

# CASE STUDY A MULTI-SENSOR ANALYSIS OF ICE IN THE BEAUFORT SEA



## Leveraging synergies between RADARSAT-2 Synthetic Aperture Radar and stereo optical 8-band WorldView-2 imagery for sea ice characterization

### The Challenge

A major international oil and gas company seeking new and emerging technologies contracted MDA to perform a detailed characterization of an individual ice floe by comparing data from multiple sensors. The goal was to determine more efficient methods of ice classification using space-based monitoring in Arctic waters for companies planning maritime activities in the

Arctic, to better understand ice behavior. The ability to classify ice types and plan safe navigational routes through these ice infested waters is an area of great interest for companies operating in the region.

Optical satellite data has the capability to provide detailed information about an ice floe and its characteristics. As a long term solution, optical data has operational constraints as cloud cover and darkness impact image usability. Synthetic Aperture Radar (SAR) satellite data can be collected regardless of darkness or cloud, but has historically been used for wide-area, low-resolution imagery collection in the Arctic primarily by national ice centers.

The need to extract more information from satellite imagery is increasing for specific area applications, such as oil and gas operations occurring in the Arctic region. Analysts have explored the use of Quad-Polarized RADARSAT-2 SAR data, as a technique for characterizing ice floe texture. The use of Quad-Polarized data has been successfully shown as an accurate means of assessing and planning ice engineering and navigation requirements in the Arctic, as it removes the impact of darkness and cloud interfering with optical-image usability.

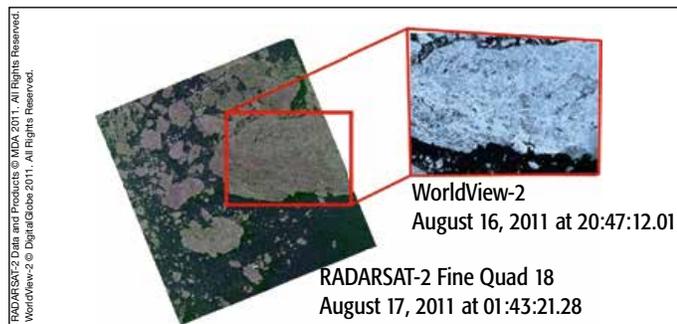
In this study, leveraging the synergies between Quad-Polarized data from RADARSAT-2 and WorldView-2 optical data is being investigated as a new method to provide better detailed information about ice floes.



The Area of Interest is highlighted by the red polygon.

## The Survey

In August 2011, researchers undertook an ice survey on multi-year (MY) ice pack in the Beaufort Sea, using the Canadian Coast Guard Service (CCGS) Icebreaker Amundsen as a mobile base. In collaboration with the 2011 ArcticNet<sup>(1)</sup> research expedition, field data collected by satellites, helicopter surveys, Global Positioning System trackers and in-situ field photographs and measurements supported the examination of ice features and conditions, including thickness and strength. DigitalGlobe's WorldView-2 satellite and MDA's RADARSAT-2 satellite acquired stereo 8-band optical imagery and Quad-Pol 8-metre radar imagery, respectively. Rapid satellite tasking enabled the acquisition of three scenes in five hours over the MY ice while the CCGS Amundsen was on-site.



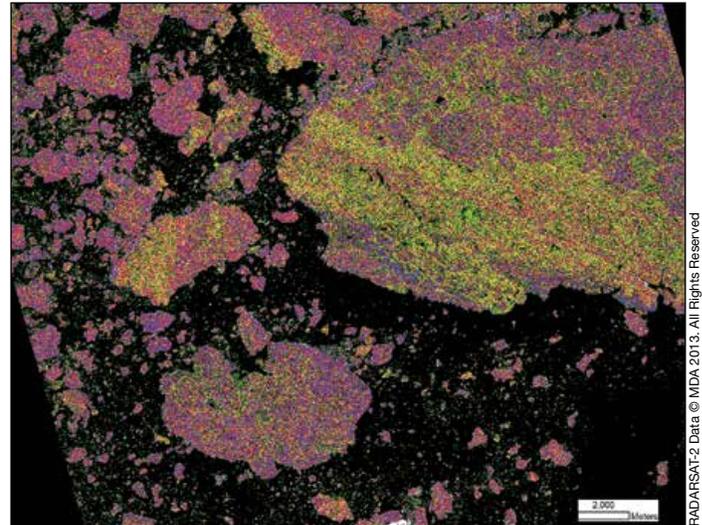
*RADARSAT-2 and overlapping WorldView 2 images (above) were acquired within five hours of each other and used in combination to differentiate between ice features.*

