*Remote Sensing*

Supporting Information for

# Signatures of Breaking Waves in a Coastal Polynya Covered with Frazil Ice: A High-Resolution Satellite Image Case Study of Terra Nova Bay Polynya

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Figures S1 to S6

**Introduction**

This file contains additional figures presenting data used and the results of analysis described in the main paper.

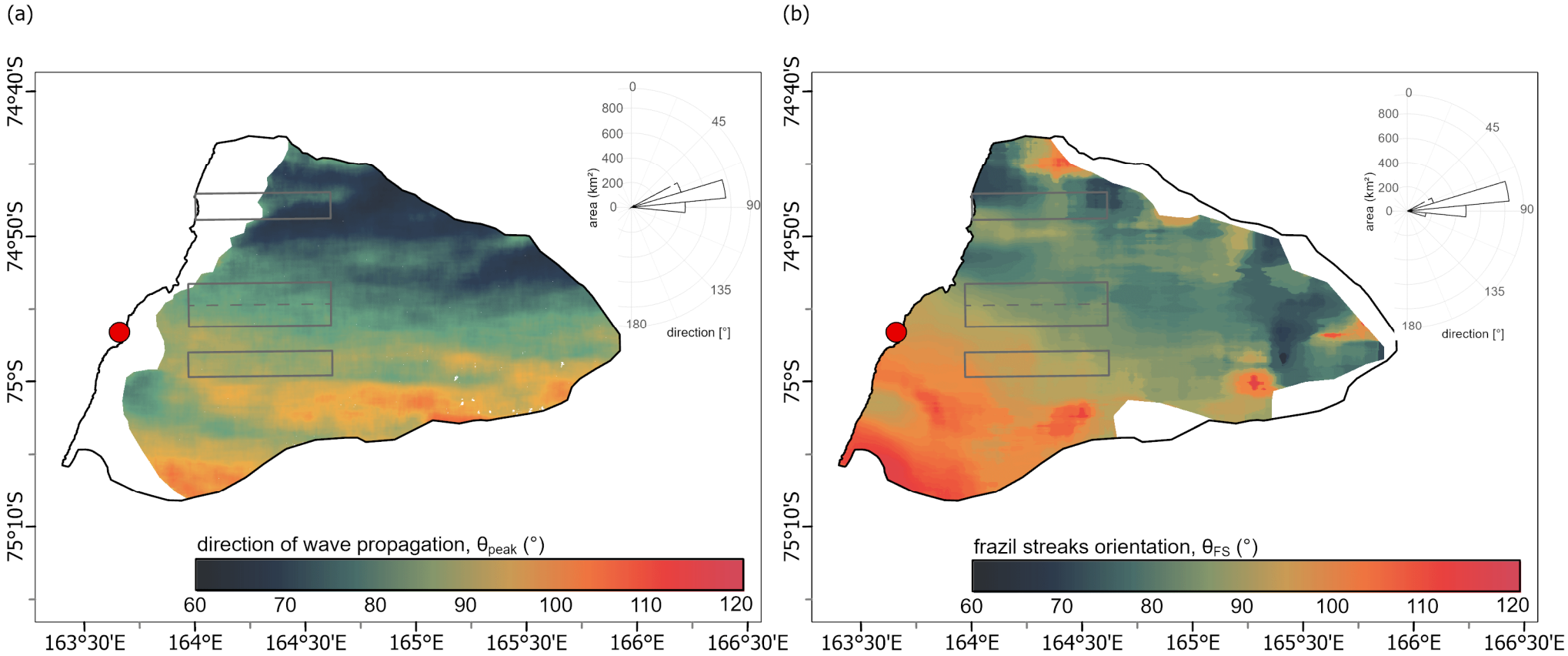



**Figure. S1.** Direction of wave propagation at the peak frequency $\theta_{peak}$ (degrees from the north) (**a**) and frazil streaks orientation, $\theta_{FS}$ (degrees from the north) (**b**) derived from Sentinel-2 satellite data for the polynya event on 19.09.2019, averaged within 5.1 × 5.1 km (512 × 512 pixels) moving windows (Bradtke and Herman, 2023); red dot marks the location of the Manuela weather station and grey outlines show location of analyzed subsets of World View-2 image.

