Coastal Improvements for Tide Models: the Impact of ALES retracker

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Outline

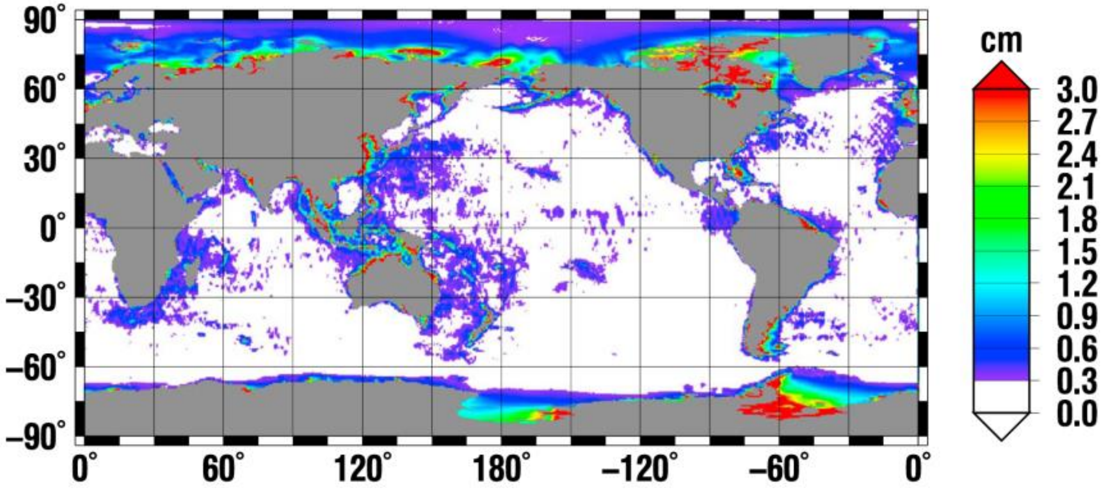
- Motivation
- ALES retracker
- Estimation of tides
- Tide gauge dataset
- Evaluation
- Results
- Conclusions
- Outlook

Motivation

- Tides are a large source of errors in coastal altimetry
- Still coastal issues in tide models (Coastal Altimetry Workshop - Feb2017)
  - High discrepancies among models in coastal areas
  - Degradation at coast due to extrapolation
  - Effects on ocean models

- Expertise at DGFI-TUM
  - EOT11a
  - ALES retracker
  - ➔ Update EOT

Elevation differences among tide models for M2

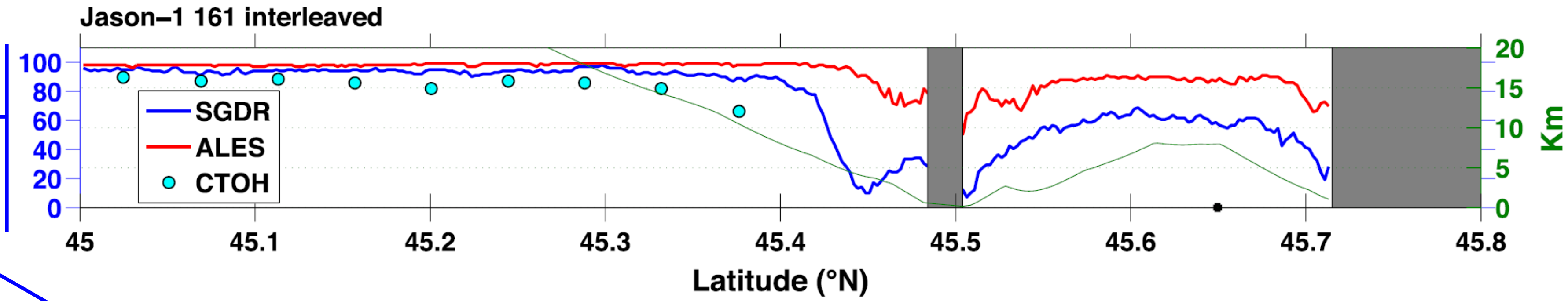


Credit: Stammer et al. 2014

The Adaptive Leading Edge Subwaveform (ALES) Retracker

- Finds optimal subwaveform according to sea state > subwaveform retracking
- More reliable at the coast:
  - Higher amount of data
  - Higher correlation with in situ data

Passaro et al., 2014. ALES: A multi-mission adaptive subwaveform retracker for coastal and open ocean altimetry



Credit: Passaro et al., 2014
https://doi.org/10.1016/j.rse.2014.02.008.

