Living with a Star
An Overview of Solar Space Missions

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Contents

Acknowledgement of Sources

This material was assembled from information on the home pages of the various missions covered. Links are given in the body of the document.

The author’s purpose in assembling the document was to communicate the depth of planning and the breadth of collaborative effort over tens of years that have been devoted to gaining an understanding of the nature of our parent star and how it affects the solar system.

Introduction

Earth orbits a star. The Sun's radiation and solar wind influence Earth's atmosphere and surface environment. Ionization of the atmosphere affects the operation of electricity distribution grids and communication networks. The Sun's inconstant output has long-term climate change implications. An ability to predict solar outbursts is essential for the protection of spacecraft systems and astronauts.

Study of the Sun and the solar wind from the vantage point of space has been an intense research activity from the start of the Space Age.

Our premier solar space observatory is the ESA/NASA Solar and Heliospheric Observatory, SOHO. Since its launch in 1995, SOHO has exponentially expanded our knowledge of the Sun. The SOHO mission has given us:

i) A good understanding of how the Sun generates the Solar wind and Coronal Mass Ejection events.
ii) A view into and through the Sun. SOHO teams have developed methods for detecting and decoding solar seismic waves to image processes occurring beneath the surface of the Sun and even on its far side.
iii) Sufficient data to model the internal processes producing the eleven-year solar cycle and predict solar activity. (The next solar cycle is expected to be 30 to 50% more intense that the preceding cycle and to arrive 6 to 12 months late.)

Over 2000 scientists have participated in SOHO observation programs. Over the past few years, SOHO researchers have had about one paper per day accepted for publication in scientific journals.

Despite some operational scares and aging systems, SOHO continues to return copious amounts of data. In May 2006, funds were allocated to extend the mission to December 2009.

Five new solar spacecraft are planned to join SOHO in orbit, over the next two years.

Solar B, built by the Japan Aerospace Exploration Agency (ISAS/JAXA) is to be launched in 2006. It will carry a coordinated set of optical, EUV, and X-ray instruments that will investigate the interaction between the Sun's magnetic field and its corona.

NASA's STEREO mission, a pair of spacecraft, will also be launched in 2006. The two spacecraft will team with SOHO, to study the Sun's atmosphere. SOHO critical third point of view will assist the analysis of STEREO's observations. SOHO's coronagraph, which blocks the glare of the solar disk, will continue to enable the tenuous outer atmosphere of the Sun to be studied.

A technology demonstration spacecraft to be launched by ESA in 2007, Proba-2 will carry a complementary instrument to SOHO's EIT camera. EIT will continue to gather data on the origin and early development of solar eruptions. Proba-2's camera will track them into space.

NASA's Solar Dynamics Orbiter will be launched in 2008. It will be the first Space Weather Research Network mission. SDO will help us understand the Sun's influence on Earth and Near-Earth space by studying the solar atmosphere in many wavelengths simultaneously.

This fleet of spacecraft will advance the *International Living With a Star* program, an international collaboration of scientists dedicated to a long-term study of the Sun and its effects on Earth and the other planets.

Current and Completed Solar Missions

Alphabetical Order

Many spacecraft missions have been launched to study the Sun. Summary details of some completed and current missions follow. Web page links to mission sites point the reader to the pages from which these summaries were derived.

ACE
Advanced Composition Explorer
NASA
http://www.srl.caltech.edu/ACE/

ACE was launched in 1997. It monitors the stream of accelerated particles coming from the Sun, interstellar and galactic sources that constantly bombard the Earth. This study contributes to our understanding of the formation and evolution of the solar system and astrophysical processes. ACE has six high-resolution sensors and three monitoring instruments to sample low-energy particles of solar origin and high-energy galactic particles.

ACE performs measurements over a wide range of energy and nuclear mass, under all solar wind flow conditions and during both large and small particle events including solar flares. ACE provides near-real-time solar wind information over short time periods. ACE can provide warning, about one hour in advance, of geomagnetic storms that can overload power grids, disrupt communications, and endanger astronauts in low Earth orbit.

ACE orbits the L1 libration point, a position of gravitational equilibrium between the Sun and Earth and about 1.5 million km from Earth. An elliptical orbit with a major axis of approximately 200,000 km ensures that ACE has a prime view of the Sun and galactic regions. The spacecraft has enough propellant to remain operational until 2019.

