Doi: 10.61435/jbes.2025.19960

Journal of Bioresources and Environmental Sciences, 4, (2), 102-111

Research Article

Identification of Variations in the Onset of the Rainy and Dry Seasons in Indonesia

Riza Adriat [1*], Aprilina[1], Haries Satyawardhana[2], Andi Ihwan[1], Yuris Sutanto[3]

[1] Department of Geophysics, Faculty of Mathematics and Natural Science, Tanjungpura University Pontianak, Indonesia;
[2] Climate and Atmosphere Research Center, National Research and Innovation Agency (BRIN), Indonesia.
[3] Department of Physics, Faculty of Mathematics and Natural Science, Tanjungpura University Pontianak, Indonesia;

* Correspondence: rizaadriat@physics.untan.ac.id

Received: 5th March 2025
Accepted: 5 June 2025
Published: 23rd August 2025

Copyright: © 2025 by the authors. This work is under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Abstract. In the equatorial region, Indonesia experiences distinct wet and dry seasons influenced by monsoon. The country's agricultural sector is highly susceptible to the impacts of climate change, including extreme weather events and shifting seasonal patterns due to global warming. This study aims to analyze variations in rainfall intensity and their effects on the onset of the seasons in Indonesia from 2001 to 2022. The research used GSMaP data, focusing on the area between 6° N - 11° S and 95° - 141° E. The start of the season was determined based on rainfall criteria from BMKG. The findings reveal significant changes in the onset of the rainy and dry seasons in regions such as Sumatra and Kalimantan, with the maximum change being eight dasarian. The study also indicates that the rainy season during the 2012-2022 period is shorter compared to the 2001-2011 period, resulting in a longer dry season. Furthermore, the maximum standard deviation is 14 dasarian, allowing the season's start to shift by up to 14 dasarian annually in some regions of Indonesia. Besides that, ENSO can influence changes in the pattern of the start of the season.

Keywords: Onset of the Rainy Season; Onset of the Dry Season; GSMaP

1. Introduction

Indonesia is in the equatorial area known as the maritime continent. The characteristics of rainfall in Indonesia are greatly influenced by the monsoon phenomenon, which shows the differences between the wet and dry seasons. High climate variability, shifts in the onset of seasons, and extreme climate phenomena are signs of climate change caused by global warming (Susilokarti et al., 2015). Climate change significantly impacts various aspects of human life directly or indirectly and is difficult to avoid (Prabaningrum & Nuriani, 2016). The most detrimental impact of climate change is occurring in the agricultural sector because this sector is susceptible to shifts at the start of the season (Beis et al., 2022).

The agricultural sector has an important role in the national economy because Indonesia is an agricultural country (Rahmadi & Santosa, 2018). In 2022, the percentage of informal workers in the agricultural sector in Indonesia will be 88.89% (BPS, 2023). The agricultural sector is very vulnerable to cropping patterns, time planting, production, and quality of the results. The close relationship between climate and weather and global warming can cause a decline in agricultural production of around 5-20% (Hidayati & Suryanto, 2015). Identify the start of the rainy season and the beginning of the dry season and see the changes from 2001-2022. It is very necessary to know whether there is a shift in the start of the season as well, which can be a reference for climate conditions in every region of Indonesia. To ensure the onset of the rainy season, the Meteorology, Climatology, and Geophysics Agency (BMKG) has established that it begins after three consecutive dasarian events in which rainfall is equal to or greater than 50 mm. The start of the rainy season is marked by the first rainfall at or above this 50 mm threshold. Conversely, the criteria for the start of the dry season are the opposite of those for the rainy season.

Rainfall has a high spatial and temporal variability (Rahman & Indra, 2020). Therefore, the bulk data conditions rain in Indonesia require long observations with a representative distribution of adequate data and a narrower obser-

vation interval (Hariarta, 2015). Rainfall observations in Indonesia are carried out in two ways, namely, directly implemented by BMKG and indirectly through satellite images (Setiawan, 2018). Compared with rain stations, satellites have advantages in measuring rain intensity; these advantages lie in spatial and temporal resolution that covers a broader area with faster and more economical access (Natadiredja et al., 2018). One of the satellites, a source of rain data, can be used as Global Satellite Mapping of Precipitation (GSMaP). GSMaP is a project initiated by the Japan Science and Technology Agency (JST), and the Japan Aerospace Exploration Agency (JAXA) promotes it to produce accumulated rainfall globally. This data has an observation range of 60° N - 60° S, and the catchment area reaches 120 km^2 (Ferdian et al., 2017). Another advantage GSMaP possesses is located at a large spatial resolution of 11.06 × 11.06 km, so rainfall data can be obtained for all regions of Indonesia that have it. The variation in the rain is quite high. GSMaP has a temporal resolution of 1 hour (Kubota et al., 2006). Research shows that the data GSMaP has quite a good performance in estimating rainfall in Bali (Duwanda & Sukarasa, 2022). GSMaP data testing has also been carried out in 14 cities in Indonesia. The results show a good correlation for patterns of monthly rainfall with a value between 0.82-0.92, and the resulting error is less than 100 mm/month (Setiyoko et al., 2019). Thus, data utilization satellites that have superior quality, both in terms of spatial resolution and temporal, could be an option to overcome problems with station data (Helda & Wijayanto, 2023).

This research discusses variations in rainfall intensity and their effects towards the start of the season. The rainfall data used is GSMaP data from 2001-2022. The study area in this research is Indonesia, with boundaries of 6° N - 11° S and 95° - 141° E. The initial determination of the season in this study uses basic rainfall criteria from the BMKG. This study employs an extended 22-year GSMaP rainfall dataset (2001–2022) to analyze rainfall variability and seasonal onset patterns across Indonesia comprehensively. The prolonged temporal coverage enables enhanced detection of climate trends, shifts in monsoon behavior, and potential linkages with large-scale atmospheric phenomena.

2. Method

2.1. Study site

The location of the research object is the Indonesian region, as shown in Figure 1. Geographically, Indonesia is located at 6° North Latitude - 11° South Latitude and 95° - 141° East Longitude. This research focuses on climate variability based on rainfall parameters from January 2001 to December 2022. The division of the data set into 2001–2011 and 2012–2022 considers different climatological conditions, such as shifts in ENSO frequency or intensity or changes in monsoon dynamics associated with Pacific or Indian Ocean variability. These analyses allow for comparing how large-scale climate drivers affect seasonal rainfall patterns before and after a potential climate transition period around the early 2010s.

