



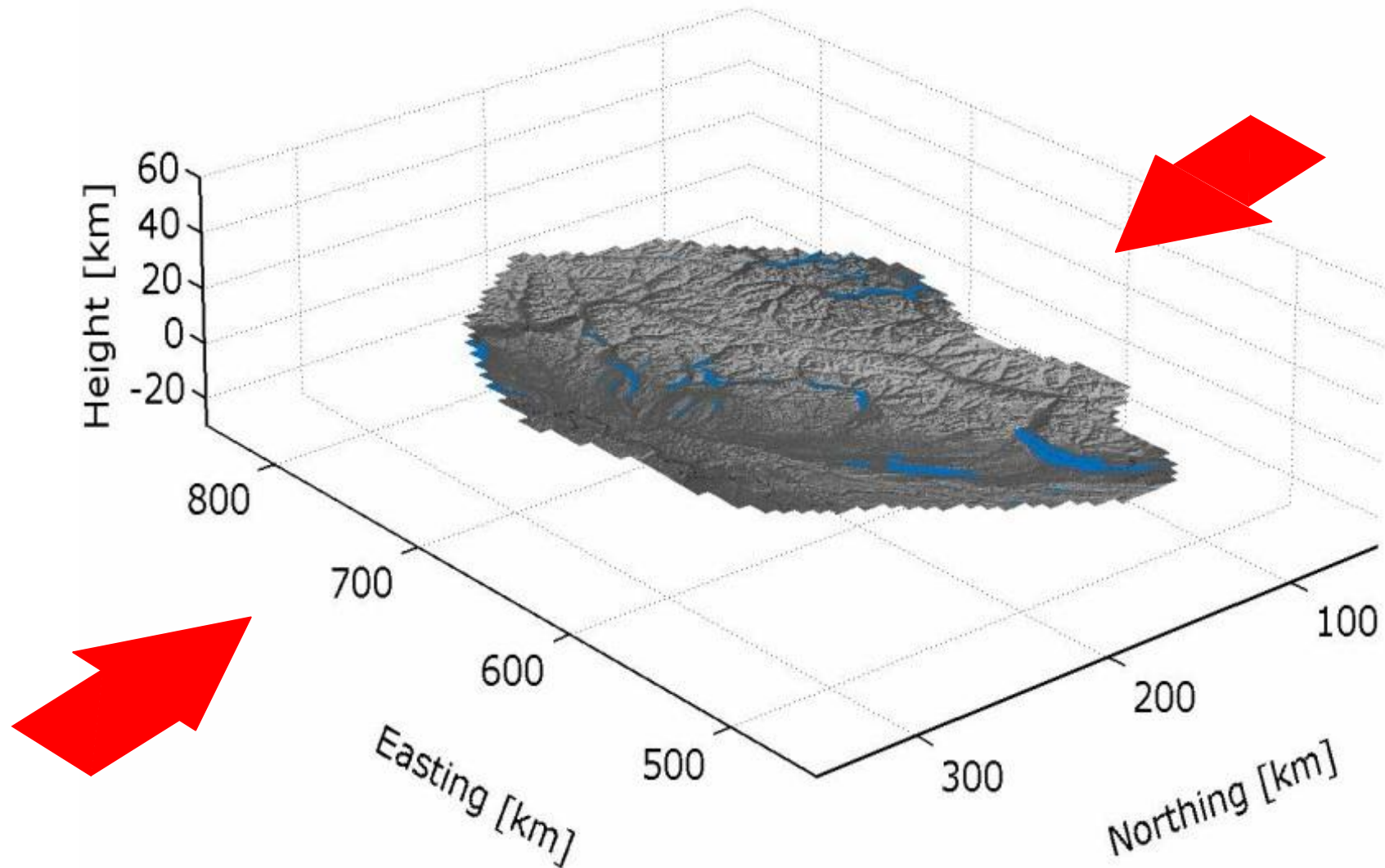
Alpentektonik und Klimaerwärmung sichtbar im GNSS-Geomonitoring ?

Alain Geiger, Markus Rothacher, Arturo Villiger, Philippe Limpach, Simon Häberling

Institut für Geodäsie und Photogrammetrie, Geodesy and Geodynamics Lab
ETH Zürich



Die Schweiz in Bewegung $0.0 \cdot 10^6$ Years

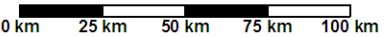
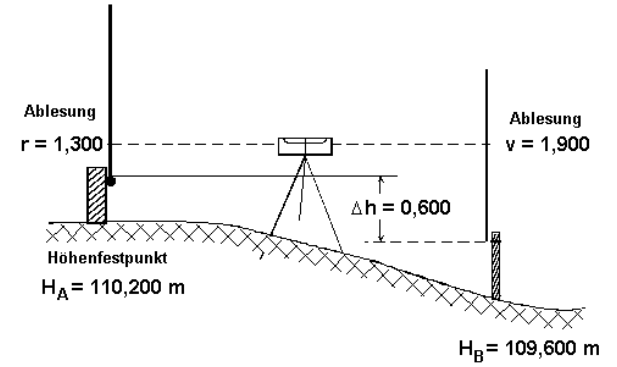
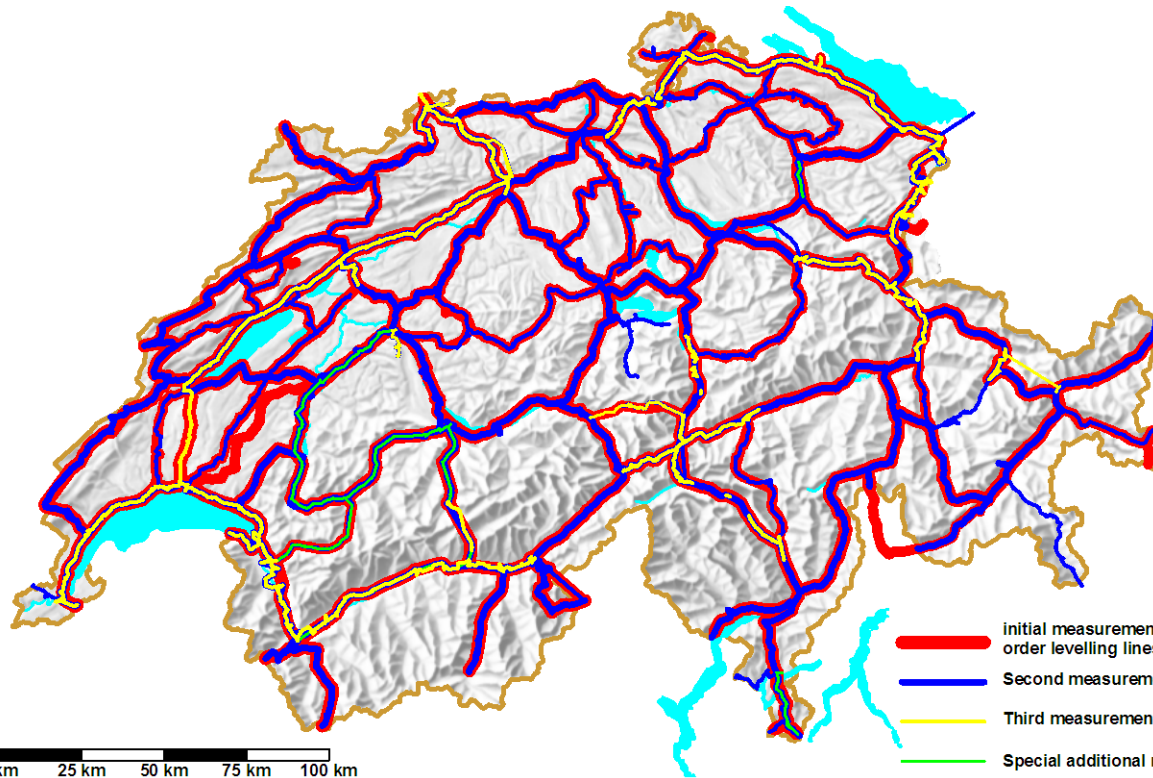


