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 Dall\textsuperscript{1}, Anders Kusk\textsuperscript{1}, Ulrik Nielsen\textsuperscript{1}, John Peter Merryman Boncori\textsuperscript{2}
\textsuperscript{1} Technical University of Denmark, \textsuperscript{2} Instituto Nazionale di Geofisica e Vulcanologia, Italy
Outline

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

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

1\textsuperscript{st} acquisition
Offset tracking with TOPS data

1\textsuperscript{st} acquisition

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

1st acquisition

GRD product: features are preserved when crossing the burst seam

2nd acquisition
Offset tracking with TOPS data

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

1\textsuperscript{st} acquisition

2\textsuperscript{nd} acquisition
Offset tracking with TOPS data

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

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

**SLC product:** gaps can also be avoided with speckle tracking if ice displacement + patch size < overlap
• 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
Ice velocity (Sentinel-1 IW SLC)

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:
- max(NCC)
- 'signal-to-noise ratio' (SNR)
Approach

1st acquisition

2nd acquisition

Corresponding bursts (exploited by IPP)
Approach

**Corresponding bursts**
(exploited by IPP)

<table>
<thead>
<tr>
<th>1\textsuperscript{st} acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>2\textsuperscript{nd} acquisition</td>
</tr>
</tbody>
</table>
Consecutive bursts

1\textsuperscript{st} acquisition

2\textsuperscript{nd} acquisition
Approach

1\textsuperscript{st} acquisition

\textbf{Patch}: 256 x 64 (ra x az pixels)

\textbf{Increment}: 40, 10 (ra, az pixels)

Consecutive bursts
(analysed in this study)

2\textsuperscript{nd} 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

IW1

IW2

IW3
Results: azimuth displacement
Results: azimuth displacement
Results: azimuth displacement

IW1

IW2

IW3
Results: SNR

IW3

IW2

IW1
Results: SNR
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.