Lower Watten Valley, 15 February 2019

Monitoring-based identification of nature-based solutions to mitigate the impact of deep-seated gravitational slope deformations

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OPEn-air laboRAtories for Nature baseD solUtions to Manage environmental risks
2020/05/04

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OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

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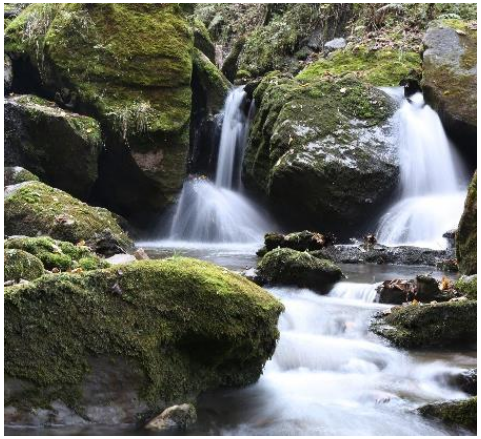


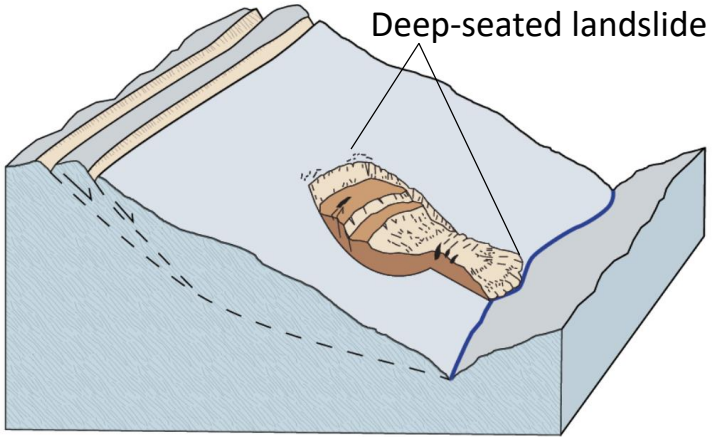
Photos: Zieher and Pfeiffer 2018 and 2019

1) Introduction

Monitoring deep-seated landslides is essential to better understand their complex (forcing) processes.

Knowledge about the landslide process is crucial for setting up **target-oriented Nature-based Solutions (NbS).**

- **Geodetic Monitoring** obtains information about deformation and aims to answer:
  - *Where, when and how fast does the landslide move?*
- **Hydrological Monitoring** obtains information about (assumed) hydrological drivers:
  - *Groundwater conditions (e.g. hydrogeology, flow paths)*
  - *Groundwater recharge (e.g. hydro-meteorological events)*



