Current Status of GSMaP Project and New MWI Over-land Precipitation Retrieval Algorithm

Kazumasa AONASHI (MRI/JMA), Satoshi KIDA, Takuji KUBOTA, Misako KACHI, Riko OKI (EORC/JAXA), Tomoo USHIO (Osaka Univ.), Shoichi SHIGE (Kyoto Univ.)

Ken’ichi OKAMOTO (Tottori Univ. of Envi. Studies)

aonashi@mri-jma.go.jp
Outline

- Introduction
  - GSMaP Project
  - Current Activities
- New over-land MWI algorithm
  - Over-land algorithm and problems in retrieval
  - Introduction of MWI indices
  - Statistical correction using MWI indices
- Results
  - Over-land retrieval for 2004
- Summary & Future directions
Current Status of GSMaP Project

GSMaP Project

Current Activities
Global Rainfall Map Processing System at JAXA/EORC

Near real time and high-resolution global rainfall map based on satellite observation

Produced Rainfall Map

produced 4 hours after observation and updated every hour

http://sharaku.eorc.jaxa.jp/GSMaP/
GSMaP Project

TRMM
TMI

AMSR-E
AMSR2

DMSP
SSM/I,SSMIS

NOAA
AMSU

MWR precip retrieval algorithm

L2 Product from each sensor

Mix

Near Real Time System
At JAXA/EORC

L3 Composite product
0.1 degree
1 hour
6 hour
1 day
1 month

Geo. Satellite
Infrared radiometer
Cloud motion vector

Composite algorithm of IR and MWR
0.1 degree • 30 min
Global Precipitation product

- TRMM TMI
- Aqua AMSR-E
- ADEOS-II AMSR
- DMSP SSM/I

Microwave radiometer algorithm

Product from each sensor

Mix

- L3 Composite product
  - 1 hour
  - 6 hour
  - 1 day
  - 1 month

0.1 degree

Composite algorithm of IR and MWR

0.1 degree · 30min
Current Activities

- **Algorithm Development**
  - New MWI over-land algorithm (Aonashi)
  - Orographic Rainfall (Shige, Session 5)
  - MWS algorithm (Kida, Poster session 2)

- **System Improvement**
  - AMSR2 on GCOMW1 (Kachi, Poster session 1)

- **Data Assimilation** (Aonashi, Poster session 2)

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Orographic Rainfall
(Shige & Taniguchi, 2010)

A large amount of condensates
Low-level orographic lifting
Maritime Air
Ocean
Mountain
Freezing Level

Warm rain with less ice precipitation
Detection of Orographic Rain
(Shige & Taniguchi, 2010)

Topographically induced upward motion

\[ w = \begin{pmatrix} S_x \\ S_y \end{pmatrix} \cdot \begin{pmatrix} u \\ v \end{pmatrix} > 0 \]

Slope from GTOP
Winds from GANAL

Low-level moisture convergence

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

Winds and Water Vapor from GANAL

Horizontal Advection and wind (Surface) [m/s²]

2004/09/29 12UTC
Algorithm Development
- New MWI over-land algorithm (Aonashi)
- Orographic Rainfall (Shige, Session 5)
- MWS algorithm (Kida, Poster session 2)

System Improvement
- AMSR2 on GCOM-W1 (Kachi, Poster session 1)

Data Assimilation (Aonashi, Poster session 2)
Rain area of GSMaP_MWS and PR

The original GSMaP_MWS fails to detect the precipitation area that has 3.4 km of rain top
Revised GSMaP_MWS can detect warm rain.
Current Activities

Algorithm Development
- New MWI over-land algorithm (Aonashi)
- Orographic Rainfall (Shige, Session 5)
- MWS algorithm (Kida, Poster session 2)

System Improvement
- AMSR2 on GCOMW1 (Kachi, MT special session)

Data Assimilation (Aonashi, Poster session 2)
GCOM-W1 “SHIZUKU” was successfully launched on May 18, 2012 (JST).
Current Activities

Algorithm Development
- New MWI over-land algorithm (Aonashi)
- Orographic Rainfall (Shige, Session 5)
- MWS algorithm (Kida, Poster session 2)

