

Application of rain scanner SANTANU and transportable weather radar in analyze of Mesoscale Convective System (MCS) events over Bandung, West Java

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Abstract. Simultaneous observation of transportable weather radar LAPAN-GMR25SP and rain-scanner SANTANU were conducted in Bandung and vicinity. The objective is to observe and analyse the weather condition in this area during rainy and transition season from March until April 2017. From the observation result reported some heavy rainfall with hail and strong winds occurred on March 17th and April 19th 2017. This events were lasted within 1 to 2 hours damaged some properties and trees in Bandung. Mesoscale convective system (MCS) are assumed to be the cause of this heavy rainfall. From two radar data analysis showed a more local convective activity in around 11.00 until 13.00 LT. This local convective activity are showed from the SANTANU observation supported by the VSECT and CMAX of the Transportable radar data that signify the convective activity within those area. MCS activity were observed one hour after that. This event are confirm by the classification of convective-stratiform echoes from radar data and also from the high convective index from Tb Himawari 8 satellite data. The different MCS activity from this two case study is that April 19 have much more MCS activity than in March 17, 2017.

1. Introduction

Mesoscale convective system (MCS) are defined as an organized convective components that have a longer duration than the individual convective elements and also have the largest area than the convective storms [1]. In the tropics, MCS play different part in the mass transport and heating process [2-3], where made an impact on the global general circulation [4-5].

MCS in a meteorological radar point of view is a precipitation that consist of two type of precipitation (convective and stratiform precipitation) [6], with a minimum of 30% are associated with convective rainfall [7]. Characteristic between convective and stratiform precipitation based on meteorological radar detection showed different pattern of gradient reflectivity, where convective precipitation have a sharp peaks gradient of reflectivity resemble its core while stratiform precipitation have a weak gradient reflectivity [8]. Spatial distribution of the reflectivity pixel from meteorological radar data were also used to distinguish between convective, stratiform and also mixed precipitation [9].

Simultaneous observation of two x band radar system, transportable weather radar LAPAN-GMR25SP and rain-scanner SANTANU, were conducted during rainy season and transition season from March until April 2017. The observation area were focused in the Bandung Basin in West Java Indonesia. During this period, there are reported of some heavy rainfall with hail and strong winds occurred at Bandung and vicinity on March 17th and April 19th 2017. The heavy rainfall are lasted



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within 1 to 2 hours damaged some properties and trees in Bandung. These two type of x band radar system are complement to each other. The transportable weather radar is a doppler x band radar that could generate doppler velocity and spectrum width beside reflectivity that could not generated in SANTANU. But since this doppler radar needs to conduct a volume scan, its temporal resolution are less than SANTANU.

This paper are discussed about the application of this two type of X-band radar during the heavy rainfall in two case study. Different with other observation [10], in this paper two type of X-band radar data are used to investigate not only the spatial distribution but also the vertical structure of the precipitation [11] and also to analyze if there is any connection between the heavy rainfall with the MCS activity. The MCS indicator are based from the radar data and Tbb Himawari satellite data.

2. Data and method

Transportable weather radar is a cost effective x band radar manufactured by GAMIC mbH with the type of GMWR-25-SP. This radar is a single polarization doppler weather radar mounted on a vehicle for conducting weather observation in different location site [12]. This radar were operated by LAPAN for research activities mainly on atmospheric research. A volume scan strategy using 20 elevation scan of altitude were applied. The volume data can reach from ground surface until up to 15 km of detection, with spatial and temporal resolution of 250 x 250 meter in every 10 minutes. Three main product from this radar were reflectivity, doppler velocity, and spectrum width, with other derivative product such as CAPPI, CMAX, VSECT, etc [13]. CAPPI (Constant Altitude Plan Position Indicator) represent the radar data in horizontal cross section at selected height above sea mean level. CMAX (column maximum) represent the vertical column maximum value. VSECT (Vertical Section) represent the vertical cross section through the volume radar data between two coordinate (start and stop coordinate).

