

# ACRIM TSI Results and Composite TSI Time Series

## ACRIM INSTRUMENT TEAM

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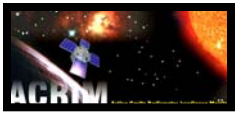
Dr. James Hansen, Director – NASA/GISS  
Co-Investigator

Dr. Hugh S. Hudson – University of CA at Berkeley  
Co-Investigator



ACRIM

Active Cavity Radiometer Irradiance Monitor



# ACRIMSAT/ACRIM3 SCIENCE STATUS

- **ACRIM3 results equal or exceed the quality of previous ACRIM's**
  - Spin mode solar pointing meets all requirements
  - Daily mean results superior to previous ACRIM results in precision, traceability
    - Precision:  $1 \sigma = 6 \text{ ppm of } 1366.7 \text{ w/m}^2 \text{ avg. TSI}$
    - Traceability:  $1 \sigma \text{ residual of degradation corrections } \sim \pm 5 \text{ ppm/yr}$
- **Degradation self-calibration**
  - 3-sensor comparisons performed at 90 day intervals
  - 2-sensor comparisons performed at 30 day intervals
  - Degradation algorithm updated every 3-sensor comparison
  - Lowest rate of degradation of all ACRIM experiments

**ACRIM3: reached degradation asymptote of 300 ppm**  
**ACRIM1: reached degradation asymptote of 600 ppm**  
**ACRIM2: reached degradation asymptote of 1500 ppm**

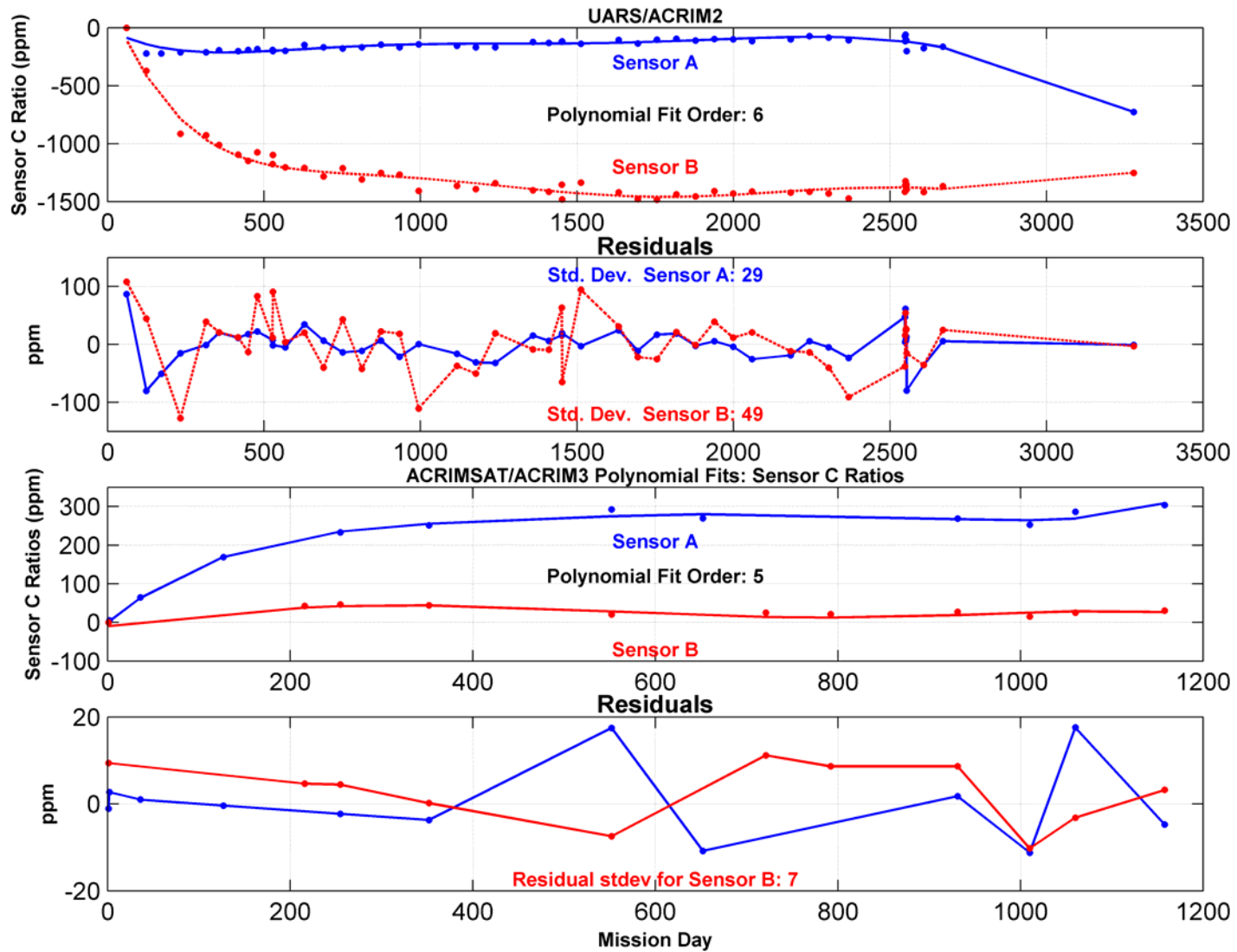


# ACRIMSAT/ACRIM3 SCIENCE STATUS

- **Validated level 2 results**
  - Level 2 results validated using updated degradation algorithm
  - Uplinked to LaRC DAAC after each algorithm degradation update
  - Daily mean time series
  - Shutter cycle summaries (time resolution: 131.072 sec.)
- **Data availability**
  - LaRC DAAC: [http://eosweb.larc.nasa.gov/HPDOCS/access\\_data.html](http://eosweb.larc.nasa.gov/HPDOCS/access_data.html)
  - ACRIM website: <http://www.acrim.com>



# ACRIM2 & ACRIM3 Degradation

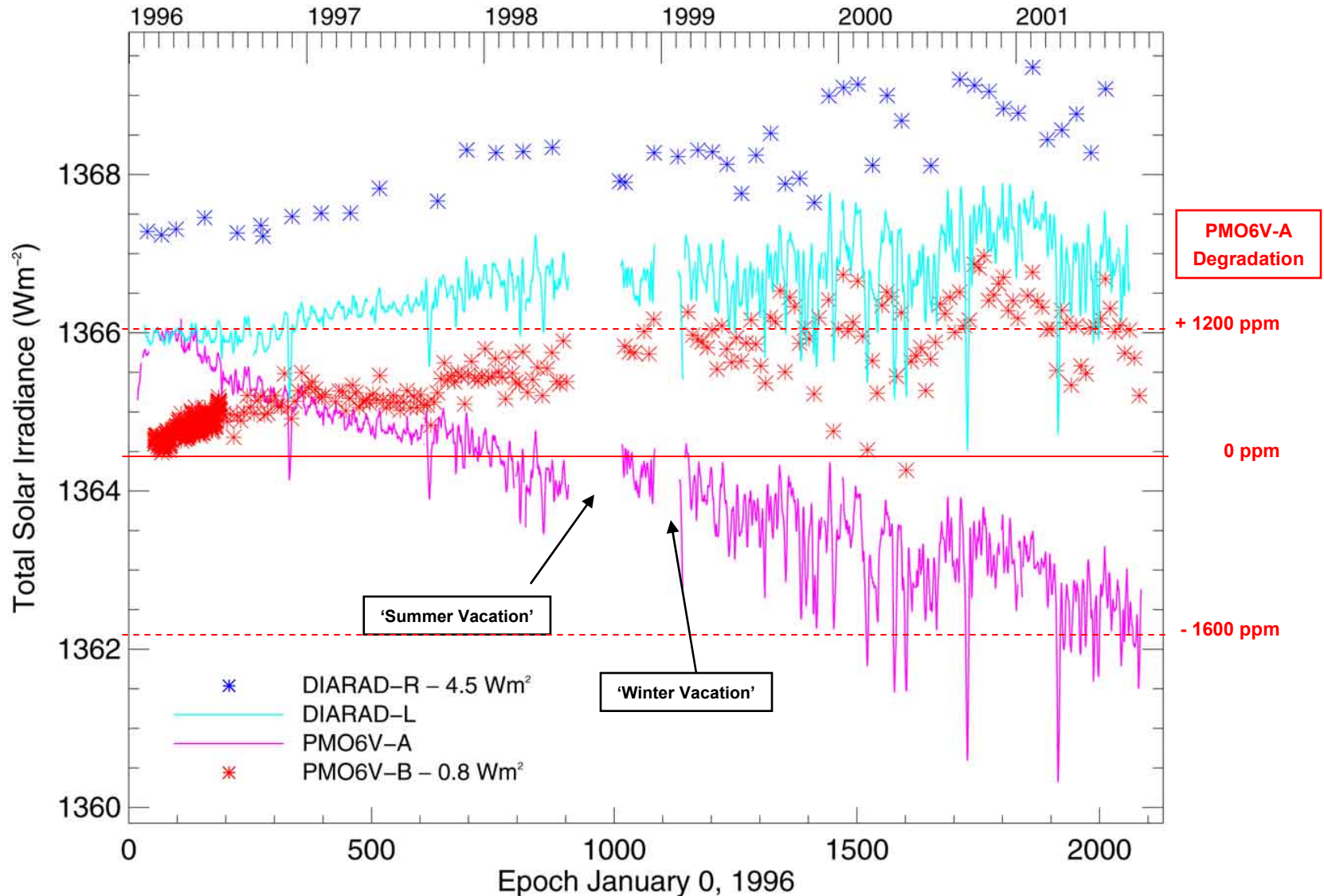


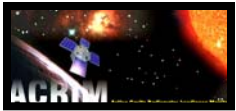
RC Willson acrim2\_acrim3\_deg 07/18/2003



