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gAia: predicting landslides based on consolidated inventory data – bridging needs and limitations

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Abstract

Climate change is expected to increase the frequency of landslide events in Austria. To improve the detection rate of such events, the gAia project seeks to supplement existing inventories by considering earth observation data and leveraging on machine learning techniques. To ensure that the project outcome is of practical relevance, the gAia team involves stakeholders from the start. Here we introduce the gAia approach and summarize the findings from our first stakeholder workshop.

Introduction and scope of the gAia project

In the context of climate change, researchers expect an increase of extreme weather events on a global scale, with the European Alps being disproportionally affected (IPCC, 2021). Recent studies found evidence that this may lead to more frequent gravitational mass movements such as landslides (Offenthaler, 2020; Maraun, et al., 2022). Since this poses a safety risk for society and can cause extensive damage to infrastructure, improved methods for detecting these events are crucial to act promptly. A high-quality data inventory – as complete as possible – Is an essential prerequisite for a better understanding of landslides and for the creation of susceptibility maps, risk analyses as well as for making decisions in disaster management. So far, landslide inventory databases stem from different sources, such as historical archives, field mappings, earth observation, as well as combined inventories. However, a holistic approach is missing, in which qualitative and multi-modal data fusion aspects are considered.

The gAia project (Predicting landslide - Development of landslide susceptibility maps based on consolidated inventory data) therefore aims to supplement these inventories by exploiting information from recently acquired, high-resolution digital terrain models (DTM) and from earth observation data, e.g., from Sentinel 1+2 constellations. Up to now, these data sources have only been used to a somewhat limited extent mainly due to a lack of methods to process them. To overcome this, gAia builds on modern machine learning techniques for (i) fusing two or more data modalities (ii) for modelling the occurrence probability of landslides (susceptibility) and (iii) for quality assurance and explainability.

Bridging needs and limitations

One outcome of gAia will be the development of improved landslide susceptibility maps and simple risk indicators tailored to the needs of specific stakeholders in the fields of spatial planning, provincial geology surveying as well as risk and crisis and disaster management. Beyond that, the resulting products can also be useful for guiding first responder organizations or the military in the event of a crisis. To ensure the practical relevance, the gAia project team is involving relevant stakeholders from the start and results are continuously cross-checked by experts. This contribution outlines the method applied for the first stakeholder requirement analysis and summarizes the found results. Additionally, it describes the limitations and uncertainties from a scientific point-of-view, which need to be clearly communicated to the community.

Stakeholder requirement analysis: method

The format of the (online) focus group was used to investigate the general acceptance among the stakeholders regarding the planned database. By involving a rather large group of twelve participants in the discussion, opinions emerge more strongly than in individual interviews (Lamnek, 2010). Starting with an introduction of the gAia project, insights into the different work packages were shared. This was followed by a moderated 1,5-hour discussion round with previously elaborated guiding questions along these four main topics:

- Available data (inventories) and limitations
- Characteristics of an improved data inventory
- Landslide detection from earth observation data (DTM, Sentinel 1+2)
- Assessing hazard potentials

The focus group was video-recorded and transcribed. For the analysis of the interview material, we employed the text analysis software ATLAS.ti8, which allows data processing according to current social science standards and facilitates the subsequent analysis and categorization of the results. Finally, a qualitative content analysis was applied (Mayring, 1991).

Stakeholder requirements analysis: results

Despite its size and heterogeneity, our stakeholder group agreed in their general assessment throughout the discussion. More specifically, there was a large consensus to consider inventory data, i.e., all recorded and modelled data of landslide events, as sensitive. The findings can be categorized in three topics: data quality, visualization, and target audience, the results of which we will briefly summarize.

Data Quality: Of high relevance are limitations due to poor data quality since this affects the whole data analysis workflow. Particular attention was drawn to historical data, which was subsequently digitized, and to redundant or inconsistent data, which must be consolidated before modelling susceptibility maps. Moreover, the geographical location often has inaccuracies of up to 50 meters, depending on the scale of the original map. Another issue is the data availability since due to the rapid reconstruction after landslide events, the process is no longer easily recognizable after a very short period.

Visualization: Most experts emphasized the importance of intuitive visualizations and had very specific suggestions on how to achieve this:

- In disaster relief operations simple maps, limited to the main information, are needed.
- A maximum of three classes for visualizing the hazard has proven to be useful in practice.
- Understandable legends are necessary, which can be extended with supporting material.
- A maximum map scale of 1:25,000 has proven to be useful in practice to guarantee usability.
- A demand to visualize the uncertainties of the underlying data and models.
- Harmonization of the maps among the federal states is desirable.

Target Audience: With respect to providing and communicating results, our stakeholder group pointed out the need to identify the target group (provincial level, municipal representatives, crisis teams, response organizations, public) and the area of application (disaster prevention or disaster response) for the susceptibility map, and then to provide different levels of details. This goes hand in hand with a need for different classifications of landslides for science and practical applications.

Conclusions & Outlook

The discussions with our stakeholder group stressed the importance of improved landslide susceptibility maps and highlighted the current limitations of existing landslide data and inventories. The experts' experience has shown that underreporting and poor data quality can lead to substantial uncertainties in modelling the susceptibility. Additionally, the visualization of results plays an important role and needs to be tailored to the target audience.

The identified requirements will now be included into the development process of the gAia project. This includes the consideration of novel earth observation data from the Sentinel missions as well as the application of AI-based multi-modal data fusion methods. Furthermore, an advanced method for the modelling of landslide susceptibility maps will be developed and different visualization techniques will be explored. In the final phase of the gAia project, two stakeholder workshops will be conducted to receive feedback on the implementation of the requirements identified.

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Literature

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