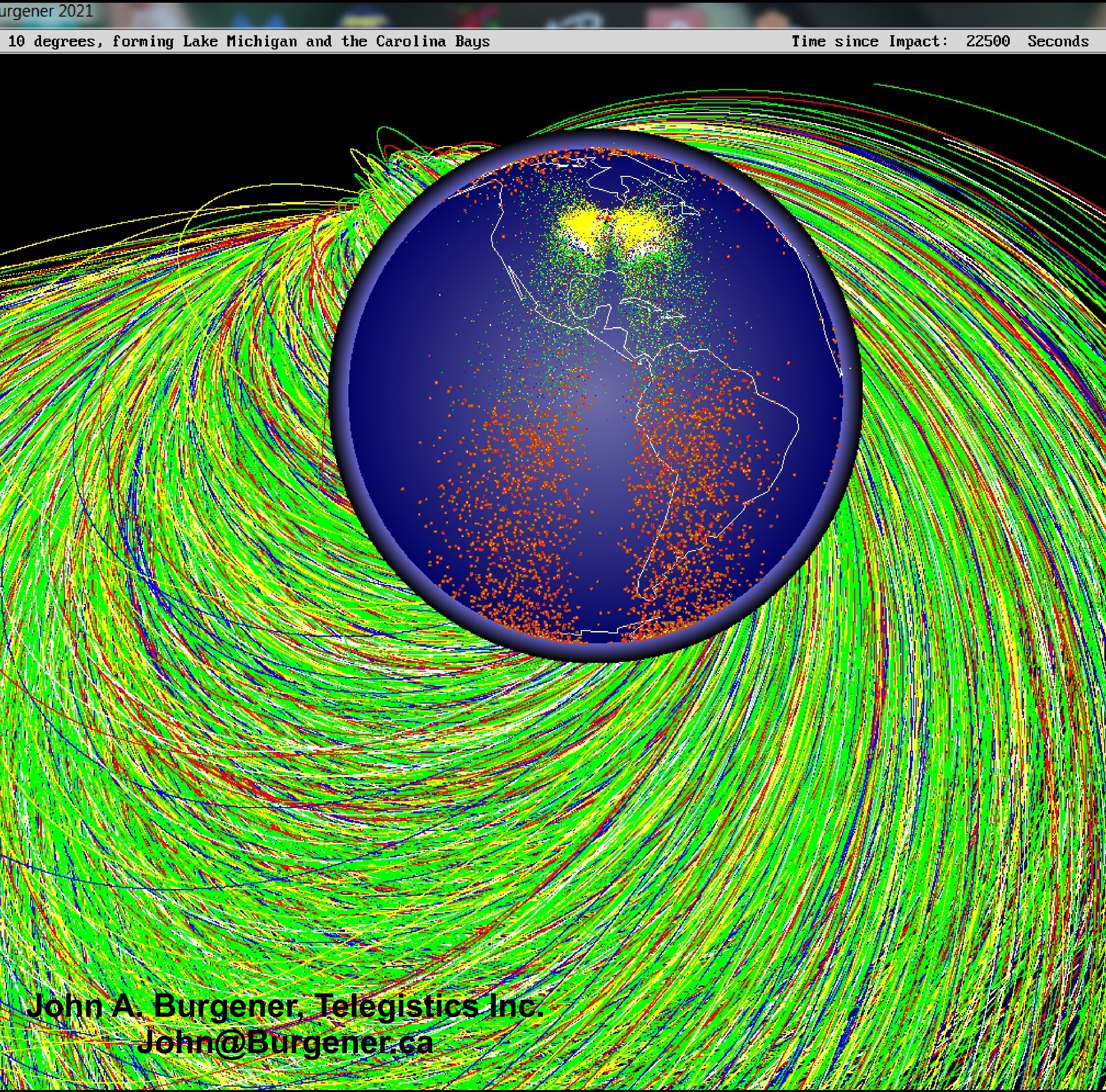
Skip Impact Program Manual



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A 3D program

to demonstrate skip impacts and their relationships to higher angle impacts

Comet Skip Impact Program
Manual

The Skip Impact program is designed to show many different aspects of impacts, with a particular emphasis on skips and low angle impacts. Most impact studies focus on impacts of 30° to 90° since they are more common and more easily recognized. But Earth has many features that may be skip or low angle impacts and being able to recognize them and their resultant effects should be interesting.

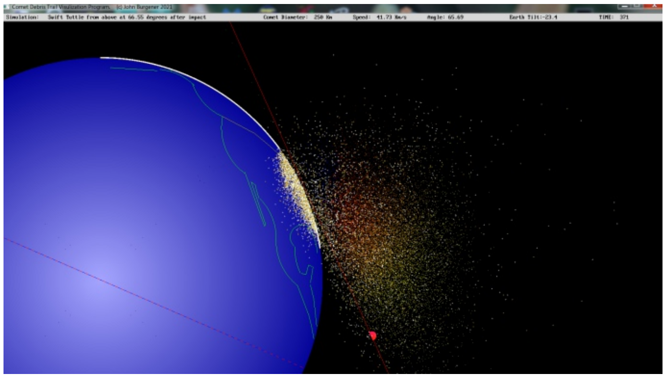
The first screen is a short note on the program, followed by this screen, the MENU. From here you can select one of the many program simulations available. You can get back to this menu by pressing Ctrl H.

The program is written in QB64 by John Burgener © 2021. QB64 is a basic language that compiles into very fast code that runs about 800 times faster than Microsoft Visual Studio programs. Speed is important when trying to simulate events that take thousands of years, and even for rapid events, a simulation of a minute is much more informative than the same simulation being several days of computer time. The program has about 10,000 lines of code, and is available on the web site: www.craters.ca and eventually will be on the QB64.com web site.

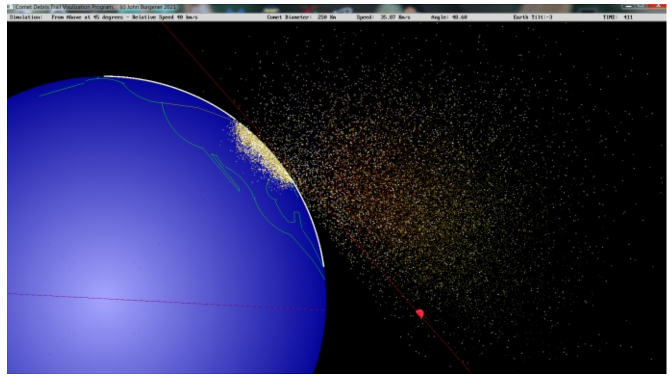
In all scenes, you can press the keys to jump to another scene or go back to the menu at any time:
F1-F5, Ctrl Q to Y, Ctrl A to H, Ctrl L, M: call up other scenes.

2 Dimensional Skip Impact Scenes:

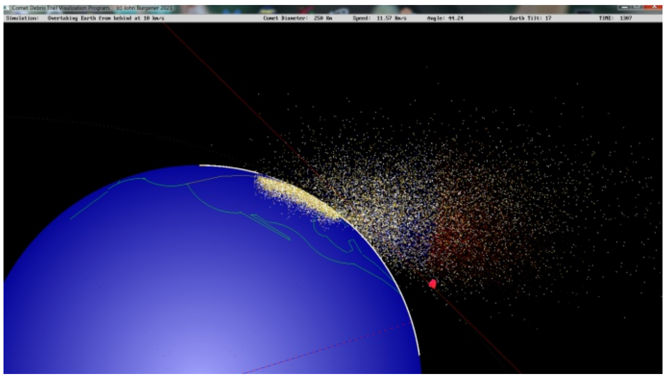
The first set of scenes shows how the debris from a skip impact will travel into space and spread debris on Earth. There are 5 variations on how a comet can approach Earth and the differences that makes to an impact.



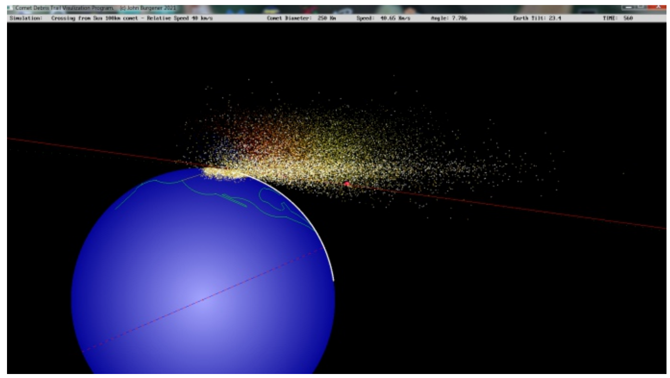
F1: Comet Swift Tuttle from above,
at 66.5° after impact. Relative Speed 42 km/s



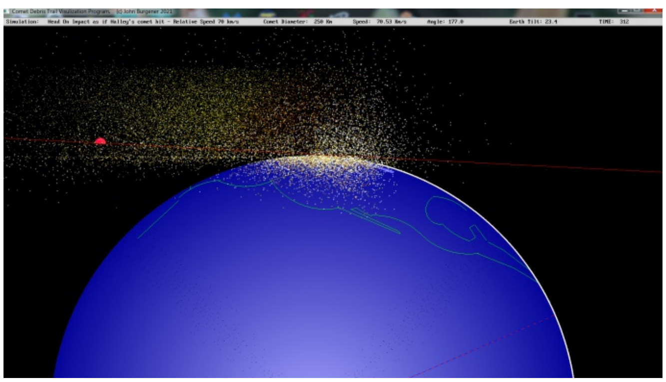
F2: From Above at 45°. Relative Speed 40 km/s



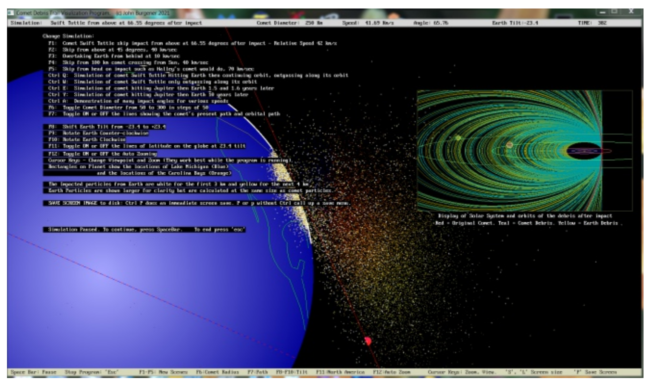
F3: Overtaking Earth from behind at 10 km/s



F4: 100 km diameter comet, crossing from Sun.
Relative Speed 40 km/s



F5: Head On Impact
as if Halley's comet hit. Relative Speed 70 km/s

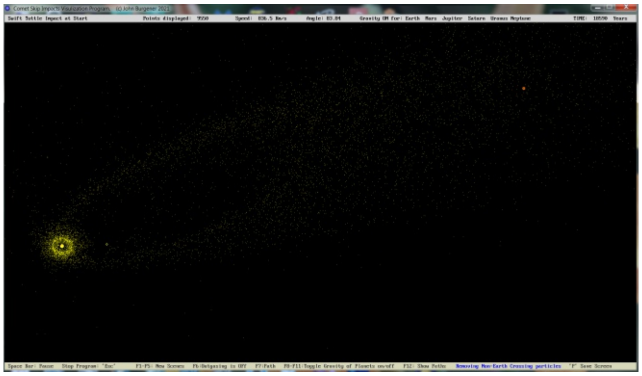


Space Bar Display
Shows some options and image of orbits of debris.

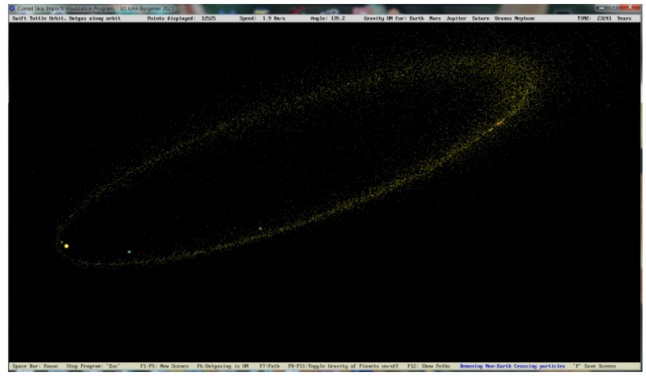
F6: Change Comet Radius.
F7: Turn on or off Comet's path. Much slower if on.
F8 – F10: Change tilt of Earth relative to comet's path
F11: Turn on or off image of North America
F12: Turn on or off auto zooming. At start auto-zooming is On.
Cursor Keys: up, down, right, left: change view. Page up or Page Down: zoom in and out.
Ctrl P: Save screen image to hard drive.
P or p: Call up save options for autosaving of selected intervals of screen images.
Space Bar: Pause and show orbits of debris from impact.

