Moist explanation for Saturn's Great White Spots

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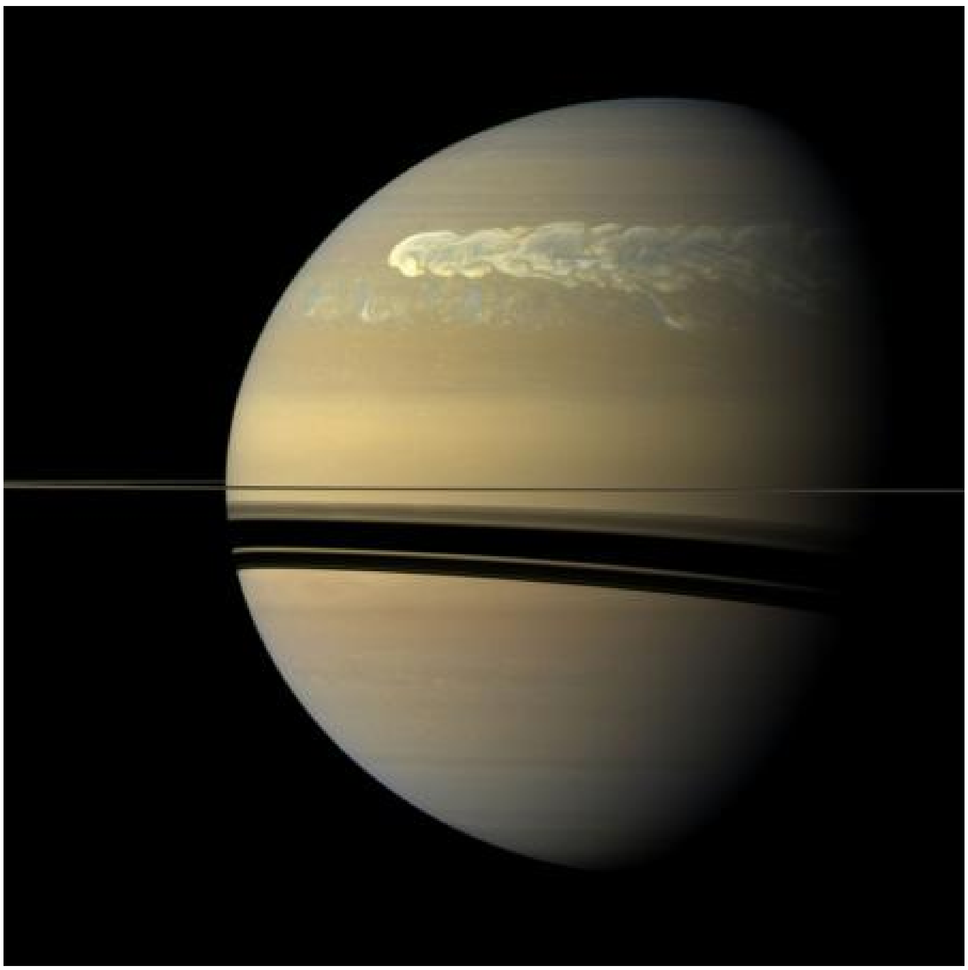


This image, taken by NASA's Cassini spacecraft in February 2011, shows a huge storm in Saturn's northern hemisphere. Credit: NASA/JPL-Caltech/Space Science Institute

Once every 20 or 30 years, a superstorm greater than Earth breaks out on Saturn and whips around the ringed planet in a violent spectacle that rages for months on end.

The storm can stretch hundreds of thousands of kilometres (miles) before fizzling out—some continue all the way around the planet until they meet their own tail.

Dubbed "Great White Spots" after the tinge of their lightning-laced brew, the outbursts are so large they can be witnessed by telescopes from Earth.

In the last century and a half, astronomers have observed six of these events, bemused by their titanic scale but puzzled why they occur so infrequently.

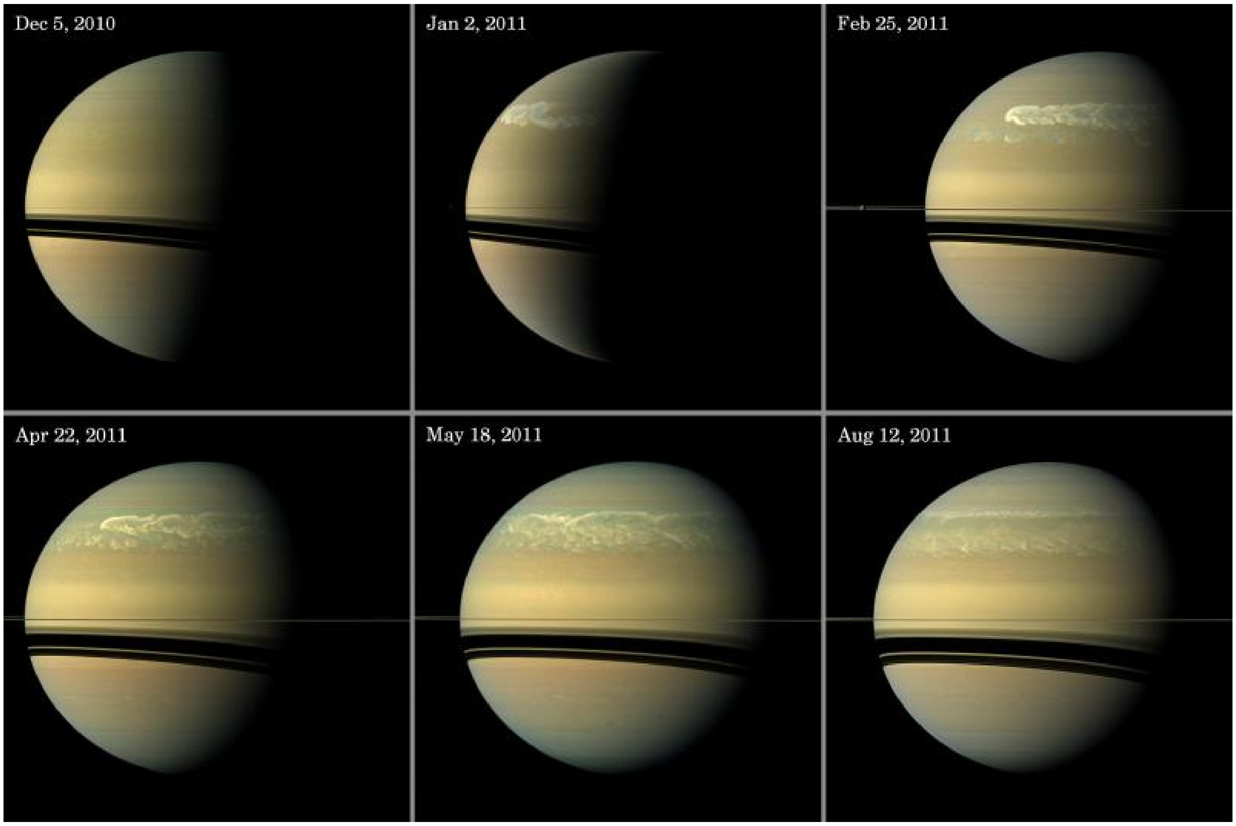
Now a team has offered an explanation: the extraordinary behaviour of water vapour in the gas giant's atmosphere.

