Heliophysics Education Community Meeting-20260804

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Laura Peticolas 4:48

Great. OK. OK, great.
Well, it's a big honor to be presenting to you all as heliophysicists.
My fellow peers in science and also educators have a great respect for those in the classroom and also in informal education worlds. It's a complicated job. So thank you for coming today.

I'm going to talk about the Eclipse MegaMovie project funded by NASA and tell you a little bit about what we've been doing and what how far we came.
1st just to let you know, I'm sitting here in Sonoma State University and I'm directing the team. I'm the director of the Edon STEM Learning group here at Sonoma State University. We're about an hour north of San Francisco in a beautiful part of California. We really work hard to collaborate with not only fellow researchers, but those we serve.

We really respect the teachers and educators and citizen scientists that we work with because people come to our programs with expertise in a variety of realms that we are not experts in. We come with our expertise as well and even on our team we have a vast diversity of expertise. Our world is changing rapidly and we need to be learning as quickly as possible. So learning from each other is a great way to kind of catalyze that learning.

So what was our goal for EclipseMega movie? Well, what we said we were going to do is characterize some features of the solar corona, specifically transients (things that are changing in the mid corona), so that area that NASA has a bit of a blind spot in for at least white light observations. And it's a perfect place for the eclipse data to fill our knowledge in terms of how things are moving from the photosphere.
From that bright part of the sun out into the outer corona where we have lots of data. How do we propose to do that?

We propose to recruit, train and really engage photographers or people who wanna be photographers, engage them in getting to very specific locations on Earth where they would be able to see the solar corona during the total solar eclipse of April 8th, 2024. They needed to bring some pretty complicated equipment with them along, so they needed to have a, you know, a decent camera.

We weren't working with anyone to use cameras on cell phones. We split that for those of you who knew Eclipse MegaMovie are kind of first effort that got split into a different project.

So we were really focused in on the cameras that could kind of get a good resolution of that mid corona. We also wanted to make sure that our volunteers could track the sun so the sun would come, stay in the middle of the photographs as they were changing their exposure times. We also really wanted them to take calibration

frames so that we could make sure that the data didn't have artifacts from the CMOS or the digital detector or from the lens.

The goal was to really support these citizen scientists to go do that. And not only were they gonna of course gather the data, but we needed to get it from them.

So we the goal was to get them to take and upload calibration frames and then to clean that data and make sure that it actually could be used to do science and then analyze it for plasma transients, along with the NASA space space data that so many of us know and love.

And so you can see here a picture of some of our volunteers. And here's a lot more. So this project really relies on all these citizen scientists. We're capitalizing on the passion that these citizen scientists have for participating in this heliophysics endeavor and also for contributing to science and their passion for eclipses and their passion for photography, or their newfound passion for photography for some of them.

So we had a wide variety of of different types of volunteers and they were instrumental in the success of this program. Thus far they have/we've all enjoyed working together so much that they asked that could we please continue our meetings so that we could keep gathering data from the 2026 eclipse coming up. So actually we'll be gathering data from that as well.

I think most of you have probably been to a total solar eclipse. But there might be some of you who have not. So if you have been to a total solar eclipse, I wanted you to put anything down about your experience that you would want to share while I talk to the slide. These are some photographs that we took in 2017.

As many of you know, to do science, you have to get funded, to do science, you actually have to do some of the science before you get funding. So we did that in 2017 at the total solar eclipse. We just wanted to know, would citizen scientists or would volunteers actually take photographs of the corona during a total solar eclipse? And if they would, would they give them to us? And the answer was yes. I was in Dubois, WY. And you can kind of see here when you take photographs of that event. During totality, it looks like the sun is blocked by the moon in this tiny little way up in the sky. But actually it looks huge, like it spans this entire sky. And you can see the dynamic range of the sun because our eyes are really adapt seeing really dim things and really bright things at the same time, unlike cameras. And we even could see these beautiful prominences in the in the chromosphere.

