An inverse methodology for coastal risk management

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For the last decade, extensive work has been done on the estimation/analysis of coastal flooding hazard/risk. One approach to assess the risk is to use a "direct" method, hazard-based, starting from offshore conditions scenarios (combination of wave, tide and surge) where each scenario is characterized by a return period. This allows estimating the induced hazards (flooding), and finally the risk. Such an approach is based upon three main hypotheses. Firstly, it makes the assumption that the probability of risk (or hazard) is equal to the probability of the offshore forcing conditions: this is not true because risk R is generally defined as R=Pf.D (D: expected damages) where Pf is the probability of flooding resulting from the failure of the pathways which is different from that related to offshore conditions. Secondly, it can lead to neglect forcing conditions that are not dramatic individually, but that can lead to major events when taking together. Coastal defense failures are good examples of such a mistake, as shown during Katrina (USA) event. Thirdly, it leads to the design of answers that are not always the most relevant in terms of risk management. Indeed, many other drivers than just environmental ones are involved in decision-making, territorial planning and societal relationships to hazards.

An alternative approach, risk-based, could consist in inversing the usual direct approach and to start from a level of risk which is judged acceptable by the society (decision-makers, stakeholders and populations), to end up with the exceedance probability associated to this risk level. Such an approach would allow identifying all the forcing conditions (and their occurrence probability or return period) inducing a threat for critical assets of the territory.

In the present paper, we first describe very briefly this new methodology of coastal risk assessment. Then, assuming we already know the maximal acceptable risk level, a first application to a real case, located on the French Mediterranean coast, is presented. The advantages of the inverse methodology for decision-making support are discussed before the conclusion outlying the key issues for future research directions is drawn.

Basically, risk can be defined as the potential adverse consequence that may or may not be realized in the future. Hence it involves two main components: extent of losses (i.e. damages) and probability of occurrence. A widely-used tool for displaying risk is the probability / damage graph (e.g., Ballard, 1993). On this basis, the critical limit between what is acceptable or not can be defined. Note that in what follows, we use both the terms "maximum acceptable" and "intolerable" to qualify the limit between the two areas. This limit can either be small damage / high probability, or high damage / low probability, and both could be "intolerable" for the society. A complete presentation of the different risk classes within this space (probability – impact) has been done by WBGU (2000). The risk analysis should be adapted to the level of what can be accepted by the society. For instance, if we consider the example of a nuclear plant, the risk of a nuclear plant accident (extreme event) can be categorized within the risk class "sword of Damocles" in the classification of WBGU (2000), such that the damage level is very high, whereas the probability of occurrence is very low. In the case of flooding, Haimes (2004) found that people are "often more concerned with low probability catastrophic events than with more frequently occurring but less severe accidents". Then, as stated by Renn (2008), the investigation of the risk perception of these rare but possible catastrophic events shows that the probability plays hardly any role. In other cases, for smaller impact events, society accepts the later to occur up to a critical occurrence probability (or return period), above which it cannot be tolerated (Renn, 2008). Furthermore, it should be noted that even if there are some differences, one of the most consistent findings across cultures and within cultures is that usually the same concepts (e.g. : dreadfulness, unknown risks, etc.) emerge, but receiving different priorities (Kasperson 1986), leading to different level of risk acceptance. For these reasons, the present approach should be based on the acceptable risk, allowing to deal with both extreme events and small damage events. The main steps of the methods are presented in the paper: identification of the acceptable risk threshold based on a global approach of the territory vulnerability; estimation (through inversion of the flooding assessment model) of the offshore conditions leading to the acceptable risk threshold; estimation of the exceedance probability of the associated combinations, and thus to the maximal acceptable risk; feedback to coastal management.

To investigate the feasibility of the inverse methodology, a first application to a real case, located on the French Mediterranean coast, is presented and analyzed. For this case, the level of acceptable risk is assumed to be known and to correspond to the water level threshold at the coast (*Rc*). Then, a modeling approach is used to find out which set of combinations of forcing offshore conditions lead to a water level overcoming the critical threshold *Rc*. Finally, the occurrence probability of these combinations is computed (using the JOIN-SEA program, Hawkes et al, 2002, HR-Wallingford, 2000).

Moreover, the paper outlines the main advantages of such an inverse approach, as well as the future challenges within this research.

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