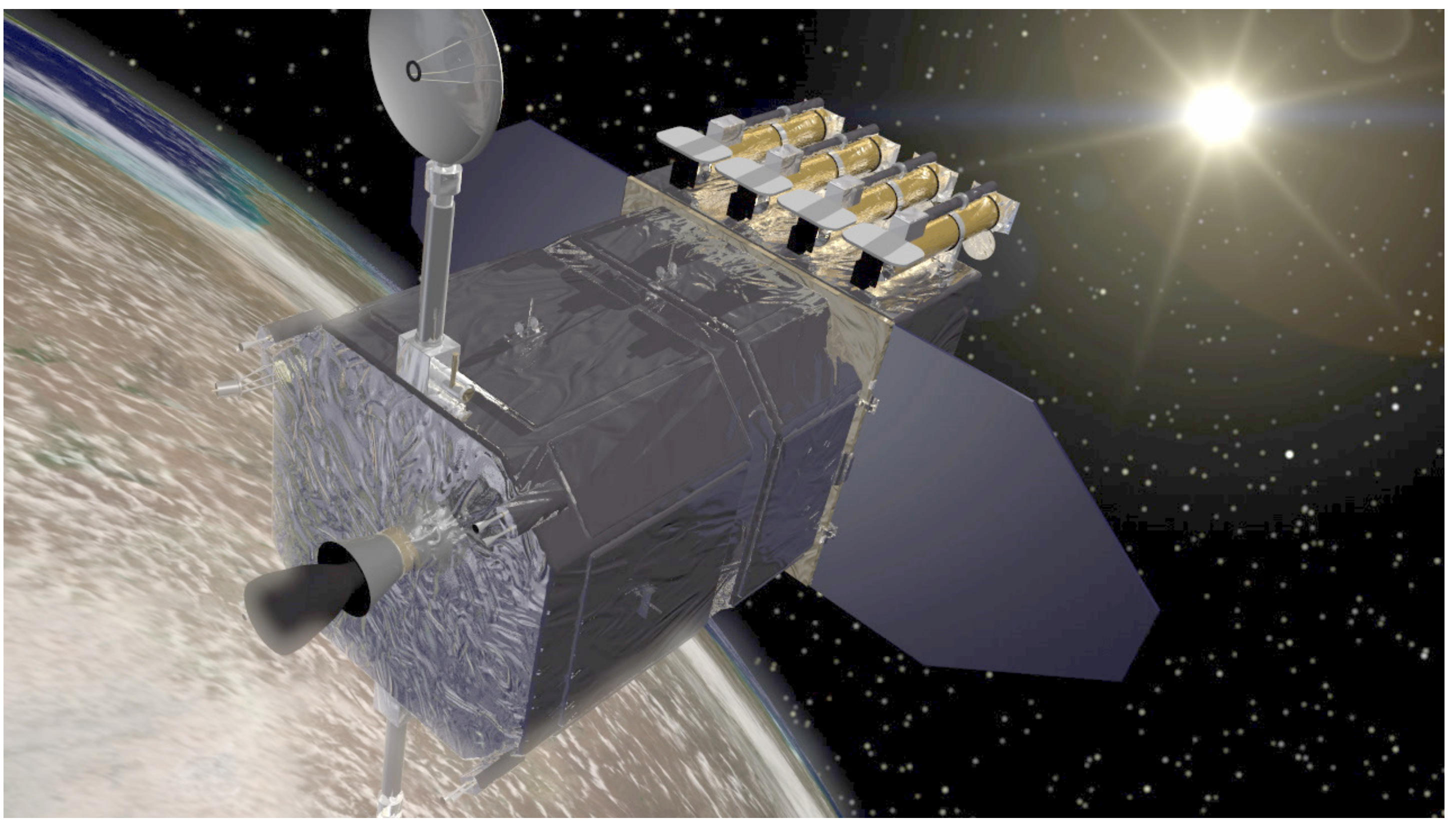
National Aeronautics and Space Administration

PRESS KIT/JANUARY 2010

Solar Dynamics Observatory (SDO):

Investigating the causes of solar variability and how space weather results from that variability



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Media Services Information

NASA Television

Effective Jan. 16, 2010, NASA Television's Public, Education and Media channels will be available for downlink on satellite AMC 3. Additionally, NASA TV has reformatted its online program schedule to improve its readability.

Cable and satellite service providers, broadcasters, and educational and scientific institutions will need to re-tune their receiving devices to AMC 3 to continue accessing NASA TV for distribution.

