Effect of Aerosol Radiation Interaction (ARI) from Increasing Land and Forest Fires on Cloud Formation in Ogan Komering Ilir (South Sumatera)

Pengaruh Aerosol Radiation Interaction (ARI) dari Peningkatan Kebakaran Lahan dan Hutan terhadap Pembentukan Awan di Kab. Ogan Komering Ilir (Sumatera Selatan)

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Intisari

Peningkatan aerosol dapat berpengaruh secara langsung terhadap pertumbuhan awan yang dikenal sebagai efek Aerosol Radiation Interaction (ARI). Hal ini berhubungan dengan sifat penyerapan dan penghamburan radiasi matahari dan menyebabkan terjadinya pengurangan radiasi matahari ke permukaan sebagai sumber energi pada proses pembentukan awan secara konvektif. Efek ARI ini dapat dilihat dari parameter Aerosol Radiative Forcing (ARF). ARF bernilai negatif berarti terjadi pengurangan radiasi, sedangkan bernilai positif berarti terjadi peningkatan radiasi. Meningkatnya kebakaran hutan dan lahan di Kab. Ogan Komering Ilir (Sumatera Selatan) dari Agustus hingga November 2019 menyebabkan peningkatan konsentrasi aerosol, yang ditunjukkan dengan peningkatan nilai Aerosol Optical Thickness (AOT) berkisar dari 1 menjadi 2. Hal ini ditandai dengan peningkatan AOT Komponen kimia Karbon Organik (OC) berkisar antara 0,3 – 1,2 dan Karbon Hitam (BC) berkisar antara 0,1 – 0,35. Tulisan ini akan membahas efek ARI dengan menggunakan data reanalysis dari Modern-Era Retrospective analysis for Research and Applications II (MERRA-2) dan ERA5 untuk kasus kebakaran hutan di Kab Ogan Komering. Hasil analisis dari data tersebut menunjukkan adanya efek ARI yang ditunjukkan dari nilai negatif pada ARF radiasi gelombang pendek di permukaan (SFC) dan di puncak atmosfer (TOA), nilai positif pada ARF radiasi gelombang panjang di SFC dan nilai negative ARF radiasi gelombang panjang di TOA. Efek ARI terhadap pembentukan awan juga dibuktikan dengan adanya pengurangan tutupan awan rendah (lcc) serta meningkatnya nilai Convective Inhibition (CIN).

Kata Kunci: Aerosol Radiasi interaksi, Aerosol Radiative Forcing, Kebakaran Lahan dan Hutan, Organic Carbon, Pembentukan Awan.

Abstract

The aerosols increase can directly affect cloud formation, known as the Aerosol Radiation Interaction (ARI) effect, related to the nature of absorption and scattering of solar radiation and causes a reduction in solar radiation to the surface as an energy source in the process of convective cloud formation. This ARI effect can be seen from the Aerosol Radiative Forcing (ARF) parameter. A negative ARF value means a reduction in radiation, while a positive value represents an increase in radiation. The increased land and forest fires in the Kab. Ogan Komering Ilir (South Sumatra) from August to November 2019 led to an increase in aerosol concentrations, which was indicated by an increase in Aerosol Optical Thickness (AOT) values ranging from 1 to 2. It is characterized by an increase in AOT Organic Carbon (OC) chemical components ranging from 0.3 – 1.2 and Black Carbon (BC) ranging from 0.1 – 0.35. This paper will discuss the effect of ARI using reanalysis data from Modern-Era Retrospective analysis for Research and Applications II (MERRA-2) and ERA5 for the case of forest fires in the Ogan Komering District. The results of the study show that there is an ARI effect, characterized by a negative value on the ARF of shortwave radiation at the surface (SFC) and the top of the atmosphere (TOA), a positive value on the ARF of longwave radiation at the SFC, and a negative value of ARF of longwave radiation in the TOA. The effect of ARI on cloud formation is also evidenced by a reduction in low cloud cover (lcc) and an increase in the value of Convective Inhibition (CIN).

Keywords: Aerosol Radiation Interaction, Aerosol Radiative Forcing, Cloud Formation, Land and Forest Fires, Organic Carbon.

1. INTRODUCTION

Aerosols play an important role in the physical and chemical processes of the atmosphere so that they can have a great impact on the atmospheric climate. Aerosols can affect the Earth's radiation balance and affect the hydrological cycle and atmospheric circulation (Ramanathan *et al.,* 2001; Satheesh, 2012). Aerosols are solid, liquid, or gaseous particles scattered in the atmosphere with different sizes ranging from 0.001 μm to 100 μm. Aerosols are produced by mechanical processes that occur over land or oceans or chemical reactions that occur in the atmosphere (Pöschl, 2005; Tjasyono, 2007). According to Pöschl (2005), the source of atmospheric aerosol particles comes from natural and anthropogenic sources. Natural sources or primary sources are aerosols that are directly emitted from sources such as biomass combustion, incomplete burning of fossil fuels, volcanic eruptions, road suspensions, soil and mineral dust driven by wind or traffic, sea salt, and biological materials. Furthermore, anthropogenic sources or secondary sources are particles formed from gas-to-particle conversion in the atmosphere and usually produce aerosols > of small size (< 1μm) in the atmosphere.

