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Accuracy of CHIRPS rainfall data and its utilization in determining the onset of the wet and dry seasons in North Sumatra

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सार – मौसम आर्द्र जलवायु प्राचलों में से एकवर्षा है जिसकी घटना की विशेषताएं वतीव्रता समय आर्द्र स्थान के साथ बहुत भिन्न होती है, जो खासकर इंडोनेशियाई समुद्री महाद्वीप (IMC) मेंभौगोलिक परिस्थितियों आर्द्र वायुमंडलीय गतिशीलता से प्रभावित होती है। विशेष रूप से इंडोनेशिया में वर्षा आर्द्र शुष्क ऋतुकी शुरुआत निर्धारित करने के लिए सटीक वर्षा डेटा की उपलब्धता बहुत महत्वपूर्ण है, जो सामुदायिक गतिविधियों को निर्धारित करने, विशेष रूप से कृषि क्षेत्र में, आर्द्र जल संसाधन नीतियों को तैयार करने में बहुत महत्वपूर्ण है।हालाँकि, वर्षा मापकों की सीमित संख्या वर्षा की जाँच में एक महत्वपूर्ण चुनौती पेश करती है। परिसीमा के कारण, वर्षा अनुमान के लिए उपग्रह व्यवहार्य समाधान प्रदान करते हैं, आर्द्र ऐसा एक डेटा सेट स्टेशन डेटा (CHIRPS) के साथ क्लाइमेट हैज़र्ड्स ग्रुप इन्फ्रारेड वर्षण है। फिर भी, CHIRPS डेटा के उपयोग कीसटीकता के लिए कड़े परीक्षण की आवश्यकता होती है। इस अध्ययन का उद्देश्य आद्र आर्द्र शुष्क ऋतु की शुरुआत का निर्धारण करने में CHIRPS डेटा की सटीकता आर्द्र इसकी प्रयोज्यता का आकलन करना है। आकस्मिकता तालिका पद्धति का उपयोग करते हुए, उत्तरी सुमात्रा क्षेत्र में चार BMKG स्टेशनों से इन-सीटू प्रेक्षण डेटा का उपयोग करके सत्यापन किया गया। निष्कर्षों से चार स्टेशनों पर भूमध्यरेखीय वर्षा पैटर्न का पता चलता है, जिसमें अधिकतम वर्षा सितंबर-अक्टूबर-नवंबर (SON) आर्द्र मार्च-अप्रैल-मई (MAM) अवधि के दौरान होती है। विशेष रूप से उच्च पियर्सन सहसंबंध मूल्यों मेंमासिक CHIRPS डेटा सर्वोच्च प्रदर्शन करता है। दैनिक वर्षा के लिए अनुपात सही (PC) औसतन 62% है, जिसमें उच्चतम सटीकता बिनाका मौसम विज्ञान केंद्र में देखी गई। विशेष रूप से, पश्चिमी तट पर दशकीय (10-दिवसीय) आर्द्र मासिक वर्षा की गणना की सटीकता उत्तरी सुमात्रा के पूर्वी तट की तुलना में बेहतर प्रदर्शन करती है। शुष्क मौसम की शुरुआत का निर्धारण करने के संबंध में, CHIRPS डेटा प्रेक्षणों की तुलना में पहले की शुरुआत का अनुमान लगाता है। इसके विपरीत, आर्द्र मौसम की शुरुआत के आकलन से उत्तरी सुमात्रा के पश्चिमी तट पर एक साथ शुरुआत का पता चलता है। ये जानकारियां वर्षा पैटर्न के बारे में हमारी समझ को बढ़ाती हैं आर्द्र उत्तरी सुमात्रा क्षेत्र में मौसमी शुरुआत के पूर्वानुमानों के लिए CHIRPS डेटा के उपयोग को परिष्कृत करती हैं।

ABSTRACT. Rainfall is one of the weather and climate parameters whose event characteristics and intensity vary greatly over time and space, which is influenced by geographical conditions and atmospheric dynamics, especially in the Indonesian Maritime Continent (IMC). The availability of accurate rainfall data is very important to determine the start of the rainy and dry seasons, especially in Indonesia, which is very important in determining community activities, especially in the agricultural sector, and formulating water resource policies. However, the limited number of rain gauges poses a significant challenge in monitoring rainfall. Due to the limitation, satellites offer a viable solution for rainfall estimation, and one such data set is the Climate Hazards Group Infrared Precipitation with Station data (CHIRPS).

Nevertheless, the use of CHIRPS data requires rigorous testing for accuracy. This study aims to assess the accuracy of CHIRPS data and its applicability in determining the onset of the wet and dry seasons. Validation was carried out using in-situ observation data from four BMKG stations in the North Sumatra region, employing the Contingency Table method. The findings reveal an Equatorial rain pattern at the four stations, with peak rainfall occurring during the September-October-November (SON) and March-April-May (MAM) periods. Monthly CHIRPS data demonstrates optimal performance, particularly in the high Pearson Correlation values. The Proportion Correct (PC) for daily rainfall averages 62%, with the highest accuracy observed at Binaka Meteorological Station. Notably, the accuracy of decade (10-day) and monthly rainfall calculations on the West Coast outperforms those on the East Coast of North Sumatra. Regarding determining the dry season onset, CHIRPS data forecasts an earlier onset compared to observations. Conversely, the assessment of the wet season onset reveals a simultaneous initiation along the west coast of North Sumatra. These insights enhance our understanding of rainfall patterns and refine the utilization of CHIRPS data for seasonal onset predictions in the North Sumatra region.

Key words– Rainfall, CHIRPS, Sumatera, Contingency table, Onset season.

1. Introduction

Rain is a form of precipitation which takes the form of liquid drops (Tjasyono, 2012). Rain is a form of precipitation in the form of liquid droplets. In Indonesia, rainfall is the most prominent climate element with great diversity and significant fluctuations, so that rainfall is used as a differentiator of the climate character in Indonesia (Tjasyono, 2004). Given Indonesia's status as an archipelago with dynamic atmospheric conditions, alterations in rainfall distribution exhibit significant variability and rapid shifts (Aldrian & Susanto, 2003; Giarno *et al*., 2012; Sucahyono & Ribudiyanto, 2013). The intricate topography further amplifies the complexity of weather patterns, particularly in the context of rainfall influence (Prasetyo *et al*., 2018).