News networks, their reporters and other broadcast media organizations must tune their satellite receivers to the Media Channel to ensure reception of clean feeds for all mission coverage, news conferences, and other agency distributed news and information. News and other media organizations will no longer be able to rely on content from the Public Channel for clean feeds of mission and other agency activities.

NASA TV's occasional HD feed and Live Interactive Media Outlet (LIMO) Channel also will migrate to AMC3. For complete downlink information effective Jan. 16, 2010, visit:

http://www.nasa.gov/multimedia/nasatv/satellite_info.html

NASA Television has made its online program schedule easier to read, with schedules for all three channels listed on one page. Listings of upcoming programs, events and features on NASA TV's Public, Education and Media channels now can be accessed easily at:

http://www.nasa.gov/multimedia/nasatv/schedule.html

NASA TV Multichannel Broadcast Includes:

- Public Services Channel (Channel 101)
- Education Channel (Channel 102)
- Media Services Channel (Channel 103)

Analog NASA TV is no longer available. For digital downlink information for each NASA TV channel, schedule information for mission activities, and access to NASA TV's public channel on the Web, visit:

http://www.nasa.gov/ntv

Briefings

A mission and science overview news conference will be held on January 21 at 1 p.m. at NASA Headquarters and Kennedy Space Center. The news conference will be broadcast live on NASA Television.

Media Services Information

The prelaunch readiness press conference will be held at 1 p.m. EST, on Monday, February 8, 2010 in the Kennedy News Center at NASA Kennedy Space Center (KSC) Fla. Immediately following that will be the SDO science briefing, also held in the Kennedy News Center. These briefings will be broadcast live on NASA Television. Media advisories will be issued in advance, outlining details of the news conferences.

Accreditation and Media Access Badges for KSC

All news media, including those who are permanently badged, must complete the accreditation process for the activities associated with the SDO launch. The press accreditation process may be done via the Web by going to https://media.ksc.nasa.gov/.

Accreditation requests for the SDO prelaunch, launch, and post launch activities at KSC must be received by close of business by Feb. 4, 2010 for domestic news media, and close of business Jan. 31, 2010 for foreign national news media. Foreign nationals must include full legal name, news organization, address, nationality/ citizenship, passport number, and date of birth. For information about media accreditation, contact Laurel Lichtenberger in the KSC news media accreditation office at 321–867–4036.

KSC News Center Hours for Launch

The NASA News Center at KSC will provide updates to the media advisories. Launch status reports will be recorded on the KSC news media codaphone that may be dialed at 321–867–2525 starting Feb 5, 2010. News center hours on L-2 and L-1 will be 8 a.m. to 4:30 p.m. EDT and 8 a.m. to 8 p.m. EDT on launch day.

NASA Television Coverage

For information about NASA Television coverage of the launch, visit
<http://www.nasa.gov/multimedia/nasatv/digital.html>.

NASA Web Prelaunch and Launch Coverage

NASA's home on the Internet, <http://www.nasa.gov>, will provide extensive prelaunch and launch day coverage of the SDO mission.

To learn more about the SDO mission, visit:

http://www.nasa.gov/sdo
http://sdo.gsfc.nasa.gov/

Multimedia Gallery

Images, video, and animations for SDO can be found at:
http://www.nasa.gov/mission_pages/sdo/multimedia/index.html

Executive Summary

The Solar Dynamics Observatory (SDO) is the most advanced spacecraft ever designed to study the sun and its dynamic behavior. SDO will provide better quality, more comprehensive science data faster than any NASA spacecraft currently studying the sun and its processes. SDO will unlock the processes inside the sun, on the sun's surface, and in its corona that result in solar variability. This variability, when experienced on Earth, is called space weather. Space weather can change the ionizing radiation doses on polar aircraft flights, disable satellites, cause power grid failures, and disrupt global positioning system, television, and telecommunications signals. Understanding the science of space weather can lead to a capability to predict space weather. This capability will allow us to accommodate or mitigate the effects of space weather.

SDO is the first mission and crown jewel in a fleet of NASA missions to study our sun. The mission is the cornerstone of a NASA science program called Living With a Star (LWS). The goal of the LWS Program is to develop the scientific understanding necessary to address those aspects of the sun and solar system that directly affect life and society. This program will provide new understanding and information concerning the sun and solar system and how the solar system responds to solar variability.

