Extreme Rainfall Analysis on the December 2014 Flood, Pahang

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Keywords: Rainfall, Inverse Distance Weighted (IDW), flood

Abstract. Extreme rainfall can be the main factor for natural disaster. Flood could occur due to the extreme rain such as the December 2014 flood event in Pahang. The objective of this study is to analyze the rainfall distribution pattern based on rain gauge stationsin Pahang (15 – 29 December 2014). The analysis uses 94 rainfall stations. The rainfall depth spatial pattern uses Inverse Distance Weighted (IDW) and Kriging spatial interpolation technique via ArcGis 10.1.2 software. With the application of ArcGis 10.2.1, spatial analysis of the computed extreme rainfall was able to be conducted. Then, the comparisons of rainfall event of December 2014 with historical rainfall of 25 years record were carried out. 9 areas (e.g Kg. Kedaik, Sg. Kepasing, Temeris, JKR Kg. Manchis, Kampung Batu Gong, Kg, Salong, Kg. Merting, Ulu Tekai (A) and Kuala Tahan) were identified as areas having rainfall values exceeding the historical records. IDW and Kriging interpolation method was also used to obtain the spatial distribution of the historical rainfall events. It was found that the extreme rainfall events could contribute to the Pahang December 2014 flood. We can conclude that, the spatial interpolation of both method Kriging and IDW show the rainfall depth pattern over the recent event and varies according to the type of model chosen. Both method does not contrast from originate data outcome of rainfall distribution. The rainfall exceeding historical records can caused flooding in certain areas.

Introduction

The heavy seasonal rains and strong winds have affected most parts of Malaysia during December 2014. The rains caused severe flooding in the East Coast Terengganu, Pahang, and Kelantan states [1]. On 20 December 2014, heavy rains had been pouring non-stop as part of the northeast monsoon and most river in Kelantan, Pahang and Terengganu had reached dangerous level [2]. By 27 December, most roads in Pahang were closed [3]. Thousands of flood victims were located in various relief centers such as in Kuantan (15,072), Jerantut (5,802), Temerloh (4,522), Maran (3,332), Pekan (3,128), Lipis (2,470), Raub (666), Bera (528) and Rompin (40) [3].

Although it is known that flood at the east coast of Peninsular Malaysia is an annual occurrence during the Northeast Monsoon, the magnitude and damage due to the flood are not as high as compared to the recent flood event in which many areas have been submerged. From the public view, the most sensation assumption that were made is the changing of land-use through uncontrolled logging for reforestation, and establishment of industrial timber and oil palm plantations at the upstream of the river. It is known, that the forest at the upstream of river reacts as a reservoir to soak up rain water. However, changing of the land in those areas will contribute to less forested area and increase the run off. This will make flood easier and frequent to form in the lower area normally at the downstream of river in which those areas consist of high population and big cities.

The December 2014 flood event which was the worst ever recorded in decades caused millions of ringgit property damage with thousands of people affected and life loss. Therefore, there is a need to study the extreme rainfall during December 2014 which could be the main cause of the Pahang December 2014 flood.

Objectives

This study aims to analyze the extreme rainfall event occurred during the December 2014 rainfall event which is hypothesized to influence the main or major flood in Pahang using reliable and sufficient amount of rain gauge station data. The analysis includes various cumulative rainfall distribution periods of 1-day, 3-day, 5-day, 7-day, 9-day, 11-day, 13-day and 15-day rainfall. There are specific objectives in this study, which are;-

- To compare historical rainfall against the event rainfall of December 2014 Pahang flood.
- To create rainfall spatial distribution using Inverse Distance Weighted Average (IDW) and Kriging Technique based on rain gauge data.
- To assess the spatial cumulated rainfall depth during the rainfall events of the 15-29 December in Pahang.

Significant of Study

The finding of this study will reveal the rainfall distribution pattern of the flood events that occurred over Pahang during December 2014. The information of the rainfall distribution patterns can help in identifying the rainfall characteristics which could be the main cause of the Pahang December 2014 flood. Two interpolation methods were used for developing the spatial rainfall distribution in Pahang. The methods chosen were Kriging and Inverse Distance Weighting (IDW) using ArcGIS software. Kriging requires analysis of a semi-variogram to ascertain which function is necessary to fit the data. At this point, Inverse Distance Weighting (IDW) was chosen for comparison to Kriging method, since no such initial condition is required.

The study also compares the rainfall event against historical records, thus identifying how severe and rare the rainfall is during the December 2014 flood.

Literature Review

Extreme Rainfall

Recent increases in the frequency and intensity of extreme rainfall events have raised concern that human activity might have resulted in an alteration of the climate system. It is believed that rise in both frequency and intensity of extreme rainfall events are the major impacts of global warming [4]. Intense rainfall occurrences in short temporal scales or persistent rainfall over long period of time often lead to massive floods resulting in hazardous situations. Peninsular Malaysia experiences unpredictable rainfall events, which causes havoc, and costs millions of Malaysian ringgit. The increase in massive flood cases, including flash flood and landslides in the last decade, is due to the increase in rainfall intensities [5].

These findings agree with several studies done throughout the Asian region particularly in Malaysia. Increasing trends in both the total amount of rainfall and the frequency of wet days during the northeast monsoon give rise to the increasing trend of rain fall intensity for the period of 1971–2004 [6]. However, both studies have found a significant decrease in the number of wet days during this period. Besides extreme rainfall trends, extreme temperature and dry spell trends are also being studied in some regions. Increasing trends in temperature extremes, particularly a significant increase in the number of warm nights and heat waves with much longer dry spells interspersed with periods of increased extreme precipitation over Australia [7].

Spatial Rainfall Distribution

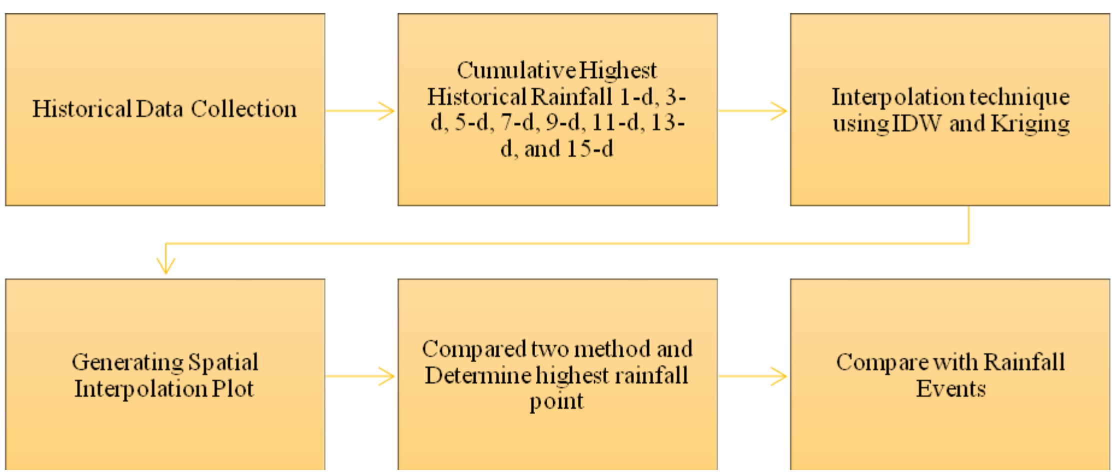
A spatial distribution is the arrangement of a phenomenon across the earth's surface and a graphical display of such an arrangement is an important tool in geographical and environmental statistics. A graphical display of a spatial distribution may summarize raw data directly or may reflect the outcome of more sophisticated data analysis. Many different aspects of a phenomenon can be shown in a single graphical display by using a suitable choice of different colors to represent differences. But for hydrology and water resources management, spatial distribution of rainfall is important for variety of applications. Many methods can be interpolated for spatial rainfall distribution but the complexity lies in choosing the one that best reproduces the most accurate data [8]. From rain gauged measurement, spatial rainfall distribution can be constructed by using different interpolation method and have two main group (deterministic and geostatiscal) [9].

