Study of Mesoscale Convective Complex (MCC) and its impact over the Makassar Strait (case study: 9 December 2014)

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Abstract. A mesoscale Convective System (MCS) is a system consisting of groups of convective cells in the mesoscale. One of the largest types of MCS subclass is Mesoscale Convective Complex (MCC) which occurred in the eastern part of the Makassar Strait near the Madjene and Polewali Mandar regions on 9 December 2014, morning to evening (09.00-15.00 LT). Using MTSAT-2 Satellite Imagery data, reanalysis of the European Centre for Medium-Range Weather Forecasts (ECMWF) interim era, the Global Satellite Mapping of Precipitation (GsMap) rainfall, sea surface temperature, surface air observation, and upper air observation, the author will examine the existence of MCC in the Makassar Strait in terms of atmospheric conditions when MCC enters the initial until extinct and the accompanying effects of precipitation. In general, it is known that the MCC formed in the waters of the Makassar Strait in the morning, and then it moved westward. The mechanism of its formation was through a process of convergence of the lower layers in the waters of the Makassar Strait and its surroundings to trigger the process of cloud formation. Warm thermal conditions also gave a big influence on the lower layers to the top and activate convective in the study area. Meanwhile, the MCC occurrence region also has high relative humidity, negative divergence values, and maximum vorticity values. The impact of the emergence of MCC on that date resulted in areas with very large humidity and cloud formation and produced rain in the surrounding area, in this case using rainfall data from Hasanuddin Meteorological Station, Makassar, South Sulawesi. With a duration of up to seven hours extinct, MCC in the Makassar Strait produces heavy rainfall in the Makassar Strait waters.

Keywords: convective activity, satellite, heavy rainfall

1. Introduction
A mesoscale convective system (MCS) is generally defined as an organized ensemble of convective elements whose lifecycle is longer than that of the individual convective elements [1,2]. One of the largest types of MCS subclasses is the Mesoscale Convective Complex (MCC) which is shaped like a circle as shown in Figure 1, otherwise, it resembles a circle that is not an MCC but somewhat the shape of a squall line. This condition can change the atmospheric conditions of the region it travels through for several hours, even daily [3–6].
Figure 1. Life phase of MCC [7]

Convective elements in the MCS show variations in system levels and types depending on the large-scale environment at the time they were formed [7]. Maddox first introduced the MCC form [1] to research using infrared satellite imagery in the United States during 1978, explaining that the MCC phenomenon should have the following criteria:

a. has cloud coverage with a top temperature of IR1 ≤ -32ºC with an area of ≥ 100,000 km²;
b. the cloud core must have an IR1 cloud top temperature of ≤ -52 ºC with an area of ≥ 50,000 km²;
c. the duration met for the criteria should be ≥ 6 hours; and
d. the eccentricity form (smallest/largest axis) should be ≥ 0.7.

Such a phenomenon has been included in the mesoscale that can cause losses, especially in the area around the waters of the Makassar Strait, in the field of aviation, and offshore oil drilling. MCC is about 13% found in the Kalimantan island area [8,9]. MCC appeared first with a large frequency in the northern coastal areas of Kalimantan Island, The Southern Waters of Kalimantan, and the Karimata Strait, and then along with the evolution process, this system moves southwest to northwest [8].

The case that occurred on 9 December 2014 at 01.00 UTC (09.00 WITA), appeared MCC pattern in the eastern part of the Makassar Strait near the Madjene, and Polewali Mandar areas, seen from satellite imagery that moved into the central region of the Makassar Strait then approached the Kotabaru Waters area of South Kalimantan, causing changes in atmospheric dynamics around the Makassar Strait with the development of Cumulus (Cu) and Cumulonimbus (Cb) type clouds that are very dense. Besides, if seen before the event on the map of streamline gradient winds, in the region of South Kalimantan to the Makassar Strait formed convergence, which influenced the development of convective clouds that grow in the region.

