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Post Processing and Analysis using 2D Combined Shear Method on X-Band Transportable Weather Radar During Strong Wind in Bandung West Java

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Abstract. LAPAN Transportable X-Band Weather Radar is an X-Band GMWR-25-SP single polarization weather radar. Field campaign were conducted from end of February until end of May 2017 in Bandung Basin urban area. The purpose of this research is to analyze the strong wind during severe storm (case study March 17) based on wind shear data. This strong wind are conform by the AWS ground based wind measurement from 11.00 LT until 12.00 LT with wind speed value varied from 4.5 - 12 m/s. A post processing using 2 dimensional (2D) combined shear method from the wind shear weather radar data were used to analyze the larger shear resulted from strong wind. 2D combined shear showed that local heavy storm generates from center location of Bandung from 10.50 LT then grew until 11.10 LT. Changes echo shape occur in 11.20 LT forming a v shape area with large value were spotted in the edge of the object, while varied color inside the v shape area showed a fluctuated wind shear that is also correlated with spectrum width value with more than 4 m/s. Based on the combined shear data in 11.30 LT, all of the impacted location recorded were located inside the wind shear area with two location were spotted having a large combined shear value reaching > 0.01 s^{-1}.

INTRODUCTION

Bandung Basin is an urban area surrounded with mountain topography, located in West Java Indonesia. In March 17, 2017 there was local heavy storm occurred in this region. This local heavy storm carrying heavy rainfall and strong wind were located in an urban region and causing damage in several infrastructure. Strong wind is the most damaging factor in this heavy storm.

An X-Band weather radar is a useful tool for observing weather, precipitation activity and hydro-meteorology [1-2]. Nowadays, X-Band weather radar utilization have grown rapidly [3] and gave a certain benefit in the form of low cost installation and maintenance and also suitable for mobile radar system application compared with other type of weather radar [4]. High resolution on spatial and temporal scale of an x band weather radar will gave a significant and accurate information on precipitation measurement at small scale such as an urban region [5-7]. X-Band weather radar is suitable for short range detection such as mountainous region [8-10], and also location near the airport [11] Many research activity that have been studied about the performance of x band weather radar network [12-13].

LAPAN-GMWR25SP is an X-Band transportable weather radar mounted on a hydraulic mounting radar vehicle. This radar are using single polarization with a power of 25 kWatt. Maximum detection range reached up to 100 km with range resolution of 100 meter. A 1.2 meter parabolic antenna with beam width of 2^0 are mounted in a pedestal controlled by control unit with a Radarcontrol II application [14] as a front end for the user to conduct a horizontal scan, vertical scan and also its combination called volume scan. Several activities have been conducted using this Transportable weather radar for observing the convective activity in certain area of West Java [15].

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The purpose of this research is to analyze the strong wind during severe storm based on wind shear data. Wind shear data are generated from an X-Band Transportable Weather Radar during a field campaign from end of February until end of May 2017. A post processing using 2 dimensional (2D) combined shear method from the wind shear data were used to analyze the larger shear resulted from strong wind. Spectrum width from radar product were added to the analysis to find out whether there is a turbulence during strong wind [16]. AWS (Automatic Weather Station) data is also used to confirm the strong wind in the surface during this event

METHODOLOGY

Transportable X-Band Weather Radar

Transportable X-Band Weather Radar is an X-Band GMWR-25-SP single polarization weather radar mounted on a vehicle for conducting weather observation in different location site. GMWR-25-SP manufactured by GAMIC is a cost effective X-band doppler weather radar operated by LAPAN for research activities mainly on atmospheric research.

Volume scan strategy are using 20 elevation scan of altitude up to 15 km with spatial resolution of 250x250 meter. Clutter mean square is using a threshold of 30 db to reduce clutter from terrain, with dual slope interpolation for DFT clutter filter process [17]. High PRF 1800 Hz with 0.3 medium pulse width are also set to increase the scan rate for monitor larger volume object in short period [18]. Meanwhile for detecting the strong wind are based from the wind shear product. The wind shear product is using the lowest elevation scan from 0^0 - 0.8^0 to investigate the near surface wind shear.

Wind Shear

The wind shear product are designed to detect divergence in the measured wind field which may be caused by downburst or microburst, gust front etc [19]. The wind shear product used in this research is the spatial shear which are radial wind shear and azimuth wind shear.

