UNIVERSITAS GADJAH MADA

JASA TIRTA I
JALAN SURABAYA 2A, MALANG

MSD NetWork

IAHR AIRH
International Association for Hydro-Environment Engineering and Research
Supported by Spain Water and IWHR, China

IAHR-APD 2018
Yogyakarta, Indonesia

PROCEEDINGS

21st IAHR-APD Congress

International Association for Hydro-Environment Engineering and Research (IAHR) Asia Pacific Division (APD)

Multi-perspective Water for Sustainable Development

Volume 2

- Water Resources
- Hydroinformatics
- Water-related Disaster Risk Reduction
- Special Sessions

Yogyakarta, Indonesia
2-5 September 2018

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FOREWORDS FROM CHAIRMAN OF THE LOCAL ORGANIZING COMMITTEE

Dear Readers,

Universitas Gadjah Mada was honored to host the 21st Congress of International Association for Hydro-Environment Engineering and Research-Asia Pacific Division (IAHR-APD) on 2-5 September 2018 in Yogyakarta which was co-hosted by PT. Jasa Tirta I (Jasa Tirta I Public Corporation) and Multimodal Sediment Disaster Network (MSD-Network). The Congress brought up the theme "Multi-perspective Water for Sustainable Development". This phrase was adopted as the main theme of the Congress to maintain awareness of the stakeholders that water should be valued from various viewpoints namely technical, socio-economic, cultural and environmental viewpoints which integrate all efforts on water resources-related development to contribute to people's welfare.

The 21st Congress of IAHR-APD accommodated the 6th AUN/SEED-Net Regional Conference on Natural Disaster (RCND 2018) which was mostly relevant to water-related natural disasters to be part of the Congress. The joint congress was aimed at introducing the IAHR-APD organization to even wider areas of hydro-environment engineers and scientists as well as strengthening cooperation with similar organizations.

The Congress has successfully encouraged the interactions among researchers, industries, and communities, on the dissemination of water-related research achievements and ideas that paves the way for sustainable water and environment-related development. The local organizing committee especially appreciates all of the staff of the IAHR and IAHR-APD for their endless and excellent support to the congress.

The cooperation and support of Universitas Katolik Parahyangan, Sekolah Tinggi Teknik Nasional Yogyakarta, Universitas Kristen Duta Wacana are also highly appreciated. We would like to thank all of the sponsors and participants for their contributions to make the Congress fruitful and memorable. Our special thanks go to the reviewers of the papers and the editors of the proceedings without whom the publication of such excellent quality proceedings would not have been possible. We hope that this proceedings will furnish the readers with excellent references and stimulate further studies and researches in the related areas.

Thank you very much and God bless you all.

Radianta Triatmadja

21st IAHR-APD 2018 Congress Chair

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FOREWORDS FROM CHAIRMAN OF THE IAHR-APD

It is my great honor and pleasure to say 'Welcome' to all the attendees of the 21st Congress of the International Association for Hydro-Environment Engineering and Research-Asia Pacific Division. The IAHR-APD Congress is the official and most important open forum for all persons, not only the members but also general participants, who are interested in presenting, discussing, and exchanging their knowledge and experiences in hydro-environment areas. Since the first congress was held in Bangkok, Thailand in 1978, this is the 21st, following the previous congress that was held in Colombo, Sri Lanka two years ago with great success in terms of numbers of papers presented and participants. You can see about the past APD congresses at the official website of IAHR-APD http://www.iahrapd.org/Apd/Congress/webinfo/2014/08/1408074914387664.htm.

We, the APD members, have tried to delineate as well as generalize the conference characteristics such as by emphasizing specialty sessions dealing with the water-issues which are especially important and sometimes unique in the Asia and Pacific region such as typhoon, monsoon, and tropic-affected water issues, as well as historical water projects and traditional water technologies in the region. For example, we have special sessions of Historical water projects and traditional water technologies in the Asia-Pacific region, Green infrastructure as disaster risk reduction measure, Ecosystem-based disaster risk reduction for floods and tsunamis, Adapting to climate change using green infrastructure and LID measures, Conceptual ideas to solve problems related to hydro-environment engineering, Volcano and multimodal sediment disaster, Simulation and risk mitigation, and Hydrology-geomorphology links in tropical rivers. At this congress, we are also hosting some international panels with recognized high-ranking officials on the water issues that are of mutual interests in the region.

