Death Plunge!

SAND2014-17216PE

Destructive impacts and airbursts with little or no warning

Mark Boslough
Sandia National Laboratories

Starmus
September 22-27, 2014
Tenerife, Canary Islands, Spain

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. Mark Boslough's funding provided by Sandia National Laboratories LDRD program.

Death Plunge! Dinosaur killer 65 Ma

10 km-diameter asteroid impact with little or no warning cannot happen now

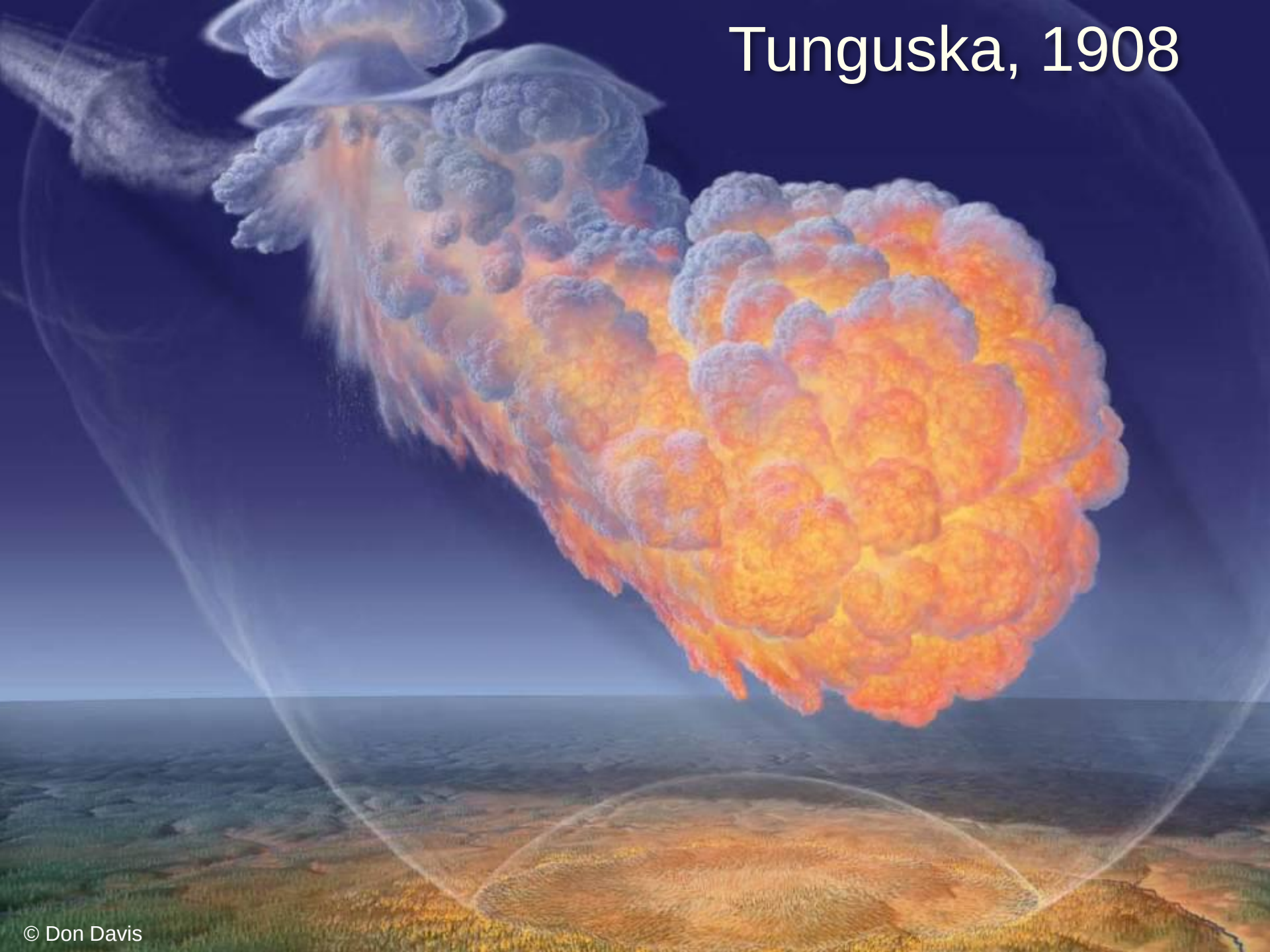
Death Plunge! Dinosaur killer 65 Ma

The asteroid almost certainly had passed close to the Earth repeatedly, and was a bright object in the sky many times before its final death plunge

Death Plunge!

A little warning is better than no warning


Death Plunge!
Tunguska, 1908


Tunguska, 1908
© Don Davis

Consequences of a 5 Mt airburst

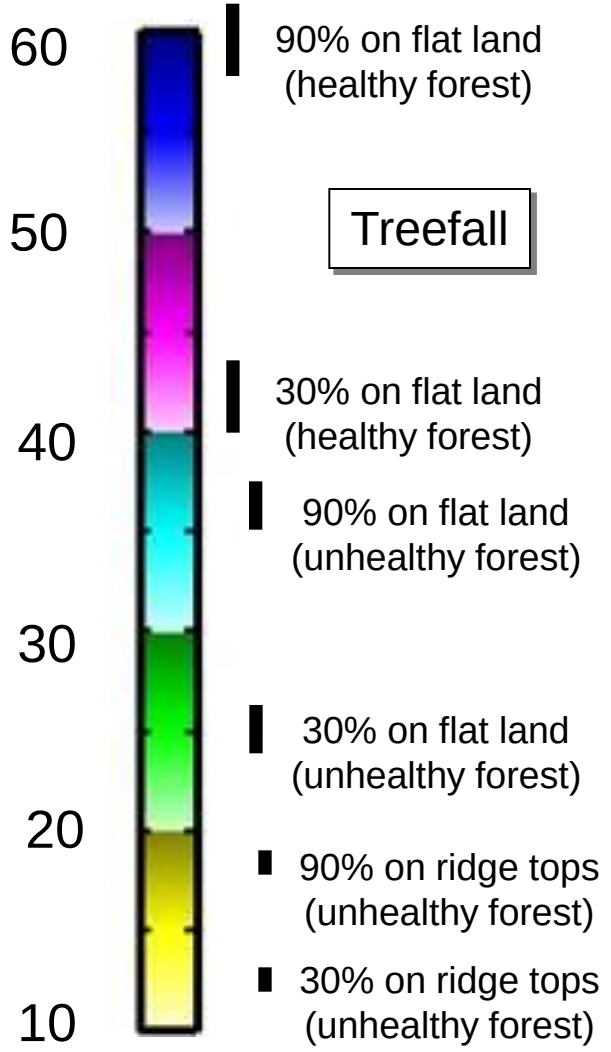
Krinov, 1963

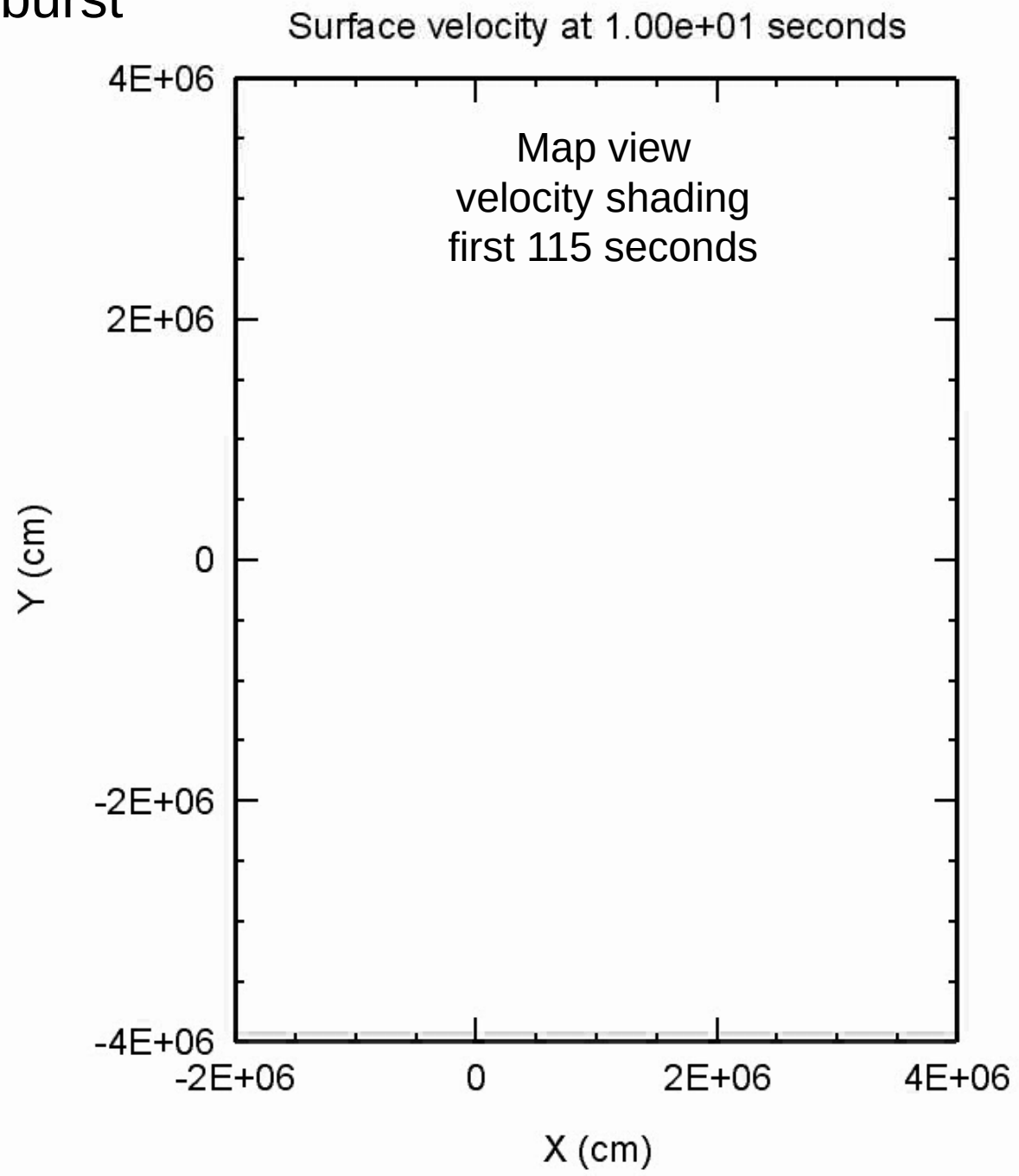
Tunguska, 1908

Fig. 485 — The siberian forest devastated by the blast from the meteorite of 30 june 1908.

