

I-
a_and_Sea_Surface_Temperatu
re_in_the_Savu_Sea_Indonesia_
1.pdf
by

Submission date: 03-Mar-2022 07:18PM (UTC+0700)

Submission ID: 1775488898

File name: I-a_and_Sea_Surface_Temperature_in_the_Savu_Sea_Indonesia_1.pdf (1.33M)

Word count: 5606

Character count: 29753

Received September 10, 2021, accepted October 18, 2021, date of publication November 4, 2021, date of current version November 19, 2021.

Digital Object Identifier 10.1109/ACCESS.2021.3125605

Impacts of Tropical Cyclone Seroja on the Phytoplankton Chlorophyll-a and Sea Surface Temperature in the Savu Sea, Indonesia

RIZA YULIRATNO SETIAWAN¹, R. DWI SUSANTO², ANINDYA WIRASATRIYA^{3,4}, INOVASITA ALIFDINI⁵, ARDIANSYAH DESMONT PURYAJATI³, LILIK MASLUKAH³, AND NURJANNAH NURDIN⁶

¹Department of Fisheries, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia

²Department of Atmospheric and Oceanic Science, University of Maryland, College Park, MD 20742, USA

³Department of Oceanography, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang 50275, Indonesia

⁴Coastal and Ocean Remote Sensing Laboratory, Center for Coastal Rehabilitation and Disaster Mitigation Studies, Diponegoro University, Semarang 50275, Indonesia

⁵Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

⁶Department of Marine Science, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar 90245, Indonesia

Corresponding author: Riza Yuliratno Setiawan (riza.y.setiawan@ugm.ac.id)

This work was supported by the Universitas Gadjah Mada Under Grant 1519/UN1/DITLIT/DIT-LIT/PT/2020. Anindya Wirasatriya and R. Dwi Susanto thank to World Class Professor Program supported by the Ministry of Education, Culture, Research, and Technology, Indonesia.

ABSTRACT Tropical cyclone (TC) Seroja was a rare climatic event in the Indonesian Seas, particularly in the Savu Sea. This unprecedented event, which occurred on April 4, 2021, caused fatalities and severe damage to the region's infrastructure and economy. High spatio-temporal resolution satellite measurements of surface winds (Cross-Calibrated Multi-Platform), surface chlorophyll-a (Himawari-8), and sea surface temperature (SST; RSS OISST) are used to disentangle the impact of extreme wind speed ($> 10 \text{ m}\cdot\text{s}^{-1}$) on chlorophyll-a and SST. High wind speed associated with TC Seroja induced strong upwelling and vertical mixing in the Savu Sea, which led to phytoplankton blooms and SST depression. An abrupt change of daily variability and positive anomaly in phytoplankton chlorophyll-a concentrations reaches $13 \text{ mg}\cdot\text{m}^{-3}$ and $0.3 \text{ mg}\cdot\text{m}^{-3}$, respectively. At the same time, the SST shows significant cooling up to 3°C . Our results provide novel insights on the exceptional occurrence of a TC within the Indonesian Seas and highlight its impact on chlorophyll-a and SST.

INDEX TERMS Tropical cyclone Seroja, chlorophyll-a, sea surface temperature, Savu Sea.

I. INTRODUCTION

The effect of global climate change on the Indonesian Seas has been prominent during the last decade, mainly through tropical cyclones (TCs). Due to its proximity to the equator, the occurrence of TCs within the Indonesian Seas is quite rare [e.g., 1]. Nevertheless, several TCs have evolved in the ocean region adjacent to the Indonesian Seas, especially in the southeastern tropical Indian Ocean, like Angrek (October 31 – November 4, 2010), Bakung (December 10 – 13, 2014), Cempaka (November 25 – 27, 2017), and Dahlia (November 27 – December 2, 2017) [2]–[6]. The two

consecutive TCs, Cempaka and Dahlia, have caused catastrophic damages to life, the environment, and the economy [7]. A simulation study by [8] demonstrates that these TCs have significantly increased wave heights in the coastal regions of south Java and Lombok. According to [5], TC Dahlia has altered the thermal stratification of the upper ocean of the southeastern tropical Indian Ocean by lowering the SST ($> 1.5^\circ\text{C}$). In addition to the effect of TCs on the oceans, some studies have revealed a positive correlation between a TC and an increase of chlorophyll-a concentration via upwelling and vertical mixing [8]–[13]. Though, based on the global model, most of the TCs do not induce chlorophyll-a bloom except in limited areas of the world ($\sim 1\%$), including northeastern Australia [14]. TC Seroja

The associate editor coordinating the review of this manuscript and approving it for publication was Jiajia Jiang.

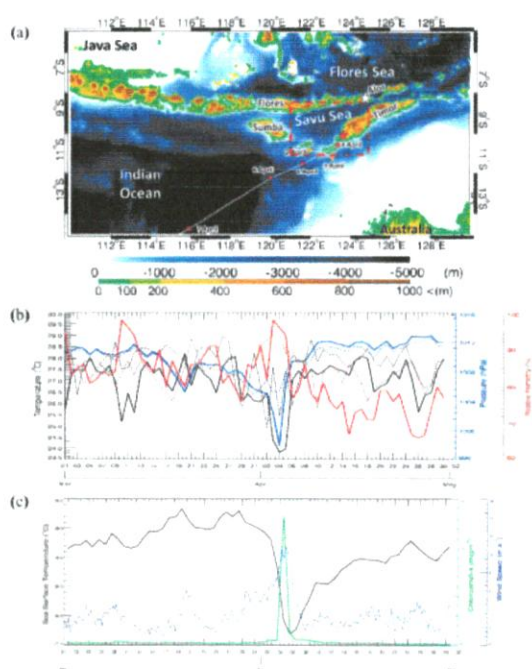


FIGURE 1. (a) Map of the Savu Sea, bathymetry (m), land topography (m), and track of TC Seroja. The orange and red circles denote the early development stage and mature stage, respectively (b) Time series of air temperature (°C), relative humidity (%), and air pressure (hPa) at meteorological station at Kupang (red star) and Alor (Orange star). (c) Time series of SST, chlorophyll-a concentration, and wind speed of the Savu Sea (average area is 121 - 125° E; 8 - 11° S; red dash box).

developed in southeastern Indonesia in one such limited region. Unfortunately, the effect of TCs on the phytoplankton chlorophyll-a concentration in the vicinity of the Indonesian Seas has been less examined, with the only study conducted by [6], hence an investigation on the relation between TCs and tropical primary productivity in the region is a top priority.

