Round Robin Assessment of altimetry algorithms for coastal Sea Surface Height data

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Compare different algorithms used in the SSH computation and gain insights into their ability to contribute to obtaining quality data in the « coastal » band.

Why?

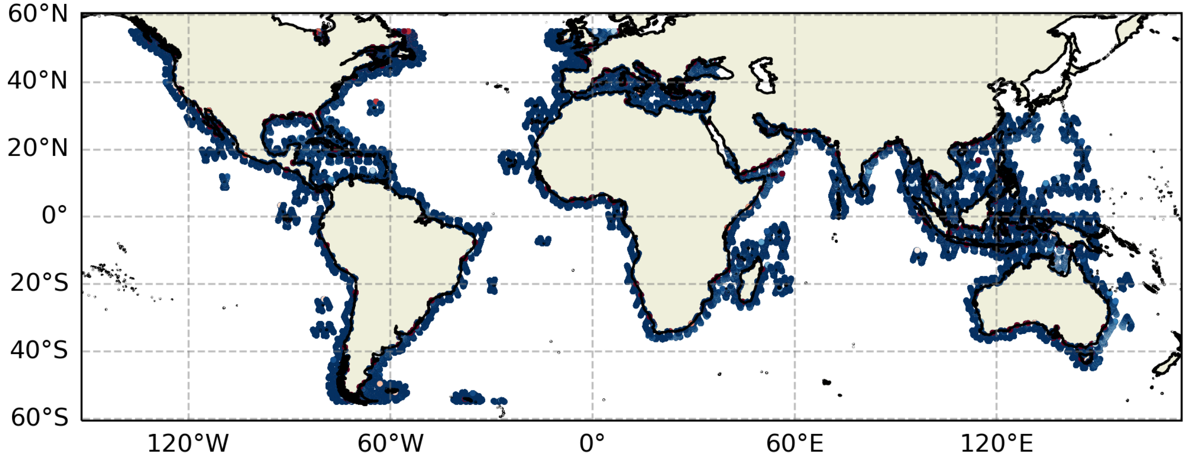
1. **Investigate which component (range, correction, MSSH) is the most limiting near the coast**
2. **Define a baseline for the generation of a new global coastal SLA product**

