Validation of GPM snowfall over northern Japan

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Outline

Objective

GV activities for algorithm validation
  - Experiment
  - Result

GV activities for products validation
  - Preliminary results

Summary
**Objective**

- GPM ground observation campaigns over northern Japan
  - for DPR L2 algorithm
    - Relationship between attenuation coefficient \(k\) and equivalent radar reflectivity \(Z_e\) in bright band
    - Relationship between radar reflectivity \(Z_e\) and equivalent rain rate \(R\) for solid precipitation
    - Particularly of precipitation particles in bright band
  - for DPR L2 products
    - Direct comparison of radar reflectivity (especially KaPR)
    - Drop size distribution of liquid precipitation
    - Snow detection
    - Brightband detection

→ providing feedback to algorithm developer
Algorithm validation

location of observation

Cumulative amount of snowfall

2014年11月1日～2015年5月11日

- Nagaoka(snow)
  Dec.2014～Mar.2015 (NIED)

- Mt.Zao
  (melting layer,snow)
  Oct.2013～Apr.2015 (JAXA)

- Sapporo (dry snow)

- Over ocean including the Arctic sea: poster (Dr. Katsumata)

Campaign observation using ground-based dual Ka-band radar (→ this presentation and poster: Prof. Suzuki)

Quantitative precipitation estimation of snow using X-POL radar and particle observation system conducting by NIED (Dr. S. Nakai)

(GOAL: Ze-R relationship parameterized by riming and melting index and center of mass flux distribution)
Observation Estimation of $Z_e$ and $k$

$Z_e(n) = \left[ Z_{SN001}(n) + Z_{SN002} - 2 \sum_{i=n}^{n-1} k(i) \delta h \right] / 2$

$k(n) = \left[ Z_{SN002}(n+1) - Z_{SN001}(n) - Z_{POSS}(n+1) \right] / 4 \delta h - 0.34$

Mobile precipitation observation system

Ka radar (SN001)

Li et al. (2001)

attenuation by water vapor (Ulaby et al. 1981)

- 2Dimensional video distrometer
- Joss-type disdrometer
- Optical rain gauge
- Tipping bucket rain gauge
- Micro-rain radar
- Ka radar
- Parsival (Laser Optical disdrometer)

Wind direction & speed

Parsival (Laser Optical disdrometer)

Thermo-hygrometer

POSS
Dual Ka-radar system

Radar antenna and mount

1.8 m
1.4 m
1.0 m
2.0 m
3.6 m
3.7 m

Radar operation equipments (PC)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>35.25 GHz (Ka-band)</td>
</tr>
<tr>
<td>Modulation Principle</td>
<td>FMCW (Frequency-modulated continuous wave)</td>
</tr>
<tr>
<td>Minimum Detect Zm</td>
<td>-20 dBZ at 10 km</td>
</tr>
<tr>
<td>Range Resolution</td>
<td>&lt; 50m (min. 12.5m)</td>
</tr>
<tr>
<td>Doppler Velocity</td>
<td>&gt; ±10 m/s</td>
</tr>
<tr>
<td>Observable range</td>
<td>From 500 m to 30 km</td>
</tr>
<tr>
<td>Antenna beam width</td>
<td>0.6 deg</td>
</tr>
<tr>
<td>Antenna Sidelobe</td>
<td>25 dBZ &gt;</td>
</tr>
</tbody>
</table>
Instruments

- Micro Rain Radar (METEK)
  24.230GHz FM-CW doppler radar
  Vertical pointing
  Estimating DSD for each rangebin
  Range resolution: 30-6000m

- G-PIMMS (Ground-based Particle Image and Mass Measurement System)
  -> poster

- Parsivel
  Disdrometer for classification of the DSD
  Optical precipitation measuring instruments for rain quantity and intensity
  - 2DVD (only 2013)
  - Melting fraction measurement instrument (only 2013)
Results of Nagaoka experiment

