Applicability of Self-Consistency Calibration Method for W-band Polarimetric Cloud Radars

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Why self consistency calibration method for S- band radar cannot be directly applied to W-band radar ?

- At higher frequencies, **attenuation due to rain strongly increases.**
- **At W band, reflectivity become less sensitive to rain rate** with increasing rain intensity. Because of non-Rayleigh scattering.
- **Estimation of K_{DP} from radar becomes complicated at** larger frequencies.

$$\Phi_{DP}(r) = \delta(r) + 2\int_0^r K_{DP}(r)\mathrm{d}r,$$

At higher frequency

$$\Phi_{DP}(r) = 2\int_0^r K_{DP}(r)\mathrm{d}r.$$

At lower frequency

A. Myagkov et al.,2020

Self Consistency Calibration Methodology

Measured

From ϕ_{DP} and Z_{DR}, retrieve

$$DP(r) = C_{DP} + 2\int_0^r K_{DP}(z)\,dz$$

$$DA(r) = C_{DA} - 2\int_0^r A_{DP}(z)\,dz$$

$$\delta = \phi_{DP} - DP$$

Calculate Z_0

$$Z_0(r) = Z(r) + C_Z + 2\int_0^r [A(z) + Ag(z)]\,dz - 10\log_{10}|K_0|^2 + 10\log_{10}|K(0)|^2$$

Calculated

Using Z_0 and δ, calculate

DP'

$$\frac{K_{DP}}{Z_0} = a_1 f(a_2\delta + a_3) + a_4 f(a_5\delta + a_6) + a_7 f(a_8\delta + a_9) + a_{10}.$$

Using A and δ calculate

DA'

$$\frac{A_{DP}}{A} = b_1 f(b_2\delta + b_3) + b_4 f(b_5\delta + b_6) + b_7 f(b_8\delta + b_9) + b_{10}.$$

Using Z_0 and δ, calculate

A'

$$A = c_1 f(c_2\delta + c_3 Z_0 + c_4) + c_5 f(c_6\delta + c_7 Z_0 + c_8) + c_9 f(c_{10}\delta + c_{11} Z_0 + c_{12}) + c_{13} f(c_{14}\delta + c_{15} Z_0 + c_{16}) + c_{17}.$$

Unknown

State Vectors

Variable	Minimum	Maximum	Units
A	0	25	dB km^{-1}
C_Z	−6	6	dB
C_{DA}	−0.05	0.05	dB
C_{DP}	−0.2	0.2	°

