

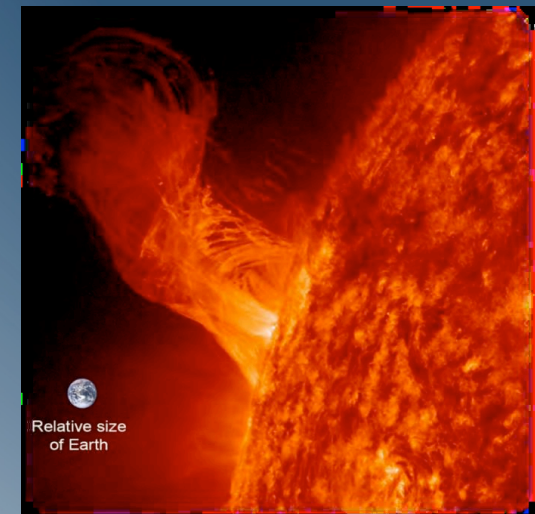
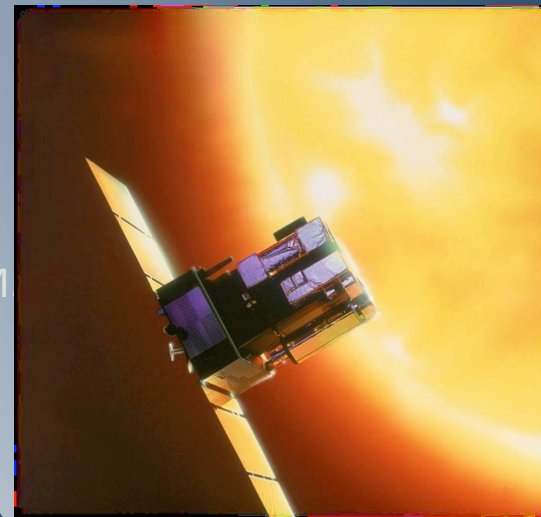
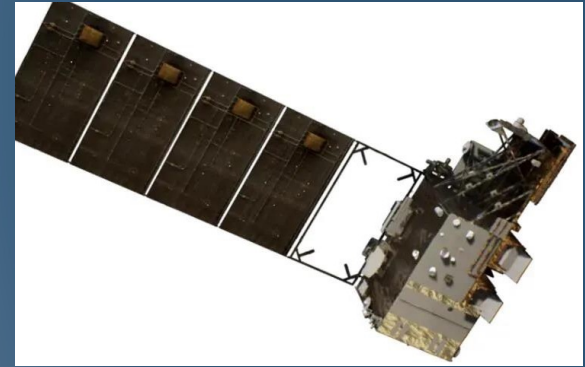
Discussion on the recent total solar irradiance products released by PMOD/WRC

Montillet, J.-P.¹, Finsterle, W.¹, Nyeki, S.¹, Haberreiter, M.¹, Schmutz, W.¹, Pfiffner, D.¹, Koller, S.¹, Gyo, M.¹

¹ *PMOD-WRC, Davos Dorf, Switzerland*

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SCOSTEP meeting, FHNW, Windisch Switzerland, 15-16
May 2023



Outline

A few words on Radiometers and TSI Current Pmo6-v8 (new!)

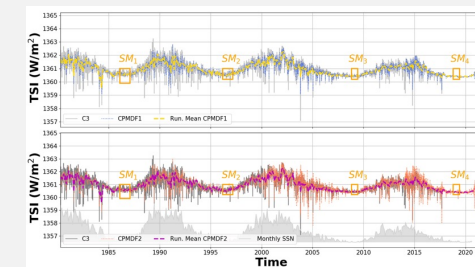
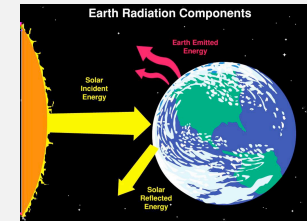
- Degradation-Corrected Data
- Available formats & where to find the datasets?

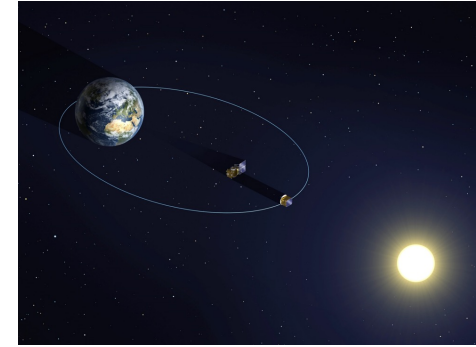
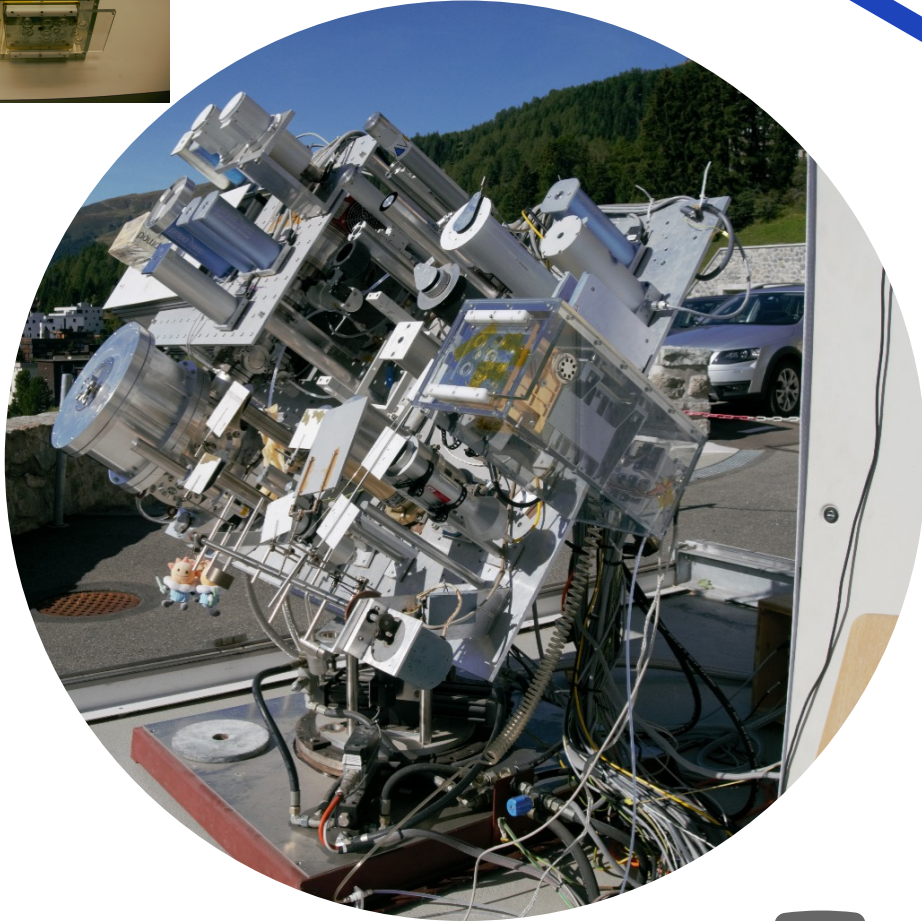
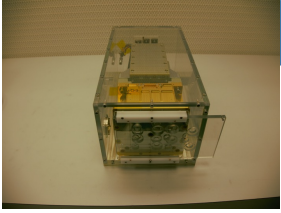
Composite TSI Time Series (New!)

