Users' Guide to

Imagery with Heavy Rainfall Potential Areas

July 2015 (Ver. 4)

Japan Meteorological Agency

Document control

Date	Issue	Status and changes	
March 2011	Ver. 1A	Original Issue	
March 2012	Ver. 2	Title	
		1. Introduction	
		3. Product specifications	(1) Coverage (3) Data format
		5. Comparison with rainfall	
August 2014	Ver. 3	3. Product specifications	(1) Coverage (4) Color assignment (Fig. 3)
July 2015	Ver. 4	Change of satellite data source from MTSAT to Himawari-8	
		Addition of comparison between MTSAT and Himawari-8 data	

Specification changes

Date	Changes
April 2011	Image data format
March 2012	Threshold values for South Pacific Islands
	Coverage for Southeast Asia
August 2014	Coverage for Southeast Asia
July 2015	Switch of satellite data source from MTSAT to Himawari-8

1. Introduction

This users' guide gives a summary of Imagery with Heavy Rainfall Potential Areas – a product derived from Himawari-series satellites (MTSAT and Himawari-8) for the WMO CBS Severe Weather Forecasting Demonstration Project (SWFDP). Chapter 2 outlines the product itself, Chapter 3 describes its specifications, Chapter 4 briefly summarizes the basic algorithm used, Chapters 5 and 6 report on the results of related comparison, and Chapter 7 highlights a number of points to note regarding the product.

2. Outline

Imagery with Heavy Rainfall Potential Areas is a satellite product in imagery form providing information about the possibility of rainfall associated with deep convective clouds. Areas where rainfall is possible or probable (referred to as "rainfall potential areas") are identified by detecting convective clouds that have tops with a low brightness temperature because the tops of such clouds causing heavy rainfall reach higher altitudes or even the tropopause.

This product helps to clarify the possibility of rainfall, but does not provide actual measurements of rainfall or estimations of precipitable water amounts because the imagers on board the Himawari-series satellites used capture infrared radiance from cloud tops but extract few signals relating to internal cloud structures.

3. Product specifications

(1) Coverage

The product covers two areas, one stretching from 30°N to 15°S and from 90°E to 165°E for SWFDP in Southeast Asia (Fig. 1). The other extends from 10°N to 35°S and from 140°E to 145°W for the Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project (SWFDDP) – a regional subproject of SWFDP in the South Pacific Islands (Fig. 2).

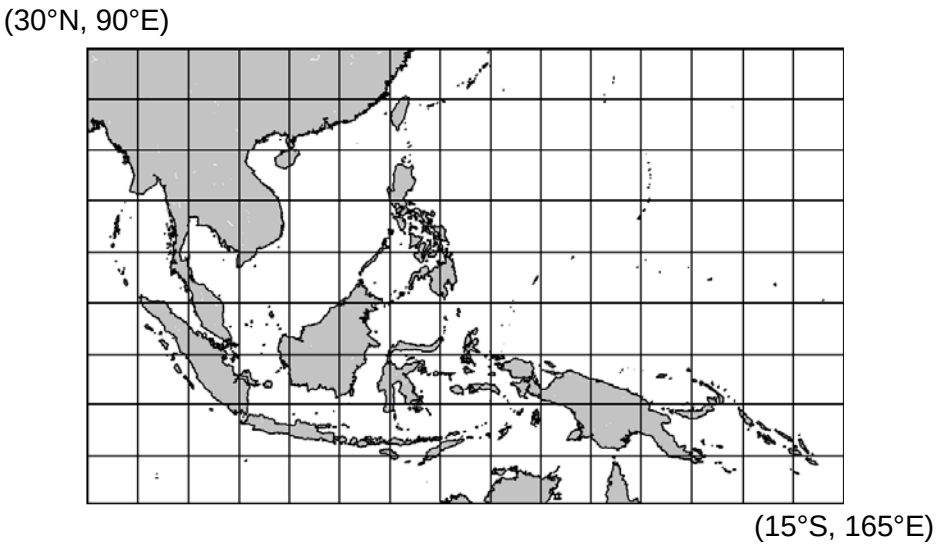
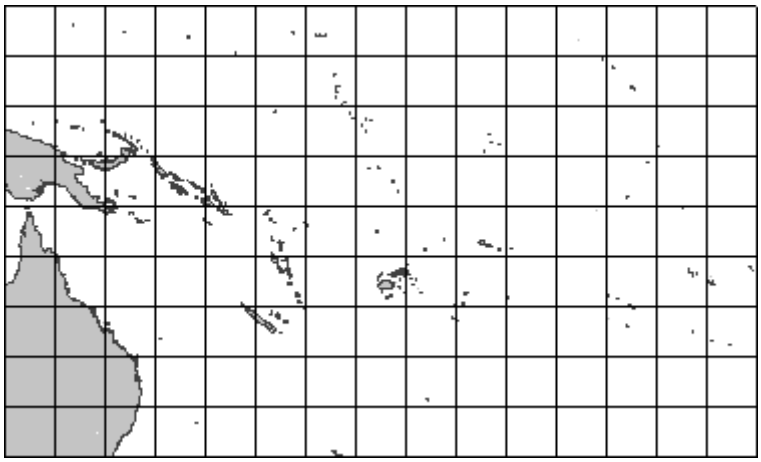