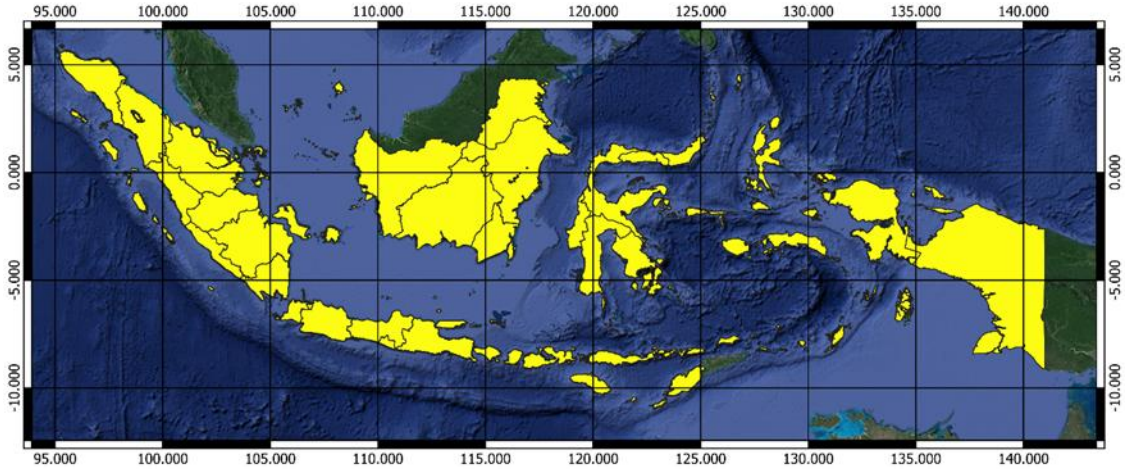

Figure 1. Research location

2.2. Data processing

Secondary data from the Global Satellite Mapping of Precipitation (GSMaP) was utilized in this research. The data is in binary format, which cannot be read directly. This study employs daily rainfall data from GSMaP_mvk version 6, accessible online via https://sharaku.eorc.jaxa.jp/GSMaP, covering the period from 2001 to 2022. GSMaP-MVK data in Indonesia with the mean accuracy for daily rainfall estimation being 85.47% in 2014, 85.74% in 2015, 82.73 in 2016, and

@The Author(s). 2025. Published by CBIORE

82.59% in 2017 (Fatkhuroyan et al., 2018). The GSMaP_mvk data is reanalysis data derived from GSMaP near real-time (GSMaP_NRT). This version 6 product is identified using a versioning algorithm (JAXA, 2015). This research was conducted under the assumption that the GSMaP grid data includes station locations that represent point data from observation stations. The obtained grid has a resolution of 0.1° × 0.1°, with the observation station situated at the center of each grid cell (Mega, 2016).

After collecting rainfall data from GSMaP, this research involves several processing stages. The first stage requires extracting the downloaded GSMaP data and converting its format from (.dat) to (.nc) using a control file with a (.ctl) extension. In the second stage, the data is trimmed to match the coordinates of the research area. The third stage accumulates the rainfall value per day into a value of basic rainfall. The dasarian is 10 days, the month is divided into three dasarian with the provisions that the first dasarian starts from the day 1st to the 10th, the second dasarian from the 11th to the 20th, and the third dasarian from the 21st to the end of the month (Aldrian et al., 2011). The fourth stage calculates the start of the rainy season and the start of the dry season using basic rainfall criteria from the Meteorology, Climatology and Geophysics Agency (BMKG) with illustrations as in Table 1. To ensure the arrival of the rainy season, the Meteorology, Climatology, and Geophysics Agency (BMKG) stipulates that the rainy season begins after three consecutive dasarian with rainfall equal to or greater than 50 mm as shown in Figure 1 starting from the second dasarian of October (blue box). The start of the rainy season is marked by the first rainfall reaching or above the 50 mm threshold. Conversely, the criteria for the start of the dry season are the opposite of those for the start of the rainy season, as shown in Figure 1 (red box). Conversely, the criteria for the start of the dry season are the opposite of those for the rainy season. After getting the initial results rainy season and the beginning of the dry season, calculate the climatology for period I (2001-2011) and period II (2012-2022), then subtract the climatology results for period I with period II to determine the changes. The next stage is calculating the standard deviation to see how far the early season events deviate from the average. The standard deviation equation for single data is based on the number of raw materials can be seen in Equation (1) (Juaeni et al., 2006).

$$\sigma = \sqrt{\frac{n\sum x^2 - (\sum x)^2}{n(n-1)}} \quad (1)$$

description:
x = variable value
n = amount of data

Table 1. Ilustration of determining the start of the season using BMKG criteria in Makassar (Giarno et al., 2012)

Year	April			Mei			October			November			December		
	DI	DII	DIII	DI	DII	DIII	DI	DII	DIII	DI	DII	DIII	DI	DII	DIII
2015	196	63	3	19	24	5	1	120	104	97	87	58	43	270	132

Description: red color is El Niño phase and blue color is La Niña phase.

3. Result and Discussion

3.1. Climatology of the Beginning of the Rainy Season

The beginning of the rainy season is determined using GSMaP data for the period from 2001 to 2022, covering mainland Indonesia. The analysis is divided into two periods: the first period ranges from 2001 to 2011, and the second spans from 2011 to 2022. The start of the rainy season is calculated based on the days from the 16th dasarian (June 1st dasarian) to the 51st dasarian (May 3rd dasarian). Figure 2 shows the climatology of the beginning of the rainy season in Riau, West Sumatra, West Kalimantan, Central Kalimantan, East Kalimantan, all over provinces on the island of Sulawesi and North Maluku generally experience a later start to the rainy season first when compared with other areas in Indonesia. This happens because the region is near the equator around the center of the Earth. The area experiences hot weather because it continues to face the sun. However, the Earth's movement can influence the position of large cloud groups so that in June, the tropics are close to the equator and experience intense heat and heavy rainfall at the beginning of the rainy season is determined using GSMaP data covering mainland Indonesia from 2001 to 2022. The analysis is divided into two periods: the first covers 2001 to 2011, and the second covers 2011 to 2022. The start of the rainy season is calculated based on the days from the 16th (June 1st dasarian) to the 51st (May 3rd dasarian) (Iskandar, 2010).

