Snow Cover Monitoring in the Swiss Alps Using Webcam Images

Céline Dizerens, Fabia Hüsler, Stefan Wunderle

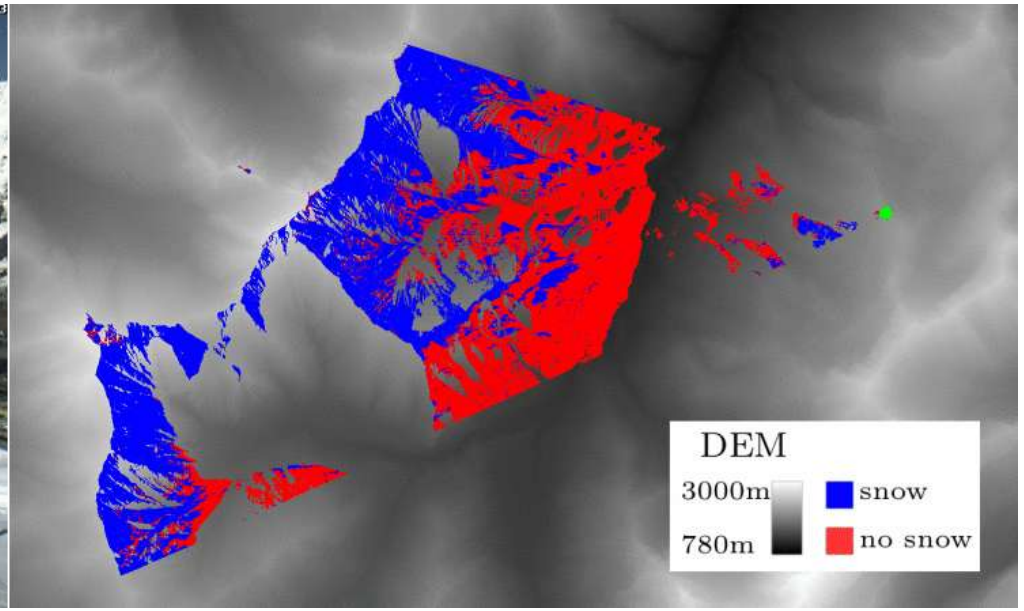
Institute of Geography and Oeschger Centre for Climate Change Research, University of Bern

8th EARSeL LISSIG workshop, 7-9 February 2017

INTRODUCTION

UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



INTRODUCTION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- Huge number of freely available webcams
  - Wordwide: more than 60’000 webcams

www.webcams.travel

INTRODUCTION

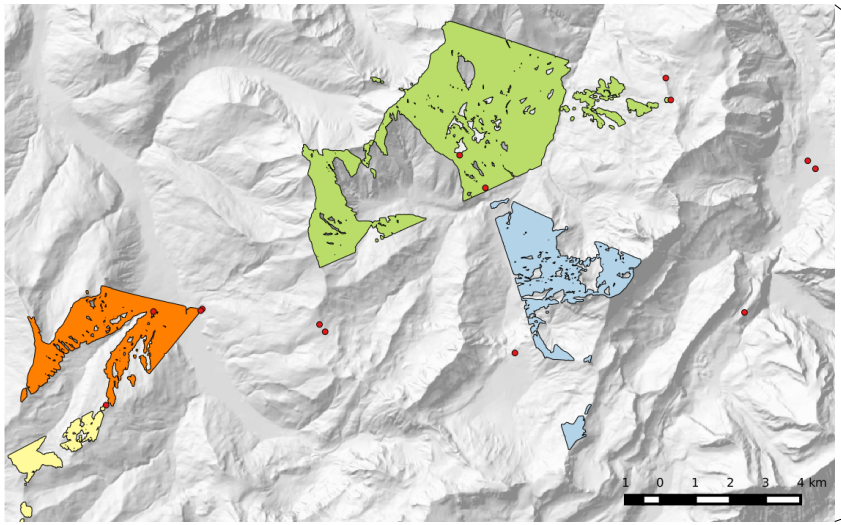
UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

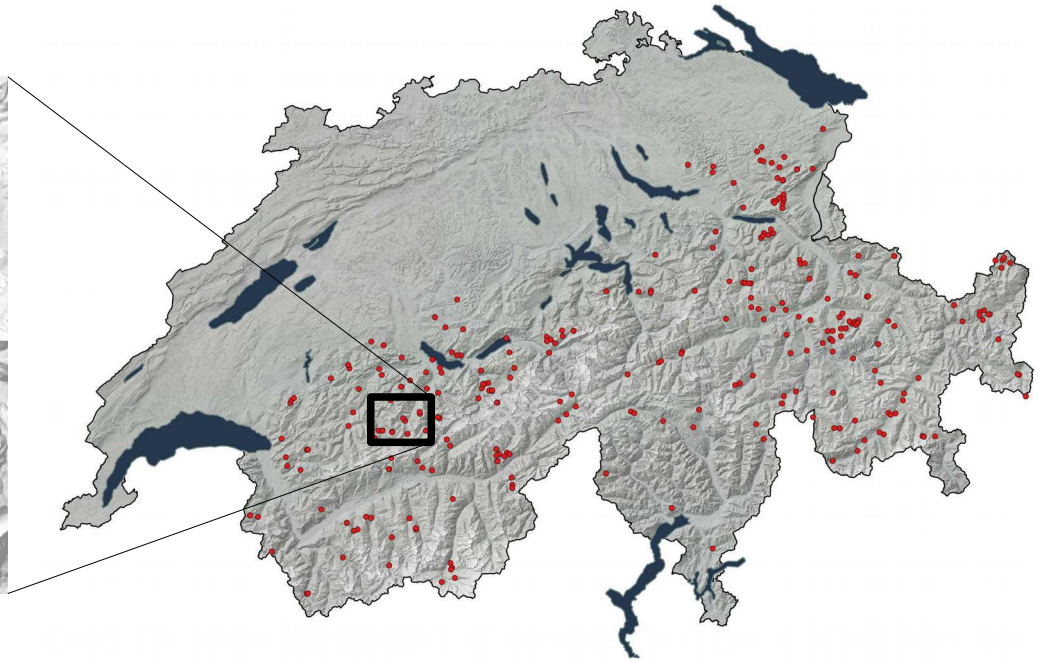
- Huge number of freely available webcams
  - Wordwide: more than 60’000 webcams
  - Switzerland: more than 3‘000 webcams (swisswebcams.ch)

INTRODUCTION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- Huge number of freely available webcams
  - Wordwide: more than 60’000 webcams
  - Switzerland: more than 3‘000 webcams (swisswebcams.ch)
  - Our archive: about 520 webcams (since 2011)
    → 296 webcams processed





INTRODUCTION

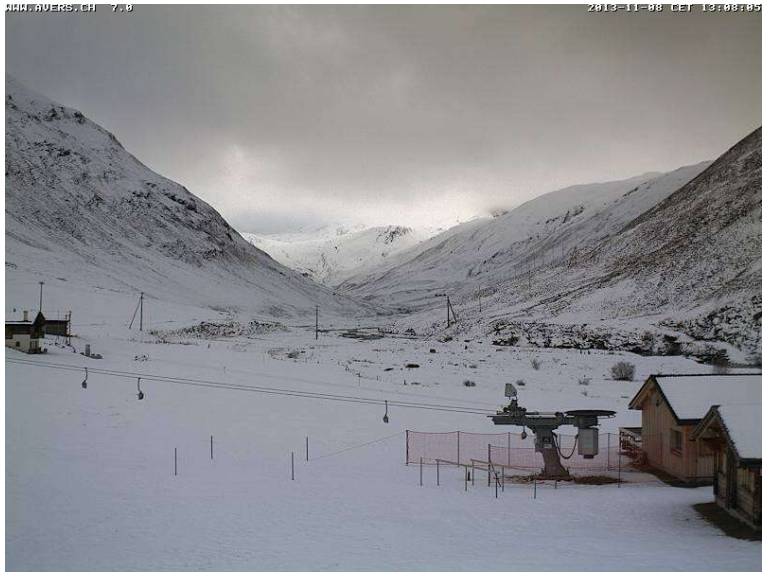
UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- Huge number of freely available webcams
- High spatial and temporal resolutions

INTRODUCTION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- Huge number of freely available webcams
- High spatial and temporal resolutions
- Provide additional information (often below cloud cover)



INTRODUCTION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- Huge number of freely available webcams
- High spatial and temporal resolutions
- Provide additional information (often below cloud cover)
- Allow detailed analyses of snow cover on steep slopes due to their oblique view on the mountains

