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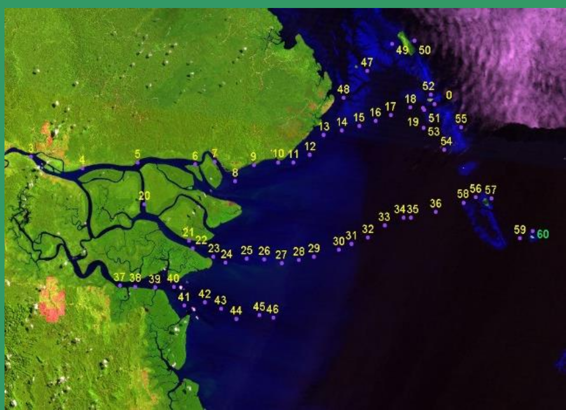

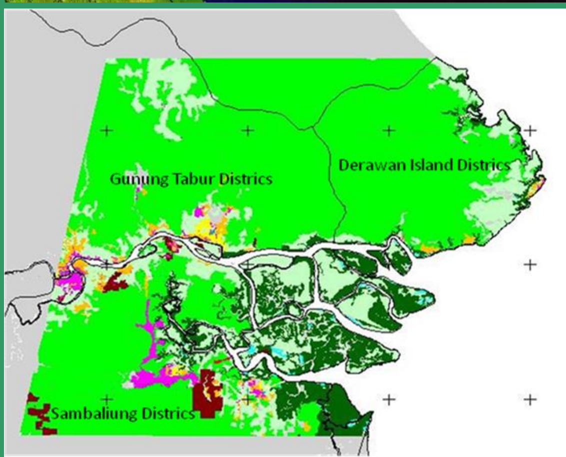

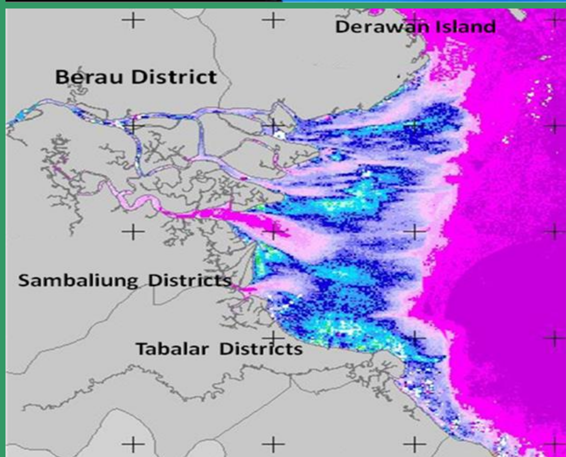

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Editorial Committee Preface

Dear IJReSES Readers,

We sincerely thank you for reading the International Journal of Remote Sensing and Earth Sciences Vol. 14 No 1, June 2017. In general, this journal is expected to enrich the serial publications on earth sciences. In particular this journal is to improve the remote sensing studies. Also, this journal serves as the enrichment on earth sciences publication not only in Indonesia and Asia but also worldwide.

This journal consists of papers discussing the particular interest in remote sensing field. Those papers are having remote sensing data for geosciences, oceanography, marine biology, fisheries, meteorology, etc. A variety of topics are discussed in this fourteenth edition. Briefly, the topics discussed in this edition are studies of remote sensing data processing issues such as partial acquisition technique of SAR system, land use/land cover classification using LAPAN-A2 microsatellite data, and simulation of direct georeferencing for geometric systematic correction on LSA pushbroom imager. Meanwhile the topics on remote sensing applications and validation are also discussed such as harmful algal bloom event verification using SPOT 4 image, red tide detection using SeaWIFS-derived chlorophyll-a data, diffuse attenuation coefficient and its relationship with water constituent and depth estimation of shallow waters, analysis of total suspended solid (TSS) using Landsat data.

The publication of IJReSES is intended to supply the demands regarding the information on the Remote Sensing and Earth Sciences. This journal is also intended to motivate Indonesian scientists to submit their research results. Thus, by their submitted research results, it will contribute to the development and the strengthening in remote sensing field particularly, but not limited, in Asia. To that end, we invite scientists to play their parts in this journal by submitting their scientific research papers. We look forward to receiving your research works for the next edition of this journal.

