Observations of glacier dynamics with PALSAR DATA

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Outline

- ESA GLOBGLACIER project
- Offset tracking of satellite SAR images
- Case studies in the Arctic: Novaya Zemlya, Svalbard, Alaska, Baffin Island
- Conclusions and recommendations
The ESA GlobGlacier project is attempting to establish a service for glacier monitoring from space that complements the existing network for global glacier monitoring.

GlobGlacier products have been identified by the user group:
- digital glacier outlines
- terminus position
- topography
- changes in glacier surface elevation
- snow covered area and elevation of the transient snowline
- velocity fields

Velocity fields for glaciers will be obtained either from feature tracking of repeat pass optical imagery or active microwave sensors using differential SAR interferometry or SAR offset-tracking.
Offset tracking of satellite SAR images

- With offset tracking the registration offsets of two SAR images in both slant-range (i.e. in the line-of-sight of the satellite) and azimuth (i.e. along the orbit of the satellite) directions are generated and used to estimate the displacement of glaciers.

- Offset-tracking is a robust and direct alternative technique to InSAR for the estimation of glacier motion in the case of rapid flow and large acquisition time intervals.
Offset tracking of satellite SAR images

\[ \Delta R \approx \frac{z B \bot}{R \sin \theta} \]
\[ z=3000m, \quad B =300m, \quad \Delta R=2m \]

\[ \Delta x \sim \frac{d}{dx} \left( \Delta \text{TotalElectonContent} \right) / f_{o2} \]

20060913_20061029
range – azimuth
offset tracking
PALSAR 46 days
“original offsets”

flight direction
(azimuth x)

line-of-sight (range R)
Offset tracking of satellite SAR images

20060913_20061029
range – azimuth
offset tracking
PALSAR 46 days
“filtered offsets”

co-registration with DEM
filter

flight direction (azimuth x)
line-of-sight (range R)
Offset tracking of satellite SAR images

Swiss Alps
20060913 / 20061029
46 days
300 m
Grosse Aletschgletscher (Switzerland)

ALOS PALSAR
09.09.06 - 29.10.06
46 days, 300 m

TerraSAR-X
11.08.08 - 22.08.08
11 days, 280 m

ERS-1/2
07.03.96 - 08.03.96
(1 day, 34 m)

\[ 64 \times 4.67 \text{ m} / \sin (38) \approx 500 \text{ m} \]
\[ 192 \times 3.15 \text{ m} \approx 600 \text{ m} > \text{PALSAR} \]

\[ 128 \times 1.36 \text{ m} / \sin (44) \approx 250 \text{ m} \]
\[ 128 \times 1.98 \text{ m} \approx 250 \text{ m} > \text{TSX} \]
Gornergletscher (Switzerland)

ERS 07/08.03.96 (horizontal plane)

PALSAR 20080202 / 20080319  Gamma Portable Radar Interferometer

<5  50  >500 m/year

25.06.2008 time interval ~1 hour

ERS 07/08.03.96 (horizontal plane)

GAMMA REMOTE SENSING
Novaya Zemlya (Russia)

ALOS PALSAR (L-band, 46 days repeat cycle)

Time series analysis

Track 525, Frame 1520
Novaya Zemlya (Russia)

Offset tracking

20070109_20070224
ALOS PALSAR
FBS-FBS
46 days

Background is MODIS imagery from July 29, 2003

Outlet glacier boundaries are after The catalogue of glaciers of the USSR (1978)
Novaya Zemlya (Russia)

Offset tracking

20070712_20070827
ALOS PALSAR
FBD-FBD
46 days

Background is MODIS imagery from July 29, 2003

Outlet glacier boundaries are after The catalogue of glaciers of the USSR (1978)
Novaya Zemlya (Russia)

Offset tracking

20070827_20071012
ALOS PALSAR
FBD-FBD
46 days

Background is MODIS imagery from July 29, 2003

Outlet glacier boundaries are after The catalogue of glaciers of the USSR (1978)
Offset tracking

20071012_20080112
ALOS PALSAR
FBD-FBS
92 days

Background is MODIS imagery from July 29, 2003

Outlet glacier boundaries are after The catalogue of glaciers of the USSR (1978)
Offset tracking

20080112_20080227
ALOS PALSAR
FBS-FBS
46 days

Background is MODIS imagery from July 29, 2003

Outlet glacier boundaries are after The catalogue of glaciers of the USSR (1978)
Ascending orbits

ALOS PALSAR offset-tracking

2 Tracks
20080201 / 20080318(W)
20080105 / 20080220(E)
46 days

“3-dim.”

Expected errors are about ±10 m/year
Ascending / descending orbits
ERS INSAR & offset-tracking

"3-dim."

Expected errors are about ±2 cm/day (±7 m/year)

Vestfonna-Austfonna, Svalbard (Norway)
Descending orbits

JERS-1 SAR offset-tracking

“3-dim.”

2 Tracks
19940323 / 19940506 (W)
19971211 / 19980124 (E)
44 days

Expected errors are about ±20 m/year

Vestfonna-Austfonna, Svalbard (Norway)
Ascending orbits

“3-dim.”

ALOS PALSAR

2 Tracks
20080201 / 20080318(W)
20080105 / 20080220(E)
46 days

Vestfonna-Austfonna, Svalbard (Norway)
Kenai Peninsula, Alaska (USA)

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ALOS PALSAR (L-band, 46 days repeat cycle)
Kenai Peninsula, Alaska (USA)

Offset tracking

20080120_20080306
ALOS PALSAR
FBS-FBS
46 days

0 m/year 300
ERS InSAR

19951220_19951221
1 day
-134 m
descending orbit

19951115_19951116
not yet available

Kenai Peninsula, Alaska (USA)
Chigmit Mountains, Alaska (USA)

ALOS PALSAR (L-band, 46 days repeat cycle)
Chigmit Mountains, Alaska (USA)

Offset tracking

20071227_20080211
ALOS PALSAR
FBS-FBS
46 days
Chigmit Mountains, Alaska (USA)

ERS InSAR

19951210_19951211
1 day
-73 m
descending orbit
Baffin Island (Canada)

ALOS PALSAR (L-band, 46 days repeat cycle)
Baffin Island (Canada)

Offset tracking 20070325_20070510
ALOS PALSAR, FBS-FBS, 46 days
Baffin Island (Canada)

Offset tracking 20071007_20071122
ALOS PALSAR, FBS-FBS, 46 days
Baffin Island (Canada)

InSAR 20071007_20071122
ALOS PALSAR, FBS-FBS, 46 days
Baffin Island (Canada)

**InSAR 19951201_19951202**
ERS-1/2 SAR, 1 day
Outlook and recommendations

- Use of ALOS PALSAR FBS and FBD data for the estimation of the motion of glaciers with offset tracking resulted in remarkably good outcomes in many regions around the world.

- For a more global use of ALOS PALSAR data in glacier dynamics the acquisition of a more consistent set of image pairs separated by a full orbital cycle of 46 days is required over glacier-covered regions, in particular in the Arctic.

- The ALOS PALSAR acquisition strategy features routine observations, that are currently not fully adapted to glacier motion studies.

- Is there the possibility to update the ALOS PALSAR acquisition strategy at continental scale in Arctic and Antarctic regions?
Thank you for your attention