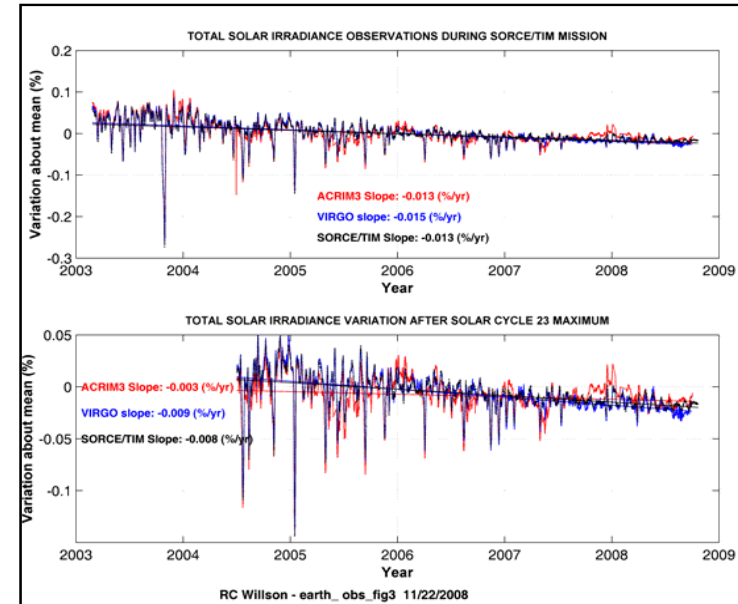
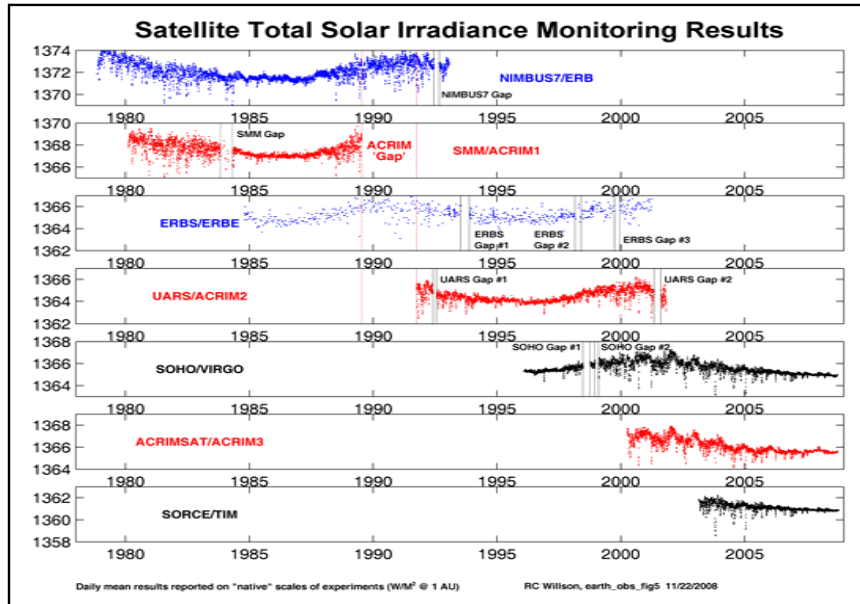


