Inter- and intraannual glacier elevation changes derived from TanDEM-X DEM data on the example of Inylchek Glacier, Tien Shan

Julia Neelmeijer$^{1,2}$, Mahdi Motagh$^{1,3}$ and Bodo Bookhagen$^2$

1) GFZ German Research Centre for Geosciences, Section 1.4 Remote Sensing, Telegrafenberg, 14473 Potsdam, Germany
2) Institute of Earth and Environmental Science, University of Potsdam, 14476 Potsdam, Germany
3) Institute of Photogrammetry and GeoInformation, Leibniz University Hannover, 30167 Hannover, Germany

neelmeijer@gfz-potsdam.de
How can high spatial resolution TanDEM-X data contribute to glacier elevation change monitoring in a high mountain area?

Research Question:

• TanDEM-X satellite mission: generate 12x12 m WorldDEM™ digital elevation model
• Launched: TerraSAR-X: June 2007
  TanDEM-X: June 2010
Inylchek Glacier: ~60 km with complex motion pattern, annual glacier lake outburst flooding of Lake Merzbacher
TanDEM-X (TDX) Data Coverage

Ascending:
- 30. January 2012
- 10. February 2012
- 01. March 2013
- 12. March 2013

Descending:
- 18. November 2013
- 29. November 2013

Comparison to C-band SRTM DEM (11.-20. February 2000)

3 mosaicked DEMs: TDX201202, TDX201303, TDX201311
DEM Generation via SAR Interferometry (InSAR)

Guido Luzi (2010)
DOI: 10.5772/9090

Exemplary TDX-DEM hillshade from March 2013 (resolution: 10 m)
Postprocessing of DEMs

1. coregistration of DEMs (adapted after Nuth and Kääb, 2011)
2. correction of potential elevation bias correction (Nuth and Kääb, 2011)
3. radar penetration depth correction between SRTM DEM and TDX DEMs
4. data void handling
Data Void Handling

common treatment: apply mean elevation change of same elevation bin to data void area (Gardelle et al. 2012, 2013; Rott et al. 2014)

mean elevation per elevation bin for different slope classes:

our solution: use mean elevation changes depending on elevation bin and slope class to fill data void areas

adapted from Neelmeijer et al. (2017)
Inylchek Glacier Elevation Change:
February 2000 (SRTM) – March 2013 (TDX)

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Northern Inylchek
absolute: -3.68 ± 5.23 m
annual mean: -0.28 ± 0.40 m a⁻¹

Southern Inylchek
absolute: -1.98 ± 5.23 m
annual mean: -0.15 ± 0.40 m a⁻¹
Inylchek Glacier Interannual/Intraannual Elevation Change

TDX DEMs:

Northern Inylchek
A-B: -0.34 ± 1.13 m
B-C: -0.57 ± 1.13 m
vs. -3.68 ± 5.23 m from TDX-SRTM comparison
2000-2013 annual mean: -0.28 ± 0.40 m a⁻¹

Southern Inylchek
A-B: -0.42 ± 1.13 m
A-B: -0.27 ± 1.13 m

-0.15 ± 0.40 m a⁻¹
Inylchek Glacier Interannual/Intraannual Elevation Change

TDX DEMs:

Northern Inylchek
A-B: -0.34 ± 1.13 m  
B-C: -0.57 ± 1.13 m

(A-B)+(B-C): -0.91 ± 1.13 m
A-C: -0.84 ± 1.28 m

difference: 0.07 m

Southern Inylchek
A-B: -0.42 ± 1.13 m  
B-C: -0.27 ± 1.13 m

(A-B)+(B-C): -0.69 ± 1.13 m
A-C: -0.72 ± 1.28 m

difference: 0.03 m
Inylchek Glacier Annual Mean Elevation Change: February 2000 – February 2012

glacier changes along the flowline:

adapted from Neelmeijer et al. (2017)

2012/02-2000/02 (m/a)
2013/03-2012/02 (m)
2013/11-2013/03 (m)
Southern Inylchek Elevation Changes - Lake Merzbacher Influence

2012/02-2000/02 (m/a)
2013/03-2012/02 (m)
2013/11-2013/03 (m)
Southern Inylchek Elevation Changes - Lake Merzbacherer Influence

Elevation Change (m)  2013/03 - 2012/02
-5 - 6  2 - 3  -1 - 0  -4 - 3
-4 - 5  1 - 2  -2 - 1  -5 - 4
-3 - 4  0 - 1  -3 - 2  -6 - 5

Elevation Change (m)  2013/11 - 2013/03
-5 - 6  2 - 3  -1 - 0  -4 - 3
-4 - 5  1 - 2  -2 - 1  -5 - 4
-3 - 4  0 - 1  -3 - 2  -6 - 5

flow direction

ice dam

Lake Merzbacher Outlines
- 2012 - 3254 m
- 2013 - 3252 m
- 2014 - 3268 m

Kirill Petrenko
Southern Inylchek Elevation Changes - Icefall

2012/02-2000/02 (m/a)
2013/03-2012/02 (m)
2013/11-2013/03 (m)
Summary

Research Question: How can high spatial resolution TanDEM-X data contribute to glacier elevation change monitoring in a high mountain area?

PRO:
• a comparison of DEMs generated from bistatic TanDEM-X data allows inter- and intraannual glacier elevation change monitoring
• low absolute uncertainty values
• good internal consistency

CON:
• suitable TanDEM-X pairs are only sparsely available
• radar imagery distortions in high mountain area can lead to data voids in glaciated area
• radar penetration depth assumption