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INDONESIA NAVAL TECHNOLOGY COLLEGE

FIELD :

1. OPERATIONS RESEARCH
2. LOGISTICS MANAGEMENT
3. POLICY STRATEGY

SURABAYA, NOVEMBER 16th 2017

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Field :

1. **Operation Research.**
2. **Logistics Management.**
3. **Policy and Strategy.**

SURABAYA, NOVEMBER 16th 2017

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INDONESIA NAVAL TECHNOLOGY COLLEGE

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PREFACE

On behalf of the Organising Committee, it is my pleasure to welcome you to the Postgraduate International Conference on Operation Research. It is hosted by Indonesia Naval Technology College (STTAL) and is being supported by Indonesia Navy.

The main theme of International Conference include Operation Reserach, Logistics Management, Policy and Strategy, Naval Technology. The goal of the conference is to provide a platform to academics, scholars, researchers and practitioners to present and disseminate the latest innovative ideas, research results, and findings on various aspects of Maritime Science.

On behalf of the organising committee, I wish to thank all authors for their papers and contributions to this conference. I would like to thank the keynote speakers for sharing their wealth of experiences and knowledge in Maritime Science.

Finally I would like to thank all speakers, participants and attendees. I look forward to days of stimulating presentations, debates, friendly interactions and thoughtful discussions that will forward Maritime Science.

Surabaya, 13 November 2017
Chairman of Committee,

Dr. Ahmadi
Captain Navy

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FIELD II
LOGISTICS MANAGEMENT

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CONSTRUCTION OF INDONESIAN ADDITIONAL MILITARY LAYER INTEGRATED WATER COLUMN (AML IWC) PROTOTYPE

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ABSTRACT

The NATO has produced what they called Additional Military Layer (AML) which basically Electronic Chart for Military purposes. Based on NATO STANAG 7170, AML is defined as : ''...a unified range of digital geospatial data products designed to satisfy the totality of NATO non navigational maritime defence requirements''.One of AML type is called Integrated Water Column Component 1 (AML IWC Component 1) in which contain water column physical properties of temperature and salinity. The purpose of IWC gridded dataset, is to provide marine climatological data to describe the likely conditions found within the water column. IWC is delivered in the netCDF format. Meanwhile US Navy has also developed the same climatological gridded dataset as AML IWC which they called Generalized Digital Environmental Model (GDEM). Inspired by the existence of AML IWC and GDEM, authors are willing to research the possibility of constructing Indonesian AML IWC Component 1 that cover the sea area of Indonesia. Observation temperature and salinity profiles are downloaded from World Ocean DataBase13 (WOD13). These thousands observation profiles collected for more than 100 years in Indonesian waters and surrounding area then processed with Ocean Data View and Mathlab to make a gridded data set with 1/4° spatial resolution and monthly temporal resolution In only one netCDF format file.

KEYWORD : Indonesian AML IWC, netCDF, salinity, temperature, WOD13.

1. INTRODUCTION

Successful execution of ASW operations (detection, prosecution, localization) depends on four factors i.e. : The ambient acoustic and meteorologic conditions, Own-force asset capabilities, The nature and tactics of the opposition, The strategic and tactical acumen of the ASW commander and his staff. When at sea, the first three factors are the ASWC's states of nature. Keen understanding of the principles of the propagation of sound through the water and the effects of the meteorologic conditions thereon is requisite since underwater sound (sonar) is virtually the only means of detecting submerged submarines (M.G. Alexandridis, 1984).

ASW acoustic predictions are done with the aid of sound velocity profiles from areas of the ocean. ASW sensor selection and tactics are determined by these acoustic predication (B.H. Brunson, 1989). One of the general form of the equation for the speed of sound was developed by Mackenzie who derived the empiric formula from three variables, they are : temperature, salinity and depth (Mackenzie, 1960).

For years, experts of Defence Maritime Geospatial Infromation has produced varies form of paper military charts. With the move to digital products, NATO has produced AML (Additional Military Layer) to provide maritime geospatial information to the defence user in an efficient and standardised digital format. AML is defined as ''...a

unified range of digital geospatial data products designed to satisfy the totality of NATO non navigational maritime defence requirements'' (Captain Jones, 2016). One type of AML that related to water column is Gridded AML products (UKHO, 2008). This type of AML shows the spatial and sometimes temporal variation in an environmental feature (UKHO, 2006). For example, gridded products can represent a large number of CTD observations collected over a long period giving the user information about the temperature and salinity that may be expected at a specific month (Peter C. Chu, 2004). Gridded information may be presented to the user in a variety of ways, including isolines derived from the grid and colour banding. Alternatively the data may be used by a specific system for computational purposes without directly representing the data to the user through a Graphical User Interface (GUI) (Captain Jones, 2016).

The NATO AML Integrated Water Column product specification is further divided into three components, which are water column physical properties, ocean currents and marrine mammals (UKHO, 2006). For this research, authors are willing to produce an AML IWC Component 1 consisting of temperature and salinity monthly variation for Indonesian Sea and surrounding in 1/4° spatial resolution. Raw data of temperature and salinity profiles are downloaded from World Ocean Database 13 (WOD13) which cover all available observations in and arround Indonesian Waters. The observation data collected then filtered and prepared to be used in estimation process of temperature and salinity values at each standar depth and spatial coordinates with a quarter degree interval. The estimation values of temperature and salinity for each month then compiled into an array for further writing become a netCDF file format which is the standard file format for AML IWC (UKHO, 2006). From that standing point, authors propose a hypothese that Indonesian AML IWC netCDF file could be constructed from WOD13 database utilizing some already available function in ODV (Schlitzer, 2013) and netCDF package in mathlab (Mathworks, 2015).

Once the Indonesian AML IWC netCDF file succesfully made, it can be presented to give a better situasional awareness for a Navy ships or operator may extract temperature and salinity data from it for computational purpose such as ray tracing of hull mounted sonar (HMS) or variabel depth sonar(VDS) so the anti submarine ship could predict its HMS shadow zone or its best VDS operational depth to get the optimum coverage. With the availability of AML IWC component 1 netCDF file may prevent the necessity of a anti submarine ships to deploy CTD or XBT to get temperature and salinity data in its operation area (W.J. Teague, 1990).

