The incredible accessibility of extremely high spatial and temporal resolution data from the Solar Dynamics Observatory creates an opportunity for students to do almost real-time investigation in an Astronomy Lab. We developed a short series of laboratory exercises using SDO data, targeted for Community College students in an introductory lab class, extendable to high school and university students. The labs initially lead students to explore what SDO can do, online, through existing SDO video clips taken on specific dates. Students then investigate solar events using the Heliophysics Events Knowledgebase (HEK), and make their own online movies of events, to discuss and share with classmates. Finally, students can investigate specific events and areas, selecting specific dates, locations, wavelength regions, and time cadences to create and gather their own SDO datasets for more detailed investigation. In exploring the Sun using actual data, students actually do real science.

Contents:

Pages 2-3 Introduction
Page 4 ProjectTimeline
Page 5 Financial Reporting and Expense Summary
Pages 6-14 Summary of Original RFP, Proposal, Subcontract, and Invoices
Pages 15-16 Student Feedback and Lessons Learned
Pages 17-32 Current Version 3 of the Lab
Pages 33-35 Initial Draft of Lab
Pages 36-49 SDO Presentation at the Astronomical Society of the Pacific’s Cosmos in the Classroom meeting in San Jose, CA, by Scott Hildreth (7/22/2013) Attendee list and presentation
Introduction

The original idea for our project arose from discussions between Chabot faculty Timothy Dave and Scott Hildreth with Philip and Debbie Scherrer of Stanford and the Hansen Experimental Physics Lab, in spring of 2011. The Solar Dynamics Observatory satellite had been in operation for about 1 year, already returning spectacular video, and we wanted to investigate how that data might be used in a classroom setting. At the same time, we had come to recognize that participative lab exercises, along the lines offered by using the Galaxy Zoo program, were more effective in energizing our students, and that student interest in and use of YouTube clips had risen significantly in the past year. Creating a lab exercise that combined these elements – online access to real data, open investigation by students using that data, and using SDO data in the classroom – was something all of us felt to have merit.

Chabot College offers its students a very standard introductory science laboratory experience, through its Astronomy 30 course, which is taught one evening per week. Astro 30 has no pre-requisites, and typically is taken by non-science majors to fulfill their science lab requirement for transfer or for a terminal degree. Astro 30 often is populated with students who have limited mathematics skills, and little exposure to current science; the course is often taken by students one or two years after completing a companion lecture course on the solar system or stars and galaxies.

Our questions at the start of the project included:

a) Given the variety of students in the current laboratory class, could we engage them effectively using real, current data?

b) Could we give students sufficient background in the science behind SDO, given that students may not have studied the Sun in their on-campus Astronomy lecture classes (if being taken concurrently), or may not remember much from the previous lecture class (if taken much earlier)?

c) Could we simplify the access to data so that students could be successful in creating a reasonable query, one that could be answered in the available class time?

After investigating the various data access methods available, we developed a two-week lab investigation based upon the following hypotheses:

1) Engaging students with access to real data will require accessing real data, creating their own movies of solar events that interest them, and sharing those movies with classmates, friends, and family members.

2) Because students may not remember much about the Sun from their previous experience with lecture when they do the lab, we will need to provide one night of introductory exercises to bring everyone to a common level of understanding. The second night of exercises would be devoted to free inquiry and creation of movies. A third night of presentations for students to share their results was included in our initial design based on the assumption we would be able to have them generate follow-up queries based on their initial results.
3) Students would need to analyze a directed set of events, and then generate their own areas of interest based on events, dates, wavelength regions, resolution, and scales. Students would be directed to create their own testable hypotheses to explore by requesting additional data in even higher resolution.

We found after creating and testing the lab activities that:

1) Students were engaged in the lab activity, and our hypothesis that they would find accessing and creating their own videos interesting was supported.

2) Students had a very hard time creating reasonable hypotheses that could be tested with the available data in a classroom setting.

3) Students did enjoy presenting their results to classmates.

4) Many students found the activities to be the most interesting and educational lab experiences offered in their semester-long course.

5) Many students enjoyed the social media upload capabilities of the HelioViewer software.

6) Faculty could easily use the Heliophysics Event Knowledgebase site, along with HelioViewer and jHelioviewer software, to access low-level data and create short movies.

7) Faculty had a more difficult time using the JSOC interface to create successful queries for detailed high-resolution data.

8) HelioViewer and jHelioviewer had unpredictable processing times that made data acquisition challenging in one class period. Sometimes the movies would be available after a few minutes and sometimes after a few hours.

We are continuing to refine the labs, and have made them freely accessible at the campus website:

http://www.chabotcollege.edu/faculty/shildreth/sdo/index.htm
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<tr>
<th>Timeline</th>
<th>Activities</th>
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<tr>
<td>March 2011</td>
<td>Concept discussed and initial proposal generated to Stanford.</td>
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<tr>
<td>May 2011</td>
<td>Proposal to NASA Goddard Accepted</td>
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<td>August 2011</td>
<td>Monthly meetings with Stanford Team to discuss lab started. Weekly meetings at Chabot with faculty participants started</td>
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<td>October 2011</td>
<td>Project funding arrived (9/29) at Stanford; Initial training on JSOC interface.</td>
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<td>November 2011</td>
<td>Initial Lab questions developed; investigation with JSOC and HEK interfaces continued.</td>
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<td>February 2012</td>
<td>Lab questions and version 1 draft of lab developed</td>
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<td>March 2012</td>
<td>Training with Priya Desai on JSOC interface</td>
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<tr>
<td>May 2012</td>
<td>Chabot Las Positas Board approval for project finalized</td>
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<tr>
<td>June 2012</td>
<td>Visit to Stanford SDO/HMI</td>
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<tr>
<td>August 2012</td>
<td>Initial Tests of Lab scheduled for November 2012 and incorporated Into Fall 2012 syllabi for labs</td>
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<tr>
<td>November 2012</td>
<td>First Draft of Lab tested in two Astro 30 sections</td>
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<tr>
<td>December 2012</td>
<td>First lab responses gathered and analyzed; second draft of lab started</td>
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<tr>
<td>January 2013</td>
<td>Poster paper for March Maryland meeting developed. Second draft of Lab scheduled for two sections of Astro 30 in Spring 2013.</td>
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<tr>
<td>March 2013</td>
<td>Second draft of lab tested; student responses gathered.</td>
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<tr>
<td>April 2013</td>
<td>Second draft of lab analyzed; requests for additional faculty tests started locally. ASP national conference abstract submitted.</td>
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<td>July 2013</td>
<td>Presentation at ASP meeting; Draft 3 developed and distributed.</td>
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<tr>
<td>August 2013</td>
<td>End of project; additional distribution of lab to interested faculty, third Draft scheduled for trial in Oct/Nov 2013 classes.</td>
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Financial Reporting and Expense Summary

While the process of receiving and financially administrating a grant at Chabot College is not significantly different from that one would find at any other College or University, it sometimes does present some unique challenges. All grants must go through an approval process that requires “sign-off” from our Grants Office, Department Dean, Vice President of Business Services at the college and Vice Chancellor of Business Services and last, but not least, the Board of Trustees of the Community College District.

The “challenge” mentioned above, comes in getting all the “players” (administrative aids, business managers, etc.) to establish a time and billing account on Banner (the financial accounting system) and in other accounting record keeping systems utilized by the District and the College. Once that is done, then there is relatively smooth sailing until approvals are received from the District Board of Trustees (BOT). The “glitch” at this level (District) revolves around the fact that the BOT only meets a limited number of times each month, so if rapid approvals or modifications to the project are needed, they may not come within the expected timeframe. While this did not impact the scope or progress of implementing the research of this project when a modification was needed to extend the contract by a year, there was a delay in getting compensation for the work done by the faculty. Hopefully such delays can be avoided in the future.