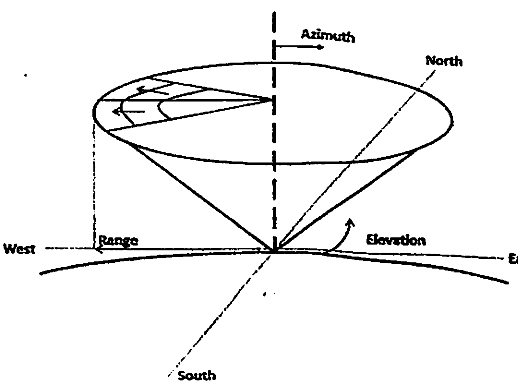


FIGURE 1. Illustration of Radial and Azimuth Shear Product.

Radial shear is a typical wind shear for measuring wind shear along the radial component. Radial shear were measured using a polar single elevation antenna azimuth scan, with bin-to-bin radial velocity difference are processed by using Clutter bin removal, zero velocity-bin to non-zero velocity-bin difference removal, smoothing, filtering, etc

Differ with Radial shear, Azimuth shear are measured using either PPI scan or polar velocity volume data to determine the azimuth signed difference between each azimuth step from radial wind vector measured. The azimuth shear calculate the difference of the radial velocity vector between adjacent azimuth cells at the same range bin (Range).

2D Combined Shear

The two dimensional (2D) combined shear was originally developed for detection of larger scale shear associated with fronts [20]. Two dimension combined shear is a method that combined two spatial wind shear product, radial (R) and azimuth (Θ), quantitatively described in equation (1).

$$Combine = \sqrt{Radial^2 + Azimuth^2} \tag{1}$$

2D combined shear computes the two dimension gradient of the radial and azimuth direction. This method are used to investigate the 2D combined shear as an indicator of a strong win d shear that could not be distinguish from the azimuth nor radial shear.

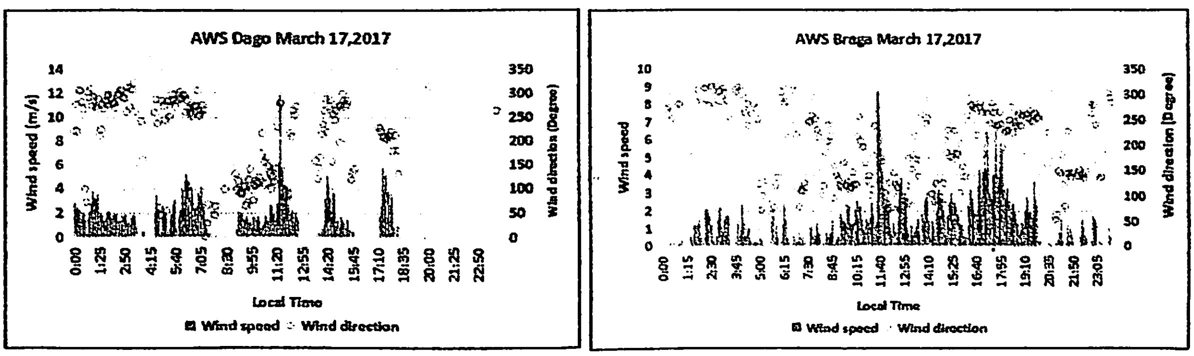
The data that were used in this research is the azimuth and radial shear, composite reflectivity, and CAPPI spectrum width from radar data, and also wind speed and wind direction from ground based AWS observation. Time period is March 17 , 2017 from 10.50 until 11.30 LT. The limited duration is due to power failure from 11.40 LT so there are no radar data observed.

RESULT

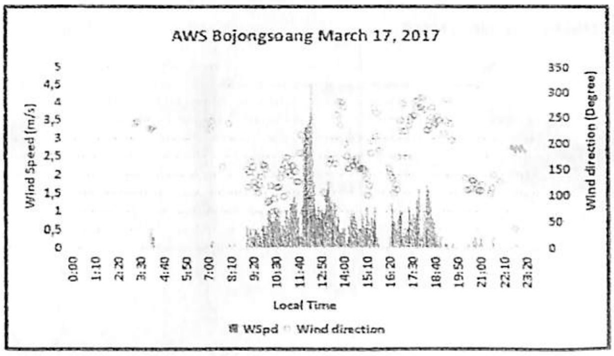
Wind measurement from AWS are collected in three different station location (Table 1). Dago and bojongsoang are located in the north and south side of the center of Bandung, while Braga located in the center of Bandung. Three measured value from different AWS (Fig. 2) showed that there are strong wind with high peak from 11.00 LT until 12.00 LT. The wind speed were varied from 4.5 - 12 m/s with very fluctuated wind direction. This indicate that there were strong wind along with random wind movement.