2. MATERIALS AND METHODOLOGY

2.1. Observation Data

To produce a climatological gridded data set such as AML IWC, we must have an adequate observations that not only has good spatial distribution but also temporally long enough with at least 50 years period time span of observations. For example in the making of first GDEM in 1990, US NAVOCEANO had been collecting for more than 100 years (W.J. Teague, 1990). And in 2010 GDEM report it was writen that final data set for GDEM4 construction consist of 4,412,454 temperature profiles and 1,969,081 salinity profiles (M. Carnes, 2010). In order to fulfill the pre-requisite of constructing a climatological dataset, authors have selected World Ocean Data Base for the reason that this product of National Oceanographic Data Centre (NODC) Ocean Climate Laboratory (OCL) is claimed as the world's largest collection of freely available oceanographic data that dating back to the late 1700's (NOAA, 2017).

As previously mentioned that temperature and salinity profiles data set used in the calculation of Indonesian IWC Component 1 was downloaded from NODC/Ocean Climate Laboratory/OCL Products/WOD13. From here, authors proceed to WOD data sorted geographically to get the webpage that shows 10 degrees square geographically sorted data set. For Indonesian sea area, authors downloaded ten squares with square number 1009, 1010, 1011, 1012, 1013, 3009, 3010, 3011, 3012 and 3013. Inside the respective square there are some types of data that collected in a .gz compression format with respect to the equipment of data acquisition, they are : OSD, MBT, CTD, XBT, PFL, MRB, DRB, APB, UOR, GLD, SUR (NOAA, 2017).

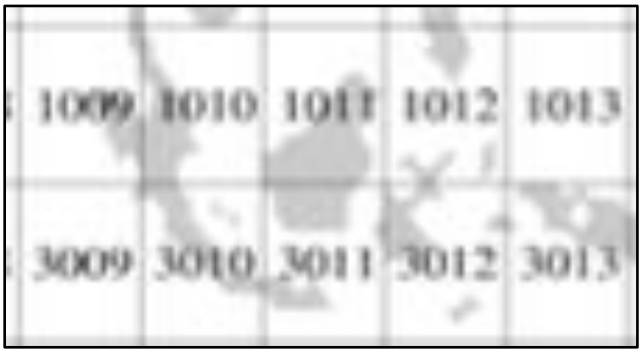

Fig 1. WOD 13 square download (NOAA, 2017)

The downloaded temperature and salinity dataset then imported, readed, extracted or collected into Ocean Data View (ODV) software for further process (Schlitzer, 2013). Based on data import statistic in ODV software, the ten downloaded squares containing 169,959 observation points with the oldest time recorded is 1827 and the newest time recorded is 2017. So this data base has been collected for 190 years. But it was not until 1914 the count of observations is more than 100 observation per year. And starting from 1961 the recorded observation hit more than 1,000 per year. The poin is with such number of observation and such a long periode historical data, the WOD13 is valid to be used in calculation, estimation and construction of Indonesian AML IWC.

2.2. Horizontal Gridding and Estimation

Once the WOD13 data sets are all imported into ODV collection, first thing to do is to prepare the xy coordinate text files. The Indonesian AML IWC is planned to have 1/4° x 1/4° spatial resolution. Meanwhile the area is limited by 90 ºE to 140 ºE and 10 ºS to 10 ºN. Using these data, authors produce a grid file utilizing the grid file generator tool that provided in the ODV software (M.R. Carnes, 2009).

Secondly, authors planned to make The Indonesian AML IWC into 63 standard depth levels. This standard depth level starts from 0 m up to 3000 m. The intervals between depth level are set so the upper layer interval will be shorter than the lower layer interval. For example the interval between 0 m to 10 m depth is set in 2 m between each standar depth, but the interval between 2000 m to 3000 m depth is set in 200 m between each standar depth (M.R. Carnes, 2009).

Before the estimation can be done, authors should add the isosurface variables for temperature and salinity at each standar depth so it can be plotted in surface window as Z values. There will be 126 isosurface variables to be added one by one (Schlitzer, 2013).

In order to be able to use the 2D estimation function in ODV software, the imported data should be gridded in the surface window. But before gridding, authors verify that station selection criteria has been done for the selected month and selected variable in the map window and sample selection criteria has been done for only accepted value data. After both criteria checks have been passed, authors plot the isosurface variable by gridding method. The gridding method used is DIVA gridding. DIVA is a gridding software developed at

the University of Liege that offers a number of advantages over the weighted averaging methods built into ODV. DIVA allows analyzing and interpolating data in an optimal way, comparable to optimal interpolation (OI). Unlike OI, DIVA also takes into account coastlines and bathymetry features to structure and subdivide the domain on which estimation is performed. Calculations are performed on a finite element mesh adapted to the specific gridding domains (Schlitzer, 2013) (Troupin, 2012).

With 2D estimation function, for each xy coordinates in the input file, ODV will estimate a Z-value, and will write the estimated values together with the respective xy coordinate to an output file. The output file is written to the same directory as the input file, and the file name is of the form <name>_est.<ext>, where <name>.<ext> is the name of the input file. Each line in the output file contains the X, Y, and Z values of one estimation point. A Z value of -1.e10 indicates that the particular xy coordinate is far from any data point and that no reliable estimation could be performed. Z values at points outside the window domain or in regions exceeding the window's quality limit (white areas in the plot) are set to -1.e10 (Schlitzer, 2013).

2.3. Bathymetri

Bathymetri is also important for construction on netCDF file. As mentioned above that the estimation through 2D estimation with DIVA gridding method takes into account coastlines and bathymetri features to perform estimation. The Indonesian AML IWC bathymetry for estimation process in ODV software is loaded from GEBCO_2014_6X6min_Global (S. Tani, 2017). Meanwhile bathymetry bottom depth at each grid point on the ¼º x ¼º grid was derived by estimation from GEBCO_2014_2D_90.0_-10.0_140.0_10.0.nc file. The bottom depth estimation was done in ODV software, the similar way as temperature and salinity estimation. The bottom depth estimation will be writen into the netCDF file (Schlitzer, 2013) (Mathworks, 2015).

