

Total Solar Irradiance as Measured with CLARA onboard NorSat-1 In Orbit Performance and Data Release (almost)

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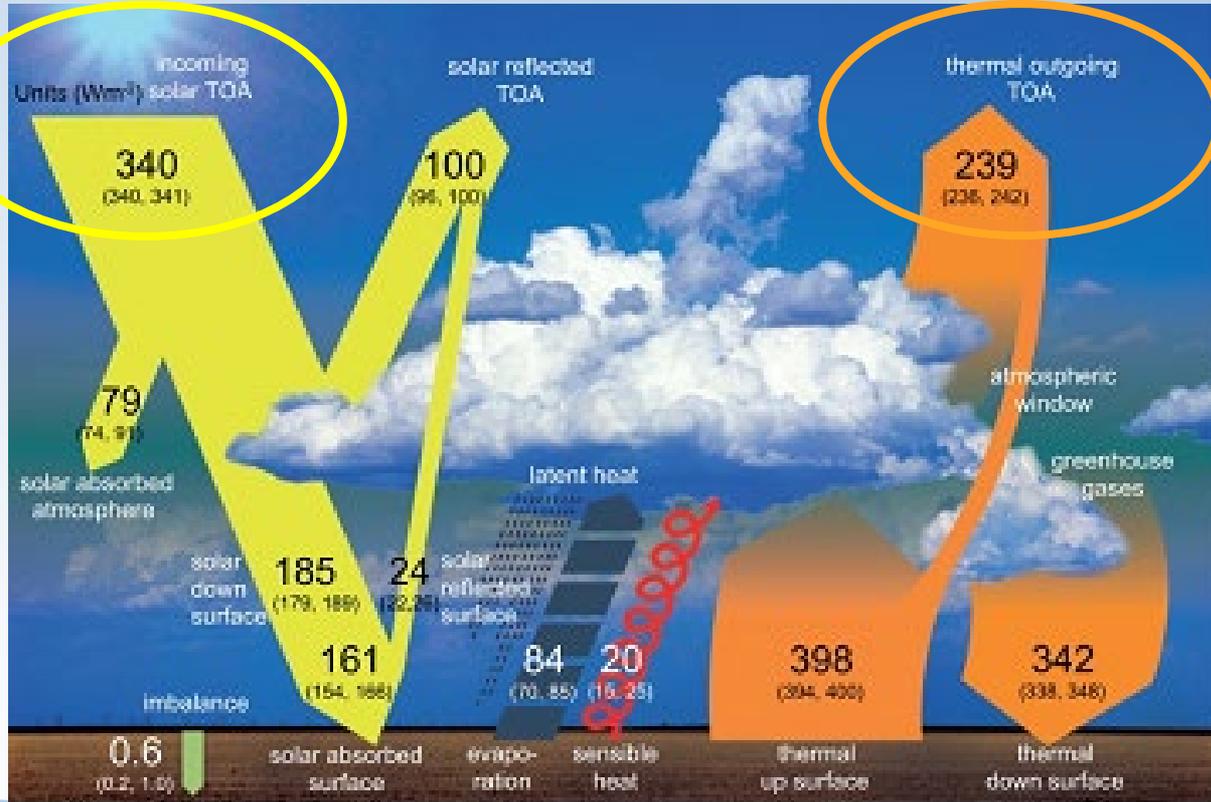
Wolfgang Finsterle, Jean-Philippe Montillet, Manfred Gyo, Dany Pfiffner, Silvio Koller, Werner Schmutz
(PMOD/WRC, CH)

Martin Mostad (Statsat, NO), Alex Baetie (UTIAS, CA) Bo Andersen (Uni Oslo, NO)
Greg Kopp (LASP, USA)

Sun Climate Symposium
Flagstaff, 18-21, October, 2023

Earth Radiation Budget

Total Solar Irradiance (TSI)



Outgoing Longwave Radiation (OLR)

(from IPCC 2013; adapted from Wild et al., 2013).

NorSat-1 key facts



Norwegian low-cost satellite

Payloads

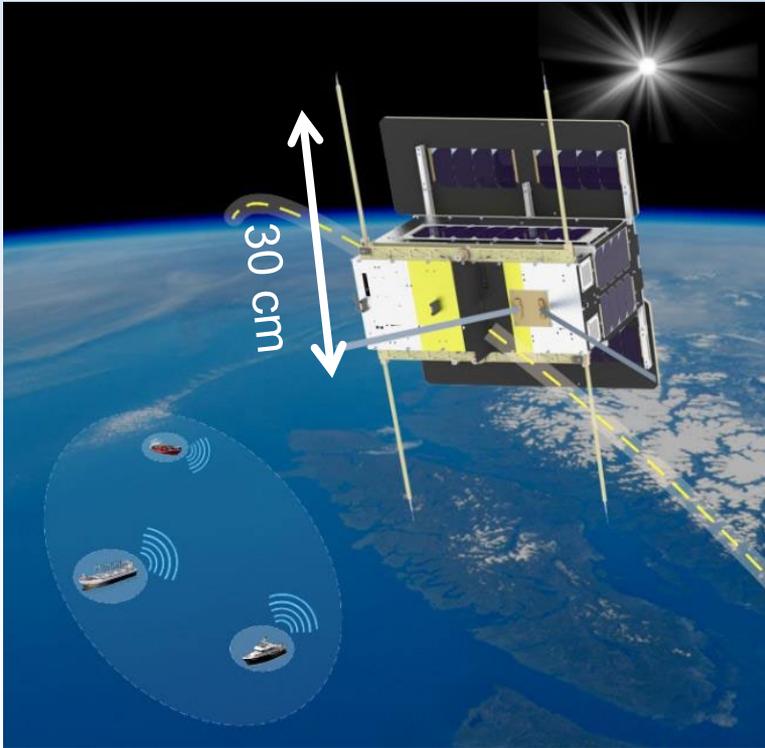
- Automatic Identification System (AIS) ship tracker
- Langmuir probes
- CLARA TSI radiometer

