Learning from Nature – Mapping of Complex Hydrological and Geomorphological Process Systems for More Realistic Modelling of Hazard-Related Maps

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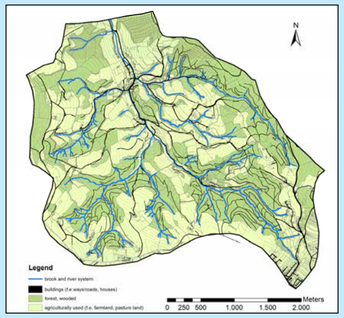
1. Introduction

Hydrological or geomorphological processes in nature are often very diverse and complex. This is partly due to the regional characteristics which vary over time and space, as well as changeable process-initiating and -controlling factors. Despite being aware of this complexity, such aspects are usually neglected in the modelling of hazard-related maps due to several reasons. But particularly when it comes to creating more realistic maps, this would be an essential component to consider.

The first important step towards solving this problem would be to collect data relating to regional conditions which vary over time and geographical location, along with indicators of complex processes. Data should be acquired promptly during and after events, and subsequently digitally combined and analysed.

2. Investigation area



In June 2009, considerable damage occurred in the residential area of Klingfurth (Lower Austria) as a result of great pre-event wetness and repeatedly heavy rainfall, leading to flooding, debris flow deposit and gravitational mass movement. One of the causes is the fact that the meso-scale watershed (16 km²) of the Klingfurth stream is characterised by adverse geological and hydrological conditions. Additionally, the river system network with its discharge concentration within the residential zone contributes considerably to flooding, particularly during excessive rainfall across the entire region, as the flood peaks from different parts of the catchment area are superposed.

3. Objectives

The main targets of the detailed geological and hydrological mapping include the investigation and documentation of

- information about the processes and the process systems and their complex spatial-temporal interactions
- local situation (geology, vegetation and land use)

Significant correlations between

- local situation
- dominant processes
- and the spatial-temporal variability of the process-induced hazard potential (e.g. bed load potential induced by mass movements and fluvial erosion)

should be deduced from this dataset.

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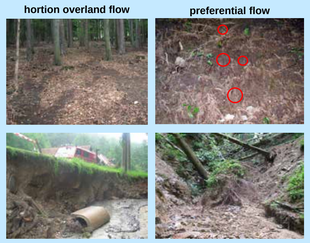
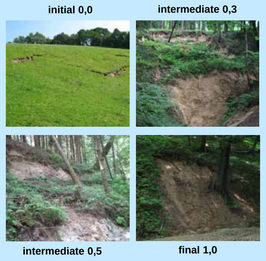
4. Issues – Processes – Definitions

