THEMIS Findings Media Teleconference

Moderator: Rani Gran
July 24, 2008
12:00 pm CT

Coordinator: Welcome, and thank you all for holding. At this time, all parties will be in a listen-only mode until the question and answer portion of today's call. The call is being recorded. If anyone has an objection, you may disconnect your line at this time. I would now like to turn the call over to Miss Rani Gran. Ma'am, you may begin.

Rani Gran: Good afternoon. My name is Rani Gran; I'm the Public Affairs Officer for the THEMIS mission. Before we get started I want to take care of some business. If you'd like to follow along with the visual presentation, there was a link at the bottom of the media advisory. But you can also go to www.nasa.gov/themis.

Again, that's www.nasa.gov/themis. And on that page there's a - in bold, it says "click here." That will take you to the media telecon page. Also on this page are links to (prec) resolution images, animations that can be downloaded for web, standard definition television and high-definition television. If you are having any problems during this press briefing, you can call 301-286-0691; again, 301-286-0691.

Another side note, video of - NASA TV will be running video news released with the signature sequences that support the press briefing during the 4:00, 8:00, and 10 p.m. video file on the media channel. The video file runs for two hours and this - the video news release for this press briefing will repeat several times. And if you have any questions about NASA TV schedule go to nasa.gov/ntv.

One other note, approximately one hour after the press briefing we will post on audio recording of this event, and you can also call in to listen to this event to hear the recording at 888-568-0131, if you're in the U.S. Again, that's 888-568-0131. Outside the U.S. it's 203-369-3897, and that's 203-369-3897. Thank you all for your patience, and now I'd like to turn it over to Nicky Fox.

Nicola Fox: Thank you Rani. And it's my pleasure to introduce you to the theme that we'll be talking about in this press conference today. So we will be focusing on some very exciting results on the generation of the polar aurora, most frequently known as the Northern and Southern Light.

And you can see a nice movie of this on the press web page, which was taken by the polar space craft looking down at the Northern Light, just sharing how dynamic they can be. And these aurora have fascinated humans for thousands of years. They've fueled myths and legends, they've foretold of disasters or great happenings. They've even led Roman armies into battle.

But more importantly for us, they actually have effects on life and society. So everyone is familiar with changes in weather on Earth, but weather also occurs in space. Just as it dries weather on Earth, the sun is responsible for disturbances in our space environment. And this "space weather," as we call it, describes the solar-driven effects that can influence the performance and reliability of satellites and ground-based technological systems, such as power grids and pipelines.

And they can also affect astronauts in orbit. Normally, we get very excited when we see large events, when the sun releases vast amounts of energy, and these drive very large aurora displays here on Earth. However, it's not just these very large events that drive the aurora. You would typically see them on average maybe once every three nights or so, if you were up in the arctic region somewhere around Alaska, Scandinavia, or Siberia.

And of course, there's the same corresponding regions in the southern hemisphere. And these are driven still by the sun, but by a more benign project. The solar atmosphere, the outer atmosphere, which we call the solar wind, carries with it the magnetic field from the sun. And it streams continuously away from the sun and bathes all of the planets. So you could really think of it as us living in the atmosphere of the sun, so if the sun changes, the Earth will feel its effects.

So it's kind of like if the sun sneezes, the Earth will catch a cold. So as I said, the solar wind carries with it the magnetic field, and this field can be in many directions. But when it is - opposes the Earth magnetic field, just like two opposite poles of a magnet will attract, the two field lines will break and join together. And we call this reconnection.

And this allows vast amounts of solar energy to enter into our own Earth magnetosphere, or the magnetic atmosphere that surrounds our planet. When enough energy has actually entered into the magnetosphere, it's been trapped on the Earth's field lines. We know that a series of processes occur, and we call this a substorm. And it culminates in the formation of the very beautiful aurora.

And it's very important for us to study these auroral processes, because the space-weather effects we see here at Earth can be varied, and can be very violent. We can see high-energy particles being dumped into the Van Allen radiation belt that can harm astronauts and satellites. We see huge currents that get sent into our own atmosphere that can disrupt power lines, pipelines and communication systems.

So understanding these substorms is very important to us so that we can in the future be able to predict where these events can happen and be able to safeguard against them. Now scientists have been arguing about exactly how auroras are powered since the start of the space age and the founding of NASA some 50 years ago. And the evidence has always pointed toward the release of energy trapped in Earth's magnetic field.

