IDENTIFICATION OF CHANGING IN DIURNAL PATTERN OF RAINFALL IN CASE OF FLOODING IN NORTHERN COASTAL OF WEST JAVA 2014

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Abstract

Documentation regarding events of Jakarta flooding in 2007 and 2013 showed heavy rains occurred in the morning until noon for a couple days on the coastal area. These indicated that the events related to a change in diurnal patterns of rainfall over land. This study was conducted to confirm the changing on diurnal rainfall pattern in the case of flooding in the northern West Java on 17 January 2014 using hourly 3B41RT rainfall data from TRMM satellite. Research results show significant changes in phase and amplitude of diurnal patterns of rainfall occurred on the north coast of West Java during 16-21 January 2014. This change was shown through opposite phase of diurnal rainfall pattern over the north coastal area, which the larger amplitude of maximum rainfall was reached in the early morning. In land, the phase of diurnal rainfall cycle has changed from diurnal to semidiurnal with peaks of rainfall occurs in the mornings and evenings. Genesis of flooding on 17 January along the northern coast of West Java preceded by heavy rainfall persistently which occurred during 18 hours on 16-17 January and it was supposed changed the cycle of diurnal rainfall average during January 2014.

Keywords: changing, diurnal rainfall, flooding, West Java, 2014

Introduction

Documentation of flooding events in Jakarta based on previous research showing that the flooding associated with heavy rains from early morning until noon (Yulihastin, 2014) and persistent occurred several days before the flood event (Trilaksono et al., 2011; Trilaksono et al., 2012; Wu et al., 2007; Wu et al., 2013). This indicates that the rainfall is not in accordance with the diurnal pattern of rainfall on land in general which should take place from noon to night with the peak of rainfall occurs in the late afternoon. Meanwhile, rainfall over sea occurred from midnight until morning with the peak of rainfall occurs in the early morning.

Differences of diurnal rainfall pattern between land and ocean are caused by local circulation due to the thermal gradient between land and ocean (Land-Sea Breeze, LSB) because of its ability to absorb insolation and the elevation difference between the mountains and the valley (Mountain-Valley Breeze, MVB). LSB occur due to heating of the sun during the day have caused the surface pressure is reduced relatively larger in the land than the sea, so that it can increase the pressure gradient, especially over boundary areas between land and sea (Biasutti et al., 2011; Yang & Smith, 2006). Meanwhile, upslope MVB would become downslope in the night. When solar radiation decreases in the afternoon which is indicated by radiative cooling at the surface, the upslope would be reduced. When radiative cooling diminished, colder air is formed on the higher slopes. Cooler air with higher densities has flowed down the slopes blowing opposites with Mountain-Breeze, which it is later called as Valley-Breeze (Biasutti et al., 2011; Yang & Smith, 2006).

For north coast of West Java, the diurnal rainfall pattern is more dominantly influenced by LSB circulation. Previous research showed that the synoptic scale of weather disturbances occurred in the Jakarta flooding event at 2007 and 2013 has weakened the effect of local influence LSB circulation,
causing torrential of persistent rain for a couple days. Yulihastin and Fathrio (2014) have proved that there is a change in rainfall patterns from diurnal to semidiurnal with the peak of rainfall occurring in the afternoon (16:00 LT) and early morning (02:00 LT) over mainland of West Java, during events of the Cross-Equatorial Northerly Surge (CENS) coincide with the Madden Julian Oscillation (MJO) in a phase of transition from strong to weak over the Indonesian Maritime Continent during the period of 2002-2013. In addition, there is a change of long-term trend in the diurnal rainfall pattern in Jakarta, namely an increase of rainfall over land occurred in the early morning and the afternoon rain phase shift to the early evening (Siswanto et al., 2015). However, no study has investigated the changing of diurnal rainfall patterns includes changes in amplitude and phase of diurnal precipitation and its difference between coastal and inland in West Java.

