RiwiSAR-SWH: A data-driven method for estimating significant wave height using Sentinel-3 SAR altimetry

Junyang Gou

ETH zürich

Mohammad J. Tourian

GIS

University of Stuttgart

This study proposes a data-driven method to determine SWH using the Sentinel-3 data for both oceanic and coastal zones. For this purpose, we propose a method based on the rise time and the width of a waveform, called RiwiSAR-SWH (rise time width model for SAR-SWH), which is free from the complexity of the SAR physical model and estimates SWH over the coastal area and open ocean in a relatively straightforward manner. The method is employed over different regions in the coastal zone of the North Sea. The results are validated against in-situ buoy data and compared with SWH estimates from SAMOSA+, SAMOSA++ and the Sentinel-3 Ocean retracker. The validation shows that the proposed method can determine SWH with accuracy ranging from 0.25m to 0.91m for different locations in the North Sea. Moreover, we obtain reliable SWH to within 1 km from the coast, which is an improvement of more than 40% compared to existing methods.

Data

Sentinel-3B Non Time Critical data from November 2018 till February 2021 are taken from Copernicus Open Access Hub:

https://scihub.copernicus.eu/dhus

We also benefited from SWH by SAMOSA+ and SAMOSA++ algorithms obtained from the SARvatore tool available on GPOD service.

For validation, in-situ data of buoys Elbe, Sylt and Butendiek are downloaded from The Copernicus Marine Environmental Monitoring Service (CMEMS): http://www.marineinsitu.eu/dashboard)

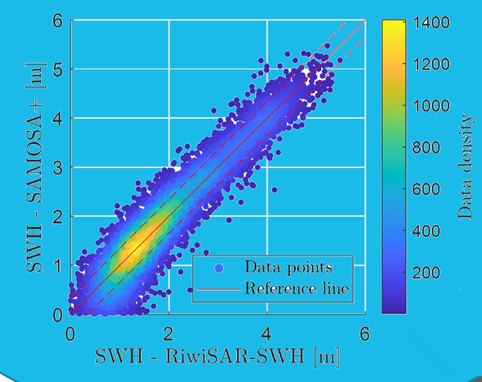
Basic principle

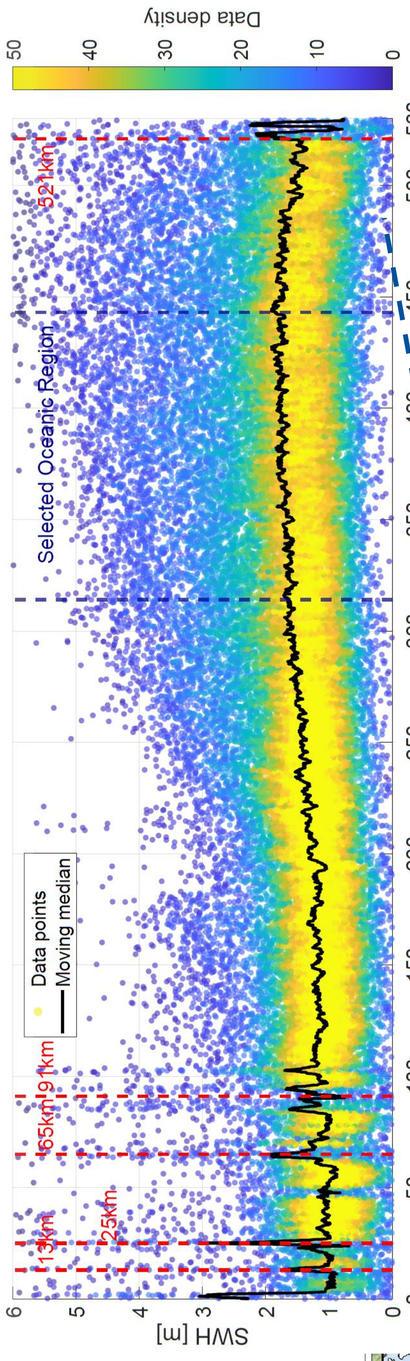
SWH is obtained based on waveform characteristics

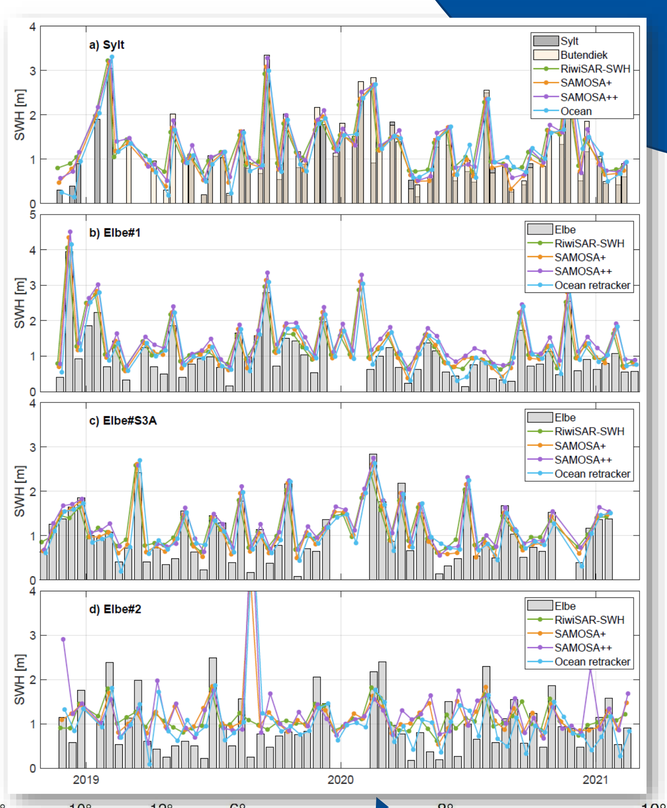
- Waveform rise time δr
- Waveform width w

