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Exploring Coastal Altimetry Datasets for Indonesian Seas in relation to Local Tide Gauges

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#EGU22 Session G3.2 - Advances in methods and applications for satellite altimetry
EGU22-538 | 23rd May 2022

Spoiler Alert!

1. Dedicated coastal retracker is more precise: X-TRACK/ALES [XA] and ALES [AL] data are more precise compared with along-track Jason-1+2+3 [NM] data on coastal zone (3-20 km)
2. However, more precise didn't mean more accurate: Interestingly, NM data has better STD of Difference compared to XA and AL.

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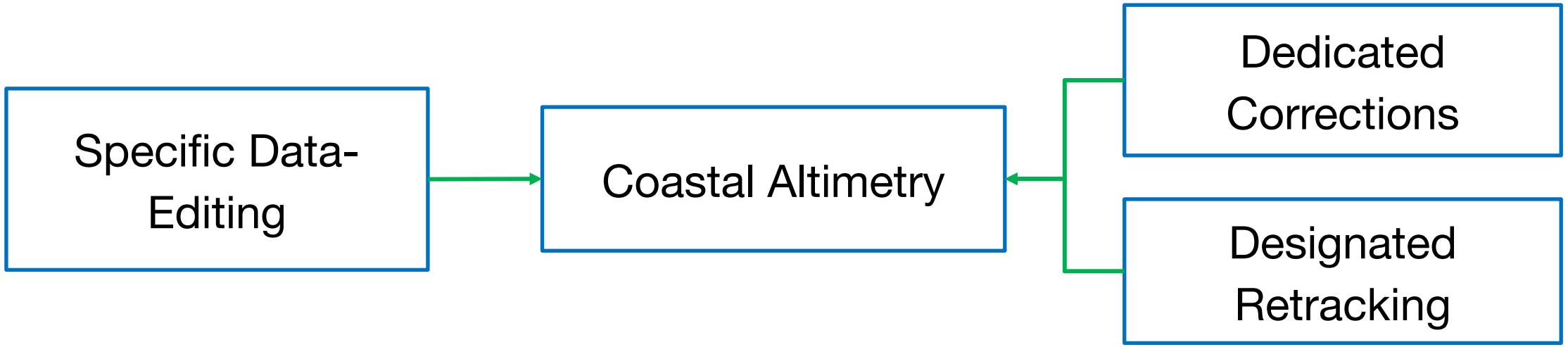
Altimetry - its deficiency on coasts and efforts to improve

- Although altimetry has good accuracy in open ocean (Stammer and Cazenave, 2018) , it is unreliable on coastal zone [<20 km]. (Benveniste et al. 2020)
- On the last 20 years, many efforts done to improve altimetry data on coasts → Coastal Altimetry (Cipollini et al., 2018)



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What motivates this study and what makes it unique?

coastal retracker
- ALES [AL]
- X-TRACK/ALES [XA]

validated separately
- AL (Passaro et al., 2015, 2016, 2017, 2018, 2021; Mangini et al., 2022)
- XA (Gaol et al. 2018; Birol et al., 2021; Bruni et al., unpublished)

compare retrackers together

?

utilizing high-frequency TG

This study aims to compare coastal retrackers on Indonesian seas using high-frequency tide gauge stations.

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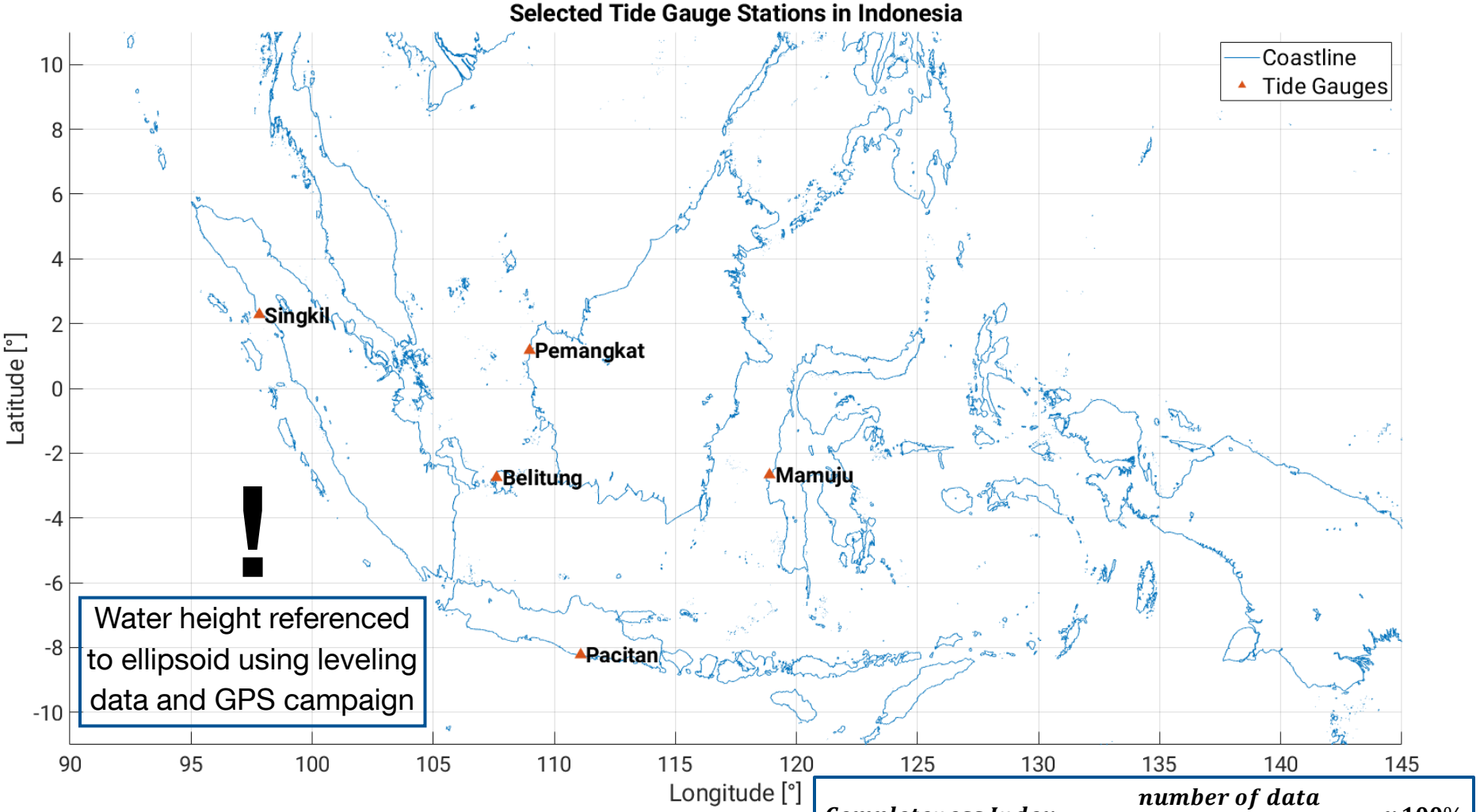
Area of study and in-situ data