- State-of-the-art of our new composite
- Data Repository

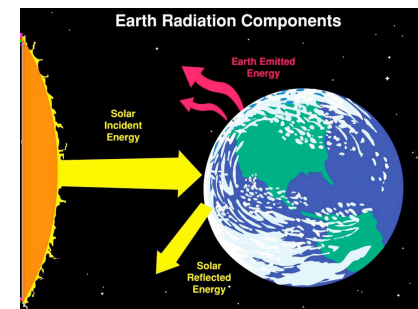
Future DARA-JTSIM – v1

- State-of-the-art
- Availability



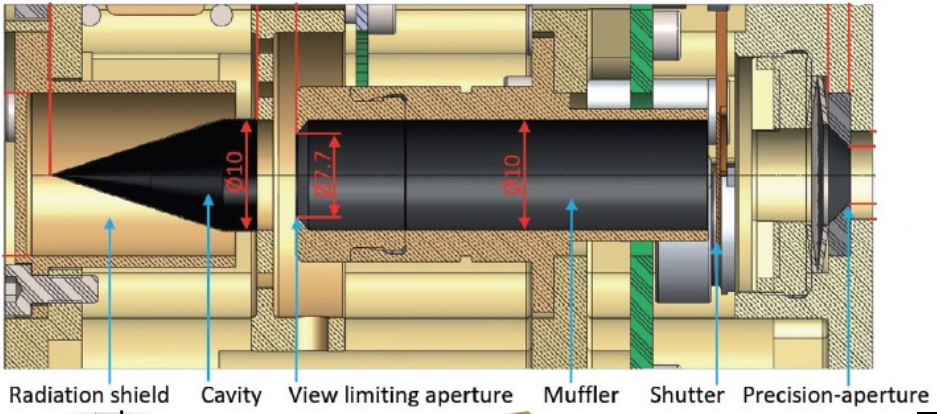


A few words on Radiometers & TSI

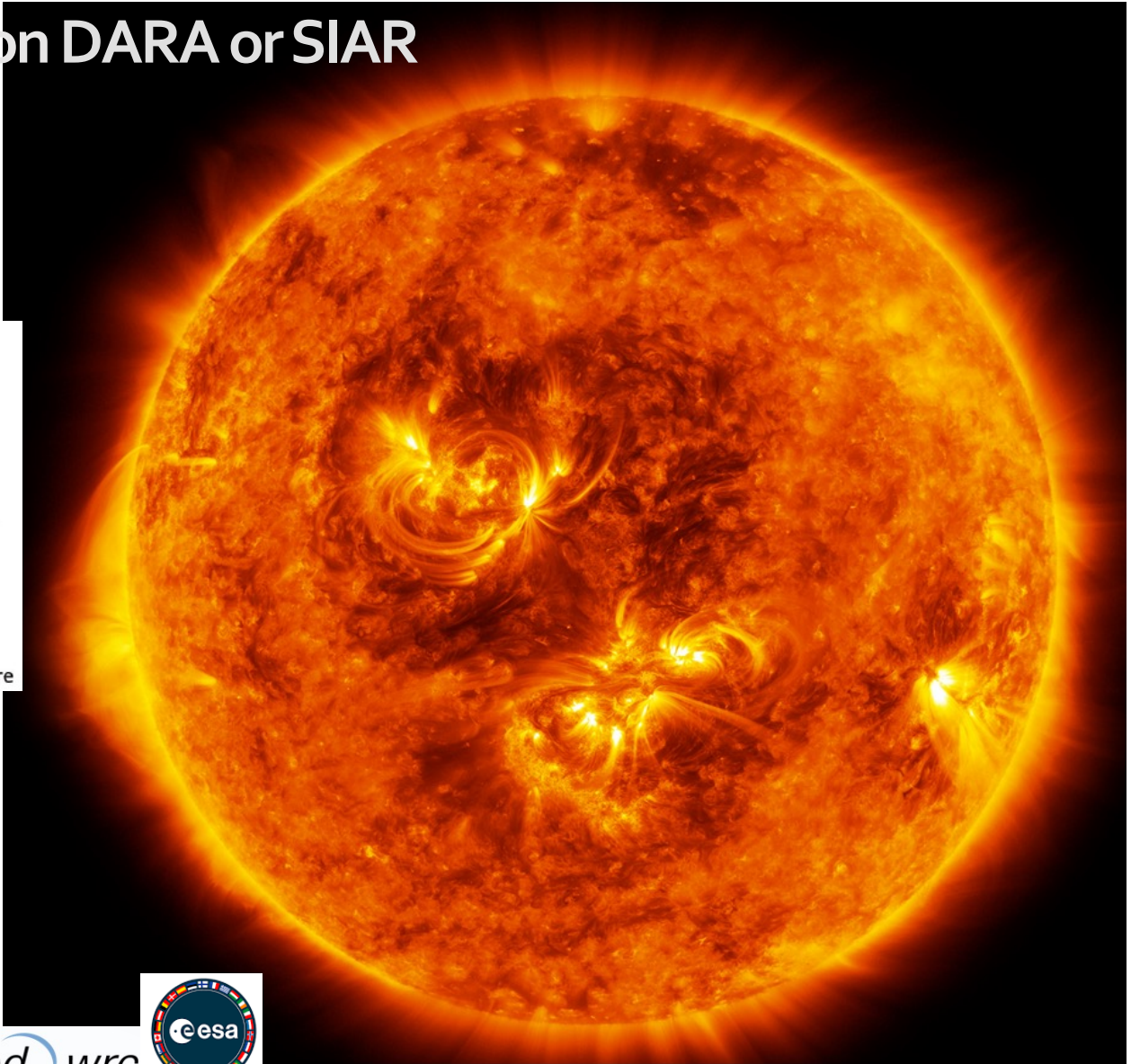
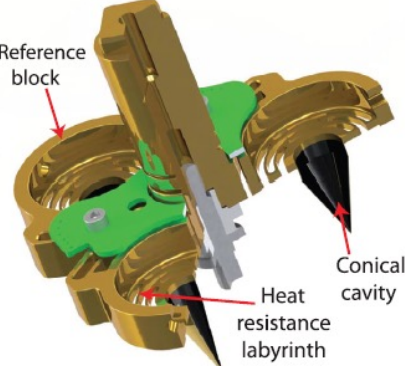


