# Assessing the applicability of satellite-based precipitation data for drought assessment

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## Abstract

There are many hazards related to the climate that affect human life, one of them is drought. According to the Food and Agriculture Organization (FAO), drought affected agriculture areas the most, absorbing around 80% of direct impacts with multiple effects on agricultural production, food security and rural livelihoods. Study about drought assessment and its impact will rely heavily on the precipitation data, especially when drought can be understood as a condition when an area experiences a water deficit from its normal condition. However, the limitations in the availability of measured precipitation data (MPD) makes satellite-based precipitation data become one of the alternative sources that can be utilized. The advantage lies not only in the availability of data that can be accessed online but also in relatively high spatial resolution that is very beneficial for drought assessment, including for agricultural applications. This study aims to assess the use of GSMaP for drought assessment by first examining the agreement between local measured (MPD) and satellite-based precipitation data (GSMaP) in West Java, Indonesia and determine an appropriate temporal scale to be used for drought analysis. Interpolation of MPD is also conducted using Inverse Distance Weighted (IDW) method to obtain the spatial precipitation distribution. From the correlation analysis results of point dataset and area dataset, it can be concluded that the appropriate temporal-scale that can be used for drought analysis is a 90-days period. Meanwhile Standardized Precipitation Index (SPI) is used for obtaining the drought index.

**Keywords:** Precipitation Data; Satellite-based Data; IDW; Drought Analysis; Temporal Scale.

## 1 Introduction

Many studies have been carried out in various fields that utilize precipitation data for various purposes. Research on drought will also rely heavily on the precipitation data, especially when drought can be understood as a condition when an area experiences a water deficit from its normal condition. However, nowadays there are many limitations in the availability of precipitation data, either it does not have enough data spatiotemporally or data not available publicly. The common precipitation data that can be used are measured precipitation data that have an advantage of high accuracy but only available on the point scale area. Satellite-based precipitation data that has high spatial resolution becomes one alternative that can be utilized but must be preceded by assessing the agreement with the local measurements dataset first.

Previous studies have shown the use of satellite-based weather data for different purposes, including drought analysis by comparing it first with the local data. For example, Mourtzinis et al., (2017) studied about the applicability of satellite-based precipitation data for agricultural application across the US Corn Belt. In this research, the objectives are i) to examine the agreement between local measured precipitation data (MPD) and satellite-based precipitation data (GSMaP) for point data analysis and interpolated-MPD and GSMaP for area data analysis, ii) determine the appropriate temporal scale that can be used for drought analysis, iii) assessing the spatial distribution of the rainfall distribution, and iv) comparing the SPI analysis results.

West Java is one of the provinces in Indonesia with the rainy season from October - March and the dry season from April - September and dominated by agricultural land which is very vulnerable to climate related hazards, such as drought and flood. The results of this study will be helpful to get a better understanding of utilizing the satellite-based precipitation data especially in the area with a limited measured precipitation data for drought analysis.

## 2 Materials and methods

### 2.1 Precipitation Data

The daily measured precipitation data (MPD) are obtained from Meteorology, Climatology, and Geophysical Agency in Indonesia from January 1981 - March 2013 with missing data for some period in some stations. There are a total of 52 stations across 16 regencies in West Java with average coverage reaching 680.38 km$^2$ per station.

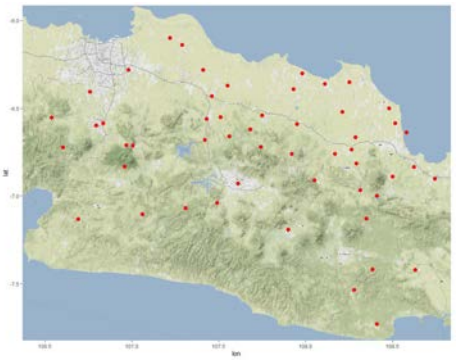

**Fig. 1. The Location of 52 Rain Gauge Stations in West Java (represented by red dots)**

Meanwhile, the satellite-based precipitation data collected from Japan Aerospace Exploration Agency (JAXA) which provide the near real-time rainfall data on their product called Global Satellite Mapping of Precipitation (GSMaP). The daily precipitation data are available from March 2000 - present date and were retrieved across West Java with 0.1° x 0.1° resolution.

### 2.2 Analysis Methods

The total precipitation for various timescale were calculated for the period between April 2000 - March 2013 both for MPD and GSMaP dataset. Then, to examine the agreement between MPD and GSMaP data, linear regression was performed and the coefficient of determination or R-square ($R^2$) was calculated to decide the appropriate timescale for drought. Those analysis applied both for point data analysis (52 locations of local rainfall gauge stations (MPD) and the grid from GSMaP that coincided with those stations) and area data analysis. For the area data analysis, the interpolation of MPD dataset was conducted using Inverse Distance Weighted (IDW) method with 0.1° x 0.1° resolution (the same with GSMaP resolution). Drought index obtained using SPI method.

## 3 Results and discussion

### 3.1 Precipitation Analysis

Figure 2 summarizes the agreement between MPD and GSMaP for point data analysis, meanwhile figure 3 shows the resume of agreement between interpolated-MPD and GSMaP dataset for area data analysis. In the graphic, the horizontal axis indicates the various timescale and vertical axis indicates the value of $R^2$. It can be seen that the agreement performed a parabolic pattern for the daily until 360-days scale with the turning point during the 150-days period and an anomaly during the 180-days period where the sudden decrease of $R^2$ values happened. This pattern and anomaly was predicted to be caused by the characteristic of the rainy and the dry season of the country which happened every 6 months. Also, the result will depend on the characteristics of the season for each region.

