Influence of river discharge on circulation and tidal process in the Java Sea, Indonesia

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Abstract. This study investigates the effect of river discharge in transport and tidal processes in the Java Sea using the Coastal and Regional Ocean Community (CROCO) hydrodynamic model. The model has 20 vertical layers and a horizontal resolution of 1/18 degrees. The oceanic and atmospheric forcing of this model is taken from the global Copernicus Marine Environment Monitoring Service (CMEMS) model and the fifth generation ECMWF atmospheric reanalysis (ERA5) hourly data. Daily Global Flood Awareness System (GloFAS) data has been successfully implemented as river flow data for this study. Two scenarios have been applied, namely, with and without river discharge. This study shows that the two scenarios and the satellite observational data agree in terms of water level with Root Mean Square Difference (RMSD) about 4 cm, Sea Surface Temperature with RMSD about 0.29°C, and Sea Surface Salinity with RMSD about 0.39 psu. The model was also validated using seven tide gauges and produced a good agreement. River discharge increase eastward transport in the eastern part of the Java Sea up to 0.1 Sv (1 Sv = 106 m3 s⁻¹). Both scenarios produce similar tidal amplitude and phase and agree well with previous studies and other tidal data sources.

Keywords: GloFAS, hydrodynamic, Java Sea, numerical model, river input

1. Introduction

The Java Sea (JS) is a shallow sea on the Sunda Shelf and is part of the Indonesian throughflow (ITF). It has many rivers that carry out freshwater and pollutants along with it. Domestic, agricultural, and industrial wastes are the primary contaminant source of coastal water [1]. A better understanding of river discharge's effect on hydrodynamic circulation is essential for successfully managing the coastal and marine environment [2].

The JS is located in the interior of the Indonesian archipelago in the middle of three main islands: Kalimantan, Java, and Sumatra, with a mean depth of 50 m. In the northwest open boundary, the JS is linked with the Natuna Sea through the Karimata Strait, whereas the eastern open boundary is connected to the Flores Sea and the Makassar Strait.

Several earlier studies have been published on the physical hydrodynamical process in the JS. K1 tide produces a significant component of tidal energy [2]. A one-year simulation of a three-dimensional circulation model showed that monsoon climate influences the JS circulation [3]. The JS freshening occurs in the northwest monsoon (NWM) due to high direct precipitation over the JS region, and the process significantly impacts the property of the ITF water [4].
The river plume provides a source of freshwater flux in the model, thereby affecting the water body. The representation of the river plume provides an improvement to simulate the baroclinic front structure more realistically, thereby improving the regional model [5, 6].

Modeling studies related to river discharge's effect on hydrodynamic circulation in the JS have never been carried out yet. The main challenge is the lack of online available river data in this region. Taking advantage of free online global discharge data, we describe the river's effect on hydrodynamic circulation using two model scenarios: with and without river discharge. The scenarios have been executed using CROCO v1.1 hydrodynamic model. CROCO is a modeling platform for the regional and coastal ocean using realistic or idealized multiscale approaches. The objectives of this study were to investigate how much the freshwater plume affects the circulation and tidal process of the JS.

2. Materials and methods

2.1. Model domain and setup

The model domain covers 2-8°S and 104-114°E with a horizontal resolution of 1/18°. The bathymetry data was obtained from the General Bathymetric Chart of the Oceans (GEBCO) 2020. The JS is connected to the Indian Ocean through the Sunda Strait (SS), which has an average depth of 100 m, and the depth increases towards the Indian Ocean to a maximum depth of 5,760 m (in this model domain). In vertical discretization, 20 vertical layers are used in stretched coordinates, as this is enough to cover baroclinic modes in most domain areas and the computation time in our experiments is faster. The simulation period was from January 1, 2016, to December 31, 2017. Two scenarios have been carried out, namely Model A (without river discharge) and Model B (with river discharge) with hourly model output data. The salinity and temperature of the river discharge is set to 20 psu and 25°C, respectively. Table 1 shows the setup model.

