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Eidgenössisches Departement für
Umwelt, Verkehr, Energie und Kommunikation UVEK

Bundesamt für Umwelt BAFU
Abteilung Gefahrenprävention

Wo und wie werden wir siedeln?

Der Blick durch die Klimabrille auf die Gefahrenkarten der Schweiz

Wolfgang Ruf - Bundesamt für Umwelt BAFU,
Abt. Gefahrenprävention



Objectives

- How do we deal with natural hazards in Switzerland?
- How does climate change alter the hazard and risk situation?
- How do we consider climate change effect in the assessment and management of natural hazards?
- How will climate change alter the suitability for settlement areas?



Natural hazards (1)

avalanches



landslides



rockfall / rock avalanches



debris flow



dynamic inundation



static inundation



pluvial floods /
overland flow



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Wolfgang Ruf, Bundesamt für Umwelt, Ärzte für Umwelt, Solothurn, 15.5.2025



Natural hazards (2)

earthquakes



windstorms



hail



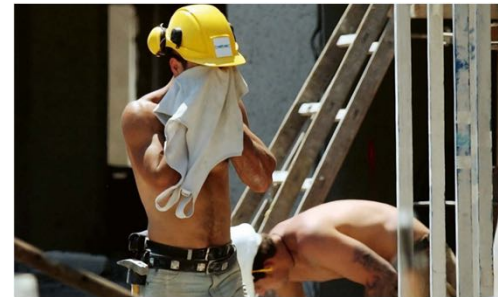
lightning



drought



heat



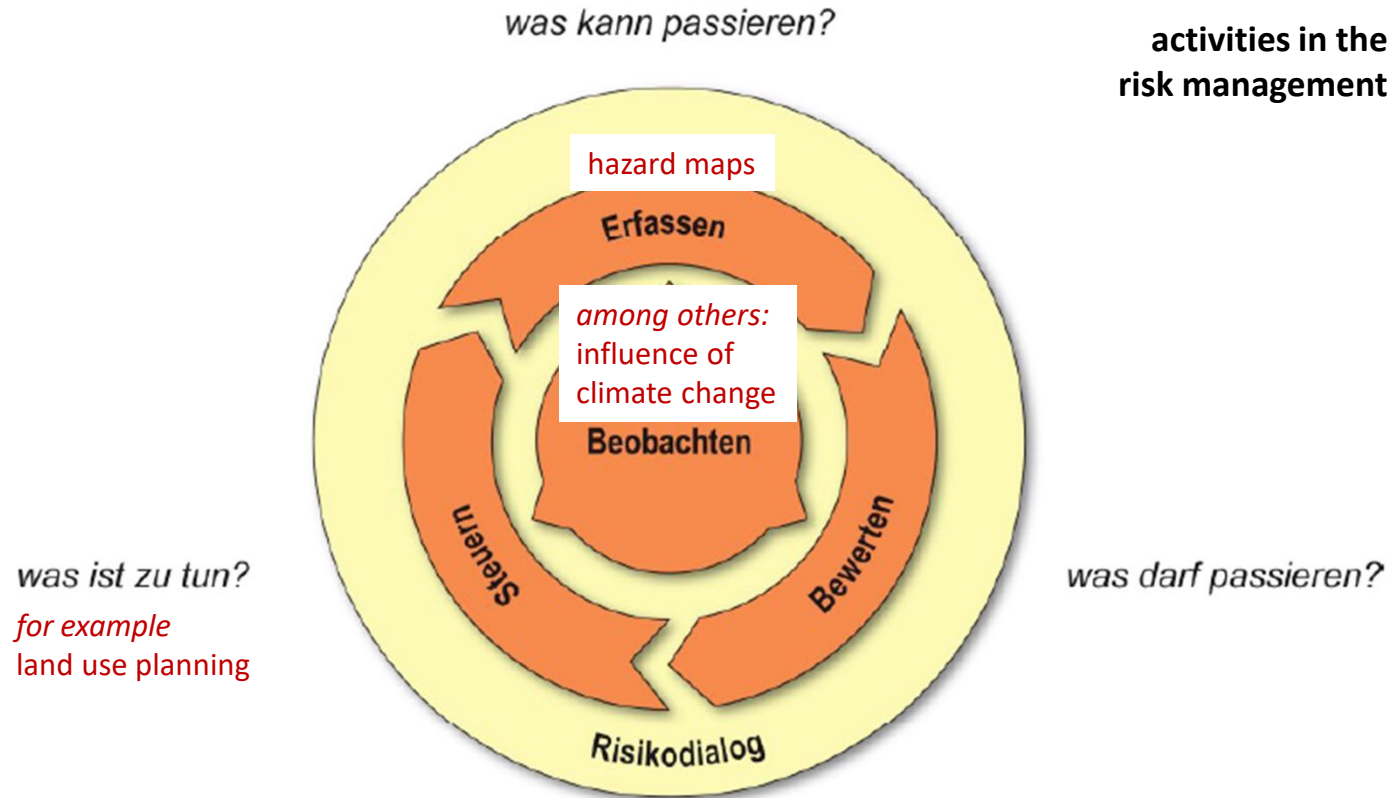
forest fires





How do we deal with natural hazards?

