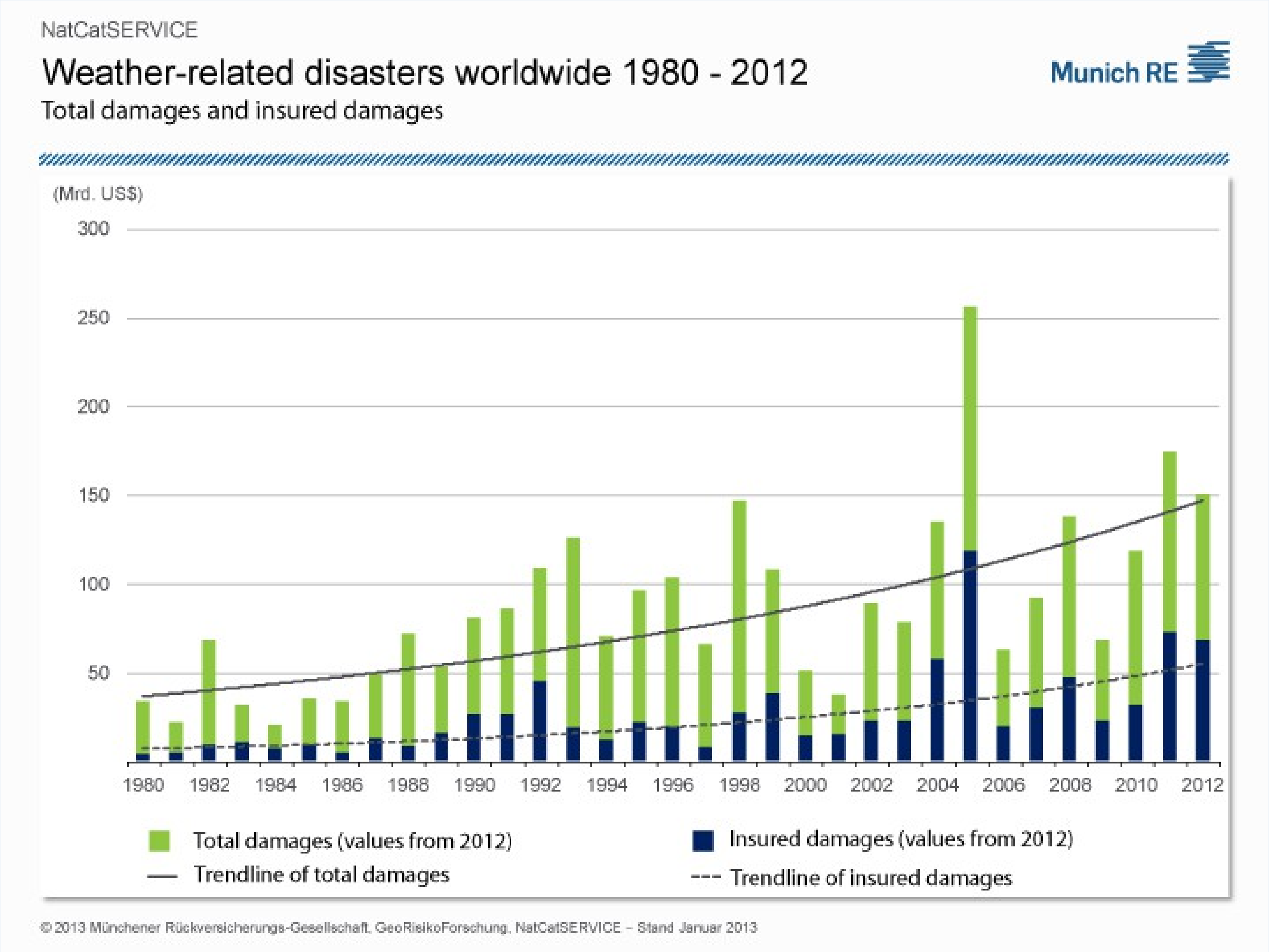
Debris flow risk evolution in Sörenberg from 1950-2014

Benjamin Fischer, Margreth Keiler
Institute of Geography, University of Bern

Jahrestagung der Schweizerischen Geomorphologischen Gesellschaft 2015
Natural Hazards & Risks – Changes and Challenges
18th June 2015, Innertkirchen