The key steps in moving this project forward from start to completion were:

a.) Getting BOT approval
b.) Establishing an internal account and charge number
c.) Submitting a Position Action Form (PAF) which identifies personnel (Faculty and Staff) working on the project which will be compensated.
d.) Encouraging a dialogue between those in the District responsible for financial matters and the funding entity (Stanford).
e.) Securing time spent on project from participating faculty and staff.
f.) Submitting relevant concluding financial paperwork to both District and funding entity.

Each of the above steps did require follow-up by project management (faculty principal investigators) to assure project goals were accomplished and accomplished on time. To date, within the Chabot/Las Positas Community District, there is no easily accessible online means to keep updated with real-time costs and encumbrances against a project, but I am assured that in the future, such data will be available.

*Reference Financial Documents in Appendix A for budgeting and spending details.*
March 7, 2011

Chabot Community College
25555 Hesperian Blvd.
Hayward, CA 04545

Subject: Request for Proposal; Due March 9, 2011

The Education and Public Outreach (EPO) team for NASA’s Solar Dynamics Observatory (SDO) is attempting to find ways to bring SDO data into K-14 classrooms in a meaningful and stimulating way. It is well-known that students who have opportunities to work with real scientific data and research are much more successful in future science courses and more likely to enter STEM careers. This Request for Proposal from Chabot Community College would support the development and testing of a physics/astronomy lab based on data from SDO.

SDO scientists and EPO team members would work with the Chabot instructors to conceive of an appropriate lab exercise which would allow students to measure and analyze data from some or all instruments on SDO.

The instructors would test the materials in one or more of their physics and/or astronomy classes. Materials would be adjusted based on the results of the experiment.

It is understood that the development of appropriate software tools to support student measurement of the data may be required. This is outside the scope of this RFP.

Subsequently the materials would be distributed to additional community colleges for formal assessment and adjustment based on that assessment. Subsequently, the labs would be more formalized and prepared for wide-scale distribution.

Further extensions might include building upon the existing lab to develop a space weather unit appropriate for community colleges.
This RFP is a request for Phase 1 of the project, for ~$20,000, to be accomplished during the period 1 June 2011 - 30 May 2012. Later phases may be funded through subsequent RFPs.

Statement of Work:

Purpose: Develop a laboratory exercise to enable student analysis of SDO data. An SDO scientist will be available for consultation with the instructors.

Tasks and Deliverables:
1. Dr. Scott Hildreth and Dr. Tim Dave will jointly with Stanford develop a 5-day [or ???] laboratory exercise that uses SDO data in a meaningful and effective way for community college students.

2. Hildreth and Dave will test run the lab in an introductory physics or astronomy class, observing students as they work with the lab and tuning the procedures as needed. [Note -- this is not formal assessment.]

3. Hildreth and Dave will produce written materials for the lab so that the lab can be sent out for formal evaluation and testing elsewhere.

4. The lab will be distributed to at least 4 other sites, in diverse environments, for formal assessment. The lab will be adjusted based on that assessment.

5. The lab will be prepared for wide-scale distribution.

6. A space-weather unit based on, or inspired by, the lab would be created for community college environments.

It is understood that additional supporting effort such as the development of software tools to enable student access to data, and adapting the laboratory to high school environments may be necessary, but are outside the scope of this RFP.

Please submit your proposal in pdf format to romeo@sun.stanford.edu by the RFP deadline (March 9, 2011). If you have any questions about the SOW, Deborah Scherrer will be your direct contact.

Thank you and best regards,

Romeo Durscher
Hansen Experimental Physics Laboratory
SUMMARY OF PROPOSAL

The Astronomy and Physics Department of Chabot College is pleased to offer our proposal to produce and test a lab exercise which would allow students to measure and analyze data from some or all instruments on SDO.

1.0 Background and Relevant Experience

Our Astronomy Instructors have over 50 years of accumulated teaching and curriculum development experience. Additionally, in the past we have formulated and administered numerous internal and national grants like that from ATE (National Science Foundation) to foster multidisciplinary learning communities. We have worked with a varied number of partners from Lawrence Livermore National Laboratory and Sandia Labs to the Hayward, Union City, and San Leandro Unified School Districts. Since we have worked with the requestor, Stanford University W.W. Hansen Experimental Physics Laboratory, in a recent NSF grant we would like to specify the bid requestor as our reference.

2.0 Statement of Work

Purpose: Develop a community college-level laboratory exercise to enable student analysis of SDO data. An SDO scientist will be available for consultation with the instructors.

Tasks and Deliverables:

1. Professors Scott Hildreth and Tim Dave will jointly with Stanford develop a laboratory exercise (possibly to be explored over two or more lab sessions) that uses SDO data in a meaningful and effective way for community college students.

2. Hildreth and Dave will test run the lab in an introductory astronomy lab class, and possibly a physics class, observing students as they work with the lab and tuning the procedures as needed.

3. Hildreth and Dave will produce written materials for the lab so that the lab can be sent out for formal evaluation and testing elsewhere.

It is understood that additional supporting effort such as the development of software tools to enable student access to data, and adapting the laboratory to high school environments may be necessary, but are outside the scope of this RFP. Additional steps in the formal assessment of the lab, distribution of the lab for further testing by other institutions, review of those results, and revision of the labs would also be beyond the scope of this initial proposal, as would developing a space weather unit.
3.0 Proposed Costs

The following budget narrative breaks down the budget for the term 1 June 2011 - 30 May 2012, and totals $20,000.

Months 1-3 (1 June to 30 Aug 2011)
The first two months of the grant will be designated as research and planning and development months, starting the development of labs and appropriate additional curriculum.

Costs: Senior Personnel (Hildreth and Dave) – $4,000

Months 3-7 (15 August to 30 Dec 2011 – Fall Semester)
Development of the lab activities and supporting student materials, and alpha testing of the lab in one laboratory section of Astronomy 30 to be led by Hildreth.

Costs: Senior Personnel (Hildreth) – $12,500 (salary/benefits reassignment from 1 class at Chabot College, to paid to the college at the start of the semester.)

Months 8-12 (1 January 2012 to 30 May 2012 – Spring Semester)
Continued testing of the lab by both Hildreth and Dave in two Astro 30 courses at Chabot College, revision of student materials, and summary of initial student reactions. Preparation of materials for the next stage of assessment.

A. Senior Personnel (Hildreth and Dave) – $3,500
**SUBRECIPIENT COMMITMENT FORM**

Subrecipient Legal Name: Chabot-Las Positas Community College District - Chabot College

Subrecipient PI Name: Timothy Dave

Address: 5020 Franklin Drive  
City: Pleasanton  
State: CA

Address where research will be performed: 25555 Hesperian Boulevard  
City: Hayward  
State: CA

Proposal Title: Chabot-Stanford Solar Dynamic Observatory (SDO) Lab Exercise Project

Performance Period Begin Date: January 17, 2012  
End Date: December 20, 2012

Stanford’s PI Name: Romeo Durscher

Prime Sponsor: NASA

### SECTION A – Proposal Documents

The following documents are included in our proposal submission and covered by the certifications below (check as applicable):

- ☒ STATEMENT OF WORK (required)
- ☒ BUDGET AND BUDGET JUSTIFICATION (required)
- ☐ Small/Small Disadvantaged Business Subcontracting Plan, in agency-required format
- ☐ Biosketches of all Key Personnel, in agency-required format
- ☐ Other:
- ☐ Other:

### SECTION B - Certifications

1. **Facilities and Administrative Rates** included in this proposal have been calculated based on:

   ☐ Our federally-negotiated F&A rates for this type of work, or a reduced F&A rate that we hereby agree to accept.  
   *(If this box is checked, please attach a copy of your F&A rate agreement or provide a URL link to the agreement.)*

   ☒ Other rates (please specify the basis on which the rate has been calculated in Section D Comments below)

2. **Fringe Benefit Rates** included in this proposal have been calculated based on:

   ☐ Rates consistent with or lower than our federally-negotiated rates  
   *(If this box is checked, please attach a copy of your FB rate agreement or provide a URL link to the agreement.)*

   ☒ Other rates (please specify the basis on which the rate has been calculated in Section D Comments below).

