Work Package 5

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NATURAL HAZARDS REPORT

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Table of Contents

CHAPTER 4

FUTURE SCENARIOS OF NATURAL HAZARDS

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Table of Contents

1. FLOODS – FUTURE SCENARIOS

1.1 Flood sensitivity and links with climate

The floods sensitivity and links to climate have already been developed in the CH1 – 1 Floods – historical processes chapter.

1.2 Potential impacts of climate change on floods

1.2.1 Flood intensity/frequency and seasonality

The simulated winter precipitation increase and the expected limited buffer effect of the snow cover (due to a higher rain/snow limit) should lead to favourable situations for floods in winter (both for intensity and frequency). These impacts would be of major importance for the basin presenting large zone at high altitude with a consequent snow cover. But on the other hand, as a consequence of the graduate snow cover melting, the intensity of the spring flood peaks would be reduced.

The river flood peak due to snow cover melting could occur a month earlier in the year.

On a global scale, during summer, diminished low waters and even droughts should be more frequent because of reduced summer precipitation and stronger evapotranspiration. Nevertheless, the rivers fed by glaciers (which represent important water stocks) may experience a flow increase in the short term with stronger glacier melting in summer. In the long term, once the glacier would have lost most of its volume (and / or surface), and so its potential water stock, the flows of these rivers would decrease. The summer flow increase has already been observed while the decrease on long term is only a strong assumption at the moment.

2. DEBRIS FLOWS – FUTURE SCENARIOS

2.1 Debris flows sensitivity and links with climate

The debris flows sensitivity and links to climate have already been developed in the CH1 – 2 Debris flows – historical processes chapter.

2.2 Potential impacts of climate change on debris flows

2.2.1 Debris flows intensity

The material availability is the critical factor that could lead a change in the future debris flows intensity. This intensity variation could lead to increased volume and stopping distance. Thus, even if the debris flows intensity can be assessed in a general manner, it is important for policy makers and technical services to also know the evolution for particular sites. The hazard areas that are linked with the periglacial area may potentially experience marked intensity changes (even if such changes have not already been observed).

Despite the important number of hypothesis proposing debris flows intensity increase with climate change, no trends has been observed, nor modelled.

2.2.2 Debris flows frequency

Model results are in good accordance with the observations in some areas (debris flows frequency decrease) because they simulate a decrease of debris flows events for a warmer climate. The often evoked increase of debris flows frequency in a climate change context, seems to be hypothetic and is confirmed neither by the observations, nor by the modelling. However, on the Alpine scale the frequency could increase in particular regions and decrease elsewhere depending on local situations and driving parameters.

2.2.3 Debris flows seasonality

Some hypotheses are also proposed concerning the debris flows activity evolution if the precipitation would increase during the transition periods (as suggested by climatic models). But this precipitation seasonal shift should not have consequences because the mean temperature during these periods would remain lower (from 4 to 7°C) than the mean temperature during the summer season (summer is the main season for debris flows occurrence).

2.2.4 Debris flows localisation

The deglaciated area and the permafrost degradation process are supposed to furnish more available materials for future debris flows activity. Moraines and active talus slopes can furnish debris flows; some dismantled rocky glaciers can also be affected by this kind of phenomenon. The trigger could occur more easily if the slope is steep in these areas. High mountain area in the periglacial zone could be more favourable to debris flows events than in the past.

3. AVALANCHES– FUTURE SCENARIOS

3.1 Avalanches sensitivity and links with climate

The avalanches sensitivity and links to climate have already been developed in the CH1 – 3. Avalanches– historical processes chapter.

3.2 Potential impacts of climate change on avalanches

Some authors propose a potential increase of the wet-snow avalanches due to more frequent and intense melting periods and an elevated snow/rain limit, but the same authors also guess that, looking at the annual mean, these changes would be almost imperceptible. Other hypotheses propose that the avalanche activity would decrease at low and middle altitudes because of reduced snow-cover while it could increase at high altitude (because of an expected snow cover increase at high altitude, as a consequence of strong precipitation increase counterbalancing the temperature rise).

Thus, it seems quite impossible to provide an overview of the evolution of avalanche activity in regards to intensity, frequency, location and seasonality in a climate change context. Some hypotheses have been proposed but the evolution proposed are not quantitative and could actually not been detected in the available data.

4. MASS MOVEMENTS – FUTURE SCENARIOS

4.1 Abstract for all classes of mass movements

The landslide activity evolution seems to be very much impacted by any change in the precipitation patterns. Intense precipitation variations would tend to impact the shallow landslides (trough the surface water runoff and stream actions), while the long term precipitation variations would impact the deep landslides (trough underground water action). The summer precipitation decrease may have a positive effect by reducing the deep and shallow landslides activity.

The rock falls seems to be insensitive toward precipitation, their activity is much more influenced by freezing/defreezing cycles. Thus, a potential temperature increase would lead to less frequent rock falls at low and middle altitude (with less freezing days) but these rock falls may also increase at high altitude (with more defreezing days).

4.2 Mass movements / Shallow landslides – future scenarios

4.2.1 Shallow landslides sensitivity and links with climate

The shallow landslides sensitivity and links to climate have already been developed in the CH1 – 4.1. Mass movements / Shallow landslides – historical processes chapter.

4.2.2 Potential impacts of climate change on shallow landslides

Shallow landslides intensity : some hypotheses propose that increased heavy rainfall, permafrost degradation and marked glacier retreat may increase the shallow landslides intensity (especially the mudflows trough increased available materials). These hypotheses have neither been confirmed nor infirmed by global observations in the Alps.