Interpolation
In the mathematical field of numerical analysis, interpolation is a method of constructing new data point within the range of a discrete set of known data point [9]. The deterministic method are the Inverse Distance Weighting (IDW), which are based on the location of the measured stations and on measured value [10]. Kriging is an example of a group of geostatistical method. Geostatiscal method has capability of producing a prediction surface but also provide some measures of the certainty and accuracy of the predictions. However, geostatistical method can estimate the rainfall values for areas where no rainfall stations exist [11].

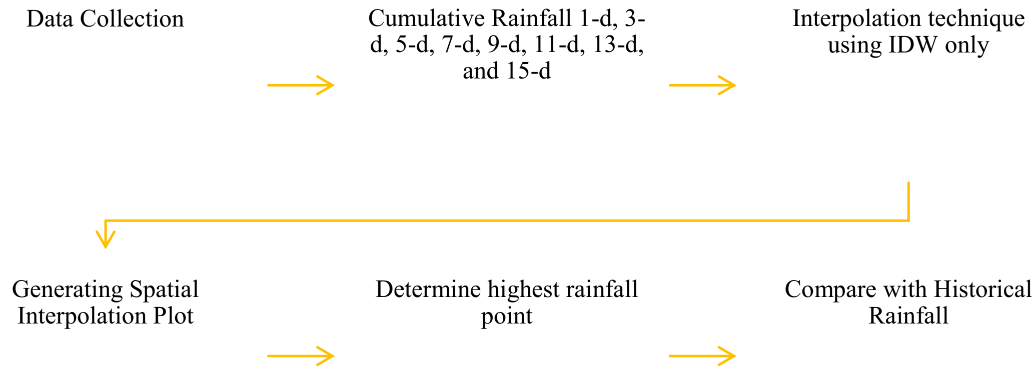
Methodology

Spatial Rainfall Distribution
Two spatial distributions were plotted. One is the spatial historical maximum rainfall plot and the other is the December 2014 rainfall event plot. Analysis on the spatial event rainfall distribution included a total of 94 rainfall station which consist of Pahang (35), Kelantan (7) and Terengganu (52). While, only a selection of stations were used for the historical plot. Stations with records of more than 25 years were used for the historical maximum rainfall plots.

Figure 1 (a) and (b) illustrates the data processing for spatial rainfall distribution for this study. Each interpolation method uses the same datasets.. These spatial interpolation methods have various decision parameters. The techniques used in this study, IDW and Kriging are available in ArcGIS 10.2.1 software.



(a)



(b)

Figure 1: Work flow for (a) historical rainfall (b) event rainfall

Data Collection
Rainfall data for the analysis were obtained from the Drainage and Irrigation Department of Hydrological (DID). Figure 2 shows the locations of the selected rainfall stations over Pahang. The stations locations were plot using ArcGis 10.2.1 based on the coordinates in Table 1.

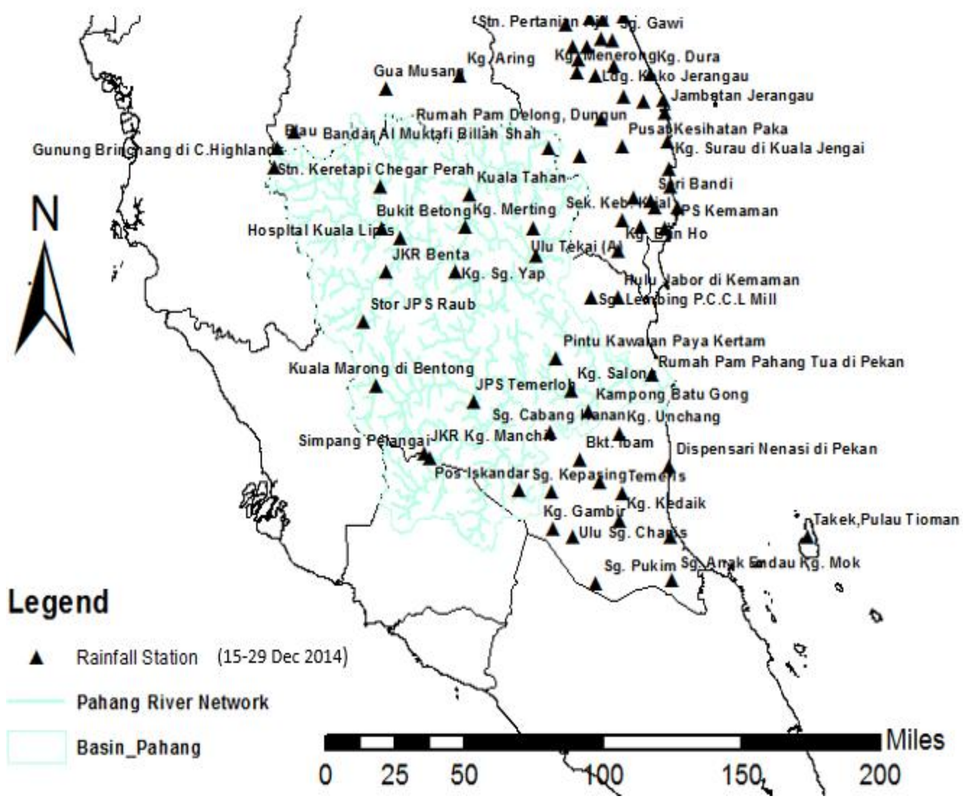


Figure 2: Rainfall station distribution map

Table 1: The list of rainfall station used for the spatial rainfall distribution

Station no	Station name	State	Latitude	Longitude
2630001	Sg. Pukim	Pahang	2.603	103.057
2634193	Sg. Anak endau kg. Mok	Pahang	2.617	103.458
2828173	Kg. Gambir	Pahang	2.85	102.839
2829001	Ulu sg. Chanis	Pahang	2.813	102.938
2831179	Kg. Kedaik	Pahang	2.889	103.186
2834001	Stn. Pertanian rompin-endau	Pahang	2.813	103.45
2841001	Takek,pulau tioman	Pahang	2.818056	104.1653
3026156	Pos iskandar	Pahang	3.027778	102.6583
3028001	Sg. Kepasing	Pahang	3.020833	102.8319
3030178	Pecah batu bkt. Raidan	Pahang	3.065278	103.0806
3032167	Temeris	Pahang	3.016667	103.1986
3121143	Simpang pelangai	Pahang	3.175	102.1972
3129177	Bkt. Ibam	Pahang	3.168056	102.9764
3134165	Dispensari nenasi di pekan	Pahang	3.1375	103.4417
3221001	Jkr kg. Manchis	Pahang	3.202778	102.1625
3228174	Sg. Cabang kanan	Pahang	3.298611	102.8222
3231163	Kg. Unchang	Pahang	3.2875	103.1889
3330109	Kampong batu gong	Pahang	3.390278	103.0264
3424081	Jps temerloh	Pahang	3.438889	102.4264
3429096	Kg. Salong	Pahang	3.486111	102.9333
3519125	Kuala marong di bentong	Pahang	3.5125	101.9153
3533102	Rumah pam pahang tua di pekan	Pahang	3.561111	103.3569
3628001	Pintu kawalan paya kertam	Pahang	3.633333	102.8556
3818054	Stor jps raub	Pahang	3.805556	101.8472
3930012	Sg. Lembing p.c.c.l mill	Pahang	3.916667	103.0361
4019001	Jkr benta	Pahang	4.033333	101.9667
4023001	Kg. Sg. Yap	Pahang	4.031944	102.325
4120064	Hospital kuala lipis	Pahang	4.186111	102.0431

