ICE MOTION OF ANTARCTIC PENINSULA OUTLET GLACIERS ABOVE LARSEN ICE SHELF OBSERVED BY TERRASAR-X IMAGE TIME SERIES

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ABSTRACT

The northern sections of Larsen Ice Shelf on the Antarctic Peninsula have been subject to accelerating retreat due to climate warming since several decades. The retreat culminated in the collapse of the two northernmost sections, the Larsen-A and Prince Gustav Channel (PGC) ice shelves in January 1995, followed by a major disintegration event of the Larsen-B Ice Shelf in March 2002. The response of the tributary glaciers after ice shelf disintegration is of great interest for estimating climate change impacts on sea level rise. Detailed studies of glacier flow were performed for the glaciers above the previous Larsen-A and PGC ice shelves, based on 24 hour interferometric repeat pass data of the ERS-1/ERS-2 tandem mission from the years 1995 to1999 [1]. These data revealed the first evidence on major acceleration of the glaciers, leading to increased calving of grounded ice. Because the backscatter signal decorrelates rapidly on glaciers and ice shelves of this region, InSAR could not be applied later on for mapping glacier motion because of the longer SAR repeat pass intervals. Image correlation techniques with Envisat ASAR amplitude images and optical images could be applied to map the motion of the large outlet glaciers above Larsen B. However, these motion maps lack the detail of the interferometric analysis, and the method could not be applied at the fast-flowing narrow outlet glaciers. The situation changed with the launch of TerraSAR-X in June 2007, providing excellent new opportunities for detailed mapping and monitoring of glacier flow.

Time series of TerraSAR-X images in stripmap mode with 30 km swath width and a spatial resolution of about 3 meters were acquired over the main outlet glaciers above the previous Larsen-A and Larsen-B ice shelves. Image correlation techniques, employing amplitude features, are applied to map the fields of ice motion. The method provides the range and azimuth components of the velocity vector. Other advantages compared to interferometry are the uniqueness of the results (no phase unwrapping is required) and no need for phase coherence. Due to the high spatial resolution of TerraSAR-X data good accuracy is achieved in the ice motion analysis. A precondition of the non-coherent technique is the availability of amplitude features. On the ice streams at the Antarctic Peninsula this condition is well met, as crevasses, drainage features and melt patterns (in melting or refrozen state) provide distinct surface patterns well visible in the high resolution X-band SAR images throughout the year.

A series of 23 TerraSAR-X 11-day repeat pass images was acquired between October 2007 and September 2008 over Drygalski Glacier. This has been the main tributary glacier to the previous Larsen-A Ice Shelf, covering 1050 km2 in area. The analysis of the ERS-1/-2 tandem interferometric data of the years 1995 and 1999 revealed significant acceleration of this glacier after the collapse of Larsen-A [1]. The TerraSAR-X data show that the accelerated ice flow is still maintained 13 years after the collapse. The ice export exceeds about five times the accumulation, contributing to major thinning of the glacier. A seasonal pattern of ice export is apparent which is linked to the existence of fast sea ice in front of the glacier. Similar magnitudes of ice flow acceleration are observed for the main glaciers above the previous Larsen-B ice shelf, including Hectoria- Green- Evans-glaciers, Crane Glacier, Jorum Glacier and several of the smaller glaciers. The motion fields derived from TerraSAR-X data in comparison to previous ice motion analysis from ERS tandem InSAR data point out that these outlet glaciers are greatly out of balance, resulting in increased ice export since the ice shelf disintegration that contributes to sea level rise.

[1] H. Rott, W. Rack, P., Skvarca and H. de Angelis. “Northern Larsen Ice Shelf, Antarctica: further retreat after collapse” *Annals of Glaciology*, Vol. 34, pp. 277-282, 2002.