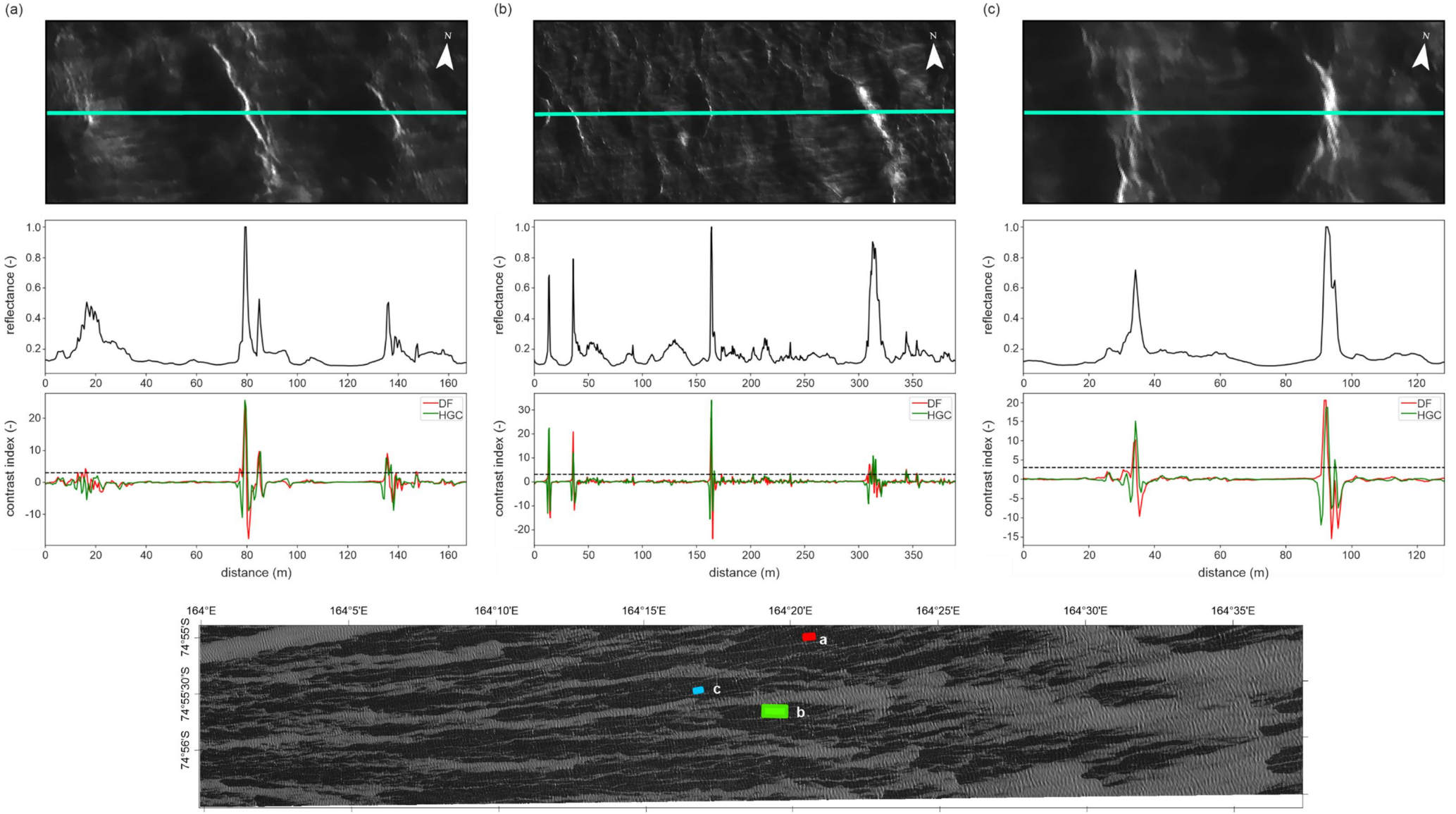



**Figure. S2.** (*Continued on the following three pages*)**:** Examples of reflectance variation and contrast index profiles along selected transects across breaking waves and sea ice features. The top panels show subsets of the WorldView-2 (WV2) panchromatic image (prefiltered using a bilateral filter) with overlaid transect lines (cyan). The middle panels display corresponding profiles of filtered reflectance and two contrast indices calculated along the transects. Both indices derived from reflectance values using, respectively, a directional filter (DF) and Haralick's model of general curvature (HGC). Dashed line represents threshold value of 3.0. The bottom panel presents the satellite image of the entire Ca subarea with the locations of the analyzed transects.

