Prediction of Monthly Rainfall using Monte Carlo Simulation in Medan City Area

Arini[1]*, Hendra Cipta[2]
Department of Mathematics Study Program, Faculty of Science and Technology, North Sumatra State Islamic University[1], [2]
Medan, Indonesia
arini0703201013@uinsu.ac.id [1], hendracipta@uinsu.ac.id [2]

***Abstract*— The climate in Indonesia, which is a tropical region, is always uncertain and makes it difficult to predict weather conditions. Weather conditions can be influenced by rainfall, air temperature, wind speed, air humidity and light radiation intensity. Rainfall is relatively high and varies throughout the year, the average monthly rainfall is around 150-300 mm in the rainy season and 50-100 mm in the dry season. There are several characteristics of rainfall, namely convective rain, frontal rain and orographic rain. For this reason, a method is needed that can solve problems in predicting monthly rainfall properties using the Monte Carlo simulation method. From this study, the results of the prediction of rainfall properties were obtained with 36 data from 2021 to 2024 which had a MAPE test result of 12.28%. The test results came from the average calculation carried out on the Monte Carlo method prediction with 5 variables.**

***Keywords*— Rainfall, Monte Carlo Simulation, Nature of Rainfall, Accuracy Test Results, Prediction**

I. INTRODUCTION

Weather is the state of the air at a particular time and in a relatively narrow area for a short period of time. Weather is formed from a combination of weather elements and a period of time that can be only a few hours. For example, morning, afternoon, evening or night and the conditions can differ from place to place and from hour to hour. Weather is different for every place and every hour. In Indonesia, weather conditions are always announced for a period of about 24 hours through weather predictions developed by the Meteorological, Climatological and Geophysical Agency (BMKG) [1].

Rainfall in Medan City is one of the important parameters in hydrological and meteorological studies, because it has a considerable role in determining the level of flood hazard and environmental damage.[2] Rainfall can be defined as the height of water collected in a flat place, not evaporating, not seeping and not flowing. To measure rainfall a tool called an observatory is used and generally rainfall is expressed in millimetres. [3]

Data for predicting rainfall and air humidity are taken from observations of tools at the Meteorology, Climatology and Geophysics Agency (BMKG). BMKG collects all climatological parameter data to study weather conditions. After the data is collected, it is continued by processing the data for prediction. The large amount of accumulated data causes the error rate in predicting to be a major problem, especially the prediction analysis of rainfall and air humidity. Predictions about monthly rainfall and air humidity must use the right prediction method.[4]

Three broad types of rainfall patterns can be identified based on the distribution of mean data: monsoon type, equatorial type, and local type. Time series analysis is a useful technique to determine how previous data can influence future data in an estimation. Data acquired over time and organised in time order is called time series data. The duration of a period can be measured in weeks, months, years, etc. [5]

In this study, there is one method that can be used to predict the nature of monthly rainfall, namely the Monte Carlo simulation method. The advantages of the Monte Carlo simulation method are that it produces clearer predictions, reduces the error value, and produces convergent solutions, but this method also has disadvantages, namely, low convergence rate, dependence on the quality of random samples.[6]

The amount of rainfall that occurs cannot be determined with certainty, but can be predicted or estimated. By using historical data on the amount of rainfall some time ago, it can be predicted how much rainfall will occur in the future. Many ways can be done to predict the amount of rainfall in a place, one of which is by using the Multy Monte Carlo Method The advantage of this method compared to other methods is that the more simulations carried out, the more convergent the prediction results are.[7].

II. LITERATURE REVIEW

A. *Prediction*

Prediction or forecasting is a business function activity that estimates the sales and usage of products so that they can be made in the right quantities. Forecasting is an estimate of future demand based on several forecasting variables, which are based on taking past data and placing it into the future in the form of a mathematical model.[8].

B. *Rainfall Rate*

Rainfall is one of the weather elements whose data is obtained by measuring it using a rain gauge, so that the amount can be known in millimetres (mm). 1mm of rainfall is the amount of rainwater that falls on the surface per unit area (m2) with a record of nothing evaporating, soaking or flowing. so rainfall of 1mm is equivalent to 1liter/$m2$.

