Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

Baltic SEAL: assessment and perspectives of Ku and Ka band sea level retrieval with and without sea ice coverage

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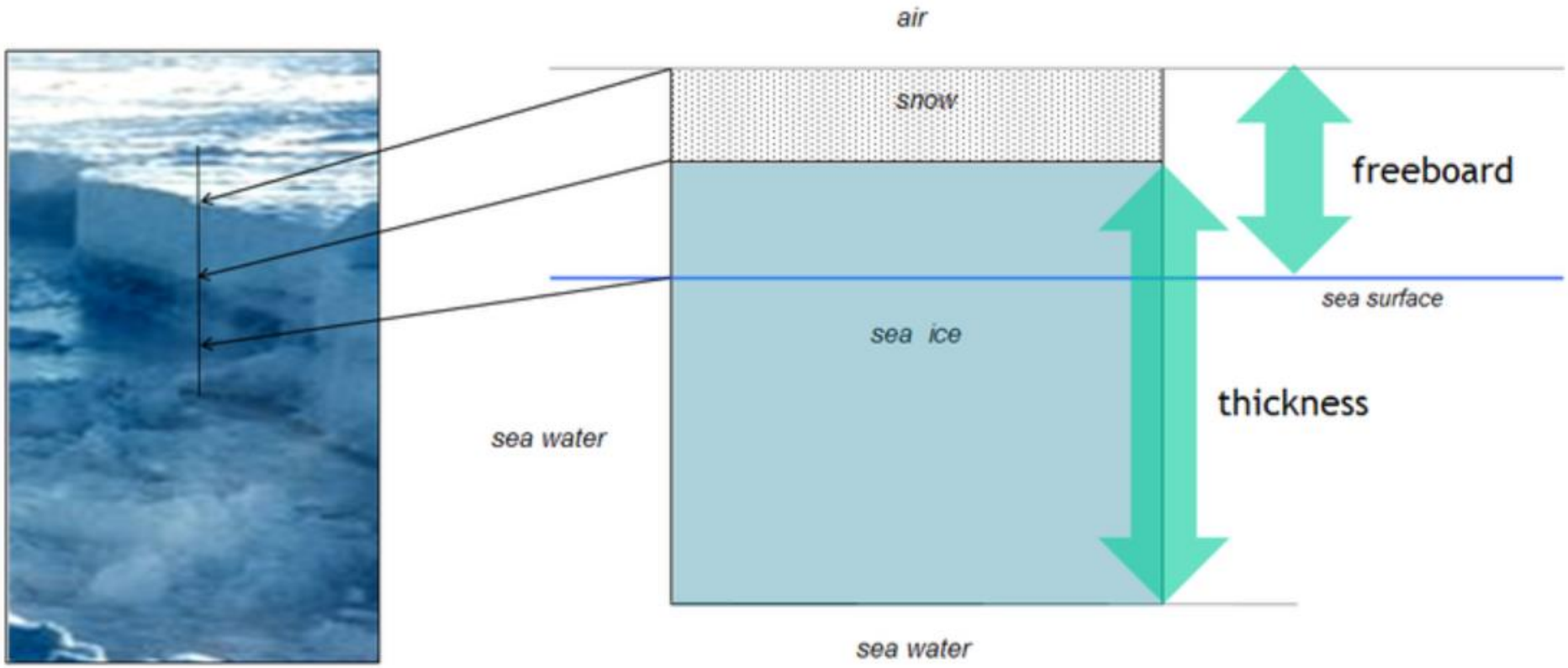
[6] ESA-ESRIN, Italy

DUAL-CRYO ESA Workshop, 14.01.2021

Motivation

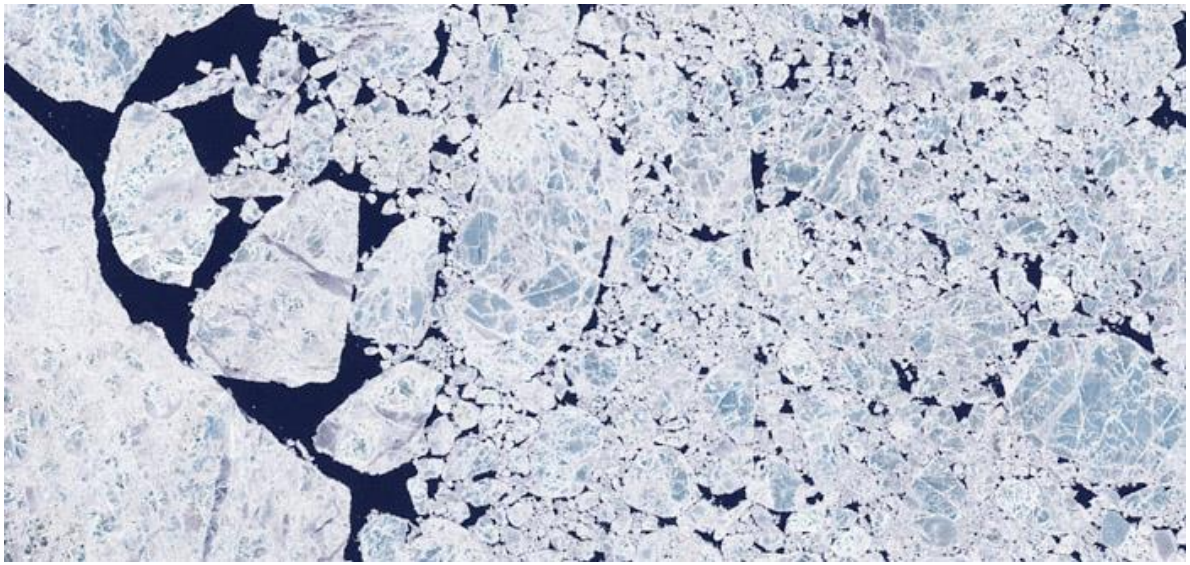
- To compute Sea Ice Freeboard, we need sea surface height



From: https://bioage.typepad.com/.a/6a00d8341c4fbe53ef011571d6eff4970b-popup

Motivation

- To compute sea surface height, we‘d like to
- 1) Correctly classify radar returns coming from open water or sea ice
- 2) Avoid biases due to different algorithms used in different situations (sea ice vs open ocean, Ku vs Ka, coast vs open ocean)

