Validation of GSMaP Using a One-Minute Precipitation Rate Product Combining Ground-based Radar and Rain Gauge Data over Japan

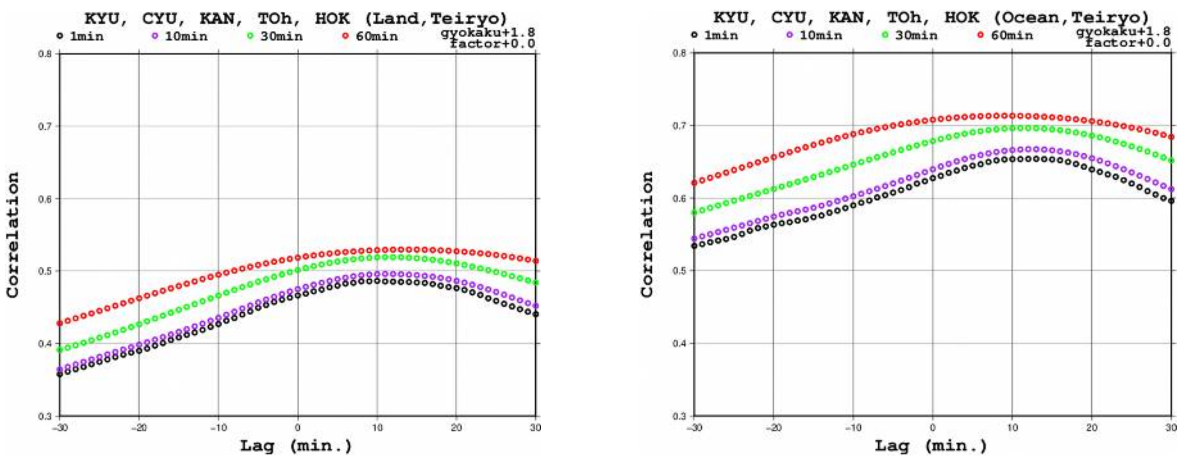
Shinta SETO[1], Nobuyuki UTSUMI[2]
(1:Nagasaki University, 2:Institute of Science Tokyo)

In the production of GSMaP, the precipitation rate estimated by microwave radiometers was designated as the estimated value for a one-hour period encompassing the observation time. Additionally, in the evaluation of GSMaP, one-hour precipitation data are frequently utilized. Consequently, in both the production and validation of GSMaP, it is challenging to assert that the time scale and time lag of precipitation rate estimates from microwave radiometers are adequately considered. In this study, with a focus on Japan, we developed a one-minute precipitation rate product (1MPR) by integrating ground-based radar XRAIN from the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) with rain gauges from both the Japan Meteorological Agency and MLIT, and employed it to validate GSMaP. The production of 1MPR is outlined as follows: at locations equipped with rain gauges, the tipping times of the tipping-bucket rain gauges are estimated, and the precipitation rate of XRAIN is adjusted using the following formula to ensure that the accumulated rainfall from XRAIN aligns with the observed rainfall amount from the rain gauges during that interval: (corrected precipitation rate) = s × (pre-correction precipitation rate) + c. When the corrected precipitation rate exceeds the pre-correction precipitation rate, $s = 1$, and $c > 0$. Conversely, when the corrected precipitation rate is less than the pre-correction precipitation rate, $s < 1$, and $c = 0$. Subsequently, the values of s and c were time-smoothed and spatially interpolated. The following formula was employed for spatial interpolation:

$$s = \left[W s_0 + \sum_{i=1}^{N} \frac{D^2 s_i}{d_i^2} \right] \Big/ \left[W + \sum_{i=1}^{N} \frac{D^2}{d_i^2} \right] \qquad c = \left[W c_0 + \sum_{i=1}^{N} \frac{D^2 c_i}{d_i^2} \right] \Big/ \left[W + \sum_{i=1}^{N} \frac{D^2}{d_i^2} \right]$$

where N and i denote the number and index of the rain gauges employed for interpolation, respectively. The variable d_i represents the distance from rain gauge i in kilometers, and D is set to 111.111 km. The weighting factor W signifies the reliability of the XRAIN and is determined based on the proximity to the nearest radar site. The parameters $s_0 = 1.0$ and $c_0 = 0.0$ were constants. The influence of the altitude difference between the XRAIN observation and the ground surface was adjusted as follows: the observation altitude of XRAIN was calculated under the assumption of an elevation angle of 1.8 degrees from the distance to the nearest radar. This difference was divided by the raindrop falling speed (250 m/min) to derive the time lag. This time lag was subsequently added to the XRAIN observation time to align it with 1MPR time. Furthermore, locations within 60 km of an X-band radar or within 120 km of a C-band radar were considered to fall within the quantitative observation range and were included in the subsequent validation process.

The GSMaP standard product (V8) for June 2022 was validated. Focusing on the timestamps, only estimates derived from microwave radiometers were extracted. Using the timestamp, the mean precipitation rate from 1MPR was calculated and evaluated by varying the time scale (1 min, 10 min, 30 min, and 60 min) and time lag (ranging from -30 min to +30 minutes in 1-minute increments). For instance, when the timestamp shows *X* minutes, with a time scale of *T* minutes and a time lag of Δt minutes, the average is computed over the period from X-[T/2]+Δt to X+([T/2]-1)+Δt ([T/2] denotes the largest integer not exceeding T/2). Figure 1 illustrates the correlation coefficients between the GSMaP and 1MPR. The correlation coefficient peaked at a lag of approximately +10 min. Additionally, the correlation coefficient tended to increase with longer time scales. This observation reflects the dependence of microwave radiometer observations on precipitation at altitudes higher than the ground surface. No significant differences were observed between the land and ocean in terms of time lag or time scale. Furthermore, the correlation coefficients were higher over the ocean than over land, indicating the superiority of the emission algorithm compared to the scattering algorithm.



(a) over land (b) over ocean

Figure 1 Correlation coefficients between GSMaP and 1MPR for different time lags and time scales.