SHIP WAKE DETECTION IN SAR IMAGERY

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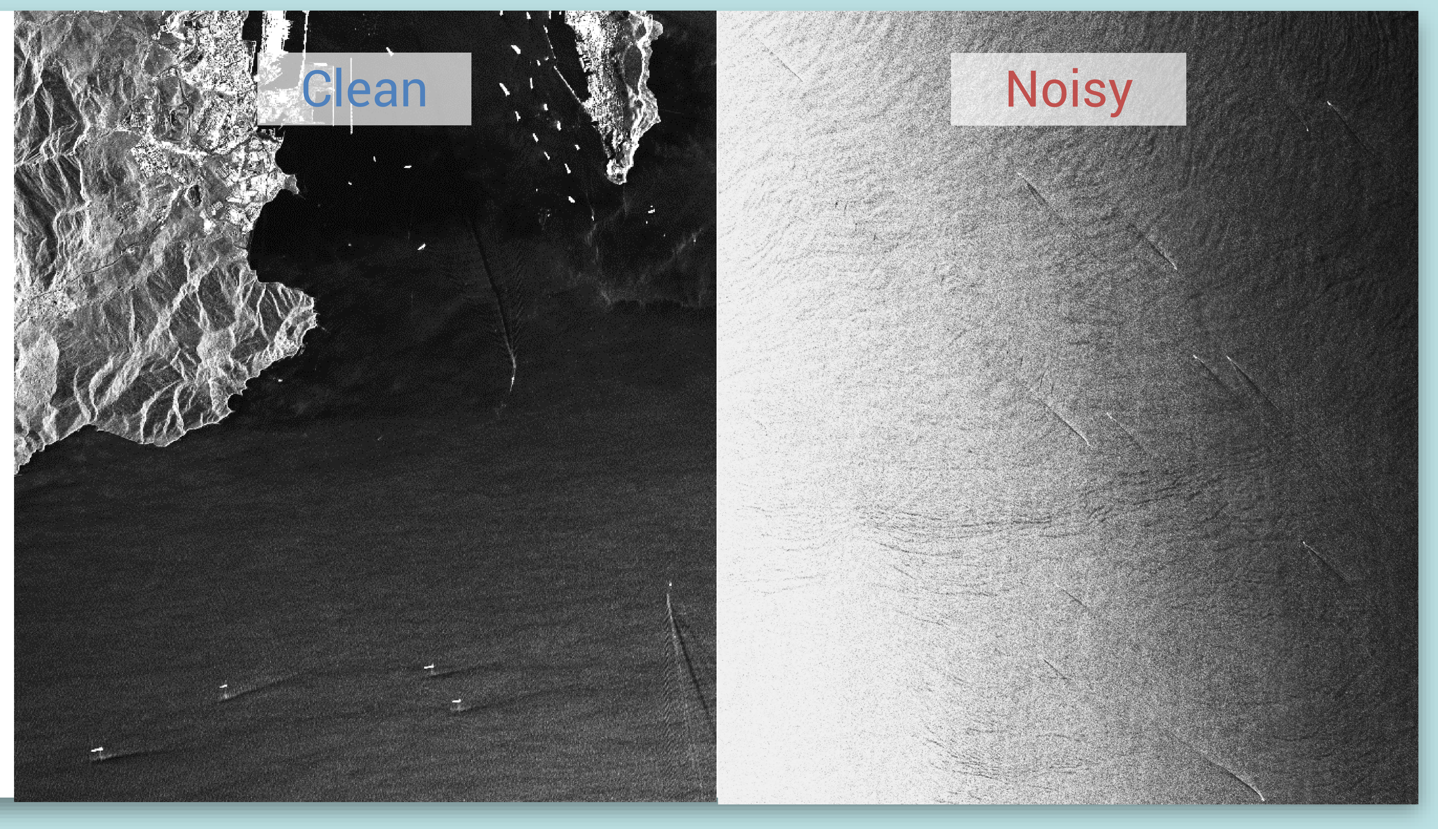
INTRODUCTION

- **Synthetic Aperture Radar** (SAR) provides all-weather and day/night imagery to accurately monitor ships and secure our waters.
- **Our project examines** the viability of combination of methods in detecting correct ship wakes, and lack thereof.
- **Ship wakes**' prominent features (length, darker/brighter shade, proximity to the ship) enable easier detection as compared to the smaller ship. This allows for the establishment of a ship's status (i.e. presence, bearing and velocity).