But how this energy is released during the course of a substorm has remained extremely controversial. Some scientists believe that the release begins with an implosion about a 6th of the distance to the moon, while others believe it begins with an explosion about a 3rd to a half of the distance to the moon. So it's kind of an outside in or an inside out approach to how these events are triggered.

And about a year and a half ago NASA launched the THEMIS mission. It's five space craft flying in formation and their goal is really to pinpoint what is triggering these substorms. So finally, we have the right instruments in the right place at the right time, and it's allowed scientists to be able to make the necessary observations to settle this heated debate once and for all.

So without further ado, it's my great pleasure to introduce Vassilis Angelopoulos, from UCLA, who's the principal investigator for the THEMIS mission, and the author of the just-published science paper on this topic. And he is going to tell us all about those exciting results, so Vassilis, over to you.

Vassilis Angelopoulos: Thank you very much Nicky. I'd like to just talk to you first, what the substorm means, and why it is important. Then I'll discuss how scientists solved this tantalizing mystery of the substorm trigger, and then explain what this knowledge we just obtained will allow us to do in the future.

As Nicky pointed out, and as you can see in the second item on the web page, it is titled “What is a substorm?” Our story begins at the sun, which constantly spews out charged particles moving at a million-miles-per-hour past Earth, and distorts Earth’s magnetic field region, which we call the magnetosphere, from its familiar bar-shaped magnets into a wind-sock shaped object.

Now on the sunward side of that interaction, where the magnetic fields; the solar wind encounters the Earth’s magnetic field. When the solar wind field points due south, that is opposite to the Earth’s field. The two fields snap and connect again. As Nicky mentioned, this process is called reconnection, and the result of that is that magnetic field lines from the solar atmosphere now connect directly with Earth’s magnetic field lines on one side, directly to Earth’s upper atmosphere.

In this way, Earth’s magnetic field lines are peeled off, as you see in this movie. They are peeled off like onion layers on the day side, and they are transported back into the Earth’s magnetic field, which we call the magnetotail. This transport stores magnetic energy into the magnetosphere and drives intense electrical currents in space. At times the input power is equivalent to the total power generating capacity in the U.S.

But you can’t stretch and compress magnetic field lines forever. Eventually, something gives, and triggers a transformation of this stored magnetic energy into hot jets of charged particles now streaming towards Earth. Around the same time, the auroras suddenly brighten.

Then they advance towards the poles, as you saw earlier in the polar movie that Nicky showed you. This sequence, which lasts three to four hours, is a cycle of solar wind energy storage and sudden release.

And this is called a substorm. So the substorms can release energy that is very large. Sometimes it is equivalent to a magnitude 5 or 6 earthquake. And they can be part of large magnetic storms, energizing charged particles in the radiation belts and disrupting communications.

But just like the meteorologists, who study tornadoes to understand the more severe thunder storms, so do we want better protect astronauts and space systems, as Nicky mentioned earlier. But what triggers this energy release?

This question is one that puzzled scientists since the beginning of the space age. Two main models exist. The two models involve the same identical processes, but they differ only in the sequence in this processes happen.

So the first model, which you can see in item number 3 as a drawing, is called the current disruption model. And it suggests that the intense space (cones), which had built due to the energy stores that we mentioned, they are disrupted. Think of your home electricity blowing a fuse. The magnetotail implodes, causing the aurora to brighten in spectacular flashes a minute or two later.

This disruption starts at about 1/6th of the way to the moon, and it releases a pressure wave, which evacuates particles from further down the tail at about a third of the way to the moon, setting off magnetic connection there. So you can see the sequence depicted in the item Number 3 as first, second, and third, showing the sequence in which phenomena happened in the current disruption model. In the other model, which is called the reconnection model, and it's shown in item Number 4.

In that model, things happen like in an explosion. And the model suggests that the spontaneous onset of magnetically reconnection happens first, about 1/3rd of their way to the moon, resulting in fast blows in it's aftermath. So imagine an explosion out there and flows coming out of it shown in red. Those flows then collide with a nearer region, resulting in current disruption there, the fuse blowing closer to Earth within one or two minutes.

And only after does the intense aurora happen, one or two minutes later. So by timing the sequence of these phenomena, the reconnection, the current disruption, and the aurora brightening, at their well-known locations, we can distinguish between the two models. And this is precisely what we're able to do for the first time with THEMIS and show in several substorms that magnetic reconnection triggered substorm onset.