@The Author(s). 2025. Published by CBIORE

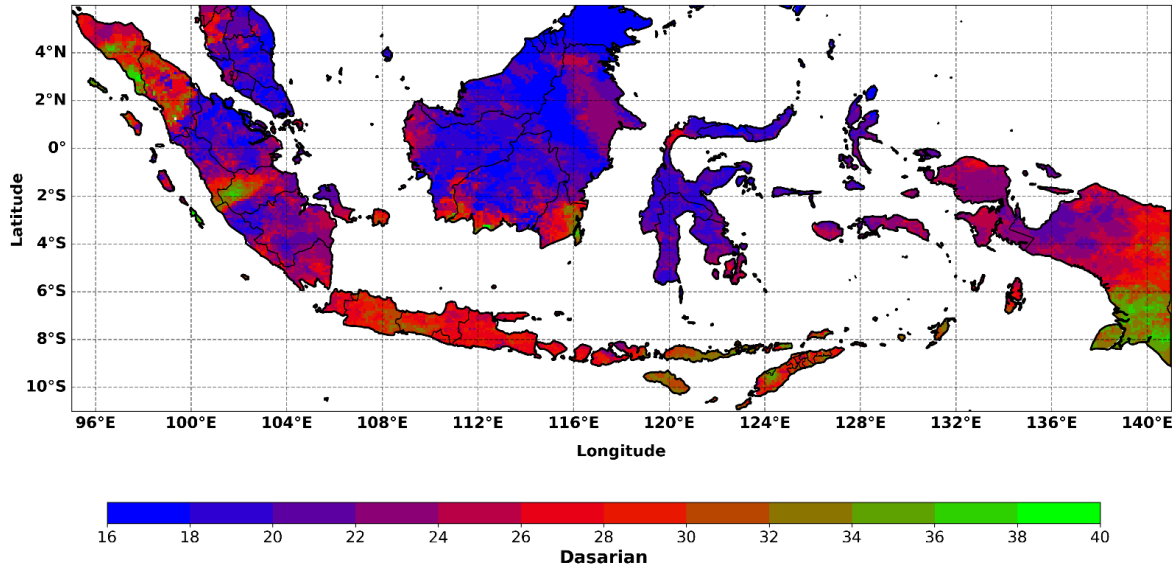

Figure 2. Climatology map of the beginning of the 2001 to 2011 rainy season

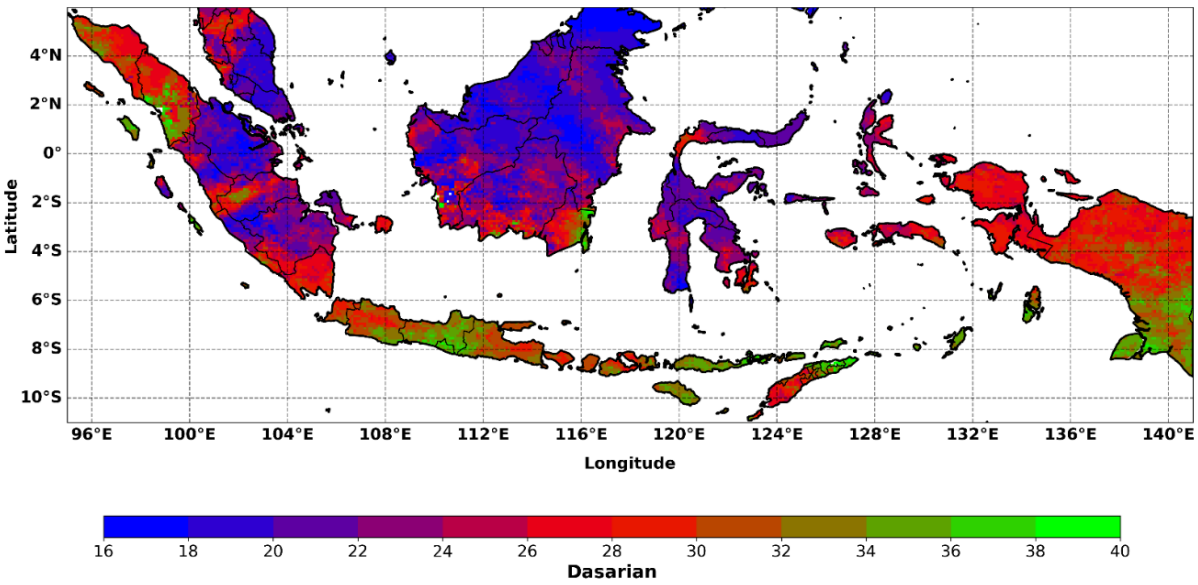

Figure 3. Climatology map of the beginning of the 2011 to 2022 rainy season

Figure 3 shows the climatology of the beginning of the rainy season in the period 2011 to 2022 in Riau Province, West Sumatra, South Sumatra, West Kalimantan, Central Kalimantan, East Kalimantan, and every province on Sulawesi Island dominant season experiences the start of the rainy season in June. Meanwhile, other areas in Indonesia predominantly experience the start of the rainy season between September and January. Matter this shows that the provinces of Riau, West Sumatra, South Sumatra, West Kalimantan, Central Kalimantan, East Kalimantan, and every province in Sulawesi Island experiences the start of the rainy season earlier compared to the provinces Aceh, West Sumatra, Jambi, Bengkulu, Lampung, every province on the island of Java, Bali, West Nusa Tenggara, East Nusa Tenggara, Maluku and Papua.