Regarding the research discussed, MCC research in Indonesia is still rare [3,5,8,10,11]. Research about MCC was conducted in Southern Papua to find out the MCC growth characteristics, the conditions of the atmosphere, and the distribution of rainfall around southern Papua. Infrared (IR) satellite imageries show that the MCC develops up to > 300,000 km² with 14 hours of existence. The rainfall distribution from GSMaP imagery depicts an 800 km rain area with varied rainfall intensity which reaches 40 mm/hour. Atmospheric condition analysis is conducted on several parameters such as wind, relative humidity, divergence, and vertical velocity from ECMWF model data. Based on the descriptive analysis result, convergence occurs on the lower troposphere of southern Papua while the
MCC growth phase and accompanied by the high relative humidity in 850 hPa level. Time series of vertical velocity also represent that there is growth and dissipation process of MCC in southern Papua on 9-10 May 2018.

Given the differences in MCC's appearance in that period, the author tried to examine and explain the process of growth and when the MCC occurred in the Makassar Strait from its phase of life along with atmospheric dynamics patterns and the accompanying precipitation impacts using remote sensing satellite imagery.

2. Methodology

2.1. Research Data

This research used the IR1 (10.8 μm) MTSAT-2 satellite data IR channels per hour (data format “.pgm”) on 9 December 2014; the hourly rainfall estimation data from Global Satellite Mapping of Precipitation (GSMaP) on 9 December 2014; the atmospheric condition per 6-hour from European Centre for Medium-Range Weather Forecasts (ECMWF) Interim Era reanalysis data on 8-9 December 2014; and the sea surface temperature (SST) data from Marine Research Centre - Indonesian Marine and Fisheries Ministry on 8-10 December 2014. Also used observation data from Hasanuddin Meteorological Station; such as surface and upper air observation data on 8-10 December 2014.

The coordinates of the research area are limited on 0.9°-5°S and 114°-120.5°E, covering the Makassar Strait (Figure 2). The selection of the area is the area where the only one MCC case in 2014 over Makassar Strait based on the result of the MCC selecting process.

2.2. Selecting the MCC

The first step is to calibrate the IR1 satellite imagery data from the MTSAT-2 satellite (GAME) (format “.pgm”) used the calibration data (CAL) (format “.dat”), then converted to “.Dat” file. After that determinate the area and the last mapping of the location and position of the occurrence of the MCC phenomenon used MATLAB. The following are the stages of the MCC selection carried out in this research (Figure 3).
The following equation is used to calculate the MCC area (Equation 1):

\[
L_{MCC} = \left( \sum_{i=1}^{n} [x_i, y_i] \right) L_p
\]

(1)

where \([x_i, y_i]\) is the grid at the pixel position of TBB ≤ 210 K, \(L_p\) is the area of one pixel of TBB ≤ 210 K, dan \(n\) is the number of grids that met TBB ≤ 210 K.

To calculate the eccentricity of an MCC, first find the center point of the MCC using the equation of Carvalho & Jones [12] as follows (Equation 2):

\[
x_0 = \frac{\sum x_i}{N}, \quad y_0 = \frac{\sum y_i}{N}
\]

(2)

where \(x_i\) is the position of the i-th pixel on the x-axis, \(y_i\) is the position of the i-th pixel on the y-axis, \(x_0\) and \(y_0\) are center points, dan \(N\) is the total number of pixels.

Then, each pixel of latitude and longitude is projected into the new coordinates using the following equation (Equation 3-6):

\[
\alpha = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{\left(\sum x_i^2 \sum y_i^2 - \left(\sum x_i \sum y_i\right)^2\right)}
\]

(3)
\[ \beta = \tan^{-1} \alpha \]
\[ xx_i = x_i \cos \beta + y_i \sin \beta \]  \hspace{1cm} (5)
\[ yy_i = x_i \sin \beta + y_i \cos \beta \]  \hspace{1cm} (6)

where \( xx_i \) and \( yy_i \) are the new coordinates on the x-axis and y-axis, respectively.

The value of eccentricity \( (\varepsilon) \) is determined by calculating the ratio of the distance of the smallest horizontal axis value to the distance of the largest horizontal axis value using the following equation (Equation 7):

\[ \varepsilon = \frac{|xx| - (xx)|}{|yy| - (yy)|} \text{ or } \varepsilon = \frac{|yy| - (yy)|}{|xx| - (xx)|} \]  \hspace{1cm} (7)

2.3. Data Analysis
After selecting the MCC event, continue to analyze the estimated precipitation data where the MCC pattern appears and moves, using hourly estimated rain data from GSMaP. This precipitation analysis aims to determine the precipitation that occurs as a result of the emergence of the MCC system. Further analysis of the atmospheric condition using the various meteorological parameters from ECMWF reanalysis data to explain atmospheric dynamics that occur from the moment before formation (appears), entering the mature phase, or at the time of extinction.

