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Glacier National Park breaks loose from the grips of winter. Looking up Glens Lake towards Pyramid Peak (right) and Cathedral Peak (center), the remains of Shepard Glacier and fast disappearing snowmelt feed Atsina and Paiota Falls as the spill over the Appekunny, Grinnell and Empire Formations. These formations, composed primarily of mudstone and siltstone, were deposited in a shallow sea during the Proterozoic, having been dated between 1.2-1.4 billion years old. (Geologic Map: http://ngmdb.usgs.gov/Prodesc/proddesc_9273.htm) Credit: David Thesenga

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Engaging Students in West Virginia in the Science of the Sun and Space Weather

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Abstract

Data from NASA missions that observe the Sun and near-Earth space are available to the public through apps developed for smartphones and tablets. A kit composed of iPads and solar telescopes and a training workshop has been developed for educators to teach students about the Sun and Space Weather. The workshop and kits are managed by the Educator Resource Center at the NASA Independent Validation and Verification (IV&V) Program in Fairmont, West Virginia. Educators that have participated in the workshop are eligible to borrow the kit for classroom use. Among the educators that have implemented the Sun and Space Weather materials, the science teacher at Paw Paw Schools has leveraged connections with NASA to develop an ongoing interdisciplinary curriculum. Elements of the kit could be incorporated into classrooms nationwide.

Introduction

Society relies on weather forecasts to prepare for extreme weather events such as hurricanes, but many people don’t realize that there are also extreme weather events in space. Scientists are working to understand these events and develop the ability to provide Space Weather forecasts. Space storms are driven by activity on the Sun and can disrupt satellites, cause power outages, and be a danger to airliners flying over the poles and to astronauts in space. The science of the Sun and the study of the region of space surrounding the Earth, and how scientists study each, encompass many important concepts that fit national educational standards (see sidebar).

The Educator Resource Center (ERC) at the NASA Independent Validation and Verification (IV&V) Program in Fairmont, West Virginia has implemented an operational model that includes hosting kits of necessary equipment and technology that can be borrowed by educators that have been trained in their use at the center (http://www.nasa.gov/centers/ivv/education/educators.html). Being able to borrow the kits reduces the barriers that educators face in being able to obtain, understand, and maintain the materials necessary to effectively implement such materials and resources in the classroom. A kit and a professional development workshop have been developed for educators to teach students about the Sun and Space Weather. The materials are appropriate for middle school science, high school physics, Earth science courses, and

National Education Standards Fulfilled by this Study of Space Weather

Teaching of the history and nature of science
Science as inquiry
Unifying themes
Specific content and subject matter
Scientific design and application
Science as experienced in a personal and social perspective
have been utilized with students as young as Kindergarten, as well as in informal education settings such as a public viewing of the Transit of Venus.

## The Sun and Space Weather Kit

The main elements of the Sun and Space Weather Kit include a classroom set of twelve iPads and four types of telescopes that provide safe solar viewing. The iPads are used for data collection and for the creation of video reports. The iPads have been set up with apps that access data from multiple NASA (and other) missions that observe the Sun and near-Earth space in real time. (See sidebar for a list of apps.) Data collected include images of the Sun at a variety of wavelengths, solar magnetograms and dopplergrams, measurements of solar wind parameters including magnetic field and velocity, magnetospheric measurements such as energetic electron and proton flux, and storm indices including: the Disturbance Storm Time (DST) and the Planetary-K (Kp) indices. Some of the apps, such as NASA’s Space Weather Media Viewer, include educational videos and related resources. The iMovie app is used to compile images and data obtained from these missions along with pictures and videos taken with the iPad camera to create “Space Weather Forecasts” or similar videos as a project based outcome. The iPads can also be used to hold a video call with an expert that enables the students to ask questions directly to a scientist working in the field. The telescopes include Sunspotters, Solarscopes, a Coronado Personal Solar Telescope, and a Celestron First Scope with a solar filter for safe solar viewing of sunspots and prominences. It has been found that teachers and students are always fascinated when they observe features on the Sun with their own eyes and compare data that matches the data they’ve obtained on the iPads. The ERC currently owns three complete kits available for educators to borrow for use in the classroom or for other educational experiences. Currently, educators usually pick up the kits from the ERC.

After piloting the training workshops, new materials were added to the kits, and additional items could be added upon suggestion. Recently added items include bar magnets and iron filings to explore magnetic fields, and materials to make an electromagnet to explore induction. A separate, but relevant, kit on the electromagnetic spectrum is available. This kit includes educational posters, a NASA DVD providing a video tour of the electromagnetic spectrum, and a power supply and selection of gas tubes along with a set of handheld spectrometers for hands-on exploration of emission and absorption spectra. The combined use of the kits allows for extension and reinforcement of the content.

