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Crowdsourcing of Twitter Social Media Data to Analyze the Hail Disaster in Surabaya

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***Abstract*—The purpose of this study is to describe the use of crowdsourcing data sources from social media, especially Twitter, in carrying out an initial analysis of an extreme weather event, in this case, hail which occurred in the city of Surabaya on February 21st, 2022. The method used in this study is data mining using data sourced from Twitter with the keywords "hujan AND es" ("Rain AND Ice") . The initial data withdrawal was carried out twice. The first only pulled data from tweets sent from the Surabaya area and its surroundings, while the second pulled data from tweets sent from all locations. Tweet count aggregation and early tweet detection were used to estimate the time of occurrence. Extracting location data from tweets is used to map the location of the incident. Adding supporting data in the form of data on weather conditions at the time of the estimated event is carried out to enrich the information and validator information obtained through crowdsourcing on social media. Meteorological analysis was carried out at the incident's time and location based on the analysis's results using social media. The supporting data used in conducting meteorological analysis are data on air temperature, air humidity, wind speed at several locations of automatic weather stations. Based on Twitter data crowdsourcing, this study's results, hail in Surabaya on February 21st, 2022, occurred at around 14:50 Local Time (LT) and was located in the western part of Surabaya.**

***Keywords*— Twitter, Crowdsourcing, Hail.**

I. INTRODUCTION

Technological developments regarding social media in Indonesia are running very fast. The first social media that entered Indonesia was Friendster in 2002 [1]. After 20 years, many social media have appeared, such as Facebook, Twitter, Instagram and others. Within the scope of social media as a service from a particular agency or company, Indonesian people's response to social media information in the form of images and videos has a positive response to information in the form of text [2].

Social media is a tool. If used properly and correctly, social media becomes a tool that can provide many benefits, including conveying information more quickly and bringing users closer together as an interactive means of learning so that they can expand networks in business activities. In science, social media can assist in verifying the results of an analysis of atmospheric conditions that are not tracked by observation devices. Social media users' information about the natural phenomenon in a particular area is complementary data for the event.

Twitter is one of the most effective social media to use as a means of crowdsourcing. As mentioned in [3] , twitter users actively participate in crowdsourcing events even without a structured reporting procedure. The active participation of Twitter users in an incident can contain various information and be used as additional information about the incident. Its utilization, among others, can be used as a detector for the emergence of an event [4] [5],[6], monitoring activities in urban areas [7],[8], as an additional sensor for earthquakes felt [9],[10], as well as providing additional information concerning weather conditions or changes [11]–[16]

The speed of Twitter users in disseminating information [9] helps gather information on a weather phenomenon. With this speed and distribution, data from Twitter can complement information spatially and temporally, although the accuracy of their observations could not be better than trained weather observers [17], [7]. According to [18], spatial and temporal information from Twitter is compatible with verified censorship data.

According to [12], regarding the weather, Twitter users tend to send more tweets that contain weather information when a change in weather (rain, storm, lightning) or an unusual weather phenomenon occurs. The accuracy of these informative tweets overall tweets is over 90%. This high accuracy is expected to help the information needed by the National Weather Service and the public, considering that some weather events occur spatially and temporally outside the range of observation sensors.

Hail is a natural phenomenon in the form of falling ice grains with a size of 2 – 11 cm for 5 - 20 minutes [19] [20] .Hail conditions in the tropics are expected to occur shorter, between 0-15 minutes. Hail can be detected using specially tuned weather radar to capture the growth of rain clouds that produce ice [21], [22]. Hail events that coincide with water rain make it difficult to analyze and predict hail.

In the concept of disaster, the natural phenomenon of hail is one of the threats that can result in the loss of property and even life. Hail events considered disasters are conditions where natural phenomena result in the nonfunctioning of society in carrying out their daily activities. The duration of the hail event is concise, resulting in short-lived community activities. However, in some conditions, the extended impact of the hailstorm phenomenon includes damage to dwellings made of easily damaged materials, so the phenomenon of hail is sufficient to be a disaster for specific communities.

