Ward Hunt Ice Shelf, Ellesmere Island, Nunavut, Canada: Change Detection With Real and Synthetic Aperture Radar Since 1981

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Background
(some ancient history)

Drilling platform in the Beaufort Sea

Ice island (iceberg)
Seasat SAR image of Fletcher’s Ice Island, T-3, ~ 5 km x 10 km.

3 October 1978.

L band, $\lambda = 235$ mm, swath width 100 km.
Airborne Real Aperture Radar Images
The Ward Hunt Ice Shelf

X band, $\lambda = 32.5$ mm

1: Hobson’s Choice Ice Island
The origin of the ribbed texture in radar images of the Ellesmere ice shelves and ice islands.

Rolling topography of ridges and troughs, $\lambda = \sim 250$ m.

Origin of the rolls? Uncertain.
Airborne X band real aperture radar, September 1981. Spatial resolution, ~200 m.

RADARSAT-1 C band synthetic aperture radar, 30 August 2002. Fine beam mode, spatial resolution ~ 12.5 m, \( \lambda = 57 \text{ mm} \).

RADAR Imaging: The Old & The New
Ice Island
Calving, August 2002

~ 6 km² of ice shelf &
~25 km² of multiyear landfast sea ice.

RADARSAT-1 Standard Beam
Ward Hunt Ice Shelf & Disraeli Fiord

Area: ~440 km², the largest ice shelf in the Arctic (Barbados, 432 km²; Grenada, 341 km²).

Origin: sea ice.

Age: 3000-4000 y.

RADARSAT-1 Standard Beam sub-scene, ~ 55 km wide 26 May 1998
Why is there strong backscatter from Disraeli Fiord?

The ice shelf acts as a hanging dam that impounds snow and ice meltwater behind it in an epishelf lake. The ice on Disraeli Fiord grows from freshwater, i.e., it is lake ice. Hence the strong backscatter/bright signature.
The Backscatter From The Disraeli Fiord Ice Cover Changed In Early 2002

RADARSAT-1 ScanSAR sub-scenes

Why?
It seems unlikely that the ice shelf thinned by 25 m in 12 months.

How do we explain the catastrophic drainage of the epishelf lake?

3.5 km$^3$ of freshwater lost, 1999-2002
The Ward Hunt Ice Shelf Cracks Up

A serpentine fracture began to appear in April 2000.

By July 2002 it was fully developed and extended from the southern to the northern edge, and from the top to the bottom of the ice shelf.

The epishelf lake drained via the serpentine crack.
Fractures in the Ward Hunt Ice Shelf
Epishelf Lakes of Northernmost Ellesmere Is.

RADARSAT-1 ScanSAR sub-scene
5 December 2001, ~200 km wide

Arctic Ocean

Ayles Fiord
Milne Fiord
McClintock Inlet
Disraeli Fiord
Alfred
Ernest
Bay
Yelverton Inlet

“… significant hydrographic changes at these locations might be detected by changes in backscatter from the ice. For example, if an ice dam failed and the stratification broke down … the SAR signature of the ice would become darker as the ice began to grow from seawater or brackish water.” [Jeffries, 2002: USGS Satellite Image Atlas of the World - North America].
Meanwhile …… back in Alaska

Mentasta Lake

RADARSAT-1
ScanSAR
sub-scenes,
~6 km along bottom

26 October 2002
Before

Magnitude 7.9 earthquake,
3 November 2002

12 November 2002
After