Table 1. AWS location.

AWS location	Coordinate
Dago	-6.8702^0 N , 107.6147^0 E
Braga	-6.9178^0 N , 107.6087^0 E
Bojongsoang	-6.9826^0 N , 107.6330^0 E



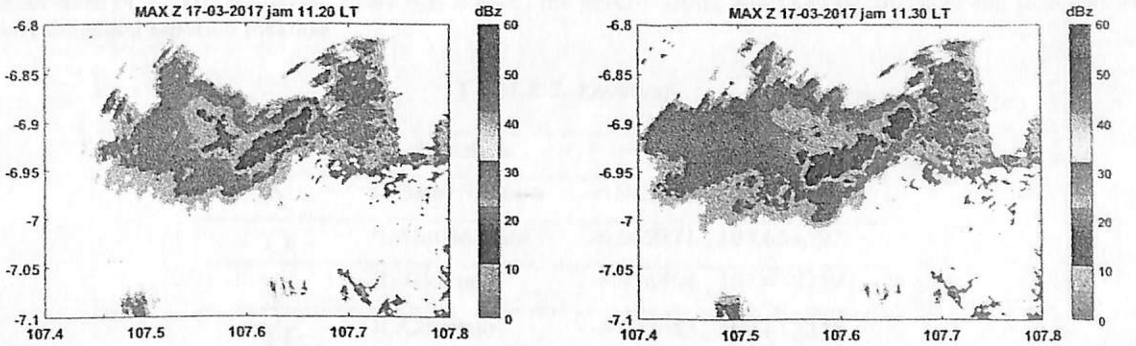
(a) (b)



(c)

FIGURE 2. Ground based of Wind speed and direction in several location, (a) AWS Dago, (b) AWS Braga, (c) AWS Bojongsoang.

Fig. 3 is the composite reflectivity from weather radar. Composite reflectivity showed the whole signature of radar volume scan. The composite reflectivity indicate strong reflectivity gradient reaching from 40 dBZ up until > 55 dBZ in 11.20 LT (Fig 3a), meanwhile in certain area it will reach 60 dBZ in 11.30 LT (Fig 3b). This strong reflectivity were located in the northwest area from the radar site, which is in the center of Bandung city. The signatures showed a v shape reflectivity area which usually represent heavy rainfall followed by strong wind .

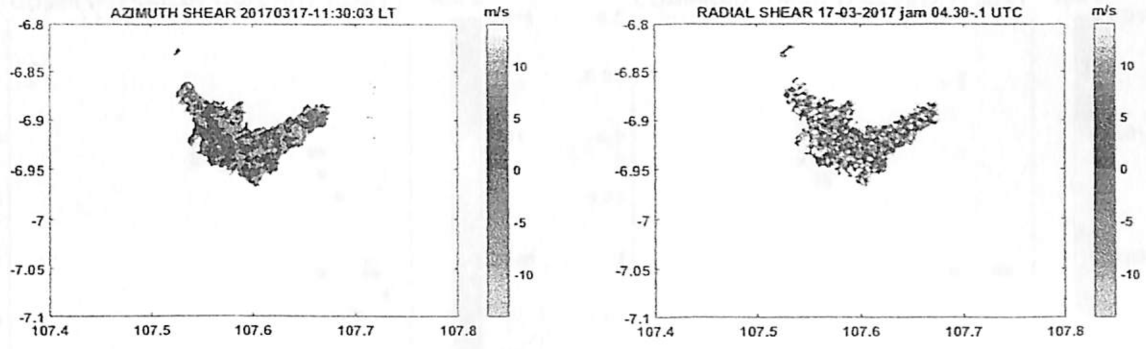


(a) (b)

FIGURE 3. Composite reflectivity, (a) 11.20 LT, (b) 11.30 LT.

