

# Evaluating the Discrepancies in Surface Temperature Estimations between MODIS Imagery and In-Situ Measurements Tuban

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**Abstract:-** Tuban Regency is one of the North Coastal areas of East Java, a lowland area whose elevation is almost the same as the sea level. Coastal areas are often used for various activities, such as residential areas, aquaculture, tourism, et cetera. Utilizing coastal areas requires good management because environmental conditions are influenced by many factors, such as wind, sea currents, tides, abrasion, sedimentation, et cetera. Case studies regarding differences in estimated surface temperature between MODIS imagery and in-situ measurements on the coast of Tuban can provide deeper insight into the region's surface temperature characteristics. The research focuses on factors such as seawater temperature, land surface temperature, microclimate influence, and differences in spatial resolution between MODIS imagery and in-situ measurements. The result is that there is a significant difference between the Insitu Sea Surface temperature data compared to the Sea Surface temperature of the Aqua Modis 2023 image as shown by the t-test results, namely  $t_{count} > t_{crit}$  with a value of  $16.64585558 > 1.729132812$ ,  $H_0$  is rejected meaning there is a difference in sea surface temperature Insitu With Aqua Modis Image. Likewise, with the ANOVA test, it was found that in-situ sea surface temperature with Aqua Modis 2023 and Aqua Modis 2022, and Terra Modis 2022 image data, there is a difference in calculated F that is greater than  $F_{crit}$  with a value of  $2.142023 > 1.729132812$ ,  $H_0$  is rejected, meaning there is a significant difference between the four sea surface temperature data.

**Keywords:-** Acidity; Dissolved oxygen; Remote Sensing; Landsat 8; Tuban Coast.

## I. INTRODUCTION

Tuban Regency is one of the North Coastal areas of East Java, a lowland area whose elevation is almost the same as the sea level. Coastal areas are often used for various activities, such as residential areas, aquaculture, tourism, et cetera. Utilizing coastal areas requires good management because environmental conditions are influenced by many factors, such as wind, sea currents, tides, abrasion, sedimentation, et cetera (Xing et al., 2021).

Tuban's coastal area is located in Tuban Regency, East Java Province, Indonesia. Tuban is one of the districts with a fairly long coastline, with a coast stretching along the Java Sea. This region has unique geographical and environmental characteristics, including variations in surface temperature which can be influenced by local factors such as seawater temperature, land influence, and microclimate (Suspidayanti et al., n.d.).

The coast of Tuban has important factors in the social, economic, and environmental context (Tanto, 2020). This region is known as an area that has abundant natural resource potential, including the fisheries, marine, and tourism sectors. Therefore, monitoring surface temperature in the coastal area of Tuban is very important to manage natural resources, protect the coastal environment, and understand the impact of climate change on marine ecosystems (Suspidayanti et al., n.d.).

Case studies regarding differences in estimated surface temperature between MODIS imagery (Wan, 2019) and in-situ measurements on the coast of Tuban can provide deeper insight into the region's surface temperature characteristics. This research focuses on factors such as seawater temperature, land surface temperature, microclimate influences, and differences in spatial resolution between MODIS imagery and in-situ measurements. Thus, this research is expected to provide valuable information about the precision and accuracy

of estimating the surface temperature in the Tuban coastal area and can be used as a basis for policy-making and sustainable management of natural resources(Hachem et al., 2012).

The purpose of this study is to analyze the extent to which Aqua Modis imagery is sensitive to differences in in-situ sea surface temperature and can be used as a database in tropical waters, especially in Indonesia (Giglio et al., 2018).

## II. METHODOLOGY

### ➤ Satellite Data Image

The satellite image data used in this study is Aqua Modis image data taken from the web page: gslc Imagery ocean color, with the file name:

```
AQUA_MODIS.20230411T065001L2.SST.Nsc
AQUA_MODIS.20220813T061501L2.SST.Nsc.NRT.nc_subset_reprojected
TERRA_MODIS.20220915T023501.L2.SST.Nsc.NRT.nc_subset_reprojected
```

The image data is Level 2 image data downloaded for April 2023 and April 2022.

