Geophysical Research Abstracts
Vol. 13, EGU2011-8986, 2011
EGU General Assembly 2011

The Hornbergl-Rockslide: 25 years of Monitoring – Space-Time Geostatistics and Visualization of Results

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The Hornbergl (Reutte, Tyrol, Austria) is a rock-slide and rock-fall area with damage mainly related to rock-slide induced debris flows. Following a pronounced, destructive debris flow activity in 1986, the Hornbergl has been subject to several surveying campaigns. Ten terrestrial surveying campaigns, two ortho-imaging flights, one airborne laser scan and continuous displacement data from automatic GPS stations are available.
To better understand the dynamics of the rock-slide process and associated damage scenarios, above data were geostatistically analyzed and interpolated in space and time, with results conveyed as cartographic animations.
Challenges were mainly related to the heterogeneous input data: different acquisition methods determine variable data configurations and different positional precisions - the displacement measurements yield 3D+t point data (terrestrial surveying, precision better than 1cm), aerotriangulation results are isoline plans and ALS provides raster data (precisions for the latter methods in the dm range). The terrestrial surveying data exhibit a clustered spatiotemporal structure, i.e. surveying points are unevenly distributed over the investigation area and the time intervals between measurement campaigns are irregular. Last not least, the geological substrate is a mix of evaporates, sandstones and carbonates. Seriously overprinted by alpine tectonics, the Hornbergl area is characterized by a complex network of geological faults, which has to be taken in account when attempting to realistically model the rockslide process.
Considering the above challenges, space-time Geostatistics was a natural candidate for data analysis and process modeling. Since geostatistical interpolation is dedicated to modeling continuous variation, the model was split up into several homogeneous areas, as confined by the network of geological faults.
Space-time variography of dislocations was performed locally, i.e. per homogeneous area. Since the following spatiotemporal homogenization had to obey the known geological discontinuities, space-time (2D+t) Kriging interpolation was controlled by the respective local variograms, with Kriging results confined to the relevant homogeneous areas.
In the Hornbergl project, the result of spatiotemporal Kriging is a set of regular 3-grids (grid node coordinates: x=easting, y=northing, z=time) of terrain height estimates and associated Kriging standard deviations. These grids act as synthetic databases, from which displacement data are extracted at user-defined times or time intervals (xy slices / 2D grids of displacements at specified z (=time) positions). They provide input data for plotting terrain-heigth contour maps or displacement vector maps related to specified times, or for the production of cartographic animations of displacement magnitudes. These reveal the fault-dominated motion pattern of the Hornbergl rock-slide; the cartographic animations are powerful explorative data analysis tools that enable the straightforward communication of the complex processes associated with land-slides and rock-slides.