



WP6 "Risk Prevention and Risk Management"

International Expert Hearing

"Adaptation of natural hazards management to climate change"

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Synthesis

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Introduction

Climate change has now become an accepted reality and the Alps are one of the European regions which are most sensitive regarding temperature increases (measured and modelled), but they are also among the regions where modelling the evolution of rainfalls is most difficult. These running changes raise questions for many sectors of the society on a short, mean and long term. It is often said, particularly to the general public after extreme meteorological event, that the natural hazards will be more severe, even if the statistical analysis of these rare phenomena is not easy and does not clearly allow incriminating climate changes.

The Alpine Convention adopted a “Climate Plan”, but the current local dynamics in different countries seems to vary a lot. Today, the French stakeholders (State, local authorities, managers, planners) are invited to think about the exposition of their territory to climate change and to formulate adaptation and attenuation strategies. In order to allow these different actors to start on coherent basis in the field of natural hazards related risks, the PARN carried out in 2008, an analysis-synthesis of the bibliography concerning climate change and its impacts on natural hazards within the frame of the ClimChAlp Interreg project. This knowledge platform “Alpes-Climat-Risques” is updated and available online: www.risknat/projets/alpes-climat-risques.

In order to reinforce the state of knowledge available on this platform, which is presently mainly scientific, the PARN has wished to collect the practical point of view of technicians and land managers through an expert hearing, gathering experts around the question “How does the natural hazards and risk management undergo climate change and how can it / should it adapt?”

This expert hearing is organized within the frame of the Alpine Space project AdaptAlp - Adaptation to climate change in the field of natural hazards. It is part of the European Territorial Cooperation Programme 2007-2013 (Interreg IV), Part B “Alpine Space”, Priority 3 “Environment and risk prevention”. It is 3 years long (2008-2011) and gathers 16 partners from 6 alpine countries (Austria, Deutschland, France, Italy, Slovenia and Switzerland), with the Bavarian Environment Ministry (StMUG) as Lead Partner.

The heart of the project is built around 3 technical Work Package:

- WP4: climate modelling and water regimes;
- WP5: hazard mapping;
- WP6: risk prevention and risk management.

Two main goals of the Work Package 6, in which this expert hearing is included, are (1) enhancing transnational exchange and cooperation regarding risk prevention and risk management methods and (2) providing input to the European Flood Directive and INSPIRE Directive.

The expert hearing “Adaptation of natural hazard management to climate change” targets these two goals. It is the opportunity for experts from Rhône-Alpes (France), Aosta Valley (Italy) and Wallis (Switzerland) to expose and exchange their knowledge on this theme, in order to get first a clear overview on the existing adaptation strategies, including practical aspects, and then to debate and propose recommendations for the land managers as well as the decision-makers.

The present invited experts:

Surname	Name	Institution	Origin	Land manager / Scientist	Function / speciality
Arborino	Tony	Canton Wallis	Sion, Wallis	Land manager	Canton specialist for flood – 3rd correction project of the Rhône river
Baillifard	François	Commune de Bagnes	Bagnes, Wallis	Land manager	Municipal geologist
Bard	Antoine	Cemagref	Lyon, Rhône-Alpes	Scientist	Probabilistic analysis of high water levels
Bardou	Eric	CREALP	Sion	Scientist	Geology/geophysics
Berger	Frédéric	Cemagref	Grenoble, Rhône-Alpes	Scientist	Protection forests
Besson	Olivier	BE Tissières	Sion	Engineer	Protection works
Curtaz	Michèle	Fondation Montagne Sure	Courmayeur, Aosta Valley	Scientist	High mountains (glaciers, permafrost)
Deline	Philip	EDYTEM	Chambéry, Rhône-Alpes	Scientist	Permafrost, rock glaciers
Eckert	Nicolas	Cemagref	Grenoble, Rhône-Alpes	Scientist	Avalanches statistics
Einhorn	Benjamin	PARN	Grenoble, Rhône-Alpes		Natural hazards/risks
Favre-Bulle	Guillaume	CREALP	Sion, Wallis	Scientist/engineer	
Gillet	François		Grenoble, Rhône-Alpes	Moderator	Natural hazards/risks
Lang	Michel	Cemagref	Lyon, Rhône	Scientist	Probabilistic analysis of high water levels
LeBidan	Valentin	Conseil Général Isère, Service des Routes	Grenoble, Rhône-Alpes	Land manager	Roads network in Isère ; Responsible for natural hazards
Lievois	Jérôme	RTM	Annecy, Rhône-Alpes	Land manager	Natural hazards in mountain areas
Lescurier	Anne	Conseil Général Savoie, Service Risques Naturels	Chambéry, Rhône-Alpes	Land manager	Roads network in Savoie ; Responsible for natural hazards
Mayoraz	Raphael	CREALP	Sion, Valais	Land manager	Geologist
Pasquier	JB	BE Geoval	Sion, Valais	Engineer	Protection works
Peisser	Carine	PARN	Grenoble, R-A		Natural hazards/risks
Richard	Didier	Cemagref	Grenoble, R-A	Scientist	Debris flows, avalanches
Rouiller	Jean-Daniel	Canton Wallis	Sion, Wallis	Land manager	Canton Geologist
Stévenin	Hervé	Region, Hydrogeological planning Directorate	Aoste, Aosta Valley	Land manager	Geologist
Vincent	Christian	LGGE, Université J. Fourier	Grenoble, R-A	Scientist	Glaciers and glacier-related risks
Voyat	Iris	Fondation Montagne Sure	Courmayeur, Aosta Valley	Scientist	Natural hazards/risks

Questions asked to the experts

Two main questions have been asked to the experts:

Q1: What are the present lacks, in terms of data, structures, organization...?

Q2: Which adaptation strategies are possible and what are the difficulties to implement them?

For answering these questions as completely as possible, the statements and talks were organized around three themes:

T1: The data about the natural phenomena

T2: The vulnerability of the territory

T3: The information to local authorities and the general public

The integral transcriptions of the presentations and the discussions on which this synthesis is based and to which it refers by interactive links are also available online on the PARN website (in French): www.risknat.org/adaptalp/expert_hearing_wp6/.

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A. Statements

1- Theme 1: the data about the natural phenomena

All the invited technical services in charge of risk management related to natural hazards observe, an **increase in the frequency of intense meteorological phenomena**, even if they often cannot really quantify it: heavy rain falls, great temperature amplitudes within short time laps (heat waves, droughts, intense frost/thaw periods). The impression is that many meteorological events are more violent and can be very local, which makes them very difficult to forecast. These phenomena trigger an apparent intensification of the mud flows/debris flows, an increase in the erosion processes (CG73, ex. Valloire, Pralognan, Champagny, CG38), as well as a modification of the period when some phenomena occur (rockfalls in winter, avalanches earlier in the season). The land managers now await some sites to react more intensively and more rapidly to meteorological events (ex. CG38).

In a general way, they all agree that the extreme values are more susceptible than the mean values to impact the phenomena that can generate risks.

In order to lay down the scientific knowledge concerning the evolution of natural phenomena, an expert of each sector presented a brief synthesis, which was followed by discussions with the round of experts. The highlights of these exchanges are summarized in the next paragraphs.

1.1. Impact of climate change on the rivers' rates of flow at the scale of the Alps ([A. Bard](#))

Analyzing series of rivers run-off, within the frame of the AdaptAlp project (WP4), does not lead to any significant tendency at the scale of the Alps. However, the study has underlined coherent and statistically significant evolutions for glacial or nival regimes alone. These evolutions seem to be closely linked to the evolution of observed temperatures, with an earlier date of glacial and nival melting. These results show that there is no general response: cases have to be considered individually.

Globally, with the existing statistical tests and taking into account the great natural variability, it is not possible to conclude about a significant increase of the intensity or frequency of the events: either the tests are not successful enough to detect them, or there is no present tendency.

