# SciencePodcast_190614

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**00:06 Sarah Crespi:** Welcome to the Science Podcast for June 14th, 2019, I'm Sarah Crespi. For this weeks show, we start with staff writer Paul Voosen he's here to talk about a constellation of satellites that scientists are trying to use to get better measurement of hurricane wind speeds despite some signal tweaks from the military. And I also talk with Samantha Trumbo, about a salty new find on Europa. Europa is a large moon of Jupiter that checks a lot of boxes for habitability. Now we have Paul Voosen a staff writer for science, he's here to talk to us about gauging the speed of hurricanes or at least trying to gauge the speed of hurricanes using satellites. Hi Paul.

**00:50 Paul Voosen:** Hello.

**00:52 SC:** Okay. I've never thought about this before, but I have seen images of hurricanes on The Weather Channel, and they show me here's the eye and they have the different wind speeds kind of labeled with color. Where are they getting those wind speed measurements?

**01:05 PV:** Well, whenever a hurricane moves close enough to the US, we still have the fleet of Hurricane Hunter Aircraft that fly into the hurricanes to make direct measurements of the wind. So that's gone on for decades, but for hurricanes that are further out there's a limit to how much you can do this. And once the water becomes dense enough it kind of deflects satellite measurements of winds the traditional measures of wind.

**01:30 SC:** Okay, so one way is with a plane that flies dangerously close to a storm.

**01:36 PV:** Through it, yeah.

**01:36 SC:** Through it. Great, that sounds awesome.

[chuckle]

**01:40 SC:** And then the other is to look at the surface of the water.

**01:42 PV:** Mm-hmm.

**01:43 SC:** And so, we're gonna talk today about a different way of measuring hurricane speeds. Can you kinda summarize how that would work?

**01:48 PV:** Sure, so this is a technique. It was first tested on these hurricane Hunter planes actually, but it takes the GPS radio signals that are beaming down all the time, everywhere, from above. Those reflect off the surface of the ocean, and this array of eight satellites catches these GPS signals and uses their roughness to infer the winds above them.

**02:10 SC:** Okay, that's gonna be more accurate than the other measures we talked about before?

**02:14 PV:** It's not so much a question of accuracy is about where it can look.

**02:17 SC:** Okay.

**02:18 PV:** So it can look into the heart of hurricanes because these long GPS radio wavelengths can penetrate through clouds.

**02:25 SC:** And as I teased at the top of the show, there was a problem here where they're trying to use GPS to do this precise measurement but then they ended up having some issues with military tweaking these GPS signals.

**02:37 PV:** Yeah, so it turns out the newest generation of GPS satellites have the ability to boost the signal strength of what they're beaming down. And since GPS is still run by the US military they started doing this soon after this mission launched as the satellites were traveling over a swath of Africa, the Middle East, and Eastern Europe, and this really kind of screwed with the calculations that the researchers had 'cause they had assumed that it would not fluctuate.

**03:05 SC:** That the signal strength was constant and not being boosted over a specific location. Interesting, so how did they account for that? They couldn't ask the military to stop doing that for whatever reason.

**03:14 PV:** No, yes.

**03:15 SC:** So they had to figure out a way around it.

**03:17 PV:** They realize they have these small antennas on the top of the satellites that are taking the normal GPS signals in, and they essentially re-wrote the software for them so that they would measure the strength of a signal in addition to using it for a location in time, that took about two years of work and they had to upload new software to all the satellites to actually make this happen.

**03:37 SC:** And you say, all the satellites there are eight? Their acronym is Cygnus, I believe?

**03:42 PV:** Yes, this is a constellation of eight micro-satellites.

**03:46 SC:** And who owns those satellites?

**03:47 PV:** This is all in the NASA program. I think it was about $150 million launched two and half years ago.

**03:53 SC:** So are micro-satellites cheaper than, say, a big regular size satellite?

**03:58 PV:** Well this is definitely much cheaper than the billion dollar weather satellites, but it's also very focused on this one application... And modern weather satellite has a bunch of different instruments mounted on it, but this was a way of testing this new technique and it could eventually get cheaper 'cause this was the first round doing it. If you wanted to do this for a weather agency, maybe it could be a bit cheaper.

**04:19 SC:** If we know more about the inside of hurricanes further away from the US, we know more about these wind speeds, what would that help us understand? What does that do for us?

