

Saying NO to Occultation Anomalies in the Twilight Zone



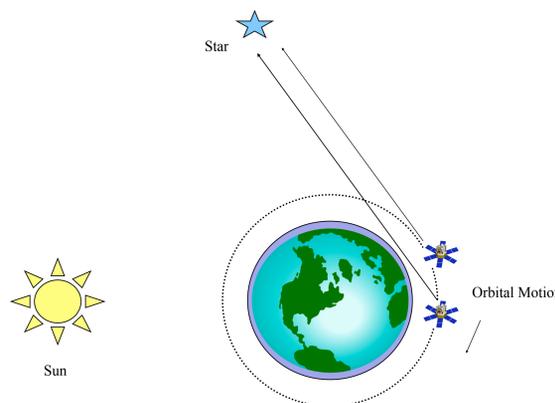
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Introduction

The SOLar STellar Irradiance Comparison Experiment (SOLSTICE) on the Solar Radiation and Climate Experiment (SORCE) makes stellar occultation measurements in the ultraviolet (250 nm). While the satellite observes these stars, the line-of-sight towards the star passes through the Earth's atmosphere and the signal from the star decreases due to Ozone absorption; however, some of these signals actually become stronger.

My goal was to determine the source of this extra signal and to correlate these peculiar signal counts with observing geometry, geomagnetic activity, or some other space weather effect.

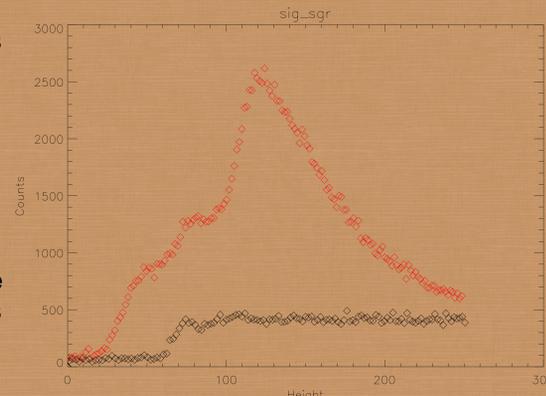


Height(km) vs. Counts

Red: Anomalous Observation

Black: Star Observation*

*Note: both observations are directed towards the same star (sig_sgr)



Photoluminescence?

We recognized the possibility that the line-of-sight of the satellite was unintentionally passing through parts of the atmosphere that were in sunlight, even though the satellite is only scheduled to observe stars in the nighttime. If this was to be the case, the instrument might be picking up UV from NO emission through photoluminescence (the process in which a substance absorbs photons and then re-radiates photons).

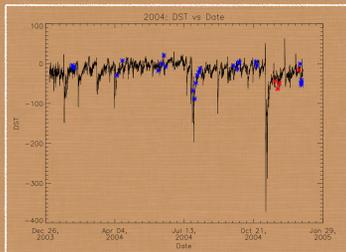
In order to test this, I plotted the satellite location, the tangent point location, and the point at which the line-of-sight exceeds 300km (extreme edge of the atmosphere) on a daylight terminator world map to see if photoluminescence was a possibility.

Although it appears photoluminescence can potentially account for one anomalous observation, the others still are rather straightforwardly taken in the nighttime - eliminating the potential for photoluminescence.

Correlation Indices

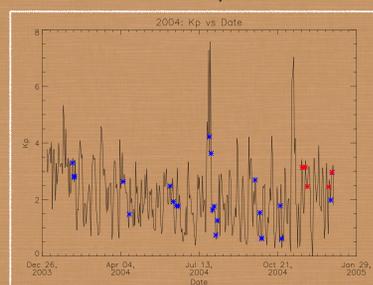
2004: DST vs. Date

2004: Kp vs. Date

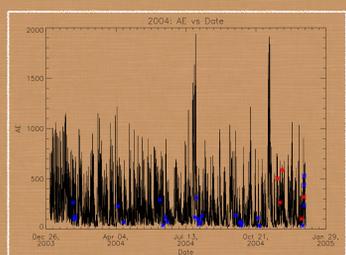


Red: Anomalous Observations

Blue: Star observations with a tangent point at similar latitude (for comparison purposes)



2004: AE vs. Date



Indices of Geomagnetic Activity

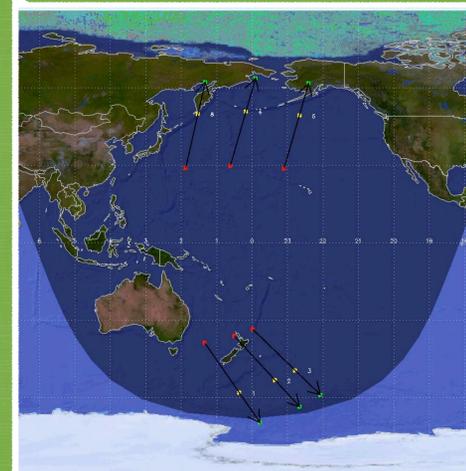
After filtering the NO observations (about eight very clear ones) and extracting information such as the time, local time, location, and the height of the tangent point above the earth, I sought to perhaps correlate the data with geomagnetic activity. I compared the data against different indices that measure this activity:

- DST (Disturbance Storm Time)
- Kp (Planetary value of K-index [measuring strength of geomagnetic storms])
- AE (Auroral Electrojet, auroral zone magnetic activity)
- IMF (Interplanetary Magnetic Field data from ACE)
- Solar Proton Events (proton storm)

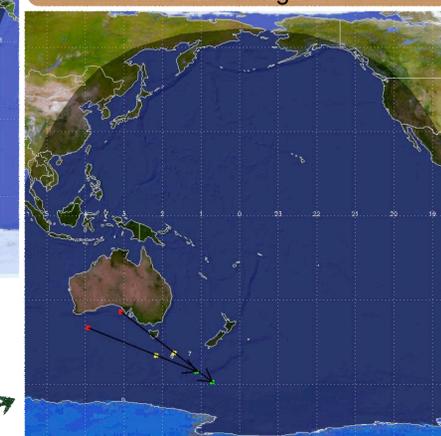
Finding no obvious correlation with any of these indices, I looked to other explanations.

Daylight Terminator Maps

Red: Satellite location
Yellow: Tangent point location
Green: Edge of Earth's atmosphere in the line of sight



November/December (Northern Winter)



June-August (Northern Summer)

Conclusions

Although there is no strong correlation with any of the indices that measure geomagnetic activity, there is a cluster of observations that occur predominately in November and December. This correlation would involve further inspection in the relationship between these observations and unique seasonal events.

After consulting with SPICAM experts, we see there is a high possibility that these emissions are a result of O and N being transported to make chemiluminescent NO in the nightside, similar to the process that has been identified in the atmosphere on Mars. Further research should be done with this SOLSTICE data to determine ways to confirm this theory.

Chemiluminescence?

Data from the Spectroscopy for Investigation of Characteristics of the Atmosphere of Mars (SPICAM) suggests that NO can emit ultraviolet in the nighttime as a result of chemiluminescence. O and N atoms in the dayside thermosphere are transported to the nightside where they descend vertically and produce gamma and delta bands of NO. This kind of motion is expected in the winter polar mesosphere, which makes it very possible for our anomalous observations to be a result of this phenomenon once we observe their location.