Trend of losses



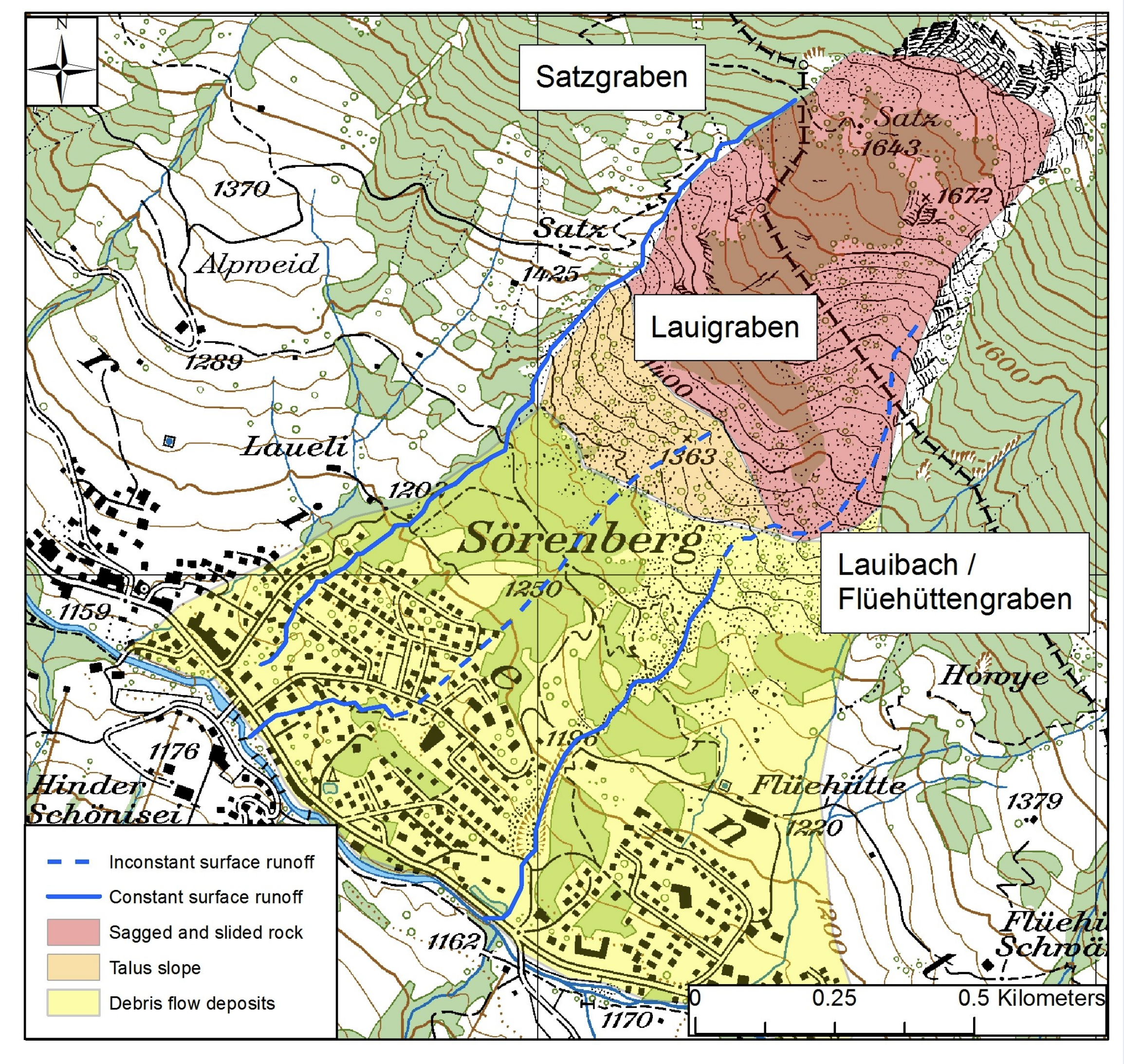
Source: Munich Re 2013

Research gaps

- Only few studies exist which focus on quantitative risk evolution (for *avalanches* and **debris flows**):
  - *Galtür, Austria (Keiler et al. 2006)*
  - **Martell, Italy (Schwendtner et al. 2013)**
  - **Reichenbach, Switzerland (Kallen 2015)**

- Rare information on long-term changes of risk parameters hazard, elements at risk and vulnerability

Investigation area



Data source: Fischer (2014)

Events of 1910 and 1999

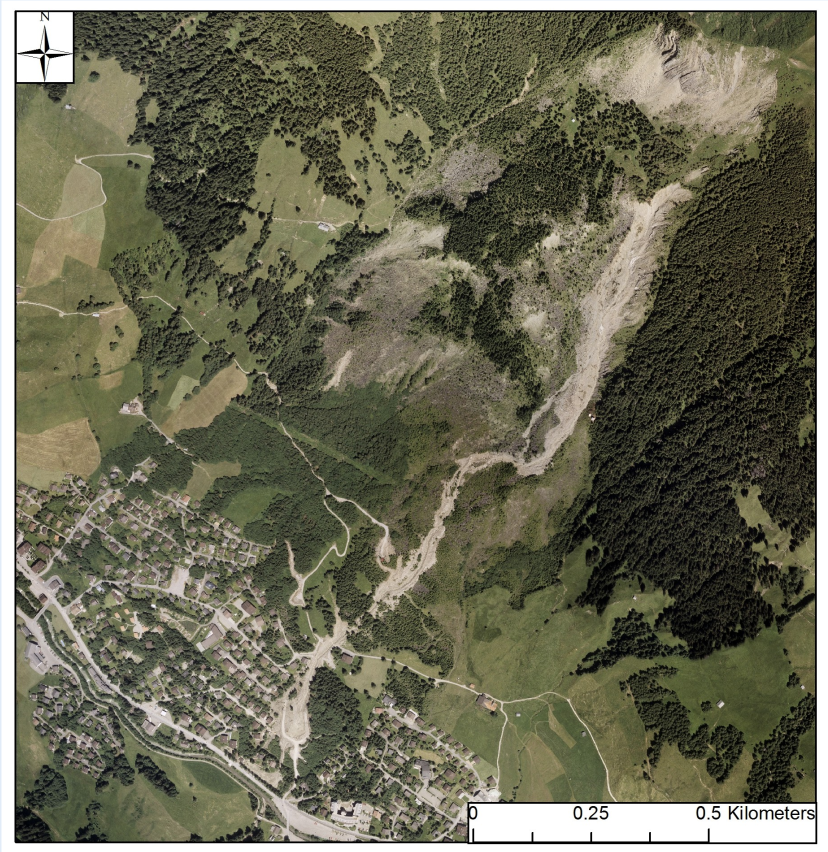
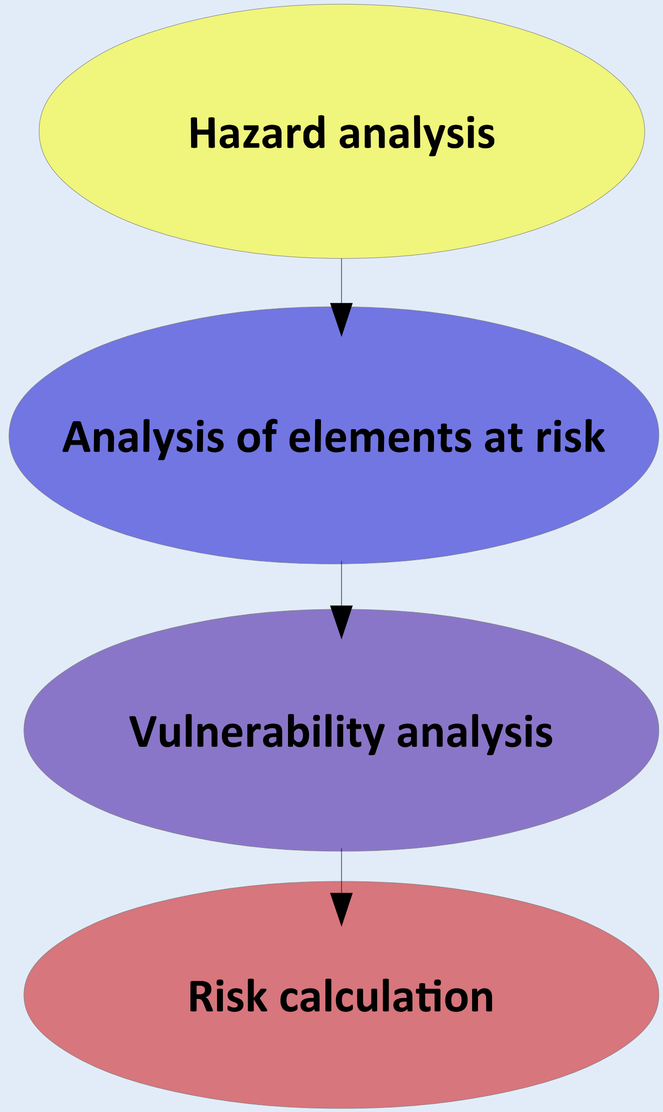
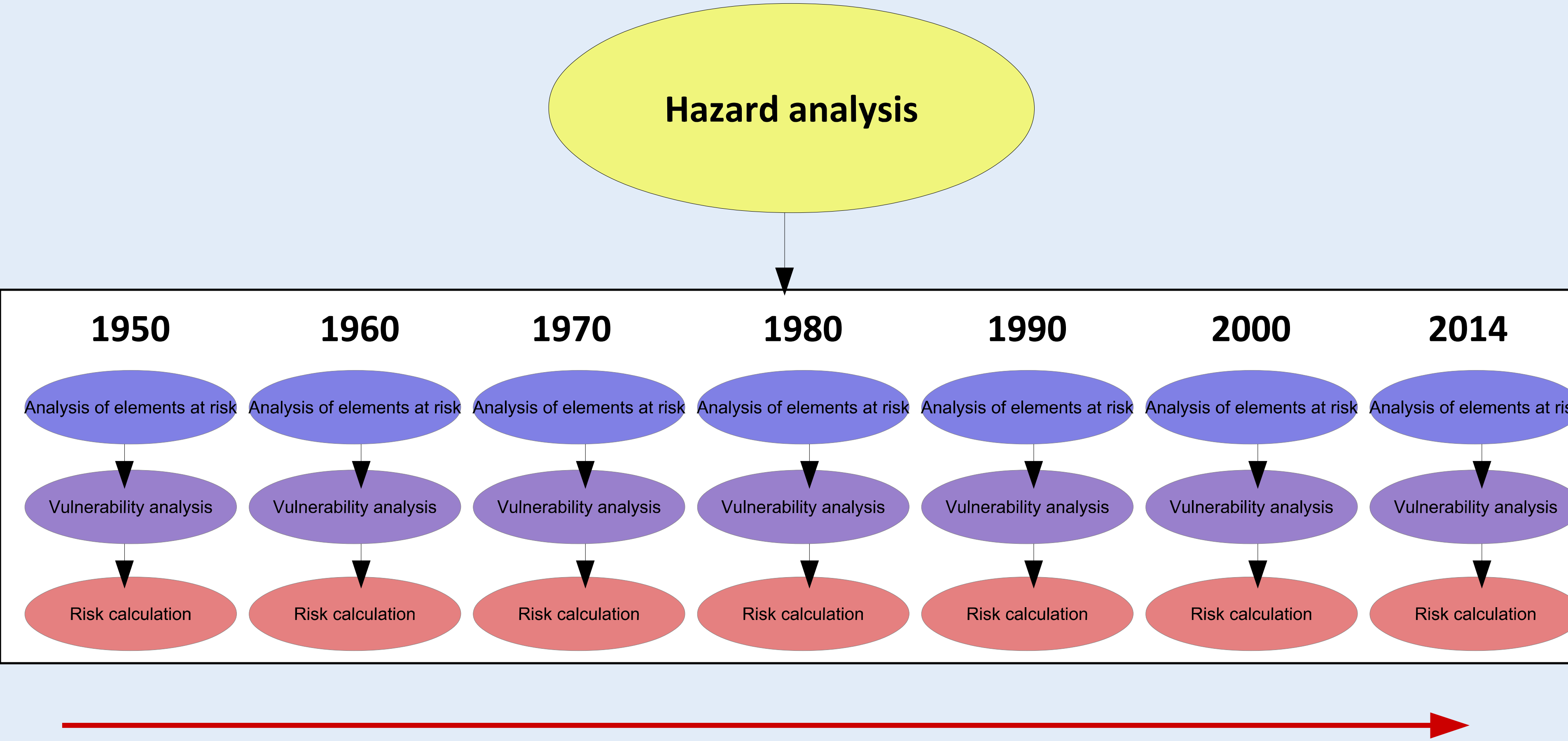


