Is Land and Forest Fire in Ogan Komering Ilir, Southern Sumatera, Affected by Climate Change?

Afifuddin
Centre for Regional Resource Development Technology (CRRDT) Agency for the Assesment and Application of Technology (BPPT)
Tangerang Selatan, Indonesia
afifuddin@bppt.go.id

Andri Purwandani
Centre for Regional Resource Development Technology (CRRDT) Agency for the Assesment and Application of Technology (BPPT)
Tangerang Selatan, Indonesia
andri.purwandani@bppt.go.id

Ruki Ardiyanto
Centre for Regional Resource Development Technology (CRRDT) Agency for the Assesment and Application of Technology (BPPT)
Tangerang Selatan, Indonesia
afifuddin@bppt.go.id

Lena Sumargana
Centre for Regional Resource Development Technology (CRRDT) Agency for the Assesment and Application of Technology (BPPT)
Tangerang Selatan, Indonesia
lena.sumargana@bppt.go.id

Marina C. G. Frederik
Centre for Regional Resource Development Technology (CRRDT) Agency for the Assesment and Application of Technology (BPPT)
Tangerang Selatan, Indonesia
marina.frederik@bppt.go.id

***Abstract*—In 2015, Southern Sumatra region, particularly Ogan Komering Ilir (OKI) regency was stricken by massive fires in peatland and forest areas. Besides intentionally burned, climate change was also suspected as a cause of the wildfire. Increasing temperature, decreasing humidity, and low precipitation are several climate indicators that trigger forest and peatland wildfire. In order to review this presumption, the research needed to be conducted in Southern Sumatra area related to climate change until 30 years long period. So that the climate change can be detected from the climate indicator variabilities such as Temperature, Pressure, Total Precipitation, Relative Humidity, and Wind Speed.**

Climate parameter data in the long period was obtained from global atmospheric reanalysis data generated by ERA ECMWF (European Centre for Mid-Range Weather Forecast). The climate parameter data are available from 1979 to 2017. This research using three-hour interval climate parameter data. The trend analysis was conducted to observe the variability of every parameter using a linear regression method. The change of every climate parameter was spatially visualized to observe whether it had impacts on land and fire occurrences or not.

From the analysis, it was found that all climate parameter was changing slightly per year. All climate parameters changed relatively small each year with increases in temperature 0.014 ^{o}C – 0.035^{o}C/year and decreasing pressure 0.0138 – 0.0207 mbar/year. Relative humidity varies from decreasing 0.0311 to increasing 0.0458% / year. Wind speed also varies slightly from decreasing -0.0059 to increasing 0.0074 m/s/year. Their precipitation varies as well from decreasing 2.58 to increasing 5.15 mm/month. The alteration of these parameters indicates the climate change present slightly in southern Sumatra region, particularly in OKI regency, but does not affect land and forest fire occurrence.

Keywords— Climate change, Land and Forest Fire, OKI Region, Trend Analysis

I. INTRODUCTION

In 2015, Southern Sumatra region, particularly Ogan Komering Ilir (OKI) regency was hit by massive fires in peatland and forest areas. The fires alters peat soil properties, reduces plant cover, plant composition; whereas severe drought can increase tree mortality, and blench huge amount of carbon into the atmosphere [1]. Previous research. as in [2] [3] have been developed in Indonesia, for mitigation and adaptation of disasters in the future, including wildfires.

Although mainly wildfires are human-caused [4], climate change also suspected as a cause of the wildfire. Increasing temperature, decreasing humidity, and low precipitation were several climate indicators that trigger forest and peatland wildfire. In order to review this presumption, the research needed to be conducted in a certain area related to climate change until 30 years long period. So that the climate change can be detected from the climate indicator variability such as Temperature, Pressure, Total Precipitation, Relative Humidity, and Wind Speed.

The burning of peatlands in South Sumatra in 2015 resulted in the spread of smog that spread to Singapore and Malaysia. Most of the peatland in South Sumatra located in Ogan Komering Ilir region, 769,000 ha broad [5]. Former research which analyze climate-driven changes in wildfires was conducted in a Mediterranean environment such as Europe [6]. Particular research should be conducted in the equatorial environment because Equatorial and Mediterranean environment has different geomorphologic and climate system. This research aimed to observe the correlation between the change of climate parameter and fire occurrence. The method used in this research was to establish a trend analysis of climate parameter and trend analysis of fire occurrences.

