

Comparison of detectability of ship wake components between C- and X-Band Synthetic Aperture Radar (SAR)

Abstract— The detectability of ship wake signatures on C-Band and X-Band SAR differs with respect to radar frequency. For comparison of detectability of individual wake components data from four satelliteborne SAR missions are collected: TerraSAR-X, RADARSAT-2, Sentinel-1 and CosmoSkymed. The data is labelled by manually retracing of wake components to derive wake component length. Detectability models are trained reproducing the detectability of wake components in dependency to influencing parameters. (Abstract)

Keywords—component, formatting, style, styling, insert (key words)

I. INTRODUCTION

The movement of ships on the water surface creates anomalies, i.e. ship wakes, which are recognizable in Synthetic Aperture Radar (SAR) imagery over hundreds of kilometers, e.g. [1]. The imaging of ship wakes and its dependency on influencing parameters like environmental conditions, ship properties and acquisition settings has been explained by researchers through theoretical considerations and simulation models, e.g. [2]. With the ongoing development of automatic methods for detection of ship wakes in SAR, the quantification of ship wake detectability with respect to the influencing parameters is still of interest today [3]. Therefore, in [4, 5] the influence of environmental conditions, ship properties and acquisition settings on the detectability of ship wakes and their individual components has been modelled. The models can also be applied to compare the detectability of ship wakes between sensors, e.g. [6, 7]. In [7] was concluded that for such a comparison between sensors an individual consideration of the wake components is crucial. Therefore, in this study results are presented, which are obtained from modelling the detectability of the wake components “near-hull turbulences”, “turbulent wakes”, “Kelvin wakes arms” and “V-narrow wakes” using two X-Band (i.e. TerraSAR-X (TS-X) and CosmoSkymed (CSK)) and two C-Band (i.e. RADARSAR-2 (RS-2) and Sentinel-1 (S-1)) SAR datasets.

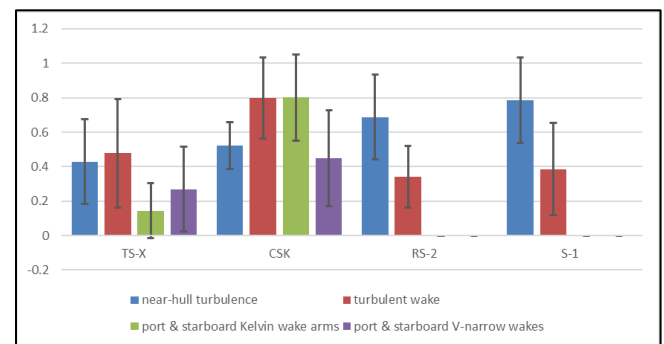
II. METHOD

Details about the method for modeling the detectability of individual ship wake components can be found in [5]. The method provides merits for wake component detectability in dependency to influencing parameters. It is applied here on each of the datasets from the different sensors: TS-X, CSK, RS-2 and S-1. In this study we focus on five influencing parameters: AIS-Vessel-Velocity, AIS-Length, AIS-Course-Over-Ground, SAR-Wind-Speed and Incidence-Angle. By integration of the merits over the whole five-dimensional feature space of influencing parameters, the overall detectability of wake components can be compared between the sensors.

III. RESULTS

The bar chart in Fig 1 displays the integrated detectability metrics for each sensor. The chart shows that Kelvin wake arms and V-narrow wakes are hardly detectable in C-Band SAR. In contrast, C-Band SARs seem better suited for the detection of near-hull turbulences than X-Band SARs. Due to the high variation of detectability merits for turbulent wakes no definite conclusion can be derived for this wake component.

FIG 1: OVERALL DETECTABILITY OF WAKE COMPONENTS FOR EACH SENSOR



IV. DISCUSSION AND CONCLUSION

It is not possible to derive an overall conclusion stating that either X-Band or C-Band SARs are better for the detection of ship wakes, because each of the frequency bands is better suited for the detection of certain wake components.

A better measure for uncertainty is currently under development.

REFERENCES

- [1] A. M. Reed and J. H. Milgram, "Ship Wakes and Their Radar Images," *Annual Review of Fluid Mechanics*, vol. 34, pp. 469-402, 2002.
- [2] I. Hennings, R. Romeiser, W. Alpers and A. Viola, "Radar imaging of Kelvin arms of ship wakes," *International Journal of Remote Sensing*, vol. 20, no. 13, pp. 2519-2543, 1999.
- [3] M. D. Graziano, "Preliminary Results of Ship Detection Technique by Wake Pattern Recognition in SAR Images," *Remote Sensing*, vol. 12, no. 18, p. 2869, 2020.
- [4] B. Tings, A. Pleskachevsky, D. Velotto and S. Jacobsen, "Extension of Ship Wake Detectability Model for Non-Linear Influences of Parameters Using Satellite Based X-Band Synthetic Aperture Radar," *Remote Sensing*, vol. 11, no. 5, pp. 1-20, 07 March 2019.
- [5] B. Tings, "Non-Linear Modeling of Detectability of Ship Wake Components in Dependency to Influencing Parameters Using Spaceborne X-Band SAR," *Remote Sensing*, vol. 13, no. 2, p. 165, 2021.
- [6] B. Tings and D. Velotto, "Comparison of ship wake detectability on C-band and X-band SAR," *International Journal of Remote Sensing*, vol. 0, no. 0, pp. 1-18, 2018.
- [7] B. Tings, S. Jacobsen, S. Wiehle, E. Schwarz and H. Daedelow, "X-Band/C-Band-Comparison of Ship Wake Detectability," in *EUSAR-Preprints 2020*, Leipzig, 2020.