Two-Dimensional Hydrodynamic Numerical Modeling in Sangihe Waters

Irsan S. Brodjonegoro[1], Widodo S. Pranowo[1], Semeidi Husrin[1], Haryadi Permana[2], Safri Burhanuddin[1]
[1]Research Center for Maritime Territories and Non-Living Resources Agency for Marine & Fisheries Research
Ministry of Marine Affairs & Fisheries The Republic of Indonesia
[2]Earth Dynamics & Geological Hazard, Research Center for Geotechnology – LIPI Email: irsansb@dkp.go.id

Abstract

The paper describes three-dimensional numerical simulation in Sangihe Waters. The 3DD Suite of Model from ASR Ltd (Black, 2001) was used to give an overall picture of the current circulation pattern and sea surface level in Sangihe Waters. The model had been worldwide applied in many coastal and sea waters. The bathymetric data obtained from DISHIDROS TNI-AL Map No: 403 with scale 1:500.000 and tide data using ORITIDE (ORI.96) was used for the input data. Numerical simulation was carried out from August 26, 2003 at 12.00 a.m. until September 10, 2003 at 10.00 p.m. and was limited to longitude of 124.00 ^{o} E - 126.50^{o} E and latitude of 1.83 ^{o} N - 4.50^{o} N. For model verification, the insitu field data from IASSHA cruise 2003) and TOPEX/ERS-2 data will be used. The current in Sangihe Waters predominantly moves from northwest direction toward south and then moves to eastern direction after passing Sangihe Isles. The maximum current occurs just before high tide with amplitude of 1.83 meter/second.

I. Introduction

Hydrodynamics is the main factor to determine the ocean condition. This Hydrodynamics assessment will give, in general, an overall picture of the current pattern, and also, in particular, the current pattern for certain time series in Sangihe Waters. Sangihe are a chain of islands stretching north from Sulawesi in the direction of the Philippines. The archipelago consists of 77 islands, of which 56 are inhabited. There are many active volcanoes and the soil is very fertile. Sangihe isles consist of Sangir Besar Island, Siau Island, Tagulandang Island and Biaro Island plus many other smaller islands(BRKP, 2003).

Ii. Objective

The objective of this assessment is to give an overall picture of the current circulation pattern and sea surface level on Sangihe Waters. This assessment will be used to get a sufficient information to develop a research on natural resources on Sangihe Waters.

Iii. Metodology

This hydrodynamics assessment contains analysis of the value and the direction of current in Sangihe Waters especially at extreme conditions, namely at low tide, just before high tide, at high tide, and just before low tide in conjunction with tide condition in Sangihe Waters, and analysis of sea surface elevation on Sangihe Waters.

The three-dimensional numerical analysis will be used for the hydrodynamics analysis. *The 3DD Suite of Model* from ASR Ltd (Black, 2001) will be used for this numerical simulation. This numerical simulation is carried out using PC Intel Pentium 4 2.4Ghz 1Gb RAM, with MS Windows XP and Surfer 7.0, and also Matlab 6.1 for plotting purposes.

Iv. Data

The input data for this model is bathymetric data using bathymetric map of Sangihe Waters obtained from DISHIDROS TNI-AL No: 403 with scale 1:500.000 (see **Figure 1**) and tide data using ORITIDE (ORI.96) that incorporate 8 main tide component: M2, S2, N2, K2, K1, O1, P1, and Q1 (see **Figures 3,4,5,** and **6**). For model verification, the insitu field data from IASSHA cruise 2003 (see **Figure 1** and **Table 2**) and TOPEX/ERS-2 data will be used (see **Figures 11** and **12**).

