10 years of monitoring of the Doesen rock glacier (Ankogel group, Austria) – a review of the research activities for the time period 1995-2005

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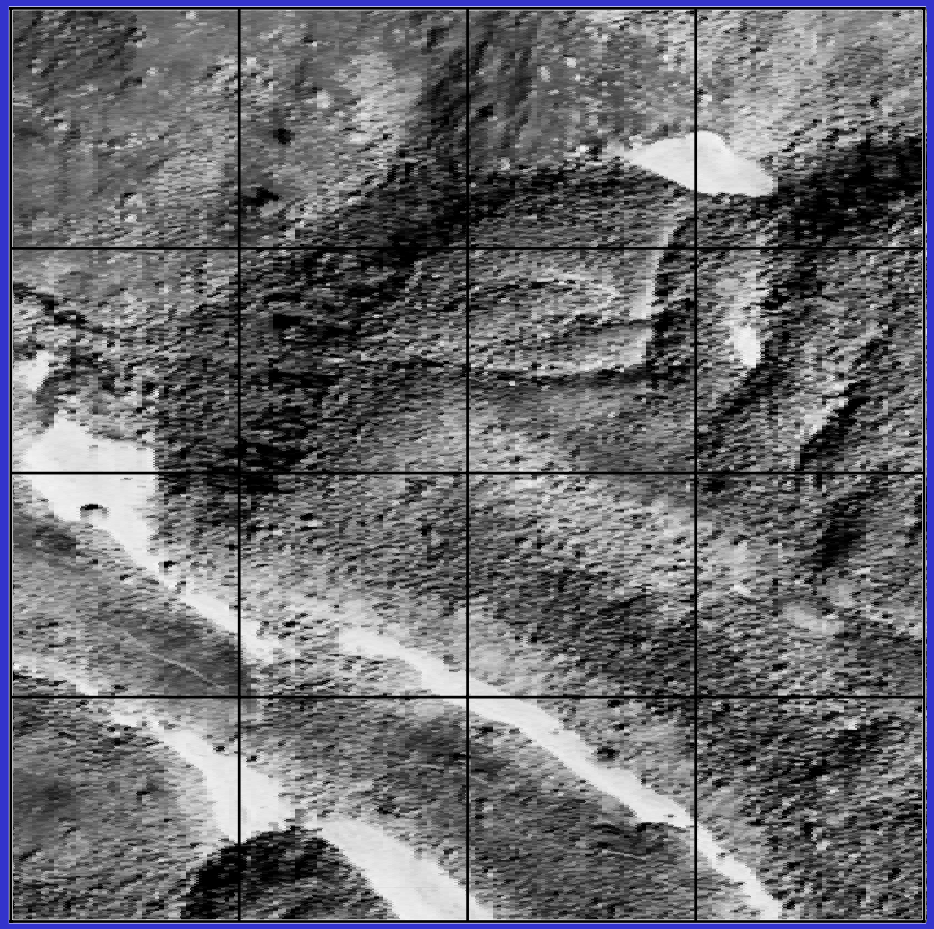
Outline

1. Introduction and geographical setting
2. Photogrammetric surveys 1954-1998
3. Geodetic Surveys 1995-2005
4. Space-borne differential SAR interferometry
5. Cartographic work
6. Comparative analysis and conclusions

1. Introduction and geographical setting



Snout of the Doesen rock glacier

Rock glaciers
are creep phenomena
of mountain permafrost
and are composed
of rocks and
interstitial ice.

1993-1997

A research initiative on mountain permafrost in Austria with a special geographical focus on the Eastern Austrian Alps started in 1993.

- Gerhard Lieb compiled an inventory of some 1450 rock glaciers.
- Doesen rock glacier is one of the largest active rock glaciers of his inventory.
- Multi-disciplinary research work funded by the Austrian Science Fund.