Hail is an unusual weather event that occurs in the Surabaya area. Based on data from the BMKG observation station in Surabaya and surrounding areas, only 4 (four) hail occurrences were recorded at the Juanda Meteorological Station from January 1st 2014 to January 1st 2022. The hail incident on 21st February 2022 was not recorded at any observation station in Surabaya or its surroundings. Reports from the public about the phenomenon of hail through social media are beneficial in detecting hail events. Reports from the public can also estimate the location and time of the hail event in more detail.

An in-depth understanding of the hail phenomenon can provide an early warning so that it can be used as a guide to control and strengthen community capacity in dealing with hail disasters in the future.

II. Material And Method

Analyzing areas affected by hailstones was conducted using data from Twitter social media tweets. Data retrieval from Twitter is focused on February 20th, 2022, to February 21st, 2022. Twitter data is retrieved through the Twitter API service using the "rtweet" library based on the R programming language. The keywords used in data retrieval are "hujan AND es", so the tweets you get always contain the word "hujan" and the word "es".

Downloading was carried out twice with different settings. The first step is to pull down general data for tweets with the keywords "hujan AND es", regardless of where the tweets were sent. The second step is retrieving tweet data specifically with the keywords "hujan AND es" sent from Surabaya and its surroundings.

The general withdrawal method is carried out to get an initial description of the location of hail events, which is then enriched using data from the specific method.

The Twitter data is then processed to obtain complete information about hail events. All data was obtained from data collected by the "rtweet" library and starting from the first tweet containing information about hail in Surabaya. All data is used for this study. They were not filtering tweets whether they contained hail information. It is based on [12] which states that in unusual weather conditions, more than 90% of tweets about the weather contain information about these weather conditions. However, in this study, rechecking the contents of tweets were still carried out manually for several tweets, which were used as a reference for determining the location and time.

The purpose of extracting Twitter data information is to estimate the location and time of hail occurrence, which can provide additional information for the relevant Agency for further analysis.

The method used in determining the estimated time of events in this study follows the method used by [9] , who plotted tweet data based on the time of occurrence when an earthquake occurred on the east coast of the United States. According to the study, the earthquake case's highest tweet rate per minute was around 4-5 minutes after the incident.

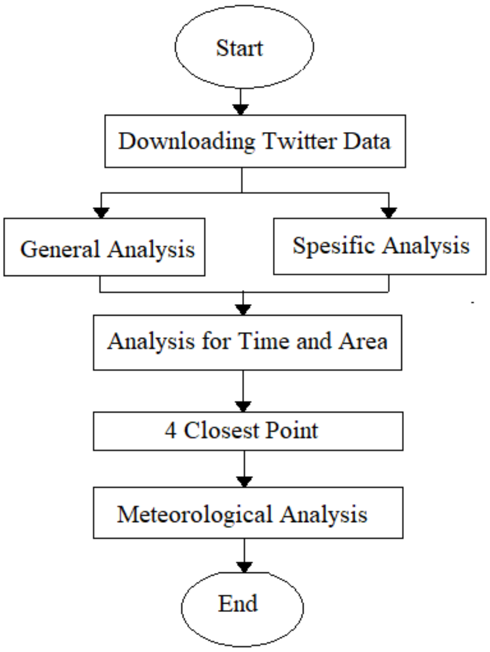

Fig 1. Flowchart Algorithm

The method used in determining the approximate location of hail events follows the method that has been carried out by [4], namely:

1. Based on geotagging data by the user's GPS sensor. If not available, then proceed to point 2.
2. Based on the content or content of the user's tweet at the time of the incident. User tweets can contain location information obtained by pre-processing the data [9]. Data processing is carried out by including data on street names and sub-district names in the city of Surabaya obtained from the Surabaya City Government website (https://surabaya.go.id), and the geographical location of each street and sub-district name obtained from the Open Street API. Map provided by the "geopy" library based on the Python programming language. If point 2 is also not possible, then for specific tweets, which are markers for the time of the incident, location estimates are carried out using the point 3 method.
3. Based on the user's metadata, which is obtained from the user's profile page. Some users place location information on their profile therefore that, according to to [4], it can be used as additional location information if needed.