Satellite Sensor	Date	Resolution
WorldView-2 Optical	August 16, 2011	0.50 m
WorldView-2 Optical Stereo Pair	August 17, 2011	0.50 m
RADARSAT-2 SAR Fine Quad-Polarized	August 17, 2011	8.0 m

*Optical and SAR satellite image acquisitions used in the survey.*

## Objective

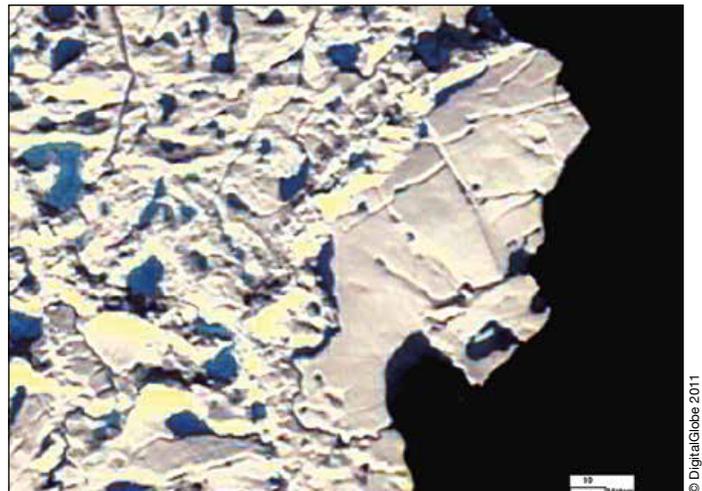
The survey objective was to perform a detailed characterization of an individual ice floe, leveraging synergies afforded by different sensors.



*Classification of the RADARSAT-2 Quad-Pol image. The dark area is water, the coloured areas correspond to different ice thickness, features, and textures.*

## Analysis

Analysts compared the textures and features observed in optical imagery with the groups of the RADARSAT-2 image showing classifications. The detailed information from the stereo optical imagery showed that there were several different ice types within the floe, and included rotten ice, smooth ice, hummocky ice, small ridges, and various combinations of these types. The classes derived from the RADARSAT-2 image were grouped and these groups were consistently associated with the ice features that were identified in the optical image.

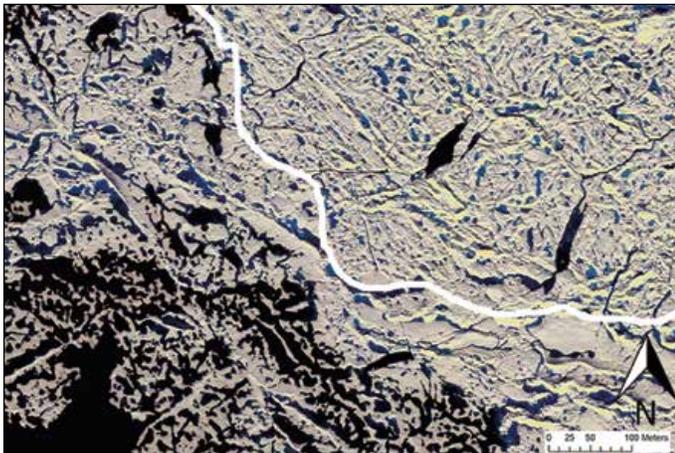


*Detail of different ice types within the floe. The area on the left has hummocky ice, and the area at right has smooth ice. The dark area is open water.*