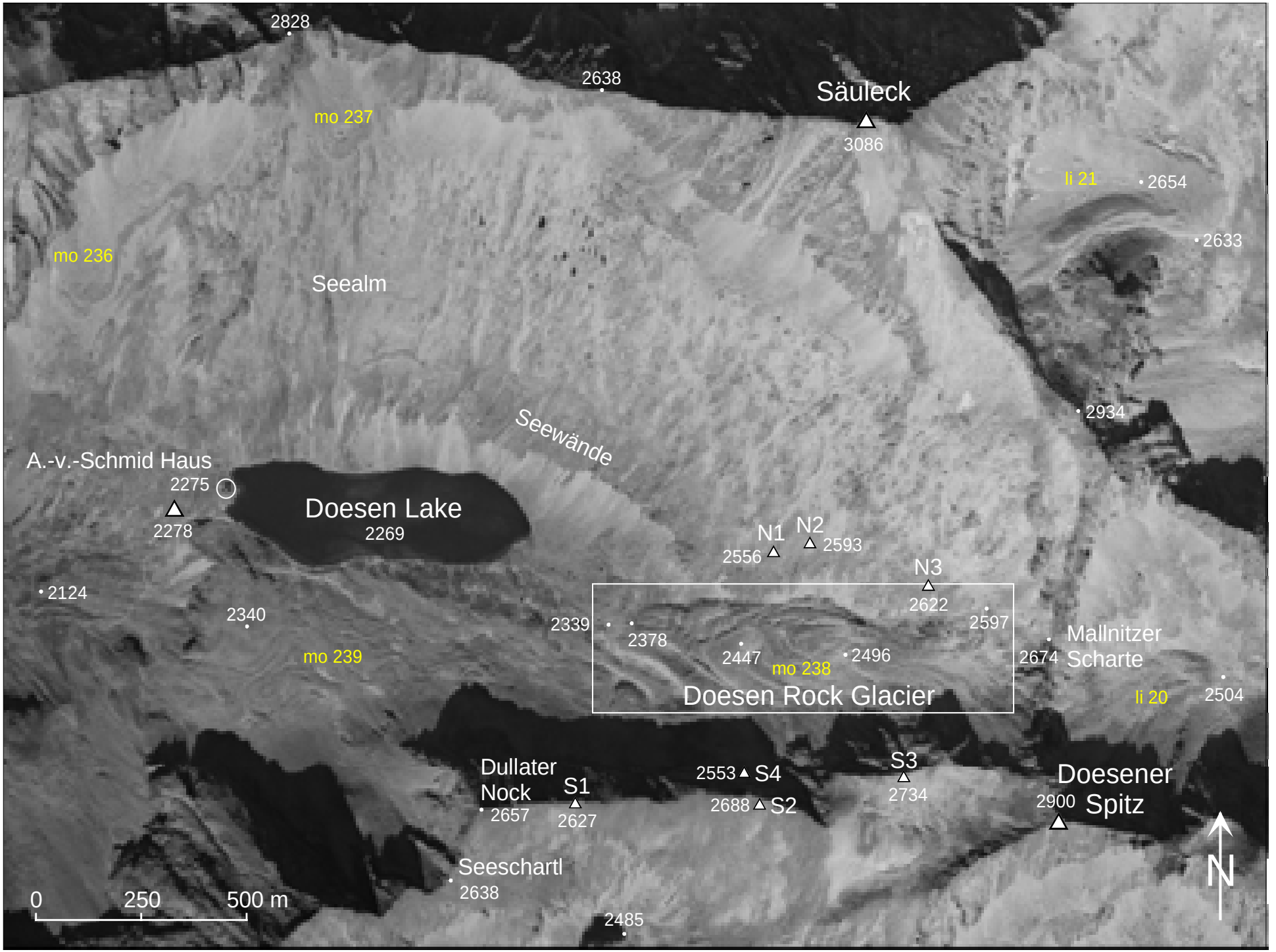
- A long-term monitoring program using various observation techniques was initiated for obtaining precise and reliable information on the spatio-temporal evolution of the surface of Doesen rock glacier.

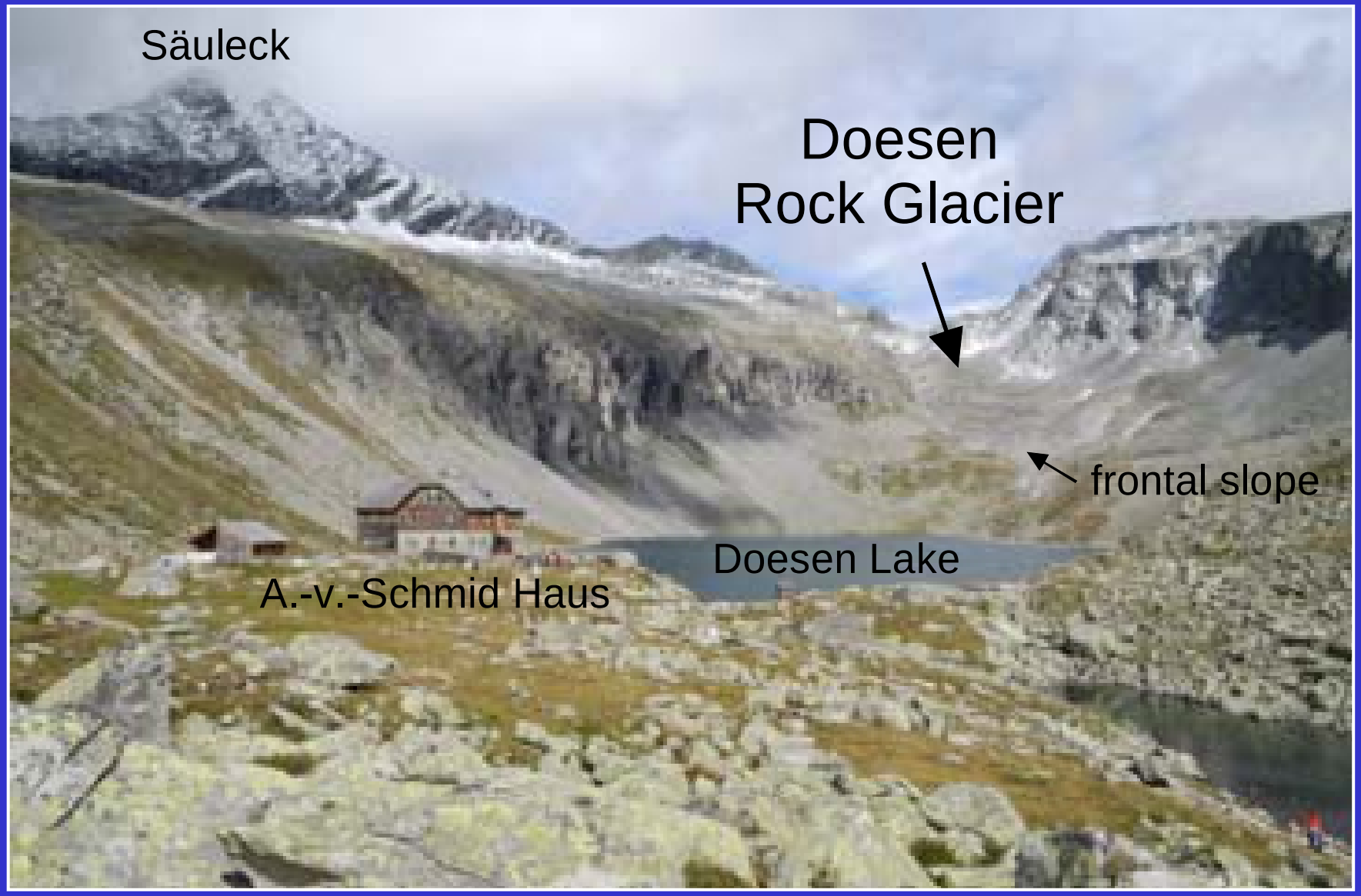
The long-term monitoring program at this sites is intended to

