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Climate change impacts on Indonesian coastal areas

Muhammad Zikra[a*], Suntoyo[a], Lukijanto[b]

[a]Department of Ocean Engineering, Institut Teknologi Sepuluh Nopember (ITS), Kampus ITS, Surabaya 60111, INDONESIA
[b]Badan Pengkajian dan Penerapan Teknologi (BPPT), M.H. Thamrin 8, Jakarta 10340, INDONESIA

Abstract

The problems in coastal area related with climate change have continued to receive a high level of attention. Elevate average of sea level, variation in significant wave height and increased ocean temperature are linked to global climate in many ways. Thus, climate variability and future climate change should become a major interest for engineer, stakeholders, and decision makers, especially for developing strategies for mitigation and adaptation for future coastal development. The objective of this paper is to compile data and information on the potential impacts of climate change to Indonesian coastal area due to global warming from various studies. This paper focus on the impacts of climate change to sea level, wave climate and sea water temperature.

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Keywords: Climate change, sea level, wave climate, sea water temperature

1. Introduction

Climate change could affect coastal and ocean environments in different of ways. Coasts are sensitive to sea level rise, changes in the frequency and intensity of wind speed, increases in significant wave height, and increases in ocean temperature. Moreover, rising concentrations of carbon dioxide (CO2) are causing the oceans to absorb more of the gas and become more acidic. This rising acidity could have significant impacts on coastal environments and marine ecosystems. The impacts of climate change are likely to worsen many problems that coastal areas already face. Coastal

* * Corresponding author. Tel.: +62-31-5928105; fax: +62-31-5928105.
E-mail address: mzikro@oe.its.ac.id

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erosion, coastal flooding, and water pollution are common problems that affect man-made infrastructure and ecosystems in coastal areas.

As the world's largest archipelagic state, Indonesia have more than 17,500 islands with over 81,000 kilometers of coastline. The coastline of Indonesia is highly populated because around 220 million Indonesians reside within 100 km of the coast, and of these over 150 million people rely on marine resources for their livelihoods (WRI, 2001). All activities in the coastal and ocean, such as marine transportation, offshore industry, naval industry, resource extraction, fish cultivation and tourism become an important part of Indonesian economy grow. Therefore, information about the effect of climate change on coastal areas is the major knowledge for engineer, stakeholders, or decision makers to develop strategies for mitigation and adaptation for future coastal development.

2. Sea level

Global warming as a result of the effects of greenhouse gases, have an impact on rise in sea levels. IPCC (2007) reported that the sea level has risen by an average of 2.5 millimeters annually. As an archipelago country with over 80.000 kilometers of coastlines, Indonesia is very vulnerable to sea level rise. Recently, there are several remote sensing technologies that can monitor the condition of the oceans continuously. Satellite altimeter technology is one of technique to monitor sea level change. During the past two decades, observations from satellite altimeters have demonstrated dramatic descriptions of sea level variability with higher spatial resolution than the traditional tide gauges (Ami et al, 2012).

This section described the projected increase in sea level based on the data of satellite altimeter. This study used the altimeter data from Jason-2 over Indonesia sea region from 2009 until 2012. The process and analysis of sea level data were carried out using Basic Radar Altimetry Toolbox 3.1.0 (BRAT). Monitoring of sea level rise is done for 4 years period (2009-2012) in 4 locations, which are Medan, Pemangkat, Ambon, and Manokwari. Defian (2012) reported that the highest sea level rise is in Manokwari 14.1 mm / year, and the lowest is in Ambon at 1,175 mm / year. Table 1 shows the statistics of sea level anomaly for Jason-2 after correcting for sea level height.

