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How the drainage of melting ponds leads to cracks? - Evidence revealed from Formosat-2 high spatiotemporal optical images of Ward-Hunt Ice Shelf, Summer 2008

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For years, formation and extinction of melting pond have been regarded as one of the main precursors to the "rapid" disintegration of large ice shelves. Many models of calving and crack propagation have been proposed in regard with melting ponds as well. However, the existing spaceborne sensors all have constraints over the Polar Regions. Narrow cracks and their propagation are not easily observed and measured, and the area change of many small melting ponds is easily under-estimated. Formosat-2 is able to provide high spatiotemporal imagery of the Polar Regions, which provides an ideal source of data to investigate the rapid disintegration caused by tiny cracks and melting ponds over the ice shelves.

In this research, we compiled a series of Formosat-2 time-sequential (16 scenes) and high-spatiotemporal (daily revisited orbit; 4 multispectral bands with 8 m, plus 1 panchromatic with 2 m) optical imagery of the Ward-Hunt Ice Shelf (WHIS) taken in the summer of 2008. Sea ice and open regions were masked prior to semi-automatic warping, minimizing errors of change detection. Fifteen out of sixteen scenes of multi-temporal imagery (from June 5th to August 30th, 2008) have been spatially co-registered with the base of the middle date (July 28th). A total of 16 sub-sets were intensively investigated, including the calved (ice island A and B, separated on July 24 and July 26 respectively) and non-calved coastal areas (in the North-eastern coast of WHIS), the southern calved coast, the crack complex in the south of Ward-Hunt Island (WHI), and other typical undulated ice shelf regions. Finally, length of cracks and area of melting ponds in the sub-sets were carefully extracted, estimated and assessed.

The results show that a series of melting ponds drained and rifts formed and propagated consequently at various scales in most regions of WHIS. In addition, in some coastal areas, drainage of melting ponds is also highly related to the process of calving events. In conclusion, the propagation of the rifts (length) was highly correlated with the abrupt decreasing of the area of melting ponds, especially in the coastal areas. Capability for change detection over cracks and melting ponds with small scale would enhance the understanding of their impacts to ice shelves.