INTRODUCTION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- Huge number of freely available webcams
- High spatial and temporal resolutions
- Provide additional information (often below cloud cover)
- Allow detailed analyses of snow cover on steep slopes due to their oblique view on the mountains

→ serve as a reference for improved validation of satellite-based approaches

→ complement satellite-based snow cover retrieval

WEBCAM PROCEDURE

UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Main issues:

- Only RGB information for snow classification
- Missing information: Almost no information about webcams available
  - Exact location
  - Orientation
  - Field of view
  - Camera/lens parameters

WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

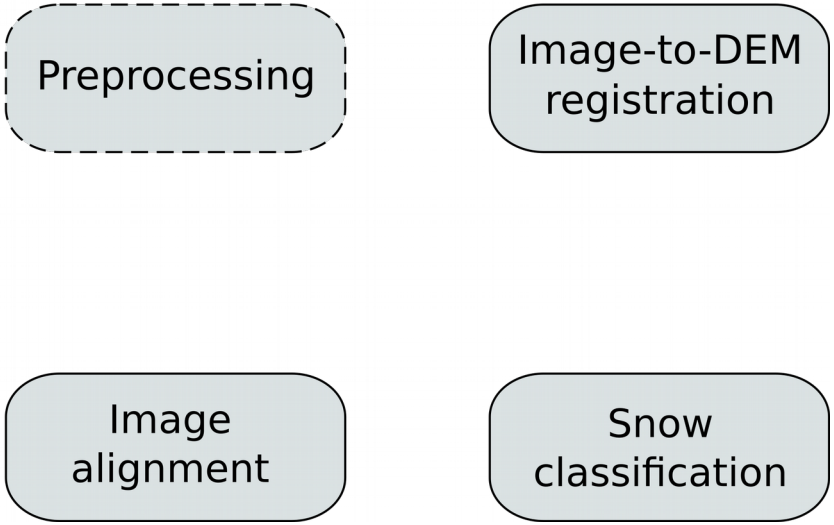
Existing rectification methods based on cam's parameters, GCPs, **few cameras**

- Corripio 2004
- Härer et al (2014, 2016)

  → too time-consuming for webcams: too many unknowns, large amount of manual user input required

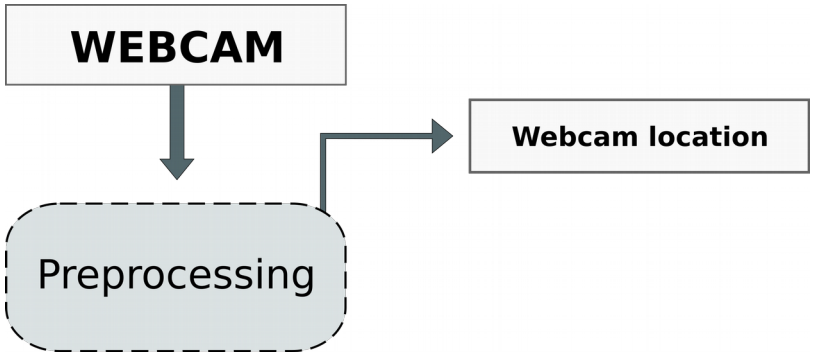
WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



WEBCAM PROCEDURE

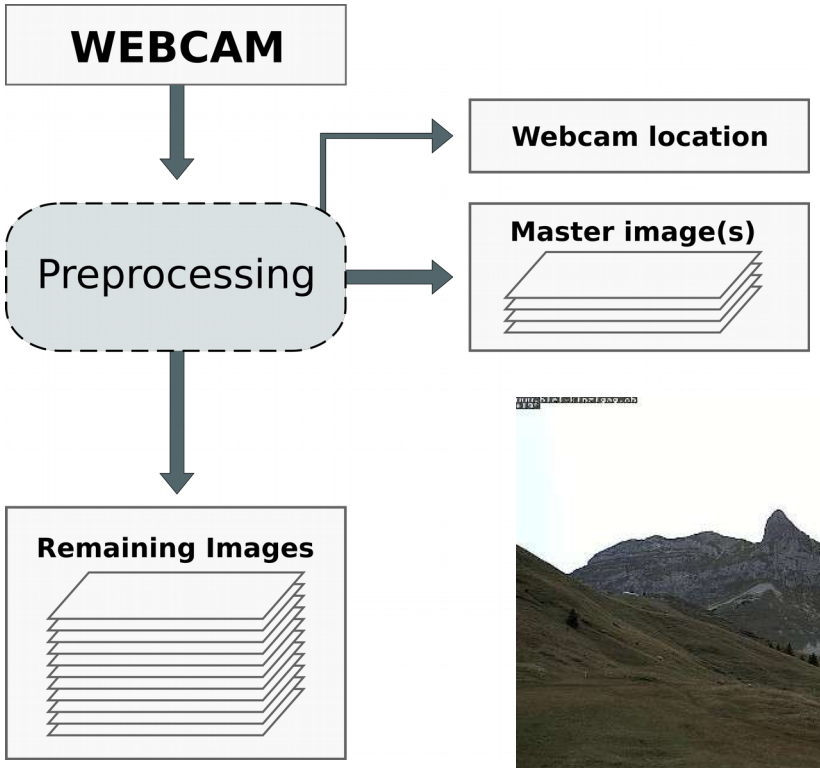
UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



Orthophoto SWISSIMAGE

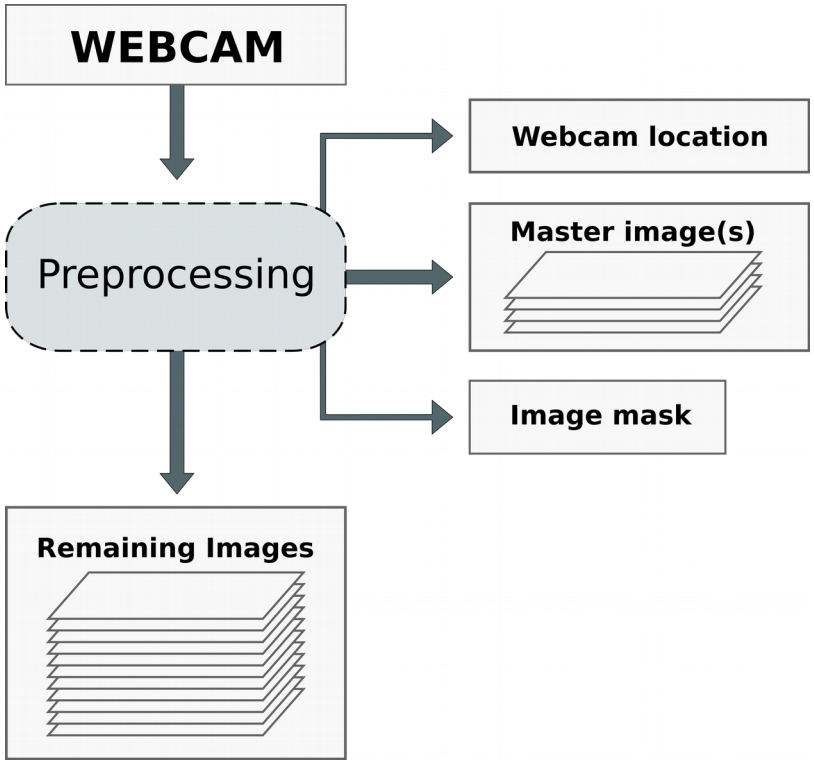
WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