2.4. Constructing one temperature array, one salinty array and one bottom depth array from the estimation txt files

From the estimation process, authors are able to produce 63 txt files for each month and each temperature and salinity variabel and 1 txt file for bottom depth. In order to be able to be writen into a netCDF format file, authors sholud combine the values into 1 array of variabel with pre-defined dimension planned.

For temperature and salinity variables the pre-defined dimension will be 201 x 81 x 63 x 2. The dimension consist of longitude by latitude by depth by month. While bottom depth variabel will have 201 x 81 dimension consist of longitude by latitude.

2.5. Construction of netCDF file from the 4-dimension and 2-dimension arrays.

NetCDF is a widely used file format in atmospheric and oceanic research – especially for weather and climate model output – which allows storage of different types of array based data, along with a short data description. The NetCDF format (Network Common Data Format, http://www.unidata.ucar. edu/software/netcdf/) has been developed since 1988 by Unidata (a programme sponsored by the United States National Science Foundation) with the main goal of making best use of atmospheric and related data for education and research (R. Rew et al, 1990) (R. Rew et al, 2011).

A NetCDF dataset contains a symbol table for variables containing their name, data type, rank (number of dimensions), dimensions, and starting disk address. Each element is stored at a disk address which is a linear function of the array

indices (subscripts) by which it is identified. Hence, these indices need not be stored separately (as in a relational database). This provides a fast and compact storage method (R. Rew et al, 2006). The advantage of the NetCDF library is that there is no need for the user to take care of the physical representation of multidimensional data on the disk.

One particular advantage of NetCDF over some other binary formats, such as the RData format used by R, is the ability to access and modify arbitrary sections of array data. This allows massive datasets to be processed efficiently, even if they are larger than the virtual memory available on a particular system. To reduce disk space requirements, floating-point values are often packed into 8- or 16-bit integers, and the NetCDF-4 (HDF5) format supports transparent compression using the zlib library (Pavel Michna et al., 2013).

For the Indonesian AML IWC experiment, authors used mathlab software to construct the netCDF file. the script is writen by netCDF package library that already available in the mathlab software. Generally the scripting steps is the un-interupted steps from the 4-D arrays and 2-D array construction (Mathworks, 2015).

Shortly, the netCDF file is produced as the following sequences :

- preparing the arrays to be writen which are longitude, latitude, depth, month, temperature, salinity and bottom depth.
- Create the netCDF file.
- Writing the global attributes.
- Define the dimension which are longitude, latitude, depth and month.
- Writing each dimension attributes.
- Define the variables which are longitude, latitude, depth, month, temperature, salinity and bottom depth.
- Writing each variable attributes.
- Writing the array to respective variable.

Result of this process is Indonesian AML IWC in the form of netCDF file.

Standard deviation of estimation values for each 4-dimension coordinate is calculated using mathlab software (M.F. Al-Saleh et al., 2009) (UKHO, 2006). This calculation utilizes the above previously produced netCDF file . The result of this step is two 4-dimension array of temperature standard deviation and salinity standard deviation. After that, those two variables will be writen into netCDF files so the last product will have 5 variables, which are temperature, salinity, temperture standard deviation, salinity standard deviation and bottom depths.

3. RESULT AND DISCUSSION

3.1. Input File Facts

The Input files facts used for the experiment that has been downloaded from the WOD13 could be extracted from WOD13 meta data which can be analyzed from the statistic function inside the ODV software (Schlitzer, 2013). Below are Input files facts summary table showing general statistic of the input data.

Table. 1 Input File facts summary

1	Format	US NODC Formats/World Ocean Data Base
2	File type	.gz
3	Size	457 MB(compressed)
4	Longitude	90 E to 140 E
5	Latitude	10 S to 10 N
6	Time	28/91827 to 2/4/2017

7	Points observed	169,959
8	Avg. points obs. by month	14,164
9	Points with T var	162,820
10	Points with Sal var	82,892

Table. 2 Input File dataset based on acquisition method

1	OSD	bottle, low res CTD and XCTD, plankton data
2	MBT	MBT, DBT, Micro BT data
3	CTD	high res CTD data
4	XBT	expandable bathytermograph data
5	PFL	profiling float data
6	MRB	moored buoy data
7	DRB	drifting buoy data
8	APB	autonomous pinned bathytermograph data
9	UOR	undulataing oceanographic recorder data
10	GLD	glider data
11	SUR	surface data

3.2. Output File Facts

From this input data, this experiment investigates the possibility of Indonesian AML IWC construction utilizing ODV software and mathlab software. General information of how to construct a climatology of ocean temperature and salinity is described in refrence describing about GDEM, products of US Navy (M.R. Carnes, 2009) (M. Carnes, 2010). These documents is the primary reference used by authors on developing steps of Indonesian AML IWC, while the decision to delivere it in the form of netCDF format file is because of it is the standard of AML IWC which produced and maintained by UKHO (UKHO, 2006).

In the netCDF output files every xyz coordinates must have values. As consequences the values on the lands and at the depth levels less than 3000 m that limited by the bathymetri will be set as -1.e10. The facts summary regarding the output files are as follows.

Table. 3 Output File facts summary

1	File type	.nc (netCDF)
2	Size	62.7 MB(uncompressed) 2 months climatology
3	Longitude	90 E to 140 E

4	Latitude	10 S to 10 N
5	Time	January and February
6	gridded sta 1 month	16,281
7	Visible gridded sta 1 month	13,125
8	gridded sta overland 1 month	3,156
9	key variables	temperature, salinity, temp_sd, sal_sd, bottom depth

This Indonesian AML IWC size is 62.7 MB equivalent with 13,125 profiles x 1 variable x 2 month equal to 26,250 profiles per variable or 105,000 profiles temperature, salinity and each standard deviation. By a simple math the 12 month Indonesian AML IWC could take about 62.7 MB x 6 or equal to 376.2 MB.

Authors also try to export the complete data from Indonesian AML IWC into text file using ODV software. The exported text file is a tab delimited single file with the size of 106 MB about twice bigger the size of netCDF file.

Each gridded station of netCDF file could be exported or extracted to be used for further calculation or modelling. Authors investigates the size of a single gridded station export which consist of station meta data, temperature, salinity and sound speed data and founded that the size of text file approximately 5.05 KB. If we want to export each Indonesian AML IWC gridded station into different text file it will take about 5.05 KB x 13,125 station or equivalent with 66.3 MB per month or 132.6 MB for 2 month, about twice larger than the size of netCDF file. Not to mention we should handle 13,125 different files only for one month.