3. **Small Business Concern** ☐ Yes ☐ No

   Subrecipient represents that it is a small business concern as defined in 13 CFR 124.1002.

   *If "Yes": Subrecipient represents that it is a:
   
   ☐ Small disadvantaged business as certified by the Small Business Administration
   ☐ Women-owned small business concern
   ☐ Veteran-owned small business concern
   ☐ Service-disabled veteran-owned small business concern
   ☐ HUBZone small business concern

4. **Cost Sharing** ☐ Yes ☒ No  

   **Amount:**

   *Cost sharing amounts and justification should be included in the subrecipient’s budget

5. **Human Subjects** ☐ Yes ☒ No  

   **Approval Date:**

   *If "Yes": Copies of the IRB approval and approved "Informed Consent" form must be provided before any subaward will be issued. Please forward these documents to Stanford’s PI and Stanford’s Office of Sponsored Research as soon as they become available. In accordance with Stanford policy, Stanford’s IRB must conduct a secondary review of the subaward work and issue a companion approval before any subaward will be issued.*
If "Yes": Have all key personnel involved completed Human Subjects Training?  ☐ Yes  ☒ No

6. Animal Subjects  ☐ Yes  ☒ No  Approval Date:_________________

If "Yes": A copy of the IACUC approval must be provided before any subaward will be issued. Please forward this document to Stanford’s PI and Stanford’s Office of Sponsored Research as soon as it becomes available. In accordance with Stanford policy, Stanford’s IACUC must conduct a secondary review of the subaward work and issue a companion approval before any subaward will be issued.

7. Conflict of Interest (applicable to NIH, NSF, or other sponsors that have adopted the federal financial disclosure requirements)
   ☒ Not applicable because this project is not being funded by NIH, NSF, or other sponsor that has adopted the federal financial disclosure requirements

   ☐ Subrecipient Organization/Institution certifies that it has an active and enforced conflict of interest policy that is consistent with the provision of 42 CFR Part 50, Subpart F “Responsibility of Applicants for Promoting Objectivity in Research.” Subrecipient also certifies that, to the best of Institution’s knowledge, (1) all financial disclosures have been made related to the activities that may be funded by or through a resulting agreement, and required by its conflict of interest policy; and, (2) all identified conflicts of interest have or will have been satisfactorily managed, reduced or eliminated in accordance with subrecipient’s conflict of interest policy prior to the expenditures of any funds under any resultant agreement.

   ☐ Subrecipient does not have an active and/or enforced conflict of interest policy and agrees to abide by Stanford’s policy, located online at http://www.stanford.edu/dept/DoR/rph/4-4.html.

8. Debarment and Suspension

   Is the PI or any other employee or student participating in this project debarred, suspended or otherwise excluded from or ineligible for participation in federal assistance programs or activities?  ☐ Yes  ☒ No

   (if “Yes”, explain in Section D Comments below)

   The Subrecipient certifies they: (answer all questions below)

   ☐ are  ☒ are not presently debarred, suspended, proposed for debarment, or declared ineligible for award of federal contracts

   ☐ are  ☒ are not presently indicted for, or otherwise criminally or civilly charged by a government entity

   ☐ have  ☒ have not within three (3) years preceding this offer, been convicted of or had a civil judgment rendered against them for commission of fraud or criminal offense in connection with obtaining, attempting to obtain, or performing a public (federal, state or local) contract of subcontract; violation of Federal or State antitrust statutes relating to the submission of offers; or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements or receiving stolen property

   ☐ have  ☒ have not within three (3) years preceding this offer, had one or more contracts terminated for default by any federal agency

SECTION C - Audit Status

9. Audit Status
   ☒ Subrecipient receives an annual audit in accordance with OMB Circular A-133.

   Most recent fiscal year completed: FY2011

   Were any audit findings reported?  (If “Yes,” explain in Section D, Comments, below.)  ☐ Yes  ☒ No

   Please attach a complete copy of your most recent A-133 audit report or provide the URL link to a complete copy.

   Chabot-Las Positas Community College District Annual Audit Report
   http://www.clpccd.org/business/BusinessServicesAudit.php

   ☐ Subrecipient DOES NOT receive an annual audit in accordance with OMB Circular A-133.

   Subrecipient is a:
   ☐ Non-profit entity (under federal funding threshold)
   ☐ Foreign entity
   ☐ For profit entity
   ☐ Government entity
Please complete an Audit Certification and Financial Status Questionnaire (OSR Form # 47). A limited scope audit may be required before a subaward will be issued.

SECTION D - Comments

The Chabot-Las Positas Community College District does not have a federally-negotiated indirect cost rate and therefore, does not charge indirect costs to federally sponsored projects. In addition, this project does not charge fringe benefits. If it were to charge fringe benefits, charges would be in accordance to actual fringe benefits rates currently paid to personnel.

APPROVED FOR SUBRECIPIENT

The information, certifications and representations above have been read, signed and made by an authorized official of the Subrecipient named herein. The appropriate programmatic and administrative personnel involved in this application are aware of agency policy in regard to subawards and are prepared to establish the necessary inter-institutional agreements consistent with those policies. Any work begun and/or expenses incurred prior to execution of a subaward agreement are at the Subrecipient’s own risk.

Chabot-Las Positas Community College District
Legal Name of Subrecipient’s Organization/Institution
5020 Franklin Drive
Address
Pleasanton, CA  94588
City, State, Zip
94-1670563
Federal Employer Identification Number (EIN)
071680961
DUNS or DUNS+4 number
CA-13, CA-09
Subrecipient’s Congressional District

Is Subrecipient owned or controlled by a parent entity? □ Yes  ☒ No

If “Yes”, please provide the following:

Parent Entity Legal Name:
Parent Entity Address, City, State, Zip:
Parent Entity Congressional District:
Parent Entity DUNS:
Parent Entity EIN:
Invoice – Part 1 of Project

Attention: Romeo Durscher  
Title: Senior Manager  
HELP Solar Physics  
Room 130 452 Lomita Mall, Room 130  
Stanford, CA 94305-4085  
Date: 6/25/2013

PROJECT TITLE: Astronomy Lab Based on SDO Data (Stanford SDO Lab Project NASA)  
PROJECT DESCRIPTION: Stanford SDO Lab Project NASA (*Part 1)  
FUND NUMBER: 312068  
ACCOUNT NUMBER: 312068-25301-1480-602000  
TERMS: 60 DAYS

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$ 0.00

$ 0.00

Subtotal $ 7,350.00

Benefits $ 778.48

Total $ 8,128.48

Project Summary: *Part 1: SDO scientists and EPO team members worked with the Chabot instructors to conceive of appropriate lab exercises which would allow students to measure and analyze data from some or all instruments on SDO. **Part 2: The instructors tested the materials in one or more of their physics and/or astronomy labs, have provided student feedback and final project report.

Sincerely yours,

Timothy A. Dave, Professor of Astronomy and Physics
Invoice – Part 2 of project

Attention: Romeo Durscher
Title: Senior Manager
HELP Solar Physics
Room 130 452 Lomita Mall, Room 130, ph. (650) 723-8320
Stanford, CA 94305-4085
Date: 7/25/2013

PROJECT TITLE: Astronomy Lab Based on SDO Data (Stanford SDO Lab Project NASA)
PROJECT DESCRIPTION: Stanford SDO Lab Project NASA (**Part 2)
FUND NUMBER: 312068
ACCOUNT NUMBER: 312068-25301-1480-602000
TERMS: 60 DAYS

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Project Summary: **Part 1:** SDO scientists and EPO team members worked with the Chabot instructors to conceive of appropriate lab exercises which would allow students to measure and analyze data from some or all instruments on SDO. **Part 2:** The instructors tested the materials in one or more of their physics and/or astronomy labs, have provided student feedback and final project report.