2.5 Dimensional Comparison of Skip Impact and Outgassing

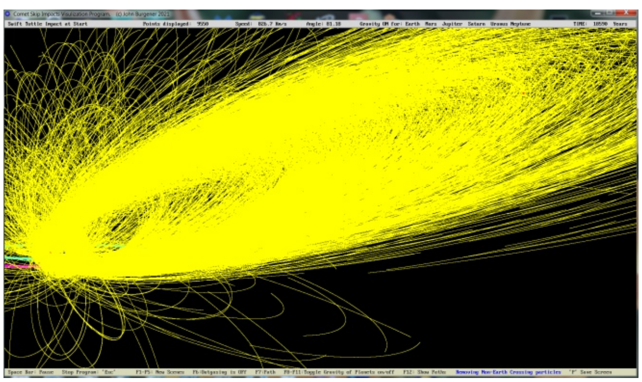
This second set of scenes shows how the debris from a skip impact will travel into the Solar System and spread out to a multitude of orbits compared to what is expected with a comet outgassing as it travels around the Sun. While outgassing does produce a wide range of orbits on the debris, it has a large concentration of the orbits close to the original comet orbit, whereas the skip impact has the debris travel on virtually every orbit possible with no concentration on the comet's path. This is mainly 2D, but the planets are in a different plane than the comet, so some aspects are 3D, thus the 2.5D designation.



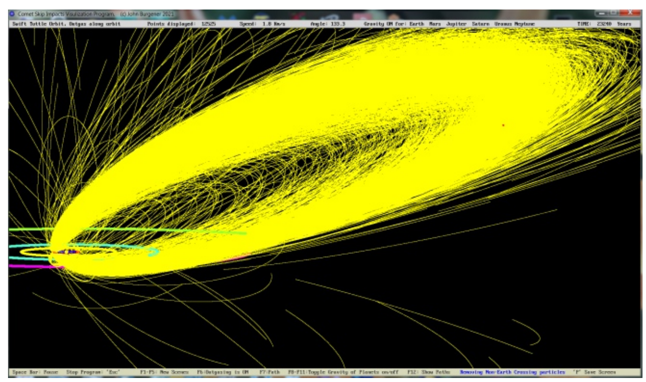
Ctrl Q: Comet Swift Tuttle 18,500 years after impact, Debris extensively in all orbits except near Jupiter, Saturn.



Ctrl W: Comet Swift Tuttle 23,240 years of outgassing, Debris concentrated along Swift Tuttle Orbit.



Ctrl Q: Impact with trails highlighted (F12)
The debris is extensively in all orbits except near Jupiter and Saturn. The large planets scatter debris from Earth Crossing orbits to other orbits. The pattern matches the observed Fireball pattern.



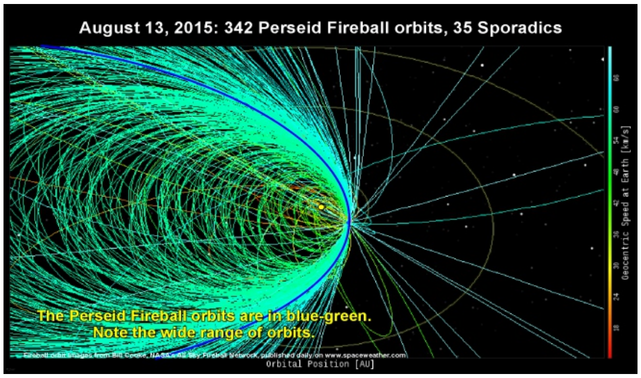
Ctrl W: Outgassing with trails highlighted (F12)
Note large inner area with few orbits. The outgassing pattern does not match the observed Fireball orbits.

F6: Toggle outgassing on or off for Ctrl Q scene.
F7: Turn on or off display of Comet's path. Slower if on.
F8 – F11: Toggle on or off the effects of gravity from the planets on the debris.
F12: Toggle on or off the paths display. When ON, the particles leave a trail behind them displaying their paths clearly.
Del / Ins buttons: Toggle removal of particles no longer on Earth-Crossing paths.
Anything that has its closest approach to the Sun > 1.5 AU is removed when that is noticed. It clarifys what can lead to fireballs associated with Swift Tuttle. Some particles remain that are moved out of the original orbits by the planets but are still within 1.5 AU at perigee.
Keys 0 to 9: Change number of particles in the comet from 5,000 to 90,000. More is more interesting, but slower.
~ key: Changes the colors presented from multi colors related to particles influenced by the planets to monotones that clarify the overall distribution of the particles.

Cursor Keys: up, down, right, left: change view. Page up or Page Down: zoom in and out.
Ctrl P: Save screen image to hard drive.
Space Bar: Pause. Press Space Bar a second time to resume.

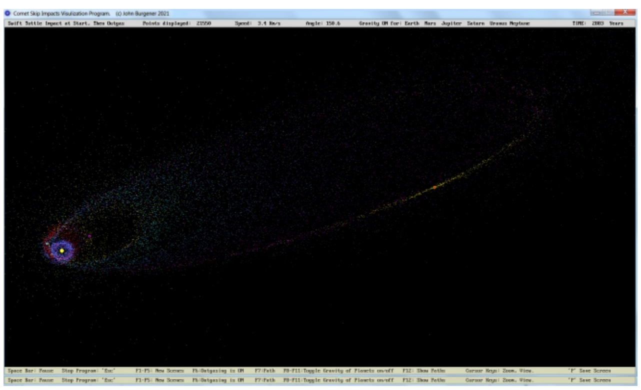
Ctrl Q, Ctrl W

Comments on the importance of comparing a skip impact and outgassing.

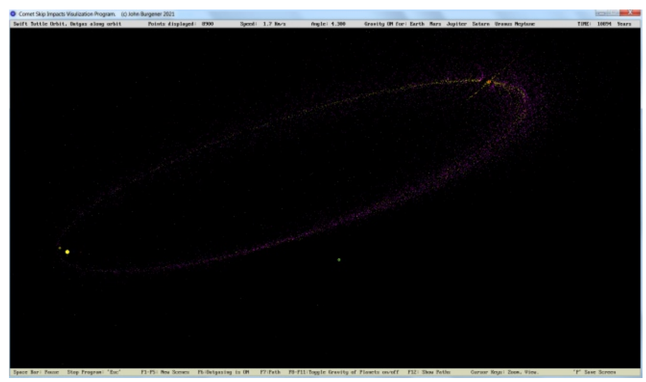


The desire to compare impact derived debris and outgassing effects relates to the Fireballs associated with comet Swift-Tuttle. Fireballs are larger than average meteors. William Cooke of NASA's Meteoroid Environment Office / All Sky Fireball Network provides plots of the orbits of fireballs seen each day on the Spaceweather.com web pages. The largest number are associated with the Perseids and comet Swift-Tuttle. They show a large range of orbits, with the necessary common factor that they all intersect Earth's orbit in mid-August. Some have very short periods and others have very long periods. The image shown here is a diagram from William Cooke's presentation of the orbital paths of 342 fireballs associated with the Perseid meteor shower on August 13, 2015. A typical day will have less than 10 fireballs occur, so the numbers associated with the Perseids is significantly higher.

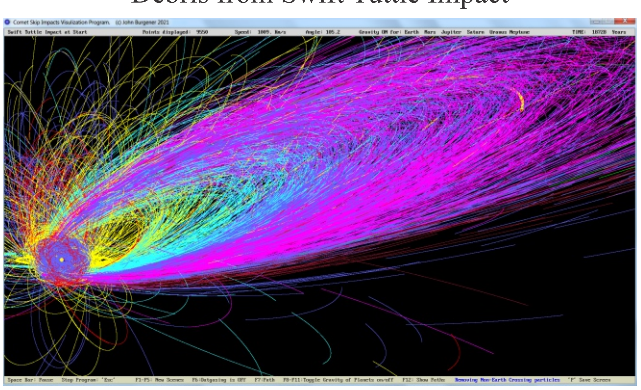
The observation that led to creating this part of the program is that the fireball orbits are widely distributed and include virtually every possible path, with the only common factor being that they cross Earth’s orbit. I would expect that outgassing would not produce such a wide array of paths. William Cooke disagrees with me. He feels that outgassing with perturbations from the planets would produce the observed distribution and that a skip impact would not provide a better explanation and is impossible anyway.



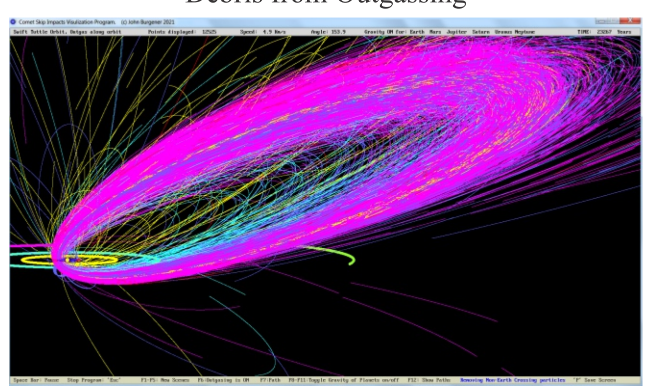
Debris from Swift Tuttle Impact



Debris from Outgassing



Debris orbits from Swift Tuttle Impact



Debris orbits from Outgassing

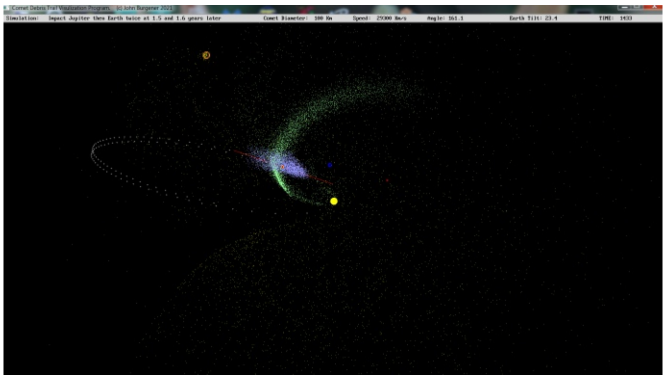
The Skip Impact Program shows that such a wide distribution of fireball orbits is not explained by outgassing of the comet as it orbits the Sun. A skip impact will produce exactly the observed fireball pattern but outgassing produces a major concentration of orbits close to the comet's orbital path. The large planets do change the orbits of the debris, but mainly by moving them away from Earth Crossing orbits. The wide set of orbits above and left of the Sun in the Swift Tuttle image are from particles effected by planets, and they are no longer in Swift Tuttle related orbits, and generally we would not see them. The pink orbits in the outgassing diagram are from particles effected by Uranus, and the center of the pattern clearly has few orbits. The upper images show the same particles, but as individual particles without an orbital trail. The multi colors show the particles effected by the corresponding colored planets.

Ctrl E, Ctrl R, Ctrl T, Ctrl Y

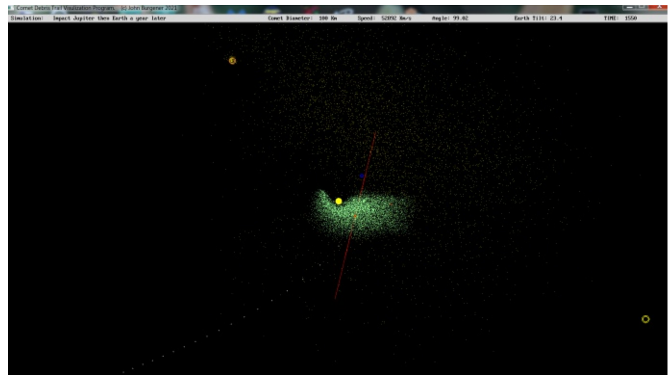
2 Dimensional Skip Impact on Jupiter followed by impact on Earth

This set of scenes was added in response to a challenge to see if a comet skip impact on Jupiter or one of its moons could then continue on to hit Earth. Perfect for a disaster movie theme. The answer is YES, and 4 such possibilities are presented. While the probability is very low, if it is possible, then it could happen.

