ASTR 3750 Planets, Moons, and Rings

Impact Crater Saturation

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a. Assumptions for Uniform Craters Simulation

- Impact at an average rate of 1 every 1000 years.
- The craters are perfectly circular, with a diameter of 10 kilometers.
- In a 500×500 array (representing the 500 km × 500 km surface area) with a total of 250,000 zeros, I used the formula below to loop and calculate the number of "damage" points for 10-km craters, and a 10-km crater is expected to "damage" 69 points when not obliterating any other craters (i.e. change 0 to 1 or nan, please refer to the picture down below for details).

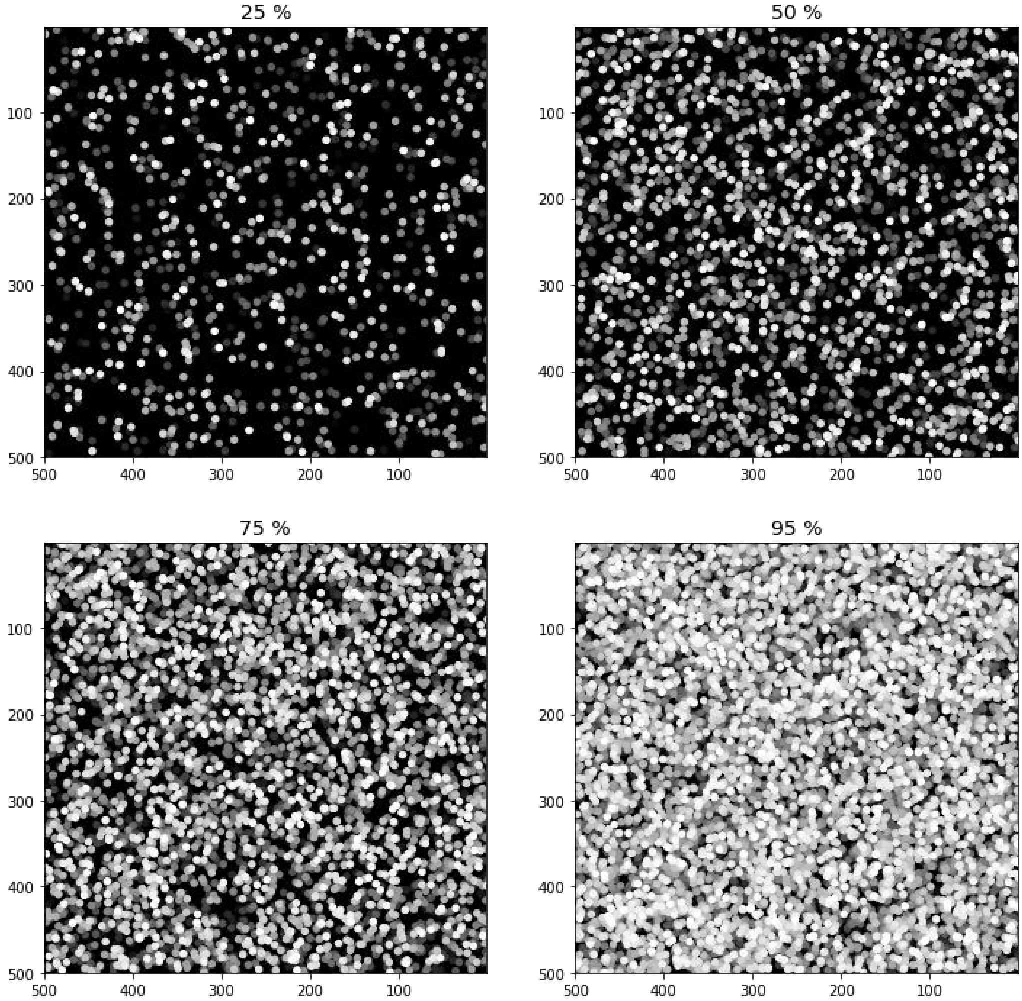
```
while (rang_x-rand_x)**2+(rang_y-rand_y)**2 < (o.d/2)**2:
    o.a[rang_x][rang_y] = np.nan
    break
```

