ACRIM TOTAL SOLAR IRRADIANCE MONITORING DURING SOLAR CYCLES 21 – 23

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Critical Characteristics of TSI Monitoring Experiments

Experiment	PI Mode	Observing Frequency	Shutter Calibration Frequency	Electrical Calibration Frequency	Degradation Calibration	Solar Pointed
Nimbus7/ERB 1978 – 1993	Quasi	3 of 4 days 5 min/LEO orbit	None	2 weeks	None	No
SMM/ACRIM1 1980 - 1989	Yes	55 min/LEO orbit	1 min. cycle	Continuous	3-fold redundant Monthly	Yes
ERBS 1984 - 2000	No	5 min. every 14 days	30 sec. cycle	2 weeks	None	No
UARS/ACRIM2 1991 →	Yes	35 min/LEO orbit	1 min. cycle	Continuous	3-fold redundant Monthly	Yes
SOHO/VIRGO 1996 →	Yes	Continuous L1 Point	Occasional using instrument door	Continuous	2-fold redundant Hiatus issues Large degradation	Yes
ACRIMSAT/ACRIM3 2000 →	Yes	62 min/LEO orbit	1 min. cycle	Continuous	3-fold redundant Monthly	Yes

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Impact on Observations	Degrading	Sub-optimal	Optimal	Optimum

ACRIM OBSERVATIONS, COMPOSITE TOTAL SOLAR IRRADIANCE TIME SERIES AND MEASUREMENT STRATEGY

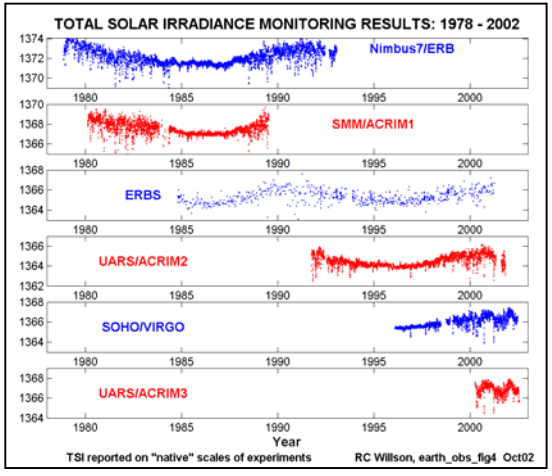
Active Cavity Radiometer Irradiance Monitoring (ACRIM) experiments have provided high precision, high traceability Total Solar Irradiance (TSI) results during 20 of the nearly 24 years of satellite monitoring.

A composite TSI time series nearly 24 years in length has been constructed from the results of the Nimbus7/ERB, SMM/ACRIM1, UARS/ACRIM2, SOHO/VIRGO and ACRIMSAT/ACRIM3 experiments.

A TSI trend + 0.04 % per decade has been found between the solar cycle minima of 1986 and 1996.

Overlap and redundancy of TSI flight experiments have been essential in the compilation of a precise, traceable TSI database to date.

Periodic calibration of satellite TSI experiments by a shuttle-based cryogenic radiometer capable of 0.01 % SI uncertainty is an essential additional component of the strategy that is needed to provide confirmation of traceability and protect the TSI database from catastrophic failure.

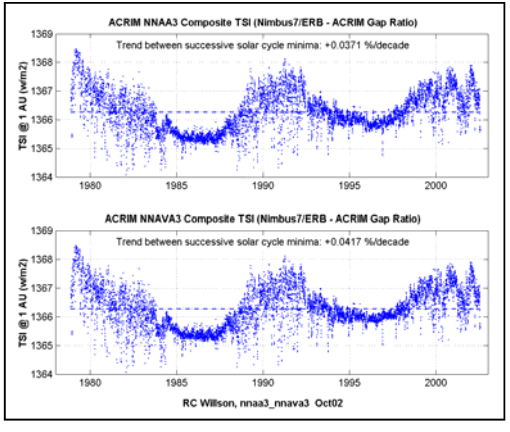


Constructing Composite TSI Time Series

- **Composite TSI time series have been constructed using results from the Nimbus7/ERB, SMM/ACRIM1, UARS/ACRIM2, SOHO/VIRGO and ACRIMSAT/ACRIM3 experiments**
- **In-flight comparisons provide contiguous results at the mutual precision level of experiments**
- **Key to constructing a 23+ year-long time series is relating the non-overlapping ACRIM1 and ACRIM2 results**
- **Nimbus7/ERB and ERBS overlap the ACRIM1-ACRIM2 gap and can be used to relate their results**

'ACRIM' Composite TSI Time Series

- **Two 'ACRIM' Composite Time Series**
- **NNAA3 uses original results from Nimbus7/ERB and ACRIM1,2,3 experiments**
- **NNAVA3 uses original results from Nimbus7/ERB, ACRIM1,2,3 and VIRGO experiments**
- **Overlapping comparisons with Nimbus7/ERB used to relate ACRIM1 and ACRIM2 results**
- **Reported on ACRIM3 'native scale' through chain of overlapping comparisons**

