Total Solar Irradiance measurements over the last 30 years and reconstruction over the last 300 years

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2015 Sun-Climate Symposium, Savannah
30+ years of TSI measurements

From various institutes and agencies.

RMIB TSI space record:

- **1983**  SPACELAB 1 NASA ESA
- **1992**  ATLAS-I NASA STS-45
- **1992**  EURECA/SOVA ESA STS-46 (returned to ground)
- **1993**  ATLAS-II NASA STS-56
- **1994**  ATLAS-III NASA STS-66
- **1995**  SOHO/VIRGO/DIARAD (ongoing >19 year)
- **1997**  HITCHHIKER NASA STS-85
- **1998**  HITCHHIKER NASA STS-95
- **2003**  FREESTAR NASA STS-107
- **2008**  ISS/sovIM/DIARAD (>1year)
- **2010**  PICARD/soVA CNES (terminated)
- **2018**  FY3E/JOIM/DIARAD CMA (planned)
121 day running TSI measurements adjusted to Diarad/Sovim absolute level

Year


DIARAD/VIRGO  PM06-B/VIRGO  TIM/SORCE  TIM/TCTE  Sova-Picard  Premos  ERBS  ACRIM1  ACRIM3  ACRIM2  ERB

1362 1362.5 1363 1363.5 1364 1364.5 1365 1365.5
Difference of TIM/SORCE with independent composite

TIM/SORCE minus composite

\[-0.139 + 0.0292 \times (x - 2003)\]
Further back: sunspots and facula

Sunspots: dark, strong magnetic field, relative short lifetime

Facula: bright, intermediate magnetic field, relative long lifetime

L: UV image. R: Magnetogram
Further back: mount Wilson indices

**MWSI**
Mt. Wilson Sunspot Index
Strong magnetic fields

**MPSI**
Magnetic Plage Strength Index
Intermediate magnetic fields
Facula

\[
\text{TSI model} = A + B \times \text{MWSI} + C \times \text{MPSI}
\]
The graph represents the 121 day running mean Total Solar Irradiance (TSI) over the years. The data is shown in three lines:

- **RMIB composite measurements** in red, follows the trend 1362.9-0.015*(x-2010).
- **Mount Wilson magnetic model** in green, follows the trend 1362.9+0.015*(x-2010).
- The blue line represents the 1362.9 value.
Total Solar Irradiance reconstruction

Year

1920 1940 1960 1980 2000 2020

TSI (W/m²)

1362.5 1363 1363.5 1364 1364.5 1365

RMIB composite measurements
Mount Wilson magnetic model
Kitt Peak Satellite magnetic model
Yearly Mount Wilson Calcium plage area model
Even further back: sunspot number

International sunspot number $S_n$:
yearly mean and 13-months smoothed number
Conclusions

Regression models on sunspot data combined with 30 year of TSI measurements are used to reconstruct the TSI over a 300 year period.

The average 11 year solar radiative forcing is of the order of 0.25 W/m² with a modulation of the order of +/- 0.125 W/m².

Within the measurement uncertainty there is no variation of the TSI at the minimum of a 11 year cycle during the last 30 years (3 minima).