Among many special sessions that are held at this conference, the session of Historical water projects and traditional water technologies in the Asia-Pacific region, would be worthwhile to introduce more in detail. It has the purpose of giving international professional recognition to the works of: 1) past water projects that contributed or are still contributing to the welfare of the people, and 2) past brilliant water technologies that blossomed once and are still useful in the Asia – Pacific region. The first special session was held in Sri Lanka congress in 2016 with seven presentations from different countries in the region. Those are now in the process of being published in the Journal of Hydro-environment Research (JHER), the official journal of IAHR-APD, as a special issue. This type of special session will continue at every APD congress and a few papers presented at the session will be strictly screened and submitted for a possible publication in JHER along with the ones receiving the best-paper award in the congress.

I strongly believe that this conference should be a very useful and effective forum in which we are able to foster interdisciplinary research and collaboration, rapid dissemination of latest findings, and will provide an opportunity for discussing how novel methods and techniques can be used interchangeably in various fields and application areas of hydro-environment engineering and research especially in the Asia and Pacific region.

Last, but not least, I as the IAHR-APD chair express many thanks to the LOC members including Prof. Radianta Triatmadja, the conference chair, for their full devotions to the preparation and proceedings of the conference for the last two years. I strongly believe that this conference will be one of the most successful events ever in the history of the IAHR-APD activities.

Hyoseop Woo

IAHR-APD Chair

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THE EFFECT OF THE LENGTH OF RAINFALL DATA TO IDF CURVE

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ABSTRAK

IDF Curve is significant for determining the rainfall intensity of design rainfall in calculating design flood which is crucial in designing hydrologic structures. The intensity of design rainfall is determined by rainfall data used. This study aims to analyse the effect of the length of rainfall data on IDF curve. This is done by comparing IDF curve developed from the entire rainfall data set to some part of rainfall data set. This study used rainfall data collected from automatic rainfall recorder of BMG Radin Inten II Station and from geophysics station Kotabumi. Rainfall data from BMG Radin Inten II Station are grouped into several data sets with data lengths of 4, 6, 8 and 10 years. While rainfall data from station Kotabumi is also grouped into several data sets with data lengths of 5, 7, 9, 11 and 13 years. All the data sets were analysed to determine the IDF curve for return periods of 2, 5, 10, 25, 50 and 100 years. This study shows that rainfall intensities of design rainfalls as expressed in IDF curves from BMG Radin Inten II station are higher compared to those from geophysics station of Kotabumi. In addition, IDF curve developed using longer rainfall data tends to be more stable and reflects possible rainfall events.

Keywords: rainfall intensity, IDF curve, length of data

1. INTRODUCTION

Sufficiently long time series of rainfall data is required for designing hydraulic structures. First rainfall data is analysed to define designed rainfall and then it is transformed into designed runoff which determines the dimension of hydraulic structures. Therefore rainfall data is significant for hydraulic structure design. Rainfall intensity designs for various rainfall durations and return periods are set in IDF (Intensity – Duration – Frequency) curve. IDF analysis is conducted to estimate peak discharge in a small catchment area, such as for urban drainage system, s, and bridges (Triatmodjo, 2008). IDF curve used as the design basis affects the reliability of hydraulic structures built. If the IDF curve does not represent the actual condition, then the resulted hydraulic structure becomes ineffective or inefficient.

The quality of the rainfall data largely determines the result of IDF curve analysis. The availability of time series rainfall data or data length plays an important role too. Different length of rainfall data impacts on different rainfall designs for the same return period. The shorter the data length the greater the deviation (Harto, 1993). According to Aslan (1997), time series of rainfall data required for urban drainage design is 10 years at minimal.

IDF analysis conducted in this research used rainfall data collected from automatic rainfall station in Lampung Province. There are four automatic rainfall stations in Lampung Province, i.e. BMG Maritim Panjang station, BMG Radin Inten station, Kotabumi geophysics station and Masgar climatology station. Of the four stations used in this study are rainfall data from BMG Radin Inten II station and Kotabumi geophysics station. BMG Radin Inten II station is located in Radin Inten II airport area in South Lampung, while BMG Kotabumi is located in North Lampung. The selection of the two rain stations due to their location is far apart and based on the results of the preliminary analysis shows the mean annual rainfall significantly.

