DETECTING ICE MOTION IN GROVE MOUNTAINS, EAST ANTARCTICA WITH ALOS/PALSAR AND ENVISAT/ASAR DATA

TIAN Xin, LIAO Mingsheng, ZHOU Chunxia, ZHOU Yu

Wuhan University
Outline

- Introduction
- D-InSAR Measurement Model
- Experiment and Analysis
- Conclusions
PART I

Introduction
• Antarctic environment can significantly reflect global climate changing, since glacier ablation is a sensitive symbol of the global warming impacts.

• Within the Antarctic region, monitoring ice flow is very important for the study of glacier dynamics and allows us inverse the mechanism of Antarctic ice sheet.
Introduction

• The conventional measures, such as GPS and leveling network, are limited in the scale of area, time, cost, accuracy and so on especially in the Antarctic region.

• Satellite radar interferometry (InSAR) provides an important new tool for determining ice-flow velocity.

• The use of InSAR techniques can give a more detailed view of the glaciers motion. And this technique has the capability of mapping the subtle change of Antarctic surface in centimeter even millimeter level.
PART II
D-InSAR Measurement Model
• The interferometric phase can be expressed

\[ \phi = \phi_{\text{geo}} + \phi_{\text{topo}} + \phi_{\text{atmos}} + \phi_{\text{offset}} + \phi_{\text{defo}} + \phi_{\text{dem_error}} + \phi_{\text{noise}} \]

• The phase resulted from the topography can be removed by using the external DEM

\[ \phi_{\text{diff}} = \phi_{\text{defo}} + \phi_{\text{dem_error}} + \phi_{\text{offset}} + \phi_{\text{atmos}} + \phi_{\text{noise}} \]

\[ \phi_{\text{defo}} = \frac{4\pi}{\lambda} \cdot \nu \cdot T \]
As InSAR technique can extract the deformation information in LOS direction, only the displacement of ice flow component in the LOS direction can be detected.

\[ D = \frac{\delta R}{|\cos u \cos v \sin \theta + \sin u \cos \theta|} \]

\[ \delta R = D_h \cos v \sin \theta + D_v \cos \theta = D_x \sin \theta + D_v \cos \theta \]
PART III

Experiment and Analysis
• The test area is selected around Grove Mountains in East Antarctica, which is located about 400-500 kilometers to the south of the Chinese Zhongshan Station in Antarctic inland areas.

• The Grove Mountains area is also situated on the eastern slope of Lambert Glacier basin - Amery Ice Shelf system (LAS) -- the largest glacier system in Antarctica.

• As the ice flow pattern is complicated and ice cracks are widely distributed, the traditional measurement is not available in this region.
• Test area

ALOS/PALSAR  Track: 584, Frame: 5630
ENVISAT/ASAR  Track: 375, Frame: 5121
## Dataset

The parameters of SAR interferometric pairs

<table>
<thead>
<tr>
<th>Data</th>
<th>Track Frame</th>
<th>Date</th>
<th>pass</th>
<th>$B_T$ (days)</th>
<th>$B_\perp$ (m)</th>
<th>$B_\parallel$ (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALOS PALSAR</td>
<td>584 5630</td>
<td>20070518</td>
<td>Asc.</td>
<td>138</td>
<td>1047</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20071003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENVISAT ASAR</td>
<td>375 5121</td>
<td>20070603</td>
<td>Des.</td>
<td>35</td>
<td>227</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20070708</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• The improved InSAR generated DEM corrected with ICESAT GLAS data is used in our work.

<table>
<thead>
<tr>
<th>Images</th>
<th>Acquisition dates</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERS-1</td>
<td>10/02/1996</td>
<td>90 m</td>
</tr>
<tr>
<td>ERS-2</td>
<td>11/02/1996</td>
<td>160 m</td>
</tr>
</tbody>
</table>
• Elevation of InSAR DEM (heavy line), BAMBER DEM (dash line), ICESat DEM (dot line) and RAMP DEM (solid line) along profiles of Grove Mountains. (a) profiles across Grove Mountains; (b) along profile A; (c) along profile B.
Experiment and Analysis

PALSAR: Coherence Map

ASAR: Coherence Map
Experiment and Analysis

PALSAR

ASAR
Experiment and Analysis

Results of SAR intensity tracking Procedures
• Reference data:

• Ice flow velocities in the Lambert Glacier - Amery Ice Shelf area have been measured from SAR data with 24 days time interval by NASA/JPL. The ice motion maps have been derived using cross-correlation optimization procedure, and the velocity of ice flow in Grove Mountains area is approximately 10m/a.

• The ground truth data were measured via GPS from Jan 17th, 2006 to Jan 31st, 2006.
### Velocities at GPS sites in Grove Mountains (Jan. 2006)

<table>
<thead>
<tr>
<th>ID</th>
<th>B (dd.mmss)</th>
<th>L (dd.mmss)</th>
<th>H (m)</th>
<th>V (m/a)</th>
<th>Azimuth (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLE1</td>
<td>-72.5102</td>
<td>75.11290</td>
<td>1979.63</td>
<td>3.53553</td>
<td>340.4017</td>
</tr>
<tr>
<td>PLE2</td>
<td>-72.5241</td>
<td>75.12449</td>
<td>2052.641</td>
<td>1.11127</td>
<td>129.1233</td>
</tr>
<tr>
<td>PLE3</td>
<td>-72.5142</td>
<td>75.12080</td>
<td>1992.532</td>
<td>0.62347</td>
<td>299.2213</td>
</tr>
<tr>
<td>PLE4</td>
<td>-72.5110</td>
<td>75.13138</td>
<td>1982.786</td>
<td>5.98475</td>
<td>328.5916</td>
</tr>
<tr>
<td>PLE5</td>
<td>-72.5043</td>
<td>75.14313</td>
<td>1973.337</td>
<td>7.31913</td>
<td>326.0517</td>
</tr>
<tr>
<td>PLE6</td>
<td>-72.5028</td>
<td>75.11048</td>
<td>1966.944</td>
<td>5.39689</td>
<td>302.185</td>
</tr>
<tr>
<td>PLE7</td>
<td>-72.5116</td>
<td>75.15019</td>
<td>1989.517</td>
<td>12.3392</td>
<td>317.4612</td>
</tr>
</tbody>
</table>
Experiment and Analysis

Velocities comparison with GPS points

- GPS
- ASAR
- PALSAR

Jan 2006
Jun-Jul 2007
May-Oct 2007
PART IV

Conclusions
Conclusions

• This study provides certain reference for detecting ice flow in Antarctic regions with SAR data. The results from L-band and C-band are coincident.

• In some cases, the velocity can not be properly detected because of the low coherence and discontinuous phase changes.

• Offset-tracking procedures of SAR images are an alternative to differential SAR interferometry for the estimation of glacier motion.

• Further study should be taken for the ice flow velocity, such as velocity fields in different seasons and years.
The work in the paper was supported by National 973 Plans Project (No. 2007CB714405) and 863 High Technology Program (Contract No.2009AA12Z133).

The authors thank European Space Agency (ESA) and Japan Aerospace Exploration Agency (JAXA) for providing the SAR data through the cooperational programmes.
Thanks!