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X-Sense RTD 2010

FNSNF

# Combination of Imaging, Digital Terrain, and GPS Data


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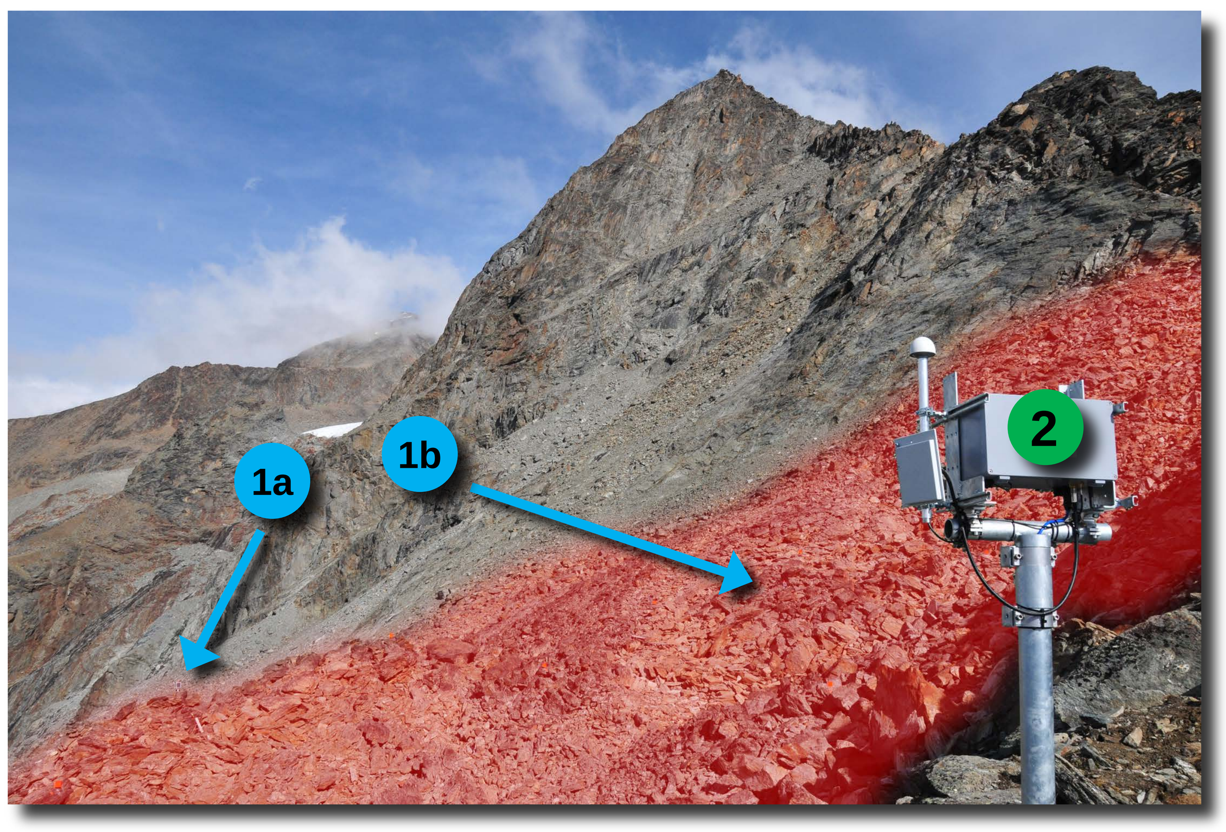
- Rock glaciers (creeping accumulations of perennically-frozen debris) are studied using a variety of devices, both for data acquisition and transmission (f.e. GPS measurements and data transfer using a WLAN network).
- In the X-Sense project, rock glaciers are studied using different sensors that are concentrated in a small area. The various measurement devices provide insides into this complex creeping phenomena from different perspectives.
- The present work illustrates the Grabengufer field site (Mattertal Valley, VS) and assesses the quality of optical imaging displacement estimation compared to L1 GPS.

## Grabengufer rock glacier – Multi sensor observations




Grabengufer rock glacier (Mattertal VS) has a complex surface motion, i.e., areas that are dominated by sagging and areas where rocks break of a ridge. The latter areas and those below are too dangerous for human and hardware to install an on-site measurement device like GPS. To overcame a measurement gab and to cover a larger surface area of the rock glacier, optical cameras are used.

The red area to the left shows the top of Grabengufer rock glacier.


X-Sense GPS logger and online antenna, power supply (solar panels with batteries) infrastructure and data transmission installation.

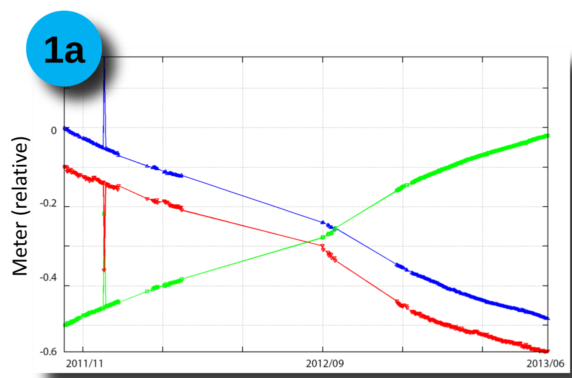

High-Resolution optical camera (12MP sensor with wide field lens) inside a robust weather proof mount and housing. A GPS antenna is mounted for position stability observation.