1.2. Use of climate models for hydrological modelling ([M. Lang + Discussion](#))

The main result concerning hydrology is that climate change increases the uncertainty but doesn't challenge the different steps used for managing the flood risk.

It is necessary to learn working with this supplementary uncertainty, which only comes upon some other already existing ones (among other in the climate models and their capacity to reproduce the present climate).

If many studies (with their uncertainty ranges), suggest for the oceanic regimes a light worsening of winter rain falls and more noticeable droughts in summer, it is much more difficult to say anything about the evolutions in the Alps, which lie on a crossroad of different influences. An important difficulty comes in particular from the different spatial and temporal scales between the climatic models and the hydrological models: the present spatial-temporal resolution of the climatic models makes the forecast of intense phenomena at a local scale uncertain. Many research studies, with a reinforcement of collaboration between hydrologists and climatologists, should enable progresses on the spatial disaggregation techniques: resulting outputs from the climatic models, available at a better resolution, will be more adapted to the scale of the hydrological models that are pertinent for the risk managers.

1.3. Evolution of the vegetation cover

According to the French forest experts, the upper forest limit has been displaced 200m higher up within a century, with a modification of the structure of the vegetation stages (broad-leaved trees on higher altitudes). The increasing temperatures due to climate change have triggered a modification of the composition of the vegetation cover, which should go on. This new repartition of the species can have consequences on the vegetation ability to catch water, as well as on its protection function against rock falls or avalanches, because of the different mechanical resistance of the species.

1.4. Impact of climate change on torrential flows/ debris flows ([D. Richard + Discussion](#))

Torrential flows are constituted by both water and sediments. They are characterized mainly by their sediment part.

For the liquid part of torrential flows, as well as for river flows, no significant evolution linked to climate change has been detected. The experts note that the lack of hydro-meteorological data is even worse for torrents than for rivers with bigger catchment areas. The phenomena of violent and localized meteorological events, which could be emphasized by climate change, already exist for debris flows, in parallel to larger scale phenomena; there is no element for predicting the potential evolution of the ratio between these two types.

Concerning the sediment part, of which debris flows are mainly constituted, the most noticeable effect is the appearance of new sources of sediments that can be mobilized due to the permafrost melting in some areas (this phenomenon is directly linked to temperature increase, ex. Glacier Bonnard in Wallis, [E. Bardou](#)).

The possibility that new sediment sources appear due to glacier melt is less clear; the volumes seem to vary depending on the underlying surface the melting glacier leaves free, bedrock or material that can be mobilized (moraine, crushed material). For example, in Chamonix valley, only the Glacier Griaaz causes such problems, as the other ones melt back on a very competent basement. In the long term, the evolution of the forest cover could also have an impact on the ability of torrents to mobilize sediments, either in the way of increased erosion or in the other way with stabilizing effects. Varied combinations of processes (with effects amplifying or cancelling each other) could give birth to contrasted scenarios. Generally, except the cases linked to permafrost melt, it is currently difficult to forecast a tendency in the oncoming evolution of the material supply for the torrents.

Finally, taking into account the combination of water and sediment responses, the response of a torrential system to a climatic forcing (relation rain fall/ run-off) is more variable than for a classical catchment area (exact localization of the rain fall, focused on one small catchment area or straddling many ones; temporary snow stocking susceptible to vary due to temperature variations in the medium altitude range). As a consequence, it seems that the tendency linked to potential climate changes is even more swamped by the existing natural variability in the case of torrential systems than for classical catchment area. This natural variability can also be accentuated by eventual human influences linked to evolution state of the protection works.

But in practice, for managing the torrential risks, the determining meteorological elements that must be taken into account are the extreme phenomena more than the mean tendencies. Even if there is a confirmation of the scenarios most commonly quoted – a mean increase of precipitations in the winter season and droughts in summer periods – the way of managing torrential flows / debris flows should be potentially modified only in two cases:

- If winter rises in water run-off (potentially more numerous and intensive than before) become more intensive than those occurring nowadays in spring and summer;
- On the contrary, if summer storms - potentially rarer -, become less violent than those of today.

At the moment, the preventive methods for managing the torrential risks do not take into account other exceptional events than those already known.

1.5. Impact of climate change on glacier-related risks ([C. Vincent](#))

Three types of glacier-related risks can be distinguished:

- Serac falls
- Glacial lake outburst flood (lake on the glacier or in front of it);

- Outburst flood from “water pockets” located into the glacier or under it. In the case of Tête Rousse, the cause of the retention of the water is relatively well-known: the glacier tongue has a negative temperature (-2°C) whereas the glacier is temperate in its upper part (polythermal glacier). Thus, the water which seeps into the glacier and reaches the bedrock is trapped into the glacier.

These phenomena are extremely destroying when they occur, but they are rare: the scientists as well as risk managers have only limited experience of them.

The main effects of climate change on these glacier hazards are:

- (1) Impact on the formation of proglacial lakes, in front of melting glaciers; ex. Arsine glacier: the level of the lake had to be lowered down to avoid a potential outburst of the moraine dam;
- (2) Direct impact of the increasing temperatures on the **stability of hanging glaciers** (ex. Taconnaz seracs in the Chamonix valley).

The impact on “water pockets” and supra-glacial lakes is much less evident to understand (indirect relationship between these phenomena and the evolving climatic parameters) and much less clearly observed (this doesn’t mean it doesn’t exist).

Many research tracks could allow improving the knowledge about glacier-related risks, in order to improve the diagnosis. However there are many difficulties: scientific ones (multidisciplinary approaches, the theme “risk” is not a central one in the laboratories), technical ones (specialized geophysical competences), organizational ones (need of a prompt reactivity in case of crisis, need of means allocated to research and to prevention).

About the inventories:

In France, there is no real up-to-date inventory of the present state of the glaciers. A huge work is being done on the “glaciers cadastre” in the GlaRiskAlp project, but the existing inventories of glacial phenomena are partly inappropriate from a scientific point of view (scarcely useful to the understanding of the phenomena, need to deepen the studies on the geophysical phenomena to better anticipate their evolution and thus avoid crisis situations).

The Aosta Valley, which targets a detailed and systematic control of its territory, owns the instrument “Glaciers cadastre”: it includes an inventory with the history of glacier-related phenomena and, since 2011, 2 new sections about glacial lakes and rock glaciers.

In Wallis, the canton has identified about 30 glaciers at risk after the project GLACIORISK. For the systematic survey, the hydroelectric companies can easily observe changes in the regimes and potential displacement of the flows getting out of the glaciers, as they directly concern their activity.

From an operational point of view, the problem lies on two points:

- On the one hand the links lack between the results of the inventory projects (e.g. GLACIORISK) and the risk managers taking them into account;
- On the other hand this inventory should be perennial and updated. The French state, disengaging itself from some of its former statutory missions, rises the problem of financing this type of survey. But a well-used inventory is normally the base for funding this problematic.

For the early and anticipated detection of hidden glacial phenomena, even if the tools are available for investigating precisely the presence of water pockets inside the glaciers (Georadar and Proton Magnetic Resonance), is it nowadays impossible to think about generalizing the prospection to all the alpine glaciers. However, some criteria could be used to establish a hierarchy of the sites susceptible to these glacial phenomena:

- The absence of any under-glacial torrent getting out of the glacier at its front is an important clue – but not infallible – that an intra-glacier water pocket may form;
- The vulnerability downstream the glacier could be taken into account.

The combination of different criteria could lead to a management system equivalent to the classification of the “Sites sensibles aux avalanches” (Sites Sensibles aux Avalanches, a French tool carried out by Cemagref with a formal covenant with the Ministry of Environment – DGPR). A work of this type is

being carried out for the glaciers at risk in the frame of the project GlaRiskAlp, program Alcotra France-Italy).

In France, knowing who finances such inventories is a major problem because of the State's disengagement. A. Lescurier thinks that it could be an option that the technical services could allow a specific budget for the scientific follow-up, under the condition that the scientists evaluate their needs quantitatively.