OBJECTIVES

We aim to construct an algorithm that would produce reliable indicators of a ship wake's presence.

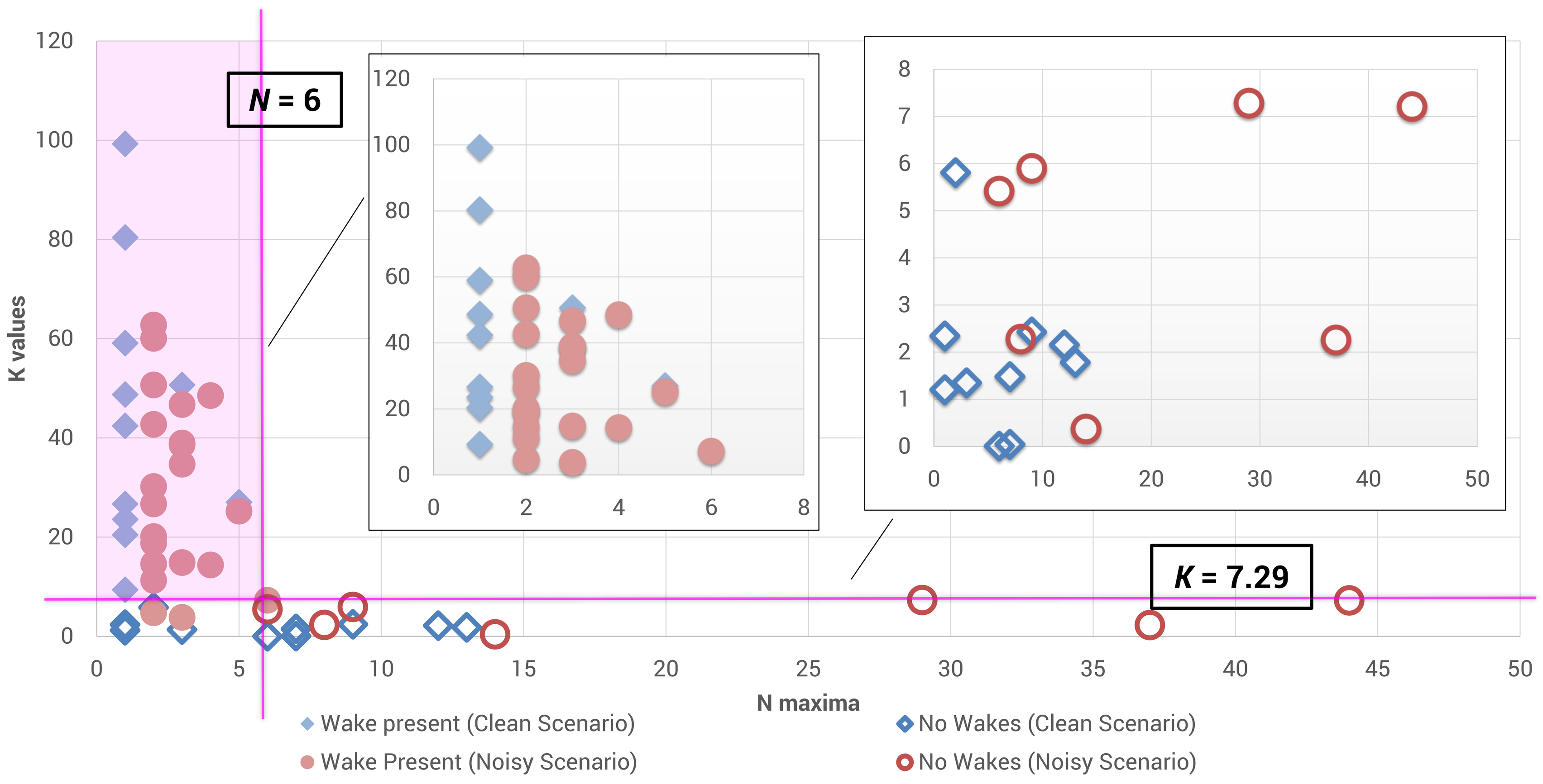
1. Compare ***N* maxima** (Proximity Criterion) and ***K* values** (Causality Criterion) obtained from chips.
2. Observe trends between chips with and without wakes.
3. Determine threshold for respective filters.
4. Ascertain importance, or lack thereof, of the criteria.