3. Result and Discussion
3.1. The identification of the MCC system
Figure 4. The MCC over the Makassar Strait on 9 December 2014 at 01.00-07.00 UTC

MTSAT-2 captured the image of cloud clusters over Makassar Strait from 8 December 2014 and continued to develop. As in Figure 4 above, based on the criteria from Maddox [1] about the characteristics of MCC, the cloud system on 9 December 2014 at 01.00-07.00 UTC was considered as MCC phenomenon over Makassar Strait. Table 4.1 showed the evolution of the area and eccentricity of the cloud system. From 01.00 - 02.00 UTC, it was seen that the MCC initialization phase cloud began to appear over Makassar Strait. Then at 03.00 - 05.00 UTC, MCC entered the mature phase. After 06.00 UTC, the MCC cloud cluster entered a decay phase with a marked shape that did not meet the requirements for MCC.

Table 1. The evolution of area and eccentricity of MCC over Makassar Strait on 9 December 2014 at 01.00-07.00 UTC

| Month | Date | Time (UTC) | Eccentricity | Core | Lon. | Lat. | Cloudcover | Lon. | Lat. |
|-------|------|------------|--------------|------|------|------|------------|------|------|
| 12    | 9    | 1          | 0.92016084   | 3897 | 117.6147549 | -4.557800872 | 12103 | 118.66 | -5.14487268 |
| 12    | 9    | 2          | 0.927135682  | 4312 | 117.4838986 | -4.654876573 | 12335 | 118.44 | -5.039724362 |
| 12    | 9    | 3          | 0.804209421  | 4562 | 117.4156604 | -5.02753324  | 11459 | 117.95 | -4.95008727 |
| 12    | 9    | 4          | 0.944252045  | 4233 | 117.1905504 | -5.018478986 | 10381 | 117.45 | -4.671096234 |
| 12    | 9    | 5          | 0.887126346  | 3861 | 117.3090132 | -4.917819218 | 9905  | 117.36 | -4.819048936 |
| 12    | 9    | 6          | 0.704011376  | 3457 | 117.3380778 | -3.984726042 | 11274 | 117.35 | -4.60011531 |
| 12    | 9    | 7          | 0.836278098  | 3182 | 117.1305311 | -5.025125564 | 11878 | 117.34 | -4.356340293 |
3.2. Atmospheric dynamics analysis

Figure 5 below shows the global-scale parameter of atmospheric condition on 9 December 2014. The Madden Julian Oscillation (MJO) analysis on 9 December 2014 was in quadrant 7, indicating that it was actively observed in the Western Pacific region. This makes the MJO movement did not have a significant impact on Indonesia which is in quadrants 4 and 5. The El Nino and Southern Oscillation (ENSO) analysis show that the weekly average Nino 3.4 index value for 9 December 2014 was +0.9, indicating that the occurrence of weak La Nina condition tended to be neutral in the Pacific Ocean which does not have a significant effect on the dynamics of weather conditions in Indonesia in general and in particular the Makassar Strait Waters. The Southern Oscillation Index (SOI) analysis shows that the value for December 2014 was -5.0, indicating that the movement of air masses from the Eastern Pacific Ocean to the study area was insignificant so that it had less effect on weather conditions in the study area. The Outgoing Longwave Radiation (OLR) analysis show that over the Indonesian region (90°-140°E) generally had a negative OLR anomaly in mid to late December 2014, especially in the western part of Indonesia, then for the research area located at the Makassar Strait has a negative OLR anomaly about -20 W/m² up to -30 W/m². A negative OLR anomaly indicates thick cloud coverage which is associated with wet conditions (lots of rain). On the other hand, a positive OLR anomaly indicates less cloud coverage which is associated with dry conditions (less rain). Westerly Wind anomalies analysis. Westerlies usually show the effect of the wet air masses that pass through the territory of Indonesia. On 9 December 2014, the research area was dominated by the meeting between westerlies and easterlies. So that from the wind pattern caused convergence and supported the cloud formation and development.
Figure 5. The global-scale atmospheric condition on 9 December 2014; (a) RMM index for MJO analysis, (b) Nino 3.4 index for ENSO analysis, (c) SOI index for SOI analysis, (d) OLR anomalies analysis, and (e) westerly wind anomalies analysis.