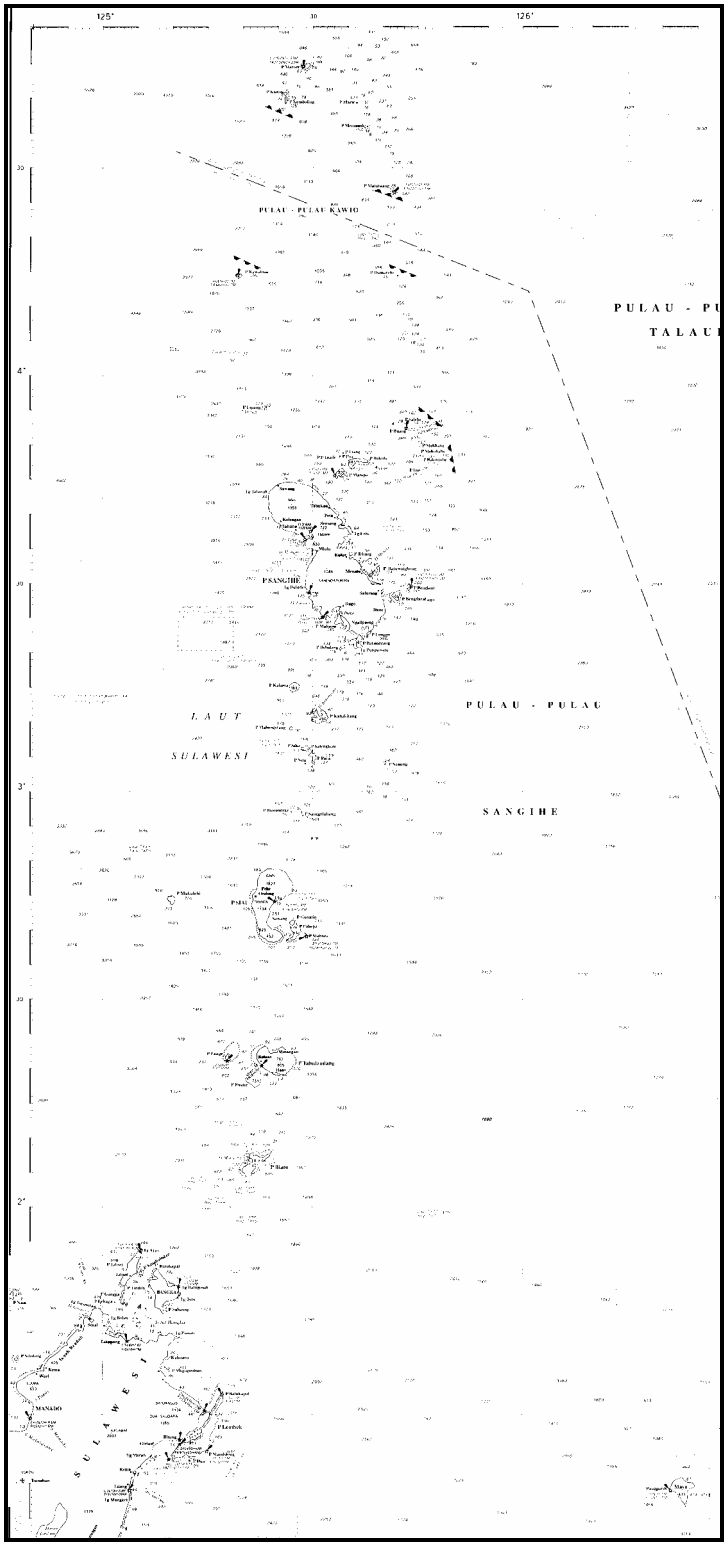

Figure 1. Bathymetric Map of Sangihe Waters

