Improvement of a Terrestric Network for Movement Analysis of a Complex Landslide (3274)

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Outline

- Introduction to the Project ILEWS
- Installed Networks
- Measurements results
- Evaluation of the installed network
- Conclusion and Outlook

I L E W S

Integrative Landslide Early Warning Systems

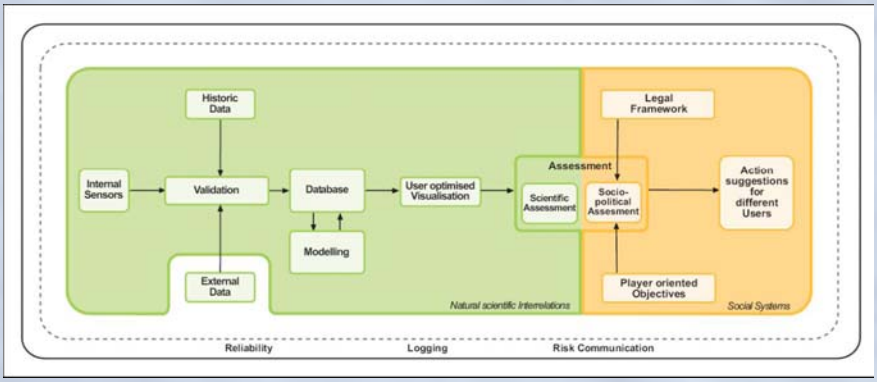


Figure 1: Scheme of the interdisciplinary Project ILEWS

Project ILEWS

- Funded by the German Ministry for Education and Research in the research program Geotechnologien

GEOTECHNOLOGIEN

Project Partners:

universitätbonn

universität wien

UNIVERSITÄT BAMBERG

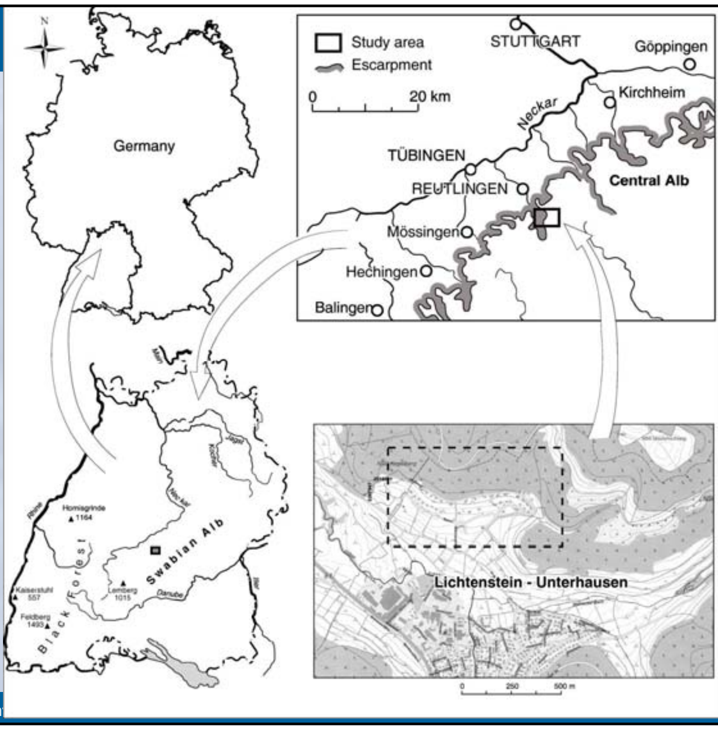
technische universität dortmund

geoFact GmbH
Geophysik • Geologie • Geotechnik • Consulting

terrestris

IMKO MICROMODULTECHNIK GMBH

Geoinformatik & Ressourcenmanagement geomer



Location of the study area in Lichtenstein-Unterhausen
Bell, R.; Thiebes, B.; Glade, T.; Becker, R.; Kuhlmann, H.; Schauerte, W.; Burghaus, S.; Krummel, H.; Janik, M.; Paulsen, H.; 2008; The technical concept within the Integrative Landslide Early Warning System (ILEWS) project; Xi'an, China; Proceeding of the 10th International Symposium on Landslides and Engineered Slopes, 30.06. - 04.07.2008