Number of cycles with correlation ≥ 0.9 with respect to in-situ timeseries

Estimation of tides

- ~ 14 years of high-rate data: Jason-1 + Jason-2
- Solutions for major tidal constituents: M2, N2, S2, K2, K1, O1, Q1, P1
- Along-track solution: node on the track, 30-km cap-size
- Least-squares-based harmonic analysis of weighted **SLA** corrected for FES2014

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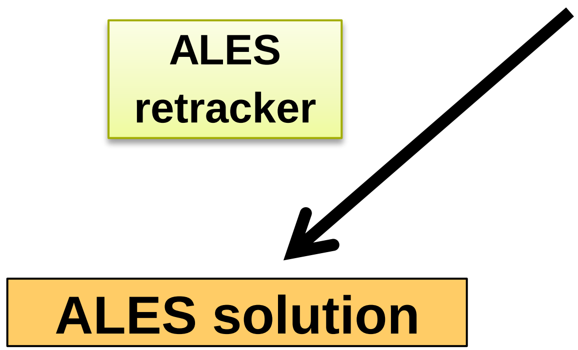

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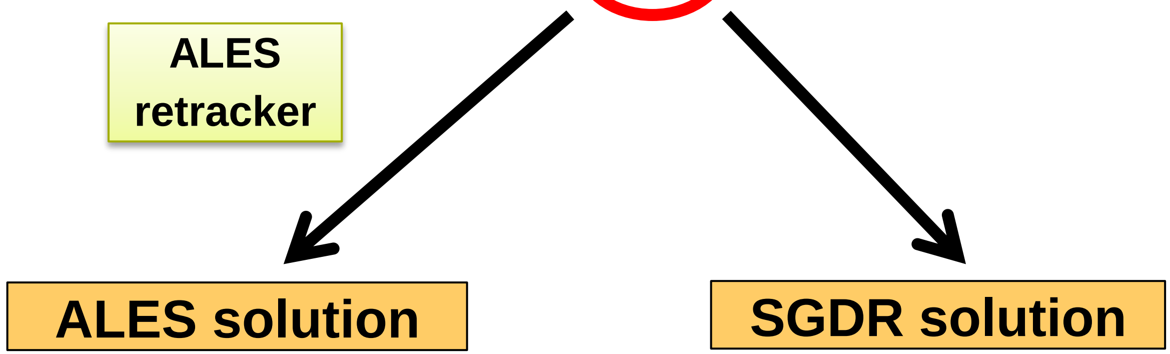


What is the impact of ALES at the coast in the estimation of tidal constants with respect to a solution with an ordinary retracker?

From OSTST 2017:

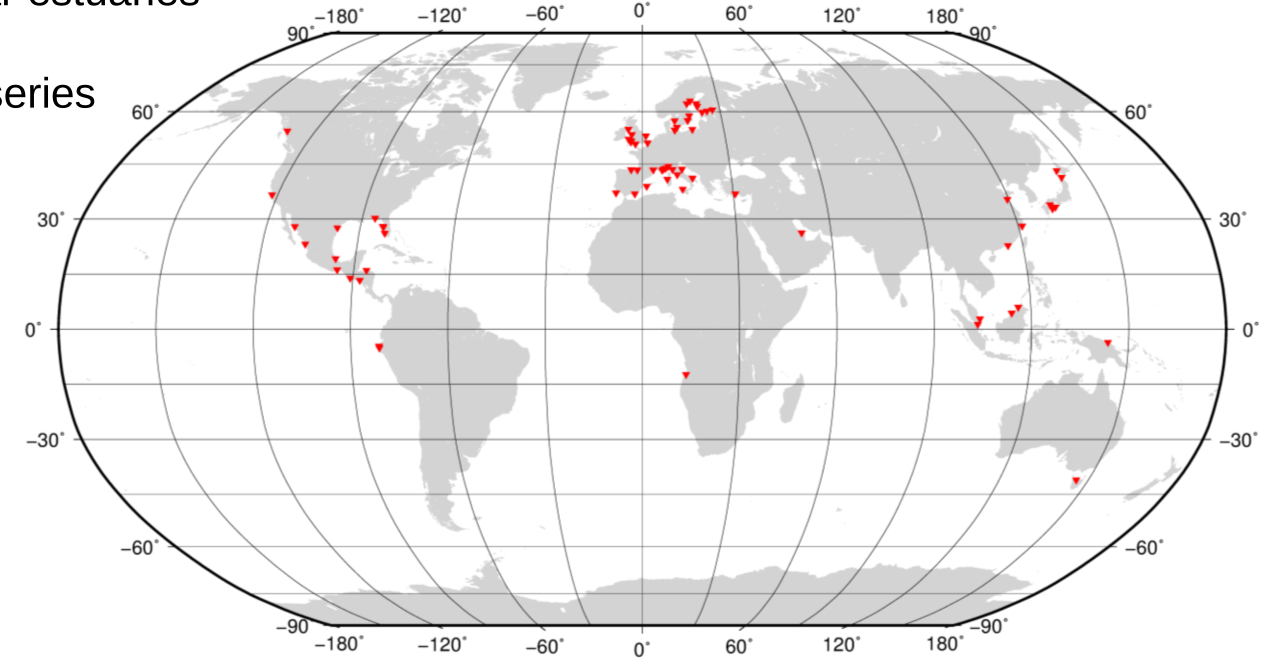
- Extend investigation on different areas
- Is ALES‘s impact on tides sea-state dependent?

