Was Tunguska a Beta Taurid?
2019 Observational Campaigns can Test Hypothesis

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Abstract

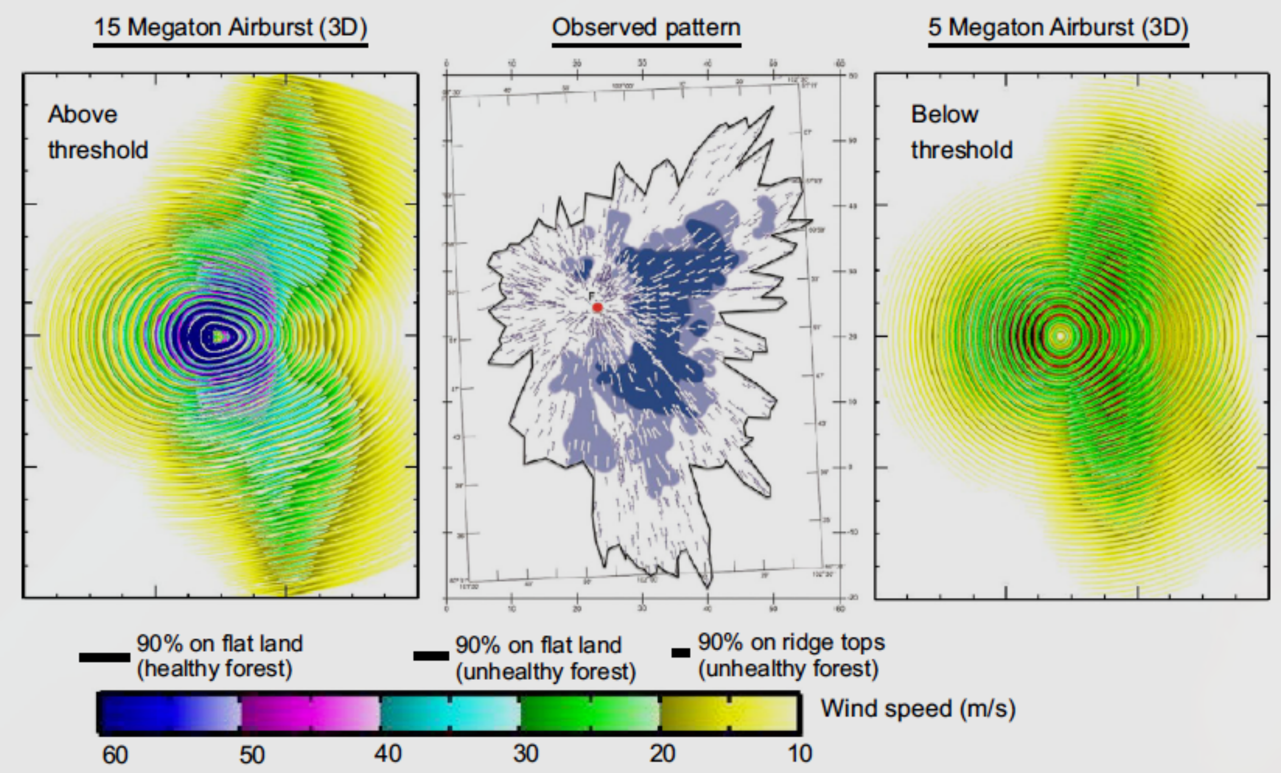
Hydrocode models of the 1908 Tunguska airburst have provided reasonable explanations for most of the phenomena associated with that event, from the shape of the treefall pattern to the bright nights over western Europe (Boslough & Crawford, 1997; 2008). Similar models are used to estimate the damage component of probabilistic risk assessment and cost/benefit analysis for planetary defense. Nevertheless, there is still an enormous range in model-based estimates of the size of the Tunguska impactor and explosive yield, from as low as 3 to as high as 30 megatons. This range of possible sizes, combined with NEO population estimates, leaves us with one unsatisfying conclusion: the Tunguska event was an extreme outlier. The probability of an impact of that magnitude having happened only 110 years ago is extremely low. The frequency of the smallest and largest possible Tunguska-like events should be on the order of once every thousand and ten thousand years, respectively.