Study Area Lichtenstein-Unterhausen

In the 1960s the settlement of the historic landslide started

Aerial photography

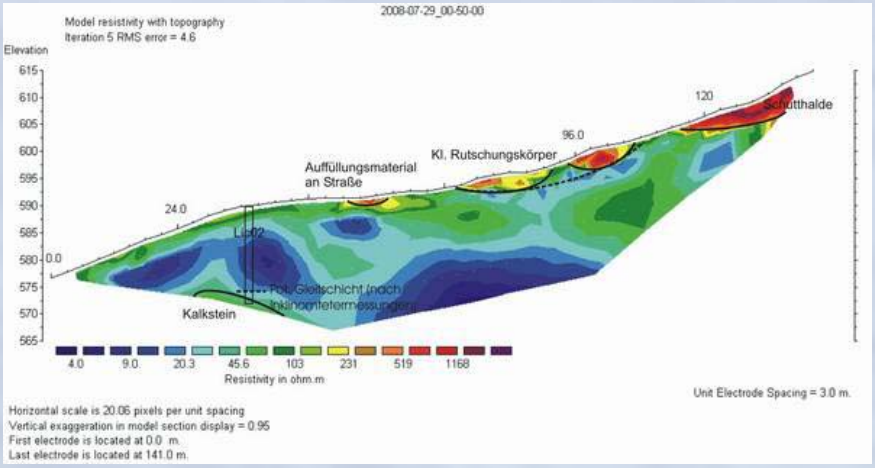
Source: Google Earth

Geoelectric Profiles

Source: Google Earth

Geoelectric Profiles

47 electrodes, spacing 3 m



Soil moisture monitoring

- 30 TDR-probes and
- 30 tensiometers at
- 10 points at a
- depth of 2 m, 5 m and 10 m

Source: Reutlinger Generalanzeiger

Development to an early warning chain

- **Add. Measurements:**
  Meteorology, Inclinometer Meas., Seismic Meas.
- Modelling of the landslide

➢ Historic data out of local and regional archives to understand frequency-magnitude relation

➢ Assessment of information requirements of local authorities (e.g. to start evacuations)

➔ **Fully working early warning chain**

Installed Networks

Installed Networks

Network, planimetric component

Source: Google Earth

Network, planimetric component

Network, planimetric component

Realized by

- 1 m steel tubes with centering marks on top in the streets.
- 1.5 m twisted aluminium cross anchors with centering marks on top in grass areas

The markings are assumed as

- stable against human influence, but
- moving with the landslide because of its movement depth.

Network, height component

Source: Google Earth

Network, height component

Network, height component

Realised by

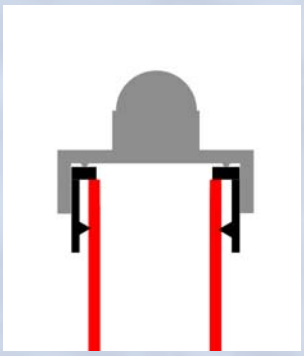
– height bolts in the sidewalk of the streets

The markings are assumed as

– stable against human influence, but
– moving with the landslide because of its movement depth.

Inclusion of geologic measurements

- The tube **(red)** was equipped with a fixed metal collar **(black)**
- On this metal collar a cap bedded on three points **(grey)** was placed during the geodetic measurements, which gives a precise height definition