The X-band radar derivative product is the wind shear (radial and azimuth shear). This product are generally generate earlier than composite reflectivity since the composite value needs to accomplish one volume scan. Fig. 4 is the radial shear and the azimuth shear product in March 17,2 017 on 11.30 LT. The v shape is very visible within this figure with a low level scan product (0.8^0) are used to optimize the acquire information of the wind field near the surface.

Positive value in azimuth shear represent anti clockwise rotation meanwhile negative value represent clockwise rotation. From the Fig. 4a showed varied positive and negative value in azimuth shear which could indicate strong and varied circulation around the v shape area. The right flank of the v shape area showed more varied of positive-negative value of azimuth shear rather than the left flank that indicate a more rapid development process (proved by high reflectivity in Fig. 4b in the right flank).



(a) (b)

FIGURE 4. Weather radar observation on March 17, 2017,(a) Azimuth Shear, (b) Radial Shear

Positive value in radial shear represent an indication of divergent wind, meanwhile the negative value represent an indication of convergent wind. Fig. 4b showed there were more negative value within the v shape area rather than positive value. This indicate that more dominant of convergent in the surface that could generate an updraft for the development of a towering cloud. It is difficult to summarize where the location of the strong wind based from this two wind shear (azimuth and radial shear) due to varied value of the wind shear.

Fig. 5 is the post processing result from azimuth and radial wind shear from 10.50 until 11.30 LT. This result represent the 2D combined shear in km/second. Inside the figure marked several symbols (Table 2) represent the reported location of heavily damaged. From this figure , the severe strong wind can be analysed and matched with the heavily damaged reported location.

TABLE 2. Location

Symbol	Location	Coordinate
△	Jl Gatot Subroto	-6.925976 , 107.633039
○	Jl.Ahmad Yani	-6.902271 , 107.654597
◇	Jl. Jakarta	-6.914494 , 107.638219
☆	Jl. Cikawao	-6.927683 , 107.615335
□	Jl. Burangrang	-6.925397 , 107.61978
▽	Jl. Setiabudi	-6.871121 , 107.595708