Figure 1 Product coverage for Southeast Asia

(10°N, 140°E)



(35°S, 145°W)

Figure 2　Product coverage for the South Pacific Islands

(2) Spatial resolution

The spatial resolution of each pixel is 0.05° in both latitude and longitude.

(3) Data format

Image data comply with the specifications of the Joint Photographic Experts Group (JPEG) format.

(4) Color assignment

Rainfall potential areas are colored, as shown in Figs. 3 and 4. Cloud imagery is based on satellite observations on the long-wave infrared band (10.4 μm), and grayscale shading is used to show brightness temperature. Lighter colors represent lower temperatures, and darker colors show higher temperatures. Convective clouds that may produce rainfall are shown in magenta.

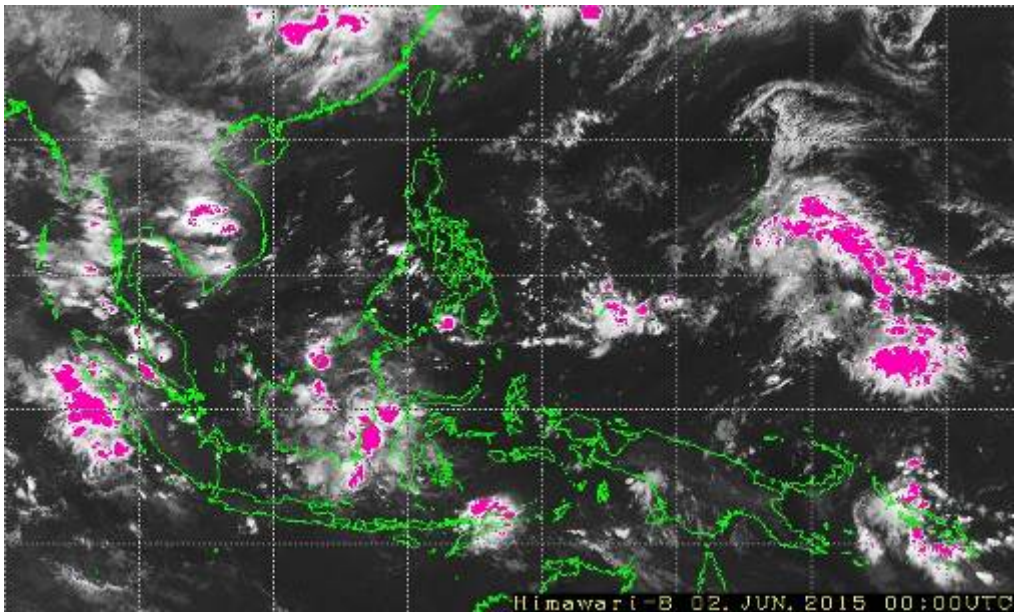


Figure 3 Product sample for Southeast Asia

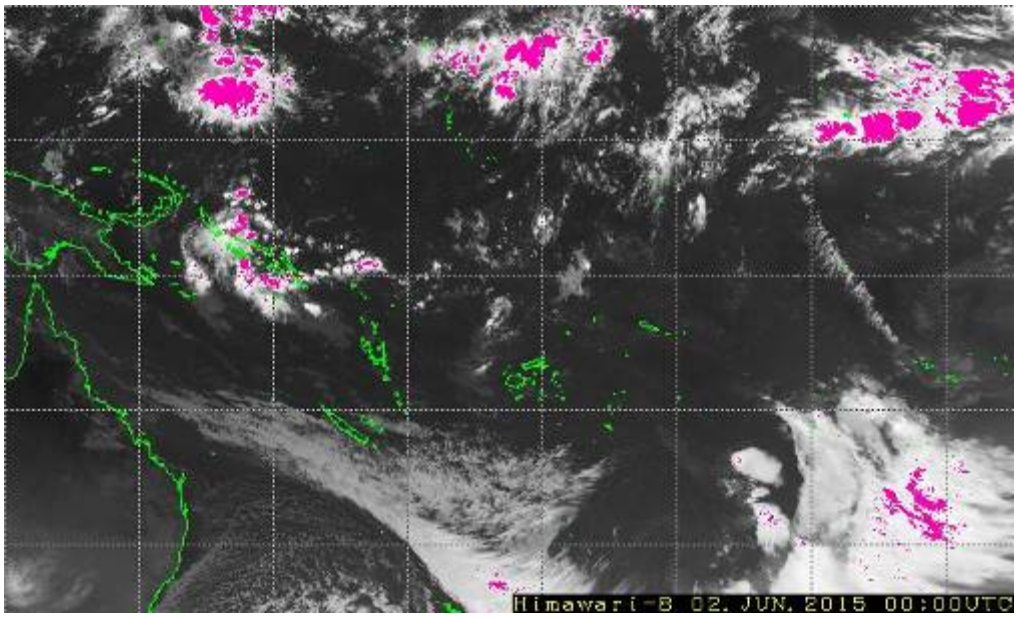


Figure 4 Product sample for the South Pacific Islands

4. Basic algorithm

The brightness temperatures of the three Himawari-8 infrared bands (6.2 μm ($T_{6.2}$), 10.4 μm ($T_{10.4}$) and 12.4 μm ($T_{12.4}$)) are used for detection of deep convective clouds. The concepts below are adopted to detect convective clouds with high tops.

- $T_{6.2}$ is lower than $T_{10.4}$ and $T_{12.4}$ when clouds are in the development stage and their tops do not reach the tropopause.
- $T_{6.2}$, $T_{10.4}$ and $T_{12.4}$ are almost identical when convective cloud tops reach the tropopause.
- $T_{6.2}$ may be higher than $T_{10.4}$ when cloud tops overshoot into the stratosphere.
- The temperature difference between $T_{10.4}$ and $T_{12.4}$ increases when thin cirrus clouds are observed.

Threshold values for the detection of deep convective clouds are adjusted to place priority on the improvement of detection probability.

5. Comparison with rainfall

The probability of detection (POD) and the success ratio (SR), which are often used in forecast verification, are calculated to evaluate the product. Rainfall potential areas based on data from the MTSAT imager are compared on a pixel-by-pixel basis to rainfall retrieval data from microwave imagers on board the polar orbiting satellites in the Global Satellite Mapping of Precipitation (GSMaP*) (hereafter simply referred to as “rainfall”). A rain rate of 20 mm/h is adopted as the criterion for heavy rainfall. The results of comparison from January through October 2011 are shown in Table 1.

