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Epistemic Uncertainty, Extreme Flood Risk, and Paleoflood Hydrology

Tao Liu (1) and Victor Baker (2)

(1) Dept. of Hydrology and Atmospheric Sciences, Univ. of Arizona, Tucson, U.S.A. (liutao@email.arizona.edu), (2) Dept. of Hydrology and Atmospheric Sciences, Univ. of Arizona, Tucson, U.S.A. (baker@email.arizona.edu)

Extreme risk assessment involves a probability P that can be defined as the extreme case of concern E divided by the total range of possibilities for that case, R. For flooding the probability P most commonly get expressed relative to the ranked magnitude of an event in a time range divided by the period of time in years. Unfortunately, reliance upon conventional measurements (rarely more than several decades for flood events) means that the time period is necessarily chosen to be the arbitrary period of measurement, and the true value of R is almost always unknown, a problem that is exacerbated when the case of concern is of exceptionally high magnitude and great rarity. Even when a major extreme of concern appears in a measured flood record, its relegation to "outlier" status leads to a minimization of importance, or at least to a state of ignorance thereto. Thus, conventional practice must make assumptions about R in order to determine P, but these assumptions are untested, and even commonly assumed to be untestable – the latter being one of the definitions of what it is to be "unscientific." Uncertainties get expressed in an aleatory sense, relying on assumptions about randomness, and informed only by the statistical record of the small common floods. While this methodology may afford the appearances of quantitative precision, it ignores the epistemic uncertainty associated with lack of knowledge concerning extremes, both as to their magnitudes and to their ranges of possibility. The consequence of inattention to this epistemic uncertainty is increasingly being manifested as the "Black Swan" phenomena in which seemingly unexpected extreme-impact events exceed expected possibilities, resulting in accelerating financial losses.

A remedy for this state of affairs is to employ the rapidly advancing science of paleoflood hydrology (PFH) for extreme risk assessment. PFH relies upon recent advances in geological/geochronological procedures and hydraulic modeling to quantify the natural recordings of ancient flooding that are commonly preserved in the form of erosional and depositional phenomena, in the absence of direct human observation. PFH is most effective in producing records of the most extreme floods – exactly those phenomena that are commonly either missed or poorly measured by conventional hydrological stream gaging. PFH produces extreme flood data records that extend back thousands of years, and it also provides for the objective quantification for subjective historical observations made by humans before the advent of modern hydrological measurements. Examples of state-of-the-art PFH are provided by assessments of extreme flooding risk for major water resources infrastructure in east-central China and the southwestern U.S. (Colorado River Basin).