Tide Gauge dataset

- Tidal constants computed from Global Extreme Sea Level Analysis (GESLA) dataset (Woodworth et al. 2017)
- Maximum distance to track: 50 km
- Discarded tide gauges assimilated in FES2014 (Cancet, personal communication)
- Discarded tide gauges near estuaries
- Manual screening on timeseries

Total tide gauges: 70

Tracks interested: 85



Evaluation

- Compare SGDR (S) and ALES (A) solutions at the nodes:

  - Number of observations VS distance to the coast: $\Delta \mathrm{obs} = \mathrm{obs}_A - \mathrm{obs}_S$

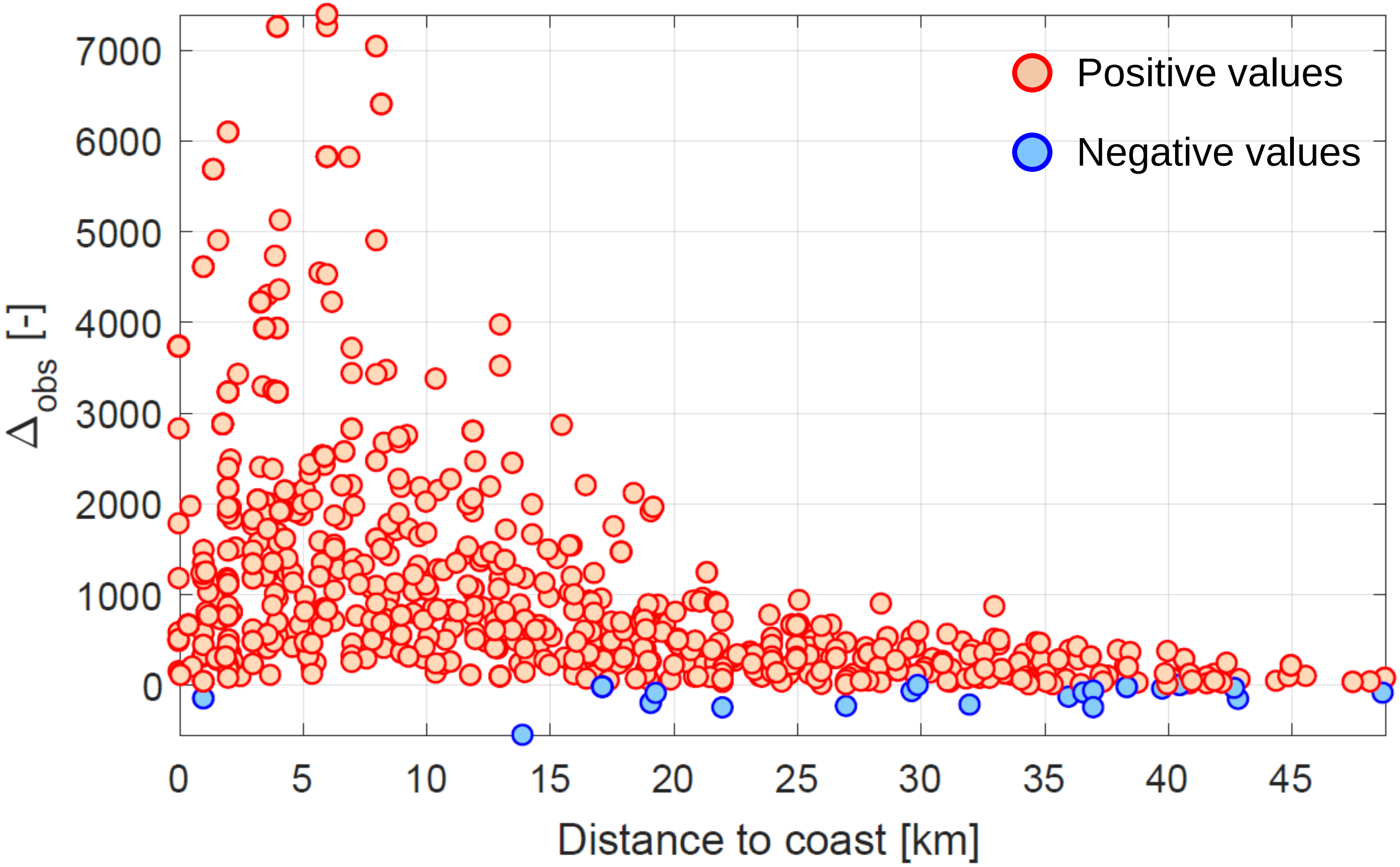
  - Uncertainty of least-squares fit VS distance to the coast: $\Delta\sigma = \sigma_S - \sigma_A$