@The Author(s). 2025. Published by CBIORE

3.2. Change of the Beginning of the Rainy Season

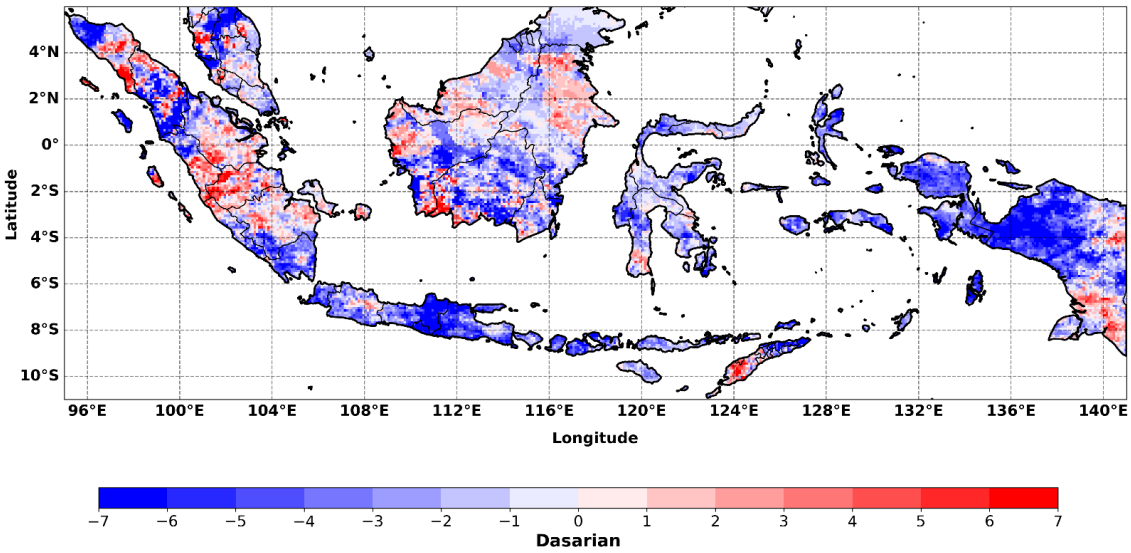

Figure 4. Map of changes in the beginning of the rainy season

Changes in the start of the rainy season were calculated by subtracting the climatology of period 1 (2001-2011) from the climatology of period 2 (2011-2022), which are shown in Figure 4. Areas that show that the start of the rainy season period 2 comes earlier than compared period 1 were in southern Aceh Province, several points in Sumatra North and Riau, southern West Sumatra, western Jambi, Bengkulu North, several points in South Sumatra, West Java, Kalimantan Island, Sulawesi South, West Nusa Tenggara, and eastern and southern Papua. Whereas areas which show that the start of the rainy season period 2 comes later than period 1 were in northern Aceh Province, central North Sumatra and south, Riau and northern West Sumatra, Bengkulu and South Sumatra southern part, almost all of Lampung and Banten, all of DI Yogyakarta, eastern Central Java, western East Java, several points areas in East Nusa Tenggara, Kalimantan Island, Sulawesi, Maluku, as well as West Papua and central Papua. The change in the rainy season from the first to the second is thought to be caused by climate change factors that affect atmospheric oscillations, such as ENSO.

3.3. Standard Deviation of the Beginning of the Rainy Season.

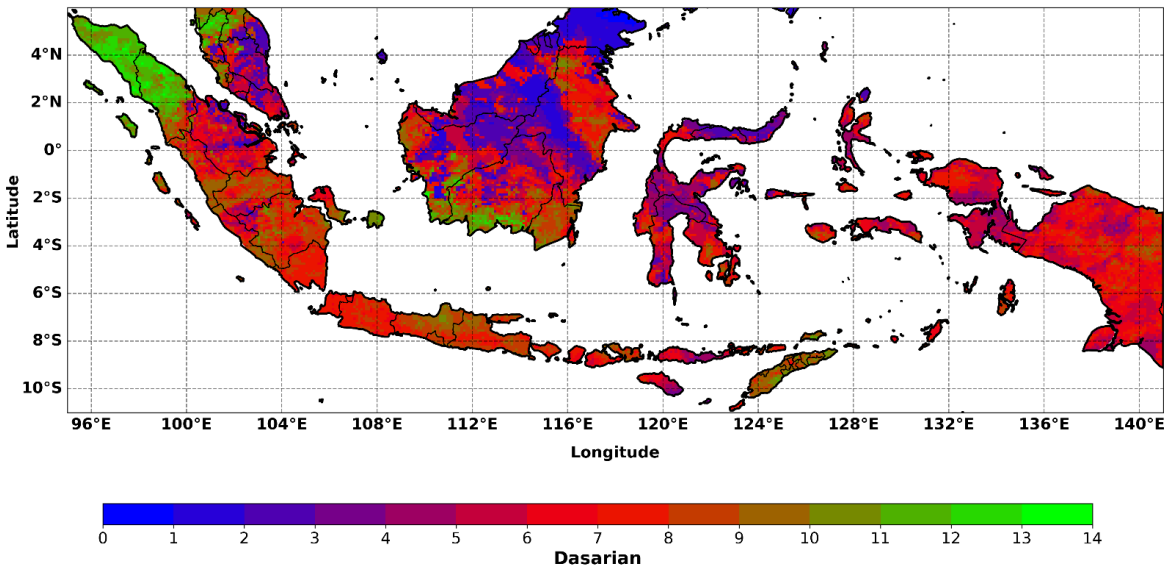

Figure 5. Standard deviation map of the beginning of the rainy season

The magnitude of the variation in changes at the start of the rainy season in Indonesia can be seen by calculating the standard deviation. Regions in Indonesia that experience variations of the most significant change at the start of the rainy season are the provinces of Aceh, North Sumatra, as well as West Kalimantan and southern Central Kalimantan, as seen in Figure 5. Meanwhile, regions in Indonesia are experiencing various changes. The beginning of the rainy

@The Author(s). 2025. Published by CBIORE

season is the lowest, and there is no variation at several points: Riau region, central Kalimantan Island, North Sumatra Province, and Gorontalo. This shows that the start of the rainy season in the province is more consistent from year to year.

3.4. Climatology of the Beginning of the Dry Season

Calculating the Beginning of the Dry Season for mainland Indonesia was also carried out using GSMaP data from the 2001-2022 period, which was analyzed into 2 periods, the first period 2001-2011 and the second period 2012-2022. The Dry Season's start is calculated from the first dasarian of January to the 36th dasarian (3rd December). Figure 6 shows the climatology of the beginning of the 2001-2011 rainy season in Northern Sumatra Island, West Kalimantan Province, Central Kalimantan, and East Kalimantan, predominantly experiencing the start of the dry season earlier than the region's other regions. Then, the dry season began in South Kalimantan Province, Northern Sulawesi Island, Maluku Island, and Papua. Next is the Island area of Southern Sumatra, Java Island, Bali, West Nusa Tenggara, Nusa Tenggara East, and southern Sulawesi Island experience the start of the dry season later if compared to other regions in Indonesia.

Figure 7 shows that the northern part of Sumatra Island and Most of Kalimantan Island experiences the start of the dry season earlier than other areas. Meanwhile, the islands of Sulawesi, Maluku, and Papua experienced this; the start of the dry season is later than in the northern part of Sumatra Island and most of Kalimantan Island. However, the islands of Sulawesi, Maluku, and Papua experience the start of the dry season earlier than parts of Sumatra Island South, Java Island, Bali, West Nusa Tenggara, and East Nusa Tenggara. This matter is caused by geographical position and dominant monsoon wind patterns.