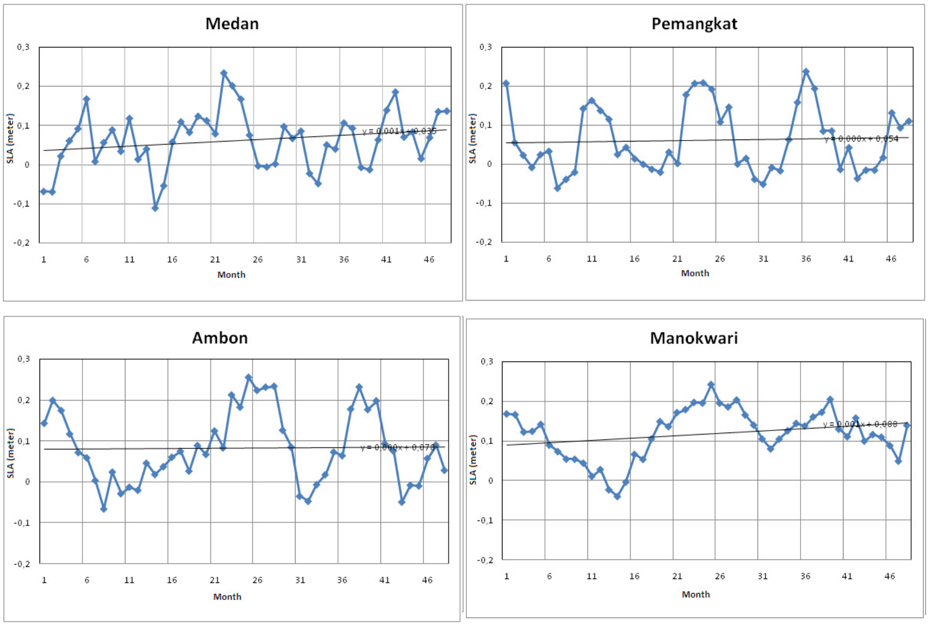


Fig 1 Trend of sea level rise

Table 1. Sea level trend based on altimeter data.

Location	Sea level anomaly (mm/year)
Medan	12.9
Pemangkat	3.53
Ambon	1.18
Manokwari	14.1

3. Variation in significant wave height from 1984-2003 around Indonesia sea

The global ocean wave climate has long been of interest to the ocean engineering community because of the need for accurate operational wave data for applications such as vessel design, design of offshore and coastal structures or naval operations. Recently, there has been a major interest in wave climate changes as a result of global warming. Therefore, studies on predicting the effect of global warming on ocean wave climate are required. The objectives of this section are to analyze the variability of significant wave height for the 20 year period 1984-2003.

This study describes the 20 year global significant wave height simulation derived from the Japan Meteorology Agency/Meteorology Research Institute (JMA/MRI)-AGCM3.2 wind climate data. The wind climate data were input into ocean wave model WAM with a global grid of spacing 1° in latitude by 1° in longitude. In situ wind and wave data sets from National Data Buoy Center (NDBC)-National Oceanic and Atmospheric Administration (NOAA) database were used to evaluate the model accuracy. The validation showed good agreement both wind and waves data (Zikra et al, 2015). Normalita et al (2014) reported that from 1984-2003, the trend of annual mean significant wave height was depend on observation location and time (season). The increasing trend of significant wave height is in North Natuna, Banda Aceh, North Papua and South Jogjakarta with the range 0.38 – 0.75 cm/year, respectively as shown in Table 2.

Table 2. Trend of significant wave height from 1984-2003.

Point	Significant wave height (cm/year)
1. 110^0 longitude, 5^0 latitude (North Natuna)	0.38
2. 90^0 longitude, 5^0 latitude (Banda Aceh)	0.52
3. 110^0 longitude, -10^0 latitude (South Jogyakarta)	0.75
4. 140^0 longitude, 10^0 latitude (North Papua)	0.75

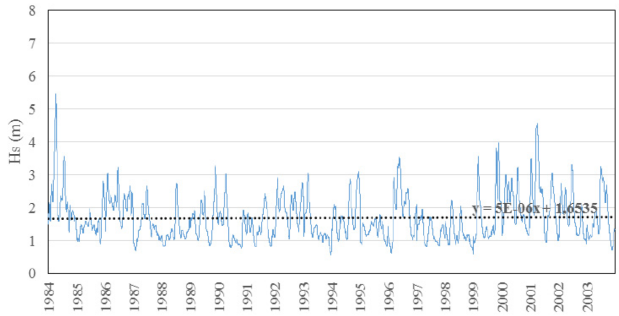


Fig. 2. Temporal variation in the mean of significant wave height
(Location : South Cina Sea – North Natuna (Longitude 110°, Latitude 5°)

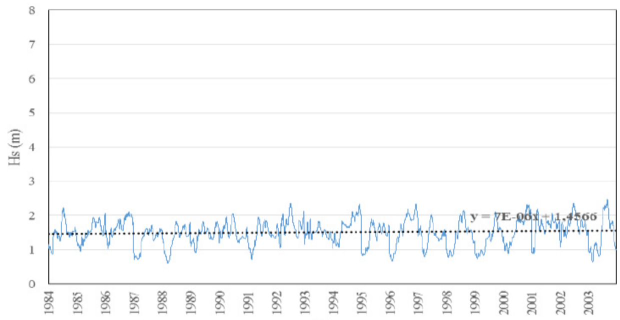


Fig. 3. Temporal variation in the mean of significant wave height
(Location : Indian Ocean – West Aceh (Longitude 90°, Latitude 5°)