4127001	Kawasan (b) ulu tekai	Pahang	4.105556	102.7531
4219001	Bukit betong	Pahang	4.233333	101.9403
4223115	Kg. Merting	Pahang	4.243056	102.3833
4227001	Ulu tekai (a)	Pahang	4.233333	102.7333
4324001	Kuala tahan	Pahang	4.386111	102.4028
4419047	Stn. Keretapi chegar perah	Pahang	4.425	101.9333
4513033	Gunung brinchang di c.highlands	Pahang	4.516667	101.3833
3933001	Hulu jabor di kemaman	Terengganu	3.918056	103.175
4131001	Kg. Ban ho	Terengganu	4.133333	103.175
4232002	Jambatan air putih	Terengganu	4.270833	103.1986
4232104	Sek. Keb. Pasir gajah	Terengganu	4.238889	103.2972
4234109	Jps kemaman	Terengganu	4.231944	103.4222
4332001	Jambatan tebak	Terengganu	4.377778	103.2625
4333001	Seri bandi	Terengganu	4.3625	103.3472
4333096	Klinik bidan di kg. Ibok	Terengganu	4.327778	103.3681
4334094	Sek. Keb. Kijal	Terengganu	4.331944	103.4875
4434093	Sek. Men. Keb. Badrul alam shah	Terengganu	4.427778	103.4514
4529001	Rumah pam paya kempian, pasir raja	Terengganu	4.568056	102.9792
4534092	Sek. Keb. Kerteh di kemaman / paya labuhan, kemaman	Terengganu	4.508333	103.4444
4631001	Bandar al muktafi billah shah	Terengganu	4.603333	102.8186
4634085	Pusat kesihatan paka	Terengganu	4.613889	103.1986
4730002	Kg. Surau di kuala jengai	Terengganu	4.636111	103.4375
4734079	Sek. Men. Sultan omar di dungun	Terengganu	4.734722	103.0875
4832011	Jambatan jerangau	Terengganu	4.7625	103.4194
4833078	Rumah pam delong, dungun	Terengganu	4.843056	103.2042
4834001	Klinik bidan di kuala abang	Terengganu	4.816667	103.3097
4929001	Kg.embong sekayu di ulu terengganu	Terengganu	4.827778	103.4167
4930038	Kg. Menerong	Terengganu	4.952778	102.9667
4931061	Ldg. Koko jerangau	Terengganu	4.938889	103.0611
4933001	Klinik bidan di jambu bongkok pindah ke sek men	Terengganu	4.977778	103.1583

	keb jambu bongkok			
5029034	Kg. Dura	Terengganu	4.943056	103.3486
5029035	Sek. Keb. Kg. Dusun di k. Brang	Terengganu	5.066667	102.9417
5030039	Hospital k. Brang / jba kuala brang (dipindahkan ke jps.hulu trg.)	Terengganu	5.008333	102.9694
5031062	Kg. Bukit diman ulu terengganu	Terengganu	5.070833	103.0139
5128001	Sg. Gawi	Terengganu	5.098056	103.1472
5129040	Rumah pam paya rapat	Terengganu	5.172222	102.9014
5130063	Stn. Pertanian ajil	Terengganu	5.102778	103.0903
5131064	Sek. Men. Bkt. Sawa	Terengganu	5.191667	103.1
5230041	Sek. Keb. Kuala telemong	Terengganu	5.202778	103.0319
5230042	Rumah pam pulau musang	Terengganu	5.294444	103.0958
5232065	Sek. Keb. Marang (pindah ke sek. Men. Tg. Lela segara) pindah ke star kanan	Terengganu	5.208333	103.2069
5328002	Bkt. Durian di chalok-site 3	Terengganu	5.390278	102.8236
5328043	Kg. Bkt. Berangan di setiu	Terengganu	5.316667	102.8389
5328044	Kg. Sg. Tong	Terengganu	5.355556	102.8861
5330046	Sek. Keb. Kg. Gemuroh	Terengganu	5.35	103.0139
5331048	Setor jps kuala terengganu	Terengganu	5.318056	103.1333
5424001	Kg. Keruak di ulu besut (sek. Keb. Keruak)	Terengganu	5.483333	102.4917
5426001	Kg.hulu seladang, setiu	Terengganu	5.476389	102.675
5428025	Sek. Keb. Kg. Rahmat	Terengganu	5.465278	102.8056
5430049	Kg. Padang maras di kuala terengganu	Terengganu	5.429167	103.0403
5524001	Kg. La	Terengganu	5.530556	102.4833
5527024	Stesen kg banggol	Terengganu	5.561111	102.7722
5529027	Kg. Merang	Terengganu	5.531944	102.9514
5624001	Empangan jajar	Terengganu	5.674833	102.49
5625003	Ibu bekalan sg. Angga, ulu besut	Terengganu	5.6	102.5153
5625011	Sek. Keb. Kg. Jabi	Terengganu	5.679167	102.5639
5626001	Institut pertanian besut	Terengganu	5.643056	102.6222
5724003	Jambatan jertih	Terengganu	5.739722	102.4931

5725006	Klinik kg. Raja di besut / sek. Men. Keb. Pengkalan nyireh	Terengganu	5.797222	102.5653
5726013	Sek. Keb. Kg. Tembila di besut	Terengganu	5.740278	102.6083
4614001	Brook	Kelantan	4.67639	101.4847
4717001	Blau	Kelantan	4.6	101.4
4819027	Gua musang	Kelantan	4.879	101.969
4923001	Kg. Aring	Kelantan	4.938	102.353
5322044	Kg. Laloh	Kelantan	5.3083	102.275
5723056	Telusan	Kelantan	5.7583	102.3222
5923081	Tok ajam	Kelantan	5.9042	102.3819

Data Processing

Hourly rainfall data for December 2014 and historical was converted to daily data. Afterwards, the data was processed using Microsoft Excel to make it into the maximum 1-day and cumulative maximum 3-day, 5-day, 7-day, 9-day, 11-day, 13-day and 15-day for the event (December 2014) rainfall. While, the historical data was sorted out using MATLAB programming software to find the highest maximum 1-day and cumulative maximum 3-day, 5-day, 7-day, 9-day, 11-day, 13-day and 15-day from 1985 until 2013.

Results and Discussion

Highest Historical Rainfall Distribution

The stations used for the highest historical rainfall analysis are shown in Figure 3. The plots are based on the datasets in table 1. The data was interpolated based on more than 25 years historical record using IDW and Kriging method. Results are shown in figure 4 (a) to (p). The highest receiving rainfall for maximum 1-day was Kawasan (B) Ulu Tekai rain station (1511.5 mm) and Sg. Cabang Kanan rain station (621.5 mm). Kawasan (B) Ulu Tekai also has the highest recorded rainfall for other rainfall periods of 3-day, 5-day, 7-day, 9-day, 11-day, 13-day and 15-day. Comparison of two different spatial distribution IDW and Kriging shows the same general pattern of rainfall distribution but slightly different amount of rainfall and cumulated rainfall depth (mm). Comparison with the rainfall during the December 2014 Pahang flood can be made against historical maximum. Hence the severity of the rainfall during the event can be shown.

