ON THE APPLICABILITY OF SATELLITE-BASED RAINFALL ESTIMATES FOR THE DETERMINATION OF MONSOON ONSET DATE: CASE STUDY IN THE AYEYARWADY DELTA, MYANMAR

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KEY WORDS: monsoon, onset, rainfall, TRMM, Myanmar

ABSTRACT: The timing when rainy season brought on by the Asian summer monsoon begins is of particular interest in Myanmar, one of the world's major rice-producing countries whose agricultural sector heavily relies on the monsoon rain. Although there is no decisive method to determine the local monsoon onset date, previous studies indicated that rainfall could be considered as an operational meteorological parameter. Satellite-based rainfall estimates from the Tropical Rainfall Measuring Mission (TRMM) available from 1998 onwards were tested for their performance in determining the summer monsoon onset dates using the modified method based on the domain-averaged rainfall index proposed by Htway and Matsumoto (2011). We used 5-day running mean (pentad) rainfall data which are compared with the annual mean pentad precipitation to identify the monsoon onset date. We conducted our case study in the Ayeyarwady Delta, central coast of Myanmar which is known as the rice bowl of the country. Spatially averaged time-series mean annual rainfall estimates from the TRMM for the study area followed a similar rainfall pattern with the local rain gauge observations with an underestimation of about 20 % of the mean annual rainfalls. The authors were able to identify the monsoon onset date for the study area using the domain-averaged rainfall index method with the time average (1998–2018) TRMM data as input. Largely due to the inter-annual rainfall variability, the same method failed to pinpoint the onset date for each individual year that corresponded with the official historical records announced by the Myanmar government. Twenty-one-year time-series of TRMM data are not yet considered long enough to study the long-term interdecadal trend of monsoon onset dates. However, our results indicated that the combined use of readily available satellite-based rainfall estimates and an easy-to-incorporate simple method proved promising in determining the monsoon onset dates in Myanmar.

1. INTRODUCTION

For most farmers in Myanmar whose agricultural practice heavily relies on monsoon rain brought on by the Asian summer monsoon, the timing of monsoon onset is of particular interest. They regularly listen to the radio and watch TV for the monsoon updates provided by the Myanmar government. Although, large-scale climatological conditions in determining when the monsoon sets in over a specific area is rather complex; the timing when the rainfall brought on by the summer monsoon becomes available is of more direct concern for most local farmers. The onset of the summer monsoon is generally perceived to shift as depicted in the Figure 1 (adopted from Krishnamurti, 2015). The authors are currently working on a research project in relation to climate change in Ayeyarwady Region of Myanmar, which is known as the rice bowl of the country, and often face comments made by local farmers that the monsoon onset dates are delaying each year. However, to our knowledge, the apparent delaying trend has not yet been fully confirmed with the data. With easily accessible satellite-based rainfall estimates around the globe becoming readily available, it is worthwhile to evaluate their applicability for determining the monsoon onset date and hence, that is the objective of this study.

2. DATA AND METHODS

2.1 The Tropical Rainfall Measuring Mission (TRMM) rainfall estimates over the Ayeyarwady Region

We used the TRMM 3B42 product (gridded, TRMM-adjusted, 3-hourly precipitation estimates with a 0.25 degree spatial resolution) (Huffman, *et al*., 2010) from 1998 through 2018. Since we were particularly interested in the Ayeyarwady Delta, which encompassed our study area, we extracted a time series containing the spatial average of Ayeyarwady Region (94.87–94.88° N; 15.95–16.25° E) using the Google Earth Engine (GEE) platform. The data were then adjusted for local time and we produced a daily precipitation data set over Ayeyarwady Region.