System Improvement
- AMSR2 on GCOM-W1 (Kachi, Poster session 1)

Data Assimilation (Aonashi, Poster session 2)
Ensemble-based variational assimilation method to incorporate MWI TB into a cloud-resolving model

Observation for 22UTC 09 Jun. 04
RAM (mm hr⁻¹)  TMI TB19v (K)

First Guess from Ensemble Forecasts (FG)
Qr (g/kg) at 930m;  TB19v from FG (K)

Displacement Error Correction (DE)
Qr (g/kg) at 930m;  TB19v from DE (K)

DE+ Ensemble Variational Assim (EnVA)
Qr (g/kg) at 930m;  TB19v from EnVA (K)
New MWI over-land algorithm

- GSMaP over-land Algorithm & Problems in over-land retrieval
- Introduction of MWI indices
- Dependency of the retrieval bias on the MWI indices
- Statistical correction using MWI indices
Find the optimal precipitation that gives RTM-calculated TBs fitting best with the observed TBs:
Atmospheric variables (Temp, FLH), surface variables (Ts, SSW, SST) are derived from the Global Analysis data of JMA.

Freezing Level Height for Jan. 1, 2003

Temperature bias of GANAL against sonde
Precip type classification

10 types (land 6, sea 4) are classified from TRMM PR data (2.5 deg, 3 monthly)

Precip Profile

Example:
TRMM PR averaged precipitation profiles for each type, surface precip, conv/stra
PR Rainsurf vs conventional GSMaP retrievals for July ‘98

Over Ocean

Over Land

PR Rainsurf (mm/hr) vs Rainspc (mm/hr)
Forward calculation for deep and shallow precip Over Land (ON,20E) Jul. 1st, 1998

Relation between TB depressions and precip is dependent on Dtop. Hence, information on Dtop is required for retrieval.
Basic Idea for Algorithm Improvement

- A priori information error is assumed to be the main cause of the retrieval bias.
- Introduction of MWI indices which the retrieval bias depends on.
- Correction LUT based on the above dependency.
• Sensitivities of TB depressions to precip variables

<table>
<thead>
<tr>
<th>Freq (GHz)</th>
<th>Depth of frozen precip</th>
<th>PSD of frozen particles</th>
<th>Non-spherical Particles</th>
<th>Freezing level height (FLH)</th>
<th>DSD of rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>○</td>
<td>◯</td>
<td>◯</td>
<td>○</td>
<td>×</td>
</tr>
<tr>
<td>37</td>
<td>○</td>
<td>○</td>
<td>×</td>
<td>◯</td>
<td>○</td>
</tr>
</tbody>
</table>

• TB85 depression was very sensitive to frozen precip properties (Dtop, PSD, shapes)
• TB37 depression was sensitive to FLH and Rain DSD in addition to frozen precip properties.
Index of Dtop, R8537

- R8537 expressed as ratio of precipitation retrieved from TB85 (Rain85) to TB37 (Rain37) using the conventional GSMaP algorithm.

- TMI R8537 increases with Dtop estimated from PR.

Retrain.v4.10.20080417 match-up data (Land ‘98)
Index of FLH: PCT37 with no rain

- For each rainy pixel, PCT37 with no rain (PCT37nr) is derived from surrounding no rain pixels.
- GANAL tends to over (under)estimate PCT37nr over cold (hot) regions.
Rain85 vs PR rainsurf depending on R8537 (1998, over Land)

Retrieval bias of Rain85 is mainly due to Dtop error
Rain37 vs PR rainsurf depending on PCT37nr (1998, over Land)

- **PCT37nr > 300 K**
  - Rain37 vs PR Rainsurf
  - Rain37 vs PR Rainsurf

- **PCT37nr 290-300 K**
  - Rain37 vs PR Rainsurf
  - Rain37 vs PR Rainsurf

- **PCT37nr 280-290 K**
  - Rain37 vs PR Rainsurf
  - Rain37 vs PR Rainsurf

- **PCT37nr < 280 K**
  - Rain37 vs PR Rainsurf
  - Rain37 vs PR Rainsurf
Rain37 vs PR rainsurf depending on dPCT37nr