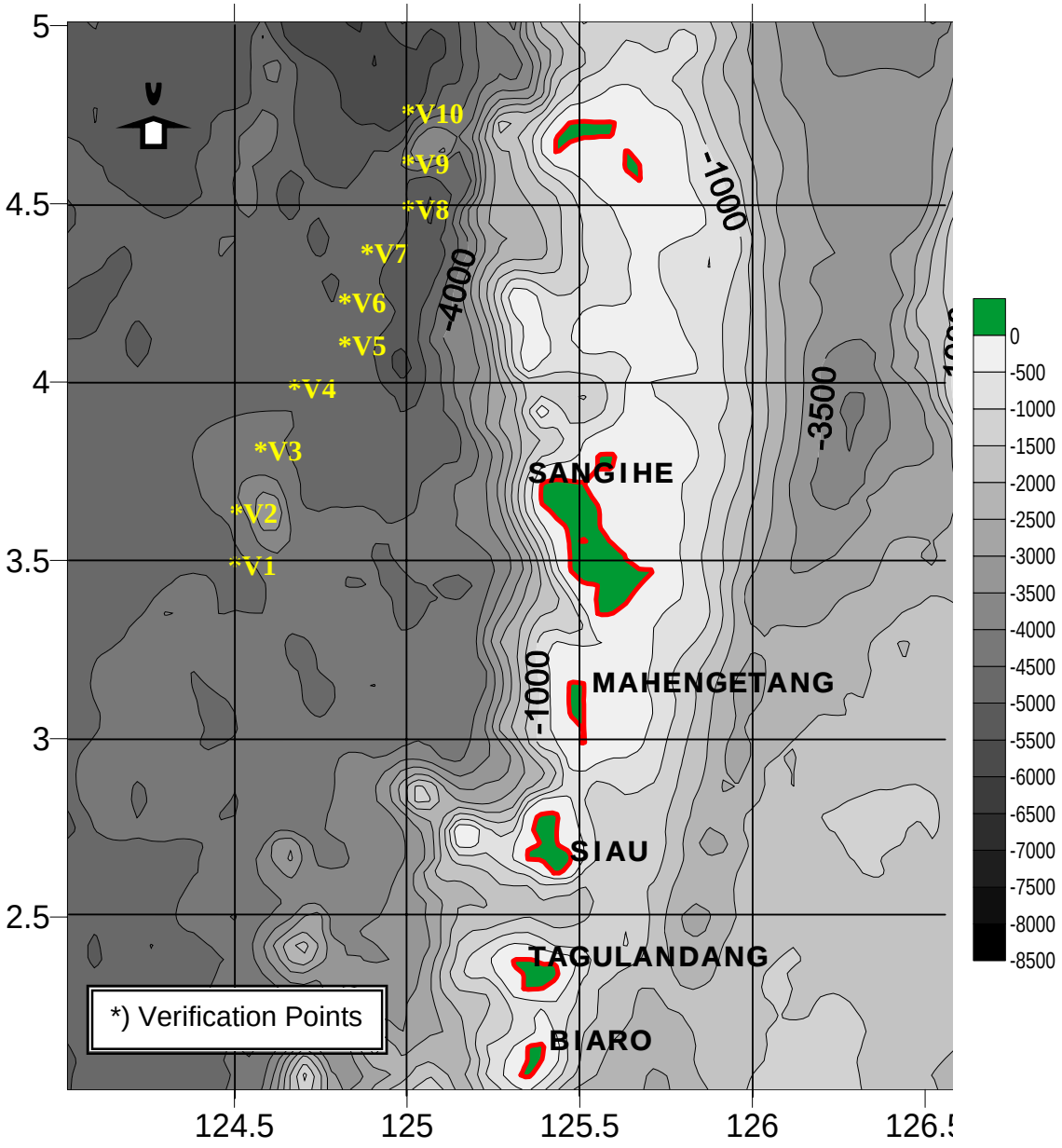

Figure 2. Model Scheme and Verification Points (from IASSHA cruise 2003)