Figure 6 below shows the regional-scale parameter of atmospheric condition on 8-9 December 2014. The gradient wind analysis shows that one hour before the MCC system in the Makassar Strait was active, there was a vortex over the Philippines region getting stronger and the vortex being formed over the Timor Sea region. The combination of the two vortices then forms a shear-line along the Kalimantan region and forms a more robust convergence pattern, the convergence area occurs from the western waters of Bengkulu, the Java Sea to the Makassar Strait. This convergence and shear-line pattern results in air masses in the area of influence and can trigger convective clouds. This factor causes the formation of a convective system in the Makassar Strait area. Winds were generally moving from the northeast, carrying air masses from Asia. The SST analysis shows that on 8 December 2014, a day before the MCC system appeared over Makassar Strait, the west coast of Sulawesi showed warm SST values. This condition persisted on the following day on 9 December, which made the area support the atmospheric dynamics for the formation of convective cloud cells in the waters, which
became the beginning of the formation of the MCC system. Warm SST is a good source of water vapor to support the convective process of MCC growth.

![Figure 6](image1.png)

**Figure 6.** The regional-scale atmospheric condition on 8-9 December 2014; (a) streamline analysis, (b) SST analysis

![Figure 7](image2.png)

**Figure 7.** The local-scale atmospheric condition on 9 December 2014; (a) CAPE analysis, (b) HCC analysis, (c) 850 hPa streamline analysis, (d) 850 hPa vertical velocity, (e) 850 hPa vorticity analysis, (f) 850 hPa divergence analysis, (g) 850 hPa relative humidity analysis

Figure 7 above shows the local-scale parameter of atmospheric condition on 9 December 2014. At 00.00 UTC showed a greater value than 6 hours before at a value of 600 - 1000 J/kg where the concentration of CAPE values was centered at the southern Makassar Strait and waters near Balikpapan. This condition indicated moderate convection in the lower layer, which can be indicated
as a convective cloud cell nucleus, and the unstable air conditions in the atmosphere, which supported the formation of convective clouds as the beginning of the MCC system over Makassar Strait. At 06.00 UTC, the CAPE value in the Makassar Strait has decreased quite significantly at the value of 200 J/kg, indicating stable atmospheric conditions in the area. At 12.00 UTC, the CAPE value was not much different from the last time and increased again at 18.00 UTC became about 500-700 J/kg.

The high cloud cover (HCC) index is used to determine the distribution of high cloud cover, and it can also be used to identify low-layer cloud types, especially Cb clouds whose growth can touch high-layer clouds. From 8 December 2014 at 18.00 UTC, the HCC value was relatively high, about 80-90%. Then, on 9 December 2014, the HCC value increased to 93-99%. That was the indication that there were Cb cloud clusters over Makassar Strait. The condition of the Cb cloud on this date was appropriate and triggered the MCC system phenomenon that occurred on 9 December 2014 at 01.00-07.00 UTC.

The streamline analysis shows that based on 925 and 850 hPa (lower troposphere) wind flow pattern at 00.00 UTC on 9 December 2014 showed the convergence pattern in the central part of the Makassar Strait with wind speed ≤ 10 knots in the MCC research area with a dominant wind direction from the west. The mechanical process of convergence is one of the triggers of convective clouds (Cb) in the lower layer [17]. Besides that, there was also a cyclonic circulation pattern found at 500 hPa (middle troposphere) streamline that supported the convective cloud development. While at 200 hPa (higher troposphere), the wind pattern showed that dominant wind direction from the east with a wind speed less than 18 knots. Then, at 06.00 UTC as the mature phase of MCC, the wind flow pattern did not change much, but the convergence pattern shifted slightly to the south area of Makassar Strait.

