Preliminary study on validation of HIMAWARI-8 data with ground based rainfall data at South Sumatera, Indonesia

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Abstract. An accurate rainfall data has an important role in the Indonesia Fire Danger Rating System (Ina-FDRS) which has been developed by PTPSW – BPPT since 2017. Continuing the previous study, during wet and dry season, an accurate rainfall data becomes one of the important inputs and has big impact on the Ina-FDRS. Unfortunately, surface rainfall data from AWS and ARG have limited availability especially on the spatial resolution data, therefore Ina-FDRS will use HIMAWARI-8 rain rate data as an input. On the other hand, satellite rainfall data also has limitation on the accuracy, HIMAWARI-8 detects top cloud temperature, then by using IMSRA method to calculate rainfall values. This preliminary study aims to validate rain rate from HIMAWARI-8 satellite image data with ground-based rainfall data from AWS/ARG during fire and non-fire period, from 1 – 31 August 2015 and 15 April – 15 May 2018. Afterward, we will use the validated rainfall data as an input for Ina-FDRS.

1. Introduction

Ina-FDRS (Indonesia Fire Danger Rating System) is a new concept to develop fire danger rating system in peatland regions. In the process, there are four components that build Ina-FDRS’s system. The components are Fire Weather Index (FWI), Human-Caused, Total Economic Value (TEV) and the Fuels. Fire Weather Index (FWI) becomes important as the main component.

Among the four components, the weather index for fire (FWI)’s component becomes the main input because of its dynamical process. There are four (4) important factors in the weather index for fire, such as rainfall amount, surface temperature, relative humidity, wind speed and direction [1]. Rainfall data is regularly obtained from meteorological station, the limitless of meteorological stations are limited number in one area, therefore they cannot cover the entire regions. If the rainfall data obtained from surface data, some obstacles might be encountered in the process of taking the data, including broken tools, demand calibration, resulting in low spatial resolution. Apart from surface data, rainfall data can be obtained from various sources, one of them is using HIMAWARI satellites. HIMAWARI satellite has high resolution so it can solve the problems related to the limitless number of surface data. On the other hand, HIMAWARI is a remote sensing satellite and the data that measured from the satellite is the top cloud temperature and it does not describe the amount of rainfall on the surface directly. This study aims to validate the rain rate from HIMAWARI-8 satellite image data with ground-based rainfall data.
from AWS/ARG during the fire and non-fire period. Afterwards, the validated rainfall data will be used as an input for Ina-FDRS.

2. Data and Method
The study area for this research is at Ogan Komering Ilir Regency (OKI), South Sumatera Province. OKI Regency is being chosen as a location in this study because there were peat fire incidents in this regency causing many lands burned, smoke disaster, etc. on 2013 to 2015 as well as occurred recently. Because of Ina-FDRS is a new concept to develop a fire danger rating system, the inputs from every component important to update recent FDRS. Figure 1 is the map of OKI Regency with longitude 104.8 – 106.2 E and latitude 2.301 – 3.798 S.

![Image](image_url)

**Figure 1.** Map of the location for surface rain gauge (Automatic Weather Station/AWS and Automatic Rain Gauge/ARG) over OKI Regency, South Sumatera.

We use three resources data on this study, HIMAWARI-8 data in 2km x 2km scale, Automatic Weather Station (AWS) data at 3 stations and Automatic Rain Gauge (ARG) data at 7 stations, see detail for each position described at Table 1. As discussed earlier, we are using HIMAWARI satellite and ground-based rainfall’s measurement to validate rainfall data. In this study, we were using HIMAWARI remote sensing satellite and comparing each coordinate from surface rainfall measurement station (AWS and ARG) with precise coordinates on the HIMAWARI data based on the same coordinates as the ground-based rainfall's stations. The ground-based rainfall data obtained from AWS and ARG stations (total 10 stations). The data period used in this study is 1 – 31 August 2015 represent fire period and 15 April – 15 May 2018 represent non-fire period over South Sumatera Province.
Table 1. Location for AWS and ARG