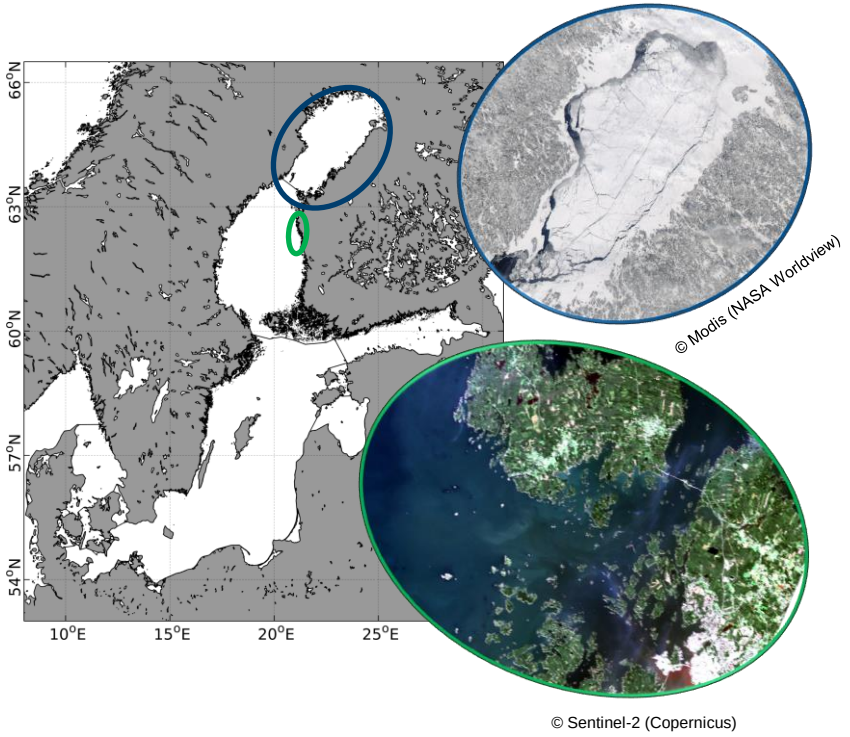


Landsat 7 Enhanced Thematic Mapper (ETM+) image of sea ice in the Arctic Ocean. (NASA)

The Baltic+ Sea Level (BALTIC SEAL) – Motivation

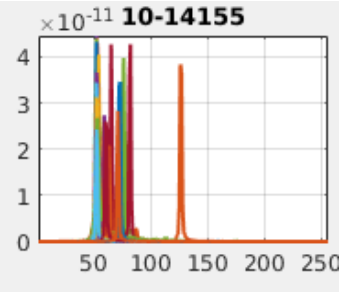
We have developed a HOMOGENOUS set of routines (classification, retracking and quality control) which are:

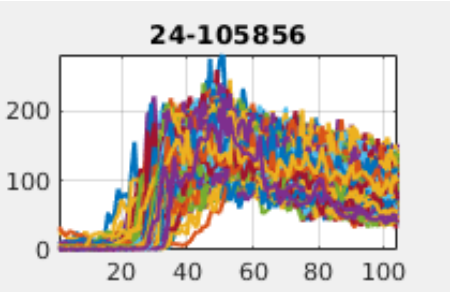
- Applicable to ALL altimetry missions (Ku, Ka, Low Resolution Mode Altimetry, SAR Altimetry, Fully Focused-SAR Altimetry)
- Applicable to all environments (sea-ice, open ocean, coast) with comparable performances



We have designed the Baltic Sea as a validation laboratory with ideal setting to test advanced processing strategies (e.g. plenty of tide gauges)

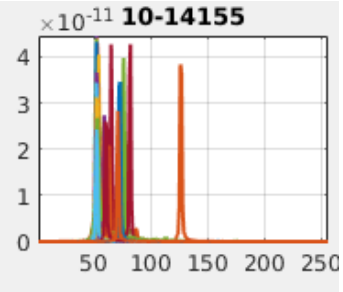
Baltic+ SEAL – Algorithm Development Challenges

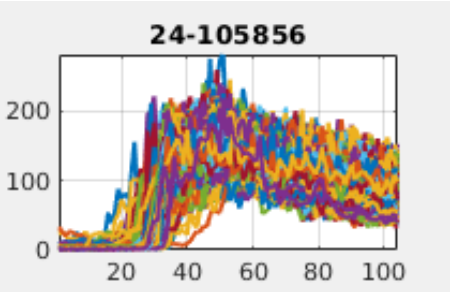




UNSUPERVISED WAVEFORM CLASSIFICATION

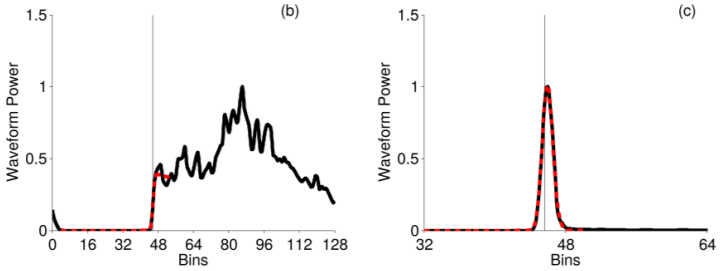
Baltic+ SEAL – Algorithm Development Challenges



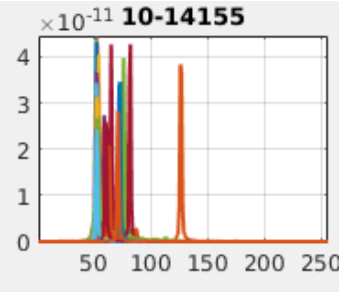


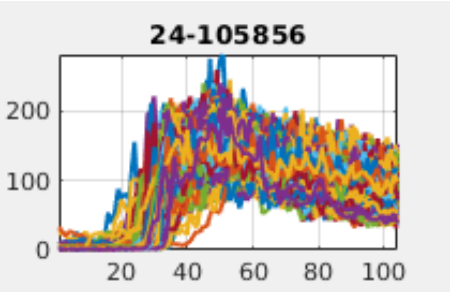
UNSUPERVISED WAVEFORM CLASSIFICATION

WAVEFORM RETRACKING
ALES+, ALES+ SAR



Baltic+ SEAL – Algorithm Development Challenges





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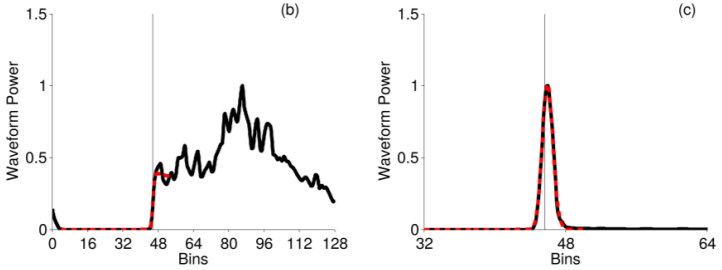
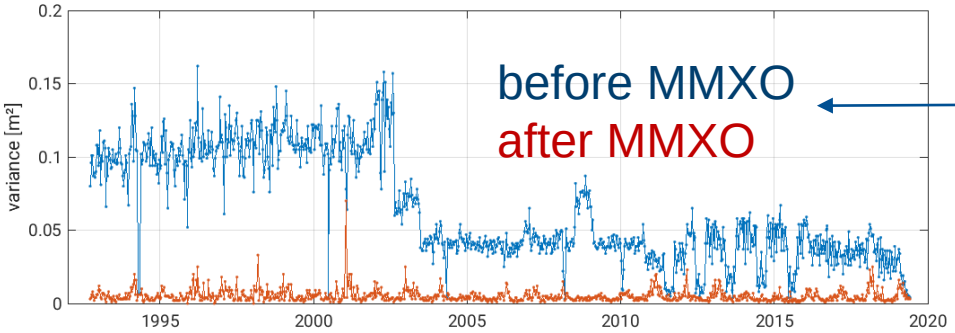
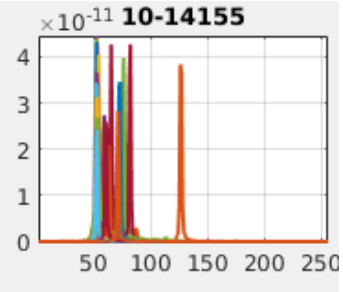
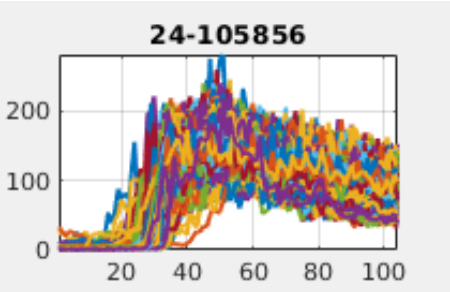




