P8

Comparison of Forward Operators for Polarimetric Radars Aiming for Data Assimilation

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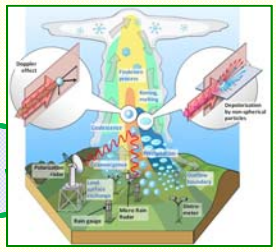


Why Dual-Polarized Radar?

- Distinguish ice and liquid phases of precipitation using radar.
- Identify specific hydrometeor populations such as hail or super-cooled water.
- Quantify rain, snow and hail fall rates using radar.

WRF model with **two-moment** microphysics (Morrison and Gettleman J. Climate 2008)

* **Predict** intense rains with WRF.

* The two moment microphysics provides:

number densities and mixing ratios of rainwater (←focused in this study)

$$\phi(D) = N_0 D^{\mu} e^{-\Lambda D}$$

N_0 Intercept parameter

Λ Slope parameter

μ Spectral shape parameter

Two types of variable convertors

A Model to observation

TMX T-matrix (direct scattering calculation)

(Doviak and Zrnic 1993, Smyth and Illingworth 1998, Oguchi 1973)

Observation

$$Z_{H,V} = \left(\frac{4\lambda^4}{\pi^4 |K_w|^2}\right) \int_{r2}^{r1} |S_{h,v}(D)|^2 n(D) dD$$

From the WRF model ($n(D)$); with T-matrix (Mishchenko 2000) ($S_{h,v}(D)$)

$$K_{DP} = \frac{2 \times 180 \times 10^{-3} \lambda}{\pi} \int_{r1}^{r2} \mathrm{Re}[S_h(D) - S_v(D)] n(D) dD$$

$$A_H = 8.686 \times 10^{-3} \lambda \int_{r1}^{r2} \mathrm{Im}[S_h(D)] n(D) dD$$

$$A_{DP} = 8.686 \times 10^{-3} \lambda \int_{r1}^{r2} \mathrm{Im}[S_h(D) - S_v(D)] n(D) dD$$

FIT Fitting (indirect scattering calculation)

(Zhang et al. 2001) Used in Jung et al. (2008)

$$|S_{h,v}(D)| = \alpha_{h,v} D^{\beta_{h,v}}$$

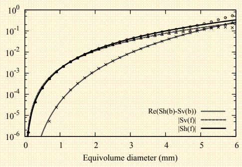
Fitting for C-band

$$Z_{H,V} = \frac{4\lambda^4}{\pi^4 |K_w|^2} \left(\alpha_{h,v}^2 N_0 \Lambda^{-(2\beta_{h,v}+1)} \Gamma(2\beta_{h,v}+1)\right)$$

$$K_{DP} = \frac{180\lambda}{\pi} N_0 \alpha_k \Lambda^{-(\beta_k+1)} \Gamma(\beta_k+1)$$

$$A_H = \alpha_H K_{DP}^{\beta_H} \quad A_{DP} = \alpha_d K_{DP}^{\beta_d}$$

α, β are fitting coefficients.



Result

Averages and standard deviations of OBS, TMX, FIT, and their differences of Z_H, Z_{DR}, and K_{DP}

	Z_H (dBZ)		Z_{DR} (dB)		K_{DP} (° km^{-1})	
	AVG	STD	AVG	STD	AVG	STD
OBS	16.41	10.76	0.93	1.05	1.30	1.54
TMX	22.28	11.65	1.01	0.58	0.61	0.57
FIT	18.80	10.33	0.64	0.46	0.27	0.19
TMX - OBS	5.76	15.11	0.15	1.03	-0.58	1.62
FIT - OBS	2.06	14.31	-0.19	1.01	-0.86	1.44

FIT is better than TMX.

B Observation to model

Derived theoretically or fitting with scattering calculation

Suggested by radar meteorologists (Bringi and Chandrasekar 2001)

Z_h, Z_{DR} and K_{DP} are observed by polarimetric radars, and compared with modeled rainwater contents Qr.

Z_ZD $\mathrm{Qr} = c_1 Z_h^{a_1} 10^{0.1 b_1 Z_{DR}}$ Used in Li and Mecikalski (2012)

KD $\mathrm{Qr} = c_2 \left(\frac{K_{DP}}{f}\right)^{b_2}$ Used in Yokota et al. (2014)

KD_ZD $\mathrm{Qr} = c_3 K_{DP}^{a_3} 10^{0.1 b_3 Z_{DR}}$ Used in Li and Mecikalski (2013)

a_x, b_x, c_x are constants

FIT is used as a TRUE-observation generator

1. WRF simulates rainwater,
2. then, FIT converts them to polarimetric factors,
3. again, Z_ZD, KD, and KD_ZD convert these factors back to rainwater.

rain drops in the model — 1. TRUE

3. Z_ZD, KD, KD_ZD — converted rain drops

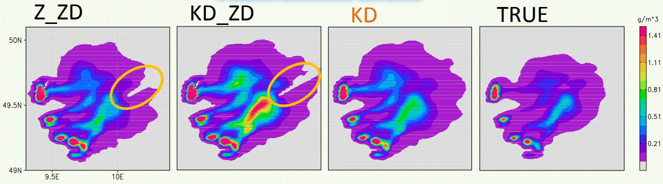
Result

Averages and standard deviations of TRUE, Z_ZD, KD, and KD_ZD, and their differences.

			Difference with TRUE	
	AVG	STD	AVG	STD
TRUE	0.073	0.12	—	—
Z_ZD	0.088	0.15	0.018	0.05
KD	0.073	0.13	0.005	0.03
KD_ZD	0.12	0.22	0.053	0.10

KD_ZD is worst among these 3 methods.

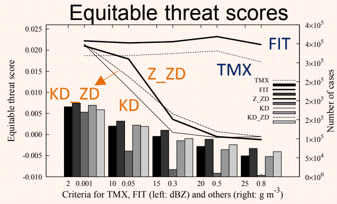
Attenuation effect



Only KD is not affected by the attenuation.

A⇔B Result Comparison between A and B operators against radar observations

Equitable threat scores

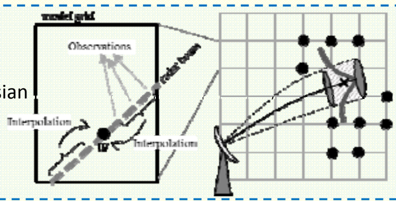


Convertors of "model to obs" (TMX and FIT) look better than that of "obs to model".

Space interpolator

The interpolator handles:

- ✓ Beam broadening with Gaussian weight in 3-D
- ✓ Statistical beam bending



Conclusion:

- Developed 5 operators for polarimetric radars with the WRF model.
- FIT is better than TMX.
- KD is better than Z_ZD and KZ_ZD.
- "model to obs" look better than "obs to model".

NEXT STEP:

- Assimilation with FIT and/or KD by WRF Var.

This study is part of the collaborative research group "Catchments As Organized Systems (CAOS, FOR 1598) funded by the German Research Foundation.