The vertical velocity analysis shows that when entering the MCC initialization phase, generally, the vertical velocity showed a negative omega value which was getting bigger in each layer. When MCC entered the mature phase, the vertical velocity values from the lower layer to the upper layer showed a negative value which was getting more prominent in each layer. This condition explained that there had been an upward vertical air movement to a lower pressure level, indicating significant convective cell growth and could be identified as a mature convective cloud cluster. This condition is supported by a powerful updraft process when the convective cloud cells entered the mature phase so that the height of the cloud reached the higher layer.

The vorticity shows that before entering the MCC initialization phase, it was seen that the vorticity value from the lower to the upper layer had a significant negative value. This condition explained that in the research area located in the southern hemisphere, the air moved upward and formed a cyclonic pattern in these layers. When the MCC mature phase, the vorticity value changed for the lower to the middle layers. At which 06.00 UTC, the vorticity value was in the negative range, but less than six hours before. This indicated that it was raining. Entering the decay phase, the value of vorticity became neutral, indicating that the convective cells that form the MCC system in the Makassar Strait had decayed.

The divergence shows that before entering the MCC initialization phase, the divergence value in the study area showed a negative value in the lower layer, indicating the condition of low-level convergence, which then moved upwards and supported the cloud formation process. Meanwhile, the divergence value in the upper layer was in the positive range, showed that the air in the upper layer tended to be scattered. At the mature phase, the divergence value was in the positive range from lower to middle level of troposphere, so that indicating convergence movement and then moved upward increasingly supported the convective cloud growth. While, on the upper level, the divergence showed
a positive value. Entering the decay phase, the divergence value showed a neutral value indicating the MCC system was no longer developed.

The relative humidity show that when MCC was in the mature phase, the humidity conditions in the lower atmosphere to the upper layer did not show a significant change, and it could be seen that the RH in the study area was above 90%, and the upper layer showed that the RH value exceeded 100% which indicating supersaturated air conditions. The RH value indicated a very saturated air condition and explained that at that time, the MCC system was in a mature phase. This condition did not show a significant change when MCC entered the decay phase.

3.3. Rainfall analysis
Based on the GSMaP product on 9 December 2014 (Figure 8), when the MCC in over Makassar Strait entered the initialization phase, about 01.00-02.00 UTC, the resulting rainfall was around 10-20 mm, the maximum rainfall was recorded around 33 mm near the Pare-pare area. Rainfall at the mature phase about 03.00-05 UTC had shifted and was concentrated in the central area of the Makassar Strait, with rainfall reaching 6-15 mm and maximum rainfall recorded at 27 mm in the Mandalle area, where at 05.00 UTC showed the most extensive precipitation impact when MCC was in its mature phase. Meanwhile, the rainfall at the decay phase about 06.00-07.00 UTC was increasingly shifted to the southern region of Kalimantan with values ranging from 6-10 mm, and the maximum rainfall shown by the GSMaP product was around 16 mm.

![Figure 8](image)

Figure 8. Spatial-rainfall distribution over Makassar Strait on 9 December 2014

3.4. Observation data analysis
The radiosonde data was retrieved from Hasanuddin Meteorological Station’s upper-air observation. Based on the graph of air temperature (°C), dew point (°C), and humidity (%) of the radiosonde data for each layer, it showed on 9 December 2014 at 00.00 UTC the graph of air temperature, and the dew point was closely coincided, indicating that the humidity of the air was very humid with lots of water vapor availability, so that it indicated the growth of convective clouds which very strong and had the
potential triggering the initialization of the MCC phenomenon. The same situation can be seen at 12.00 UTC, the temperature graph and the dew point coincided, resulting in a significant RH value with a value of 100% indicating a supersaturated air condition. The RH value indicated a very saturated air condition. It explained that at that time, when the MCC system was in the decay phase, the atmosphere was still humid, indicating there was still cloud development. This was appropriate to the lapse rate calculations that the atmospheric conditions at that time were unstable.