SANTANU is a x band rain scanner based on marine radar development. This radar have a wide vertical beam that could scan a very large volume of precipitation. A clutter map were applied to extract the ground clutter in order to achieve the precipitation data [14]. Spatial and temporal resolution are 240x240 meter in every 2 minutes. High temporal resolution can be utilized to analyse the precipitation movement and also the rate of growth/decay area of precipitation [15].

Three X band radar are used in this research. Two rain scanner radar type and one transportable Doppler radar type are used to scan around Bandung area. Figure 1 is the scheme of the location of the X-band radar, with coloured circle represent the coverage area. A and B are the two X band rain scanner SANTANU. Each of the SANTANU radar are complementing each other due to limited coverage area and also very sensitive to attenuation. Meanwhile C is the X band Transportable Doppler radar.

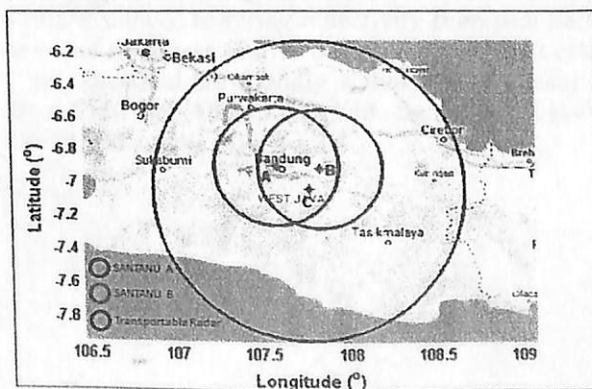


Figure 1. Coverage area of SANTANU A, B, and Transportable Weather Radar.

Observation period were conducted from March 2017 until End of April 2017. During the period of March 17 and April 19 2017 there are a heavy storm that suspected from the generation of an MCS

phenomena. In order to prove this, several data were used such as VSECT and CMAX of reflectivity and doppler velocity from transportable radar to analyse the convective process within those heavy storm. In order to distinguish between convective and stratiform precipitation, Steiner method were applied to the CAPPI 3 km data. Meanwhile PPI of reflectivity from SANTANU were used to confirm the location of the heavy storm followed with heavy precipitation.

Steiner method are able to distinguish between convective and stratiform precipitation from the reflectivity radar data. This method are based from the intensity of the reflectivity and also the sharpest maxima from the spatial pattern of the radar reflectivity [16]. Steiner method in this paper are only applied to the Transportable Radar since the SANTANU have less range of reflectivity value than the Transportable radar. Steiner method applied to the CAPPI 3 km product since this product have less ground clutter and noise but still represent the echo activity in the mid-level of the precipitation [17]. Satellite data from Himawari were also used to confirm the MCS activity during the observation period. MCS is indicated by the largest area and the black body temperature (hereafter Tbb) value [18].

3. Result and discussion

3.1. Case study in March 17, 2017

Two case study were presented in this paper. In March 17. Precipitation were occurred from 11.00 LT until 20.00 LT to 21.00 LT. This precipitation were spread almost the entire Bandung area based on SANTANU observation (figure 2). SANTANU A and B are detected the early stage of precipitation in the middle of Bandung city area which started around 11.00 LT. In thirty minutes this object then grow into a wider area, with the SANTANU B showed a unique form similar with a v shape. In the next thirty minutes the object lost the v shape consistency and change its form until disappeared in 12.48 LT. There are time with less precipitation from 13.00 until 13.30, but after that several precipitation were occurred. Long span of precipitation area were observed between 16.00 – 16.30 LT in the north side of Bandung with reflectivity from 15 – 28 dbz. Large area of precipitation were observed between 18.00 – 20.00 LT in the east and in the south east of Bandung ranging from 12- 30 dbz.