In the Aosta Valley, all the glaciers of the territory have been classified according to their level of danger, on the base of the glaciers cadastre, the vulnerability and the history of events, in order to point out the sites to control as a priority.

1.6. Impact of climate change on the avalanches (N. Eckert + Discussion 3)

The avalanche phenomena are controlled rather directly by meteorological conditions (recent snow falls, metamorphism of the snow pack, etc...) and thus potentially by the climate. However, it is difficult to quantify the response of the avalanche activity to climate change: collecting data is difficult, which triggers a lack of long enough data series, the avalanche types are various, the controlling factors are complex, different space and time scales can be intricate, the statistical methods must be improved and better supplied with data.

The main results come from (1) the analysis of direct data (based in France on the Permanent Avalanche Survey, real observatory maintained by forestry technicians since the beginning of the XXth century), (2) indirect or "fossil" data, mainly issued from geomorphologic observations (dendrochronology and measuring of lichens), (3) simulations of the snow pack evolution, for recent periods as well as for scenarios of change based on climate projections.

These results show:

- on some places, the absence during the last tens of years of major avalanches that used to occur during the Little Ice Age: this would tend to confirm that the avalanche activity is to some extent controlled by the climate;
- a possible increase of the proportion of wet snow avalanches compared to dry snow avalanches. This result could have consequences on the risk management, since the kind of snow influences the flow regimes and thus the distances the avalanches can reach.
- a relative maximum, despite a high inter-annual variability, of the number of avalanches observed each winter around 1980, followed by a decrease of the avalanche number. The same tendency is even amplified regarding the lower altitudes reached by the avalanches where they stop, which show a relative minimum around 1980.

The relative increase of the avalanche activity over the period 1960-1980 could correspond to colder winters, well documented by other climatic indicators. The decrease of activity during the years 1980-2005 is part of a noticeable warming period. On the contrary, even if not enough time has passed, colder winters have been observed since 2005, with more avalanches of high intensity (December 2008 in the French Southern Alps and Haute-Maurienne). Cemagref is carrying out studies with Meteo France to better understand these evolutions and relate them directly to the evolutions of the snow pack at a winter timescale.

In conclusion, the climatic control of the avalanche activity on a long time begins to be well documented, even if it is still an emerging research theme, the results of which have accordingly to be considered with precaution. On the contrary, there are up to now very few elements concerning the evolution of shorter periods of intense avalanche activity, in particular their response to more intensive winter precipitation as assumed by climate change models: the problem is certainly more complex.

For some technical services (CG73, CG38), the most significant element is the modification of the time of occurrence of small avalanches originating from road embankments: they occur more and more in deep winter, as soon as a frost/thaw event occur, whereas they used to occur more from March on, during snow melt periods.

In terms of risk avalanche management, it is important to distinguish well the tendencies, observed through longer or shorter temporal windows, from the individual events there are made of: if some tendencies indicate a decrease in the frequency and/or distance of the avalanches, exceptional phenomena will always go on occurring at the scale of a century

The management adaptation depends on the time laps considered. The response is different for the time laps of daily management of the avalanche risks on skiing areas and for land use planning, for which a longer observation window is needed for decision-making. In practice, some municipalities have already raised the question, particularly in the French Southern Alps: they would have liked to consider that the climate warming would make the avalanches disappear at lower altitudes and so allow the building of houses (referring to studies about the diminution of the snow pack at low altitude, Col de Porte near Grenoble – France). But even if the global warming continues and leads to a diminution of the snow pack and the avalanche frequency, avalanches will go on occurring as they used to during cold and snowy periods, even very short (ex. avalanche Col du Coq, 1400m, 2 fatalities in December 2010).

It is thus particularly important to let the decision-makers understand that the observation of a tendency (decrease of the maximum extension of avalanches since the 80th) **does not however allow to change the planning rules** (it is even more tempting to extrapolate from a short observation window since land use planning highly influences the land value).

1.7. Impact of climate change on high altitude rock falls / rock slides and permafrost degradation

([P. Deline](#) + [Discussion générale 2](#))

The study of the relation between high altitude rock slides and permafrost degradation due to climate change is related to:

- A proper knowledge of the permafrost, which is not visible (localization, distribution in depth and evolution);
- A precise knowledge of the relation between the occurrence of rock falls / rock slides and the potential permafrost degradation;
- An appreciation of the evolution of the frequency/intensity of rock falls/rock slides over time (taking into account if possible biases linked to the increasing interest for these phenomena and the improved observation means).

The historical analysis of the events in the Chamonix valley (west-side of Drus peak and north-side of "Aiguilles de Chamonix" peaks; photo analysis over 150 years) has pointed out two periods showing an increased frequency of events: the first one during the late 40th – early 50th, then a second one from the 80th on (increase of the number and volume of events).

The correlation is strong to the warmest periods observed in Chamonix in the XXth century: maximum mean temperature in 1947, high increase in mean temperatures (annual and over summer) during the two last decades.

For the present rockslides, an analysis by a network of observers on both Italian and French sides of the Mt Blanc massif (2007-2010, projects *PERMAdataROC* and *PermaNET*) has shown a good correspondence between the event and the warm periods (ex. Between August the 10th and early September 2009, or during the first 3 weeks of July 2010).

Analyzing the satellite images shows a similar tendency (comparison warm summer 2003 / summer 2009).

Even if the observation series is rather short, the relation between high altitude events and the climatic-meteorological conditions under which they occur, which has been pointed out over the last 150 years, is also **valid for much shorter time laps**.

More precise studies are in progress in order to better understand the rock slide processes and their relations to the evolution of the temperatures measured in the rock walls (by laserscanning and sensors in the rock), linked to a study about the permafrost (*PermaNET* project at the Aiguille du Midi, permanent measures of the rock temperatures).

For the rock falls in high altitude areas, where there is permafrost and thus a special sensitivity to heat waves, the rise in temperatures leads quite clearly to a rise in the events frequency. Even if high intensity events have been observed during summer 2003 (particularly in Switzerland), the data are not yet sufficient to conclude about the impact of evolving temperatures on the volumes. The duration of the heat wave could have an effect, but complex water seepages come upon the permafrost degradation.

However, a large part of the rock falls which create risks for the territories (danger for roads and houses) occur at lower altitudes and originate from areas affected by frost/thaw phenomena.

For rock falls in general (whatever the altitude), a study from RTM shows that **the frequency of the phenomena varies according to climate conditions (maxima in 1999 – cold winter- and 2003 – hot summer), whereas the intensity seems to be stable.** The technical services daily notice (CG73, CG38):

- An apparent augmentation of the block falls phenomena, even in wintertime; this observation has to be moderated by 2 remarks:
 - o The awareness about these problems has raised (more events are reported along the roads, in particular thanks to users' phone calls – influence of mobile phones);
 - o In Wallis, the number of interventions related to rock falls rather tends to decrease; this could be partly due to the multiplication of protection works.
- The longer the frost periods, the more numerous the rock falls when thaw comes (difficult to quantify): longer cold waves penetrate deeper into the rock, allowing larger volumes to be mobilized when it thaws.

Around the same idea, CG73 and CG38 notice a rising number of superficial landslides and erosion phenomena, but no remarkable evolution concerning deep landslides.

In terms of preventive risk management of rock falls, this evolution raises **the question of the frequency of the reference phenomenon** (rather than its volume) that must be considered for the design of protection works.

2. Theme 2: the territories vulnerability

In a general way, the land use has changed in the last tens of years; it has almost everywhere increased, generating an increase of the situations at risk. In particular, the cities, where elements at risk are concentrated, have got a higher vulnerability when facing a constant hazard (F. Gillet).

The problem of vulnerabilities, which has to be taken into account in parallel to the hazards for risk management, does not only concern the physical vulnerability of people and goods, but also:

- The functional vulnerabilities of public buildings: hospitals, schools, administrations...
- The vulnerabilities of all the networks (communication, energy), which can cause severe troubles when they are disorganized, especially in the areas where the population concentration is high;
- The organizational vulnerabilities.

