The effect of parallax and cadence on asteroid impact probabilities and warning times

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We study the time evolution of the impact probability for synthetic but realistic impacting (Vereš et al., 2009) and close-approaching (Bottke et al., 2002) asteroids detected in a simulated all-sky survey (Tonry, 2011). We use the impact probability to calculate the impact warning time ($t_{\rm warn}$) as the time interval between when an object reaches a Palermo Scale value of -2 and when it impacts the Earth. A simple argument shows that $t_{\rm warn} \propto D^x$ with the exponent in the range of $[1.0, 1.5]$ and our derived value being $x = 1.3 \pm 0.1$. The low-precision astrometry from the single simulated all-sky survey could require many days or weeks to establish an imminent impact for asteroids larger than 100 m in diameter that are discovered far from the Earth. Most close-approaching asteroids are quickly identified as not being impactors, but a size-dependent percentage, even for those larger than 50 m in diameter, have a persistent impact probability of greater than 10^{-6} on the day of the closest approach. Thus, a single all-sky survey can be of tremendous value in identifying Earth-impacting and close-approaching asteroids in advance of their closest approach but it cannot solve the problem on its own: high-precision astrometry from other optical or radar systems is necessary to rapidly establish an object as an impactor or close-approacher. We show that the parallax afforded by surveying the sky from two sites is only of benefit for a small fraction of the smallest objects detected within a couple days before impact: probably not enough to justify the increased operating costs of a 2-site survey. Finally, the survey cadence within a fixed time span is relatively unimportant to the impact probability calculation. We tested three different reasonable cadences and found that one provided ~ 10 times higher (better) value for the impact probability on the discovery night for the smallest (10 m in diameter) objects but the consequences on the overall impact-probability calculation is negligible.

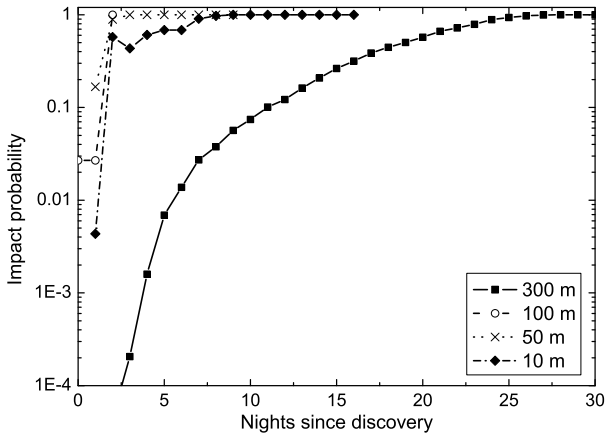

Figure: Impact-probability time evolution for four synthetic objects of 10 m, 50 m, 100 m and 300 m in diameter.

Acknowledgements: We thank J. Tonry and L. Denneau of the ATLAS survey for assistance in characterizing and designing a representative ATLAS survey. D. Farnocchia was supported for this research by an appointment to the NASA Postdoctoral Program at the Jet Propulsion Laboratory, California Institute of Technology, administered by Oak Ridge Associated Universities through a contract with NASA. Peter Vereš's Pan-STARRS MOPS Postdoctoral Fellowship was sponsored by NASA NEOO grant No. NNX12AR65G.

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