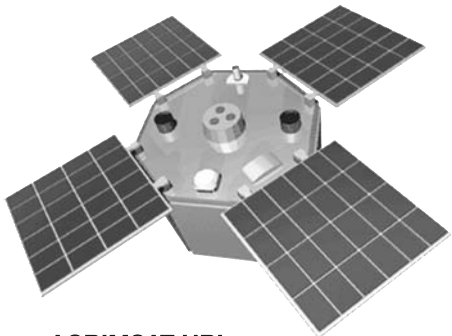
ACRIMSAT

Active Cavity Radiometer Irradiance Monitor Satellite



ACRIMSAT URLs

Science Team: www.acrim.com

Instrument Team: acrim.jpl.nasa.gov

Summary

ACRIMSAT was launched on December 20, 1999, as a secondary payload on a Taurus launch vehicle and carries the Active Cavity Radiometer Irradiance Monitor 3 (ACRIM3) instrument. The science mission began on April 5, 2000, following a period of on-orbit adjustment of the solar-pointing software on ACRIMSAT. The purpose of ACRIM3 is to study Total Solar Irradiance (TSI). ACRIM3, the third in a series of ACRIM solar-monitoring experiments built for NASA by the Jet Propulsion Laboratory (JPL), extends the database begun by ACRIM1, launched in 1980 on the Solar Maximum Mission (SMM) spacecraft, and continued by ACRIM2, launched on the Upper Atmosphere Research Satellite (UARS) in 1991. ACRIMSAT/ACRIM3 completed its five-year Minimum Mission in 2005 and recently began the second year of its Extended Mission. Spacecraft and instrument engineering vital signs indicate that operations could continue for at least another decade. The spacecraft orbit will not decay significantly for several decades.

Instrument

- Active Cavity Radiometer Irradiance Monitor (ACRIM3)

Point of Contact

- *ACRIMSAT Principal Investigator:* Richard Willson, Columbia University

Other Key Personnel

- *ACRIMSAT Program Scientist:* Don Anderson, NASA Headquarters
- *ACRIMSAT Program Executive:* Lou Schuster, NASA Headquarters

Key ACRIMSAT Facts

Orbit:

Type: Near polar, sun-synchronous

Altitude: 713 km (apogee), 672 km (perigee)

Equatorial Crossing: 10:00 a.m.

Inclination: 98°

Period: 98.6 minutes

Dimensions: 1 m^3

Downlink: Table Mountain Observatory (JPL)

Design Life: 5-year minimum lifetime

Partners

Columbia University, Center for Climate Systems Research: Science team

Jet Propulsion Laboratory: ACRIM3 instrument, ground station, satellite operation, data archiving

Orbital Sciences Corporation: ACRIMSAT satellite, Taurus launch vehicle

Langley Research Center (LaRC), Distributed Active Archive Center (DAAC): Archive of ACRIM3 results

Mission Type

Earth Observing System (EOS) Systematic Measurements

Launch and Location

- *Date and Location:* December 20, 1999, from Vandenberg Air Force Base, California
- *Vehicle:* Taurus

Relevant Science Focus Areas

(see NASA's Earth Science Program section)

- Climate Variability and Change
- Water and Energy Cycles

Related Applications

(see Applied Sciences Program section)

- Carbon Management
- Energy Management
- Public Health

ACRIMSAT Science Goals

- Extend the TSI observational database with maximum precision and traceability.

- Continue the TSI monitoring precision-overlap measurement paradigm to relate past and future TSI databases through ACRIM3 results using comparisons with the UARS/ACRIM2 experiment, the Solar Heliospheric Observatory (SOHO)/Variability of Solar Irradiance and Gravity Oscillations (VIRGO) experiment, and the Solar Radiation and Climate Experiment (SORCE)/Total Irradiance Monitor (TIM) experiment.

- Develop a composite TSI time series incorporating results from satellite TSI observations since 1978.

