Spatio-temporal analysis of soil degradation in Swiss alpine grasslands

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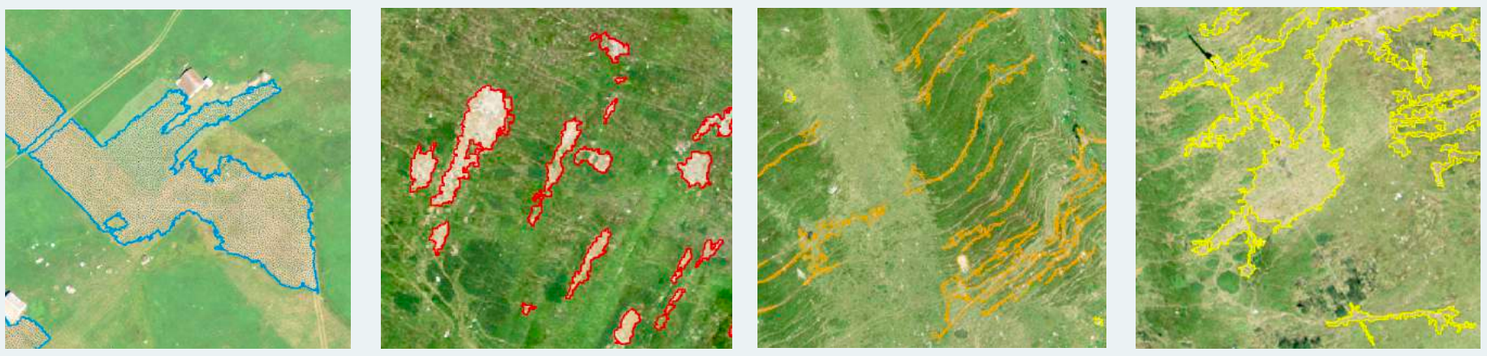
Introduction

Alpine grasslands are seriously affected by soil degradation due to various forms of soil erosion, amplified by the extreme prevailing topographic and climatic conditions.
A combination of changing climate conditions and land-use practices is anticipated to increase soil erosion risk[1].

