Work Package 5

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NATURAL HAZARDS REPORT

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CHAPTER 6

GAPS AND RESEARCH NEEDS

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1. FLOODS – GAPS AND RESEARCH NEEDS REGARDING CLIMATIC ISSUES

1.1 Gaps:

- Data and studies mainly concern peri-alpine large rivers, e.g. Rhône or Rhine Rivers. Tributaries of those rivers are less studied; when they are studied it is mainly as small part of a larger basin and not considering the area where they have consequences (such as Isère, Doubs and Durance, smaller tributaries basins in the larger Rhône basin). Thus, focus has to be given to the river having direct consequences for the Alpine area.

1.2 Research needs:

- Historical reconstructions of the river floods have already been developed in many countries. Such analyses provide homogeneous and quality information. European networks need to be develop to provide analysis at the alpine scale; such working groups would have to collect the data chronicles for each river and then compare them, calibrate them, to provide comparative analysis.
- Probabilistic approach based on non-stationarity (like those developed by the French Cemagref) have to be further developed. These new approaches are necessary to take into account the reference events fluctuation of river flow regimes with new climatic conditions.
- Take into account the precipitation/flows models for a better assessment of the links between precipitation evolutions and expected future floods situations.
- Hydrological models have to be developed in the future for the Alpine area. These hydrological models have to integrate as much features as possible (vegetation cover, erosion, topography, orientation, etc.) and also have to be developed with quite small space grids (few kilometres at best).

2. DEBRIS FLOWS AND TORRENTIAL FLOODS – GAPS AND RESEARCH NEEDS REGARDING CLIMATIC ISSUES

2.1 Gaps:

- The historical documents assessment for debris flows at the alpine scale is quite rare and the different event reconstruction techniques (e.g. dendromorphology) are not sufficiently developed to provide significant chronicles. Even considering a particular debris flows catchment in a particular valley, the available information (considering any event's characteristic) do not enable researchers to propose potential future evolution of the events for this area.

2.2 Research needs:

- Needs for a better hydro-meteorological measure network covering various altitude ranges and various sites.
- Needs for quantitative information concerning the unstable volumes that might be transformed in debris flows in case of heavy precipitation events (sedimentary budgets method).
- Build up homogeneous data base for the sediment volume storage in the deposit area.

Develop sensitivity indicators for both meteorological and climatic parameters (precipitation thresholds for debris flows triggering, data concerning the precipitation amounts during the days preceding the event, soil moisture, etc.).

3. AVALANCHES – GAPS AND RESEARCH NEEDS REGARDING CLIMATIC ISSUES NEEDS

3.1 Gaps:

- The avalanche data chronicles are not systematic and concern mainly the area where human stakes are threatened by the avalanche activity. They are not enough accurate to allow a trend detection (particularly because the occurrence frequency of avalanches are generally relatively low – "return periods" from some years to some decades).
- Even for the places where avalanches are observed, there is a lack of data in the triggering zone and on the avalanche trajectory. The mechanisms of avalanche triggering and flowing are not well known and the present models still need further development.
- Furthermore, there are no climatic observations connected with the avalanche data for restrained area. Thus the links between any changes in the avalanche activity and the corresponding changes in the climatic parameters are not possible to directly assess.
- Climatic parameters can be obtained from model analysis for long periods (several decades) and allow to explain trends for snow pack data. But the scale of these data is actually too large to use them for avalanches studies.

3.2 Research needs:

- Needs for a better measurement network (snow pack, meteorology and avalanches) with a good spatial density (particularly in triggering zones) and long term observations (allowing statistical modelling).
- Needs for new observation tools for a better avalanche observation (complementary to human ground network). Research should be done or continued on seismic or sonic detection, ground or spatial remote sensing, etc. Mechanical snow properties need also to be more studied in order to improve avalanche dynamics and snow pack models.

- As the avalanche activity assessment is closely linked to the snow cover and solid precipitation characteristics, it would be efficient to create shared and homogeneous data bases for both snow and avalanche parameters.
- The protection forest rule has to be further studied as it represents a "natural" and very efficient protection measure. This kind of research is already under development in different alpine countries.
- The development of models combining both the snow falls evolution, the vegetation evolution (especially the tree line altitudinal location), and the avalanche triggering/flows would help to understand in a better way the future avalanche activity.

