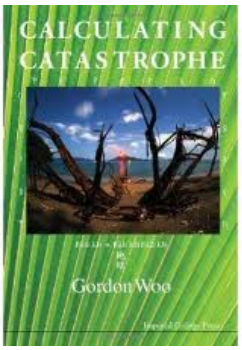
Calculating catastrophe, *Gordon Woo* Imperial College Press, 2011 (xi+355 p.), soft cover, ISBN 978-1-84816-739-1, US$29 / £19 (paperback)



Let me start by a warning. Just as his earlier *The Mathematics of Natural Catastrophes* (World Scientific, 1999) which was not a book about 'mathematics'; this one is not about 'calculating' either. This one is a timely update of the predecessor, broadening it and including data of the last decade. The reader will not find the precise models, or computational methods to rigorously simulate or predict catastrophes. There are however a lot of data and many underlying principles are explained.

The first two chapters form a phenomenal collection of data about all kinds of hazards both natural (extra terrestrial, meteorological, geomorphic, or hydrological) or man-made (political violence, infectious diseases, industrial accidents, or financial crises) that have happened in the past or could happen in the future. There are some common characteristics for these two types of hazards so that flood, tsunami, quake, shock wave etc., use for man-made hazards are actually more than linguistic hyperboles. The massive recollection of disasters that have happened recently and that the reader has so easily forgotten is quite confronting. Notable (but essential in chaotic systems) are the almost philosophical reflections by Woo about whether some event is a cause or a consequence of another one. There is the classic story that Mary Shelley wrote *Frankenstein* in 1816 because she, together with her friends got bored of sitting inside because the weather conditions were so bad that year. That was caused by the debris in the atmosphere, remainders of the explosion of the Indonesian volcano Tambora in 1815. There is some causal connection, but this does not mean that she, or somebody else, would not have written the book, had the Tambora not exploded. Thinking of the butterfly-effect, it might be clear that complex nonlinear dynamics make it very difficult to find the cause of disastrous events. The problem being posed, the subsequent chapters will point to some possible answers.

Chapter 3 discusses the different scales and units in which the strength of all these phenomena are measured. Richter's scale for earthquakes is well known, but here one learns about the Fujita scale for tornados, Volcanic Explositivity Index (VEI) for volcanic eruptions, etc. Another aspect is to measure how far in time and space cataclysmic effects propagate. There are of course formulas to describe the decay of impact from an earthquake, a pollution, etc., but this is also a matter of the scale on which one wants to look. This gives Woo the occasion to introduce fractals. Earthquakes on a macro scale can be caused by instability of fine cracks in rocks on a micro scale.


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That brings us to uncertainty and evidence. Historical and philosophical issues of probability theory and related notions are contemplated in chapter 4. Woo succeeds in sneaking in wavelets in this chapter when he discusses the analysis of fault ruptures in the soil to predict a probability of an earthquake. Hazards are rather exceptional, which make them hard to analyse and to predict? Risk management depends often on people's believe about what is going to happen, and not always on the laws of statistics. Think of the Ellsberg paradox and Knightian uncertainty. So when do people accept or believe evidence and how should one measure that believe? The chapter has some formulas, but it is mainly philosophical and narrative.

The previous chapter forms the basis to explain some statistics in chapter 5. Notions such as Poisson and Markov processes, Brownian motion, statistics of observed extremes, etc. are illustrated with examples and a few sporadic mathematical formulas. In this way it is hoped that the arrival-time of the next extreme situation can be predicted which may have a hazard as a possible consequence. Although precise prediction of man-made hazards such as the start of a war or a financial crash is very difficult, it is possible to recognize the conditions for instability and



