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The Potential of Merging Multiscale Data Sequences

F. Neyer[1], Z. Su [1], P. Limpach [1], R. Delaloye [2], H. Raetzo [3], J. Beutel [4], S. Gruber [5]

[1] Institute of Geodesy and Photogrammetry, ETH Zurich [2] Department of Geosciences, Geography, University of Fribourg
[3] Federal Office for the Environment [4] Computer Engineering and Networks Laboratory, ETH Zurich
[5] Department of Geography, University of Zurich

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich
University of Zurich[UZH]
UNIVERSITAS FRIBURGENSIS
Schweizerische Eidgenossenschaft
Confédération suisse
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Motivation

- Rock glaciers (creeping accumulations of perennially-frozen debris) have the potential to dramatically change the landscape.
- The increasing degradation of permafrost can strongly influence this behavior.
- Monitoring rock glaciers is a difficult task because of their distribution in high alpine areas, i.e. limited access, lack of power supply,....
- There are existing/developing measurement systems suitable for long term remote operation, i.e. high precision GPS measurements, satellite based InSAR, terrestrial InSAR, optical imaging sources, LiDAR, and more.
- Each method has its own strengths and weaknesses. Different methods could potentially be merged to go beyond their limitations.

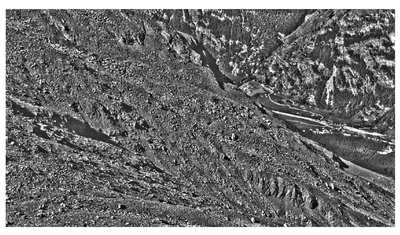
Areal displacement extraction

Off-the-shelf cameras can produce useful image series for the extraction of displacement fields. A so-called Optical Flow estimation algorithm has been developed and optimized for the rough terrain of rock glaciers. The processing steps are:

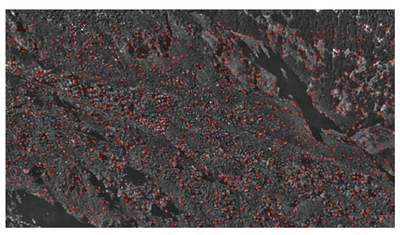
(1) Orientation of Images
Necessary due to slightly changing field of view between image acquisition epochs

(2) Shadow extraction
To protect displacement estimates of moving shadow borders

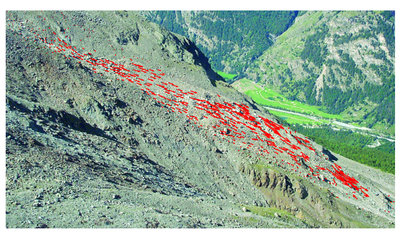
(3) High contrast image
Generate black-and-white image by optimally weighting RGB channels



(4) Adjust local histogram
Equalize illumination differences with Wallis filtering



(5) Feature detection
Harris Corner detection is used to detect suitable image regions



(6) Displacement extraction
A combined method of cross-correlation and LSQR matching is used to estimate the transformation matrices

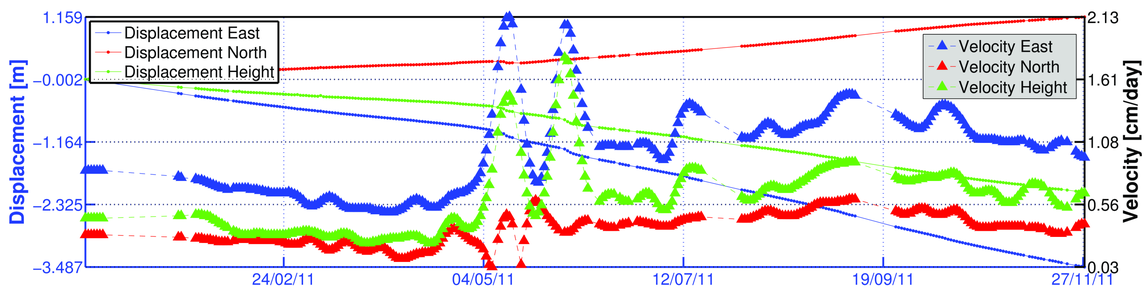
Strengths:
- Good areal coverage
- Fast data processing
- Regular data sequences

Weaknesses:
- Non-constant accuracy
- Only 2-dimensional
- Prone to illumination changes and weather

GPS derived displacements

Computing GPS position coordinates is a trade off between temporal resolution and accuracy.

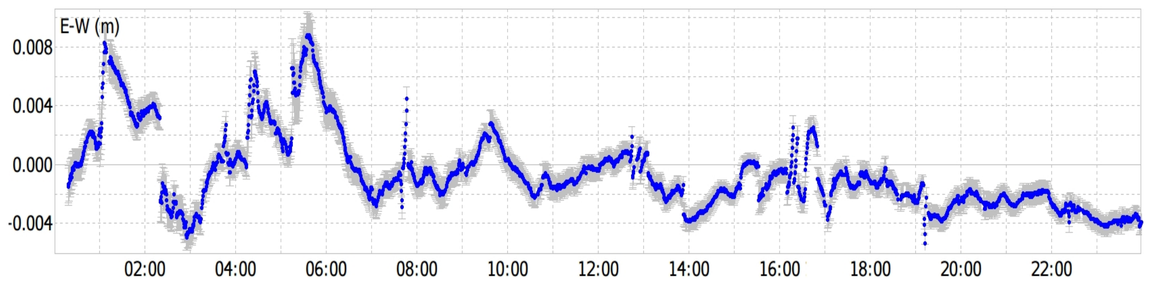
Daily GPS solutions (24h):



DI57, moving GPS station in Dirru rock glacier: relative position change (small markers) and estimated velocity (large markers). Blue, red, and green colors represent east, north and vertical components, respectively.

- High precision: 2mm horizontal, 3mm vertical standard deviation of coordinates repeatability
- Low temporal resolution: one position per 24 hours.

Near real-time epoch wise (30s) GPS solutions:



DI05, non-moving GPS station in Dirru rock glacier: East-West position estimates (blue) with corresponding error bars (gray)

- High temporal resolution: positions estimated in near real time
- Decreased accuracy: up to 1cm deviation from true position which is due to remaining systematic errors (not seen in the error bars)

Strengths:
- Generally high accuracy
- 3-dimensional estimates
- Independent of weather

Weaknesses:
- Valid only point-wisely
- Need of satellite availability
- Prone to data gaps

Potential of merging both results

Overcome weakness of Optical Flow and GPS derived displacement estimates:
- Calibrate 2D Optical Flow with high accuracy 3D GPS results
- Validate and adjust absolute accuracy of areal displacement field
- Merge both measurements using common data structure
- Optionally include other measurements