Information propagation and representation in the mountain risks management processes

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ABSTRACT. *Natural phenomena in mountains such as debris-flows and rockfalls put people and assets at risk. Risk management is based on an integrated expertise process using both thematic and spatial information. A key issue consists in tracing and capitalizing the expertise process from raw data to decisions. This paper describes needs and present trends for spatialized information management including and advanced methods to represent information imperfection.*

RÉSUMÉ. *La gestion des risques naturels en montagne tels que les laves torrentielles et les chutes de blocs repose sur un processus d'expertise intégré qui utilise des données spatiales et thématiques. La traçabilité et la capitalisation des informations dans le processus d'expertise de la donnée brute á la décision sont des enjeux importants. Cet article présente les besoins et les tendances actuelles pour la gestion de l'information géographique notamment dans un contexte d'information imparfaite*

KEYWORDS: *natural hazards, mountains, spatial information, expert assessment process, decision support systems, information imperfection*

MOTS-CLÉS : *risques naturels, montagne, information spatiale, systémes d'aide á la décision, imperfection de l'information*

DOI:10.3166/HSP.x.1-9 © 2014 Lavoisier

1. Risk management framework

Natural phenomena in mountainous areas put people and assets at risk . Risk is classically assessed as a combination of hazard and vulnerability in the natural hazard context. Hazard relates to the intensity and frequency of phenomena, whereas vulnerability concerns damages and values assessment (of elements at risk) and can be seen as a combination of exposure and potential losses. The risk reduction measures consist either in structural or non structural measures (FIG. 1 - (Tacnet, Dezert *et al.*, 2014)).

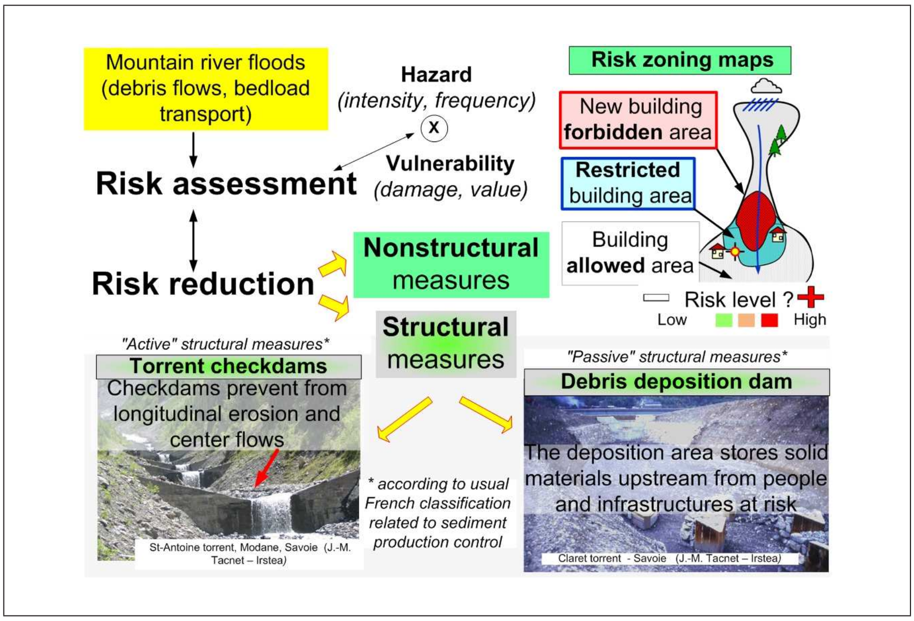

Figure 1. Structural and non-structural measures for risk reduction.

Main steps of the expert assessment process consists in data collection, risk analysis and . Information chain goes therefore from data acquisition to expert assessment and decision-making. Information systems and decision support systems (DSS) are expected to help the different decisions (FIG. 2)(Tacnet, Curt, 2010).

