New mini-satellite will measure howling winds high in Earth's atmosphere

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WindCube will measure the Doppler shift of red light emitted from atomic oxygen (the same light that adds a red glow to auroras) as it's blown along with the thermospheric winds. WindCube is being led by our High Altitude Observatory. Credit: NASA

The National Center for Atmospheric Research (NCAR) has received

$6.5 million in funding from NASA to launch a roughly shoebox-sized satellite into space carrying an instrument designed to measure the howling thermospheric winds, which can gust more than 300 miles per hour through the highest reaches of the Earth's atmosphere.

The blustery winds in the thermosphere—the upper layer of the atmosphere that thins into space and which hosts orbiting satellites and dazzling auroras—can impact radio and GPS communications. But despite their disruptive potential, thermospheric winds are sparsely observed.

NCAR's new, rectangular "CubeSat," which will check in at just over a foot on its longest side, will contribute a wealth of new observational data that can help scientists improve models of the upper atmosphere and, ultimately, better predict impacts to communication systems and satellites. The CubeSat, dubbed WindCube, will likely be ready for launch in about three years.

"This is a significant achievement for NCAR and its High Altitude Observatory (HAO)," said NCAR Director Everette Joseph. "While the observatory has supported many satellite missions in the past, this is the first project our organization is leading. I am excited that we will be able to provide the research community with critical data for fundamental research that will ultimately help society better prepare for these disruptions in Earth's upper atmosphere."

The data from WindCube will help improve models of the upper atmosphere, which can be a challenge to accurately represent the winds in the real world.

WindCube is one of 4 new CubeSat missions announced by NASA's Heliophysics Flight Opportunities in Research and Technology program in cooperation with NASA's Space Weather Science Application. NCAR is sponsored by the National Science Foundation.

High-quality observations for a fraction of the cost

Thermospheric winds are driven by the intense heating of the Sun at that altitude; the region can be more than 350 degrees Fahrenheit hotter in the daytime than at night. However, the winds are also impacted by large-scale oscillations in the lower layers of the atmosphere, such as planetary waves and atmospheric tides, as well as by the solar wind.

The impact of thermospheric winds on radio waves is related to how they affect the ionosphere, which is made up of regions in the upper atmosphere that contain electrically charged ions. These charged regions, which overlay the thermosphere, are constantly changing and evolving. Depending on its regional characteristics at any given time, the ionosphere can reflect, bend, absorb, and otherwise alter radio waves, sometimes aiding propagation and sometimes disrupting it.

The neutral winds in the thermosphere blow around these charged structures in the ionosphere, and can force the ionosphere generally higher or lower, changing its characteristics. The winds can also change how the ionosphere reacts to disruptions from geomagnetic storms from solar activity.

For decades, scientists have measured thermospheric winds using a Fabry-Perot interferometer, which can detect the faint Doppler shift of red light (630 nanometer wavelength) emitted from atomic oxygen in the thermosphere as it's blown along. A stretching or bunching of the lightwaves indicates the speed at which the wind carrying the oxygen is moving. But it's challenging to take such measurements from the ground, especially during the daylight hours.

"The signal we're looking for is very weak," said NCAR project scientist

Qian Wu, WindCube's joint team leader. "During the day, the sunlight obscures the signals we want to observe making it almost impossible."

Fabry-Perot interferometers launched into space overcome these challenges, but until recently, such instruments required a large satellite platform in order to have enough stability. For example, an interferometer onboard NASA's Ionospheric Connection Explorer (ICON) spacecraft currently observes the thermospheric winds from its orbit around the equator.

WindCube, which is set to orbit Earth around its poles, will be the first time a wind-measuring interferometer will be carried on a small CubeSat. This advancement is made possible because the CubeSat platform has become more stable and because scientists are able to build smaller instruments. The Fabry-Perot interferometer that will fly on WindCube will be built by HAO.

"The ability to install our instrument on a CubeSat allows us to increase critical measurements of the thermospheric winds at a fraction of the cost of a full-fledged satellite mission," said HAO Director Holly Gilbert. "We're excited to be able to make high-quality, cost-effective observations in the thermosphere, and we're hopeful that our success could enable more, similar missions in the future."

Provided by NCAR & UCAR

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