The classification of monthly rainfall according to BMKG is[9]:

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v13i3.2307, Copyright ©2024
Submitted : October 30, 2024, Revised : November 5, 2024, Accepted : November 10, 2024, Published : November 25, 2024

a. Low 0-100mm/month

b. Medium 100-300 mm/month

c. High 300-500 mm/month

d. Very Heavy > 500 mm/month s.

C. Properties of Rain

Rain in the tropics generally consists of convection rain, frontal rain, and orographic rain.Forecasting is a method of predicting future events based on past data. Monte Carlo simulation is a statistical technique for estimating the solution of quantitative problems by a process of randomising data.[10].

D. Monte Carlo Simulation Steps

This method is used in systems that involve probabilities, with randomisation of variables to produce predictive results.[11]

a. Probability distribution

A probability distribution is calculated by dividing the frequency of an event by the total frequency:

$$P_i = \frac{F_i}{n} \quad (2.1)$$

Description:
P_i= Probability distribution
F_i = Frequency
n = Total frequency

b. Cumulative probability distribution

The cumulative distribution is obtained by summing the current probability with previous cumulative values

$$PK = HPK + P \quad (2.2)$$

Description:
PK = Cumulative probability
HPK = Previous cumulative result
P = Next probability distribution

c. Determination of random number intervals

each value in the probability distribution is assigned a random number. The initial limit value of the first variable is 0, and subsequent limits are calculated by multiplying the cumulative probability by 100.[12]

d. Random number generation (rng)

Random numbers are generated using the linear congruence method (lcm)[13]:

$$Zi = (a.\ Zi - 1 + C) \text{ Mod } m \quad (2.3)$$

Description:
Zi = i-th number value
Zi-1 = initial number (integer >=0, Z0<M)
a = Multiplier constant (a < m)
c = Shift constant (c < m)
m = Modulus constant (m > 0)

e. Mean absolute percentage error (mape)

mape measures prediction accuracy as the percentage error between actual and predicted data:

$$\text{MAPE} = \frac{\sum_{t=1}^{n}\left|\left(\frac{A_t - F_t}{A_t}\right)\right| x100}{n} \quad (2.4)$$

Where:
n = Number of Periods
A_t = Actual data in period t
F_t = Predicted value in period t
Interpretation of mape:
1. <10% = very good
2. 10-20% = good
3. 20-50% = reasonable
4. 50% = inaccurate

The smaller the mape value, the more accurate the prediction.[14]

III. RESEARCH METHODS

This study uses data from the BMKG station in Medan City, the data used is taken from 2021-2023, where there are 5 variables, namely rainfall (Y), (X1) air temperature, (X2) wind speed, (X3) air humidity and (X4) light radiation intensity, from these 5 variables we will determine the probability distribution, cumulative distribution, random interval then generate random numbers and finally determine the Mape of this data to determine the data for 2024-2026.[13]

Table 3.1. Initial Data

Moon	Rainfall	Temperatures	Wind Speed	Air Humidity	Light Intensity
	(Y)	(X1)	(X2)	(X3)	(X4)
Jan (2021)	518,3	26,5	1,12	86	2,09
Feb	87,9	27,8	1,57	80	5,14
Mar	222,7	27,7	1,32	82	3,84
Apr	300,2	27,7	1,3	83	2,97
May	158	28,2	1,25	83	3,73
Jun	243,8	27,8	1,23	81	4,01
Jul	193,7	28	1,22	80	4,99
Aug	295,2	27,6	1	84	2,65
Sept	287,1	28,3	1,66	82	3,42
Oct	257,7	29	1,77	79	327,3
Nov	497,4	27,7	1,6	85	3,68
Des	189,2	27,5	1,64	86	3,47
Jan (2022)	181	28,1	1,61	83	3,95
Feb	334,8	27,8	1,42	85	3,33
Mar	191,2	29,3	1,77	82	5,04
Apr	184,2	29,6	1,5	83	4,26
May	125,5	29,4	1,29	85	4,55

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v13i3.2307, Copyright ©2024
Submitted : October 30, 2024, Revised : November 5, 2024, Accepted : November 10, 2024, Published : November 25, 2024

