EVALUATION OF DEBRIS FLOW

SUSCEPTIBILITY MAPS IN A REGIONAL SCALE

AN ATTEPT TO CONVERT A METHOD FROM A LOCAL SCALE TO A REGIONAL SCALE

Overview about susceptibility maps in Bavaria:

Since 2008 evaluation of landslide susceptibility maps in alpine areas of Bavaria

- **Maps are made for to give a first overview about the geological dangers**

   → regional scale between 1:10.000 and 1:25.000
   → not as precise as in a local scale

- **No information about the hazard and risk**
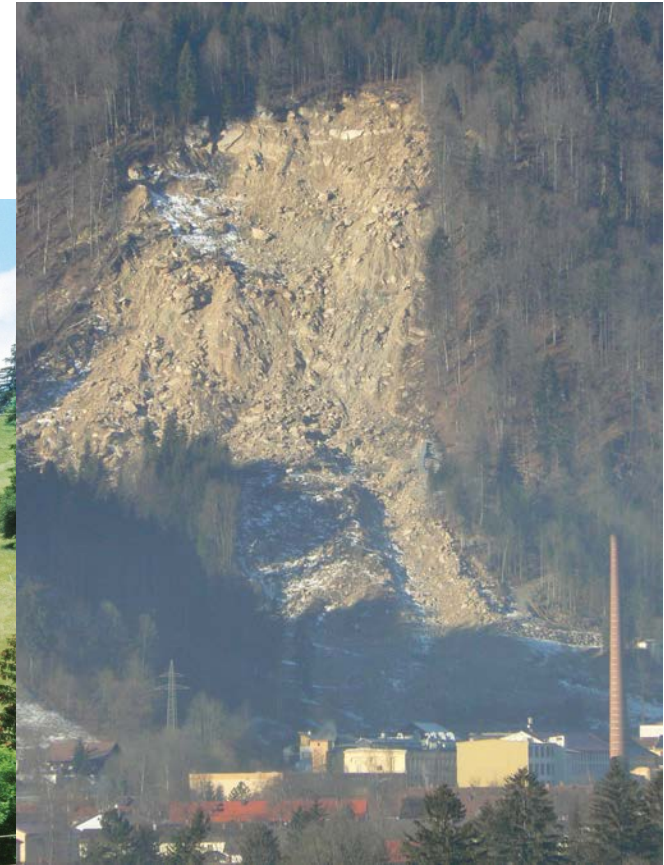
   → no intensity, no probability

First rough information about conflicting interests in land use!

Overview about susceptibility maps in Bavaria:

shallow landslides

rock fall

deep seated landslides

what's up with the susceptibility maps for debris flows ??
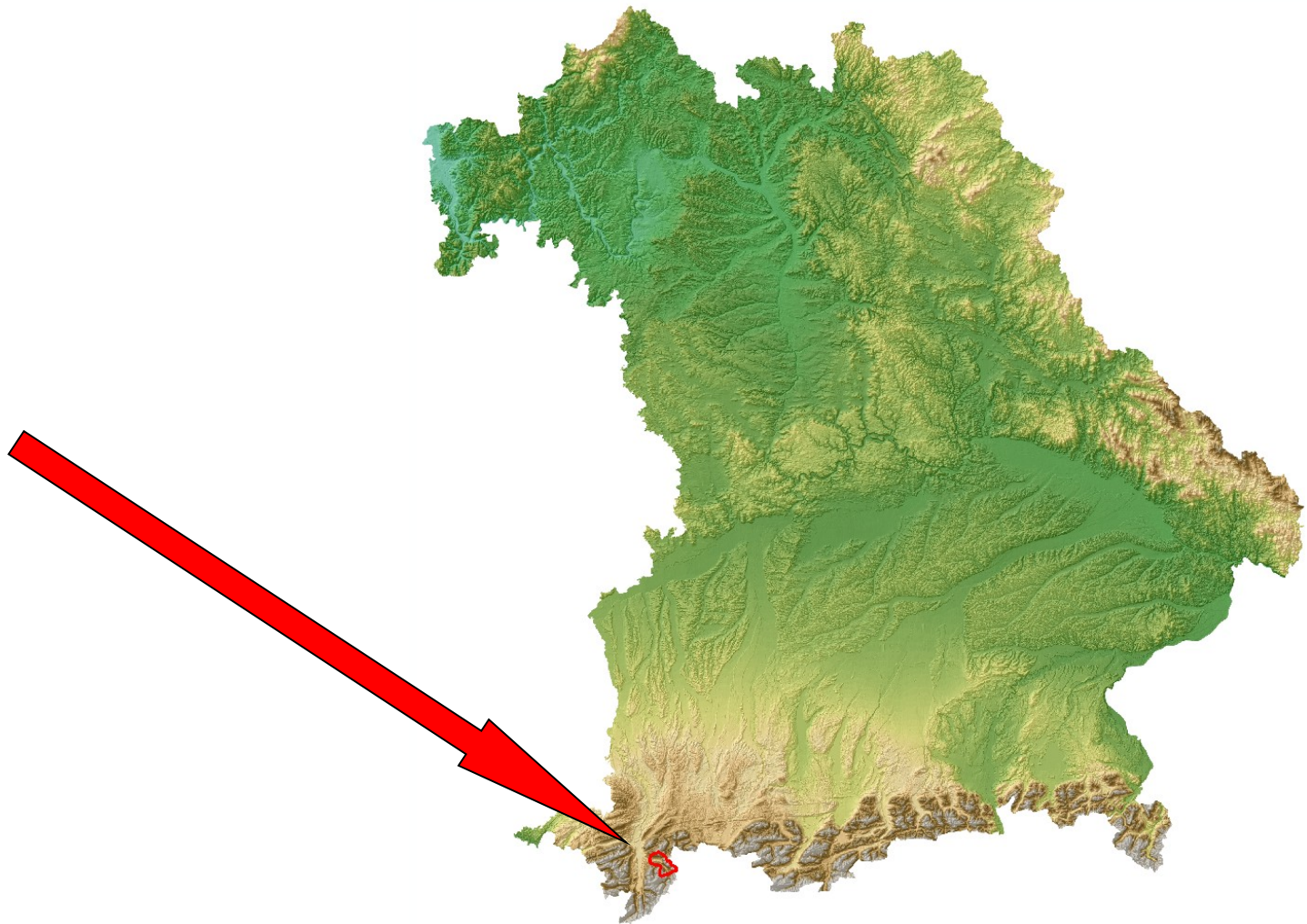
What's up with the susceptibility maps for debris flows ??

Project: Debris Flow susceptibility map (regional scale)

Project area:

Project: Debris Flow susceptibility map (regional scale)
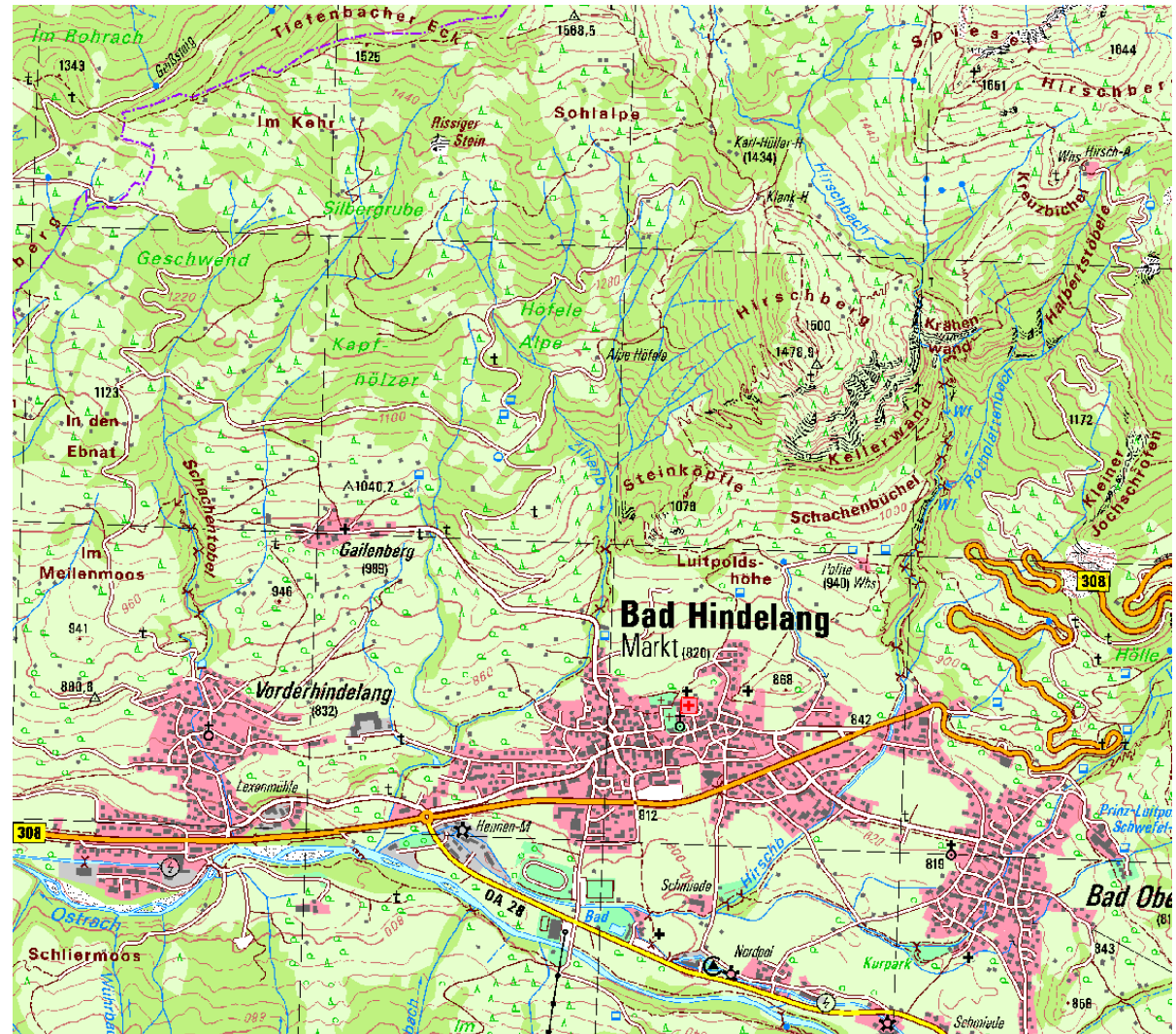
Project area:

Allgäu around

Bad Hindelang

- 52 km²
- 42 different water-
  sheds
- 140 km torrents
- 20 km torrents with protection measures

Project: Debris Flow susceptibility map (regional scale)

Data availability:

Topographic data

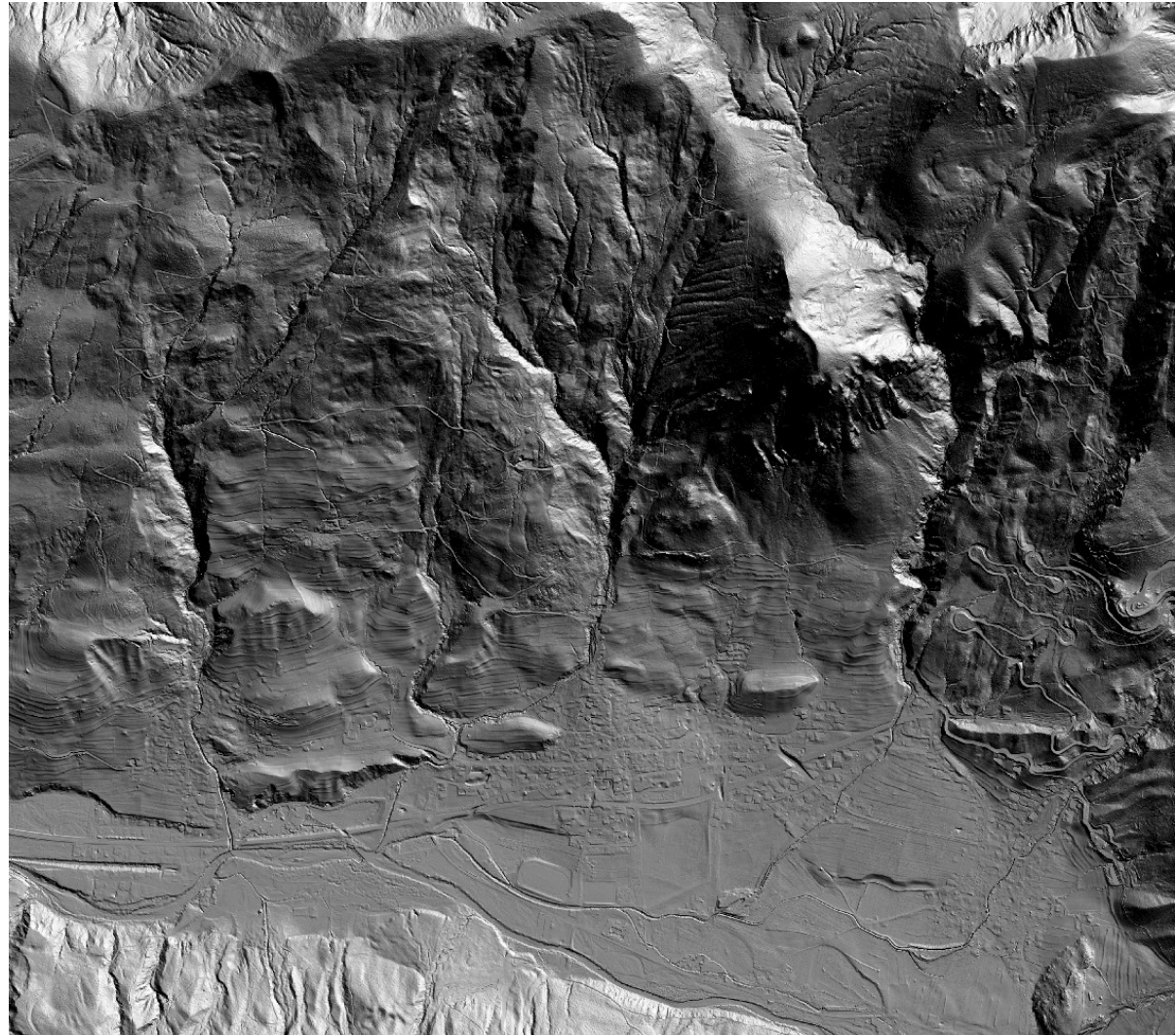## Project: Debris Flow susceptibility map (regional scale)
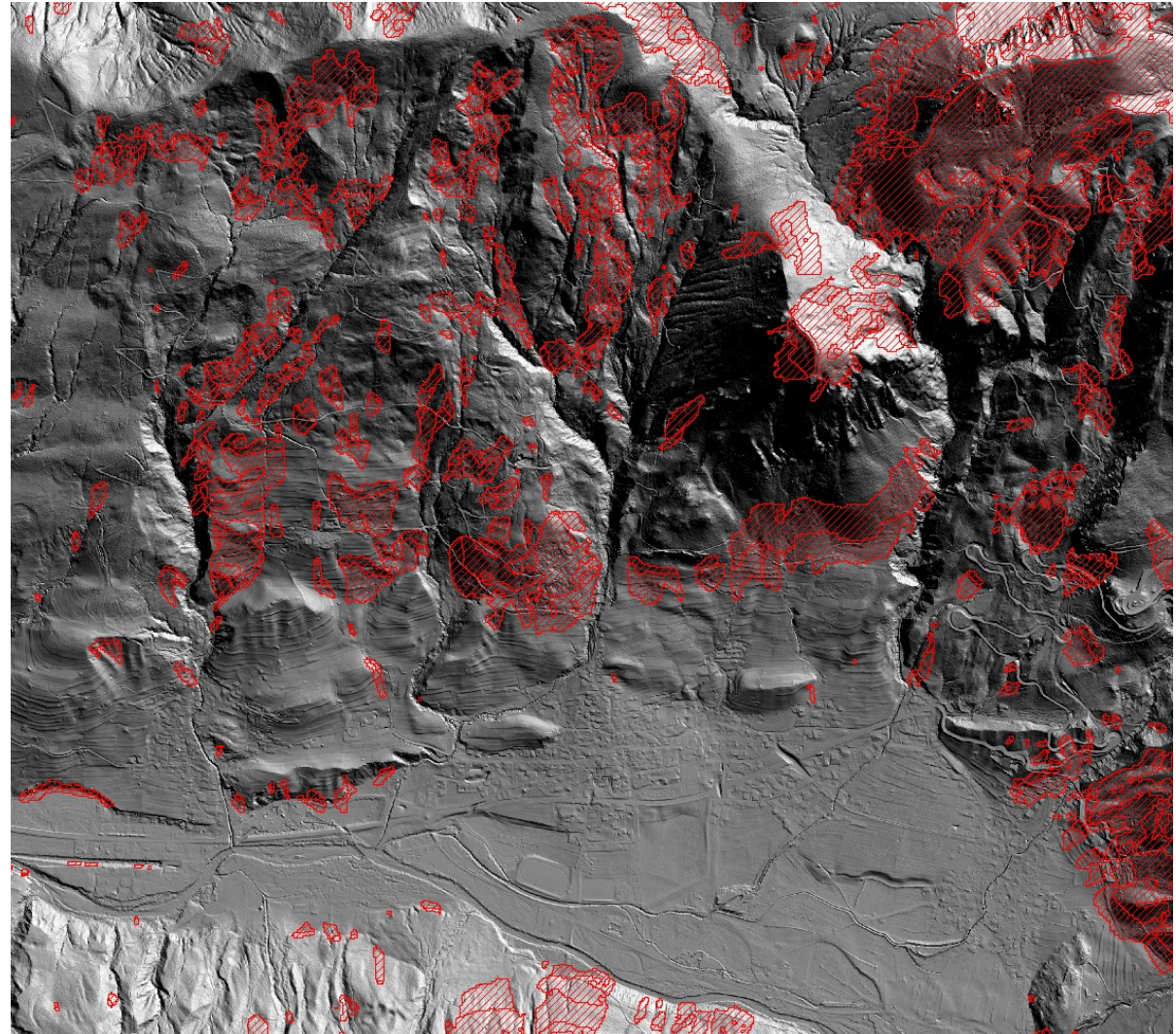
Data availability:

Areal photos

Project: Debris Flow susceptibility map (regional scale)

Data availability:

Laserscan DTM

1m resolution

Project: Debris Flow susceptibility map (regional scale)

Data availability:

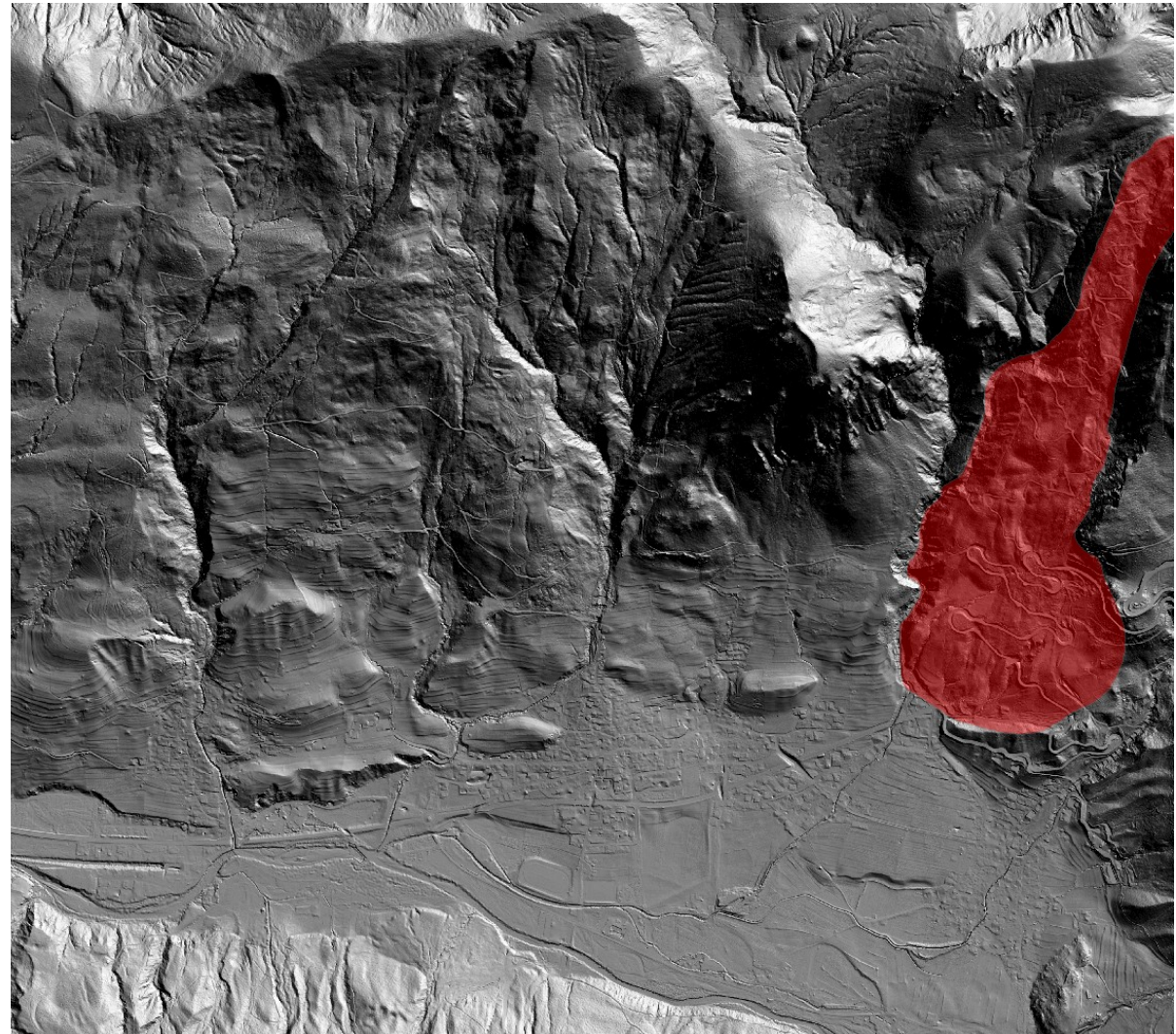Susceptibility map

Shallow landslides

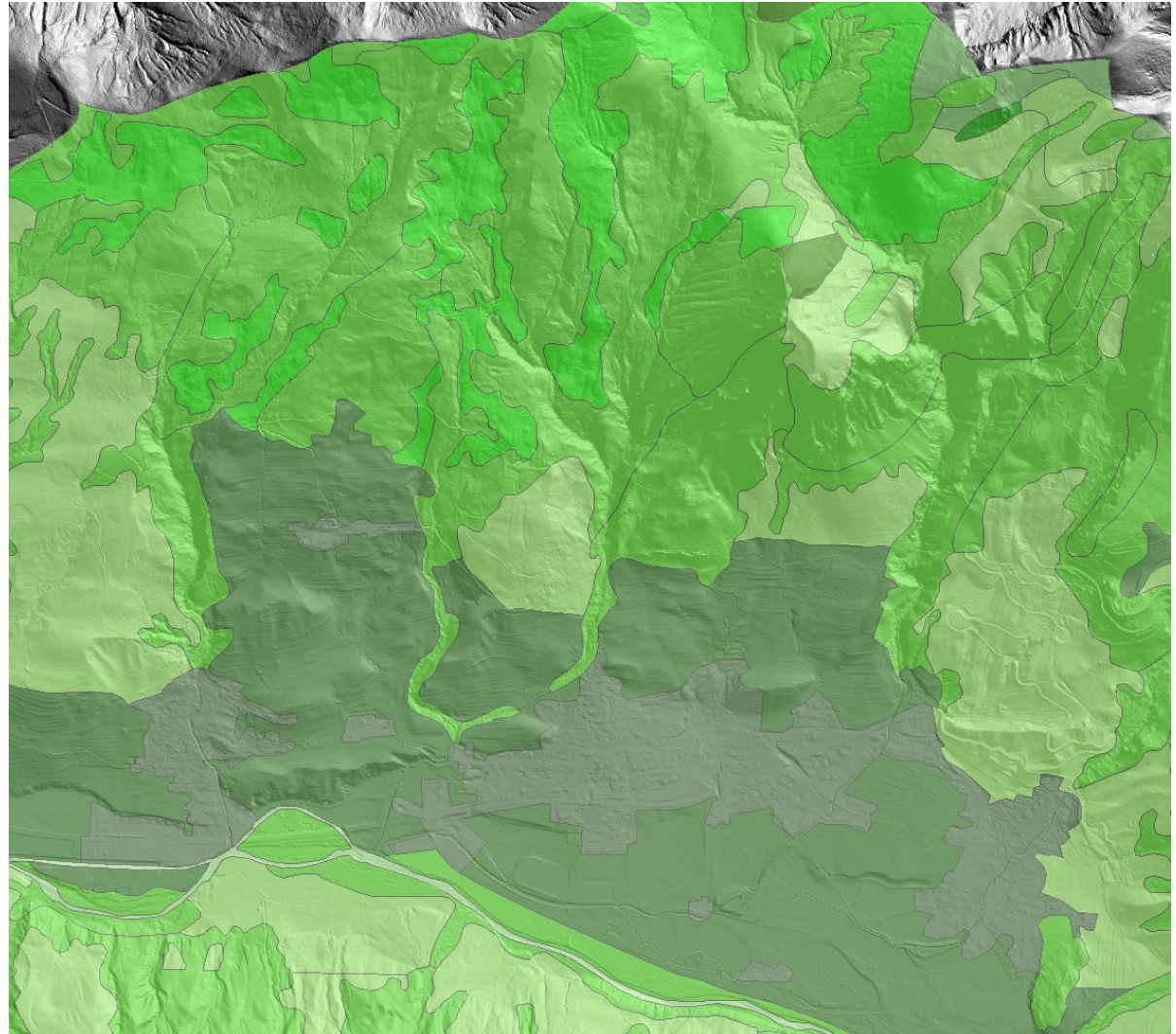## Project: Debris Flow susceptibility map (regional scale)

Data availability:

Susceptibility map

Deep seated landslides

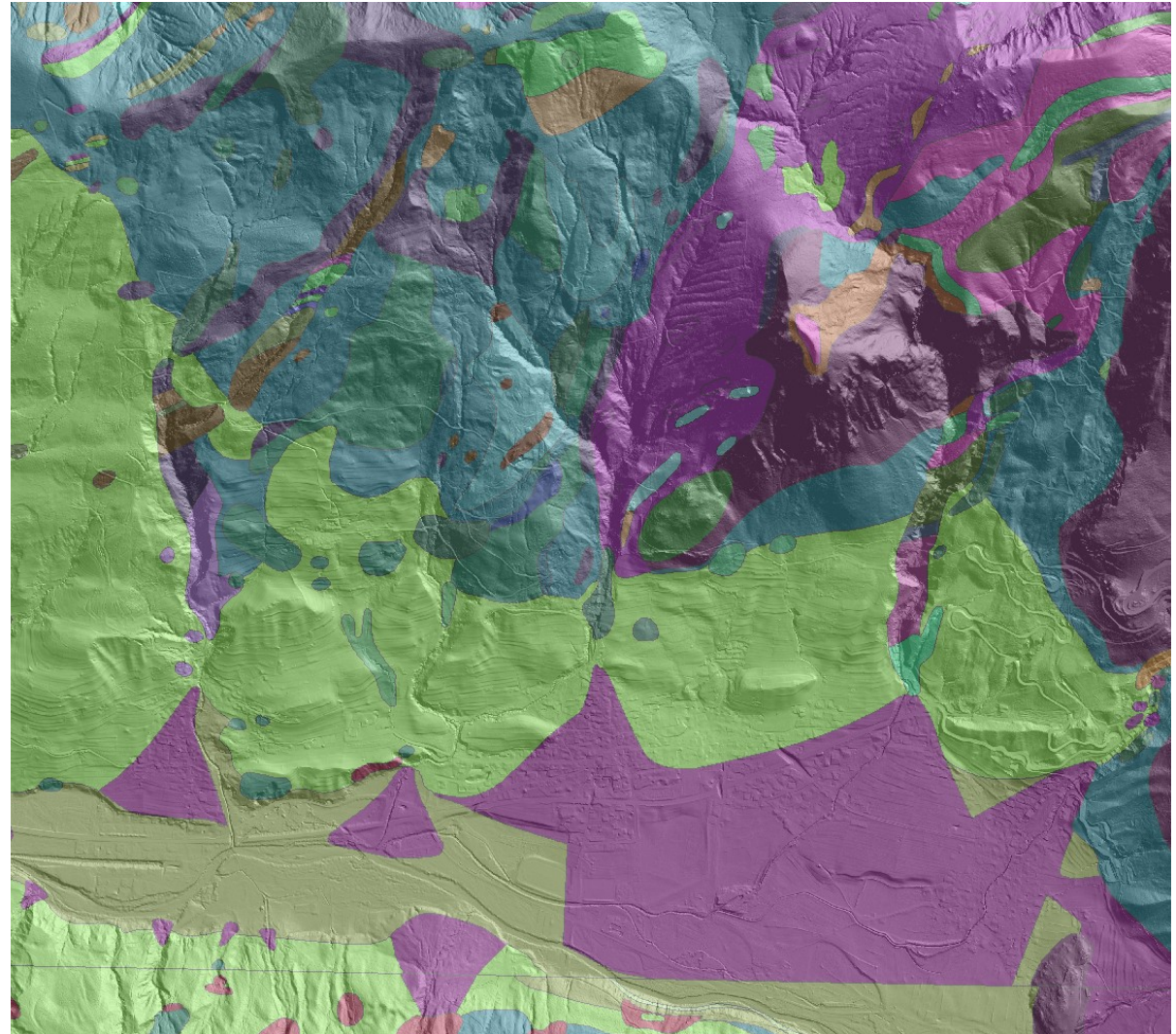# Project: Debris Flow susceptibility map (regional scale)

Data availability:

Land use and

Vegetation

Project: Debris Flow susceptibility map (regional scale)

Data availability:

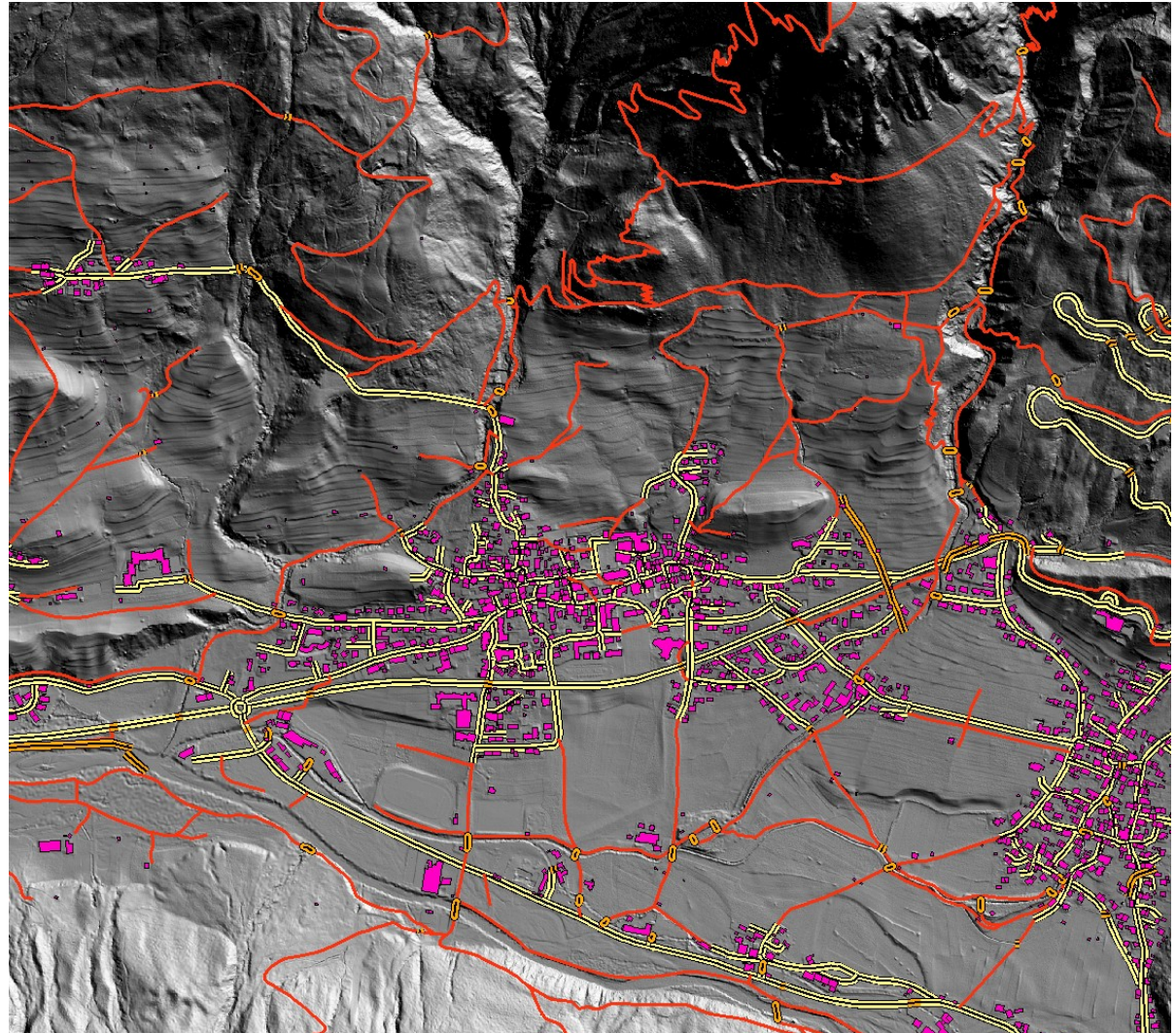Geological map and information about the weathering products:

Friction angle

Permeability

Erosion behavior

Project: Debris Flow susceptibility map (regional scale)
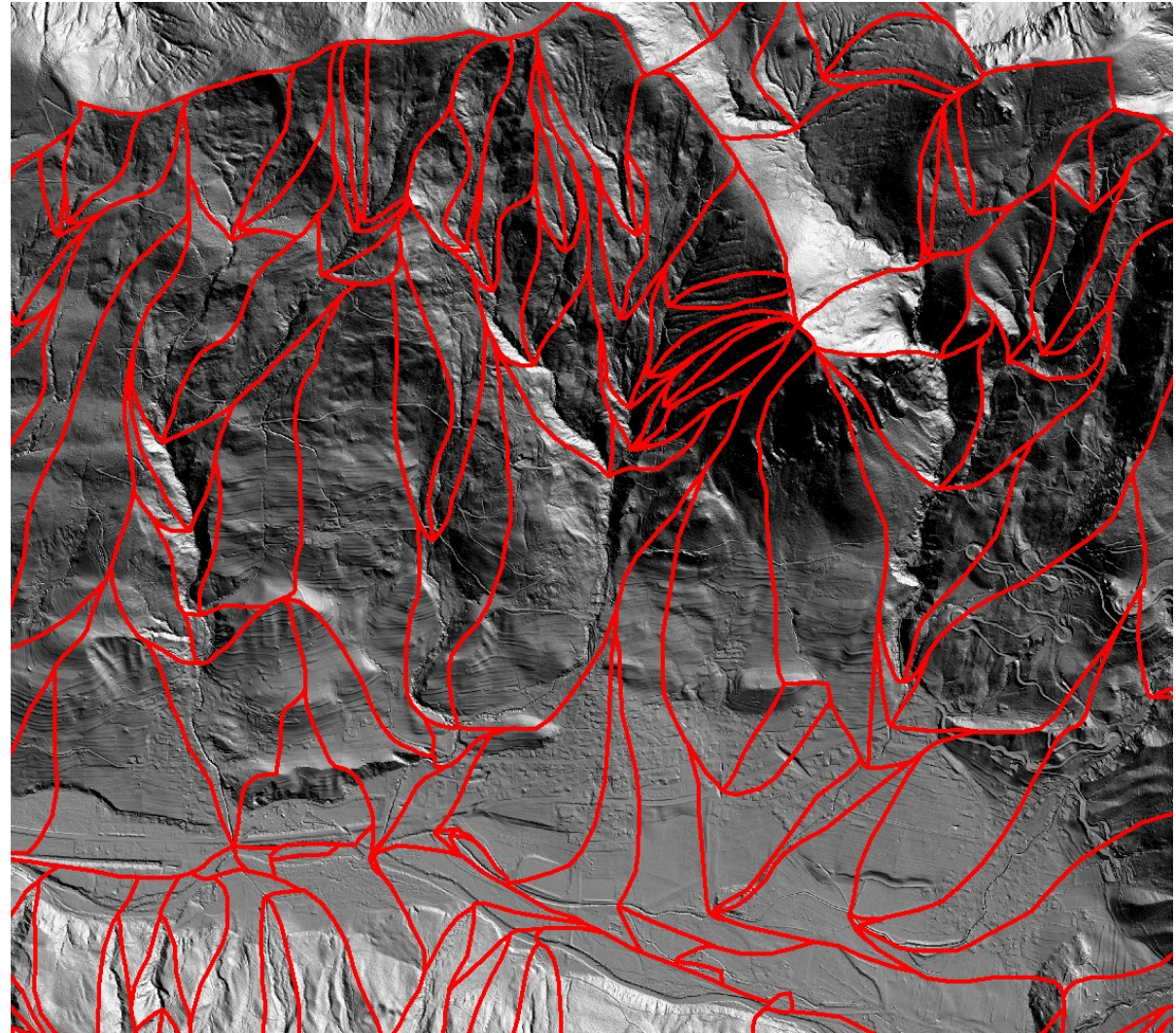
Data availability:

- Construction
- Roads
- Small ways
- Bridges
- Water ducts

Project: Debris Flow susceptibility map (regional scale)
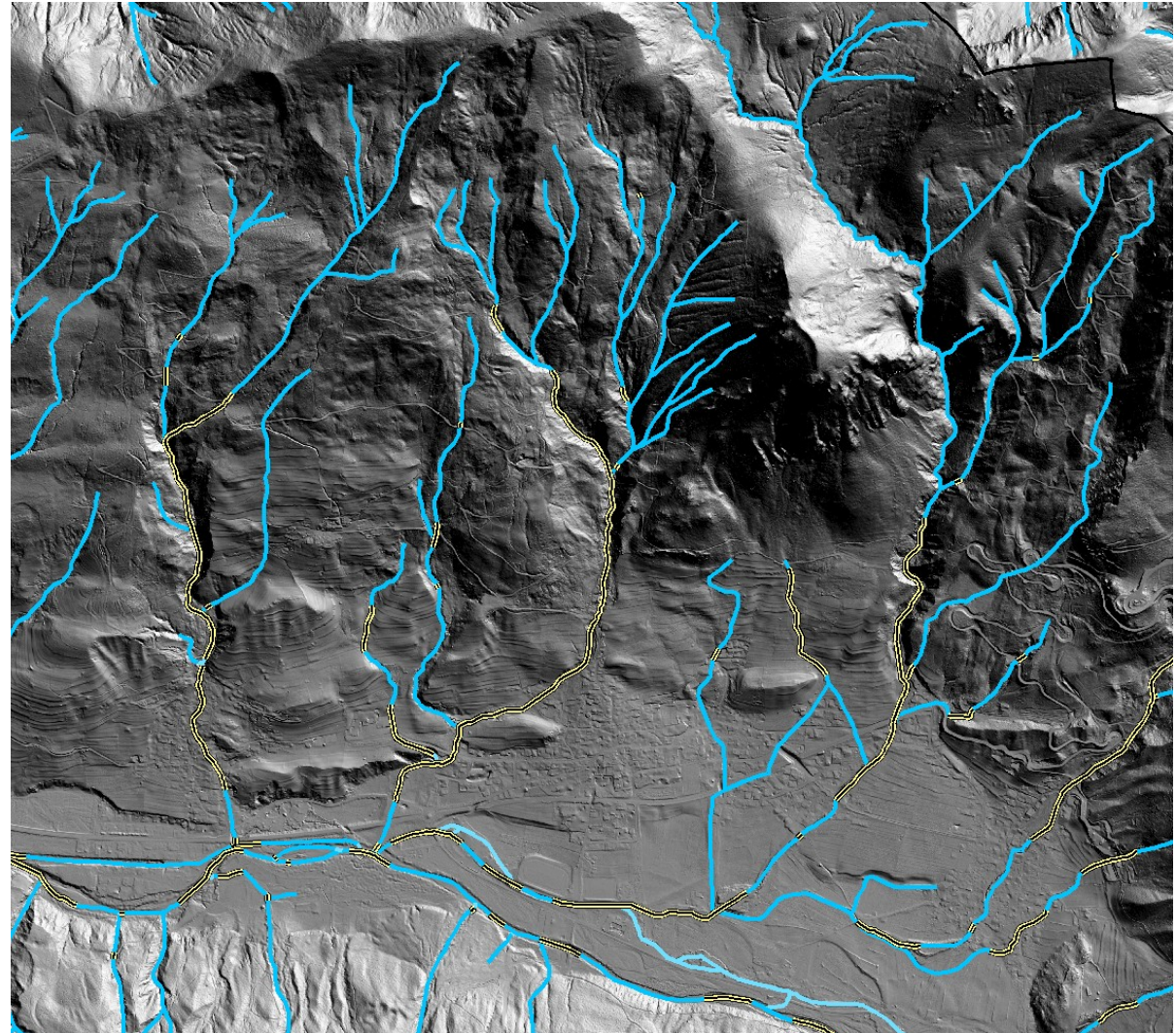
Data availability:

Watersheds

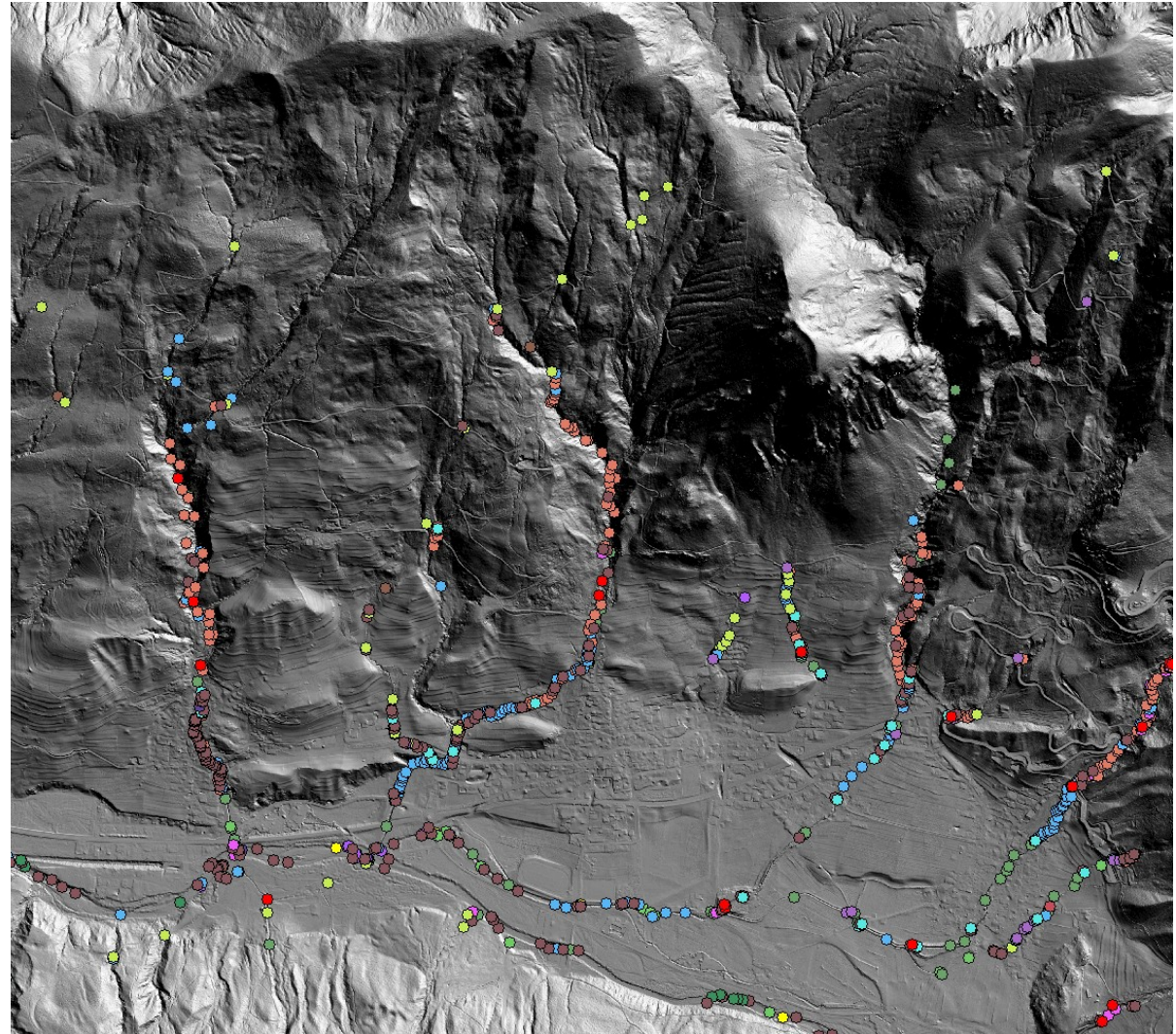## Project: Debris Flow susceptibility map (regional scale)

Data availability:

- Torrents

- Torrent parts with protection measures

Project: Debris Flow susceptibility map (regional scale)

Data availability:

Check dams and

detailed Information

about

protection measures

All the data are available area wide in the whole Bavarian Alps

All the data are available area wide in the whole Bavarian Alps

but how can we make susceptibility maps for

debris flows out of this data?

RAMMS – <u>R</u>apid <u>M</u>ass <u>M</u>ovement<u>s</u>

RAMMS:

is a 2-D debris flow simulation program and was developed by the *Swiss Federal Institute for Forest, Snow and Landscape Research (WSL).*

Model basis:

Friction model of Voellmy-Salm.

**Parameters**, which are essential for the behaviour of debris flows, are included in the model:

• Turbulent friction
• Dry friction
• Density
• Flow pressure

Additionally to the Voellmy-Salm - Model important continuum mechanical approaches have been integrated in RAMMS. In general the main equations are based on the conservation of momentum and conservation of mass.
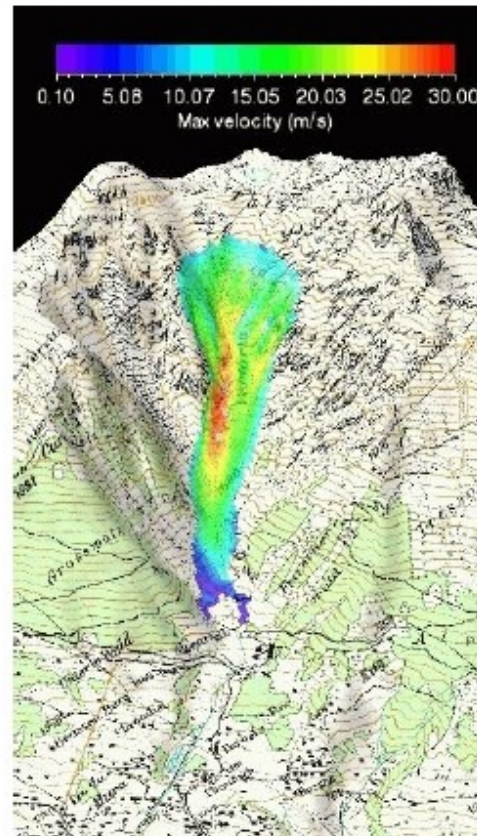
RAMMS – <u>R</u>apid <u>M</u>ass <u>M</u>ovements
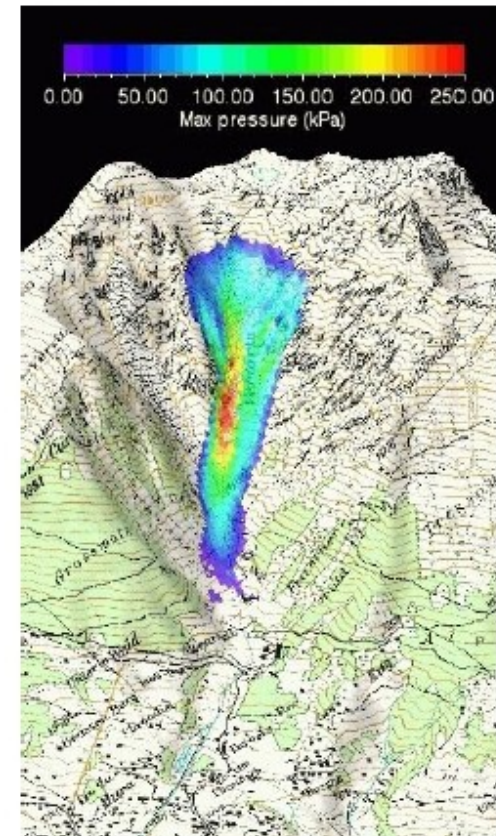
Results of a RAMMS-simulation are:
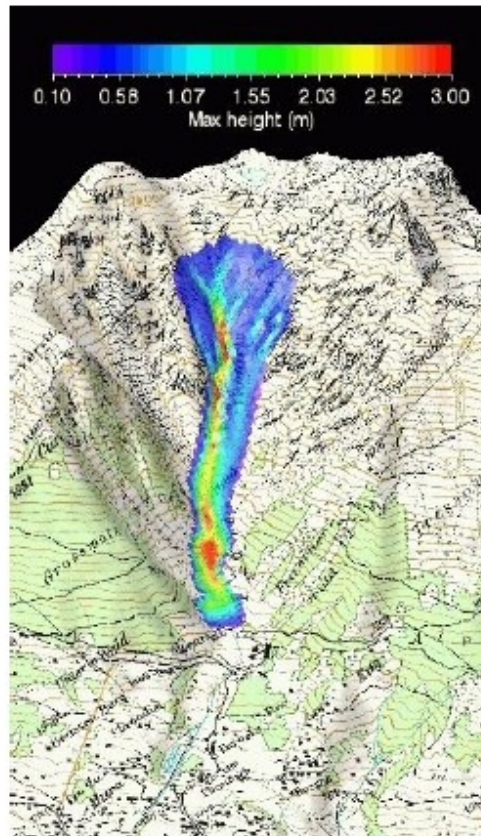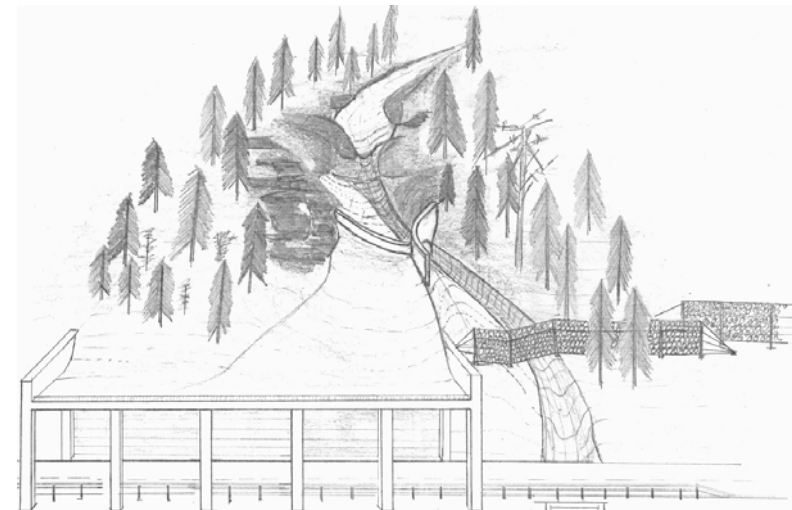
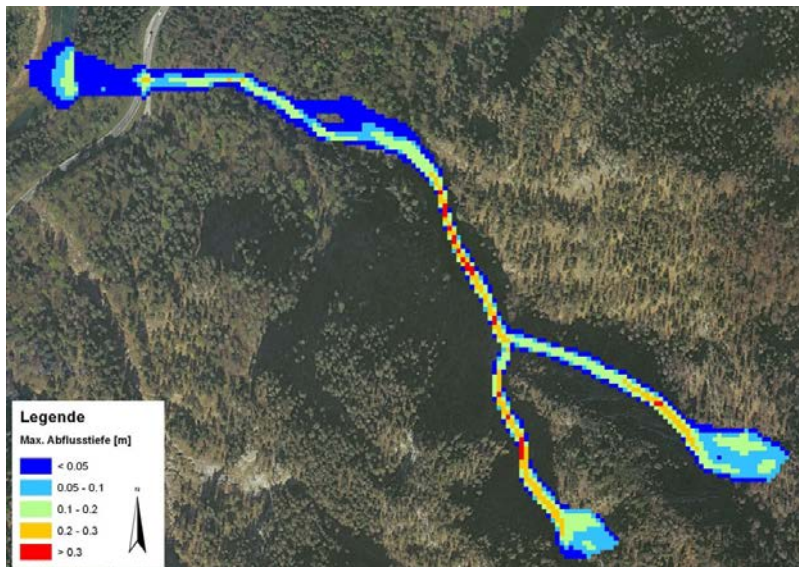| Maximum height	Maximum velocity	Maximum pressure

