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Estimation of Extremes from Limited Time Histories: The Routine `MaxFits` With Wind Turbine Examples

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Executive Summary

This report describes and illustrates the use of the routine `MaxFits`. This routine estimates statistics of extremes corresponding to arbitrary dynamic load or response processes. It estimates statistics of extremes from limited-duration time histories, which may arise either from experimental tests or computationally expensive simulation. A wide range of statistics—e.g., mean, standard deviation, and arbitrary fractiles—can be estimated for an extreme over an arbitrary duration T. The routine also assesses, through bootstrapping methods, the statistical uncertainty associated with these extremal statistics due to the amount of data at hand. This will consistently reflect the growing uncertainty as, for example, we extrapolate to (1) increasingly high fractiles of the extreme response; or (2) increasingly long target durations T, relative to the length of the input signal.

Central to this routine is a core group of algorithms used to probabilistically model various aspects of the dynamic process of interest. The user is permitted to model either the time history itself, a set of local peaks (maxima), or a coarser set of global peaks (e.g., 5- or 10-minute maxima). A number of distribution types are included for these various purposes. For example, normal distributions and their 4-moment transformations ("Hermite") are included as likely candidates to apply directly to the process itself. Weibull models and their 3-moment distortions ("Quadratic Weibull") have been found particularly useful in modelling local peaks and ranges. Extremal, Gumbel models are also included to permit natural choices of global peaks. These algorithms build on the distribution library of the `FITS` routine, most recently documented in RMS Report 38 (Manuel et al, 1999).

To focus on upper tails of interest, the user can also supply an arbitrary lower-bound threshold, x_{low}, above which a shifted version of a positive random variable model—exponential, Weibull, or quadratic Weibull—is fit. In estimating statistics of the maximum response, the program automatically adjusts for the decreasing rate of response events as the threshold x_{low} is raised.

This program is intended to be applicable to general cases of dynamic re-

sponse. A particular example shown here concerns the estimation of extreme bending moments experienced by wind turbine blades under stationary Gaussian random field simulations. This is a topic of ongoing interest within the general wind turbine community. It is shown here how the use of the fitted models provided in `MaxFits` can produce accurate estimates—in comparison with extensive simulation results—with reduced data needs.