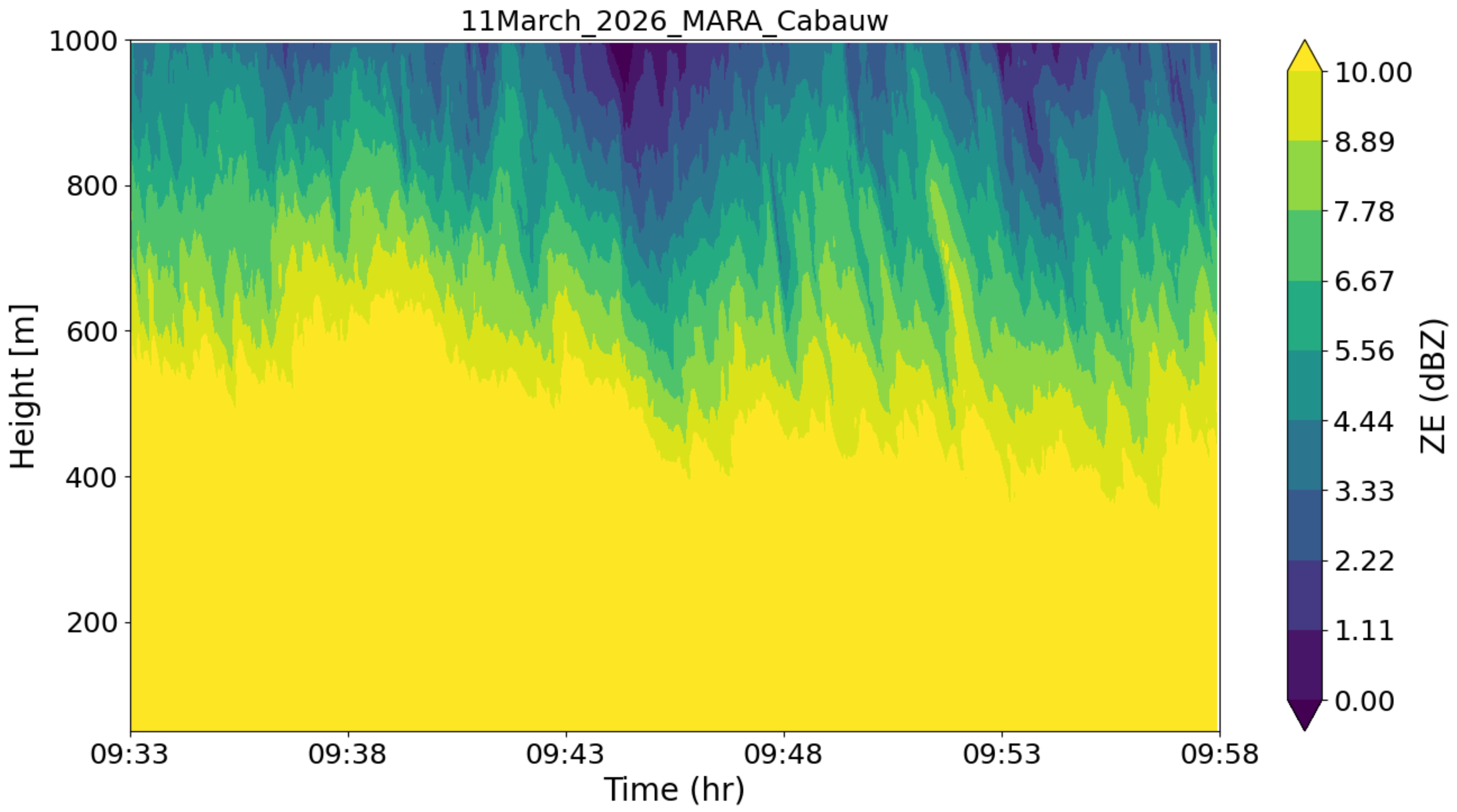
Differential Evolution Optimization Approach Using State Vectors

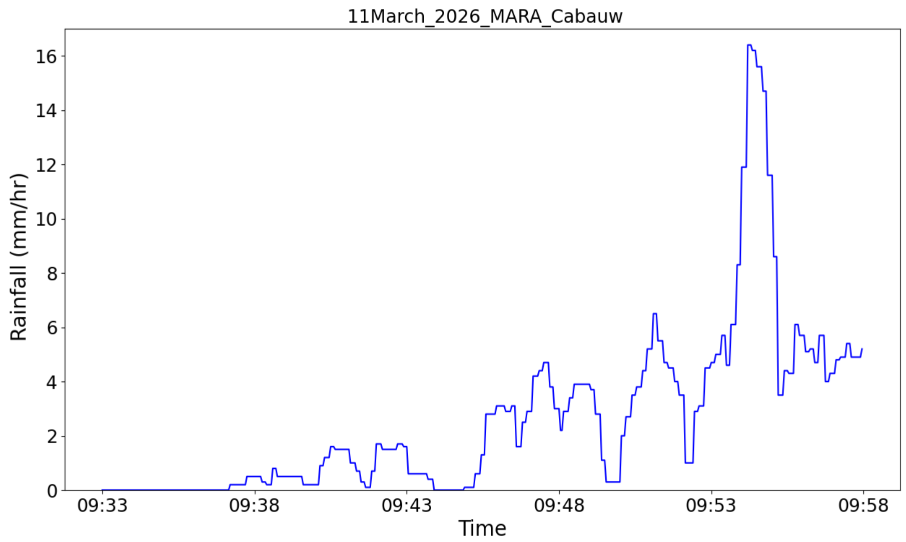
Compare **Measured** and **Calculated** profiles using cost function