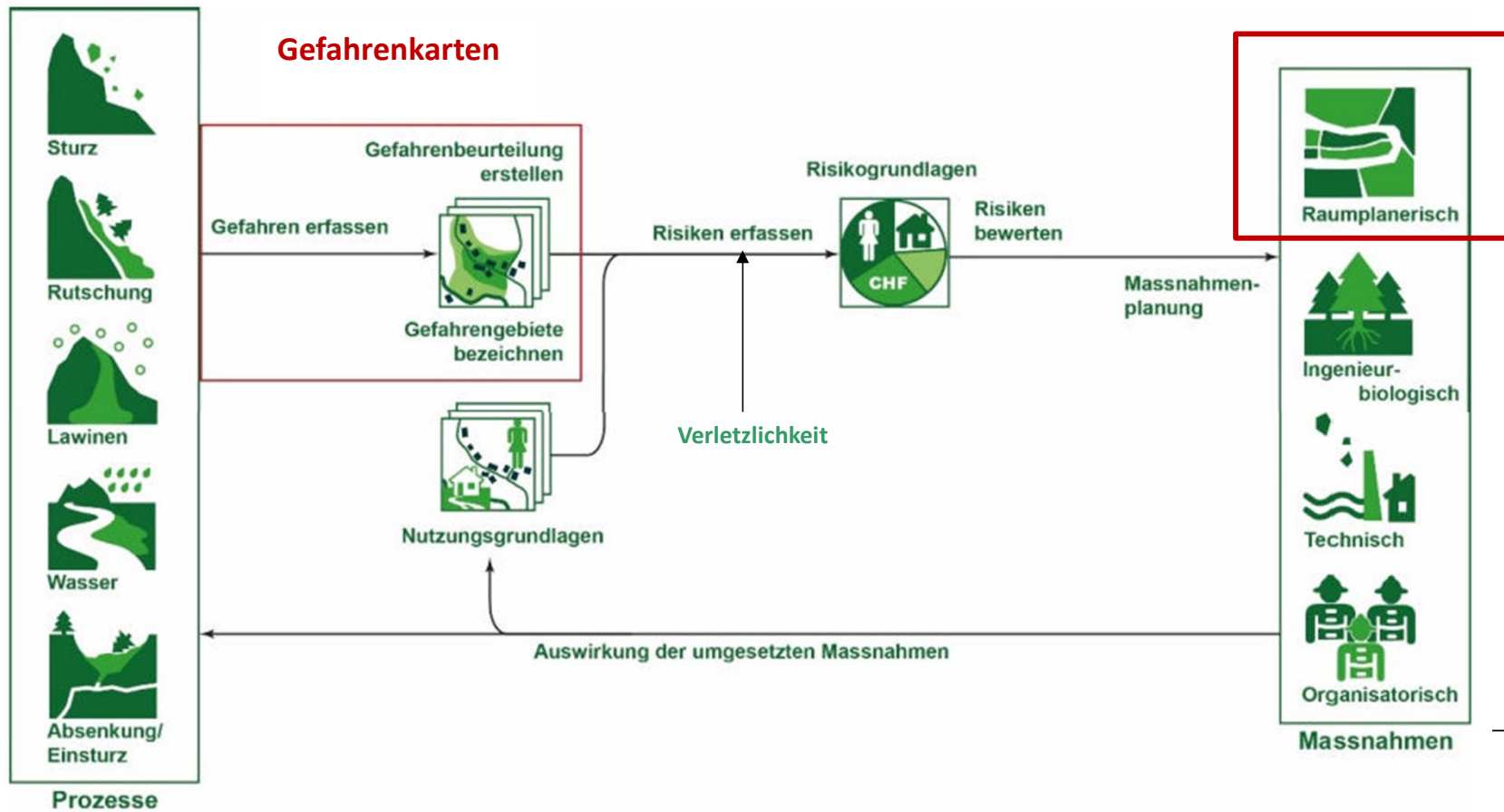
Integrated risk management





How do we deal with natural hazards?

Integrated risk management





Palette of measures

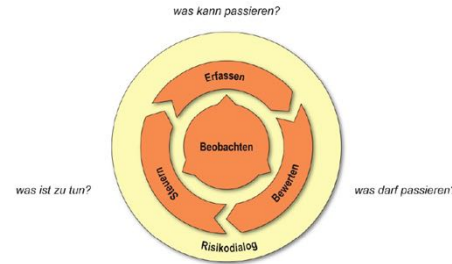
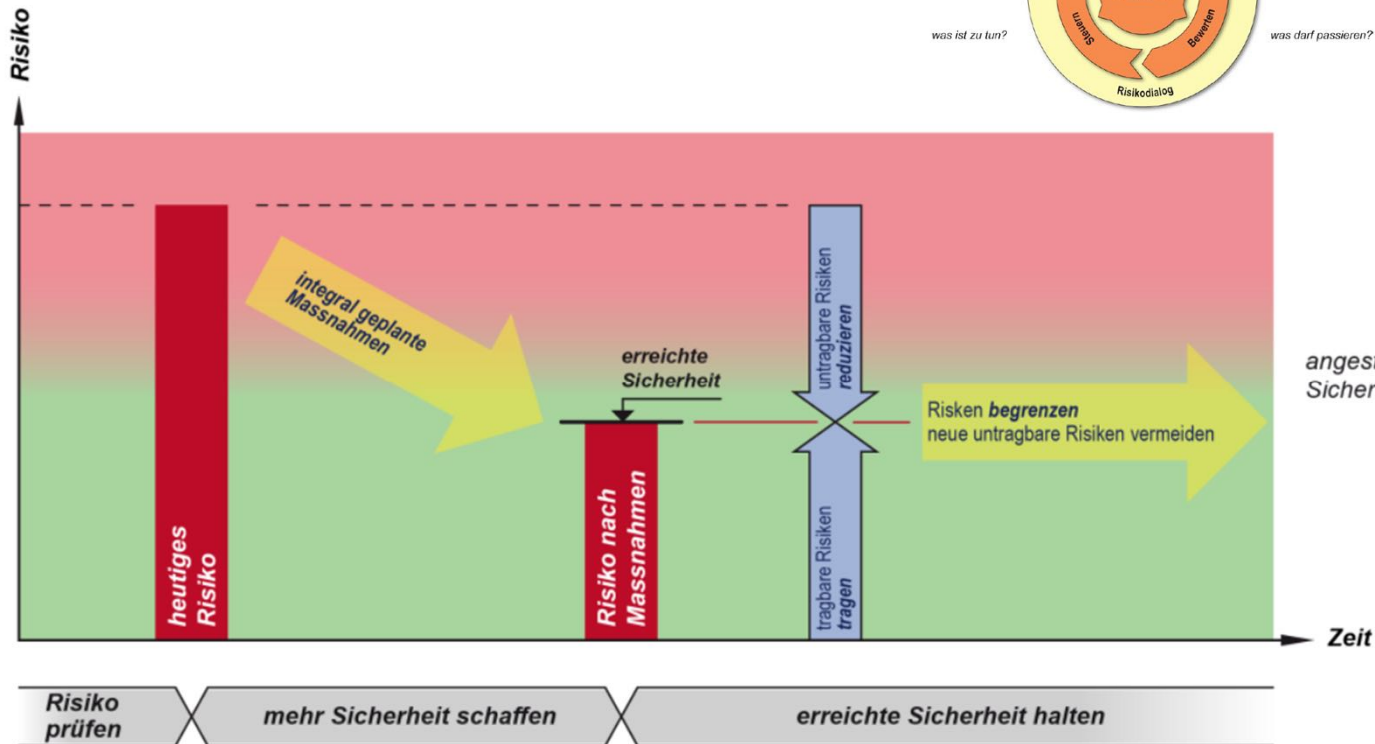
- spatial planning measures
 - comprehensive planning (canton)
 - land use planning (commune) → proactive
 - building codes, construction obligations → reactive
- biological measures
 - protective forest
- technical measures
 - protective structures
- organisational measures
 - emergency planning
 - early warning systems

*optimal combination
of measures to reduce risk:*

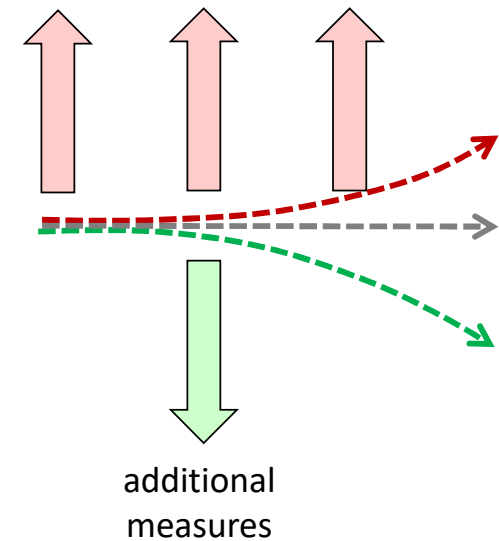
- robust
- flexible
- overload capacity



safety level



damage potential spatial demand **climate change**



what can happen? what is allowed to happen?



Revision of federal legislation



First legislation **1991/1994**

- Federal Act / Ordinance on Hydraulic Engineering
- Federal Act / Ordinance on Forests

Objective:

Protection of people and significant material assets against natural hazards
(flooding, debris flow, avalanche, rockfall, landslide)