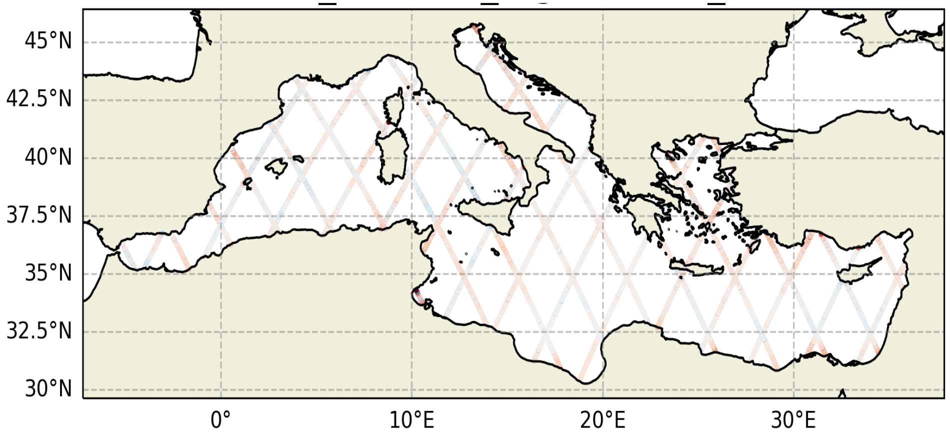
SWOT ST 2023/09/20

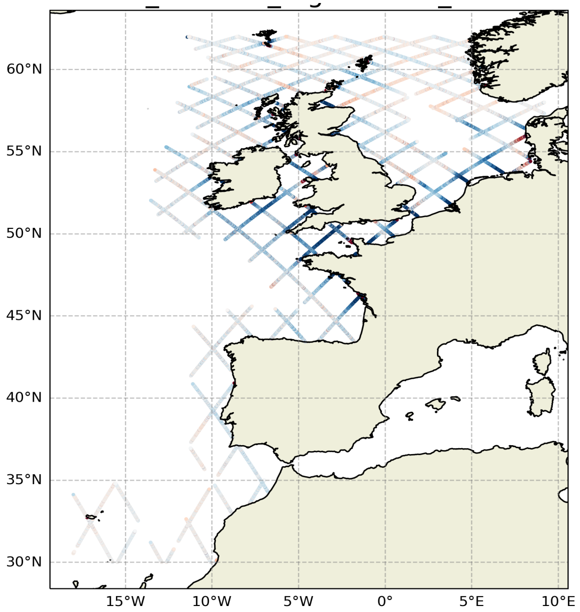
Specifications

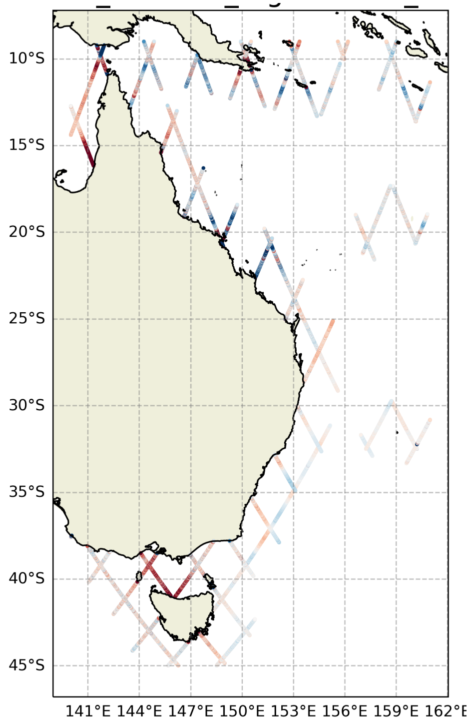
- **Altimetry:** **LRM (focus on long time series)**
- **Variable** : **SLA**
- **Frequency**: **20 Hz**
- **Missions**: **Jason-2 & Jason-3**
- **Period :** **3 years for each mission (111 cycles)**
- **Zone**: **Global coastal ocean (0-200km) + regional.**

3 regions: Mediterranean Sea, NEA, Eastern Australia









Parameters considered

Selected because available at global scale for both Jason-2 & Jason-3 and over the period analysed

SLA component	List of algorithms	
Range	MLE4 (REF), Adaptive, ALES	→ 3 solutions
Ionospheric correction	Dual frequency filtered (REF), GIM	→ 2 solutions
Wet tropo correction	Radiometer (REF), ECMWF, GPD+	→ 3 solutions
Ocean tide	DTU16, EOT20, FES2014 (REF: regular grid, unstructured mesh), GOT4.10, TPX09, CNES Regional models (NEA, Med, Australia, Arctic), FES2022 (regular grid, unstructured mesh)	→ 8 solutions
SSB	MLE4 2D 1Hz (REF), MLE4 20Hz, MLE4 3D 20Hz, Adaptive 2D 20Hz, Adaptive 3D 20Hz, solution ALES 20Hz	→ 6 solutions
MSSH	CNES15 (REF), SIO, CNES22	→ 3 solutions

Reference: standards used today in the GDRs to compute the SSHA parameter, as well as in the L3/L4 SLA products

Total: 24 algorithms tested

A framework for assessing performance

- **Intercomparison between the different algorithms for each SLA component**

Objective: for each algorithm, measure the internal consistency compared to the reference solution and its performance in terms of SLA data availability and SLA variance reduction, as a function of distance to the coast

Histograms, maps of MEAN and STD, % of data as a function of distance to the coast, MEAN and STD as a function of distance to the coast. GLOBAL + REGIONAL

- **External data comparison using in-situ measurements:**

Objective: use independent tide gauge data to measure the impact of each algorithm on the SLA calculation.

Statistics (correlation, RMSD), SLA data availability at local scale, Taylor diagrams. REGIONAL

- **Intercomparison between 2 altimetry missions:**

Objective: for each algorithm, measure the consistency of all the results between different altimetry missions

