

Bringing planetary surfaces to life

Divya Persaud explores creative approaches to studying planetary surfaces and the ethical challenges of space technology

Q Tell us about your background

Before and during university, I worked on various remote sensing projects, which taught me how to analyse satellite data for Earth and other planets. I also studied palaeomagnetism, so I learned about meteorites and other materials that record magnetic fields.

One of my main research methods is using images to study icy bodies, such as the moons of Saturn and Jupiter, but also small bodies like Ceres and Pluto. For my PhD, I combined images of Mars to reconstruct the surface in three dimensions, creating an immersive experience for me as a geologist, and

helping me to study the history of a small area of the planet. I love using these 3D images for outreach and pushing boundaries to see how we can use imaging techniques to study planetary surfaces in new and creative ways.

My journey has involved pulling at different strings of what is understudied. That's taken me everywhere: I did research at NASA in the US, completed my PhD in the UK, went back to the US for my postdoc, and then came back to the UK. Saying 'yes' to everything has been the guiding light in my career.

Q How can we study the Solar System in 3D?

We perceive the world in 3D through our senses. Evolution has given us two eyes and two ears, so anything that we look at with our eyes, we're observing at the same point in space but from slightly different angles. Our brain understands light, space, and angles, so can calculate distance or depth automatically, allowing us to move around effectively or understand where a sound is coming from.

The computer science of 3D images is modelled on the same principles. If you take two images of a planet at

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NASA's *Perseverance*
rover's landing wreckage
photographed by the
Ingenuity Mars helicopter

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slightly different angles and understand the lighting and other factors, you can understand the depth and topography of different features. Instead of two eyes, I can use a pair of cameras on a Mars rover or satellite images from different orbits. Feeding those images into a computer programme, we get a black and white depth map, where different pixels represent different depths. The same principles are used for 3D movies or virtual reality software. You can manipulate planetary surfaces, rotate them, or fly over them – this is powerful because it brings the surface of a planet to life.

Q What are you working on?

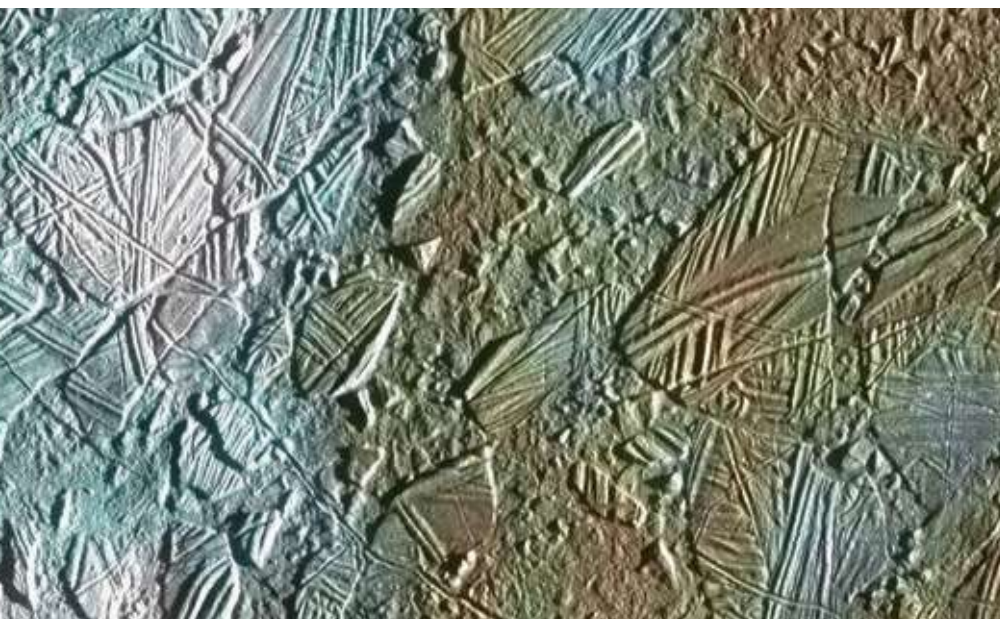
I'm in a collaborative Research Fellowship with an engineer and we've been researching cameras on spacecraft. When a spacecraft, such as NASA's *Perseverance* rover, is landing, you get fantastic images of the planet's surface from cameras on the base of the spacecraft. These cameras are designed for engineering purposes and to aid the landing process by identifying hazards. But there's a lot of scientific data that we could get from those images at a regional and local scale, so we're designing a science-focused camera that can also be used for landing. We've conducted initial

experiments in a quarry using a drone and prototype commercial camera to understand what data cameras can collect about a planet's surface during descent.