Launch

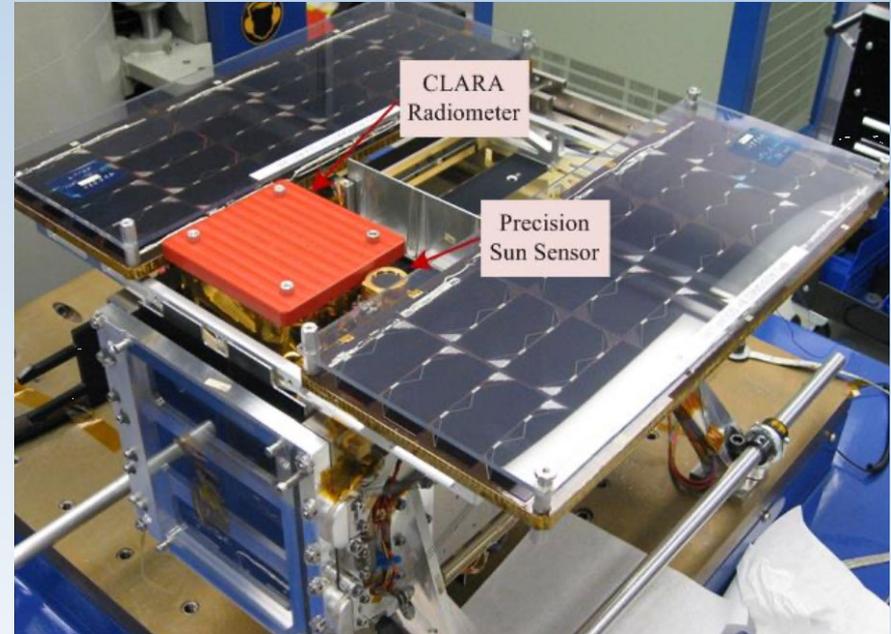
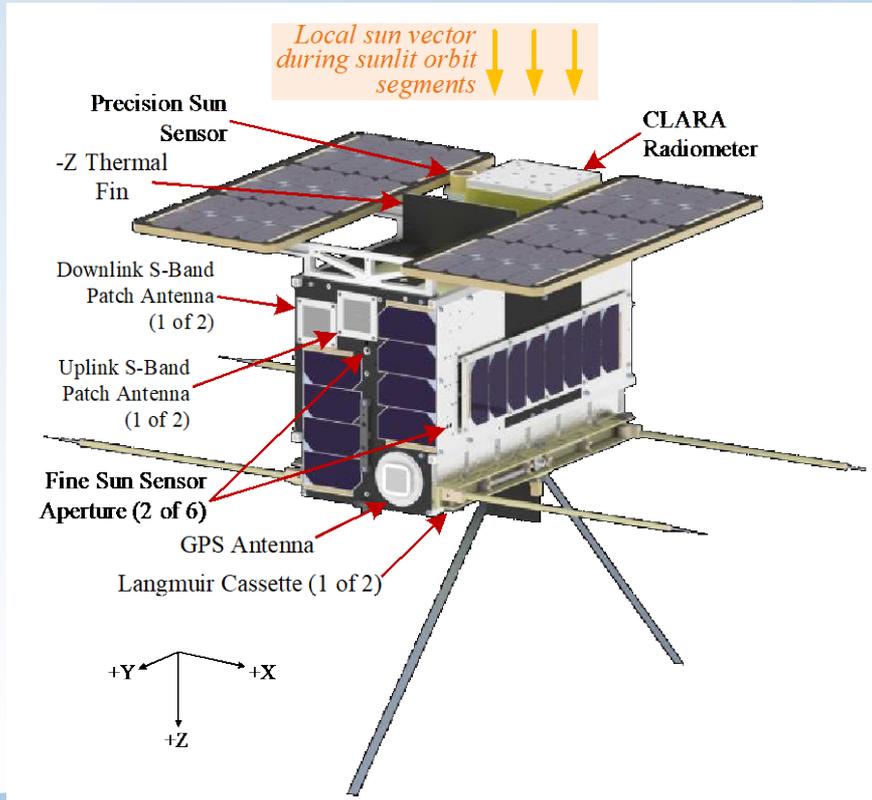
14 July, 2017

Orbit

Polar Low Earth Orbit
midnight-noon, drifting
height 600 km



NorSat-1 Platform



NorSat-1 at SFL vibration test facility

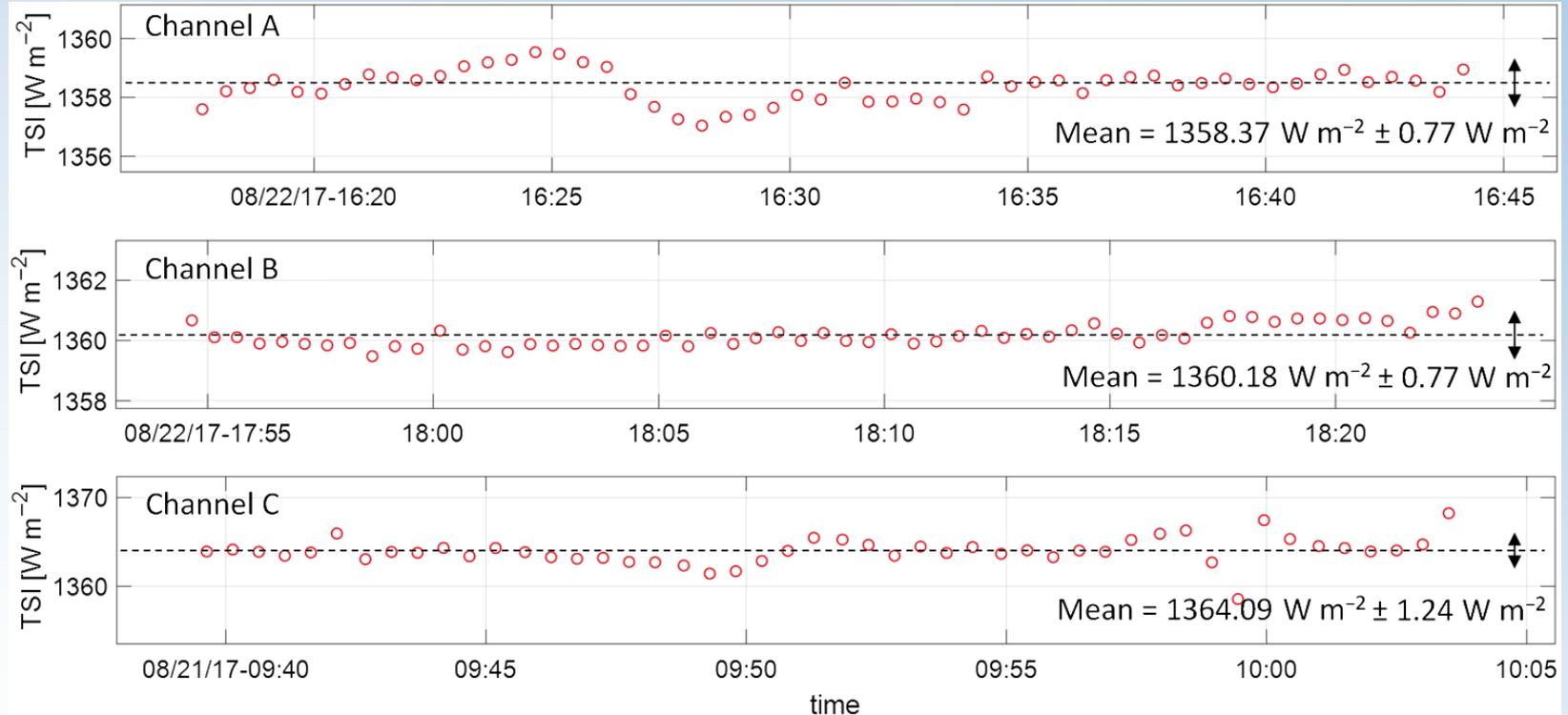
Schematic view of the payload

CLARA brief operation history

July 14, 2017	NorSat-1 Launch
Aug 21, 2017	First Light
April 2018	Issues with reaction wheel started
May 13, 2018	Solar measurements were stopped
Nov 8, 2019	“2 nd First Light” (TSI and OLR)
Aug 19, 2021	Firmware issue with 2 nd reaction wheel
June 14, 2022	Restart of CLARA TSI and OLR measurements
Nov 2018	Issues with reaction wheel started

- NorSat-1 now operates only with two reaction wheels
- Limited fine pointing stability

First Light measurements



Average for same time period for SOHO/VIRGO: 1360.15 W m^{-2}

Level 0:
Uncalibrated U and I for heater power

← *electrical calibration*

Level 1:
Calibrated U and I for power measurements

← *component level characterization
and end to end TRF calibration*

Level 2a:
SI-traceable irradiance in W/m^2

← *backup measurements
and solar pointing filter*

Level 2b:
degradation corrected SI-traceable irradiance in W/m^2

CLARA Data pipeline

Revisit of TRF calibration of Walter et al. (2017) with updated electrical calibration