Figure on the left: Holliger (2002)
Figure on the right: provided by Geo7

Methods: Risk analysis



Methods



Risk evolution from 1950 to 2014

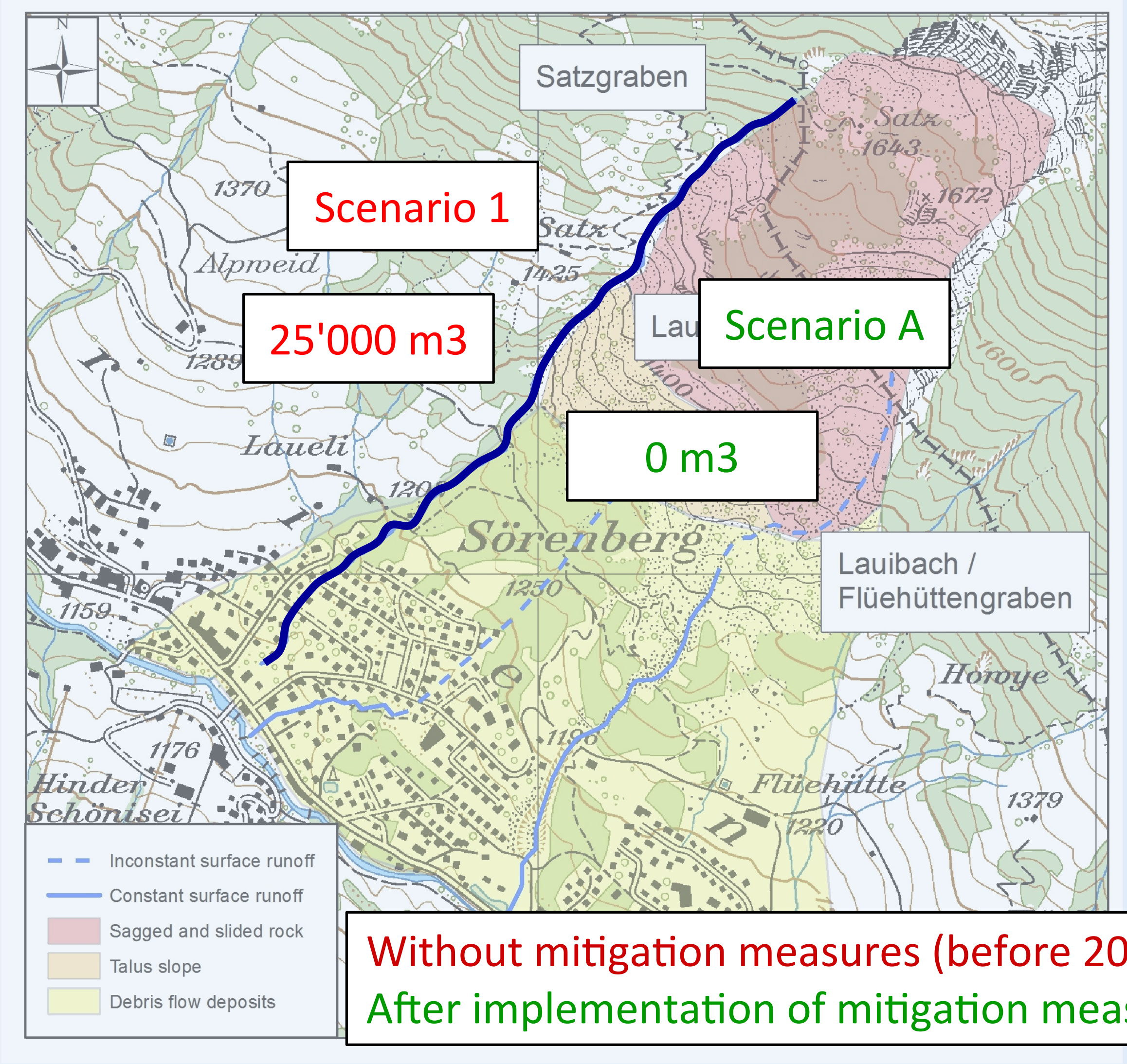
Modelling of hazard scenarios

- 8 event scenarios (with and without mitigation measures) were modelled using RAMMS debris flow (Christen et al. 2012)

- Model calibration
  - Event analysis from 1999
  - Previous modelling
  - Intensity maps

Output: Quantitative intensity maps (maximum flow height)