Revision: 1. August **2025**



considering climate change

enabling change in paradigm:
from hazard defense to risk culture

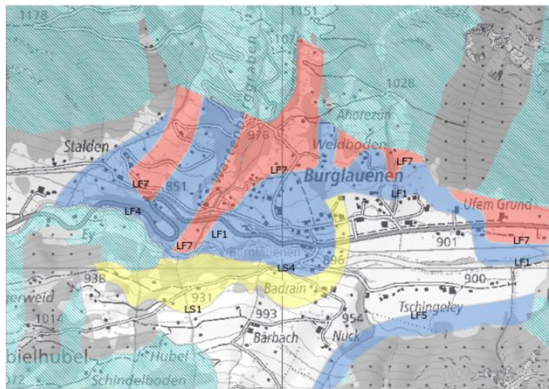
- not only hazard, but also risk assessment
- acceptable risks
- avoiding new risks

integrated and risk-based planning of measures

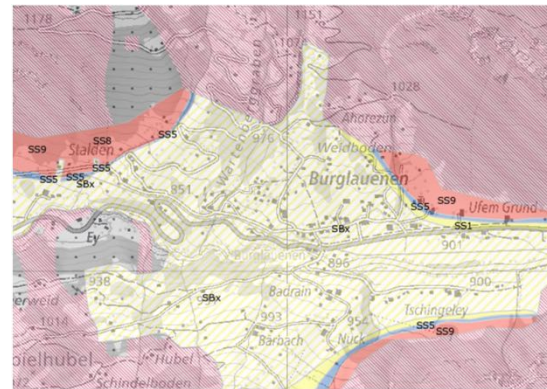


Hazard maps

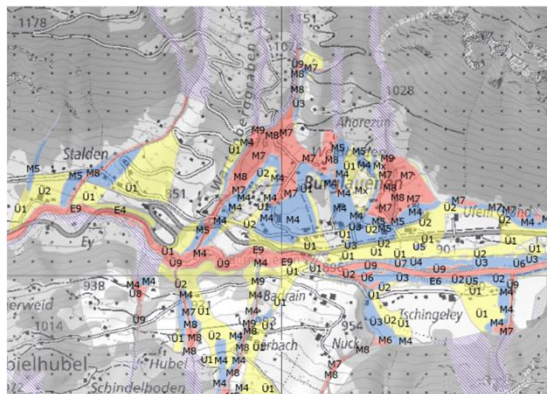
example: Burglauenen, Bernese Oberland



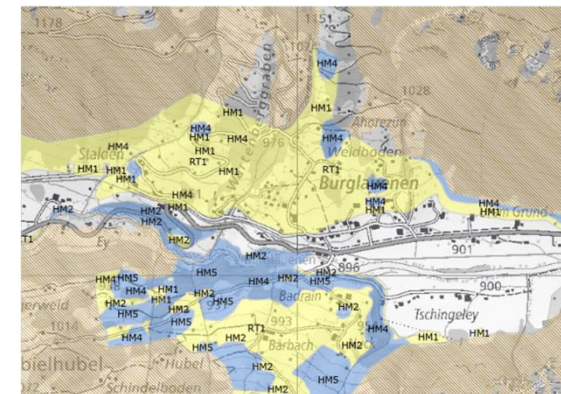
avalanche



rockfall
rock avalanche



flood
debris flow



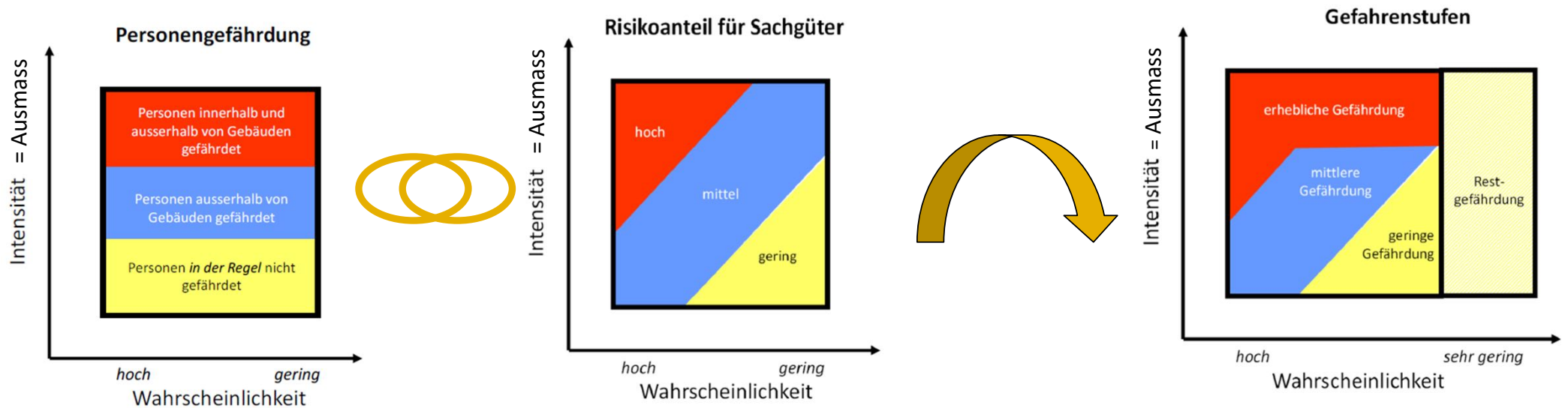
landslide

Source:
Geoportal of the Canton of Berne

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Construction of hazard maps based on probability and magnitude



$$\text{Risiko} = \text{Wahrscheinlichkeit} \times \text{Ausmass} \times \text{Exposition} \times \text{Verletzlichkeit} \times \text{Schadenpotenzial}$$

= Intensität

= 1

bei unbeweglichen
Sachgütern

«Risikoanteil»



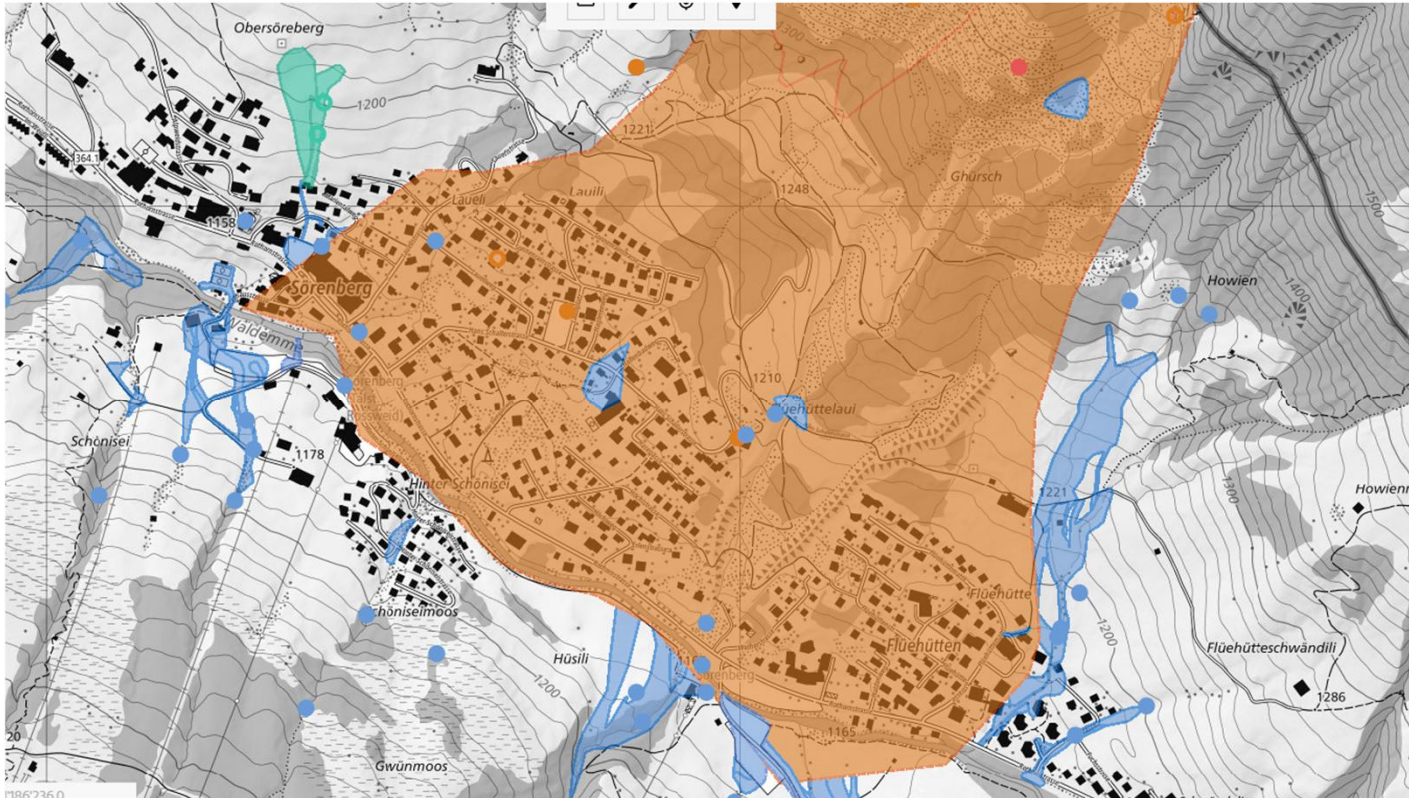
What do hazard maps tell us?