1. Channel A (first measurement)

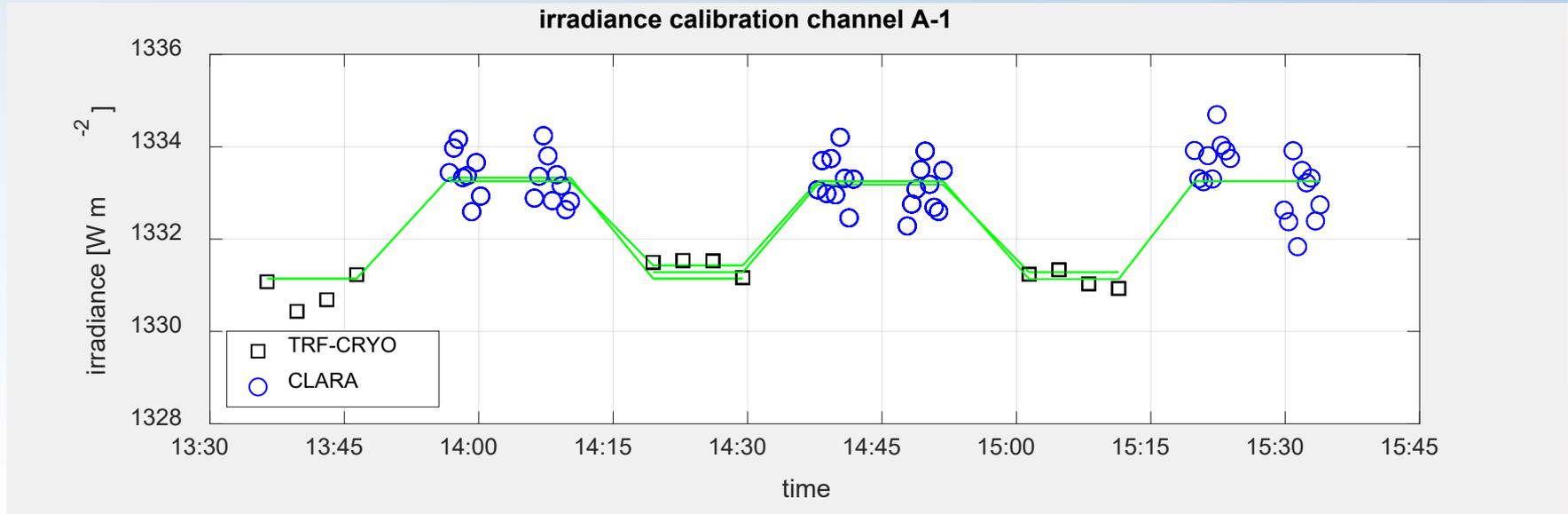
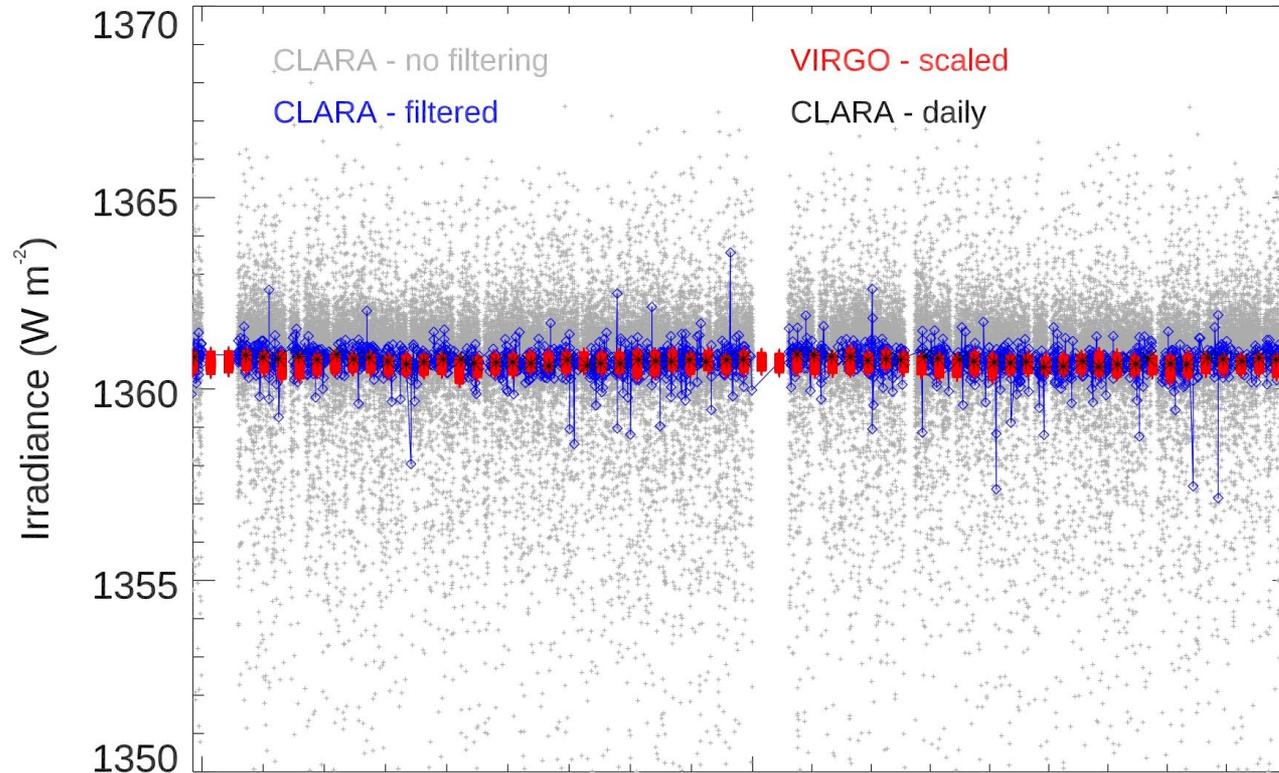