| No | Station                              | Latitude | Longitude |
|----|--------------------------------------|----------|-----------|
| 1  | StaKlim Kenten *)                    | -2.92711 | 104.771944 |
| 2  | StaMet SMB II *)                     | -2.89461 | 104.7012778 |
| 3  | Sriwijaya University (UNSRI *)       | -3.22025 | 104.6456944 |
| 4  | Kayu Agung **)                       | -3.39553 | 104.82253 |
| 5  | Celikah **)                          | -3.36972 | 104.82144 |
| 6  | Lempuing Induk **)                   | -3.89467 | 104.88392 |
| 7  | SP. Padang **)                       | -3.27045 | 104.87413 |
| 8  | Tulung Selapan **)                   | -3.25043 | 105.30948 |
| 9  | Pampangan **)                        | -3.20900 | 105.01244 |
| 10 | Jejawi **)                           | -3.26083 | 104.86078 |

Note: *) for AWS Station and **) for ARG Station.

The algorithm used to estimate 10-min rainfall rate is INSAT Multi-Spectral Rainfall Algorithm (IMSRA) [2, 3]. The regression between the rainfall rate from mean precipitation radar and cloud top temperature, is given as:

\[ R = 8.613098 \times \exp\left(-\frac{(TB - 197.97)}{15.7061}\right) \]

where, rainfall rate (R) in mm/hr and cloud top brightness (TB) in Kelvin. Total rainfall amount for 1-day will be calculated from average of 10-minute data.

HIMAWARI-8 data has 10-min temporal resolution, for making comparison with surface meteorological data then in ten minutes format or hours it must be averaged to hourly or daily resolution respectively. Surface meteorological data both AWS and ARG have different temporal resolution too, ARG data is in daily, while AWS data in hourly except for AWS at Sriwijaya University (UNSRI) in every minute. All data (AWS and HIMAWARI) will be averaged in hourly format. Afterwards, all the data (HIMAWARI, AWS, and ARG) will be in the form of daily based.

The following are the graph of data from each station. Data collected in 2015 at three stations of AWS/ARG and HIMAWARI data, we can see that the graph shows rainfall events tends to occur early in the morning (04 – 06 LT) and night-time (20 – 22 LT), the graph shows rainfall tends to occur in the night-time (Figure 2a), no rainfall (Figure 2b) and early in the morning (Figure 2c). The occurring of this rainfall was described from HIMAWARI data too (Figure 2d). During the period of non-fire in 2018, the following graph shows every condition in each station. Figure 3 shows that rainfall occurs from morning until midnight at Station of Kenten and at SMB II rainfall only occurs in the early morning (00 – 02 LT) and morning (07 – 11 LT). But from the HIMAWARI data, we can see the typical of diurnal cycle rainfall during one-month period, rainfall tends to occur almost all day, minimum in the morning (07 – 10 LT) and maximum in the late afternoon (15 – 19 LT).
Figure 2. The graphs show us the diurnal rainfall data at AWS/ARG Station of (a) Kenten, (b) SMB II, (c) Sriwijaya University (UNSRI), and (d) the daily rainfall data from all of AWS/ARG stations in August, 2015.
Figure 3. The graphs show us the diurnal rainfall data at AWS/ARG Station of (a) Kenten, (b) SMB II, (c) Sriwijaya University (UNSRI), and (d) the daily rainfall data from all of AWS/ARG stations in April – May 2018.

Figure 4 shows the diurnal rainfall data from HIMAWARI satellite that associate with the coordinate of AWS/ARG’s locations. The diagram shows us that all stations have the same pattern, which are rainfall tends to occur in the late afternoon around 15 – 18 LT.
Figure 4. The graphs show us the diurnal rainfall from HIMAWARI satellite associate with each AWS/ARG stations respectively at Kenten, SMB II, UNSRI, Kayu Agung, Celikah, Lempuing Induk, SP Padang, Tulung Selapan, Jejawi, Pampangan (clockwise from top left to bottom right).