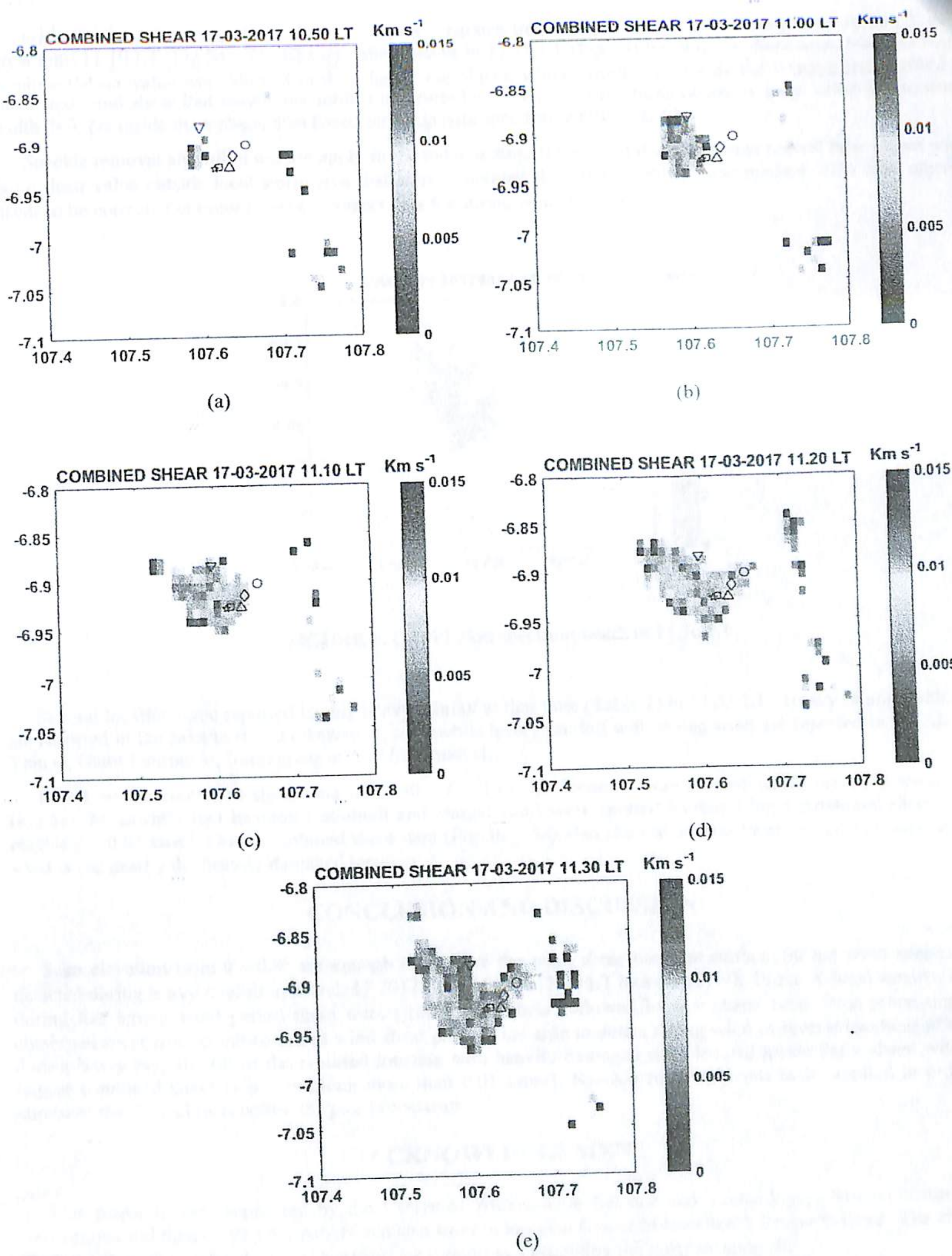


FIGURE 5. 2D combined shear, (a) 10.50 , (b) 11.00 , (c) 11.10, (d) 11.20 , (e) 11.30