We're currently moving into a new project focused on creating 3D images of icy moons, which look very different to rocky bodies because they're covered in ice and are very smooth, making them extremely bright and reflective. We have limited flyby images of varying quality of most icy moons, so creating 3D images of them is exceptionally difficult and researchers have gotten different results over the years. For my research, I'm unpicking how high reflectance affects the 3D images created by computer models and the data that can be collected. We've been using a software suite that simulates images of a planetary body's surface with different conditions, such as camera type, altitude, and reflectance. By changing these conditions, we can understand how to create the best quality 3D images. This method will become important for analysing future images from icy moons, such as NASA's Europa Clipper mission, which launched in October 2024 and should arrive at Jupiter's moon, Europa, in 2030. We hope that our methods will help scientists answer fundamental questions about Europa's unique icy history.

Q How does your work overlap with space ethics?

Space ethics is a broad term that deals with legal, moral, and political questions around space exploration. It arose in the 1950s and 60s with the United Nations Outer Space Treaty of 1967, which questioned our responsibilities as individuals and nations over stewarding space. During the Cold War, satellites and missiles were an emerging use of space, so the Outer Space Treaty introduced legislation committing countries to not use space for war, not claim →



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Ice structures on the surface of Jupiter's moon Europa, with distinct colouration due to ice particle deposition and mineral contamination

territory in space, and be responsible when landing on other planetary bodies. Not all countries ratified the treaty, but space ethics grew from there. It covers everything from how the space sector communicates with society and where spacecraft launch facilities are built, to dual-use technologies that have both civilian and military applications.

Everything that we, as planetary scientists, do touches space ethics. My own interest stemmed from reading papers about space and politics for an essay at school. I came across some interesting articles about French Guiana, which neighbours my home country, Guyana. French Guiana is still a department of France and home to the Guiana Space Centre. As recently as 2017, there was a strike in French Guiana to pressure the government to invest in the country's economy. The striking workers occupied Guiana Space Centre because it is seen as a symbol of continued colonial control. They won that strike and received millions of francs worth of investment in infrastructure, which is amazing. I read about this at the beginning of my career and seeing that happen in my homeland stuck with me.

I started reading more work by space historians and sociologists, particularly

about spacecraft launch facilities that have infringed on Indigenous land and dual-use technologies. All the space missions I've worked on have components built by companies that also build military arms – that became very troubling for me. I started speaking out about this and talking to colleagues to understand why this happens and why we accept this as the status quo. I recently became involved with the Palestine Space Institute, where I research the economy of space militarism, which questions why and how companies end up building spacecraft for science but also weapons for wars.

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Q How do you combine your research with art?

For many years I separated my love of science and my love of art. I fought it, but then realised I really love making art about space! There are beautiful words in geology, so it lends itself to poetry well. I write mostly about place, memory, and my heritage with migration. I think a lot about the planetary travel that migrants take and the memory that becomes embedded in land.

My music explores similar themes. Most recently, I collaborated with Dr

Adeene Denton, a planetary geologist, dancer, and resident astronomer at Grand Canyon National Park. I was commissioned to write music to accompany a dance filmed in the Grand Canyon, which was especially moving because I researched a canyon on Mars for my PhD. People love studying the layers in canyons on Earth and Mars, so I wrote a piece about these two canyons forming like sisters across two planets. The piece covered stages like water trickling, a braided stream forming, a storm, and then the canyons drying up. I played the cello and recorded many sounds using objects in my house. A lot of music about space tends to make space sound otherworldly or alien. We wanted to make something that made it feel like home. We have a responsibility to ethically steward and understand Mars as nature, just as the Grand Canyon is nature. We wanted to convey a warm, inviting sound with familiar noises, with nothing that alienates you, because the Grand Canyon is still home to Indigenous people, and Mars is, in many ways, our home as well. 



DR DIVYA PERSAUD
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This interview is an excerpt from the podcast episode Geo Conversations: Divya Persaud. Listen to the full interview at geoscientist.online. Find out more about Divya's work and music at divyampersaud.com

Interview by Marissa Lo, Associate Editor, *Geoscientist* magazine

FURTHER READING

- The Space Ethics Library; spaceethicslibrary.wordpress.com
- Palestine Space Institute. Space and the Military-Industrial Complex: A PSI Database; palestinespace.org/psi-database