RAMMS normally is used for the local scale to plan protection measures

for this work always detailed field work is necessary

Project: Debris Flow susceptibility map (regional scale)

The aim is to develop a method for the regional scale (1:25.000) which is based on already existing data available in the *Bavarian Environment Agency*, so that no further field investigations had to be necessary.

Additionally the method should afford a very economic and rapid way to assemble area-wide susceptibility maps.

THE DISPOSITION MODEL

In debris flow processes exists a relationship between the slope angle of the debris flow initiation site and the torrential catchment area above this site.

$$J = 0,32 * EG -0,2$$

with *J* as critical slope angle [-] and *EG* as the size of the torrential catchment above the debris flow initiation site [km²].

by Zimmermann et al. (1997)

THE DISPOSITION MODEL (channel process)
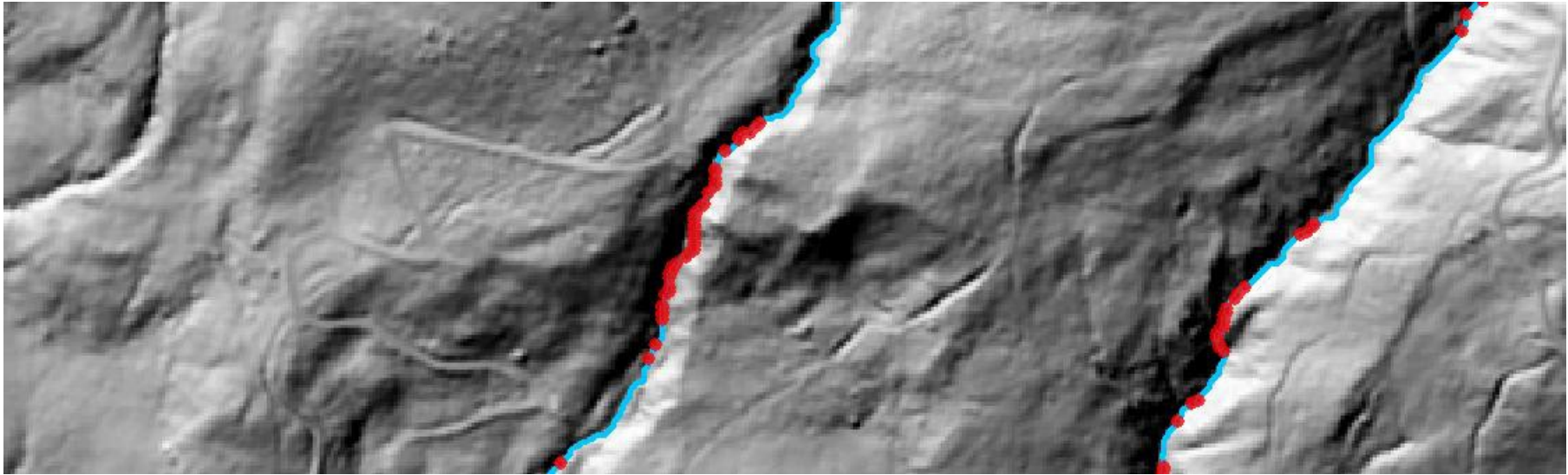
Finding initiation sites for debris flows with GIS:

• the critical slope angles are calculated for all torrent raster cells.

• the calculated critical slope angle is compared with the channel slope angle and those raster cells are selected as potential debris flow initiation site, were the channel slope angle is greater than the calculated critical slope angle.
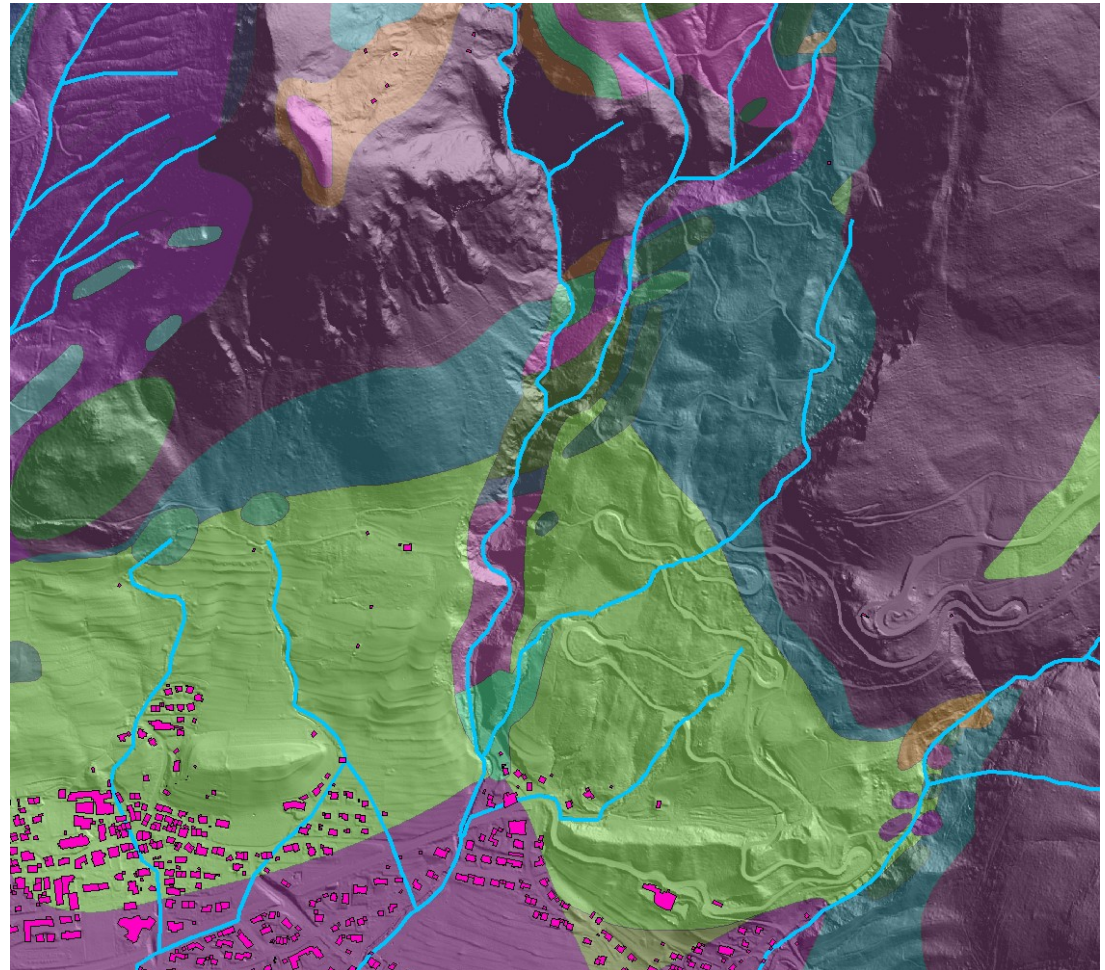
For those watersheds were raster cells achieve this criteria a simulation is carried out