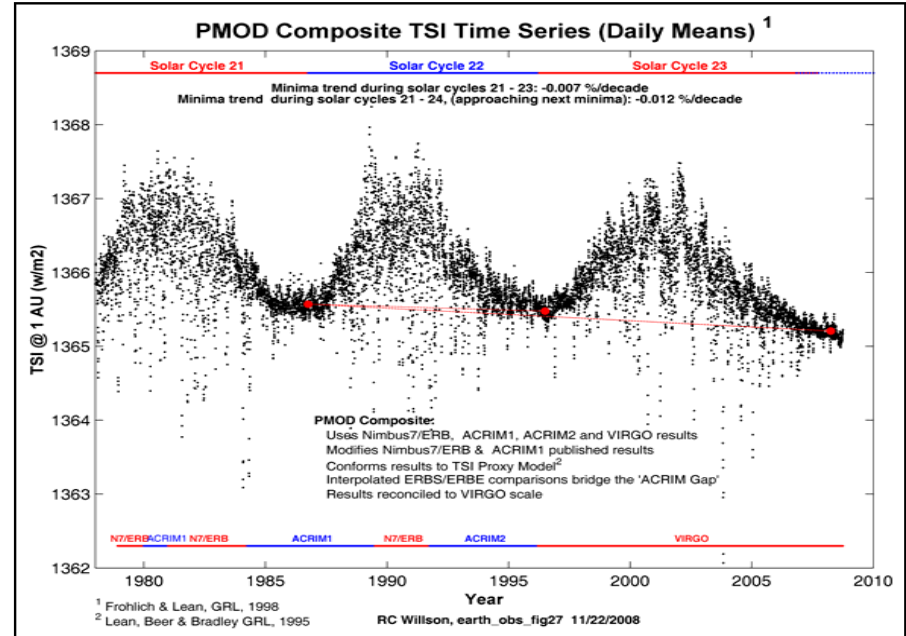
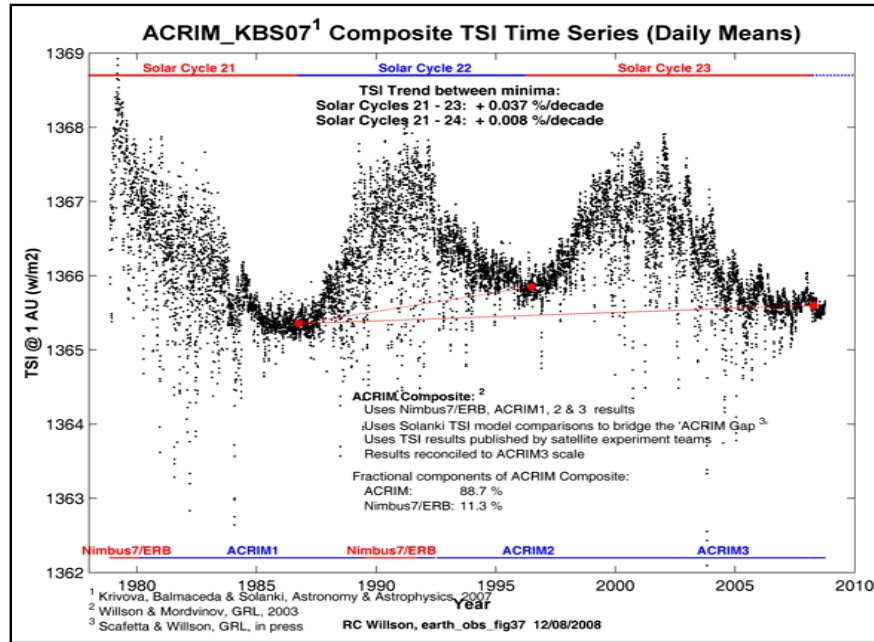
# Three Decades of Total Solar Irradiance Monitoring