Land and forest fires are common in Sumatera and Kalimantan every year. These land and forest fires always have a negative impact on the environment. One such negative impact is an increase in aerosols in the atmosphere. Twomey (1977), Albrecht (1989), Rosenfeld *et al.* (2008), and IPCC (2013) explained that increased aerosol concentrations could affect weather and climate through direct effects related to solar radiation processes and indirect effects related to cloud microphysics processes. The direct effect of this aerosol is known as Aerosol Radiation Interaction (ARI), where aerosols serve as absorbers and dissipators of solar radiation, and the indirect effect of aerosols is known as Aerosol Cloud Interaction (ACI), where aerosols serve as cloud condensation nuclei.

The direct effect of aerosols (ARI) on cloud formation is related to the equilibrium of the solar energy budget. Solar energy is the main source of energy needed in the process of forming clouds, which enter through the atmosphere and up to the Earth's surface. In the process, not all the sun's energy reaches the Earth's surface because there is energy reflected into space, and some are absorbed by aerosols. According to Ding *et al.* (2013), increased aerosol absorption can lead to warming of the lower atmosphere and cooling at the bottom of the PBL, or it can be said that aerosols reduce the amount of radiation reaching the surface and increase the amount of solar radiation in the lower atmosphere.

Analysis of aerosol influence on radiative parameters in Indonesia has been conducted by Rosida & Susanti (2016), but the study has not discussed the province of South Sumatera specifically, and there has been no discussion related to ARI's relationship with cloud formation. Some other studies that are referenced in discussing the direct effects of aerosols ARI are Wang *et al.* (2013), Li *et al.* (2016), and Ackerman *et al.* (2000), which state that the direct effects of ARI can affect convective cloud processes, which can reduce cloud cover.

South Sumatera provinces in Indonesia often experience land and forest fire disasters in the dry season every year. One of the reasons is because it has a large area of peatland. When the water content of peatlands decreases, the land will be easily burned, so it is often used by local communities to open plantation land. When land and forest fires occur, the atmospheric conditions look clear from the clouds. So, it isn't easy to find potential rain clouds, causing the authors to assume a correlation between the increase in aerosols due to land and forest fires with cloud formation. Therefore, this paper aims to analyze the impact of aerosol smoke from forest and land fires on cloud formation. This study focuses on the effect of increasing aerosols on radiation effects.

2. METHODS

This study used secondary data from reanalysis data, ERA5 and MERRA-2. Further process uses Microsoft Office, Python, Grid Analysis and Display System (GrADS), and Climate Data Operator (CDO) software. We used aerosol data and atmospheric radiation data in the analysis. The first working procedure in this study is to determine the value of each parameter needed to analysis the effect of the aerosol increase on cloud formation from the effect of ARI. After that, we analysis the time series trend of each parameter. Furthermore, an analysis of AOD's relationship with radiative data was carried out when there was an increase in smoke due to land and forest fires. The data used in this study is 2019 data.

2.1. Aerosol

Aerosol data was obtained from a reanalysis of MERRA-2 data, with a spatial resolution of 0.5 x 0.625 and a temporal resolution of 1 hour. MERRA-2 data can be retrieved from https://disc.gsfc.nasa.gov/. MERRA-2 is the latest atmospheric reanalysis of the modern satellite era produced by the Global Modeling and Assimilation Office (GMAO), National Aeronautics and Space Administration (NASA). MERRA-2 assimilates observations which is not available in its previous application, MERRA and it updates to Goddard Earth Observing System (GEOS) version 5 model and analysis the scheme so as to provide available and sustainable climate analysis (Ostrenga, 2010; Gelaro *et al.,* 2017; Randles *et al.,* 2017).

Aerosol data analysis from MERRA-2 is in the form of Aerosol Optical Thickness (AOT) data, consisting of total aerosols, SO4, Organic Carbon (OC), Black Carbon (BC), dust, and sea salt. According to Adiningsih *et al.* (2015), Aerosol Optical Thickness (AOT) is the same as Aerosol Optical Depth (AOD) which is the extinction coefficient along the vertical column of the atmosphere. The coefficient of extinction is the fractional thinning of light per unit length of the line (also referred to as weakening in radar signals). This AOT data can be used for air quality observation, air visibility, monitoring volcanic eruptions and forest fires, earth radiation balance, and climate change.

In this study, before using the AOT data from MERRA-2, validation of the AOT observation data from the Aerosol Robotic Network (AERONET) was carried out using the regression method. The location of Jambi (1.6320S, 103.6420E) is the object in the AOT data validation because of Kab. OKI does not have AERONET measurements. AERONET is a land-based remote sensing aerosol network program founded in the 1990s by NASA (Holben et al., 1998) and can be retrieved from https://aeronet.gsfc.nasa.gov/. For information on aerosol measurements using AERONET, there is not AOT available with a wavelength of 550nm (AOT (550nm)), while in MERRA-2, there is only an AOT with a wavelength of 550nm (AOT (550nm). So to be able to validate the AOT value of MERRA-2, AERONET data must first be converted using the equation (i) (Prasad and Singh, 2007; Zhai *et al.,* 2021; Ou *et al.,* 2022). The AERONET data used is the daily average AOD level 2 (500nm) data, while the MERRA-2 data is the daily average AOT (550nm) for the period January 2013 to December 2019. Because AERONET data is point data, the MERRA-2 data was the first regridding using the bilinear method from a spatial resolution of 0.5 x 0.625 to 0.1 x 0.1 using Climate Data Operators (CDO) software.