## Educator Training Workshops

One-day and week-long workshops have been presented to train educators in the use of the kit materials and to teach the relevant science concepts. The one-day workshops provide a basic introduction to the science concepts and training in the main elements of the kit. One of these...
workshops was presented to a group of pre-service teachers at West Virginia State University who used the kit as the basis of a science summer camp for low-income children in Charleston, WV. The week-long workshop enables deeper immersion into the science material, more time working with kit materials, and training in supplementary materials including the electromagnetic spectrum kit. In addition, a partnership was developed with Troy Cline (NASA Goddard Space Flight Center) to offer training in educational materials related to the NASA Magnetospheric Multi-Scale (MMS) mission that will study phenomena related to Space Weather. Professional development and graduate education credit are offered for these workshops through Fairmont State University.

Results from Classroom Implementation in Paw Paw Schools

Carol Coryea attended the first week-long workshop and has implemented the material in her Physical Science, Biology, CATS 7 (Coordinated and Thematic Science), CATS 8 Science, and Earth Science classes at Paw Paw Schools. Distinctive features of Paw Paw Schools are the small class size (one grade per class) and the Kindergarten-12th grade building configuration that allows for interaction between the lower grades and upper grades. As the second smallest school in the state of West Virginia, science standards at Paw Paw Schools are easily matched up to a wide range of content standards across the grade levels. Student learning goals can be reached with the use of the Sun and Space Weather kits to facilitate the teaching of the history and nature of science, science as inquiry, unifying themes, specific content and subject matter, scientific design and application, and science as experienced in a personal and social perspective. Since 2012 every student at Paw Paw Schools has had access to the Sun and Space Weather program. The current 2014-2015 kindergarten class is scheduled to visit the science laboratory in the late fall to work with our high school space weather team on several sun and space lessons.

After attending the first workshop, Ms. Coryea returned to Paw Paw Schools and presented students with the task of creating solar weather forecasts by researching solar cycles and the impact of solar events on human activity. In a two week time frame, students became proficient with the use of the iPads, apps, and resources from NASA and made several factual and authentic space weather videos and forecasts. As a result of this project, Carol Coryea and five students, ranging from middle school through high school, prepared a presentation for the West Virginia Science Teachers Association (WVSTA) Conference in the fall of 2012. Following that, with the assistance of Todd Ensign, Carol Coryea submitted a proposal to the National Science Teachers Association (NSTA) and was accepted, along with five students, to deliver a hands-on-workshop at the annual meeting in San Antonio, TX in April, 2013. This was co-presented with the support of Todd Ensign and NASA’s MMS mission courtesy of Troy Cline. The opportunity to partner directly with NASA has led to an in-depth study of space weather in all the science courses taught at Paw Paw Schools. Paw Paw Schools are unique in their remote, rural location, and their offering of multiple science courses by one instructor. The noteworthy position as the sole science teacher...
for both the middle school and high school has allowed Ms. Coryea to incorporate space weather
directly into the curriculum for grades 7-12 and to provide special, space weather programs directly
to the students in grades K-6. Additionally, this allows for support for science content and instruc-
tion in the lower grade levels. Classroom teachers in grades K-6 often request visits from older
science students to present in their classrooms. Each time the school accesses the Sun and Space
Weather kits from NASA, younger students are invited along, to visit the science lab and to even
join older students out in the field, for safe, solar viewing.

This environment has led to multiple cross curriculum activities within the school, including the
engineering and building of a full-scale model of the current MMS mission in collaboration with
high school students who are part of the Mountaineer Area RoboticS (MARS) team in Morgantown,
WV. The full-scale model project at Paw Paw Schools was developed as a cross-curricular team
project of the Technology Education Department working with Chris Poniris, and the Math
Department, working with Rebecca Ryan. The model has been completed, was displayed for three
weeks at NASA Goddard Space Flight Center, and is currently located at the Clay Science Center in
Charleston, WV. This project has presented an outstanding opportunity for Science, Technology,
Engineering, and Mathematics (STEM) based learning. Students’ involvement in Paw Paw Schools’
STEM program has soared. The full-scale model project along with the presentations by students
at the NSTA conference was funded through a NASA Education and Public Outreach (EPO) grant
from the MMS mission. This grant was written by the Paw Paw educators, local NASA Education
Specialist Todd Ensign, and Dr. Earl Scime (WVU Physicist and coach of the MARS robotics team).
With the encouragement of MMS EPO lead, Troy Cline (NASA Goddard Space Flight Center), the
students have been able to present directly at NASA Goddard Space Flight Center, (Greenbelt, MD),
including several presentations and interactions with lead NASA scientists and engineers of past
and current missions.