## Available and processed Data

GPS and optical image data are continuously captured, sent to a common server and individually processed. GPS solutions can be given in absolute position coordinates whereas the optical image analysis is related to the reference system by:

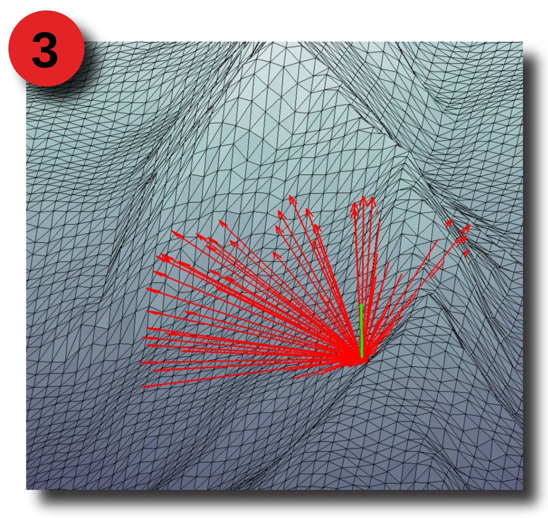
$$X_{abs} = A[R\ t]\ X_{rel}$$

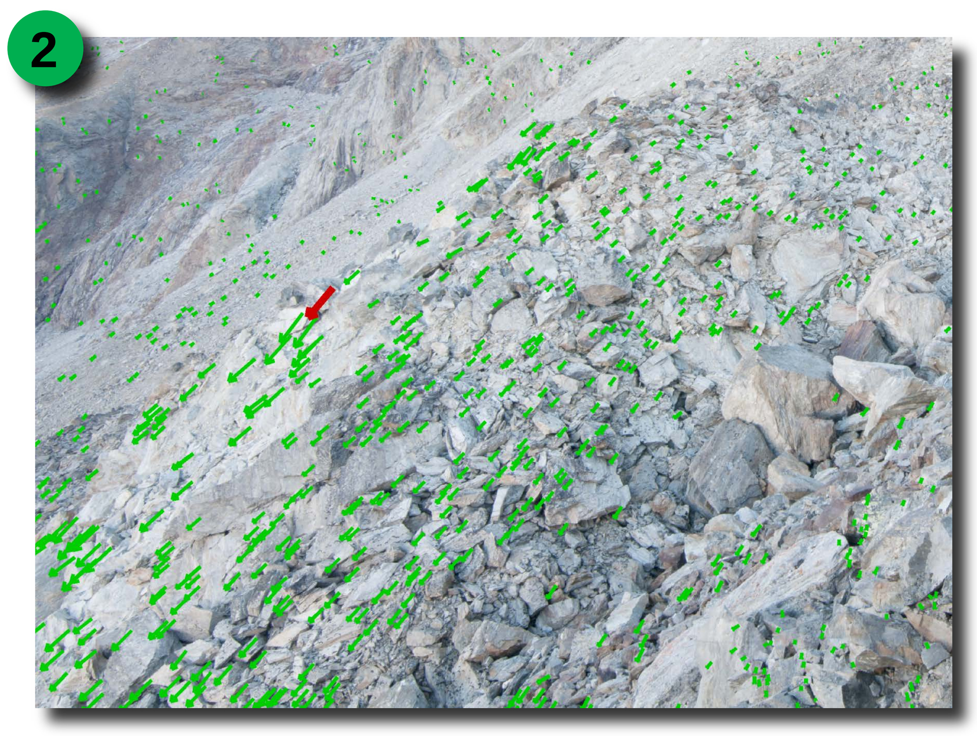
$A$ is the intrinsic calibration matrix determined by examination of a calibration pattern from different perspectives. $R$ (rotation) and $t$ (translation) are the extrinsic calibration matrices that are estimated with absolute calibration patterns and the approximate knowledge of the camera position.




Example of estimated GPS positions (east-, north-, and height components) over almost two years.

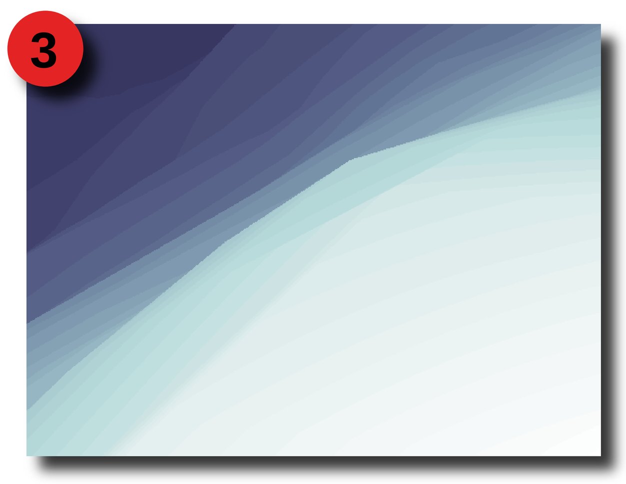
Estimated extrinsic camera parameters showing the camera position and the projecting image rays. To fully associate the image coordinates with absolute coordinates, depth information is needed: Digital Terrain Model (DTM)