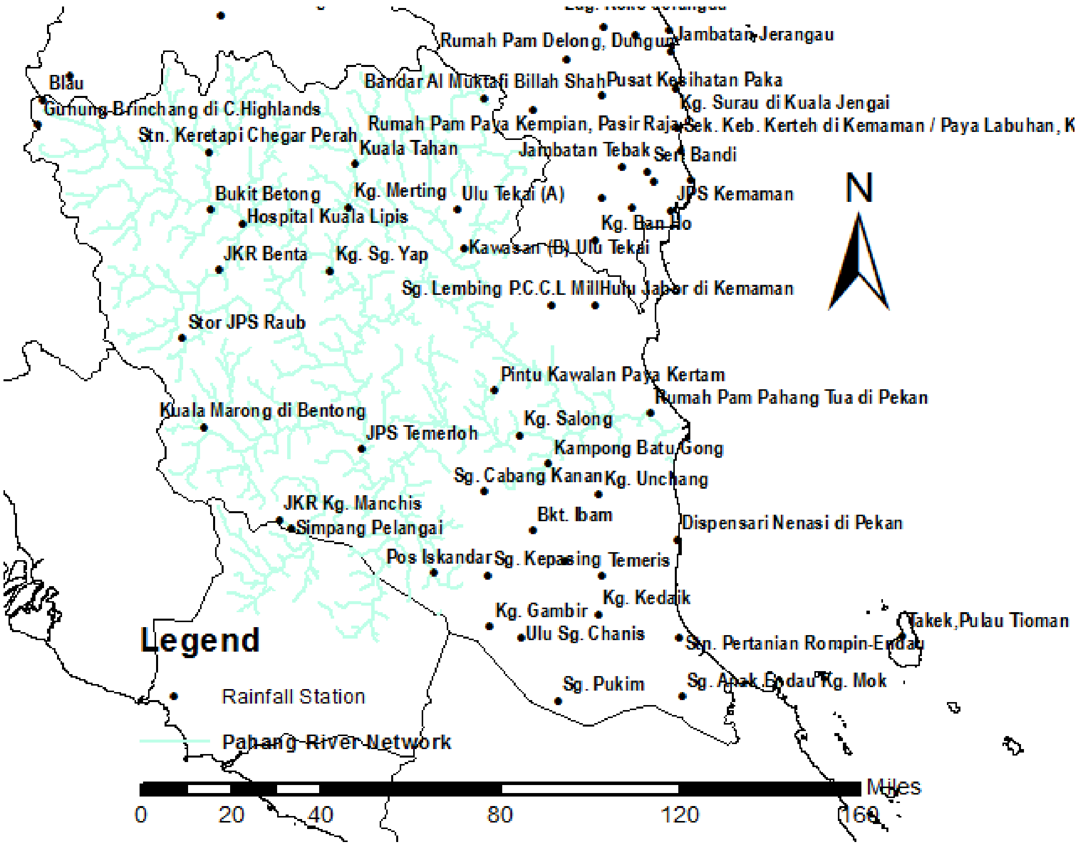
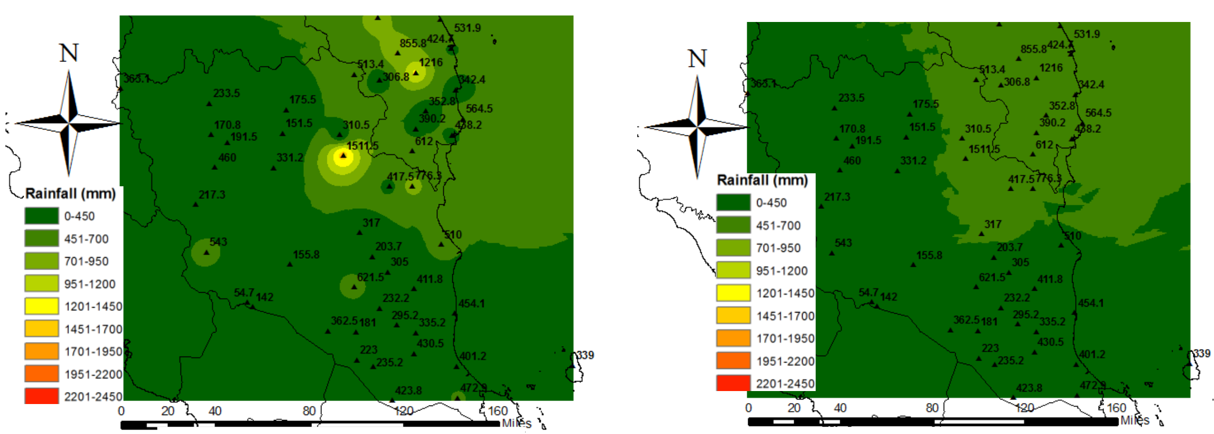
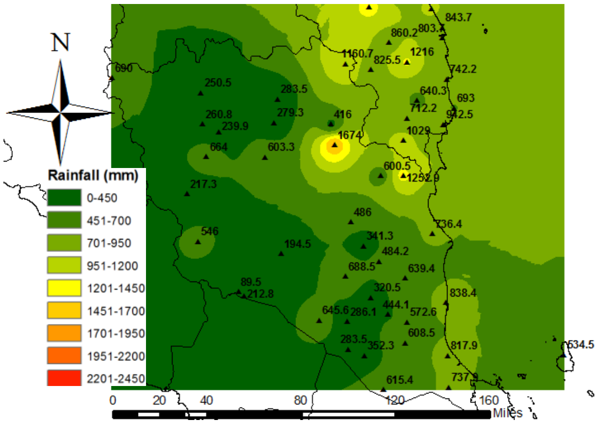


Figure 3: Location of selected rainfall stations for highest historical record

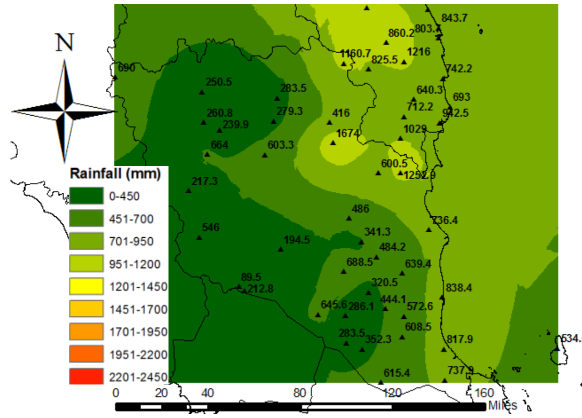


(a) Max 1-day (IDW)

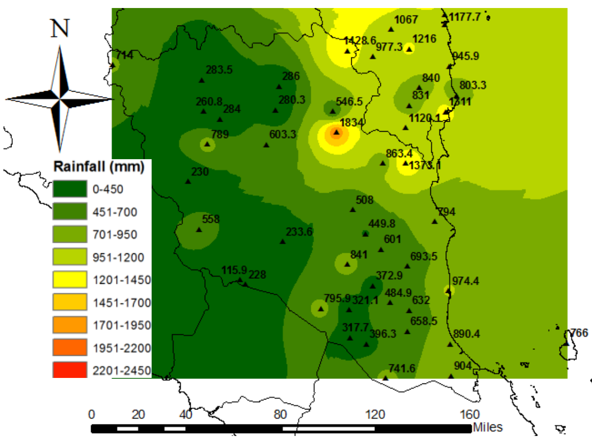
(b) Max 1-day (Kriging)



