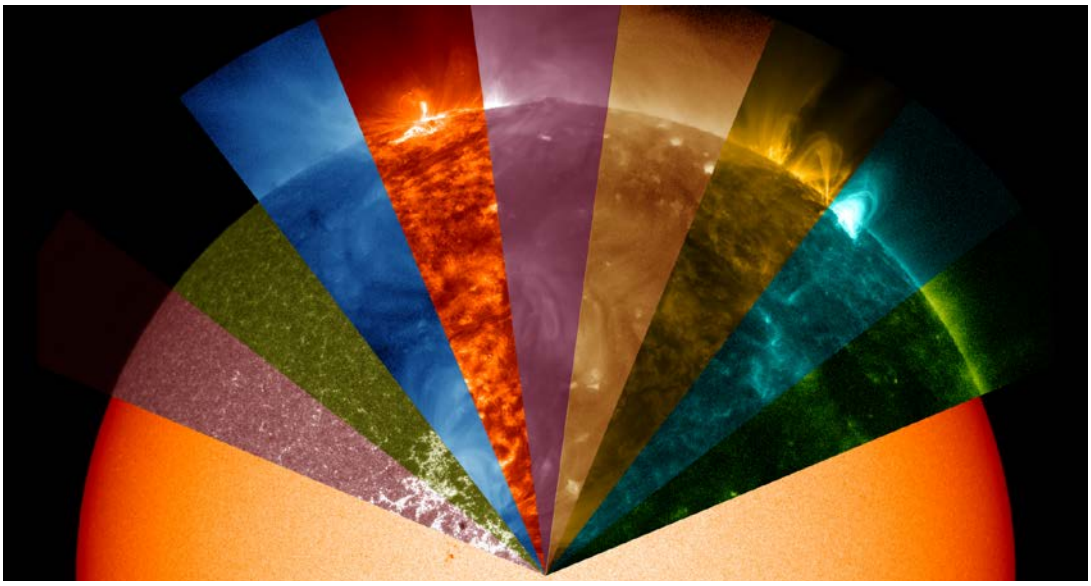
SDO Project Suite

Student-Scientists Exploring Solar Science



CIRES
Cooperative Institute for Research in Environmental Sciences

LASP
Laboratory for Atmospheric and Space Physics
University of Colorado at Boulder

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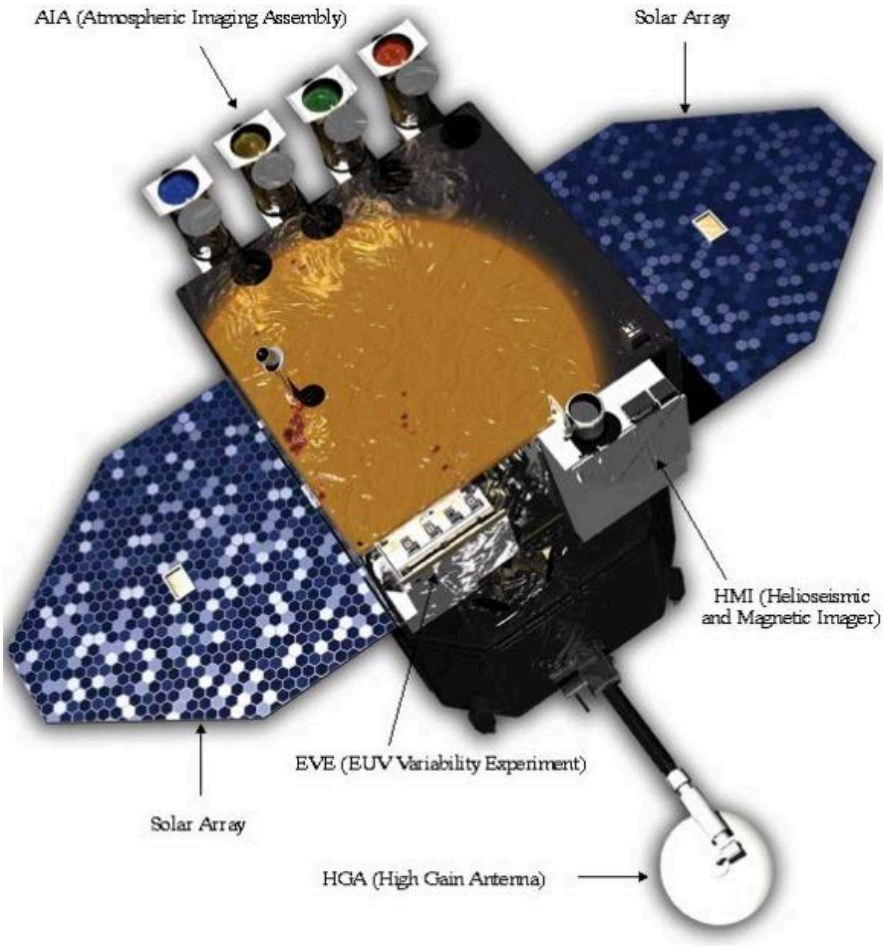
For further information on this project please contact:
CIRES Education Outreach Program
University of Colorado
UCB 449
Boulder, CO 80309
(303) 492-5670
ciresoutreach@colorado.edu

