A composite analysis of the Mesoscale Convective Complexes (MCCs) development over the Central Kalimantan and its relation with the propagation of the rainfall systems

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Abstract. The composite analysis for 45-cases of the MCC which identified by using infrared satellite imagery over the Central Kalimantan (110° - 116°E, 4°S - 1°N) has been observed. The data used is a combination of satellite data and reanalysis data. This study reported that the MCCs develops triggered by the orographic convective that helped by the convergent surface wind flow through interaction with the sea breeze in the afternoon until midnight and dissipated in the morning. The new convective systems are generated by the divergent outflow of the cold pool, in conjunction with the morning land breeze during MCCs mature. After dissipated, the new convective systems induce the land convection over the Java Island that became heavy rainfall. The initial and mature region are characterized by weak low-level convergence and upper-level divergence, but the low-level divergence begin appear during mature. The MCC develops largely driven by MCC-scale moisture convergence in the lower troposphere and cold core structure in the lower level. The weak surface divergence and upper-level divergence, warm advection in the lower atmosphere are dissipation characteristics. MCCs develop due to low-level cold advection and temperature and separated when dissipated that indicate the existence of the new convective systems propagation.

1. Introduction
Prior to 1980, the study of convective activity at the mesoscale level had been limited to tropical phenomena like cloud clusters, squalls and hurricanes, midlatitude squall lines and land-sea breeze systems. In 1980, Robert A. Maddox introduced the concept of the MCC (hereafter MCCs) after a careful study of satellite IR images over the central United States during 1978. MCCs are a special case of mesoscale convective systems (hereafter MCSs), where MCSs are generally defined as an organized ensemble of convective elements, whose lifecycle is longer than that of the individual convective elements, and the largest of the convective storms. Maddox [1] original definition stated that MCCs have cloud shield with continuously brightness temperature or black body temperature (hereafter T_{BB}) $\leq -32^\circ$C or 241 K must have an area $\geq 100,000$ km$^2$ and the interior cold cloud T_{BB} $\leq -52^\circ$C or 221 K must have an area $\geq 50,000$ km$^2$ for over six hours, although the cloud shield does not have to maintain an eccentricity of $\geq 0.7$ for its entire life cycle. The eccentricity is also important to distinguish MCC from the other MCS types, for example; squall line, bow echo, cloud cluster, and the others. The areal
extent and eccentricity values were used to determine the duration and life cycle of the MCCs, while the centroid position indicated the path of propagation of the systems.

The large-scale environment is very effect to the development of MCCs. Laing and Fritsch [2] is also found that MCCs around the globe typically form near a maximum in low-level shear, lending support to the idea that low-level shear may be important for the development of long-lived MCSs. And also globally, MCCs tend to initiate in locations where there is: (1) a low-level jet (LLJ); (2) a low-level convergence; (3) upper-level divergence; (4) an approaching mid-level vorticity maximum (associated with a weak short wave trough). The early stage of the MCC lifecycle is characterized by convergence, vertical motion, and heating being centered in the lower troposphere. The systems achieve and maintain its maximum divergence, upward motion, and anticyclonic vorticity in the upper troposphere during the latter half of the life cycle [4]. The MCC typically forms in association with a weak mid-tropospheric short-wave trough and a weak surface front or outflow boundary. Its environment often exhibits pronounced low-level temperature and moisture advection in association with a well-defined low-level jet [3][4][5].

In generally, the previous researcher found that some area has environment are very similar and exhibit many of the same dynamic and thermodynamic structure that is present with systems but several areas has different environmental condition during MCCs event. It is interesting to analyze the environmental condition during MCC that occur over IMC and compare its result with the previous work in several regions due to the analyses about that is not well understood. A Recent study by Trismidianto et al. [6] also reported that several convective systems were generated during the decay stage of the MCC over the Indian Ocean (hereafter IO) because of convergence between the land breeze and westerly wind. The new convective systems around the decaying MCC were generated during MCC event, and they propagated to the surrounding area because of the divergent outflow from the cold pool (hereafter CP). The combination of the land breeze and the CP outflow from the decay MCC was a significant factor in the formation of the convective system that caused the heavy rainfall. Therefore, the goal of this paper is to analyze the development and movement of MCC using composite analysis with taking the 45-cases of MCC over Central Kalimantan (hereafter CK).