$$AOT_{550} = AOT_{500}\left(\frac{550}{500}\right)^{-\alpha} \quad \ldots\ldots\ldots \text{(i)}$$

α : Angstrom exponent (440-870 nm)

AOT_{500} : aerosol optical depth at 500 nm

2.2. Radiative Data

This study used atmospheric reanalysis data from ERA5 (https://cds.climate.copernicus.eu) with a spatial resolution of 0.25 x 0.25 and a temporal resolution of 1 hour and MERRA-2 data (https://disc.gsfc.nasa.gov/) with a spatial resolution of 0.5 x 0.625 and a temporal resolution of 1 hour, to analyze the effect of increasing aerosols on radiation parameters in the atmosphere. All data is first regridding with bilinear methods to be resolution 0.1 x 0.1 using Climate Data Operators (CDO) software. The data analyzed *were shortwave radiation, sensible heat, latent heat,* boundary layer height *(BLH),* low cloud cover *(lcc),* and Convective Inhibition *(CIN). According to* (Syaifullah, 2013), CIN is a CAPE negative in the lower tropical layer, where the thicker the CIN, the more difficult the convective removal of air parcels. The air parcel that is lifted to the *boundary layer* will drop back down.

This study also calculated aerosol radiative forcing (ARF) values for the surface and top atmosphere. This research requires data on shortwave and longwave radiation flux under conditions with aerosols and no aerosols in the atmosphere. These data can be obtained from the MERRA-2 reanalysis data. ARF can be calculated using equations (ii) for top atmosphere (TOA) and equation (iii) for surface (SFC) (Huang *et al.,* 2006; Hatzianastassiou *et al.,* 2007; Rosida & Susanti, 2016)

$$ARF_{sfc} = F_{aer}(sfc) - F_{nonaero}(sfc) \quad \ldots\ldots \text{(ii)}$$

$$ARF_{TOA} = F_{aer}(TOA) - F_{nonaero}(TOA) \quad \ldots\ldots \text{(iii)}$$

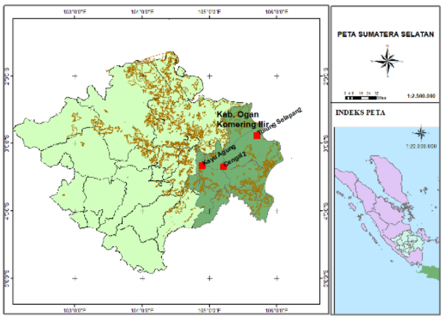
ARF : Aerosol Radiative Forcing (Wm^{-2})

F_{aer} : Net Radiation Flux for unclean or polluted atmospheric conditions

$F_{nonaero}$: Net Radiation Flux for clean or polluted atmospheric conditions

2.3. Observation Location

The object of research on the influence of smoke aerosols due to land and forest fires on cloud formation is the Ogan Komering Ilir district (Kab. OKI). Wahyunto *et al.* (2004) explained that the Kab. OKI is an area in South Sumatera that has the largest peatland. Based on the report of the Badan Restorasi Gambut (2019) explained that the area of peat ecosystems in the Kab.OKI is 1.03 million ha or 49.28% of the total peat ecosystem in Prov. South Sumatera. To be able to do a time series analysis, then in this research object will be divided into 3 locations that are Kayuagung, Cengal2, and Tulung Selapan2. The three locations were chosen based on locations where there were many land and forest fires in 2019. The location point can be seen in figure 1.



Nama Lokasi	Lon	Lat
Cengal2	105.2130	-3.347
Kayu Agung	104.9010	-3.3290
Tulung Selapan2	105.7160	-2.8850