Research on IDF has been done widely which generally can be categorized into two major methods, using an empirical equation to derive daily rainfall data into small rainfall duration and using the small duration of rainfall data to determine rainfall intensity. Susilowati and Kusumastuti (2010) in their research for the calculation of rain intensity used van Breen method with Talbot equation as a reference to form IDF curve. Some other researchers which used empirical method for deriving small rainfall durations include Alfieri *et al*. (2008). Rashid et al. (2012), Russel and Hossain (2015), Fauziyah et al. (2013), Yulius (2014) and Handayani (2007). On the other hand, some researchers which used small duration recorded rainfall data to develop IDF curve were done by Kusumastuti et al. (2016), Adam and Howard (2013) and Moncho et al. (2009). In those studies, recorded rainfall data at small durations are directly converted to rainfall intensity. In the conversion from rainfall depth (P) to rainfall intensity (I) used the relation $I = 60\ P/t$ (Triatmodjo, 2008).

The intensity of extreme rainfall for various return period presented in the IDF curve was calculated using frequency analysis. This analysis aims to determine the relationship between the magnitude of extreme events to the frequency of events by using the probability distribution. The rainfall data used for the frequency analysis is selected from the complete series of records for several years. Data selection can use either partial duration series or annual maximum series. Partial duration series is a series of rainfall data that is greater than a certain lower limit value so that in one year it is possible to have more than one data used for analysis. On the other hand, the annual maximum series uses only one maximum rainfall data for each year.

In the field of hydrology, There are several probability distribution functions used in frequency analysis, such as normal distribution, lognormal, Gumbel and Log Pearson III (Triatmodjo, 2008). The normal distribution is symmetrical to the vertical axis and bell-shaped. A normal log distribution is used if the value of the random variable does not match the normal distribution, but the logarithm value corresponds to the normal distribution. Gumbel distribution or often called probability distribution of the extremes suitable for maximum data analysis. The Log Pearson III distribution is used if the statistical parameters *Cs* and *Ck* have values other than the statistical parameters for other distributions (normal, normal logs and Gumbel distributions).

2. METHOD

The data required in this research are rainfall data used in this study is taken from the Hellman type automatic rain gauge at the following two stations (a) Kotabumi Geophysical Station from 1998 to 2011, with a data length of 13 years because the data in 2006 did not exist; and (b) BMG Radin Inten II Station from 2001 to 2014, with a data length of 14 years. Rainfall data used is short-term rainfall data with duration of 5, 10, 15, 30, 45, 60, 120 minutes, 3 hours, 6 hours, and 12 hours.

The procedure of this study includes:

1. Grouping rainfall data from BMG Radin Inten into 6 sets of data length, i.e. 4 years (2001-2004), 6 years (2001-2006), 8 years (2001-2008), 10 years (2001-2010), 12 years (2001-2012) and 14 years (2001-2014), and rainfall data from Kotabumi Geophysical Station into 5 sets of data length ie 5 years (1998-2002), 7 years (1998-2004), 9 years (1998-2006) , 11 years (1998-2009) and 13 years (1998-2011).
2. Conducting a frequency analysis to determine rainfall depth for each duration with a return period of 2 years, 5 years, 10 years, 25 years, 50 years and 100 years.
3. Determining the rain intensity value for each duration and return period.
4. Drawing intensity duration frequency curve (IDF) for 2, 5, 10, 25, 50 and 100 years of return periods for each data set according to the length of the rainfall data
5. Comparing IDF curves generated from each set of data lengths with the longest data length in the same station to determine the effect of data length on IDF curve.

3. RESULT AND DISCUSSION

The maximum rainfall depth per year with various durations for BMG Radin Inten and Kotabumi Geophysics stations are presented in Table 1 and Table 2.