Cluster
ESA
http://clusterlaunch.esa.int/
The four cluster spacecraft were launched in July and August 2000. The set of spacecraft are in elliptical polar orbits with perigees of 19 000 km, apogees of 119

000 km and orbital periods of 57 hours.

The mission is investigating the small-scale structure in three dimensions of the Earth's plasma environment, such as those involved in the interaction between the solar wind and the magnetospheric plasma, in global magnetotail dynamics, in cross-tail currents, and in the formation and dynamics of the neutral line and of plasmoids.

The spacecraft have so far provided a detailed three-dimensional map of the magnetosphere that has surprised researchers.

The mission is scheduled to continue until Dec 2009

Genesis
NASA
http://genesismission.jpl.nasa.gov/
Launched in 2001, the Genesis spacecraft spent several years sampling the Solar Wind. The sample capsule returned to Earth on schedule in Jan 2006, but a descent stage malfunction resulted in a crash landing. Most of the samples are apparently intact.
analysis results have yet to be released

The mission's objectives are:

- To measure isotopic compositions of oxygen, nitrogen, and noble gases. These data will enable scientists to better understand the isotopic variations in meteorites, comets, lunar samples, and planetary atmospheres.
- To obtain greatly improved measures of solar elemental abundances.
- To provide a reservoir of solar matter for 21st century science research, eliminating the need for future solar wind sample return mission.

Geotail
JAXA and NASA, ISTP
http://www-istp.gsfc.nasa.gov/istp/geotail/
Launched 1992, the GEOTAIL mission is a collaborative project undertaken by the Japanese Institute of Space and Astronautical Science (ISAS) and NASA Its primary objective is to study the dynamics of the Earth's magnetotail over a wide range of distance, extending from the near-Earth region (8 Earth radii) out to the distant tail (about 200 Earth radii).

The Geotail mission measures global energy flow and transformation in the magnetotail. The main mission objective is to gather data of fundamental magnetospheric processes. Understanding of the physics of the magnetopause, the plasma sheet, and reconnection and neutral line formation, or the mechanisms of input, transport, storage, release and conversion of energy in the magnetotail will be enhanced. Geotail, together with Wind, Polar, SOHO, and Cluster projects, constitute a cooperative scientific satellite project designated the International Solar-Terrestrial Physics (ISTP) program which aims at gaining improved understanding of the physics of solar terrestrial relations.

Geotail is a two-phase mission. During the initial two-year phase, the orbit apogee was kept on the night side of the Earth by using the Moon's gravity in a series of double-lunar-swing-by maneuvers that resulted in the spacecraft spending most of its time in the distant magnetotail (maximum apogee about 200 Earth radii) with a period varying from one to four months. In February 1995, phase two was commenced as the apogee was reduced to 30 Earth radii to study the near-Earth magnetotail processes.

IMP8
NASA
ftp://space.mit.edu/pub/plasma/imp/www/imp.html

IMP8 was launched in 1973. It measures currents from solar wind ions, thus enabling the velocity, density, and temperature of the solar wind to be calculated.

The mission objective is to measure the magnetic fields, plasmas, and energetic charged particles (*e.g.*, cosmic rays) of the Earth's magnetotail and magnetosheath and of the near-Earth solar wind.

IMP8 continues to operate in its near-circular, 35 Earth Radii, 12-day orbit. It is an important adjunct to the International Solar Terrestrial Physics program, provides in-ecliptic, one Astronomical Unit baseline data for the deep space Voyager and Ulysses missions, and continues to accumulate a long-time series database useful in understanding long-term solar processes.

Interball
Russian Space Agency
http://arc.iki.rssi.ru/eng/index.htm
A international mission that ran from 1995 to 2000, INTERBALL was the first attempt to systematically investigate space plasmas by a coordinated fleet of spacecraft. It consisted of four spacecraft equipped by an international consortium and launched by the Russian Space Agency,

The program studied various plasma processes in the Earth's magnetosphere by simultaneously observing from above the polar aurora and the magnetospheric tail.