Illustration of Pointing filter and Quality check

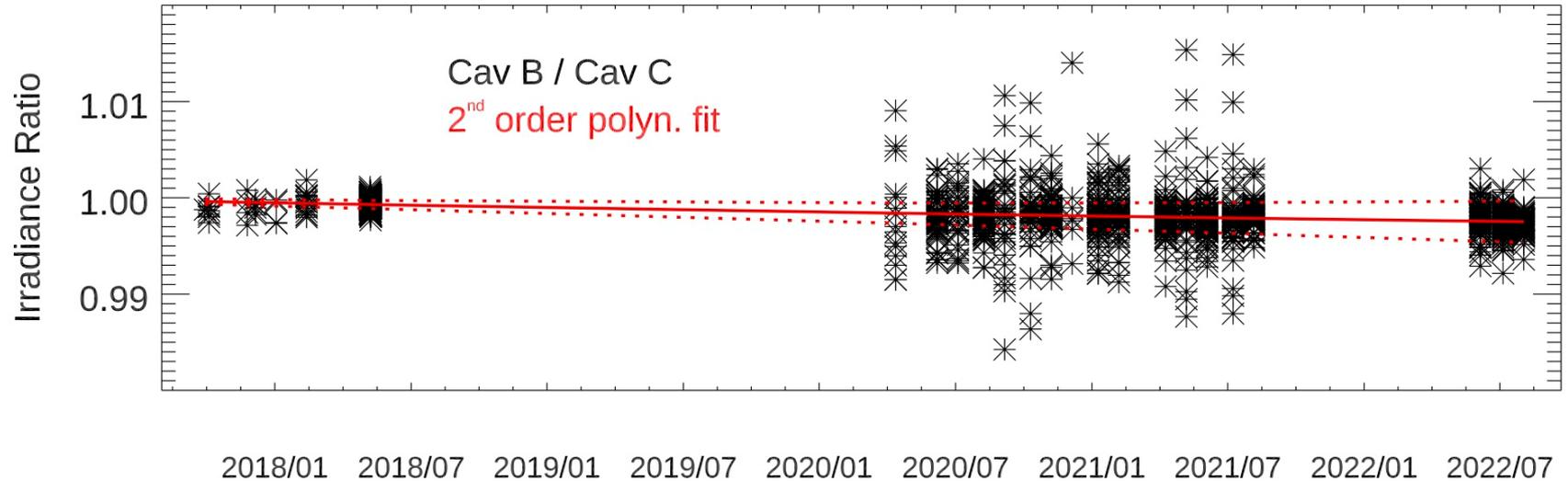


2020/05

2020/06

2020/07

Monitoring CLARA Degradation

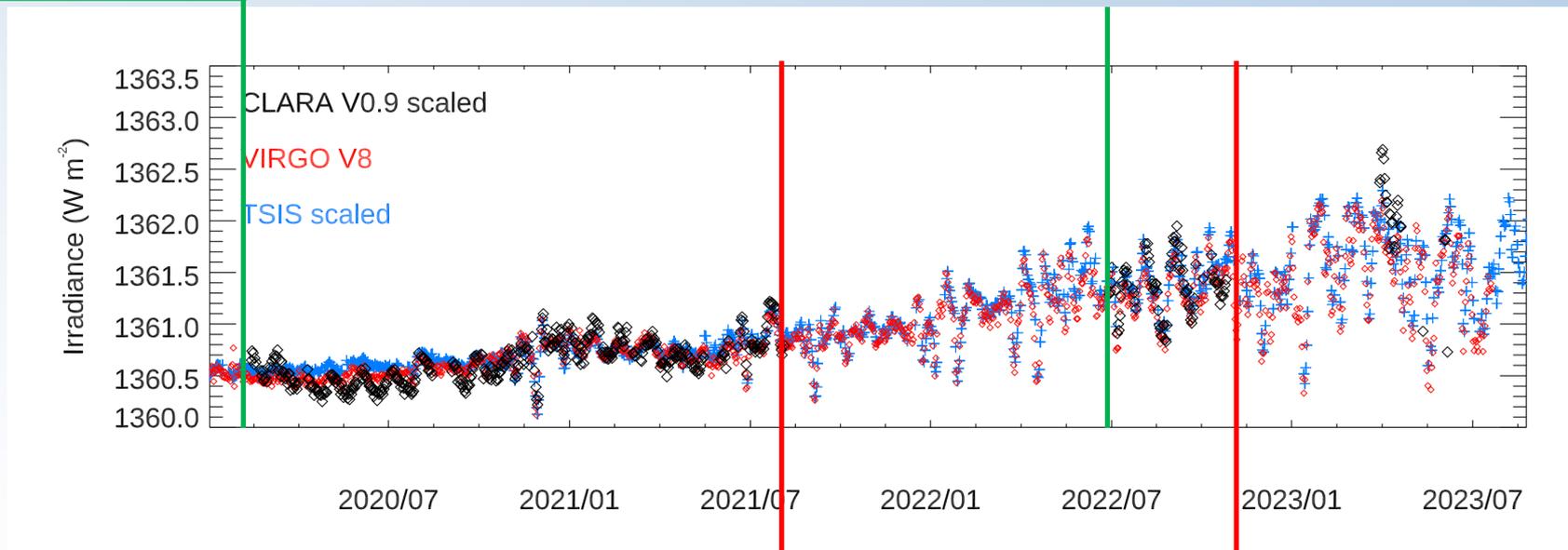


- Variation of irradiance ratio of Cav B/Cav C
- Polynomial fit shows smooth degradation of nominal cavity (Cav B)
- Increased scatter starting Mar 2020 due to lower NorSat-1 pointing performance

CLARA observes solar variability

Restart of solar measurements
Jan 2020

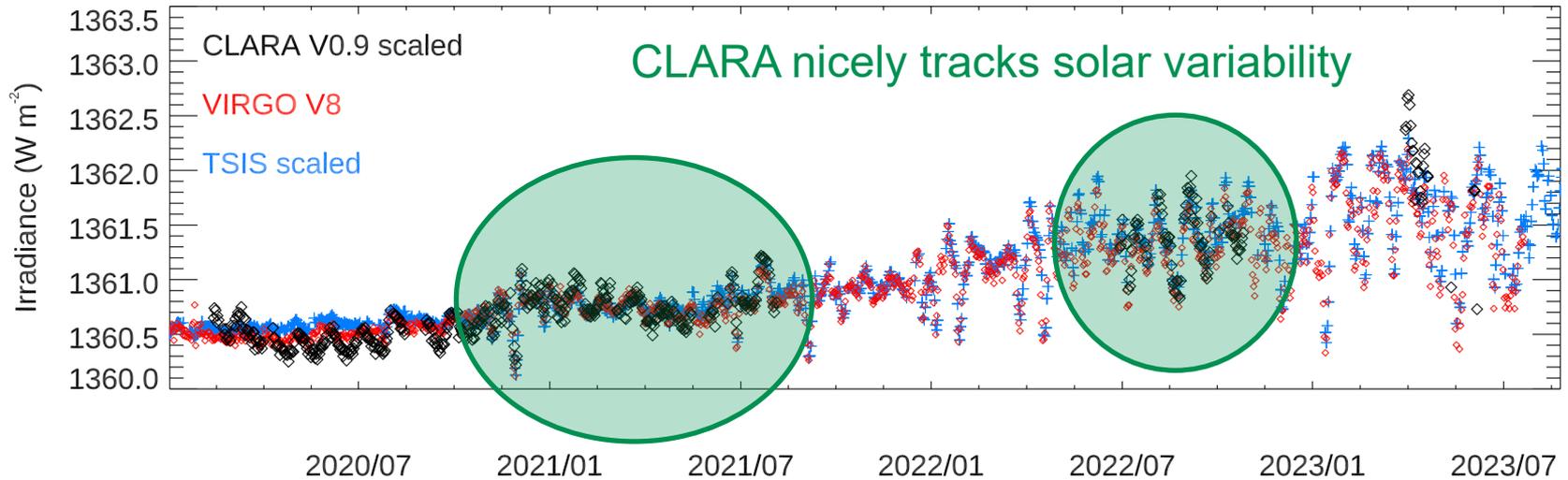
Jun 14, 2022:
Restart of solar measurements



Aug 19, 2021:
Interruption of
2nd satellite
reaction wheel

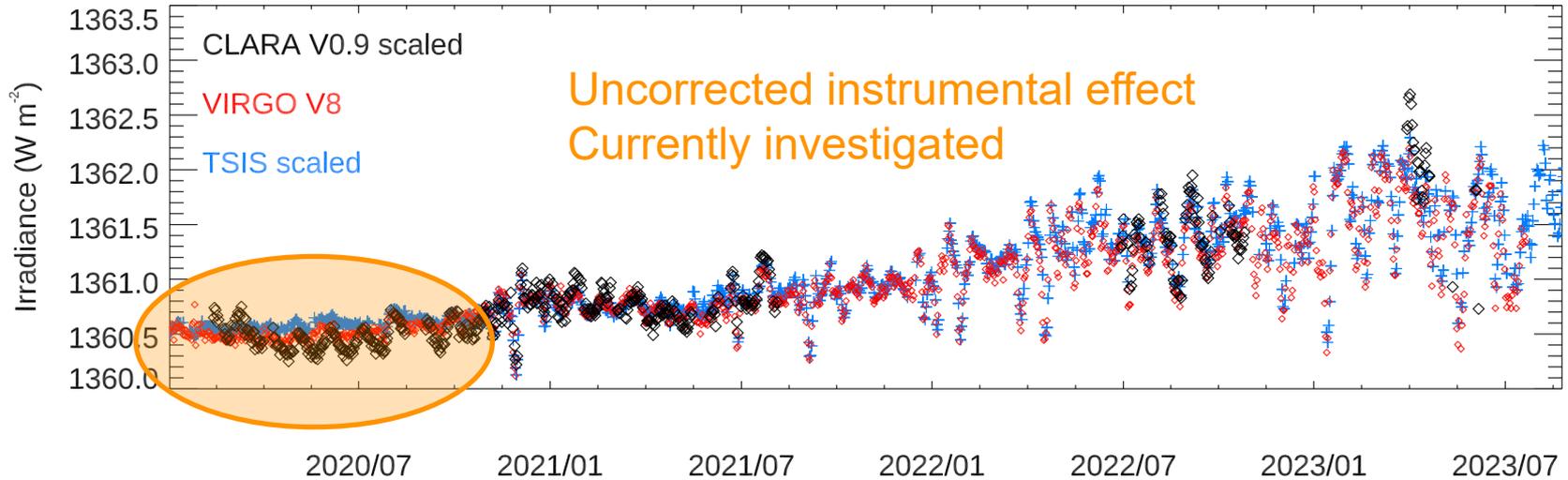
November, 2022:
Recurring issues on
NorSat-1 platform