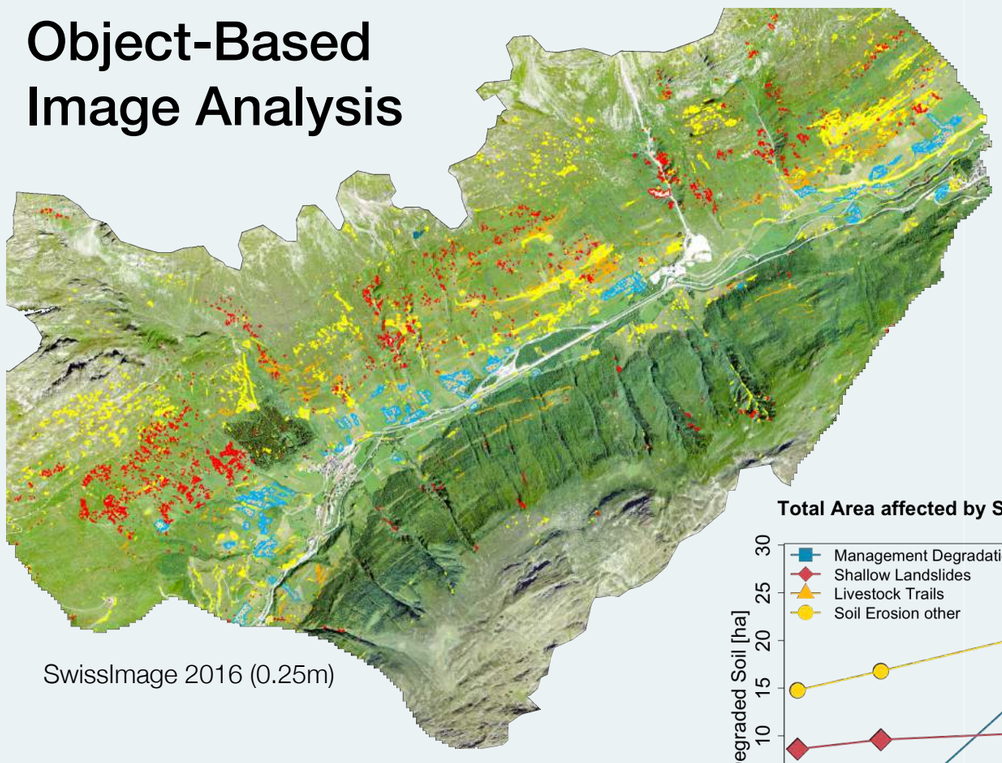
Research Questions

- What areas are affected by soil degradation?
- How strongly are these areas affected by soil degradation?
- What type of process dominates?
- Which areas are changing over time?

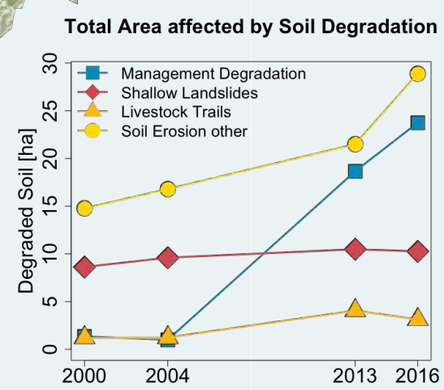


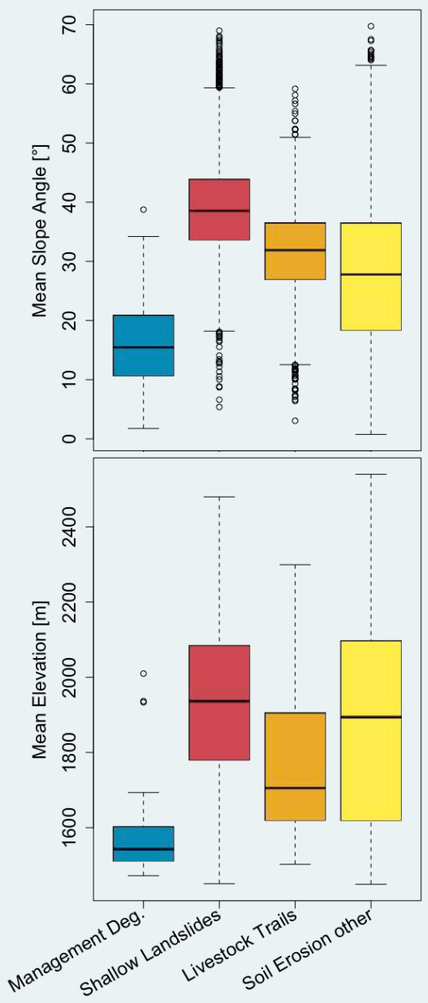
Management degradation | Shallow landslides | Livestock trails | Other form of soil degradation