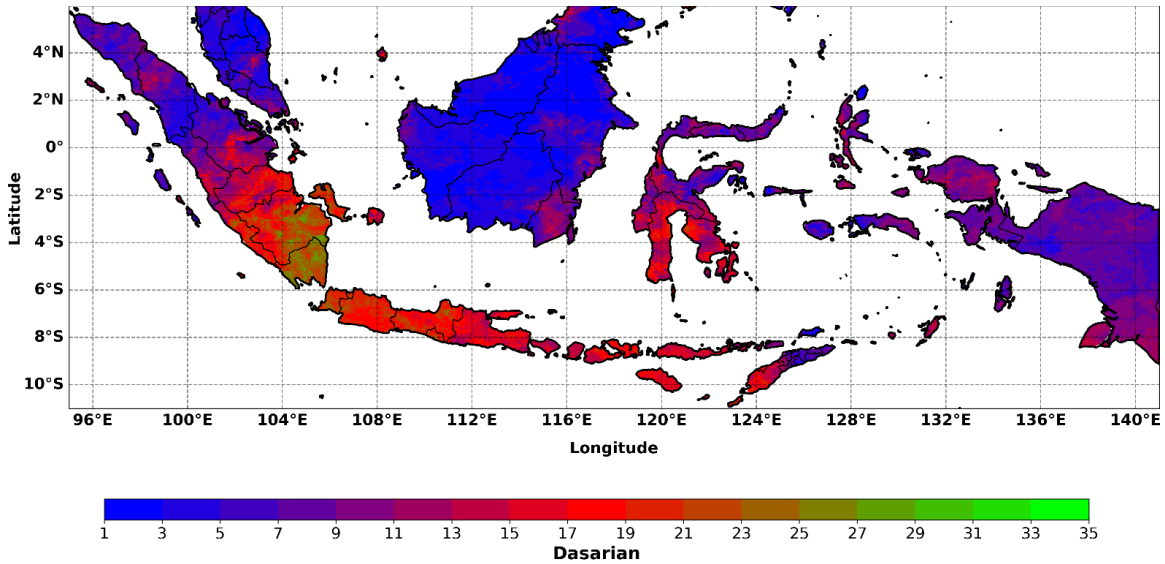

Figure 6. Climatology map of the beginning of the 2001 to 2011 dry season

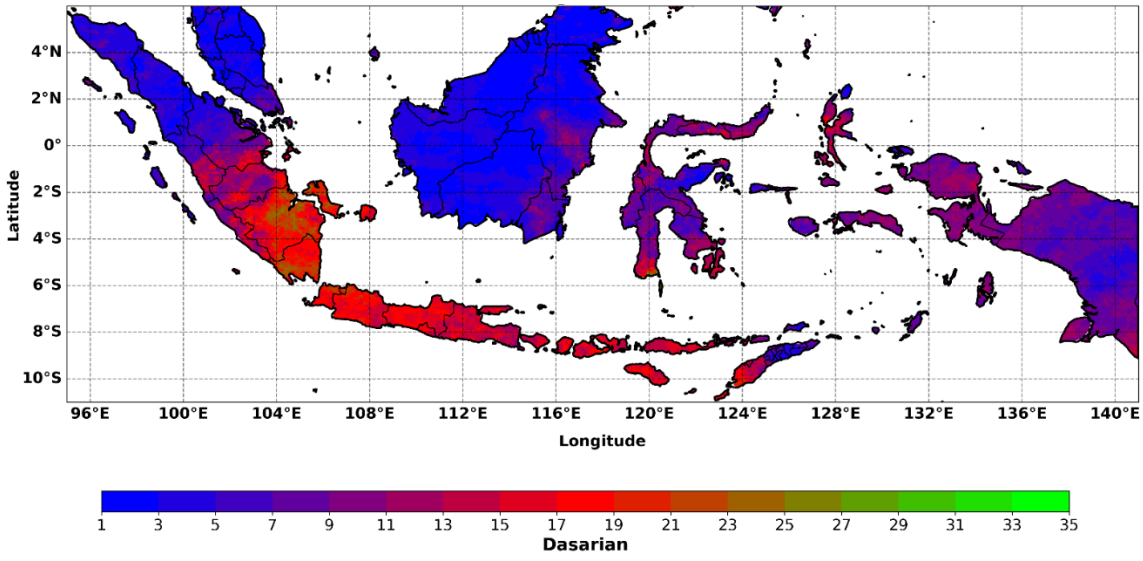

Figure 7. Climatology map of the beginning of the 2012 to 2022 dry season

3.4. Changes to the Beginning of the Dry Season

Changes in the start of the dry season were also calculated by subtracting period 1 climatology (2001-2011) from climatology period 2 (2012-2022); the results are shown in Figure 8. Areas showing that the beginning of the dry season period 2 is coming faster than period 1 in most of the islands of Sumatra, Java, South Kalimantan Province, and the southern part of Papua Island. Meanwhile, the region which shows that period 2 comes later than period 1 is in the southern part of Riau Province and West Sumatra, South Sumatra north, several points in East Java, Bali, West Nusa Tenggara, Kalimantan East, northern Sulawesi Island, most of Maluku Island, and Papua middle part.