2.2. Initial conditions and boundary conditions

Initial conditions and boundary conditions are taken from Copernicus Marine Environment Monitoring Service (CMEMS) data with a resolution of 1/12° for parameters of temperature, salinity, current, and sea surface height (SSH) [10]. Various oceanographic data sources can be used as the oceanic forcing (boundary conditions), such as Simple Ocean Data Assimilation (SODA), the Estimating the Circulation and Climate of the Ocean (ECCO), and the Second Phase of ECCO project (ECCO2). In this study, CMEMS data is chosen because it has the highest resolution and provides ten days of 3D global ocean forecasts updated daily. Table 2 shows a comparison of the various available oceanic forcing data sources.

| Table 1. Model configuration for Model A and Model B. |
|-----------------|---------|---------------------------------|
| Parameter       | Value   | Description                     |
| LLm0            | 179     | Dimension in the ξ direction.   |
| MMMm0           | 110     | Dimension in the η direction.   |
| N               | 20      | Number of ρ-vertical points, in the vertical grid. |
| Dt              | 600     | Model time step                 |
| Nfast           | 60      | Number of barotropic time steps within one baroclinic time step |
| θs              | 6       | Vertical S-coordinate surface stretching parameter. |
| θb              | 1       | Vertical S-coordinate bottom stretching parameter. |
| hc              | 8       | Vertical S-coordinate Hc parameter. |
Figure 1. The model domain covers 2-8°S and 104-114°E with a horizontal resolution of 1/18°, model validation area using satellite data (red box), sections (red line) in transport calculation (Section A and B).

Table 2 Comparison of the various available oceanic forcing data sources.

| Data Source | Description | Hor. Res. | Vert. Lev. | Time Coverage |
|-------------|-------------|-----------|------------|---------------|
| SODA (Simple Ocean Data Assimilation) | Based on the assimilation between MOM2 oceanographic model, the World Ocean Atlas-94 data, and satellite altimeter data [7]. | 1/2° | 20 | Dec. 1869 to Dec. 2010 |
| ECCO (The Estimating the Circulation and Climate of the Ocean) | Based on global oceanographic model with input data from Satellite Altimeter data, ARGO (temperature and salinity data), GRACE (subsea pressure), Aquarius (surface salinity), CTD, and XBT (temperature) [8]. | 1° | Jan. 1992 to Dec. 2017 |
| ECCO2 | Phase 2 of ECCO project. Has higher resolution to capture the phenomenon of ocean eddies [9]. | 1/4° | 50 | Jan. 1992 to Jan. 2020 |
| GLORYS12V1 | Based on NEMO platform and the generating force of the ECMWF ERA-Interim ERA-5 reanalysis. The model has implemented assimilation with altimeter satellite, Sea Surface Temperature satellite, and in situ temperature and vertical salinity observation data. The evolution of the long-term bias of the model was corrected by the 3D-VAR method. | 1/12° | 50 | Jan. 1993 to Jun. 2019 |
| CMEMS | Continuation of GLORYS12V1. The Operational Mercator global ocean analysis and forecast system provides ten days of 3D global ocean forecasts updated daily [10] | 1/12° | 50 | Jan. 2016 to 10 days forecast updated daily |

2.3. River data
River discharge data used on this model is taken from the Global Flood Awareness System (GloFAS). GloFAS contains daily river discharges data based on meteorological from European Centre for Medium-Range Weather Forecasts (ECMWF) [11]. The dataset is in grid data with a resolution of 0.1° x 0.1° with a global coverage area. GloFAS data are available between January 1, 1979, until now. Several global river discharge data are available and can be used as model inputs, such as the Japanese 55-year Reanalysis (JRA-55) [12], Water-GLOBAL Analysis and Prognosis (WaterGAP) [13], and Dai and Trenberth Global River Flow and Continental Discharge dataset [14]. Dai and Trenberth Global River
Flow and Continental Discharge dataset contain monthly river discharge data from the 925 largest rivers in the world with a period between January 1, 1900, and December 31, 2018. Table 3 shows a comparison of the various available river data sources. GloFAS data is chosen because it has the highest resolution and provides data updated daily.

| Data Source                                | Hor. Res. | Time Coverage           |
|--------------------------------------------|-----------|-------------------------|
| GloFAS (the Global Flood Awareness System) | 0.1°      | Jan. 1979 until now     |
| JRA-55 (the Japanese 55-year Reanalysis)   | 0.25°     | Jan. 1958 to Dec. 2020  |
| WaterGAP (Water-Global Analysis and Prognosis) | 0.5°    | Jan. 1901 to Dec. 2018  |
| Dai and Trenberth                          | -         | Jan. 1990 to Dec. 2018  |

