Rainfall estimation from an operational S-band dual-polarization radar in the monsoon dominant environment

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Objective

Rain QPE with an operational S-Pol.

1. Effect of Z calibration

2. Effect of ZDR calibration

3. Point vs. Area

4. Update period (volume scan time)
Two distinctive precipitation systems
DSD characteristics

(a) 3.6

(b) 1.0

Frequency (%)

Log$_{10}$[$N_w$ (mm$^{-1}$m$^{-3}$)]

Frequency (%)

$D_m$ (mm)
ZDR-Z: Oklahoma vs. South Korea

From Dr. T. Schuur
Bisl Mt. S-Pol radar

- Diameter: 8.5m
- Polarization: Slant 45 deg.
- Beam Width: 0.95°
- Transmitter: Klystron
- Peak Power: 750kW
- Frequency: 2.795MHz (S-band)

Radar height: 1050m
Scan: 6 PPIs every 2.5 min. (including -0.5 deg.)
### Rainfall estimators

Derived from disrometer data

<table>
<thead>
<tr>
<th>Relationships</th>
<th>Ryzhkov et al. (2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R(Z_H) )</td>
<td>( R = 1.7 \times 10^{-2} Z_H^{0.71} ) ( (Z_H=300 R^{1.4}) )</td>
</tr>
<tr>
<td>( R(K_{DP}) )</td>
<td>( R = 46.83 K_{DP}^{0.82} )</td>
</tr>
<tr>
<td>( R(Z_H, Z_{DR}) )</td>
<td>( R = 7.3 \times 10^{-3} Z_H^{0.95} Z_{DR}^{-5.37} )</td>
</tr>
<tr>
<td>( R(Z_H, \xi_{DR}) )</td>
<td>( R = 0.257 Z_H^{0.9410^{-1.61}Z_{DR}} )</td>
</tr>
<tr>
<td>( R(K_{DP}, Z_{DR}) )</td>
<td>( R = 129.52 K_{DP}^{0.96} Z_{DR}^{-2.94} )</td>
</tr>
<tr>
<td>( R(K_{DP}, \xi_{DR}) )</td>
<td>( R = 851.70 K_{DP}^{0.95} 10^{-0.89Z_{DR}} )</td>
</tr>
<tr>
<td>( R(Z_H, K_{DP}) )</td>
<td>( R = 2.8 \times 10^7 Z_H^{-1.19} K_{DP}^{2.17} )</td>
</tr>
</tbody>
</table>
Z & ZDR calibration

Zh
1. Self-consistency (Zh-KDP)

ZDR
1. Vertically pointing
2. Mean ZDR-ZH relationship (10~20 dBZ)

\[ \tan \theta = \frac{\sum \Phi_{DP\_cal} \Phi_{DP\_obs}}{\sum \Phi_{DP\_obs}^2} \]

\[ \varepsilon [dB] = 10 b \log(\tan \theta) \]
Z & ZDR calibration

Zh calibration bias: 35 events (2010~2011)
Z & ZDR calibration

Vertically pointing measurement

PPI measurement of wide spread rain
Z & ZDR calibration

Zh calibration bias: 35 events (2010~2011)

Zh calibration bias

Vertical pointing

1.6 1.2 0.8 0.5 0.0 -0.5
Effect of Z & ZDR calibration

Average Calibration bias
Zh = -2.3 dB
ZDR = 0.5 dB

- Bf cal.
- Af cal.

Adaptive Calibration bias
Point vs. Area

Radar ($R_r$) & Gauge ($R_G$)

$R_r$ (2km$^2$) & $R_G$ (0.018km$^2$)

$R_r$ (2km$^2$) & $R_G$ (2km$^2$)
Adjustment of rainfall estimators

\[ R(Z_H, Z_{DR}) = 7.3 \times 10^{-3} Z_H^{0.95} Z_{DR}^{-5.37} \]

\[ R(Z_H, \xi_{DR}) = 0.257 Z_H^{0.94} \xi_{DR}^{-1.16} \]

\[ R(Z_H, \xi_{DR}) = 6.16 \times 10^{-3} Z_H^{0.95} Z_{DR}^{-5.55} \]

\[ R(Z_H, \xi_{DR}) = 4.39 \times 10^{-1} Z_H^{0.94} \xi_{DR}^{-1.88} \]

Before Adjustment

After Adjustment
Summary statistics

After calibration (1h)
Before calibration (1h)
After calibration (1h)
After adjustment (1h)
After adjustment (2h)
After adjustment (10min)

Ryzhkov et al. (2005)

Hourly rain
Point: 1 km by 1 deg
Area: 42*(1 km by 1 deg)

Area: 1.6km by 1.2km
Update period (volume scan time)

$R(Z_H)$

KMA volume scan

$R(Z_H, Z_{DR})$

Data update frequency [min]
Summary

Rain QPE with S-Pol. in Korea: works!

1. Effect of Z and ZDR calibration
   - Adaptive calibration, in particular in ZDR
   - Azimuthal dependency (ZDR)
   - Both vertically pointing and ZDR-Zh work.

2. Adjustment of rain estimators

3. Point vs. Area: 3~6 %

4. Update period (volume scan time)
   - More sensitive to dual-pol estimators
Two distinctive systems

From Dr. T. Schuur
## Effect of Z & ZDR calibration

<table>
<thead>
<tr>
<th></th>
<th>Bf calibration</th>
<th>Af avg. calibration</th>
<th>Af adaptive calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SD</td>
<td>NSD [%]</td>
<td>SD</td>
</tr>
<tr>
<td>10 min</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$R(Z_H)$</td>
<td>3.75</td>
<td>77</td>
<td>3.49</td>
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<tr>
<td>$R(Z_H, Z_{DR})$</td>
<td>3.97</td>
<td>78</td>
<td>5.15</td>
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<tr>
<td>$R(Z_H, \xi_{DR})$</td>
<td>3.89</td>
<td>76</td>
<td>5.26</td>
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<td>60 min</td>
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<tr>
<td>$R(Z_H)$</td>
<td>2.24</td>
<td>56</td>
<td>1.72</td>
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<tr>
<td>$R(Z_H, Z_{DR})$</td>
<td>2.54</td>
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<td>2.37</td>
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<td>$R(Z_H, \xi_{DR})$</td>
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<td>2.42</td>
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<td>120 min</td>
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<tr>
<td>$R(Z_H)$</td>
<td>1.75</td>
<td>48</td>
<td>1.21</td>
</tr>
<tr>
<td>$R(Z_H, Z_{DR})$</td>
<td>2.13</td>
<td>56</td>
<td>1.92</td>
</tr>
<tr>
<td>$R(Z_H, \xi_{DR})$</td>
<td>2.05</td>
<td>54</td>
<td>1.94</td>
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</tbody>
</table>