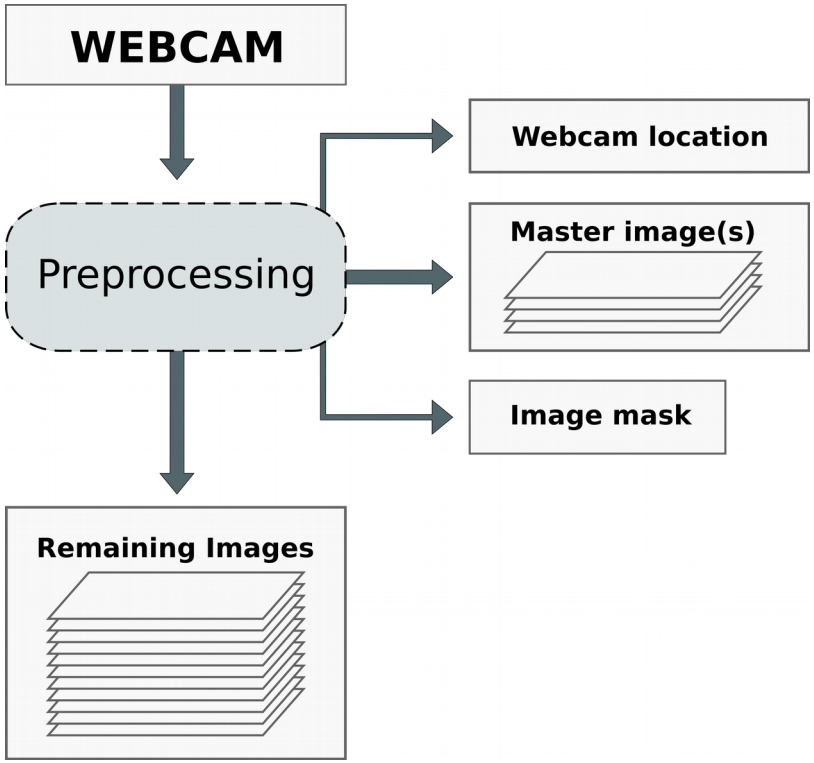
WEBCAM PROCEDURE

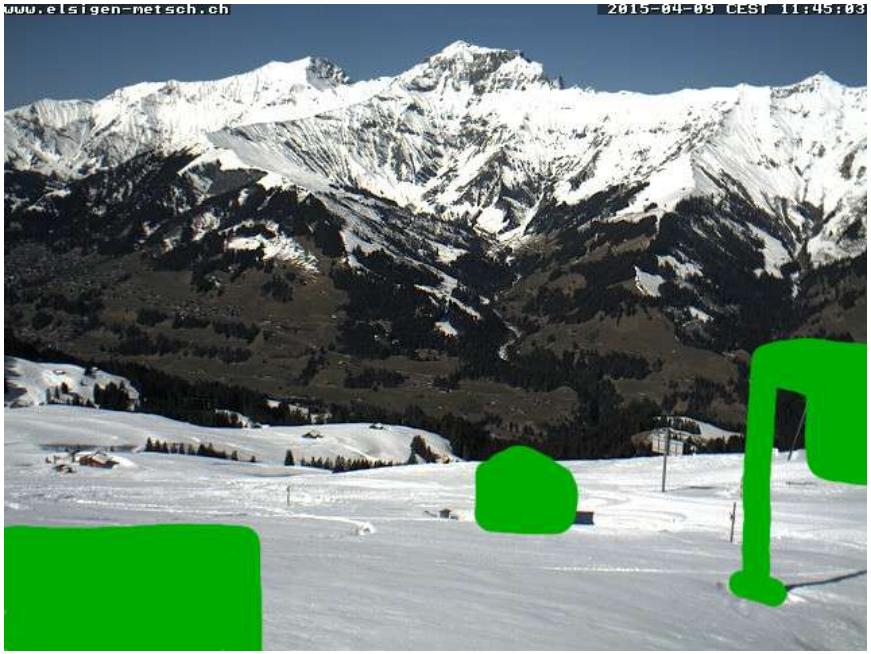
UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



WEBCAM PROCEDURE

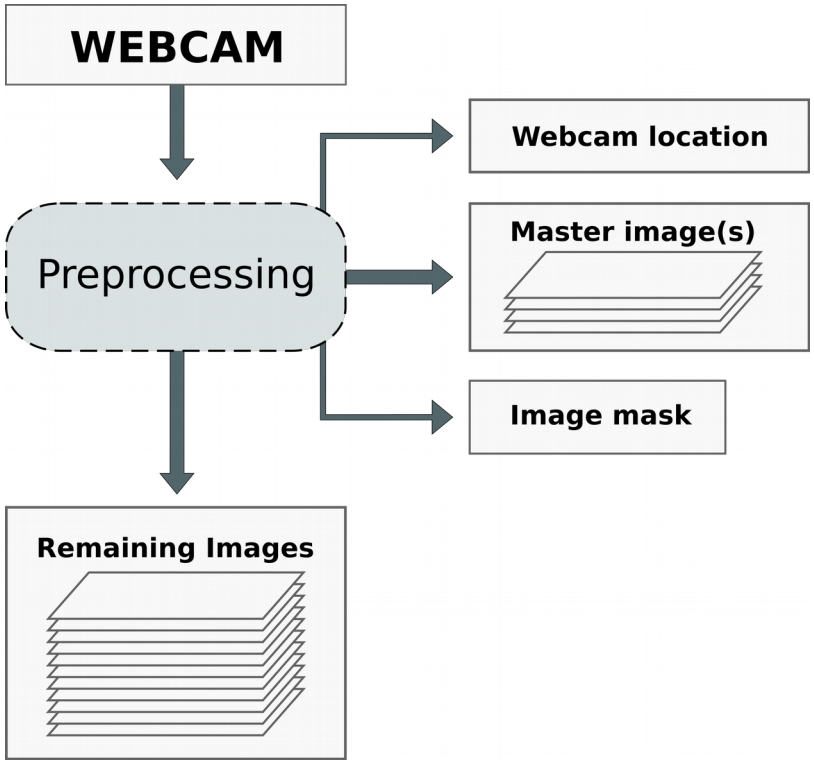
UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

