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X-Sense RTD 2010

FNSNF

Long Term Rock Glacier Monitoring with DSLR Cameras

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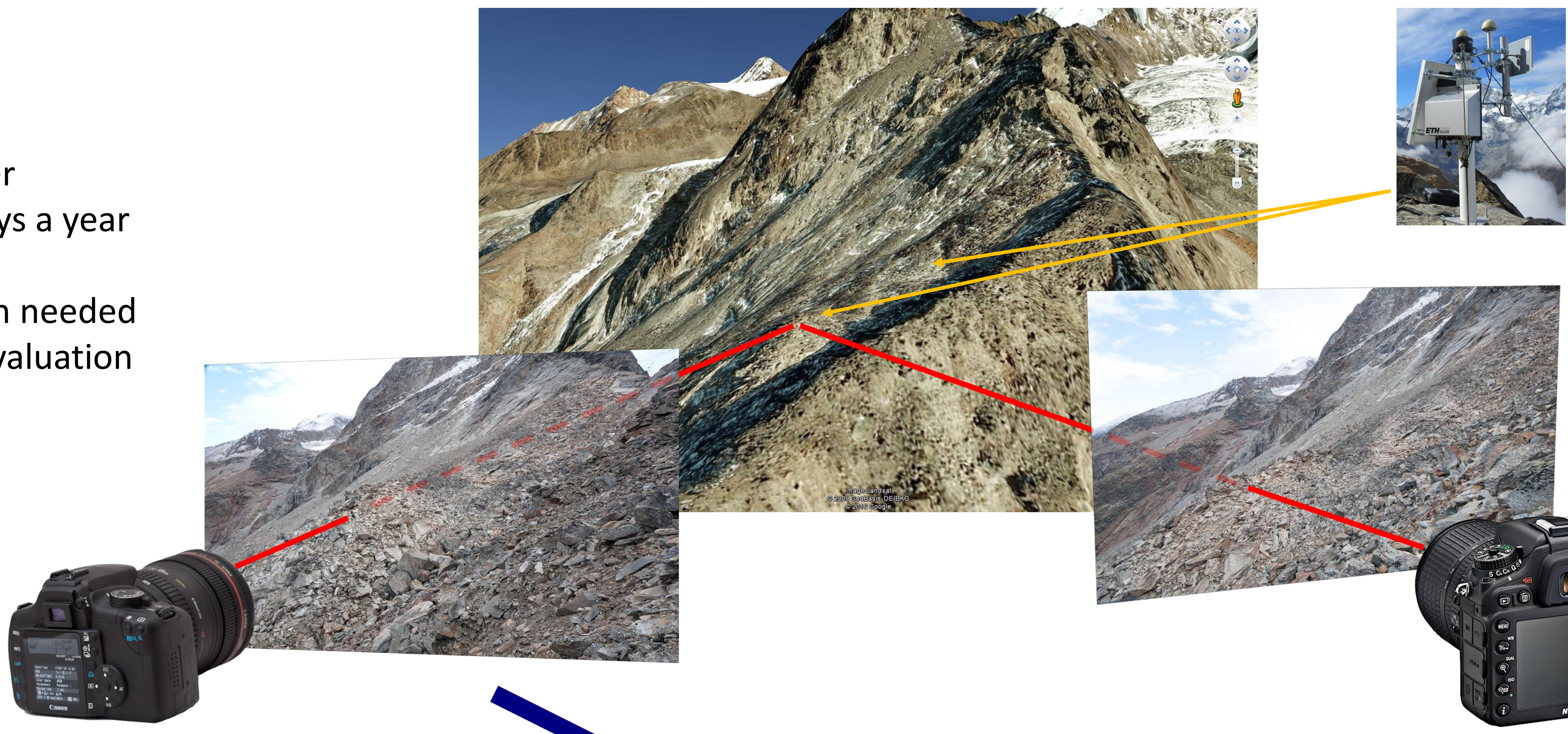
Field Setup

Sub-daily image acquisition and data transfer

- Operational since October 2012, ~365 days a year
- Huge amount of data
- Automatic image selection and evaluation needed
- Permanent GNSS observation and data evaluation with daily to sub-daily position solutions



