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The Variability of Sea Surface Height Anomaly in The Seas Along The Northern And Southern Coast of Java Island

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Abstract. The dynamics coastal in Indonesia is fluctuative. It is caused by geographical location of Indonesia. This study aims to analyze the sea surface height anomalies in the southern and northern waters of the Java Island. This assessment was based on data of sea surface height anomalies from the Jason 2 satellite in 2010-2016 obtained from Copernicus. Data processing use MATLAB R2014a to compare the sea surface height in the northern and southern waters of Java Island. The sea surface height anomaly in the northern waters of Java Island ranged from 0 - 0, 15 meters and in the southern ranged from -0, 1 – 0.15 meters. It is because southern waters of Java Island directly adjacent to the Indian Ocean. The highest sea surface height anomaly in the both of area occurs in May and minimum anomaly in September, influencing by monsoon. Generally, sea surface height anomaly in southern was higher than northern waters of Java Island.

1. Introduction

Climate change is a phenomenon of changes the weather patterns that occur in a significant way and at certain times. Climate change refers to the variation in climatic conditions rate or on the real variability in statistics for long periods [1]. IPCC convey that global warming may cause significant changes in physical and biological systems such as an increase the intensity of tropical storms, changes in patterns of precipitation, the salinity of sea water, a change in wind patterns, affect the time animal and plant reproduction, distribution of species and population size, the frequency of attacks of pests and disease outbreaks, as well as affecting various ecosystems that are found in areas with a high latitude, location, as well as coastal ecosystems [2].

Changing the physical condition of the Earth's atmosphere cause changes in marine ecosystems, it is caused by the interaction between the ocean and the atmosphere. One example of the interaction of the ocean and the atmosphere, among others, the existences of a sea temperature rise and the distribution of rainfall and melting of polar ice caps which brings extensive impact on various sectors.

Indonesia is a tropical country, located in the region of the equator. So Indonesia has two seasons, that is the rainy season and the dry season. Season in Indonesia besides being influenced



by the Monsoon and local influence, it is also influenced by the presence of global phenomena, such as the circulation of Hadley, Walker circulation, El Nino, La Nina, Indian Ocean Dipole and others. This location of Indonesia caused very dynamic [3]. Indonesia geography which is flanked by two oceans, namely, the Indian Ocean and the Pacific Ocean, so it has a potential and considerable influence on the waters of Indonesia. Therefore, we need for an understanding of the influence of the physical dynamics. One of the physical parameters which can be observed, namely sea surface height anomaly. Sea surface height is the distance between the surfaces of the sea with the reference ellipsoid. This research aims to know the characteristics of the sea surface height anomaly in southern waters and northern waters of Java in spatial and temporal visualization.

2. Research Methods

2.1 Altimetry Dataset

Altimetry satellite is one of the remote sensing technology. It used to observe the dynamics of ocean surface topography and measured against the reference field can be any ellipsoid, geoid, or mean sea surface. Reference field is a reference to define the position of sea level. As for the selection of the reference field the high adjusted to the purpose of its utilization. Current satellite technology altimetry applied for the determination of sea surface topography, ice surface topography determination, determination of the geoid, the determination of the characteristics of the ocean currents, the determination of the height and the length of the waves of the ocean, waves, tides, determination of wind speed above sea level, the El Niño phenomenon and the unification datum between high Island [4].

Altimetry satellite used to monitor variations in sea level, with a high degree of precision, high resolution in spatial and temporal visualization, wide oceanic coverage, and references to the mass center of the earth can be used as an alternative to estimate sea level [5]. The advantage of the Topex / Poseidon altimetry satellite compared to other satellites is that it has a main altimetry radar sensor that operates simultaneously on two frequencies (dual frequency) so that it can reduce the effects of the ionosphere bias. The Topex / Poseidon has a 10-day temporal resolution and spatial resolution along the satellite trajectory of approximately 7 km and the distance between tracks with a longitude width of about 3° or about 300 km at the equator. The mission of the altimetry satellite provides measurement accuracy of about 2 cm and the spatial resolution of 0.25°×0.25° grids provided by Copernicus Marine Environment Monitoring Service (<http://marine.copernicus.eu/>) [6]. Thus, satellite altimetry techniques can be used to monitor spatio-temporal sea level position.

