EVALUATION OF COASTAL SEA LEVELS FROM JASON-2 SATELLITE ALTIMETER IN INDONESIAN REGIONAL SEAS

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Introduction

- 01 Indonesia is the largest archipelagic country and the second longest coastline in the world. Several cities in Indonesia are in low-lying coastal areas. They face serious risks due to sea level rise. Therefore, the continuous monitoring of the sea level changes in Indonesia is extremely crucial.
- 02 Unfortunately, very few tide gauges with long time series are available in Indonesia. But, sea level can be also measured with satellites using radar altimeters.
- 03 Sea level studies in Indonesia have generally used gridded global altimetry data sets, which are too coarse and impacted by the presence of many islands (see the map below for an example).

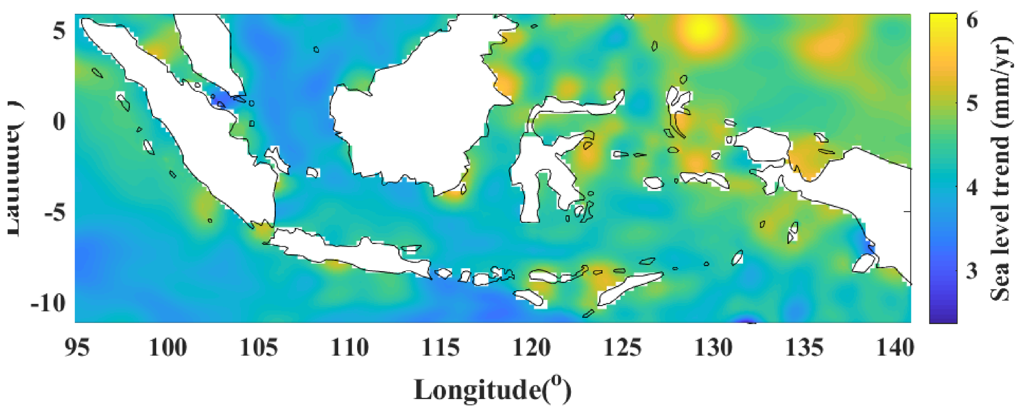

Figure 1. Sea level trend in Indonesia using gridded 0.25°×0.25° sea level anomaly data from 1993 to 2021 distributed by Copernicus Marine Environment Monitoring Service.

- 04 Hence, along-track data are better suited for Indonesia thanks to the possibility of re-tracking waveforms and improve processing.
- 05 There are several re-trackers that have been developed with different strategies in order to obtain the highest possible accuracy of sea level data in complex areas.
- 06 The aim of this study is to evaluate their performances over regional Indonesian seas within 20 km from the coast by selecting the case-study of Jason-2 mission with available overlapping tide gauge measurements.

Methodology

Altimetry data

20-Hz data of Jason-2, February 2011 to May 2015 from:
- SGDR-D
- Coastal products (PISTACH and X-TRACK/ALES)

Re-trackers applied

MLE4, Ice1[1], OCOG[2], Improved Th Threshold (Th)[3], Improved Th (ITh)[4], Mod-CAWRES[5], PISTACH[6] (Ice3, Oce3, Red3), X-TRACK/ALES[7]