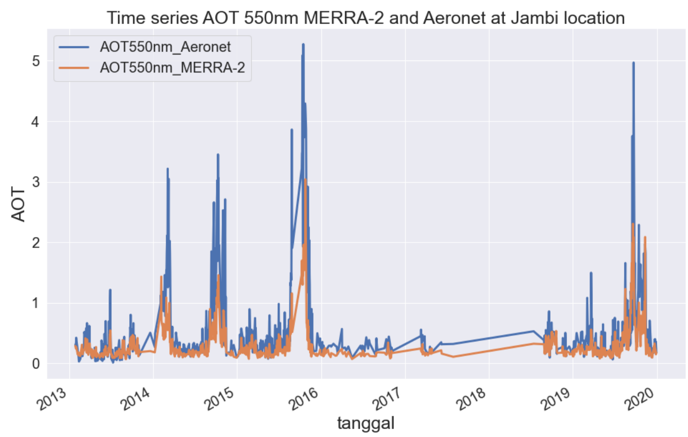
Figure 1. Observation Location

3. ANALYSIS AND DISCUSSION

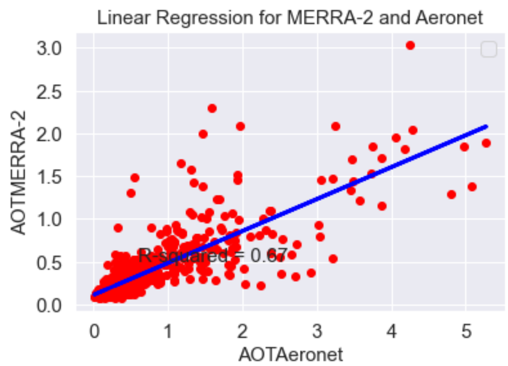
The study used MERRA-2 reanalysis data for aerosol value analysis, namely: AOT (550nm). Based on the results of the validation of the AOT value against the AERONET observation data displayed in figure 2, there is a similarity in the time series pattern of MERRA-2 and AERONET aerosol measurements. Although the aerosol value of MERRA-2 measurement results is slightly below the aerosol value of AERONET measurement results, the value of the AOT (550nm) of MERRA-2 reanalysis data is very suitable to be used to replace AERONET data because *the r-square* value resulting from linear regression of both data is 0.67 and this is still above the value of 0.5. These results are in accordance with Aldabash *et al.* (2020), who validated MODIS and MERRA-2 data against AERONET observation data for the Turkish region, with validation results showing *a linear r-square* regression ranging from 0.6. Che *et al.* (2019) conducted AOD validation from MERRA-2 against AERONET observation data in China with a linear regression r-square result of around 0.8.

MERRA-2 reanalysis data is further used to analyze aerosol data (AOT) in the Kab. OKI, where in 2019, the average hours of AOT in the region (figure 3a) ranged from 0.01-0.4 in December - July 2019. There was an increase ranging from 0.35 to 0.8 in August - November 2019. The results of processing historical data AOT in 2009-2018 (figure 3b) show that the AOT value in 2019 was in the normal category to slightly above normal in the period January, March, May - September and November - December, and in the category below normal to normal in February, April, and October period in the northern Kab. OKI.

This increase in aerosols is directly proportional to the region's increase in land and forest fires. Figure 3c can prove this statement. The data displayed is obtained from MODIS satellite imagery results. The picture shows an increase in land and forest fires in the Kab. OKI in September-October-November 2019, with hotspots (hs) for all locations ranging from 50 – 600 hs. According to Kusumaningtyas *et al.* (2016), there is a strong correlation between increased land and forest fires to the increase in aerosol concentrations due to the burning of biomass which causes the accumulation of smoke particles in the atmosphere. Eck *et al.* (2019) have conducted research about aerosols due to land and forest fires in Kalimantan and Jambi during a strong El Nino (in 2015). The results of the study showed that the increase in aerosols began to rise in early August and began to fall in late November 2015.



(a)



Mean squared error : 0.03
Coefficient of determination: 0.67
Root Mean Square Error (RMSE): 0.18

(b)

Figure 2. Graphs (a) Time series AOT MERRA-2 and AERONET 550nm at Jambi location, (b) linear regression graphs AOT MERRA-2 and AERONET

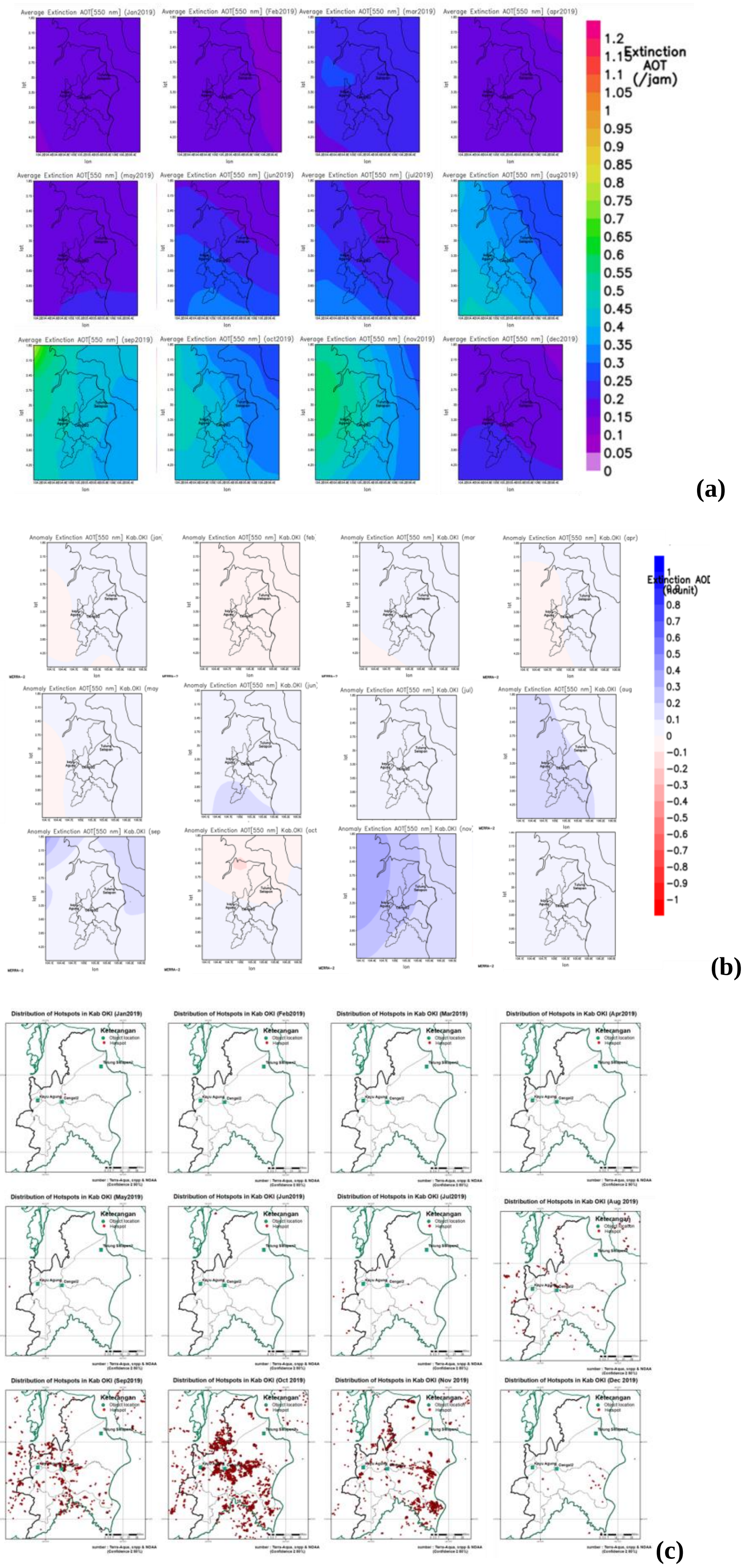
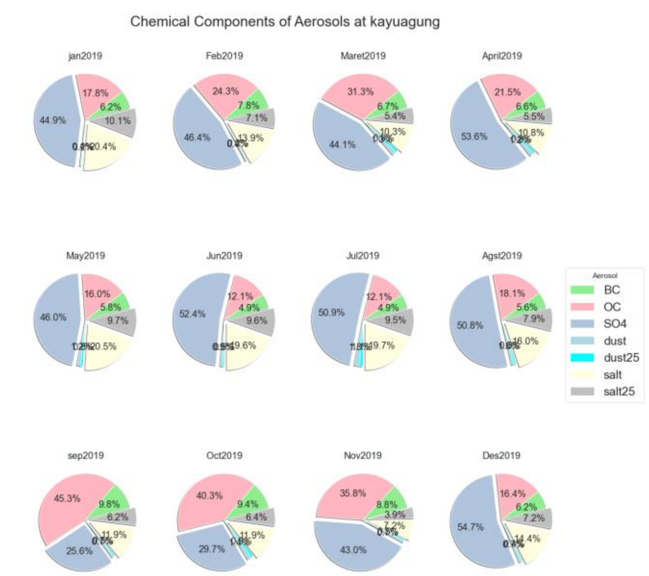