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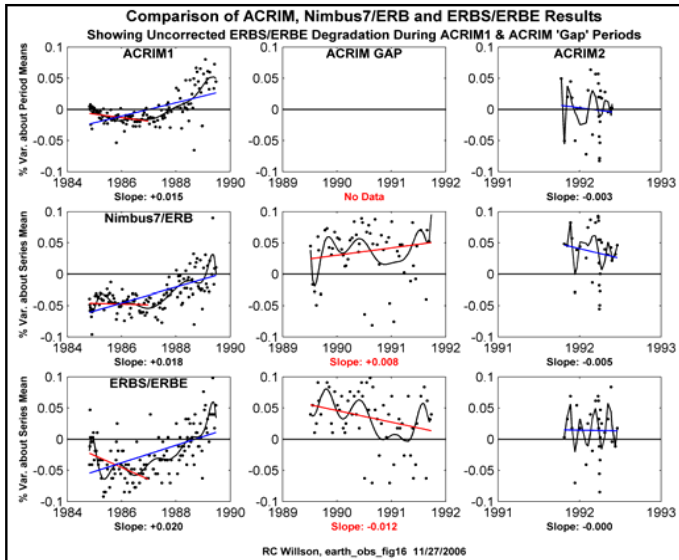
- Total solar irradiance (TSI) has been monitored for three decades (1978 - 2008) by a series of contiguous, overlapping satellite experiments
- Accuracy and precision varies between experiments but the end-to-end traceability (relative precision) of the ACRIM composite time series is ~ of a few hundred ppm.
- A three decade TSI composite time series requires relating ACRIM1 and ACRIM2 results across a two year gap (the 'ACRIM Gap') between their observations.
- The 'absolute' scale of TSI observations is not significantly less than 1000 ppm.
- The precision of the ACRIMSAT/ACRIM3 results is ~ 5 ppm/year.
- The Traceability of the ACRIM composite TSI over 3 decades is known to ~ 300 ppm.
- Traceability is provided by overlapping comparisons of satellite TSI experiments at instrument precision levels.
- Recent TSI results from 3 solar monitoring experiments (ACRIM3, VIRGO and TIM) agree closely.
- Redundant, overlapping experiments is the science and cost effective approach for sustaining a long term TSI database for climate change investigations.

# Composite TSI : Comparison of ACRIM and PMOD Time Series



- The ACRIM TSI composite uses the Nimbus7/ERB ACRIM gap ratio and exhibits a 0.037 percent per decade trend between the minima of cycles 21 to 23. A trend of this magnitude, sustained over many decades or centuries, could be a significant climate forcing.
- Recent phenomenological analyses indicate a greater climate change sensitivity to solar variations than previously indicated by Global Circulation Models. Climate sensitivity to solar variability must be understood to evaluate the relative effects of natural and anthropogenic contributions on climate change.
- TSI in the recent minimum (between solar cycles 23 and 24) is lower than the last and only slightly higher than the cycle 21 – 22 minimum. The ACRIM composite trend to higher TSI during cycles 21 – 23 and then back to approximately the level of the cycle 21 – 22 minimum may be the signature of a Hale cycle.
- The PMOD composite approach uses the ERBS/ERBE ACRIM gap ratio, a different subset of the satellite TSI database, and modified Nimbus7/ERB and ACRIM1 results (based on the predictions of TSI proxy models) but finds no significant trend over the cycle 21 to 23 period.
- TSI proxy models are not competitive in precision or accuracy with satellite TSI observations. Their use in constructing the PMOD composite convolutes the relatively high uncertainties of the models with the more precise observational data and conforms the PMOD composite to the proxy model rather than providing the most valid interpretation of the extant TSI observational database.
- The absence of a trend in the PMOD composite and any composite based on the ERBS/ERBE ACRIM gap ratio has been shown to be an artifact of uncorrected degradation of ERBS/ERBE results during the gap.<sup>1</sup>