MULTIMISSION CROSSCALIBRATION

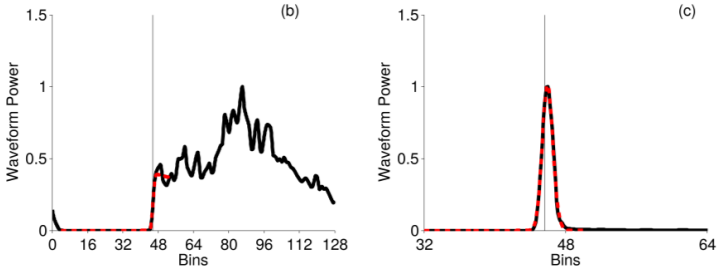
Baltic+ SEAL – Algorithm Development Challenges

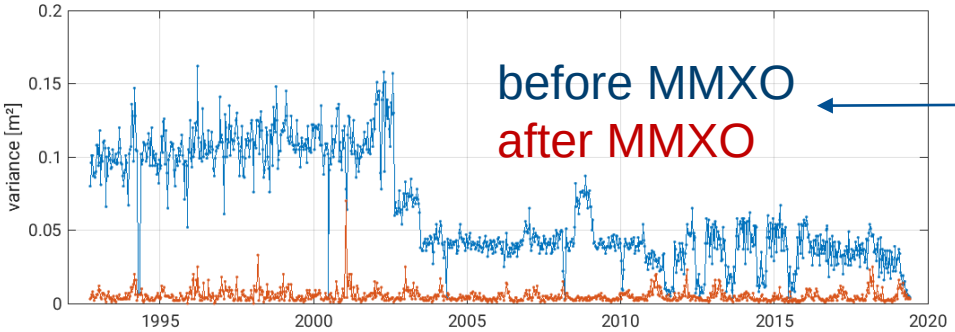




UNSUPERVISED WAVEFORM CLASSIFICATION

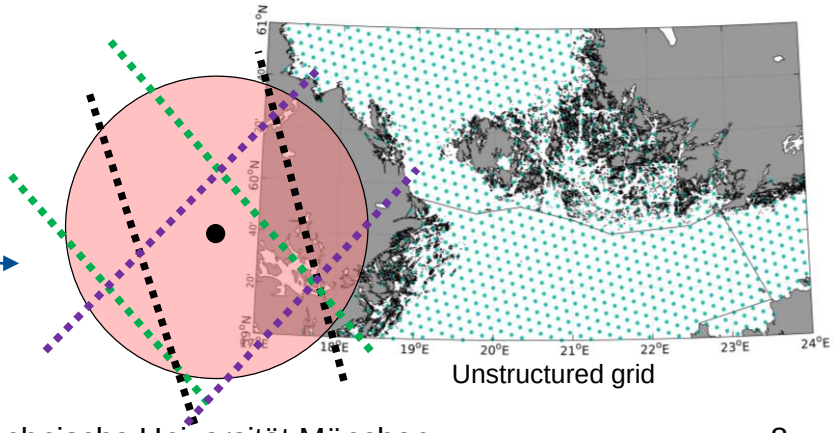
WAVEFORM RETRACKING
ALES+, ALES+ SAR



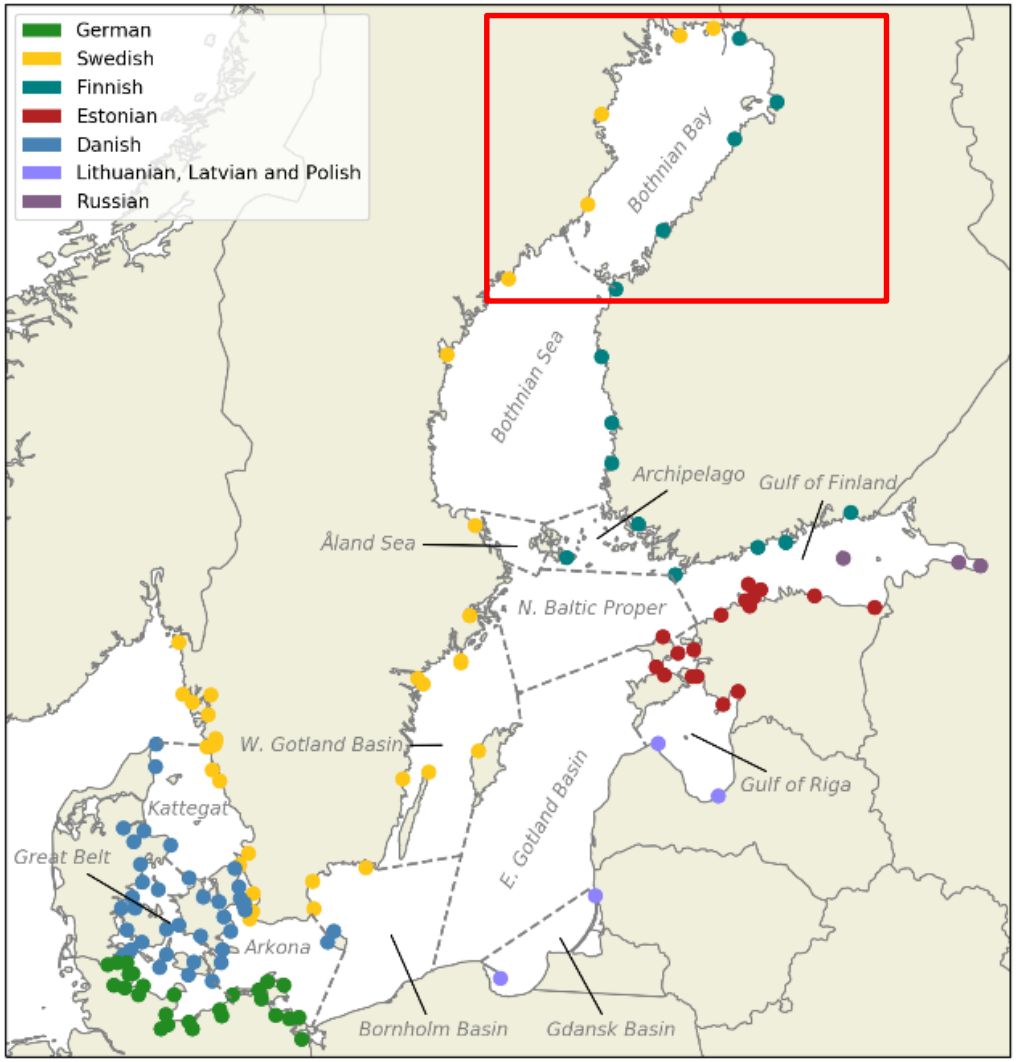


MULTIMISSION CROSSCALIBRATION

GRIDDING



Baltic+ SEAL – Validation steps

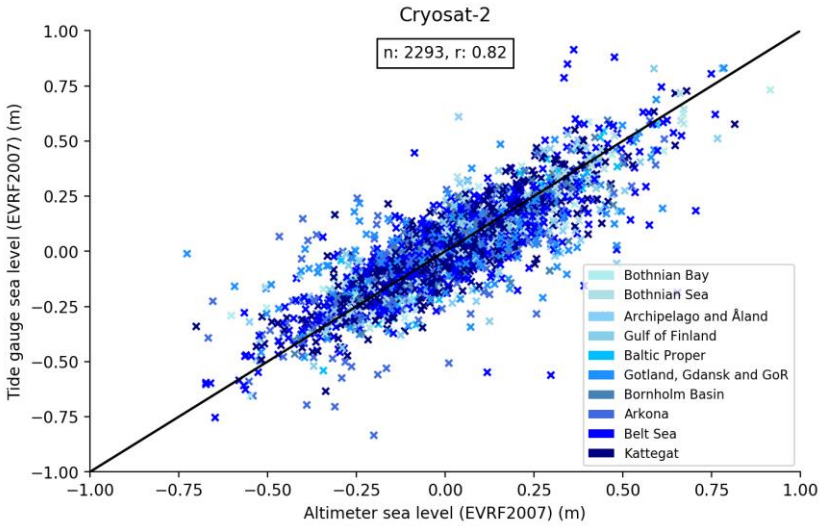


Validation of sea level products through tide gauges

Pearson‘s correlation 3-10 km away from coast and TG

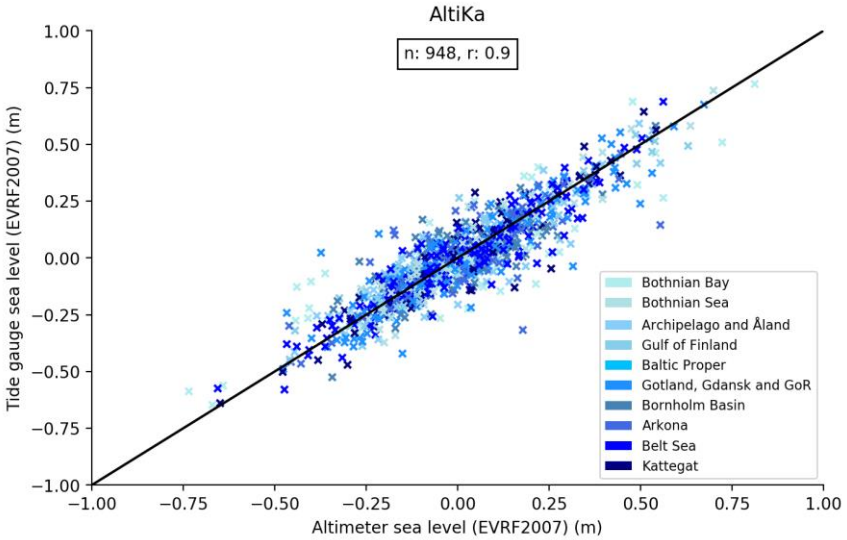
Focus on Bothnian Bay: typical sea ice season November to March (full coverage)