Accurate and comprehensive information regarding the quality and quantity of rainfall data plays a fundamental role in the field of water resources. This data serves as a fundamental basis for formulating policies, devising strategies, and planning water-related initiatives within a region. The Indonesian region, characterized by high rainfall variability, necessitates special attention, particularly in the context of hydro-meteorological disaster mitigation. Given the substantial impact of such disasters, both on a societal and governmental scale, there is an imperative to enhance preparedness measures. Acknowledging this urgency, the government and society must collectively bolster their readiness to address the challenges posed by hydro meteorological disasters (BNPB, 2021). This region very often experiences significant spikes in rainfall (Tjasyono, 2007). This preventive approach serves as an important mechanism to minimize risks and increase resilience in the face of unpredictable weather patterns, thereby making a significant contribution to overall disaster preparedness in the region.

The Meteorology, Climatology and Geophysics Agency (BMKG), an Indonesian state institution which is responsible for national weather information services, has installed many conventional and automatic rain gauges. However, to date, the amount of rainfall data is still insufficient (Giarno, *et al*., 2021). Limited funds, human resources and field conditions are why rainfall measurements on the earth's surface are minimal. Detailed analysis, such as the sub-district or village level of rainfall, requires thick rain gauges, which are still unavailable in Indonesia. The development of remote-sensing rain observation technology can be used as one of the solutions to overcome the problem of the lack of distribution of rain gauges on the surface (Kidd *et al*., 2003; Wright *et al*., 2017; Giarno *et al*., 2020a; Giarno *et al.*, 2020b).

In remote sensing observations, rainfall is calculated using the knowledge of electromagnetic waves emitted by clouds and captured by satellites/radar. Satellite rainfall estimation cover an extensive area with various spatial and temporal resolutions (Martin & Scherer, 1973). The advantages of satellites compared to surface observations are high spatial and temporal resolution and real-time (Shrestha *et al*., 2017), making it more economical. Some rainfall estimation results such as Tropical Rainfall Measuring Mission (TRMM) (Islam & Uyeda, 2006; Karaseva *et al*., 2012), Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) (Sorooshian *et al*., 2002; Moazami *et al.*, 2012; Shukla, *et al*., 2016) and The Climate Prediction Center (CPC) MORPHing technique (CMORPH) (Joyce, *et al*., 2004), however, rainfall estimation results from these remote-sensing data vary in accuracy over space (place) and time (Giarno, *et al*., 2018). Validation of CHIRPS rainfall estimates shows that CHIRPS performs well in estimating monthly and annual rainfall (Shrestha *et al*., 2017; Bai *et al*., 2018; Gao *et al*., 2018).

In the context of tropical region, several comparisons of CHIRPS with other satellite products in Indonesia demonstrate that CHIRPS estimates are notably accurate

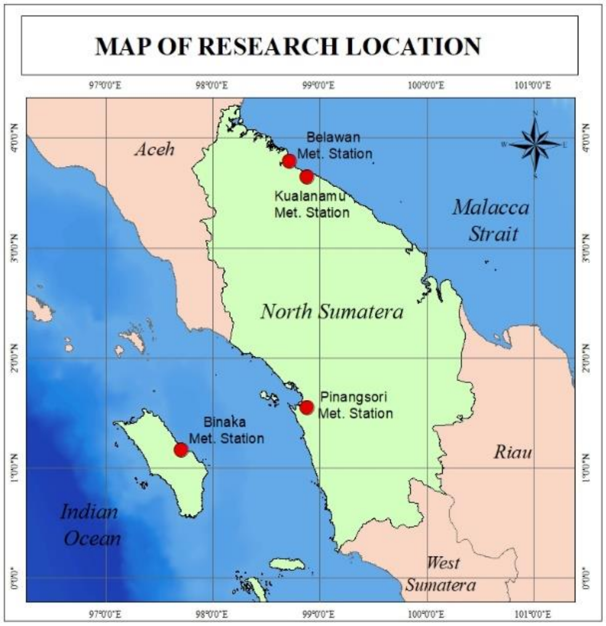


Fig. 1. Map of research location

compared to alternative satellite products in specific provinces, including Yogyakarta (Rahmawati *et al.*, 2021), Bali (Liu *et al.*, 2020), East Java (Faisol *et al.*, 2020; Wiwoho *et al.*, 2021), East Nusa Tenggara (Gerland *et al.*, 2023) and Indonesia as a whole (Wati *et al.*, 2021; Asferizal, 2022). Meanwhile, accuracy calculations for CHIRPS alone, without comparison, have been conducted in various locations such as Papua (Faisol and Paga, 2021; Budiyono and Faisol, 2021), North Sumatra (Saragih *et al.*, 2022), West Kalimantan (JokoSuryanto *et al.*, 2023), and East Java (Wahyuni *et al.*, 2021; Hastina *et al.*, 2023). The results of these assessments indicate that CHIRPS accuracy is commendable. In Indonesia, CHIRPS is applied for drought monitoring (Narulita *et al.*, 2021; Faisol *et al.*, 2021; Viddaroini *et al.*, 2023). In this research, we endeavour to apply the CHIRPS product uniquely to determine the onset of the rainy season and the dry season in North Sumatra. The topography of North Sumatra consists of many mountains and lowlands. In predicting the onset of the wet and dry seasons, data from rain gauges are usually used, which are limited in number. Its high resolution and specificity in estimating rain on the ground make CHIRPS an alternative for determining the onset of wetand dry season. However, it is necessary to test the accuracy of CHIRPS on its usefulness in determining the season.

2. Data and methods

The study area for this research is located North Sumatra Province, as shown in Fig. 1. Four observation stations were used as test points: Stamar Belawan, Stamet Kualanamu, Stamet Pinangsori and Stamet Binaka is located on the east and west coasts of this province. This study used daily rainfall accumulation data from January 1, 2007 to December 31, 2021.

TABLE 1

Position of rainfall observation stations

Meteorological Observation	Station Code	Latitude (°N)	Longitude (°E)	Elevation (masl)
Belawan	96033	3.78824	98.71492	3
Kualanamu	96035	3.64573	98.88488	23
Pinangsori	96073	1.55000	98.88000	10
Binaka	96075	1.16490	97.70360	7

The data of CHIRPS version 2.0 Final daily rainfall estimation data with a spatial resolution of 0.05° (± 5.5 km) is used for remote sensing rainfall estimation. This data can be accessed from the CHIRPS dataset web page, https://data.chc.ucsb.edu/products/CHIRPS-2.0/. CHIRPS data is global data extracted from four observation station coordinates, as shown in Table 1. Observed rainfall data from the four BMKG observation stations was used as comparison data (validation). The selected four stations were due to completeness and access to data. Specifically, the selection includes the Belawan Meteorological Station, Kualanamu Meteorological Station, Pinangsori Meteorological Station and Binaka Meteorological Station, all of which are main observation stations so that the data quality is guaranteed. Interestingly, these four stations offer a relatively diverse spatial distribution throughout the North Sumatra region, including the west coast, east coast and islands. Observations at land-based weather stations spatially play an important role in producing reliable operational rainfall analysis. The strategic selection of stations increases the study's capacity to capture and understand the various rainfall patterns prevalent in the North Sumatra region.