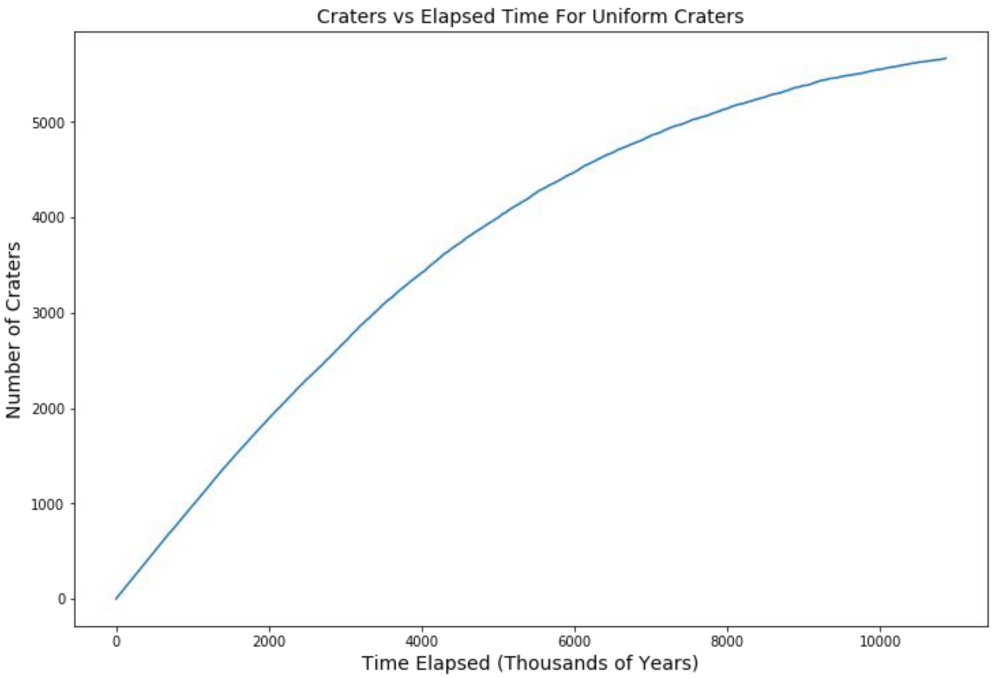
```
[[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 1. 1. 1. 1. 1. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
```

- When the impact for every 1000 years leads to only less than or equal to 15% of the expected damaged area (69*0.15 = 10 points), crater counts do not go up (i.e., an older crater is being mostly obliterated by the new crater). Which also means the assumption that a crater is considered as recognizable on the surface when the impact damages more than 59 points.
- The total surface would be considered 25% saturated when the "damaged" points divided by the total number of points (i.e. 250,000) exceeds 0.25, 50% when exceeds 0.5, 75% when exceeds 0.75, and fully saturated (100%) when exceeds 0.95.

b. Simulation of Impact Crater Saturation (Uniform)

Saturation at 25%, 50%, 75%, and 100% for Uniform Craters





```
-----------------------------------------------------
Time for 25% saturation (Thousands of Years):  1053
The number of craters evident on the surface:  1029
-----------------------------------------------------
Time for 50% saturation (Thousands of Years):  2497
The number of craters evident on the surface:  2328
-----------------------------------------------------
Time for 75% saturation (Thousands of Years):  5007
The number of craters evident on the surface:  4007
-----------------------------------------------------
Time for 100% saturation (Thousands of Years):  10792
The number of craters evident on the surface:  5626
-----------------------------------------------------
```