Object-Based Image Analysis



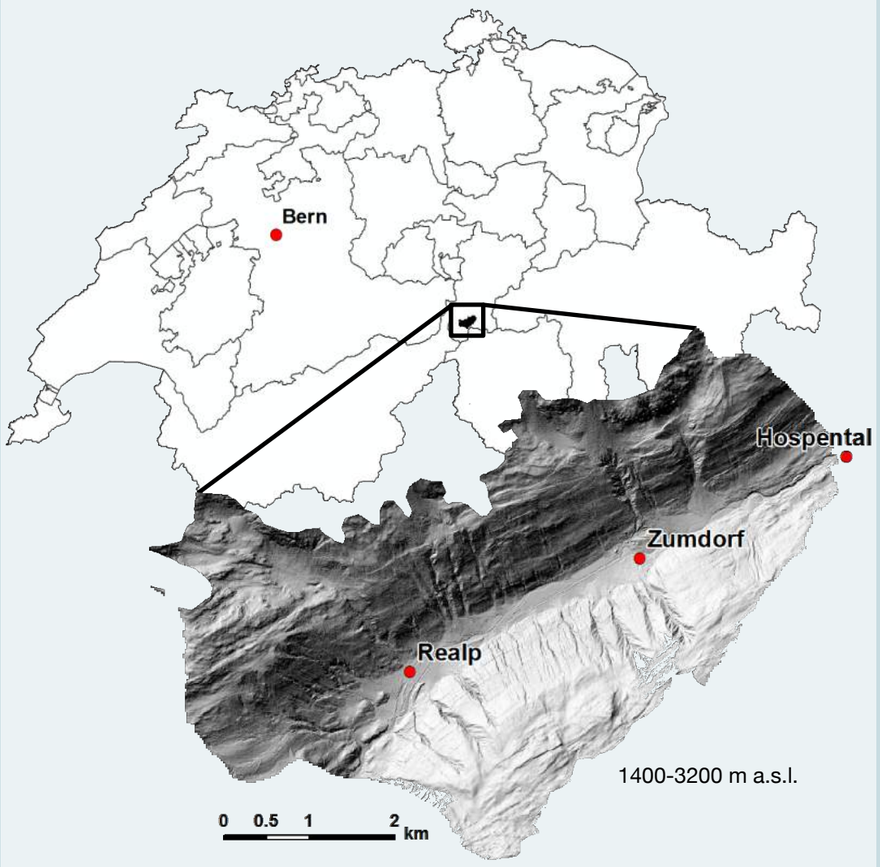
SwissImage 2016 (0.25m)





1. Aggregation of Pixels into Objects
2. Assigning Objects to Classes

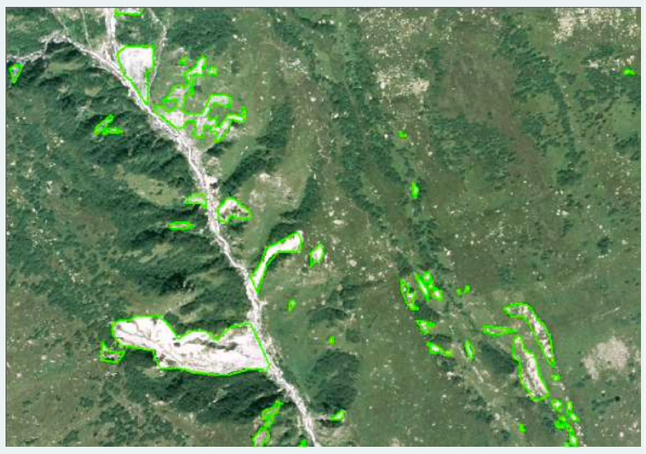
Study Site: Urseren Valley



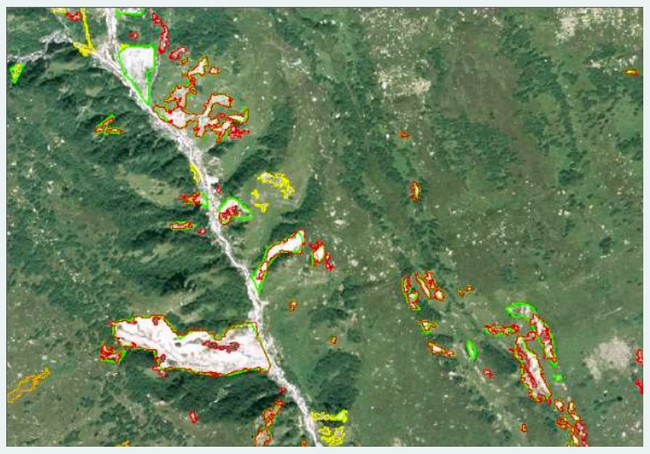
Deep Learning

In addition to the Object-Based Image Analysis (OBIA) method, we are working on a faster and less observer dependent method to map areas with degraded soil.