The two pairs of satellites studied the cause-and-effect relationships in the solar wind/magnetosphere interactions. Such interactions cause magnetic storms, accelerated particle beams, auroral phenomena, radio-wave emissions and variations in the neutral atmosphere. The large and small scale plasma processes which cause these phenomena are difficult if not impossible to study in the laboratory.

In 2000, after more than five years of successful operation, when the fuel resources for attitude control were depleted, the spacecraft were deliberately grounded.

Polar
NASA
http://pwg.gsfc.nasa.gov/polar/
The Polar satellite, launched in 1996, is in a highly elliptical, 86 deg inclination orbit with a period of about 17.5 hours.

It is part of the Sun-Earth Connections fleet. Polar has the responsibility for multi-wavelength imaging of the aurora, measuring the entry of plasma into the polar magnetosphere and the geomagnetic tail, the flow of plasma to and from the ionosphere, and the deposition of particle energy in the ionosphere and upper atmosphere. Polar was launched to observe the polar magnetosphere and, as its orbit has precessed with time, has observed the equatorial inner magnetosphere and is now progressing toward an extended southern hemisphere campaign.

RHESSI
The Reuven Ramaty High Energy Solar Spectroscopic Imager
NASA
http://hesperia.gsfc.nasa.gov/hessi/
Launched 2002, RHESSI is exploring the basic physics of particle acceleration and explosive energy release in solar flares. The spacecraft has successfully performed these solar observations:

- Hard X-ray imaging spectroscopy
- Hard X-ray and gamma-ray imaging above 100 keV
- Imaging in narrow gamma-ray lines
- Determination of solar gamma-ray line shapes
- Combination of spatial, spectral, and time resolution that is commensurate with physically relevant scales for energy loss and transport of >10 keV electrons
- Dynamic range to both detect microflares and make quantitative spectral measurements of the largest flares

It has also observed:

- High resolution X-ray and gamma-ray spectra of cosmic sources
- Hard X-ray images of the Crab Nebula with 2 arcsecond resolution

SMEI
Solar Mass Ejection Imager
US Navy, NSO National Solar Observatory
http://cassfos02.ucsd.edu/solar/smei_new/smei.html

The Solar Mass Ejection Imager is a proof of concept mission on the US Navy's Coriolis Spacecraft which was launched into a circular 840 km, circular, sun-synchronous orbit in 2003, The mission has a projected duration of 3 years.

SMEI is an all-sky camera experiment capable of imaging coronal mass ejections (CMEs) as they propagate from the Sun through the solar wind or inner heliosphere. SMEI can obtain 1-3 day forecasts of magnetic storms at Earth by tracking CMEs from the Sun to near-Earth space.

SMEI observed its first Earth-directed ("halo") CME in late May 2003. This fast (1000 km/s) event was detected in the all-sky SMEI images ~15 hours before it passed over the Earth on May 29-30 causing a major geomagnetic storm. The CME erupted from the Sun following two X-class flares from an active region near Sun center. The two ejections likely merged to become a single halo, which was seen moving outward near the Sun by the SoHO/LASCO coronagraphs.

SOHO
Solar & Heliospheric Observatory
ESA and NASA
http://soho.esac.esa.int/
http://soho.nascom.nasa.gov/

The SOHO mission was launched in 1995 and maneuvered into orbit round the First Lagrangian Point, 1.5 million km from Earth, towards the Sun, where the gravities of both bodies balance. The mission is scheduled to continue through to Dec 2009. The SOHO spacecraft was built in Europe by an industry team, and its instruments were provided by European and American scientists. There are nine European Principal Investigators and three American ones. Large engineering teams and more than 200 co-investigators from many institutions collaborated to develop the instruments and prepare operation and data analysis procedures.

NASA launched the spacecraft into a and is now responsible for mission operations. NASA's Deep Space Network tracks the spacecraft beyond the Earth's orbit. Mission control is at the Goddard Space Flight Center, Maryland.

The mission is part of the Solar Terrestrial Science Program (STSP) comprising SOHO and CLUSTER, and the International Solar-Terrestrial Physics Program (ISTP), with Geotail (ISAS-Japan), Wind, and Polar.

As outlined in the introduction, SOHO has fundamentally altered our understanding of solar processes.