Basin-wide Validation results

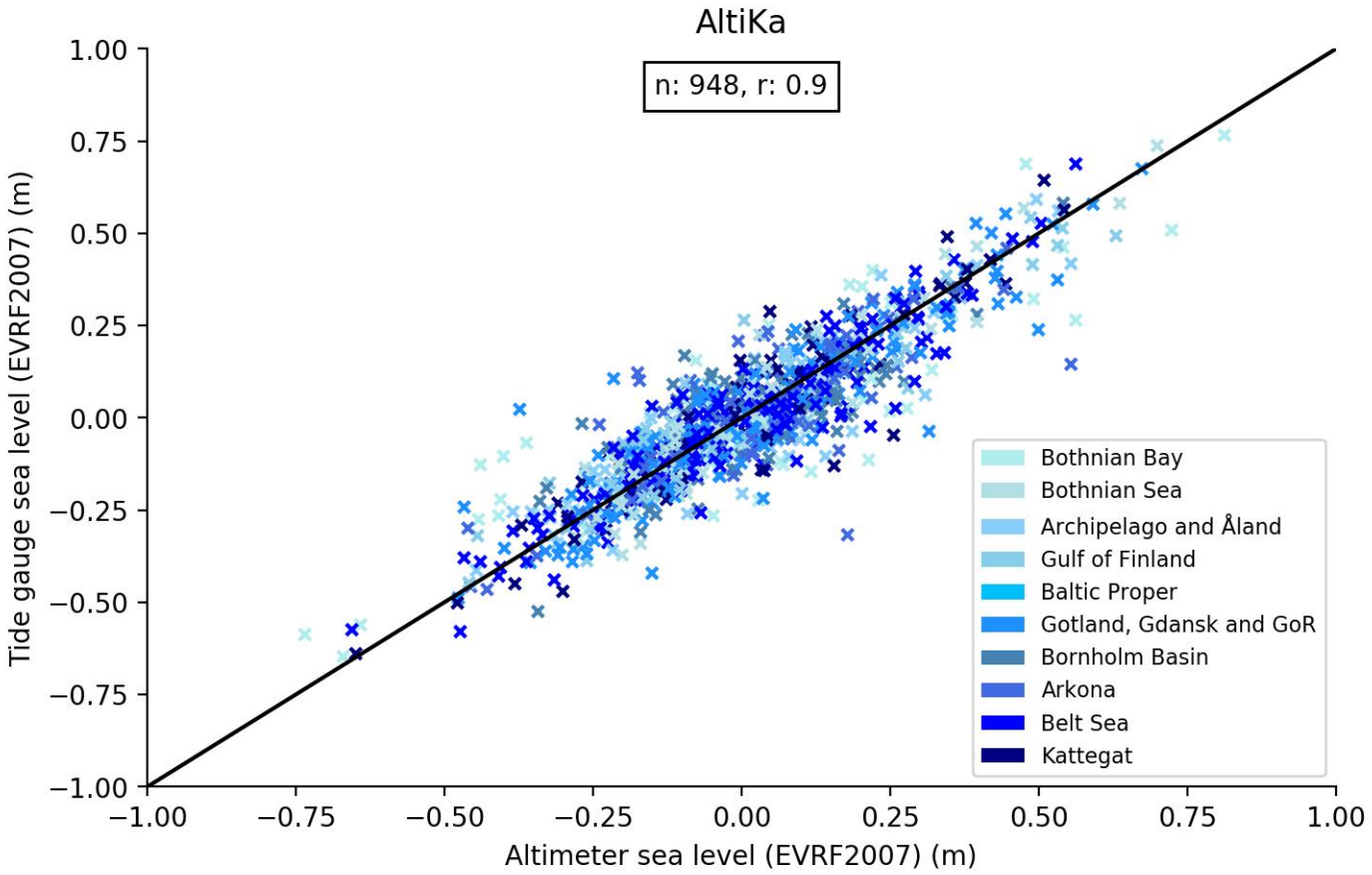


Cryosat-2 (Ku – SAR): r=0.82

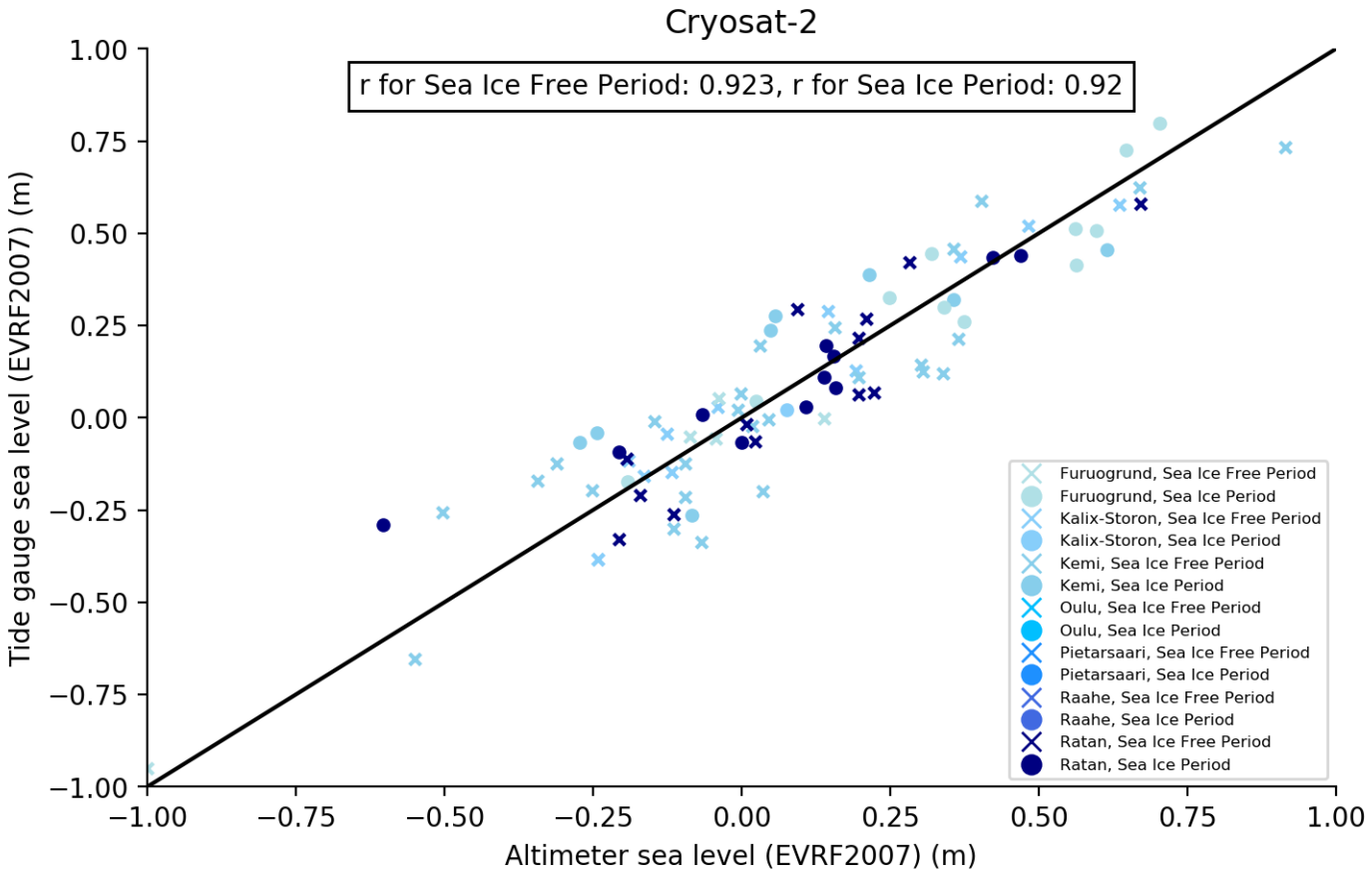