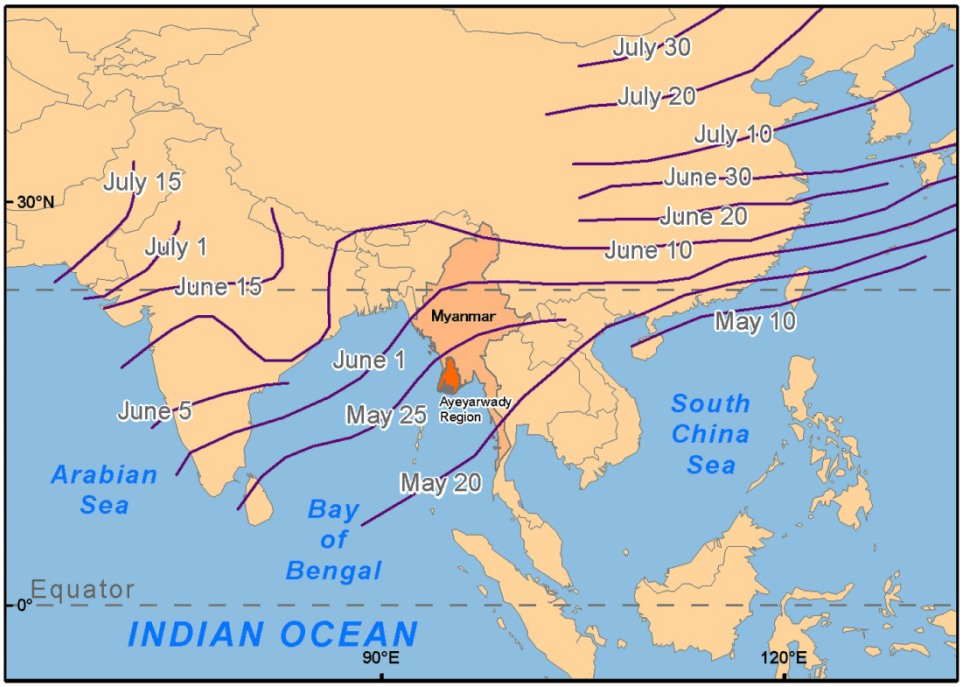

Figure 1. Average date of onset of summer monsoon across different regions of Asia; Ayeyarwady Region of Myanmar, our study area is highlighted. (Adopted from Krishnamurti (2015), Encyclopedia Britannica, Inc.)

2.2 Historical rain gauge observations in Labutta Township

Department of Agriculture (DOA) in Labutta Township (16.14° N, 94.75° E) located on the coastline of Ayeyarwady Region has manually recorded daily rainfall with a rain gauge since 1979. Although it is quite common that the rainfall measurements at a single location can vary greatly from the pixel-based TRMM rainfall estimates, we proceeded to compare the rainfall measurements from the ground measurements at the DOA Labutta and the TRMM rainfall estimates across the entire Ayeyarwady Region of approximately 26,000 km^2 for the period of 1998 to 2018.

2.3 Domain-averaged rainfall index for determination of summer monsoon onset date

There is no single, decisive meteorological parameter that determines the summer monsoon onset date in a given area. However, it is generally accepted that rainfall (precipitation) is considered as an important and operational meteorological parameter for this purpose. Rainfall variation usually captures the variability of the entire monsoon circulation system. In order to depict the large-scale climatology, some simple method for determining the summer monsoon onset was called for. Zhang *et al*. (2002) originally constructed the domain-averaged rainfall index for the central Indochina Peninsula to define the onset of the summer monsoon using 5-day running mean rainfall data. This index was further modified by using the definition proposed by Matsumoto (1997) tailored for Myanmar (Hteay and Matsumoto, 2011). The onset date was defined as follows: The first pentad exceeding annual mean pentad precipitation (Pm) followed by at least two consecutive pentads above Pm (in total, 3 consecutive pentads all above Pm) was first identified. The middle date of the first pentad of these three consecutive pentads was then regarded as the onset date. We adopted this method and determined the onset date for each year from 1998 through 2018. The uniqueness of this study was that we used the rainfall estimates of spatially continuous area coverage using the TRMM data as opposed to using the average of rainfall measurements only from selected weather stations.

2.4 Official records of historical monsoon onset dates for Deltaic region

We obtained the official records of monsoon onset dates in Myanmar from the Department of Meteorology and Hydrology (DMH). These records were meant to be compared with our estimated monsoon onset dates based on TRMM data. The official records covered the period from 1955 through 2019 (Northern, Southern, and Deltaic regions: 1955–2019; Central region: 1984–2019). We used the records for the Deltaic region which corresponded with our study area.