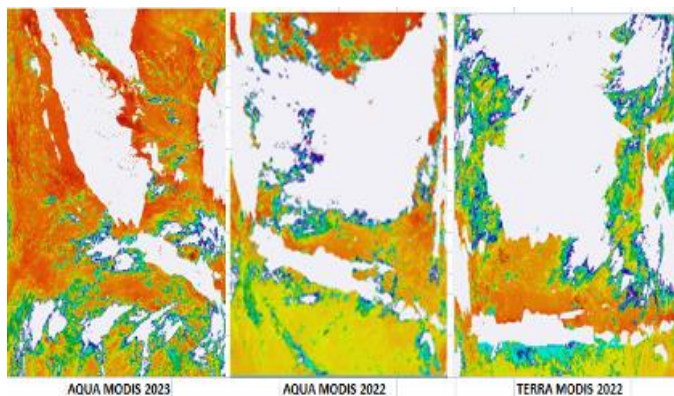


Fig 1. Citra Aqua Modis and Terra Modis 2022 and 2023

Below is the research location of the Tuban Coast



Fig 2. Map of research locations for the coastal area of Tuban

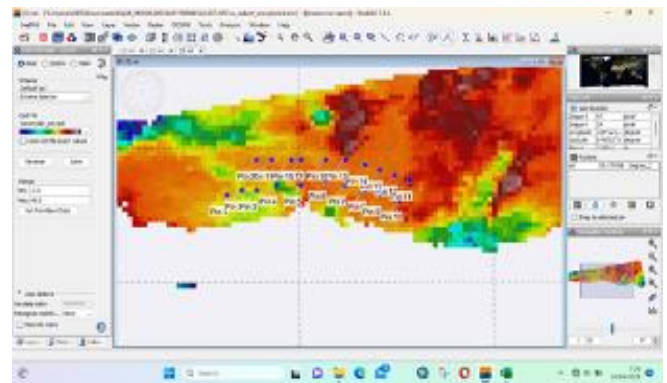


Fig 3. Aqua Modis satellite image data with survey locations

### ➤ Modis Imagery

The Aqua Modis image above is placed from pin 1 to pin 20 at the Aqua Modis Image coordinates

The Aqua satellite is one of the satellite images owned by NASA (National Aeronautics and Space Administration), which was launched on May 4, 2005, at Vandenberg Air Force Base, California, using the Boeing Delta II rocket(Shah et al., 2013). As the name implies, which is taken from the Latin language, Aqua, which means water, is intended to observe the processes that occur due to the interaction between the atmosphere, oceans, and land. Map of research locations for the coastal area of Tuban.

The Aqua instrument can obtain data on the profile of atmospheric temperature and humidity, clouds, evaporation and radiative balance, terrestrial snow, sea ice, sea surface temperature and water productivity, and soil moisture and use it to predict the weather (Sobrino et al., 2004). The Aqua satellite provides a very large contribution to monitoring the dynamics of land and sea. Aqua carries six types of instrument sensors in orbit, namely:

- AIRS (*Atmospheric Infrared Sounder*).
- AMSU-A (*Advanced Microwave Sounding Unit*).
- HSB (*Humidity Sounder of Brazil*).
- AMSR-E (*Advanced Microwave Scanning Radiometer for EOS*).
- MODIS (*Moderate Resolution Imaging Spectroradiometer*).
- CERES (*Clouds and the Earth's Radiant Energy System*).

MODIS (*Moderate Resolution Imaging Spectroradiometer*) which is one of the sensors belonging to EOS (Earth Observing System) and carried by two rides produced by NASA, namely Terra and Aqua. The MODIS sensor is a derivative of the AVHRR (Advanced Very High-Resolution Radiometer) sensor, Sea WiFS (Sea-viewing Wide Field of View Sensor), and HIRS (High-Resolution Imaging Spectrometer) owned by EOS, which previously orbited so that it can be used to measure parameters that are located at sea level to the atmosphere, including measuring sea surface temperature, chlorophyll concentration, water vapor content and marine phenomena, such as the occurrence of upwelling, thermal fronts, and others (<http://modis.gsfc.nasa.gov>, 2007).

MODIS orbits the earth polarly (north-south direction) at an altitude of 705 km, and every day it crosses the equator at 10.30 local time.

The width of the land coverage on the earth's surface each rotation is around 2330 km. The reflection of electromagnetic waves received by the MODIS sensor is 36 bands (36 wavelength intervals), starting from 0,405 to 14,385 fÊm (1 fÊm = 1/1.000.000 meter). Data is sent from the satellite at a speed of 11 Megabytes every second with a radiometric resolution of 12 bits. This means that objects can be detected and distinguished up to 212 (= 4.096) degrees of gray (gray levels).

One image element (pixels, picture element) measures 250 m (band 1-2), 500 m (band 3-7), and 1000 m (band 8-36). In the world of remote sensing, this is known as spatial resolution. MODIS can observe the same place on the earth's surface every day, for areas above latitude 30, and every two days, for areas below latitude 30, including Indonesia (<http://modis.gsfc.nasa.gov>, 2007).

