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Identification of Mesoscale Convective Complex (MCC) Over Bangka Belitung Area

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Abstract. Mesoscale Convective Complex (MCC) is a mesoscale cloud convective system characterized by large, long-lived and quasi-circular pattern. The existence of MCC may trigger extreme weather events such as heavy rains which cause floods and landslides around the center of interest area. This paper aims to identify the presence of a storm cloud system which is observed as the MCC. For that purpose, this study used Himawari-8 satellite infrared channel data. Case of the study is the rain event in Bangka Belitung on 8 February 2016 which recorded 183.9 mm rainfall a day. Satellite data was processed using image processing software by applying MCC cloud system identification algorithm based on its physical characteristics, i.e. peak cloud temperature, coverage area, central point of cloud, cloud eccentricity and ellipse fitting, and lifetime of the cloud system. The final result of this study is able to yield the coordinates of latitude and longitude of MCC location, which are MCC cloud systems appeared around Bangka Belitung. This result confirmed that the occurrence of heavy rain on February 8th, 2016 in Bangka Belitung was caused by the presence of MCC around the interest area.

Keywords : MCC, quasi-circular, floods and landslides.

1. Introduction

Mesoscale Convective System (MCS) is a complex convection system that grows up into a larger scale of convection system and normally lasts for several hours or more [1]. Mesoscale Convective Complex (MCC) is one of the MCS characterized by large, long-lived and quasi-circular pattern. Generally, MCC is nocturnal and tends to cause severe weather such as heavy rain, strong wind, and thunderstorm in a large coverage which may cause floods even landslide around a point of interest. This group of convective system is triggered by low level jet causing larger cumulonimbus coverage (hundred kilometers in approximation) and has more than three hours lifetime cycle [2].

Researchers have shown that the MCSs produce huge precipitation at the Midwest and the Great Plains when growing season [3]. Previous research on South Afrika [4] and on South America [5] mentioned that the impact of MCC are quite dangerous, which include heavy rain, strong winds, hail, tornadoes, and may result in flooding if it occurs for a long enough duration. The rainfall effects of MCC can be found not only on MCC area but also on its surrounding area [6]. On February. 8th and 9th, 2016 in Bangka Belitung region, there were heavy rains with an intensity of 183.9 mm a day. Rain on February 8th 2016 occurred with a long duration and had caused flooding in the region, therefore it can be expected that on the day of the heavy rain there was an MCC phenomenon. This paper aims to identify and confirm the existence of a storm cloud system that is monitored as an MCC cloud system using Himawari-8 satellite infrared channel data. Identification of the existence of MCC is done by processing the satellite data using image processing software and algorithms that are built based on the characteristics of MCC referring to the results of research conducted [7].

2. Data and Methods

The area that became the focus of the research is Bangka Belitung and its surroundings with geographical location at 104⁰ BT and -1⁰ LS to 106⁰BT and -3⁰LS. This area covers the entire Province of Bangka Belitung.



