Suitability aero-geophysical methods for generating conceptual soil maps and their use in the modeling of process-related susceptibility maps

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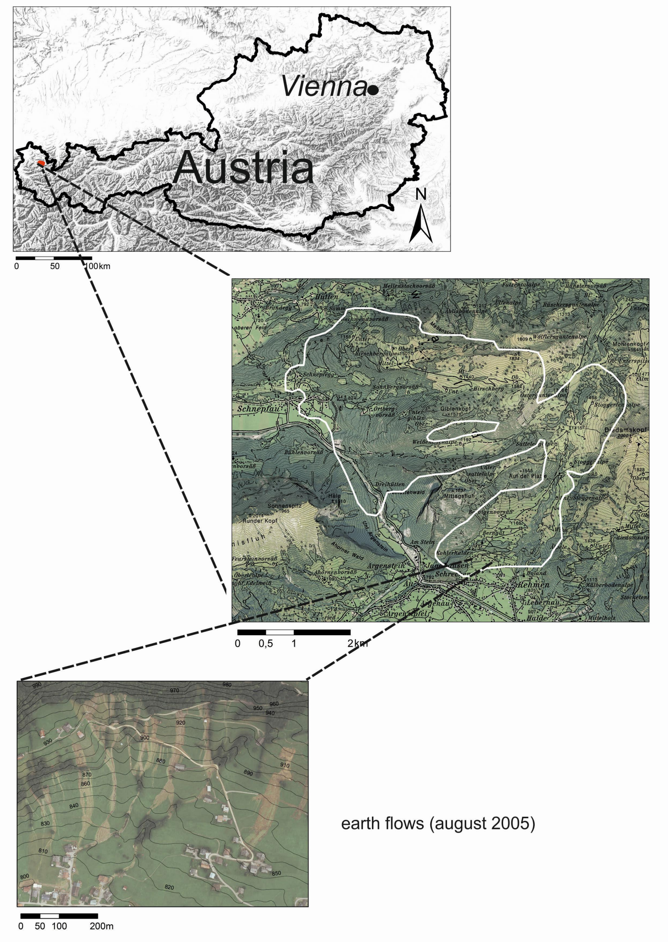
Introduction

In the past years, several times large-scale disasters occurred in Austria, which were characterized not only by flooding, but also by numerous shallow landslides and debris flows. Therefore national and regional authorities also require more objective and realistic maps with information about spatially variable susceptibility of the geosphere for hazard-relevant gravitational mass movements.There are many and various proven methods and models available to create such process-related suszeptibility maps. But numerous national and international studies show a dependence of the suitability of a method on the quality of process data and parameter maps. In this case, it is important that also maps with detailed and process-oriented information on the process-relevant geosphere will be considered.

Study area

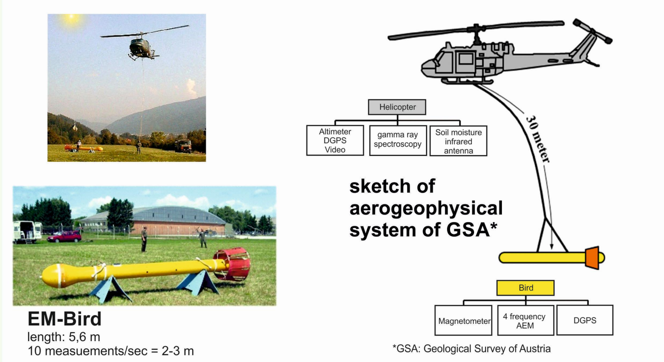


Challenges and goals

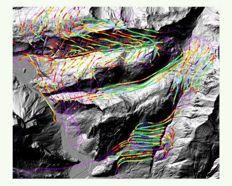
Everyone frequently face the problem, that only occasionally area-wide and process-relevant information (see flat gravitational mass movements in soil) exists. Similarly, in Austria often only soil maps for treeless areas are available. However, in almost all previous studies, randomly existing geological and geotechnical maps were used, which have been specially adapted to the issues and objectives. This is one reason why conceptual soil maps must be derived from geological maps with only hard rock information. Based on these maps, for example, neighboring regions with different geological composition and process-relevant physical properties are razor sharp delineated, which in nature is rarely the case. In order to obtain more realistic information about the spatial variability of the process-relevant geosphere (soil cover) and its physical soil properties, we have used aerogeophysical methods (electromagnetic, radiometric) and interpreted the results.