(1) better understand mass transport systems, with special regard to rock glacier dynamics and genesis,
(2) facilitate comparative analysis of glacial and permafrost areas, and
(3) contribute to climate change studies in high-mountain areas.

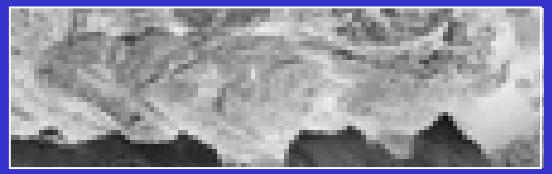
Location map

Russian KFA-1000 space image
(25. September 1991,
AUSTROMIR project)

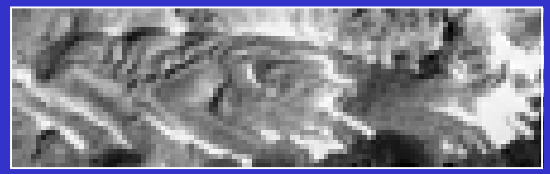

2828
2638
Säuleck
3086
mo 237
li 21
2654
2633
mo 236
Seealm
Seewände
2934
A.-v.-Schmid Haus
2275
2278
Doesen Lake
2269
N1
N2
2556
2593
N3
2622
2124
2340
2339
2378
2597
2447
2496
mo 239
mo 238
Doesen Rock Glacier
2674
Mallnitzer Scharte
li 20
2504
Dullater Nock
2657
S1
2627
2553
S4
2688
S2
S3
2734
Doesener Spitz
2900
Seeschartl
2638
2485
0
250
500 m
N