  - Difference of Root-Mean-Squares (RMS) VS tide gauge at closest node with the relative difference: $\Delta \mathrm{RMS}\,[\,\%\,] = \frac{\mathrm{RMS}_S - \mathrm{RMS}_A}{\mathrm{RMS}_S} \cdot 100$

  - Root-Sum Squared (RSS) for overall accuracy: $\Delta \mathrm{RSS}\,[\mathrm{cm}] = \mathrm{RSS}_S - \mathrm{RSS}_A$

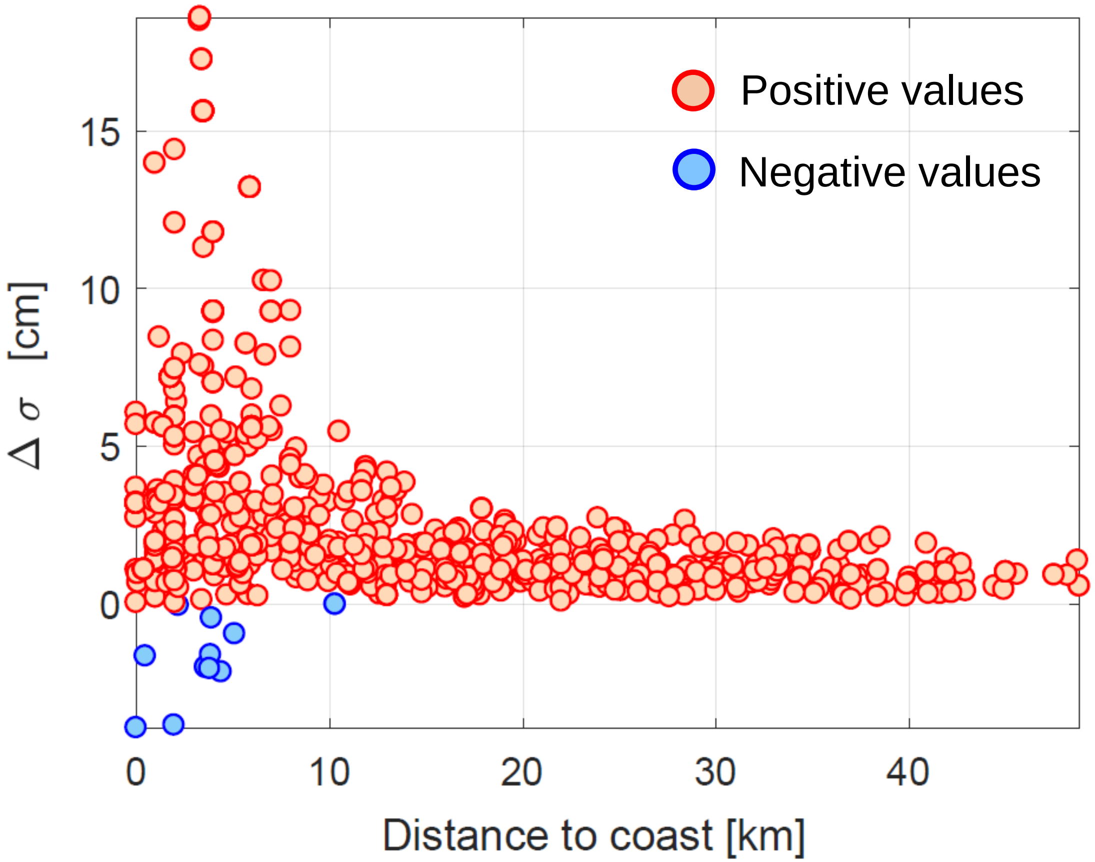
Results - Number of Observations

- Computed for all the nodes along-track



Results - Fitting Uncertainty

- Computed for all the nodes along-track
- Smaller fitting error with ALES solutions in 98.5 % of cases



Results - RMS differences

- Average computed for the closest nodes to the tide gauge