Vertikale Bewegung



swisstopo

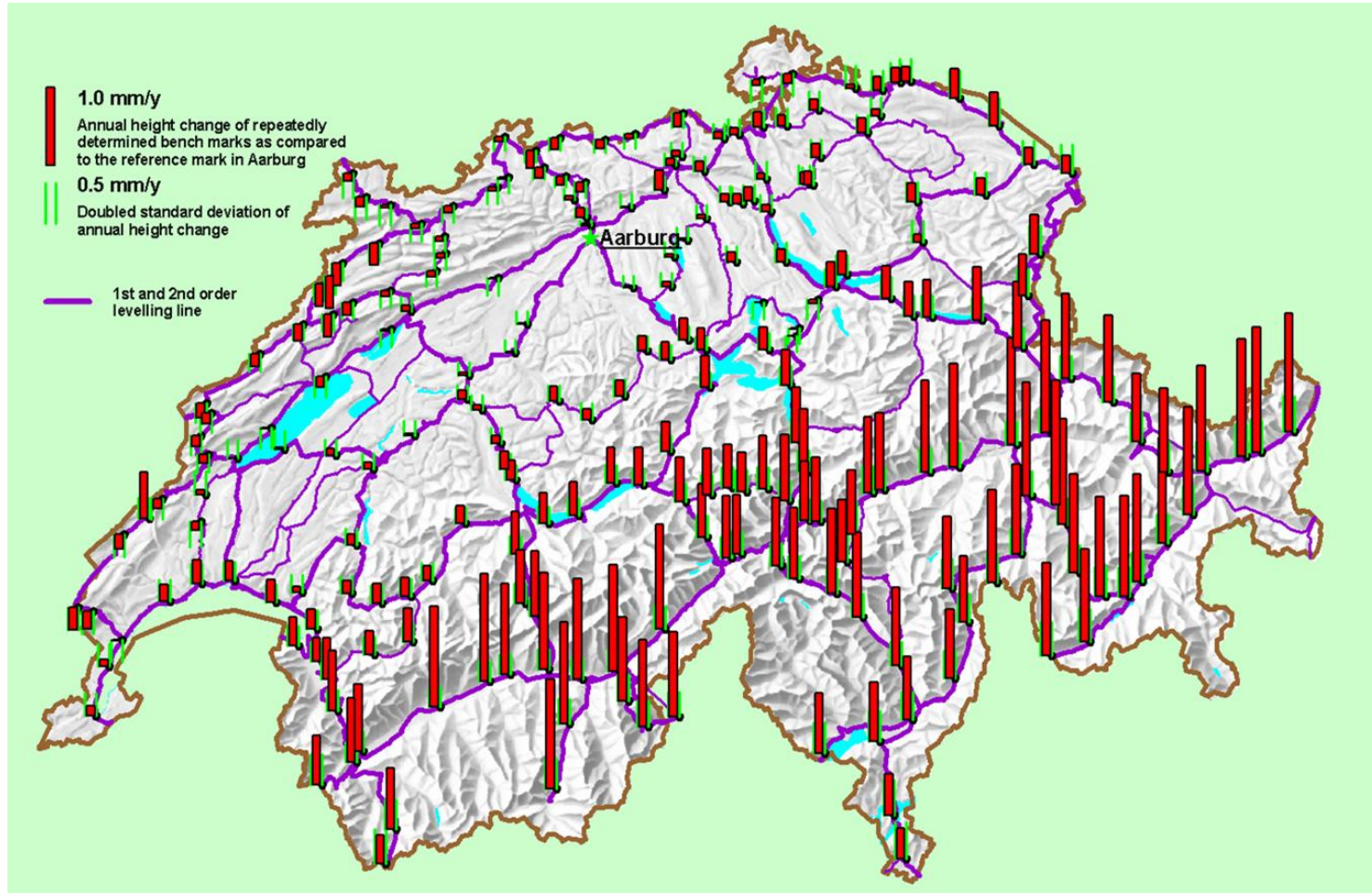
Landeshöhennetz LHN95



Vertikale Bewegung



swisstopo

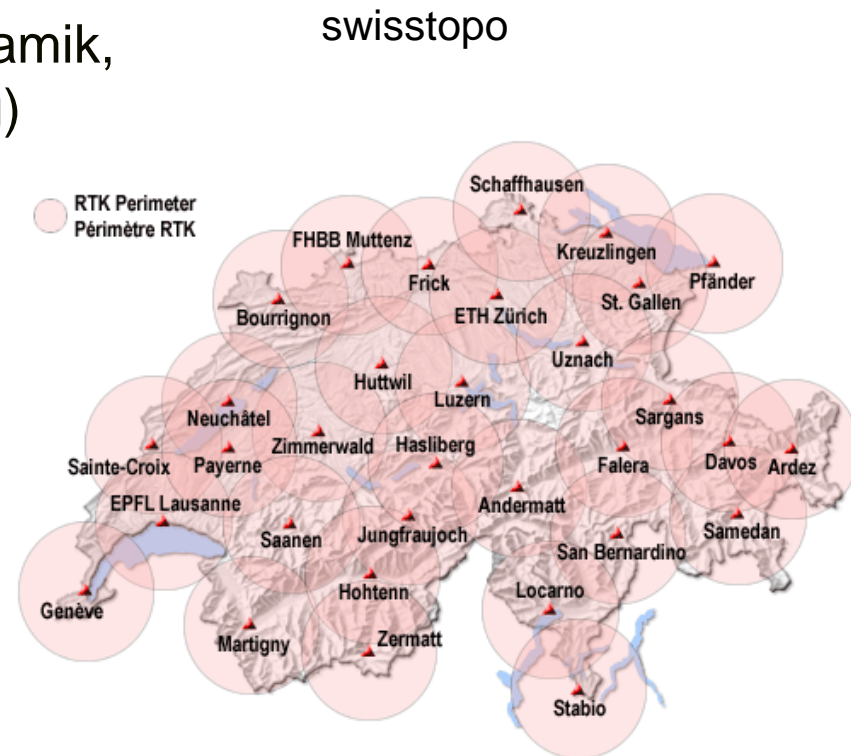


Schlatter et al.

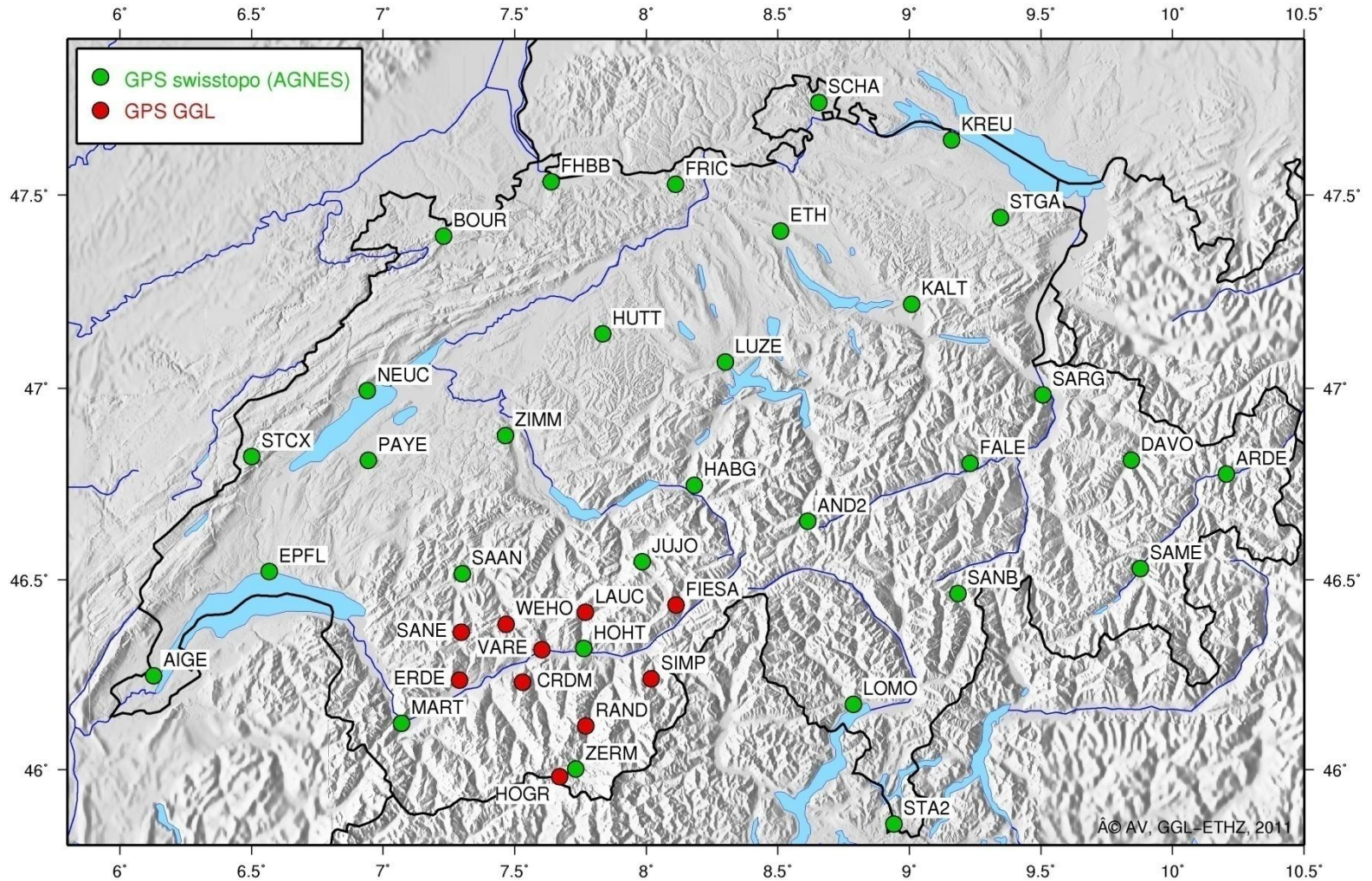
Automatisches GNSS-Netz (AGNES)

31 permanent betriebene Stationen
für Anwendungen in:

- Wissenschaft (Geodynamik, Atmosphärenforschung)
- Landesvermessung
- Amtliche Vermessung
- Positionierungsdienste



GNSS Instrumentation



Randa (RAND)

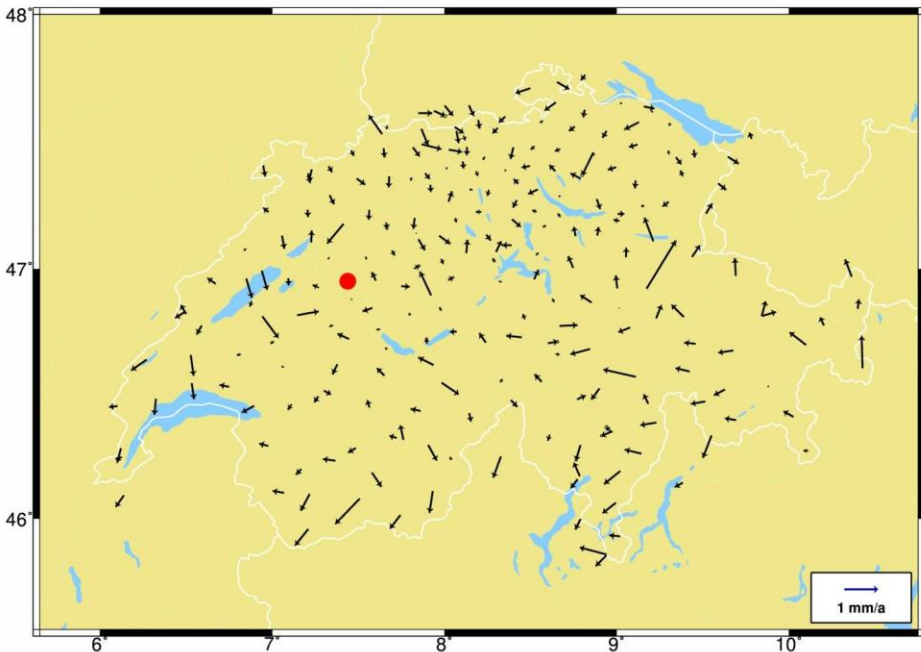
Kretz, Villiger, Limpach, Moore, 2011



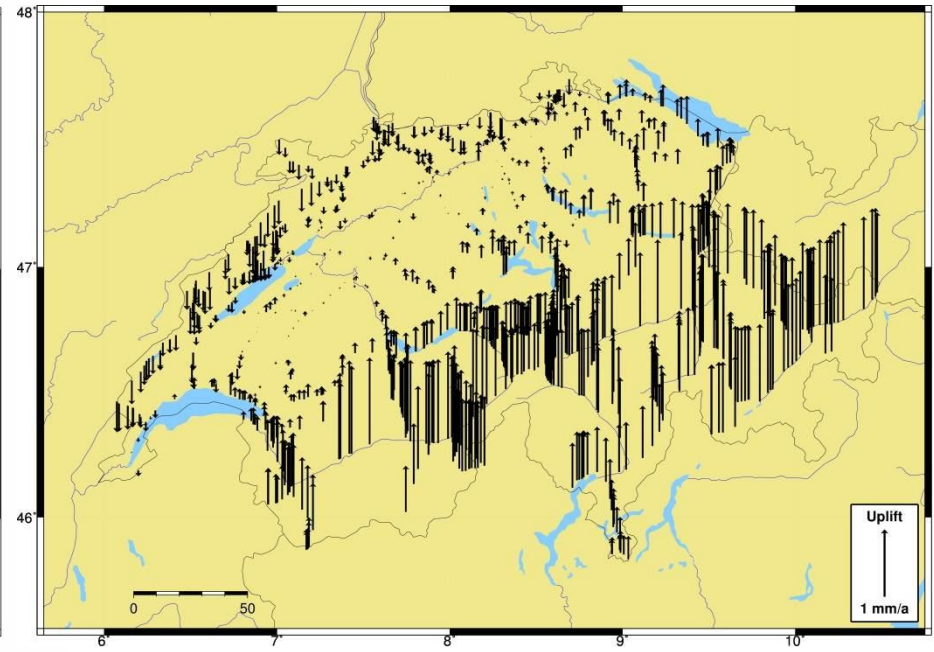
ALSC applied to CHTRF 2010 & levelling data