**04:28 PV:** It's all about the prediction of the storm it's about both, the path it will take and especially the intensity of the winds and how it will develop the long-term hope is that by measuring the inside the guts of these winds fairly frequently, you can really improve your... Because this data is then ingested into the models used by the Weather Service to look at the future of these storms. And they've had a lot of issues with getting intensity, the strength of storms, right. And this type of equipment could boost that.

**04:58 SC:** I also read in your story that this can be used over land as well to understand more about storms?

**05:04 PV:** Yeah, so this is about a soil moisture actually, so there are satellite to look at soil moisture and purpose built, but frequently this... So they can see the same place maybe every three days. So that doesn't allow you to ask questions about the short-term evolution, of soil and how it responds to water and gets rid of water.

**05:22 SC:** So we care about this because of flooding?

**05:24 PV:** Flooding and soil water in the soil, it feeds back into rainfall. And all sorts of connections.

**05:30 SC:** What are some of the broader questions, that these satellites could answer?

**05:35 PV:** When researchers realized that these would be able to measure wind beneath storms. It's not just about hurricanes, there's this thing called the Madden Julian Oscillation these series of storms that march across the belly of the planet from the Indian Ocean East and they really kind of tell connections from and help control a lot about the weather year to year and researchers can't see the winds underneath these storms, but now with signals, it seems like you can start to see that winds are actually feeding the precipitation that allows these storms to continue. Which some have thought was one reason, but there had been other theories on how this might really start to help people figure out how these storms could change with climate change.

**06:14 SC:** What's the next step here? These satellites are gonna die at some point, right?

**06:18 PV:** The limiting factor of these satellites are the batteries likely, and those should last for seven years, they're in low earth orbit, so they will descend into the atmosphere and burn up. The big question going forward is, will NOAH start to use these satellites or satellites like them in the future to inform weather forecast. So this is a NASA mission it's only supposed to last seven years. NOAH's unlikely to use these satellites for their own, weather predictions 'cause they like to own their hardware, but this could really make the case for launching something like this in the future.

**06:48 SC:** Okay, thank you so much, Paul.

**06:50 PV:** Yeah, my pleasure.

**06:51 SC:** Paul Voosen is a staff writer for science. You can find a link to his history at sciencemag.org/podcast, stay tuned for an interview with Samantha Trumbo, about new data from Europa. KiwiCo creates super cool hands-on projects for kids to make learning about science, technology, engineering, art and math Fun With the KiwiCo subscription each month. The kid in your life will receive a fun, engaging new project which will help develop their creativity and confidence. The projects are designed to spark tinkering and learning in children of all ages, all projects inspiration and activities are created by a team of product designers, in-house, in Mountain View California and rigorously tested, by kids. Every crate includes all the supplies needed for that month's project. Detailed easy-to-follow instructions and an educational magazine to learn even more about that crate STEAM KiwiCo inspires kids to see themselves as makers and is on a mission to empower kids, not just to make a project, but to make a difference. KiwiCo is offering Science Magazine podcast listeners, the chance to try them for free to redeem this offer and learn more about their projects for kids of all ages. Visit Kiwico.com/magazine, that's Kiwico.com/magazine.

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**09:50 SC:** Europa is one of the four Galilean moons that surround Jupiter Galilean meaning it was first spotted by Galileo in the early 1600s. That also means that it's a pretty big moon almost as large as Earth's moon but while it's similar in size to our moon it has a much different composition and based on what we know about it so far, Europa seems to check a lot of boxes for habitability. Samantha Trumbo and colleagues write about finding chloride salts on the surface of Europa this week in Science Advances Samantha's here to walk us through what that means for the composition of the moon and its ability to harbor life. Hi Samantha.

**10:30 Samantha Trumbo:** Hello.

**10:32 SC:** We know that Europa is smooth and covered in water ice, on its surface. What do we know about what's underneath that icy crust.

**10:40 ST:** So We know that underneath the icy crust Europa likely has a liquid water ocean salty one and then we know that from the Galileo Mission that went to the Jupiter system in the 1990s, it measured an induced magnetic field coming from Europa, using this magnetometer instrument and the scientists were able to infer that that implied a subsurface ocean of salty liquid water, beneath the ice crust.

**11:07 SC:** How thick is the ice crust? Do we know that?

**11:10 ST:** We don't know that for sure, but estimates are on the order of several kilometers to up to maybe 20 kilometers.

