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Analysis of Sea Surface Temperature (SST) Patterns in Arafura Waters Using Google Earth Engine (GEE) for Early Detection of Environmental Threats

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A B S T R A C T

Global warming that is happening today can result in an increase in sea surface temperatures. High sea surface temperatures can potentially disrupt the stability of ecosystems in Arafuru Waters. The waters of Arafuru are located in the south of Papua and border the country of Australia. This study aims to analyze the increase in sea surface temperature in waters using a satellite image processing method with Google Earth Engine (gee) software in a span of one year in 2021. The results obtained in this study are that the sea surface temperature value is around 28-30^{0}C which is in the medium category according to the Ministry of Marine Affairs and Fisheries. In this study, it is expected to be able to deal with environmental threats caused by rising sea surface temperatures, especially marine life.

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INTRODUCTION

Oceanographic dynamics, especially sea surface temperature, are influential parameters in aspects of marine life. Sea surface temperatures are prone to various variations in climate change phenomena such as global warming (Van Woesik et al., 2022). Global warming is happening all over the world, including Indonesia. If global warming occurs continuously, it will increase the temperature of Indonesian waters, including the waters of Arafuru. Rising water temperatures can have an impact on the biomass (Shlesinger dan van Woesik, 2023).

The waters of Arafuru are large (~1000km×1000km horizontally) and shallow (40–60m deep) high seas, east of which is connected to the Coral Sea of the Pacific Ocean via the Torres Strait, which is 150 km wide and<10m deep (Mahardhika dan Harsono, 2022). The waters of Arafuru have a wide variety of species in its waters and are rich in marine biodiversity (Nurulludin et al., 2022). Rising sea surface temperatures in the Arafuru Waters could pose a threat to the ecosystem. Rising temperatures trigger stress in marine species that can affect the growth and reproduction of marine life. For example, on corals that will experience coral bleaching. Coral bleaching can occur because the temperature in the waters is too hot which makes the corals stressed, so they turn white (Van Woesik et al., 2022). Rising temperatures can also lead to massive migration of fish to lower temperature regions. Eventually it will have an impact on fishermen because of reduced fishery products. This is a threat to the surrounding community which is directly affected by the economy.

Sea surface temperatures can be analyzed and monitored using satellite imagery through various platforms. One of them is google earth engine. Google earth engine is a platform developed by Google in the form of cloud computing that is used to analyze geospatial data on a large scale (Latue et al., 2023). Google Earth Engine offers programming capabilities with JavaScript and Python, as well as data visualization and analysis tools such as time series, image segmentation, and spatial analysis (Philia., 2023). So on google earth engine there is no need to download data, all that is needed is a call to data that is already available in the google earth catalog.

In the analysis of the final results, it is hoped that it will be able to understand the threat of rising sea surface temperature to the ecosystem in Arafuru waters. So as to encourage efforts to manage marine resources in Arafuru Waters with a sustainable concept.

Study Area

The Research Area used in the study is Arafuru Waters. Arafuru is located between Northern Australia and southern Indonesia, especially the island region of Papua. It is located east of the Torres Strait, southwest of the Pacific Ocean, north of Australia's Carpentaria Bay, and south of West Papua Province. The map of the research location can be seen in Figure 1.