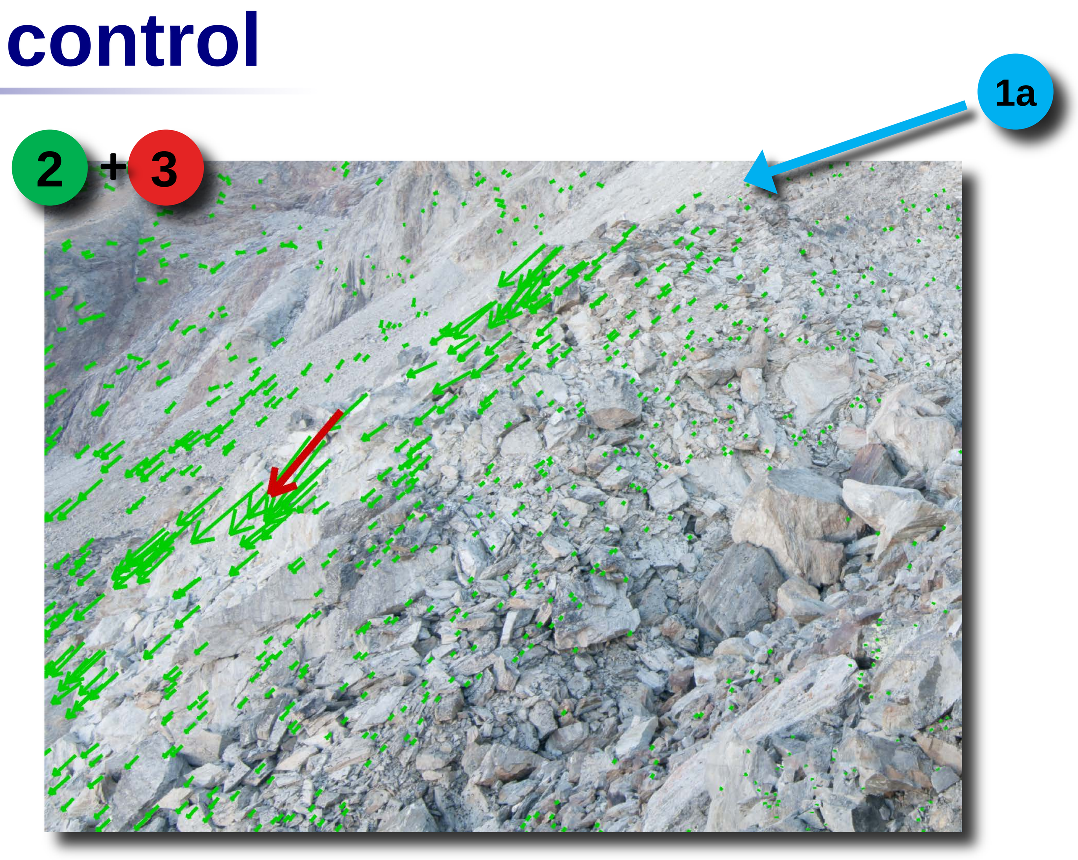

Example of estimated displacements between two epochs (18 days) in image coordinates. Red arrow is 4.58 pixels

## Data Combination and Quality control




Z-buffer (image depth) computed using a 25m DTM (swisstopo) - bright areas are close to the camera

Scaled image displacement estimates (between 18 days). Red arrow corresponds to a movement of 14cm (perpendicular to the image plane).




Once all camera parameters are known, a Z-buffer can be computed in case a suitable DTM is available. This relates the image coordinates to the absolute coordinates and therefore the extracted displacement estimates can properly be scaled for absolute values.

The table below shows the agreement between (projected) GPS and image displacement estimates. The agreements are in the range of millimeters in case the image depth was correctly retrieved.

Assigning image depth values is critical in areas with flat incidence angles, easily causing wrong scaling factors by one order of magnitude. In an environment with fast changing topology and flat projection geometry, precise surface height information is needed.

| Reference, GPS | projected GPS 1a ($x = -28.9mm$ $y = 24.6mm$) | | projected GPS 1b ($x = -18.6mm$ $y = 13.1mm$) | |
|---|---|---|---|---|
| Rough DTM (25m) | $\Delta x = 51.8mm$ $\Delta y = -50.4mm$ | @ $405m$ | $\Delta x = -5.4mm$ $\Delta y = 8.3mm$ | @ $168m$ |
| Correct distances | $\Delta x = -2.9mm$ $\Delta y = 5.0mm$ | @ $160m$ $(correct)$ | $\Delta x = -3.1mm$ $\Delta y = 7.4mm$ | @ $198m$ $(correct)$ |

Agreement between the two measurement systems, absolute displacements in camera view