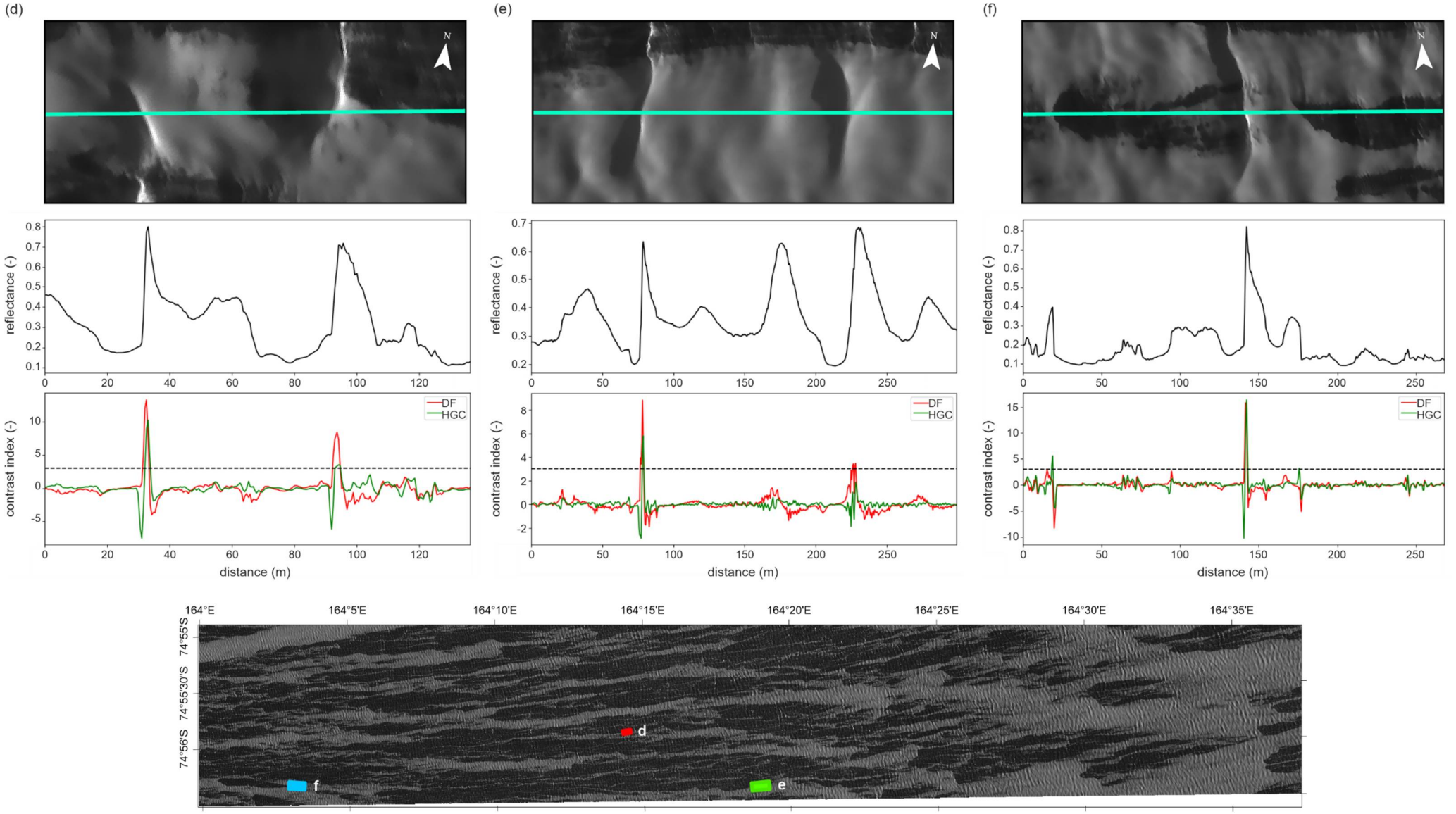
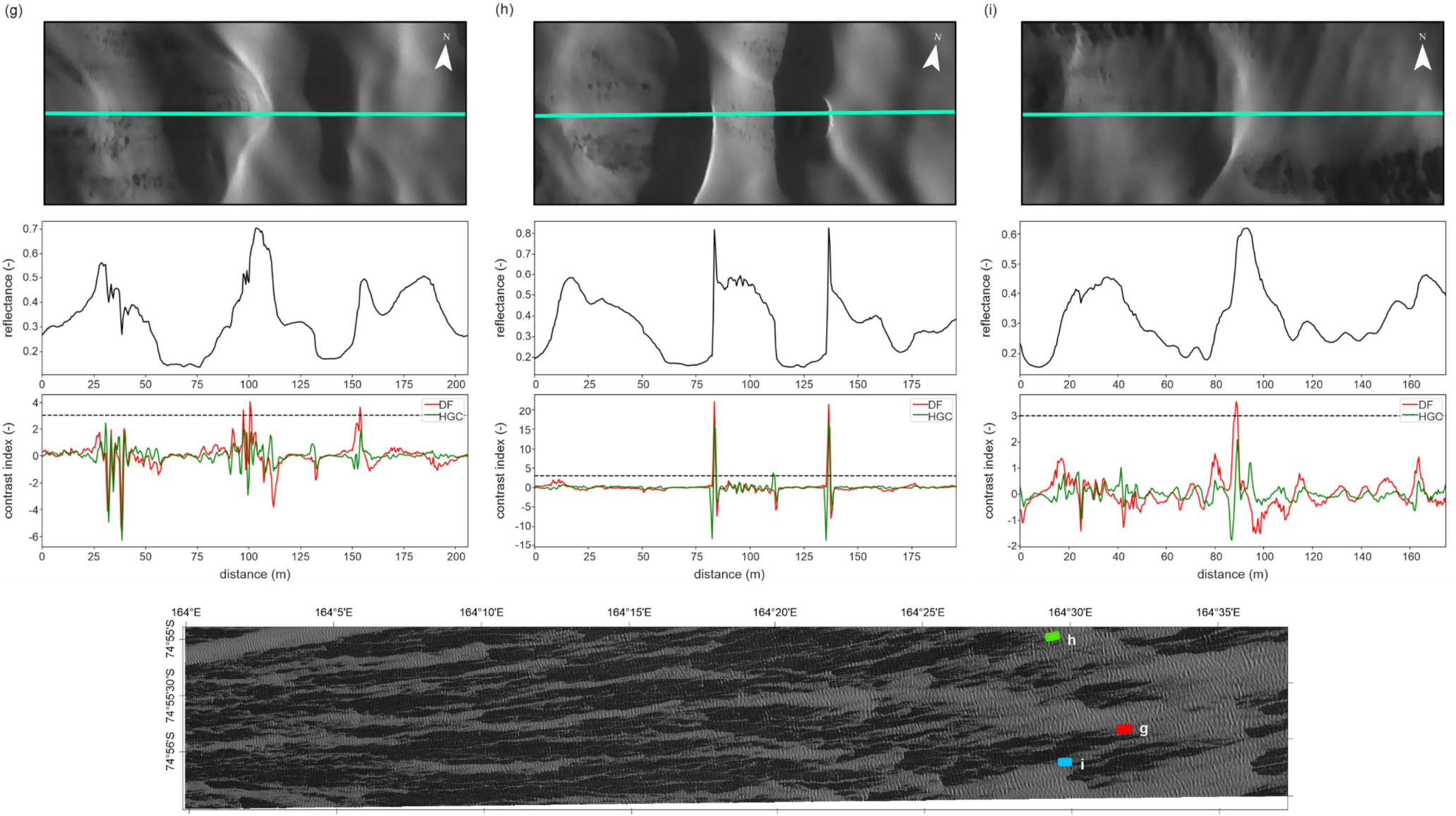