Meteorological analysis was carried out at the incident's time and location based on the analysis's results using social media. The supporting data used [23] in conducting meteorological analysis are data on air temperature, air humidity, wind speed at several locations of automatic weather stations or AWS (Automatic Weather Systems) close to the location of hail events. The AWS locations are AWS Karang Pilang, AWS Sambikerep, AWS Juanda, and AWS Perak.

Meteorological analysis was also carried out using the temperature slope diagram (Skew T) from the upper air observation data and vertical slice analysis of air humidity data from the ECMWF reanalysis model. The flow chart can be seen in Figure 1.

III. RESULT AND DISCUSSION

Technical settings for the download process The keywords “hujan” and “es” in the R language application were set on February 22, 2022. The download process has been running backwards since February 22, 2022, attracting all tweets from Twitter users, wherever users are as many as 18,000 tweets. The following download process can be done by repeating the same steps at 15-minute intervals using the last downloaded identity number.

A. Estimated Time of Hail

The first step in determining the estimated time of the event is to plot the number of tweets containing the words "hujan" and "es" on February 21st, 2022, sent by Twitter users per hour, as shown in Figure 2.

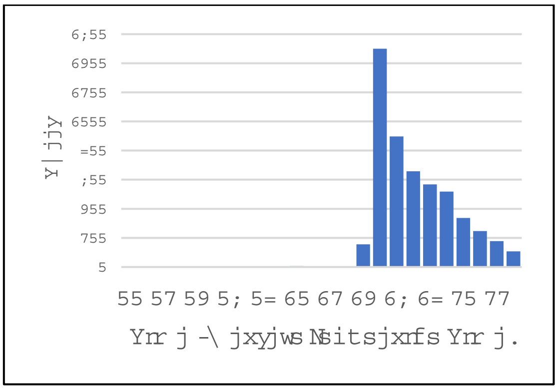

Fig 2. Amount tweets per hour

The hourly rate of tweets started to increase at 14:00 – 15:00 LT, reached its highest rate at 15:00 – 16:00 LT, and decreased after that. Based on these conditions, an initial estimate was obtained that hail in Surabaya occurred between 14:00 LT - 16:00 LT. To obtain more accurate results, manual checking of tweets is carried out in two stages :

1. Checking tweets which, according to Twitter's algorithm, detect that the tweets were sent from Surabaya and their surroundings.
2. Checking the tweets in general.

Based on manual checking of tweets, the following results were obtained for each stage:

1. For tweets detected by the Twitter algorithm sent from the Surabaya and surrounding areas, the account @agatha_frogie first sent the hail information at 14:51:39 LT from the Lidah Wetan area, Surabaya (Figure 3).
2. For tweets in general, hail information is sent by several accounts whose location were not accurately detected. Based on a user's metadata search that includes location information on their profile page, hail was first informed at 14:50:49 LT by the account @zhunainy, who informed the location of"SUB" or "Surabaya" on their profile page.

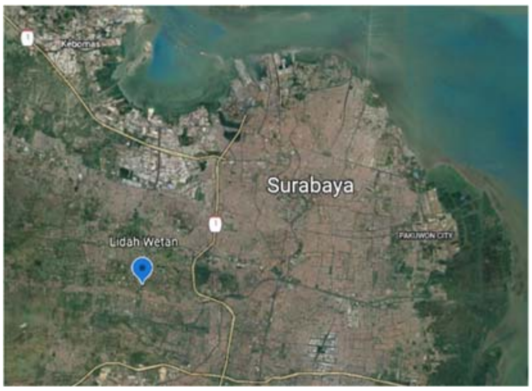

Fig 3. Lidah Wetan, Area

The two stages of tracing the tweets manually concluded the estimated time for the first hailstorm to occur at around 14:50 LT.

