Heliophysics Education Community-20250902_130852-Meeting Recording

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29m 35s

HD **Samuel Schonfeld** 0:03

Just basic stuff which I see by who's on the call. A lot of you already know better than I, but.

Just to make sure we're on the same page here, right?

The Sun drives the variability throughout the heliosphere and that's due to the changing magnetic field on the sun and we see that most prominently in things like solar flares and chronal mass ejections that send light and particles in magnetic fields out into interplanetary space and those.

SS **Samuel Schonfeld** 0:32

Changing environment from the sun impacts Earth's environment, primarily by driving changes in Earth's magnetosphere and the upper atmosphere. The thermosphere and ionosphere.

Yeah. And so that those changes can lead to.

They cause change in the space environment and that leads to impacts on humans and our technologies.

That starts as we were talking about.

Just before this from the ground with the ground induced currents. So this is.

Currents traveling through the ground and through the electrical grid that can.

Disrupt power transmission systems, destroy Transformers, and generally cause a lot of damage and disruption.

Also, we can have effects in the atmosphere, particularly in the polar environments due to a rural precipitation and other high energy particles entering near the geomagnetic poles in the North and South, particularly in the north.

This is a problem for airlines that that fly through the polar regions and during geomagnetic storms these can be dangerous.

So those flights divert.

Southward, increasing their flight time, costing fuel costs and time.

There's also impacts on communications.

So the ionosphere gets disrupted when there are large energy depositions, either by solar flares or through other geomagnetic storms.

And that can impact GPS accuracy.

I saw a recent report recent study that the disruption was it the Gannon storm? I think. Last year. Cost something like $500 million in lost in damages and lost revenue because of GPS disruptions just for farmers.
So big economic impacts and potentially dangerous ones as well, if you're really relying on GPS during an outage.
The ionosphere also interferes with radio signals.
It can cause radio blackouts and communication disruptions.
And then if you're in space, there's a whole host of effects.
You know most prominent for I think or largely important particularly for the Moon to Mars mission is astronaut safety.
There's these high energy particle environment events can be dangerous and lead to unhealthy radiation doses.
It can cause single event absence in electronics and space where time view particles can flip a bit in a computer and lead to code crashing.
And sometimes even being unrecoverable to join satellites also.
In changing plasma environment can lead to charging on spacecraft surfaces which when it discharges in an arcing event, can damage components and again destroy satellites. And then in a sort of more regular environment, anything that's in in anything that's in any satellites in low Earth orbit are inter.
With the atmosphere and if the density increases due to increased extreme ultraviolet.
Radiation that can increase the drag causing satellites to be disrupted, and I think most people are going to be familiar with the SpaceX event from a few years ago where there was a small geomagnetic storm that increased the density and those satellites hadn't boosted their final orbits yet they.
Had to go into safe mode and something like 3030 Starlink satellites came crashing back down because of the increased drag environment, so.
There's all sorts of effects that we have to worry about with space weather.
And the Air Force and Space Force care about a lot of these, and because of that, they've been studying the space environment for over 75 years, in fact.
The starts of AFRL and the Geospace studies that it does happen before NASA was formed. Since 1949, AFRL has been operating or involved in the operations of the Sacramento Peak Observatory in Sunspot, NM, South of me, about four-hour drive.
And since then, AFRL has been studying the space environment from the ground at sunspot, using the Arecibo receivers, using other ionospheric Sounders and similar devices.
Through satellite. Sorry. Through

Sounding rocket launches, studying the atmosphere and the auroras, and then through satellites.
Studying the neuro (near?) space environment.
Studying
Out into the inner heliospheric space.
There we go.
So I'm looking for the SME solar orbiter looking at coronal mass ejections propagating through the inner sphere and this has been taking place, as I said from.
The 1940s all the way through to the current decade. The Demonstration and Science Experiments (DSX) satellite was an Air Force Research Laboratory's (AFRL) mission that was delayed for quite a long time but launched.
Six years ago and provided really interesting results about.
The upper atmosphere and the radiation belt, so AFRL is involved in a wide range of things.
And it is a core funded.
Part of the duty Science and technology development.
So there's a bunch of different things that that AFRL as a whole gets involved in.
One sub part is the Air Force Office of Scientific Research (AFOSR), which provides grants to fund basic research both within the Department of Defense and also to external partners.
So there's opportunities for funding there.
In fact, one of the things that I do is an afsr.
I believe funded project that does outreach in the local community to teach
Middle school and high school students how to launch rockets.
I'm part of the Space Vehicles Directorate, which is one of the different focuses of AFRL. AFRL does work much broader than just space weather and Geospace sciences, but space vehicles.
That's the focus.
And the space vehicles does basic research and applied research and advanced technology development supporting space.
And provides subject matter expertise.
Piece for major commands and program offices and operational units in the Department of Defense.
And really, the main point here is that AFL is a key bridge between the research community and the military operators in.
Their day-to-day operational environment.
Alright, so now I'm going to talk about specifically what I work on as part of the