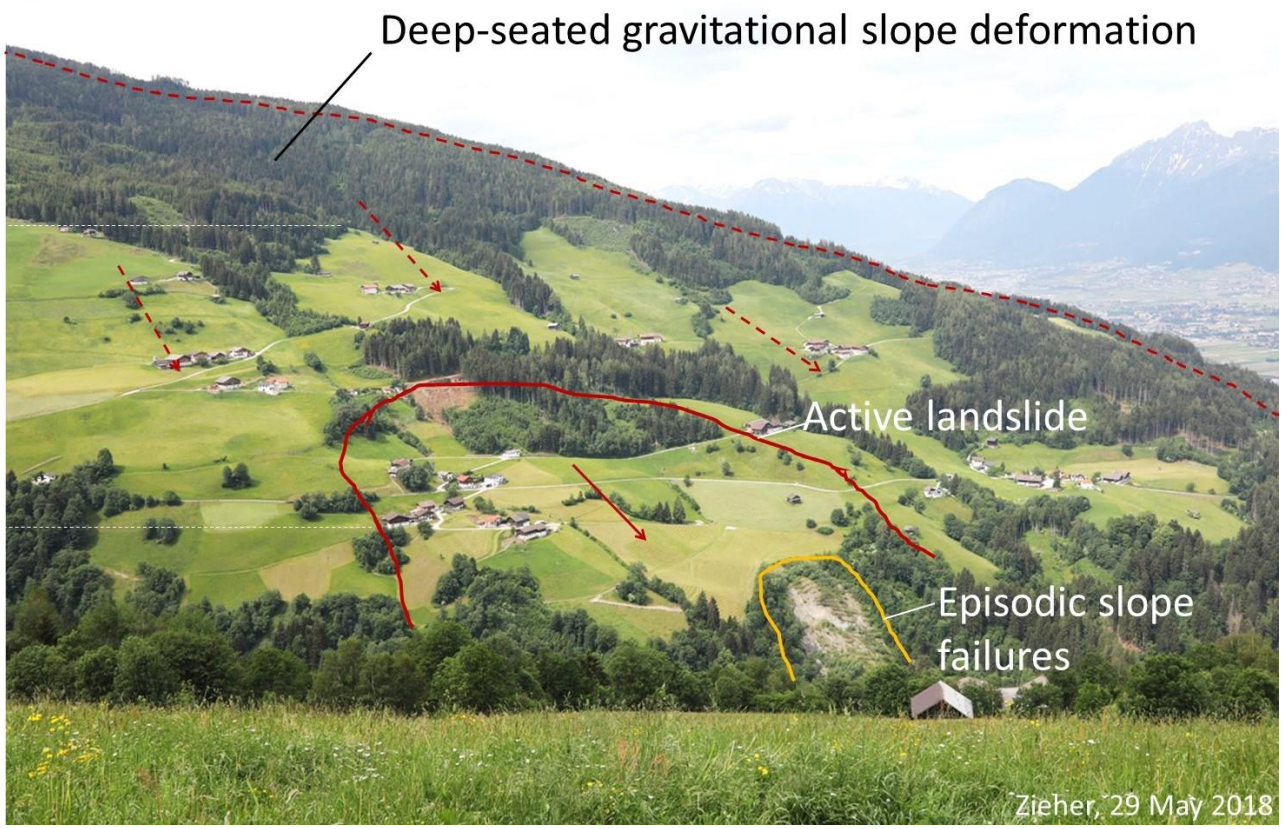
Schematic illustration of a deep-seated landslide embedded in a deep-seated gravitational slope deformation (DSGSD) complex (modified after Highland and Bobrowsky 2008)

Nature-based Solutions (NbS): "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges (…)". IUCN

2) Study Area

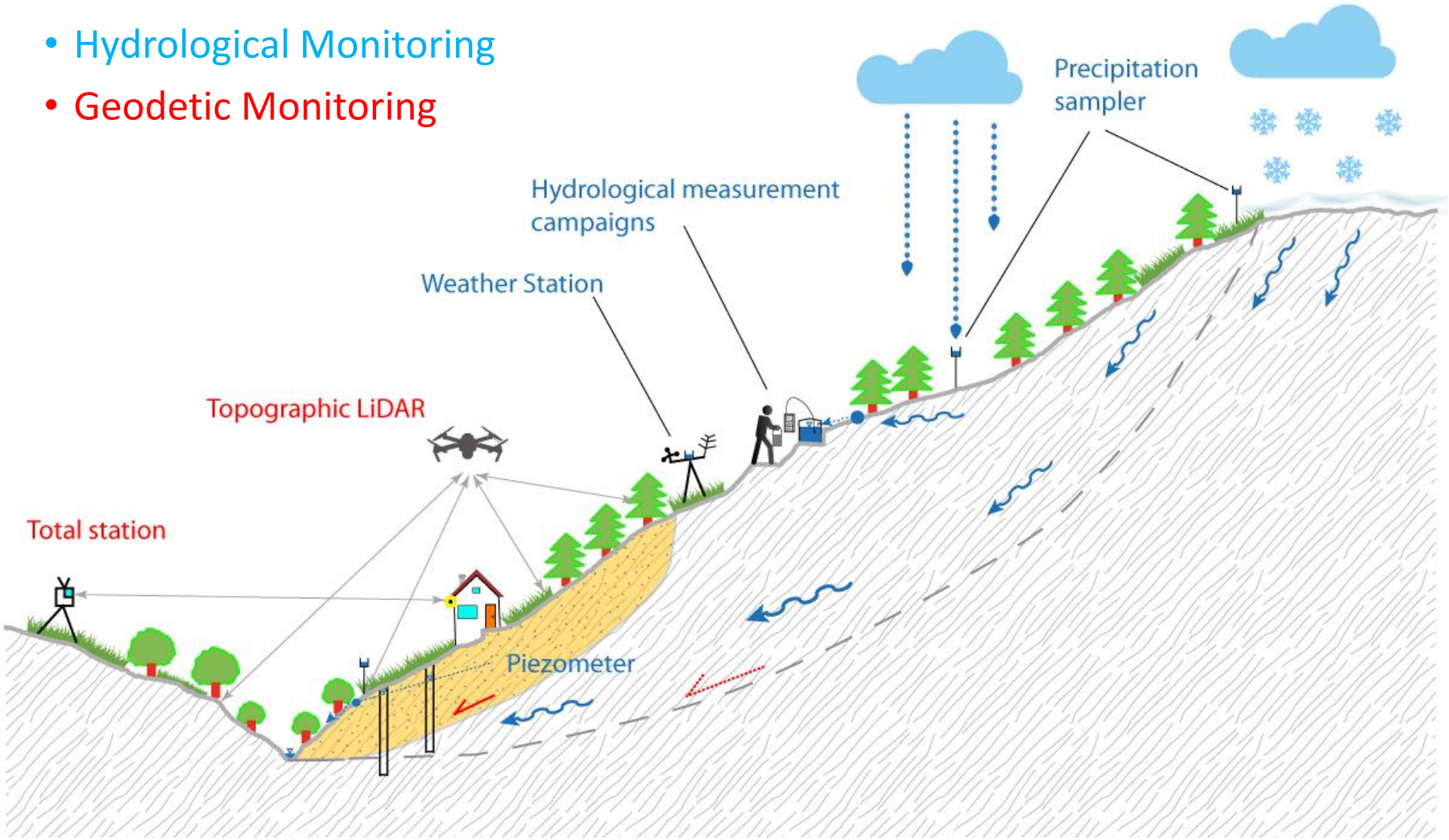
Deep-seated landslide in the Lower Watten Valley (Tyrol, AT)