GloFAS data can be implemented into the model by extracting the point grid at the boundary between land and sea. The extracted point is then placed in the corresponding position on u or v points of the CROCO-staggered Arakawa C-grid schematic depending on discharge direction. The discharge direction is determined as follows: the coastal grid which borders the sea in the north is determined as a positive v direction, and vice versa. If it borders the sea in the south, it is determined as a negative v direction. The coastal grid bordering the sea in the east is determined as a positive u direction. Conversely, the coastal grid bordering the sea in the west is determined as a negative u direction. Figure 2 shows the flowchart of GloFAS data implementation on the CROCO v1.1 model.
2.4. Atmospheric and tidal forcing

Hourly ERA5-reanalysis data from ECMWF is used as the atmospheric forcing in this model. Hourly ERA5-reanalysis data has a resolution of 0.25° x 0.25°, higher than previously released ERA-Interim reanalysis, with a spatial resolution of 0.7° x 0.7°. In this study, ERA5-reanalysis data is used because it provides a higher resolution than the ERA-Interim reanalysis data. Surface forcing fluxes: heat, momentum, and freshwater fluxes are used to force the ocean model. In this study, two scenarios (Model A and B) have implemented tidal forcing from TPXO9 with a spatial resolution of 1/6°. TPXO9 is the ninth version of the TPXO series of fully global models of ocean tides, which was produced from an analysis of altimetry data.

2.5. CROCO Model

CROCO v1.1 was developed by the France Institute for Research and Development (IRD-France) based on the Regional Ocean Modelling System (ROMS) AGRIF version [15], with a more efficient numerical scheme and Hybrid Coordinate Ocean Model (HYCOM) based vertical coordinates. In addition, the interface CROCO TOOLS (https://www.croco-ocean.org) was provided in the MATLAB 64 bits language that can be used to build a regional configuration rapidly from preprocessing to executing calculations. The advantage of the CROCO model is its ability to complete local scale models (coastal areas) and their interactions with the open ocean in terms of atmospheric components, surface waves, sediments, biogeochemistry, and ecosystems (add references). CROCO is equipped with tools for the process of preparing input model data (preprocessing) and can be downloaded at https://www.croco-ocean.org.

2.6. Observational data

The observations were taken from seven tide gauges and three satellite data from CMEMS. The seven tide gauges are referred to as Belitung (Station 1), Kota Waringin (Station 2), Sampit (Station 3), Pari Island (Station 4), Jakarta (Station 5), Cirebon (Station 6), and Semarang (Station 7). However, only two stations provide hourly tidal elevation records, namely: Pari Island and Jakarta. The hourly data were taken from the Joint Archive for Sea Level of the University of Hawaii, contributed by the National Coordinating Agency for Surveys and Mapping, Indonesia, and the Research Center for Oceanography, Indonesia. The other five tide gauges predicted the amplitude and phase of the four main tidal constituents O1, K1, M2, and S2. This information is available from Tide Table of Indonesian Archipelago 2003, provided by the Indonesian Navy Hydrographic and Oceanographic Center.

Sea Surface Temperature (SST) satellite observational data were acquired from a global, operational, high resolution, combined sea surface temperature and sea ice analysis system (OSTIA) global foundation Sea Surface Temperature from CMEMS (SST_GLO_SST_L4_NRT_OBSERVATIONS daily data) that provides SST at 0.05° x 0.05° horizontal grid resolution. The temporal coverage of the data is from January 1, 2007, to the present. Sea Surface Salinity (SSS) model was validated by satellite observational data taken from CMEMS (MULTI OBS_GLO_PHY_SURFACE_MYNRT weekly data) with a spatial resolution of 0.25° x 0.25°. The Sea Surface Salinity (SSS) observational data is available from January 1, 1993, to the present. Sea Level Anomaly (SLA) satellite observational data taken from CMEMS (SEALEVEL_GLO_PHY_CLIMATE_L4 REP__ OBSERVATIONS) with a spatial resolution of 0.25° x 0.25° and temporal coverage from January 1, 1993, to the present.

3. Results and discussion

3.1. Discharge data extraction

GloFAS data was extracted to the model grid and obtained 259 point sources (Figure 3). Almost all parts of the beach are covered with discharge point sources. There are 104 point sources (40.15%) with an annual mean discharge below 10 m³/s, 117 point sources (45.17%) with an annual mean discharge between 10 m³/s and 60 m³/s, and only 38 point sources (14.67%) with an annual mean discharge above 60 m³/s.
Figure 3. Extracted GloFAS point sources in the model domain. (A) representative point sources located at Kalimantan, (B) representative point sources located at Sumatra, (C) representative point sources located at Java.

