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Warning and prevention based on estimates with large uncertainties: the case of low-frequency and large-impact events like tsunamis

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Geoscientists deal often with hazardous processes like earthquakes, volcanic eruptions, tsunamis, hurricanes, etc., and their research is aimed not only to a better understanding of the physical processes, but also to provide assessment of the space and temporal evolution of a given individual event (i.e. to provide short-term prediction) and of the expected evolution of a group of events (i.e. to provide statistical estimates referred to a given return period, and a given geographical area).

One of the main issues of any scientific method is how to cope with measurement errors, a topic which in case of forecast of ongoing or of future events translates into how to deal with forecast uncertainties. In general, the more data are available and processed to make a prediction, the more accurate the prediction is expected to be if the scientific approach is sound, and the smaller the associated uncertainties are. However, there are several important cases where assessment is to be made with insufficient data or insufficient time for processing, which leads to large uncertainties.

Two examples can be given taken from tsunami science, since tsunamis are rare events that may have destructive power and very large impact. One example is the case of warning for a tsunami generated by a near-coast earthquake, which is an issue at the focus of the European funded project NearToWarn. Warning has to be launched before tsunami hits the coast, that is in a few minutes after its generation. This may imply that data collected in such a short time are not yet enough for an accurate evaluation, also because the implemented monitoring system (if any) could be inadequate (f.i. one reason of inadequacy could be that implementing a dense instrumental network could be judged too expensive for rare events)

The second case is the long term prevention from tsunami strikes. Tsunami infrequency may imply that the historical record for a given piece of coast is too short to capture a statistical sufficient number of large tsunamis, which entails that tsunami hazard has to be estimated by means of speculated worst-case scenarios, and their consequences are evaluated accordingly and usually result associated with large uncertainty bands.

In case of large uncertainties, the main issues for geoscientists are how to communicate the information (prediction and uncertainties) to stakeholders and citizens and how to build and implement together responsive procedures that should be adequate. Usually there is a tradeoff between the cost of the countermeasure (warning and prevention) and its efficacy (i.e. its capability of minimizing the damage). The level of the acceptable tradeoff is an issue pertaining to decision makers and to local threatened communities.

This paper, that represents a contribution from the European project TRIDEC on management of emergency crises, discusses the role of geoscientists in providing predictions and the related uncertainties. It is stressed that through academic education geoscientists are formed more to better their understanding of processes and the quantification of uncertainties, but are often unprepared to communicate their results in a way appropriate for society. Filling this gap is crucial for improving the way geoscience and society handle natural hazards and devise proper defense means.