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7-8 March 2017
Ijen Suites Resort and Convention
Malang, Indonesia

Basic Science for Improving Survival & Quality of Life

Sub Topics:
Botany
Enviromental Science and Technology
Instrumental and Measurement

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Brawijaya University
Jl. Veteran, Malang, East Java, Indonesia 65145
Phone: +62 0341 575833
Fax: +62 0341 575834
E-mail: basicsciences2017@gmail.com
Website: http://basic.ub.ac.id

Spatial Variability of Diurnal Precipitation over Southern of Sumatra during 2009−2010

Muhamad Nur[1*], Iskhaq Iskandar[1,2], M. Yusup Nur Khakim[1,2]

[1] Graduate School of Physics, Faculty of Mathematics and Natural Sciences, University of Sriwijaya, Palembang, Indonesia
[2] Department of Physics, Faculty of Mathematics and Natural Sciences, University of Sriwijaya, Palembang, Indonesia
* Corresponding authors: muhamadnur.pplh@gmail.com

Abstract – This study was designed to examine spatial variations of diurnal precipitation over Southern of Sumatra for a period of 1 January 2009−31 December 2010. The Indonesian maritime continent is surrounding by many islands and sea. Therefore, the spatial variation of its precipitation will be strongly influenced by the interactions between land and adjacent sea. The data of this study were provided by the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) and the National Centers for Environmental Prediction (NCEP)/the National Centers for Atmospheric Research (NCAR) reanalysis. In other, to evaluate the spatial variations of the diurnal cycle of precipitation and other climate variables, the diurnal climatology analysis is focused on the area of 0.5°S – 6.5°S and 95°E – 112°E. The study result shows that the intensity of precipitation over the ocean is much higher than that over the land. High precipitation over the ocean region occurred in the early morning during 0400-1000 Local Time (LT), while lower precipitation was observed in the evening (1900-2200 LT). On the other hand, the rainfall peak over the land was observed in the evening (1900-2200 LT) and the low rainfall was occurring in the daytime (1300-1600 LT). In addition, high precipitation both over the land and over the ocean is associated with the upward motion. Based on the hovmöller diagram, the precipitation intensity was concentrated near the coast, but it shows offshore migration during the daytime.

1. INTRODUCTION

Indonesia is a maritime continent surrounded by two oceans and two continents. This position makes Indonesia climate is influenced by Monsoon wind that flows over the Indonesian continent. The thermal difference between land and sea regions will cause the pressure difference between land and sea regions. It corresponds to the annual movement of the sun. In addition, local and regional characteristics of the lands in Indonesia were also influenced by convection variations in Indonesian continent. In concludes, the interaction between the Monsoon wind and complex topography were caused high variation of the spatial and temporal precipitation intensity over Indonesian continent [1]. In addition, other global climate factors also influence rainfall patterns in Indonesia, such as the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) events. Those phenomena also contribute to the interannual climate variations. Both the climate events are important because of their large environmental and societal impacts, globally and regionally [2].

Precipitation displays high space-time variability that requires frequent observations for adequate representation [3]. Rain gauge observations yield relatively accurate point measurements of precipitation but suffer from sampling errors in representing real means and are not available over most oceanic and unpopulated land areas [4]. However, nowadays, rainfall data required for a wide range of scientific applications can be achieved through meteorological satellites [5]. Meteorological satellites expand the coverage and time span of conventional ground-based rainfall data for a number of applications by which all hydrology and weather forecasting are made [6]. The use of remote sensing, which has better spatial and temporal resolution data, in a study about rainfall and its spatial relationship to ENSO and IOD in Indonesia, thus offers an exciting opportunity.

Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) satellite launched in 1997 because it has the advantage of detecting raindrops directly from space, which allows us to reveal the rainfall diurnal variation accurately over the globe [7]. A considerable amount of validation has been performed to certify that the estimated near-surface rainfall rate is reliable [8]. TRMM satellite data have good performance to representing rain gauge data that is shown by correlation coefficient both of the data is significant [9].