**Figure. S2.** (*continued*)

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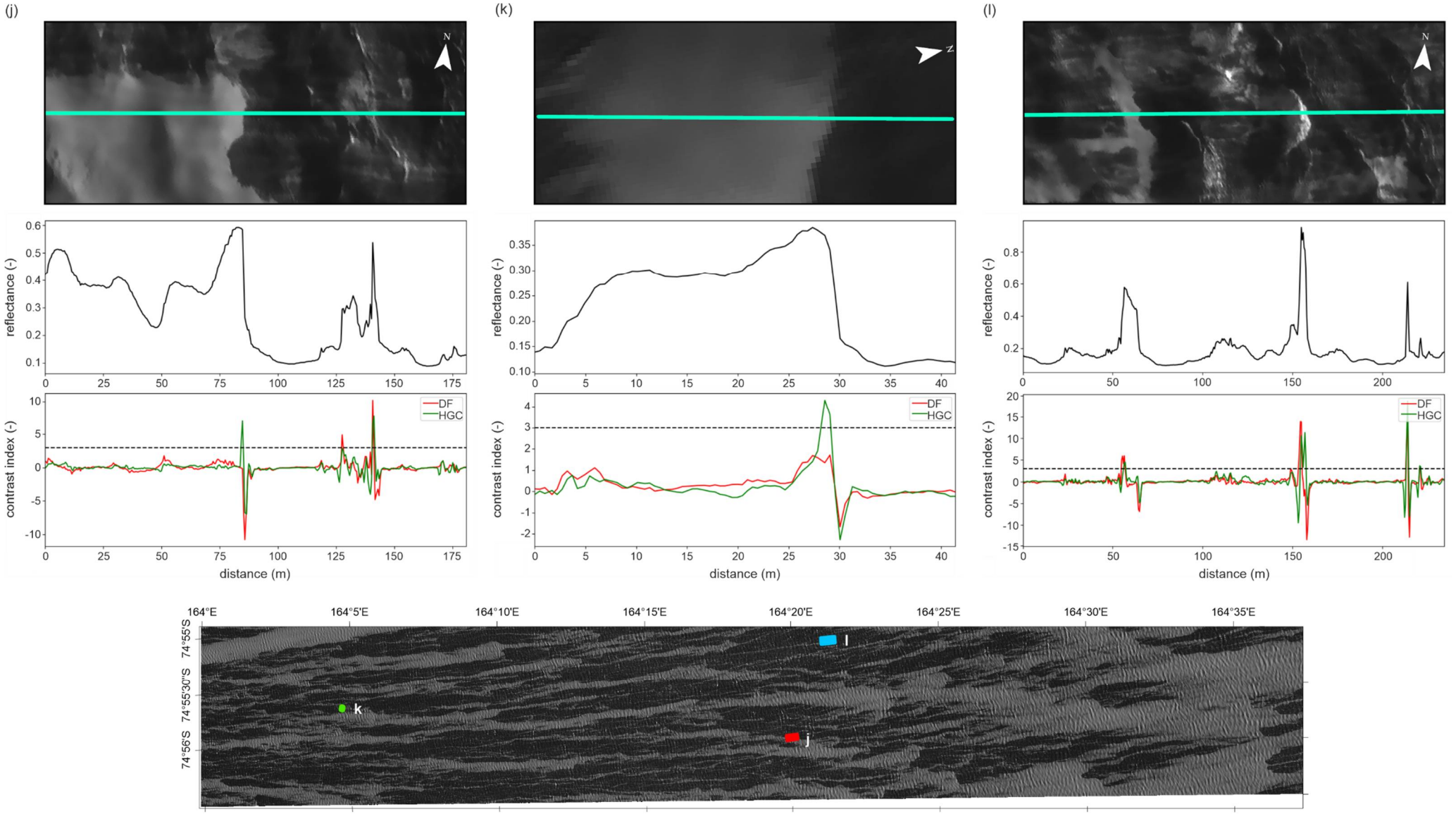