Altimetry satellite measurements will be generate information the position of the sea surface height. Altimetry satellite do observations using altimetry radar that sends pulses of electromagnetic waves to the ocean surface and reflected back to the satellite (7).

2.2 Data processing

Data processing was carried out with sea surface height anomalies dataset in the 2010-2016 from <http://marine.copernicus.eu> with .nc extension. The data filtered by research site. It was for the southern waters of Java with coordinates of 5.5 ° - 7 ° LS and 108 ° -112 ° E and the northern water of Java 105 °-115 ° E and 7 °-15 ° S and. Data processing used Matlab R2014a and have analyzed spatial visualization and temporal visualization.

3. Result and Discussion

3.1 The southern waters of java island

Analysis of variability of sea surface height anomalies made in spatial and temporal. Based on spatial visualization, the value of sea surface height anomalies in the southern of Java Island influenced by season and the direction of the wind that brought masses of water. The pattern of sea surface height in the waters of southern Java is a semi-annual fluctuation. In spatial, sea surface height anomaly is highest in May and lowest in September [8].

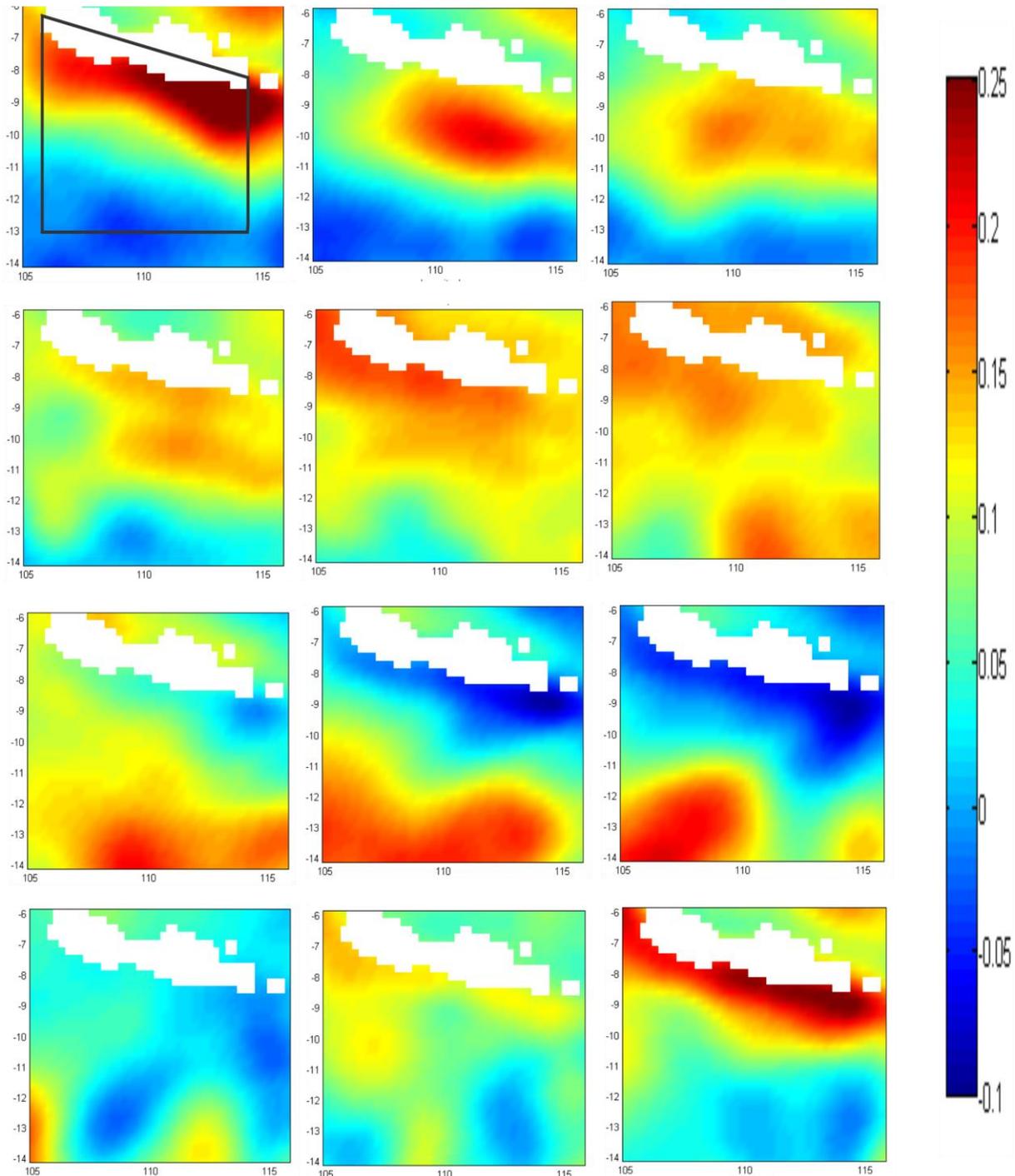


Figure 1. Spatial visualization of sea surface height anomaly 2010-2016

The waters of southern Java have a dynamic sea level height anomaly. Variability in sea level anomalies shows that in November to June anomalies in the southern waters of Java that approached the coast is higher than offshore areas. However, in July to October, anomalies occur in the open waters higher than the coast. The formation of these cycles are related upwelling and downwelling [9].