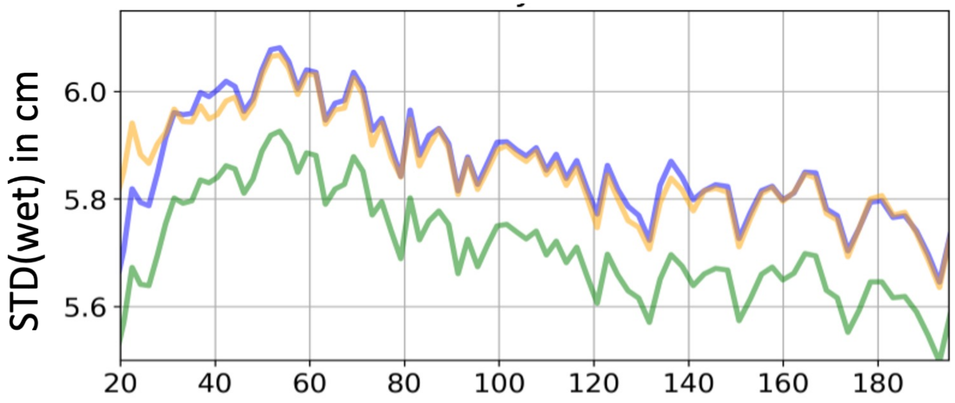
All the reports mentioned above

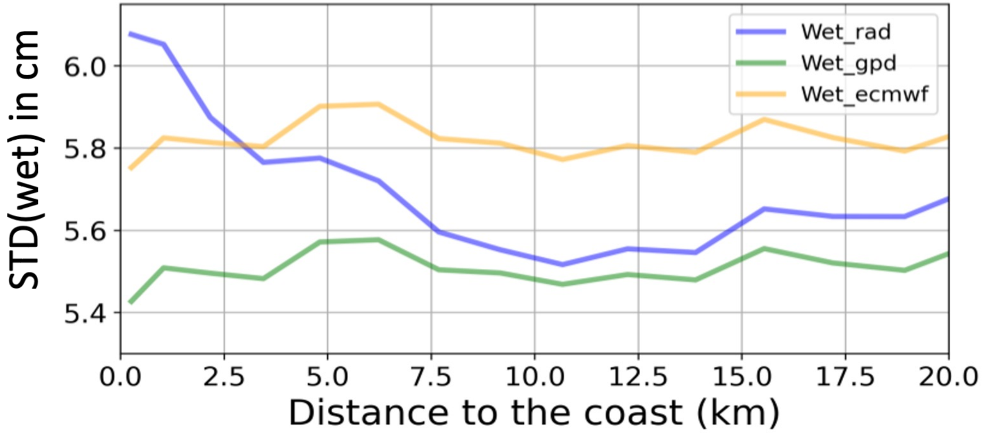
A specification document will be made freely available

Results – wet tropo

Analysis at global scale - Jason-2

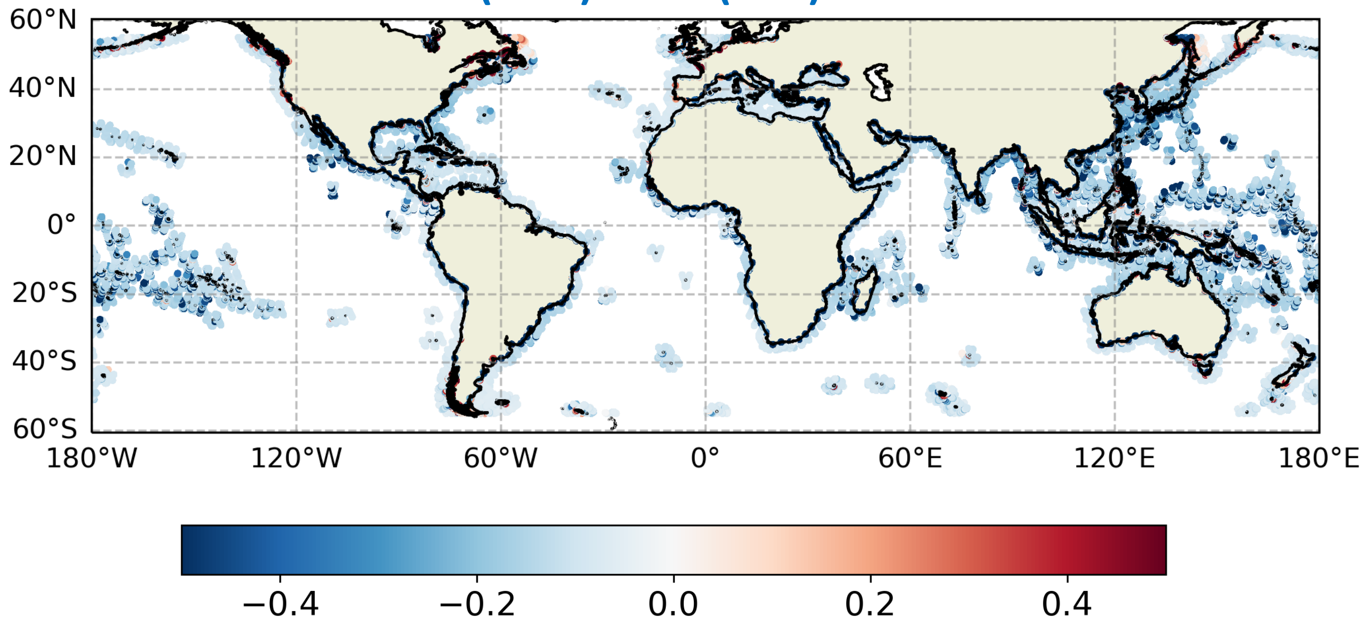
STD(wet) as a function of distance to the coast for the 3 solutions