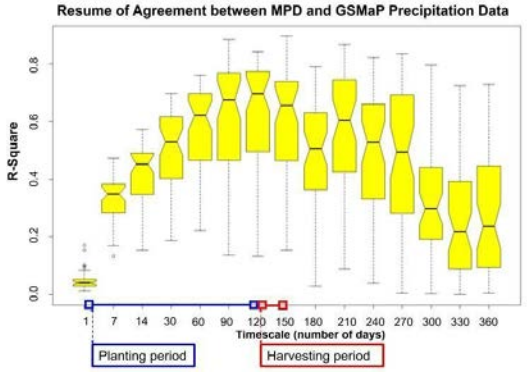


**Fig. 2. Resume of agreement between MPD and GSMaP data**

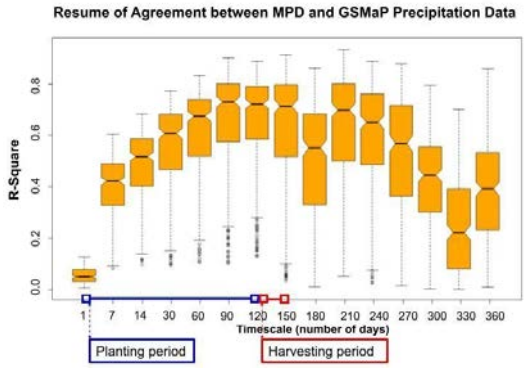


**Fig. 3. Resume of agreement between interpolated-MPD and GSMaP data**

Based on this result, it can be concluded that the acceptable timescale that can be considered to be used for drought assessment is a 90-days (3-months) period when the value of $R^2$ reaches the peak. For additional information, the blue line on the horizontal axis indicates the planting period of paddy occurred within 120 days and the red line indicated the harvesting period which usually occurred in the 30 days after the planting period ended. This result shows a good agreement of the two datasets occurred during the paddy's planting and harvesting period, so the timescale can be used for monitoring agricultural drought that might affect the paddy during crop season.

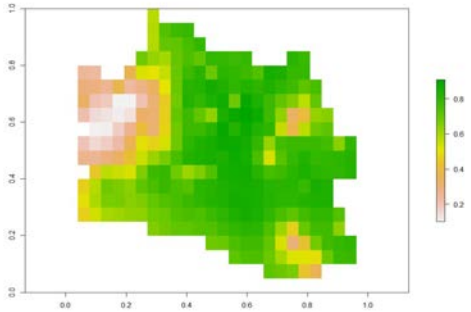

**Fig. 4. Map of distribution R-square value for 90-days**

To see the difference in spatial distribution of precipitation between interpolated-MPD and GSMaP dataset, Figure 4 shows the map of West Java with information about 90-days R-square values on each grid from various timescale. The greenish color indicated higher R-square values which meen better agreement between two dataset, meanwhile the reddish color indicated lower R-square values or lower agreement between the two dataset. This good agreement can be interpreted that GSMaP able to catch the spatial rainfall distribution that will be useful for drought assessment.

### 3.2 SPI Analysis

Indramayu Regency is selected to be the focus location study for drought analysis because it has the highest rice production and is affected by drought the most compared to other regencies in West Java. The SPI analysis was conducted separately for both dataset within their available period, where for Interpolated-MPD dataset was conducted from January 1981 - March 2013 and for GSMaP dataset was conducted from March 2000 - October 2020. For the comparison of SPI results, different analysis was calculated between their overlapping period, April 2000 - March 2013.

The SPI analysis was calculated for different aggregation (SPI-1, SPI-3, SPI-6, SPI-9, and SPI-12) and for each pixel within the Indramayu Regency (with 0.1°×0.1° resolution). The result of SPI analysis can be seen on Figure 5 for Interpolated-MPD dataset and Figure 6 for GSMaP dataset.

According to the result, for Interpolated-MPD and GSMaP dataset, both SPI-3 and SPI-6 shows that there is a drought event during periode 2003, 2006, and 2008 which coincided with the decreases of rice production and the high affected area.

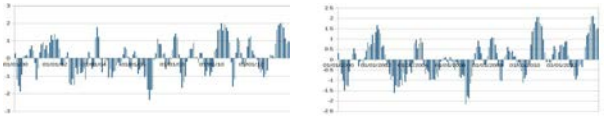

**Fig. 6. The result of SPI-3 (left) and SPI-6 (right) for Interpolated-MPD dataset from 2000-2013**

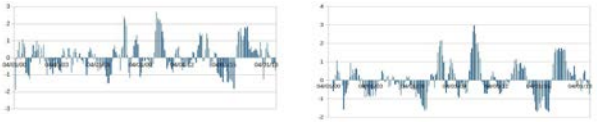

**Fig. 7. The result of SPI-3 (left) and SPI-6 (right) for GSMaP dataset from 2000-2018**

As for the comparison of SPI index between two datasets, the results show that both datasets generated relatively similar patterns for SPI-1, SPI-3, and SPI-6. But the validation is also needed to determine which dataset is more suitable for drought assessment in West Java, Indonesia.

## Conclusions

For the location with limited measured precipitation data, the satellite-based data can be utilized by assessing the agreement between the two datasets first. In West Java, it is suggested that the drought analysis can be conducted by using GSMaP precipitation data with 3-months period timescale, both for point dataset or area dataset. The SPI analysis result also shows that both datasets were able to catch the drought events which occurred in Indramayu Regency. But further research is needed to validate the correlation between the drought event and SPI index. This validation will be conducted using NDVI analysis.

## Reference

[1] Mourtzinis, S. et al, From grid to field: Assessing quality of gridded weather data for agricultural applications, European Journal of Agronomy, 82 (2017), 163-172.

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