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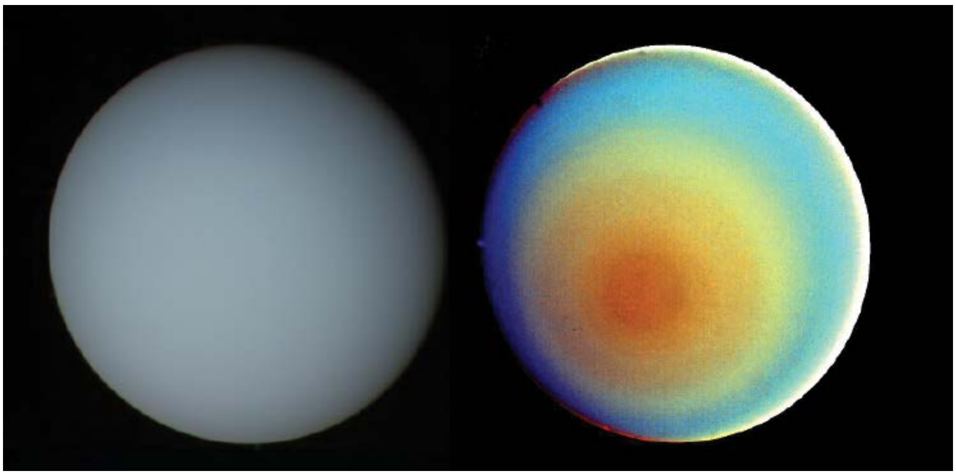
What Caused the Sudden Heating of Uranus's Atmosphere?



NASA/JPL

The Voyager 2 spacecraft snapped these (left) true-color and (right) false-color images of Uranus in 1986.

Models of Jupiter, Saturn, Uranus, and Neptune predict that the temperatures of their upper atmospheres—the zones of dilute gases far above the planets' frigid cloud tops—should be around 200 kelvins, or −73°C. However, when the two Voyager spacecraft zipped by those gas giants in the late 1980s, scientists discovered that the planets' outermost atmospheres were much hotter than expected—nearing 1000 kelvins, or more than 700°C.

Scientists have had trouble coming up with a mechanism to explain these searing temperatures. Now, after decades of observation, they might be closer to an answer.

Although close monitoring has shown that Uranus's upper atmosphere underwent consistent cooling over the past 20 years, measurements since 2014 by University of Leicester's Henrik Melin and colleagues revealed a reversal toward heating.

During this time, other observers detected a storm in the planet's lower atmosphere. Could the two phenomena be related?

"The fact that this turbulent weather phenomenon in the lower atmosphere occurs at the same time as there is significant heating in the upper atmosphere suggests that [the storm] is an important mechanism" in that heating process, Melin said.

Melin suspects that the recently spotted Uranian storm (see http://bit.ly/U-storm) could have generated enough heat to reverse the 20-year cooling trend in the upper atmosphere of the planet. Also, because storms occur all the time on Jupiter and Saturn, the disturbances might have a hand in maintaining high temperatures in their upper atmospheres, he suggested.

Melin presented the data on the Uranian heating last December at the 2015 AGU Fall Meeting in San Francisco, Calif. (see http://bit.ly/FM15-abstract).

Turning Up the Heat

During the past 20 Earth years, the upper atmosphere of Uranus cooled from 750 to 550 kelvins, but since 2013, it has heated by about 50 kelvins per Earth year, Melin said. A Uranus year is 84 Earth years, so small variations in Uranus's atmospheric temperature while the planet orbits the Sun should take place gradually. That the reversal happened relatively quickly means that "something dramatic has changed," Melin said.

Several mechanisms can heat a planet, but none solve the mystery of the gas giants' so-called "energy crisis," Melin explained. The Sun warms the gas giants, but because those planets are so large and far away, scientists know that solar photons don't supply enough energy to heat their upper atmospheres to current temperatures.

Scientific evidence suggests that Jupiter and Saturn hold extremely hot cores left over from their formation about 4.5 billion years ago, but the core of Uranus generates relatively little heat. Also, the process that creates auroras on Earth—high-energy solar particles interacting with the planet's magnetic field—can cause heating. However, because the gas giants are so huge and rotate so fast, this heat circles the poles without spreading globally, so it wouldn't account for the global upper atmospheric heating that's been observed, Melin said.

Given the storm in Uranus's lower atmosphere, Melin suspects that another factor could be at work: low-amplitude "acoustic waves"—also known as gravity waves—generated by huge, turbulent storms. These waves originate from disturbances, like ripples in a pond. On Earth, gravity waves come from violent thunderstorms or when wind blows over a mountain. On the gas giants, storms in the lower altitudes create these waves, which propagate toward the higher altitudes and generate heat, Melin said.

"Uranus is unique in that it has remained so very quiet [stormwise] for so long and that the appearance of these storms in 2014 correlates so well with the abrupt heating of the upper atmosphere," Melin said.

Stormy Waves

Astronomers have seen a similar effect before on Saturn, said Leigh Fletcher, a planetary scientist who is also at the University of Leicester in the United Kingdom but wasn't involved in the research by Melin and his colleagues. In 2010, a huge storm erupted in Saturn's lower atmosphere, and scientists witnessed the evolution of a region of hot gases that rose into the upper atmosphere (see http://bit.ly/Saturn-Storm).

"Connecting this middle-atmospheric activity to the tropospheric storms is very challenging, but it's also possible that waves can transfer their energy all the way up to the top of the atmosphere, where Dr. Melin has been working," Fletcher continued.

However, scientists remain unclear as to how these planets' lower atmospheres interact with their upper atmospheres. "The apparent increase in storminess of Uranus over the past few years might just be an observational bias, as our observing techniques continue to improve," Fletcher said. "Only a long-term campaign of Uranus storm tracking can accurately tell us the statistics of Uranian storms, although the [2014] storms do appear to have been bigger and brighter than anything we've seen before."

By **JoAnna Wendel,** Staff Writer