Same results for Jason-3

STD(GPD) – STD(Rad) in cm

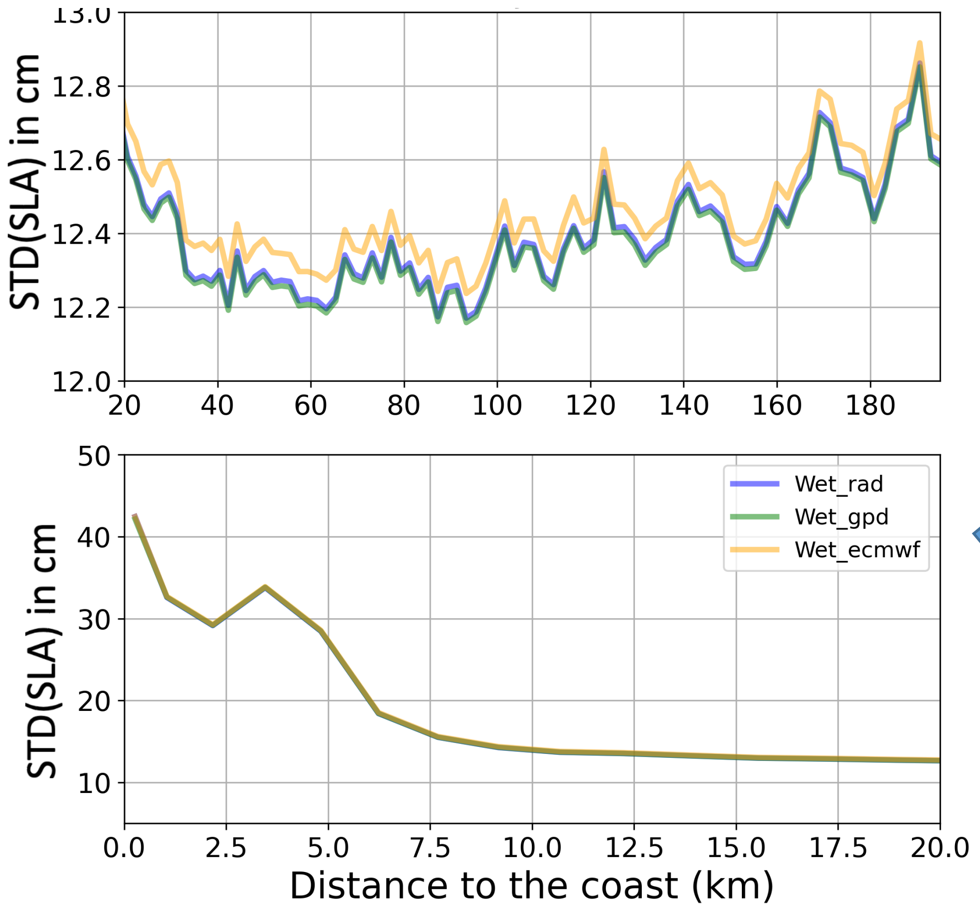


→ STD: Differences between the 3 solutions < 0.3 cm
→ Differences between RAD & GPD solutions very small up to 7-8 km to the coast

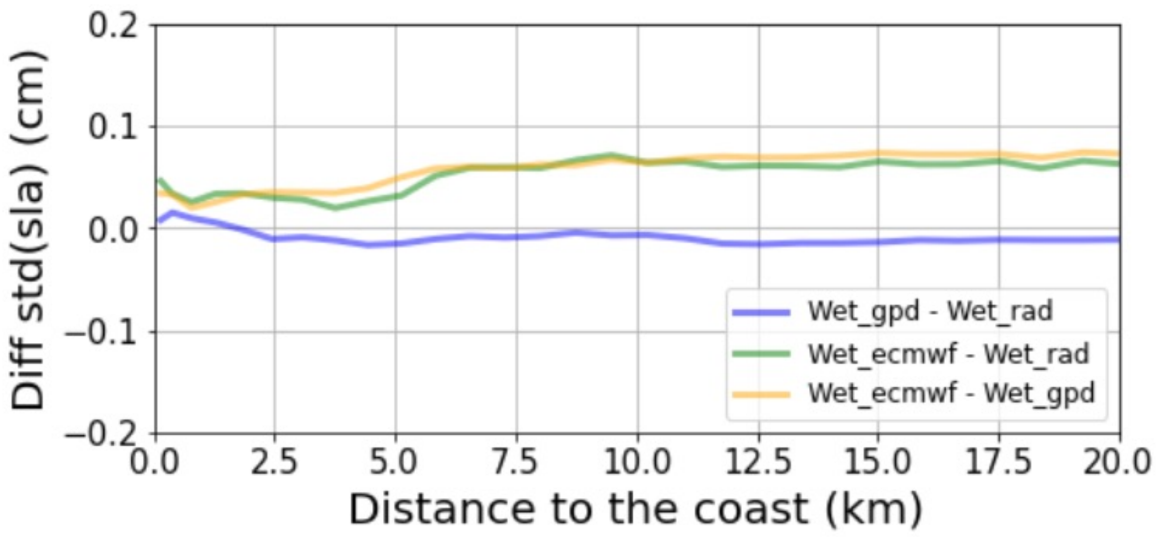
Results – wet tropo

Analysis at global scale - Jason-2

STD(SLA) = f(dist_to_coast)



STD(SLA_wet1) - STD(SLA_wet2)



→ Impact on STD(SLA) < 0.1 cm near the coast at global scale, but can be slightly larger locally