In other words, we show that the process begins far from Earth first, and propagates Earthward later. So bear with me now, as I will show you some really data from one such substorm, which happened last February, on February 26, 2008 to just demonstrate how we performed this timing.

In this schematic, like you see in item number 5, on the top you see images of the aurora from several ground stations. These are 3 out of 20 ground stations we deployed over in north - in the North America continent in order to capture the aurora brightening.

At the bottom, you see the positions of the five THEMIS satellites, which were along the same local time meridian as the aurora, but out in space, of course. Two of the satellites, which are marked P 1 and P 2 and they're called

- colored red and green, were on either side of the reconnection site; two other satellites, P 3 and P 4, other colors yellow and blue.

They were near the current disruption region. So the magnetic field and the flows from these satellites are what we use to do the timing. And they're shown on the next graph. At the next graph, you see on the left the same pictorial representation of that location, so the satellite's part of the right. You see the data from the satellites.

So you can see that satellites P 1 and P 2, which are in red color traces and in green color traces, respectively, they observe changes in the magnetic field and in the flow, indicated by, at the time that is indicated by the vertical bar at PRX - P reconnection.

The northward or the Z component of the magnetic field reduced at P 1 and increased at P 2 showing that reconnection started to occur right between those two space craft at the time marked first. About one half minute later, the aurora brightens. And this is shown in the auroral intensity panel, which is a black trace just below. It is constructed from auroral images like the ones we show earlier.

The auroral intensity increased very sharply at time P sub AI, or auroral intensification, and marked second. Next, satellite P 3 is yellow. Observe classical signatures of current disruption. Then northward magnetic field component, which is shown in the first of the two traces suddenly increased toward the volume close to that of the Earth's bar magnetic value.

That's expected from the reduction of the space current at time P sub CD for current disruption. So this happened, and maybe it didn't have after-auroral intensification and a full three minutes after reconnection. So cause and effect requires that - requires an interpretation in which a reconnection, and not current disruption, triggers the substorms and the auroral brightening.

What was then surprising to us was that the aurora brightened almost immediately after reconnection, but before current disruption. This defies our old paradigms. It’s not one of the sequences that I showed earlier.

This suggested the aurora is linked much more closely and directly to the reconnection process than we previously thought. So to summarize our findings, I want to point you to the next movie showing an August rendition of the substorm onset based on our findings.

This movie shows how the outer semi-strobes observe the reconnection process and how the accelerated particles may result in the prompt auroral brightening and polar motion that we observed in this event. Of course, we will be looking at many more of these events in the next year to see how general these findings are.

But where do we go from here? Solving this age-old mystery is expected to galvanize research in modeling the fundamental process of substorms and contributing to better space weather model tools.

Moreover, now that we see that reconnection starts the substorm process, we want to understand what causes a reconnection to begin in the first place, (unintelligible). What we learned from the Earth space environment can also lead to better understanding of energy releases in other (unintelligible) settings where a connection occurs, such as within the solar wind itself, at the sun, and other planetary and stellar systems.

At this point, I would like to introduce to you Dr. David Sibeck, who is the THEMIS/NASA project scientist, and he's here to describe how the THEMIS mission has enabled these findings. David?

David Sibeck: Thank you very much, Vassilis. Vassilis was able to make this discovery thanks to the many years of a dedicated team of scientists and engineers put into planning the THEMIS mission. The THEMIS mission comprises five identical space craft and an array of ground observatories in Alaska and Canada.

Each of the spinning space craft is about the size of a washing machine, and carry sensitive instruments capable of measuring the magnetic field, the electric fields, and the particles in Earth's environment. You can see in film number 8, you've got item number 8, a film which begins with a picture of the auroral oval around the Earth, and then zooms out to show the individual orbits of the space craft.

Each space craft has its own orbit. Once each four days they line up in the night side on the opposite side of the sun on the opposite side of the Earth from the sun to measure the dynamic processes that occur within the Earth's magnetic field. We can use these five space craft like stop watches, to pinpoint when and where the processes that cause the aurora begin, and to track the corresponding disturbances spreading like wildfires in space.

The other key component of our mission are the ground observatories. Because substorms routinely involve the Earth's atmosphere, we can make observations from the ground of the aurora, and the currents that are dumped into the Earth's atmosphere from these substorms on a daily basis. We're talking about million amp currents pumped into the Earth's atmosphere. We measure the magnetic field perturbations that these currents make.