NASA's Solar Dynamics Observatory Spacecraft



SDO Spacecraft Details:

- The total mass of SDO at launch was 3000 kg (6620 lb.); instruments 300 kg (660 lb.), spacecraft 1300 kg (2870 lb.), and fuel 1400 kg (3090 lb.).
- SDO overall length along the sun-pointing axis is 4.5m, and each side is 2.2m.
- The span of the extended solar panels is 6.25m.
- Total available power is 1500 W from 6.6m2 solar arrays operating at an efficiency of 16%.
- The high-gain antennas rotate once each orbit to follow the Earth.
- The SDO satellite maintains a geosynchronous orbit above Earth (a geostationary orbit that moves at the same speed as the Earth's rotation and does not move relative to the Earth's surface).

Title page & above images: NASA

Introduction for Teachers: Curriculum Overview

Solar Dynamics Observatory (SDO) Project Suite Overview

Imagine a classroom of "student scientists" that master standards-based STEM content through integration of language arts, social studies, and art. Picture motivated, student-led teams actively engaging in an authentic exploration of our nearest star, the Sun, that are:

- Designing a Solar Science movie, image sequence, and more created from real-time solar imagery and data from NASA's SDO satellite;
- Predicting space weather using actual SDO solar data to make a forecast
- Building and investigating with instrumentation used to study the Sun;
- Presenting an interactive Solar Science exhibit to a community audience to explain and demonstrate the Sun's effects on Earth's life and society.

The *SDO Project Suite* engages students in these innovative types of learning experiences. Teaching students through self-directed solar explorations encourages them to be engaged learners in order to understand the science of our Sun and to apply the knowledge they gain to solve tomorrow's solar situations. The *SDO Project Suite* assists teachers by offering a coherent, project-based Solar Science curriculum that integrates core STEM content through a multi-disciplinary lens that includes language arts, social studies and art. Not only do students master content standards but they also develop 21st century skills related to digital literacy, media literacy, critical thinking, problem solving, and collaboration with peers – similar to scientists' experiences!

Living With a Star Program: SDO Mission

Heliophysics is the study of the Sun and its interactions with Earth and the solar system. NASA's Heliophysics science program consists of two main programs: 'Solar Terrestrial Probes' and 'Living with a Star' (LWS). LWS emphasizes the science necessary to understand those aspects of the Sun and space environment that most directly affect life and society on our planet. The first LWS mission is the Solar Dynamics Observatory, which was launched on February 11, 2010. LWS investigations research the interconnected systems between the Earth and Sun with the ultimate goal of enabling a predictive understanding of the causes of solar activity and its effects on Earth. SDO observes how the Sun's magnetic field is generated, structured, and how stored magnetic energy is converted and released into the heliosphere in the form of solar wind, energetic particles, and variations in the solar irradiance.

Image: NASA

SDO Solar Modules 1, 2, 3

Activities A, B, C

The series of four Solar Modules in the *SDO Project Suite* lead students through an interactive exploration of Solar Science. The first module provides an understanding of the structure of the Sun, the second module investigates how and why the Sun is studied, and the third module explains the significance of solar activity on Earth's habitability and the affects of space weather on Earth. Students will learn directly from actual data that scientists collect and use. Student teams independently choose and complete one Activity (A, B or C) from each of the first three modules, which act as formative assessments. In the fourth and final module, teams collaborate to design and present their three Solar Module activities as part of their 3-D Solar Exhibit summative assessment.