RESULTS & DISCUSSION

Algorithm \ Visual	Wake Present*	No Wake*
Detected as **wakes**	Clean: 11 of 11 + Noisy: 17 of 21 **87.5%** (28 of 32)	Clean: 0 of 10 + Noisy: 0 of 7 **0%** (0 of 17)
Detected as **no wakes**	Clean: 0 of 11 + Noisy: 4 of 21 **12.5%** (4 of 32)	Clean: 10 of 10 + Noisy: 7 of 7 **100%** (17 of 17)

*Wake present: correctly detected using visual inspection.
*No wake: non-existent or curved (i.e. undetectable).

Preliminary analysis confirms successful implementation of algorithm ensures 100% detection of no wakes, and highly reliable detection of present wakes.



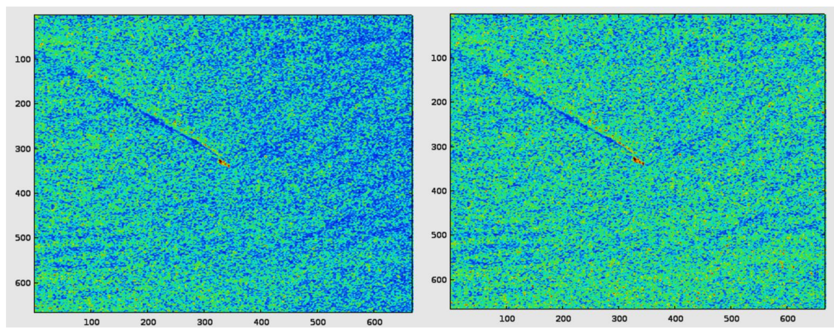
A clean, and, a noisier scenario were chosen to compare results of the number (***N***) of rejections prior to detection, and causality distribution of pixels (***K***). Results are promising, indicating that ***K* value** suffice for cleaner conditions, while ***N*** and ***K*** thresholds are necessary in noisier conditions.

CONCLUSION / APPLICATION

In this project, we worked to improve existing methods by incorporating filters into the widely used Radon transform for ship wake detection in non-ideal SAR imagery. In terms of verification, the use of thresholds (***N* = 6**, ***K* = 7.29**) has proven necessary to reliably determine a wake's presence, or lack thereof. The constructed algorithm has, thus, succeeded in overcoming various noisy conditions that are inevitable in the real-world scenario, allowing for ship traffic surveillance to still be carried out.

METHODOLOGY

PRE-PROCESSING



Original chip. After pre-processing.

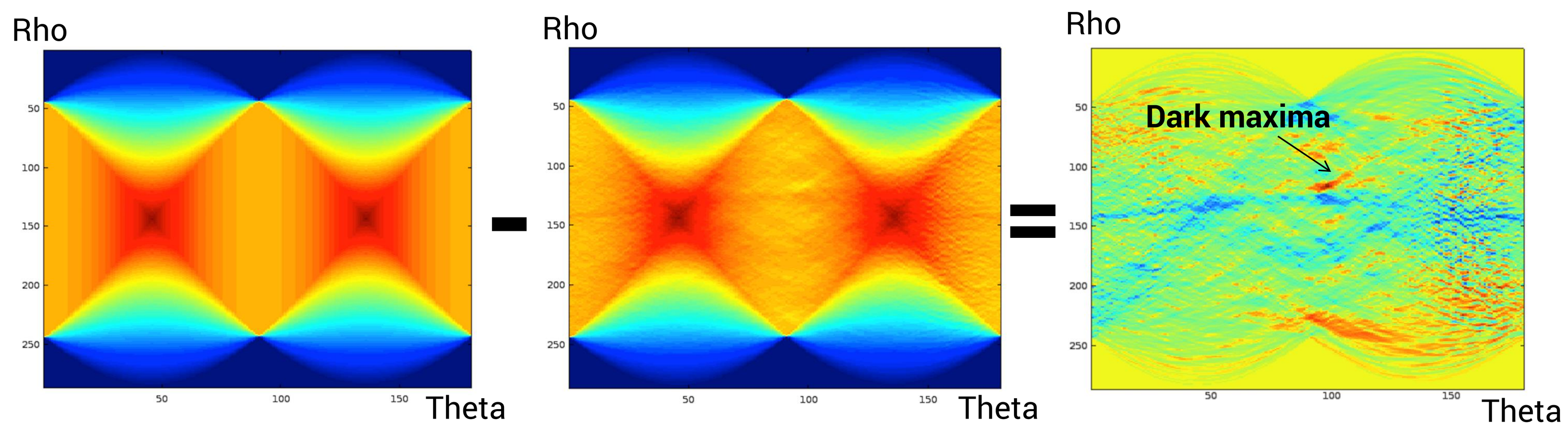
Block-process chip → decrease processing time and speckle noise