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Water height referenced to ellipsoid using leveling data and GPS campaign

5 hourly TG stations on Indonesian seas selected from 40 available stations (from BIG)

Selected using several criteria, developed from Fenoglio et al., 2012

Criteria

1. Completeness Index
2. Gap and Step Existence
3. Data Length (in years)
4. Distance between TG and CORS
5. Distribution along Indonesian coasts
6. Vertical Trend of CORS and TG

$$Completeness\ Index = \frac{number\ of\ data}{expected\ number\ of\ data}\ x\ 100\%$$

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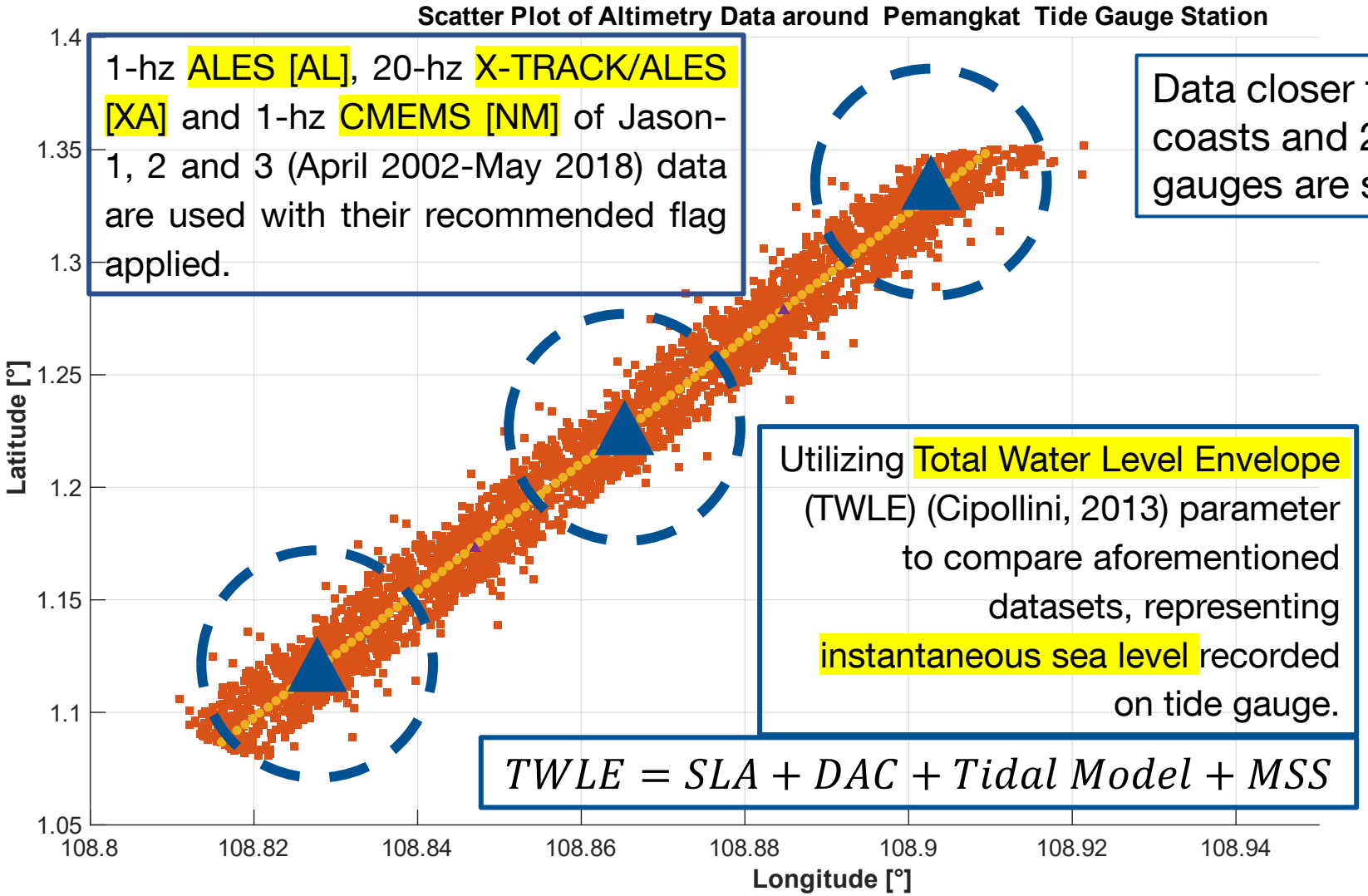
Compared retrackers and their harmonization