CLARA vs VIRGO and TSIS



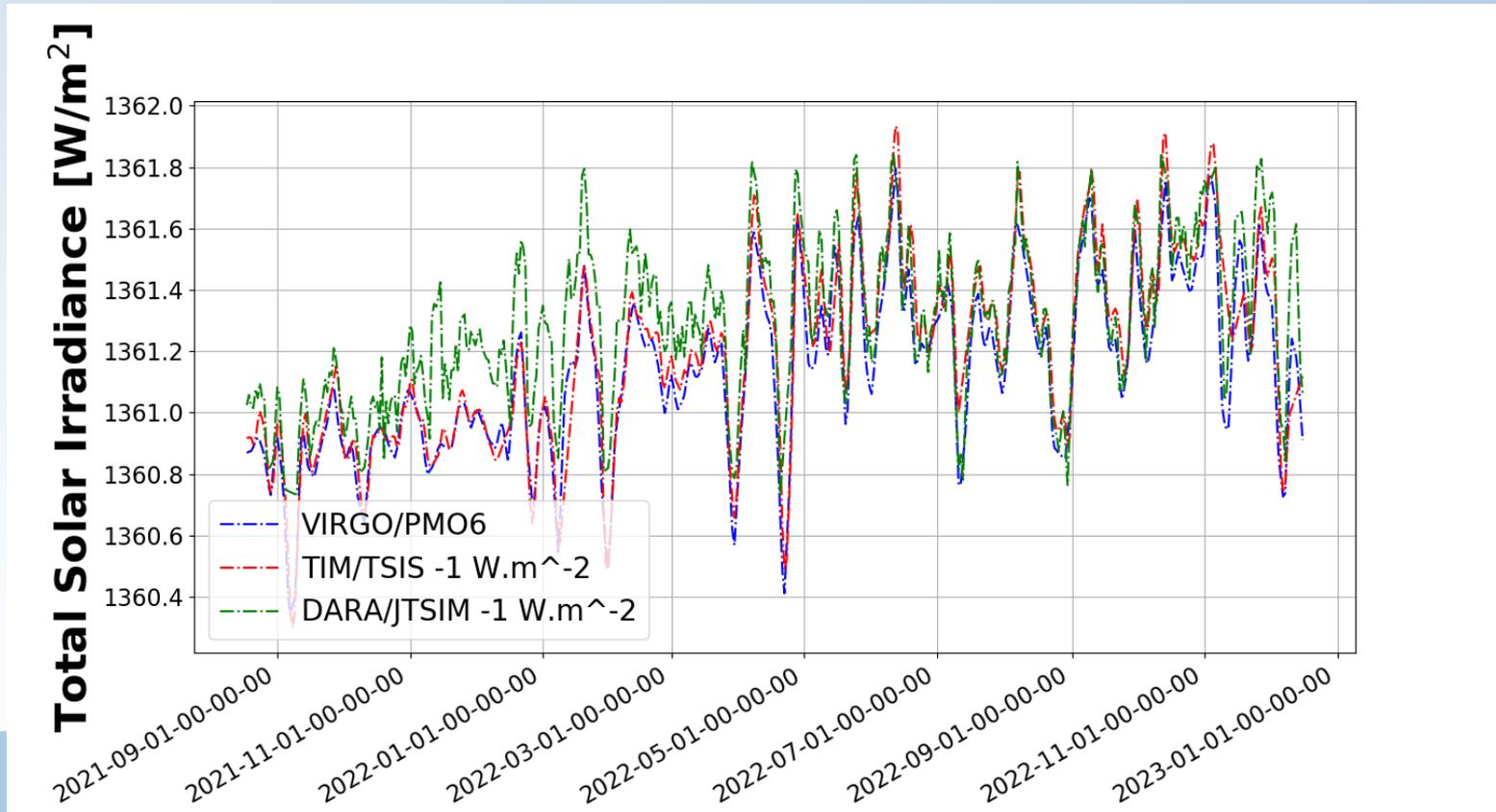
Haberreiter et al. in preparation

CLARA vs VIRGO and TSIS



Haberreiter et al., in preparation

DARA/JTSIM



DARA-JTSIM v1.0 Soon available on the PMODWRC ftp server

- Daily and 6-hourly data
- Degradation correction based on ML algorithm by Finsterle et al. (2021) applied successfully to the SOHO/VIRGO data: <https://doi.org/10.1038/s41598-021-87108-y>
- First light study in Xe et al., 2023, EGU23, [10.5194/egusphere-egu23-1716](https://doi.org/10.5194/egusphere-egu23-1716); Zhu et al., 2023, ESS, under review
- Daily product to be included in TSI composite time series (Montillet et al., 2024 – in preparation)
- Please, look at the PMOD/WRC webpage to get the data soon:

<https://www.pmodwrc.ch/en/research-development/space/fy-3e/#1605855293631-69abe877-b9c1>

FY-3E

Space > FY-3E



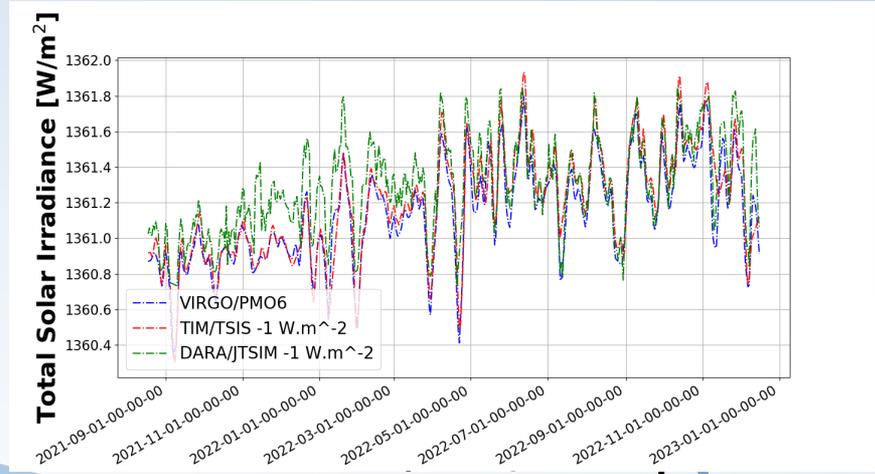
News & Links FY-3E Mission PMOD/WRC Instrument: JTSIM-DARA Mission Facts