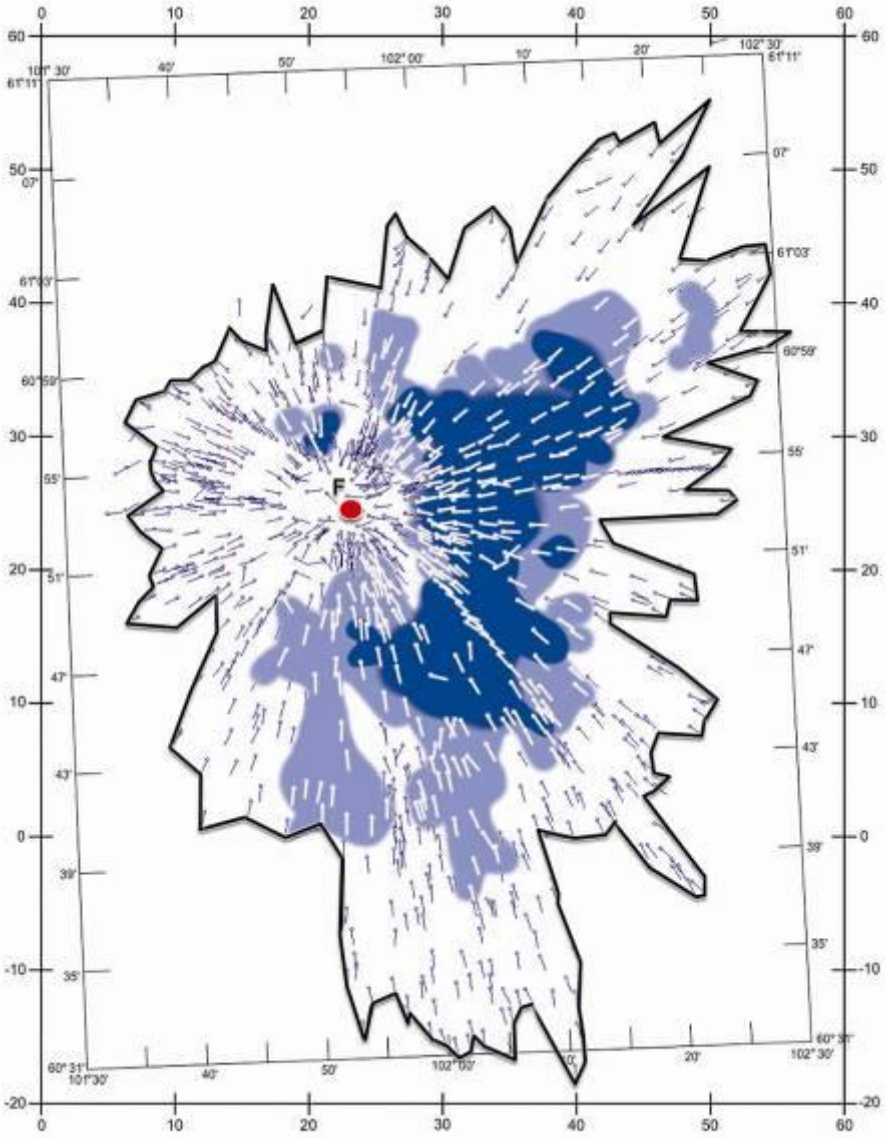
Tunguska airburst simulation: 5 megaton

Modeling Tunguska airburst

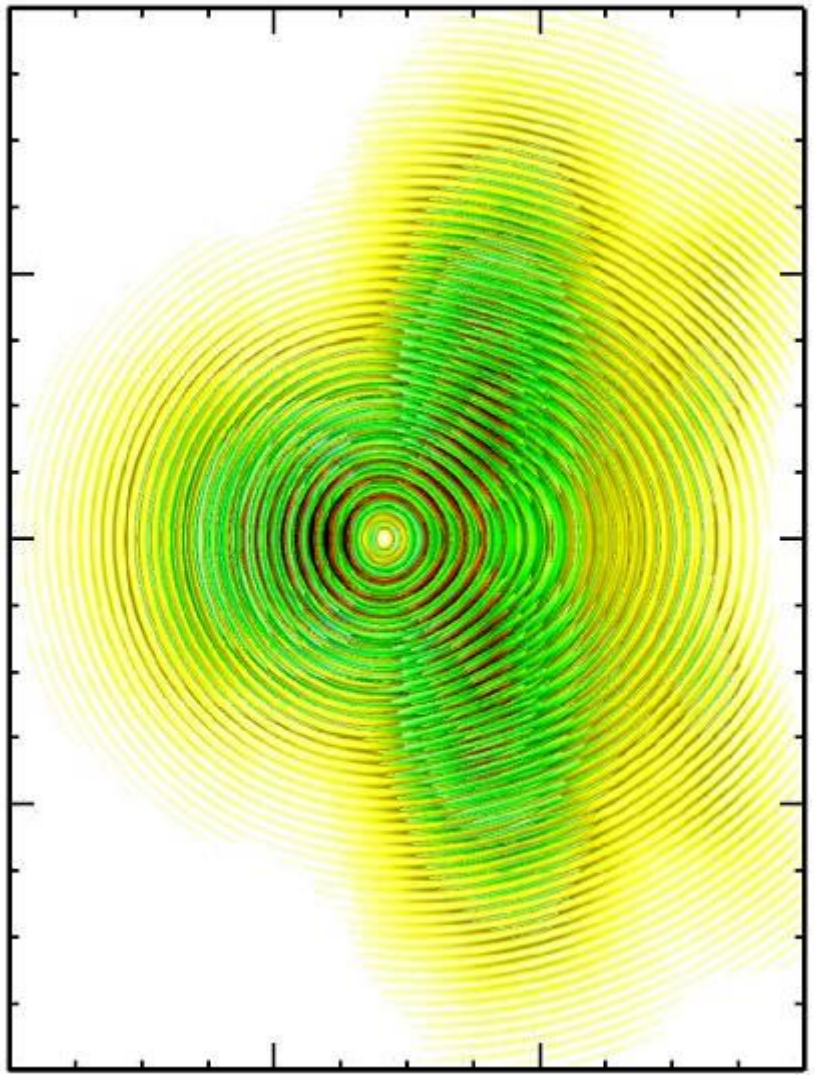




5 Mt explosion at 12 km above surface, 35° entry angle



Tunguska treefall map (Longo et al, 2005)



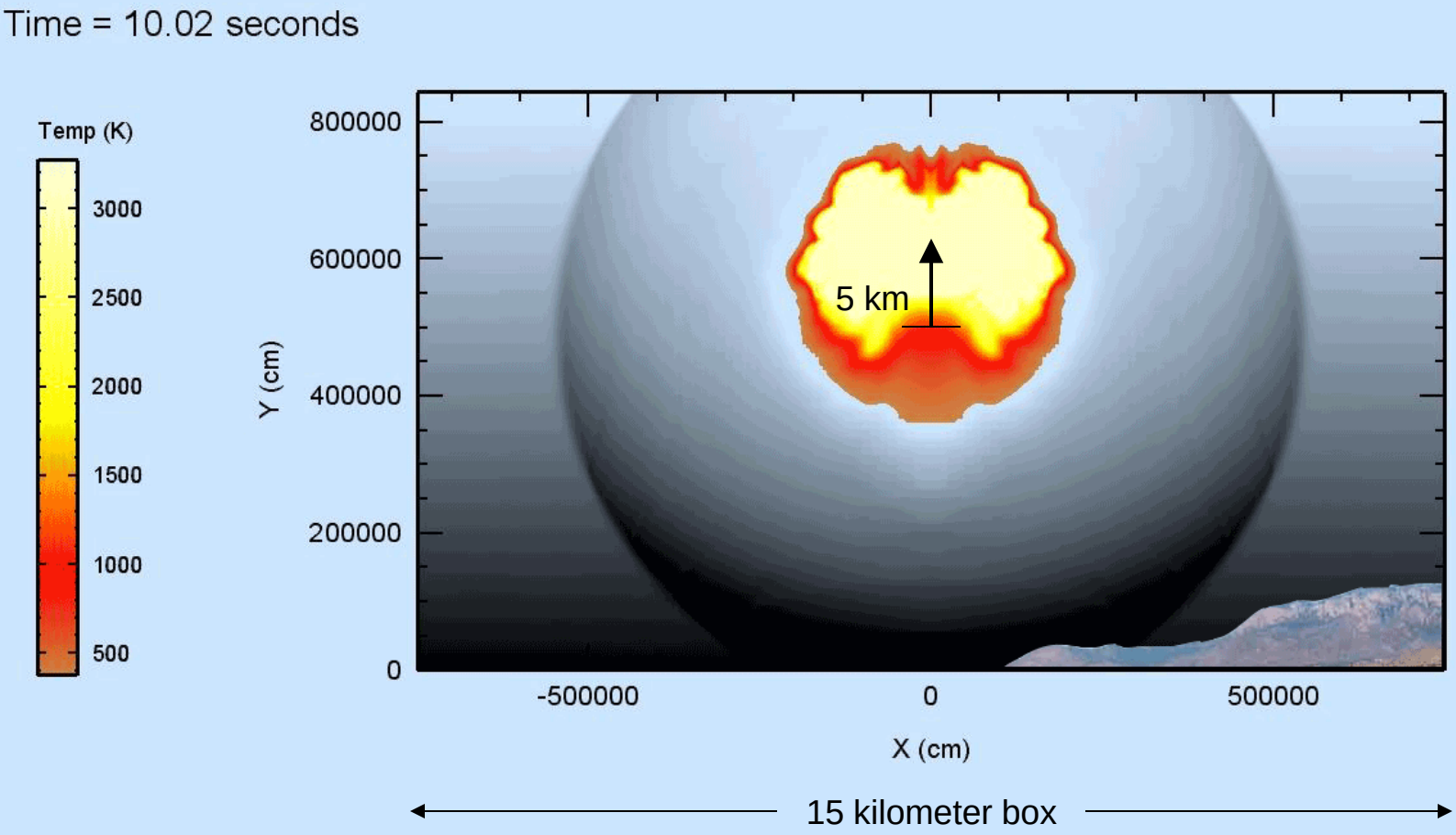
Wind speed map (this study)