➤ *Sea Surface Temperature Data*

To obtain Sea Surface Temperature data consisting of primary and secondary data, primary data is obtained from data collection carried out directly in the field using fishing boats and temperature measuring devices (Xiong & Qiu, 2011). Measurements are taken from one point to the next point approximately 50 meters away. Measurements were made with the help of GPS navigation from an existing application device and recorded the coordinates along with the Insitu sea surface temperature (SPL\_Insitu). While the secondary sea surface temperature data (SPL\_Citra Aqua Modis) were obtained by Downloading the SST Aqua Modis Image (Sea Surface Temperature), which was opened via the Seadas software, the Aqua Modis satellite image map was then cropped on the image, so a map image of the research location was obtained. Cropping is necessary to reduce and focus on the area under study. After the map image has been cropped, what is done is to enter the pins containing the coordinates of the sampling adjusted to the coordinates of the field. At the same time, statistical analysis using standard deviation and t-test. In the following, coordinate data and sea surface temperature (SST) of Insitu and sea surface temperature (SST) data from Aqua Modis imagery.

TABLE I. SEA SURFACE TEMPARATURE DATA AND COORDINATE DATA

Point	Longitude	Latitude	SPL_Insitu (°C)	SPL_Citra Aqua Modis (°C) 2023	SPL_Citra Aqua Modis (°C) 2022	SPL_Citra Terra Modis (°C) 2022
1	112,0547222	-6,883885	30,50	29,615	29,305	29,820
2	112,0536111	-6,882771	31,00	29,270	29,755	29,545
3	112,0530555	-6,880548	33,30	29,565	29,775	30,165
4	112,0527777	-6,878882	33,20	29,455	29,705	30,370
5	112,0525000	-6,877493	32,90	28,940	30,240	29,650
6	112,0520000	-6,875271	32,00	28,940	30,055	29,605
7	112,0519444	-6,874437	31,90	29,510	29,995	29,485
8	112,0519444	-6,867437	32,20	29,120	29,975	29,710
9	112,0520000	-6,873326	32,10	29,120	29,425	30,625
10	112,0525000	-6,867243	31,70	28,730	29,645	30,350
11	112,0527777	-6,871104	32,00	29,880	29,655	30,215
12	112,0536111	-6,871382	32,70	29,545	29,775	29,895
13	112,0538888	-6,872215	32,30	29,545	29,560	30,005
14	112,0544444	-6,872771	31,80	28,735	29,580	29,560
15	112,0550000	-6,873882	31,90	28,990	29,250	29,060
16	112,0550000	-6,874715	31,70	28,990	28,565	30,055
17	112,0552777	-6,867804	32,50	29,160	29,885	29,575
18	112,0552777	6,876937	33,30	29,235	29,725	29,950
19	112,0555555	-6,878048	33,70	29,615	29,890	29,845
20	112,0555555	-6,879160	33,30	29,440	29,950	29,390

Source: taken from field measurement

III. RESULT AND DISCUSSION

From the data obtained in Table 1, the standard deviation is obtained for further statistical analysis calculations between in-situ sea surface temperature and sea surface temperature obtained from the 2023 Aqua Modis satellite imagery using Excel.

TABLE II. MODEL MATHEMATIC CALCULATION AT BAND\_RRS\_547 WAVELENGTH SEA SURFACE

Information	SPL_Insitu (°C)	SPL_Aqua Modis (°C)
Mean	32,3	29,2699496
Standard Error	0,183389146	0,072171464
Median	32,15	29,252499
Mode	33,3	29,615
Standard Deviation	0,820141195	0,322760598
Sample Variance	0,672631579	0,104174404
Kurtosis	-0,122465428	-0,908877795
Skewness	-0,213711818	-0,05742296
Range	3,2	1,15
Minimum	30,5	28,73
Maximum	33,7	29,88
Sum	646	585,398992
Count	20	20



Table 2 shows the average in-situ sea surface temperature is 32.3 °C with a standard deviation of 0.820141195, 10% smaller. In comparison, the sea surface temperature of the Aqua Modis imagery averages 29.2699496 °C and a standard deviation of 0.322760598, less than 10 %, with 20 survey points. The standard deviation is less than 0.1 or 10%, and this is the limit allowed for the standard deviation value.