Mission Quick Facts

Mission

Launch Period:	February 9, 2010 (10:30 – 11:30 a.m. EST)
Launch Site:	Cape Canaveral Air Force Station, Fla., Launch Complex 41
Launch Vehicle:	United Launch Alliance Atlas V rocket
Orbit:	SDO will be placed into an inclined geosynchronous orbit
Orbital Period:	SDO's orbital period is approximately 24 hours
Mission Operations:	Mission operations center will be located at NASA’s Goddard Space Flight Center in Greenbelt, MD.
Ground System:	A new, dedicated Ka-band ground system was developed to support SDO's high data rates and will be available to other missions when SDO ceases operations.

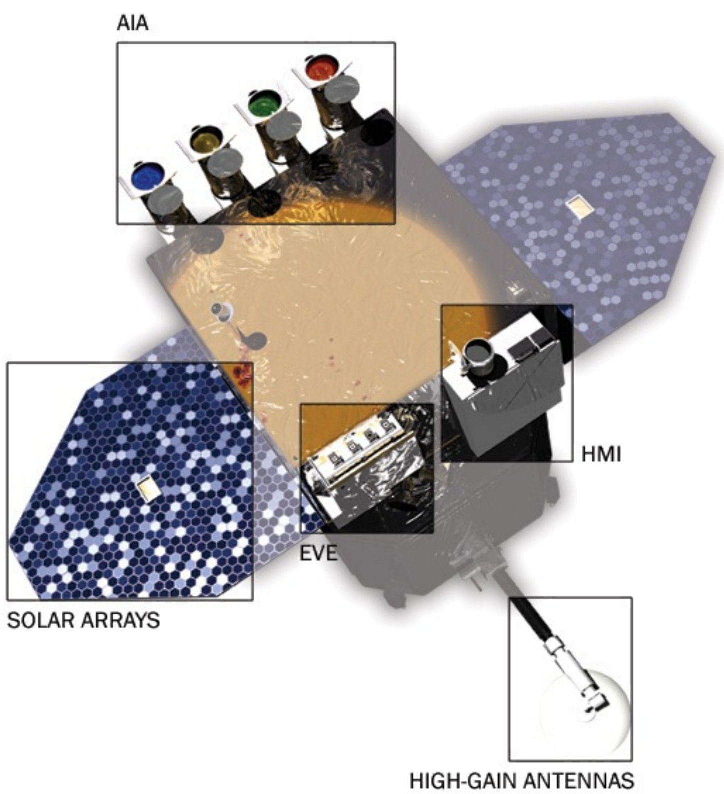
- SDO is the first mission in NASA's Living With A Star (LWS) program. The spacecraft's long-term measurements will give solar scientists in-depth information about how and why changes in the sun's magnetic field occur.

- SDO will be a major component of the Heliophysics System Observatory, a fleet of widely deployed solar, heliospheric, and geospace spacecraft that are working together to discover the larger scale and/or coupled processes at work throughout the complex system that makes up our space environment.

Spacecraft Quick Facts

Satellite: 3-axis stabilized and fully redundant spacecraft.
Duration: SDO has a five-year science mission and carries enough fuel to operate for an additional five years.
Mass: Total mass of the spacecraft at launch is 3,100 kg (8,800 lb); payload 290 kg (640 lb) and fuel 1,450 kg (3,086 lb).
Power: Total available power is 1,540 Watts (W) from 6.5 m^2 of solar arrays
Dimensions: The overall length of the spacecraft along the sun-pointing axis is 4.5 m (14.8 ft), and each side is 2.22 m (7.3 ft). The span of the spacecraft with extended solar panels is 6.5 m (21.3 ft).
High-gain Antennas: The high-gain antennas rotate once each orbit to follow Earth.
Solar Array: The solar panels cover an area of 6.6 m^2 producing 1,450 W of power. The homeplate shape prevents the solar panel from blocking the high-gain antennas.
Maximum Downlink Rate: The spacecraft has a continuous, high-rate science data downlink rate of 130 Megabits per second (Mbps) at a Ka-Band frequency of about 26 GHz.
Spacecraft Command Center: The spacecraft command center will be located at Goddard Space Flight Center.

SDO Spacecraft



Mission Overview

SDO will study how solar activity is created and how space weather results from that activity. Measurements of the sun’s interior, magnetic field, the hot plasma of the solar corona, and the irradiance will help meet the objectives of the SDO mission.

