# Scientists show 'breaking waves' perturb Earth's magnetic field

May 11 2015

Kelvin-Helmholtz waves in the atmosphere form when high-speed wind blows over more stagnant air masses. The waves create turbulence and mix the air masses. New research has shown that similar Kelvin-Helmholtz waves also frequently occur in Earth's magnetosphere and allow particles from the solar wind to enter the magnetosphere to produce oscillations that affect Earth's protective radiation belts. Credit: Copyright University Corporation for Atmospheric Research, photo by Benjamin Foster.

The underlying physical process that creates striking "breaking wave" cloud patterns in our atmosphere also frequently opens the gates to high-energy solar wind plasma that perturbs Earth's magnetic field, or magnetosphere, which protects us from cosmic radiation. The discovery was made by two University of New Hampshire space physicists, who published their findings in the online journal *Nature Communications* Monday, May 11, 2015.

The phenomenon involves ultra low-frequency Kelvin-Helmholtz waves, which are ubiquitous throughout the universe and create the distinctive patterns—from Earth's clouds and ocean surfaces to the atmosphere of Jupiter—but were not thought to be a common mechanism for changing the dynamics of the magnetosphere.

"Our paper shows that the waves, which are created by what's known as the Kelvin-Helmholtz instability, happens much more frequently than previously thought," says coauthor Joachim "Jimmy" Raeder of the UNH Space Science Center within the Institute for the Study of Earth, Oceans, and Space. "And this is significant because whenever the edge of Earth's magnetosphere, the magnetopause, gets rattled it will create waves that propagate everywhere in the magnetosphere, which in turn can energize or de-energize the particles in the radiation belts."

Using data from NASA's Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission, Raeder and his Ph.D. student Shiva Kavosi (lead author) found that Kelvin-Helmholtz waves actually occur 20 percent of the time at the magnetopause and can change the energy levels of our planet's radiation belts.

These changing energy levels can have impacts on how the radiation belts either protect or threaten spacecraft and Earth-based technologies. But Raeder notes the finding is less about the affects of so-called "space weather" on space- and Earth-based communications and more about a better understanding of the basic physics of how the magnetosphere works.

"It's another piece of the puzzle," Raeder says. "Previously, people thought Kelvin-Helmholtz waves at the magnetopause would be rare, but we found it happens all the time."

The effect of Kelvin-Helmholtz instability waves (named for 19th century scientists Lord William Thomson Kelvin and Hermann von Helmholtz) can commonly be seen in cloud patterns, on the surface of oceans or lakes, or even a backyard pool. The distinctive waves with capped tops and cloudless troughs are created by what's known as velocity shear, which occurs when a fluid or two different fluids—wind and water, for example—interact at different speeds to create differing pressures at the back and front ends of the wave.

Notes Kavosi, "In clouds, you see it because the lower atmosphere is more stagnant and you have a higher speed wind going over it, which creates that distinctive swirl pattern. The phenomenon is really ubiquitous in nature. Often, the waves are present in the atmosphere but not visible if there are no clouds. In that case, pilots cannot see them and aircraft may experience severe and unexpected turbulence."

The five-satellite THEMIS mission launched in 2007 and has provided a unique, long-term dataset that allowed Kavosi and Raeder to do robust statistical analysis of the occurrence of Kelvin-Helmholtz waves. Raeder has been a co-investigator on the THEMIS mission since its conception more than 15 years ago and continues to analyze the data in collaboration with his graduate students.

"Previous missions were either too short or the observations didn't occur in the right place," Raeder says. "THEMIS's elliptical orbits achieved over one thousand magnetopause crossings and provided unprecedented observations. We didn't have a database like this before and therefore couldn't do the analysis."

**More information:** The *Nature Communications* paper, "Ubiquity of Kelvin-Helmholtz waves at Earth's magnetopause," can be viewed at www.nature.com/ncomms/2015/150 … full/ncomms8019.html

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