Scatter plots of $k$ and $Z_e$ for all snow events

\[
k = \begin{cases} 
1.7 \times 10^{-2} Z_e^{0.64} & \text{for } T < -1 \text{ deg C} 
\end{cases}
\]

\[
k = \begin{cases} 
3.4 \times 10^{-2} Z_e^{0.53} & \text{for } -1 \leq T < 0 \text{ deg C} 
\end{cases}
\]

\[
k = \begin{cases} 
2.0 \times 10^{-3} Z_e^{0.91} & \text{for } 0 \leq T < 1 \text{ deg C} 
\end{cases}
\]

bias = 0.02 dB/km
RMS = 0.44 dB/km
corr = 0.71
N = 637

bias = -0.03 dB/km
RMS = 0.40 dB/km
corr = 0.82
N = 342

bias = -0.03 dB/km
RMS = 0.47 dB/km
corr = 0.85
N = 232

Experiment in Mt. Zao

- **Target is Melting layer**
- **4 times of Intensive observation period**
  - 2013. November-December (4 weeks)
  - 2014. March (3 weeks)
  - 2014. November-December (4 weeks)
  - 2015. March (2 weeks)
Mountain side

Mountain side (autumn)

base side
The accuracy of measurement was not enough
- The radar beam was stirred slightly upward to avoid receiving noise from each other.
- But the melting layer shows a large variance in a vertical direction.
- The assumption that the total attenuations of 2 radars are equal is not correct if the two beams path were not same.
- It was hard to eliminate the effect of beam mismatching.

Ka-radar malfunctioning
- The sensitivity gradually declined while 1-2 weeks
- Troubleshooting reveals that it is attributed to the radiator or the antenna and it can not fix without extensive repair.
- Study of Zm correction by other instruments data was done
  - Effective correction is enable by Parsivel
Results of 2014

- Beam mismatching was resolved
- Sensitivity declination occurred therefore Zm of Ka-radar was corrected by the Parsivel data
- Other instruments worked well
K-Ze relationship by Ka-radar observation

Comparison (after correction of Zm of Ka-radar)

K-Ze relationship From DPR products
products validation

Direct comparison of radar reflectivity

- Instantaneous observation of KaPR and ground radar when GPM overpass
- Direct comparison of radar reflectivity using Ground-based Ka radar
- Selection criteria: type of precipitation (stratiform), surface wind speed (under 5m/s), no rapid change in echo of ground radar

2015/4/13 18:44 (JST)
Stratiform rain

50 [dBZ]
Comparison between paramDSD(DPR) and DSD(parsivel)

<table>
<thead>
<tr>
<th></th>
<th>period of observation</th>
<th>Number of case</th>
<th>2DV</th>
<th>Parsivel</th>
<th>Disdrometer</th>
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</thead>
<tbody>
<tr>
<td>Tsukuba</td>
<td>2014/6-2014/7</td>
<td>0</td>
<td></td>
<td>○</td>
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<tr>
<td>Koganei</td>
<td>2014/6-2014/7</td>
<td>0</td>
<td></td>
<td>○</td>
<td></td>
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<tr>
<td>Yamagata (2 sites)</td>
<td>2014/11-2015/4</td>
<td>5</td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Okinawa</td>
<td>2014/3-2015/3</td>
<td>5</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Nagaoka (3 sites)</td>
<td>2014/11-2015/1</td>
<td>7</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Sapporo</td>
<td>2014/3-2015/2</td>
<td>2</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R/V MIRAI</td>
<td>-</td>
<td>-</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Selection criteria:
- type of precipitation (stratiform),
- no rapid change in echo of ground radar (if there is any radar data)
Comparison between paramDSD(DPR) and DSD(parsivel) in Mt.Zao

Tendency:

Moderate rain case: Retrieved DSD parameters are consistent with ground instruments.

Light rain case: DPR overestimates N(D) where D<0.5mm but the detection limit of Parsivel should be considered.

Snow case: DPR underestimates N(D) where 1mm<D.
Summary

The series of ground observation campaigns by dual Ka-radar system for algorithm has finished.

k-Ze relationships in bright band was obtained but data requires Zm correction and proper selection criteria to classify B.B in the form to compare the model in algorithm.

Many tasks for analyses yet remain.
- k, Ze vs. particle video images from G-PIMMS
- Ze vs. equivalent rain rate from G-PIMMS
- k-Ze comparison with surface temperature (Snowflakes do not have high Ze and k either)
- Turbulence vs. BB
- Re-analysis of data (Nagaoka and Sapporo, and Zao-2013) (Some results: TGRS in revision)

Other observations such as G-PIMMS has successfully done.

Products validation is undergoing but the number of cases is not enough to validate products statistically. Observation will continue in long-term.
Acknowledgment

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Thank you for your kind attention!