Figure 3 is the CMAX product from the Transportable radar in March 17 2017 from 10.50 LT until 11.30 LT with no data after that due to electrical failure. This figure not only confirm the early stage of the convective precipitation but also more detailed information about the forming of the v-shape area. From the maximum value of the CMAX in 11.30 LT there are differences between the two part of the V-shape (left flank and right flank), with the right flank possess higher reflectivity than the other flank. Using a vertical point of view from the VSECT data showed more detail of the vertical structure of this right flank. Figure 4 is the VSECT in 11.30 LT data of the v-shape side (right flank). This VSECT showed towering reflectivity from near surface until 12 km. Based on the higher reflectivity, there are three consecutive convective cell. First cell is located in the altitude between 620 meter until 7 km, stretched horizontally within 6 km. Second cell is a possess smaller reflectivity with altitude from 2 km until 4 km. Meanwhile the third cell showed a vertical convective reflectivity with altitude in 620 meter until 3.5 km.

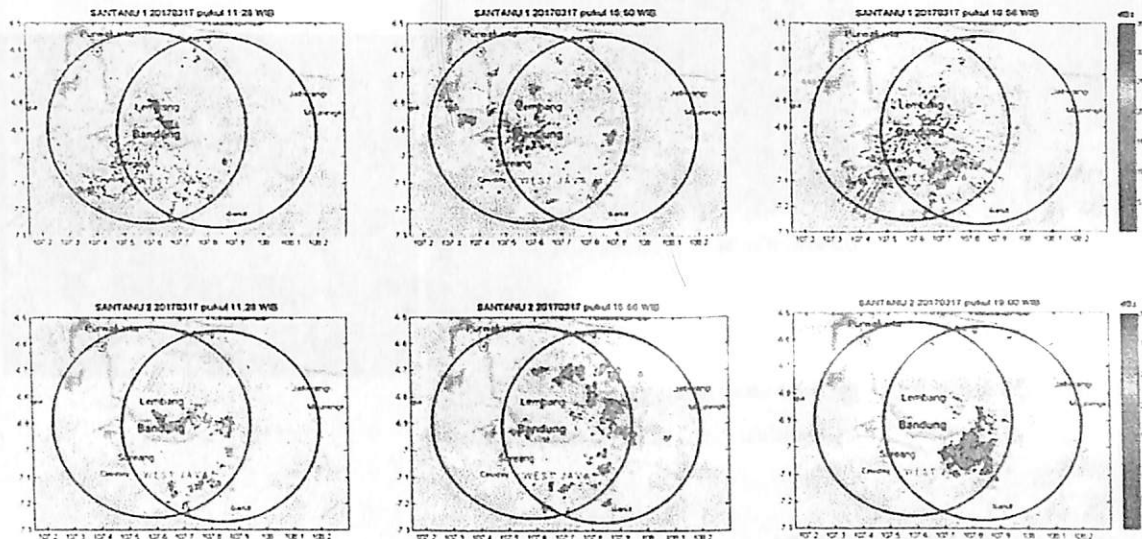


Figure 2. SANTANU in March 17.