Sincerely yours,

Timothy A. Dave, Professor of Astronomy and Physics
SDO LAB – Selected Student Comments

First semester (trial #1) Student comments
From this two week exercise what are some of the most significant things you have learned about the Sun?
“How powerful solar flares are and what an impact they can have on our lives (our dependence on technology)”

What are some of the most significant things you have learned about this process of data analysis that Solar astronomers go through?
“I have learned that data analysis is a very specific task that is detail oriented”
“I learned that it is long frustrating and awful”
“You can use the same image and change the resolution and get different information”
“I learned how staggering the amount of data is. It will take years to go through the data collected in a single day”

What would you have liked to do with this activity that you were not able to do, or not given enough time to do?
“I would like to learn more about how the magnetic fields affect us on Earth”
“I would have liked to view more videos over a longer period of time”
“I would have liked to create a longer video to see how Sunspots evolve”

What would you keep and what would you change overall?
“The at home video was great and the presentation was fun”
“I definitely liked that we were able to present our video to the class and view other videos for comparison.”
“Overall cool lab”
“Start with this lab at the beginning of the semester and make observations throughout the semester”
“I would keep the same format but I would make it more focused on making one movie of a single sunspot”

What was the most challenging part of this lab?
“moving around within the software, changing views, colors, instruments, going back and forth between different views”
“trying to make sure the layers match up”
“Learning how to use the various programs effectively, some were not very user friendly”

Shannon’s thoughts on our rewrite and trial 2

After our first trial we decided to change a few areas of the lab to better facilitate our time constraints, student comprehension and the student experience working with real data.

We tried to re-write some of the questions so that it would prod students to be more descriptive and more thoughtful in their responses. Our original questions were perhaps too open ended which incited answers like “because it is pretty” or “I see bright parts”. We wanted to encourage students to use more analytical and critical thinking when recording their observations. I think we could improve these questions even more so that we inspire even higher order thinking from participants.
Many students seemed ill prepared for the level of scientific inquiry that we were asking for. Some of this stems from the academic level of community college students these days, but also I think I could have done more to prepare them. Our other labs require sufficient levels of inquiry but perhaps I was not rigorous enough in grading their responses to encourage their progress and to enforce my level of expectation.

All the students struggled with how to write a research question to explore. Some were rather juvenile while others were good places to start but needed to be rewritten. I wish I had more time to guide/instruct students on how to write a good research question.

Students enjoyed making their own video’s but struggled while working with Jhelioviewer. Jhelioviewer was a more powerful tool and had more options for students to choose from to create and analyze movies. In hindsight I would have liked to have set aside more class time so that I could demonstrate all the abilities of this tool, although you could argue that letting students explore this tool on their own could be a fundamental part of the process. Sometimes we must pick our battles.

The limitations of jhelioviewer are its resolution and download times. In order to make the data accessible at reasonable time frames the resolution of the data is binned down which limits some of the research our students can do. On our second attempt on the lab we included an extra week where the instructors could download full resolution data directly from JSOC operations for SDO to allow students to explore longer time frames and more detailed images. This idea didn’t work due to the time commitment it would take on the instructor’s part but due to the nature of our students research questions perhaps the more advanced data is unnecessary. For those students who showed particular interest (and aptitude) in this lab we could always download this additional data for them or instruct them on how to use JSOC themselves. On a small scale the time commitment for the download would be minimized.

Other thoughts
A back up plan may be needed for portions of the lab that require the HEK data if that website is down for the day.

The intro video really needs to be done as a homework assignment and not in class. For our lab course homework (other than the lab reports) are not part of the regular curriculum. We would have more success implementing a “prelab” activity that is done at home if we built this type of activity into the regular class culture.

Students really enjoyed presenting their videos to the class and also sharing videos they made on social media. I was unable to do the presentation portion of the lab with my class last semester and really regret skipping it. I would like to make this an integral part of this lab experience for students.

Final thoughts
I still feel that this should be a 3 week (1 lab per week) lab activity to give students the most benefit. The last lab class should be devoted to final video analysis and presentations.

Shannon Lee, Adjunct Instructor, Chabot College
The process of Science
Historically observations in astronomy have been done by people gazing through a telescope, that gathered light our eyes couldn’t see, to view objects in the night sky. Observations originally had to be recorded by the astronomers making drawings by hand, as Galileo did making sketches of the four moons of Jupiter, or the sunspots on the Sun; more recently we attached film cameras to the eye pieces to make photographs. But still, we gathered and analyzed only the visible light from astronomical objects.

As technology has advanced we have begun to launch satellites above our atmosphere, to observe celestial objects with other wavelengths of light, and collect that light using computerized telescopes that transmit their data digitally back to computers on Earth, and we again use computers to analyze the data to do our science experiments. In this activity you will access and use real data, taken recently from the Solar Dynamic Observatory (SDO) space craft to do research on sunspots and solar activity as part of a Stanford University and NASA project for citizen science.

Introduction
There are many stars that dot the night sky but the most important star is the one that you can only see in the day: The Sun. Nearly every organism on Earth depends on the Sun for survival. While it is necessary for our existence, the Sun may also be our undoing. Our modern way of life depends on technology and the more dependent we become the more vulnerable we are to the Sun’s outbursts.

On March 13 1989, an estimated 6 million people in the region of Quebec Canada lost power for 9 hours. This large blackout was caused by the Sun. A massive eruption called a coronal mass ejection had occurred on the Sun and was aimed right at Earth. These eruptions are actually quite common and we call this connection between solar activity and its impact on the Earth “Space Weather”.

The Solar Dynamic Observatory (SDO) is a space telescope that was launched on February 11th 2010. SDO is sitting in a geosynchronous orbit about 22,000 miles above the surface of the Earth. There are three instruments aboard: AIA, MDI and EVE.

For this lab we will be using real data from AIA and MDI instruments to observe sunspots and solar eruptions. These observations will be reported to Stanford to be used in current research in NASA’s “Living with a Star” investigations. You can read more about SDO at the NASA website: http://sdo.gsfc.nasa.gov/mission/about.php

Objectives
1. Create movies using real data from AIA and HMI to observe sunspots and solar flares.
2. Identify and catalog sunspot rotation data for selected active regions.
3. Explore the connection between sunspot rotation and “space weather”.
4. Use different types of data to develop an experiment to test a hypothesis about solar activity.
5. Collaborate with other students to combine data to explore a hypothesis.
6. Publish results and movies to Stanford for use in future experiments.

Part 1: Background Activity
Using SDO Data to do Real Science – A Community College Astronomy Lab Investigation
The SDO mission is a groundbreaking venture into the future of solar science. As we progress into the social media age, science is being promoted to the public on many different levels. We will need some information about the SDO mission before we can begin analyzing data. We will take advantage of a YouTube video called “Journey to the Sun” by KQED quest to get some information that will be useful in our lab. As you watch the video there will be some questions you will need to answer to guide you; pay close attention and pause it frequently so that you don’t miss any important information. The video is located here: http://tinyurl.com/journeyintothesus and http://www.youtube.com/watch?v=fqKFQ7z0Nuk
Solar Dynamics Observatory Laboratory

Name: __________________________ Date: ______________

Lab Partners: ____________________________________________

Video questions:

1) What is the resolution for SDO? _______________________________________________________

2) What do we call the extension of the Sun’s atmosphere into the solar system?

3) Describe a difference between coronal mass ejections and solar flares

   ____________________________________________________________

4) How will SDO help us deal with “space weather”?

   ____________________________________________________________

5) How are sunspots and space weather connected?

   ____________________________________________________________

6) How long is the solar cycle? What is changing during the cycle?

   ____________________________________________________________

7) The AIA instrument measures light in what range of light? What region of the Sun emits this radiation?

   ____________________________________________________________

8) What does the HMI instrument measure?