Normalising Filter (horizontal median filter) → eliminate intensity gradient, cancel sea clutter, preserve lines

Sea threshold → separate ship and sea

LOCALISED RADON TRANSFORM

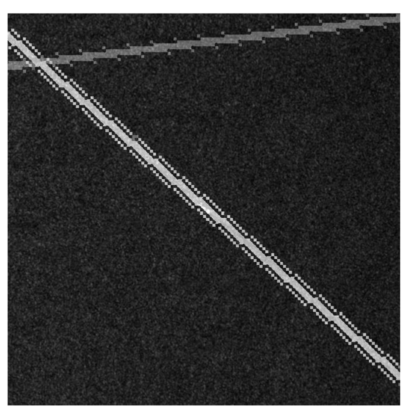
to detect wake as linear features



Simulated Background Radon Transform — Chip (Wake + Background) Radon Transform = Dark Wake Radon Transform

PROXIMITY CRITERION

N Maxima

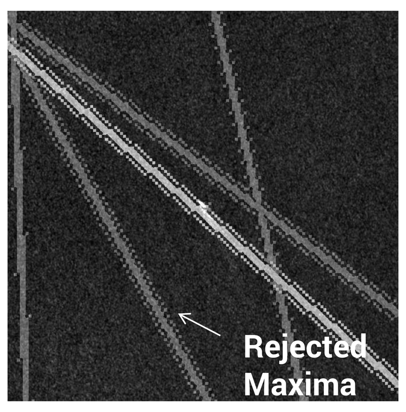


Checks detected line against

Proximity Criterion (maximum Doppler displacement of ship from wake [4])