Total Solar Irradiance - Estimation DARA or SIAR

The raw observations are the electrical heater power values recorded by the radiometer. The estimated irradiance is the optical heating (difference between closed and open electrical heating) divided by the Aperture Area for each cavity and corrected by different factors intrinsic to the instrument and the influence of the space environment.



Thermal Link
REFERENCE BLOCK

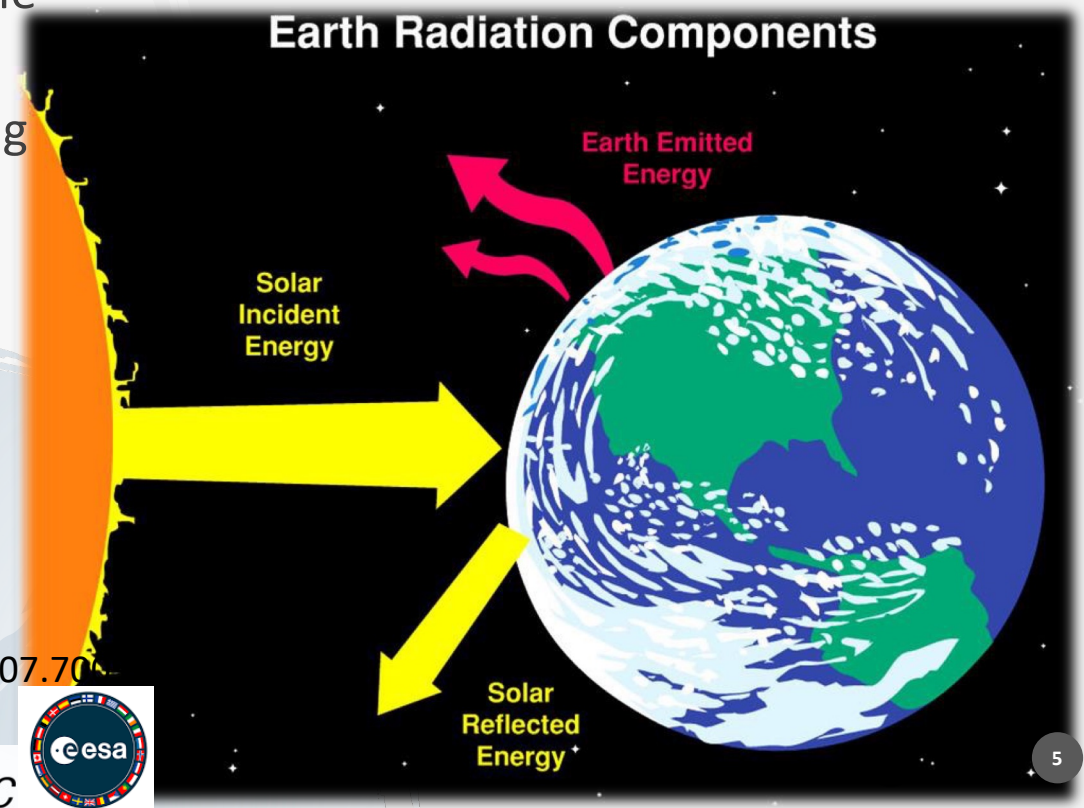


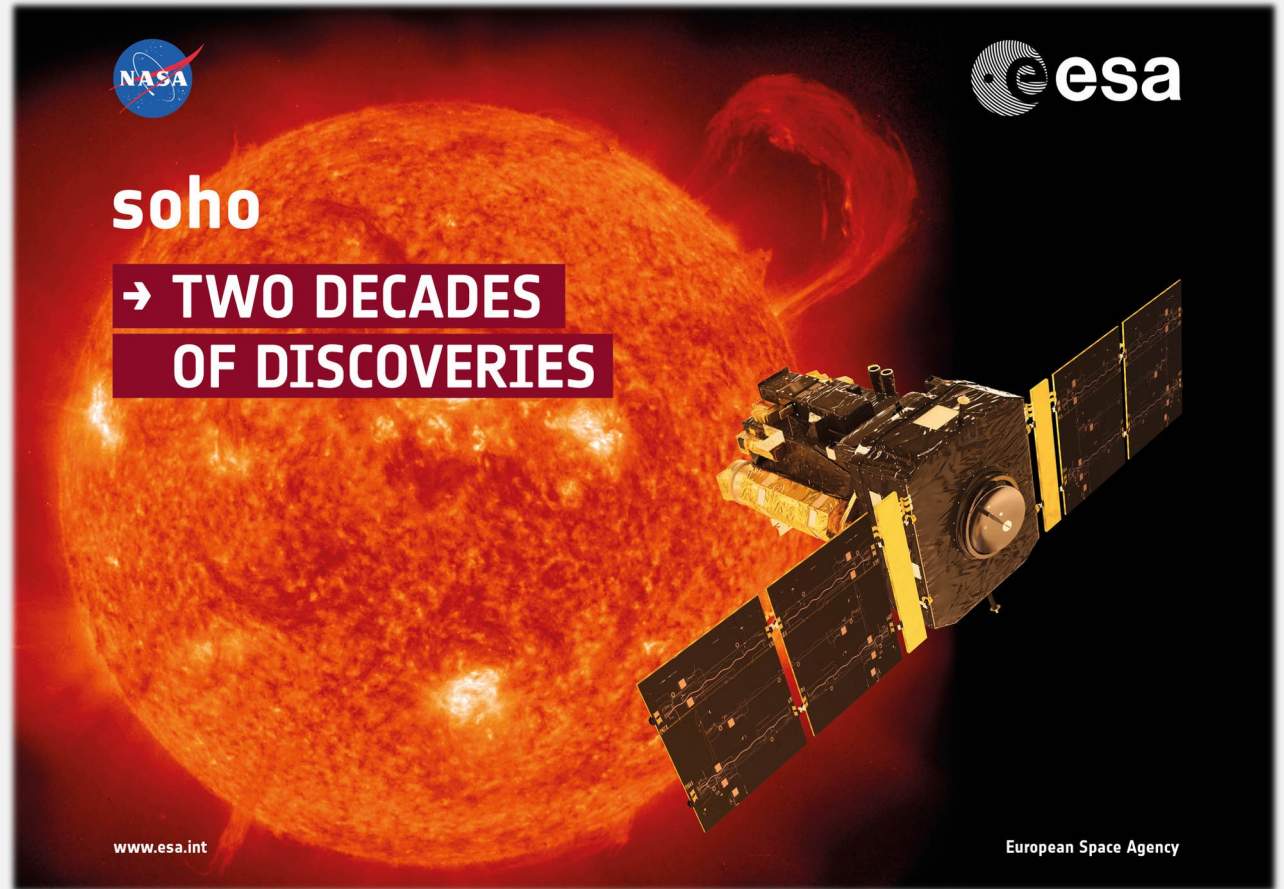
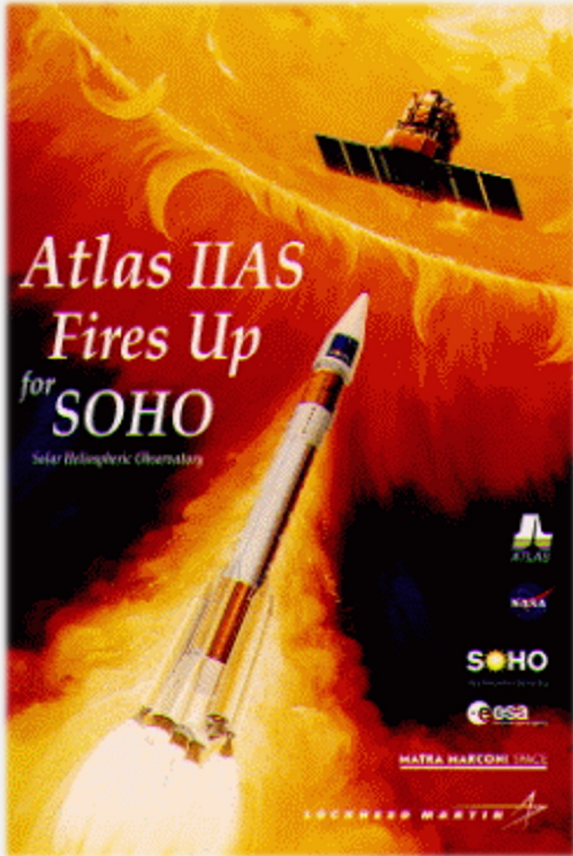
A few words on Radiometers and TSI