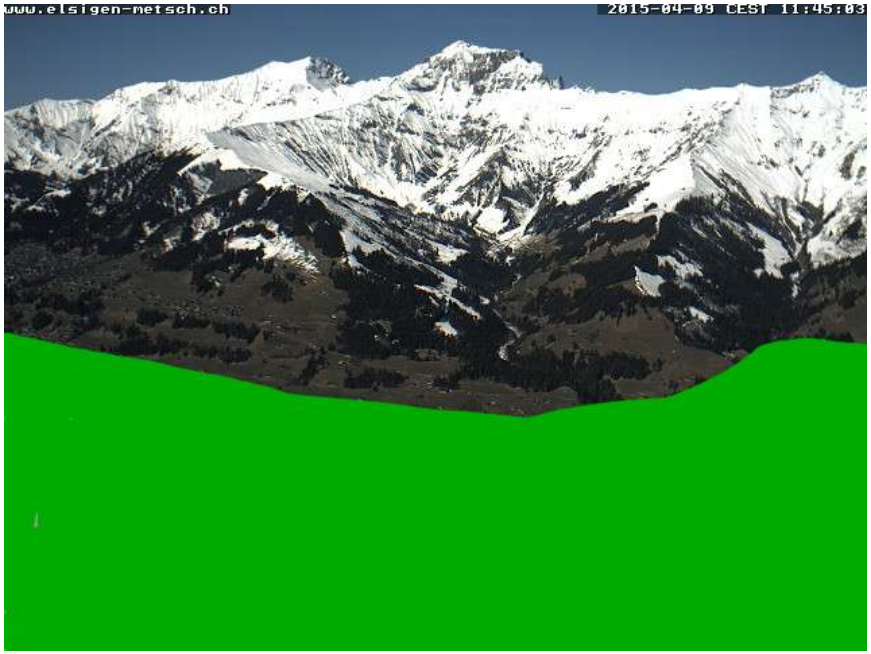




WEBCAM PROCEDURE

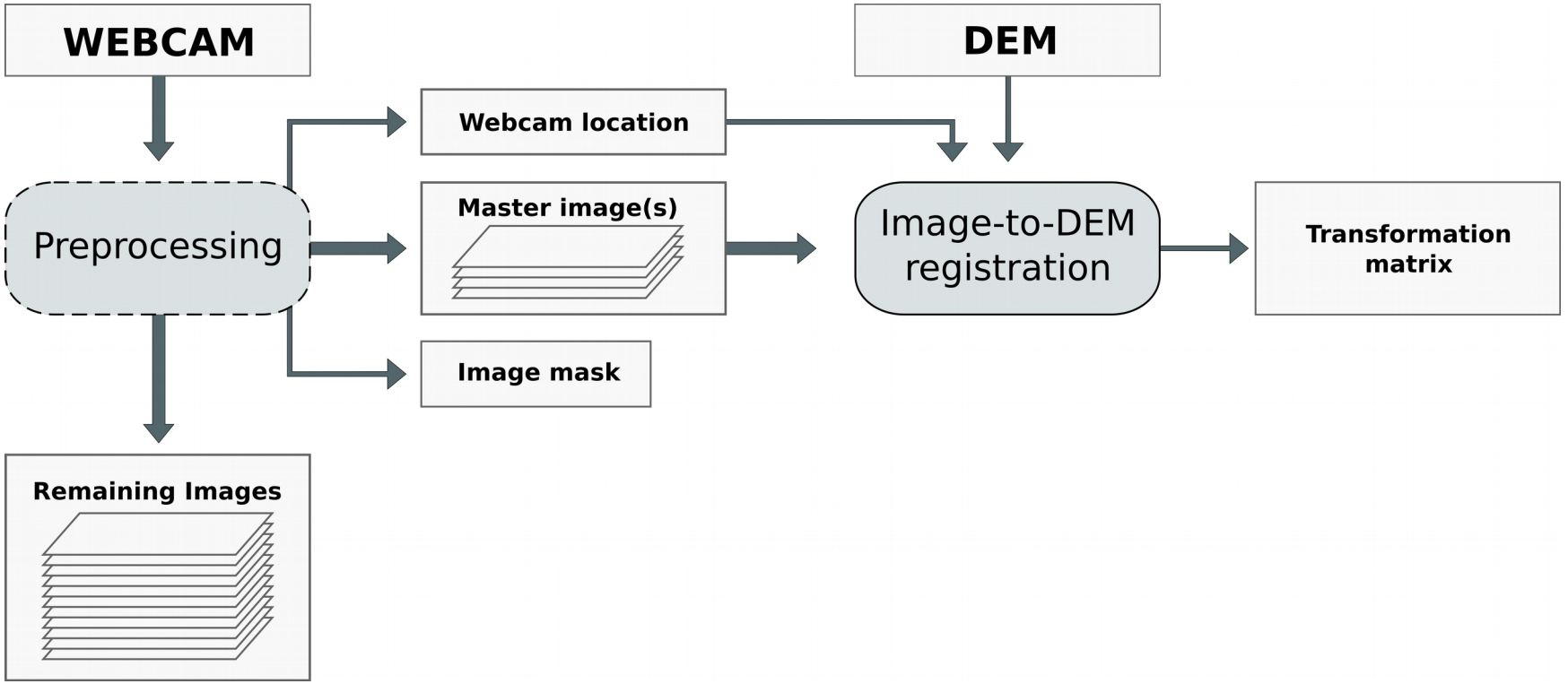
UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH





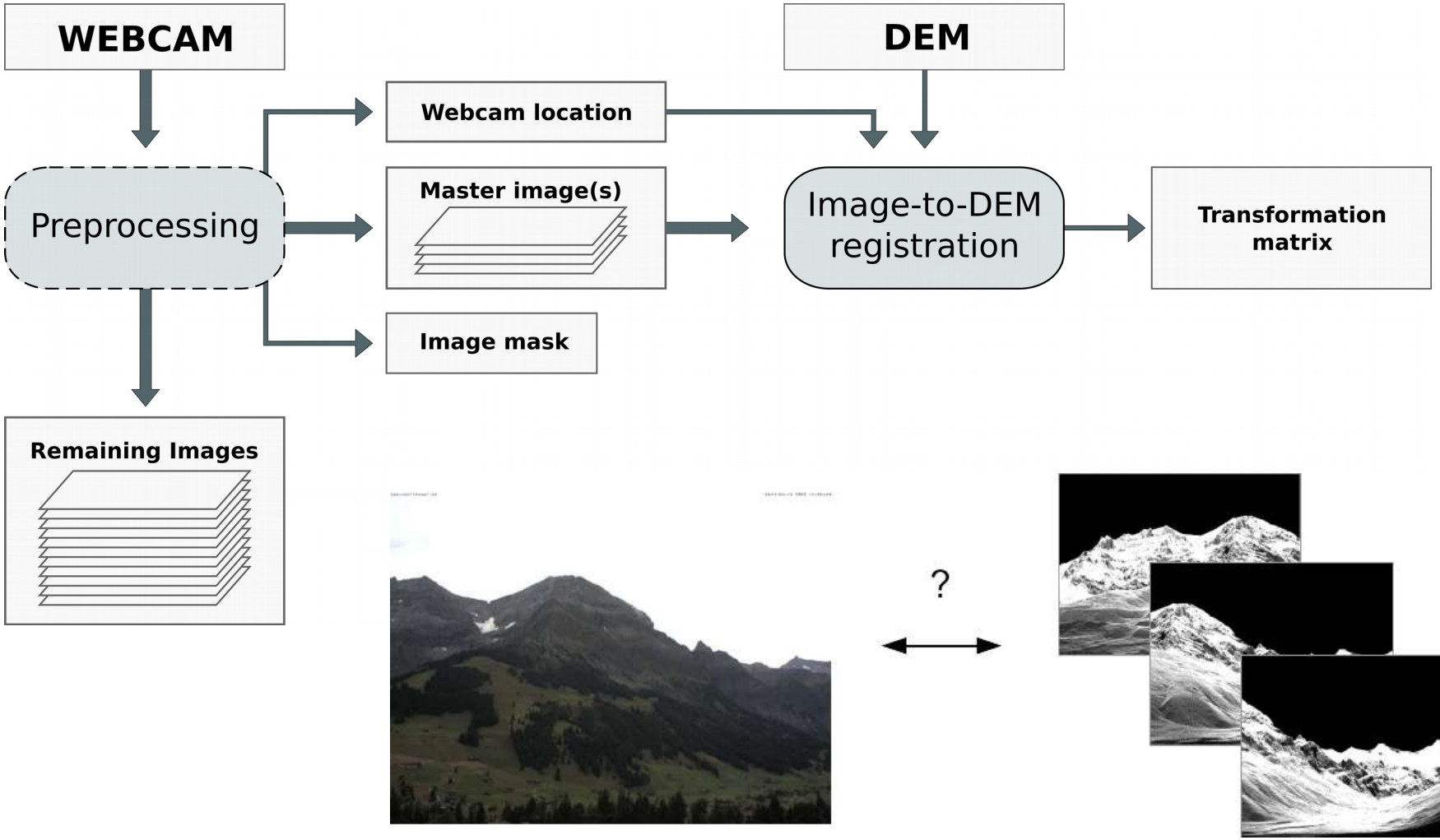
WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



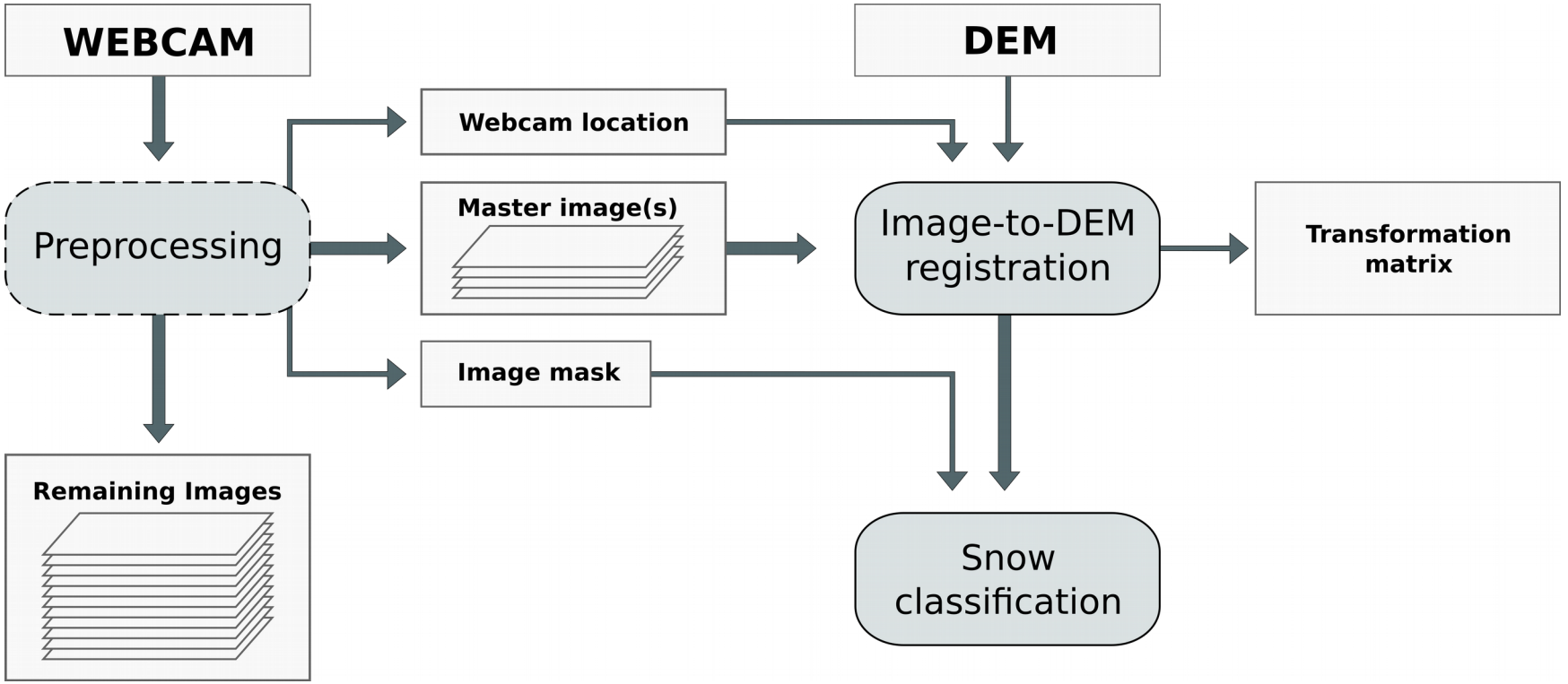
WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