![Figure 9](image.jpg)

Figure 9. Upper air observation data from Hasanuddin Meteorological Station; (a) 8 December 2014 at 00.00 UTC, (b) 8 December 2014 at 12.00 UTC, (c) 9 December 2014 at 00.00 UTC, (d) 9 December 2014 at 12.00 UTC

Based on atmosphere stability index (Table 2) show that on 9 December 2014 at 00.00 UTC and 12.00 UTC, the LI values of -0.9 and -1.1 indicated the possibility of a thunderstorm, then the K index values of 37.3 and 33.5 indicated that at 00.00 UTC, the formation of unstable air and the potential for a thunderstorm phenomenon were 80-90%. Then, the SI index showed a value of -0.4 and 1.5, indicating that the stability of the air in the medium layer was probably a thunderstorm. Furthermore, the TT indexes of 44.8 and 40.9 indicated that there was a potential thunderstorm activity. The SWEAT index value showed 203.7 and 228.2 indicated that the air condition was relatively stable at that time. Then, the CAPE index had a value of 121.9 and 446.4, indicating that the potential for atmospheric lability at that time was considered weak and was in the stable category. Thus, according to the air stability index for 9 December 2014 at 00.00 UTC and 12.00 UTC, it had the potential for air stability in the stable category.

| Date          | Time (UTC) | LI  | KI  | SI  | TT   | SWEAT | CAPE  |
|---------------|------------|-----|-----|-----|------|-------|-------|
| 8-10 December |            |     |     |     |      |       |       |

Table 2. Atmosphere stability index based on Radiosonde Data from Hasanuddin Meteorological Station on 8-10 December 2014
The surface observation data from Hasanuddin Meteorological Station show that when MCC began to appear and developed, the air temperature chart explained that at the beginning of the observation, the air temperature experienced a fluctuating movement of decline then rose slowly until it fell back down in the next hour, it could be seen at 00.00-09.00 UTC. When the air temperature fluctuated then rose slowly until it fell again, the air pressure graph showed the opposite condition, and it increased then decreased slowly until it rose again in the same hour. Such conditions indicated the formation of a cloud growth process that had the potential to produced rain. This was following the conditions when the MCC phase entered the initialization stage, mature, until decay phase over the Makassar Strait area.

The hodograph analysis (Figure 10) shows that when MCC appeared, that the lower layer of the hodograph on 9 December 2014 at 00.00 UTC had an anticyclonic (anti-clockwise) circulation direction characterized by warm advection characteristics in the region. Meanwhile, the upper layer showed the direction of the cyclonic circulation (clockwise) with the characteristic of having cold advection characteristics, so that the wind in each layer was primarily stable. Due to warm advection at the lower level, and in the upper layer, there was cold advection.

3.5. Discussions

Based on the results, it can be seen how the atmospheric conditions when the MCC phenomenon appeared over the Makassar Strait area on 9 December 2014. The MCC system appeared due to the dominant influence of regional and local scales. When viewed from the wind field analysis showed that there were a convergence zone and a shear-line area over Makassar Strait waters which had been seen an hour before the MCC appeared. The resulting air masses in the surrounding area triggered the formation of convective clouds. This condition was also influenced by the west monsoon wind that
activated in December, thus increasing the potential for the formation of rain clouds which were thick clouds accompanied by shear and convergence areas. Then, from the SST condition, it showed that the Makassar Strait area had a relatively warm SST, either before, during, or when the MCC system decayed. These conditions also affected the initialization of the MCC system in that area.

Based on the local scale analysis in the analysis section of the Hasanuddin Meteorological Station radiosonde observation data on 8-9 December 2014, it was explained that the graph of air temperature and dew point per layer looked very coincidental, indicating that the humidity of the air is very humid with a lot of water vapor availability so that it indicated a convective cloud growth very strong and had the potential to trigger the emergence of the MCC phenomenon. Based on the analysis of surface air observations, it showed the air temperature conditions, which also supported the formation of clouds. These results about the atmospheric dynamics related to the MCC phenomenon are similar to Perdana et. al. [13].

Then from all the explanations above, it can be seen that in the case of MCC, which appeared and moved westward on 9 December 2014 in the morning, the formation mechanism was through the convergence process of the lower layers in the Makassar Strait waters and its surroundings, thus triggering the cloud formation process. When compared with the concept in subtropical areas based on the study, the MCC phenomenon over Makassar Strait was similar because there were also areas having humid RH, negative divergence values, and maximum vorticity values in the area where MCC occurred. The impact of the emergence of MCC on that date resulted in areas with a significant humidity accompanied by cloud formation and producing rain in the surrounding area, in this case using rainfall data from Stamet Hasanuddin, Makassar, South Sulawesi. With a duration of initialization to decay phase of up to seven hours, the MCC over Makassar Strait produced heavy rainfall in the waters of the Makassar Strait and around the Makassar mainland with the recorded rainfall on 9 December 2014.