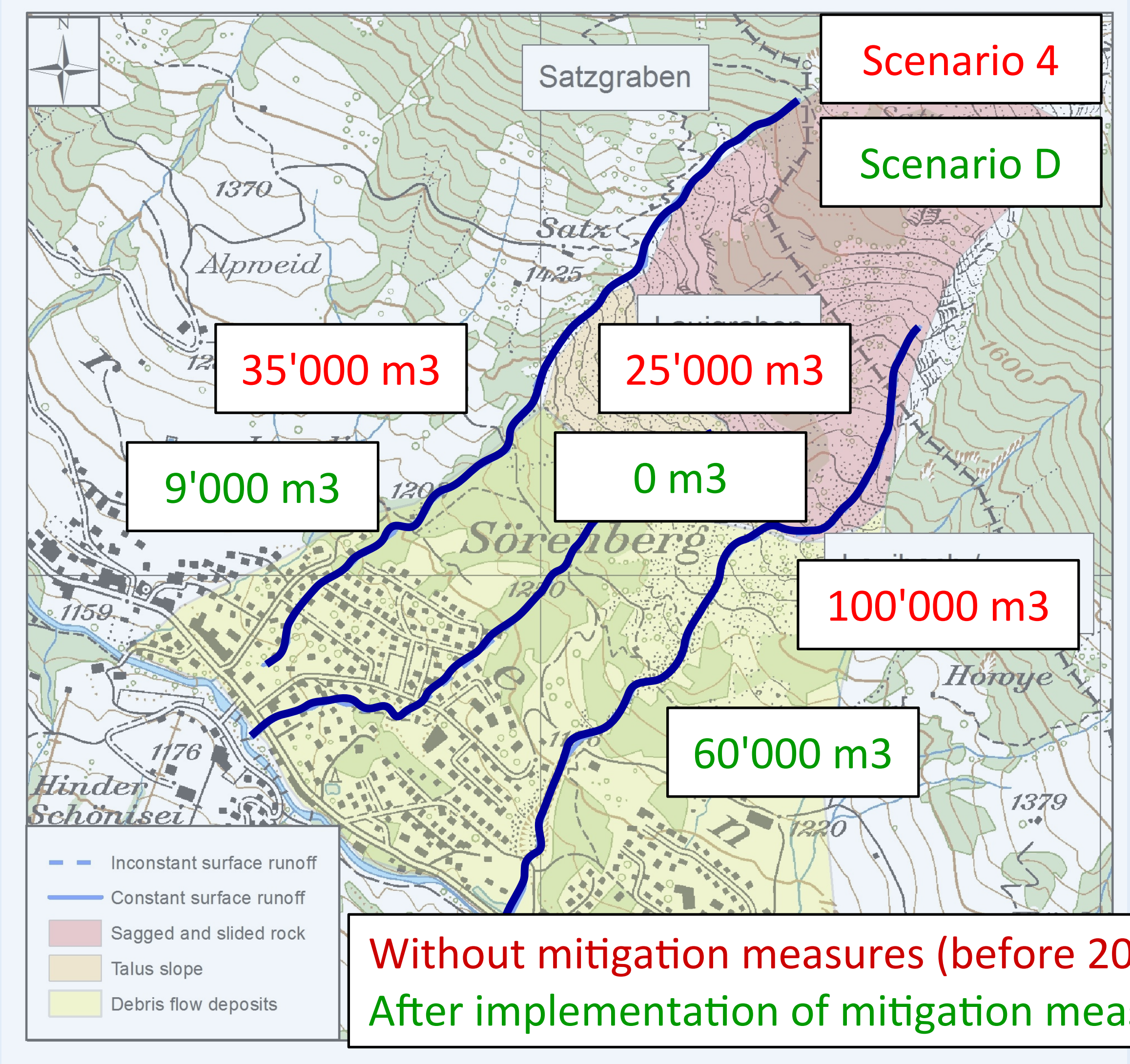
Hazard scenarios



Without mitigation measures (before 2014)
After implementation of mitigation measures (2014)

Data source of the subdivide of the investigation area: Manser 1991, data source of map: Swisstopo 2010.

Hazard scenarios



Without mitigation measures (before 2014)

After implementation of mitigation measures (2014)

Data source of the subdivide of the investigation area: Manser 1991, data source of map: Swisstopo 2010.

Elements at risk and vulnerability

- Focus on physical economic damages to building structures
- Building structure values based on cantonal building insurance data (Canton of Lucerne 2014)

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- Building structure values based on cantonal building insurance data (Canton of Lucerne 2014)

- Empirical vulnerability curve by Papathoma-Köhle et al. (2012):

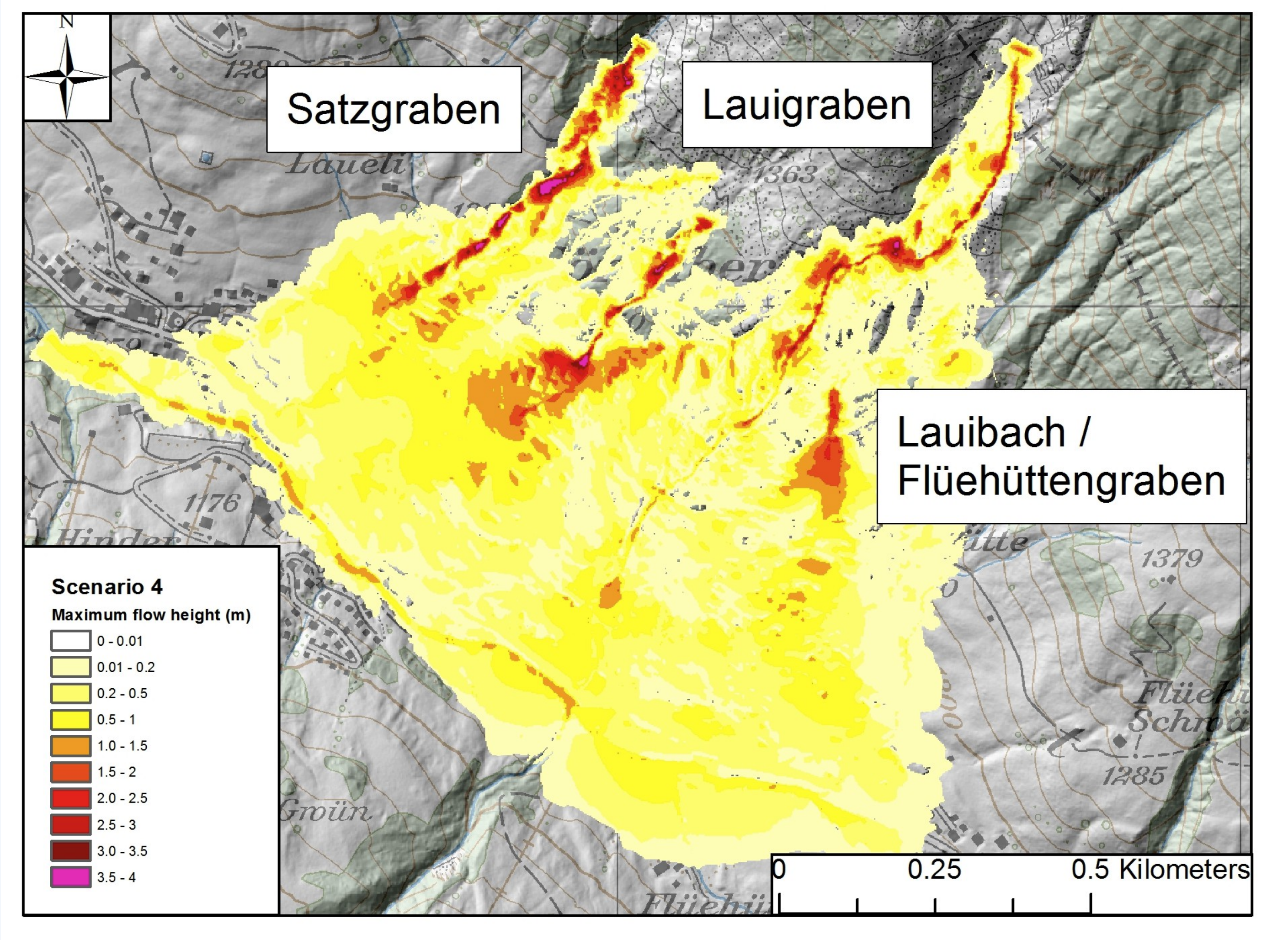
$$V = 1 - e^{(-1.528((I + 2.432) / 2.432 - 1)^{2.285}}$$