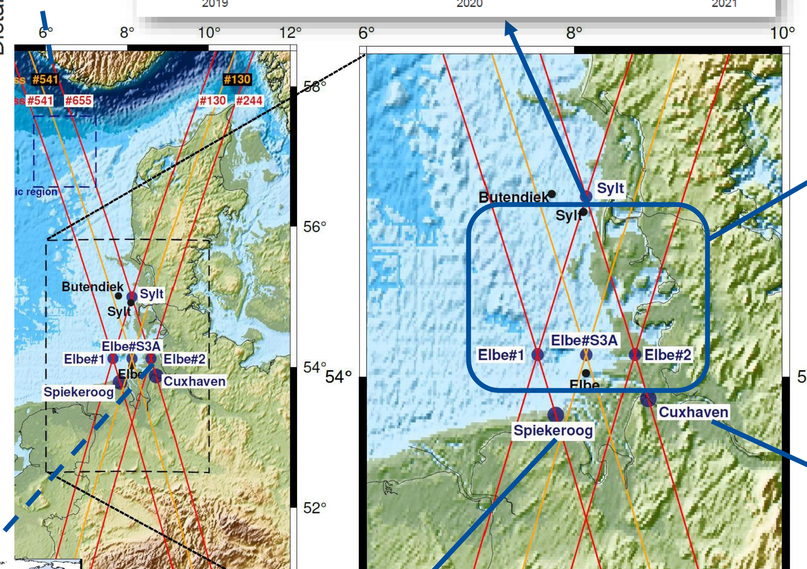
$$\mathrm{SWH} = a \cdot \delta r + b \cdot w - c$$

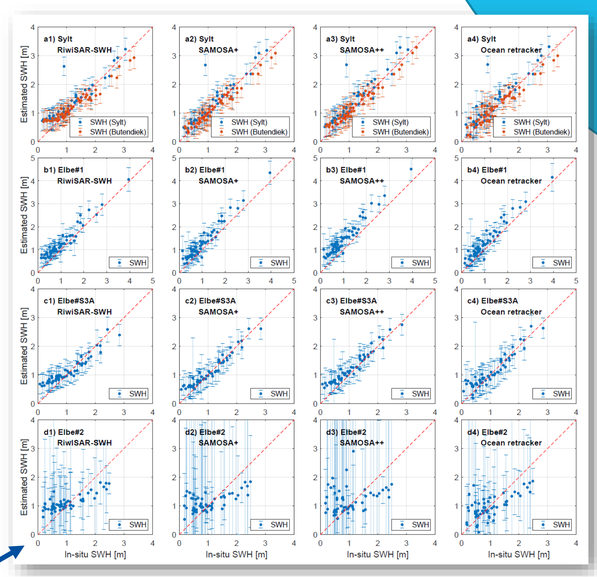
a, b and c are obtained based on SAMOSA+[1] SWH estimates

