Title of dissertation				
Study on Spatio-Temporal Variabilities of Indonesian Rainfall Using TRMM Multi-Satellite Precipitation Analysis Data				
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The Indonesia is uniquely located in the most active convection area of the world, and influenced by global, regional, and local conditions; e.g. Asian-Australian monsoon, tropical convective zones, intra-seasonal oscillation, and complex land-sea-topography. Because that rain gauges are only located over land and not in the Indonesian sea area, comprehensive study of the rainfall variability over Indonesia is difficult. Using the remotely sensed meteorological satellite data is one of the solutions to record the rainfall data in the land and ocean areas simultaneously. This study aims to determine the quality of satellite rainfall data called the Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA) products (TRMM 3B42 for 3-hourly data and TRMM 3B43 for monthly) and evaluate their applications for Indonesian region to understand spatio-temporal patterns of climatological rainfall characteristics that are impacted by two main factors including the monsoon and atmosphere-ocean interactions near Indonesia. This study is motivated by the lack of studies on rainfall variability over Indonesia using long-term satellite meteorological data. This study attempts to analyse and introduce the quality of daily-monthly satellite TMPA products, especially over the Bali area, and use them to explain Indonesian rainfall characteristics from the aspects of diurnal rainfall cycles, the impact of monsoon activity, land-sea distribution, topography diversity and the interaction with the El Niño‐Southern Oscillation (ENSO; hereafter conventional El Niño) and the El Niño Modoki.

Chapter 2 describes the first result of this research. This chapter shows the comparison results of daily-monthly rainfall from TRMM 3B42 daily and 3B43 monthly products with rain gauge measurements over Bali. The main objective of chapter 2 is to advance our quantitative understanding of the capability of TMPA products for the analyses of climatological-scale rainfall. The results indicate that TMPA products tend to underestimate the rainfall with large errors on daily timescales but show better agreement on monthly

timescales. In general, the TMPA products are usable and valuable in analysing climatological-scale rainfall, particularly over the areas without rain gauge measurements.

Chapter 3 illustrates the second result of this research. This chapter presents the TMPA product analysis for TRMM 3B43 monthly data to understand the variabilities of Indonesian rainfall on annual, seasonal and monthly time scales, as well as their connection with monsoon activity, land-sea scattering, and topography distribution. The results show that the oceans, islands, monsoons, and topographical diversity clearly affect the spatial patterns of Indonesian rainfall. The high-rainfall events in Indonesia peak during the December-January-February seasons and the low-rainfall events occur during the June-July-August seasons. Most of the highest annual and monthly rainfall typically occurs over island areas.

Chapter 4 presents the third result of this research. This chapter explains the role of monsoon, topography, and El Niño Modoki on the rainfall variability in the Maritime Continent (MC) by analysing the long-term monthly TRMM 3B43 data. The results indicate that the north-south MC precipitation is associated with and generated by the monsoon patterns. In addition, the large-scale circulations are linked with heavy rainfall over this land-ocean region. The conventional El Niño (El Niño Modoki) has a higher impact on rainfall variability than El Niño Modoki (conventional El Niño) especially during northern winter and spring (northern fall), while two phenomena similarly affect during northern summer.

Chapter 5 displays the fourth result of this research. The main objective of chapter 5 is to describe spatial and seasonal differences in the diurnal rainfall cycles using long-term (17-year) 3-hourly TRMM 3B42 data over the Sumatera Island. The results point out for the first time that early-afternoon initiation of daily rainfall not only in the Barisan Mountains in the west of island but also in the east-coastal small islands. Westward and eastward migrations of rainfall areas from the Barisan Mountains vary with seasons and regions, with the most remarkable westward migration during September-October-November season in the central region and the least remarkable one during June-July-August season in the southern region.

In summary, the present study indicates that rainfall data captured by satellite remote sensing (e.g., TMPA products) can be used to analyse the characteristics of Indonesian rainfall, because of the long-term accumulation of datasets, reliable spatial distribution, and better agreement with the gauge data, although they still have some errors (underestimation in the east and overestimation in the west of Indonesia). This study also demonstrates that TMPA data products can be applied for analysing climatological rainfall pattern over Indonesian Maritime Continent, which has a complex land-sea-topography distribution, in

different spatial scales (from local to regional) and different temporal scales (from diurnal to annual rainfall pattern), although in certain specific local conditions such as over small islands, the spatial and temporal resolutions are not enough to illustrate rainfall area migrations. Finally, this study shows that the state-of-the-art satellite meteorology can provide comprehensive information about Indonesian rainfall characteristics in land and sea, local to regional, and diurnal to annual.

Photos

Dissertation guidance with Supervisor at Udayana University, Bali, Indonesia.

Presentation of PhD dissertation public hearing at Yamaguchi University