HIGH PRECISION AND HIGH RESOLUTION GLOBAL PRECIPITATION MAP FROM SATELLITE DATA

GSMaP (Global Satellite Mapping of Precipitation)

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Research Goals

Production of high precision and high resolution global precipitation map by using satelliteborne microwave radiometer data
- Microwave radiometer
- TRMM/PR
- GEO’s IR

Evaluation, dissemination, utilization of precipitation map
- Contribution to the IPWG/PEHRPP
- Application to flood prediction and warning
- GPM

Development of reliable microwave radiometer algorithm
- Production of precipitation physical model by using TRMM PR data
- Algorithm consistent with PR

Microwave Radiometer Data
- AMSR-E, AMSR
- SSM/I×3
- TMI/TMI, PR
- AMSU-A, B

Global Precipitation Map

GPM satellites
Four pillars of the research

Production of global precipitation maps

- High temporal resolution map
- Precipitation map database
- Data dissemination

Algorithm development

- Observation data
- Estimation of rain rate
- Look-up table

Precipitation physical model development

- Radiative transfer equation
- Improvement of algorithm

Ground radar observation

- Local precipitation map
- Global precipitation map by TRMM/PR

Database of precipitation structure

Feedback

- Observation by TRMM/PR

Cloud motion vector algorithm

GEO meteorological satellite

IR data

TRMM/TMI
Aqua/AMSR-E
ADEOOS-II/AMSR
DMSP/SSM/I
We use TRMM precipitation radar database and also the ground-based radar database, and produce precipitation physical models.

Using RTM, daily the lookup tables that show the relationship between rainfall rates and TBs are computed in $5.0^\circ \times 5.0^\circ$ lat-lon boxes, with atmospheric variables being given by the JMA Global Analysis (GANAL).

The rain rates giving the nearest TBs to the observed ones are considered to be the most appropriate estimation.

Details will be presented by Dr. Aonashi (Dr. Eito) in this session
We analyze TMI, AMSR-E, AMSR, and SSM/I data using our algorithm, which is called GSMaP algorithm and obtain rain rates from six microwave radiometer, then combine these rain rates to produce a map of spatial resolution of 0.25° ×0.25° and temporal resolution of 6-hours, 1-day, 1-month and so on.
Global Precipitation Map by GSMaP_TMI, JJA, DJF(1998-2005)

[GSMap_TMI V4.7.2] Rain rate (0.25x0.25deg, JJA, 98–05)

[GSMap_TMI V4.7.2] Rain rate (0.25x0.25deg, DJF, 98–05)
Comparison of TRMM rain rates by using TRMM/PR, TMI/GPROF, TMI/GSMaP algorithms (1998-2006)

Ocean

PR 2A25V6
TMI 2A12 V6
GSMaP_TMI V4.8.4

1998-2006 average

PR swath only

PR, GPROF and GSMaP give almost the same results.
Comparison of TRMM rain rates by using TRMM/PR, TMI/GPROF, TMI/GSMaP algorithms (1998-2006)

Land

PR 2A25V6
TMI 2A12 V6
GSMaP_TMI V4.8.4

1998-2006 average

PR swath only

GSMaP and PR give almost the same rain rates and GPROF gives larger rain rates than PR and GSMaP.

GSMaP and PR give almost the same rain rates and GPROF gives larger rain rates than PR and GSMaP.
Integrated 6-hour microwave radiometer precipitation map (GSMaP_MWR)

MWR(TMI+AMSR+AMSR-E+F13, 14, 15 SSM/I)

[GSMaP_MWR V4.7.2] Rain rate: 00Z01JUL2003
Comparison of monthly rain rates by ground-based rain gauge (GPCC) with GSMaP_MWR

Regression line: \[ y = 1.20 \times + 30.8 \text{ (mm/month)} \]
Correlation coefficient: 0.79

- **GPCC Monthly Precipitation (Monitoring) Product** (Rudolf et al. 2005)
  - ground-based rain gauge
  - about 7000 rain gauges in the world
  - monthly average

- Analysis method
  - Tropical Area (20S ~ 20N)
  - There are at least 2 rain gauges in the 1.0 × 1.0
  - 2003-2005

The GSMaP_MWR gives smaller rain rates than GPCC rain gauges.
Composition of GSMaP Products

As the 1-hour map made from only six microwave radiometer data has so many uncompleted areas that we try to fill the blank area by adding the data by IR cloud motion vector estimated from the geostationary meteorological satellites.