While the usual observation data is generally delivered as txt file or excel file. With netCDF format, authors are able to compile thousands of temperature and salinity profiles for Indonesian area in only one single file with less memory storage required. This bring benefit over the storing of every temperature and salinity profiles in different txt or excel files.

3.3. Discussion

Indonesian AML IWC is more regularly spaced compared to original WOD13 observation data which maintain their observation position as reported. Below figures shows the differences between WOD13 and Indonesian AML IWC spatial distribution.

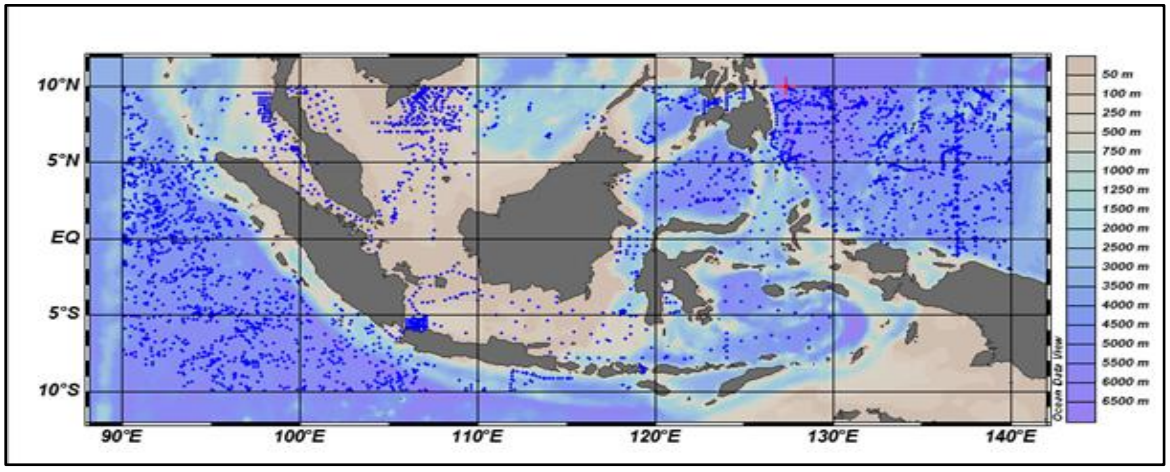

Fig 2. Spatial distribution of WOD 13 in January

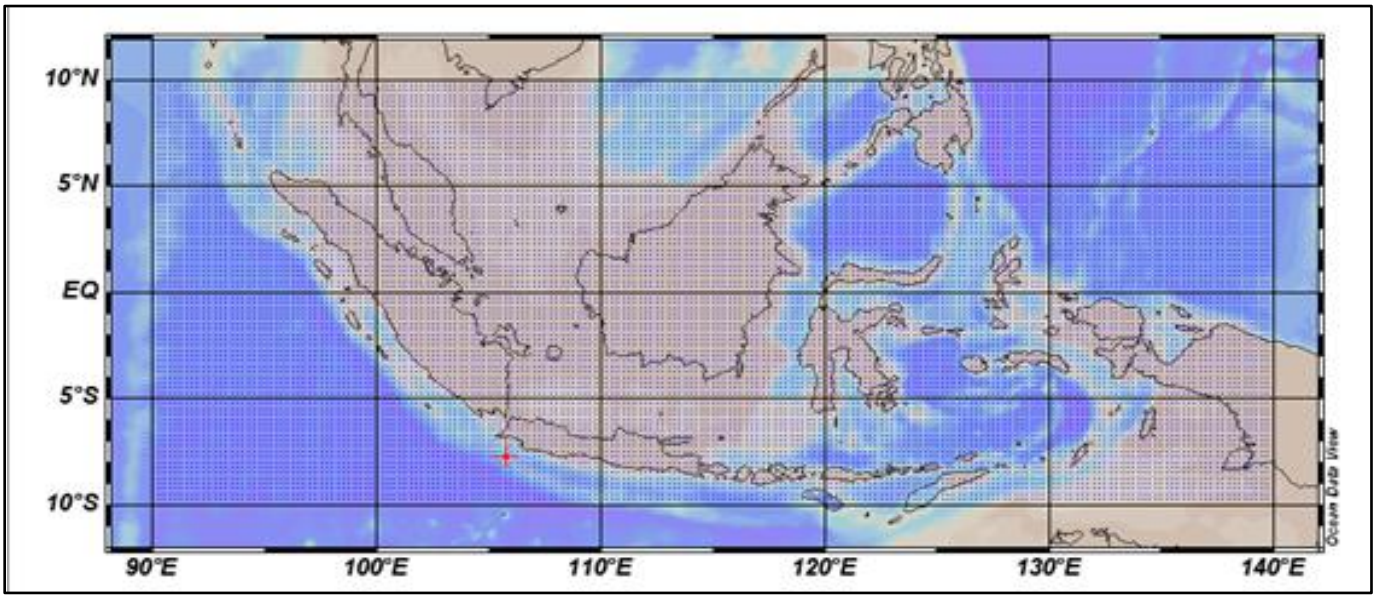

Fig. 3 Spatial distribution of Indonesian AML IWC in January

A pictorial comparisons of the input and output file plotting are also conducted to check the validity of the output file. surface plotting temperature at depth 0 metre for January are compared for WOD13 and Indonesian AML IWC as follows.

