CG (*Cloud-To-Ground*) Lightning Strike Distribution Patterns In Bandar Lampung and South Lampung in 2022

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Abstract. This study aims to identify patterns in the distribution of CG-type lightning strikes in the regions of Bandar Lampung and South Lampung during the year 2022. This study employs quantitative descriptive research methods. The data for this study was collected from the BMKG office of North Lampung Class III Geophysical Station, located in Lampung Province. The data includes latitude, longitude, and CG-type lightning data for 2022. The sensor was positioned at coordinates 4.83° S latitude and 104.87° E longitude, with an elevation of 60 meters. It utilized the Boltek Lightning Detection System for lightning detection. The analysis indicated that the patterns of CG-type lightning strikes in Lampung Province in 2022 varied every month. This variation can be attributed to the specific topographic conditions of different areas. The Bandar Lampung and South Lampung areas experienced a significant number of lightning strikes in the year 2022. In Bandar Lampung, there were 28,502 lightning strikes, including CG+ and CG- lightning. Meanwhile, the South Lampung area recorded more lightning strikes, totaling 191,353 occurrences. The high frequency of lightning strikes in the South Lampung region can be attributed to its topography, close to Panjang and Bakauheni Harbors. These areas have many coastal regions that contribute to cloud formation, thereby increasing the likelihood of lightning. Cumulonimbus clouds are formed through the evaporation of water from sources, such as the sea, lakes, or rivers, in line with the established theory of cloud formation. Additional research is required to analyze weather data about parameters that specifically impact the frequency of lightning strikes in different regions.

1 Introduction

Indonesia experiences two distinct seasons: the rainy season and the dry season. During the dry season, several adverse effects occur, including drought, a scarcity of clean water, and an increased risk of forest fires. During the rainy season, floods, landslides, and lightning strikes occur [1]. Lightning is generated when charged clouds induce charges on the Earth's surface. When the charge in the cloud increases, the induced charge also increases, resulting in a

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greater potential difference between the cloud and the Earth. The occurrence involved a pioneer strike originating from the sky, followed by another emerging from the ground, approaching the descending pioneer strike. The occurrence is called a lightning occurrence [2]. Lightning strikes can be categorized into three types: intra-cloud lightning, cloud-to-cloud lightning, and cloud-to-ground lightning. One form of hazardous lightning is cloud-to-ground (CG) lightning, which occurs when lightning strikes the ground [3].

As indicated by experts in the field, Indonesia is highly susceptible to lightning strikes [4]. According to a source, Indonesia experiences 200 days of thunder, while the United States, Brazil, and Africa have 100, 140, and 60 days of thunder, respectively [5]. The electric field generated by lightning can reach a minimum of one megavolt per meter. Due to its geographical characteristics, Indonesia experiences a significant frequency of Thunder Days, characterized by a substantial number of lightning occurrences annually. Lightning strikes can pose various hazards [6].

Previous research indicates that numerous regions in Indonesia possess a significant susceptibility to lightning strikes. Supardiyono Umaya's calculations indicate that the sub-districts of Tegalsari, Simokerto, Tambaksari, Bubutan, Genteng, Gubeng, Tenggilis Mejoyo, and Mulyorejo exhibit significant susceptibility to lightning strikes, as evidenced by their areas with exceptionally high potential vulnerability levels [7]. Based on research data collected between 2016 and 2018, the city of Balikpapan experienced a total of 29,336 lightning strikes in 2013 [1], the Surabaya area in 2013 experienced 26,762 lightning strikes [8], and Kupang recorded 26,762 lightning strikes in 2015 [9]. The Gowa Regency area witnessed 26,797 lightning strikes between 2017 and 2018 [10]. In the Pontianak City area, there were an average of 14,570 lightning strikes per year between 2018 and 2020 [11]. Furthermore, the Special Region of Yogyakarta also observed lightning activity, but specific data is not provided [12]. Lampung province, located in Indonesia, is prone to lightning-induced disasters.

Lampung province is situated in the southernmost region of Sumatra Island, and its capital city is Bandar Lampung. The geographical features of Lampung Province facilitate the formation of convective clouds in areas characterized by sloping and steep mountain slopes. The system's vulnerability to lightning strikes can lead to interruptions in transmitting high-voltage electricity. Lightning, being a hazardous natural phenomenon, poses a significant danger due to its potential release of millions of volts of energy [13]. The energy possesses a magnitude that can potentially destroy contact with any object. Lightning, specifically CG-type lightning, frequently interacts with human activities, leading to potential material loss or loss of life [14]. In August 2021, the Lampung province experienced 171,182 lightning strikes, as reported by the Meteorology, Climatology, and Geophysics Agency (BMKG) [15]. Table 1 presents the data about the individuals affected by lightning strikes in the region of Lampung in 2022.