II. DOMAIN STUDY

A. Time and Location Study

The domain of this study located in Southern Sumatera region, particularly area covers Ogan Komering Ilir Regency which extended from 104^{o} to 107^{o} East and 1.5^{o} to 4.63^{o} South. Climate parameters used in this research were temperature, pressure, total precipitation, relative humidity, and wind speed. This research used three-hour interval climate parameter data from January 1st, 1979 to December 31st, 2017 with 0.125 degrees resolution. Active fire data as

978-1-7281-5077-2/19/$31.00 ©2019 IEEE

land and forest fire references using 2000 to 2017 due to availability of data.

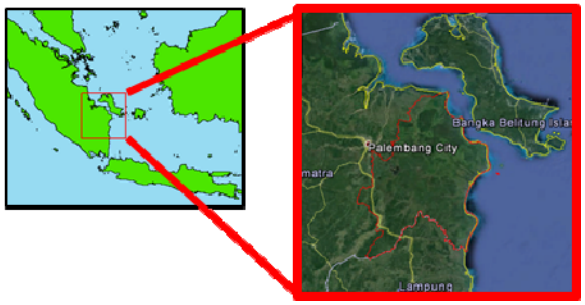

Fig. 1. Study Location

B. Data Source

Climate data parameter was obtained from global atmospheric reanalysis data generated by ERA-Interim ECMWF (European Centre for Mid-Range Weather Forecast). ERA-Interim is the latest global atmospheric reanalysis produced by the ECMWF [7]. Reanalysis is a process of assimilation from various models and observations which produce the best global estimation of atmospheric, wave, and oceanographic parameters.

Active fire data was obtained from The Moderate Resolution Imaging Spectroradiometer (MODIS). MODIS began collecting image data in 2000. MODIS produces two types of fire products: active fire products and a burned area product. The primary emphasis during the first 18 months since launch has been given to generating and refining the MODIS active fire products [8]. The active fire algorithm uses multiple channels to detect thermal anomalies on a per-pixel basis, which in addition to fire.

III. METHODOLOGY

A. Climate Trend

There are many climate parameters available on ERA-Interim. This research uses several parameters, following: utilize 2-meter temperature, surface pressure, dewpoint temperature, total precipitation, U & V wind component data. The data obtained from ERA-Interim can be utilized without any pre-processing step. The first processing step is to change the unit from default into International Standards unit. Subsequently, relative humidity was calculated from the temperature and dewpoint temperature data. The wind speed parameter obtained from the Zonal (U) and Meridional (V) wind component. Comparison table between Climate parameter and ERA-Interim parameter presented in table 1.

TABLE I. COMPARISON BETWEEN CLIMATE PARAMETER AND ERA INTERIM PARAMETER

Climate Parameter	ERA Interim Parameter
Temperature [°C]	2 metre temperature
Pressure [mbar]	Surface pressure
Relative Humidity [%]	= 100 * (2 metre dewpoint temperature [°C] / 2 metre temperature [°]) [%]
Wind Speed [m/s]	10 metre U wind component [m/s] dan 10 metre V wind component [m/s]
Total Precipitation [mm]	Total precipitation [m]

After calculating the climate parameter from 1979 to 2017, the synoptic normal of each parameter generated on 0.125 degrees interval. Each parameter containing 650 station data. The Data clustered for every station so that each station contains a climate parameter from 1979 to 2017. The climate parameter trend was obtained from every station time series using linear regression. Linear regression is a statistical method that allows us to summarize and study relationships between two continuous (quantitative) variables [9]:

- One variable denoted x is regarded as the predictor, explanatory, or independent variable.
- The other variable denoted y is regarded as the response, outcome, or dependent variable.

On simple linear regression determined 'best-fit line'. 'Best fit line' is a line which minimalizes sum of an independent least-square variable. To determine the best fit line the following model was used:

$$y = a + bx \quad (1)$$

a and b value determined from equation (2) and (3):

$$a = \bar{y} - b\bar{x} \quad (2)$$

$$b = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (3)$$

The change of every parameter per year can be known from constant b. Value of constant b from all station will be visualized spatially to find variability distribution.