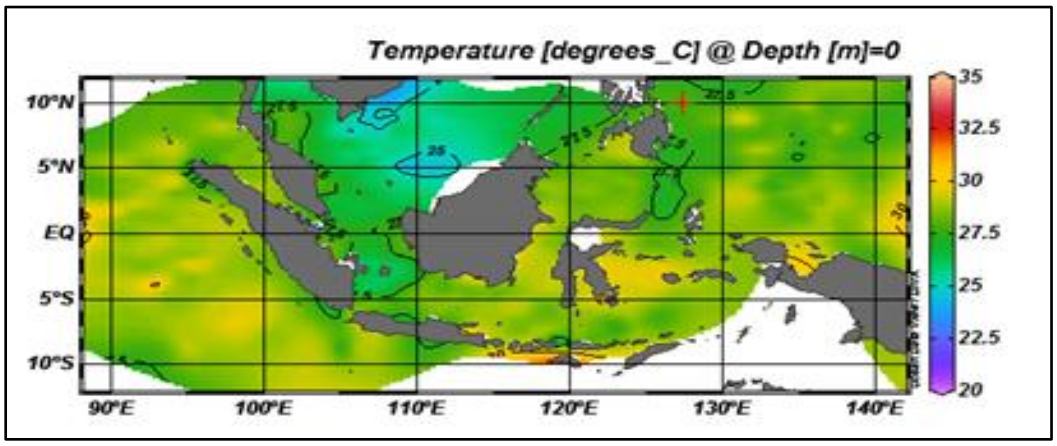

Fig 4. Surface plot of WOD 13 in January

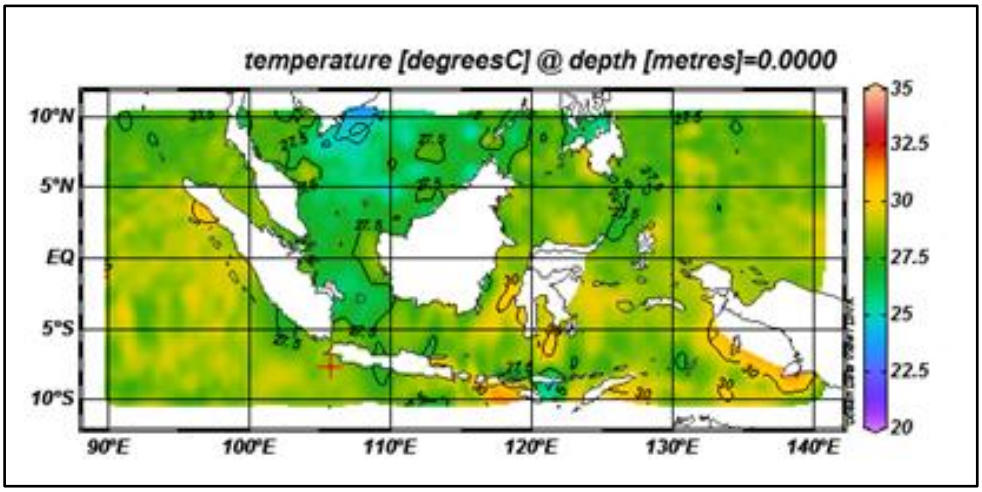

Fig 5. Surface plot of Indonesian AML IWC in January

For station comparison authors take sample of observation point located at 106° E and 8° S. Both temperature data with the same point location from WOD 13 and Indonesian AML IWC then plotted on the station plotting window with the a very similar profile.

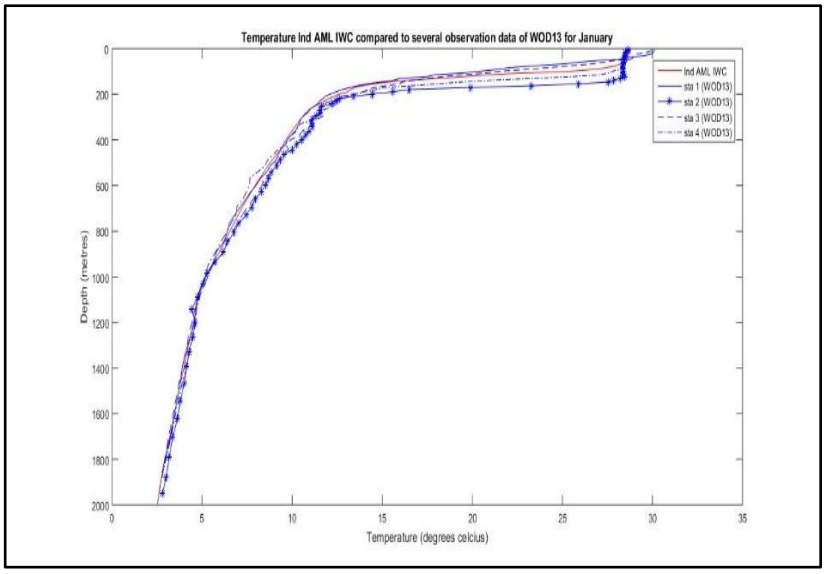

Fig 6. Station plot comparison between WOD13 obs and Ind AML IWC on January at about 106 E and 8 S

3.4. Outlook

Validation is a working process in an experiment to compare a result to another tipically same product. In this experiment validation of Indonesian AML IWC will be compared to World Ocean Atlas 13 (WOA13) temperature and salinity climatology product of NODC/OCL. General production method of WOA is described in WOA 13 tutorial with the title of WORLD OCEAN ATLAS 2013 Volume 1 : Temperature (R.A. Locarnini et al., 2013). Generally the production concept is the same for both products. But, off course each institution has copyright and details that is not

published. For that reason there will be some differences between WOA 13 and Ind AML IWC.