TSI Background...

- Since the late 70's TSI observations used to measure energy received by the sun – part of the Earth radiation budget
- TSI observations used to constrain solar forcing model within global climate simulations

Further reading: Preface to Monitoring the Earth Radiation Budget and its implication to Climate Simulations – <https://essopenarchive.org/doi/full/10.22541/essoar.168298707.70>





PMO6 on board of SOHO/VIRGO

Active: 1995 – Now : the longest TSI mission [+25 years]

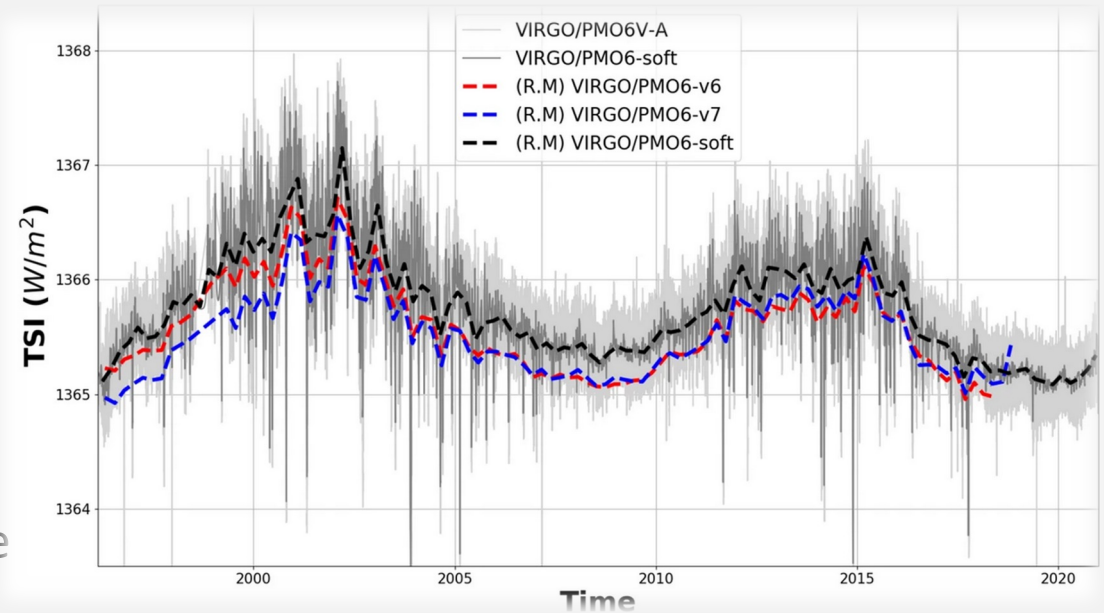


Current Pmo6-v8

What is inside Pmo6-v8?

