Gage Adjusted Global Satellite Mapping of Precipitation (GSMaP Gauge)

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Introduction

Fresh water is one of the most important resource. Precipitation is main source of fresh water. Latent heat is one of the most important source of global energy transfer. Accurate global precipitation map is important information for science and human activity. However, ground observation area is not uniform. Space-borne Passive Microwave Radiometers(PMRs) observation is globally uniform. PMR observe emission signals from liquid hydrometeors and scattering signals from ice particles. Precipitation retrieval algorithms for PMRs is based on emission and scattering signals.
Land is radiometrically hot and variable temperature surface. PMR algorithm is depend on scattering signals over land. Therefore, PMR precipitation over land is underestimation. However land precipitation is the most important for practical uses of precipitation map.

Aim of the study

The aim is to improve reliability of land rain retrieved by PMR to that of ground-base observation. We are developing an adjustment algorithm using rain-gauge for "Global Satellite Mapping of Precipitation with moving vector with Kalman filter" (GSMaP MVK) . The algorithm is named “GSMaP Gauge”.

Fitting Models

$$\begin{cases} \boldsymbol{x}_{n+1} &= \boldsymbol{x}_n + \mathcal{N}(\mu_w, \sigma_w^2) \\ \boldsymbol{y}_n &= c\boldsymbol{x}_n + \mathcal{N}(\mu_v, \sigma_v^2) \end{cases} \quad (1)$$

cost function

$$J(\boldsymbol{x}) = J_1(\boldsymbol{x}) + \lambda J_2(\boldsymbol{x}, W) \quad (2)$$

$$J_1(\boldsymbol{x}) = -\ln \Pr(\boldsymbol{x}, \boldsymbol{y})$$

$$J_2(x) = \frac{1}{2}\left(\sum_{n=1}^{24} \boldsymbol{x}_n - W\right)^2$$

$\boldsymbol{y}_n$	:	Estimated precipitation rate (GSMaP MVK)
$\boldsymbol{x}_n$	:	Precipitation Rate
c	:	Coefficient of proportionality of the estimation of precipitation
$\mathcal{N}$	:	Standerd distribution
μ_v	:	Variance of estimation errorb
μ_w	:	Change rate of precipitation
σ_v	:	Estimation error
σ_w	:	Variance of precipitaton
W	:	Daily precipitation
n	:	hour
$\boldsymbol{x}, \boldsymbol{y})$	:	Probability of $\boldsymbol{x}$ and $\boldsymbol{y}$ (Gaussian distribution)
λ	:	weight

(1) Precipitation and observation model
- Difference of hourly precipitation rate have normal distribution
- Estimated precipitation is linear relation to true precipitation and noise

(2)fitting Rain gauge
to minimize the cost function *J*(x) .

$$\begin{pmatrix} \frac{\partial J}{\partial x_1} \\ \vdots \\ \frac{\partial J}{\partial x_n} \\ \vdots \\ \frac{\partial J}{\partial x_{24}} \end{pmatrix} = \mathbf{0}$$

Daily rainfall rate is the NOAA CPC Unified Gauge-Based Analysis of Global Daily Precipitation (CPC).
CPC is a daily and 0.5 grid, real time operation and global precipitation map.