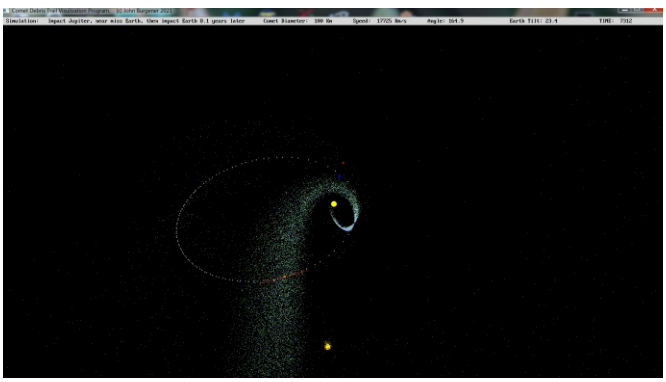
This is not serious science - but it is an interesting question and fun to try running it.



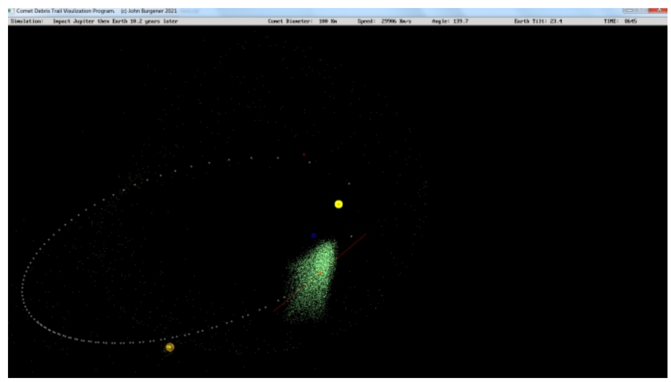
Ctrl E: Comet impacts Jupiter,
then Earth twice at 1.5 and 1.6 years later.



Ctrl R: Comet impacts Jupiter,
then Earth a year later.



Ctrl T: Comet impacts Jupiter, near miss Earth,
then impacts Earth 8.1 years later.



Ctrl Y: Comet impacts Jupiter,
then impacts Earth 10.2 years later.

F6: Change Comet Radius. Need to re-start scene to see effects.
F7: Turn on or off Comet's path. Slower if on.
Cursor Keys: up, down, right, left: change view. Page up or Page Down: zoom in and out.
Ctrl P: Save screen image to hard drive.
P or p: not active.
Space Bar: Pause on or off.
F8 – F12: Not active.

Ctrl A

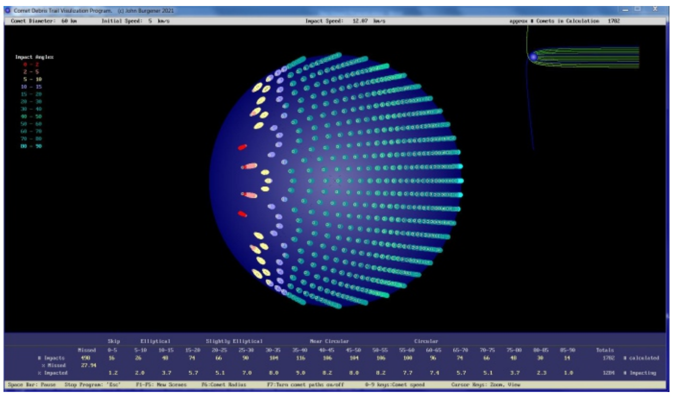
3 Dimensional Presentation of impact probabilities

Educational Presentation of numbers of impacts possible for given comet size and incoming speed.

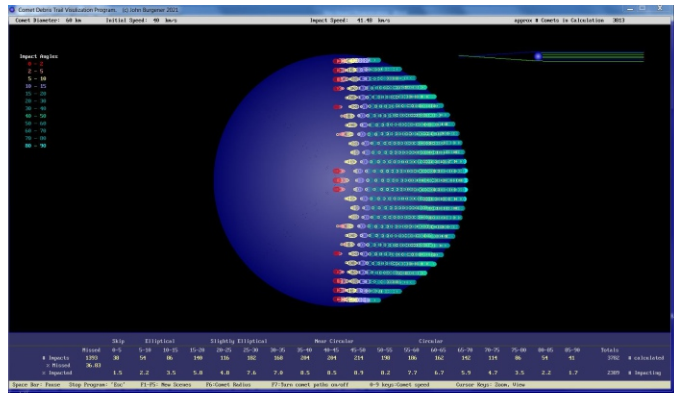
Most impact studies are focused on 30° - 90° impacts. I have heard some say that one should only study 45° impacts since they are most common. Yes, its true that 45° is the highest probability, but this shows that ignoring the rest ignores most impacts and all of the interesting impacts. Skip impacts are seldom mentioned in the literature, and this is intended to show that skips and impacts less than 30° are a significant part of the overall potential impacts and should be studied.

A wide range of impacts is calculated for each scene based on an array of thousands of comets starting from 160,000 km distance and moving towards Earth at a fixed initial speed. When all are done, you can change the viewpoint on the entire globe using the cursor and Ctrl Z and X keys.

NOTE that the skip impacts change shape depending on where they hit. The shape is calculated from the amount of the comet interacting with Earth at the point of contact while it is hitting.



Ctrl A: Impact array of probabilities for 12 km/s

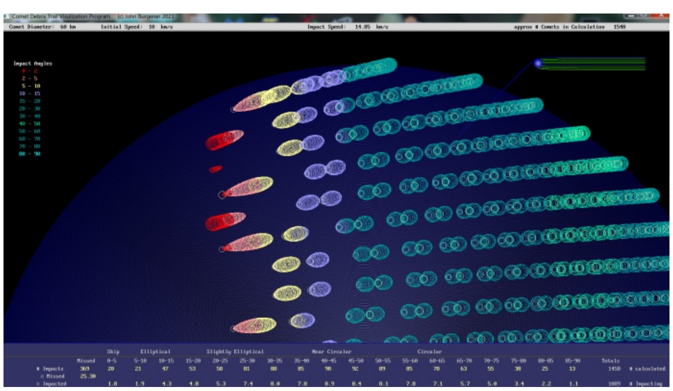


Ctrl A: Impact array of probabilities for 41 km/s

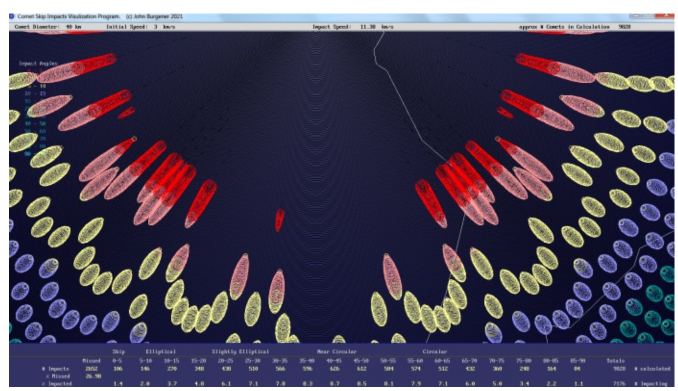
F6: Change Comet Radius. Need to re-start scene to see effects.
F7: Turn on or off Comets paths. Gets confusing, so mini image in upper right shows the basic paths being demonstrated. Slower makes the comets paths bend more from Earth's gravity. At lower incoming speeds, the comets can hit behind Earth.

Keys 0 to 9: Change incoming Comet speeds. From 0 to 80 km/s: 0, 1, 2, 3, 5, 10, 20, 40, 60, 80
Cursor Keys: up, down, right, left: change view. Page up or Page Down: zoom in and out.
Ctrl Z, X: Rotate globe 90 degrees
Ctrl P: Save screen image to hard drive.
P or p: not active.
Space Bar: Pause on or off.
F8 – F12: Not active.

60 km diameter comets, 10 km/s initial speed



40 km diameter comets, 3 km/s initial speed

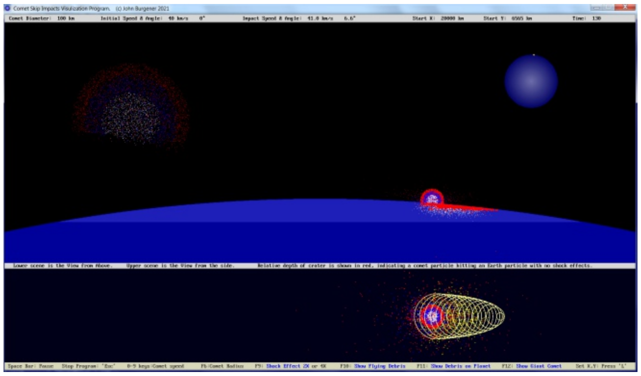


Close ups of scene of probabilities with comets starting at 10km/s and 3 km/s
Note the wide range of crater shapes particularly for low angle impacts.

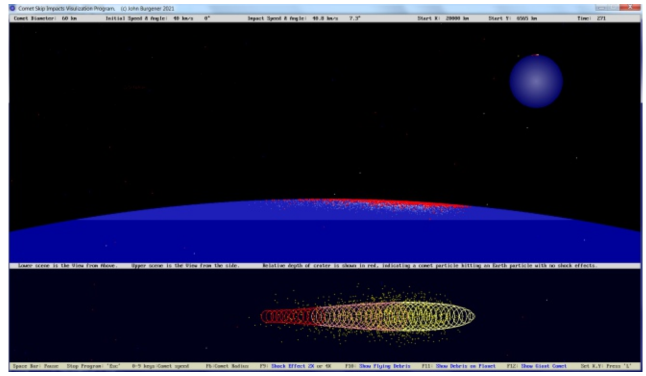
3 Dimensional Presentation of impact probabilities - Detailed View

Educational Presentation of user selected comet size, initial speed and initial location.

The Ctrl A scene shows many unexpected, unusual shapes of craters due to low angle impacts, especially from large comets. When a comet is large, the curvature of Planet Earth becomes significant and impacts can drag out for long distances. Some calculated skip impact craters are narrow at the departing end and wide at the beginning. This routine is designed to show how these shapes can occur and that they are realistic for large comets. It also allows you to select the starting points for the comet, and have it show impacts from 0° to 90°.



Ctrl L: Impact of large comet at 6°, 40 km/s



Unusual shaped crater from low impact angle.

F6: Change Comet Radius. Program re-starts scene.
F7, F8: Not active.
F9: Change width of impact crater. The impact crater will be due to both debris tossed by the comet and debris tossed by the shock waves. A factor of 2X seems to match iSALE simulations best and is the default setting.
F10: The screen can get cluttered so F10 allows you to turn off the display of debris flying after impacting Earth.
F11: The red area on the Planet is showing the Earth particles that have been tossed by the comet as it impacts. Some of the debris is tossed sideways and impacts Earth almost immediately, but it can cover the red particles or crater. Pressing F11 hides those particles.
F12: The comet is impacting the outer edges of the comet with the planet. You can display a very large view of the comet to see what is actually impacting at any moment. Press the space bar to stop the action.
As the comet impacts points on Earth, the points that impact go away and fly out as debris.
Note that the comet is not solid. The program would be too slow with solids, and comets are expected to be porous, so the program uses a limited number of points (22,500 for large comets, less for smaller ones) scattered within the radius of the comet. The Comet is 3D. The planet is 2D. A 2D planet allows for a high speed simulation.

Keys 0 to 9: Change incoming Comet speeds. From 0 to 80 km/s: 0, 1, 2, 3, 5, 10, 20, 40, 60, 80
Cursor Keys: up, down: change incoming angle by +/- 1°.
Page up or Page Down: change incoming angle by +/- 10°
Right or Left: Not Active.
Home: 90° impact.
End: 0° impact - original scene.
Ctrl L: Re-run present scene. No changes to settings since last change.
Ctrl P: Save screen image to hard drive.
P or p: Not active.
Space Bar: Pause on or off.

NOTE that the skip impacts change shape depending on where they hit. The shape is calculated from the amount of the comet interacting with Earth at the point of contact while it is hitting.