The VIRGO/PMO6v data still being recorded after 10,000 M.days! (large dataset)

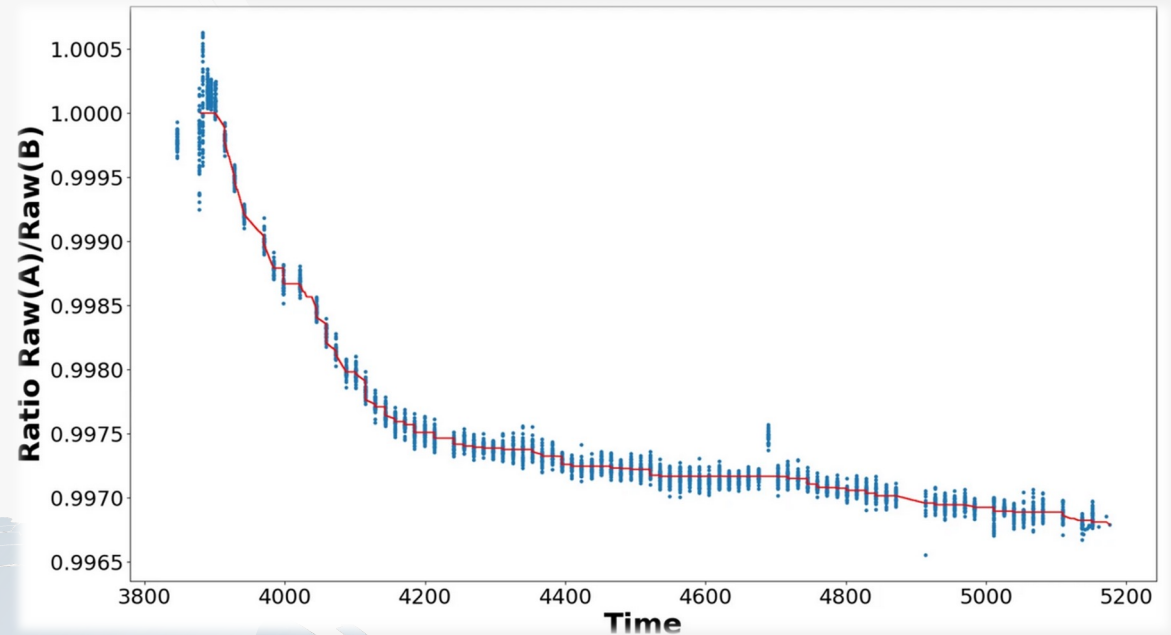
- Take into account «**Early Increase**» within the dataset
- Take into account «**Degradation**» due to UV/EUV exposure corrected with Machine Learning algorithm developed in Finsterle et al. 2021
- **Data Fusion (new TSI product)** using active and back-up channels to reduce instrumental noise



The degradation-corrected PMO6-VA (v8) time series (light grey), the fused PMO6-VA and -VB (PMO6-soft /Pmo6v8, dark grey) and the previous versions of the VIRGO/PMO6 degradation corrected TSI time series (PMO6-v6 (red), PMO6-v7 (blue)). The dashed lines are 81-day running means (R.M.).

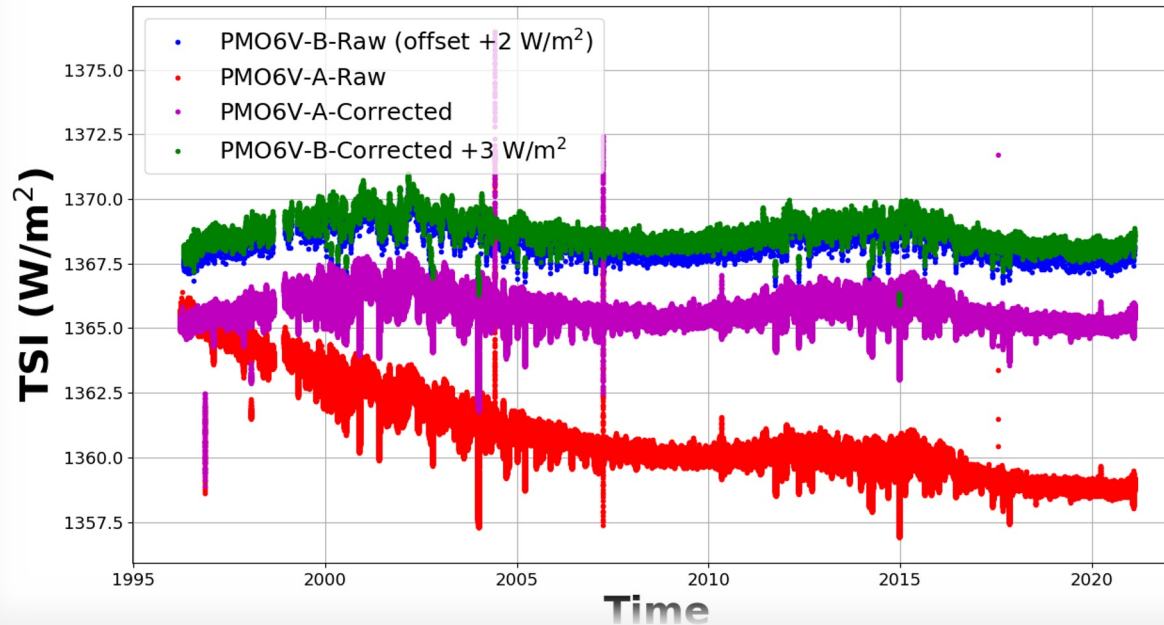
Current Pmo6-v8 -Correction of «Degradation» with ML

- “Early increase” – due to coating paint properties when first exposed to UV/EUV and solar radiation
- “Degradation” – instrument’s cavity properties (reflection) degrades with long exposure time to EUV/UV
- Need correction to provide reliable and accurate TSI measurements



Ratio of the raw measurements PMO6-PA and PMO6-PB as a function of time (days since 1 January 2000). Red curve is degradation correction function.