SORCE
Solar Radiation and Climate Experiment
NASA
http://lasp.colorado.edu/sorce/
Launched 2003, the Solar Radiation and Climate Experiment provides measurements of incoming x-ray, ultraviolet, visible, near-infrared, and total solar radiation. The measurements specifically address long-term climate change, natural variability and enhanced climate prediction, and atmospheric ozone and UV-B radiation. These measurements are critical to studies of the Sun and its effect on the Earth.

SORCE measures the Sun's output with the use of radiometers, spectrometers, photodiodes, detectors, and bolometers. SORCE gathers solar data from Earth orbit, SORCE. SORCE data will be used to model the Sun's output and to explain and predict the effect of the Sun's radiation on the Earth's atmosphere and climate.

TRACE
NASA
http://trace.lmsal.com/

TRACE, The Transition Region and Coronal Explorer, was launched in 1998. The launch was scheduled to allow joint observations with SOHO during the rising phase of the solar cycle to sunspot maximum.

TRACE studies the connections between fine-scale magnetic fields and the associated plasma structures on the Sun by observing the photosphere, the transition region, and the corona. With TRACE, these temperature domains are observed nearly simultaneously, with a spatial resolution of one second of arc. TRACE obtains precisely co-aligned image sequences of photosphere, transition region, and corona. TRACE is able to view the Sun without interruption for up to eight months.

Ulysses
ESA, NASA
http://helio.estec.esa.nl/ulysses/

Carried into space in 1990 by the space shuttle Discovery, the European-built Ulysses spacecraft has traveled an amazing 7 billion km and is still going strong after 15 years in orbit. During its exploratory voyage, Ulysses has made unprecedented observations of the region of space carved out by the Sun's influence, the heliosphere.

Ulysses uniqueness is two fold: Firstly, Ulysses is the first probe to be placed in a polar orbit around the Sun. Ulysses is thus able to study in situ the previously unexplored regions of space above the Sun's poles. Secondly, Ulysses carries a comprehensive suite of sophisticated scientific instruments. With these, it is carrying out the first survey of the solar wind in four dimensions (three spatial dimensions and time) and has made many discoveries, some in areas not even imagined when the mission was planned.

Ulysses achievements include:

- First direct measurements of interstellar dust and neutral helium gas
- First measurements of rare cosmic-ray isotopes
- First measurements of so-called "pickup" ions of both interstellar and near-Sun origin
- First in-situ observations of comet tails at large distances from the Sun
- First observations of particles from solar storms over the solar poles

Ulysses has also obtained data on origin of the solar wind, the way the Sun's magnetic field reverses polarity, the nature of the boundary of the heliosphere and the interstellar medium. In addition, Ulysses data places important constraints on theories of the evolution of matter in the Universe.

Ulysses is a key member of the fleet of spacecraft collectively referred to as The Sun-Solar System Connections Great Observatory that includes SOHO, ACE, Wind, Voyager, the four Cluster spacecraft and the soon-to-be launched twin STEREO probes and Solar-B. Together this impressive fleet will study the Sun and the heliosphere as an integrated system. During International Heliophysical Year in 2007, they will work in concert to study our star in extraordinary detail.

The dream of the visionary scientists who discussed the possibility of an out-of-ecliptic space probe back in 1959 has become a most successful reality.

Voyager 2
NASA
http://web.mit.edu/space/www/voyager.html

Launched in 1977, Voyager 2 is continuing to study the Solar Wind. In February 2006, Voyager 2 was 79 Astronomical Units from the Sun. Light travel time from Voyager 2 to Earth was 11 hours. Data are returned from the spacecraft at 160 bits per second, using a transmitter with about 25 watts of power. It is leaving the solar system at 57,000 km per hour, which is 3.2 AU per year, or 1 light year per 18,600 years.

Wind
NASA
http://www-istp.gsfc.nasa.gov/istp/wind/
WIND was launched in 1994. It is the first of two NASA spacecraft in the Global Geospace Science initiative and is part of the ISTP Project. WIND was positioned in a sunward, multiple double-lunar swing-by orbit with a maximum apogee of 250Re during the first two years of operation. It was then shifted into a halo orbit at the Earth-Sun L1 point.
Its objectives are to:

- Provide complete plasma, energetic particle, and magnetic field input for magnetospheric and ionospheric studies.
- Determine the magnetospheric output to interplanetary space in the up-stream region
- Investigate basic plasma processes occurring in the near-Earth solar wind
- Provide baseline ecliptic plane observations to be used in heliospheric latitudes from Ulysses.