   ____________________________________________________________

9) How much of the Sun does each pixel on the camera represent?

10) Heliosismology studies the inside of the Sun by using what kind of waves?

   ____________________________________________________________

11) What do the black and white colors on the magnetic map of the Sun represent?

   ____________________________________________________________

12) How often does HMI take a picture of the Sun? How often does it make a full map of the Sun?

   ____________________________________________________________

Part 2: Directed Introductory Student Activity

There are some fantastic collections of data from the instruments aboard the SDO spacecraft that have been put up on the web for the public. Let’s look at some examples.

Video 1: http://tinyurl.com/SDOyear1

http://www.youtube.com/watch?v=U_MKL_fjDLo&feature=youtu.be
This is a compilation of data from both the AIA and HMI instruments for the first year that SDO was in operation. **Prominences** are solar eruptions that are fairly stable. They last for hours or even days as charged particles of gas flow along **magnetic field loops**. Bright glowing gas will look like water flowing from a hose into the Sun's atmosphere. **Flares** are seen as bright bursts of energy that last for only a brief moment. You can also see **sunspots** as they evolve over time as they cross the solar surface. Sunspots look like very dark patches on the surface, almost like solar acne. Notice that the Sun is imaged in different colors. Each color represents a different kind of light and temperature. Watch the video carefully and try to identify which parts of the video are showcasing the different types of solar activity. Note the time on the video when each feature appears.

**Prominences:** video times ________,_______,_______,_______,______

**Solar flares:** video times ________,_______,_______,_______,______

**Sunspots:** video times ________,_______,_______,_______,______

**Unknown features:** video times ________,_______,_______,_______,______

No go to the following website [http://sdo.gsfc.nasa.gov/data/](http://sdo.gsfc.nasa.gov/data/). Here we can see the data from the Sun today. Each image has been labeled with important information. At the top you will see AIA and then a number (like AIA 193) this tells you the AIA instrument took the data and that the wavelength of light is 193 **Angstroms** (or \(193 \times 10^{-10} \text{ m}\)). The figure shown is an example.

1) Compare and contrast the different wavelength images. Specifically comment on which of the images seems the most “active”, which of the images seem the most “quiet”? Also mention what criteria you are using to differentiate quiet from active.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

2) For any of the AIA wavelength channels, click on each of the numbers (4096 2048 1024 512) directly underneath the image. Each is a hyperlink. What is the difference between the numbers?

___________________________________________________________________________
3) For any of the AIA wavelength channels, click again on each of the numbers labeled with “PFSS” underneath the image. PFSS stands for Potential Field Source Surface model, and the lines you see are approximated magnetic field lines. What do you notice about the number of lines, and the “density” of lines (how many are packed into a small region) you see coming from particular features on the Sun?


An active region is an area on the Sun where the magnetic fields are stronger than the surrounding area. Sunspots are visible manifestations of active regions. Active regions are also responsible for solar eruptions like flares and prominences. In this video we see an active region in three different wavelengths of light side by side.

This image is an artistic rendering of an active region. The area under the active region can be represented by a bar magnet with a north and south pole. Charged particles are trapped along the magnetic field lines and create unstable glowing loops above the active region. (Windows to the Universe original artwork by Randy Russell using an image from NASA’s TRACE spacecraft.)

5) What features of the Sun are uniquely visible in each of the three frames of the video

a. Orange (AIA 304 Å, Chromosphere, 50,000 K)
b. Yellow (AIA 171 A, Corona, 630,000 K )

__________________________________________________________________

c. Black and White (HMI intensitygram, Photosphere, 5,000 K )

__________________________________________________________________

Video 3: http://tinyurl.com/onerotation
(http://www.youtube.com/watch?v=oInoNnPxcA&feature=youtu.be)

Now let’s focus our attention on sunspots. This video is one solar rotation worth of images in white light (photosphere: 5,000 K). The Earth rotates on its axis once every 24 hours (one day). The Sun also rotates on its axis but it takes much longer than one Earth day.

6) How long is one solar rotation (in Earth days)?

__________________________________________________________________

7) How many active regions can you count on the Sun in this solar rotation?

__________________________________________________________________

8) Do you think this is a time of high solar activity or low solar activity? Explain why.

__________________________________________________________________

9) Are there any active regions that you believe would be more likely to cause a solar eruption than others? Explain!

__________________________________________________________________

10) How could you check this hypothesis?

__________________________________________________________________

Now check out the next videoclip:

Video 4: http://tinyurl.com/largesunspot
(http://www.youtube.com/watch?v=Nnwqkm6rL4M&feature=youtu.be)

Active regions on the Sun are carefully labeled and catalogued. Each sunspot is given an active region number. This may seem a simple categorizing task but as sunspots evolve they can shrink, grow, split or disappear altogether. Video 4 is data from the same dates as video 3 (but only a few days instead of the full solar rotation). Here the active regions are labeled and we can focus on one in particular, region AR1339 on 11/06/11. The video will show you many details about this active region.

11) Pause the video at the 5 second mark. How large is the sunspot group, in terms of our planet’s diameter? (In other words, how many “Earth’s” across is this sunspot group?)
12) How many Earth’s tall is this sunspot group?

13) Area is calculated by multiplying length times width. Multiply your answers from the previous two questions. Approximately how many Earth’s in area is AR 1339?

The next portion of the video deals with magnetic fields. Sunspots are really pairs of magnetic poles, when you get a large group of sunspots it can be very hard to separate them. Draw a quick sketch of this image and label the N and S polarity of the main magnetic fields.

The last portion of the video looks at sunspot evolution data. Watch carefully and see if the sunspots rotate.

14) Is it easier to see the large spots or the small spots rotate?

15) Choose one or two spots to watch and draw them in the box below, and indicate with arrows which way the sunspots are rotating.

Video 5: [http://tinyurl.com/X1flare](http://tinyurl.com/X1flare)  
([http://www.youtube.com/watch?v=6MWL_gQVWQk&feature=youtu.be](http://www.youtube.com/watch?v=6MWL_gQVWQk&feature=youtu.be))
Solar flares are the some of the most energetic and violent eruptions in our solar system. During “Solar maximum” they can occur very frequently and can have a significant impact on our daily lives. X-ray radiation is shot out from the Sun and if aimed towards Earth can destroy satellites and harm astronauts. Solar flares are classed based upon their intensity: B and C flares are the weakest and least energetic, M flares are fairly strong and can cause us some worry, X class flares are the most powerful and dangerous. The video shows one particular flare seen with SDO in different wavelengths of light. After watching the video please answer these questions to guide your observations.

16) Does the flare emanate from an active region (sunspot) or does it emanate from a “quiet” place on the Sun? How can you tell?

______________________________________________________________________________

17) Compare and contrast the appearance of the flare with the other bright places on the Sun at that time? What makes the flare so different?

______________________________________________________________________________

______________________________________________________________________________

18) Is the flare just a flash of light? Do you see anything else occurring in that region?

______________________________________________________________________________

______________________________________________________________________________

Finally, take a look at this final short video clip:
We have been observing and trying to predict the occurrence of solar flares for many years but they can still surprise us. SDO is not equipped to detect gamma rays from the Sun, mostly because the Sun doesn’t usually produce much gamma radiation, but there are other telescopes in space sensitive to that wavelength. We can get very useful and informative observation data when telescopes work together to observe the same event.

After watching the video, please answer the following questions.

19) Do you think it would be cost effective to build and launch a gamma ray telescope that only looks at the Sun? Provide reasoning to support your argument.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

20) After all your research that you have done so far in this lab, what topic do you find most interesting? If you were asked to choose one topic to continue researching what would you choose and what questions would like to explore further?
(As a reminder, we have learned about SDO, temperature and wavelength, prominences, sunspots and active regions, and flares. You also can choose a topic not on this list that you find interesting.)
Now that we have some background knowledge of the Sun we can start to explore ways to make movies of our own using the same data! First we need to find an “active day” on the Sun as a starting place. We already know from the previous youtube video’s that November of 2011 was particularly active (with lots of large sunspots). But there have been more recent dates that have been very interesting.