TABLE I. THE RATE OF TWEETS PER MINUTE IN THE FIRST 60 MINUTES OF THE EVENT

Time	Amount Tweet	Rate of Tweet per minute
0m 0s -- 0m 59s	5	5
1m 0s -- 1m 59s	10	10
2m 0s -- 2m 59s	10	10
3m 0s -- 3m 59s	7	7
4m 0s -- 4m 59s	12	12
5m 0s -- 5m 59 s	19	19
6m 0s -- 09m 59s	73	18
10m 0s -- 60m 0s	1300	25

We made a table of tweets per minute for the first 60 minutes based on the estimated time obtained to get an overview of netizens' responses to informed hail events. The results of the plot of the tweet rate per minute are presented in Table 1.

Based on Table 1, for the first 10 minutes after the hail incident, the highest tweet rate was in the 5th minute. The rate of tweets is getting higher in the range of 10 – 60 minutes after the incident as the information spreads. It is under the results of [9]. Social media analysis was also carried out to estimate the completion time of hail events. The analysis process was carried out by filtering tweets of the words "berhenti", "berenti", "reda", "sudah", "selesai", "udah", "mari", "uwis", "wis", "terang". The results of the screening were the first tweet by the @3c_eny account at 16:29:39 LT. The tweet read *"@e100ss Hujan es memang sudah reda dan angin puting beliungnya juga sudah usai, tapi sebaiknya jangan keluar rumah dulu, banyak pohon tumbang dan banjir dimana² kabel besar PLN juga banyak yg menjuntai ke bawah."*

Filtering the data in determining the estimated completion time of the hail is difficult because there are very few tweets from netizens regarding the information that the hail has "stopped". The addition of search keywords was carried out in various languages, and there were alleged errors in typing and had not been able to provide meaningful information.

B. Estimated Location of Hail

Determining the location of hail using the method used [4] produces the following information:

1. There are no tweets from netizens whose location can be accurately identified using GPS. So, all tweets are detected using the second method, which is checking the location information contained in each tweet content.
2. Examination of location information on each tweet content is based on location data in the form of street and sub-district names in the city of Surabaya. An example of determining the location is presented in Table 2. The results of checking the location information are presented in Table 3.

TABLE II. AN EXAMPLE OF EXTRACTING THE LOCATION INFORMATION ON A TWEET

Tweet	Locations on Tweet	User
Eh surabaya lg hujan es @e100ss Lokasi **manukan wetan** sby https://t.co/rn8jm7VEGY	Manukan Wetan	ZaaIhza
HUJAN ES DI **MARGOMULYO** SURABAYA @infoBMKG ?	Margomulyo	gkslzktlndpe
@glossiebabyxyz **Wonokromo** hujan es	Wonokromo	prischaputrii

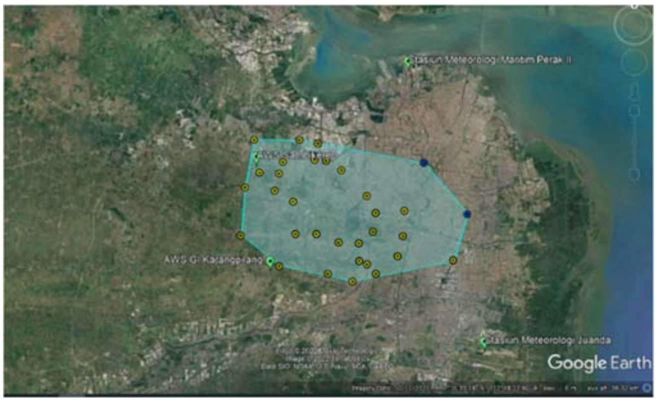

Fig 4. Estimated Hail Area

The results of extracting information on the estimated location of the hail were then plotted using Google Earth and obtained the area of the location where hail was predicted to occur, as shown in Figure 4. The polygon formed from location points has an area of around 100 square kilometres. Based on Figure 4, hail is quite close to the AWS Karangpilang and AWS Sambikerep locations. Air Temperature Analysis