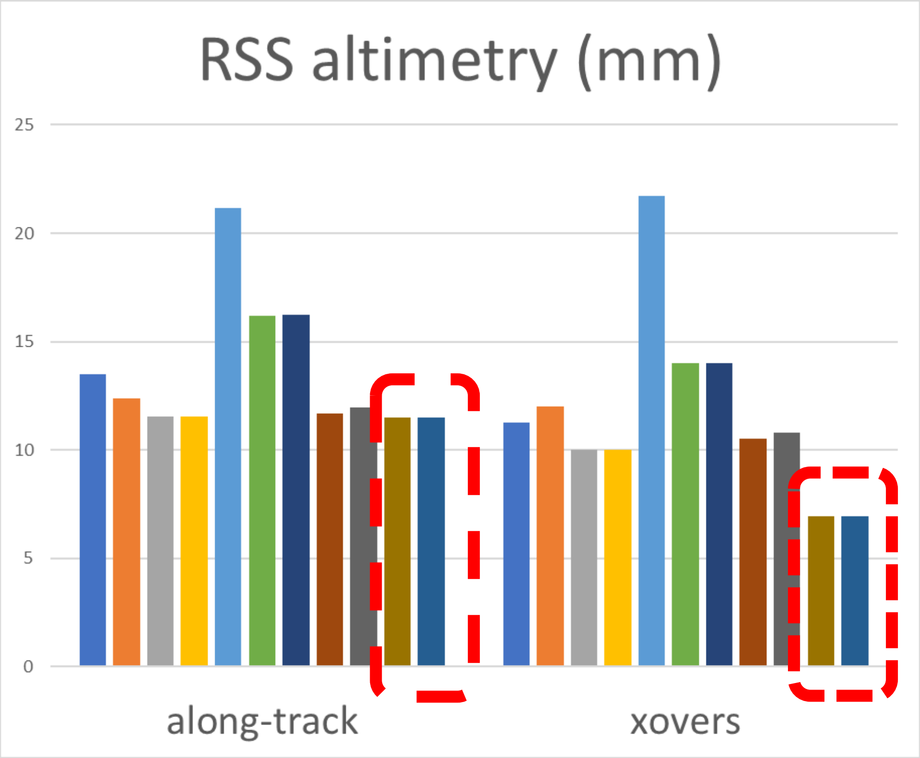
R1: For RAD, the results depend strongly on the processing version

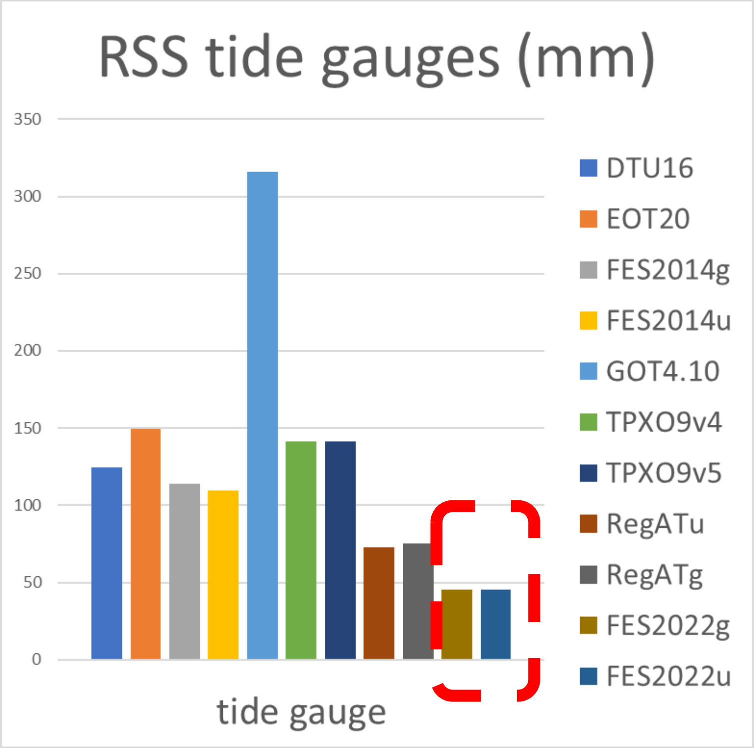
R2: Impact on the long term SLA evolution not included in this RR exercise

Results – ocean tide

Analysis at regional scale - Jason-3

Example of the NEA region





6 model families compared with tide gauge and altimetry, assessing **DAC compatibility :**

DTU, EOT20, FES(g/u), GOT4.10, TPX09, RegAT(g/u)

→ Best performance for FES2022 (gridded, unstructured mesh)

See also poster COA2022_004

Residual Sum of Squares = sea level variance not explained by the ocean tidal model (REF: altimetry or TG)

Round Robin Results: summary

Objective 1: Investigate which component is the most limiting near the coast

Differences observed near the coast in terms of STD(SLA), according to the SLA component: first analysis