- Continuously creeping active deep-seated landslide moving between 1.7 – 5.2 cm per year
- Alternating acceleration and deceleration phases
- Infrastructure and houses are damaged



3) Monitoring Framework

- Hydrological Monitoring
- Geodetic Monitoring



3) Monitoring Framework

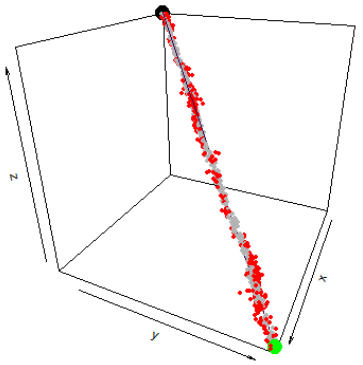
Geodetic Monitoring

Continuous, single points

- Automatic tracking total station (ATTS)
- Unmanned aerial vehicle based laser scanning (ULS)
- Terrestrial laser scanning (TLS)
- Airborne laser scanning (ALS)

Periodic, area-wide

Federal state of Tyrol



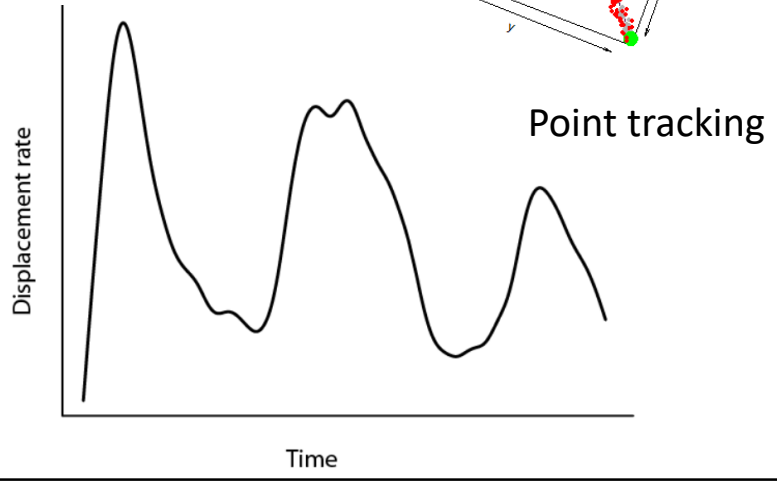
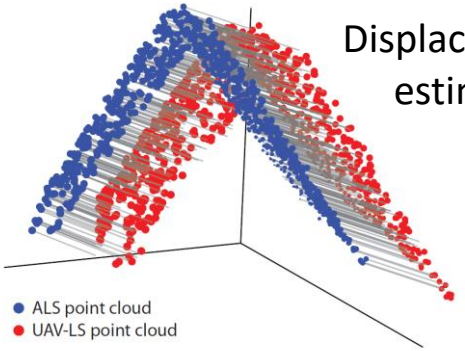