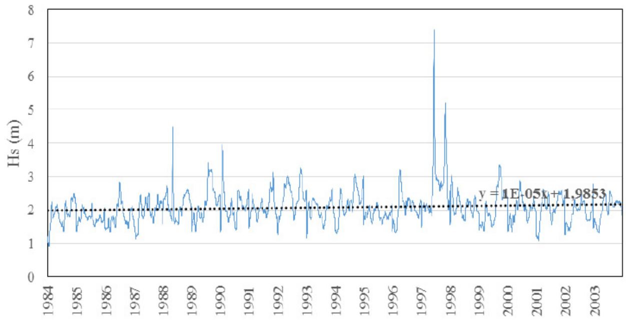


Fig. 4. Temporal variation in the mean of significant wave height
(Location : Pacific Ocean – North Papua (Longitude 140°, Latitude 10°)

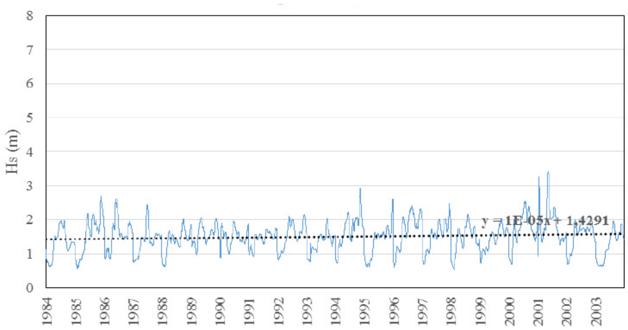


Fig. 5. Temporal variation in the mean of significant wave height
(Location : Indian Ocean – South Yogyakarta (Longitude 110°, Latitude -10°)

4. Sea water temperature

Coastal waters have warmed during the last century, and are very likely to continue to warm by as much as 4 to 8°F in the 21st century (IPCC, 2007). This warming may lead to big changes in oceanic circulation patterns and salinity, affecting species that inhabit these areas. Along with the intensification of the process of global warming, the intensity of El Nino and La Nina is also increasing (Timmermann et al. (1999). The El Nino event in 1997/1998 caused a long dry season and caused coral bleaching in Indonesia. At the time of occurrence of La Nina in 1999, Indonesia experienced an increase in high rainfall, and high rise sea level of 20cm to 30cm, causing flooding in most Indonesian coastal territory areas (PEACE, 2007).

This section specifically analyze about the pattern of temperature and salinity changes upon the Pacific Ocean caused by El Nino and La Nina based on study by Firra et al. (2013). This study used temperature and salinity data from TRITON buoy located at precisely 0°N 138°E south west side of the Pacific Ocean for 5 year period (2005-2010) as shown in Figure 6. This TRITON buoy was developed and deployed in the western equatorial Pacific and Indian Ocean since 1998 by Japan Agency for Marine-Earth Science and Technology. Basically, the purpose of this project is to observe ocean and atmosphere in the western tropical Pacific Ocean for better understanding of climate variability involving the El Nino and La Nina phenomena (JAMSTEC, 2010). The study concluded that the change in the sea surface temperature in the south west side of the Pacific Ocean towards the warm side, which explains the stronger and more frequent El Nino observed during 2005-2010 as shown in Figure 7.