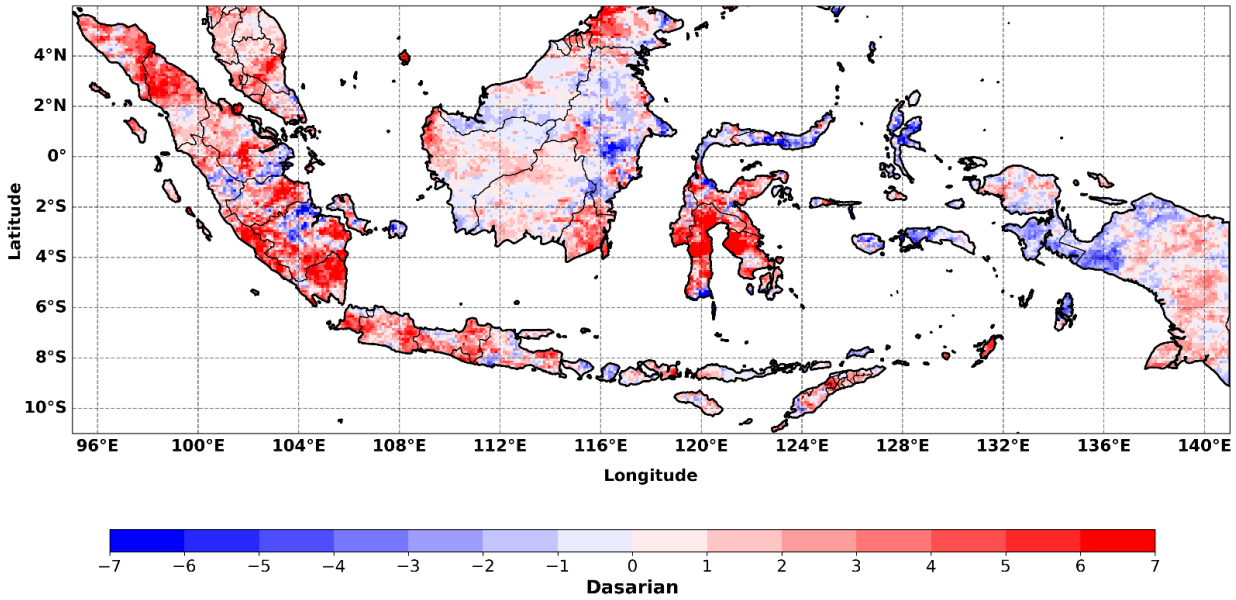

Figure 8. Map of changes in the beginning of the dry season

3.5. Standard Deviation of the Beginning of the Dry Season

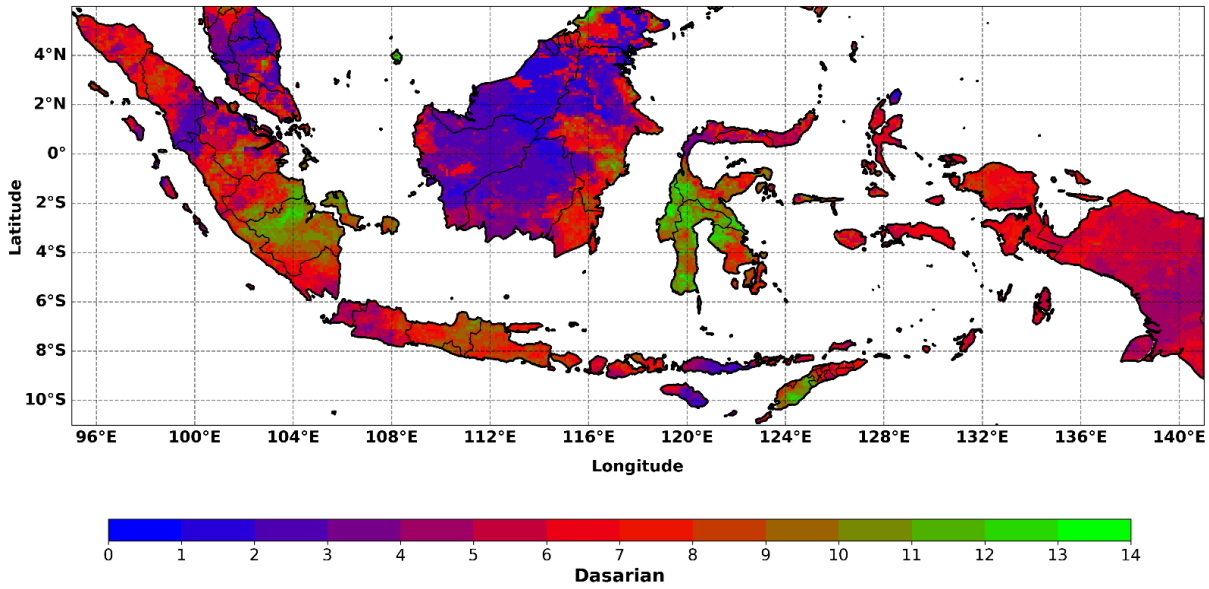

Figure 9. Standard deviation map of the beginning of the dry season

For the beginning of the dry season, the standard deviation is also calculated to determine the magnitude of variations in changes at the start of the dry season in Indonesia, as seen in Figure 9. Areas experiencing the most significant change at the beginning of the dry season were in the southern part of Sumatra Island, Province Central Java, parts of East Kalimantan, and parts of Sulawesi Island south. Meanwhile, areas that have variations at the start of the dry season are quite low or do not have variations in the southern provinces of North Sumatra, Riau, and Northern West Sumatra,

@The Author(s). 2025. Published by CBIORE

most of West Kalimantan Province, Kalimantan Central, East Kalimantan, and Central East Nusa Tenggara. Other regions have variations in the start of the dry season of around 5 to 9 dasarian: topographic variations and the influence of local atmospheric circulation cause this matter.

This difference in the start time of the season indicates significant variations in climate patterns in various regions of Indonesia. This happens due to geography, topography, and the influence of monsoon winds and regional atmospheric circulation. This variation has significant implications for agricultural activities in Indonesia. Additionally, knowing these early season variations is important for managing water resources, flood control, and infrastructure planning.

3.6. ENSO's Influence on the Beginning of the Season

According to BMKG, rainfall patterns in Indonesia are divided into three criteria: equatorial, monsoon, and local. The three patterns are influenced by their respective dominant factors. Heating or convection activity is the main factor in the equatorial pattern. Then, monsoon wind activity is the dominant factor for the monsoon pattern. Meanwhile, geographical conditions are the main factor in local patterns. Variations in dasarian rainfall during El Niño-Southern Oscillation (ENSO) were also seen by selecting several sample regions in Indonesia. The selected regional points can be seen in Table 2. The selection of these regions is based on differences in rainfall patterns. During the El Niño phase, data from 2015, La Niña in 2022, and the neutral phase in 2013 were compared.

Table 2. Regional sample points

Region	Rainfall Patterns	Latitude	Longitude
Pontianak	Equatorial	-0.15	109.05
		-0.05	109.15
		0.05	109.25
		0.15	109.35
Bandung	Monsoon	-6.95	107.45
		-6.85	107.55
		-6.75	107.65
		-6.65	107.75
Sorong	Local	-0.85	131.05
		-0.75	131.15
		-0.65	131.25
		-0.55	131.35

In Pontianak, during the El Niño phase in 2015, there was a dry season from the 3rd dasarian of June to the 2nd dasarian of October. From January to the 2nd dasarian of June and the 3rd dasarian of October to December, there is a rainy season, as shown in Figure 10(a). During the La Niña phase, nothing meets the conditions for the start of the dry season. Throughout 2022, there will be a rainy season. Meanwhile, during the neutral phase in 2013, there was a dry season in June, and the other months experienced a rainy season.

In Bandung, during the El Niño phase 2015, there was a dry season from the 2nd dasarian of May to October. There is a rainy season from January to the 1st dasarian of May and November to December. During the La Niña phase, there is a dry season from the 3rd dasarian of July to September, while the other months experience a rainy season, as shown in Figure 10(b). Meanwhile, during the neutral phase in 2013, there was a dry season from the 3rd dasarian July to October 2nd dasarian October. The rainy season occurs from January to the 2nd dasarian July and the 3rd dasarian of October to December.

In Sorong, during the El Niño phase in 2015, there was a dry season in January, the 2nd dasarian from April to May, the 3rd dasarian June to the 2nd dasarian October, and December, the other months experienced the rainy season. During the La Niña phase, throughout 2022, there is a rainy season because there are no three consecutive cesarian where the rainfall value is below 50 mm. Meanwhile, during the neutral phase in 2013, there was a dry season from the 3rd dasarian September to the 2nd dasarian October, and the other months experienced the rainy season, as shown in Figure 10(c).