4. MASS MOVEMENTS – GAPS AND RESEARCH NEEDS REGARDING CLIMATIC ISSUES

4.1 Gaps:

- As for the avalanche, the existing data base (at the national level) mainly deals with the event characteristics, rather than with the conditions leading to the event's triggering. Only some experimental sites can provide a full range of indicators (e.g. climatic parameter, geological conditions, etc.) that would enable scientists to assess any links between a change in the in situ conditions and any potential activity changes.
- Regarding the potential changes in the permafrost distribution and pattern in high altitude rock walls (> 2500 m a.s.l), there is a lack of observations for the rock falls occurring at such altitudes.

4.2 Research needs:

- Develop even more the existing data base and include some in situ information (i.e. climatic conditions before and during the event, human activities that may have consequences in the vicinity of the movement, etc.). This data base should be carried on by regional services under trans-national supervising.
- Develop the meteorological indicators that are relevant for the considered hazards (precipitation triggering threshold for both shallow and deep landslides, data for the monthly and daily precipitation falls preceding the mass movement, soil moisture…).
- As the empiric approach can not solely be used to assess the mass movement activity, it is important to develop numerical model in a way to implement attenuation measures for high altitude mass movements. Such kind of movement would be closely linked to permafrost degradation and glacier retreat. Thus the consequences of the evolution of both glacier and permafrost soils should be monitored considering mass movement issues.

4.3 Mass movements / Shallow landslides – Gaps and research needs regarding climatic issues

4.3.1 Research needs:

- As shallow landslides are closely related to short term precipitation patterns and daily rainfalls characteristics, the identification of precipitation thresholds for shallow landslides triggering would enable a better management of such hazards.
- The impacts of changes in factors that are not primary linked to climatic conditions, such as tree line altitudinal limit, permafrost evolution, vegetation cover evolution (especially the effect of root system to stabilize the superficial part of the slopes…) would be also interesting to assess.
- Such changes would take place in longer terms than the climate related changes but could aggravate the slope destabilisation.

4.4 Mass movements / Deep landslides – Gaps and research needs regarding climatic issues

4.4.1 Research needs:

- There is a need for a state of knowledge concerning the deep movement sensitivity to both superficial and deep hydrological characteristics (precipitation, snow falls, superficial runoff, underground runoff, etc.).

4.5 Mass movements / Rock fall – Gaps and research needs regarding climatic issues

4.5.1 Gaps:

- There is a lack of measurement in the steep slopes and rock walls presenting permafrost occurrence (most of these area are located above 2500 m a.s.l in the Alps); the evolution of permafrost patterns in such slopes is particularly relevant regarding the future rock falls activity in high altitude.

4.5.2 Research needs:

- Some links between the freezing-defreezing cycles have already been highlighted by scientific research. Such links need to be further studied for different altitude range (the studies concern mainly the middle mountain level, < 2000 m a.s.l).

5. GLACIAL HAZARDS – GAPS AND RESEARCH NEEDS REGARDING CLIMATIC ISSUES

5.1 Gaps:

- Glacial hazards in the Alps did not lead to major catastrophes during the last decades (despite existing potentially hazardous situations in the Alps). Thus the research did not focus on such natural events. However, considering the on-going climate change

and its already striking consequences on glaciers, it would be very useful to develop glacial hazards monitoring and research.

5.2 Research needs:

- The "Gridabase" database developed in the frame of the FP5 GLACIORISK program (2001-2003), including 4 alpine countries (Austria, Italy, France, and Switzerland) has to be continued. This data base is a unique piece considering glacial hazards events. However, there are still some glaciers which need to be integrated and the information forms for each glacier could be improved with maps, localisation, pictures, technical reports, etc. In other terms, such a database should evolve from an "events" database, to a "potentially dangerous glaciers" database.
- As the empiric approach can not solely be used to assess the glacial hazard activity, it is important to further develop numerical model in a way to implement attenuation measures for this kind of hazards.