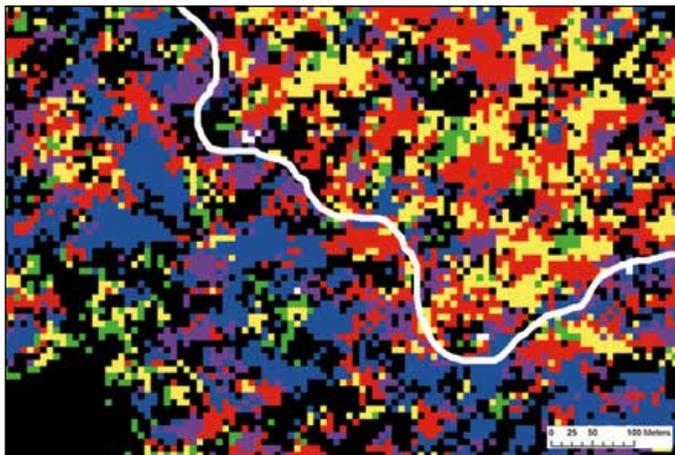
## Methodology

The optical image was analyzed by an experienced ice analyst with the aim to assess the regional and detailed ice features. The RADARSAT-2 Quad-Pol image was classified using the optical image as a means of ground truthing the ice features. The two images below, obtained by WorldView-2 and RADARSAT-2, show similarities in the features that can be used to differentiate ice types. The white line is the demarcation between hummocky ice and smoother ice, but due to differences in resolution, the shape of the white line was not the same for each image. The WorldView-2 image was used as a source of ground truth information to aid with the interpretation and identification of ice features on the RADARSAT-2 Quad-Pol image.

In the next image pair, large features such as the wedge-shaped area of open water and other areas of pooling and ice leads can be easily identified. The ice structure and characteristics observed



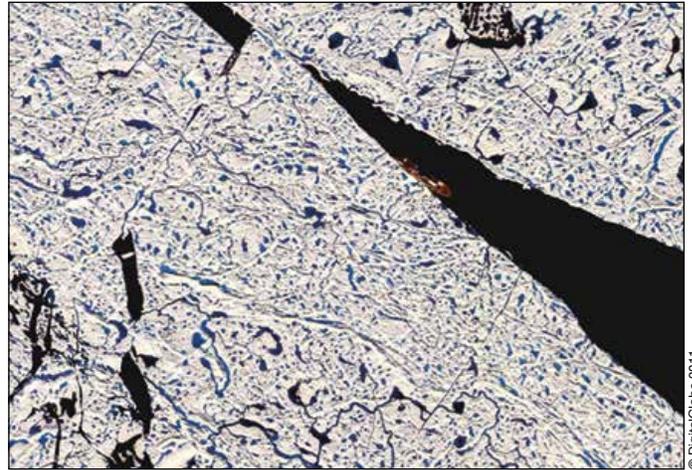
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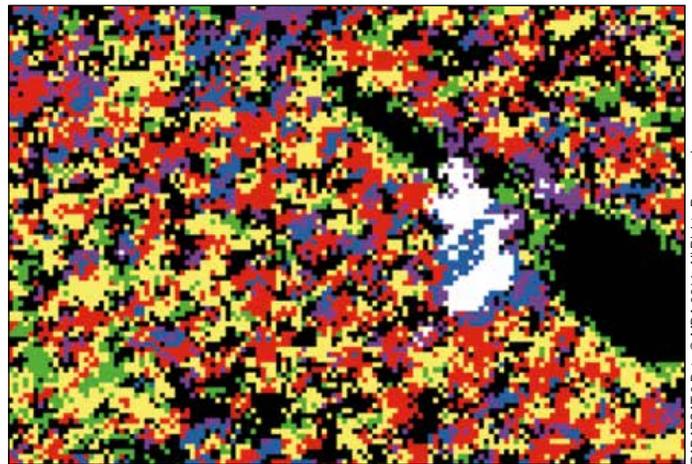
RADARSAT-2 Data © MDA 2014. All Rights Reserved

*Top: Area with both hummocky and smooth sea ice shown in the WorldView-2 optical image. Bottom: RADARSAT-2 output of the same area shown above. The white line in each image shows the approximate contact between the ice types.*

in the optical imagery can be readily identified in the RADARSAT-2 Quad Pol image that is shown below it.



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*Top: WorldView 2 optical image of ship anchored in hummocky ice floe. Bottom: RADARSAT-2 Quad-Pol derived ice classes over same region as the preceding optical image of the ship in sea ice.*

## Conclusion

The combination of optical and SAR imagery explored in the study was used to differentiate ice features. It was determined that several ice features are consistently associated with certain types of textural variation identifiable with the ice classes from the SAR imagery. The results indicate that the combination of the optical data and the RADARSAT-2 SAR data revealed ice information that would not have been apparent from just a single data source. By using the complimentary information from both SAR and optical data, better ice classification can be achieved to support planning navigational routes. With additional research, it is expected that RADARSAT-2 Quad-Pol imagery will yield sufficient data in times when optical data are not available.

## Survey Participants

The Beaufort Sea Ice Study was a collaborative effort, performed by the following companies:

- MDA
- ExxonMobil Upstream Research
- Isaacs Consulting
- Brovey & Associates Geoscience Imaging LLC

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### *References*

*(1) <http://www.arcticnet.ulaval.ca>*