As we have known, in addition to major flood events in Jakarta in 2007 and 2013, heavy floods again occurred in Jakarta and made a high impact on socio-economic which reach 30 trillion rupiahs. The peak of the flooding that occurred on 17 January 2014 in Jakarta is further expanded to the whole region of the north coast of West Java, soaking the paddy fields for days and resulted in hundreds of people to be evacuated (BNPB, 2014).

Previous research on Jakarta floods in 2007 and 2013 did not specifically analyze the tendency of changing patterns of rainfall diurnal cycle but a more focused on investigation main factors causing flooding associated with synoptic-scale disturbances. Therefore, this study aimed to find changes in diurnal patterns of rainfall that occurred along the northern coast of West Java in relation to cases of flooding that occurred in the region in January 2014. Nevertheless, the study is limited to the identification of changes in diurnal patterns which include amplitude and phase of rainfall. The physical process that causes changes in the pattern will be followed in subsequent studies.

Materials and Methods

We use an hourly rainfall data of 3B41RT with a spatial resolution of 5 km from the TRMM satellite during the period January 2014 and January 2012. The period of January 2012 has been selected as a comparison of the normally condition of rainy season. The research method developed to investigate the pattern and cycle of diurnal precipitation diurnal both of spatial and time of flood events in Jakarta and West Java's northern coast in January 2014.

We arranged method as below. The first, conducted a cross-sectional time- latitude hovmöller diagram analysis to determine the evolution of rainfall during the period January 2014 over West Java. Second, we are averaging diurnal rainfall 4-hourly during the month of January 2014 to understand the patterns of change in spatial rainfall over West Java. Third, time series analysis is done by dividing the region into coastal and land of West Java to determine differences in the diurnal cycle of rainfall that occurred in the region during the flood event in January 2014 compared with the normal conditions in January 2012.

Results and Discussion

Figure 1 shows the evolution of hourly rainfall average for January over the north coast of West Java. It appears that from 1 to 14 January 2014, large of rainfall occurs both of over the land and the sea as well. Nevertheless, it appears that the maximum rainfall occurred intensified during 15 to 17 January and clearly concentrated over north coastal sea areas.

During that period, the spatial features of rainfall exhibit that the maximum rainfall occurs more over land and minimum over the sea. Differences of rainfall intensity between land and sea indicated the disruption of the normal pattern of rainfall which generated by LSB.
Figure 1. Time-Latitude cross section of precipitation evolution during 1-31 January 2014 (left side), 15-17 January 2014 during Jakarta flooding event (right side). Red boxes of dash lines show location of the northern coastal sea of West Java.

Figure 2 illustrates the spatial evolution of hourly rainfall average for January over the north coast of West Java. It seems that the maximum rainfall over the northern coast of West Java occurred a long time since just before midnight (23:00 LT) to noon (11:00 LT) with a maximum peak of the rainfall occurs in the morning (03:00 LT - 07:00 LT). While the maximum rainfall in the central part of West Java occurred at 15:00 LT till night 19:00 LT. Maximum rainfall since midnight until noon that fell on the territory of coastal sea is not in accordance with the general pattern of diurnal rainfall over the coast that should reach maximum in the afternoon (Mori et al., 2004; Teo et al., 2012; Biasutti et al., 2015; Nuryanto, 2011; Pandawana et al., 2013; Qian, 2008). The area divided as coastal sea and land in West Java depicted in Figure 3.

Figure 2. Spatial of diurnal rainfall average (mm/hr) during 1-31 January 2014 over West Java region.
Figure 3. Coastal sea region (blue box) and land region (red box) of West Java region.

Furthermore, comparison of the normal pattern of diurnal rainfall cycle over the coastal sea area defined in Figure 4 (b) which shows an average hourly of diurnal rainfall pattern during normal condition on 1-10 January 2014. In these patterns, diurnal rainfall has a peak value in the night at 19:00 LT. In the other hand, the diurnal pattern of rainfall during January 2014 experienced a phase change into a semidiurnal with peak rainfall occurs at night at 19:00 LT and 04:00 LT early morning. It also appears that the average rainfall that occurred in the early days had a peak amplitude which greater than the peak of rainfall during the night.