# Resolution of the 'ACRIM-gap' dilemma: ERBE degradation

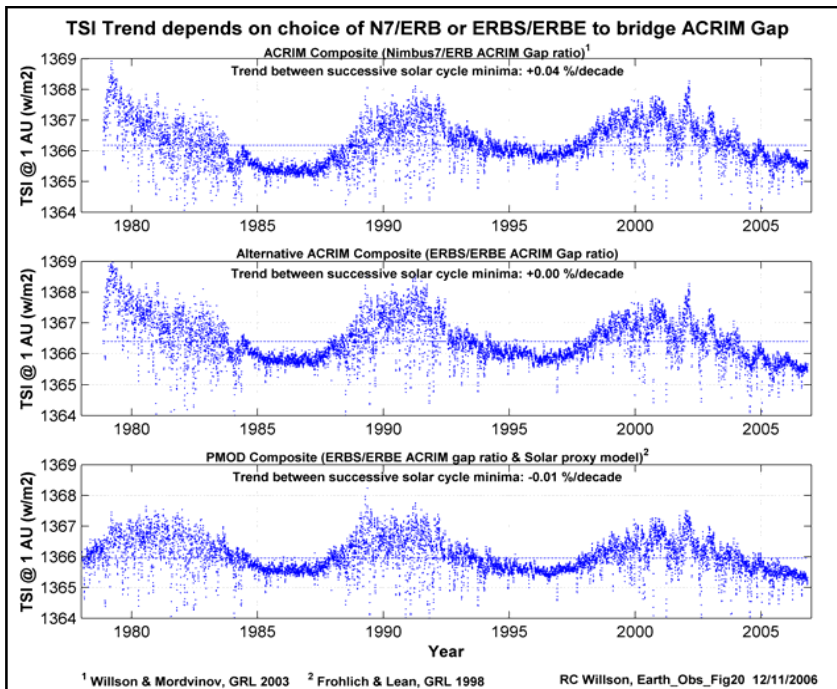


## Uncorrected Degradation Of ERBS/ERBE

- ERBS/ERBE results exhibit uncorrected degradation during the ACRIM gap (1989 – 1991)
- Slopes of ACRIM, Nimbus7/ERB and ERBS/ERBE comparable during ACRIM1 and ACRIM2 overlap periods
- ERBS/ERBE degrades significantly during ACRIM gap when TSI should be increasing due to rising solar activity levels.
- ERBS/ERBE degradation during ACRIM gap equals the trend difference between the Nimbus7/ERB-based and ERBS/ERBE-based composite TSI's

## Conclusions

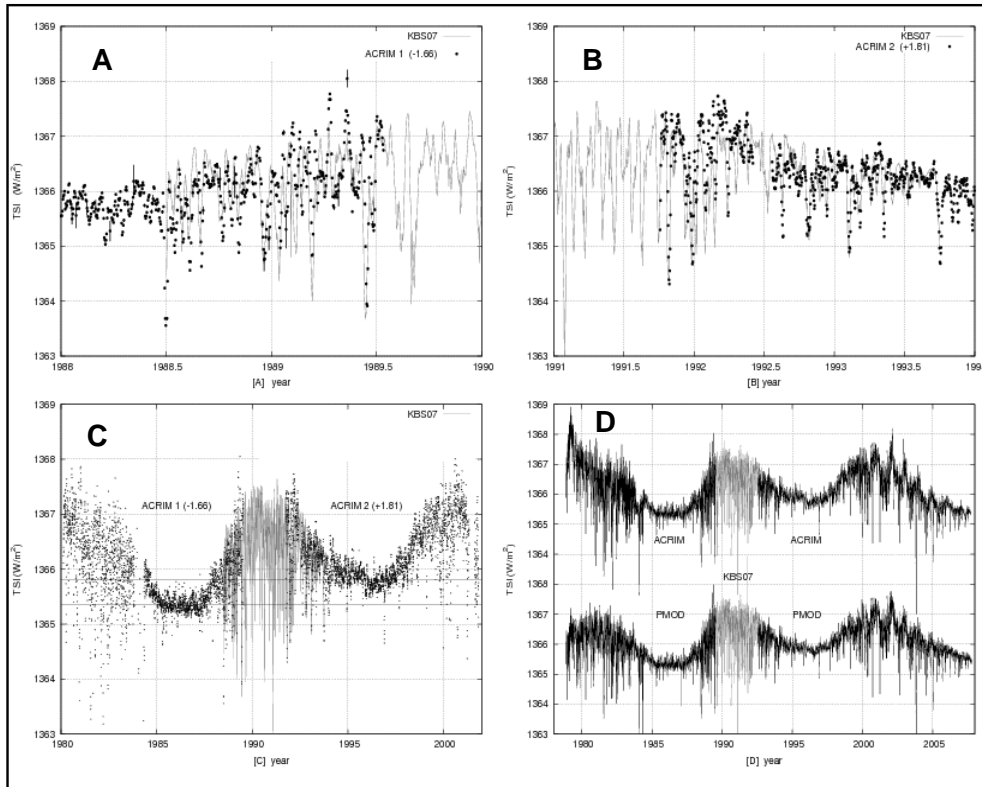
- The ACRIM TSI composite time series is the most accurate representation of the extant TSI satellite measurement database. It doesn't rely on imprecise proxy modeling or modifications of published observational results.
- The trend difference between ACRIM and PMOD composites is an artifact of ERBS/ERBE degradation during the ACRIM Gap
- Lower PMOD composite results TSI at solar maxima are artifacts of:
- Cycle 21: Alteration of published ACRIM1 and Nimbus7/ERB results to conform to solar proxy models
- Cycles 22 & 23: ERBS/ERBE degradation during ACRIM gap