PCT37nr ~ (280-290 K) (1998, over Land)

dPCT37nr

> 5 K

dPCT37nr

0-5 K

-5 – 0 K

dPCT37nr

< -5 K

\[
dPCT37nr = (PCT37nr - CPCT370m)
\]
Rain37 vs PR rainsurf depending on PCT37nr

dPCT37nr = (-3 ~ +3 K)(1998, over Land)

PCT37nr > 300 K

PCT37nr 290-300 K

dPCT37nr = (PCT37nr - CPCT370m)

PCT37nr 280-290 K

PCT37nr < 280 K

Forward calculation error is main cause of Rain37 biases.
New Over-Land Algorithm: Statistical correction of LUTs using (PCT37nr,R8537)

- TRMM data sets for 1998 are classified by (R8537,PCT37nr).
- Linear fitting coefficients between Rain37, Rain85 and PR surface precipitation rates.
Validation Results

Over-land retrieval for 2004
Comparison of over-land retrievals

Rainsurf vs. Rainspc over Land (Jul. ‘04)

**Conventional Algorithm**

![Graph showing comparison of PR Rainsurf vs Rainspc](image1)

**New Algorithm**

![Graph showing comparison of PR Rainsurf vs Rainspc](image2)
Comparison of over-land retrievals
Rainsurf vs. Rainspc over Land (Jul. ‘04)

Conventional Algorithm

New Algorithm

PCT37nr > 300 K

PCT37nr 290-300 K

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Comparison of over-land retrievals
Rainsurf vs. Rainspc over Land (Jul. ‘04)

Conventional Algorithm

New Algorithm

PCT37nr
280-290 K

PCT37nr
< 280 K

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Daily precip (mm/day) of rain37 and their difference from PR rainsurf: over land for Jul. ‘03
Future Directions

- Orographic Rain
- Bias reduction of weak precip over coast and ocean
- Frozen precip over high latitudes
Summary

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- Current Activities

New over-land MWI algorithm
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- Statistical correction using MWI indices
- Over-land retrieval for 2004

Future directions
- Find reason for PCT37_nr dependency
Orographic Rainfall
(Shige & Taniguchi, 2010)

- Maritime Air
- Low-level orographic lifting
- Ocean
- Water
- Ice
- Freezing Level

A large amount of condensates
Warm rain with less ice precipitation

Precipitation Profile

Rainfall Rate [mm/h]

Height from 1 degree C Level [km]
Detection of Orographic Rain
(Shige & Taniguchi, 2010)

Topographically induced upward motion

\[ w = \left( \begin{array}{c} S_x \\ S_y \end{array} \right) \cdot \begin{pmatrix} u \\ v \end{pmatrix} > 0 \]

Slope from GTOP
Winds from GANAL

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Summary

New over-land MWI algorithm
Statistical correction of LUTs using Indices of Dtop(R8537) and SRR(Sigma85)

Validation results (2003)

Future directions
Parameters for RTM calculation

- Particle Size Distribution
- Refractivity of Particles
- Precipitation Profile
- Inhomogeneity of Precipitation

Surface Condition (Surface Temp, Sea-surface Wind)

Freezing Level Height

Mixed Phase Particle

Frozen Particles

Rain

Fig.1 Parameters for RTM calculation
Fast Radiative Transfer Code (Liu, 1998)

\[
\mu \frac{dT_B(\tau, \mu, \varphi)}{d\tau} = T_B - (1 - \omega_0)T(\tau) - \\
\frac{\omega_0}{4\pi} \int \int P(\tau, \mu, \varphi, \mu', \varphi') TB(\tau, \mu', \varphi') d\mu' d\varphi'
\]

where \( \mu = \cos \theta, \tau = \int K_{ab} + K_{sc} dz, \omega_0 = K_{sc} / (K_{ab} + K_{sc}) \),

\( P \) is phase function

- One-dimensional model (Plane-parallel)
- 4 stream approximation
- Mie Scattering (Sphere)
- Assuming constant effective density for frozen precipitation particles
Precip inhomogeneity estimated from variability of Rain85 within the TB10v FOVs (Kubota et al. 2009).

Sigma85 tends to decrease with SRR.