Photo: Zieher 2018

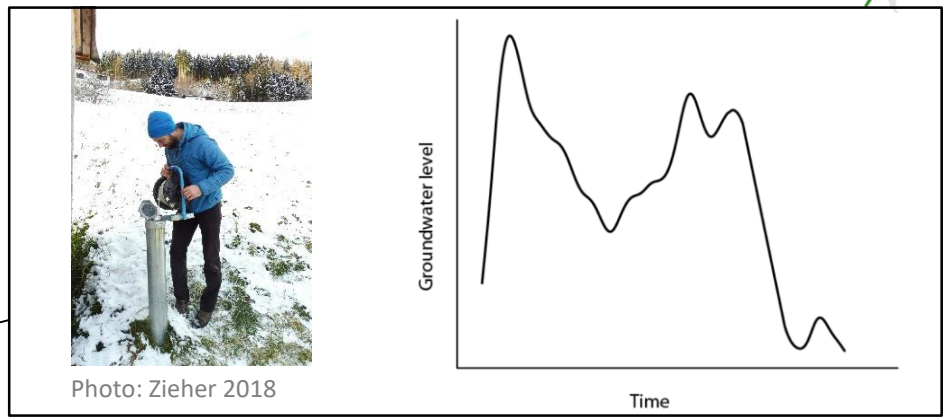
Photo: Pfeiffer 2018



Zieher et al. 2019

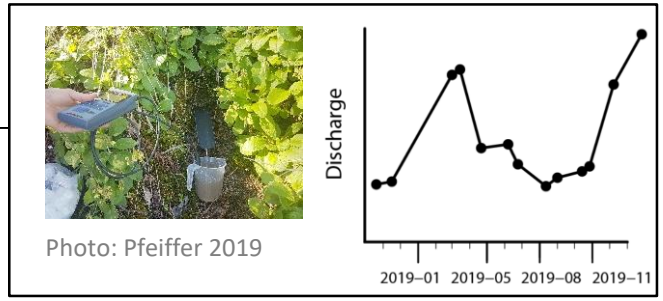
3) Monitoring Framework

Hydrological Monitoring



Measurements

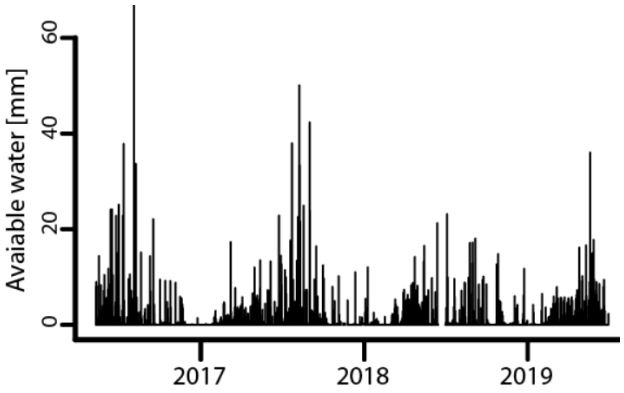
- Piezometer
- Measurement campaigns at drainages, streams and **springs**
- Precipitation sampling

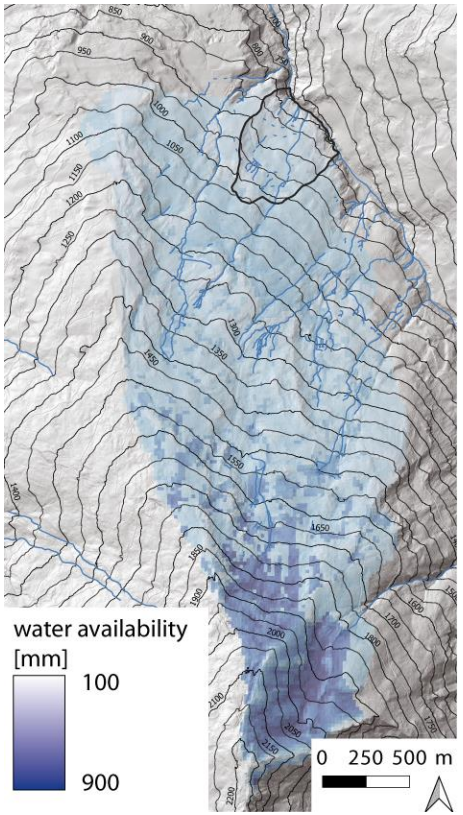


Modelling

Numerical model provides spatio-temporal information of water available for groundwater recharge:

- Snow melt
- Rainfall

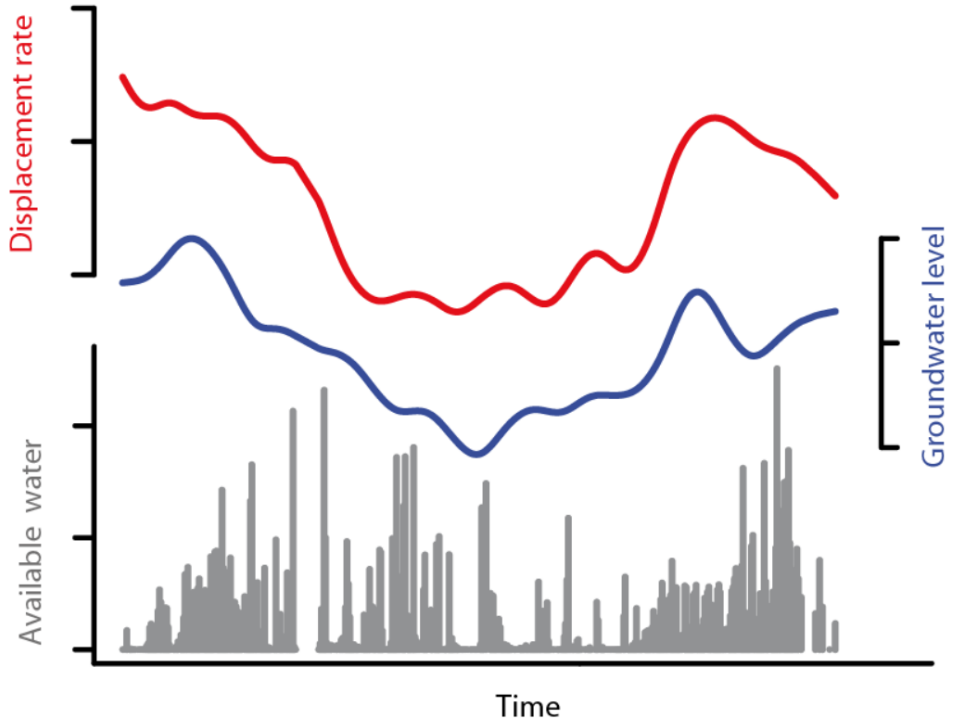


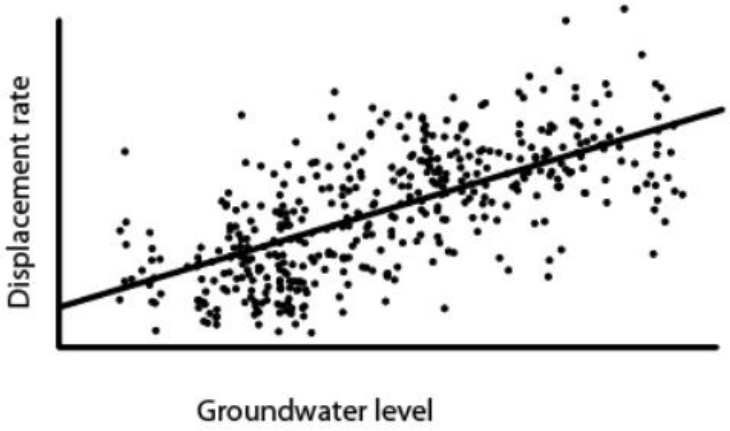


4) Monitoring and Process Understanding

Consolidation of interdisciplinary monitoring data provides essential information about the landslide process which is required for the identification of nature-based solutions.

