Calculating Catastrophe

by Gordon Woo

LONDON: IMPERIAL COLLEGE PRESS, 2011, 355 PP., US $27.41,
ISBN 1-84816-739-3

REVIEWED BY CHRIS IMPEY

Life involves risk, but to maintain our daily equanimity we are well advised not to dwell on the many possible threats to our existence and well-being. However, the consideration of catastrophe involves important mathematics and fascinating history, so we can be glad that Gordon Woo has taken on the topic in *Calculating Catastrophe*. A sequel to his earlier *The Mathematics of Natural Catastrophes*, the book is only mildly technical and so aimed at a broader audience.

Woo works for Risk Management Solutions, a California-based consultancy in the area of risk assessment. He is well equipped for the task of a conveying a subject that touches on so many areas of mathematics. He graduated as wrangler at Cambridge, and although that might bring to mind someone who is argumentative or good with horses, it in fact connotes a pinnacle of mathematics achievement as an undergraduate. In centuries past, when the top scorers were ranked, the highest scorer – the Senior Wrangler – was instantly famous; this illustrious cohort includes John Herschel, Lord Rayleigh, and Arthur Eddington. We can imagine the turn a dinner-party conversation might take after Woo has introduced himself as a catastrophist.

Calculating Catastrophe covers everything from man-made and environmental disasters to the kind of catastrophe that rains in from space. That scope is both a strength and occasionally a weakness. Woo's encyclopedic grasp of the applied mathematics of mayhem means there is almost nothing not covered by the book. It can be fruitfully and entertainingly browsed as well as read straight through. But it also means that hazards of modest scope are included, such as mud slides and localized political violence. It might have made a more consistent framework if Woo had limited himself to dramatic and widespread threats that encapsulate the apocalyptic sense of the word catastrophe.

The arc of the book starts with natural and societal hazards of all types, follows with some discussion of scale and uncertainty, talks about complexity, takes a brief detour into terrorism, then covers forecasting and prediction, and finishes with the assessment of risk. The flow within chapters makes more sense than the flow between chapters, but Woo sets himself an organizational challenge by his desire to be encyclopedic in his coverage. Many topics reappear from chapter to chapter, like the pumpernickel in a loaf of marble rye. Generally, this layering is successful, though a minor frustration is provided by the skimpy index, which is inadequate to the task of referencing Woo's magpie-like gathering of facts on so many different topics.

The casual reader in another field will find some of the formalism challenging, such as the Hamiltonian and wavelets formalisms presented in the chapter on uncertainty, but in general there are only brief and occasional incursions of algebra and calculus. The book would have benefited from a more generous selection of graphs and charts. A modest number of schematics and tables are dotted through the text, but material can be enlivened by visualization, and the publisher has missed this opportunity. The book is densely, but well, written.

Woo makes some elegant connections between human and natural calamities, such as when Baring Bank's infamous "rogue trader" Nick Leeson was unable to claw back his initial loss after an earthquake hit Kobe in 1995. In Leeson's words, "the market was butchered," and in Woo's recounting, "a back-office tremor evolved into a corporate earthquake." Another example is the influence of culture on etymology; in the geologically placid Amazon region, some tribes have no word for earthquake.

Subsidiary themes in the book are complexity and the chaotic and nonlinear behaviors that characterize many catastrophic phenomena. The formalism is laid elegantly and minimally, but in sufficient detail that the reader can see how well the explanatory power of mathematics spans many disciplines.

Sometimes Woo overreaches. His eclectic subject matter brackets physics and financial markets, geology and terrorism, but the application of mathematics to social science is on fairly weak ground. As they read a list of the nonlinear and instability conditions as applied to the stock markets, readers will recall that it was "boutique" financial vehicles based on chaos theory and poor modeling of risk that helped create several major fiscal disasters. The chapter on terrorism is an oddball—the incidents quoted rarely rise to the level of catastrophe, and the application of mathematics to pathological political behavior seems forced and unsatisfying.

This is a minor cavil, however. In general, Woo masters his many briefs with panache. The last third of the book concerns prediction and risk assessment. Here, the reader can see the amount of progress that has been made in taming the seemingly untamable and creating models that can guide public policy and save lives. He illustrates this in the Disaster Scenarios chapter with an excellent series of Fermi problems: order of magnitude estimations conveying the essence of the outcome without an obscuring level of detail.

Although the subject matter is dark, this is an optimistic book. Woo believes in the power of mathematics to explain the natural world and even to shine a little light into the darker corners of human affairs. He justifies this optimism with many examples and with applications of almost every branch of mathematics. When the subject of mathematics began 2500 years ago as a numerological cult on an island off the coast of Greece, it would have been hard to imagine the myriad and often invisible ways it would now affect the lives of Earth's seven billion inhabitants.

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DOI 10.1007/s00283-012-9278-z