B. Determining Location with Minimum Human Intervention

The trend of changes in climate parameters that occurred every year can be assumed to trigger an increase or decrease in the number of land and forest fires. To prove this assumption, the climate parameter trend needed to be compared with the trend of fire occurrences from active fire MODIS data. The data that was compared must be in areas with minimum human interventions to minimize fires that occur due to anthropogenic factors. The chosen area was Protected Forest or Natural Reserved Forest in OKI District. Areas in the coast were not included in this criterion because they were mangrove areas that rarely burnt. The selected area was about 15,157 ha.

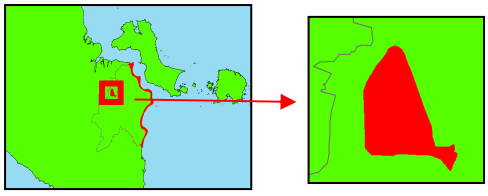

Fig. 2. The area with minimum human intervention

978-1-7281-5077-2/19/$31.00 ©2019 IEEE

IV. RESULT AND ANALYSIS

A. Climate Trend

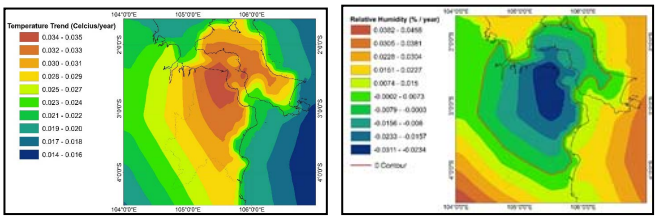

Fig. 3. The trend of Temperature (left) and Relative Humidity (right)

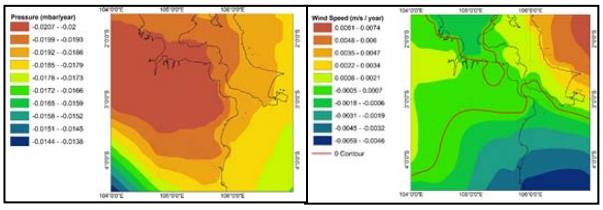

Fig. 4. The trend of Pressure (left) and Wind Speed (right)

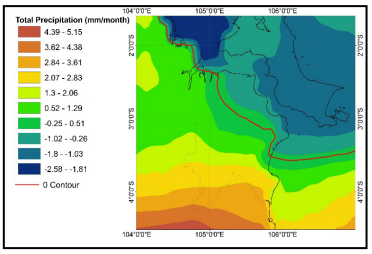

Fig. 5. The trend of Total Precipitation

The trend of temperature from 1979 to 2017 was generally increasing in the range of increases from 0.014º to 0.035ºC per year with an average increase of 0.023ºC. Areas that had the highest temperature increase were located in the near of Bangka Strait due to its soil characteristics that receive and releases heat rapidly. This area is also not affected by the climate process that occurs in the sea which is more stable, because it is blocked by Bangka Island. The increasing trend of temperature will cause the uprising of the evaporation rate of fuel material on soil, so the water content in combustible materials decreases and the material becomes flammable.

The trend of air humidity had varying values, ranging from 0.0311% / year decrease to 0.0458% / year increase. On average, the humidity in this area had a 0.009% / year increase. Changes in humidity in the southern part of Sumatra were not quite dominant. Areas that had the greatest decrease in air humidity were in the same areas that had the highest increasing temperature.

Air pressure had a decreasing trend from the range of 0.0138 to 0.0207 Pa/year, with an average of decrease 0.0191 Pa/year. The air pressure decreasing range was relatively small, with regions having quite varied changes in the hilly topography in the south of OKI district. But the biggest air pressure decreasing, which was more than 0.02 Pa/year, was in the middle to northwest. Low air pressure could trigger greater wind speeds.