TIMED
Thermosphere Ionosphere Mesosphere Energetics and Dynamics Mission
NASA
http://www.timed.jhuapl.edu/WWW/index.php

Launched in 2001, TIMED is the terrestrial anchor of the Heliophysics Great Observatory. TIMED is studying the influences of the Sun and humans on the least explored and understood region of Earth's atmosphere - the Mesosphere and Lower Thermosphere/Ionosphere (MLTI). The MLTI region is a gateway between Earth's environment and space, where the Sun's energy is first deposited into Earth's environment. TIMED is focusing on a portion of this atmospheric region located approximately 60-180 kilometers above the surface.

Yohkoh
LISASS Japan
http://www.lmsal.com/SXT/
The Yohkoh Solar Observatory was active from 1991 to 2001. It was a cooperative mission of Japan, the USA, and the UK. Yohkoh observed the solar atmosphere in X-ray radiation continuously for more than nine years. The Solar-B mission, to be launched in September 2006, will follow on from where the Yohkoh mission left off.

Planned Missions

In order of projected launch date

STEREO
Solar TErrestrial RElations Observatory,
NASA
http://stereo.jhuapl.edu/
To be launched in July 2006, STEREO is a 2-year mission employing two nearly identical observatories to provide 3-D measurements of coronal mass ejections. These powerful eruptions are a major source of the magnetic disruptions on Earth and a key component of space weather, which can greatly affect satellite operations, communications, power systems, the lives of humans in space, and global climate.

Solar-B
JAXA
http://www.isas.ac.jp/e/enterp/missions/solar-b/
To be launched in September 2006., the Solar-B mission is a follow-on to the highly successful Japan/US/UK Yohkoh (Solar-A) satellite which operated between 1991 and 2001. Led by the Japanese Aerospace Exploration Agency's (JAXA) Space Science Research Division, Solar-B carries a coordinated set of optical, EUV, and X-ray instruments that will investigate the interaction between the Sun's magnetic field and its corona. The result will be an improved understanding of the mechanisms that power the solar atmosphere and drive solar eruptions. This information will tell us much about how the Sun generates magnetic disturbances and high-energy particle storms that propagate from the Sun to the Earth and beyond. Solar-B will help us predict "space weather".

THEMIS
Timed History of Events and Macroscale Interactions during Substorms
NASA
http://sprg.ssl.berkeley.edu/themis/about_themis.html

THEMIS, a fleet of five spacecraft, will be launched in October 2006 to answer fundamental outstanding questions regarding the magnetospheric substorm instability, a dominant mechanism of transport and explosive release of solar wind energy within Geospace.

THEMIS is designed to determine which magnetotail process is responsible for substorm onset at around 10 Earth radii, in the region where substorm auroras map – either: (i) a local disruption of the plasma sheet current or (ii) that current's interaction with the rapid influx of plasma emanating from lobe flux annihilation at 25 Earth radii.

Correlative observations from long-baseline (2 to 25 Earth radii) probe conjunctions, will delineate the causal relationship and macroscale interaction between the substorm components. THEMIS's five identical probes measure particles and fields on orbits which optimize tail-aligned conjunctions over North America. Ground observatories time auroral breakup onset. Three inner probes at around 10 Earth radii monitor current disruption onset, while two outer probes, at 20 and 30 Earth radii respectively, remotely monitor plasma acceleration due to lobe flux dissipation.

THEMIS will also answer critical questions in radiation belt physics and solar wind - magnetosphere energy coupling. THEMIS's probes use flight-proven instruments and subsystems, yet demonstrate spacecraft design strategies ideal for Constellation class missions. THEMIS is complementary to MMS and a science and a technology pathfinder for future STP missions.

Proba-2
ESA
No apparent web site
To be launched in 2007, Proba-2 is technology demonstration satellite that will carry solar dedicated instruments. In particular, it will carry a complementary instrument to SOHO's EIT camera. Whilst EIT concentrates on the origin and early development of solar eruptions, Proba-2's camera will be able to track them into space.