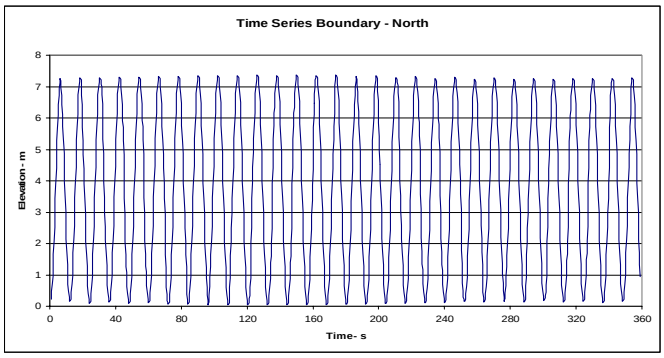

Figure 3. 15-day Sea Surface Elevation at Northern Open Boundary

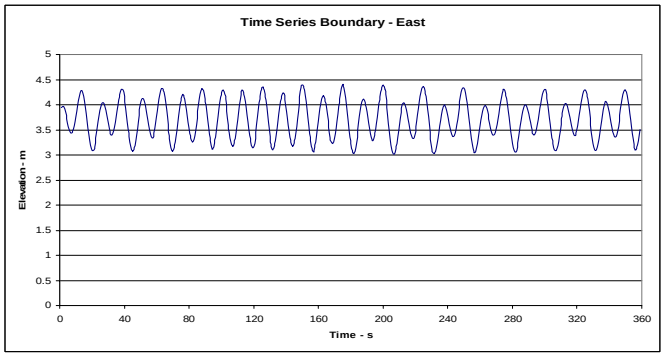

Figure 4. 15-day Sea Surface Elevation at Eastern Open Boundary

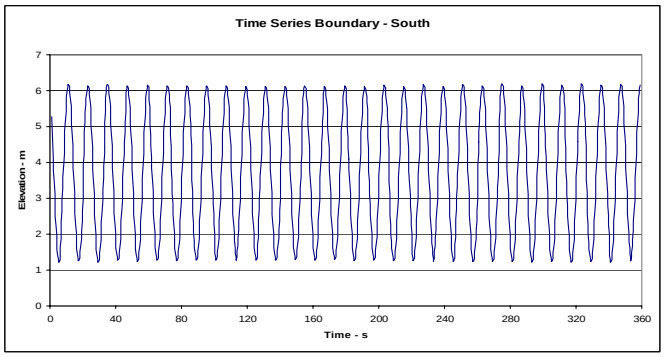

Figure 5. 15-day Sea Surface Elevation at Southern Open Boundary

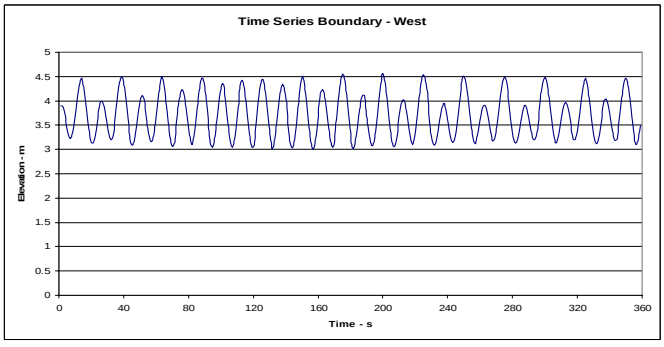

Figure 6. 15-day Sea Surface Elevation at Western Open Boundary

V. DESIGN MODEL

In this analysis, numerical simulation is carried out from August 26, 2003 at 12.00 a.m. until September 10, 2003 at 10.00 p.m. The simulation area is limited to longitude of 124.00^{o} E - 126.50^{o} E and latitude of 1.83^{o} N - 4.50^{o} N. The detail is shown on **Table 1**.

Parameter	Value	Unit
Number Of X (I) Cells	100	-
Number Of Y (J) Cells	92	-
X Grid Size	100	m
Y Grid Size	100	m
Time Step Of Model	0.25	second
First Time Step	1	second
Maximum Number Of Time Steps	5184000	second
Roughness Length	0.08	m
Effective Depth	0.3	m
Drying Height	0.05	m
Initial Sea Level	99	set by model
Latitude	0	corriolis neglected
Orientation	0	-
Horizontal Eddy Viscosity	5	m^2/ second
Eddy Viscosity Mult Factor	2	-
Number Of Steps To Apply	1	-
Diffusion Percentage Slip	97	%

Table 1. Hydrodynamics Model Design

Vi. Results & Discussion

The discussion of this numerical analysis will be laid out in two sections, the first section will discuss the current circulation pattern and sea surface elevation in Sangihe Waters; the second section will discuss the validity of this simulation model using the insitu field data taken during IASSHA cruise 2003. Model Scheme and Verification Points (from IASSHA cruise 2003) is shown in **Figure 2**.

1. Current Circulation Pattern and Sea Surface Elevation

In general, the current in Sangihe Waters predominantly moves from northwest to south and then moves to east after passing the Sangihe Isles, once a while this current pattern changes, where the current moves from North/Northeast to south Sangihe Waters and turns toward west direction where the movement is relatively slow.

The tide in Sangihe Waters is *Mixed Tide Prevailing Semidiurnal* type(*after* Wyrtki, 1961). The prediction of tide elevation is carried out using Oritide(ORI.96) – *Global Tide Model*(Matsumoto, 1996)for month of September shows that mean highest high tide elevation is +86.26 *cm*, the lowest low tide elevation is -69.12 *cm*.

Just before the low tide (see **Figure 7**), the current moves from northern and northeast direction. From the northern direction (east side of Sangihe Isles), current moves to south and will turn to northwest after meets the current originated from northeast (east side of Sangihe Isles) that moves to southwest through the straits around Sangihe Isles.