Three GloFAS discharge point sources have been extracted as representatives of the three main islands, point A for Kalimantan (located around Mendawai River), Point B for Sumatra (located around Tulang Bawang River), and Point C for Java (located around Citarum River). Between 2015 and 2017, the minimum river discharge occurred from August 2015 to September 2015, which coincided with a strong El Niño for the 2015-2016 period. In this period, monthly discharge is only about 174 m$^3$/s, 23 m$^3$/s, and 20 m$^3$/s for point source A, B, and C, respectively. The maximum river discharge occurred from March 2016 to April 2016, which coincided with the weak la Nina that occurred after the 2015-2016 strong El Nino. In this period, monthly discharge is only about 1,850 m$^3$/s, 390 m$^3$/s, and 657 m$^3$/s for point sources A, B, and C.

Figure 4. Daily discharge at 3 different point sources: (A) representative point sources located at Kalimantan (around Mendawai River), (B) representative point sources located at Sumatra (around Tulang Bawang River), (C) representative point sources located at Java (around Citarum River).
3.2. Model validation
3.2.1. Tidal validation
The sea level data were analyzed using the least-squares method in MATLAB, referred to as the u_tide program [16]. The analysis uses white noise floor assumption to define confidence interval. For tide validation using seven tide gauges, we focus on the four main tidal constituents (O1, K1, M2, and S2) only. The amplitude and phase (relative to Greenwich meridian) for the seven tide gauge stations are summarized in Table 4. We note that the diurnal tides in the western (Station 3) and eastern (Station 1) parts are larger than those in the central part (Station 6 and Station 7), whereas the semi-diurnal tides are larger in the eastern part (Station 3) of the Java Sea. The M2 tide, in particular, peaks around the southern coast of Kalimantan.

Table 4. Comparison of observed and modeled tidal elevation at reference sites for Model A (without river) and Model B (with River).

| Station       | Amplitude-H (cm) | Phase-Ø (°C) |
|---------------|------------------|--------------|
|               | Obs.  | A  | ΔHA | B  | ΔHB | Obs.  | ØA  | ΔØA | ØB  | ΔØB |
| O1            |       |    |     |    |     |       |     |     |     |     |
| Belitung (1)  | 42    | 28.71 | -13.29 | 28.49 | -13.51 | 341.40 | 331.03 | -10.37 | 329.84 | -11.56 |
| Kota Waringin (2) | 16    | 13.8 | -2.2 | 13.74 | -2.26 | 131.40 | 116.12 | -15.28 | 116.24 | -15.16 |
| Sampit (3)    | 31    | 31.4 | 0.4  | 31.36 | 0.36  | 166.40 | 144.88 | -21.52 | 144.64 | -21.76 |
| Pari (4)      | 12.21 | 12.39 | 0.18  | 12.61 | 0.4   | 8.89  | 3.99  | -4.9  | 4.911 | -3.979  |
| Jakarta (5)   | 13.75 | 13.66 | -0.09 | 13.78 | 0.03  | 25.32 | 2.96  | -22.36 | 3.51  | -21.81  |
| Cirebon (6)   | 5     | 6.03 | 1.03  | 5.88  | 0.88  | 57.4  | 43.2  | -14.2 | 43.88 | -13.52  |
| Semarang (7)  | 8     | 5   | -3   | 5    | -3    | 134.4 | 108.77 | -25.63 | 108.54 | -25.86  |
| K1            |       |     |      |      |       |       |      |      |      |      |
| Belitung (1)  | 72    | 57.69 | -14.31 | 57.66 | -14.34 | 33.71 | 49.9  | 16.19 | 49.17 | 15.46  |
| Kota Waringin (2) | 36    | 30.8 | -5.2 | 31.07 | -4.93 | 220.71 | 231.13 | 10.42 | 230.36 | 9.65   |
| Sampit (3)    | 60    | 70.82 | 10.82 | 71.21 | 11.21 | 230.71 | 231.2 | 0.49  | 230.78 | 0.07   |
| Pari (4)      | 21.29 | 32.08 | 10.79 | 32.76 | 11.47 | 18.82 | 51.36 | 32.54 | 52.21 | 33.39  |
| Jakarta (5)   | 25.17 | 33.82 | 8.65  | 34.35 | 9.18  | 34.73 | 48.13 | 13.4  | 48.85 | 14.12  |
| Cirebon (6)   | 14    | 11.2 | -2.8 | 10.89 | -3.11 | 302.71 | 343.07 | 40.29 | 341.73 | 39.02  |
| Semarang (7)  | 22    | 12   | -10.15 | -11.85 | -0.1  | 224.11 | 278.56 | 54.45 | 281.29 | 57.18  |
| M2            |       |     |      |      |      |       |      |      |      |      |
| Belitung (1)  | 8     | 8.24 | 0.24  | 7.9  | -0.1 | 224.11 | 278.56 | 54.45 | 281.29 | 57.18  |
| Kota Waringin (2) | 22    | 21.41 | -0.59 | 21.49 | -0.51 | 335.11 | 329.91 | -5.2  | 326.48 | -8.63  |
| Sampit (3)    | 49    | 52.35 | 3.35  | 53.61 | 4.61  | 306.11 | 291.61 | -14.5 | 291.11 | -15    |
| Pari (4)      | 1.76  | 6.29 | 4.53  | 6.02  | 4.26  | 91.89 | 215.7 | 123.81 | 217.76 | 125.87 |
| Jakarta (5)   | 5.41  | 9.45 | 4.04  | 9.02  | 3.61  | 140.85 | 185.24 | 44.39 | 184.28 | 43.43  |
| Cirebon (6)   | 16    | 22.67 | 6.67  | 23.46 | 7.46  | 101.11 | 100.47 | -0.64 | 99.96  | -1.15  |
| Semarang (7)  | 10    | 11.18 | 1.18  | 11.45 | 1.45  | 55.11 | 71.28 | 16.17 | 72.6  | 17.49  |
| S2            |       |     |      |      |      |       |      |      |      |      |
| Belitung (1)  | 7     | 4.79 | -2.21 | 4.59 | -2.41 | 175   | 225.52 | 50.52 | 223.71 | 48.71  |
3.2.2. Sea level validation
Model and satellite data are compared on the sample box, between 108E - 109E and 4S - 5S (red box in figure 1). Model results and altimeter data agree well in terms of sea level. The root means square difference (RMSD) between model and altimeter satellite is about 4.00 cm for Model A and 4.25 cm for Model B. Figure 5 shows the comparison of model sea level and altimeter data for Model A and B.

