Ice Velocity Mapping Using TOPS SAR Data and Offset Tracking

Dall, Jørgen; Kusk, Anders; Nielsen, Ulrik; Merryman Boncori, John Peter

Publication date: 2015

Document Version: Peer reviewed version

Citation (APA):
Ice Velocity Mapping Using TOPS SAR Data and Offset Tracking

Jørgen Dall¹, Anders Kusk¹, Ulrik Nielsen¹, John Peter Merryman Boncori²
¹ Technical University of Denmark, ² Instituto Nazionale di Geofisica e Vulcanologia, Italy
Outline

• Introduction
• Problem (TOPS + large displacements)
• Method
• Results
• Conclusions
## Offset tracking

<table>
<thead>
<tr>
<th>Method</th>
<th>Feature tracking</th>
<th>Speckle tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data type</td>
<td>Detected</td>
<td>Detected or complex</td>
</tr>
<tr>
<td>Features</td>
<td>Required</td>
<td>Not required</td>
</tr>
<tr>
<td>Coherence</td>
<td>Not required</td>
<td>Required</td>
</tr>
<tr>
<td>Patch size</td>
<td>Larger</td>
<td>Smaller</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Coarser</td>
<td>Finer</td>
</tr>
</tbody>
</table>
Offset tracking with TOPS data

1st acquisition
Offset tracking with TOPS data

1st acquisition

IW SLC product:
- Spatial overlap
- No spectral overlap => speckle pattern differs
Offset tracking with TOPS data

**1st acquisition**

**2nd acquisition**

**GRD product:** features are preserved when crossing the burst seam
Offset tracking with TOPS data

**GRD product:** Speckle changes when crossing the burst seam => gap

1\(^{st}\) acquisition

2\(^{nd}\) acquisition
Offset tracking with TOPS data

1st acquisition

2nd acquisition

SLC product: gaps can also be avoided with speckle tracking if ice displacement + patch size < overlap
Offset tracking with TOPS data

1st acquisition

2nd acquisition

SLC product: gaps can also be avoided with speckle tracking if ice displacement + patch size < overlap
**SLC product:** gaps can also be avoided with speckle tracking if ice displacement + patch size < overlap
IPP processor

- Intended for DInSAR (DEM elimination & Double Difference)
- Upgraded for ESA’s Climate Change Initiative (GrIS CCI, AIS CCI):
  - Offset Tracking
  - Bulk processing (cloud computing)
  - Sentinel-1 IW SLC product
Upernavik glaciers

M. Fahnestock et al., 1992
Normalized cross-correlation:

\[
NCC(i,j) = \frac{\sum_{k,l} (s(i+k,j+l)-\mu_s)(r(k,l)-\mu_r)}{\sqrt{\sum_{k,l} (s(i+k,j+l)-\mu_s)^2 \sum_{k,l} (r(k,l)-\mu_r)^2}}
\]

Figures of merit:
- \( \text{max}(NCC) \)
- 'signal-to-noise ratio' (SNR)
Approach

1st acquisition

2nd acquisition

Corresponding bursts (exploited by IPP)
Corresponding bursts
(exploited by IPP)

1st acquisition

2nd acquisition
Consecutive bursts

1st acquisition

2nd acquisition
Approach

1st acquisition

Patch: 256 x 64 (ra x az pixels)

Increment: 40, 10 (ra, az pixels)

Consecutive bursts (analysed in this study)

2nd acquisition
Questions addressed

Questions:

• In the overlap area four multi-temporal cross-correlations can be computed. Which ones are useful?
• Where do consecutive (multi-temporal) bursts decorrelate?
• Does the GRD product lead to more velocity gaps?
• Do the dual squint angles within the burst overlap provide valuable glaciological information?
Results: NCC
Results: NCC
Results: NCC
Results: azimuth displacement
Results: azimuth displacement
Results: azimuth displacement
Results: azimuth displacement
Results: SNR

IW3

IW2

IW1
Results: SNR
Landsat imagery
Landsat imagery
Landsat imagery
Conclusions

- Velocity map successfully generated from Sentinel-1 IW SLC data in areas with and without features
- At high elevations, two corresponding (multi-temporal) bursts can be successfully cross-correlated, but two consecutive bursts cannot (presumably due to a lack of ice features)
- At low elevations (where ice features are often abundant) also consecutive (multi-temporal) bursts can often be successfully cross-correlated
- The IW GRD product may be applicable for (gap-free) feature tracking
- The IW SLC product is required for (gap-free) speckle tracking