Additional extensions included weekly Skype conferences with Dr. Amy
Keesee at her Heliophysics laboratory located at West Virginia University
in Morgantown, WV. Additionally, Paw Paw students have continued to
monitor solar activity, complete space weather forecasts, and build small
scale models of NASA’s Magnetospheric Multi-Scale (MMS) mission. The
models are constructed by students in the lower grades with the help of
older students. The MMS model is made of printed cardstock paper and
is a good first step in introducing students to the mission. With a unique
octahedron shape, it is easy to manipulate and folds into a model using
inexpensive materials and tape. Building scale models provides a hands-
on project that incorporates teaching of all four STEM components. The
MMS model can be used to discuss the science of magnetic fields, the tech-
nology of solar panels, the engineering challenges of launching a payload into
space, and mathematics in the octagonal geometry of the satellite. Space
weather forecast videos are created using iMovie to compile screenshots
of collected data, as well as student photos and videos captured using the
iPad camera. Students work in teams, collect live data, write scripts, edit
text, and record live reports. The students use the videos to describe aspects
of what they have learned and to make a prediction for upcoming space
weather activity based on the data they collected. As students have become
familiar with the apps and the science behind space weather forecasts,
many have downloaded the same apps for personal use and do continue
to monitor space weather events on a daily basis at home. The project has
proved to be a huge success and has allowed the formation of a partnership

Figure 4. Students at Paw Paw Schools working on the full-scale
MMS model.
[Photo by Carol Coryea]
with a local solar company, making in class presentations about the use of solar power in the community. What started out as a one-day training, expanded to a week-long workshop, and has now become a significant part of the daily science curriculum at Paw Paw Schools. This project has directly resulted in an interest by students in pursuing future degrees in the STEM fields.

Ways to Incorporate into Classrooms Beyond West Virginia

The cost to purchase all of the main elements in our Sun and Space Weather Kit is approximately $12,000. It is recognized that the cost of this equipment is a barrier to duplicating the exact model in individual classrooms. However, it is possible to scale down the kit or combine with other resources to implement a similar program. The kit includes twelve iPad 2’s and an Apple Airport Express base station ($399 and $99 from www.apple.com) in a Pelican Case ($160 from http://www.pelicancases.com). Also, included are 6 telescopes: two Solarscopes ($89 from http://www.solarscope.com/us/index.us.html), 2 Sunspotters ($364 from http://www.sciencefirst.com), one First Scope ($50 from www.celestron.com) with a Baader Solar Filter ($50 from http://www.highpointscientific.com), and a Coronado Personal Solar Telescope ($720 from http://www.meade.com). All, but one, of the apps used to obtain data are available for free (see list in sidebar). The iMovie app used to create, edit, and display video reports is $4.99. Thus, classes with access to iPads can access the data for minimal or no cost.

About the Authors

Amy Keesee is a Research Assistant Professor in the Department of Physics & Astronomy at West Virginia University. She studies plasma physics, both in space and the laboratory. She is interested in improving scientific literacy and encouraging more people to pursue science careers. For seven years she served as the President of the West Virginia Chapter of the Association for Women in Science (AWIS) (http://www.hsc.wvu.edu/awis; http://www.awis.org/) and is currently chairing the AWIS Chapters Committee. She is also coaching a Jr. FIRST Lego League Team. Amy can be reached at Amy.Keesee@mail.wvu.edu

Carol Coryea is a middle school and high school science teacher at Paw Paw Schools in Paw Paw located in Morgan County, WV. She studied agronomy at Colorado State University, and received her Masters for Science and Teaching in secondary Earth Science at Plattsburgh State University. She is currently building a STEM based curriculum for K-12 students at Paw Paw Schools. In the fall of 2013, a grant-supported, after-school STEM program was introduced and now services approximately 60 students per month. This past fall, an all girls FIRST Lego League Team was launched, and is expected to double by the end of the school year. Carol can be reached at coryeac@gmail.com or coryea@k12.wv.us

Todd Ensign is the Program Manager and Science and Technology Specialist for the Educator Resource Center at the NASA IV&V Facility in Fairmont, WV. He is also an Assistant Professor of Geoscience Education in the Department of Biology, Chemistry, and Geoscience at Fairmont State University. Prior to working at FSU, Todd designed and taught professional development opportunities for teachers across West Virginia with The EdVenture Group. Todd received B.S. in Earth Science Education and a M. Ed. in Educational Technology from Northern Arizona University. Todd can be reached at todd.i.ensign@ivv.nasa.gov
Looking north, the Garden Wall looms over the Granite Park Chalet on the western side of the Continental Divide in Glacier National Park. The Garden Wall is a prominent arête separating the Lake McDonald Valley to the west from the Many Glacier Valley. Credit: David Thesenga