The climate change is one element among others which should stress the land managers to take more care of these vulnerabilities: in terms of management, it is essential to know how to reduce them, or at least to stabilize them, whereas in practice they go on increasing (new building permits).

In the Aosta Valley ([H. Stévenin](#)) the administrations do not yet have any real vulnerability maps. The **municipality is in charge of evaluating the vulnerability on its territory** for the definition of the Civil Protection Plans, which are theoretically compulsory in any municipality but in practice need much more work (4 pilot municipalities work on this point).

The Region wishes it would come to an integration of the civil protection plans at a regional level, in order to manage inter-municipal crisis situations: an important improvement should take place within the next 10 years.

In France ([Discussion 3](#)), it is still very difficult to collect the data in their various forms. Information exists but it is spread in many services: for example, the General Councils (CG) have a mission for road management but also a mission for public buildings, another one for high schools, for road transports, each of them in a different directorate; but the circulation of data between the directorates is difficult. It is even more difficult towards external users, such as scientists for whom these data would offer new opportunities to calibrate their models (ex. from A. Lescurier: the data base Risk from CG73 is not at disposal because of responsibility matters).

Moreover, in France and in Italy, the **insurance system** does not allow to access to data very useful for the economical definition of damages to goods, activities and people, contrary to what is feasible in Switzerland.

The theme of vulnerability also raises the question of the risk acceptance. In some regions, the risk is very well accepted. For example in the Bourne gorges (Isère, F), elected representatives and citizen wish the protection works would be limited. But generally in the Alps, **the risk culture has decreased**, partly because of population mixing (arrival of urban population in mountain areas, more or less independent on climate change). There are many examples that show how these new populations tend to look more for responsible people in case a destroying natural phenomenon occurs: Evolene avalanche – Vs, Bourne gorges – Isere (striking contrast with the acceptance of the local population cited above). In Italy, it seems according to I. Voyat that this risk culture doesn't exist at all, even for local people: the land manager must guaranty 100% protection. Justice reacts always in the same way than the population who search for a responsible person.

The notion of risk acceptance can also be related to the problem of the **acceptability threshold** which needs, according to all the experts, **a clear position from the elected representatives**.

Reducing the people's vulnerability

Nowadays, in most cases, the citizens almost don't contribute to risk management policies ([Discussion 4](#)). In particular, the majority doesn't know how to behave when facing a natural hazard (ex. Mud flow in Grand Bornand – Haute-Savoie, 1987). Only the populations who are subjected to repetitive events – floods, cyclones in the French Antilles- begin to know how to react. It is therefore necessary, if we think we could face in the future a higher frequency of potentially damageable extreme events, to handle this question more deeply than it has been done up to now.

Even with good quality information, it is difficult to let the adults' behaviour change. It seems to be more efficient to **target the education of the children**, who are more receptive (example of waste sorting). Nevertheless it seems important to train the whole population to crisis management thanks to practical exercises, as in Japan for earthquakes.

The planning rules and the interdiction of building or not in areas at risk are also essential. In Wallis, a law on land use planning forbids building in a zone of danger and a law on construction details that building in a zone of danger is possible only after a favourable advice from the cantonal expert. Out of 560 advices T. Arborino delivers yearly for projects in flooding areas, the greatest part forbids buildings, in order to avoid an inflation of the vulnerability (independent from climate change) which leads to an inflation of the protection works.

3. Theme 3: information to the public and the local authorities

The discussion about information mainly concerned during this expert hearing the information to the public.

3.1. State of the art on the information to the public:

In the Aosta Valley ([H. Stévenin](#)), the mayor must legally inform the citizens about the risks on the municipal territory, which is a difficult task for an elected representative. Its responsibility is lowered before a court if he has fulfilled this information duty.

As the information bulletins are often not well understood by the broad public, communication experts are sometimes employed to make the message more concrete, with the objective of not being uselessly alarmist while giving proper information.

At the moment, the communication about natural risks does not deal with the possible impacts of climate change.

In France ([Discussion 4](#)), all the Risk Prevention Plans, as well as the planning documents (Local planning map - PLU) are submitted to a public enquiry: the public is henceforth informed at this occasion. The mayor must then implement a municipality safeguard plan (PCS), which defines measures to be undertaken and notably the rules the citizens must apply at the individual level. The PCS is completed in school buildings by a particular plan for ensuring the security of pupils and workers (PPMS): this plan seems to be promising, since children are a good vector for cultural change and society adaptation.

Moreover, the mayor of a community exposed to risks (about a third of the 36.000 French municipalities) must regularly inform its inhabitants, more or less every two years. This obligation (law 1987, modified) allows among others new inhabitants to be informed as well as those who had taken part to the initial public enquiry during the elaboration of the Risk Prevention Plan.

On the other hand, when buying or renting a good, buyers and leasers must be informed by the seller/landlord or the notary about the risks the good they buy/rent is exposed to: the displaying of risks must be appended to the sale contract or rental agreement. This rule applies up to the camping places, where the owners must display the risk exposition for the holidaymakers who rent a place.

The direct information to the citizen seems very important to avoid reinforcing the people's feeling that the risk is a State's matter, to the detriment of the feeling of individual responsibility.

These rules are not related to climate change. Maybe some climate related information could be provided also if reliable hypotheses or observed trends were available concerning the evolution of natural hazards, which is today not the case.

In Wallis ([Discussion 4](#)), the projected zones of danger (hazard map) must be submitted to a public enquiry, with possibility of opposition, which generates to important public debates. This recent obligation follows a judgment of the Federal Court which pointed out that the possibility to oppose to an administrative decision which wrongs him is a fundamental right of the owner.

Concerning communication, Japan is an interesting example, where any new inhabitant receives personally and with acknowledgement of receipt the hazard map of the area where he lives, coupled with information about the evacuation system in case of problem. This example should lead us to think about the feasibility to inform systematically the population about the behaviour rules in case of danger (T. Arborino), with a focus on associating information about hazard maps / Risk prevention plans and behaviour rules.

Finally, for F. Berger, it is important to let the population understand that it has rights but also duties regarding risks. Example: anyone has the right of attacking a hazard map before a court, but the duty to behave civilly, by informing other people in case of occurrence of phenomena and by adopting the proper behaviour.

3.2. Role of the medias:

Climate change is not a new phenomenon (it has been known for 150 years); but people have been recently aware of it. According to J. Liévois, **the massive arrival of Medias and of speeches around this theme is the real novelty for the managers and stakeholders of natural hazards prevention, much more than the evolution of the hazards themselves.** The political world has similarly progressively understood the mobilizing effect that the security speech can have in this field. But different social actors can have different temporal references for answering this societal demand:

- The population wants to be protected and comforted immediately and continuously;
- The medias display their "products" often in a seasonal way and renew regularly their subjects;
- The scientists make their knowledge progress, but irregularly, depending on their pluri-annual programs and available funds;
- The politicians, who decide the funding, want as far as they are concerned to get results rapidly.

The communication problems encountered by practitioners and risk managers can widely result from these different time scales considered by different players.

However **the different roles the media can play in different countries** must be underlined. After J.D. Rouiller, in Switzerland the technicians communicate directly with the journalists; this allows to pass on messages and to repeat them according to circumstances. This is also an efficient mean of raising the public awareness of the risk management policies. It seems that in France and Italy the technicians and politicians communicate with each other but don't use the media enough for informing the population regularly.

Many other aspects related to information were not dealt with during the debates. The following questions for example would be worth being deepened:

- Can the level of information obligation be a base for adaptation strategies?
- At each step of the risk management cycle, is the information chain efficient and complete enough to be able to adapt itself rapidly (in case of crisis management)?
- What about the new technologies which enable rapid real time information?