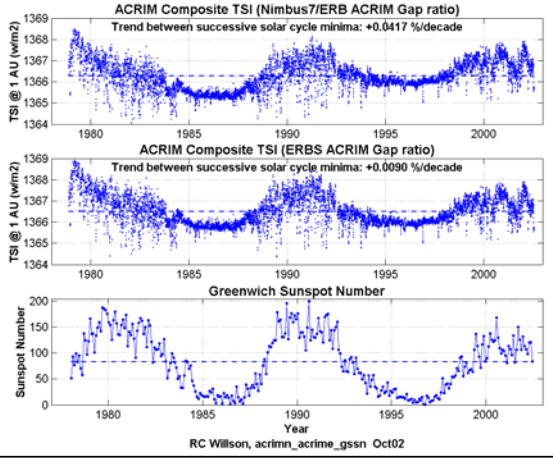


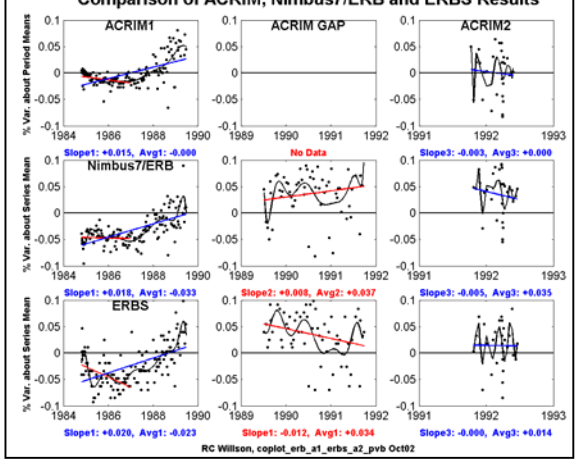
The ACRIM_NNAA3 Composite TSI Model

Experiment	Lifetime	Results in Model	Model Fraction
Nimbus7/ERB	1978–1993	1978-80 1984 (ACRIM1 gap) 1989-91 1992 (ACRIM2 gap)	.0545 .0074 .0971 .0059
SMM/ACRIM1	1980 – 1989	1980 - 1989	.4035
UARS/ACRIM2	1991 – 2001	1991 – 2000	.3657
ACRIMSAT/ACRIM3	2000 →	2000 →	.0659
Total Nimbus7/ERB	1978 – 1993	1978 - 1992	0.1649
Total ACRIM	1980 - 2001	1980 - 2001	0.8351

The ACRIM_NNAVA3 Composite TSI Model

Experiment	Lifetime	Results in Model	Model Fraction
Nimbus7/ERB	1978–1993	1978-80 1984 (ACRIM1 gap) 1989-91 1992 (ACRIM2 gap)	.054 .007 .097 .006
SMM/ACRIM1	1980 – 1989	1980 - 1989	.404
UARS/ACRIM2	1991 →	1991 - 1996 1998 - 2000	.366
SOHO/VIRGO	1996 →	1996 - 1998	.110
ACRIMSAT/ACRIM3	2000 →	2000 →	.066
Total SOHO/VIRGO	1996 →	1996 - 1998	.110
Total Nimbus7/ERB	1978 – 1993	1978 - 1992	.165
Total ACRIM	1980 - 2001	1980 - 2001	.725





Comparison of Composite TSI Time Series Using Nimbus7/ERB and ERBS ACRIM Gap Comparisons

- Nimbus7/ERB comparisons produce + 0.04 %/decade trend between minima during solar cycles 21 – 23
- ERBS comparisons yield no little or no trend between minima during solar cycles 21 – 23
- ERBS exhibits uncorrected degradation during ACRIM Gap
- ERBS degradation equals difference between trends

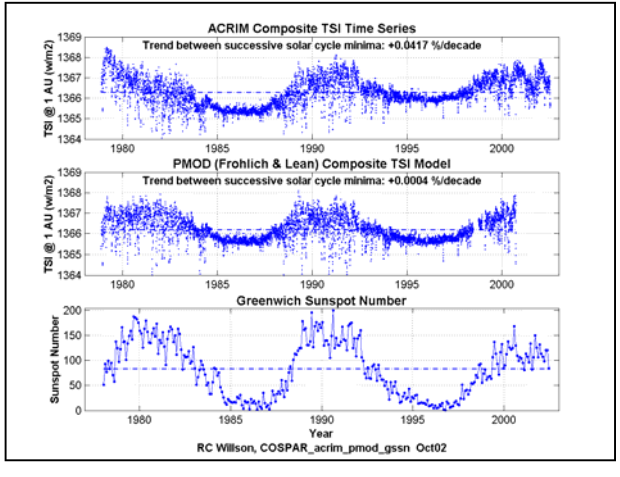
Comparison of 'ACRIM' and 'PMOD' Composite TSI Time Series

- ACRIM Approach

  Nimbus7/ERB, ACRIM1,2,3 and VIRGO results
  Nimbus7/ERB comparisons relate ACRIM1 and ACRIM2 results
  ACRIM3 'native scale'

- PMOD Approach

  Nimbus7/ERB, ACRIM1,2,3 and VIRGO results
  Modifies Nimbus7/ERB to conform to ERBS over ACRIM gap
  Modifies Nimbus7/ERB & ACRIM to conform to solar proxy model predictions during solar cycle 21 maximum
  VIRGO pre/post 1998 SOHO hiatus results related using ACRIM2 comparisons



Conclusions

- Difference in minima-to-minima trends for Nimbus7/ERB and ERBS referenced TSI composites is an artifact of ERBS degradation during ACRIM Gap
- 'ACRIM' + 0.04 %/decade minima-to-minima trend resolved with +/- 0.005 – 0.01 %/decade uncertainty
- Lower TSI during solar maxima of 'PMOD' composite likely an artifact of conformance to TSI solar proxy model that underestimates TSI during maxima