Horizontal velocities (GNSS campaign data): CHTRF 2010

Uplift rates based on levelling data



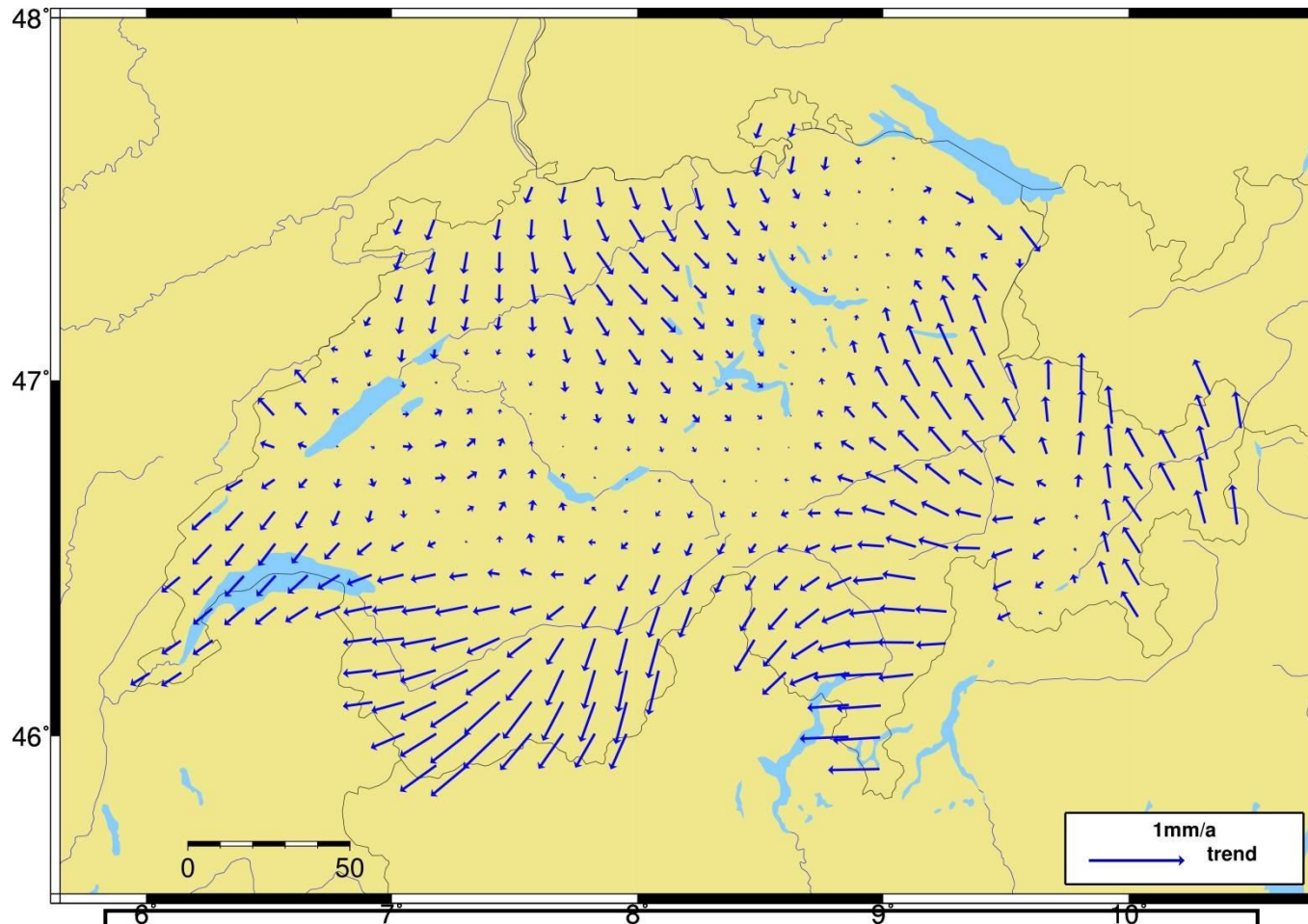
1 mm / a



1 mm / a

In 3D: Observation = vel_{tectonic} + vel_{local} + vel_{noise}

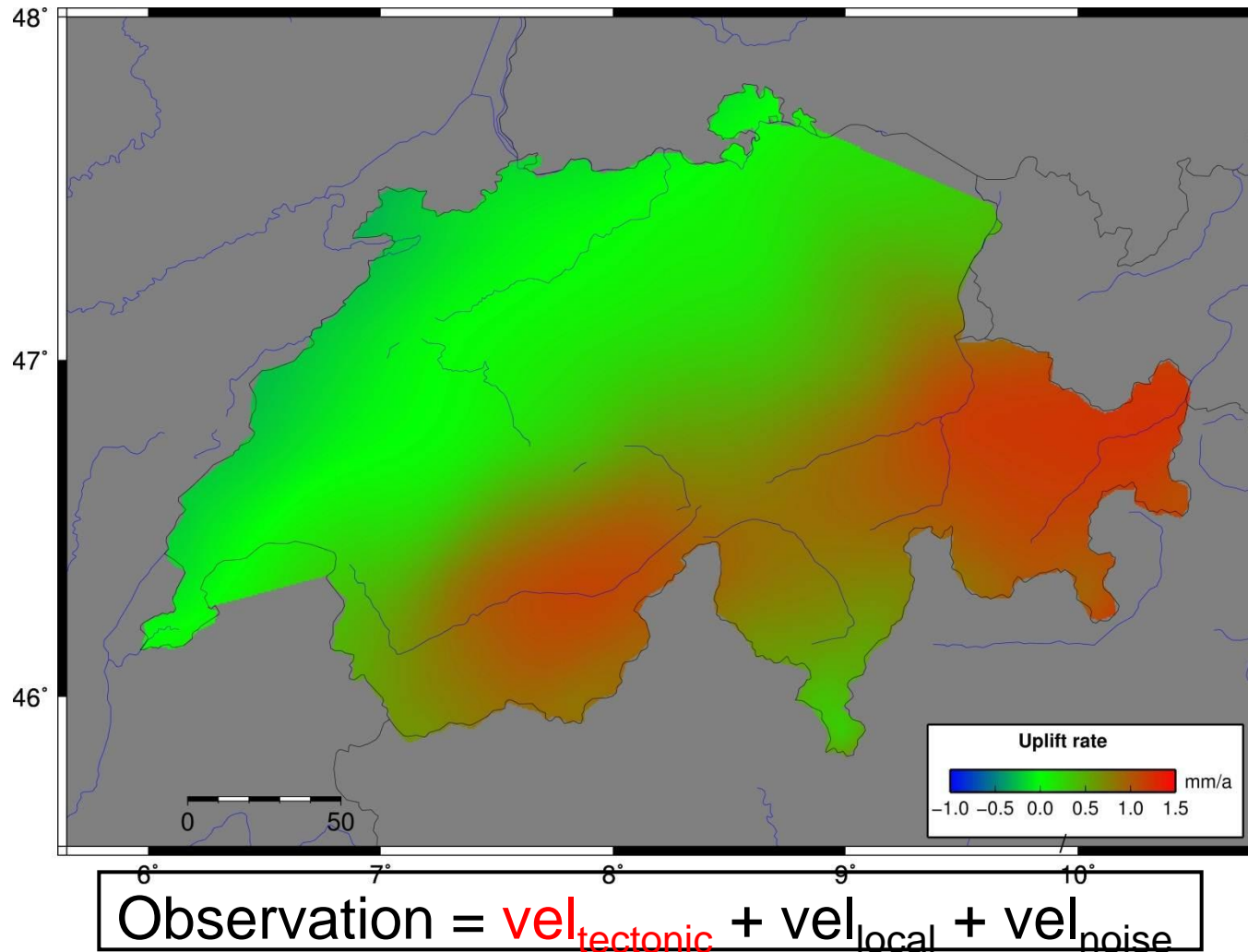
Collocated Velocity Field: tectonic part



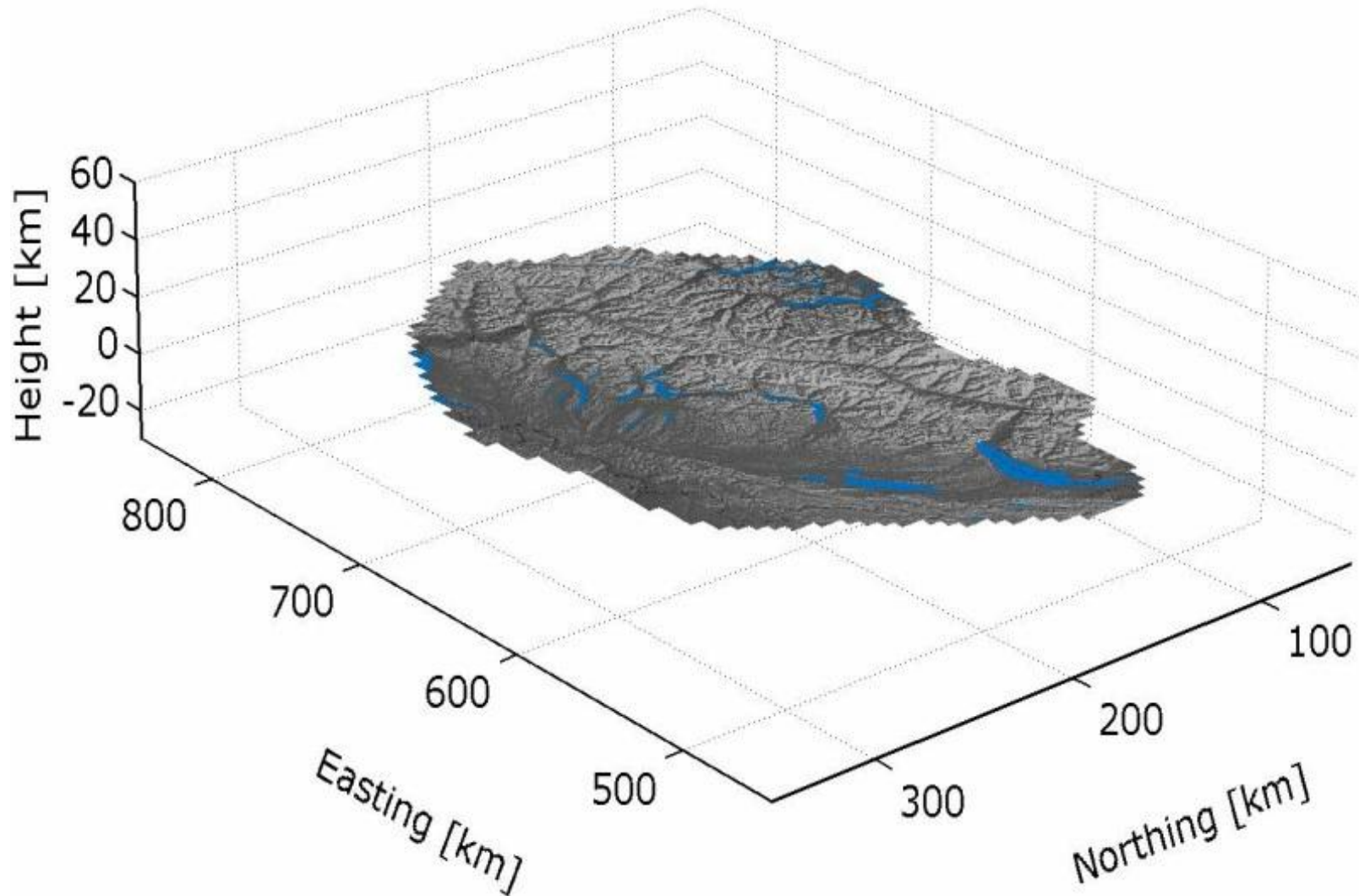
1 mm / a

$$\text{Observation} = \text{vel}_{\text{tectonic}} + \text{vel}_{\text{local}} + \text{vel}_{\text{noise}}$$

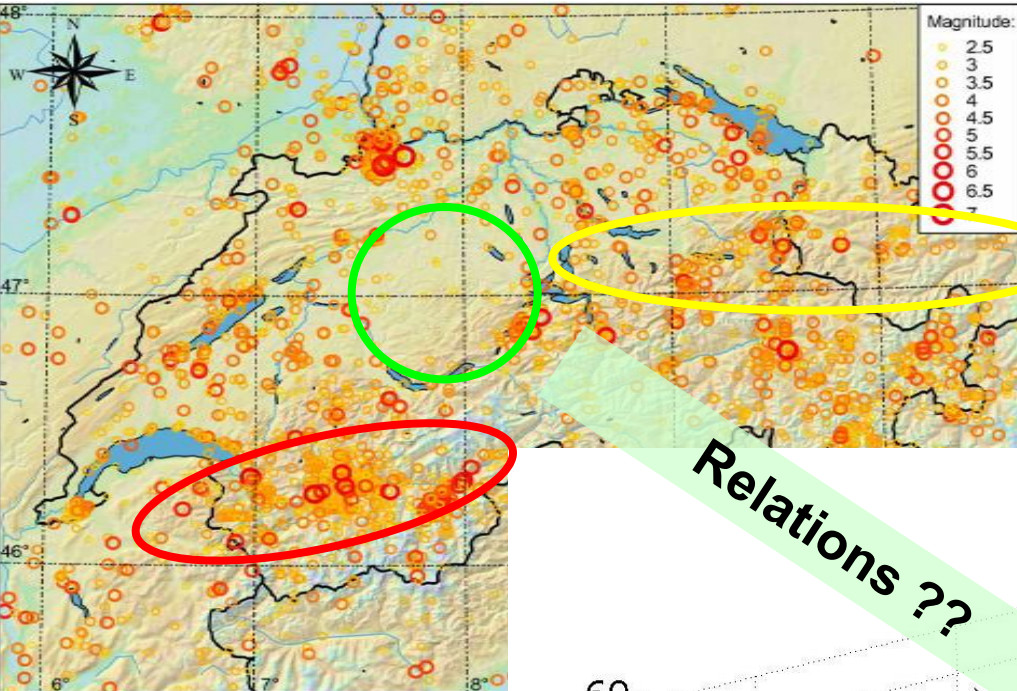
Collocated Velocity Field: tectonic part