SLA component	Difference Amplitude	Coastal zone with differences	Comment
Range	1-10 cm ~1 cm	10-15 km 0-200 km	Very important in the first 10 km, especially for MLE4 Impact also (but less) further offshore
Ionospheric correction	0.2 cm	Not specific to the coastal zone	Dual frequency solution: loss of points due to filtering, especially on J3
Wet tropo correction	< 0.5 cm	7-8 km	For the radiometer, the result depends on processing versions
Ocean tide	< 5 cm	10 km	< 2 cm beyond 5 km But results very heterogeneous spatially
SSB	1-15 cm ~1 cm	10-15 km 0-200 km	To be refined by removing impact of the retracker
MSSH	0-5 cm	~30-50 km	Impact < 0.1 cm offshore and < 1 cm up to 7-8 km

Round Robin Results: summary

Objective 2: Define a baseline for the generation of a new global coastal SLA product

Baseline selected considering algorithms available on J2&3 and results on the whole [0-200 km] coastal band

SLA component	List of algorithms	
Range	MLE4, **Adaptive**, ALES	→ NEW
Ionospheric correction	Dual frequency filtered, **GIM**	→ NEW
Wet tropo correction	Radiometer, ECMWF, **GPD+**	→ NEW
Ocean tide	GOT4.10, FES2014 regular grid, FES2014 unstructured mesh, CNES regional models (NEA, Med, Australia, Arctic), TPXO9v4, EOT20, FES2022 regular grid, **FES2022 unstructured mesh**	→ NEW
SSB	MLE4 2D 1Hz, MLE4 20Hz, MLE4 3D 20Hz, Adaptive 2D 20Hz, **Adaptive 3D 20Hz**, solution ALES 20Hz	→ NEW
MSSH	CNES15, SIO, **CNES22**	→ NEW

Many changes!

Conclusion

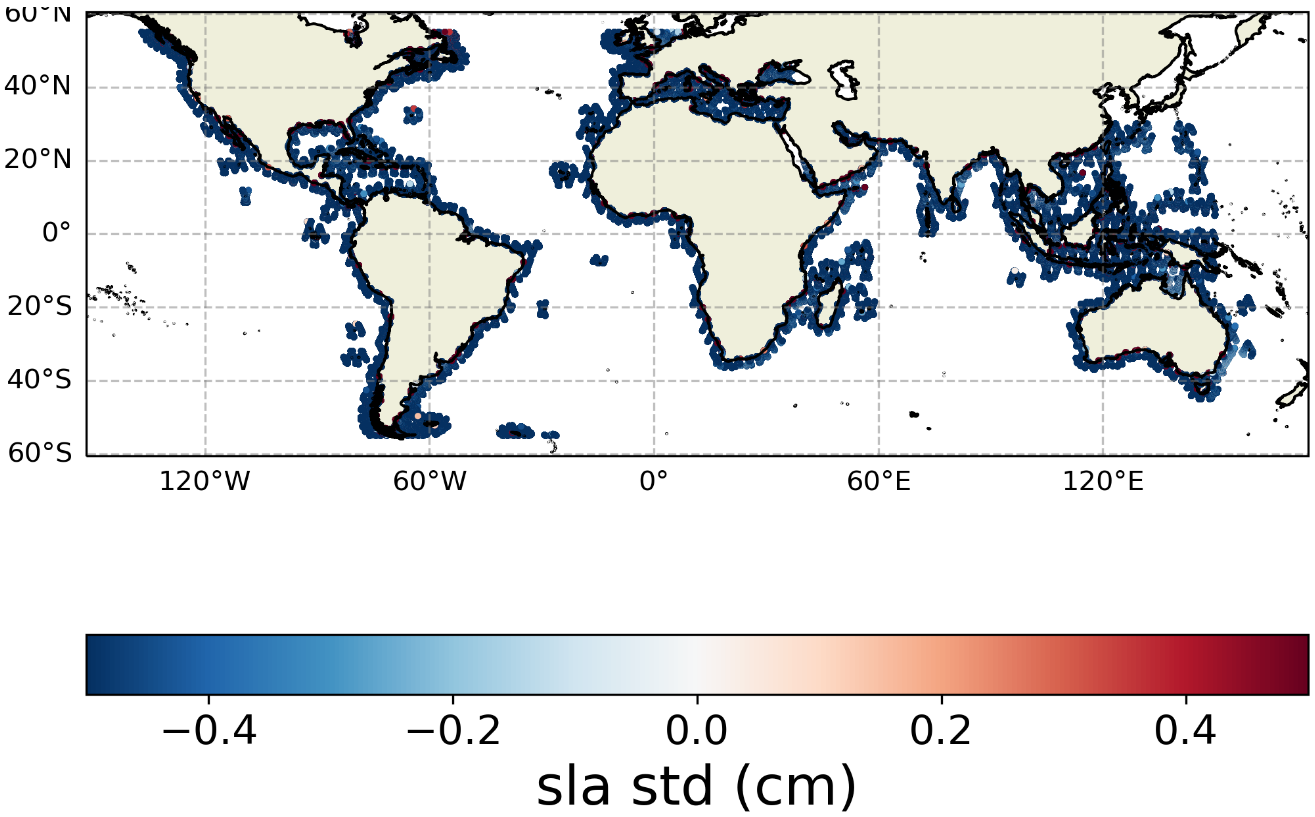
- Numerous reporting tools available; a summary of the protocol and main results will be published soon.
- Many CNES/LEGOS/CLS/Noveltis exchanges of expertise in the technical and scientific domain… and now an established working group
- A new global product (L2P) covering the [0-500 km] coastal band and the Jason-3 mission planned for Q4 2023
- Recommendations to space agencies in terms of studies to be funded (range, corrections)
- Altimetry corrections should be computed at 20Hz in L2 products (SSB, iono, tide, MSS, …)