Table 1. Data on Lightning Strike Victims in the Lampung Region in 2022

No.	Date	Area	News Title	Source
1.	27/09/2022	Waluyo Village st., Trisno Village, Negeri Katon District, Pesawaran.	The moment four children in Lampung were struck by lightning while walking in the evening, two children suffered burns.	Kompas.com
2.	17/08/2022	Tanggamus Lampung	The moment a man died when he was struck by lightning during *a panjat pinang* competition in Lampung. He had an opportunity to take the prize.	Kompas.com
3.	07/09/2022	Ratnadaya Village, North Raman District, East Lampung Regency.	Riding a motorbike home from the fields, a husband and his wife in North Raman, East Lampung, were struck by lightning, and one died.	Lampungpro. co
4.	16/12/2022	Sukajaya Hamlet, Pekon Tanjung Heran, Pugung District, Tanggamus, Lampung	While playing in a rice field, a boy died when lightning struck him in Tanggamus, Lampung.	TribunLampung.co.id
5.	03/05/2022	Kebon Damar Village, Mataram Baru District, East Lampung.	The prayer room in Mataram was struck by lightning.	Lampost. co
6.	04/10/2022	Bumi Dipasena Agung Village, East Rawajitu District, Tulang Bawang Regency	South Rawajitu Police investigates the crime scene of victims killed by lightning strikes.	Lampung.rilis.id
7.	12/01/2022	Minang Rua Beach, Kelawi Village, Bakauheni District.	Three fishermen from Way Muli Village were struck by lightning while fishing.	Hanuang.com

Lightning strikes often lead to burns and fatalities among the individuals affected. Indonesia is considered one of the three major regions with high lightning activity, alongside Central Africa and the Arizona River valley [16]. This can be attributed to its tropical geographical location and its proximity to surrounding oceans. Cloud-to-ground (CG) lightning is a dangerous and detrimental form of lightning. Lightning is caused by the discharge of negatively charged particles from lower clouds towards the Earth. CG lightning is considered hazardous due to its ability to strike objects above the Earth's surface, resulting in potential damage. CG lightning is characterized by two types of charge: +CG and -CG [17]. When lightning strikes the Earth, it releases positive ions called CG (+) and negative

ions called CG (-). Lightning is a natural phenomenon in which positive cloud-to-ground (CG) lightning involves the release of excess positive charge from the cloud to the Earth.

In contrast, negative CG lightning occurs when there is an excess of negative ions transferring from the cloud to the Earth [18]. Cloud-to-ground (CG) lightning significantly affects human safety, infrastructure, and the environment in Indonesia. CG lightning results from the interaction between electrical charges in clouds and the Earth's surface. This interaction leads to the occurrence of lightning strikes, which have the potential to cause harm, destruction, and even ignite fires. The distribution patterns of CG lightning in Indonesia are influenced by the country's weather conditions, climate, and topography. It is crucial to understand this phenomenon comprehensively to develop efficient early warning systems and strategies for mitigating its impact. In addition, this research is significant in the context of climate change as it can affect the occurrence and characteristics of lightning in the area and influence the local microclimate. Hence, acquiring a comprehensive comprehension of cloud-to-ground (CG) lightning occurrences in Indonesia will contribute to safeguarding society, infrastructure, and the environment in forthcoming times.

Lightning is caused by a difference in electrical potential between two mediums, leading to charge transfer until equilibrium is reached. Air serves as the medium for the discharge of electrons. Lightning can manifest in various forms, including inter-cloud, intra-cloud, cloud-air, and cloud-ground discharges [19]. Rain is frequently linked to lightning strikes. Direct strikes are the primary source of disruptions caused by lightning [20]. Lightning and rain events may occur in close succession, but it is not always the case that rain is accompanied by lightning or vice versa. According to a study conducted by Muhammad Fakhrul Islam Masruri, it has been confirmed that the South Bogor sub-district is highly susceptible to lightning strikes [21]. The majority of lightning incidents tend to occur during the transition season. However, there is no observed positive correlation between lightning incidents and rainfall. Therefore, it is necessary to research to establish a correlation between the intensity of lightning strikes and rainfall. Rainfall is associated with the months characterized by higher precipitation levels, commonly called the wet months. These rainy seasons typically experience an average rainfall exceeding 200 mm, coinciding with the rainy season. No research has been conducted on the distribution of lightning strikes in Lampung Province, which has sparked the interest of researchers. Therefore, they aim to conduct a study titled "Lightning Distribution Patterns in the Lampung Region" to assess the potential level of CG-type lightning in the Lampung region in 2022. This study aims to analyze the spatial distribution of lightning occurrences in the Lampung region during the wet season. The data for this analysis were obtained from the BMKG office, specifically the class III geophysical station in North Lampung, Lampung province. The data includes latitude, longitude, and CG-type lightning occurrences recorded in 2022.