Die Schweiz in Bewegung $0.0 \cdot 10^6$ Years



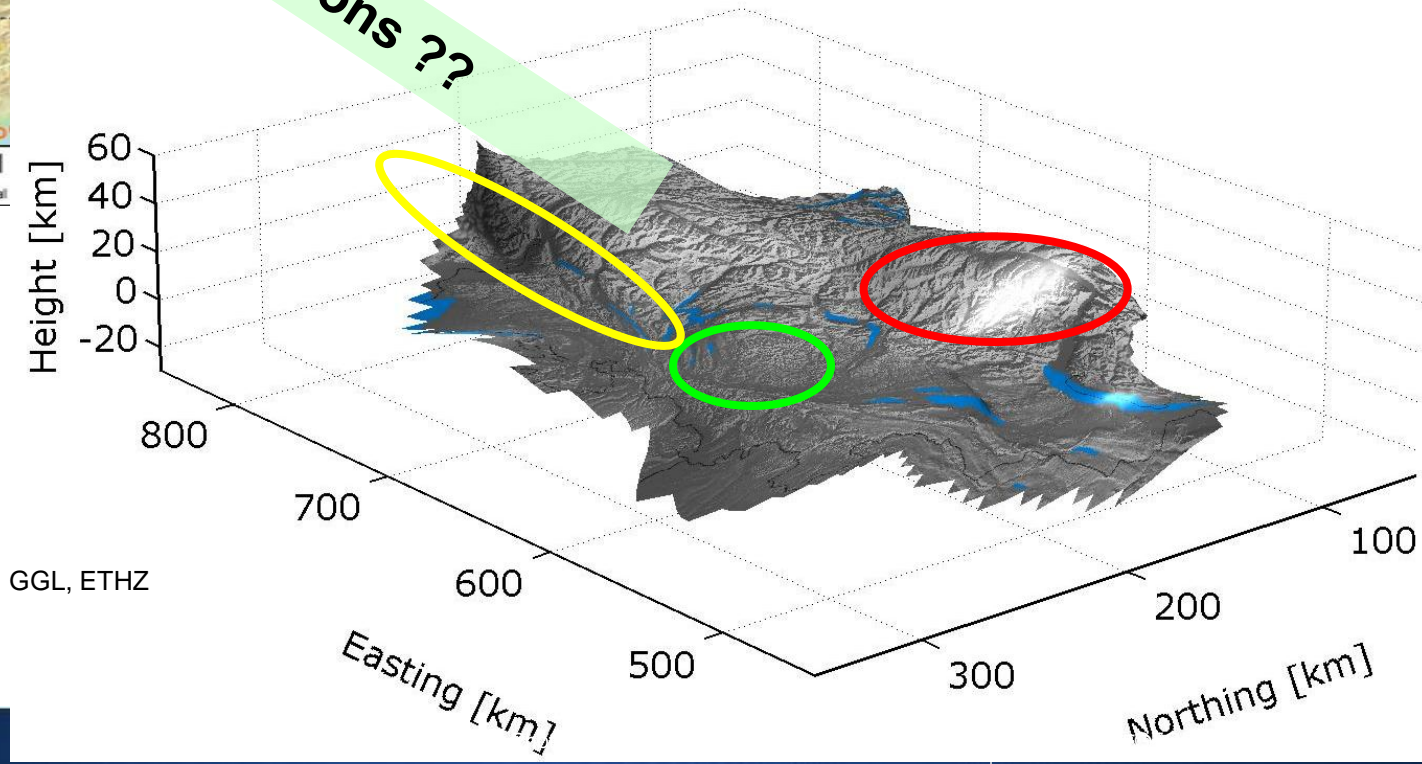
Deformation und Seismizität



Earthquakes in Switzerland 250-2001
From ECOS - Earthquake Catalog of Switzerland. (c) Swiss Seismological

Relations ??

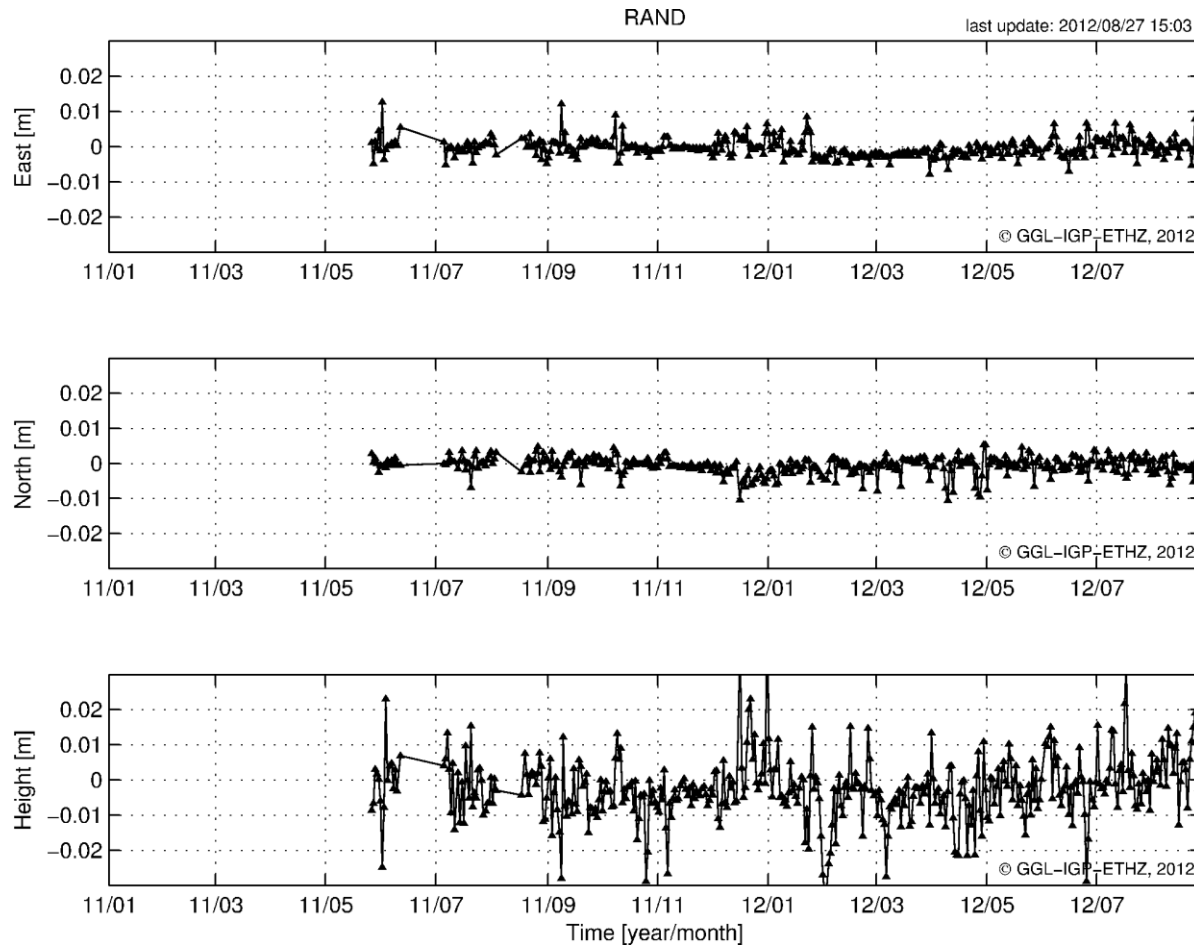
$30.0 \cdot 10^6$ Years



GGL, ETHZ

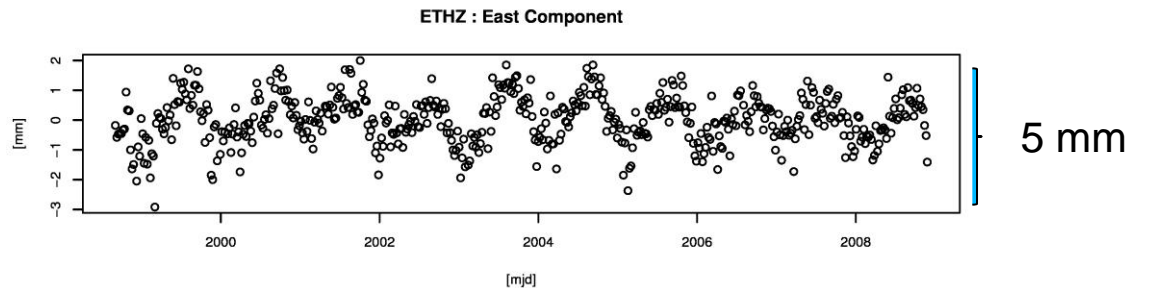
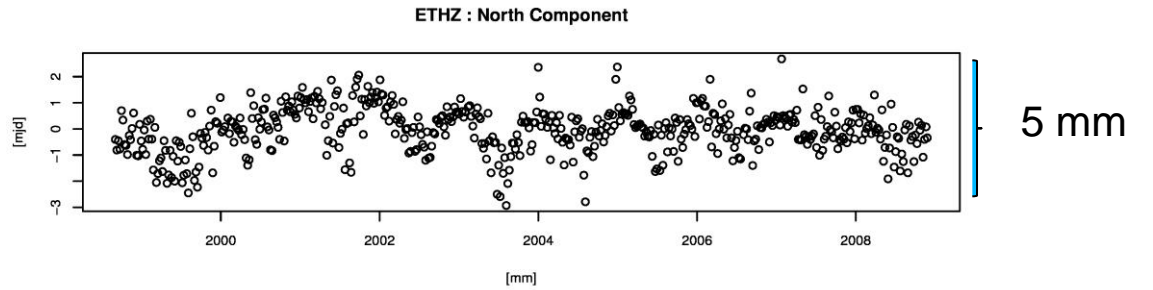
Timeseries Randa (RAND)