As on Earth, Saturn's atmosphere consists of different layers, explain Cheng Li and Andrew Ingersoll of the California Institute of Technology, the authors of the report published on Monday in *Nature Geoscience*.

For most of the time, the outer layer where clouds form is less dense than the sub-cloud layer that stretches all the way down to the centre of the gassy planet.

Like oil floating on water, the less dense outer layer rests on top of a denser air mix of mainly hydrogen and helium, but also water molecules.

In Saturn's case, the outer layer prevents the warmer air underneath from rising, cooling and condensing—the process required to create thunderstorms.



This series of images from NASA's Cassini spacecraft shows the development of the largest storm seen on the planet since 1990. These true-color and composite near-true-color views chronicle the storm from its start in late 2010 through mid-2011, showing how the distinct head of the storm quickly grew large but eventually became engulfed by the storm's tail. The earliest image of the storm, taken Dec. 5, 2010, is in the top left of the panel. The storm appears only as a small, white cloud on the terminator between the day side and night side of the planet. The next view, in the top middle of the panel and taken Jan. 2, 2011, shows that the head quickly grew much larger and a tail began to trail a great distance eastward. Some of the clouds moved south and got caught up in a current that flows to the east (to the right) relative to the storm head. In the top right of the panel, this tail, which appears as slightly blue clouds south and now west (left) of the storm head, can be seen encountering the storm in the Feb. 25 image. The April 22 image, in the bottom left of the panel, is one of Cassini's last views of the storm when it still had a recognizable head. In this view, the tail is south of the head and is well established by this time. The May 18 view, in the bottom middle, shows only the storm's tail. The head still existed at this time, but it is beyond the horizon and out of the field of view here. Between the time of the May 18 image and the next image shown here (from Aug. 12), the head of the storm was engulfed by the part of the storm's tail that spread eastward at the same latitude as the head. The Aug. 12 image, in the bottom right, shows that the head has lost its distinct identity and is now just part of the jumble of the storm. Also visible in these images are several of Saturn's moons and the shadows cast onto the planet by moons. For example, the planet's second largest moon, Rhea, can be seen in the Feb. 25 view. The Feb. 25 and Aug. 12 views are true color. Images taken using red, green and blue spectral filters were combined to create these natural-color views. The Dec. 5, Jan. 2, April 22 and May 18 views are nearly true color. Because a visible red light image was not available, an image taken using a spectral filter sensitive to wavelengths of near-infrared light centered at 752 nanometers was used in place of red. So the color is close to natural color, but it is not exact. These views were acquired at distances ranges from approximately 1.4 million miles (2.2 million kilometers) to 1.9 million miles (3.0 million kilometers) from Saturn and at sun-Saturn-spacecraft, or phase, angles of 41 degrees to 99 degrees. All the views are set to a scale of 101 miles (162 kilometers) per pixel. Credit: NASA/JPL-Caltech/Space Science Institute

This state of affairs lasts for decades at a time.

During the very long calm before the storm, the outer atmosphere radiates heat into space and progressively cools until finally it becomes more dense then the lower layer.

The balance between the layers becomes disrupted, and the warm air that had been kettled up below punches its way outward.

The heavier water molecules in the roiling mix are then shed in massive storms until the original balance is restored, and calm returns.

"The time scale depends on how fast the planet can cool by radiating heat into space," Li said by email. "Because Saturn has a massive atmosphere, it takes decades to cool."

Saturn and its gas giant neighbour Jupiter both sport massive storms. But rather than giant thunderstorms, the rain that falls in Jupiter's "Great Red Spot" is more similar to an Earthly drizzle, said Li.

This is likely because Saturn has more water that can condense to form clouds than Jupiter.

The two scientists tested their theory by developing simulation software similar to that used for weather forecasting on Earth, and compared the results to observations of the Cassini spacecraft orbiting Saturn.

More information: Moist convection in hydrogen atmospheres and the frequency of Saturn's giant storms, *Nature Geoscience*, DOI: 10.1038/ngeo2405

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