B- Questionings

1. Question 1: identifying the lacks/gaps

Taking into account the synthesis of the available and published knowledge, reinforced by what has been stated earlier in this document, the experts point out a series of aspects that are not yet developed enough to make a complete diagnosis on the impacts of climate change on the different natural mountain hazards and the related risk prevention/management, obligatory step before the definition of pertinent adaptation policies.

1.1. The data

According to all the experts, the first evaluations available on already observed changes (see § *Phenomena*) are not sufficient to make previsions for the future, as the hypothesis are still too often qualitative.

Therefore, there is still now an important lack of data on the natural phenomena: in order to consider adaptation strategies, the actors of risk management feel the need to analyze **larger and more homogeneous data series, spatially as well as temporally**.

Efforts in progress

In the Aosta Valley, some works are dedicated to the improvement of the meteorological network, particularly in high altitude (from 16 stations in 2000 to 110 station in 2010)

In Savoie, the General Council (CG73) has invested in a network of small pluviographs: the Flowcapt stations (initially designed for monitoring the snow transport by wind) have been completed with pluviometers to intensify the survey network and improve the covering of sectors that are known for being sensitive to heavy rainfalls – superficial landslides, mud flows... ([A. Lescurier](#)).

In Wallis, some sites are continuously surveyed in details, in the frame of research programs (ex. glacier Bonnard, [E. Bardou](#)).

The most evident lacks :

- Few historical data on the run-off ([M. Lang and A. Bard](#)). Moreover, it is difficult to rebuild the natural run-off of rivers that have been influenced by human activities for a long time (hydro-electrical uses, irrigation...);
- Lack of pluvio-hydrometric stations on mountain massifs, already stated for some years ([D. Richard](#)). The lack of hydro-meteorological data is even more severe for torrents than for larger catchment basins;
- Few data in high altitude, particularly for quantifying the snow depth ([H. Stévenin, A. Lescurier](#));
- Lack of appropriateness between the quality/quantity of data and the capacity of existing tools (ex: sophisticated rock fall models are applied on DTM with an insufficient 10m resolution);
- Difference of scales between the available data and the decision / action, in spite of efficient measure networks ([H. Stévenin](#));
- Data exchange still insufficient. The exchanges are easier within public structures (in Aosta valley, [H. Stévenin](#)), but they still present difficulties, because of different data formats and problems linked to data property. These exchanges must be reinforced:
 - o At a regional level, collaboration with the hydro-electrical companies;
 - o At an alpine scale, thanks to Interreg projects facilitating transnational exchanges.

The inventories

The notion of inventory is not always well enough defined: does it cover a data base, an information system?

Some inventories of natural phenomena exist, such as the glacier cadastre in Aosta Valley). Nevertheless for many of them, initiated in the frame of short-term projects, the organization after the project's end is a recurrent problem for the inventory to be maintained and updated (ex. Inventory of glacial phenomena in France initiated in the GLACIORISK project).

A. Lescurier notices the lack of links between the results of an inventory (here GLACIORISK) and the managers taking them into account.

Need for an observatory of natural phenomena

In a general way, all the thinking converges to the idea that it is necessary to **increase the measure network**, but also to **centralize all the pertinent information in an adequate observatory**, with all the adapted equipment for monitoring any kind of hazards.

In order to cover homogeneously the alpine territories, the idea of a network of observatories, broader than the national territory, has been proposed (F. Berger). These statements raise many problems:

- (1) In terms of data acquisition and exchanges, it would be ideal to integrate the networks, that is to say to network the networks which already exist over varied spatial units (D. Richard). We could take example on the agreement between the regions Aosta Valley – Piedmont, signed in the frame of the Risknat Alcotra project, and consider it at an international scale. It is in particular necessary to be vigilant respecting the following points ([Discussion 3](#)):

- Importance of the data harmonization (data types and measure protocols) so that they can be comparable between different services, regions and countries. In particular the needs for measure intervals on the field can vary from one user to the other (scientist or technician) and must thus be properly defined.

- **Importance that the data become free at disposal.** For example in the Aosta Valley, the technical services have free access to run-off data from the hydro-electricity producers, in exchange for collaboration on the hydrological model they intend to use for their production forecasts.

These statements perfectly fit the frame of the European Directive INSPIRE.

- (2) With the target of observing the climate evolution, the present implementation of new measure networks implies important means (high density of observation necessary), that the decision-makers are not necessarily ready to finance. Indeed, such an observatory will provide useful results only on the long term. However, the example of avalanches in France shows that it is thanks to the Mougin's initiative, more than 100 years ago, that rather long observation series on avalanches are today available for analyzing the effects of climate change. Therefore, **it seems essential that the financiers appropriate the problem.**

1.2. The research on risk management

The following statements, developed by [C. Vincent](#) concerning glacier-related risks, can partly be enlarged to other natural phenomena:

- The research laboratories study the risks only on the merge of their activities; because of this, the researchers can't be easily mobilized when risk generating natural phenomena occur and would necessitate a rapid intervention for managing the crisis;
- The natural phenomena necessitate specialized and varied competences, which often imply interdisciplinary approaches that are still too scarcely widespread (ex. Tête Rousse water pocket, 3 laboratories worked together): there is a need for intensifying the scientists networks;
- There is generally a lack of reactivity of the authorities (prefect, mayors...) when the situation is not yet declared as alarming: it is very difficult to get the (financial) means for studying the phenomenon before the situation comes to a crisis (ex. Taconnaz) => need for allocating specific means to the research;
- When glacial phenomena generating risks occur, little space is given in parallel to the crisis management for scientists to carry out research for better understanding the phenomenon. But it is however during these crisis situations (ex. Tete Rousse glacier) that the necessary means should be implemented for acquiring the necessary experience for risk analysis (which is still limited because of the rarity of the phenomena) => think about specific means for the research within the crisis management.

1.3. Integrated management

Taking into account the risk in its different aspects is not an easy task, given the high number of social actors within the risk management cycle. Nevertheless, the difficulty to make the different social actors work together, still noticed today (F. Gillet), represents an increasing problem. Indeed, in a climate change context, the more difficult to manage events (with high uncertainties) there will be, the more it will be necessary to work on this organization, in order to better take into account the problems in an integrative way. It is thus about **developing more the notion of integrated risk management**, which consists in considering as a whole the problems of prevention, protection, alert, crisis management and post crisis management by back-analysis, and to make the different social actors better work together. The French examples from Rochemelon or Tête Rousse show how important the articulations are between the scientists, practitioners, politicians...

In France we should underline the problem of the poor articulation between the prevention services and the crisis management services (coordinated by the Civil Protection). The Xynthia storm case, on the French Atlantic coast in 2010, is a striking example of lack of coordination and of insufficient surveying level (V. Lebidan).

On the other hand, the scientists are most of the time on the merge of the risk management processes. The judiciary world is also absent from this scheme, whereas the questions about the responsibilities of the different social actors along the chain are essential.

In Switzerland the integrated risk management, which is more developed than in some other countries, is yet not always systematically implemented at the local scale, because it is sometimes felt as being imposed by the Confederation. Even if it sometimes presents difficulties (T. Arborino, [Discussion 4](#), the coordination between the prevention/protection services and the emergency services, is **made coherent** by the following principle: any request for a diagnosis/solution made by the cantonal specialist for the danger in question (cantonal hydrologist, geologist) to an specialized engineer includes the hazard map, the protection concept and also the emergency plan. Requesting for the 3 products simultaneously, the cantonal specialist makes sure that a unique brain conceives everything and thus insures the coherence of the whole system. Then there is only one global system to transfer to the municipality, which handles the emergency plan. Finally, the Civil Protection, responsible for the implementation and intervention of the crisis staff, always acts with the support of the cantonal specialist of the concerned phenomenon (J.D. Rouiller).

The land rules (planning rules) are more directly linked to the hazard map than in France, where managing the territory more depends on the municipality.