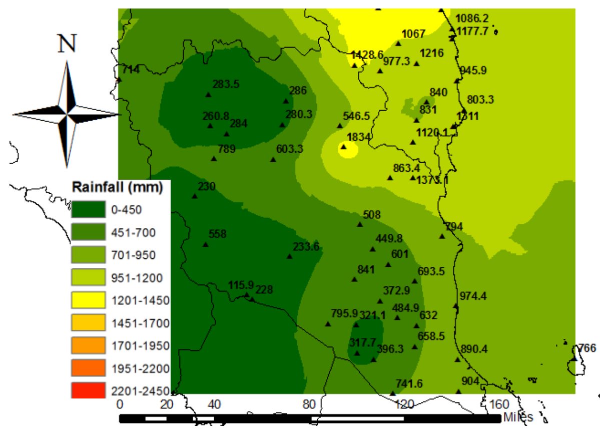
(c) Max 3-day (IDW)



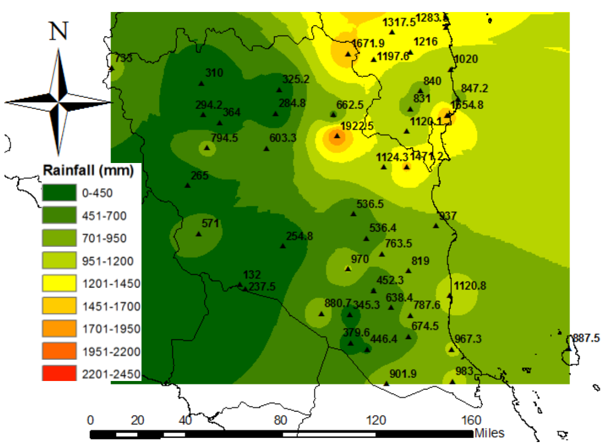
(d) Max 3-day (Kriging)



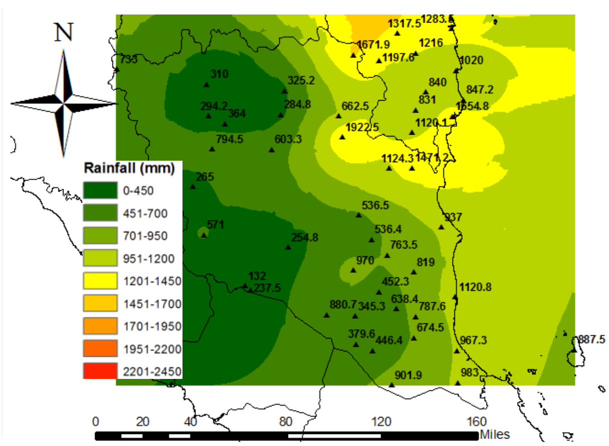
(e) Max 5-day (IDW)



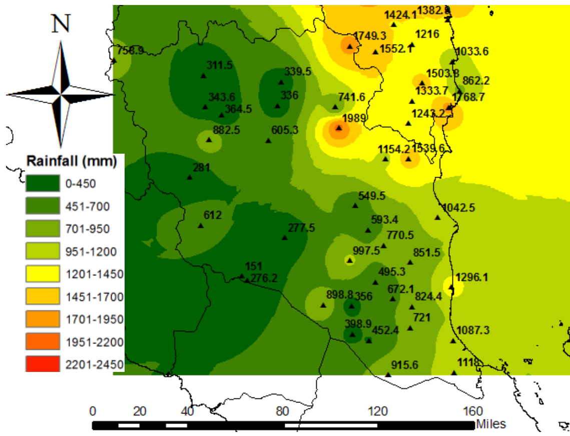
(f) Max 5-day (Kriging)



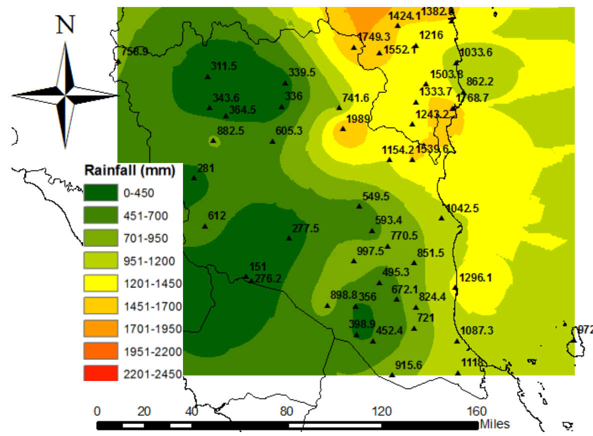
(g) Max 7-day (IDW)



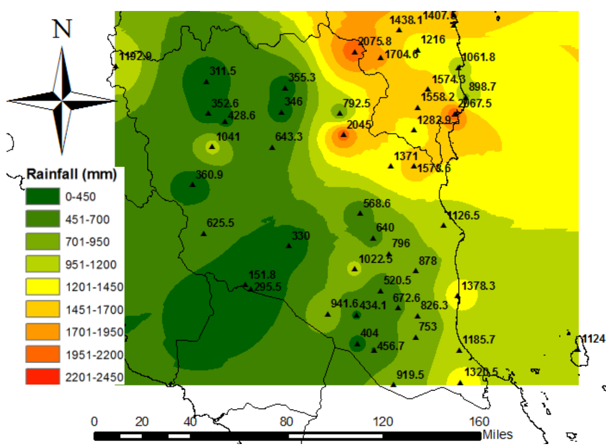
(h) Max 7-day (Kriging)



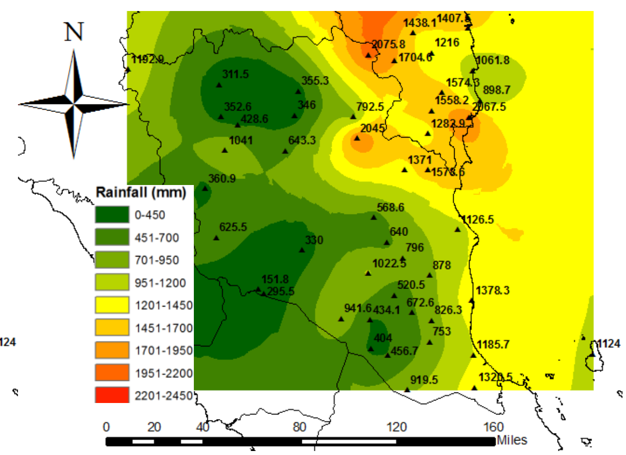
(i) Max 9-day (IDW)



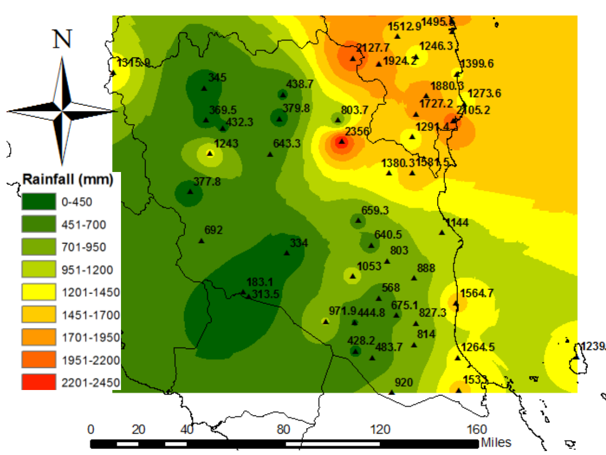
(j) Max 9-day (Kriging)



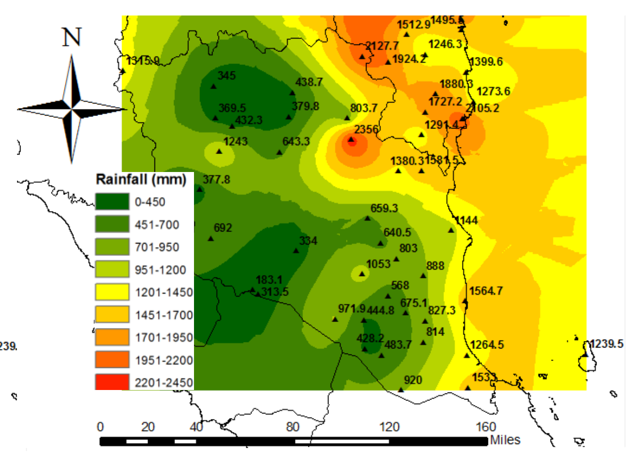
(k) Max 11-day (IDW)