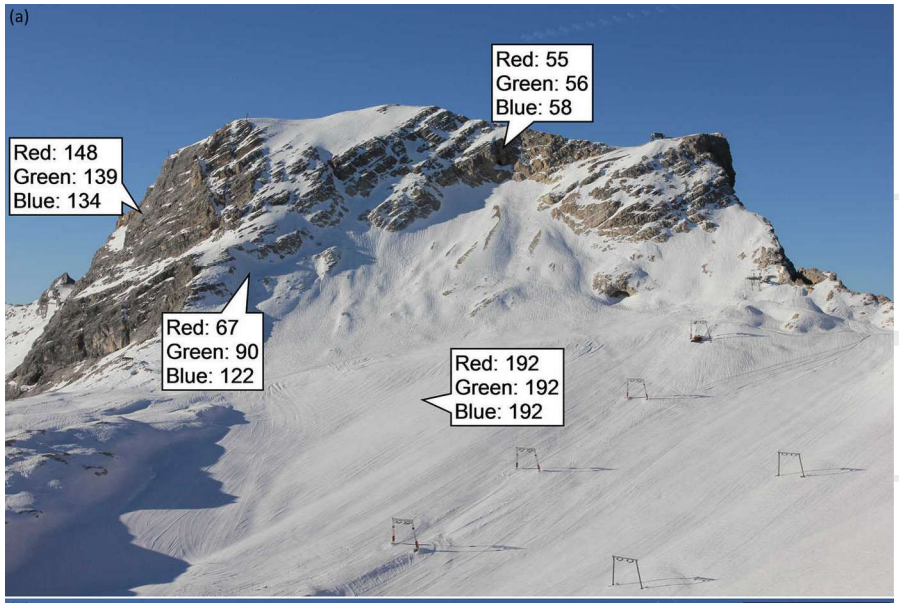
WEBCAM PROCEDURE

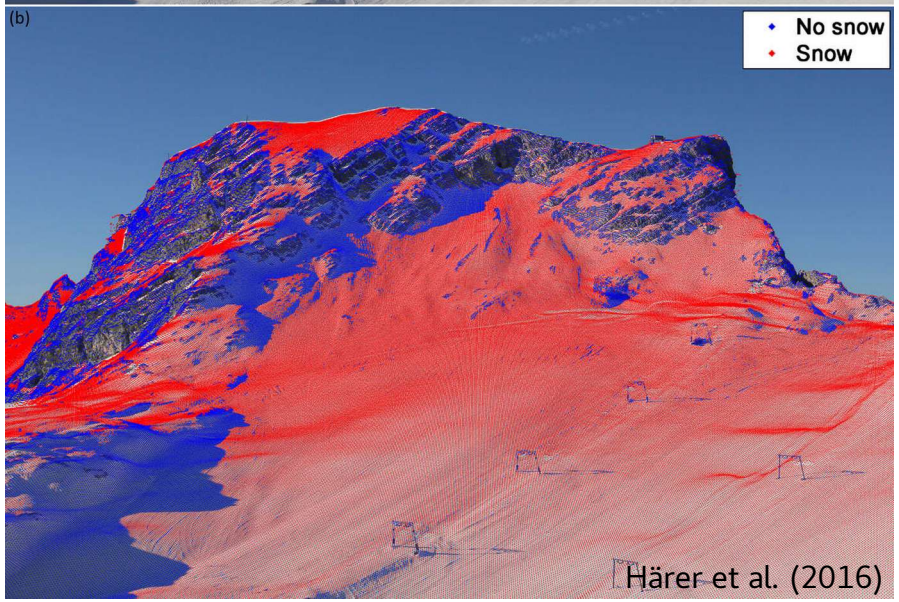
UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH





DEM

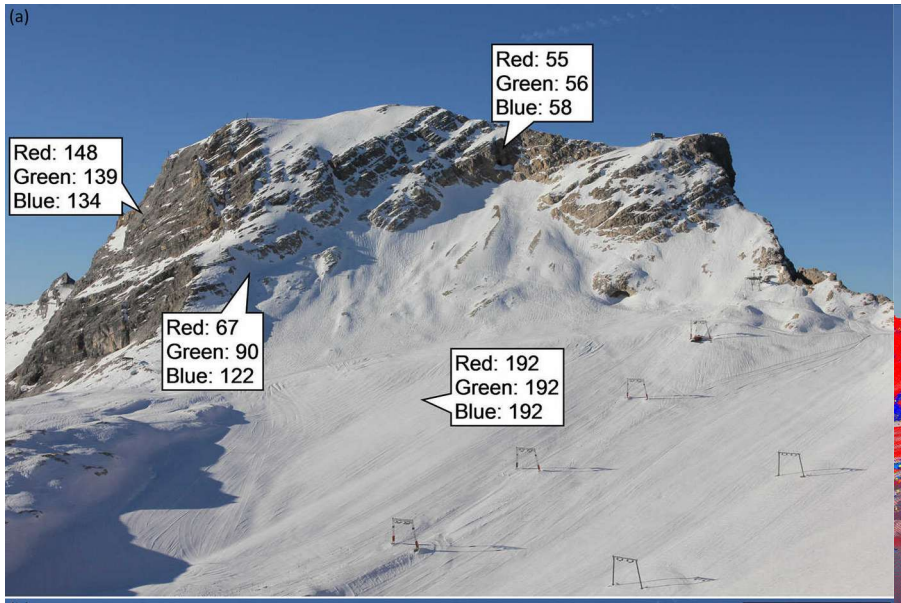
Image-to-DEM registration

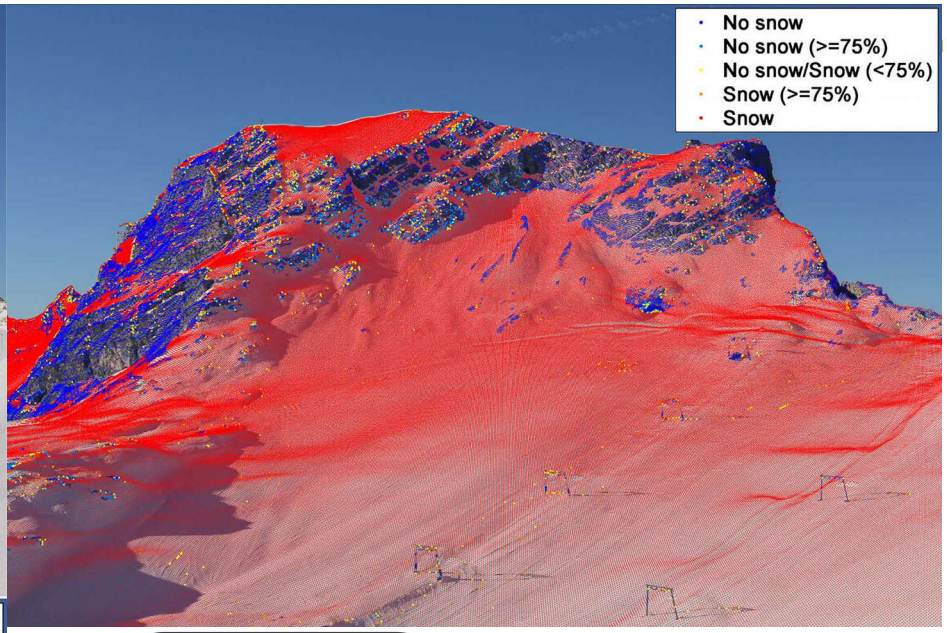
Transformation matrix

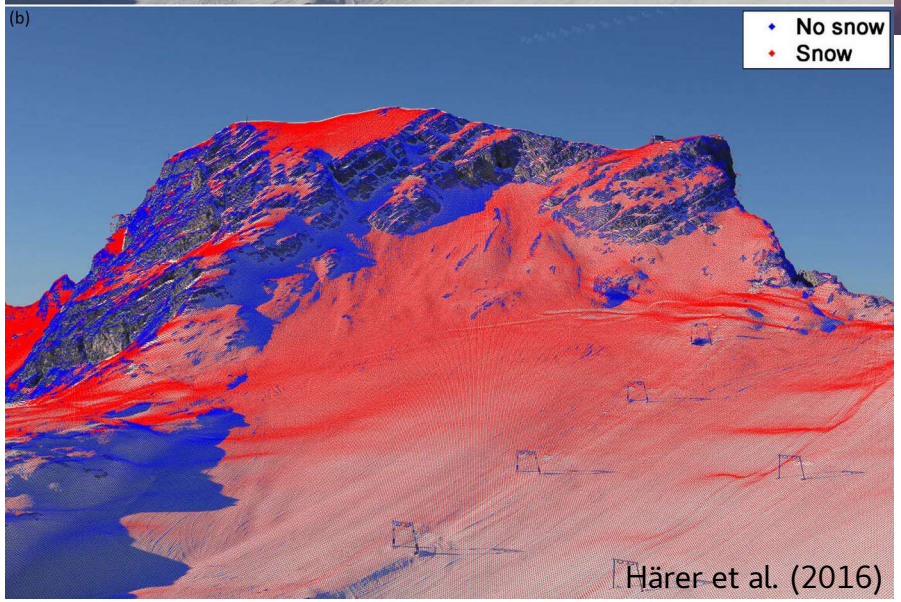
Snow classification

← algorithm of Salvatori et al. (2011)

WEBCAM PROCEDURE







Härer et al. (2016)

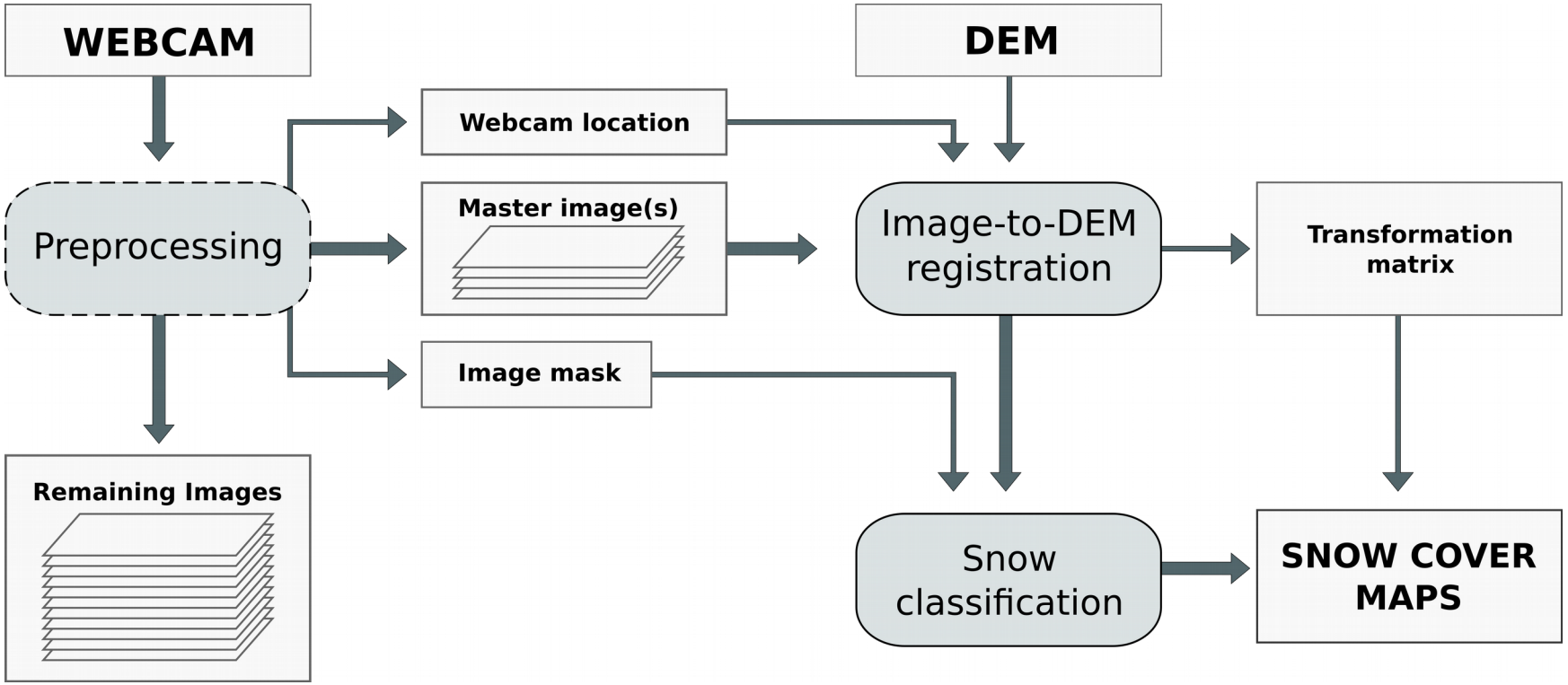
Snow classification

principal component analysis (PCA) for separating shaded snow cover from sunlit rock surfaces (Härer et al., 2016)

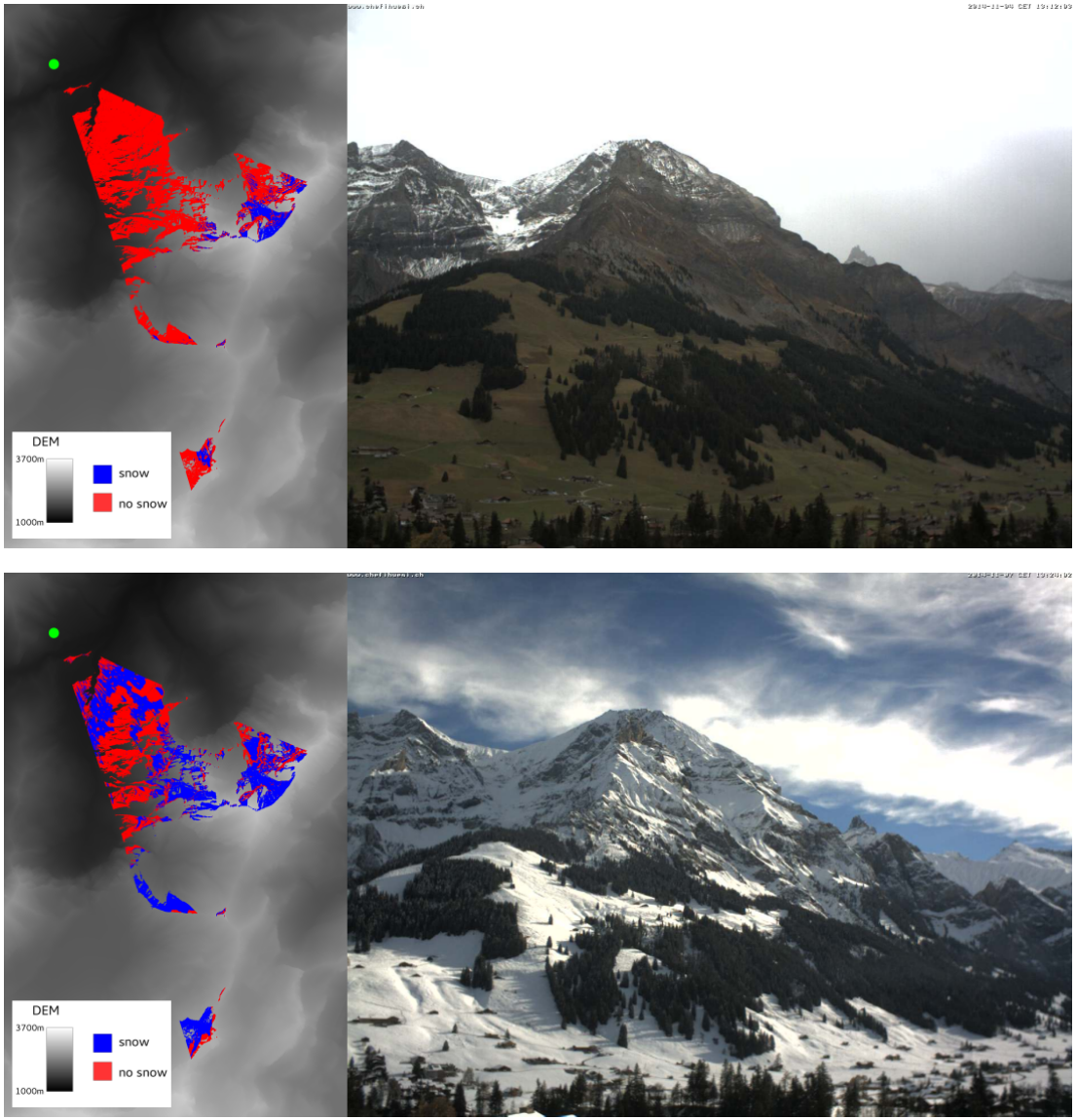
← algorithm of Salvatori et al. (2011)

WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

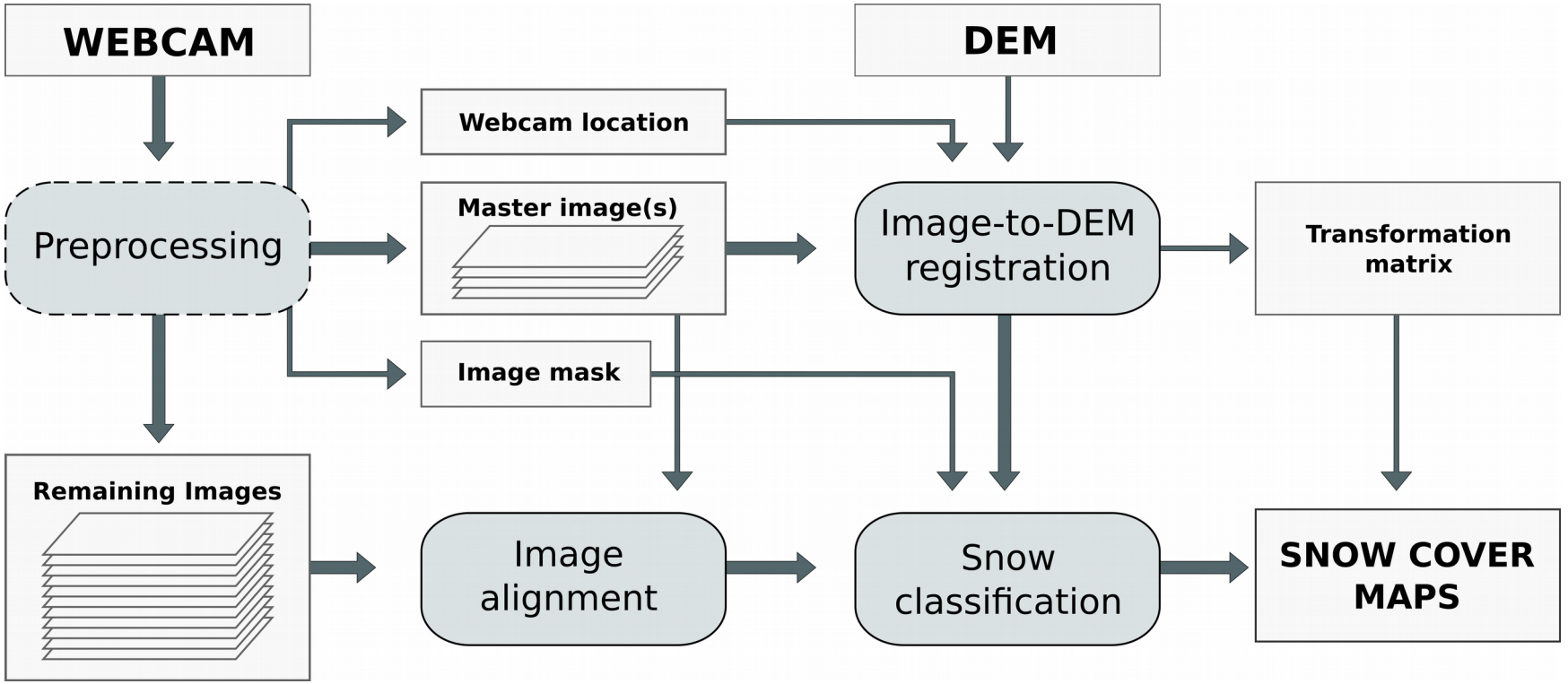


WEBCAM PROCEDURE



WEBCAM PROCEDURE

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



EVALUATION

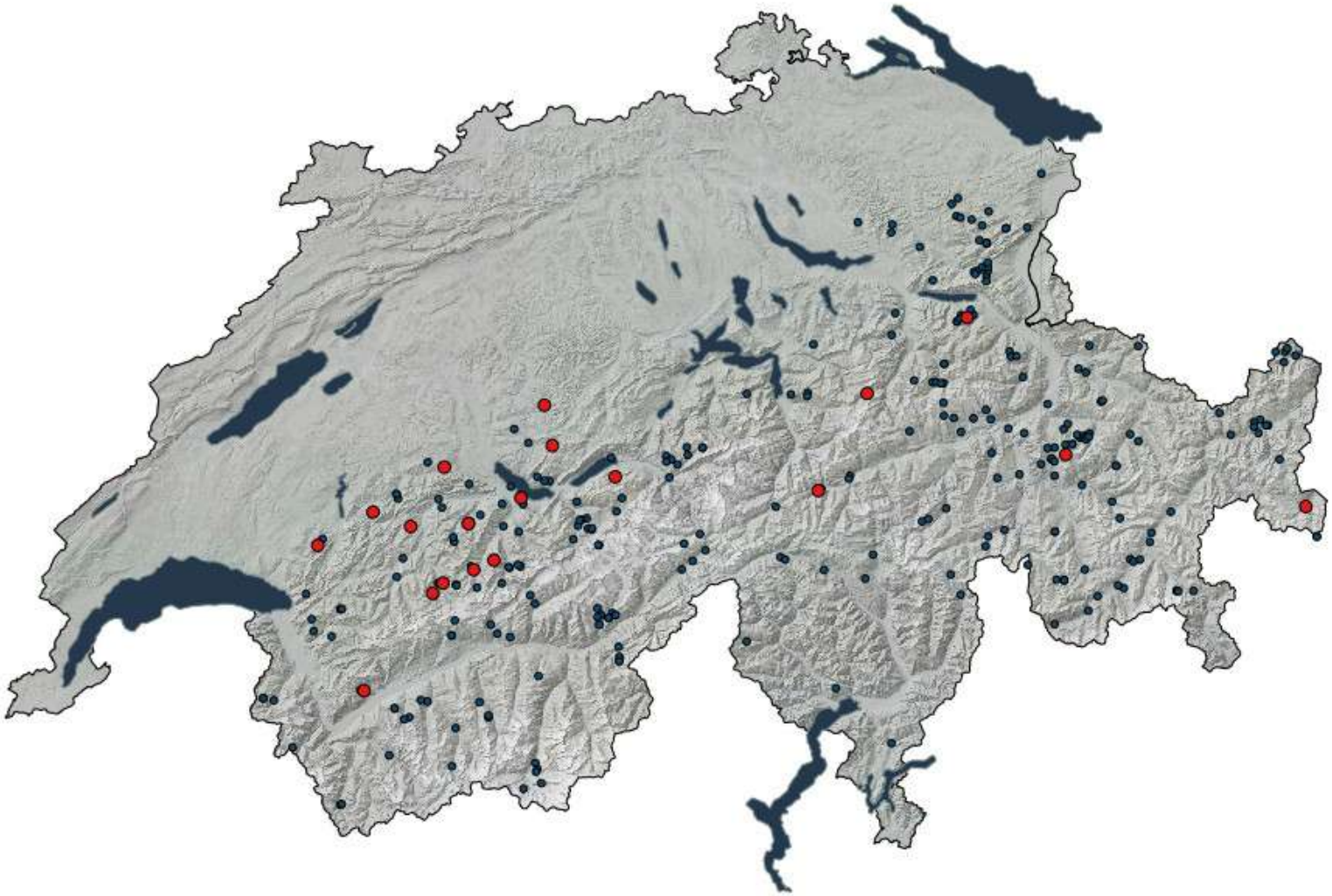
UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