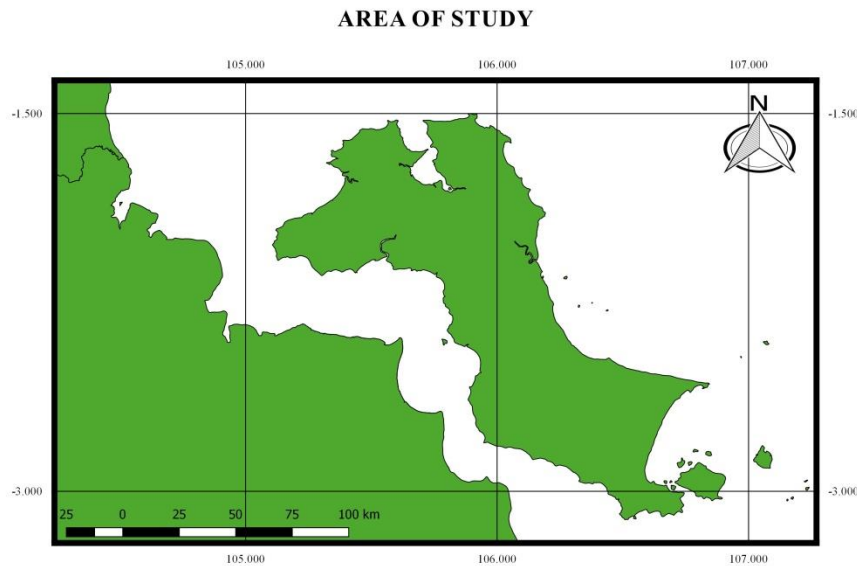


Figure 1. Map of Research Area

The data used in this study were Himawari-8 infrared channel (IR1) satellite imagery on 8 February 2016 from Kochi University website (hourly data) and for verification, rainfall data were taken from Pangkal Pinang Meteorological Station observation on 8 February 2016 and 9 February 2016. The method used in the data processing process to identify the existence of MCC is by processing satellite data using image processing software and algorithms that are built based on the characteristics of the MCC cloud system [7,8,9]. The methods are :

1. First, satellite data in portable gray map format (PGM) with a scale of 0-255 were converted to cloud top temperature data in Kelvin.
2. Determine the blanket clouds with the characteristics of the MCCs [7]. The value of the cloud peak temperature < 241 K signed as a coverage cloud (SA) [7,8] and 217 K as a cloud core (IA) [7,8]. Temperature which every grid met the requirement will be regarded as 1 or 0 (changing data into binary data form)
3. Find the area that meets the temperature requirements (procedure 2, the pixel that has a binary value "1") by counting the number of pixels that are connected to 4 surrounding grid. Select area requirements by selecting SA area that has an area of $\geq 100,000$ km² [7,8] or if it is converted into pixels, there are 3305 pixels, because Himawari-8 satellite data has a resolution of 5 km, and IA area that has $\geq 50,000$ km² [7,8] or around 1652 pixels.
4. Find the center point of the selected area from the procedure 1-3 where the center point is the center of mass of the interconnected area, calculated by this formula [10].

$$X_0 = \frac{\sum_1^N X_i}{N} \text{ and } Y_0 = \frac{\sum_1^N Y_i}{N} \quad (1)$$

Where:

X_i : pixels to-i at X-axis
 Y_i : pixels to-i at Y-axis
 X_0 and Y_0 : center
 N : total of pixels

5. Determine the MCC based on the eccentricity value using the Machado threshold method with a value of M_{ad} is 0.7 [7], and added with the Ellipse Fitting method with a limit of ≤ 0.8 to capture cloud clusters that have relatively sloping shapes [8].
6. Determine and identify MCC after the conditions in the procedure 1-5 above are fulfilled based on the active life of the cloud system for at least 6 hours.

3. Results

On February 8th, 2016, Pangkal Pinang Meteorological Station reported that moderate to heavy rainfall had occurred in Bangka Belitung area from February 8th, 2016 at 9:00 UTC until February 9th, 2016 at 07.00 UTC. Accumulated 24-hours rainfall on February 8th, 2016 was 183.9 mm. To find out the cloud system that was formed on that day, verification of the causes of rain was done using Himawari-8 satellite image data. On the same day, the area of the cloud that spread above Bangka Belitung region was observed and almost formed a circle pattern that lasted for more than six hours starting at 21:00 UTC around Bangka Belitung area.