Constituents	RMS_A [cm]	RMS_S [cm]	ΔRMS [%]
M2	8.0	8.2	2.4
K1	2.1	2.2	4.5
S2	3.5	3.7	5.4
N2	2.1	2.3	8.7
K2	1.4	1.6	12.5
O1	1.4	1.6	12.5
P1	1.2	1.4	14.3
Q1	0.8	1.1	27.3

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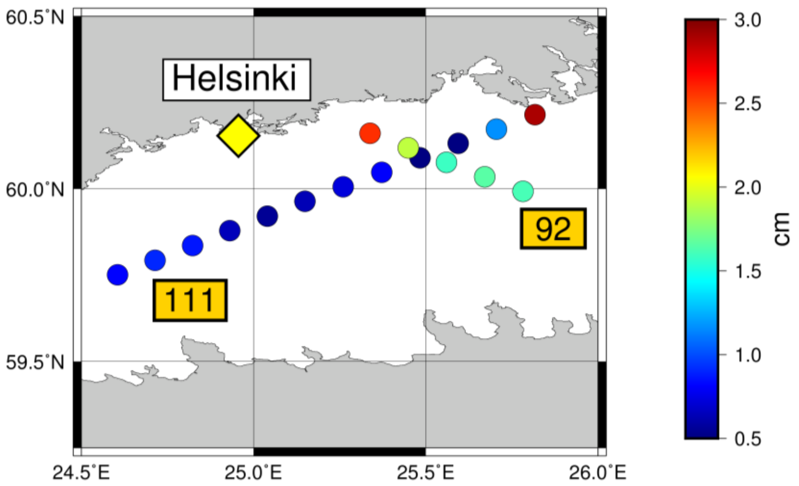
Q1	0.8	1.1	27.3

Results - Dependence on track direction

Const.	Land to ocean (30 tracks)		Ocean to land (34 tracks)	
	RMSA	RMSS	RMSA	RMSS
M2	6.6	6.9	4.8	5.0
N2	1.7	1.8	1.3	1.6
S2	3.1	3.2	2.1	2.4
K2	1.2	1.3	1.0	1.3
K1	1.9	1.9	1.4	1.5
O1	1.2	1.3	1.0	1.3
Q1	0.8	0.9	0.7	1.0
P1	1.5	1.7	0.7	0.9
RSS	8.4	8.5	5.8	6.4

RMS values for M2 computed with ALES solutions for tracks 111 (ascending) and 92 (descending)



(All values in cm)