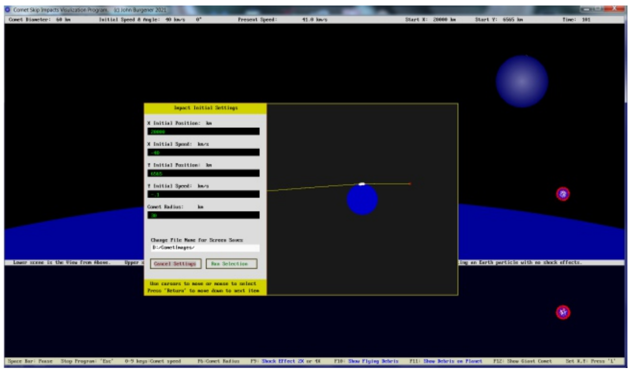
Press L to get user selection of incoming speeds and start locations.

Ctrl L’s ‘L’ menu option

3 Dimensional Presentation of impact probabilities - Detailed View

Educational Presentation of user selected comet size, initial speed and initial location.

The Ctrl L scene gives excellent high resolution details of many pre-set comet impact options, but it is nice to be able to set your own. If you press ‘L’ while in the Ctrl L scene, you will get a menu allowing you to select the comet’s incoming speeds and positions (x and y coordinates only, Z is always 0 in this), and its size.



‘L’: Menu to set settings for comet

The menu allows you to type in your desired initial X position and speed, Y position and speed and comet radius.

The file name line allows you to change the location and file names of any screen saves you do with **Ctrl P.**

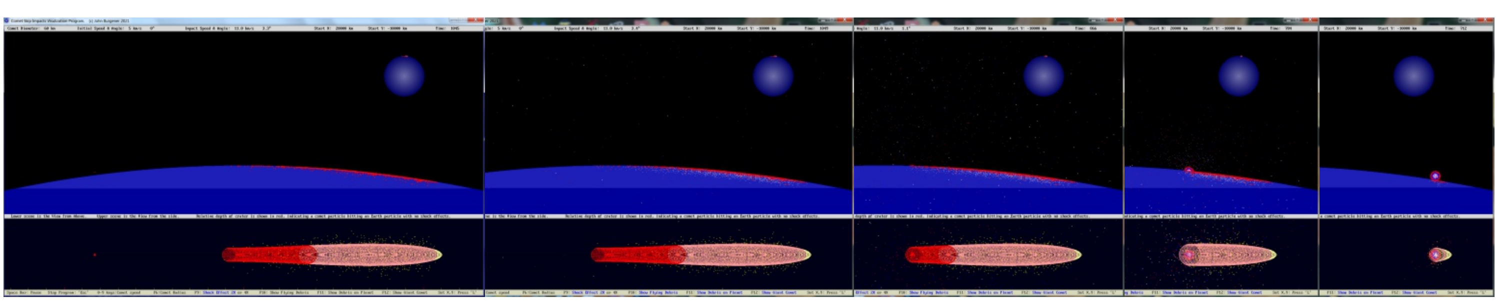
If you press the “Cancel” button, or press esc, then the menu closes and nothing is changed.

If you press the return button, the menu steps down to the next item. Several Return presses will step down to the “Run Selection” button and start the simulation.

There is a small preview of the planet and comet showing the comet’s location as you select it, and its selected orbit and impact (or not) of the planet. Any impact of the planet in the red box at the top of the planet will show in the enlarged view while running the simulation. Any impact outside of the red box will not be in the final scene. The preview scene is limited to +/-50,000 km for both the x and y co-ordinates. You can select points farther away, but they will not show in the preview and may take longer than the program allows for a simulation. Also to keep the preview able to update instantly, the preview is limited to 5,000 time steps, and will draw a line of 5,000 steps of the proposed orbit, but may end before impact.

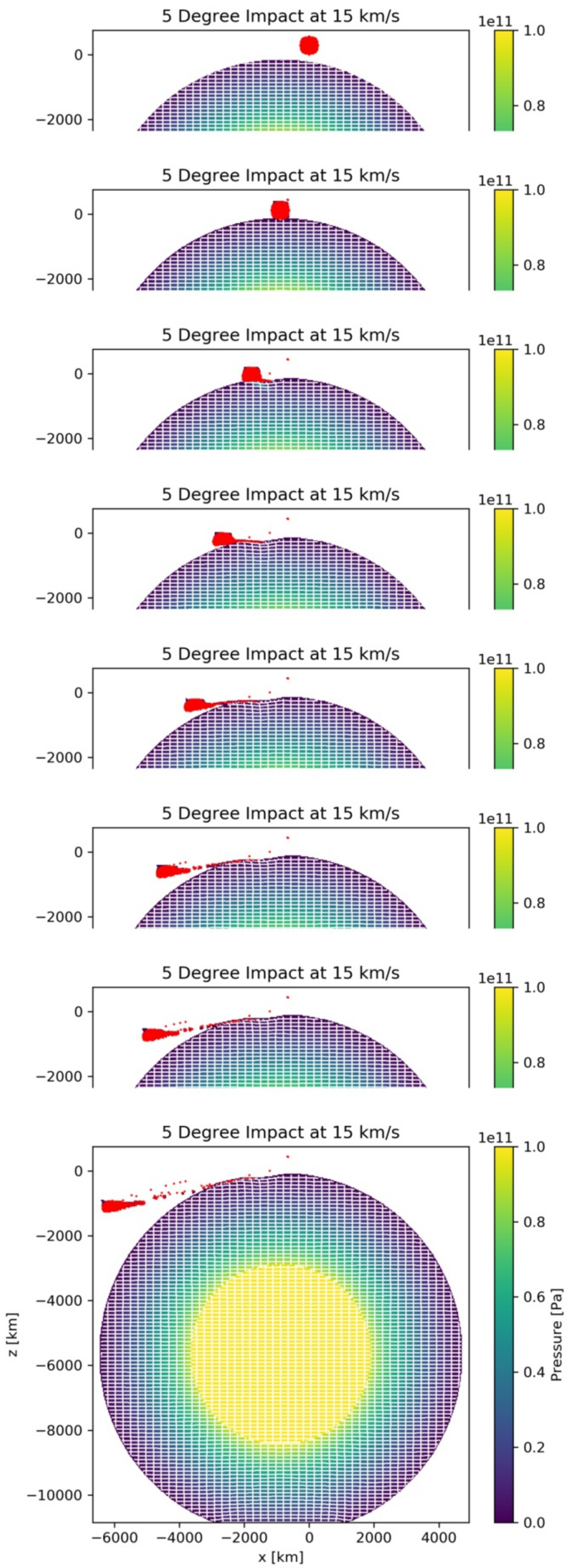
For Y, negative speeds are down, positive is up. For X, positive is to the right, negative to the left.

Try something interesting such as:
X: 20,000; X Speed: -2.9; Y: -10,000; Y Speed: 4.97; Comet Radius: 30



It produces a skip crater ~ 1,200 km long from a comet with a 30 km radius, with a tiny bit continuing on orbit.

Here is an iSALE simulation of a skip impact on Earth.



The iSALE simulation shows that a comet CAN hit Earth and continue on its orbit.

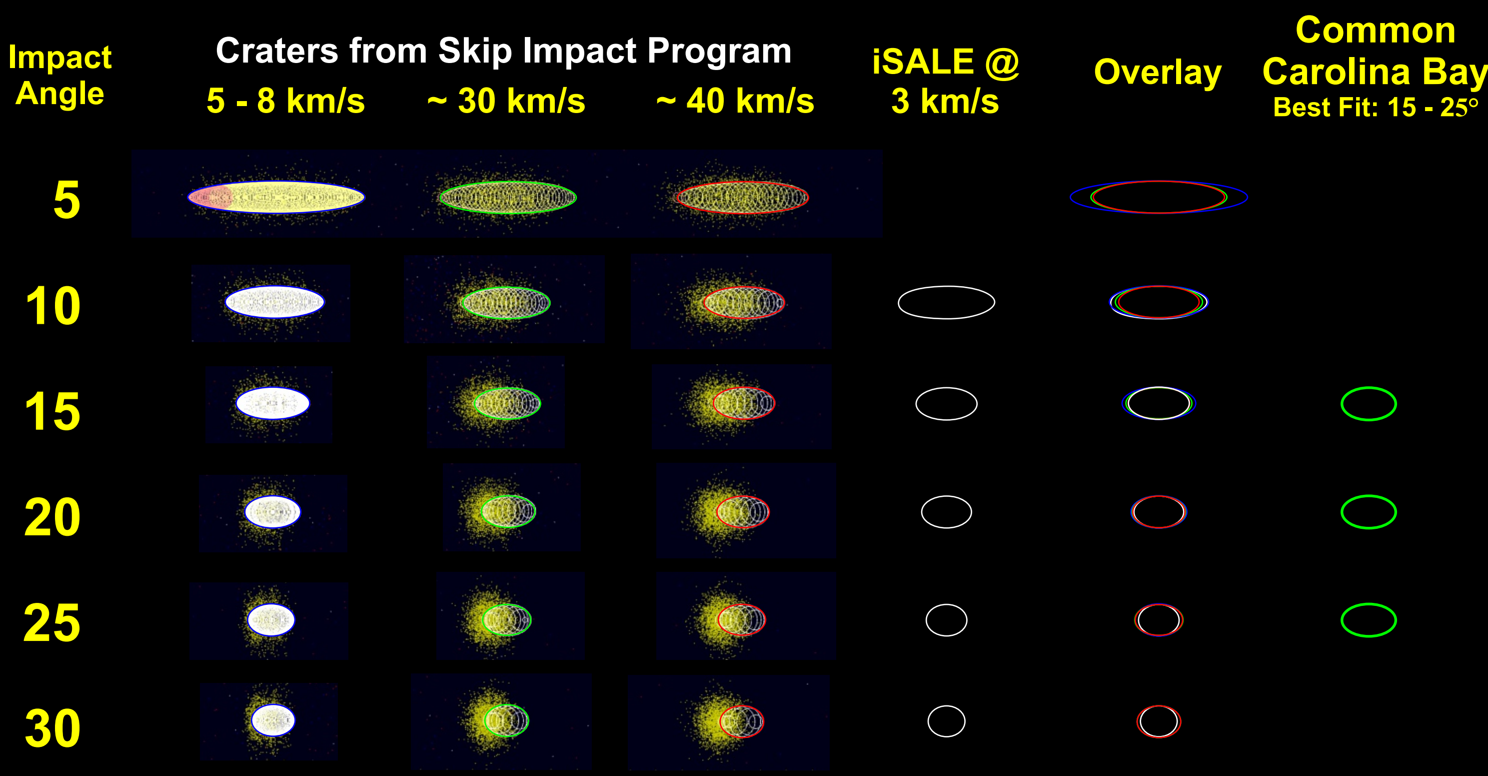
**Part continues on orbit,
Part is shattered and tossed back into space as debris, mixed with a lot of debris from Earth.**

iSALE is a verified, geologically correct hydrocode program designed to simulate impacts and calculate the craters resulting from impacts.

