On Continuation of the Use of Daily TSI for CERES Processing

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Background

• Use of daily TSI data started with CERES Edition-4 processing.

• SORCE data covers most of this period with some gaps.
  (CERES period: March 2000 – present)

• Complete coverage of CERES period accomplished as follows:
  Mar2000 – Feb2003: WRC Data
  Jul2013 - Oct2014: RMIB Composite (SORCE interruption)
  Mar2020 – present: TSIS1

• TSIS1 and SORCE overlap period: Jan2018 – Feb2020
• Allows intercomparison (intercalibration) of the two timeseries
• Allows development of a unique method of gap-filling in both
Total Solar Irradiance for CERES Edition-4 (20000301 - 20191231)

Year

WRC Comp
01Mar2000 - 24Feb2003

SORCE (V15/V17/V18)
25Feb2003 - 30Jun2013
01Nov2014 - 31Dec2019

RMIB Comp
01Jul2013 - 31Oct2014
Over the 26-month overlap period, both timeseries show gaps. Numbers above show that TSIS1 data gaps are more frequent and longer. Strong temporal correlation and a steady offset between the two timeseries can be clearly seen. Note that gaps in the two timeseries are not temporally correlated.
The difference is determined by creating new timeseries constituted by only those days that have good measurements in both timeseries. The number of days and the mean difference are shown above. This difference is well within the absolute accuracy of SORCE (350 ppm) and TSIS1 (410 ppm) and has not triggered any action by providers.
We tried to determine if there was any drift/trend in this difference plot but did not find any. We also ascertained that there was no significant trend in either SORCE or TSIS1 timeseries individually (plots not included).
The non-correlation of gaps allows us to fill most gaps applying this mean difference to both timeseries. A very few gaps (total of 3) remain on days when neither dataset has a good value. Those are still filled by linear interpolation.

I CALL THIS DATASET MY TRUTH DATASET
TSIS1 Gaps and Gap-Filling After the Overlap Period

• TSIS1 data shows more frequent and longer gaps, why?

  1) Obstruction of the TSIS1 FOV by Space Station structure, and
  2) Frequent extra-vehicular activities around the Space Station.

Need: Look for a different gap-filling strategy for use with TSIS1 data.

• Used linear interpolation as for SORCE and tried one more method with TSIS1 data and compared results of the two methods.

• The completely filled “truth” dataset provides a testbed for evaluating any filling strategy:
  1) Tried linear interpolation for filling gaps like before, and
  2) Tried an average over one solar rotation (27 days) immediately before the gap
     a. Used Jan2018 data for computing the initial value of the 27-day average
     b. Then filled gaps in the remaining 25-month timeseries with averages of
        the preceding 27 days.
Gap-filling in TSIS1 data by two methods (201802-202002)

**TSI_Unfilled**

**TSI_Interp.**

Mean = 1361.1498 Wm$^{-2}$  S.D. = 0.0574 Wm$^{-2}$

**TSI_27PT**

Mean = 1361.1478 Wm$^{-2}$  S.D. = 0.0557 Wm$^{-2}$
Comparison of the filled datasets with the truth

Mean = 1361.1489 Wm$^{-2}$  S.D. = 0.0587 Wm$^{-2}$

Mean = 1361.1498 Wm$^{-2}$  S.D. = 0.0574 Wm$^{-2}$

Mean = 1361.1478 Wm$^{-2}$  S.D. = 0.0557 Wm$^{-2}$
Comparison of the Two Filling Method Results

Gaps Filled by Linear Interpolation

N = 99
Mean Bias = 0.0069
Slope = 0.4746
Correlation = 0.5967
RMSD = 0.0478 (35 ppm)

Gaps Filled by 27-Day Averaging

N = 99
Mean Bias = -0.0081
Slope = 0.1285
Correlation = 0.2882
RMSD = 0.0561 (41 ppm)
Summary

• More frequent and longer gaps in TSIS1 data are caused by:

  1) Obstruction of the TSIS1 FOV by Space Station structure, and
  2) Frequent extra-vehicular activities around the Space Station.

• Hence, longer and more frequent gaps may continue indefinitely.

  Solution: Linear interpolation appears to be adequate at this time. Averaging over a solar rotation does not appear to offer any advantage.

• The offset of 0.4783 Wm\(^{-2}\) in TSI may affect the quality of CERES SW products.

  Solution: Offset TSIS1 data to SORCE V15 level as long as Edition-4 is being processed. Revisit when Edition-5 or other processing is undertaken.
Backup Slides
Outline

• Background

• Stitching together a daily TSI dataset for the entire CERES record (March 2000 – present)

• Intercomparison and gap-filling during the SORCE and TSIS1 overlap period

• Causes of frequent and longer gaps in TSIS1 data

• Gap-filling after the overlap period
Total Solar Irradiance (Wm\(^{-2}\))

**Straight Line Fit to SORCE TSI - Jan2018-Dec2019**

N = 594
Mean TSI = 1360.6702 Wm\(^{-2}\)
Slope = -0.0160 Wm\(^{-2}\)/year
Uncertainty on slope = 0.0043
Value at 2018 = 1360.6861
Value at 2020 = 1360.6541

**Straight Line Fit to TSIS1 TSI - Jan2018-Dec2019**

N = 594
Mean TSI = 1361.1476 Wm\(^{-2}\)
Slope = -0.0154 Wm\(^{-2}\)/year
Uncertainty on slope = 0.0044
Value at 2018 = 1361.1629
Value at 2020 = 1361.1321
Comparison of Gap Distribution in TSIS1 and SORCE  
(In the 25-month timeseries)

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Frequencies of Gap Sizes in TSIS1 and SORCE Data

Frequencies of Gap Sizes in TSIS1 Data

Total Number = 99

Frequencies of Gap Sizes in SORCE Data

Total Number = 33
Points other than those created for gaps are the same in both datasets