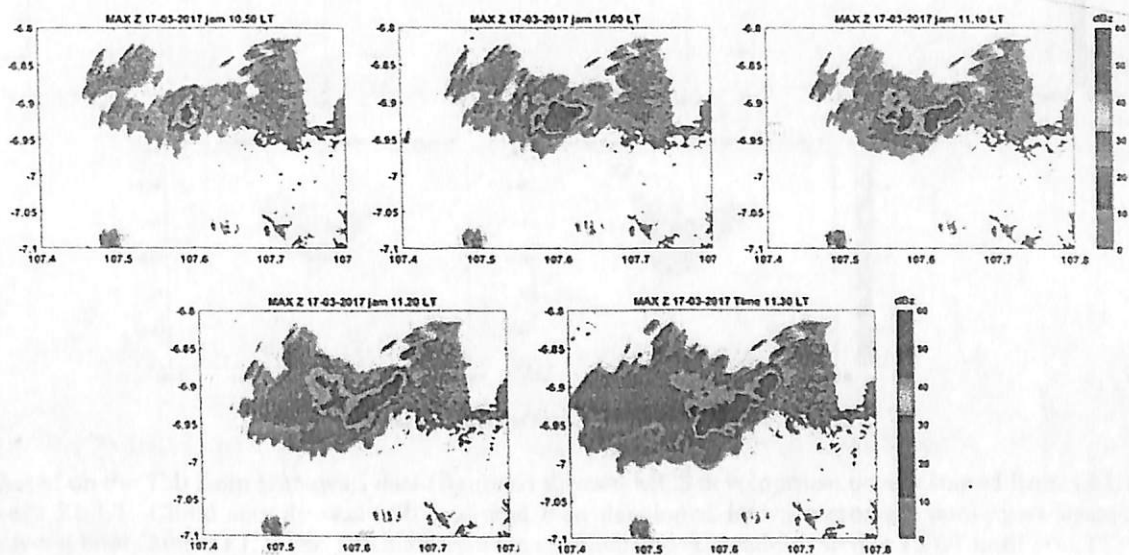


Figure 3. CMAX in March 17.

Based on the steiner method on the v shape (figure 5) object contain 2 type of precipitation (convective and stratiform). First stage from this figure showed two early convective in 10.50 LT and combined into one single convective cell in 11.00 LT, with the later process of convective type are located inside the V-shape area with the stratiform around those area from 11.10 until 11.30 LT.

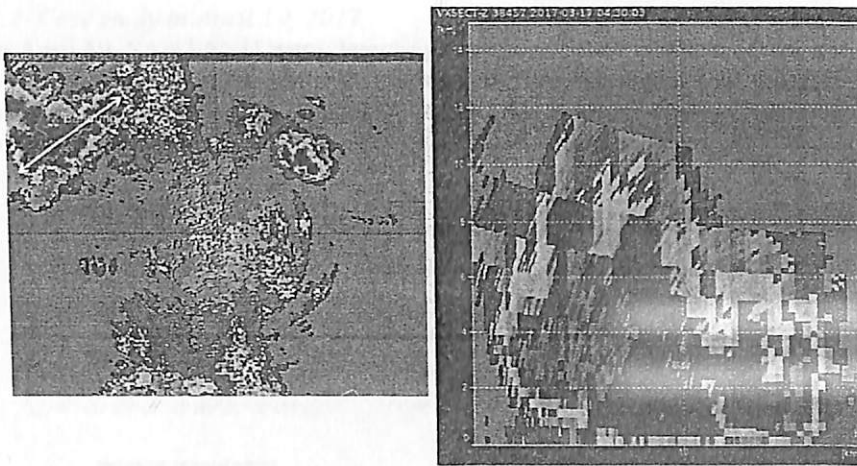


Figure 4. VSECT in March 17.