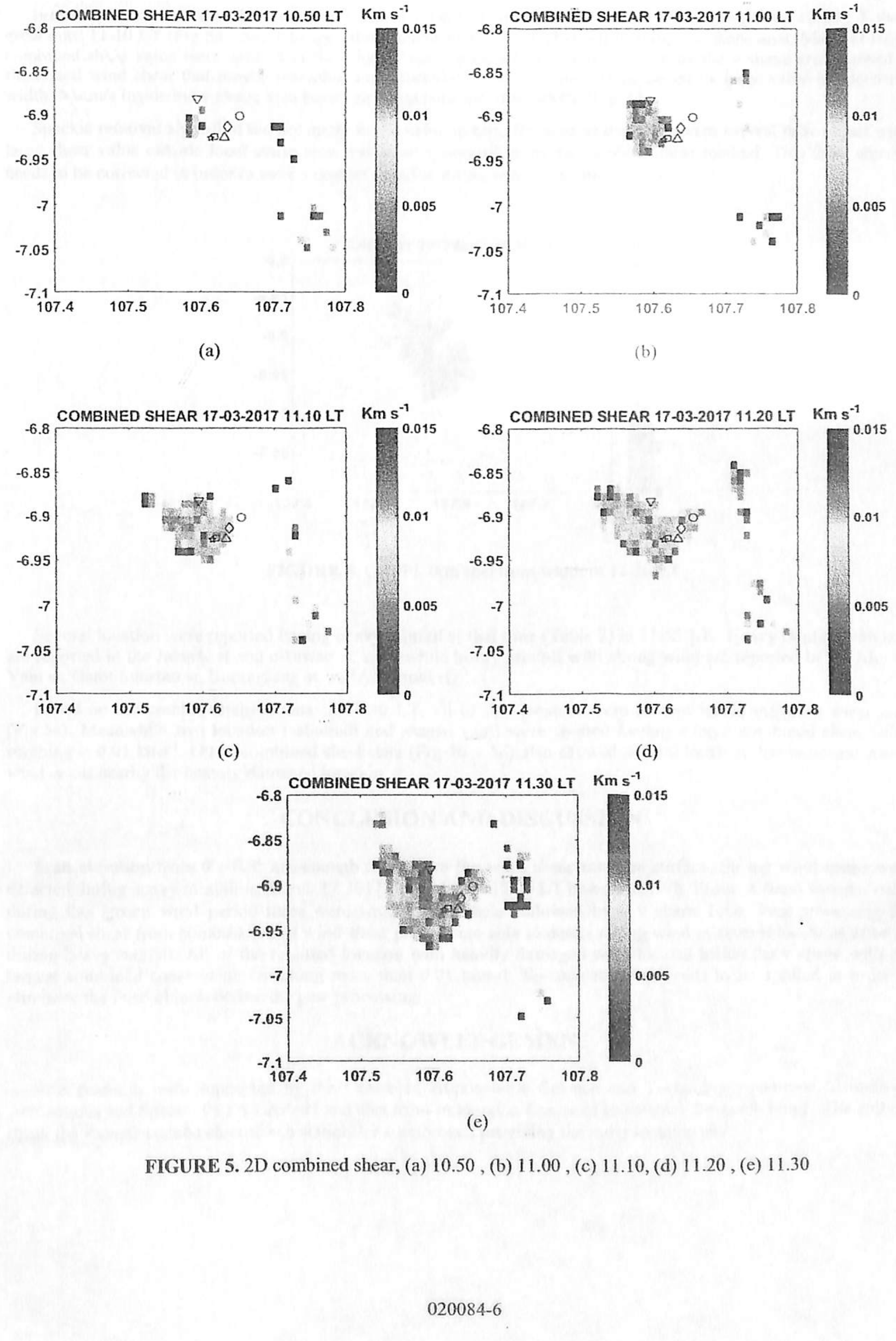


FIGURE 5. 2D combined shear, (a) 10.50 , (b) 11.00 , (c) 11.10, (d) 11.20 , (e) 11.30

From figure showed that the local heavy storm generates from center location of Bandung from 10.50 LT then grew until 11.10 LT (Fig 5a - 5c). Changes shape occur in 11.20 LT (Fig 5d) forming a v shape area. Many of large combined shear value were spotted in the edge of the object, while varied color inside the v shape area showed a fluctuated wind shear that maybe resemble some turbulence. This is also strengthened by large value of spectrum width > 4 m/s inside the v shape area based on composite spectrum width (Fig. 6).

Speckle removal algorithm did not apply in the radar setting. Because of that there were several false object with large shear value outside local storm area that were generated from the combine shear method. This false objects needs to be corrected in order to have a correct data for strong wind detection.

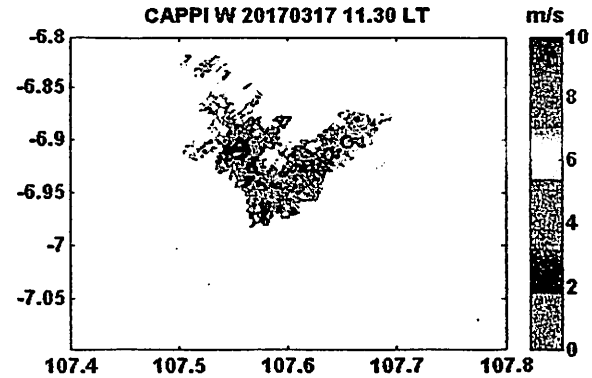


FIGURE 6. CAPPI 2km spectrum width in 11.30 LT

Several location were reported having heavy rainfall at that time (Table 2) in 11.55 LT. Heavy rainfall with hail are reported in the Jakarta st and cikawao st, meanwhile heavy rainfall with strong wind are reported in the Ahmad Yani st, Gatot Subroto st, Burangrang st, and Setiabudi st.

Based on the combined shear data in 11.30 LT, all of this location were located inside the wind shear area (Fig.5e). Meanwhile two location (setiabudi and ahmad yani) were spotted having a large combined shear value reaching > 0.01 kms^{-1}. Other combined shear data (Fig 5b – 5d) also showed several location that indicated strong wind occur nearby the heavily damaged location.

CONCLUSION AND DISCUSSION

Scan elevation from 0 - 0.8^0 are enough to observe the wind shear near the surface. Strong wind speed were detected during heavy rainfall in March 17 2017 from 11.00 - 12.00 LT based on AWS. From X-band weather radar during this strong wind period there were strong wind shear followed by a v shape echo. Post processing 2D combined shear from combination of wind shear product are able to detect strong wind in several locations affected during heavy rainfall. All of the reported location with heavily damaged were located inside the v shape with the largest combined shear value reaching more than 0.01 kms-1. Speckle removal needs to be applied in order to eliminate the false objects before the post processing.

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