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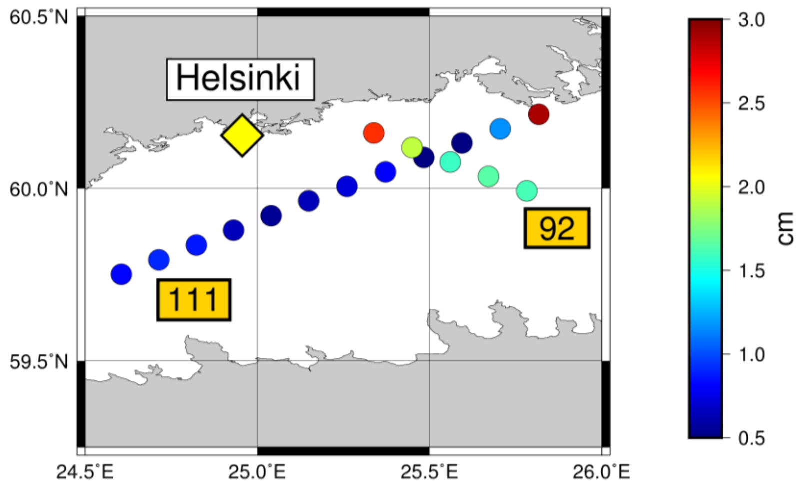
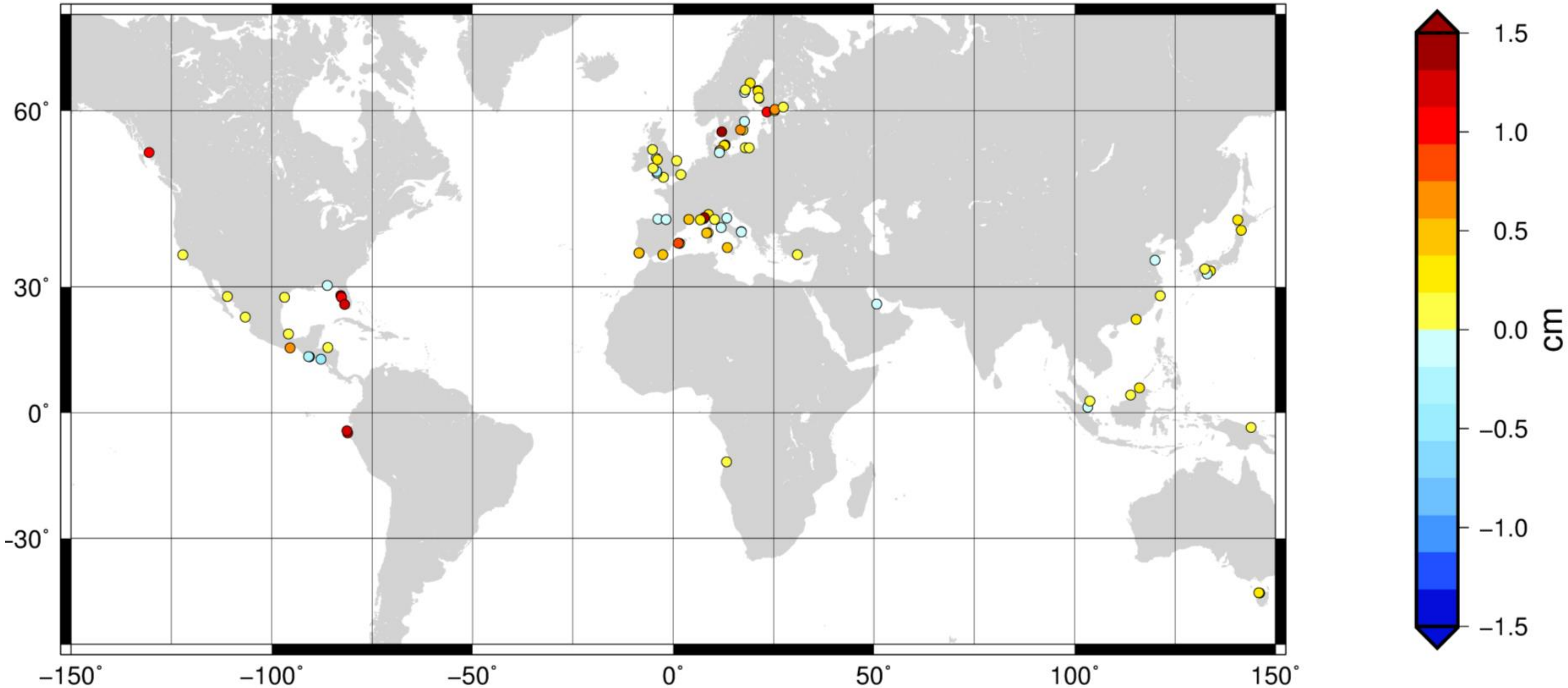


(All values in cm)

