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Very-High-Resolution Image Acquisition Over Arctic Sea Ice Using Multiple Remote Sensing Platforms

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ABSTRACT

Remote sensing of arctic sea ice provides useful information on the status of sea ice such as concentration, extent, motion and surface composition. Very-high-resolution (VHR) imaging acquiring the images with a spatial resolution from few meters to few centimeters has become available from various remote sensing platforms. In this study VHR image acquisition over arctic sea ice using multiple remote sensing platforms, and image processing protocols for extracting information from the acquired images are demonstrated. The VHR images and products from the images can be applicable to validate sea ice concentration and motion data from coarse resolution remote sensing data, and can be used as an alternative reference data decreasing requirements for in-situ measurements. Furthermore, the VHR images can support safe research activities using icebreaker research vessel by providing the sea ice condition around the vessel.

KEY WORDS: Sea ice, Remote sensing, Very-high-resolution, Satellite image, Arctic ocean

INTRODUCTION

Sea ice and its temporal changes have been observed to understand dynamic climate system and to predict long-term changes, and low-resolution satellite remote sensing with a spatial resolution of 1 km or larger pixel size has provided useful information on the status of sea ice such as concentration, extent and motion (e.g. Heil et al., 2001, Holland and Kwok, 2012, Vincent et al., 2001). Relatively higher spatial resolution satellite remote sensing has been rarely used for the sea ice observation. Recently, very-high-resolution (VHR) imaging acquiring images with a spatial resolution from few centimeters to few meters has become available from various remote sensing platforms, e.g., satellite, helicopter and unmanned aerial vehicle. This study presents the feasibility of the VHR image acquisition over arctic sea ice using multiple remote sensing platforms, and image processing protocols for extracting information from the acquired images.

VERY-HIGH-RESOLUTION IMAGE ACQUISITION USING HELICIPTER

The VHR images over the arctic ocean were captured by helicopter camera on Aug 16, 2016 during 2-day sea ice camp supported by Korean icebreaker research vessel Araon. The geographical coordinates of the position of camera at each imaging site were recorded using GPS logger. The images were preprocessed and mosaicked using structure-from-motion (SfM) technique. The processing chain consists of image alignment, extraction of the dense cloud from overlapping regions between images, generation of a digital elevation model from the dense cloud, and mosaicking the orthorectified image. Detailed surface features of surrounding sea ice are clearly visible in the mosaicked image using 449 photos (Figure 1). The mosaicked photo includes target melt ponds for in-situ scientific activities with sufficient details and shows small-scale morphological features of sea ice around the icebreaker.

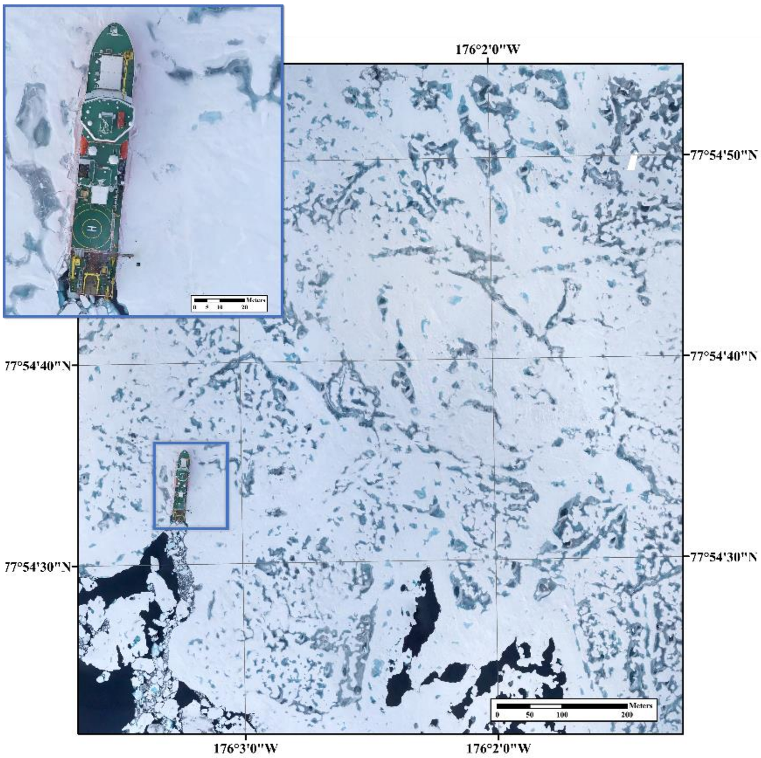

Figure 1. Arctic sea ice and Korean icebreaker research vessel Araon captured by helicopter during sea ice camp