Rainfall observed and rainfall CHIRPS daily estimates data is grouped into accumulating rainfall values every ten days or named basis. One month is divided into three days and because the number of days in a month is not the same, the division is as follows:

(*i*) 1st Dasarian, consisting of the 1st to the 10th;

(*ii*) 2nd Dasarian, consisting of the 11th through the 20th;

(*iii*) 3rd Dasarian, consisting of the 21st to the end of the month.

TABLE 2

Contingency Table Scheme used in the study

		Rainfall observation data		
CHIRPS rainfall estimation data	Yes	*hit* (a)	*false alarm* (b)	a + b
	No	*miss* (c)	*correct negative* (d)	c + d
	Total	a + c	b + d	a + b + c + d = n

The classification 10 days rainfall determines how dry and wet seasons begin. Each dasarian data was classified into dry and wet categories. If its value less than 50 mm, it called dry and conversely if more than 50 mm is called wet. Moreover, determination of the onset of wet and dry season is based on 10 days rainfall accumulation series, with provisions as per the criteria of Giarno *et al*. (2012), such as:

(*i*) If there is one dasarian of less than 50 mm followed by the next two dasarians and the aggregation less than 150 mm for three consecutive dasarians, then the first rainfall accumulation 10 days of less than 50 mm is the onset of the dry season.

(*ii*) If there is one dasarian of more than or equal to 50 mm and is followed by two subsequent dasarians and the rainfall accumulation more than or equal to 150 mm for three consecutive dasarians, then first precipitation accumulation 10 days of more than 50 mm is the onset of the wet season.

The point-based comparison in this study involved extracting grid values from a specific raster grid dataset, ensuring an overlap with the stations of rain gauges. While this method holds efficacy, it does have a vulnerability, particularly when rain gauges are positioned in close proximity, stemming from limitations in spatial resolution. It is important to note, however, that in the current study, the rain gauges are strategically located at distances greater than 13 kilometers. This considerable distance ensures that the values derived from CHIRPS effectively represent the precipitation encompassing the areas surrounding the rain gauges. This deliberate placement mitigates potential spatial resolution constraints and enhances the reliability of the comparison, facilitating a more robust assessment of the accuracy and representativeness of the CHIRPS dataset in capturing precipitation patterns across the study area.

Validation of CHIRPS rainfall using correlation and Contingency Tables. The positive correlation value means the relationship is unidirectional, with the range of values ranging from 0 - 1, where 1 indicates a perfect correlation.

TABLE 3

Rainfall validation scheme used in research

Period	Category	Indicator	Rainfall Amount
Daily	Rain	Yes	<0 mm/day
		No	>0 mm/day
Dasarian (10-day)	Light	Yes	0-50 mm/dasarian
		No	>50 mm/dasarian
	Moderate	Yes	51-150 mm/dasarian
		No	<50 mm/dasarian or >150 mm/dasarian
	Heavy	Yes	151-300 mm/dasarian
		No	<150 mm/dasarian or >300 mm/dasarian
	Very Heavy	Yes	>300 mm/dasarian
		No	<300 mm/dasarian
Monthly	Light	Yes	0-100 mm/month
		No	>100 mm/dasarian
	Moderate	Yes	101-300 mm/month
		No	<100 mm/month or >300 mm/month
	Heavy	Yes	301-500 mm/month
		No	<300 mm/month or >500 mm/month
	Very Heavy	Yes	>500 mm/month
		No	<500 mm/month

The following equation is used to calculate the Pearson Correlation value:

$$r = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{\sqrt{\left\{n\sum_{i=1}^{n}(X_i)^2 - \left(\sum_{i=1}^{n} X_i\right)^2\right\}\left\{n\sum_{i=1}^{n}(Y_i)^2 - \left(\sum_{i=1}^{n} Y_i\right)^2\right\}}} \quad (1)$$

where r is the Pearson correlation value, X_i is the CHIRPS rainfall data, Y_i is the observed rainfall data and n is the total amount of data.

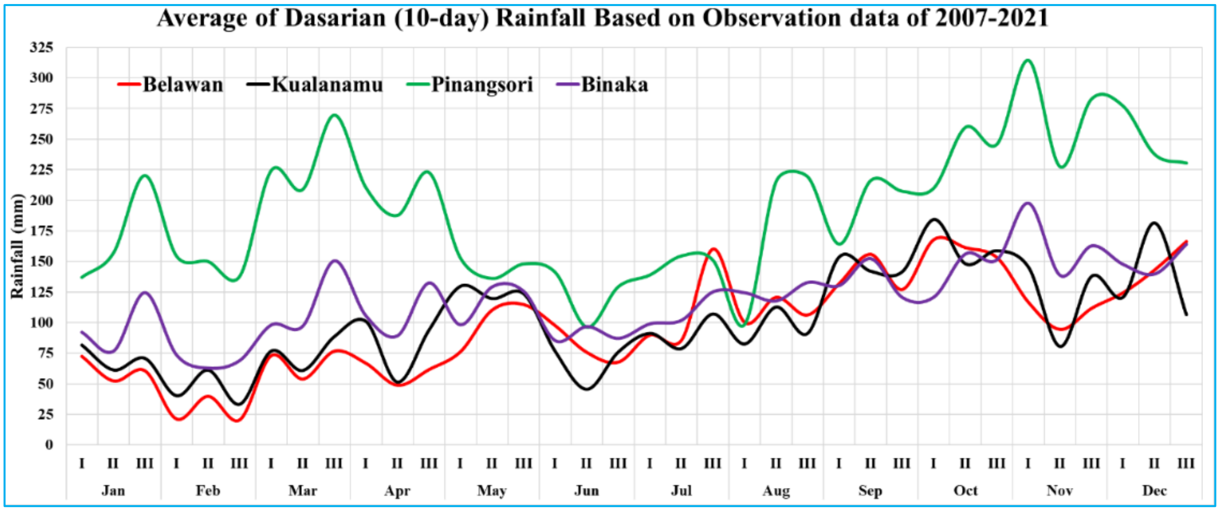


Fig. 2. Graph of average dasarian rainfall values based on observation data

The contingency table method is performed with two categories (dichotomous), indicating the frequency of "Yes" or "No" in forecasts and events with four distributions: hits, false alarms, misses, and correct negatives (Didiharyono & Giarno, 2021). What is calculated in this research is the number of forecasts stating whether it will rain or not, compared with the number of observations, whether it will rain or not. Contingency tables are two-dimensional tables that describe the discrete distribution of a composite sample of a deterministic forecast and categorical observations. The correspondence of hits, false alarms, misses, and correct negatives to CHIRPS predictions and rain observations are shown in Table 2.