An example: 20Hz SSB

- Calculation of altimeter corrections at 20Hz in L2 products (SSB, iono, tide, MSS, …)

Example of Jason-2 SSB MLE4 20 Hz versus the SSB MLE4 1Hz interpolated

STD(SLA_ssb20Hz) – STD(SLA_ssbinterp)



→ Impact on STD(SLA): the SSB directly computed at 20Hz reduces the STD by ~0.4 cm in average (7.14 cm against 7.55 cm), compared to the SSB 1Hz interpolated at 20 Hz

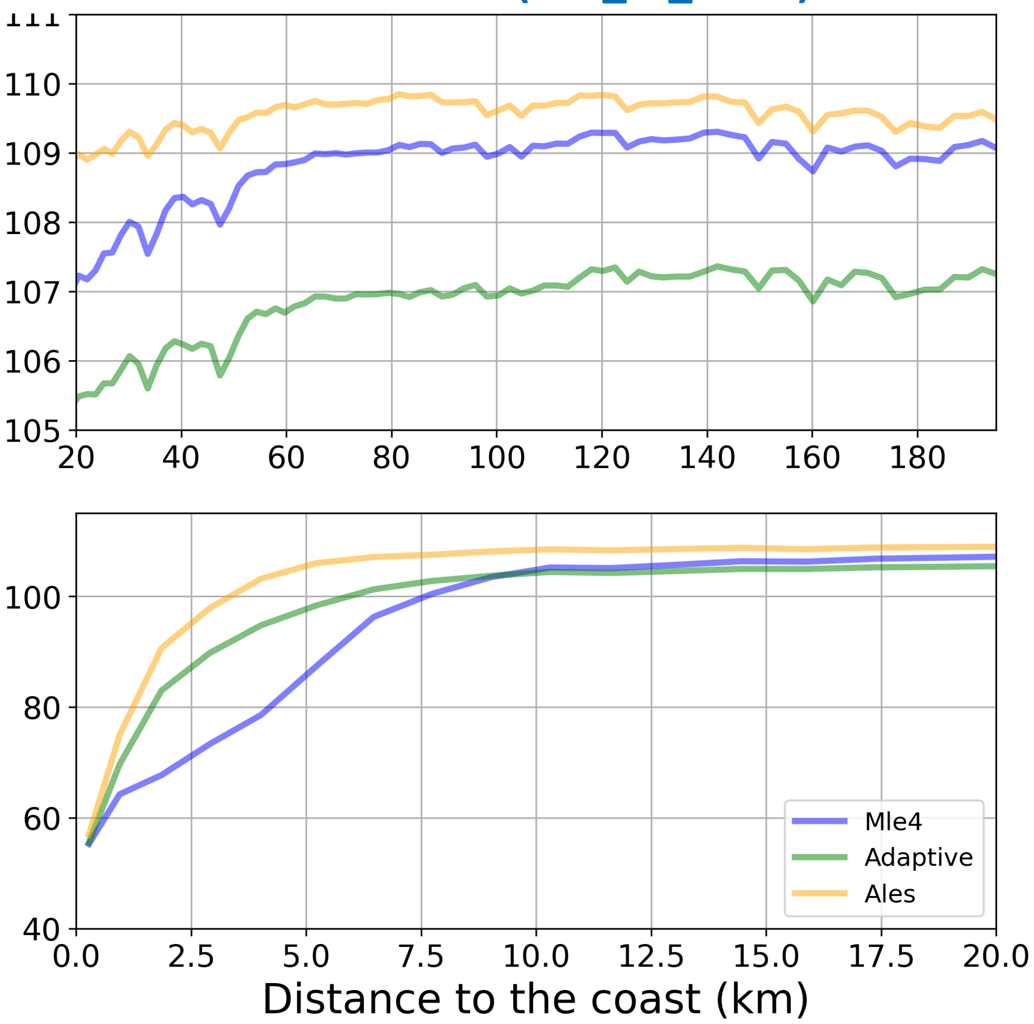
→ Impact observed in the entire 0-200 km coastal band at global scale, **but** tends to increase in the 0-8 km coastal band