2. Data and Method

To identify the MCC in this study, we use $T_{BB}$ from the Himawari geostationary satellites, operated by the Japan Meteorological Agency (JMA) that consists of Himawari-5/GMS-5 for data from January 2001- April 2003, Pacific GOES/GOES-9 for data from May 2003- June 2005, Himawari-6/MTSAT-1R for data from July 2005 - June 2010, Himawari-7/MTSAT-2 for data from July 2010 - June 2015, and Himawari-8 for data from July 2015 - December 2015. That satellite data has spatial and time resolutions 0.05°×0.05° and one hour, respectively. This paper adapts the method from Ismanto [7] and Trismidianto [8] that based on the maximum spatial correlation tracking technique (MASCOTTE) method by Carvalho and Jones [9] and almost similar way with Laing and Fritsch [10] to identify MCC with input the temperature, latitude, and longitude values for each cloud shield pixel that obtained from IR to a modified version of a computerized MCC program using MATLAB for measuring the satellite-observed characteristics of the MCCs by Maddox [1] as described in introduction section.

To explain the evolution and propagation of the MCCs in this study is utilized composite analysis that adapted from McAnelly and Cotton [11][12]. The focus of this study is to the analysis of 45-cases of the MCC which occurred in the same area center over CK (110°E - 116°E, 4°S - 1°N), in the next will be mentioned as MCCs composite. In the composite category, MCCs composites are considered to have common composite times of initiation, mature, decay and dissipation. Besides the similarities in genesis region, maximum area, and mature duration, the MCCs in each category were reasonably consistent in term of other $T_{BB}$ characteristics. These include: the duration of initiation to mature stage, mature to decay and decay to dissipation or post-MCC stage. The composite for initiation, mature, decay and dissipation are determined by the average the hour of initiation, mature, decay and dissipation for each MCC, around to the nearest hour. In the first, we determined the average the hour of the initiation of all case in each region, and then plus 1, 2 or 3 hours until reaches the average the hour of mature, the same
way until reaches the average the hours of dissipation or post-MCC. So that, the average from initial-
to-maximum, maximum-to-dissipation with 1, 2, or 3 duration time.

The estimated rainfall data, corresponding to the MCCs, were obtained from the Real Time Tropical
Rainfall Measuring Mission’s (TRMM) Multi-Satellite Precipitation Analysis (TMPA-RT) v7
data set, which has hourly temporal resolution and 0.25° × 0.25° spatial resolution [13]. To analyse
the surface wind is utilized several data from Cross-Calibrated Multi-Platform (CCMP), which are available
at 6-hourly intervals with 0.25° horizontal resolution and the environments condition during MCC event
is utilized several data from the European Centre for Medium-Range Weather Forecasts (ECMWF)
ERA-Interim analysis fields, which are available at 6-hourly intervals with 1° × 1° horizontal resolution
[14]. Maddox [3] presents a summary of environmental conditions for MCC generation and
development in the USA using a composite of the wind and thermodynamic fields. Cotton et al. [4] also
reported the environmental condition during MCC over the USA using composite model. This study
adapts the method like them to analysis the MCC development. The composite analysis of the
environmental condition is just analyzed during the critical stage of MCCs, i.e., initial, mature and
dissipation stage which following the data available in 6-hourly at 0000, 0600, 1200 and 1800 UTC. In
this study, we consider the data on time in 2300, 0000 and 0100 UTC as the time on 0000 UTC, and the
data on time in 0500, 0600 and 0700 UTC as the time on 0600 UTC, while the data on time in 1100,
1200 and 1300 UTC as the time on 1200 UTC, and the data on time in 1700, 1800 and 1900 UTC as the
time on 1800 UTC.