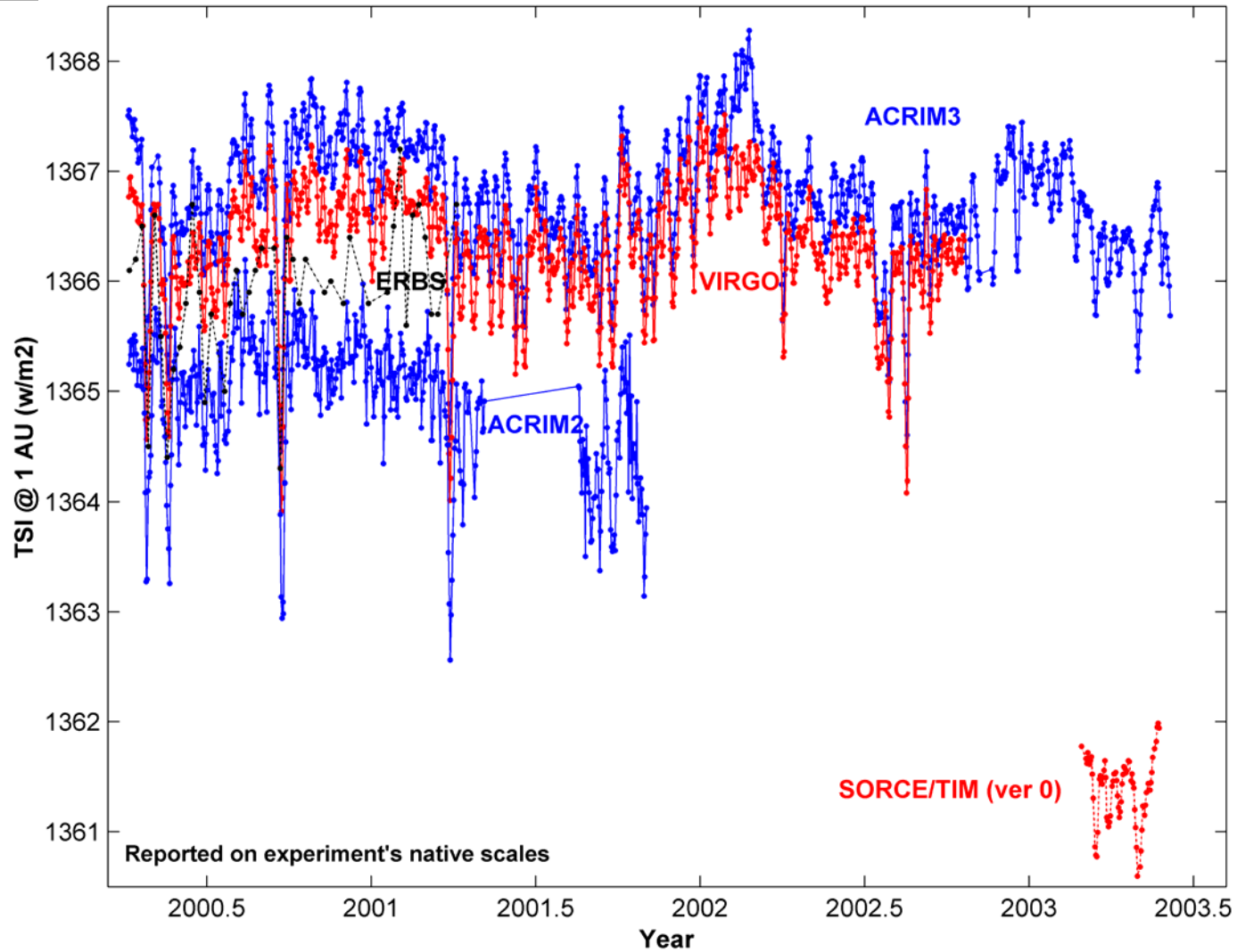
# Degradation of the SOHO/VIRGO Experiment \*

\*(Frohlich & Finsterle, IAU Symposium 2001)

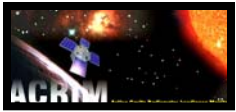




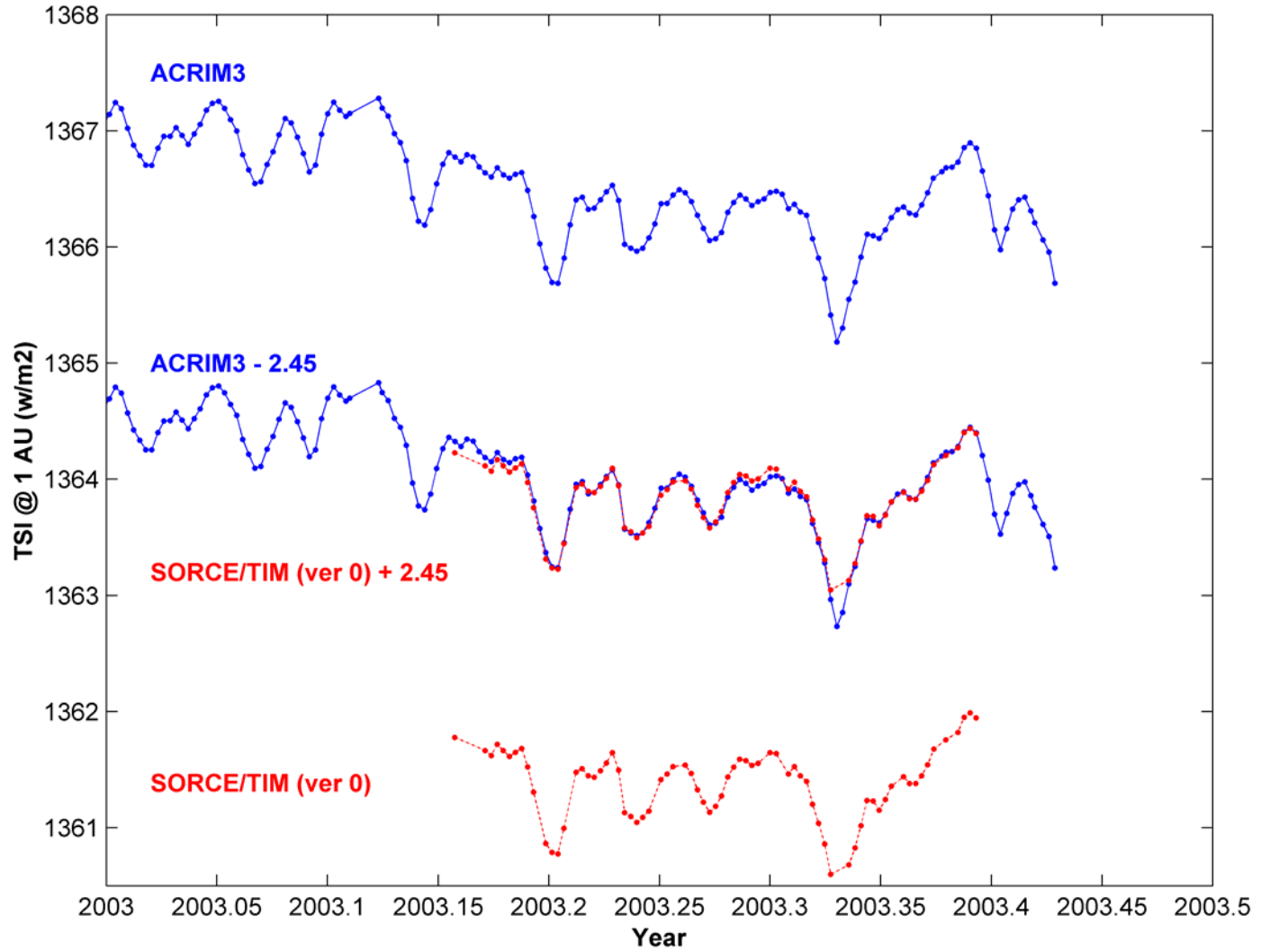
# TOTAL SOLAR IRRADIANCE MONITORING DURING ACRIM3 MISSION



