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Potential impacts of climate change on estimates of probable maximum precipitation

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Probable Maximum Precipitation (PMP) is the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage basin at a particular time of year. PMP values are used in the design of long-lived structures with lifetimes of many decades, such as dams. Climate change is an unavoidable consideration on those time scales. Many studies have documented an upward temporal trend in the frequency and intensity of extreme precipitation events. As the globe warms in response to increasing greenhouse gas concentrations, there is the potential for further changes in precipitation extremes. There are reasons why warming could lead to increased PMP values. One, the Clausius-Clapeyron relationship indicates that the saturation water vapor pressure increases with temperature; thus, precipitation-producing systems could have more "fuel" to precipitate. Two, warming may lead to an increase in the length of the convective season, when most of the extreme precipitation events occur. The methodology for estimation of PMP values has changed little over the last 30-40 years. The basic approach is to consider the factors that contribute to heavy precipitation and then consider the potential precipitation rates if all of those factors were simultaneously maximized. Convergence and vertical motion is one factor. Past work has assumed that there no empirical or satisfactory theoretical basis for assigning maximum values to this factor. The approach has been to use observed rainfall in notable storms as an indirect measure of maximum convergence and vertical motion. Notable storms are chosen to indicate the likely occurrence of near-maximum values. A second central factor is moisture availability. Observational data are used to determine maximum levels of moisture availability. Where topographic effects are important, wind maximization is a third factor. We are examining these factors in present-day and future simulations from global and regional climate models. Initial results strongly indicate the possibility for large future increases in maximum moisture, by about the same amount as increases in mean moisture content. This would lead directly to substantial increases in PMP values. Given the potential catastrophic consequences of dam failure, these findings should be considered carefully in future design activities.