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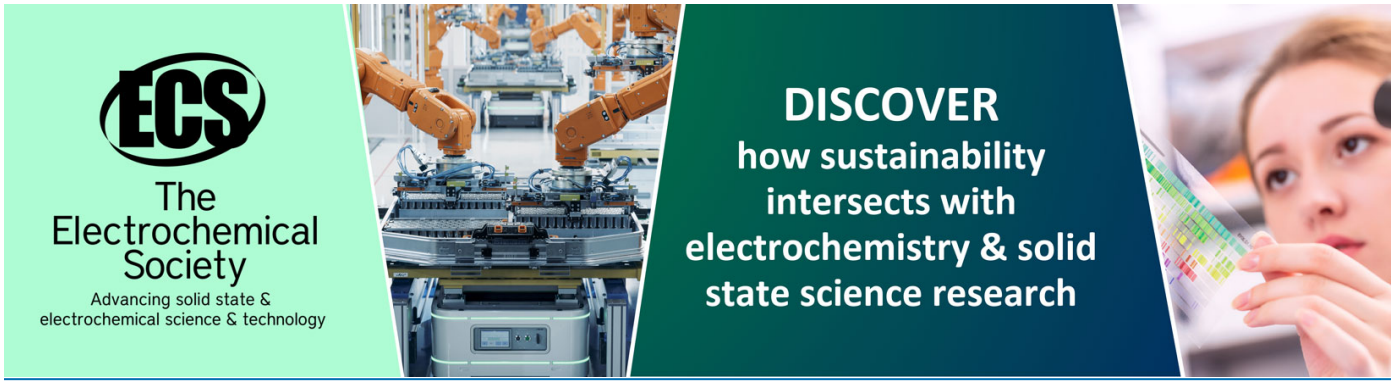

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Analysis and projection of sea level rise in Medana Bay, North Lombok district

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Abstract. Medana bay located in North Lombok District and administratively located in Medana Village. Located in small island, climate change impact become a serious threat to sustainability of society livelihood and ecosystem. One of the impact was sea level rise in which analyzed by using the sea level anomaly data from altimetry satellite of AVISO. the satelite data became a baseline data to produce and extracted into a trend graphic of sea level rise using Ocean Data View Model. Furthermore, sea level projection conducted by using tidal data which obtained through the Wxtide software to produce the statistic data from monitoring station of geophysics, climatology and meteorology bureau. Sea level projection analyzed by simple linker regression of Least Square. Sea level rise in Medana Bay area is 0.19 m or 19 cm during this 20 years from 1994 to 2014. It shows the increase is about 0.0096 m or 0.96 cm per year. Based on the data analysis due to 2100, the sea level will increase by 0.29 m or 29 cm since 1994. The result of simple method projection analysis then validate by SRESS Model of IPCC projection. The result between 2 methods are nearly equal.
Keywords: *Medana Bay, Sea Level Rise, Sea Level Rise Projection, Least Square, Altimetry Satelite*

1. Introduction

Indonesia is an archipelagic Nation with 13.446 islands and 81.000 km coastline.[1] It consists of small, medium, and large island with small island is the largest number. Based on Rancak (2012), Constitution No 27 2007 (Juncto Constitution No. 1, 2014) said that Lombok Island in West Nusa Tenggara Province is not include as the small island (($\leq$ 2.000 km^2).[2] Meanwhile based on Kukuh *et al* (2011), Lombok Island due to United Nation Convention on the Law of Sea (UNCLOS) has the category to become small island because its area less than 13.000 km^2 (Lombok Area only 4.725 Km^2).[3]

CTI (2013) mentioned if coastal area especially the small island has a higher risk of vulnerability than mainland or continent. Climate change affected a multisector such as livelihood, socio-economic, ecology, health, education, land use, and human settlement.[4] Furthermore, Hernandez *et al* (2018) mentioned if small islands are already being affected by climate change: morbidity and mortality are a consequence of extreme weather events, as well as vector- and food- and water-borne disease.[5] Those extreme weather events refer to tropical cyclons, storm surges, flooding and droughts leading to affects on human helath, including drowning, injuries, disease transmission, and helath effects derived from poor water quality.[6]

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One of those coastal which lies in small island was Medana Bay. It lies in small island area in North Lombok District which affected by climate change impact in multisector area.[7] One of them is sea level rise impact. It accelerates per year and has a consequence for destroying the coastal habitat. More further, it may cause the erosion, wetland flood, agriculture contamination, and loss of habitat for several animals.[8] When it happened with a storm, it will also increase the wave energy and may cause a massive destruction in coastal area.[9]

The situation may cause more damage in the future. It has tendency to increase in the future.[10] Adaptation and mitigation concept and action are being needed. Meanwhile, before the adaptation and mitigation concept are going to take an action, the Sea Level Rise (SLR) condition (annual) and projection has to be obtained.[11] it may become a baseline data to a better spatial planning for adaptation and mitigation in Medana Bay. What to address is how the projection may be continued in the future annually by a community as adaptation database -from baseline above-. A simple method *Least Square* will accommodate the procces while it is being integrated and verified by the IPCC model of sea level rise.