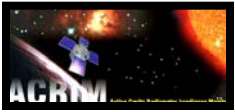
RC Willson - earth\_obs\_fig2 09/12/2003



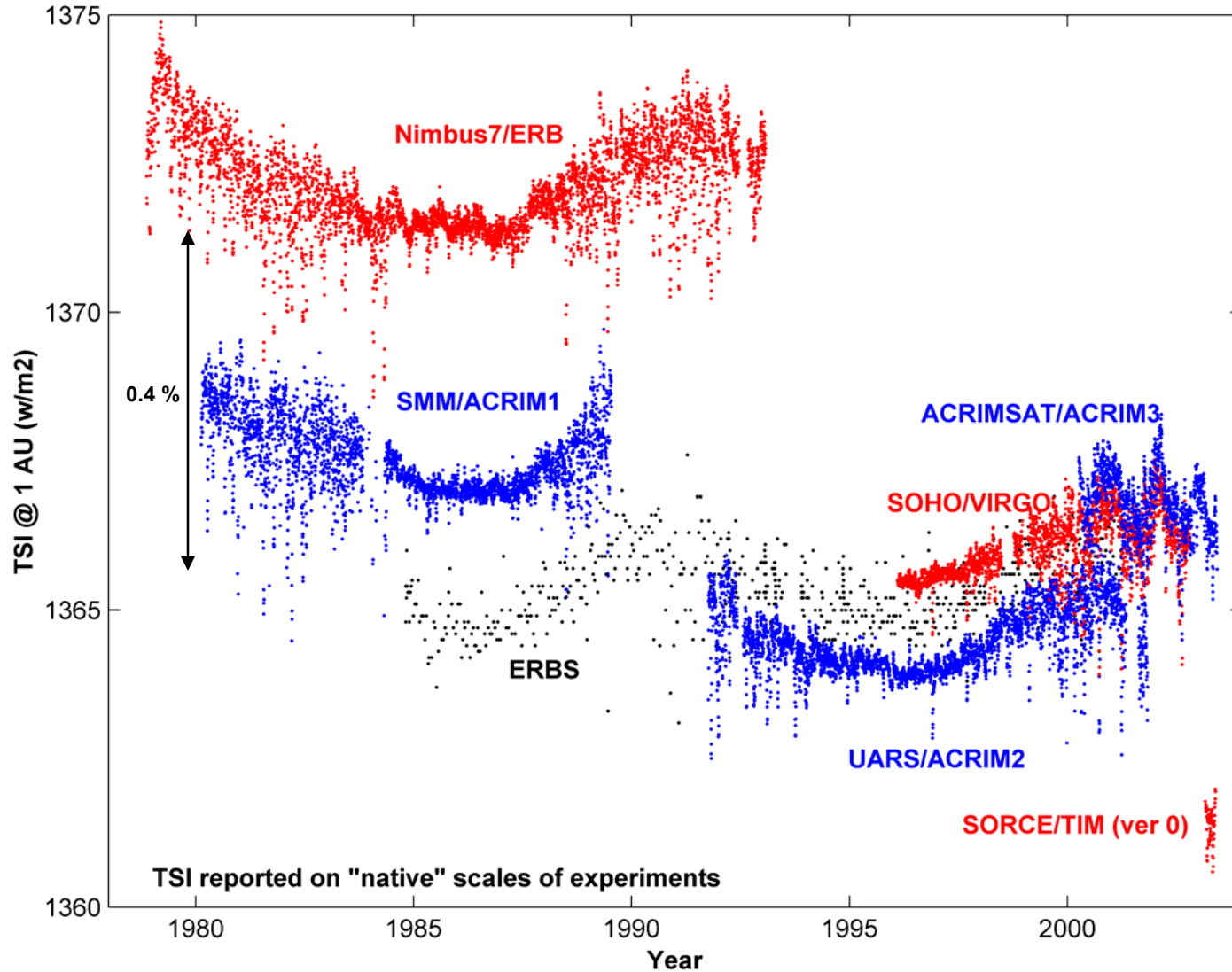
### COMPARISON OF ACRIM3 & TIM TSI RESULTS



RC Willson - earth\_obs\_fig11 09/11/2003



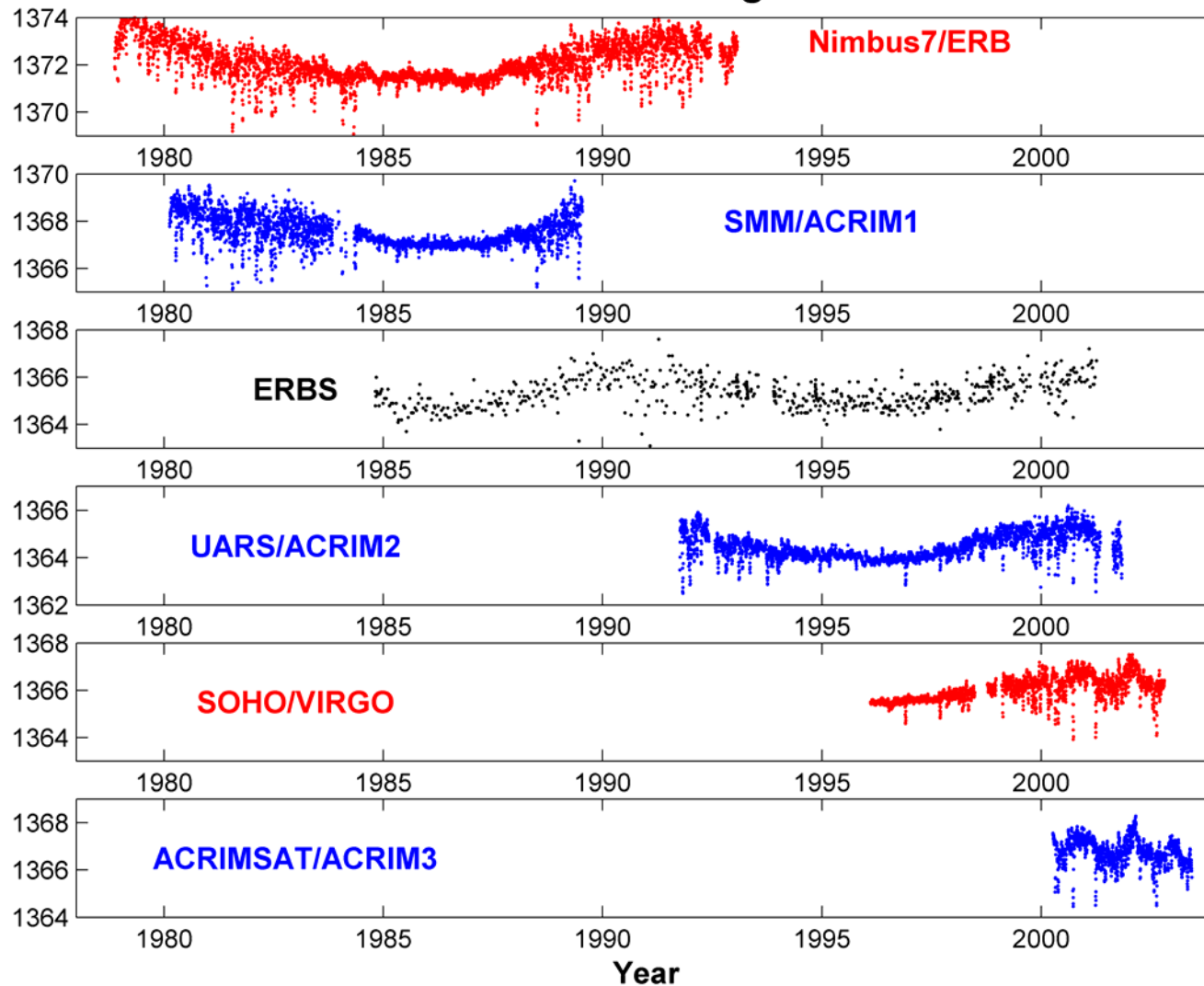
# TOTAL SOLAR IRRADIANCE MONITORING RESULTS: 1978 to Present