In November to June, sea level height anomalies are higher in the open sea. This is caused by the influence of the circulation of the Indian Ocean waters and the west monsoon that can push the mass of water to the coastal areas [9]. In July to October shows that anomalies in the offshore area are higher than in coastal areas. This is due to the existence of east winds and causes the mass of the sea water to be pushed into the open sea [9].

Indonesia's southern sea monsoon system is influenced by seasonal winds that affect the movement of sea water masses [10]. Sea surface height anomaly in the southern waters of Java is more dynamic due to strong upwelling and downwelling and the position of the southern Java Sea which is directly connected to the Indian Ocean. In upwelling areas where there is a strong divergence current causing the area to experience a vacuum of water mass, the sea surface height anomaly value becomes low and even reaches a minus, while in the downwelling area it shows the opposite. Sea surface height was also influenced by the melting of the polar ice.

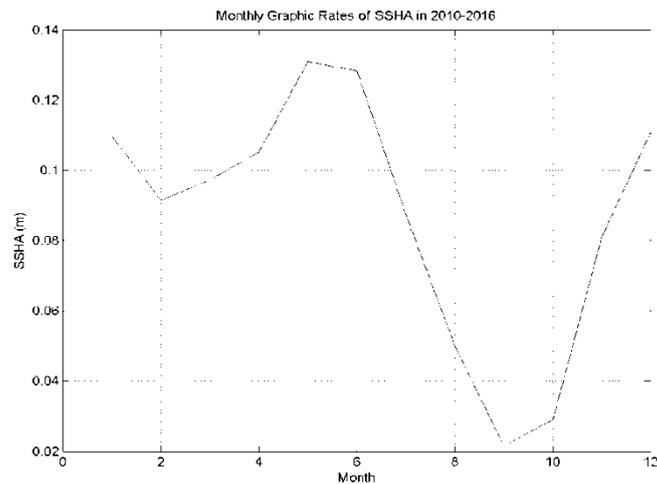


Figure 2. Temporal visualization of sea surface height anomaly 2010-2016

Table 1. SSHA rate in southern waters of Java Island (Black box in Fig.1, January)

Month	Southern Java Island (m)
1	0.1098
2	0.0915
3	0.0972
4	0.1053
5	0.1310
6	0.1283
7	0.0875
8	0.0499
9	0.0216
10	0.0291
11	0.0811
12	0.1110

Based on temporal visualization, sea surface height anomaly in the southern waters of Java decreased from January to February, then increased and up to the highest point in May which was 0.1310 m. In June to September it decreased significantly where this month the lowest sea level anomaly, specifically 0.0216 m, then in October to December increased significantly. Based on these results, the pattern of distribution is a sinusoidal pattern. This pattern shows the existence of factors that periodically affect sea level height anomalies [1].