Seasonal and interannual variability over the Indonesian Maritime Continent including Sumatra Island have been examined using long term statistical data [10]. Relation between rainfall amount at Kotatabang and background wind circulation for a limited period and also study about diurnal land-sea rainfall peak migration over Sumatra Island has been also documented [11]. These studies have described unique characteristics of both regional and temporal rainfall over this area, but the spatial variation of diurnal precipitation over Southern of Sumatra has not been addressed. This study presents the diurnal variations of rainfall cycle and its regional climate impacts over the Indonesian Maritime Continent, especially around Southern of Sumatra.

2. METHODS

2.1 TRMM PR satellite data

The precipitation data were provided by the TRMM-PR satellite with spatial and temporal resolutions of 0.1° × 0.1° which contains an hourly gridded Network Common Data Form (NetCDF) format dataset. In other, to evaluate the spatial variation of the diurnal cycle of precipitation, the diurnal climatology was calculated for a period of 1 January 2009 through 31 December 2010. The analysis is focused on the area of 0.5°S – 6.5°S and 95°E – 112°E.

2.2 Other climate data

Objective reanalysis data, that are the vertical and horizontal wind, the specific humidity, and the vertical velocity data, provided by the National Centers for Environmental Prediction (NCEP)/the National Center of Atmospheric Research (NCAR) reanalysis. These data were used to analyze diurnal variability. The spatial and temporal of those data are 2.5° × 2.5° and 6-hour, respectively. Interpolation data is needed in these data. It is to set same data period between precipitation and other climate data which were 6-hours interpolated to 8-hour data. In addition, to evaluate the spatial variation of the diurnal variability of these data, the calculations have been done for the same time period and area coverage of all the data.

3. RESULTS AND DISCUSSION

This study has been examined diurnal variation of precipitation over the Southern Sumatra region. The spatial variation of diurnal precipitation is shown in Fig 1. The intensity of precipitation over the ocean is much higher than that over the land. High precipitation over the ocean region occurred in the early morning during 0400 until 1000 Local Time (LT). The intensity of rainfall area is concentrated along the coastal area of Sumatra Island at 0400 LT, then expands its area to the ocean region at 1000 LT. Whereas, lower precipitation was observed in the evening (1900–2200 LT). Rainfall intensity over the Northwestern of Java Sea and Karimata Strait is almost cleared up in the evening rain.

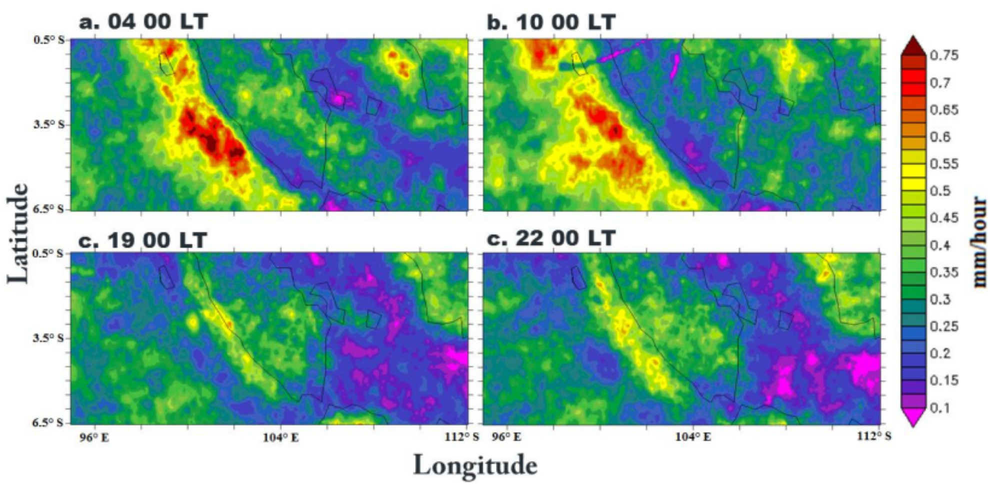

Figure 1. The high and low intensity of diurnal precipitation over the ocean region