whereas: V = vulnerability of the building

I = intensity in form of deposition height

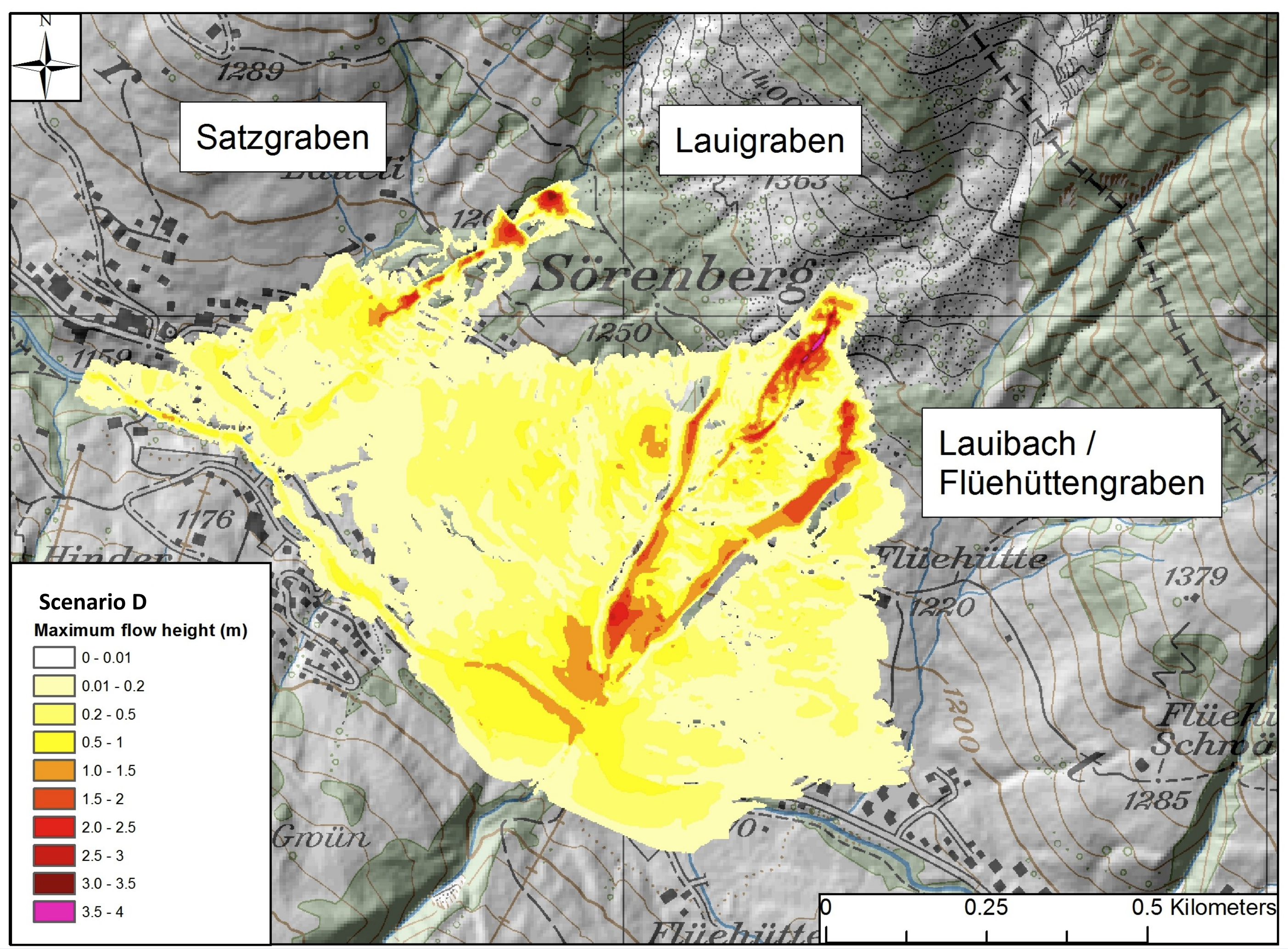
- Applied in risk evolution analyses in Martell, Italy (Schwendtner et al. 2013) and Reichenbach, Switzerland (Kallen 2015)

