Encyclopedia of Quantitative Risk Assessment

risk0289: Extreme event risk

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Abstract.
"Extreme event" is a vague concept with a variety of formal definitions based on specific cases and contexts. Particular extreme events include: great earthquakes, floods, droughts, nuclear meltdowns, space shuttle losses, deaths, giant sea waves, stock crashes, landslides, storms, hurricanes, tornadoes, wildfires, and consequences of any of the preceding. The event of interest might caused be man or by nature. They may occur in time or space. The size might be measured in deaths or costs. The study of extreme event situations has led to important research results and management methods. The specific oncern of the entry is quantitative formulation of the problem.

EXTREME EVENT RISK.

"Extreme event" is a vague concept. It has a variety of formal definitions based on specific cases and contexts. Particular extreme events include: great earthquakes, floods, droughts, nuclear meltdowns, space shuttle losses, deaths, giant sea waves, stock crashes, landslides, storms, hurricanes, tornadoes, wildfires, and consequences of any of the preceding. The event of interest might caused be man or by nature. The events occur in time or space. They may be purely random or somehow correlated. Their size might be measured in deaths or costs. The formal study of extreme event situations has led to important research results and management methods.

The concern of this encyclopedia is quantitative risk assessment and one specific definition of extreme event risk is,

Prob{certain performance variates exceed relevant critical values as a function of explanatories}

The performance variate might be a binary variable corresponding to whether or not the event occurs, or it might be the loss and damage associated with the event. In seismic engineering a concern is the damage resulting from forces generated by an earthquake in a physical component of a structure, say a nuclear reactor. In this case the models have become quite subtle. Three dimensional motion measured in historical earthquakes is employed in simulations. The performance variate might be the force being applied to a piece of piping. An explanatory might be the duration of the shaking of the earthquake. The duration of the applied forces is crucial. A very brief application may cause no damage, but a lengthy one may cause a catastrophe.

Phrased as above one has a statistics problem whose solutions may be based on stochastic modeling, data collection and data analysis. Particular statistical methods prove helpful. These include: Bayes Rule, influence diagrams, state space formulations, threshold models, aggregation, stratification, marked point process technology, trend models, cluster models, model validation, limit theorems, asymptotic approximations and smoothing. The Poisson process plays and important role, but so too do renewal processes and marked point processes. These last have the form $\{t_j,M_j\}$ where t_j refers to the time of the event and the mark M_j is associated information that might perhaps involve the past. The index of the Encyclopedia of Environmetrics, [6] references these various concepts.

The subject matter of physics, chemistry, engineering contributes to evaluations of risk as do the ideas of systems analysis. The latter's include: box and arrow diagrams, simulation, decision tools, geographic information systems, and data base management tools.

Typically one seeks risk estimates for some future time interval. In seeking solutions to such a forecasting problem one might employ leading indicators. For example in their concern with flooding in the Amazon city of Manaus, the authorities estimate the probability of eventual flooding during the year by the height of the river at the end of March and when time has passed the height at the end of April. See [1].

Desired products of an extreme event risk analysis include: hazard/risk maps, formulas, graphics, time plots and forecasts. Risk probabilities, such as the one above, have been built into government regulations by NASA and the Nuclear Regulation Commission for example.

Difficulties of the work include: small data sets, time change and other inhomogeneities, poorly defined concepts, nonstandard situations, missing data, outliers, measurement bias.

The demand for risk analyses is growing, in part because the costs of replacing destroyed structures are growing and in part because of the steady increase in the number of people living in hazardous areas.

Reference [1] provides some details concerning the particular cases of seismic risk assessment, wildfire occurrence and flooding of the Amazon River. The book [2] has a chapter concerning seismic risk analysis. Reference [3] concerns risk assessment for space missions and hardware. The books [4] and [5] present relevant statistical models and methods with the emphasis in [5] on the insurance case. Catastrophe models are discussed in reference [7]. The book [8] provides substantive and statistical material concerning climate research. Journals containing papers devoted to risk assessment include: Extremes, Geneva Papers on Risk and Insurance, Human and Environmental Risk Assessment, Natural Hazards, Risk Analysis, Risk and Reliability, Risk Research, Risk and Uncertainty, and Stochastic Environmental Research and Risk Assessment.

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