Table 1. The maximum rainfall depth for each duration on BMG Radin Inten II 2001-2014

Years	Rainfall Depth for Each Duration (in millimeters)									
	5 min	10 min	15 min	30 min	45 min	60 min	120 min	3 hr	6 hr	12 hr
2014	10.0	20.0	26.0	36.0	40.0	50.0	80.0	80.0	80.0	101.0
2013	10.0	18.0	26.0	45.0	50.0	56.0	87.0	90.0	115.0	160.0
2012	10.0	26.0	30.0	52.0	66.0	76.0	120.0	90.0	115.0	160.0
2011	11.6	26.8	40.7	59.4	64.5	73.0	90.6	94.6	98.5	99.1
2010	19.0	30.0	42.0	63.0	85.0	90.0	116.0	119.0	119.1	119.1
2009	15.0	25.0	35.0	40.0	48.0	72.0	74.0	74.8	74.8	81.0
2008	10.0	20.0	42.2	52.5	54.2	64.0	70.6	70.6	72.6	72.6
2007	15.0	27.0	30.0	44.0	58.5	83.0	103.0	107.0	113.0	113.0
2006	48.4	68.4	72.4	84.2	90.6	100.4	101.6	101.6	101.6	101.6
2005	12.0	22.0	29.0	37.7	40.0	40.0	51.3	60.0	76.0	76.0
2004	16.0	30.0	38.0	53.5	58.8	67.3	77.1	79.8	84.8	85.0
2003	15.0	27.0	37.0	50.5	57.4	58.6	68.0	68.0	68.0	68.0
2002	50.0	55.0	60.0	60.0	85.0	90.0	109.7	109.7	109.7	109.7
2001	30.0	30.0	36.4	42.3	49.8	57.0	66.4	69.4	71.4	71.6

Table 2. Maximum rainfall depth for each duration at Kotabumi Geophysics Station 1998-2011

Years	Rainfall Depth for Each Duration (in millimeters)									
	5 min	10 min	15 min	30 min	45 min	60 min	120 min	3 hr	6 hr	12 hr
2011	8.0	10.0	15.0	54.3	55.6	72.0	72.0	72.0	144.7	145.9
2010	5.0	10.0	16.0	40.0	45.0	49.0	72.0	80.5	85.8	86.0
2009	4.0	10.0	14.0	23.0	50.0	63.7	69.2	69.2	78.5	78.5
2008	5.3	14.0	20.0	40.0	40.0	50.0	90.0	93.8	106.0	110.2
2007	8.5	10.0	20.0	36.0	45.0	65.0	71.8	74.6	80.0	81.2
2005	10.0	20.0	30.0	60.0	75.0	85.0	85.7	86.0	86.0	102.5
2004	5.5	10.0	15.0	40.0	47.4	53.0	68.2	68.2	97.7	98.5
2003	5.2	9.5	14.5	30.0	50.0	50.5	51.5	58.0	73.5	117.0
2002	8.6	16.5	25.0	46.5	62.0	64.0	74.5	78.5	78.6	104.8
2001	4.0	11.0	19.0	36.0	43.5	53.2	81.8	82.8	83.4	83.4
2000	3.0	10.0	20.4	32.0	42.2	49.0	59.8	59.8	59.8	59.8
1999	5.0	10.0	13.5	31.0	52.0	66.2	100.0	100.0	100.0	127.2
1998	5.0	13.0	18.0	38.6	56.0	62.0	103.9	109.4	112.8	114.1

The maximum rainfall depth for each year with various durations is converted into rainfall intensity. Table 3 and Table 4 shows the maximum rainfall intensity for each duration for BMG Radin Inten II and Kotabumi Geophysical Station respectively. Rainfall intensities for low durations in BMG Radin Inten II station are higher than rainfall intensities given the same durations recorded in Kotabumi geophysical station. The highest rainfall intensity for 5 minutes duration at BMG Radin Inten II station reaches 5 times of the highest rainfall intensity in the same duration at Kotabumi Geophysics Station. The different intensity of the rainfall decreases as rainfall duration increases.

The maximum annual rainfall intensity data for various durations were analyzed using frequency analysis method. From the calculation, it was found that data distribution was in accordance with Log Pearson Type III distribution. Based on the equation for Log Pearson Type III distribution, rainfall intensity for some return periods (2, 5, 10, 25, 50 and 100 years) was calculated and the curve which relates rainfall intensity and duration for various return periods were determined. Regression analysis was done to define the equation which represents data distribution for the IDF curve.