This paper briefly describes the key challenges and trends. First section focuses on the use of geographic information for hazard and vulnerability assessment

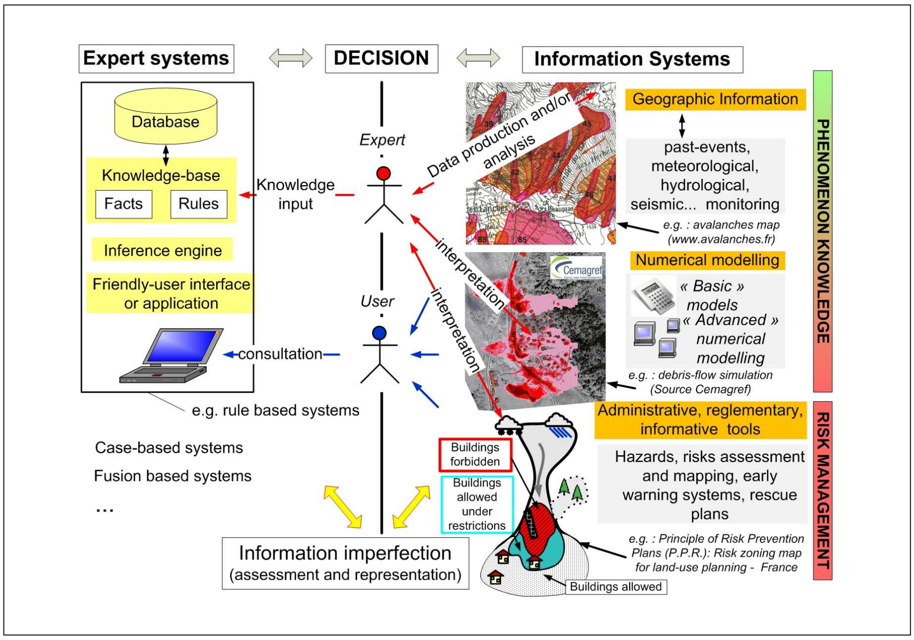

Figure 2. Information processing in the risk management process.

2. Which geographic information is needed for risk assessment?

2.0.1. Hazard assessment

Hazard assessment consists first in phenomena description such as past-events data collection (e.g. CLPA [1] maps - (Bonnefoy *et al.*, 2010)). Statistical and historical surveys are handled to identified the triggering potential and the phenomena probability with regard to their spatial extension: Applications exist either from debris-flows, rockfalls (Tacnet, 2012) and/or snow avalanches(Gaume *et al.*, 2013). As an example, statistical analysis are done to analyze climatic evolution (FIG. 3 - (Lavigne *et al.*, 2014)).

2.0.2. Direct and indirect vulnerability assessment

Direct vulnerability assessment consist in the assessment of phenomena effects resulting from direct physical impact on objects and people at risk: e.g. analysis of the damage potential due to debris-flows, rockfalls . This step is classic in the risk assessment process and usually includes the description of vulnerable equipments using existing geographic databases (FIG. 7. Indirect vulnerability is more difficult to assess. It can consist in measuring the remote consequences of natural hazards such in case of road closures: what are the economic consequences of transport network disruptions?

1. *www.avalanches.fr*

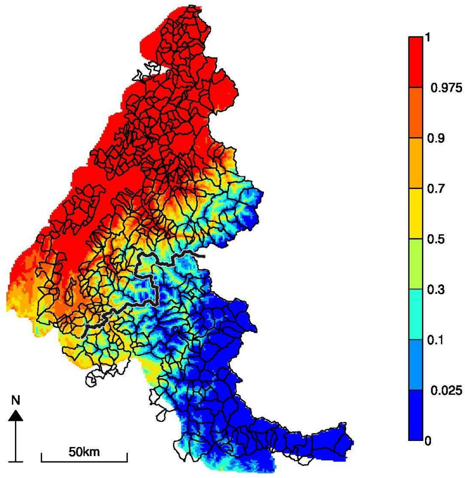

Figure 3. Map of the a posteriori probability of belonging to the north avalanche-climate zone. The thick line represents the usual fixed north/south boundary. The thin line corresponds to the township boundaries.