Jun	313,4	28,9	1,2	84	4,11
Jul	165,9	29,5	1,83	81	4,88
Aug	505,1	28,8	1,8	84	3,98
Sept	308,2	28,2	2	82	3,27
Oct	321,5	27,5	1,51	86	2,45
Nov	525,9	26,8	1,56	88	3,1
Des	321,2	26,1	1,7	88	2,15
Jan (2023)	164,5	26,5	1,93	85	3,2
Feb	163,2	27	1,71	85	4,27
Mar	193,5	27,3	1,77	85	4,75
Apr	196,1	27,9	1,56	85	5,14
May	189,1	28,6	1,61	83	4,97
Jun	348,4	28,3	1,3	84	4,7
Jul	196,8	28,2	1,32	84	4,73
Aug	606,6	27,4	1,54	87	3,44
Sept	577,5	27,5	1,53	86	3,05
Oct	278	27,4	1,45	87	3,09
Nov	183,6	27,2	1,73	87	3,1
Des	335,5	27	1,48	88	1,78
Sum	**10162**	**1004**	**54,8**	**3028**	**458,6**

Source: Meteorology, Climatology and Geophysics Agency Region 1[15]

IV. RESULTS AND DISCUSSION

This study calculates the prediction of monthly rainfall properties with Monte Carlo simulation in the city of Medan using the above data samples. In the step of generating random numbers, the Monte Carlo method calculation uses five different variables. The following are the steps taken in the research.

a. Determine The Probability Distribution

Y1= 518,3/10161,9 = 0,05 Y7 = 193,7/10161,9 = 0,01
Y2= 87,9/10161,9 = 0,00 Y8 = 295,2/10161,9 = 0,02
Y3=222,7/10161,9 = 0,02 Y9 = 287,1/10161,9 = 0,02

Table 4.1. Pobability distribution

Moon	(Y)	Pro	(X1)	Pro	(X2)	Pro
Jan (2021)	518,3	0,05	26,5	0,02	1,12	0,02
Feb	87,9	0	27,8	0,02	1,57	0,02
Mar	222,7	0,02	27,7	0,02	1,32	0,02
April	300,2	0,02	27,7	0,02	1,3	0,02
Okt (2023)	278	0,02	27,4	0,02	1,45	0,02
Nov	183,6	0,01	27,2	0,02	1,73	0,03
Des	335,5	0,03	27	0,02	1,48	0,02
Sum	**10162**	**0,78**	**1004**	**1,73**	**54,8**	**0,82**

(X3)	Pro	(X4)	Pro
86	0,02	2,09	0
80	1,45	5,14	0
82	0,02	3,84	0
83	0,02	2,97	0
87	0,02	3,09	0
87	0,02	3,1	0
88	0,02	1,78	0
3028	**2,15**	**458,6**	**0,8**

b. Determine The Cumulative Distribution

PK1 = 0,05
PK2 = 0,05+0,00 = 0,05
PK3 = 0,05+0,02 = 0,07
PK7=0,12+0,01=0,13
PK8=0,13+0,02=0,15
PK9=0,15+0,0 = 0,17

Table 4.2. Cumulative Distribution

Moon	(Y)	Pro	Cum	(X1)	Pro	Cum
Jan (2021)	518,3	0,05	0,05	26,5	0,02	0,02
Feb	87,9	0	0,05	27,8	0,02	0,04
Mar	222,7	0,02	0,07	27,7	0,02	0,06
Apr	300,2	0,02	0,09	27,7	0,02	0,08
Oct (2023)	278	0,02	0,74	27,4	0,02	1,69
Nov	183,6	0,01	0,75	27,2	0,02	1,71
Des	335,5	0,03	0,78	27	0,02	1,73
Sum	**10162**	**0,78**		**1004**	**1,73**	

Moon	(X3)	Pro	Cum	(X4)	Pro	Cum
Jan(2021)	86	0,02	0,02	2,09	0	0
Feb	80	1,45	1,47	5,14	0,01	0,01
Mar	82	0,02	1,49	3,84	0	0,01
Apr	83	0,02	1,51	2,97	0	0,01
Oct(2023)	87	0,02	2,11	3,09	0	0,8
Nov	87	0,02	2,13	3,1	0	0,8
Des	88	0,02	2,15	1,78	0	0,8
Sum	**3028**	**2,15**		**458,61**	**0,8**	

c. Determining the Random Interval

Assign random interval numbers starting from zero for the first number of random interval numbers and the final number based on the results of the distribution of the commulation.

