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Size Distribution Retrievals For Dual Radars Measurement Using Deterministic Inverse

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Many radar retrieval algorithms assume a Particle Size Distribution (PSD) and Rayleigh scattering to obtain relations of the form $Z=aR^b$ and $k=\alpha R^\beta$, which are directly invertible to obtain rain rate given radar reflectivity measurements. These methods have the advantage that they cast the problem into a simple analytical form, which results in a computationally quick and relatively simple retrieval algorithm. However, these assumptions lead to two potential sources of uncertainty: i) the assumption of a PSD strongly influences the values of a, b, α and β, and ii) the Rayleigh assumption is not valid for radars with a frequency greater than 10GHz. Some authors tried to solve such retrievals problem of the rain rate from radar measurements using Optimal Estimation Method (OEM). However, it is very much questionable to develop *a priori* profile and *a priori* covariance matrices of the parameters of PSD because the variability of these parameters is very large in some sense each measurement consists of a unique profile of the parameters. Thus, it will be the greatest mistake in science if OEM is implemented in such a problem.

In this talk, a simulated retrieval experiment is conducted to determine the PSD from nadir-pointing dual frequencies' (94 and 14 GHz) radar measurements for a geometry as equivalent to the CloudSat cloud profiling radar. The forward model is based on lookup tables: single scattering properties are pre-computed using the Discrete Dipole Approximation (DDA) method and Lorenz-Mie theory. The effective radar reflectivity factor for any atmospheric profile and the approximated number concentration of the spherical droplets of rain is calculated as

$$Z_{eff} = \frac{\lambda^4}{4\pi^5 |K|^2} e^{-2\int_0^r \kappa_{ext}(s)ds} \int Q_{scat} P(\theta=180)\pi D^2 N(D) dD \quad \text{and} \quad \mathbf{N}(D) = \mathbf{N}_0 \, e^{-\lambda_{sd} D} \qquad (1)$$

All symbols and nomenclature are available in [1]. The inverse model is based on the Regularized Total Least Squares (RTLS) method, which is a forward model-based data-driven deterministic optimization technique [1]. 2418 true profiles of PSD are collected from Goddard Cumulus Ensemble Cloud Resolving Model (GCE-CRM) to test the retrieval methodology. A noise of 1dB is added on the simulated signals and 16 vertical range bins, each with a vertical thickness of 250 m are considered. The results are shown in Fig. 1.

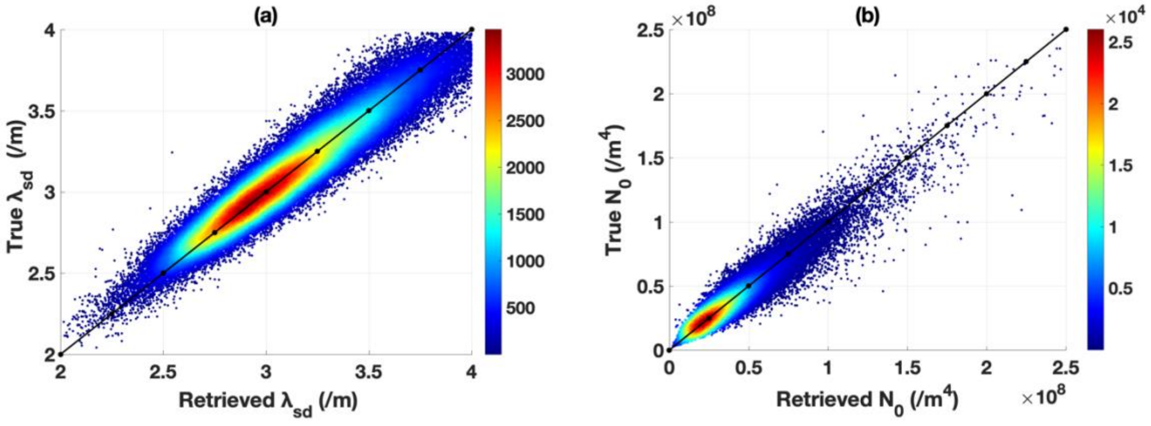

Figure 1. A density plot between all points of the 2418 profiles of true and retrieved parameters of: a) $\boldsymbol{\lambda_{sd}}$ and b) $\mathbf{N_0}$.

Fig. 1 shows that the Root Mean Square Error (RMSE) of N_0 and λ_{sd} are 11% and 3.5%, respectively. It confirms that the physical deterministic inverse method can be used for unambiguous parameters from ill-posed remote sensing radar measurements. The main advantage of the proposed retrieval method is that it does not require the errors as input parameters as opposed to the most popular method, OEM, in satellite retrieval community, where the errors are treated as definite information.

References

[1] P. K. Koner, A. Battaglia and C. Simmer, 'A Rain Rate Retrieval algorithm for Attenuating Radars Measurement,' J. Appl. Meteorol. Climatol., **49**, 2010, pp. 381–393.