How can we assess and consider them in the global process? In case of transport networks, new methods have been proposed to combine decision-making methods and structural properties analysis. Indirect vulnerability assessment is measured through structural indexes such as centrality resulting from a previous socio-economic analyis that provides attractivity indicators (FIG. 4 - (Tacnet *et al.*, 2013)).

GeoGraphLab (GGL) free open-source software [2] is used for structural analysis index calculation: those indexes are then represented in GIS to identify the most important, critical and alos resilient sections (FIG. 5 - (Tacnet *et al.*, 2013)).

3. Information quality assessment and propagation

The question of information quality assessment and propagation is essential from field data collection to numerical modeling and processing. Information imperfection resulting from field data collection has to be represented : snow avalanches extensions [3] are described according to confidence related to information sources (FIG. 6 - (Tacnet *et al.*, 2013)).

2. Graph-It
3. Snow avalanches localization maps - (Bonnefoy *et al.*, 2010)

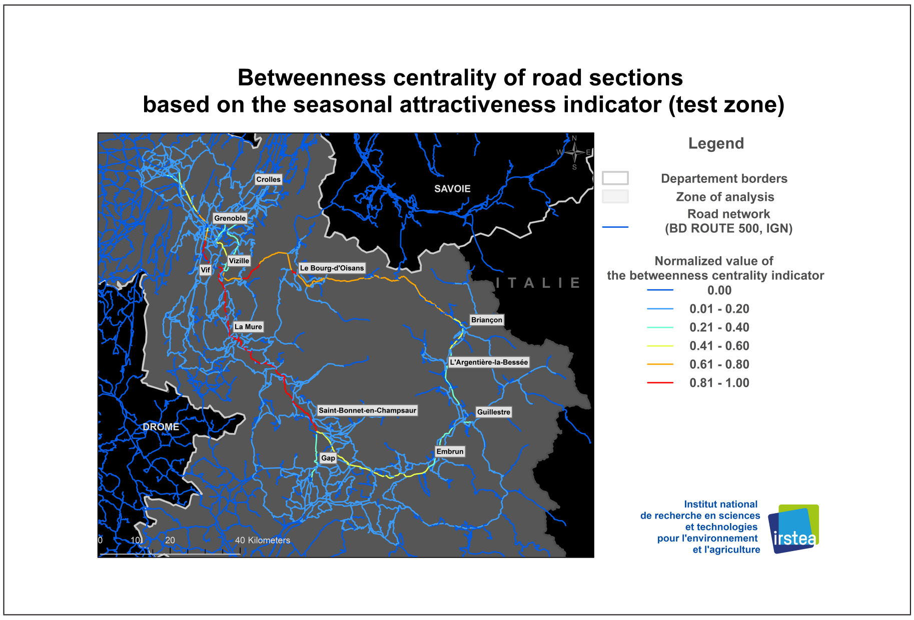

Figure 4. Centrality index based on seasonal tourism attractiveness.