Table 4.3. Random intervals

Moon	Cum (Y)	Intervals	Cum (X1)	Intervals

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v13i3.2307, Copyright ©2024
Submitted : October 30, 2024, Revised : November 5, 2024, Accepted : November 10, 2024, Published : November 25, 2024

Jan(2021)	0,05	0-5	0,02	0-2
Feb	0,05	05-05	0,04	03-04
Mar	0,07	06-06	0,06	05-06
Apr	0,09	08-09	0,08	07-08
Oct(2023)	0,74	73-74	1,69	168-169
Nov	0,75	75-75	1,71	170-171
Dec	0,78	76-78	1,73	172-173

Moon	Cum (X2)	Intervals	Cum (X3)	Intervals
Jan(2021)	0,02	0-2	0,02	0-2
Feb	0,04	03-04	1,47	3-147
Mar	0,06	05-06	1,49	148-149
Apr	0,08	07-08	1,51	150-151
Oct(2023)	0,77	76-77	2,11	210-211
Nov	0,8	78-80	2,13	212-213
Dec	0,82	81-82	2,15	214-215

Cum (X4)	Intervals
0	0
0,01	0-1
0,01	1-1
0,01	1-1
0,8	80-80
0,8	80-80
0,8	80-80

Pada tabel di atas, interval angka acak ditentukan dari nilai probabilitas kumulatif sebelumnya. Fungsi angka acak adalah sebagai pembatas antara variabel yang berfungsi sebagai acuan hasil simulasi.

d. Generating Random Numbers

Before generating random numbers, random number intervals must be available. This research uses the mixed congruence method, which requires 4 parameters: a, c, m, and Z0. Random numbers are generated using the formula equation (2.3)

Rainfall (Y)

Z_{I-1}= 7 $Z_1 = (32x7 + 9) \bmod 99 = 35$
a=32 $Z_2 = (32X35 + 9) \bmod 99 = 40$
c=9 $Z_3 = (32X40 + 9) \bmod 99 = 2$
m=99

Table 4.4.Generating random numbers

Moon	Intervals (Y)	R. Numbers	Intervals (X1)	R. Numbers
Jan(2021)	0-5	35	0-2	142
Feb	05-05	40	03-04	104
Mar	06-07	2	05-06	85
Apr	08-09	73	07-08	175
Oct(2023)	73-74	73	168-169	162
Nov	75-75	68	170-171	114
Dec	76-78	7	172-173	90

Moon	Intervals (X2)	R. Numbers	Intervals (X3)	R. Numbers
Jan(2021)	0-2	46	0-2	159
Feb	03-04	19	3-147	120
Mar	05-06	73	148-149	50
Apr	07-08	64	150-151	6
Oct(2023)	76-77	64	210-211	148
Nov	78-80	82	212-213	187
Dec	81-82	46	214-215	58

Interval (X4)	R. Numbers
0	46
0-1	79
01-Jan	79
01-Jan	79
80-80	79
80-80	79
80-80	79

e. *Determining Mape Validity Tes*t

$$\text{MAPE} = \frac{\sum_{t=1}^{n}\left|\left(\frac{A_t - F_t}{A_t}\right)\right| x100}{n}$$

$$\text{MAPE} = \frac{\left|\left(\frac{A_1 - F_1}{A_1}\right)+\left(\frac{A_2 - F_2}{A_2}\right)+\cdots+\left(\frac{A_{12} - F_{12}}{A_{12}}\right)X100\right|}{12}$$

$$\text{MAPE} = \frac{\left|\left(\frac{518,3-165,9}{518,3}\right)+\left(\frac{87,9-308,2}{87,9}\right)+\cdots+\left(\frac{189,2-222,7}{189,2}\right)X100\right|}{12}$$

$$\text{MAPE} = \frac{67,99+(-250)+\cdots+0,17}{12}$$

$$\text{MAPE} = \frac{8}{12} = 0,66\%$$

Table 4.5.MAPE Results

Moon	S.result (Y)	MAPE	S.result (X1)	MAPE
Jan	165,9	0,6799	28,2	0,0642
Feb	308,2	2,5063	28,2	0,0144
Mar	518,3	1,3273	28,2	0,0181
Nov	577,5	0,161	26,5	0,0433
Des	222,7	0,1771	28,2	0,0255
	MAPE	**0,667**		**3,0438**