Table 1 Results of comparison for rainfall of 20 mm/h or more

	Area	
	Southeast Asia	South Pacific Islands
POD	0.812	0.805
SR	0.012	0.012

POD = H / (H + M), known as the hit rate (HR), shows the ratio of correctly identified rainfall.
SR = H / (H + F) gives the ratio of the rainfall potential area where rainfall is actually observed.

Situations are categorized in three ways based on cloud detection and rainfall presence:

- "H" denotes hits (i.e., rainfall is observed in the rainfall potential area).
- "M" denotes missed detections (i.e., rainfall is observed outside the rainfall potential area).
- "F" denotes false alarms (i.e., rainfall is not observed in the rainfall potential area).

		Rainfall (≥ 20 mm/h)	
		Yes	No
Potential areas	Yes	H	F
	No	M	

** The GSMaP Project is sponsored by JST-CREST and promoted by the JAXA Precipitation Measuring Mission (PMM) Science Team. GSMaP products are distributed by the Earth Observation Research Center of the Japan Aerospace Exploration Agency.*

Rainfall potential areas and visualized images of GSMaP rainfall retrieval data are shown in Figs. 5 and 6.

Figure 5 indicates a close relationship between rainfall potential areas and heavy rainfall areas. The potential areas across Thailand, Lao PDR and Vietnam (left) show good correspondence to heavy rainfall areas with a rain rate equal to or more than 20 mm/h (right). As shown by the POD score, the potential areas match around 81% of the actual heavy rainfall areas.

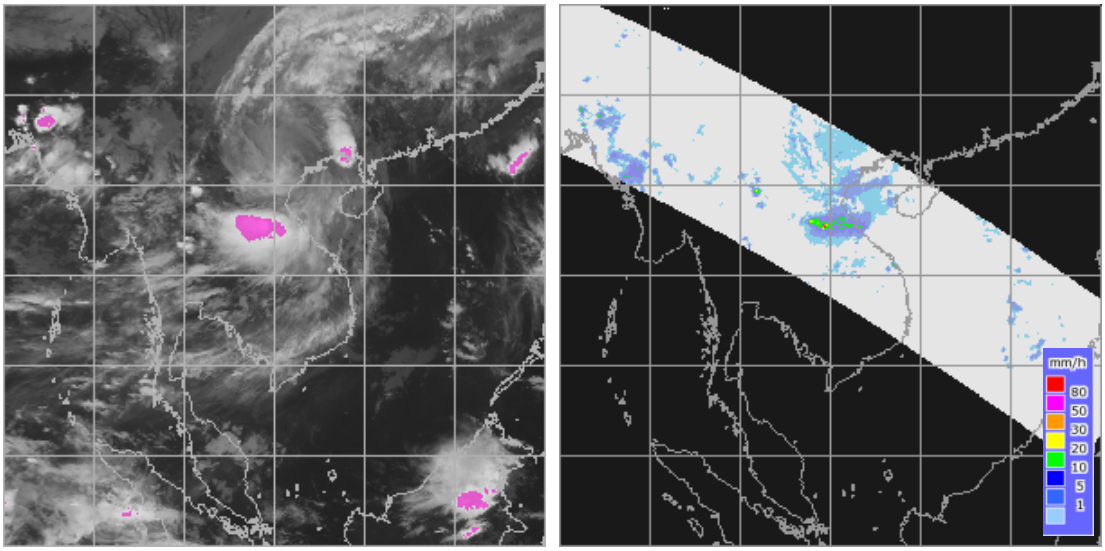


Figure 5 Comparison of rainfall potential areas and GSMaP rainfall areas (1632 UTC, 30 September, 2011)

Figure 6 shows overestimation of heavy rainfall areas. Rainfall potential areas over Myanmar, Thailand, Lao PDR and Vietnam correspond to actual rainfall areas, although most of these have a rain rate of less than 20 mm/h. As shown by the success ratio (SR) in Table 1, around 1.2% of potential areas experienced heavy rainfall equal to or more than 20 mm/h, meaning that almost 99% of such areas experienced rainfall of less than 20 mm/h or no rain.

