SAR DATA EXPLOITATION FOR MONITORING ANTARCTIC ICE SHEETS AND GLACIER

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Abstract

Change in volume of the Antarctic ice sheet is a relevant control on global mean sea level, while ocean circulation patterns are influenced by cold bottom waters formed by interactions between the ice shelves and ocean and hence affecting the earth's climate. In this context the movement of the ice shelves is an important parameter for the estimation of the ice mass balance. Interferometrically processed ERS-1/-2 SAR data from the Ice phases and Tandem Mission are used to derive velocity fields from the surface of the ice shelf Ekströmisen (71°S, 9°W, 8700 km²).

Keywords: Glaciology, SAR-Interferometry, ice shelf, ice movement, Antarctica, Ekströmisen

Introduction

On ice shelves such as the Ekströmisen the interferometric phase derived from repeat pass SAR data includes topography and motion of the surface during the acquisition periods, both influenced by tidal variations.

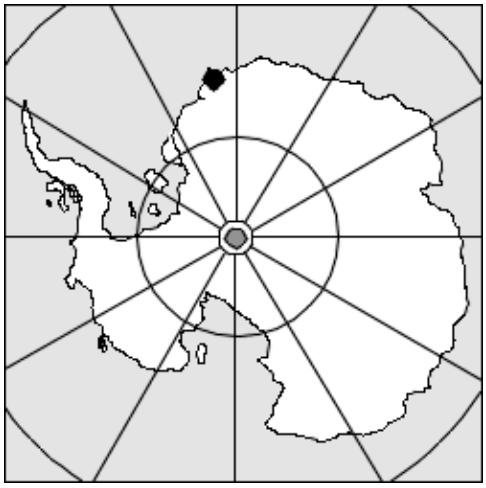
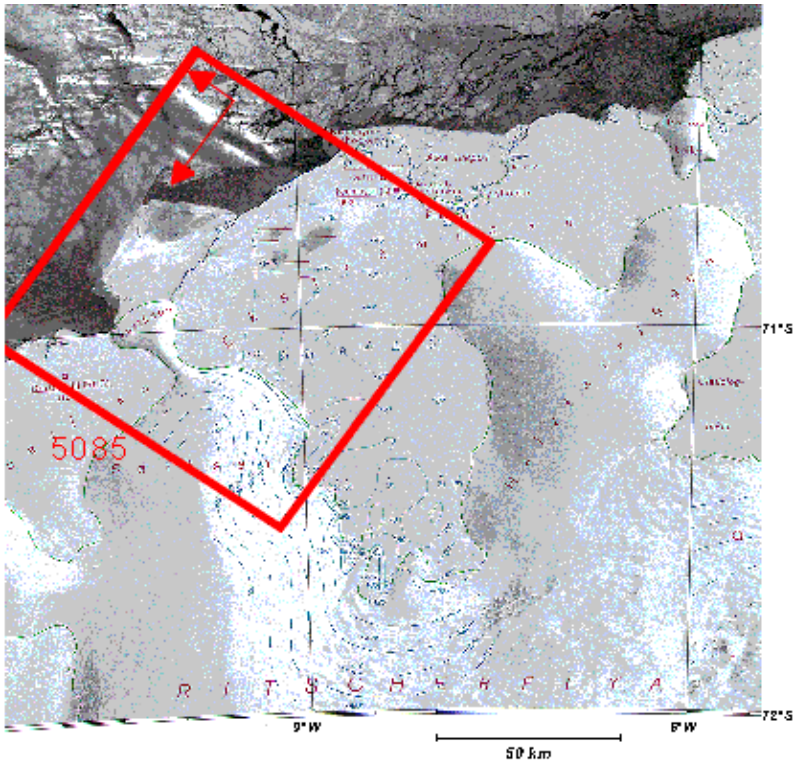


Figure 1: Antarctica. Investigation Area Ekströmisen (71°S, 9°W).

This means that interferometric data processing (e.g. double differencing, cf.References) for the isolation either of topography or ice shelf motion, which usually does not vary in time, will result in uncorrect estimations. As a first step it is necessary to determine the tidal movement of the ice shelf between SAR observations. This must be done for the whole surface, because ice shelves are elastic bodies and the tidal influence differs from point to point. The resulting tidal information can then be used to generate synthetic fringes of this vertical motion in order to eliminate them from the interferometric phase. Digital elevation models (DEM) or surface motion can then be extracted.