![Figure 5. Comparison of model sea level and altimeter data for Model A and B.](image)

3.2.3. SST validation
SST results from Model A and B in the sample box are in good agreement with satellite data. The RMSD between model and altimeter satellite is about 0.298°C for Model A, and 0.296°C cm for Model B. Figure 6 shows that peak SST in JS occurs in transition 1 season, March to May (MAM) and transition 2 seasons, September to November (SON), where the sun is perpendicular to the equator. The minimum SST occurs in the northwest monsoon, December to February (DJF) and southeast monsoon, June to April (JJA), where the heat flux is minimum due to the increasing distance between the JS and the sun.

![Figure 6. Comparison of model SST and satellite data for Model A and B.](image)
3.2.4. SSS validation

SSS model result shows overestimated value period of February 2017 until June 2017. The RMSD between model and satellite is about 0.385 psu for Model A and 0.3933 psu for Model B. The peak SSS occurs in SON, transition season after the dry season in JJA. This high SSS value occurs when the evaporation rate increases due to higher SST and lower air relative humidity.

![Figure 7. Comparison of model SSS and satellite data for Model A and B.](image)

3.3. River impact in circulation

Two sections have been determined to investigate river discharge impact in mass transport. Section A computes the transport along the eastern part of the JS and Section B for the SS. These sections parallel to the latitude axis, so transport is calculated based on u component velocity. A positive transport sign means the eastward transport, and vice versa; the negative one means the westward transport. Transport is calculated by integrating u component velocity over the section and all depth layers.

Figure 8 shows the transport in section A. Positive transport occurs around northwest monsoon and transition 1 season, December to May (DJFMAM), and negative transport occurs around southeast monsoon and transition 2 seasons, June to November (JJASON). The transport is dominated by positive transport, so the annual net transport of the JS is going to the east. The average positive transport for two years of simulations is 2.1 Sv, and the average negative transport is -1.1 Sv. The green bar shows the transport difference between Model B (with river scenario) and Model A (without river scenario). The green bar dominantly has a positive value. It means that river discharge in the domain model increases the transport to the east.

![Figure 8. Transport in section A (eastern part of JS) for Model A and B. Green.](image)
Figure 9 shows the transport in section B. The transport is dominated by a negative value, which means the mass transport occurs out of the JS via the SS. Green bar dominantly has a positive value, which means river discharge reduces the mass transport from the JS to SS, but when the discharge is in peak season like in April to May 2016 and April 2017, river increase the transport from JS to SS up to 0.1 Sv.