Our ground observatories also take snap shots of the nighttime sky each three seconds all night long every night. We use those snap shots to make movies of the aurora over North America. The next movie, that's item number 9, shows one night's worth of auroral activity. Here we zoom in on a nighttime picture of the northern United States and Canada.

As sun sets from the east to the west, the cameras turn on and begin observing the aurora, and you can see just how extensive the aurora are, covering all of north America from Alaska to Newfoundland, and you can see just how dynamic they are, all night long, swirling in the nighttime sky over all of the northern part of the north American continent.

As day break occurs, the cameras turn off, first in eastern Canada, then one by one moving westward toward aurora. As the sun rises, we can no longer see the aurora in the nighttime sky. Combined, the space craft and ground observations provide precisely the observations needed to solve not only the substorm question, but also many other problems in near-Earth magnetospheric physics, and the physics of the magnetic field that surrounds the Earth.

I'd like to turn the microphone over to Dr. Chuck Goodrich, from NASA headquarters, who can tell you just what THEMIS means to NASA.

Chuck Goodrich: Thank you David. We at NASA headquarters are extremely excited and proud of the success of the THEMIS mission. It's a key mission in our Heliospheric division where I work, and I'm program scientist for THEMIS, where we focus on the sun, the solar wind and their impacts on the magnetosphere and the upper atmosphere; all the space weather effects that we've been talking earlier.

THEMIS is the latest medium-class mission of the NASA explorer program, which is our oldest, most efficient, and scientifically productive space flight program. THEMIS is a great success in the tradition of this program, not only because of its terrific scientific results, which you've just seen, but for the technical achievement, for the first time launching a feat of five space craft and analyzing their data as a coherent constellation.

THEMIS will continue its study of substorms for another year while it's in its prime mission. After that, it will join the Heliospheric (Great) Observatory, a fleet of more than a dozen space craft that monitor the Sun-Earth system and get - take care of all the space weather effects. It's going to add a critical new coverage to this whole system we have. And over the next years, we look forward to many new and exciting results from the THEMIS space craft and ground stations.

Thank you and back to Rani.

Rani Gran: All right operator, we are ready to take questions. So I will hand it to you.

Coordinator: Thank you very much. At this time we'll begin the question and answer session. If you would like to ask a question, please press star 1 on your touch tone phone. To withdraw a question, press star 2. Once again, if you would like to ask a question, please press star, 1. One moment please, for our first question.

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Our first question comes from Marcia Dunn with Associated Press. Ma'am, your line is open for your question.

Marcia Dunn: Thank you, can you hear me?

Chuck Goodrich: Yes.

Marcia Dunn: Oh, I am looking at all the literature put out regarding this subject, and there isn't Northern Lights mentioned anywhere. And I believe you said, and I wanted to double check that the same phenomena is responsible - are responsible for the Southern Lights as well, and is it as common in the Southern Lights as the Northern Lights? I think you mentioned, once every three days, and I was wondering if that indeed is year-round. Thank you.

Rani Gran: Yes. The same processes do cause the Southern Light. If you actually looked at the movie that Vassilis was showing, you'll see that particles were dumped in both the north and the southern hemisphere when that reconnection was occurring. So they do happen simultaneously and we've been able to image them with a polar space craft to see the - we call them the conjugate aurora, because you do see them at the Northern and the Southern Light.

And I was kind of hesitating when I said once every three days, because it's always very difficult to say this. Sometimes they happen nightly, and then you send people up on campaigns and they don't see an aurora for the entire week that they're in Alaska because something was really quiet. So I try to kind of average it. It is usually once every two, once every three days over a year.

But you will see, you know, you just have some nights that are just so active, and you see these fabulous aurora. And then, you know, I go off on a campaign to northern Alaska and freeze to death, and I don't see anything for four days. So, you know, it's always difficult to kind of predict it. But they do - they happen very frequently. When you take about the big storm-driven events, they're happening much less frequently.

So I just wanted to give a, you know, a sense that these things do happen on a - almost a nightly, two nightly, three nightly basis.

Marcia Dunn: Thank you. Could I ask another question?

Rani Gran: Sure, go ahead.

