Earth Sciences Sector

Reducing Canada's vulnerability to climate change

Past, Present and Future Role of RADARSAT in Polar Science and Climate Change

Laurence Gray and Naomi Short

RADARSAT-1 has provided a wealth of operational and scientific information on the Earth's polar regions. Data have been used for sea ice reconnaissance and dynamics, and to map and determine the motion and mass balance of glaciers and ice sheets. The Antarctic Mapping Mission provided the first high resolution map of the entire Antarctic continent as well as the first large scale picture of ice movement. Results from SAR interferometry have led to the discovery of new tributaries and ice streams, improved mapping of ice shelf grounding lines, more reliable estimates of mass balance and hence better estimates of Antarctic contributions to sea level rise. A new three-dimensional InSAR technique, see below, illustrates the unique potential of RADARSAT-2 to add to this body of knowledge.

RADARSAT-1 in the Arctic

RADARSAT-1 interferometry is also providing the first large scale views of ice dynamics in the Canadian Arctic. Results from SAR interferometry show that high Arctic glaciers flow considerably faster and with a higher frequency of surging than previously thought. Figure 1 shows the sites studied using RADARSAT-1 interferometry. Figures 2 and 3 show the results from two of the most dynamic Arctic glaciers.

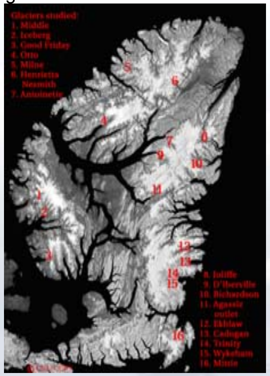

Figure 1. Canadian high Arctic with sites studied using RADARSAT-1 interferometry

Figure 2. Surface velocities of Mittie Glacier

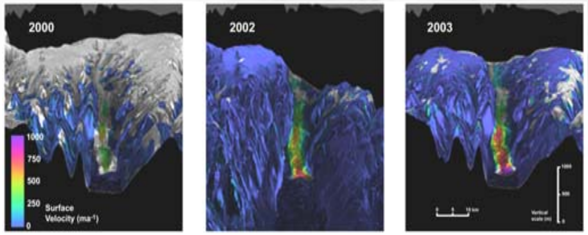

Figure 3. Velocities of Otto Glacier showing the progression of a surge cycle

Using estimates of accumulation, ablation and ice thickness from field work, it is possible to estimate the theoretical glacier velocity required to maintain equilibrium. Table 1 lists some of these 'balance velocities' and the corresponding measured velocities. In several cases glaciers seem to be losing mass at a rapid rate.

Table 1. Balance and measured velocities of selected Arctic glaciers

Glacier	Balance velocities (ma^{-1})	Measured velocities (ma^{-1})	Rate summary
Otto	21- 48	40 -122	Losing mass at 3 to 6 times the rate of accumulation
Canon	100	72 - 91	Balanced, perhaps slight growth of glacier
Middle	11-22	35 - 108	Losing mass at 3 to 9 times the rate of accumulation
Good Friday	8	17 - 49	Losing mass at 2 to 6 times the rate of accumulation
Milne	25 - 48	25 - 53	Balanced

This massive rate of ice loss may not be climate induced but rather it could be a result of cyclical glacier surging, a phenomenon which is not yet well understood. This surging behavior is being investigated because it will need to be accounted for in any models of cryospheric response to climate change, and in the interpretation of the new altimeter data from CRYOSAT and ICESAT.

RADARSAT-1 and Glacier Surging

To further investigate ice flow and surging behavior, we are using data from overlapping ascending and descending interferometric pairs for three-dimensional ice motion. Initial results show discrete areas with vertical motion that is much larger than would be expected from normal down-slope ice movement. Figure 4 is an image of vertical displacement over an ice stream in Antarctica, a distinct area of surface subsidence is clearly visible. Tentatively, we attribute this subsidence to the sudden movement of pockets of subglacial water. These results have important implications for the study of surging motion and ice mass stability, particularly in West Antarctica.

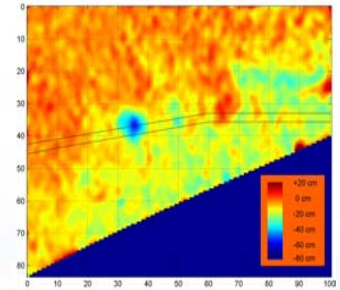

Figure 4. Vertical displacement over the RADARSAT-1 repeat cycle of 24 days for an area of an Antarctic ice stream.The distinctive blue blob, which is ~100 km^2, represents surface subsidence of up to 50 cm.

It is expected that RADARSAT-2 with its fine spatial resolution and left- and right-looking modes will enable many more sites to be studied, and in greater detail. In particular, more complete measurement of three-dimensional motion will be possible. Other techniques, which to date have only been possible in the Antarctic, will hopefully become possible for the Arctic. Results will add considerably to our growing knowledge of polar ice dynamics and hence to our understanding of the interactions of ice masses and climate.

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