Methods

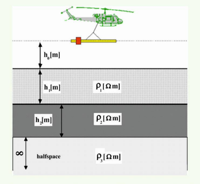
aerogeophysics



Airborne radiometric methods are used to determine the natural radioactivity (gamma radiation) of near-surface rocks and soils using a gamma ray spectrometer installed in an aircraft. The measurements reveal information on rock and soil properties, particularly their contents of natural radionuclides (Potassium, Uranium and Thorium). They occur in various concentrations in the minerals of crustal rocks, as well as in their weathering products (http://www.bgr.bund.de/en.html).
With the electromagnetic measurements, a layered earth model of electrical resitivities for geological interpretation can be constructed.



flight lines in survey area

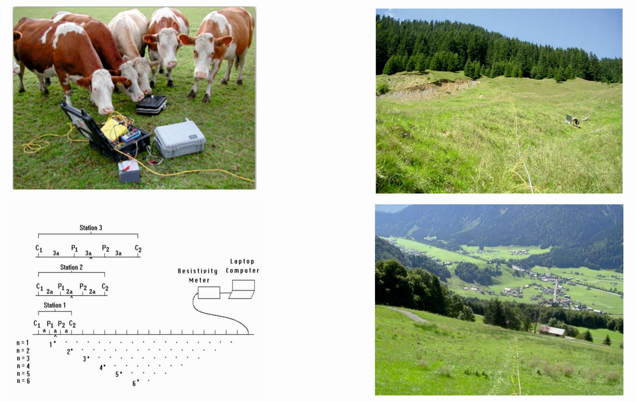


layered earth model

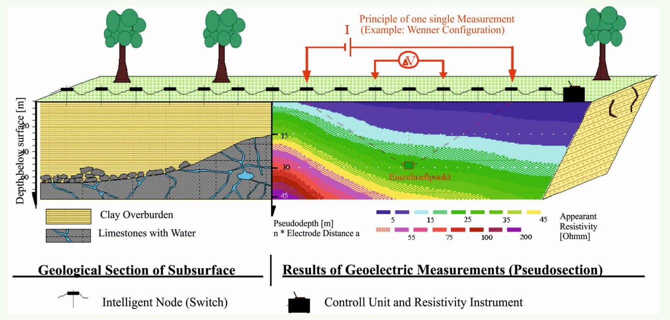
METHOD	distance in flight direction [m] at 120km/h	covered surface area at 80m flight altitude
electromagnetics	2-3 m	20 m
radiometrics	30 m	30 m

data coverage

terrestrial geophysics

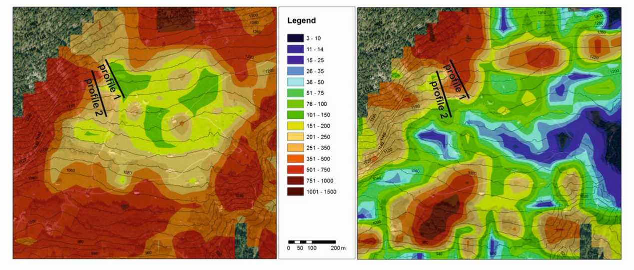


Different materials have characteristic electr. resistivity, ranging from very low (clay) to very high (hard rock), depending also from water content. Electrical resistivity tomography (ERT) is a geophysical technique for imaging sub-surface structures from electrical resistivity measurements made at the surface.
With the combination of different 4 point electrode configurations and e.g. 100 electrodes 4000 data points can be measured.
The outcome is a 2-D depth section of electr. resistivities.
This can be interpreted in geological terms.

