


London is destroyed by an asteroid in 2006 BBC/National Geographic documentary "Ancient Asteroid"


Frankfurt meets its demise in 2008 German TV documentary "Big Bang in Tunguska"


Paris comes to an abrupt end in the Touchstone Pictures 1998 movie "Armageddon"

U41D-0034: Global Catastrophes in Perspective: Asteroid Impacts vs Climate Change

Mark Boslough
Sandia National Laboratories
PO Box 5800, Albuquerque, NM 87185-0370
(mbboslo@sandia.gov)

Alan Harris
Space Science Institute
4603 Orange Knoll Ave., La Canada, CA 91011-3364
(awharris@SpaceScience.org)

When allocating resources to address threats, decision makers are best served by having objective assessments of the relative magnitude of the threats in question. Asteroids greater than about 1 km in diameter are assumed by the planetary impact community to exceed a "global catastrophe threshold". Impacts from smaller objects are expected to cause local or regional destruction, and would be the proximate cause of most associated fatalities. Impacts above the threshold would be expected to alter the climate, killing billions of people and causing a collapse of civilization. In this apocalyptic scenario, only a small fraction of the casualties would be attributable to direct effects of the impact: the blast wave, thermal radiation, debris, ground motion, or tsunami. The vast majority of deaths would come later and be due to indirect causes: starvation, disease, or violence as a consequence of societal disruption related to the impact-induced global climate change. The concept of a catastrophe threshold comes from "nuclear winter" studies, which form the basis for quantitative estimates of the consequences of a large impact. The probability estimates come from astronomical observations and statistical analysis. Much of the impact threat, at its core, is a climate-change threat. Prior to the Spaceguard Survey of Near-Earth Objects (NEOs), the chance of dying from an asteroid impact was estimated to be 1 in 25,000 (Chapman & Morrison, 1994). Most of the large asteroids have now been discovered, and none is on an impact trajectory. Moreover, new data show that mid-sized asteroids (tens to hundreds of meters across) are less abundant than previously thought, by a factor of three. We now estimate that the lifetime odds of being killed by the impact of one of the remaining undiscovered NEOs are about one in 720,000 for individuals with a life expectancy of 80 years (Harris, 2008). One objective way to compare the relative magnitude of the impact threat to that of anthropogenic climate change is to estimate the long-term worldwide fatality rate. For asteroids, the average is about a hundred deaths per year–about half of which are climate-change related. By contrast, the World Health Organization (WHO) has estimated that 150,000 deaths per year are currently attributable to anthropogenic climate change. Both estimates are similarly impacted by uncertainty in our understanding of climate change and statistical attribution of indirect causes. The WHO estimate is a lower bound, because it does not account for the unknown probability of a human-triggered abrupt climate change comparable to the speed or magnitude of the Bolling/Allerod or Younger Dryas boundaries, which are not impact related. Nevertheless, by any objective measure the impact threat is minuscule (by a factor of at least a thousand) compared to the threat from anthropogenic climate change.

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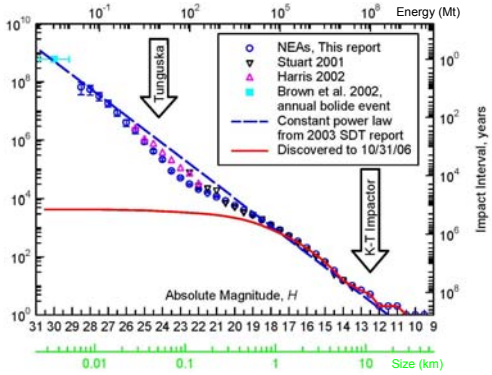
References

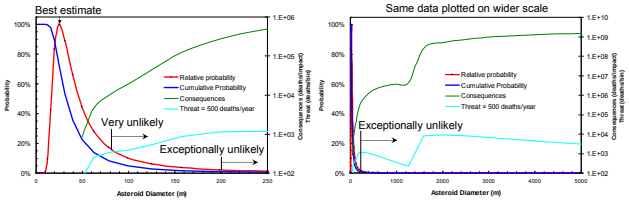
Murphy, J.M., *et al.*, 2004, Quantification of modelling uncertainties in a large ensemble of climate change simulations: Nature, v. 430, p. 768-772.

Stroeve, J., *et al.*, 2007, Arctic sea ice decline: Faster than forecast: Geophysical Research Letters, v. 34, p. L09501.

Asteroid Impact Threat Assessment



The size distribution of Earth-crossing asteroids is well-constrained by astronomical observations, DoD satellite bolide frequencies, and the cratering record. This curve can be transformed to a probability density function (PDF).