The Savu Sea is a semi-enclosed deep sea with a bathymetry of more than 1,000 m. As part of the Lesser Sunda Islands, the Savu Sea is surrounded by Flores Island, Alor Island, Timor Island, Rote Island, Savu Island, and Sumba Island [Fig. 1a]. The geographic position of the Savu Sea, which is located nearby the equator and enclosed by islands, theoretically makes the generation of TC impossible. TC could be generated only on the wide ocean between 10° - 20° N/S [15]. Nevertheless, on April 4, 2021, a TC called Seroja had formed within the Indonesian Seas and struck the Savu Sea with a maximum wind speed of about 80 km/h [16]. This unprecedented event has caused severe impacts and fatalities in the Lesser Sunda Islands and Australian regions. The consequence of TC Seroja on the Savu Sea and ocean region off the Lesser Sunda Islands remains elusive. Typically, the seasonal and interannual dynamics of the Savu Sea are affected by the Australia Indonesia Monsoon, Indonesian

throughflow, and the El Niño-Southern Oscillation (ENSO), as well as the Indian Ocean Dipole (IOD) [17]–[22]. These climate events have played a prominent role in determining sea surface temperature (SST) and surface phytoplankton chlorophyll-a concentration in the Savu Sea and ocean region off the Lesser Sunda Islands [17], [19]–[20], [22]. Specifically, the southeasterly winds during the Austral winter (June-September) generate significant SST cooling and increased chlorophyll-a due to an increase in Ekman transport, which enhances ocean surface productivity [20]. This condition is further intensified when the El Niño and the positive IOD occur at the same time. In contrast, during the Austral summer (December-February), the northwesterly winds induce an oligotrophic condition in the upper ocean due to the winds' favor downwelling. Intense downwelling events happen during the La Niña and the negative IOD [19], [20].

The Savu Sea has experienced extraordinary oceanographic and meteorological conditions due to the development of TC Seroja. In this research, we attempt to decipher the impact of TC Seroja on the phytoplankton chlorophyll-a concentration in the Savu Sea by analyzing high spatial and temporal resolutions of satellite-derived surface chlorophyll-a, SST, and surface wind. The present research is the earliest investigation on the evidence of elevated surface chlorophyll-a concentration within the Indonesian Seas generated by a TC.

II. MATERIALS AND METHODS

A. SURFACE WIND

To understand the physical forcing of TC Seroja, we analyzed the surface wind data obtained from the Cross-Calibrated Multi-Platform (CCMP) gridded surface vector winds version 2.0 for the period of 31 March-15 April 2021. This dataset can be downloaded from <https://www.remss.com/measurements/cmp/> (accessed on September 9, 2021). The CCMP used level-3 ocean wind vector product generated from various satellites, moored buoy, and model wind data. The surface wind data's temporal and spatial resolutions are six hourly and 0.25° × 0.25°, respectively. The accuracy of CCMP is higher than the other wind reanalysis data. We calculated the Ekman Pumping Velocity (EPV) by using the following formula [24]:

$$\bar{\tau} = \rho_a C_d U_{10}^2 \quad (1)$$

where ρ_a is the density of air (1.25 kg m^{-3}), C_d is the drag coefficient, and U_{10} is the wind speed 10 m above sea level. We used an equation of [25] to determine the drag coefficient as follows:

$$1000C_d = 1.29 \quad \text{for } 0 < U_{10} < 7.5 \text{ m} \cdot \text{s}^{-1} \quad (2a)$$

$$1000C_d = 0.8 + 0.0065U_{10} \quad \text{for } 7.5 < U_{10} < 50 \text{ m} \cdot \text{s}^{-1} \quad (2b)$$

$$\text{curl} = \frac{\partial \tau_y}{\partial x} - \frac{\partial \tau_x}{\partial y} \quad (3)$$

$$EPV = -\frac{curl}{\rho_w f} \quad (4)$$

where f is the Coriolis parameter and ρ_w is the density of seawater calculated using an equation of [26]. The EPV's unit is $m \cdot s^{-1}$.

B. SURFACE CHLOROPHYLL-A CONCENTRATION

The surface chlorophyll-a data employed in this research is a daily satellite image of the Himawari-8 Level 3 (<https://www.rc.jaxa.jp/tree/>) (accessed on June 3, 2021). The image has a spatial resolution of 5×5 km and a daily temporal resolution [27]. We will plot daily surface chlorophyll-a for the Savu Sea from March 1 to April 30, 2021, to depict the response of phytoplankton chlorophyll-a to TC Seroja.

C. SEA SURFACE TEMPERATURE (SST)

We analyzed the Optimally Interpolated (OI) SST daily products obtained from the Remote Sensing System (<http://www.remss.com/measurements/sea-surface-temperature/>) (accessed on September 9, 2021). Specially, we computed the 9 km microwave-infrared OI SST product, which has a daily temporal resolution, to discriminate the SST reaction to TC Seroja.

D. SEA LEVEL PRESSURE (SLP)

The hourly SLP data was obtained from the European Re-analysis (ERA) 5 produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) with a grid interval of 0.25° [28]. The data are available at <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=form> (accessed on June 3, 2021). The hourly data were averaged into daily data.

E. OBSERVATIONAL DATA

We used observational data from the weather stations operated by the Indonesian Agency of Meteorology, Climatology, and Geophysics (BMKG) at Kupang City and Alor Island as denoted by red and orange stars in Fig. 1a, respectively. The analyzed parameters were air temperature, relative humidity, air pressure. Air temperature and air pressure data can be obtained from the National Centers for Environmental Information (NCEI) of the National Oceanic and Atmospheric Administration (NOAA), while the relative humidity data is available at <https://dataonline.bmkg.go.id/home>.

In order to better understand the impact of TC Seroja on the ocean parameters above, we computed the daily anomaly of the wind speed, chlorophyll-a concentration, SST, and EPV from March 31 to April 15, 2021 to represent prior, during, and after the passages of TC Seroja. The period for climatological calculation was from 2015 to 2021.