→ reject maxima until satisfied

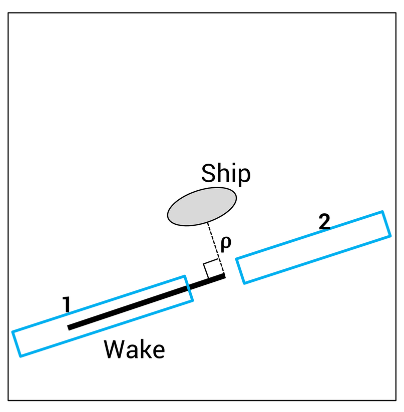
→ obtain ***N*th maxima**



Low ***N*** ⟷ High ***N***

CAUSALITY CRITERION

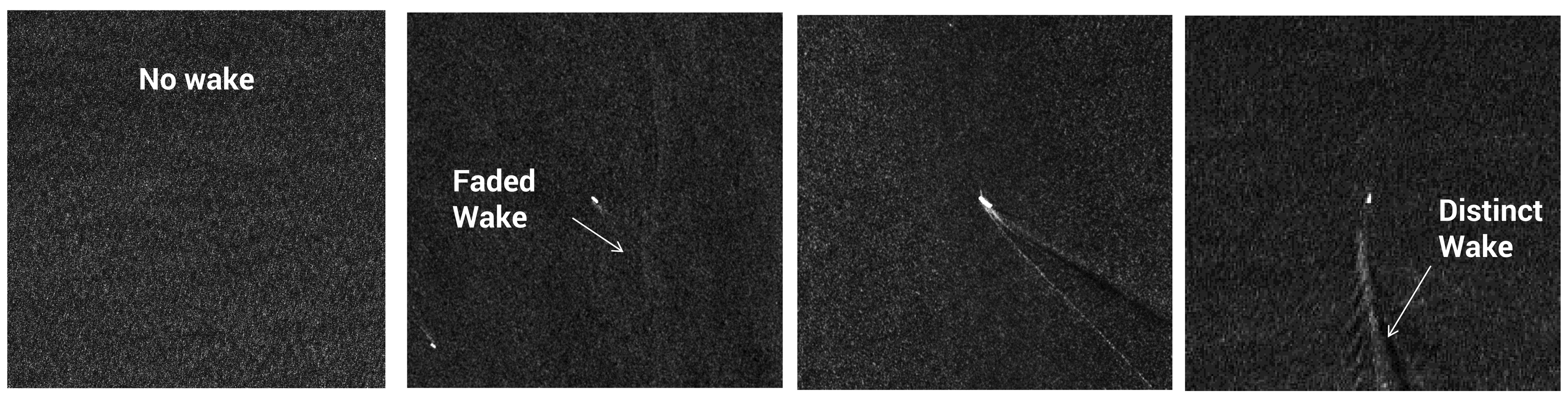
K Value



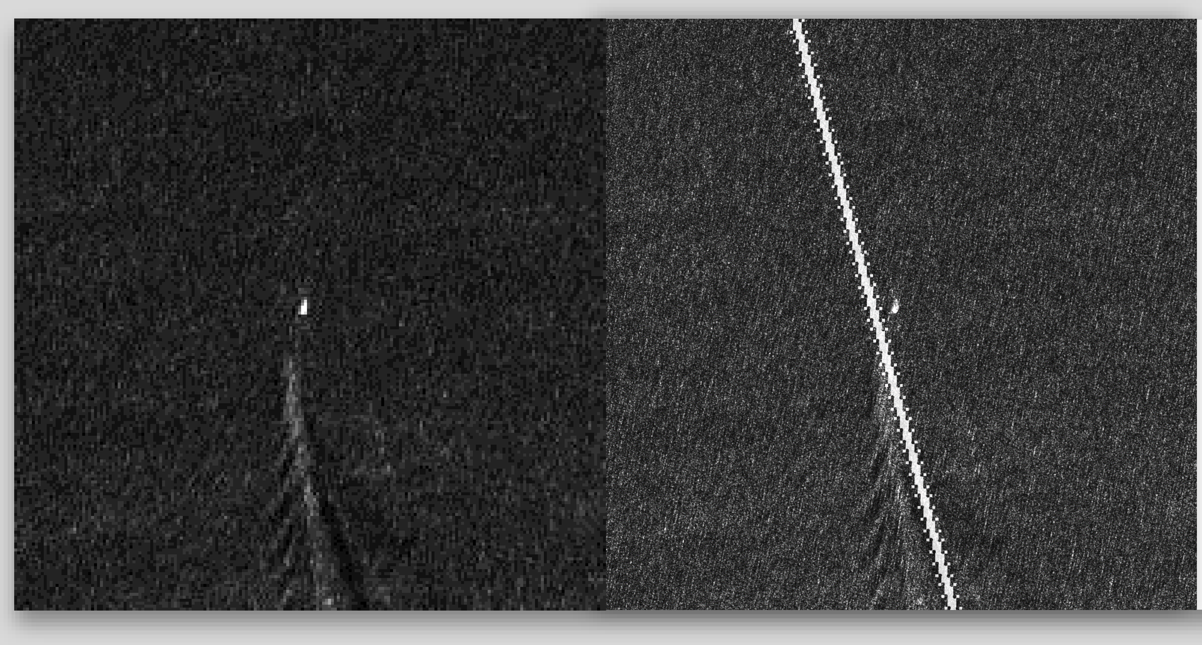
Causality Criterion [4] → divide detected line containing wake → compare pixel distributions → obtain ***K* value**

$$\sigma_{\mu_i} = \frac{\sigma}{\sqrt{n_i}}, i = \{1,2\}, \qquad K = \frac{|\mu_1 - \mu_2|}{\sqrt{\sigma^2_{\mu_1} + \sigma^2_{\mu_2}}} > R(\alpha)$$

μ: mean, σ: standard deviation, n: pixel count, R(α): normal distribution (e.g. R(0.05) = 1.96)



Low ***K*** ⟷ High ***K***



Chip with detected wake mapped back onto it.

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