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Satellite Observation and Indirect Solar Irradiance

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Abstract

The optical properties of satellites are attracting attention as Space Domain Awareness (SDA) develops. Typically, satellites were thought to have no other light source outside sunlight. However, during the actual observation, scientists discovered that moonlight and earthshine would increase the observation results' errors, which had a significant impact on their estimation of the satellite's state. We offer a suggestion for an observation strategy to counteract this influence. First, we suggest a precise earthshine model that favors long-term continuous satellite observation and takes into account the size of the earth. The impact of moonlight and earthshine on satellite observation results is then examined, and it is discovered that this impact varies depending on the characteristics of the satellite. Additionally, we deduce the impact law and establish a link between it and observation geometry. Finally, a Period Contribution model is suggested to offer a suitable observation strategy to counteract the impact of moonlight and earth shine.

Keywords: Satellite observation, Reflection, Material, Indirect solar irradiance

Introduction

The use of optical observation from the ground is crucial for collecting satellite parameters. The optical information from satellites is primarily determined by the observation geometry, which is in this paper defined as the relationship between the position of the light source, satellite, and detector. The optical signal received by detectors will vary with the different shapes, sizes, materials, and operational states of the satellite. With reference to it, we may distinguish between satellites using photometric data and observation. The sun was typically thought to be the only source of illumination for space-based spacecraft. However, there are other light sources in space besides the sun, which causes a mixing light made up of lights at various incident angles. The mixing light is received by the detector as the satellite's optical information after being reflected by the satellite, which results in a non-negligible error for the satellite estimation. The moon and the earth are the two main sources of obtrusive light. Known as Indirect Solar Irradiance (ISI), they reflect sunlight to illuminate the satellite rather than emitting any light themselves. They are not like stray lights that obstruct the telescope lens while being observed. They alter the observational outcomes by increasing incident light to the satellite from various directions. Sunlight cannot simultaneously enlighten both the entire surface of the moon and the earth since it is a parallel light coming from a single point. The geometric relationship between the satellite, the indirect light sources, and

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the sun influences the satellite's indirect solar irradiance. Additionally, the shapes and composition of the majority of satellites are erratic, which results in a close correlation between the optical signal detected by the detector and the observation geometry (relative position of the light source, the satellite, and the detector). The relative positions of the sun, indirect light sources, the satellite, and the detector must therefore be taken into account for satellite observation. We determine how indirect solar irradiance can affect satellite observations and when observers should take indirect solar irradiance into consideration in order to provide a theoretical guide for satellite observers to avoid the influence of indirect solar irradiance at the moment. This paper considers observation geometries at various times. First, an accurate earthshine model that divides the earth's surface into quantities of slices is proposed. This model can simulate the earth's irradiance at various times at the satellite. Second, we collect photometric data (spectrum integrals) from multiple light sources and conduct long-term, continuous satellite observations. Third, a 'Contribution' concept is proposed to quantify each light source's influence on satellite photometry. The 'Contribution' is defined as the ratio of satellite irradiance caused by a single light source to total satellite irradiance. Following that, we investigate the Contribution of each light source on satellites of various orbits and materials, discovering that the Contribution of Indirect Solar Irradiance varies with satellite and orbital attributes. The observation geometry is used to explain the variation law. Finally, a Period Contribution model is proposed to assist satellite observers in better planning their observation time.

Conclusion

We propose an accurate earthshine model in this paper. This model takes into account the actual volume of the light source, implying the multi-directional incidence of earthshine. Following that, we develop three irradiance transfer models: solar irradiance, lunar irradiance, and satellite reflection. During one solar year, we investigated the irradiance of various light sources at the satellite and detector observation and analysed the laws governing the observation geometry and the influence of Indirect Solar Irradiance on satellites with various attributes. Furthermore, the Period Contributions model is proposed to analyse the primary light source to satellite observation over time. Finally, we present a specific strategy for mitigating the effects of indirect solar irradiance.