**Figure. S2.** (*continued*)

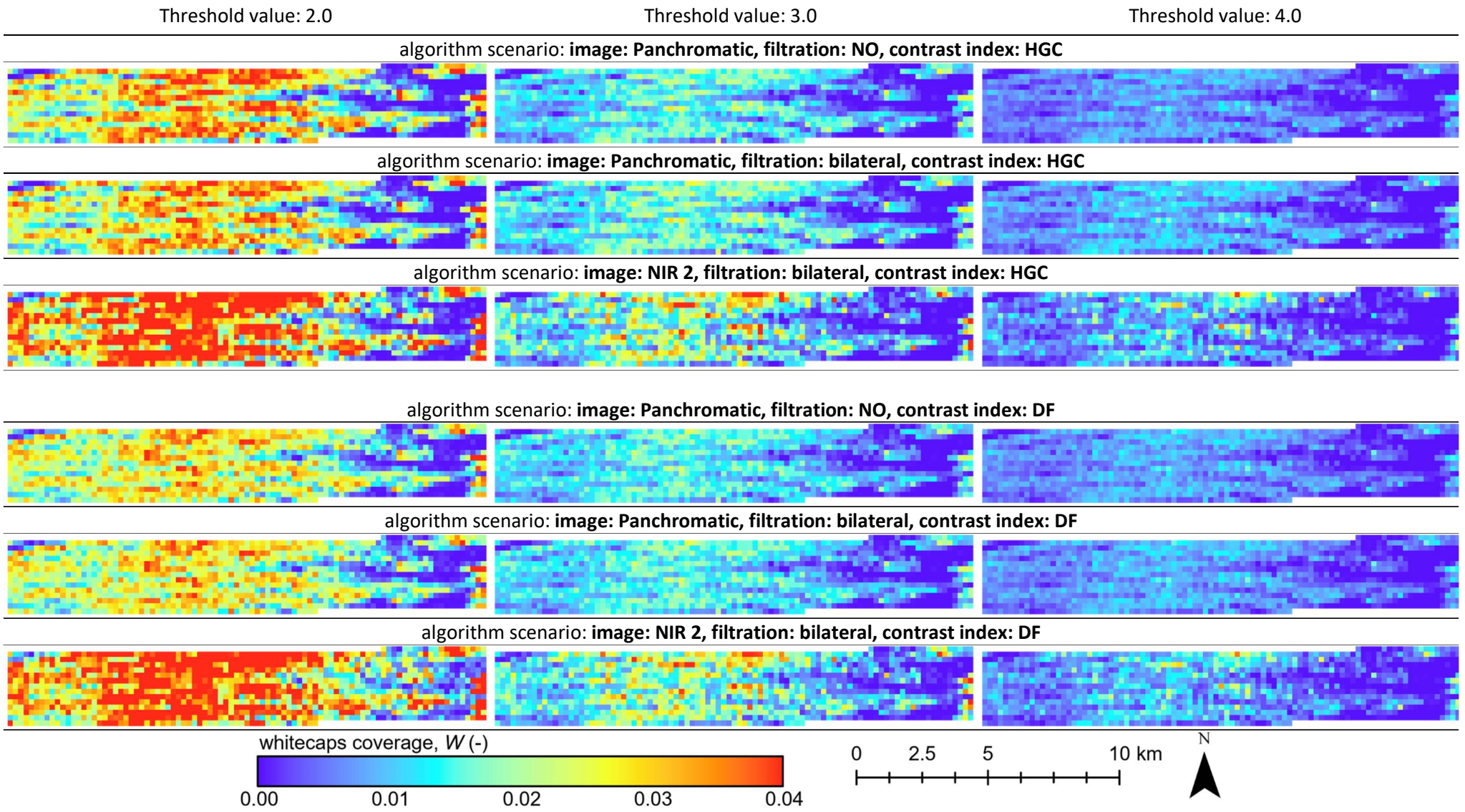


**Figure. S3.** Spatial distribution of whitecap coverage (*W*) in subarea Ca, derived from various algorithm configurations using selected threshold values for contrast index. The scenarios differ by source image type (panchromatic or near-infrared NIR 2), presence or absence of bilateral filtering, and the applied contrast index: either Haralick's General Curvature (HGC) or directional filter (DF). Whitecap coverage was calculated based on pixel fractions within 200 × 200 m blocks.