Data Processing

From the ERS-1 phase D (2nd ice phase) ERS-1-SAR-SLC I data of our investigation area Ekströmisen (cf.figure 1 figure 1) was available. Scenes were only acquired from descending orbits (cf.figure 3), according to the mission phase in three-day intervals. Figure 2 illustrates the coverage of our investigation area with SAR data. Three immediately successive acquisitions present sufficient coherence for interferometric processing (cf.table 1).



Topographic Map: *E K S T R Ö M I S E N*
1 : 1 000 000, IfAG 1993

Figure 2: Ekströmisen. Location of ERS-1 Frame 5085.

Orbit	Frame	Acquisition [UT]	$B_{perp.}$ [m]	$B_{par.}$ [m]	h_{fringe} [m]	
13737	5085	02.03.1994, 8.47				(descending)
			14.3	-2.1	662	
13780	5085	05.03.1994, 8.47				(descending)
			22.1	14.9	428	
13823	5085	08.03.1994, 8.47				(descending)

Table 1: Suitable ERS-1-SAR-SLC I data for interferometric processing.

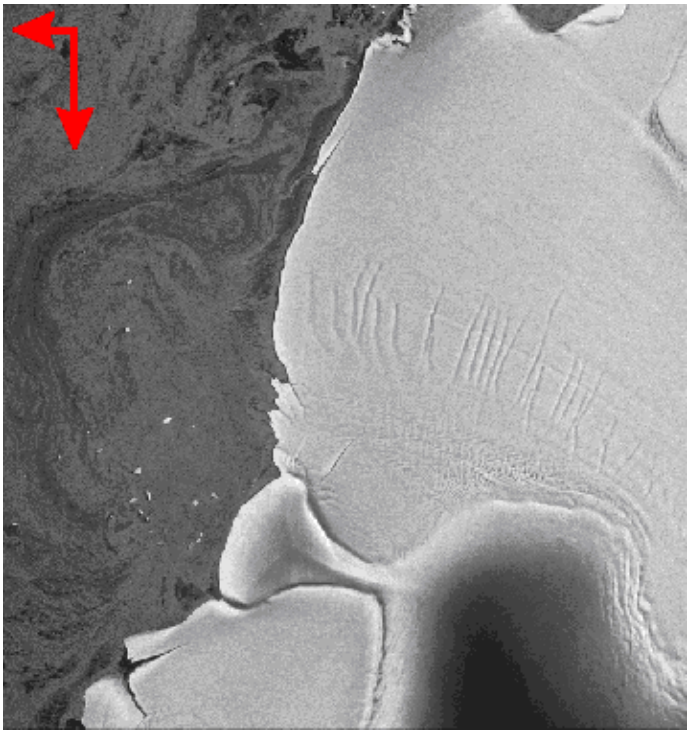


Figure 3: Ekströmisen. Amplitude image of orbit 13780, frame 5085, 05.03.ï994, 8.47

UT. legend

In this case the baselines between these acquisitions are so small, that for the ice shelf area the influence of the surface topography on the interferometric phase can be neglected (cf.figures 2, table 1). From the SAR scenes taken at equal intervals of three days the interferograms $I.phase_{flat.\ (5.3.1994\text{-}2.3.1994)}$ and $I.phase_{flat.\ (5.3.1994\text{-}8.3.1994)}$ are derived using precise ERS-1 orbit data (PRC) (cf.figures 4,5). Owing to the neglectibility of the topographic influence on the interferometric phase the arising fringes result only from the forward motion of the ice shelf and the tidal movement of the surface between the dates of acquisition. Adding these two interferograms leads to the elimination of the portion of steady motion of the ice, since these enter into the computation with the same order of magnitude and inverse sign. Thus an interferogram is obtained which is only based on the elastic motion of the ice shelf surface due to tidal influences (cf.figure 6).