@The Author(s). 2025. Published by CBIORE

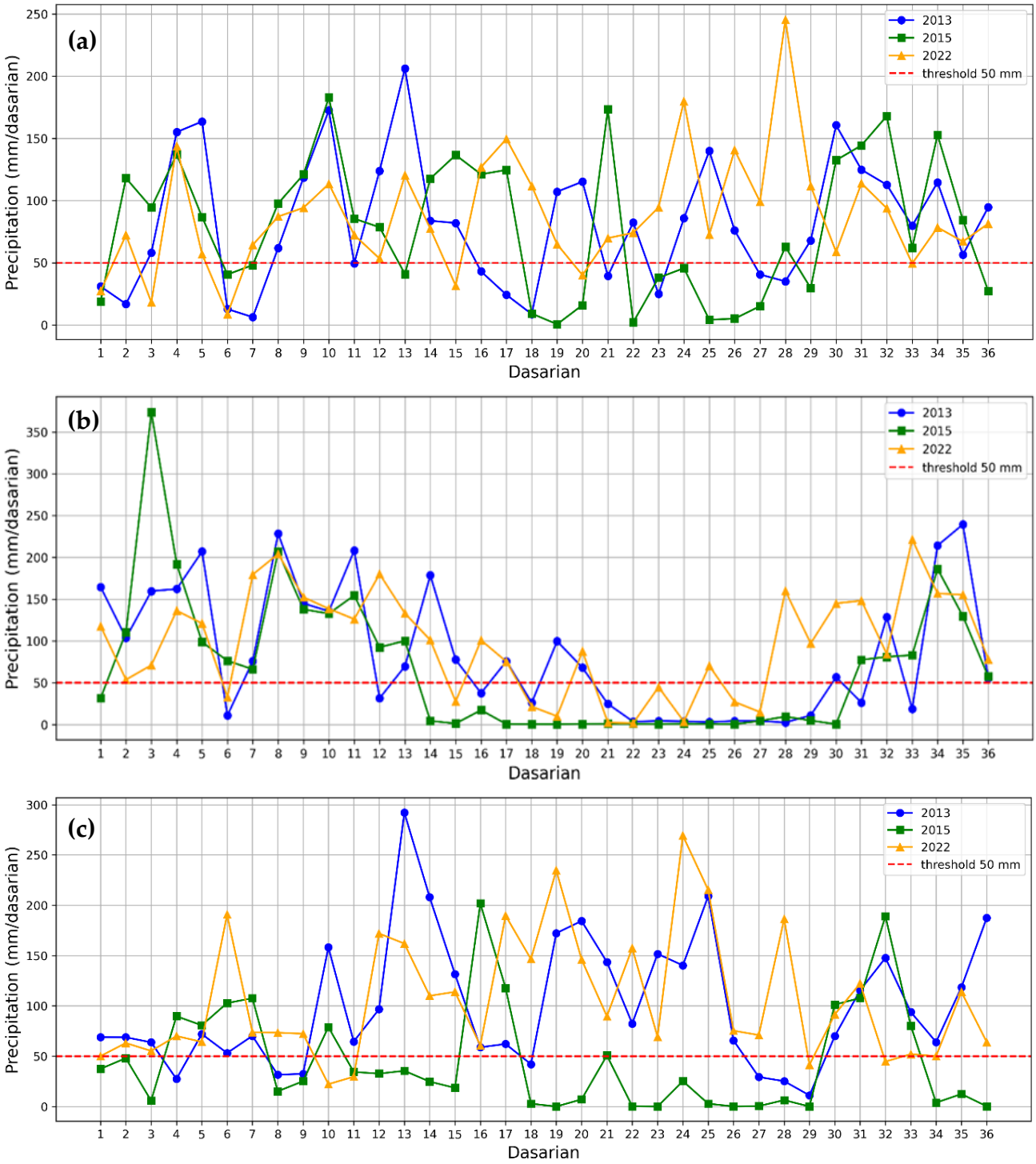

Figure 10. Dasarian rainfall patterns in (a) Pontianak, (b) Bandung, and (c) Sorong

From the three sample points, the region shows that during the El Niño phase, it experiences a longer dry season and a shorter rainy season than neutral conditions. Meanwhile, during the La Niña phase, on the other hand, the dry season is shorter, and the rainy season is longer, which can even cause the rainy season to occur throughout the year compared to neutral conditions. Indonesian rainfall is strongly affected by ENSO, and this, in turn, is reflected in seasonal and annual rice paddy production. Of particular significance is the early onset of the dry season and late onset of the dry season in El Niño years, which results in reduced dry season and annual rainfall totals (Kirono & Tapper, 2015). In El Niño's case, the reduced rainfall amount in the dry season means a severe negative impact. On the other hand, the increase in rainfall amount in the dry season during La Niña events means a positive impact (Aldrian, 2002). Based on the results of this study, it is suspected that El Nino causes the rainy season in Indonesia to come later and the dry season to last longer than normal because, during El Nino, the sea surface in Indonesia is colder so that evaporation can

@The Author(s). 2025. Published by CBIORE

cause rain is difficult to occur. La Nina causes the rainy season in Indonesia to come earlier and the dry season to come later than normal because during La Nina, the surface temperature in the Indonesian sea is hotter, so evaporation easily occurs, which can cause rain.

4. Conclusion

Based on research that identifies the beginning of the rainy and dry seasons in Indonesia, the following conclusions can be drawn. The areas that experience the start of the rainy season first are in Riau Province, northern West Sumatra, southern Jambi, Bengkulu northern part, parts of South Sumatra, West Kalimantan, Central Kalimantan, East Kalimantan, and Sulawesi Island. Whereas for the start of the dry season, the dominant regions experience it first in the northern part of Sumatra Island and most of the island Kalimantan, compared to other regions in Indonesia. Changes at the beginning of the rainy season in Indonesia are predominantly negative, this indicates that climatology period 2 (2011-2022) experiences a rainy season that is shorter compared to period 1 (2001-2011). Meanwhile changes in the start of the dry season in Indonesia are predominantly positive, this is the case indicating that period 2 (2012-2022) experienced a drier season longer compared to period 1 (2001-2011). The standard deviation between the start of the rainy season and the start of the dry season in Indonesia is a maximum of 14 dasarian. This indicates that the occurrence of the beginning of the rainy season and the beginning of the dry season in certain areas in every year Indonesia can move forward or backward by 14 dasarian. ENSO can influence changes in the pattern of the start of the season.

Acknowledgement

The author is grateful to Tanjungpura University for providing computer laboratory facilities to complete this research. The authors also thank the National Research and Innovation Agency for supporting this research.

References

Aldrian, E. (2002). Spatial Patterns of Enso Impact on Indonesian Rainfall. *Jurnal Sains & Teknologi Modifikasi Cuaca*, 3(1), 5–15.

Aldrian, E., Karmini, M., & Budiman. (2011). *Adaptasi dan Mitigasi Perubahan Iklim di Indonesia;* Pusat Perubahan Iklim dan Kualitas Udara BMKG: Jakarta, Indonesia, ISBN: 978-602-19508-0-7; pp. 174.