So for that kind of preamble to our 2024 NASA funded eclipse, we did work with Google to make a Eclipse MegaMovie. So I laugh because when we think of a movie, usually there's a plot. There are people. There's all of these. You know, you go to the movie theater. There's sound. This movie doesn't have any of that. I mean in the background it does. For those of you who are at a total solar eclipse, you know all of those components are there. Are you going to make it to the eclipse? Was there clouds? Did you have to like pivot and go to a new location? What kind of

complications were there with family? I mean, there is a whole drama behind getting photographs of the total eclipse. But when we actually make the movie, it can look to most people like not much. It looks like a beautiful solar corona, at least for those of us who are looking for changes in the solar corona. You can see some features in this if you're really looking carefully. Over time, they are there and they are moving very slowly from a human perspective. Within an hour or so, hour and a half, there are some kind of features that you can pull out of here. But we didn't. And in fact, we didn't have calibration frames for this eclipse and we just wanted to see: can you know, can we get people at the path of totality or not and and will they take photographs? And the answer was yes. And there was a little documentary that Google made of us. I put that here as a QR code.

I also love the patch idea that we have the norm of having a patch permission in NASA. So we made a Eclipse MegaMovie patch for our volunteers effort. Actually, I think just the team. We didn't manage to get that out to the volunteers for 2017, but that was something we changed in 2024 and so I'm showing you here today.

The very first public release of our 2024 MegaMovie.

We didn't focus on making this mega movie right away because we really were trying to get the data in a state that we could do some science with it. And if you've talked to any of the other 2024 eclipse teams, you will hear the same theme, which is figuring out how to rotate all the frames of different exposure times and from different locations was quite a challenge. And all of the teams who got funded by NASA, we've all been kind of lamenting and just validating the challenge that is alignment of a solar corona from Earth. Everything's rotating: Earth is rotating. Moon's rotating, the sun is rotating. Everything's rotating and then orbiting as well.
We have things rotating and orbiting – a lot of motion. So this is our movie and this time we were able to get patches out to all of our volunteers who provided our calibrated eclipse data.

Here you see where on the bottom.
I have a map here of kind of where our volunteers were located.
Who supplied us these photographs for those of you who did go to the total solar eclipse or attempt to be at the total solar eclipse. You know that there was a big storm clouds that came through and made seeing the sun interesting and definitely making data more complex to get.
So it was nice to have people kind of spread out across the path at totality.
So we did gather quite a bit of data we.

I think we can claim I'm gonna claim, but you all can tell me if this is not true.
I think we now between the 2017 and 2024 database we have the largest public white light calibrated total solar eclipse data set.
So maybe that's true.
I think it's true.

We have a lot of data and a part of our challenge for the last year and a half has been analyzing getting that data to a point where we can use it. I would love if any of you who are working on NASA mission around coronal science about the solar corona. If you want to look and see if any of that data is useful to you, this QR code

is for you.
Or if you just want to do some art projects with Eclipse data that QR code is for you as well.
So it is, we do have some FITS files.
Thanks to Michael Kirk for helping us with kind of determining how to do our FITS files. For those of you who don't know what FITS are there, it's a way to.
Basically, make sure that all the information about where that photograph is taken, the exposure time, how many pixels you have, the depth of the pixels.
All of that data, kind of we call it metadata, is associated with the picture itself.
So you don't have to go and find that date that information elsewhere.
It gets kind of coded into your picture.
So then and so astronomers have been using this FITS file format forever.
So that they can just grab files and they know they have all that metadata that's going to help them analyze it.
So we use that too, but for each mission you have to kind of change that a bit because instruments are different and so we have in our FITS files the camera that is used, the make and model and all the details since everybody had different cameras.
Our team's really proud of those firsts.

We're also just really proud of just the way we worked with our volunteers.
We really recognized them as coming with. They came as experts about their camera.
So because we weren't giving each of them very specific instrumentation, we had to rely on them to tell us if what we were proposing made sense for their instrumentation, basically.
And we have a lot of engineers, like professional engineers in industry working with us and I'm a scientist and I work with engineers, but I am not an engineer, so I really got to learn from them about kind of the engineering process and bring it to eclipse movie. So I talked.