Säuleck
Doesen
Rock Glacier
frontal slope
Doesen Lake
A.-v.-Schmid Haus

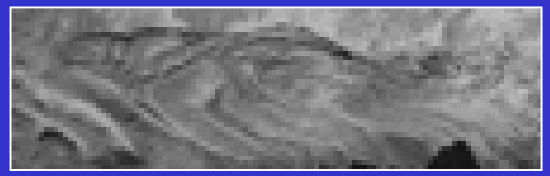
2. Photogrammetric surveys 1954-1998



1954



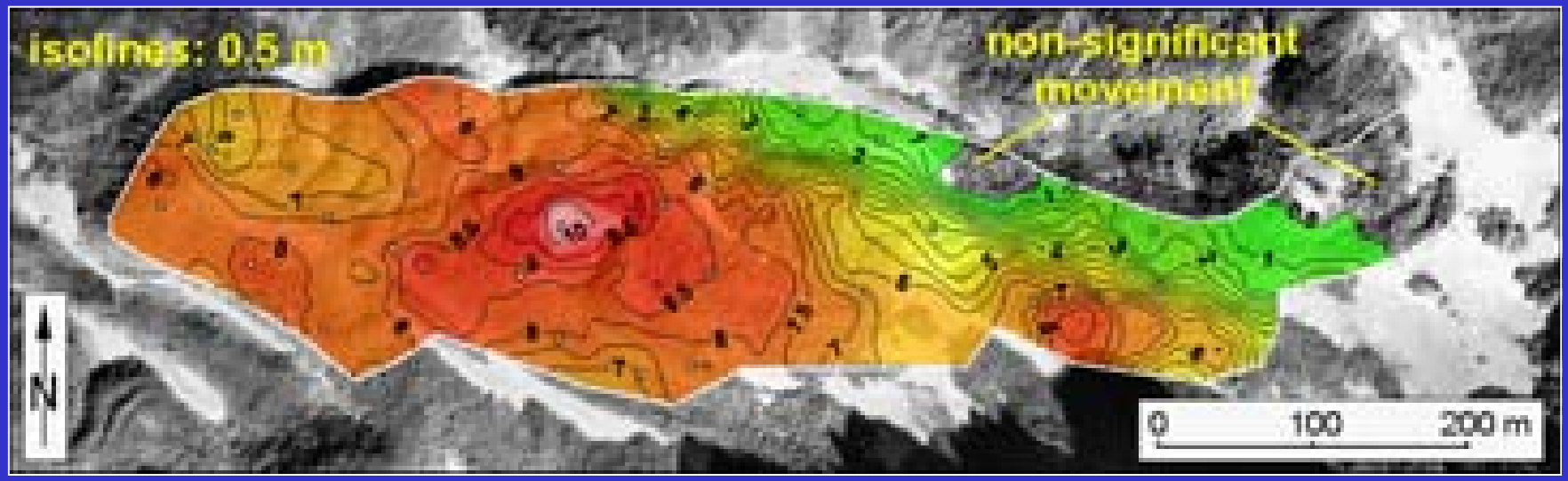
1993



1998

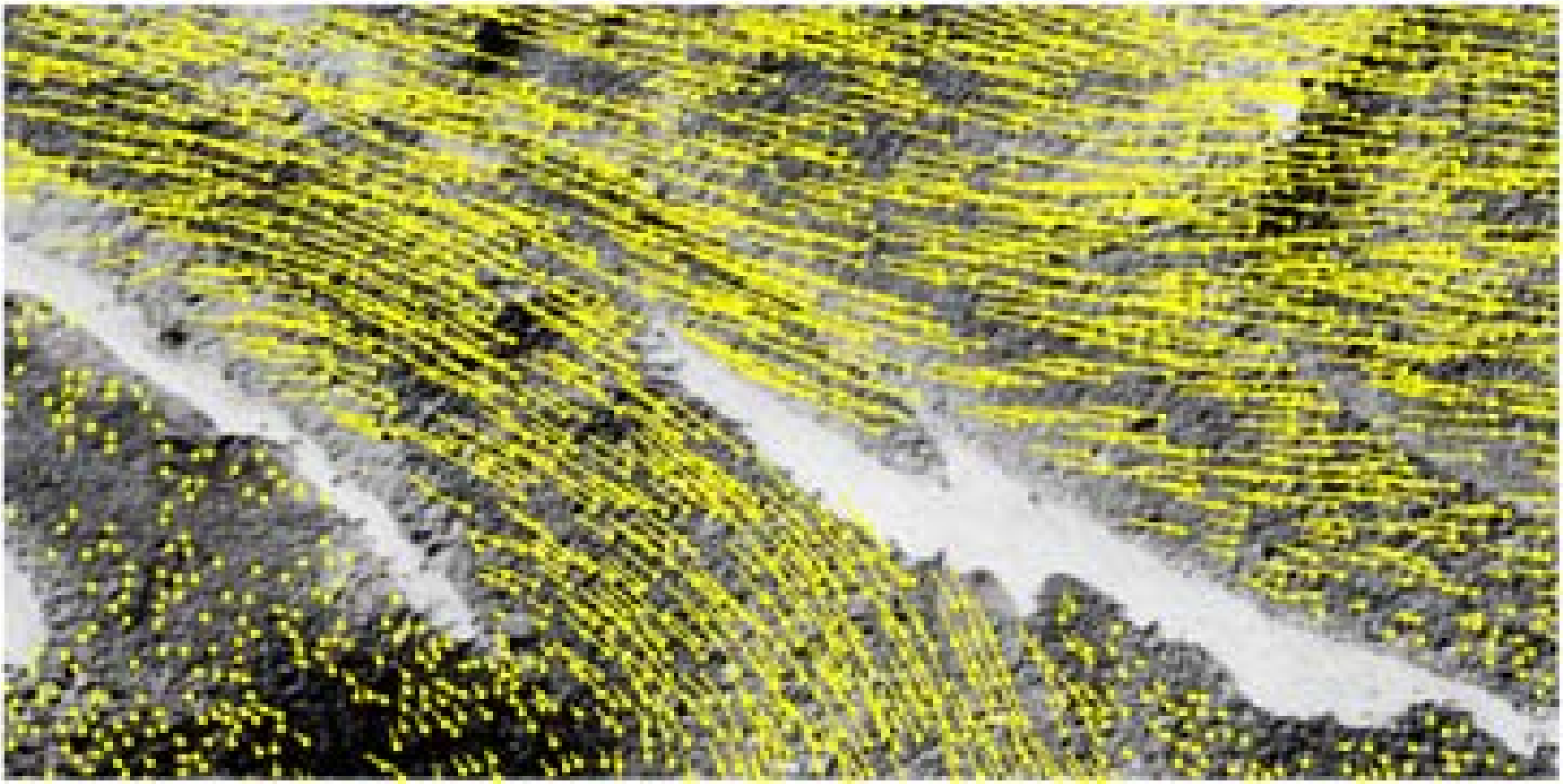
year	photos	image scale	focal length	type of film
1954	3	1:16,300	210 mm	B & W
1969	2	1:29,700	153 mm	B & W
1975	5	1:19,800	153 mm	B & W
1983	5	1:46,400	153 mm	B & W
1993	5	1:11,300	215 mm	color infrared
1997	2	1:14,000	152 mm	B & W
1998	2	1:33,400	153 mm	B & W