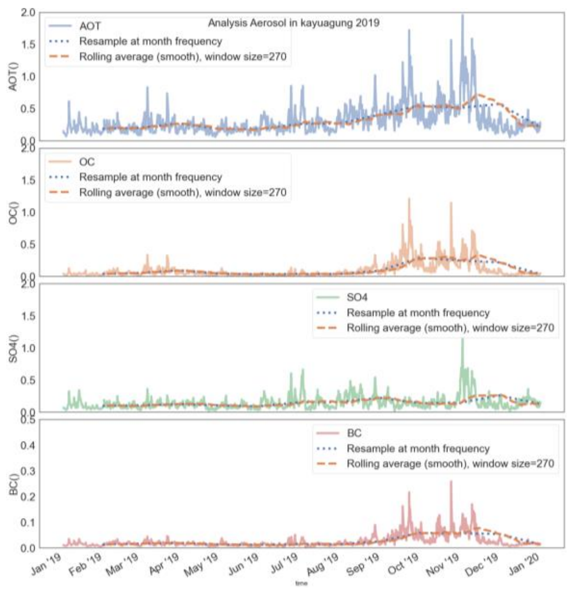
Figure 3. Spatial Data of AOT in the Kab. OKI; (a) average hours of AOT; (b) AOT anomalies; (c) Distribution of fire points.

The effect of land and forest fires on aerosol increases can also be observed in figure 4, which presents time series data and aerosol source data in the region. The time series data for three locations (Kayuagung, Cengal2, and Tulung Selapan 2) only presents data from noon to evening, from 02 UTC to 10 UTC, because the day to evening is the time of the convective process of cloud formation in the atmosphere. In the figure, the AOT value increased in the period July - November 2019, ranging from 1.0 - 2.0, with the highest value occurring on the end week of 2 until the end of September 2019 and the mid of third week of October 2019 until the first week of November 2019. The results of this measurement are in line with the results of the (Kusumaningtyas (2020), which measures the historical data AOT (July 2012 - June 2017) for the Jambi region. The highest value in the period September - November ranged from 1 - 1.63. However, when compared with the value of aerosols in urban areas (China), the AOT value is quite high, whereas the results of AOT measurements in the Chinese region by Che *et al.* (2015) range from 0.4 to 1.5.

From the MERRA-2 data, an analysis of chemical components from natural and anthropogenic sources can also be carried out at each location. The chemical components for natural aerosols consist of dust and sea salt, while the chemical components for anthropogenic aerosols that can be analyzed in this study consist of Black Carbon (BC), Organic Carbon (OC), and sulfuric acid (SO_4). During the period of a little land and forest fires, aerosol sources at the Kayuagung, Cengal2, and Tulung Selapan2 were dominated by chemical components consisting of SO_4, sea salt, and OC (figure 4). When land and forest fires begin to increase, the source of anthropogenic aerosols also increases. It is evidenced by the increase in chemical components consisting of OC and BC.