Evaluation perform of rainfall estimation capability is quantified using the calculation of Proportion Correct (PC) and Threat Score (TS) or Critical Success Index (SCI) values using the following equations:

$$PC = \frac{\text{Hits} + \text{CorrectNegatives}}{\text{Total}} \quad (2)$$

$$CSI = \frac{\text{Hits}}{\text{HITS} + \text{False Alarms} + \text{Misses}} \quad (3)$$

Rainfall validation calculated daily rainfall event and its intensity. Meanwhile, the dasarian and monthly accumulations are divided into low, medium and high, as shown in Table 3. This dasarian and monthly classification is by the operations used by BMKG in describing dasarian and monthly rainfall conditions when making seasonal forecasts.

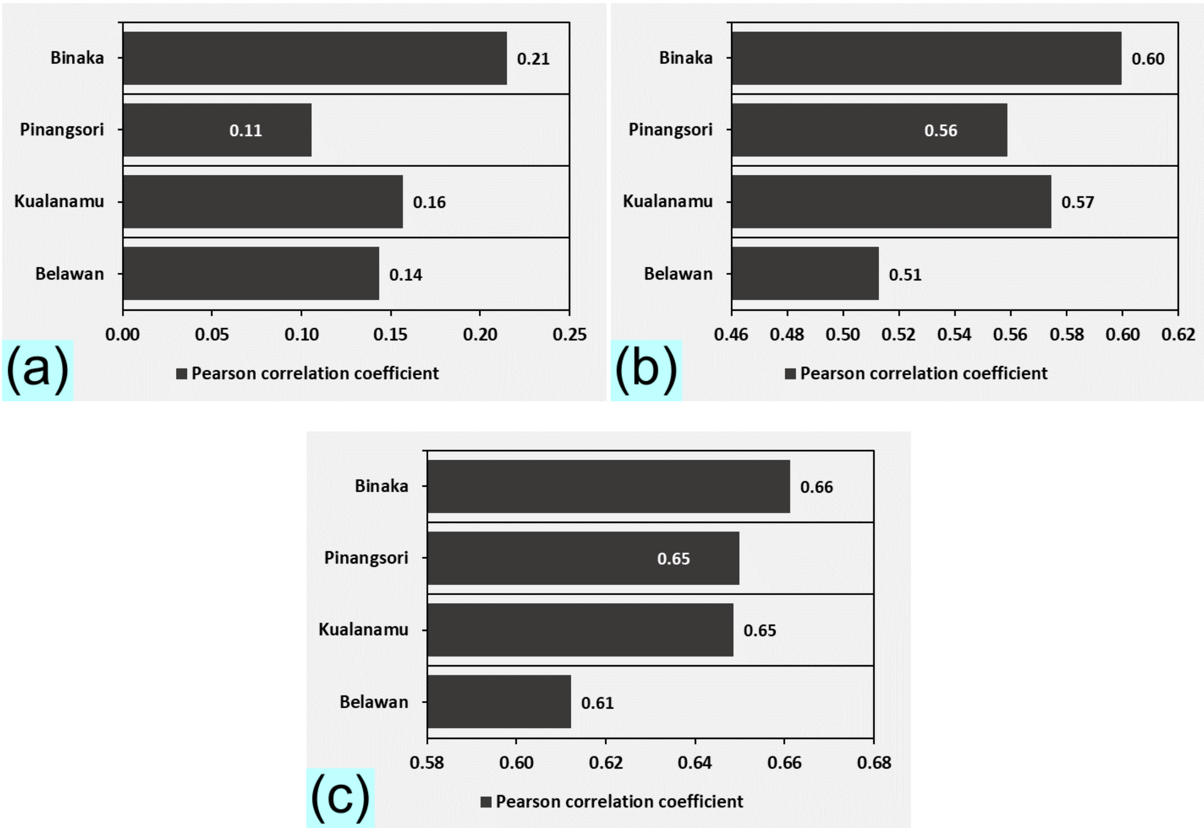
3. Result and discussion

3.1. *Rainfall Patterns in North Sumatra*

Based on the plotting resulted of the average rainfall from 2007-2021, the rainfall pattern at the four observation stations resembled an equatorial pattern. The feature of the equatorial rainfall pattern is the monthly rainfall distribution has bimodal or two peaks in a year. The first peak of the wet season at Belawanand Kualanamu occurs in the first dasarian of October, while at Pinangsori and Binaka, occurs in the first dasarian of November. Then the second peak of the wet season at Belawanand Kualanamu occurred in the third dasarian of May and the first dasarian of May. In contrast to Pinangsori and Binaka, which have peak of the wetseason occurs in the third dasarian of March. Based on the results of plots and locations at the four stations, it can be seen that the peak of the first wetseason on the East Coast of North Sumatra is earlier, but the peak of the second wetseason is later than the West Coast of North Sumatra.

3.2. *Quantitative accuracy of rainfall*

The relationship between daily rainfall observation and CHIRPS rainfall estimation was quantitatively calculated using Pearson Correlation. The results showed that the highest accuracy was found at Binaka Station with its correlation spanned between 0.14 to 0.21. However, the accuracy increase, if the calculation considered longer rainfall accumulation. In dasarian scheme, the correlation value is between 0.51 to 0.60, and in monthly accumulation 0.61 to 0.66, as shown in Fig. 3.



Figs. 3(a-c). Pearson Correlation CHIRPS rainfall data compared to the observation data; daily period (a) dasarian period (b) and monthly period (c)

3.3. *Qualitative accuracy of rainfall*

Quantitative accuracy was calculated by the dichotomous method used to determine the suitability of the CHIRPS rainfall estimates to the observation data as shown in Table 3. The resulted shows the distribution of validation scores of daily rainfall estimation of CHIRPS data against observational data, which was calculated based on the value of hits, false alarms, misses, and correct negatives. Regarding accuracy or PC value, the CHIRPS forecast score at four locations relatively high, with an average accuracy of about 62%. Compared to the TS value, it is known that the CHIRPS skill in predicting rain events is highest at Binaka. However, when viewed from the Bias value, CHIRPS rainfall forecasts are dominantly over forecast compared to observational data, except at Binaka Station, which is under forecast. This means that the CHIRPS estimate is more likely to rain than not rain.