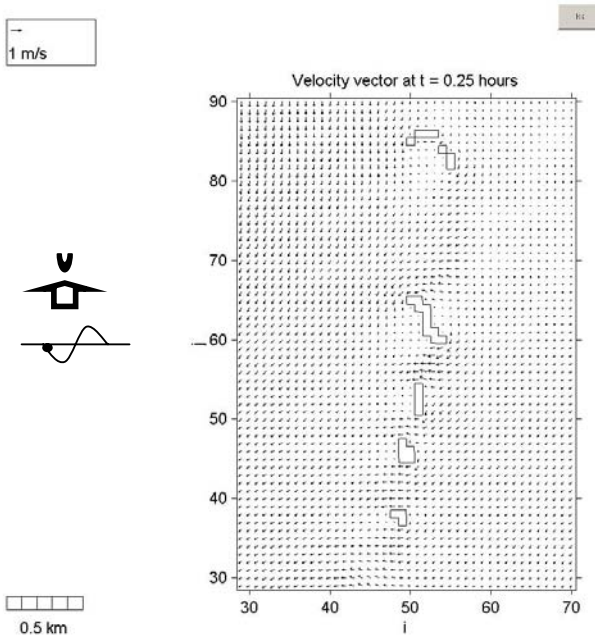

Figure 7. Current Pattern in Sangihe Waters just before Low Tide

At the low tide (see **Figure 8**), current pattern has the same pattern as the pattern just before the low tide, but there is a significant increase of current velocity that comes from the northern direction (west side of Sangihe Isles) and from northeast direction (southwest of Sangihe Isles), while the current that comes from northeast of Sangihe Isles is decreasing.

Just before the high tide (see **Figure 9**), the current movement starts from northern and southeast direction of Sangihe Isles. At the east side of Sangihe Isles, the current moves from the northeast direction and join the current that originated from west side of Sangihe Isles toward west direction. The current that comes from northwest direction (east side of Sangihe Isles) form *eddy* and moves to northwest direction through a strait between Sangihe Island and Kawio Isles then join the current that originated from west side of Sangihe Isles.

