Detection of Ice Sheet Elevation and Grounding Line Using ALOS / PALSAR Data

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Abstract
This paper describes the research plan to use ALOS / PALSAR data for Antarctic ice sheet analysis. The final goal of our study is to extract the precise ice sheet elevation and estimate accurate position of grounding line using ALOS / PALSAR data. The authors have been studying the grounding line and ice sheet topography from InSAR data, which mainly used ERS-1/2 tandem data. We plan to adopt the same analysis approach as ERS-1/2 data to PALSAR data. In this paper we introduce the analysis method of grounding line and ice sheet topography and describe the possible application of PALSAR data, advantage and disadvantage of PALSAR data in comparison with ERS-1/2 data, and some preliminary results using PALSAR data.

Keywords: Antarctica, PALSAR, Grounding line, Digital Elevation Model, ICESat/GLAS.

1. INTRODUCTION

The behavior of Antarctic ice sheet has gotten a lot of attention recently in the context of the global environmental changes. It is also important issue to reveal the mass flux of water content in polar region through monitoring the advance or retreat of ice sheet. However, it is no DEM (Digital Elevation Model) of Antarctica to sustain for this kind of study. Currently, there are two efficient ways to generate DEM of ice sheet using satellite data. One is application of InSAR technique. The advantage of InSAR DEM is high spatial observation density (< 50m), though it is necessary to prepare several Ground Control Point (GCPs) on a SAR image for the accurate DEM generation. However, it is quite difficult to collect GCPs on Antarctica due to severe weather and geographic condition. The other is use of laser altimeter data. Geoscience Laser Altimeter System (GLAS) equipped on ICESat (Ice, Cloud, and land Elevation Satellite) can measure the ice sheet topography with ultimate high accuracy[1]. However, its spatial observation density is lower than InSAR DEM, which is approximately 170m for along track direction and 2500m for cross track direction at ±80º latitude.

2. ANALYSIS METHOD

2.1. Determination of grounding line

The conventional grounding line data is stored in ADD[2] (Antarctic Digital Database) which compiled by BAS (British Antarctic Survey). Grounding line data in ADD has coordinate on WGS84 reference system. Projection of ADD data is South Pole Polar Stereographic (PS). Therefore, it is necessary to assign geodetic coordinates to grounding line extracted from the interferogram in comparison with ADD grounding line. In order to assign geodetic coordinate values to interferogram, we used the existing SAR mosaicked image data made from RADARSAT, namely the RADARSAT Antarctic Mapping Project[3] (RAMP) image data. RAMP image is a mosaicked image of whole Antarctica which has coordinate on WGS84 reference system. Projection of RAMP image is also South Pole Polar Stereographic. The interferogram was assigned WGS84 coordinate to apply geometric correction with RAMP image. Finally, we digitized and extracted grounding line from interferogram. Fig. 1 shows the example interferogram at Lazarevisen, east Antarctica using ERS-1/2 tandem data[4]. Red line shows the InSAR-derived grounding line and yellow line is from ADD. The yellow line shows an erroneous peninsula-like grounding line. In contrast to the ADD grounding line, detailed shapes are delineated in the red line. Actually, there is no peninsula in this region; the false pattern in the ADD grounding line must be generated by amalgamation of three isolated islands or ice rises.

2.2. Ice sheet elevation

In this study, we used GLAS data as GCPs instead of actual observation data on the ground for the improvement of InSAR DEM accuracy. First of all, we created an interferogram from ERS-1/2 tandem data and executed phase unwrapping process. After the phase unwrapping, we made orthorectified DEM and ERS-1 intensity image. However, this DEM and intensity image has no geographic coordinate. Next step is geometric correction of InSAR DEM and ERS-1 intensity image referring to RAMP image. After the geometric correction, we extracted the topographic height difference of ice sheet between InSAR DEM and GLAS along with the GLAS observation track. Then we assumed this height difference as a quadratic surface and estimated this quadratic surface using least square fitting. Finally, subtract this quadratic surface of height difference from InSAR DEM and obtained high accuracy and spatially dense DEM. We applied this method at Breivika, east Antarctica. InSAR DEM which corrected by this method using ERS-1/2 tandem data showed good correspondence, which has approximately ±25m difference to GLAS data and ±30m to 28th Japanese Antarctic Research Expedition[5] (JARE) GPS observation results.