Rainfall intensity data at BMG Radin Inten station significantly higher than Kotabumi Geophysics Station (Table 3 and Table 4) has the consequence that the rain intensity from IDF curves for the same duration and return period is higher than that from BMG Radin Inten station.

Table 3. The maximum rainfall intensity of each duration on BMG Radin Inten II 2001-2014

Years	Rainfall Intensity for Each Duration (in millimeters)									
	5 min	10 min	15 min	30 min	45 min	60 min	120 min	3 hr	6 hr	12 hr
2014	120.0	120.0	104.0	72.0	53.3	50.0	40.0	26.7	13.3	8.4
2013	120.0	108.0	104.0	90.0	66.7	56.0	43.5	30.0	19.2	13.3
2012	120.0	156.0	120.0	104.0	88.0	76.0	60.0	30.0	19.2	13.3
2011	139.2	160.8	162.8	118.8	86.0	73.0	45.3	31.5	16.4	8.3
2010	228.0	180.0	168.0	126.0	113.3	90.0	58.0	39.7	19.9	9.9
2009	180.0	150.0	140.0	80.0	64.0	72.0	37.0	24.9	12.5	6.8
2008	120.0	120.0	168.8	105.0	72.3	64.0	35.3	23.5	12.1	6.1
2007	180.0	162.0	120.0	88.0	78.0	83.0	51.5	35.7	18.8	9.4
2006	580.8	410.4	289.6	168.4	120.8	100.4	50.8	33.9	16.9	8.5
2005	144.0	132.0	116.0	75.4	53.3	40.0	25.7	20.0	12.7	6.3
2004	192.0	180.0	152.0	107.0	78.4	67.3	38.6	26.6	14.1	7.1
2003	180.0	162.0	148.0	101.0	76.5	58.6	34.0	22.7	11.3	5.7
2002	600.0	330.0	240.0	120.0	113.3	90.0	54.9	36.6	18.3	9.1
2001	360.0	180.0	145.6	84.6	66.3	57.0	33.2	23.1	11.9	6.0

Table 4. The maximum rainfall intensity of each duration at Kotabumi Geophysical Station 1998-2011

Years	Rainfall Intensity for Each Duration (in millimeters)									
	5 min	10 min	15 min	30 min	45 min	60 min	120 min	3 hr	6 hr	12 hr
2011	96.0	60.0	60.0	108.6	74.1	72.0	36.0	24.0	24.1	12.2
2010	60.0	60.0	64.0	80.0	60.0	49.0	36.0	26.8	14.3	7.2
2009	48.0	60.0	56.0	46.0	66.7	63.7	34.6	23.1	13.1	6.5
2008	63.6	84.0	80.0	80.0	53.3	50.0	45.0	31.3	17.7	9.2
2007	102.0	60.0	80.0	72.0	60.0	65.0	35.9	24.9	13.3	6.8
2005	120.0	120.0	120.0	120.0	100.0	85.0	42.9	28.7	14.3	8.5
2004	66.0	60.0	60.0	80.0	63.2	53.0	34.1	22.7	16.3	8.2
2003	62.4	57.0	58.0	60.0	66.7	50.5	25.8	19.3	12.3	9.8
2002	103.2	99.0	100.0	93.0	82.7	64.0	37.3	26.2	13.1	8.7
2001	48.0	66.0	76.0	72.0	58.0	53.2	40.9	27.6	13.9	7.0
2000	36.0	60.0	81.6	64.0	56.3	49.0	29.9	19.9	10.0	5.0
1999	60.0	60.0	54.0	62.0	69.3	66.2	50.0	33.3	16.7	10.6
1998	60.0	78.0	72.0	77.2	74.7	62.0	52.0	36.5	18.8	9.5