III. RESULTS AND DISCUSSION

A. THE FORMATION OF TC SEROJA

Fig. 2 exhibits the development of the TC Seroja. On March 31, intense easterly winds appeared at the eastern

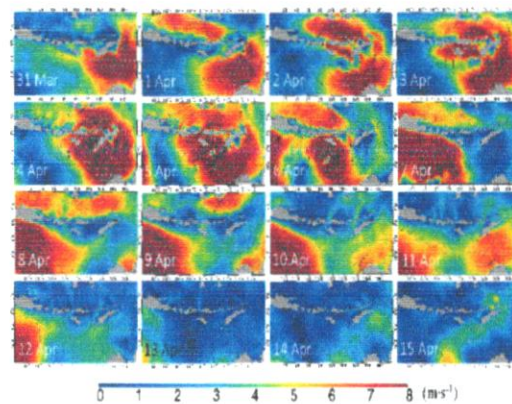


FIGURE 2. Anomaly maps of wind speed ($m \cdot s^{-1}$) from March 31 to April 15, 2021.

Timor Island, followed by the formation of a depression zone at the eastern Timor and the Savu Sea on April 1 as denoted by low SLP by less than 1,005.2 hPa. On April 2, significant positive wind speed anomalies were observed in the Savu Sea, the Flores Sea, and the ocean region off northern Australia. Meanwhile, the depression zone shrinks and strengthens, forming a low-pressure system centered at the Savu Island. The low-pressure systems on April 2-3 generated a cyclonic wind pattern, which was the early developmental stage of TC Seroja. The translation speed of TC Seroja during this time was ~ 5.7 $km \cdot hr^{-1}$ (Table 1). TC Seroja was fully developed over the Savu Sea on April 4 and persisted until April 6 as denoted by the anomaly of cyclonic wind speed by more than $8 m \cdot s^{-1}$ and low SLP by less than 1,000 hPa at the eye/core of TC. On April 7, TC Seroja moved southwestward with a translation speed between 18 and 22.1 $km \cdot hr^{-1}$. From April 7 to 15, the Savu Sea was characterized by weak wind speeds. The track and translation speed of TC Seroja are summarized in Fig. 1a and Table 1.

The formation of a low-pressure system cannot separate the generation of TC Seroja that occurred at the southern Savu Sea. The observational evidence of the formation of this low-pressure system is depicted by the variation of air pressure at the meteorological station at Kupang City, which is located nearby the center of TC Seroja (Fig. 1b). On March 21, the air pressure started to decrease and drop, indicating the early development stage of TC Seroja. The lowest air pressure occurred on April 4, reaching 998 hPa at the mature stage of TC Seroja. After that, the air pressure increased along with the southwestward movement of TC Seroja leaving the Savu Sea. The drop of air pressure before TC Seroja may correspond to the rise of relative humidity. As the relative humidity increased, the air became lighter, reducing the air pressure. In contrast, the air temperature may play a pivotal role as the impact of TC Seroja was robust since the air temperature decreased (increased) following the decline (acceleration) of air pressure before (after) the mature stage

TABLE 1. The translation speed of TC Seroja and statistics of the investigated parameters.

Date	Distance (km)	Velocity (km·hr ⁻¹)
2-3 April 2021	137.4	5.7
3-4 April 2021	82.1	3.4
4-5 April 2021	217.6	9.1
5-6 April 2021	191.4	8
6-7 April 2021	529.3	22.1
7-8 April 2021	454.3	18.9

Parameter	Mean	Standard Deviation
Wind speed (m·s ⁻¹)	3.3	1.7
SST (°C)	29.1	0.4
Chlorophyll-a (mg·m ⁻³)	0.4	1.6
EPV (m·s ⁻¹)	3.7	69.2

of the cyclone. The increasing wind speed (Fig. 1c) and the decreasing air pressure during the development of TC Seroja may cool the surface air temperature. The same indication is also found in the Alor meteorological station, which TC Seroja also impacted. The decrease (increase) of air pressure before (after) the mature stage of TC Seroja corresponded to the increase (decrease) of the relative humidity in the lower amplitude. Furthermore, the importance of humidity for TC generation has been well simulated by previous studies, e.g. [29]–[31]. TCs develop more quickly and become more intense in a moist environment [29]. Accumulated TC during dry environmental conditions exhibits reduced precipitation outside TC core, a narrower potential vorticity distribution, and reduced lateral extension of the wind field relative to storms in more moist environments [30]. Thus, the increase of relative humidity from March 29 to April 4 may play a vital role in developing TC Seroja, which is theoretically difficult to form in this area. Further analysis is needed to prove this hypothesis. Moreover, the formation of the low-pressure system may also correspond to the SST warming, which is observed in the Savu Sea from March 1 to 29 (Fig. 1c). The peak of SST warming reached 29.8°C on March 20 and 29. This warm SST may induce air temperature warming, which reduces SLP. However, the detail of TC Seroja formation is beyond the present research's scope, which focuses on the impact of TC Seroja on the variability of chlorophyll-a and SST in the Savu Sea. This task will be explored in our future study.

B. THE EFFECT OF TC SEROJA ON THE CHLOROPHYLL-A AND SST IN THE SAVU SEA

The analyses of surface wind speed and chlorophyll-a anomalies (Fig. 2 and 3) demonstrated that the strong winds associated with TC Seroja are the primary forcing for the positive anomaly of phytoplankton chlorophyll-a concentration (~3 mg·m⁻³) in the Savu Sea as well as in the adjacent

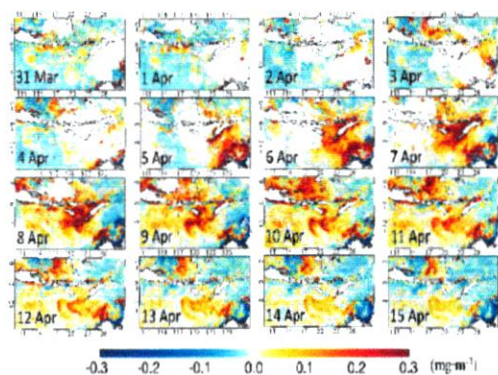


FIGURE 3. Anomaly maps of phytoplankton chlorophyll-a concentration (mg·m⁻³) from March 31 to April 15, 2021.