→ Compare and find the **best fitting value of C_Z**

→ Calculate **reflectivity bias $Z - Z_0$**

MARA_Cloud Radar Data_11 March 2026_Cabauw

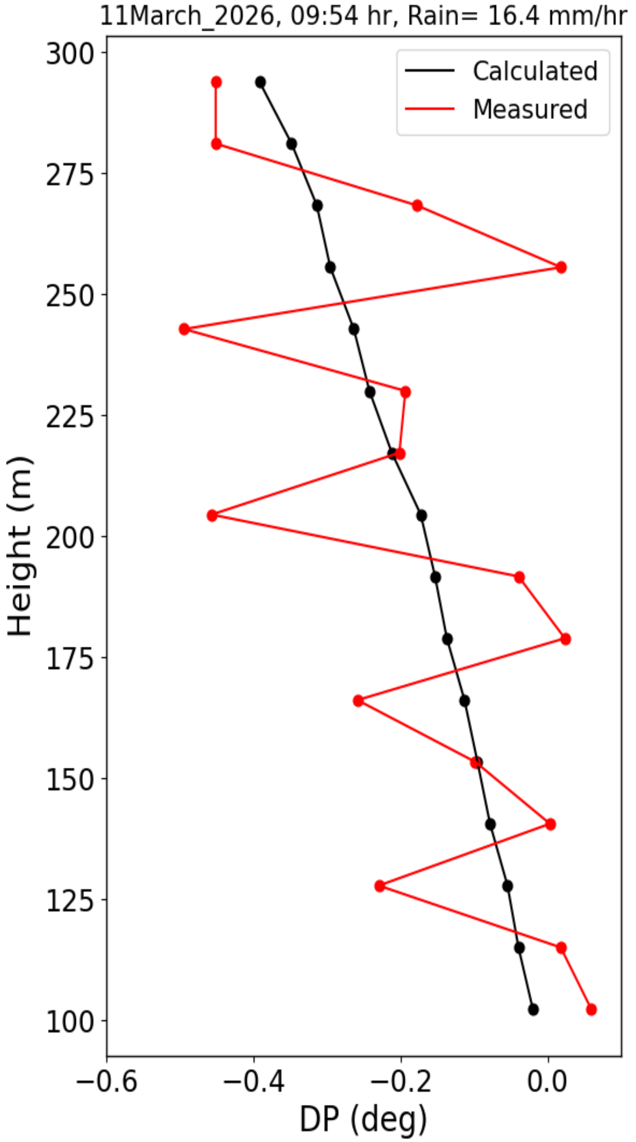


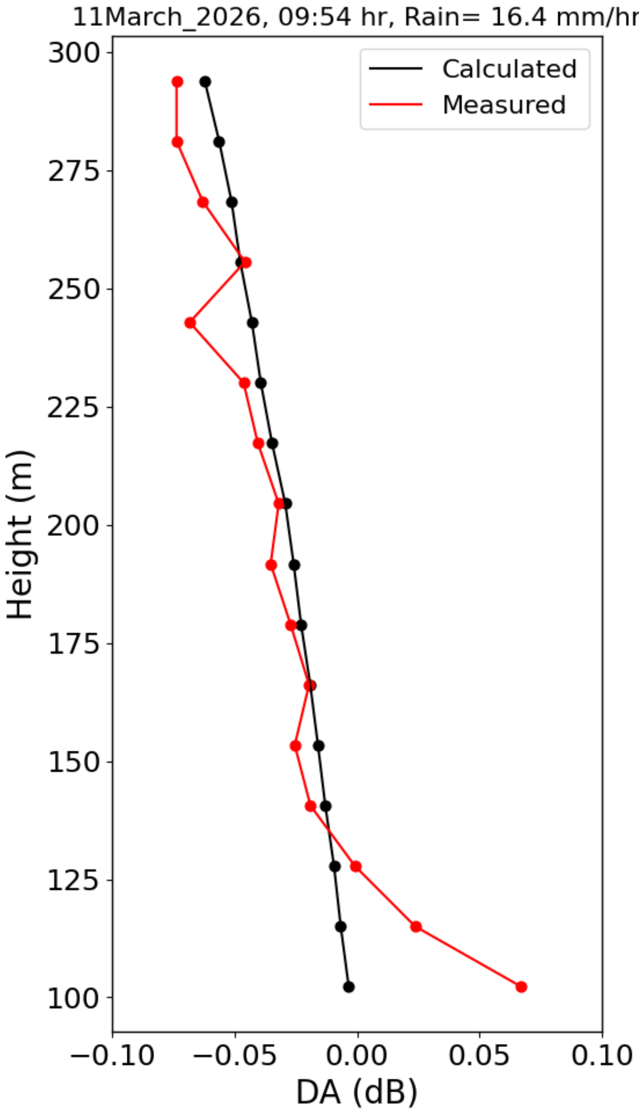


Data with 30^0 elevation angle and rainfall rate < 20 mm/hr

Measured & Calculated DP and DA

Differential Evolution Optimization Approach Using State Vectors





Measured

$$DP(r) = C_{DP} + 2\int_0^r K_{DP}(z)\,dz$$

$$DA(r) = C_{DA} - 2\int_0^r A_{DP}(z)\,dz$$

Calculated

$$\frac{K_{DP}}{Z_0} = a_1 f(a_2\delta + a_3) + a_4 f(a_5\delta + a_6) + a_7 f(a_8\delta + a_9) + a_{10}.$$

$$\frac{A_{DP}}{A} = b_1 f(b_2\delta + b_3) + b_4 f(b_5\delta + b_6) + b_7 f(b_8\delta + b_9) + b_{10}.$$

