

Science AMA Series: Hi Reddit, we're Benoit Lavraud, Bill Peterson, and Andrew Yau. We're all part of AGU's Geophysical Research Letters and investigate Sun-Earth magnetic fields. Ask us anything!

AmGeophysicalU-AMA¹ and r/Science AMAs¹

¹Affiliation not available

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Abstract

I am Benoit Lavraud, I am permanent staff researcher at the Institut de Recherche en Astrophysique et Planétologie in Toulouse - France, and Editor of Geophysical Research Letters (GRL), a research journal published by AGU focusing on high-impact scientific advances in all major geoscience disciplines. My research topics include the whole chain of phenomena occurring during solar storms between the Sun and the Earth: What are the basic processes of solar storm release? How do solar storm propagate/interact in interplanetary space? How do solar storms trigger geomagnetic activity? What are the key plasma processes controlling this interaction? Can solar and geomagnetic storms be predicted? What are the potential impacts of solar storms on society? I try to tackle these questions through both basic science and instrumentation (ion and electron spectrometers in space). I am Bill Peterson, a research associate at the University of Colorado, Boulder, at the Laboratory of Atmospheric and Space Physics. I have been studying the space weather and the coupling of the ionospheric, magnetospheric, and solar wind plasmas using satellite instrumentation since 1973. I have participated in the design, implementation, and operation of instruments on several NASA missions focused on space weather. I started out studying the physical process that cause the aurora and the effects of the aurora on the Earth's magnetosphere and ionosphere. I'm currently working on identifying how these processes differ at Mars using data from the MAVEN spacecraft. I am Andrew Yau, Professor of Physics at University of Calgary, Canada, and Associate Editor of Geophysical Research Letters (GRL), a research journal published by AGU focusing on high-impact scientific advances in all major geoscience disciplines. I am a space scientist. I design satellite instruments such as ion mass spectrometers, and I study the effects of weather in space on the Earth's upper atmosphere and ionosphere. For example, how and why do solar storms and other space phenomena cause the heating of the upper atmosphere and its escape into space? How does this heating impact Earth-orbiting satellites? How does the solar wind produce the aurora, and the associated electrical currents in the ionosphere? How do these electrical currents affect radio communications - and impact the operations of satellite navigation systems such as my cell phone's GPS receiver? We'll be back at 11 am EST (8 am PST, 4 pm UTC) to answer your questions, ask me anything!

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AMGEOPHYSICALU-AMA [R/SCIENCE](#)

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How substantial of a threat are solar storms to satellites in earth orbit? Is there a chance that we will see the GPS system disrupted one day?

[nate](#)

Solar storms have disabled satellites in Earth orbit. Satellites are designed to withstand the largest known storm, but we are not sure we have seen the largest possible storm and satellite components degrade over time, making them more prone to failure. That said, it is highly unlikely that all of the GPS satellites would simultaneously fail due to a solar storm.

How did you get into this field and what is your favorite aspect of it?

[Hearthsynkrz](#)

Well, first you have to like science. Then to like Physics. Then to have some preference for

Letters and investigate Sun-Earth magnetic fields. Ask us anything!, *The Winnower* 3:e147463.35037, 2016, DOI: [10.15200/winn.147463.35037](https://doi.org/10.15200/winn.147463.35037)

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Astrophysics-type topics. And eventually just some random/chaotic interaction processes come into play... The favorite aspect is just that your daily job is to try to understand new things. This is true for all science/research topic, not just ours of course.

Is there any chance of being able to harness these space storms to generate energy? If so how?

[djb85511](#)

The short answer is no. No technology would currently allow to harness, or else, this energy into a really useable form of energy on ground (for human usage purposes). The comment from "hurlga" is very pertinent, though. The induced currents on ground are a form of energy conversion, into a ground system, but this is indeed more of a problem than a benefit (at least for now).

Is the magnetic shift of the earth gradual or instant?

[AmberEmotions](#)

jack_the_beagle and orge121 are correct!

Not sure if this is relevant your you field specifically, but how would you handle communications between the Earth and another body if the sun was in between them?

[nickthequic](#)

Dear nickthequic, we are not able to handle it. The Sun is too opaque. Such loss of communication has in fact happened recently with the two STEREO spacecraft, which drifted ahead and beyond the Earth on a similar orbit around the Sun, until at some point they past beyond the Sun. Communications were cut as planned and then we got back online (though one spacecraft had issues).