- Investigate the multi-decadal upward TSI trend during solar cycles 21–23 using ACRIM3 observations of the solar activity minimum preceding cycle 24.

- Provide a redundant monitoring capability in an extended mission to prevent catastrophic loss of the TSI long-term database in the event of the failure of the SORCE/TIM experiment.

ACRIMSAT Mission Background

Sustained changes in the TSI of as little as a few tenths of one percent per century could be important causal factors for significant climate change. It is clear from paleo-climate research that solar-irradiance-driven climate changes have occurred in the past. There is compelling evidence that some of these may have been at least partially driven by intrinsic solar variability. A precise, long-term record of TSI is required to provide empirical evidence of the Sun's role in climate change and to separate its effect from other climate forcings such as greenhouse warming. The same record, together with other solar observations, will also yield an improved understanding of the physics of the Sun and the causes of luminosity variations, and could eventually lead to a predictive capability for solar-driven climate change.

In 1994, the National Research Council published its findings regarding research priorities for "Solar Influences on Global Change," one of the seven science elements of the U.S. Global Change Research Program (USGCRP). Its recommendations include "monitoring total and spectral solar irradiance from an uninterrupted, overlapping series of spacecraft radiometers employing in-flight sensitivity tracking" as this element's highest priority and most urgent activity. The ACRIMSAT/ACRIM3 experiment is designed to be a cost-effective, small-satellite approach to meeting the total solar irradiance priority during the first phase of the Earth Observing System (EOS) program.

There is a contiguous satellite TSI observational database extending over the past 25+ years with useful precision for solar physics and climatology investigations. A composite TSI database can be constructed from this database by reconciling published results from the Nimbus-7/Earth Radiation Budget (ERB), SMM/ACRIM1, UARS/ACRIM2, and ACRIMSAT/ACRIM3 experiments to a common scale, using overlapping comparisons. Key to this process is determining the relationship of the results of the non-overlapping ACRIM1 and ACRIM2 experiments. The ACRIM composite approach, which reconciles the unmodified results published by the science teams of each experiment to the ACRIM3 scale, demonstrates a resolved + 0.04 (± 0.01) %/decade trend between the solar minima of 1986 and 1996, using the Nimbus-7/ERB data to relate ACRIM1 & 2 results.

Observations by ACRIM and other satellite experiments have established the Sun as a variable star. Its luminosity varies by more than 0.3% during the passage of large sunspot groups across the visible side of the Sun (1 week–10 days) and by 0.1% over a solar cycle in phase with the level of solar magnetic activity (10–11 years). It demonstrates a secular trend at a rate of +0.04% per decade between the solar cycle minima in 1986 and 1996, the physical cause of which has yet to be discovered. Photometric observations of many solar-type stars have revealed that brightness variations correlated with magnetic activity like the Sun's are a common phenomenon. Many solar-type stars demonstrate higher variability than the Sun, leading to speculation that the Sun's variability may have been greater in the past and may be greater again in the future. The 0.04%/decade trend during solar cycles 21–23 is supported by recent findings by solar physicists observing similar trends in other luminosity-dependent phenomena. This would clearly have significant implications for climate change.

The lifetimes of previous ACRIM experiments, designed for 18-month-minimum missions, have averaged nearly 10 years (e.g., UARS/ACRIM2 acquired science data from October 4, 1991 through November 1, 2001). ACRIM3, designed to meet the EOS 5-year-minimum mission requirement, has already exceeded that by over a year and indications from analyses of ACRIMSAT/ACRIM3 satellite, instrument, and orbit data are that it could function without loss of data quality for at least another decade. The ACRIM3 experiment began its extended mission in 2005 and it is hoped that it will be able to continue well through the next solar-activity minimum between the solar maxima of cycles 23 and 24.