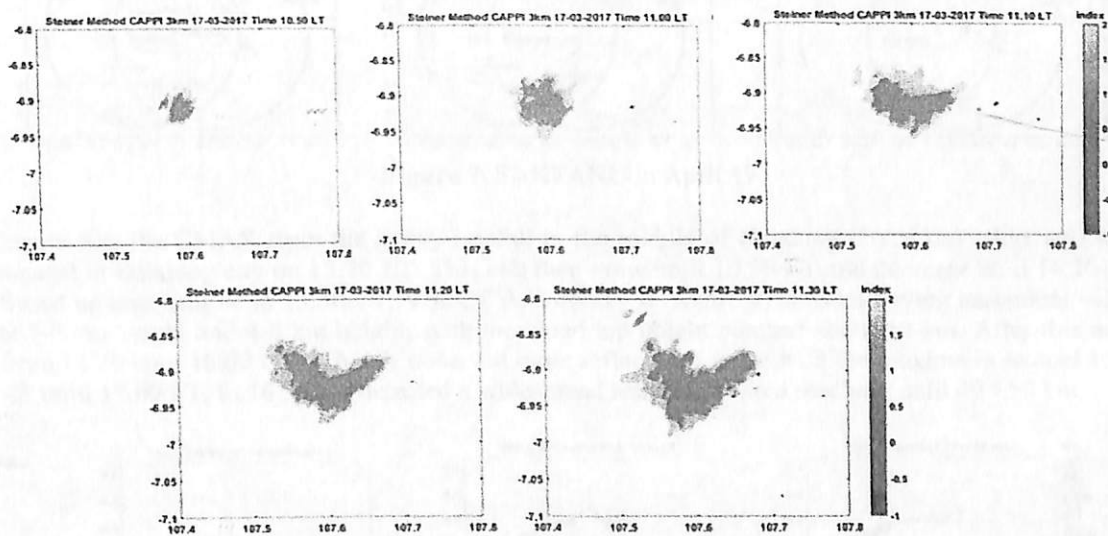


Figure 5. Steiner method in March 17.

Based on the Tbb from Himawari data (figure 6) showed MCS development occurs started from 13 LT until 21 LT. Cloud activity was still low, and then developed into a mesoscale convective system several hours after 11 LT. The Tbb activity were captured above Bandung area at 15 LT until 16 LT.



Figure 6. Tbb Himawari on March 17.

3.2. Case study in April 19, 2017

In April 19, SANTANU were detecting precipitation from 11.00 LT until 19.00 to 20.00 LT (figure 7). Various precipitation object were observed during those period. Heavy rainfall are occur in the middle of Bandung area from 13.20 until 14.40 LT. Twenty minutes later heavy precipitation were also observed in almost every coverage area of the SANTANU A and B.

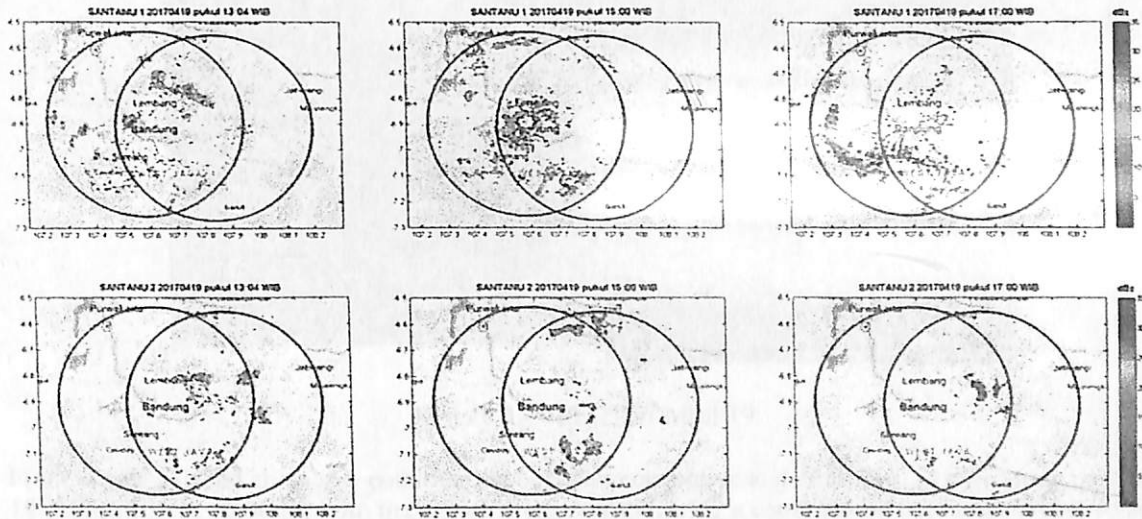


Figure 7. SANTANU in April 19.