**11:17 SC:** This is not a thin shell of ice that we can somehow see through with certain kinds of instruments.

**11:22 ST:** Correct. Correct.

**11:23 SC:** Okay, well, let's get to the observations from your paper, what did you see and how did you see it.

**11:30 ST:** Using the Hubble Space Telescope, we used an instrument called the spectrograph it's a long slit spectrograph. That gives you information at visible wavelengths. The same wavelengths our eyes can see we use that to get this spectra across the entire surface at a spatial resolution that's actually meaningful for composition in geology on the order of a few hundred kilometers. I know that sounds big, but compared to the whole size of the moon, we can see different regions distinctly we saw an absorption feature in the visible portion of the spectrum, near 450 nanometer wavelengths so that tells us that there's something on the surface that is absorbing the light at that wavelength, and in this case we think that that substance is sodium chloride or table salt like we are so familiar with.

**12:21 SC:** It's a very salty ice there on the surface.

**12:23 ST:** Yes.

**12:24 SC:** And does that... What does that line up with when you're observing these geological features that you mentioned that you saw in your survey?

**12:32 ST:** In our data set since we have spatial resolution, we can actually see where this substance is located on the surface and we find that it is preferentially concentrated within regions called chaos terrain, and so these...

**12:46 SC:** Great name.

**12:46 ST:** Yeah, I know, exactly. So these are places on the surface that are very heavily disrupted. And you can look at images from the Galileo spacecraft and you can see that the surface ice in those locations have been rafted apart and you can kind of piece it back together with your brain like a puzzle, you can see how it used to be all connected, but something came up from below and disrupted the surface in those regions.

**13:11 SC:** If something was disturbed from underneath there's salt on top of it, so perhaps there's salt in the ocean. Is that kind of what you're getting at?

**13:21 ST:** Yeah exactly, so we think that these are places where the sub-surface environment is expressing itself onto the surface and so the composition of these chaos regions may be reflective of the composition of the interior. So in this case it would suggest that sodium chloride is in the sub-surface as well in the ocean.

**13:39 SC:** I know that Enceladus is a different Moon obviously it has these plumes, these cryo-volcanoes that spew out salt water from its oceans. Is there anything similar to that on Europa that might explain the presence of salt on the surface?

**13:55 ST:** So that's interesting. Yeah Enceladus is a moon of Saturn, it also possesses a sub-surface ocean and people have measured the composition of its plumes using a Cassini spacecraft and found sodium chloride there as well on Europa there are some tentative detections of plumes but they are right on the detectable limit, and they are certainly not confirmed yet, in this case, at the chaos regions, it's unlikely I would say that that's salt, originated in a plume probably some sort of upwelling of material through the ice crust. We do think that that's sodium chloride originated in the ocean. And the simple explanation is that that's reflective of the dominant salt composition of the sub-surface ocean.

**14:40 SC:** Before this study, it was thought that the salt on the surface, were sulfate salts. Why was that the kind of predominant view and why did take so long to figure out that that they are probably chloride salts?

**14:52 ST:** The infrared spectra that were returned from the Galileo mission were distorted and suggested some substance other than water ice. Potentially a hydrated salt of some kind, and for a long time, the major accepted candidate for these salts were sulfate salts because they fit the Galileo Spectra and they fit some geochemical expectation that people had prior just based on what one would expect the sub-surface composition to be. But more recent ground-based infrared spectra, which were obtained from the Keck Observatory in Hawaii on Mauna Kea were higher quality, so these had higher spectral resolution in the Galileo data, they use more modern spectrometers and at this resolution if there were sulfate salts in these terrains, that we expect to reflect into your composition they should show distinct absorption, but the spectra from Keck were completely smooth and bland so...

**15:53 SC:** You gotta look somewhere else besides the infrared then?

**15:56 ST:** You gotta look somewhere else besides the infrared because chlorides don't have distinct features there. And so, Galileo could not have seen them the Galileo Mission but when these salts are irradiated like we know happens at the surface of Europa they actually change colors they develop distinct absorption features due to what are called Color centers that we can then go look for at visible wavelengths.

**16:18 SC:** I looked at a lot of pictures when I was researching for this podcast interview and Europa is kind of amazing looking and it is described as smooth, if you read about it, but if you look at it it has a lot of features. How do you describe what Europa looks like?

**16:36 ST:** So I would say Europa is fascinating to look at for one, it has this curious lack of impact craters like we see on our own moon or on lots of other bodies in the solar system, and this tells us that the surface is very young in terms of geologic time scales it's been resurfaced in some way, and we know this also by looking at the various geologic features we can see across the surface there's an abundance of fractures and cracks and there are regions called chaos terrain where it seems the materials coming up from below and there's also an abundance of really interesting colors on the surface some red on the trailing hemisphere, which faces backwards, in its orbit some of that color is thought to come from sulfur impact in the surface ultimately originating from the volcanoes of Jupiter's innermost Galilean moon, Io. But then some quotients are more of a yellow color. Specifically, this large-scale chaos region on the leading Hemisphere called [17:34] ____ Terrosio is yellow and we've known that for almost 20 years from the Galileo Mission and this region is where we see the strongest sodium chloride absorptions. And so, we've known the color of this region for more than 20 years, and it's just now that we think we know why and we think it's due to these color Center.

