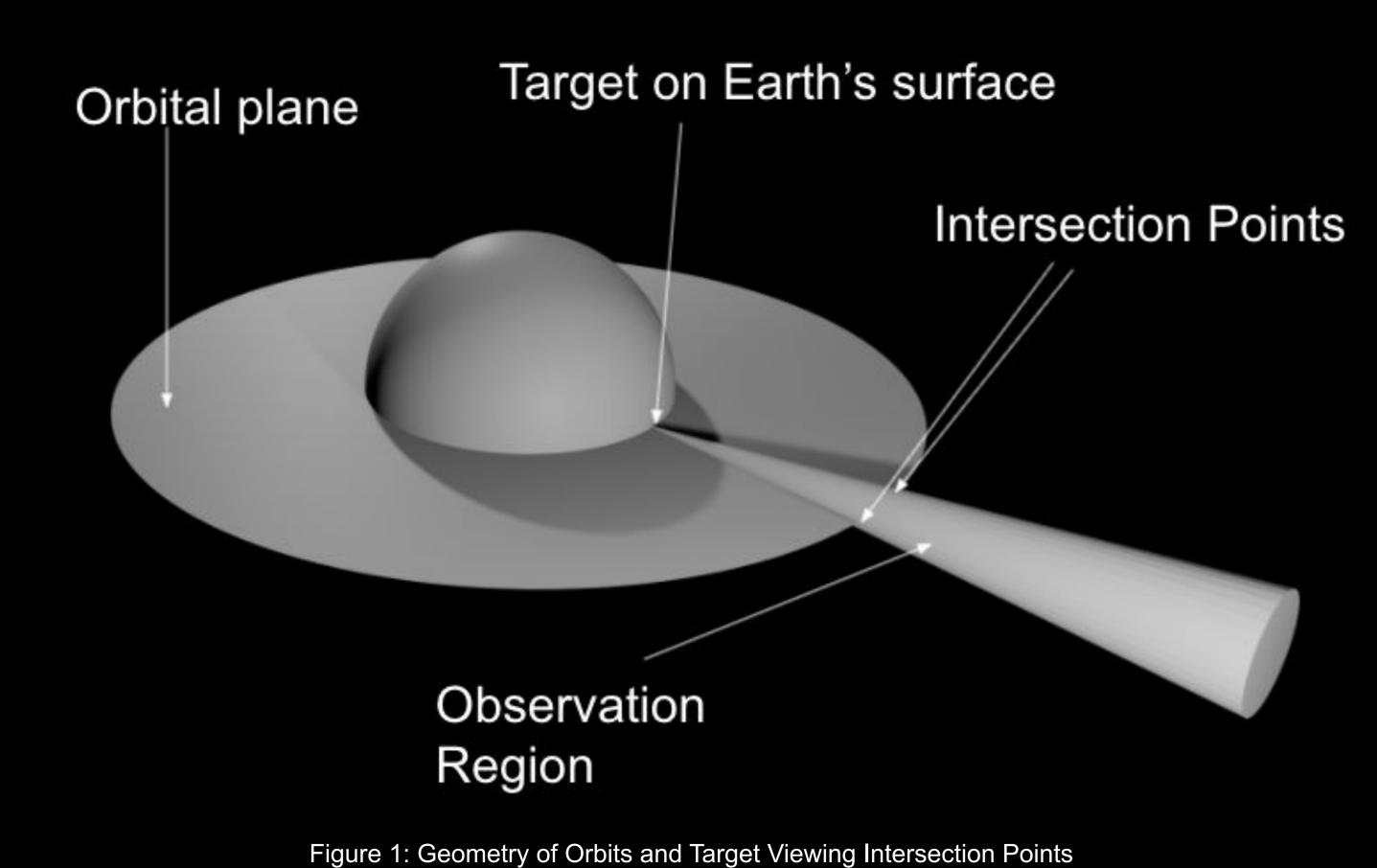
Orbital Mechanics Design to Maximize Satellite Service Time for Earth-Based Regions of Interest