2 Research Methods

This study employed a quantitative descriptive research methodology to analyze numerical data from the BMKG office of Lampung Class III Geophysical Station of North Lampung province. This research aimed to identify the distribution pattern of lightning in the Lampung area during the rainy season of 2022. The data includes the CG type's latitude, longitude, and lightning information. The sensor was positioned at coordinates 4.83° S and 104.87° E, with an elevation of 60 meters. The research was conducted at the Meteorology, Climatology, and Geophysics Agency (BMKG) in Kotabumi, Lampung province. The lightning detection tool was a real-time lightning detection and analysis system, specifically the NexStorm software, integrated with the Boltek Lightning Detection System. The Storm Tracker was a device used to monitor and track storms. The system could efficiently detect lightning strikes within a

range of approximately 300 miles. These strokes were then automatically plotted in real time on the system. As more strokes were detected, the system determined the maximum position.

3 DATA ANALYSIS

Data analysis was crucial in uncovering lightning distribution patterns in the Lampung region in 2022. Presented below is a map depicting the geographical region of Lampung province:

Fig.1. Map of Lampung Island

Data analysis in this research is as follows:

a. The lightning data collected in 2022 represented the annual range. This data was obtained through the collection of electromagnetic wave data.
b. The Boltek Lightning detector sensor was utilized to capture electromagnetic wave data produced by lightning. When lightning happens, it emits electromagnetic waves, which are then detected by the LD sensor. The sensor detected the waves based on their frequency and then translated them using the receiver.
c. The data recorded by the sensor was stored in the Lighting Detector Card. Idc format. The computer can display a range of lightning patterns using the Nexstrom or LD/2000 Display Program. The data recorded by the sensor was stored in a lightning detection card in the form of a .ldc file. This file served as raw data for creating contour maps.
d. The process involves utilizing LD/2000 to access lightning data and exporting it to Microsoft Excel in the .kml format. During this stage, the process of filtering CG+ and CG- lightning data was performed and subsequently saved in separate files. The data was subsequently transformed into .csv format.
e. To begin, start the lightning software and import the .csv file. After importing, save the file in the .srf format.
f. The lightning data was obtained from the .srf format and converted into .txt format.

4 Results and Discussion

Lightning is a natural phenomenon that appears as a flash of light accompanied by a booming sound and is frequently seen before or during rain. Lightning strikes are caused by Indonesia's proximity to the equator, which causes the country to have more lightning days than other countries, averaging around 100 days per year[13]. Lightning is a natural phenomenon that occurs during the rainy season and is characterized by a brief flash of dazzling light in the sky, followed by a booming sound commonly referred to as thunder. The difference in appearance time is caused by the difference in the speeds of sound and light [14]. That is not to say that when it rains, it is always accompanied by lightning. Lightning occurs only when there are Cumulonimbus clouds (Cb). A discharge of electrostatic charge accompanied by light emission and other electromagnetic radiation is another definition of lightning. Cumulonimbus clouds, which form due to high heating on the Earth's surface, have the potential to cause lightning. Water vapor rises rapidly as the Earth's surface heats up. Cumulonimbus clouds are distinguished by their shape, which clumps like cotton and soars high in the sky [22].

The presence of charged clouds above the Earth causes the initial process of lightning to occur. The humidity in the air and the upward movement of air (updraft) cause the formation of charged clouds. Air humidity is caused by the influence of sunlight, which causes water evaporation, and the water vapor rises due to movement updraft. Continuous process updraft will result in charged clouds [23]. Lightning happens as a result of a potential difference between two mediums. In this case, the two mediums are clouds and Earth or clouds and clouds. In this case, the two mediums are clouds and Earth or clouds and clouds. The potential difference between the Earth's surface and the ionosphere is approximately 200,000 to 500,000 volts under normal weather conditions, with a current density of approximately 2x10-12 Ampere/m2. The distribution of thunderstorms on the Earth's surface causes this potential difference [24]. The charge process on a cloud occurs because it moves continuously and regularly. It will interact with other clouds during its movement, causing negative charges to gather on one side (top or bottom) and positive charges to gather on the opposite side. If the potential difference between the cloud and the Earth is large enough, a discharge of negative charges (electrons) from the cloud to the Earth or vice versa will occur to achieve equilibrium [9].