Combined analytical and digital photogrammetric evaluation of data.
Multi-photo constrained image matching using ADVM software.
➔ DTMs, orthophotos and 3D displacement vectors



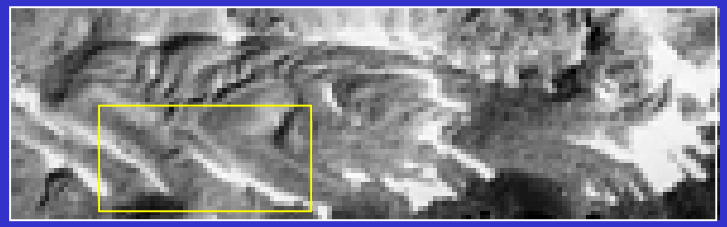
Total horizontal movement of Doesen rock glacier for the time period 1954-1997.

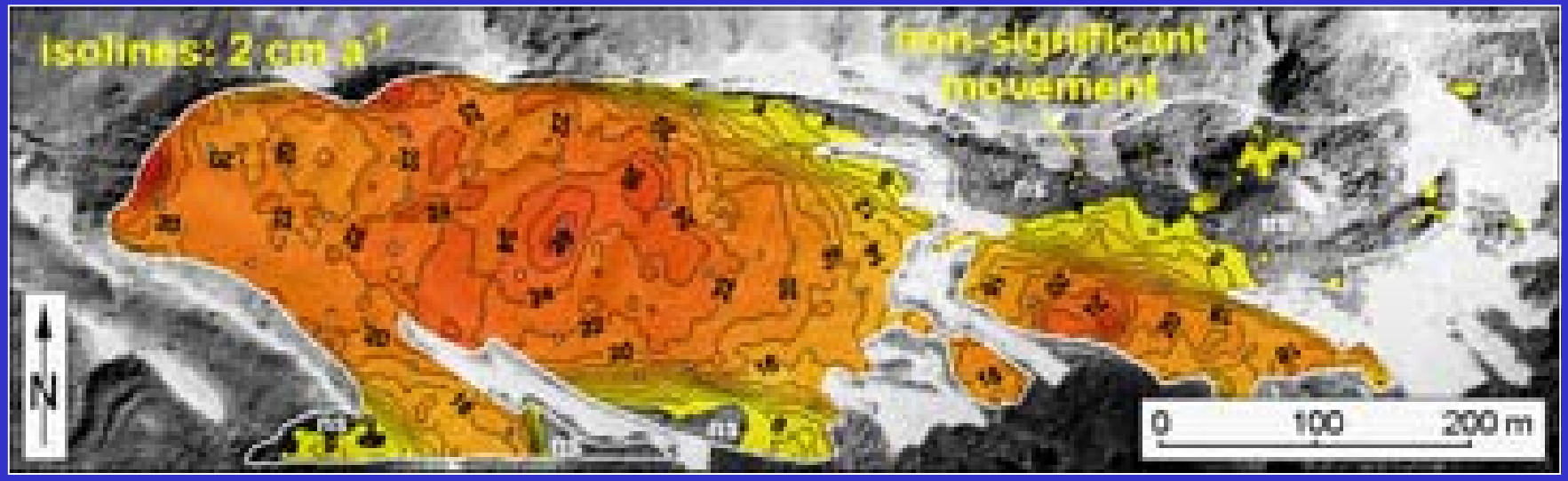
- Visual tracking of some 600 distinct boulders of the rock glacier surface.



Horizontal displacement vectors derived from large-scale aerial photographs 1993 and 1997.

- Automatic tracking of thousands of points through image matching (ADVM).