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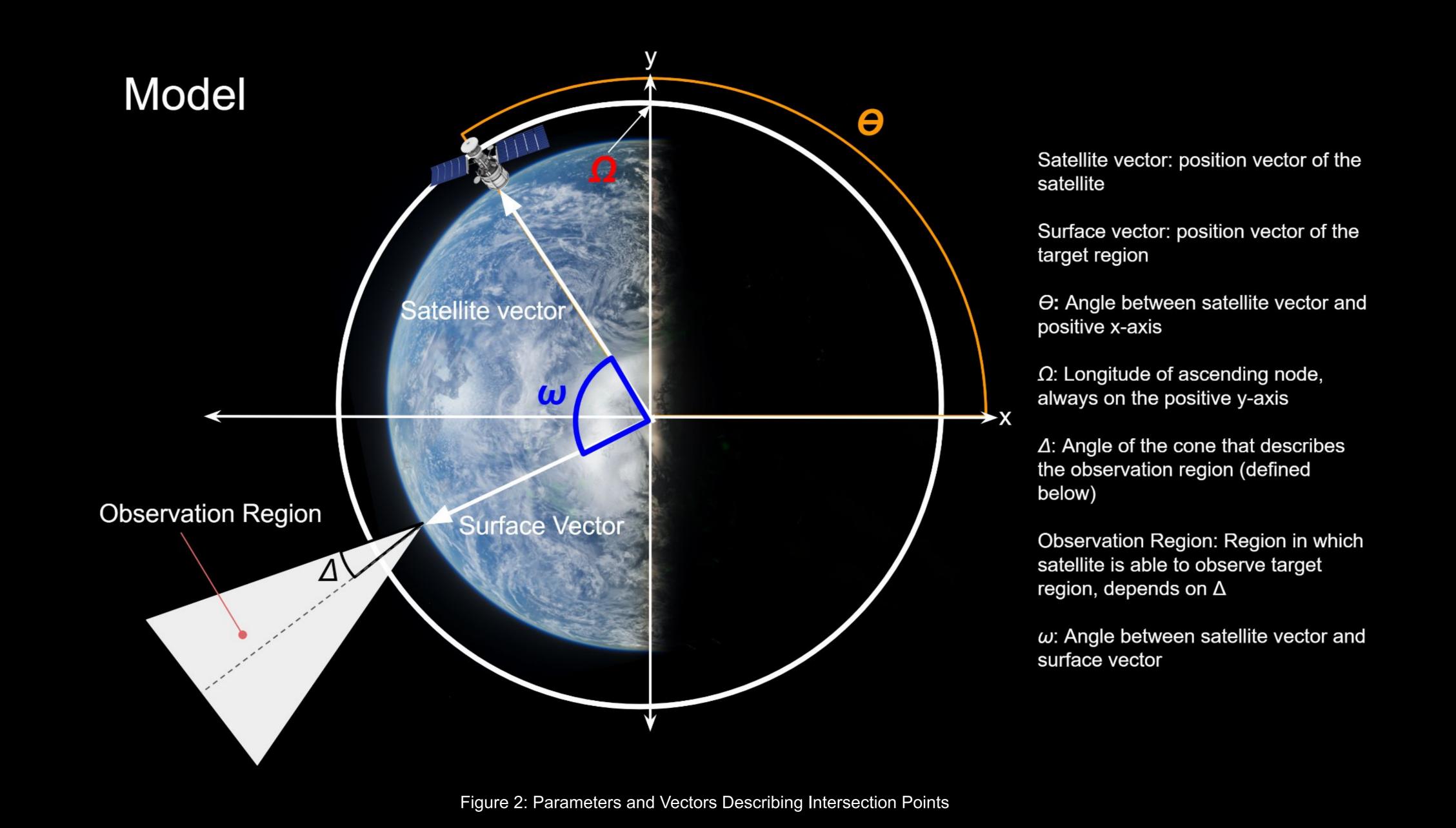
Introduction/Problem