3. RESULTS AND DISCUSSION

3.1 Comparison of the mean annual rainfalls between TRMM estimates and ground measurements

The mean annual rainfall retrieved from the TRMM for the entire Ayeyarwady Region (1998–2018) was 2,554 mm while that from the rain gauge measurements at DOA Labutta was 3,258 mm. Statistical analysis indicated that 1) the means were statistically different—the TRMM rainfall estimates being lower than the ground measurements by about 700 mm or 20 %, 2) there was no difference between the two variances, and that 3) a significant correlation (r = 0.66; p = 0.001) was observed between the two measurements (Figure 2; Figure 3). Overall, we concluded that the use of the TRMM data enabled us to reasonably capture the inter-annual rainfall pattern although they constantly under-estimated the ground measurements by about 20 % in the area of our interest.

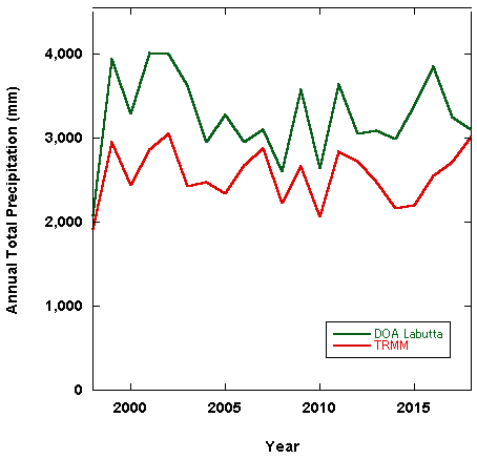

Figure 2. Annual rainfalls (1998–2018) measured at the DOA Labutta and the TRMM data.

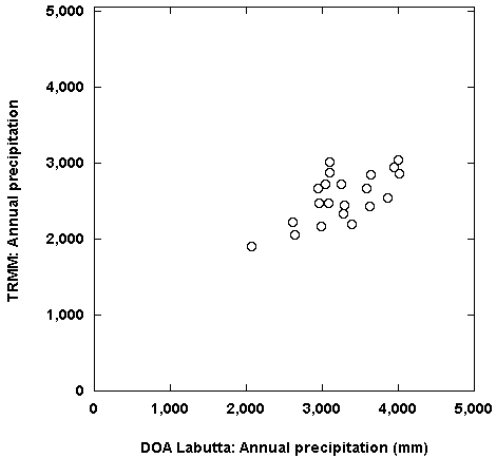

Figure 3. Correlation between the annual rainfalls from the DOA Labutta and the TRMM data. (r = 0.66)

3.2 Summer monsoon onset dates based on TRMM data

Using the domain-averaged rainfall index method, we defined the summer monsoon onset date of Ayeyarwady Region (1998–2018) as being the middle date of the pentad number 28 which corresponded to May 18. Interestingly, this date was exactly the same as the one reported by Htway and Matsumoto (2011) for the period of 1968–2000. Although these two onset dates should not be directly compared because the input rainfall data of Htway and Matsumoto (2011) came from the average of 24 selected weather stations while the data for this study came from the spatial average of the continuous area coverage over Ayeyarwady Region, this can raise some concerns as to whether the summer monsoon onset dates in Myanmar have exhibited a delaying trend over the last couple of decades as often reported in conference presentations and United Nations paper (Lwin, 2002). Figure 4 showed how we determined the onset date of the summer monsoon (1998–2018) while Figure 5 showed how we attempted to determine the onset date for each year using the same domain-averaged rainfall index method. Notice that while rainfall patterns varied greatly every year, the estimated monsoon onset dates stayed rather constant.

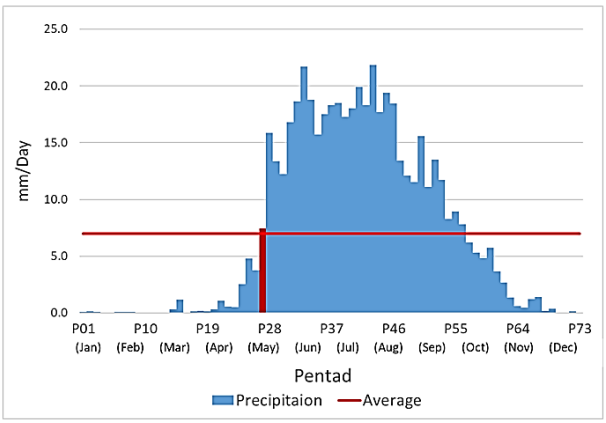

Figure 4. Determination of summer monsoon onset date over Ayeyarwady Region using the domain-averaged rainfall index method with the TRMM rainfall estimates (1998–2018).

