GOLD's bird's-eye reveals dynamics in Earth's interface to space

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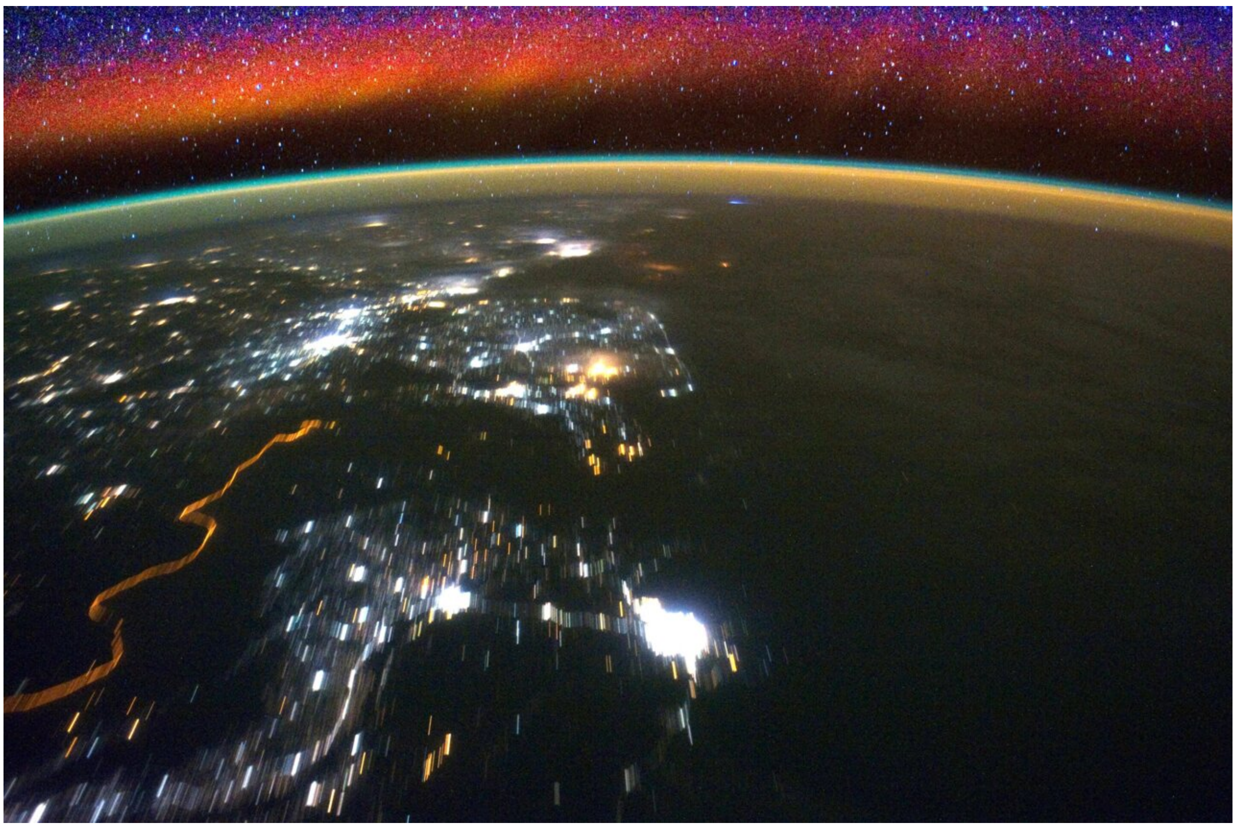

Processes in Earth's upper atmosphere create bright swaths of color known as airglow, as seen here in an image taken from the International Space Station. Credit: NASA

New research using data from NASA's Global-scale Observations of the Limb and Disk, or GOLD, mission, has revealed unexpected behavior in the swaths of charged particles that band Earth's equator—made possibly by GOLD's long-term global view, the first of its kind for this type of measurement.

