Why You Should Care About the Thermosphere and Space Weather

Aaron Ridley
University of Michigan

Charles Bussy-Virat, Daniel Brandt
University of Michigan

ABSTRACT

The thermosphere extends from about 100-700 km altitude, and is home to the majority of low Earth orbiting satellites and debris. In this regime, atmospheric drag is the most important in-track force on objects in orbit. Therefore, in order to determine precise orbits, needed to avoid collisions, an understanding of the thermosphere and how it varies is important. The thermosphere is incredibly interesting because it is transition region of the atmosphere: in the lower thermosphere, fluid dynamics dominate and it is strongly controlled by lower atmospheric dynamics, while in the upper thermosphere, it is collisions with the overlapping ionosphere that dominate the behavior. These collisions cause significant variability in the upper atmosphere. This is because on the dayside, the sun's extreme ultraviolet radiation creates the ionosphere, which is relatively steady on large scales and over longer time-scales, but at the high latitudes, the ionosphere is created by the auroral precipitation from the magnetosphere. This precipitation is highly variable and can, at times, extend to extremely low latitudes. Associated with the aurora exist strong electric fields that move the charged particles at speeds of over 2,000 miles per hour. The neutral atmosphere is not influenced by the electric fields, so the ions move through the neutrals, colliding with them, imparting both momentum and energy into the atmosphere. This energy transfer can, at times, be larger than the EUV heating on the dayside, and can cause the global temperature to increase by several hundreds of degrees within a few hours. The heating drives atmospheric expansion, causing the drag to increase dramatically on low Earth orbiting satellites. If these effects is not accounted for when precise orbits are determined for collision avoidance, operators can significantly misunderstand the probability of collisions between objects. Indeed, even during relatively quiet times, the uncertainty in predicting the behaviour of the upper atmosphere can significantly change the probability of collision between objects.

This talk will describe the thermosphere, how the thermosphere influences orbital mechanics, how the thermospheric dynamics are controlled by external forcing that is hard to predict, and how that uncertainty can cause difficulties in understanding the probabilities of collisions between objects in orbit around Earth.