3. **Result and Discussion**

3.1 **Composite analysis of the MCC evolution.**

The life-cycle of the MCCs composite has been quantified by the composite analysis as shown in figure
1. On average, the evolution of the development of the MCCs composite began in the late afternoon
at around 1900 LT. The MCC that generated by the orography along the mountain in the northern of the
MCC area is one of the contributors to the development of the MCC as shown in figure 1(a) and (b).
The system reaches the maximum size around 4 hours from the initiation. The mature stage of the MCC
occurs in midnight around 0100 LT as shown in figure 1(c) and (d). This system might be able to survive
for 4 hours in maximum size and will begin decayed at around 0400 LT - 0700 LT as shown in figure
1(e) and (f). MCCs became dissipated in the early morning at around 1000 LT - 1100 LT (figure 1(g)
and (h)). However interesting for the analyzed from this MCCs development is the existence of
convective clouds over the Java Island and southern Sumatra after a few hours of the MCC dissipated,
as shown in figure 1(i), (j), (k) and (l).

![Figure 1](image_url)

**Figure 1.** Horizontal distribution of composite of the T_{BB} for MCCs composites: (a), (b) Initial stage
(around 1800 LT and 2000 LT), (c),(d) mature stage (around 2300 LT to 0100 LT), (e),(f) decay stage
(around 0400 LT and 0700 LT), (g),(h) dissipation stage (around 1000 LT and 1100 LT), (i) post-MCC
stage (1400 LT) and (j), (k), (l) a few hours after post-MCC stage. The time illustrates the average
timing of the hours of initiation, mature, decay and dissipation for the 45-case composite in region 3 in term of the normalized life cycle using composite analyses. Unit for $T_{BB}$ is Kelvin.

Figure 2. Same with Figure 1 but for horizontal distribution of rainfall (shaded) from TRMM TMPA-RT 3B41RT v7 data. Unit for rainfall is mm/hr.

Figure 2 shows that most of the MCC composites were developed by the orographic rainfall as shown in figure 2(a) and (b). During the MCC reach maximum size, the rainfall system also reaches the peak value, on average around more than 6 mm/hour as shown in figure 2(c) and (d). The intensity of the rainfall began decreased during the MCC start decayed (figure 2(e) and (f)), but new rainfall clouds begin generated during the MCC dissipated as shown in figure 2(g) and (h). Even the new rainfall clouds were propagated until to Java Island and make the rainfall over Java Island after a few hours from MCC dissipated. The comparison figure 1 and 2 shows that there is relationship about the MCC to the rainfall system over the CK, similar with Trismidianto et al. [6] that have been found the MCC over the IO influencing the rainfall over Sumatra Island.