AltiKa (Ka – LRM): r=0.9



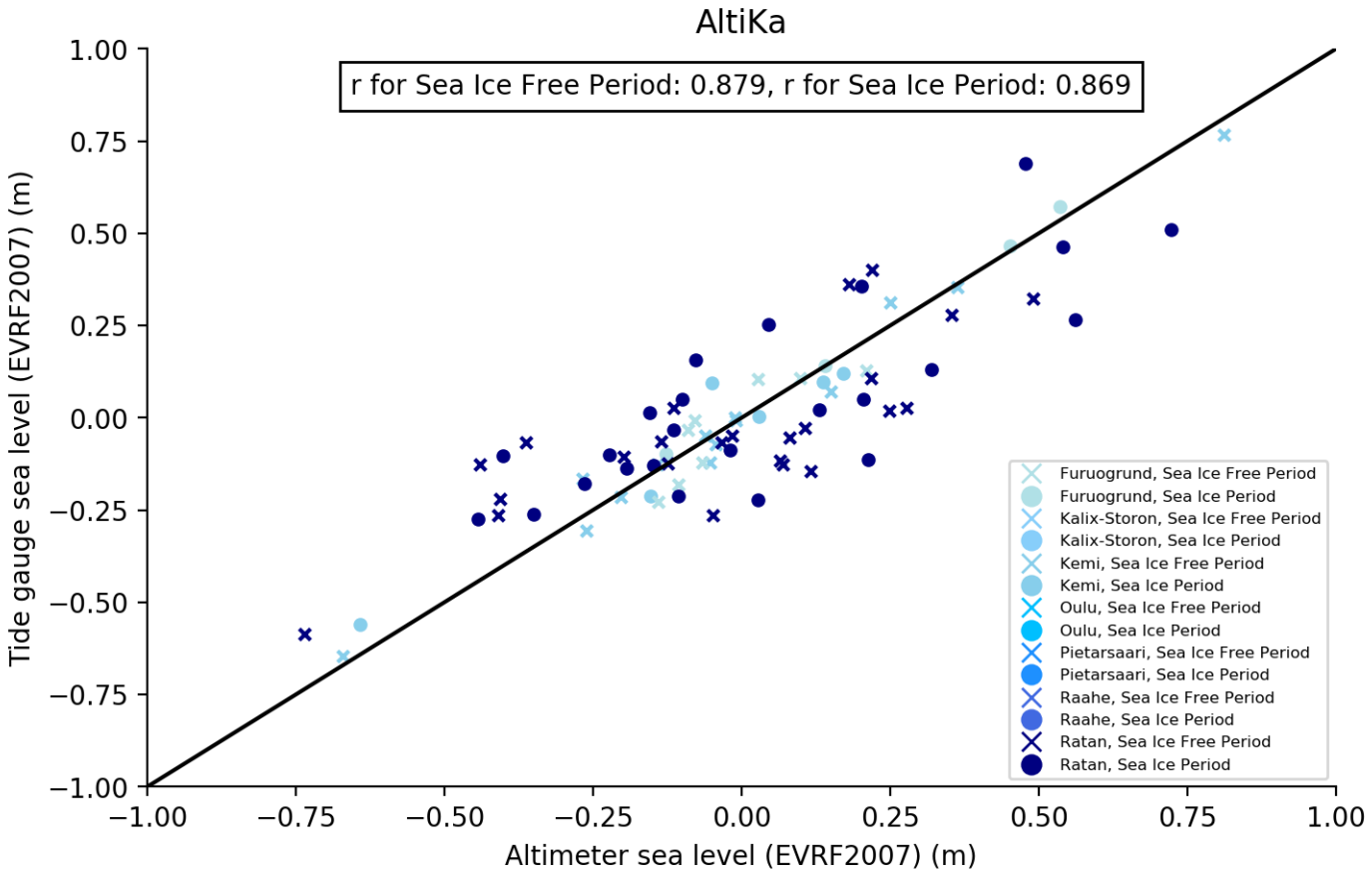
Basin-wide Validation results: AltiKa (Ka – LRM)