Figure 8 is the CMAX from the heavy rainfall in the middle of Bandung city. Convective cell were located in Bandung city on 13.20 LT. This cell then grew until 13.50 LT and decrease until 14.10 LT. Based on data sample in 13.30 LT, VSECT data observed (figure 9) showed having maximum values at 1-2 km height and 4-6 km height, with the cloud top height reached about 12 km. After this event from 14.20 until 18.00 LT, CMAX observed more reflectivity value with the maxima in around 15.00 LT until 17.00 LT. In 16.30 LT detected a widespread reflectivity area reaching until 40 - 50 km.

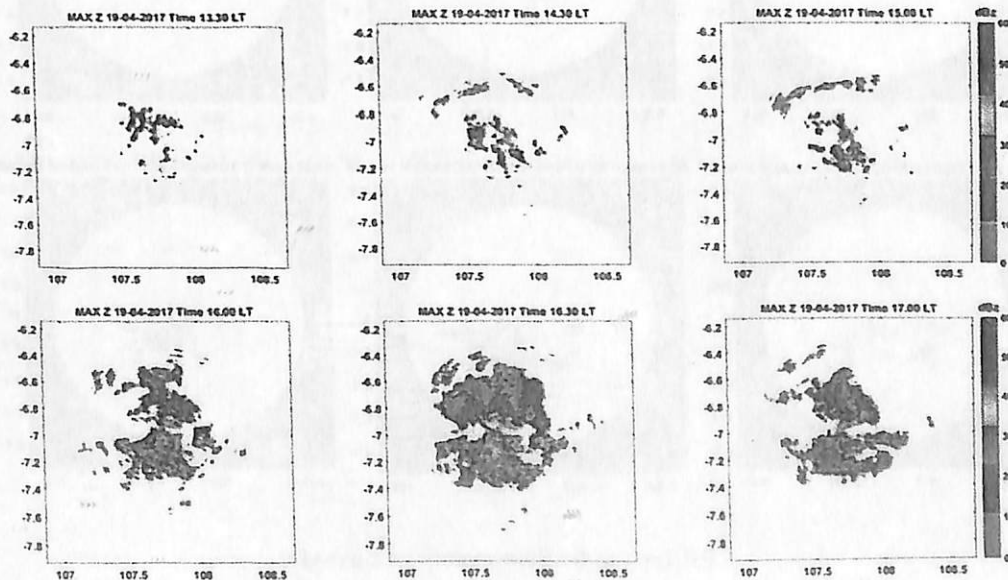


Figure 8. CMAX in April 19.

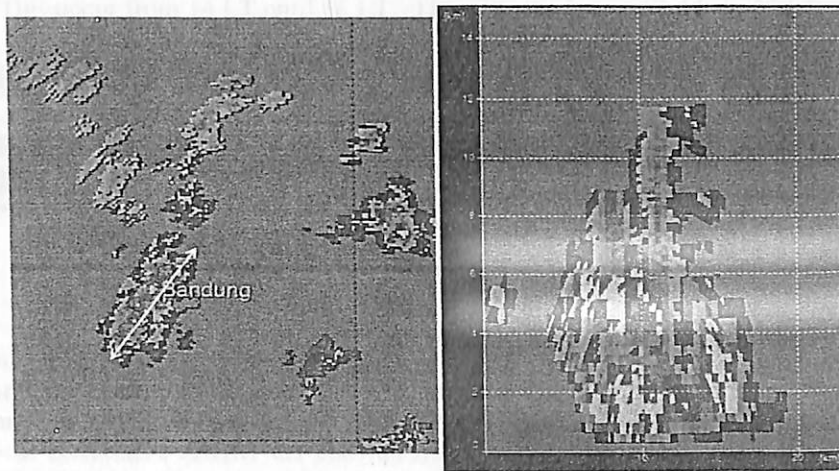


Figure 9. VSECT in April 19.

From steiner method showed a combination between convective and stratiform in case study on April 19 (figure 10). In 16.30 LT with maximum area are also having a combination between convective and stratiform with the convective index are having more than 50% of the area.