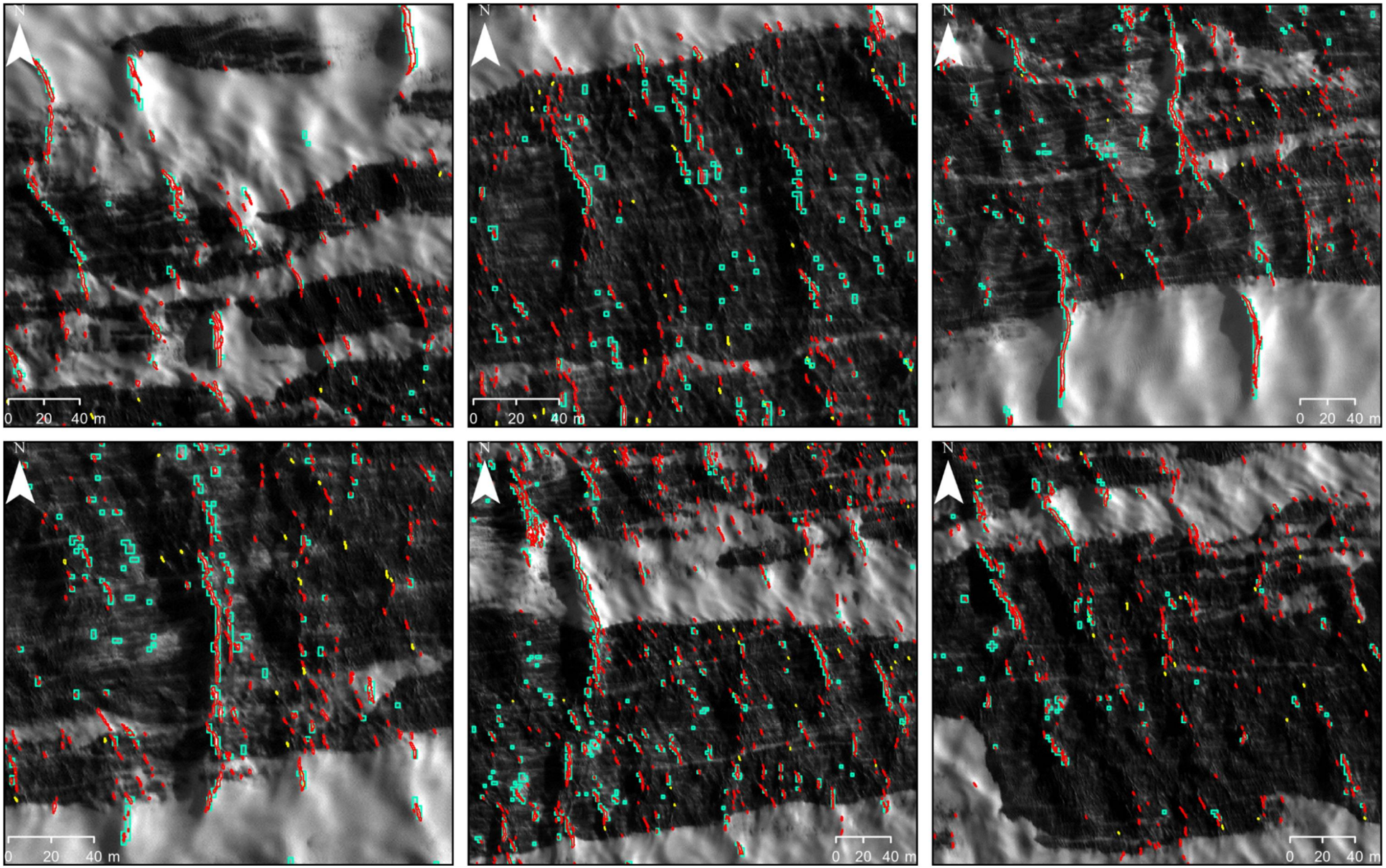


**Figure. S4.** Zoomed fragments of WorldView-2 panchromatic image (Imagery ⓒ 2019 Maxar Technologies) illustrating variability in pixel brightness. Detected breaker outlines are marked in red and cyan, based on filtered panchromatic and NIR 2 images, respectively, using the directional filter (DF) contrast index and threshold value of 3.0. Yellow outlines indicate additional breakers detected only when the PAN image is not prefiltered.

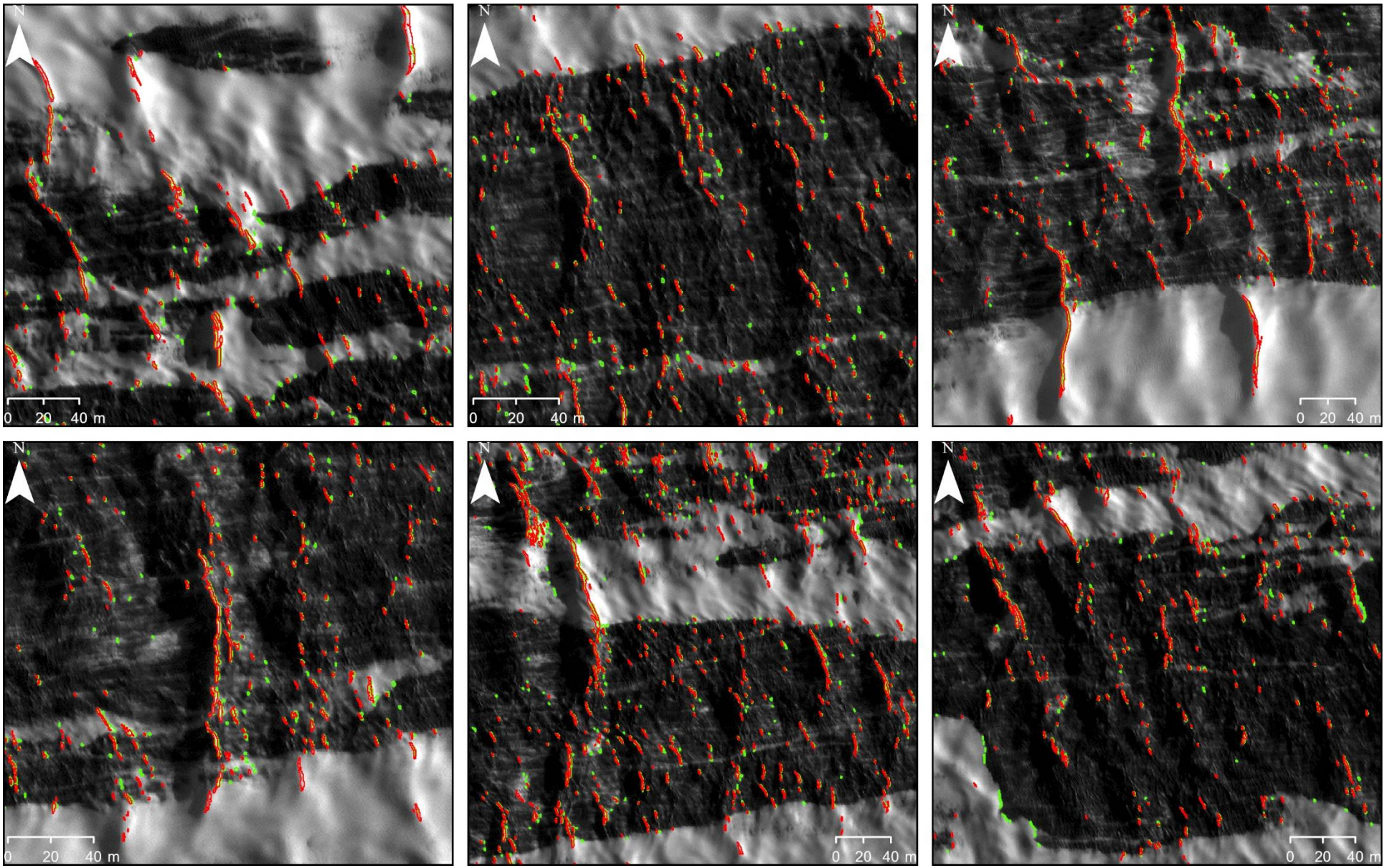


**Figure. S5.** Comparison of breaker detection results using filtered panchromatic image and both contrast indices with a threshold value of 3.0 and additional filtering of objects whose orientation is closely aligned with the wave propagation direction (deviation less than 45°). Detected breaker outlines are marked in red and green, based on DF and HGC contrast indices, respectively. The WorldView-2 panchromatic image (Imagery © 2019 Maxar Technologies) illustrating pixel brightness variability is shown in the background (same fragments as in Figure S4).