THE DISPOSITION MODEL

Based on the
• geological maps and
  maps of the vegetation

for every selected raster cell in the channel a cubature of loose material can be allocated.
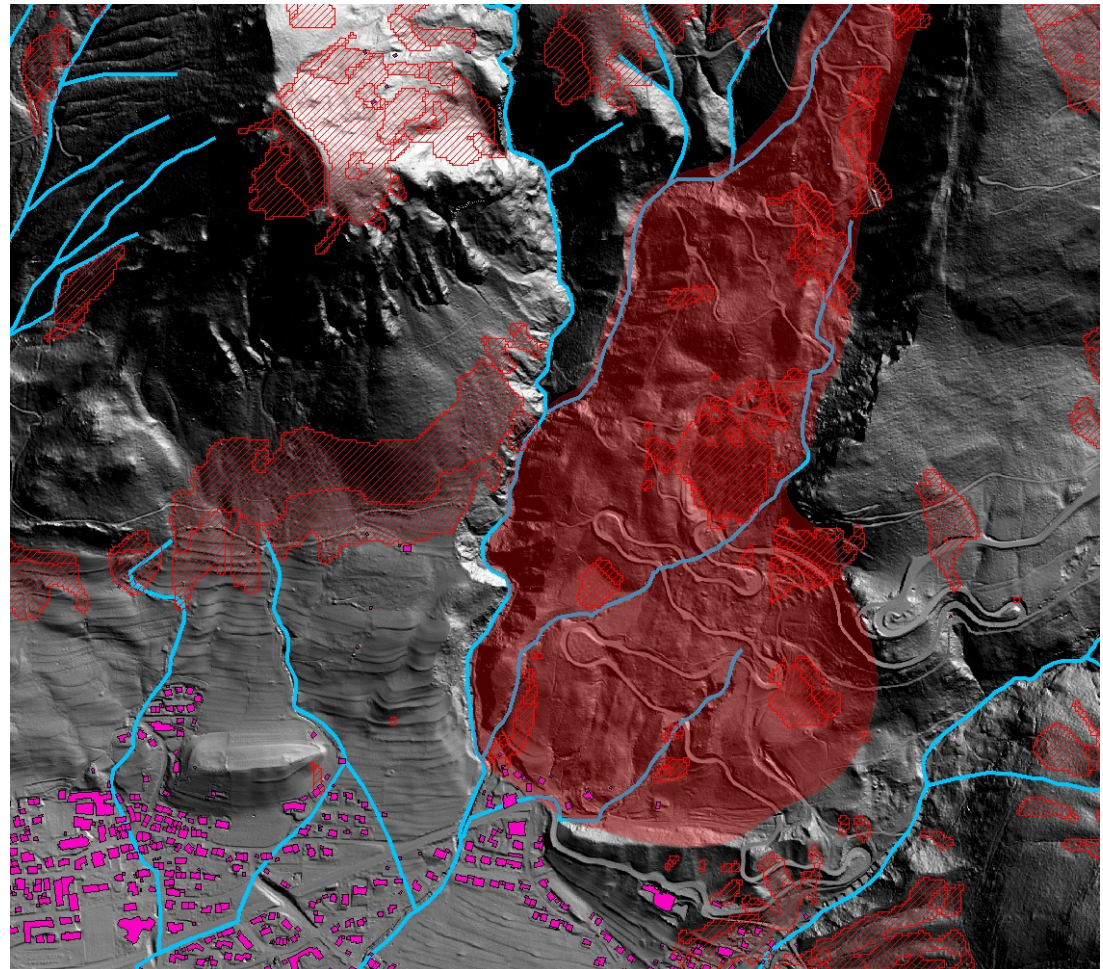
THE DISPOSITION MODEL

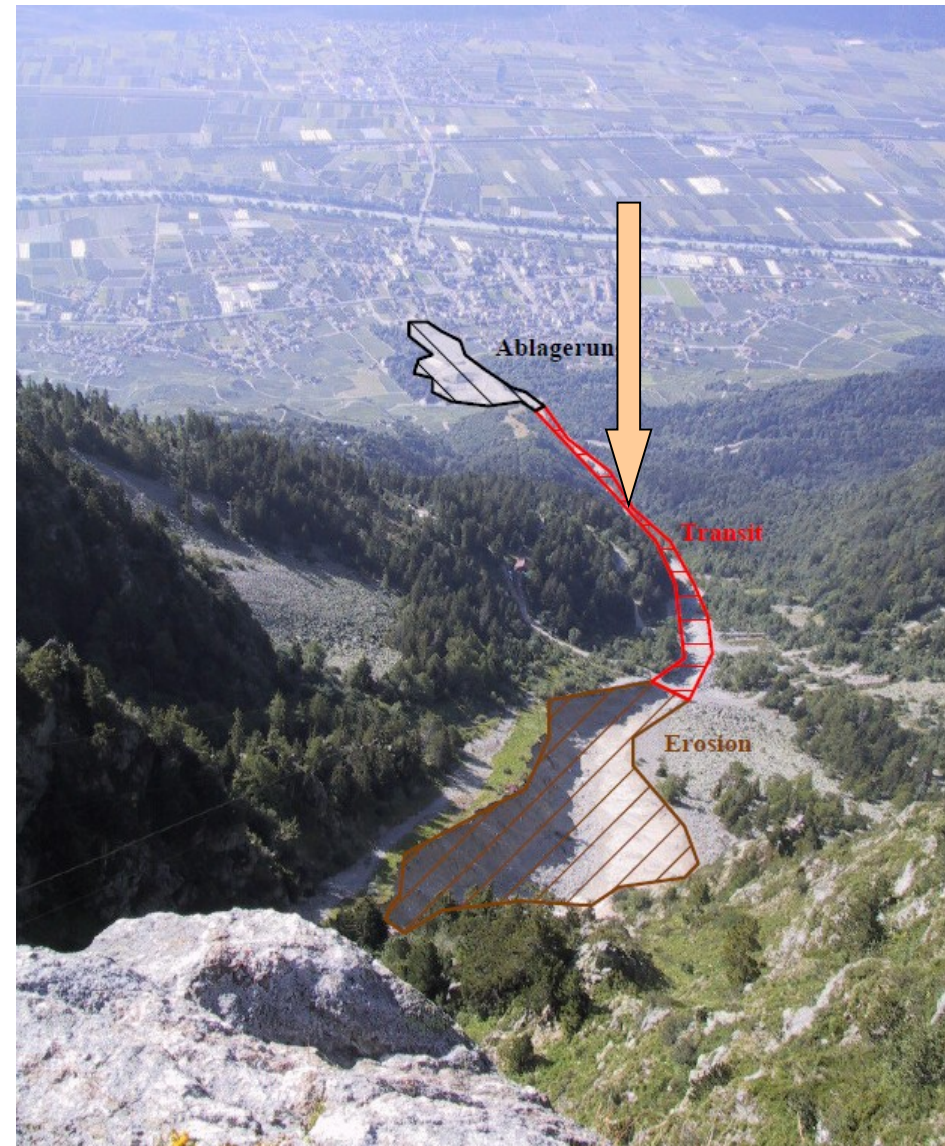Based on the

• the landslide susceptibility
  maps

for every selected raster cell
a cubature of loose material
from the neighboring slope
can be allocated.
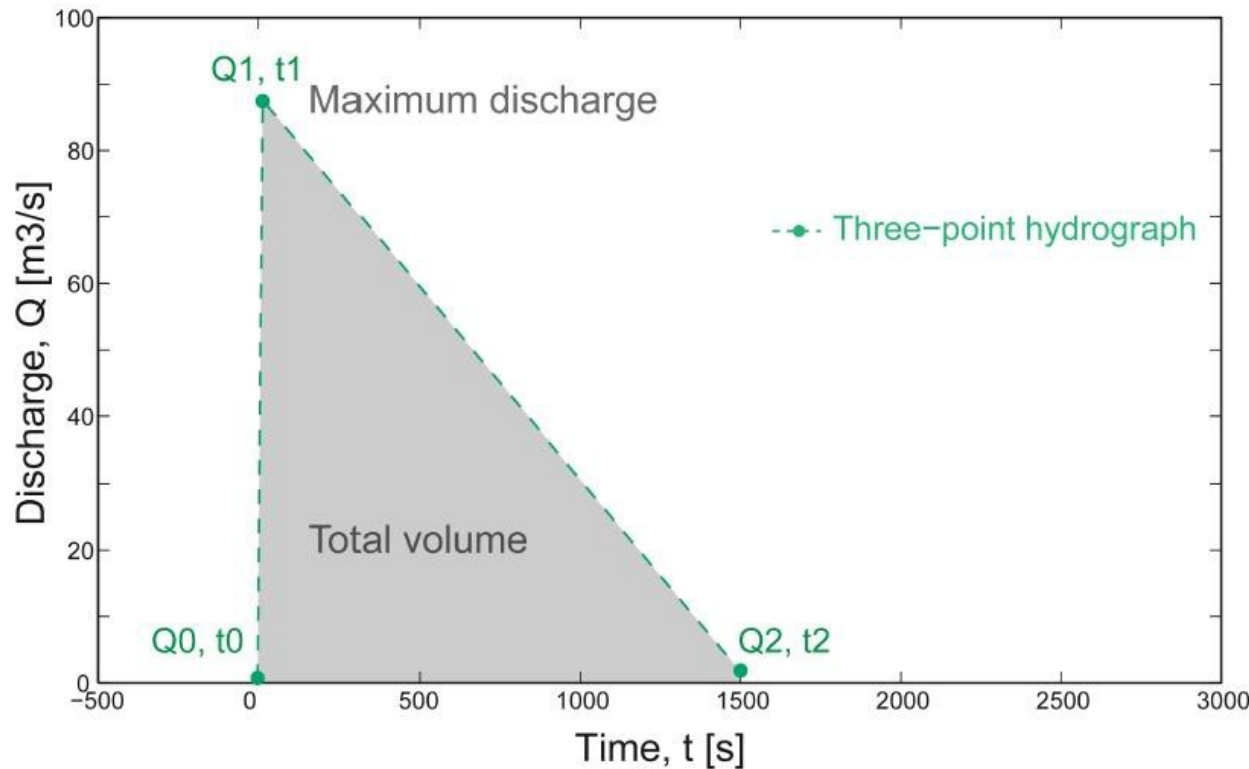
THE PROCESS MODEL

The **loose material input** for the modelling with RAMMS is at least 200m above the alluvial fan in the channel.