1.4. Risk culture and residual risk

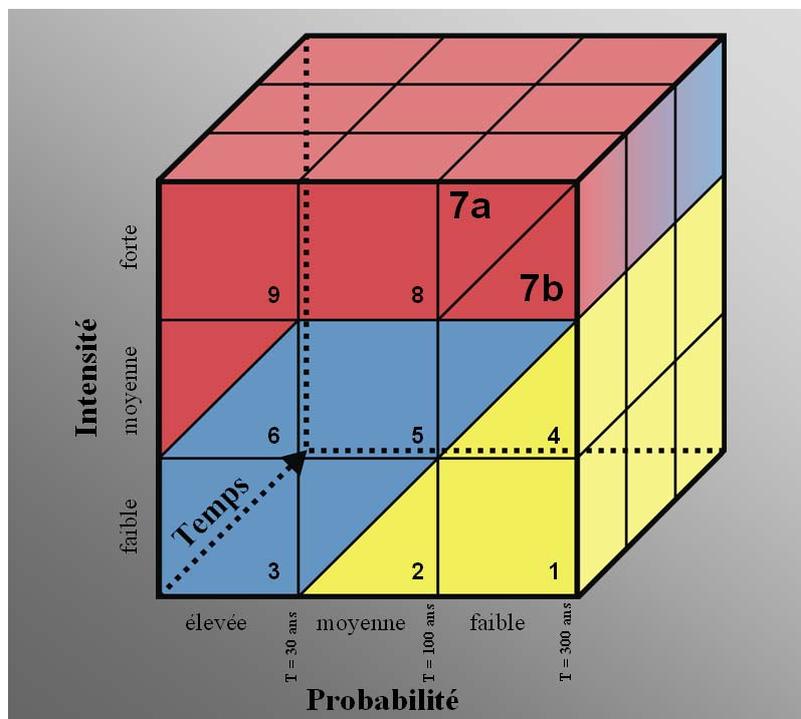
The poor risk culture nowadays observed within the populations, on almost any territory (see § *Vulnerability*), results in different weaknesses which have important incidences on the current risk management of natural hazards and on the adaptation possibilities to climate change:

- A lack of self-responsibility and auto-protection of the individuals (up to the absence of these concepts in Italy, after [H. Stévenin](#));
- A lack of acceptance of residual risk, from the lawyers as well as from the population. This societal lack is amplified by the absence of a harmonized definition of the acceptability thresholds. In practice, the technical services must choose the probability thresholds guarantying the security of goods and persons, whereas the politicians (and citizens) could, or even should assume this choice.

1.5. Introducing the « time » parameter

For [Tony Arborino](#), not taking the propagation speed of the phenomena into account in the risk analysis represents nowadays a break to the elaboration of pertinent adaptation strategies. Indeed, for slow enough phenomena (flat land floods, landslides), the existing means of territory management, emergency intervention and risk culture can allow to live with this hazard, even in the case of rather intense events susceptible to occur more frequently due to climate change.

Introducing the "time" parameter could allow to better enhance the emergency plans and the risk management over the territory and to save construction works for the phenomena with long propagation times (excluding rockfalls, avalanches and some mud flows / debris flows). It would also make the sensitivity analysis to climate evolution scenario more pertinent, considering the hazards (phenomena) but also the vulnerability (damage potential).



Introduction of the « time » parameter in the risk matrix « intensity / probability » (T. Arborino)

2. Question 2: possible adaptation strategies and practical implementation difficulties

The PARN wished to gather the experts' experience concerning the adaptation strategies to climate change that are already implemented or, if not, their advise on the necessity of conceiving such strategies (from the diagnosis to the action), in a general way or for each of the natural hazard independently.

Do we have to reinforce the various aspects of the running risk management policies, use new measures, tools and methods? What can be the concrete difficulties in entering this approach?

All the solicited land managers agree to say that the risk management policies implemented in Italy, France and Switzerland (and more generally on a European level) are globally good and have to be maintained, without necessarily modifying their fundamental elements. The know-how and the organization of the different social actors of the natural risks management result from a long experience concerning crisis management related to natural phenomena. From this point of view, the climate change doesn't modify many things.

Moreover, as detailed in § *Theme 1*, the first available evaluations about natural hazards evolutions linked to climate change are not sufficient to make previsions for the future, which is a necessary step for integrating reliable evolution scenarios into the risk management policies.

Thus, in practice, most of the practitioners haven't implemented any specific action for adapting to climate change on an operational level (ex. Aosta Valley, cf. [H. Stévenin](#)).

And yet the Flood Directive states clearly that climate change will have to be taken into account ([Discussion 3](#)). For the risk managers, it seems essential to **study a common strategy** for implementing the Flood Directive in a coordinated manner within the alpine countries. This strategy could go towards a necessary adaptation or on the contrary towards no specific adaptation: the question remains today open.

On the other hand, the views on climate change, which have been expressed a lot in the medias for 15 years, exacerbate the interrogations about the evolution of the probability of occurrence of the events and their intensity ([J. Liévois](#)). With no clear answer to this question (see § *Q1 Data*), the experts unanimously answer that it is necessary to:

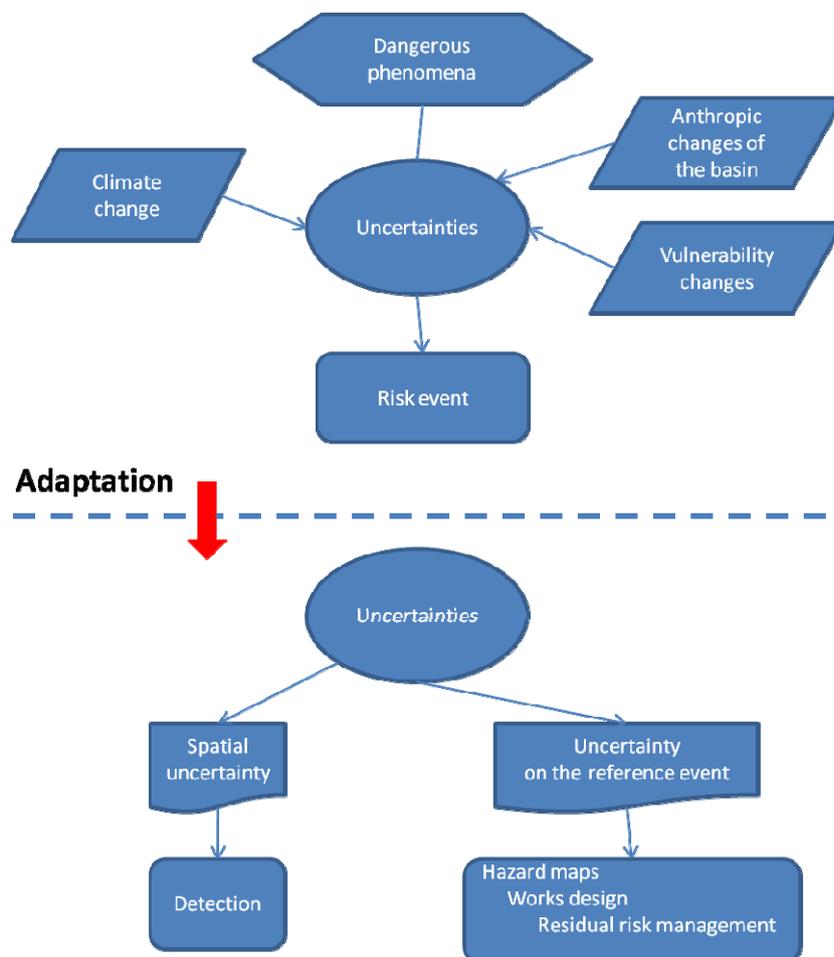
- Learn to better work with uncertainty;
- Provide them with the means to better survey the territory;
- Design protection systems that are robust and adaptable to allow managing the residual risk.