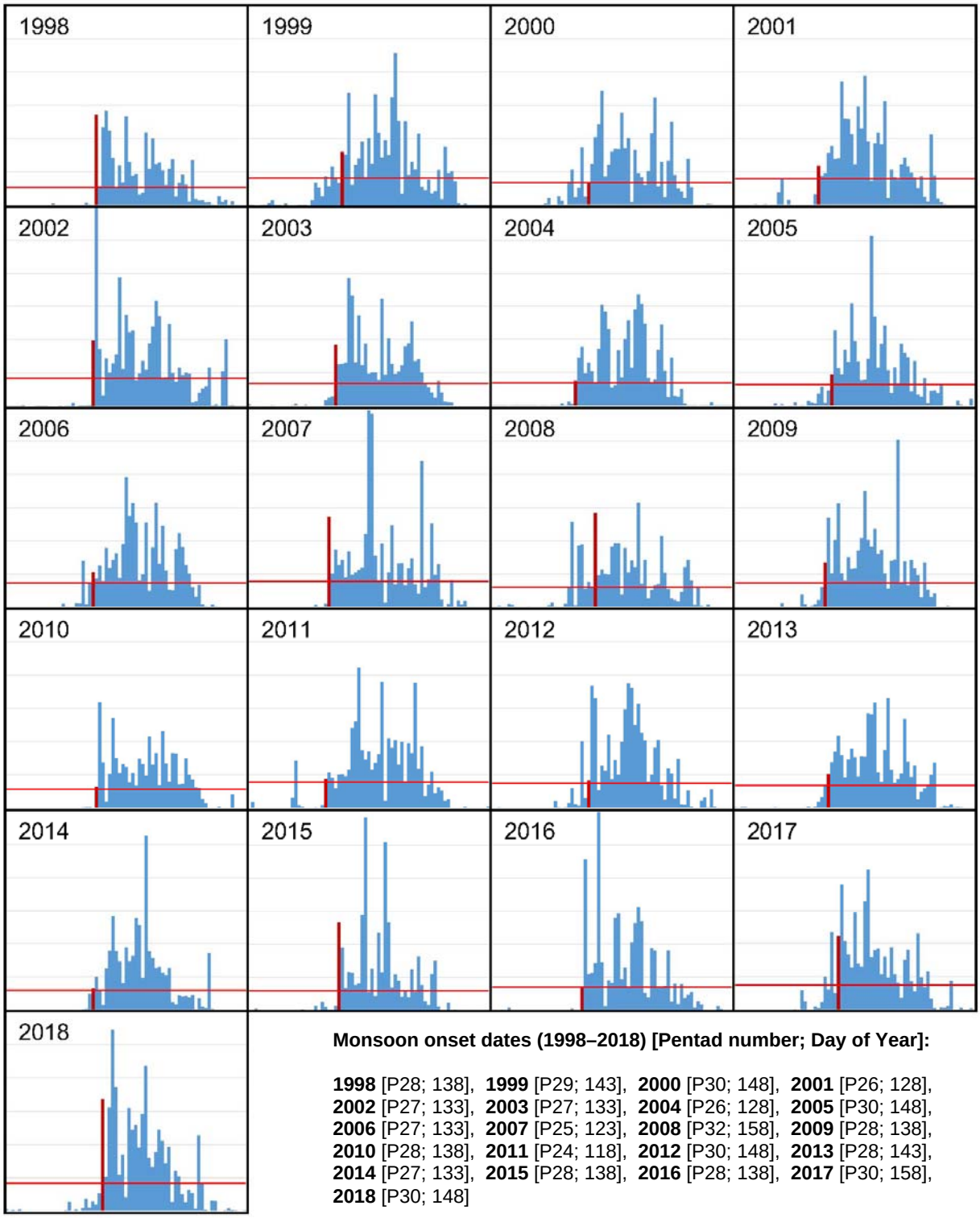

Figure 5. Determination of the monsoon onset date for each year during 1998 and 2018 using the domain-averaged rainfall index method with the TRMM rainfall estimates. Although the rainfall patterns showed a great deal of year-to-year variability, the identified dates stayed more or less the same.