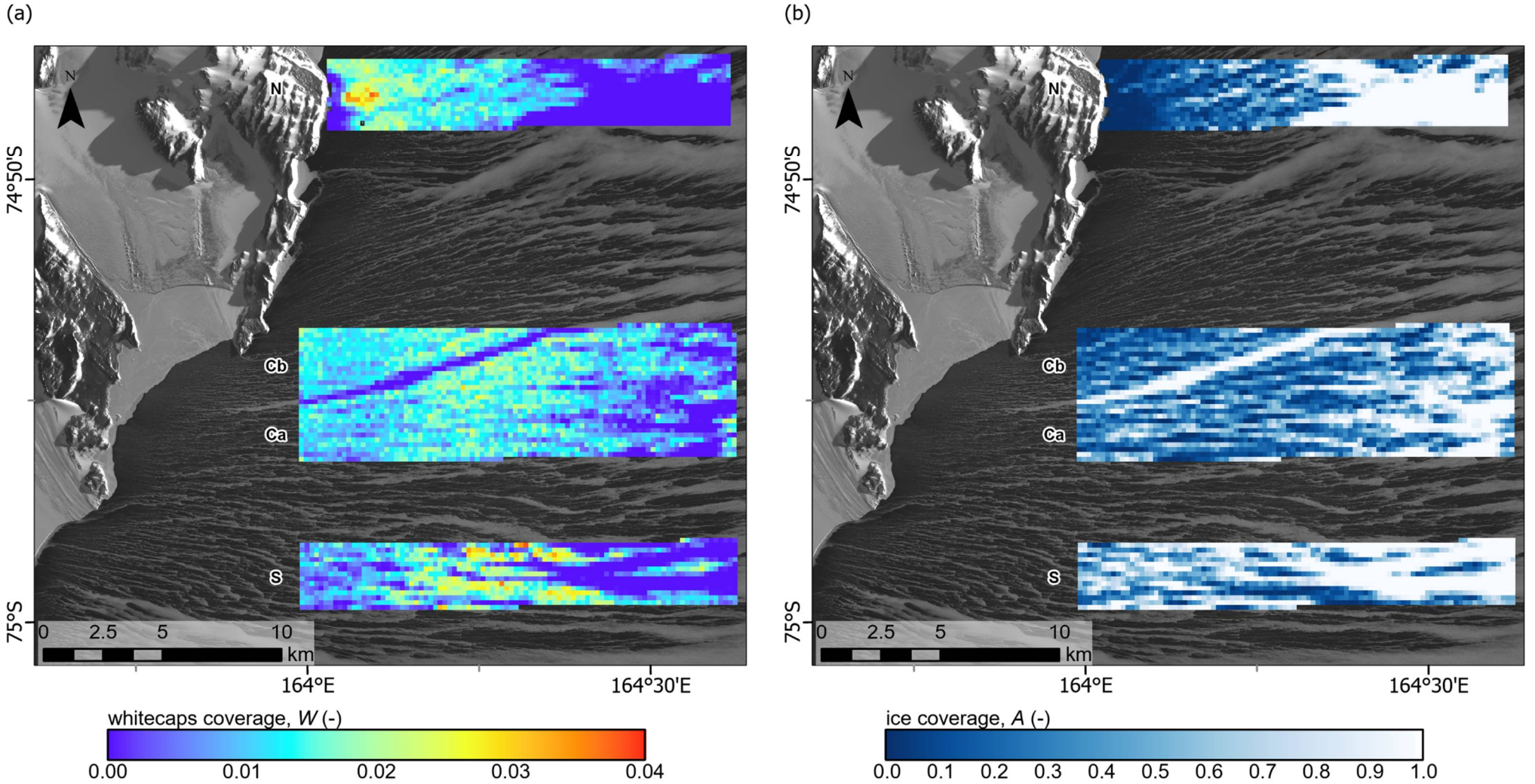


**Figure. S6.** Spatial distribution of whitecap coverage (*W*) (**a**) and ice concentration (*A*) (**b**) across all analyzed subareas. The background shows the Terra Nova Bay Polynya (TNBP) captured in a true color composite from Sentinel-2 imagery acquired on September 19, 2019, at 21:00 (Copernicus Sentinel data 2019). Both whitecap coverage and ice concentration were calculated based on pixel fractions within 200 × 200 m blocks.