One aspect of atmospheric dynamics that can be used to detect the presence of convective clouds is the lightning process. The calculation of lightning frequency cannot be obtained accurately if only manual observation is used [25]. The Kotabumi Meteorology, Climatology, and Geophysics Agency (BMKG) employs a lightning detection and analysis system. NexStorm real-time software is used in conjunction with the Boltek Lightning Detection System. StormTracker can detect strokes lightning is optimally around 300 miles, which will then be plotted automatically and in real-time to the system, where more and more strokes, then the system's maximum position determination. StormTracker detects radio signals (AM) produced by lightning or antennas. Storm Tracker can provide direction and distance information about a thunderstorm based on the strength of the received signal. A thunderstorm is another name for lightning. An electrical storm/lightning storm is a type of weather distinguished by lightning's presence. Thunderstorms can create a classification and warning system for activity using lightning. Based on the results of processing lightning data from the Lampung region between January and December 2022 using lightning detection tools, there were 219,855 lightning strikes recorded in the Bandar Lampung and South Lampung areas. Figure 2 depicts data on the number of lightning strikes.

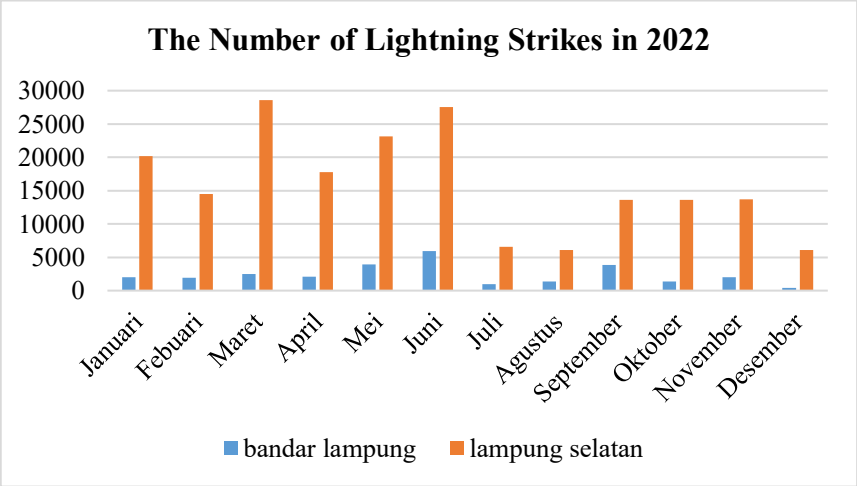

Fig. 2. Data on the Number of Lightning Strike

There were several lightning strikes in Lampung Province, varying by region. The first graph depicts the number of lightning strikes in Bandar Lampung and South Lampung in 2022. The most lightning strikes occur between January and June in these two areas. Bandar Lampung had the most strikes in June 2022, with 5914 strikes, and the fewest in December 2022, with 414 strikes. Meanwhile, South Lampung had the most strikes in March 2022, with 28,560 strikes, and the fewest in December 2022, with 6,077 strikes. According to BMKG, the high number of lightning strikes until June was caused by climate anomalies, specifically warm Indonesian sea surface temperatures, a weak girl, and a negative indexIndian Ocean Dipole (IOD). Warm sea surface temperatures indicate intensive evaporation processes and contribute to significant water vapor in the surrounding area. Areas with the potential for lightning are also related to the local air conditions. Lightning is caused by sufficient heating, which allows evaporation to produce a large amount of water vapor in the air and wind movement, which can collect clouds. It also has high air humidity or a high water vapor content and an upward push to aid Cumulonimbus cloud formation [17]. Based on this table, it is possible to conclude that South Lampung has the most strikes and Bandar Lampung has the fewest. This data is supported by PMG Madya BMKG Kotabumi, which states that the areas in Lampung where lightning frequently occurs are those with high rainfall, namely South Lampung.