Tsunami



Volcano



Land slide



Flood



Bhopal



Pandemic



Chernobyl



Tessorism



Financial crisis



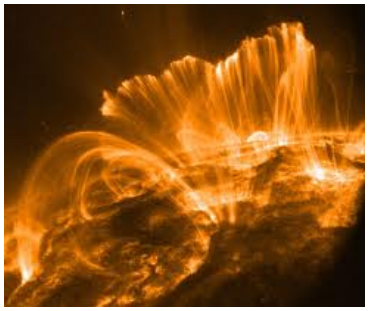
Cyclone



Meteorite impact



Earthquake



Solar storm



Tornado



Extra terrestrial attack

indicators for an imminent outbreak as illustrated in chapter 6. And these are the simple cases because there are the laws of nature or of society that allows some predictability. The problem is to find or recognize the tipping point, i.e., when some threshold has been surpassed that will trigger a disaster. An illustration is taken form the financial markets. However when men with evil intentions come into play, safe predictions are quasi impossible. For example threats of terrorist attacks are very difficult to catch in mathematical laws. Nevertheless some of the mechanisms in a terrorist network and signs or conditions that can provoke a terrorist action are discussed in chapter 7.

The next chapter is somewhat more accurate where it is explained how forecasts can be made for earthquakes, tsunamis, tornadoes and floods. Predicting a major earthquake is still precarious, but predicting tsunamis or floods after an earthquake is realistic. As everywhere in this book all this is amply illustrated with examples from real life and greased with anecdotes or quotations from the literature.

Once a disaster is predicted, one should decide what precautions to take. When should one decide to evacuate? When is it safe enough to allow airplanes to fly after an ash cloud alarm? What scenarios should be followed e.g., when a solar storm is observed and satellites and electrical power plants can fail? When and how to inform the public? Woo ponders on possible scenarios of global disasters like a meteorite strike or a visit of extraterrestrials, major tsunamis or earthquakes, or world pandemics (e.g. H5N1 avian influenza). All this is discussed in chapters 9 and 10.

After the event is over, insurance companies have to deal with the survivors and the consequences of the disaster. These companies cannot be run with the gut feelings of their CEO's. They are bound to use probability theory. They have to give a reasonable argument for the answers they give to questions such as 'What is the probable maximum loss?' What should be covered and for what prize? How to calculate the risk of insuring something? What and how to reinsure? Not that Woo gives precise answers or the one-and-only-solution to all these questions, he gives some principles and a few formulas of possible lines of thought in his chapters 11 and 12. The final chapter deals with long-term planning about situations that we do observe but where it is not known what it will lead to and if or when it will reach a tipping point after which a disaster is unavoidable such as for example global warming, or the outburst of another world war or genetic modification.

As it is stated in the conclusion: the majority of catastrophes will not be controlled by force or science. The only thing one can do is to try and understand the principles. That is exactly what the author has achieved for a very broad readership. The reader is not supposed to be skilled in mathematics. The formulas interlacing the text could even be skipped, and what remains will still be enjoyable to read. However mathematics from secondary school suffice. The reader who is a mathematician could be a bit disappointed if he is after ready-made applicable models, proofs or derivations. But after he has accepted that this is not a book about the mathematics, but a book about facts and principles, he will definitely enjoy the reading as well. The tsunami of disastrous events that have happened, or that have been described in the literature is overwhelming. A new topic is never started with boring mathematics but with an anecdote, an evocation of a situation in a novel, and quotations are generously sown as you read along. For example from Einstein: "intellectuals solve problems, geniuses prevent them" and there are many like this. The eruption of erudition and literacy displayed by the author is amazing. It is a true intellectual pleasure to read. Besides the names of scientists, you can find a lot of names of artists and citations from their work: from Henry Longfellow and Graham Green to Fyodor Dostoevsky and from Paul Cézanne to Franz Kafka, Samuel Becket and Hokusai. Even phenomena such as Harry Potter, Lord of the Rings, and Star Wars are featuring. Woo succeeds is shuffling into this book about any buzz word possible, modern hypes or facts that are still vivid in our collective memory. Tying this to the many events that are very recognizable or unsolvable questions the keep mass imagination busy, the book will be a commercial success. In my opinion rightfully so. Hence be part of the crowd: read and enjoy before the next hazard strikes!

Adhemar Bultheel