RC Willson, earth\_obs\_fig1 09/12/2003



## Total Solar Irradiance Monitoring Results: 1978 - 2003



TSI on "native" scales of experiments:  $W/m^2$  @ 1 AU

RC Willson, earth\_obs\_fig4 09/12/2003



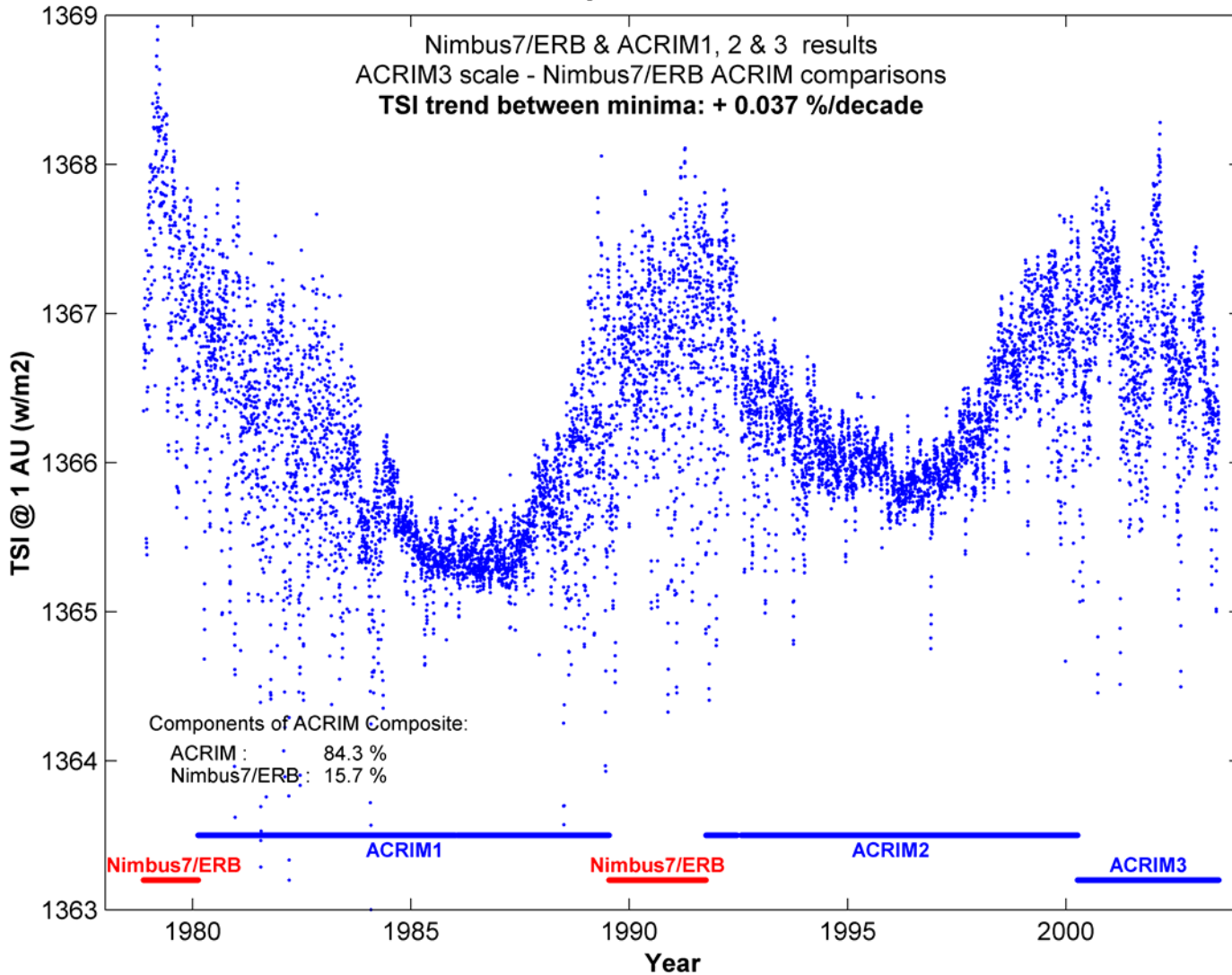
# ACRIM Composite TSI Time Series

- Published Nimbus7/ERB, ACRIM1,2 & 3 results
- Results related through overlapping comparisons
- Normalized to ACRIM3 scale
- ACRIM1 & ACRIM2 results related using overlapping NIMBUS7/ERB comparisons

Experiment	Lifetime	ACRIM Composite Contribution (period)	ACRIM Composite Contribution (Fraction of total)
Nimbus7/ERB	1978 - 1993	1978-80 1984 <sup>(1)</sup> 1989-91 <sup>(2)</sup> 1992 <sup>(3)</sup>	.053 .007 .095 .006
SMM/ACRIM1	1980 - 1989	1980 - 1989	.396
UARS/ACRIM2	1991 - 2001	1991 - 2000	.358
ACRIMSAT/ACRIM3	2000 →	2000 →	.085
<b>Total Nimbus7/ERB</b>	<b>1978 – 1993</b>	<b>1978 - 1992</b>	<b>0.157</b>
<b>Total ACRIM</b>	<b>1980 - 2003</b>	<b>1980 - 2003</b>	<b>0.843</b>
(1) ACRIM1 data loss during SMM/Shuttle repair mission (2) ACRIM Gap between ACRIM1 and ACRIM2 experiments (3) ACRIM2 data loss during UARS solar panel problem			