In addition to satellite-based Internet services such as Starlink and OneWeb, the advent of cubesat and rideshare programs has made it easier for student-led groups and citizen science efforts to launch satellites for astronomical and Earth-based imaging. Many of these satellites carry instruments for Earth observation, such as sea level mapping, recording the rate of deforestation, and polar ice cap melting. Through orbital mechanics with vector analysis and computing, my project develops a method of maximizing the *observation time*, i.e., the time that a satellite spends over a user-specified region on the Earth's surface. Although the primary focus of this project is Earth observation satellites, a similar approach and some similar instrumentation could be used on cubesats for astronomical imaging. This will become especially important when the Hubble Space Telescope is eventually decommissioned, since cubesats' positions above the atmosphere makes them ideal for measuring photometry in the ultraviolet region of the spectrum. Moreover, as cubesats can be launched through rideshares with commercial space missions, their cost puts them within reach of college projects.

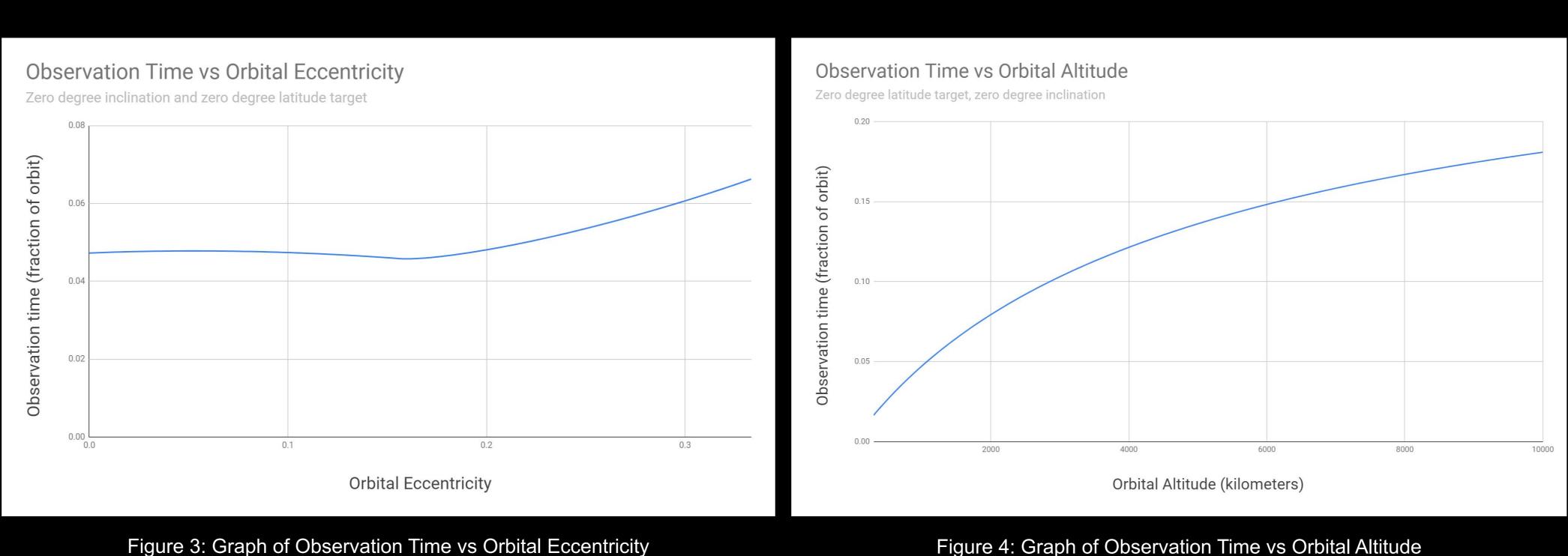


Method Development

I developed vectors for the position of a target region on Earth's surface, as well as for the position of the satellite, based on the satellite's orbital elements. I then performed trigonometric vector computation in Python to determine a specific angle, ω, between these two vectors that would result in the satellite within viewing distance of the target. Given ω, I determined the fraction of the orbit that was spent in viewing distance, and by accounting for precession and the Earth's rotation, the total observation time over the course of a satellite's lifetime. Through iteration over all possible orbital elements, I computed a unique orbit that maximizes the observation time for any given target on the surface of the Earth. My algorithm yielded geostationary and polar orbits for targets on the equator and the North Pole, respectively.



