Comparison and Analysis of The First Signal Detection of Two X-Band Radar with RGB Himawari Satellite Data before Localized Heavy Rain March 17 2017 Bandung Basin Indonesia

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Abstract. Early detection of the localized heavy rainfall is necessary to avoid heavy losses and even casualties. Localized heavy rainfall occurred in complex topography Bandung Basin March 17, 2017. Previous research showed a distinctive v-shaped pattern (peak period of heavy rainfall) followed with heavy rainfall and strong wind in 11.30 LT. Early dataset from two x-band radar observation data (GMWR25SP and SANTANU) and composite RGB Himawari satellite are used to investigate the first signal before the v-shaped occurred. The period of the dataset is from 10.50 LT until 11.10 LT. Comparison from both time and visualization of the dataset are conducted to analyze the event. Time comparison from three dataset showed differences for the emergence of early indication. GMWR25SP is the first that could detect the early origin of convective cell. Visual comparison in three dataset showed slightly different pattern, especially for composite RGB Himawari. Similarity pattern are only showed in the period 11.00 LT. Analysis of each dataset are necessary to see more detailed on the generation process. SANTANU showed a rapid growth process from one cell into two convective cells spatially within 20 minutes period. The vertical growth of these two convective cells are persistent and reaching up to 10 km based on GMWR25SP. These strong convective cells are probably because of the vorticity couplet that occur in 11.00 LT until 11.10 LT. The dominant air mass movement based on the water vapor distribution RGB Himawari are showed towards the west side. This probably affect the position of the generated second convective cell (position on the left side of the previous cell). Data indication in 11.10 LT is the important period because it showed the generated second convective cell. Combination from three dataset give a more comprehensive analysis on the process before localized heavy rainfall occurred.

Keywords: localized heavy rainfall, v-shaped, GMWR25SP, SANTANU, RGB Himawari

1. Introduction
Localized severe weather in Bandung Basin have occurred in March 17, 2017. Severe weather with the radar reflectivity area reach up to ± 30 km and an indicate maximum winds shear of 14.5 m/s have caused several damages in infrastructure. Strong wind speed has thrown away rooftop, billboard, traffic sign, etc. Preliminary study showed the location of this storm are located in the middle of Bandung urban area in a period between 10.50 LT until 12.00 LT [1]. This local convective storm reached its maximum in 11.20 LT until 11.30 LT and forming a v-shaped pattern and caused heavy rainfall and also strong wind speed. The strong wind speed is calculated reaching maximum of 12 – 15 m/s around 11.30 LT until 12.00 LT based on the ground based automatic weather station observation and Doppler velocity of x-band radar [2]. All of the reported location with heavily damaged were located inside this v-shaped.
Hail event are also occurred during this local convective storm based on visual report. Result from the x-band radar data processing for the estimated total amount of liquid water concentration using VIL (Vertically Integrated Liquid) showed strong potential of hail in one of flank of the v-shaped area [4]. Preliminary comparison between radar data with Himawari satellite data are studied from the dataset to analyze that is there any MCS contribution during the v-shaped period. Based on T_{BB} value the cloud activity is still low in 11 LT and increase several hours afterwards [1].

A localized heavy rainfall is generally formed by even an isolated cumulonimbus cloud which is suddenly generated aloft and develops rapidly in a very short time [5]. Due to short period of time, it is essential to detect the early detection before this heavy rainfall reaches the ground. Based on the previous study and combination with RGB composite Himawari data, this research is intended to analyze the dataset before 11.20 LT and what variables that can become a parameter for early warning system.

2. Data and Method

Two x-band radar with different type were used in this research. The first radar is the LAPAN Transportable GMWR25SP. It is a single polarization Doppler X-band radar. It is capable to conduct a volume scan with maximum radius of 83 km. The radar is mounted on a vehicle for mobile observation purpose. The second radar is the rain scanner SANTANU. This radar is a single polarization X-band non-doppler radar. This fixed-mounted radar can only scan in a single level of altitude and have a relatively large vertical beam width with maximum radius of 44 km. Both radars have its own advantage and disadvantage. GMWR25SP is able to scan spatially and vertically with a volume scan, but low temporal resolution since it needs time to achieve a whole volume scan. Meanwhile, SANTANU is able to scan only spatially, but high temporal resolution.