seas from April 6 to 12 (Fig. 3). The absence of chlorophyll-a concentration data from April 1 to 5 was mainly due to cloud cover over the studied area. Fig. 2 shows a strong wind anomaly (> 9 m·s⁻¹) in the Savu Sea with its most significant spatial extent on April 4-5. During normal conditions, monsoon winds do not favor a phytoplankton chlorophyll-a bloom in the region. A robust effect of TC Seroja winds is also apparent on the SST anomaly as there is a prominent SST decline (up to 3°C) in the region of interest at the same period (Fig. 4). Thus, in the early development of TC Seroja, the warmer SST contributed to the development of TC, but then when the TC was fully developed, the SST was impacted by the TC. Indeed, our novel results provide robust evidence on the consequence of TC Seroja on the sea surface due to the position and timing of the strong winds are congruent with the location and timing of the phytoplankton chlorophyll-a blooms and SST depressions. TC Seroja likely triggered the injection of nutrients from the deeper layer to the euphotic layer, possibly via upwelling and mixing, which led to primary productivity enhancements of the ocean surfaces of the Savu Sea and its surrounding sea. Daily observation of the three parameters in the Savu Sea also shows good conformity, suggesting TC Seroja wind (> 10 m·s⁻¹) is the primary driver for the phytoplankton chlorophyll-a maximum (> 12 mg·m⁻³) and SST minimum (< 28°C) in the Savu Sea (Fig. 1c). The rapid chlorophyll-a fluctuation may also be related to the translation speed of TC Seroja (Table 1). From April 2 to 3, the translation speed was 5.73 km·hr⁻¹. Then from April 3 to 4, when the wind speed reached maximum over the Savu Sea, the translation speed was only 3.42 km/hr. The strong wind persisted longer in the Savu Sea, which then effectively generated nutrient enrichment. Moreover, since the Savu Sea is semi-enclosed, this escalating nutrient was not flushed away by current as usually occurs in the open ocean. The large (weak) changes of SST and chlorophyll-a associated with typhoons correspond to the high (low) wind speeds and slow (fast) translation speeds [13].

Fig. 1c inarguably suggests the abrupt change in phytoplankton chlorophyll-a concentration is a direct ocean

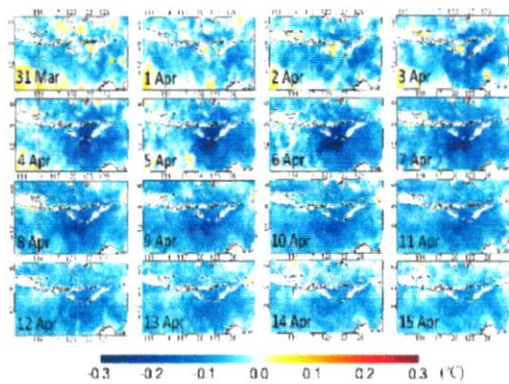


FIGURE 4. Anomaly maps of SST ($^{\circ}\text{C}$) from March 31 to April 15, 2021.

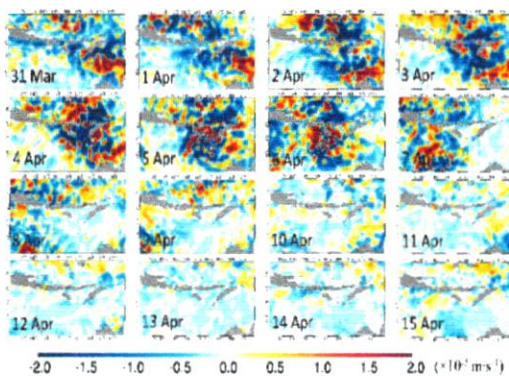


FIGURE 5. Anomaly maps of EPV ($\text{m}\cdot\text{s}^{-1}$) from March 31 to April 15, 2021.

surface response to TC Seroja-induced upwelling and mixing in the Savu Sea. The increased chlorophyll-a during TC Seroja was significantly greater compared to Cempaka and Dahlia Cyclones (November 25 to December 2, 2017) in the southern Java of the Indian Ocean. The chlorophyll-a maximum during Cempaka and Dahlia Cyclones was only $0.16 \text{ mg}\cdot\text{m}^{-3}$ [6]. Thus, the present study demonstrates an extreme chlorophyll-a bloom as a result of a TC occurrence in a semi-enclosed sea. However, noting that the chlorophyll-a data is retrieved from the visible bands, which are limited during heavy cloudy conditions under TC occurrences, the chlorophyll-a on April 4 in Fig. 1c is obtained only based on the mean value of seven grids within the dashed red box depicted in Fig. 1a.

The EPV anomaly analysis, as illustrated in Fig. 5, delineates convincing evidence on the episodes of upwelling due to TC Seroja. Negative EPV anomalies suggest upwelling, with the most substantial upwelling, occurred on April 4. Interestingly, although the EPV anomaly values were usually zero from April 7 to 11, the ocean surface of the Savu Sea was still dominated by positive anomalies of phytoplankton chlorophyll-a concentration (up to $0.3 \text{ mg}\cdot\text{m}^{-3}$) and

negative SST anomalies (up to -3°C) during this time frame. It is unlikely that the positive anomaly of phytoplankton chlorophyll-a concentration resulted from wind mixing and terrestrial nutrient input because the wind showed a low speed and seasonally nutrient fluxes from the continental runoff into the Savu Sea are negligible [16]. Instead, we postulate that it resulted from vigorous upwelling that can substantially uplift the nutricline and thermocline, which led to increases in phytoplankton chlorophyll-a concentrations after the passage of TC Seroja. The abundance of nutrients in the Savu Sea after the passage of TC Seroja may indicate that the phytoplankton needs time to grow. It is difficult to quantify the contribution of upwelling and mixing in perturbing the upper ocean structure in the present research as the Savu Sea lacked long-term in situ measurement. Thus, it is noteworthy to investigate such disturbance in future studies using the ocean model. A diagnostic analysis of observational and simulation data would give insight into TC Seroja on the vertical profile of the Savu Sea, as TC Seroja may have significantly impacted biogeochemical processes like carbon fixation [32], [33].