Limpach, 2012

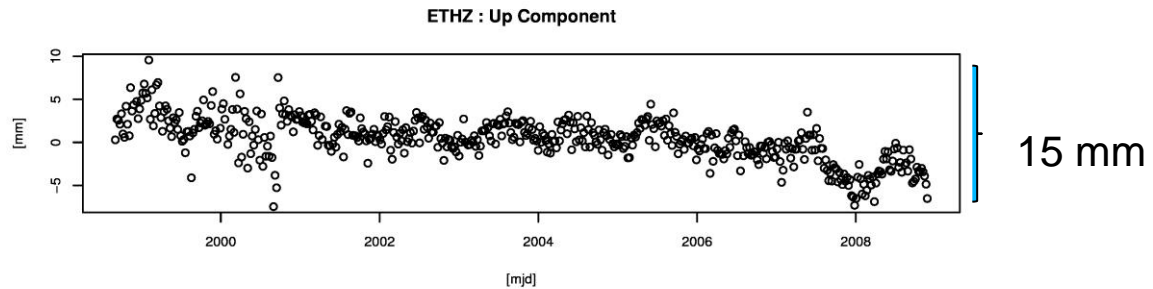


Zeitreihe Station ETHZ

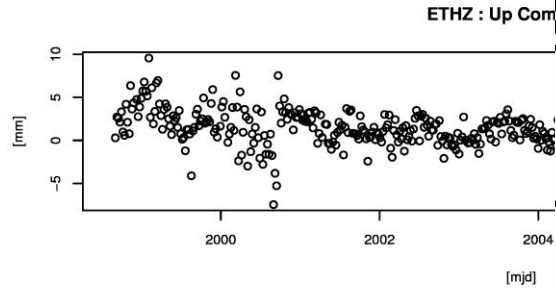
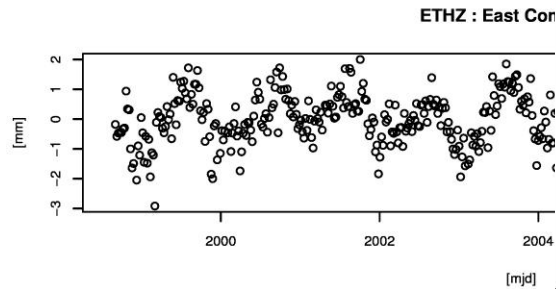
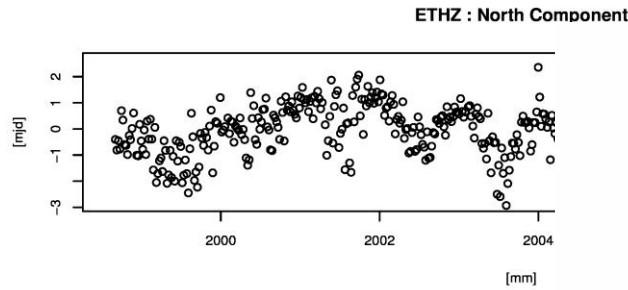
Villiger and swisstopo, 2011



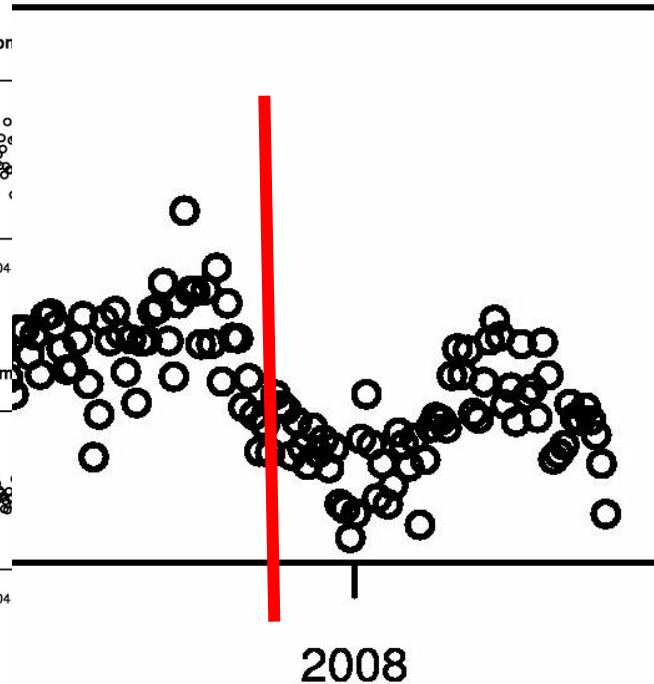
ETHZ



Zeitreihe Station ETHZ



Bau Sporthalle neben der Station ETHZ



ETHZ

2008

Standort ETH Zürich



Changes in Temperature, Sea Level and Northern Hemisphere Snow Cover

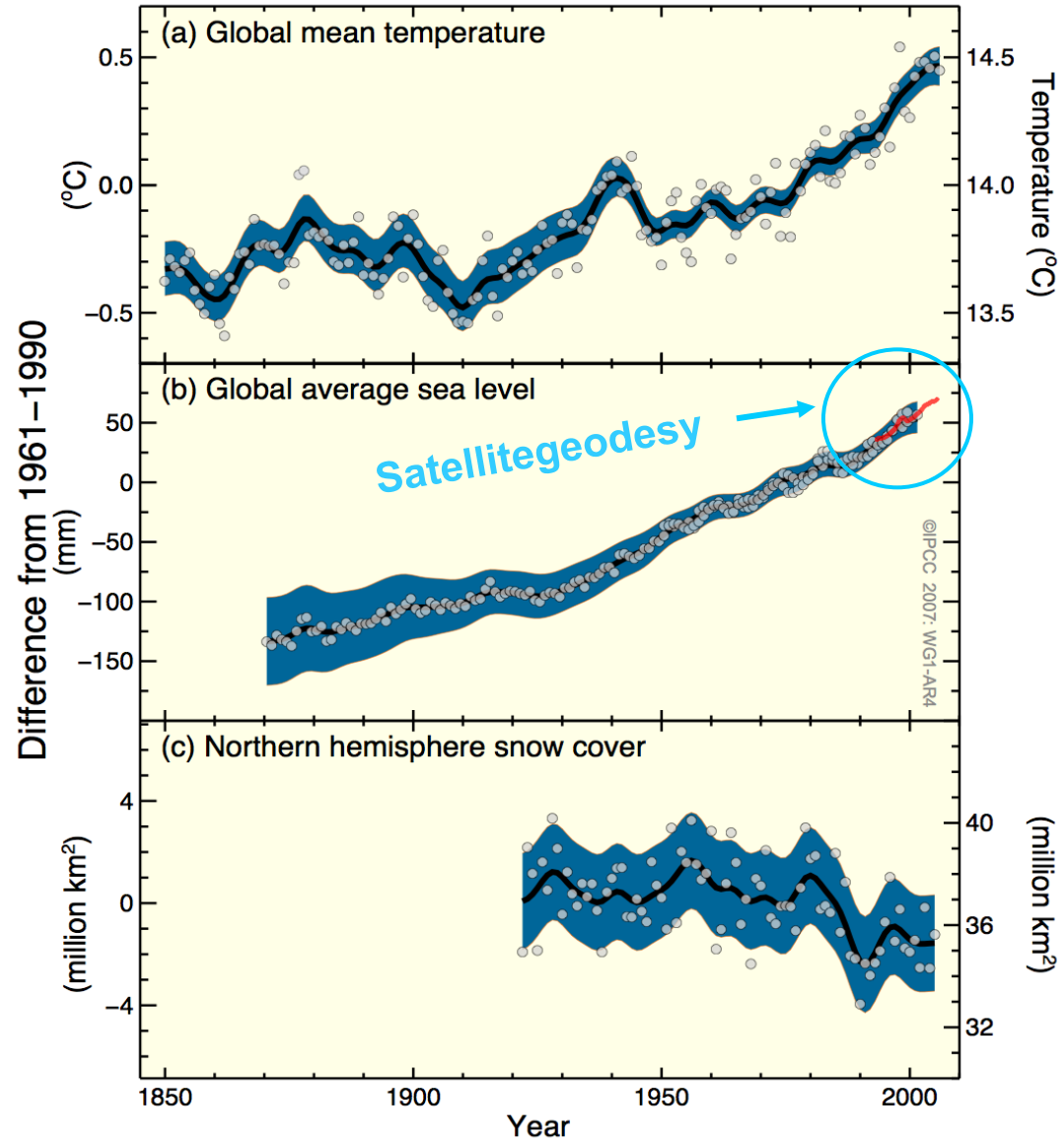
Evidenzen für Erwärmung

Drei Beispiele

Rising atmospheric temperature

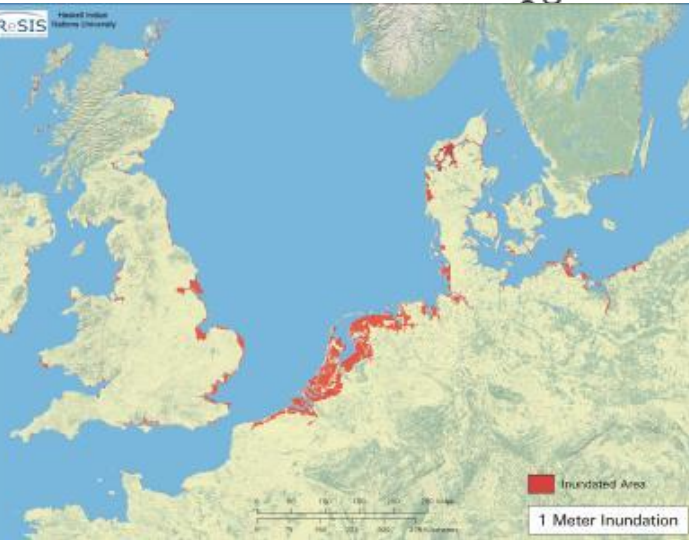
Rising sea level

Reductions in NH snow cover

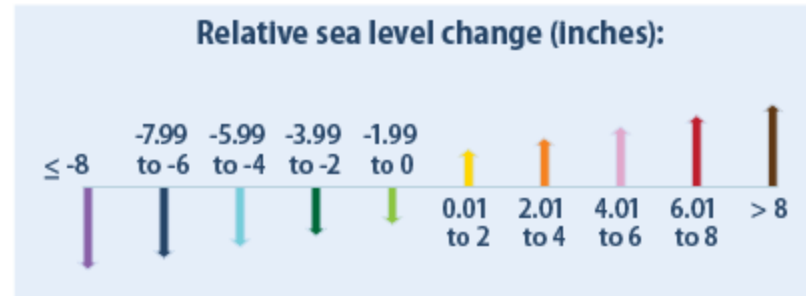
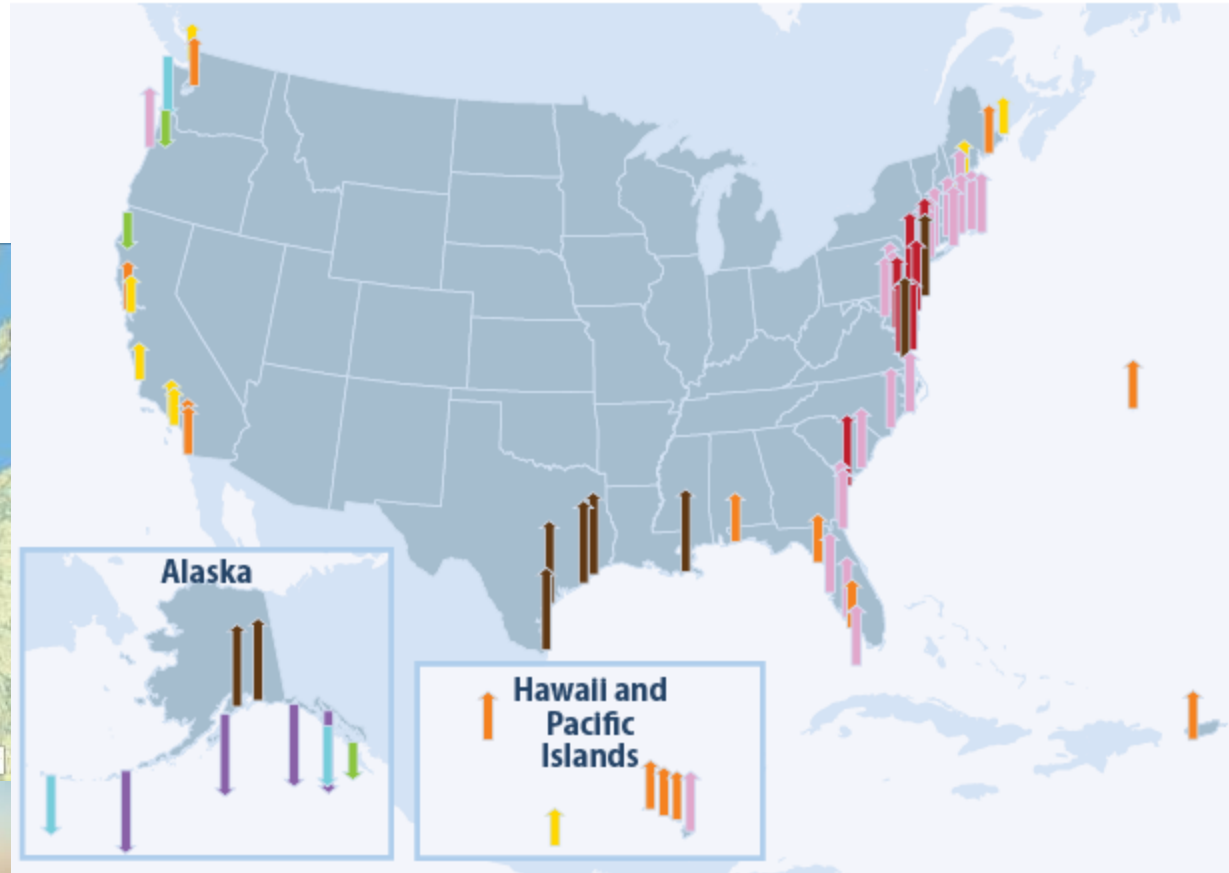