Marcia Dunn: Yes, you mentioned those bigger events, with bigger solar releases. Could you talk just briefly about that and how often those are believed to occur and how much bigger the Northern and Southern Lights are in their brightening with the big events versus the events that we're talking about today?

Rani Gran: Yes, certainly. They're driven by large storms that occur on the sun. We call them coronal mass ejections, because they literally do throw pieces of the corona. They do have a mass, and they're ejected extremely fast from the sun. As Vassilis mentioned, the solar wind usually travels at about a million-miles-an-hour. But when we have these solar events, instead of taking about three and a half days for what is thrown off the sun to get to the Earth, they can be with us in as little as 24 hours.

So these things are moving very fast. So they, number one, they hit the magnetosphere and they cause it to ring like a bell, and they really do, you know, disturb the entire system much more. Plus Vassilis mentioned that you need to have the sun's magnetic field opposing the Earth's magnetic field, and that's what allows all the energy to come in and allows these reconnection processes to start.

Often when we see these big solar events, the southward pointing magnetic field coming from the sun, the one that is opposing the Earth, is - there's a big patch of it, it's called a flux rope, and you see it coming. It starts off southward then it can remain southward for 12, 24 hours, sometimes even longer.

So you are continually driving the system, you are continually dumping energy in. So this causes a huge disturbance to happen. And so these substorms that are going off are happening one after the other. You see large substorms, they drive the aurora down to much lower latitude, and that's both in the north and the south. And so the aurora can be visible from places like Texas and Florida, so that they are - the substorms are pieces, building blocks of these bigger storms.

So when we're studying these substorms it's important because they do build into these large events, because if you can really understand the building blocks it allows you to build really good predictive models, and that's our ultimate goal.

Chuck Goodrich: This is Chuck Goodrich. I'd like to add one thing if I might. The difference in magnitude of the substorms we're talking about versus some of the big storms, in some ways it's not intensity so much as coverage. These storms cover a huge extent of the Earth and the ionosphere, whereas a substorm will be more localized. But where it's localized, it's going to be quite intense.

Rani Gran: That's right.

Chuck Goodrich: That's why you can't see it all the time in Alaska, because you should have been in Norway to see it; or vice versa.

Rani Gran: Operator, next question.

Coordinator: Our next question comes from Marc Kaufman, with the Washington Post. Sir, you may ask your question.

Marc Kaufman: Okay, thank you very much. Its two questions, the first is, if you could just kind of help walk through again the - what the reconnection needs and some of the dynamics of it. Not that I fully understood what you did - how you were describing it and, you know, if you know ways to put it into layman's terms that would be very helpful.

And then also you had said at the very beginning that the more you learn about these things, the more that you can predict them. And that would be, and you in terms of predicting for satellites and pipelines and other kind of protection. And I was wondering what kind of timeframe we're talking about here. I mean, are there minutes, hours, days and weeks, so, what kind of predictions would you be making?

Vassilis Angelopoulos: Yeah, I'd be happy to answer that question. The reconnection - imagine two field lines that are anti-parallel to each other, like strings, and they're pressed against each other. This represents the magnetic field lines that are compressed against each other, either by the action of the solar wind buffeting Earth or as the field lines on the night side are stored by the interaction with the solar wind, and that compress against each other on the north and south hemisphere.

So they end up being anti-parallel to each other, and when that happens then something snaps within them. We still do not understand what causes reconnection to go off in particular in the case of the magnetotail, but that's a subject we intend to study very intensely in the future.

Nonetheless, we know what that - what happens is that once reconnection starts, then the field lines snap somewhere in the middle, and they connect to each other so that they form instead of anti-parallel strings, they form U-shaped objects.

And when they do that, they are in a state of increased distress, like a rubber band that you stress by opening it up with your forefinger and your thumb. And that is a situation of that requires relaxation. It tends to want to relax in a lower-stayed configuration that accelerates particles in the process, like the rubber band accelerates if it is contracting.

And so in the process of contracting, the field lines accelerate flows, and that sling shot acceleration is what converts magnetic energy into kinetic energy of particles. So regarding the second question, how I could have the prediction model and how can we build, and how - what is the timeframe of - timescale of predictive capability we can reach.

Our goal is to understand the basic physics of these processes by understanding where reconnection is about to happen, what location then, that is, and what time it is about to happen, and put them within our large scale models of the Sun-Earth interaction. Obviously, what we need is simplified physics-based models based on our physics understanding.