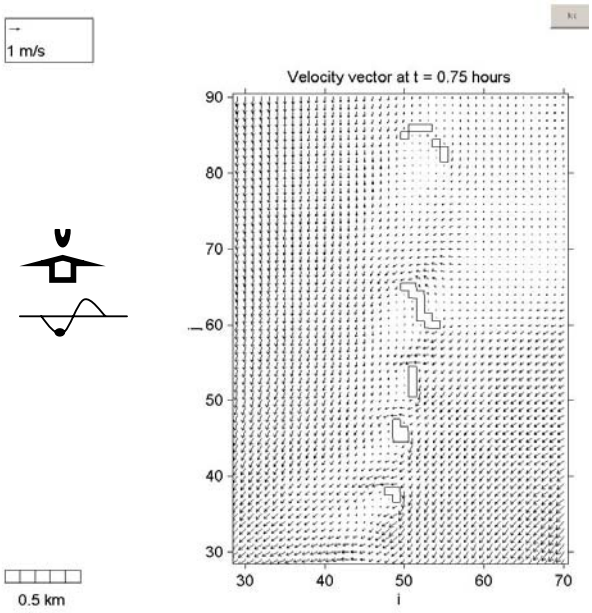

Figure 8. Current Pattern in Sangihe Waters at the Low Tide

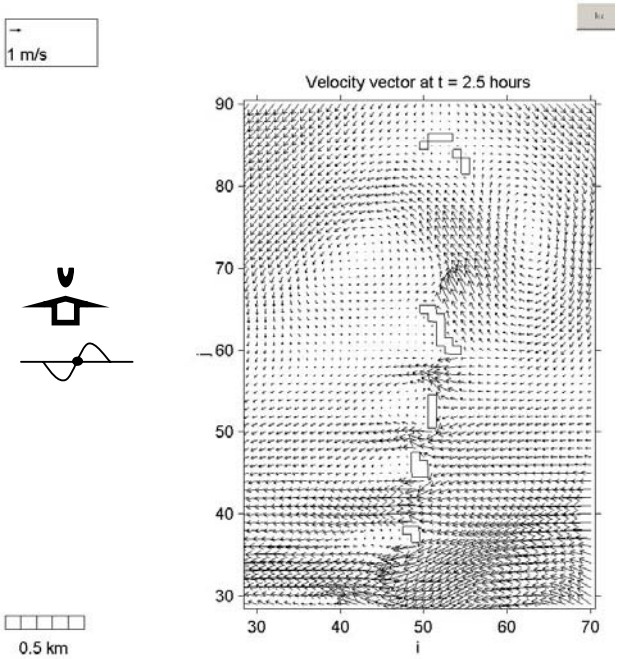

Figure 9. Current Pattern in Sangihe Waters just before high tide

At high tide (see **Figure 10**), the current movement starts from west of Sangihe Isles and predominantly moves to southeast direction through passages between Sangihe Isles and turns to northeast direction. A less dominant current moves toward northeast direction on the north side of Kawio Isles.

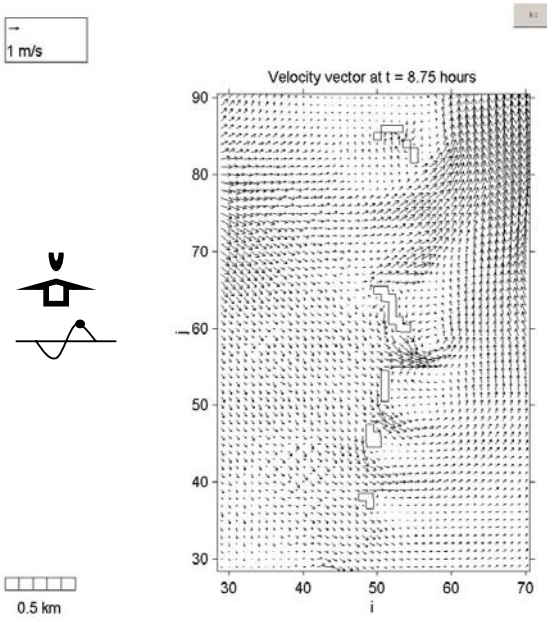

Figure 10. Current Pattern in Sangihe Waters at High Tide

2. Verification

Verification is carried out by comparing the output from numerical simulation with the insitu field data and also comparing with secondary data taken from TOPEX/ERS–2 Analysis 2002(BRKP, 2002). This comparison can be done because the tide is harmonic, only the amplitude is different, so that the assumption is the surface current pattern in year of 2002 can be used for year of 2003.

The verification is carried out by starting on the 2nd day until the end of simulation. The 2nd day is chosen as the verification initial time to avoid unstable simulation condition at the beginning of numerical simulation.

The result of model simulation just before high tide shows the same pattern with the data analyzed using TOPEX/ERS–2 for September 2, 2002 (see **Figure 11**). The data analyzed using TOPEX/ERS–2 for September 5, 2002 (see **Figure 12**) shows that the current pattern is similar with the result from numerical modeling at high tide.

This numerical simulation verification is relatively good, but it needs more improvement on modeling and more scenarios in running the model. This improvement input data for the model such as salinity, temperature, wind, and current at certain depth

No	Field Data							Numerical Model		
	Loc	Date	Time	Position		Current	Direction	Grid Position	Current	Direction
				Latitude	Longitude					
1	V1	1/9/2003	20.2	124.51	3.58	0.1	165	(30,60)	0.2	190
2	V2	1/9/2003	23.2	124.53	3.72	0.1	315	(30,65)	0.18	200
3	V3	2/9/2003	19.2	124.66	3.80	0.1	232	(32,68)	0.17	240
4	V4	2/9/2003	21.2	124.79	4.06	0.1	87	(33,70)	0.12	175
5	V5	2/9/2003	22	124.83	4.14	0.2	87	(36,72)	0.2	205
6	V6	2/9/2003	22.4	124.87	4.22	0.3	217	(36,75)	0.4	220
7	V7	2/9/2003	24	124.96	4.38	0.3	226	(38,78)	0.4	220
8	V8	3/9/2003	1	125.02	4.50	0.1	5	(40,80)	0.1	45
9	V9	3/9/2003	2.2	125.07	4.66	0.2	308	(40,82)	0.18	40
10	V10	3/9/2003	18.4	125.08	4.66	0.2	81	(40,85)	0.16	45