1-hour data by TRMM/TMI, Aqua/AMSR-E, ADEOS-II/AMSR, DMSP/SSMI (F13, 14, 15)
Composition of GSMaP Products

TRMM TMI
Aqua AMSR-E
ADEOS-II AMSR
DMSP SSM/I×3

GSMaP Microwave Radiometer Algorithms

Rain rates retrieved by each satellite microwave radiometer

Combination

Combined Product
0.25º grid

6 hours
1 day
1 month

1-hour data by TRMM/TMI, Aqua/AMSR-E, ADEOS-II/AMSR, DMSP/SSM/I (F13, 14, 15)

Geostationary Satellite

IR Cloud Motion Vector

Combined IR/Microwave Radiometer Products
0.1º grid·1 hour
Production of high temporal (1 hr)/high spatial (0.1° × 0.1°) resolution precipitation map (GSMaP)

Algorithm flow to predict the movement of raining areas by applying the cloud motion vector of the past 1 hour estimated from the IR cloud image.
Combined global precipitation map
-MW radiometer + cloud motion vector with Kalman filter-
(0.1°, 1 hour, 8-10 July 2005)

MVK: MWR(TMI+AMSR+AMSR-E+F13, 14, 15 SSM/I) +IR Cloud Motion Vector +Kalman Filter

[GSMap_MVK V4.7.2] Rain rate: 00Z08JUL2005
Combined Typhoon Banyan’s precipitation map
-MW radiometer + cloud motion vector with Kalman filter-
(0.1°, 1 hour, 25 July 2005)
Example of validation of GSMaP_MVK using Radar-AMeDAS (8 July 2005)

GSMaP_MVK estimates for 20050708

<table>
<thead>
<tr>
<th>Daily fraction by occurrence</th>
<th>GSMaP_MVK</th>
<th>Radar-AMeDAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>&lt;1</td>
<td>2502</td>
</tr>
<tr>
<td></td>
<td>&gt;1</td>
<td>235</td>
</tr>
<tr>
<td>Rainfall accumulation by amount</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Verification statistics for 20050708

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Analyzed</th>
<th>GSMaP_MVK</th>
<th>Mean abs error</th>
<th>RMS error</th>
<th>Correlation coeff</th>
<th>Probability of detection</th>
<th>False alarm ratio</th>
<th>Hsuen &amp; Kuppers score</th>
<th>Equitable threat score</th>
</tr>
</thead>
<tbody>
<tr>
<td># gridpoints raining</td>
<td>1092</td>
<td>1016</td>
<td></td>
<td></td>
<td>0.881</td>
<td>0.785</td>
<td>0.156</td>
<td>0.725</td>
<td>0.566</td>
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<tr>
<td>Average rain</td>
<td>6.5</td>
<td>6.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditional rain</td>
<td>21.5</td>
<td>21.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain volume (mm×km²×10⁷)</td>
<td>15.3</td>
<td>14.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Maximum rain</td>
<td>232.5</td>
<td>214.1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Evaluation of various high resolution precipitation map using Radar-AMeDAS rain map

GSMaP_MVK and CMORPH show high correlation with Radar-AMeDAS throughout the period. If we add NOAA AMSU data to GSMaP_MVK, the combined GSMaP_MVK+ shows remarkably high correlation coefficient.

Daily variation of correlation coefficient (0.25° x 0.25°) July, 2005

Correlation

Date

GSMaP_MVK
GSMaP_MVK+
CMORPH
3B42RT

CMORPH: NOAA/CPC
3B42RT: NASA/GSFC

July, 2005
Dissemination of research products

**Dissemination of GSMaP data**
- DVD-R
- Data release via the Internet

**Application to the flood prediction and warning**

**Participation in the international project**
IPWG (International Precipitation Working Group) / PEHRPP (Pilot Evaluation of High Resolution Precipitation Product)

**GSMaP Precipitation data**
JAXA/EORC has started to release global rainfall data in near real time (about four hours after observations) on the Internet using GSMaP algorithms.

GSMaP NRT System in JAXA/EORC

Global Rainfall Map in Near Real Time by JAXA/EORC
http://sharaku.eorc.jaxa.jp/GSMaP/
Summary

Academic contributions
- Microwave radiometer rain retrieval algorithm
- Combined microwave and IR radiometer algorithm
- Production and validation of the global precipitation maps

International contributions
- GPM project
- Participation in the PEHRPP/IPWG

Social contributions
- Construction of System for Near-Real-Time Global Rainfall Maps by GSMaP algorithms (JAXA)
- Contribution to the joint research by Public Works Research Institute and JAXA to use satellite rain data for the flood prediction and warning system especially in Asian countries.
BACKUP SLIDES
Combined precipitation map around Japan - MW radiometer + cloud motion vector with Kalman filter - (0.1 ° , 1 hour, 9-10 July 2005)
Developments of Precipitation Physical Model

Improvement of scattering algorithm

Mixed ice and water

Snow Particle Model

Freezing Level

Liquid water

Rain drop size distribution (DSD) model

Precipitation profile model

Classification of Rain Types

Melting Layer

Melting layer model

Classification of Rain Types

Melting Layer

Precipitation profile model
Production of high temporal (1 hr)/high spatial (0.1° × 0.1°) resolution precipitation map (GSMaP)

Algorithm flow to predict the movement of raining areas by applying the cloud motion vector of the past 1 hour estimated from the IR cloud image.