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# Comparison of tidal model using mike21 and delft3d-flow in part of Java Sea, Indonesia

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Abstract. This article presents about the comparison between two numerical model for tidal modelling. The tidal in North Coast of Central Java, a part of Java Sea were modelled in 2D to get the sea water level using DELFT3D and MIKE21 in order to identify model performance and efficiency. As the results, both model's bathymetry results show similar interpolation. Both models have been shown to be able to perform small error on tidal models but still need to be revise in further research. The K1 is dominant tidal constituent in the North Coast of Java sea. Unstructured grid results to be more efficient in running time and grid construction. This research is a preliminary research and will be developed in further research.

#### 1. Introduction

Coastal zones are the important for many studies i.e. sediment transport, tidal flood inundation, storm surge inundation, sea level rise, fisheries, and many others [1]; [2]. Based on this importance, the accurate tidal predictions are correlated to several domain for substantial usage. Nowadays, many numerical models exist for modelling coastal hydrodynamics [3], yet the most suitable model has not been clear for a specific application. The selection processes of the best model to represent the hydrodynamics needs several factors considering the spatial temporal and the type of model, either 1D, 2D, or 3D to present the phenomenon happens in the study area [4].

The Java Sea tidal amplitude varies between 0.1 to 1 m. However, the study area in the north coast of Java Island has the tidal range between 0.1-0.3 m [5] and is classified as microtidal coast with the tidal range less than 2 meters [6]. The calibration and validation of microtidal process is quite hard due to small amplitude. In order to have best results and efficient time of modelling, we try several models for comparison.

The North coast of Central Java, part of Java Sea, was selected for the location of this research study. It is consisted of 1 tidal station near the Semarang city, Indonesia. Due to the lack of observational tidal station, only one station represents the global data for the study. The aims of the study will be focus on comparing the model results between DELFT3D and MIKE21 for microtidal coast based on amplitude and tidal phase.

#### 2. Methods

The tidal observation point was extracted from TPXO 9, located on (-6.89161; 110.4102). The bathymetry data was extracted from GEBCO images and combined with the field data sampling. The



computational grid for MIKE21 and DELFT3D was constructed differently (**Fig 1**). The tidal constituent input in the model are M2, K1, O1, and S2, based on its tidal characteristic which is semidiurnal mixed tides.

The MIKE21 mesh model (unstructured grid) based on finite volume model (FVM) [7]. The model set up or MIKE21 was divided into large are on the ocean and small area near the estuary of Wulan Delta. The delta has been modelled because of its unique characteristics. The bigger mesh in the ocean model area covers max 9.300.000 m2 use from the default setting. Meanwhile for the smaller mesh for the local maximum area is 1.600.000 m2. The simulation periods run for 30 days and time step setting was 1 minutes during January 2018. The manning was using the default system after its modelled the bathymetry.

The Delft3D structured grid was constructed larger in the ocean and detail in the delta. The structured grid performs spatial discretization based on finite difference method (FDM) [8]. The grid resolution varies from 83 - 107 m in the estuary and its surrounding, 181-403 m in the detail area, and the coarser grid around 981-1500 m. The model was simulated for 30 days in January 2018 and the results will be calibrated in the observation point. Time step for the model was set to be 0.25. Wind data was also input to the DELFT3D model. The manning setting was set for 0.05.



Figure 1. Model grid of (a) DELFT3D FLOW (b) MIKE21

#### 3. Results

#### 3.1 Tidal Model Results

Bathymetry results from MIKE21 and DELFT3D shows similar patterns of bathymetry which meant that both of the model have the same interface bathymetry (**Fig2**). The tidal model results were compared with the monitoring data in the observation point (**Table 1**) shows that the both DELFT3D-Flow and MIKE 21 model give the best fit to the observation data for both amplitudes and phase, even there are errors around 10-20%. For constituent M2, shows small error between observation and simulation, meanwhile for other parameters the gap errors still acceptable.

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Figure 2. Bathymetry (a) DELFT3D FLOW based on observation data and GEBCO using triangular interpolation (b) MIKE21 based on Admiralty interpolation (for Java Sea) and observation data.

The tidal amplitudes from the observation ranges between 3.5 to 24.5 cm, whereas the simulation shows range 5.7 to 21.1 for the DELFT3D and 5.6 to 20 cm for MIKE21. It shows errors around 0.6 to 4 cm, which was very difficult to calibrated [9]. From the **Fig 3**. we can compare the phase results for both DELFT3D and MIKE21 shows huge phase lag for S2. The observation data graph and the simulation graph wouldn't fit each other due to phase lag, especially results from MIKE21. K1 is a dominant parameter in the Java Sea especially in the north coast with the amplitude exceed 24.2 cm.

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Table 1. Observed and Simulated Amplitude						
Tidal Constituent	MIKE 21		DELFT3D			
	observation	simulation	observation	simulation		
	(cm)	(cm)	(cm)	(cm)		
01	6.6	7.2	6.6	7.6		
K1	24.2	20.0	24.2	21.1		
M2	9.7	9.1	9.7	9.1		
S2	3.5	5.6	3.5	5.7		

Table 1. Observed	and Simulated	Amplitude

Table 2. Observed and Simulated Flase							
Tidal Constituent	<b>MIKE 21</b>		DELFT3D				
	observation	simulation	observation	simulation			
	(°)	(°)	(°)	(°)			
01	178.34	183.05	178.34	182.99			
K1	353.02	336.1	353.02	335.87			
M2	231.34	249.3	231.34	246.34			
<b>S2</b>	155.78	163.93	155.78	163.82			

# Table ? Observed and Simulated Dhase

#### 3.2 Efficiency Comparison

Between structured and unstructured grid, the unstructured grid gives more flexibility to construct the domain [10], particularly for river and curve domain. However, mesh was not manually constructed as the DELFT3D grid. On the other hand, different model such as DELFT3D FM can construct grid manually using unstructured grid and combine both structured and unstructured. The structured grid sometimes left blank spots on the domain which could not be calculated. Based on the run time, for 30 days simulation and only simulate tides, MIKE21 need 5 minutes for single core, meanwhile DELFT3D needs 30 to 40 minutes running.

Improving the model results quality and minimizing errors could be done using several steps as follow.

- 1. Improving the bathymetry data using field survey in the coastal area so that we can obtain good bathymetry resolution
- 2. Updating the coastline.
- 3. Change the bottom friction and manning
- 4. For DELFT3D, revising the grid into more detail grid in near the coastal area.

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Figure 3. Simulated sea level compared with observations

#### 4. Conclusions

The preliminary research of the numerical modelling using DELFT3D and MIKE21 produce similar bathymetry and tidal constituents. The results also fit with the monitoring data. However, the water level shows gap due to phase lag which should be revise in the further research. In the further research the hydrodynamics model should be developed and simulated using different grid, discharge input, and manning value to decrease the error. MIKE21 was found to be more efficient in running time. Meanwhile the DELFT3D gird can be constructed manually, while MIKE21 couldn't.

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