2. Research Method

2.1 Data Collection

Sea level data (anomaly data) was collected by Altimetry AVISO (Archiving, Validation and Interpretation of Satellite Oceanographic) Satellite extraction. It combined a several data from specific satellite such as JASON, TOPEX, and Poseidon which measured and monitored the parameter of oceanography.

Table 1. Data Source and Purpose on Conducting The Baseline Projection

Source	Data	Satellite	Purpose
AVISO Altimetry	1. NetCDF 2. Grafik	Topex Poseidon-ERS Jason-Envisat 1 dan 2	Sea Level Anomaly Data

Sea level rise projection needs a tidal data from *Wxtide* software to extract the Meteorology, Climatology and Geophysics Council (BMKG) monitoring station of oceanography.

2.2 Data Analysis

Sea level rise analysis conducted with a Sea Level Anomaly (SLA) data from AVISO Altimetry satellite. The data extracted and produced into trend graphic using the Ocean Data View (ODV) and Microsoft Excel. The spatial map of the sea level conducted by using the scatter plot method in 1500 x 1500 grid concentration.

Sea Level Rise projection conducted by a simple model of linier regression a *least square*. It will follow by a simple formula of linier regression

$$Y = aX + b \quad (1)$$

Which :
Y = Mean Sea Level (MSL)
a = Constant
b = Graphic Slope
X = Years

3. Result and Discussion

The tidal data of Medana Bay comes from the BMKG monitoring station of Ampenan, Lombok which extracted by using the *Wxtide* software. Tidal baseline data which collected each 4 hour a day from year 2004-2014 (1 decades). Figure 1 shows 11 figure corresponcent with the text.

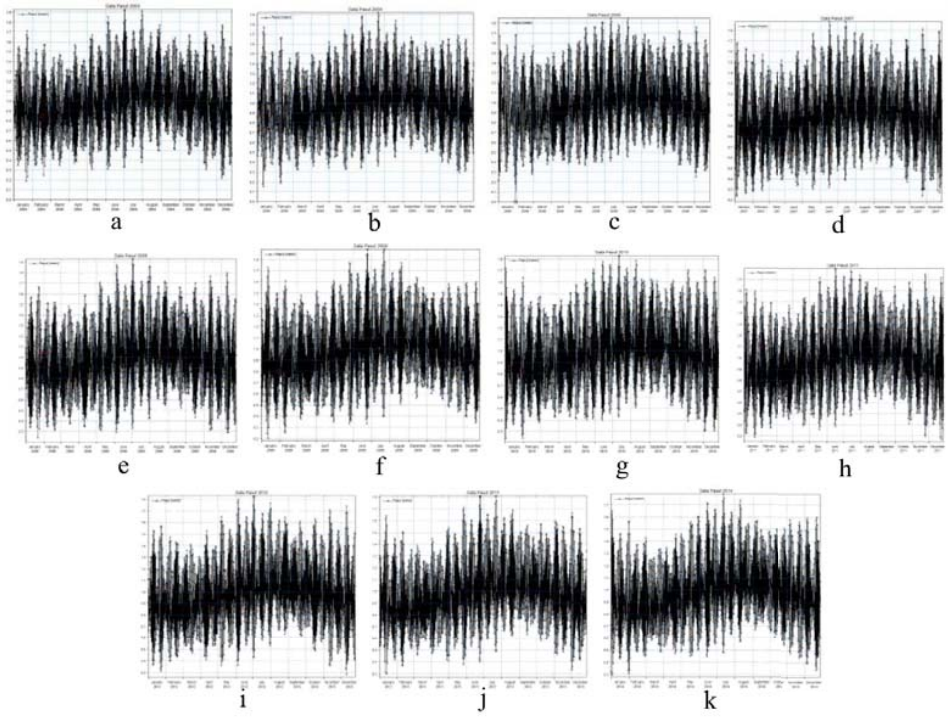

Figure 1. Tidal Wave Extraction Based on BMKG monitoring Station in Ampenan, Lombok

a. Tidal Data of 2004
b. Tidal Data of 2005
c. Tidal Data of 2006
d. Tidal Data of 2007
e. Tidal Data of 2008
f. Tidal Data of 2009
g. Tidal Data of 2010
h. Tidal Data of 2011
i. Tidal Data of 2012
j. Tidal Data of 2013
k. Tidal Data of 2014