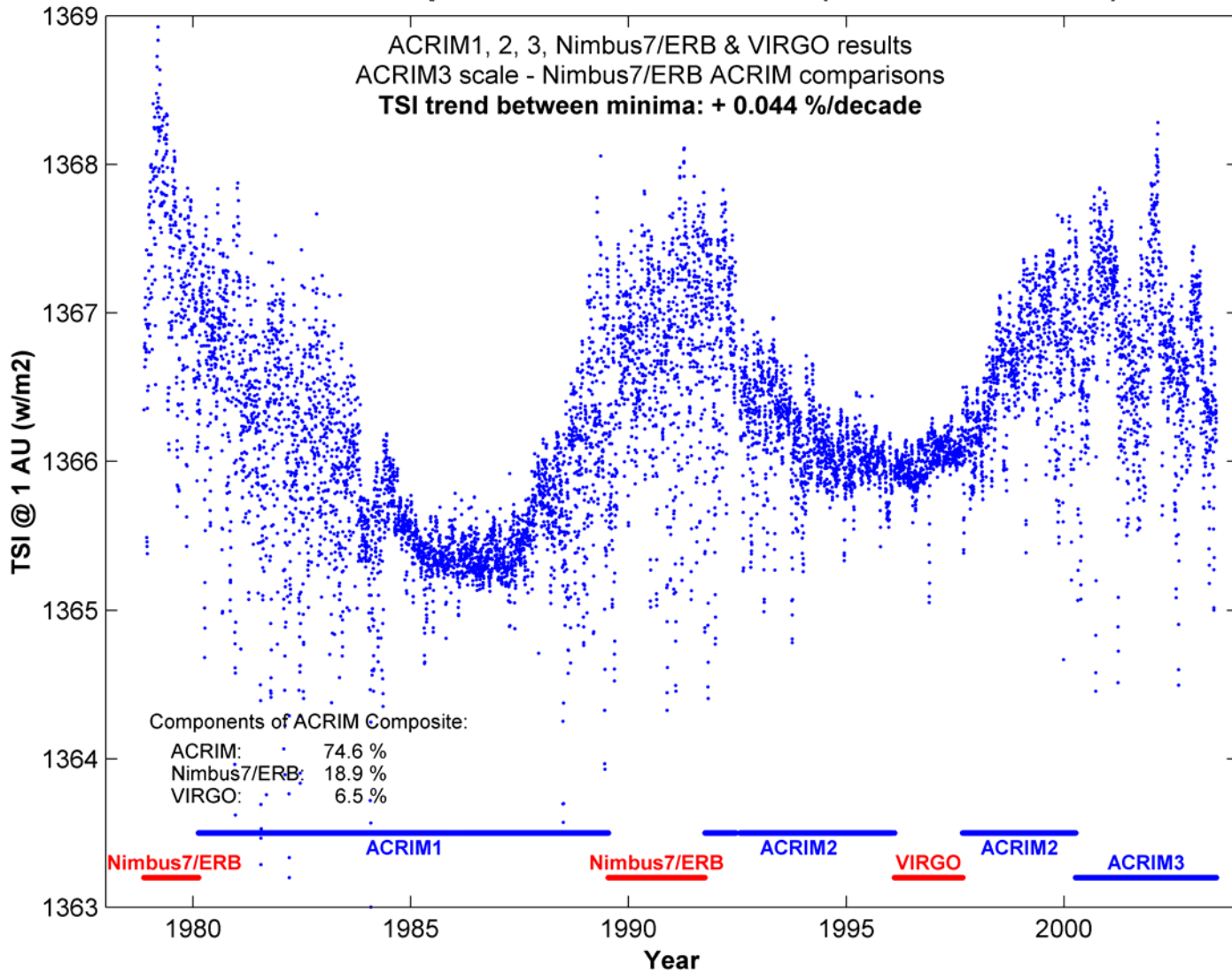
# ACRIM Composite TSI Time Series



RC Willson, earth\_obs\_fig9 09/12/2003



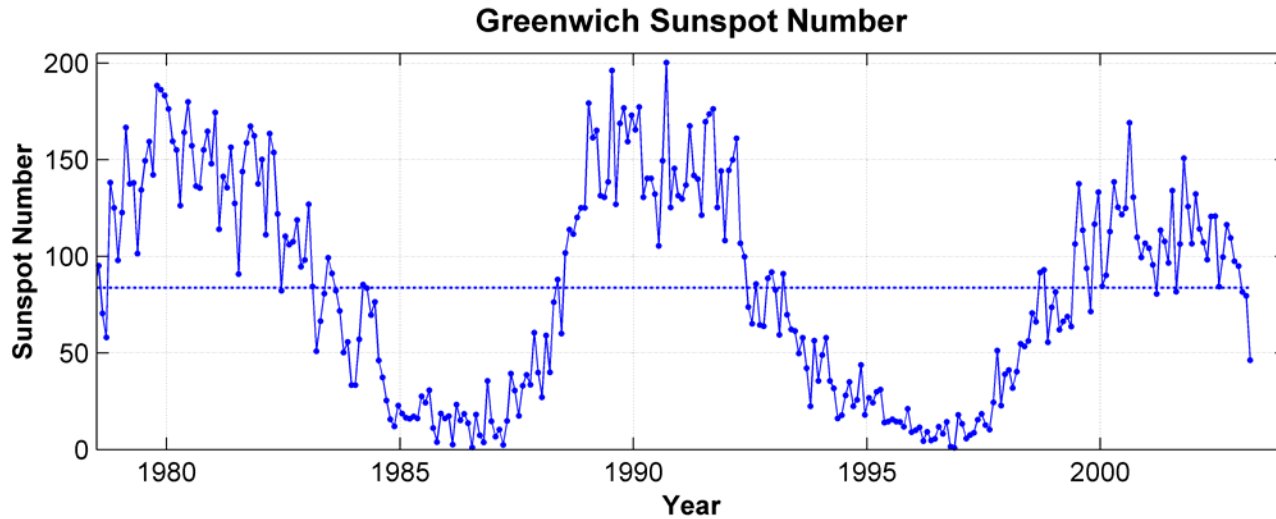
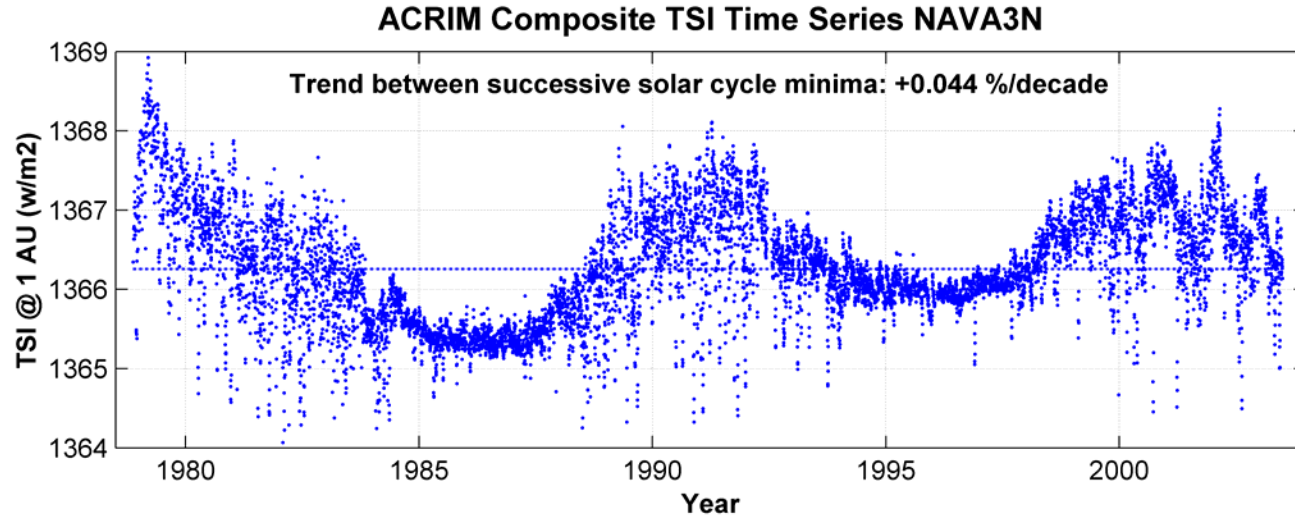
## ACRIM Composite TSI Time Series (w/VIRGO results)



RC Willson, earth\_obs\_fig8 09/12/2003



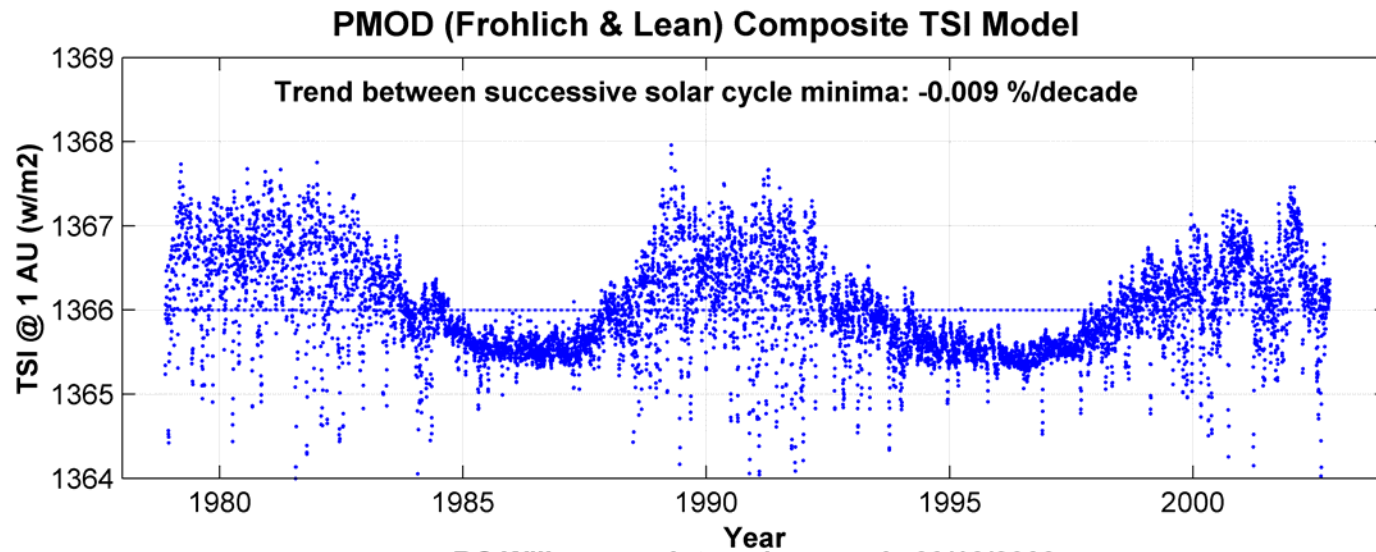
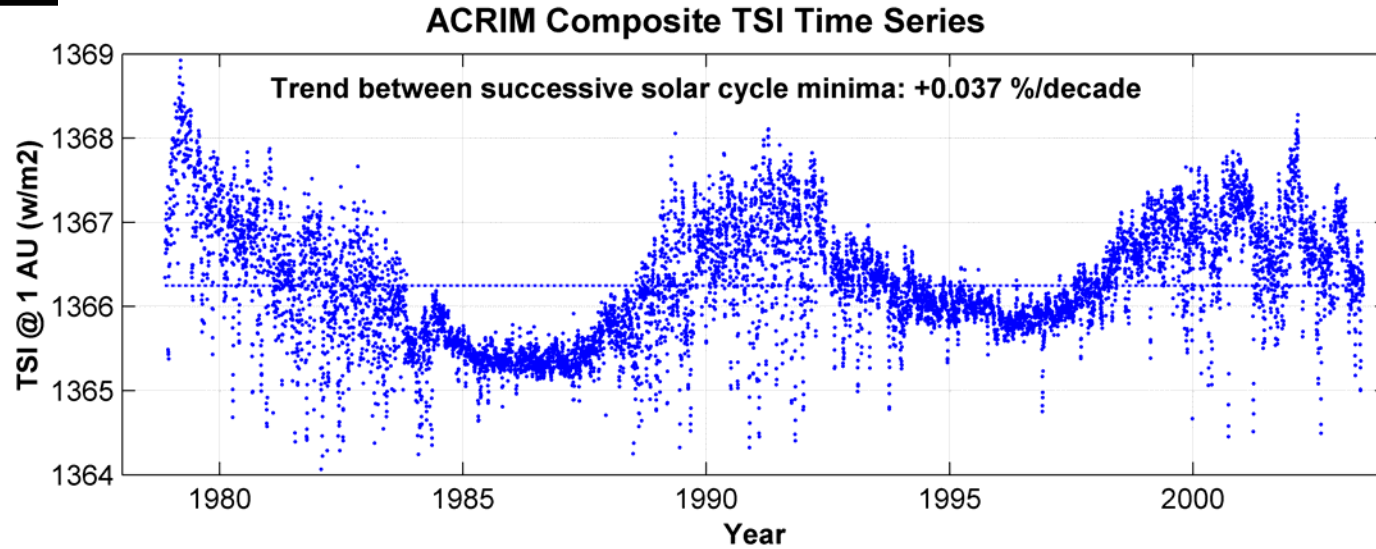
# Comparison of ACRIM Composite TSI and Greenwich Sunspot Number



