Prof. Dr. Roberto Ranzi: **Geotechnical uncertanty, levees breaches and flood hazard mapping**

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Levee breaches statistics and "geotechnical uncertainty" in flood risk mapping

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In flood hazard mapping different sources of uncertainty including the hydrological, climatic, geotechnical and hydraulic ones need to be taken into account. In a recent interview to experts in flood hazard assessment and management, "geotechnical" uncertainty related to the possibility of levees' collapse because of piping or erosion was identified as the third factor in order of importance, before the effect of hydraulic modelling of flooding processes in determining uncertainties in flood hazard mapping. Hydrological forcing was indicted as the most important factor. The aim of this study is to implement a stochastic approach to model the position, length and depth of the levee breaches in order to assess the flooding volume and area. Extending previous analyses on statistics of levee failure type and breach size on a 98 km-reach of the Po River, here we analyze flood events occurred in the Piave, Tagliamento and Adige rivers providing statistics of some hundreds of historical breaches occurred in the last two centuries. Levee failure spatial density, temporal frequency and, partially, size are presented as a function of the geomorphology of the river (i.e. braided, sinuous and meandering) of levees geometry and flood intensity. A stochastic framework for probabilistic flood mapping is discussed, taking into account in a Monte Carlo approach the effect of position, size, density of levees failures on the statistics of depth and velocity of inundated areas. An example is shown of the

resulting probabilistic map for a 98km-reach within the middle-lower portion of the Po River catchment between the gauging station of Cremona (upstream) and Borgoforte (downstream), in particular in a floodprone area of 100 km2 within the left and right levees of the Taro and Parma rivers.