1-hz ALES [AL], 20-hz X-TRACK/ALES [XA] and 1-hz CMEMS [NM] of Jason-1, 2 and 3 (April 2002-May 2018) data are used with their recommended flag applied.

Data closer than 20 km from the coasts and 20 km from the tide gauges are selected.

Utilizing Total Water Level Envelope (TWLE) (Cipollini, 2013) parameter to compare aforementioned datasets, representing instantaneous sea level recorded on tide gauge.

$$TWLE = SLA + DAC + Tidal\ Model + MSS$$

'*nominal-point*' method is developed to built time series. It is done by averaging data inside 3 km radius from the nominal-point that was harmonized among all datasets.
The error assigned represents standard deviation of averaged data.

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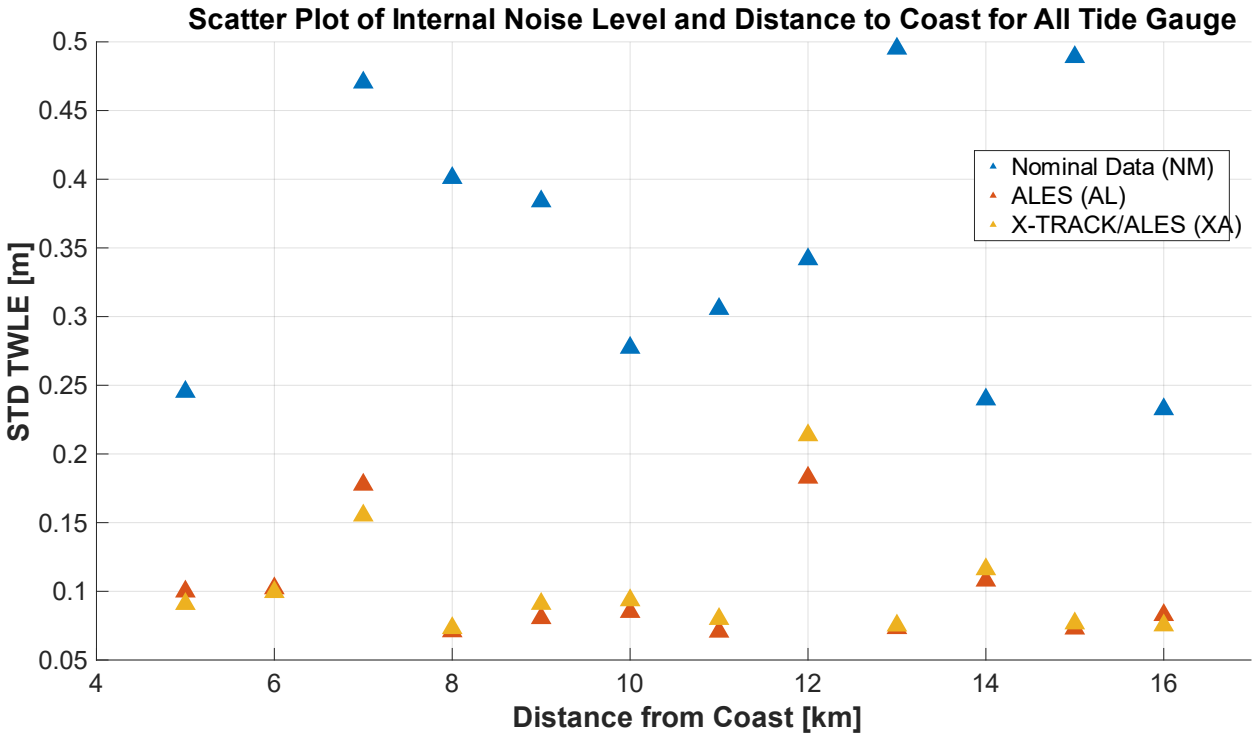
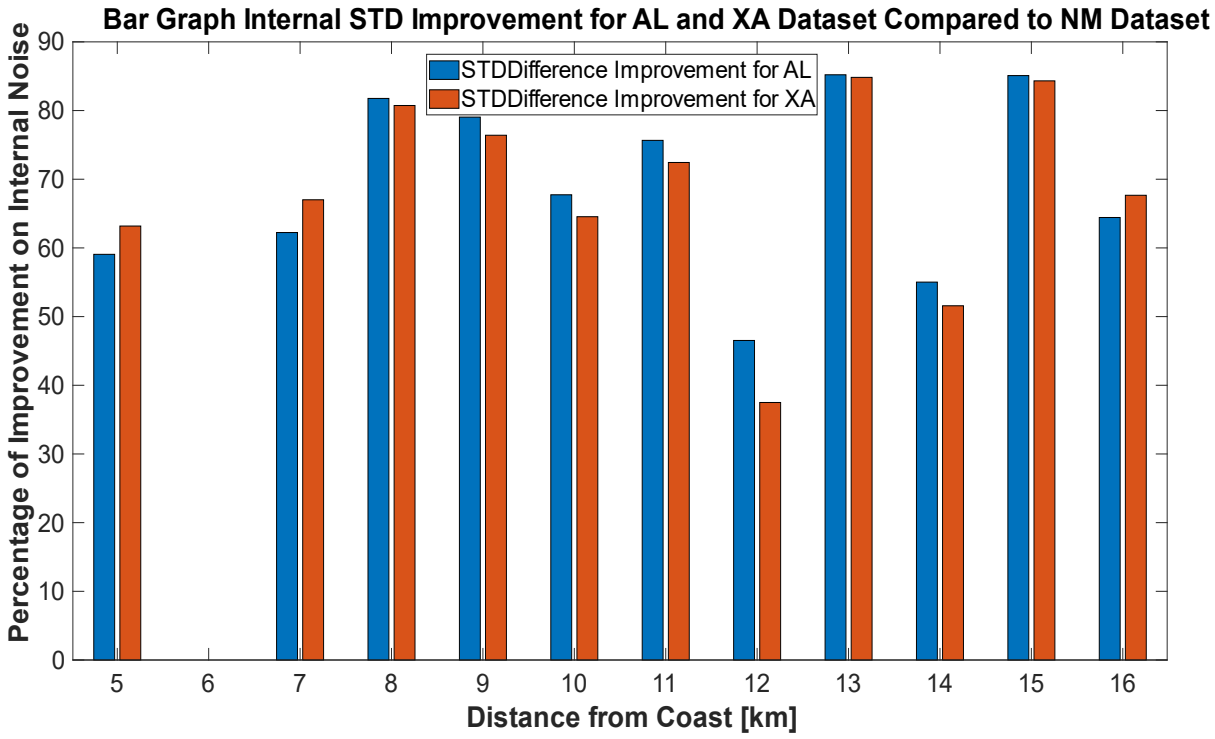
‘Internal’ comparison among retrackers → STD of data (noise level)