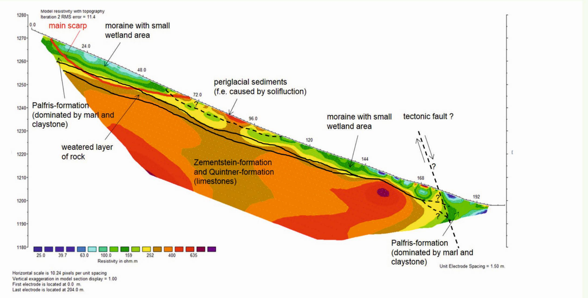


Measurement results

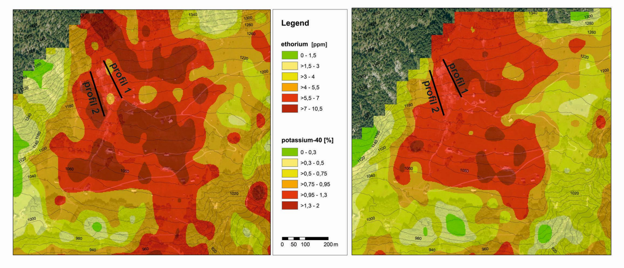
spatial variability of the electrical resistivity with electromagnetics [Ohmm]



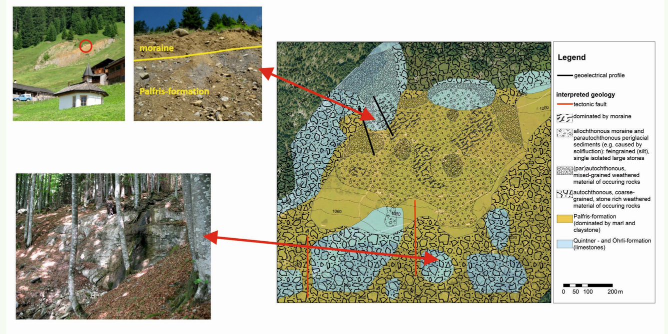
variability of geoelectric resistivity [Ohmm] and the geological interpretation - profile 1-