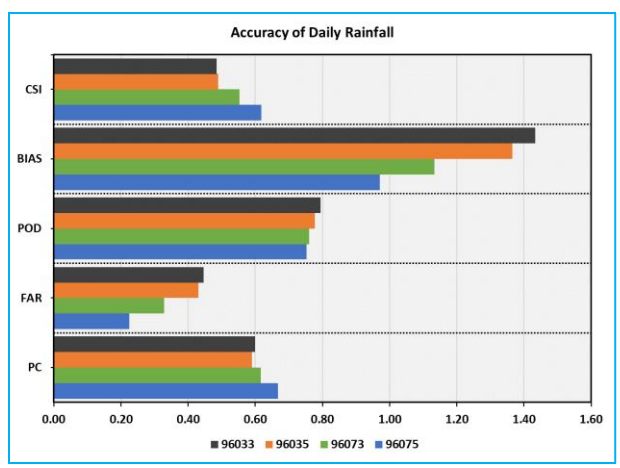
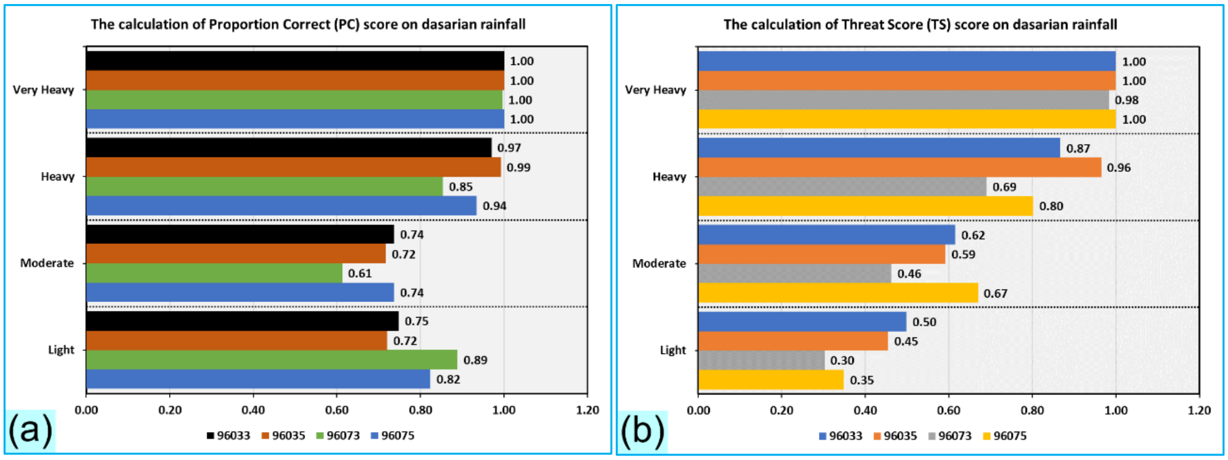
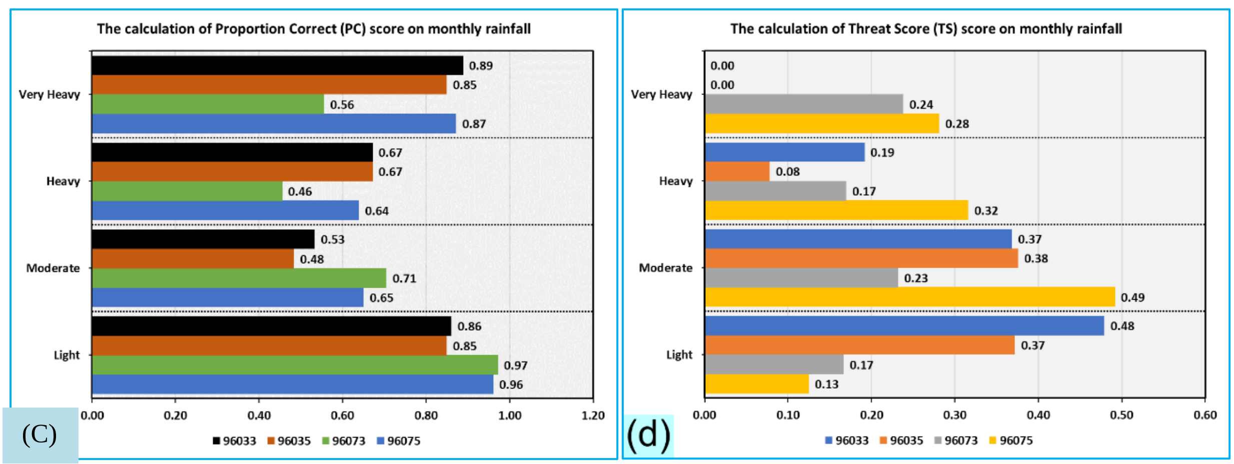


Fig. 4. The calculation of the validation score of daily rainfall estimation at Belawan (96033), Kualanamu (96035), Pinangsori (96073) and Binaka (96075)

The performance of CHIRPS rainfall intensity estimation based on Proportion Correct (PC) and Threat Score (TS) scores or Critical Success Index (SCI) can be seen in Fig. 5. The PC score showed that the light category of the basic rainfall estimates of CHIRPS at four stations has an average accuracy of about 0.8 or 80%.



Figs. 5(a&b). Score of PC (a) and TS (b) based on dasarian (10-day) rainfall at Belawan (96033), Kualanamu (96035), Pinangsori (96073), and Binaka (96075)



Figs. 5(c&d). Score of PC (c) and TS (d) based on monthly rainfall at Belawan (96033), Kualanamu (96035), Pinangsori (96073) and Binaka (96075)

Moreover, compared to the TS value, it is known that the highest skill of CHIRPS is in predicting the highest rainfall event at Belawan. On the other hand, the moderate ranfall for forecast score has an average accuracy of around 0.7 or 70%, and the highest score in Binangka. Meanwhile, the TS scores calculation shows the highest CHIRPS performance located at Binaka. The high category dashboard rainfall forecast score has average accuracy, and the TS score comparison shows the highest CHIRPS performance at Kualanamu. Very high category based on rainfall forecast score has an average accuracy of 1.0 or 100%.

Meanwhile, the Proportion Correct (PC) value based on accumulated monthly rainfall shows that when rainfall is categorized as low, the average value is between 0.85 to 0.95, with the best value in Pinangsori. Compared to the TS value, it is known that the highest skill of CHIRPS is in predicting the highest rainfall events at Belawan. Moreover, at the moderate monthly rainfall, forecast PC score has an average accuracy of around 59%, while based on TS scores, the highest CHIRPS performance is located at Binaka. The high monthly rainfall category, the average PC value of CHIRPS rainfall estimates is 0.61 or 61%. Meanwhile, compared with TS showed that the highest CHIRPS performance at Binaka. The very high category monthly rainfall forecast score has an average accuracy of 79% and the TS score comparison shows the highest CHIRPS performance at Binaka.