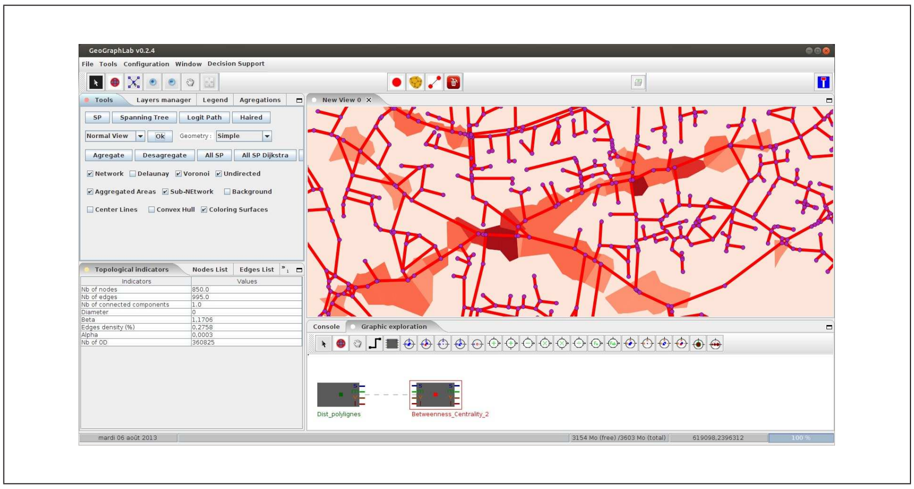

Figure 5. Centrality index calculation in GeoGraphLab (GGL) Environment - developped by Graph-It.

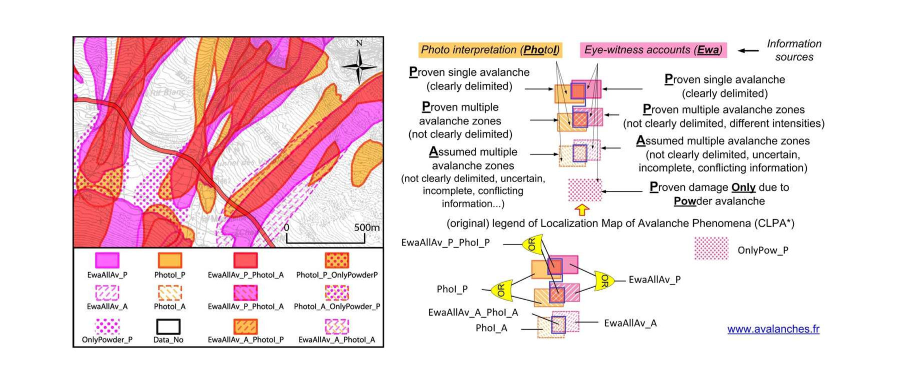

Figure 6. Information imperfection representation in snow avalanches localization maps (CLPA).

Numerical modeling is now widely used to assess hazard level and to represent the phenomena extension. Thematic information imperfection is propagated using Monte-Carlo (probability-based approach) or Hybrid (possibility-based approach) with a key issue corresponding to complex uncertain extensions visualisation (FIG. 7 - (Dupouy *et al.*, 2012),(Tacnet, 2012)).

In addition to thematic information imperfection assessment and propagation, on-going developments consist in introducing and analyzing the influence of terrain data on numericl modeling results such as proposed in ModTer project (Tacnet, Dupouy *et al.*, 2014).

4. Computing science infrastructures for information management

To handle and capitalize information, information systems developments are expected in order to represent and store information flows processes ranging from raw to processed data (FIG. 8 - (Vidaud-Barral *et al.*, 2010)). In order to improve data collection process, other present works consist in developing web-based frameworks to improve data accessibility (Bourova *et al.*, 2014).

5. Trends and perspectives

Spatial information management is closely linked to natural risk assessment steps: it includes the past-event phenomena description as well as vulnerability assessment and information imperfection propagation. From our point of view, main needs consist in, first, the development of multi-scale spatial decision support systems (territorial vulnerability, protection works effectiveness assessment . . .) and, secondly, the design of versatile geographic DBMS able to handle information imperfection and trace the information flows and reasoning processes.

