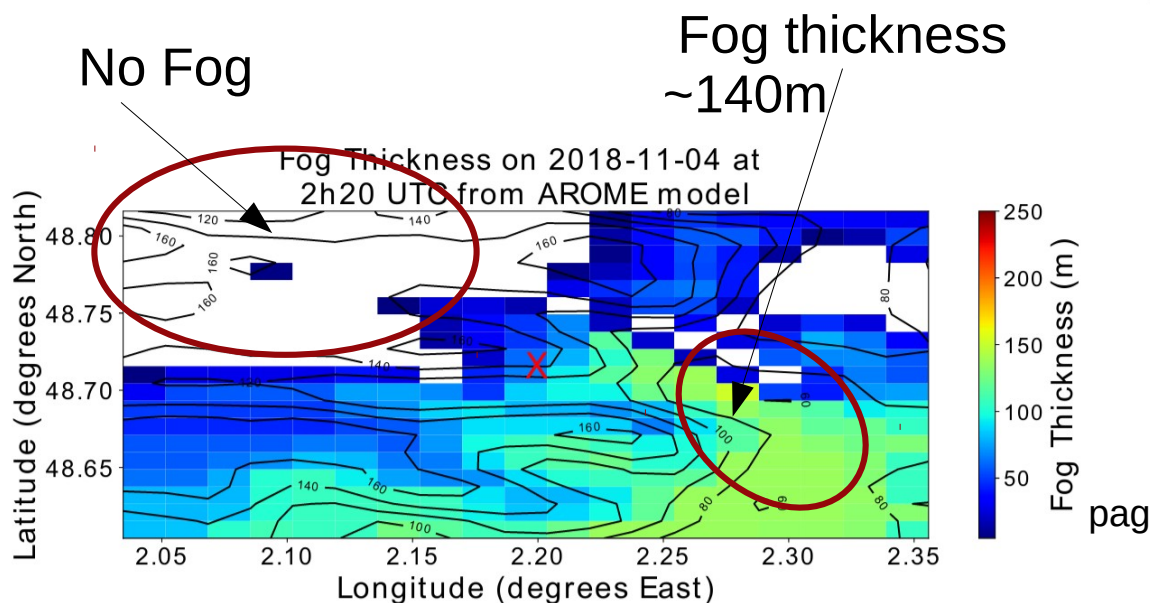
Quality of Background Profile

- Correction for time of fog formation/dissipation

- Better agreement in fog top height

- Statistics made for observation period winter 2018/2019 at Sirta (near Paris)

- Standard deviation (STD) and bias were compared for methods of closest grid point/time and MRP method

- Substantial improvement in both STD and bias