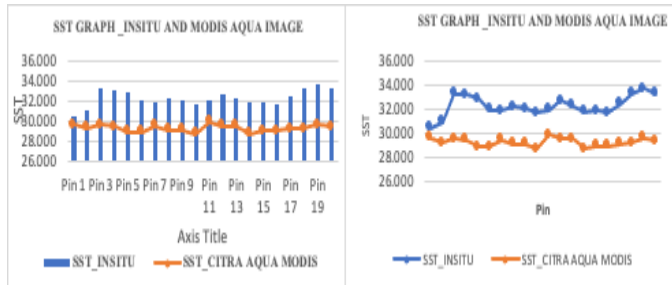


Fig 4. SPL\_Insitu graphic images and SPL\_ Aqua Modis 2023 satellite images

For the graph of the Insitu Sea Surface temperature with the Sea Surface temperature of the Aqua Modis Image, it can be seen that the Insitu temperature is higher than the Aqua Modis Image Temperature, obtained with a minimum in situ temperature of 30.5 °C and a maximum of 33.7 °C, while the temperature obtained from the image is a minimum of 28.73 °C and a maximum of 29.88 °C in the coastal area of Tuban.

	SST INSITU	SST AQUA MODIS
Mean	32,3	29,2699496
Variance	0,672631579	0,104174404
Observations	20	20
Pearson Correlation	0,215529372	
Hypothesized Mean Difference	0	
df	19	
t Stat	16,64585558	
P(T<=t) one-tail	4,35036E-13	
t Critical one-tail	1,729132812	
P(T<=t) two-tail	8,70073E-13	
t Critical two-tail	2,093024054	

The data processing in table 3 is the Insitu Sea Surface temperature data compared to the Sea Surface temperature of the Aqua Modis imagery, showing that the  $t_{count}$  is greater than the  $t_{crit}$  with a value of  $16.64585558 > 1.729132812$ ,  $H_0$  is rejected, meaning that there is a significant difference between the two data.

For comparison of in situ sea surface temperature with image data, Aqua Modis 2023, The sea level between Aqua Modis 2022 averaged 29.68549935oC and Terra Modis 2022 averaged 29.8437495oC, there is no difference.

TABLE IV. SEA SURFACE TEMPERATURE DATA WITH REFLECTANCE RRS\_547 YEAR 2018-2022

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	8,549508	19	0,449974	2,142023	0,0141	1,771972
Columns	98,77238	3	32,92413	156,7296	1,69E-27	2,766438
Error	11,97397	57	0,21007			
Total	119,2959	79				

In table 4, using the ANOVA test, it was found that in-situ sea surface temperature with Aqua Modis 2023 and Aqua Modis 2022, and Terra Modis 2022 image data, there is a difference in calculated F that is greater than  $F_{crit}$  with a value of  $2.142023 > 1.729132812$ ,  $H_0$  is rejected, meaning that there is a significant difference between the four sea surface temperature data.

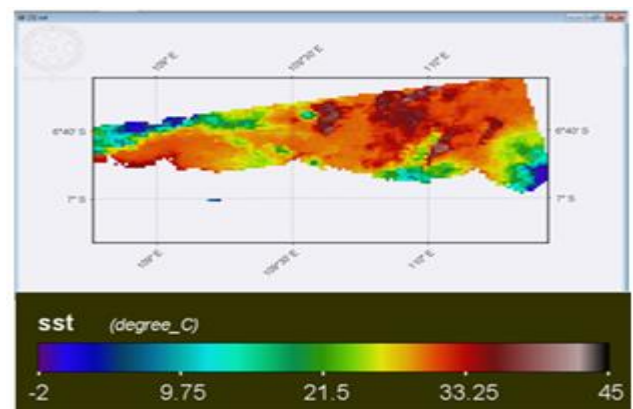


Fig 5. Image of the thematic map SPL satellite imagery of Aqua Modis

#### IV. CONCLUSION

- It can be concluded that there is a significant difference between the Insitu Sea Surface temperature data compared to the Sea Surface temperature of the Aqua Modis 2023 imagery as shown by the t-test results, namely  $t_{count} > t_{crit}$  with a value of  $16.64585558 > 1.729132812$ ,  $H_0$  is rejected meaning there is a difference in in situ sea surface temperature with the Aqua Modis image,
- Likewise, with the ANOVA test, it was found that in-situ sea surface temperature with Aqua Modis 2023 and Aqua Modis 2022, and Terra Modis 2022 image data, there is a difference in calculated F that is greater than  $F_{crit}$  with a value of  $2.142023 > 1.729132812$ ,  $H_0$  is rejected, meaning there is a significant difference between the four sea surface temperature data.

However, both can be used as a database for further research.

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