RC Willson, coplot\_nava3n\_gssn 07/18/2003

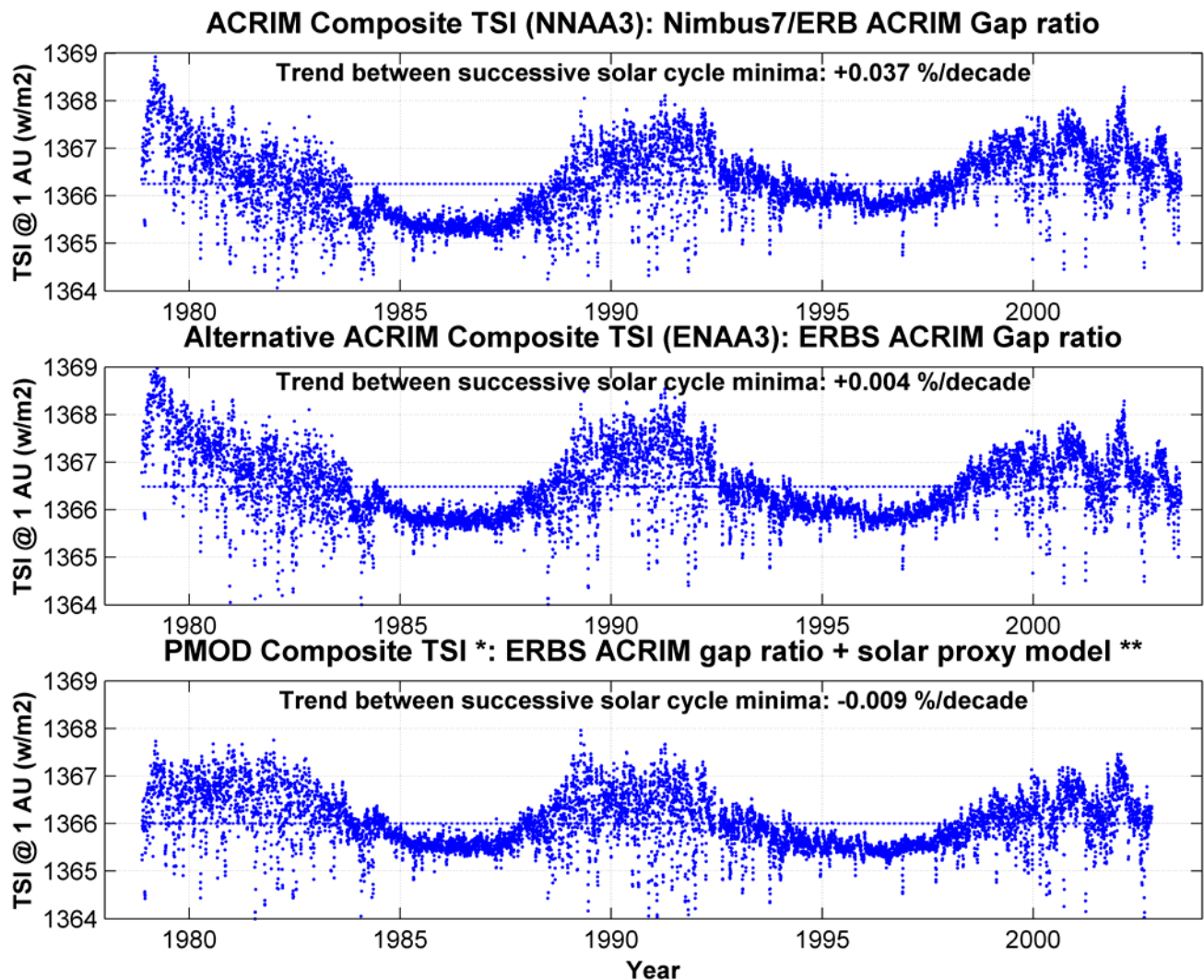


# Comparison of ACRIM and PMOD Composite TSI

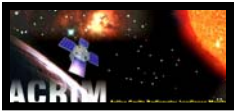


RC Willson, coplot\_acrim\_pmod 09/12/2003

# The trend difference between ACRIM & PMOD composites is an artifact of using Nimbus7/ERB or ERBS ACRIM gap comparisons

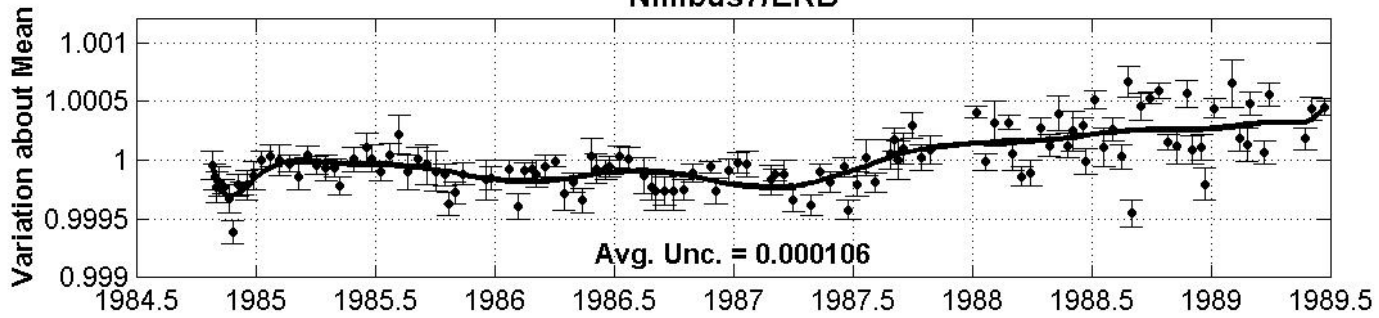


\* (Frohlich & Lean) \*\* (Foukal & Lean) RC Willson, coplot\_acrim\_enaa3\_pmod 09/15/2003