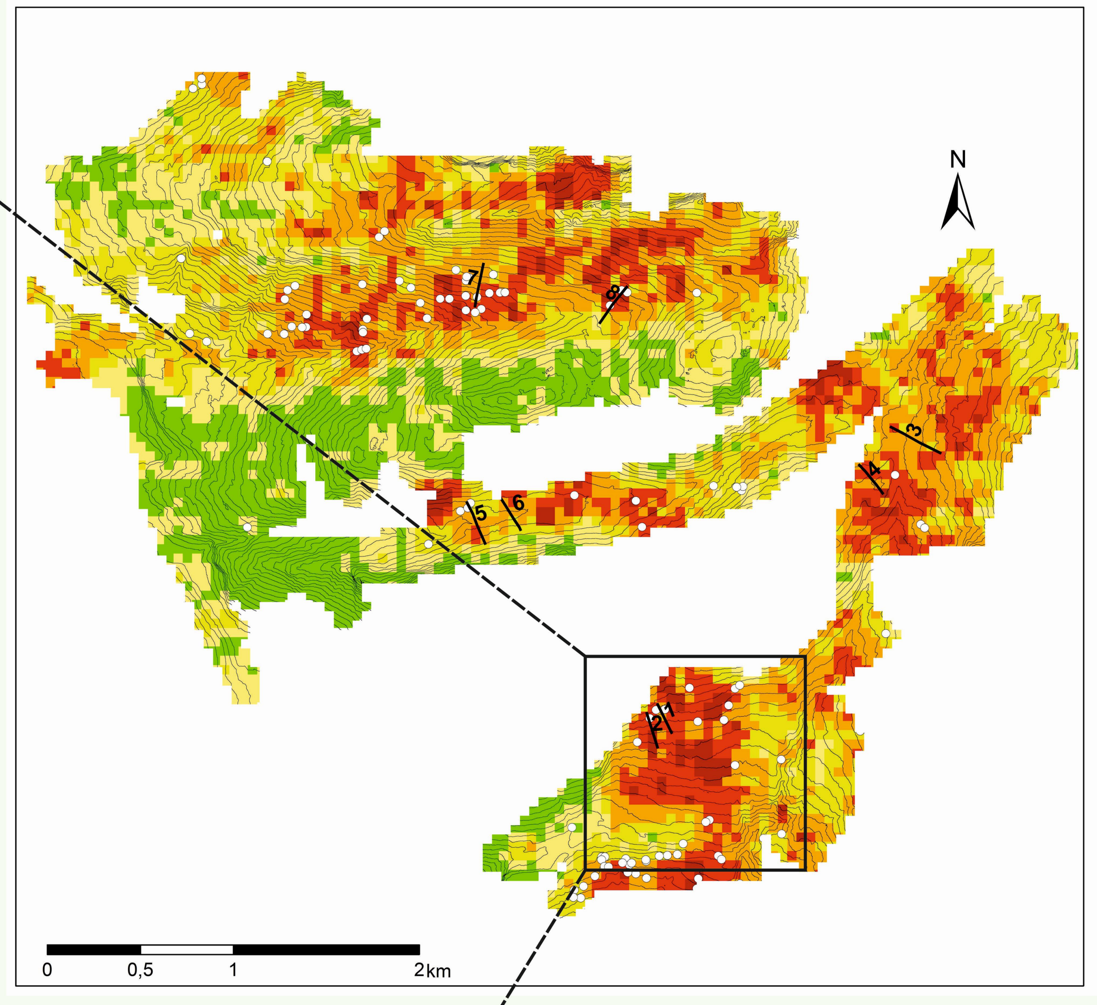
spatial variability of radiometric parameters



geological interpretation and plausibility check



Interpretation of the data in soil classes and the resulting substrate concept map (e.g. eThorium)