1) We will go to the online database for the Lockheed Martin Solar and Astrophysics Laboratory (LMSAL) and search their Heliophysics Events Knowledgebase (HEK). The data base is located here:  http://www.lmsal.com/isolsearch

We need to restrict ourselves to just a few hours of the Solar data to see the results clearly

2) Enter 2012-10-23T00:00:00 in the start date box and 2012-10-23T04:00:00 in the end date box. Next, restrict the visible event types to only active regions and flares; to do this quickly, CLEAR all of the preselected event types, and then check Active Regions and Flares. Your screen should now look like this:

To the right, you have a list of search results. If you mouse over the spots on the Sun you should see the particular event (region) highlighted on the right. If you click on them you can get some links to appear on the far right, including movies. Some active region results will have more useful data than others.

3) If you click on result “31. AR” you will see the data menu pictured above on the right. Click on the picture at the top, it will have the actual active region number labeled (starting with 15XX)

4) Click on SSW Movie Menu for “31.AR”. You will see some movies that you can explore in different video formats (JavaScript, Flash, MPEG). Try each one and be patient for loading times.
5) Pick a few active regions from results “31.AR to 37.AR” and “52.AR to 57.AR”. Click on the SSW Movie Menu, and from there view the FLASH or JavaScript representations of the event. Record your observations briefly, and with your team, develop at least one research question to explore further based upon the data you have seen. An example is done below.

EXAMPLE: SDO Recording of observations for (Date/Time): 2012-10-23T00:00:00-04:00:00
Active Region # 31 Data Viewed (JavaScript Movie, Flash Movie, etc.) Flash Movie
Observations (Did you notice patterns, loops, whorls, structures? Events like a flare or sudden brightening of the image? Try to be as specific about what you see, and when it occurred, as possible.)
Visible active region with loops of glowing gas flowing from one sunspot to another. A small amount of brightening on the left.
Research Question to Explore further:
Is the small amount of brightening a weak solar flare?

First Active Region # Data Viewed (JavaScript Movie, Flash Movie, etc.)
Observations (Did you notice patterns, loops, whorls, structures? Events like a flare or sudden brightening of the image? Try to be as specific about what you see, and when it occurred, as possible.)

Research Question to Explore further:

Second Active Region # Data Viewed (JavaScript Movie, Flash Movie, etc.)
Observations (Did you notice patterns, loops, whorls, structures? Events like a flare or sudden brightening of the image? Try to be as specific about what you see, and when it occurred, as possible.)

Research Question to Explore further:

To answer your questions, you’ll need to get more data of the area you selected. You can do that quickly, with low-resolution data, using HELIOVIEWER, available at www.helioviewer.org.

6) For one of the Active Regions you found, use the menu in the right window to go to HELIOVIEWER.org.
   a. In the Time box, enter the Date and Time to match your observation from the 2012-10-23T00:00:00 event. Leave a Time-step of 1 Day.

   b. In the Images window, select SDO observations in the AIA 171 wavelength band, and click on the [Add] link to create another observation set that will be overlaid on top of the AIA band. The initial default will be a LASCO set from the Solar and Heliophysics Observatory (SOHO).
c. Change the LASCO set to the SDO Observatory, the Helioseismic and Magnetic Imager (HMI) instrument and detector, and the Continuum measurement. (You can learn more about the HMI’s role in the Solar Dynamics Observatory mission at http://www.youtube.com/watch?v=vSSs7-O5IqY)

d. Delete any other observations using the “X” button on the right.

You can toggle the images from each instrument using the “eye” symbol. Try that now, and notice how the HMI continuum data overlays the AIA Far Ultraviolet range. You can vary the “opacity” of the HMI data from minimum (so that only the AIA data is visible) to maximum (so that the HMI data is visible). Select an opacity mid-way so that you can see both the visual surface of the sun’s photosphere (the continuum layer) and the AIA features.

7) Click on MOVIE, select an “interesting” area of the sun to focus upon using the “Select Area” button. Draw a box around that area of interest, making it small enough to enclose the region (you might want to make it longer to the right). Click OK, and then select a movie duration of 2 days. The movie will be processed, and returned to your computer browser in a matter of a minute or two. (You are accessing actual data of the Sun with your request, in real time, for the area YOU want to study! This movie is uniquely your own.)

Click on the MOVIE button to see the progress of your clip. You’ll see it completed, and you can watch it, or post it to YouTube if you have an account, or access it from a link.

Once the movie is returned, it will show up in a small window. Mouse over it, and you’ll see a
8) Record your observations from the movie you created. In particular, what did you notice about the resolution (detail) in the movie you obtained with Helioviewer compared to that linked in the original SDO Heliophysics Event Registry.

Active Region # ______ Data Viewed (AIA/HMI bands) ____________________________

Movie URL created: __________________________

More Observations (Did you notice patterns, loops, whorls, structures? Events like a flare or sudden brightening of the image? Try to be as specific about what you see, and when it occurred, as possible.)
____________________________________________________________________________
____________________________________________________________________________

Resolution (compared with original SDO movie clip) Better? Worse? Which had more detail?
____________________________________________________________________________
____________________________________________________________________________

9) With your first movie exported, you may or may not yet have more useful information to help with your question. But you can now begin to investigate! You could view the same area with different wavelengths of the AIA instrument, or view the magnetograms from the HMI instrument to look for correlations in active regions with magnetic field motions. Return to the initial Helioviewer.org screen, and adjust the Images window according to what you want to view next, create another movie, and record your observations below:

Briefly, what is your goal for next part of data acquisition and analysis? What would you like to gather, or explore further?
____________________________________________________________________________
____________________________________________________________________________

Active Region # ______ Data Viewed (AIA/HMI bands) ____________________________

Movie URL created: __________________________
More Observations  (Did you notice patterns, loops, whorls, structures? Events like a flare or sudden brightening of the image? Try to be as specific about what you see, and when it occurred, as possible.)

In particular, did your repeated exploration help to give you more answers to the question(s) you asked about this particular active region? Why or why not?

10) Based on your work so far, what would you like to research next? For example, you might want to follow this particular active region in time, or, see how it looks one solar rotation later (or earlier) to explore how these active regions evolve over time. Or, you might want to zoom in tighter and with more data resolution.

It is quite possible that you will need more detailed data to investigate your questions, or you might need to play with other image settings. Additional more powerful data image analysis tools are available online to accomplish this, but they require programs to be downloaded to take advantage of more computer processing power. One such tool is “jHelioviewer” available at http://jhelioviewer.org/. It will have been downloaded to your computer already (or, you can download it yourself for free.)
11) Start up this application, input the date and time (anytime you want) for your observations, **ADD layers** for the AIA and HMI instruments as you did before, adjust the speed of the playback in the Movie Controls area, and use the Adjustments window to explore contrast, color, and opacity for each layer. After you have created a movie you find interesting, export it (using the FILE menu command) to your desktop.

12) The next step is up to you – you can continue to explore the data from the 23 Oct 2012 date, or look at the current day’s solar weather, and investigate some of the sunspots, flares, and active regions going on today. As you do this, record what you access, your observations, and any questions or hypotheses you have generated as a result of your research.

**Date/Time of Observation**

**Active Region # _____ Data Viewed** (JavaScript Movie, Flash Movie, etc.)

**Tool(s) Used** (check all that apply)
- □ HEK
- □ Helioviewer
- □ jHelioviewer
- □ The Sun Today
- □ __________ (other)

**Observations** (Did you notice patterns, loops, whorls, structures? Events like a flare or sudden brightening of the image? Try to be as specific about what you see, and when it occurred, as possible.)