Moon	S.result (X2)	MAPE	S.result (X3)	MAPE
Jan	84	0,0233	84	0,0233

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v13i3.2307, Copyright ©2024
Submitted : October 30, 2024, Revised : November 5, 2024, Accepted : November 10, 2024, Published : November 25, 2024

Feb	80	0	80	0
Mar	80	0,0244	80	0,0244
Nov	80	0,0588	80	0,0588
Des	80	0,0698	80	0,0698
		3,091		**3,0905**

S.result (X4)	MAPE
327,3	155,617
4,7	0,0856
4,7	0,22396
4,7	0,27717
4,7	0,35447
	13,314

Year 2022

$$\text{MAPE} = \frac{\sum_{t=1}^{n}\left|\left(\frac{A_t - F_t}{A_t}\right)\right| x100}{n}$$

$$\text{MAPE} = \frac{\left|\left(\frac{A_1 - F_1}{A_1}\right)+\left(\frac{A_2 - F_2}{A_2}\right)+\cdots+\left(\frac{A_{12} - F_{12}}{A_{12}}\right)X100\right|}{12}$$

$$\text{MAPE} = \frac{\left|\left(\frac{181-165,9}{181}\right)+\left(\frac{334,8-308,2}{334,8}\right)+\cdots+\left(\frac{321,2-222,7}{321,2}\right)X100\right|}{12}$$

$$\text{MAPE} = \frac{0,08+0,07+0,30}{12}$$

$$\text{MAPE} = \frac{7,88}{12} = 0,65\%$$

Table 4.6 MAPE Results

Moon	S.result (Y)	MAPE	S.result (X1)	MAPE
Jan	165,9	0,0834	26,1	0,0712
Feb	308,2	0,0795	27,7	0,0036
Mar	518,3	1,7108	28,2	0,0375
Nov	577,5	0,0981	28,2	0,0522
Des	222,7	0,3067	28,2	0,0805
		0,657		**11,767**

Moon	S.result (X2)	MAPE	S.result (X3)	MAPE
Jan	1,54	0,0435	80	0,03615
Feb	1,56	0,0986	80	0,05882
Mar	1,48	0,1638	86	0,04878
Nov	1,54	0,0128	79	0,10227
Des	1,56	0,0824	80	0,09091
		15,73		**8,0218**

S.result (X4)	MAPE
4,7	0,18987
4,7	0,41141
4,7	0,06746
4,7	0,51613
4,7	1,18605
	35,202

Year 2023

$$\text{MAPE} = \frac{\sum_{t=1}^{n}\left|\left(\frac{A_t - F_t}{A_t}\right)\right| x100}{n}$$

$$\text{MAPE} = \frac{\left|\left(\frac{A_1 - F_1}{A_1}\right)+\left(\frac{A_2 - F_2}{A_2}\right)+\cdots+\left(\frac{A_{12} - F_{12}}{A_{12}}\right)X100\right|}{12}$$

$$\text{MAPE} = \frac{\left|\left(\frac{164,5-165,9}{164,5}\right)+\left(\frac{163,2-308,2}{163,2}\right)+\cdots+\left(\frac{335,5-222,7}{335,5}\right)X100\right|}{12}$$

