# Towards a theoretical determination of the geographical probability distribution of meteoroid impacts on Earth

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## Introduction

Earth's surface has been impacted by asteroids and meteoroids during the last couple of Giga years. The number of impacts has disminished, but still lots of potential hazardous asteroids and undetected meteoroids are threating our now overpopulated planet. The capture and colision of these bodies could be enhanced by the complex combined gravitational field generated of the Earth - Moon system [1]. Are impacts randomly distributed on the surface of the Earth? The largest impacts witnessed by modern humans, Tunguska and Chelyabinsk events, happen just ~3,000 km away. The "Campos del Cielo" in Argentina and tektites fields in Chile and Colombia, possibly hints to a link between different impact events. Since the distribution of asteroids in the Solar System is not random it is natural to think that impacts will also be clustered on the Earth (following for example the ecliptic); however, relative Earth-asteroid velocity and the complex dynamics of the earth moon system may modify this natural expectation [2]. Several authors have studied the geographic distribution of falls, impact craters and fireballs. However, the fact that recovery of meteorites, fireball observations and discovery of craters are mostly restricted to continental areas, their conclusions are restricted and possibly biased. Space-based observations have contributed recently to improve this situation, but they are also limited by the size and time of impacts.

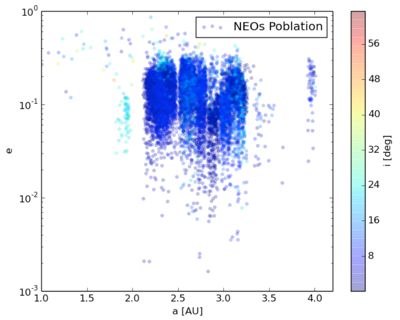


Fig 1. The distribution of already known NEOs in the configuration space.

The aim of this work is to asses the problem of estimating in an efficient way the geographical distribution of the probability of meteoroid impact and/or capture at a given time. Our technique could be used to study the distribution of impacts of objects of any size, including the largest ones where few data points are available and the smallest ones which are mostly unobservable.

## Methods

We have adapted well known techniques used in numerical optics and scientific visualization, namely "ray tracing" or "ray casting" [3]. Our adapted technique, called "gravitational ray tracing" (GRT) studies the propagation of meteoroids (analogues to photons) from Earth back to their asymptotic place in configuration space (analogues to light sources). The distribution of already discovered asteroids (Fig.1) provide us the properties of the sources and allows us a way to assign probabilities to impact places. In GRT we use methods familiar to the original "ray casting" including, for example the methods for generating initial conditions (Fig. 2).

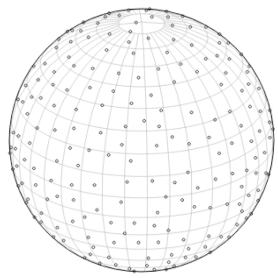

Fig. 2. Generation of initial conditions over the surface of the Earth using the Poisson disk distribution widely applied in ray casting [4].

## Challenges and prospects

Our technique is intrinsically inexpensive in terms of computing resources. Still the size of the initial configuration space is huge. In order to tackle this problem, we are developing innovative tools, including scavenging grids of mobile devices. The same technique can be applied to study the distribution of impact in other bodies of the solar system, e.g. the Moon. We are also attempting to apply the technique to asses the probability of capture of TCO for future manned and unmanned missions.

## References

[1] Granvik, M. et al. (2012). The population of natural Earth satellites. Icarus, 218.

[2] Appel, A. (1968). Some techniques for shading machine renderings of solids. AFIPS.

[3] Dunbar, D. & Humphreys, G. (2006). A spatial data structure for fast poisson-disk sample generation. ACM Trans. Graph., 25(3).