____________________________________________________________________________
____________________________________________________________________________

**Research Question to Explore Further?**

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

13) Up to this point, all of the data you have had access too has been “binned down”. This means that instead of giving you the full possible resolution for an image they have given you less data to work with (an analogy would be diluting a solution). There are many reasons to do this but the biggest is that full images of the Sun with SDO have so much data in them they would take a very long time to download. A movie would take even longer! There are additional ways to request more detailed data. Please see your professor if you wish to pursue this step for additional credit!

**Review of Solar Dynamics Observatory Lab**

From this two-week exercise, what are the some of the most significant things you have learned about the Sun?

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Using SDO Data to do Real Science – A Community College Astronomy Lab Investigation 31
From this two-week exercise, what are the some of the most significant things you have learned about the process of data analysis that Solar Astronomers go through?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

What would have liked to do with this activity that you were not able to do, or not given enough time to do?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

What would you keep, and what would you change overall, in this lab activity?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
Outline

1) Introduction
   a) Show stills and movie clips to get interest.
   b) What is SDO?
   c) What kinds of data are available (AIA, wavelengths, HMI)?
   d) What kinds of questions are we exploring?

2) Background
   a) Sun's rotation direction
   b) Stonyhurst and Carrington coordinates
   c) Terminology: Sunspots, Flares, Prominences, Active Regions, etc.

3) (This section could have some exercises and calculations - scales of sunspot sizes, etc.)

4) *Investigation 1
   a) Demonstration(s) of sunspot rotation, flares, loops, etc. from a list of selected movie clips already available.
   b) Model the investigative process - looking for changes over time, or dates, or location
   c) Concentrate on getting them to observe key features as the start of scientific process, and then ask questions about what they are seeing.

5) Investigation 2
   a) Students use current data to investigate their own areas and phenomena of interest
   b) Document what they look at, where/when, with what datasets,
   c) Develop questions about that data
   d) Develop hypotheses to investigate with available data
   e) Build data query (with HEK/Helieoviewer) and wait for results
   f) do some additional investigations while they wait
   g) analyze returned data

6) ** Optional Extensions**

7) Publishing
   a) Students present their questions and results to the rest of the class in teams (I do this now with Galaxy Zoo data and students really love it - like mini conference presentations)

8) Further Study
   a) Students follow up on their inquiries in groups

9) Collaboration
   a) Students pool inquiries, vote, and decide collectively to focus upon 1 idea with multiple teams getting more data.

Key Dates and Data to use for exemplars:

http://sdowww.lmsal.com/suntoday/ The sun today. AIA (Atmospheric Imaging Assembly)

Note history page http://aia.lmsal.com/public/results.htm has results by month.

http://jsoc.stanford.edu/~priya/HMI/JSOC_Exportdata_Cheatsheet.html

Using SDO Data to do Real Science – A Community College Astronomy Lab Investigation 33
Lab Activities

Look at June 2012 as an example.
http://sdowww.lmsal.com/sdomeedia/SunInTime/2012/06/sdo_monthly_2012-06_211-193-171_1k_600s_720p.mov

Play the movie. (Grab image of this page in Snagit)

What do you notice?
- The clock in the corner moving fast. Is this real time, or time lapse? What is the time rate between each image?
- Stop the movie at any time by clicking on the image. Continue by double-clicking the image. To re-start the movie, reload the webpage (Firefox: View: Reload; IE: Refresh)

Note the next line when the movie starts:
**Time: 2012-06-01T00:01:48.086Z, dt=600.0s**
dt=600.0 s tells us the images are taken 600 seconds (10 minutes) apart. So this is the time “cadence” that gives us the motion of the sun.
The additional lines below give us information about the instruments gathering the data, and the wavelength regions used.
**aia_201206##T0#####_211-193-171-blos_1K.pr_gb**
channel =211,193, 171, source=AIA,AIA,AIA,HMI

What do you notice happens around the time period of June 5-6, 2012? (2012-06-05 – 2012-06-06)? Watch the movie again. Find a date where you see evidence of flares or changes in the surface of the sun or in its outer atmosphere. Let’s investigate those in more detail!

Example: 6/30/12 around 6:21 in the left-edge of the disk.

Go to the Heliophysics Event Database at [http://www.lmsal.com/hek/](http://www.lmsal.com/hek/) and click on Search Events. In the Search box, change the Start Date: to 2012-06-28 and End Date to 2012-06-29, and click the Search button at the bottom. You can use the calendar icon to select these dates quickly.
The image that appears is a map of the Sun’s disk. The symbols that represent Feature/Event types that appear are explained if you click on the KEY icon at the bottom right of the screen. In particular, you might look for: AR (active regions), SS (sunspots), and FL (flares). You can easily “zoom” into the image and magnify the display using a mousewheel or clicking on the + icon above. Try that now, and look in particular at the lower –left section of the image.

Click on one of the AR icons in the area of interest. Note that each event is numbered, and another viewer window will pop up for that particular event.
A movie link for that event is now available, with a smaller field and greater magnification. Try it! Like the previous movie, you can click to stop it, or double-click to restart.
- What do you notice about this movie?
- What do the colors mean?
- What instruments were used to take this image?
- What did the sun look like in visible light at this time? (What would we “see” with our eyes looking through a telescope from Earth?)
Click on the link at the bottom, get SDO data. A new window pops up, and with it, you can now look at the same area in time, and restrict your view to particular wavelength regions. Enter your first name, email ID, and submit once you select particular images. A confirmation screen appears, and then you can await receipt of YOUR data for that region!

1) Try AIA 171, and HMI B(Ios); Cadence of 12 seconds.

**See how long it takes to get this response back? 10 minutes? Is this day/time sensitive? Can faculty check this out first with a trial to estimate response time from students in a lab?**

The Solar Zoo idea.

Start collecting movie clips:

Past Narratives to use/quote/cite:

From Phil:

A 2009 intro from et al, Nightingale. starts:

High-quality observations of the slow evolution of photospheric magnetic fields in active regions, in concert with improved models of the gradual growth of coronal energy associated with them, are presently advancing understanding of the physical processes that power solar flares and coronal mass ejections (CMEs) much beyond a qualitative cartoon level. Sunspot rotation was first observed nearly a century (Evershed 1910; St. John 1913). However, accurate measurement of the rate and amount of rotation with high spatial resolution and temporal continuity for long periods of time is a much more recent capability. Brown et al. (2003) studied seven cases of rotating sunspots using white light observations from TRACE (Handy et al. 1999), and found sunspots that rotated as much as 200° over 3–5 days. Comparable values have been found by others (Zhang et al. 2007; Liu et al. 2008). Zhang et al. (2007) studied several rotating spots in NOAA 10930 and found 240° total rotations in periods from two to three days. Liu et al. (2008) studied the super-AR NOAA 10486 and found about 220° over six days.

and a 2010 paper “SUNSPOT ROTATION, FLARE ENERGETICS, AND FLUX ROPE HELICITY: THE HALLOWEEN FLARE ON 2003 OCTOBER 28” by Maria D. Kazachenko, Richard C. Canfield, Dana W. Longcope, and Jiong Qiu from Montana State does an in-depth study of one event in 2003 using MDI data.

3. SUNSPOT ROTATION

3.1. Observations of Rotation

Observations of the large, positive sunspots P02 and P01 in MDI full-disk intensity images show them to be rotating around their umbral centers during 2003 October 25–30 (Zhang et al. 2008). To find the rotation rate, Zhang et al. (2008) measure the angular displacement of the sunspots between two successive days and look at the fluctuations of the umbra profile on the MDI intensitygrams. MDI magnetograms of the same temporal and spatial resolution are not useful for rotation measurements since they exhibit lower contrast of the features in the penumbra than intensitygrams. Using rotation rates from Zhang et al. (2008), we find that in 46 hr, between t0 and tflare, P02 rotated by 123°, whereas the southern part of P01 rotated by only 12°.

there are a few others, but the idea is that this is a current research topic. Not one that was settled 30 years ago.