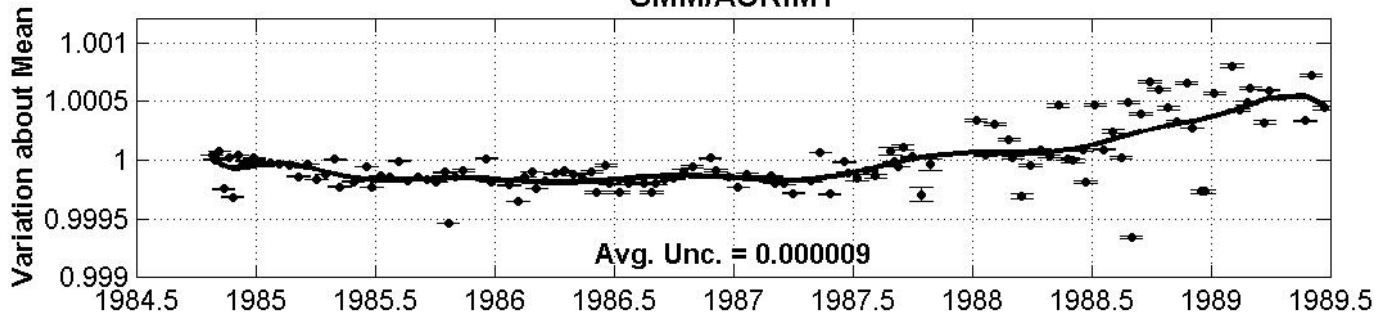


# Comparison of Nimbus7/ERB, SMM/ACRIM1 and ERBS results (Simultaneous Daily Means)

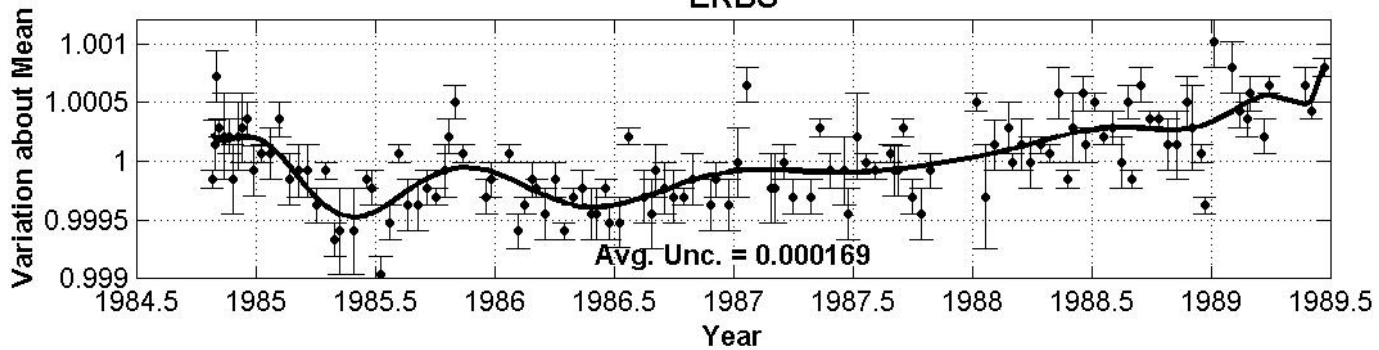
## TSI Observations and Uncertainties - ACRIM1 Period Nimbus7/ERB



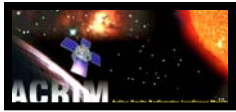
## SMM/ACRIM1



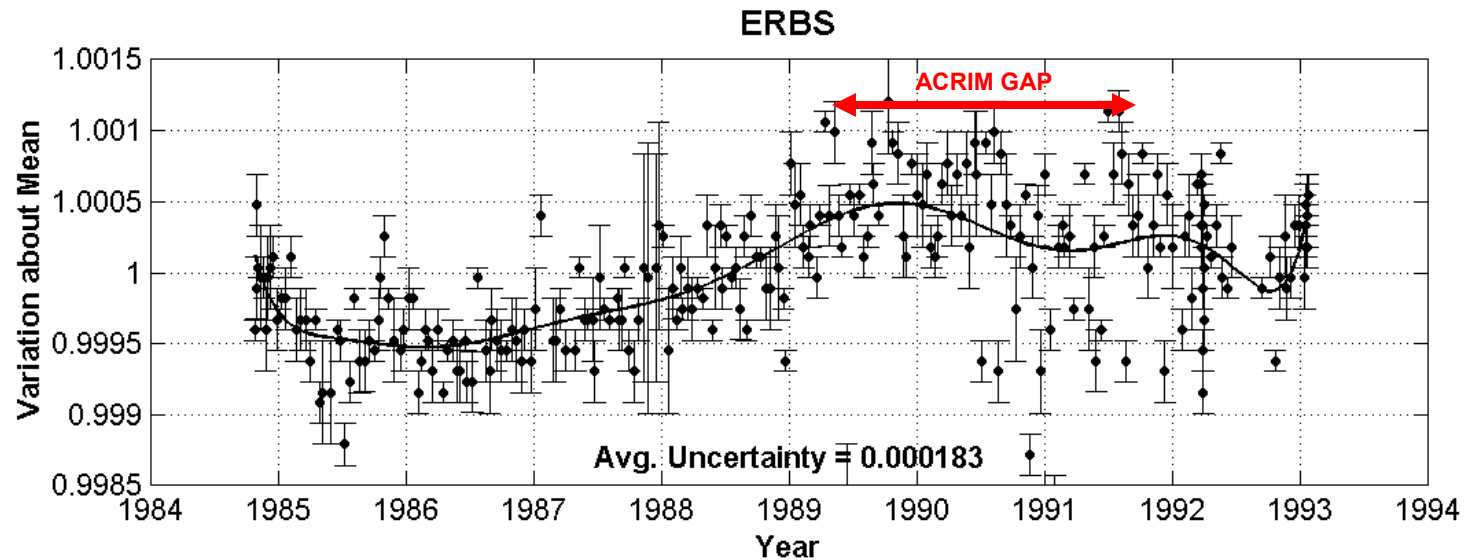
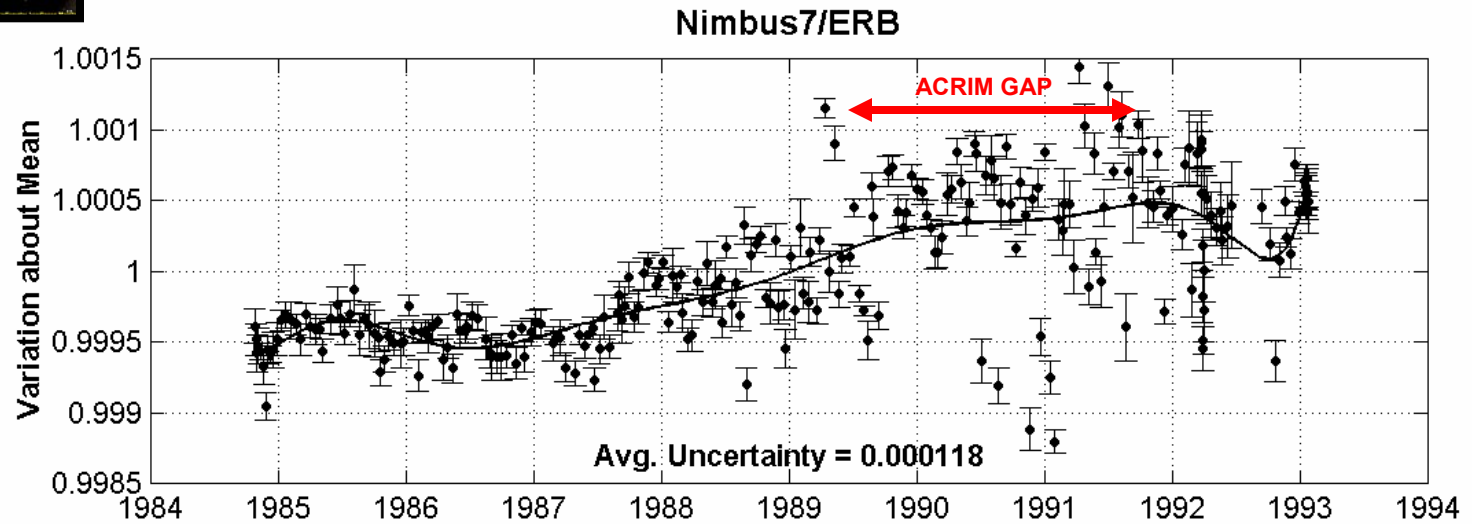
## ERBS