Wind speed had variety of trends, ranging from 0.0059 m/s/year decrease to 0.0074 m/s/year increase and the average reduction was 0.0002 m/s/year. Most of these areas experienced a trend of decreasing wind speeds per year with relatively small values. Areas that had an increase in wind speed were in water bodies in the northeast of Bangka Island. While the biggest decrease in wind speed was in the southeast of OKI district which was affected by conditions in the Java Sea.

Precipitation also had a variety of change trends, ranging from 2.58mm/month decrease to 5.15mm/month increase and the average was 0.6951 mm/month. The regions that had the largest increase in precipitation were in areas with varied topography in the south of the OKI district. While the decrease in precipitation was in the waters north of OKI district.

The trend of changes in each climate parameter had a relatively small value in the Southern Sumatra region. OKI district itself had changes in precipitation and wind speeds close to zero. The increase of air temperature occurred in the north of OKI regency, in which this area is blocked from the influence of the sea by Bangka Island. Long-term increase in air temperature will increase evaporation of the surrounding water. Increase in wind speed even though small will reduce the potential for rain in the area so that humidity would decrease. Rising air temperature, falling humidity, and precipitation were expected to trigger fires in forests and land. To prove the relevance of climate change and the occurrence of forest fires, it needed to be compared to the data on trends in forest and land fires per year.

B. Fire Occurrence Trend

Protected Forest Areas and Natural Reserved Forests that was selected as sample areas were assumed to be non-human intervention areas in which the emergence of fires was purely caused by non-anthropogenic factors. But there is also a possibility that fires caused by human factor, such as spreading fire from the outside forest area. From 2000 to 2017, there were only eight years with no fire occurrence. The biggest fire occurred in 2009 with a total of burn area about 8828 ha. Table 2 shows the cumulative burnt area per year. While Figure 4 shows the pattern of area burned per year. It can be seen that the trend of forest fires that occurred for 17 years was decreasing. From 2005 to 2016 there was a pattern of a year without fire, then followed with fire occurrences within the next two years, and the year after, again, without fire.

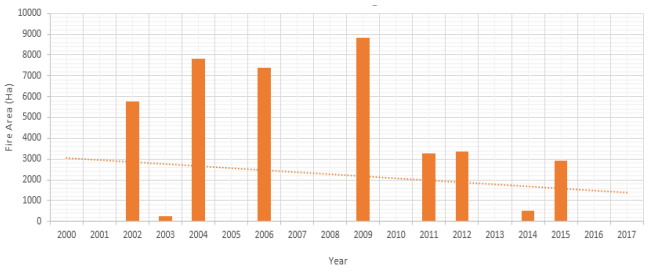

Fig. 6. Fire Occurrence Trend

978-1-7281-5077-2/19/$31.00 ©2019 IEEE

TABLE II. COVERAGE OF FIRE OCCURRENCE PER-YEAR

Year	Area (ha)	Year	Area (ha)
2000	-	2009	8,828
2001	-	2010	-
2002	5,782	2011	3,251
2003	261	2012	3,349
2004	7,840	2013	-
2005	-	2014	506
2006	7,387	2015	2,923
2007	-	2016	-
2008	24	2017	-

C. Analysis

The occurrence of fires in the natural reserved forest and protected forests is assumed to occur naturally, although there is still a small possibility of human factors. Fires were assumed to be caused by natural factors, such as high temperatures and low humidity. The relation between climate change and the incidence of forest fires could be seen from the observations of both trends.

If there was a trend that increasing temperature and wind speed accompanied by decreasing air humidity, air pressure, and rainfall, it should cause an increase in the trend of forest fires in natural conditions. From the analysis, changes in climate parameters occurred even though not significant enough and the trend of forest fires actually declined. It might be concluded that climate change did not directly affect forest fires occurrences.

V. CONCLUSIONS

Climate change in the land area can be detected spatially. Although the climate parameter change slightly, there is a variation on several parameters containing partially increasing trend and some of decreasing trend such as on relative humidity, wind speed, and precipitation

From the analysis on the climate parameters of 1979 to 2017, that climate change occurred in OKI regency and Southern Sumatra. All climate parameters changed relatively small each year with increases in temperature 0.014 ^{o}C – 0.035^{o}C/year and decreasing pressure 0.0138 – 0.0207 mbar/year. Relative humidity varies from decreasing 0.0311 to increasing 0.0458% / year. Wind speed also varies slightly from decreasing -0.0059 to increasing 0.0074 m/s/year. Their precipitation varies as well from decreasing 2.58 to increasing 5.15 mm/month.