Space Vehicles Directorate and AFRL, which are primarily the ADAPT and SIFT models. ADAPT is the Air Force Data Assimilative Photospheric Flux Transport model. It produces global solar magnetic maps through a comb.
Of magnetic flux, transport modeling and data assimilation.
The purpose is to drive coronal solar wind geomagnetic activity models as well as the SIFT model which is below and it's used by NASA and NOAA and the European Space Agency, the UK Meteorological Office, and the research community at large.

SIFT is the solar indices forecasting tool, which produces forecasts of the sunspot number. And F10.7 and magnesium two, which are proxies of solar activity and it can also produce forecasts of directly extreme ultraviolet and far ultraviolet irradiance, which impacts the Earth's upper atmosphere and influences the ionosphere on the thermosphere, and it can forecast one to seven days in advance.

And it's these products can be used in ionospheric thermospheric and satellite drag models to forecast.

The communication and near Earth space environment currently used by NASA and NOAA and also internally in the Department of Defense as well.

Both ADAPT and SIFT are transitioning to operational use at the Space Weather Prediction Center at NOAA, and I'm going to walk you through a little bit more of the details about how each of these work.

So in order to model.
The coronal magnetic fields, the magnetic field in the Sun's atmosphere which drives all the variability in the inner heliosphere.
And then forecast out the solar wind from that magnetic field extrapolation, we need to know the magnetic field on the surface of the sun and we need to know the full sun magnetic field. But.
We are only observing typically from one perspective.
For a long time, that was from Earth.
We now have the solar order spacecraft that goes around the sun, but from Earth we see one perspective and that means that we have to wait 27 days.
For the Sun to rotate.
Underneath the earth to see the full surface and the way these maps have traditionally been generated is depicted in this animation in the lower right, where

with the Sun spinning you take the magnetic fields that are observed on the.
The subarth point and the line of longitude from that point and then wait for that Sun to spin to sort of unroll the Sun into this full sun map.
That works been used for a long time, but it means that the information at the left edge of the map is way older than the information at the right edge of the map. That can lead to discontinuities when you wrap this this representation and it just means.
That that the state.
Of the Sun is.
Is older in certain parts of the map than in others, and that is a sort of an inaccurate representation of what the magnetic fields are. And these magnetic fields determine all of the structure of the inner heliosphere.
So it's really important to get them right.
So adapt tries to update these fields more frequently than a traditional full Sun map, and it does that through this flux transport modeling.
So adapt starts with one of these existing poles on maps generated just like.
That one shown above.
And then.
It is forward modeled, so we move the magnetic fields around on the surface.
Based on known flow patterns on the Sun, so differential rotation is the fact that the solar equator rotates much faster than the poles murderer almost circulation is a flow pattern that moves magnetic fields near the surface.
Towards the Poles, sorry near the equator towards the poles and that takes sort of a five year period.
So it's slow movement and then super granulation is the relatively quickly evolving.
Random flow patterns that are on the scale of an individual active region.
So a sort of a combined white and black region here in this map.
And there's sort of a random.
Flow patterns that jostle the fields around.
And on small scales, changing over the course of about a day.
So take a map.
Evolve it forward in time based on these known flow patterns, known or statistically represented flow pattern. In the case of the super panellation and then take an observation from Earth.
Here's the image of the Sun.
We remap that into the same full sun frame, and then we assimilate that data into the model representation based on the uncertainties in the observation and the model representation, and then that gives us a new map.