Study site

Pemangkat, Gebe, Sadeng, Waikelo and Saumlaki

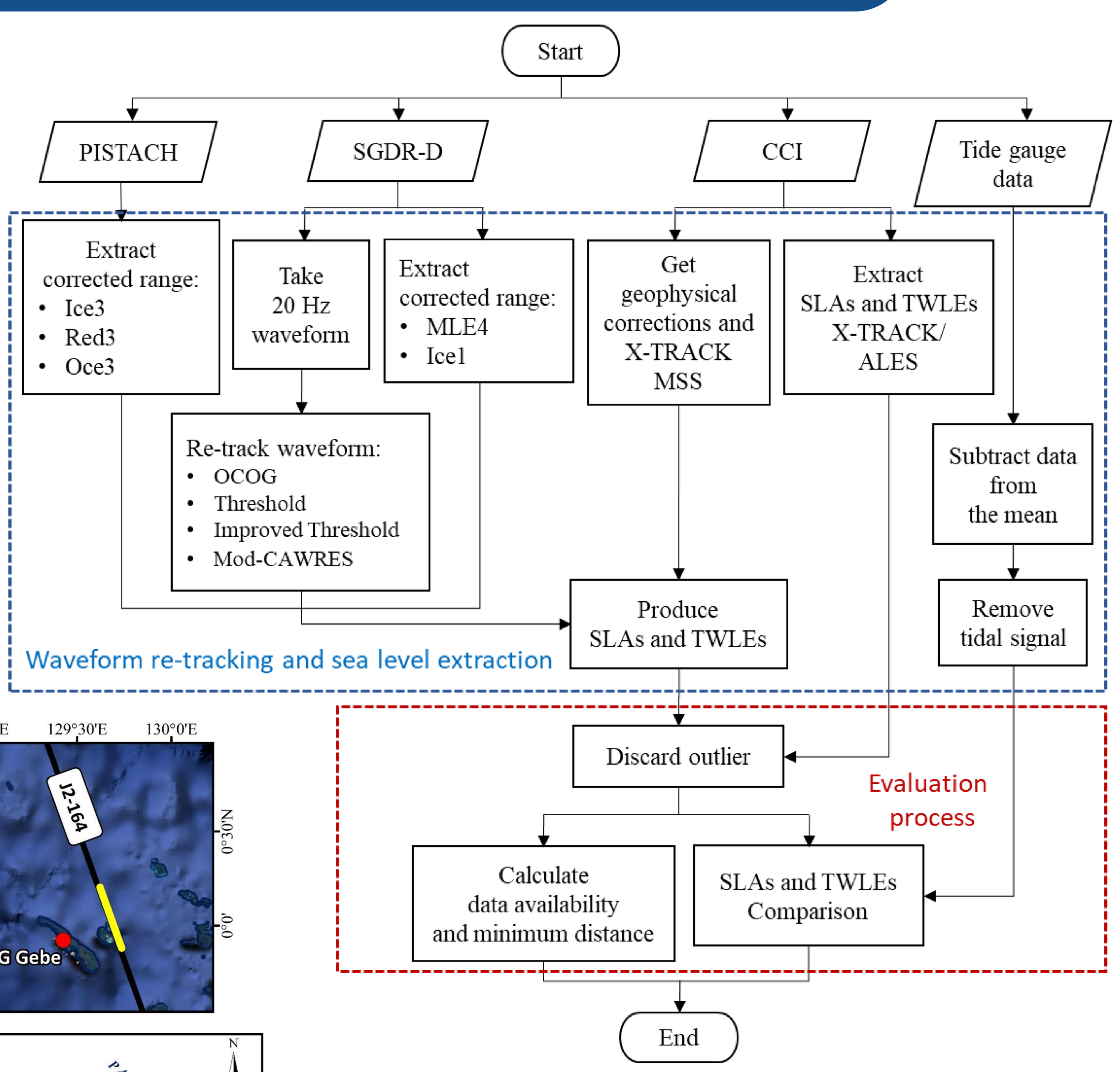

Figure 2. Data processing flow diagram

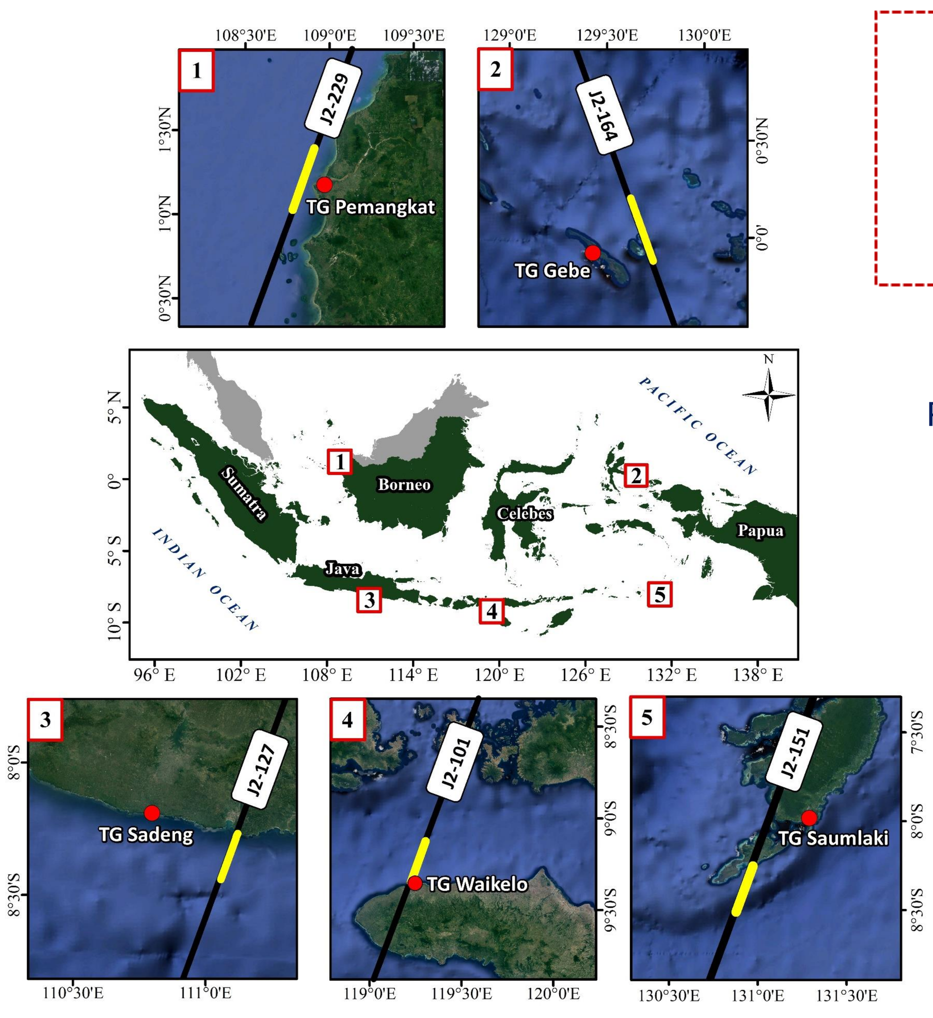

Figure 3. Study site. Red points are tide gauge (TG) stations. The yellow lines denote experimental points

Data Availability and Minimum Distance

To assess data availability, outliers were excluded using a criteria of -0.5 m < Sea Level Anomaly (SLA) < 0.5 m. The minimum distance was determined from the nearest point to the coast, which has a mean percentage of data availability of over 80%.

Comparison to Tide Gauge Data

For evaluation to TG, we calculated the correlation (r) and the root mean square error (RMSE) between re-tracked sea levels and the corresponding TG data. The comparison included both SLAs and total water level envelopes (TWLEs).

Results

1 Available Data and Minimum Distance

Table 1. Mean percentage of available data on 123 cycles within 20 km to the coast and the minimum distance. The best results are shown in bold red.

Re-tracker	Mean percentage of available data (minimum distance in unit km)				
	Pemangkat	Gebe	Sadeng	Waikelo	Saumlaki
MLE4	85 (7.6)	89 (**4.2**)	91 (4.5)	82 (7.8)	81 (7.1)
OCOG	56 (11.9)	48 (12.8)	82 (4.8)	71 (13.2)	56 (9.3)
Ice	81 (8.1)	92 (**4.2**)	91 (4.5)	85 (**7.3**)	80 (7.1)
Th 10	92 (7.0)	91 (**4.2**)	87 (4.5)	82 (**7.3**)	79 (7.5)