Figure 2 show the Mean Sea Level (MSL) based on the sea level data which collected using the AVISO Altimetry satellite in 2 decades (1994-2014). Figure 3 shows the data extraction based on data processing. Sea level in the Medana Bay rising about 0.0096 mm or 0.96 cm each year. It means the sea level increased about 0.19 m or 19 cm in 2 decades in average. Figure 4 show the result the trend of sea level rise in 2 decades.

Figure 4 shows the *downscaling* of sea level trend each year. It will show the *least square* method due to = $0.0048x - 0.0218$. This equation are going to use as a baseline to project the sea level rise in the future year, while x is year, starting from 1994.

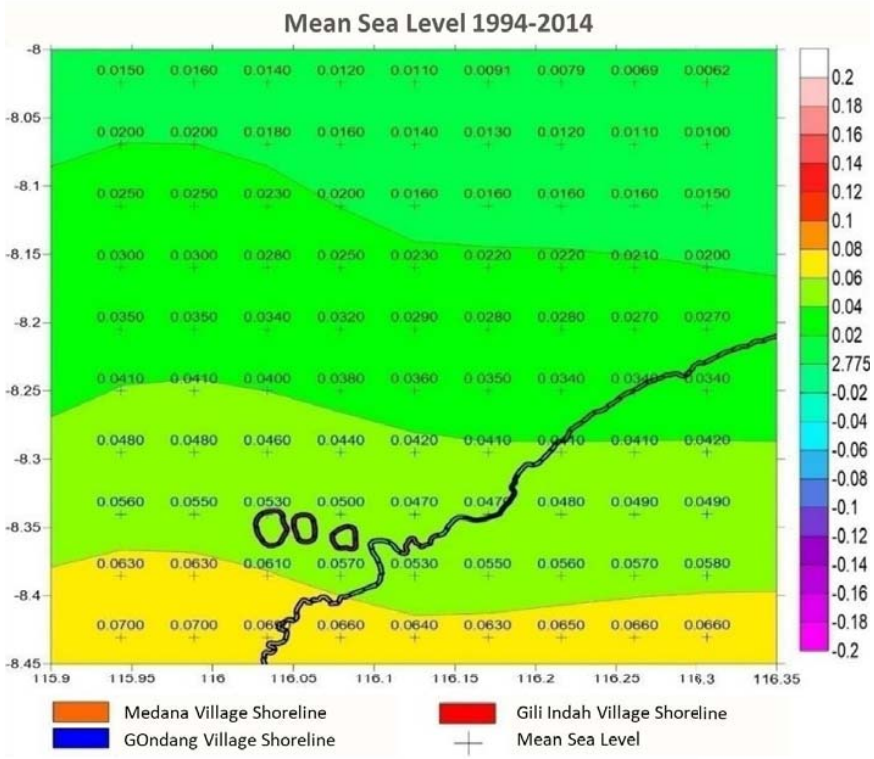

Figure 2. Mean Sea Level Spread in Medana Bay and Several Area in North Lombok District

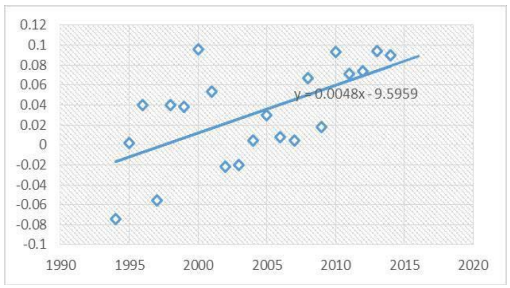

Figure 3. Sea Level Rise Trend Data Based on Processing the AVISO Altimetri Satellite Data

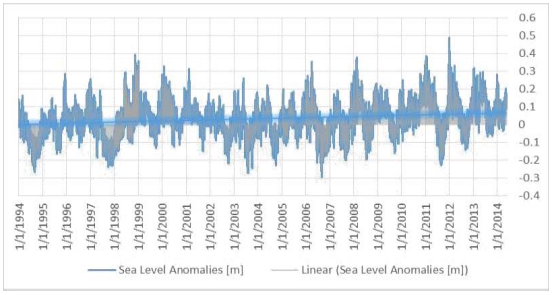

Figure 4. Mean Sea Level Rise in each year from 1994-2014

Table 2 showing the sea level rise in Medana Bay until 2100. The sea level rise projection in Medana Bay are due to 0.29 m or increase about 29 cm from 1994 to 2100. Based on IPCC Model of SRES, sea level increasing in Lombok Area due to 40-60 cm in 2100. It obtained from modelling calculation of oceanography including the factor of 40 cm melted iceberg in both north or south pole.