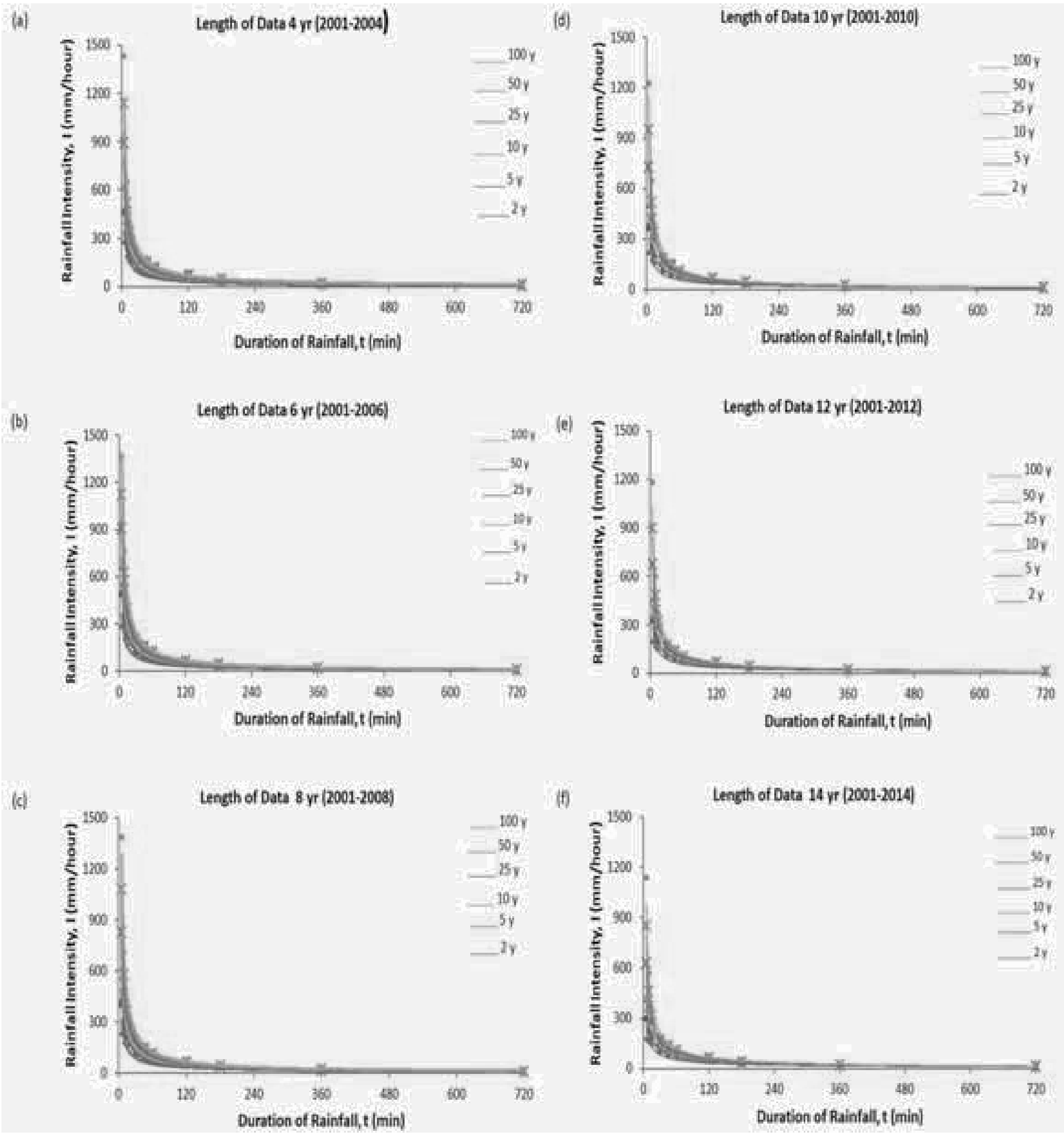

Figure 1. IDF curves for BMG Radin Inten II station using data length (a) 4 years (2001-2004), (b) 6 years (2001-2006), (c) 8 years (2001-2008), (d) 10 years (2001-2010), (e) 12 years (2001-2012) and (f) 14 years (2001-2014)