SDO will improve our understanding of the physics behind the activity displayed by the sun’s atmosphere, which drives space weather in the heliosphere, the region of the sun’s influence, and in planetary environments. The sun's 11-year cycle of activity is driven by the change in polarity of sun's magnetic dipole. The magnetic field lines run from pole to pole of the sun, and over an 11-year time period they "turn inside out" to switch the polarity. The field lines get scrambled during the inversion, resulting in the loops of magnetic reconnection observed in NASA's Transition Region and Coronal Explorer (TRACE) science images. The extent of solar activity is associated with the amount of scrambling. Inside the field lines, at the center of the sun, is the sun's dynamo.

Particles and ionizing radiation from these solar storm events propagate to Earth and enter at Earth's poles. In some instances, aurora result. The increased particles and radiation produce space-weather effects such as changing the ionizing radiation doses for passengers and electronics on polar aircraft flights, disabling satellites, causing power grid failures, and disrupting signals for the global positioning system, television, and telecommunications. Understanding the science of space weather can lead to a capability to predict space weather. This capability will allow us to accommodate or mitigate the effects of space weather. SDO will determine how the sun’s magnetic field is generated, structured, and converted into violent solar events that cause space weather.

SDO observations start in the interior of the sun where the magnetic field that is the driver for space weather is created. Next, SDO will observe the solar surface to directly measure the magnetic field and the solar atmosphere to understand how magnetic energy is linked to the interior and converted to space weather-causing events. Finally, SDO will measure the extreme ultraviolet irradiance of the sun that is a key driver to the structure and composition of Earth’s upper atmosphere.

Mission Operations

Mission Orbit

- The rapid cadence and continuous coverage required for SDO observations led to placing the satellite into an inclined geosynchronous orbit. This allows for a nearly continuous, high data-rate contact with a single, dedicated ground station.

- Nearly continuous observations of the sun can be obtained from other orbits, such as low Earth orbit (LEO). If SDO was placed into a LEO, it would be necessary to store large volumes of scientific data onboard until a downlink opportunity was available, and multiple sites around the globe would be needed to down-link the data. However, no space-qualified data recorder with the capability to handle this large data volume exists. This lack of a data recorder, the large data rate of SDO, and the ability to continuously stream data from the spacecraft if a geosynchronous orbit was selected led to the selection of the inclined geosynchronous orbit.

- The disadvantage of this inclined geosynchronous orbit includes higher launch and orbit acquisition costs (relative to LEO) and eclipse (Earth shadow) seasons twice annually. During these 2-3 week eclipse periods, SDO will experience a daily interruption of solar observations, and these interruptions have been included in SDO's data capture budget. There will also be three lunar shadow events each year from this orbit.

- This inclined geosynchronous orbit is located on the outer edges of Earth's radiation belt, where the radiation dose can be quite high. Additional shielding was added to reduce (or mitigate) the effects of exposure to this ionizing radiation. Because the potential for damage due to space radiation effects is a space weather effect, SDO is affected by the very processes it is designed to study.

Data Path and Rate

- To gather data from all three of SDO's instruments, NASA has set up a new Ka-band antenna facility that includes a pair of dedicated radio antennas near Las Cruces, New Mexico. SDO's geosynchronous orbit will keep the observatory in constant view of the two 18-meter dishes around the clock for the duration of the observatory's five-year mission.

- SDO will send back 150 million bits of data per second, 24 hours a day, 7 days a week. That's almost 50 times more science data than any other mission in NASA history. This is equivalent to downloading half-a-million songs each day.

- Every 0.75 seconds, SDO will record images with 10 times greater resolution than high-definition television. When these images are seen sequentially, a very high resolution movie results.

- A bank of multi-wavelength telescopes and cameras called the Atmospheric Imaging Assembly (AIA) will produce a high-definition image of the sun in 8 selected wavelengths out of the 10 available every 10 seconds. The 10 wavelength bands include nine ultraviolet and extreme ultraviolet bands and one visible-light band to reveal key aspects of solar activity.

SDO Instruments

The Solar Dynamics Observatory has three instruments.