Standard deviation of each dataset (called ‘noise level’) is being compared as a metric to assess improvement in precision (similar with Nadzir, 2017; Passaro et al., 2018; Fenoglio et al., 2020)

AL and XA ‘improves’ the noise level by ~69% compared to NM





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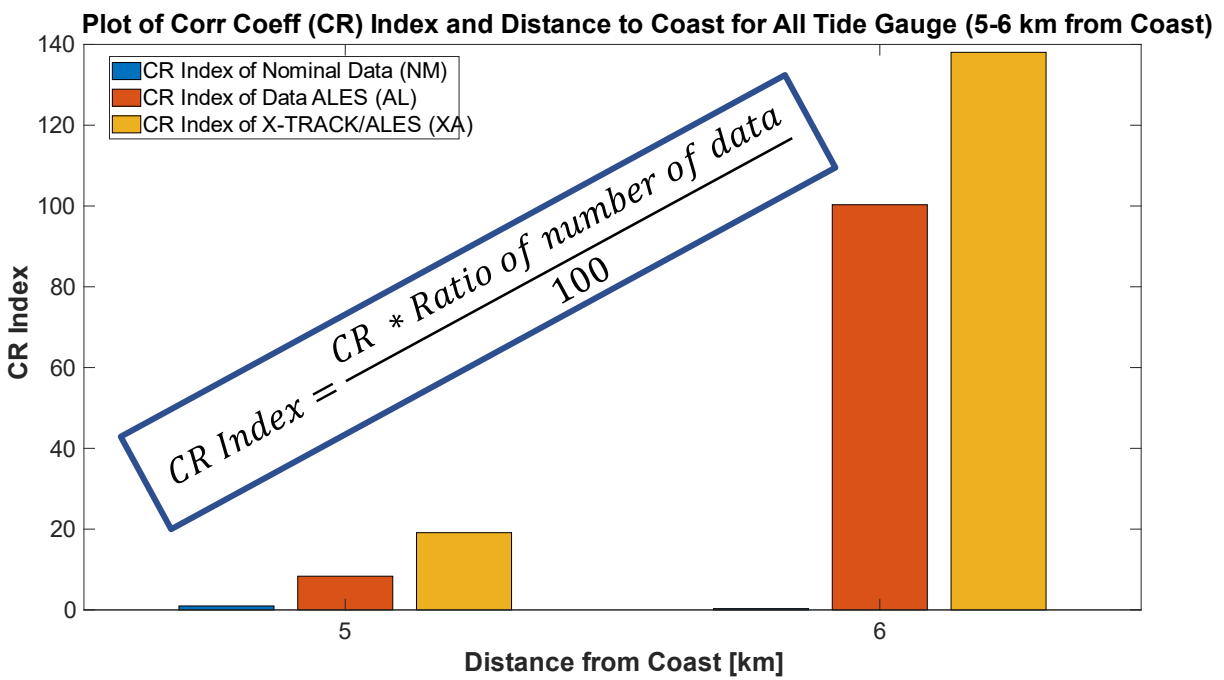
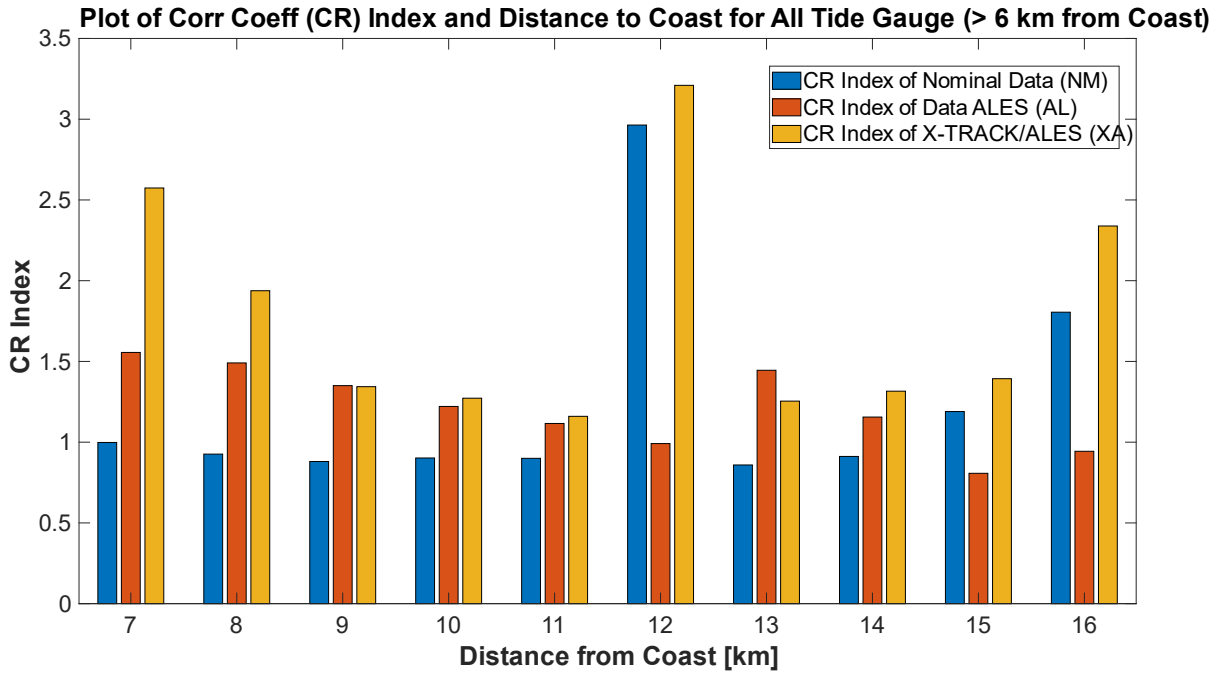
‘External’ performance w.r.t. TG #1 – Correlation Coefficient