IV. CONCLUSION

In the present research, the impacts of TC Seroja on phytoplankton chlorophyll-a concentration and SST in the Savu Sea were investigated using satellite remote sensing data. The formation of TC Seroja was well captured by satellite-derived surface wind speed. The early development of TC Seroja was started on April 2 and peak on April 4. A low-pressure system was formed during the development of TC Seroja and possibly was influenced by an increase in the relative humidity within the study area. The effect of the TC Seroja was also accurately documented by satellite-derived surface chlorophyll-a concentration and SST. Daily variations and anomalies of surface wind, chlorophyll-a concentration, SST, and EPV show a robust congruency. The strong wind associated with TC Seroja was a predominant driving force for the phytoplankton chlorophyll-a maxima and SST cooling in the Savu Sea, perhaps via upwelling and water column mixing. The extent that upwelling and mixing deteriorates water column stratification of the Savu Sea be investigated in our future research using numerical simulation. Nevertheless, our results can be used as a reference for future studies concerning the impact of TC on the Indonesian Seas.

ACKNOWLEDGMENT

The authors would like to thank the E.U. Copernicus Marine Service Information (<https://marine.copernicus.eu/>), Remote Sensing Systems and NASA (www.remss.com), and Japan Meteorological Agency (https://www.eorc.jaxa.jp/tree/registration_top.html). RYS thanks to Venny Nasution for the strong supports.

REFERENCES

- [1] M. D. Yamanaka, S.-Y. Ogino, P.-M. Wu, H. J. Ichi, S. Mori, J. Matsumoto, and F. Syamsudin, "Maritime continent coastlines controlling Earth's climate," *Prog. Earth Planet. Sci.*, vol. 5, no. 21, p. 21, Apr. 2018, doi: 10.1186/s40645-018-0174-9.