Th 20	87 (7.6)	92 (**4.2**)	89 (4.5)	85 (**7.3**)	81 (7.2)
Th 50	73 (9.3)	91 (**4.2**)	91 (4.5)	84 (**7.3**)	73 (7.4)
ITh 10	93 (**6.8**)	92 (**4.2**)	88 (4.5)	**85** (**7.3**)	79 (7.4)
ITh 20	90 (7.4)	92 (**4.2**)	90 (4.5)	**85** (**7.3**)	81 (7.1)
ITh 50	79 (8.5)	92 (**4.2**)	91 (4.5)	**85** (**7.3**)	76 (7.4)
Ice3	91 (7.6)	94 (**4.2**)	**97** (**3.6**)	84 (**7.3**)	89 (5.7)
Oce3	83 (9.1)	80 (7.5)	96 (**3.6**)	79 (8.4)	83 (5.9)
Red3	95 (**6.8**)	92 (**4.2**)	**97** (**3.6**)	71 (12.7)	88 (5.8)
Mod-CAWRES	92 (7.2)	91 (**4.2**)	87 (4.5)	84 (**7.3**)	79 (7.5)
X-TRACK/ALES	**96** (**6.8**)	94 (**4.2**)	**97** (**3.6**)	**85** (**7.3**)	**91** (**4.0**)

2 Evaluation with Tide Gauge Data

- Re-tracker's performance varies at each observation point within an area.
- The correlations and RMSEs in all observation regions differ for SLA and TWLE.
- Clear gap between the products used → Ice3, Oce3, Red3, and X-TRACK/ALES which are from the coastal products (PISTACH and X-TRACK/ALES) perform much better in a cluster range than SGDR-D.
- SLAs comparison is much lower correlations (mean <0.6) than TWLEs (mean>0.8). This is explained by the current global tidal model and dynamic atmospheric correction (DAC) are insufficient in Indonesian coastal areas.
- The best performance is at Sadeng while the worst is at Waikelo.