Physical understanding of how things happen, and that will allow us then to predict where one of these things - one of these substorms is going to occur, and what intensity, and what location. And the kind of predictive capability we can reach then depends not any longer on our models, but on the input that we get. And we have input satellites that can give us such input as far away as the LaGrange point, the point between Earth and sun, that where this is the force of the - gravity force of the sun is equal to the gravity force of the Earth.

That's about a million miles from upstream from Earth. And that gives us a warning on the order of one and a half, two hours. And then once we obtain the data from that point, we can put that data's input to our higher fidelity models, and predict when the next of the substorms or storms is about to happen.

Rani Gran: Next question?

Coordinator: As a reminder, if you would like to ask a question, please press star 1. Our next question comes from David Perlman, with the San Francisco Chronicle. Sir, your line is open.

David Perlman: Thanks very much. This is Dave Perlman from the Chronicle. Apparently you have - THEMIS has resolved one mystery, at least. Some or a selected one of two models, and I'm not at all clear on which of the two - I'd like you to describe the two models again, if you don't mind. And then say which of the models seems to be a preferred model at this point.

Now the results, as I gather, was the big mystery you went out there to solve. If I'm wrong, that may be due to my misunderstanding.

David Sibeck: You're absolutely right. This is David Sibeck, the project scientist here at NASA Goddard Space Flight Center. There were two models. One of them was the current disruption model, in which it begins like a short circuit at a distance about 1/6th the distance to the moon. The other model was the reconnection model, in which it begins with these field nights snapping and reconnecting and acceleration of particles at about the distance - 1/3rd the distance to the moon.

And the model that Vassilis has shone to be correct is the reconnection model, the one that starts further from Earth and things propagate towards the Earth.

Vassilis Angelopoulos: And let me add to that, David, that there is a twist. That exact sequence we were expecting from either of the models did not pan out. And nature surprised us in the sense that it showed us, at least in these events, that we have finalized, that the sequence happens as reconnections first, aurora brightening next, and then current disruption.

It was unexpected even in the reconnection model, and we want to solidify these results in the next- result in the next year with more data. And also try to understand it better.

Chuck Goodrich: This is Chuck Goodrich, from NASA headquarters. It's also important because the different models somewhat differently predict what's going to be injected into the radiation belts, their geosynchronous satellites. What kind of hazard they'll see, and how soon you'll see it and when you'll see it in the ionosphere, which will have the effects of disturbing the ionosphere greatly, effecting high frequency communications on aircraft and other things.

Vassilis Angelopoulos: David, does that answer your question?

David Perlman: I said, I think that did, yeah.

Rani Gran: Okay.

Vassilis Angelopoulos: Okay.

Rani Gran: Operator, we'll take the next question.

Coordinator: Thank you. Once again, if you would like to ask a question, please press star 1. Our next question comes from David Kohn, with the Baltimore Sun.

David Kohn Hey Dave, I had a question for you. You mentioned just a second ago that something was unexpected, and I wanted you to just to elaborate on that a little bit, and also to ask you were you guys surprised by these results?

David Sibeck: I want to direct that to Vassilis and those who are listening should look at Items 3 and 4 on the graphics list, so that Vassilis can explain what that unexpected item was.

Vassilis Angelopoulos: Thank you for the lead, David. Item number 3 shows the version of the current disruption model that we had in our minds before these observations, and it - we expected the current disruption to start first, roughly a 6th of the way to the moon, and then we expected the aurora to brighten, two minutes later and then we expected reconnection to happen.

In the next model, in the reconnection model, we expected the explosion to start the reconnection, to start first. And followed by current disruption and this was current disruption the 6th of the way to the moon, and then followed by auroral disruption. What we saw, you can see in Item Number 6, in a pictorial presentation of our event, which showed first, tail reconnection.

Second, auroral intensification and only third, current disruption. And that was the unusual thing. That was something that we didn't expect. True, it is true that our results indicate that reconnection is the trigger of these substorms, but yet not exactly in the way that we expected. We find that to our surprise that the auroral intensification is linked much more directly to tail reconnection than we previously thought.

And this is something we want to understand much better in the future.

Rani Gran: Operator is there - take another question.

Coordinator: Yes ma'am, our last question comes from Annie Hudon-Friceau with CBC Radio Canada.