Results

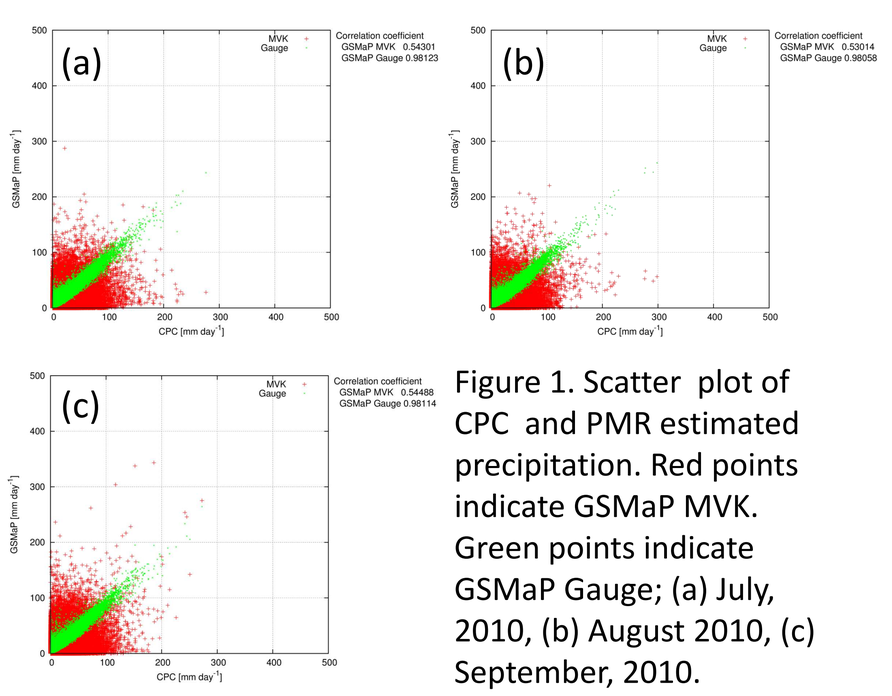

Figure 1. Scatter plot of CPC and PMR estimated precipitation. Red points indicate GSMaP MVK. Green points indicate GSMaP Gauge; (a) July, 2010, (b) August 2010, (c) September, 2010.

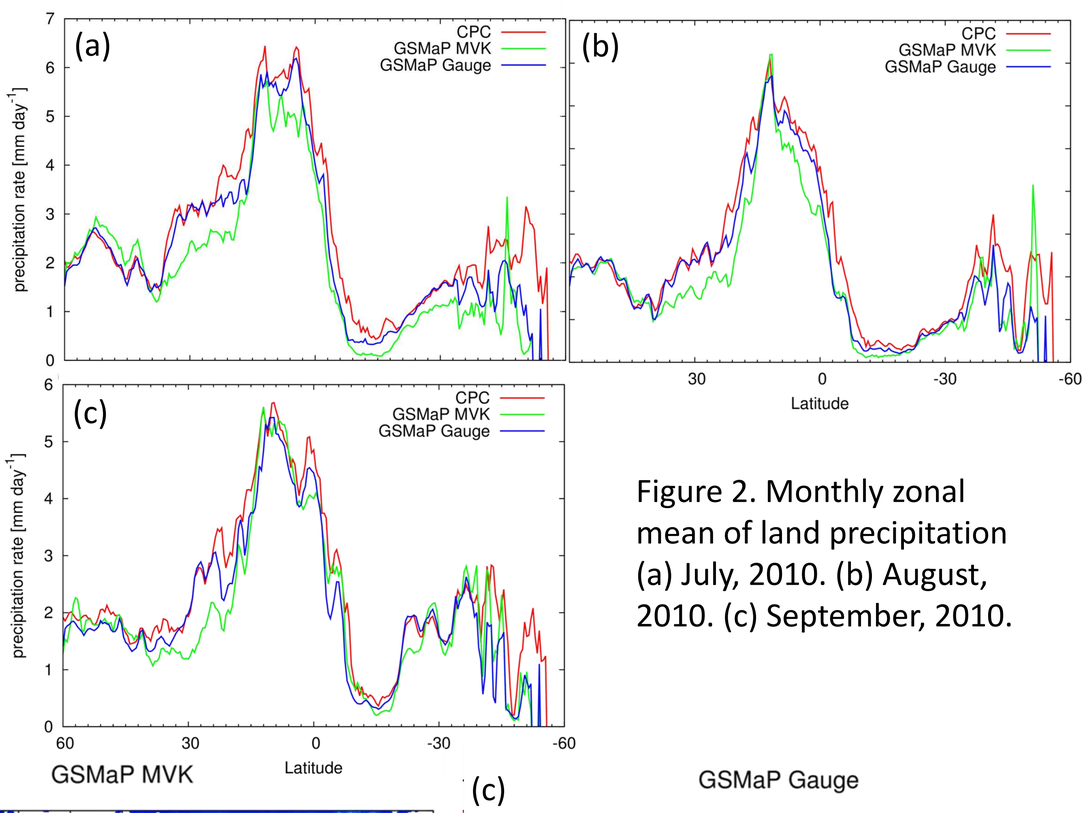

Figure 2. Monthly zonal mean of land precipitation (a) July, 2010. (b) August, 2010. (c) September, 2010.

Figure 1 shows relation between CPC and PMR of GSMaP Gauge is very sharp and linear.
The GSMaP Gauge algorithm improve correlation from 0.53-0.54 to 0.98.
Figure 2 shows that GSMaP Gauge improves underestimation of GSMaP MVK precipitation from 40N to 15N and from 20S to 40S.

