Scientists simulate the space environment during New Horizons flyby

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When destined to stay close to Earth, spacecraft often must withstand the hazards of our space environment. They can be exposed to regular radiation showers from the sun and - if the space weather is particularly intense, such as when the giant clouds of solar material that erupt off the sun called coronal mass ejections pass by - they can go into safe mode.

However, because there is less data available, we know less about what a spacecraft endures further away. So, as NASA's New Horizons mission reaches a historical milestone on its journey to explore the outer solar system, scientists have an all new question: What is the space environment like at Pluto?

A few months before New Horizons was due to reach this icy dwarf planet, a community of scientists came together to determine just what kind of a environment the mission would experience during its historic flyby. While the simulations aren't 100% conclusive, this first ever attempt to characterize space weather conditions so far from our own home opens the door to better protecting our spacecraft - and eventually humans—as we continue to explore the solar system and beyond.

To attempt to map what surges of particles are passing by Pluto, the Community Coordinated Modeling Center, or CCMC, at NASA's Goddard Space Flight Center in Greenbelt, Maryland, sought input from space weather scientists around the nation. The CCMC houses numerous software models to help scientists with their research and also to enable improved space weather forecasting.

"Here at Goddard, we focus on the space environment near Earth," said Peter MacNeice, who led the CCMC's attempt to gather the models. "But past Earth, farther away from the sun, the environment changes quite a bit. So we reached out to teams all around the country for their expertise."

Such characterizations of space rely on understanding an environment far different from the one we experience in our day-to-day lives on Earth. The particles in space are few and far between - though space is not, in fact, a perfect vacuum. A constant stream of particles from the sun, called the solar wind streams outward. This population of particles can also be enhanced by the coronal mass ejections, or CMEs, that sometimes erupt from the sun. Various particles from outside our heliosphere can also make it into the solar system, adding to the mix. Once out past Jupiter, flows of hydrogen from outside our solar system can also be detected, flying upstream against the solar wind.

What's more, many of these particles are electrically charged, creating a complex, constantly changing electromagnetic environment with magnetic fields traveling along for the journey. Consequently, assessing just what percentage of the particles in a region of space are neutral or charged is a crucial part of understanding how material moves through space. Close to the sun, the charged particles are in abundance; past Jupiter and Saturn, the neutrals dominate.

Taking such things into consideration, scientists modeled what temperature, density and wind speed could be expected around Pluto in mid-July 2015. One model that was updated to accommodate such differences in the outer solar system is called Enlil-named after the Sumerian god of the wind. Created by Dusan Odstricil in the 1990s, Enlil is regularly used to simulate the movement of CMEs as they move through the inner solar system. For the New Horizons project, Odstricil, a space weather scientist at Goddard, incorporated additional models and expanded the simulation to reach all the way out to Pluto.

"We set the simulation to start in January of 2015, because the particles passing Pluto in July 2015 took some six months to make the journey from the sun," said Odstricil. "During that time there were 120 separate CMEs."

The new version of the model tracks these giant clouds of solar gas in a way never before done. Because of the way the sun spins, the solar wind and CMEs all end up leaving the sun radially and form a spiral pattern, looking - if viewed from above—a little like the swirls on a peppermint candy. This can be seen in normal Enlil simulations, but given the many months of travel time in the new simulation, the CMEs slow down and ultimately merge with other CMEs and with the solar wind to form even larger clouds. The shape of these merged regions changes, getting thinner and longer until they appear almost as semicircular tree rings around the sun—with some of the clouds ultimately being as long as the distance between the sun and Pluto itself. These CMEs end up looking very little like the balloon-shaped CMEs we see closer to home.

"Our simulation estimates that during the New Horizon approach, Pluto might be immersed in a region with very low solar wind densities, lasting for about one month," said Odstricil. "This will be followed by a large merged region which could significantly compress Pluto's atmosphere."

As this is the first time such a concerted effort has been made to simulate the space environment so far from Earth, the scientists who have worked on these models know that they are unlikely to be a perfect reflection of reality. Odstricil, for example, says his model could be off by two to three weeks. However, comparing the models to real time measurements from New Horizons will help with calibration and making the simulations more sophisticated.

In combination, taking such steps opens up the door to better understand the space environment further away than ever before. Expanding models to incorporate the outer planets can help us protect our spacecraft - and ultimately human travelers - from the sun's radiation.

Moreover, such research helps us understand the very evolution of the outer solar system. Space weather events near Venus, for example, are known to rip parts of the atmosphere off. What could similar eruptions have done farther out? Combining New Horizons data with the space weather models could well help us find out.

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