SDO
Solar Dynamics Observatory
NASA
http://sdo.gsfc.nasa.gov/
To be launched in 2008, SDO will he first Space Weather Research Network mission in NASA's Living With a Star Program. SDO will to help us understand the Sun's influence on Earth and Near-Earth space by returning data about the solar atmosphere on small scales of space and time and in many wavelengths simultaneously.

The mission goals are to:
- Understand the Solar Cycle.
- Identify the role of the magnetic field in delivering energy to the solar atmosphere and its many layers.
- Study how the outer regions of the Sun's atmosphere evolve over time - ranging from seconds to centuries - and space.
- Monitor the radiation (ex: UV, EUV, etc.) levels of solar output.

MMS
Magnetospheric MultiScale Mission
NASA
http://stp.gsfc.nasa.gov/missions/mms/mms.htm

The projected launch date for the MMS mission is 2013. From missions to date, we know that fundamental processes occurring in thin boundary layers connect broad regions of the magnetosphere and that processes on vastly different scales are strongly interacting. To understand these phenomena we will have to make rapid-fire multiple-point measurements to characterise variations in time and 3D space. The Magnetospheric Multiscale mission will give us that capability.

The MMS mission is being planned to answer these questions:
- How do small-scale processes control large-scale phenomenology, such as magnetotail dynamics, plasma entry into the magnetosphere, and substorm initiation?
- What are the processes that permit and control the reconnection of magnetic field lines across collisionless plasma boundaries?
- How do energy conversion processes accelerate particles at these boundaries, and

what role do parallel electric fields play?
- How are electric currents, which connect distant regions of the magnetosphere, generated, controlled, and disrupted at boundaries?
- What is the importance and character of the coupling across scales (micro-to mesoscales) in all of these processes?
- What is the spatial and temporal structure of collisionless shocks?

The MMS spacecraft will be able to:
- Determine the small-scale basic plasma processes which transport, accelerate and energize plasmas in thin boundary and current layers – and which control the structure and dynamics of the Earth's magnetosphere.
- Measure, for the first time, the 3D structure and dynamics of the key magneto-spheric boundary regions, from the subsolar magnetopause to the distant tail.
- Pave the way for future missions.

Solar Probe
NASA
http://solarprobe.gsfc.nasa.gov/

The projected launch date for Solar Probe is in 2014. It will become the first spacecraft to fly close to the Sun, with flybys as close as 3 solar radii above the Sun's surface planned in 2018 and 2023.

Solar Probe will fly into one of the last unexplored regions of the solar system, the Sun's atmosphere or corona. It will perform in-situ measurements and imaging to gather data on how the Sun's corona is heated and how the solar wind is accelerated.

Solar Probe will revolutionize our knowledge of the physics of the origin and evolution of the solar wind.

Solar Orbiter
ESA
http://sci.esa.int/science-e/www/area/index.cfm?fareaid=45

As part of the International Living With a Star program ESA will possibly launch an advanced satellite, Solar Orbiter, around 2015. It is designed to orbit close to the Sun, to gain a close-up look at the powerful processes at the heart of our Solar System.

Multi-Mission Solar Observation Programs

ILWS
International Living With a Star Program
http://ilws.gsfc.nasa.gov/

We live in the extended atmosphere of an active star. While sunlight enables and sustains life, the Sun's variability produces streams of high-energy particles and radiation that can affect life.

Under the protective shield of its the magnetic field and atmosphere, the Earth is an island in the solar system where life has developed and flourished. The origins and fate of life on Earth are intimately connected to the way the Earth responds to the Sun's variations. Understanding the changing Sun and its effects on the Solar System, life, and society is the goal of the Sun-Earth Connection Theme.

The ILWS Space Weather Research Network utilises two types of spacecraft:
- Solar Dynamics Observatory/Sentinels that observe the Sun and track solar disturbances through the heliosphere
- Geospace missions located in the magnetosphere and ionosphere to gather data on the Geospace response to varying solar and solar wind inputs

For an overview of the various ILWS mission, see the document: *ILWS Missions.pdf*

For a summary of Australia's contribution to the ILWS program, see the document: *ILWS Australian Contribution.pdf*

STP
Solar Terrestrial Probes Program
http://stp.gsfc.nasa.gov/

The Solar Terrestrial Probes Program aims to gather data of our changing Sun and its effects on the Solar System and Earth in particular. The STP Program constitutes an ambitious in-depth look at space weather and solar science with implications for improving life on Earth, space exploration and vastly increasing our understanding of star system processes. The primary questions the program is seeking answers for are:
- Why does the Sun vary?
- How do the planets respond to solar variability?
- How do the Sun and galaxy interact?
- How does solar variability affect life and society?