The increase occurred from mid-August to mid-November 2019. Increased AOT values for OC and BC indicate that in the region, there has been an increase in smoke particles with a size of ± 2.5 (PM2.5) due to land and forest fires. OC is a particulate containing carbon and hydrogen while BC is a particulate consisting of only carbon elements, OC is scattering radiation while BC is absorbing radiation, and the molecular weight of OC is lower than BC molecular weight (Jacobson, 2001). According to Reid *et al.* (2005), smoke particles consisting of 50-60% OC and 5-10% BC that will affect the radiative properties of the atmosphere because these particles can absorb and scatter solar radiation. At the time of the increase in land and forest fires at the three-research location, the AOT value for OC ranged from 0.3 to 1.2, and the AOT value for BC ranged from 0.1 to 0.35. This AOT value for anthropogenic sources (OC and BC) is quite high when compared to the study of Rizza *et al.* (2019), which conducted an analysis of anthropogenic aerosol sources for five industrial and metropolitan cities in Italy from 1986 to 2018, where the AOT value for OC and BC < 0.05 and the largest chemical component was SO4. It is also the same as chemical components from anthropogenic sources at the three-research location when land and forest fires do not occur





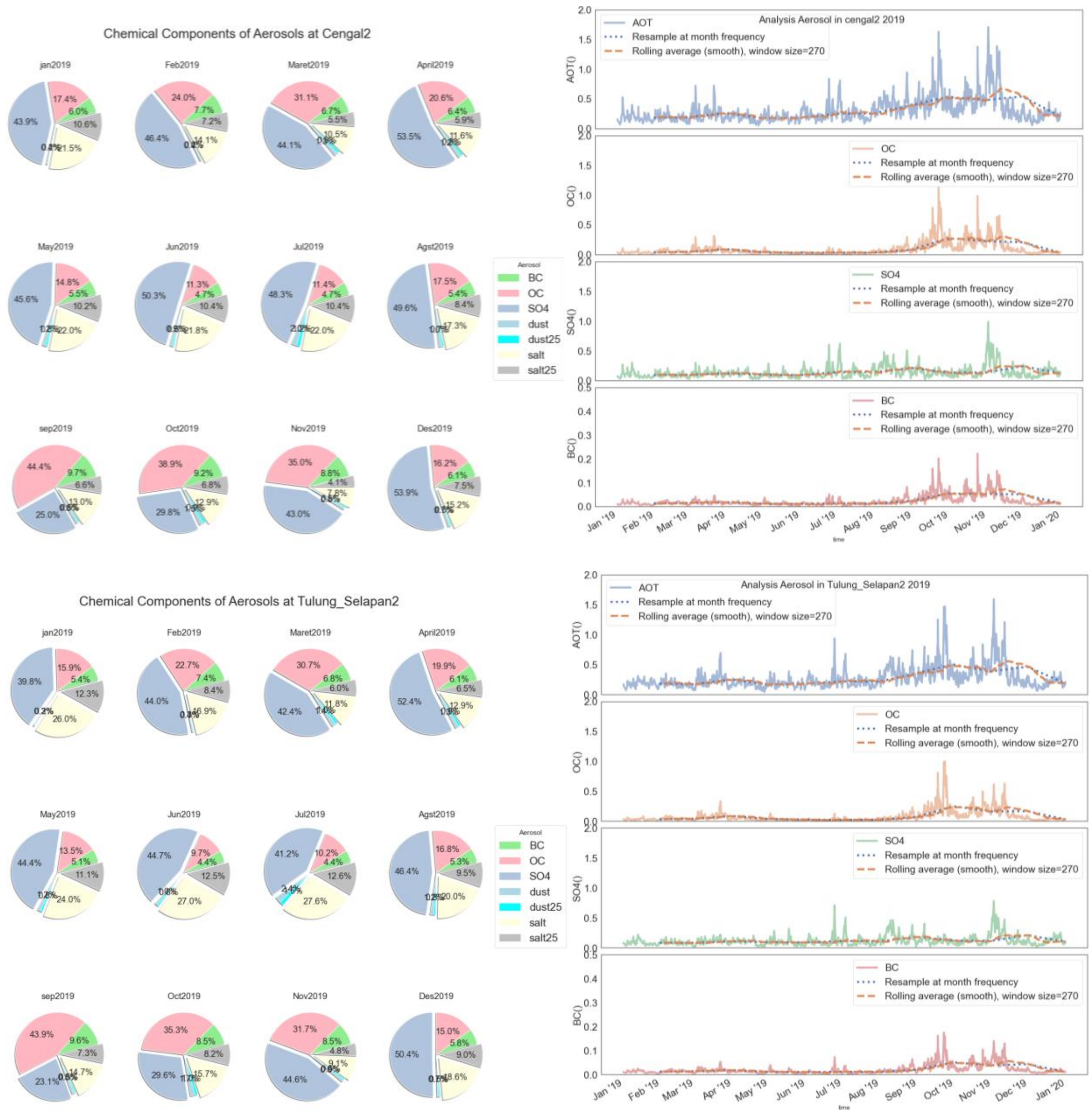


Figure 4. Analysis of total AOT and chemical components of aerosol anthropogenic (Organic Carbon (OC), Black Carbon (BC) and SO_4) in Kayuagung, Cengal2 and Tulung Selapan2.

