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Wave Climate Variations in Indonesia Based on ERA-Interim Reanalysis Data from 1980 to 2014

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ABSTRACT

In this study, temporal variation in significant wave height are studied using ERA-Interim reanalysis data from ECMWF (European Centre for Medium-Range Weather Forecasts) for 35 years period from 1980-2014. The ERA-Interim reanalysis data provides wind speed and wave height data with resolution of 1 x 1 degree. This paper studied monthly variation in significant wave height and wind speed by creating monthly data and taking the mean of those months over a period 35 years. The results show that the mean wind speed and significant wave height in the South of Java Sea have an increasing trend for all month.

KEY WORDS: *Wave, wind speed, ERA-Interim*

1.0 INTRODUCTION

Indonesia as an archipelago country, especially in coastal area, is very vulnerable to climate change such as sea level rise, warmer ocean temperature and increased of wave height [1]. Numerous studies reported that climate change has a significant impact on the future of wind and wave climate condition [2][3][4].

Knowledge of wave climate change due to global warming is required for engineering purpose. Especially, knowledge about wave information in a certain area is important for all activities related to the marine sector. For example offshore industry, ship design for safety and seakeeping, marine transportation management, renewable wave energy etc. Therefore, understanding the long-term variations in the wave parameter is key element for sustainable management of both offshore and coastal activities.

The objective of this study is to analyze the monthly variability of the wind and wave climate at Indonesia Sea based on the wind speed and significant wave height (SWH) obtained from ECMWF reanalysis ERA-Interim data for 35 years (1980 - 2014). ERA-Interim data has proved a better spatial resolution than ERA 40 to analysis SWH at North Sea [5]. This analysis study can serve as basis data source for possible wave energy evaluation projects in Indonesia.

2.0 DATA

In Indonesia, long-term wave records based on in situ measurements are still limited. Due to that reason, in this study, temporal variation in wind speed and significant wave height are studied using hindcasting model from ERA-Interim reanalysis data from ECMWF (European Centre for Medium-Range Weather Forecasts) for 35 years period from 1980-2014.

The ERA-Interim reanalysis data provides wind speed and significant wave height data with resolution of 1^o x 1^o. ERA-Interim is the first re-analysis using adaptive and fully automated bias corrections of satellite radiance observations [5] and contains improvements to ERA-40 such as the complete use of four-dimensional variation data assimilation from various kinds of sources such as scatterometers, altimeters, US wind profiler data, etc. For this study, 10 observation locations were chosen on the nearest of Indonesia sea. Those observation points are shown in the Figure 1 and names of each location is presented in Table 1.