The SORCE satellite carrying the TIM instrument, launched in 2003, will pick up the thread of TSI monitoring during EOS phase 2. Overlapping comparisons will establish the relationship between TIM and ACRIM3 at the level of their mutual precisions. This is essential in sustaining the long-term TSI database at a level of traceability required for climate investigations of solar forcing, since the 'absolute' uncertainty of this technology (~0.1% in S.I. units) is insufficient. Operation of the ACRIM3 mission through at least the next solar-activity minimum (~2006) is important for the long-term TSI database for two reasons: 1) the most precise information on the nature of any long-term variation in TSI that may be of climatological significance will be most traceably resolved by extension of the ACRIM2-ACRIM3 results; and 2) the redundancy provided by coincident ACRIM3 and TIM experiments is required to prevent loss of the database in the event of the failure of one of them.

Discovery of subtle but important rates of TSI variability on solar cycle (~ 1000 ppm) and longer time scales (~ 400 ppm/decade) has made it clear that a useful long-term TSI database for climate change and solar physics should have the maximum traceability accessible using current technology. This can be provided by a measurement paradigm employing the relative precision of overlapping satellite TSI monitors, which can be smaller than 5 ppm/yr (ACRIM3 traceability is 3 ppm/yr). Comparable traceability using sensor accuracy is not possible since the 'absolute' (solar irradiance) uncertainty of the ambient temperature from sensors used in all satellite TSI experiments to date is not significantly less than ~1000 ppm. Sensors operating at liquid helium temperatures have demonstrated solar irradiance accuracy in the 100 ppm range, but this level of performance has only been realized by ground-based, laboratory instrumentation that is not practically adaptable to satellite operations.

TSI proxy models using linear regression techniques and solar emission proxies related to solar magnetic activity are not competitive in accuracy, precision, or traceability with satellite TSI observations. Regression models, misused to 'fine tune' TSI observations in some recent TSI composite time series, can actually offer only qualitative information regarding solar-luminosity variability on all time scales that is orders of magnitude inferior to even the least traceable satellite TSI observations.

The single approach capable of providing the required precision of the long-term TSI database with current measurement technology employs a redundant 'overlap strategy' in which successive ambient-temperature TSI satellite experiments are compared in flight, transferring their operational precision to the database.

ACRIM3

Active Cavity Radiometer Irradiance Monitor

ACRIM3 was designed to monitor the total solar irradiance with the highest precision and traceability accessible using current technology. It continues the state-of-the-art measurements of TSI begun with the SMM/ACRIM1 and UARS/ACRIM2 experiments. The SMM and UARS satellites were launched in 1980 and 1991, respectively.

The ACRIMSAT spacecraft was launched on December 20, 1999, into a 700-km sun-synchronous orbit with a 98° inclination. Instrument checkout and optimization of solar-pointing algorithms were carried out during January–March 2000. The science mission

Key ACRIM3 Facts

Heritage: ACRIM1 (SMM) and ACRIM2 (UARS)

Instrument Type: Active Cavity Radiometer type 4 sensors

Scan Type: Solar pointed

Solar Pointing: Spin stabilization about axis of symmetry

Calibration: By metrology of instrument optics and electronics in the Systeme Internationale (SI) (International System of Units)

Field of View: ± 2.5°

Instrument IFOV: ± 1.0°

Sampling Interval: ~2 minutes

Physical Size: 0.1 m^3

Mass: 10 kg

Power: 5 W (average)

Duty Cycle: Continuous

Data Rate: < 1 kbps

Direct Readout: No

began April 5, 2000, and has provided an average of 65 minutes of TSI data per orbit.

ACRIMSAT References

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ACRIMSAT Data Products

For more information about the data products please see EOS Data Products Handbook, Volume 2 available at: eospso.gsfc.nasa.gov/eos_homepage/for_scientists/data_products/.

Product Name or Grouping	Processing Level	Coverage	Browse Available
ACRIM3 Instrument *Data Set Start Date: April 5, 2000*			
Radiometric Products	1, 2	~2 minutes	Daily solar irradiance graphs

ACRIMSAT Data Products