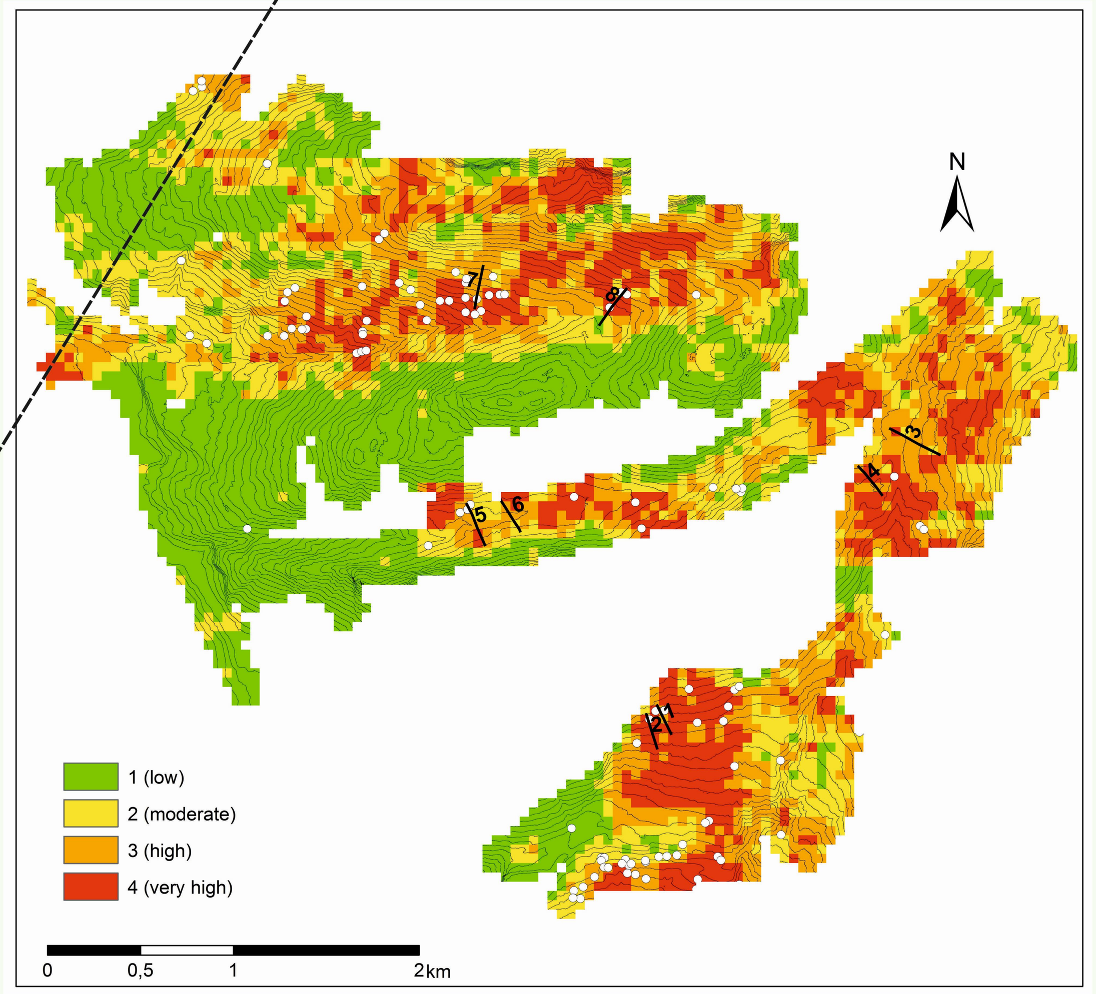
Legend

- ○ gravitational mass movement

substrate {eThorium [%]}

- supported by rough-grained, gravel-rich soil/sediment, very high portion of stones, small or very small portion of fine-grained soil/sediment (silty) and partly loamy (sandy slope cover) {0 - 1,5}
- supported by rough-grained, sandy-gravelly soil/sediment, moderately portion of stones, moderately of fine-grained soil/sediment (silty) and partly or somewhat loamy (silty slope cover) {>1,5 - 3}
- supported by rough-grained, sandy-gravelly soil/sediment, moderately portion of stones, high portion of fine-grained soil/sediment (strongly silty) and partly or somewhat loamy (silty sand) {>3 - 4,5}
- supported by fine-grained silty soil, sandy, small portion of stones and moderate loamy (sandy loam) {>4,5 - 6}
- supported by fine-grained, silty-claylike soil/sediment, small portion of stones and strongly loamy (from clay-rich silt to silt) {>6 - 7,5}
- supported by fine-grained silty-claylike soil/sediment, small portion of stones and very strongly loamy (from silty clay to clay) {>7,5 - 10,5}

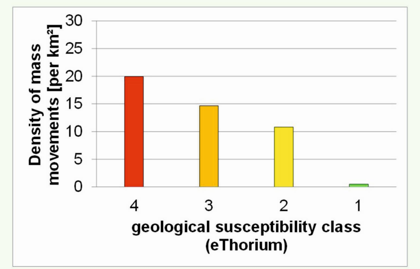
Deriving of susceptibility map (e.g. eThorium)