Death Plunge! Libyan Desert, 29 Ma


Libyan Desert Glass

Movies: Difference between explosion and impact

5 megaton point explosion at 5 km altitude: first 20 seconds



Difference between explosion and impact

Temperature: 500 K  3000 K

5 megatons: first 20 seconds

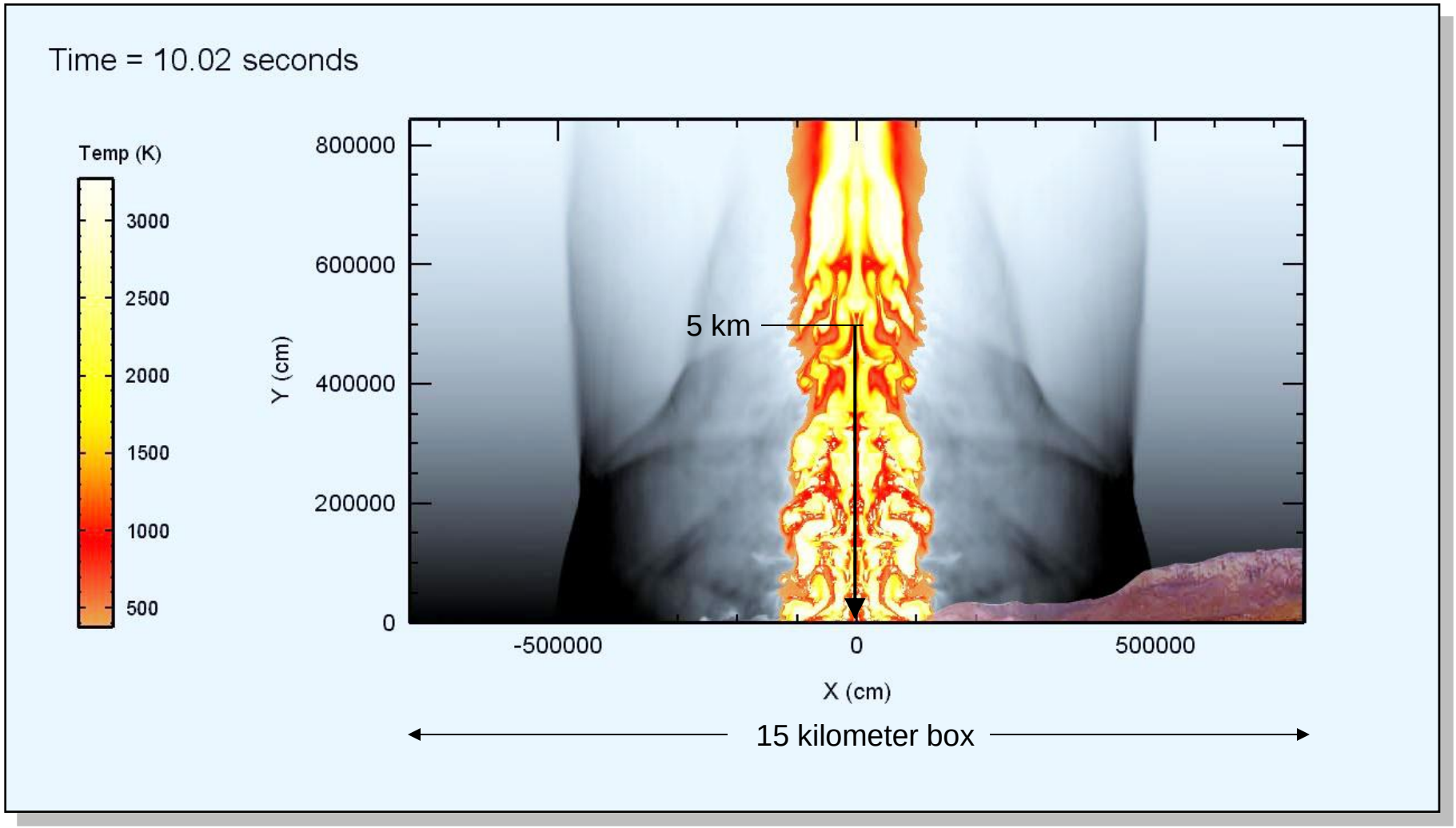
Explosion

5 km

15 km

Movies: Difference between explosion and impact

5 megaton impact airburst at 5 km altitude: first 20 seconds



Difference between explosion and impact

Temperature: 500 K  3000 K

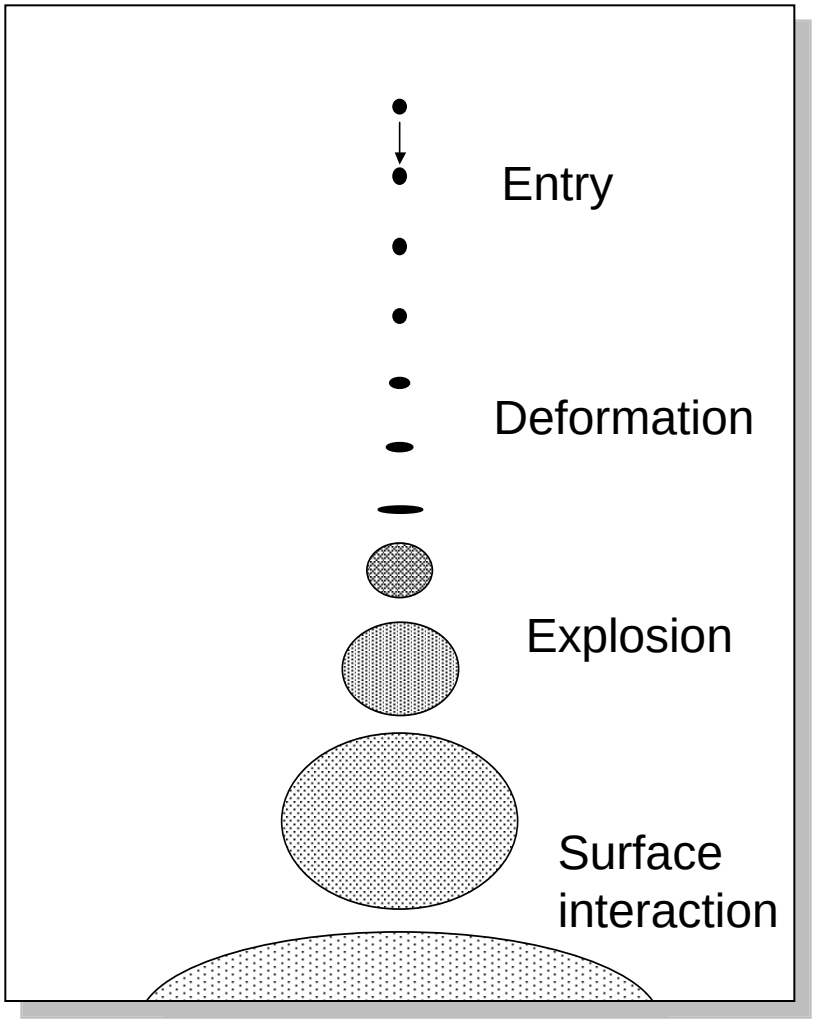
5 megatons: first 20 seconds

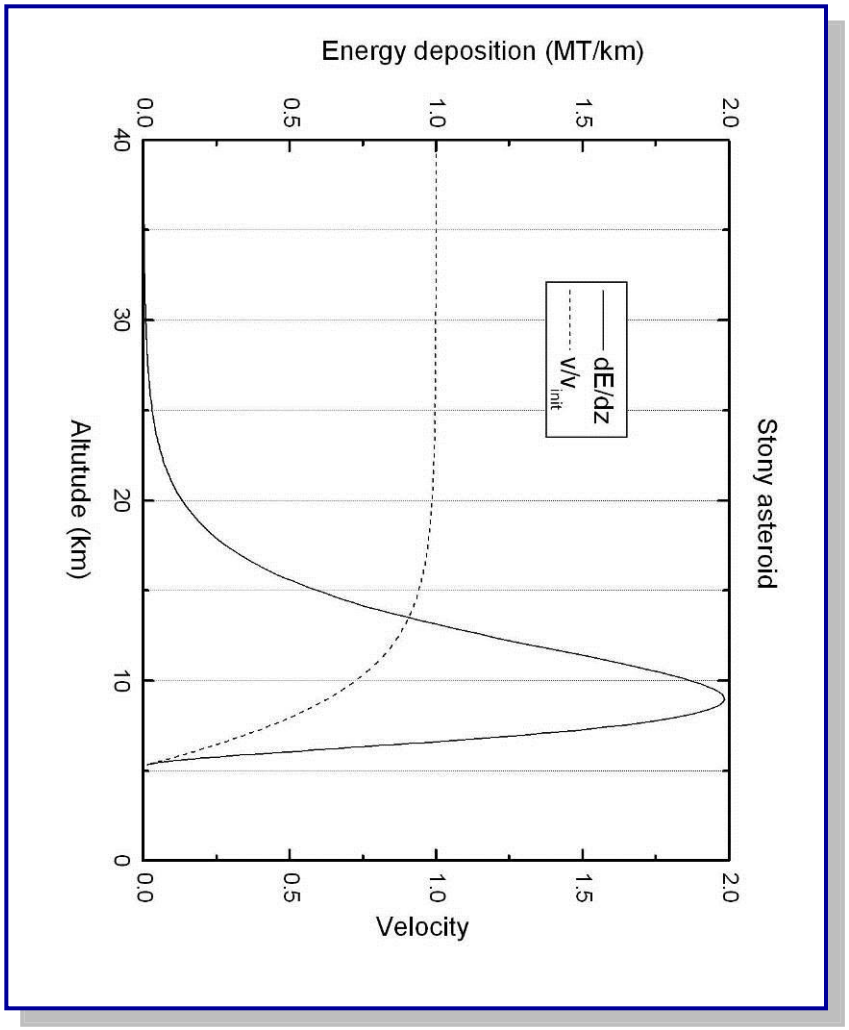
Impact Airburst

5 km

15 km

Earth’s atmosphere is penetrated by hot vapor jet





The “point source explosion” model is a poor approximation.

Two types of Low-Altitude Airburst

Tunguska tree-fall

Libyan Desert Glass

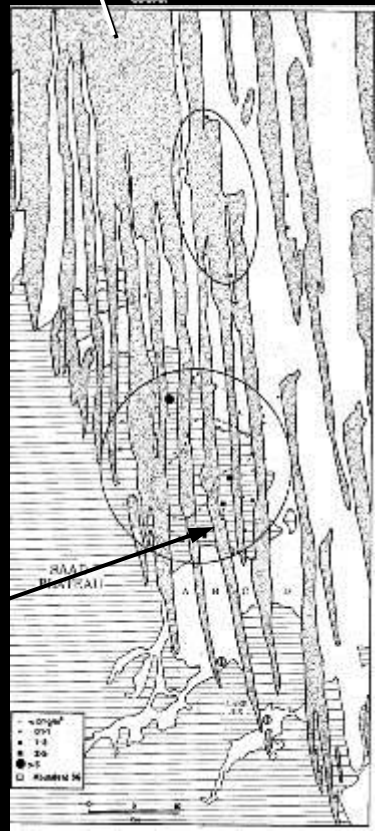
Type 1: Tunguska

Scorches and blows down trees

Type 2: Libyan Desert

Vaporizes trees and melts rocks

BBC Documentary



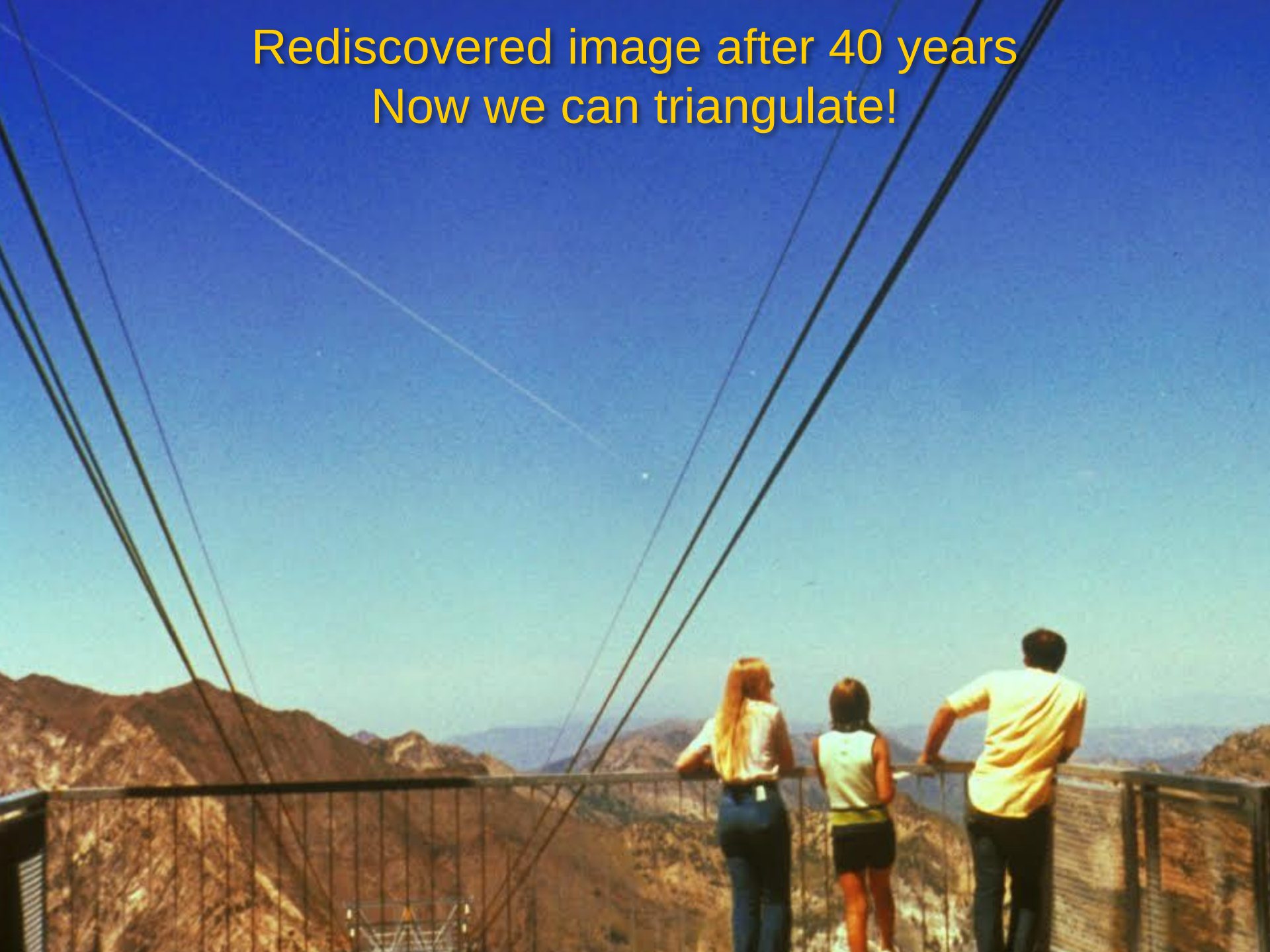
Tutankhamun’s Fireball (Ancient Asteroid)