The nature of absorbing and scattering radiation in aerosols causes disturbances in the atmosphere. This property will affect the radiative parameters that play an important role in cloud formation. In figure 5 (a1, b1, and c1) can be seen time series data at the locations of Kayuagung, Cengal2, and Tulung Selapan2 for radiative parameters (only presenting data from noon to evening, namely: from 02 UTC – 10 UTC), namely: surface net downward shortwave flux clear, sensible heat flux, latent heat flux, BLH, CIN and lcc (low cloud cover). The increase in aerosols associated with land and forest fires occurred from mid-August to early November 2019 (characterized by an increase in OC and BC aerosols). The relationship of increased AOT value to solar surface radiation is represented by time series surface net downward shortwave flux clear sky data (SWv_bc). In time series data for the 3rd locations, there was a decrease in the value of the SWv_bc, but it was not followed by an increase in the AOT that happened in June. This is because of the solstice of the sun, which is in June. The southern hemisphere will tend to stay away from the sun. So that it can cause solar radiation in the southern hemisphere region will be slightly reduced. The decrease in the value of the SWv_bc also occurs when there is an increase in AOT, characterized by a decrease in the value of SWv_bc by ± 10 - 25 Wm-2 (maximum value of 900-925 Wm-2 in the period January - March 2019 and a maximum value of 860 - 900 Wm-2 in the period August - November 2019). This indicates that there is a reduction in surface solar radiation by aerosols.

The increase in AOT also affects sensible heat flux and latent heat flux, which is an increase in sensible heat flux and a decrease in the latent heat flux. On the graph, there is an increase in sensible heat flux up to 400 Wm-2 and a reduction in latent heat flux up to 200 Wm-2 (sign – means leaving the surface). This results in an increase in heat by the body and is usually associated with surface heating effects of the return of thermal radiation energy (longwave radiation) to the surface, which can be seen from Aerosol Radiative Forcing (ARF) data.

Many studies have discussed this ARF, which states that if there is an increase in AOT, both aerosols that absorb radiation and aerosols that are scattering radiation will result in a negative ARF shortwave radiation ARF value and a positive value for ARF longwave radiation. Negative signs indicate cooling, and positive signs indicate warming (Huang *et al.,* 2006; Liu *et al.,* 2014; Rosida & Susanti, 2016). This is in accordance with the results of the analysis presented in figure 5 (a2, b2, and c2) of the time series graph of ARF shortwave radiation (SW_sfc), ARF of longwave radiation (LW_sfc) at the surface, and ARF of shortwave radiation (SW_TOA), ARF of longwave radiation (LW_TOA) at the top atmosphere in each location. For surface ARF in the period of increased AOT, the value of SW_sfc ranges from -50 Wm-2 to -250 Wm-2, and the value of the LW_sfc ranges from 1 Wm-2 to 5 Wm-2. Negative signs on SW_sfc indicate that there is a reduction in shortwave radiation reaching the surface, while a positive sign of LW_sfc indicates an increase in thermal radiation entering the surface.

Furthermore, for the top atmospheric ARF, SW_TOA values range from -20 Wm-2 to -80 Wm-2, and LW_TOA ranges from -0.5 Wm-2 to -1.75 Wm-2. A negative sign on the ARF-_TOA indicates cooling in the top atmosphere due to an increase in outgoing SW radiation and a reduction in incoming LW radiation (Hatzianastassiou *et al.,* 2007). This results in warming in the atmosphere due to the absorption of SW by aerosols, while more LW is reflected on the surface than on the top of the atmosphere. From this ARF analysis, aerosols due to land and forest fires can affect the process of cloud formation by reducing solar radiation to the surface, where solar radiation is absorbed by aerosols in the atmosphere resulting in warming in the atmosphere.

Planetary Boundary Layer (PBL) is a radiative parameter that is affected by the aerosol increase. Because PBL is the lower layer of the troposphere that still gets direct influence from the surface so it will be affected by the increased absorption and scattering of radiation by aerosols. The impact can lead to surface cooling that will affect conditions within the PBL, as well as atmospheric heating, which can warm the atmosphere above the PBL, leading to the formation of a stable layer or stamp inversion. Aerosol absorption in PBL will not result in increased heat by aerosol absorption and will not cause a decrease in PBL height, the decrease in altitude can be caused due to a decrease in sensible heat (Wang *et al.,* 2013; Li *et al.,* 2016).

Figure 5 (a1, b1, c1) shows that at the time of an increase in AOT, the value of boundary layer height (BLH) increases to reach a maximum value of 2500 m. This is in accordance with the research of Shikwambana (2019), which conducted BLH analysis in central Africa (CA), central South America (CSA), and East Asia (EA). The results showed that when there was an increase in OC and BC aerosols, BLH at CA and CSA locations reached the maximum value, while at EA locations which are industrial areas, the change in BLH values was relatively small. This increase in BLH value is followed by an increase in the base height of the low cloud (LCL) and a reduction in low cloud cover (lcc) which can be seen from the figure. As is known in the previous explanation above, PBL is a stable layer of the effect of aerosol absorption that can inhibit the occurrence of vertical movement, causing aerosols to be confined in PBL. Wang *et al.* (2013) explained that cooling the surface and the presence of this stable layer of the atmosphere can weaken the convective process of cloud formation as well as reduce Relative Humidity (RH) above the PBL layer, which will lead to cloud dissipation. Inhibition of vertical movement and weakening of convective processes at the time of increased AOT can be seen from the increase in the value of CIN (negative signs are inhibitory energy).