Changes in climate parameters did not affect forest and land fires. Because in the sample areas, Protected Forests and Natural Reserved Forests, actually there was a decrease in the trend of forest fires from 2000 to 2017. In the future, it is necessary to conduct further research in a larger sample area by considering the trends of La Nina and El Nino events that affect climate parameters in the local area. Hopefully this research. Since the data been used here was the assimilation of many observations and models, the existence of operational earth observation satellites in Indonesia must be put into national development priorities [10] [11].

ACKNOWLEDGMENT

We would like to thank European Centre for Medium-Range Weather Forecasts (ECMWF) for the availability of climate parameter model and National Aeronautics and Space Administration (NASA) for providing active burn area from Moderate Resolution Imaging Spectrometer (MODIS) imagery. This research was funded and facilitated by the Center for Regional Resource Development Technology at Agency for the Assessment and Application of Technology (BPPT).

REFERENCES

[1] F. Marpaung, S. Putiamini, E. Avianti, H. Priyadi, A. Darmawan, “Identification of Tropical Peatland Using ALOS 2 Palsar”, in Earth and Environmental Science, p.165. http://doi.org/10.1088/1755-1315/165/1/012014

[2] Udrech, Agustan, S. Yulianto, and O.B. Bintoro, "RAPID TIMEER: An Alternative Solution for Post-Disaster Rapid Assessment". In 2018 IEEE International Conference on Communication, Networks and Satellite (Comnetsat) (pp. 24-27). IEEE. 2018.

[3] Sadly, M., Agustan., Yulianto, S., Bintoro, O. B., Sutrisno, D., & Alhasanah, F. (2018, September). An Application of SMART Method in vendor selection of Satellite Systems Case study of Indonesia Remote Sensing Satellite Systems (InaRSSat). In 2018 IEEE International Conference on Aerospace Electronics and Remote Sensing Technology (ICARES) (pp. 1-6). IEEE.

[4] A. Ganteaume, A. Camia, M. Jappiot, J. San-Miguel-Ayanz, M. Long-Fournel, C. Lampin, “A Review of the Main Driving Factors of Forest Fire Ignition Over Europe”, Springer Environmental Management, vol. 51, 2013, pp. 651-662. doi:10.1007/s00267-012-9961-z

[5] Wahyunto, S. Ritung, Suparto, H. Subagjo, “Sebaran Gambut dan Kandungan Karbon di Sumatera dan Kalimantan”, Climate change project, Forests and Peatlands in Indonesia, Wetland International – Indonesia Programme and Wildlife Habitat Canada, 2005.

[6] M. Turco, M. Llasat, J. v. Hardenberg, A. Provenzale, “Climate change impacts on wildfires in a Mediterranean environment”, Springer Climate Change, 2014. doi:10.1007/s10584-014-1183-3.

[7] D.P. Dee, et al, “The ERA-Interim reanalysis: configuration and performance of the data assimilation system”, Quarterly Journal of the Royal Meteorological Society, 2011, pp 553-598.

[8] C.O. Justice, et al (2002), “The MODIS fire products”. Elsevier Remote Sensing of Environment., vol. 83, 2002, pp 244-262

[9] PSU Department of Statistics, “Regression method”. Pennsylvania State University, 2002.

[10] O. B. Bintoro, Agustan, D. Sutrisno, and M. Sadly. "Key Issues of the National Initiative for Indonesia Remote Sensing Satellite: Three rounds Delphi Study". In 2018 IEEE International Conference on Aerospace Electronics and Remote Sensing Technology (ICARES) (pp. 1-5). IEEE. 2018.

[11] Agustan, M. Sadly, S. Yulianto, D. Sutrisno, O. B. Bintoro, F. Alhasanah, “Participatory Scenario Planning for Indonesian Space Industry in 2025”, in IEEE International Conference on Aerospace Electronics and Remote Sensing Technology (ICARES), 2018

978-1-7281-5077-2/19/$31.00 ©2019 IEEE