Is there more than one kind of airburst glass?

Shui Jing Glass

Libyan Desert Glass

Not quite a Death Plunge! August 10, 1972

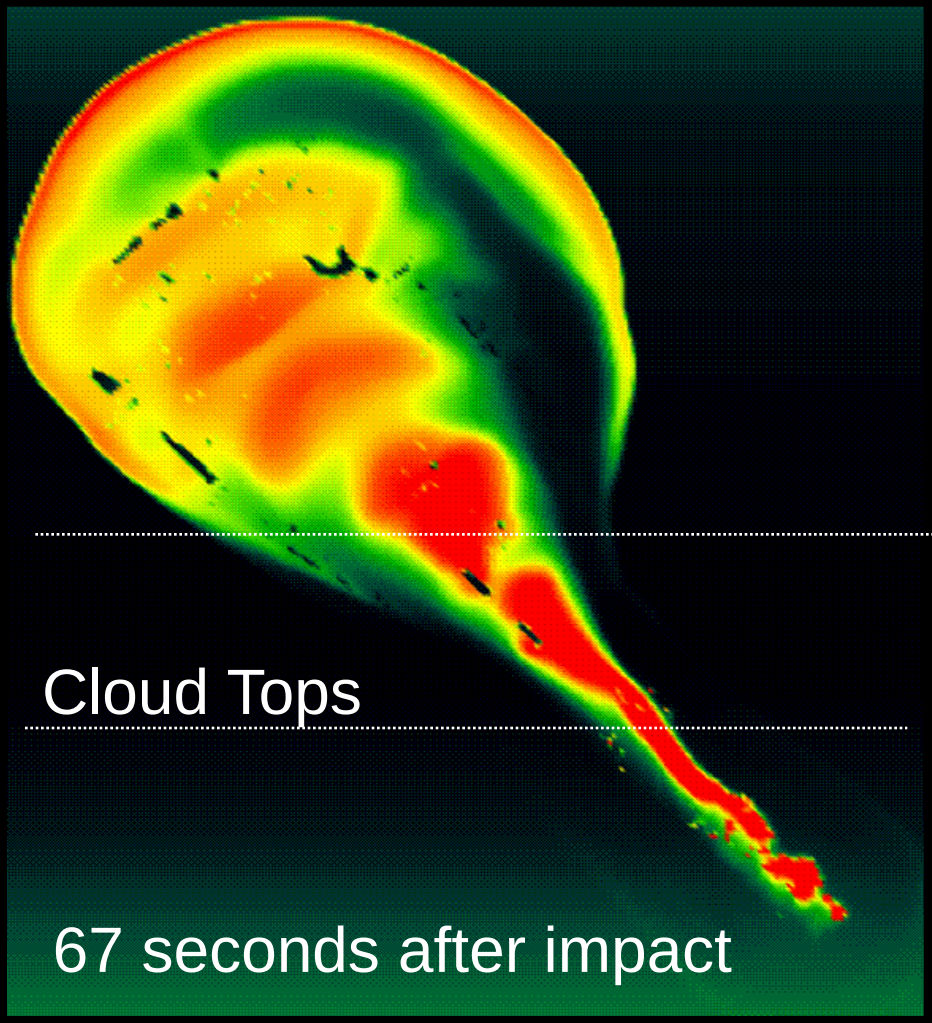

Rediscovered image after 40 years
Now we can triangulate!

Death Plunge! Jupiter, 1994

First such event with warning time and observations!

Comet Shoemaker-Levy 9

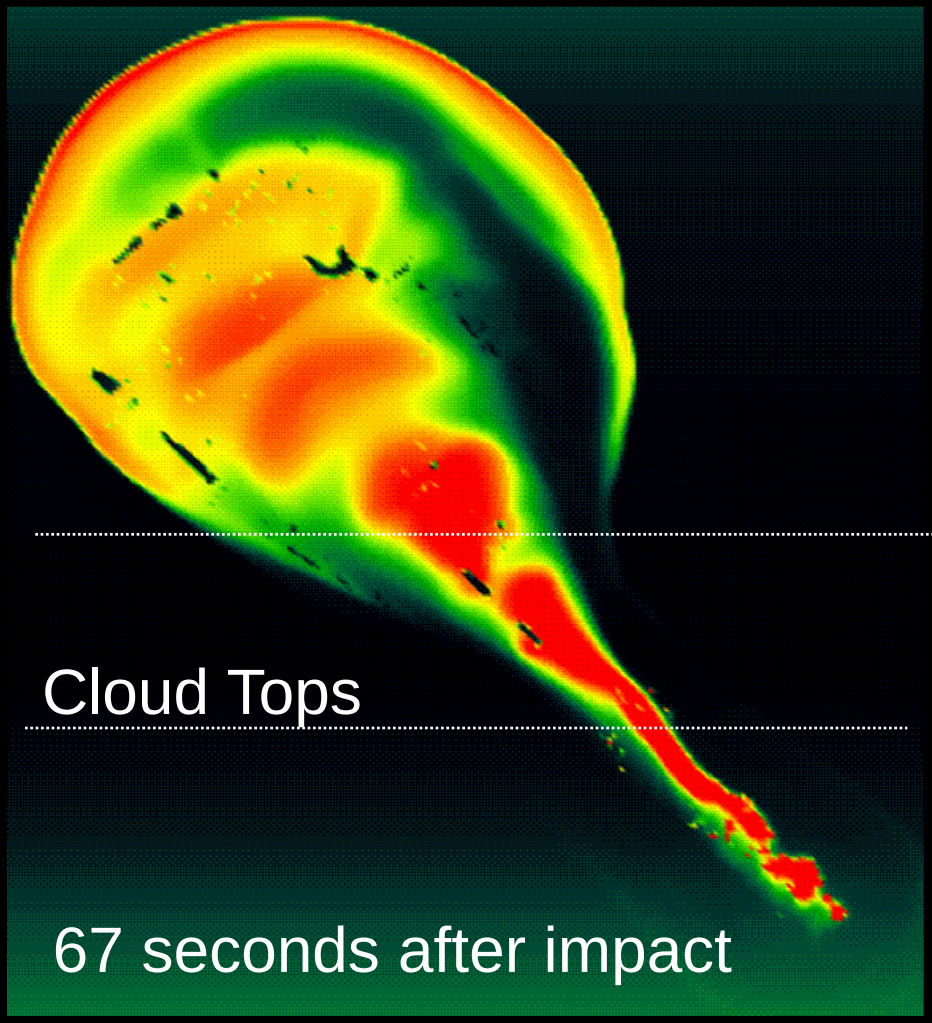
Plumes from collisional airbursts: Emergent phenomenon
Discovered in 1993 by computation of Shoemaker-Levy 9



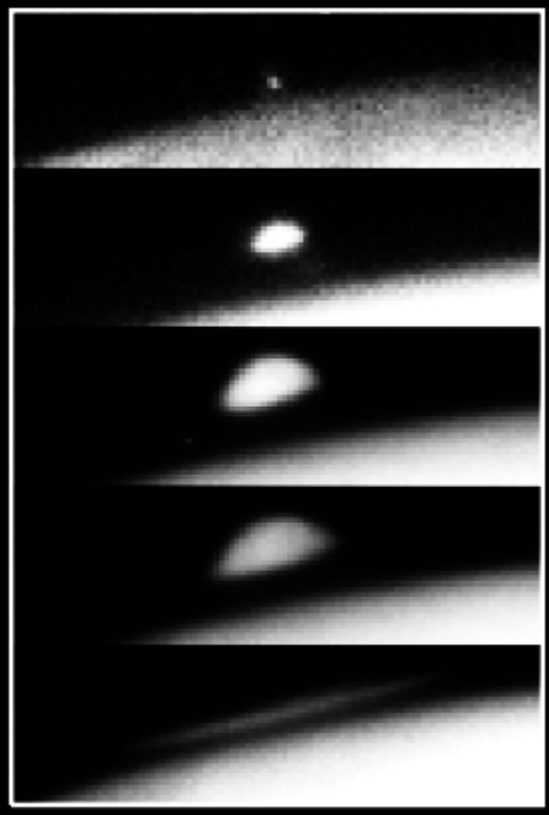
Visible From Earth

Behind Jupiter

Airburst is a line explosion that ejects a plume: Observational validation by Shoemaker-Levy 9 impact