4. Conclusions
The growth process of MCC began with the influence of a regional scale and a local scale seen from the convergence area and shear-line from the West Sumatra, Java Sea, Bali to the Arafura waters. This condition was supported by SST in the waters of the Makassar Strait and the formation of disturbances in the form of vortices in the Philippines and the Timor Sea so that at that time, it can trigger the growth of elements of convective clouds to form the MCC system. The changes when entering the decay phase were marked by a weakening of the convergence area, then a less humid humidity value, and less heating on the surface compared to when MCC entered the mature phase. This was what made MCC entered a decay phase. The resulting precipitation impact was recorded on GSMaP with a maximum rainfall of 33 mm per hour in the central part of the Makassar Strait and was recorded in the surface air observation of the Hasanuddin Meteorological Station, Makassar on 9 December 2014 at 1.8 mm, including as the light rain according to the BMKG rainfall category.

References
[1] Maddox R A 1980 Mesoscale convective complexes Bull. Am. Meteorol. Soc. 1374--1387
[2] Holton J R 2004 An Introduction to Dynamic Meteorology: Fourth Edition ed R Dmowska, J R Holton and H T Rossby (California: Elsevier Academic Press)
[3] Trismidianto and Satyawardhana H 2018 Mesoscale Convective Complexes (MCCs) over the Indonesian Maritime Continent during the ENSO events IOP Conf. Ser. Earth Environ. Sci. 149
[4] Trismidianto, Hadi T W, Ishida S, Moteki Q, Manda A and Iizuka S 2016 Development processes of oceanic convective systems inducing the heavy rainfall over the western coast of Sumatra on 28 October 2007 Sci. Online Lett. Atmos. 12 6–11
[5] Rinaldy N, Saragih I J A, Wandala Putra A, Redha Nugraheni I, Wijaya Yonas B, Putra A W, Nugraheni I R and Yonas B W 2017 Identification of Mesoscale Convective Complex (MCC) phenomenon with image of Himawari 8 Satellite and WRF ARW Model on Bangka Island (Case Study: 7-8 February 2016) *IOP Conf. Ser. Earth Environ. Sci.* **98** 7–8

[6] Putri N S, Iwabuchi H and Hayasaka T 2018 Evolution of Mesoscale Convective System Properties as Derived from Himawari-8 High Resolution Data Analyses *J. Meteorol. Soc. Japan*

[7] Wallace J M and Hobbs P V. 2006 *Atmospheric Science: An Introduction Survey* (Elsevier)

[8] Ismanto H 2011 *Karacteristik kompleks konvektif skala meso di benua maritim* (Institut Teknologi Bandung)

[9] Ismanto H 2013 Distribusi Spasial dan Temporal Mesoscale Convective Complexes di Benua Maritim *Megasains* **4** 74–81

[10] Nuryanto D E, Pawitan H, Hidayat R and Aldrian E 2018 Simulation of Mesoscale Convective System Propagation in Greater Jakarta during 13 - 19 January 2014 *IOP Conf. Ser. Earth Environ. Sci.* **187** 0–10

[11] Putri N S, Hayasaka T and Whitehall K D 2017 *The Properties of Mesoscale Convective Systems in Indonesia Detected Using the Grab ‘Em Tag ‘Em Graph ‘Em (GTG) Algorithm* vol 95

[12] Carvalho L M V and Jones C 2001 A Satellite Method to Identify Structural Properties of Mesoscale Convective Systems Based on the Maximum Spatial Correlation Tracking Technique (MASCOTTE) *J. Appl. Meteorol.* **40** 1683–701

[13] Perdana I F P, Rismana Y I, Prasetya F A and Mulsandi A 2019 Studi Kejadian Mesoscale Convective Complex (MCC) di Wilayah Papua Bagian Selatan pada 9-10 Mei 2018 *J. Meteorol. Klimatologi dan Geofis.* **6** 58–66