- [2] L. Paterson, *Tropical Low AU1011_01U (Anggrek)*. Bur. Meteorology, Australia. Accessed: May 29, 2012. [Online]. Available: <http://www.bom.gov.au/cyclone/history/pdf/anggrek.pdf>
- [3] R. Gutro, *Bakung (Southern Indian Ocean)*. NASA's Goddard Space Flight Center, USA. Accessed: Dec. 16, 2014. [Online]. Available: <https://www.nasa.gov/content/goddard/bakung-southern-indian-ocean/>
- [4] G. Samodra, N. Ngadish, M. N. Malawani, D. Mardiatno, A. Cahyadi, and F. S. Nugroho, "Frequency-magnitude of landslides affected by the 27–29 November 2017 tropical cyclone Cempaka in Pacitan, East Java." *J. Mountain Sci.*, vol. 17, pp. 773–786, Apr. 2020, doi: [10.1007/s11629-019-5734-y](https://doi.org/10.1007/s11629-019-5734-y).
- [5] Y. Yang, L. Liu, K. Liu, W. Yu, and H. Wang, "Diurnal Sea surface temperature response to tropical cyclone Dahlia in the Eastern tropical Indian Ocean in 2017 revealed by the Bailong buoy." *Dyn. Atmos. Oceans*, vol. 92, Dec. 2020, Art. no. 101163, doi: [10.1016/j.dynatmocc.2020.101163](https://doi.org/10.1016/j.dynatmocc.2020.101163).
- [6] H. N. Aditya, A. Wirasatriya, Kumarso, D. H. Ismunarti, A. Rifai, A. Ismanto, and R. Widiaratih, "Impact of tropical Cyclones Cempaka and Dahlia to the variability of chlorophyll-a and sea surface temperature in the Seas Southern Coast of Java Island." *Eco. Env. Cons.*, vol. 27, pp. S379–S387, Aug. 2021. [Online]. Available: http://www.envirobiotechjournals.com/article_abstract.php?aid=11625&iid=334&jid=3
- [7] J. Globe, *Tropical Cyclone Cempaka Kills 19 on Java Island*. Accessed: Nov. 29, 2017. [Online]. Available: <https://jakartaglobe.id/news/tropical-cyclone-cempaka-kills-19-on-java-island/>
- [8] W. Windupranata, C. A. D. S. Nusantara, D. D. Wijaya, and K. Prijatna, "Impact analysis of tropical cyclone cempaka-dahlia on wave heights in Indonesian waters from numerical model and altimetry satellite." *KnE Eng.*, vol. 4, no. 3, pp. 203–214, Dec. 2019, doi: [10.18502/knE.v4i3.5851](https://doi.org/10.18502/knE.v4i3.5851).
- [9] I. Lin, W. T. Liu, C.-C. Wu, G. T. F. Wong, C. Hu, Z. Chen, W.-D. Liang, Y. Yang, and K.-K. Liu, "New evidence for enhanced ocean primary production triggered by tropical cyclone." *Geophys. Res. Lett.*, vol. 30, no. 13, p. 1718, Jul. 2003, doi: [10.1029/2003GL017141](https://doi.org/10.1029/2003GL017141).
- [10] P. R. C. Reddy, P. S. Salvekar, and S. Nayak, "Super cyclone induces a mesoscale phytoplankton Bloom in the Bay of Bengal." *IEEE Geosci. Remote Sens. Lett.*, vol. 5, no. 4, pp. 588–592, Oct. 2008, doi: [10.1109/LGRS.2008.2000650](https://doi.org/10.1109/LGRS.2008.2000650).
- [11] L. Sun, Y. Yang, T. Xian, Z. Lu, and Y. Fu, "Strong enhancement of chlorophyll a concentration by a weak typhoon." *Mar. Ecol. Prog. Ser.*, vol. 404, pp. 39–50, Apr. 2010, doi: [10.3354/meps08477](https://doi.org/10.3354/meps08477).
- [12] H. Zhao, J. Shao, G. Han, D. Yang, and J. Lv, "Influence of typhoon Matsa on phytoplankton chlorophyll-a off East China." *PLoS ONE*, vol. 10, no. 9, Sep. 2015, Art. no. e0137863, doi: [10.1371/journal.pone.0137863](https://doi.org/10.1371/journal.pone.0137863).
- [13] Y. Wang, "Composite of typhoon-induced sea surface temperature and chlorophyll-a responses in the South China sea." *J. Geophys. Res.: Oceans*, vol. 125, no. 10, Oct. 2020, Art. no. e2020JC016243, doi: [10.1029/2020JC016243](https://doi.org/10.1029/2020JC016243).
- [14] C. E. Menkes, M. Lengaige, M. Lévy, C. Ethé, L. Bopp, O. Aumont, E. Vincent, J. Vialard, and S. Jullien, "Global impact of tropical cyclones on primary production." *Global Biogeochem. Cycles*, vol. 30, no. 5, pp. 767–786, May 2016, doi: [10.1002/2015GB005214](https://doi.org/10.1002/2015GB005214).
- [15] S. Nieuwolt, *Tropical Climatology: An Introduction to the Climates of the Low Latitudes*. Hoboken, NJ, USA: Wiley, 1977, p. 207.
- [16] BMKG, *Update on the Development of Tropical Cyclone Seroja and the Growth of Tropical cyclone Odette*. Accessed: Apr. 9, 2021. [Online]. Available: https://cdn.bmkg.go.id/web/Siaran-Pers-TC-Odette_90S_20210409_00UTC_edit-KMU.pdf
- [17] M. R. Muskananfolo and A. Wirasatriya, "Spatio-temporal distribution of chlorophyll-a concentration, sea surface temperature and wind speed using aqua-modis satellite imagery over the Savu Sea, Indonesia." *Remote Sens. Appl., Soc. Environ.*, vol. 22, Apr. 2021, Art. no. 100483, doi: [10.1016/j.rsase.2021.100483](https://doi.org/10.1016/j.rsase.2021.100483).
- [18] I. Alifidini, T. Shimada, and A. Wirasatriya, "Seasonal distribution and variability of surface winds in the Indonesian seas using scatterometer and reanalysis data." *Int. J. Climatol.*, vol. 41, no. 10, pp. 4825–4843, Aug. 2021, doi: [10.1002/joc.7101](https://doi.org/10.1002/joc.7101).
- [19] E. Siswanto, T. Horii, I. Iskandar, J. L. Gaol, R. Y. Setiawan, and R. D. Susanto, "Impacts of climate changes on the phytoplankton biomass of the Indonesian maritime continent." *J. Mar. Syst.*, vol. 212, Dec. 2020, Art. no. 103451, doi: [10.1016/j.jmarsys.2020.103451](https://doi.org/10.1016/j.jmarsys.2020.103451).
- [20] R. Y. Setiawan, E. Setyobudi, A. Wirasatriya, A. S. Muttaqin, and I. Maslukab, "The influence of seasonal and interannual variability on surface chlorophyll-a off the western lesser Sunda islands." *IEEE J. Sel. Topics Appl. Earth Observ. Remote Sens.*, vol. 12, no. 11, pp. 4191–4197, Nov. 2019, doi: [10.1109/JSTARS.2019.2948385](https://doi.org/10.1109/JSTARS.2019.2948385).
- [21] J. Sprintall, A. L. Gordon, S. E. Wijffels, and M. Feng, "Detecting change in Indonesian seas." *Frontiers Mar. Sci.*, vol. 6, p. 549, Sep. 2019, doi: [10.3389/fmars.2019.00549](https://doi.org/10.3389/fmars.2019.00549).
- [22] N. S. Ningsih, N. Rakhmaputeri, and A. B. Harto, "Upwelling variability along the southern coast of Bali and in Nusa Tenggara waters." *Ocean Sci. J.*, vol. 48, no. 1, pp. 49–57, Mar. 2013, doi: [10.1007/s12601-013-0004-3](https://doi.org/10.1007/s12601-013-0004-3).
- [23] R. Atlas, N. Hoffman, J. Ardizzone, S. M. Leidner, J. C. Jusem, D. K. Smith, and D. Gombos, "A cross-calibrated, multiplatform ocean surface wind velocity product for meteorological and oceanographic applications." *Bull. Amer. Meteorol. Soc.*, vol. 92, no. 2, pp. 157–174, Feb. 2011, doi: [10.1175/2010BAMS2946.1](https://doi.org/10.1175/2010BAMS2946.1).
- [24] A. Wirasatriya, J. D. Setiawan, D. N. Sugianto, I. A. Rosyadi, H. Haryadi, G. Winarso, R. Y. Setiawan, and R. D. Susanto, "Ekman dynamics variability along the southern coast of Java revealed by satellite data." *Int. J. Remote Sens.*, vol. 41, no. 21, pp. 8475–8496, Aug. 2020, doi: [10.1080/01431161.2020.1797215](https://doi.org/10.1080/01431161.2020.1797215).
- [25] W. Group, "The WAM model—A third generation ocean wave prediction model." *J. Phys. Oceanogr.*, vol. 18, no. 12, pp. 1775–1810, Dec. 1988, doi: [10.1175/2010BAMS2946.1](https://doi.org/10.1175/2010BAMS2946.1).
- [26] UNESCO, (Sep. 1980). *Tenth Report of the Joint Panel on Oceanographic Tables and Standards*. UNESCO Technical Papers in Marine Science. [Online]. Available: https://www.jodc.go.jp/info/ioc_doc/UNESCO_tech/046148eb.pdf
- [27] H. Murakami, "Ocean color estimation by Himawari-8/AHI." *Proc. SPIE*, vol. 9878, May 2016, Art. no. 987810, doi: [10.1117/12.2225422](https://doi.org/10.1117/12.2225422).
- [28] H. Hersbach, B. Bell, P. Berrisford, S. Hirahara, A. Horányi, J. Muñoz-Sabater, J. Nicolas, C. Peubey, R. Radu, D. Schepers, and A. Simmons, "The ERA5 global reanalysis." *Quart. J. Roy. Meteorol. Soc.*, vol. 146, no. 730, pp. 1999–2049, 2020, doi: [10.1002/qj.3803](https://doi.org/10.1002/qj.3803).
- [29] J. S. Hobgood, "The influence of relative humidity on the development of tropical cyclones." *Phys. Geography*, vol. 7, no. 4, pp. 283–291, Oct. 1986, doi: [10.1080/02723646.1986.10642298](https://doi.org/10.1080/02723646.1986.10642298).
- [30] K. A. Hill and G. M. Lackmann, "Influence of environmental humidity on tropical cyclone size." *Monthly Weather Rev.*, vol. 137, no. 10, pp. 3294–3315, Oct. 2009, doi: [10.1175/2009MWR2679.1](https://doi.org/10.1175/2009MWR2679.1).
- [31] L. Wu, H. Su, R. G. Fovell, T. J. Dunkerton, Z. Wang, and B. H. Kahn, "Impact of environmental moisture on tropical cyclone intensification." *Atmos. Chem. Phys.*, vol. 15, no. 24, pp. 14041–14053, Dec. 2015, doi: [10.5194/acp-15-14041-2015](https://doi.org/10.5194/acp-15-14041-2015).
- [32] J.-H. Lee, J.-H. Moon, and T. Kim, "Typhoon-triggered phytoplankton Bloom and associated upper-ocean conditions in the Northwestern Pacific: Evidence from satellite remote sensing, Argo profile, and an ocean circulation model." *J. Mar. Sci. Eng.*, vol. 8, no. 10, p. 788, Aug. 2020, doi: [10.3390/mse8100788](https://doi.org/10.3390/mse8100788).
- [33] F. Chai, Y. Wang, X. Xing, Y. Yan, H. Xue, M. Wells, and E. Boss, "A limited effect of sub-tropical typhoons on phytoplankton dynamics." *Biogeosciences*, vol. 18, no. 3, pp. 849–859, Feb. 2021, doi: [10.5194/bg-18-849-2021](https://doi.org/10.5194/bg-18-849-2021).