FY-3E Mission

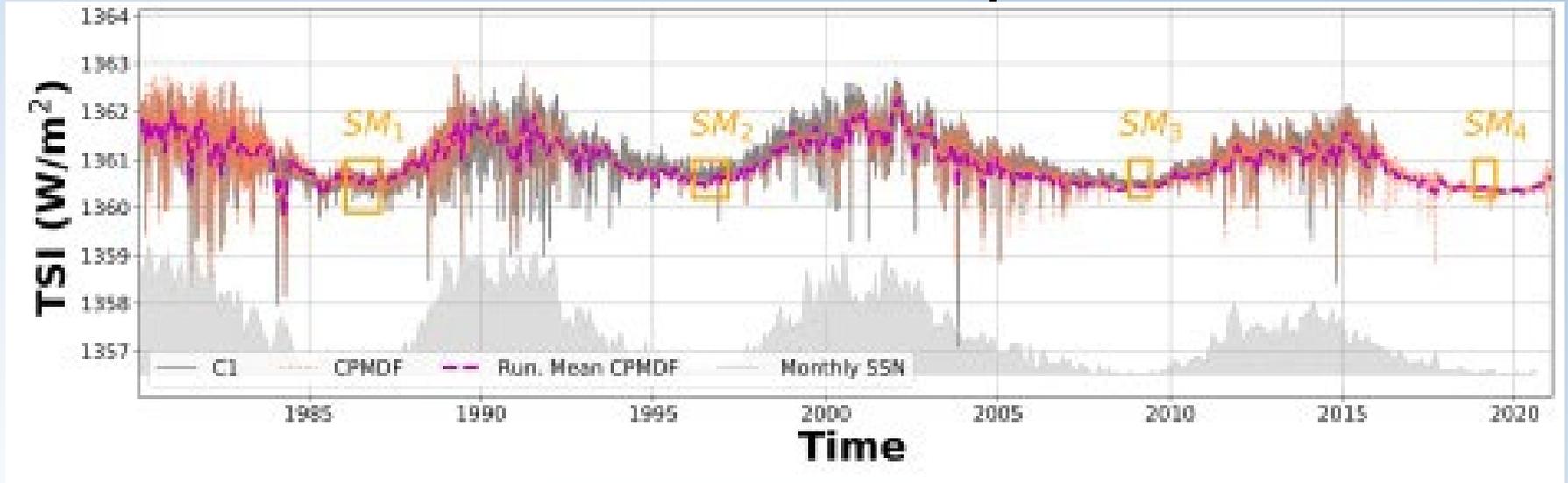
Various space instruments have measured TSI since 1978. One of the latest is the Joint Total Solar Irradiance Monitor (JTSIM) on the Fengyun-3E (FY-3E) satellite. FY-3E is the 5th flight unit of the FY-3 series. Its main mission is operational meteorology. It will provide a substantial contribution to ocean and ice monitoring, climate monitoring, atmospheric chemistry and space weather. JTSIM has two absolute radiometers on board: the Digital Absolute Radiometer (DARA) developed by PMOD/WRC, and the Solar Irradiance Absolute Radiometer (SIAR), developed by the Changchun Institute of Optics, Fine Mechanics and Physics / Chinese Academy of Sciences (CIOMP/CAS), China. FY-3E was launched on 4 July 2021 at 23:28 UTC according to CASC (China Aerospace Science and Technology Corp.) on a Long March 4C vehicle from the Jiuquan Space Launch Center in China. The orbit is sun-synchronous and near-circular (inclination of 98.7°) with an altitude slightly higher than 800 km. The nominal lifetime of the satellite is eight years. The JTSIM experiment is part of the solar activities monitoring package.



The launch of FY-3E on 4 July 2021. Image credits: ECH2O



PMOD TSI Composite



New composite (CPMDF) based on merging 41 years of TSI measurements.

30-day running mean of Composite

Community Composite C1 (Dudok de Wit et al., 2017)

Boxes: Solar minima (SM) for each solar cycle, no significant difference between minima

Monthly sunspot number is also displayed.

Montillet et al., 2022, JGR

Continuation of the PMOD-composite based on updated ML techniques

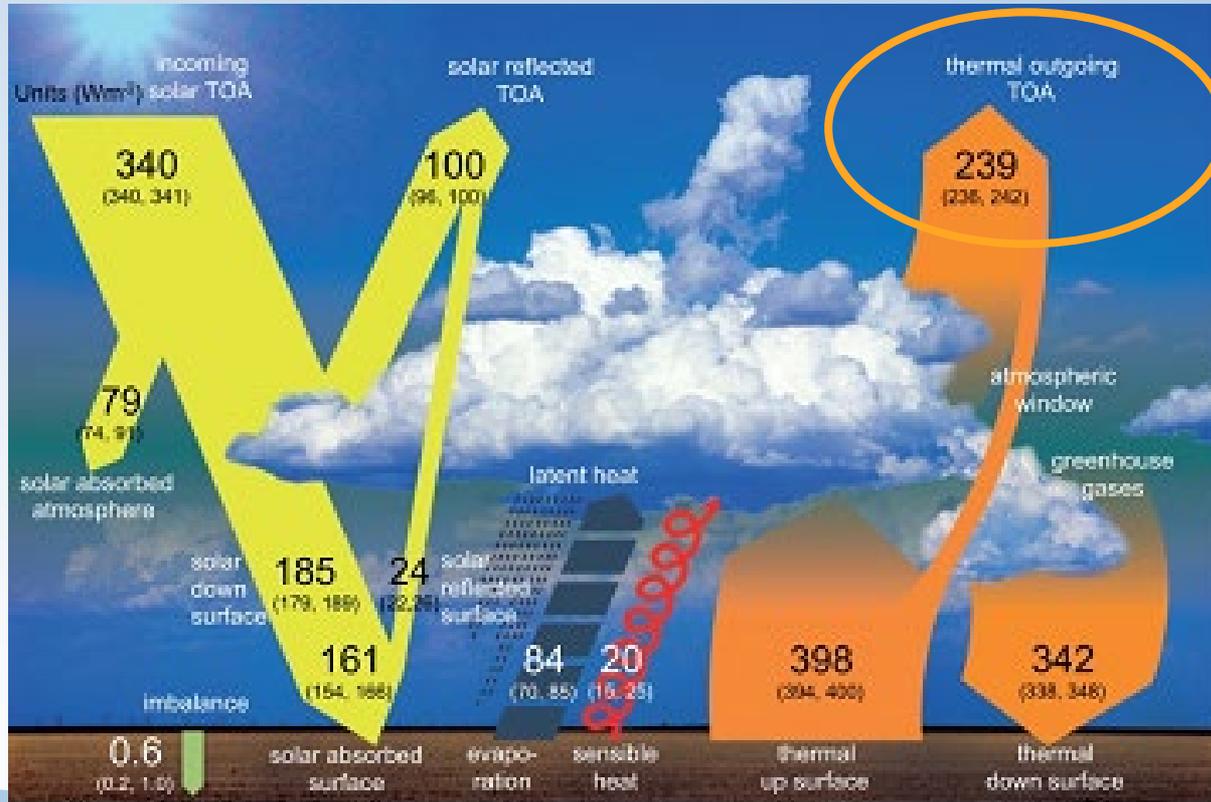
ISSI International Team

Towards Determining the Earth Energy Imbalance from Space



- Julien Amand, Stijn Nevens (RMI)
- Peter Pilewskie, Dave Harber (LASP)
- Bill Swartz (JPL)
- Ping Zhu (Shenzhen University, CN)
- Margit Haberreiter, Wolfgang Fintnersle (PMOD/WRC, CH)
- Martin Wild (ETHZ, CH)
- Nigel Fox (NPL, UK)

Earth Radiation Budget



Outgoing Longwave Radiation (OLR)

(from IPCC 2013; adapted from Wild et al., 2013).