What will happen when the moon is too far away to have any effect on the oceans?

[Endless_Vanity](#)

[https://en.wikipedia.org/wiki/Lunar_distance_\(astronomy\)](https://en.wikipedia.org/wiki/Lunar_distance_(astronomy)) tells us that the moon is moving at 1.5 inches per year away from Earth. It will have to move many thousands of miles before there is any measurable effect on the tides.

Do these magnetic fields have effects that contribute to or alter storms or lightning in any significant way?

[Foxyedarko](#)

The short answer is we don't know. Several researchers have attempted to find such effects, but to date none have been reported.

If you had to explain what you do and your main professional interests to a five year old, what would you say?

[rhia160](#)

Hello rhia160! Well I would tell him/her, that I use data to study the Sun and its impact on the Earth. In particular I try to understand solar storms and how these eventually lead to auroras. Of course, when you do that you want to show him/her pictures and movies of solar storms and auroras!

What events/effects would we experience from a magnetic pole shift? Is one occurring now?

[curtis7676](#)

The slow wander of the Earth's dipole requires knowledge of the pole position as a function of time to magnetically navigate. During intervals of dipole reversal higher order components of the field dominate. During these times aurora will occur at all latitudes.

Are there plans in place to rebuild technological infrastructure and society as we know it today in the event of a solar flare catastrophe?

If so,:

How long would it take for us to rebuild our technological infrastructure?

Would all computer memory be erased?

What would be the safest way to protect our data from solar flare radiation?

What would the level of solar flare needed to effect humans? (ex: X1, X2, X3...)

Considering cell phone communication would be impaired in a catastrophe, would radio signals still work?

Considering cell phone communication would be impaired in a catastrophe, would Walkie Talkies still work?

Thank you for doing what you do. Not a lot of people know about the sun and how it effects us when certain geomagnetic events occur. You are important to our world.

[n0tabene](#)

hi n0tabene: The chances of global catastrophes are extremely small and unlikely in our lifetimes. Nevertheless people have been thinking about what could be done to minimize the impacts of, for example an extremely large solar flare. The work has been nicely summarized by a US Office of Science and Technology report that can be found at:

<https://www.whitehouse.gov/blog/2015/10/28/enhancing-national-preparedness-space-weather-events>

I like to hike. Does the normal drift in the magnetic field mean that I need to get updated maps with new declination settings on them? If so, how often?

[REI is saying that I should always use online tools to determine the correct declination](#), do you agree?

[zverkalt](#)

yes

I was recently in Iceland and got witness the northern lights in a pretty grand scale (even had red to the naked eye). That's it. no question. Space stuff is amazing.

[J_Paul](#)

Hi J-Paul. The aurora is amazing. I've seen it in Fairbanks Alaska several times and my colleagues in Kiruna Sweden regularly see it. During magnetic storms the Aurora is visible even in Colorado. There is a website (<http://www.aurorasaurus.org/>) that keeps track of where the aurora is currently visible.

How much does Earth's magnetic field fluctuate in intensity on a day to day basis compared to the sun's?

Also, is it possible we could have another Carrington event in our lifetimes?

[Stuck In the Matrix](#)

Earth's magnetic field moment does not change on a day to day basis but on much longer timescales. What changes though is the magnetic field in the magnetosphere and down to the surface in response to solar wind properties, solar storms, auroral currents, etc. Regarding a Carrington event, the STEREO-A spacecraft has in fact observed an event with very intense properties on 24 July 2012. But hopefully it was not directed to Earth, but some 120° away from it!

Thanks for coming by to do this AMA. These questions aren't anything technical, but is instead a request for advice.

I'm a 28 year old woman with no background in science or mathematics (besides school and a little personal studying in math), and no special education (I'm about halfway through an Associates, but my classes are a bit scattered). I would like to study geophysics, but I am curious about the opportunities after school (college is not cheap in the US).

How high of an education level would you suggest? Or what kind of opportunities would be available after a Bachelors, if I chose not to continue.

Also, does it matter where I get my degrees from? As in, would the school I go to have any bearing on my success in the field.

Is this the kind of field that someone with a general curiosity and a decently high level of intelligence could do well in? Or is it better suited for someone with a very specific burning passion?