2 permanent GPS/ GNSS measurement installations

On-site camera installation

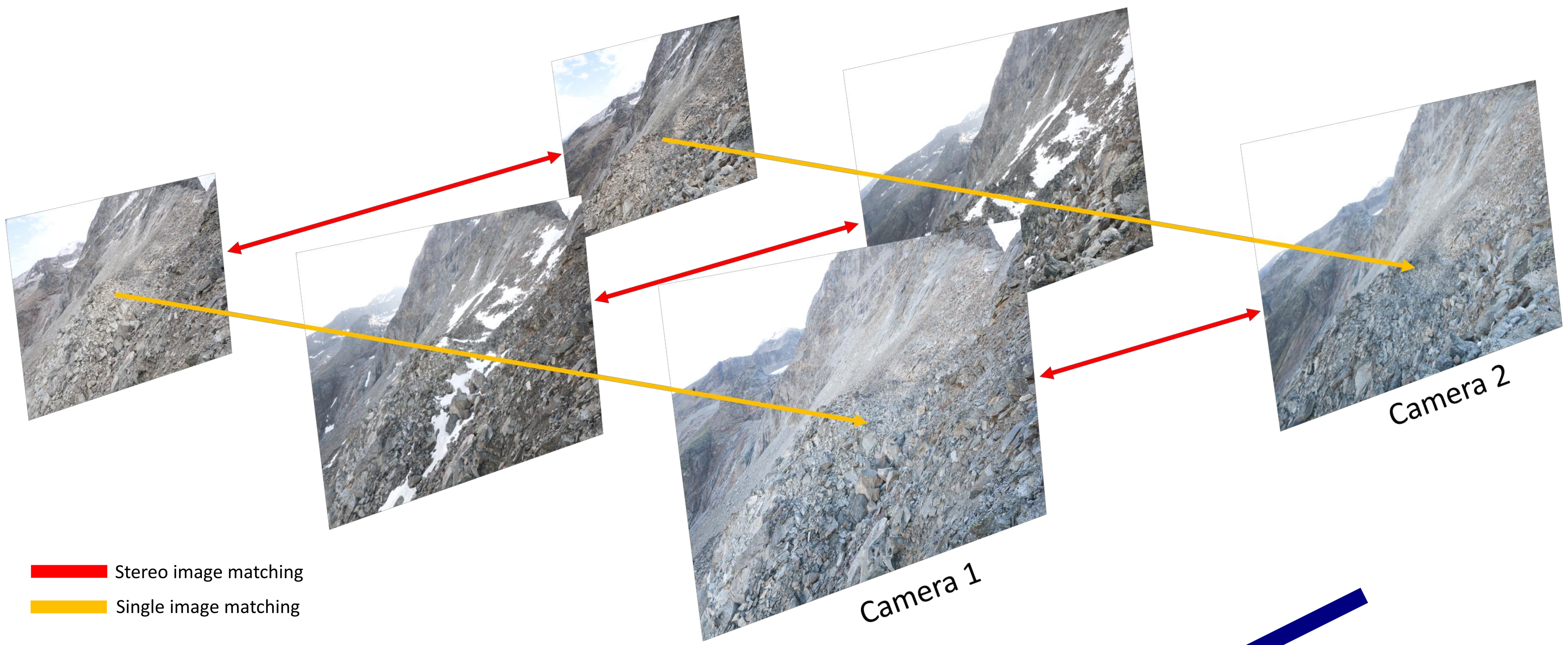
- Weatherproof box
- Battery
- Solar Panels
- GNSS
- WLAN

Image Matching Pipeline

Image Matching based on optimized high precision Least-Squares Feature Tracking:

- Detection of snow covered areas prior to matching
- Matching for each camera sequence, difficulties:
  - Variable surface illumination
  - Variable surface structure (e.g. missing rocks)

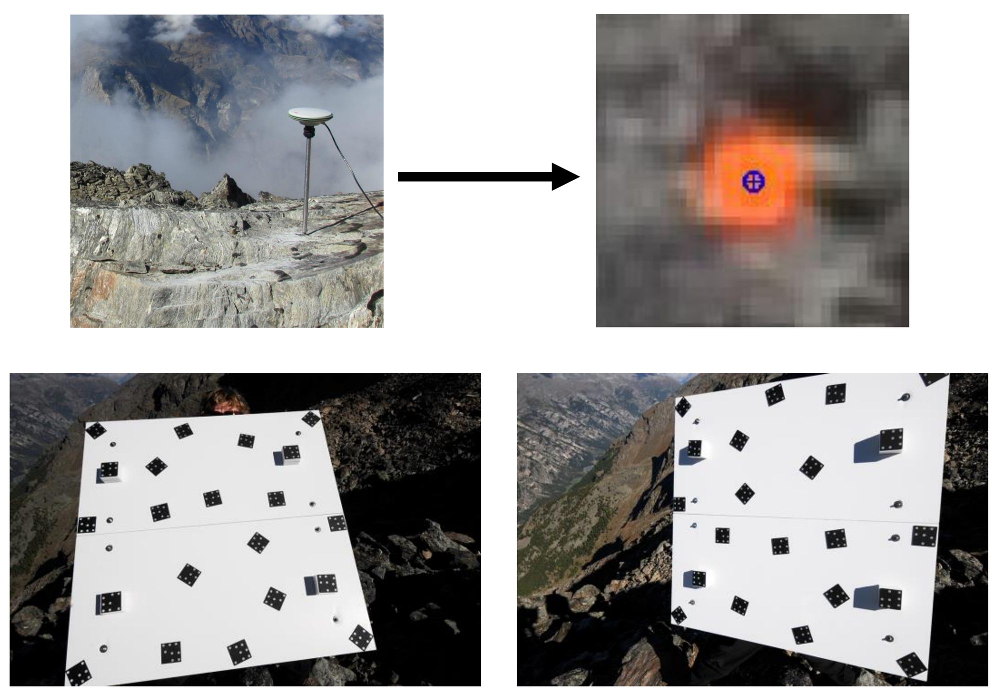
- Stereo matching between the cameras, difficulties:
  - More complex transformation needed
  - Occultations (structures are visible in one image but not in the other)