EVALUATION

UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH



EVALUATION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

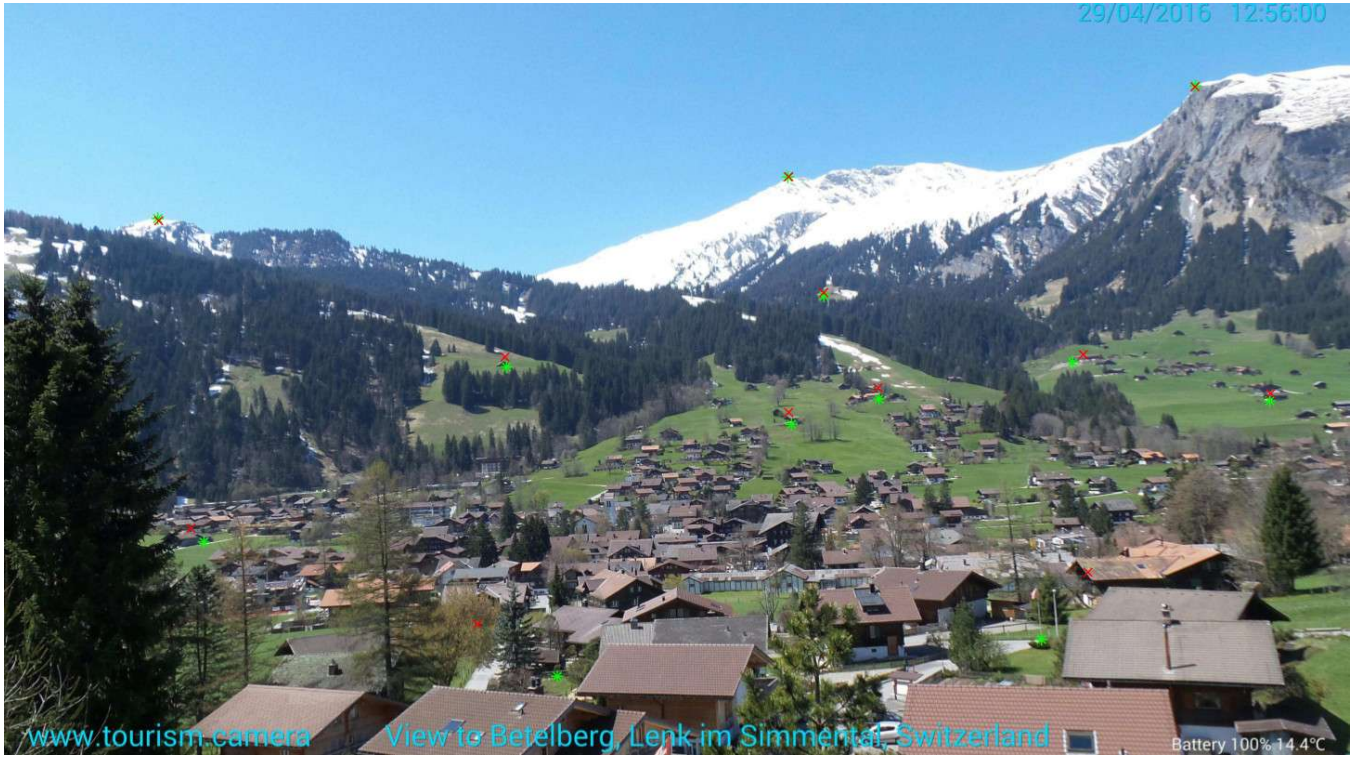
For each webcam: between 5 and 15 manually selected GCPs
(total: 130 GCPs)

```
 1 #long lat elevation imgX imgY pixelCategory(1:silhouette,0:noSilhouette) pi
 2 600640.9 145271.8 1087.7 3547 2178 0 2 pole 01
 3 600648.1 145210.7 1083.8 1898 2304 0 2 carShelter 03
 4 599537.0 145079.7 1170.2 2994 1361 0 3 houseInTriagle 04
 5 599550.7 144617.2 1239.8 1725 1252 0 3 singleHouseLeftTop 05
 6 598892.6 145311.6 1239.5 3653 1236 0 3 housegroupRight 06
 7 599719.2 145019.8 1142 2695 1447 0 3 singleHouseMiddle 07
 8 596086.9 144194.5 2347.8 2683 606 1 3 laaglehore 08
 9 597826.2 145643.6 1975.7 4072 297 1 3 floeschhore 09
10 598233.7 144758.9 1482.1 2806 1011 0 3 singleTree 10
11 599378.6 145494.5 1143.5 4324 1367 0 3 houseRight 11
12 598108.5 142620.5 1935.7 537 748 1 3 muelkerblatte 12
13 600176.1 144717.1 1069.9 694 1848 0 2 smallHouseLeft 13
```

EVALUATION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

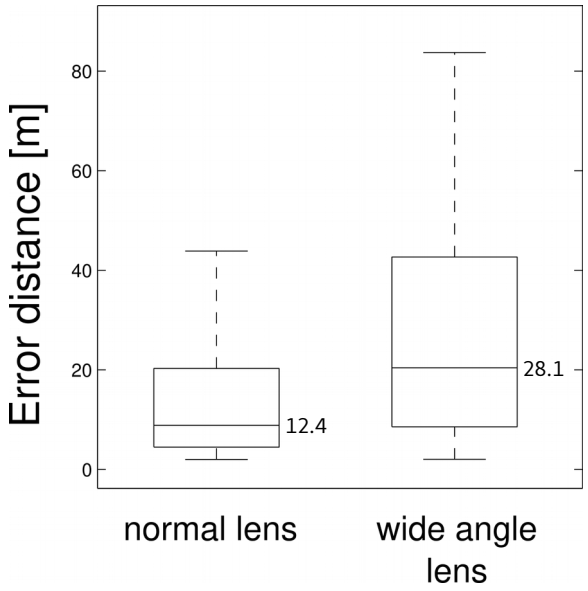
- (relative) pixel error (error in image space, #pixels)
- distance error (error in world coordinates, meters)



EVALUATION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

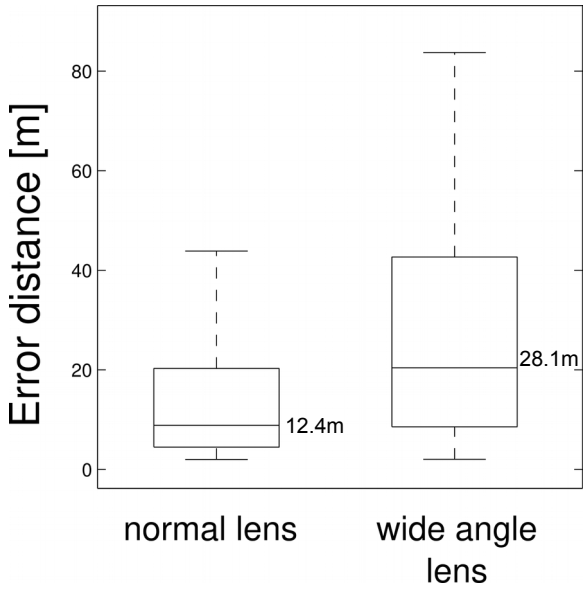
- In general: closer to the webcam, bigger error distances
- Average distance error: 18.2 meters
- Huge differences between normal and wide-angle webcams

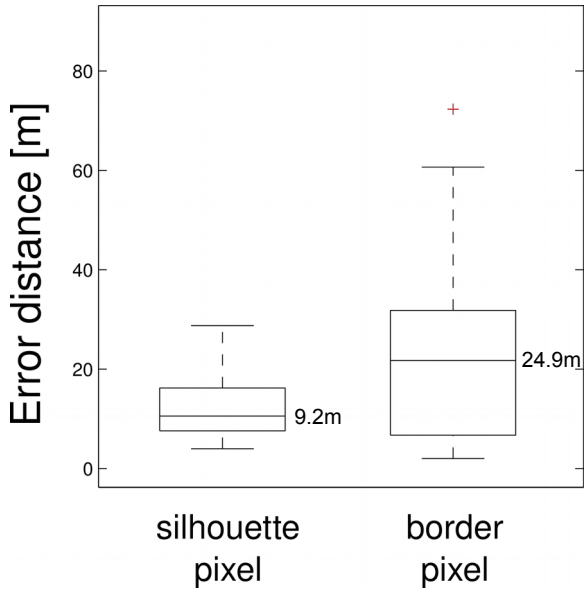


EVALUATION

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- In general: closer to the webcam, bigger error distances
- Average distance error: 18.2 meters
- Huge differences between normal and wide-angle webcams
- Difference between silhouette GCPs and image border border GCPs





CONCLUDING REMARKS

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

- Webcams offer a huge potential (widely unexplored)
- Feasibility of using webcams images to generate snow cover maps
- Evaluation allowed to identify limitations and possible improvements
- Evaluation and comparison with satellite-based snow cover maps (either as reference or as complement)
- Methodological improvements
  - Improved camera model (lens distortion)
  - Snow / cloud classification
  - Find ‘balance‘ between mapping accuracy and automation

Many thanks for your attention!