reclassification of soil classes

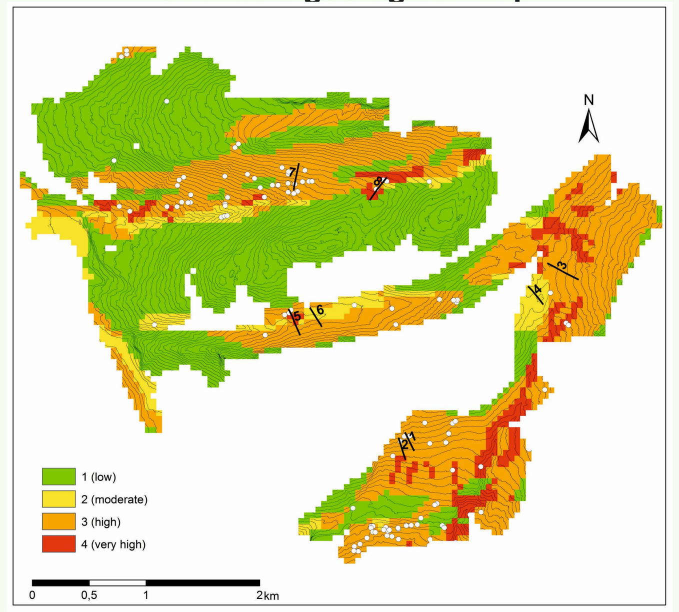
soil type/class	Kf [-]	SOF [-]	ϕ`[°]	slide susc. [-]
11	4	1	30	1
12	3	2	30	1
13	2	2	30	1
14	2	3	25	2
23	2	3	20	3
24	1	4	15	4
25	1	4	15	4

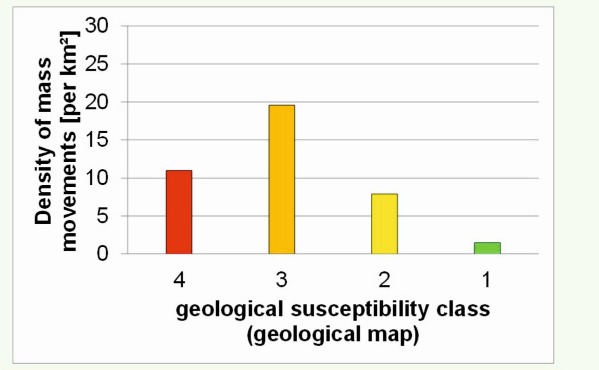
validation

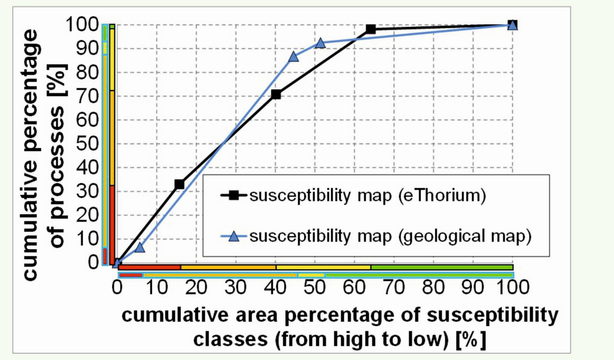


Comparative Study

Susceptibility map, based on the available geological map







Method after Chung & Fabbri (2003)

Conclusion and further work

Previous study shows that,

⇒ especially with radiometric measurements, the two-dimensional spatial variability of the nature of the process-relevant soil, close to the surface can be determined.

⇒ in addition, the electromagnetic measurements are more important to obtain three-dimensional information of the deeper geological conditions and to improve the area specific geological knowledge and understanding. The plausibilty check of these measurements is done with terrestrial geoelectrical measurements.

⇒ so both aspects, radiometric and electromagnetic measurements, are important.

⇒ the geophysical based parameter maps have been well validated by the existing process data using a variety of methods. In contrast, only moderate validation results were obtained for the parameter map, which is based on the geological map.

In the future, we need to check and improve this cocktail of methods in several study areas of different landscapes. We also want to integrate the so-obtained geology-based susceptibility maps (based on thorium, potassium and other measured parameters) together with other important parameter maps (e.g. slope, topological slope classification) in modeling to get complex well-founded susceptibility maps for shallow soil slips and earth flows.

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literature:

CHUNG, C. J., FABBRI, A.G. (2003): Validation of spatial prediction models for landslide hazard mapping, in: Natural Hazards, 30, S. 451-472.

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