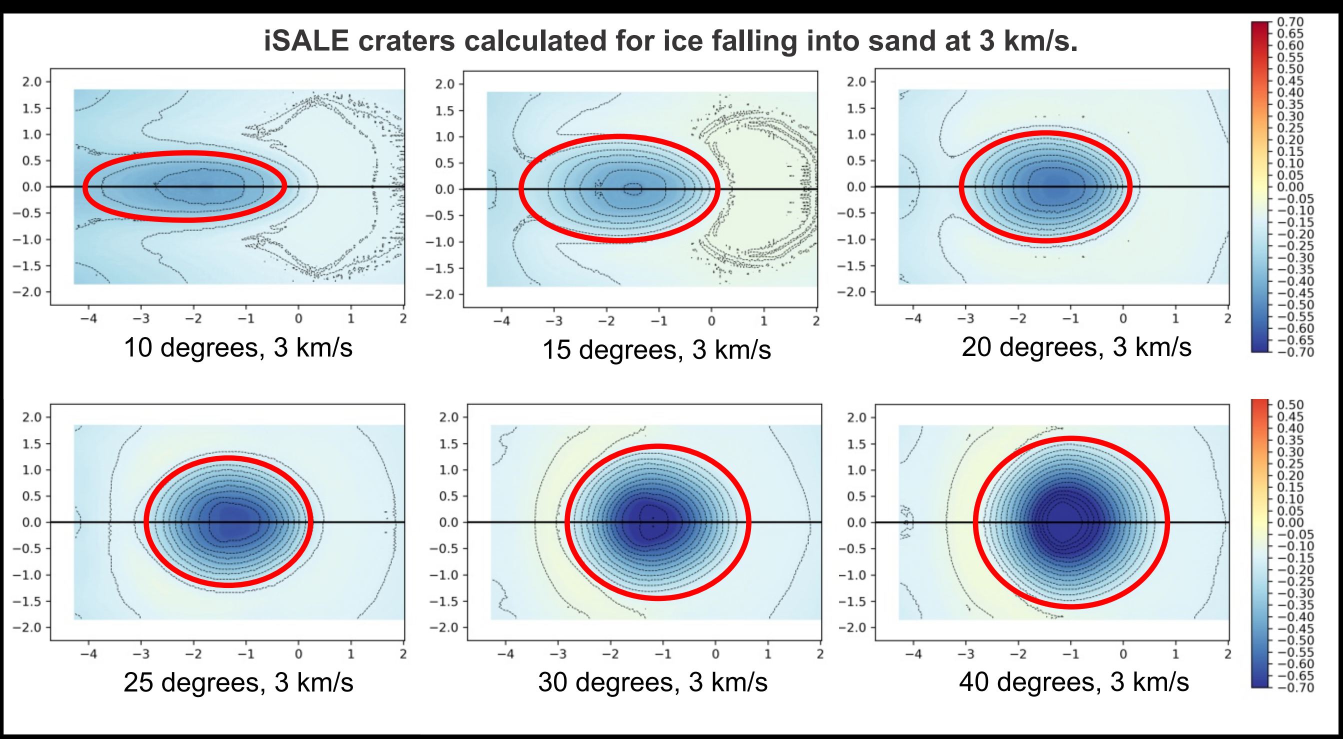
The Skip Impact program is not geologically correct, but the resultant craters it produces do match what iSALE produces for some situations - especially for low speed impacts. Higher speeds have significant shock energy associated and the shock causes most of the standard craters. Low speed impacts are calculated in the Skip Impact program by simply indicating what portion of the spherical impactor is hitting the ground removing part of the ground as it does so. No shock energy is included.

Pleasantly, the craters calculated are nearly identical to what iSALE would calculate for low speed impacts at low angles. So iSALE predicts that skip type impacts can happen, and that the secondary craters formed at low speeds and angles will look like what the Skip Impact program is producing.

Comparison of Skip Impact craters to iSALE calculated craters and Carolina Bays

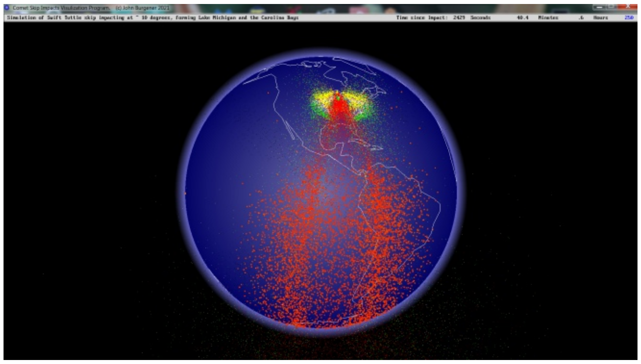


For 15° - 30°, the impact speed has little effect on the shape of the crater when ignoring impact shock energy as the Skip Impact program does. At angles of 10° or less, a lower impact speed will slightly increase the length of the crater. At these angles, the shape is largely determined by the impact angle not the speed of impact. Comparing the typical Carolina Bay shapes, a very common shape is best fitted to the 15° - 25° range. One would expect some at higher or lower angles, but the program shows that a very significant portion should be in this range. The debris craters falling on North America in the program should be similar to shapes found among the Carolina Bays.

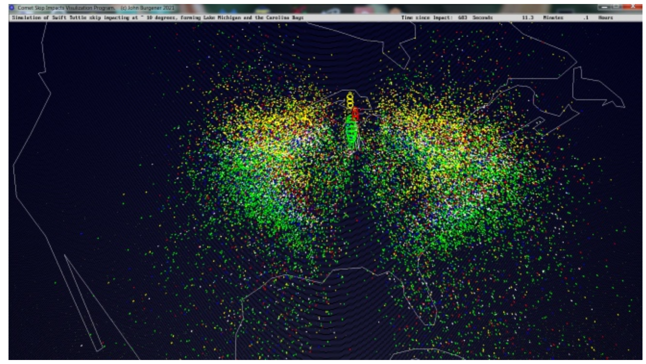


3 Dimensional Presentation of Proposed Swift Tuttle Skip Impact

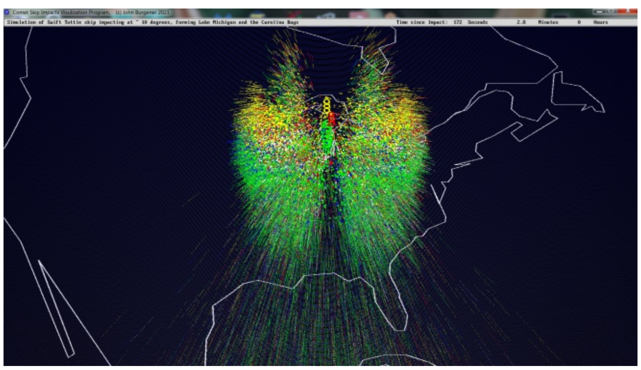
Ctrl S: This scene shows 5 pieces of a very large comet skip impacting the ice covering North America, leaving behind a long shallow crater that filled in with water and is now Lake Michigan, which is almost identical to Mars' Orcus Patera crater. The impact would cause many secondary craters across the planet with a concentration on the eastern side of North America, forming the Carolina Bays. The program includes Earth's rotation, Atmospheric drag, and can add heating effects due to re-entry atmospheric heating. The debris falling around the planet would have caused massive fires and destruction to large areas of the planet, particularly North and South America and Eurasia. Australia has no fallout hit it.



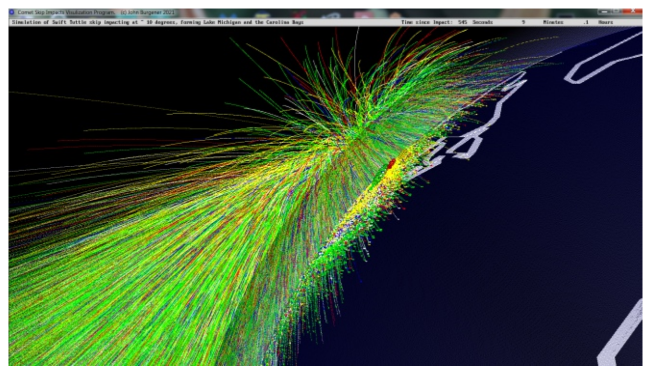
Planet Earth, 40 minutes after impact
with debris falling over South America



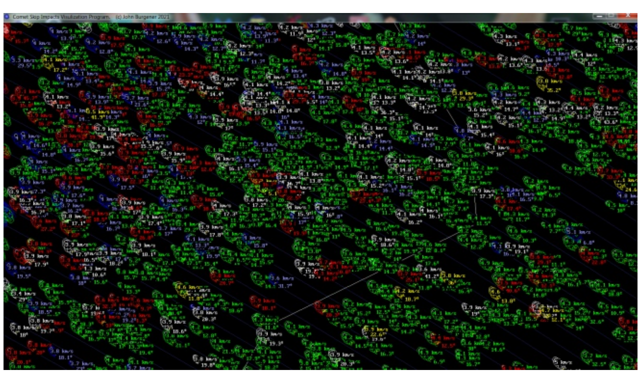
Closer view of the secondary debris
falling on North America



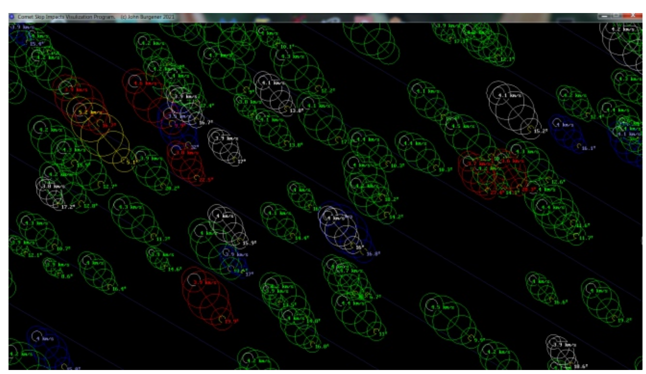
Comet Debris flying out from impact site.



Comet Debris flying out from impact site. Side View.



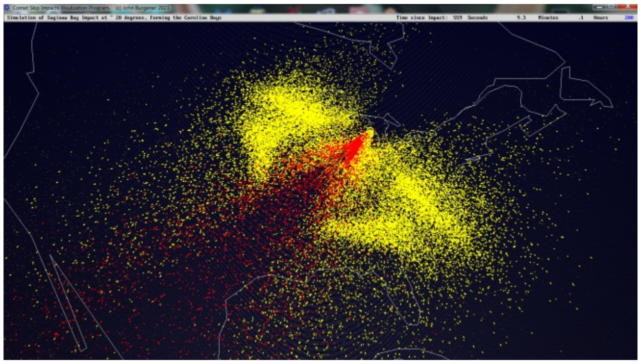
Close-up of secondary craters along
eastern North America.
The program shows the impact angles and speeds.



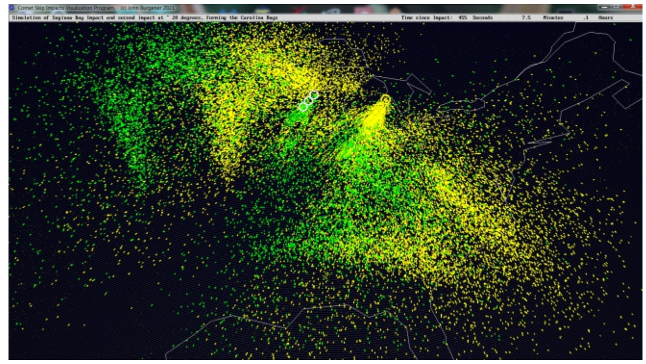
Closer close-up of secondary craters along
eastern North America.
The program shows the impact angles and speeds.

3 Dimensional Presentation of Saginaw Impacts

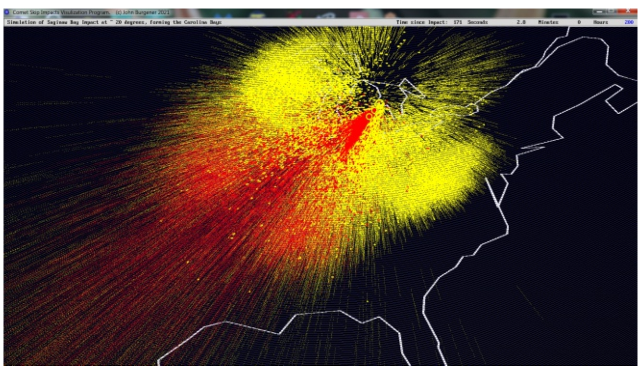
Ctrl D: These scenes shows 1 or 2 pieces of large comets impacting the ice covering North America, as suggested by Michael Davias as the source of the Carolina Bays. These also will produce a wide range of secondary craters, and will fit the expected size and angles of impact for the secondary craters, as will the Lake Michigan impacts. The main difference is that the Lake Michigan impacts will provide more sources over a larger length and therefore more variations in impact angles. Both can be considered realistic sources of the Carolina Bays.



