Validation of near-real-time precipitation estimates over Japan and improvement of passive microwave rain retrievals in mountainous areas

S. Shige¹, T. Mega¹, M. K. Yamamoto¹, S. Kida², T. Kubota², M. Kachi², T. Ushio³, K. Aonashi⁴, and K. Okamoto⁵

¹Kyoto University, Kyoto, Japan
²Japan Aerospace Exploration Agency, Tsukuba, Japan
³Osaka University, Suita, Japan
⁴Meteorological Research Institute, Tsukuba, Japan
⁵Tottori University of Environmental Studies, Tottori, Japan

Outline:
1. IPWG Japan intercomparison/validation website
2. Orographic rainfall associated typhoon Morakot (2009)
IPWG regional intercomparison/validation websites

Europe

Japan

United States

Australia

South America
IPWG Japan intercomparison/validation website
http://www-ipwg.kugi.kyoto-u.ac.jp/IPWG/sat_val_Japan.html

Monthly statics for all products

Hourly validation for GSMaP
Hourly validation of near-real-time precipitation estimates from GSMaP
GSMaP_NRT vs. Radar-AMEDAS

7 March 2011: Original

GSMaP_MVK (MWR + IR) vs. RA (Radar + Guage)

Verification statistics for 20110307

<table>
<thead>
<tr>
<th></th>
<th>Analysed</th>
<th>GSMaP_NRT</th>
</tr>
</thead>
<tbody>
<tr>
<td># gridpoints raining</td>
<td>1464</td>
<td>1068</td>
</tr>
<tr>
<td>Average rain</td>
<td>17.7</td>
<td>40.2</td>
</tr>
<tr>
<td>Conditional rain</td>
<td>18.6</td>
<td>58.0</td>
</tr>
<tr>
<td>Rain volume (mm×km×10⁴)</td>
<td>17.2</td>
<td>39.1</td>
</tr>
<tr>
<td>Maximum rain</td>
<td>75.2</td>
<td>806.6</td>
</tr>
</tbody>
</table>

Mean abs error = 34.2
RMS error = 86.9
Correlation coeff = 0.225
Frequency bias = 0.730
Probability of detection = 0.718
False alarm ratio = 0.016
Hanssen & Kuipers score = 0.497
Equitable threat score = 0.078
GSMaP_NRT vs. Radar-AMEDAS
7 March 2011: Revised

GSMaP_MVK (MWR + IR)

RA (Radar + Guage)
Heavy Rainfall associated with Typhoon Morakot in Taiwan on August 8, 2009

Heavy orographic rains are found over the western slope of Central Mountain Range in data from TRMM Precipitation Radar (PR).

These heavy rains are underestimated by GSMaP algorithm for TRMM Microwave Imager (TMI).
MWR Rainfall Algorithm

**Over Land**

- **Scattering Algorithm**
  - Scattering by ice particles (above freezing level) at high frequency (37, 85GHz)

- **Emission Algorithm**
  - Emission by water particles (below freezing level) at low frequency (10, 19GHz)

- **Height**
  - Freezing Level

- **WATER**
  - Emission

- **ICE**
  - Scattering

- High and variable emission from land surface
Look-up table: Relationship between $Tbs$ and rain rates

Look Up Table (2004 07/30)

- **Obs. TB**
- **Original**
- **Orographic**
- **Typhoon Namtheun**
- **Underestimate**
- **Est. Rain**

LUT@85 GHz

- **Ice**
- **Water**
Precipitation associated with Typhoon Morakot over Taiwan area on August 8, 2009

LUT calculated from orographic precipitation profile

Widely overestimation

Need to classify into orographic/non-orographic rainfall
Orographic/Non-Orographic Rainfall Classification Scheme

Orographically forced upward motion & convergence of surface moisture flux over Taiwan Area, calculated from SRTM30 and JCDAS

\[ w = \left( \frac{\partial h}{\partial x}, \frac{\partial h}{\partial y} \right) \cdot \begin{pmatrix} u \\ v \end{pmatrix} > 0 \]

\[ -\left( \frac{\partial (u q)}{\partial x} + \frac{\partial (v q)}{\partial y} \right) > 0 \]

\[ h : \text{Terrain Height (SRTM30)} \]
\[ u, v : \text{Surface Horizontal Wind (JCDAS)} \]
\[ q : \text{Surface Water Vapor Mixing Ratio (JCDAS)} \]

18 UTC August 8 2009
Precipitation associated with Typhoon Morakot over Taiwan area on August 8, 2009

PR _ Near Surface Rain

GSMaP_TMI_Surface Rain (orig.)

GSMaP_TMI_Surface Rain

Applied orographic profile

Applied condition:
Upward wind > 0.0 (m/s)
Vapor convergence > 0.5 × 10^{-6} (1/s)

SRTM30_Topography

Orographic Forced Lifting

Successfully estimated
Applied to Other MWR Sensors $\rightarrow$ GSMaP_MVK Product

TRMM/TMI  Aqua/AMSR-E  DMSP/SSMI  NOAA/AMSU

Microwave radiometer algorithm (GSMaP)

Gridded product from each sensor

Combined

GSMaP_MVK

MWR+IR combined product
0.1° grid box, 1-hourly

Infrared Radiometer (IR)
Cloud motion vector

Geostationary satellite
GSMaP_MVK
Original GSMaP vs. Revised GSMaP
15UTC 6 August 2009 ~ 10UTC 9 August 2009
TRMM 3B42RT vs. Revised GSMaP
15UTC 6 August 2009～ 15UTC 9 August 2009 3hourly
TRMM 3B42RT vs. Original GSMaP
2009/08/06 ~ 2009/08/10 Accumulated Rainfall

3B42RT

Original GSMaP

Both products underestimate ... ↓↓
TRMM 3B42 vs. Revised GSMaP
2009/08/06 ~ 2009/08/10 Accumulated Rainfall

Revised GSMaP

Better Agreement!!
Summary

• The updated IPWG Japan website at Kyoto University has been contributing to monitoring errors of GSMaP near-real time system at JAXA/EORC.

• The GSMaP algorithm underestimates orographic heavy rainfall as we as the other algorithms (e.g. GPROF) does.

• Precipitation profiles associated with orographic heavy rainfall are shallower than precipitation profiles used in the GSMaP algorithm, leading to its underestimation.

• Dynamically selection of precipitation profiles and their associated LUT based on slope-forced vertical motion and moisture convergence leads to a better results for Typhoon Morakot.