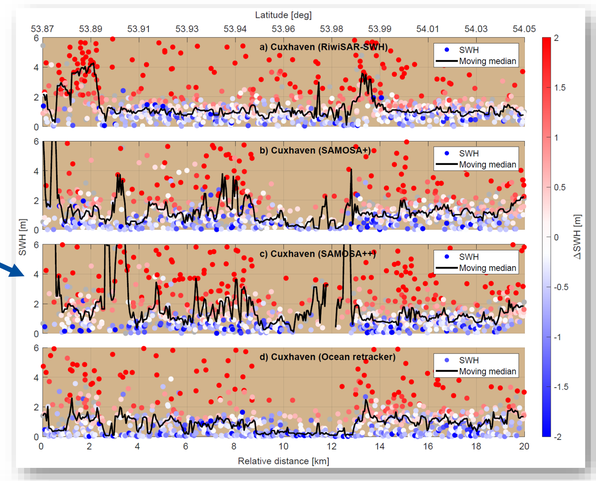


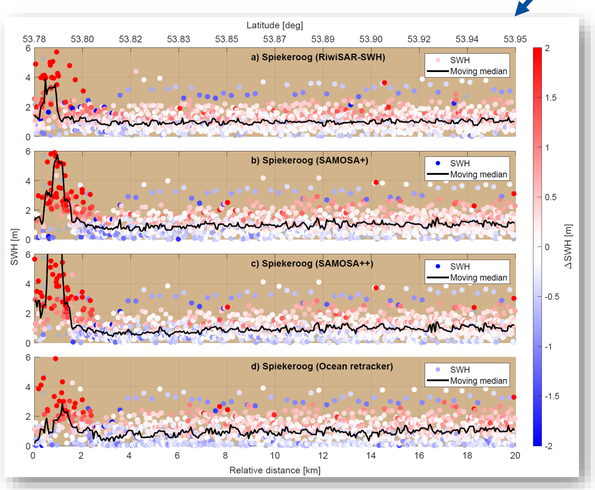


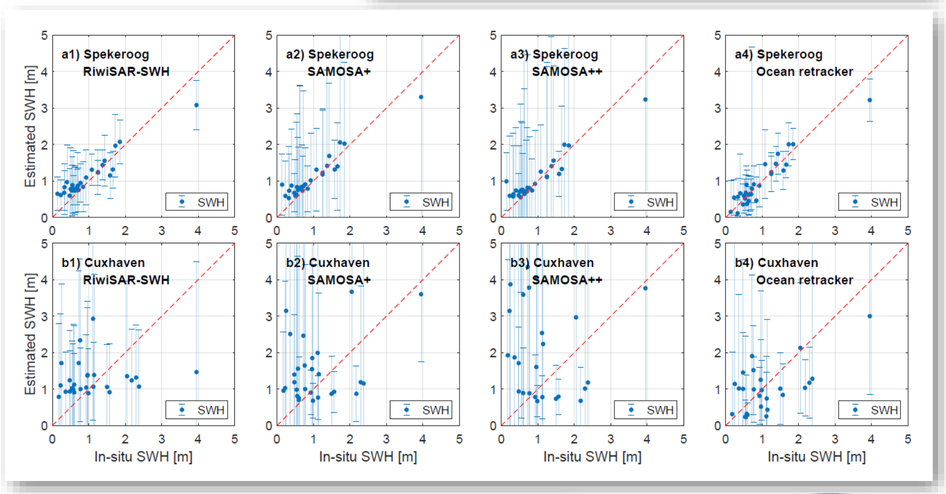






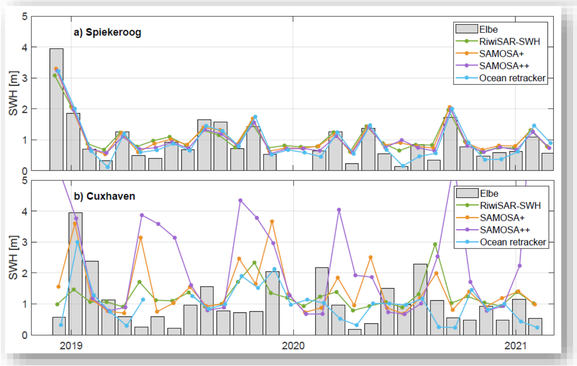






To estimate the rise time, we model the leading edge (only the leading edge excluding the trailing edge) using the **4-β model**. We then determine the rise time in a modelled leading edge by considering a **Dwf of 0.5%** in a normalized SAR waveform. To extract the width of a waveform, we employ the known OCOG retracker. The extracted rise time and the width are then the bases for estimating the SWH for standard SAR waveforms. However, for the non-standard waveforms, like those obtained along the coast, the obtained width from OCOG does not provide a representative value due to the fast decay of the waveform. Therefore, we introduce an auxiliary function to obtain the width through the rise time. In the end, we combine rise time and width linearly and introduce the data-driven method RiwiSAR-SWH the estimation of SWH.

	Method	RMSE_m [m]	RMSE_i [m]	Valid ratio
Cuxhaven	RiwiSAR-SWH	0.91	**1.9**	**57%**
	SAMOSA+	1.05	4.69	51%
	SAMOSA++	2.7	5.98	53%
	Ocean	**0.68**	2.26	51%
Spiekeroog	RiwiSAR-SWH	0.31	**0.77**	**96%**
	SAMOSA+	0.28	1.92	85%
	SAMOSA++	0.28	2.45	84%
	Ocean	**0.24**	0.95	82%



Reliable SWH estimates without considering the complicated physical model

Better performance in the coastal zones

Applicable globally for all types of SAR waveforms

[1] Dinardo, S., Fenoglio-Marc, L., Buchhaupt, C., Becker, M., Scharroo, R., Joana Fernandes, M., & Benveniste, J. (2018). Coastal SAR and PLRM altimetry in German Bight and West Baltic Sea. Advances in Space Research, 62 , 1371-1404. The CryoSat Satellite Altimetry Mission: Eight Years of Scientic Exploitation.

[2] Gou, J., & Tourian, M. J. (2022). RiwiSAR-SWH: A data-driven method for estimating significant wave height using Sentinel-3 SAR altimetry. *Advances in Space Research*, *69*(5), 2061-2080.