The *SDO Project Suite* guide is designed as a comprehensive curriculum that integrates new and adapts existing Solar Science lessons into a series of coherent lessons and projects with real-life application. Included are integrated technology components and online resources like Helioviewer. The SDO Solar Module Matrix enables student-led teams to demonstrate higher-order thinking skills and student content mastery of STEM disciplines while also incorporating language arts, social studies, and art standards. Though the SDO Solar Modules are designed as a scope and sequence for a comprehensive unit, each module activity may be completed as a stand-alone scientific investigation.

SDO Solar Module Teacher Guide Components:

Grade Level: 6-8

Unit Length: 4-6 weeks total (may be chunked over a quarter, semester, year)
Individual Solar Modules: 1-10 days each, 3-D Solar Exhibit: 1-2 weeks total

Overview
Each *SDO Project Suite* Solar Module is introduced with a module overview. This introduces important and essential content that is necessary for both teachers and students to know in order to build knowledge and successfully complete the modules.

Objectives
Each SDO Solar Module has specific learning objectives that provide a scope and sequence that foster independent learning within a collective student-directed approach to investigating Solar Science.

Essential Vocabulary
Essential terminology is embedded within the modules to support student comprehension of Solar Science and SDO content.

Module Lesson
Materials:
Each *SDO Project Suite* Solar Module provides a complete list of equipment and materials required per student team.
Teacher Prep:
Sequential steps to prepare for each *SDO Project Suite* Solar Module are provided to support teachers in managing their student-led teams.

Student Engage & Explore!
The *SDO Project Suite* is unique in that it enables collaborative student teams to select their own pathway in choosing and completing three of the nine SDO Solar Modules Activities. Based on their interests, teams select one Activity (A, B, or C) from each of the three Solar Modules (1, 2, and 3). The fourth Solar Module culminates in teams presenting their 3-D Solar Exhibit as part of a class-wide SDO Exploration Museum. The museum event is a unique opportunity for teams to illustrate and demonstrate student learning and mastery of Solar Science concepts via a summative performance assessment. Each SDO Solar Module activity is broken down into the following steps that sequentially develop student skills order to:

BUILD Knowledge
APPLY Learning
DEMONSTRATE Ability
CREATE Resources & CONNECT to the Real World

Differentiation & Extension
A range of activity options are presented, which can be included and adapted for the *SDO Project Suite* based upon student interest, ability, and timeframe available. The SDO Solar Modules are designed for teachers to act as mentor and coach and empower students to develop their own passion for learning.

Internet Resources
A wide variety of additional resources that support the *SDO Project Suite* Solar Modules are included as part of each module's Teacher's Guide. These resources have been reviewed and provide teachers with additional scientific information and opportunities to further student engagement and exploration.

SDO Module 4 Performance Project

3-D Solar Exhibit

The culminating activity for the *SDO Project Suite* is the classroom SDO Exploration Museum event. As part of the collective museum, each student team designs, constructs, and curates their own interactive 3-D Solar Exhibit that consists of the activities and artifacts, which the teams completed for Solar Modules 1, 2, and 3. The SDO Solar Exploration Museum event is a great opportunity to showcase and share student learning not only between student teams but also within the school, district, and community.

Regular group "check-ins" throughout this module's performance-based assessment provides teams with the monitoring and support they need to ensure progress and success in demonstrating proficient student achievement. A teacher-completed Content & Exhibit Rubric and a Group Self-Evaluation Rubric are provided for evaluating this summative assessment module.

Summative Performance-based Assessment

3-D Solar Exhibit Elements

- Videos
- Demo Stations
- Models
- Dioramas
- Posters & Murals
- Slide Shows
- Interactive Exhibits
- Podcasts
- Digital Exhibits
- Students-as-Curators

Solar Exhibit Components & Sequence:

Part 1: Solar Exhibit Planning

1) Identify Completed Solar Module Content Activities
2) Select Solar Exhibit Design Format

Part 2: Solar Exhibit Preparation

3) Write Draft - Content, Image & Artifact Descriptions
4) Cite Sources - Content, Images & Artifacts
5) Type Final Copy - Content, Image & Artifact Descriptions
6) Prepare Images & Artifacts for Exhibit

Part 3: Solar Exhibit Creation & Evaluation

7) Create 3-D Solar Exhibit (following exhibit guidelines)
8) Content & Exhibit Rubric and Group Self-Evaluation Rubric

Part 4: SDO Exploration Museum

9) Attend Class SDO Exploration Museum Event
10) Congratulations, SDO Module 4 is finished!