C_{DP} = 0.23 ^{0}

C_{DA} = 0.12 dB

The measured and expected profiles of DA and DP shown good agreement

Estimation of one-way Attenuation profile

Differential Evolution Optimization Approach Using State Vectors

$$A = c_1 f(c_2\delta + c_3 Z_0 + c_4) + c_5 f(c_6\delta + c_7 Z_0 + c_8)$$
$$+ c_9 f(c_{10}\delta + c_{11} Z_0 + c_{12})$$
$$+ c_{13} f(c_{14}\delta + c_{15} Z_0 + c_{16}) + c_{17}.$$

Variable	Minimum	Maximum	Units
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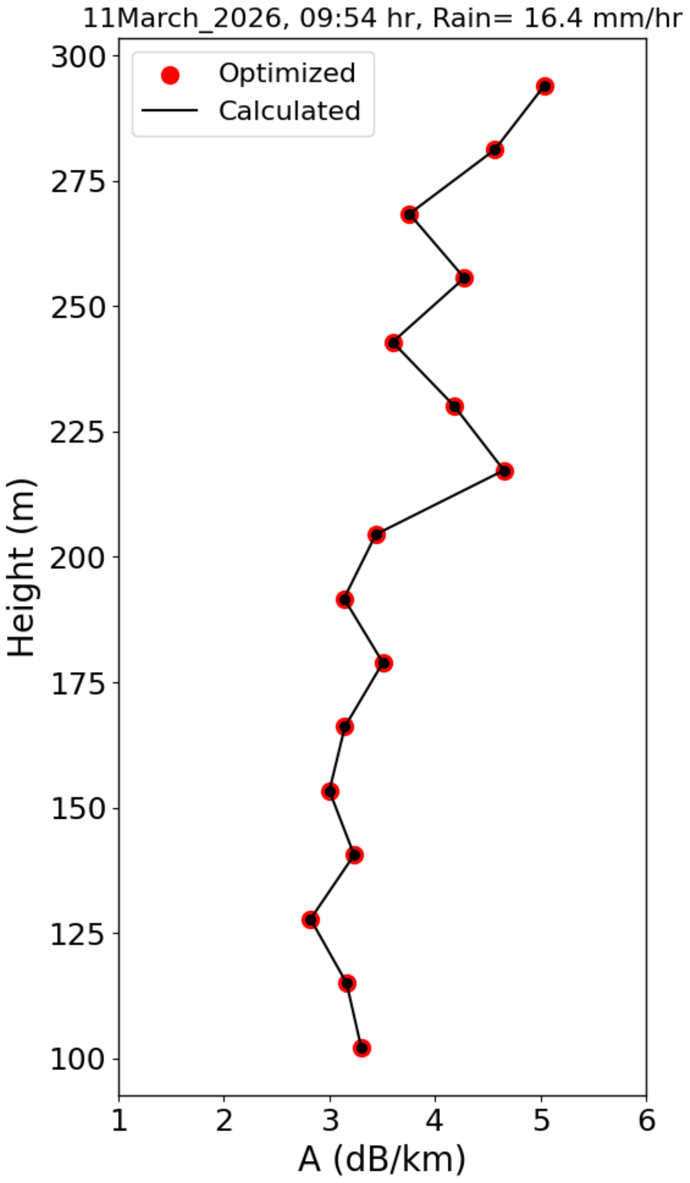
Retrieval of the one-way attenuation profile is shown to be another significant output of the self-consistency calibration technique.