Hazard scenario 4 without mitigation measures



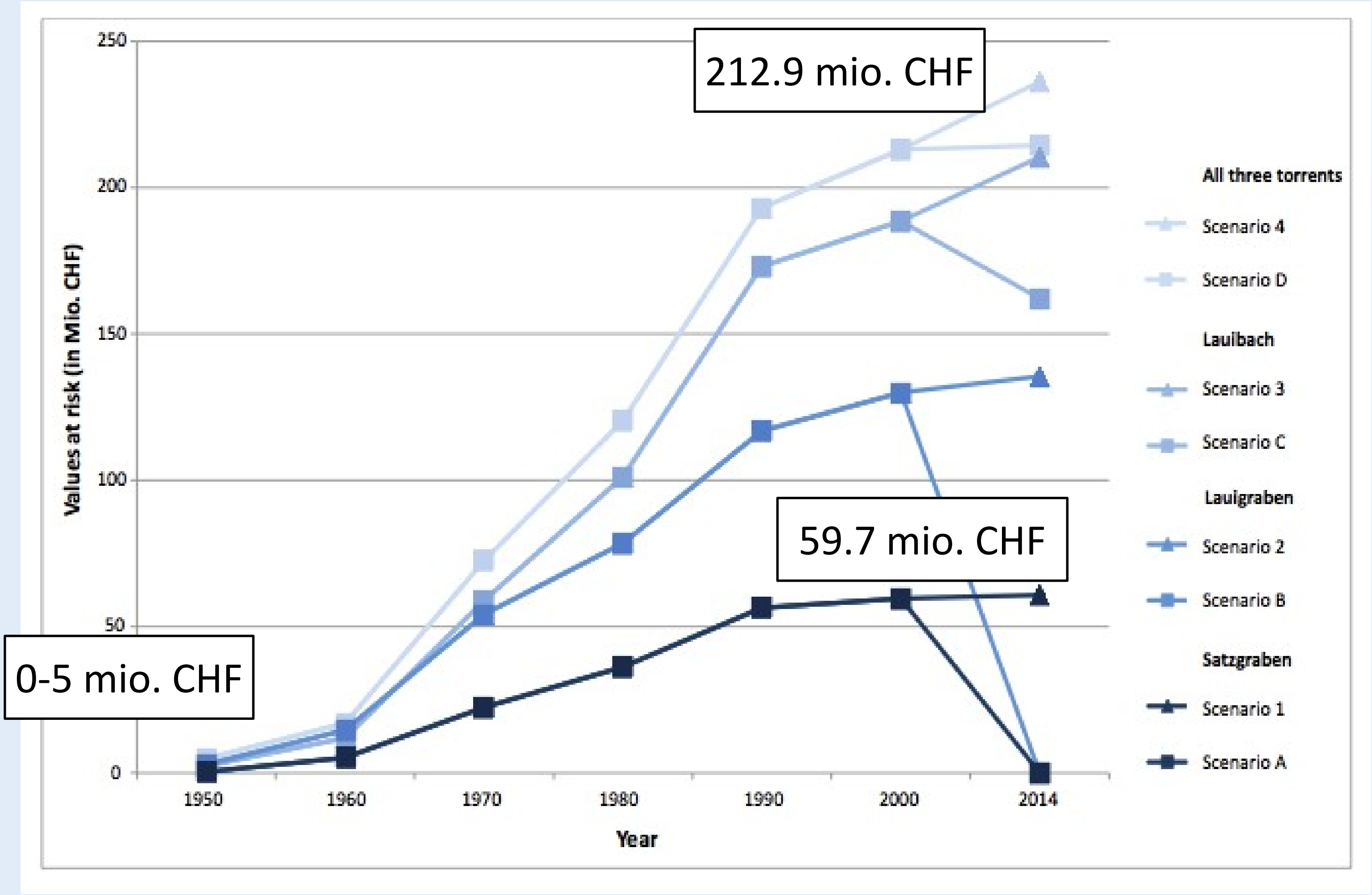
Data source of map and digital terrain model: Swisstopo 2012, 2010; modelled with RAMMS debris flow.

Hazard scenario D with implemented mitigation measures



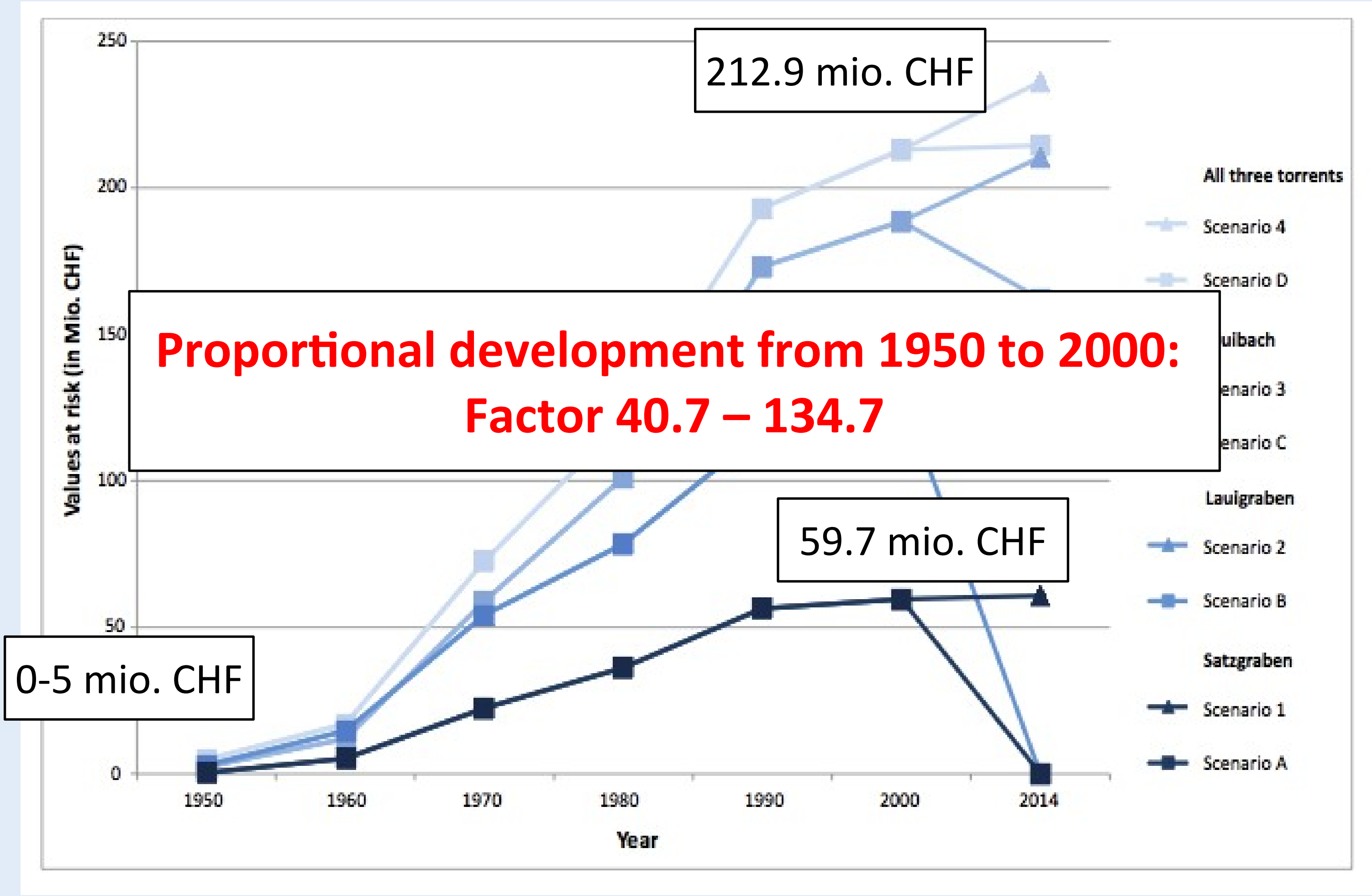
Data source of map and digital terrain model: Swisstopo 2012, 2010, Geo7 2011; modelled with RAMMS debris flow.