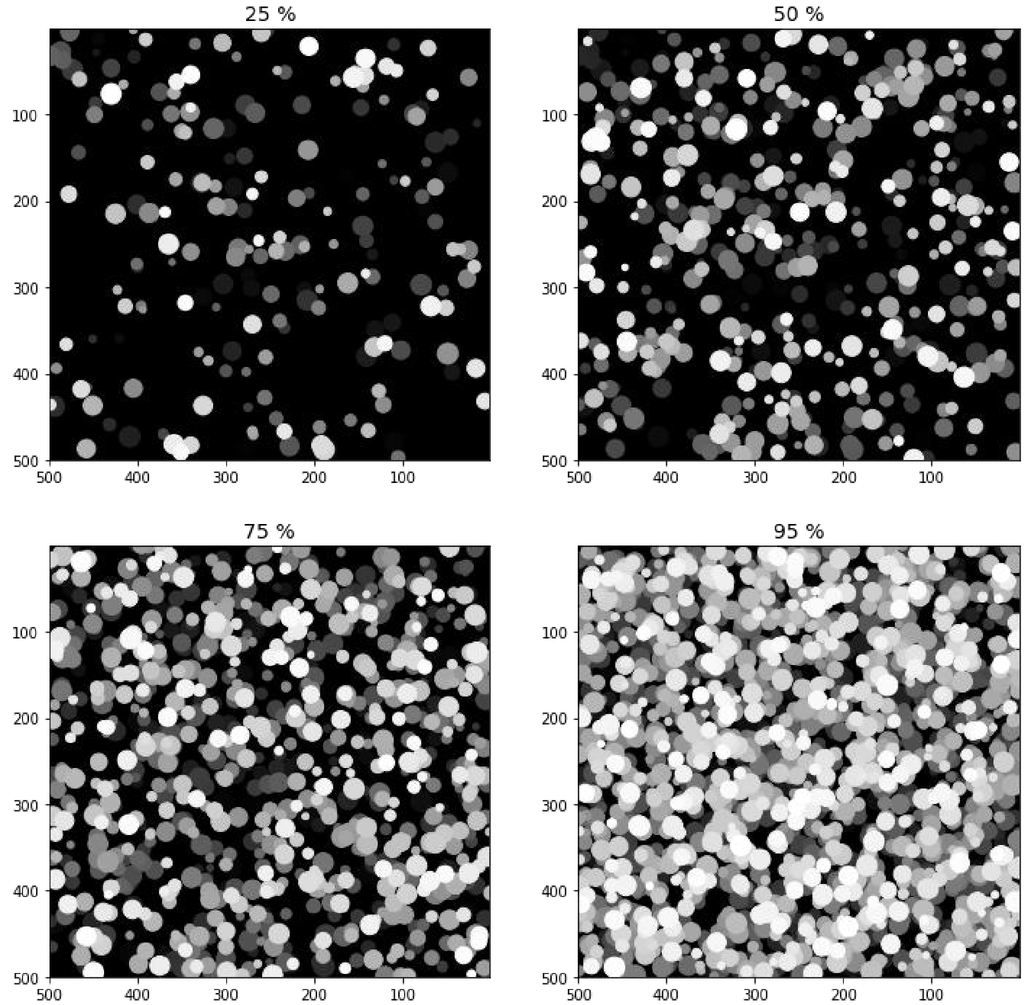
Description

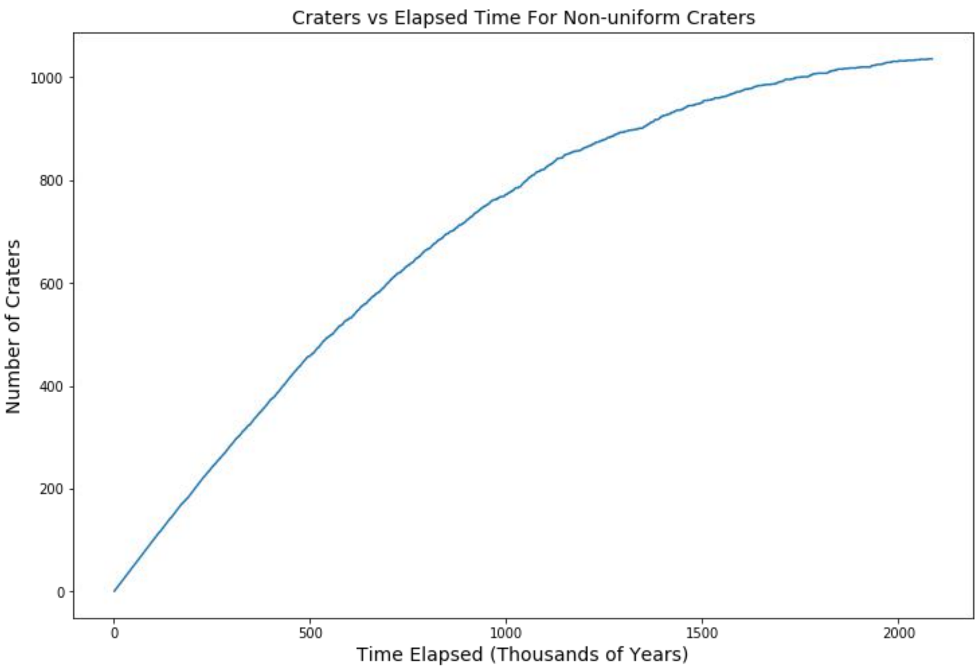
As new craters become more possibly to erase old ones through time, we can observe that the slope of the curve also starts to decrease, meaning that the increase for number of craters slows down through time. The graph meets my expectation.

c. Assumptions for Non -uniform Craters Simulation

- Impact at an average rate of 1 every 1000 years.
- <u>The craters are circular but with random diameters from 10 to 100 kilometers.</u>
- In a 500×500 array (representing the 500 km × 500 km surface area) with a total of 250,000 zeros, I used the same calculation as stated in part <u>a</u> to loop and find the damaged points result from craters of different radius.
- When the impact for every 1000 years leads to only less than or equal to 15% of the expected damaged area (69*0.15 = 10 points), crater counts do not go up (i.e., an older crater is being mostly obliterated by the new crater). Which also means the assumption that a crater is considered as recognizable on the surface when the impact damages more than 59 points.
- The total surface would be considered 25% saturated when the "damaged" points divided by the total number of points (i.e. 250,000) exceeds 0.25, 50% when exceeds 0.5, 75% when exceeds 0.75, and fully saturated (100%) when exceeds 0.95.

d. Simulation of Impact Crater Saturation (Non-uniform)





```
--------------------------------------------------
Time for 25% saturation (Thousands of Years):  203
The number of craters evident on the surface:  192
--------------------------------------------------
Time for 50% saturation (Thousands of Years):  472
The number of craters evident on the surface:  429
--------------------------------------------------
Time for 75% saturation (Thousands of Years):  939
The number of craters evident on the surface:  742
--------------------------------------------------
Time for 100% saturation (Thousands of Years):  2115
The number of craters evident on the surface:  1042
--------------------------------------------------
```

Description

Same as for the result from the simulation of uniform craters saturation. As new craters become more possibly to erase old ones through time, we observe that the slope of the curve also starts to decrease, meaning that the increase for number of craters slows down through time. However, some part becomes more turbulent rather than smooth curving, which meets my expection that the non-uniform and a succession of larger craters could have erased many pre-existing craters, showing as the disrupts on the curve above. And also, the craters and time taken are much less compared to the results of uniform craters saturation simulation earlier, which meets my expectation, too.