Annie Hudon-Friceau: Yes, hello. Okay, I'm not too, too sure I still understand very well the origin, what triggers exactly with the reconnection of what. So I would like to get that cleared up. And also I was wondering if by any chance if you do speak French, I would like to hear your findings in French, if that would be possible?

Rani Gran: Do you have any French speakers? No.

Annie Hudon-Friceau: No? I'm hearing an accent there, so I thought maybe we had some chance. But in any case, I'm not too, too sure what you're talking about when these things reconnect. What does reconnect exactly, in simple terms? Because I have only two minutes to explain your discovery, and I want to make sure that I really understand in very easy, easy words.

Vassilis Angelopoulos: Would you like me to talk that?

Man: Go ahead and try.

Vassilis Angelopoulos: Okay, when we look at Item Number 6, you see field lines that originated at Earth, obviously, and go all the way down to the right, to what's the Earth's magnetotail. Those field lines are pointing, or the fields lines that are linked to the northern hemisphere are pointing towards Earth. That's the way the magnetic field is. And the ones that link to the southern hemisphere are pointing away from Earth.

Now imagine those two field lines that are pretty much straight originally, they are - imagine those compressed against each other. That's the process by which the solar wind energy drives the system, by compressing those field lines against each other. And then something causes those field lines to snap right where there's an X.

When they snap, they connect to each other, so the field line that was previously connected to the northern hemisphere, now connects also to the field line that goes to the southern hemisphere. And it forms a U-shaped field line. It was straight before, now it's U-shaped on both sides; both of the side towards Earth and also the side away from Earth.

And so those U-shaped lines are - that have just reconnected, have the energy to propel the particles towards Earth, causing transformation of magnetic into kinetic energy.

David Sibeck: I'll follow up with that, too. Reconnection occurs when the Earth, this is David Sibeck at NASA, reconnection occurs when the Earth's magnetic field absorbs energy from the sun and from the solar wind, and it does that by stretching the Earth's magnetic field, stretching them like rubber bands far, far off into the distance.

And as Vassilis said during his talk, you can only stretch them so far before they snap. You build up these big currents, you store a lot of energy, and then suddenly bang, they snap.

They're flung back to Earth. The reconnection means that you draw a closed loop and you push them back towards Earth, back towards the familiar dipole - bar magnet configuration. The bar magnetic configuration of the north and the south pole, with field lines going from the south pole up to the north pole.

And so reconnection is a way for the Earth's magnetic field to release the energy that it has captured from the sun.

Rani Gran: This is Rani, is there - it is a hard analogy to get, even as a public affairs officer here. But is there an analogy, I know I've heard you guys talk about a circuit box in your house, or something like that in between the two. Can you give an analogy for that?

David Sibeck: Yeah, another way of thinking about that is when you stretch those magnetic field lines, you have some that are pointing towards the Earth, and some that are pointing away. And they're separated by a really, really strong current. When reconnection occurs, that current is broken, and it flows down to the Earth, so you had like a short circuit out in the Earth's magnetic field.

And it's that current that's going to power the aurora and dump into the Earth's ionosphere and cause power line disruption in Canada, for example, by blowing out transformers.

Rani Gran: Did that answer the question? If the CBC person's on, how did we do? Okay, is there anymore questions?

Coordinator: Yes ma'am, we do have one additional question, and that is from David Pearlman, with San Francisco Chronicle.

David Perlman: Oh, hi. I had no way of saying I don't need the answer anymore because I think that last explanation of reconnection was well done, and I think all of us who were struggling with a way to present this to the lay readers, if anybody's reading it, will - yeah, thanks a lot. I don't - I got as much as I can handle.

David Sibeck: We appreciate knowing that we finally done a good job on this, or at least an adequate job.

David Perlman: Yeah, thanks.

Rani Gran: And I do have cheat sheets there, FAQs, and I hope I tried to write it out - we tried to write it out in lay too for the reporters. And please feel free to follow up with us, if you need further help. Just going to double check, anymore questions?

Coordinator: No ma'am, I'm showing no further questions.

Rani Gran: Great. All right, I just want to thank everybody for joining and thank the reporters for tuning in to us. If anybody needs follow up interviews, we do have a radio booth, and we could set up an (IFD) in-line. We do have the ability to do some television interviews. We got some folks on the west coast, the east coast and in Canada.

Otherwise, thank you all. End the conversation here.

Coordinator: That does conclude today's call. Thank you all for joining, you may disconnect your lines at this time.

((Crosstalk))

END