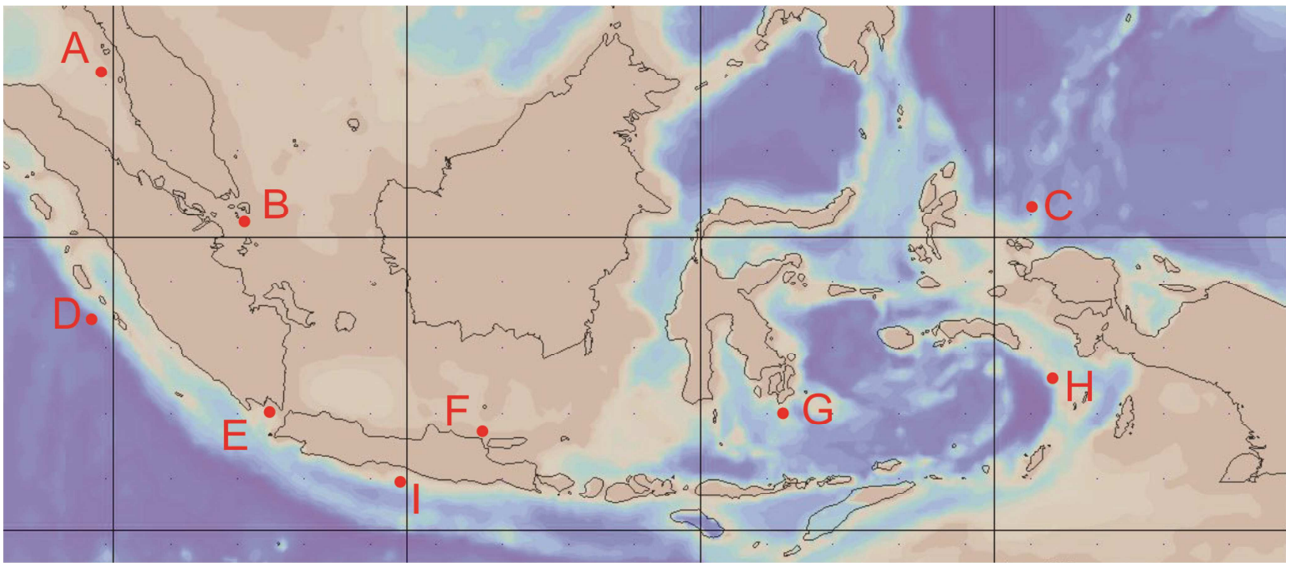

Figure 1: Observations points in Indonesia seas

Table 1: Observation points

Point	Coordinate	Location
A	3.75^0 N and 99.75^0 E	Malacca Strait
B	0.75^0 N and 105^0 E	Natuna sea, Riau Island
C	0.75^0 N and 130.50^0 E	Pacific Ocean
D	3.75^0 S and 99.75^0 E	Indian Ocean, Mentawai Island
E	6.00^0 S and 105.75^0 E	Sunda Strait
F	6.75^0 S and 112.50^0 E	Java Sea
G	6.75^0 S and 121.50^0 E	Flores Sea
H	2.25^0 S and 131.25^0 E	Banda Sea
I	110.5^0 S and 2.25 E	South of Java Sea

In this study, wind speed and significant wave heights (SWH) downloaded for the period 35 years from 1984 to 2014 at 6-hourly intervals. We studied variation in parameters wind speed and SWH by creating monthly data from the 6-hourly data and taking the mean of those months over a period of 35 years. Simple linear regression is used to estimate the linear trend (slope) of wind speed and wave height time series data:

$$y_t = a + bt$$

where t is specified number of time periods from t=0, y_t is forecast for time period t, a is the value of y at t and b is the slope of the line. The trend is the rate at which wind speed or wave height changes over 35 years period

3.0 RESULTS

The monthly mean wind speed trends are calculated for 35 years are shown in Table 2. Monthly mean wind speed trend at Natuna Sea, Pacific Ocean, Flores Sea and Banda Sea show negative trend from January to March. Other locations (Malacca strait, Indian Ocean and South of Java Sea) show an upward trend during January to March with maximum trend 3.18 cm.s-1/years.

The increasing trends have occurred in all month during a year for monthly mean wind speed in Malacca strait, Mentawai Island and South of Java Sea. South of Java Sea has a higher increasing trend of monthly mean wind speed with 4.2 cm.s-1/years. Meanwhile, the trend of monthly mean wind speed in Natuna Sea and Sunda strait has decreasing trends for all month with the value between -0.09 cm.s-1/years to -3.42 cm.s-1/years. Sunda strait has a higher decreasing trend on May with -3.42 cm.s-1/years. For other locations, the trends of monthly mean wind speed are varying depending on month during west monsoon or east monsoon seasons.

The monthly mean of significant wave height (SWH) trends are calculated for 35 years are shown in Table 3. For the trend of monthly mean SWH, Pacific Ocean, Banda Sea and South of Java Sea have increasing trend during all month. South Java Sea has the highest trend of mean significant wave height (SWH) with 5.05 cm/years on January as shown in Table 3.

Meanwhile, for other location, the trends of monthly mean SWH are varying depend on month. During March and April, all trend of monthly mean of significant wave height show increasing trend. Start from April, monthly mean SWH trend in Malacca strait show decreasing value become -0.84 cm/years. Same situation in Java Sea, start from May the trend of SWH become negative value until -4.08 cm/year on December.

Added, the present study shows the monthly mean of wind speed and significant wave height have a decreasing trend all month during 35 years period that in South of Java Sea, as shown in Figure 2 and 3, respectively.

Table 2: Trend of monthly mean wind speed during 1980- 2014

Month	Monthly Mean Wind Speed Trend (cm.s^{-1}/years)								
	A	B	C	D	E	F	G	H	I
January	2.23	-1.01	-0.41	0.46	-0.09	-1.87	-2.73	-0.41	0.37
February	1.73	-0.61	-2.47	1.11	-0.21	0.84	-2.86	-2.47	1.30
March	1.16	-0.26	-2.21	1.86	0.68	1.82	-0.81	-2.21	3.18
April	0.52	-0.29	0.46	-0.03	-2.04	1.23	1.62	0.46	1.26
May	0.80	-0.61	-0.11	0.19	-3.42	-0.08	2.36	-0.11	2.33
June	0.54	-1.46	-0.40	0.89	-2.97	-1.48	0.52	-0.40	2.93
July	1.43	-1.56	-0.20	0.96	-3.05	-2.47	0.10	-0.20	2.39
August	0.89	-2.34	-2.19	1.07	-2.51	-2.62	-2.81	-2.19	3.33
September	1.20	-0.99	-0.69	1.34	-1.36	-1.50	-2.59	-0.69	4.21
October	0.81	-0.42	0.79	0.28	0.42	-0.73	-1.61	0.79	2.75
November	0.05	-1.24	0.80	0.48	-1.19	-2.34	-2.38	0.80	0.37
December	1.10	-0.31	-2.91	0.63	-1.02	-4.08	-2.86	-2.91	0.57