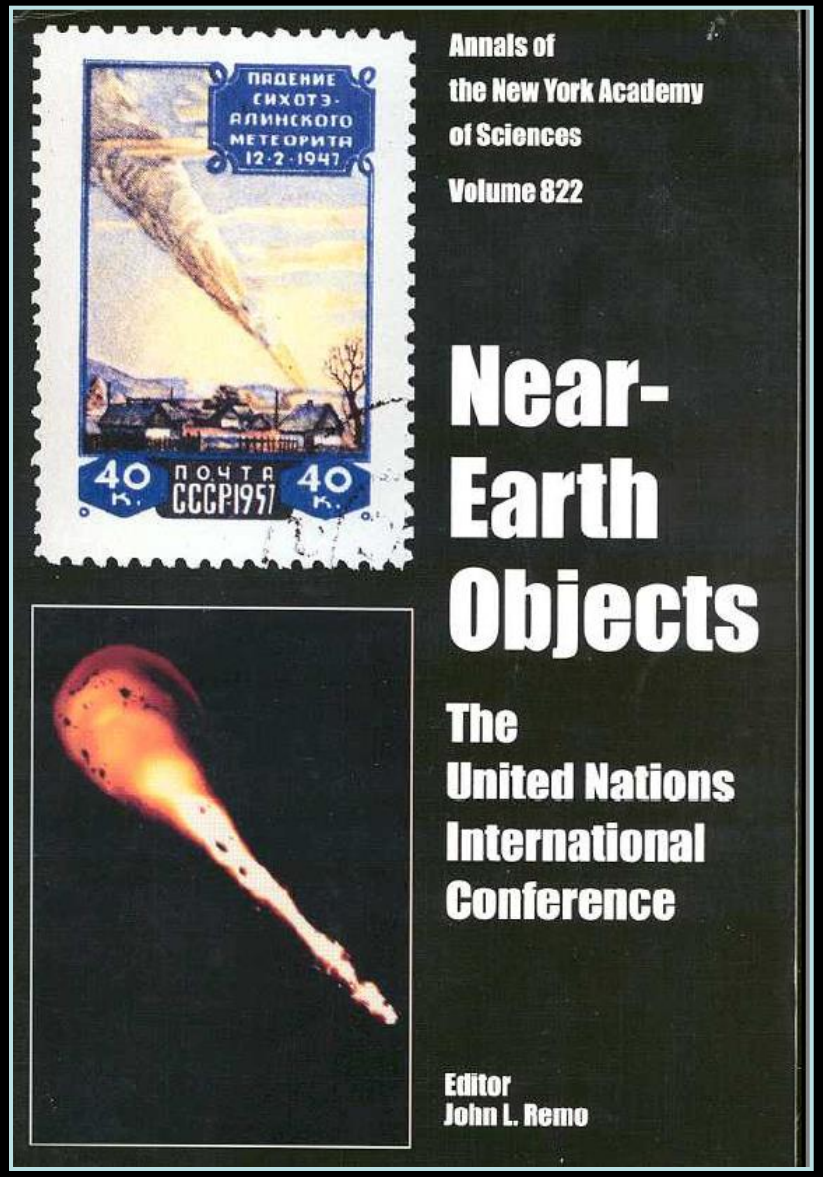


Impact G



Hubble Space Telescope Image

Plumes and line explosions on Earth



Death Plunge! Northern Sudan, 2008

Second event with warning time and observations

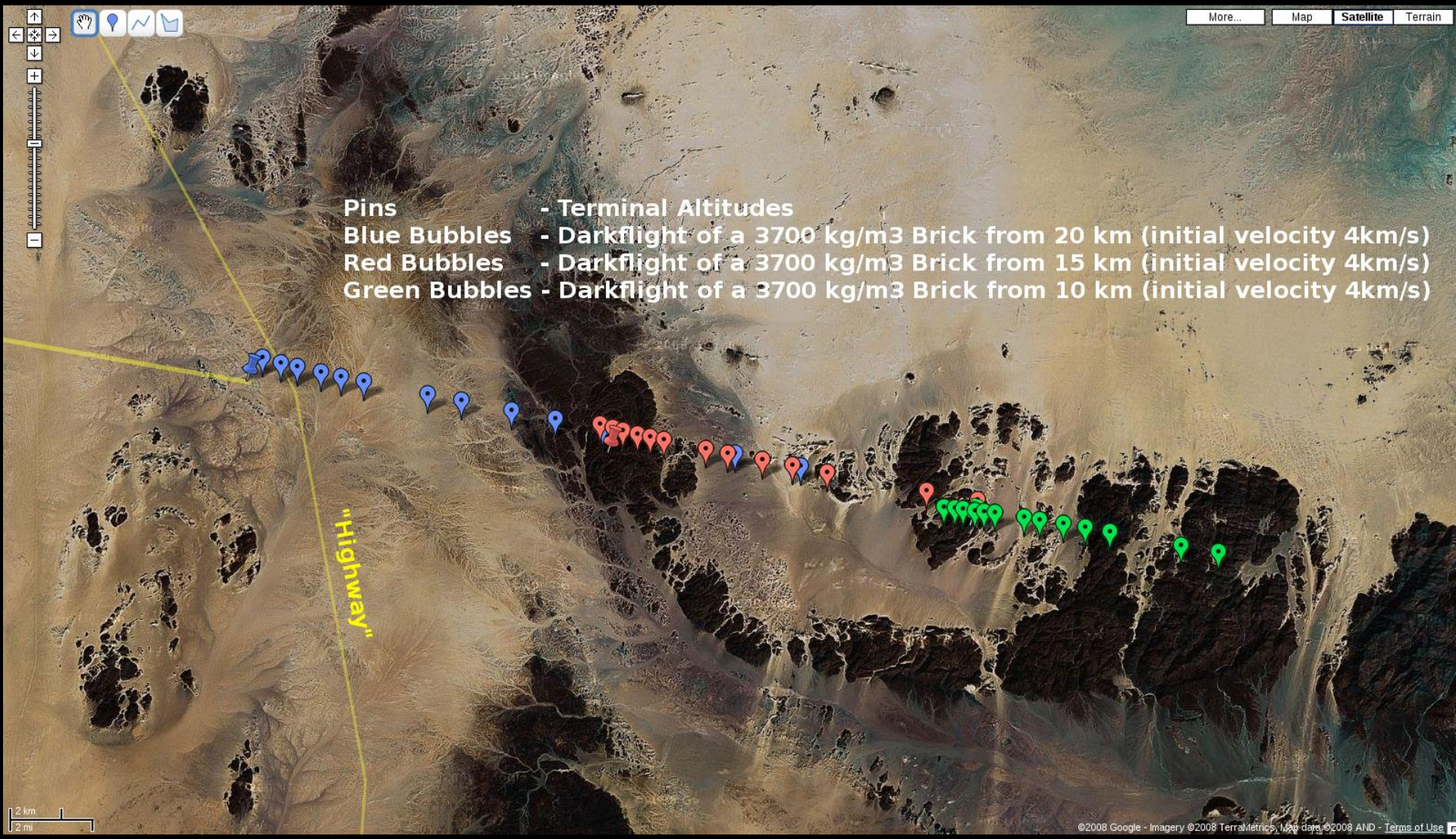
At 11:08 AM 10/6/2008, Andrea Milani wrote:

>Today the object with the provisional designation 8TA9D69 was submitted
>to impact monitoring by using the normal software of the NEODyS system,
>by using the observations as reported by the MPC on the NEO
>Confirmation Page.
>
>
>Based on 26 optical observations (of which 0 are rejected as outliers)
>from 2008/10/06.278 to 2008/10/06.643.
>
>Coordinates are given on the Target Plane Unit is one Earth radius, but
>impact cross section has radius between 2.02 and 2.02 Earth radii
>
>The probability of impact is, according to different computations done
>in slightly different ways, between 99.8% and 100%; **in practice the
>impact can be considered sure and is for tonight.** Our computation has
>already been confirmed independently by others, including the JPL NEO
>group (with which we consult in all relevant cases of possible impact).

Asteroid 2008 TC_3 observed in space


Observed entering and exploding

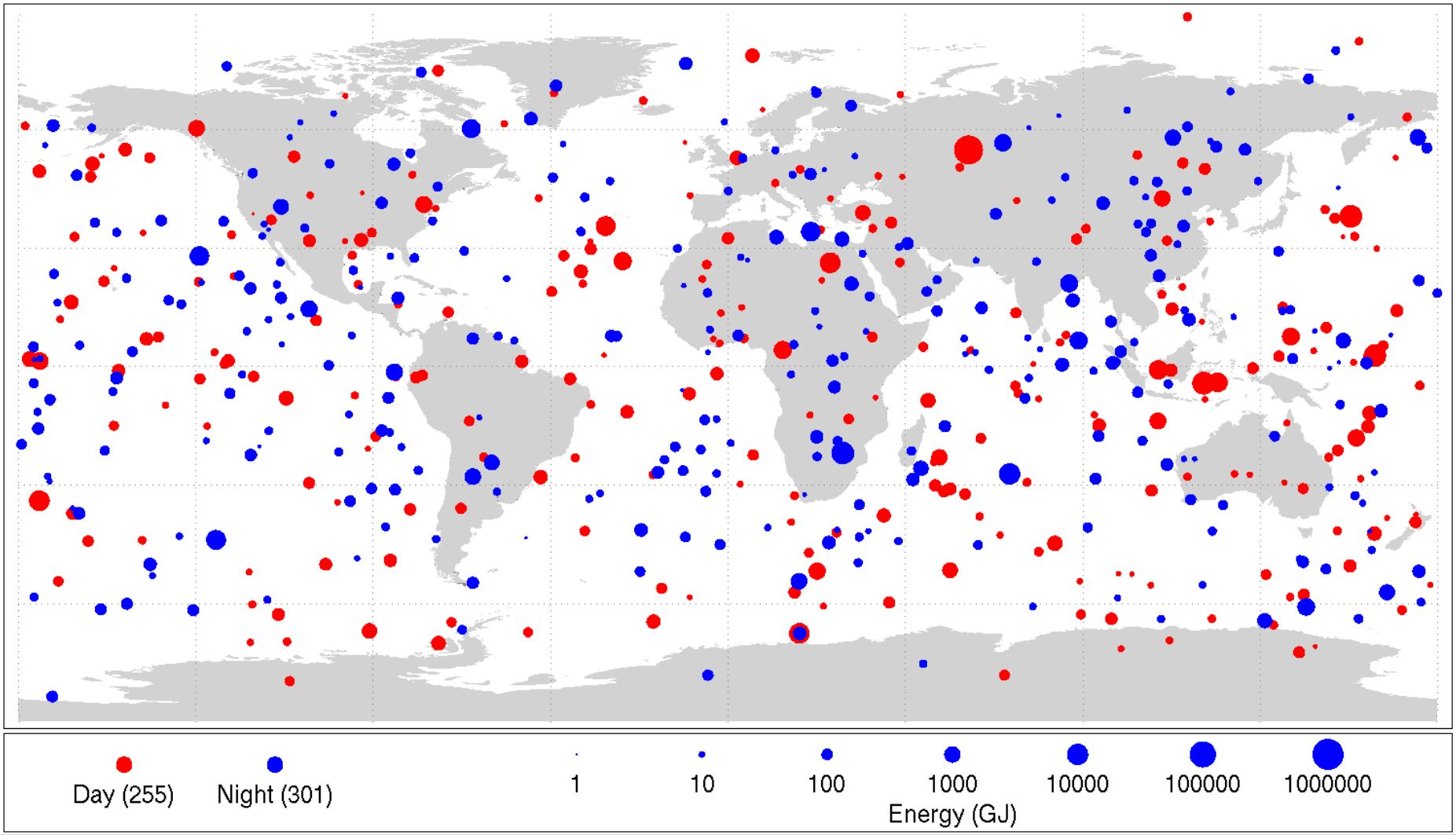
Recovery of meteorites guided by “Dark flight” calculations using known trajectory