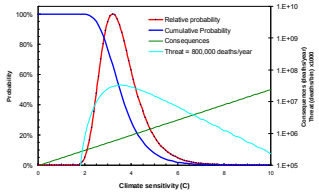
PDF of largest asteroid to impact the Earth in the next 100 years, based on constant power law fit to asteroid size distribution. Consequences are based on nominal number of fatalities per event from 2003 NASA NEO Science Definition Team report, which assumes a global catastrophe threshold of 1.5 km. The threat curve is calculated by multiplying consequences by probability for each size bin. Total threat is the area under the threat curve. The best estimate for the size of the largest impacting asteroid of the century is 25 meters, which would explode in the atmosphere with zero consequences in terms of expected fatalities. There is a large statistical uncertainty in the expected largest impact. The cumulative distribution function can be used to determine the likelihood of impacts of various size. The probability of an impact greater than 50 m in diameter (about the size of the Tunguska event) is about 23% (an *unlikely* occurrence according the IPCC Likelihood Scale). An asteroid larger than 80 m has an 8% chance of impact (a *very unlikely* occurrence), and there is less than a 1% chance of an impact greater than 200 m (an *exceptionally unlikely* occurrence). About 99% of the total impact threat is from very unlikely events, and 90% from exceptionally unlikely events.

Conclusions

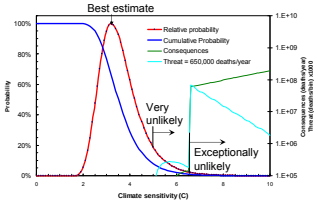
The risk of global catastrophe is dominated by low-probability, high-consequence occurrences. The asteroid threat community has been much more successful than the climate change community in characterizing the dominant "worst-case" scenarios and communicating them to policy makers, the media, and the public–even though the climate change threat is more than a thousand times greater. Media focus on exceptionally unlikely impact scenarios is common, whereas focus on high-consequence climate scenarios is often unfairly labeled as "alarmist". Quantitative comparison of climate change to asteroid impact is a valuable way to put both threats into perspective.

Climate Change Threat Assessment

PDFs can also be generated for risk parameters associated with climate change, such as climate sensitivity (increase in mean global surface temperature due to equivalent CO_2 doubling). This provides a reasonable distribution of expected temperature rise over the next 100 years, consistent with realistic IPCC SRES emissions scenarios.

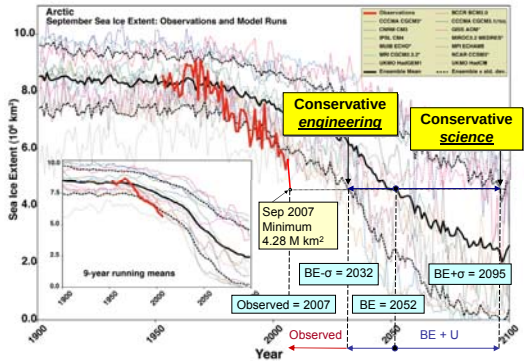


Case 1: interpolated consequences

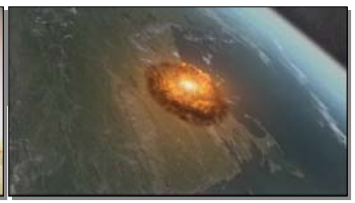


Case 2: threshold consequences

Murphy, *et al.*, 2004 used a "perturbed physics" ensemble method which systematically varies 29 model parameters to determine a probability distribution function that has a 5% to 95% range of 2.4 to 5.4 °C, with a median of 3.5°C and a "most probable" value of 3.2°C. On the IPCC Likelihood Scale, warming of greater than 5°C is *very unlikely*, and an increase exceeding 6.5°C is *exceptionally unlikely* (with probabilities similar to impacts by 80- and 200-m asteroids, respectively). We estimated consequences two ways. Case1: We interpolated between the WHO estimate of 150,000 fatalities per year for current warming (ΔT=0.8°C) up to extinction at 20°C. Case 2: We assumed no consequences below 5°C, and then a gradual onset up to a global catastrophe threshold at 6.5°C in which an excess ¼ of the world's population dies over 25 years. Case 2 is very similar to the assumptions made for the impact threat. Both sets of consequence curves lead to a total threat of more than 1000 times the impact threat.



Stroeve, *et al.*, 2007 plotted observed Arctic September sea ice extent (red) together with 13 IPCC AR4 climate model predictions. A naïve "best estimate plus uncertainty" (BE + U) based on this ensemble would have predicted that drop below 4.3 million km² in 2007 would have been extraordinarily unlikely. The observations suggest that uncertainty determined from ensembles of climate models neglect a significant "lack-of-knowledge" component. This implies that the probability of unlikely but high-consequence climate change has been underestimated. The term "conservative" tends to have an opposite meaning in science than it does in engineering and risk assessment, where it means "precautionary". In science, it tends to refer to assumptions that have the least effect on an outcome. Engineering conservatism is the best approach for policy decisions.

Boston goes bye-bye in 2008 Discovery Canada documentary "Asteroid Trackers"


An unidentified city is ruined in 2008 National Geographic Channel documentary "Asteroid Alert"


San Francisco is laid to waste in 2008 Discovery Channel documentary "Siberian Apocalypse"