3.2 The northern waters of java island

Based on the spatial visualization of sea surface height anomalies in the northern waters of Java, it was seen that in May-October the sea water height anomaly was higher in the coastal areas than the offshore areas because of east wind, while in November-April, sea surface height anomaly in the offshore areas is higher than the coastal areas. This is because the west winds that push the sea water mass from the north to the east coast and reduce the anomalies on the north coast and vice versa on the east winds [1].

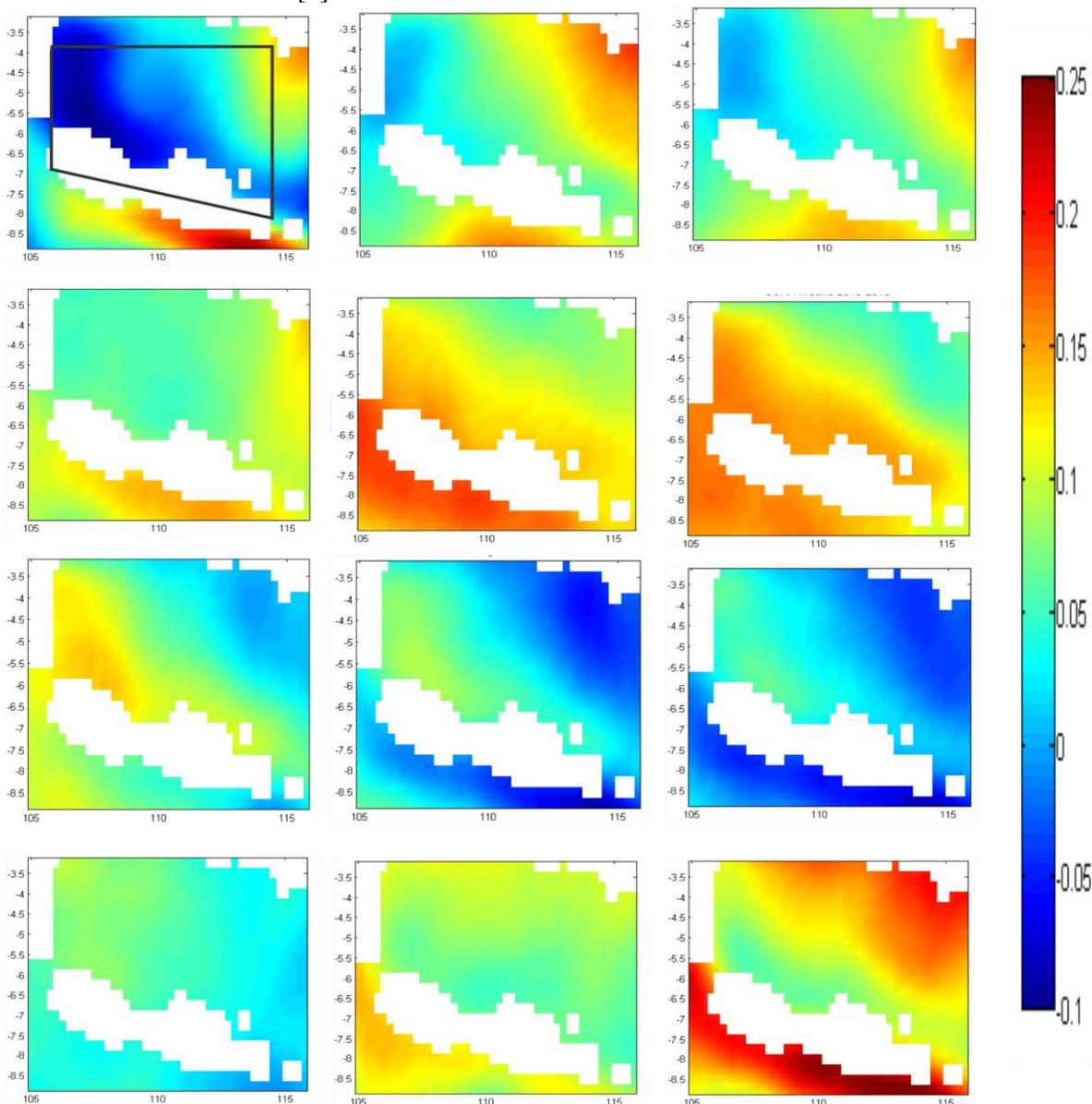


Figure 3. Spatial visualization of sea surface height anomaly in northern waters of java 2010-2016

This sea level height anomaly phenomenon is stronger in the southern waters of Java than the northern waters of Java. This is influenced by the geographical position of the waters. The northern waters are located in a closed sea so they are not as dynamic as the southern waters of Java. This geographical position causes the northern waters of Java to be affected by the southern China sea currents where there is a reversal of the current direction every time there is a change in seasons throughout the year as well as Indonesian cross currents which cause surface currents to flow strongly into the Java Sea.