The diurnal variations of rainfall from HIMAWARI data associate with ten (10) AWS/ARG stations over OKI can be seen at Figure 5 below, during both period of fire (August 2015) and non-fire (April – May 2018).
3. Result and Discussion

During fire and non-fire season, if we compared HIMAWARI satellite data with ground-based rainfall measurement data from AWS and ARG, we can see the typical pattern of rainfall at South Sumatera. Rainfall occurred in the first week of August 2015 but the intensities were very low. Rainfall intensity around 30 – 40 mm/day occurred on August 6 – 7 and 13, 2015, but afterward the rainfall was disappeared until in the end of August (see Figure 6). These phenomena also similar in the HIMAWARI data during same period of 2015. Rainfall amount from HIMAWARI data compared with surface meteorological stations were mostly less estimate, due to rainfall estimation equation, but it has similar pattern (see Figure 6c). Further study will develop the correction of rainfall estimation for HIMAWARI data. Continuing the previous study, the weather condition during August 2015 mostly dry and less rainfall, therefore the forest fire often occurred during those period [4].

Figure 5. The graphs show us the diurnal rainfall from HIMAWARI satellite associate with each AWS/ARG stations during (a) August 2015 and (b) April – May 2018.

Figure 6. Daily rainfall data both from (a) HIMAWARI satellite and (b) AWS/ARG over OKI regions, and (c) Comparation of HIMAWARI and ground-based rainfall data during 01 – 31 August 2015. Compare with the condition during 2018, rainfall occurred almost every day since 15 April to 15 May 2018, even though the intensity also very low (see at Figure 7). During these one-month period, rainfall
intensity around 30–40 mm/day occurred during second and third weeks of April and maximum at 60 mm/day on May 25, 2018. Rainfall tends to decreasing on May but we can see in May 4, 2018 rainfall occurred around 40 mm/day. If we compare the HIMAWARI and ground-based rainfall data, we can see the less estimation rainfall amount but it has similar pattern during all period (Figure 7c). The condition during 2018 relatively wet because of rainfall occurred almost every day.

**Figure 7.** Daily rainfall data both from (a) HIMAWARI satellite and (b) AWS/ARG over OKI regions, and (c) Comparation of HIMAWARI and ground-based rainfall data during 15 April – 15 May 2018.

Figure 5 shown the diurnal variations of rainfall during fire (August 2015) and non-fire period (April to May 2018). On 2015, rainfall occurred in the early morning and late night with very small intensity (0.2 – 0.4 mm/hr) compared with rainfall on 2018. During 2018, rainfall tend to occur in the late afternoon (16 – 18 LT) with maximum intensity about 1.4 mm/hr. This is the typical pattern of diurnal rainfall in the Maritime Continent [5]. If we calculate using ground-based rainfall data which has about 10-times different between HIMAWARI and ground-based rainfall, then in 2018 maximum rainfall around 14 mm/hr or 42 mm/3-hr. The diurnal variations from HIMAWARI data shown the rainfall condition during 2018 mostly wet compared with 2015.

The similarity pattern between HIMAWARI satellite data and ground-based rainfall data shown in the Figure 6c and 7c, must be studying more in the next step. By using the simple correlation method, the coefficient determination ($R^2$) between HIMAWARI and ground-based data is 55.5% (see Figure 8).
Figure 8. Graph of simple correlation method between HIMAWARI and ground-based rainfall data.

4. Conclusion
Rainfall data from HIMAWARI satellite data and ground-based rainfall data have been analyzed during fire (01 – 31 August 2015) and non-fire (15 April – 15 May 2018) period. Comparison between satellite and ground-based rainfall data have the similarity on the pattern but HIMAWARI data have less rainfall intensity compared with ground-based rainfall data, it needs further study to estimate rainfall intensity from satellite remote sensing data. During 2015, rainfall occurred only view days compare with 2018 with many rainfall days. The simple correlation method has shown the coefficient determination of 55.5% between HIMAWARI and AWS/ARG data.

5. References
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