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CubeSats for measuring the Earth's energy imbalance

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The Earth's Energy Imbalance (EEI) is a crucial parameter quantifying the magnitude of global warming. Unfortunately, measuring the EEI is extremely difficult. In particular, the Total Outgoing Radiation (TOR), which requires sophisticated spatial and temporal averaging and interpolation, has never been measured with sufficient accuracy. Currently, the most promising approach to sample the TOR across the entire virtual sphere that represents the Top Of the Atmosphere (TOA) is to employ a fleet of CubeSats, each equipped with a nadir-pointing absolute radiometer. However, spatial and temporal interpolation and/or averaging is still required in order to account for the part of the outgoing radiation which is not directed towards and thus not measured by any of the CubeSats. Therefore, assumptions regarding the directional distribution of the reflected and emitted radiation have to be made. While the directional distribution of the reflected radiation strongly depends on the Earth's surface features and atmospheric conditions, the (thermal) emission is likely well represented by Lambert's cosine law.
The Compact and Light-Weight Absolute Radiometer (CLARA) can simultaneously measure total and thermal (long-wave) outgoing radiation and can thus distinguish between both directional distribution regimes. We will study and quantify the improvement in accuracy of the TOR measurements if the reflected (total minus long-wave) and emitted (long-wave) components of the TOR can be interpolated separately based on their different directional characteristics.
The CLARA is an electrical substitution radiometer currently flying on the NORSAT-1 mission to measure Total Solar Irradiance (TSI). It features three measurement channels of which two can be operated simultaneously. For the EEI measurement, a black coated receiver is used to measure TOR while an additional white coating will be used on the second receiver to measure the long-wave radiation. Both channels can be cross-calibrated against deep space (cold reference) and the night side of the Earth (hot reference) to provide measurements of total and long-wave radiation on an absolute scale (Wm-2).