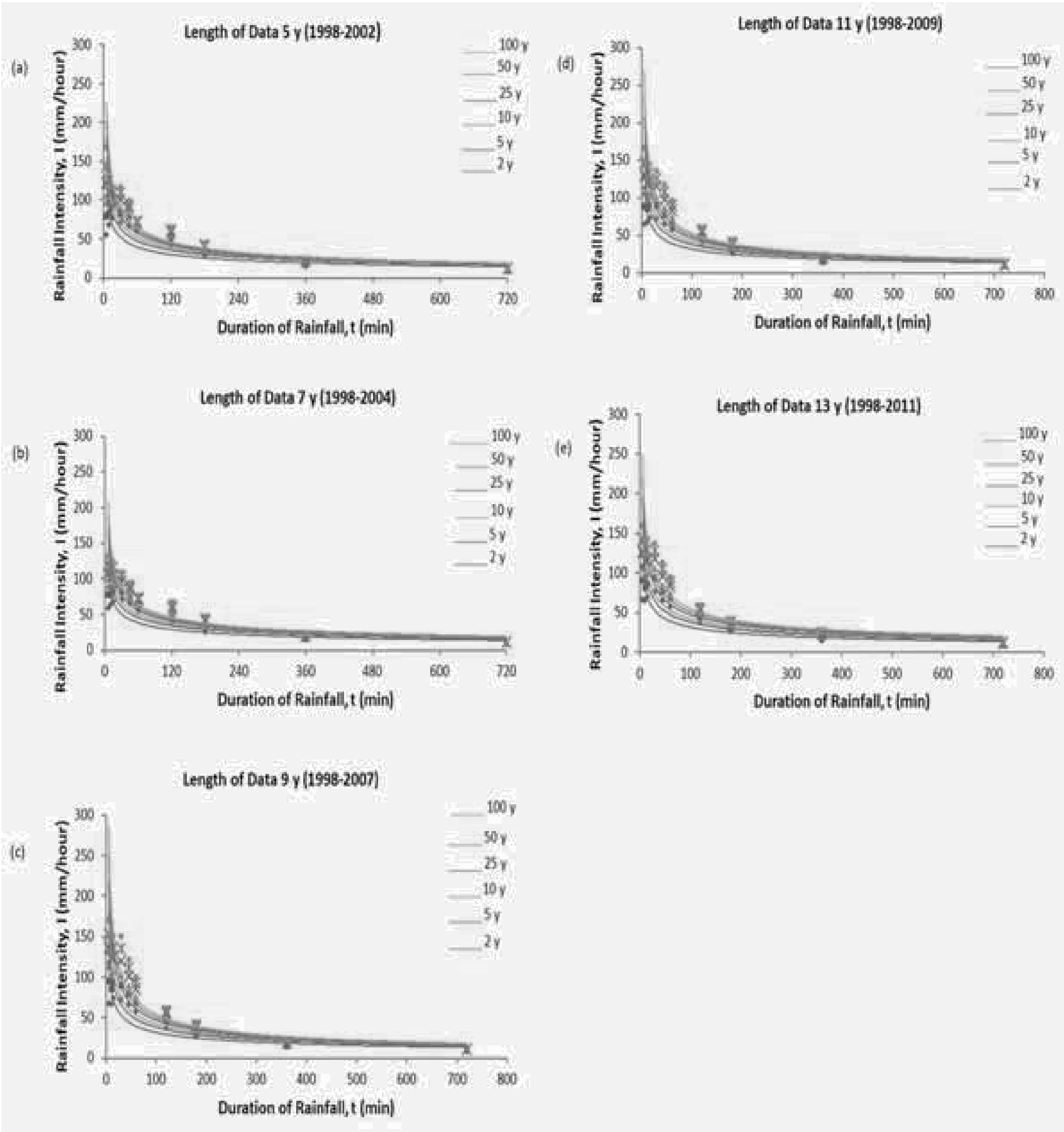

Figure 2. IDF curve for Kotabumi geophysical station using data length (a) 5 years (1998-2002), (b) 7 years (1998-2004), (c) 9 years (1998-2006), (d) 11 years (1998-2008) and (e) 13 years (1998-2001).