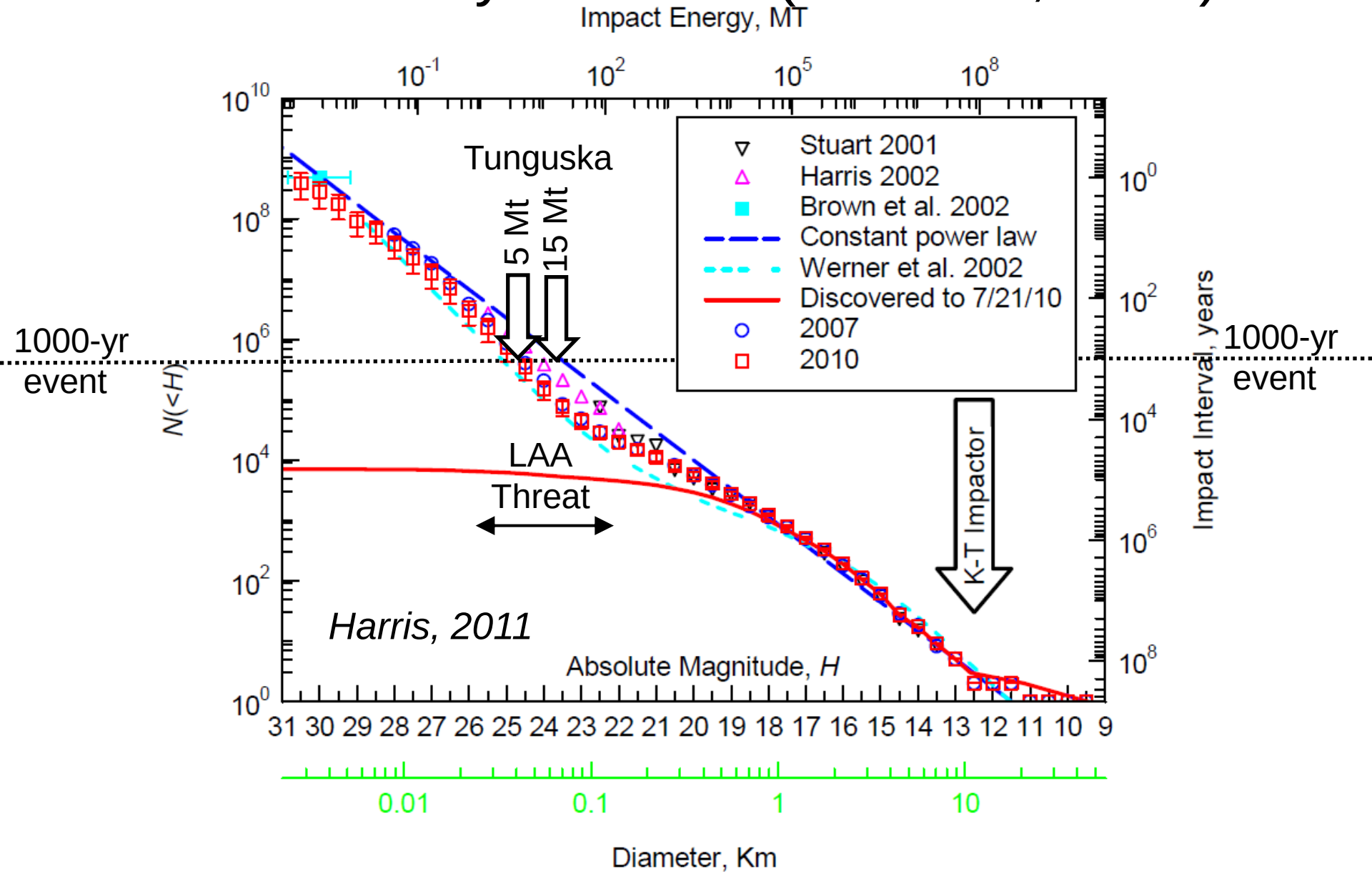
Found on the ground… Trifecta!

Nature **458**, 485-488 (26 March 2009)

Death Plunge Bolide Events 1994 - 2013



Tunguska yield reduced from ~15 to ~5 Mt
Still a 1000-year event (Al Harris, 2008)



Death Plunge!
Chelyabinsk, Russia, Feb. 15, 2013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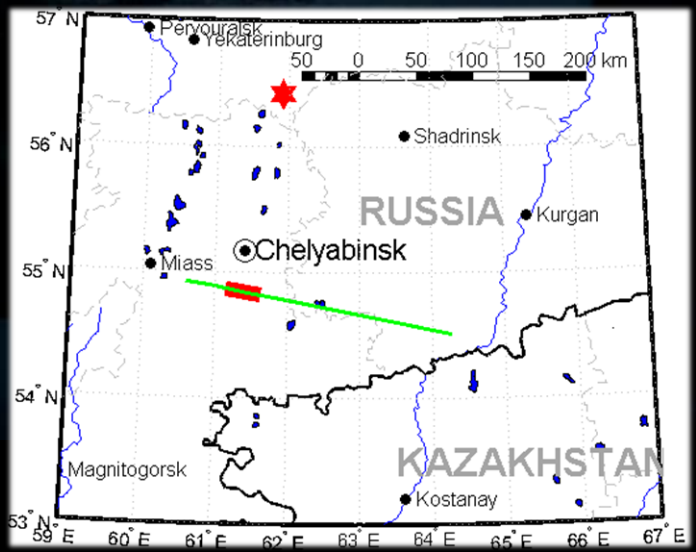
57° N
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59° E
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63° E
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66° E
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Yekaterinburg
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Shadrinsk
RUSSIA
Kurgan
Chelyabinsk
Miass
Magnitogorsk
KAZAKHSTAN
Kostanay


57° N
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Chelyabinsk
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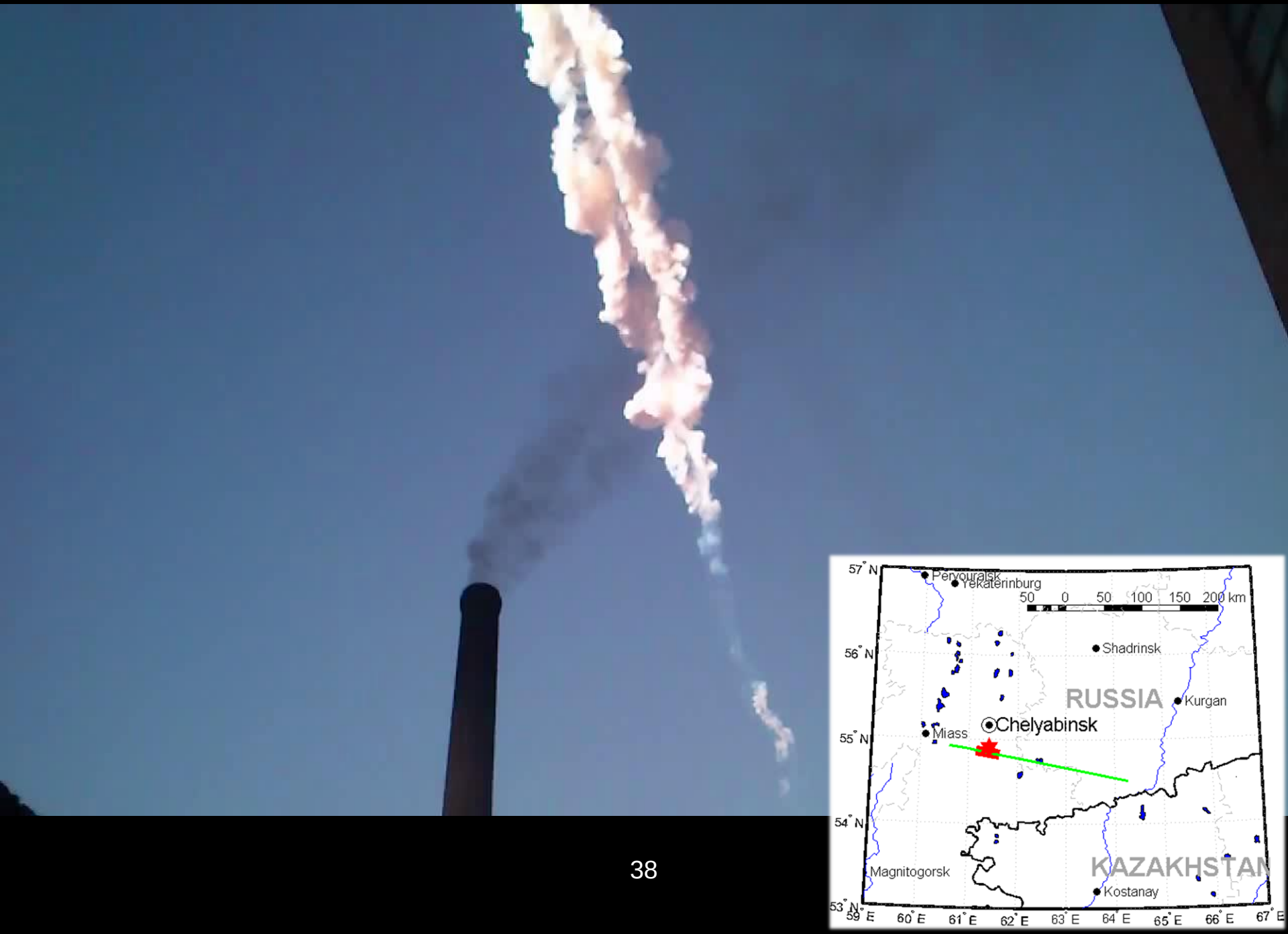
Kostanay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Yekaterinburg
50 0 50 100 150 200 km
Shadrinsk
RUSSIA
Kurgan
Chelyabinsk
Miass
Magnitogorsk
KAZAKHSTAN
Kostanay