## Composite TSI Trend depends on choice of ACRIM gap ratio

1. ACRIM composite, based on Nimbus7/ERB ACRIM gap ratio. Yields a + 0.04 %/decade trend between solar cycles 21 – 23 minima.
2. An alternative ACRIM composite, using the ERBS/ERBE ACRIM gap ratio, yields a negligible trend between solar cycles 21 – 23 minima, similar to PMOD.
3. The PMOD composite, based on the ERBS/ERBE ACRIM gap ratio, and yields a negligible trend between solar cycles 21 – 23 minima.

# Resolution of the 'ACRIM-gap' dilemma: The KBS07 Proxy



## ACRIM-KBS07 Composite

Panels A and B: ACRIM1 & ACRIM2 (black dots) compared with the KBS07 TSI.

Panel C: ACRIM-KBS07 composite TSI over 1980 – 2005 common data range.

Panel D Comparison of ACRIM-KBS07 and PMOD-KBS07 composites.

Both use KBS07 (gray line) to connect ACRIM1 and ACRIM2 across the ACRIM-gap.

A TSI trend between successive minima of + 0.03 % is found for both mixed composites.

## Conclusions

- The ACRIM-gap dilemma for composite satellite TSI observations can also be resolved by bridging the ACRIM gap with TSI derived from Krivova's [2007]<sup>1</sup> proxy model relating variations of the surface distribution of solar magnetic flux.<sup>2</sup>
- ACRIM-KBS07 and PMOD-KBS07 TSI composites are constructed using ACRIM and PMOD original values except for the ACRIM gap, where Krivova modeled TSI is used to connect ACRIM1 and ACRIM2 results.
- Both ACRIM-KBS07 and PMOD-KBS07 composites demonstrate a significant TSI trend of 0.033 (+/- 0.004) %/decade between the solar activity minima of 1986 and 1996.
- This trend is NOT significantly different from the 0.037 %/decade trend in the ACRIM composite [Willson & Mordvinov, 2003]<sup>3</sup>.
- This finding supports the contention that the ERBS/ERBE results are flawed by uncorrected degradation during the ACRIM gap. [Willson 1997]<sup>3</sup>
- This finding refutes the upward adjustment of Nimbus7/ERB ACRIM gap results used to construct the PMOD. [Frohlich and Lean 1998]<sup>4</sup>

1 Krivova N. A., L. Balmaceda, and S. K. Solanki, 2007, Reconstruction of solar total irradiance since 1700 from the surface magnetic flux: *Astronomy and Astrophysics*, v. 467, p. 335-346.

2 Scafetta, N. and R.C. Willson, ACRIM-gap and TSI trend issue resolved using a surface magnetic flux TSI proxy model, *GRL*, in press 2008

3 Willson R.C., and A.V. Mordvinov, 2003, Secular total solar irradiance trend during solar cycles 21-23: *Geophysical Research Letters*, v. 30, p. 1199-1202. (doi: 10.1029/2002GL016038).

4 Frohlich C. and J. Lean, 1998, The Sun's total irradiance: cycles, trends and related climate change uncertainties since 1978: *Geophysical Research Letters*, v. 25, p. 4377-4380. (doi:10.1029/1998GL900157).