Yakov Ben-Haim, 2022, Inferring extreme values from measured averages under deep uncertainty, ASME *Journal of Verification, Validation and Uncertainty Quantification,* to appear.

Highlights

- Averages are used for diagnosis, prediction, or surveillance, but hide important extremes.
- Averages are measured on uncertain varying processes.
- Info-gap theory is employed to model and manage process uncertainty.
- Assessing robustness to uncertainty enables interpretation of averages regarding adverse extremes.
- Assessing opportuneness from uncertainty enables interpretation of averages regarding favorable extremes.

Abstract Averages are measured in many circumstances for diagnostic, predictive, or surveillance purposes. Examples include: average stress along a beam, average speed along a section of highway, average alcohol consumption per month, average GDP over a large region, a student's average grade over 4 years of study. However, the average value of a variable reveals nothing about fluctuations of the variable along the path that is averaged. Extremes — stress concentrations, speeding violations, binge drinking, poverty and wealth, intellectual incompetence in particular topics — may be more significant than the average. This paper explores the choice of design variables and performance requirements to achieve robustness against uncertainty when interpreting an average, in face of uncertain fluctuations of the averaged variable. Extremes are not observed, but robustness against those extremes enhances the ability to interpret the observed average in terms of the extremes. The opportuneness from favorable uncertainty is also explored. We examine the design of a cantilever beam with uncertain loads. We derive 4 generic propositions, based on info-gap decision theory, that establish necessary and sufficient conditions for robust or opportune dominance, and for sympathetic relations between robustness to pernicious uncertainty and opportuneness from propitious uncertainty.

Keywords averages, deviations from average, inference, info-gaps, monitoring, uncertainty, robustness, opportuneness.