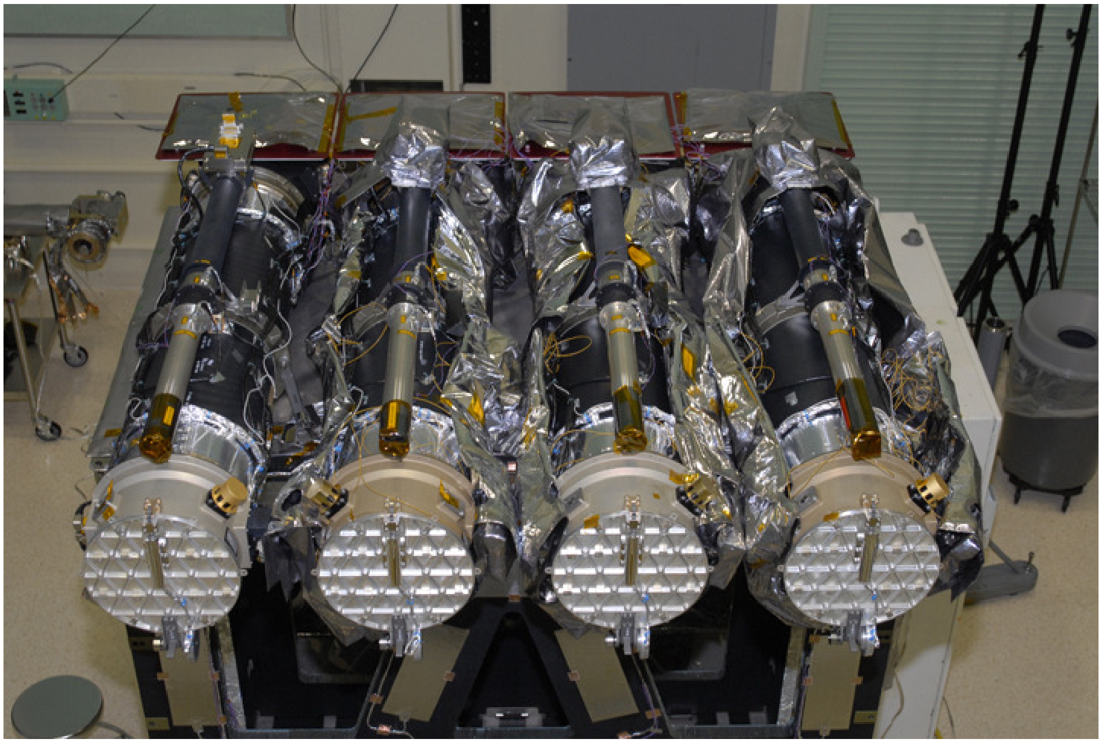
The Atmospheric Imaging Assembly (AIA) is an array of four telescopes that will observe the surface and atmosphere of the sun. The AIA filters cover 10 different wavelength bands that are selected to reveal key aspects of solar activity. The AIA was built by the Lockheed Martin Solar Astrophysics Laboratory (LMSAL), Palo Alto, California. The AIA’s Principal Investigator is Dr. Alan Title of LMSAL.

The Extreme Ultraviolet Variability Experiment (EVE) will measure fluctuations in the sun’s ultraviolet output. Extreme ultraviolet (EUV) radiation from the sun has a direct and powerful effect on Earth’s upper atmosphere; it heats it, inflates it, and inserts enough energy to break apart atoms and molecules. Researchers don’t know how fast the sun can vary at many of these wavelengths, so they expect to make many new discoveries about flare events. EVE was built by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado. Dr. Tom Woods is the Principal Investigator.

The Helioseismic and Magnetic Imager (HMI) will map solar magnetic fields and peer beneath the sun’s opaque surface using a technique called helioseismology. A key goal of this experiment is to decipher the physics of the sun’s magnetic dynamo. HMI was built by Lockheed Martin Solar and Astrophysics Laboratory (LMSAL), Palo Alto, California. The Principal Investigator for HMI is Dr. Phil Scherrer of Stanford University.

SDO Instruments

Atmospheric Imaging Assembly (AIA)



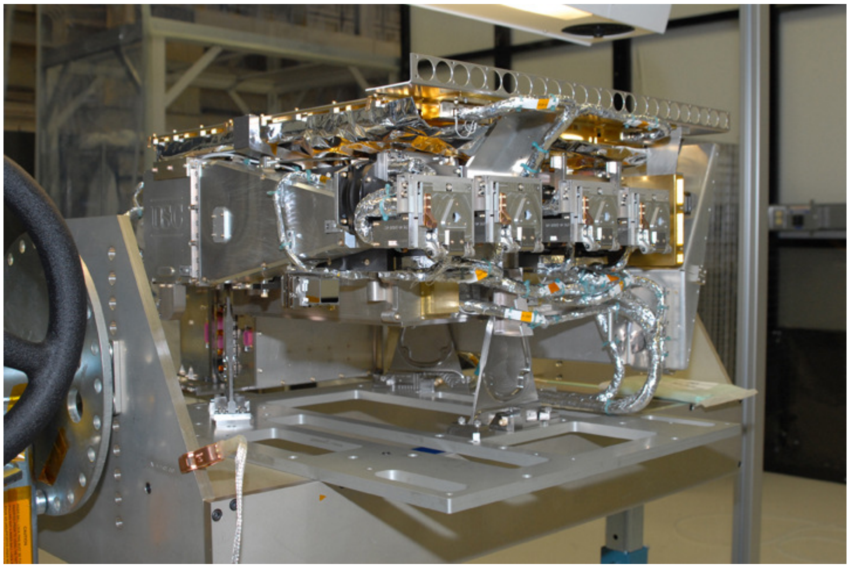
What will AIA study?
The AIA will image multiple wavelengths of the corona, or outer layer of the sun's atmosphere, nearly simultaneously.