The main cause of lightning, according to PMG Madya BMKG Kotabumi, is the potential difference between the clouds and the Earth, which is quite large and high rainfall. Geographic location, humid cloud conditions, and high rainfall are all factors that influence the occurrence of lightning. Cumulonimbus clouds (Cb) form primarily when there is a tapered topographic condition that can lift water vapor. The high number of lightning strikes in the South Lampung region is due to the area's topography, which is close to Panjang Harbor and Bakauheni. There are 15 beaches in South Lampung, including Embe Beach, Bagoes Beach, Grand Elty Krakatoa Resort, Indah Krakatoa Beach, Marina Kalianda Beach, Ketang Beach or Baru Rame Kalianda Beach, Kahai Beach, Canti Indah Beach, Guci Batu Kapal Rajabasa Beach, and Tanjong Selaki Beach, which can lift a lot of water vapor in the air; the more water vapor in the air, the more humid the air will be, and wind movement can gather clouds. High-rise buildings are thought to play a role in the number of lightning strikes in the area. The height of a building also influences the height of lightning strikes. Areas with a lot of high-rise buildings have a lot of lightning strikes [26].

Lightning tends to prefer open areas. The same applies to tall objects and bulges on the Earth's surface. Tall objects and protrusions are not the same thing. Tall objects can be poles

or buildings, whereas protrusions can be people, animals, or plants out in the open [27]. People playing in the field, people standing in the middle of rice fields, and people in the middle of the ocean are all objects that could be struck by lightning [28].

5 Conclusion

Based on the findings of the analysis and discussion, it is possible to conclude that the pattern of CG-type lightning strikes in Lampung province in 2022 was different every month due to the topographic conditions of a specific area. The pattern of lightning strikes in the Bandar Lampung area was 28,502, including CG+ and CG- lightning. On the other hand, in the South Lampung area, 191,353 lightning strikes occurred during 2022. The number of lightning strikes in the South Lampung region was due to the topographic shape of the region, which is close to Panjang and Bakauheni Harbors, with many coastal areas. They can cause lots of cumulonimbus clouds. It is consistent with the existing theory that clouds are formed due to the evaporation of water originating from the sea, lakes, or rivers.

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References

1. S. Ferruzi Agfanny, Djayus, J. Geosains Kutai Basin **3**, (2020)
2. H. Maulana, P. Studi, T. Elektro, S. Tinggi, and T. Mandala, **12**, 9 (2017)
3. R. Puspita, P. S. Matematika, F. Sains, D. A. N. Teknologi, U. Islam, N. Maulana, and M. Ibrahim, (2022)
4. D. Setiawan and M. P. Halilintar, Pros. Persidang. Antarabangsa Kelestarian Insa. 2015 **D**, 19 (2015)
5. T. Gunawan and L. N. L. Pandiangan, Meteorol. Klimatologi Dan Geofis. Wil. **15**, 193 (2014)
6. N. Sugiyono, J. Telemat. MKOM, ISSN 2085-725X **4**, 90 (2016)
7. Umaya and Supardiyono, J. Inov. Fis. Indones. **06**, 25 (2017)
8. M. Kriging, D. A. N. Idw, and K. Surabaya, **4**, 145 (2015)
9. F. Narut, A. Wahid, and S. Sumawan, J. Fis. Fis. Sains Dan Apl. **3**, 110 (2018)
10. M. L. Firdaus, N. Nasiah, and U. Uca, J. Environ. Sci. **3**, (2021)
11. M. S. Tanalepy, (2022)
12. T. dkk Plomp, Angew. Chemie Int. Ed. 6(11), 951–952. **2**, 2018 (2007)
13. K. Mehranzamir, Z. Abdul-malek, and B. Salimi, **554**, 583 (2014)
14. S. Opu, L. Detector, and D. Rawan, **02**, 137 (2018)
15. K. Pengantar, (n.d.)
16. A. M. HARYO and S. Haryono., T, Perpust. Univ. Gadjah Mada (2017)
17. I. D. Septiarini, U. A. Gani, and M. Rajagukguk, J. Tek. Elektro Univ. Tanjungpura **1**, 198 (2022)
18. N. P. T. I Ketutu Sukarasa.,)2017(43, **العدد الحا**
19. Erwan Susanto, Muhamad Rizky Noor Wahyuddin, Akbar Rian Setyahagi, and Roby Hidayat, Pros. Semin. Nas. Fis. PPs UNM **2**, 96 (2020)
20. (2017)
21. B. Nanda, M. F. I. Masruri, and M. Syirojudin, Pros. Semin. PEKAN Ilm. Fis. XXVIII 2017 **1**, (2017)