Editor-in-Chief,

Dr M. Rokhis Khomarudin

Editorial Committee Members
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Contents

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VERIFICATION OF PISCES DISSOLVED OXYGEN MODEL USING IN SITU MEASUREMENT IN BIAK, ROTE, AND TANIMBAR SEAS, INDONESIA

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Abstract. Dissolved oxygen (DO) is one of the most chemical primary data in supported life for marine organisms. Ministry of Marine Affairs and Fisheries Republic of Indonesia through Infrastructure Development for Space Oceanography (INDESO) Project provides dissolved oxygen data services in Indonesian Seas for 7 days backward and 10 days ahead (9,25 km x 9.25 km, 1 daily). The data based on Biogeochemical model (PISCES) coupled with hydrodynamic model (NEMO), with input data from satellite acquisition. This study investigated the performance and accuracy of dissolved oxygen from PISCES model, by comparing with the measurement in situ data in Indonesian Seas specifically in three outermost islands of Indonesia (Biak Island, Rote Island, and Tanimbar Island). Results of standard deviation values between in situ DO and model are around two (St.dev ± 2). Based on the calculation of linear regression between in situ DO with the standard deviation obtained a high determinant coefficient, greater than 0.9 ($R^2 \geq 0.9$). Furthermore, RMSE calculation showed a minor error, less than 0.05. These results showed that the equation of the linear regression might be used as a correction equation to gain the verified dissolved oxygen.

Keywords: verification, PISCES model, dissolved oxygen, in situ measurement, indonesia, linear regression

1 INTRODUCTION

Indonesia is one of the countries with the largest number of islands in the world. In the 1945 Constitution of the Republic Indonesia, appointed that Indonesia is an archipelagic country with many islands consists of 17,480 and 92 small islands are the outermost islands. Three among the outermost islands are Biak Island, Rote Island, and Tanimbar Island. Geo-strategically, those outermost islands require an effort to strengthen identity as a maritime state of Unitary State of the Republic of Indonesia. With its strategic position and close to several notable countries: Biak Island whose territorial sea adjacent to the ZEE region which border to Papua New Guinea (in the East) and Palau (in the Northeast) (Pranowo *et al.* 2016a); Rote Island whose territorial sea adjacent to the ZEE region which border to Australia (in the South) and Palau (in the Northeast) (Pranowo *et al.* 2016b); and Tanimbar Island whose territorial sea adjacent to the ZEE region which border to Papua New Guinea (in the East) and Australia (in the South) (Pranowo *et al.* 2016c).

Outermost islands have a mega biodiversity with a productive ecosystem to be developed, for instance coral reefs, seagrass, mangrove, fisheries, and conservation area, become important factors in developing marine tourism (Kusumo 2010). With the complex ecosystems, interactions between land, sea, and human activities in coastal areas could affect the nutrient, pH, and dissolved oxygen which are the indicators of water exuberance (Patty *et al.* 2015).

Oxygen is one of the primary chemical parameters in supported life for various marine organisms. Dissolved Oxygen (DO) in the waters came from photosynthesis of phytoplankton or other aquatic plants and from air diffusion (Purba & Pranowo 2015). DO was used by marine organism in respiration process and decomposing organic matter into inorganic matter by microorganism (Simanjuntak 2007). DO data is one of the primary data in marine dataset. Hence DO distribution could be used to determine the water exuberance level. Furthermore the measurement of DO also to discover the capability of waters in accommodate the organism such as fish and microorganism (Samosir *et al.* 2012).

Generally, in situ measurement and observation data in the sea are highly limited and not continuous. The other alternative is to use satellite imagery or modelling data. One of the models used by Ministry of Marine Affairs and Fisheries (KKP) to provide DO data was through Biogeochemical Model through Infrastructure Development for Space Oceanography (INDESO) Project. INDESO-Project KKP is a collaboration project between Indonesia and France to improve the institutional capacity and human resources of oceanographic operational systems. Oceanographic data service has been running since 2014 through www.indeso.web.id.

The ocean biogeochemical model used for the INDESO Project was a regionalized version of the PISCES model coupled to NEMO hydrodynamics model for ocean data provision. This model has a spatial resolution of 0.08°with horizontal grid size about 9.25 km x 9.25 km, and 1 day temporal resolution, with a forecasting time of 7 days backward and up to 10 days ahead (Purba & Pranowo 2015). As for the input data model, it was from downscaling data of chlorophyll, sea surface temperature, sea surface height, and wind.

To investigate the performance and accuracy of modeling data, a linear regression analysis can be used. Linear regression analysis has been used to validate modeling data or satellite imagery, as did by Kurniawan *et al.* (2013) on verification of the windwave-05 model output with altimeter satellites, and research on MODIS standard (OC3) chlorophyll-a algorithm evaluation in Indonesian Seas by Winarso & Marini (2014).

Until now there has been no research about the verification of DO data from PISCES (INDESO Project) Model with in situ measurement in Indonesian Seas specifically in coastal areas. This research was aimed to investigate the performance and accuracy of DO from PISCES model, by comparing with the measurement in situ data in Indonesian Seas specifically in three outermost islands of Indonesia (Biak Island, Rote Island, and Tanimbar Island).