Measurement results

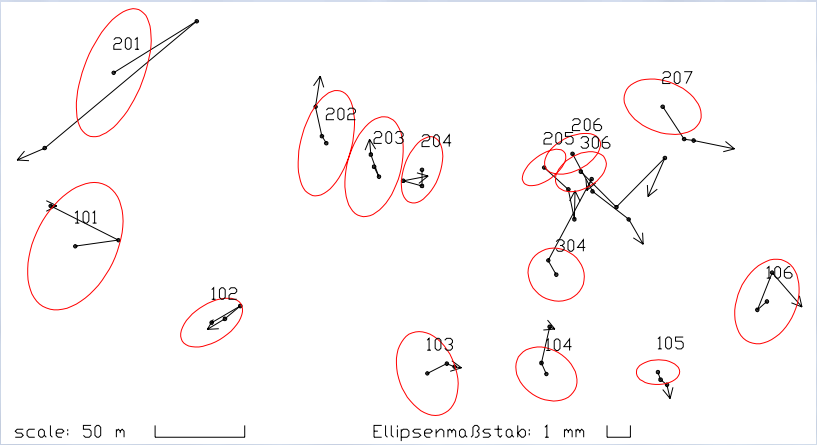
Measurement results

Position Network

Position Measurement

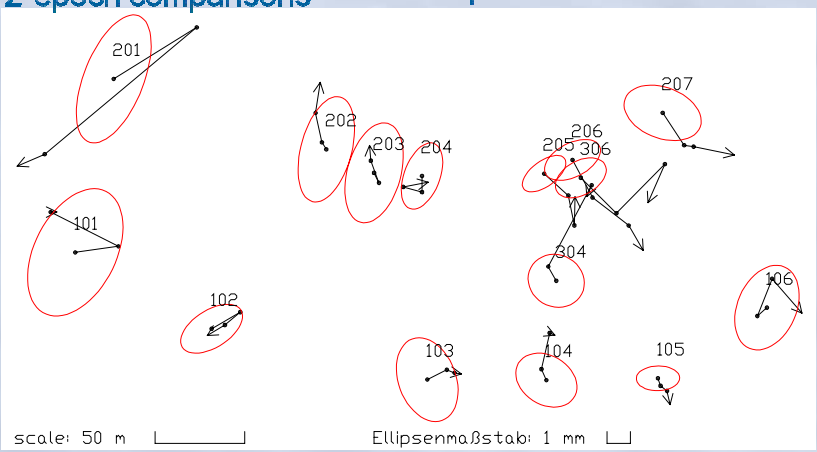
Epochs:

- November 2007
- March 2008
- August 2008
- September 2008



Position Measurement

- Free Adjustment
- Deformation analysis was done in multiple 2-epoch comparisons
- Confidence Elipses with a confidence level set to 95 %, out of epoch comparison 1-4

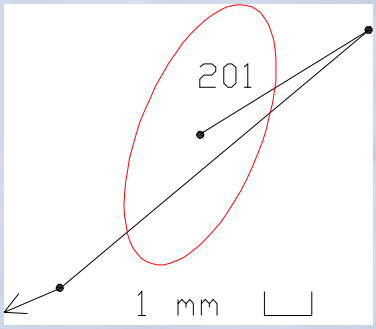


Point 201

Movements

- Uphill during the winter, and
- Downhill during the summer

Interpretated as an effect of swelling and shrinking of the clayrich soils, following dry and wet periods

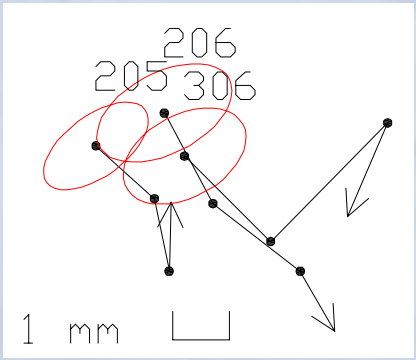


Point 306

Measured in

- November 2007
- March 2008
- August 2008
- September 2008

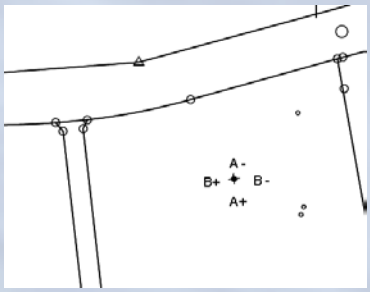
Eye-catching:
Sidewards Movement!!!

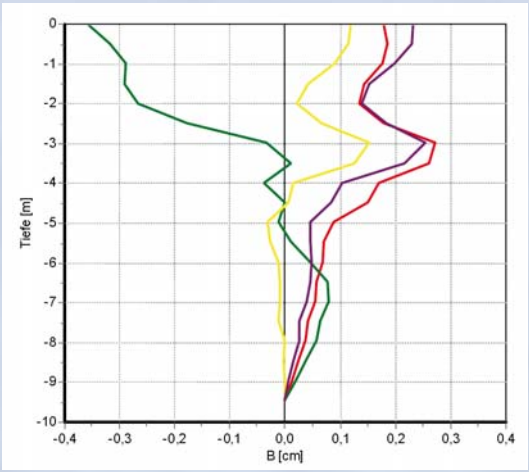


Inclinometer Measurements

Epochs:

- 6.5.2008 (red)
- 17.6.2008 (green),
- 9.11.2008 (yellow)
- 12.2.2009 (violet)