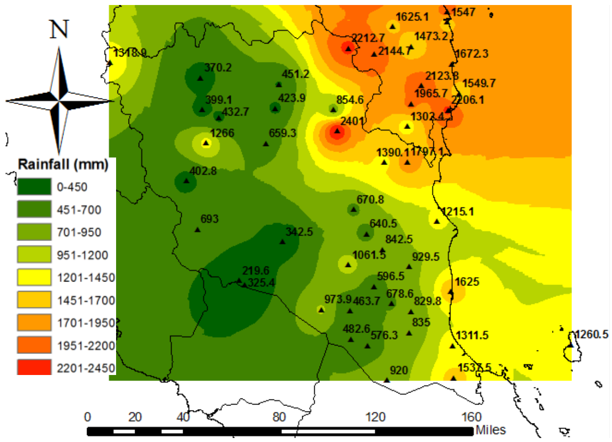
(l) Max 11-day (Kriging)



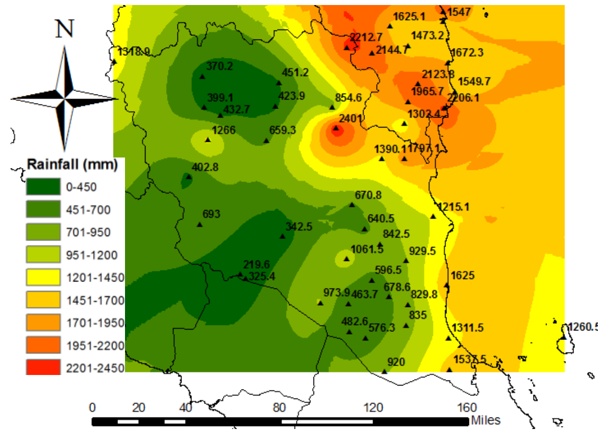
(m) Max 13-day (IDW)



(n) Max 13-day (Kriging)



(o) Max 15-day (IDW)



(p) Max 15-day (Kriging)

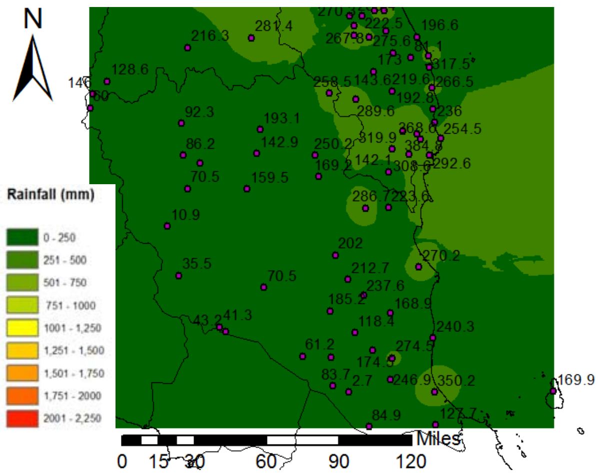
Figure 4: (a) – (p) Historical maximum rainfall

For this particular study, result of Kriging and IDW interpolation shows IDW method is better because IDW did not change the original data. For Kawasan (B) Ulu Tekai rain station for 1-day historical is 1511 mm, this agree with figure 4(a) where the data plotted has the range of 1451-1700 mm. But in figure 4(b) using Kriging interpolation method, Kawasan (B) Ulu Tekai rain station was plotted as in the range of701-900 mm. So, from this Kriging has change the original data.

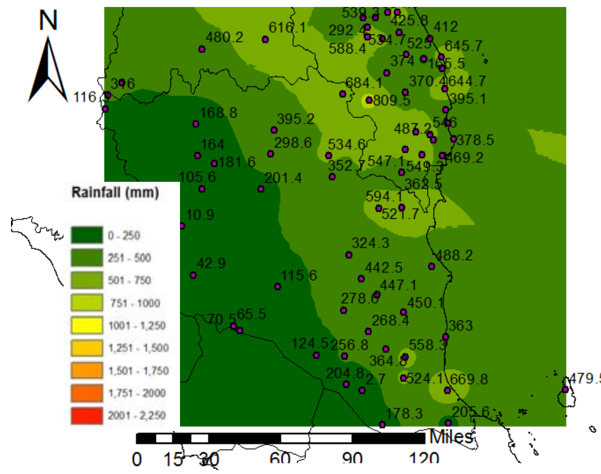
Dispersion of interpolated rainfall depths are focused on the rainfall station when using the IDW as the interpolation method. That is why we can see the concentration of rainfall depths focusing on the rain gauge station itself. On the other hand, Kriging rainfall depths is much dispersing around the area of the interpolated station. Kriging and IDW interpolation has other differences also. IDW interpolation tools used directly based on the surrounding rainfall station to measure the interpolated rainfall depth. While Kriging is much more complex using a mathematical function to a specific number of rainfall station to determine the cumulative rainfall depth for each location. Thus for the next interpolation for determining the Pahang extreme rainfall event on the 15-29 December 2014, method IDW interpolation were used, since it shows better and accurate result.

Extreme Rainfall Event

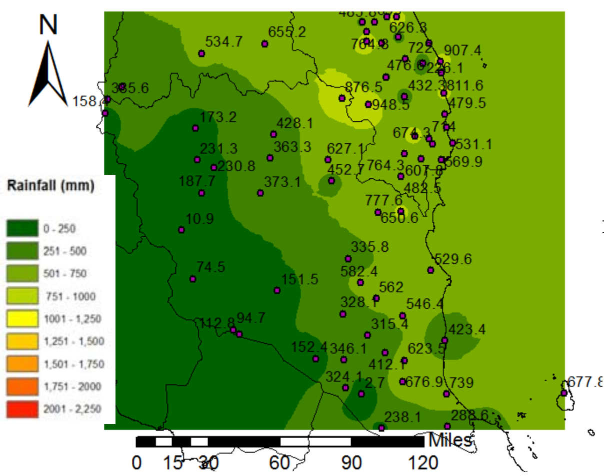
IDW interpolation method were used to see whether the event during the December 2014 Pahang flood exceed the historical flood. The spatial cumulated rainfall depth during the rainfall events of the 15-29 December in Pahang are assessed. That means, the analysis includes various cumulative rainfall distribution periods of 1-day, 3-day, 5-day, 7-day, 9-day, 11-day, 13-day and 15-day. In the 1-day event, heavy rainfall was pouring which are the North-West of Pahang (eg. Stn. Pertanian Rompin-Endau, 350.2 mm) and two station (Kg. Salong and Kuala Tahan station) was exceeding the value of historical rainfall. Comparison can be made to see whether the event rainfall during the December 2014 Pahang flood exceed the historical. Following 3-day event, Kg. Merting at the North-West of Pahang are exceeding the value of historical rainfall (298.6 mm).