Following correlations between monitored observables were observed:



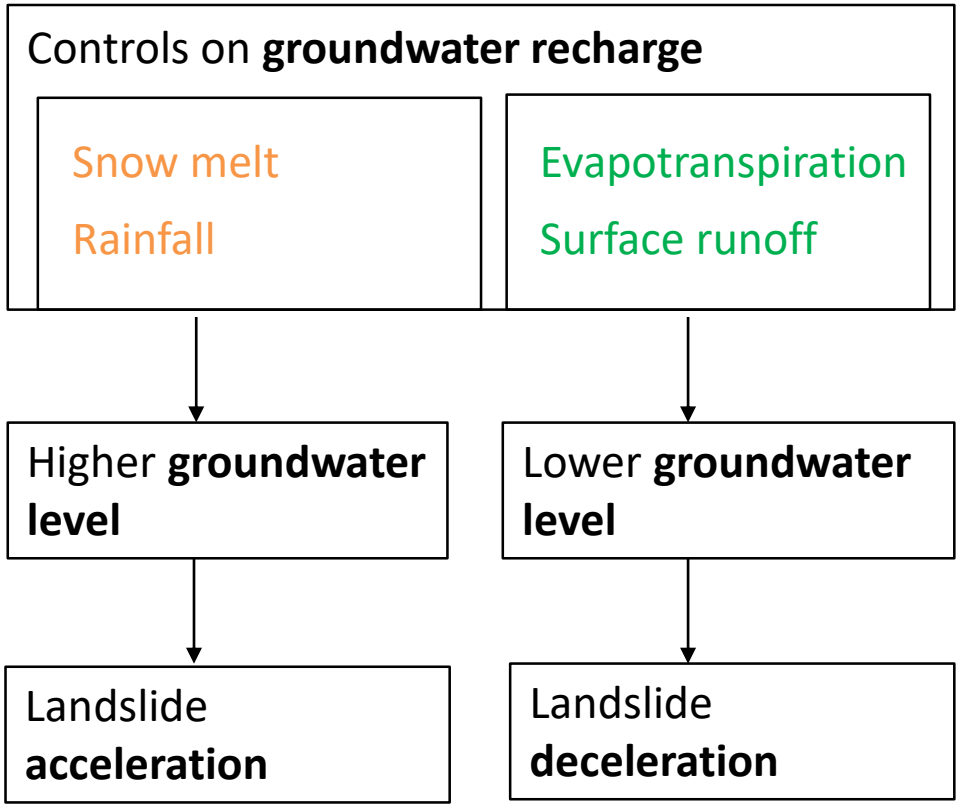


- The higher the groundwater level the faster the landslide moves
- Periods with low precipitation input (snow melt and rainfall) correlate with low displacement rates

Basis for planning mitigation measures

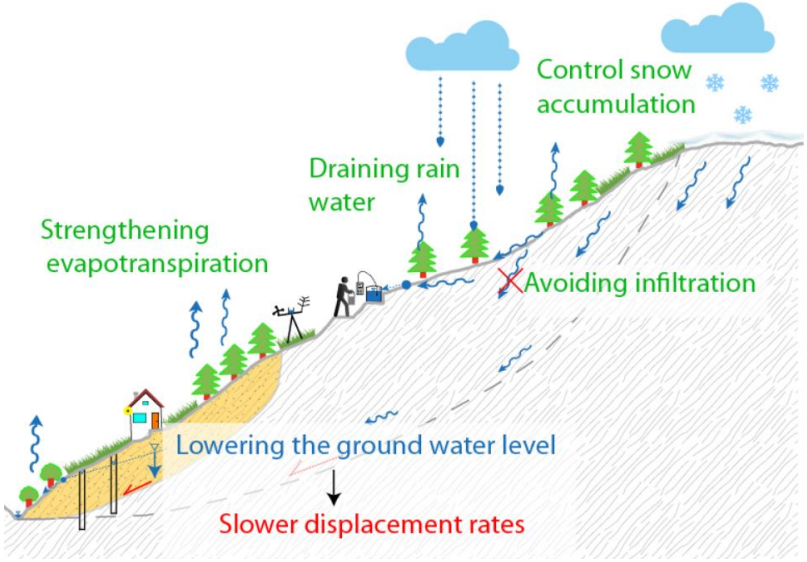
4) Monitoring and Process Understanding

Establishing simplified process cascades for the specific deep-seated landslide:



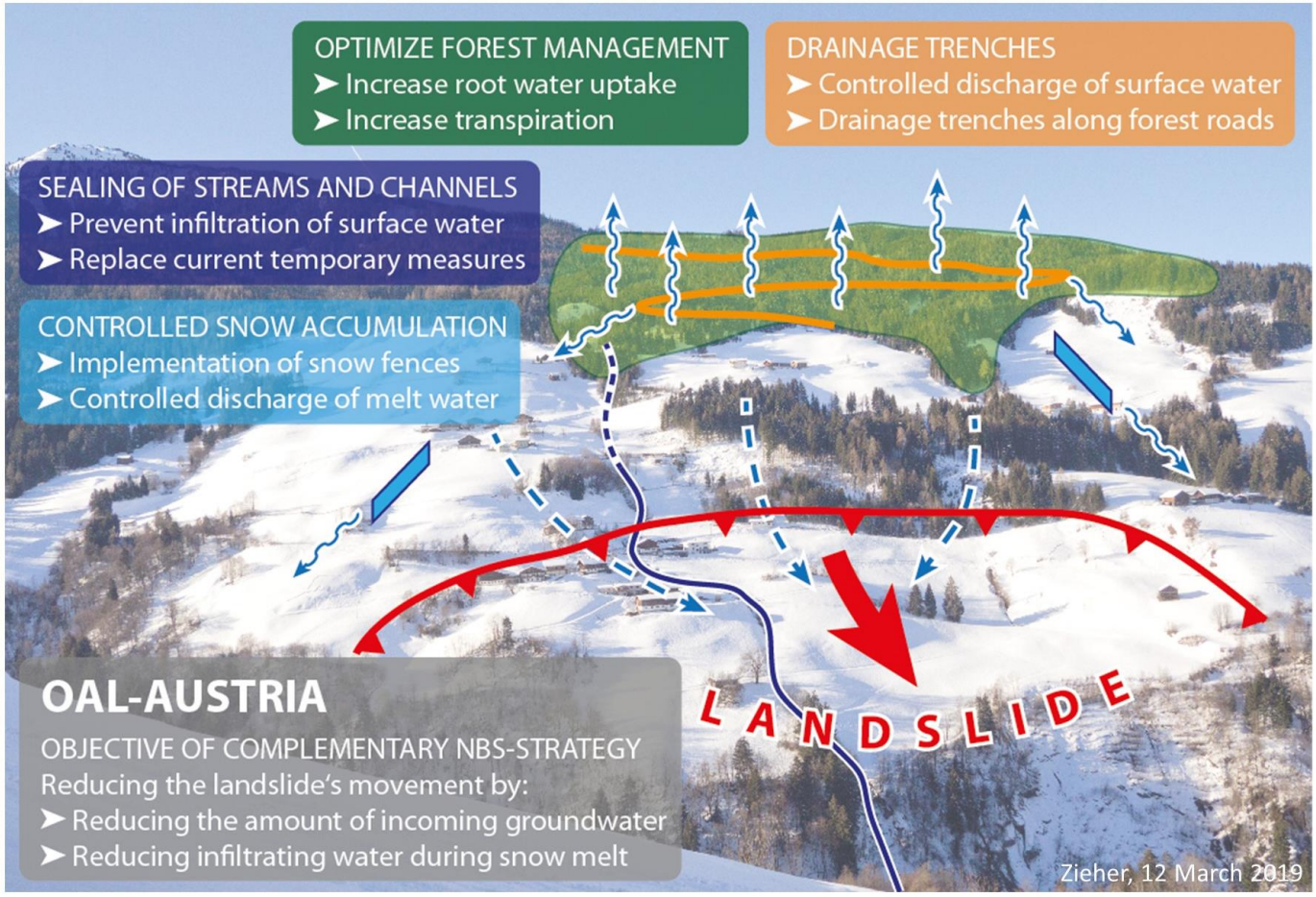
Nature-based Solutions for the shown case study should consider the following mitigation aims:

- ↓ Lower snow melt input
- ↓ Lower rainfall input
- ↑ Enhance evapotranspiration
- ↑ Drain surface runoff efficiently and minimize infiltration



4) Identifying Nature-based Solutions

Following framework of NbS options was developed:



5) Conclusion

- Monitoring is essential to acquire knowledge about complex landslide processes

↓

- Process knowledge is essential for identifying target-oriented measures aiming to reduce landslide's velocity

↓

- We identified four NBS options tackling different parts of the hydrological cycle to support landslide deceleration

→ NbS for deep-seated landslides have to be tailor-made according to the local conditions

5) Outlook

- Further monitoring and modelling tasks will quantify the effectiveness of implemented NbS in future
- Hydrogeological processes will further be investigated to improve and support the detailed planning of further and accompanying measures

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