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Air-LUSI: Supporting Advancement [STC1] of the Moon as a Reference for Earth Observations from Space Air-LUSI: Supporting Advancement of the Moon as a Reference for Earth Observations from Space

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To monitor global environments from space, satellites must be calibrated accurately and consistently across time, missions and instruments. This requires the use of a stable, common reference that is continuously accessible to Earth observing satellites, whether they make up series of missions spanning long periods of time or comprise constellations acquiring many simultaneous observations across the planet. The Moon can serve well as such a common reference. Its surface reflectance is stable to within one part in 10^8. It is theorized that its radiant output with time changes repeatedly and very predictably with viewing and illumination geometry. In addition, it has a radiant flux more comparable to the Earth's surface than the Sun and can be viewed directly by the instrument. Currently, to predict the lunar irradiance given an illumination and viewing geometry, the United States Geological Survey (USGS) has developed the Robotic Lunar Observatory (ROLO) Model of exo-atmospheric lunar spectral irradiance. The USGS ROLO model represents the current most precise knowledge of lunar spectral irradiance and is used frequently as a relative calibration standard by space-borne Earth-observing sensors. Current knowledge of the Moon's spectral irradiance is thought to be limited to 5-10% uncertainty. However, monitoring changing Earth environments calls for an absolute lunar reference with higher accuracy.

The development of the ROLO model and subsequent attempts to better characterize the lunar spectral irradiance cycle were based on observations made from the Earth surface. This requires applying corrections to remove effects of the atmosphere, which limits the accuracy. The Airborne LUnar Spectral Irradiance (Air-LUSI) system was developed to make highly accurate, SI-traceable measurements of lunar spectral irradiance from NASA's ER-2 aircraft flying at 21 km, above 95% of the atmosphere. To that end, the air-LUSI system employs an autonomous, robotic telescope system that tracks the Moon in flight and a stable spectrometer housed in an enclosure providing

a robustly controlled environment. During November 2019, the Air-LUSI system was demonstrated with flights on five consecutive nights acquiring observations of the Moon at lunar phases of 10°, 21°, 34°, 46°, and 59°. Air-LUSI is now ready for operational use. This paper provides an overview of this new capability and how it, along with other efforts underway, can help transform how we monitor the Earth from space.