Thoughts on Extreme Events
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from
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Extreme events are multi-faceted, that is, they occur in many different traditionally isolated contexts. Yet, the literature strongly points to unifying themes that research can target. Several of these themes are described below referencing some of my own work in these areas as examples (underscoring the fact that a very large body of literature exists in these areas).

Extremes and How We Live

All around us extreme events seem to be increasing in number and severity. A contributing factor may be the increased complexity of society and its relationship to the natural environment. Activities are closer together and interact to a greater extent. A key research question is whether in fact it is the intersection of these events that is moving extremes toward the center.

In the area of natural hazards, for example, the question is frequently raised as to whether the increased severity or consequences of hazards is the result of increased exposure. Larger populations, populations living in closer proximity to areas vulnerable to natural hazards, and increased vulnerability of those areas are all a result of the way we live and increase the probability, magnitude and consequences of extreme events.

Population concentrations, for example, along coastal areas that are subject to flood hazards are not an unusual phenomenon, and the trend is expected to continue. According to a 1990 NOAA study entitled, "50 Years of Population Change along the Nation's Coasts 1960-2010," by Culliton, et al., coastal populations are expected to grow from 80 million back in 1960 to 127 million by 2010 – a rate of 60 percent. Not only are these numbers high, but densities are increasing as well given the land restrictions in high hazard areas, such as coasts and floodplains. The New York area, for example, is one of the most populous. According to national and local environmental organizations, the counties and boroughs adjoining the coastline surrounding Long Island Sound alone have an estimated population density of over a couple of thousand people per square mile. Policies toward population distribution in hazard areas as well as the nature of structural controls used to reduce exposure are at the heart of understanding some of the extreme weather events such as flooding (Zimmerman, 1994).

The increase in land consumption per capita is a well known phenomenon that is occurring in the outer portions of our metropolitan areas, and has become a major indicator of sprawl. Much of this phenomenon, related to population growth, is occurring in hazard areas or environmentally sensitive areas.

Interfacing New Technology with Existing Systems

The rapid emergence of new technologies will likely be accompanied by the emergence of extreme events because of their inevitable unintended consequences – consequences that occur primarily because of the rapidity with which they emerge and the inherent uncertainty that arises from the interconnectedness they have with existing systems.

Extreme events can increase in frequency because a number of unlikely circumstances come together that increase the probability of the event occurring. Examples abound in structural failures of infrastructure. In the area of bridge collapses, for example, events that were individually rare have occurred in combinations that have proven fatal (Zimmerman in *Natural Hazard Management*, 1999). Similar patterns have been observed historically for industrial accidents (Zimmerman, 1988).

How We Measure Extremes and Their Precursors

Extremes are to some extent artifacts of measurement systems. They are, for example, an outcome of expressing patterns and trends in terms of averages and probabilities. An average by definition will have outliers as does a statistical distribution. However, the spread is obviously what distinguishes a true extreme from just a deviation from the average of central tendency.

Detection limits are also becoming finer and finer given developments in measurement technologies. Limits of our detection capability at any given moment by definition are outliers.

Some conditions that bypassed existing measurement systems and later became relatively severe hazards exemplify how our detection capabilities can affect how we come to understand extreme situations. One example was the build up of aldicarb oxime, a material used in the manufacture of the pesticide aldicarb, at the Institute, West Virginia Union Carbide plant even after the incident at the Union Carbide plant in Bhopal, India (Zimmerman, 1988). The Institute plant had an extensive computer system to detect the escape of gases, but it was not programmed to incorporate aldicarb oxime. A second example is the well known one where for a long time the thinning of the ozone layer in the upper atmosphere was not detected because measurement systems were not programmed to detect ozone at such low levels.

Extremes and Perception

Extremes, like beauty, are probably in the eye of the beholder. What is one person's extreme is probably another person's average condition worthy only of a yawn. Increased knowledge from detection technologies and knowledge availability through advances in information technologies have brought society to a whole new level of understanding about threats and risks. A critical

aspect of analysis of and decision-making with respect to extreme events is understanding these perceptions in light of the knowledge base, experiences (Lichtenberg and Zimmerman, 1999), and the array of other factors typically studied in perception research. In particular, there is a need to link the very well known findings in the fields of risk perception and social psychology to the study of extremes.

My research and publications in these areas:

Zimmerman, R. and M. Cusker, "Institutional Decision-making," in *Climate Change and a Global City: An Assessment of the Metropolitan East Coast Region*, edited by C. Rosenzweig and W. Solecki. New York, NY: Columbia University and Goddard Institute of Space Studies, in press, 2001.

Zimmerman, R., "Planning and administration: Frameworks and case studies" [integrating risk management and natural hazard management], in *Natural Disaster Management*. Edited by John Ingleton. Leicester, England: Tudor Rose, 1999. Pp. 225-227. [Commemorative volume of the United Nations' International Decade for Natural Disaster Reduction 1990—2000.]

Bier, V.M., Y.Y. Haimes, J.H. Lambert, N.C. Matalas, and R. Zimmerman, "Assessing and Managing Risks of Extremes," (with), *Risk Analysis: An International Journal*, Volume 19, No. 1 (1999), pp. 83-94.

Lichtenberg, E. and R. Zimmerman, "Adverse Health Effects, Environmental Attitudes, and Pesticide Usage Behavior of Farm Operators," *Risk Analysis: An International Journal*, Volume 19, No. 2 (1999), pp. 283-294.

Zimmerman, R. "After the Deluge," The Sciences, Volume 34 Number 4 (July/August, 1994), pp. 18-23.

Zimmerman, R. and M. Gerrard, "Hazardous Substance Emergencies in New York City," *Disaster Management*, Vol. 6, No. 3 (1994), pp. 133-140.

Zimmerman, R., "Understanding Industrial Accidents Associated with New Technologies: A Human Resources Management Approach," *Industrial Crisis Quarterly*, Vol. 2, Nos. 3-4 (1988), pp. 229-256.