Bothnian Bay: Cryosat-2 (Ku – SAR)



Bothnian Bay: AltiKa (Ka – LRM)



The way forward

- Our dataset classifies and flags sea ice returns…but we have not used those yet
- We know that our waveform fitting works on sea ice returns as well -> we want to exploit this
- ALES+ SAR retracking data can be already processed through ESA GPOD for Cryosat and the Sentinels.
- We have already tested ALES+ FF-SAR on Sentinel-6 -> we want to exploit this

VISIT http://balticseal.eu/ for documentation and (in the next couple of weeks) data access

TWIT to **@Baltic_SEAL**

SPARE SLIDES

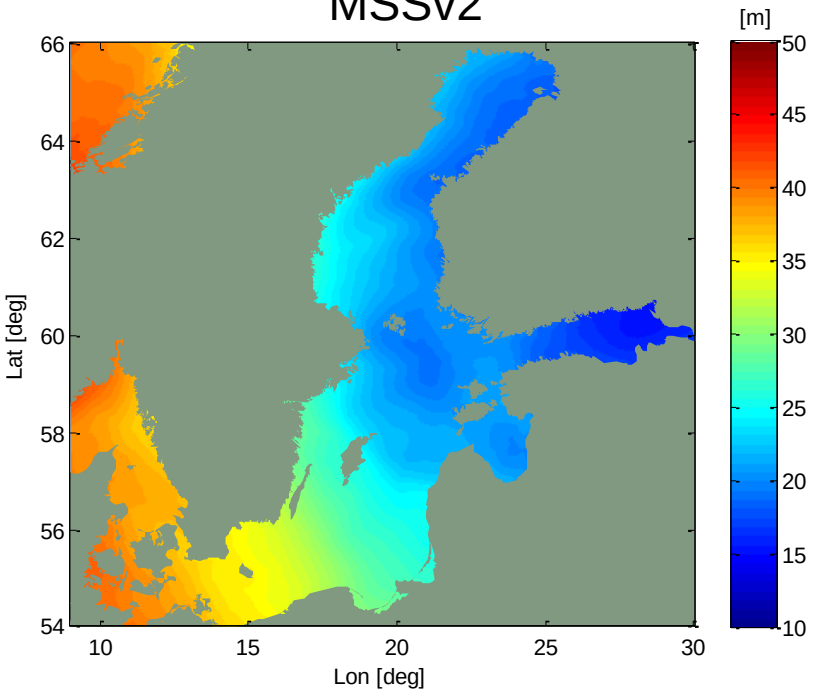
SPARE SLIDES

A Mean Sea Surface for the Baltic Sea

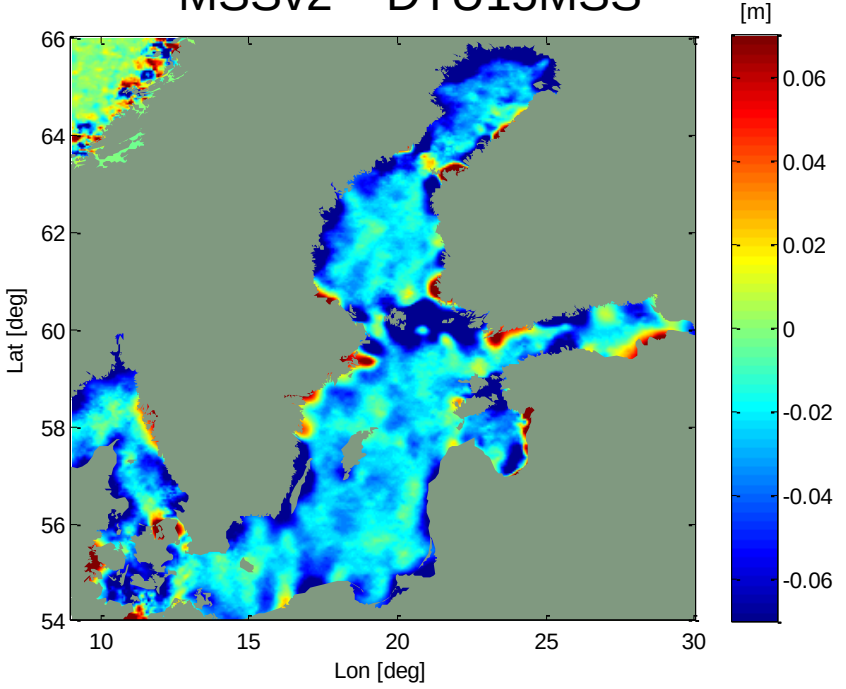
- Mean Sea Surface is often used to interpolate among distant leads: we can improve it!