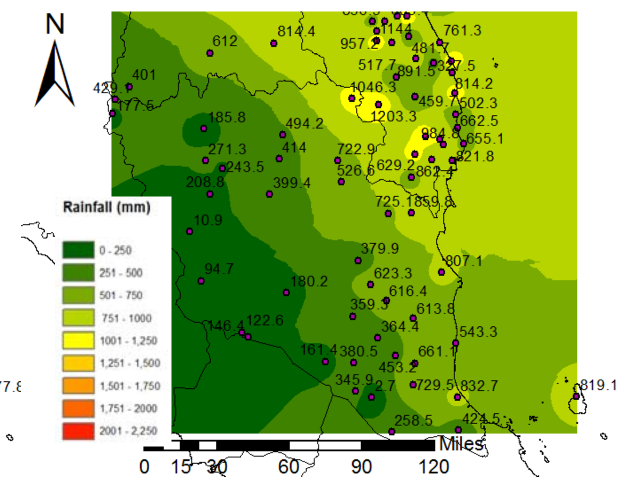
(a) 1-day



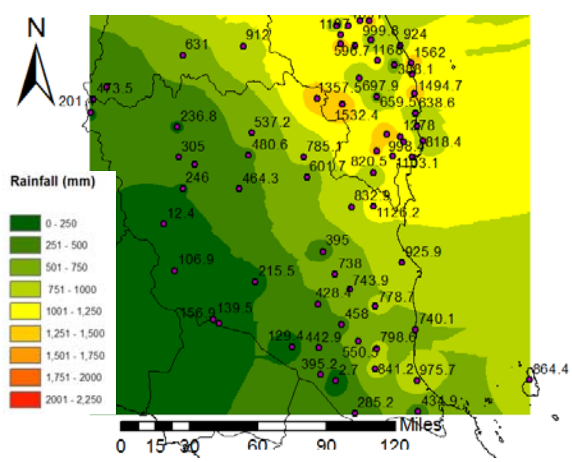
(b) 3-day



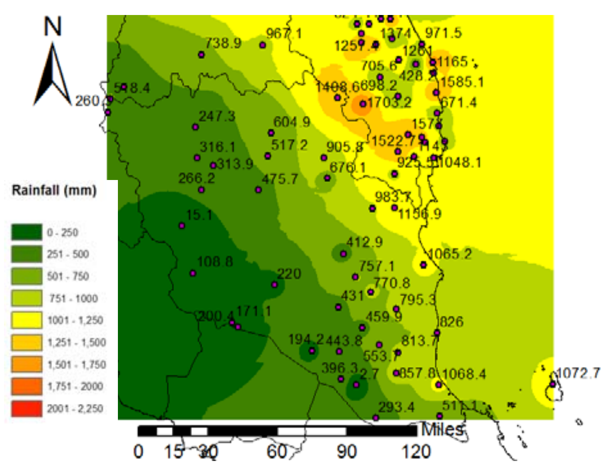
(c) 5-day



(d) 7-day



(e) 9-day



(f) 11-day

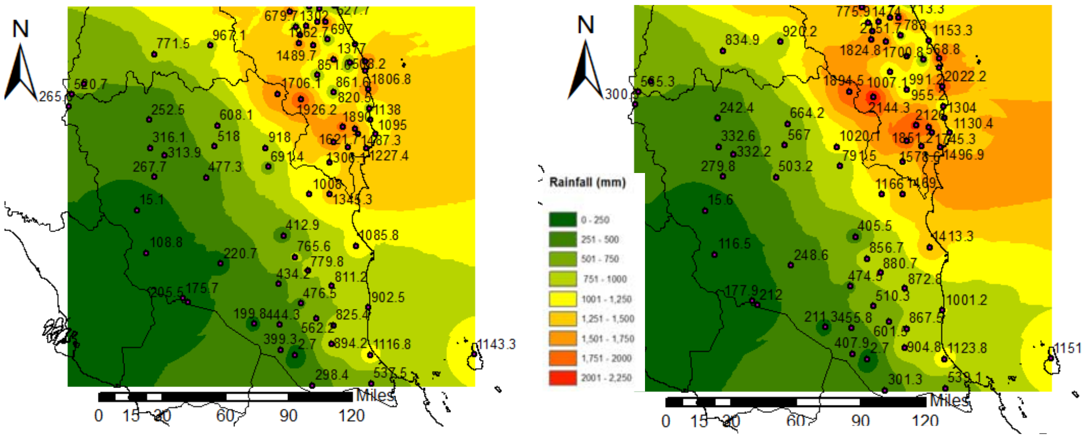


Figure 5 (a) – (h) Spatial distribution using IDW interpolation on the flood event 15 – 29 December 2014

For 5-day event, there were six stations exceeding historical rainfall in the North-East, East and South-East area. The first area is North-East was Kuala Tahan, Ulu Tekai (A) and Kg. Merting with cumulative rainfall of 428.1 mm, 627.1 mm and 363.3 mm exceeding the historical rainfall of 286 mm, 546.5 mm and 363.3 mm respectively. For the east area, Kg. Salong receiving cumulated rainfall of 582.4 mm exceeding historical rainfall of 449.8 mm. Meanwhile, the third area located in South-East area was Kg. Kedaik and Sg. Kepasing, receiving cumulative rainfall for 5-day event of 676.9 mm and 346.1 mm exceeding historical rainfall of 658.5 mm and 321.1 mm respectively. Heavy rainfall continue on moving downwards from North and South side of Pahang. Later on the 15-day event at Ulu Tekai (A) located in North-East area with cumulative rainfall of 1021.1 mm surpassing historical rainfall of 854.6 mm. In Temeris and Kampong Batu Gong also in North-East area, it receives a cumulative rainfall of 867.5 mm and 880.7 mm exceeding historical value of 829 mm and 842.5 mm.

Comparison of Highest Historical Rainfall and Rainfall Event

In earlier discussion, the comparison between historical rainfall with cumulative rainfall depth has been made and 9 main area identified to exceed historical rainfall are Kg. Kedaik, Sg. Kepasing, Temeris, JKR Kg. Manchis, Kampung Batu Gong, Kg, Salong, Kg. Merting, Ulu Tekai (A) and Kuala Tahan. Table 2 shows the comparison between highest historical rainfall for 25 years and rainfall event for 15-29 December 2014. This comparison has been made using IDW and Kriging interpolation in the previous section. The highlighted area in table 2 show the value of rainfall events exceeding highest historical events. From this, it can be summarized extreme rainfall occurred at these 9 areas could be the cause of flood during Pahang December 2014 flood.

Table 2: Comparison of historical rainfall and cumulative rainfall depth

Station name	1-day Historical (mm)	1-day Event (mm)	3-day Historical (mm)	3-day Event (mm)	5-day Historical (mm)	5-day Event (mm)	7-day Historical (mm)	7-day Event (mm)
Kg. Kedaik	430.5	246.9	608.5	524.1	658.5	676.9	674.5	729.5
Sg. Kepasing	181	151.1	286.1	256.8	321.1	346.1	345.3	380.5
Temeris	335.2	274.5	572.6	558.3	632	623.5	787.6	661.1
JKR Kg. Manchis	54.7	41.3	89.5	65.5	115.9	94.7	132	122.6
Kampong Batu Gong	305	237.6	484.2	447.1	601	562	763.5	616.4
Kg. Salong	203.7	212.7	341.3	442.5	449.8	582.4	536.4	623.3
Kg. Merting	151.5	142.9	279.3	298.6	280.3	363.3	284.8	414
Ulu Tekai (A)	310.5	250.2	416	534.6	546.5	627.1	662.5	722.9
Kuala Tahan	175.5	193.1	283.5	395.2	286	428.1	325.2	494.2