5.3 Glacial hazards / Glacial Lake Outburst Flooding (GLOF) – Gaps and research needs regarding climatic issues

5.3.1 Gaps:

- The mechanisms leading to pro-glacial lakes formation are quite well understood. But all the other kind of glacial lakes formation mechanisms are not very well understood and their links with climatic parameter are not very clear.
- The processes of ice erosion under the effect of water runoff are still not well known at this moment.

5.3.2 Research needs:

- The conditions leading to the formation of most types of glacial lakes (except for pro-glacial lakes) need to be better understood.
- The behaviour of ice channel during supra-glacial lakes emptying operation needs to be better understood.
- The reaction of glacial lakes after emptying operations needs to be studied to check the state of the lake bank, of the lake dikes and emptying channel years after the emptying operation and thus the potential actions to implement (reinforcement of the emptying channel, monitoring the banks evolution to avoid sudden bursting, etc.).

5.4 Glacial hazards / Glacial water pocket – Gaps and research needs regarding climatic issues

5.4.1 Gaps:

- There is very little knowledge concerning the glacial water pockets. No methods enable yet scientists or technical services to detect this kind of phenomena. Thus, the study of glacial water pockets does not exist at the moment.
- Liquid water flows in the glacier remain very poorly understood at the moment. Some hypotheses are proposed but none of the suppositions has been scientifically demonstrated.

5.4.2 Research needs:

- The glacier liquid water runoff needs to be better understood. Some liquid water releases have already been observed but the origin of such water release has never been clearly identified.
- The data concerning the rivers fed by glaciers should be made accessible for scientific use (from hydro-power plants managing companies by example).

5.5 Glacial hazards / Ice avalanche – Gaps and research needs regarding climatic issues

5.5.1 Gaps:

- The monitoring of ice avalanches is not developed enough considering that this phenomenon is the main ablation mode for hanging glaciers and also represents a high intensity potential hazard that could be enhanced by climate change.
- Potential consequences of ice avalanches downstream (i.e. when it triggers snow avalanches or debris flows) are not fully understood.

5.5.2 Research needs:

- A numerical model has been successfully developed to predict the breaking of ice avalanches from glaciers by Swiss scientists. It would be useful to share this knowledge and accurate even more the model with other countries scientist team.
- The future development of hanging glaciers could be a key topic for future hazards in the periglacial area. Thus temperature measurements in hanging glaciers (both in surface and inside the glacier, up to the bedrock) would help scientists to evaluate the potential hazardous situations due to warming hanging glaciers.

6. STORMS – GAPS AND RESEARCH NEEDS REGARDING CLIMATIC ISSUES

6.1 Gaps:

Even if it is possible to build and analyse relevant natural events chronicles, the conclusions based on these instrumental and historical data sources would be of limited use considering the "hazardous" occurrence of natural events (the occurrence of catastrophic situations does not mean that such situations would occur in the future and catastrophic situations can occur without previous activity). However, such research work and findings is of great help to assess the potential "hazardous level" of some areas and give precious reference values (intensity, frequency, localisation and seasonality) for natural hazard management.

6.2 Research needs:

- Strengthen the phenomenon monitoring to better understand the complexity and heterogeneity of the natural systems, in order to better anticipate their evolution (for different altitude ranges for example).
- Develop the approaches based on systemic models. Such a systemic approach can highlight the relation between different types of natural hazards and also help to implement "integrated management" of natural hazards.
- Needs to further develop natural hazards observatories and experimental sites:
- With identified manager, resources, action plans
- By straightening the existing structures
- With action plans, funding institutions, operational organisations well defined and included in long term programs.
- By taking into account the propositions corresponding to these objectives in the thematic groups of the strategic project "Natural Hazards " of INTERREG IV ALCOTRA.
- Continue and improve the projects aiming to propose common data bases and common research programs at the alpine scale. Considering the important systemic interrelation and the importance of systemic approaches, such projects need also to be developed in a multi-disciplinary scheme, involving hydrologists, glaciologists, botanists, etc. The results obtained for the alpine region should be compared with the results obtained from other European mountain ranges (Pyrénées, Scandinavian Alps, Sierra Nevada, etc.).
- Improve regional precipitation thresholds knowledge considering hydro-gravitational phenomena (landslides, river floods, torrential events, etc.), especially by collecting all the information on different natural events triggered during a single heavy precipitation event.