GOLD is in geostationary orbit, which means it orbits around Earth at the same pace the planet turns and "hovers" over the same spot overhead. This allows GOLD to watch the same area for changes over time across longitude and latitude, something that most satellites studying the upper atmosphere can't do.

"Since GOLD is on a geostationary satellite, we can capture 2D time evolution of these dynamics," said Dr. Xuguang Cai, a researcher at the High Altitude Observatory in Boulder, Colorado, and lead author on a new research paper.

GOLD focuses on parts of Earth's upper atmosphere stretching from about 50 to 400 miles in altitude, including a neutral layer called the thermosphere and the electrically charged particles that make up the ionosphere. Unlike the neutral particles in most of Earth's atmosphere, the ionosphere's charged particles respond to the electric and magnetic fields threading through the atmosphere and near-Earth space. But because the charged and neutral particles are mixed together, something that influences one population can also impact the other.

This means the ionosphere and upper atmosphere are shaped by a host of complex factors, including space weather conditions—such as geomagnetic storms, driven by the Sun—and terrestrial weather. These regions also act as a highway for many of our communications and navigation signals. Changes in the ionosphere's density and composition can muddle the signals passing through, like radio and GPS.

From its vantage point on a commercial communications satellite in geostationary orbit, GOLD makes hemisphere-wide observations of the ionosphere about every 30 minutes. This unprecedented birds-eye view is giving scientists new insights into how this region changes.

Mysterious movement

One of the nighttime ionosphere's most distinctive features are twin bands of dense charged particles on either side of Earth's magnetic equator. These bands—called the Equatorial Ionization Anomaly, or EIA—can change in size, shape, and intensity, depending on the conditions in the ionosphere.

The bands can also move position. Until now, scientists have relied on data captured by satellites passing through the region, averaging measurements over months to see just how the bands might be shifting in the long term. But short-term changes were more difficult to track.

Before GOLD, scientists suspected that any quick changes that happen in the bands would be symmetrical. If the northern band moves north, the southern band makes a mirror motion south. One night in November 2018, though, GOLD saw something that challenged this idea: the southern band of particles drifted southward, while the northern band remained steady—all in less than two hours.

This isn't the first time scientists have seen the bands move like this, but this shorter event—only about two hours, compared to a more typical six to eight hours seen prior—was seen for the first time, and could only have been observed by GOLD. The observations are outlined in a paper published on Dec. 29, 2020, in the *Journal of Geophysical Research: Space Physics*.

The symmetrical drifting of these bands is caused by rising air that drags charged particles along with it. As night falls and temperatures cool, warmer pockets of air surge upwards. The charged particles carried within these warmer air pockets are bound by magnetic field lines, and for those pockets near Earth's magnetic equator the shape of Earth's magnetic field means that upward motion also pushes the charged particles horizontally. This creates the symmetrical northward and southward drift of the two charged particle bands.

The exact cause of the asymmetric drift observed by GOLD is still a mystery—though Cai suspects the answer lies in some combination of the many factors that shape the motion of electrons in the ionosphere: ongoing chemical reactions, electric fields, and high-altitude winds blowing through the region.

Though surprising, these findings can help scientists peer behind the curtain of the ionosphere and better understand what drives its changes. Because it's impossible to observe every process with a satellite or ground-based sensor, scientists rely heavily on computer models to study the ionosphere, much like models that help meteorologists predict weather on the ground. To create these simulations, scientists code in what they suspect are the underlying physics at work and compare the model's prediction to observed data.

Before GOLD, scientists got that data from occasional passing satellites and limited ground-based observations. Now, GOLD gives scientists a bird's-eye view.

More information: Xuguang Cai et al, Observation of Postsunset OI 135.6 nm Radiance Enhancement Over South America by the GOLD Mission, *Journal of Geophysical Research: Space Physics* (2020). DOI: 10.1029/2020JA028108

Provided by NASA

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