RC Willson, coplot\_cna1e\_3pno\_err 12/01

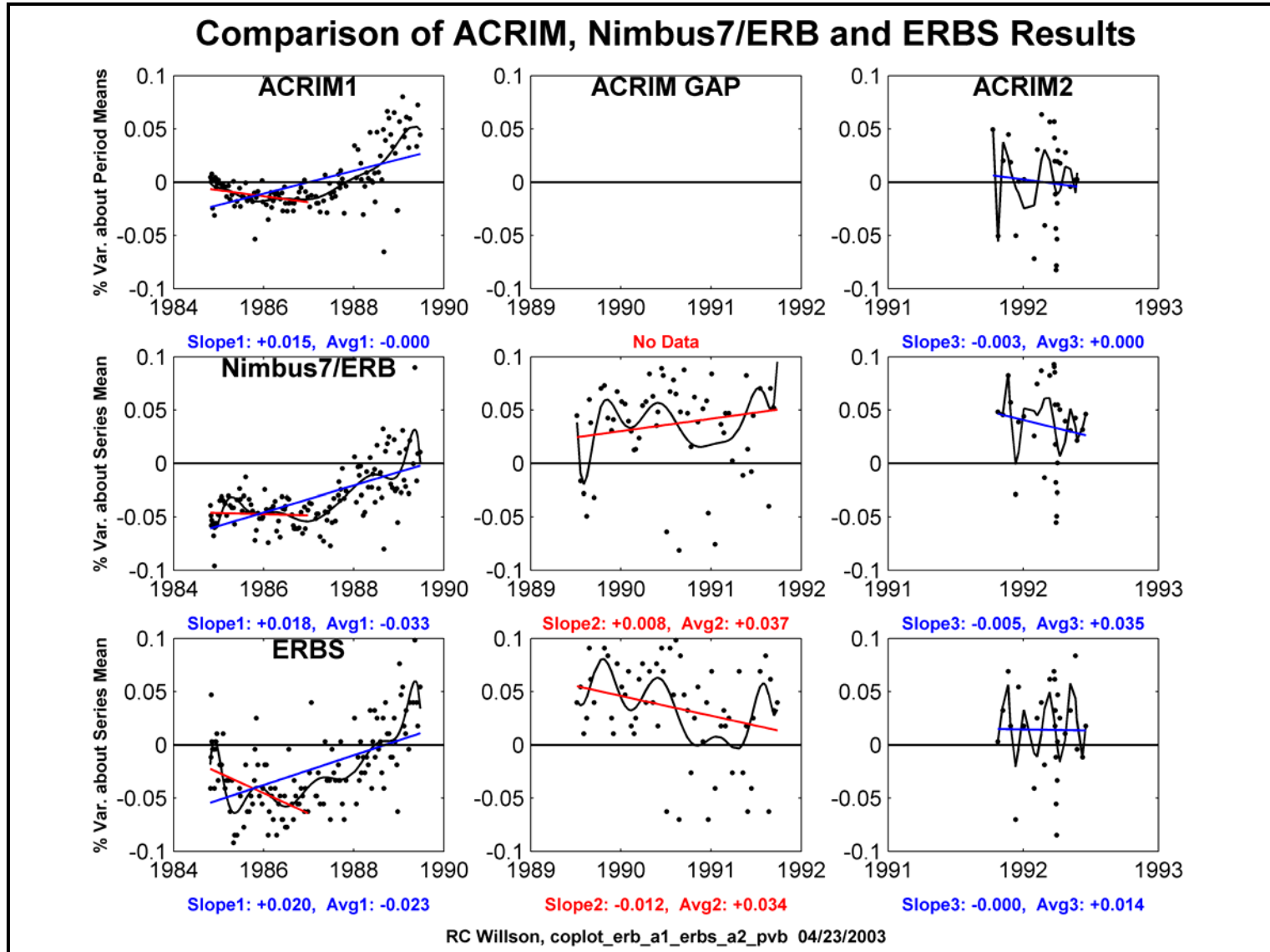


# Comparison of Nimbus7/ERB and ERBS results





# Comparison of TSI Observations during ACRIM1, ACRIM Gap and ACRIM2 Periods





# Composite TSI - Observations

## Observations

- **Uncorrected ERBS degradation during ACRIM gap = ACRIM-PMOD trend difference**
- **PMOD alterations of ERB results during ACRIM gap = ACRIM-PMOD trend difference**
- **PMOD degradation of ACRIM1 during solar cycle 21 maximum based on incorrect assumptions about ACRIM1 'spin mode' performance**
- **PMOD adjustments of published ACRIM1 and Nimbus7/ERB results:**

**Not based on analysis of basic experiment data or algorithms**

**Driven by effort to conform PMOD composite to TSI solar proxy models**



# Composite TSI Observations and Conclusions

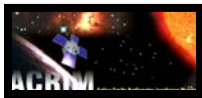
## Conclusions

- ‘Zero’ PMOD composite trend is an artifact of ERBS degradation during ACRIM gap
- Lower PMOD composite TSI at solar maxima is an artifact of:

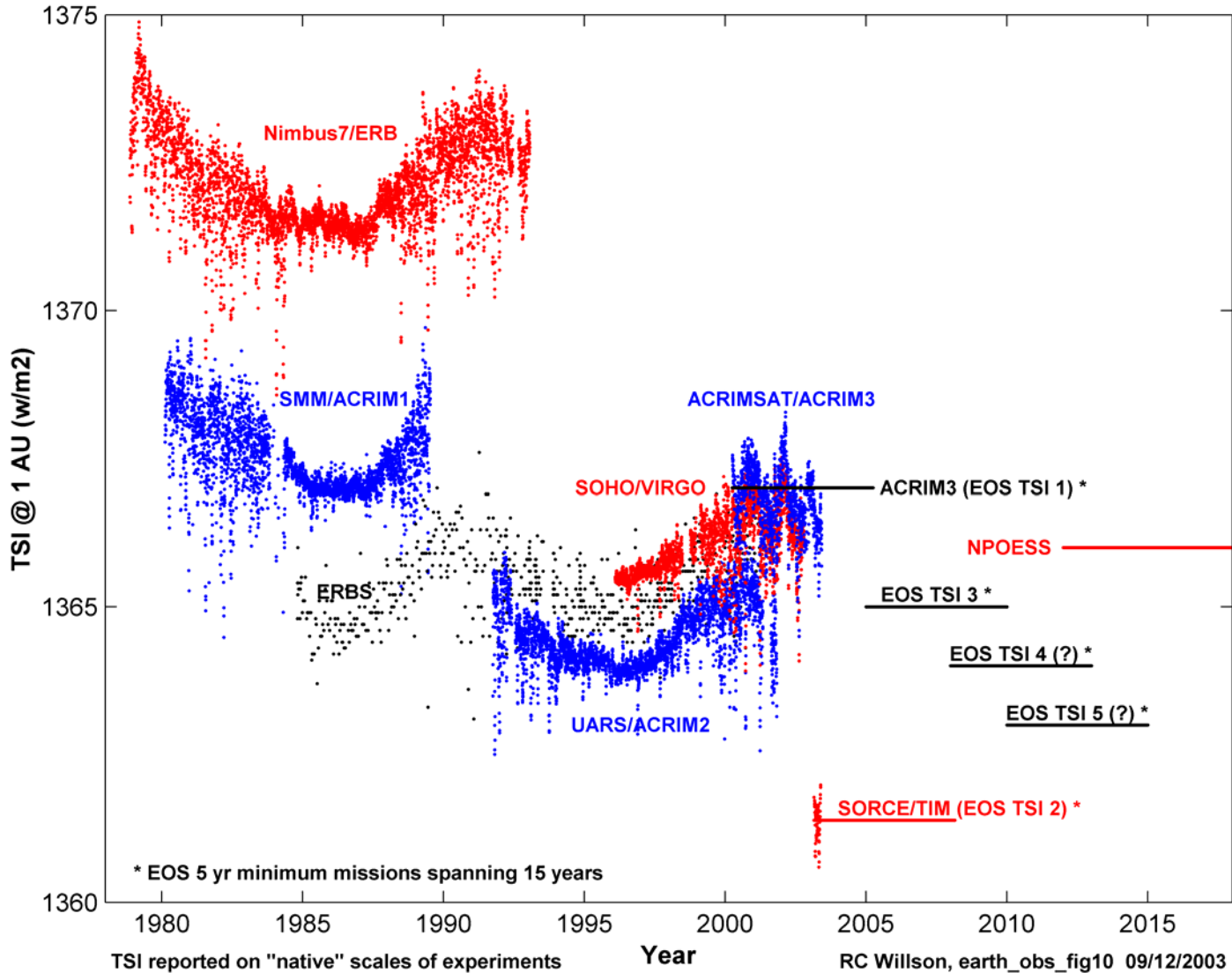
**Cycle 21:**                      **Alteration of published ACRIM1 and Nimbus7/ERB results to agree with solar proxy models**

**Cycles 22 & 23:**              **ERBS degradation during ACRIM gap**

- **TSI solar proxy models are not competitive in precision or traceability with observational results**



# TSI MONITORING RESULTS AND AN OVERLAP- REDUNDANCY STRATEGY





# TSI Database Continuity Strategy

## Observations

- TSI traceability from 1978 to present provided by a redundant Overlap Strategy: **~ 100 ppm**
- TSI observational traceability goal for climate change: **~ 100 ppm on a centennial time scale**
- Traceability achievable with a redundant Overlap Strategy and current instrumentation: **~ 5 ppm/yr**
- SI uncertainty required for paradigm change in TSI observational strategy: **100 ppm**
- SI uncertainty achieved by satellite instrumentation: **not yet demonstrably less than 1000 ppm**
- Achievement of 100 ppm SI uncertainty to date: **laboratory instrumentation at LHe temperatures**

## Conclusions

- An Overlap Strategy provides maximum TSI database traceability with current technology
- Redundant satellite experiments are required to prevent single point failure in the Overlap Strategy