2.1. Managing the uncertainty

Nowadays, there are already many uncertainties in terms of hazards knowledge; moreover, the reaction of the environment to climatic events (temperatures, precipitations) is variable. Taking into account climate change – which can hardly be assigned an absolute value – adds one more uncertainty, especially in relation to the evolution of precipitations. Still, it is important to remember that - when it comes to natural phenomena - the scope of the evolutions linked to climate change often falls within the normal range of uncertainty which characterizes the definition itself of hazards. Any **trend linked to climate change is thus surrounded by a mix of uncertainties and existing natural variability.**

When dealing with risk management, we must add to these natural parameters financial uncertainties, uncertainties about the way the risk is understood by populations and medias...

As a consequence, when it comes to risk management, experts advocate a better understanding of how to manage uncertainties. Climate change does not directly challenge the various approaches already used to manage risks, but those who are in charge of risk management should better **analyse the consequences of uncertainty**, so as to allow politicians to make the right choices related to safeguard, prevention, and land use. A consistent management system should be based on analyses of vulnerability, an adequate choice of reference values and a sensible consideration of residual risk.



Adaptation strategy / uncertainty management scheme in Wallis

2.2. Surveying the territory

In order to (1) on the one hand fill in the lack of data allowing to have previsions of evolution and (2) on the other hand survey in real time the phenomena generating risks, the **intensification in space and time of the surveying activities** has been identified by the practitioners as an answer to better be ready to face potentially more intense and/or frequent phenomena. Some local initiatives, presented during the expert hearing have been welcomed by the experts as good practices that should be generalized.

Some concrete examples:

The general Council of Savoie (CG73) has decided to provide all its Flowcapt stations (initially used to measure the snow transport by the wind) with pluviometers to intensify the surveying networks for the intense and localized meteorological phenomena, and to improve the covering of areas that were known for being the most critical (sensitive to heavy rain falls, triggering mud flows, superficial landslides...; cf. [A. Lescurier](#)).

The region Aosta Valley ([H. Stévenin](#)) targets a systematic and detailed control of its territory:

- Some works are in progress to improve the meteorological network, particularly under high elevation (from 16 to 110 station between 2000 and 2010);
- Systematic helicopter flights are organized at least once a year to detect potential changes (among other creation of glacial lakes): it is very important to have the means – financial, technical, and human – to update the inventories as regularly as possible.
- The professionals who are directly in contact with the high mountain environment are solicited to carry out systematic and very regular surveys, in order to be able to detect as soon as possible dangerous situations. Ex: RAVA calls for the mountain guides for measuring the snow pack stability.

Research tracks

D. Richard tells about his thinking about a multi-criteria classification tool based on levels of sensitivity to risk. The work that has been done for the avalanches (Sites Sensitive to Avalanches – SSA – supported by the French Ministry of the environment) could be adapted to the torrent sites (thinking in progress) or the glacier sites (mentioned during the discussion). This kind of approach raises many questions, such as: what would be the use? Who are the users? How to communicate about the tool and towards whom? ect...

2.3. The reference event: increasing or not the threshold value

The reference event is used as a base for many policies of prevention and protection against natural hazards. In a context of climate change, there is a possibility to have more frequent extreme phenomena. The question is to know if the threshold value chosen for the design of the hazard map (100 year event for example) has to be increased so as to take into account the observed climate modification. As already mentioned in the § *Introduction* and *Theme 1*, we must remember that the temperatures are identified and quantified after various scenarios, but it is not the case for the rain falls and thus the run-off; it seems difficult at the present state to base a decision of increasing the threshold values on strong scientific bases.

The flood directorate of Bavaria is up to now, as far as we know, the only one from those in charge of natural hazards and risk management in the Alps who apply in practice a systematic increase of the reference event. Considering climate change has been statutory written in the Watter Law since 2004 (Bayerisches Wassergesetz, Art.43 to 50, after the large floods in central Europe in 2002 among others). A 15% increase of the calculated 100 year flood is recommended for the design of protection works. It is indeed a recommendation to those responsible for the flood services, coming from an intern note from the Bavarian Ministry for the Environment and Health (Bayerisches Staatsministerium für Umwelt und Gesundheit).

Remark from T.Loipesberger (Adaptalp WP6 member): this 15% value falls in the uncertainty range the hydraulic models can reach.

Remark:

The notion of reference event defines the level above which the protection costs too much or is too difficult to implement. There is hence a social compromise, which is subject to discussion, with the population who mostly wishes a total protection. The definition rules vary from one country to the other. In France, the 100 year reference event, frequently mentioned in the risk management policies related to recurrent phenomena, is in fact written in the law only for the flood problematic.

The reference events are defined by the State, via the prefect who approves the reference event taken into account for each hazard in each Risk Prevention Plan (the reference event can change on one single municipality according to the type of hazard).

In Switzerland, the responsible federal technicians have the force of law for fixing the reference events, out of any political intervention. For the floods the reference event is voluntarily fixed by a "floating limit", between 100 and 300 years, beyond which the risk becomes residual. This flexibility allows softening the risk curve beyond the reference event (cf. [Discussion 4](#)).

T. Arborino proposes not to modify the threshold values, at least for the flat land flood phenomena.

One of the arguments in this direction is that the climate modification is already partly integrated simply by taking into account in the hydrological analysis the last observed events: in Wallis, the floods in 1987, 93, 2000 and 2005 may be the result of a climate change and they already influence the statistics of the run-off.

But this position must go parallel to the elaboration of a protection strategy which enables potential climate changes to be taken into account (see below, protection concept).

Concerning the erosion phenomena (water runoff, mud flows, superficial landslides) the road directorate of the General Council Isère (CG38), increasingly facing problems of managing the damages on its roads network, concludes, as far as it is concerned, that there is a **need for increasing the exceptional threshold** of these phenomena ([V. Le Bidan](#)). At the moment nothing statutory has been done in this direction.

According to anyone of the experts, the scientific effort must go on to better define the evolution of the natural phenomena and to have at disposal on the mean term, if so, new threshold values (see § *Q1 Observatory*).

But in a wider way, the experts express the need for enlarging the thinking about this problematic to a broader cycle than the technical one. They all point out the necessity of a **harmonized definition of the acceptability thresholds**, with the central question of knowing **who (or which structure) has to determine the threshold values**. In practice, the technical services must chose the threshold probabilities guarantying the security of goods and persons, whereas ideally the politician should assume this choice. At the moment, the authorities let the judges decide case by case, often after the level of damage of the victim and not after a general referential ([Discussion 4](#)).

This point, which is technical but also political and societal, is rather completely linked to the question about the residual risk and its acceptation.

2.4. Managing the residual risk

Generally, the residual risk is still poorly considered in the risk management policies, and more particularly for the mountain risks (except for the floods, see below).

As for floods, changes will be introduced by the Flood Directive ([Discussion 4](#)). Three levels of hazards will have to be considered: low, mean and high. As the mean hazard is related to the 100 year flood, it

will be necessary to consider more severe floods than the ones that have been considered up to now: this will force us to handle the idea of residual risk. The Flood Directive also states the mapping of the "exceptional event". The methodology is being elaborated – in Wallis- so as to know if the most severe historical event will have to be mapped (which is normally already the case if it is more severe than the 100 year event), or an even more extreme one.

Also, the Flood Directive introduces the obligation of implementing management plans (before 2015), which will have to be updated every 6 years. T. Arborino wishes there will be a better dialogue between the different social actors at this occasion.

A possible adaptation strategy is the one that has been set by the General Council Isère: the management policy that is being elaborated within the road directorate **proposes notably to operate in a deteriorated mode**, while associating a specific communication to the users for informing them about this way of managing the potential damages. This kind of operation is already the rule regarding the snow-clearing of roads: the priority is put on the most strategic access roads, whereas the other less important accesses are operated in a deteriorated mode. This approach is also part of a political context of budgets cuts. (financial restriction)

2.5. The protection concepts

The protection concept elaborated in Wallis for the third Rhône correction proposes, in the context of climate change, a **robust and flexible adaptation strategy** concerning protection works and vulnerability control ([T. Arborino](#)).