VERY-HIGH-RESOLUTION IMAGE ACQUISITION USING SATELLITE

Sea ice motion from low-resolution satellite sensors (e.g. passive-microwave sensor and Advanced Very High Resolution Radiometer (AVHRR) sensor) with feature tracking methods, e.g. maximum cross-correlation (MCC), has been widely used to monitor changes in sea ice covers (e.g. Ninnis et al., 1986, Emery et al., 1991, Lavergne et al., 2010). This study presents measuring arctic sea ice motion using high-resolution optical satellite images acquired on August 2014. The high-resolution optical images were obtained from Korea Multi-Purpose Satellite-2 (KOMPSAT-2) and Korea Multi-Purpose Satellite-3 (KOMPSAT-3) with 1.0 m spatial resolution panchromatic (PAN) band and 4.0 m spatial resolution multi-spectral (MS) bands and 0.7 m spatial resolution PAN band and 2.8 m spatial resolution MS bands, respectively. The study area was around 77°20′N, 146°10′W in the Beaufort Sea.

The sea ice motion was retrieved using the MCC strategy, an automated block-based motion estimation technique by repeatedly evaluating the correlation between two image templates, i.e., reference block and candidate block. The velocity vector (or motion vector) can be calculated by measuring the displacement and the time gap between the two images. The motion measuring results can be represented as displacement vectors (Figure 2). The measurement results were able to be assessed by comparison with the track of the drifting buoy locating in the satellite images.

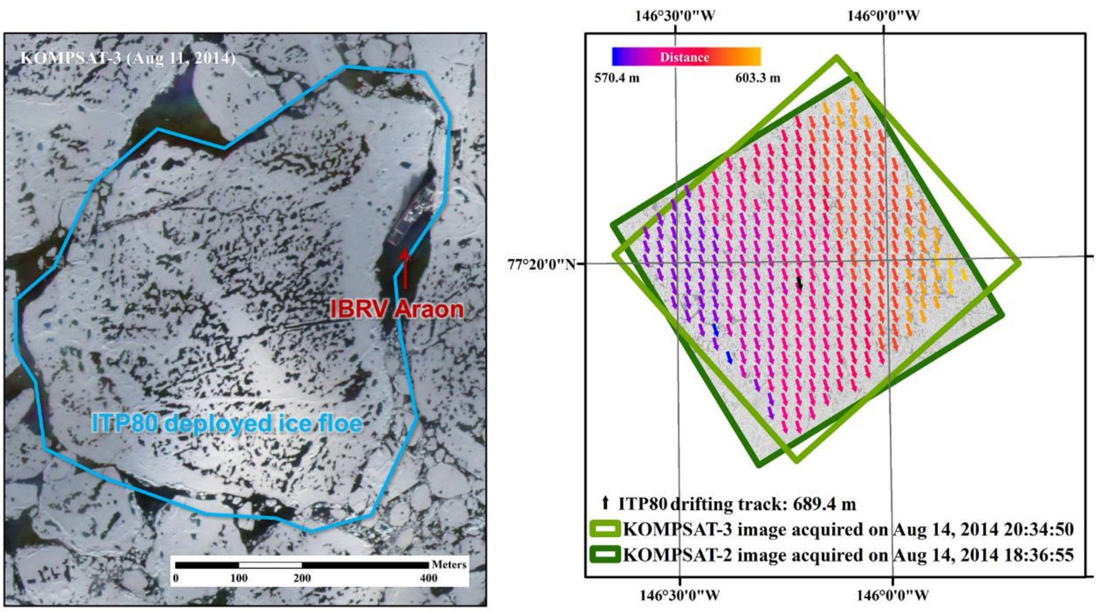

Figure 2. Arctic sea ice and Korean icebreaker research vessel Araon captured by satellite, and an example of the sea ice motions extracted from sequential VHR satellite images

The sea ice motions extracted from the sequential VHR satellite images are applicable to fill the gaps between sparse buoy data and the motions from low-resolution satellite data, so this sea ice motion from the high resolution optical satellite images can be used to expand reference dataset for arctic sea ice motion data validation.

CONCLUSIONS

The VHR image acquisition over arctic sea ice using multiple remote sensing platforms, and image processing protocols for extracting information from the acquired images are demonstrated. The VHR images and products from the images can be applicable to validate sea ice concentration data from coarse resolution remote sensing data and can be used as an alternative reference data decreasing requirements for in-situ measurements. Furthermore, the VHR images can support safe research activities using icebreaker research vessel by providing the sea ice condition around the vessel.

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