3.2 The propagation of rainfall systems during MCC events

Figure 3 shows the horizontal distribution of rainfall, wind surface vector anomaly, and surface potential temperature (theta) during the initial, mature, decay and post-MCC stage of the MCC composites. Figure 3(a) shows that during the initial stage in the evening around 1900 LT, the convergent surface wind flow that indicated as the westerly wind from Sumatra, northerly wind from South China Sea and the southerly wind from Java triggered convection through interaction with the strong sea breeze circulation and through the topography lifting effect as a mountain breeze from the north. This consistent with several previous papers that stated the complex topography of the IMC leads to strong land–sea breeze circulations, with integral convection and precipitation over Borneo/Kalimantan Island [15]. During the mature stage of the MCC in midnight around 0100 - 0200 LT based on the composite analysis (figure 3(b)), the convergent wind begin weakened and seen the divergent wind from the leading edge of MCC system. Perhaps that is due to by the CP where the surface theta at the center of the MCC was also relatively low (at around 297.5 K) compared with the surrounding area (298–300 K). According to Engerer et al. [16], this area is the so-called CP, which is an area of downdraft air cooled by evaporation that spreads out horizontally beneath a precipitating cloud. In addition, the CPs were associated with theta decreases [17] and generated by these individual convective cells in an MCS typically spread out over the surface and combine to form a large mesoscale CP covering a contiguous area on the scale of the entire MCS [18]. Trismidianto et al. [6] also reported that the existence of new convective systems generated by the CP during MCC system over the IO.
The CP still see clearly during the MCC decayed which indicated by the existence of the theta decreases in the leading edge of the MCCs system as shown in figure 3(c). The difference in surface theta could have acted as a trigger for the development of new convective systems to form along the leading edge of the CP, which is consistent with the findings of Wilson and Schreber [19]. The several of new rainfall clouds begin developed on the leading edge of the MCCs, which are generated by the CP in the below of MCC system. The new rainfall cloud begins propagated to the surrounding area of the MCCs system due to of the divergent outflow of the CP, in conjunction with the morning land breeze. The divergent wind becomes stronger after the MCC dissipated due to the existence of the mountain breeze as shown in figure 3(d). The rainfall system propagates toward to the Java Sea, this is possible make the rainfall system over Java are more extensive during the evening (1900 LT) after a few hours from MCC dissipated due to the new convective systems induce the land convection over the Java Island as shown in figure 2. Moncrieff and Miller [20] that factors other than the strength of the shear and the CP affect the structure, organization, and longevity of the MCSs or/and MCCs. Therefore, this study gave a deeper insight into the mechanism of the propagation of rainfall system during MCC event. The structure and evolution of the MCC composites are related to the rainfall system.

3.3 Analysis of the environmental condition during MCC

3.3.1 Conditions over the initial region

During the MCC initial stage, the initial region is characterized by weak low-level convergence (surface to ~750 hPa) with a deep layer of a weak divergence (figure 4(a), (b), (c) and (d)). The strong wind convergence in the surface level is very clearly from the north. This is similar with MCC in USA that has been found by Maddox [3] and Cotton et al. [4], they stated that the early stage of the MCC life cycle is characterized by convergence, vertical motion, and heating being centered in the lower troposphere. An important area of convergence can be seen over the center of the MCC area in the black box but that is weak convergences. The initial region is characterized by a short-wave trough pattern of the geopotential height in surface and the low-level (figure 4(a) and (c)). The short-wave trough is also very clearly in temperature field at 850 hPa (figure 4(b)). Figure 5(b) also shows that the relative humidity is higher than the surrounding area and MCC became an alow-temperature center in the level of the 850 hPa which consistent with the Maddox [3].
Figure 4. Composite analysis of the MCC composites during initial stage using ECMWF ERA-Interim data, showing (a) 1000-hPa divergence ($10^{-5}$ s$^{-1}$, shaded), 1000-hPa geopotential height (m, contour) and 1000-hPa wind vector (m/s, vector); (b) 850-hPa relative humidity (% shaded), 850-hPa temperature (K, contour) and 850-hPa wind vector (m/s, vector); (c) 850-hPa geopotential height (m, contour), 850-hPa moisture flux convergence ($10^{-3}$ g kg$^{-1}$ s$^{-1}$, shaded) and 850-hPa wind vector (m/s, vector); (d) 700-hPa moisture flux convergence ($10^{-3}$ g kg$^{-1}$ s$^{-1}$, shaded), 700-hPa geopotential height (m, contour) and 700-hPa wind vector (m/s, vector); (e) 500-hPa geopotential height (m, contour) and 500-hPa vorticity ($10^{-6}$ s$^{-1}$, shaded) and 500-hPa wind vector (m/s, vector); (f) 200-hPa divergence ($10^{-5}$ s$^{-1}$, shaded), 200-hPa geopotential height (m, contour) and 200-hPa wind vector (m/s, vector).