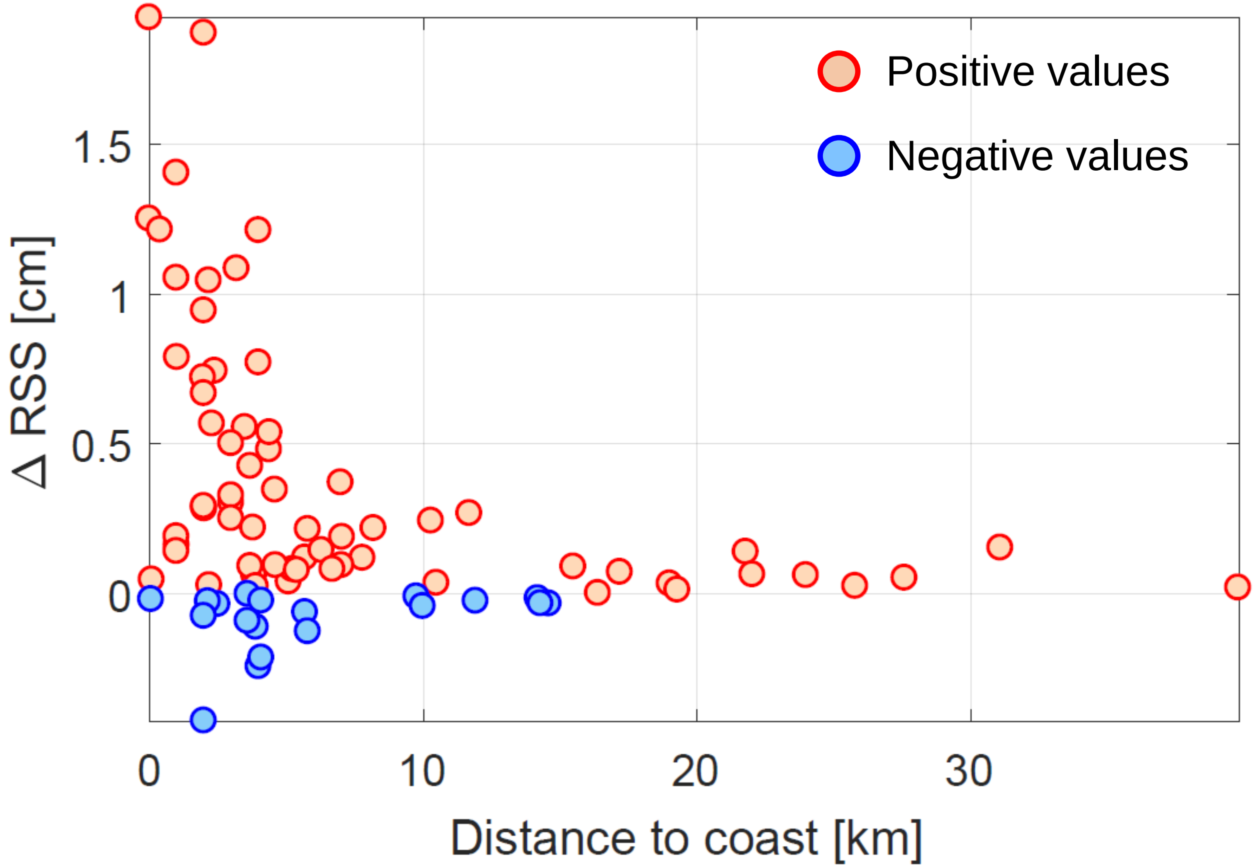
Results - RSS differences

- Computed for the closest nodes to the tide gauges
- Uneven distribution of improvement
- Average improvement of 0.4 cm with maximum 1.9 cm