- synoptic view of result of hazard assessment
 - basis for risk assessment, planning of measures
 - basis for risk dialogue and decision making
 - among other purposes, it is basis for spatial planning
- hazard maps are essential fundamental of controlling land use (new buildings and infrastructure, dealing with existing ones).
- challenge: settlements are older than the obligation to hazard assessment



How are hazard maps established?

analysis of past events



Source:
Geoportal of the Canton of Lucerne



1. past events



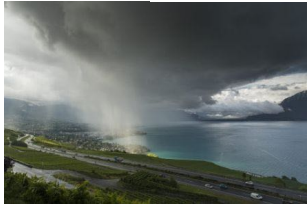
2. modelling and
expert assessment



3. hazard
assessment
and mapping



Modelling: example water processes



precipitation



antecedent
soil moisture



bed load material



flood protection dam



protective forest



blocking,
bed load aggradation
weak points
process chains



inundation
debris flow deposition

*(climatic)
input
variables*

*disposition
parameters*

*protective
measures*

*scenario
analysis*

impact analysis



How do natural hazards alter due to climate change?

- depends on geographic region
- depends on the natural process
- high uncertainty
- but overall:
for many processes frequency and magnitude of natural event are expected to be increased



Permafrost indicative map

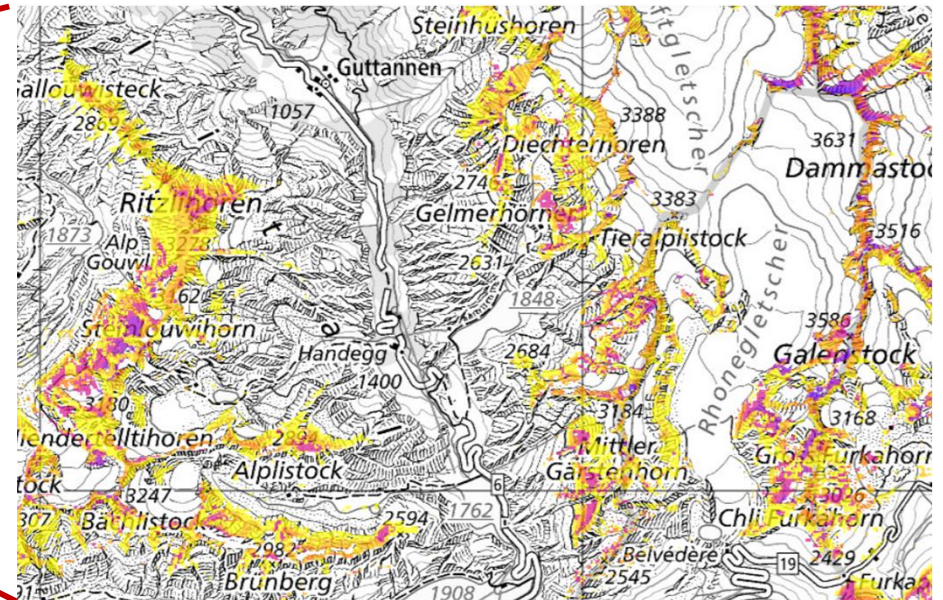
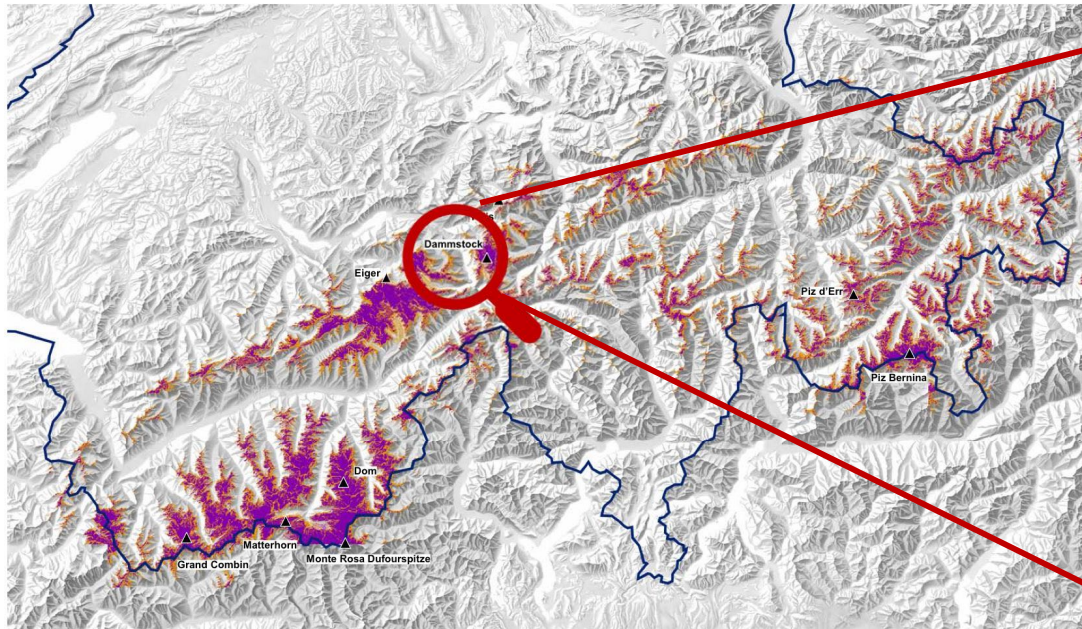


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Office fédéral de l'environnement OFEV
Ufficio federale dell'ambiente UFAM
Uffiz federal d'ambient UFAM

Hinweiskarte Permafrost Schweiz

Potentielle Permafrostverbreitung aufgrund von
Modellierungen mit dem DHM25 (BAFU 7/06)



