AirSpace Season 4, Episode 11 - Radar Love

Nick:

Don't you just love that new planet smell?

Emily:

That new planet smell.

Nick:

Smells like sulfuric acid and-

Matt:

Yeah, that's a bad smell.

Nick:

... scorched rocks.

Matt:

That's a bad smell.

Emily:

Welcome to AirSpace from the Smithsonian's National Air and Space Museum. I'm Emily.

Nick:

I'm Nick.

Matt:

And I'm Matt.

Nick:

Not so very far from us here on Earth, there is a planet whose surface may once have held a vast liquid ocean beneath an atmosphere of mostly carbon dioxide. And for once, we're not talking about the thin rarefied air of Mars, we're talking about Venus.

Matt:

Venus is not very friendly for life, or at least not any life that we've discovered yet. And for that matter, it's not very friendly to our robots either. It's carbon dioxide atmosphere is full of sulfuric acid clouds. It runs a balmy 870 degrees Fahrenheit.

Emily:

Because of all of that, we can't take pictures of the surface using regular cameras, and landing a robot on Venus isn't exactly impossible, but it might as well be. So scientists use Earth and space-based radar to study the planet. We're taking a look at the wonder of Venus and the magic of radar today on AirSpace.

Music

Emily: Did you hear we're going back to Venus?

Matt:

Yeah. And that we're going as a caravan. It's not just one spacecraft, but two spacecraft.

Emily:

Yes, it is a caravan. NASA just announced last month that it's funding two Discovery class missions to Venus. These are the smallest class missions that we've talked about before on previous episodes.

Matt:

Right. And in honor of that, we're going to do a deep dive into Venus today and get into some of what we love about Venus and why Venus is such an important planet in terms of us as humans understanding our place in the solar system.

Emily:

You mean we're going to talk about all the reasons why Venus is cool?

Matt:

Or hot.

Emily:

So hot.

Matt:

Yeah, so hot. Thinking about Earth situated in between Venus and Mars, you'll often hear people describe a sort of Goldilocks story, right? Where Goldilocks shows up to the three bears' house and presumes to eat their porridge, where one bowl of porridge is too hot, one bowl of porridge is too cold, and one is just right. Earth is just right, Venus, too hot Mars, too cold, or at least that's the very oversimplified version of why we on the Earth have this incredible hospitable planet while we're surrounded by two other planets that show us pretty radical extremes of what a planet can be.

Emily:

Well, in addition to being the too hot planet in the Goldilocks analogy, Venus is often called Earth's twin. If you haven't heard that before, you've heard it here now. You should hear it because it's the most common superlative attached to Venus. Part of the reason it's considered Earth's twin is because it has a very similar size and mass, which means it's kind of made up of a lot of the same bits and it's about the same distance from the sun. So since none of us are actually experts in Venus, we actually reached out to a Venus expert to get an idea about why they think this planet is so special.

Jennifer Whitten:

Hello, my name is Dr. Jennifer Whitten and I am an assistant professor at Tulane University and a planetary scientist who studies Venus. You can call me Jenny.

Nick:

Jenny says scientists sometimes take the Earth's twin nickname a little further.

Jennifer Whitten:

Everybody calls Venus, Earth's evil twin.

Emily:

Evil twin? I've never heard this.

Jennifer Whitten:

Yeah, because-

Emily:

It's not evil.

Jennifer Whitten:

Well, I guess it goes towards the reason for some of the differences. So the surface pressure on Venus is over 90 times the surface pressure on Earth. It squeezes things, basically. The surface is very hot. It's around 870 degrees Fahrenheit. That's hot enough to melt lead. So that kind of generates really unpleasant surface temperature conditions for people.

Emily:

And robots.

Jennifer Whitten:

And robots, yeah. So I think that has led to this idea of it being this evil twin, but I don't really like that. People, they call it a hellscape, but I've decided I'm just going to call Venus, Earth's twin that has a flare for the dramatic.

Emily:

Some newer discoveries are showing ways that Venus may be even more Earth-like than previously thought.

Jennifer Whitten:

What's cool, though, is that recent modeling efforts combined with measurements of the atmosphere have shown that Venus used to have an ocean's worth of water on its surface. Yeah. And that as recently as about a billion years ago, which maybe that doesn't sound recent, but kind of planetary science-wise, that's pretty recent, that's potentially having water on the surface of Venus longer than water was on the surface of Mars. An ocean's worth of water for billions of years. So it's really fascinating to think about that, right? Like Venus and Earth are so close, relatively, their distance from the sun is similar. They both potentially had a lot of water really early on that persisted for a long time. So that begs the question of, was there life?