TABLE III. THE TEN LOCATIONS WITH THE HIGHEST NUMBER OF MENTIONS ON TWEETS

Locations	Number of Mentions
Wiyung	53
Semarang	52
Genteng	38
Menur	14
Babatan	9
Jakarta	9
Lakarsantri	8
Lidah wetan	7
Wonokromo	5
Airlangga	4

C. Air Temperature Analysis

The occurrence of hail in an area is closely related to the decrease in air temperature around it [24], [25]. Analysis of air temperature at the closest points of hail shows a decrease in air temperature that co-occurs at four different locations. Everything shows a decrease in temperature from 6 UTC (13.00 LT) to 15.00 LT. The air temperature increases slightly after 15.00 LT, but generally, the value remains constant in the afternoon until the evening.

The decrease in air temperature in AWS GI Karang Plang and AWS Juanda has identical values. This condition strengthens the existence of broad natural phenomena that affect the two AWS locations. The graph of the temperature drop can be seen in Figure 5.

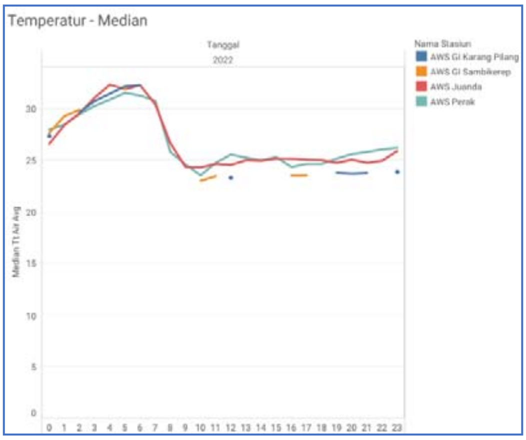

Fig 5. The Air Temperature at the 4 Closest Points

The use of median statistics in the analysis of air temperature data is expected to avoid extreme data. The original data (Raw Data) from AWS has a time resolution of 10 minutes, while the data shown in Figure 5 shows air temperature every hour.

D. Relative Humidity Analysis

Hail events will naturally increase the value of air humidity [24]. This condition can be seen in the graph of the increase in air humidity observed at AWS Karang Plang, Sambikerep, Juanda, and Perak. The subsequent meteorological analysis is relative

Humidity at the closest points to hail. Dry air was seen in the morning at 01.00 UTC (08.00 LT) at the four closest locations. The air started to get wetter at 14.00 LT, sometime after the hail happened.

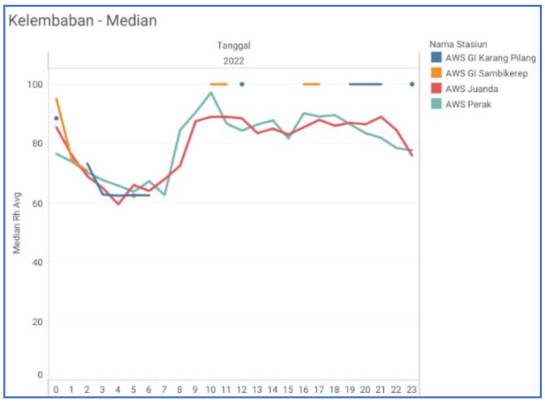

Fig 6. Relative Humidity at the 4 Closests Points

Meteorological analysis of air humidity in Figure 6 adds validity to the fact that during these hours, it was confirmed that hail occurred.

E. Wind Speed Analysis

The event of falling hail accompanied by strong winds on a large enough scale [26], resulted in the monitoring of the wind speed device moving identically at several points [27]. The average wind speed suddenly increases significantly on AWS Juanda and AWS Perak at 15.00 - 17.00 LT. This condition strengthens the occurrence of hail in the region. High wind speeds are expected to occur from blowing cumulonimbus clouds when hail occurs.