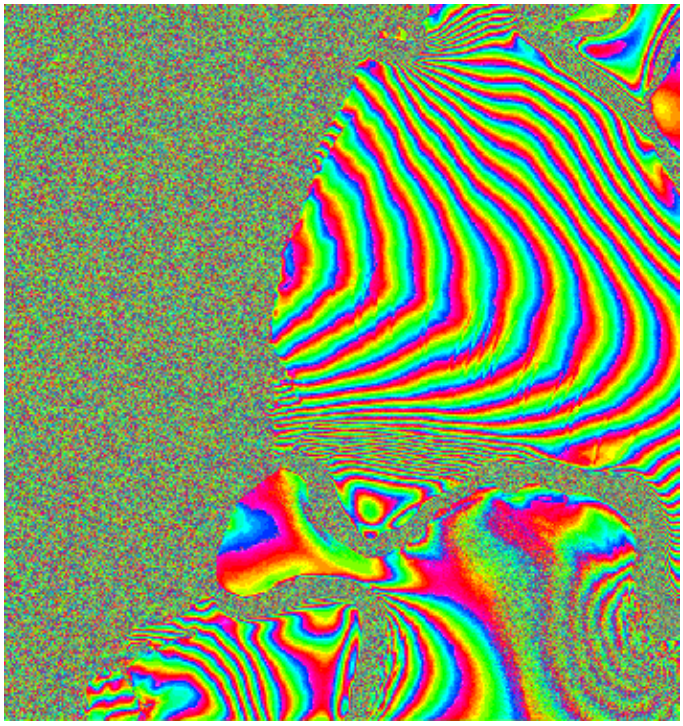


Figure 4: Ekströmisen. $I.phase_{flat.\ (5.3.1994\text{-}2.3.1994)}$.
Interferometric phase between the ERS-1-SAR-SLC I scenes from 5.3.1994 and 2.3.1994 (cf.table 1, legend).

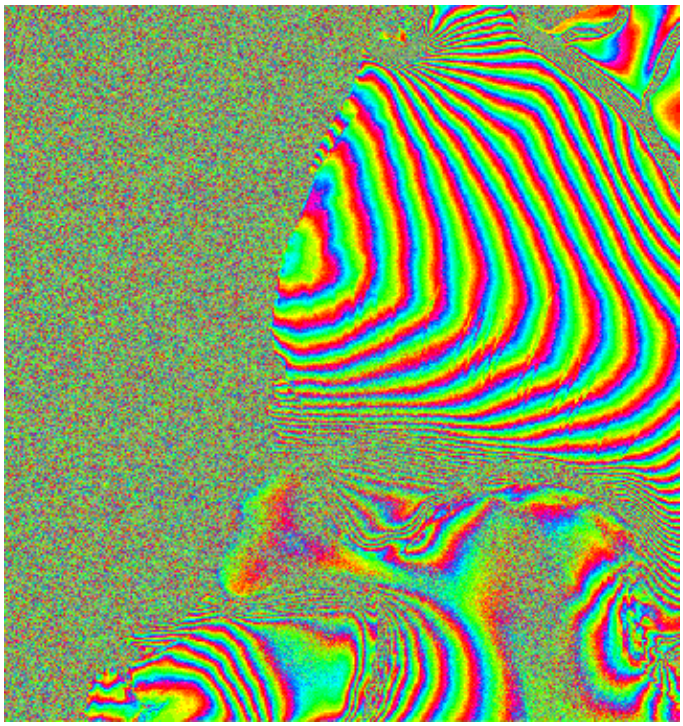


Figure 5: Ekströmisen. $I.phase_{flat.\ (5.3.1994\text{-}8.3.1994)}$.
Interferometric phase between the ERS-1-

SAR-SLC I scenes from 5.3.1994 and 8.3.1994 (cf.table 1, legend).

After unwrapping the interferogram and taking into account the local incidence angle one obtains directly the metric linear relation $Z_{5.3.1994}$ - 0.5 ($Z_{8.5.1994}$ - $Z_{2.3.1994}$) of the vertical tidal surface motion of the Ekströmisen (cf.figure 7).