Additional slides

Results – Range + SSB

Analysis at global scale - Jason-3

Nb of SLA = f(dist_to_coast)



SLA data availability

Total number of cycles : 111

→ Compared to other retrackers, MLE4 stalls at 10km to the coast

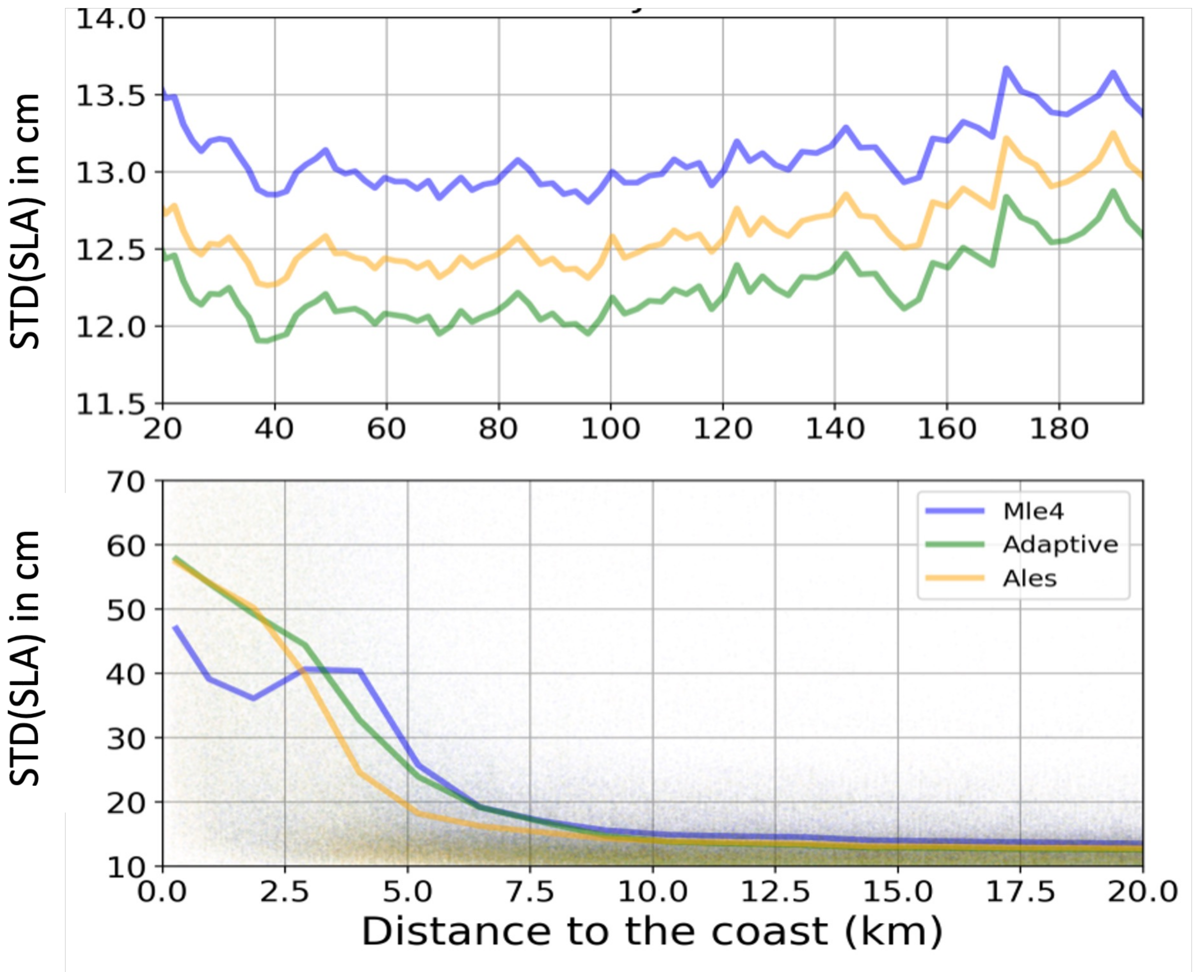
→ Adaptive and ALES both recover significantly more data within 10 km of the coast

→ In terms of number of coastal SLA data, ALES is the most efficient algorithm

Results – Range + SSB

Analysis at global scale - Jason-3

STD(SLA) = f(dist_to_coast)



SLA Variance reduction

Important remarks:

- the HFA correction (Adaptive) and its equivalent for ALES are not used in this study
- For each solution, the SSB used changes depending on the retracker (2D solutions used for MLE4 & Adaptive)

→ Differences observed: ~1.5 cm offshore, ~15 cm at 4 km

→ **15 km < dist < 200 km** : the adaptive retracker gives the lowest values in terms of STD(SLA)

→ **2 km < dist < 15 km** (if we forget MLE4 not significant because of data loss): the ALES retracker gives the lowest values in terms of STD(SLA)

→ ALES generally slightly better in terms of statistics at the tide gauges (not shown)