2 MATERIALS AND METHODOLOGY

2.1 In Situ Measurement

The DO from in situ measurement was acquired from research survey held by Basis Data of Outermost Islands Team, Research and Development Center (R&D) for Marine and Coastal Resources, Agency for Marine and Fisheries R&D in 2016.

In situ data measurement survey conducted in the Indonesian Seas specifically in East Indonesian Sea Region, on three outermost islands of

Biak Island (136.1 – 136.4°E and 1.1 – 1.3°S), Rote Island (123.3 – 123.5°E and 10.3 – 10.6°S), and Tanimbar Island (136.1 – 136.4°E and 1.1 – 1.3°S). The location of study area can be seen in Figure 2-1.

Survey on Biak Island held at 24 – 28 August 2016 with a total of 61 stations measurement; Rote Island held at 22 – 26 October 2016 with a total of 53 stations measurement; and Tanimbar Island held at 8 – 11 August 2016 with a total of 35 stations measurement. The survey used measurement tools of TOA DKK Water Quality Checker (WQC), Garmin eTrex 30X GPS, Garmin GPSmap 585 Echosounder, and Plankton net. The measured parameters were temperature, salinity, pH, DO, conductivity, total suspended solids, density, plankton, and nutrient data (Xu & Xu 2016).

2.2 PISCES Model

Pelagic Interaction Scheme for Carbon and Ecosystem Studies (PISCES) is a model used in INDESO Project Biogeochemical Modeling, coupled to NEMO (Nucleus for European Modeling of the Ocean) model system. The PISCES 3.2 version was used in INDESO Project. Because of biogeochemical model in INDESO Project coupled between PISCES and NEMO model, hence it has the same output data characteristics which has a horizontal grid resolution of 9.25 km x 9.25 km and followed with vertical layers that increased resolution near the surface (INDESO – KKP 2015).

PISCES is a model with intermediary complexity initially developed for the global ocean. It simulates the marine biological productivity and describes the biogeochemical cycles of carbon and the main nutrients (P, N, Si, Fe) (INDESO – KKP 2015). PISCES model has currently twenty-four compartments that contained on the algorithm, and divided into two parts of biological and non-biological component. For the biological component consist of phytoplankton and zooplankton, while non-biological component consists of dissolved organic material. In addition to the ecosystem model, PISCES also simulates dissolved inorganic carbon, total alkalinity, and DO (Aumont 2004). PISCES model builder description scheme can be seen in Figure 2-2.

NEMO 2.3 version was used in INDESO Project. NEMO is a model developed by France (Mercator Ocean) and highly accurate in observe the ocean circulation in Indonesia, because it has a high resolution for the capture fisheries (Tussadiah *et al.* 2016; Pranowo *et al.* 2016). The input data of NEMO model has included the satellite data which were sea surface height altimetry, wind from radar, bathymetry, and tidal.

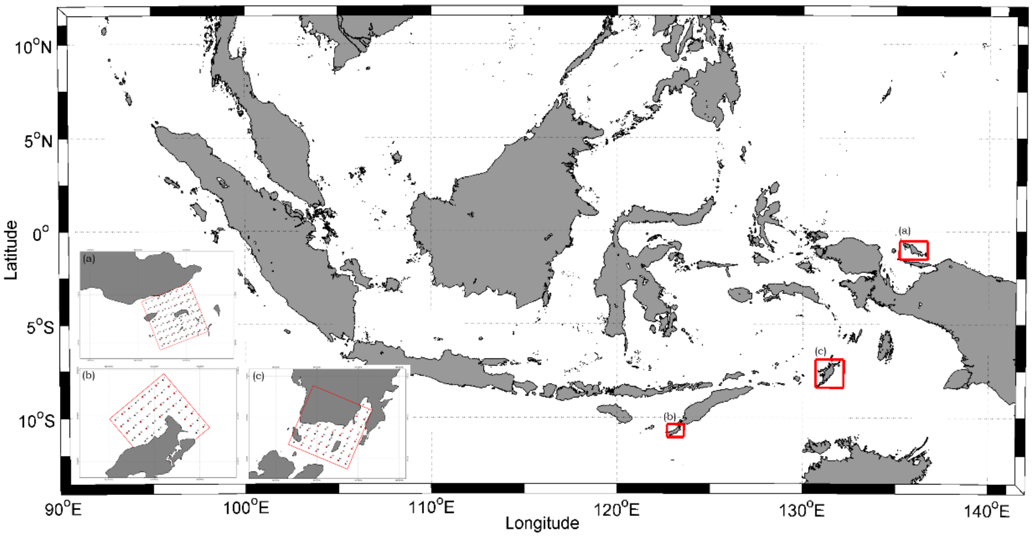

Figure 2-1: Study area location

Range values of biogeochemical PISCES model can be so huge so a consequent sensitivity analysis is required for calibration (INDESO – KKP 2015).