How does it work?
AIA is an array of four telescopes that will observe the surface and atmosphere of our star with big-screen clarity and unprecedented time resolution. It's like an IMAX® camera for the sun.
AIA will produce a high-definition image of the sun in eight selected wavelengths out of the 10 available every 10 seconds. The 10 wavelength bands include nine ultraviolet and extreme ultraviolet bands and one visible-light band to reveal key aspects of solar activity. To accomplish this, AIA uses four telescopes, each of which can see details on the sun as small as 725 km (450 mi) across—equivalent to looking at a human hair held 10 m (33 ft) away.

Because such fast cadences with multiple telescopes have never been attempted before by an orbiting solar observatory, the potential for discovery is significant. In particular, researchers hope to learn how storms get started near the sun's surface and how they propagate upward through the sun's atmosphere toward Earth and elsewhere in the solar system. Scientists will also use AIA data to help them understand how the Sun's changing magnetic fields release the energy that heats the corona and creates solar flares.

SDO Instruments

Extreme Ultraviolet Variability Experiment (EVE)



What will EVE study?
Solar scientists will use the Extreme Ultraviolet Variability Experiment (EVE) to measure the sun's brightness in the most variable and unpredictable part of the solar spectrum. The extreme ultraviolet, or EUV, ranges in wavelength from 0.1 to 105 nm.

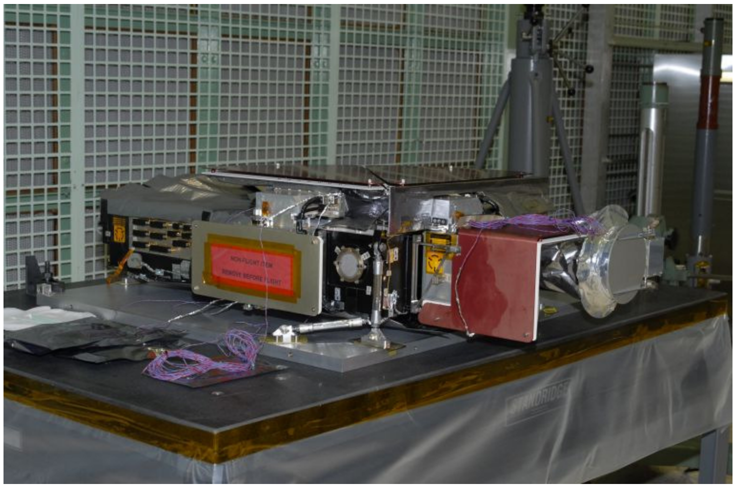
EUV photons are much more energetic and dangerous than the ordinary ultraviolet rays that cause burns. If enough EUV rays were able to reach the ground, a day at the beach could be fatal. Fortunately, Earth's upper atmosphere intercepts the sun's EUV emissions.

In fact, solar EUV photons are the dominant source of heating for Earth's upper atmosphere. When the sun is active, EUV emissions can rise and fall by factors of hundreds to thousands in just a matter of seconds. These surges heat the upper atmosphere, puffing it up and increasing the drag on man-made satellites. EUV photons also can break the bonds of atmospheric atoms and molecules, creating a layer of ions that alters and sometimes severely disturbs radio communications and global positioning system navigation.

How does it work?
EVE will allow solar scientists to monitor EUV emissions between 0.1 and 105 nm with the best time resolution (10 seconds) and the highest spectral resolution (better than 0.1 nm) ever achieved by a space-based observatory. EVE also measures the very important Lyman alpha line at 121.6 nm, the single brightest line in the EUV. EVE will collect data 24 hours a day, 7 days a week, offering the first complete picture of solar EUV fluctuations that vary by factors of 2-100 over time scales of minutes.