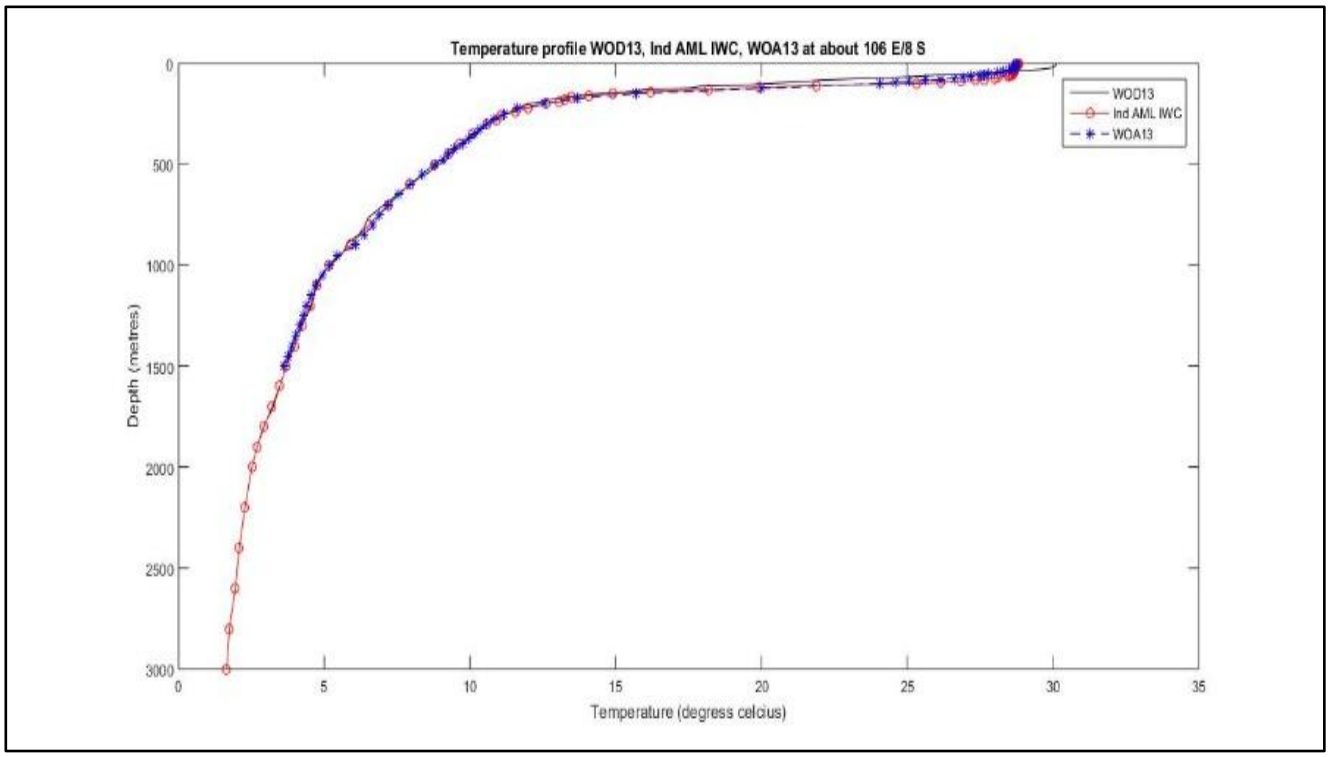

Fig. 7. Station plot comparison between WOD13 obs, Ind AML IWC, WOA 13 on January at about 106 E and 8 S