Current Pmo6-v8 -Correction of «Degradation» with ML



Further Reading: Finsterle, W., Montillet, J., Schmutz, W., Sikonja, R., Kolar, L., & Treven, L. (2021). The total solar irradiance during the recent solar minimum period measured by SOHO/VIRGO. Nature Scientific Reports, Doi: 10.1038/s41598-021-87108-y

Montillet, J.-P., Finsterle, W., Schmutz, W. (2020) A New Methodology to Process the Total Solar Irradiance observations Using ML and Data Fusion, AGU, doi: 10.1002/essoar.10504836.1

Current Pmo6-v8 --- Availability ---

- The **data pipeline** for the VIRGO data on the SOHO archive is currently being updated at:

<https://soho.nascom.nasa.gov/data/archive/Information>

- About the mission and new products are also available on the PMOD/WRC website:

<https://www.pmodwrc.ch/en/research/development/space/soho/#SOHO-VIRGO>

- And ftp:

<ftp://ftp.pmodwrc.ch/pub/data/irradiance/virgo/TSI/>

- **Previous versions (v6, v7) also available on the ftp at**

<ftp://ftp.pmodwrc.ch/pub/data/irradiance/virgo/TSI/old/>

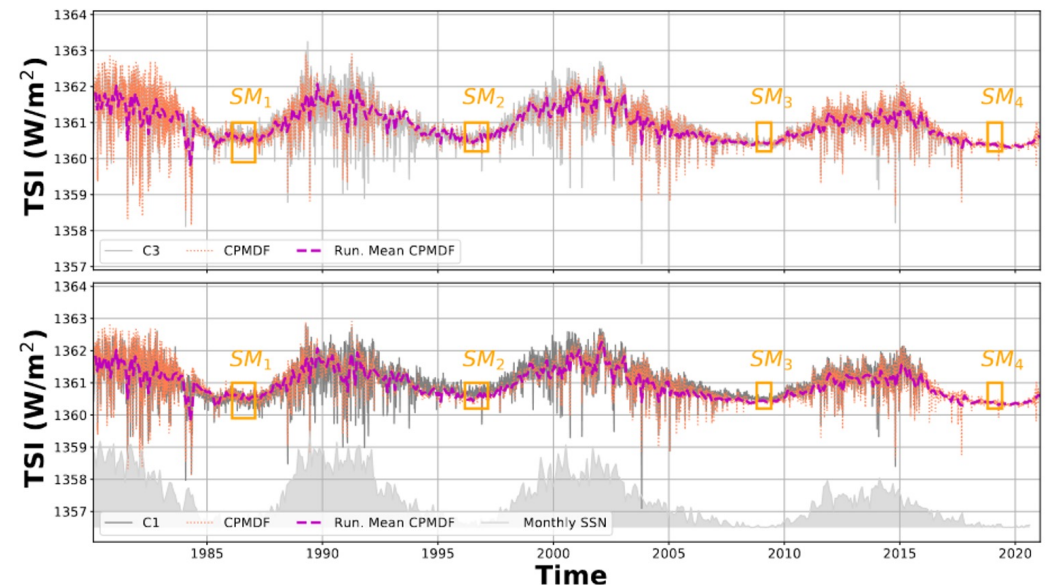
- **More details about previous versions in «Miscellaneous»**

<ftp://ftp.pmodwrc.ch/pub/data/irradiance/virgo/TSI/old/Miscellaneous/>

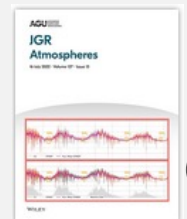


Composite TSI Time Series

- New algorithm to merge all the TSI time series recorded by successive missions since 1978 published in <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2021JD036146>
- Visit also new PMOD/WRC web page for all the details and update: <https://www.pmodwrc.ch/en/research-development/solar-physics/tsi-composite/>
- The composite TSI time series be updated with new update of VIRGO and in future with new missions/datasets (DARA-JTSIM)



New composite (CPMDf, orange) based on merging 41 years of TSI measurements. For comparison, C3 (Fröhlich, 2006) and C1 (Dudok de Wit et al., 2017) are also shown (grey line). A 30-day running mean of CPMDf is shown as a yellow/purple dashed line. The orange boxes are associated with the solar minima (SM) for each solar cycle described in Table 2. For context, the monthly sunspot number is also displayed.



Composite TSI Time Series

Availability

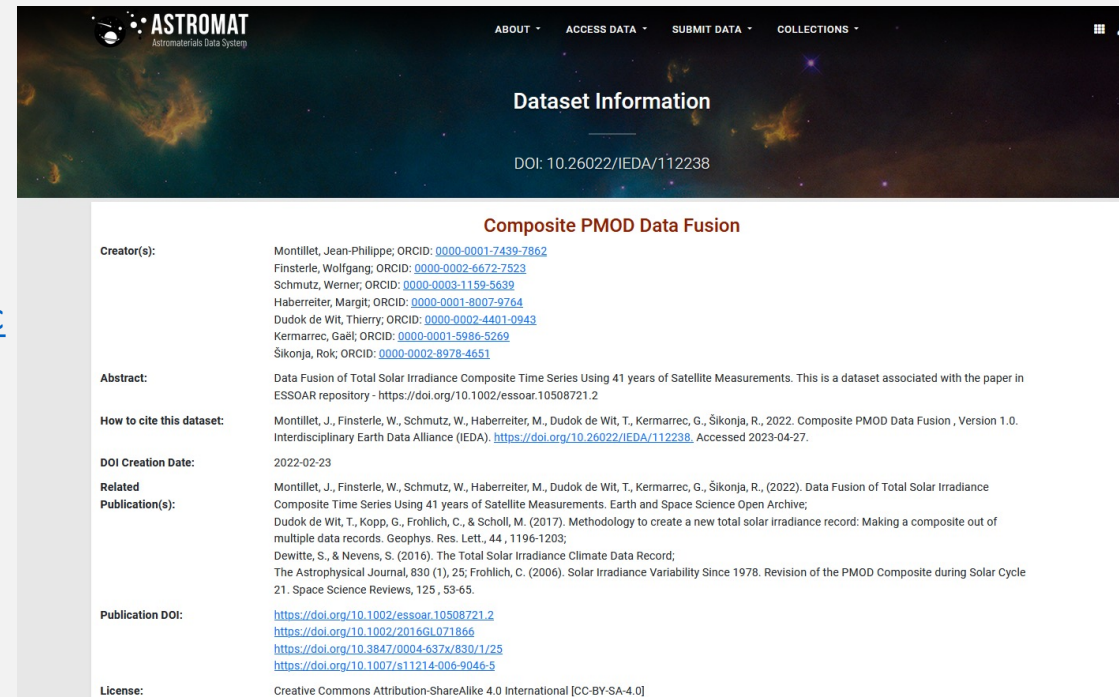
- On the PMOD/WRC ftp at :

ftp://ftp.pmodwrc.ch/pub/data/irradiance/virgo/TSI/TSI_composite/

- Via the Astromat repository:

<https://repo.astromat.org/>

[Keyword/Author: « Montillet »]



The screenshot shows the 'Dataset Information' page for 'Composite PMOD Data Fusion' on the Astromat repository. The page includes the following details:

- DOI:** 10.26022/IEDA/112238
- Creator(s):** Montillet, Jean-Philippe; ORCID: 0000-0001-7439-7862; Finsterle, Wolfgang; ORCID: 0000-0002-6672-7523; Schmutz, Werner; ORCID: 0000-0003-1159-5639; Haberreiter, Margit; ORCID: 0000-0001-8007-9764; Dudok de Wit, Thierry; ORCID: 0000-0002-4401-0943; Kermarrec, Gaël; ORCID: 0000-0001-5986-5269; Šikonja, Rok; ORCID: 0000-0002-8978-4651
- Abstract:** Data Fusion of Total Solar Irradiance Composite Time Series Using 41 years of Satellite Measurements. This is a dataset associated with the paper in ESSOAR repository - <https://doi.org/10.1002/essoar.10508721.2>
- How to cite this dataset:** Montillet, J., Finsterle, W., Schmutz, W., Haberreiter, M., Dudok de Wit, T., Kermarrec, G., Šikonja, R., 2022. Composite PMOD Data Fusion, Version 1.0. Interdisciplinary Earth Data Alliance (IEDA). <https://doi.org/10.26022/IEDA/112238>. Accessed 2023-04-27.
- DOI Creation Date:** 2022-02-23
- Related Publication(s):** Montillet, J., Finsterle, W., Schmutz, W., Haberreiter, M., Dudok de Wit, T., Kermarrec, G., Šikonja, R., (2022). Data Fusion of Total Solar Irradiance Composite Time Series Using 41 years of Satellite Measurements. Earth and Space Science Open Archive; Dudok de Wit, T., Kopp, G., Frohlich, C., & Scholl, M. (2017). Methodology to create a new total solar irradiance record: Making a composite out of multiple data records. Geophys. Res. Lett., 44, 1196-1203; Dewitte, S., & Nevens, S. (2016). The Total Solar Irradiance Climate Data Record; The Astrophysical Journal, 830 (1), 25; Frohlich, C. (2006). Solar Irradiance Variability Since 1978. Revision of the PMOD Composite during Solar Cycle 21. Space Science Reviews, 125, 53-65.
- Publication DOI:** <https://doi.org/10.1002/essoar.10508721.2>; <https://doi.org/10.1002/2016GL071866>; <https://doi.org/10.3847/0004-637x/830/1/25>; <https://doi.org/10.1007/s11214-006-9046-5>
- License:** Creative Commons Attribution-ShareAlike 4.0 International [CC-BY-SA-4.0]

Publication & DOI for the datasets: Montillet, J.-P., Finsterle, W., Kermarrec, G., Šikonja, R., Haberreiter, M., Schmutz, W., Dudok de

Wit (2022). DF of total solar irradiance composite TS using 41 years of satellite measurements. *JGR: Atmospheres*.

Montillet, J., Finsterle, W., Schmutz, W., Haberreiter, M., Dudok de Wit, T., Kermarrec, G., Šikonja, R., 2022. Composite PMOD DF Interdisciplinary Earth Data Alliance (IEDA). <https://doi.org/10.26022/IEDA/112238>. Accessed 2022-02-23.





DARA on board of FY₃E/JTSIM

Active: 2021 – Now

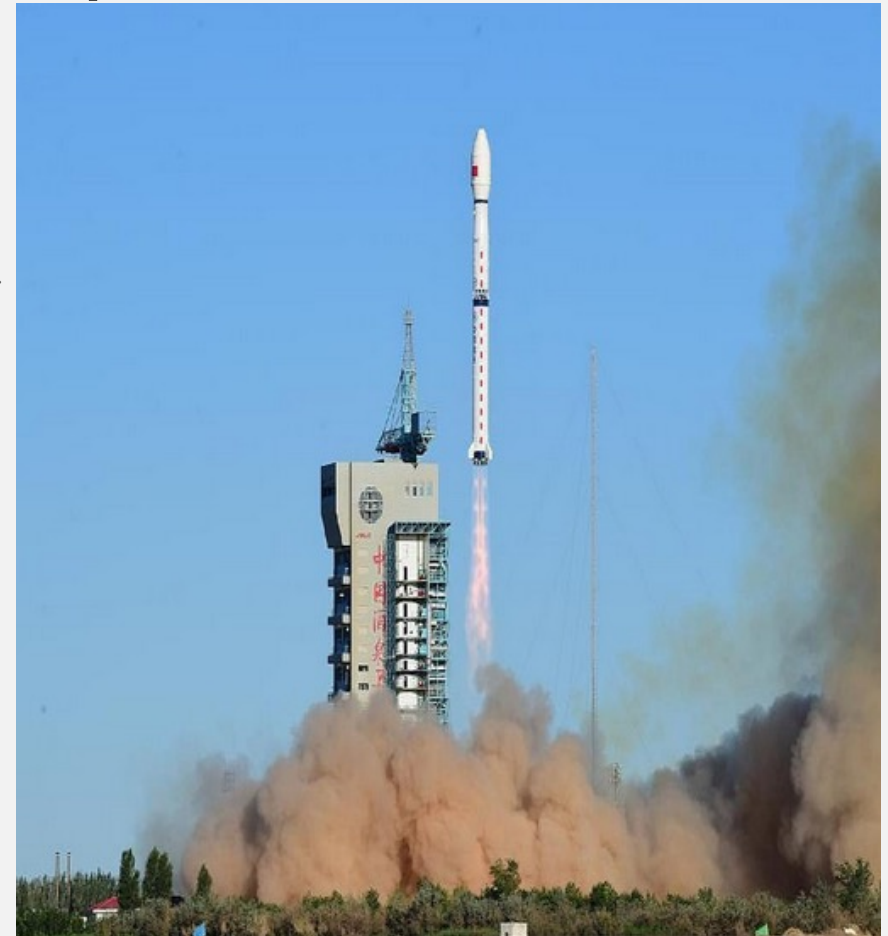


DARA & SIAR on Board of the FY₃E / JTSIM Spacecraft

The *Joint Total Solar Irradiance Monitor (JTSIM)* is the new generation of TSI monitoring instruments, built by the Changchun Institute of Optics, Fine Mechanics and Physics Chinese Academy of Sciences (CIOMP/CAS) in Changchun, China, with the aim of long-term monitoring of TSI in space. JTSIM is one of the payloads on the Chinese *Fengyun-3E (FY-3E)* spacecraft. The *Fengyun* program develops a Chinese meteorological-series spacecraft supported by the National Satellite Meteorological Center (NSMC), China. The FY-3 series satellites monitor large-scale meteorological disasters, weather-induced secondary natural hazards and environment changes, and provides geophysical parameters for scientific research in climate change and its variability, climate diagnosis, and predictions. **FY3E was launched** successfully on the **4th of July 2021**.