3.4. *Comparison of the onset of dry and wet seasons*

The benefits of remote sensing products for rainfall estimation such as CHIRPS are by using them to determine the start of the rainy season and the start of the dry season. Because the North Sumatra area has an

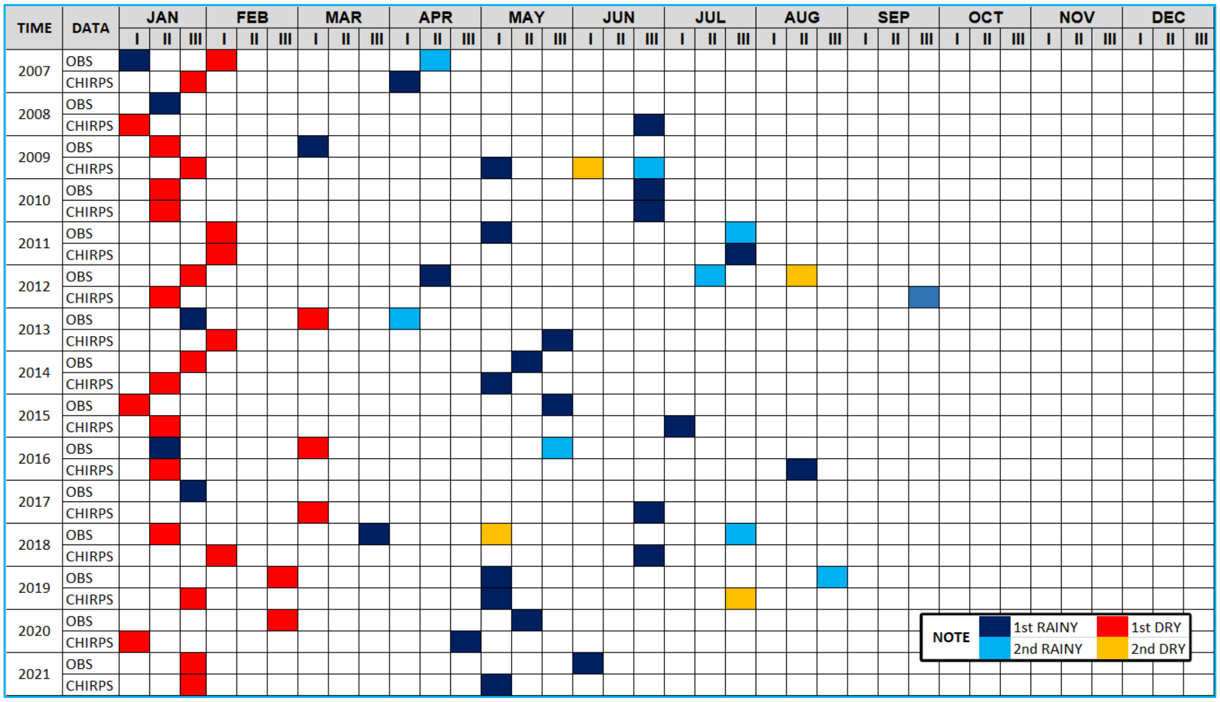


Fig. 7. Time-series determination of the onset of the dry season (DRY) and the onset of the wet season (RAINY) in Belawan

ecautorial type of rain which has 2 rain peaks, this area has two onsets and withdrawals. Calculations for the entry of the first rainy season based on calculations in Belawan from 2007 to 2021, the onset of the first wet season of observation data generally occurs in the range of Jan-I to Jun-III, with most events occurring from May-I to May-III as shown at Fig. 7. Meanwhile, based on the CHIRPS data, the onset of the wet season generally occurs in the range from Apr-I to Sep-III. Compared with CHIRPS data, the onset of the first wet season occurred between May-I and June-III. This result showed that the onset of Binangka was delayed (backward) compared with the observation data. Moreover, the onset of the wet season is approximately 1 to 21dasarian earlier than the observation data. However, in 2010 and 2019, the onset of the first wet season of the CHIRPS and observational data were at the same range of elementary times. Determination of the onset of the dry season in observational data generally occurs in the range from Jan-I to Mar-I, which dominantly occurs from Jan-I to Jan-III. Meanwhile, the CHIRPS data showed that the onset of the dry season commonly occurred in the Jan-I to Mar-I range, with most occurring in Jan-I to Jan-III. The difference between the onset of the first dry season was that the onset of the first dry season of the CHIRPS data occurred earlier (forward) than the observation data, *i.e.*, the onset of the first dry season of the CHIRPS data occurred approximately 1 to 5 days earlier than the observation data. However, in 2010, 2011 and 2021, the onset of the first dry season of the CHIRPS and observation data were at the same range of elementary times. In addition, in 2008 and 2017, there was no dry season for both the CHIRPS and observation data.

The determination of the onset of the second wet season from observation and CHIRPS data shows that the onset of the second wet season was not found in all years. Rainfall measured in the Binangka area is not stable enough, the value is more than 50 mm in 10 consecutive days. In surface rainfall data, events were found twice in the rainy season and twice in the dry season only in 2012 and 2018, while rainfall estimates using CHIRPS were only in 2009. Moreover, from the onset of the second wet season in both observation and CHIRPS data, it is known that the onset of the second wet season occurred in the range from Apr-I to Aug-III. The determination of the onset of the second dry season of the CHIRPS and observation data often did not occur in the same year, so it wasn't easy to compare the onset of the second dry season between the CHIRPS and observation data.