Measured & Calculated Z

Differential Evolution Optimization Approach Using State Vectors

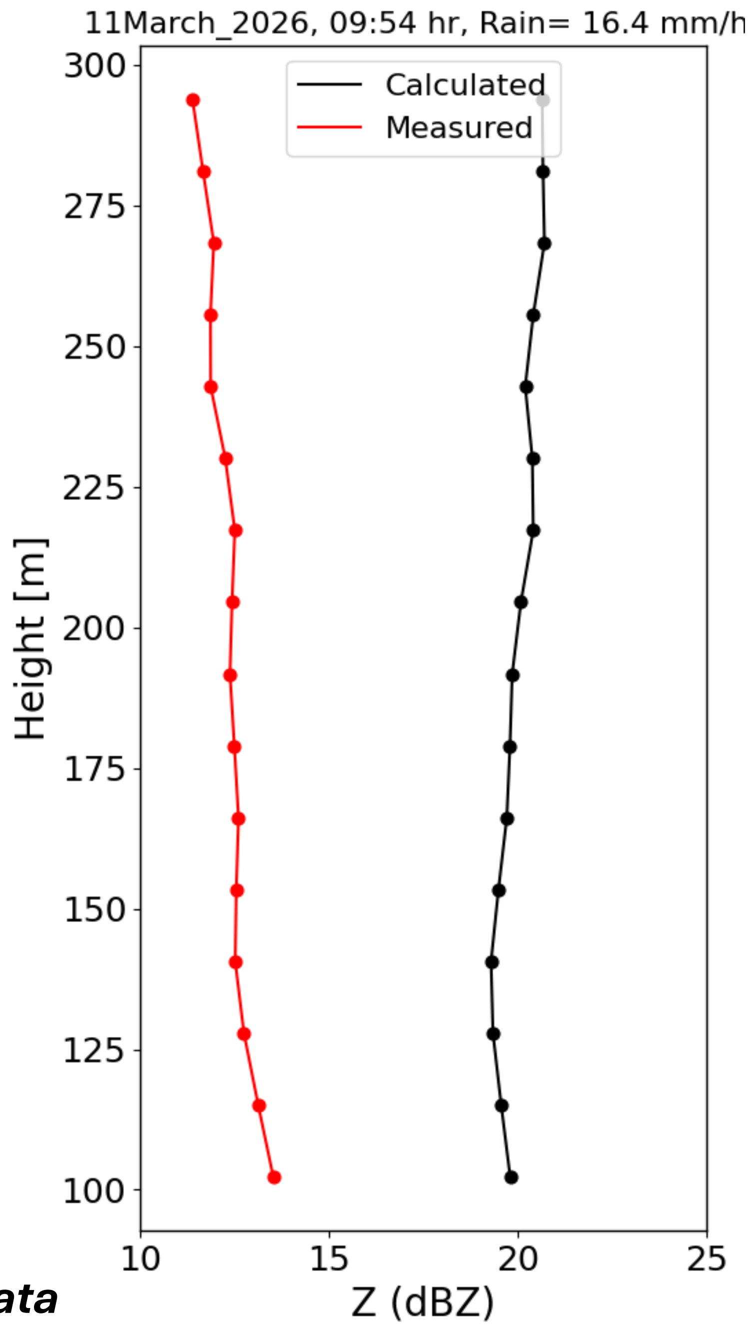
Calculate non-attenuated reflectivity $\mathbf{Z_0}$

$$Z_0(r) = Z(r) + C_Z + 2\int_0^r [A(z) + Ag(z)]\,dz - 10\log_{10}|K_0|^2 + 10\log_{10}|K(0)|^2$$

Measured

C_Z = 5.56 dB

Preliminary result



Needs to apply the self consistency methodology on more W band cloud radar data

Conclusions from the preliminary results

- To apply self-consistency calibration method,

  a) Delta needs to be greater than 1 deg (without considering canting angle).

  b) Rainfall rate greater than 2 mm/hr and less than 20 mm/hr.

  c) Elevation angle should not be >45 and <30 deg (based on simulation).

- Separation of differential phase into backscattering and propagational phase helps to understand whether polarimetric calibration is needed or not.

- Retrieval of the one-way attenuation profile is shown to be another significant output of the self-consistency calibration technique.