Reconstruction of DEM

Absolute coordinate estimation of common image structures using stereo matches and initial calibration estimates. Highlights and difficulties:

- Accurate camera position retrieved from GNSS
- Initial calibration parameters optimized every epoch
- Separate template matching used for tracking (moving) GNSS stations
- Moving GNSS installations on rock glacier used for absolute ground truth
- Atmospheric correction (refraction)
- Interpolation of DEM during winter (too few image correspondences)
- Interpolation/integration of reconstructed DEM with other sources in case of occultation



Camera Calibration:

(1) Absolute orientation, used to relate image with world coordinates. Realized by field target measurements.

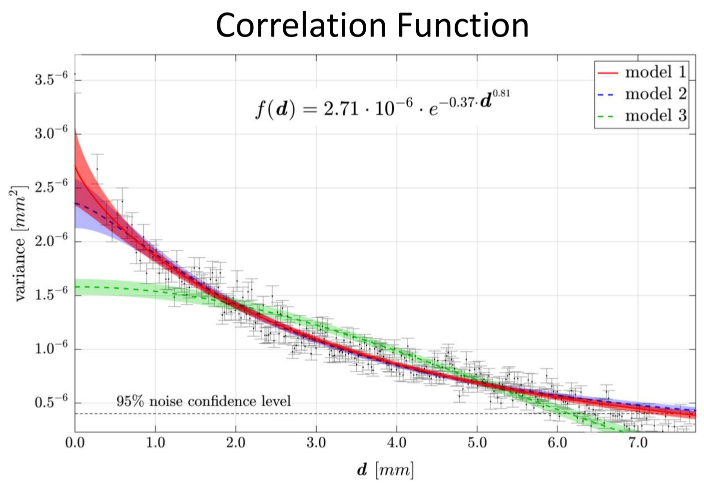
(2) Intrinsic corrections, used to calibrate optical effects due to lens and camera housing.

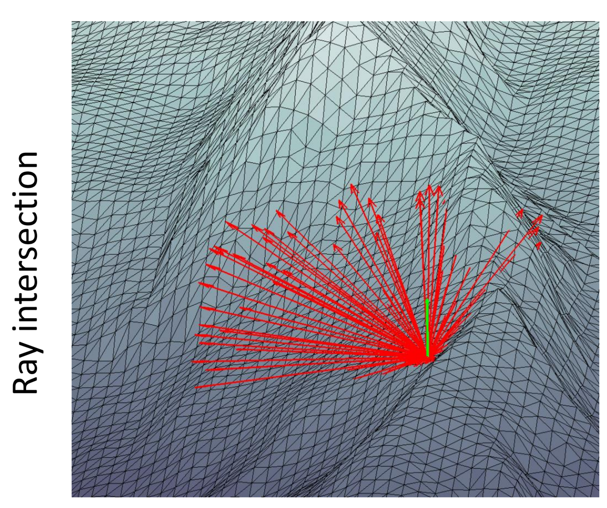
Total calibration error:

$$RMS(x,y,z) = [2\ \ 5\ \ 10]\ cm$$
$$RMS(u,v) = [0.7\ \ 0.3]\ pixel$$

Estimated displacement of Grabengufer rock glacier based on forward ray projection onto estimated DEM

Correlation Function





Estimation of 3D Rock Glacier Velocity

Flow field consistency is increased by adaptive collocation:

- An empirical correlation function is estimated
- Decorrelation of flow areas based on iterative strain field analyses

Forward intersection of estimated 2D flow with estimated/ interpolated 3D model. Critical aspects:

- Intersection in very oblique areas (DEM errors have large effects)
- Plausibility analysis for critical areas

Most critical part for the complete processing pipeline: Proper error propagation throughout the various processes