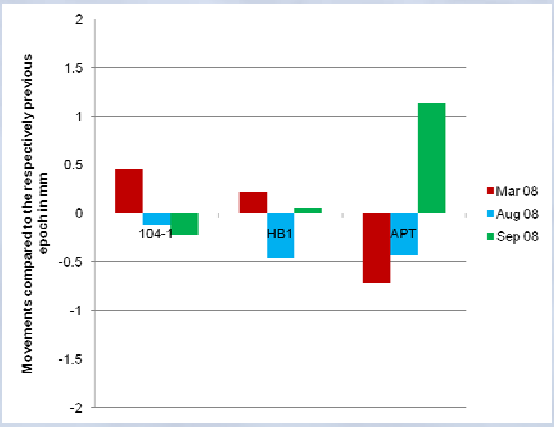
Measurement results

Height Network

Connection to concrete bridge

- Free Adjustment
- Datum fixed to identic points

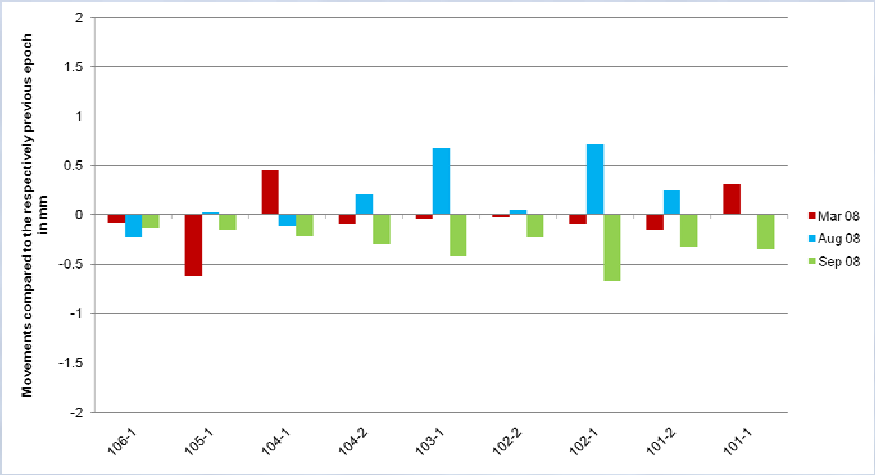
➔Point APT is detected as changed!!



Was the stability assumption of point APT correct?

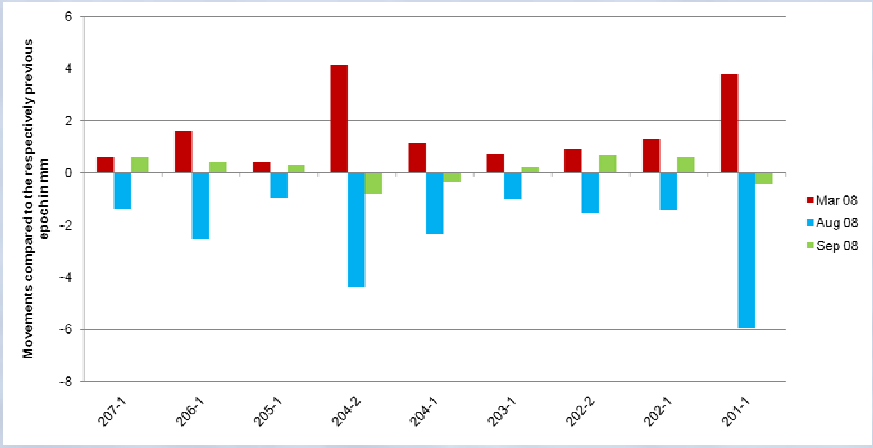
Lower street

The Deformation analysis recognizes the points 105-1, 104-1, 103-1 and 102-1 as moved.