Table 2. Sea Level Rise Projection in 2100

Year Projection	X (increase from 1994)	Sea Level (m)
2020	26	0.103
2050	56	0.247
2100	106	0.487

Source: Data Processing

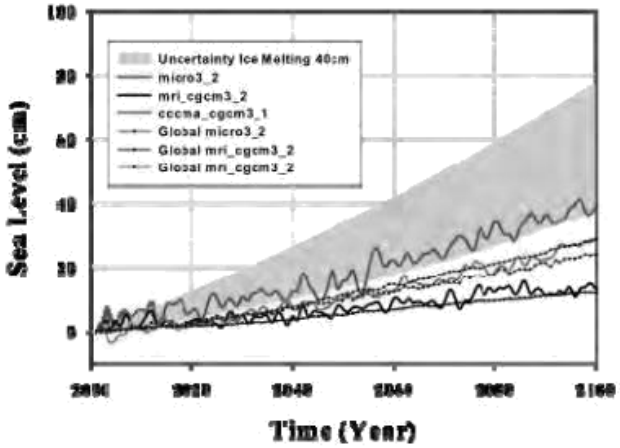

Figure 5. Sea Level Rise Projection Based on SRES-IPCC
(*Source: IPCC, 2012, in GTZ, 2012*)[12]

Furthermore, IPCC also measure the sea surface temperature (SST) increase about 3^{O}C-3,5^{O}C in 2100. Each 1^{O}C increase, it will equivalent with approximately 20 cm of sea level. Based on thus measurement, sea level will increase due to 60-70 cm in 2100.

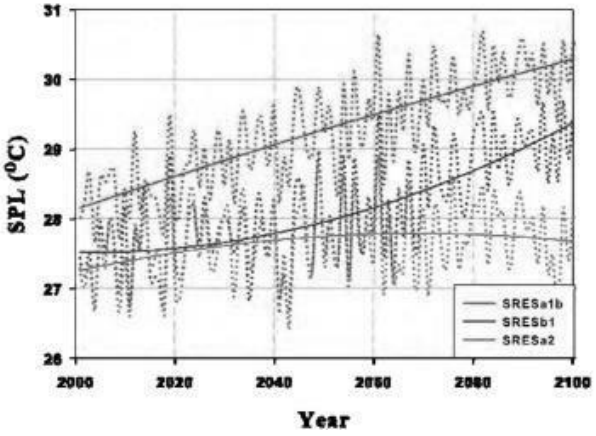

Figure 6. Sea Surface Temperature Based on Model MRI_CGCM 3.2
(*Source: IPCC, 2012 in GTZ, 2012*)[12]

Table 3 show the comparison of measurement from the two methods. Based on this table, the measurement by using the AVISO satellite and simple method *least square*, nearly close with the complex SRES-IPCC model.

Table 3. The Comparison Result of Sea Level Rise Projection Due to Altimetry-Tidal-Least Square and SRES-IPCC

Year	Sea Level Rise Projection in Medana Bay	
	Least Square Method (m)	SRESS Model of IPCC (m)
2020	0.103	0.051 – 0.129 0.034 – 0.094 0.067 – 0.155
2050	0.247	0.136 – 0.334 0.112 – 0.20 0.162 – 0.35
2100	0.487	0.378 – 0.78 0.511 – 0.129 0.34 – 0.94

Source: Data Processing from Altimetry-Tidal-Least Square and IPCC Data Model

4. Conclusion

An established tidal model, validated for present-day conditions, is used to investigate the effect of large levels of sea-level rise on tidal characteristics around Australasia, [13] Including West Nusa Tenggara and Indonesia.

Sea level in the Medana Bay rising about 0.0096 cm or 0.96 each year. It means the sea level will rise about 0.19 or 19 cm in 2 decades. The sea level rise projection in Medana Bay are due to 0.29 m or increase about 29 cm from 1994 to 2100.

Furthermore, to conduct the analysis and projection of Sea-Level Rise, a simple method of linier regression of Least Square is considerable. Based on research data, it is about average (inside the range) of SRESS method of IPCC due to same database.

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