Red Green Blue Himawari (hereafter stated as RGB Himawari) composite imagery works based on the principle of color combination which consists of three primary colors, i.e. red, green and blue [6]. Combination of three image bands (individual or channel difference) of satellite data can be displayed as one image, showing new color information that can be used for various analysis. This technique is simple and creates image that relatively easy to be interpreted since the objects are able to be distinguished from their appearances. Furthermore, the use of high spectral resolution of Himawari-8 satellite data in this study enables us to generate more information from this RGB method. The water vapor classification from RGB combination of Himawari band (Table 1) are used to analyze the effect of the water vapor distribution with the process generation of the v-shaped.

Three early datasets (GMWR25SP, SANTANU, and Himawari) are used to see the first indication before the V-shaped echo in March 17, 2017. The period will be in the interval from 10.50 LT until 11.10 LT. Each dataset is extracted only from the desired area of the v-shaped. Time and coordinate location comparison from this dataset are used to see the similarity process for the early indicator as well as visual comparison.
Each dataset is then analyzed based on its characteristic to see the process before the v-shaped occur. Calculation of the object are used to estimate the area. Growth-decay rate of the reflectivity area from more high temporal resolution SANTANU data are used to calculate the rapid growth process [7]. Image processing are very useful tool to analyze rainfall distribution including growth-decay rate [8]. Meanwhile, the height profile in each CAPPI reflectivity and doppler velocity data from GMWR25SP are used to analyze the position and the generation of the convective cell.

### Table 1. RGB combination band for water vapor

| Classification          | R        | G        | B        |
|-------------------------|----------|----------|----------|
| True color              | 0.64 µm  | 0.51 µm  | 0.47 µm  |
| Water vapor             | 6.2 µm   | 6.9 µm   | 7.3 µm   |
| Natural color           | 2.3 µm   | 0.86 µm  | 0.64 µm  |
| Day microphysics        | 0.86 µm  | 3.9 µm   | 10.4 µm  |

### 3. Result and Discussion

Time comparison from the early data in each dataset are showed in Figure 2 and Table 2. There are differences for the emergence of early indication. Data from two x band radar is nearly in the same time (10.50-10.52 LT), but for Himawari data (RGB water vapor distribution) start to appear in the 11.00 LT. GMWR25SP is able to detect the first data compared with the other dataset. From this data showed there is one convective cell (> 40 dBZ). SANTANU are able to detect the first data in 10.52 LT (Figure 3) but with relatively small area compared to GMWR25SP. Meanwhile first data of RGB Himawari is in 11.00 LT that relatively showed low response than the other two datasets.

Visual comparison in three dataset showed slightly different pattern, especially for composite RGB Himawari. Similarity pattern are only showed in the period 11.00 LT. Initial stage of the second convective cell are detected in period 11.10 LT with both x-band radar. In this period, RGB Himawari only showed one cell but have a large area spread to the left from its origin. This showed that RGB Himawari is also detect the growth of the second cell, but could not distinguish both cells. Analysis of each dataset are necessary to see more detailed on the generation process.

### Table 2. Comparison of the First data in each dataset

| No | Dataset   | Spatial Resolution | Temporal Resolution | Time (LT) |
|----|-----------|--------------------|---------------------|-----------|
| 1  | SANTANU   | 120x120 meters     | 2 minutes           | 10.52     |
| 2  | GMWR25SP  | 250x250 meters     | 5 minutes           | 10.50     |
| 3  | Himawari  | 2000 x 2000 meters | 10 minutes          | 11.00     |

Growth reflectivity are used to analyze the growth process of reflectivity area. SANTANU image data are used for the growth rate calculation due to more high temporal resolution compared with the other dataset. Figure 3 showed the SANTANU data of accumulated and area reflectivity every 2 minutes from 10.50 LT to 11.10 LT. This figure showed rapid growth of the area and also the high slope of accumulated reflectivity from 10.52 LT until 11.00 LT. The average growth rate of the accumulated reflectivity within this period (10.52 LT – 11.00 LT) is 15.6% from total area, meanwhile from 11.04 until 11.10 only reach 1.2%. This rapid process showed a second convective cell appear in 10.58 LT. Since SANTANU only have data in single level, so we need a volume scan data to observe more on the convective cell.