Emily:

Losing its water is part of the story of how Earth's twin, Venus, got less Earth-like. Oceans on Venus evaporated, putting water vapor into the atmosphere, which contributed to a runaway greenhouse effect. And because Venus, unlike earth, has no protective magnetic field, the water in Venus's atmosphere was lost into space. Venus's surface doesn't seem to have many craters on it. And scientists have a few theories why.

Jennifer Whitten:

What this has signaled to people is that there was some sort of large-scale volcanic eruption. And the jury is still out on whether the eruption was a near global, near, I guess, sort of geologically instantaneous resurfacing where just the whole planet in one go had enough volcanic activity that the whole surface kind of hit the reset button and all the old craters got erased. So it was a fresh surface and the thousand craters that currently exist were formed on that surface. And then the other end of the spectrum is that people think that Venus might have continued to be active. We know that Earth is still active, we're all living on it, has a lot of heat in it and earth is still releasing a lot of its internal heat. And because Venus is similarly sized, similarly positioned in the solar system, the same thoughts apply to Venus, that it probably has a lot of internal heat that it's still trying to release. And one effective way for planets to release heat is through volcanic activity.

Emily:

And I think this is one of the most intriguing questions of Venus science right now, which is, is Venus still currently geologically active? Does it still have vulcanism on the surface? Is it still cooling off in the dramatic ways that our own planet is cooling off, right? All those volcanoes, the mid-ocean ridges, the eruptions in Iceland still going on right now, all of those are signals that our planet is still trying to cool off from all of that heat that it still has inside of it from when our planet formed. So with Venus being even closer to the Sun, a big question remains, which is, is Venus still cooling off? If it is, can we find evidence for that cooling off on its surface through things like volcanism? Venus's atmosphere is one of the really cool reasons that people are excited about it, but it's also one of the barriers to some of the research that folks want to do.

Nick:

Yeah. And it's fun to talk in superlative terms about how extreme the atmosphere is on Venus. And you can make a lot of cool jokes about, like hell on almost Earth, but I've seen a version of the Lander that went to Venus. And the thing that we have landed on Venus looks a lot more like a submarine than it does like the Mars rovers that we're familiar with. It's a pressure vessel. It looks like the kind of thing that you would send into deep space itself or to the bottom of the ocean. Matt, can you tell us what happened when we landed something on Venus?

Matt:

Well, when we say, we, of course, we mean the Soviet Union, right? So these were the Venera probes.

Nick:

That's right, comrade.

Matt:

They sent multiple probes to Venus. In fact, Russia has lately claimed that Venus is a Russian planet because they've done the most with it. And yeah, they landed probes, the first descending in the

atmosphere and then landing on the surface. And those probes did not last very long because they very quickly overheated. You can't really set electronics into an environment like that and expect them to last for a long time.

Nick:

A good way to think of it is, in practical terms, it is thermodynamically impossible for us to explore Venus from the surface with the technology we've got because there's just nowhere to put the heat. You can build a heat sink inside the thing, you can maybe try and cool it for a little while, but everywhere around your spacecraft is average of 870 degrees. And the poor thing is just like a pat of butter on a hot skillet surface. It's only going to be able to operate for minutes at a time. And that's how we got the extraordinary first photos of Venus. And currently, only photos of Venus were from the few minutes that this valiant space probe sat cooking on the surface of this distant griddle.

Emily:

So one of the biggest differences between Earth's atmosphere and Venus's atmosphere are their compositions. We have a mostly nitrogen atmosphere. I know you're all shook because we only ever hear about carbon dioxide going into our atmosphere, but really, our atmosphere is mostly made up of nitrogen. Venus's atmosphere is made up mostly of carbon dioxide. But why that's really important is that it's a really interesting test bed for us to do a better job of understanding how greater and greater levels of carbon dioxide in our atmosphere will affect our environment, what's going on globally. So Venus is a very interesting end member, if you will, for scientists to study how atmospheres interact with the surface of planets.

Emily:

The Venus atmosphere being almost 97% carbon dioxide is really interesting to keep studying so that we can learn more about the effect of greenhouse gases on surface temperatures and environmental changes. So while the atmosphere of Venus is really important to study with respect to climate change, it poses this problem, which is that you can't just take your traditional CCD camera up there the way we've been doing since we started planetary exploration. You have to bring radar instruments, which are kind of cameras. So we talked to Jenny about using radar and how that's different than using cameras, but it can be used to image the surface in a way to better understand what's going on, on Venus and a little bit in Venus.