Table 2. Comparison between Numerical Model with Insitu Field Data of IASSHA 2003

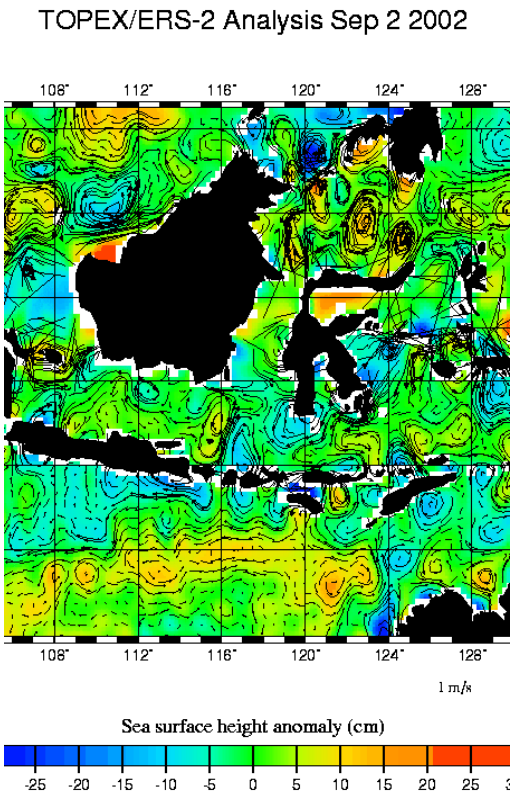

Figure 11. Current Pattern using *TOPEX/ERS–2 Analysis 2002* for September 2, 2002

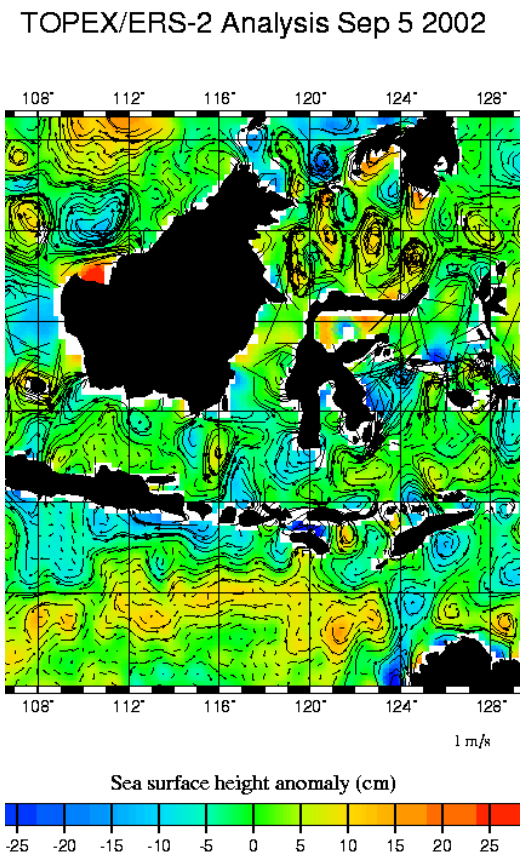

Figure 12. Current pattern using *TOPEX/ERS–2 Analysis 2002* for September 5, 2002

Vii. Conclusion And Recommendation

Conclusion

From the hydrodynamics model simulation in Sangihe Waters, it can be concluded that:

1. Tide pattern is mixed tide pattern and it is mostly semidiurnal.
2. The current in Sangihe Isles predominantly moves from northwest direction toward south and then moves to eastern direction after passing Sangihe Isles. At certain condition, the current pattern moves from northern/northeast direction to south side of Sangihe Waters and turns slowly to western direction.
3. The current direction changes twice daily.
4. The maximum current occurs just before high tide with amplitude of 1.83 *m/s*.

Recommendation

The Sangihe Waters is an open seas area so that the movement of current will be mostly affected by the surrounding condition. Wind is a dominant factor that can affect the pattern of surface current movement at an open seas. Meanwhile the current dynamics at certain depth is still affected by the tide. The wind current and direction measurements in Sangihe Waters will be needed. More insitu field data such as elevation and current will be needed as well, and it can be used as an input data as well as for verification purposes, so that the accuracy of numerical model can be improved.

Acknowledgement
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Viii. Refference

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