On the other hand, the intensity of precipitation over the land region shows more rainfall in the evening than that in the daytime. Figure 2 shows that the rainfall peak over the land was observed in the evening which starts at 1900 LT until reach its peak at 2200 LT. The rainfall area covers most of the Southern Sumatra land at 2200 LT. But, most of strong precipitation intensity was shown over the coastal sea region at this time. Rainfall over the land region expands its area into the ocean region and the low precipitation over the land was occurring in the daytime (1300–1600 LT). The clear up of the rainfall intensity over the land was observed at 1300 LT.

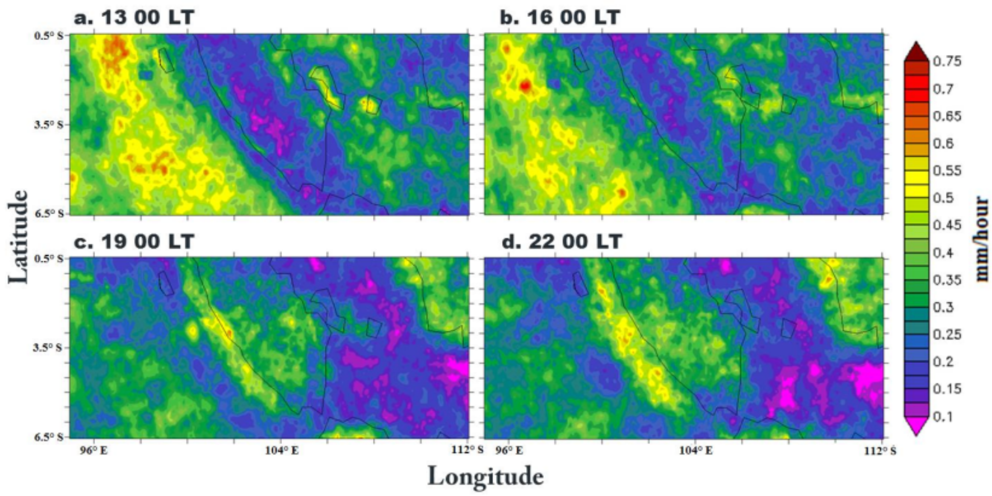

Figure 2. The high and low intensity of diurnal precipitation over the land region

We also examine moisture flux which is generated by zonal and meridional wind and specific humidity data to relate background conditions to spatial variation of diurnal rainfall intensity. Moisture flux convergence area is concentrated in the offshore region (0100 LT–0400 LT), then migrate to the land region along the northwestern Sumatra Island at 1600 LT and increase with time until meet its peak at 1900 LT (not shown). Based on the hovmouller diagram of precipitation and moisture flux data that is present in figure 3, the precipitation intensity is concentrated near the coastal