- In the Baltic Sea: Major improvements observed near the coast

MSSv2

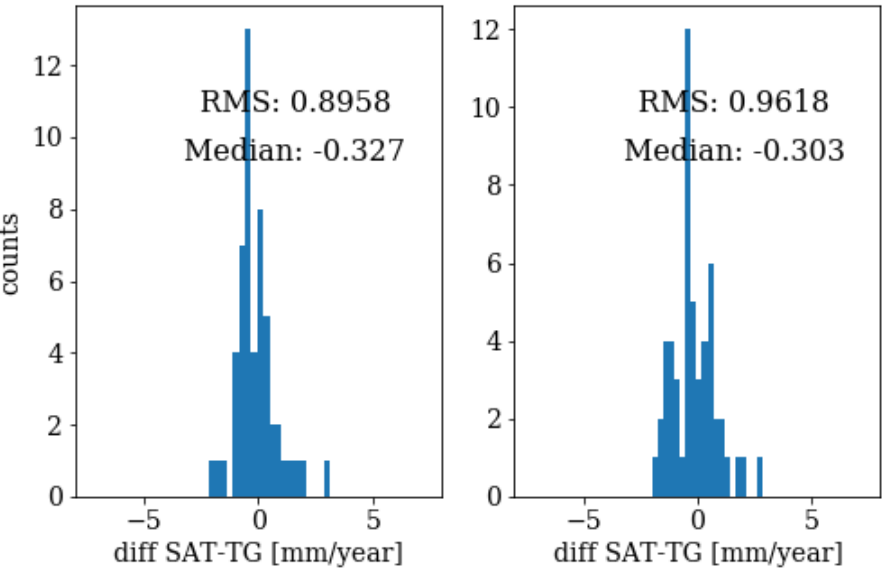


MSSv2 – DTU15MSS



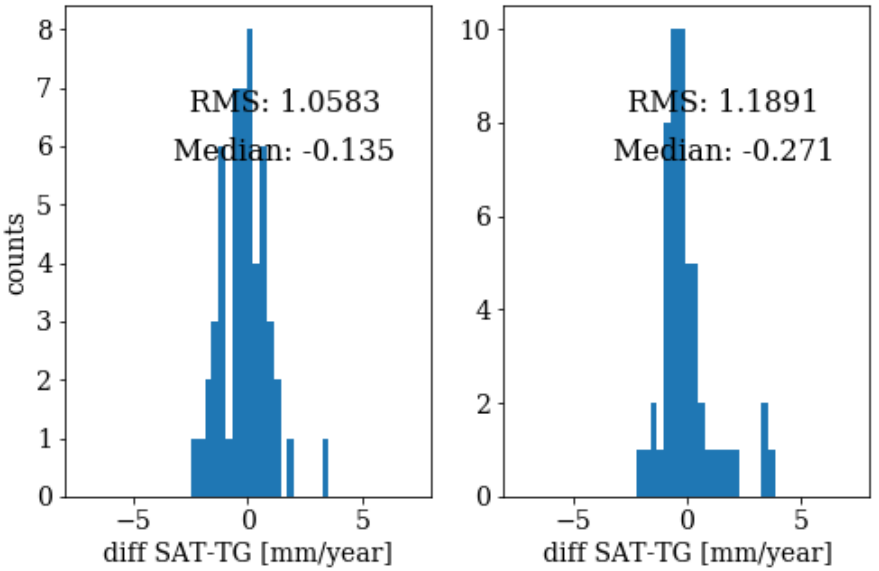
Comparison of trends

Baltic+ AVISO



1995-2018

Baltic+ SL_cci

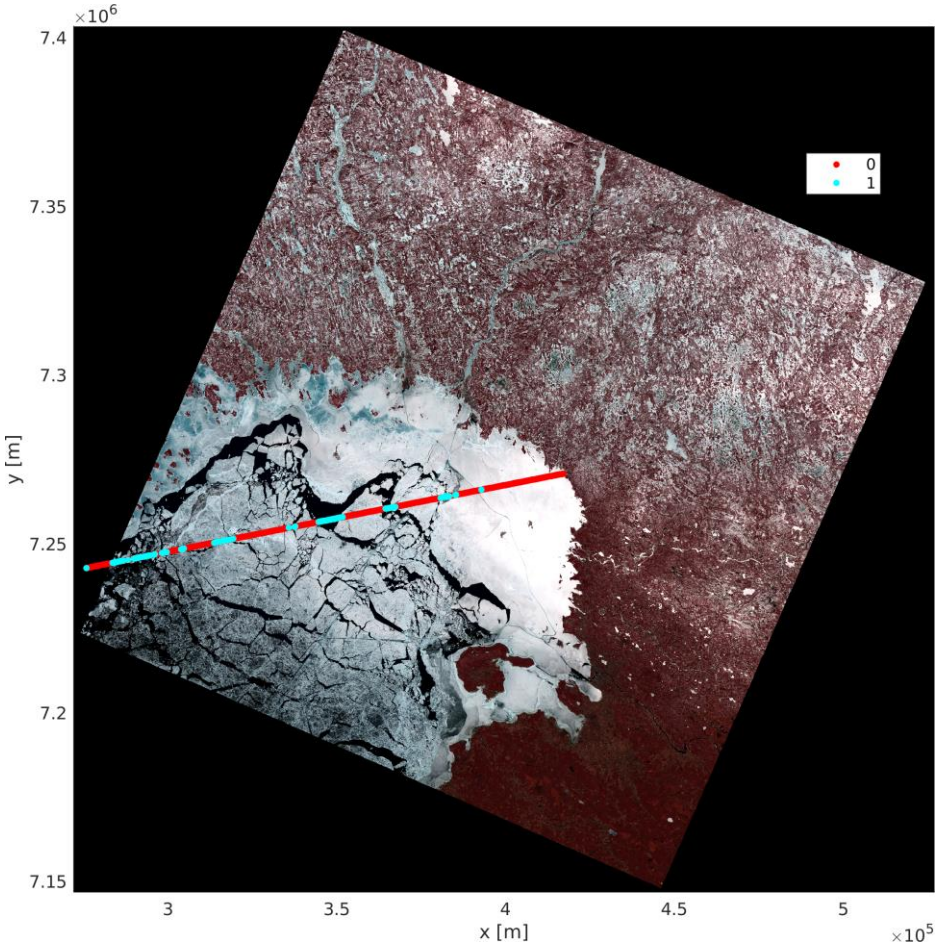


1995-2015

AVISO: Monthly averaged MSLA (all satellites) from https://www.aviso.altimetry.fr/index.php?id=1526#c10358