Legende: ■ Permafrost lokal möglich ■ Permafrost flächenhaft wahrscheinlich

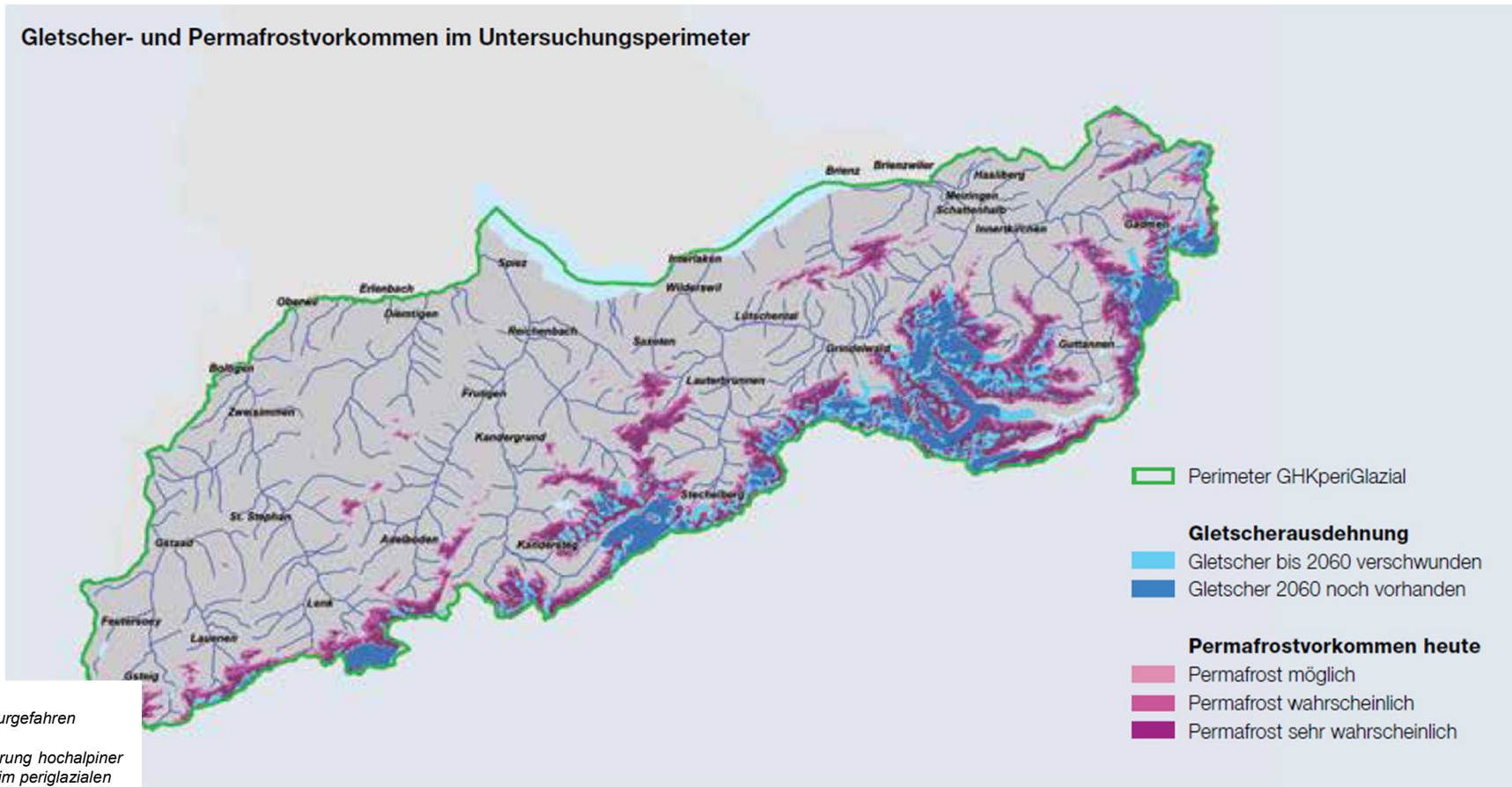
Source:
Federal Office for the Environment (FOEN/BAFU), published on map.geo.admin.ch

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Permafrost and glacierized areas canton BE

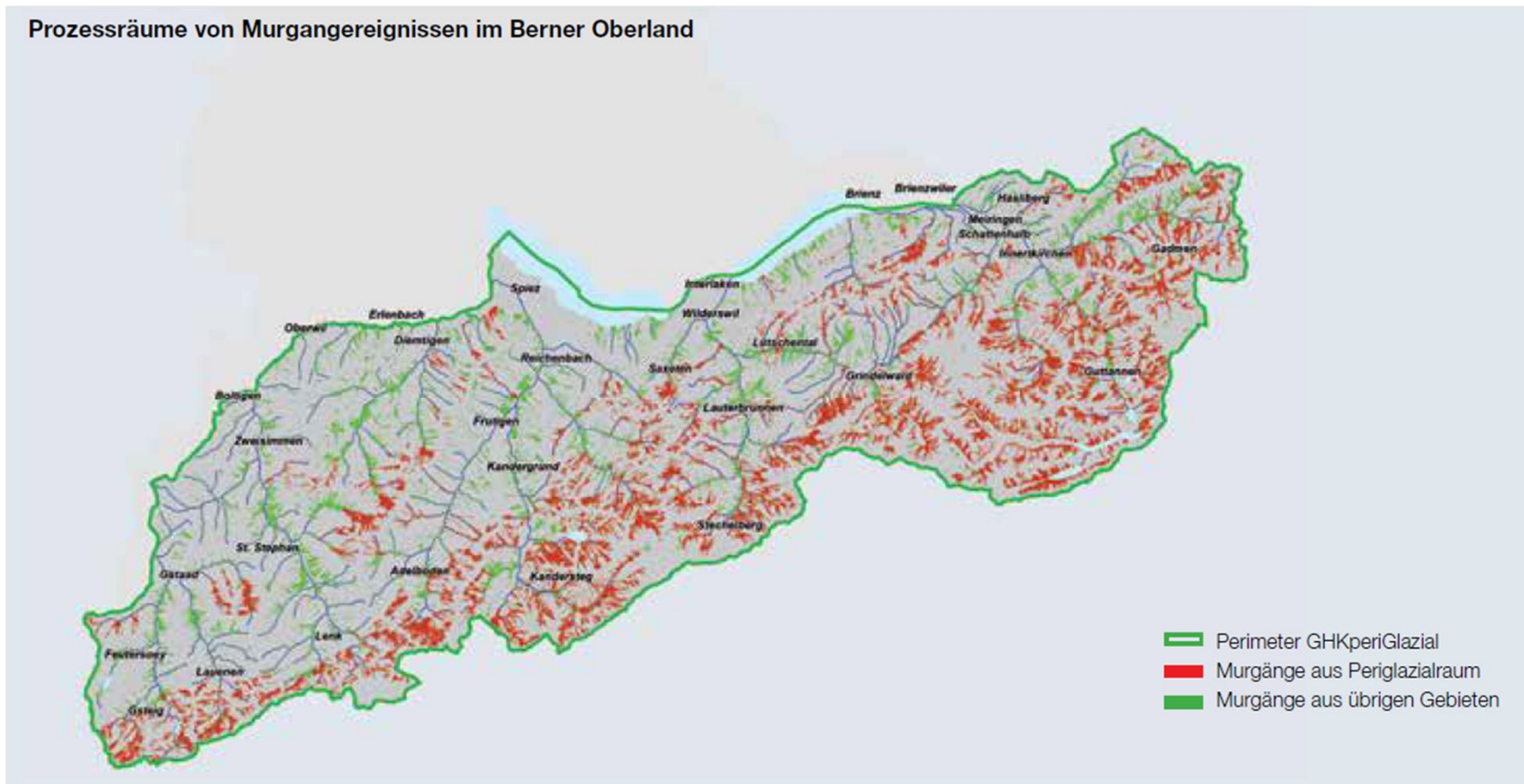
Gletscher- und Permafrostvorkommen im Untersuchungsperimeter



Source:
AG NAGEF – Arbeitsgruppe Naturgefahren
des Kantons Bern (2015):
GHKperiGlazial – Gefahrenabklärung hochalpiner
Prozesse durch Veränderungen im periglazialen
Bereich des Berner Oberlandes;