Beis, D. S., Pattipeilohy, W. J., & Hadi, A. S. (2022). Kajian Identifikasi Penurunan Tren Curah Hujan, CDD dan CWD di Kota Kupang, Nusa Tenggara Timur. *Buletin GAW Bariri*, 3(1), 8–16. https://doi.org/10.31172/bgb.v3i1.62

BPS. (2023). *Persentase Tenaga Kerja Informal Sektor Pertanian (Persen)*, 2021-2022. Badan Pusat Statistik. https://www.bps.go.id/id/statistics-table/2/MTE3MSMy/persentase-tenaga-kerja-informal-sektor-pertanian.html

Duwanda, I. G. A. M. D., & Sukarasa, I. K. (2022). Validasi Curah Hujan Harian Berdasarkan Data Global Satellite Mapping of Precipitation (GSMaP) dengan Data Observasi di Wilayah Bali. *Buletin Fisika*, 23(2), 106–112. https://ojs.unud.ac.id/index.php/buletinfisika/article/download/75971/41129/

Fatkhuroyan, Wati, T., Sukmana, A., & Kurniawan, R. (2018). Validation of Satellite Daily Rainfall Estimates Over Indonesia. *Forum Geografi*, 32(2), 170–180. http://dx.doi.org/10.23917/forgeo.v32i2.6288

Ferdian, H., Sutikno, S., & Fauzi, M. (2017). Penggunaan Data Hujan Satelit Terkoreksi untuk Analisis Kejadian Banjir di DAS Rokan. *Jurnal Rab Construction Research*, 2(2), 233–247.

Giarno, G., Dupe, Z. L., & Mustofa, M. A. (2012). Kajian Awal Musim Hujan Dan Awal Musim Kemarau Di Indonesia. *Jurnal Meteorologi Dan Geofisika*, 13(1). https://doi.org/10.31172/jmg.v13i1.113

Hariarta, I. G. W. (2015). *Verifikasi Data Curah Hujan TRMM di Sumbawa Menggunakan Metode Inverse Distance Weighting, Mean, dan Point.* Undergraduate Thesis, Sekolah Tinggi meteorologi Klimatologi dan Geofisika, Tangerang, 2015.

Helda, N., & Wijayanto, M. R. (2023). Identifikasi Kejadian Hujan dengan Menggunakan Data Satelit GSMaP (Global Satellite Mapping of Precipitation) di Banjarbaru. *Buletin Profesi Insinyur*, 6(2), 1–6. https://doi.org/10.20527/bpi.v6i2.195

Hidayati, I. N., & Suryanto, S. (2015). Pengaruh Perubahan Iklim Terhadap Produksi Pertanian Dan Strategi Adaptasi Pada Lahan Rawan Kekeringan. *Jurnal Ekonomi & Studi Pembangunan*., 16(1), 42–52. https://doi.org/10.18196/jesp.16.1.1217

Iskandar, D. (2010). *Cuaca dan Iklim (U. Mustain (ed.))*. ALPRIN.

@The Author(s). 2025. Published by CBIORE

JAXA. (2015). Global Satellite Mapping of Precipitation Microwave-IR Combined Product (GSMaP _ MVK) and Gauge-calibrated Rainfall Product (GSMaP_Gauge), Reanalysis Products (GSMaP_RNL), and Gauge-calibrated Reanalysis Product (GSMaP_Gauge_RNL) Data Format Description f.

Juaeni, I., Penerbangan, L., & Terapan, M. (2006). Analisis Variabilitas Curah Hujan Wilayah Indonesia Berdasarkan Pengamatan Tahun 1975-2004. *Jurnal Matematika Undip*, 9(2), 172–180.

Kirono, D. G. C., & Tapper, N. J. (2015). Enso rainfall variability and impacts on crop production in Indonesia. *Physical Geography*, 20(6), 508–519. https://doi.org/10.1080/02723646.1999.10642693

Kubota, T., Hashizume, H., Shige, S., Okamoto, K., Aonashi, K., Takahashi, N., Ushio, T., & Kachi, M. (2006). Global precipitation map using satelliteborne microwave radiometers by the GSMaP project: Production and validation. *International Geoscience and Remote Sensing Symposium (IGARSS)*, 45(7), 2584–2587. https://doi.org/10.1109/IGARSS.2006.668

Mega, F. (2016). *Validasi Data Curah Hujan Global Satellite Mapping of Precipitation (GSMaP) pada Tiga Pola Hujan Di Indonesia*. Undergraduate Thesis, Geophysics and Meteorology, IPB University, Bogor, 31st May 2016.

Natadiredja, S., Sukarasa, I. K., & Sutapa, G. N. (2018). Validasi Curah Hujan Harian Berdasarkan Data Global Satellite Mapping of Precipitation (GSMaP) di Wilayah Bali dan Nusa Tenggara. *Buletin Fisika*, 19(1), 12–15. https://doi.org/10.24843/BF.2018.V19.I01.P03

Prabaningrum, R., & Nuriani, E. (2016). Identifikasi perubahan zona agroklimat metode oldeman Di Provinsi Jawa Barat. *Bumi Indonesia*, 5(4), 1–10.

Rahmadi, P. Z., & Santosa, B. (2018). Modal Sosial Petani Sawah Berlahan Sempit Dalam Pemenuhan Nafkah Rumah Tangga. *Jurnal Analisa Sosiologi*, 5(1). https://doi.org/10.20961/jas.v5i1.17986

Rahman, R. N., & Indra. (2020). Validasi Performa Satelit Presipitasi GSMaP Dalam Mengestimasi Curah Hujan Di Jabodetabek. *Jurnal Widya Climago*, 2(2), 78.

Setiawan, D. (2018). Pengelompokan Zona Musim di Indonesia Berdasarkan Data Curah Hujan Menggunakan Time Series Based Clustering. https://repository.its.ac.id/56777/%0Ahttps://repository.its.ac.id/56777/1/062114400000071-Undergraduate_Theses.pdf

Setiyoko, A., Osawa, T., & Nuarsa, I. W. (2019). Evaluation of GSMaP Precipitation Estimates Over Indonesia. *International Journal of Environment and Geosciences*, 3(1), 26–43.

Susilokarti, D., Arif, S. S., Susanto, S., & Sutiarso, L. (2015). Identifikasi Perubahan Iklim Berdasarkan Data Curah Hujan di Wilayah Selatan Jatiluhur Kabupaten Subang, Jawa Barat. *Jurnal Agritech*, 35(01), 98. https://journal.ugm.ac.id/agritech/article/view/13038/15155

@The Author(s). 2025. Published by CBIORE