US Government sensors

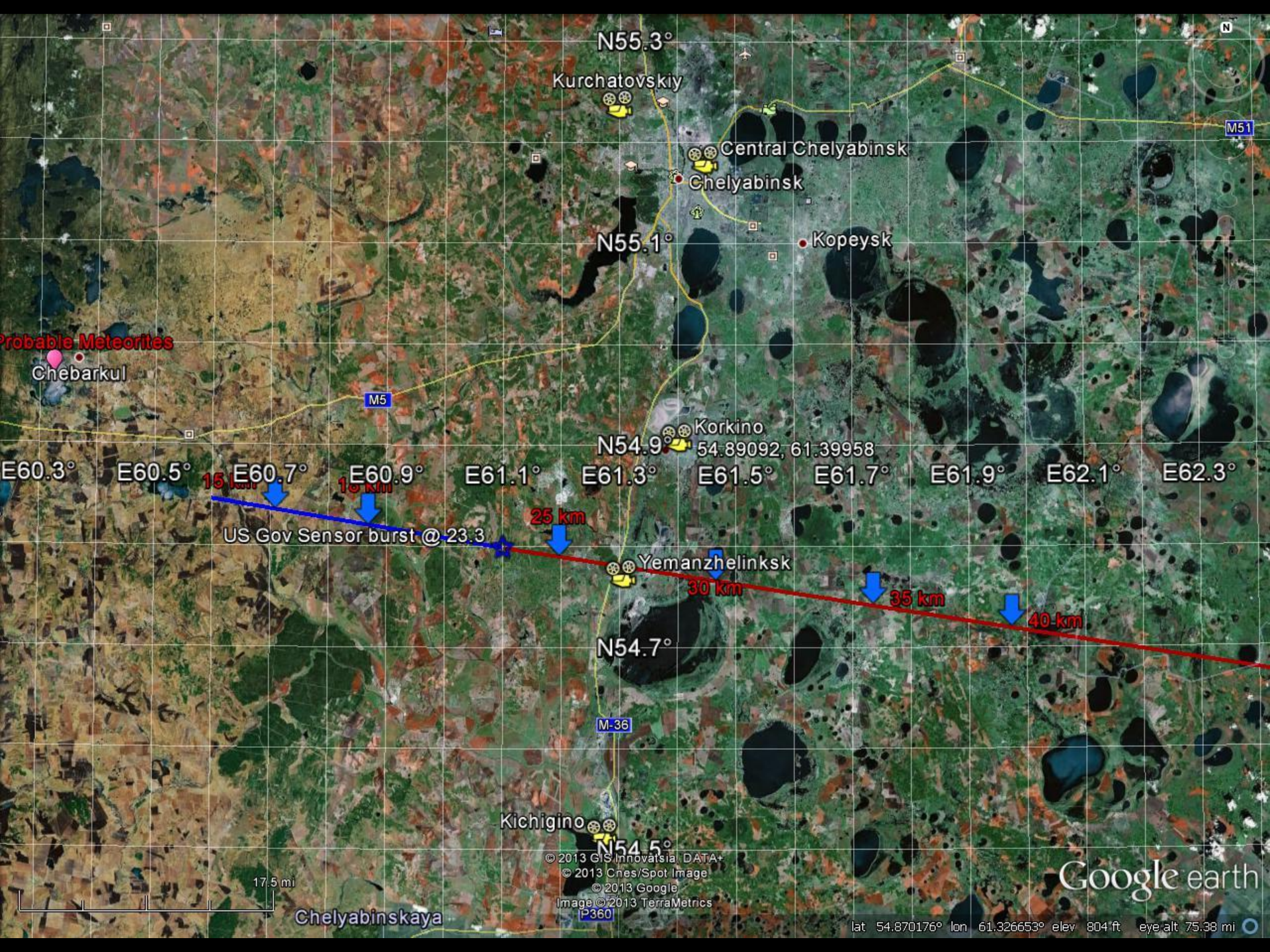
IIIIIIIIIIIIIIII START OF REPORT IIIIIIIIIIIIIIII

FOR PUBLIC RELEASE Distribution A
Bolide: On 15 February 2013
Sensors detected the following indications of a meteoroid entry into Earth's atmosphere:
a. Dateltime at peak brightness: 15 February 2013/03:20:33 GMT
b. Location at peak brightness: Latitude 54.8o N, Longitude 61.1o E
c. Altitude at peak brightness: 23.3 km
d. Velocity at peak brightness: 18.6 km/sec
e. Approximate total radiated energy: Under Assessment
f. Pre-entry velocity vector (ECF): X= +12.8 km/sec; Y = -13.3 km/sec;
Z=-2.4 km/sec

90 kT TNT

IIIIIIIIIIIIIIII END OF REPORT IIIIIIIIIIIIIIII

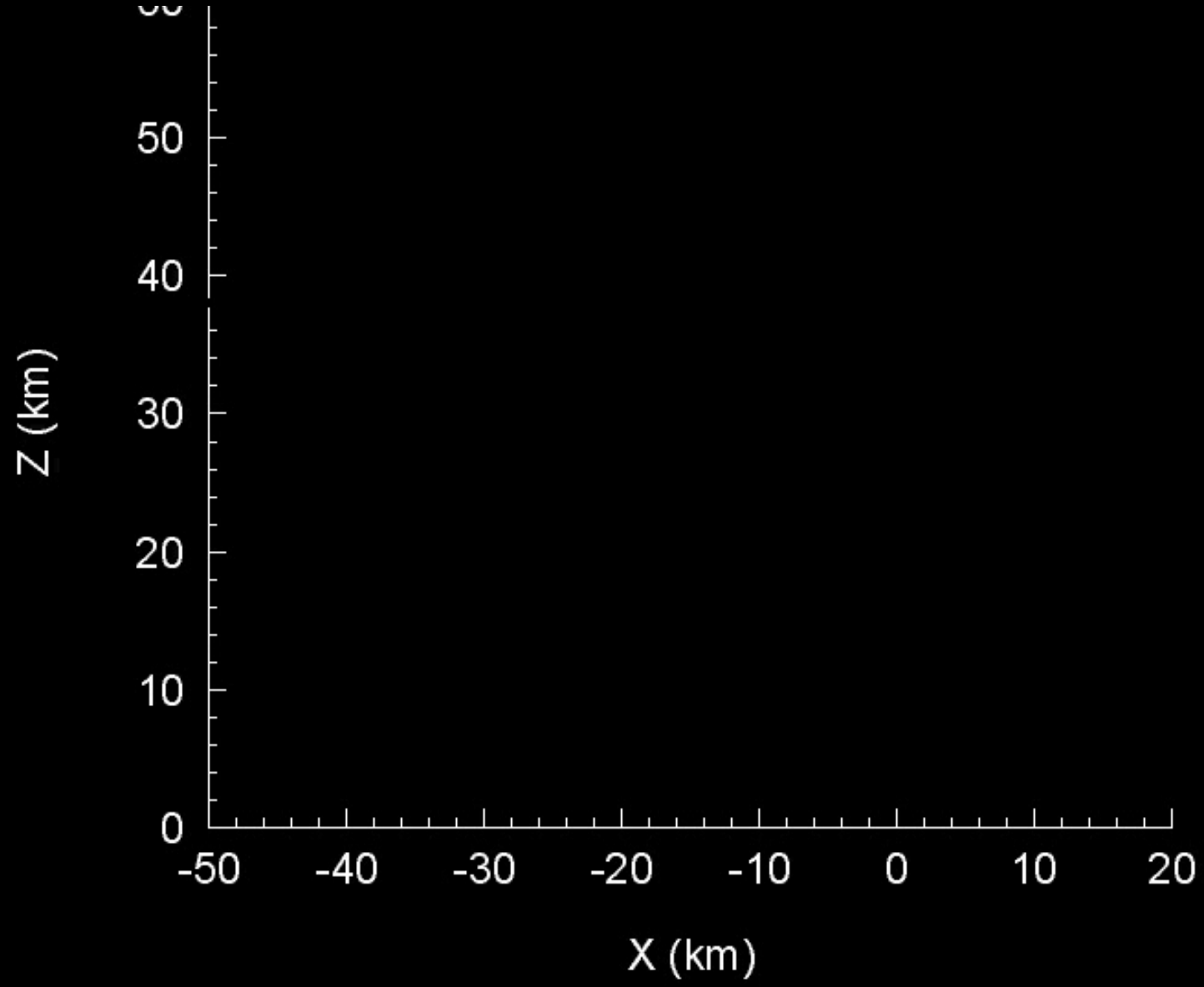
http://jpl.nasa.gov/fireball


N55.3°
Kurchatovskiy
Central Chelyabinsk
Chelyabinsk
M51
N55.1°
Kopeysk
Probable Meteorites
Chebarkul
M5
Korkino
N54.9°
54.89092, 61.39958
E60.3°
E60.5°
E60.7°
E60.9°
E61.1°
E61.3°
E61.5°
E61.7°
E61.9°
E62.1°
E62.3°
15 km
16 km
25 km
US Gov Sensor burst @ 23.3
Yemanzhelinksk
30 km
35 km
40 km
N54.7°
M-36
Kichigino
N54.5°
© 2013 GIS Innovatsia, DATA+
© 2013 Cnes/Spot Image
© 2013 Google
Image © 2013 TerraMetrics
P360
17.5 mi
Chelyabinskaya
Google earth
lat 54.870176° lon 61.326653° elev 804 ft eye alt 75.38 mi

