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Combination of uncertainty theories and decision-aiding methods for natural risk management in a context of imperfect information

Jean-Marc Tacnet (1), Guillaume Dupouy (1), Simon Carladous (2), Jean Dezert (3), and Mireille Batton-Hubert (4)

(1) UGA-Irstea, Snow Avalanche Engineeering and Torrent Control Research unit, Saint-Martin d'Heres, France (jean-marc.tacnet@irstea.fr), (2) French National Forest Office, Natural Risks Department, Grenoble, France (simon.carladous@irstea.fr), (3) French Aerospace Lab, Palaiseau, France (jean.dezert@onera.fr), (4) ENSMSE-DEMO team, Saint-Etienne, France (mbatton@emse.fr)

In mountain areas, natural phenomena such as snow avalanches, debris-flows and rock-falls, put people and objects at risk with sometimes dramatic consequences. Risk is classically considered as a combination of hazard, the combination of the intensity and frequency of the phenomenon, and vulnerability which corresponds to the consequences of the phenomenon on exposed people and material assets. Risk management consists in identifying the risk level as well as choosing the best strategies for risk prevention, i.e. mitigation. In the context of natural phenomena in mountainous areas, technical and scientific knowledge is often lacking. Risk management decisions are therefore based on imperfect information. This information comes from more or less reliable sources ranging from historical data, expert assessments, numerical simulations etc. Finally, risk management decisions are the result of complex knowledge management and reasoning processes. Tracing the information and propagating information quality from data acquisition to decisions are therefore important steps in the decision-making process. One major goal today is therefore to assist decision-making while considering the availability, quality and reliability of information content and sources.

A global integrated framework is proposed to improve the risk management process in a context of information imperfection provided by more or less reliable sources: uncertainty as well as imprecision, inconsistency and incompleteness are considered. Several methods are used and associated in an original way: sequential decision context description, development of specific multi-criteria decision-making methods, imperfection propagation in numerical modeling and information fusion. This framework not only assists in decision-making but also traces the process and evaluates the impact of information quality on decision-making.

We focus and present two main developments. The first one relates to uncertainty and imprecision propagation in numerical modeling using both classical Monte-Carlo probabilistic approach and also so–called Hybrid approach using possibility theory.

Second approach deals with new multi-criteria decision-making methods which consider information imperfection, source reliability, importance and conflict, using fuzzy sets as well as possibility and belief function theories. Implemented methods consider information imperfection propagation and information fusion in total aggregation methods such as AHP (Saaty, 1980) or partial aggregation methods such as the Electre outranking method (see Soft Electre Tri) or decisions in certain but also risky or uncertain contexts (see new COWA-ER and FOWA-ER- Cautious and Fuzzy Ordered Weighted Averaging-Evidential Reasoning). For example, the ER-MCDA methodology considers expert assessment as a multi-criteria decision process based on imperfect information provided by more or less heterogeneous, reliable and conflicting sources: it mixes AHP, fuzzy sets theory, possibility theory and belief function theory using DSmT (Dezert-Smarandache Theory) framework which provides powerful fusion rules.