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Glacial Contact Lake Risk Analysis - The Miage Lake (Italian Alps) case

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Within the common terminology of risk analysis and assessment it is possible to describe a number of scenarios pertaining to the hazardous events which take place at glacial contact lakes. As a site study for an applied approach of the principles exposed below we will discuss the underlying key issues with reference to the Miage Lake (Mont Blanc Massif, Western Italian Alps). The relevant factors are discussed, together with some issues of possible interest to local policy-makers pertaining simple risk-mitigation measures through exposure and vulnerability reduction which could be profitably implemented. We believe that such actions should be considered whenever glacial contact lakes are found in areas which are easily accessed by the public or anyhow capable of affecting human activities, both directly at the site and indirectly through the social and economic effects that a major accident would produce in the neighboring mountain areas and resorts. Nonetheless, as with the assessment and management of any other natural risk, for any recommended action to be focused and cost-effective it is necessary that detailed and site-specific investigations and a formal risk analysis were carried out. Such a risk analysis, which we will define "Glacial Contact Lake Risk Analysis" (GCLRA), is a definitely different subject from investigations of other glacier-related hazards, such as those pertaining to the effects of sublglacial eruptions (Jokulhaups), to failure of epiglacial ("ephemerous") lakes or of lake-damming moraines, ice cored moraines or ice dams in Glacial Outburst Floods (GLOF). A quantitative, or at least semi-quantitative treatment of the single factors is feasible and would allow the discussion presented here to be developed into a risk assessment tailored to the peculiarities of the target site. In the site characterization phase it would be necessary to recognize and account for the uncertainties inherently associated with any data collection on natural features, both from the instrumental

accuracy and the natural variability points of view. In the problem modelling phase probabilistic methods such as Monte Carlo analysis, already used in other Environmental Risk Assessment (ERA) studies, would likely prove very useful. The presence and evolution of an active calving cliff imply a number of hazardous phenomena such as collapsing hanging cliffs, supraglacial debris falling into the lake, waves risen by the above-mentioned ice and debris as they enters the lake, and the anomalous wave propagation in presence of a shallow lake bottom of irregular morphology. Though they are not exclusive to freshwater calving, these processes are all typical of freshwater calving, and their expression in the Alpine environment is expected to intensify and spread in the coming years due to the general trend of Alpine glaciers to become more and more debris-covered and to create new glacial contact lakes where calving is active.

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