WFOV and NFOV Radiometers

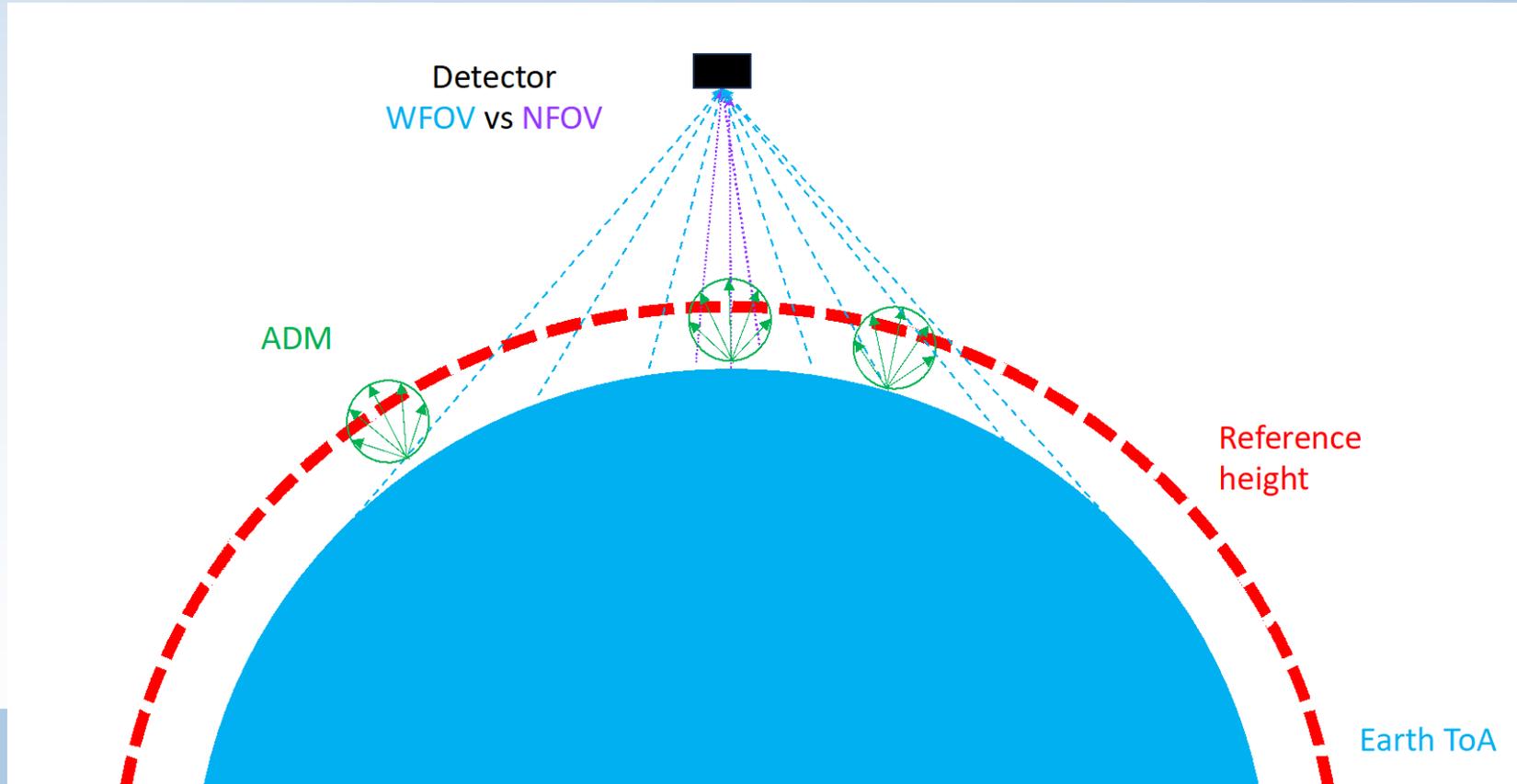
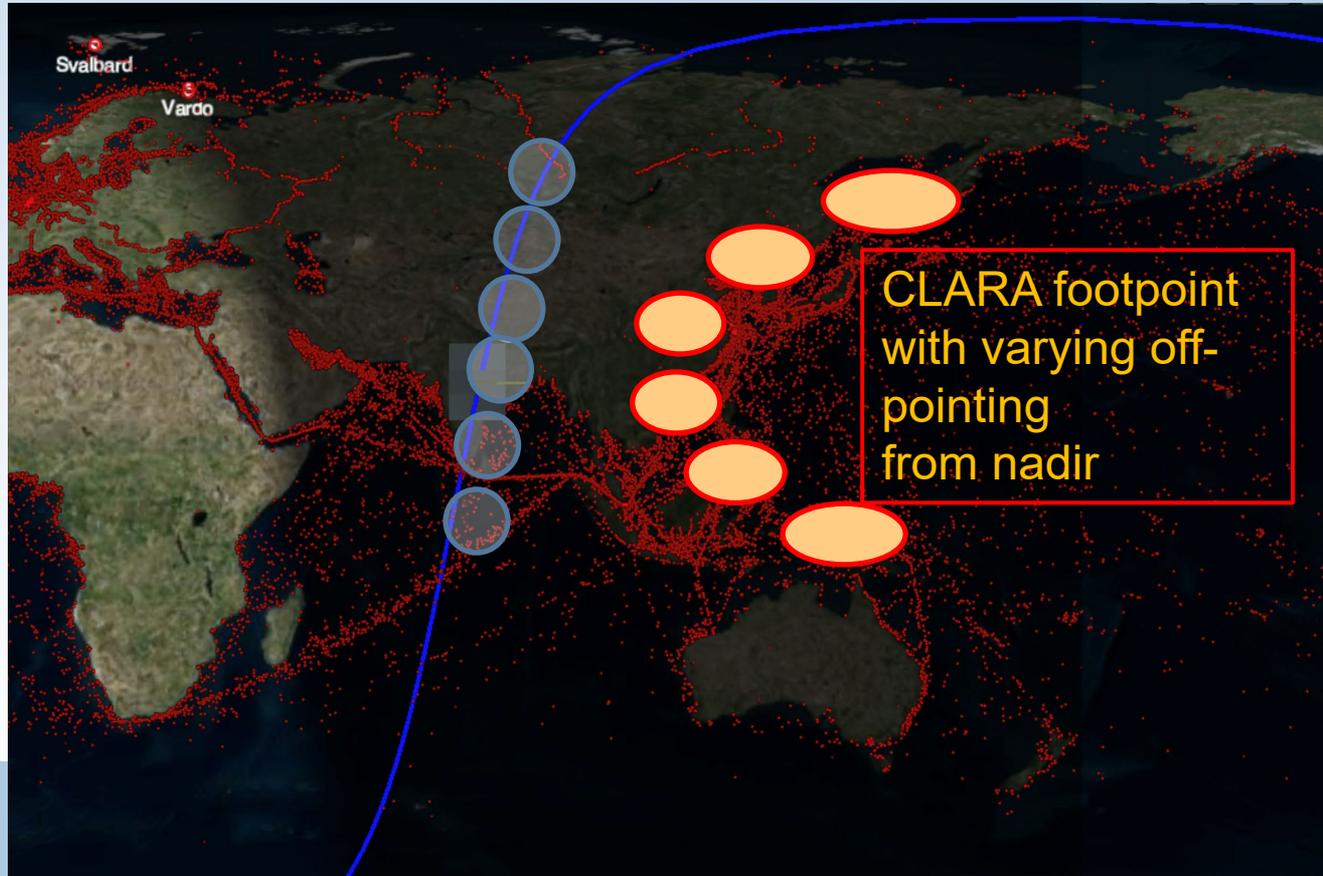
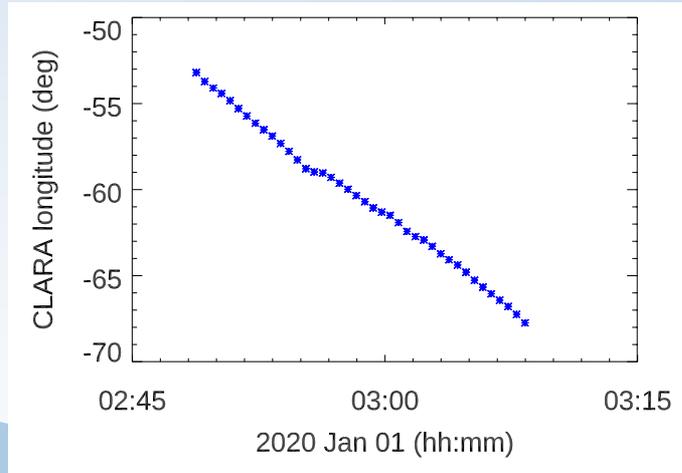
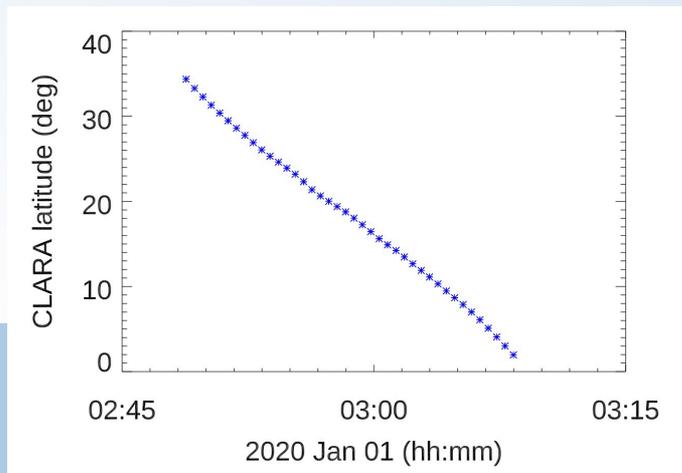
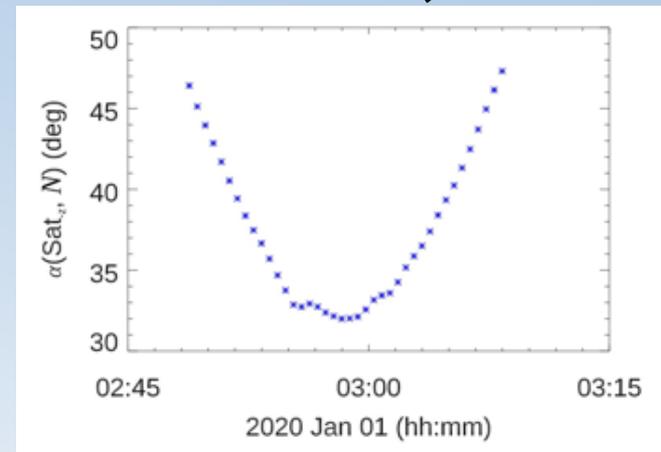
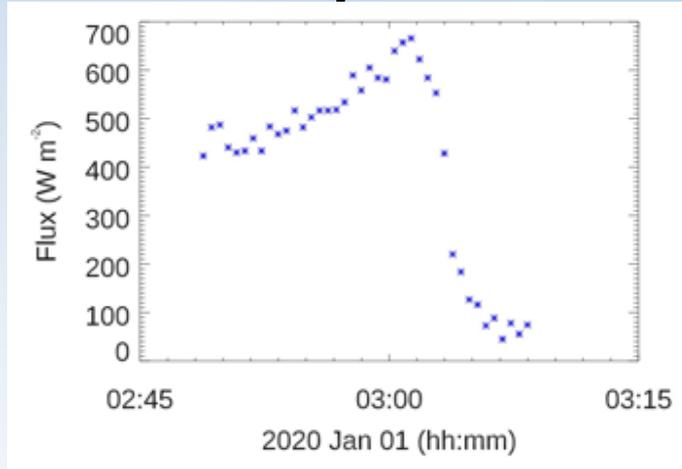