The coordinated sequence of STP projects focus on the Sun and the Earth as an integrated system. The various STP missions are:
- Operating: TIMED
- In Development: STEREO, Solar-B
- Under Study: MMS

The SSSC Great Observatory
The Sun – Solar System Connections Great Observatory
http://sec.gsfc.nasa.gov/sec_roadmap.htm

Currently operating spacecraft missions supporting Sun – Solar System Connections collectively constitute a Great Observatory that provides simultaneous measurements in multiple locations at the necessary temporal and spatial resolution. The data they gather enables researcher to model and predict how the Sun generates the Solar Wind and how that impacts on the planets.

More comprehensive understanding and predictive capabilities are essential to support the continued expansion of human activity into space. In time, portions of the SSSC fleet will be configured into sets of strategically located satellites providing data on a continuous basis through virtual observatories. Researchers will work together to provide timely, on-demand data and analysis for scientific research, national policymaking, economic growth, hazard mitigation, and exploration elsewhere in the solar system and beyond.

The SSSC Great Observatory is currently configured for studying:

- Solar structure and phenomena (SOHO, TRACE, RHESSI)
- Production of solar energetic particles and solar wind at 1 AU (Wind, ACE, SOHO)
- Production of solar energetic particles and solar wind in other regions of the heliosphere (Cluster, Geotail, Ulysses, Voyager),
- The terrestrial magnetospheric which responds to solar drivers (Cluster, Geotail, FAST, IMAGE, Polar, geosynchronous measurements),
- The upper terrestrial atmosphere (IMAGE, TIMED, and ground-based optical and magnetometer networks).

The value of each mission is enhanced significantly by the synergism among the missions of the SSSC Great Observatory.

Between 2007 and 2010, new missions will augment the SSSC Great Observatory*. In 2006, CINDI, TWINS, STEREO, Solar-B, AIM, and THEMIS will be launched. SDO and IBEX will join them in 2008. These additions will facilitate study of a wide variety of phenomena with unrivalled accuracy and resolution and provide solar researchers with unprecedented opportunities.

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* The SSSC Great Observatory overview above is based on information in the document: Senior Review of the Sun-Solar System Connection Mission Operations and Data Analysis Program, February 7, 2006
Source: http://science.hq.nasa.gov/earth-sun/docs/SSC_Senior_Review_2005.pdf

The information is reiterated in the document:
http://sec.gsfc.nasa.gov/HeliophysicsRoadmap050806.pdf

Links at: http://sec.gsfc.nasa.gov/sec_missions.htm lead to mission web pages for CINDI, TWINS, AIM and IBEX. These sites do not appear to be maintained and give no indication that the missions are on schedule and that launch is imminent. It is difficult to ascertain whether or when these missions will be put into orbit.

Additional Reading

Solar Cycle Solved.pdf
A Sky and Telescope report of how SOHO data has led to a predictive understanding of the processes that cause the eleven-year solar cycle.

ILWS Missions.pdf
A comprehensive summary, together with timelines of the various missions in the International Living with a Star Program.

ILWS Australian Contribution.pdf
A summary of Australia's contribution to the International Living with a Star Program.

SSC_Senior_Review_2005.pdf
Senior Review of the Sun-Solar System Connection Mission Operations and Data Analysis Program, February 7, 2006. This is a Space Solar Research Plan submitted to Richard R. Fisher, Director Heliophysics Division, Science Mission Directorate.

HeliophysicsRoadmap050806.pdf
The thirty-year plan of Richard R. Fisher, Director Heliophysics Division, Science Mission Directorate, for answering the questions:

- How and Why Does the Sun Vary?
- How Do Planetary Systems Respond?
- What Are the Impacts on Humanity?

This document, ***Living with a Star.pdf***
along with the above files
can be found on the ESC Curriculum network at:
PCPublic_Science\Astronomy\Solar System\The Sun\Living with a Star