by Susan Solomon, co-chair WG I, IPCC

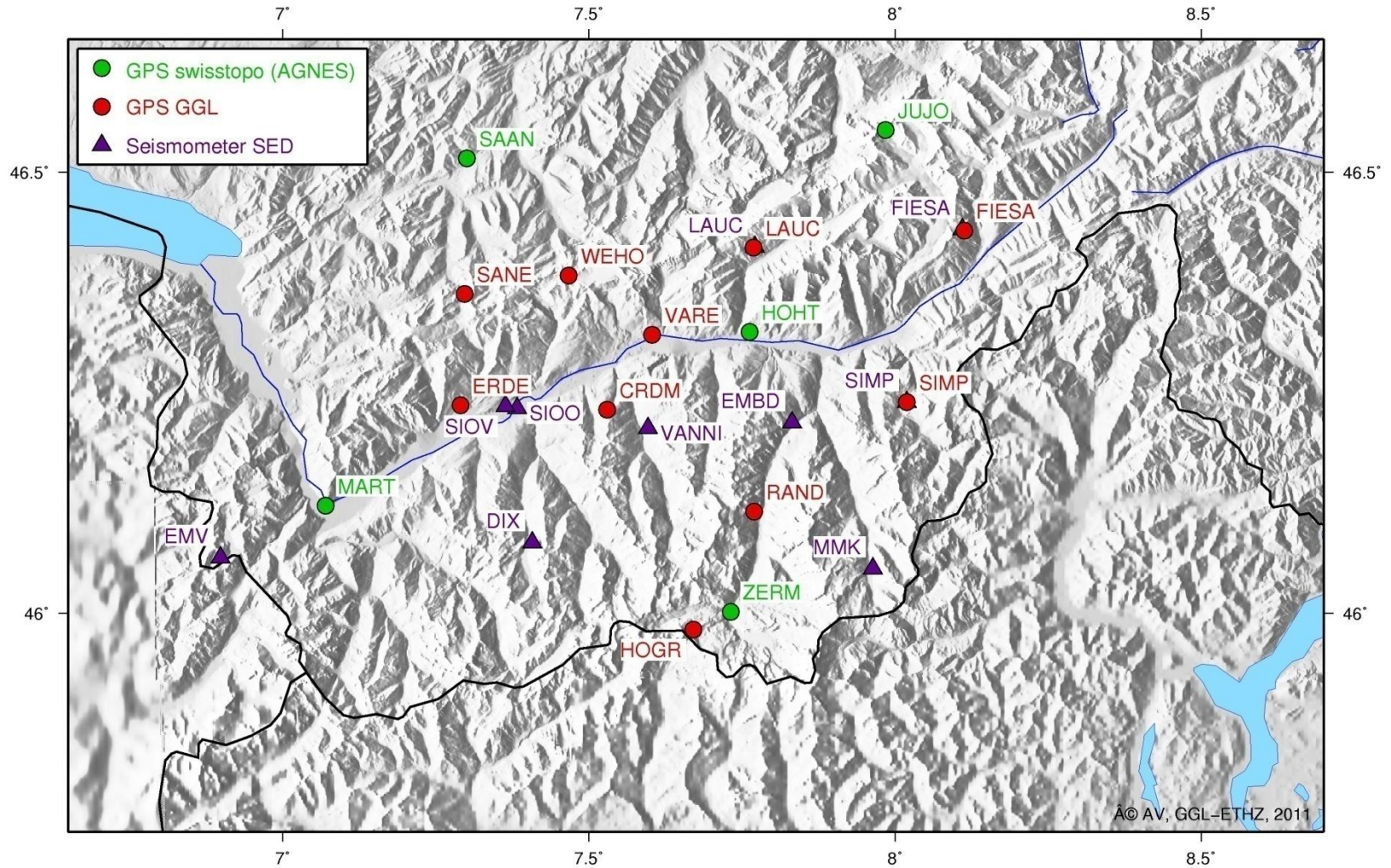
originally published in:
CO-OPS 36.



Trends in Relative Sea Level Along U.S. Coasts, 1958–2008



GNSS Instrumentation



Low-cost GPS network in the Mattertal



**Graben Gufer Blockgletscher
(Mattertal, Wallis)**

25.07.2009

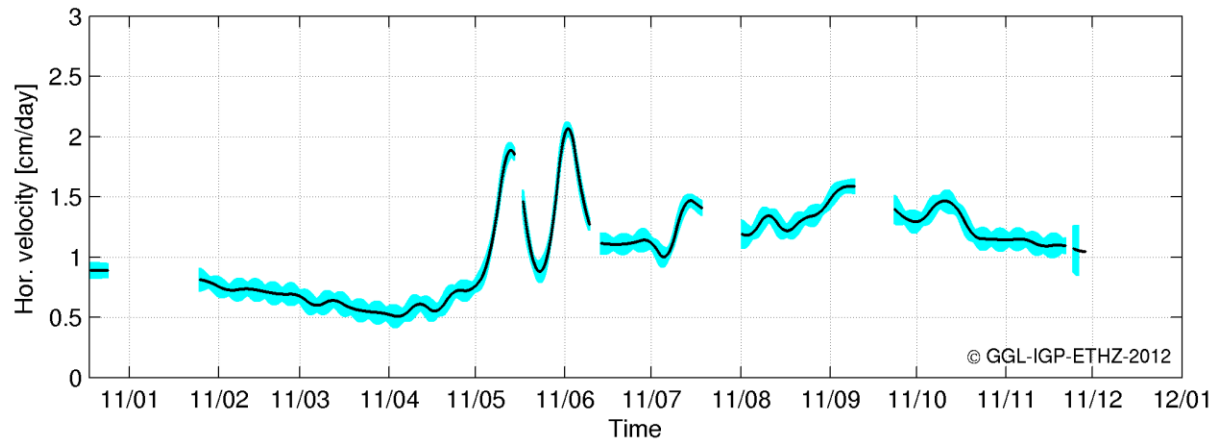
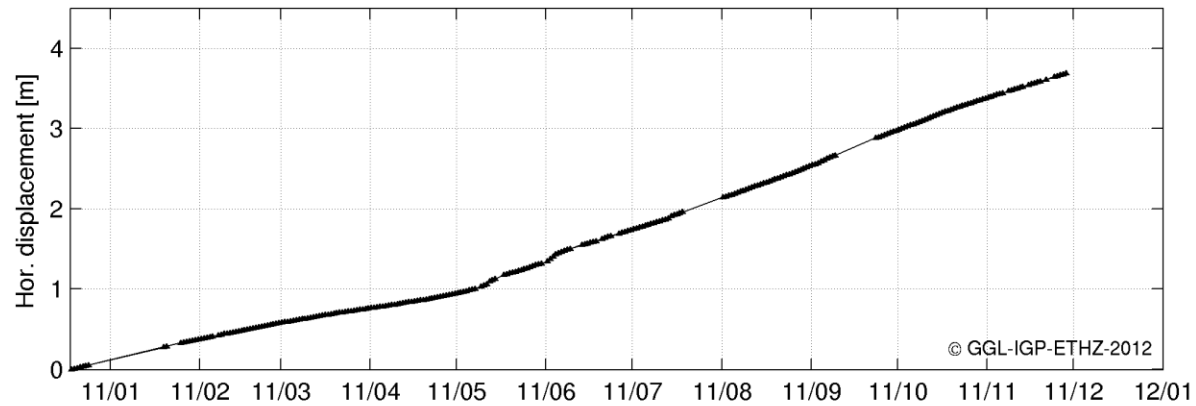
**CANTON DU VALAIS
KANTON WALLIS**



R. Delaloye

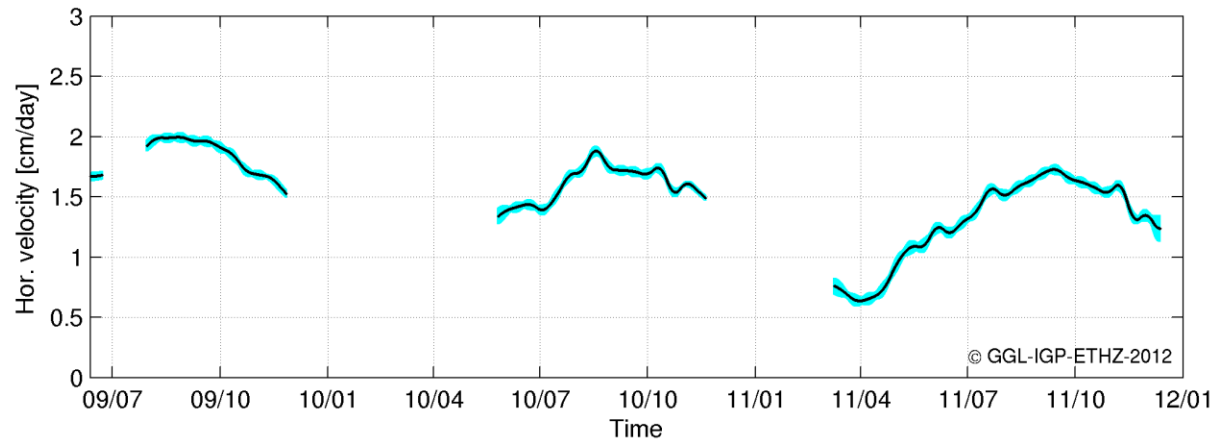
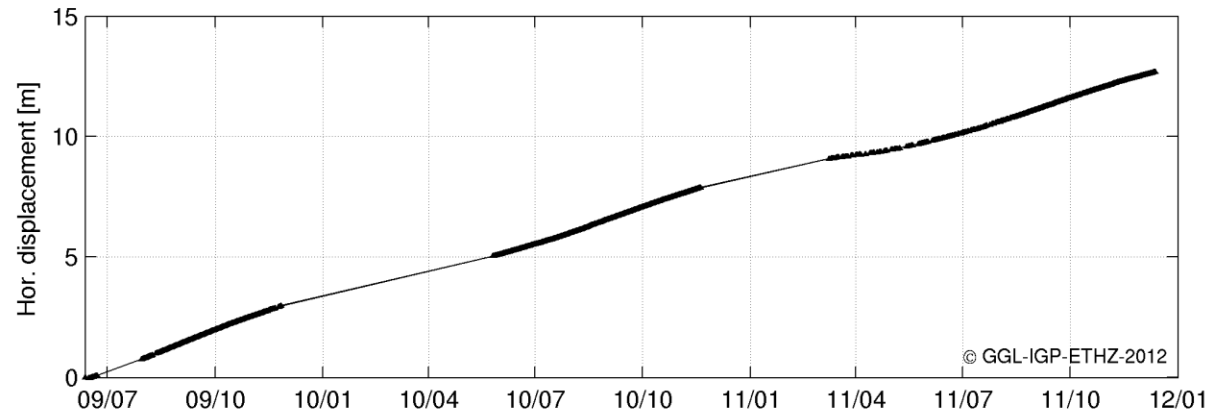
Fast stations