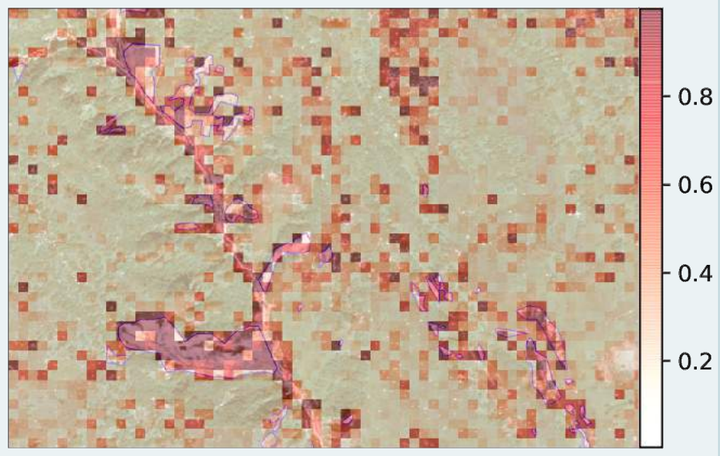
- Convolutional Neural Networks (CNN) using *ResNet-152*



Manually Mapped Shallow Landslides



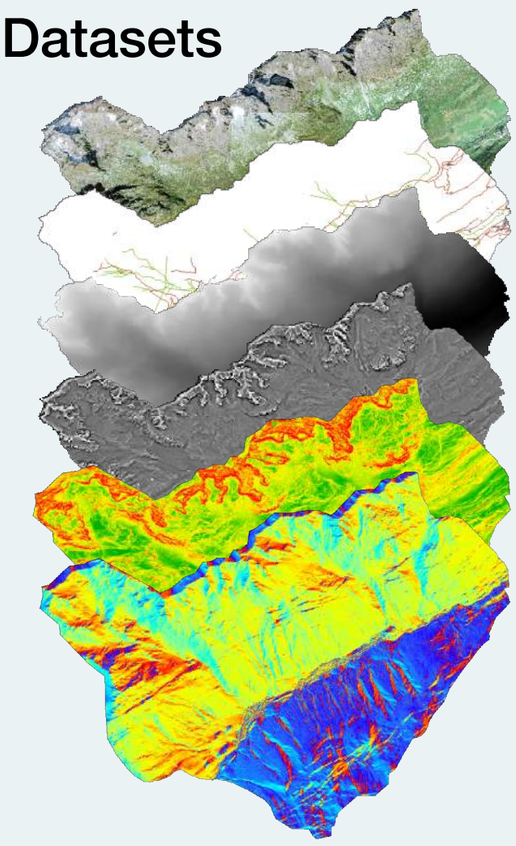
Object-Based Image Analysis Results
Precision: 0.74 Recall: 0.69



Deep Learning (CNN) Results
Precision: 0.90 Recall: 0.84

- Identification of *Shallow Landslides*
- The model is trained with manually mapped landslides
- Results are a pixel-wise classification (likelihood of shallow landslide)

Datasets



- **SwissImage**
  Red/Green/Blue Information, 0.5 - 0.25m spatial resolution, updated every 3 years
- **Thematic Information Layers**
  e.g. Roads, Buildings, Rivers
- **Digital Elevation Model (DEM)**
  Height information and basis for DEM derivatives
- **Curvature**
  Shape of slope (concave, convex)
- **Slope**
  Measure of change in elevation
- **Aspect**
  Direction of the steepest slope
- **Flow Direction & Length**
  Direction of steepest downslope neighbour; Distance along flow path

Conclusions & Outlook

- With OBIA we have a holistic approach, that can map all different types of occurring soil erosion processes simultaneously
- However, with OBIA subjective and labour intensive steps are necessary!
- CNN is objective, fast, automated, transferable
- So far CNN was applied to detect *landslides*, is should however be possible to apply it to other categories
- CNN takes a couple of hours (1 GPU)— OBIA takes days with intermediate decision making
- CNN achieves good scores using only RGB channels. Future work will include further data (DEM etc.) and therefore an increase in accuracy is expected

- At a later stage also other categories of soil erosion will be mapped using CNN
- Application of CNN to historical black/white images will be tested
- When CNN delivers reliable results it becomes possible to map larger areas in the Alps

References
[1] Meusburger, K., Alewell, C., 2008. Impacts of anthropogenic and environmental factors on the occurrence of shallow landslides in an alpine catchment (Urseren Valley, Switzerland). Nat. Hazard. Earth Syst. 8, 509–520.

Acknowledgements
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