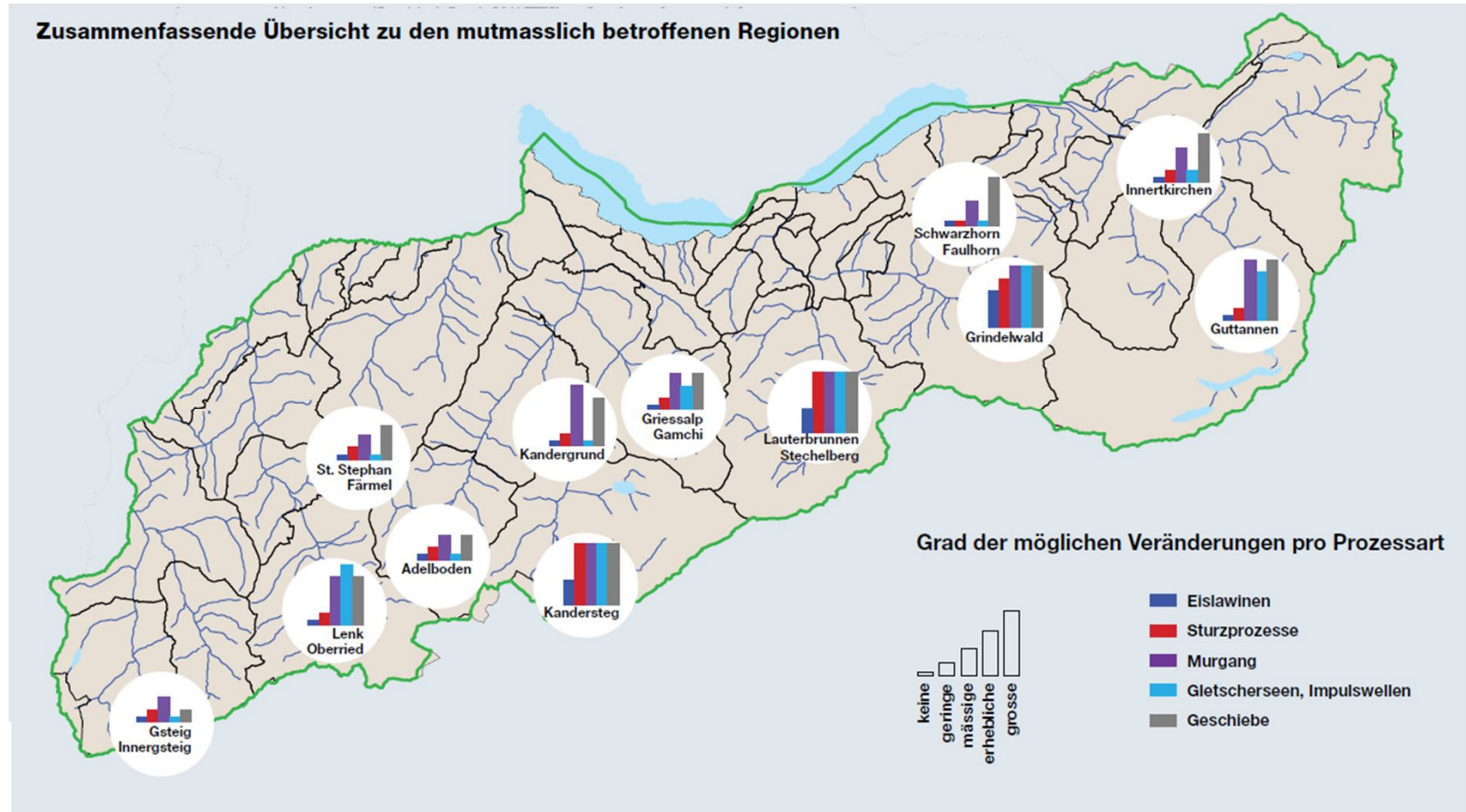
Permafrost and glacierized areas canton BE



Source:
AG NAGEF – Arbeitsgruppe
Naturgefahren
des Kantons Bern (2015):



Permafrost and glacierized areas canton BE



Source:
AG NAGEF – Arbeitsgruppe
Naturgefahren
des Kantons Bern (2015):



Indicative hazard map canton BE periGlazial-2015

findings / assumptions

avalanches

- **large avalanches** are caused by extreme weather conditions
→ no large change expected
- **ice avalanches** in some areas higher risk due to glacier retreat during transition time

destabilisation of slopes

due to glacier retreat and permafrost degradation:

- **rockfall** more frequent
- together with higher precipitation intensities: increase in **landslide** activity
- delivers additional material for **debris flow**
- → higher sediment rates in rivers → risk of deposition in river bed causing **inundation**
- **rock avalanche:**
BE: most cases: little change in risk expected or in remote areas, highest risk by indirect processes: material for debris flow and sediment transport in rivers, impoundment of rivers, momentum waves if falling into lakes

glacier lakes: new occurring → risk of glacier lake outbursts

- new process chains are important to consider (ex. Ritzlihore Gadmen)
- largest effects for debris flow
- BE: hazard maps are robust, since most affected areas are outside of settlements, however each particular case must be assessed individually

Source:
AG NAGEF – Arbeitsgruppe
Naturgefahren
des Kantons Bern (2015):



Indicative hazard map canton BE periGlazial-2015

findings / assumptions

Conclusion

- new process chains are important to consider (ex. Ritzlihare Gadmen)
- largest effects for debris flow
- BE: hazard maps are robust, since most affected areas are outside of settlements, however, each particular case must be assessed individually

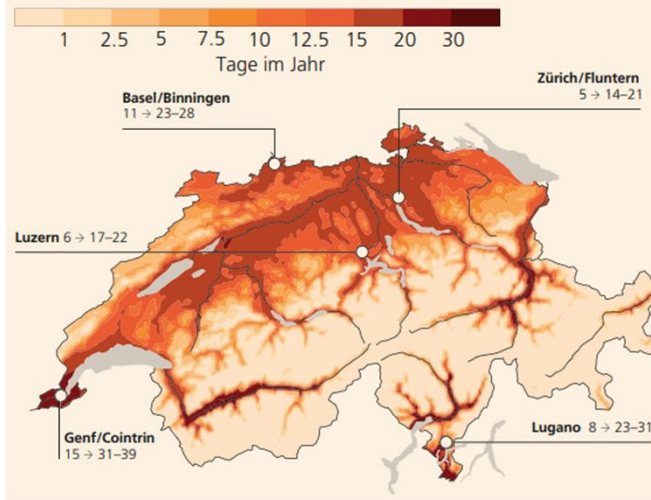
Source:
AG NAGEF – Arbeitsgruppe
Naturgefahren
des Kantons Bern (2015):



Heat

Änderung Anzahl Hitzetage

Ohne Klimaschutz erwartete Änderungen der Anzahl Tage mit Temperaturen über 30 Grad Celsius um 2060 gegenüber 1981-2010 (30-jährige Mittel). Werte zeigen die Norm 1981-2010 und den möglichen Bereich um 2060.



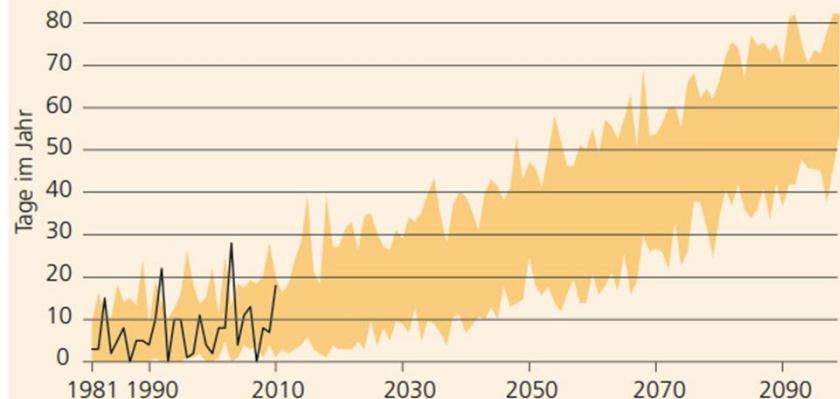
change of number of heat days

Tage mit Hitzestress in Lugano

Tage an denen sich der Körper aufgrund des Zusammenwirkens von Wärme und Luftfeuchtigkeit nicht mehr auf eine angenehme Temperatur abkühlen kann.