Solar Dynamics Observatory: Solar Module Matrix

SDO Solar Module Topics	Activity A	Activity B	Activity C
Module 1 What are the features of the Sun?	1 A. Structure of Earth's Star	1 B. Observing the Sun	1 C. Solar Research: Pinhole Camera
	• Intro to SDO Video • SDO Science Overview Video • Sun 101 Video • The Sun's Energy Video • Colors of the Sun Video • Sun Comparison Activities • Sun|Trek Fact-ary • Sun Origami Model	• Intro to SDO Video • SDO Science Overview Video • Solar Space Telescopes Video • Sunspot Quiz • Galileo's Claim Student-Scientist Investigation	• Intro to SDO Video • SDO Science Overview Video • How to Safely View the Sun Video • Create a Pinhole Camera
Module 2 How and why do we study the Sun?	2 A. The Sun & EM Spectrum	2 B. Solar Activity & Magnetism	2 C. Solar Research: Spectroscope
	• SDO AIA Video • SDO EVE Video • EM Spectrum Tour • The Sun & EM Spectrum Video • How to Use Helioviewer Video & User Guide • Helioviewer Activity	• The Dynamic Sun Video • SDO HMI Video • Solar System Magnetism • Magnetic Solar System PowerPoint • Making Sense of Magnetism Activities	• Spectroscopy in Action Video • Spectroscopy Explained • Graphing the Rainbow Activity • Build a Spectroscope
Module 3 How does the Sun affect the Earth?	3 A. Sun-Earth Interactions	3 B. Space Weather	3 C. Solar Research: Magnetometer
	• Our World: Sunsets and Atmosphere • Launchpad: Aurora Lights • Real World: Monitoring Earth's Energy Budget • What is the tilt of Earth's Axis? • Why are days longer in the summer? • Why are days hotter in the summer? • Why are there four seasons on Earth? • What causes the seasons? • Reasons for Seasons Activity	• Solar Wind and Storms Video • The Threat to Earth Video • NOAA Space Weather Videos • NOAA Space Weather Poster & Booklet • Camilla Space Weather Forecast & SDO Solar Storm Prediction Data Sheet	• Earth's Magnetic Shield Video • NASA Space Weather Media Viewer: Videos "Magnetosphere #1-6" • NASA Space Weather Media Viewer: Illustrations "The Magnetosphere" • Make a Magnetometer
Module 4 SDO Exploration Museum Performance Project	3-D Solar Exhibit		
	Summative performance-based assessment of SDO curriculum: • Three Solar Module artifacts – at least one artifact from each SDO module • Explanation, and demonstration of SDO artifacts • Jigsaw "museum tour" between student team 3-D Solar Exhibits • Group self-evaluation rubric		

Introduction for Students: Curriculum Overview

Solar Dynamics Observatory (SDO) Project Suite Background

Imagine being part of an active team of student-scientists that uses sophisticated, real-time data of our nearest star, the Sun, just like solar physicists, cosmologists, and astronomers do! By taking part in the *SDO Project Suite* your team plans its own course of research by engaging in a range of exciting activities to study the Sun including:

- Designing a Solar Science movie, image sequence, and more created from real-time solar imagery and data from NASA's SDO satellite;
- Predicting space weather using actual SDO solar data to make a forecast
- Building and investigating with instrumentation used to study the Sun;
- Presenting an interactive Solar Science exhibit to a community audience to explain and demonstrate the Sun's effects on Earth's life and society.

The *SDO Project Suite* engages you and your team members in these innovative types of learning experiences. Your team will determine its own solar exploration pathway to investigate and understand the science of our Sun and to apply that knowledge to solve tomorrow's solar situations. The *SDO Project Suite* presents your team with real-world, project-based Solar Science activities that integrate STEM (science, technology, engineering & math) with language arts, social studies, and art. Your team will build 21st century skills such as digital and media literacy, critical thinking, and problem solving through collaboration with peers, just like scientists do every day in their own research!

NASA Living With a Star Program: The SDO Mission

Image: NASA

Heliophysics is the study of the Sun and its interactions with Earth and the solar system. NASA's Heliophysics science program consists of two main programs: 'Solar Terrestrial Probes' and 'Living with a Star' (LWS). LWS emphasizes the science necessary to understand those aspects of the Sun and space environment that most directly affect life and society on our planet. The first LWS mission is the Solar Dynamics Observatory, which was launched on February 11, 2010. LWS missions research the interconnected systems between the Earth and Sun with the ultimate goal of enabling a predictive understanding of the causes of solar activity and its effects on Earth. SDO observes how the Sun's magnetic field is generated, structured, and how stored magnetic energy is converted and released into the heliosphere in the form of solar wind, fast-moving solar particles, and sunlight.