Evolution of elements at risk



Data source: Fischer (2014) © Geoinformation Kanton Luzern

Evolution of elements at risk



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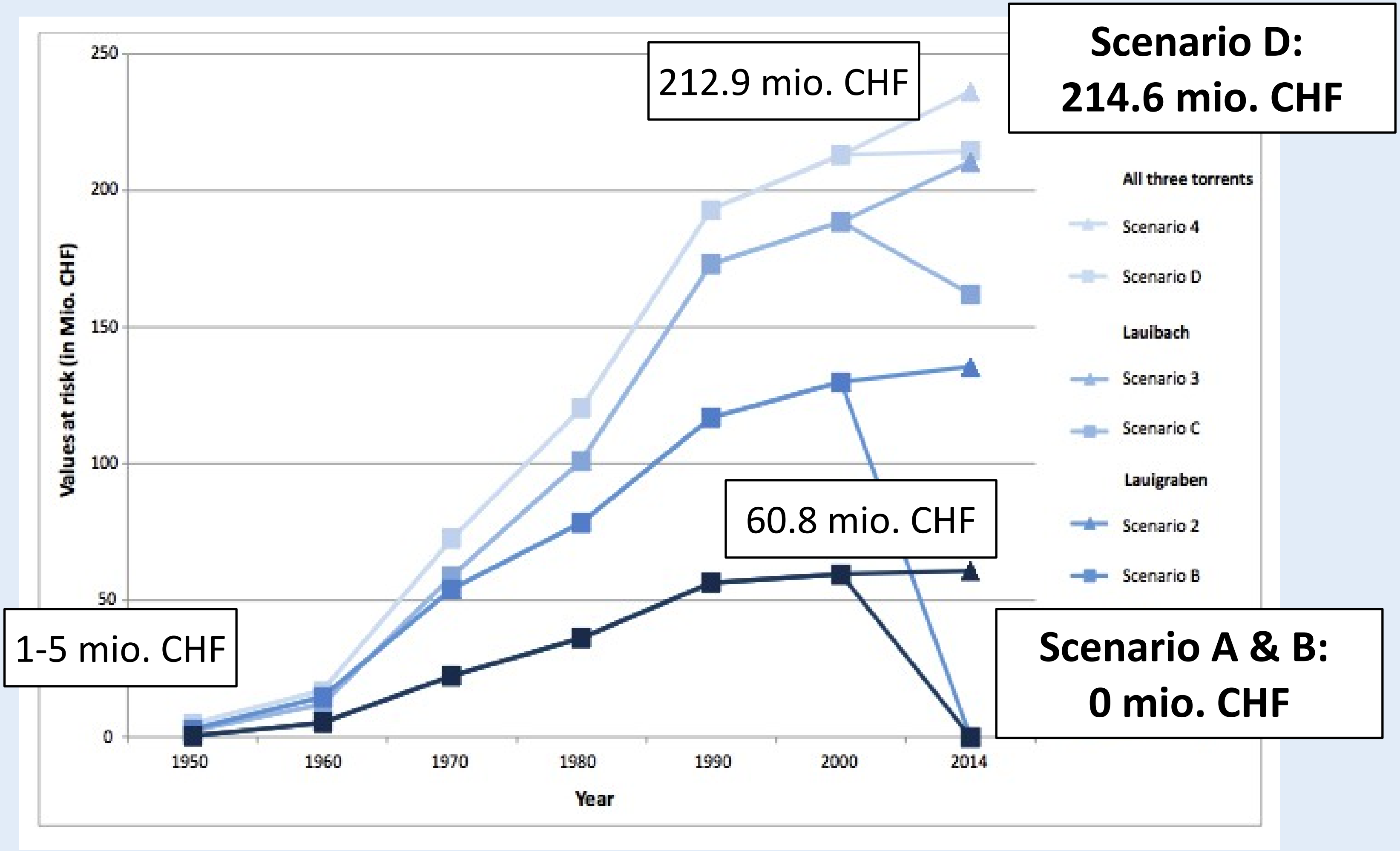
Evolution of elements at risk



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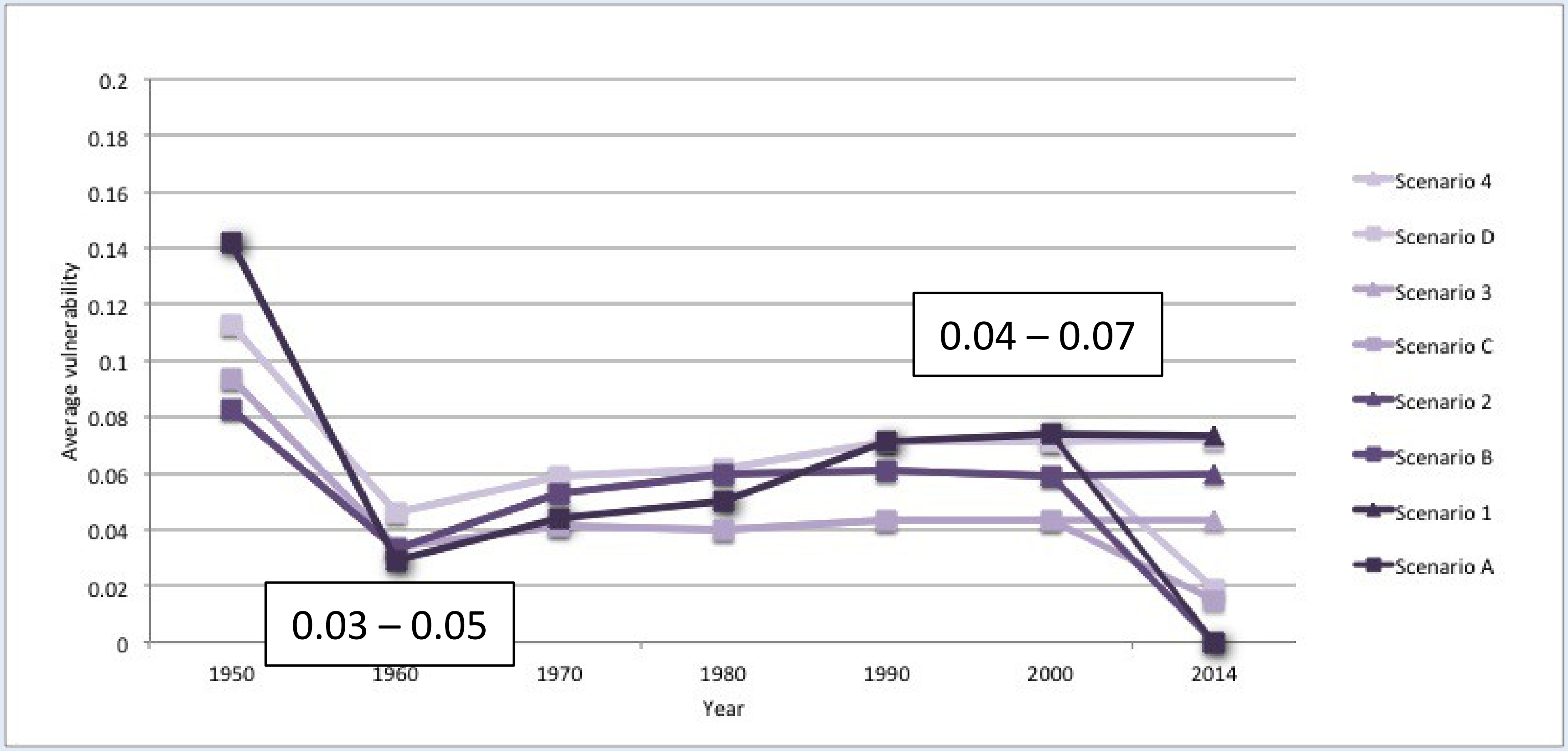
Evolution of vulnerability