One way out of this dilemma is to question a built-in assumption in our probability estimates that small NEOs are effectively distributed randomly. Whereas the most sensational claims of "coherent catastrophism" lack merit, it is reasonable to speculate that the Taurid complex has significant concentrations of Tunguska-sized fragments that are too small to be observed unless in the vicinity of the Earth. Large fireballs--some associated with meter-class impactors--were observed during the Nov, 2015 Taurid swarm return (Spurny et al., 2017). Additionally, several small asteroids--such as 2015 TX24--have orbits that are nearly identical to the 2015 Taurid fireball swarm (Olech et al., 2016; 2017). When the Earth intersects with this stream, the probability of impact is elevated. If the Tunguska object was a member of a Beta Taurid stream (Kresák, 1978) then the last week in June 2019 will be the next occasion with a high probability for Tunguska-like collisions or near-misses (Asher & Izumi, 1998). Because the Beta Taurids approach from the sunward side, we propose a survey designed to observe such objects after they have passed into the night sky which would have little lunar interference because the moon is new on July 3, 2019. Moreover, the possibility of enhanced daylight fireballs and significant airbursts should be anticipated during that time.

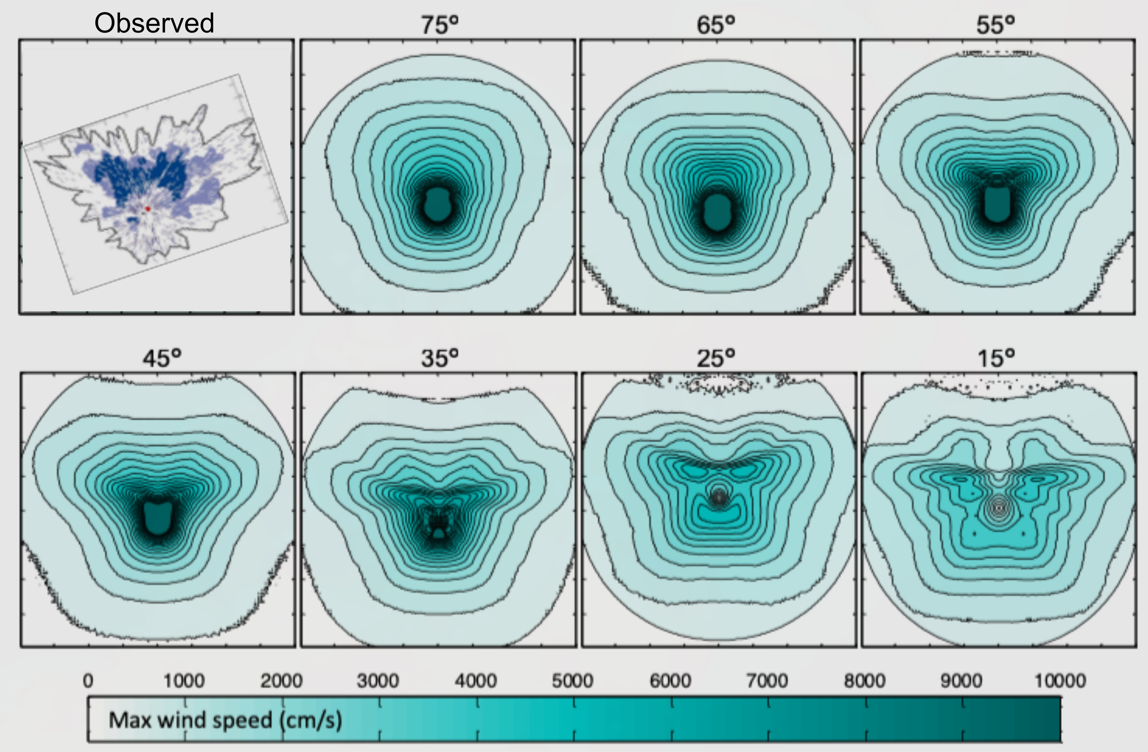
Above: Forest damage from the 1908 Tunguska explosion

Below: 5 megaton asteroid explodes 12 km above surface: frames are every second

Tunguska models suggest Beta Taurid



Boslough (2013) simulations provide best match to observed treefall data (Longo, 2015) for 5 Mt body entering at 35° elevation. Orientation of treefall symmetry suggests 104° entry azimuth. According to Brown et al. (2010) a Beta Taurid radiant at Tunguska event time and location would imply a 32° elevation and 104° azimuth entry.