Table 1. The output of satellite data processing by Image Processing Software and MCC characteristic algorithm

Month	Day	Time	Core				Coverage			
			Eccentricity	Pixel	Lon	Lat	Pixel	Lon	Lat	Eccentricity
2	8	21	0,865	5478	105,5	-1,04	8708	105,4	-0,70	0,666
2	8	21	0,878	2213	108,9	-5,24	9745	109,3	-5,36	0,876
2	8	22	0,979	8426	92,50	-2,63	27226	93,36	-2,95	0,795
2	8	22	0,948	2905	92,73	-12,39	7529	93,52	-12,70	0,789
2	8	22	0,912	5723	105,5	-1,00	17469	106,8	-2,73	0,72
2	8	23	0,980	8367	93,95	-5,10	28342	93,33	-2,84	0,882
2	8	23	0,985	3225	92,81	-12,58	7941	93,67	-12,72	0,733
2	8	23	0,994	5737	105,7	-1,08	16359	106,9	-2,38	0,636
2	9	0	0,949	7432	93,84	-5,29	28347	93,14	-2,96	0,856
2	9	0	0,910	3137	92,90	-12,72	8014	93,62	-12,75	0,61
2	9	0	0,965	6164	105,7	-1,02	10003	105,5	-0,65	0,638
2	9	1	0,926	2362	91,93	-3,58	28304	93,01	-2,70	0,863
2	9	1	0,993	2962	93,04	-12,85	6073	92,81	-13,02	0,471
2	9	1	0,882	6635	105,8	-1,01	11102	105,6	-0,70	0,649
2	9	2	0,920	2156	93,03	-13,18	5792	92,72	-13,14	0,534
2	9	2	0,927	6507	105,9	-1,06	17953	107,3	-2,29	0,727
2	9	3	0,954	2056	92,90	-13,41	5308	92,74	-13,19	0,68
2	9	3	0,919	6162	106,4	-1,23	19388	107,2	-2,09	0,817
2	9	4	0,971	6030	93,63	-6,65	15573	93,55	-6,03	0,95
2	9	4	0,946	2069	92,89	-13,52	4791	92,86	-13,37	0,684
2	9	4	0,934	6014	106,7	-1,42	20411	107,4	-2,25	0,816
2	9	5	0,988	6003	93,54	-6,63	15142	93,56	-6,171	0,958
2	9	5	0,968	1969	92,94	-13,64	4734	92,96	-13,236	0,714
2	9	5	0,993	6072	106,9	-1,58	26946	107,8	-1,036	0,766
2	9	6	0,998	6059	93,10	-6,71	15765	93,52	-6,352	0,956
2	9	6	0,985	1871	92,99	-13,73	4738	93,18	-13,20	0,645
2	9	6	0,805	6086	106,9	-1,41	28088	107,7	-1,05	0,803
2	9	7	0,883	6042	106,9	-1,22	22459	106,7	0,48	0,818

The characteristics of cloud life cycle and cloud cluster shape patterns observed were identified as the characteristics of MCC cloud clusters. The identification of MCC cloud events around Bangka Belitung region as a cause of rain was done using Himawari-8 satellite image data, which were processed

by using image processing software with an algorithm adapted to MCC cloud characteristics. This process produced several identifications of cloud clusters with blanket and cloud core area in accordance with MCC characteristics. These results can be seen in table 1 below.

Based on table 1, MCC has been detected since February 8th, 2016 at 21.00 UTC until February 9, 2016 at 07.00 UTC. The largest coverage of cloud cluster occurred at 06.00 UTC which covered 28088 pixels or approximately equal to 842.640 km² and the widest core cloud occurred at 01.00 UTC, covered 6635 pixels or 199.050 km². However, not all cloud cluster that fulfilled the characteristics of MCC's cloud coverage and core cloud could be categorized as MCC, because some of the observed cloud clusters did not grow and last more than six hours.

One of the cloud clusters that has active life cloud system more than six hours is displayed as yellow boxes in the table, which then identified as the MCC because its clusters fulfilled all the characteristics of MCC. This cloud cluster lasts from 21.00 UTC until 07.00 UTC, which mean the cloud cluster that caused heavy rainfall in Bangka Belitung start to grow at 21.00 UTC. The result of the identification can be seen in figure 2.