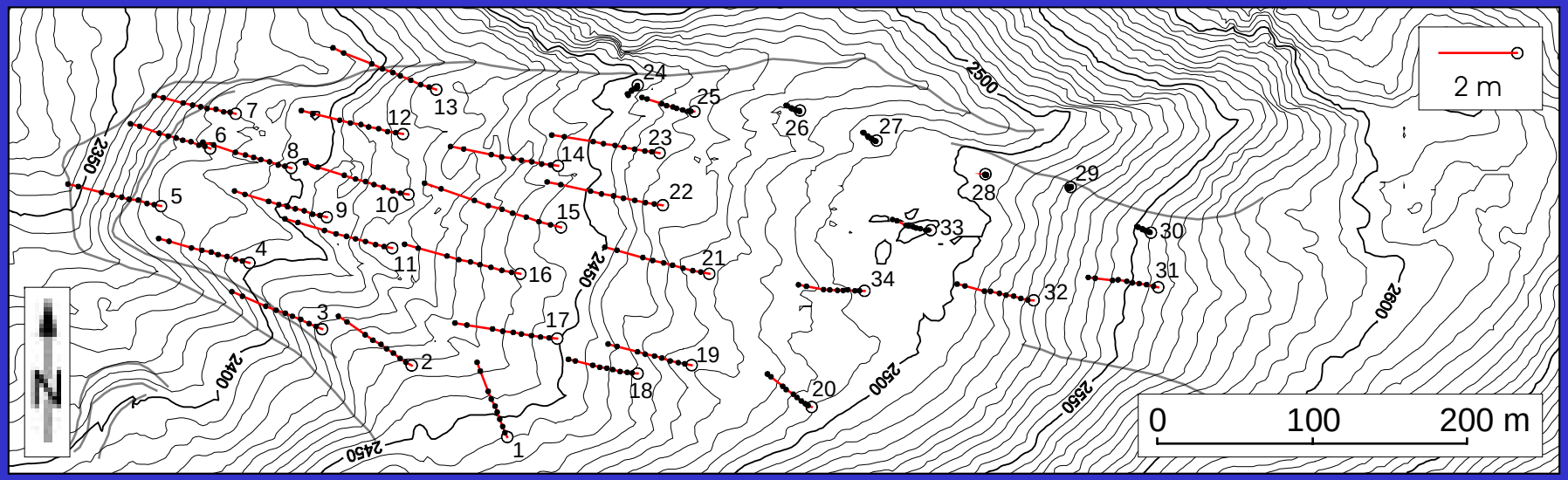




Mean annual horizontal flow velocity of Doesen rock glacier for the time period 1993-1997.

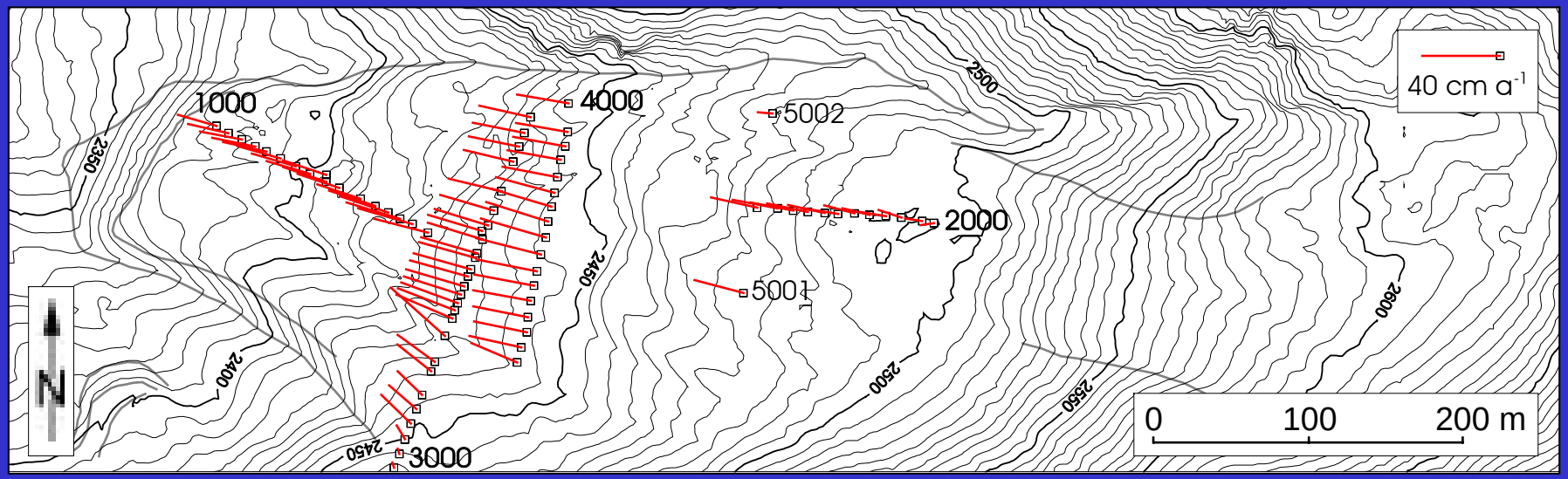
3. Geodetic surveys 1995-2005

7 stable reference points: N1-N3, S1-S4
34 object points
75 additional points (4 profiles)
surveys: each year 1995-2005, except 2003
accuracy: 0.5 – 1 cm in planimetry and height



Total horizontal movement of the 34 points marked with brass bolts on the Doesen rock glacier for the time period 1995-2005.