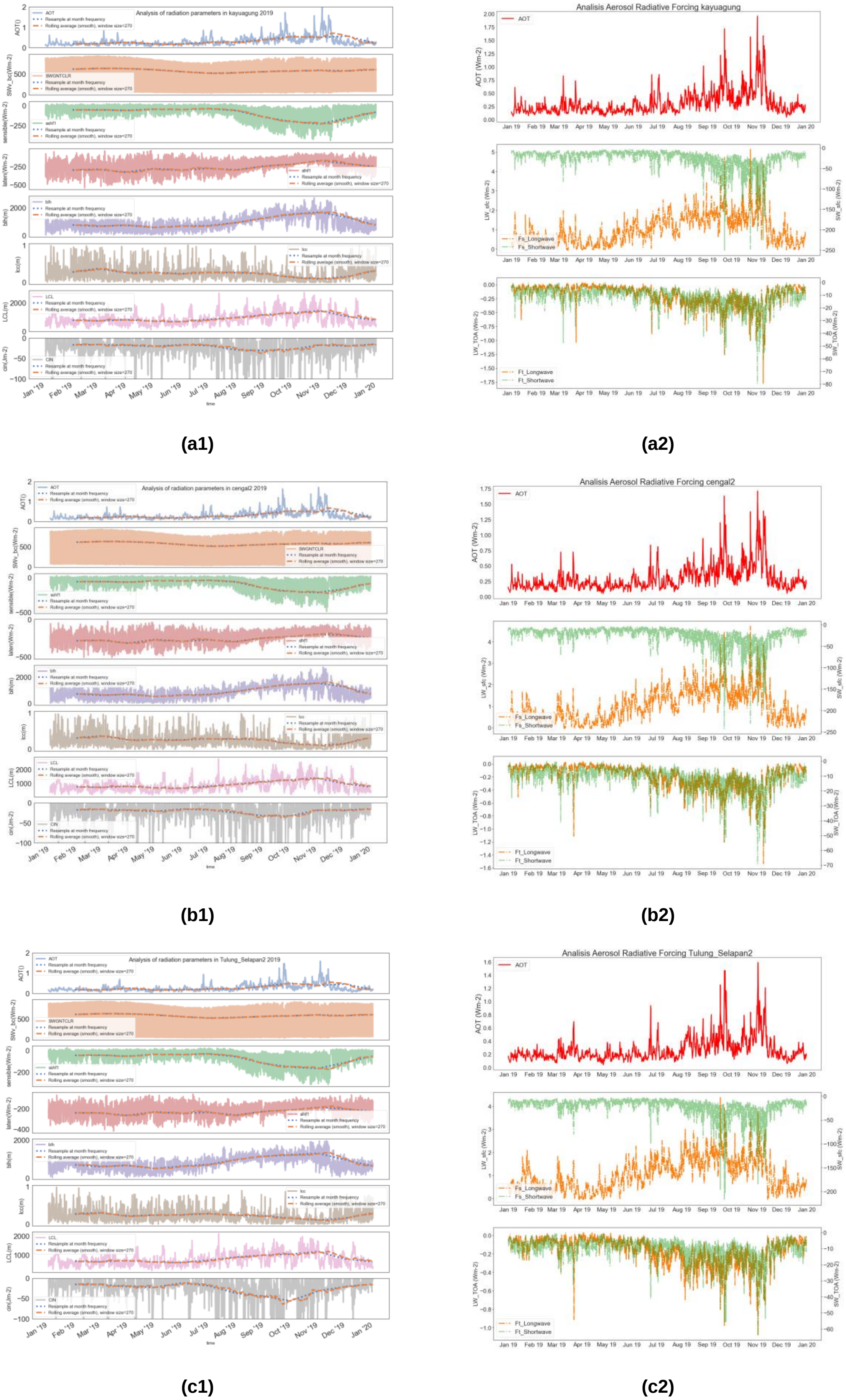


Figure 5. Time series analysis of Radiative parameters (a1, b1, c1) and Aerosol Radiative Forcing (a2, b2, c2) in Kayuagung (a), Cengal2 (b), and Tulung Selapan (c).

4. CONCLUSIONS

The increase in aerosols due to land and forest fires in Kayuagung, Cengal2, and Tulung Selapan2 occurred in the period July - November 2019, with AOT values ranging from 1.0 - 2.0. Land and forest fires are quite high at the location that occurred from the period August to November 2019, with the number of hotspots ranging from 50 to 600 Hs. This high land and forest fire are evidenced by an increase in AOT Organic Carbon (OC) ranging from 0.3 - 1.2 and AOT Black Carbon (BC) ranging from 0.1 - 0.35. The increase in aerosols causes surface cooling and atmospheric heating, which is characterized by reduced solar radiation values or surface net downward shortwave flux *clear sky* (SWv_bc), negative values from ARF SW_sfc, ARF SW_TOA, ARF LW_TOA, and positive values of ARF long wave radiation LW_sfc. A negative sign on the ARF indicates a reduction in energy. And a positive sign on the ARF indicates an increase in energy. The increase in AOT also *affects sensible heat flux and latent heat flux,* which is an increase in sensible value and a decrease in the latent value of heat flux. The graph shows an increase in sensible heat flux up to 400 Wm-2 and a reduction in latent heat fluxes up to 200 Wm-2. Boundary Layer Height (BLH) also increased to reach a maximum value of 2500 m during the period of increase in land and forest fires. This was followed by an increase in the base height of low clouds (LCL), a reduction in low cloud cover (lcc), and an increase in the value of *Convective Inhibition* (CIN). This parameter indicates a decrease in the formation of convective clouds.

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