For reference, the SR for rainfall with a rain rate of more than 0.1 mm/h is around 80%.

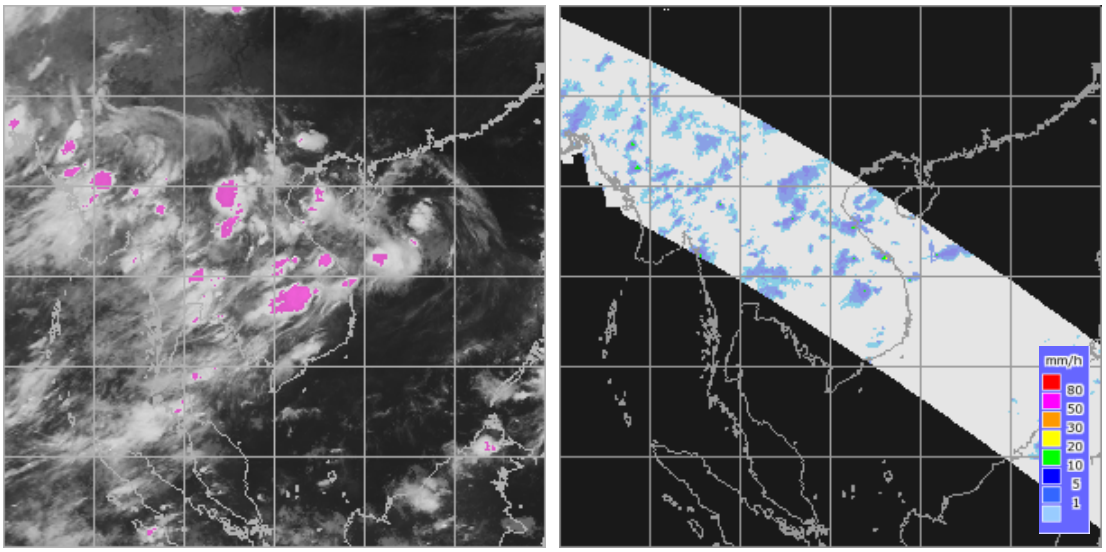


Figure 6 Comparison of rainfall potential areas and GSMaP rainfall areas (1532 UTC, 16 August, 2011)

6. Comparison between MTSAT and Himawari-8

Comparison of rainfall potential areas based on Himawari-8 data and MTSAT data shows very close correspondence (Figs. 7 and 8) because the bands used are similar for both satellites (see Table 2).

Figure 7 shows rainfall potential areas for Southeast Asia derived from MTSAT data (left) and Himawari data (right) every six hours, and Figure 8 shows the same for the South Pacific Islands. Distribution in these areas is similar for all times.

Table 2 Observation wavelengths [μm] used for detection of deep convective clouds

MTSAT	Himawari-8
6.7	6.2 (band 8)
10.8	10.4 (band 13)
12.0	12.4 (band 15)