3.3 Comparison of the TRMM-based onset dates and those from the official records

The mean onset date of the Ayeyarwady Region based on the TRMM data over 21 years resulted in May 18 while that of the DMH official records for the same time period was May 22 (Figure 6). The difference was only 4 days in the entire year but the statistical analysis indicated that the difference was significant while the variances between them were not significantly different. In addition, we did not observe a significant correlation between the two classes (r = 0.08; p = 0.75) which suggested that the domain-average rainfall index method was not capable of identifying the onset date for each individual year. The method, nonetheless, proved capable of identifying the onset date for a given region when using the average rainfall data over 20+ years. For farmers—particularly local rice farmers—heavily relying on the monsoon rain in our study area, any shift of monsoon onset dates can greatly affect their farming practices. At present, the time-series TRMM data still fall short in providing a trustworthy insight into persistent trend (if any) but the growing accumulation of time-series data is likely to offer promise. Meanwhile, the historical records of summer monsoon onset dates we obtained from the DMH did not support a clear delaying trend.

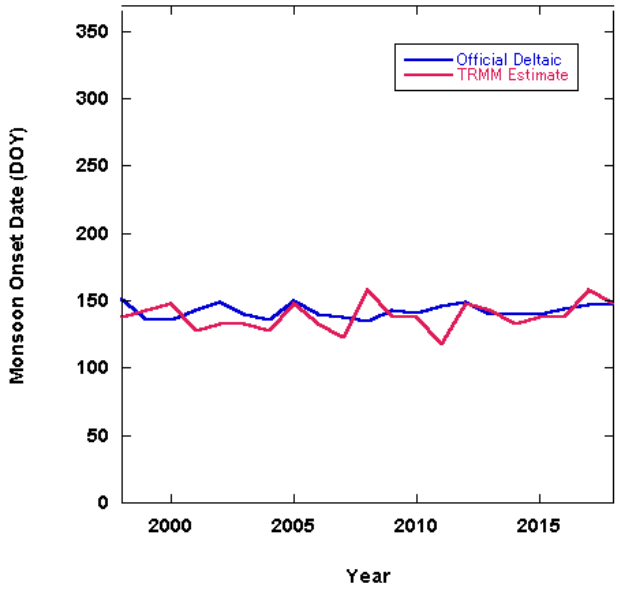

Figure 6. Comparison of the monsoon onset dates (day of year: DOY) from the official record and those determined using the TRMM data in our study (1998–2018).

4. CONCLUSION

We tested the performance of the domain-average rainfall index method using the readily available time-series of satellite-based TRMM rainfall estimates in determining the summer onset date in the Ayeyarwady Delta, central coast of Myanmar. The TRMM data reasonably captured the inter-annual rainfall patterns when compared with the rain gauge observations on the ground. We were able to identify the summer monsoon onset date when using the 21-year time average (1998–2018) TRMM data just as in the same manner as in the previous studies using the rainfall observations of selected weather stations. The method employed in this study using the time-series TRMM data could pinpoint the monsoon onset date of an individual year within 4 days on average but failed to work as a reliable substitute for the official onset date announce by the DMH. At present, 20+ years of the TRMM data accumulation is not yet long enough to offer a dependable proxy for the monsoon onset date in the area of our interest. However, we expect the use of extended decadal time average TRMM data which will become available in future can potentially provide a useful insight into inter-decadal trend of the summer monsoon onset date in the Ayeyarwady Delta.

ACKNOWLEDGMENT

This work is a part of the Japan International Research Center for Agricultural Sciences (JIRCAS) research project "Development of agricultural technologies for reducing greenhouse gas emissions and climate-related risks in developing countries" (2016–2020). The authors are grateful to Mr. Akinobu Kawai, research assistant at JIRCAS for data cleaning and preparation of the domain-averaged rainfall index charts.

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