TSI and OLR measurements with CLARA onboard NorSat-1

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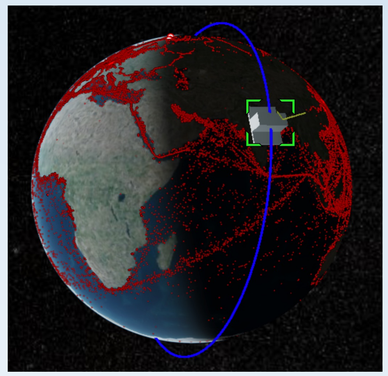
Abstract: *The Earth Radiation Budget at the Top of the Atmosphere (ToA) governs the status of climate change on our planet. The ERB is the balance between the incoming Total Solar Irradiance (TSI) and total outgoing radiation at the ToA. If more energy is stored in the system the Earth Energy Imbalance (EEI) is positive and the temperature in the system rises. The Compact Lightweight Absolute RAdiometer (CLARA) experiment onboard the Norwegian micro satellite NorSat-1 is an SI traceable radiometer with the primary science goal to measure TSI from space. Besides TSI, CLARA also measures the terrestrial Outgoing Longwave Radiation (OLR) at the ToA on the night side of Earth. We present the latest status of the data and degradation correction obtained with this SI-traceable radiometer and compare the CLARA TSI and OLR time series with other available observations and reanalysis data. The validation of these measurements is key to advance the instrumental requirements to determine the EEI from space.*



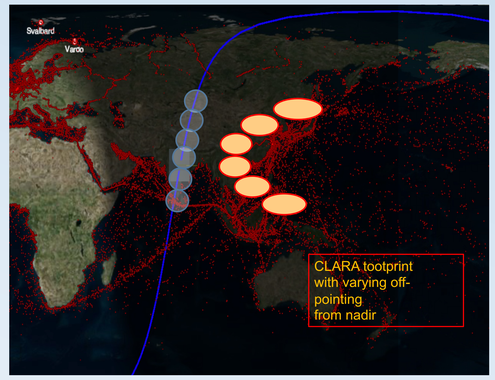


Figure 2: Illustration of the NorSat-1 orbit (left panel) and CLARA footprint during the OLR measurements for on individual orbit. Not to scale.

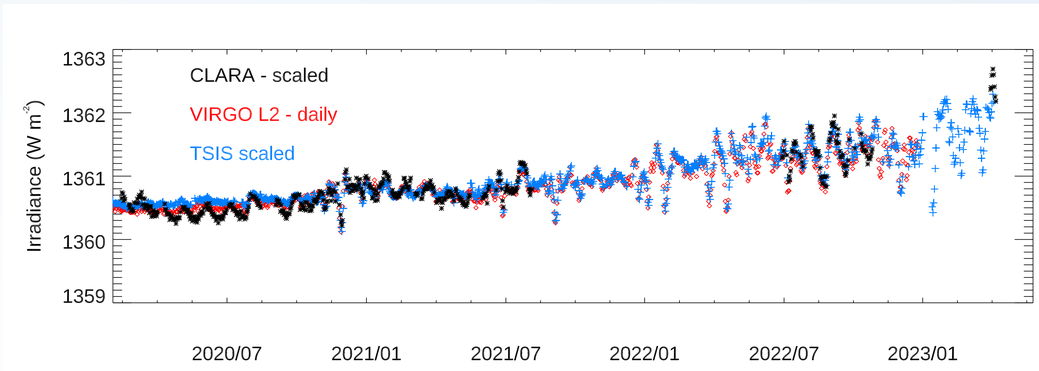


Figure 1: *Comparison of the latest version of CLARA TSI L2A data (black, scaled to VIRGO L2) with the SOHO/VIRGO(v8)(red) and TSIS (blue) data. The comparison shows that since the beginning of 2021 the CLARA measurements follows the solar irradiance variability as measured with VIRGO and TSIS. However, from March to November 2020 CLARA measures slightly lower values with a higher variability.*

Summary: CLARA is the first solar radiometer that alternately measures the TSI and the OLR. Some instrumental effects that affect the data quality are still being investigated.

NorSat-1 was launched July 14, 2017. Besides measuring TSI (Figure 1), CLARA (Walter et al., 2017, 2020) also obtains OLR measurement when the satellite is in eclipse (see Figure 2 for illustration and Figure 3, left panel examples for one day). As can be seen, the OLR measurements show quite some variation over each orbit.

While for the TSI measurements, the solar fine-pointing mode is required, the Earth outgoing radiation measurements are obtained without an active pointing mode. Therefore, to derive where CLARA points on the Earth, the exact knowledge of the position and attitude of NorSat-1 is required (see Figure 3, middle panel as example). Moreover, the OLR measurements need to be filtered to reject data points when the Earth does not fill the entire field of view of the instrument. To do this, we determine the angle between the nadir vector (i.e., the vector pointing to the center of Earth) and Line-of-Sight (LoS) vector and select only those measurements where the LoS vector is less than 50^{O} from the nadir vector.

These terrestrial measurements are a new scientific avenue for PMOD's absolute radiometers. Specifically, they serve as in-flight demonstration for the determination of the Earth's radiation budget and ultimately also the Earth Energy Imbalance (EEI) from space.

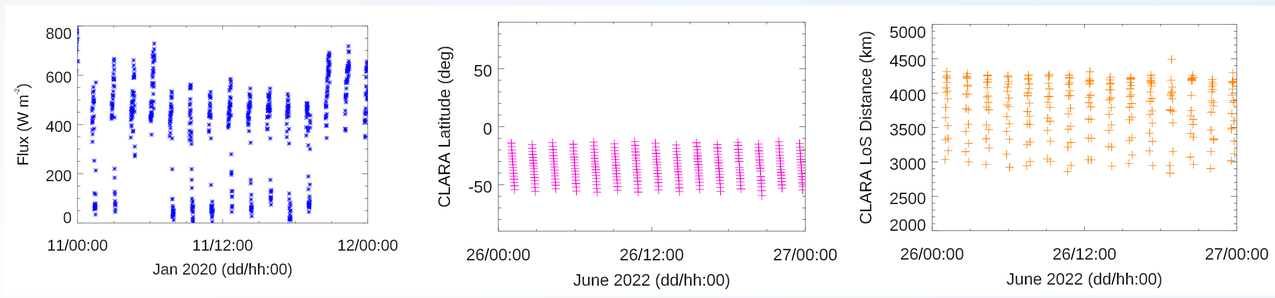


Figure 3: *Left panel: Earth outgoing radiation as measured with CLARA for individual orbits over the full days of 11 January. The middle panel show the latitude of the CLARA footprint and the right panel the distance between CLARA and the Earth's surface in Line-of-sight (LoS) direction.*

References:

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Walter, B., Andersen, B., Beattie, A., Finsterle, W., Kopp, G., Pfiffner, D., & Schmutz, W. (2018). First TSI results and status report of the CLARA/NorSat-1 solar absolute radiometer. *Proceedings of the International Astronomical Union, 14*(A30), 358-360. doi:10.1017/S1743921319004617

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