Hazards and Damages

Hazard relevant processes and process systems

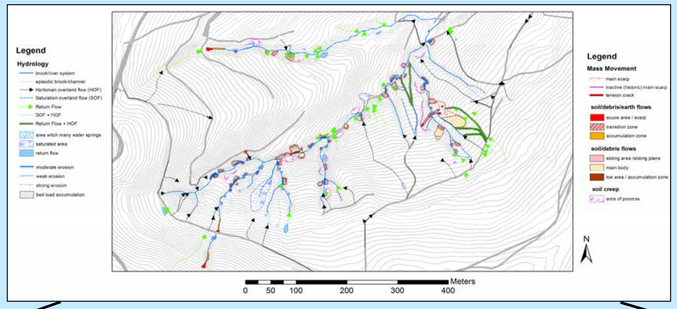


Developement stages of mass movements

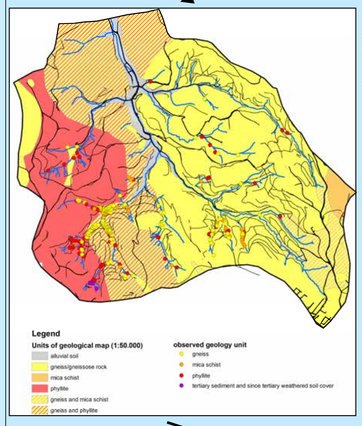


5. Mapping and Analysis

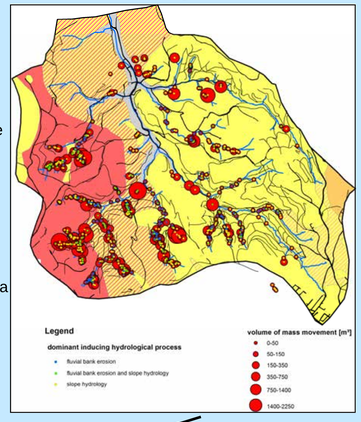
Process Map



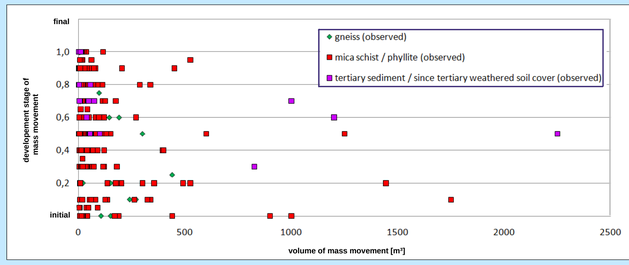
First spatial analysis results

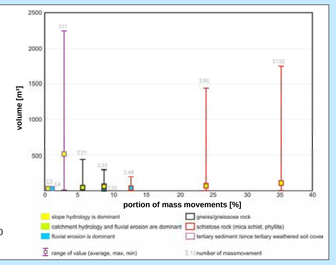


- over 600 gravitational mass movements of various type and stage
- 516 of those acted as a bed load source
- 325 mass movements had not reached the final stage yet and could thus supply bed load in the future
- Largely dimensioned (> 500 m³), particularly by slope-hydrological processes (return flow, macropore discharge, surface discharge) induced progressive mass movements exclusively occured within the range of slate rocks and tertiary coined sediment cover, which are relatively fine-grained and slip susceptible. Altogether the mass movement density and the induced bed load volume are there very large.
- Relatively small mass movements (< 500 m³) occurred in gneiss coined areas, which were released depending upon local conditions by fluvial erosion (catchment hydrology) and/or slope-hydrologic processes.
- numerous marks of surface runoff were found over the entire catchment area
- Western part of the catchment: signs of surface runoff commonly found in forests as a result of an up-hill infiltration surplus in areas of fields and pastures, or an infiltration surplus in the forest itself.
- Eastern part: signs of surface runoff are unimportant and often linked to mainly anthropogenic concentrated inputs of surface discharge.

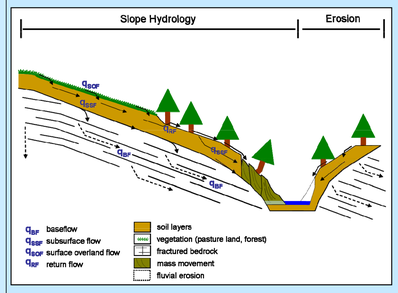


First statistical analysis results



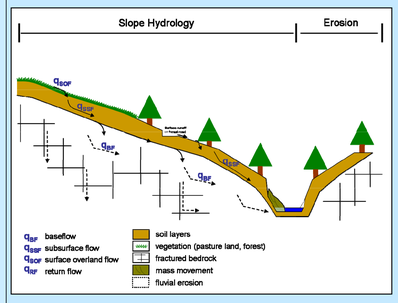


6. Process concepts for the catchment scale



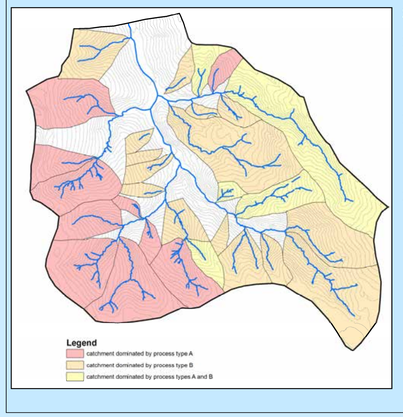
Process Type A

- process type A occurs mainly on schistose rock (mica schist, phyllite)
- very large volume of mass movements
- mass movements mainly induced by slope hydrology
- return flow causes surface runoff in forests
- mass movements on tertiary sediments show the same behaviour as movements on mica schist and phyllite. Thus they have been combined in one process type.



Process Type B

- process type B occurs mainly on gneiss rock
- rapid infiltration of surface overland flow
- very small volume of mass movements
- mass movements induced by fluvial erosion and slope hydrology



Spatial process distribution

- subcatchments in the western part of the investigation area are dominated by process type A
- subcatchments in the eastern part of the investigation area are dominated by process type B
- in the middle part the process types are mixed caused by the spatial changing of the geology

7. Conclusions and future work

Based on the acquired field knowledge, it was possible to distinguish areas of different heterogeneities/homogeneities of the dominant process chains for several micro-scale parts of the catchment area.

Subsequently, conceptual slope profiles should be derived from the detailed field data, and these should include information of the dominant and complex process systems.

This forms an essential starting point in order to be able to realistically consider relevant hazard-related processes as part of process-oriented modelling.