Shallow landslides frequency : the hypotheses developed in the intensity chapter (based on glacier retreat and permafrost degradation) are also valid for the event frequency. The vegetation cover disappearing after a forest fire or a storm is a cause for shallow landslide triggering. In a climate change context, such cases may be more frequent. In general, the scientists propose a shallow landslide frequency increase with a warmer climate, but these scenarios of “indirect impacts” are difficult to model and lack of sufficient time-series to calibrate and validate the models.

The scree slopes and rock chaos re-vegetation may lead to decreased slopes instabilities trough better slope cohesion. But there are not observations for the moment to validate this hypothesis.

4.3 Mass movements / Deep landslides – future scenarios

4.3.1 Deep landslides sensitivity and links with climate

The deep landslides sensitivity and links to climate have already been developed in the CH1 – 4.2. Mass movements / Deep landslides – historical processes chapter.

4.3.2 Potential impacts of climate change on deep landslides

Deep landslides intensity : each deep landslide has its own characteristics (lithology, hydrogeology, topography, vegetation, etc.) and regime of deformation. Some of them will react to precipitation increase with an acceleration of their movements. This reaction will not be systematic and will be strongly influenced by local conditions.

Deep landslides frequency : for the movements presenting sensitivity to short term meteorological parameter, an increase of acceleration phases can be expected (as a consequence of the expected intense precipitation increase).

Deep landslides localisation : as a consequence of new climatic conditions, and more especially changes in precipitation patterns, there would rather be a re-activation of old deep landslides than an activation of new deep landslides.

4.4 Mass movements / Rockf falls – future scenarios

4.4.1 Rock falls sensitivity and links with climate

The rock falls sensitivity and links to climate have already been developed in the CH1 – 4.3 Mass movements / Rock falls – historical processes chapter.

4.4.2 Potential impacts of climate change on rock falls

Rock falls intensity : some hypotheses propose a link between permafrost degradation and future rock falls intensity increase in the zones affected, but it remains difficult to propose trends for future events intensity.

Rock falls frequency : the assumptions for the rock falls propose a frequency increase in the permafrost area influenced by freezing/defrezzing cycles. Thus it is very likely the frequency would increase in theses zones but is also very likely that the frequency would decrease in lower zones.

5. GLACIAL HAZARDS – FUTURE SCENARIOS

5.1 Abstract for all classes of glacial hazards

By and large, with the general glacier retreat (and even their disappearance in some cases), potential glacial hazards should decrease in the long term. Many glacial hazards and the parameters governing their formation and their triggering remains poorly understood, thus their evolution in a climate change context is hypothetic. However, pro-glacial lakes and sérac falls from hanging glaciers are the two main glacial events that could lead to glacial hazard situation in the next years.

5.2 Glacial hazards / Glacial Lakes Outburst Floods– future scenarios

5.2.1 Glacial Lakes Outburst Floods sensitivity and links with climate

The Glacial Lakes Outburst Floods sensitivity and links to climate have already been developed in the CH1 – 5.1. Glacial hazards / Glacial Lakes Outburst Floods – historical processes chapter.

5.2.2 Potential impacts of climate change on Glacial Lakes Outburst Floods

Some hypotheses propose that climate warming (with accelerated glacier retreat and heavy precipitation increase at high altitude as expected consequences of this warming) may lead to a potential increase of the glacial lake formation, without distinction.

These conjectures are based on weak arguments because the influence of climatic conditions on supra-glacial, peri-glacial, drainpipe and confluence lakes is not clear. Only the evolution of pro-glacial lakes is clear and there would be a multiplication of these lakes with a strong glacier retreat.

5.3 Glacial hazards / Glacial water pocket – future scenarios

5.3.1 Glacial water pockets sensitivity and links with climate

The glacial water pockets sensitivity and links to climate have already been developed in the CH1 – 5.2. Glacial hazards / Glacial water pockets – historical processes chapter.

5.3.2 Potential impacts of climate change on glacial water pocket

Considering the lack of knowledge mentioned in the CH1 – 5.2 chapter, the evolution of glacial water pockets in a climate change context is impossible to assess.

5.4 Glacial hazards / Sérac falls– future scenarios

5.4.1 Sérac falls sensitivity and links with climate

The sérac falls sensitivity and links to climate have already been developed in the CH1 – 5.3. Glacial hazards / Sérac falls – historical processes chapter.

5.4.2 Potential impacts of climate change on serac falls

Serac falls frequency should not increase. There are few direct observations of this phenomenon and the predisposition evolution for this natural event is mainly hypothetical. Even if a local short term serac fall frequency increase can be extrapolated on some sites, the ice volume decrease and general glacier retreat should attenuate this increase.

6. STORMS – FUTURE SCENARIOS

6.1 Storms sensitivity and links with climate

The storm sensitivity and links to climate have already been developed in the CH1 – 6. Storms – historical processes chapter.

6.2 Potential impacts of climate change on storms

6.2.1 Tempest intensity

The water steam increase may have two diverging impacts : facilitate the water steam condensation during the clouds and precipitation formation, or help the energy tempest transfer to the high latitudes. So, the hypotheses for the tempest intensity evolution are contradictory for the moment.

6.2.2 Tempest frequency

The atmosphere warming may have contradictory consequences with a North-South gradient increased or decreased (depending on the warming if either the high or low atmosphere is more impacted) and thus a tempest frequency increased or decreased.

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