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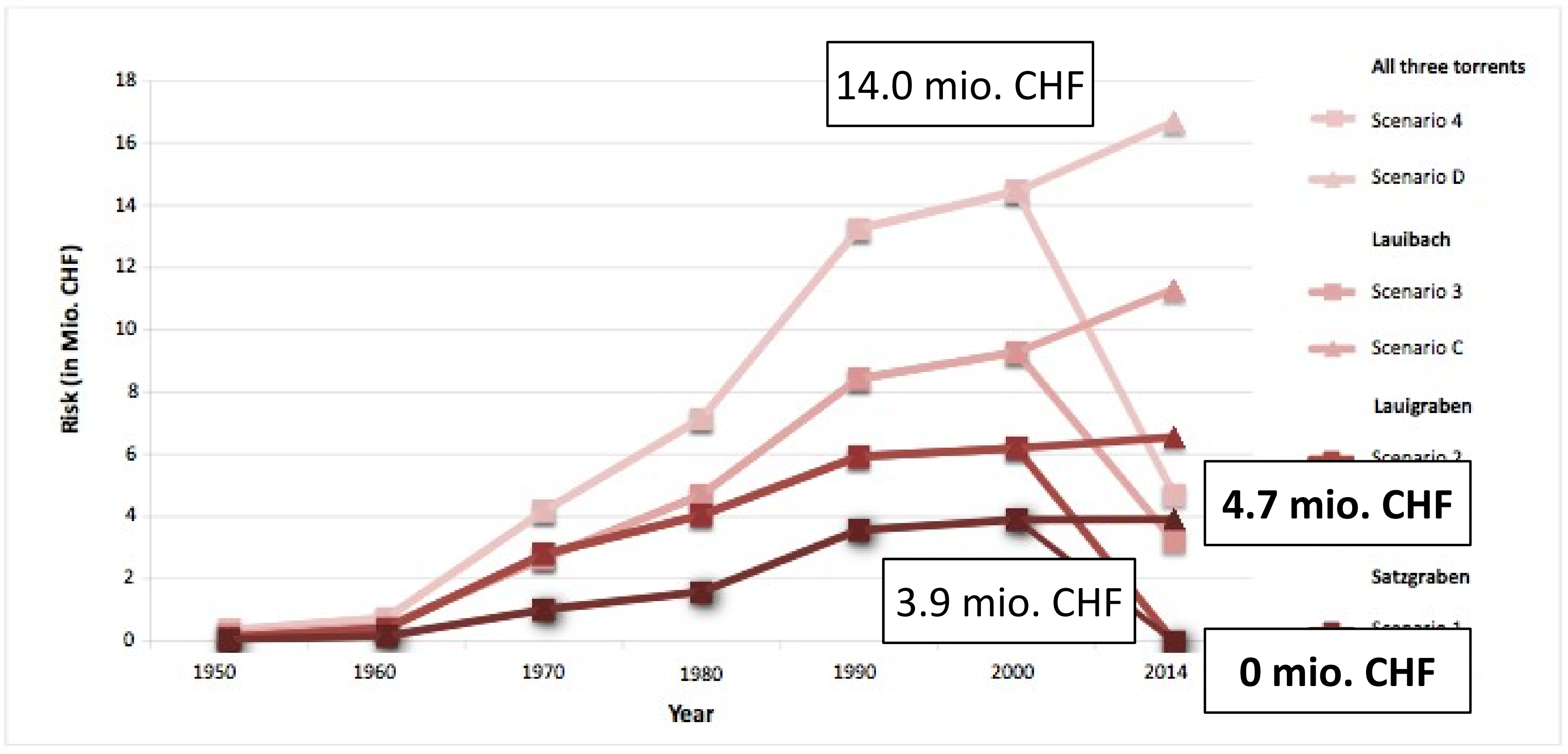
Risk evolution



Data source: Fischer (2014) © Geoinformation Kanton Luzern

Proportional risk evolution

Decade	Scenario A	Scenario B	Scenario C	Scenario D	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1950	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1960	2.7	3.4	2.1	2.1	2.7	3.4	2.1	2.1
1970	17.1	22.5	11.8	11.9	17.1	22.5	11.8	11.9
1980	26.7	32.6	20.8	20.3	26.7	32.6	20.8	20.3
1990	59.8	47.7	37.3	37.7	59.8	47.7	37.7	37.7
2000	65.6	49.9	41.1	41.1	65.6	49.9	41.1	41.1
2014	**0.0**	**0.0**	**14.3**	**13.4**	**65.8**	**52.7**	**50.0**	**47.5**

Implemented mitigation measures

no mitigation measures

Scenarios A-D including mitigation measure (between 2000 and 2014), scenarios 1-4 excluding mitigation measures. Data source: Fischer (2014), © Geoinformation Kanton Luzern.

Comparison of methods: Scenario A

- Quantitative method according to Papathoma-Köhle et al. (2012)

- Semi-quantitative approach using defined vulnerability values in **EconoMe 2.2** (Krummenacher et al. 2010) which is applied in Swiss practice

Comparison of methods: Scenario A

Year	Risk (vulnerability curve in Mio. CHF)	Risk (EconoMe in Mio. CHF)	Difference (in Mio. CHF)
1950	0.06	0.23	0.17
1960	0.16	2.90	2.74
1970	1.02	12.24	11.22
1980	1.59	19.63	18.04
1990	3.56	31.71	28.15
2000	**3.91**	**32.85**	**28.94**
2014	0.00	0.00	0.00

Data source: Fischer (2014) © Geoinformation Kanton Luzern

Introduction of a lower boundary for quantitative analyses

	Scenario A				
Lower boundary	Affected buildings above the lower boundary	**Elements at risk (CHF)**	Scenario B	Scenario C	Scenario D
0	119	**62'065'000**	238	345	363
0.01	***114***	***59'723'000***	***220***	***338***	***359***
0.1	94	**40'005'000**	164	299	338
0.2	85	**36'647'000**	136	262	303
0.3	75	**33'316'000**	112	204	253
0.4	69	**30'202'000**	91	162	207
0.5	54	**22'722'000**	65	101	152

Data source: Fischer (2014) © Geoinformation Kanton Luzern

Conclusions

- The mitigation measures reduce the risk between 3.9 and 9.3 million CHF depending on the scenario
- Two scenarios show a distinct risk increase of factor 13 and 14 from 1950 to 2014 despite the implementation of mitigation measures
- The definition of the hazard scenarios and the method selection are crucial for the observed risk evolution
- The case study shows that EconoMe overestimates the damage of low debris flow intensities. It is thus suggested that a lower boundary for the application of the medium intensity class values is introduced

Conclusions

- More case studies are required to develop specific vulnerability curves for different building types
- Other case studies (e.g. Galtür (Keiler et al. 2006) or Davos (Fuchs et al. 2004)) showed a risk increase in the years after the implementation of the mitigation measures. The further investigation of the case study in Sörenberg is thus fundamental.

SCHWEIZERISCHE GEOMORPHOLOGISCHE GESELLSCHAFT

SOCIÉTÉ SUISSE DE GÉOMORPHOLOGIE

Thanks to SGmG for the support and thank you for your attention!

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