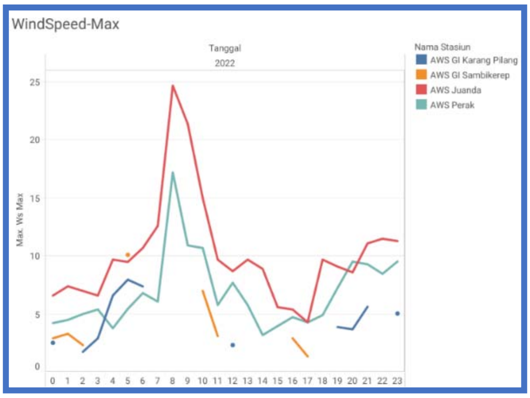

Fig 7. Wind Speed at the Closests Points

The wind speed at AWS Juanda was recorded at 25 knots. This condition ensures that the wind was not from the average wind speed which only around 3-5 knots.

F. Skew T Analysis

Analysis of upper air observations in Figure 8 at the Juanda Meteorological Station at 07.00 LT shows air instability on 21 February 2022. The instability of the morning atmosphere can be seen from the image marked with red shaded areas. Large amount of water vapour were lifted and forms convective clouds, which have the potential to become hail [28], [29]. Intrusion or the entry process of dry air from the middle layer (green colour) accelerates the freezing process through the evaporation cooling process. Ice grains are thought to form on the ice layer (freezing level), marked on the blue line.

Observation of the upper air requires a lot of money [30], [31]. The horizontal distance of the balloon flying in observing the upper air provides information that varies in direction and distance. The variation in information on balloons' direction and horizontal distance makes it challenging to verify aerial observation data.

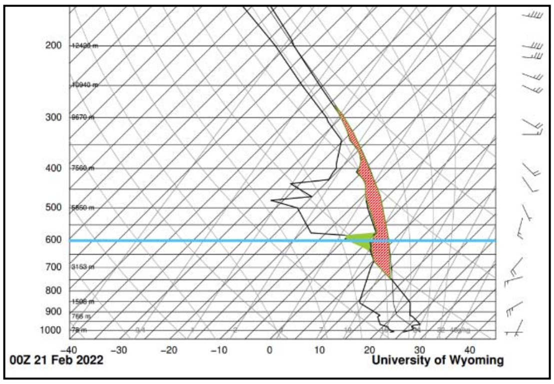

Fig 8. Temperature Skew Chart

G. *Vertical Cross Analysis*

Cross-sectional analysis (Vertical Cross) taken at a certain point using air humidity data shows the presence of dry air since the morning at 07.00 LT. This condition is an early indication of the formation of convective rain clouds, which can form hail.

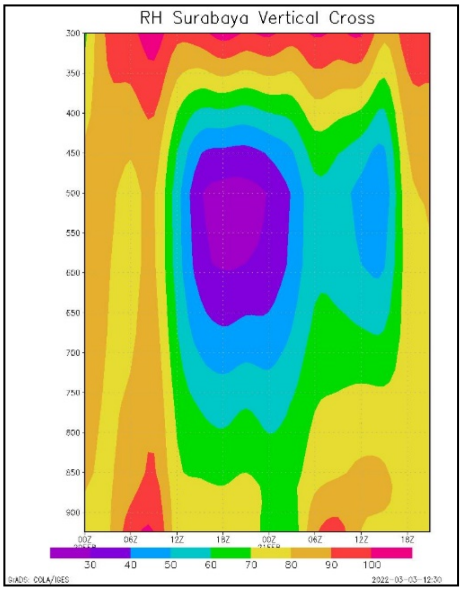

Fig 9. Relative Humidity Vertical Cross

Figure 9 shows that the air humidity at 07.00 LT is the ideal condition for the formation of convective clouds vertically. At 13.00 LT, the humidity conditions in the upper layers were still quite dry and gradually wetter in the lower layers so that the formation of convective rain clouds became more evident

IV. Conclusions

Tweets from people in cyberspace especially twitter can help predict the area and time of hail. The meteorological analysis adds to the validity of a natural phenomenon (hail) that took place in the city of Surabaya.

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