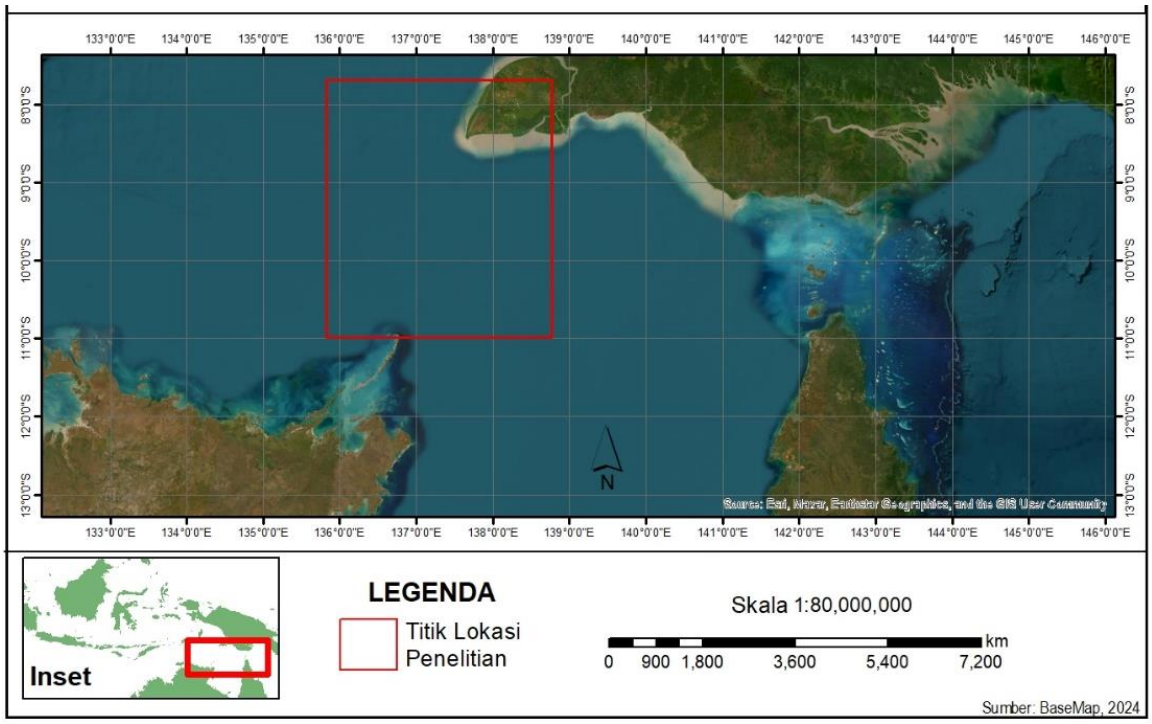

Figure 1. Research Location

METHODOLOGY

According to Wibisana et al. (2018), sea surface temperature (SST) is one of the parameters that is often used to detect climate change and ecosystems in a water. As a parameter, SPL plays a role in the change in the average temperature of sea level. A temperature change of 1°Celsius will have a significant impact, where marine life will undergo changes. There are several species of fish that are sensitive to temperature changes, so that this change will result in the transfer of fish populations to habitats that are suitable for the living conditions of the fish.

Research on the distribution of sea surface temperature temporally and spatially, oceanographic processes such as monsoon winds and ENSO phenomena can affect water conditions (Azizah and Wibisana, 2020). Sea surface temperature is one of the main factors in the movement of the seasonal cycle in both tropical and subtropical areas. Where sea surface temperature affects atmospheric conditions, weather, upwelling, and seasonality, even the emergence of El-Nino and La-Nina phenomena can be studied through sea surface temperature (Cheng et al., 2024; Rifai et al., 2020). The distribution of SPL can also find out the location of upwelling in the waters. The area where upwelling occurs is generally fertile waters, where the waters are rich in nutrients (Rosalina et al., 2023).

In this study, sea surface temperature data collection was carried out by not downloading data. Processing is carried out by invoking data from the Google Earth Engine (GEE) data catalog itself. The GEE data catalog can be seen in figure 2.