- Correlation coefficient w.r.t. TG used as a metric to assess each retracker’s performance (similar with Nadzir, 2017; Fenoglio et al., 2020; Esselborn et al., 2022; Mangini et al., 2022 and Bruni et al., unpublished)
- An experimental metric called CR-Index is proposed due to significant difference in data number on each datasets.

AL and XA performs ‘better’ than NM almost on all distance band





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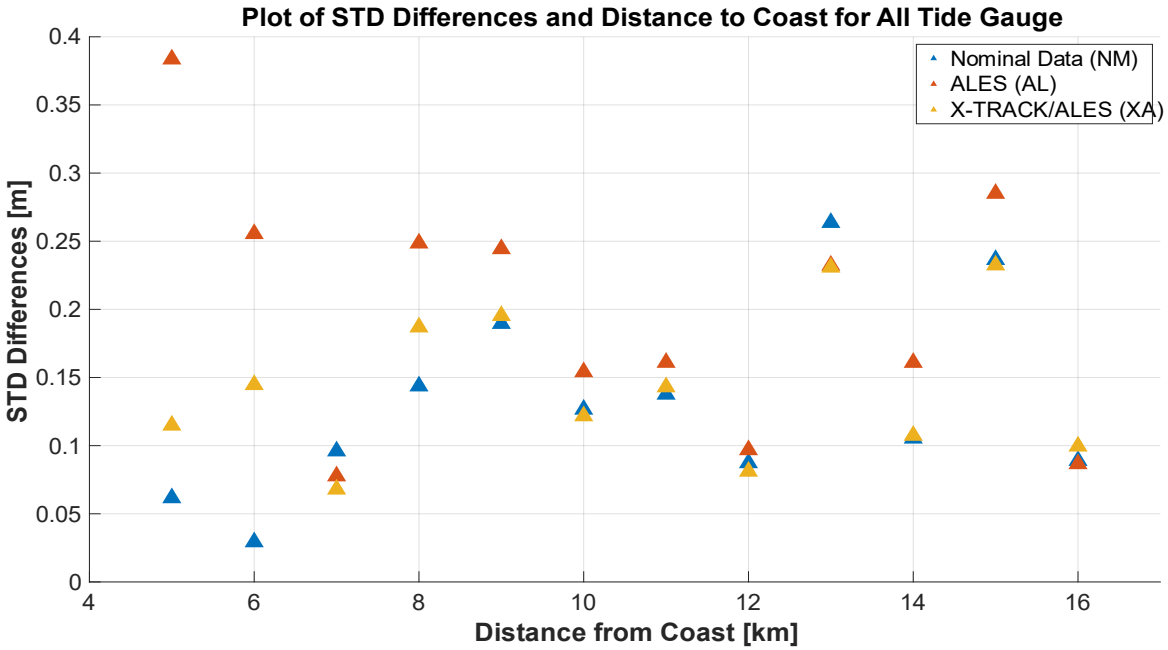
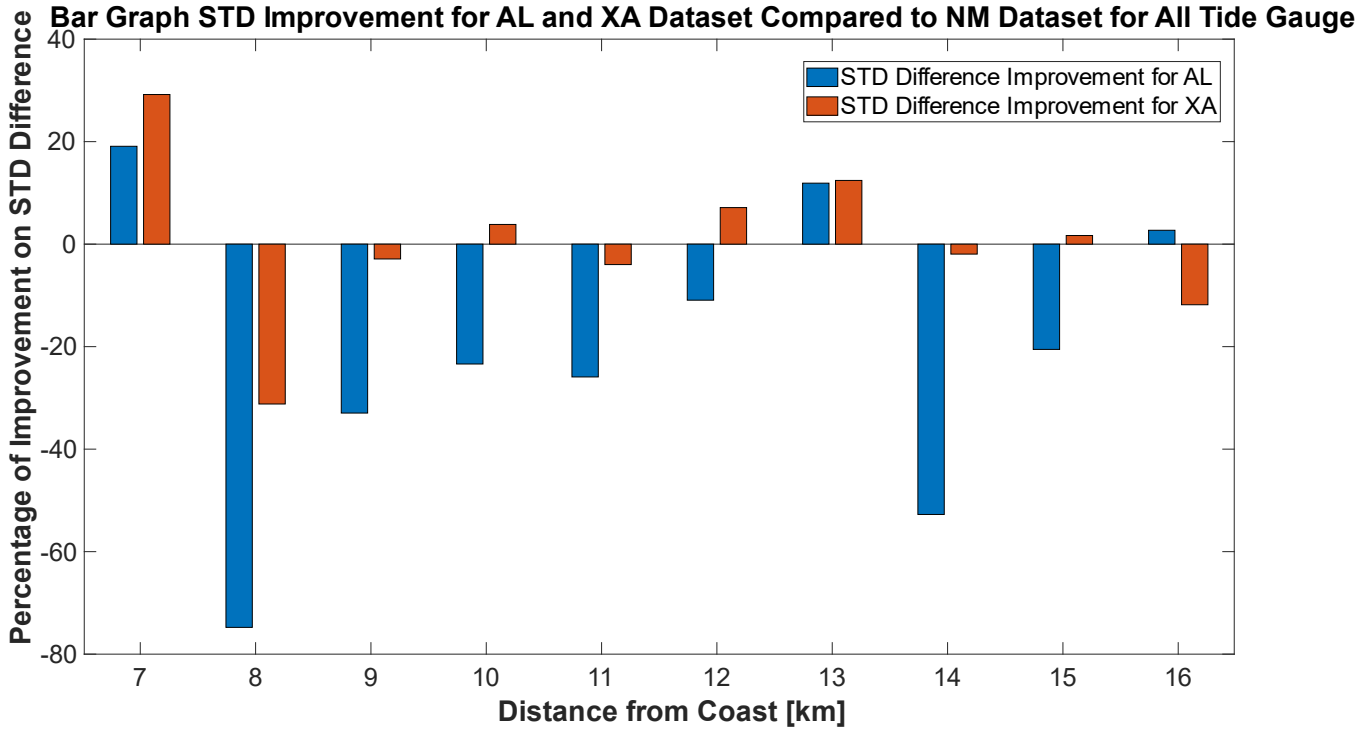
‘External’ performance w.r.t. TG #2 – STD of Difference

STD of differences between TWLE of altimetry and height recorded on TG is second metric to gauge each dataset’s performance.

AL and XA have worse STD of difference w.r.t NM (similar with result from Bruni et al., unpublished)



$$STD\ Improvement = \frac{STD1\ - STD2}{STD1}\ x\ 100\%$$



Take home messages

1. Dedicated coastal retracker is more precise: XA and AL data are more precise compared with NM data on coastal zone (3-20 km)
2. More precise didn't mean more accurate: Interestingly, NM data has better STD of Difference compared to XA and AL.
3. Expand the study area to paint better picture: Additional tide gauge stations need to be included to paint a better picture on precision and accuracy comparison between NM, AL and XA dataset.
4. Add SAR datasets into the mix: Utilization of SAR dataset could add to the dynamics of comparison between aforementioned dataset