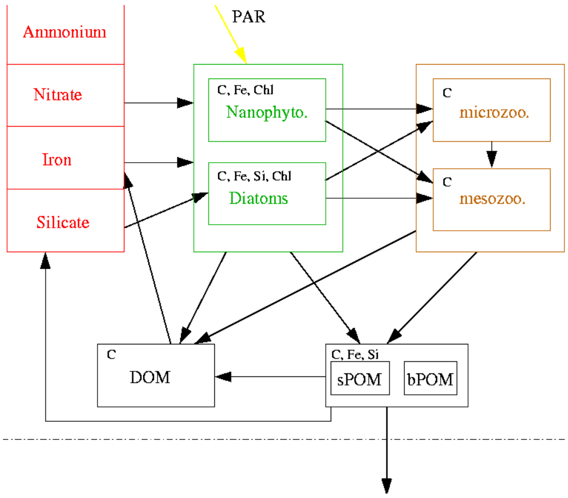

Figure 2-2: PISCES ecosystem scheme

2.3 Linear Regression Analysis

Linear regression analysis was used to measure the relation between in situ DO with the DO of PISCES model, where this method was common and has been used to analyze the waters and fisheries environmental parameters (Teliandi *et al.* 2013; Abigail *et al.* 2015). In addition, the linear regression analysis was used to perceive the trend between in situ DO and PISCES model. By using the equation Y = a + bX, we then obtained a correction equation which used to get a verified DO. Here, we compared two calculation of linear regression (Figure 3-3 and Figure 3-4). As the first linear regression the X variable was in situ DO and Y variable was DO of PISCES model, and the other linear regression the X variable was standard deviation of the dataset resulted by the model and Y variable was the in situ DO. Standard deviation was computed based on dataset of each point modeling data, which then compared with in situ DO.

In linear regression analysis, we also observed the determination coefficient(R^2). Determination coefficient was used to measure the capability of model in represent the variation of the dependent variable. If the value of R^2 is close to 1 then the regression equation was good in predicting the variation of the dependent variable, in other words the correlation was almost perfect.

2.4 *Root Mean Square Error* (RMSE)

Root Mean Square Error (RMSE) has been used as a standard statistical metric to measure model performance in meteorology, air quality, and climate research studies (Chai & Draxler 2014). The RMSE equation was used to determine the deviation or error level between in situ DO with DO new model. RMSE was calculated using the following formula:

$$RMSE = \sqrt{\frac{1}{n}\sum(di - d'i)^2} \quad (2\text{-}1)$$

Where: n = total data, di = DO new model (mg/l), and d'i = in situ DO (mg/l).

If the RMSE calculation results greater values, it indicates the prediction between in situ DO and DO new model is getting further, and vice versa. The best result of RMSE is 0 (Swarinoto & Husain 2012).

3 RESULTS AND DISCUSSION

3.1 Dissolved Oxygen In Situ Distribution

Spatial distribution of in situ DO measurement at three outermost islands can be seen in Figure 3-1 and the graph between in situ DO with PISCES model can be seen in Figure 3-2.

In situ measurement on Biak Island occurred around the Padaido Island, Auki Island, and Owi Island with a total of 61 stations measurement. Based on the measurement, it showed the DO range in study area was between 6.50 –

8.00 mg/l, with an average of 7.07 mg/l. The highest DO (8.17 mg/l) found at station 34 near of the Auki Island, while the lowest found at station 23 (6.71 mg/l).

In situ measurement on Rote Island occurred around the Rote Strait with a total of 53 stations measurement. DO range near the Rote Strait waters was 6.40 – 9.00 mg/l with an average of 6.93 mg/l. Highest DO (9.94 mg/l) found at station 1 near the Pukuafu coastal coast, with the lowest DO (6.41 mg/l) found at station 37 near the "Mulut Seribu" waters.

Furthermore, in situ measurement on Tanimbar Island occurred around "Teluk Dalam" waters with a total of 35 stations measurement. The DO values range at "Teluk Dalam" waters was 6.50 – 7.30 mg/l with an average of 7.09 mg/l. Highest DO found at station 25 (7.33 mg/l), and the lowest DO found at station 34 near the Anggormasa coastal (6.63 mg/l).