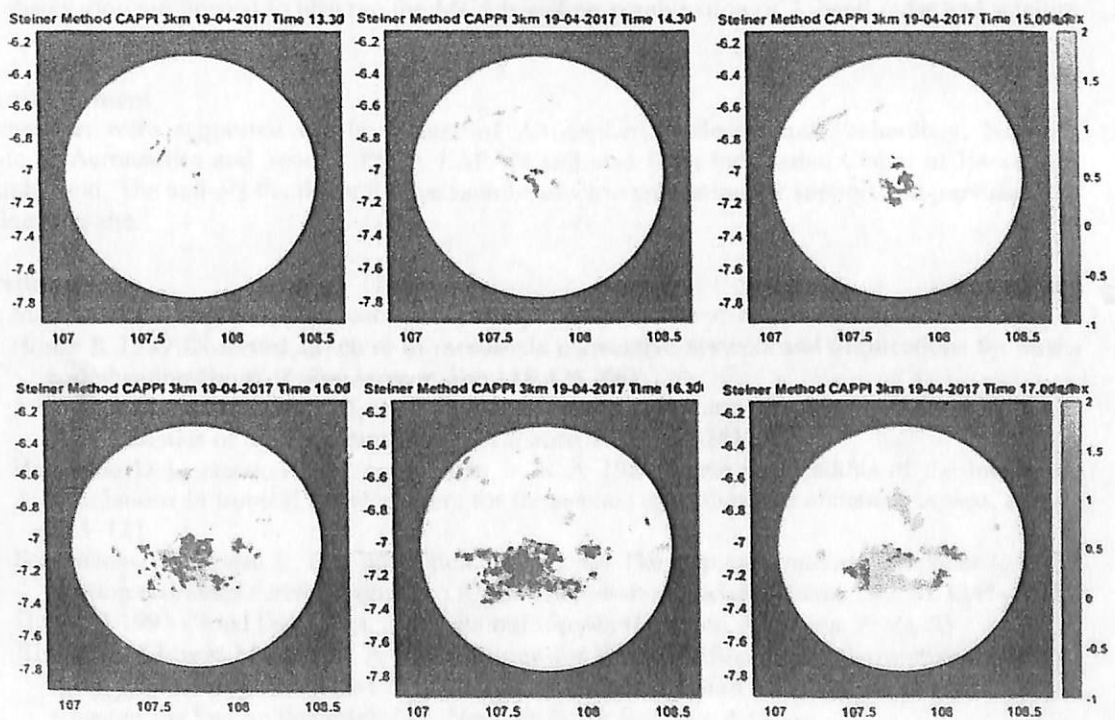


Figure 10. Steiner method in April 19.

In contrast with case study before, the Tbb from Himawari data showed a larger scale of MCS development. This occur from 14 LT until 18 LT. There are no data available in 17 LT.



Figure 11. Tbb Himawari on April 19.

4. Conclusion

The heavy rainfall on March 17 and April 19 that occur in Bandung city around 11.00 until 13.00 LT are based from a local convective cell in the middle of Bandung city based on two type of x-band radar. This local convective activity are showed from the SANTANU observation supported by the VSECT and CMAX of the Transportable radar data that signify the convective activity within those area. A unique reflectivity forming a v-shape area are observed from this x-band radar.

After this heavy rainfall, there are MCS activity occur around Bandung area. This event are confirm by the classification of convective-stratiform echoes from radar data and also from the Tbb Himawari 8 satelliite data. The different MCS activity from this two case study is that April 19 have much more MCS activity than in March 17, 2017. The maximum of MCS activity in April 19 on 16.30 LT were having a combination of convective and stratiform with an area reached up to 40 - 50 km. More observation are needed to observe the MCS based on combination of X-band radar and satellite data.

Acknowledgement

This research were supported by the Center of Atmospheric Science and Technology, National Institute of Aeronautics and Space - PSTA LAPAN and also from Indonesian Center of Excellence Research Fund. The authors thank the Rancakasumba electric substation for support and providing the radar location site.

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