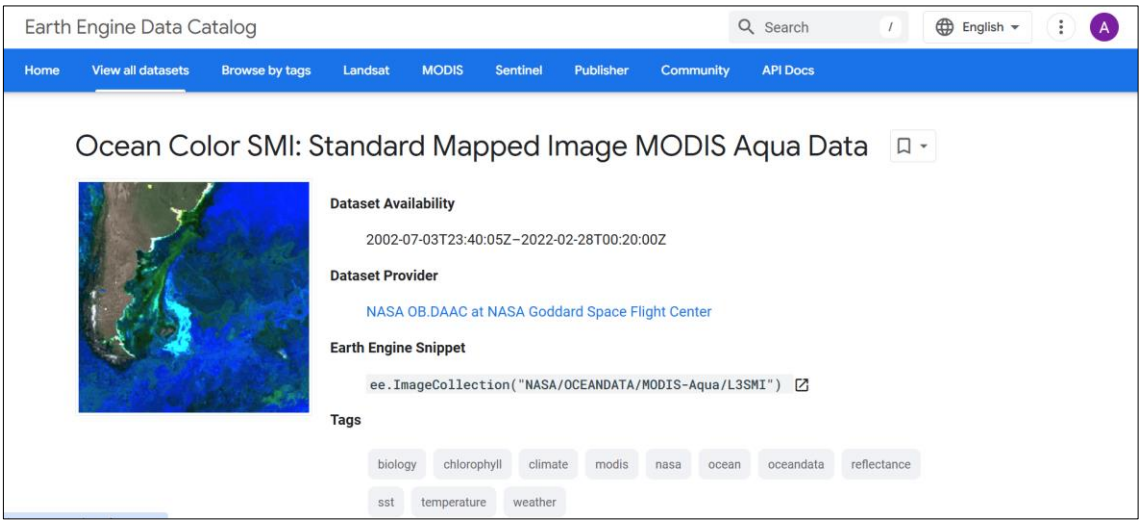

Figure 2. GEE Catalog

The AquaMODIS satellite has the following bands.

Name	Units	Min	Max	Wavelength	Description
chlor_a	mg/m^3	0*	99.99*		Chlorophyll a concentration
nflh	mW cm-2 µm-1 sr-1	-0.5*	5.03*		Normalized fluorescence line height
poc	mg/m^3	-2147.48*	12953.4*		Particulate organic carbon
Rrs_412	sr-1	0*	0.11*	412nm	Remote sensing reflectance at band 412nm
Rrs_443	sr-1	0*	0.08*	443nm	Remote sensing reflectance at band 443nm
Rrs_469	sr-1	0*	0.08*	469nm	Remote sensing reflectance at band 469nm
Rrs_488	sr-1	0*	0.08*	488nm	Remote sensing reflectance at band 488nm
Rrs_531	sr-1	0*	0.07*	531nm	Remote sensing reflectance at band 531nm
Rrs_547	sr-1	0*	0.07*	547nm	Remote sensing reflectance at band 547nm
Rrs_555	sr-1	0*	0.07*	555nm	Remote sensing reflectance at band 555nm
Rrs_645	sr-1	0*	0.05*	645nm	Remote sensing reflectance at band 645nm
Rrs_667	sr-1	0*	0.04*	667nm	Remote sensing reflectance at band 667nm
Rrs_678	sr-1	0*	0.04*	678nm	Remote sensing reflectance at band 678nm
sst	°C	-2*	40*		Sea surface temperature

* estimated min or max value

Figure 3. Bands of AquaMODIS satellite

The data collected is data on sea surface temperatures in Arafuru Waters within one year in 2021. The year 2021 was chosen because of the availability of Aqua MODIS satellite image data on the Google Earth Engine (GEE) platform. After obtaining the results of data processing, it was continued by analyzing the sea surface temperature. Based on the Ministry of Marine Affairs and Fisheries, it is stated that the division of sea surface temperatures is divided into 3 types, namely low, medium and high. The division can be seen from the following table.

Table 1. Sea Surface Temperature Category Indicator

Sea Surface Temperature (^{0}C)	**Category**
25^0 – 28^0	Low
28^0 – 30^0	Medium
>30^0	High

Sources: Ministry of Maritime Affairs and Fisheries

To analyze the sea surface temperature in the AquaMODIS imagery using cloud computing-based google earth engine (GEE). The following is the code script used by the researcher:

```
//code
var dataset = ee.ImageCollection('NASA/OCEANDATA/MODIS-Aqua/L3SMI')
.filterDate('2022-02-01', '2022-02-28')
.map(function(dataset){ return dataset.clip(batas);});
var remoteSensingReflectance =
dataset.select(['sst']);
var remoteSensingReflectanceVis = {
min: -2,
max: 40,
palette:['040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
'0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
'3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
'ff0000', 'de0101', 'c21301', 'a71001', '911003']
};
Map.centerObject(batas, 4);
Map.addLayer(
   remoteSensingReflectance, remoteSensingReflectanceVis,
   'MODIS SST 2021');
Export.image.toDrive({
image:
remoteSensingReflectance.mean().visualize(remoteSensingReflectanceVis),
description: 'SST_Mean_2021_Image',
folder: 'praktikumunhan',
scale: 1000,
region: batas,
fileFormat: 'Geotiff',
maxPixels: 1e13
});
```

After the processing is completed in Google Earth Engine, then download the file from Google Drive, then a map of the distribution of sea temperature is made as shown in figure 2.