And one last question, would a Bachelors of Science in Environmental Studies degree transfer or benefit me in any way if I chose to continue onto Geophysics? The school that I am thinking of going to has no other science options, aside from Information Technologies.

Also, for Bill: Hooray for Colorado! I'm from Colorado Springs. I liked Boulder, the one time I made it up there. It's a strange, but nice city.

Thanks for your time!

[kmdonnelly](#)

Hi Kmonnelly: I think Boulder is not strange! Excitement for the science/job is still the best way to convince someone to hire you!

How much could we learn from the Juno spacecraft about planetary magnetic fields in general?

[illiriya](#)

hi illiriya. That's a good question. Progress in the theory of magnetic dynamos (which generate planetary and solar magnetic fields) has been limited by a lack experimental evidence to test the theory. Juno will provide data that will be compared to theoretical estimates.

Hi thanks for doing this AMA. What are solar storms and what causes them between the sun and earth?

[mistymountainz](#)

Dear mistymountainz, to first order solar storms are huge balls of particles and magnetic field ejected

from the Sun. These then propagate outward in the interplanetary medium, where they interact with the regular solar wind. Depending on their trajectory, they then might hit the Earth, or other planets/satellites etc. Again this is a first order response, you're welcome to refine your question.

If something like the Carrington flare happens today, what would be the fallout(apart from seeing awesome Auroras latitude 30)?

[tsk1979](#)

The impact on human technology (satellites/GPS/ground electrical grids, etc.) would be huge and dramatic.

Check details of impacts and mitigation at:

https://www.whitehouse.gov/sites/default/files/microsites/ostp/final_nationalspaceweatheractionplan_20151028.pdf

How exposed is ours/your electrical grid when a Coronal Mass Ejection hits Earth? Are there disaster recovery backup plants that will save us or does it become 1800s?

[DiaSolky](#)

You should have a look at this:

https://www.whitehouse.gov/sites/default/files/microsites/ostp/final_nationalspaceweatheractionplan_20151028.pdf

can you recommend a book about Sun-Earth magnetic fields - for an Elc/Eng ? thanks for AMA

[AlphaPrime90](#)

One typically given to students starting to study space physics is this one: Introduction to Space Physics, by Margaret G. Kivelson (Editor), Christopher T. Russell (Editor)

The shock front where the Earth's magnetic field stops the solar wind is a few thousand kilometers thick, yet the particle mean free path in the solar wind is much much greater. What is the nature of the shock front.

[interguru](#)

The solar wind plasma is essentially collision-less, so that the mean-free path for actual interactions is indeed much much larger than the shock front. The behavior of particles is primarily driven by interaction with electro-magnetic fields. The particles' behavior at the shock depends on the local properties of these fields. At the shock they change on a very short scale, and dramatically, in such a way as to alter the bulk properties of the particles (they are slowed down through the shock and heated by these electromagnetic fields). Hope it (partially) answers your question.

I'm an amateur radio operator who uses the HF bands (frequencies up to 30MHz) using ionospheric skywave propagation to bounce signals around the world. Propagation has been awful this year due to lower solar activity from lower ionization of the D, E and F layers. The amateur radio community is worried about the future from less solar activity.

How do you see the sun activity ending up in the next few years and longer?

[hamhameggsandham](#)

hi hamhameggsandham: Yes this solar cycle has been weaker than most of the ones have had in the last century. We are just past the peak approaching solar minimum. The next solar maximum will be in

a few year. Predictions on how large it will be vary a lot. So we really don't yet understand solar dynamics well enough to predict activity.

Hi! I am a student at CU and I had the pleasure of a small discussion based class led by Marty Goldman. Can you tell us a bit about the recent MMS mission and some of the information that has been found? Thanks :)

[imsortawesome97](#)

MMS is a great mission, indeed, which has already shed important new lights on the process of magnetic reconnection. This process is at work in many areas of astrophysics from solar eruption to eruptions, including laboratory devices and black hole jets.

In one of my favorite short stories by the late, great Arthur Clarke, a sporting event of the future is solar sailing, in which light craft are powered by actual Mylar-like sails that harness solar energy and use the various space weather conditions to "sail" a plotted course throughout the solar system and beyond. Assuming we had the ability of this kind of leisurely space flight, is this something that could happen? Or is it too little energy gain for the output required, despite the weightlessness of general space?