And we have only circumstantial evidence that there is a connection to rotation and X-class flares. And relations to helicity and energy build up in the corona. A few minute look at the 14 Feb 2-day movie shows clear rotation of 6 spots in one region - which produced an X-class flare, where the different polarity spots rotate in different directions. I would guess there is fodder for at least a note or poster at SPD from that one alone. And over the next few years we will have an opportunity to do the first statistically valid survey over the rising phase of a cycle. Of course the research interests can “run over” the CC students, but that is OK too - the point is that it is a current topic that is approachable.
Attendee List for ASP Presentation 7/22/13

Using SDO Data to do Real Science - A Community College Lab Investigation
Distribution List for Lab Draft #3
Astronomical Society of the Pacific Cosmos in the Classroom
July 22, 2013
San Jose State University

Tammy Smecker-Hane (US Irvine)
Amy Fredericks (US Naval Observatory)
Benjamin Mendelsohn (West Valley College)
Yvonne R. Alexander (Hopkins Jr. High Planetarium)
Gibor Basri (UCB)
Beth Hufnagel (Anne Arundel Community College)
Matt Craig (Minnesota State U, Moorhead)
David Devine (Coastline CC)
Laura Sparks (Santa Rosa JC - Petaluma Campus)
Katie Berryhill (Assistant Professor at American Public University System)
Kendra Sibbernsen (Metropolitan CC)
Diane Friend (University of Montana)
Jessica Fielder (Santa Rosa JC)
Laura Lege (American River College)
Bob Swanson (Itawamba CC, Tuppola, MS)
Andrew Reid (SJSU Grad Student)
Ruolan Jin (Taipei First Girls HS)
Heidi Gerster
Aaron Romanowsky (SJSU)
Bethany Cobb (George Washington Univ)
Jeremy Murphy (Princeton)
Carlos Apodaca (Center for Space Robotics)
Christine Jones (CfA, Harvard)
Darryl Stanford (SMCC)
Using Solar Dynamics Observatory Data in the Classroom to Do Real Science

Participants

- From Chabot College
  - Scott Hildreth
  - Tim Dave
  - Shannon Lee

- From SDO/Stanford Solar Center
  - Deborah Scherrer
  - Philip Scherrer

Our Goals Today

- Background
  - Chabot College, Astro Lab, SDO Project
- Description of the Lab
  - What worked, what didn’t
- Student Results & Feedback
- Next Steps

Your feedback & questions are welcome anytime (email us)!
Our *real* goal...

Helping Students to be excited by Astronomy, and Science

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Chabot College

Hayward, CA

- Two-year Community College
- Hispanic-Serving Institution
- 12,000 FTE
- ~600 students/year in Astro Lecture

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Chabot College

Astro Lab

- 1-unit, 3-hour/week evening lab class
- ~25 students
- Taken with or subsequent to standard lecture
- Non-science majors
- Limited math & reading skills
Solar Physics Labs

- Lots of existing Labs
  - Direct Sunspot Observation
  - Sunspot Tracking via SOHO data
  - Solar Rotation (CLEA simulation)

An “Aha” moment

Get Students to use “real-time” SDO Data

Chabot Students in SDO lab
Our Goals for SDO lab

- More open exploration
- More opportunity for individual creativity as well as teamwork
- Use of real-time data
- Model processes of Science

Build off “Galaxy Zoo” model

Lab Format: Part 1

- Background (Pre-lab)
  Lead students to explore what SDO can do, online, through **KOED Quest** & existing SDO video clips taken on specific dates.
Lab Format: Part 2

- Research - Let students loose with HEK to selected key dates/events

Heliophysics Event Knowledgebase

- Browse by Date
- Activity
  - Flares, Spots, CME’s, etc.
- Active Region #
- SDO movies

http://www.lmsal.com/isolsearch
Lab Format: Part 3

- Let students create their own videos with Helioviewer & jHelioviewer

Helioviewer

- Online Access
- Easy creation & export of movies
- Not high-resolution
- 2 min to 2 hrs

jHelioviewer

- Downloadable
- Also creation of movies
- JPEG 2000 compression
- Longer movie retrieval times
- More time needed
Lab Format: Part 4

- Encourage students to develop their own hypotheses and search for data
  
  - Are solar flares synchronized across the various wavelength regions?
  
  - How did active regions match what we see in HMI?
  
  - Are active spots the same after one rotation of the Sun?

Tip:

Lots of hints about what makes a good hypothesis may be needed...
**Higher Detail Imagery**

LMSAL “Get Data”

**Highest Detail Imagery**

JSOC direct interface

http://jsoc.stanford.edu/ajax/exportdata.html

**Lab Format: Part 4**

- Students present results as teams in front of the class for peer review & questions

  and

- Investigate further hypotheses with more data requests
Using Teams to Help Students make effective presentations
Student Results

- Some really good hypotheses…

“We questioned whether all solar activity moved in a counter-clockwise rotation, and found through exploring other areas of the sun that it was not.”

- And some less reasonable hypotheses…

“I want to look at the entire sun over 1 year in each wavelength band at 45 second intervals to see when the flares reappear.”

- Some really good attempts to experiment…

“We experimented with AIA video options and observed a clear 3D view of the same sunspot. It helped us confirm our hypothesis.”
Student Results

- And some less “scientific” experiments...

“I thought the loops were really pretty. I wanted to see if we could find others.”

Student Feedback

What are some of the most significant things you have learned about this process of data analysis that Solar astronomers go through?

• “I have learned that data analysis is a very specific task that is detail oriented”

• “I learned that it is long frustrating and awful”

• “You can use the same image and change the resolution and get different information”

• “I learned how staggering the amount of data is. It will take years to go through the data collected in a single day”

Student Feedback

What would you have liked to do with this activity that you were not able to do, or not given enough time to do?

• “I would like to learn more about how the magnetic fields affect us on Earth”

• “I would have liked to view more videos over a longer period of time”

• “I would have liked to create a longer video to see how Sunspots evolve”
Shannon’s Thoughts

- Do Part 1 as pre-lab
- 3-week lab if possible
- Backup plan if online access out
- Students need help writing research questions

Our Goal

Getting Students to DO real science...

Discussing Ethics in Science

Data Rights and Rules for Data Use

The SDO science investigators agree to abide by the Rules of the Road developed for the Sun-Earth Connection and its successor, the Heliosphere Division. These are:

1. The Principal Investigator (PI) shall make available to the science data user community (Users) the same science methods to reach the data and tools as the PI uses.
2. The PI shall notify Users of updates to processing software and calibrations via metadata and other appropriate documentation.
3. Users shall consult with the PI to ensure that the Users are accessing the most recent available versions of the data and analysis routines.
4. Browse products are not intended for science analysis or publication and should not be used for those purposes without consent of the PI.
5. Users shall acknowledge the sources of data used in all publications and reports.
6. Users shall include in publications the information necessary to allow others to access the particular data used.
7. Users shall transmit to the PI a copy of each manuscript that uses the PI's data upon submission of that manuscript for consideration for publication.
8. Users are encouraged to make tools of general utility widely available to the community.
9. Users are encouraged to make available useful derived data products. Users producing such products must notify the PI and must clearly label the product as being different from the original PI-produced data product. Use of such derived products should proceed with care to ensure that such products are based on the most recent versions of the data and analysis routines. With mutual agreement, Users may work with the PI to enhance the instrument data processing system, de-scrambling their products and tools.
10. The authors and referees of scientific journals should avail themselves of the expertise of the PI while a data set is unfamiliar to the community, and when it is uncertain whether authors have employed the most up-to-date 2010 and calibrations.
What you might need...

Getting Started

- Try the lab for yourself
- Use HEK & existing movies
- Try Helioviewer
- Let us know what happens!

Questions? Discussion?

- Email us with questions!
  shildreth@chabotcollege.edu
tdave@chabotcollege.edu
slee@chabotcollege.edu

- Request an e-copy of the lab for your (free!) use and customization