Detecting change in Earth's radiation budget from the surface temperature time series from the Apollo 15 landing site

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The energy budget of the climate system of Earth represents the balance between incoming energy from the Sun in the form of solar radiation, and outgoing energy from Earth in the forms of albedo and long-wave infrared radiation. Space-borne monitoring of this radiation budget began in late 1978 by the Nimbus 7 Earth Radiation Budget Experiment. However, the first important observation from deep space of both incoming and outgoing radiation might have been made inadvertently by the Apollo 15 mission three decades ago.

At the Apollo 15 landing site, two boreholes were drilled for the purpose of measuring the rate of heat flowing from the interior of the Moon to study its evolution and deep structure. However the boreholes were much shallower than expected. Six thermometers originally designed to be lowed into the boreholes were deployed on or above the regolith surface. Six lunar surface temperature time series were therefore recorded over a 41-month period by accident.

Analysis of these accidentally obtained Apollo 15 temperature time series reveals different characteristics in the lunar daytime and nighttime surface temperatures. The seasonal variability is greater in daytime than in nighttime. Superimposed on the diurnal and seasonal variations was an inter-annual daytime cooling trend over the observation period. In contrast, there was an upward trend in the lunar nighttime temperature. Additionally, the fluctuation in the lunar nighttime temperature does not keep the same rhythm as the fluctuation in the daytime temperature.

Because there is no complication of atmosphere and hydrosphere in the climate system of the Moon, temperature at the Moon's surface is determined directly by the radiation it receives from the Sun and Earth. Using the JPL Horizons Ephemeris System, the observed daytime surface temperature change over the entire observation period can be reasonably well explained by the insolation variation associated with the variations in the distance and elevation of the Sun with respect to the Apollo 15 landing site.

However, the orbital excursus of the Earth-Moon system can only explain a small portion of the observed nighttime temperature variation. While the ephemeris of the Moon predicts a nighttime cooling tend, a significant nighttime warming trend is recorded in

the Apollo 15 lunar surface temperature time series. The different characteristics of the daytime and nighttime temperatures at the Apollo 15 landing site is a confirmation of both a stable radiation incoming from the Sun and a changing radiation outgoing from Earth. The observed lunar nighttime warming is consistent with the global dimming in the 1970s recorded in widespread ground-based radiation records.