And we can then repeat this process over and over again. Forward modeling.
Assimilating data where we have it and updating the representation of the Sun and one key feature of ADAPT is that it's actually doing this for 12 different ensemble members at the same time.
So it has 12 different representations of the Sun which are intended.

Kalee Meurlott 13:38
You get form cadre, yeah.

Samuel Schonfeld 13:41
To.

Kalee Meurlott 13:43
And–

Samuel Schonfeld 13:43
Is there a question?

Kirk, Michael S. (GSFC-6700) 13:46
Just a hot Mike. You're good.

Samuel Schonfeld 13:48
OK.
12 different realizations that represent the uncertainty in the current state of the Sun.
And then with each of these realizations, we can drive interfere solar wind model like WSA, the wing xili RG model.
So we can take each member of the ADAPT ensemble, produce a coronal magnetic field model from that ensemble, and then from this chronomagnetic field.
Predict the solar wind at the outer edge of that model, shown here in these maps, and then pass a satellite through space.
Propagate the solar wind out to that satellite.
And that's shown here in these two middle panels showing the solar wind speed and the magnetic field polarity through time, as would be observed by a satellite.
The blue points here are showing the model and the black points are showing what was actually observed.
So we can compare the model forecasts with observations and then because we have 12 different states of the sun, we can actually get uncertainty in these

forecasts as well.
So we can know when the model is confident and when it is.
Less certain about what's happening.
So that's the ADAPT model and how one way that it's used, it's also used to drive the SIFT model.
Again, this is the solar indices forecasting tool.
And its purpose is to.
Again, to predict the solar irradiance the light coming from the Sun.
And so it's driven with adapt nowcast and forecast magnetic maps and the way it works is it takes the earth facing hemisphere outlined with the white box here.
And adds up all the magnetic fields.
In two bins of magnetic field strength, a weak field and a strong field represented by the red and blue respectively.
In this window.
And then we add those up into a linear regression model, including now also a persistence term and some recurrence terms in order to forecast what we expect the arrange is going to be. And so here on the right, I'm showing some early examples of SIFT work where the.
The two lines in the top panel here show the weighted magnetic sums.
In the weak field and the solid line and the.
Strong field in the dotted line and then a now cast of F 10.7 which is the most commonly used proxy for solar activity in atmosphere modeling.
So the observed F 10.7 is a solid line and the nowcast from sift is the dog line.
And you see that it reproduces it pretty well over a full solar cycle.
And we can. This was the now cast, but we can also do forecasts simply by shifting the window.
That is facing towards Earth in the ADAPT map, while also applying the forward.
The forward modeling adapt steps so on the top here I'm showing a one day forecast and then showing how the field of view changes as the sun is rotating and the earth is moving for the three day forecast and the seven day forecast. And you'll notice that in.
These regions here the amount of strong field is changing in that region as the ADAPT model forecasts forward.
How the fields are going to evolve due to the flow patterns?
These forecasts are available live right now.
I should have put a link I can add that in the chat once I'm done talking.
They are.

They are public and live right now. The forecasts of F 7.7 sunspot number and magnesium two index.
And we compare them with the observations to see how well it's working.
We tend to see that.
The one in three day do pretty well on the seven day can often struggle.
Quite a bit lagging behind what's actually happening, but these are available now and as I said, they're being transitioned for use at NOAA.
Both adapt and sift are also being used prominently at NASA.
We're working closely with the NASA WSA team with specifically with Nick Arge, who was previously at the Air Force Research Lab and is now at NASA Goddard.
To provide real time products supporting.
The moon to Mars architecture that that Michael was talking about so.
We are updating adapt to utilize Solar Orbiter low latency magnetogram observations so that we can use that data in a real time sense.
And we are modifying the SIFT model to produce irradiance and solar activity proxy forecasts at Mars just by shifting that that target window to be pointing towards Mars as opposed to pointing towards Earth.
And here's an example of some of the forecasts that are being made right now using WSA in real time using adapt inputs.
So that was all I had to talk about.
Thanks very much and I'd be happy to answer any questions, although I can't see the screen so I'm going to have to get someone reading them to me or stop presenting. Thanks very much.

◉ **Ng, Carolyn Y. (GSFC-670.0)[ADNET SYSTEMS INC]** stopped transcription