Based on the in situ measurement at three outermost islands, the DO ranged from 6 – 9 mg/l with an average of 7 mg/l. These values are the same as the DO in the ocean. According to Sidabutar & Edward (1994) in Arifin *et al.* (2011) generally, DO concentration in the ocean ranged from 5.7 to 8.5 mg/l. The high concentration of in situ DO can occur because of the high oxygen infiltration into the waters through diffusion and photosynthesis process (Arifin *et al.* 2011). Furthermore, according to Whepe (2011) in Samosir *et al.* (2012) if the concentrations of DO increased, then it indicates that the water has a high exuberance. Otherwise, if DO concentrations was low, it indicates that the water has been contaminated. In addition, high oxygen levels also have a relation with the visibility of the water. According to Patty (2013) high concentration of DO in open sea might be due to the visibility of the water, so the oxygen infiltration in waters can occur smoothly.

Figure 3-2 shown that the DO concentration starts from station 34 to 61 in Biak Island tend to have higher values than other locations. This might happen because of that location occur in the open sea. According to Arifin *et al.* (2011) high distribution of DO mostly found in the station far-off from the coastal, whereas low DO mostly found in the station near the coastal. Moreover, high DO in Biak Island waters can be influenced by the occurrence of New Guinea Eddies (NGE) and Halmahera Eddies (HE). Kashino *et al.* (2007) in Harsono & Darmanik (2017) reported that the NGE center point was found around 2^{o}N 138^{o}E. According to Pranowo *et al.* (2016) eddies play a role in the water transport from the bottom layer to the upper layer, and it can increase the nutrient. Furthermore, Harsono & Darmanik (2017) stated that HE delivered water mass from the southern hemisphere as New Guinea Coastal Current (NGCC), which carried many nutrients then spread it to the east region.

Compared to the seawater quality standard for marine organism and marine tourism set by Ministry of Environment Decree No. 51 of 2004, the DO concentration in these three outermost islands was above the range of the standard quality (DO > 5 mg/l), which strongly supports the activity of marine organism to live and breed naturally.