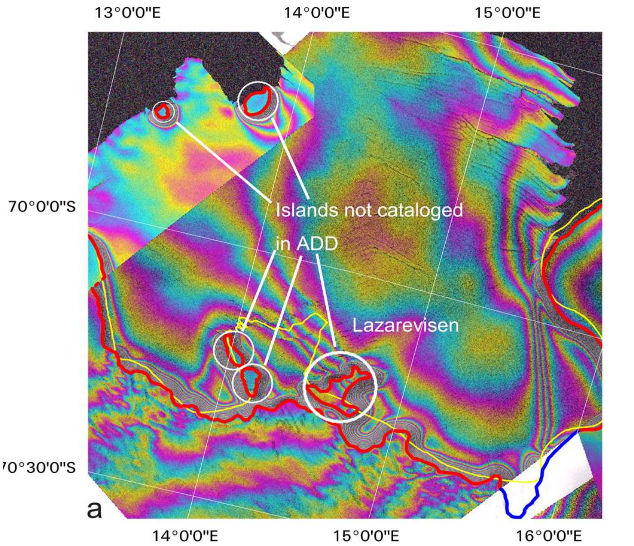

Figure 1. ERS-1/2 tandem interferogram at Lazarevisen

3. PRELIMINARY RESULTS

Fig. 2 shows the preliminary analysis result using PALSAR data at Princesse Ragnhild Kyst, east Antarctica. Left images are made by PALSAR and right images are made by ERS-1/2 tandem data. PALSAR backscatter imagery clearly shows the ice sheet surface features and PALSAR interferogram also show clear fringe patterns. However, the spatial distance between fringes is concentrated in comparison with ERS-1/2 tandem data possibly based on the ice sheet flow and tidal motion.

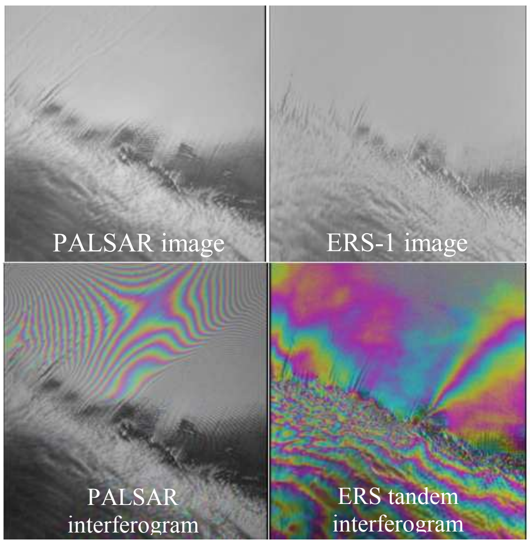

Figure 2.PALSAR and ERS-1/2 interferogram at Prinsesse Ragnhild Kyst, East Antarctica

4. SUMMARY AND FUTURE PLAN

In this paper we showed potential ability of InSAR technique for Antarctic ice sheet research and demonstrated sample InSAR analysis results. For the extraction of DEM and grounding line on Antarctic ice sheet, it is preferable to have short observation time interval. Though ALOS has a long observation interval (46days), it has high radiometric characteristics and good baseline control for InSAR processing. Therefore, it is necessary to evaluate the usability of PALSAR data for our purpose. Furthermore, it is preferable to adopt 3pass InSAR technique for removal of fringe due to ice sheet flow. We have a plan to apply 3pass InSAR using PALSAR data. Unfortunately there are few 3pass observations on Antarctica and we aspire to observe 3pass PALSAR imagery at Antarctica.

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