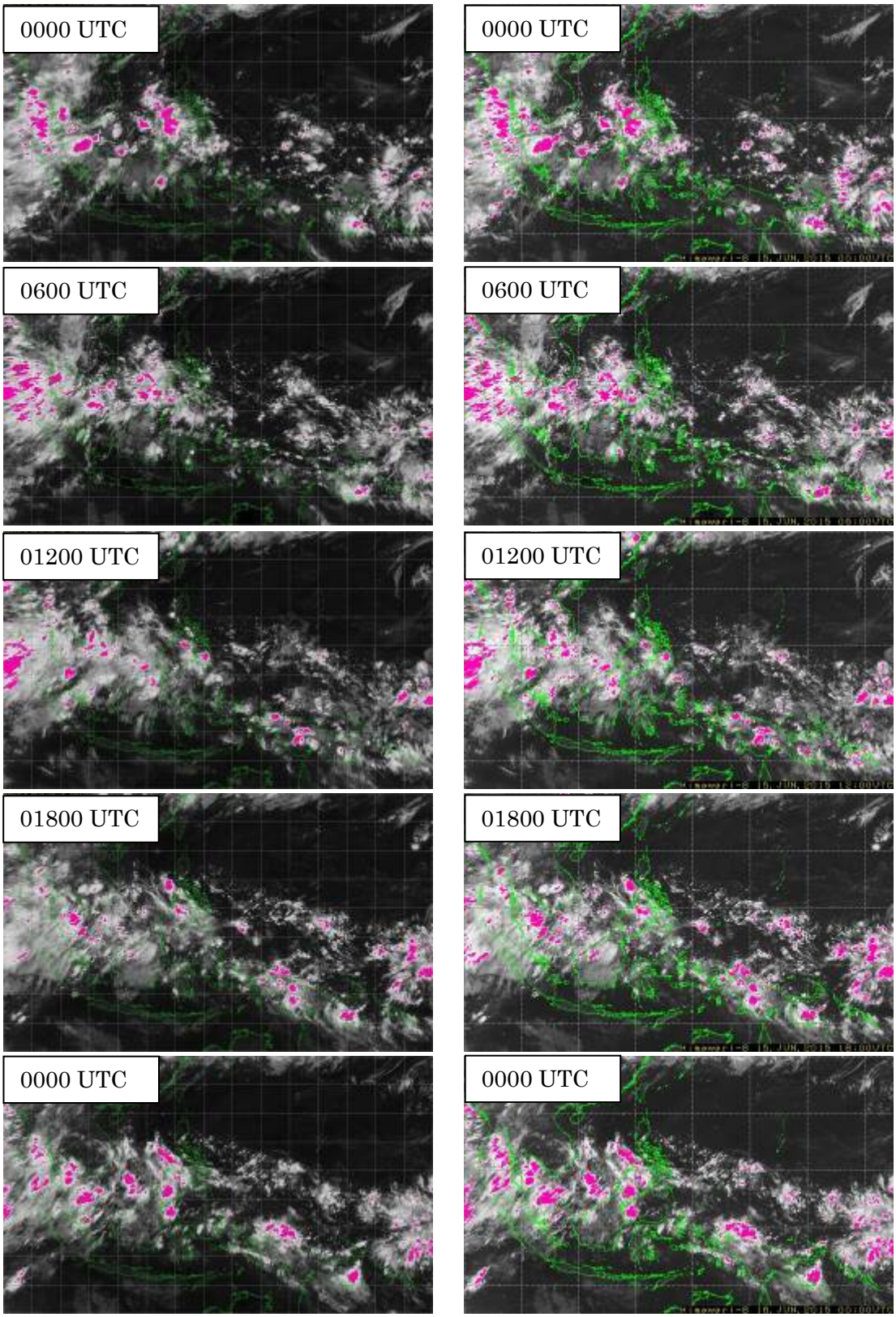


Figure 7　Left: imagery derived using MTSAT data from 0000 UTC on 15 June 2015 to 0000 UTC on 16 June 2015 every six hours. Right: imagery derived from Himawari-8 data.