You know, our goal ultimately is to look at jets and I haven't really talked at all about what is a solar jet. Many of you may know what a solar jet is.
You probably for sure know what a coronal mass ejection is, and the solar flare and jets are yet a different feature that come from the sun.
We learn a lot about jets from different wavelengths like we do about most of the features of the sun.
The different wavelengths tell us things about the energy of the feature that we're studying.
So here you're looking at extreme ultraviolet.
Jets you can see in these pictures.
This is also from a citizen science project, so I thought that was really appropriate since I'm talking about a citizen science project too, and they have these beautiful.
They basically had citizens find citizen scientists, find the Jets in this Solar Dynamic Observatory data.

So here are some of the ones that they found. You can see their long and thin narrow super narrow. Sometimes these jets you can see they kind of come off the sun and then they fall back to the sun.

Sometimes they get ejected into the corona through the transition zone and they last about 10 minutes, sometimes less.
In principle we should be able to see these, but in white light, so white light of course is visible light and we because we can see it.

It's all the different colors that are visible into a white into white.
And so extreme I put this little electromagnetic spectrum here to kind of remind us all where extreme ultraviolet sits in the electromagnetic spectrum. Since we have a lot of emissions from that area of the spectrum and one of the reasons that we care about this question of jets is:

Could jets contribute to the heating of the corona?

There's lots of ideas about the heating of the corona. For those of you who don't know, maybe you're new here to the HEAT community.
But surely you cook on your stove and you know that.
As you walk away from your stovetop, that source of heat things cool down.
So you never kind of walk away from your stove and then hit this wall of heat generated by your stove. That just never happens in our kitchens, thankfully.
But that does happen at the sun, so it does cool down from the nuclear fusion.

So within the sun it does. You have the source of the energy of the sun, and it does cool down as you would expect.
And then something happens kind of at this photosphere where which is the sun that we see in the sky and we're used to kind of thinking about that photosphere sun.
That's kind of the coolest part of the sun.

Before then, the atmosphere, the sun, the chromosphere and corona.
Especially the corona gets super hot.
And that was a big surprise as we started studying the sun from a spectroscopy perspective. And now we get to really try to understand what's heating the corona.
And as we as maybe some of you have seen Parker Solar Probe is starting to provide some more evidence for different models of what's heating the sun.
So solar jets potentially could also add to the heating as a heating source and some of our colleagues from Japan hanaka and went to the 2017 Eclipse and they took. seven different cameras.
They located themselves across the path of totality, and they were using similar equipment as our volunteers were using.
And they had calibrated frames, and so they published a paper showing white light jets from their camera systems.
So they subtracted data from different stations to find these jets and then calculated the velocities. So you can kind of see here it says 1234.
On this image here and you can see these brighter spots in the corona where these jets were located over on the right. I'm showing a subtracted image from the Eclipse Mega movie project for that same, trying to see if we can also see some of those jets and we had just started doing that one and we proposed to do the 2024 data.

We haven't come back to project.
So we haven't come back to this yet, but we're kind of on the crux of doing that.
So I'm gonna show you a few pictures of.

So we have finally gotten all our data rotated and calibrated and.
We've used a couple different well known eclipse.
Those kind of science algorithms to create high dynamic range.
Or HDR images Gaussian or using a Gaussian normalized algorithm to really pull out the edges of the feature.
So here you can see all the complicated magnetic structures close to the sun. You can see streamers coming out of this from the sun.
There's some interesting features.
That are showing up also in this kind of mid coronal region.
And.
Then we overlaid on top of that another extreme ultraviolet image.
171 angstrom image of the of the sun from a space based Solar Dynamic Observatory camera, and so you can see some of these loops are kind of aligning with some of these bright features on the extreme ultraviolet image and some are not.
And that could be, you know, we're flattening a very dynamic three dimensional object onto a two dimensional plane.
So it's complicated, especially during solar Max. You might have noticed that on that last in 2017, that was during solar minimum and there were a lot fewer of these loops than there are now during solar maximum.