Reflectivity profile ascending with time are the evidence of an updraft occur, in which the precipitation is generated and carried upward [9]. From reflectivity profile showed the first convective cell are already have a strong updraft with the echo top reaching up to 6 km (Figure 4a). The second convective cell then exist at 11.00 LT (more specific at 10.58 LT) in the left side from previous cell. Two reflectivity columns (Figure 4b) then exist in 11.00 LT with echo top in different height (first cell at 9 km, second cell at 6 km). Within the next 10 minutes (Figure 4c) the echo top change with stronger
updraft in the second cell rather in the first cell. These two convective cells that appear in 11.10 LT become the bases of the \( \gamma \)-shaped pattern.

![Figure 2](image1.png)

**Figure 2.** Comparison of GMWR25SP, SANTANU, and RGB Himawari in 10.50 LT, 11.00 LT, and 11.10 LT.

![Figure 3](image2.png)

**Figure 3.** Area and Accumulated reflectivity from SANTANU data

It is shown by the radial velocity profile that there is single vorticity with clockwise rotation detected in 10.50 LT (Figure 4d). High activity (Figure 4e – 4f) are shown in the next 10 until 20 minutes (11.00 LT until 11.10 LT) where there are exhibited two vorticities, usually called vorticity couplet [4], which have a different movement (clockwise and anticlockwise) in the middle altitude (3 - 4 km). This vorticity couplet is also showed until certain altitude that probably related with the vorticity tube that need to be analyze further.
Figure 4. Reflectivity and Radial velocity profile from CAPPI data
Water vapor distribution from RGB Himawari sequence from 10.50 until 11.30 are shown in Figure 5. From this figure we can be estimated that ambient flow is characterized by water vapor moving towards the west side. This condition did not affect the updraft condition of the first convective cell in 10.50 LT.

![Figure 5. Water vapor distribution](image)

However, for the newest updraft from second convective cell started tilting and move to the right side of the first cell. This ambient airflow possibly affects the location of the second convective cell (the left side from previous cell). Ambient flow started tilting the reflectivity to downward direction with height, with the second cell did not reach higher than the first cell [10]. This condition is the result of the v-shaped reflectivity pattern.

Three datasets give a more comprehensive analysis on the process before the localized severe weather with v-shaped pattern on March 17, 2017 happened. Data indication in 11.10 LT is the important period for the early indicator of this severe weather. In this period, the second convective cell was detected. Several indicators that presumably could become an early indicator of this severe weather are rapid reflectivity growth rate, second convective cell, and vorticity couplet.

4. Conclusion
Localized heavy rainfall occurred in Bandung Basin March 17, 2017 were observed from GMWR25SP, SANTANU, and also RGB Himawari Satellite. The early convective cell is detected in 10.50 LT. Then, it grows rapidly for the next 10 minutes and generate another convective cell on its left. Based on the water vapor distribution it showed the dominant movement towards the west part. This condition is probably the cause why the second cell generates on the left from previous cell. The strong convective activity is related with these two convective cell activities, with two vorticities (vorticity couplet) are detected in the 3 to 4 km altitude both in 11.00 LT until 11.10 LT. This vorticity couplet is also shown until certain altitude that probably related with the vorticity tube that need to be analyzed further. Data indication in 11.10 LT is the important period for the early indicator of localized heavy rainfall in March 17, 2017 followed by existence of rapid reflectivity growth rate, second convective cell, and vorticity couplet.

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