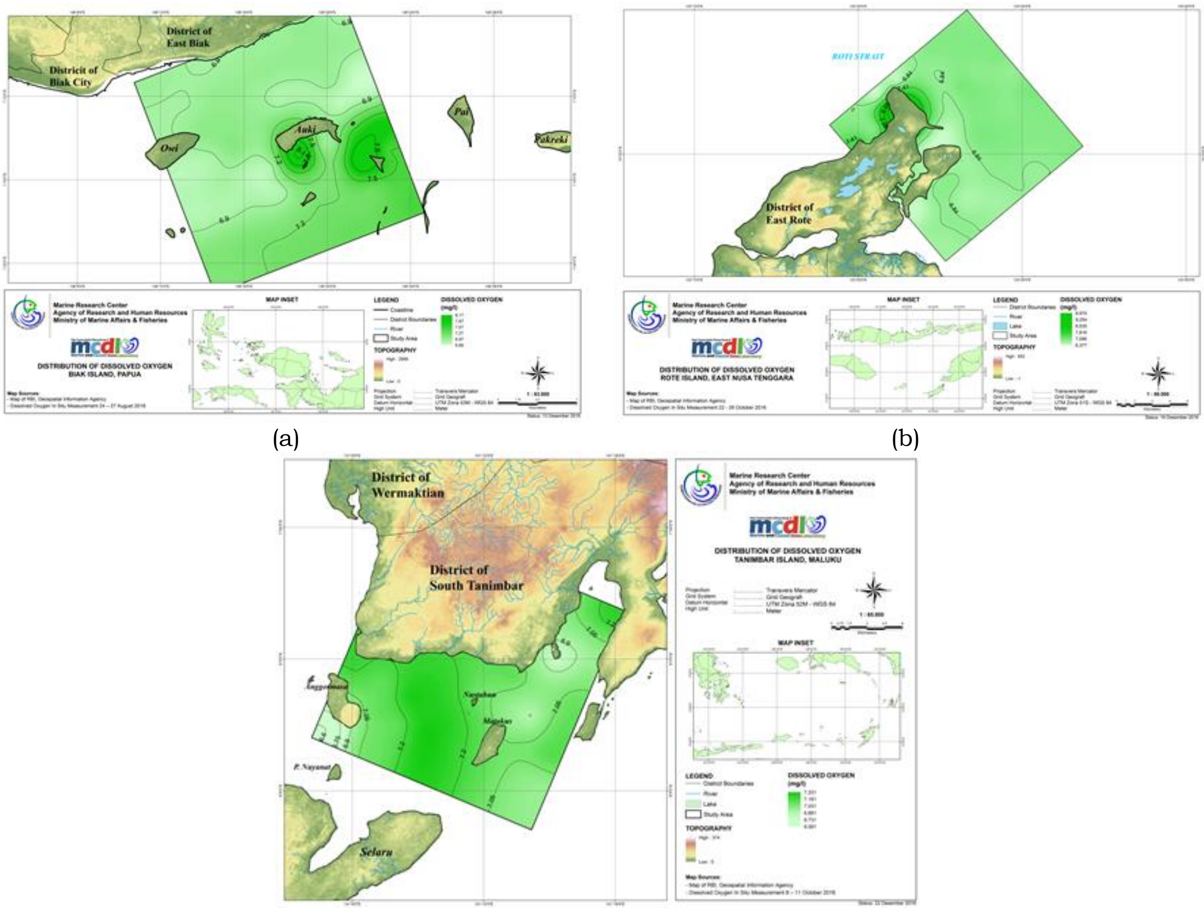

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Figure 3-1: In Situ Dissolved Oxygen Distribution (a) Biak Island, (b) Rote Island, and (c) Tanimbar Island

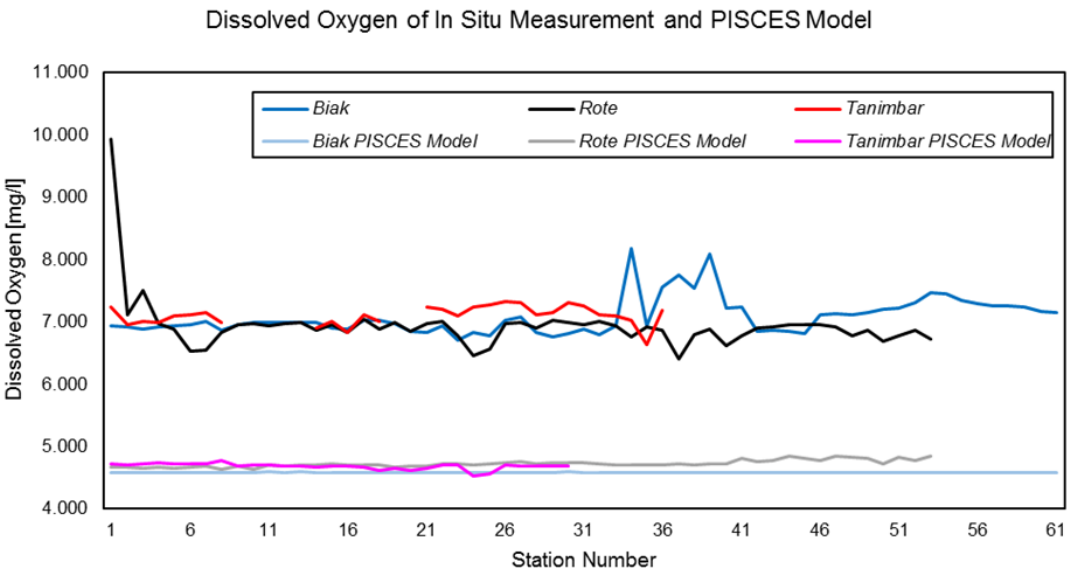


Figure 3-2: Dissolved Oxygen of In Situ Measurement and PISCES Model in Three Locations

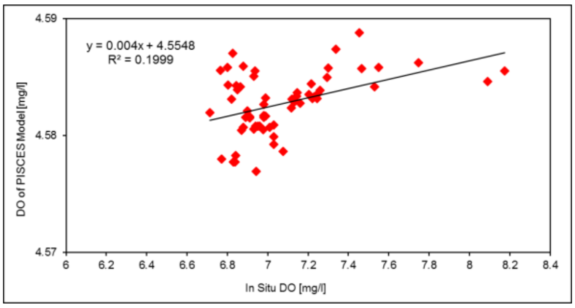
3.2 Result of Linear Regression Analysis between Model and In Situ

PISCES model has been used so far to address a wide range of scientific question, for instance by Brasseur *et al.* (2009) to analyse intra-seasonal and Gorgues *et al.* (2005) to analyse inter-annual timescales (Aumont *et al.* 2015). Based on the linear regression analysis between in situ DO and PISCES model showed a low determinant coefficient (R^2) (as can see in Figure 3-3). The figure shows DO of PISCES model has a low concentration than expected. As reported by Aumont *et al.* (2015) based on the evaluation between modeled oxygen against observation showed a quite well result in the surface. But at the over Pacific Ocean and Antarctica showed an overestimation of oxygen concentration.

Because of range values of PISCES model can be so huge so a consequent sensitivity analysis is required for calibration (INDESO – KKP 2015). In this case, standard deviation between in situ DO and PISCES model was calculated. Then the standard deviation used in linear regression equation with the in situ DO to see the consistency of the pattern.