— Aus Messungen berechnet

■ Möglich ohne Klimaschutz (Bandbreite der Simulationen)



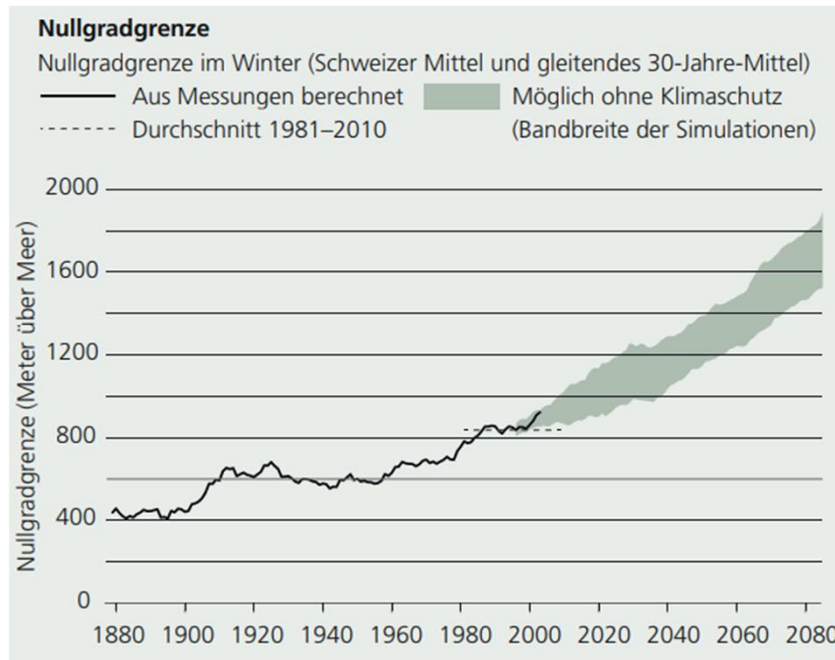
days of heat stress in Lugano

Question:

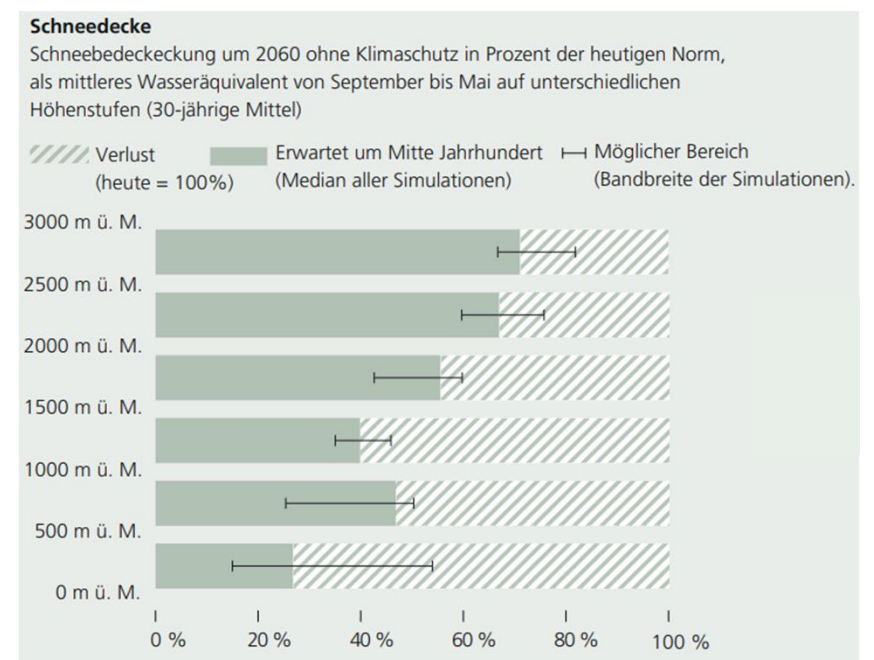
Do hot summers and nowadays possibilities of digitalization and mobile work facilities lead to move away from low urban areas to high mountain areas, which are generally more affected by many other natural hazards?



Snow and avalanches



zero-degree line



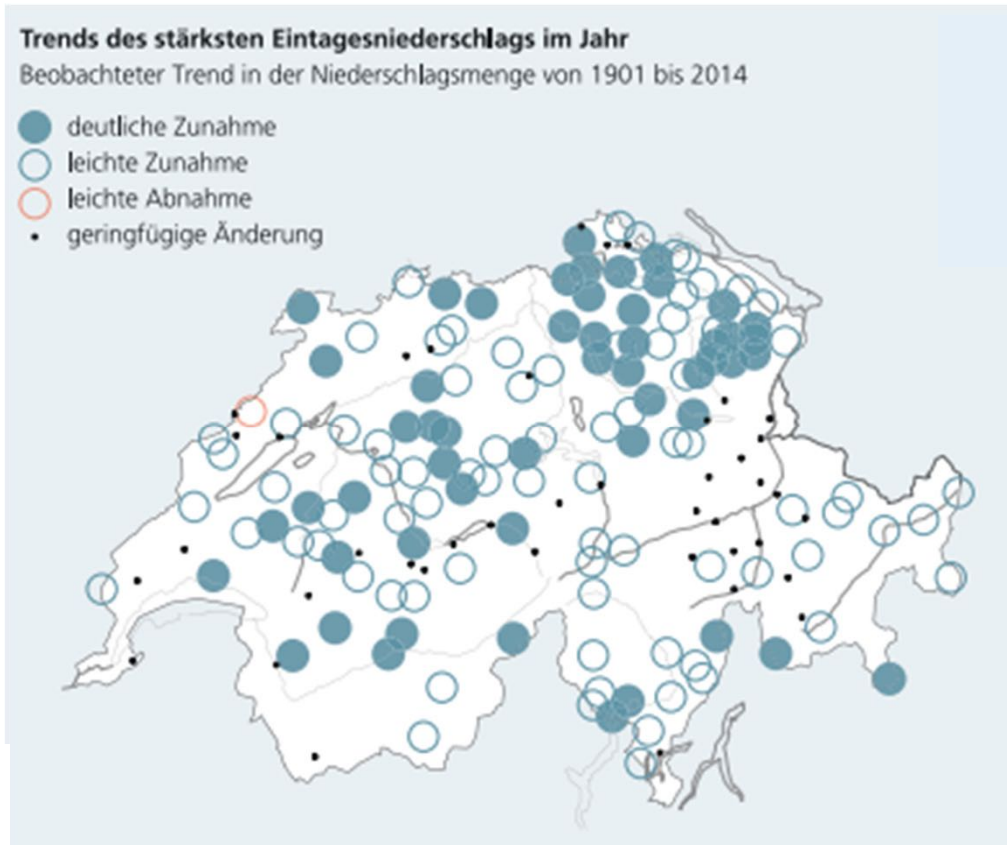
change in snow pack

processes are complex
small and mid-sized avalanches in lower areas may decrease,
large and extreme avalanches may not decrease

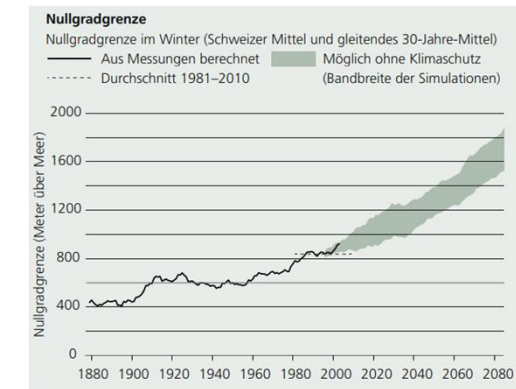
Source:
NCCS (Hrsg.) 2018: CH2018 -
Klimaszenarien für die
Schweiz.