Identification of onset and withdrawal at Kualanamu shows that the onset of the first wet season of the observation data commonly occurs in the range of Jan-I to Sep-I, with the most frequent occurrence in Jan-I to Apr-III as shown at Fig. 8. While the onset of the first wet season of the CHIRPS data commonly occurs in the range

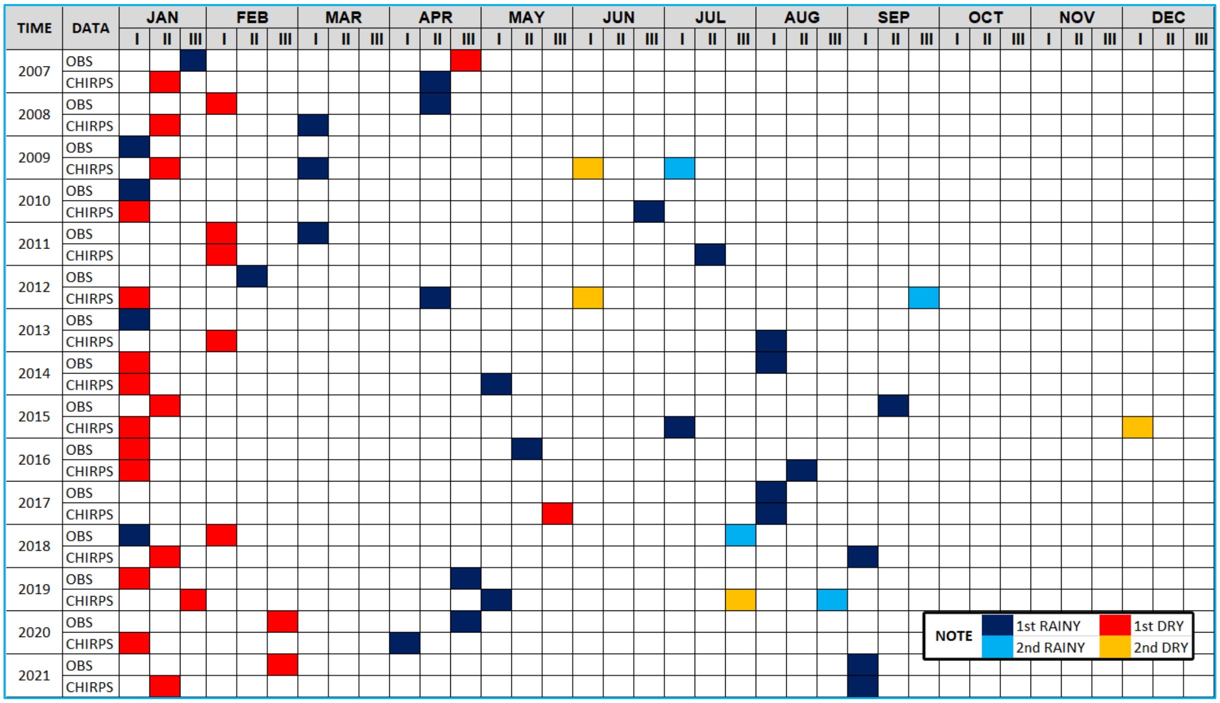


Fig. 8. Time-series determination of the onset of the dry season (DRY) and the onset of the wet season (RAINY) in Kualanamu

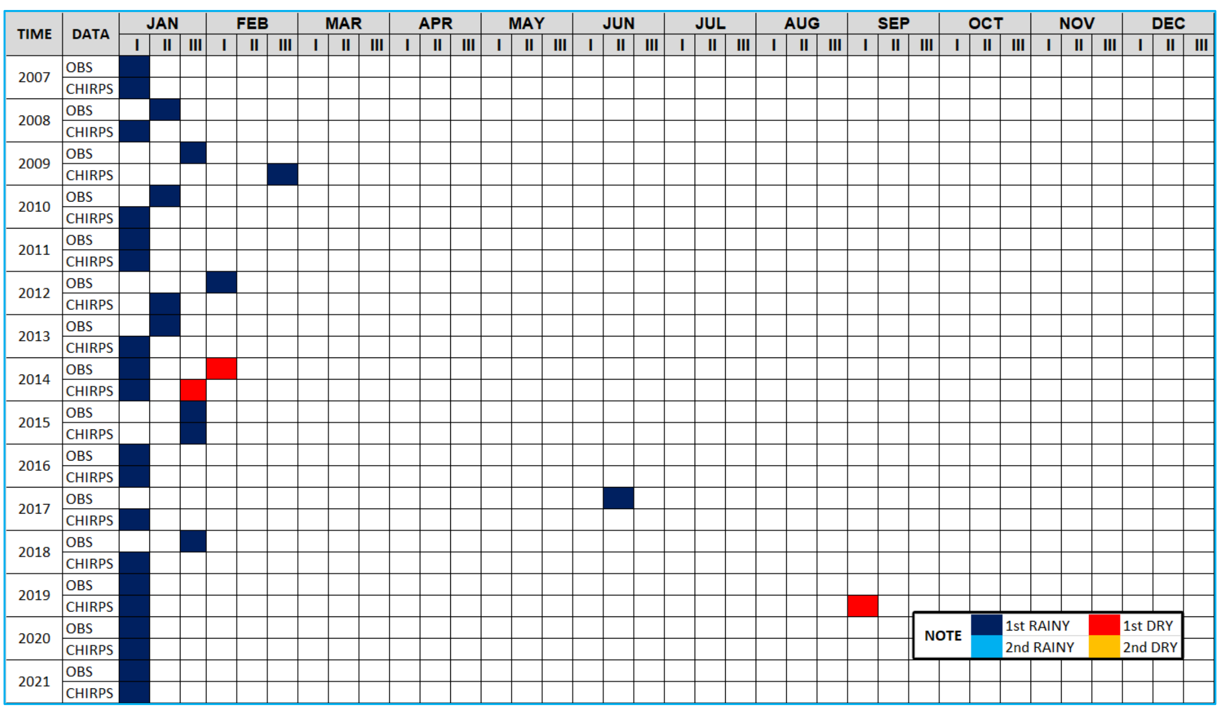


Fig. 9. Time-series determination of the onset of the dry season (DRY) and the onset of the wet season (RAINY) in Pinangsori Met Station

from Mar-I to Sep-I, with most of the events occurring in Mar-I to May-I. The difference is that the onset of the first wet season of the CHIRPS data was delayed (backwards) than the observation data. These time differences are approximately 1 to 24 basis. However, in 2017 and 2021, there is a similarity in the timing of the onset of the first