Limpach, 2011

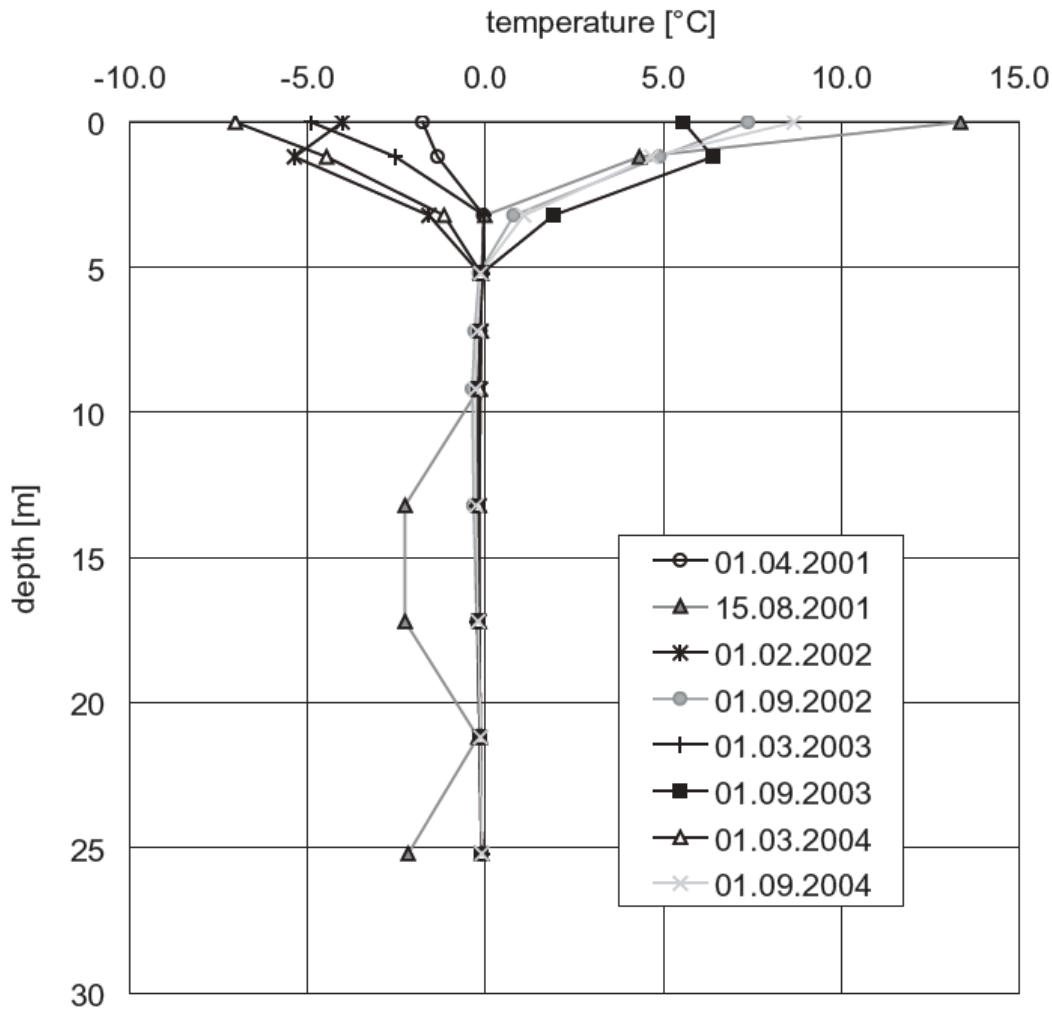


Fast stations

Limpach, 2011



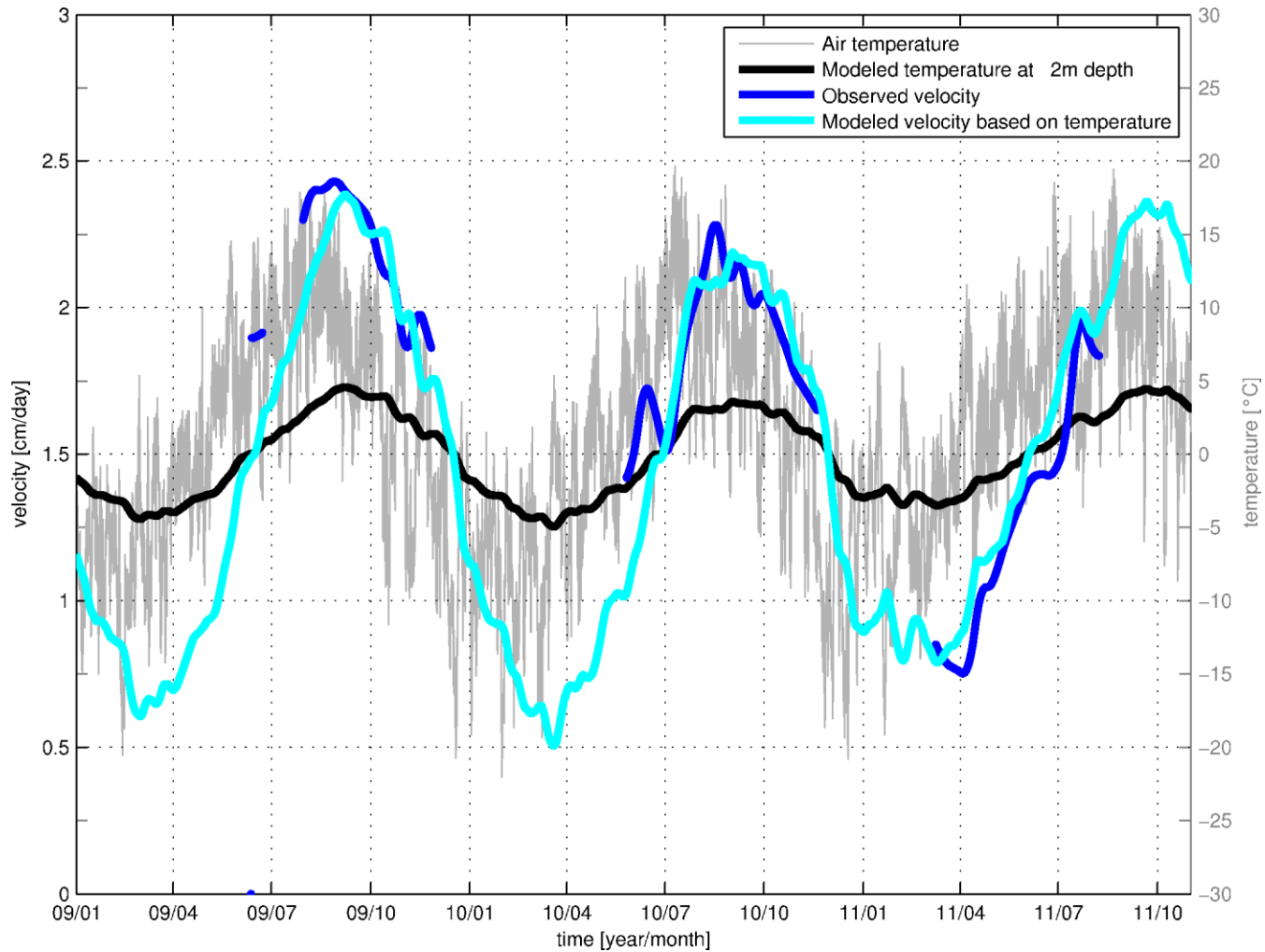
Temperature Profile for Schafberg



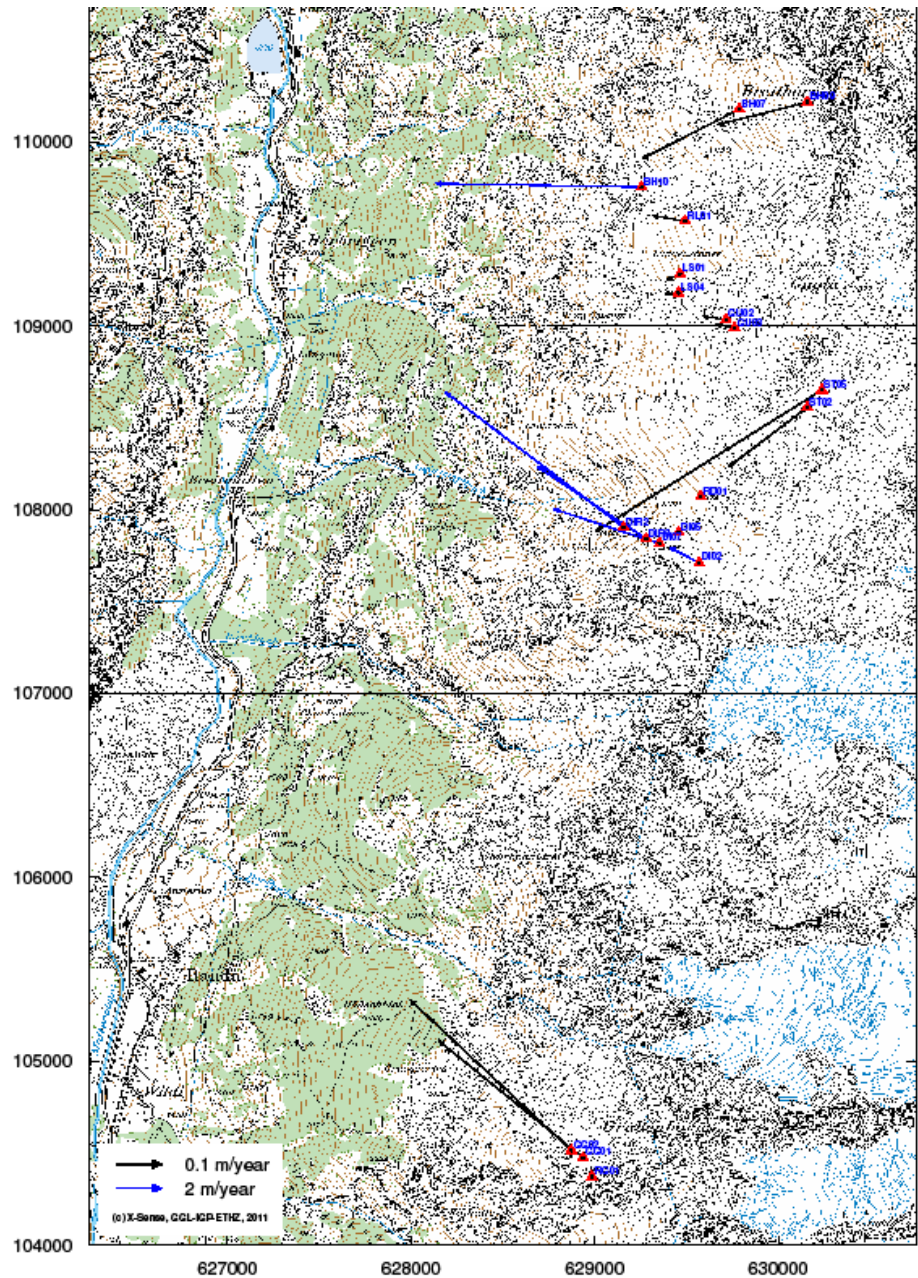
Permafrost in
Switzerland, BAFU

Velocity/Temperature correlation

Limpach, 2011



Today's result



**Graben Gufer Blockgletscher
(Mattertal, Wallis)**

25.07.2009

**CANTON DU VALAIS
KANTON WALLIS**



R. Delaloye



Shadow detection

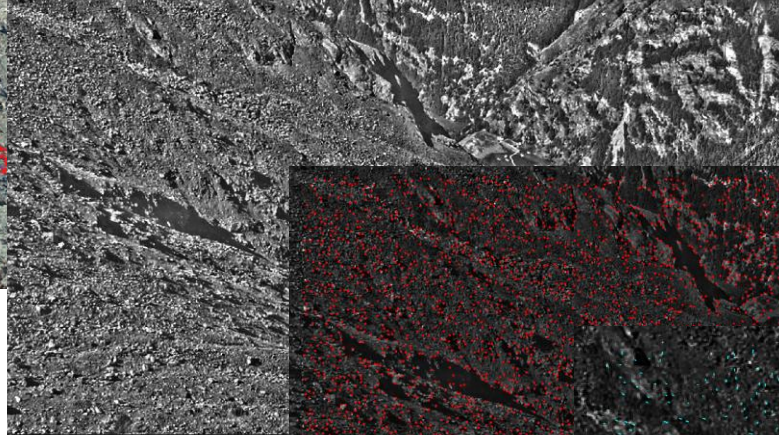
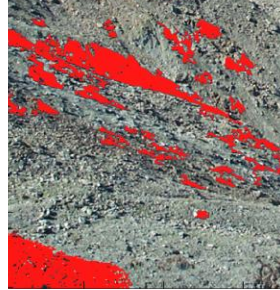
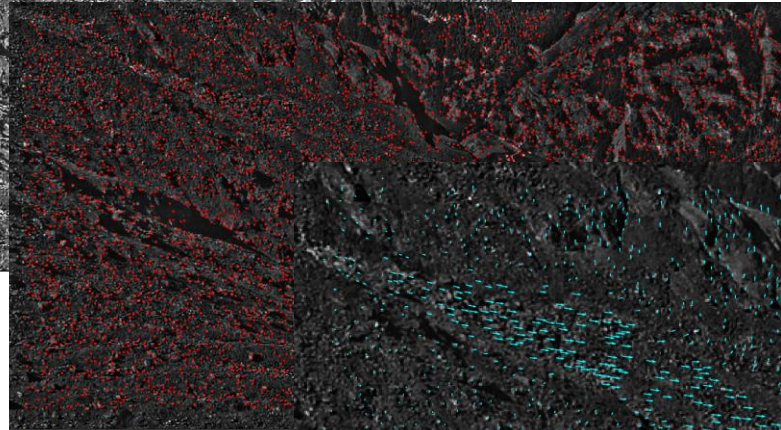
