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The Influence of Anisotropic Surface Reflection on Earth's Outgoing Shortwave Radiance in the Lunar Direction

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Abstract

The most basic indicator of the state of climate change at the top of the atmosphere (TOA) is the fluctuation in the radiation budget. To study Earth's radiation budget, a precise assessment of shortwave radiant exitance is essential (ERB) at TOA. Obtaining data on the Earth's outgoing shortwave radiation (OSR) is crucial for calculating the planet's radiant exitance of shortwaves. Moon-based sensors are less advanced than satellites that are sent into orbit. (MS) might offer extensive, long-term, and continuous data for Earth radiation measurements, giving ERB a fresh viewpoint. However, the elements influencing the calculation of Earth's OSR in the lunar direction, such as anisotropic surface reflection and the impacts of clouds and aerosols on the radiation budget, have not yet been well investigated. We solely considered the impact of anisotropic surface reflection in this paper. We built a model to estimate Earth's OSR in the lunar direction (EOSRiLD), integrating the factors of anisotropic surface reflection (scene types, solar zenith angles, viewing zenith angles, and relative azimuth angles), as well as a radiant flux in Moon-viewed sunlit regions, to determine the extent of this influence. Then, we spoke about it throughout three time periods (Earth's rotation, the span of a revolution, and synodic month cycle) and examined the effects of three factors on anisotropic EOSRiLD: the extent of the Moon-viewed sunlit zone, scene kinds, and incident-viewing angular bins. Our findings reveal that whereas EOSRiLD based on anisotropic and isotropic reflection assumptions differ, they all exhibit the same monthly cycle shift that is connected to the size of the sunlight region as seen from the Moon. The discrepancies between anisotropy and isotropy are highest at the beginning and end of the lunar month; when it is nearing the beginning of each cycle, there is a tiny differential peak. The respective azimuth angles between the Sun and Moon induce both anisotropy and isotropy.

Keywords: Earth's radiation budget; Moon-based observation; outgoing shortwave radiance; anisotropic surface reflection

Introduction

Extreme weather events have been more frequent in recent years, which has increased scientists' interest in global climate change. The most basic indicator of the state of global climate change is the fluctuation in the radiation budget at the TOA (top of the atmosphere). An increase in energy in the Earth system is represented by a positive budget balance, whereas a decrease in energy is represented by a negative budget balance. In the long run, the Earth's remaining gets transformed into various forms and stored in the Earth system, where it will finally be released into the atmosphere, ocean, and land surface directly reflecting and scattering around 30% of the incoming solar shortwave radiation. a longwave radiation source. In general, the Earth system is in an energy-balanced state if the entering shortwave radiation matches the departing radiation (the reflected shortwave radiation and the longwave radiation that is released over time). The absolute determination of incoming radiation and outgoing radiation at TOA is therefore the fundamental factor to quantify or estimate Earth's radiation budget. The measurement of incoming radiation at Earth's TOA is far more accurate than the calculation of departing radiation because of the steadiness of Earth's orbit. Particularly, the complicated anisotropic properties have a considerable impact on the calculation of total shortwave outgoing radiation. Earth system reflection and scattering processes. To enhance the calculation of the ERB (Earth's radiation budget) at TOA, the precise measurement of the OSR (outgoing shortwave radiance) is crucial.

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To estimate ERB, a variety of methods have been developed. The first is dependent on satellite-based equipment that gauges thermal radiation emissions, solar radiation reflections, and incoming solar radiation. Scientists from the United States and Europe have run several satellite observation projects during the 1980s, including the Solar Radiation and Climate Experiment, the Clouds and Earth's Radiant Energy System, and the Earth Radiation Budget Experiment (ERBE, 1984–1994). These LEO (low-Earth orbit) satellites are crucial for the study of the global equilibrium of radiant energy. They do not, however, allow for monitoring fluctuations at tiny time scales, such as changes in cloud fraction and aerosols, which are essential characteristics to effectively predict ERB, because of the restricted temporal sampling.

The first dedicated observation of ERB from a geostationary orbit was made by the Geostationary Earth Radiation Budget (GERB) instrument, which also revealed cloud effects at each observed site. However, we can only provide worldwide coverage when three geostationary satellites are positioned equally in orbit. The Deep Space Climate Observatory's (DSCOVR's) National Institute of Standards and Technology Advanced Radiometer (NISTAR) is a cavity radiometer made to measure the neutral, L1-orbital, absolute, spectrally integrated irradiance reflected and transmitted from the whole sunny face of Earth the Sun and Earth's gravitational center (approximately one million miles from Earth).

It offers a distinctive angular perspective in addition to serving as a complement to more ERB observational systems. A different estimating method is dependent on the estimated overall change in energy held in the climate system. one common Estimating the change in ocean heat capacity (OHC), which is the first stage in this strategy, is produced along a vertical axis from the difference between the observed temperature and the climate profile of the water. Mostly, the Argo array of autonomous profiling floats is used in its implementation. However, faults in this technique are present because of the floats' coverage restriction. too big to offer reliable deep ocean contribution estimates.

Earthshine A ground-based approach to determining Earth's planetary albedo is observation. You can distinguish between the sunny and the dark portions of the Moon's nearside that faces Earth. Direct sunlight is responsible for the sunlit part's brightness, while indirect sunlight depends on how well Earth's atmosphere reflects sunlight.

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