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Grand Theft Galaxy
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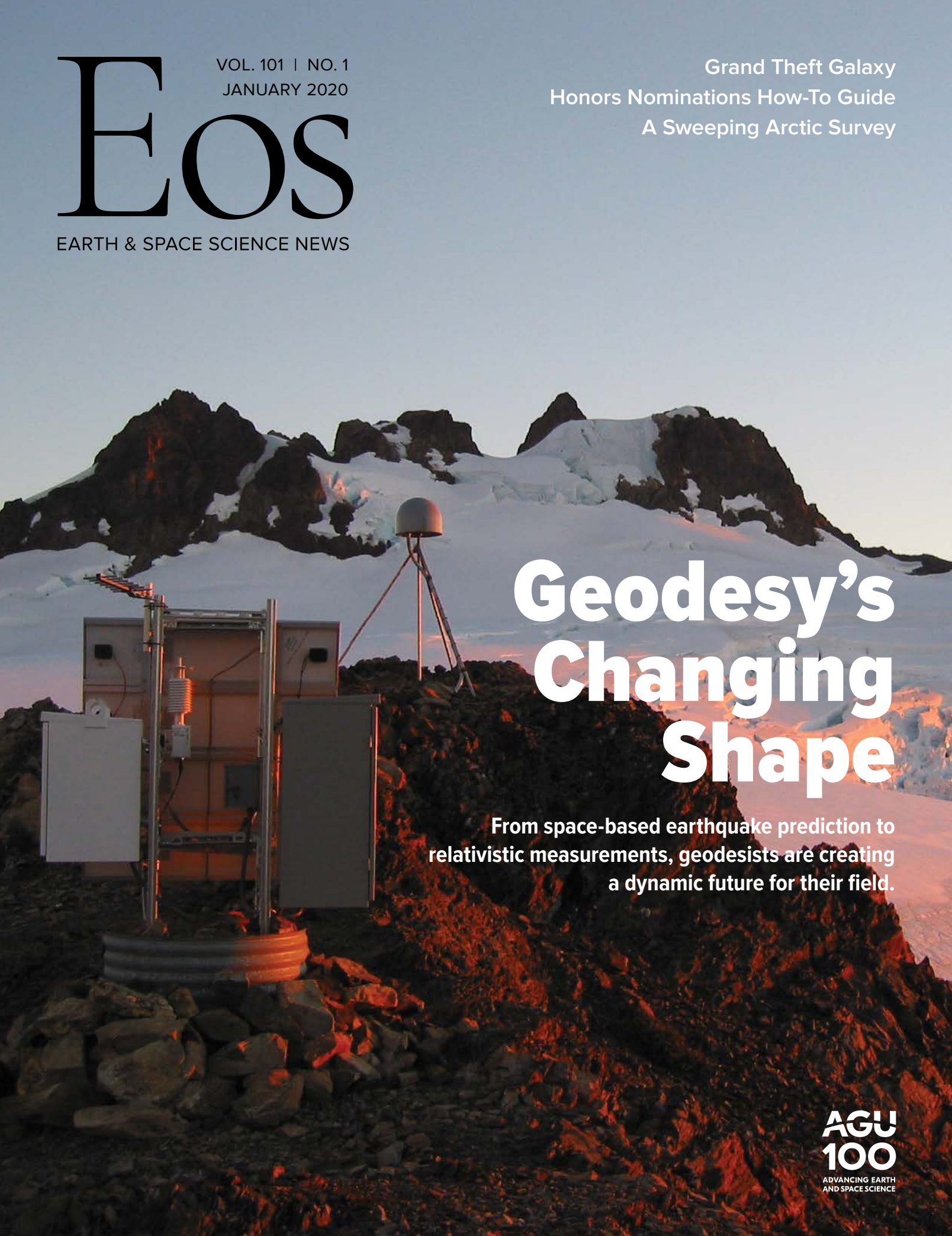

Geodesy's Changing Shape

From space-based earthquake prediction to relativistic measurements, geodesists are creating a dynamic future for their field.