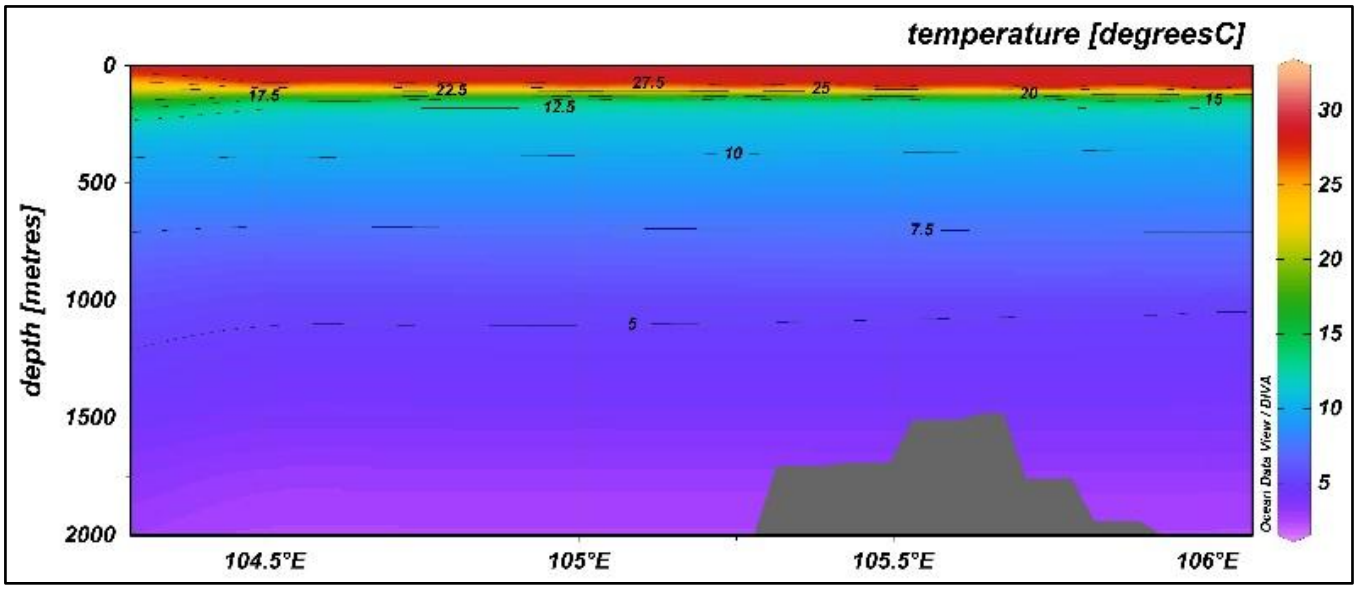

Fig. 8. Section plot Ind AML IWC on January at south of West Java

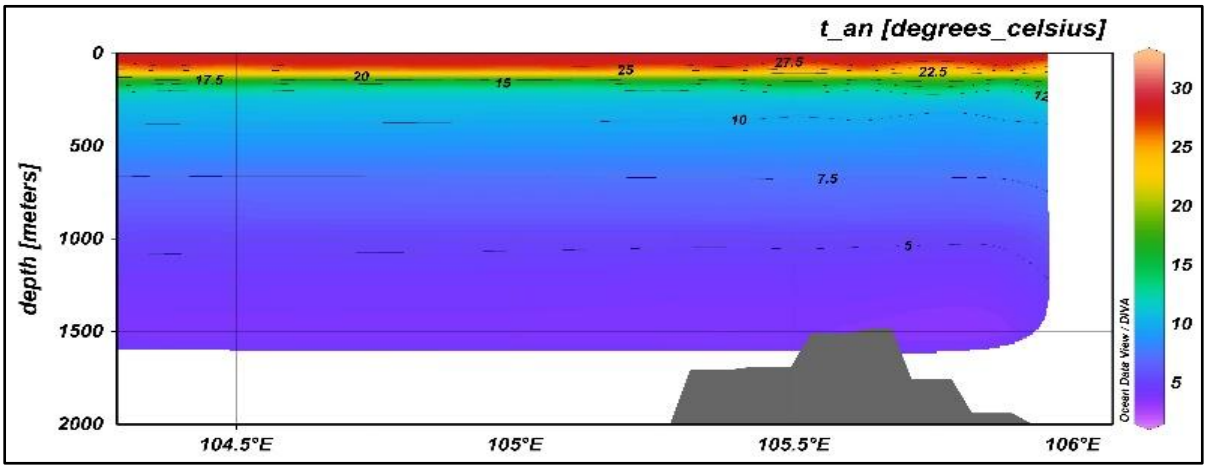

Fig. 9. Section plot WOA 13 on January at south of West Java

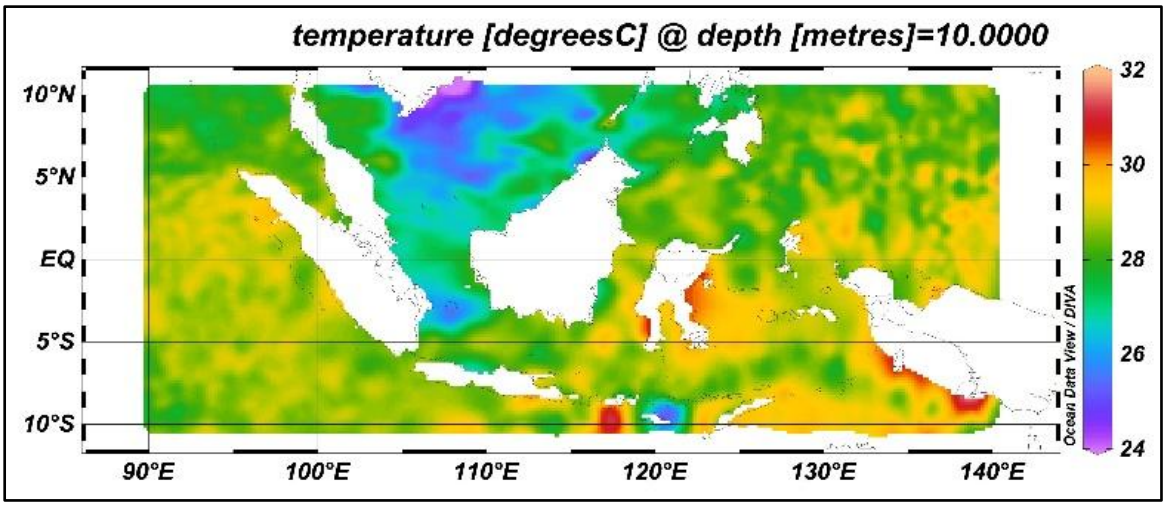

Fig. 10. Surface plot Ind AML IWC on January at 10 m

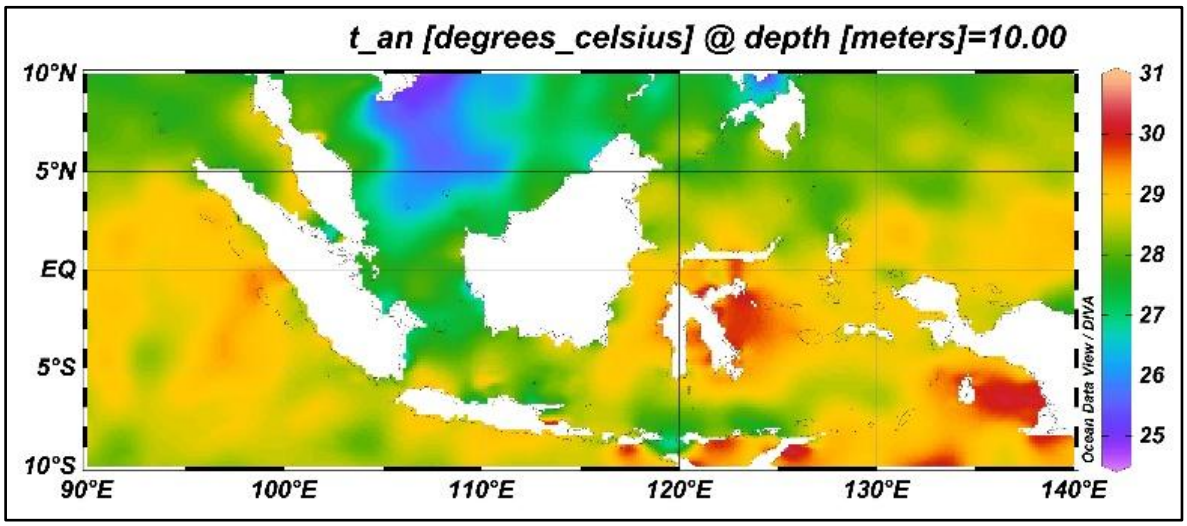

Fig. 11. Surface plot WOA 13 on January at 10 m

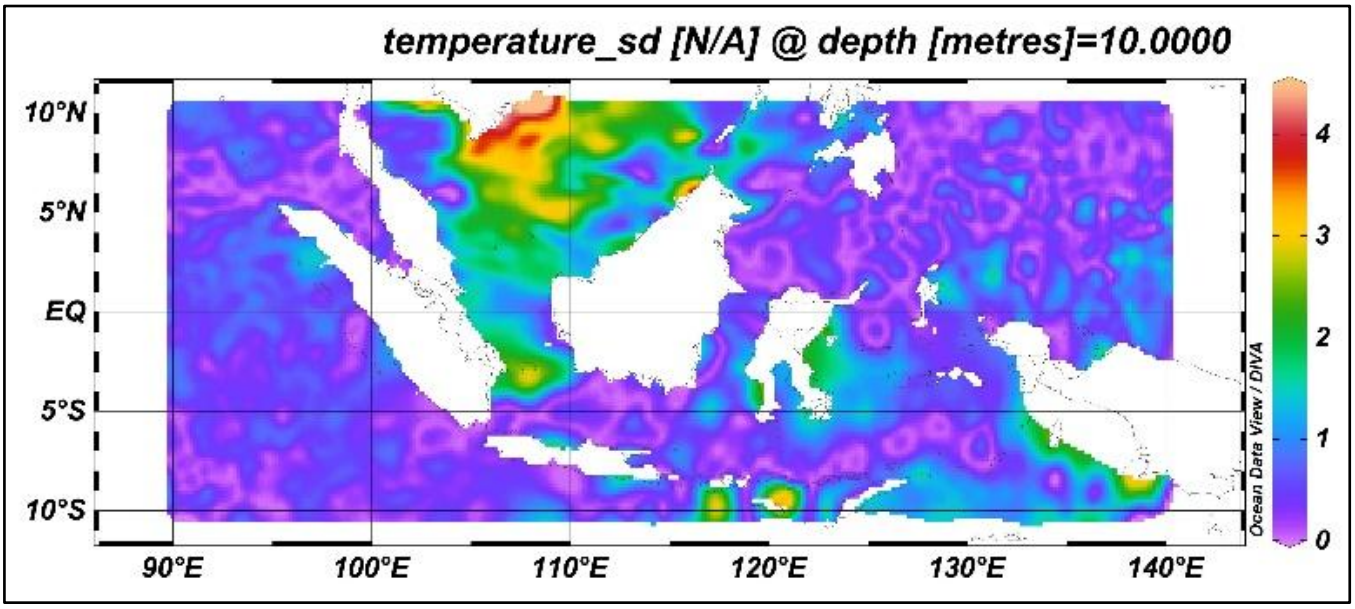

Fig. 12. Surface plot Ind AML IWC temperature standard deviation on January at 10 m

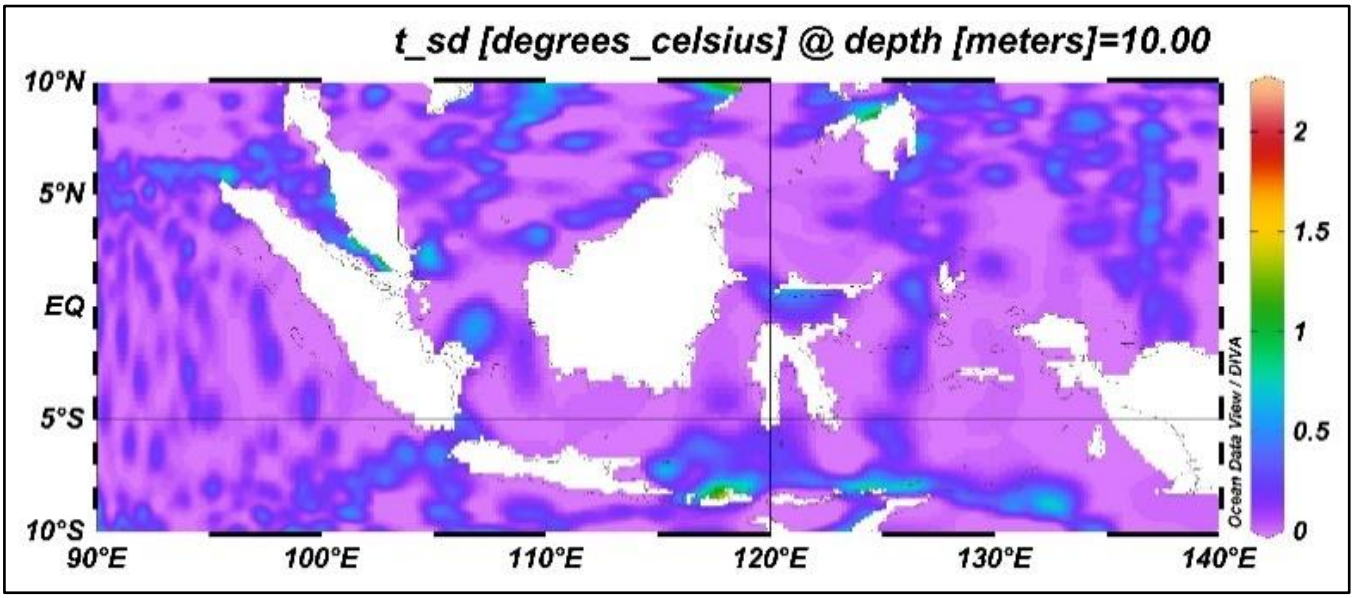

Fig. 13. Surface plot WOA 13 temperature standard deviation on January at 10 m

4. CONCLUSION

In conclusion, the proposed hypothese of this paper that Indonesian AML IWC netCDF file could be constructed from WOD13 database utilizing some already available function in ODV and netCDF package in mathlab has been successfully tested and can be accepted. This experiment has resulted Indonesian AML IWC, a gridded data set products in the form of netCDF file that has been tested its representation and data extraction in ODV software.

The experiment conducted by the authors utilizing raw observation temperature and salinity data set from WOD13 with the support of ODV and Mathlab software resulted a netCDF file containing temperature and salinity profiles regularly distributed geographically in monthly temporal

resolution. This file basically has the same product specification with NATO AML IWC Component 1.