RESEARCH RESULT

Based on data processing, the average monthly distribution of sea surface temperature (SPL) in the waters of the Arafura Sea from January 2021 to December 2021 was obtained. The following results of the temperature distribution can be seen in table 2.

Table 2. Temperature Distribution Value

Year	Month	Temperature (°C)
2021	Januari	29.63500023
	Februari	28.19499969
	Maret	31.53999901
	April	30.31999969
	Mei	27.30500031
	Juni	26.34499931
	Juli	26.35999870
	Agustus	26.11999893
	September	26.23499870
	Oktober	29.23999977
	November	30.94499969
	Desember	31.71500015

The results of sea surface temperature (SST) data were obtained from the Aqua MODIS satellite which has been processed using Google Earth Engine (GEE). On the Aqua MODIS satellite, which is on the Google Earth Engine (GEE) platform, data is available from January 2021 to December 2021. According to the KKP (2016), there are three categories of sea surface temperature (SST), namely low, medium and high. The lowest temperature in the period January 2021 to December 2021, occurred in August at 26.11999893°C. Moderate temperature values occur in 2021 in January, February and October. The high temperature value occurred in December 2021 at 31.71500015°C. The indicator on the temperature distribution map shows that the redder the map, the higher the temperature in the waters. Meanwhile, the blue color on the map indicates a low temperature. Differences in sea surface temperatures can occur due to different levels of solar radiation (Ningsih et al., 2024).

Sea Surface Temperature (SST) has a low value around August and a high SST value around December or January. The influence of monsoon winds has a significant impact on SST changes because wind direction reversals also occur periodically or seasonally. In the western season, there is a western monsoon that blows from the Asian Continent to the Australian Continent. These western monsoon winds pass through Indonesian waters and cause the transfer of water masses from the Pacific Ocean, which tends to be warm, to the territory of

Indonesia bordering the Indian Ocean. As a result, there is a downwelling phenomenon in the Indonesian region (Nababan et al., 2022). The increase in SST that occurs during the western season is followed by increased evaporation of seawater, so that most of Indonesia will experience the rainy season. Meanwhile, the low Sea Surface Temperature (SST) in the eastern season is caused by the position of the sun in the northern part of the earth, so that areas located in the south receive less sunlight (Rahman et al., 2019).

When the Sea Surface Temperature (SST) increases, the temperature of the air above it will rise which causes an increase in air pressure at higher altitudes (Wangdiarta et al., 2024). On the other hand, if the SST decreases, the air temperature above it will also drop, so the air pressure will increase as the altitude decreases. During the El-Nino phase, warm water pools in the eastern Pacific region will cause SST conditions in the western Pacific to become colder due to the upwelling of Rossby waves, especially in Indonesia (Wangdiarta et al., 2024). This results in air pressure in Eastern Indonesia, so that the wind in Eastern Indonesia will blow in the direction that has low air pressure.