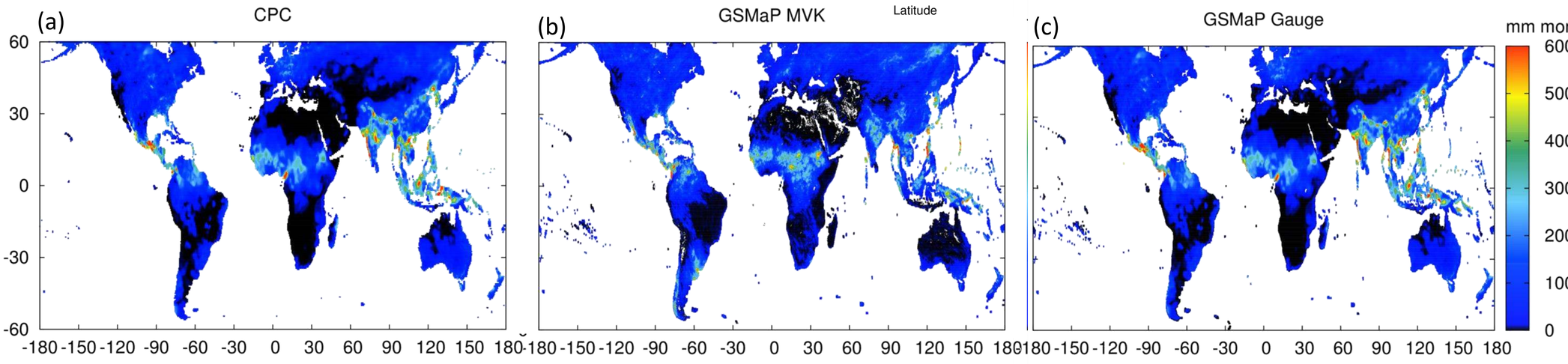

Figure 3. Monthly precipitation maps for august, 2010; (a) CPC, (b) GSMaP MVK, (c) GSMaP Gauge

<u>GSMaP MVK</u>
Precipitation patterns are different; such as India, Central Africa and Australia.
Overestimation in Siberia and South America.
<u>GSMaP Gauge</u>
Estimated precipitation pattern is more similar to CPC.
The algorithm remove overestimation in Siberia and South America.

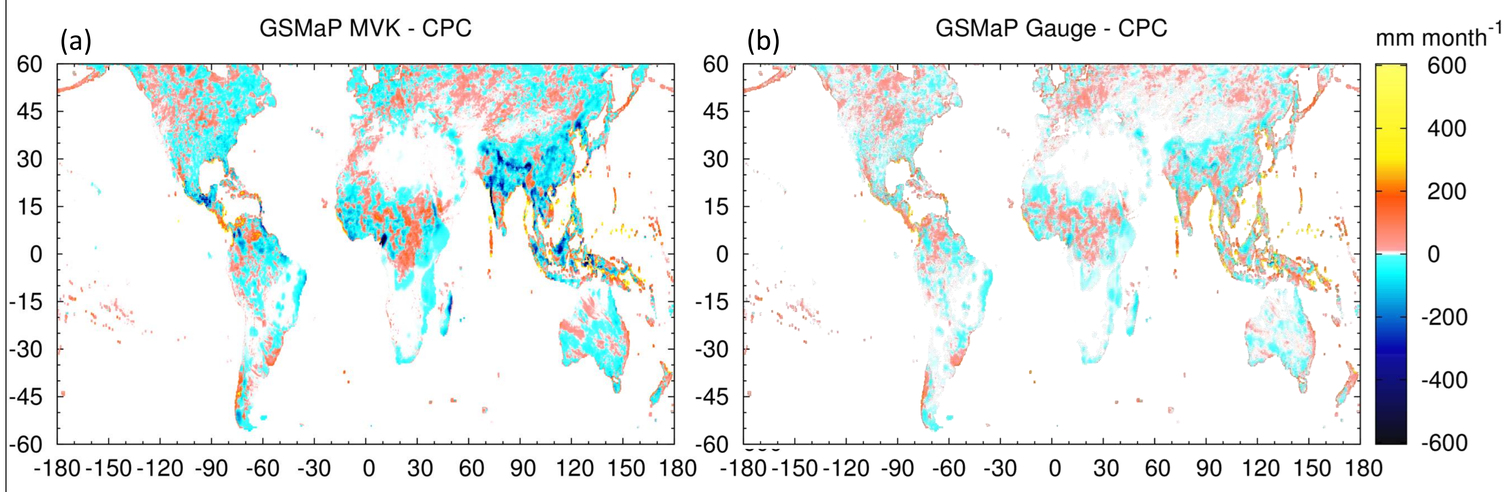

Figure 4. Difference monthly precipitation from CPC for August 2010.(a) GSMaP MVK (b) GSMaP Gauge.

Summary

- New Gauge adjustment algorithm for global precipitation map has been developed.
- We adapt the new algorithm for GSMaP MVK. (GSMaP Gauge)
- The GSMaP Gauge improves correlation coefficient between GSMaP and CPC from 0.53-0.54 to 0.98.
- Under estimation of precipitation over land GSMaP MVK precipitation is improved
- Monthly rainfall of GSMaP Gauge is similar pattern to CPC.
- The GSMaP Gauge improve PMR-based precipitation map equivalent to CPC.