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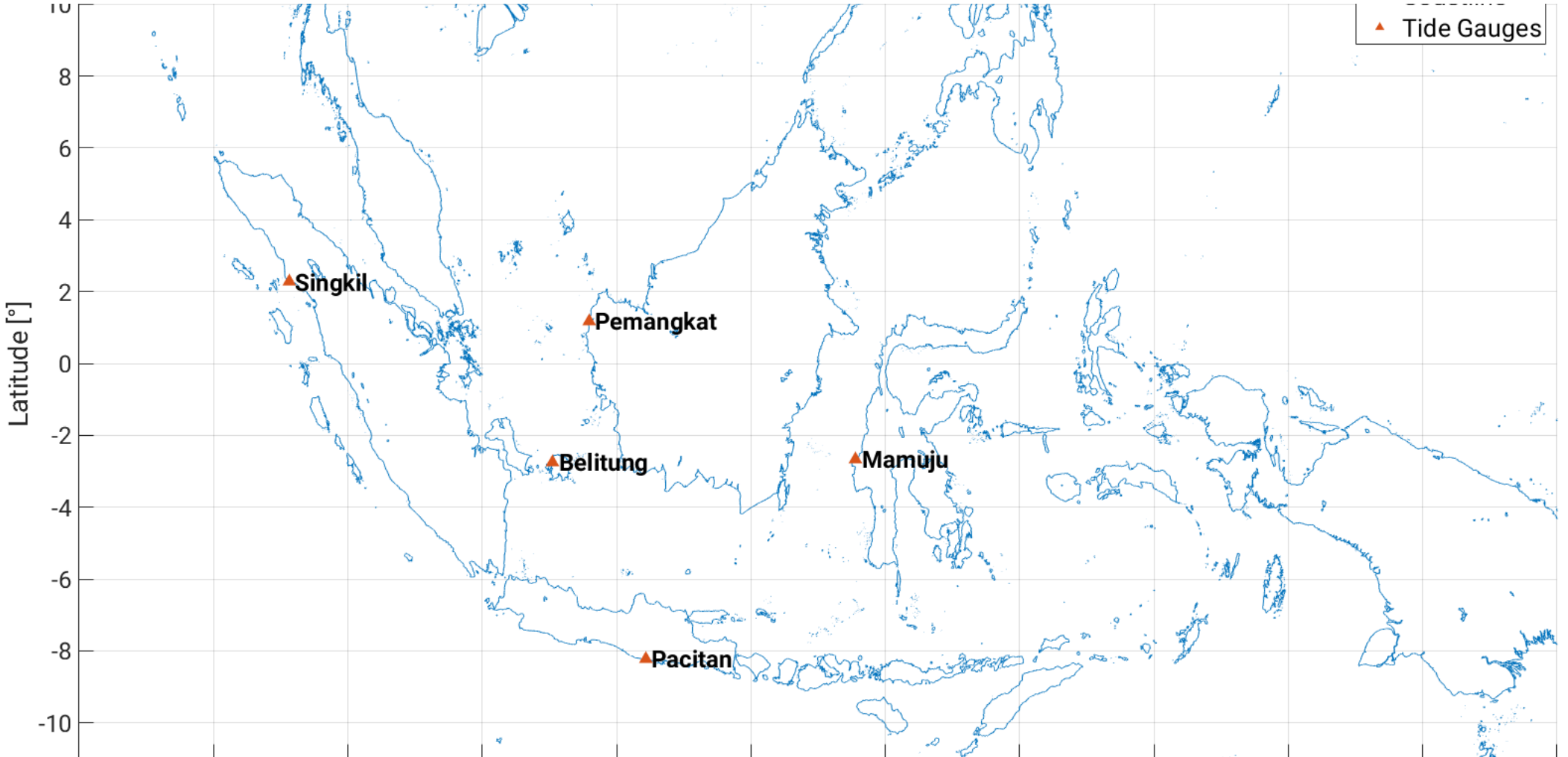
Thank You ☺
any questions? → please e-mail nadzir@uni-bonn.de



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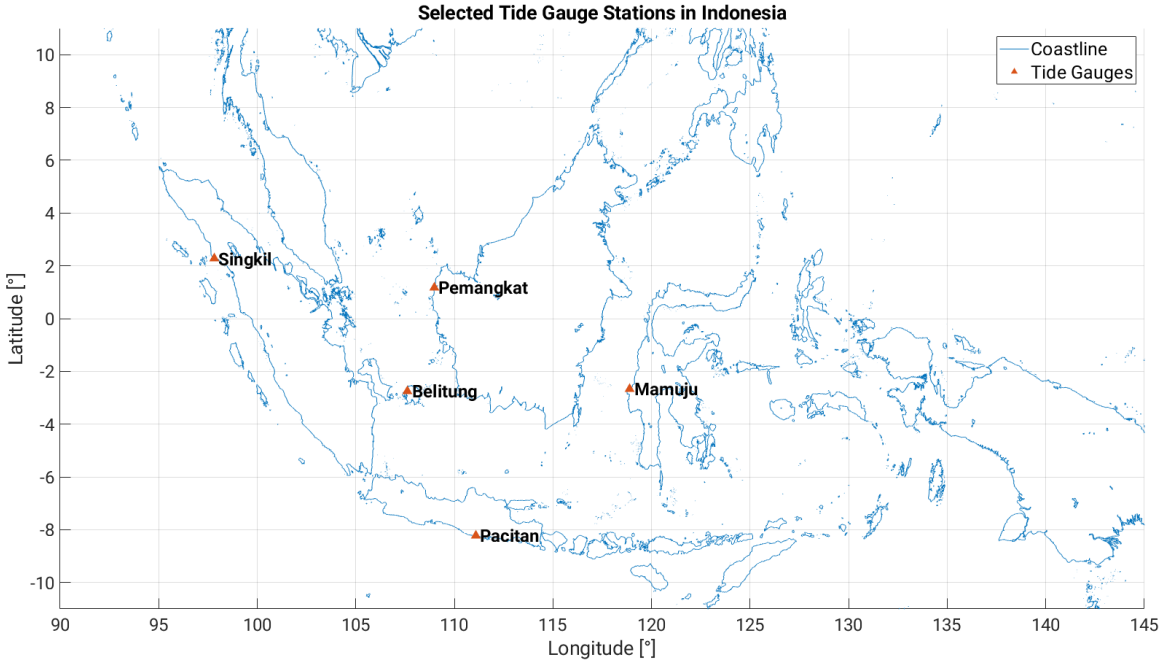
Spare Slide #1 → Going further on TG Selection

- 40 TG stations are processed, in relation with 29 CORS Stations.
- Based on CI Index, Gap and Jump existence, number of years of available data, distance between TG and CORS station, and distribution on Indonesian seas, 8 stations are selected (SINGKIL, BELITUNG, PACITAN, MAMUJU, KARIMUN JAWA, PAINAN, PEMANGKAT and WAINGAPU).