**17:53 SC:** So, if you irradiate Sodium chloride if you irradiate salt, does it turn yellow here on earth?

**17:58 ST:** Yes, it does, actually. And one of my co-authors Kevin Hand has done those experiments. He took some table salt subjected it, he actually did Europa like temperatures but it can happen at room temperature as well. And he blasted it with electrons in his lab and saw the color change. And you can look at those pictures and it's quite striking how much it resembles the color we see on Europa.

**18:21 SC:** Very cool. Let's circle back to the salt content of the ocean. If it is a lot of sodium chloride in there, what does that mean for the composition of this Moon and what does it tell us about its history?

**18:33 ST:** If the Sodium chloride on the surface is truly reflective of the ocean, it means that the composition in the ocean is much different than we thought for decades since the Galileo Mission, and it also means and it's much more similar at least in its salt composition to Earth's ocean into the ocean of Enceladus like you've mentioned. And in terms of the geochemistry if the salts in the ocean were sulfate salts this would be expected from just a long passive leaching from the rocky sea floor. Slow passive interaction with the rocks at the bottom of the ocean. But if there were terrestrial style hydrothermal processes, these would have altered the ocean composition away from sulfate rich to a more chloride dominated system, like we suspect in this paper and like we have on Earth and Enceladus. And so this is potentially very exciting.

**19:27 SC:** Very cool. Let's get to the habitability question. If this ocean is salty with sodium chloride, what does that tell us about the potential habitability of Europa?

**19:37 ST:** So it doesn't say anything directly, but it certainly is a positive in terms of habitability, I would say. Because it means that there is this potential for a history of hydrothermal processing at the sea floor. And on Earth that's something that's very good for life because it provides a lot of reduced compounds that are useful, and it's something that could be potentially useful on Enceladus as well where there are chemical indicators of hydrothermal activity aside from just the sodium chloride.

**20:06 SC:** You're talking about the vents on the, say really deep in our oceans, using heat and chemicals to kinda sustain life. We're not talking about photosynthesis or eating things.

**20:17 ST:** Correct, exactly. So this would be life... Life at the hydrothermal vents on Earth are independent of the sun. And so this is one of the only ways we can imagine having life on any of these ocean worlds that are covered in ice and so far from the sun.

**20:33 SC:** I was gonna say, you know we're not gonna move into this. When we say habitability, no one wants to live on the surface of Europa.

**20:39 PV:** Exactly. Irradiation all over the place, sulfur mostly on the trailing hemisphere. You don't wanna be on the surface for long.

**20:47 SC:** Is there anything that you can do with the current data we have on hand to confirm this in a different way, or are there missions planned to this moon to further investigate the presence of salt and the composition of the oceans?

**21:00 ST:** There is an upcoming mission to Europa. The Europa Clipper Mission from NASA. It will have a lot of interesting capabilities. It doesn't carry a visible wavelength spectrometer, so it won't look at this feature that we discuss in this paper. But it will get something we can't get from Earth and that's really high spatial resolution. And so with all of its other instruments, it's imager, it's near infrared spectrograph, it can look at the regions where we see the sodium chloride, and see if there's anything else interesting going on, any other indicators of material coming up from below.

**21:35 SC:** Alright Samantha. Thank you so much for talking with me.

**21:37 ST:** Thank you.

**21:38 SC:** Samantha Trumbo is a PhD candidate in Planetary science at the California Institute of Technology, and a NASA Earth and Space Science Fellow. You can find a link to her paper at sciencemag.org/podcast. And that concludes this edition of the Science Podcast. If you have any comments or suggestions for the show, write to us at sciencepodcast@aaas.org. You can subscribe to the show on iTunes, Stitcher, Spotify, many other places. Or you can listen on the science website sciencemag.org/podcasts. There you'll also find links to the research and news discussed in the episode. To place an ad on the podcast, contact midroll.com The show was produced by Sarah Crespi and edited by Potta G. Jeffrey Cook composed the music. On behalf of Science Magazine and its publisher AAAS, thanks for joining us.

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