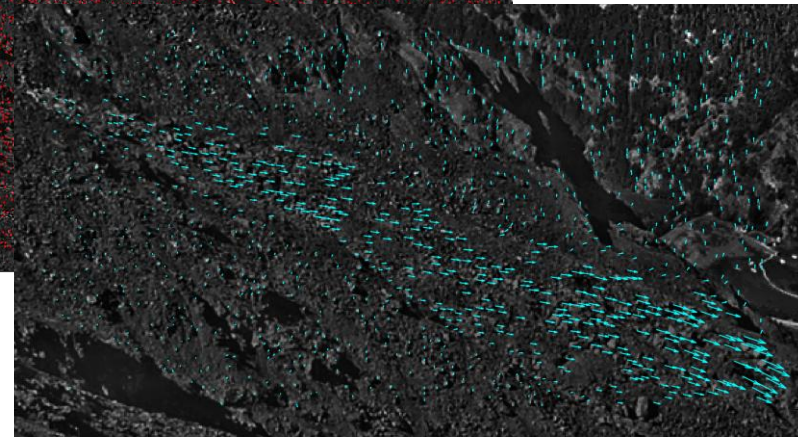


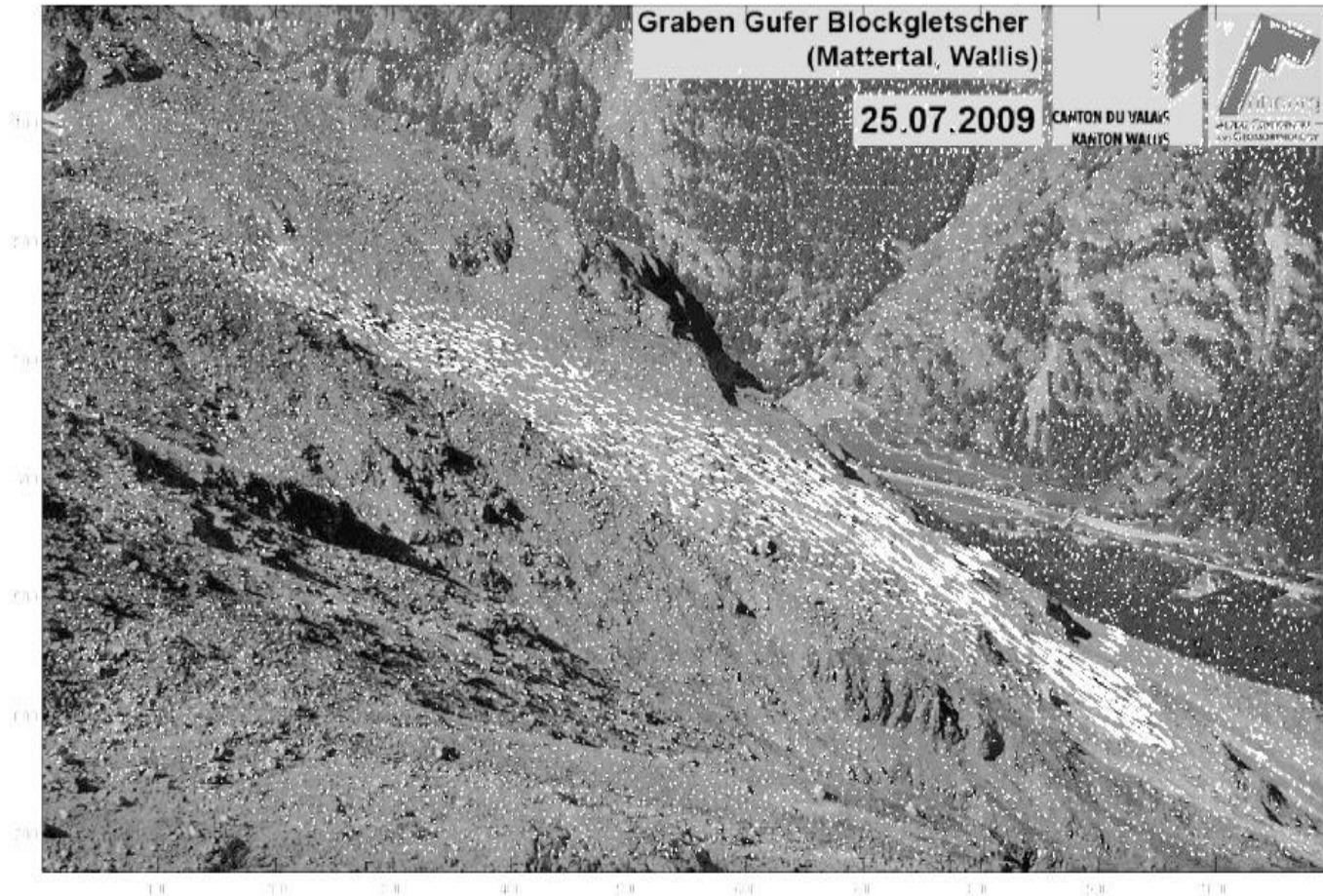
Image enhancement



Feature detection



Displacement extraction



Automatically analyzed sequence of single camera frames (pictures: R. Delaloye, Uni Fribourg). White points: stable areas, also used for picture calibration. White arrows: deforming area, difference over 15 days. Grabengufer rock glacier.

Fabian Neyer

Cluster Bildung für die Interpretation

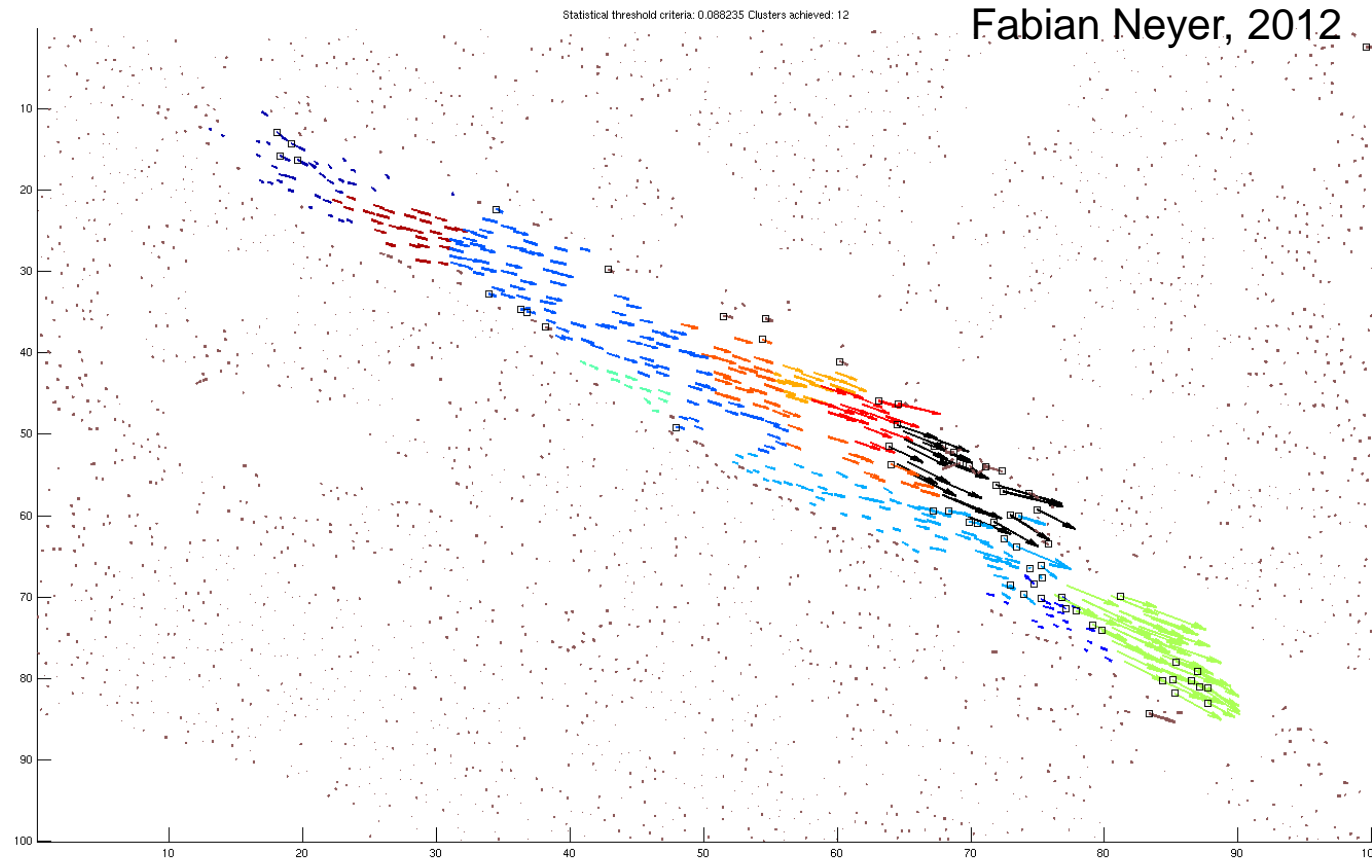




Foto @ Jan Beutel, TIK-ETHZ



Vielen Dank