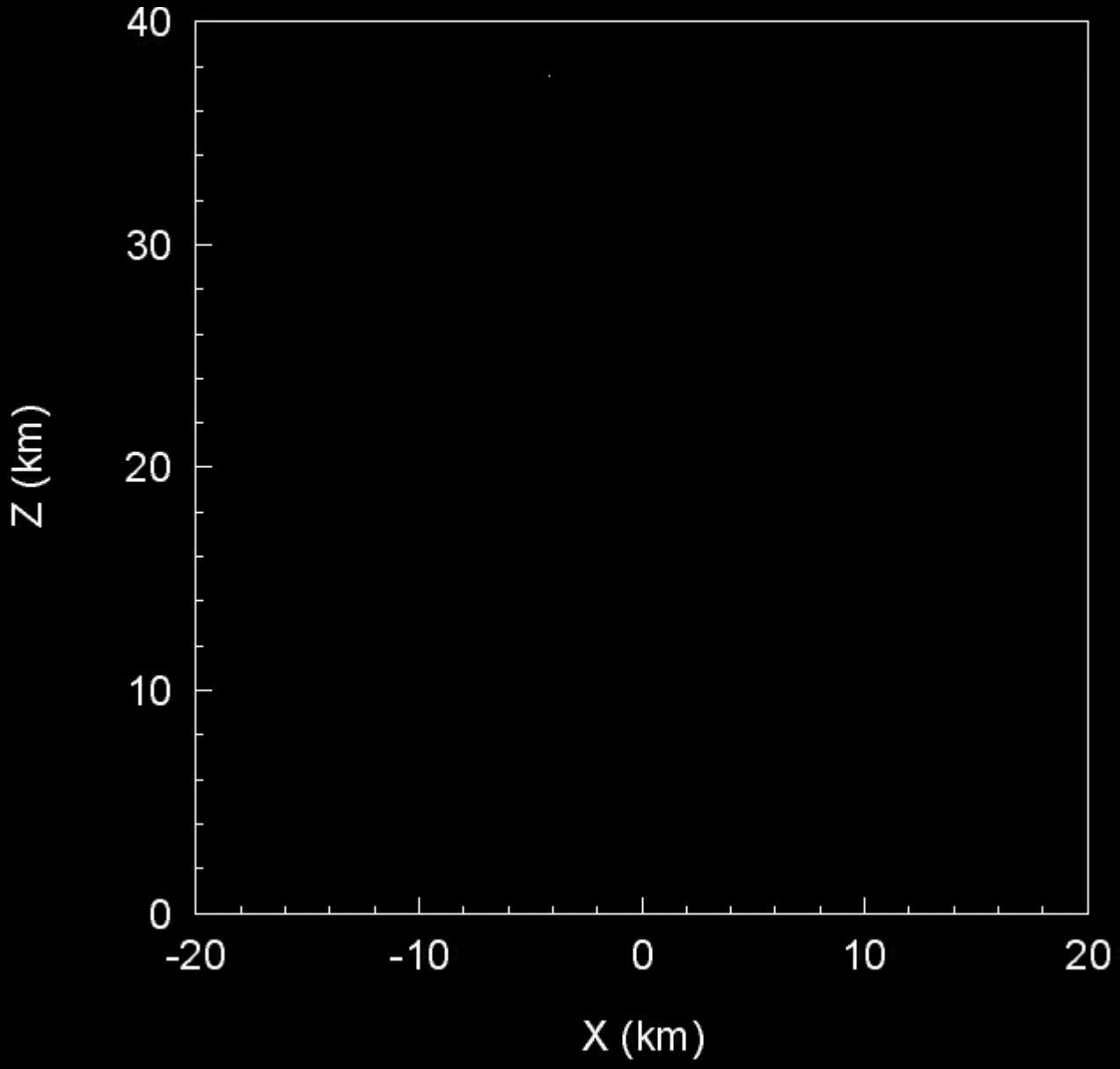
High-fidelity validation data

High-fidelity validation data

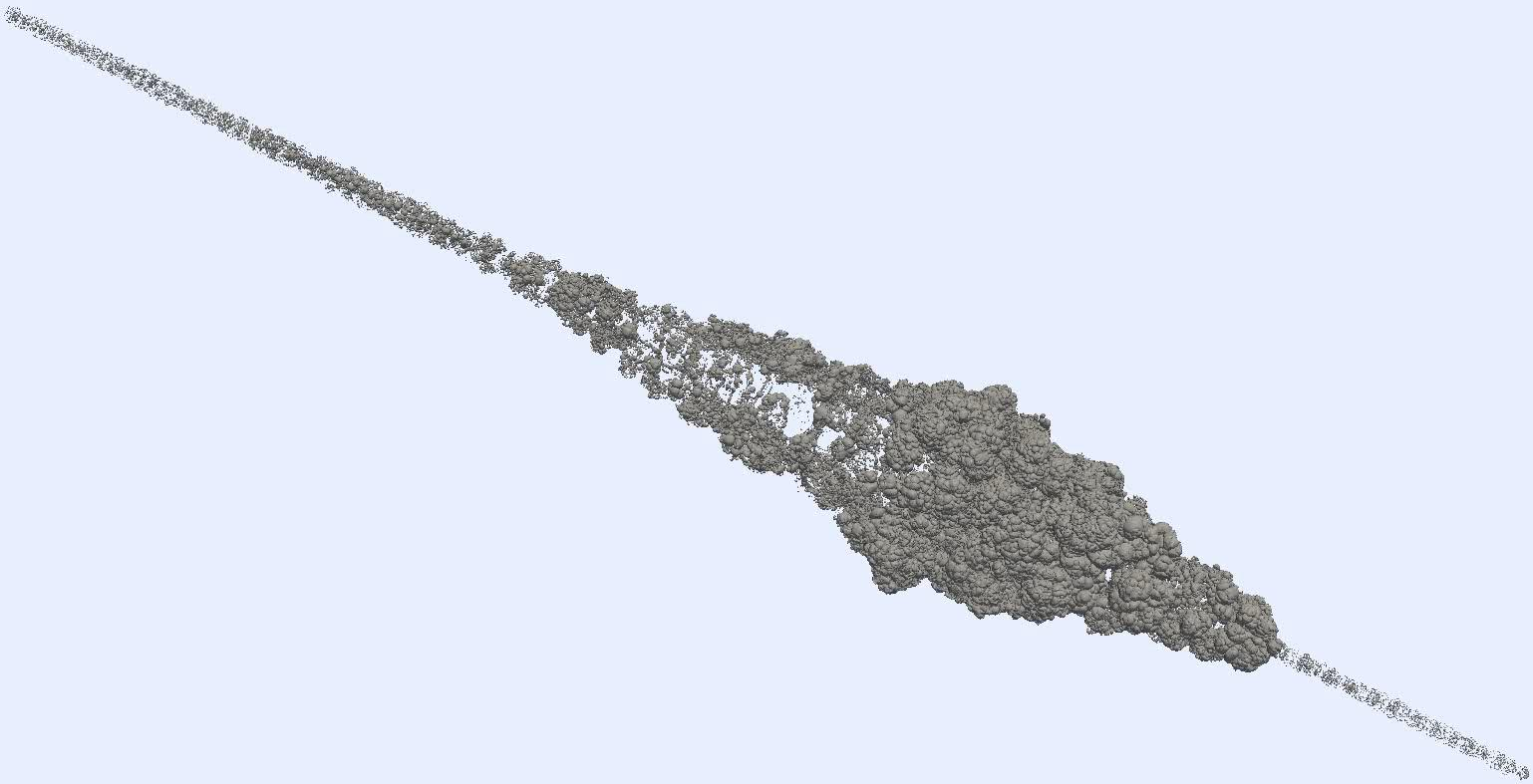
Chelyabinsk airburst simulation: 0.5 Mt



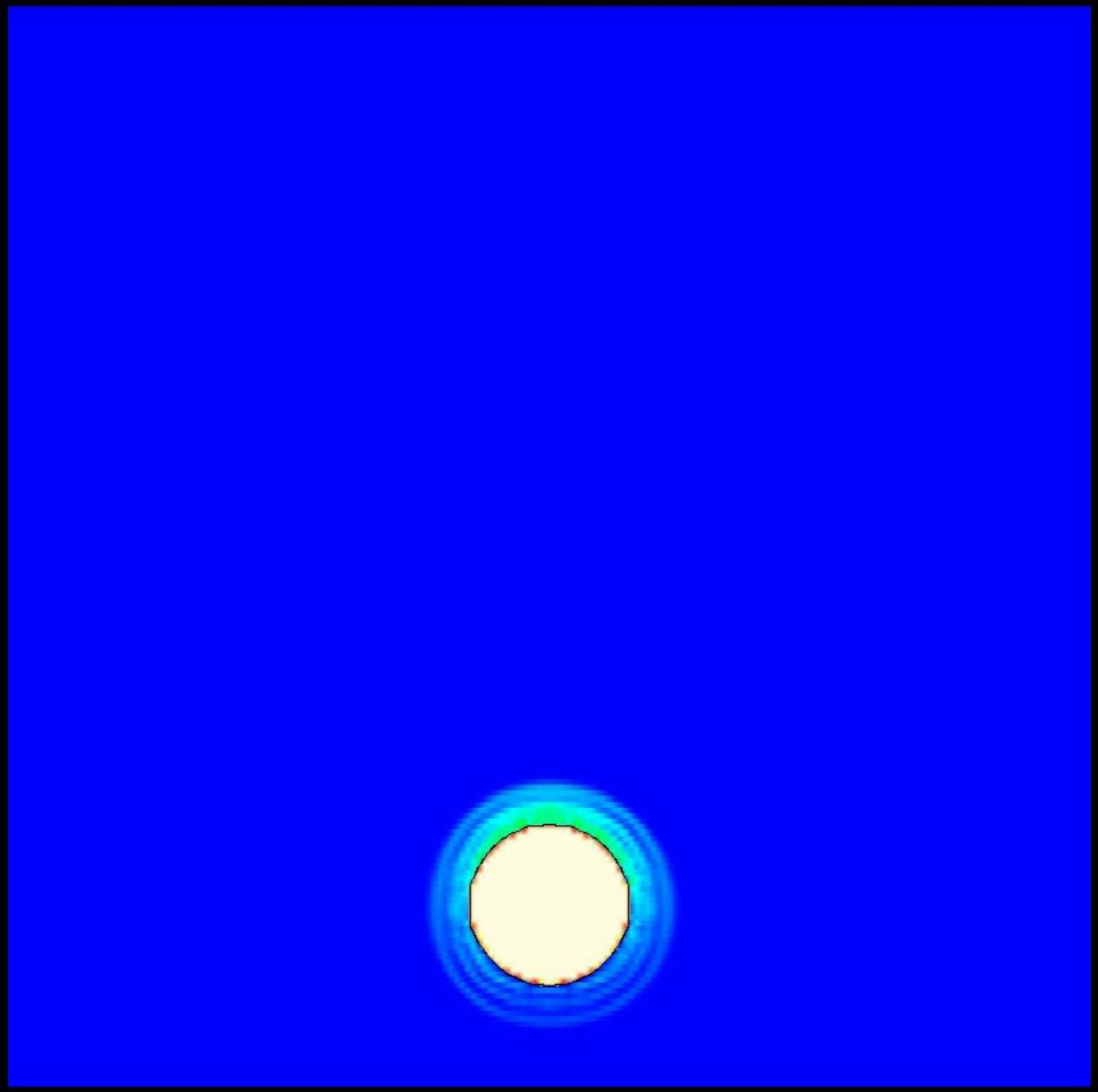
Steep airburst simulation: 0.5 Mt



Why were there two trails?



2D wake simulation

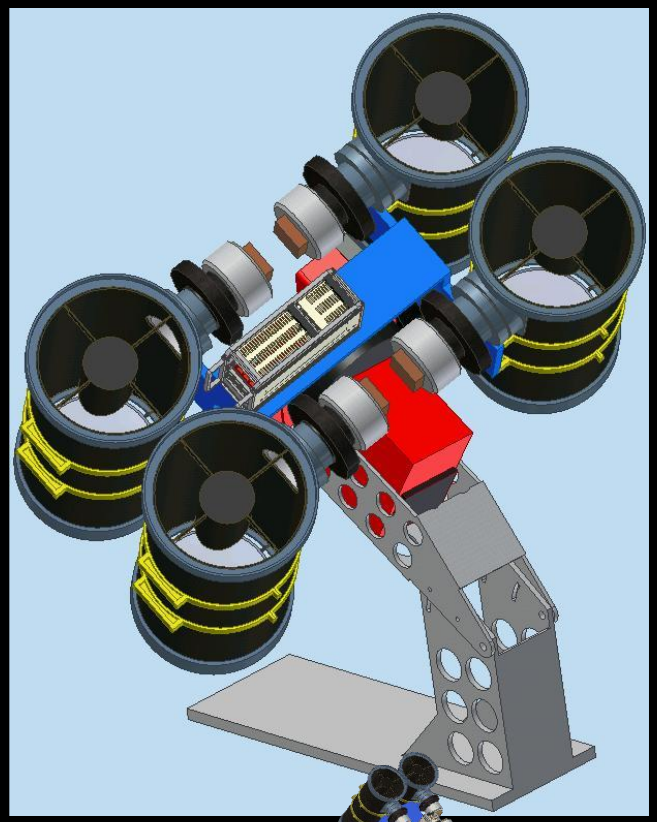


“Death Plunge” recommendation

Finding: It is highly probable that the next destructive NEO event will be an airburst from a <50-meter object, not a crater-forming impact.

Recommendation: Because recent studies of meteor airbursts have suggested that near-Earth objects as small as 30 to 50 meters in diameter could be highly destructive, surveys should attempt to detect as many 30- to 50-meter objects as possible. This search for smaller-diameter objects should not be allowed to interfere with the survey for objects 140-meters in diameter or greater.

National Research Council, *Defending Planet Earth*, 2010



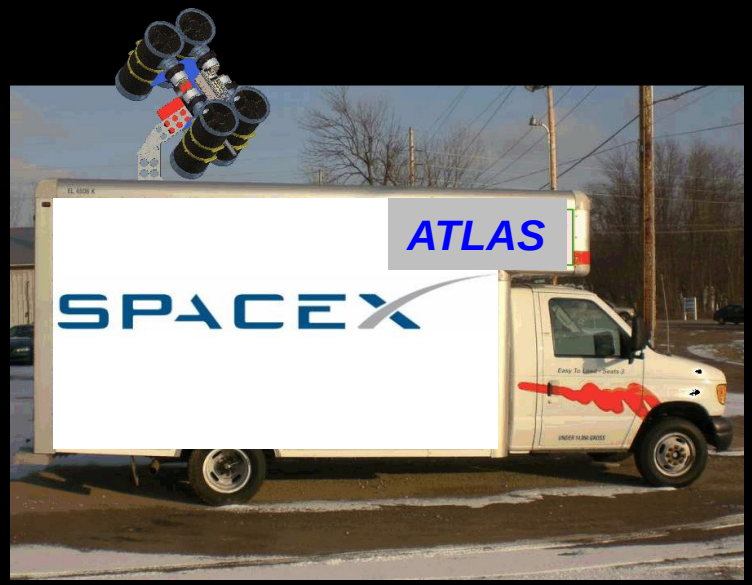
ATLAS

Last Minute Warning

John Tonry, PI

100 km

Death Plunge! Entrepreneurial opportunity



You logo here. Watch (this) Space!

Death Plunge! Adventure tourism?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VISION
Meteorites!
Death Plunge collection
On loan from
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Questions?