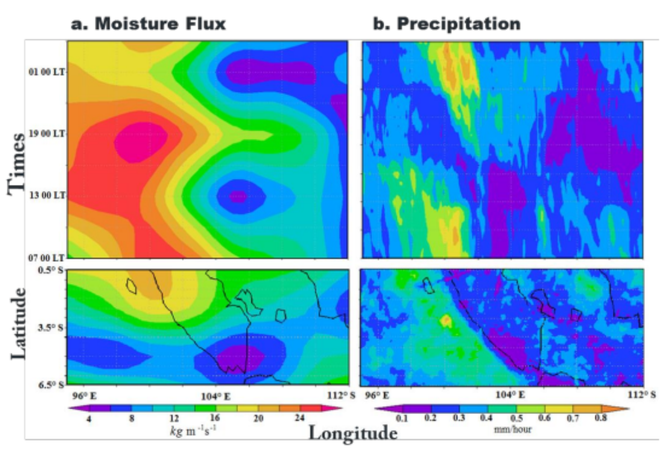

Figure 3. The hovmouller diagram: a. moisture flux and b. precipitation

region, but it shows offshore migration during the daytime. The area of increased (decreased) precipitations associated to the enhanced (reduced) moisture flux. Most of strong intensity of moisture flux appears in the ocean region during 13 00 LT until 19 00 LT. Spatial distribution of rainfall intensity is also influenced by vertical and horizontal wind that is blow towards and backwards the ocean and land regions. The westerly wind is stronger than easterly wind. It causes moisture flux from the ocean migrate towards inland regions during 13 00–19 00 LT, then migrates toward the ocean until the late evening (not shown). We also have examined wind convergence in this study that is present in figure 4. Clear convergence over Sumatra Island appears at 00 00 LT. This condition maintains the wind divergence until reach its peaks at 04 00 LT. The convergence is observed in the daytime that is start at 13 00 LT over the northwest Sumatra. In addition, strong convergence appears mostly in large islands, for example, Sumatra and Kalimantan. This suggests that most of the convective clouds over the land region in the daytime. On the other hand, the convective cloud maintains its area over the ocean region in the evening. This result is consistent with the study of diurnal land-sea rainfall peak migration that is done by Mori et al. This study result shows that the convergence field appears 4–6 hours earlier than that of the strong precipitation intensity over both the land and ocean regions. In addition, Convergence wind is associated with the upward motion calculation (not shown). Consistent and strong upward motion of moisture

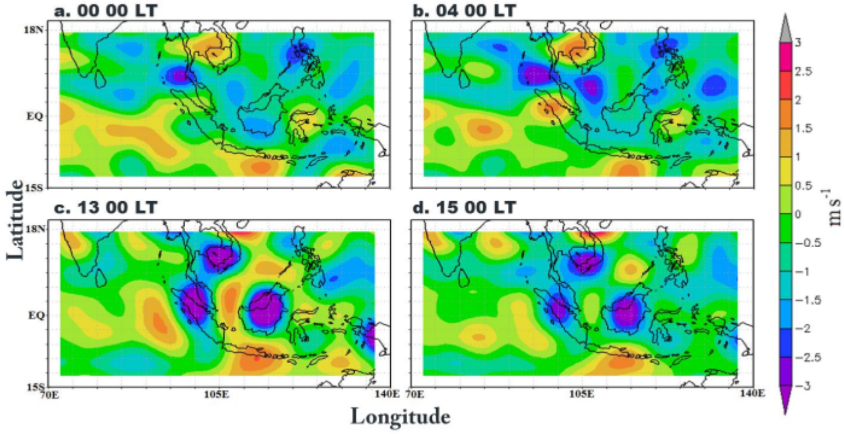

Figure 4. Diurnal variations of convergence (minus/-) and divergence (plus/+) winds

air show at 13 00 LT. Based on the figure 4a, consistent upward motion maintains its coverage area over 98°E to 105°E. These results indicate that upward motion is developed over northwestern Sumatra and also along the northwest coastal region of Sumatra Island. In addition, high precipitation both over the land and over the ocean is associated with the upward motion.

4. CONCLUSIONS

Spatial variations of diurnal precipitation cycle over Southern Sumatra have been examined using TRMM and objective reanalysis data, and the results are summarized as follows:

1. The intensity of precipitation over the ocean is much higher than that over the land. High and low intensity of the precipitation over the ocean is about 1 mm/hour and above and 0.2 mm/hour, respectively. On the other hand, High and low intensity of the precipitation over the land is about 0.5 mm/hour and 0.1 mm/hour, respectively.
2. Based on hovmoller diagram, spatial variability of precipitation is caused by the migration of the rainfall intensity from the coastline toward the land region in the daytime and toward the offshore in the nighttime.
3. The convergence field appears 4-6 hour earlier than that of rainfall over both the land and sea regions.

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