RIZA YULIRATNO SETIAWAN received the M.Sc. degree from the Department of Geophysics, Graduate School of Science, Tohoku University, Japan, in 2008, and the Ph.D. degree from the Department of Geosciences, University of Bremen, Germany, in 2015. He is currently a Faculty Staff with the Department of Fisheries, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia. He has been working on scientific analyses of remote sensing and observational data to understand mesoscale atmosphere–ocean–land interaction in the Indonesian Seas.



R. DWI SUSANTO received the bachelor's degree from the Bandung Institute of Technology, Indonesia, in 1986, the master's degree in engineering science from Louisiana State University, in 1992, the master's degree in underwater acoustics from the Ocean Engineering Department, MIT, in 1994, and the Ph.D. degree from the College of Marine Studies, University of Delaware, in 1998. He has a long experience working as an Ocean Scientist with the Lamont-Doherty Earth Observatory, Columbia University, USA, from 1998 to 2013. He is currently a Senior Research Scientist with the Department of Atmospheric and Oceanic Science, University of Maryland, USA. His expertise is in the ocean and climate dynamics of the Indo-Pacific region, especially related to Pacific-Indian Ocean Exchange/Indonesian Throughflow (ITF) dynamics.



ANINDYA WIRASATRIYA was born in Banyumas, in 1977. He received the B.S. degree from the Department of Marine Science, Universitas Diponegoro, Indonesia, in 2000, and the M.Sc. and Ph.D. degrees from the Department of Geophysics (Satellite Oceanography), Graduate School of Science, Tohoku University, Japan, in 2011 and 2015, respectively. He is currently an Associate Professor with the Department of Oceanography, Faculty of Fisheries and Marine Science, Universitas Diponegoro. He was held a position as the **Head of the Center for Coastal Rehabilitation and Disaster Mitigation Studies**, Universitas Diponegoro (2016–2017), and the **Head of the Oceanography Laboratory**, Universitas Diponegoro (2017–2020). His expertise is related to the application of remote sensing for observing **mesoscale air-sea interaction phenomena**.



INOVASITA ALIFDINI received the Master of Science and Technology degree from Hirotsaki University, Japan, with a research focus on wind climate over the Maritime Continent. During the B.Sc. degree program with the Department of Oceanography, Universitas Diponegoro, Indonesia, her interest falls on the research field of physical oceanography (e.g., ocean waves, tidal, and temperature). She was awarded several prestigious international awards, including the Best Student Oral Presentation Award at the American Meteorological Society (AMS) annual meeting 2020 and the Outstanding Student Presentation Award (OSPA) at American Geophysical Union (AGU) Fall meeting 2020.



ARDIANSYAH DESMONT PURYAJATI was born in Banyumas, in 1998. He received the Bachelor of Science degree from the Department of Oceanography, Universitas Diponegoro, Indonesia. Since 2020, he has been a Research Assistant with the Department of Oceanography, Universitas Diponegoro. His expertises are related to remote sensing and GIS applications for oceanography.



LILIK MASLUKAH received the B.Sc. degree in marine sciences from Diponegoro University, Indonesia, in 1998, the M.Sc. degree from IPB University, Indonesia, in 2006, and the Ph.D. degree from the Faculty of Fisheries and Marine Sciences, Diponegoro University, in 2021. She is currently a Faculty Staff with the Department of Oceanography, Diponegoro University. Her research interests include environmental pollution, eutrophication, and primary productivity in the marine and freshwater ecosystems.



NURJANNAH NURDIN received the B.Sc. degree from Hasanuddin University, in 1994, and the M.Sc. and Ph.D. degrees from IPB University, in 1998 and 2006, respectively. She is currently the Head of the Research and Development Center for Sea, Coastal and Small Islands, Hasanuddin University, Makassar, Indonesia, and an Associate Professor with the Department of Marine Science, Hasanuddin University. Her expertise covers analyses of radiometric observation and spectral reflectance for discriminating coral reef ecosystems.

I-

a_and_Sea_Surface_Temperature_in_the_Savu_Sea_Indonesi...