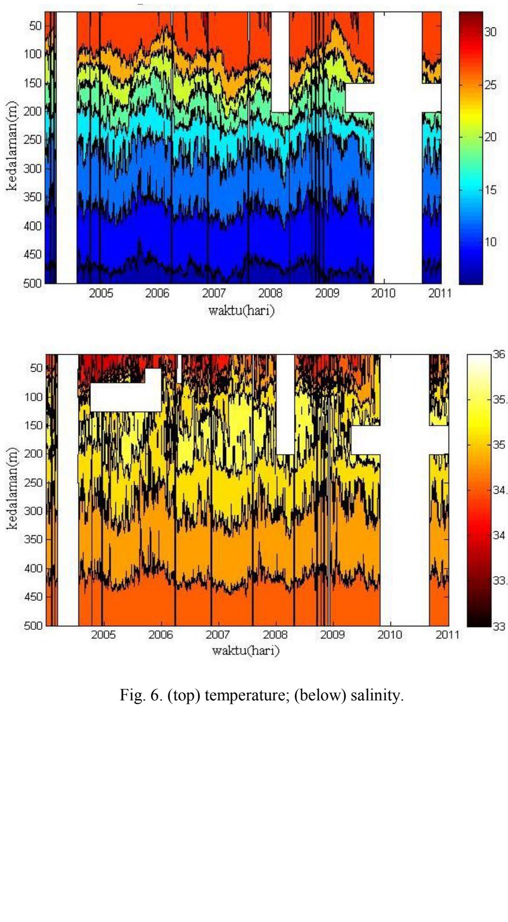
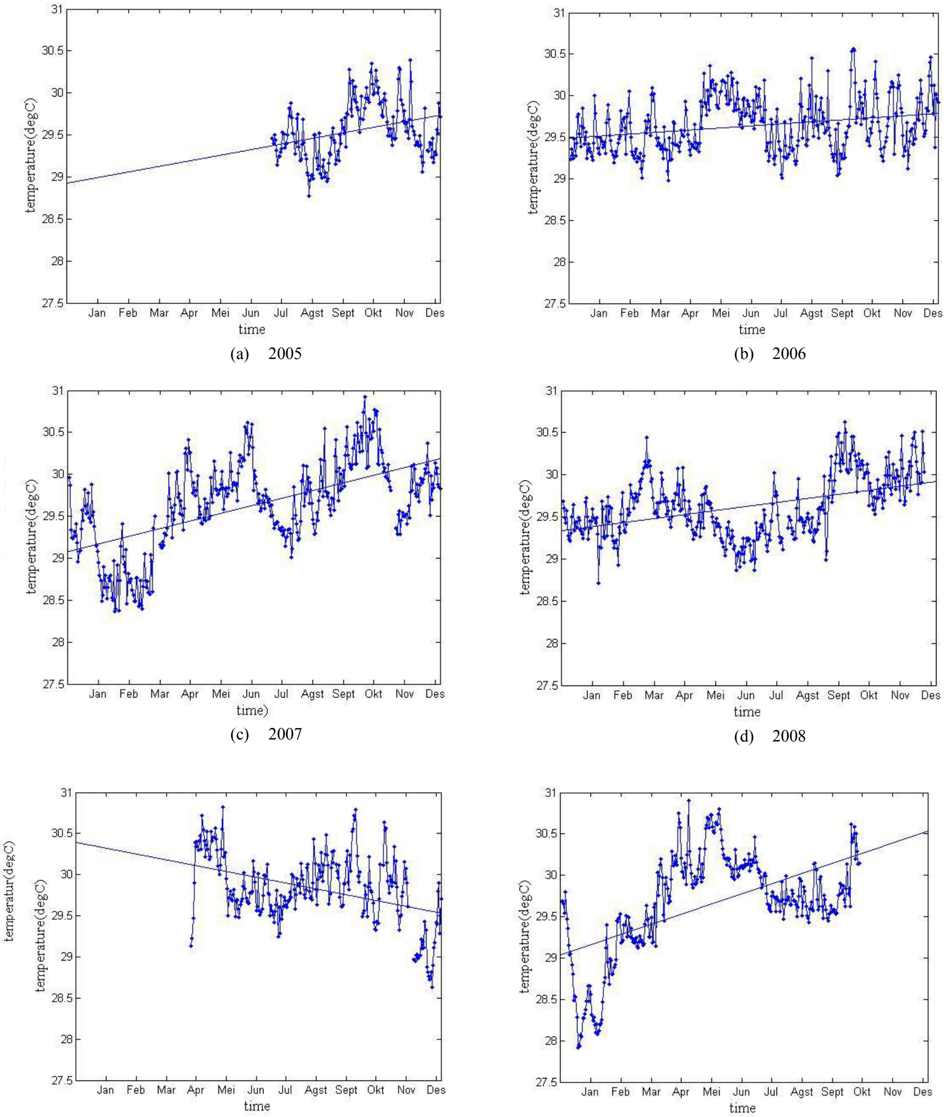


Fig. 6. (top) temperature; (below) salinity.



(a) 2005 (b) 2006

(c) 2007 (d) 2008

(e) 2009 (f) 2010

Fig. 7. Trend of sea surface temperature from 2005-2010

5. Conclusions

As an archipelago with over 17.500 islands and over 81,000 kilometers of coastline, Indonesia coastal area is very vulnerable to climate change. Increasing trend of sea level rise, warmer ocean temperature and increased of significant wave height are among a few example of what climate change may bring to Indonesia. These problems should received serious attention from government to develop adaptation and mitigation plans for future development associated with coastal areas.

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