No	Name of Stations	CI Index [%]	Number of Gap	Number of Jump	Number of Years	Trend from TG [cm/year]	Usable?	Selected?	Nearest CORS	Distance [deg]	Trend from CORS [cm/year]	CORS Status
1	Pacitan	97,19	0	0	4	138,6728	Yes	Yes	CPAC	0,0387	-0,0864	USED
2	Belitung	97,07	0	0	6	-63,2045	Yes	Yes	CBLT	0,6518	-0,1669	USED
3	Singkil	96,41	0	0	9	-61,2943	Yes	Yes	CSBS	0,4189	0,9165	USED
4	Mamuju	92,56	0	0	9	-64,6527	Yes	Yes	CPAL	1,3422	0,0749	USED
5	Karimun Jawa	92,16	0	0	5	-12,6812	Yes	Yes	CJPR	0,8306	-0,3181	NOT USED
6	Painan	91,77	0	0	10	-19,3722	Yes	Yes	CPDG	0,4475	0,0411	USED
7	Pemangkat	91,19	0	0	9	-2,9147	Yes	Yes	CBAS	0,3780	-0,1543	USED
8	Waingapu	83,59	0	0	11	-9,0455	Yes	Yes	CWAI	0,02154	0,0917	USED

Notes
Processing Done
Selected for further Processing
Selected for further Processing as optional location

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Spare Slide #2 → Deep into TWLE and Harmonization

In order to make the comparison between all three datasets empirically valid, one should harmonize the sea level height into one comparable parameter. For this case we use a parameter called TWLE (Total Water Level Envelope) that represents the 'real' water level on the coast → $TWLE = SLA + DAC + Tidal\ Model + MSS$

Corrections model applied to the given SLA/SSH data is shown below.

Parameters	X-TRACK/ALES (XA)	ALES (AL)	Nominal Data (NM)
SLA	Given on the Data	-	Given on the Data
SSH	-	Given on the Data	-
MSS	X-TRACK Mean Sea Surface (Birol, 2017)	DTU15 Model (Andersen, et.al., 2016)	SSALTO DUACS Mean Profile (not provided by the model)
DAC	from MOG2D-G high freq (Carrere and Lyard, 2003) + inverse barometer	no DAC exist on the data	from TUGO (J1+J2)/MOG2D-G (J2+J3) high freq (Carrere and Lyard, 2003) + inverse barometer
Tides	from FES2014 (Carrere at. al., 2012) including ocean tide, long period equilibrium tide and S1 tide	from EOT11a (Savcenko and Bosch, 2011)	from Ocean Model FES 2014 B [Carrère et al. 2016] + Internal Tide from ZARON 2019 (HRETv8.1 tidal frequencies: M2, K1, S2, O1)
STD Computation	Could be done using std of every averaged 20hz location	Given on 'STD_ALT' Flag	Computed from each nominal track

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Spare Slide #3 → TG and Altimetry Data Treatment

According to results further literature review, a check into TG and Altimetry data treatment was performed, listed below:

Topic	Nadzir, 2017	Fenoglio, 2020	Esselborn, 2022	Mangini, 2022	Bruni, unpublished)
TG Data Treatment	as-is (hourly and 30-min data)	as-is (1-min data)	as-is (1-min data)	monthly averaged-detrended	monthly averaged-detrended
Altimetry Data Treatment	20-km radius from TG	Overpass (5-10 km radius), virtual pass (select nearest point) and gridding (0.25°)	1 virtual station nearest from TG station	20-km radius from TG	1 virtual station nearest grid point from TG station

Results presented make use of the as-is approach to TG Data and averaging observations on 1 hz reference points – every 7 km to Altimetry (XA, AL and NM) data in radius of 3 km

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Spare Slide #4 → Overview of TG and Altimetry Data Treatment - Harmonization

Using data of 5 Tide Gauges, the time-series are harmonized and data inside every points are quantified in a list below.

TG Name	TG Time Series Start	TG Time Series End	Number of Reference Points	Number of Points of NM Data	Number of Points of AL Data	Number of Points of XA Data
Pacitan	17 Jan 2018	25 May 2018	2	17 (100%)	12 (142%)	26 (217%)
Belitung	1 Jan 2015	29 May 2018	3	232 (100%)	318 (137%)	370 (159%)
Singkil	1 Jan 2012	27 May 2018	8	757 (100%)	1558 (210%)	1758 (232%)
Mamuju	1 Jan 2012	21 May 2018	2	123 (100%)	403 (328%)	465 (378%)
Pemangkat	1 Jan 2012	29 May 2018	5	1003 (100%)	1215 (121%)	1162 (116%)

Result shows that XA and AL data retained higher number of points on the coasts w.r.t the NM data (16% to 278 % and 21% to 227% more, respectively)

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Spare Slide#5 → Dive into Performance Indicators

Using several papers to identify the best approach to gauge the performance of each datasets statistically

Performance Indicators	Nadzir, 2017	Passaro, 2018	Fenoglio, 2020	Esselborn, 2022	Mangini, 2022	Bruni, unpublished)
'Internal_Verification'	STD_Improvement	Var_Improvement	Noise level (STD of SLA)	Mean Position and Time Corr (unrelated)	Trend agreement_improvement	- (no comparison)
'External_Validation	Corr_Coef; RMS of Difference	- (didn't use TG data)	STD of difference	Var_Explained and RMS of Difference	Corr_Coeff; RMS of Difference	Corr_Coef; RMS of Difference: Linear Trend