The Indonesian AML IWC plotting pictorial comparison with raw WOD13 data showed both files are similar. Therefore it is valid for presentation of likely condition in an environment or profile data extraction for further calculation, prediction or simulaton concerning military operation in the sea such as anti submarine warfare operation.

This paper may contribute to the production initiation of gridded data products of AML by Indonesian Navy Hydrograpy and Oceanoraphy Centre for the support of Indonesian Navy Military Operation. As this file existence onboard a ships may prevent the ships to launch CTD or XBT to get temperature and salinity profiles in particular sea area. Since in the time of war, decision oftenly should be made in a split seconds. In the other hand we don't have enough time to get the information we need such as launching CTD. In such particular situation AML IWC could help the officer in charge to make the right battle manoevres to gain advantages from the environment.

5. ACKNOWLEDGEMENT

This work was supported by ODV Software and Mathlab Software. Raw data was extracted from WOD13 and validation product WOA 13 are products of NODC Ocean and Climate Laboratory. 4 dimension netCDF data writing sample was downloaded from unidata website. Bathymetri was downloaded from GEBCO.

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Title :

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In :

STTAL POSTGRADUATE INTERNATIONAL CONFERENCE 2017

Surabaya, November 16, 2017
Commander of STTAL,

Ir. AGUNDO BASTARI, M.Phil.
COMMODORE (TNI)

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