Illustration of CLARA Earth pointing

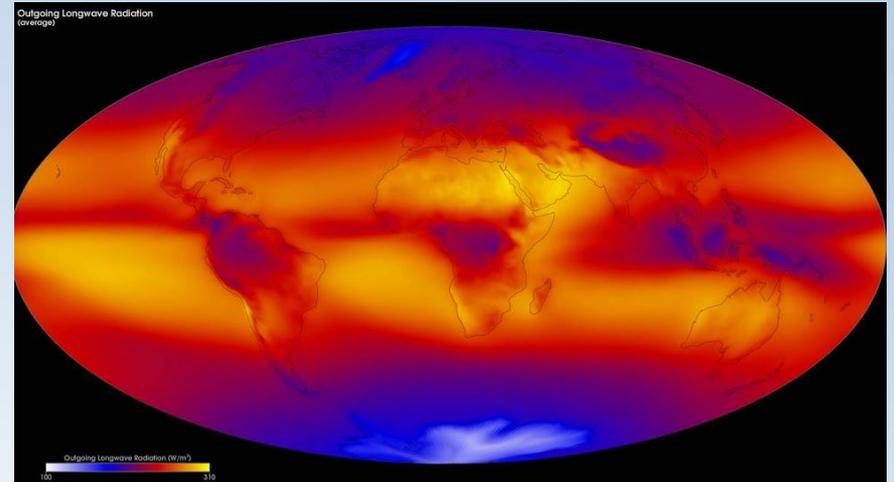
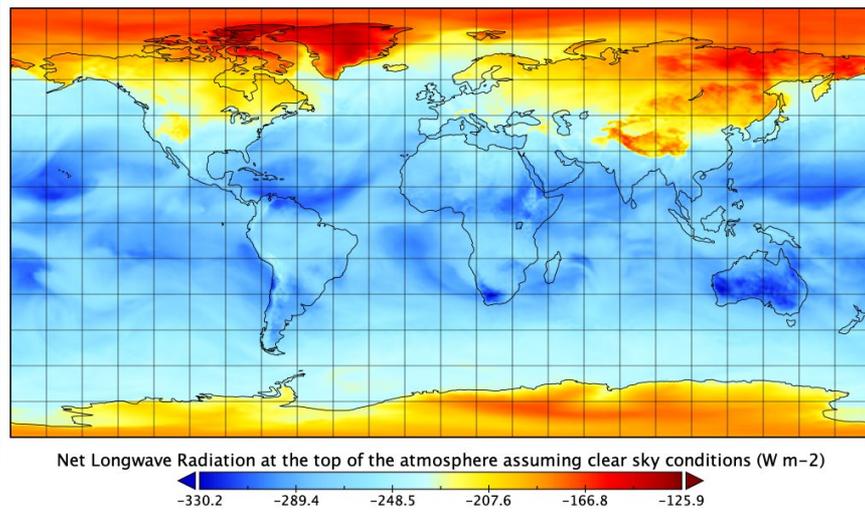


Not to scale

Example of OLR for Jan 1, 2020



Comparison with ERA5 and CERES data



Summary

- Despite issues with the NorSat-1 platform
 - CLARA is healthy and takes
 - TSI measurements track solar activity (if solar pointing is active)
 - OLR data analysis ongoing
- CLARA TSI data available towards the end of the year
- Statsat in Norway works on platform issue
- JTSIM/DARA data will be released towards the end of the year
- PMOD Composite (Montillet et al., 2022) will be routinely updated and replaces the composite by Claus Frölich