Table 3: Trend of monthly mean significant wave height (SWH) during 1980- 2014

Month	Monthly Mean SWH Trend (cm/years)								
	A	B	C	D	E	F	G	H	I
January	0.20	0.04	0.76	-0.52	0.55	-1.87	-0.50	0.76	5.05
February	0.20	0.20	0.34	0.56	0.34	0.84	-0.47	0.34	2.09
March	0.20	0.55	0.38	0.37	0.61	1.82	0.02	0.38	2.70
April	-0.18	0.18	0.61	0.05	0.20	1.23	0.57	0.61	2.80
May	-0.19	0.22	0.51	-0.17	-0.11	-0.08	0.87	0.51	2.63
June	-0.37	0.09	0.56	-0.35	-0.19	-1.48	0.81	0.56	2.47
July	-0.29	0.03	0.60	0.03	-0.02	-2.47	1.11	0.60	2.73
August	-0.27	-0.03	0.10	0.16	0.04	-2.62	0.50	0.10	2.54
September	-0.20	0.17	0.19	0.14	0.52	-1.50	-0.02	0.19	0.17
October	-0.84	-0.40	0.51	0.17	0.59	-0.73	-0.30	0.51	2.29
November	0.07	-0.02	0.51	-0.07	0.29	-2.34	-0.04	0.51	5.05
December	-0.45	-0.20	0.14	0.01	0.30	-4.08	-0.20	0.14	1.85

4.0 CONCLUSION

Temporal variation of significant wave height in Indonesia sea are studied using ERA-Interim reanalysis data from ECMWF for 35 years period from 1980-2014. The ERA-Interim reanalysis data provides wind speed and wave height data with resolution of 1 x 1 degree. This paper studied monthly variation in significant wave height and wind speed by creating monthly data and taking the mean of those months over a period 35 years. The results show that the mean wind speed and significant wave height in the South of Java Sea have an increasing trend for all months.

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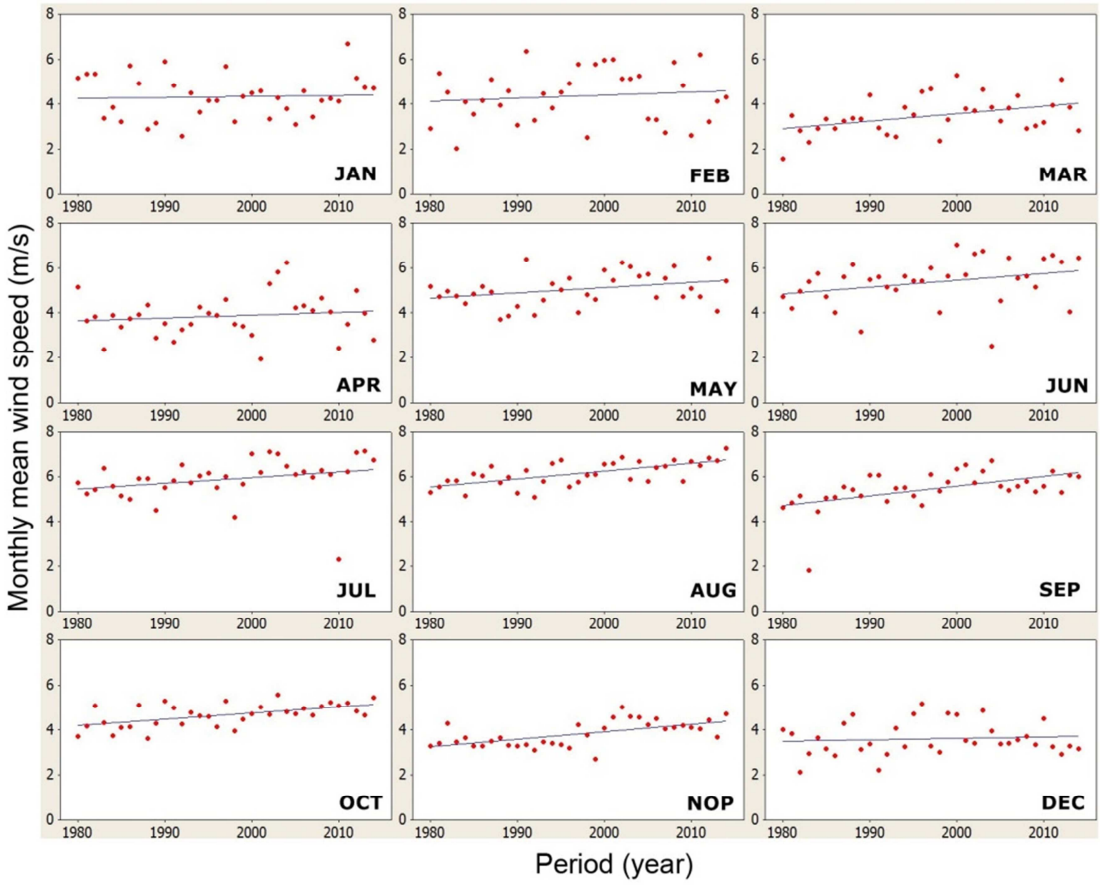