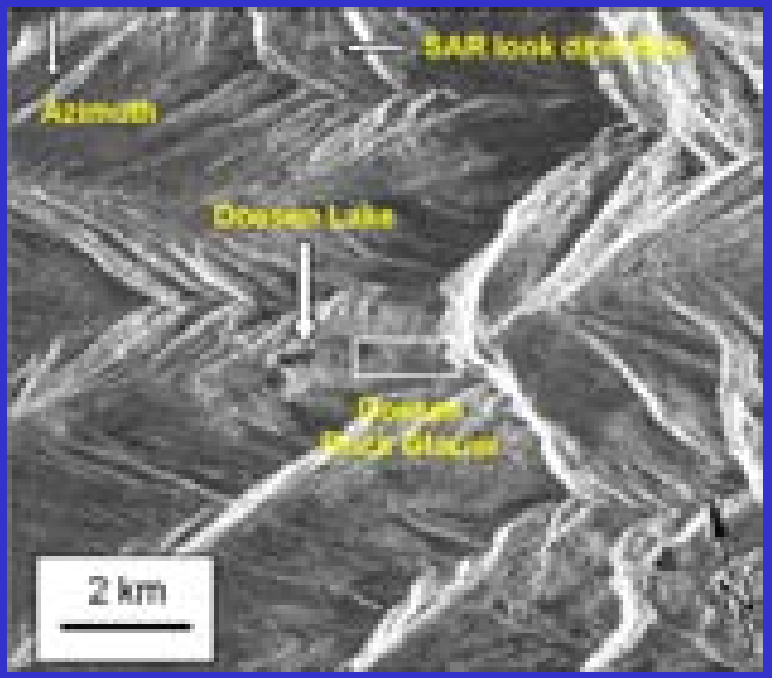
Note that the depicted displacements are exaggerated by a factor of 25.



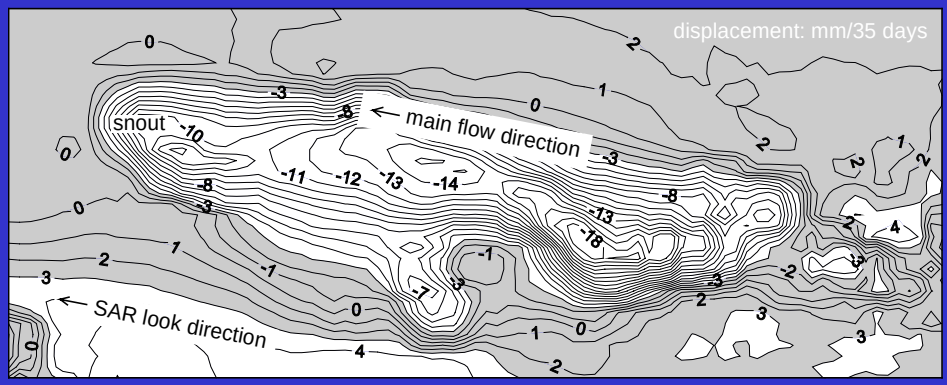
Mean annual horizontal movement of the 75 profile points of the Doesen rock glacier for the time period 1995-2005.

Note that the depicted displacements are exaggerated by a factor of 125.

4. Space-borne differential SAR interferometry



ERS-1 SAR amplitude image



Isolines of 1mm displacement for a 35 day orbit pair

For the Doesen rock glacier an ERS-1 orbit pair of 35 days temporal baseline and very small perpendicular baseline (7m) in August 1992 showed sufficient coherence for computing surface deformation.

5. Cartographic work

Five maps have been published:

- an orthophoto map 1:10,000 of the study area
- a hill-shaded map 1:10,000
- a stereo orthophoto map 1:30,000 for stereo viewing of the study area
- stereo orthophoto map and line map 1:5,000 of the Doesen rock glacier area
- a thematic map 1:5,000 showing photogrammetrically derived flow vectors

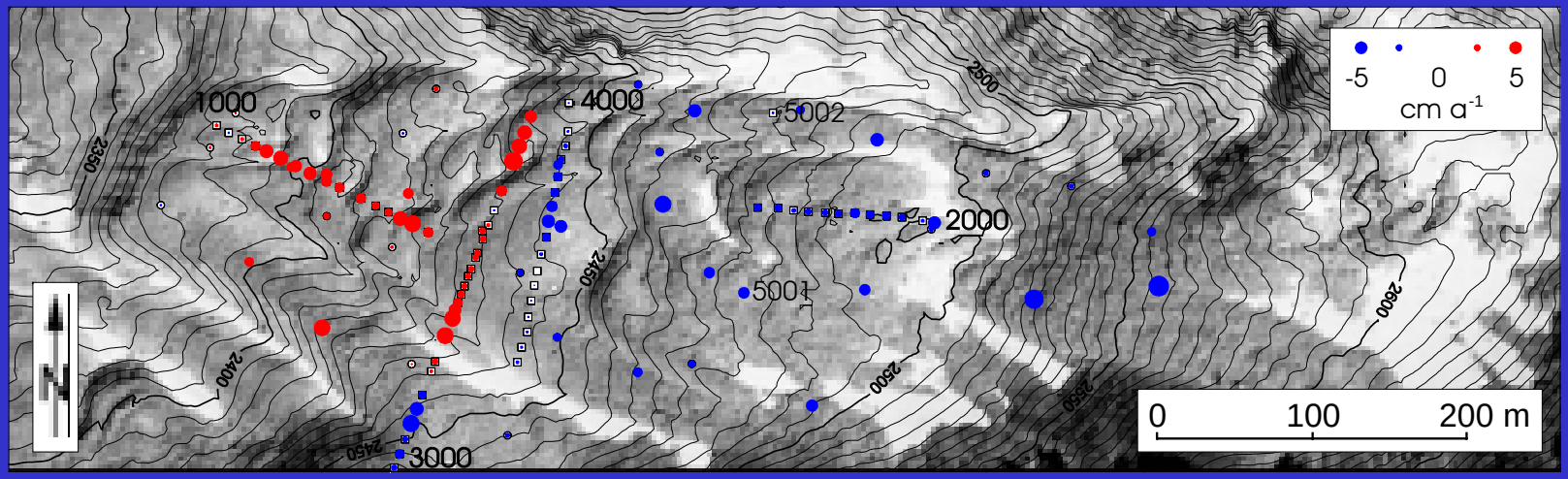
6. Comparative analysis and conclusions

The measured displacement vector fields are smooth.