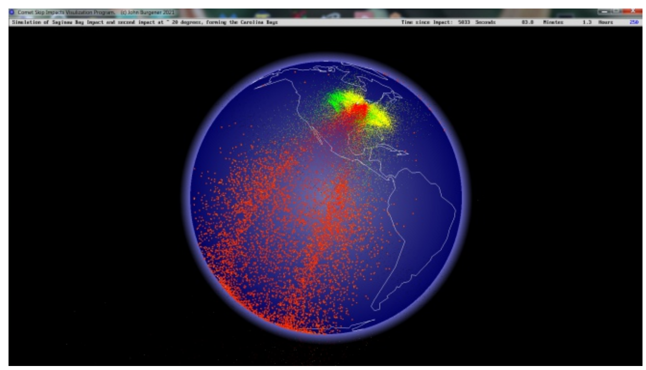
Saginaw impact at ~ 42° angle, east of Lake Michigan.



Saginaw Impact with second impact just west of Lake Michigan

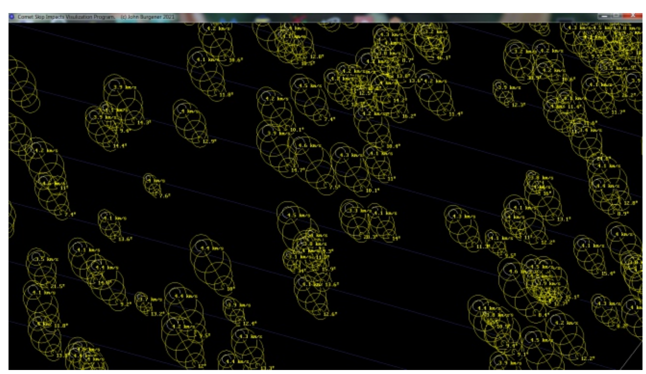


Comet Debris flying out from impact site.



Earth with debris from Saginaw impacts spreading over the planet.

Close-up of secondary craters along eastern North America.
The program shows the impact angles and speeds.



Closer close-up of secondary craters along eastern North America.
These are similar to the results from the Lake Michigan impact proposal

3 Dimensional Presentation of Proposed Swift Tuttle and Saginaw Skip Impacts
Options and details.

Ctrl S: Runs the Swift Tuttle Skip Impact / Carolina Bays origins scene. To re-start it, press Ctrl S.
Ctrl D: Runs the Saginaw Impact / Carolina Bays origins scene. To re-start it, press Ctrl D.
Ctrl F: Runs the Saginaw two comet impacts / Carolina Bays origins scene. To re-start it, press Ctrl F.

F6: Turn mini crater images on or off. Slower if on. At times, too many overlapping craters are confusing, and off shows more details. Toggles between crater images and text, just images, just text, just lines.

F7: Turn on or off atmospheric drag. The US Standard Atmosphere densities are used for this calculation: US Standard Atmosphere charts of 1976 - us-standard-atmosphere_st76-1562_noaa.pdf.

With drag ON the comet splash particles slow a bit and arrive at slightly higher angles. The particles considered are large enough that drag is a minor effect. The program only is showing particles between 25 to 250 m radius. Smaller ones will not make significant Carolina Bays, and larger ones are rare. If there is no atmospheric drag, some particles will orbit Earth with part of their orbit a few meters above the surface. With drag On, all hit Earth in their first cycle around the planet.

F8: Turn on or off the Earth's rotation. A rotating Earth will have the impact angles slightly skewed relative to a stationary Earth. However, the difference is small since the comet splash particles have some of the Earth's rotational energy and speed added to their impact speed. To correctly show this, you need to re-start the scene after selecting a change in Earth's rotation. However, you can turn off the rotation in mid scene to stop the images shifting each 1/10 of a second for a better view.

F9: Toggles on/off the display of high speed impacts being shown as hot spots or fires. Particles tossed into space at higher velocities will fall back at higher velocities also, and will heat in the atmosphere as they fall back. The program is set to show particles falling at speeds above 6 km/s as hot burning particles, and those that land at speeds above 6 km/s as causing local fires. Smaller particles will slow on entering the atmosphere and larger ones will minimally slow, so larger particles are more likely to heat up on hitting the atmosphere and cause fires when hitting the ground. The program can not tell if the particle is rock or ice. Obviously, ice falling from the sky will not heat past boiling and can not start fires. Instead the larger ice blocks will ablate and land as ice blocks, and the smaller ones will melt, disperse and fall as heavy rain or melt and splash on the land as really large drops (lumps) of water.

F10: Toggles between a coloration of particles in orbit based on origin of which part of Swift Tuttle hit or based on present speed of the particle. The speed range is white for over 11.2 km/s (escape Velocity – nothing above this speed will come back to hit Earth), blue for 9 - 11.2, yellow for 7 - 9, red for 5 – 7, green for 3 – 5, and turquoise for 2 – 3. Less than 2 is light green, but rarely is visible.
Note: the particles moving above escape velocity are largely removed from the simulation in the first 3500 seconds to improve speed of the program. More points is slower. After 3500 seconds, all points remain in play, until they impact Earth. The cloud moves far from Earth after a long time, then mainly crashes back on Earth if their speed was less than escape velocity. It takes many hours for all to crash.

F11: Add more particles to the display - slows the simulation but shows more details on the spread of particles around the planet. The default is 150 X 300 and F11 bumps it up to 200, 250 or 300 X 300. The program runs slower with more particles.

F12: Toggle on or off showing the particles' paths. Each time you change the view or do a screen save (ctrl P) the display clears and you lose the path's presentation. It begins from where a change has been made.

~ key: Changes the colors presented from multi colors related to speed or the original comet pieces to monotones that clarify the overall distribution of the particles.

Number Keys: Rerun the program with a limited range of speeds displayed. Shows which group of particles is impacting where. Press "0" to go back to showing all speed ranges. It shows that the vast majority of impacts in the Carolina Bay area is from particles tossed out at speeds of 3 to 5 km/s.
The ranges are as follows:
'0': all speeds; '1': 0 - 2 km/s; '2': 2 - 3 km/; '3': 3 – 4 km/s; '4': 4 – 5 km/s; '5': 5 – 6 km/s; '6': 6 – 7 km/s;
'7': 7 – 8 km/s; '8': 8 – 10 km/s; '9': 0 – 10 km/s

Cursor Keys: up, down, right, left: change view. Page up or Page Down: zoom in and out.
Ctrl P: Save screen image to hard drive.
Space Bar: Pause on or off.

Comments on how realistically the program has set the splash and debris particles's velocities.

There are three effects in a skip impact causing debris particles to be tossed. Each tosses in its own way. The distribution is likely to be very different from what is shown. However, the point of the program is not to perfectly present the event but to show that such an event could toss a lot of debris to the eastern coast of North America and form the Carolina Bays. If the majority of debris particles in the program just head off to space, and never return, it does not allow the program to show what is intended. So the program artificially has a higher proportion of the debris points set to be tossed sideways than I expect actually occurred. When millions of points are being represented by a few thousand, one must focus on the ones of importance or the results will not show anything.

Impact Debris source 1: When the comet touches Earth, it causes a shock wave that spreads out in a spherical wave. The shock wave travels on the surface as well as down and up. The surface part is the main source of the crater edges. As the comet moves forward, the spherical shock wave center moves forward also, eventually forming a thin elliptical shaped shock wave. The shock wave effects what is below the comet, but that can not move far. It also tosses particles up in all directions (spherical), but mainly it tosses particles sideways since there is nothing above and little motion below. So a significant number of particles move sideways, typically to a distance about ten times the diameter of the impactor in near vertical impacts, but most likely only about 2 to 4 times the diameter of the impactor in a skip. I have assigned 16% of the particles to the shock wave effect, mainly tossing sideways, but also up, backwards and forwards. The program uses a calculation that is the speed between (zero and the comet's speed) +/- 1/5 of the comet's speed, in any X,Y, and or Z direction, but with the added criteria that it may not aim down into the planet.

Impact Debris source #2: The comet is not hitting and exploding. It is moving forward dragging the lower part of the comet through the surface layers of the planet. It must push material ahead of it, at speeds near the comet's speed or a bit more or less. The particles will be sent forward mainly but also up and down and sideways. I have assigned another 16% of the particles to this effect, with their speeds ranging from near zero to twice the comet's speed, and their directions heavily oriented in front and slightly sideways from the comet's path.

Comments on how realistically the program has set the splash and debris particles's velocities.

Impact Debris source #3: The bow wave. What is directly in front of the comet must be pushed forward. The comet is moving at speeds above the speed of sound or the speed of shock waves, so the particles can not move out of the way since the energy is transferred to them too quickly. But what is not exactly in front will be pushed more or less at right angles to the edge of the comet, which means that anything a little way away from the center will have a significant sideways motion added to their path. This can be considered as a bow wave seen at the front of a boat traveling through water at a high speed. A typical bow wave forms a specific angle and forward motion and specific breaking or falling down point. Usually it is very well defined and limited in location. There have been no studies that I am aware of for such a phenomena in comet impacts, so I have estimated a wider range than actually likely and assigned speed and angles wider than is actually likely to happen.

This is NOT a perfect program able to perfectly calculate the effects of an impact. The point is to show that secondary debris can form the Carolina Bays and that a single event can account for all of their observed features. I have assigned 33% of the debris particles to this region of the impact debris, and I have their speeds ranging from 1 to 3.5 km/s in the X direction; 0.2 to 2.2 km/s in the Z direction and 0.5 to 3.5 km/s in the Y direction. Z is down, Y to the side and X forward. The total speed is the square Root of their squares or 1 to 5.4 km/sec.

Impact Debris source # 3b: The remaining 33% of the particles are assumed to be on the top of the bow wave. Assuming that some particles will be tossed off the top of the bow wave instead of sideways, I have assigned a set of higher speeds to half of the bow wave. These are calculated as X = 0 to 1/2 the comet speed +/- 0 to 1/10 the comet speed; Z = 0 to 1/5 the comet speed +/- 0 to 1/10 the comet speed, and Y = 0 to 5 km/sec. This gives a range of 0 to 24 km/sec, slightly higher than ½ the comet speed in reasonably random directions with those aimed down into the Earth re-calculated to something going away, and with a bias away from the center line. Only zero values for Y will travel along the center line. Some do that but not the majority.

In summary:

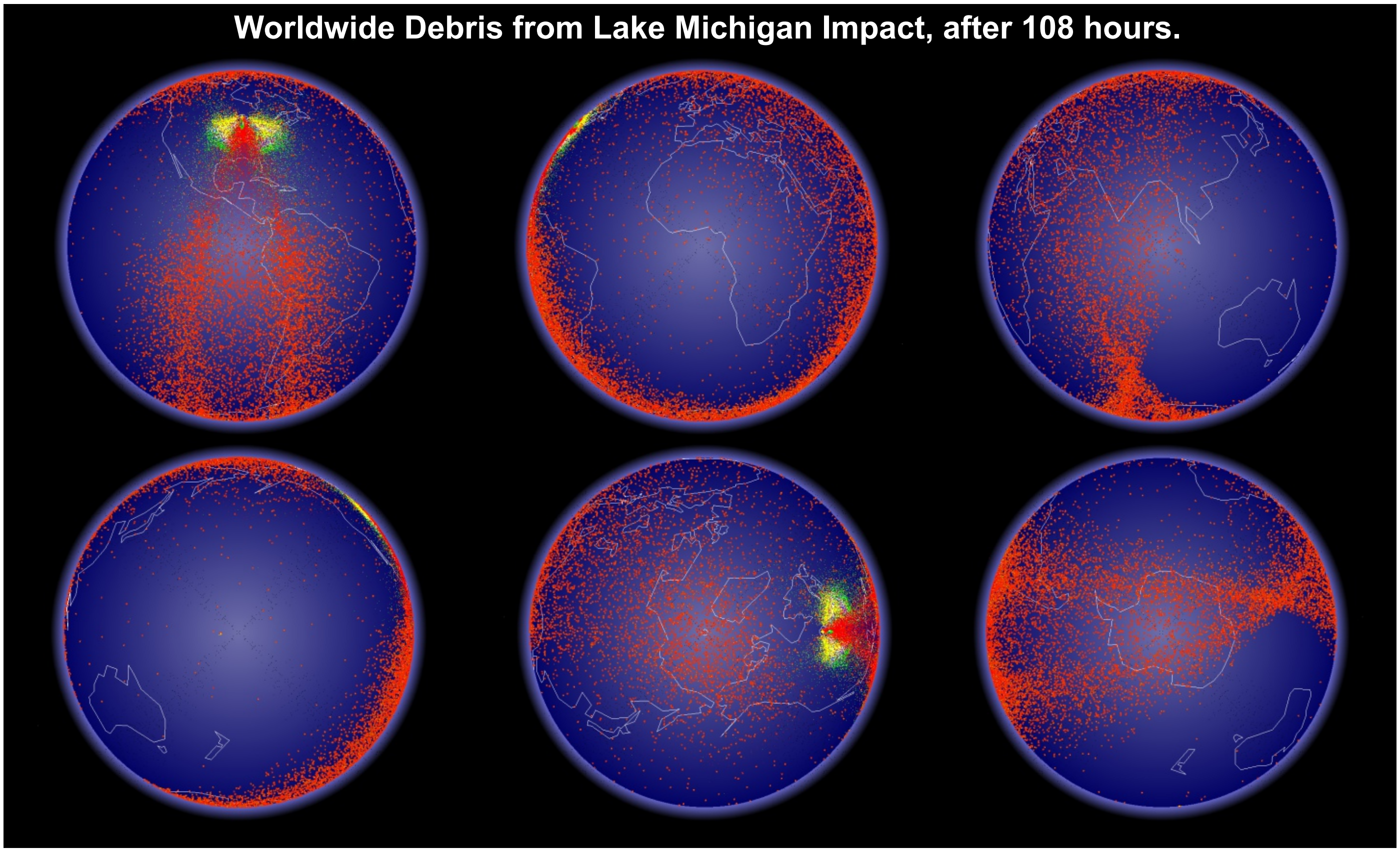
16.6% shock wave spherically tossed in all directions but down. Most go into space, many above escape velocity. Some form the edge of the crater wall and splash behind the comet.
16.6% pushed ahead of the comet. Most go into space, many above escape velocity, but some eventually fall back to Earth.
33.3% fast top of bow wave. Most go into space but a lot fall back to Earth.
33.3% slower middle of bow wave. Most fall back to Earth relatively quickly.