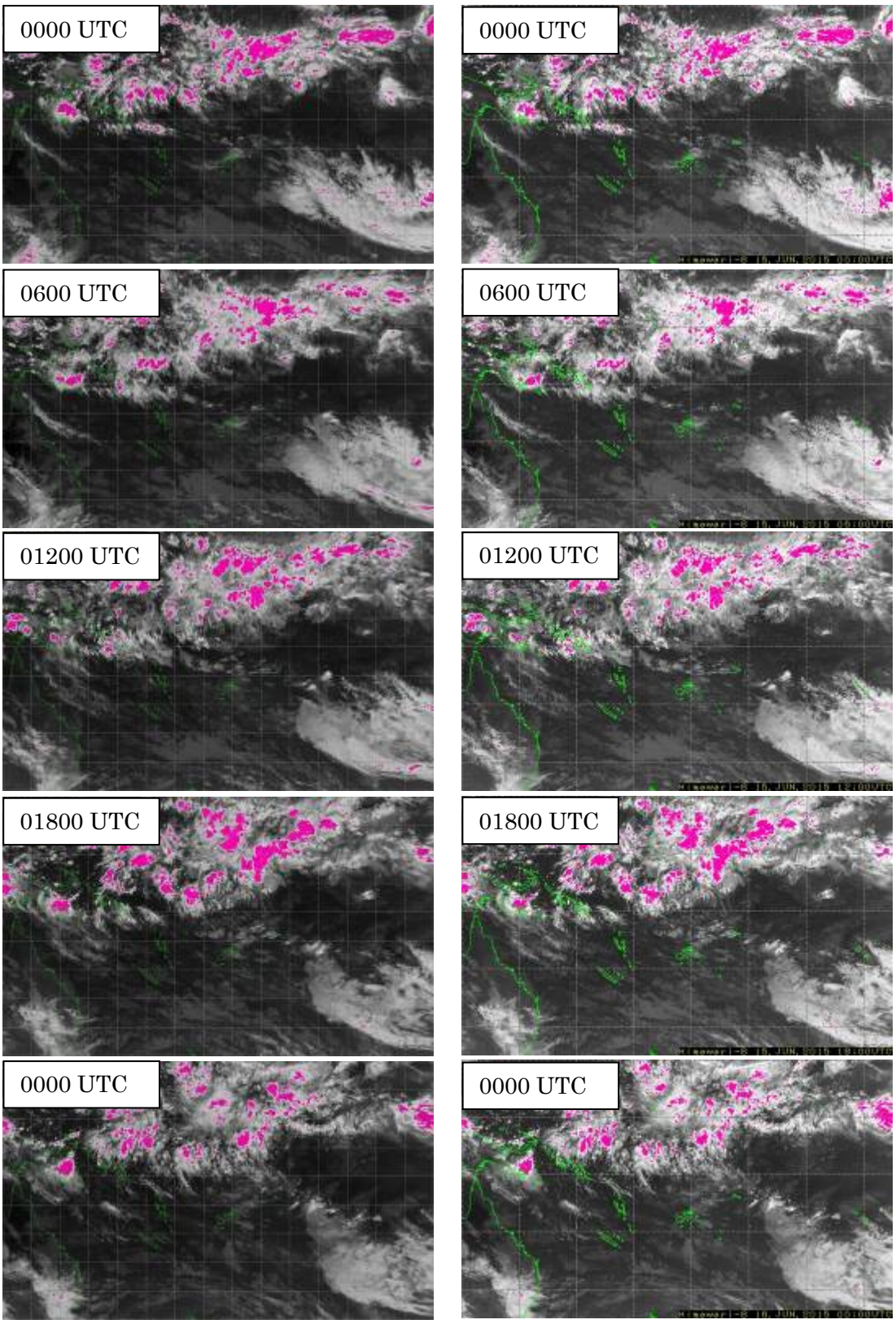


Figure 8 Left: imagery derived using MTSAT data from 0000 UTC on 15 June 2015 to 0000 UTC on 16 June 2015 every six hours. Right: imagery derived from Himawari-8 data.

7. Points to note

- Rainfall potential areas indicated by this product do not always correspond to areas of actual rainfall.
- Dense cirrus clouds may be misclassified as deep convective clouds.
- Clouds smaller than the spatial resolution of satellite observation may remain undetected.
- The specifications of this product are subject to change without notice.
- The product is derived using Himawari-8 data from July 2015.