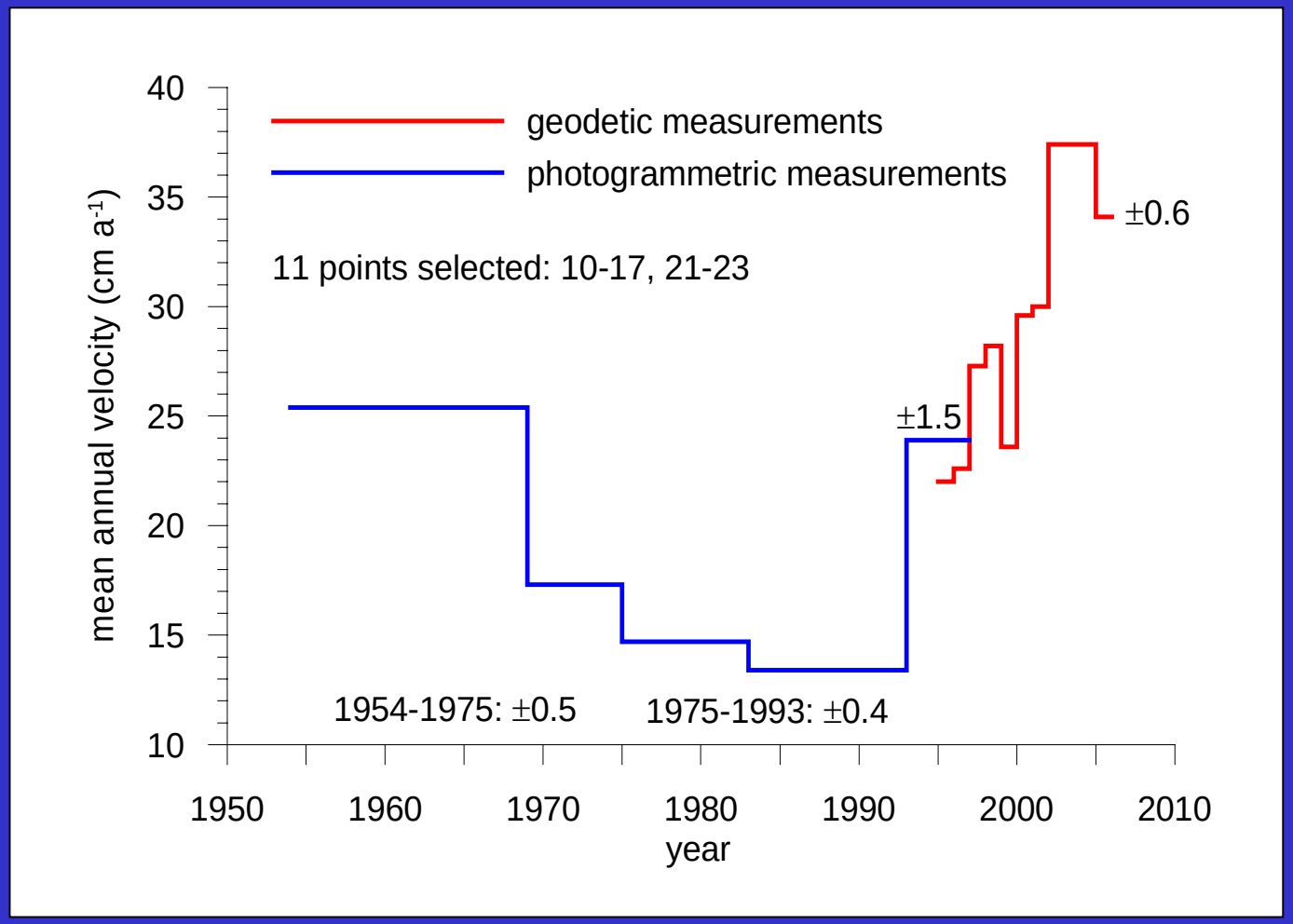
The maximum flow velocity was measured in 2002/2004 and amounts to 45.6 cm a^{-1}.

The geodetic measurements reveal a significant 64% increase in overall flow velocity for the observation period 1995-2005.

The vertical components of the displacement vectors were decomposed based on the "kinematic boundary condition at the surface". A rough estimate of –2 to –2.5 cm a^{-1} for general surface lowering (= permafrost melt) was calculated.



Mean annual vertical particle displacement of the 109 points of the Doesen rock glacier for the time period 1996-2005. Blue dots = submergence, red dots = emergence.



Change of mean annual surface flow/creep velocity at Doesen rock glacier.

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