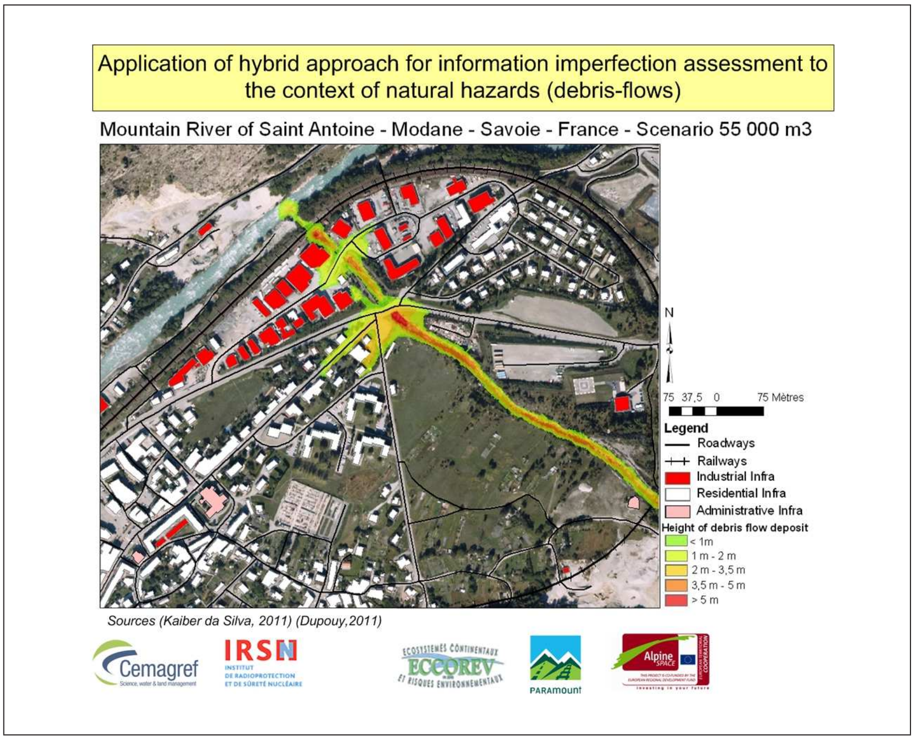

Figure 7. Uncertainty propagation in debris-flows numerical modeling .

Acknowledgements

Those developments were partially funded by the French Minstry of Ecology (MEDDE) in charge of natural risks, the ECCOREV program,Paramount and StartItUp - Intereg Alpine Space projects and also the French Ministry of Defense (DGA).

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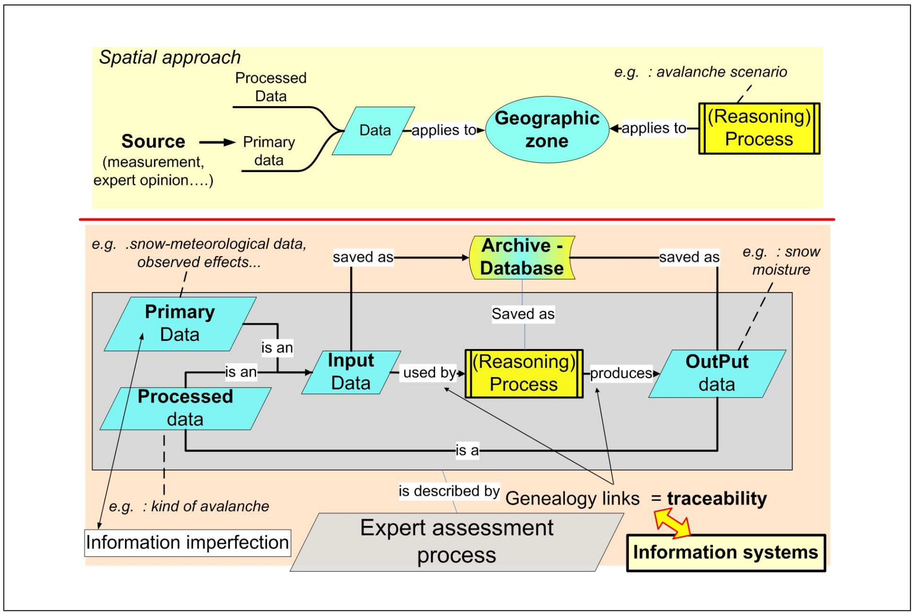

Figure 8. *Information chain.*

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