Verification of data models was very useful to understand the accuracy of the model outputs (Joos *et al.* 2003). Because the result of data modeling sometime contained an error. This might happen because of data modeling never measure the exact variables like in situ measurement. To understand the algorithmic performance of the PISCES model, a linear regression analysis was used to measure the relation between in situ DO with DO from PISCES model.

Linear regression analysis equation was using the in situ measurement and data output from PISCES model. Based on the linear regression equation between standard deviation values with data output of PISCES obtained the determination coefficient at three outermost islands has greater than 0.9 ($R^2 > 0.9$). Determinationcoefficient known to measure the capability of model in represents the variation of the dependent variable. If the value of R^2 is close to 1 then the regression equation was good in predicting the variation of the dependent variable, or in other words the correlation is almost perfect.



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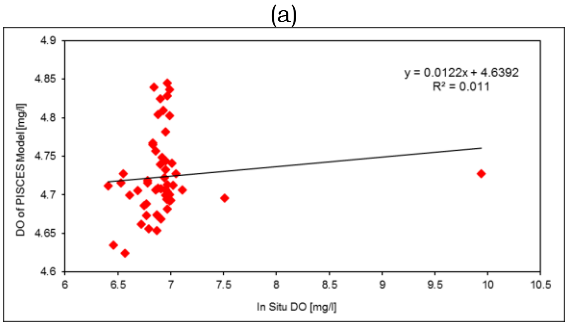

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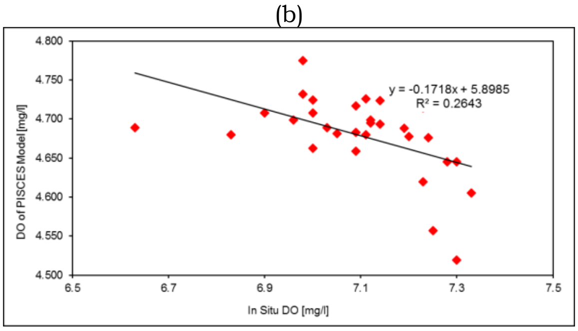


(c)

Figure 3-3: Linear Regression between Dissolved Oxygen PISCES model and In Situ Measurement (a) Biak Island, (b) Rote Island, and (c) Tanimbar Island

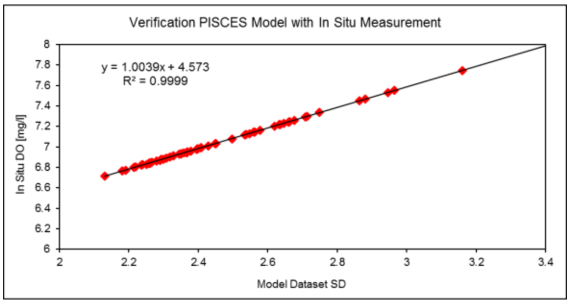
Result of linear regression analysis showed a high value of R^2 or tends to be perfect. This indicates that the equation from linear regression at three outermost islands can be used as a correction equation to obtain the verified DO new model. As shown in Figure 3-4, the result of linear regression in three locations has a straight data distribution and trendline, it is indicated a good result.

Biak Island has the best result of linear regression among three locations, with the determinant coefficient (R^2) was 0.99, as for the equation from the linear regression was y = 1.0039x + 4.573. The result of linear regression at Rote Island has a determinant coefficient of 0.98, as for the equation y = 0.9987x + 4.7266. On Tanimbar Island, the determinant coefficient was 0.94, as for the linear regression equation was y = 0.8052x + 5.1501. Furthermore, verified DO of a new model obtained from those linear regression equations. With the X variable was in situ DO.

3.3 Result of Root Mean Square (RMSE) Between Model and In Situ

Root Mean Square Error (RMSE) is a parameter used to evaluate the difference between model data prediction with the measurement data (Fikri 2009). RMSE has a best result, if it showed smaller values or close to 0. In this research RMSE calculation was used to determine the deviation or error of the equation from linear regression method.

Based on RMSE, calculation between DO of new model and in situ measurement showed an excellent amount of RMSE. From the three locations, Biak Island has the best RMSE result or tend to 0, with the RMSE value was at 0.002. This result indicated the error level of new model equation from linear regression was only 2%. In other words, the accuracy from that equation was 98%. Furthermore, RMSE resulted at Rote Island was 0.05. This result indicated the error level of new model equation from linear regression was only 5%, with the accuracy level was 95%. At Tanimbar Island showed RMSE values was 0.03.