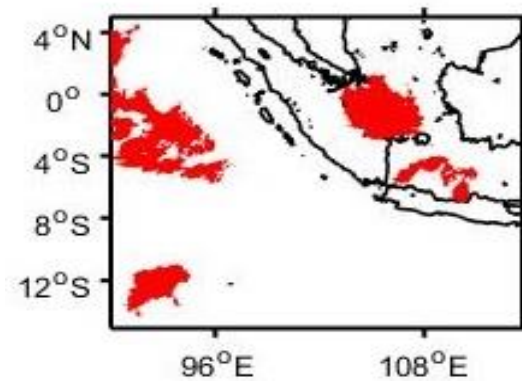


Figure 2. Satellite image of cloud cluster at 21.00 UTC

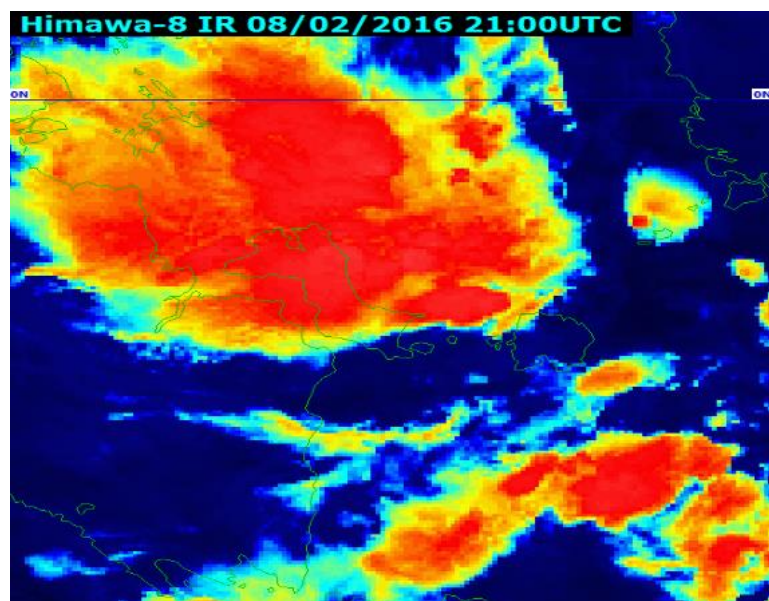
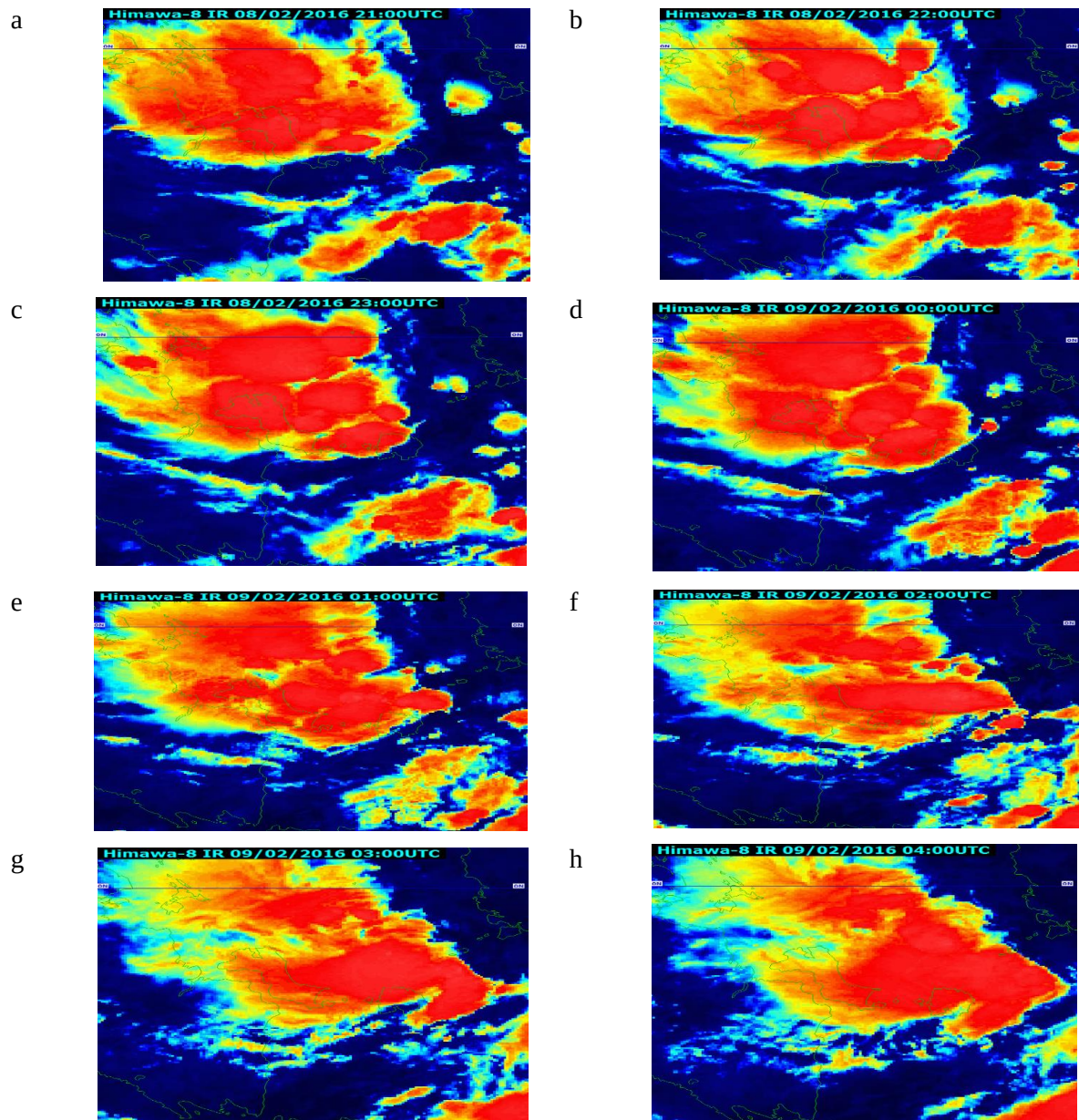