![Transport Difference](image-url)

**Figure 9.** Transport in section B (SS) for Model A and B. Green.

### 3.4. River impact in tidal

River discharge impact in the tidal process was analyzed by performing u_tide tidal analysis overall grid domain in both models. Monthly separated output model data are combined from January 2016 to December 2017. Every grid consists of hourly time series of water levels and then processed by u_tide to produce amplitude and phase relative to Greenwich at every grid point.

Tidal analysis for O1, K1, M2, and S2 components of Model A and Model B shows in figures 10, 11, 12, 13, and 14, respectively. Both scenarios produce similar amplitude and phase patterns. River discharge does not have a significant impact on the four tidal components. Although the river does not affect the tide much, the results of the tidal analysis of the two models are still discussed to confirm the model's validity. This simulation shows that K1, M2, and S2 propagate westward parallel to the closed boundary, i.e., the northern part of the Java and the southern part of Kalimantan. These tides are then deflected to the northerly direction in the western part of the JS.

The K1 co-amplitude shows that its amplitude decreases in the central part of the JS from 0.6 m in the western and eastern part of the JS to only 0.1 m in the center. This small amplitude indicates a node in the central part of the JS. Co-phase of K1 closes to each other in the central part of the JS, indicating slower wave propagation. The phase difference between the eastern and western parts is about 12 hours (180°). Therefore, when the flood condition occurs in the western part, the ebb condition occurs in the eastern part and vice versa. This phenomenon indicates a node in the central part and antinodes in the eastern and western parts of the JS, supporting co-oscillation tides or resonance effect. The JS basin period is very close to the K1 constituent's 23.9 hours, and it causes resonance in the JS [2].

Although both are diurnal components, the O1 component propagates in the opposite direction to K1. O1 runs from the western part of the JS to the eastern part of the JS. This result is similar to the FES2014 tidal model from AVISO altimetry. The O1 co-amplitude decreases in the central part of the JS. It reduces from 0.3 m in the western and eastern part of the JS to 0.1 m in the center. The phase difference between the eastern and western parts is about 12 hours (180°). The simulated O1 tide
propagation does not resolve the same phenomenon of resonance with the K1. The O1 co-phase does not connect as the K1 co-phase does in the northern part of the JS.

![Figure 10. Modeled co-amplitude (A) and co-phase (relative to the Greenwich meridian) distribution for O1 tidal constituent for Model A and Model B.](image1)

![Figure 11. Modeled co-amplitude (A) and co-phase (relative to the Greenwich meridian) distribution for K1 tidal constituent for Model A and Model B.](image2)

The M2 co-phase shows that the wave propagates from the eastern part to the western part of the JS, and it is refracted due to decreases in the propagation speed and the wavelength in the southern part of the M2 wave when it enters shallow water (the JS). The northern part of M2 travels faster than the southern part triggering the wave amplification in the southern part of Kalimantan. This amplification increases the co-amplitude from 0.1 m in the central part of the JS to 0.4 m. The co-phase of S2 shows that S2 amplitude in the JS is only about 0.1 m.
4. Conclusion
In this study, both initial conditions, boundary conditions, atmospheric forcing, and tidal forcing have used the best data available on the internet to maximize the accuracy of the resulting model. The validation results of the two model scenarios produce a similar value between the model results and the observation data. SST model output in both scenarios produces SST values that are very close to satellite data.

In this study, the daily GloFAS data has been successfully implemented in the CROCOv1.1 model. The availability of GloFAS data, which continues to be updated every day, makes GloFAS an alternative solution to the lack of availability of river discharge data in Indonesia. The influence of rivers on circulation in the JS has been carried out by comparing the transport on the eastern side of the JS and the mass transport of water through the SS. In this simulation, it is found that the river generally increases the transport out from the eastern the JS up to 0.1 Sv. The amount of water mass transport in the SS also shows the difference between Model A (without rivers) and Model B (with rivers). Both models have
successfully reproduced the tidal process in the JS. From this study, it is found that the river does not have much effect on the tide.

Author Contributions
H.R. designed integration of GloFas data to the model, performed the calculations, and analyzed the data. D.N designed the research concept, developed the computational framework, tested and evaluated ROMS-CROCO with hourly ERA5 data forcing and TPXO9. H.R. and D.N. wrote the manuscript with input from all authors. I.W.N. and A.S.A conceived the study and gave overall direction and planning. This study has been conducted using E.U. Copernicus Marine Service Information.

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