Precipitation



Source:
NCCS (Hrsg.) 2018: CH2018 -
Klimaszenarien für die
Schweiz.



combination of

- increase in precipitation intensity
- and
- warmer temperature
(lower ratio of snow during precipitation)



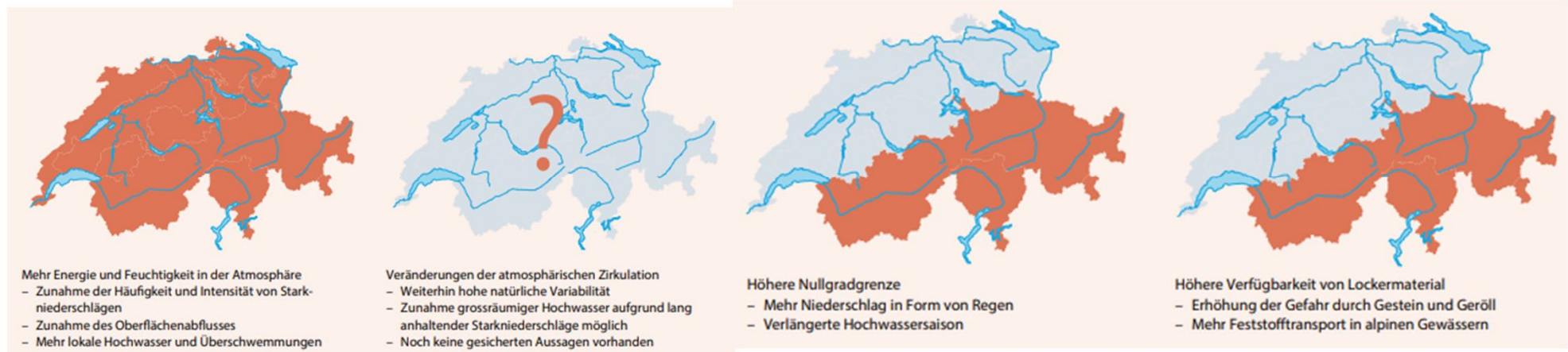
Influencing factors on flooding activities and their alteration with climate change - *Hydro-CH2018*

more energy and humidity
in the atmosphere

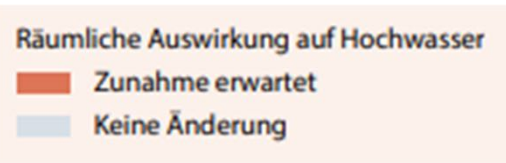
alterations in the
atmospheric circulation

higher zero-degree-line

increased availability of loose material



Source:
BAFU (Hrsg.) 2021: Auswirkungen des
Klimawandels auf die Schweizer Gewässer.
Hydrologie, Gewässerökologie und
Wasserwirtschaft.



2071-2100 compared to 1981-2010

	Mit Klimaschutz bis Ende Jahrhundert	Ohne Klimaschutz bis Ende Jahrhundert
100-jährlicher Eintagesniederschlag	+5 %	+20 %
Gletschervolumen Alpen	–50 bis –80 %	–90 bis –100 %



How can we account for climate change?

Reassessment of hazards

- as hitherto: hazard maps must regularly be reassessed, because of
 - new methods
 - new input data
 - new events
 - changes within process area
- additionally: **climate change** must be considered within reassessment



“Climate glasses”

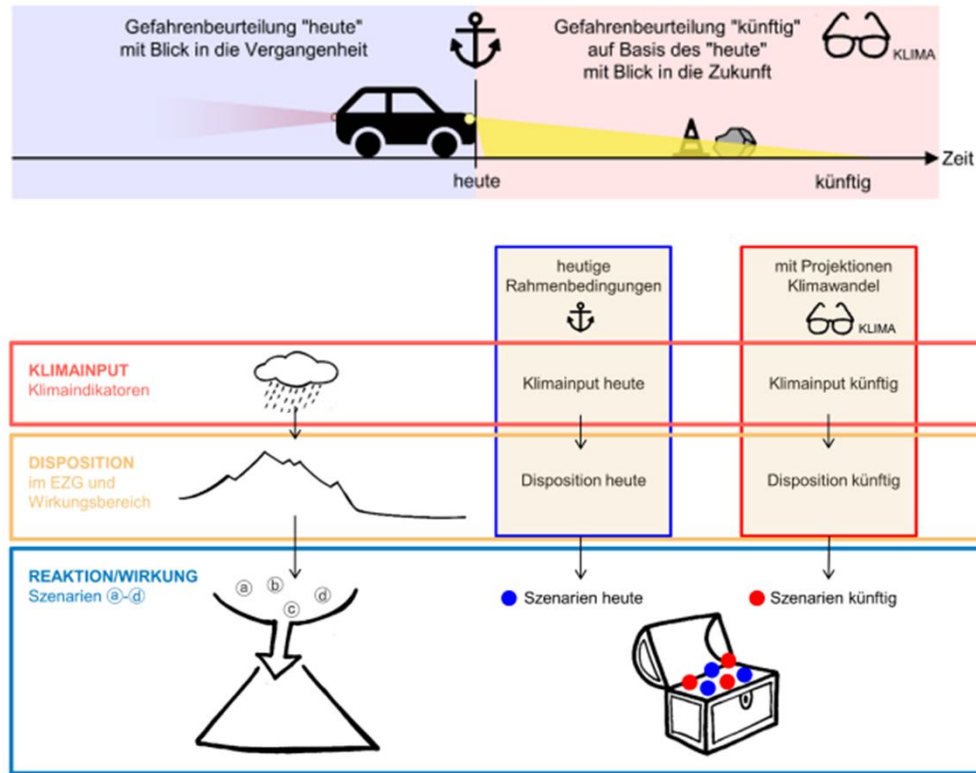


Abbildung 14: Situationsanalyse und Szenarien "heute" und "künftig" mit Projektion des Klimawandels. Resultate sind Systemverständnis und ein ergänzter Szenarienschatz.

climate indicators:

some are available as result of climate change scenarios
some are missing
uncertainty

disposition (parameters):

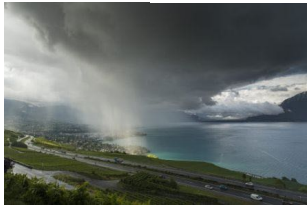
dependent on natural process:
high uncertainty of future change and influence
state and role of protective forests
methodology for use in practice still needed

process chains:

mutual dependency between different natural processes
under climate change need to be better understood



Modelling: example water processes



precipitation



climate scenario
parameters

*(climatic)
input
variables*

dry soils in
summer



antecedent
soil moisture



wet soils



bed load material

*disposition
parameters*



robust, flexible,
overload case?



flood protection dam



protective forest



sufficiently adapted
and functional?



*protective
measures*



blocking,
bed load aggregation
weak points
process chains



- scenario developments
sufficiently considered?
- new process chains?

*scenario
analysis*



inundation
debris flow deposition
impacts on result



impact analysis



Natural hazards (1)

avalanches



landslides



rockfall / rock avalanches



debris flow



dynamic inundation



static inundation



pluvial floods /
overland flow



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Natural hazards (2)

earthquakes



windstorms



hail



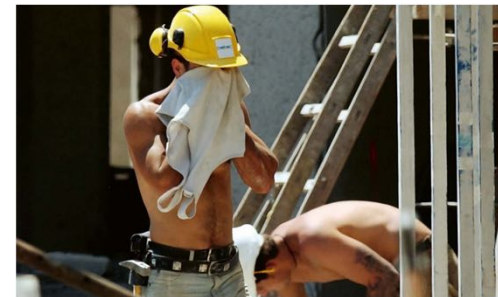
lightning



drought



heat



forest fires





Where will we live and build our infrastructure?

- hazard maps will tell us also in future about the areas of risk (frequency, magnitude of events)
- however, results of hazard and risk assessment will change depending on the evolution of the climate change scenarios (degree of climate mitigation measures, additional parameters to be simulated, reliability of scenario results)
→ future adaptations of hazard maps with decreasing uncertainty
- areas prone to natural hazards will change
- high mountain areas more affected for ex. by rockfall, debris flow, forest fires, urban areas in lower areas by heat waves



Conclusion

- natural hazard situation within Switzerland will generally become more severe
 - new areas affected
 - existing areas may face higher magnitude or frequency of natural events
- not all regions will be affected equally
- not all natural processes will change equally
- quantification difficult due to high uncertainties
- additional process understanding still needed
- basic concepts of integrated risk management in Switzerland remain
 - accounting for uncertainties
 - “think the unthinkable”
 - measures: robust, flexible, overload case
- challenges increases due to additional driver
(increasing damage potential resp. land use / higher spatial demand and now additional climate change)