Figure 3. Himawari-8 satellite image on February 8th, 2016 at 21.00 UTC which is the beginning of MCC over Bangka Belitung which caused heavy rainfall on February 8-9, 20

From figure 2 and figure 3, it can be seen that not all cloud clusters that have the coverage more than 100.000 km² will also have the core more than 50.000 km². There are only a little number of cloud clusters that fulfilled the MCC's characteristics. Figure 2 is a Himawari-8 satellite image at 21.00 UTC which shows a cloud cluster with cloud coverage and core cloud that fulfilled the characteristics of MCC, where the pattern almost forms a circle, around Bangka Belitung.

Furthermore, to identify the cloud system that already fulfilled the MCC's characteristic, which located in 105.615 E, 0.703 S and 105.884 E, 1.011 S, its life cycle should be analyzed. The life cycle of the MCC can be seen in figure 4.



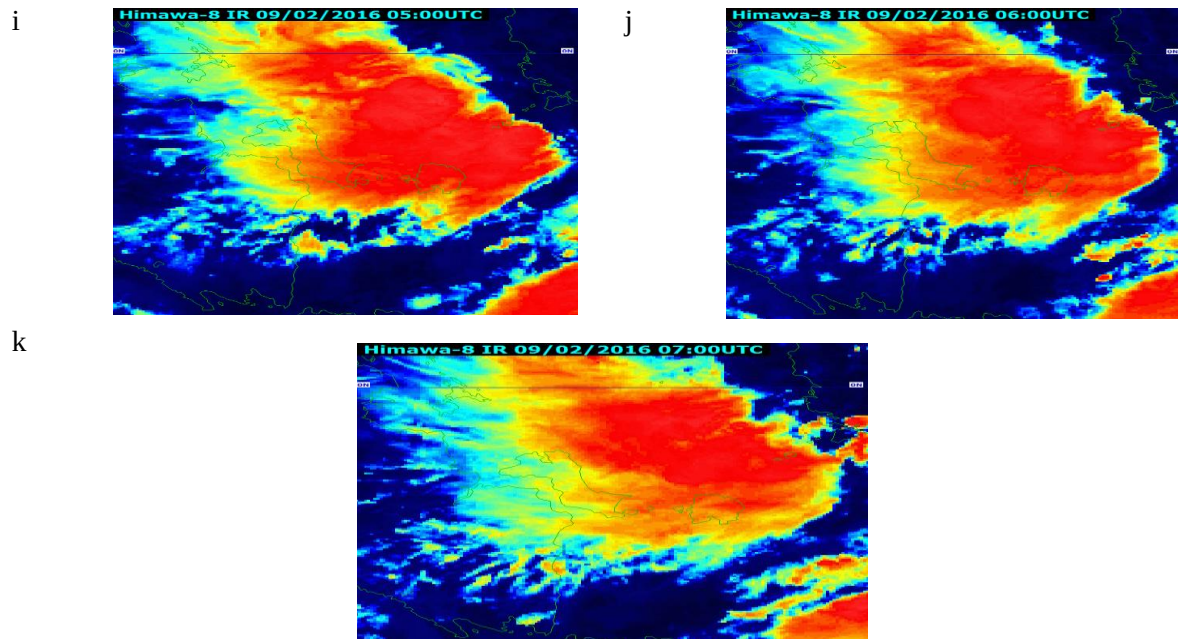


Figure 4. Output of Image Processing Software and satellite image of Himawari-8 at (a) 21.00 UTC (b) 22.00 UTC (c) 23.00 UTC (d) 00.00 UTC (e) 01.00 UTC (f) 02.00 (g) 03.00 (h) 04.00 (i) 05.00 (j) 06.00 (k) 07.00

Figure 4 shows that cloud cluster of MCC continued to develop from 21.00 UTC on February 8th, 2016 until its deployment on February 9th, 2016 at 07.00 UTC. The circle pattern was formed on February 8th, 2016 at 21.00 UTC (figure 3a), the development and the growth phase occurred since 22.00 UTC until 07.00 UTC on February 9th, 2016.

The MCC's location which being monitored from satellite image is then verified using synoptic data for every three hours using rainfall data from Pangkal Pinang Meteorological Station. The rainfall data can be seen in table 2 as below.

Table 2. 3-Hourly rainfall data from Pangkal Pinang meteorological station [11]

Date/Hour	03.00	06.00	09.00	12.00	15.00	18.00	21.00	00.00	Total Rainfall
8	4,5	53,8	56,5	47,3	1,3	1,1	3,4	16,0	183,9
9	22,8	0,8	TTU	0,0	0,0	0,0	0,0	0,0	23,6

Table 2 shows that rain had occurred even before 21.00 UTC on February 8th, 2016, but the cloud cluster that showed the formation of MCC has not been seen on the satellite processed data. Rain still continues until 07.00 UTC on February 9th, 2016 but the cloud cluster that forms a circle pattern has begun to split based on Himawari-8 satellite data which was the MCC's dissipation period.

4. Conclusion

Based on the processing of infrared channel of Himawari-8 satellite data using image processing software and algorithm that has been adapted to the characteristics of MCC, it can be shown that MCC cloud clusters have been formed with a life cycle more than six hours over Bangka Belitung area. This has verified that moderate to heavy rainfall with thunderstorms occurred on February 8th, 2016 from

21.00 UTC until February 9th, 2016 at 07.00 UTC which caused a total 24-hours rainfall of 183,9 mm over Bangka Belitung area. This condition is consistent with the previous research [4,5,8] which stating that MCC contributes significantly to rainfall almost throughout the MCC area. It is also proved that the presence of MCC as a cloud system that has a life cycle more than six hours with the possibility of integrating with other cloud system is related to the occurrence of heavy rainfall in a long duration of time around its system as happened in Bangka Belitung area.

Acknowledgements

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