The 850 hPa geopotential field and moisture flux convergence (hereafter MFC) shown in figure 4 (c). The initiation of the MCCs is largely driven by MCC-scale moisture convergence in the lower troposphere which is then transported to the midlevel, even up to upper levels through deep convection as shown in figure 4(c) and (d), but the moisture convergence in upper levels is not shown in this study. The initial region is characterized by the region between the positive/negative patterns of the MFC. This region seen clearly at the level of 700 (figure 4(d)), this condition shows that possible to generate the deep convection in this area as initial development for MCCs. MFC is high at a surface level over the mountains that contribute to the development of the MCCs in the CK. The short-wave trough is very clearly in the initial region at 700 hPa as shown in figure 4(d). The southwesterly jet is not clearly seen at 850 hPa but the mid-level jet to the south from the north is clearer (figure 4(c) and (d)). This is a contrast with Cotton et al. [4] and Maddox [3] that shows the strong low-level jet over the initial region. The strong positive vorticity at 500 hPa over the MCCs area indicates counterclockwise rotation of the wind and it is associated with cyclones or storm at upper levels as shown in figure 4(e). This is similar with Maddox [3] that stated the composite MCC initially exhibits strengthening cyclonic vorticity confined within the surface to 700 hPa layer and anticyclonic vorticity located exclusively in the upper troposphere and Laing and Fritsch [10] that stated the MCC in the USA develops just to the northeast of the weak cyclone at 1000 hPa. The divergence on the upper level is weak over the initial region of MCC as shown in figure 4(f). The presence of a low-level convergence and upper-level divergence couplet helps in maintaining the inflow and outflow of mass necessary for long periods of sustained deep convection, while the attendant release of latent heat further enhances the low- to mid-level
convergence, thus continuously providing fuel for the MCC systems. But the latent heating is not shown in this study.

3.3.2 Condition over the mature region
Figure 5(a) shows the weak convergence at surface level is still presented during mature stage, but seen clearly the weak divergence in the western and eastern leading edge in the mature region, this is indicates that possibly due to the CP exist in the surface below of MCC system that make the surface wind divergence in the leading edge. However, Maddox [3] stated that the low-level divergence seen in the mature stage show the low-level downdraft on mature stage. The MCC has left the region of surface convergence and the mature region is characterized by weak divergence. The short-wave trough is still clearly seen in the mature region at surface level. The relative humidity is still high more than 88% during at this stage (figure 5(b)), by the mature stage nocturnal cooling, and evaporatively chilled mesohigh at the surface effectively decouple the MCC from the boundary layer, and the system is sustained by convectively unstable air from 900-700 hPa. The MCC exhibits a cold-core structure at surface level (figure 5(b)). This is similar with MCC in the USA by Maddox [3]. The tropopause cooling and rising reach their maximum intensity at the mature stage, reflecting the contribution of mesoscale ascent and longwave radiative cooling by the upper-level cloud shield.

Figure 5(c) and (d) shows the geopotential height and MFC over 850 hPa and 700 hPa, respectively. The region of the positive/negative pattern of the MFC is very clearly at 850 hPa and become stronger in the middle level, according to Maddox [3]. The MCC is maintained by intensified mid-level convergence in association with developing mid-level cyclonic shear. The negative of MFC in surrounding area of the mature region shows that the downdraft motion start occurs below 700 hPa. The short-wave trough of geopotential height is still clearly seen at 850 hPa and 700 hPa. The strong wind convergence flows from the northeastern toward the mature area, and there are change the motion of the wind significantly from the north to the south cross the mature region at mid-level 700 hPa. Figure 5(e) show the weak positive vorticity during the mature stage, but the vorticity is located in between the two area of negative vorticity, this condition indicates the existence of cyclones or storm at the upper level. The upper-level jet stream and strong divergence are presented during the mature stage that produced by storm's divergent outflow as shown in figure 5(f).