It is the **added cubature** of loose material, which is allocated to the debris-flow prone raster cells in the **DISPOSITION MODEL**

THE PROCESS MODEL

Here also the simplified Hydrograph will be added to the model

Based on the **total volume** (added cubature) the **maximum discharge** and the **end time** can be calculated

THE PROCESS MODEL

The last required input data for RAMMS are:

- Turbulent friction

- Dry friction

- Density

THE PROCESS MODEL

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- Turbulent friction

- Dry friction

- Density

Empirical and experienced data are:

THE PROCESS MODEL

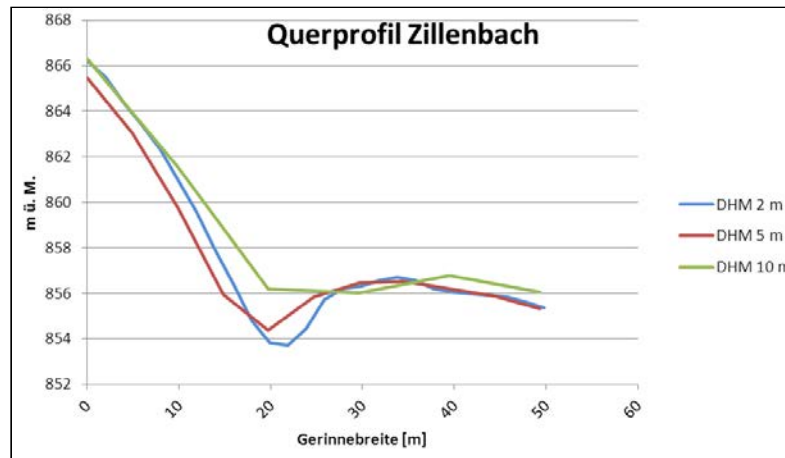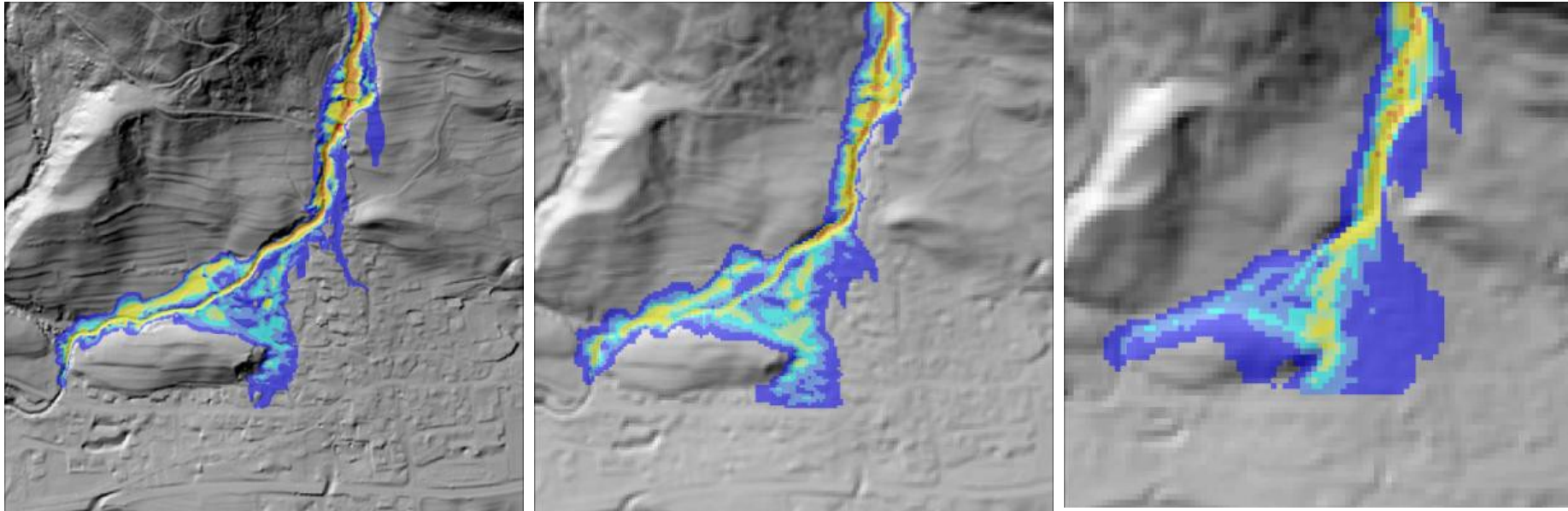The last required input data for RAMMS are:

• Turbulent friction

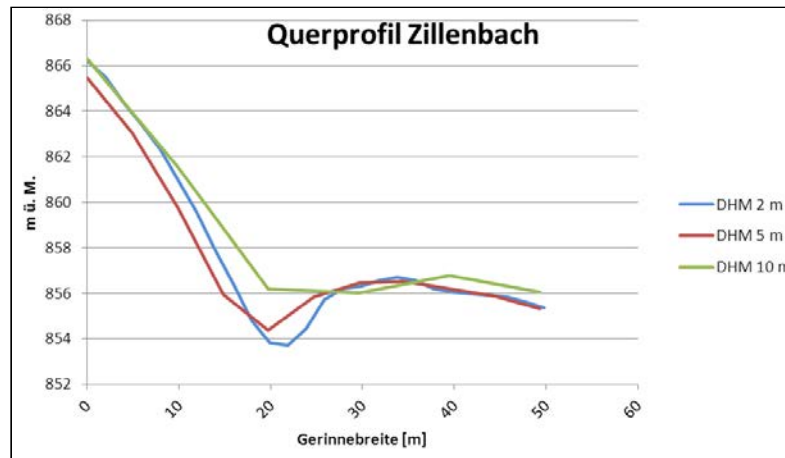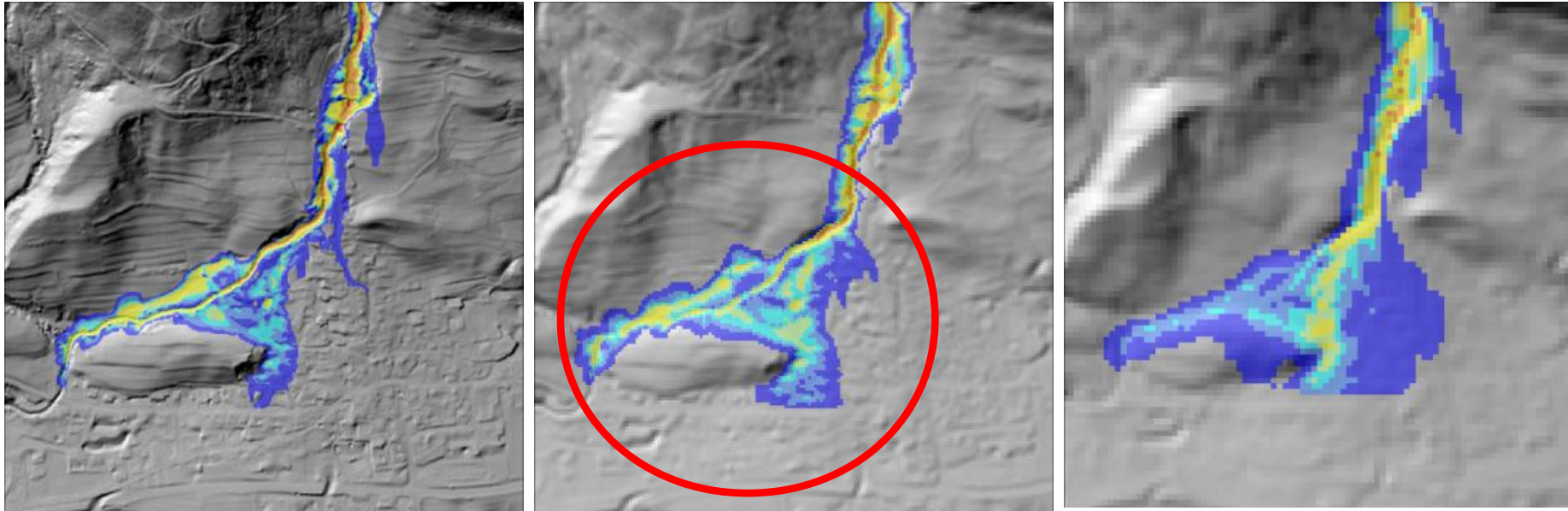• Dry friction

• Density

Empirical and experienced data are:

• Turbulent friction 250 m/s²

• Dry friction 0,1

• Density 1,9 t/m³

Modelling:

Modelling: Resolution of the DEM

Modelling: Resolution of the DEM 5m

Project: Debris Flow susceptibility map (regional scale)

Problems to solve and questions:

- good calibration of the model (frictions and density)
- how to deal with check-dams which are not in the DEM 5m
- how to deal with wood in debris flows
- scenario building: what is a frequent scenario and what an extreme scenario
- is it allowed to bring the whole loose material input in the channel 200m above the alluvial fan. Does this results in too large areas prone to the debris flow?

Project: Debris Flow susceptibility map (regional scale)

Advantages of the method:

- all input data are consistent over more than 4400 km²

- no more field work necessarily

- the maps fit very good together with the Landslide Susceptibility Maps of Bavaria for geological dangers (scale, input data, accuracy)

Project: Debris Flow susceptibility map (regional scale)

The maps are made to give a first overview about areas prone to possible debris-flows

They are a first rough information about conflicting interests in land use and a basis for further steps!