Boslough & Crawford (1997) matrix of simulations (reproduced here for 8 Mt airburst) show best match for 35° elevation angle.

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Argument for 2019 observational campaigns

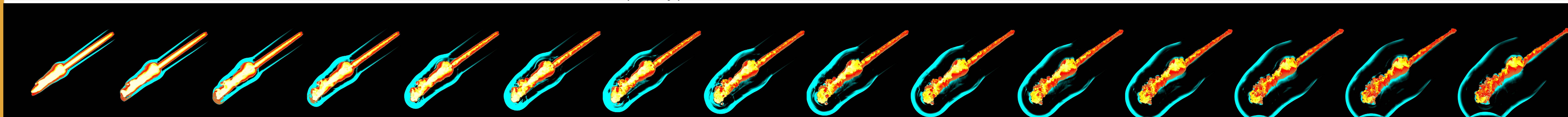
The Tunguska connection to the Beta Taurids has been posited for some time (Kresák, 1978) and that within uncertainty the trajectory (entry direction) for Tunguska fits with a Beta Taurid link. The timeliness of this connection next year is the expected return of the resonant Taurid swarm (Asher et al., 1993) in June, 2019, which will be the closest Earth passes to the outbound leg (daytime) portion of the resonant stream since 1975. The 1975 daytime Taurid resonant swarm has been associated with an order of magnitude increase in the impact rate on the Moon as measured by Apollo – era seismometers (Duennebier et al., 1976). Moreover, the overall behavior of the Taurid resonant swarm and its apparent linkage with large meteoroids has been recently demonstrated through a large number of high precision fireball measurements of the 2015 nighttime (Taurid) resonant swarm return (Spurny et al., 2017). These measurements confirmed with high precision the apparent resonant swarm 7:2 MMR with Jupiter, showing that large meteoroids can be "shepherded and concentrated" by the resonance. In addition, several NEAs (2015 TX24 and 2005 UR with diameters of several hundred meters) were found to have orbits placing them inside the resonant branch, establishing that the enhancement in meteoroid spatial density due to the resonance extends from sub-mm sized meteoroids to large NEAs. This makes the connection with the Beta Taurids more plausible and suggests that both in-atmosphere and exo-atmosphere observational campaigns of the swarm return near the end of June, 2019 could be productive. In the table, Delta M is the encounter offset in units of Mean Anomaly (degrees) relative to the resonant swarm center.

Year (Jun)	Delta M
1904	19
1907	-22
1914	2
1917	-40
1921	25
1924	-16
1931	7
1934	-34
1938	31
1941	-10
1948	13
1951	-28
1955	37
1958	-5
1965	19
1968	-22
1975	1
1982	25
1985	-17
1992	7
1995	-34
1999	30
Year (Jun)	**Delta M**
2002	-11
2009	13
2012	-29
2016	36
2019	-5
2026	18
2029	-23
2036	1

Asher et al. (1993). M is Mean Anomaly in degrees

Summary

According to most current estimates, airbursts the size of the June 30, 1908 Tunguska explosion should happen only once every thousand to ten thousand years. We propose an observational campaign during the last week of June 2019 that could change that estimate and revise the impact risk upward. Such a campaign would test the idea that the Earth will pass through a swarm of small near-Earth objects (NEOs) called the Beta Taurids. Because they would be coming from the direction of the sun, they will not be seen by optical telescopes until after they pass our planet and recede into the night sky. A significant concentration of small objects intersecting the Earth's orbit at this time would also support the hypothesis that Tunguska was caused by the impact of a Beta Taurid. If that is the case, we should also anticipate increased probability of bright daytime fireballs and infrasound-generating airbursts. While we are not predicting another Tunguska airburst, an enhanced population of of small NEOs in the Beta Taurids would increase the probability of another such event on or near next year's Tunguska anniversary.



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