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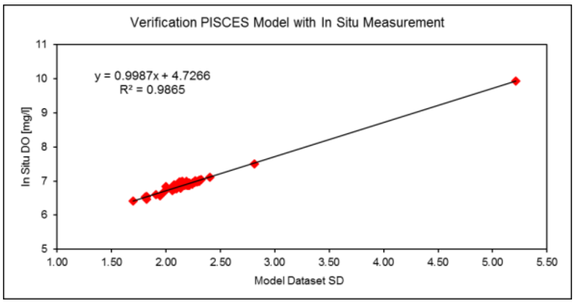

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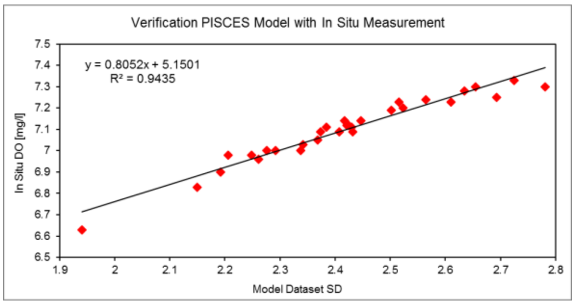

(c)

Figure 3-4: Linear Regression between Dissolved Oxygen In Situ and Standard Deviation (SD) (a) Biak Island, (b) Rote Island, and (c) Tanimbar Island

This result indicated the equation from linear regression in calculating the DO of new model has a 3% of error level, in other words the accuracy of the regression equation was 97%. Statistical result of linear regression and RMSE at three locations can be seen in Table 3-1.

Table 3-1: Statistical result of linear regresion and RMSE

No.	Location	Linear Regression Equation	R^2	RMSE	n (data) *in situ*
1.	Biak Island, Papua	y = 1.0039x + 4.573	0.99	0.002	61
2.	Rote Island, East Nusa Tenggara	y = 0.9987x + 4.7266	0.98	0.05	53
3.	Tanimbar Island, Maluku	y = 0.8052x + 5.1501	0.94	0.03	30

4 CONCLUSION

Verification results of DO PISCES model with in situ measurement showed a low determinant coefficient (R^2< 0.26). So, the verification of this model was required. By using linear regression analysis between standard deviation and DO in situ measurement, the results showed a high determinant coefficient, which greater than 0.9 (R^2 > 0.9).

Error level of the equation from linear regression was calculated using RMSE metric. At three locations in Indonesian Seas showed the lowest RMSE found at Biak Island, New Guinea Papua (RMSE = 0.02), next at Tanimbar Island, Maluku (RMSE = 0.03), and last at Rote Island, East Nusa Tenggara (RMSE = 0.05). The result indicates the equation from linear regression can be used in calculating a verified DO new model.

It is suggested for the users of DO data from INDESO KKP web service, the data to be recomputed first using the regression equation y = 1.0039x + 4.573 for Biak Island, y = 0.8052x + 5.1501 for Tanimbar Island, and y = 0.9987x + 4.7266 Rote Island. These equations should be applied before the outputs of the PISCES model could be used for further applications.

ACKNOWLEDGEMENTS

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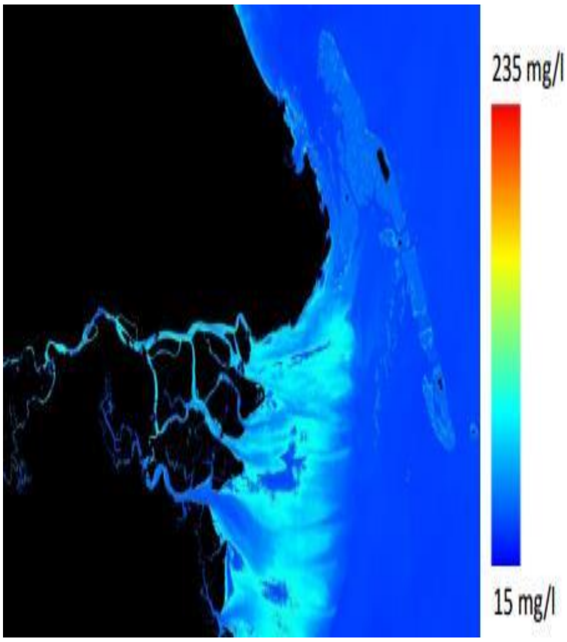

Figure 3-1: TSS distribution for 2002 in Berau Delta waters.
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Tabel 3-1: List of 22 classes of TSS concentration by slicing method.
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Class Number	TSS concentration (mg/l)
1	0-10
2	10-15
3	15-20
4	20-25
5	25-30
6	30-35
7	35-40
8	40-45
9	45-50
10	50-55
11	55-60

4. CONCLUSION

The important matters in the papers which is the conclusion of research or study.

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