$$\text{MAPE} = \frac{-0,08+(-0,88+0,33}{12}$$

$$\text{MAPE} = \frac{8,69}{12} = 0,72\%$$

Table 4.7 MAPE Results

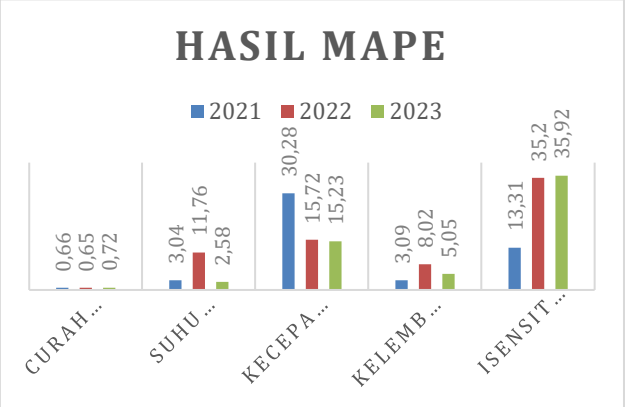
Moon	S.result (Y)	MAPE	S.result (X1)	MAPE
Jan	165,9	0,0085	28,2	0,0642
Feb	308,2	0,8885	27,4	0,0148
Mar	518,3	1,6786	28,2	0,033
Nov	577,5	2,1454	28	0,0294
Des	222,7	0,3362	28,2	0,0444
		0,724		**2,5889**

Moon	S.result (X2)	MAPE	S.result (X3)	MAPE
Jan	1,48	0,23316	80	0,059
Feb	2	0,16959	80	0,059
Mar	1,77	0	85	0
Nov	1,48	0,14451	86	0,011
Des	2	0,35135	80	0,091
		15,2321		**5,052**

S.result (X4)	MAPE
4,7	0,469
4,7	0,101
4,7	0,011
4,7	0,516
4,7	1,64
	35,93

Diagram 4.1 : Hasil Mape

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v13i3.2307, Copyright ©2024
Submitted : October 30, 2024, Revised : November 5, 2024, Accepted : November 10, 2024, Published : November 25, 2024



Based on the graph above which shows the mean absolute percentage error (MAPE) value for 5 variables (rainfall, air temperature, wind speed, humidity and light radiation intensity) from 2021-2023 for rainfall is relatively low and stable for three years, air temperature has decreased in the MAPE value from 2021 to 2023. In 2021 the highest value (3.04) then in 2022 it decreased (11.76) and even lower in 2023 (2.58). Wind speed decreased from 2021 to 2023, in 2021 Mape was quite high (30.28), then decreased sharply in 2022 (15.72), and in 2023 it decreased again (15.23) for humidity decreased from year to year and intensity with increasing Mape values from 2021 to 2023 (13.35 in 2021, 35.2 in 2023 22, and 35.92 in 2023).

f. Prediction Results

Table 4.8 Prediction Results

Moon	(Y)	(X1)	(X2)	(X3)	(X4)
Jan (2024)	165,9	28,2	2	84	327,33
Feb	308,2	28,2	1,77	80	4,7
Mar	518,3	28,2	1,54	80	4,7
Apr	278	27	1,56	80	4,7
Mei	577,5	28,2	1,48	80	4,7
Jun	222,7	28,2	2	80	4,7
Jul	165,9	27,7	1,77	80	4,7
Agust	308,2	29,4	1,54	80	4,7
Sept	308,2	26,5	1,56	80	4,7
Okt	278	29,6	1,48	82	4,7
Nov	577,5	26,5	2	80	4,7
Dec	222,7	28,2	1,77	80	4,7
Jan (2025)	165,9	26,1	1,54	80	4,7
Feb	308,2	27,7	1,56	80	4,7
Mar	518,3	28,2	1,48	86	4,7
Apr	278	26,5	2	80	4,7
May	577,5	2,82	1,77	80	4,7
Jun	222,5	28,9	1,54	80	4,7
Jul	165,9	26,2	1,56	85	4,7
Agus	308,2	28,2	1,48	86	4,7
Sept	518,3	28,2	2	80	4,7
Okt	278	28,2	1,77	80	4,7
Nov	577,5	28,2	1,54	79	4,7
Des	222,7	28,2	1,56	80	4,7
Jan (2026)	165,9	28,2	1,48	80	4,7
Feb	308,2	27,4	2	80	4,7
Mar	518,3	28,2	1,77	85	4,7
Aprl	278	28,2	1,54	81	4,7
May	577,5	27	1,56	80	4,7
Jun	222,7	28,2	1,48	80	4,7
July	155,9	28,2	2	80	4,7
Agus	308,2	28,2	1,77	80	4,7
Sept	518,3	28,2	1,54	80	4,7
Okt	278	27,4	1,56	82	4,7
Nov	577,5	28	1,48	86	4,7
Des	222,7	28,2	2	80	4,7

V. CONCLUSION

The results of the research conducted by the author for the prediction of monthly rainfall properties with the Monte Carlo simulation method in the Medan city area, there are MAPE test results of 12.28%, the test results come from the average calculation performed on the Monte Carlo method prediction with 5 different variables at each stage. MAPE testing to find out the error value.This method is successfully applied to predict the nature of monthly rain in the city of Medan with fairly good results.