SDO Instruments

Helioseismic and Magnetic Imager (HMI)



What will HMI study?
HMI will use the acoustic waves and magnetic field measured at the surface of the sun to study the motions of material inside the sun and the origins of the solar magnetic field.

How does it work?
Solar physicists will use HMI to measure the sound waves rippling across the surface of the sun and the magnetic field that erupts through the surface of the sun. HMI measures the Doppler shift of a spectral line (the change in the light's wavelength when the source moves toward or away from an observer) to give the velocity over the sun's entire visible disk. The Zeeman effect is used to interpret the polarization of the same line to give the magnetic field over the visible face of the sun.

We use the wave data to study the inside of the sun. As the waves travel through the sun they are influenced by conditions inside the sun. The speed of sound waves increases where solar material is hotter, so the speed and angle at which the wave is generated determine how far it will penetrate into the solar interior. The shallower the angle, the shallower the penetration; the steeper the angle, the deeper the wave will travel. It takes about 2 hours for a sound wave to propagate through the Sun's interior. The frequency and spatial pattern the waves make on the surface indicate where the waves have traveled. Scientists learn about the temperature, chemical makeup, pressure, density, and motions of material throughout the sun by analyzing the detailed properties of these waves.

HMI will provide the first rapid-cadence measurements of the strength and direction of the solar magnetic field over the visible disk of the sun. Scientists use this information to understand how the magnetic field is produced and, when combined with measurements from AIA, how that field produces flares and coronal mass ejections (CMEs), the storms of space weather.

Solar Science Basics

What Is Heliophysics?

Heliophysics is the exploration of the magnetic variable star we call the sun, its effects on the planets of the solar system, including Earth, environmental conditions in the space surrounding the sun and planets, and the evolution of our nearest star.

What Is Space Weather?

Space weather originates with the variable magnetic activity of the sun. Activity on the sun’s surface, such as coronal mass ejections (CMEs) and solar flares, can cause high levels of radiation in space. This radiation comes to Earth as plasma (electrically charged particles) or electromagnetic radiation (light), including X-rays and ultraviolet wavelengths.

Sources of Space Weather

- **Coronal Mass Ejections:** A Coronal Mass Ejection (CME) occurs when a prominence suspended above the surface of the sun erupts and sends millions of tons of material into space. This cloud of charged particles is generally confined within a magnetic field (like a magnetic bubble), expanding and traveling out through the solar system at speeds from about 200 km/s up to a staggering 2000 km/s. When directed toward Earth, a CME typically arrives 2-3 days after eruption but in exceptional cases can arrive in less than 24 hours.
- **Solar Flares:** A solar flare is a bright flash of X-rays seen during an energetic explosion in an active region of the sun. It's usually seen as a large burst of X-rays, but may also have a coincident bright flash of white light. A flare lasts a matter of minutes but releases an immense amount of energy. During solar flares the sun can be 1000 times brighter in X-rays than usual.
- **High-speed Streams in the Solar Wind:** A high-speed stream (HSS) is like a powerful gust in the solar wind. Near the edges of a HSS are regions of high particle density and strong magnetic fields, while inside the stream the density and field are low and the temperature and velocity are high. The flow velocity inside a HSS can reach 300 to 1000 km/s. In some cases they will produce interplanetary shocks. A HSS comes from a coronal hole, a dark region in the solar corona, and is most common during the declining phase of the solar cycle. A HSS can last a long time: we often see a HSS every 27 days as its home coronal hole rotates into the right position.
- **Geomagnetic Storms:** Earth's magnetosphere is a bubble created around us by our magnetic field, which protects us from most of the particles the sun throws at us. When a CME or high-speed stream arrives at Earth, it buffets the magnetosphere. If the arriving solar magnetic field is directed southward, it interacts strongly with Earth's oppositely oriented magnetic field. As a result, Earth's magnetic field is peeled open like an onion, allowing energetic solar wind particles to stream down the field lines to hit the atmosphere over the poles. At Earth's surface, a magnetic storm is seen as a rapid drop in Earth's magnetic field strength (typically a drop of 30 to 500 nT in 1-2 hours). This decrease lasts about 6 to 12 hours, after which the magnetic field gradually recovers over a period of several days.