AGU 100
ADVANCING EARTH AND SPACE SCIENCE

Wanted for Grand Theft Galaxy: The Milky Way

A visualization of the study's simulations, with dark matter shown at center (in white) and a galaxy similar to the Large Magellanic Cloud (along with stars and gas) shown at bottom right. Also pictured are multiple companion galaxies. Credit: Ethan Jahn, University of California, Riverside

In a case that's outside the jurisdictions of earthly courts, the Milky Way has been accused of stealing from one of its closest neighbors and satellite galaxies, the Large Magellanic Cloud (LMC). Instead of taking cars or garden gnomes, however, the Milky Way likely stole several small galaxies.

In a study published in *Monthly Notices of the Royal Astronomical Society,* researchers assert that two classical dwarf galaxies—Carina and Fornax—are "consistent with the LMC system by our calculations of angular momenta" (bit.ly/LMC-galaxies). In addition, the team's analysis bolsters the findings of previous studies indicating that several ultrafaint dwarf galaxies show signs of previous associations with the Large Magellanic Cloud.

In total, there are seven small galaxies currently associated with the Milky Way, including the Small Magellanic Cloud, that researchers have confirmed once orbited the Large Magellanic Cloud. Remarkably, until recent years, the Small Magellanic Cloud was the only known satellite of its larger counterpart, according to Ethan Jahn, a graduate student of astronomy at the University of California, Riverside and the lead author on the study.

Eight additional dwarfs appear to have a history of orbiting the Large Magellanic Cloud, but additional work is needed to confirm these possible relationships, researchers noted.

Gaia Data and FIRE Simulations

The researchers' calculations are based on publicly available proper motions data from the European Space Agency's Gaia mission, Jahn said. Gaia collected the most accurate position and velocity data of any satellite to date—"state-of-the-art data," he added.

The researchers compared these data with "a sample of five cosmological zoom-in simulations of LMC-mass host galaxy systems" from the Feedback in Realistic Environments (FIRE) project. FIRE's zoom-in approach enables researchers to create high-resolution galaxy formation simulations that can grapple with complex physical effects that elude other simulations, Jahn said.

FIRE simulations predicted the presence of between 5 and 10 luminous satellite galaxies orbiting hosts with the mass of the Large Magellanic Cloud, Jahn said. Galaxies similar to the Milky Way have only about double the number of such satellites, even though the Milky Way is 10 times larger than the LMC.

Cosmological Questions

"Some of the most interesting outstanding questions in cosmology and structural formation are small-scale cosmological questions," Jahn said.

One such question is how to resolve the missing-satellites problem, the discrepancy between the high number of satellite galaxies predicted by simulations to orbit the Milky Way and the lower number of satellites observed. By looking at satellite galaxies of the Large Magellanic Cloud, the recent study explores similar questions from "one step down," Jahn said.

"This study is a very nice update from previous work that looked at the abundance of satellites around LMC-mass galaxies using just dark-matter-only simulations," said Ekta Patel, a fellow at the University of California, Berkeley's Miller Institute for Basic Research in Science. She wasn't involved with the study.

"Since the FIRE simulations encompass a fully hydrodynamical model, these results provide a rigorous study of the subhalos and corresponding galaxies that survive when baryons are added. This reduces some of the uncertainty that can arise when neglecting baryonic processes such as feedback, the effect of reionization, gas hydrodynamics, and tidal effects from the disk of the host galaxy," Patel added.

She's currently working "to confirm whether the satellites suggested to be satellites of the LMC in this study have orbital histories that are suggestive of true satellites.... This work looks mainly at the orbital poles of such galaxies only today and compares the real abundances to the abundances of satellites in simulations of the LMC. I think my study will be complementary and not competitive since it uses a different approach, but we are targeting a similar question."

Jahn plans to use new simulations to explore additional questions about satellites of the Large Magellanic Cloud, such as how they form and under what conditions they stop forming stars.

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