REFERENCES

[1] L. Qadri, "Prediksi Curah Hujan Dengan Menggunakan Algoritma Support Vector Regression," No. 8.5.2017. Hal. 2003–2005, 2022.

[2] F. Andika Dan R. P. Sari, "Peramalan Menggunakan Fuzzy Time Series (Studi Kasus Curah Hujan Kota Langsa)," 2021.Hal.03

[3] Wenny Marta Dolok Saribu, "Prediksi Jumlah Penumpang Armada Bus Pt Raja Perdana Inti (Rapi) Dengan Simulasi Monte Carlo." Hal. 5–24, 2017.

[4] Dian Puspita Chandra Dan Alethea Suryadibrata, Analisis Prediksi Curah Hujan Dan. 2019.Hal.6

[5] A. Nasir, Et, "Analisis Diagnostik Variabel Cuaca Untuk Estimasi Pola Curah Hujan Di Medan Menggunakan Model Bayesian Vector Autoregressive," Vol. 9, Hal. 356–363, 2023.

[6] Yovi, Ringgo Dwika, Dan Eka, "Penerapan Metode Monte Carlo Pada Simulasi Prediksi Jumlah Calon Mahasiswa Baru Universitas Muhammadiyah Bengkulu," J. Process., Vol. 17, No. 2, Hal. 74–81, 2022

[7] S. Peronika, J. Fisika, F. Matematika, D. A. N. Ilmu, P. Alam, Dan U. Sriwijaya, "Prediksi Curah Hujan Di Daerah Bandara Sultan Mahmud Badaruddin Ii Menggunakan Jaringan Syaraf Tiruan Dengan Metode Backpropagation Dan Radial Basis Function Network," 2017.Hal 05

[8] F. T. Industri Dan U. I. Indonesia, "Prediksi Curah Hujan Menggunakan Metode Long Short Term Memory (Studi Kasus : Kota Bandung) Prediksi Curah Hujan Menggunakan Metode Long Short Term Memory (Studi Kasus : Kota Bandung)," 2022.Hal. 5-6

[9] S. Andriani, D. M. Akhmad, Dan F. D. Wihartiko, "Pemodelan Monte Carlo Untuk Prediksi Sifat Hujan Harian," Comput. J. Comput. Sci. Inf. Syst., Vol. 4, No. 2, Hal. 124, 2020,

[10] H. Cipta, "Fuzzy Model Tahani As Decision Support System For Employee Promotion," Int. J. Eng. Technol., Vol. 7, No. 2.5 Special Issue 5, Hal. 88–91, 2018,

[11] N. A. Dalimunthe, "Simulasi Prediksi Permintaan Kue Kacang Di Cv. Fawas Jaya Medan Menggunakan Metode Monte Carlo," 2021. Hal.20-22

[12] D. E. Malla Avila, "Prediksi Curah Hujan Kecamatan Jawa Timur Menggunakan Algoritma Backpropagation Neural Network Berdasarkan Faktor Penentu Curah Hujan," No. 8.5.2017. Hal. 2003–2005, 2022.

[13] I. A. Hasugian, K. Muhyi, Dan N. Firlidany, "Simulasi Monte Carlo Dalam Memprediksi Jumlah Pengiriman Dan Total Pendapatan," Cetak) Bul. Utama Tek., Vol. 17, No. 2, Hal. 1410–4520, 2022.

[14] Eka Larasati Amalia, Yoppy Yunhasnawa, Dan A. R. Rahmatanti, "Sistem Prediksi Penjualan Frozen Food Dengan Metode Monte Carlo (Studi Kasus: Supermama Frozen Food)," J. Buana Inform., Vol. 13, No. 02, Hal. 136–145, 2022,

[15] B. P. S. S. Utara, "Data Curah Hujan Tahun 2021-2023.

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v13i3.2307, Copyright ©2024
Submitted : October 30, 2024, Revised : November 5, 2024, Accepted : November 10, 2024, Published : November 25, 2024