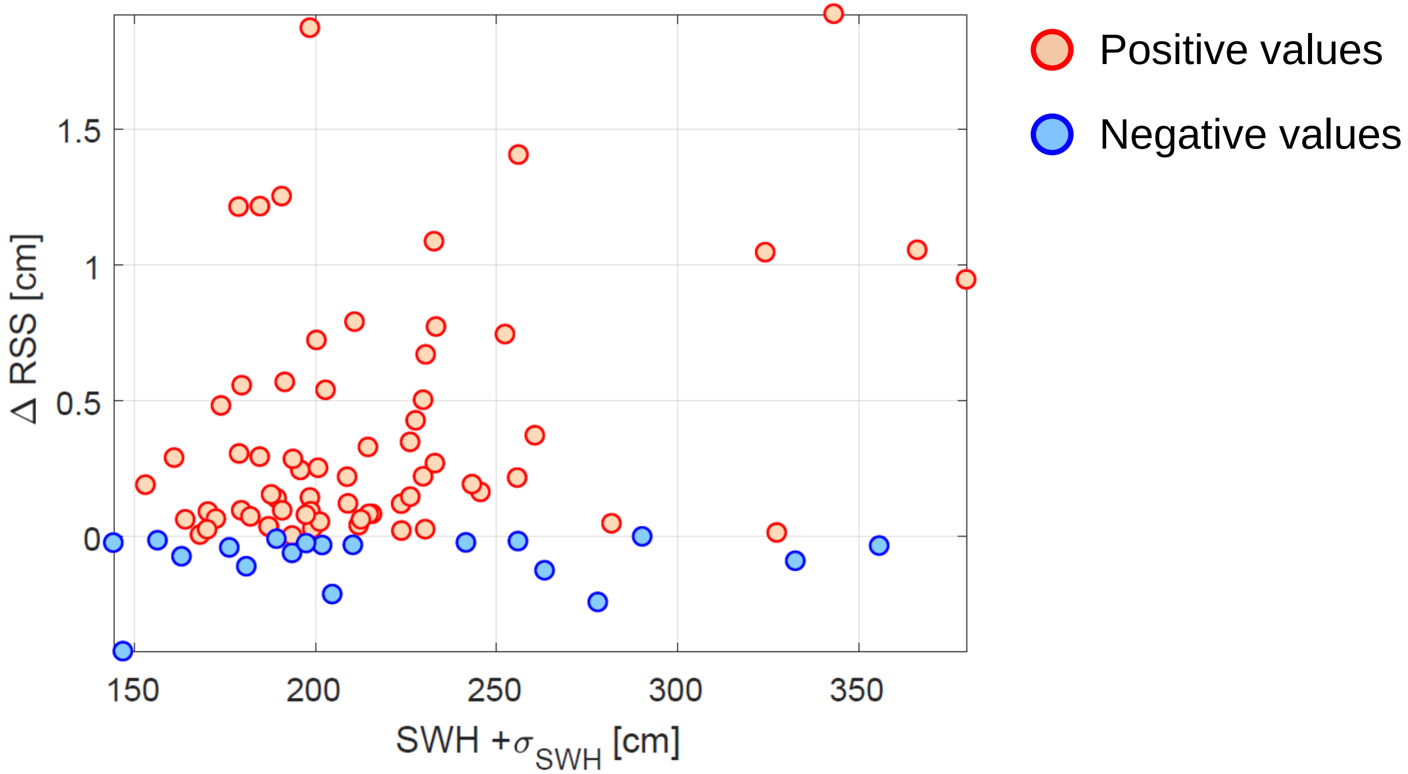
Results - RSS differences

- Computed for the closest nodes to the tide gauges
- Improvements of 0.5 cm for nodes closer than 5 km to coast



Results – RSS differences

- SWH values from ALES estimations
- No clear dependence on sea state
- Only few examples for high sea states



Conclusions

- With ALES larger number of observations available for coastal nodes
- Smaller fitting error, especially at distances < 10 km to coast
- Positive impact of 0.1-0.3 cm on single constituents (2.4 % < ΔRMS < 27.3 %)
- Average improvement for 66 tracks (mean ΔRSS = 0.4 cm) and independent on the location
- ΔRSS > 0.5 cm at distances < 5 km to coast
- Results influenced by flight direction: differences of ca. 2 cm
- Improvements of ALES‘s tidal solutions have no clear dependence on sea state

Outlook

- Continue use of ALES for coastal tidal analysis
- Dedicated regional analyses
- Analyse impact of ALES on minor tides
- Quantitative impact analysis of additional altimetric corrections on tidal estimation
- Long-term goal: new global EOT model

Thank you!

More on this:

Piccioni et al. 2018. Coastal Improvements for Tide Models: The Impact of ALES Retracker. Remote Sens. 2018, 10(5), 700; https://doi.org/10.3390/rs10050700

Thanks to the GESLA authors for the in-situ data! Data downloaded from: **gesla.org**
Altimetry data are available on: **https://openadb.dgfi.tum.de**