Jennifer Whitten:

Radar is very useful because it has a really long wavelength of energy. So we get all this energy that comes from the Sun and the energy has a variety of wavelengths. And we're most familiar with the visible spectrum, right? It facilitates us seeing. And with radar, we can actually take advantage of that energy that's got really long wavelengths, sort of like centimeters, tens of centimeters, meters. And because they're longer wavelengths, when they travel through materials, they don't stop. They continue traveling through them. So in the case of Venus, we can use radar data to look at the surface. It can travel through the atmosphere, unlike visible light, which cannot travel through the atmosphere. So when you see these beautiful images of Venus, it either looks like a sort of light yellow pastel, yellow orb, or maybe there's a filter on it so you can see some of the clouds, but you can't really see the surface when you look at it with the visible light. So radar allows you to see through that because it's got that longer wavelength, so the molecules in the atmosphere don't prevent it from reaching the surface.

Emily:

So NASA and other space agencies have put radar instruments on spacecraft, but that's not the only way to get images of Venus using radar. We have a lot of ground-based telescopes that have these capabilities. I think maybe most famously if you were ever a big James Bond fan and seen Goldeneye, there's the Arecibo telescope, RIP, that used to be in Puerto Rico. You have the Green Bank Telescope in Green Bank, West Virginia, among many other much smaller radio telescopes that allow you to take images of Venus from Earth.

Nick:

I've got a question, is the fact that Venus is close to Earth part of why we can study the surface with Earth-based radar?

Emily:

That's a big part of it. It's Venus's proximity to Earth that allows us to see it. In fact, anybody who spends a lot of time looking at the sky, especially at night, Venus is always that real big, bright thing in the sky that's not the moon. But we don't get the same kinds of resolutions that we would get from space-based spacecraft. So I don't know if I answered your question, Nick, but a big part of it is that you can study it from Earth because it's so close. So you can actually get good resolutions, but they're never going to be as good as a space-based spacecraft.

Nick:

Yeah. I kind of thought that was the case. And it was a nice illustrative reminder that Venus is, for practical intents and purposes like math and trivia aside, the closest planet to Earth. All of our robots spend a lot more time over at Mars's house, but that's just because they decided it was cooler.

Emily:

I think you bring up a good point though, Nick, in that there are big advantages to Earth-based observations of Venus using these really big ground-based radio telescopes, even though the resolutions aren't as good as the space-based spacecraft. And when we were talking to Jenny about it, the point that she made that I thought was the most interesting is change detection. We talked a lot earlier about why there are so few impact craters on Venus and are they getting covered up? Did they used to be there? Are they getting filtered out by the atmosphere? What's going on? Venus is close enough that we actually can do that. So using these radio telescopes doesn't get us amazing resolution, but it's really pretty good.

Jennifer Whitten:

But in terms of looking at the surface, we can use these Earth-based telescopes to image the same portions of the surface over time. And we think Venus is pretty active. There are lots of indications of that from atmospheric measurements, from measurements of the surface, experiments models, you name it. So what we're trying to do with some of these Earth-based datasets is trying to keep a record of that change.

Nick:

So Venus is nearby, it's beautiful, it glows brightly in the sky in the nighttime and the day, and it's roughly about our size, but it's exactly what would happen if the atmosphere just up and went nuts in

the greenhouse direction. What next? What do we have to learn from it? How do we explore it? Anyone booking a summer holiday there?

Matt:

Well, as we mentioned at the top, NASA is planning a couple of trips back to Venus. And these two Discovery missions are scheduled to launch before the end of this decade, which is really exciting since the US hasn't been to Venus since the Magellan missions of the 1990s. And the Japanese space program, JAXA, has been to Venus more recently than we have. Their Akatsuki orbiter is using radar to study the planet's weather, clouds, and its vulcanism.

Emily:

Yeah. And this is a really cool mission and a really cool spacecraft because this is where I think a lot of the international cooperation between space agencies is really valuable because they're really filling the gaps in the programs that we have going on at NASA, because we can't necessarily have a robot at every planet at all times. But the two missions that NASA is now working on to go back to Venus are the DAVINCI+ mission and the VERITAS mission. And being the space geologist that we all know I am, I'm especially excited about the VERITAS mission because it's going to have a radar instrument on it that's going to peer through the atmosphere and do a really great job of mapping the surface and all of the beautiful tectonic structures that I'm really excited to see. And it's going to be the first time that the US has taken photos of Venus's surface from a space-based spacecraft since Magellan

Nick:

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