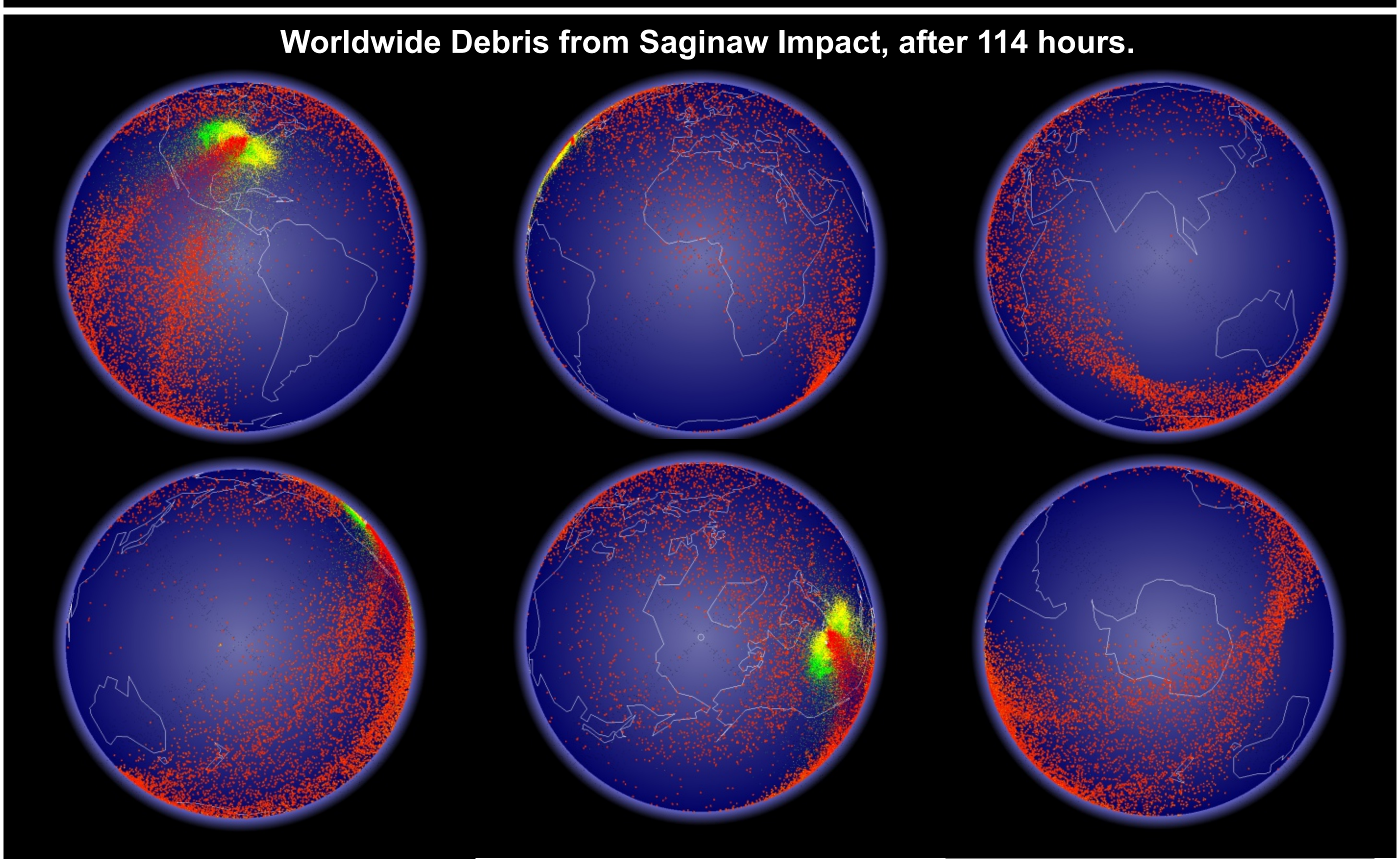
From the above notes it is apparent that a high percentage of the particles are tossed into space and will not fall back. They are well shown in the other scenes of this program (F1 to F5, Ctrl Q,W) and are not the focus of this scene, but remain in the program to ensure that all aspects are properly considered. The distribution of particles being tossed away from the impact is not even in all sections due to the above distributions. You can see a cloud of faster particles when viewed from above that looks too small for the full distribution – which is the 16% forward group showing relative to the 33% of the bow wave particles. Also some of the particles should more closely follow the comet itself. In the F1 to F5 scenes, they correctly do that. In this scene, any particle with velocity down below the Z=0 point is re-assigned to one with Z>0 which leaves a straight line at the bottom of the cloud which is not perfectly exact to the distribution. However, the missing sections would all head out into space at above escape velocity so their absence does not effect the considerations about the potential of a skip impact causing the Carolina Bays as secondary impacts.

Ctrl S, D, F

3 Dimensional Presentation of Proposed Swift Tuttle and Saginaw Skip Impacts

These scenes allow one to run the simulation for as long as desired. The images below have been running for 108 & 114 hours simulation time. Most of the particles falling back on Earth have landed. Some more will land over several weeks, but only a small percentage relative to the main group. Apparently the Swift Tuttle impact would spread a lot of debris over North America, western South America, Antarctica, and Eurasia. Almost nothing would fall on Australia or Africa. The Saginaw impact fallout would miss South America, Australia and Eurasia and hit Africa.



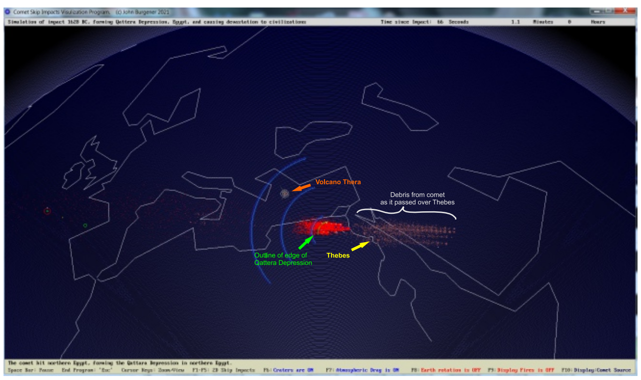


3 Dimensional Presentation of Qattera Depression Impact, Egypt

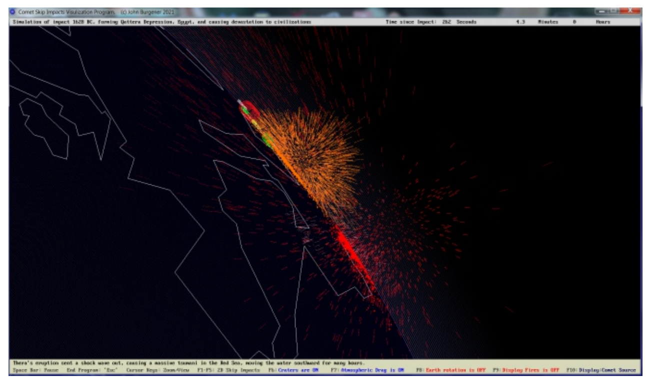
Ctrl G: This scene shows a proposed event of ~ 1628 BC when a comet passed over Thebes (present day Luxor) causing the destruction of the city from the shock waves and from debris showered down and along its path. The comet hit northern Egypt, creating the present Qattera Depression - a 300 km wide, 300 meter deep, partial ellipsoid shaped crater. The shock wave from the impact caused massive sediment slumping with thousands of cubic meters shifting in the Mediterranean Sea, and triggering the eruption of Thera, the largest volcano eruption in recorded history. Between the impact and the eruption, most civilizations based around the Mediterranean were devastated.

It is proposed that Exodus happened at this time, with the comet passing over Thebes being the angel of death, and the eruption of Thera causing a tsunami to move the surface waters of the Red Sea southward, lowering the ocean levels by 20 to 30 meters for several hours. The Biblical story of the Hebrews crossing the Red Sea are later additions. The original story was that they camped by the sea and found the dead Egyptians the next morning. The Egyptian army had arrived in the night and were seeking the camp by the ocean shore, but the ocean shore was far from the normal shore due to the tsunami. The Egyptians went out onto the ocean bed, got stuck in the mud and drowned when the water returned from the shock wave that had moved it southwards.

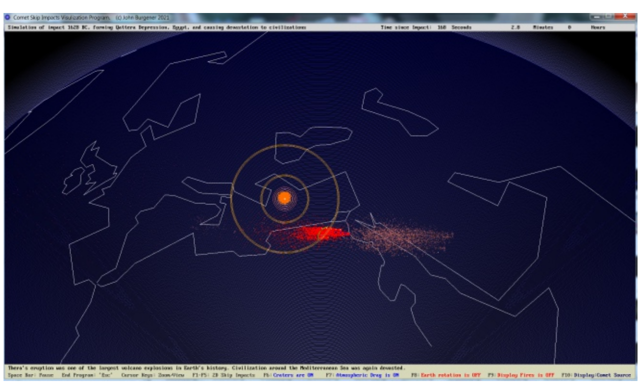
Between the impact and the Thera eruption was probably 10 days or more, but waiting for a long time while running the simulation is undesirable so the simulation has the two events happen quickly with little time between.



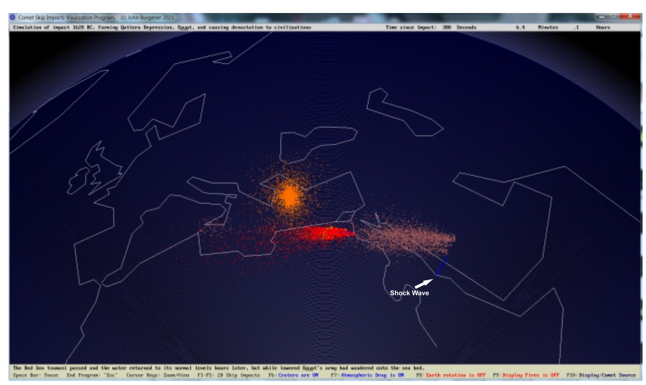
Details of proposed impact forming the Qattera Depression, triggering Thera, and destroying Thebes.



The view from the side of Thera erupting.



The shock waves from Thera's eruption.