JTSIM includes the Digital Absolute Radiometer (DARA), from the PMOD/WRC in Davos, Switzerland, **and the Solar Irradiance Absolute Radiometer (SIAR)**, from CIOMP/CAS. SIAR and DARA are mounted on the same pointing system. DARA is the result of the latest radiometer developments at PMOD/WRC and comprises several innovations compared to the previous generation of PMO6-type radiometers.

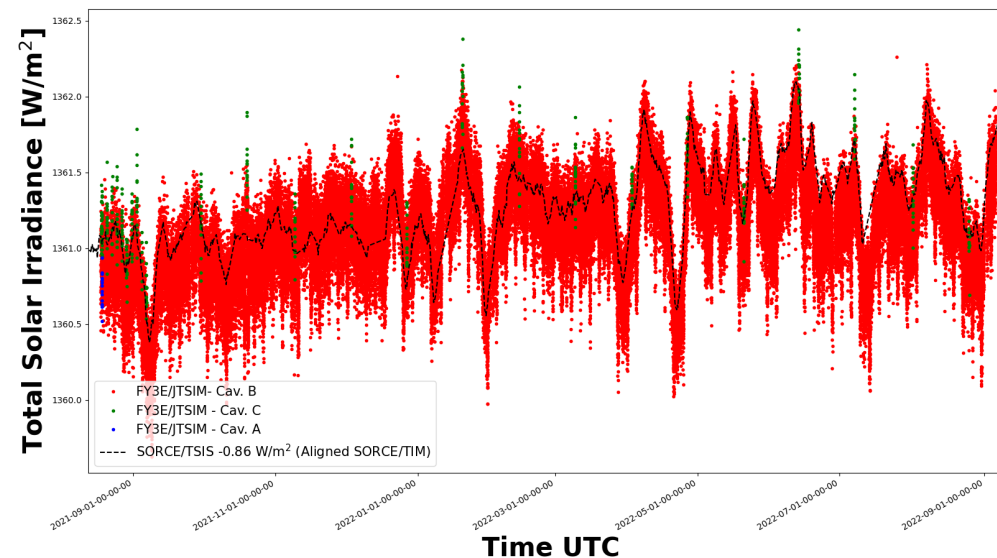
- For more information: <https://directory.eoportal.org/web/eoportal/satellite-missions/f/fy-3>



Future DARA-JTSIM – v1

FY3E/DARA-JTSIM

- Mission launched the 4/07/2021
- Since then process regularly the data
- Various parameters still under validation (heater power, Deep Space / dark correction ...)



First Light DARA-JTSIM – 18/07/2021



Paper submitted DARA & SIAR «First Light»

Instrument	Channel A	Channel B	Channel C	Statistics ($\mu \pm \sigma$)
DARA (whole day)	1360.82	1360.85	1361.20	1360.96 ± 0.17
DARA (first light - $K=1$)	1361.02	1361.13	1361.5	1361.22 ± 0.20
SIAR (whole day)	1361.60	N/A	N/A	N/A
VIRGO/PMO6	1360.80	1360.92	1360.89	1360.87 ± 0.05
TSIS/TIM	1361.89	1361.93	1361.93	1361.92 ± 0.019



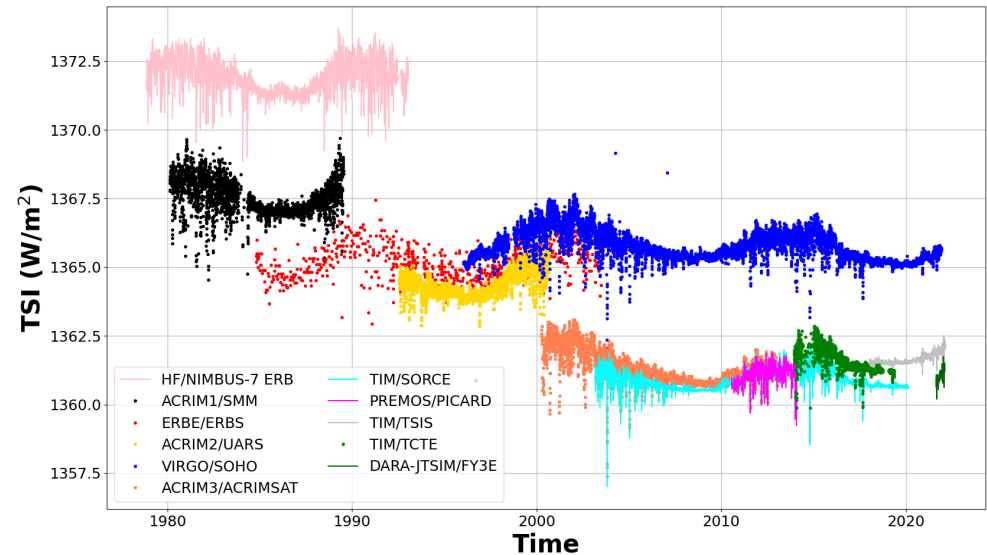
Future DARA-JTSIM – v1

Information & future release

DARA-JTSIM dataset will be accessible via

- PMOD/WRC ftp
- PMOD/WRC webpage :
<https://www.pmodwrc.ch/en/research-development/space/fy-3e/>
- Fengyun satellite data center
<https://satellite.nsmc.org.cn/>

After the full study of the DARA data (including «early increase»), data incorporate to TSI composite time series



Any Questions?

Thanks !

Acknowledgments:
Work supported by Karbacher and ESA-PRODEX funds