SDO Solar Modules 1, 2, 3

Activities A, B, C

Attention, future Solar Scientists! Your team is on a mission to learn about the structure of the Sun, explore how and why we study the Sun, and determine what effects our neighborhood star has on our planet Earth.

The main objective of the *SDO Project Suite* is to build knowledge, apply learning, and demonstrate understanding of Solar Science through real-world activities. Your team works together as a group to choose and complete one activity (A, B, or C) from each of the three Solar Modules (1, 2, and 3).

SDO Solar Module Student Guide Components:

Overview
This provides your team with essential background information and the science and purpose of each *SDO Project Suite* Solar Module.

Team Goal
The goal clearly states what your team's objective is upon successful completion of each *SDO Project Suite* Solar Module.

Materials
Materials and equipment are listed to support your team in completing each *SDO Project Suite* Solar Module activity.

Engage & Explore!
Depending upon the three SDO Solar Module Activities that your team selects, each module is broken down into the following steps that develop skills in order to:

- BUILD Knowledge
- APPLY Learning
- DEMONSTRATE Ability
- CREATE Resources & CONNECT to the Real World

SDO Module 4 Performance Project

3-D Solar Exhibit

The fourth and final module is the 3-D Solar Exhibit, which is a performance-based assessment. Each teams' exhibit is part of a whole class SDO Exploration Museum. To showcase your team's Solar Science expertise, your group designs an exhibit that presents the previous three Solar Module activities that you completed. The activity artifacts are incorporated into a creative and interactive team exhibit that engages "museum visitors" in learning about the Sun and SDO. During the museum event, student teams curate their own 3-D Solar Exhibit and visit other teams' exhibits to share and build knowledge about Solar Science.

Timely group "check-ins" throughout the final module with your team members and teacher will help monitor and support your group's progress and success. A teacher-completed Content & Exhibit Rubric and a Group Self-Evaluation Rubric are provided for evaluating your team's 3-D Solar Exhibit performance-based project.

Summative Performance-based Assessment

3-D Solar Exhibit Elements

- Videos
- Demo Stations
- Models
- Dioramas
- Posters & Murals
- Slide Shows
- Interactive Exhibits
- Podcasts
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Solar Exhibit Components & Sequence:

Part 1: Solar Exhibit Planning

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Part 3: Solar Exhibit Creation & Evaluation

7) Create 3-D Solar Exhibit (following exhibit guidelines)
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Part 4: SDO Exploration Museum

9) Attend Class SDO Exploration Museum Event
10) Congratulations, SDO Module 4 is finished!

Solar Dynamics Observatory: Solar Module Matrix

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	Summative performance-based assessment of SDO curriculum: • Three Solar Module artifacts – at least one artifact from each SDO module • Explanation, and demonstration of SDO artifacts • Jigsaw "museum tour" between student team 3-D Solar Exhibits • Group self-evaluation rubric		

SDO Solar Modules Timeline:

First, fill in the title of the activities your team selects for each module. Next, create a schedule to complete each module. Finally check off each module as your team completes them. Remember, it is important that each student contributes to the team and that your team stays on schedule to complete your project on time. Enjoy your exciting exploration of our nearest star!

Solar Dynamics Observatory: SDO Project Suite						
Module	Activity A		Activity B		Activity C	
Module 1 What are the features of the Sun?	1 A. Structure of Earth's Star		1 B. Observing the Sun		1 C. Pinhole Camera	
	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed:	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed:	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed:
Module 2 How and why do we study the Sun?	2 A. The Sun & EM Spectrum		2 B. Solar Activity & Magnetism		2 C. Spectroscope	
	Module Goal: Leader:	Date(s) & Time to Complete Date Completed:	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed:	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed
Module 3 How does the Sun affect the Earth?	3 A. Sun-Earth Interactions		3 B. Space Weather		3 C. Magnetometer	
	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed:	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed:	Module Goal: Leader:	Date(s) & Time to Complete: Date Completed:
Module 4 SDO Exploration Museum Performance Project	3-D Solar Exhibit				Notes:	
	Exhibit Title: Team Roles:			Date(s) & Time to Complete: Date Completed:		