Station name	9-day Historical (mm)	9-day Event (mm)	11-day Historical (mm)	11-day Event (mm)	13-day Historical (mm)	13-day Event (mm)	15-day Historical (mm)	15-day Event (mm)
Kg. Kedaik	721	841.2	753	857.8	814	894.2	835	904.8
Sg. Kepasing	356	442.9	434.1	443.8	444.8	444.3	463.7	455.8
Temeris	824.4	798.6	826.3	813.7	827.3	825.4	829.8	867.5
JKR Kg. Manchis	151	139.5	151.8	171.1	183.1	175.7	219.6	177.9
Kampong Batu Gong	770.5	743.9	796	770.8	803	779.8	842.5	880.7
Kg. Salong	593.4	738	640	757.1	640.5	765.6	640.5	856.7
Kg. Merting	336	480.6	346	517.2	379.8	518	423.9	567
Ulu Tekai (A)	741.6	785.1	792.5	905.8	803.7	918	854.6	1020.1
Kuala Tahan	339.5	537.2	355.3	604.9	438.7	608.1	451.2	664.2

Topography and River

Flooding occurs most commonly from heavy rainfall when natural watercourses do not have the capacity to convey excess water. However, floods are not directly caused by heavy rainfall. They can result from other influences such as topography and river location. During flood December 2014 Pahang, areas flooded were influenced by the topography. Heavy rainfall at higher area will flow to the lower area. Figure 6 shows the flood area having lower elevation. They are Kg. Kedaik, Sg. Kepasing, Temeris, JKR Kg. Manchis, Kampung Batu Gong, Kg, Salong, Kg. Merting, Ulu Tekai (A) and Kuala Tahan.

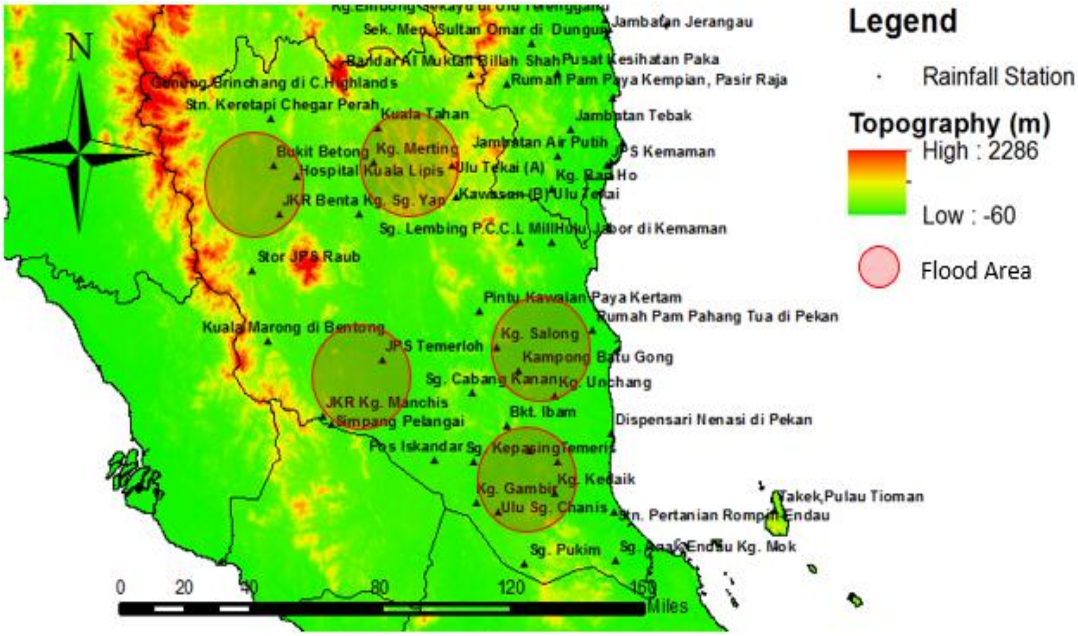


Figure 6: Area flood during December 2014 Pahang.

Figure 7 shows the main river in Pahang. Stations nearby to Sungai Pahang were flooded (e.g. Kuala Tahan, Ulu Tekai (A), Kg. Merting, Kg. Salong, Kampung Batu Gong and JKR Kg. Manchis). While stations near Sungai Rompin; stations Temeris, Sg. Kepasing and Kg. Kedaik were also flooded. Flooding often occurs in lowlands. This is because rivers flow more slowly in low-lying areas. If the water volume increases suddenly, floods occur. Heavy rainfall raises the water level. When the water level is higher than the river bank or the dams, the water overflowfrom the river, causing flooding.

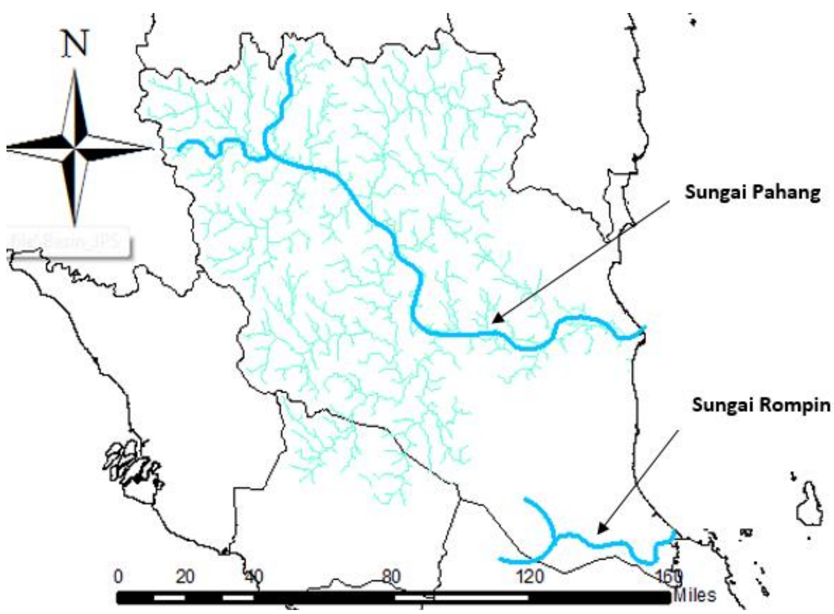


Figure 7: River in Pahang state

Conclusion

Extreme rainfall can be the main factor leading to natural disasters such as flood especially during the December 2014 flood event in Pahang. Besides, topography and location of river also influence flood event in Pahang. The objective of this study is to analyze the rainfall distribution pattern based on extreme rainfall in Pahang (15 – 29 December 2014) using rain gauge stations. From the analyses of the rainfall pattern, more than 90 rainfall stations were used. The rainfall depth pattern were developed using Inverse Distance Weighted (IDW) and Kriging spatial interpolation technique via ArcGis 10.1.2 software. With the application of ArcGis 10.2.1, spatial analysis of the computed extreme rainfall was able to be conducted. Then, the comparison of rainfall event of December 2014 with historical rainfall of 25 years record was carried out. 9 areas (e.g Kg. Kedaik, Sg. Kepasing, Temeris, JKR Kg. Manchis, Kampung Batu Gong, Kg, Salong, Kg. Merting, Ulu Tekai (A) and Kuala Tahan) were identified as values of rainfall event exceeding the values of historical events. IDW and Kriging interpolation method were also used to get the spatial distribution of historical events. However to get the cumulative rainfall event for December 2014 flood in Pahang, IDW interpolation method was only used. When using ArcGis 10.2.1 software, method IDW interpolation is more accurate than method Kriging interpolation.

For this particular study, IDW were seen to be more accurate. IDW method can be become good tools for engineers to understand and analyze extreme rainfall event using interpolation to construct spatial distributions of the rainfall. Meanwhile the results presented here may benefits for many local agencies partners such as state and country civil defense or state department of land and natural resources who are concerned with flood and relevant policy making. In future study, if the extreme rainfall statistics from the presented study were merged with other geographic information system data layer like historical damage and land use, then it would be possible to update the state flood risk management.

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