Figure 4. Cycle of diurnal rainfall average (mm/hr) during 1-31 January 2014 (a), 1-31 January 2012 (b) over coastal sea of West Java region.

The diurnal cycle of rainfall over land of central West Java for January 2014 is also changing the phase of diurnal be semidiurnal with major peaks occur in the afternoon until the evening (16:00-19:00 LT), while the second peak occurred in the early morning (04:00 LT). Meanwhile, during the period of flooding in Jakarta and the northern coast of West Java (16 to 21 January), there appeared to
be a significant change in the phase and amplitude of the diurnal cycle of rainfall over coastal and mainland (Figure 5).

The phase which changes over coastal region shows the opposite phase with the general pattern, which it reaches the peak in the afternoon. Moreover, the amplitude of rainfall increased to two times than the average amplitude of diurnal rainfall during January 2014. The phase of diurnal rainfall cycle also occurred over the land of central West Java that firmly demonstrated through maximum rainfall which took place on early morning not in the afternoon or evening as a general pattern of rainfall diurnal over land (Figure 6). Patterns with opposite phases that occur in coastal areas and land of this kind does not correspond to Mori et al. (2004), which asserts that the rainfall over coastal sea and inland in Sumatra reached the peak in the afternoon, also Qian et al. (2008) who found that during the DJF period diurnal rainfall in Java Island reaches its maximum in the afternoon (17:00 LT).

Evidence of phase change in West Java is also contrary to the claims of Kikuchi and Wang (2007), which argue that the diurnal cycle of rainfall were mixed on a seasonal basis in the tropics and can undergo changes in amplitude but not in phase. Love et al. (2011) even showed through the rainfall data of TRMM satellite at 2008-2009 period that diurnal rainfall over Java attain a maximum value at night 21:00 LT and minimum in the morning 09:00 LT.

However, the identification of changes in amplitude and phase of diurnal rainfall in northern West Java confirm to Siswanto et al. (2015) which showed that an enhance in the intensity of rainfall in the early morning and shifting phase of peak precipitation from the afternoon into the evening during the DJF period in Jakarta during 2001-2010 based on ground-based stations rainfall data. In addition, changes in diurnal patterns become semidiurnal over land in West Java have also been investigated occurred during the past 10 years (2002-2013) during CENS events in conjunction with the transition phase of the MJO from strong to weak (Yulihastin and Fathrio, 2013). Changes of phase and amplitude of diurnal rainfall that occurred during the flood event due to persistent rainfall in northern West Java for 24 hours on January 16 and reach maximum intensity in early midnight until morning at 09:00 on January 17 (Figure 7).

Figure 5. Same as Figure 4, but for land region of central West Java.
Figure 6. Cycle of diurnal rainfall average (mm/hr) during flooding event 16–21 January 2014 (a) and normal conditions 1–10 January 2014 in coastal sea of West Java region (b).

Figure 7. Evolution of hourly rainfall over West Java from 16 January on 22:00 LT (a) to 17 January 9:00 LT (l).

Conclusion

Changes in phase and amplitude of diurnal precipitation occur during flood events 16 to 21 January 2014 for the coastal sea and mainland of West Java. The opposite phase change occurred significantly where the maximum peak rainfall in coastal and inland occurred in the morning and early morning. Meanwhile, the maximum amplitude of rainfall increased twofold during flood events than the maximum amplitude of the average for the month of January 2014. Changes in the diurnal cycle of rainfall into semidiurnal with main peaks occurred in the morning also took place during January 2014.
indicating that there has been a deviation diurnal pattern of rainfall during the period. Deviations diurnal pattern of the average rainfall for January 2014 show that the most rainfall more occurred and concentrated on the north coast of West Java.

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