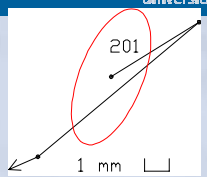
Upper Street

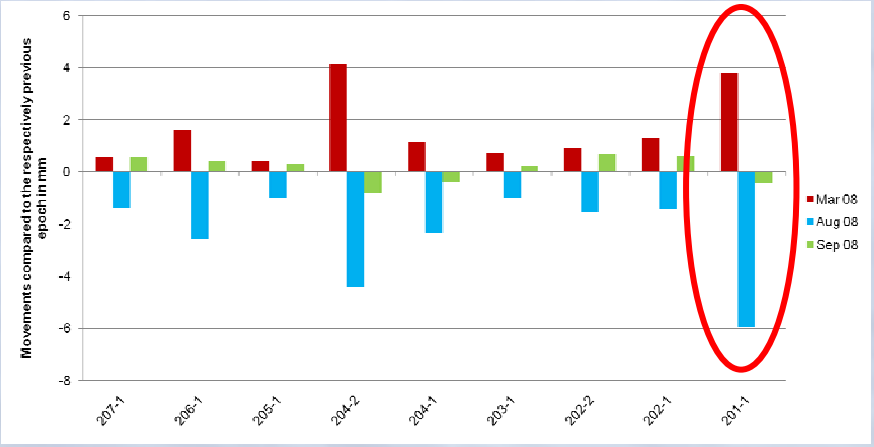
Significant are especially the movements in the Points 201-1 and 204-2



Upper Street

The height changes in 201-1 confirm the theory of swelling and shrinking of the clayrich soils.





Upper Street

A house in direct proximity to these two points shows up to 5 cm wide fissures that proof strongly the ground movements

Evaluation of the installed networks

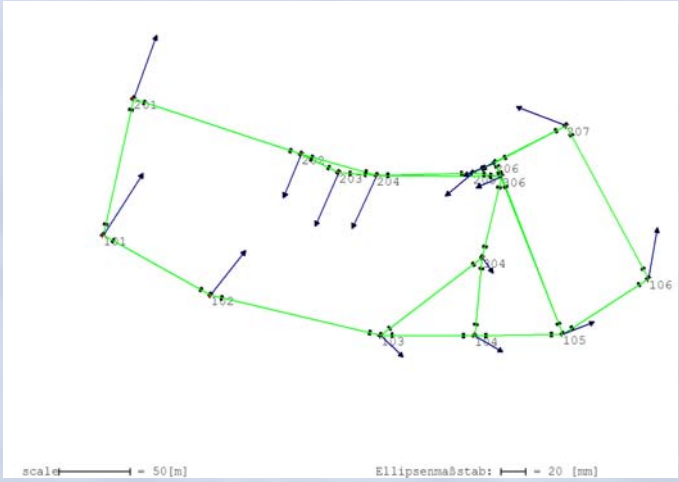
Evaluation of the installed networks

Principal component analysis

The principal component analysis shows a weakness area at the western part of the network.

The principal component vectors have the same direction as the slope gradient

➔random coordinate deviations can be recognized as deformations that never happend !!

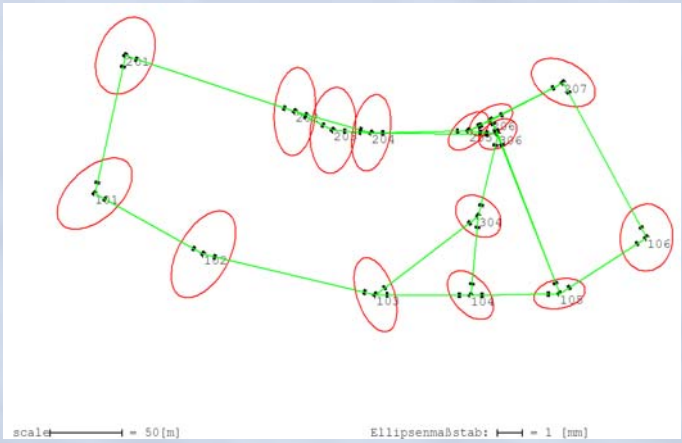


Confidence ellipses

• Standard deviation of 0.8 mgon in the direction measurement and 0.4 mm in the distance measurement out of a variance component estimation

• Confidence level of 95 %

•The confidence ellipses also show the weakness of the network in the western part



Sensivitivity analysis

A sensivitivity analysis for point 201 returns a minimal, as deformation recognizeable movement between two epochs of 2 mm

→that ist 2-4 times larger then the already found movements

➔the sensitivity of the network is high enough to recognize the movements of the landslide body

Conclusion and Outlook

Conclusion and Outlook

Conclusion for the installed networks

- The installed measuring network shows a weak area in the western part.
- A workaround (e. g. cross beams) for that is not possible due to the given situation in the study area.
- The actual measuring precision seems to be sufficient to discover the ongoing movements.

Outlook

- Integrating all data from the other project parts might give the possibility to conduct a dynamic modelling of this landslide.
- This model will then be based not only upon geodetic measurements, but will also respect the causal connection between geological and meteorological influence variables and the observed landslide movements.

Thank You

Thank you for your attention