Solar Science Basics

Sources of Space Weather (Continued)

- **Galactic Cosmic Rays:** A constant rain of galactic cosmic rays (GCRs) passes through all of space. These charged particles are accelerated to extremely high energies by galactic events such as supernovae (the catastrophic collapse of a star), although some may come from outside the Milky Way. Their high energy allows GCRs to penetrate through Earth's magnetosphere and deep into the atmosphere. As they enter the atmosphere, they collide with molecules of oxygen and nitrogen and produce millions of tiny fragments. The GCR ionization rate (roughly the radiation dose) reaches a maximum at an altitude of about 12 km (40,000 ft) and then decreases toward Earth's surface. The intensity of GCRs at Earth is highest during solar minimum. This happens because the intense regions of magnetic field extending out from the sun into the solar system during solar maximum divert the charged cosmic rays away from the solar system. As a result, the GCR intensity at Earth during solar maximum is half the GCR intensity during solar minimum.

Solar Activity or Space Weather?

Solar activity describes events that take place on the sun, while space weather describes the change in solar activity as seen on our planet, by technology, and in the magnetic organization of the solar system.

How Will SDO Improve Our Knowledge and Understanding of Space Weather?

SDO will improve our understanding of the physics behind the activity displayed by the sun’s atmosphere, which drives space weather in the heliosphere and in planetary environments. SDO will determine how the sun’s magnetic field is generated, structured, and converted into violent solar events that cause space weather. SDO observations start in the interior of the Sun where the magnetic field that is the driver for space weather is created. Next, SDO will observe the solar surface, directly measuring the magnetic field and the solar atmosphere, to understand how magnetic energy is linked to the interior and converted to space weather-causing events. Finally, SDO will measure the extreme ultraviolet irradiance of the Sun that is a key driver for the structure and composition of Earth’s upper atmosphere.

What Is the Solar Cycle?

The solar cycle is an 11-year pattern in the number of sunspots, coronal mass ejections (CMEs), solar flares, and other solar activity. About every 11 years the sun’s magnetic field changes polarity from north to south. Eleven years later it flips back. People may have heard of this as the 22-year cycle, because after two 11-year sunspot cycles the sun’s magnetic field will be back the way it was at the start of the 22 years. During solar minimum, the sun may churn out strong CMEs every two days; that’s approximately 180 CMEs per year, although only about 10 to 15 CMEs are directed at Earth. During solar maximum, the sun averages five CMEs daily and sends about 100 to 150 CMEs toward Earth each year.

SDO Is the First Mission of NASA's Living With A Star Program

The goal of NASA's Living With a Star (LWS) Program is to provide the scientific understanding needed to effectively address those aspects of Heliophysics science that may affect life and society. The ultimate goal is to develop an understanding that will allow for capability to predict space weather conditions at Earth and in the interplanetary medium.

The LWS missions have been formulated to answer specific science questions needed to understand the linkages among the interconnected systems that impact us. These missions will give us a far better understanding of the causes of space weather, whose effects can disable satellites, cause power grid failures, and disrupt global positioning system and other communications signals. Also, insights gained from SDO observations will lead to an increased understanding of the role solar variability plays in changes in Earth's atmospheric chemistry and climate. The coordinated LWS program includes strategic missions, targeted research and technology development, a space environment testbed flight opportunity, and partnerships with other agencies and nations.

LWS Web Sites:
Missions:
SDO http://sdo.gsfc.nasa.gov/
RBSP http://nasascience.nasa.gov/missions/rbsp
BARREL http://nasascience.nasa.gov/missions/barrel-1
Solar Orbiter http://nasascience.nasa.gov/missions/solar-orbiter
Solar Probe Plus http://nasascience.nasa.gov/missions/solar-probe

Other Program Elements:
LWS Targeted Research and Technology Program http://lwstrt.gsfc.nasa.gov/
Space Environment Testbed Flight Opportunity http://lws-set.gsfc.nasa.gov/
International Living With a Star Program http://ilws.gsfc.nasa.gov/

SDO Mission Management

NASA's Solar Dynamics Observatory (SDO) is a five-year mission to study the sun. As the first mission of NASA's Living With a Star Program, SDO will investigate the causes of solar variability. The spacecraft will study the solar atmosphere in many wavelengths simultaneously to determine how the sun's magnetic field is generated and structured, and how this stored magnetic energy is converted and released in the form of the solar wind, energetic particles, and changes in solar irradiance. SDO is managed by NASA's Goddard Space Flight Center for the agency's Science Mission Directorate at NASA Headquarters in Washington DC.

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SDO Web Sites for More Information:

http://www.nasa.gov/sdo
http://sdo.gsfc.nasa.gov

SDO Instrument Web Sites:

http://hmi.stanford.edu
http://aia.lmsal.com
http://lasp.colorado.edu/eve