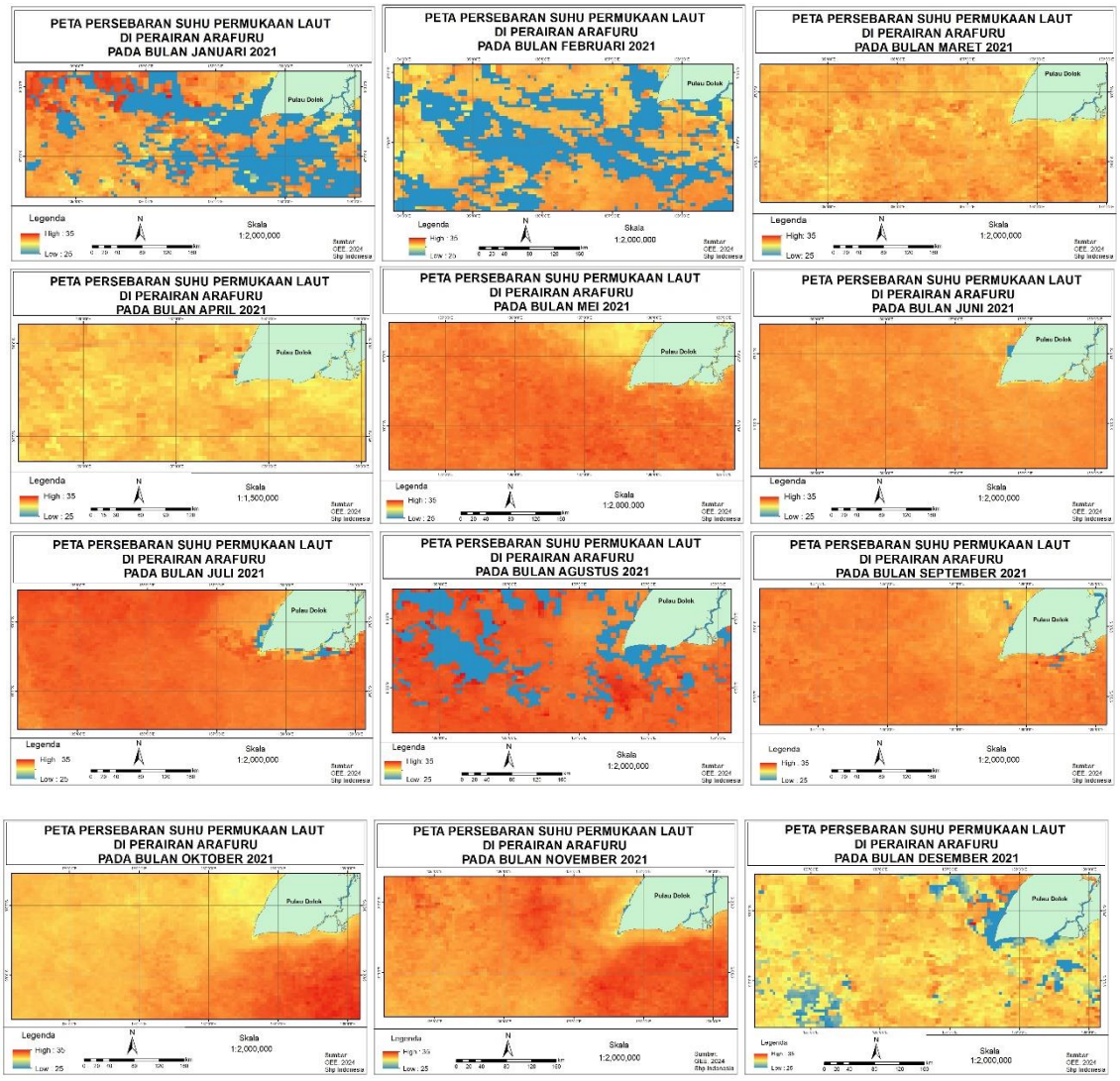

Figure 4. Temperature Distribution Map

The category of sea surface temperature that is included in the moderate will affect the ecosystem in Arafuru Waters. In relation to the life of aquatic organisms, sea surface temperature is one of the physical parameters of the waters that contribute to identifying areas with the potential for fish (Ningsih et al., 2024). Sea surface temperature (SST) is an oceanographic parameter that has a very dominant influence on ecosystem life in a water. For example, in fish, each type of fish has an optimal temperature for its life. At certain suitable temperature conditions, fish tend to have a better appetite. In addition to temperature, the most influential factor on the distribution of fish is chlorophyll-a. The intensity of the sun affects the high value of sea surface temperature which can affect the speed of phytoplankton in carrying out photosynthesis. This leads to high concentrations of chlorophyll-a can lead to an increase in the productivity of the catch potential.

CONCLUSIONS AND RECOMMENDATIONS

From data processing using google earth engine (GEE), it can be concluded that the sea surface temperature (SPL) in Arafuru waters is included in the moderate category in 2021 according to the ministry of marine affairs and fisheries. It is feared that if the temperature continues to rise, it will have an impact on marine ecosystems, especially fisheries. Therefore, let's keep global warming from happening continuously because it can threaten the environment.

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