Figure 5. Same with figure 4 but for the time of MCC mature stage.

3.3.3 Condition over the dissipation region
The dissipation region is characterized by the strong surface divergence as shown in figure 6(a). The convergence is start left the MCC area, is similar to Cotton et al. [4]. The strong convergence is presented
in the south of dissipation region (on Java Island) so that the strong convergent wind toward to Java Island. At 850 hPa as shown in figure 6(b) and (c), the strongest temperature gradients remain meridional and a cold trough is evident at the western edge of the dissipation region that content the cold advection, this result is very similar to the result by Maddox [3].

Figure 6. Same with figure 4 but for the time of MCC dissipation stage.

The cold trough makes the MCC as cold-core in dissipation region. The relative humidity at 850 hPa decreased in dissipation region. The MFC is begin left the MCC area to the western south and eastern north leading edge at 850 hPa but the high MFC (negative value) in the south and north of leading edge of dissipation region. In the mid-level the weak MFC is presented in the dissipation region, this indicates that downward motion still occurs in the dissipation region. The short-wave trough remain meridional of geopotential height still found in dissipation region still presents from low-level to the upper level (figure 6(c), (d), (e) and (f)), is similar with Maddox [3] that stated the short-wave trough is very pronounced in the height and temperature field. figure 6(e) shows that the cyclonic shear in the upper level in dissipation region is left from the MCC area. The weak divergence with the strong short-wave trough of the geopotential height still occurs on the upper level, that indicate the jet streak still present in dissipation region as shown in figure 6(f).

3.4 Vertical cross section analysis
The vertical distribution of divergence and vertical velocity during a critical stage of the MCC composites is presented in figure 7. The MCC composites are also triggered by the strong surface and low-level convergence at the initial stage. Surface convergence is confined to the lower half of the troposphere (from surface until 850 hPa), at the same time, strong divergence prevails above 700 hPa until 400 hPa as shown in figure 7 (a). The vertical velocity with the short-wave trough/ridge/trough pattern in the strong low-level convergence area is seen clearly. The negative value of vertical velocity indicates ascending air. The ascending motion is associated with cloudiness and rain. The wind convergences from the upper level to the initial region indicate there is moisture support from the upper-level by the wind. The presence of a low-level convergence and upper-level divergence couplet helps in maintaining the inflow and outflow of mass necessary for long periods of sustained deep convection, while the attendant release of latent heat further enhances the low- to mid-level convergence, thus continuously providing fuel for the MCC systems.

By the mature stage, as shown in figure 7 (b), the development of the MCC in this stage is triggered by the westerly and southerly wind that interacted the mountain breeze which makes merging the clouds system that shown in the initial stage. The upward process in the growth of the cloud has been started
in this stage with averaged vertical velocity around $12 \times 10^{-2}$ Pa s$^{-1}$ in the upper level. The convergence during mature became weak in surface until low-level and only in the western side of the system. In fact, the strong divergence began to appear on the surface of the system, it is due to the effect from midnight land breeze. Upper-level strong divergence has developed a sharp maximum at 200 hPa. The updraft also becomes stronger with the averaged vertical velocity around $-12 \times 10^{-2}$ Pa s$^{-1}$. At the dissipation stage, as shown in figure 7 (c), the convergence is becoming dissipated and changed to strong surface divergence. The divergence also expands in upper-level above 300 hPa. However, the strong divergence also appears on the upper level. This condition indicates that the downdraft process already occurs during decay in the system. This convergence is southward widespread, it indicates the new convective system began generated in the southern and northwestern side of the MCCs system. The new convective systems indicated by the propagation of the convergence zone from the system.

![Figure 7](image)

**Figure 7.** Pressure-latitude cross section (averaged for longitude 110° - 116°E) of divergence ($10^{-5}$ s$^{-1}$, shaded) and vertical velocity ($10^{-2}$ Pa s$^{-1}$, contour) for MCC composites during (a) initiation, (b) mature, (c) dissipation.