Results





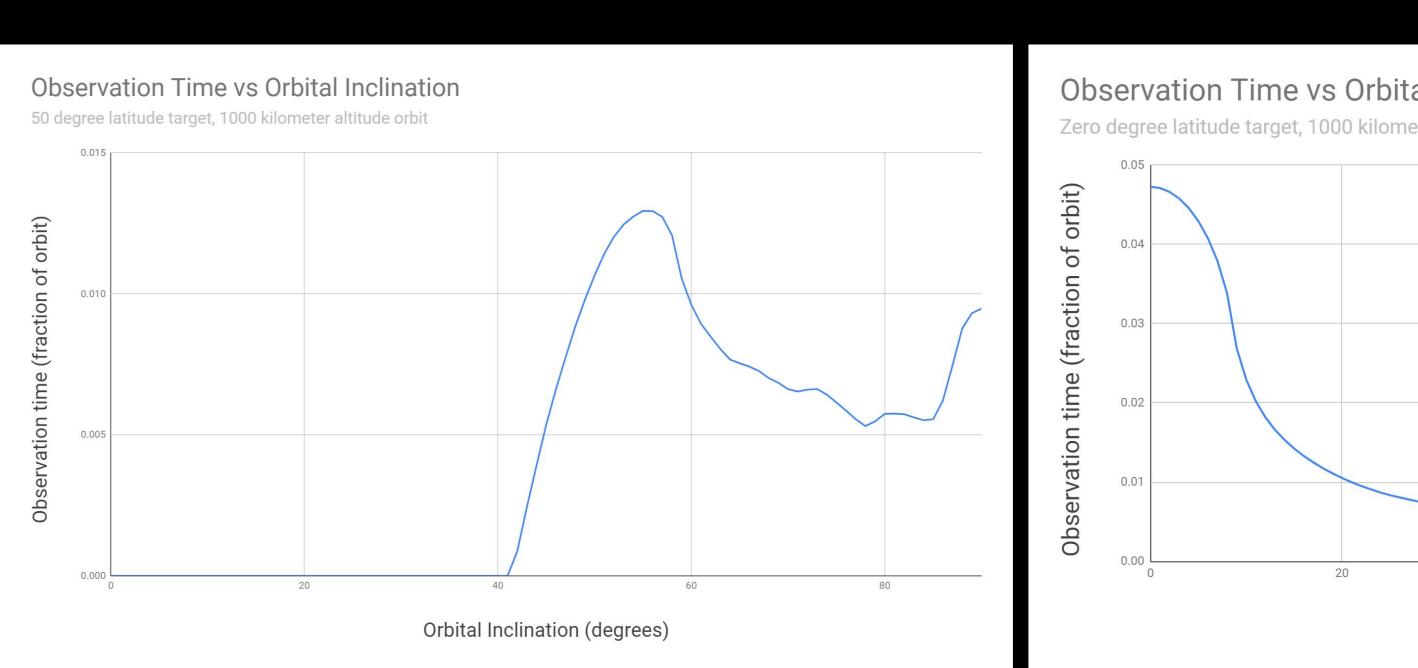


Figure 5: Graph of Observation Time vs Inclination (50 degree latitude)



Orbital Inclination (degrees)

Conclusions

There are four main conclusions that can be drawn from my project.

- Inclinations similar to the target's latitude are necessary to ever be within viewing distance of the target
- the initial longitude of the ascending node as well as the target's longitude have little effect on the observation time
- an eccentric orbit yields the highest observation time when paired with the above factors
- Higher altitude orbits yield higher observation times

References

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