ORIGINALITY REPORT

17%

SIMILARITY INDEX

12%

INTERNET SOURCES

14%

PUBLICATIONS

5%

STUDENT PAPERS

PRIMARY SOURCES

- 1 Anindya Wirasatriya, Denny Nugroho Sugianto, Muhammad Helmi, Riza Yuliratno Setiawan, Magaly Koch. "Distinct Characteristics of SST Variabilities in the Sulawesi Sea and the Northern Part of the Maluku Sea During the Southeast Monsoon", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2019
Publication 1%
- 2 Q.W. Sari, P.A. Utari, D. Setiabudidaya, I. Yustian, E. Siswanto, I. Iskandar. "Surface chlorophyll-a variations in the Southeastern Tropical Indian Ocean during various types of the positive Indian Ocean Dipole events", International Journal of Remote Sensing, 2019
Publication 1%
- 3 journal.gnest.org
Internet Source 1%
- 4 cpk-front-devel.mzk.cz
Internet Source 1%

5	journals.ametsoc.org Internet Source	1 %
6	Submitted to Sungshin Women's University Student Paper	1 %
7	www.envirobiotechjournals.com Internet Source	1 %
8	Anindya Wirasatriya, Riza Yuliratno Setiawan, Petrus Subardjo. "The Effect of ENSO on the Variability of Chlorophyll-a and Sea Surface Temperature in the Maluku Sea", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2017 Publication	1 %
9	ee.maynoothuniversity.ie Internet Source	1 %
10	Anindya Wirasatriya, Denny Nugroho Sugianto, Muhammad Helmi, Riza Yuliratno Setiawan, Magaly Koch. "Erratum to "Distinct Characteristics of SST Variabilities in the Sulawesi Sea and the Northern Part of the Maluku Sea During the Southeast Monsoon" [Jun 19 1763-1770]", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2019 Publication	1 %

11	Tongyu Wang, Shuwen Zhang, Fajin Chen, Yonggui Ma, Chen Jiang, Jie Yu. "Influence of sequential tropical cyclones on phytoplankton blooms in the northwestern South China Sea", <i>Journal of Oceanology and Limnology</i> , 2020 Publication	1 %
12	www.tandfonline.com Internet Source	1 %
13	www.gjesm.net Internet Source	<1 %
14	www.mdpi.com Internet Source	<1 %
15	Submitted to King Mongkut's Institute of Technology Ladkrabang Student Paper	<1 %
16	ehp.niehs.nih.gov Internet Source	<1 %
17	Inovasita Alifdini, Teruhisa Shimada, Anindya Wirasatriya. "Seasonal Distribution and Variability of Surface Winds in the Indonesian Seas using Scatterometer and Reanalysis Data", <i>International Journal of Climatology</i> , 2021 Publication	<1 %
18	Riza Yuliratno Setiawan, Eko Setyobudi, Anindya Wirasatriya, Andi Syahid Muttaqin,	<1 %

Lilik Maslukah. "The Influence of Seasonal and Interannual Variability on Surface Chlorophyll-a Off the Western Lesser Sunda Islands", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2019

Publication

19	Submitted to Universitas Trunojoyo Student Paper	<1 %
20	Submitted to Felician College Student Paper	<1 %
21	Dyah Aruming Tyas, Sri Hartati, Agus Harjoko, Tri Ratnaningsih. "Morphological, Texture, and Color Feature Analysis for Erythrocyte Classification in Thalassemia Cases", IEEE Access, 2020 Publication	<1 %
22	Guoqiang Qiu, Xiaogang Xing, Fei Chai, Xiao-Hai Yan, Zhiyu Liu, Haili Wang. "Far-Field Impacts of a Super Typhoon on Upper Ocean Phytoplankton Dynamics", Frontiers in Marine Science, 2021 Publication	<1 %
23	cires.colorado.edu Internet Source	<1 %
24	jonuns.com Internet Source	<1 %

public.wmo.int

25	Internet Source	<1 %
26	www.nature.com Internet Source	<1 %
27	acp.copernicus.org Internet Source	<1 %
28	agupubs.onlinelibrary.wiley.com Internet Source	<1 %
29	M. Maes. "Synchronized annual rhythms in violent suicide rate, ambient temperature and the light-dark span", Acta Psychiatrica Scandinavica, 11/1994 Publication	<1 %
30	Y. Wang. "Composite of typhoon induced sea surface temperature and chlorophyll - a responses in the South China Sea", Journal of Geophysical Research: Oceans, 2020 Publication	<1 %
31	A. J. Paul, L. T. Bach, K.-G. Schulz, T. Boxhammer et al. " Effect of elevated CO on organic matter pools and fluxes in a summer, post spring-bloom Baltic Sea plankton community ", Biogeosciences Discussions, 2015 Publication	<1 %

-
- 32 Liu, Xin, Jing Wang, Xuhua Cheng, and Yan Du. "Abnormal upwelling and chlorophyll-*a* concentration off South Vietnam in summer 2007", *Journal of Geophysical Research*, 2012.
Publication <1 %
-
- 33 M. S. Girishkumar, V. P. Thangaprakash, T. V. S. Udaya Bhaskar, K. Suprit et al. "Quantifying Tropical Cyclone's Effect on the Biogeochemical Processes Using Profiling Float Observations in the Bay of Bengal", *Journal of Geophysical Research: Oceans*, 2019
Publication <1 %
-
- 34 aslopubs.onlinelibrary.wiley.com
Internet Source <1 %
-
- 35 ebin.pub
Internet Source <1 %
-
- 36 research-repository.griffith.edu.au
Internet Source <1 %
-
- 37 www.frontiersin.org
Internet Source <1 %
-
- 38 H.J. Ye, Y. Sui, D.L. Tang, Y.D. Afanasyev. "A subsurface chlorophyll *a* bloom induced by typhoon in the South China Sea", *Journal of Marine Systems*, 2013
Publication <1 %
-

39 Haibin Lü, Xiao Ma, Yuntao Wang, Huijie Xue, Fei Chai. "Impacts of the unique landfall Typhoons Damrey on chlorophyll-a in the Yellow Sea off Jiangsu Province, China", *Regional Studies in Marine Science*, 2020
Publication <1 %

40 Ryota Shibano. "Responses of marine ecosystem to typhoon passages in the western subtropical North Pacific", *Geophysical Research Letters*, 09/29/2011
Publication <1 %

41 Shaolei Tang, Xiaofeng Yang, Di Dong, Ziwei Li. "Merging daily sea surface temperature data from multiple satellites using a Bayesian maximum entropy method", *Frontiers of Earth Science*, 2015
Publication <1 %

Exclude quotes On

Exclude bibliography On

Exclude matches < 5 words