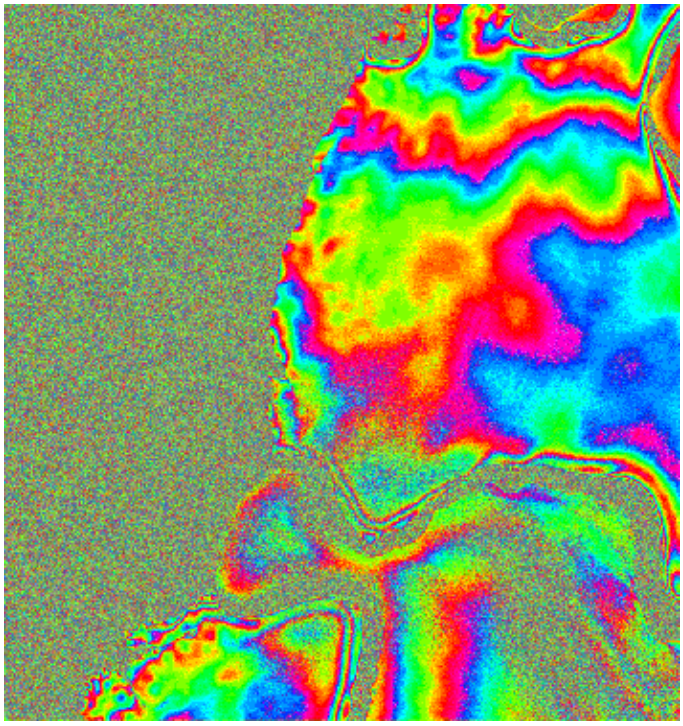


Figure 6: Ekströmisen.
$I.phase_{flat.\ (5.3.1994\text{-}2.3.1994)}$ + $I.phase_{flat.\ (5.3.1994\text{-}2.3.1994)}$.
(cf.legend).

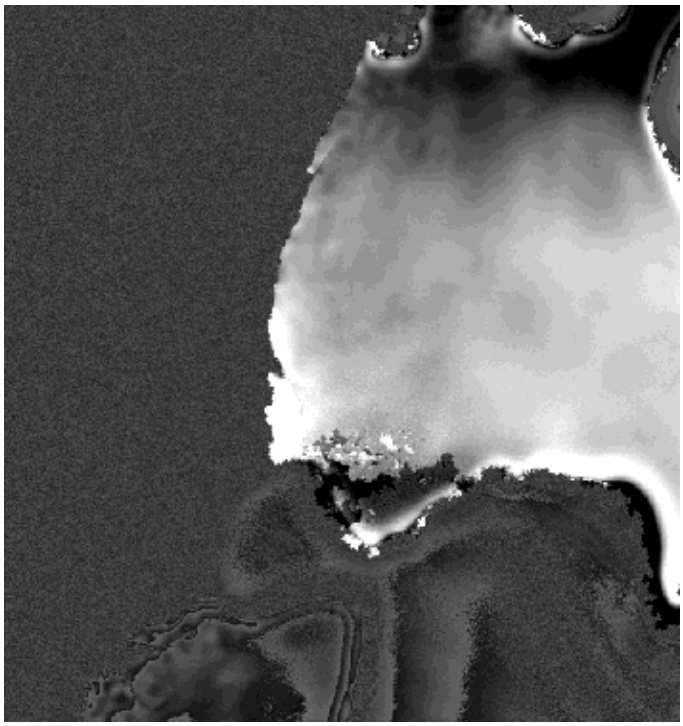


Figure 7: Ekströmisen. Tidal variations of the surface.
$Z_{5.3.1994}$ - 0.5 ($Z_{8.5.1994}$ - $Z_{2.3.1994}$).

Current and future work

The work presented constitutes only an intermediate result of the current project activities. The tidal deformations of the Ekströmisen derived interferometricaly are integrated as calibration / validation data in tide models of the area considered. After that, the validated tide model will be used as additional information for the determination of isolated topography and surface motion of the Ekströmisen with INSAR and DINSAR as mentioned above.

Conclusions

SAR data interferometry over remote regions is an important tool for the area-wide estimation of topography and motion of the surface. In this way the extent of in-situ investigations can in many cases be minimized or even substituted. However, with regard to the investigation of ice shelf dynamics the influence of tides must be allowed for, as a factor that cannot be neglected, which has an additional effect on the elastic ice body. This requires supplementary information for interferometric evaluations, as under the aspects mentioned above, in the form of precise tide models. On the other side, interferometric procedures contribute considerably to the formation and validation of such models.

Acknowlegment

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ERS-1/-2 SAR Data **© ESA**

References

Glaciological Applications of Satellite Radar Interferometry,
Meeting, NASA/Jet Propulsion Laboratory, Pasadena, CA, March 28-29 1996

Legend