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The other thing that we did here is we took that image and we've taken all of our HDR images and we're combining them with the coronographs from SOHO.
Those are also white light images. So those are also images that are white light.
We made it purple and yellow in order to show that that is a different instrument, but this is white light on these rims here these discs.
And you can see how our Eclipse Mega movie data
fills in the hole here where the space based telescopes and instruments cameras can't fill in due to a plethora of ID reasons that I can explain later if you're interested.
But what I love seeing here is with the Gaussian normalized
Analysis of this HDR image you can see how fine of structures that we have in the corona that simply can't be captured here with the C2 and C3 data.
But you do kind of see how these features are originating from the sun and then coming out into space.

Here what you can see was those were overlaid data.
With this, we took a different volunteers set of images.
HDR image and we use a normalized Analysis

So we can average out those really narrow features and it aligns even better of course with C2 and C3 data because it's more similar to how the C2 and C3 data is analyzed as well. And so then what?

I have a lot of students here at Sonoma State University who work with US computer science students and Physics students. This is a physics grad. He just graduated. He's off to grad school in the fall. In a couple weeks, he took all this data and weighted them.

So we're trying to show you here in the inner circle. So in the inner circle is just the

Eclipse mega movie data.
So that white light eclipse data and then it's combined it's weighted with C2.
And then this middle ring.
1/3 ring out is C2 C3 and the Eclipse data from Eclipse Mega movie and then this next ring is the Eclipse Mega movie data and C3.
And then finally C3.

So you get to see how these features are coming from the sun all the way out into the solar wind.
So the secret lives of jets and plumes.
We're still looking for those.
And we want to write a paper.
We're writing papers on this, and we know that if you all are reviewers, you're gonna say that
Can you believe the data?
So that's taking us a bit of time.
This is a subtracted image.
Subtract 2 HDR images using the normalized algorithms and you can see some of the features.
Popping out so this may be a large plasma blob, but transient it's clearly not a jet because it's too big. There may be some jets in here, but there're also some features that were changing in these areas.
Here's some smaller features that could be related to jets.
There is a big active region in this area, so this will be looking more into this future here.
And if you had noticed in the C2 and C3.
These features were also brighter kind of right at this edge of where our data starts and those data that data picks up.
So I do think there was kind of a a feature, a plasma feature that was moving out into the solar wind.
And we can kind of look at that some more.
So I know there's some educators on the call here with us and I we partnered with NASA's Neurodiversity Network.
I'm also a Co-investigator on that project.
That's wrapping up like HEAT is wrapping up and Lily is one of our Neuro Divergent interns who worked with Juan Carlos Olivieris Martinez, who is the Science PI on this project. And she worked to do one of the first rotation efforts with the data and presented at AGU.

Another part of this NASA Diversity Network is developing a
High school level curriculum and also middle school level curriculum.
So we have solar science activities for both middle school and high school that really focus on supporting these neuro divergent students.
So if you have any of those students that you want to have some good activities for, and as we know when you're supporting through universal design, when you support many different types of learners, then everybody benefits.

So the QR code here will take you to our website there.
Where you can find those activities. So I just want to end with a big thank you to

everyone who made this possible so far.
We are publishing our methods paper right now.
We're getting that information out to everybody what our methodologies in doing this.
We have our data paper almost ready.

So those two papers are being written and almost submitted.
As I said, the data is already out. You can use it and then we will be also finishing up our science paper, even as this grant ends and we, you know, hope to bring in more solar scientists into our project.

Some of you are joining us and helping us in multitudes of ways, and hopefully this data will be really useful to you all.
So you know my expertise is in the Aurora borealis and kinetic Alfvén waves and that type of thing. Which I hear there are those also in the sun.

So um, thank you. Thank you to NASA for funding this.
We're not gonna let go of it, so some way we will make it continue into the future.
So thanks to the team, to the students who supported us, to the volunteers, to all of you, and with that, I think I am done.