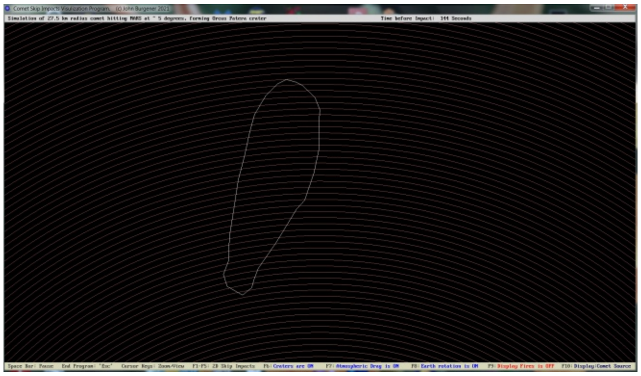
The shock wave from Thera causing a tsunami in the Red Sea.

The simulation is a variation of the Ctrl S, D, F scenes, and has most of the same options and key actions.

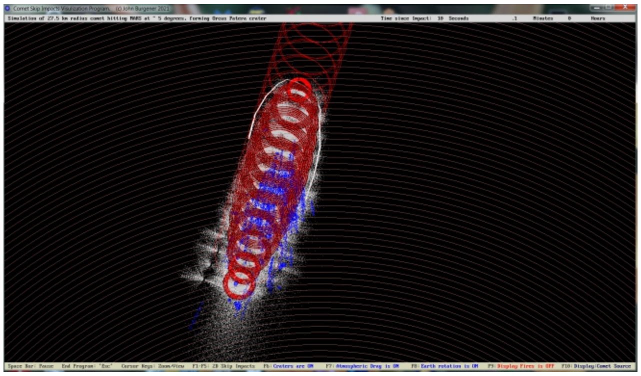
3 Dimensional Presentation of Orcus Patera, Mars

Ctrl M: This scene shows a proposed skip impact on Mars that would form a crater matching the shape of Orcus Patera. The best fit to make the shape and size matching Orcus Patera is a comet of 27.5 km radius, traveling at 27.75 km/s. impacting at 0-5 degrees.

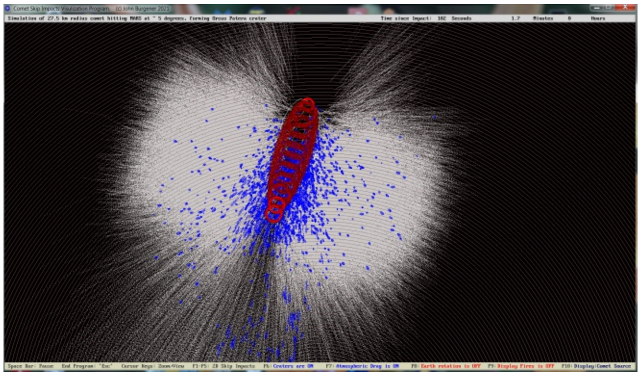
It would be expected that such an impact would leave many secondary craters. The gravity of Mars is much lower than on Earth, and the program shows very little of the debris will impact Mars. The program includes Mars' rotation and atmospheric drag, but with minimal atmosphere and low gravity, the vast majority of the ejecta and debris leaves Mars at above escape velocity.



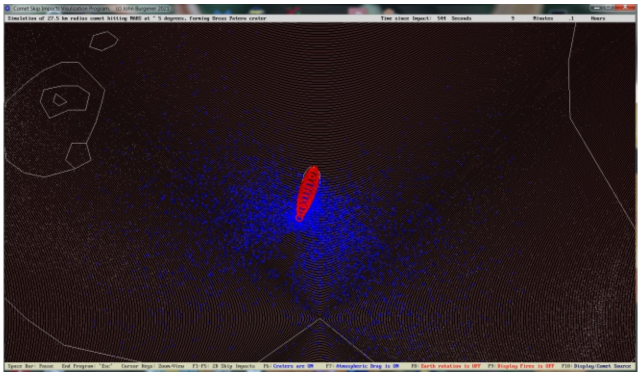
Outlline of Orcus Patera on Mars.



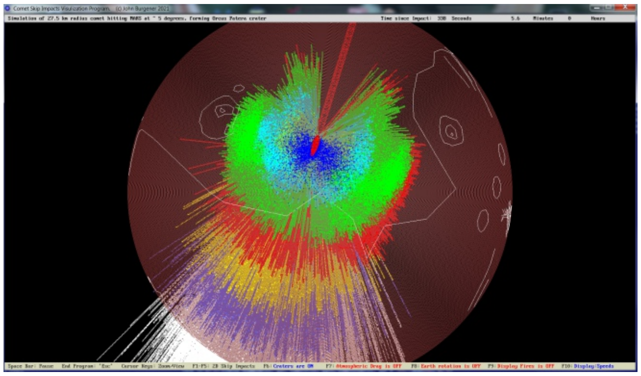
27.5 km radius comet, 5 degree impact on Mars, forms a crater matching Orcus Patera.



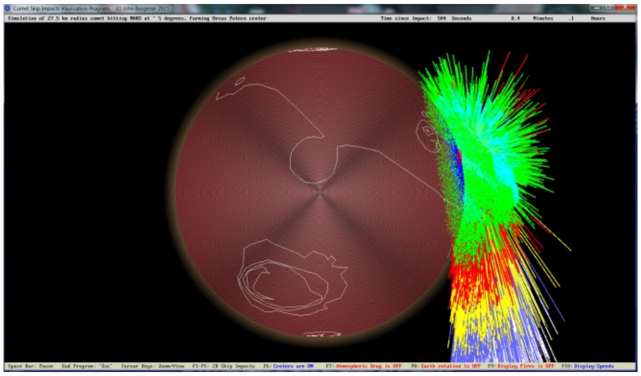
Most ejecta from impact will be above escape velocity, indicated here as white lines. The blue spots are particles that hit Mars.



A few seconds later most ejecta has moved far from the impact: only a few particles hitting Mars are visible.



Ejecta shown in colors according to speed in km/s:
Cyan < 3, Green < 4.25 (escape Velocity of Mars),
Red < 5, Yellow = 7, Purple < 10, White > 10

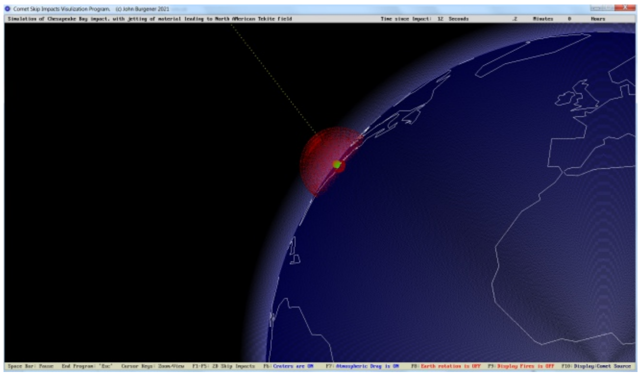


A few seconds later most ejecta has moved far from the impact: only a few particles hitting Mars are visible.

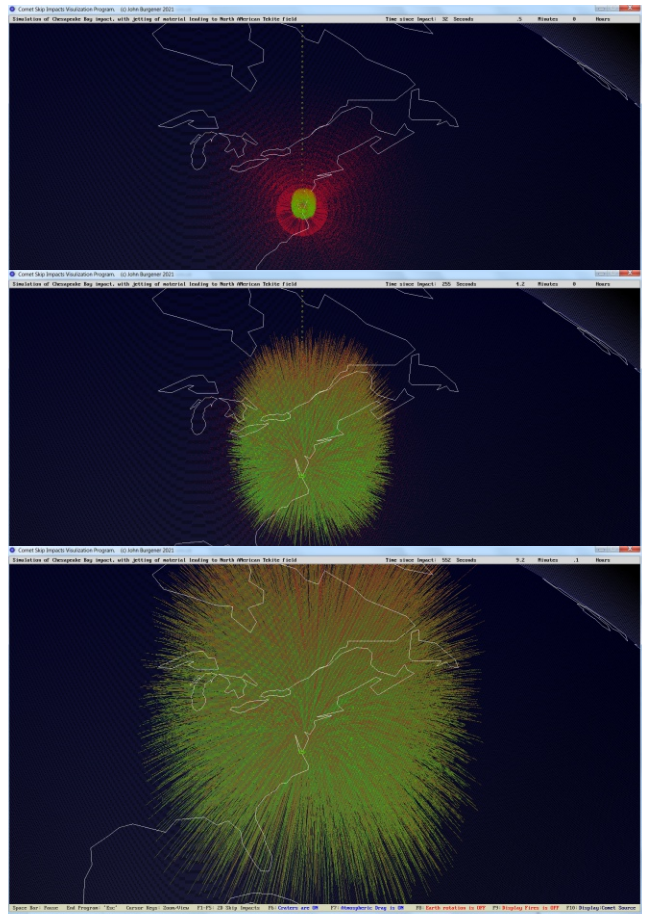
The simulation is a variation of the Ctrl S, D, F scenes, and has most of the same options and key actions.

3 Dimensional Presentation of Chesapeake Bay

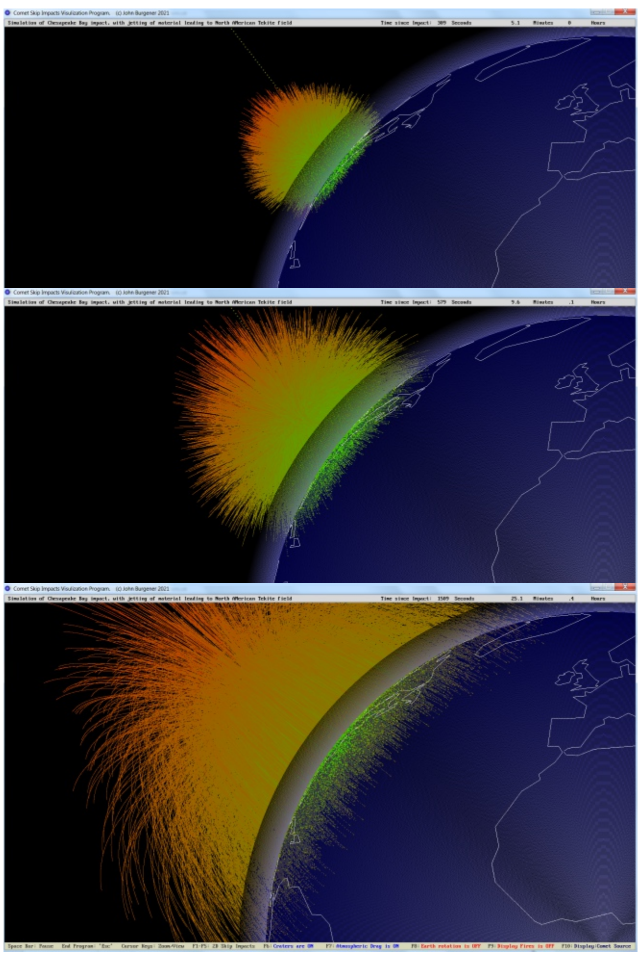
Ctrl J: This scene shows a proposed impact on Earth forming the Chesapeake Bay. This is a work in progress and not completed as of December 2022. However, it shows a fireball from the impact explosion, and debris rising in a spherical cloud that spreads debris across the planet. The final crater is not perfect nor is the spherical debris cloud. But it already shows some aspects of the impact and its likely debris cloud, so it is worth showing. I hope to improve it and make it more accurate in 2023.



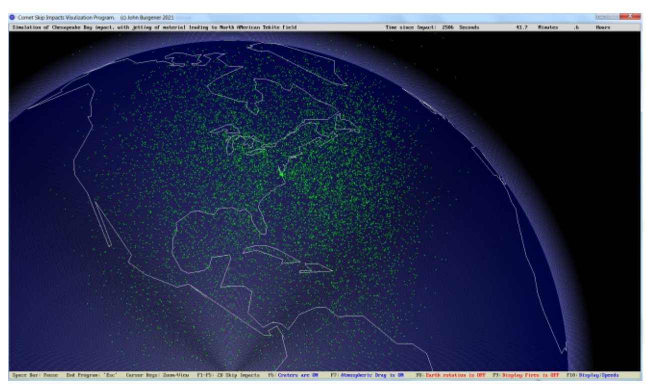
Chesapeake Bay fireball after impact.



Chesapeake Bay debris cloud / ejecta.



Chesapeake Bay debris cloud / ejecta.



Extent of debris impacting Earth.

The simulation is a variation of the Ctrl S, D, F scenes, and has most of the same options and key actions.