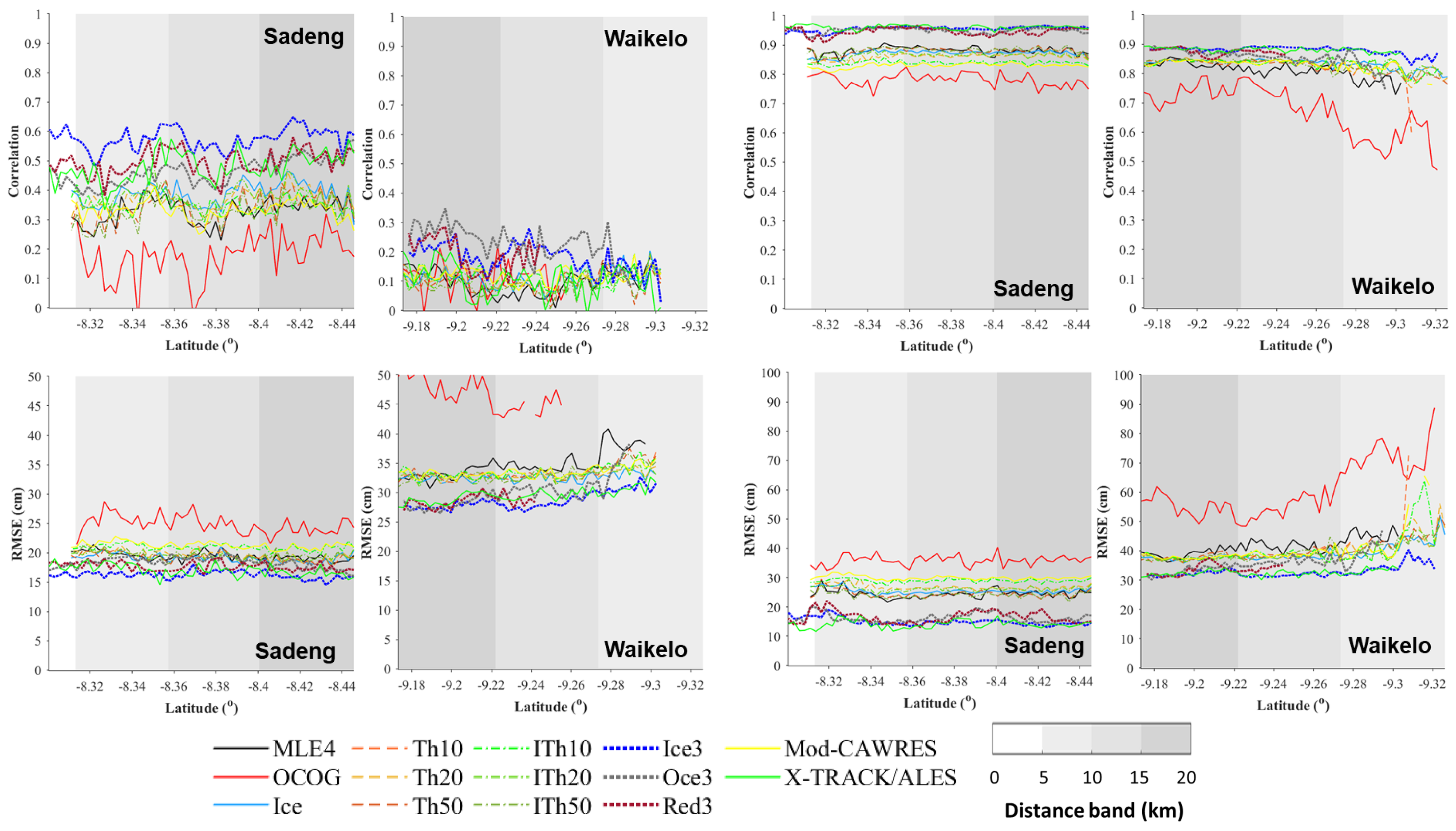

Figure 4. Comparison of re-tracked altimetry sea level to TG data at Sadeng and Waikelo. The top plots show correlations, while the down plots are RMSEs. The left side is SLAs comparison and the right side is TWLEs comparison.

Conclusion

- X-TRACK-ALES offers the highest percentage of available data in all observation regions (up to 97%) and brings reliable data up to 3.6 km to the coast.
- The comparison to TG results confirms that re-trackers from coastal products, particularly Ice3 and X-TRACK/ALES, provide the best performance with correlation of up to 0.98 and RMSE of up to 11 cm for TWLE.
- Geophysical correction is still challenging in Indonesian coastal regions, necessitating further study.

Reference/Footnotes

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