Figure 2: Variation of monthly mean wind speed in the South of Java Sea (Point I)

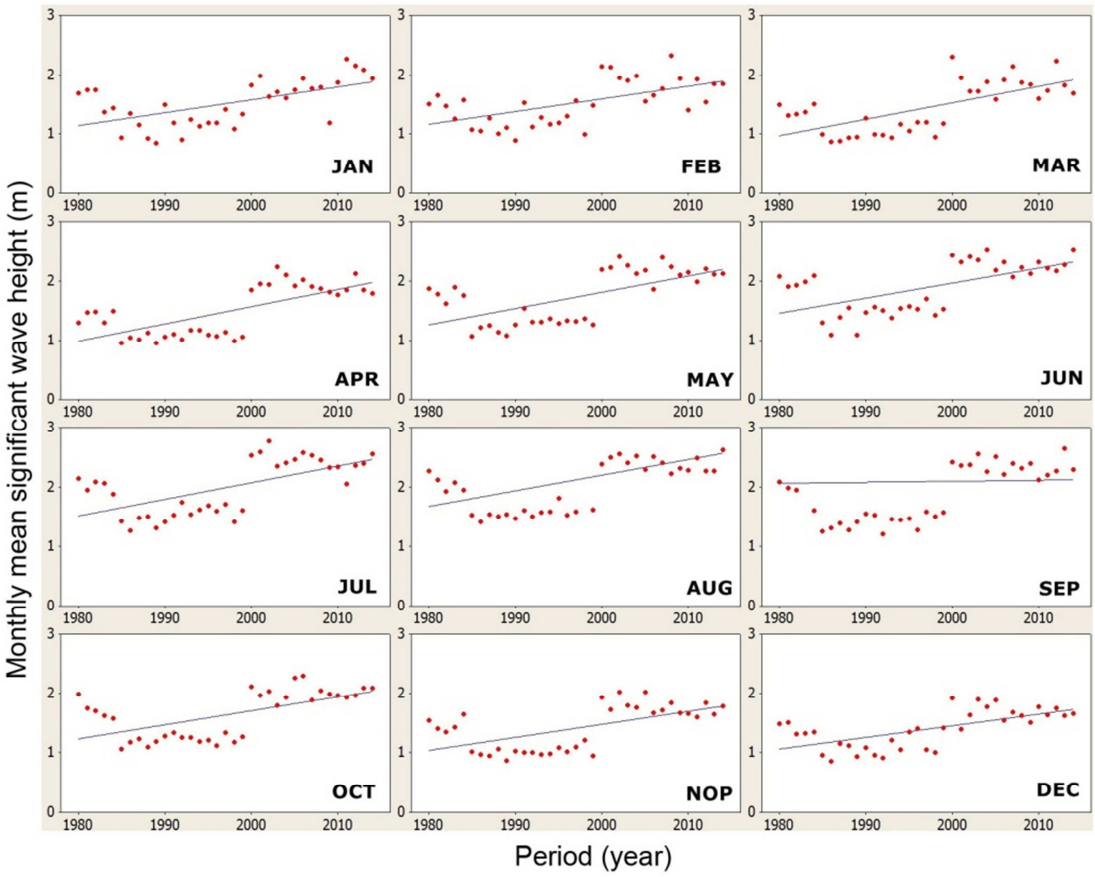

Figure 3: Variation of monthly means SWH in the South of Java Sea (Point I)