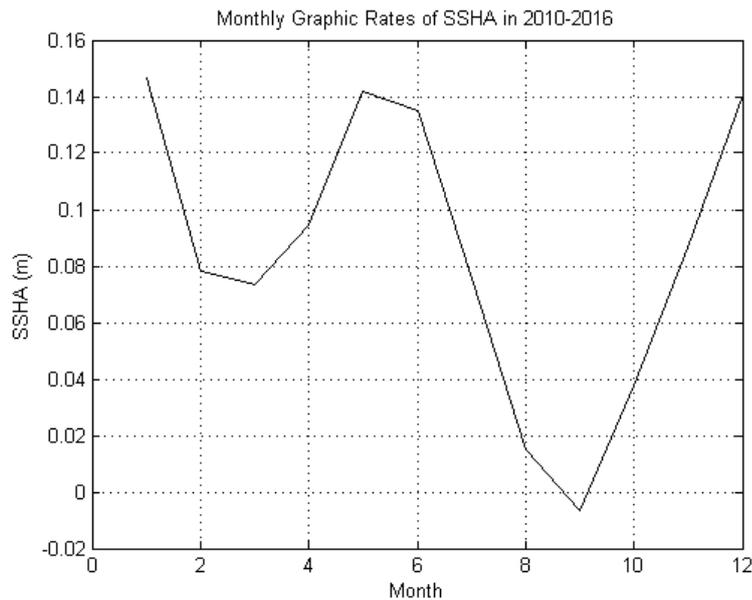


Figure. 4. Temporal visualization of sea surface height anomaly 2010-2016

Table 2. Monthly Sea surface height anomalies rate in northern waters of Java Island (Black box in Fig.2, January)

Month	Northern Java Island
1	0.1468
2	0.0782
3	0.0733
4	0.0943
5	0.1418
6	0.1352
7	0.0754
8	0.0149
9	-0.0066
10	0.0378
11	0.0868
12	0.1406

Based on temporal visualization, it can be seen that the highest sea surface anomaly value occurred in January which was 0.1468 m and the lowest in September was -0.0066 m. It can be seen that the anomaly value of sea level decreases from January to February, then rises significantly until May. In May-September was decreases and rise again in September to

December.

4. Conclusion

Based on this data processing it can be concluded that the characteristics of sea surface height anomaly in the southern waters of Java and northern waters of Java are influenced by the location of waters and monsoon. Southern waters of Java is more dynamic than the northern waters of Java due to direct connection with the Indian Ocean. However, these two waters have the same pattern namely sinusoidal pattern, reaching the highest sea surface height anomaly in May and the lowest in September.

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