For some reasons detailed above (§ *Reference event*), the design runoff have not been systematically increased (but their calculation includes the extra uncertainty due to climate change). The protection system is designed so as to be able to resist to a wide range of runoff, including a possible increase related to climate change: the principle is to manage the risk of overflowing instead of designing protection works on the base of a reference flood that is susceptible to change:

- Avoiding the dam breaks with overflowing systems;
- Planning reserved flat land areas for controlled flooding in order to impact as few houses and inhabitants as possible, while elaborating emergency plans => **management of the residual risk**.

The aim is to set up a protection system hardly sensitive to climatic variations, which can absorb higher rises of water level resulting from climate changes with minimum damages and will be more easily adapted in case of the design runoff being changed because of climate effects...or because of the increase of potential damages.

The General Council Savoie has formalized a policy relative to the **choice of the security level** for rock falls along roads ([Discussion 2](#)). It is here a policy essentially linked to budget constraints but which can also be used as a base for an adaptation strategy to the increase of natural phenomena – frequency and magnitude – in a context of climate change.

It has been chosen to reach a homogeneous security level – but not a maximum one – all along the itinerary instead of having punctually a maximum protection. This policy is today adopted on the department level, and is shared by the elected representatives. But yet it is not known from the general public and it raises several problems:

- 1- Before a court, the one in charge of managing the risks is always alone for defending the chosen policy; he is not supported by a criteria of acceptability which should be decreed by a national directive (see § *Reference event*);
- 2- Informing the citizens is very difficult when it comes to make them understand that all the possible protection has not been implemented at a particular dangerous location because it is better to protect the whole of the itinerary with a protection level corresponding to the most common events.

This policy is coupled together with a policy of preserving the technical heritage (roads + protection works), which has also been written and is shared by the elected representatives ([A. Lescurier](#) + discussion). The underlying principle is that one should be able, in case of accident, to justify before a court how the works have been oriented.

In order to face the avalanches – more frequently widespread over the winter season – the multiplication of the tripods seems to be an efficient solution ([A. Lescurier](#)).

2.6. Crisis management: increasing the reactivity

In order to better face the possible augmentation of phenomena potentially more intensive and localized, thus difficult to forecast, it is important that the technical services and the crisis management services have a great reactivity.

The experience of the General Council Savoie on this matter is an interesting example to be shared: all the events occurring on the roads of the department network (permanent 24h/24 survey) are reported to the centralizing management centre (Information and road traffic management Center OSIRIS in Albertville), which displays the information to all the social actors in charge of crisis management, in coordination with the Civil Protection; the presence of a **coordinator in each valley** also enables a good coordination in the emergency processes; the information to the users is provided by OSIRIS and broadcasted by the local radio France Bleu Pays de Savoie.

C - Conclusions and Recommendations

The presentations that have been done during this expert hearing by the land managers and the scientists have filled in intense discussions of a great richness, which have pointed out some major elements regarding the adaptation of natural hazards and risk management to climate change. On the base of the exposed statements, the PARN and the solicited experts propose a series of recommendations directed to the land managers but also to the decision-makers.

According to all the alpine experts asked, the first available evaluations concerning the climate-change related evolutions of the natural phenomena generating risks are at this stage insufficient to make reliable previsions for the future. In order to progress in this direction, it seems essential to **intensify the efforts in terms of data acquisition**: meteorological data on the one hand via measurements networks and events data bases on the other hand via inventories. This approach must target a double goal:

- The real-time survey of the territory for the very short term events management (better anticipation of localized phenomena);
- The analysis of long data series usable for more accurate previsions.

The acquired data must be (1) dense enough in space and time (regular updates), (2) homogeneous in space and time so that they can be compared, (3) free and easily at disposal, (4) mutualisable.

In order to facilitate the centralization, the exchange and the analysis of the data, the experts advocate **setting up a network of natural phenomena observatories, perennial and at the scale of all the alpine countries**.

Such observatories could include an **important part on the vulnerability data** (any kind of vulnerability), still too often neglected in the current data bases.

These essential improvements around data acquisition will only be possible if **the financiers appropriate the problem; the awareness of the elected representatives must thus be raised on the importance of this approach**, which will give results only on the mean/long term.

With not enough data for integrating quantitatively the climate change into the current risk management of natural hazards, the main orientations are the following ones:

The climate change adds some more uncertainties to already existing ones (variability of the natural phenomena, uncertainties in the models, about the finances...). It reinforces the necessity to **better integrate the uncertainty into the risk management policies**, on the one hand in the mathematical models but also – above all - in the global risk management decision making.

In this frame, it becomes fundamental to **develop an integrated risk management**. Progressing towards a better articulation between all the stakeholders, including the scientists, is surely one of the ways to face an increasing numbers of difficult to handle events, with their high uncertainties. In particular, the vulnerability will have to be considered in a more global way – a more appropriate organization of the emergency aid and crisis management leads to decreasing the vulnerability.

Several recommendations cover this very transversal theme:

- (1) **To provide the system "prevention/protection/emergency aid" with coherence**, by following for example the practice of Wallis which couples together (1) the hazard map / risk prevention plan – which rules the land use, (2) the protection concept and (3) the emergency plan /safeguard plan – which defines how to react-, to the point of making the 3 elements be designed at the same moment by the same engineer.
- (2) To work on a **more powerful and implemented reasoning on residual risk management**. This reasoning requires a clear definition of the limit between the risk against which we want to be protected and the residual risk. If the recommendations are not unanimous on the opportunity to increase or not the threshold values, depending on the type of hazard, the need is on the contrary clearly expressed to reach **a harmonized definition of the acceptability thresholds**. It should be the politicians/ decision makers' responsibility to fix the choice of these thresholds.

- (3) To develop **protection concepts that are flexible** (easily adaptable to new requirements) **and robust** (able to face an overwhelming of the design event without too many damages), which won't be much sensitive to climatic variations (ex. 3rd Rhône correction); without this or in parallel, to give the possibility **to operate in a deteriorated mode** following an event;
- (4) To **control the vulnerability of the exposed areas**: tighter links between the risk management and the land use planning;
- (5) To improve the **reactivity of the services** for managing the emergency (as some phenomena could become more unpredictable). The practice in Savoie can serve as an example to follow, with the **presence of a risk coordinator in each valley** for providing a most local coordination of the emergency situations.

The possible progresses in terms of risk acceptance will probably be linked to a reinforcement of the information display towards the local authorities and the population, in particular the children: **developing the education** about natural hazards and related risks in mountain territories for improving the risk culture.

In order to let the population better contribute to the risk management and to reduce the people's vulnerability, we should **systematically associate the information about the hazard map/risk map to information about the rules to follow in case of danger**.

For fulfilling the increasing requirements to take into account the climate change, it seems essential to **study a common strategy for all the risk managers**, in particular to implement the Flood Directive in a coordinated manner in the different alpine countries. This reasoning can be based on a dialogue between the concerned technicians, but it should also be supported by a harmonization of the laws – national, local, cantonal ones.

Finally, concerning the research on natural hazards and its links with the land managers, several recommendations are made:

- To put in closer relation the research teams that have various scientific approaches, including private companies, for developing competence networks;
- To provide specific means to the diagnosis of potential risk without waiting for the crisis situation;
- To encourage and to invest in research in parallel to the operational risk management, so as to enlarge the knowledge and increase the experience on the risk analysis;
- To deepen the thinking about a multi-criteria classification tool using sensitivity levels to the risk, on the base of the tool "Sites sensitive to avalanches SSA" and adapted to torrential and glacial sites;
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In a general way, it seems important to **let the scientists contribute more to the risk management processes**, as they are still often at the merge of them. Setting tighter links between the scientists and the risk managers could notably be developed through **exchange days** – the example of the present expert hearing appears fruitful.