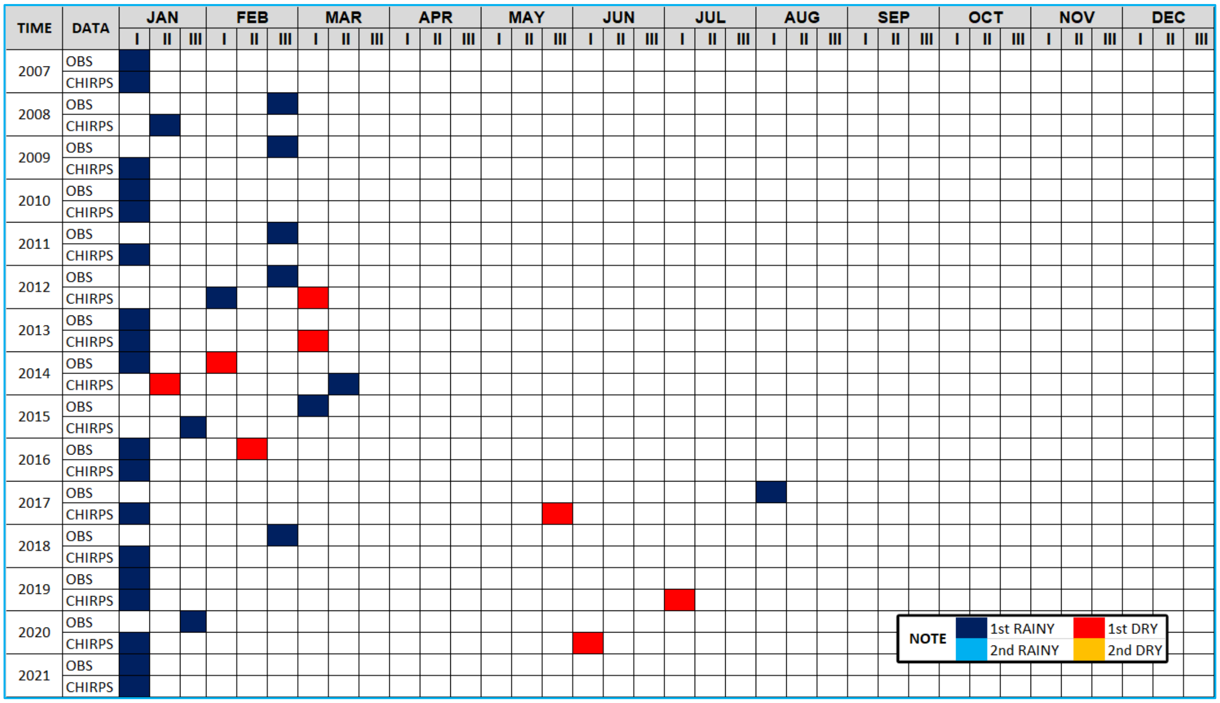


Fig. 10. Time-series determination of the onset of the dry season (DRY) and the onset of the wet season (RAINY) in Binaka Met Station

wet season of CHIRPS and observation data. Determination of the onset of the first dry season shows that the onset of the first dry season of the observation data usually occurs in the range from Jan-I to Apr-III, with the frequency occurring in Jan-I to Feb-III. While the onset of the first dry season of the CHIRPS data commonly occurs in the range from Jan-I to May-III, with the majority of its occurrence in Jan-I to Jan-III. The difference is that the onset of the first dry season of the CHIRPS data is earlier (forward) than the observation data. The time difference is about 1 to 10 days. However, the onset of the CHIRPS and observation data's first dry season occurred simultaneously in 2011, 2014 and 2016.

The determination of the onset of the second wet season shows only one onset based on observational data, such as in 2018. At the same time, there are three onsets of second wet seasons based on CHIRPS data, such as in 2009, 2012 and 2019. These unequal years of the occurrence of the onset of the second wet season make it impossible to compare the onset of the second wet season. The determination of the onset of the second dry season shows no onset of the second dry season in the observation data. Four onsets of the second dry season started in the CHIRPS data, such as in 2009, 2012, 2015 and 2019. Therefore, the onset of the second dry season in CHIRPS data cannot be compared to the onset of the second dry season in observational data.

While, Fig. 9 showed the determination of the onset of wet and dry seasons at Pinangsori that found the first onset of the wet season of CHIRPS data and observation data generally occurs in the range of Jan-I to Jun-II, which dominantly occurs in Jan-I. In addition, most of the first onset of the wet season events from both data co-occur. Although there are differences in the start of the first onset of the wet season in some years, there is a delay in the beginning (backward) of the first onset of the wet season, both from CHIRPS data and observational data. The delay in the start of the first onset of the wet season ranges from 1 to 3 dasarian. Determination of the second onset of the wet season from CHIRPS data and observation data shows the absence of the double onset of the wet season during the observation year.

The first onset of the dry season from rainfall estimate of CHIRPS and observation showed that only 1 to 2 events of the first onset of the dry season identified. The first onset of the dry season from CHIRPS data occurred in 2014 and 2019, while the first onset of the dry season from observation data occurred in 2014. In 2014, the first onset of the dry season from the CHIRPS data was one dasarian earlier (forward) than the observation data. Meanwhile, the first onset of the dry season in 2019 cannot be compared because there is no onset of the dry season from observation data. The determination of the second onset of the dry season from CHIRPS and observation data shows the absence of the second dry season.

Finally, identification onset of wet season and withdrawal of dry seasons at Binaka obtained in the range of Jan-I to Aug-I. The first onset of the wet season at this area predominantly occurs in Jan I, both in CHIRPS data and observation data. In addition, most of the first onset of the wet season events from CHIRPS and observation data are simultaneous. Although in some years, there is a difference in the start of the first onset of the wet season. From observation and CHIRPS data, there is a delay of about 1 to 5 dasarian at the onset of the first wet season. The determination of the second wet season shows no second wet season during the observation year. There are only two onsets of the dry season from observation data during the observation years, namely 2014 and 2016, while there are 6 onsets of the dry season from CHIRPS data. However, only the onset of the dry season in 2014 can be compared, which the onset of CHIRPS data about 1 dasarian ahead. The determination of the second dry season shows no second dry season from CHIRPS and observation data during the observation year.

4. Conclusions

Based on comparison CHIRPS rainfall estimates during 2007-2021 in North Sumatra and 4 meteorological stations at Belawan, Kualanamu, Pinangsori and Binaka, found:

(*i*) The correlation rainfall between surface observation and CHIRPS rainfall estimates is relatively weak for daily rainfall but increases if accumulation longer. Moreover, kemampuan menebak hujan CHIRPS reached 62%, with the highest performance located at Binaka.

(*ii*) Four equatorial rainfall pattern station that be identified each location had different characteristics. The wet season at Belawan and Kualanamu, began at the first ten days of October, while at Pinangsori and Binaka region occured in the first dasarian of November. Furthermore, the second peak of the wet season at the four stations simultaneously occurs in range of the Feb-II to Feb-III. The peak of the rainy season on the East Coast of North Sumatra occurs earlier than on the West Coast of North Sumatra.

(*iii*) Using CHIRPS data, the onset of wet and dry seasons resulted one to two dasarians ahead, comparison of the rainfall data observation. In the first of wet season at Pinangsori and Binaka (West Coast of North Sumatra) tended to coincide for both CHIRPS and observation data. (West Coast of North Sumatra). Conversely, in determining the first withdrawal using CHIRPS data tends to be more advanced with low accuracy.

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