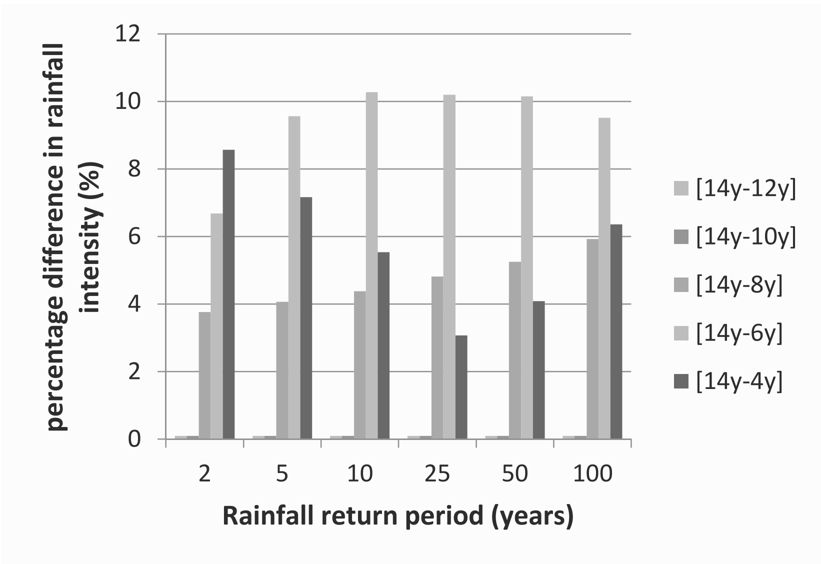

Figure 3. Percentage of mean difference of rainfall intensity and its return period for each data length BMG of Radin Inten II

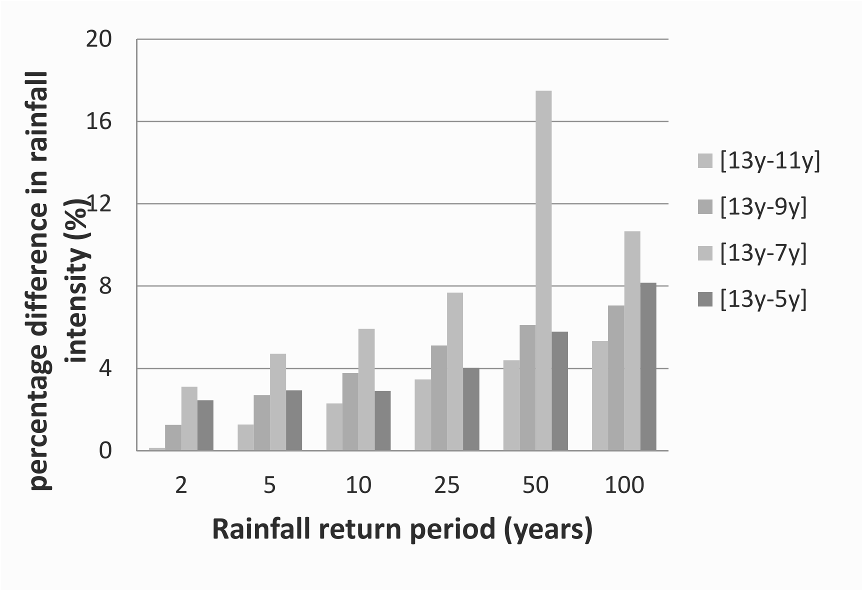

Figure 4. Percentage of mean difference of rain intensity and its return period for each length of Kotabumi Geophysics Station data

The effect of data length on the IDF curve is done by calculating the percentage of differences of rain intensity values resulted from regression analysis for the same duration and return period for a certain length of data length compared to the longest data set on the station. For BMG Radin Inten II station the longest data set is 14 years of data, while other datasets have a data length of 4, 6, 8, 10 and 12 years. The mean percentage of each data set compared to the longest data set for BMG Radin Inten II station is shown in Figure 3. It shows that for long data sets, i.e. 10 and 12 years, the differences of rainfall intensities from those data sets compared to those in the longest data set are small. A dataset with 8 years data length indicates the consistency of increasing values as return period increases, while data sets with data length less than 8 years do not show the consistency of difference of rain intensity to return period.

The same trend is shown in the percentage of rainfall intensity difference of each data set compared to the longest data set on the Kotabumi geophysical station as shown in Figure 4. On the long data set, which is 9 and 11 years, shows the consistency of increasing difference of rainfall intensity values as return period increases. On data sets shorter than 9 years, there is no such consistency.

4. CONCLUSIONS

The IDF curves generated from analysing rainfall data from BMG Radin Inten II station and Kotabumi geophysical station show that the length of the data influences the IDF curve. The intensity of rainfall on IDF curves resulting from relatively long data tends to be more stable, as it reflects various possible rain events.

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