[Pellantana](#)

Pellantana: Yes solar sails have been constructed and flow in space:
https://en.wikipedia.org/wiki/Solar_sail#Projects_operating_or_completed They are useful for going away from the sun

[deleted]

[\[deleted\]](#)

There are no credible observations supporting this assertion.

[deleted]

[\[deleted\]](#)

There are no evidences of this, as far as we know.

Is there physical evidence that we got hit with a massive solar storm in the past? I'm talking "If it happened today we'd be back to the iron age" size of one.

Space seems to be filled with things that can kill us all relatively easy, but I'm just wondering if it already happened sometime in the planet's history. We've only been out of caves for a very short time (cosmic scale).

[lurking_my_ass_off](#)

There has been a huge event observed by Carrington in 1859. Luckily, technology was not as developed then.

As a geologist (by training), I've always wondered if the cycles of the sun affect the geologic processes on earth, particularly the warming/cooling periods. For example, could a period of few solar storms have contributed to glacial formation and ices ages? Or conversely, could an active solar flare period have contributed to global warming? My senior thesis was about calculating the natural contribution of

pollutant chemicals by rock erosion so that anthropogenic contribution to pollution could be more accurately estimated. So I'm curious how our planet's and the solar system's natural processes may contribute to Earth's cooling and warming. If we factor that into the baseline, we may be able to more accurately estimate man's contribution to our current warming cycle.

[SKlalaluu](#)

This is a very controversial topic right now. There is no accepted evidence at this moment that this would be true, despite some arguing in its favor.

Nice to see another geophysicist on Reddit. I have a question. On college I learned about polarity reversal and its effect, and what I learned from that is the reason is still unknown. Is there any research regarding polarity reversal and its reason or further effects? What do you think will happen if polarity reversal is happening today? Thank!

[revrae](#)

There are many people trying to understand the drivers of polarity reversals. There are many ideas but as I understand it there is still no consensus about the mechanism or even if we are currently experiencing a reversal.

I do know that there have been many reversals, but none of them occurred at the same time as a major extinction event, so the effects on life, if any, are small.

Hi, thank you for doing an AMA! What are your degrees in? I just graduated with my undergrad in geology.

Since we are headed into a period of low activity in the solar cycle, how will this affect your studies?

[alliecat712](#)

Our degrees are in physics, with different specialty for the three of us. The fact that the Sun is more quiet than past cycles (remember that right now we're near maximum activity, it is just lower than past cycles) will not really affect our studies in the sense that active and non-active periods are both interesting for understanding Solar activity as a whole. Also, we still have all datasets from past years to work on, and that's a lot of data to look at...

What are the best tools for the general public to use to predict and calculate the chances of a good aurora display? I'm aware of the [Aurora Forecast](#) from the University of Alaska Fairbanks and the [30 min Forecast](#) by NOAA. Are there any other tools that may go more into depth for those looking to get more nerdy?

[JohnnyMojo](#)

There is a website (<http://www.aurorasaurus.org/>) that keeps track of where the aurora is currently visible.

Is the earth's magnetic field wearing out like a battery? Or does it somehow charge it self.

[wrestler1977](#)

The Earth's magnetic field is driven by the dynamo which is thermally driven. As the Earth cools the dynamo will decay and the magnetic field will 'wear out' as it did on Mars. The time scale for this is measured in the millions of years.

Did you all remember what got you into this profession? And, what would you say to those who are possibly getting into or wish they could get in your profession? One last question: what food you like the most?

[UnknownSpeci3](#)

1 - Passion for Physics/Astrophysics. 2 - Persevere 3 - Wine ;-) (I'm French)

I have always thought that there could be a possibility that the greenhouse effect was not due to ozone depletion, but that it could actually be the Earth coming closer to the sun. Is there a possibility that I am right?

[timception](#)

There is no study (to our knowledge) that supports this.

What is your view of using distributed systems of simple sensors to make measurements, such as Ampere? Do you anticipate doing anything similar in the future?

[Taquito69](#)

Such distributed measurements are very useful for what we call "data assimilation": we use a physics-based model into which we inject actual data (e.g., from spacecraft like Ampere and others). The more data we inject, the better we constrain the physical model, and this allows us to better model and forecast near-Earth environment properties.