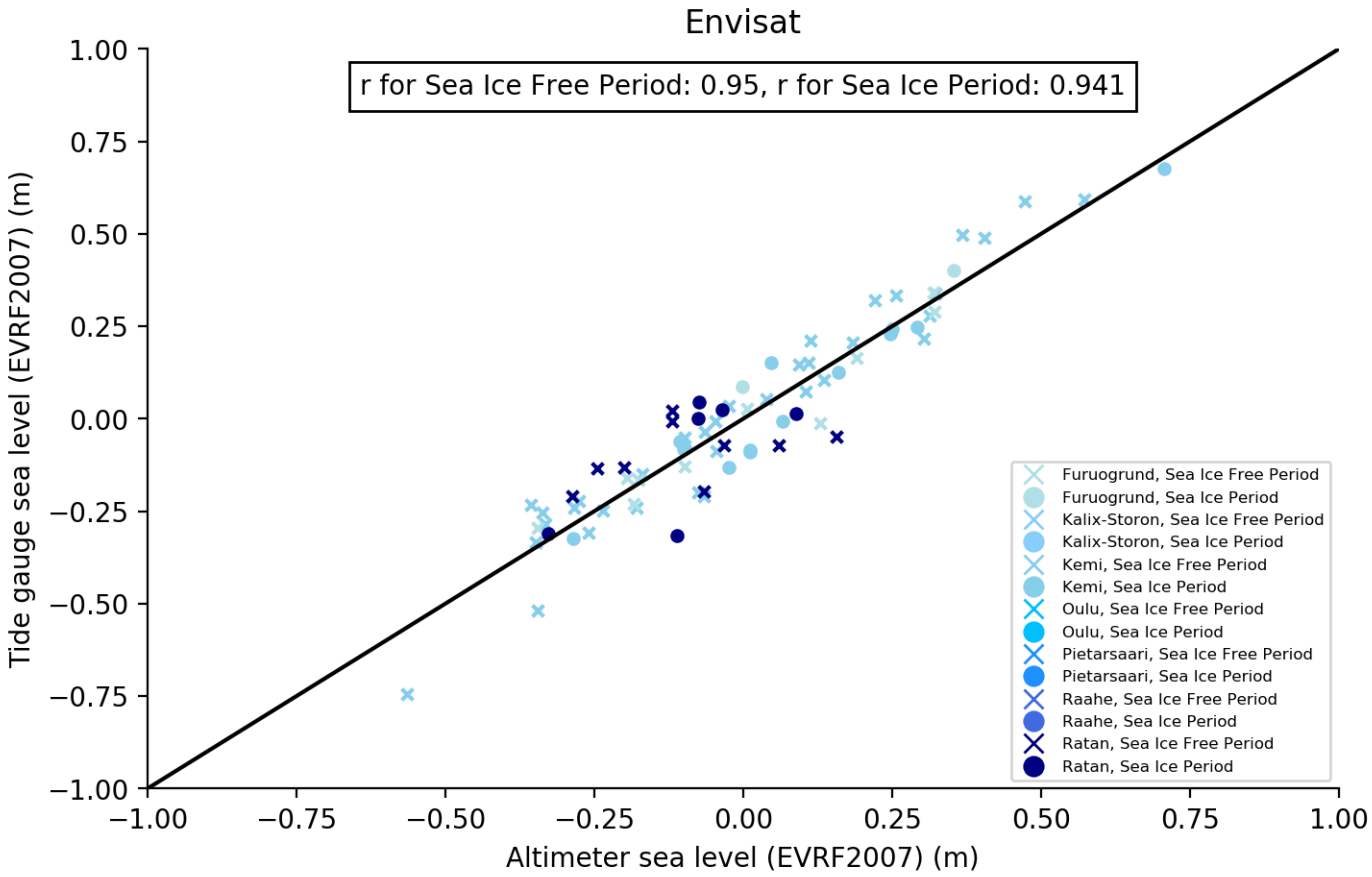
Sea Level ECV v2.0, Legeais et al., 2018, Quartly et al., 2017

Baltic+ SEAL – Validation steps



Validation of classification with SAR and Optical images

More info*: Müller F.L et al.*: **Monitoring the Arctic Seas: How Satellite Altimetry Can Be Used to Detect Open Water in Sea-Ice Regions**. Remote Sensing, 9(6), 551, 10.3390/rs9060551, 2017c


Envisat
r for Sea Ice Free Period: 0.95, r for Sea Ice Period: 0.941
Tide gauge sea level (EVRF2007) (m)
Altimeter sea level (EVRF2007) (m)
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
Furuogrund, Sea Ice Free Period
Furuogrund, Sea Ice Period
Kalix-Storon, Sea Ice Free Period
Kalix-Storon, Sea Ice Period
Kemi, Sea Ice Free Period
Kemi, Sea Ice Period
Oulu, Sea Ice Free Period
Oulu, Sea Ice Period
Pietarsaari, Sea Ice Free Period
Pietarsaari, Sea Ice Period
Raahe, Sea Ice Free Period
Raahe, Sea Ice Period
Ratan, Sea Ice Free Period
Ratan, Sea Ice Period

Mission	TG	Period	RMSE	r	p	n
Sentinel-3	Kalix-Storc	Sea Ice Pe	0.08	0.98	0	8
Sentinel-3	Kalix-Storc	Sea Ice Fre	0.16	0.77	0.006	11
Sentinel-3	Ratan	Sea Ice Pe	0.12	0.9	0	13
Sentinel-3	Ratan	Sea Ice Fre	0.11	0.93	0	13
Sentinel-3	Bothnian E	Sea Ice Pe	0.11	0.931	0	21
Sentinel-3	Bothnian E	Sea Ice Fre	0.14	0.87	0	24
AltiKa	Kemi	Sea Ice Pe	0.08	0.96	0.002	6
AltiKa	Kemi	Sea Ice Fre	0.05	0.99	0	14
AltiKa	Furuogrun	Sea Ice Pe	0.03	1	0.001	4
AltiKa	Furuogrun	Sea Ice Fre	0.07	0.85	0.007	8
AltiKa	Ratan	Sea Ice Pe	0.18	0.82	0	24
AltiKa	Ratan	Sea Ice Fre	0.18	0.79	0	24
AltiKa	Bothnian E	Sea Ice Pe	0.15	0.869	0	34
AltiKa	Bothnian E	Sea Ice Fre	0.13	0.879	0	46
Cryosat-2	Kalix-Storc	Sea Ice Pe	0.05	0		1
Cryosat-2	Kalix-Storc	Sea Ice Fre	0.09	0.96	0	12
Cryosat-2	Kemi	Sea Ice Pe	0.18	0.82	0.013	8
Cryosat-2	Kemi	Sea Ice Fre	0.15	0.89	0	26
Cryosat-2	Furuogrun	Sea Ice Pe	0.09	0.94	0	11
Cryosat-2	Furuogrun	Sea Ice Fre	0.08	0.98	0.003	5
Cryosat-2	Ratan	Sea Ice Pe	0.11	0.94	0	11
Cryosat-2	Ratan	Sea Ice Fre	0.11	0.91	0	13
Cryosat-2	Bothnian E	Sea Ice Pe	0.12	0.92	0	31
Cryosat-2	Bothnian E	Sea Ice Fre	0.13	0.923	0	56
Envisat	Kemi	Sea Ice Pe	0.06	0.97	0	14
Envisat	Kemi	Sea Ice Fre	0.08	0.97	0	35
Envisat	Furuogrun	Sea Ice Pe	0.07	1	0	2
Envisat	Furuogrun	Sea Ice Fre	0.05	0.97	0	10
Envisat	Ratan	Sea Ice Pe	0.11	0.73	0.099	6
Envisat	Ratan	Sea Ice Fre	0.12	0.44	0.234	9
Envisat	Bothnian E	Sea Ice Pe	0.08	0.941	0	22
Envisat	Bothnian E	Sea Ice Fre	0.08	0.95	0	54