The vertical distribution of temperature advection and vorticity advection during critical stages of the MCC composite is presented in figure 8. The initial region of the MCC composites is characterized by the strong cold advection in the surface of the initial region. However, the strong warm advection is presented in the level of 900 - 700 hPa, while the weak cold advection appearance in the midlevel until upper level. This condition just followed the positive of vorticity advection in surface until midlevel as shown in figure 8(a). The upward motion also occurs in the initial region by the strong surface cold advection. During mature stage as shown in figure 8(b), cool advection is dominant on the southern edge of the system, possible due to the land breeze. However, the strong warm advection still appears in the lower level of the system. It indicates the existence of the process of updraft and downdraft motion. The surface cold advection is dissipated and widespread throughout the surrounding area of the MCC system during dissipation stage as shown in figure 8(c). The cold advection migrates eastward and westward by helped the westerly wind and sea breeze.

![Figure 8](image)

**Figure 8.** Same with figure 7 but for temperature advection (shaded: $10^{-5}$ K s$^{-1}$) and vorticity advection (contour: $10^{-5}$ s$^{-1}$).

4. **Conclusion**

The composite analysis of the evolution and propagation for 45-cases of the MCC which occurred in the same area center over CK (110°E - 116°E, 4°S - 1°N) has been observed. On average, MCCs began
develop in the late afternoon which generated by the orographic convective that interaction with the other convective cloud in the surrounding of the MCC area. The convergent surface wind flow that indicated as the westerly wind from Sumatra, northerly wind from the South China Sea and the southerly wind from Java through interaction with the strong sea breeze circulation and through the topography lifting effect as a mountain breeze from the north is helping the MCC development. The MCCs system reaches the maximum size in midnight and will begin decayed and dissipated in the morning. During the mature stage, the convergent wind begins weakened and seen the divergent wind from the leading edge of the MCC system due to by the CPs which generate the new convective systems when the MCCs decayed. The new convective systems southward propagated toward Java Island due to of the divergent outflow of the CPs, in conjunction with the morning land breeze. The rainfall systems over the Java Island are more extensive after a few hours of the MCCs dissipated due to the new convective systems induce the land convection over the Java Island. This study also shows that there is relationship about the MCC to the rainfall system over the CK.

The composite analysis of the environmental condition during critical stages of the MCC composites has been presented. The initial and mature regions are characterized by weak low-level convergence and upper-level divergence, but during mature, the weak divergence in the western and eastern leading edge in the mature region. The convergence is start left the MCC area when the MCC dissipated, while the weak divergence with still occurs at the upper level. This convergence is southward widespread, it indicates the new convective system began generated in the southern and northwestern side of the MCC system. The new convective systems indicated by the propagation of the convergence zone from the MCC systems. The wind convergences from the upper level to the initial region indicate there is moisture support from the upper-level by the wind. The presence of a low-level convergence and upper-level divergence couplet helps in maintaining the inflow and outflow of mass necessary for long periods of sustained deep convection, while the attendant release of latent heat further enhances the low- to mid-level convergence, thus continuously providing fuel for the MCC systems. The favorite areas for the MCC development are indicated by the short-wave of the geopotential height in each level from initial until MCC dissipated. The MCC composite development is largely driven by MCC-scale moisture convergence in the lower troposphere which is then transported to the midlevel, even up to upper levels through deep convection. MCCs become the center of cold advection and temperature at more a low level which followed the higher relative humidity during develop and then cold core separated when the MCC dissipated that indicate the propagation of the new convective systems. The strong midlevel positive vorticity that indicates counterclockwise rotation of the wind and it is associated with cyclones or storm at upper levels during the initial and mature stage. The upper-level jet stream and strong divergence are presented during the mature stage that produced by storm's divergent outflow.

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